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VALIDATION OF THE TEN-YEAR INTEGRATIONS OF THE ARPEGE MODEL (T21,T42 AND T79) OVER THE EUROPEAN REGION: IMPACT OF THE INCREASED HORIZONTAL RESOLUTION

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Asunción Pastor

This report has been developed in the framework of the Spanish-French collaboration, in which the following teams have taken part:

1.- **METEO-FRANCE**

a) CNRM/GMGEC/EAC

b) SCEM/CBD/DEV

2.- **INM**

SUB. DE CLIMATOLOGIA Y APLICACIONES/SAIC

1. OBJECTIVES

The aims of the present work are:

1) **to validate the French Community Climate Model over the European area.**

2) **to study the impact of increased horizontal resolution.**

These tasks will be performed by comparing:

a) the model outputs with analyses made at ECMWF (Section A of the present report).
b) the model outputs with the observed climatology for the French and Spanish areas, being selected as atmospheric variables precipitation and temperature, essential parameters for impact assessment (Section B of the present report).

The general circulation model used in this study is the French Community Climate Model, derived from the Arpège forecast model. The model uses the spectral transform method in the horizontal, and the spherical harmonic expansions are truncated in a triangular way. Integrations have been performed at three truncation wavenumbers (T21,T42 and T79) and with 30 levels in the vertical discretization. The three spectral truncations correspond to collocation grids of 64 longitudes by 32 latitudes (T21), 128 longitudes by 64 latitudes (T42) and 240 longitudes by 120 latitudes (T79).

This report is divided in the following sections:

- Section A,
  - A.1.- Introduction
  - A.2.- Study and analysis of the simulations
  - A.3.- Summary and conclusions
- Section B,
  - B.1.- Introduction
  - B.2.- Data
  - B.3.- Methodology
  - B.4.- Results
  - B.5.- Conclusions

- Section C, contains the following annexes:

  1.- Orography of the different resolutions.
  2.- Graphics of the mean and mean square errors and charts of the geographical distributions and differences of the fields corresponding to section A.
  3.- Graphics and charts of precipitation and temperature corresponding to section B.

SECTION A

A.1.- INTRODUCTION

The aim of this work is to validate over the **european region** the Arpège model outputs available at present with the analyses obtained at ECMWF.

The ARPEGE outputs available are:

- 10 Januaries and 10 Julies, from 1979 to 1988, for the truncations T21, T42 and T79 (Atmospheric Model Intercomparison Project -AMIP- experiment).

The names of the simulated experiences are:
BA6 for the truncation T21.
BA5 for the truncation T42.
BA7 for the truncation T79.

The validation will be done comparing these outputs with the analyses made at the ECMWF for 6 Januaries and 6 Julies from 1986 to 1991. These analyses have been obtained, from MARS (ECMWF), and averaged by A. Braun. The truncation of these analyses is T106.

In order to compare the ARPEGE outputs with the ECMWF analyses, it has been necessary to interpolate these outputs at the same resolution as the analyses (T106).

The fields available to compare are the following:

a) Height fields:

Geopotential (200,500 and 850 hPa)
Temperature (200,500 and 850 hPa)
Humidity (200,500 and 850 hPa)
Wind components (U,V) (200,500 and 850 hPa)
Sea level pressure

b) Surface fields:

Pluie C, Pluie S, Pluie T
Preci C, Precip
Neige T
Top solar radiation, Surface solar radiation,
Top thermal radiation, Surface thermal radiation,
Surface sensible heat, evaporation, cloud cover,
Surface temperature and Wind stress.

To plot all these fields it has been used **MAGICS** (software developed at ECMWF) as the graphics software. They have been obtained plots for **each output** of the model, for **each analysis** of ECMWF and for the **differences** between Arpège outputs and the ECMWF analyses.

It has been used the following legend for the maps:

- 1st title ARPEGE BAN 10MM or CEP EUROPE 6MM
  BAN, name of the experience of the model outputs
  CEP, for ECMWF analyses
  MM, month simulated JAN or JUL
- 2nd title name of the field (and level for the height fields).

The methodology used to do this comparison has been:

1) **General description** of the main features of the ECMWF analysis, for each field.

2) **General description** of the main features of the Arpège outputs for each field and for each simulation: BA6, BA5, BA7 showing the agreements and discrepancies with respect to the analysis.

3) **Analysis** of the differences maps (between Arpège outputs and ECMWF analyses), to examine the biases.

4) **Study** and analysis of the mean and mean square errors.

A.2.- STUDY AND ANALYSIS OF THE SIMULATIONS

HEIGHT FIELDS

SIMULATIONS OF THE WINTER CLIMATOLOGY

THE GEOPOTENTIAL (Z) DISTRIBUTION IN JANUARY

Z200

CEP

Main features:

A main circulation over the Atlantic splits into two, causing two circulations over:

1) North Europe
   A ridge extending along East of Great Britain from (0°W,58°N) southwards to the English Channel.
2) South Europe
   A ridge-trough pattern from West of the Iberian Peninsula to Southern Corsica.

WNW flow over Europe.

MODEL

BA6: The model simulates only one main circulation over Europe:
- A large amplitude ridge-trough system drifted westwards respect to the analysis system, with an increase of the gradient at Southeastern Europe.
- NW flow over Europe.

BA5: The model simulates only one main circulation over Europe, displacing eastwards and enhancing the ridge, with an increase of the gradient over South Europe.
- WSW flow over Britain and Iberian Peninsula, WNW flow over the rest of Europe.

BA7: The model simulates very well the main circulation, displacing the split eastwards and shifting, slightly, the circulation southwards.
- WNW flow over Europe.

SUMMARY

The main features of the circulation are reproduced in all the simulations.

The position and amplitude of the main wave are in well accordance with the analysis in BA7 and BA5, but only BA7 simulates the southern wave. BA6 enhances considerably the wave.

In all the cases the values of the geopotential are lower than in the analysis, tending to the analyzed ones with resolution.

It is shown a great improvement of the pattern with resolution.

Z500

CEP

Main features:

A main circulation over the Atlantic splits, causing two circulations:

1) Over North Europe
   - A ridge extending from Scandinavia to North of France.
2) Over South Europe
   - A ridge extending along West of the Iberian Peninsula.
   - A trough extending from Corsica southwards.

WSW flow West of Europe, WNW flow Eastern Europe.

MODEL

BA6: The model simulates only one main circulation, defined by:
- A ridge from East Iceland southwards.
- A trough from Kola Peninsula to South of Italy.

WNW flow over all Europe.

BA5: The model simulates only one main circulation, defined by:
- A ridge over Scandinavia southwards.

The circulation over Central and Northern Europe is very well simulated but the model does not reproduce the southern one of the analysis.

WSW flow west of the ridge, WNW flow east of the ridge.

BA7: The model simulates the two circulations, displacing eastwards the south one. The north circulation places pretty well the ridge.
- WSW flow Western Europe, WNW flow Eastern Europe.

SUMMARY

The main features of the circulation are reproduced in all the simulations.

The circulation over Central and Northern Europe is very well simulated in BA5 and BA7. BA7 is the only one that reproduces the two circulations, being the southern wave shifted westwards.

As in Z200, BA6 enhances and pronounces the main wave.

In all the cases the model values are lower than in the analysis.

It is shown an improvement of the pattern with resolution mainly between BA6 and BA5.

Z850

CEP

Main features:

The main circulation extends over Great Britain and Scandinavia with WSW flow over Northwestern Europe and WNW flow Northeastern it. Strong gradient over the Atlantic.

- A high pressure area placed over Madeira.
- A low pressure area placed Eastern offshore Iceland.
- The maximum, of 1554 hPa, is located over Northern Africa.

MODEL

BA6: The model enhances the wave centered over West of Europe. The structure of the circulation is not very well simulated.
The high and low areas are well placed but less extended.

BA5: The circulation is very well simulated. The low and high areas are reproduced and quite well placed, being the low wider than the analysis. The maximum value is very well placed.

BA7: The circulation is very well simulated, amplifying slightly the high area. The low area and the maximum value are very well placed. The model places quite faithfully the strong gradient over the Atlantic.

SUMMARY

BA5 and BA7 simulate very well the circulation, being BA7 the best.

The values of BA5 and BA7 are lower in all areas, BA6 values are lower in South of Europe and higher North of it, respect to the analysis ones.

It is shown a great improvement of the pattern with resolution, mainly between BA6 and BA5, but not in the values.

SEA LEVEL PRESSURE (SLP) DISTRIBUTION IN JANUARY

SLP

CEP

Main features:

The main circulation is over North of Europe, with WSW flow in this area, and no

circulation at all over Southern Europe.
- A high area placed over Madeira Island.
- A low area placed over West of Iceland.

MODEL

BA6: The model does not reproduce the structure, showing a very weak circulation over Europe.

BA5: The circulation is well simulated, specially Northern Europe. The low area is well placed but wider than in the analysis while the high area is displaced eastwards.

BA7: The circulation is very well simulated but showing less gradient over the Central Atlantic.
The low area is well placed, but the model does not reproduce the high area over Madeira Island.

SUMMARY

BA5 and BA7 simulate very well the circulation. Their values are lower in all Europe. BA6 shows lower values over Southern Europe and higher Northern it.

There is a substantial misrepresentation of the circulation in BA6.

It is shown a big improvement with resolution.

THE TEMPERATURE (T) DISTRIBUTION IN JANUARY

T200

CEP

Main features:

- It shows a uniform structure over all Europe, being the temperature bounded between -56^0 (Mediterranean Sea), and -60^0 (North Europe).
- There is a warm tongue placed over Western Ireland.

MODEL

BA6: The configuration of isotherms is quite different from the analysis.
The coldest area is spread over the Iberian Peninsula, France and Great Britain. The temperature increases northwards.

BA5: The isotherms are quite well simulated, weakening and shifting westwards the warm tongue. Minimum values over South of Spain.

BA7: The model does not reproduce the isotherms structure over Europe. There is shown a slight improvement in the position of the warm and cold areas.

SUMMARY

BA6 is the best simulation. BA5 and BA7 are colder than the analysis, with the exception of a narrow strip northwards. BA6 is warmer over Northeastern Europe and colder over the rest.

In all the cases, the model increases the temperature northwards, showing BA5 a cold area (the coldest) over the Iberian Peninsula, which does not appear in the analysis.

T500

CEP

Main features:

- A warm ridge over Great Britain, extending its influence to the whole Europe.
- The isotherms values are bounded between -20° and -32° over Europe.

MODEL

BA6: The model simulates:

- A warm ridge over West Britain.
- A trough extending from Northeastern Europe to Southern Greece.
- Strong gradient over Southern Europe.
- The isotherms values are bounded between -24° and -40°.
- The model is colder everywhere.

BA5: The structure of isotherms is in a very good agreement with the analysis, though the gradient over Southern Europe is bigger.

BA7: A very good simulation over the whole area. The isotherms over Europe are bounded between -20°C and -32°C.

SUMMARY

BA7 is the best simulation. BA5 and BA7 become colder than the analysis northwards, showing no differences Northern Africa, Iberian Peninsula and some areas of France.

In BA6 the amplitude of the wave is considerably enhanced.

It is shown a clear improvement either in the pattern or in the accuracy with the increase of resolution.

T850

CEP

Main features:

- The 0°C isotherm extends from the parallel 50°N along West of Europe to the 40°N Eastern Europe.
- The isotherms show a rather meridionally distribution over continental areas whilst zonally over the Atlantic.
- The temperature values are bounded between 4° and -8°, with a slack gradient.

MODEL

BA6: The temperatures are below zero over all Europe except at SW of the Iberian Peninsula.
A bigger gradient of isotherms over Europe mainly at the SE area.
The model becomes colder everywhere.

BA5: The 0°C isotherm and isotherms are very well placed, with a little more gradient mainly northwards.

BA7: The structure of isotherms is very well simulated, the only difference is a greater gradient over Iceland and Northeastern Europe.

SUMMARY

BA5 and BA7 simulations are in a very well agreement with the analysis.
BA5 and BA7 become colder from Spain eastwards and warmer over some areas in the Atlantic.
It is shown an improvement mainly between BA6 and BA5.

THE HUMIDITY (R) DISTRIBUTION IN JANUARY

R200

CEP
Main features:

- An homogeneous structure over Europe, with only two isolines located in Northern and Southern Europe.
- The maximum value is placed over Northern Madeira Islands.

MODEL

BA6: The model shows a quite different structure of isolines, remarking a maximum area over the Azores Islands, which is absent in the analysis. Some maximum values spread from W Europe to the Atlantic.
The model is wetter everywhere duplicating the analysis values.

BA5: The structure of isolines is quite similar to the analysis, but with bigger gradient over Europe. The maximum value is well placed. The model is wetter everywhere, doubling the analysis values, showing the bigger differences are over West the Mediterranean Sea.

BA7: The model shows homogeneous values over all Europe. The structure of isolines is similar to the analysis one. The model becomes wetter everywhere.

SUMMARY

In all the cases the model is wetter everywhere, decreasing these positive biases with resolution.

It is shown a clear improvement with resolution in all the cases.

R500

CEP

Main features:

- A very homogeneous structure with only one isoline over Central Europe.
- A maximum value placed NW Madeira Island.
- A minimum value placed near Kiev.

MODEL

BA6: The model shows a long-length wave, completely absent in the analysis, with the maximum values placed over the Atlantic.
The model is wetter over the Atlantic,W Europe and the Mediterranean Sea, and drier over Northeastern Europe, emphasizing the differences between wet and dry areas.

BA5: The structure is quite similar to the analysis, showing more gradient over Europe.The maximum area is well placed but it is stretched over West of Europe. The minimum value is very well placed. The model is wetter everywhere apart from a small area over the Atlantic. The biggest differences are located over Spain.

BA7: The structure is very similar to the analysis. The maximum area is well placed. The model is wetter everywhere except over Iceland and Northern Africa.

SUMMARY

As a general rule, the model is wetter everywhere with the exception of East Europe in BA6. The wet bias does not exceed 0.4 gr/kg in all the simulations.

It is shown a great improvement in the pattern and values with resolution. This improvement is notorious between BA6 and BA5.

R850

CEP

Main features:

- The humidity increases southwards, placing the maximum area over SW of the Iberian Peninsula.
- The isolines show a zonal distribution over maritime areas and tend to be quasi-meridional over continental areas.

MODEL

BA6: The structure of isolines tends to be reproduced, smoothing them. The model reproduces the maximum and minimum areas. The model becomes drier everywhere mainly Eastern Europe.

BA5: The structure is quite similar to the analysis, with smooth isolines and values approaching to the analysis ones. The maximum value is very well placed. The model is wetter over Central Europe, North of the Iberian Peninsula, Scandinavia, Great Britain and Northern Atlantic, and drier Eastwards the Mediterranean Sea.

BA7: The structure is very similar to the analysis, with an important improvement over the Mediterranean Sea, reproducing very well the analysis details. The model is drier everywhere except in the Alps region.

SUMMARY

BA5 places properly the maximum area. In all the cases the continental region is better simulated than the Atlantic area.

The model is mostly drier everywhere. This negative bias decreases considerably from BA6 to BA5, and slightly increases again with resolution.

It is shown an improvement with resolution. The contrasts between continental and maritime areas are better simulated with resolution.

THE WIND (V) DISTRIBUTION IN JANUARY

V200

CEP

Main features:

- Two maxima of westerlies areas placed over:
  1) South Mediterranean Sea, with a strength of 40 m/s.
  2) The Atlantic, West of Ireland, with a strength of 32 m/s.
- A minimum area (12 m/s) over Central Europe.

MODEL

BA6: The model only reproduces the maximum area over Southern the Mediterranean Sea, although strengthing it (44 m/s).
Over the Atlantic the model gives a weaker wind, showing few isotachs in this area. The model is less westerly North of Europe.

BA5: The model reproduces the two maxima of westerlies placed over:
- South Mediterranean Sea (36m/s).
- The Atlantic, West of the Iberian Peninsula (32 m/s).
The model is a little less westerly over South Atlantic and the Iberian Peninsula.

BA7: The model shows the two maxima of westerlies placed over:
- Southeastern Mediterranean Sea (40 m/s).
- The Atlantic, West of Europe (28 m/s), weaker respect to the analysis.
The minimum area is shifted to the Eastern Europe.

SUMMARY

The structure is very well reproduced in BA5 and BA7. BA5 and BA7 show greater values over Europe, shifting the minimun area of the analysis eastwards.

In all the cases, the Mediterranean Sea maximum is well located and the minimum area is displaced Eastern Europe. The maximum over the Atlantic is generally displaced southwards.

The model values are generally higher than the analysis over Southern Europe and smaller over Northern Atlantic.

V500

CEP

Main features:

- A maximum westerly area placed over the Atlantic, Western Europe, with a strength of 24 m/s.
- A minimum area placed over the Alps.

MODEL

BA6: The model shifts the minimum area over Southern of the Iberian Peninsula.
There are two maxima areas placed over:
- South Mediterranean Sea (20 m/s).
- The Azores Islands (16 m/s).
The model is a little less westerly North of Europe.

BA5: The structure of isotachs is well simulated. The maximum area over the Atlantic and West Europe is wider than in the analysis and displaced southwards.

BA7: The simulation is quite similar to BA5, showing BA7 less gradient than BA5.

SUMMARY

BA5 and BA7 reproduce quite faithfully the structure of the analysis, being BA7 the best. BA6 winds, over the Atlantic, are weaker than the analysis.

There is a westerly bias over Madeira Island and an easterly one over the Atlantic, Western Ireland, due to the shifting of the maximum southwards.

V850

CEP

Main features:

A maximum westerly area placed 50°N over the Atlantic, with a strength of 12 m/s. A minimum area placed over Central Europe.

MODEL

BA6: The model only shows a very weak maximum area (4 m/s) over the Atlantic, France and Britain, much more attenuated than in the analysis. The model shows an easterly bias mostly in the whole area.

BA5: The structure is very similar to the analysis, although the model spreads the maximum area over West of Europe, and displaces it southwards.

BA7: The model reproduces quite well the structure, placing properly the maximum area, though disminishing its value. The structure and values over North and South Europe are in a very well agreement with the analysis.

SUMMARY

The BA6 simulation is clearly weaker than the analysis.

It is shown an important improvement with resolution, being BA7 the best simulation.

SIMULATIONS OF THE SUMMER CLIMATOLOGY

THE GEOPOTENTIAL (Z) DISTRIBUTION IN JULY

Z200

CEP

Main features:

- A quasi-zonal circulation over Central Europe, with a slight gradient.
- A very weak ridge-trough system over Southern Europe, with the ridge placed West of the Iberian Peninsula and the trough East of Greece.

W flow over Europe.

MODEL

BA6: The model simulates very well the circulation and values South of Europe, although shortens the analysis wave. Over North Europe the model gives a zonal circulation with a stronger gradient respect to the analysis.

BA5: The model spreads the ridge-trough system over Europe, changing the wave phase and placing the ridge from Leningrad to Bulgaria and the trough from Britain to North Spain. The values are in quite well agreement with the analysis ones, except over Northern Atantic and Scandinavia.

BA7: The model shows the same structure as BA5. The values are very well reproduced, except over Northern Atlantic and Scandinavia.

SUMMARY

BA6 is the best simulation from North British Islands southwards.

BA5 and BA7 simulations are quite similar, both of them reproduce the zonal characteristics although enhance the principal wave.

The geopotential values are very well reproduced in all the simulations mainly from Great Britain southwards.

In this case there is not an improvement with resolution.

Z500

CEP

Main features:

- A quasi zonal circulation over the Atlantic, West of Great Britain, which causes two weak waves over Europe, one to the north, with a ridge over Eastern Finland and the other to the south, with a trough over Bulgaria.
- A shortlength wave, clearly marked, placed over North of Africa.

W flow over Europe.

MODEL

BA6: The model reproduces the zonal circulation over the Atlantic, but shifts it norther, reaching Iceland, and with much more gradient. Also reproduces the southern wave but placing it norther than in the analysis, enhancing the trough over Western Italy.
The shortlenght wave placed North of Africa is not captured.

BA5: The model tends to reproduce the analysis circulation, mainly Northern Europe, with a stronger gradient, but does not simulate properly the southern wave.

BA7: The simulation is quite similar to BA5 reproducing the analysis circulation with a stronger gradient over Northern Europe. The values and the gradient are quite accurate.

SUMMARY

As in Z200, BA6 is the best simulation, reproducing quite well the main features and values of the analysis, although giving a bigger gradient at upper latitudes. The mean error is nearly zero.

The BA5 and BA7 values are lower than in the analysis except at Central Russia.

In this case there is not an improvement with resolution.

Z850

CEP

Main features:

- A zonal circulation placed West of Ireland, which diverges over Northern Europe.
- A high area placed over the Azores Islands.
- A high area placed over Algeria, Tunisia and South of Spain.

MODEL

BA6: The model simulates quite faithfully all the main features of the analysis, although it shows a bigger gradient at upper latitudes, with values quite similar to the analysis.

BA5: The model structure is quite similar to the analysis, with a little more gradient over the Atlantic. The values are lower everywhere with respect to the analysis.

BA7: The model structure and values are similar to BA5, placing accurately the high area over the Azores Islands.

SUMMARY

In all the cases the model reproduces very well all the main features of the analysis. The values are always lower, being BA6 the most accurate of the simulations.

There is not an improvement with resolution.

SEA LEVEL PRESSURE (SLP) DISTRIBUTION IN JULY

SLP

CEP

Main features:

- A very homogeneous structure over Europe.
- A high area placed from West of the Iberian Peninsula to Central Europe.
- Two low areas placed over Iceland and Turkey.

MODEL

BA6: The model tends to simulate the analysis structure, placing quite well the high and lows areas, but gives a bigger gradient Southeastern Europe, deepening the low over Turkey. The values are lower than in the analysis.

BA5: The model tends to reproduce the analysis structure altough spreads the high and low areas, increasing the gradient everywhere.
The values are lower than in the analysis.

BA7: The simulation is very similar to BA5, reproducing quite well the analysis structure over Europe. The values are lower than in the analysis.

SUMMARY

In all the cases the model simulates quite well the main features of the analysis. There is an improvement of the pattern with resolution.

The values are lower for all resolutions, growing up the differences as the resolution increases.

THE TEMPERATURE (T) DISTRIBUTION IN JULY

T200

CEP

Main features:

- A zonal distribution over Northern Europe, increasing the temperature northwards.
- A meridional distribution over Southern Europe with a cold area located from the Atlantic, up to Central Europe and a warm area over Turkey.

MODEL

BA6: The model simulates quite well the warmest and the coldest areas, increasing the colder gradient. The model becomes colder and the temperature increases northwards.

BA5: The model simulates the coldest area but reduces its extension, giving a quasi zonal distribution over Europe with nearly no gradient. The model becomes colder everywhere.

BA7: The model does not capture the coldest area, showing an isotherm structure over North of Europe. The model becomes colder everywhere.

SUMMARY

BA6 is the only one which simulates and places quite well the coldest area. BA5 and BA7 tend to reproduce an isothermal structure over Northern Europe. The model is colder than the analysis.

There is not an improvement with resolution.

T500

CEP

Main features:

- A zonal distribution with a very slight gradient over Europe and isotherms bounded between -16°C and -4°C . The temperature decreases northwards.

MODEL

BA6: The simulation is quite accurate from Great Britain southwards. It gives a very strong gradient North of Britain, due to this, the temperatures are bounded between -24°C and -4°C . The model is generally colder than the analysis.

BA5: The model is nearly similar to the analysis, reproducing faithfully the pattern and values.

BA7: The structure of isotherms is quite similar to BA5, being BA7 warmer than BA5.

SUMMARY

It is shown an improvement with resolution between BA6 and BA5, mainly North of Great Britain, but not between BA5 and BA7.

The model becomes warmer with resolution.

T850

CEP

Main features:

- A zonal distribution with a slight gradient over Central and Northern Europe.
- Two warm areas placed over North Africa and Turkey.

MODEL

BA6: The model tends to simulate the analysis pattern, but produces a bigger gradient, also spreads and strengths considerably the two warm areas, being generally warmer everywhere.

BA5: The model simulates the analysis pattern but also spreads and strengths the two warm areas. Due to this the model shows a strong gradient over Central Europe, being warmer everywhere.

BA7: The model spreads the two warm areas, mainly the east one, modifying considerably the isothermal structure over Europe. The model is warmer everywhere.

SUMMARY

In all the cases, the model spreads considerably the two warm areas and gives a strong gradient over Europe which does not appear in the analysis. Due to this the model becomes warmer, with a mean error of about 4°C for all of them.

There is not a clear improvement with resolution, being BA5 the simulation whose values are the most accurate.

THE HUMIDITY (R) DISTRIBUTION IN JULY

R200

CEP

Main features:

The structure is characterized by a strong gradient over Europe and the Atlantic with:

- Three areas of maximum values placed over:
  a) Iceland.
  b) North of Africa

c) Eastern Europe
- A minimum area placed over Madeira Islands.

MODEL

BA6: The structure is quite different from the analysis, does not reproduce the maxima areas and the isolines are very smoothed, so neither captures the major features at synoptical scale, nor the little details of the structure.

BA5: The model simulates very badly the structure, does not capture neither the maxima not the minima areas, weakens considerably the gradient and smooths the isolines.

BA7: The model shows a very similar structure and values to BA5.

SUMMARY

In all the cases, the model does not reproduce the main features, the structure is very badly taken into account, the only thing which improves with resolution is the minimum area, over Madeira, captured by BA7.

The model is generally drier. Nevertheless the mean error is nearly zero, which does not mean that the simulation is good, as we have seen, more to the opposite it means that it is due to the very small values of the humidity at 200 hPa.

R500

CEP
Main features:

- A very homogeneous structure over Europe with only one isoline.
- A maximum area located over Morocco.

MODEL

BA6: The model simulates very badly the structure,marking a strong gradient and does not taking into account the maximum area.

BA5: The model tends to simulate the analysis pattern, giving a bigger gradient Southern Europe, and placing very well the maximum area. The model is drier over Southern Europe and wetter Northern of it.

BA7: The model simulation is very good over Southern Europe placing properly the maximum area with very accurate values. Over the Atlantic the model shows a bigger gradient. The model becomes drier over Southern Europe and wetter Northern of it.

SUMMARY

It is shown a clear improvement with resolution, reproducing the maximum areas with more accurate values.

The model is drier Southern Europe and wetter Northern of it.

R850

CEP

Main features:

- Maximum areas placed along the Mediterranean area, with a very strong gradient, mainly over Morocco.
- A zonal distribution at upper latitudes, diminishing northwards.

MODEL

BA6: The model simulation is very bad, it does not reproduce any of the maxima areas, showing a very different pattern.

BA5: The model structure tends to simulate some of the maxima areas but in a very smoothly way.

BA7: The model tends to capture the maxima areas and the little details over Europe.

SUMMARY

It is shown an improvement with resolution, mainly between BA6 and BA5, in spite of that the mean and mean square error increase with resolution, due to the fact that the model becomes drier with resolution.

The model is always drier over Southern Europe and wetter Northern of it.

THE WIND (V) DISTRIBUTION IN JULY

V200

CEP

Main features:

- Two maxima of westerlies placed over the Atlantic:
  1) West of Ireland with a strength of 20 m/s.
  2) West of the Iberian Peninsula with a strength of 16 m/s.
- One maximum westerly area over Turkey of 28 m/s.

MODEL

BA6: The model only reproduces one maximum area over the Atlantic, West of Ireland, displaced northwards, with a strength of 28 m/s. Also displaces northwards the maximum over Turkey placing it Eastern Europe and with a strength of 24 m/s, due to this the model is more westerly over North Atlantic and Europe.

BA5: The model captures the two maxima areas over the Atlantic, well placed, although weaker than in the analysis but it does not reproduce the maximum area over Turkey. The model shows a maximum area over Northern Spain, France and Northern Germany which does not appear in the analysis.

BA7: The model simulation is quite similar to BA5, but showing less gradient Northern Europe.

SUMMARY

There is an improvement with resolution, mainly between BA6 and BA5.

V500

CEP

Main features:

- A maximum westerly area over the Atlantic placed West of Ireland with a strength of 16 m/s.
- A minimum area placed North of Madeira Islands.

MODEL

BA6: The model simulates the minima and the maxima areas although spreads and strengths (20 m/s) the maximum, also shifts it slightly northwards. The model is a little less westerly all over the south area and more westerly over Northern Atlantic and Scandinavia.

BA5: The model reproduces quite faithfully the position and strength of the maximum area.

BA7: The model simulation is quite similar to BA5, but weakening the maximum area over the Atlantic.

SUMMARY

There is an improvement between BA6 and BA5, but not a clear one between BA5 and BA7.

V850

CEP
Main features:

- A maximum westerly area placed over the Atlantic, 50°N, with a strength of 8 m/s.
- A maximum westerly area placed over South of Turkey, with a strength of 8 m/s.
- A minimum area placed over Greece.

MODEL

BA6: The model captures the maximum although shifts it slightly northwards.

BA5: The model simulates very well the pattern, placing accurately the maximum area over the Atlantic and slightly shifting northwards the maximun area over Turkey.

BA7: The model simulation is quite similar to BA5, locating faithfully the two maxima areas.

SUMMARY

It is shown an improvement with resolution, mainly between BA6 and BA5.

SURFACE FIELDS

SIMULATIONS OF THE WINTER CLIMATOLOGY

SURFACE TEMPERATURE (Tsol) DISTRIBUTION IN JANUARY

CEP
Main features:

- The isotherms show a quasi-zonal distribution over the Atlantic, meridional over Eastern Europe and tend to follow the coastline.
- The 0° isotherm is always placed over the continental area.
- The negative temperatures are placed over Iceland, Central and Eastern Europe and Scandinavia decreasing eastwards.
- Over the Atlantic the negative temperatures are located at 65° N while over East of Europe descend up to 40°N.
- Some local minima areas with temperatures smaller than -5°C, are placed over the Alps, Carpatians and East of Turkey.
- A maximum value (19°C) over Madeira Island.

MODEL

BA6: The distribution is somewhat well simulated, although the model shows a stronger gradient eastwards, and places the coldiest area (-15°C) North of

Russia. The 0° isotherm is quite well placed, but smoothed. The maximum value (18°C) and position are very well reproduced.
The isolines are smoothed and do not follow the coastline.
The model does not reproduce any of the local minima areas. The temperatures below -10°C are located over North of Scandinavia and North of Russia.
The largest negative bias (below -5°C) appears Eastern Russia. A positive bias only appears over some continental areas Western Europe, with a maximum positive bias of about 10°C over the Alps region.
On average the bias is negative and does not exceed 1°C.

BA5: The isotherms are zonally distributed over the Atlantic and rather meridionally over all Europe and tend to follow the coastline Southern Europe. The 0° isotherm is well placed but less extended. The values are lower over the Atlantic and the Mediterrean Sea and higher over all Europe. The maximum value is bad placed. The model does not reproduce any of the local minima areas.
The bias is positive mostly over the continental area and negative over the maritime one. Both of them do not generally exceed 5°C. The maximum positive bias, of about 10°C is located over the Alps region.
On average there is a positive bias which does not exceed 1°C.

BA7: The model reproduces faithfully all the main features of the analysis, placing accurately the 0° and 5°C isotherms. The isotherms tend to follow the coastline. The model only captures the minimum area over Eastern Turkey. The model extends over the Iberian Peninsula the 5°C isotherm, feature which only reproduces this simulation. The bias is positive over the continental areas and negative over the maritime ones. On average the mean error is very close to 0°C.

SUMMARY

It is shown a clear improvement with resolution. With the increase of resolution the isotherms are not so smoothed and tend to simulate all the little details. This improvement is surely due to the more detailed orography with resolution.

PRECIPITATION (Precip) DISTRIBUTION IN JANUARY

CEP

Main features:

- Almost the whole area has precipitation above 1.0 mm/day.
- The precipitation generally increases northwards.
- The isoline of 2.0 mm/day goes from Azores throughout North of the Iberian Peninsula, North of Italy to Southern Russia. Over the Mediterranean Sea and Eastern Europe there are some little areas above 2.0 mm/day.

- The largest precipitation area (above 5.0 mm/day) appears over:
  1) The Atlantic, West of Ireland, northwards to Iceland.
  2) The Alps, Balkans, Pyrenees and Northwest of Spain.
- Almost all the precipitation over the continental areas comes from stratiform precipitation, only over the maritime areas the precipitation is convective. Neither over the Mediterranean Sea nor over South and East the Azores Islands appears stratiform precipitation.
- There is an important convective precipitation area of 2.0 mm/day over the Atlantic, West of Ireland and South of Iceland, with a maximum of 5.0 mm/day over West Scotland and some little areas over the Mediterranean Sea.
- The analysis shows snow precipitation, above 1.0 mm/day, Northern Scotland, Pyrenees and Balkan area and areas with 2.0 mm/day over Iceland, Scandinavia, East of Europe, the Alps and Turkey, with a maximum value of 8.0 mm/day over Southeastern Norway.

MODEL

BA6: The model shows a poorly detailed structure, with very smoothed isolines. The precipitation above 2.0 mm/day is located only over the Atlantic, Scotland and South of Scandinavia, with a maximum value of 4.0 mm/day over West of Scotland, Italy and the Balkanic area.
As in the analysis the model only simulates convective precipitation over the maritime areas, being overestimated South of the Azores Islands and underestimated West of Scotland, where appears the largest negative bias -3.0 mm/day.
There is a substantial misrepresentation of the stratiform precipitation locating it over Scandinavia and North of the Balkanic area.
With respect to the snow precipitation there is also a misrepresentation of it, simulating snow above 1.0 mm/day only over Scandinavia and Northern the Balkanic area.

BA5: The model still shows a not detailed structure with smoothed isolines. The model gives precipitation above 2.0 mm/day over the Atlantic, Northwest of Europe, Scandinavia and the Balkanic area.
There is a maximum above 5.0 mm/day located over North of the Azores Islands.
As in the analysis the model simulates convective precipitation over maritime areas overestimating it over the Atlantic, North of the Azores with the largest positive bias above 5.0 mm/day, and underestimating it West of Scotland, being the largest negative bias -4.0 mm/day, and over some Mediterranean areas.
The stratiform precipitation is generally underestimated.
With respect to the snow precipitation the model only captures the areas over Iceland, Scandinavia and Russia, misrepresentating the rest of the snow analysis areas.

BA7: The model shows a littlle more detailed structure than BA5. The 2.0 mm/day isoline is quite well placed West of Europe but is displaced

northwards East of Europe.
The maximum over the Atlantic is reproduced, the model also captures the maximum South of Norway, although it is underestimated (5.0 mm/day).
As in the analysis the model simulates the convective precipitation over maritime areas, with values quite accurate except over West of Scotland and West of Norway, where the negative bias is about -3.0 mm/day. The model also captures an area above 2.0 mm/day over Eastern and Central the Mediterranean Sea, although spreads it eastwards.
The convective precipitation is overestimated over the Atlantic and East of the Mediterranean, however the model underestimates the stratiform precipitation Northern Europe and over Iceland, with the largest negative bias over Norway.
With respect to the snow precipitation the model reproduces quite faithfully the positions of almost all the snow areas, although underestimates them, the only ones which are not captured are the Pyrenees and Northern Scotland.

SUMMARY

The model shows a clear improvement with resolution.

This improvement is notorious between BA5 and BA7, in which the model begins to capture some of the main features, absent in BA6 and BA5, mainly the snow precipitation, the location of the Atlantic area above 5.0 mm/day and the 2.0 mm/day of convective precipitation over the Mediterranean Sea.

The precipitation over the continental area is mainly stratiform and convective over the Mediterranean area.

The model neither captures the two local maxima of convective precipitation over North of Scotland and South of Norway nor the largest maximum of stratiform precipitation over Norway (above 5.0 mm/day).

The stratiform precipitation has the largest bias.

As a general rule, the convective precipitation is overestimated and the stratiform underestimated.

Summarizing there is a clear improvement with resolution due to the more detailed orography with resolution.

CLOUD COVER (NebulT) DISTRIBUTION IN JANUARY

CEP

Main features:

- The analysis shows cloudiness mainly over the whole area with the exception of the Mediterranean Sea, where there is hardly cloudiness.
- Over the continental areas the area between 40% and 60% of cloudiness covers Central and Northern Europe and between 20% and 40% covers Great Britain, the Iberian Peninsula, Southern France, Italy and Greece.
- Over the Atlantic there is above 40% of cloudiness over an area surrounding

Iceland, and below 20% over the rest of the area.

MODEL

BA6: The model does not simulate properly either the pattern or the values of the analysis giving cloudiness over the whole area. Over Europe the model gives 40% of cloudiness offshore the Mediterranean Sea, increasing northwards with a strong gradient, reaching 80% from Central Europe to Northern of it. Over the Atlantic the model gives 40% of cloudiness from North of Madeira Island to 60% North of the Atlantic.

BA5: The model shows a very similar structure and values to BA6, the only difference is that the simulation reproduces the lack of cloudiness (below 20%) Northern Africa. The isolines tend to follow the coastline with a strong gradient.

BA7: Over Europe the model shows a similar structure and values to BA5, however, over the Atlantic the extension of the 60% isoline is reduced to Iceland.

SUMMARY

In general the model does not capture properly the main features of the analysis, showing bigger values than the analysis ones for all the simulations. The isolines tend to follow the coastlines and so much as the resolution increases. There is a sligth improvement with resolution mainly between BA5 and BA7.

On average the bias is positive in all the simulations.

RADIATION (Ray) DISTRIBUTION IN JANUARY

RAY ST (SOLAR RADIATION AT THE TOP OF THE ATMOSPHERE)

CEP

Main features:

- A zonal distribution, with the exception of a little area Northern Africa, where the analysis shows a local minimum area. The values increase southwards.
- A maximum value (183W/m^2) placed over Tunisia.
- A minimum value (6W/m^2) placed over Iceland.

MODEL

BA6: The model reproduces faithfully the analysis structure and places accurately the maximum value (154W/m^2), giving generally lower values than in the analysis.

BA5: The model simulates in a good way, although displaces eastwards the maximum value (191W/m^2). The values are generally lower than in the analysis.

BA7: The model simulates very well and places accurately the maximum value (191W/m^2). The values are lower than in the analysis, except a narrow strip southern the studied area.

SUMMARY

In all the cases the model shows a similar distribution, placing accurately the maximum value. The bias is mostly negative decreasing with resolution.

There is an improvement with resolution with respect either to the values or to the pattern.

RAY S B (SOLAR RADIATION AT THE BOTTOM OF THE ATMOSPHERE)

CEP

Main features:

- A zonal distribution over Europe.
- A maximum value (127W/m^2) placed over Tunisia.

MODEL

BA6: The isolines are slightly displaced southwards and show a bigger undulation than in the analysis. The values are lower than in the analysis.

BA5: The isolines are displaced southwards showing a bigger gradient and undulation that do not appear in the analysis.

BA7: The model simulation is similar to BA5, showing less undulated isolines, with the maximum value (144W/m^2) very well placed.

SUMMARY

In all the cases the model shows the same behaviour, simulating faithfully the analysis structure. The position of the maximum value improves with resolution.

The model values are lower than the analysis ones, with the exception of the Mediterranean and southwards areas.

There is an improvement with resolution.

RAY L T (TERRESTRIAL RADIATION AT THE TOP OF THE ATMOSPHERE)

CEP

Main features:

- A very homogeneous structure. There are only two isolines: -210W/m^2 and -240W/m^2.
- A minimum value (-253W/m^2) placed Northern Libya.

MODEL

BA6: The model places quite well the isolines of -240W/m^2, but displaces southwards the -210W/m^2 isoline. Northern Europe the model shows bigger values than in the analysis, with a maximum value of -175W/m^2 over Finland.

BA5: The model simulation is quite good, displacing southwards the -210W/m^2 isoline over Europe.

BA7: The model simulates quite well the structure and values, displacing slightly the isolines northwards.

SUMMARY

In all the cases the model simulates quite well the main features, displacing eastwards the minimum value. On average the bias is positive in BA6 and negative for the other simulations.

It is shown a clear improvement with resolution between BA6 and BA5 but not between BA5 and BA7.

RAY L B (TERRESTRIAL RADIATION AT THE BOTTOM OF THE ATMOSPHERE)

CEP

Main features:

- A very homogeneous distribution, the isolines tend to follow the coastline over the Mediterranean Sea and Scandinavia.
- A minimum value (-104W/m^2) placed Southern Anatolian Peninsula.
- A maximum value (-26W/m^2) placed Northern Finland.

MODEL

BA6: The model does not simulate the main features, giving a stronger gradient, mainly along the coastal areas and Northern Europe.

BA5: The model places quite accurately the maximum and minimum values and shows a more faithfull distribution mainly along the coastal areas.
As in BA6 the model gives much more gradient.

BA7: The model reproduces quite faithfully the analysis pattern, the isolines tend to follow the coastlines although increasing the gradient. The model places quite accurately the minimum value.

SUMMARY

In all the cases the model shows a bigger gradient, being their values lower than in the analysis over the maritime areas and higher over the continental ones.

It is shown an improvement with resolution with respect to the pattern.

SENSIBLE HEAT (Chal Ss) DISTRIBUTION IN JANUARY

CEP

Main features:

- The sensible heat is positive over the continental areas with the exception of the Central and Southern parts of the Iberian Peninsula. The maxima areas are placed over the Alps and Scandinavia, with a maximum value of $84W/m^2$.
- The sensible heat is negative over the maritime areas.
- There is a big gradient along the coastlines, tending the isolines to follow them.

MODEL

BA6: The model shows positive values over the continental areas with the exception of Southern Spain, Italy, Greece and Anatolia, and negative values over the maritime ones. The isolines surround the coastlines but in a much more smoothed way than in the analysis.
The model reproduces lower values over Europe and the Mediterranean Sea than the analysis.

BA5: The model shows positive values over the continental areas with the exception of Southern Spain and Italy, and negative values over the maritime ones. In this simulation the model tends to follow the coastline, but showing less gradient than the analysis.
In general the model reproduces bigger values than in the analysis with the exception of Northern and Eastern Europe.

BA7: The model reproduces quite faithfully the main features of the analysis. In this simulation the isolines follow the coastlines showing a big gradient over them. The model provides lower values than the analysis Northern the area under study and some small areas over the Mediterranean Sea.

SUMMARY

In general the model tends to simulate the main features with the exception of the BA6 simulation.

On average the bias is positive for all the simulations.

It is shown a big improvement with resolution.

EVAPORATION (Evapo) DISTRIBUTION IN JANUARY

CEP

Main features:

- The analysis only gives evaporation over the maritime areas.
- The values are above 2.0 mm/day, with the exception of small areas over the Baltic and North of Iceland.
- The isolines of 1.0 mm/day an 2.0 mm/day follow the coastlines showing a strong gradient.
- The maximum value (6.0mm/day) is placed near the Creti Island.

MODEL

BA6: The model shows evaporation over almost all the maritime areas. The isolines above 2.0 mm/day are placed over the Mediterranean Sea and Central Atlantic. The isolines are very smoothed and do not follow the coastlines. There is a lack of evaporation over the Baltic, Black and North Seas.

BA5: The model is quite similar to BA6 but showing a more detailed isolines, tending to follow the coastlines mainly over the Mediterranean Sea. The model simulates the evaporation over the Black Sea but not over the Baltic and North Seas.

BA7: The model simulates quite properly the main features. The main difference with the analysis is the fact that it gives evaporation over some continental areas as: Great Britain, the Iberian Peninsula and Greece. The model places accurately the maximum value (5.0 mm/day).

SUMMARY

The model tends to reproduce the main features with the increase of resolution. On average the bias is negative and decreases with resolution, being the mean error near zero for the BA7 simulation. There is a notorious improvement with resolution.

TURBULENT FLUX (Tu Flux) DISTRIBUTION IN JANUARY

CEP

Main features:

- The whole Europe is above the $100N/m^2$ isoline, being Central Europe above the $200N/m^2$ one.
- A local maximum of $587N/m^2$ is placed over Western Scandinavia.
- The direction of the turbulent flux is of SW component over Northern Europe, of

N component Southern it and W component Central Atlantic.

MODEL

BA6: The model neither reproduces any of the main features nor captures any of the analysis isolines at all.
The bias is mainly easterly, reaching 200N/m^2 over Central Europe, Western Scandinavia and Western of the Atlantic with a maximum value of 573N/m^2 over Western Scandinavia.

BA5: The model captures the local maximum area (200N/m^2) over Central Europe though reducing its extension. The isoline of 100N/m^2 is quite well reproduced. The direction is faithfully simulated. The bias is mainly easterly over North of the Atlantic and southerly South of it.

BA7: The model captures the maxima areas over Central Europe and Western Scandinavia. The isolines of 100N/m^2 and 200N/m^2 are well placed. The direction of the turbulent flux is quite well reproduced, except over Iceland and some Mediterranean areas. The bias is northerly over North of the Atlantic, southerly South of it and easterly Eastern Europe.

SUMMARY

The BA6 simulation does not capture any of the main features of the analysis.
It is shown a clear improvement with resolution, either in the structure or in the values.
On average the bias is easterly for the zonal component, and for the meridional component the bias is southerly for BA6 and northerly for BA5 and BA7.

SIMULATIONS OF THE SUMMER CLIMATOLOGY

SURFACE TEMPERATURE (Tsol) DISTRIBUTION IN JULY

CEP

Main features:

- The isotherms show a quasi-zonal distribution over the Atlantic, and tend to follow the coastline over the Mediterranean Sea.
- There is a local minimum (10°C) over the Alps.
- The temperature decreases with latitude, and the isotherms are bounded between 20° and 5°C over the Atlantic and between 30°C and 15°C over continental areas.

MODEL

BA6: The model reproduces the distribution and values over the Atlantic, but over the continental areas shows a quite different pattern with two warm areas placed over: a) North of Africa and South of Spain, b) East of Europe, with a strong gradient. These features are completely absent in the analysis. The bias is mostly positive and exceeds 5°C in most part of Europe, placing the largest biases over:

1) East of Europe, of about 10°C.
2) The Alps, North of Africa and South of Spain, of about 15°C.

The negative bias (below -5°C) appears only over some Atlantic areas. On average there is a positive bias of about 3.5°C.

BA5: The model reproduces the distribution and values over the Atlantic, but over the continental areas shows a similar structure as BA6, even though with less smoothed isotherms and reducing the warm area over Eastern Europe where the strong gradient decreases.
The bias is mostly positive and exceeds 5°C South and East of Europe. The largest positive biases are placed over the Alps, some small areas Eastern Europe and the Iberian Peninsula.
On average the bias is positive of about 2°C.

BA7: The model reproduces quite faithfully the structure of isotherms over all the area. Also captures the local minimum area over the Alps.
The model becomes warmer over continental areas, where the bias is always positive (about 5°C), being the largest value located over the Balkanic region with a value of about 13°C.
On average the bias is positive of about 2°C.

SUMMARY

It is showns a great improvement either in the pattern or in the values with resolution, mainly between BA5 and BA7.

PRECIPITATION (Precip) DISTRIBUTION IN JULY

CEP
Main features:

- The area with precipitation above 1.0 mm/day is extended over:
  1) the Atlantic, from the paralel 50°N northwards.
  2) all Europe, with the exception of South Iberian Peninsula, South of Italy, Greece and South of Russia.
- The area above 2.0 mm/day covers all Scandinavia, Northern and Central Europe, Southeast of France, the Pyrenees and some areas located over Great Britain and West of it. The maximum value of 8.0 mm/day is located over the Alps region. Another local maximum is placed over the Atlas.
- The precipitation over continental areas is mostly convective, apart from some small areas over the Alps, Great Britain and Norway, where the stratiform

precipitation is relevant. The maximum appears over the Alps with a value of 6 mm/day.

- The largest stratiform precipitation (above 2.0 mm/day) appears over Iceland, Western Scotland and Norway with a maximum of 4.0 mm/day over Iceland.

MODEL

BA6: The model shows a very smoothed pattern and does not capture the stratiform precipitation at all, so the precipitation given by the model is mainly convective.

The model shows four areas with precipitation above 1.0 mm/day, placed over:

- Scandinavia
- Central and Southeastern Europe
- North of Africa
- West of British Islands.

The areas with precipitation above 2.0 mm/day are reduced to Central Europe. The model captures the maximum over the Alps although diminishes it (4.0 mm/day), also captures the maximum over the Atlas. In both of them the model spreads the maximum area.

The bias is negative over Northern Spain, Pyrenees, Southern Scandinavia, Northeastern Europe, the Alps and the Balkans with a maximum bias of -5 mm/day in the Alps region.

There is a positive bias over some areas in Central Europe, Crimean Peninsula, South of Russia and North of Africa with a maximum positive bias of +3 mm/day over the Crimean Peninsula.

On average there is a negative bias due to the nearly misrepresentation of the stratiform precipitation.

BA5: The model shows a smoothed structure, but more detailed than BA6. As in the case of BA6, the model does not capture any significant stratiform precipitation, only shows three small areas over: Iceland, Southeast of Norway and North of Sweden, which are in a very good agreement with the position of the three maxima of the analysis. The model also reproduces quite faithfully the position of the 1.0 mm/day isoline, giving only an area above 2.0 mm/day over Central Europe, Scandinavia and North of Russia. Mostly of this precipitation is convective, as in the analysis, capturing the local maximum over the Atlas, although spreading it.

The convective precipitation is in general overestimated, apart from some small areas over the Alps and the Balkans where is underestimated, with a maximum negative bias of -4.0 mm/day over the Alps.

The largest positive bias appears over the Atlas.

On average there is a small positive bias for the convective precipitation and a negative one for the total precipitation due to the misrepresentation of the stratiform precipitation.

BA7: The model shows a quite faithful structure over the continental areas. Over

the Atlantic the model places accurately the 1.0 mm/day isoline but diminishes the local maxima areas Western British Islands and over Iceland. The model underestimates the stratiform precipitation over the Atlantic, captures the local maximum Southern Norway, which is in a very good agreement with the analysis.
The pattern and main features of the convective precipitation are quite accurate with respect to the analysis, only the local maximum over the Alps is underestimated with the largest negative bias (above -4.0 mm/day). The convective precipitation has also a negative bias over the Balkans, some small areas over Eastern Europe and Southern Scandinavia. There is an important positive bias over the Atlas, where the model shows a local maximum of about 7.0 mm/day, which is well placed but overestimated. Also the model shows a positive bias located over the Pyrenees and Central the Iberian Peninsula.
On average there is not a significant bias for the convective precipitation. As in BA5 there is a negative bias for the total precipitation due to the misrepresentation of the stratiform precipitation.

SUMMARY

The stratiform precipitation is underestimated in all the areas. The model shows a little improvement with resolution respect to the patterns of the stratiform precipitation. BA5 and BA7 capture some of the local maxima over Iceland and Norway, being BA7 more accurate over Norway but not over Iceland.

With respect to the convective precipitation there is an important improvement with resolution. In BA5 the pattern tends to the analysis and more accurately in BA7.

The local maxima areas are very well reproduced in BA7, although they are in general underestimated.

As a normal rule, the model enhances the local maximum over the Atlas, and much more as the resolution increases, being the largest positive bias (6 mm/day) for BA7.

CLOUD COVER (Nebul T) DISTRIBUTION IN JULY

CEP

Main features:

- The cloudiness, in general, increases with latitude.
- The analysis shows cloudiness, above 20%, mostly over the whole area considered, with the exception of the following areas:
  Southern of the Iberian Peninsula, most part of France, Italy, Greece, Turkey and Algeria.
- The area between 20% and 40% of cloudiness covers the rest part of Europe, the Mediterranean Sea and the Atlantic from West of Great Britain southwards.
- The area between 40% and 60% of cloudiness is extended over Northern Atlantic and some areas along the Mediterranean Sea.

MODEL

BA6: The model does not simulate properly neither the pattern nor the values, giving cloudiness over the Atlantic from Azores Islands northwards and over Great Britain, Central and Northern Europe, with a strong gradient reaching the value of 80% Northern Europe. From Central Europe southwards the model does not reproduce any cloudiness area at all. The model shows bigger values from Central Europe northwards and lower ones southwards.

BA5: The model shows a similar structure to BA6, the only difference is a little less gradient at northern latitudes. The model shows cloudiness exclusively over Northern Atlantic, Great Britain and Scandinavia, overestimating it and with a strong gradient, feature that does not appear in the analysis.

BA7: The model reproduces the same pattern as BA6 and BA5, but with less gradient and smaller values, so it gives cloudiness over the Atlantic from Azores Islands northwards, Great Britain and Scandinavia where it reaches the value of 60%. With the exception of these areas the model does not give any cloudiness over continental areas.

SUMMARY

The model does not reproduce the main features of the cloudiness. Over the continental areas, the model does not capture any cloudiness from Central Europe southwards, while over Northern Europe the model reproduces much more cloudiness than in the analysis. Over the Atlantic the model reproduces the cloudiness areas but with a stronger gradient. So it is shown a misrepresentation of cloudiness Southern Europe and an overestimation Northern it.

The BA7 mean error is nearly zero, wich does not mean that BA7 reproduces the analysis values, much more to the opposite, it means that the northern overstimation is balanced by the southern underestimation.

With respect to the structure there is not an improvement with resolution, however it is shown a little improvement with respect to the values.

RADIATION (Ray) DISTRIBUTION IN JULY

RAY ST (SOLAR RADIATION AT THE TOP OF THE ATMOSPHERE)

CEP

Main features:

- A very homogeneous structure, with the isolines bounded between 300W/m^2 and 400W/m^2
- The maximum value (412W/m^2)is placed over Southern Greece.

MODEL

BA6: The model does not simulate properly the analysis structure, showing much more gradient, mainly over Great Britain and Northern Europe, and the isolines are bounded between 250W/m^2 and 400W/m^2. The maximum value (419W/m^2) is placed over East of Tunisia. The bias is negative Northern Europe and positive over the rest of the area.

BA5: The model tends to simulate the analysis structure, but showing a bigger gradient Northern Europe. The isolines are bounded between 300W/m^2 and 400W/m^2. The maximum value (419W/m^2) is placed South of the Anatolian Peninsula.

BA7: The model simulation is quite similar to BA5, showing less gradient. The values are bigger than in the analysis, mainly Southern Europe. The maximum value (420W/m^2) is placed East of Tunisia.

SUMMARY

There is shown an improvement with resolution mainly in the pattern. On average the bias is mostly positive for all the simulations.

RAY SB (SOLAR RADIATION AT THE BOTTOM OF THE ATMOSPHERE)

CEP

Main features:

- A quite homogeneous structure over Europe. The isolines tend to have a quasi-latitudinal distribution.
- The isolines are bounded between 300W/m^2 and 180W/m^2.
- The maximum value (315W/m^2) is placed East of Greece.

MODEL

BA6: The model simulates in a bad way, showing a notorious gradient, mainly from North the Azores Islands to Northern Europe. This makes the isolines to be bounded between 60W/m^2 and 330W/m^2.

BA5: The model simulation is nearly similar to BA6 with a little less gradient but as bad simulation as BA6.

BA7: The model simulates quite badly the analysis structure, with a strong gradient Northern and Southern Europe. The isolines are bounded between 120W/m^2 and 330W/m^2.

SUMMARY

In all the cases, the model simulates very bad the analysis. There is a slight improvement with resolution, due to the decrease of the bigger gradient.

On average the bias is mostly positive from Central Europe soutwards and negative Northern Europe.

RAY LT (TERRESTRIAL RADIATION AT THE TOP OF THE ATMOSPHERE)

CEP

Main features:

- An homogeneous structure, with a rather latitudinal distribution of isolines.
- The isolines are bounded between $-240W/m^2$ and $-300W/m^2$.
- Maximum value ($-222W/m^2$) placed over Iceland.

MODEL

BA6: The model tends to simulate quite well the analysis structure, showing a little more gradient over Europe. The isolines are bounded between $-240W/m^2$ and $-330W/m^2$.

BA5: The model reproduces quite well the main features of the analysis, placing accurately the maximum value, and as in BA6 showing a bigger gradient over Europe. The bias is mostly negative.

BA7: The model simulation is similar to BA5, placing the isolines almost over the same places, but displacing the maximum value ($-238W/m^2$) over Scandinavia.

SUMMARY

In all the cases, the model reproduces quite well the analysis. On average the bias is mostly negative over the whole area.

There is shown an improvement with resolution, mainly between BA6 and BA5.

RAY LB (TERRESTRIAL RADIATION AT THE BOTTOM OF THE ATMOSPHERE)

CEP

Main features:

- A very homogeneous structure mainly over Central Europe, with only three isolines: one of $-120W/m^2$ placed over Northern Africa, other of $-90W/m^2$ over the Anatolian Peninsula and Southern the Mediterranean Sea and the last one of $-60W/m^2$ from 40^0N in the Atlantic to 65^0N Northern Scandinavia.

MODEL

BA6: The model does not simulate the main features, giving a gradient all over along the West and North Europe coastline.

The model reproduces lower values over Eastern Mediterranean Sea and bigger Northern Atlantic.

BA5: The model simulation is quite similar to BA6, with less gradient and tending to reproduce the analysis pattern.

BA7: The model places very well the -60 W/m^2 isoline and tends to simulate the analysis Southern Mediterranean Sea, but giving lower values than the analysis. Over Northern Atlantic the model shows a much more gradient.

SUMMARY

In general the model tends to reproduce the main features of the analysis with the increase of resolution.
On average the bias is mostly negative.

SENSIBLE HEAT (Chal Ss) DISTRIBUTION IN JULY

CEP
Main features:

- The sensible heat is mostly negative over the whole area considered, with the exception of a narrow strip surrounded all the European and Great Britain coastline, the Baltic Sea and North of Iceland.
- The isolines are distributed following the coastlines and showing a strong gradient over them.
- The minimum value (-198W/m^2) is placed over the coast of Southern Anatolia.

MODEL

BA6: The model does not simulate properly the analysis structure, mainly due to the fact that the isolines do not follow the coastlines, showing values from 0W/m^2 to -162W/m^2 over Europe. The sensible heat values are mostly negative over continental areas and positive over the maritime ones. The minimum value (-162W/m^2) is placed in Northern Spain.

BA5: The model tends to simulate quite well the analysis, showing a stronger gradient over Central Europe which does not appear in the analysis. The model shows negative values over continental areas and positive over the maritime ones. The minimum value (-162W/m^2) is placed in Northern Spain.

BA7: The model simulates quite well the main features of the analysis, capturing the positive values of the Baltic and Mediterranean Seas, but showing positive values over the whole Atlantic area. The isolines tend to follow the coastlines with a strong gradient, this gradient is extended to Central Europe, though weakening it, so the main differences appear over Central and Northern Europe.

SUMMARY

The model tends to reproduce the main features, and much more as the resolution increases showing a notorious improvement in BA7, surely due to the better orography of the simulation.

In all the cases the model does not place properly the minimum value.

On average the bias is positive for BA6 and BA5 and near zero for BA7.

EVAPORATION (Evapo) DISTRIBUTION IN JULY

CEP

Main features:

- The analysis gives evaporation above 1.0 mm/day over mostly the whole area, with the exception of Northern Africa, Turkey and Northern Atlantic. Over Southern Atlantic, Eastern Mediterranean Sea and most of the continental area of Europe the evaporation is above 2.0 mm/day with a maximum of 5.0 mm/day over the Balkanic area.
- The isolines tend to folllow the coastlines with a strong gradient.

MODEL

BA6: The model only simulates properly over Europe, Eastern Mediteranean Sea and Southern Atlantic. The maximum value (5.0 mm/day) is well placed, but the isolines do not reproduce a detailed structure. The model gives a local maximum (above 2.0 mm/day) over the Atlas, maximum which does not appear in the analysis.

BA5: The model tends to reproduce the pattern of the analysis. The maximum value (5.0 mm/day) is well placed. This simulation also gives the local maximum over the Atlas (as BA6).

BA7: The model simulates quite well the structure giving a more detailed isolines, and tending to follow the coastlines. The bias is negative over Central Europe. The model does not simulate the maximum value of the analysis but reproduces the local maximum (6.0 mm/day) over the Atlas.

SUMMARY

Only BA5 and BA7 tend to reproduce the main features. On average the bias is negative and decreases with resolution.

It is shown an improvement with resolution.

TURBULENT FLUX (Tu Flux) DISTRIBUTION IN JULY

CEP

Main features:

- A small maximum area Western Anatolia reaching 530N/m^2, other maxima areas (100N/m^2) over Central and Northern Europe, Great Britain and Alps.
- The direction of the turbulent flux is generally of W component over Central and Northern Europe and the Atlantic and of N component over Southern Atlantic and Southern Europe.

MODEL

BA6: The model does not locate properly any of the maxima areas.
The direction of the turbulent flux is mainly of N component over Central and Southern Europe and of W component over the Atlantic and Northern Europe.

BA5: The model tends to capture the maxima areas placed over Western Anatolian Peninsula but weakening it, moreover the model shows a maximum area Northwestern the Iberian Peninsula which does not appear in the analysis. The direction of the turbulent flux is quite well reproduced.

BA7: The model simulation reproduces quite faithfully the main features, placing accurately with the maximum (500N/m2), although shows some little maxima areas that do not appear in the analysis (Northwestern the Iberian Peninsula). The direction of the turbulent flux is quite well reproduced.

SUMMARY

BA6 does not locate properly any of the maxima areas of the analysis, BA5 gives lower values, being BA7 the simulation which better reproduces the analysis.

The direction of the turbulent flux is quite well reproduced.

The model tends to give less values than the analysis. On average the bias of the zonal component is easterly and southerly for the meridional component.

There is a clear improvement with resolution either for the zonal or the meridional components.

A.3.- SUMMARY

HEIGHT FIELDS

GEOPOTENTIAL AND SEA LEVEL PRESSURE DISTRIBUTION

JANUARY

a) Pattern

All the simulations reproduce the main features at every level, with the exception of BA6 which does not capture them at 850 hPa and SLP.
There is an improvement with resolution, being it more important between BA6 and BA5 and mainly at low levels.

b) Accuracy

The bias is mostly negative increasing with altitude.
The values tend to the analysis ones when resolution increases.

JULY

a) Pattern

There is not an improvement with resolution at every level, with the exception of the SLP, being BA6 the simulation which better captures the main features of the analysis except for the upper latitudes.
For SLP, BA7 is the best simulation.

b) Accuracy

The bias is mostly negative, increasing with resolution between BA6 and BA5 and decreasing from BA5 to BA7. In BA6 the bias is the smallest over South of Europe.
There is not an improvement with resolution.
Generally the biases are smaller in the mid and upper levels and increase near the surface, the oppossite occurs in wintertime.

TEMPERATURE DISTRIBUTION

JANUARY

a) Pattern

BA5 and BA7 are in a very well agreement with the analysis at 850 hPa.
At 200 hPa the model shows important discrepancies.
There is a clear improvement with resolution mainly between BA6 and BA5.

b) Accuracy

The bias is mostly **negative**, the model becomes colder at every level. This cold bias does not exceed 8°C at 200 hPa decreasing with latitude and increasing from mid to upper levels.
There is an improvement with resolution except at 200 hPa.

Remarkable points:
- At 850 hPa, the values and pattern of BA5 are very accurate, being the mean square error nearly 1°C and the mean error about zero degrees.
- At 500 hPa, the values and pattern of BA7 are quite accurate specially South of Europe, being the mean square error lower than 1°C and the mean error near zero degrees.

JULY

a) Pattern

There is an improvement with resolution only between BA6 and BA5 and not at 200 hPa, in which BA6 is the best simulation.

b) Accuracy

The bias is mostly **negative** at 200 hPa and increases with latitude, reaching a maximum value of 10°C. At 500 and 850 hPa the bias is mostly **positive** with the largest values over the continental areas and a maximum located Southeastern Europe, this maximum does not exceed 4°C at 500 hPa but grows up to lower levels reaching a maximum of 16°C in BA6, and 12°C in BA5 and BA7 at 850 hPa.

The average bias is negative at every level in wintertime and positive for mid and low levels in summertime. This average bias decreases with resolution except at 200 hPa in winter but not in summer.

In winter the cold bias increases with altitude, in summer the warm bias decreases from 850 hPa to mid levels changing to a cold bias above 500 hPa, and increasing this effect with altitude.

HUMIDITY DISTRIBUTION

JANUARY

a) Pattern

There is a clear improvement with resolution, being this improvement notorious at 850 hPa.

b) Accuracy

The bias is mostly positive at mid and upper levels and generally negative at 850 hPa.

The bias decreases with resolution at upper levels but increases at 850 hPa, with the exception of BA6 and BA5.

JULY

a) Pattern

BA6 is a very bad simulation at all levels.

There is shown an improvement with resolution for all the levels, specially at 850 hPa and between BA5 and BA7, which captures the extreme areas and the analysis details.

b) Accuracy

The bias is negative at 200 hPa almost in the whole area. At mid and lower levels the bias is positive in the North area and negative in the South. So the model shows a lower contrast between North and South areas than in the analysis.
The bias does not decrease with resolution, except at 500 hPa, and it is maximum Northern Africa and Southeastern Europe at every level.
In summer the largest average bias is at 850 hPa.

WIND DISTRIBUTION

JANUARY

a) Pattern

There is an improvement with resolution at every level, generally BA5 and BA7 reproduce quite well the main features.
At mid and upper levels the model displaces southwards the maximum located over the Atlantic.

b) Accuracy

b1) Zonal Component

There is an improvement with resolution at every level.
The model is mostly less westerly, this easterly bias becomes maximum over the Atlantic, West of Ireland, at mid and upper levels due to the maximum displacement southwards. This bias decreases with resolution. On average this bias becomes smaller at 500 hPa.

b2) Meridional Component

There is not an improvement with resolution. The bias is northerly in BA6 and southerly for the rest of the simulations. This bias is smaller at 850 hPa and increases with altitude.
The bias decreases with resolution.

JULY

a) Pattern

There is an improvement with resolution at every level, mainly between BA6 and BA5.

b) Accuracy

b1) Zonal Component

On average there is a westerly bias at 200 hPa and an easterly one at 850 and 500 hPa. This bias decreases with resolution.

b2) Meridional Component

On average there is a northerly bias at 500 hPa and southerly at 200 and 850 hPa.

SURFACE FIELDS

SURFACE TEMPERATURE DISTRIBUTION

JANUARY

a) Pattern

The model always simulates quite well the configuration of isotherms, with a clear improvement with resolution. As resolution increases the isotherms are less smoothed and tend to simulate all the little details. BA7 places accurately almost all the isotherms, the maxima values and the minima local areas. This is clearly due to the improvement of the orogaphy with resolution.

b) Accuracy

There is also a clear improvement with resolution.
The bias is generally positive over the continental areas and negative over the maritime ones, and tend to decrease with resolution. On average the mean error is very close to zero degrees for the BA7 simulation.

JULY

a) Pattern

The model simulates faithfully the Atlantic areas, with respect to the continental areas only BA7 is able to reproduce the main features.

b) Accuracy

The values over the Atlantic are quite accurate, over the continental areas there is generally a positive bias (by about 5°C) with some areas exceeding 10°C, these largest biases are located over Eastern Europe, the Alps and the Iberian Peninsula.
The bias decreases with resolution.
On average the bias shows a clear improvement between BA6 and BA5. The bias of the model over maritime areas is always small in summer and wintertime, but over continental areas the bias is mostly positive in winter and always in summer, showing the largest values in summer, which exceeds by about 5°C.

PRECIPITATION DISTRIBUTION

JANUARY

a) Pattern

The model shows a clear improvement with resolution.
This improvement is notorious between BA5 and BA7, in which the model begins to capture some of the main features, mainly the snow and the convective precipitation over the Atlantic and the Mediterranean sea, absent in BA6 and BA5.
As a normal rule the precipitation over the continental areas is mainly stratiform and convective over the Mediterranean sea.

b) Accuracy

The model neither captures the two local maxima of convective precipitation nor the largest maximum of stratiform precipitation.
The stratiform precipitation has the largest bias.
As a general rule the convective precipitation is overestimated and the stratiform and the snow precipitation underestimated.

JULY

a) Pattern

There is a misrepresentation of the stratiform precipitation, so as a general rule the stratiform precipitation is underestimated in all the areas. The model shows a little improvement with resolution respect to the stratiform precipitation and an important improvement respect to the convective one.

b) Accuracy

The local maxima areas are very well reproduced in BA7, altough they are in general underestimated.
The model enhances the local maximum over the Atlas and so much as the resolution increases, being the largest positive bias (6mm/day) for BA7.
Summarizing, the model reproduces faithfully the source of the precipitation over the continental and maritime areas as much in summer as in winter.
In summer the precipitation over the continental areas is mostly convective and in winter stratiform.
As a normal rule the stratiform precipitation is always underestimated in winter and in summer. The convective precipitation is mostly overestimated mainly in winter.
There is a clear improvement with resolution mainly in the convective and in the snow precipitation.

CLOUD COVER DISTRIBUTION

JANUARY

a) Pattern

In general the model **does not capture** the main features of the analysis. The isolines tend to follow the coastlines and so much as the resolution increases, feature which is absent in the analysis. There is not a clear improvement with resolution.

b) Accuracy

On average the bias is positive in all the simulations, and decreases with resolution mainly between BA5 and BA7.

JULY

a) Pattern

The model **does not reproduce** the main features of the cloudiness. Over the continental areas, the model does not capture any cloudiness Southern

Europe, while over Northern Europe the model provides much more cloudiness than in the analysis. Over the Atlantic the model reproduces the cloudiness areas but with a stronger gradient.

b) Accuracy

With respect to the pattern there is not an improvement with resolution, however it is shown a little improvement with respect to the values. On average the bias is positive for BA6 and BA5 and negative for BA7.

RADIATION (RAY) DISTRIBUTION

JANUARY

RAY ST (SOLAR RADIATION AT THE TOP OF THE ATMOSPHERE)

In all the cases the model shows a similar distribution, placing accurately the maximum value. The bias is mostly negative decreasing with resolution. There is an improvement with resolution with respect either to the values or to the pattern.

RAY S B (SOLAR RADIATION AT THE BOTTOM OF THE ATMOSPHERE)

In all the cases the model shows the same behaviour, simulating faithfully the analysis structure. The position of the maximum value improves with resolution.

The model values are lower than the analysis ones, with the exception of the Mediterranean and southwards areas. On average the bias is negative decreasing with resolution.

There is an improvement with resolution.

RAY L T (TERRESTRIAL RADIATION AT THE TOP OF THE ATMOSPHERE)

In all the cases the model simulates quite well the main features, displacing eastwards the maximum value. On average the bias is positive in BA6 and negative for the other simulations.

It is shown an improvement with resolution, mainly between BA6 and BA5 but not between BA5 and BA7.

RAY L B (TERRESTRIAL RADIATION AT THE BOTTOM OF THE ATMOSPHERE)

The model tends to simulate the main features in BA5 and BA7.

In all the cases the model provides a bigger gradient, being their values lower than in the analysis. On average the bias is negative.

It is shown an improvement with resolution with respect to the pattern.

JULY

RAY ST

BA5 and BA7 tend to simulate the analysis pattern. There is shown an improvement with resolution either in the structure and in the values. On average the bias is mostly positive for all the simulations.

RAY SB

In all the cases, the model simulates **very bad** the analysis. There is not an improvement with resolution. The only improvement is the decrease of the bigger gradient shown in all the simulations.
On average the bias is mostly positive from the Mediterranean sea southwards and negative Northern Europe.

RAY LT

In all the cases, the model reproduces quite well the analysis. On average the bias is mostly negative over the whole area.
There is shown an improvement with resolution, mainly between BA6 and BA5.

RAY LB

In general the model **does not reproduce** the main features of the analysis but it is shown an improvement with resolution mainly between BA5 and BA7. On average the bias is mostly negative.

SENSIBLE HEAT DISTRIBUTION

JANUARY

a) Pattern
In general the model simulates the main features with the exception of the BA6 simulation.

b) Accuracy
On average the bias is positive and it is shown a big improvement with resolution, mainly due to the better representation of the orography with resolution.

JULY

a) Pattern
The model tends to reproduce the main features, with the exception of BA6, and much more as the resolution increases showing a notorious improvement in BA7.

b) Accuracy
In all the cases the model does not place properly the minimum value.
On average the bias is positive for BA6 and BA5 and near zero for BA7.

EVAPORATION DISTRIBUTION

JANUARY

a) Pattern

The model tends to reproduce the main features with the increase of resolution. BA6 isolines are very smoothed and do not follow the coastlines. BA7 simulates quite properly the main features, placing accurately the maximum value.

b) Accuracy

On average the bias is negative and decreases with resolution, being the mean error near zero for the BA7 simulation. There is a notorious improvement with resolution.

JULY

a) Pattern

Only BA5 and BA7 tend to reproduce the main features. BA6 isolines do not reproduce a detailed structure while BA7 simulates quite well the pattern showing a more detailed isolines which follow the coastlines. The model gives a local maximum over the Atlas region, feature that does not appear in the analysis, this maximum increases with resolution.

b) Accuracy

On average the bias is negative and decreases with resolution. It is shown an improvement with resolution.

TURBULENT FLUX DISTRIBUTION

JANUARY

The BA6 simulation does not capture any of the main features of the analysis. BA5 and BA7 tend to capture some of the main features.
It is shown a clear improvement with resolution either in the structure or in the values.

JULY

The model **does not locate properly** any of the maxima areas of the analysis. The direction of the turbulent flux is quite well reproduced in BA5 and BA7. The model tends to give less values than the analysis. There is an improvement with resolution either for the zonal or meridional components, being more important between BA6 and BA5.

CONCLUSIONS

With regard to the **first objective** (validation of the Arpège model over the European region), the following conclusions can be derived concerning the different fields under study:

1) **geopotential and sea level pressure**, the model in general simulates the main features, except the BA6 simulation at 850 hPa and for the sea level pressure. The bias is mostly negative increasing with altitude in winter and near the surface in summer.

2) **temperature**, the model simulates the main features except at 200 hPa, where the simulations do not capture them. The bias is mostly negative at every level in winter and mostly positive at mid and low levels in summer, decreasing with resolution in winter but not in summer. The largest bias occurs in summer at 850 hPa for all the resolutions.

3) **humidity**, the model simulations are quite good except for BA6. The bias is mostly positive at mid and upper levels and generally negative at 850 hPa.

4) **wind**, the model tends to simulate the main features. For the zonal component the bias is easterly for BA6 and westerly for BA5 and BA7 except at 850 hPa in winter, while in summer is mostly westerly at 200 hPa and easterly at 500 and 850 hPa. For the meridional component the bias is southerly for the BA6 simulation and northerly for the other simulations in winter.
In summer the average bias is northerly at 500 hPa and southerly at 200 and 850 hPa.

5) **surface temperature**, the model simulates quite well in winter. In summer the simulation is quite faithful over the Atlantic areas but over the continental ones only the BA7 simulation is able to reproduce the main features. The bias is positive over continental areas with some areas exceeding 10°C in summer. Over the maritime areas the bias is always small and mostly negative.

6) **precipitation**, the model reproduces faithfully the source of the precipitation, showing a great improvement with resolution being BA7 the simulation which begins to capture the main features, mainly for convective and snow precipitation. The convective and the snow precipitation are always overestimated and the stratiform underestimated. In general there is an important lack of stratiform precipitation.

7) **cloudiness**, the model does not reproduce the main features neither in winter nor in summer. The bias is always positive.

8) **radiation**, in winter the model tends to simulate the main features while in summer the model simulation is good only for ST and LT and not for SB and LB radiation. In general, the bias is negative in winter while in summer is positive for

the ST and SB and negative for the LT and LB radiation.

9) **heat sensible flux**, the model simulates quite faithfully with the exception of the BA6 simulation. The bias is generally positive except for BA7 in summer.

10) **evaporation**, the model tends to simulate the main features with the exception BA6 in summer. There is a notorious improvement with resolution. The bias is generally negative decreasing with resolution.

11) **turbulent flux**, the model simulates properly in winter with the exception of the BA6 simulation, in summer the model simulates the direction but only BA7 reproduces some of the local maxima areas.

With regard to the **second objective** (study the impact of increased horizontal resolution), it is possible conclude that there are **many improvements** in the simulations as the resolution increases, mainly over all the fields. The only aspects of the simulation that do not improve with resolution are:

1) The geopotential in July, being BA6 the simulation that better reproduces the main features of the analysis.

2) The temperature at 200 hPa in July.

3) The SB radiation in July, in which the model simulates very bad the analysis at all resolutions.

4) The cloudiness in January and July.

The biases which decrease with resolution refer to the following fields:

- Temperature in wintertime, except at 200 hPa.
- Wind in winter and summertime.
- Surface temperature in winter and summertime.
- Cloudiness in winter and summertime.
- Precipitation in winter and summertime.
- Turbulent flux in winter and summertime.
- Evaporation in winter and summertime.

SECTION B

B.1.- **INTRODUCTION**

The aim of this part is to validate over the **French and Spanish areas** the Arpège and the Emeraude model outputs **- precipitation and temperature-** available at present with the observed climatology.

B.2.- **DATA**

2.1.MODEL outputs

There have been used:

a) **EMERAUDE**

The T42L30 version of this model has been used for the French area.

b) **ARPEGE**

The T42L30 and the T79L30 versions have been used.

The model outputs available are:

-10 Januaries and 10 Julies, from 1979 to 1988 .

The surface temperature and precipitation data corresponding to the grid points of the model (T42 and T79) have been obtained by the procedure PRICHS available at METEO FRANCE.

2.2.Observations

Monthly total precipitation and mean surface air temperature data from The French and the Spanish Meteorological Network covering the ten years 1979-88 have been used.

B.3.- **METHODOLOGY**

3.1 Strategy

As it had been said in the previous paper, kriging method was selected as the spatial interpolation method.

The T42L30 version of the Emeraude model uses a 64x128 Gaussian grid with 2.8125° longitudinal separation, which gives a resolution over France by about 210x310 km^2.

The area of validation consists finally in 9 grid points of the operational model, 3 in longitude x 3 in latitude.

The T79L30 version of the Arpège model uses a 120x240 Gaussian grid with 1.500° longitudinal separation, which gives a resolution over Northern France by about 110x160 km^2, and over Southern France by about 120x170 km^2.

The area of validation consists finally on 20 grid points of the operational model, 5 in longitude x 4 in latitude.

The T42L30 version of the Arpège model uses a 64x128 Gaussian grid with 2.8125° longitudinal separation, which gives a resolution over Spain by about 250x310 km^2.

The area of validation consists finally on 4 grid points of the operational model, 2 in longitude x 2 in latitude.

The T79L30 version of the model uses a 120x240 Gaussian grid with 1.500° longitudinal separation, which gives a resolution over Northern Spain by about 130x160 km^2, and over Southern Spain by about 140x170 km^2.

The area of validation consists finally on 12 grid points of the operational model, 3 in longitude x 4 in latitude.

The geographical distribution of these points is shown in Fig B1-B2.

3.1.1.Precipitation

The procedure used to produce grid point values from station reports is an adaptation of the corresponding for the T42 version made by C.Canellas (SCEM/CBD/DEV) who has also prepared and launched the procedures for the Spanish data.

Concisely, this procedure extracts the precipitation data from the PLUVIO DATA BANK and calls for the BLUEPACK module in order to interpolate the values.

3.1.2.Temperature

Surface air temperature ("temperature sous abri") data have been taken out from the LOS bands (Bands of daily temperature data from the synoptic network). A similar procedure to the precipitation one has been applied.

As temperature exhibits a much more regular behaviour, no previous classification of homogeneous geographic areas have been made and the procedure has been launched for the whole study area, that is to say, France or Spain.

As in the precipitation case, kriging has been used as spatial interpolator. It must be pointed out that the surface air temperature is not strictly comparable to the output model, surface temperature ("temperature au sol"). Nevertheless, it could be of interest to make a comparison between these both parameters.

3.2.Statistical Tests

Several univariate tests have been applied, considering each grid point and the atmospheric variables separately. These tests are useful for diagnosing.

a) Mann - Whitney U - test . As in our case we are restricted to small sample sizes (N<20), it is preferable to use non-parametric methods which don't need so strict assumptions about the population parameters.

This test is a powerful one, very useful in preliminary studies to which later we may consider to apply the more severe parametric techniques. For data from two independent samples, this test combines and ranks the data from the two samples, then sums the ranks over all observations, and compares the average ranks.

b) Two - tailed F -tests . An F test is a useful test to check whether or not the variability of two samples (in our case, model and observation) should be considered the same.

In this way, it is used as a preliminary step before testing hypothesis about means. Although, strictly speaking, these statistical testing procedures should only be applied to data which have at least an approximately Gaussian distribution; it has been assumed that samples verify this assumption.

Two - tailed F-tests with 9 degrees of freedom (n_t -1) in the numerator and denominator have been employed. Therefore, a calculated variance greater than 4.03 is needed in order to achieve significance at the 5% level. Concerning the 1% level, a calculated variance of 6.54 is required.

c) Two - tailed t-test. For comparing the means of the two samples of study.

The null hypotheses is that the samples come from the same population; the observed difference between the means (expected to be zero) is tested for significance.

B.4.- RESULTS

I.- FRANCE

a) T42 10-YEAR MEAN PRECIPITATION (FRANCE)

JANUARY

The **model precipitation** varies in the range 1.4 mm/day (pt8) - 8.9 mm/day(pt3) whilst the **observation values** do in the range 2.0 mm/day (pt2) - 4.0 mm/day (pt7).

The model overestimates precipitation in the northern and central regions - by about 3.0 times the observed values at some points (pt3)- and underestimates in the southern region -between 0.4 and 0.9 times observed values.

The **standard deviation** for the mean January model precipitation, calculated over the 10 Januaries, ranges from a minimum of 0.44 mm/day to a maximum of 1.77 mm/day, whereas the observations are in the range 1.02 mm/day - 2.02 mm/day.

This parameter which constitues a measure of the year-to-year or interannual variability, shows great spatial variability.

Over the northern gridpoints (pt1,pt2,pt3), the simulated standard deviation is in the range 0.70 mm/day -1.77 mm/day . It increases as we move away from the coasts towards the interior.

The observed standard deviation is in the range 1.04 mm/day - 1.90 mm/day. There is a sharp decrease between the two first points, followed by a slight increase.

The simulated standard deviation is about 13 - 20% of the model-produced precipitation over this area.

The observed standard deviation is about 38 - 60% of the precipitation over this area.

Over the central gridpoints (pt4,pt5,pt6), the simulated standard deviation is in the range 1.26 mm/day - 1.57 mm/day. Firstly it increases between the points (pt4,pt5) then it decreases.

The observed standard deviation is in the range 1.02 mm/day - 1.91 mm/day. The tendency shows an strong V-shape.

The simulated standard deviation is about 17 - 23% of the model-produced precipitation over this area.

The observed standard deviation is about 42 - 55% of the precipitation over this area.

Over the southern gridpoints (pt7,pt8,pt9), the simulated standard deviation is in the range 0.41 mm/day - 0.78 mm/day, the tendency is thus reverse relative to the central points. It decreases between points (pt7,pt8) and after it increases.

The observed standard deviation is in the range 1.53 mm/day - 2.02 mm/day. It has a tendency to decrease.

The simulated standard deviation is about 29 - 38% of the model-produced precipitation over this area.

The observed standard deviation is about 47 - 69% of the precipitation over this area.

Results from the Mann-Whitney U-test indicate that the set of grid points with difference in means significant at or greater than the 1% level is constituted by the points (pt1,pt2,pt3,pt4,pt5,pt6), that is to say, the north and central areas.

Applications of two - tailed F -tests with 9 degrees of freedom in the numerator and denominator shows that the variances in the two sampled sets (observation and model) are considered not equal at or greater than the 1% level of significance, at the following grid points (pt1,pt7 and pt8).

Application of the t - test shows that with the exception of the points pt7 and pt9, the difference in means is statistically significant at either the 5% and the 1% level

SUMMARY

The precipitation in the model generally tends to be **larger** than observed (more than 2.5 times) over northern and central areas of France and **smaller** over the southern area.

The model does not capture any of the observed features of the first two gridpoints rows.

Both the observations and the model exhibit substantial variability.

The model overestimates the interannual variability of January precipitation over pt2, pt3 and pt5.

JULY

The **model precipitation** varies in the range 0.2 mm/day (pt2)-0.9 mm/day (pt6) whilst the **observation values** do in the range 0.9 mm/day (pt9) -2.3 mm/day(pt3).

The model **underestimates** precipitation over the entire study area.

The **standard deviation** for the mean July model precipitation, calculated over the 10 Julies, ranges from a minimum of 0.12 mm/day to a maximum of 0.73 mm/day, whereas the observations are in the range 0.66 mm/day - 1.14 mm/day.

Over the northern gridpoints (pt1,pt2,pt3), the simulated standard deviation is in the range 0.12 mm/day-0.31 mm/day. It has an V-shape.

The observed standard deviation is in the range 0.66 mm/day - 1.14 mm/day. There is a sharp increase between the two first points, followed by a slight decrease.

The simulated standard deviation is about 50 - 64% of the model-produced precipitation over this area.

The observed standard 34 - 53% of the precipitation over this area.

Over the central gridpoints (pt4,pt5,pt6), the simulated standard deviation is

in the range 0.26 mm/day - 0.73 mm/day. The tendency is increasing eastwards.
The observed standard deviation is in the range 0.74 mm/day - 1.13 mm/day. It has a V -shape.
The simulated standard deviation is about 58 - 78% of the model-produced precipitation over this area.
The observed standard deviation is about 47 - 50% of the precipitation over this area.

Over the southern gridpoints (pt7,pt8,pt9), the simulated standard deviation is in the range 0.15 mm/day - 0.58 mm/day. The tendency is decreasing eastwards.
The observed standard deviation is in the range 0.67 mm/day - 0.88 mm/day. The tendency is the same than that of the central points.
The simulated standard deviation is about 44 - 66% of the model-produced precipitation over this area.
The observed standard deviation is about 39 - 66% of the precipitation over this area.

Results from the Mann-Whitney U-test indicate that the set of grid points whose difference in means is significant at or greater than the 1% level is constituted by the points (pt1,pt2,pt3,pt4,pt5,pt6), as in January. Differences in means significant at the 5% level occur at the points (pt7,pt8,pt9).

Application of two - tailed F -tests with 9 degrees of freedom in the numerator and denominator shows that the variances in the two sampled sets (observation and model) are considered not equal at or greater than the 1% level of significance, at the following grid points (pt1,pt2,pt3,pt4,pt8,pt9).

Application of the t - test shows that the difference in means is statistically significant at either the 5% and the 1% level for all the grid points selected.

SUMMARY

The model **tends to underestimate precipitation** over the whole area.
The observed year-to-year variability is greater than the variability simulated by the model over the entire study area.
The model is successful in reproducing the observed features of the last gridpoints row (the southern one).

CONCLUSIONS

Better agreement with observations in January. The model appears to be able to represent wintertime precipitation better than summertime.

Overestimation of precipitation over the northern and central parts of France and underestimation over the southern region (January).

General underestimation of precipitation over the entire study area (July).

The observed year-to-year variability exceeds considerably the simulated by the model over the southern region (pt7, pt8 and pt9) (January).

The model underestimates the interannual variability of precipitation over the entire study area (July).

The Mann - Whitney U - test results for January and July indicate that the north and central areas exhibit differences in means significant at or greater than the 1% level.

Results from the t - statistic reveals that the number of grid points with difference statiscally significant at the 1% level or greater is large in July and covers the study area, that is to say, errors in the time mean field are larger in July than in January.

Results from the F - test show that the number of grid points where the difference between model variance and observed variance is significant is greater in July.

b) T42 10-YEAR MEAN TEMPERATURE (FRANCE)

JANUARY

The **model temperature** varies in the range 2.7°C(pt6) - 8.9°C(pt9) whilst the **observation values** do in the range 0.6°C(pt3) - 7.6°C(pt9).

The model simulates temperatures which are 0.8°C - 4°C warmer than observed over the entire study region. The model is able to capture the observed features of the gridpoints rows. Over the first two gridpoints rows, the temperature decreases as we move away from the coasts towards the interior.

The **standard deviation** for the mean January model temperatures calculated over the 10 Januaries ranges from a minimum of 0.44°C to a maximum of 0.68°C whereas the observations are in the range of 2.04°C - 3.23°C.

This parameter which constitutes a measure of the interannual variability shows considerable less spatial variability compared with precipitation.

Over the northern gridpoints (pt1,pt2,pt3), the simulated standard deviation is in the range 0.62°C - 0.68°C. The variation is very small.

The observed standard deviation is in the range 2.91°C - 3.26°C. There is a tendency to increase eastwards.

The simulated standard deviation is about 10 - 21 % of the model temperature over this area.

The observed standard deviation is about 79 - 573 % of the temperature over this area.

Over the central gridpoints (pt4,pt5,pt6), the simulated standard deviation is in the range 0.49°C - 0.61°C. There is a tendency to increase eastwards in a steady

way.
The observed standard deviation is in the range 2.94°C - 3.23°C. Firstly, it increases and after it decreases.
The simulated standard deviation is about 7 - 22 % of the model temperature over this area.
The observed standard deviation is about 67 - 377 % of the temperature over this area.

Over the southern gridpoints (pt7,pt8,pt9), the simulated standard deviation is in the range 0.44°C - 0.66°C. There is a sharp decrease eastwards.
The observed standard deviation is in the range 2.04°C - 2.27°C. It increases eastwards.
The simulated standard deviation is about 4 - 6 % of the model temperature over this area.
The observed standard deviation is about 7 % of the temperature over this area.
Results from the Mann-Whitney U-test indicate that the set of grid points whose difference in means is significant at or greater than the 1% level is constituted by the points pt1 and pt2. The set of grid points with difference in means significant at the 5% level are constituted by the points pt3, pt4, pt5 and pt8.

Applications of two - tailed F -tests with 9 degrees of freedom in the numerator and denominator shows that the variances in the two sampled sets (observation and model) are considered not equal at or greater than the 1% level of signification, for all the grid points of the area of study.

Application of the t - test (approximation of the t - statistic for situation with unequal variances) shows that the difference in means is statistically significant at either the 5% and the 1% level for the following grid points: pt1, pt2, pt4 and pt5.

SUMMARY

The model shows a general **overestimation** of the surface air temperature over the whole area, overestimation which is more noticeable over the northern and central regions - exceeding at some points 3.5°C (pt1).

The model reproduces quite faithfully all the main features of the observations: the tendency to decrease inland over the northern and central regions and the reverse tendency over the southern region.

As far as the northern and central regions are concerned, the distribution of temperature is clearly controlled by the continentality whilst for the southern region, the influence of latitude is enhanced

The model **underestimates** considerably the interannual variability of January surface temperature over the whole region.

Special mention of points pt3, pt5 and pt6 which are characterized by a low mean surface air temperature but a highly interannual variability.

JULY

The **model temperature** varies in the range 22.7°C(pt9) - 28.6°C(pt8) whilst the **observation values** do in the range 17.6°C(pt1) - 23.2°C (pt9).

As a general rule, the model **overestimates** the surface air temperature with the exception of the point (pt9), where a slight underestimation takes place.
The overestimation exceeds on average 5°C, reaching up to 8°C at some points (pt2,pt1,pt5).
The model does not reproduce the main features of the observations.

The **standard deviation** for the mean July model temperatures calculated over the 10 Julies ranges from a minimum of 0.88°C to a maximum of 2.00° C whereas the observations are in the range of 1.45°C - 1.87°C.

Over the northern gridpoints (pt1,pt2,pt3), the simulated standard deviation is in the range 1.84°C - 2.00°C. The tendency is decreasing eastwards.
The observed standard deviation is in the range 1.51°C - 1.77°C. There is a tendency to increase eastwards. Excellent agreement over point pt3.
The simulated standard deviation is about 7 - 8 % of the model temperature over this area.
The observed standard deviation is about 8 - 10 % of the temperature over this area.

Over the central gridpoints (pt4,pt5,pt6), the simulated standard deviation is in the range 1.64°C -1.85°C. There is a tendency to decrease eastward.
The observed standard deviation is in the range 1.67°C-1.87°C. It increases eastwards, firstly, in a steady way.
The simulated standard deviation is about 7 % of the model air temperature over this area.
The observed standard deviation is about 8 - 10 % of the temperature over this area.

Over the southern gridpoints (pt7,pt8,pt9), the simulated standard deviation is in the range 0.88°C - 1.40°C. There is a sharp decrease eastwards.
The observed standard deviation is in the range 1.45°C - 1.57°C. It increases eastwards.
The simulated standard deviation is about 4 - 6 % of the model air temperature over this area.
The observed standard deviation is about 7 % of the temperature over this area.

Results from the Mann-Whitney U-test indicate that the set of grid points whose difference in means is significant at or greater than the 1% level covers practically almost the entire study area.

Applications of two - tailed F -tests with 9 degrees of freedom in the numerator and denominator shows that the variances in the two sampled sets (observation and model) are considered not significant at or greater than the 1% level

Application of the t - test (approximation of the t - statistic for situation with unequal variances) shows that the difference in means is statistically significant at either the 5% and the 1% level for almost all the points with the exception of pt9.

SUMMARY

The model shows an overestimation of the surface air temperature, exceeding on average 5^0C over almost the study area with the sole exception of the point (pt9).

The July temperature bias is larger - apart from pt9 - than in January, which is to be expected.

The model does not reproduce the main features of the observations, in contrast to the January situation.

The model overestimates slightly the interannual variability of July surface air temperature over the points (pt1, pt2, pt3, pt4) though underestimates it over the southern region.

CONCLUSIONS

Better agreement with observations in January.

As a general rule, overestimation of the surface air temperatures over the whole area, being the larger overestimations in July.

General underestimations of the interannual variability of January surface air temperatures.

Underestimation of the interannual variability of July surface air temperatures over the southern region and some areas of the central region (eastern part).

The Mann - Whitney U - test results indicate that the area with differences in means significant at or greater than the 1% level is larger for July.

Results for the t - statistic reveals that the number of grid points with difference statiscally significant at the 1% level or greater is large in July and covers practically the study area with the exception of pt9.

Results for the F - test shows that the differences between model variance and observed variance are significant for all the points of the area of study in July, in clear contrast with the January case.

c) T79 10-YEAR MEAN PRECIPITATION (FRANCE)

JANUARY

The **model precipitation** varies in the range 2.1 mm/day (pt7) - 4.4 mm/day (pt15) whilst the **observation values** do in the range 1.9 mm/day (pt19) - 4.4 mm/day (pt10).

The model overpredicts precipitation in the three first points of the northern grid points row - by about 1.2 times observed values - and in the eastern part of the third grid points row - by about 2.2 times observed values at some points (pt14) - and underpredicts especially in the southwest region - by about 0.7 times observed values.

The **standard deviation** for the mean January observation precipitation calculated over the 10 Januaries ranges from a minimum of 0.95 mm/day (pt2) to a maximum of 1.91 mm/day (pt11).

Over the first grid points row (pt1,pt2,pt3,pt4,pt5), the observed standard deviation is in the range 0.95 mm/day - 1.47 mm/day . There is a decrease between the two first points, followed by an increase.

The observed standard deviation is about 43 - 52% of the precipitation over this area.

Over the second grid points row (pt6,pt7,pt8,pt9,pt10), the observed standard deviation is in the range 1.08 mm/day - 1.19 mm/day. Firstly, it increases between the points (pt6,pt7) and after a decrease, it finished by an increase.

The observed standard deviation is about 27 - 51% of the precipitation over this area.

Over the third grid points row (pt11,pt12,pt13,pt14,pt15), the observed standard deviation is in the range 1.05 mm/day - 1.91 mm/day. It decreases eastwards.

The observed standard deviation is about 34 - 58% of the precipitation over this area.

Over the fourth grid points row (pt16,pt17,pt18,pt19,pt20), the observed standard deviation is in the range 1.09 mm/day - 1.49 mm/day. The tendency has a V-shape.

The observed standard deviation is about 40 - 77% of the precipitation over this area.

SUMMARY

The precipitation is rather well simulated by the model, over the two first grid points rows, especially over the second one . While showing an overestimation in the first grid points row - the northern one -, it shows a light deficit over the second one.

Big underestimations take place in the southwest and excess of precipitation appears across the eastern central part.

JULY

The **model precipitation** varies in the range 0.7 mm/day (pt11)- 3.2 mm/day (pt15) whilst the **observation values** do in the range 1.2 mm/day (pt20) -3.0 mm/day(pt10).

The model **underestimates** precipitation with the exception of some areas over Central East - by about 1.8 times observed values - and South East. The largest underestimations correspond to the Southwest - by about 0.3 times observed values-.

Over the three first grid points rows, the model increases eastwards, especially over the second and third rows.

The **standard deviation** for the mean July observation precipitation calculated over the 10 Julies ranges from a minimum of 0.50 mm/day (pt16) to a maximum of 1.53 mm/day (pt10).

Over the first grid points row (pt1,pt2,pt3,pt4,pt5), the observed standard deviation is in the range 0.83 mm/day - 1.15 mm/day . There is an increase between the first fourth points followed by a slight decrease.
The observed standard deviation is about 42 - 57% of the precipitation over this area.

Over the second grid points row (pt6,pt7,pt8,pt9,pt10), the observed standard deviation is in the range 0.85 mm/day - 1.53 mm/day. Firstly, it increases between the points (pt6,pt7) and after a decrease, it finished by an increase.
The observed standard deviation is about 45 - 55% of the precipitation over this area.

Over the third grid points row (pt11,pt12,pt13,pt14,pt15), the observed standard deviation is in the range 0.70 mm/day - 1.42 mm/day. The tendency is decreasing.
The observed standard deviation is about 37 - 66% of the precipitation over this area.

Over the fourth grid points row (pt16,pt17,pt18,pt19,pt20), the observed standard deviation is in the range 1.16 mm/day - 1.48 mm/day. The tendency has an V-shape.

The observed standard deviation is about 33 - 99% of the precipitation over this area.

SUMMARY

The model tends to underestimate precipitation with the exception of some areas over Central East and South East; being localised the biggest underestimations over the Southwest.

The model is successful in reproducing the observed features of the last gridpoints row - the southern one -.

The largest discrepancies between the model and observations occur in connection with the major topographical features.

CONCLUSIONS

Precipitation is rather well simulated by the model, over the two first grid points rows (January).

Overestimation of precipitation in some areas of the northwest - by about 1.2 times observed values - (January).

Big underestimations across the southwest in both January and July.

Excessive precipitation across the eastern central part.

d) T79 10-YEAR MEAN TEMPERATURE (FRANCE)

JANUARY

The surface temperature (**model temperature**) varies in the range -0.7°C(pt15) - 5.9°C(pt11) whilst the surface air temperature (observation temperature) do in the range 0.1°C(pt5) - 5.2°C(pt16).

The surface temperature tends to be greater than the surface air temperature with the exception of some isolated points and the southern grid points row.

The agreement between both parameters is quite good for the second grid points row, where differences are less than 1.5°C.

It shows a tendency to decrease as we move away from the coasts towards the interior.

The **standard deviation** for the mean January observation temperatures calculated over the 10 Januaries ranges from a minimum of 2.09°C (pt20) to a maximum of 3.35°C (pt8).

Over the first northern grid points row (pt1,pt2,pt3,pt4,pt5), the observed standard deviation is in the range 3.08°C - 3.32°C, being the variation very little.

Over the second grid points row (pt4,pt5,pt6,pt7,pt8,pt9,pt10), the observed standard deviation is in the range 3.04°C - 3.35°C. Firstly, it increases and then it decreases.

Over the third grid points row (pt11,pt12,pt13,pt14,pt15), the observed standard deviation is in the range 2.57°C - 3.09°C. Firstly, it increases and then it decreases.

Over the fourth grid points row (pt16,pt17,pt18,pt19,pt20), the observed standard deviation is in the range 2.09°C - 2.85°C. Firstly, it increases and then decreases.

SUMMARY

The surface temperature tends to be greater than the surface air temperature with the exception of some points and the southern grid points row.

The greatest difference between both parameters corresponds to the first grid points row - by about 2°C-.

JULY

The surface temperature (**model temperature**) varies in the range 22.8°C(pt10) - 28.0°C(pt20) whilst the surface air temperature (observation temperature) do in the range 18.2°C(pt1) - 22.1°C(pt19).
As a general rule, surface temperature exceeds surface air temperature, reaching up to 8°C at some points (pt3,pt7). The close agreement between both parameters is shown in points (pt14 and pt10)
The model does not reproduce the main features of the observations.

The **standard deviation** for the mean July observation temperatures calculated over the 10 Julies ranges from a minimum of 1.46°C (pt20) to a maximum of 2.03°C (pt13).

Over the first northern grid points row (pt1,pt2,pt3,pt4,pt5), the observed standard deviation is in the range 1.50°C - 1.81°C. It increases eastwards.

Over the second grid points row (pt4,pt5,pt6,pt7,pt8,pt9,pt10), the observed standard deviation is in the range 1.66°C - 1.89°C. It increases eastwards.

Over the third grid points row (pt11,pt12,pt13,pt14,pt15), the observed standard deviation is in the range 1.75°C - 2.03°C. Firstly, it increases and then it decreases slowly.

Over the fourth grid points row (pt16,pt17,pt18,pt19,pt20), the observed standard deviation is in the range 1.46°C - 1.91°C. Firstly, it increases and then it decreases.

SUMMARY

The surface temperature is higher than the surface air temperature, exceeding on average 6°C over almost the study area.

The difference between model and observation is larger than in January.

The model does not reproduce the main features of the observations, in contrast to the January situation.

CONCLUSIONS

The surface temperature is higher than the surface air temperature with the exception of some points and the southern grid points row in January.

The surface temperature reproduces the main features of the observed one in January.

The surface temperature is greater than the surface air temperature over all the entire studied area, exceeding on average 6°C in July.

II.- SPAIN

a) T42 10-YEAR MEAN PRECIPITATION (SPAIN)

JANUARY

The **model precipitation** varies in the range 0.1 mm/day (pt4) - 1.0 mm/day (pt1) whilst the **observation values** do in the range 1.5 mm/day (pt4) - 3.3 mm/day (pt1).

As a result of its geography, Spain experiences marked spatial and temporal variations in both precipitation and temperature.

The model underestimates precipitation over all the study area, especially over the points pt1 and pt3 - the western ones by about 0.3 times observed values.

The model does not reproduce any of the observed features of the two northern grid points, located over the south part of the Iberian Plateau.

The **standard deviation** for the mean January observation precipitation calculated over the 10 Januaries ranges from a minimum of 1.13 mm/day (pt4) to a maximum of 2.52 mm/day (pt1).

Over the first grid points row (pt1,pt2) the observed standard deviation is in the range 1.40 mm/day - 2.52 mm/day . There is a decrease .

The observed standard deviation is about 76 - 89% of the precipitation over this area.

Over the second grid points row (pt3,pt4), the observed standard deviation is in the range 1.13 mm/day - 2.00 mm/day. There is a decrease.

The observed standard deviation is about 78 - 86% of the precipitation over this area.

SUMMARY

The model does not reproduce satisfactorily the observed features.

The model underestimates considerably the precipitation, showing a smooth structure.

JULY

The **model precipitation** varies in the range 0.3 mm/day (pt4)- 2.2 mm/day (pt1) whilst the **observation values** do in the range 0.1 mm/day (pt3) -0.7 mm/day(pt2).

The model overestimates precipitation considerably over pt1 - by about 4.5 times observation values- and over pt3. There is an excellent agreement over points pt2 and pt4.

Over the grid points rows of study, the model decreases eastwards.

The **standard deviation** for the mean July observation precipitation calculated over the 10 Julies ranges from a minimum of 0.21 mm/day (pt3) to a maximum of 1.10 mm/day (pt2).

Over the first grid points row (pt1,pt2) the observed standard deviation is in the range 0.49 mm/day - 1.10 mm/day . There is an increase .

The observed standard deviation is about 122 - 153% of the precipitation over this area.

Over the second grid points row (pt3,pt4), the observed standard deviation is in the range 0.21 mm/day - 0.48 mm/day. It increases eastwards.

The observed standard deviation is about 147 - 175% of the precipitation over this area.

SUMMARY

The model precipitation is considerably higher than the observed over the point pt1 and to a much lesser extent over pt3 while it shows a quite good agreement over pt2 and pt4.

CONCLUSIONS

The model is not very successful in reproducing the observed features because of the smoothed representation of the orography.

In January, it shows a general underestimation, especially noticeable over points pt3 and pt4 (S. of Gredos and Guadalquivir Valley), whereas in July, big overestimations take place over these points.

b) T42 10-YEAR MEAN TEMPERATURE (SPAIN)

JANUARY

The surface temperature (**model temperature**) varies in the range 4.9^{o}C(pt1) - 15.0^{o}C(pt4) whilst the surface air temperature (observation temperature) do in the range 4.8^{o}C(pt2) - 9.7^{o}C(pt3).

The surface temperature is greater than the surface air temperature over the points pt2 and pt4, exceeding by more than 10^{o}C. The agreement between both parameters is quite good over points pt1 and pt3, where differences are less than 2.0^{o}C.

Contrarily to the surface air temperature, the surface temperature tends to increase towards the interior.

The **standard deviation** for the mean January observation temperatures calculated over the 10 Januaries ranges from a minimum of 1.07^{o}C (pt3) to a maximum of 1.52^{o}C (pt2).

Over the first grid points row (pt1,pt2) the observed standard deviation is in the range 1.08°C - 1.52°C.

The observed standard deviation is about 17 - 32% of the temperature over this area.

Over the second grid points row (pt3,pt4), the observed standard deviation is in the range 1.07°C - 1.19°C.

The observed standard deviation is about 11 - 21% of the temperature over this area.

SUMMARY

The surface temperature tends to be greater than the surface air temperature over the points pt2 and pt4 by as much as 10°C.

JULY

The surface temperature (**model temperature**) varies in the range 23.1°C(pt4) - 31.6°C(pt3) whilst the surface air temperature (observation temperature) do in the range 23.8°C(pt1) - 26.12°C(pt3).

As a general rule, surface temperature exceeds surface air temperature, reaching up to 6°C at some points (pt2,pt3). The close agreement between both parameters is shown over point pt4(1°C).

The model enhances in a extraordinary way the observed features.

The **standard deviation** for the mean July observation temperatures calculated over the 10 Julies ranges from a minimum of 1.07°C (pt3) to a maximum of 1.89°C (pt1).

Over the first grid points row (pt1,pt2) the observed standard deviation is in the range 1.24°C - 1.89°C. It decreases eastwards.

The observed standard deviation is about 8 - 11% of the temperature over this area.

Over the second grid points row (pt3,pt4), the observed standard deviation is in the range 1.07°C - 1.47°C.

The observed standard deviation is about 5 - 6% of the temperature over this area.

SUMMARY

The surface temperature is higher than the surface air temperature, exceeding more than 6°C over the points pt2 and pt3. There is a slight underestimation over the point pt4.

CONCLUSIONS

The surface temperature tends to be higher than the surface air temperature .

The greatest difference between both parameters corresponds to the point pt4 in January - by about 10°C.

The smaller differences correspond to July.

c) T79 10-YEAR MEAN PRECIPITATION (SPAIN)

JANUARY

The **model precipitation** varies in the range 1.0 mm/day (pt7) - 3.4 mm/day (pt7) whilst the **observation values** do in the range 1.1 mm/day (pt5) - 3.2 mm/day (pt12).

The model reproduces quite faithfully the precipitation over the northern grid points but overpredicts over the second grid points row - by about 2 times observed values at some points (pt6) - and underpredicts especially in the southwest region - by about 0.5 times observed values.

The **standard deviation** for the mean January observation precipitation calculated over the 10 Januaries ranges from a minimum of 0.78 mm/day (pt5) to a maximum of 2.60 mm/day (pt11).

Over the first grid points row (pt1,pt2,pt3), the observed standard deviation is in the range 1.01 mm/day - 2.03 mm/day . There is an increase.
The observed standard deviation is about 69 - 81% of the precipitation over this area.

Over the second grid points row (pt4,pt5,pt6), the observed standard deviation is in the range 0.78 mm/day - 1.54 mm/day. Firstly, it increases between the points (pt4,pt5) and after it decreases.
The observed standard deviation is about 69 - 84% of the precipitation over this area.

Over the third grid points row (pt7,pt8,pt9), the observed standard deviation is in the range 1.01 mm/day - 1.86 mm/day. It is almost no variation.

The observed standard deviation is about 87 - 88% of the precipitation over this area.

Over the fourth grid points row (pt10,pt11,pt12), the observed standard deviation is in the range 1.75 mm/day - 2.60 mm/day. Firstly, it increases between the points (pt7,pt8) and after it decreases.

The observed standard deviation is about 66 - 88% of the precipitation over this area.

SUMMARY

The precipitation is rather well simulated by the model, over the first grid points row. While showing a big overestimation over the second grid points row - in connection with some mountain ranges that surround the Meseta - the central plateau of the Iberian Peninsula-.

Big underestimations take place in the south areas.

JULY

The **model precipitation** varies in the range 0.1 mm/day (pt12)- 4.0 mm/day (pt5) whilst the **observation values** do in the range 0.2 mm/day (pt9) - 1.2 mm/day(pt1).

The model **overestimates** precipitation with the exception of some areas over the South where underestimation takes place (pt12). The largest overestimations correspond to the points (pt4,pt5)- by about 5.0 times observed values-.

The model reproduces in a reasonable way the observed features over the first grid points row and there is a good agreement over the points pt10 and pt11.

The **standard deviation** for the mean July observation precipitation calculated over the 10 Julies ranges from a minimum of 0.40 mm/day (pt10) to a maximum of 1.36 mm/day (pt12).

Over the first grid points row (pt1,pt2,pt3), the observed standard deviation is in the range 0.62 mm/day - 1.01 mm/day . There is an increase followed by a decrease.

The observed standard deviation is about 53 - 97% of the precipitation over this area.

Over the second grid points row (pt4,pt5,pt6), the observed standard deviation is in the range 0.60 mm/day - 0.77 mm/day. Firstly, it decreases between the points (pt4,pt5) and after it increases.

The observed standard deviation is about 87 - 132% of the precipitation over this area.

Over the third grid points row (pt7,pt8,pt9), the observed standard deviation is in the range 0.28 mm/day - 0.50 mm/day. Firstly, it increases between the points (pt7,pt8) and after it decreases.

The observed standard deviation is about 117 - 143% of the precipitation over this area.

Over the fourth grid points row (pt10,pt11,pt12), the observed standard deviation is in the range 0.40 mm/day - 1.36 mm/day. There is an increase.

The observed standard deviation is about 154 - 214% of the precipitation over this area.

SUMMARY

The model tends to overestimate precipitation with the exception of some areas over the South.

The model is successful in reproducing some of the observed features of the last gridpoints row and it is also a good agreement over the point pt3 -northern region-.

The largest discrepancies between the model and observations occur in connection with the major topographical features.

CONCLUSIONS

Precipitation is rather well simulated by the model, over the first grid points row (January).

Big underestimations across the south areas in January.

Excessive precipitation in connection with some topographical features.

Overestimation of precipitation with the exception of some areas in the South (July).

The model is successful in reproducing some of the observed features of the last gridpoints row.

d) T79 10-YEAR MEAN TEMPERATURE (SPAIN)

JANUARY

The surface temperature (**model temperature**) varies in the range 0.8^{o}C(pt5) -

7.7^{o}C(pt12) whilst the surface air temperature (observation temperature) do in the range 1.9^{o}C(pt3) - 8.2^{o}C(pt11).

With the exception of the points pt3, pt2 and pt10 -over these last two, there is a complete agreement; the surface air temperature tends to be greater than the surface temperature.

The agreement between both parameters is quite good for the fourth grid points row, where differences are less than 2.0^{o}C.

The **standard deviation** for the mean January observation temperatures calculated over the 10 Januaries ranges from a minimum of 0.95^{o}C (pt10) to a maximum of 2.92^{o}C (pt1).

Over the first grid points row (pt1,pt2,pt3), the observed standard deviation is in the range 1.84^{o}C - 2.92^{o}C . There is a decrease followed by a slight increase.

Over the second grid points row (pt4,pt5,pt6), the observed standard deviation is in the range 1.31^{o}C - 1.56^{o}C. There in a decrease.

Over the third grid points row (pt7,pt8,pt9), the observed standard deviation is in the range 1.06^{o}C - 1.39^{o}C. There in a decrease.

Over the fourth grid points row (pt10,pt11,pt12), the observed standard deviation is in the range 0.95^{o}C - 1.32^{o}C. There is an increase followed by a slight decrease.

SUMMARY

The surface air temperature tends to be greater than the surface temperature with the exception of some points.

The greatest difference between both parameters corresponds to the central grid points row - second and third rows - reaching at some points 3^{o}C-.

JULY

The surface temperature (**model temperature**) varies in the range 22.3^{o}C(pt1) - 29.80^{o}C(pt12) whilst the surface air temperature (observation temperature) do in the range 17.4^{o}C(pt3) - 26.8^{o}C(pt11).

With the exception of the point pt1, surface temperature exceeds surface air temperature, but as a general rule, there is a close agreement between both parameters, especially over the second and third grid points rows.

The major discrepancies take place over pt3, by more than 4^{o}C and over the last grid points row - the southern one - around 5°C.

The **standard deviation** for the mean July observation temperatures calculated over the 10 Julies ranges from a minimum of 0.69°C (pt8) to a maximum of 1.86°C (pt1).

Over the first grid points row (pt1,pt2,pt3), the observed standard deviation is in the range 0.77°C - 1.86°C . There is a decrease.

Over the second grid points row (pt4,pt5,pt6), the observed standard deviation is in the range 1.16°C - 1.30°C. There is a decrease followed by an increase.

Over the third grid points row (pt7,pt8,pt9), the observed standard deviation is in the range 0.69°C - 0.97°C. There in a decrease followed by a strong increase.

Over the fourth grid points row (pt10,pt11,pt12), the observed standard deviation is in the range 0.81°C - 1.10°C. It has a V-shaped.

SUMMARY

The surface temperature is higher than the surface air temperature, with the exception of pt1, being the differences between 2°C and 6°C .

The July temperature bias is larger than in January, which is to be expected.

CONCLUSIONS

The surface air temperature tends to be greater than the surface temperature with the exception of some points.(January)

The greatest difference between both parameters corresponds to the central grid points row - second and third rows - reaching at some points 3°C-.(January).

The surface temperature is higher than the surface air temperature, with the exception of pt1, being the differences between 2°C and 6°C .

The July temperature bias is larger than in January, which is to be expected.

CONCLUSIONS

PRECIPITATION

Increasing the model resolution (T42 to T79) has led to an improvement in the simulation of precipitation.

As precipitation shows a large spatial and temporal variability, better agreement with observations has been found when the averaging interval has been increased to 10 years.

With regard to T42 resolution over Spain the model is not successful in reproducing the observed features, being the disagreement very notorious over areas in the vicinity of Gredos, a mountain range of the Iberian Plateau that is not captured by the model.

With regard to T42 resolution over France the model is not successful being the simulated precipitation in much better agreement with the observations in January. The model shows an overestimation over the northern and central parts of France and an underestimation over the southern region. The model shows a general underestimation in July.

With regard to T79 resolution over Spain the simulated precipitation is in a very good agreement with the observations, mainly over the central-north areas and in January. In general the model shows an overestimation, mainly related to topographical features and an underestimation over the south area. In July the model overestimates over the whole area.

With regard to T79 resolution over France the simulation is better in January, mainly over the north and central regions. The model shows big underestimations over the southwest area either in January or in July and overestimations across the eastern and central areas.

TEMPERATURE

With regard to T42 resolution over France the simulated temperature is in better agreement with observations in January. As a general rule, the model overestimates the surface. air temperatures over the whole area, being the largest overestimations in July.

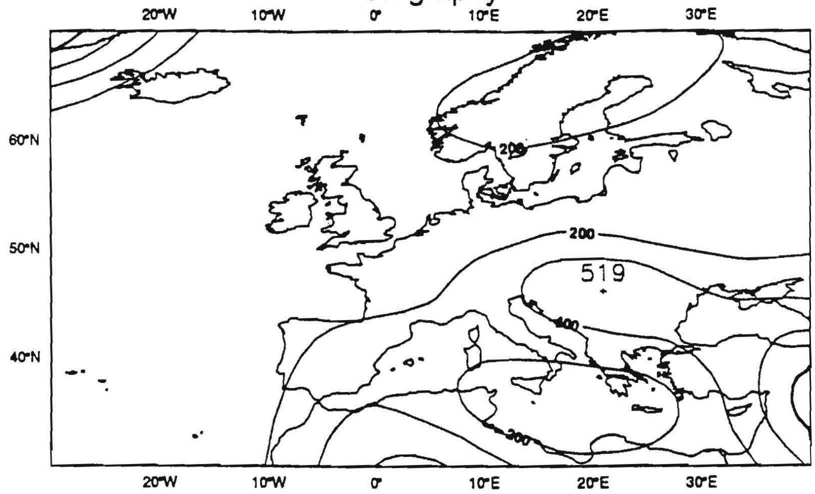
With regard to T42 resolution over Spain the surface temperature does not show a good agreement with surface air temperature in January nor in July. The surface temperature tends to be higher over the most eastern points, reaching up to $10^{0}C$ (January). In July, the surface temperature exceeds the surface air temperature over more than $5^{0}C$ with the exception of the south east area where a slight underestimation takes place.

With regard to T79 resolution over France the surface temperature is higher than the surface air temperature with the exception of some isolated points and the southern grid points row in January, but showing a general overestimation in July. The surface temperature is able to reproduce the main features of the surface air temperature in January.

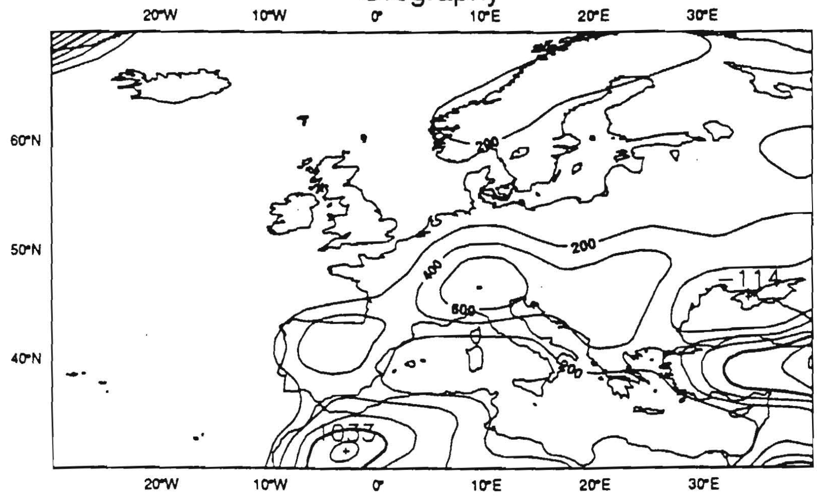
With regard to T79 resolution over Spain the surface air temperature tends to be greater than the surface temperature, being the greatest differences located over the central area in January. As far as July is concerned, the surface temperature is greater than the surface air temperature, being the differences between 2^{0}C and 6^{0}C and corresponding the major discrepancies to the southern area.

SECTION C.1 Orography at different resolutions

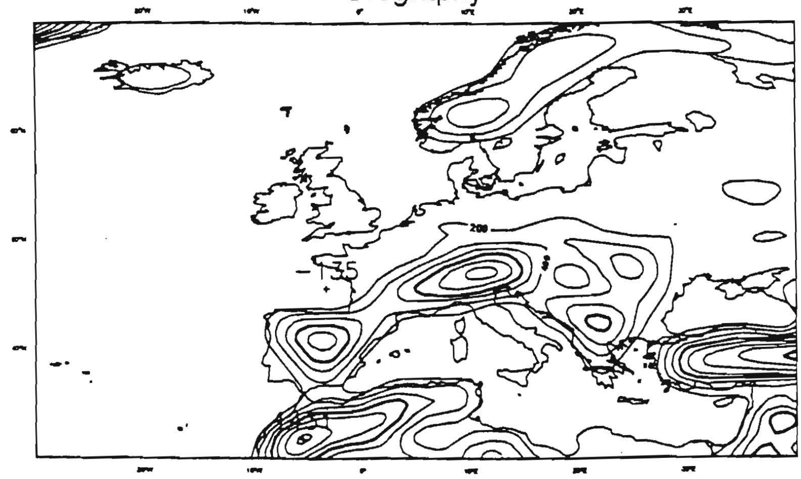
ARPEGE BA6
Orography



ARPEGE BA5
Orography



ARPEGE BA7
Orography

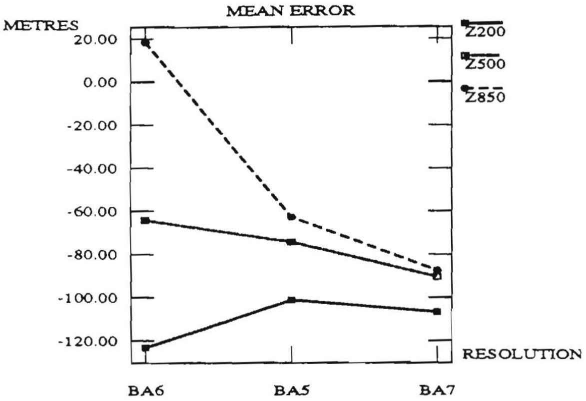


Orography at different resolutions

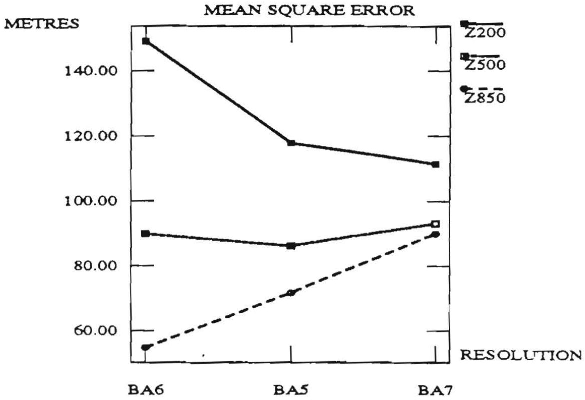
SECTION C.2

- Graphics of the mean and mean square errors
- Charts of the geographical distributions and differences of the fields corresponding to section A.

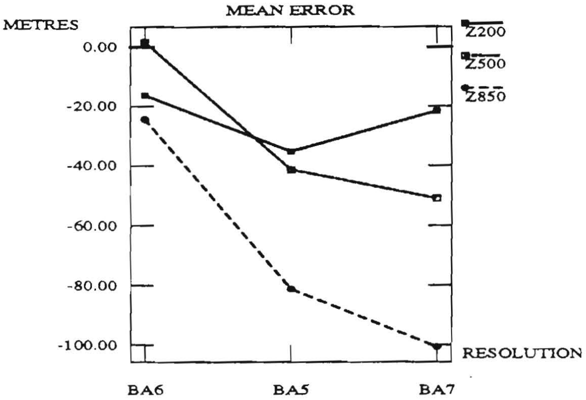
GEOPOTENTIAL JANUARY
MEAN ERROR



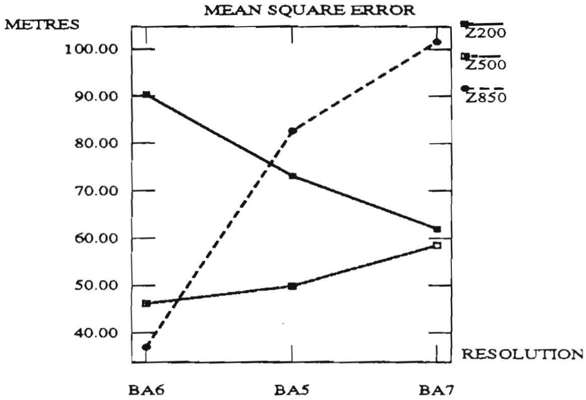
GEOPOTENTIAL JANUARY
MEAN SQUARE ERROR



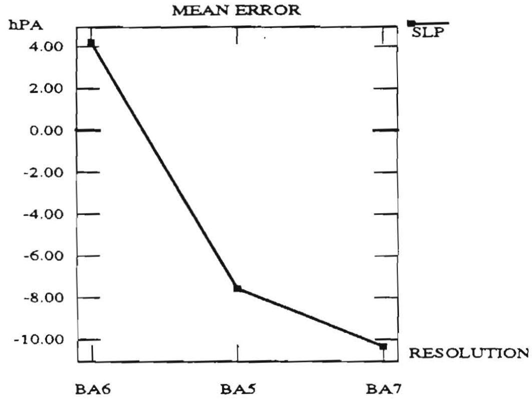
GEOPOTENTIAL JULY
MEAN ERROR



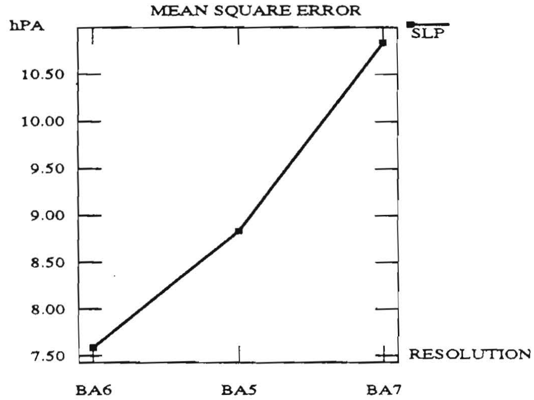
GEOPOTENTIAL JULY
MEAN SQUARE ERROR



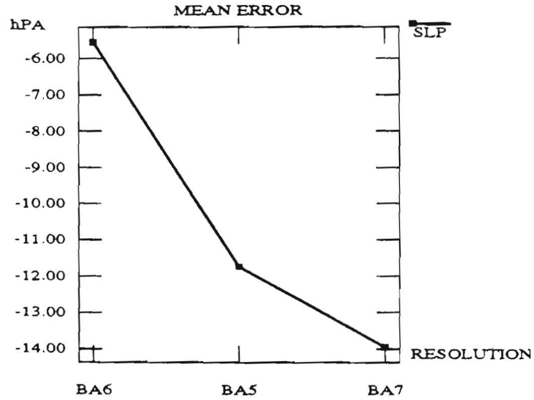
S-L PRESSURE JANUARY
MEAN ERROR



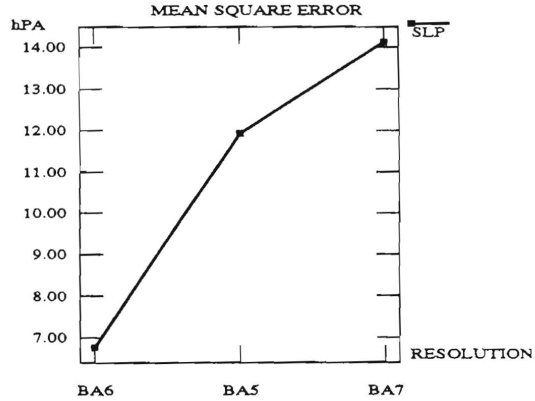
S-L PRESSURE JANUARY
MEAN SQUARE ERROR

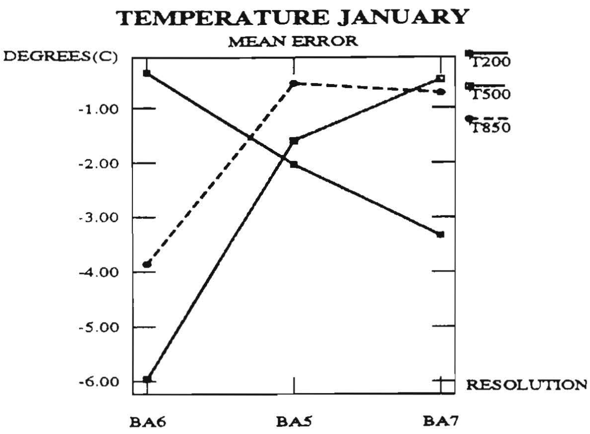


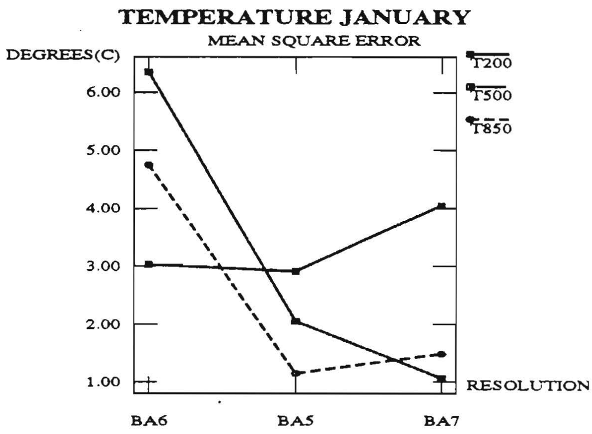
S-L PRESSURE JULY
MEAN ERROR

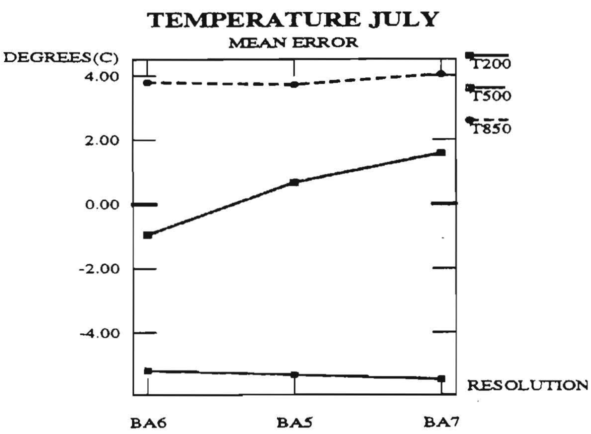


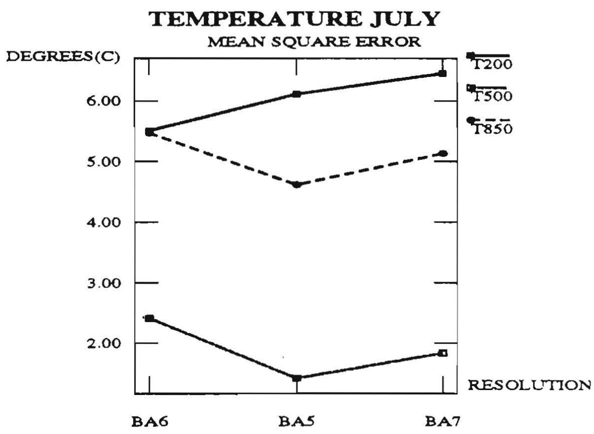
S-L PRESSURE JULY
MEAN SQUARE ERROR

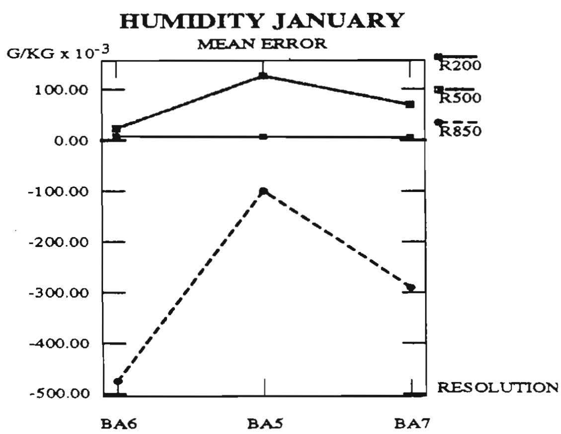


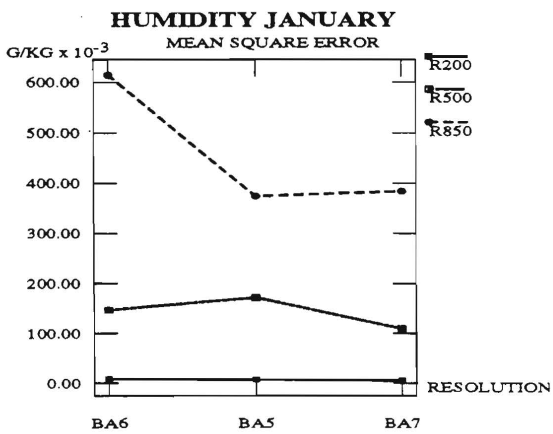

TEMPERATURE JANUARY
MEAN ERROR
DEGREES(C)
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
T200
T500
T850
RESOLUTION
BA6
BA5
BA7

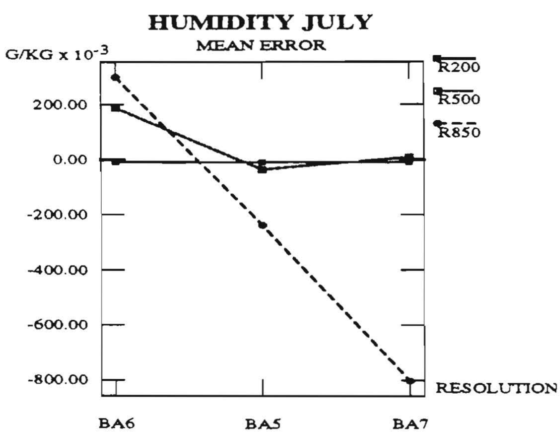

TEMPERATURE JANUARY
MEAN SQUARE ERROR
DEGREES(C)
6.00
5.00
4.00
3.00
2.00
1.00
T200
T500
T850
RESOLUTION
BA6
BA5
BA7

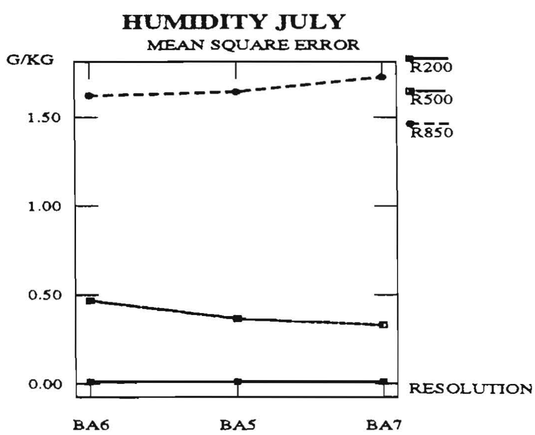

TEMPERATURE JULY
MEAN ERROR
DEGREES(C)
4.00
2.00
0.00
-2.00
-4.00
T200
T500
T850
RESOLUTION
BA6
BA5
BA7

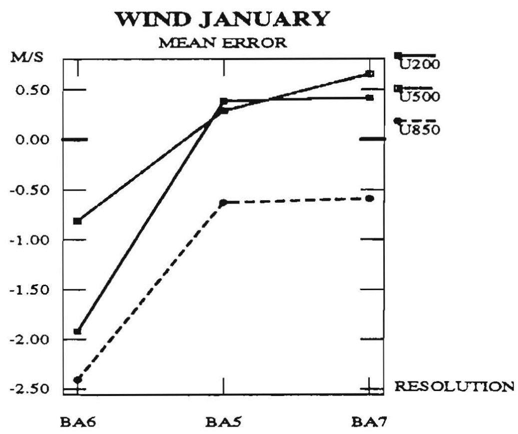

TEMPERATURE JULY
MEAN SQUARE ERROR
DEGREES(C)
6.00
5.00
4.00
3.00
2.00
T200
T500
T850
RESOLUTION
BA6
BA5
BA7

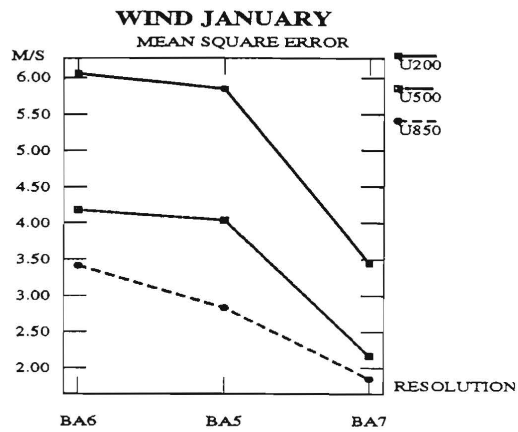

HUMIDITY JANUARY
MEAN ERROR
G/KG x 10-3
100.00
0.00
-100.00
-200.00
-300.00
-400.00
-500.00
R200
R500
R850
RESOLUTION
BA6
BA5
BA7

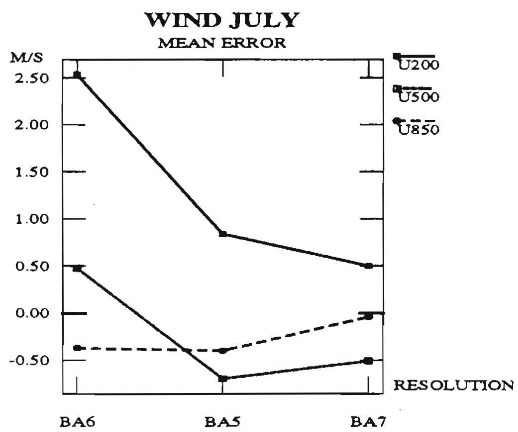

HUMIDITY JANUARY
MEAN SQUARE ERROR
G/KG x 10-3
600.00
500.00
400.00
300.00
200.00
100.00
0.00
R200
R500
R850
RESOLUTION
BA6
BA5
BA7

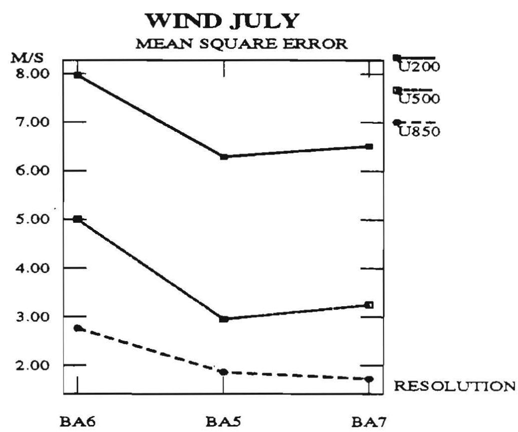

HUMIDITY JULY
MEAN ERROR
G/KG x 10-3
200.00
0.00
-200.00
-400.00
-600.00
-800.00
R200
R500
R850
RESOLUTION
BA6
BA5
BA7

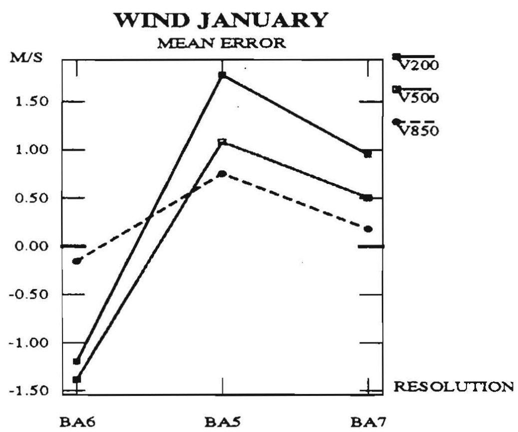

HUMIDITY JULY
MEAN SQUARE ERROR
G/KG
1.50
1.00
0.50
0.00
R200
R500
R850
RESOLUTION
BA6
BA5
BA7

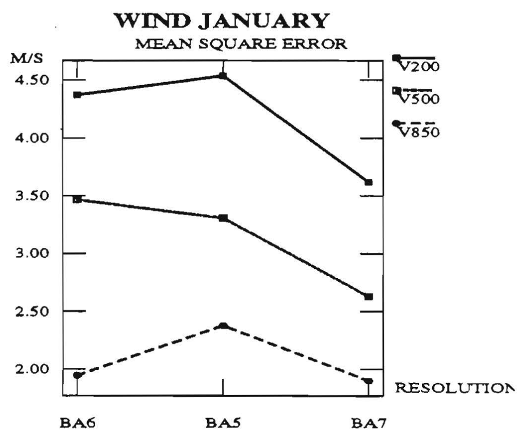

WIND JANUARY
MEAN ERROR
M/S
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
U200
U500
U850
RESOLUTION
BA6
BA5
BA7

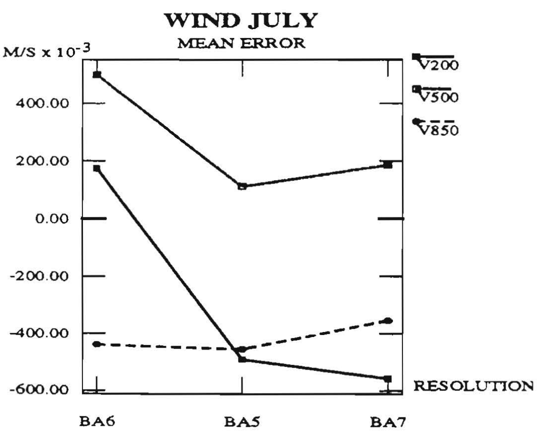

WIND JANUARY
MEAN SQUARE ERROR
M/S
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
U200
U500
U850
RESOLUTION
BA6
BA5
BA7

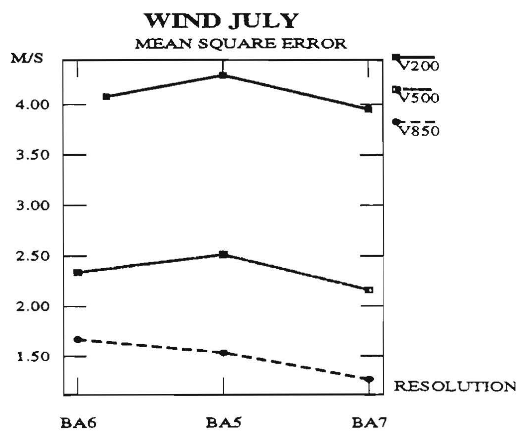

WIND JULY
MEAN ERROR
M/S
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
U200
U500
U850
RESOLUTION
BA6
BA5
BA7

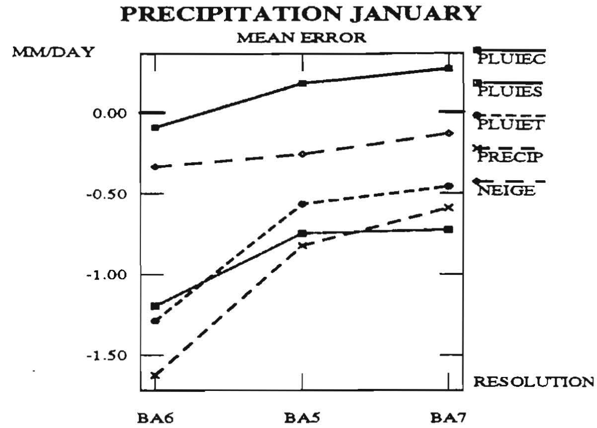

WIND JULY
MEAN SQUARE ERROR
M/S
8.00
7.00
6.00
5.00
4.00
3.00
2.00
U200
U500
U850
RESOLUTION
BA6
BA5
BA7

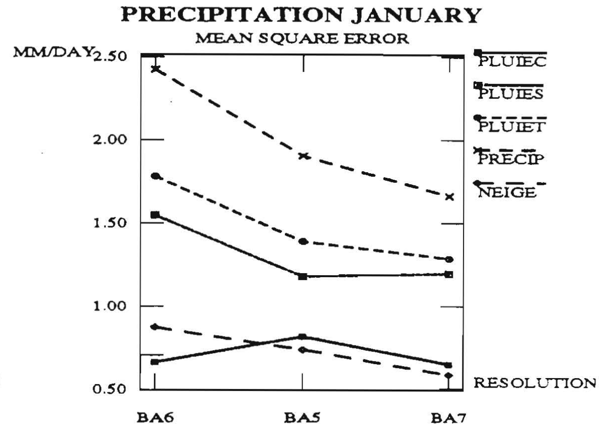

WIND JANUARY
MEAN ERROR
M/S
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
V200
V500
V850
RESOLUTION
BA6
BA5
BA7

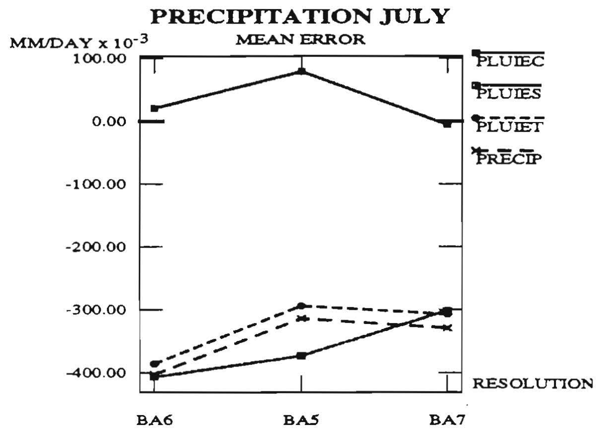

WIND JANUARY
MEAN SQUARE ERROR
M/S
4.50
4.00
3.50
3.00
2.50
2.00
V200
V500
V850
RESOLUTION
BA6
BA5
BA7

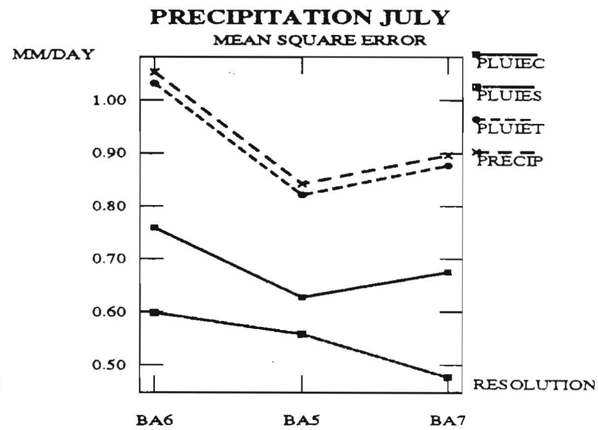

WIND JULY
MEAN ERROR
M/S x 10-3
400.00
200.00
0.00
-200.00
-400.00
-600.00
V200
V500
V850
RESOLUTION
BA6
BA5
BA7

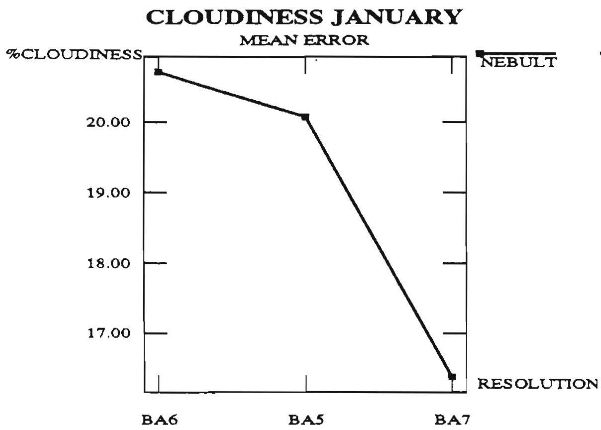

WIND JULY
MEAN SQUARE ERROR
M/S
4.00
3.50
3.00
2.50
2.00
1.50
V200
V500
V850
RESOLUTION
BA6
BA5
BA7

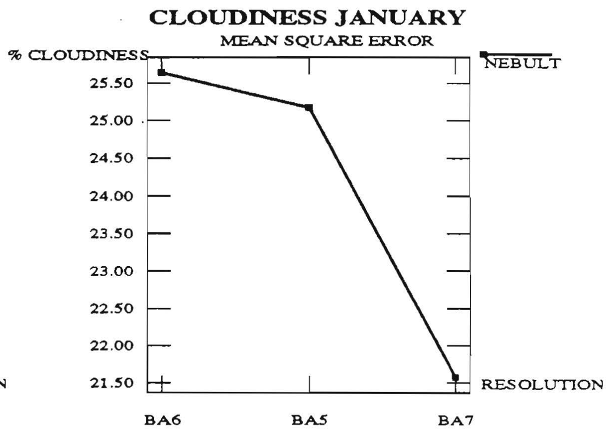

PRECIPITATION JANUARY
MEAN ERROR
MM/DAY
0.00
-0.50
-1.00
-1.50
PLUIEC
PLUIES
PLUIET
PRECIP
NEIGE
RESOLUTION
BA6
BA5
BA7

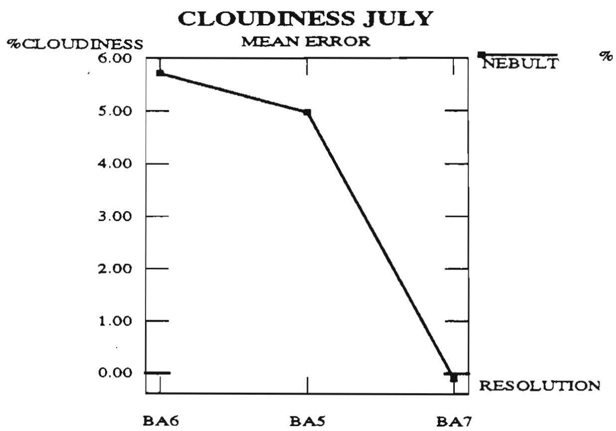

PRECIPITATION JANUARY
MEAN SQUARE ERROR
MM/DAY
2.50
2.00
1.50
1.00
0.50
PLUIEC
PLUIES
PLUIET
PRECIP
NEIGE
RESOLUTION
BA6
BA5
BA7

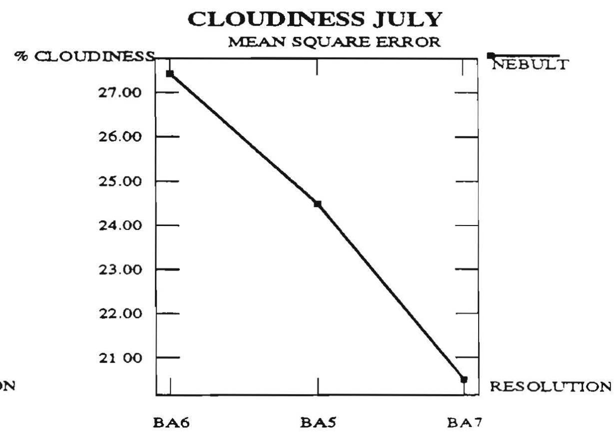

PRECIPITATION JULY
MEAN ERROR
MM/DAY x 10-3
100.00
0.00
-100.00
-200.00
-300.00
-400.00
PLUIEC
PLUIES
PLUIET
PRECIP
RESOLUTION
BA6
BA5
BA7

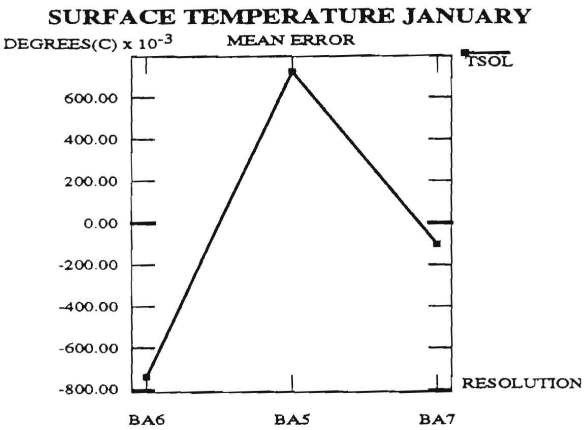

PRECIPITATION JULY
MEAN SQUARE ERROR
MM/DAY
1.00
0.90
0.80
0.70
0.60
0.50
PLUIEC
PLUIES
PLUIET
PRECIP
RESOLUTION
BA6
BA5
BA7

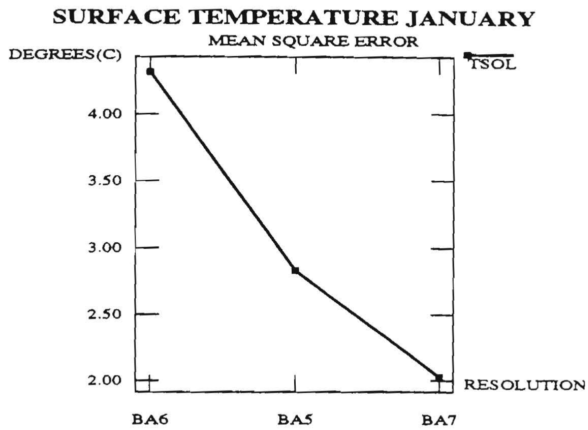

CLOUDINESS JANUARY
MEAN ERROR
%CLOUDINESS
20.00
19.00
18.00
17.00
NEBULT
RESOLUTION
BA6
BA5
BA7

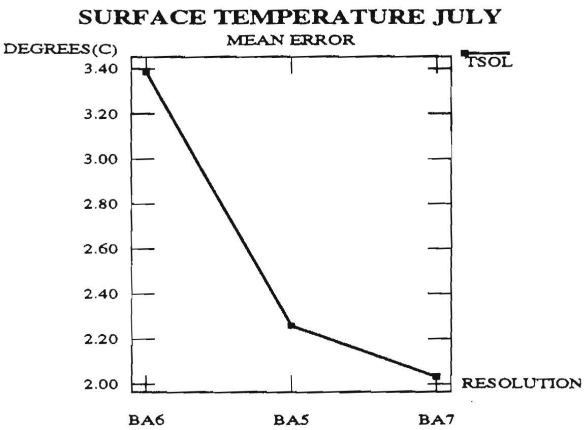

CLOUDINESS JANUARY
MEAN SQUARE ERROR
% CLOUDINESS
25.50
25.00
24.50
24.00
23.50
23.00
22.50
22.00
21.50
NEBULT
RESOLUTION
BA6
BA5
BA7

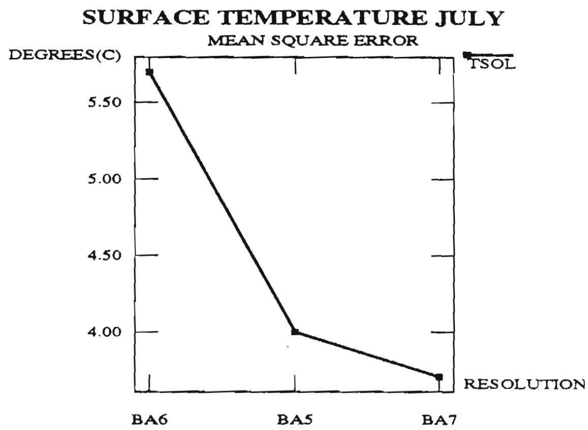

CLOUDINESS JULY
MEAN ERROR
%CLOUDINESS
6.00
5.00
4.00
3.00
2.00
1.00
0.00
NEBULT
RESOLUTION
BA6
BA5
BA7

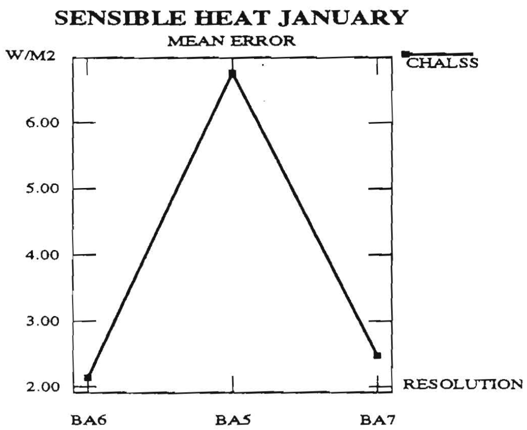

CLOUDINESS JULY
MEAN SQUARE ERROR
% CLOUDINESS
27.00
26.00
25.00
24.00
23.00
22.00
21 00
NEBULT
RESOLUTION
BA6
BA5
BA7

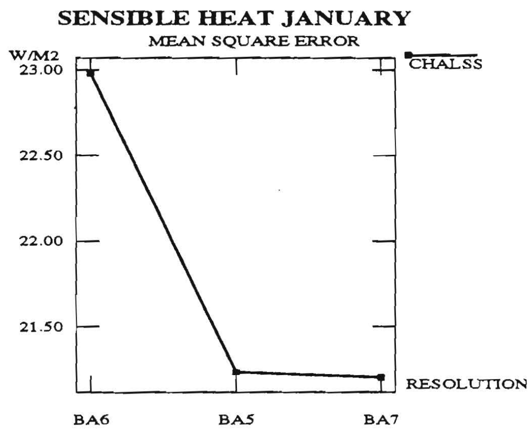

SURFACE TEMPERATURE JANUARY
MEAN ERROR
DEGREES(C) x 10-3
600.00
400.00
200.00
0.00
-200.00
-400.00
-600.00
-800.00
TSOL
RESOLUTION
BA6
BA5
BA7

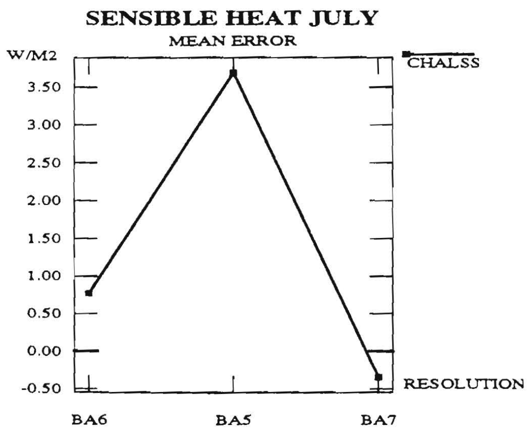

SURFACE TEMPERATURE JANUARY
MEAN SQUARE ERROR
DEGREES(C)
4.00
3.50
3.00
2.50
2.00
TSOL
RESOLUTION
BA6
BA5
BA7

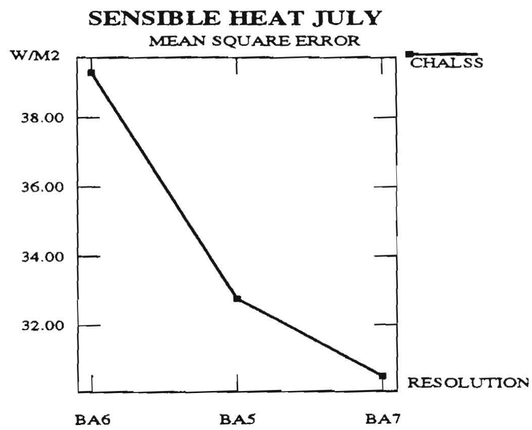

SURFACE TEMPERATURE JULY
MEAN ERROR
DEGREES(C)
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
TSOL
RESOLUTION
BA6
BA5
BA7

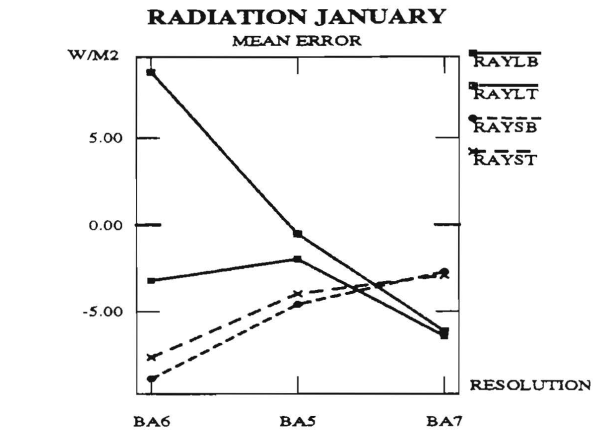

SURFACE TEMPERATURE JULY
MEAN SQUARE ERROR
DEGREES(C)
5.50
5.00
4.50
4.00
TSOL
RESOLUTION
BA6
BA5
BA7

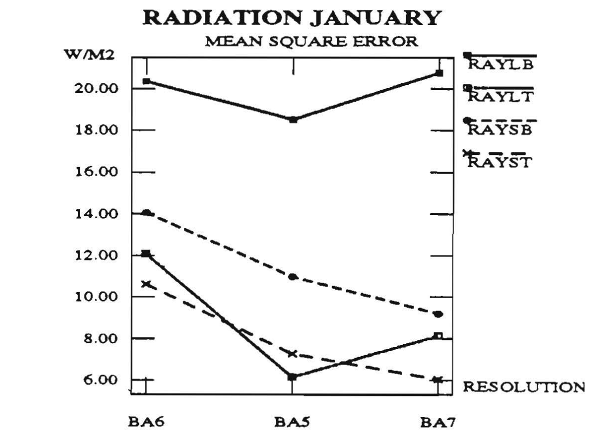

SENSIBLE HEAT JANUARY
MEAN ERROR
W/M2
6.00
5.00
4.00
3.00
2.00
CHALSS
RESOLUTION
BA6
BA5
BA7

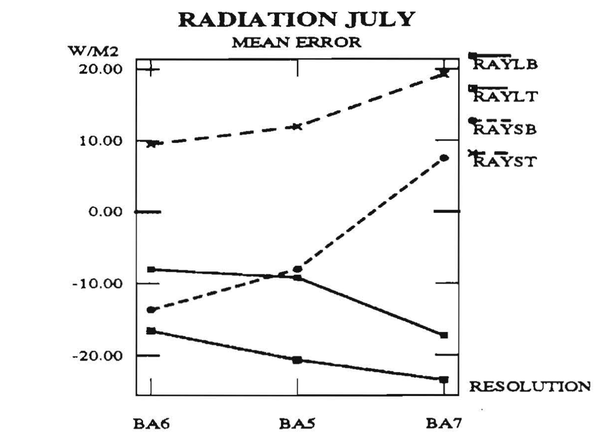

SENSIBLE HEAT JANUARY
MEAN SQUARE ERROR
W/M2
23.00
22.50
22.00
21.50
CHALSS
RESOLUTION
BA6
BA5
BA7

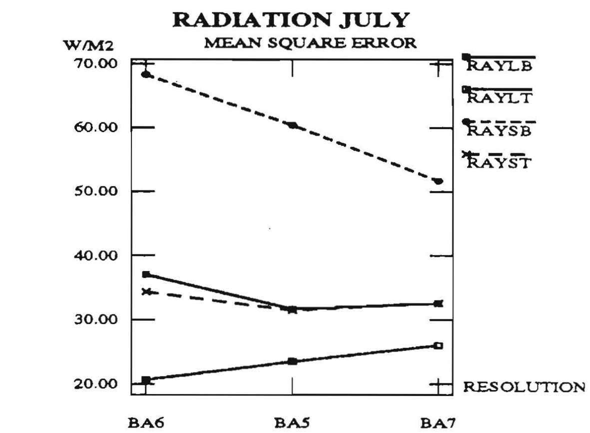

SENSIBLE HEAT JULY
MEAN ERROR
W/M2
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
CHALSS
RESOLUTION
BA6
BA5
BA7

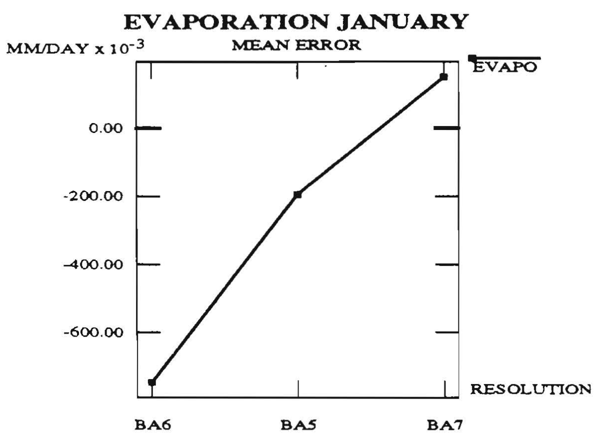

SENSIBLE HEAT JULY
MEAN SQUARE ERROR
W/M2
38.00
36.00
34.00
32.00
CHALSS
RESOLUTION
BA6
BA5
BA7

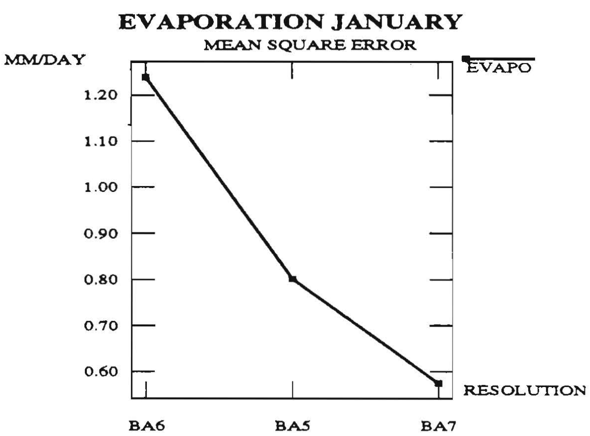

RADIATION JANUARY
MEAN ERROR
W/M2
5.00
0.00
-5.00
RAYLB
RAYLT
RAYSB
RAYST
RESOLUTION
BA6
BA5
BA7

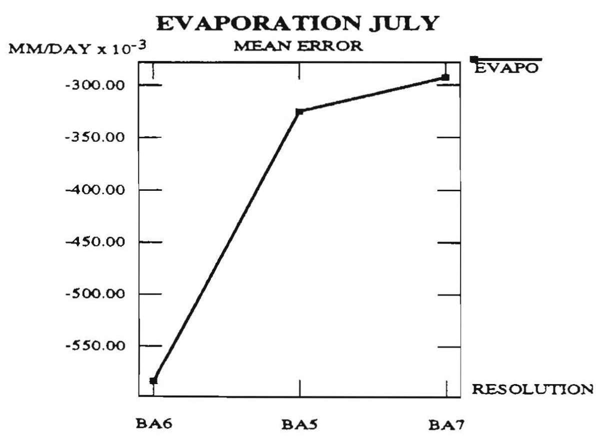

RADIATION JANUARY
MEAN SQUARE ERROR
W/M2
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
RAYLB
RAYLT
RAYSB
RAYST
RESOLUTION
BA6
BA5
BA7

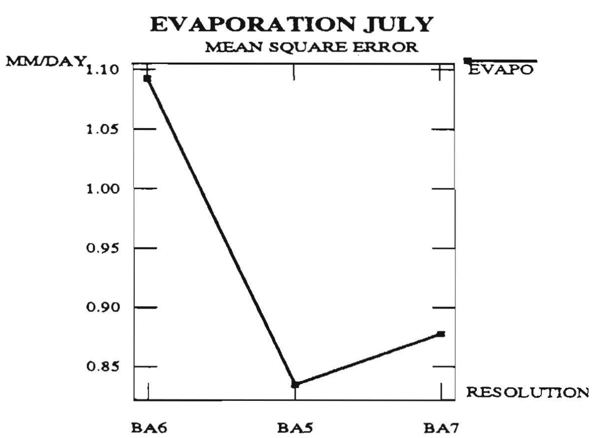

RADIATION JULY
MEAN ERROR
W/M2
20.00
10.00
0.00
-10.00
-20.00
RAYLB
RAYLT
RAYSB
RAYST
RESOLUTION
BA6
BA5
BA7


RADIATION JULY
MEAN SQUARE ERROR
W/M2
70.00
60.00
50.00
40.00
30.00
20.00
RAYLB
RAYLT
RAYSB
RAYST
RESOLUTION
BA6
BA5
BA7


EVAPORATION JANUARY
MEAN ERROR
MM/DAY x 10-3
0.00
-200.00
-400.00
-600.00
EVAPO
RESOLUTION
BA6
BA5
BA7


EVAPORATION JANUARY
MEAN SQUARE ERROR
MM/DAY
1.20
1.10
1.00
0.90
0.80
0.70
0.60
EVAPO
RESOLUTION
BA6
BA5
BA7


EVAPORATION JULY
MEAN ERROR
MM/DAY x 10-3
-300.00
-350.00
-400.00
-450.00
-500.00
-550.00
EVAPO
RESOLUTION
BA6
BA5
BA7


EVAPORATION JULY
MEAN SQUARE ERROR
MM/DAY
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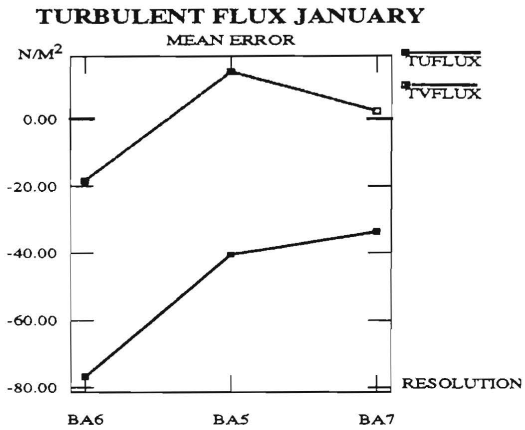
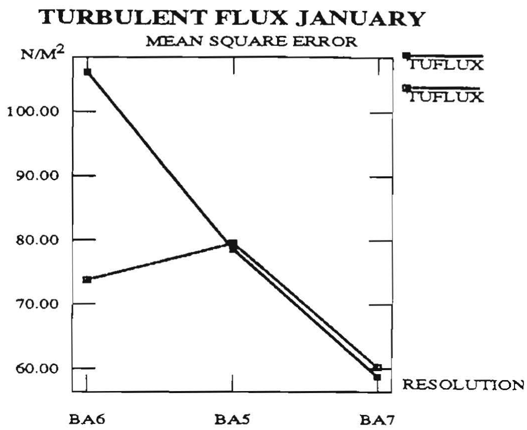
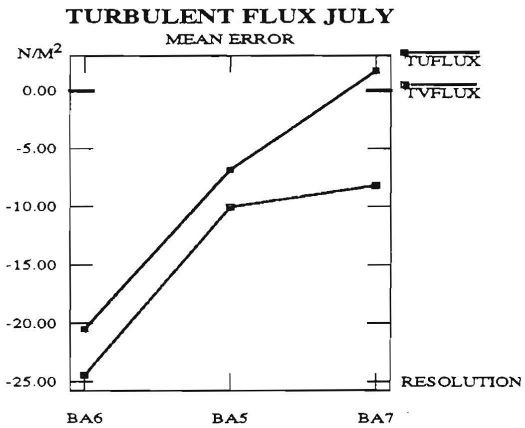
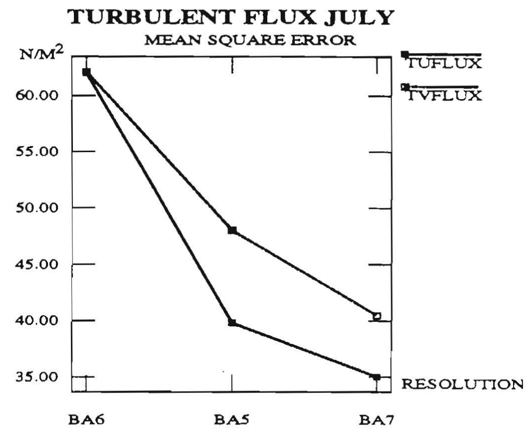
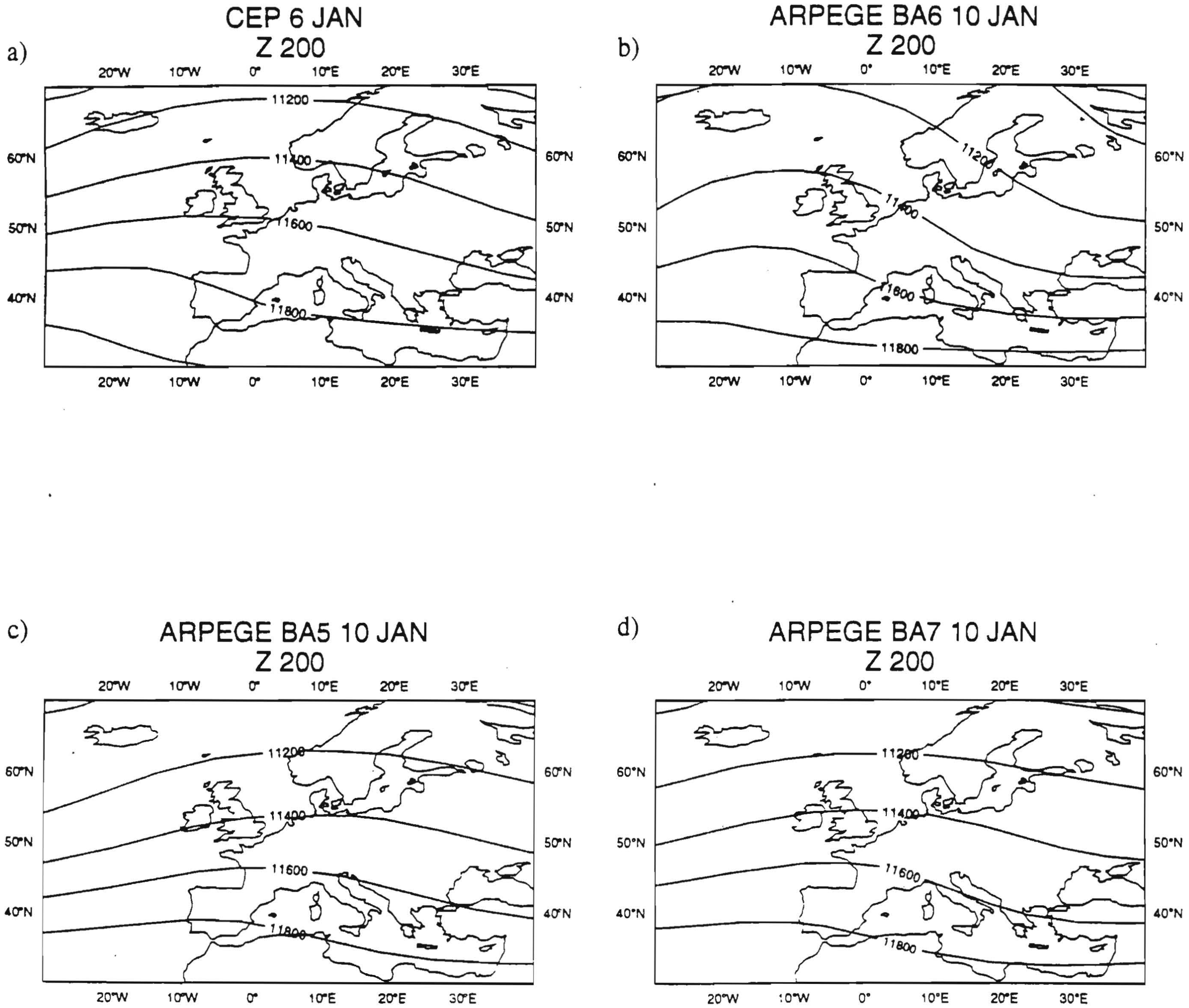
1.05
1.00
0.95
0.90
0.85
EVAPO
RESOLUTION
BA6
BA5
BA7


TURBULENT FLUX JANUARY
MEAN ERROR
N/M2
0.00
-20.00
-40.00
-60.00
-80.00
TUFLUX
TVFLUX
RESOLUTION
BA6
BA5
BA7

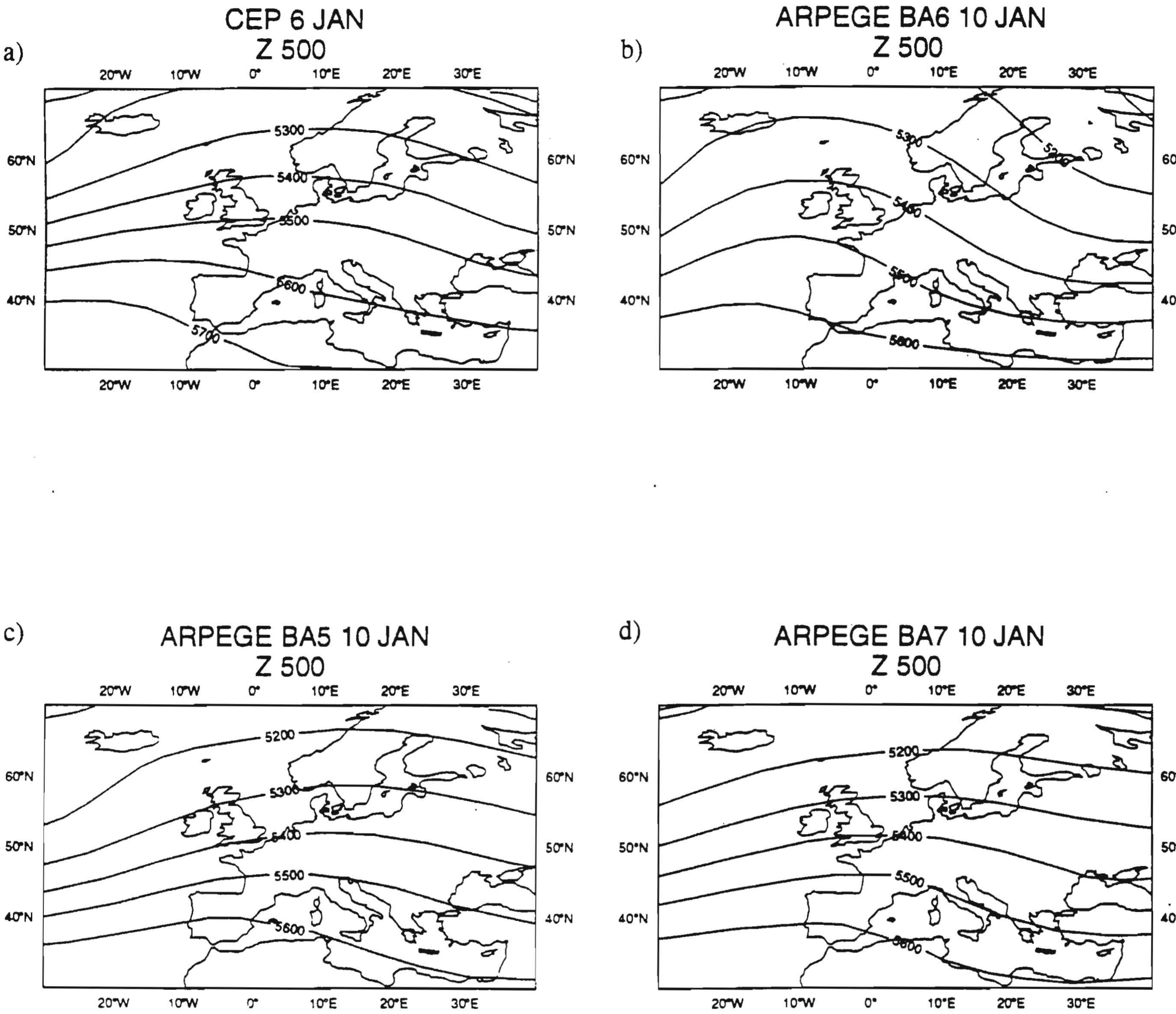

TURBULENT FLUX JANUARY
MEAN SQUARE ERROR
N/M2
100.00
90.00
80.00
70.00
60.00
TUFLUX
TUFLUX
RESOLUTION
BA6
BA5
BA7


TURBULENT FLUX JULY
MEAN ERROR
N/M2
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
TUFLUX
TVFLUX
RESOLUTION
BA6
BA5
BA7

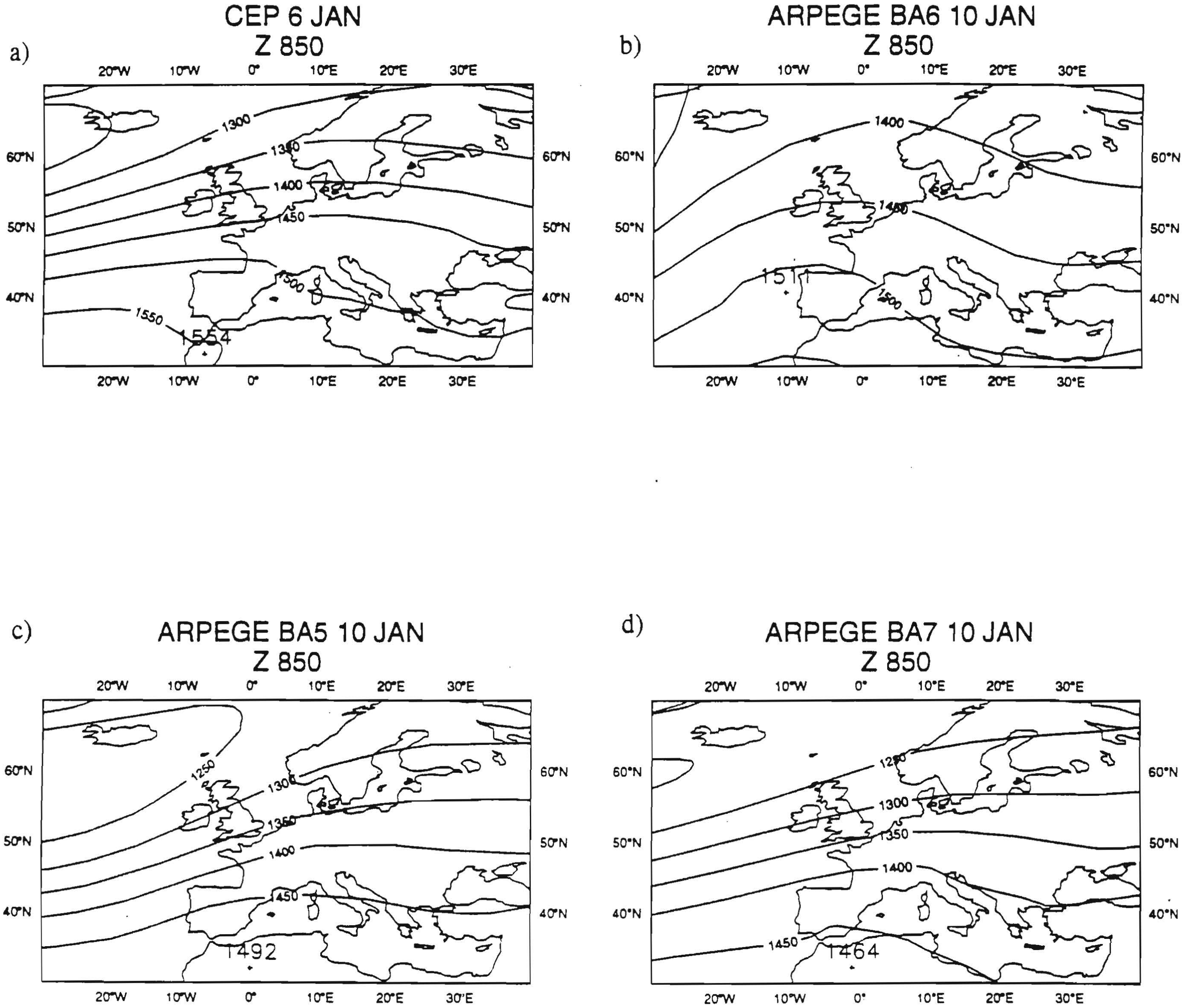

TURBULENT FLUX JULY
MEAN SQUARE ERROR
N/M2
60.00
55.00
50.00
45.00
40.00
35.00
TUFLUX
TVFLUX
RESOLUTION
BA6
BA5
BA7



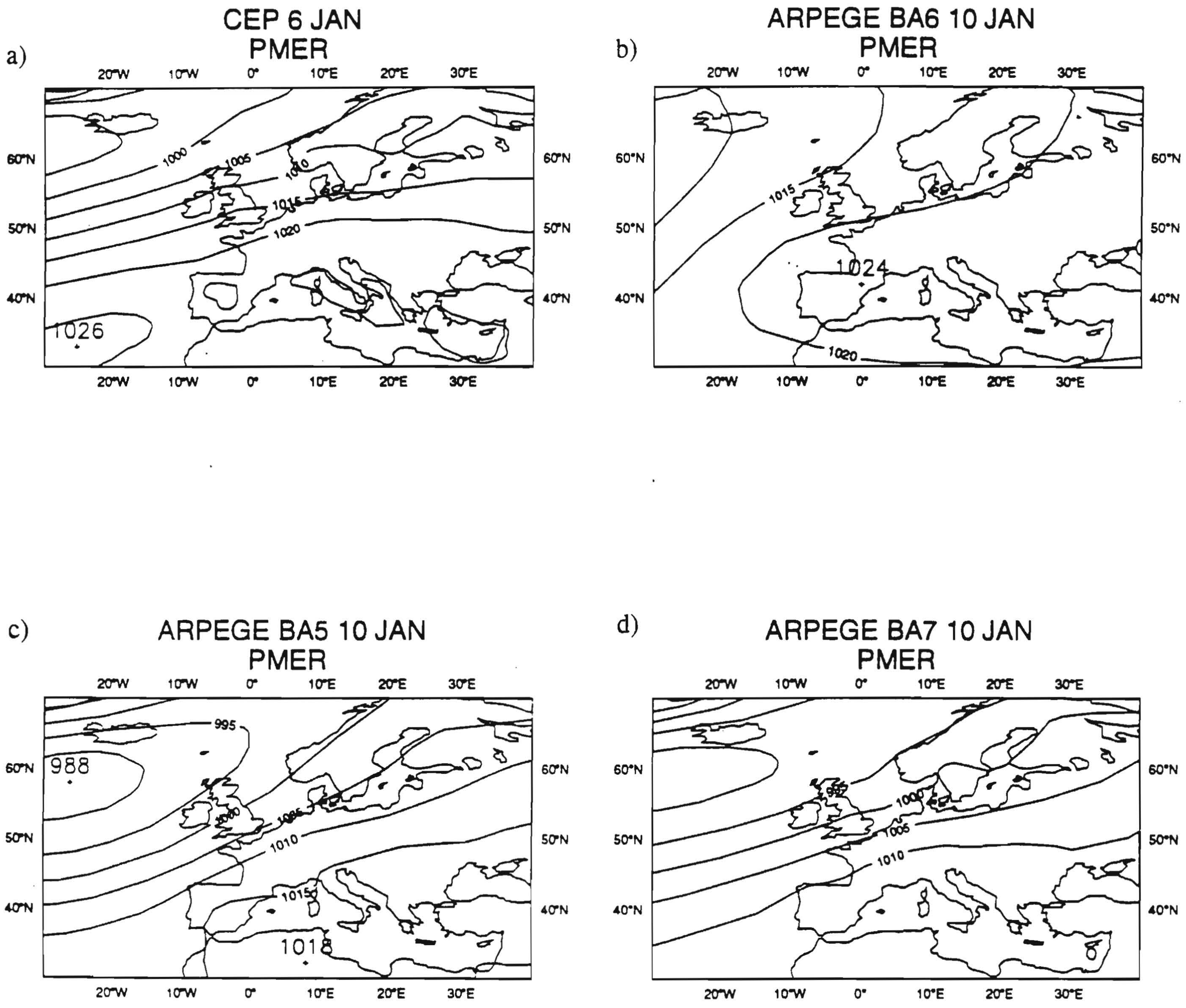
a) Climatological distribution of 200 hPa geopotential (m) for January based on ECMWF analyses. b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 200m.



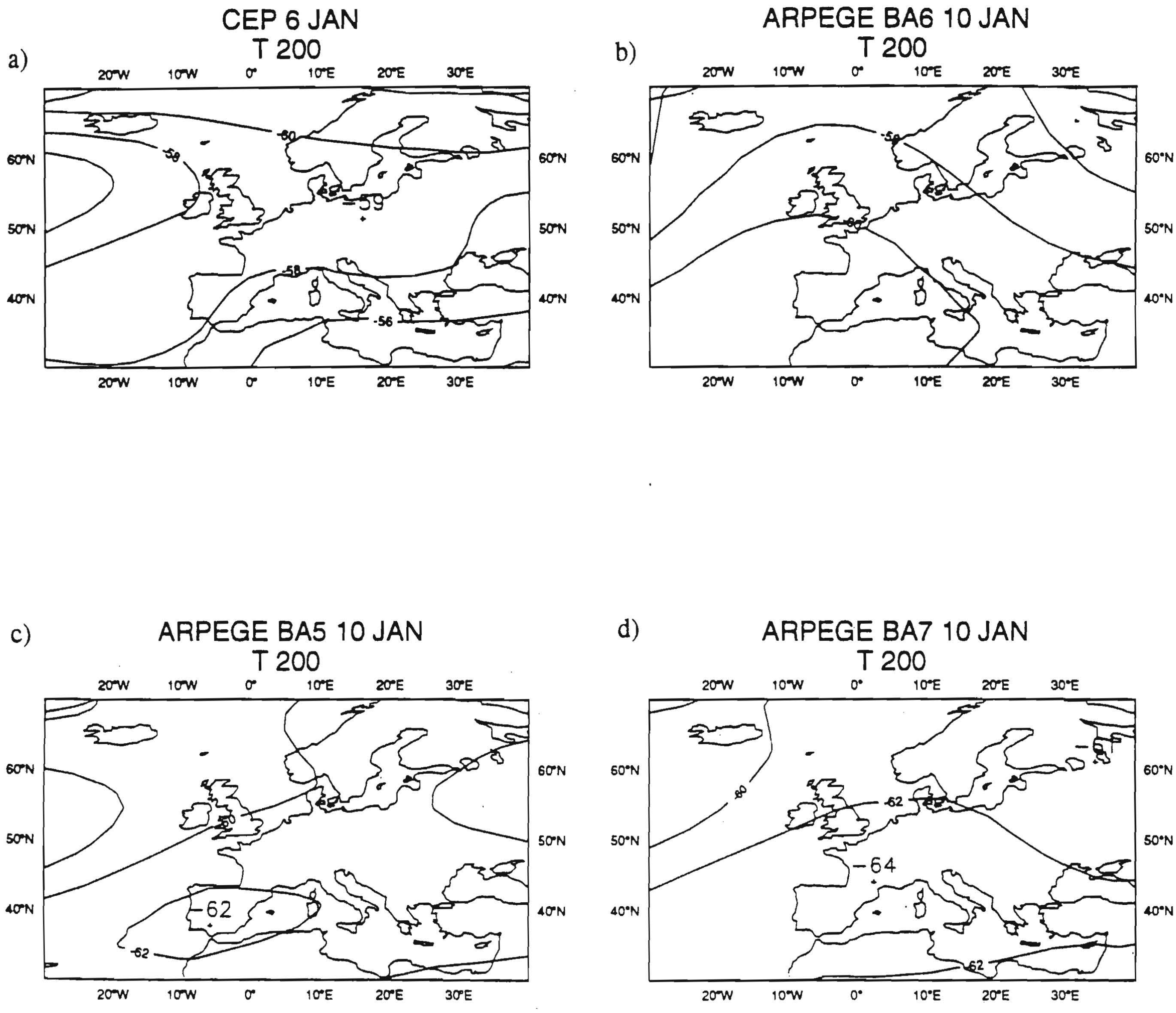
a) Climatological distribution of 500 hPa geopotential (m) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 100m.



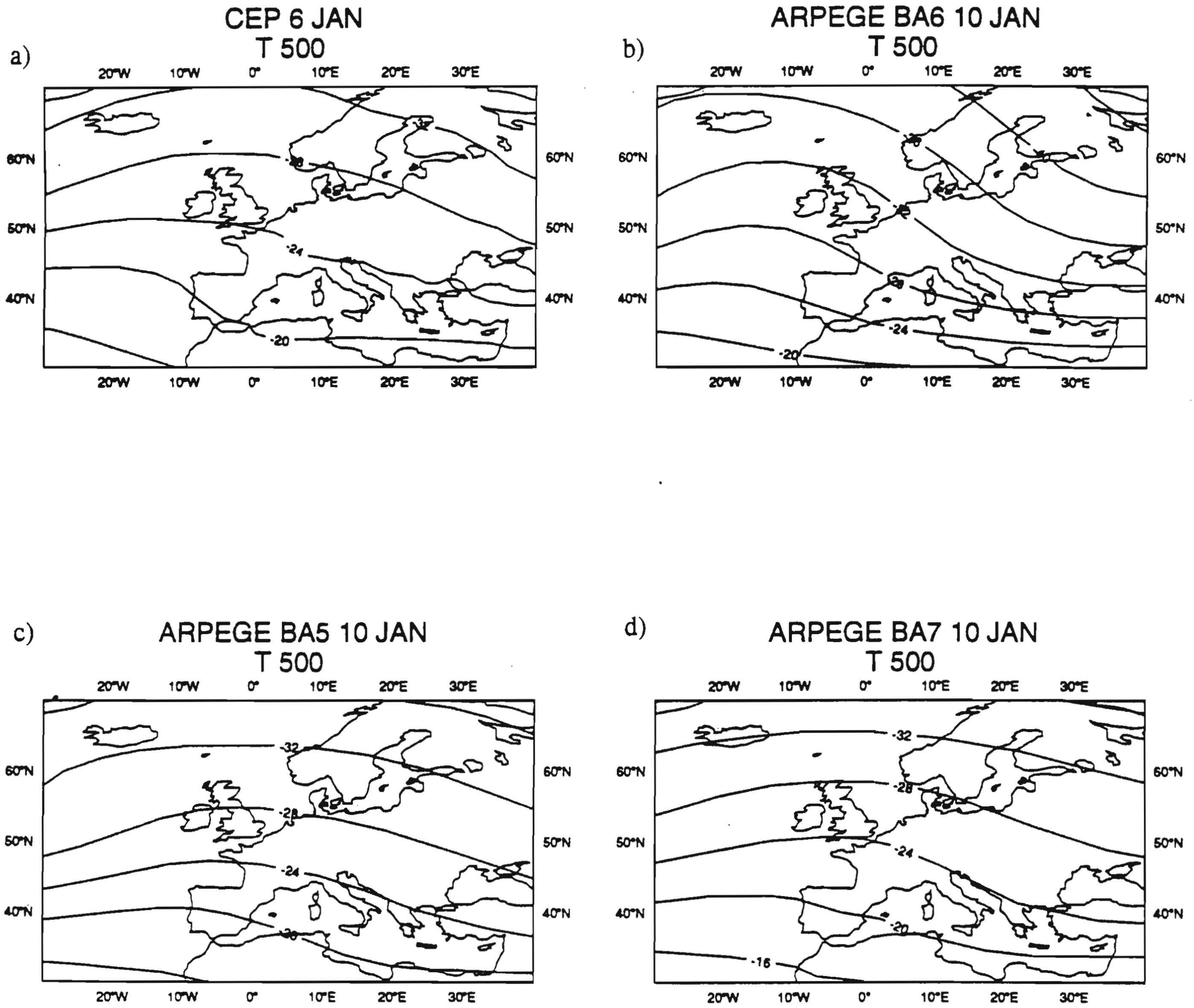
a) Climatological distribution of 850 hPa geopotential (m) for January based on ECMWF analyses. b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 50m.



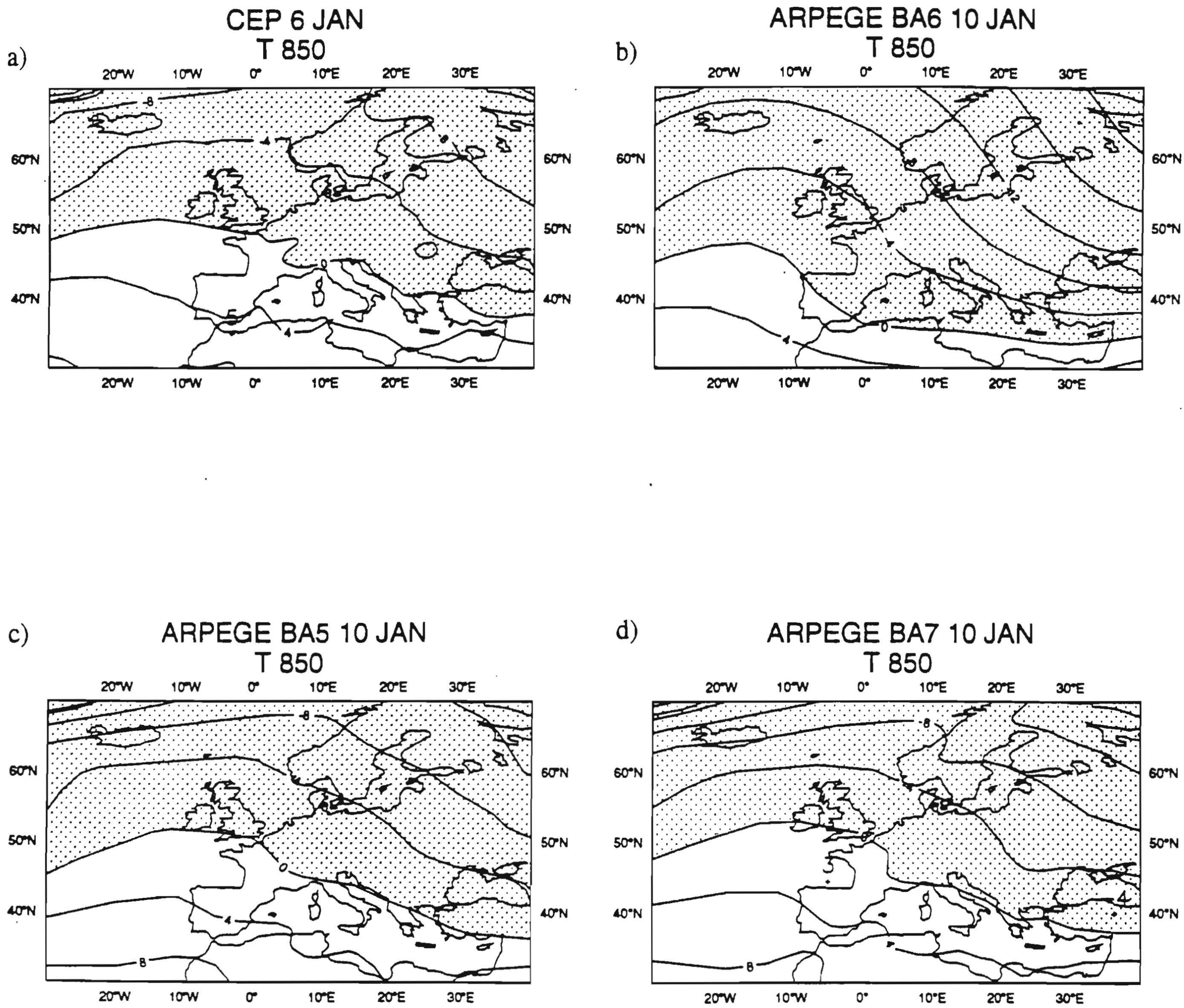
a) Climatological distribution of mean sea level pressure (hPa) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 5hPa.



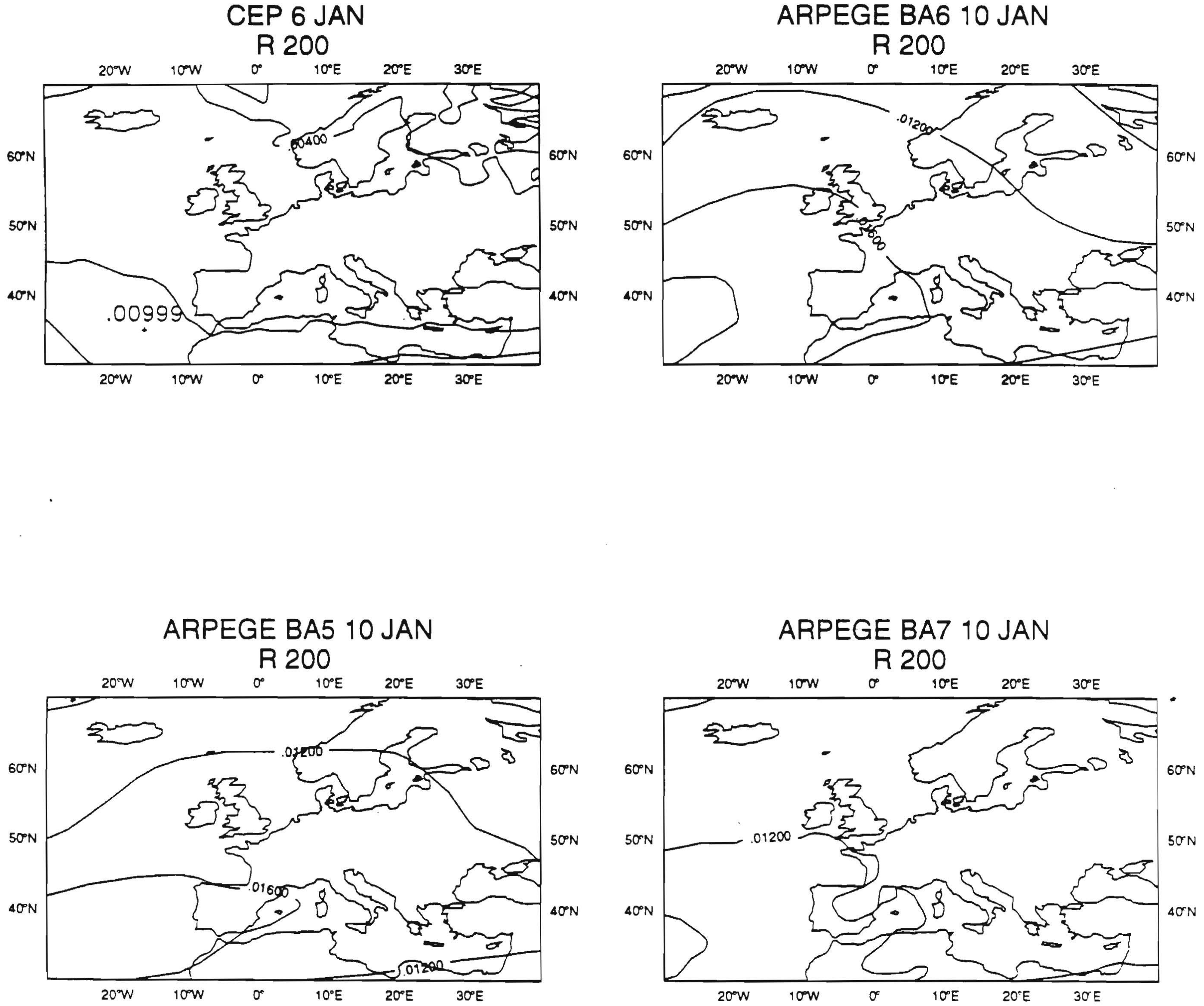
a) Climatological distribution of temperature at 200 hPa (^{0}C) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 2^{0}C.



a) Climatological distribution of temperature at 500 hPa (^{0}C) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 4^{0}C.



a) Climatological distribution of temperature at 850 hPa (^{0}C) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 4^{0}C.



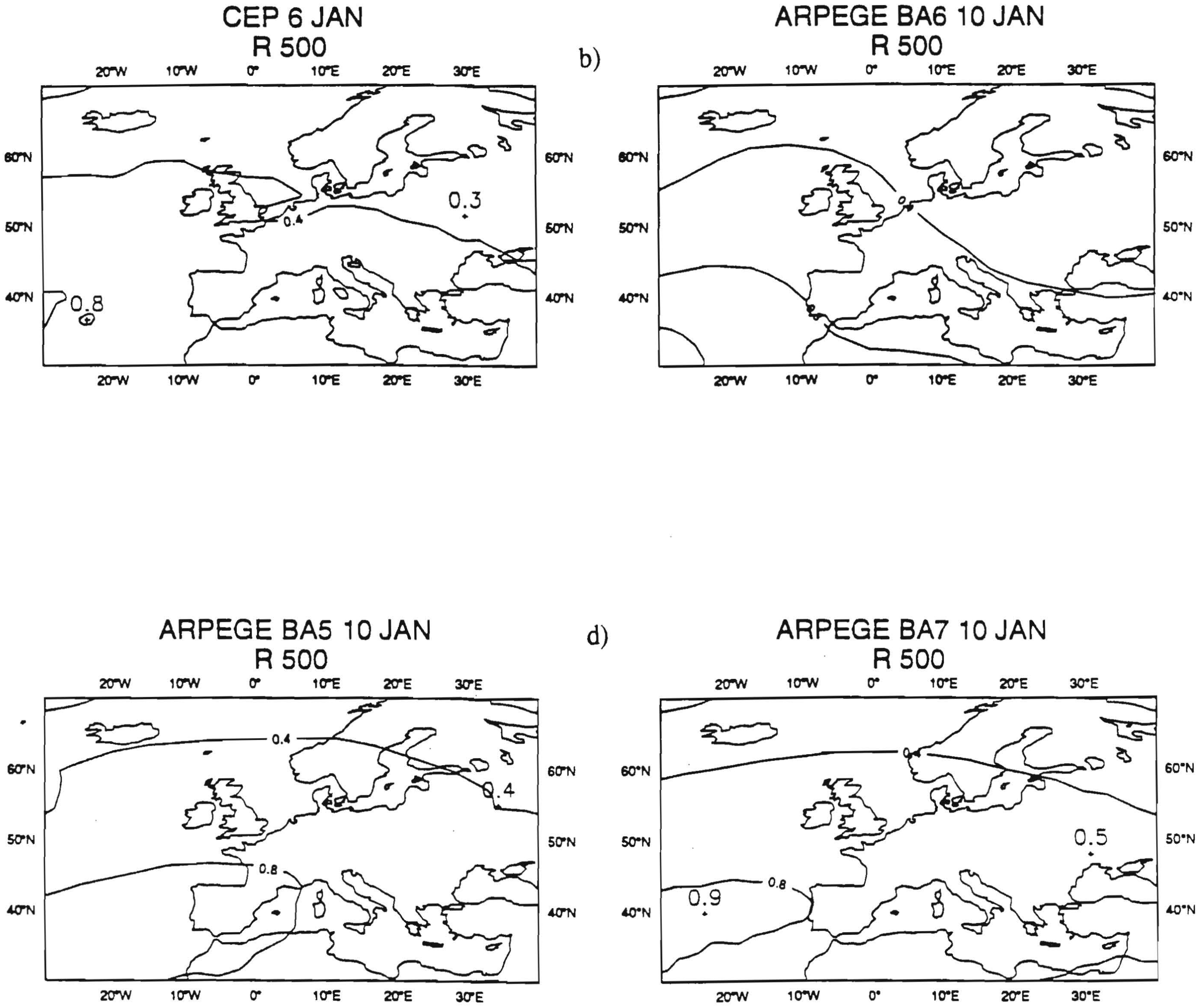
a) Climatological distribution of humidity at 200 hPa (g/kg) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing .004g/kg.

a)

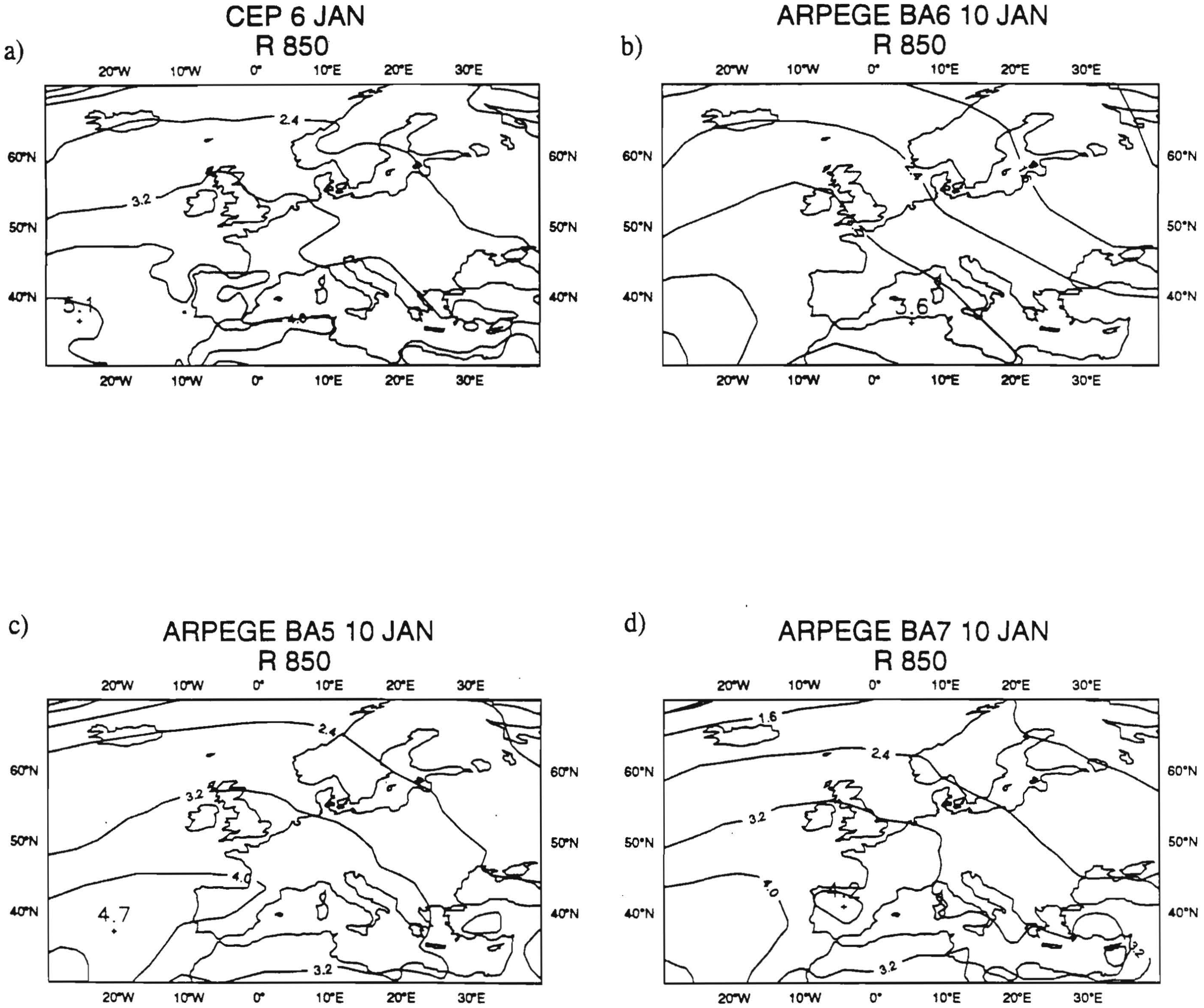
b)

c)

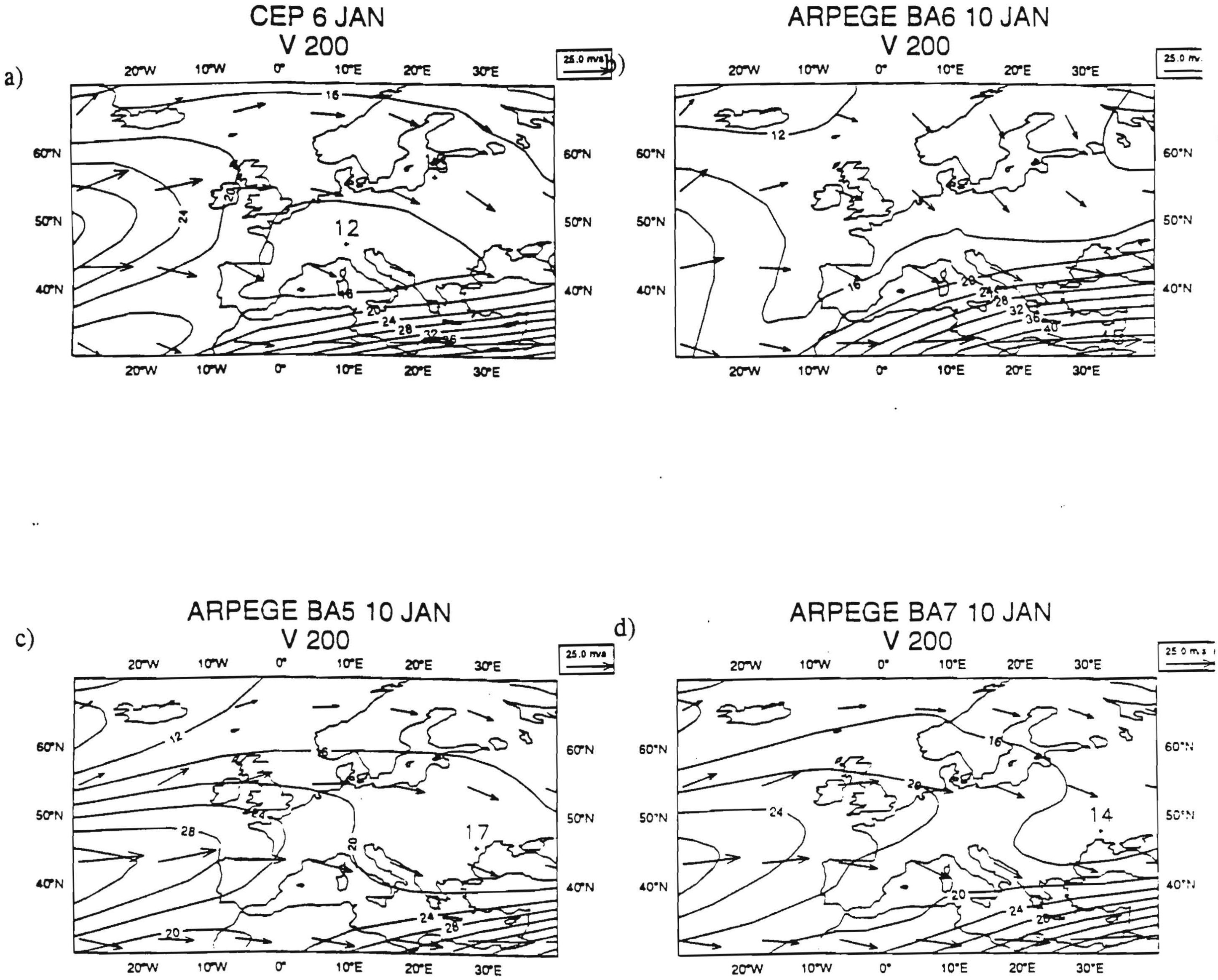
d)



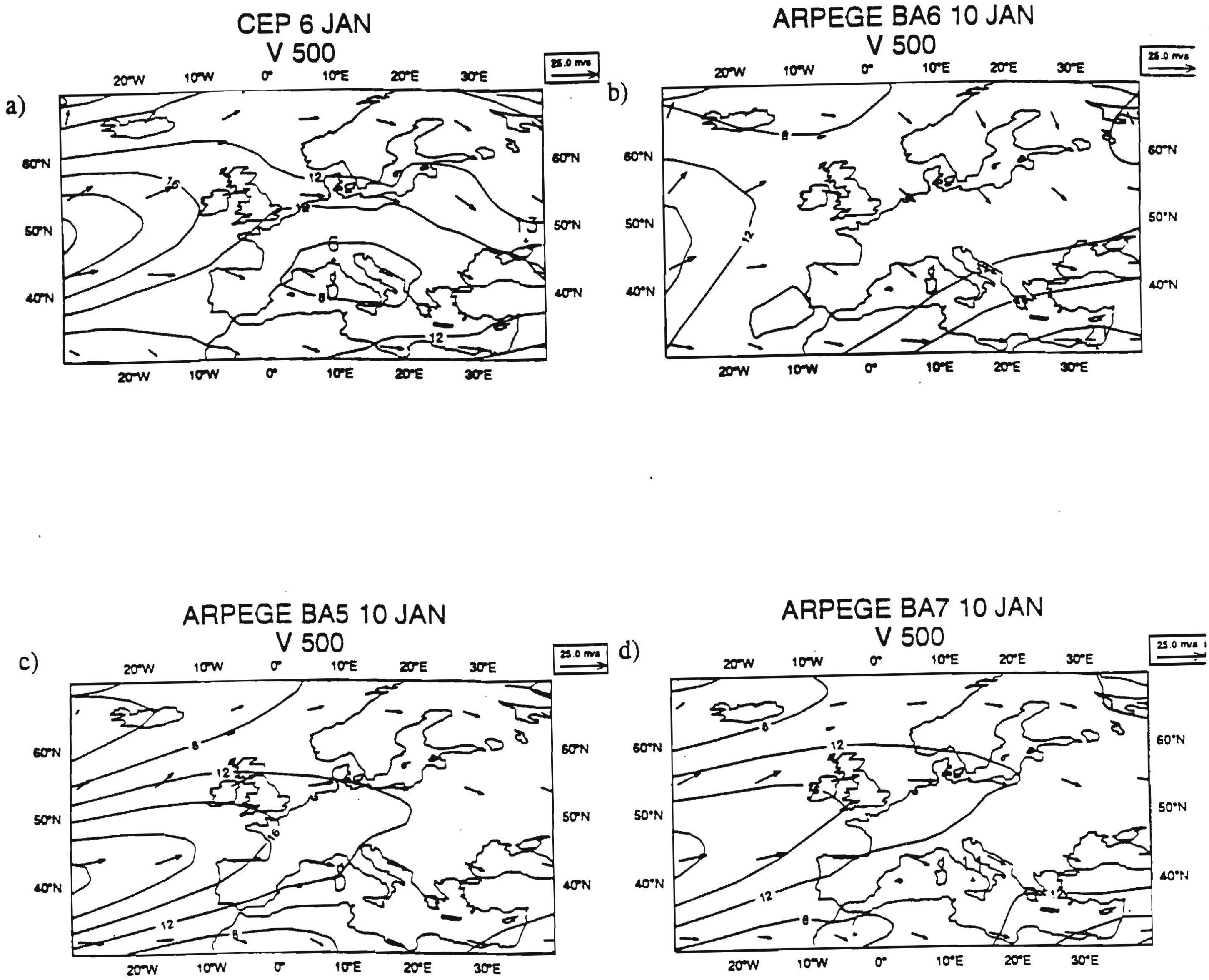
a) Climatological distribution of humidity at 500 hPa (g/kg) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing .4g/kg.



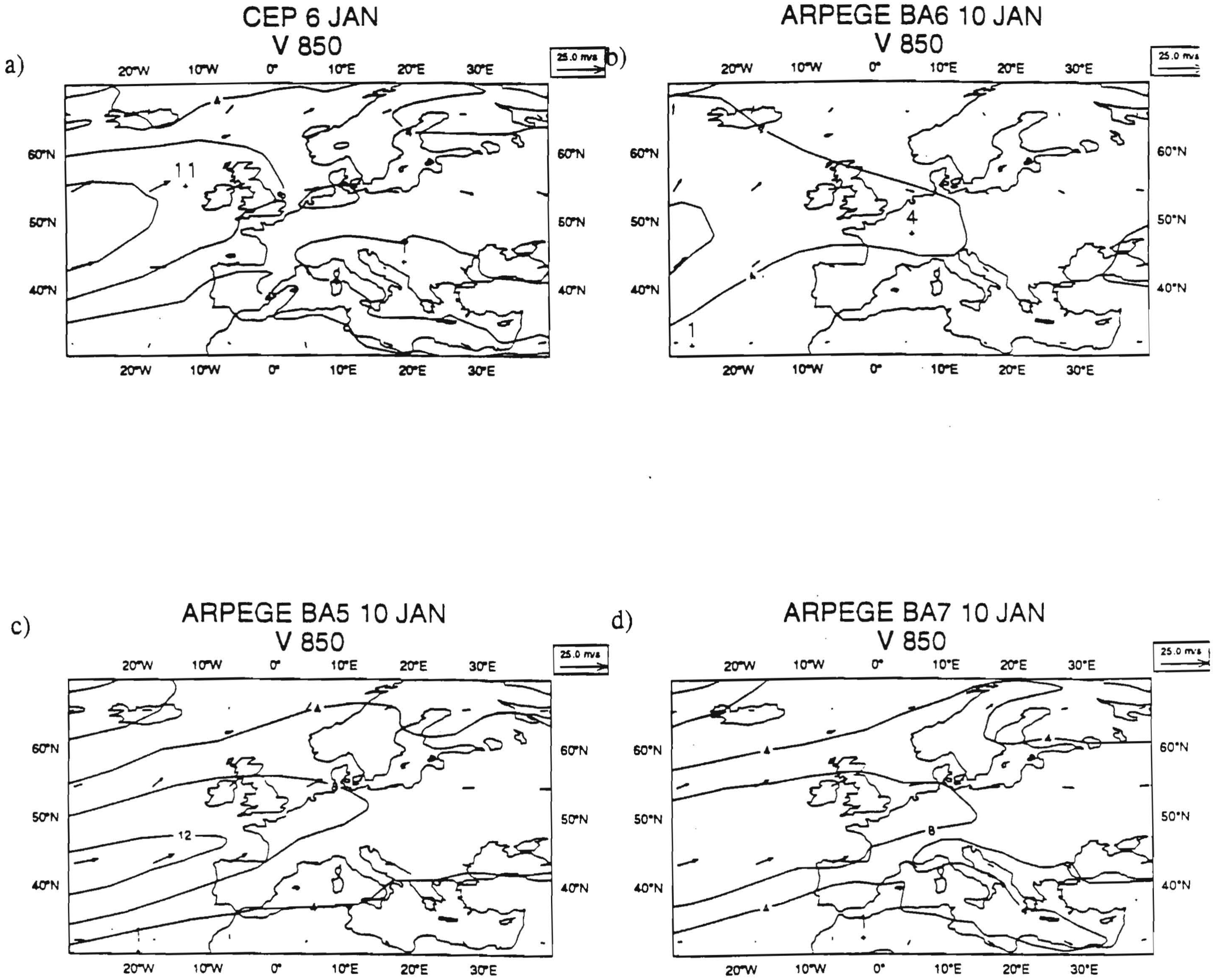
a) Climatological distribution of humidity at 850 hPa (g/kg) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing .8g/kg.



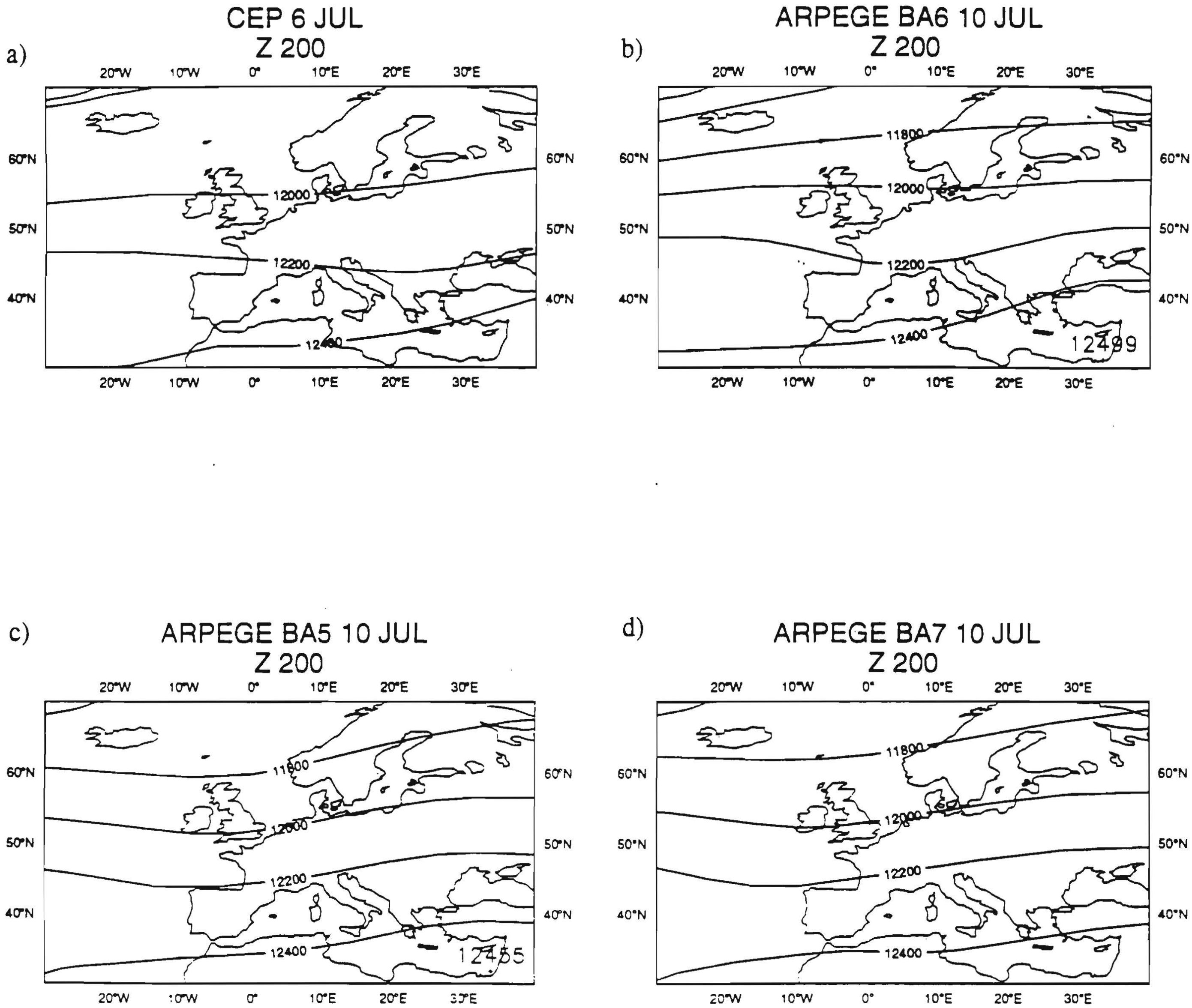
a) Climatological distribution of wind at 200 hPa (m/s) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 4m/s.



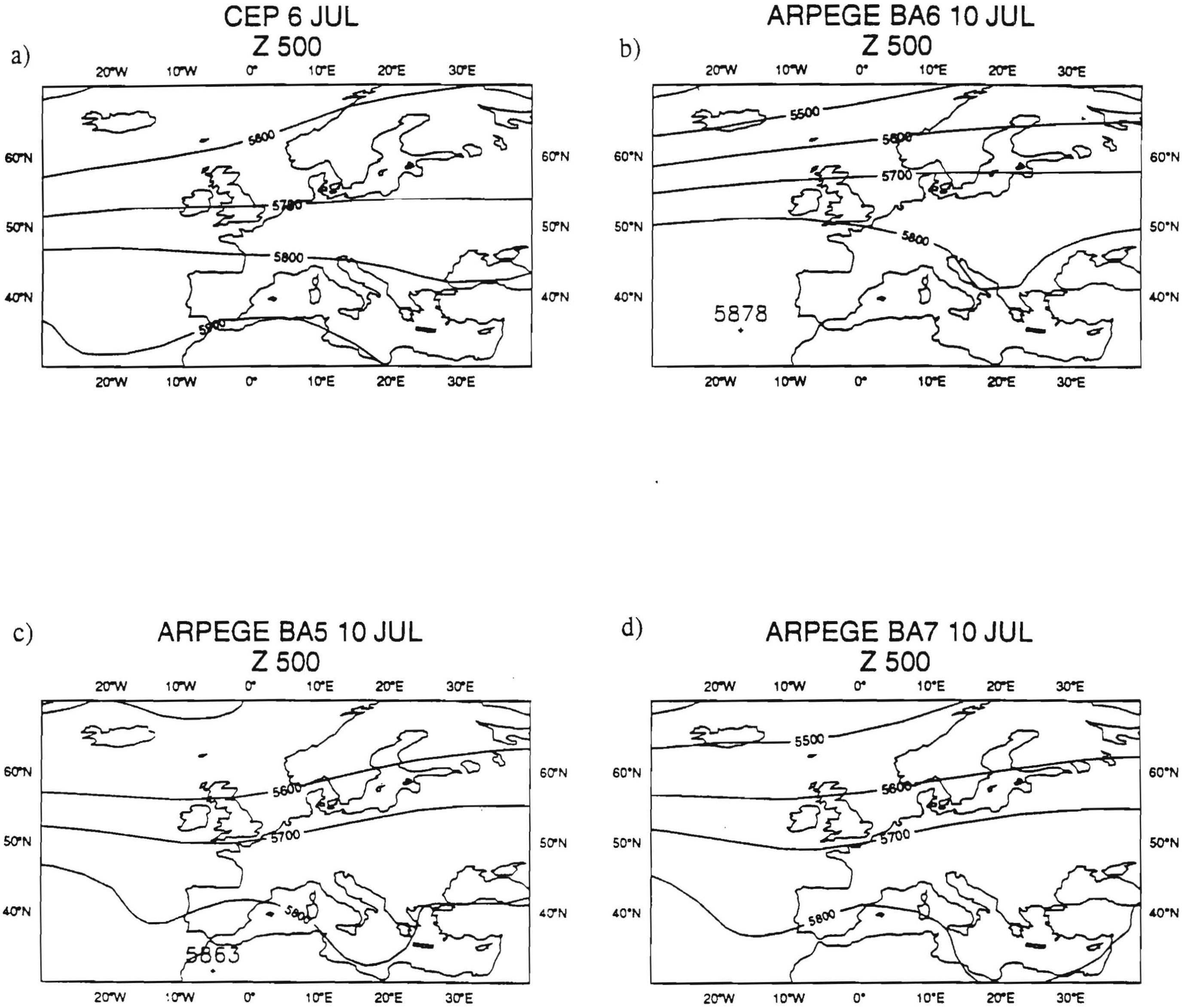
a) Climatological distribution of wind at 500 hPa (m/s) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 4m/s.



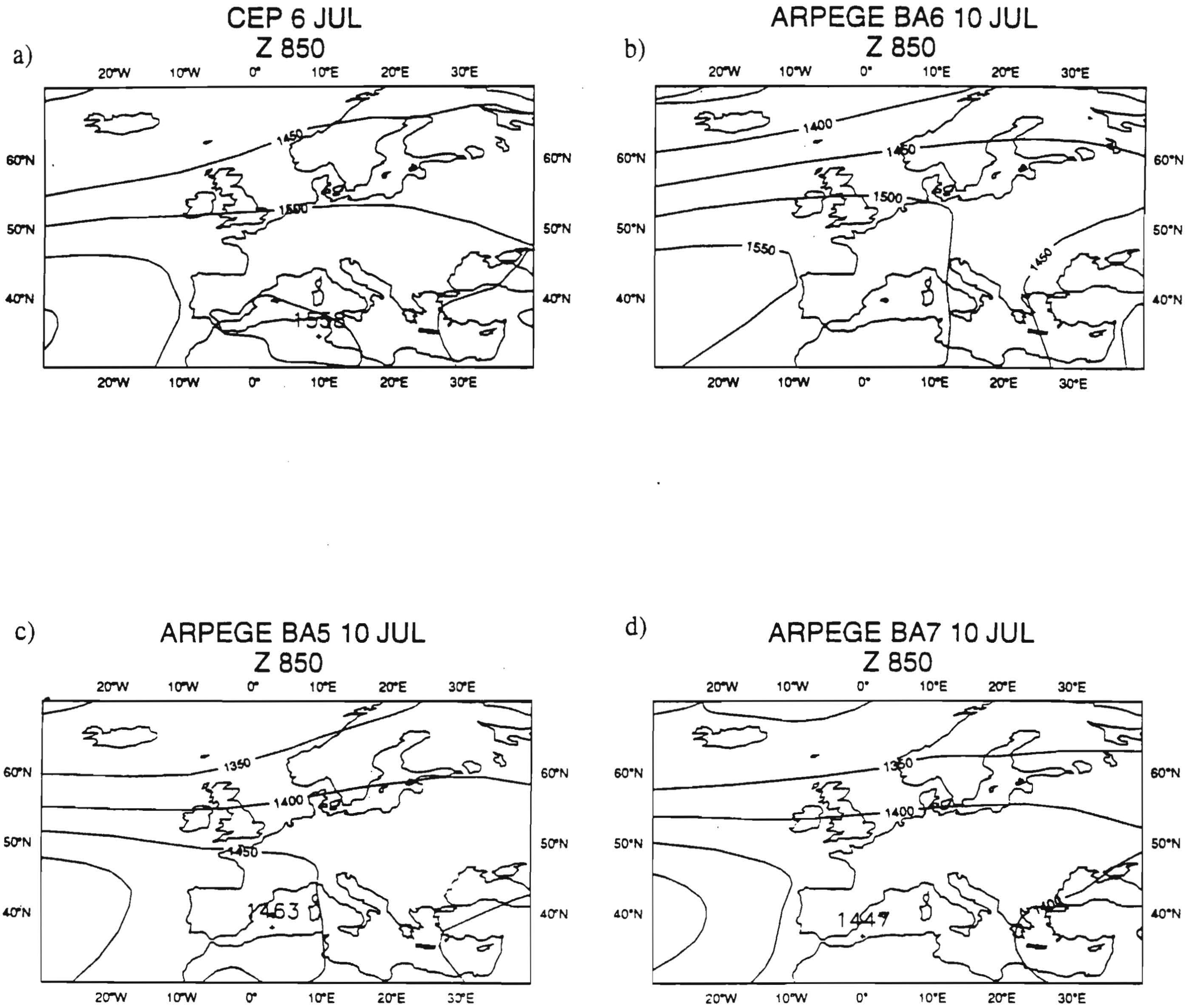
a) Climatological distribution of wind at 850 hPa (m/s) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 4m/s.



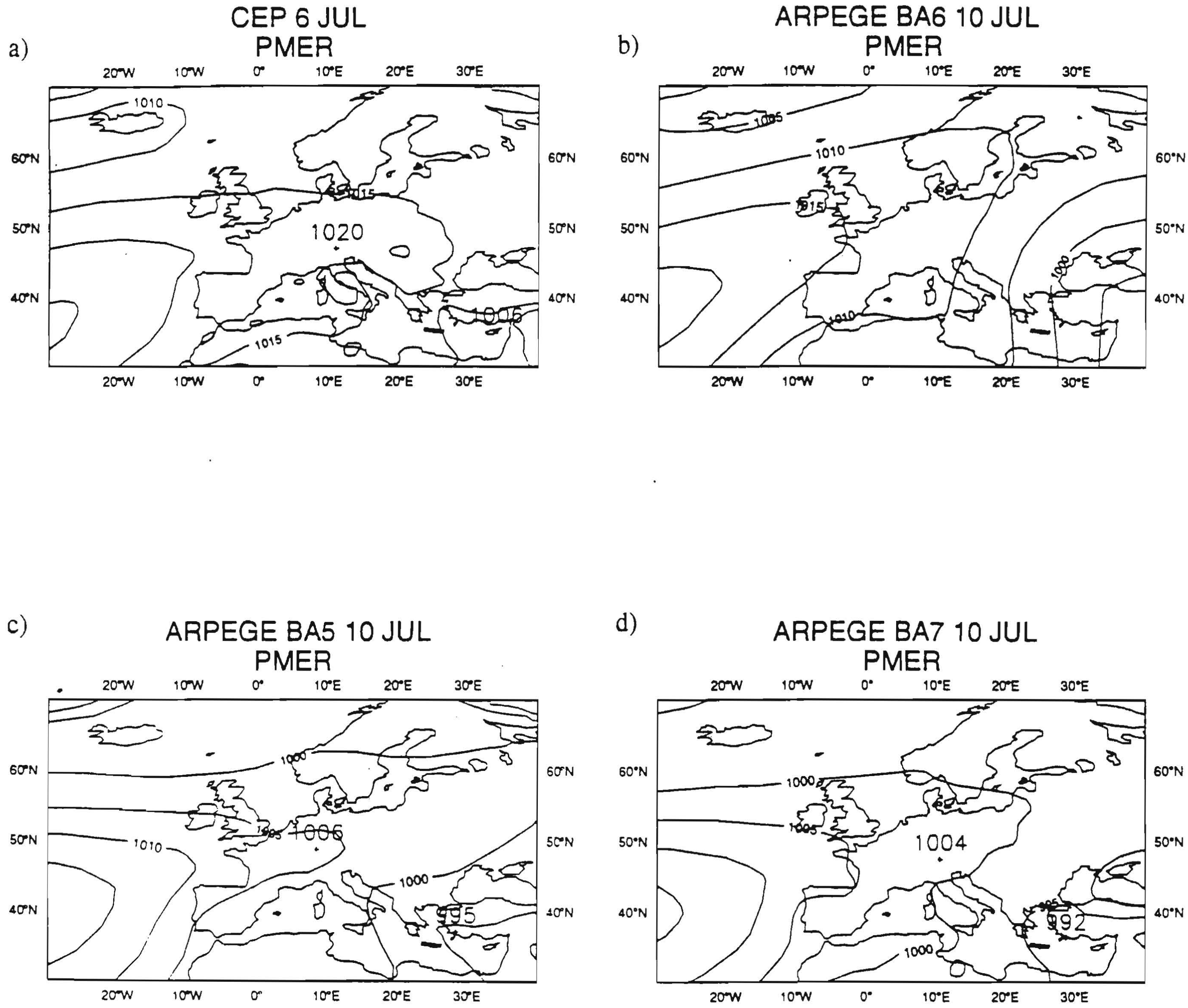
a) Climatological distribution of 200 hPa geopotential (m) for July based on ECMWF analyses. b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 200m.



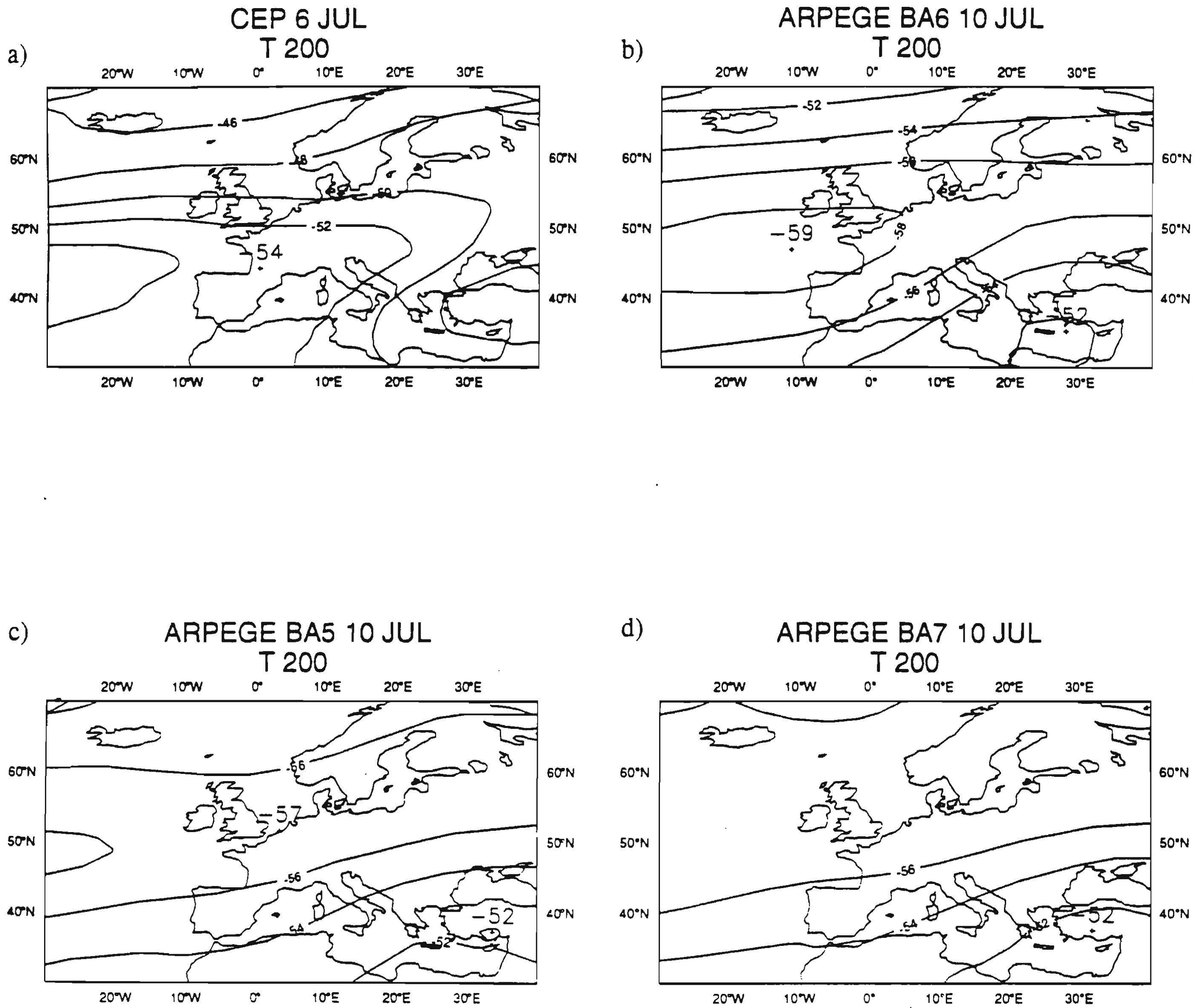
a) Climatological distribution of 500 hPa geopotential (m) for July based on ECMWF analyses. b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 100m.



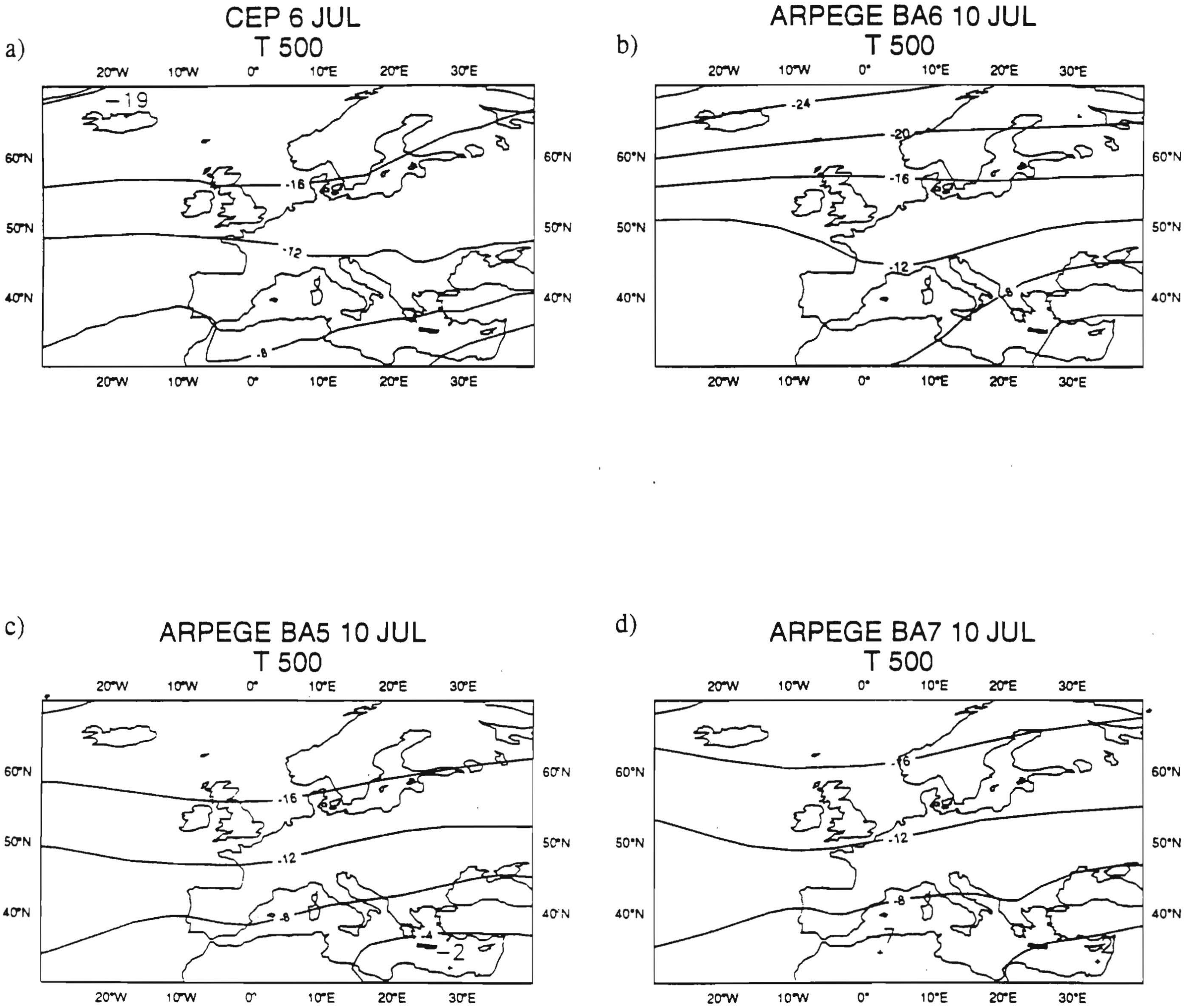
a) Climatological distribution of 850 hPa geopotential (m) for July based on ECMWF analyses. b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 50m.



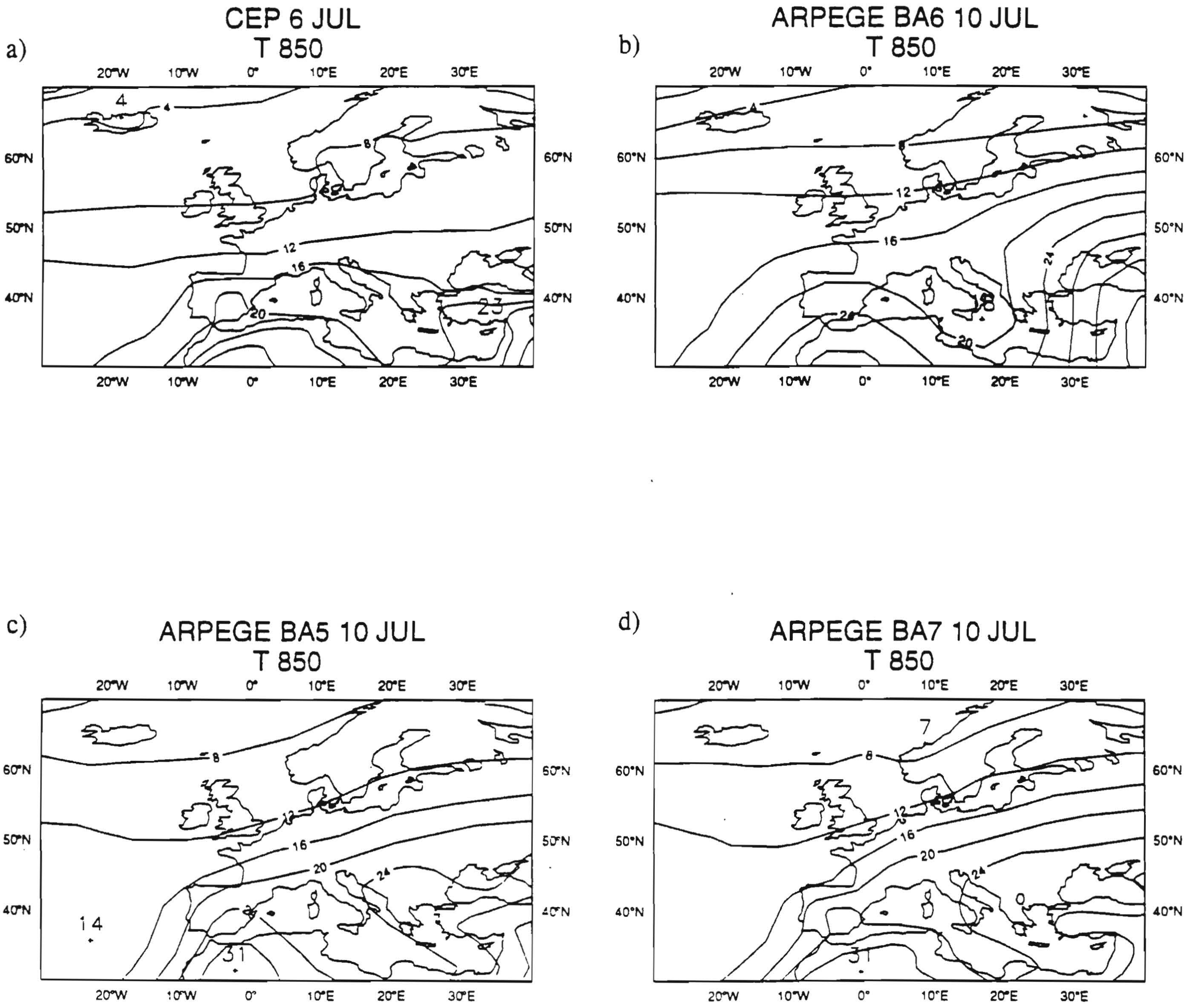
a) Climatological distribution of mean sea level pressure (hPa) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 5hPa.



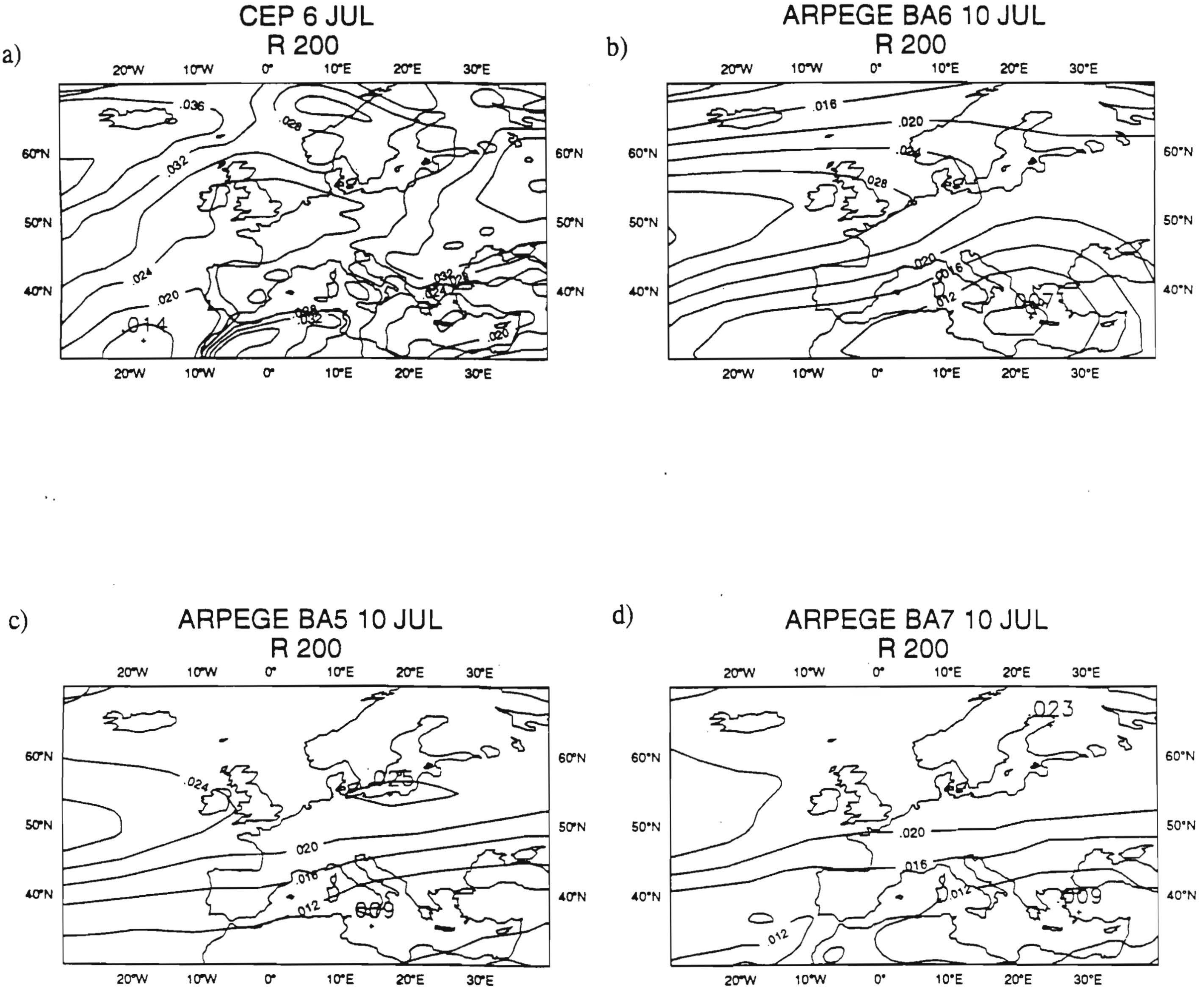
a) Climatological distribution of temperature at 200 hPa (^{0}C) for July based on ECMWF analyses. b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 2^{0}C.



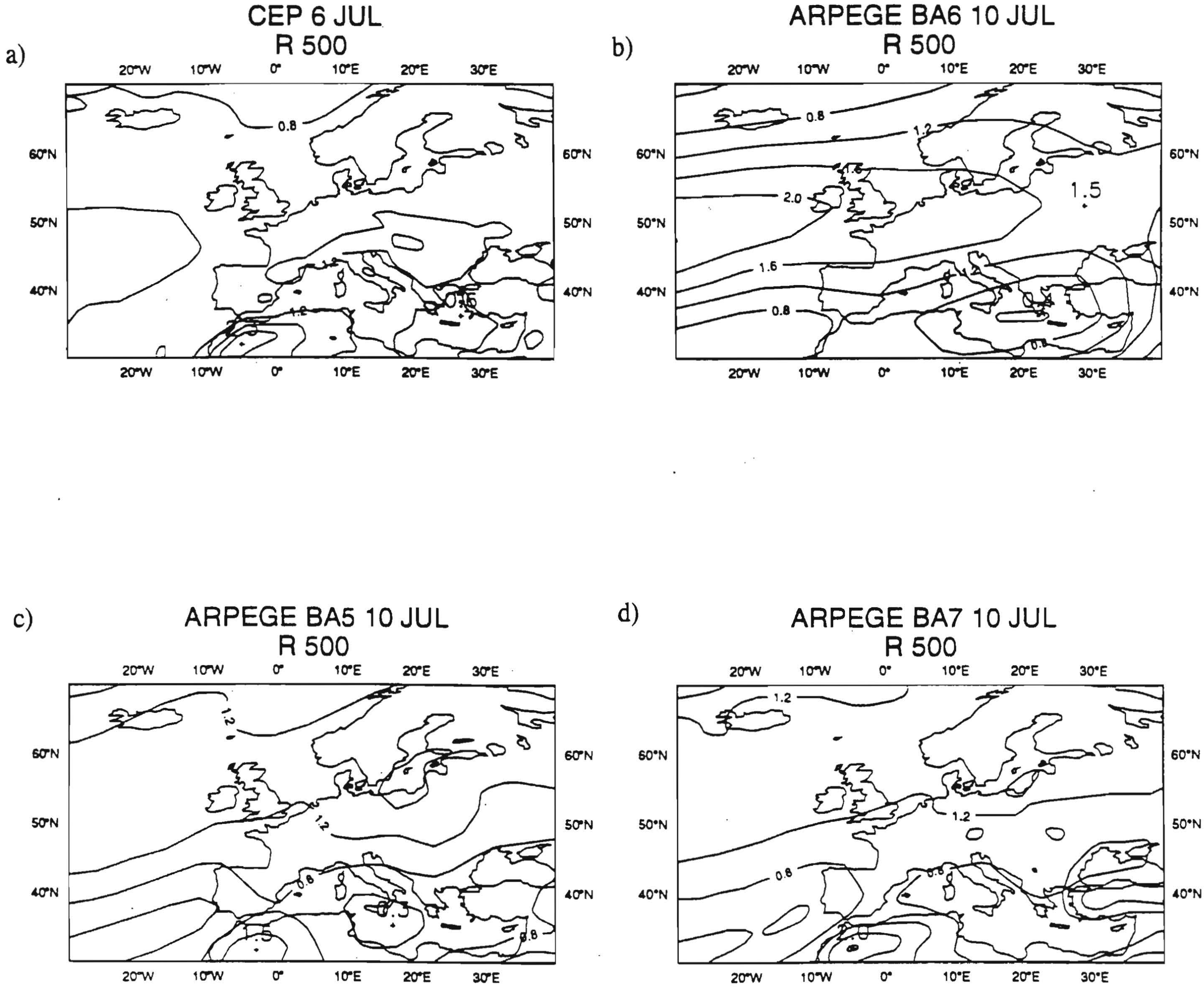
a) Climatological distribution of temperature at 500 hPa (^{0}C) for July based on ECMWF analyses. b-d) based on ARPEGE model at different resolutions T21(BA6). T42(BA5) and T79(BA7). Contour spacing 4^{0}C.



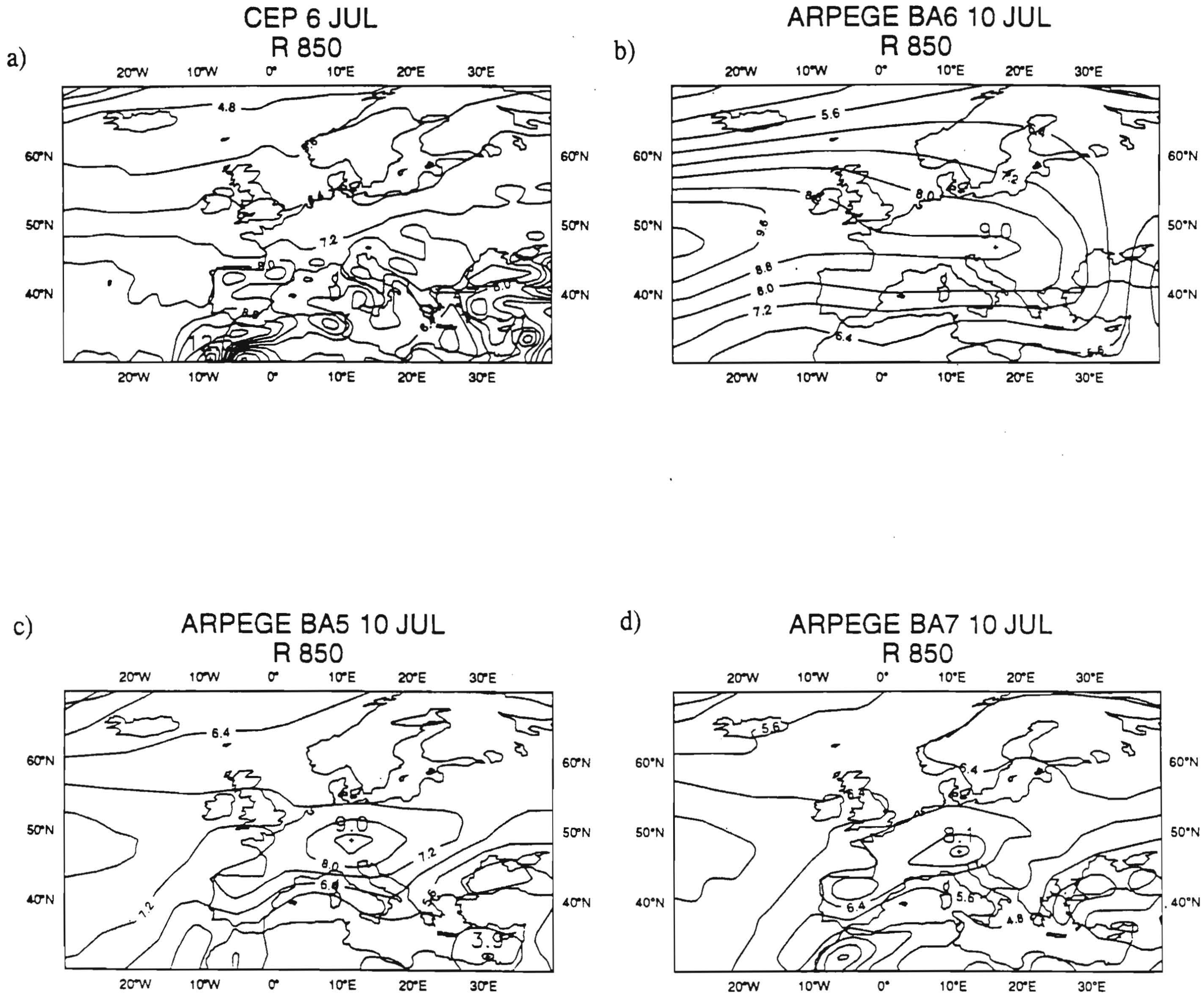
a) Climatological distribution of temperature at 850 hPa (°C) for July based on ECMWF analyses. b-d) based on ARPEGE model at different resolutions T21(BA6). T42(BA5) and T79(BA7). Contour spacing 4°C.



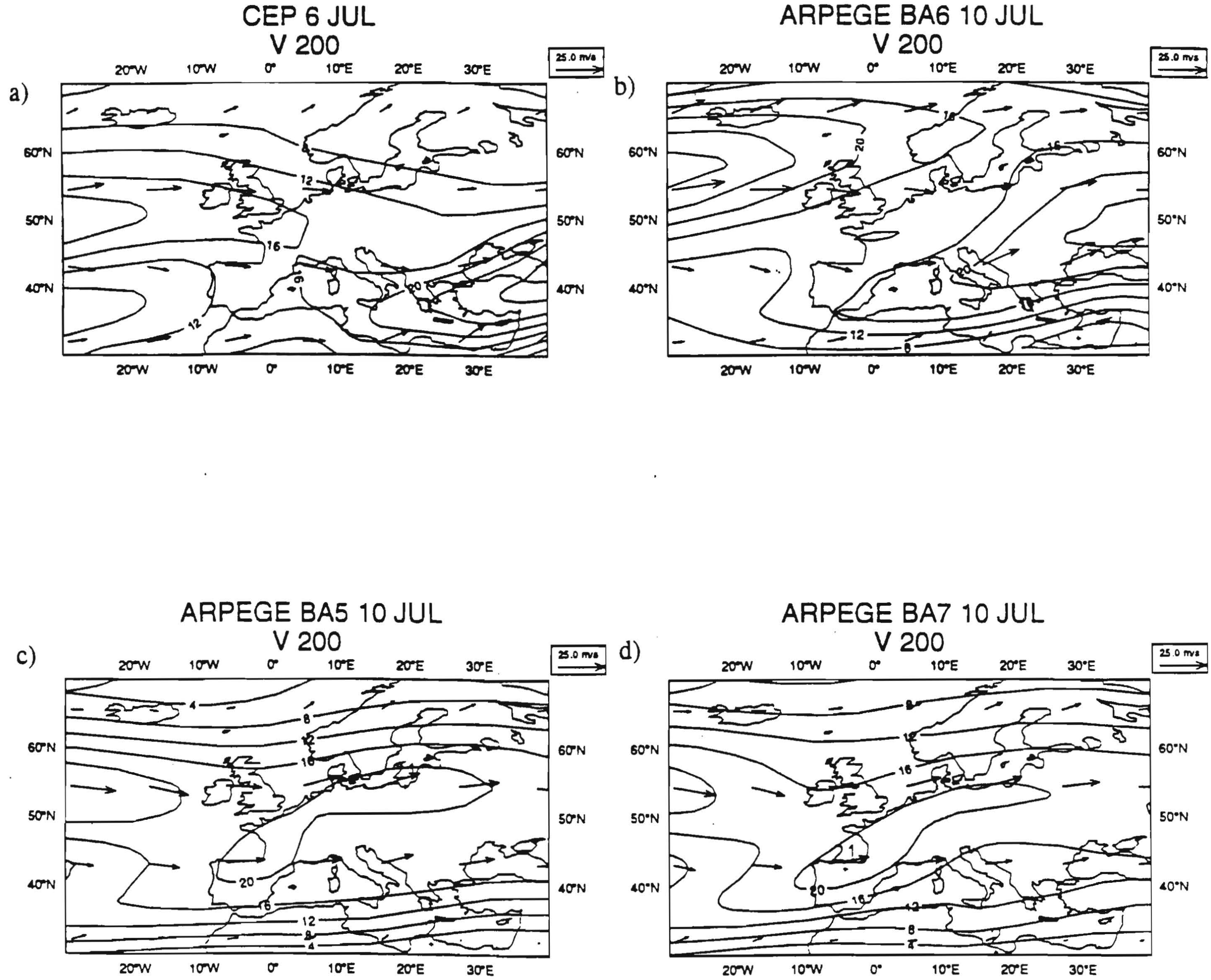
a) Climatological distribution of humidity at 200 hPa (g/kg) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing .004g/kg.



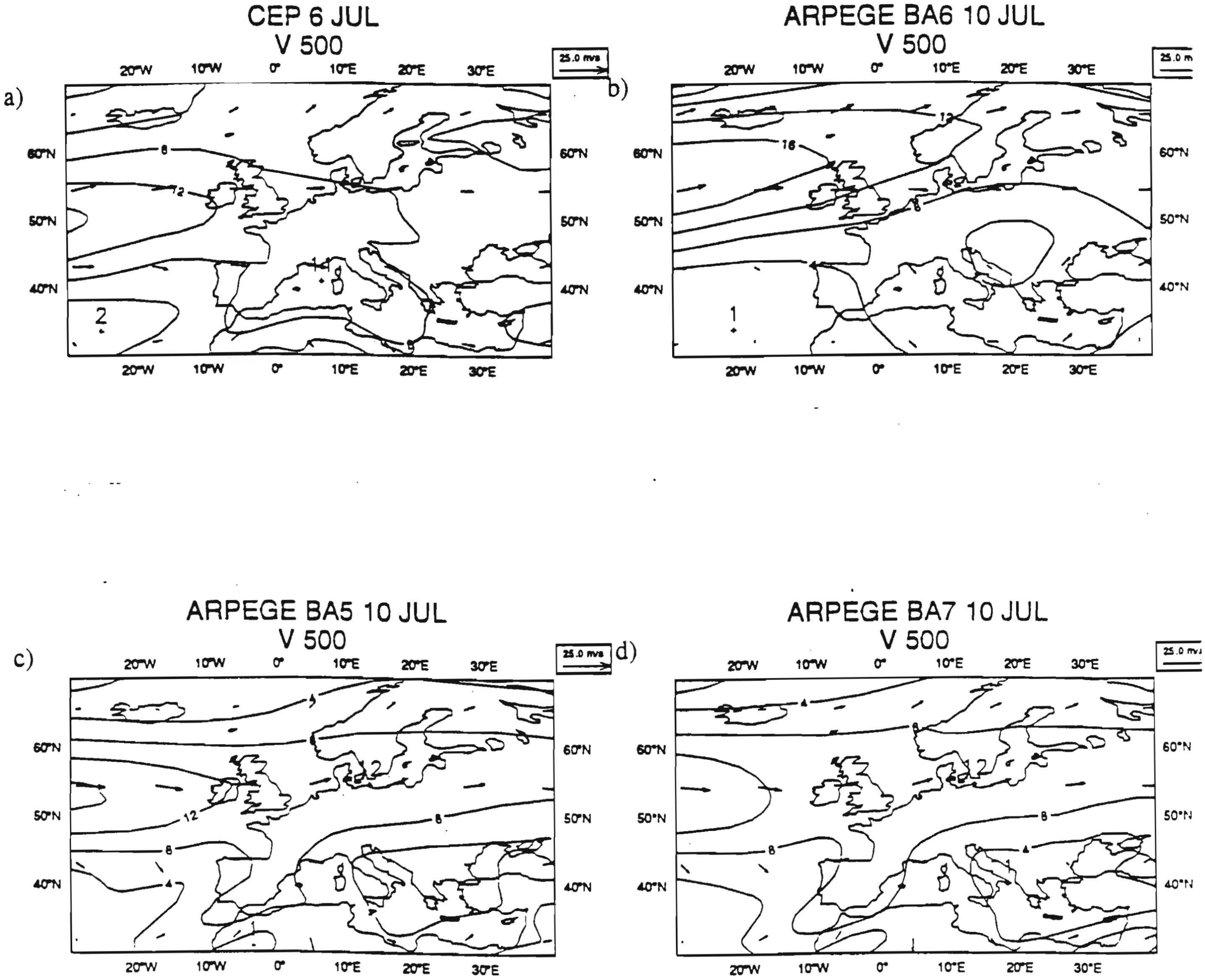
a) Climatological distribution of humidity at 500 hPa (g/kg) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing .4g/kg.



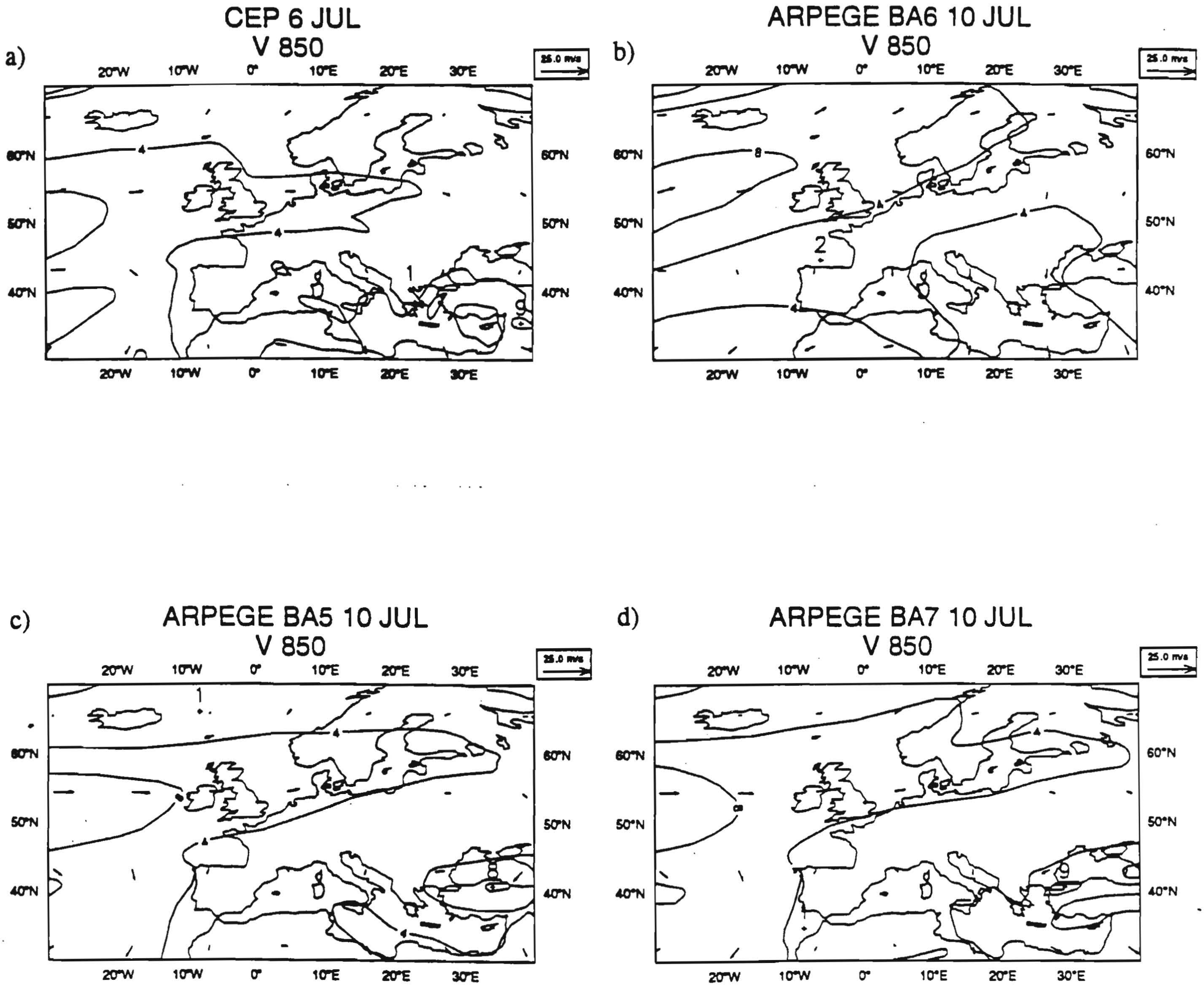
a) Climatological distribution of humidity at 850 hPa (g/kg) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing .8g/kg.



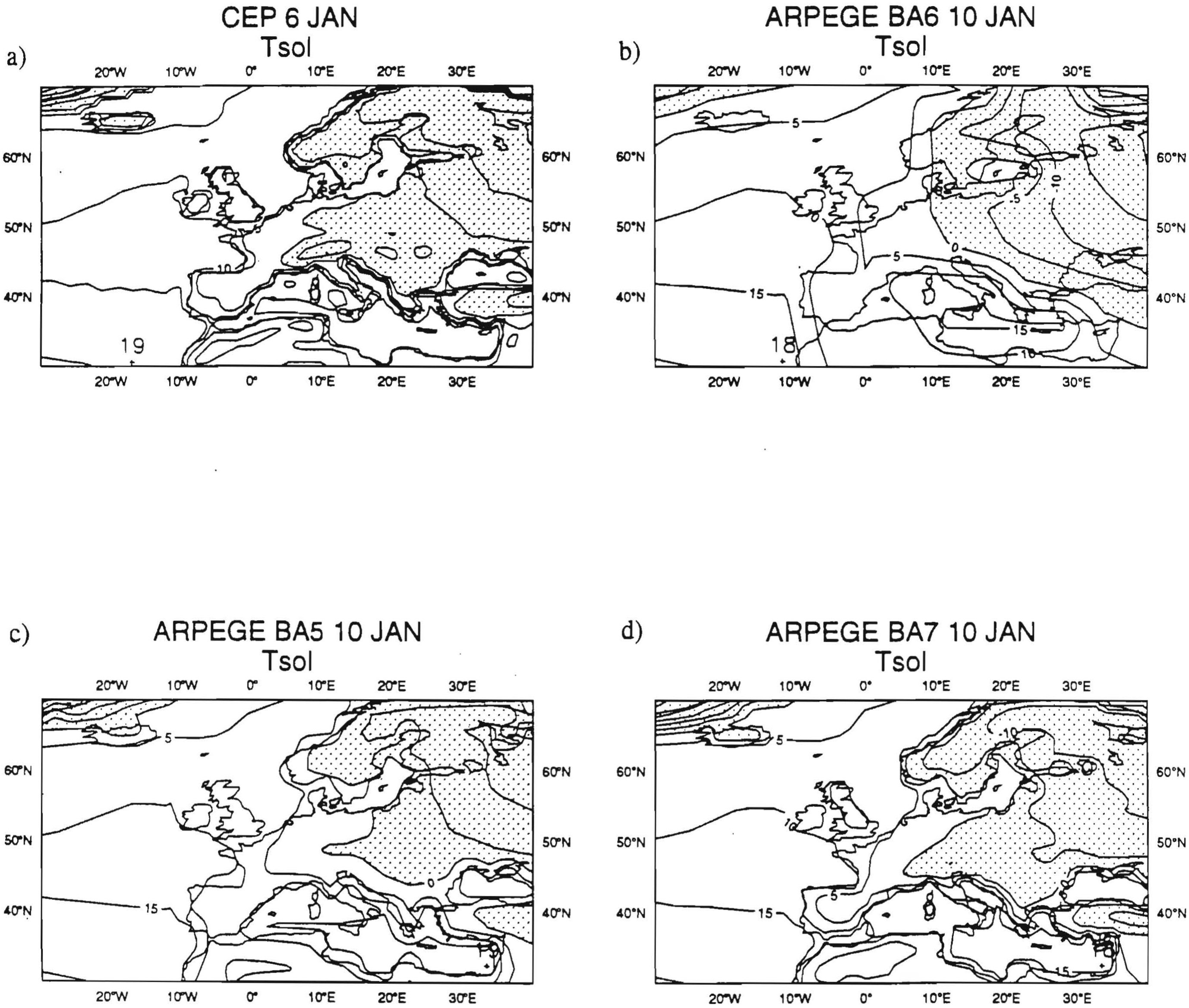
a) Climatological distribution of wind at 200 hPa (m/s) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 4m/s.



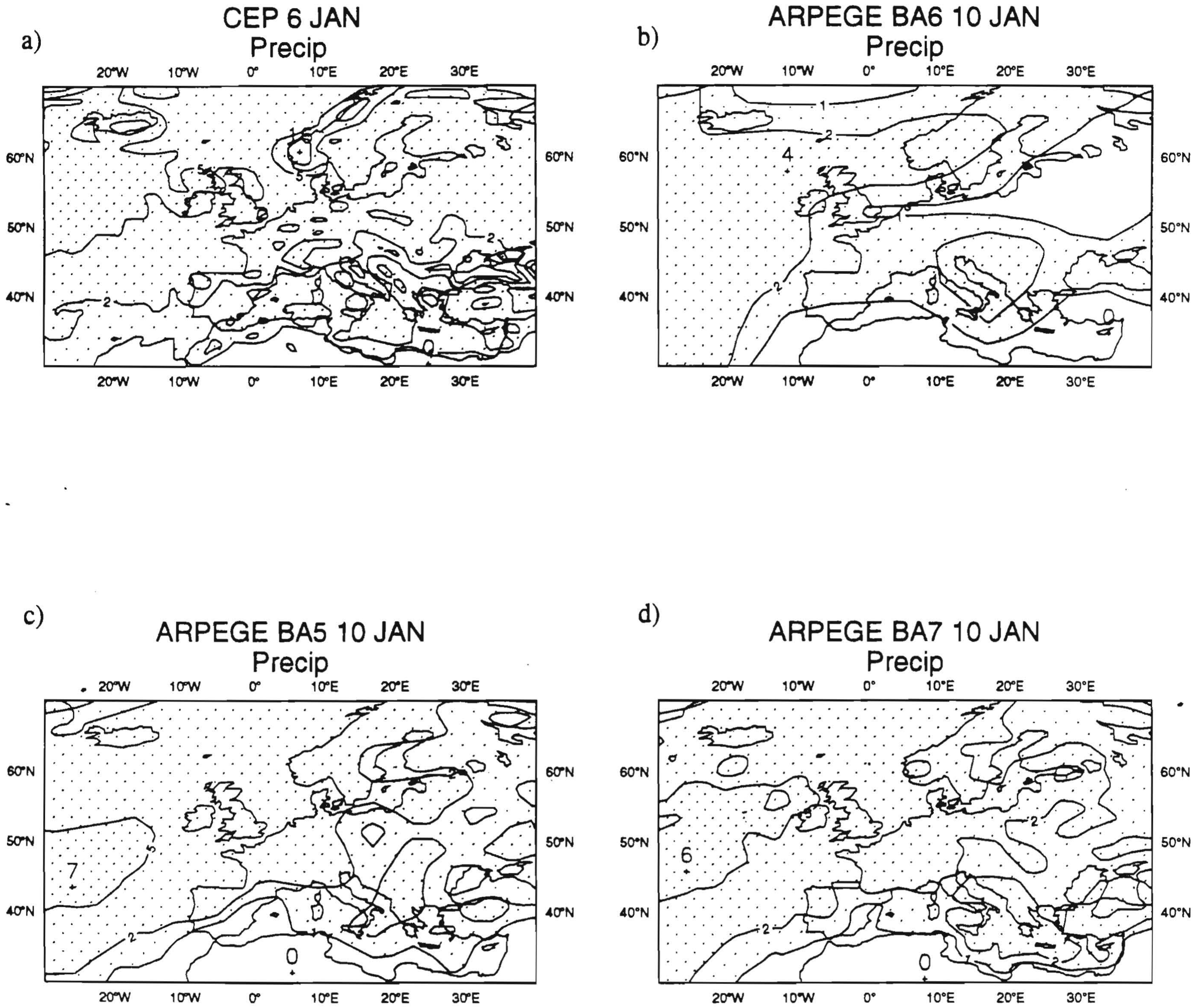
a) Climatological distribution of wind at 500 hPa (m/s) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 4m/s.



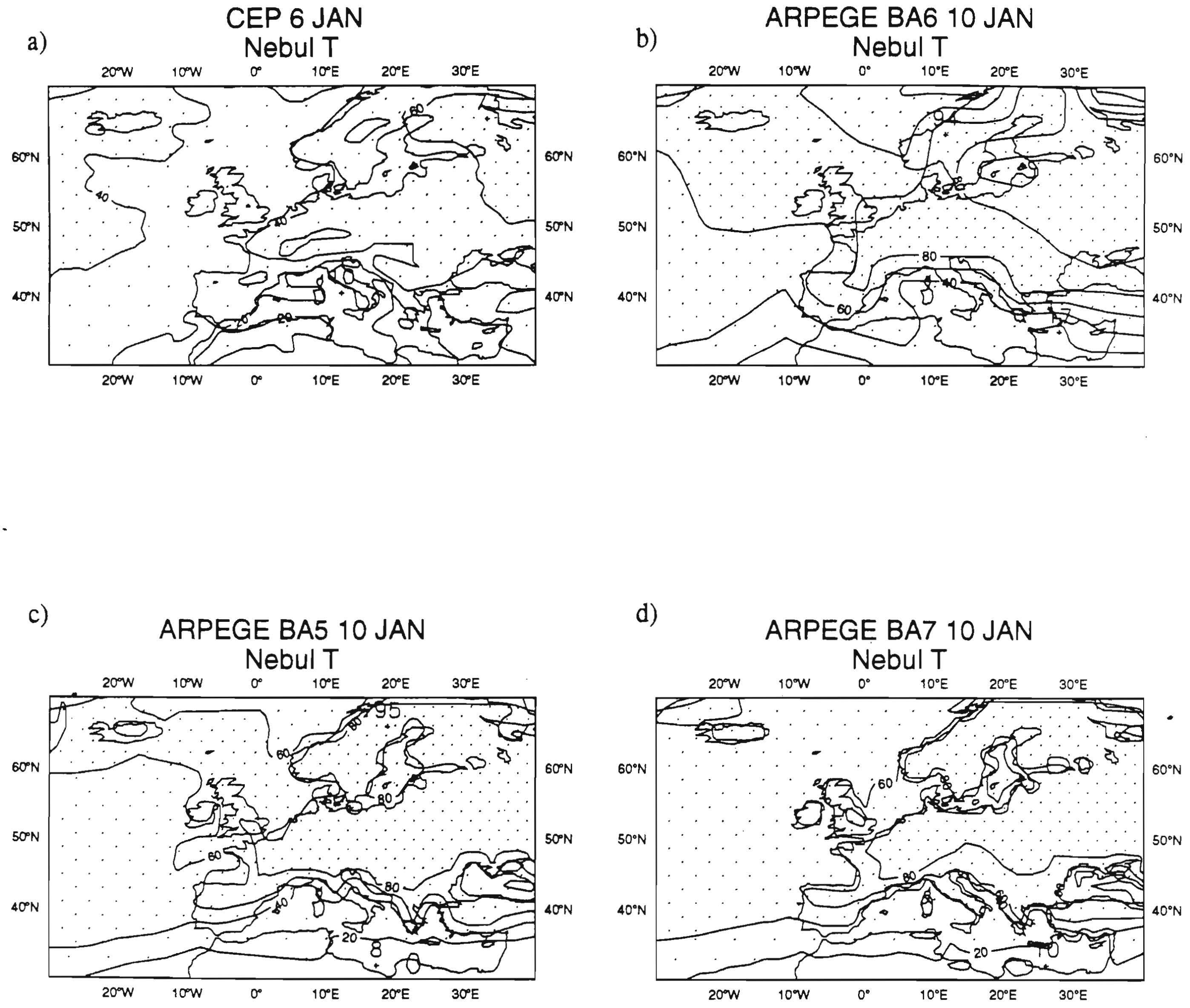
a) Climatological distribution of wind at 850 hPa (m/s) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 4m/s.



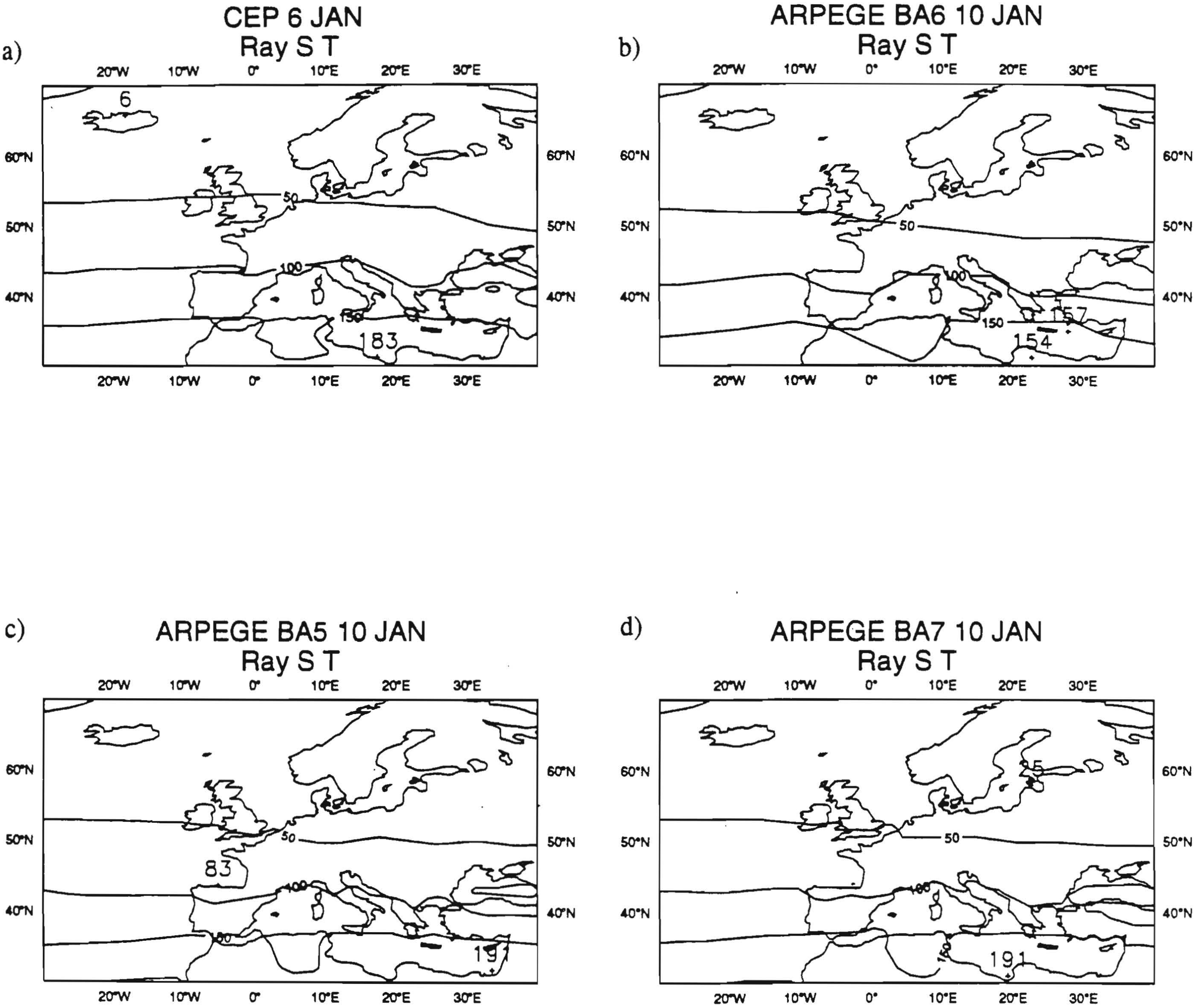
a) Climatological distribution of surface temperature (°C) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 5°C.



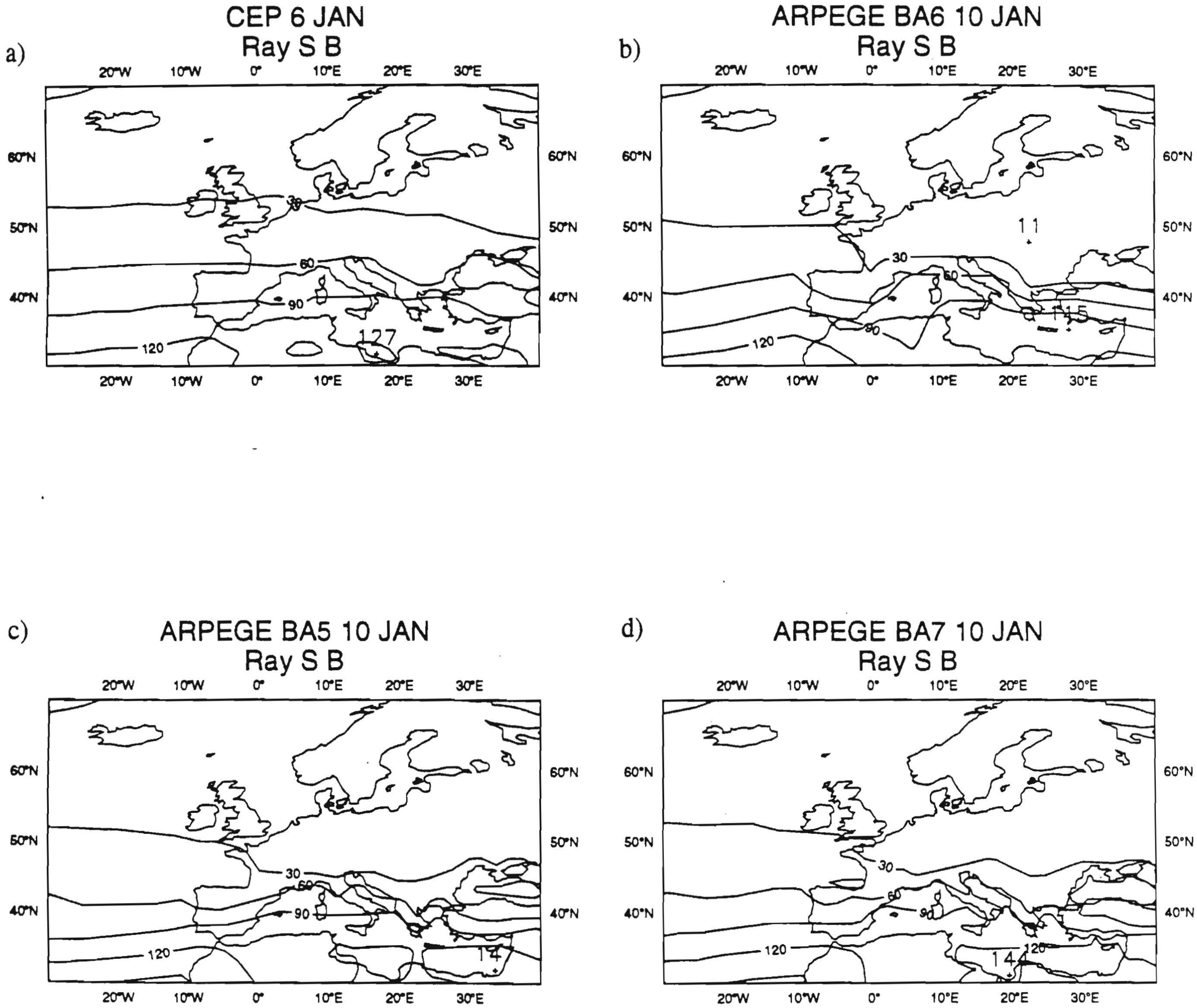
a) Climatological distribution of precipitation (mm/day) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacings: 1., 2., 5. mm/day.



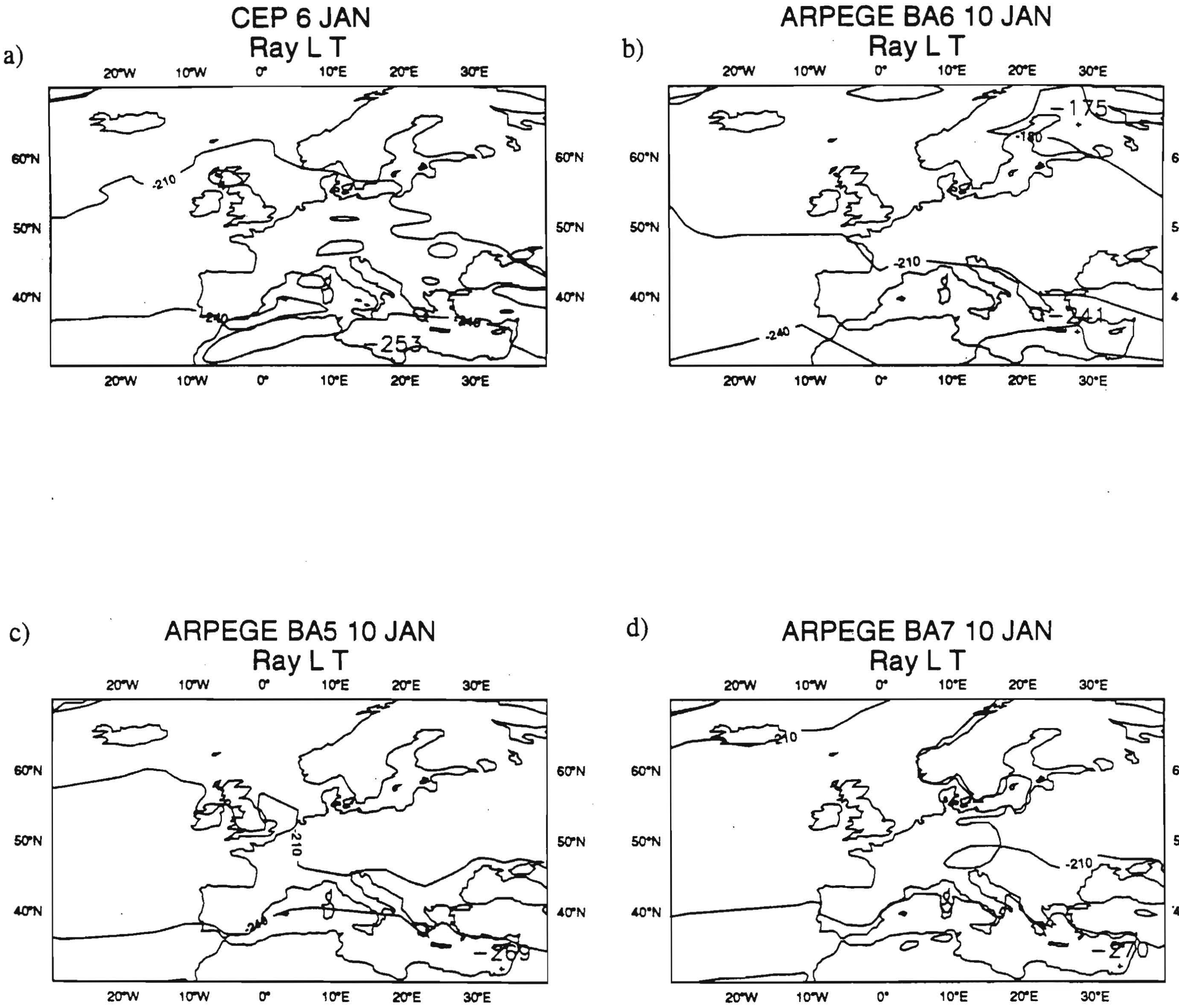
a) Climatological distribution of cloudiness (%) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacings: 20,40 60 and 80%.



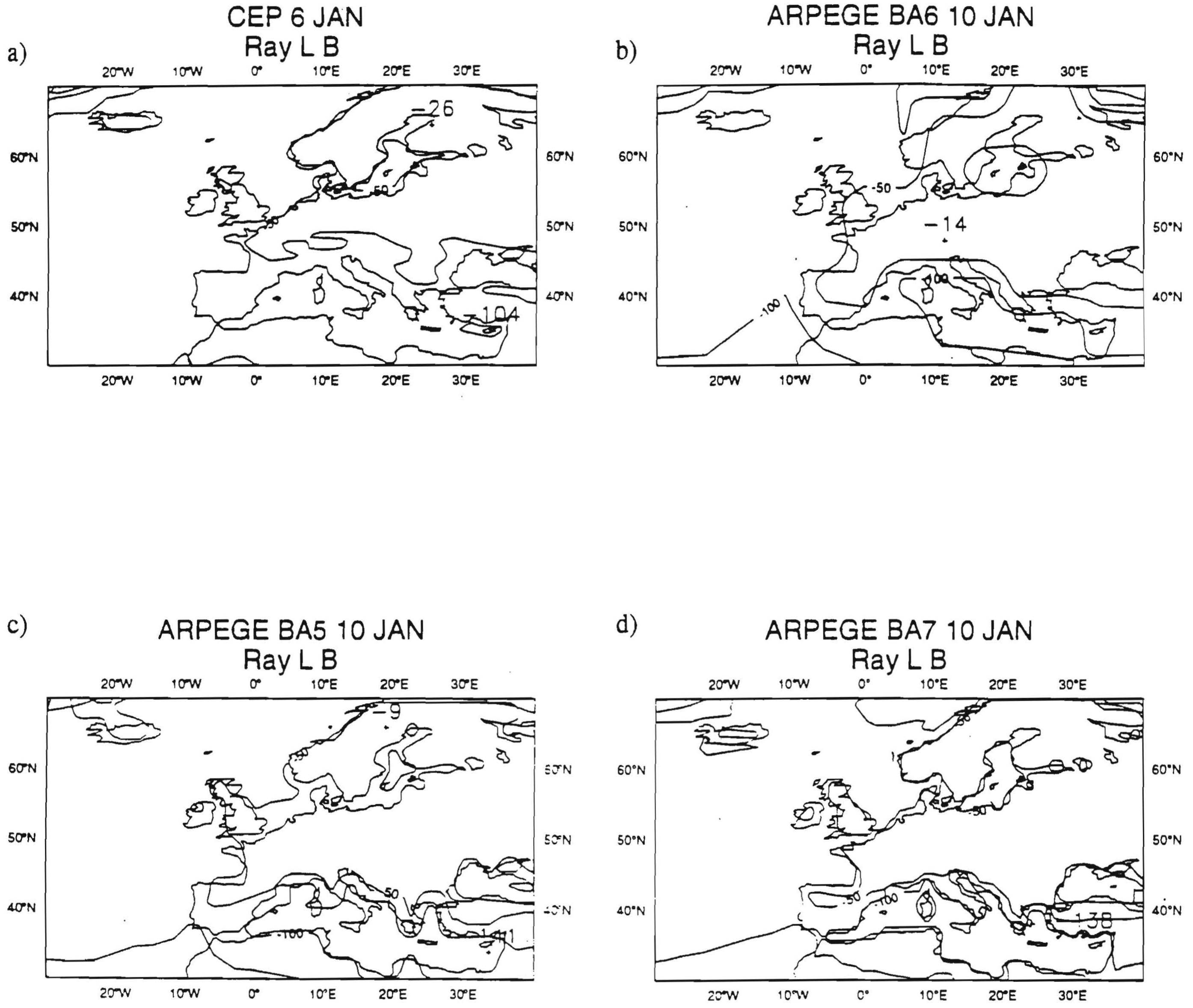
a) Climatological distribution of ST radiation (W/m^2) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 50W/m^2.



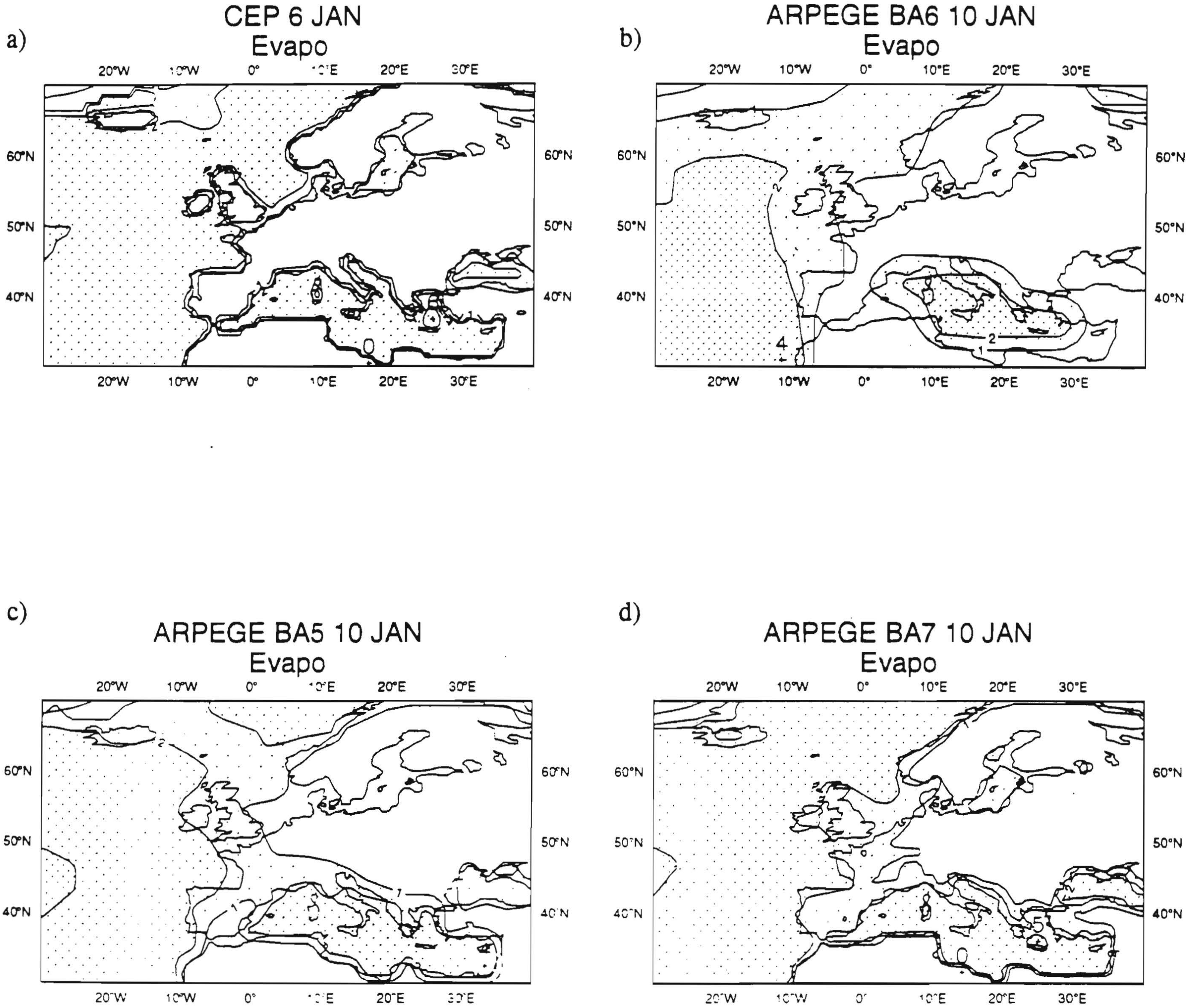
a) Climatological distribution of SB radiation (W/m^2) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: $30W/m^2$.



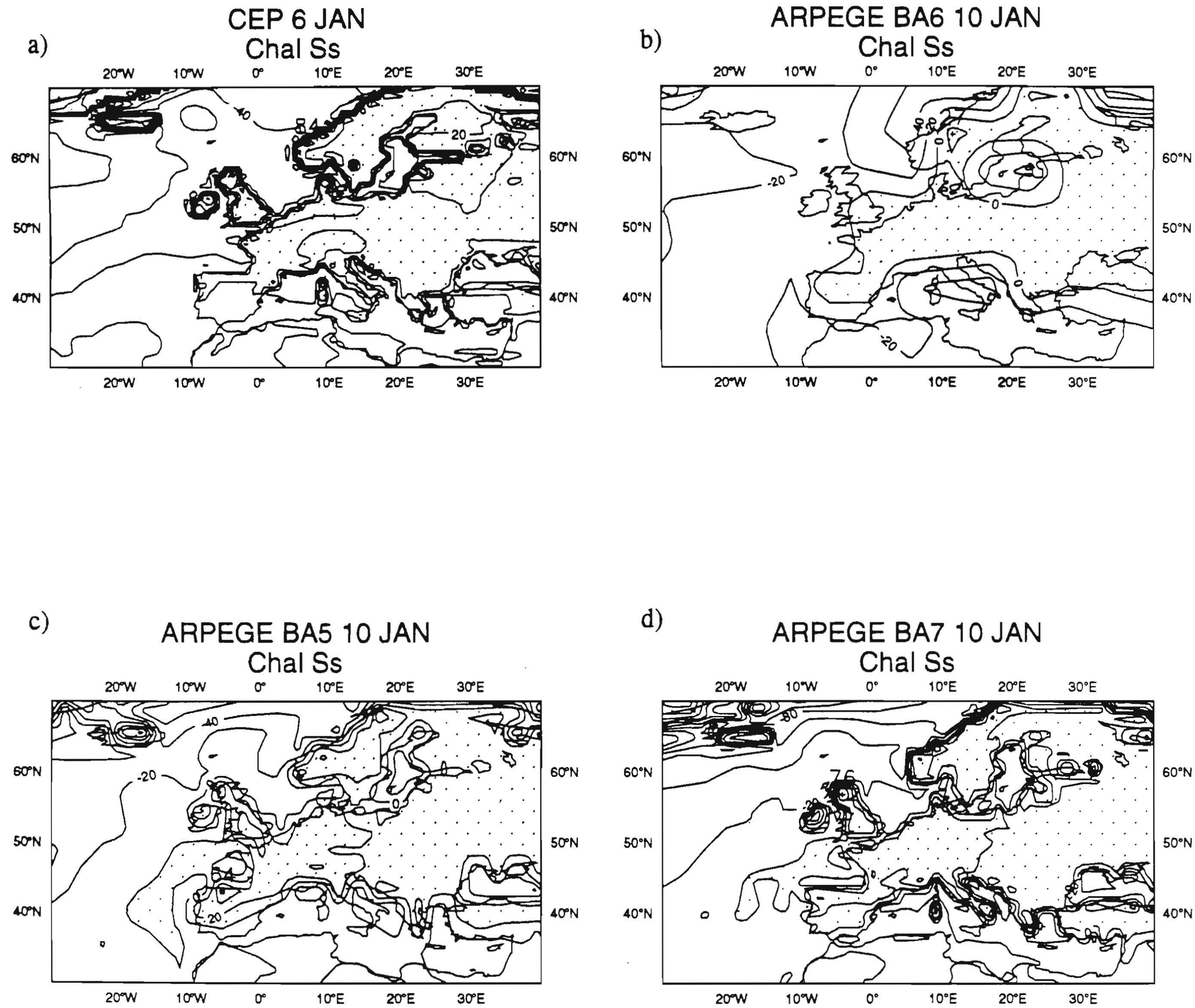
a) Climatological distribution of LT radiation (W/m²) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 30W/m².



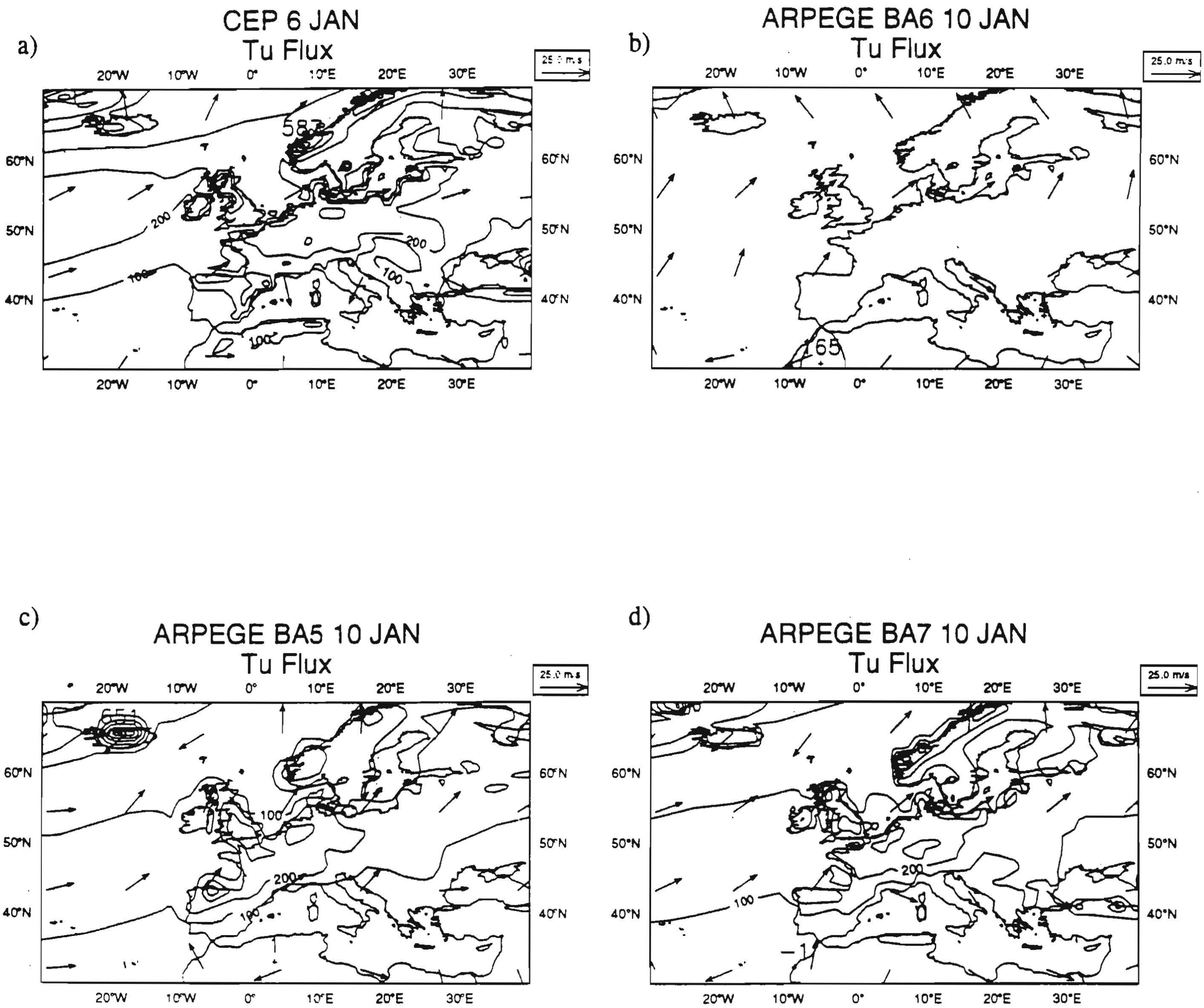
a) Climatological distribution of LB radiation (W/m²) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 50W/m².



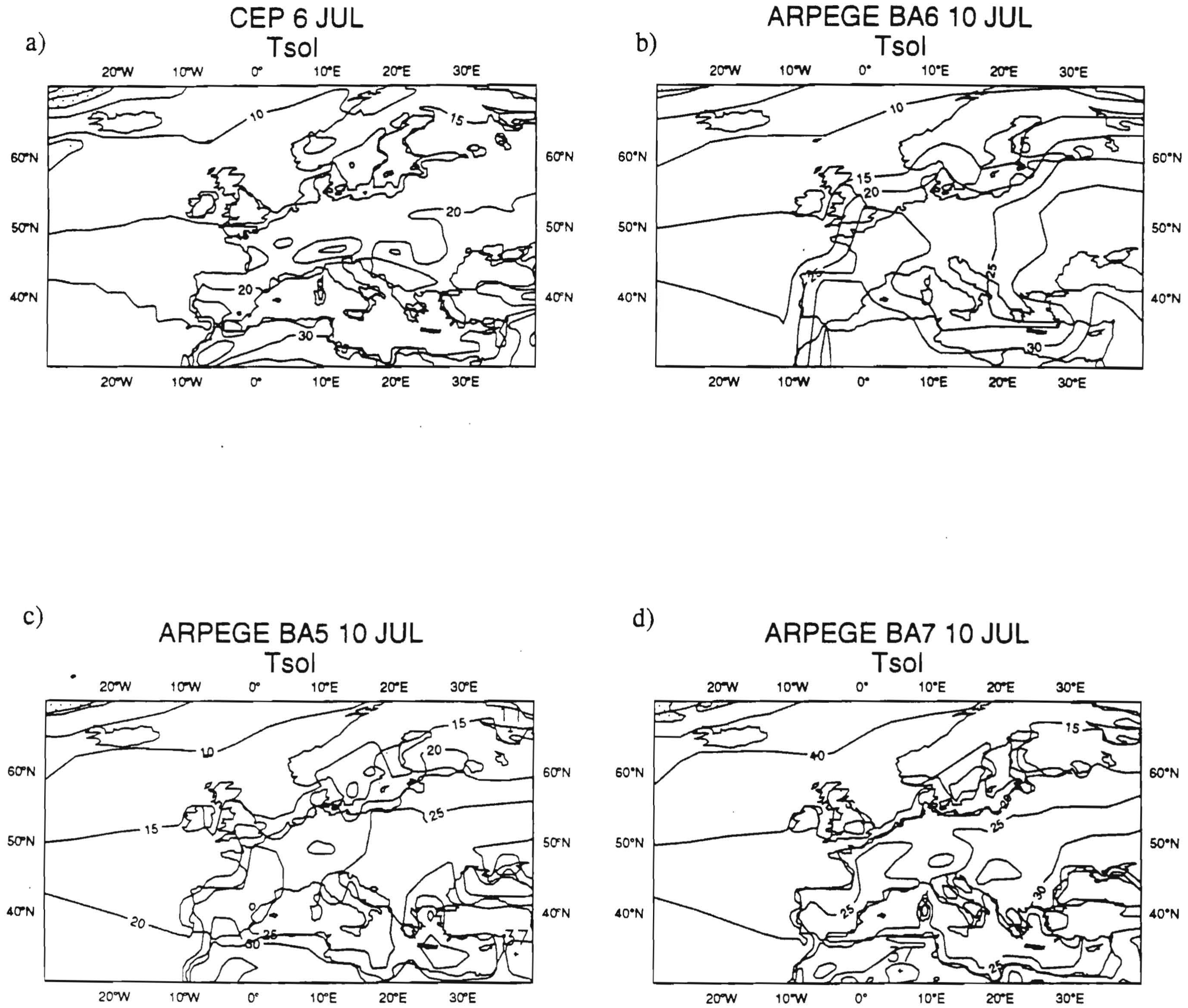
a) Climatological distribution of evaporation (mm/day) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacings: 1., 2., 5. mm/day.



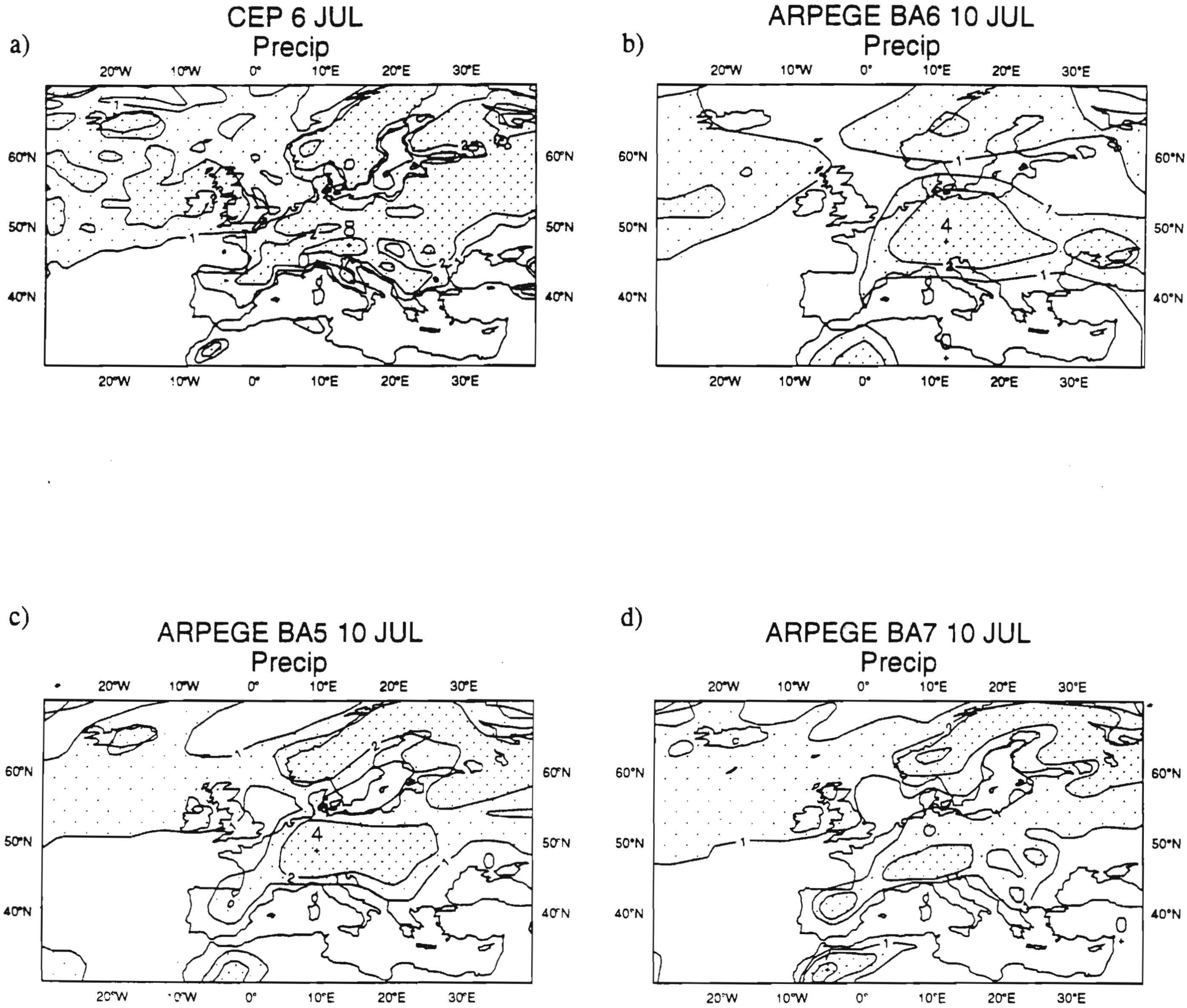
a) Climatological distribution of sensible heat (W/m²) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 20W/m².



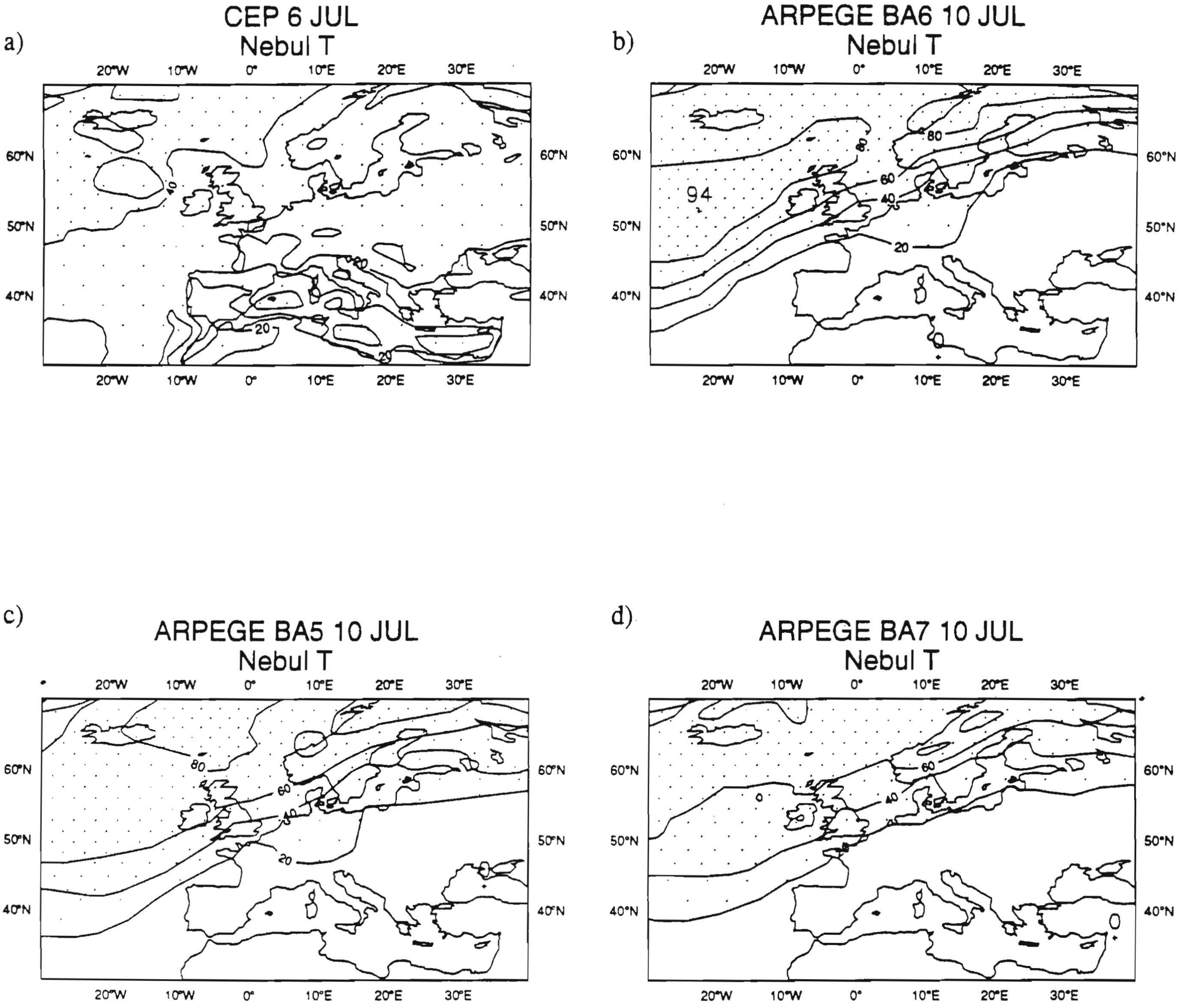
a) Climatological distribution of turbulent flux (N/m^2) for January based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 100NW/m^2.



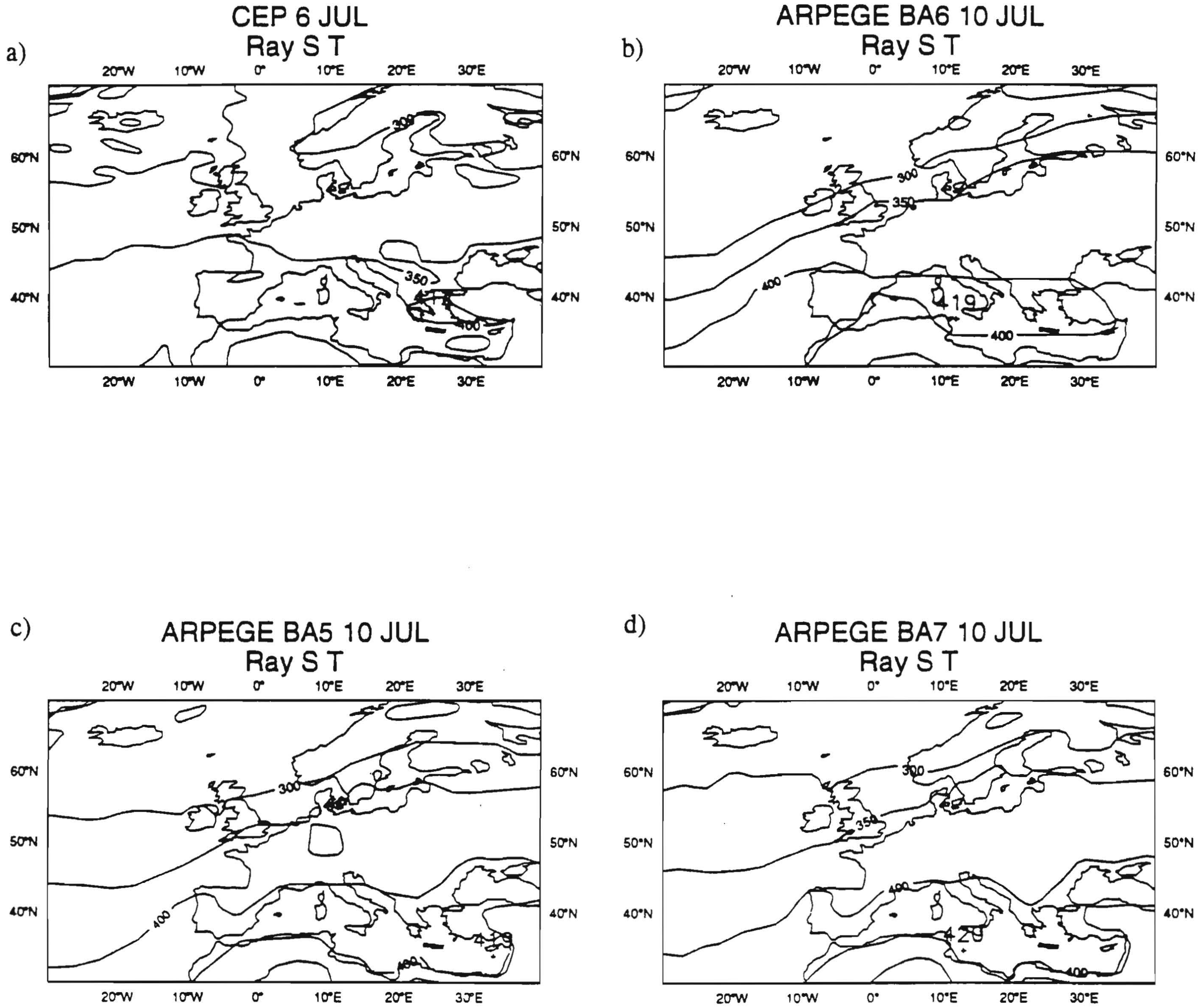
a) Climatological distribution of surface temperature (^{0}C) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing 5^{0}C.



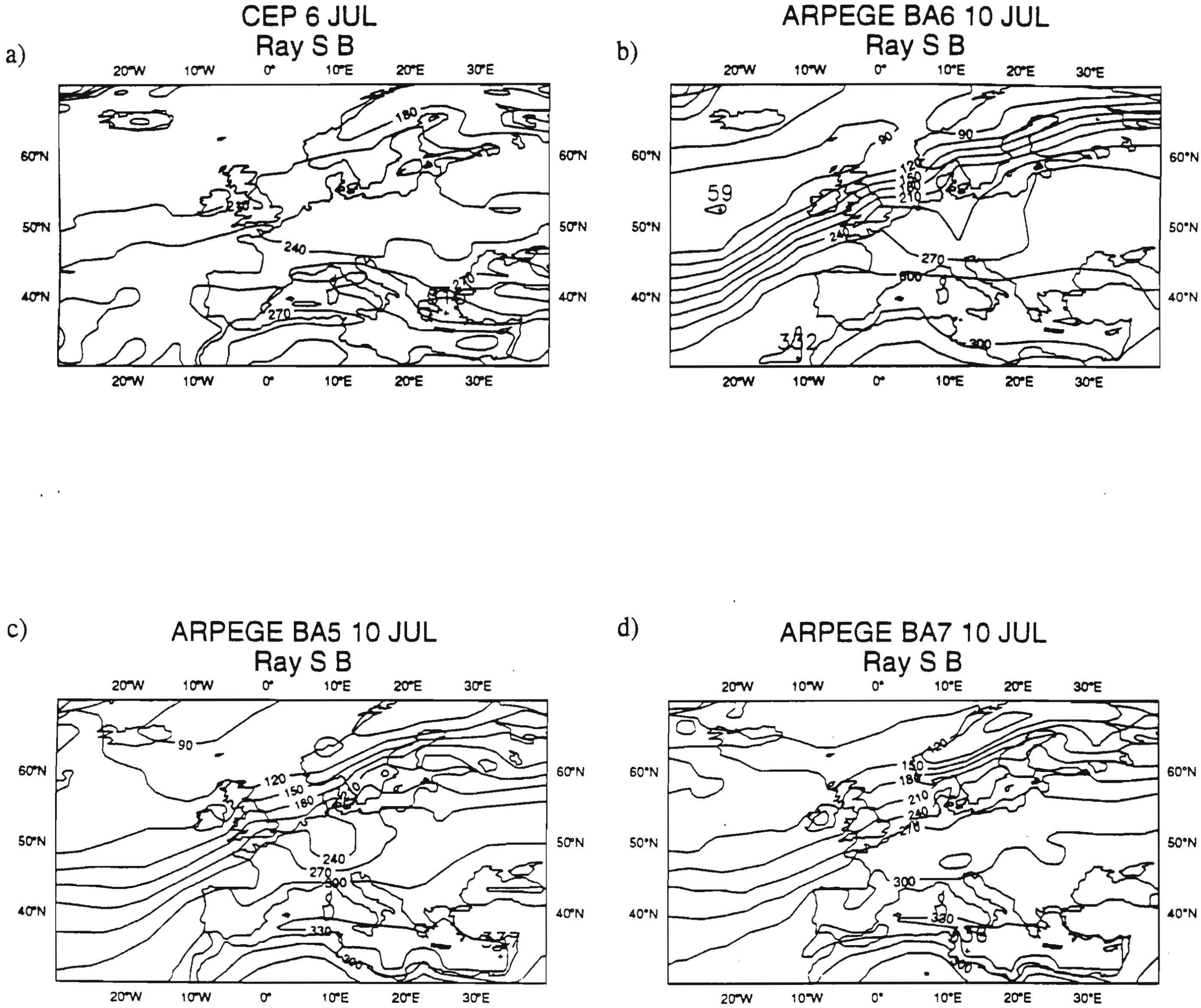
a) Climatological distribution of precipitation (mm/day) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacings: 1., 2., 5. mm/day.



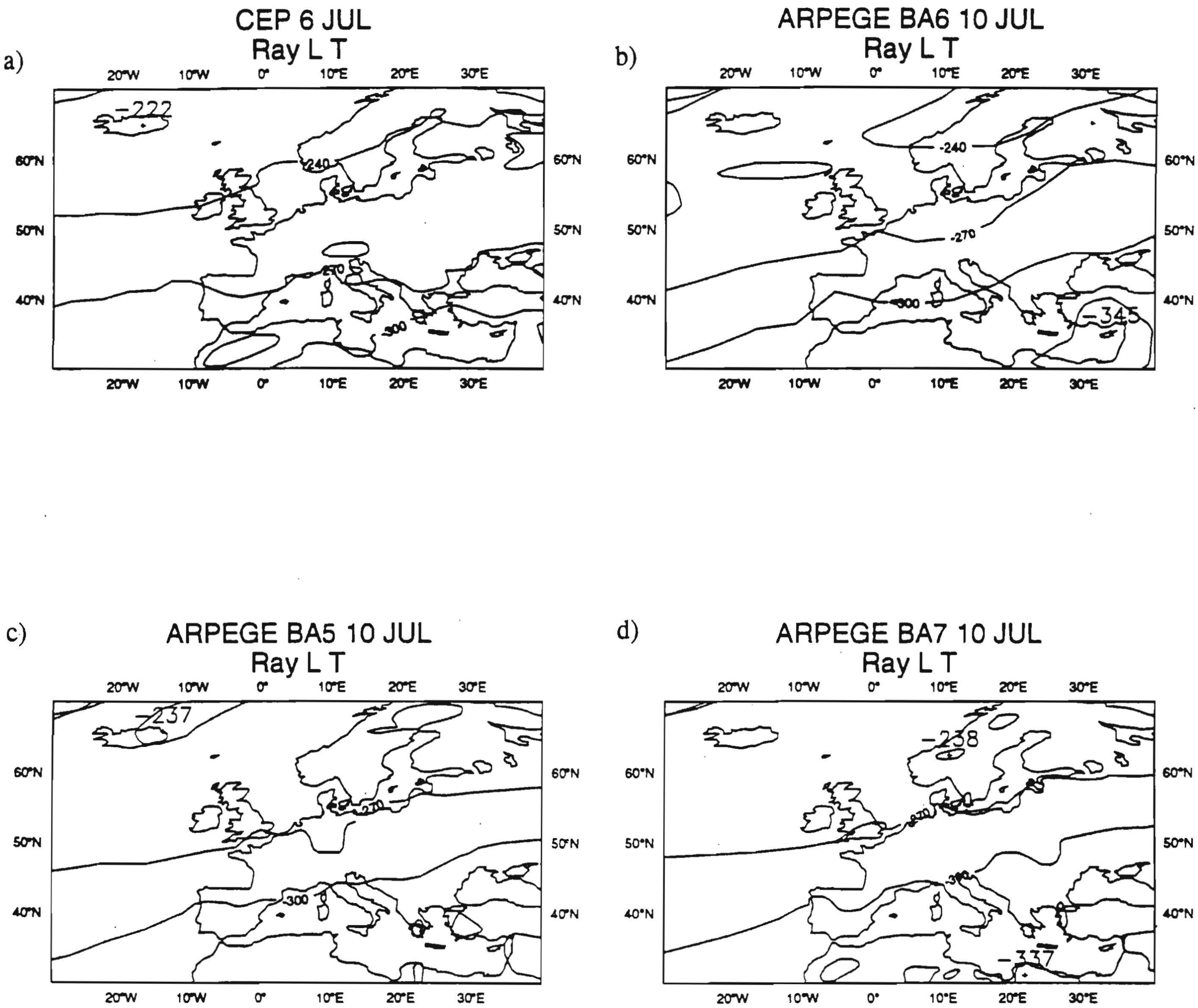
a) Climatological distribution of cloudiness (%) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacings: 20,40,60 and 80%.



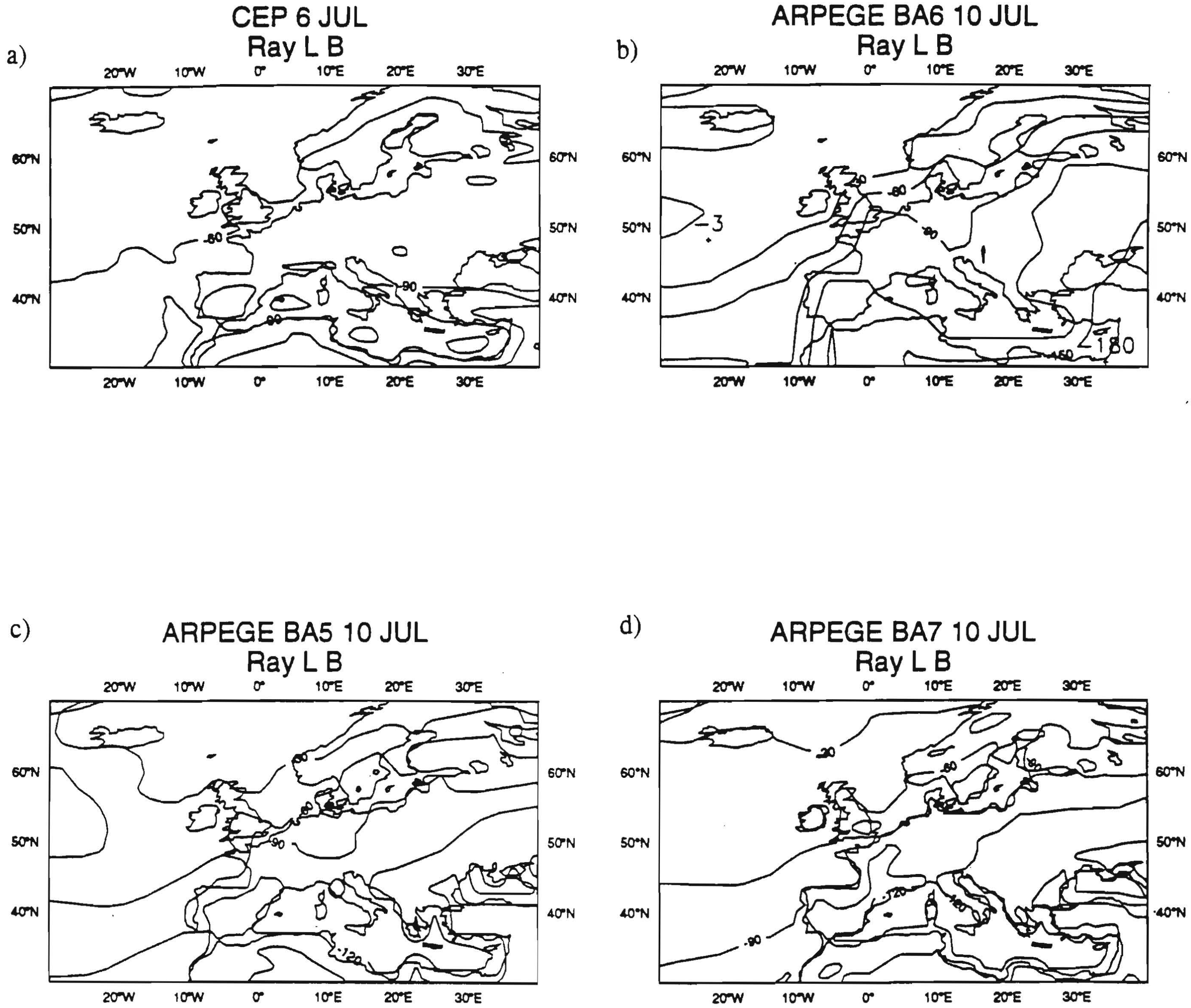
a) Climatological distribution of ST radiation (W/m^2) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: $50W/m^2$.



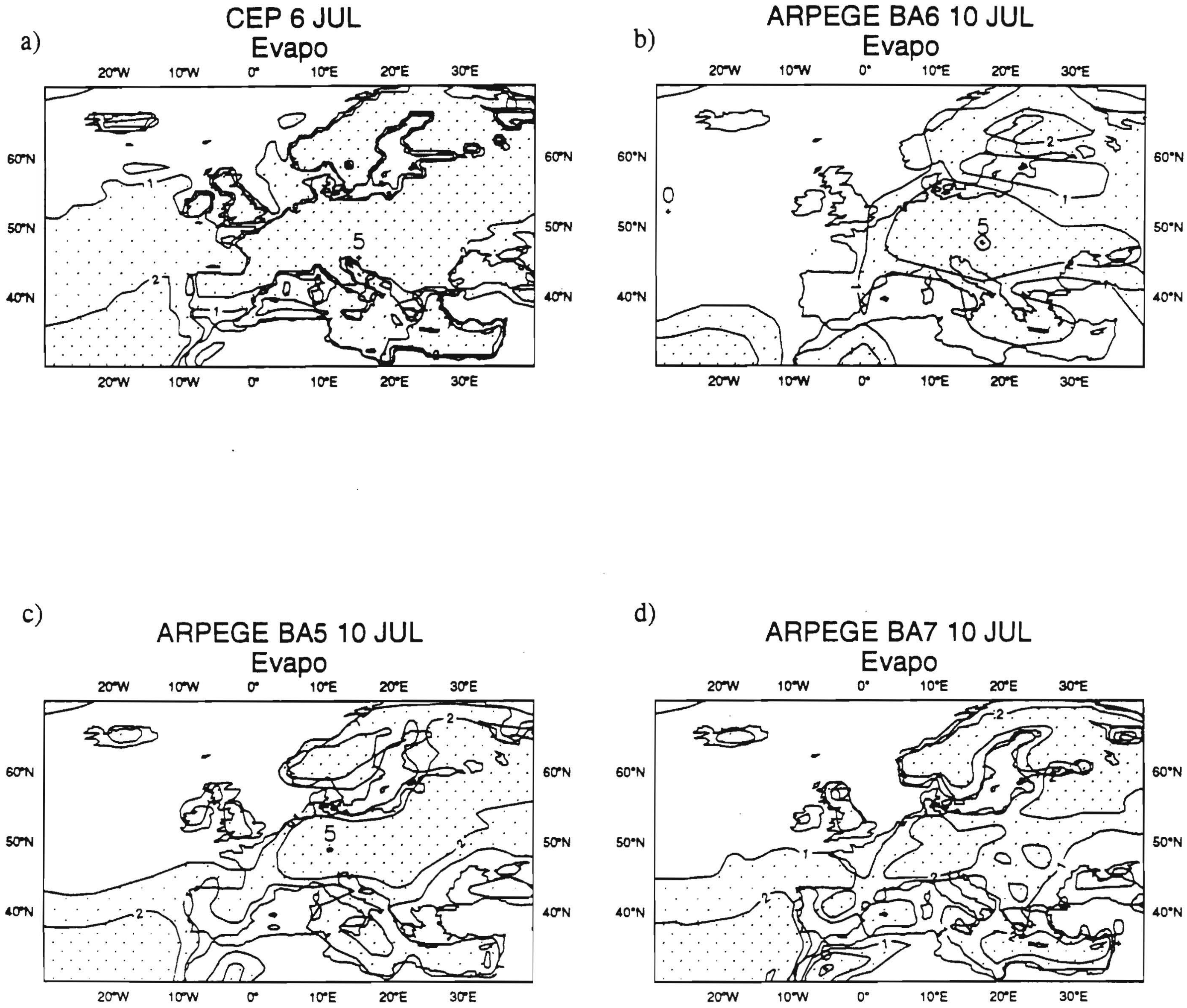
a) Climatological distribution of SB radiation (W/m^2) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 30W/m^2.



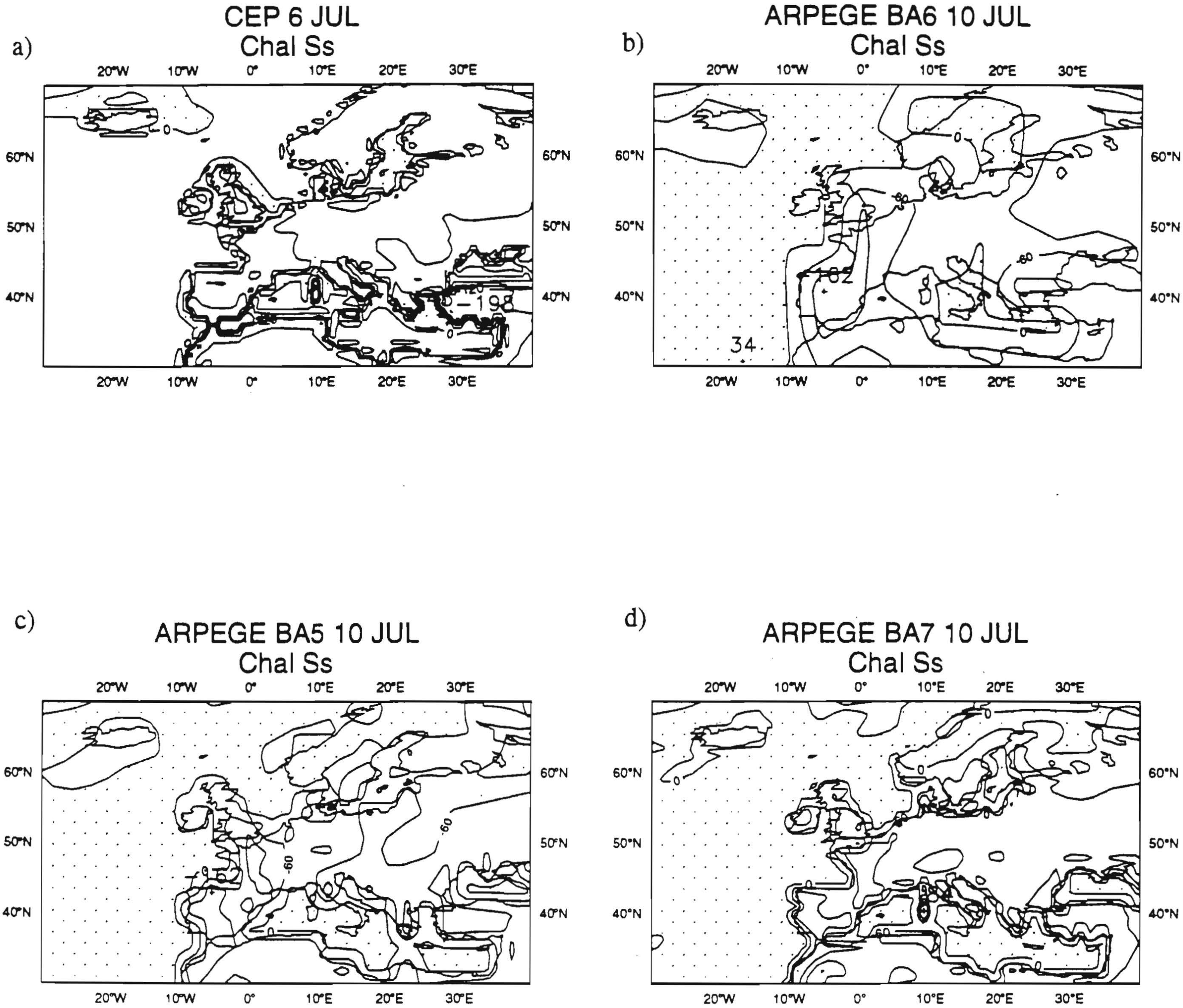
a) Climatological distribution of LT radiation (W/m^2) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 30W/m^2.



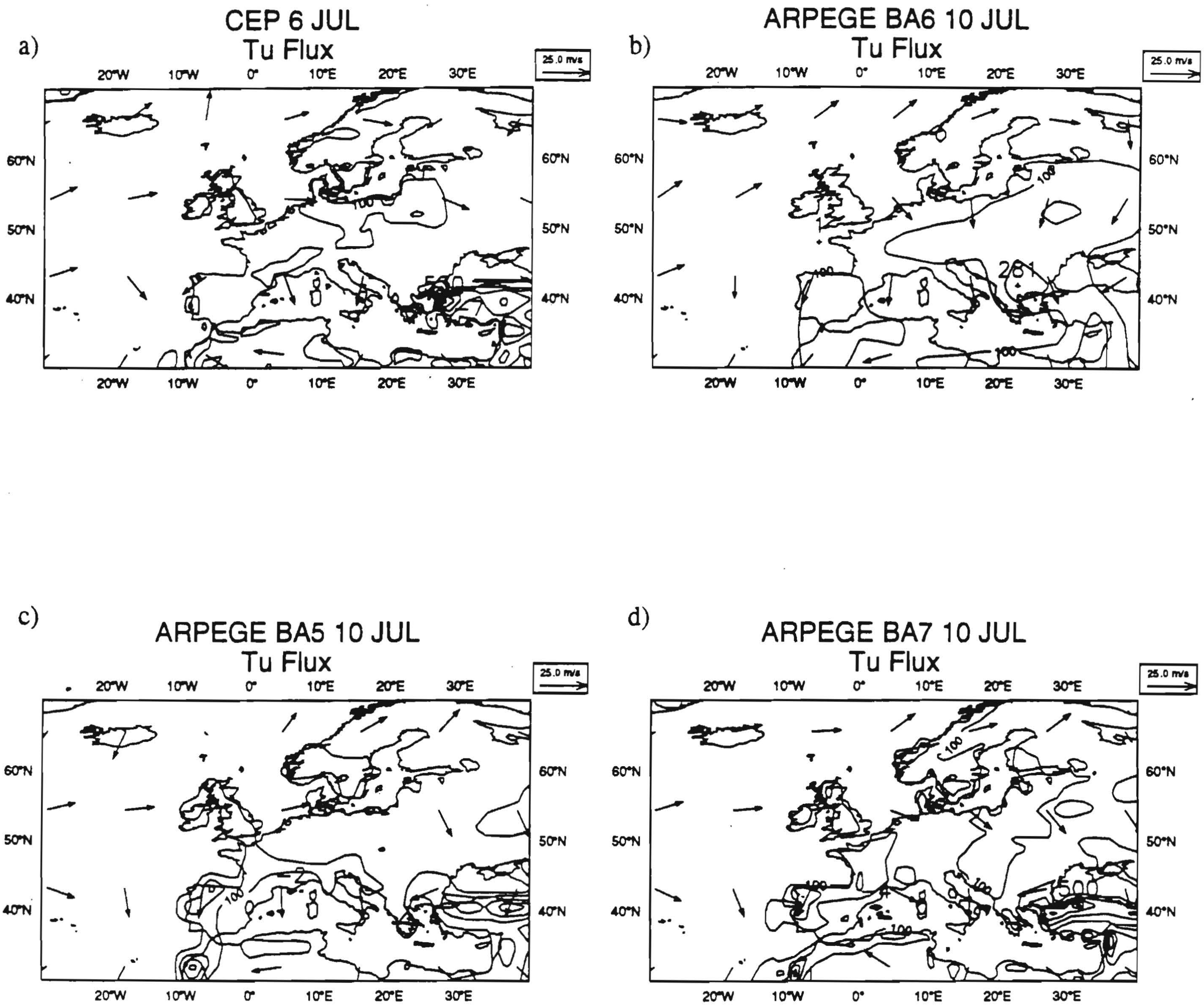
a) Climatological distribution of LB radiation (W/m²) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 50W/m².



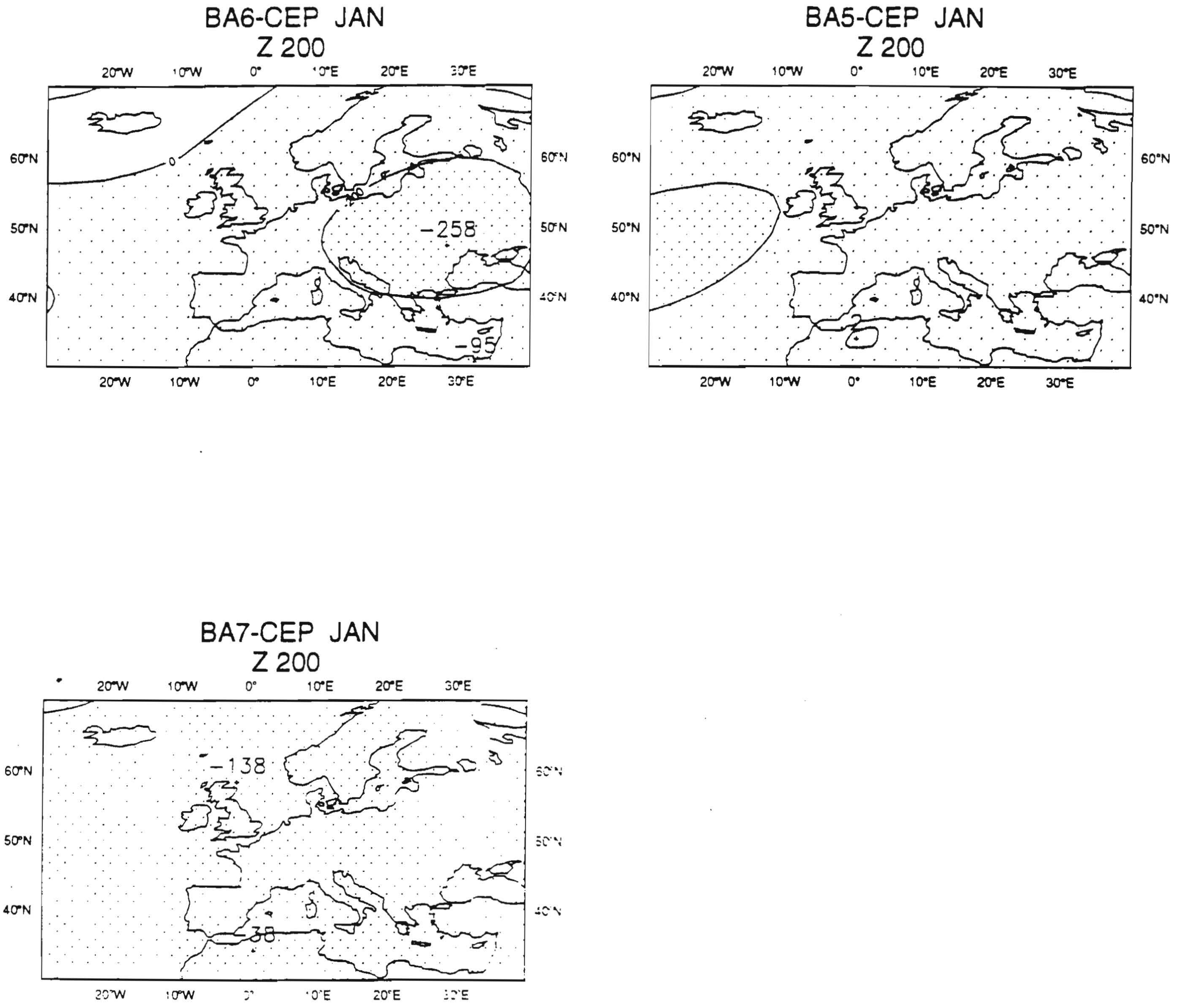
a) Climatological distribution of evaporation (mm/day) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacings: 1., 2., 5. mm/day.



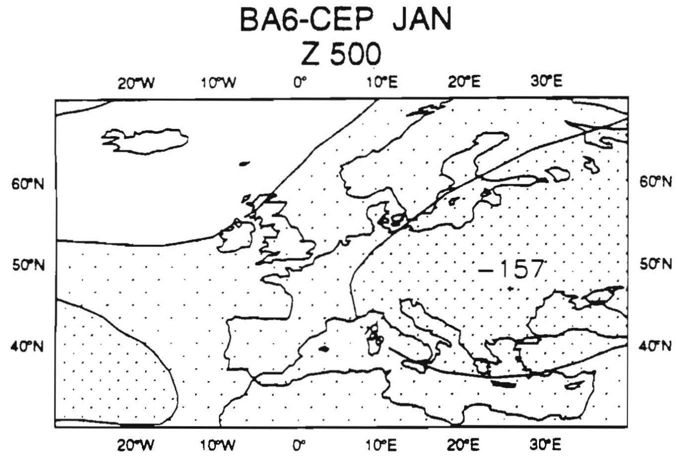
a) Climatological distribution of sensible heat (W/m²) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 60W/m².

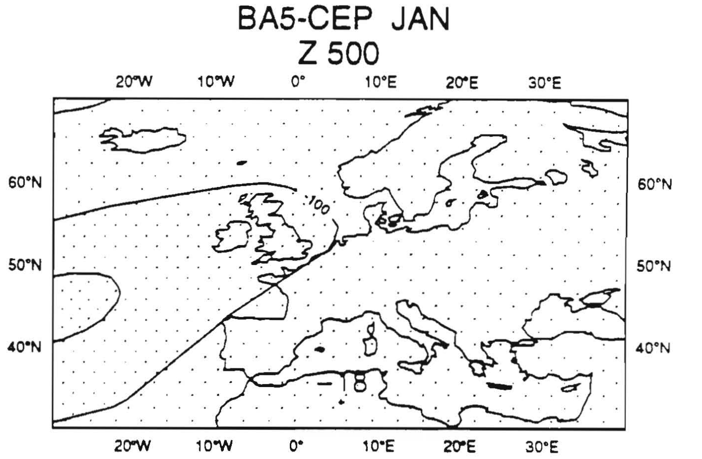


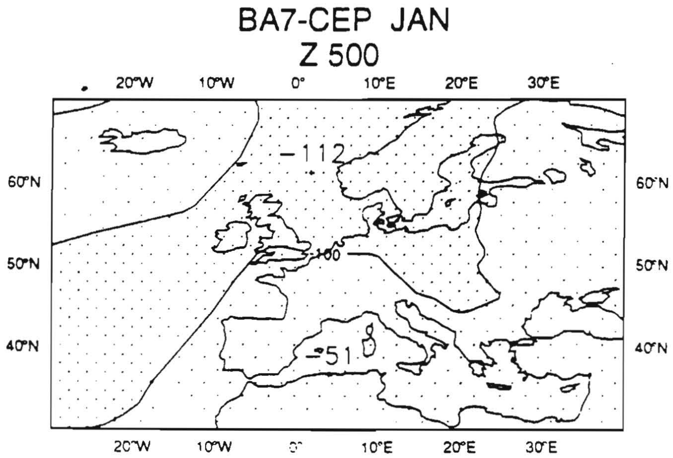
a) Climatological distribution of turbulent flux (N/m^2) for July based on ECMWF analyses, b-d) based on ARPEGE model at different resolutions T21(BA6), T42(BA5) and T79(BA7). Contour spacing: 100N/m^2.



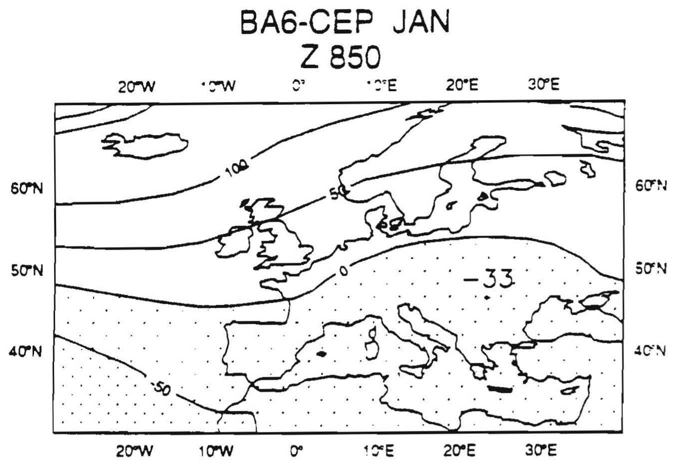
Differences between Arpège model and ECMWF analyses for the geopotential distribution at 200 hPa in January. Contour spacing 200m.

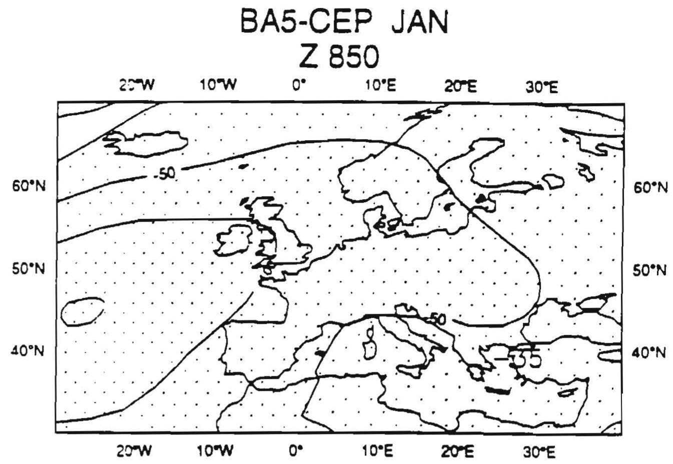


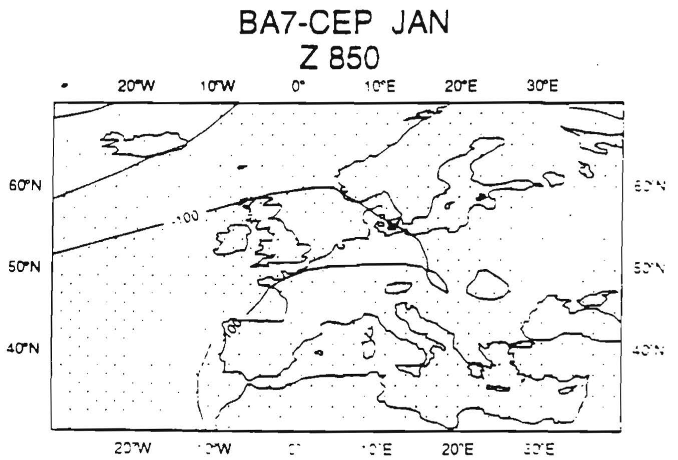




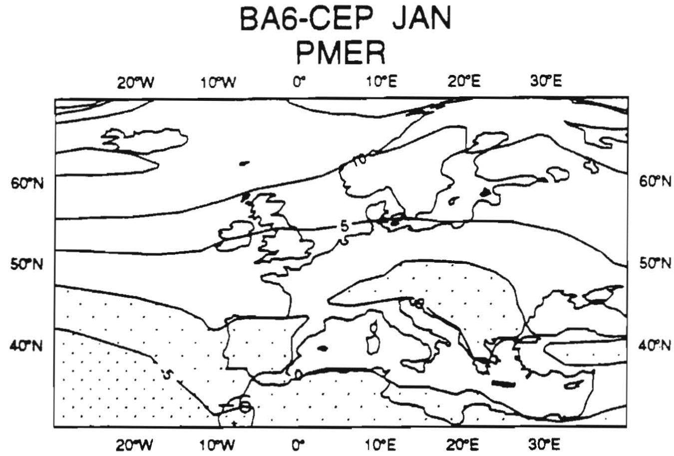
Differences between Arpège model and ECMWF analyses for the geopotential distribution at 500 hPa in January. Contour spacing 100m.

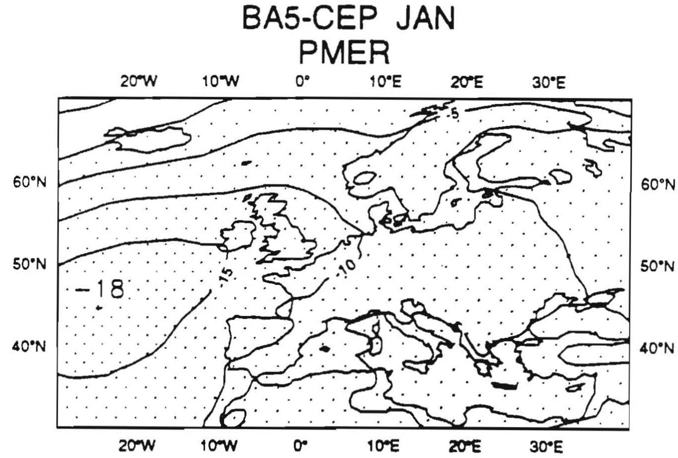


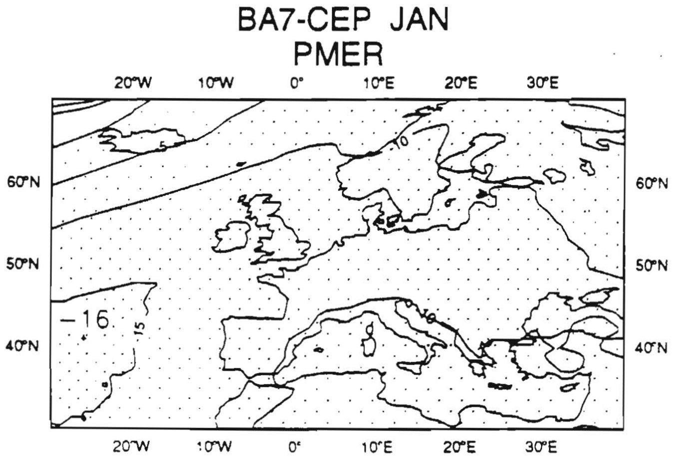




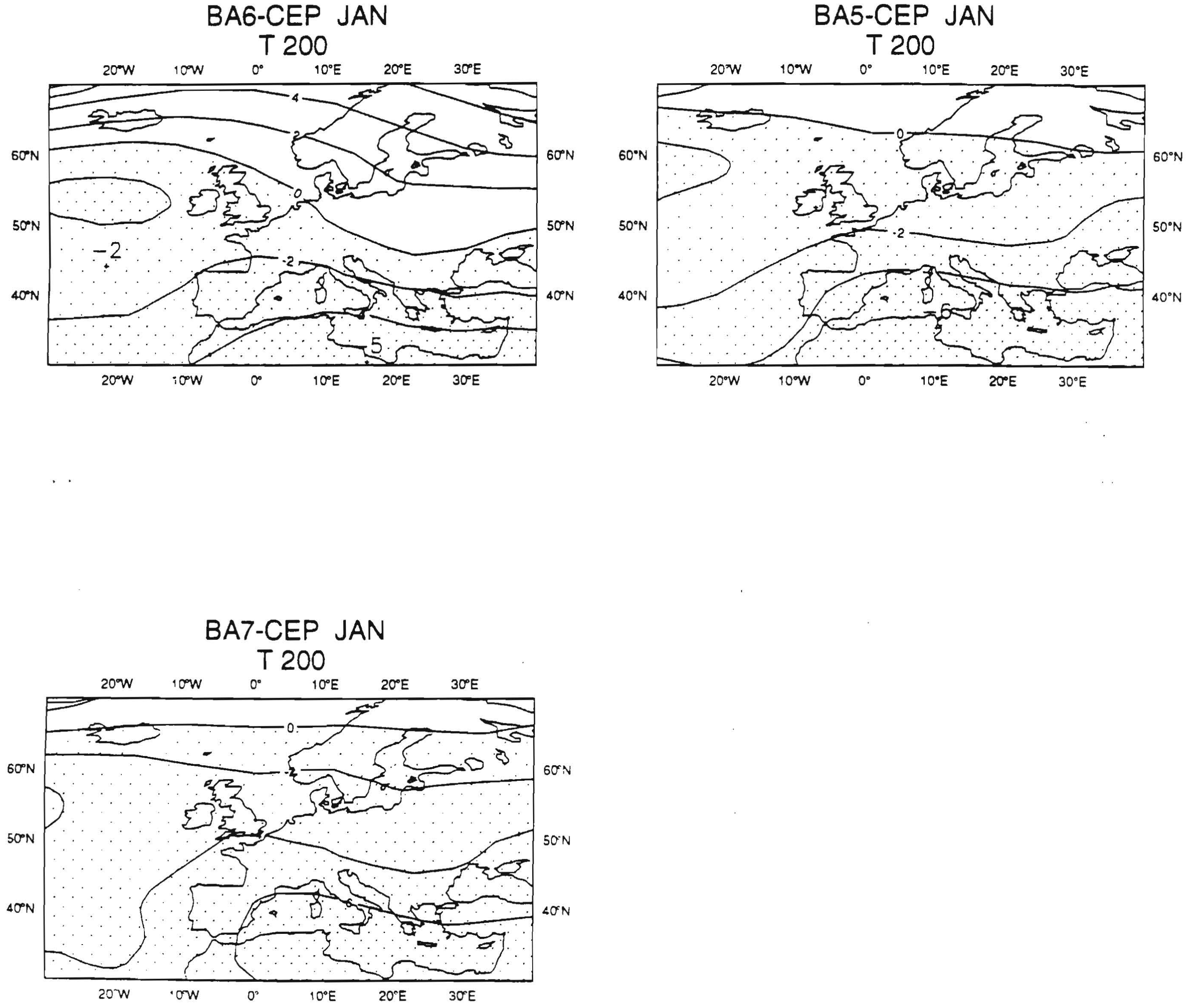
Differences between Arpège model and ECMWF analyses for the geopotential distribution at 850 hPa in January. Contour spacing 50m.



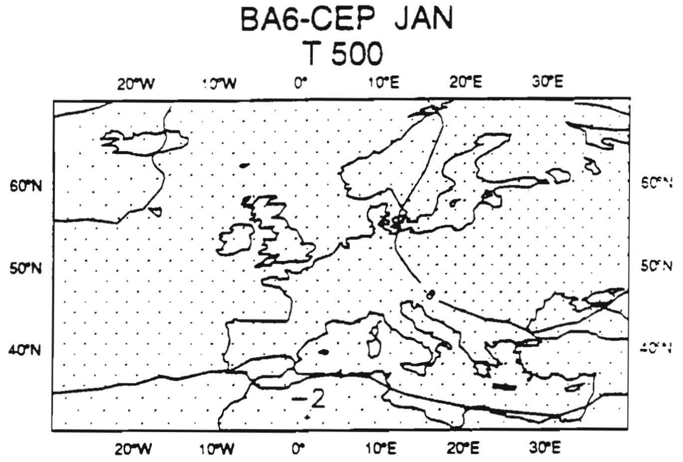


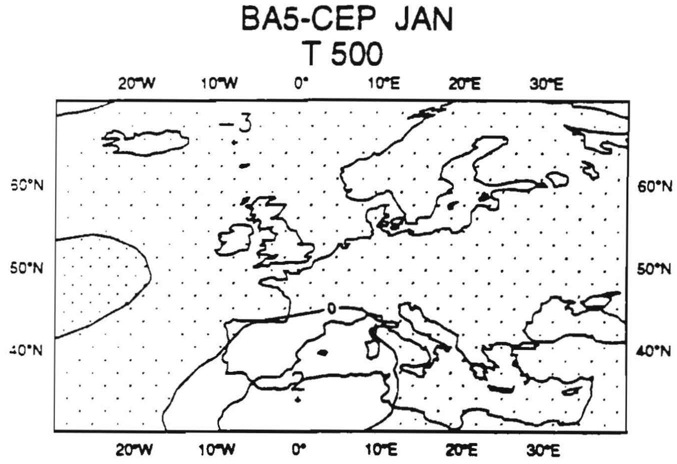


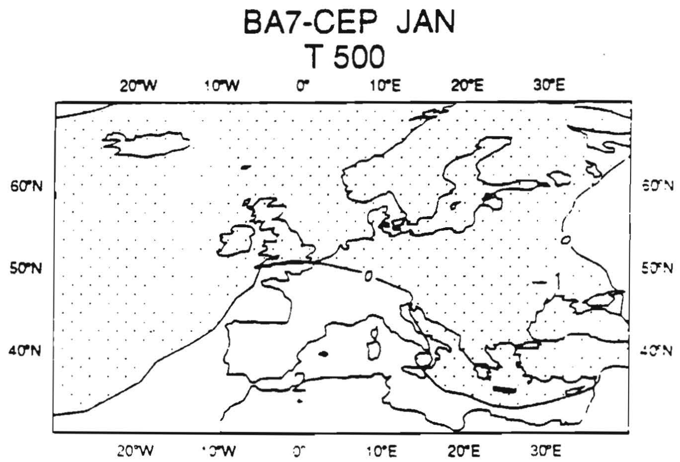
Differences between Arpège model and ECMWF analyses for the sea level pressure distribution January. Contour spacing 5hPa.



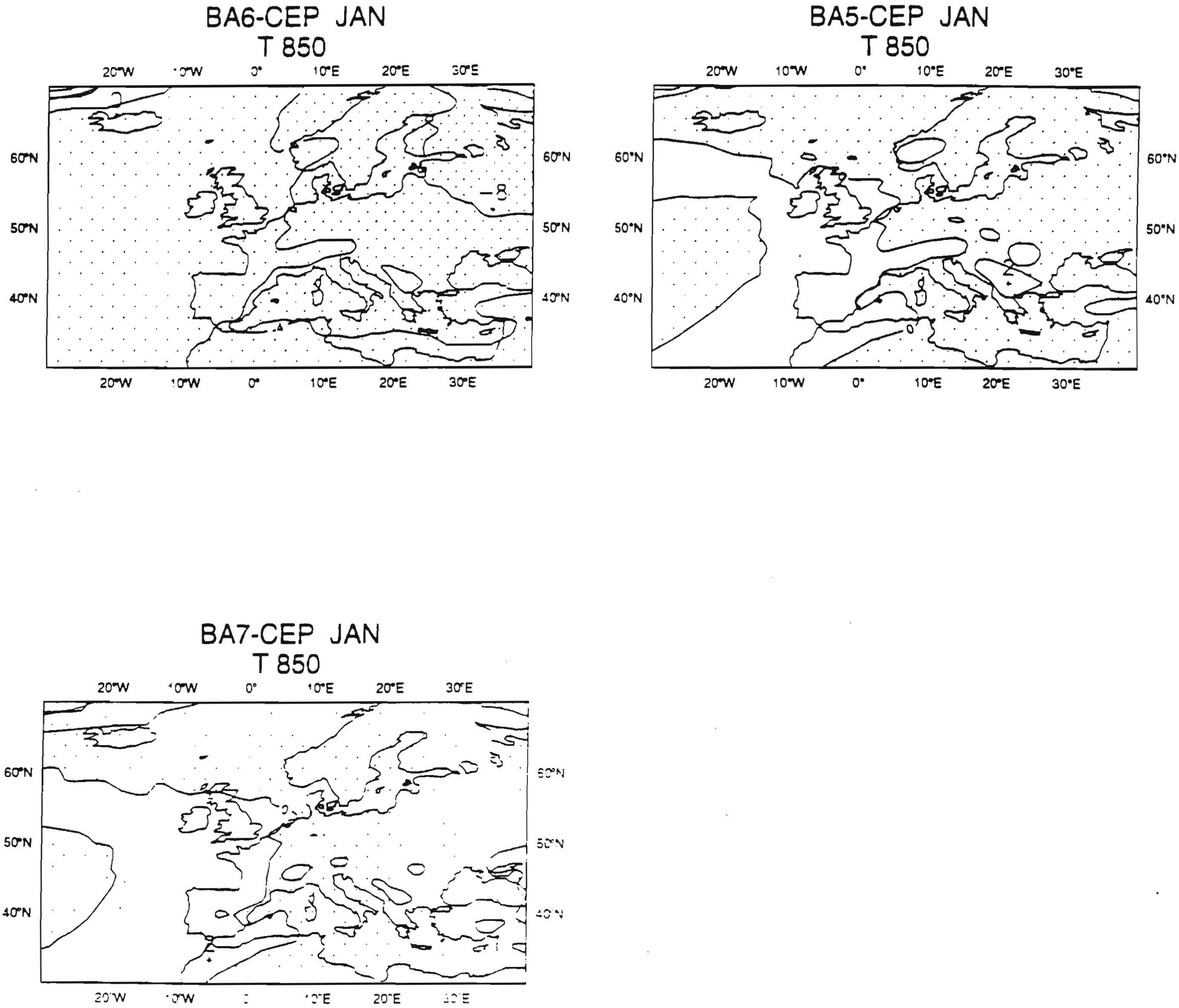
Differences between Arpège model and ECMWF analyses for the temperature distribution at 200 hPa in January. Contour spacing 2°C.



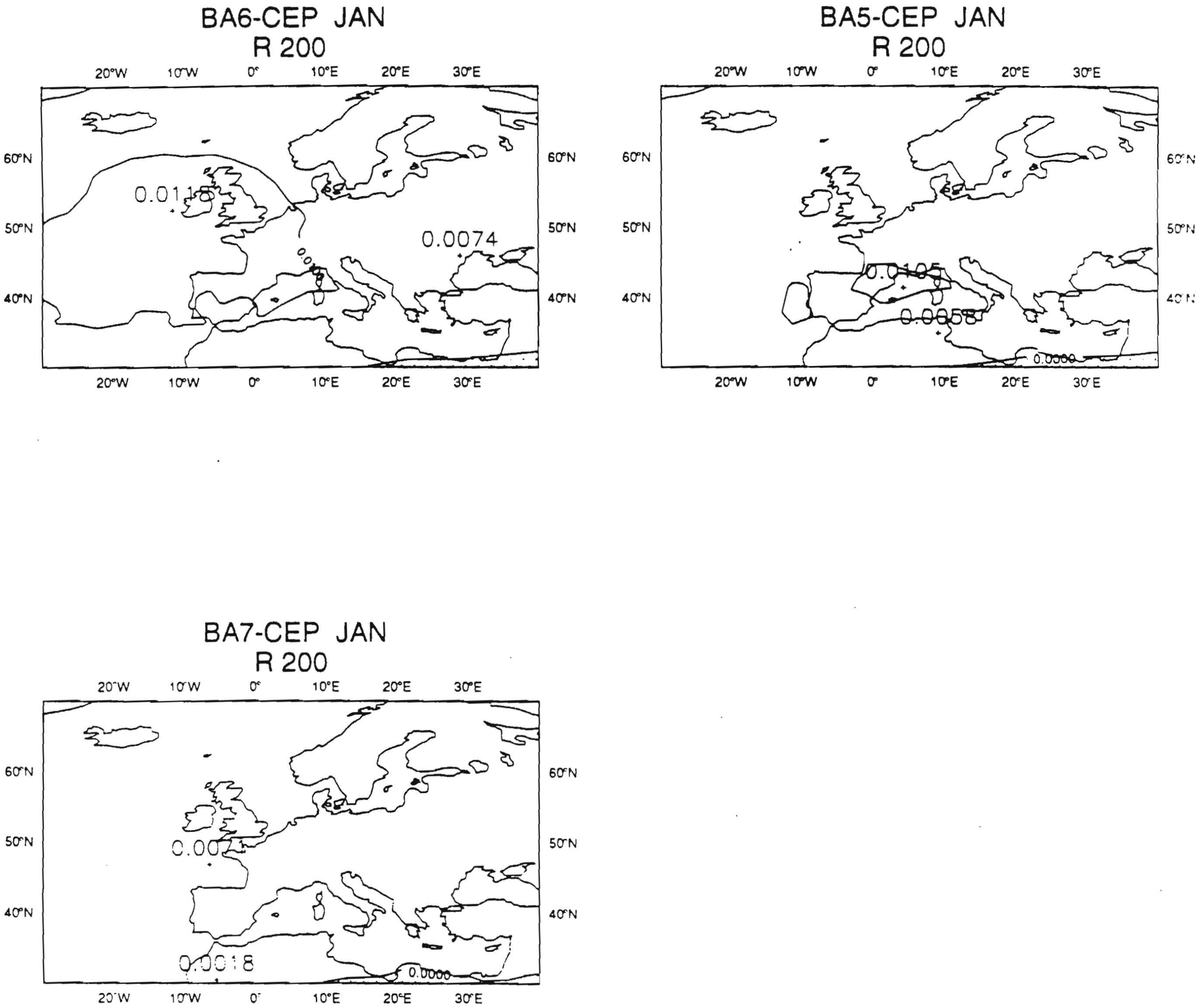




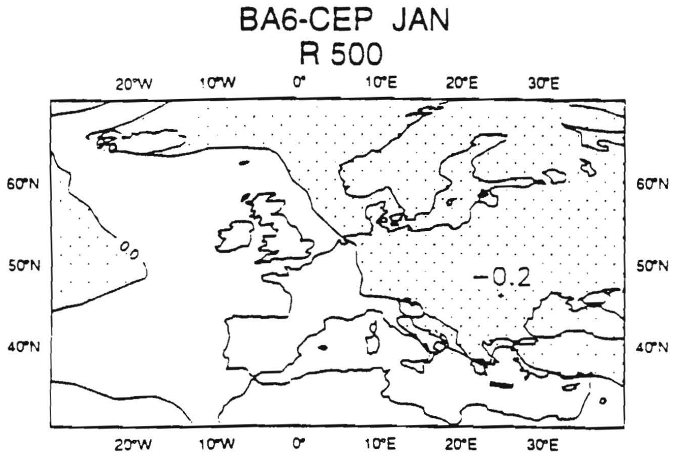
Differences between Arpège model and ECMWF analyses for the temperature distribution at 500 hPa in January. Contour spacing 4°C.

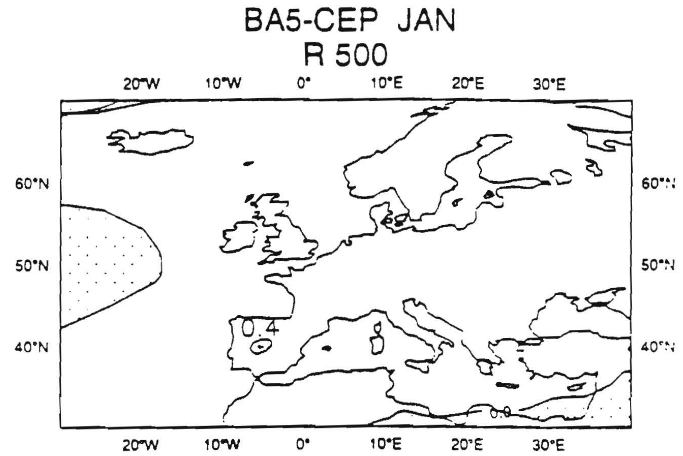


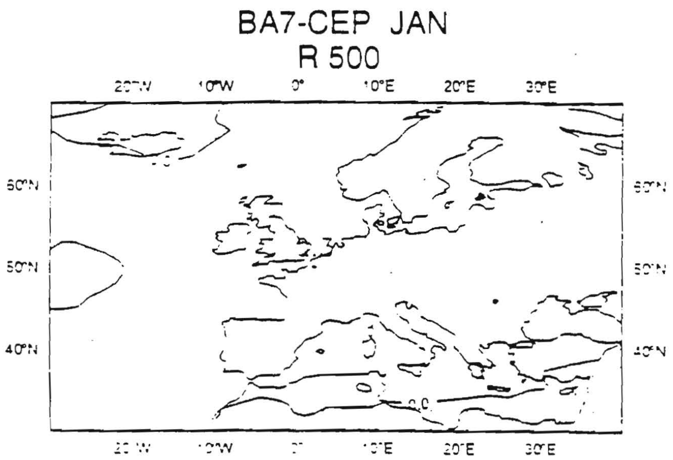
Differences between Arpège model and ECMWF analyses for the temperature distribution at 850 hPa in January. Contour spacing 4°C.



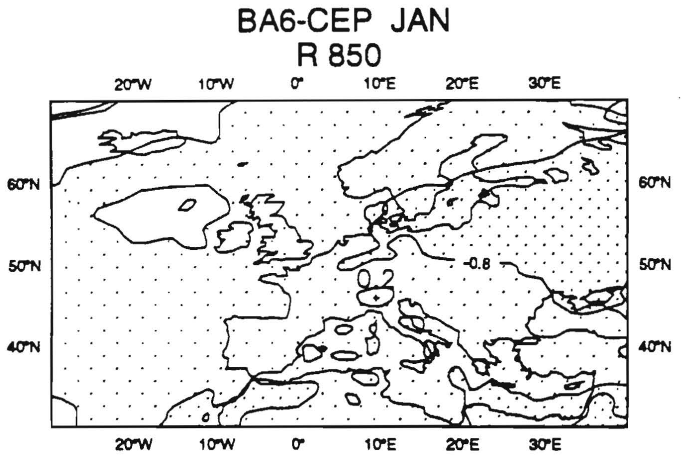
Differences between Arpège model and ECMWF analyses for the humidity distribution at 200 hPa in January. Contour spacing .004g/kg.

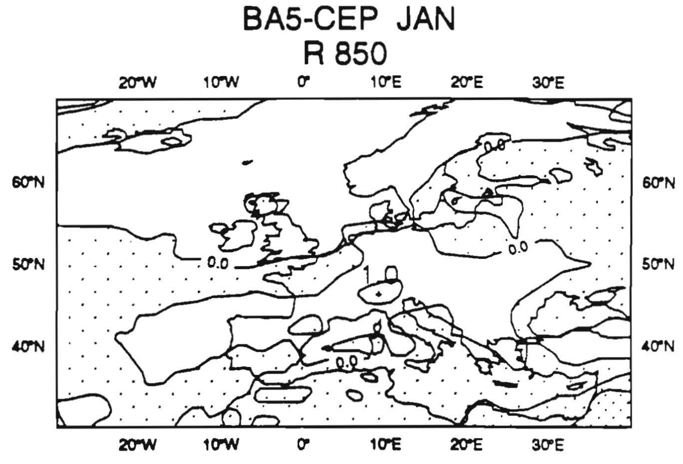


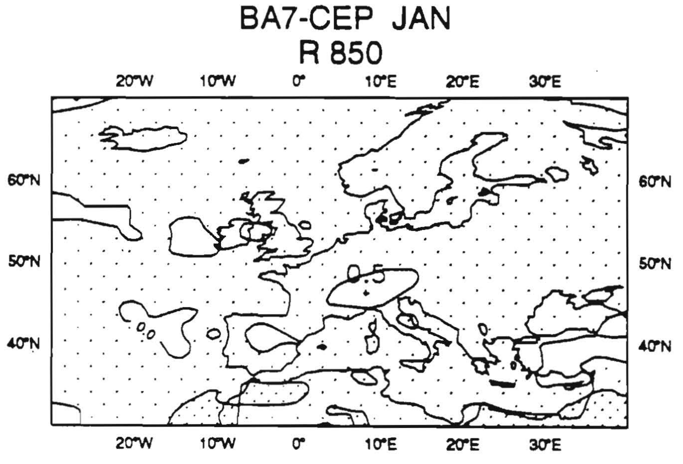




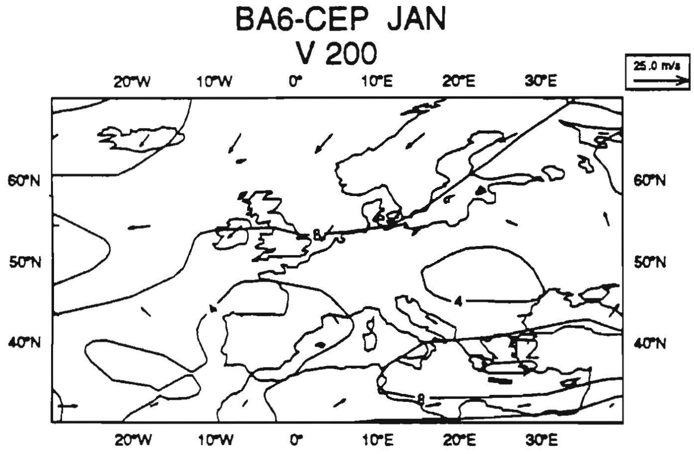
Differences between Arpège model and ECMWF analyses for the humidity distribution at 500 hPa in January. Contour spacing .4g/kg.

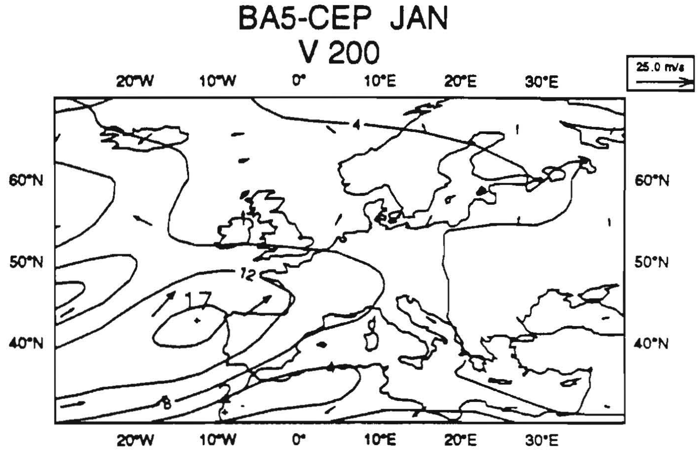


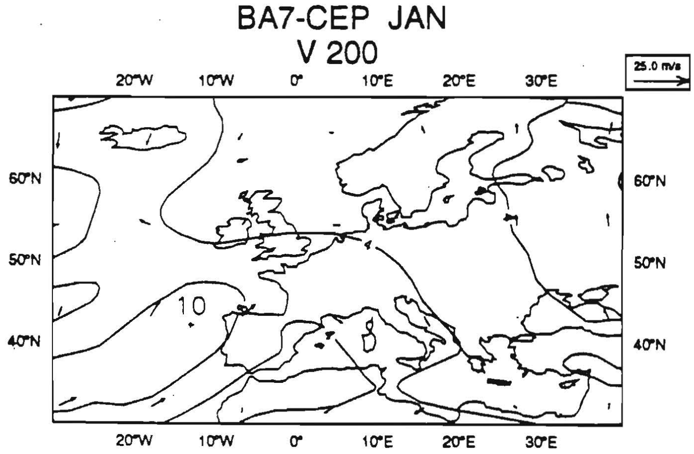




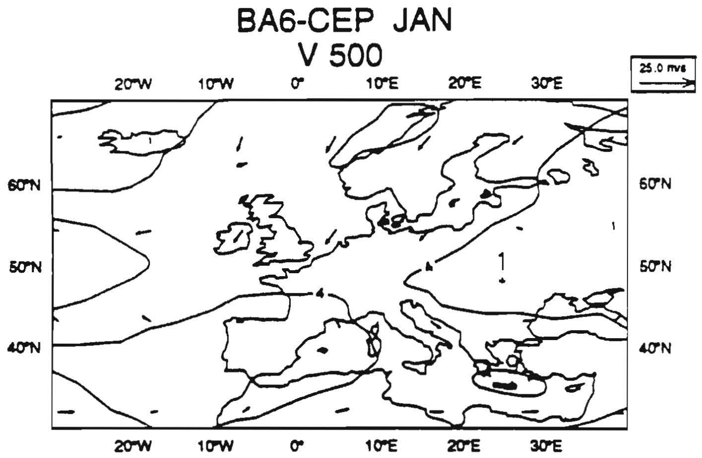
Differences between Arpège model and ECMWF analyses for the humidity distribution at 850 hPa in January. Contour spacing .4g/kg.

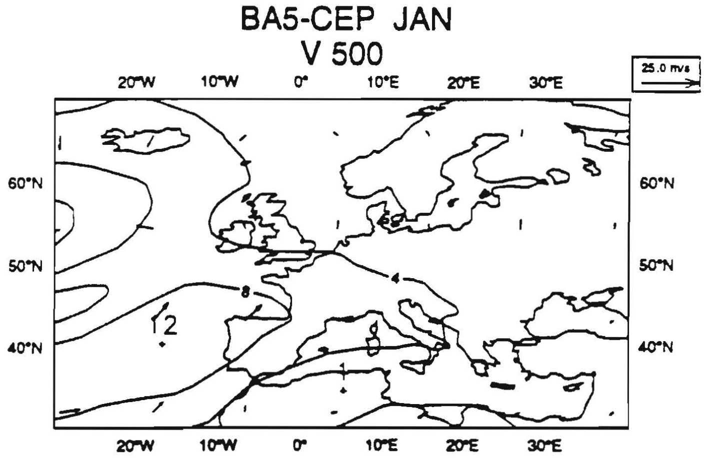


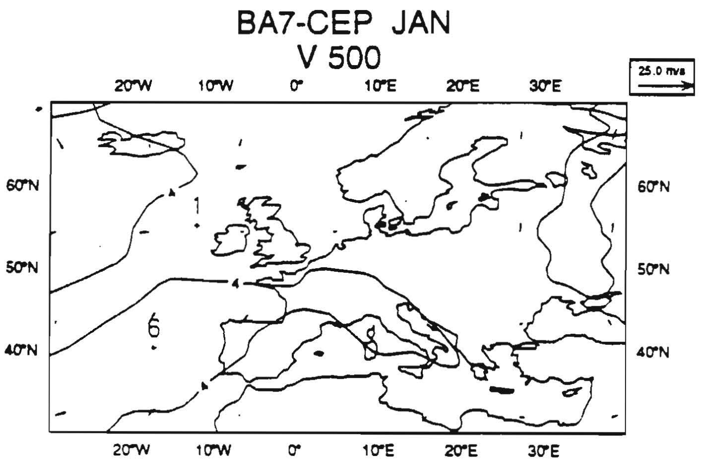




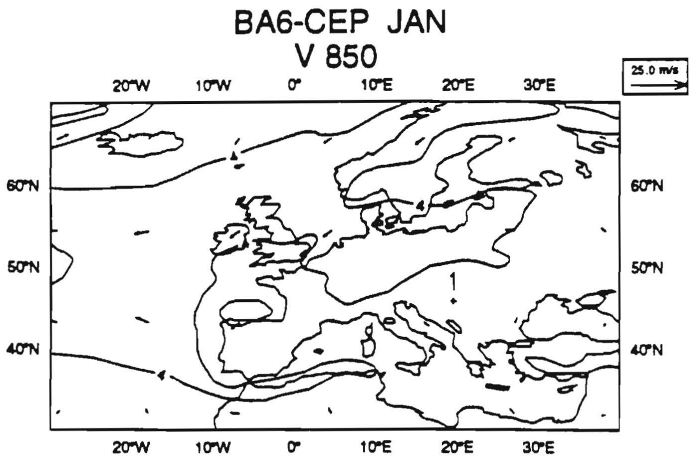
Differences between Arpège model and ECMWF analyses for the wind distribution at 200 hPa in January. Contour spacing 4m/s.

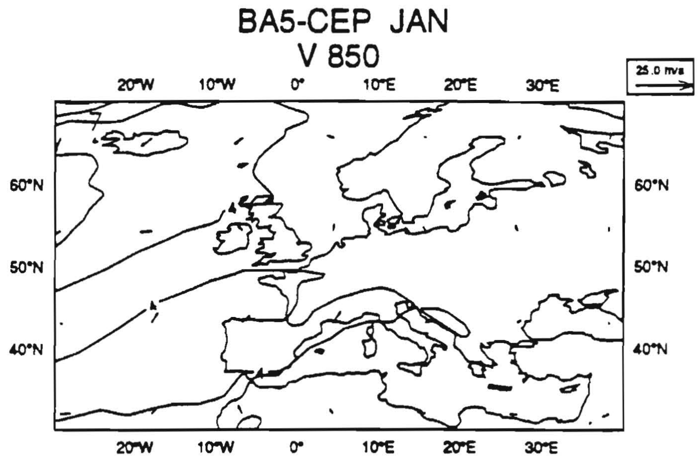


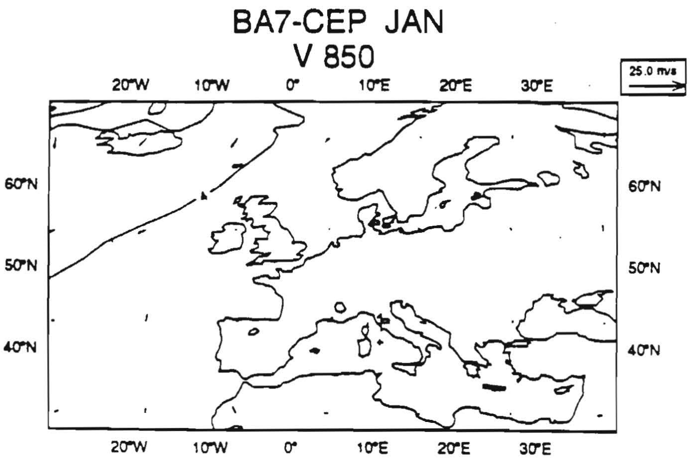




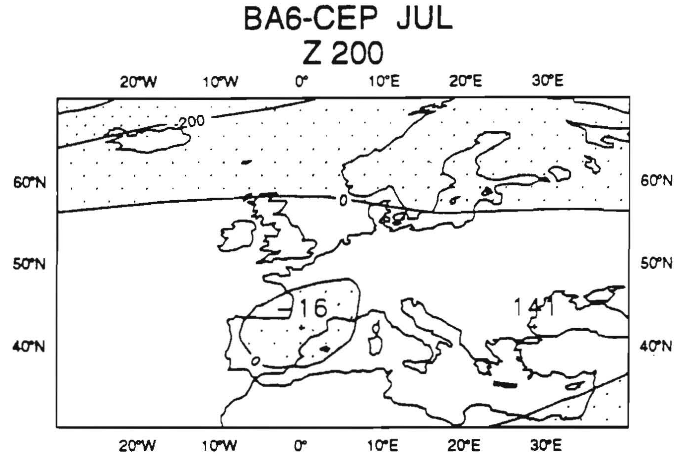
Differences between Arpège model and ECMWF analyses for the wind distribution at 500 hPa in January. Contour spacing 4m/s.

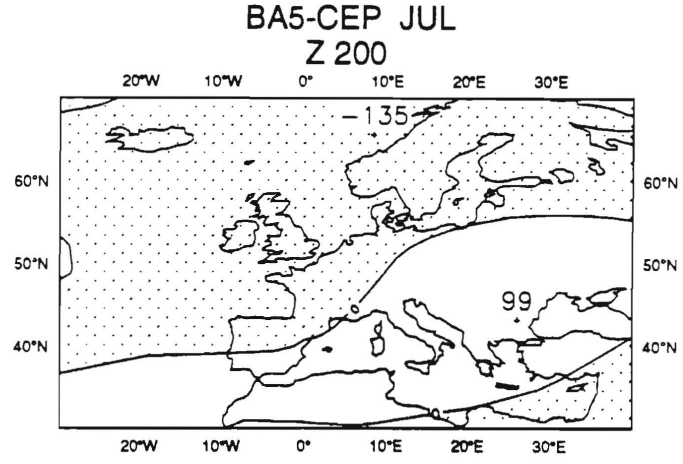


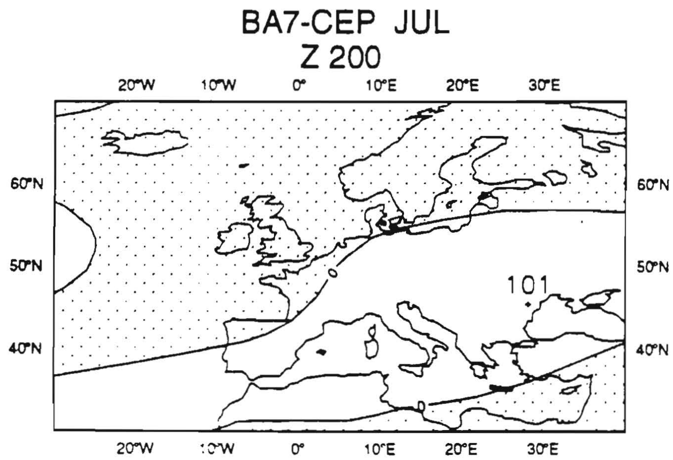




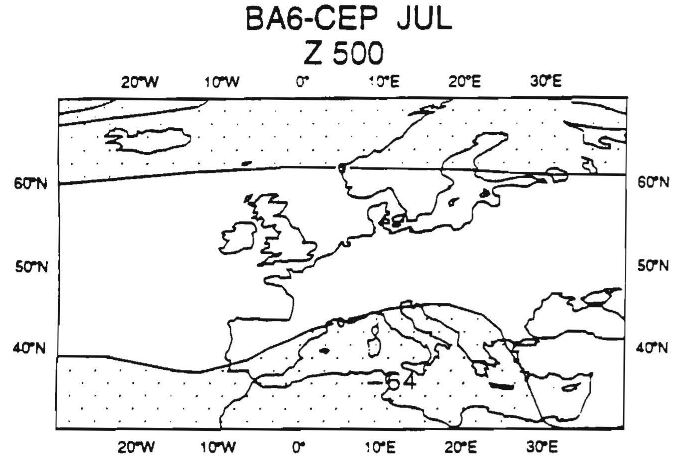
Differences between Arpège model and ECMWF analyses for the wind distribution at 850 hPa in January. Contour spacing 4m/s.

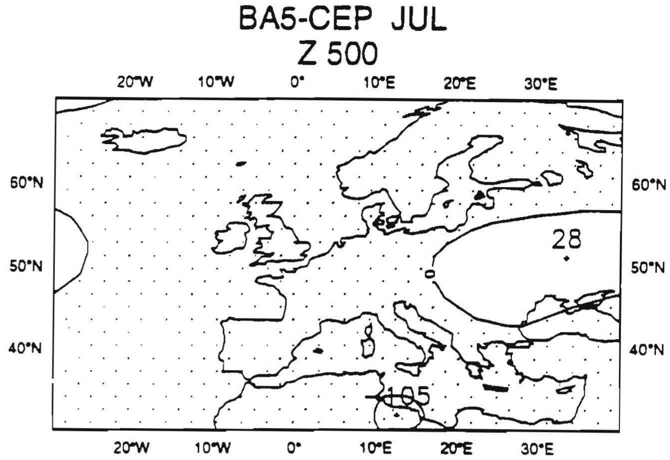


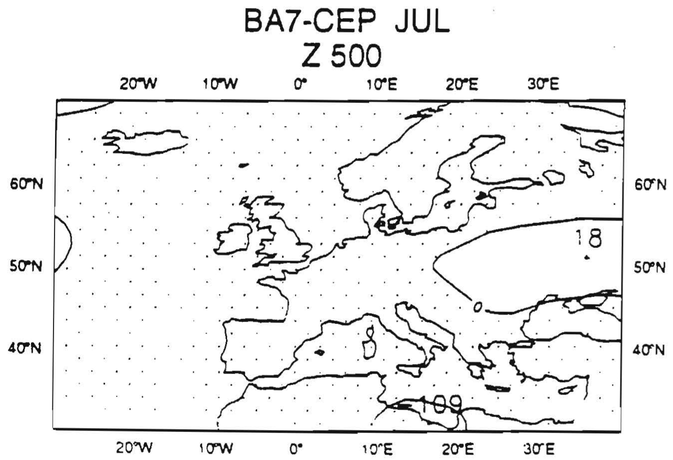




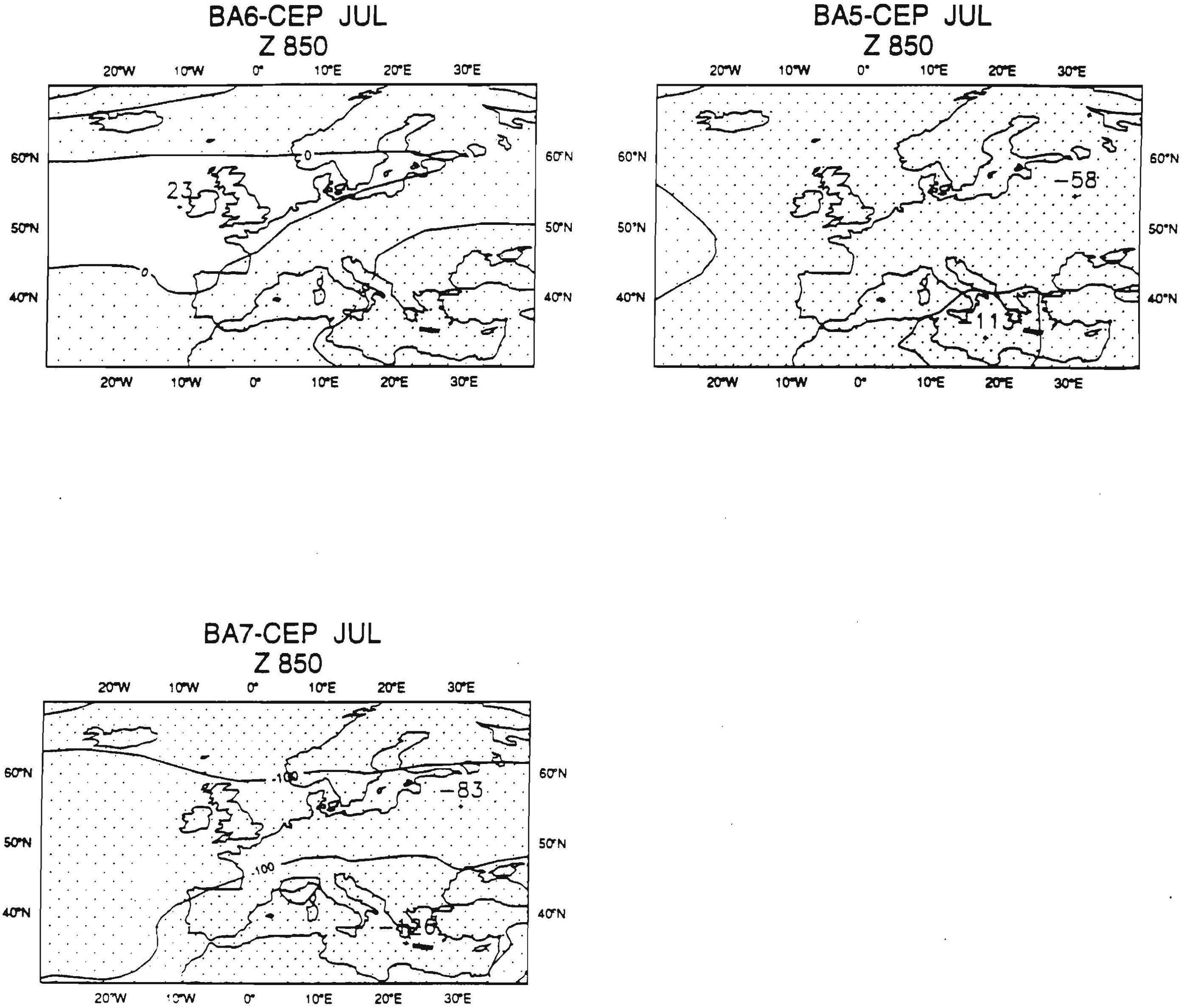
Differences between Arpège model and ECMWF analyses for the geopotential distribution at 200 hPa in July. Contour spacing 200m.





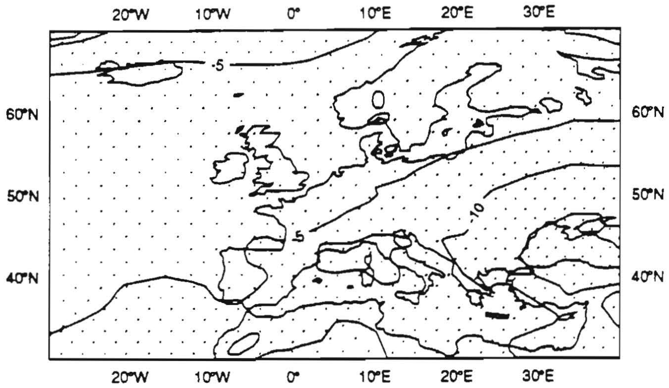


Differences between Arpège model and ECMWF analyses for the geopotential distribution at 500 hPa in July. Contour spacing 100m.

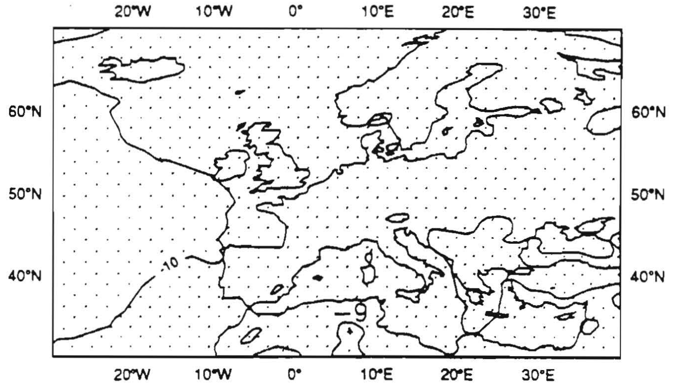


Differences between Arpège model and ECMWF analyses for the geopotential distribution at 850 hPa in July. Contour spacing 50m.

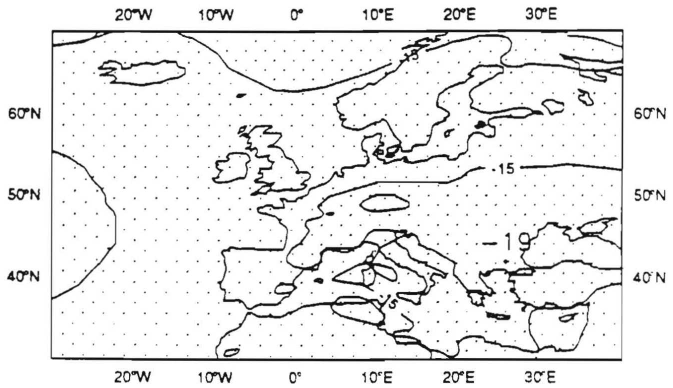
BA6-CEP JUL
PMER



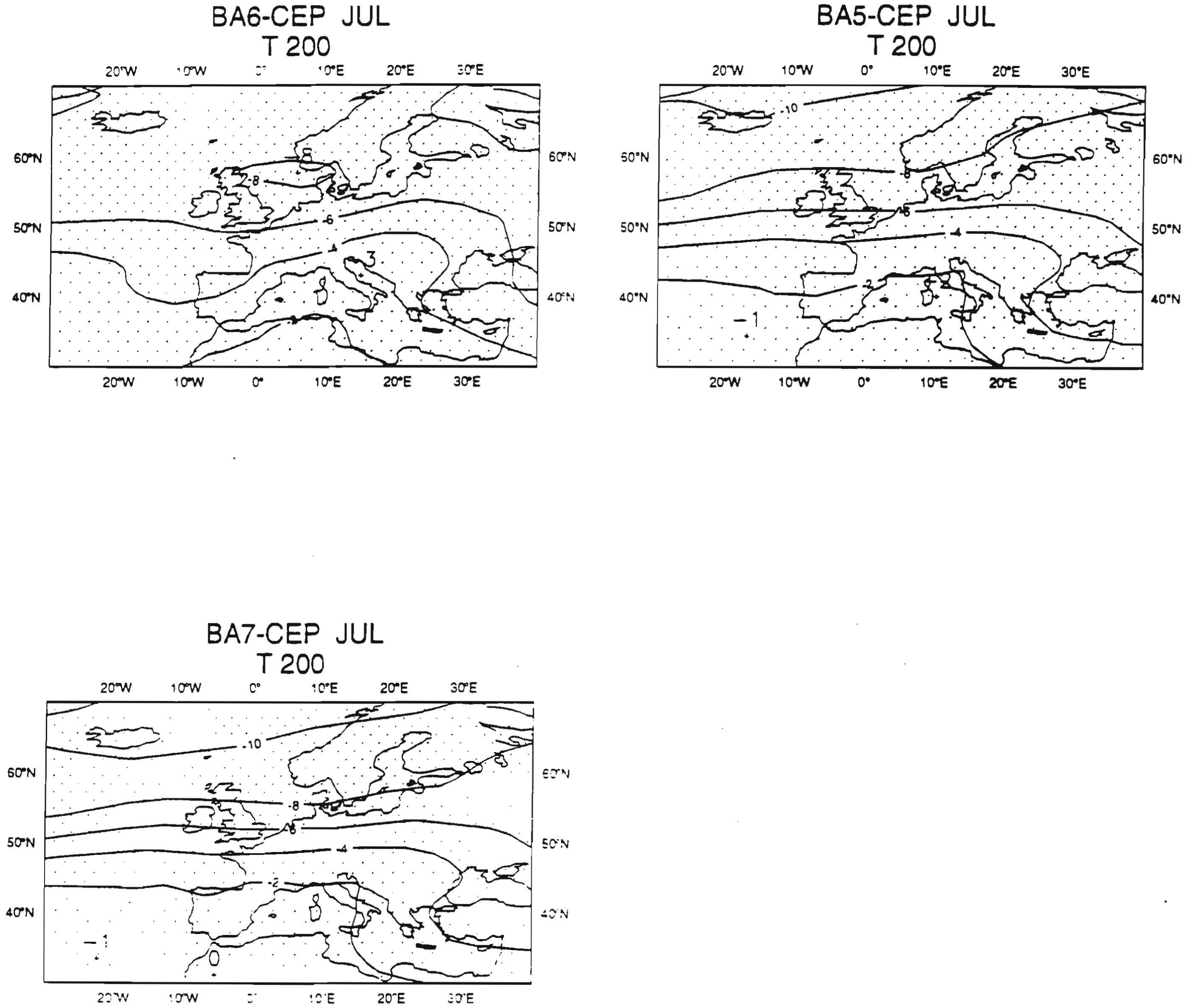
BA5-CEP JUL
PMER



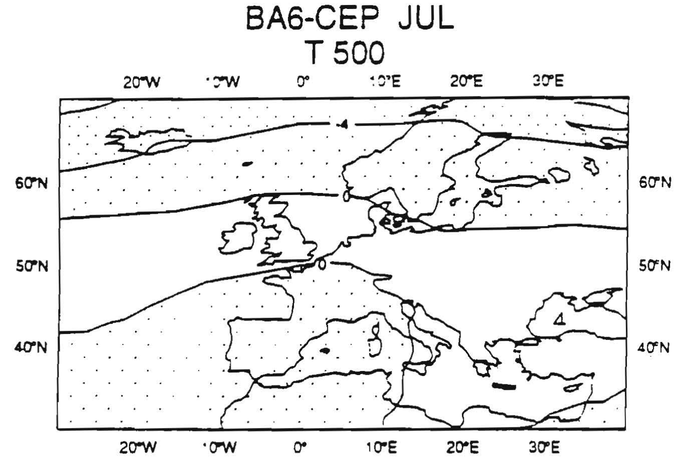
BA7-CEP JUL
PMER

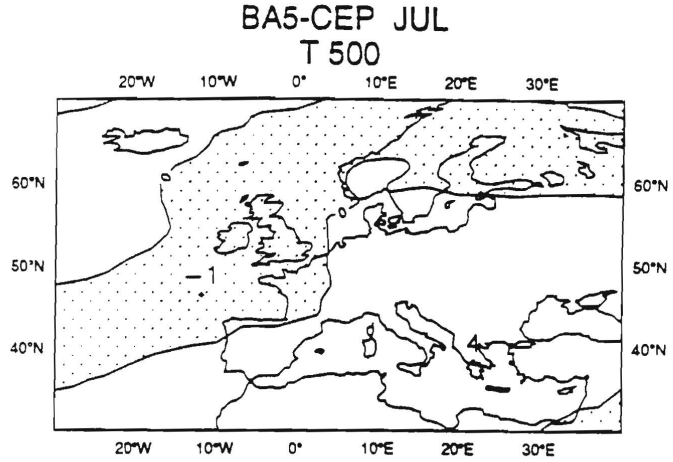


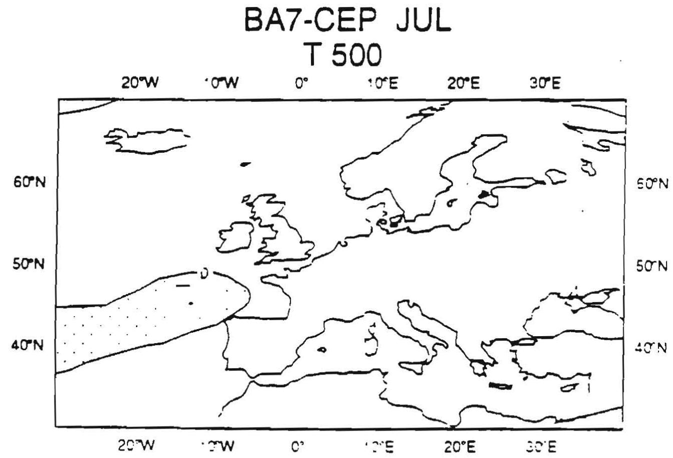
Differences between Arpège model and ECMWF analyses for the sea level pressure distribution July. Contour spacing 5hPa.



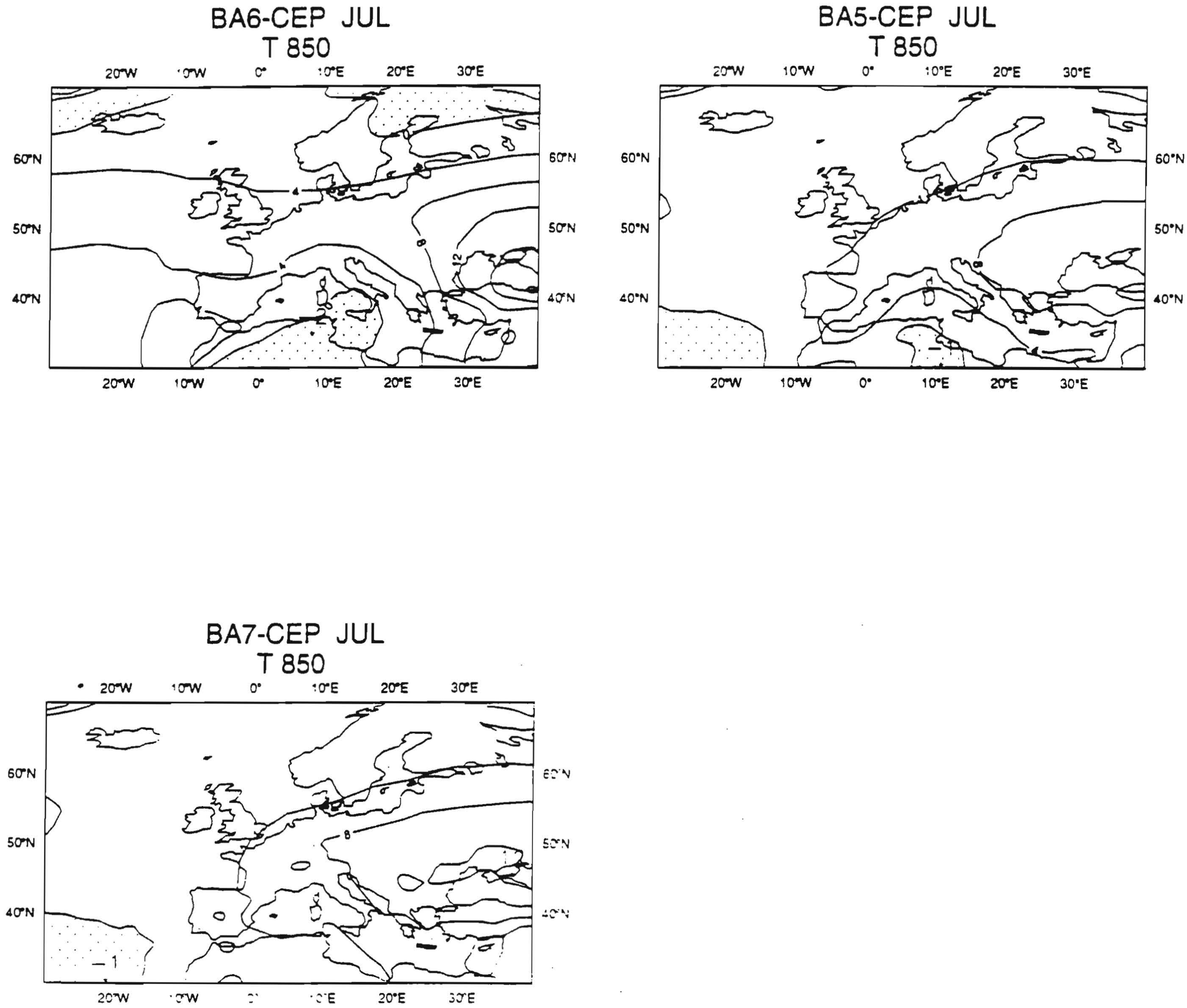
Differences between Arpège model and ECMWF analyses for the temperature distribution at 200 hPa in July. Contour spacing 4°C.



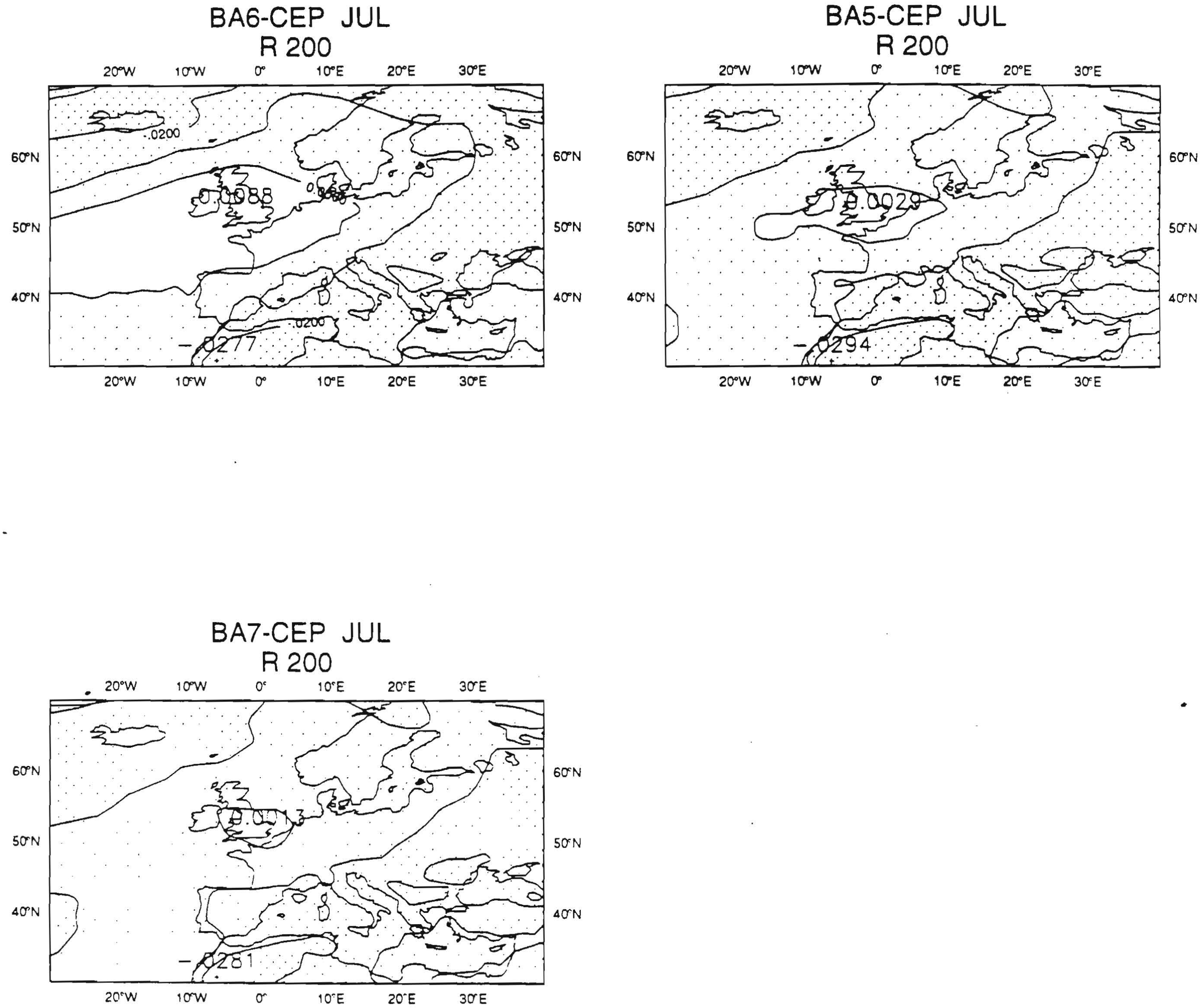




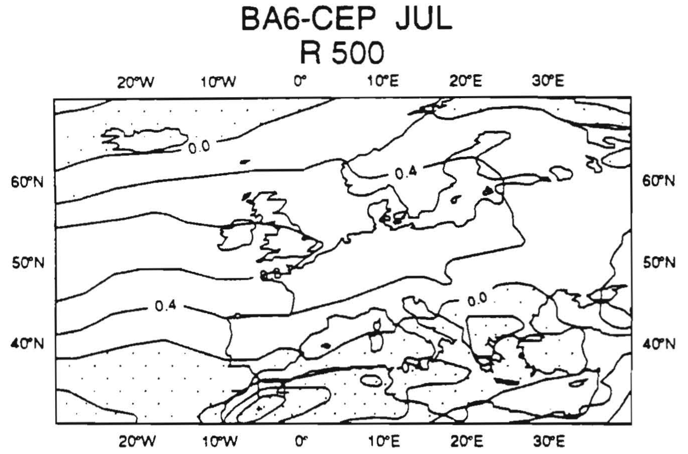
Differences between Arpège model and ECMWF analyses for the temperature distribution at 500 hPa in July. Contour spacing 4°C.

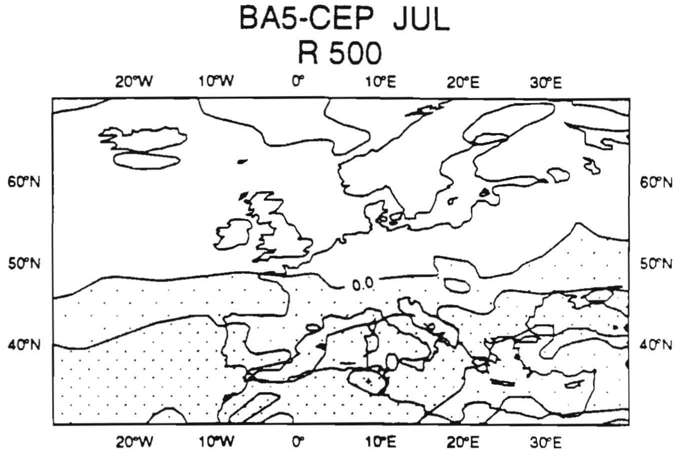


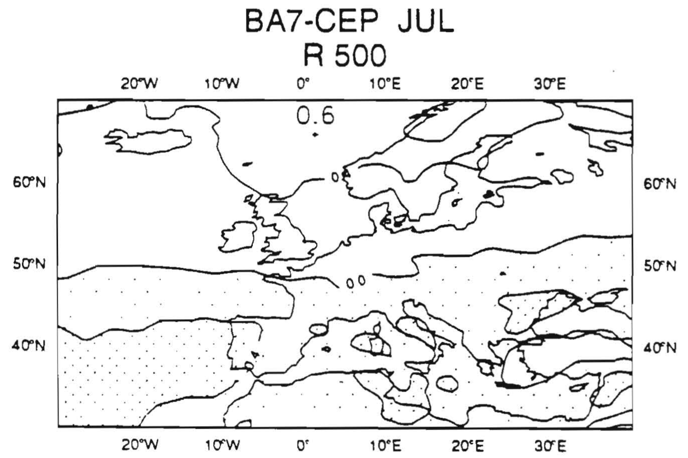
Differences between Arpège model and ECMWF analyses for the temperature distribution at 850 hPa in July. Contour spacing 4°C.



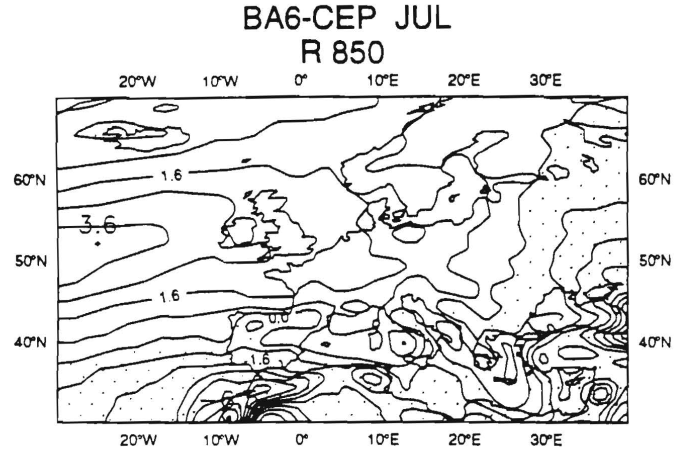
Differences between Arpège model and ECMWF analyses for the humidity distribution at 200 hPa in July. Contour spacing .01g/kg.

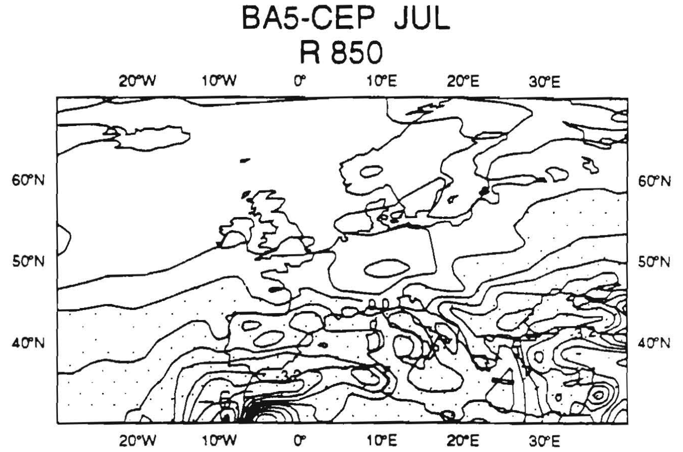


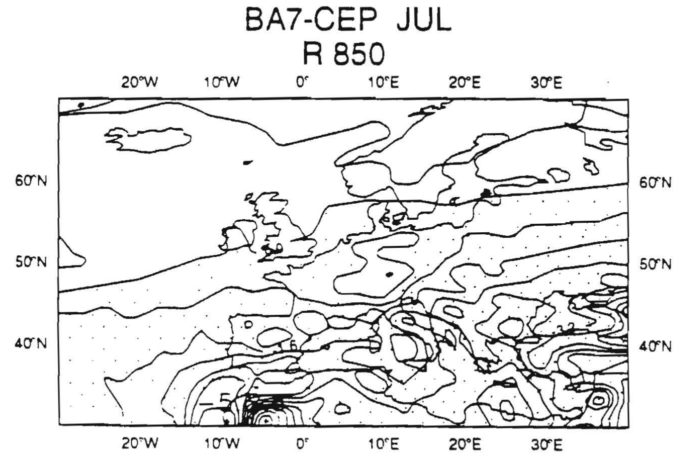




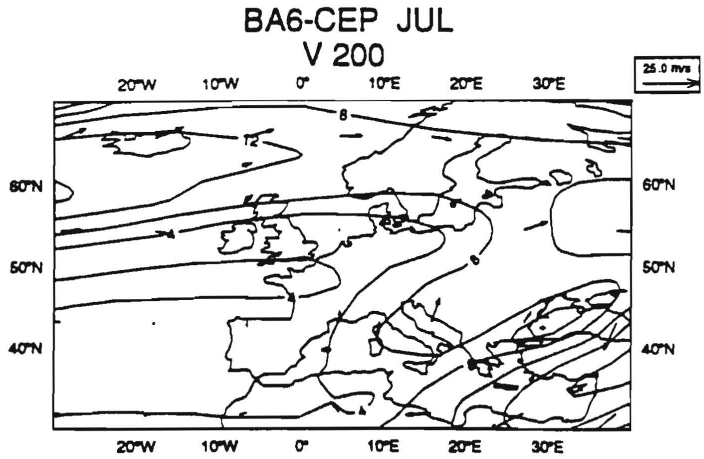
Differences between Arpège model and ECMWF analyses for the humidity distribution at 500 hPa in July. Contour spacing .4g/kg.

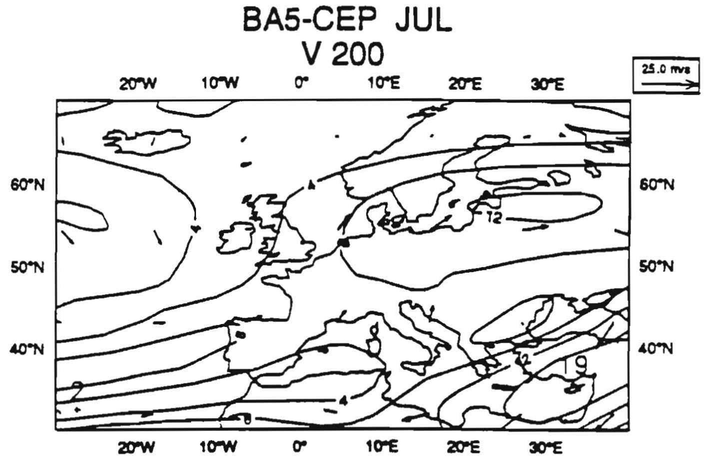


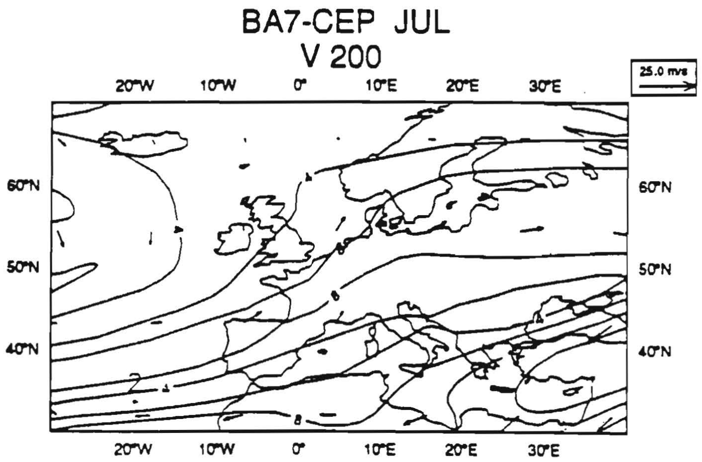




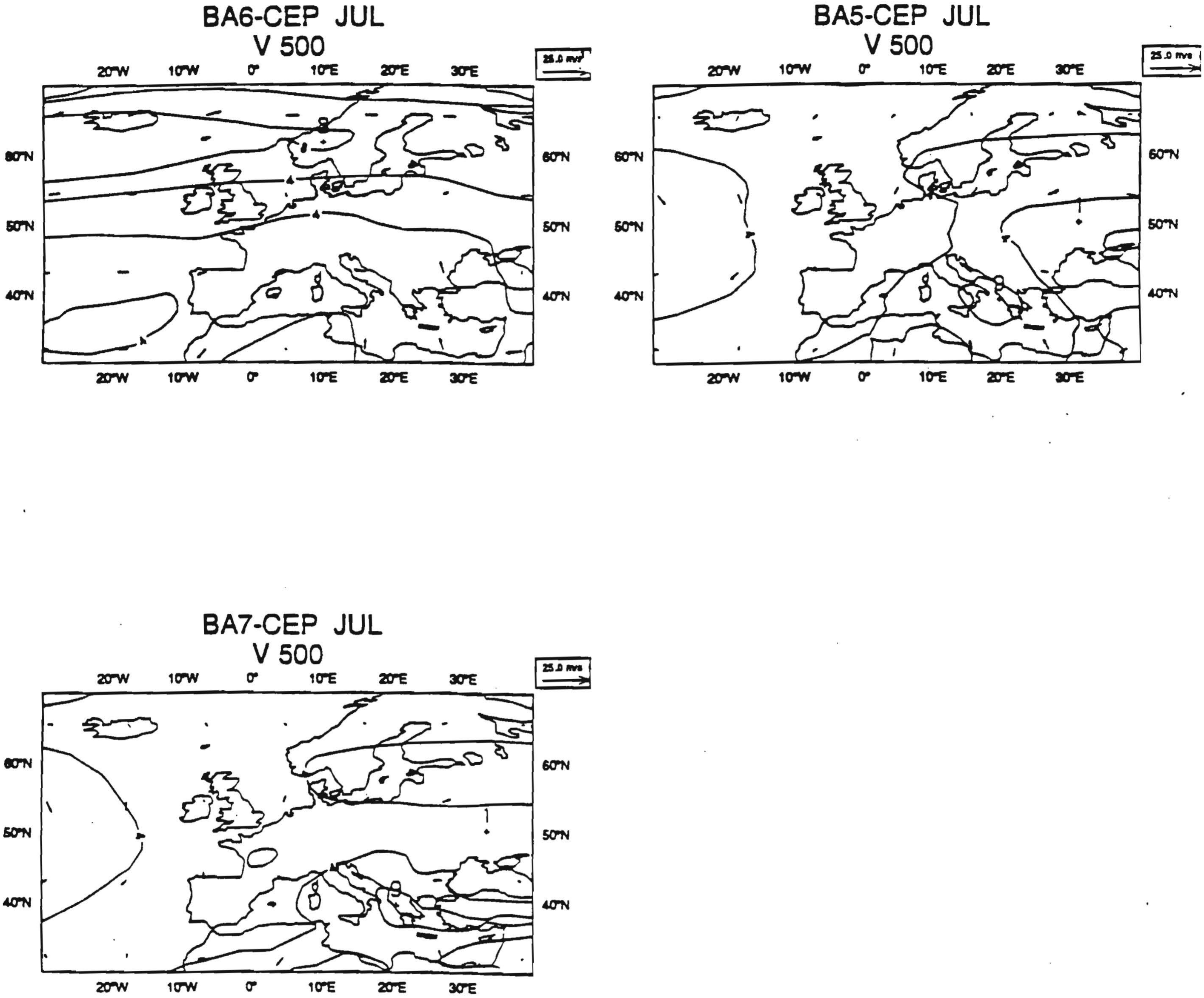
Differences between Arpège model and ECMWF analyses for the humidity distribution at 850 hPa in July. Contour spacing .8g/kg.





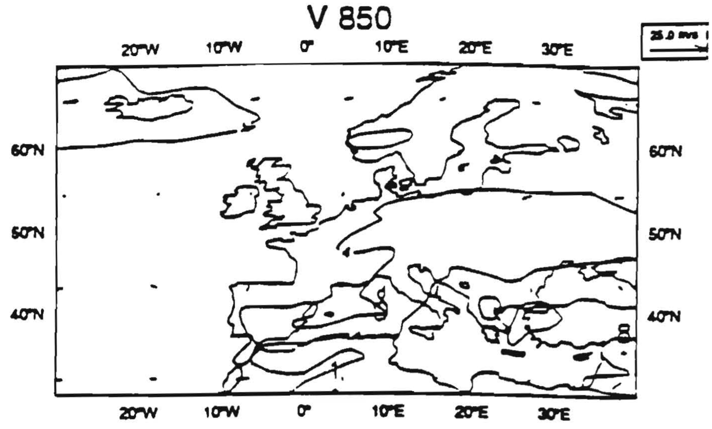


Differences between Arpège model and ECMWF analyses for the wind distribution at 200 hPa in July. Contour spacing 4m/s.

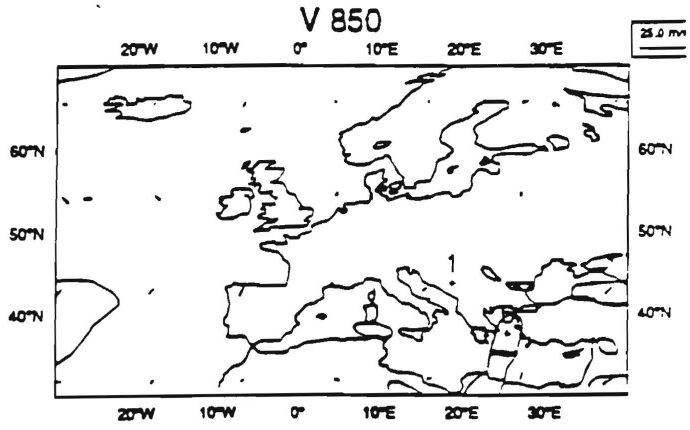


Differences between Arpège model and ECMWF analyses for the wind distribution at 500 hPa in July. Contour spacing 4m/s.

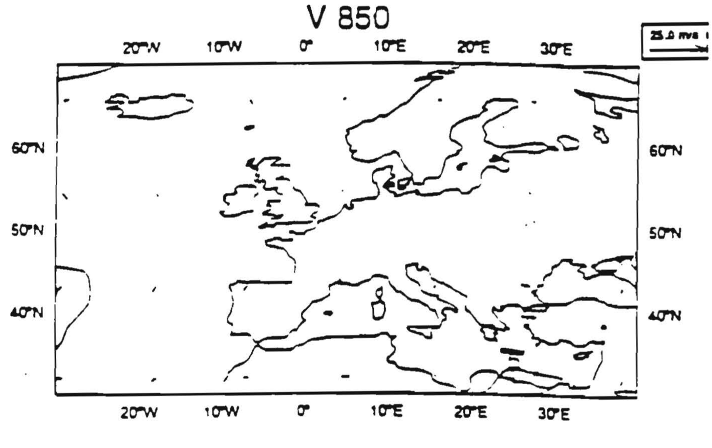
BA6-CEP JUL
V 850



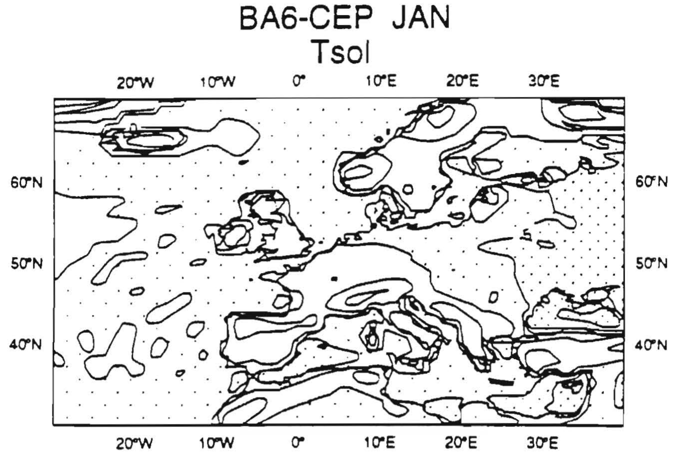
BA5-CEP JUL
V 850

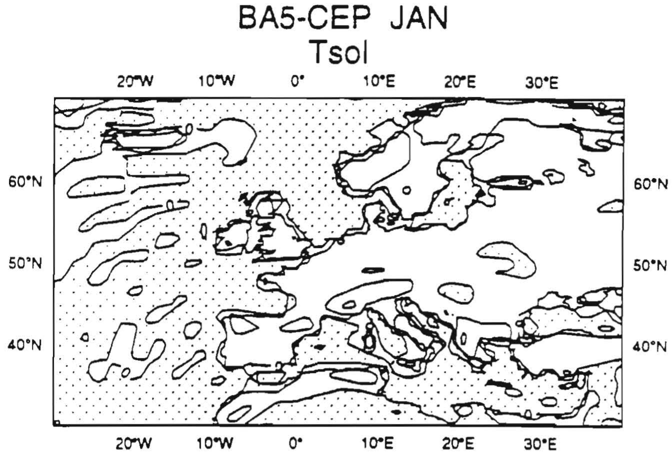


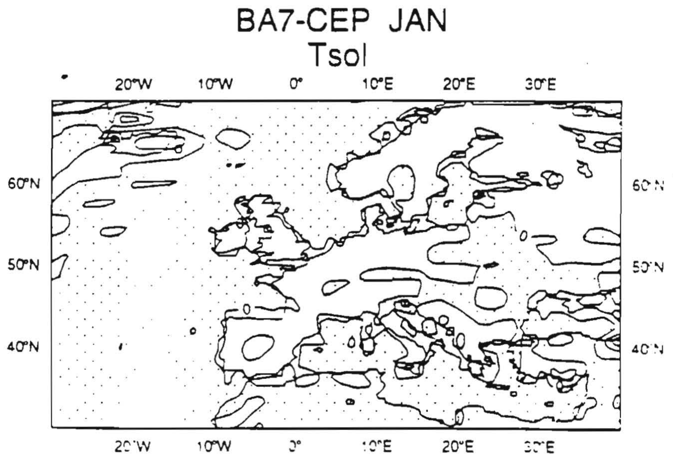
BA7-CEP JUL
V 850



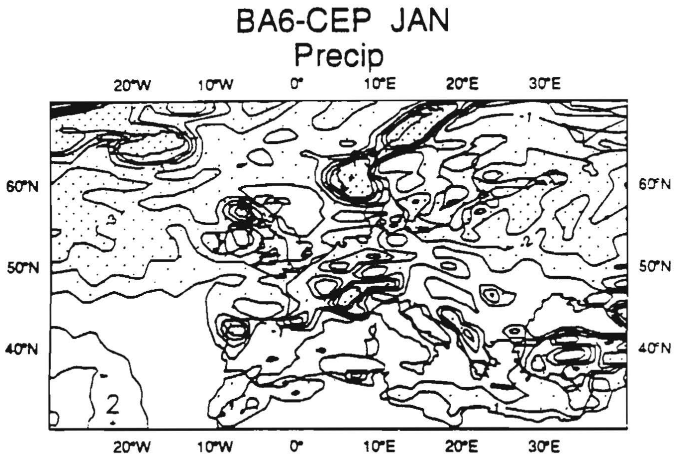
Differences between Arpège model and ECMWF analyses for the wind distribution at 850 hPa in July. Contour spacing 4m/s.

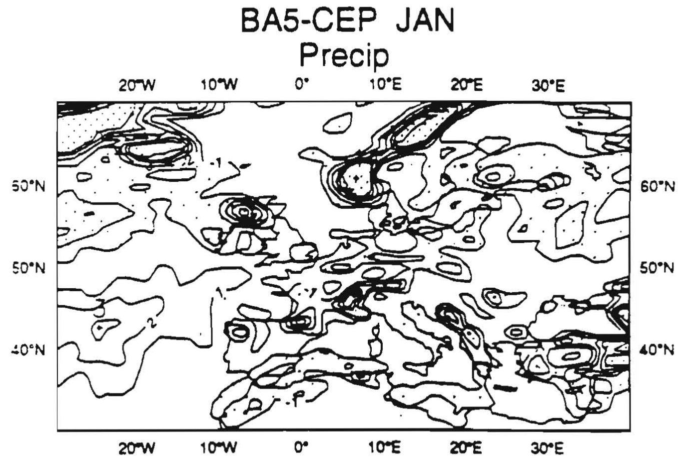


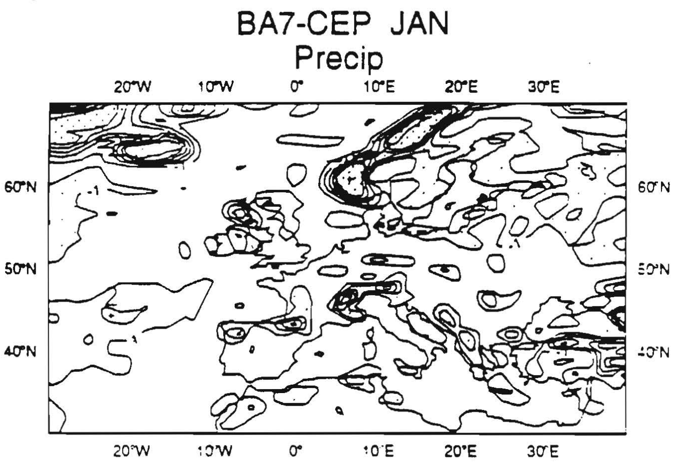




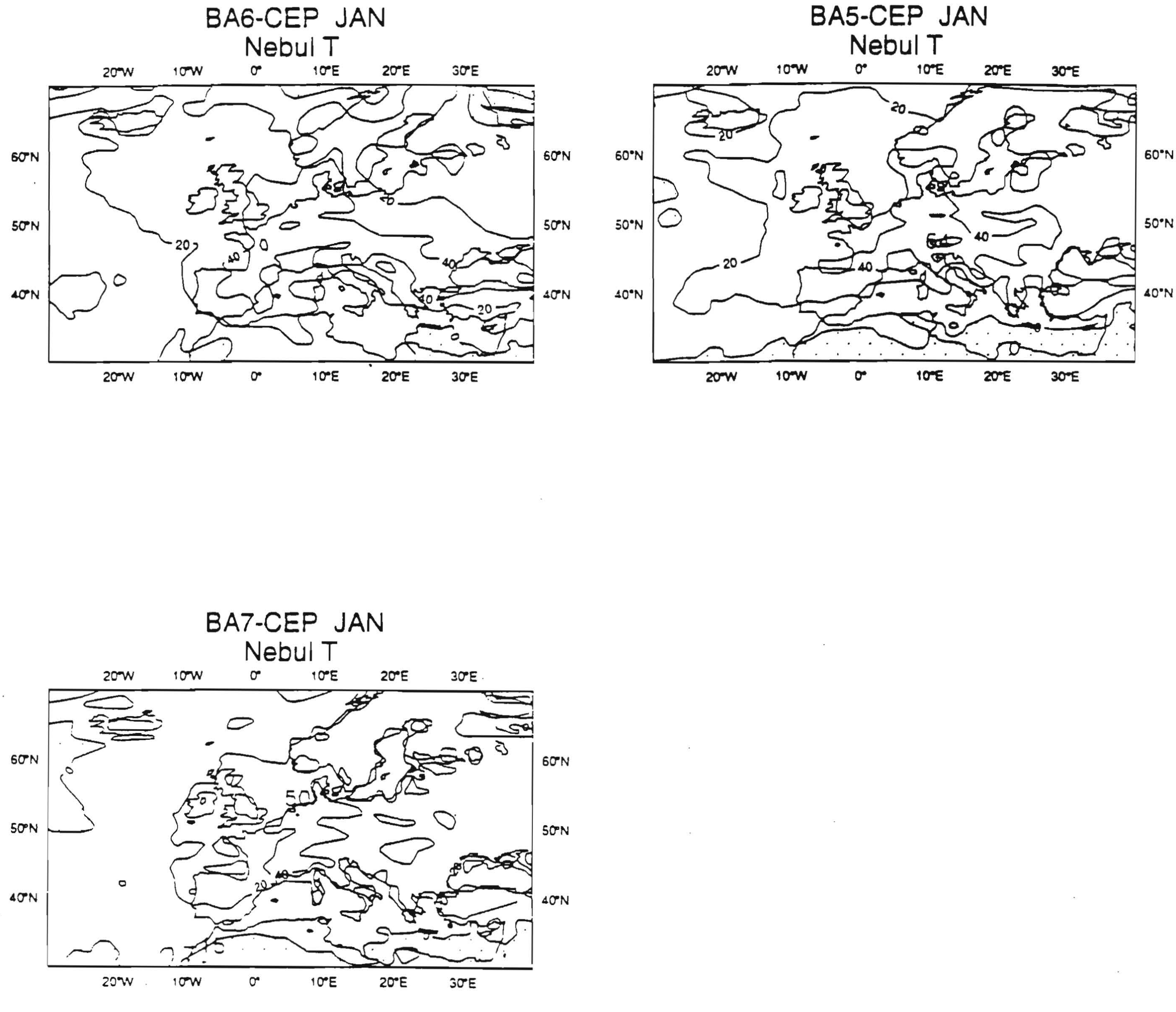
Differences between Arpège model and ECMWF analyses for the surface temperature distribution in January. Contour spacing 5°C.



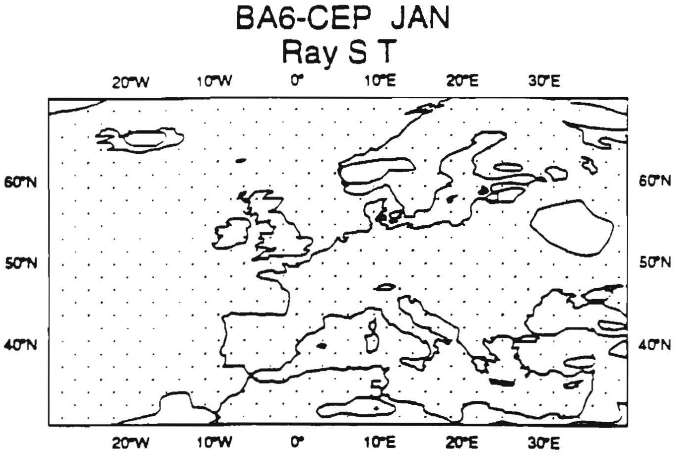


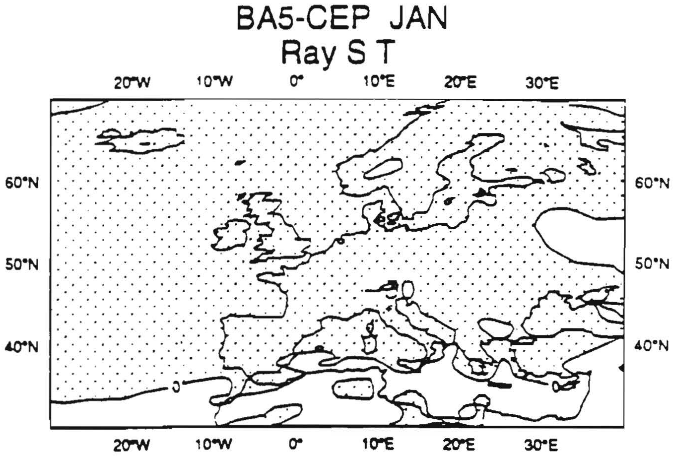


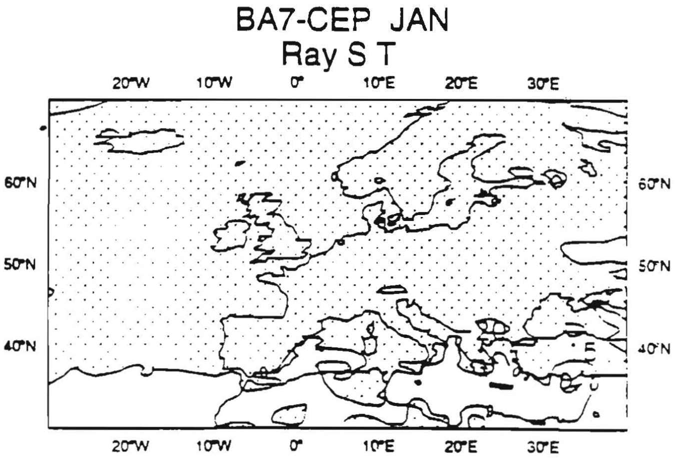
Differences between Arpège model and ECMWF analyses for the precipitation distribution in January. Contour spacing 1mm/day.



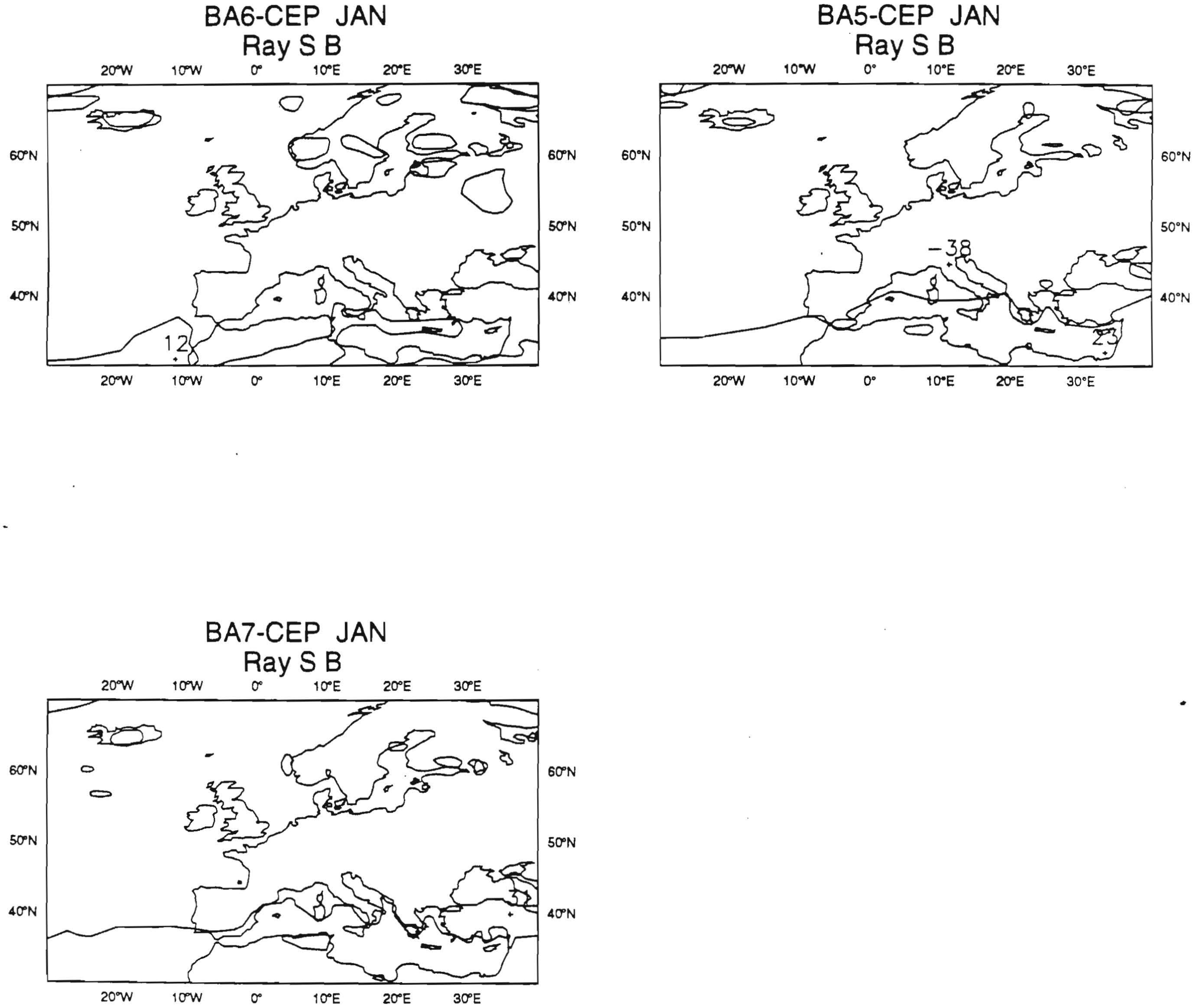
Differences between Arpège model and ECMWF analyses for the cloudiness distribution in January. Contour spacings: 20, 40 and 60%.





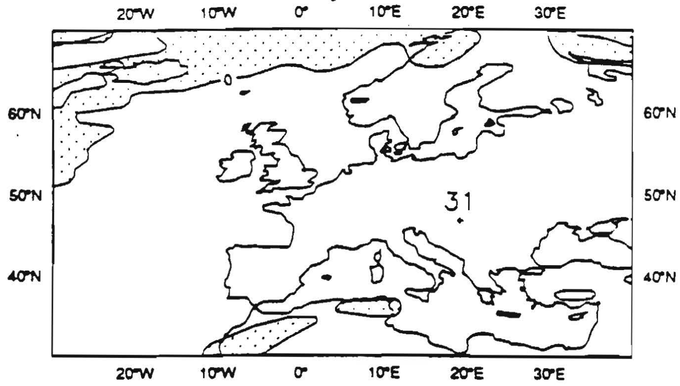


Differences between Arpège model and ECMWF analyses for the ST radiation distribution in January. Contour spacing $40W/m^2$.

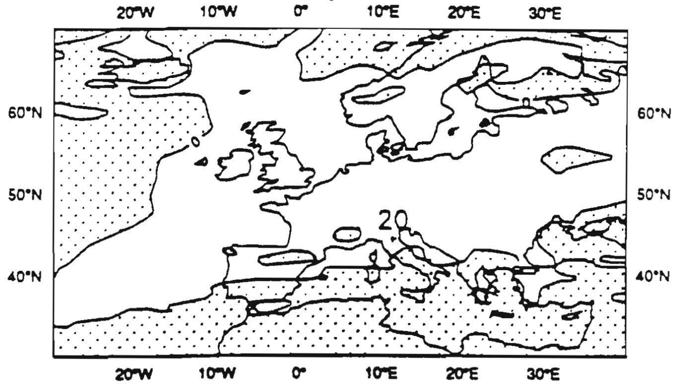


a) Differences between Arpège model and ECMWF analyses for the SB radiation distribution in January. Contour spacing 40W/m^2.

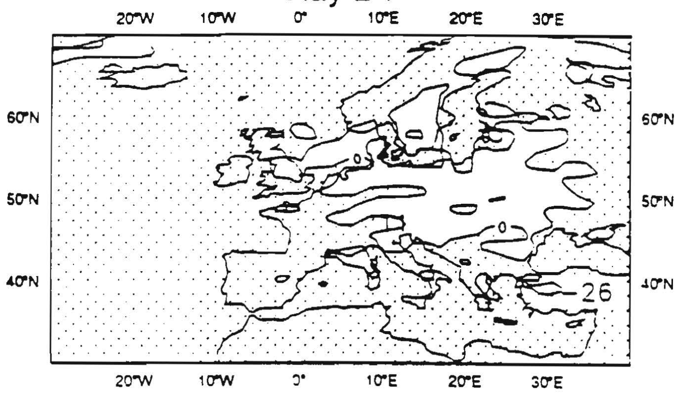
BA6-CEP JAN
Ray L T



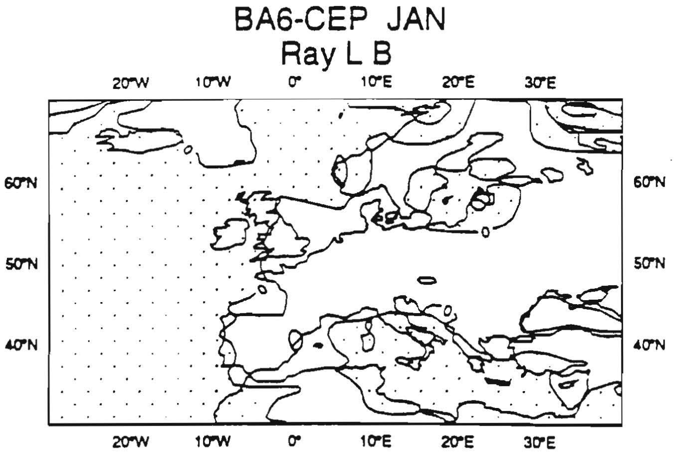
BA5-CEP JAN
Ray L T

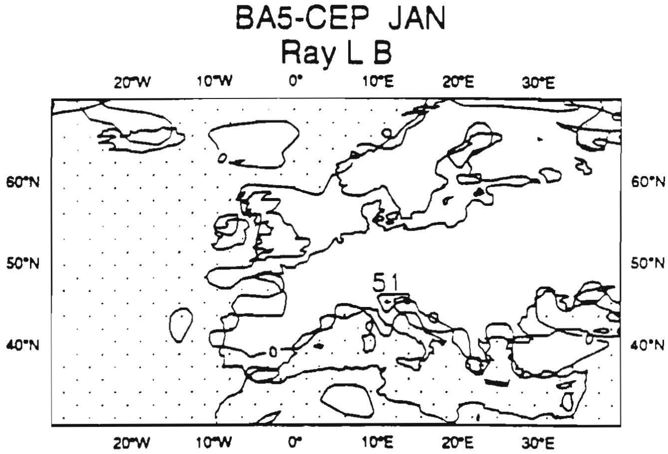


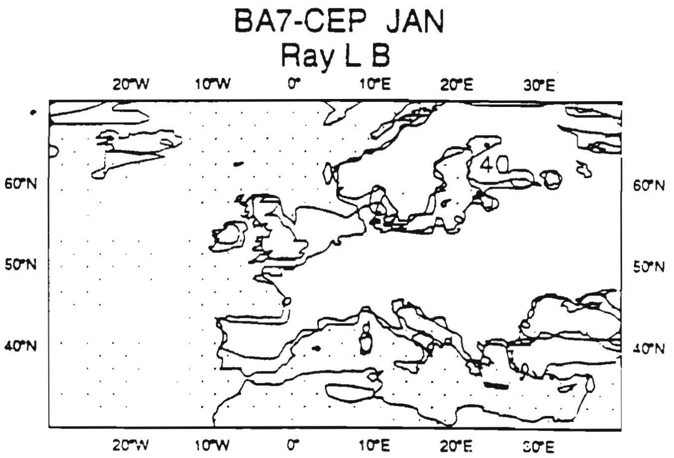
BA7-CEP JAN
Ray L T



Differences between Arpège model and ECMWF analyses for the LT radiation distribution in January. Contour spacing 40W/m².

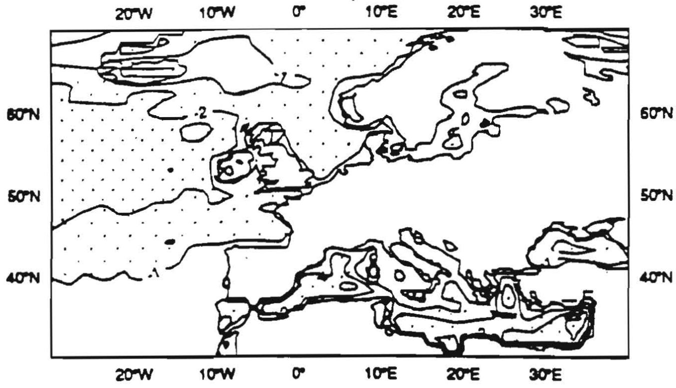




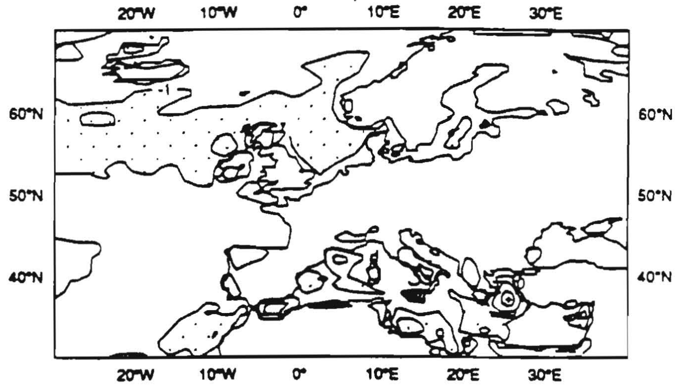


Differences between Arpège model and ECMWF analyses for the LB radiation distribution in January. Contour spacing $40W/m^2$.

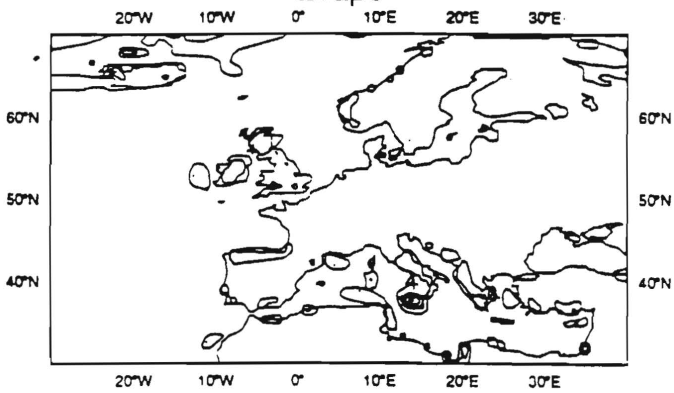
BA6-CEP JAN
Evapo



BA5-CEP JAN
Evapo

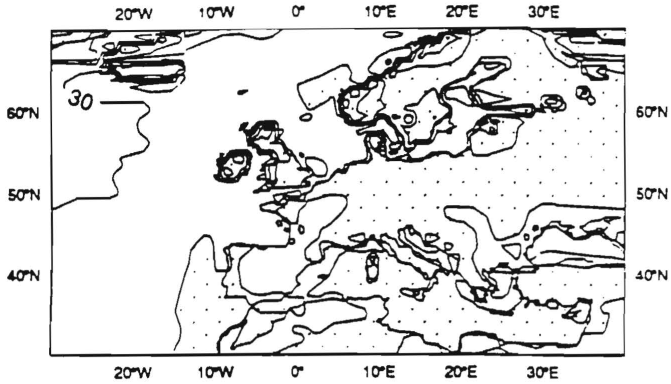


BA7-CEP JAN
Evapo

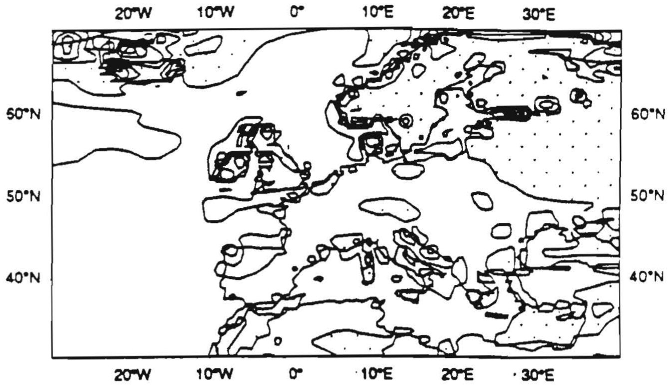


Differences between Arpège model and ECMWF analyses for the evaporation distribution in January. Contour spacing 1mm/day.

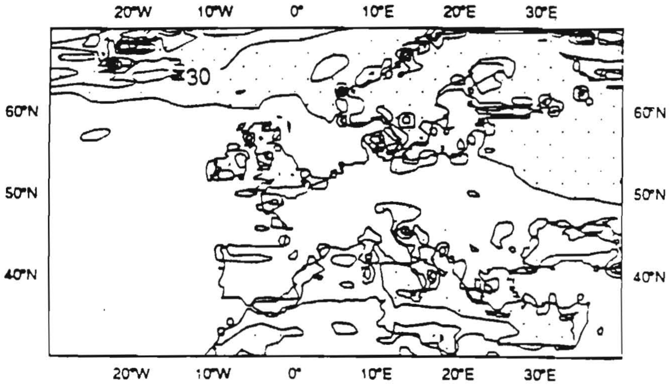
BA6-CEP JAN
Chal Ss



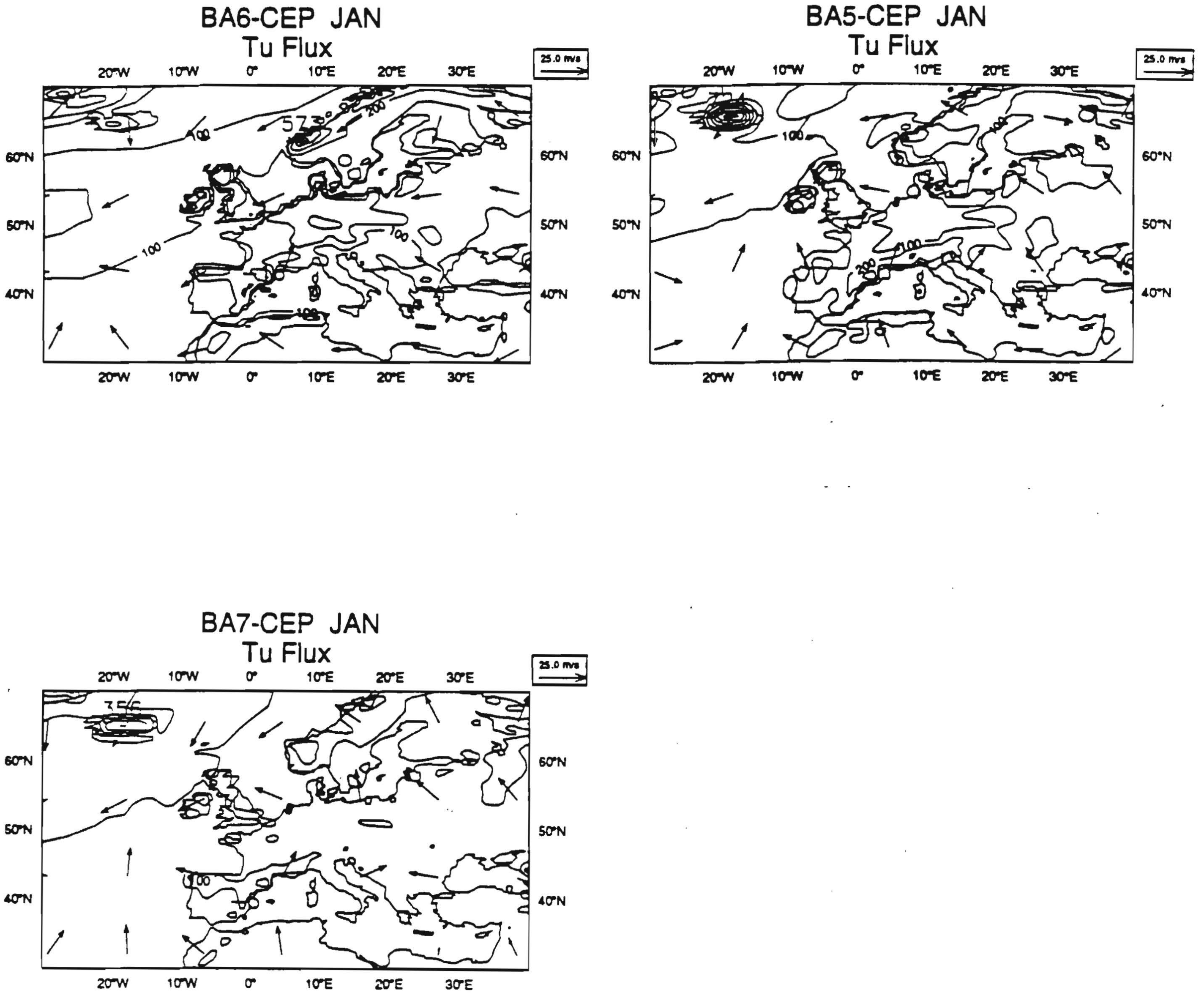
BA5-CEP JAN
Chal Ss



BA7-CEP JAN
Chal Ss

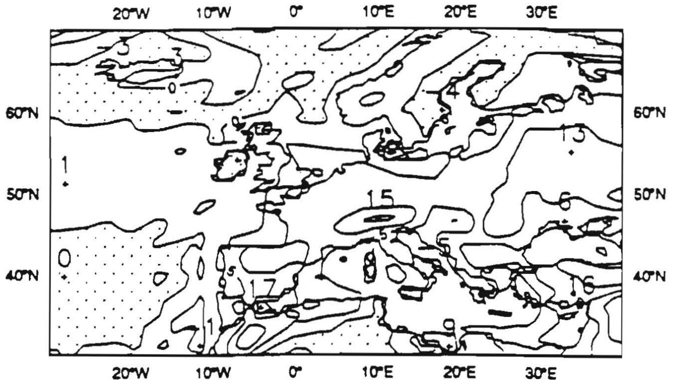


Differences between Arpège model and ECMWF analyses for the sensible hat distribution in January. Contour spacing 30W/m².

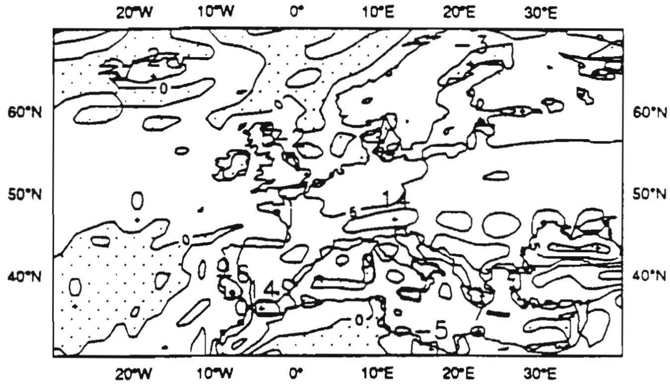


Differences between Arpège model and ECMWF analyses for the turbulent flux distribution in January. Contour spacing 100N/m^2.

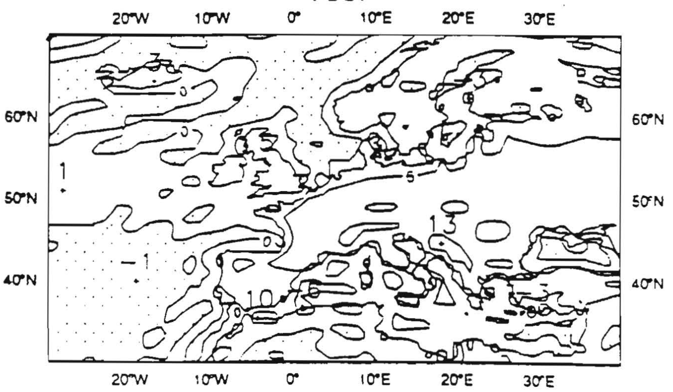
BA6-CEP JUL
Tsol



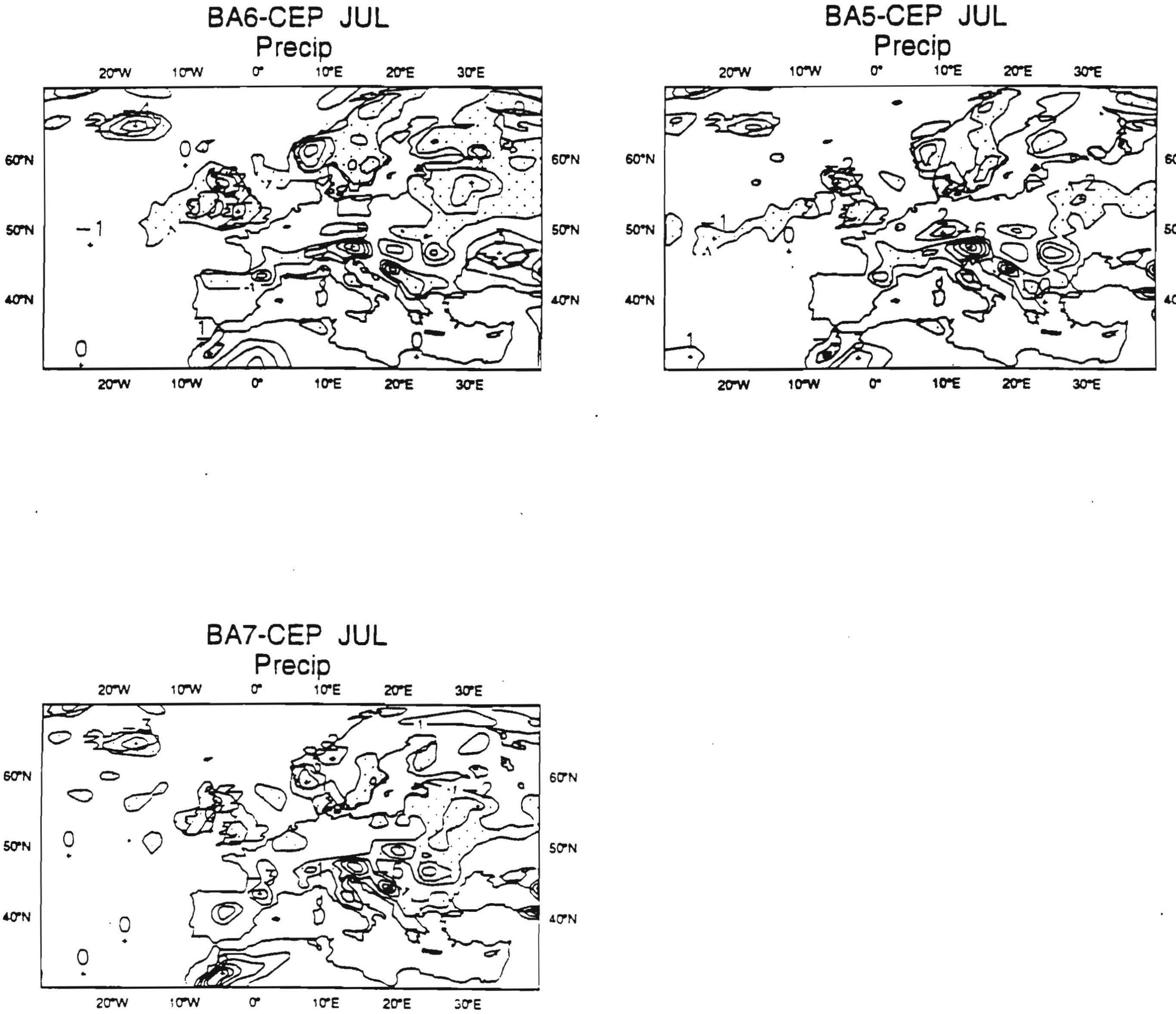
BA5-CEP JUL
Tsol



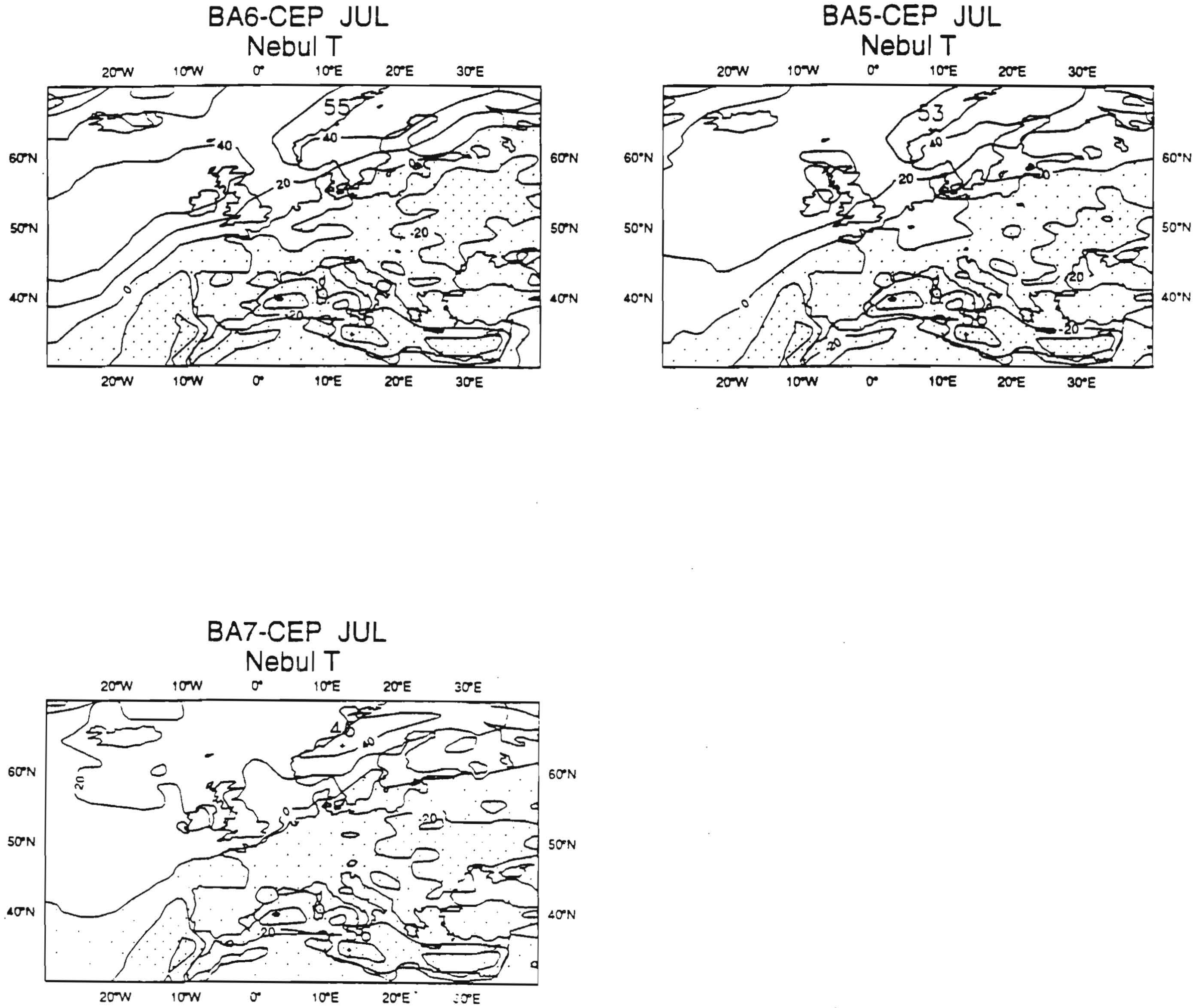
BA7-CEP JUL
Tsol



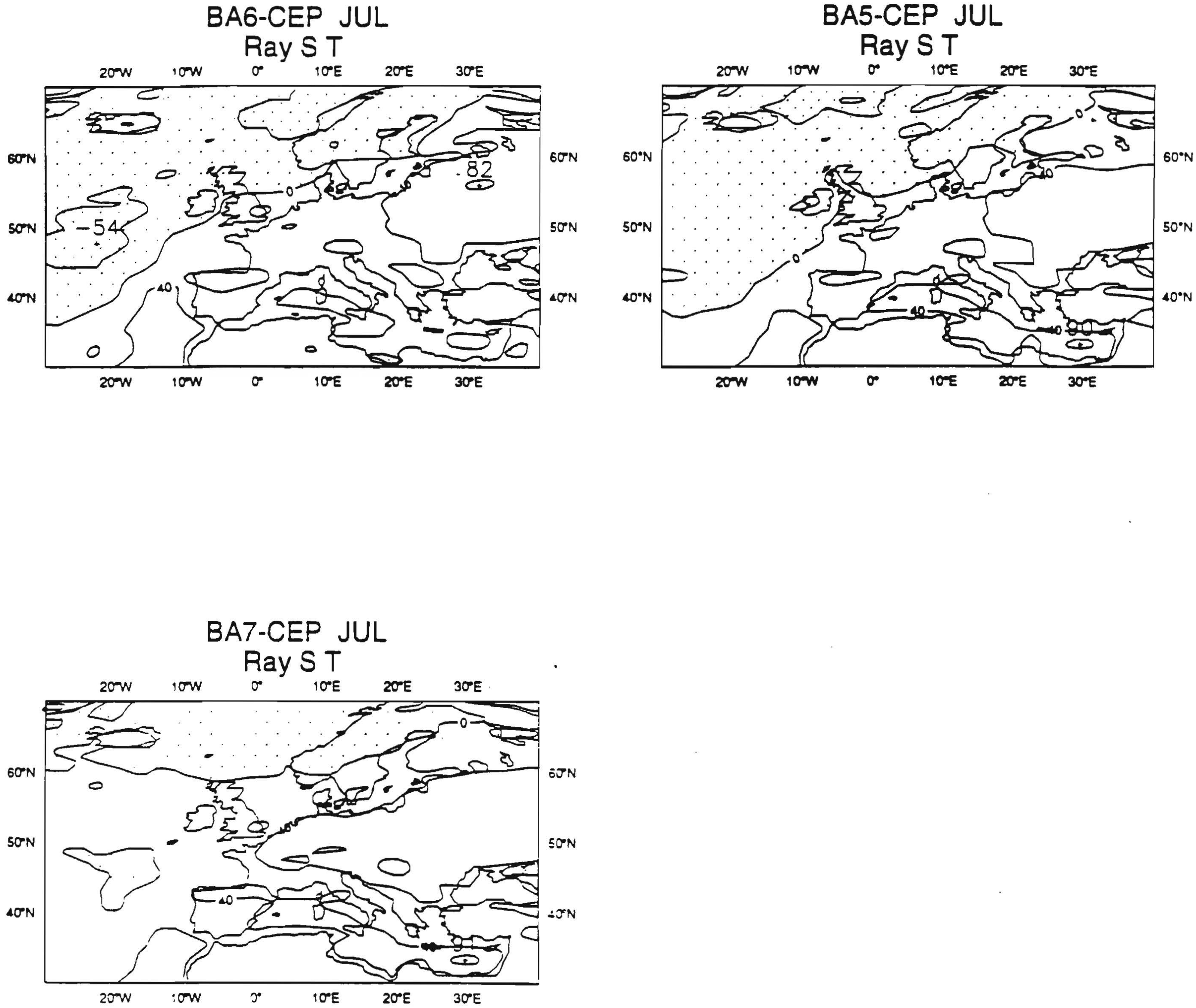
Differences between Arpège model and ECMWF analyses for the surface temperature distribution in July. Contour spacing 5°C.



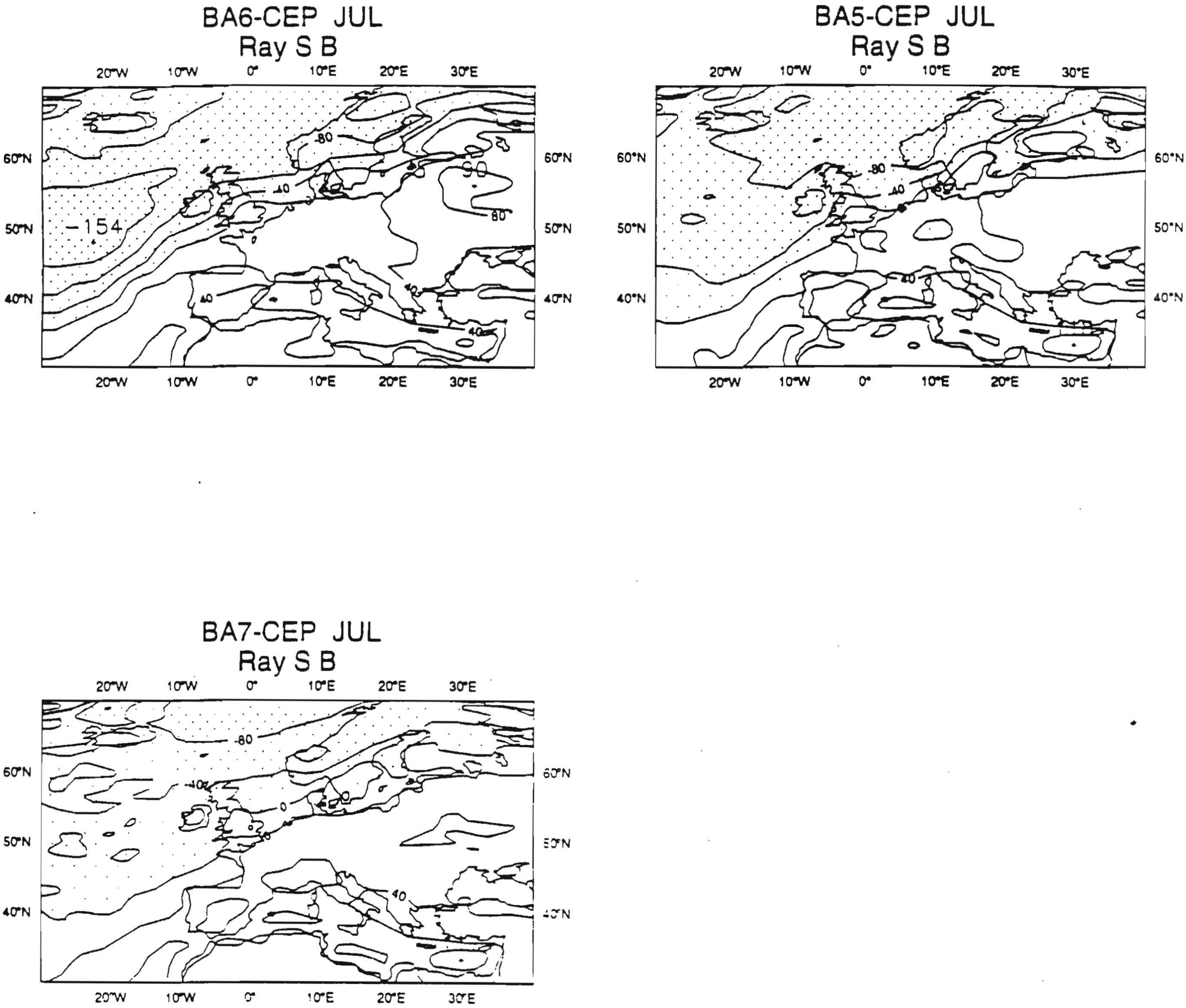
Differences between Arpège model and ECMWF analyses for the precipitation distribution in July. Contour spacing 1mm/day.



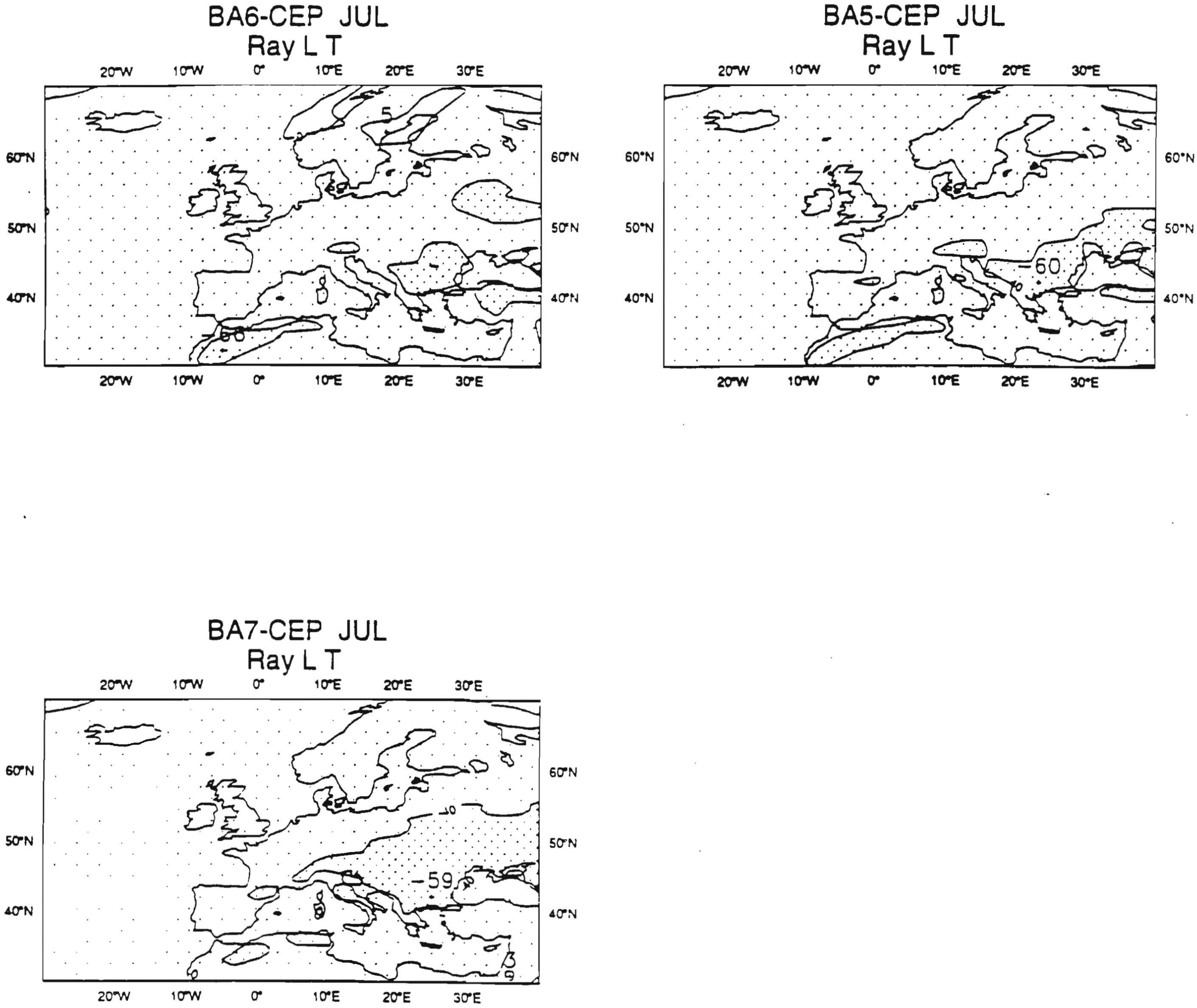
Differences between Arpège model and ECMWF analyses for the cloudiness distribution in July. Contour spacings: 20, 40 and 60%.



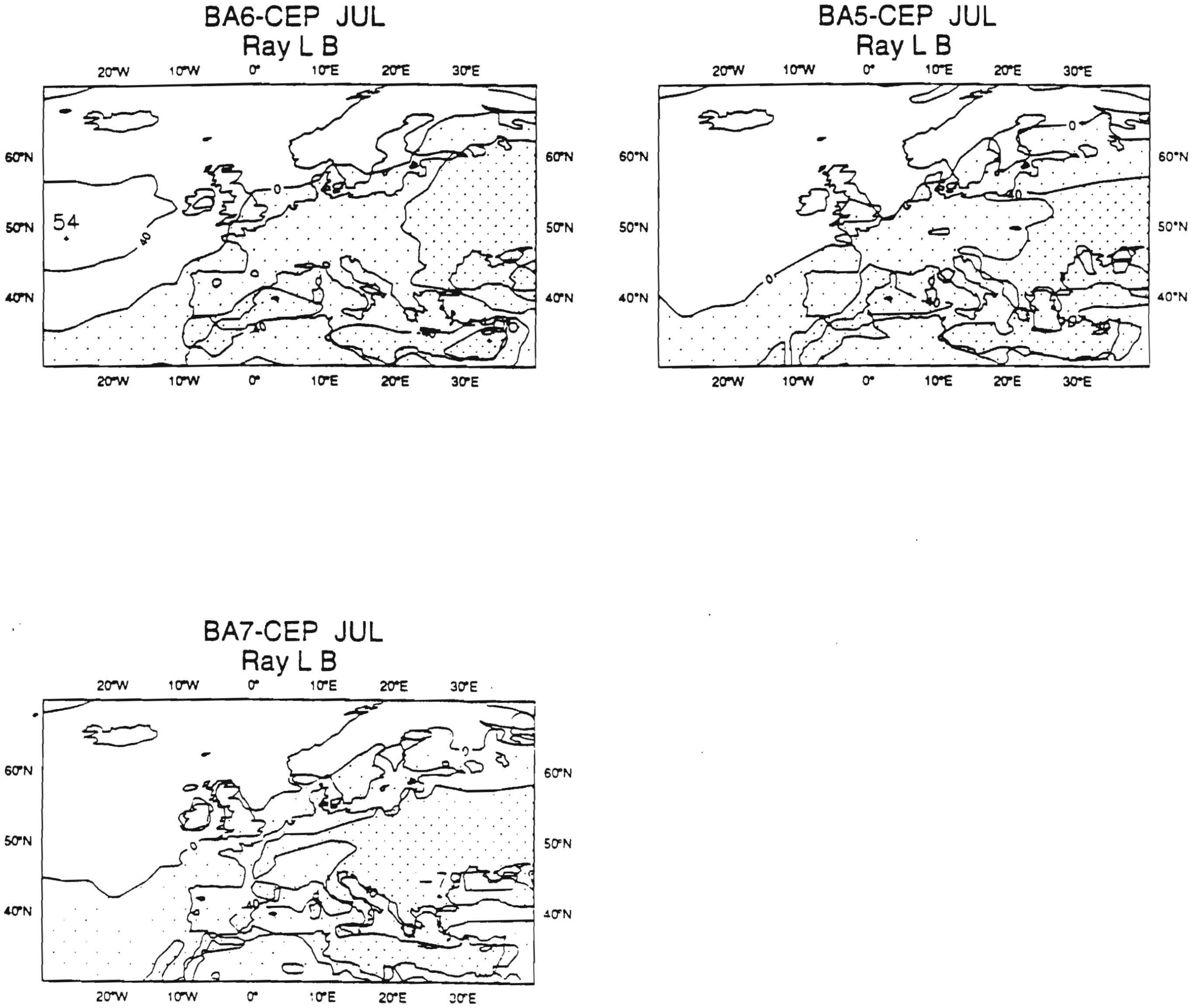
Differences between Arpège model and ECMWF analyses for the ST radiation distribution in July. Contour spacing $40W/m^2$.



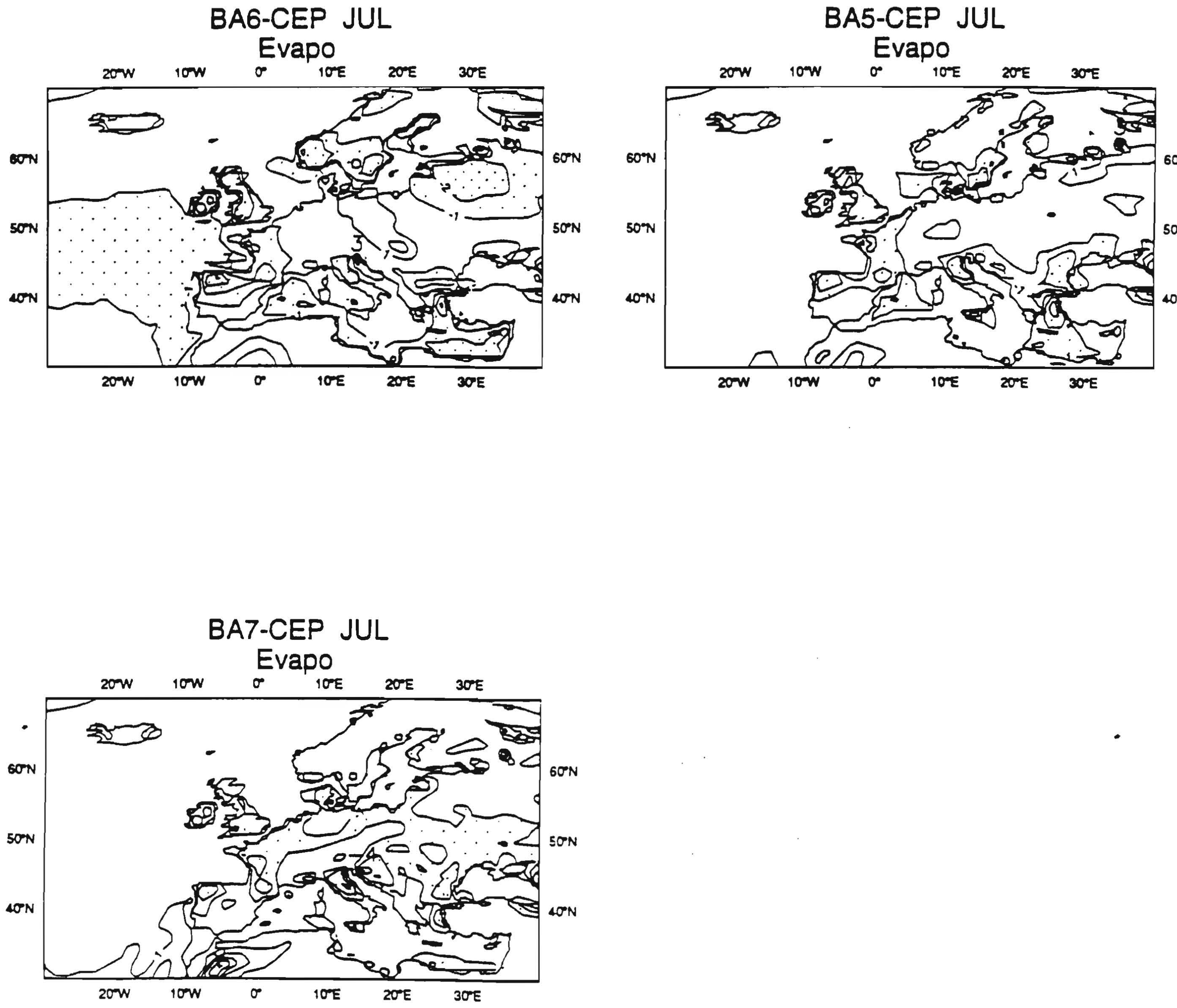
Differences between Arpège model and ECMWF analyses for the SB radiation distribution in July. Contour spacing $40 W/m^2$.



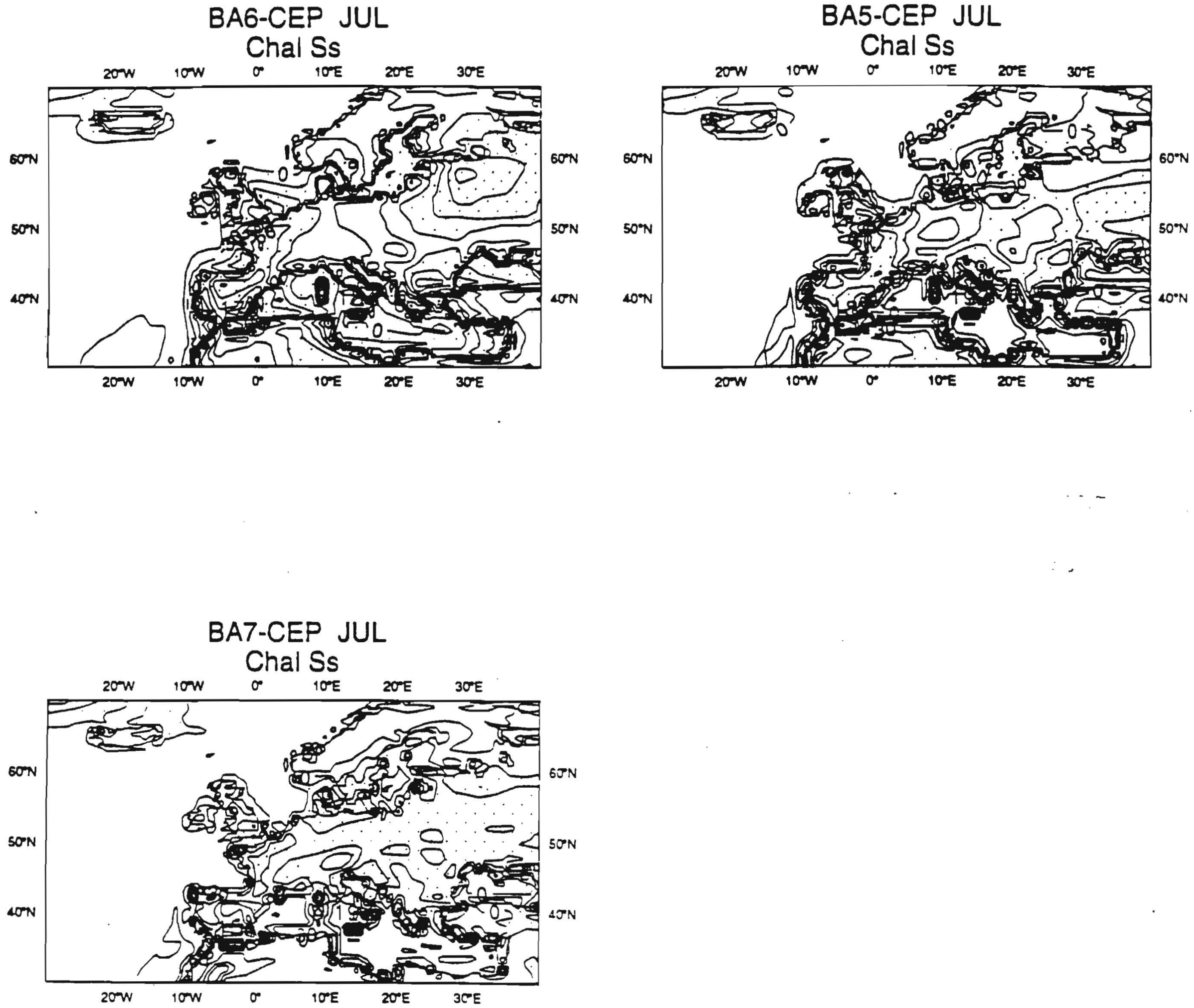
Differences between Arpège model and ECMWF analyses for the LT radiation distribution in July. Contour spacing $40W/m^2$.



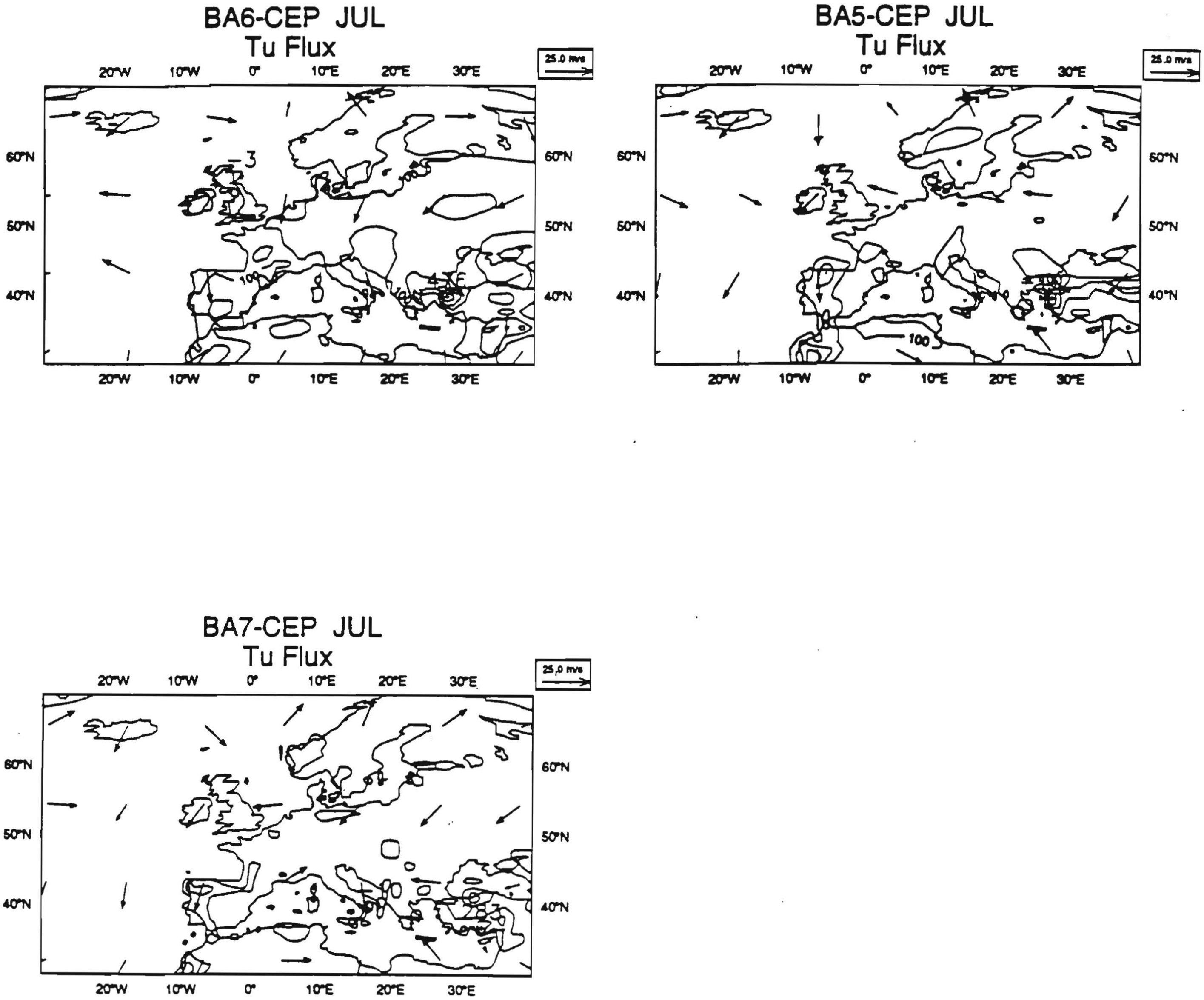
Differences between Arpège model and ECMWF analyses for the LB radiation distribution in July. Contour spacing 40W/m².



Differences between Arpège model and ECMWF analyses for the evaporation distribution in July. Contour spacing 1mm/day.



Differences between Arpège model and ECMWF analyses for the sensible hat distribution in July. Contour spacing 30W/m².

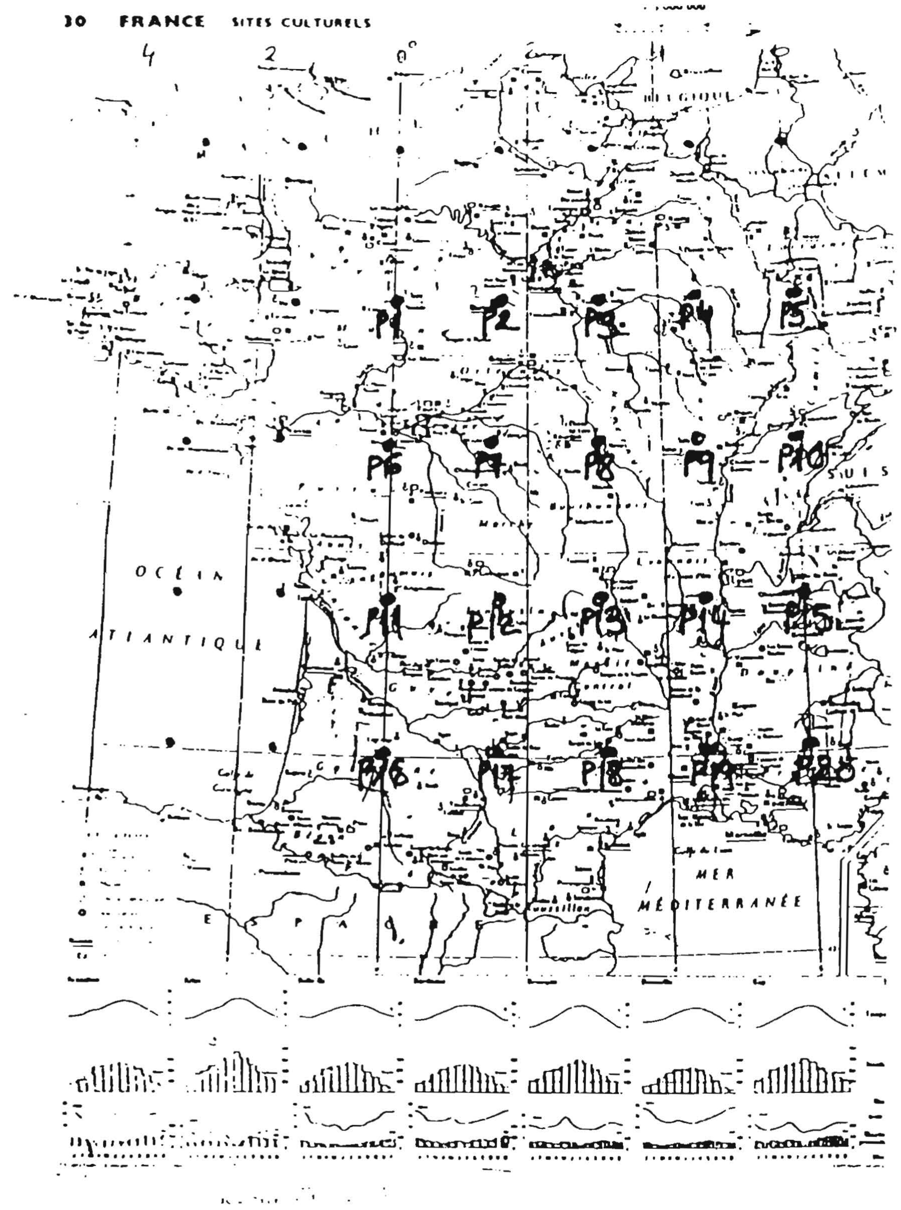


Differences between Arpège model and ECMWF analyses for the turbulent flux distribution in July. Contour spacing $100 N/m^2$.

SECTION C.3

- Graphics and charts of precipitation and temperature corresponding to Section B.

VERSION T79 (FRANCE)



VERSION T42 (FRANCE)

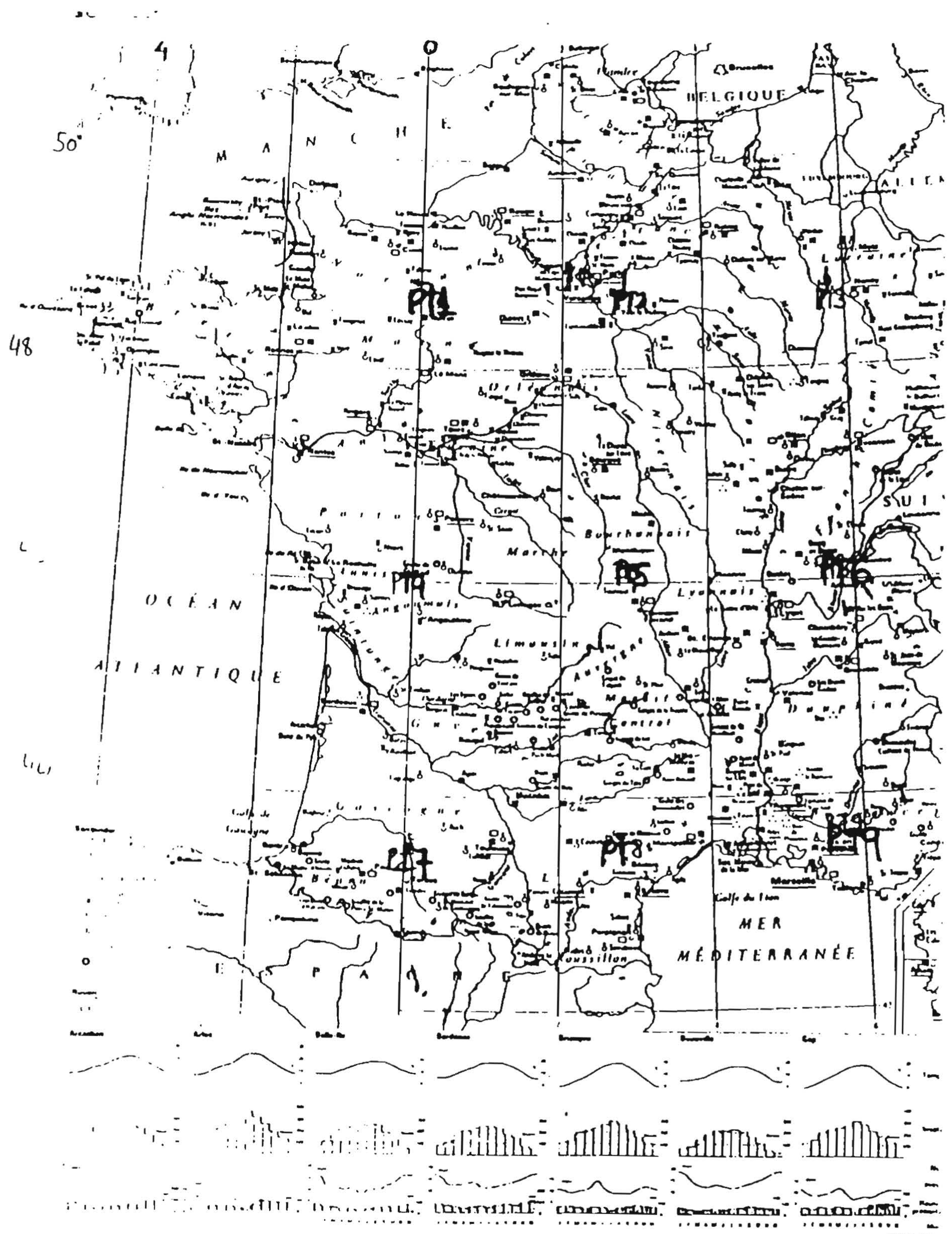


Figure B1 Geographical distributions of the gridpoints (T42 and T79)

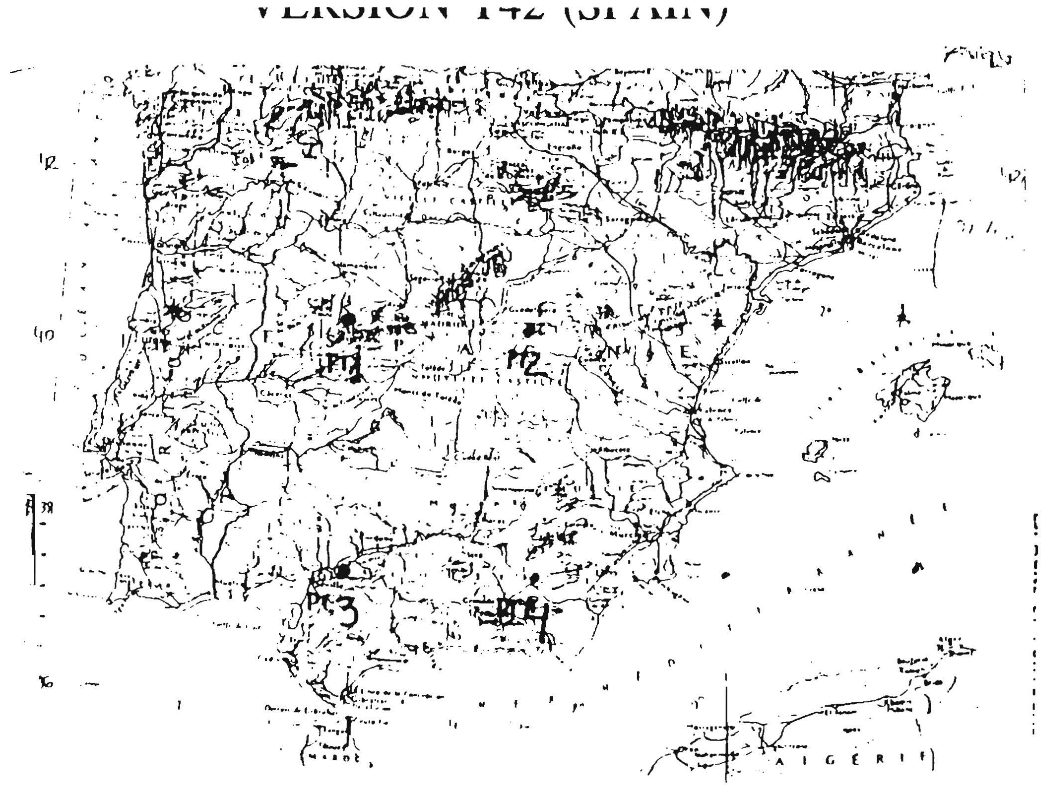


Figure B2 Geographical distributions of the gridpoints (T42 and T79)

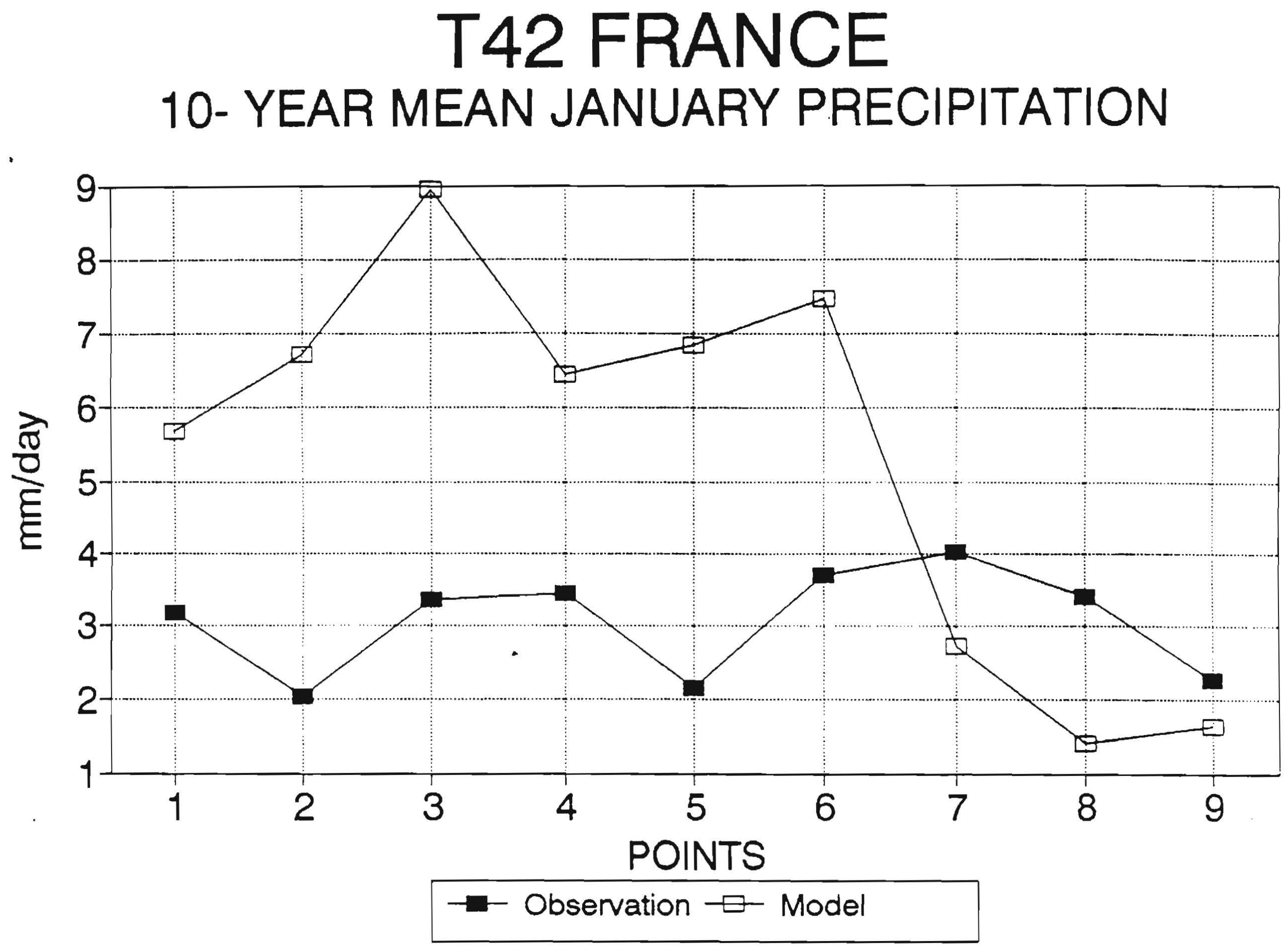


Fig B3 .- Evolution of precipitation for Emeraude model (T42) and observations for January.

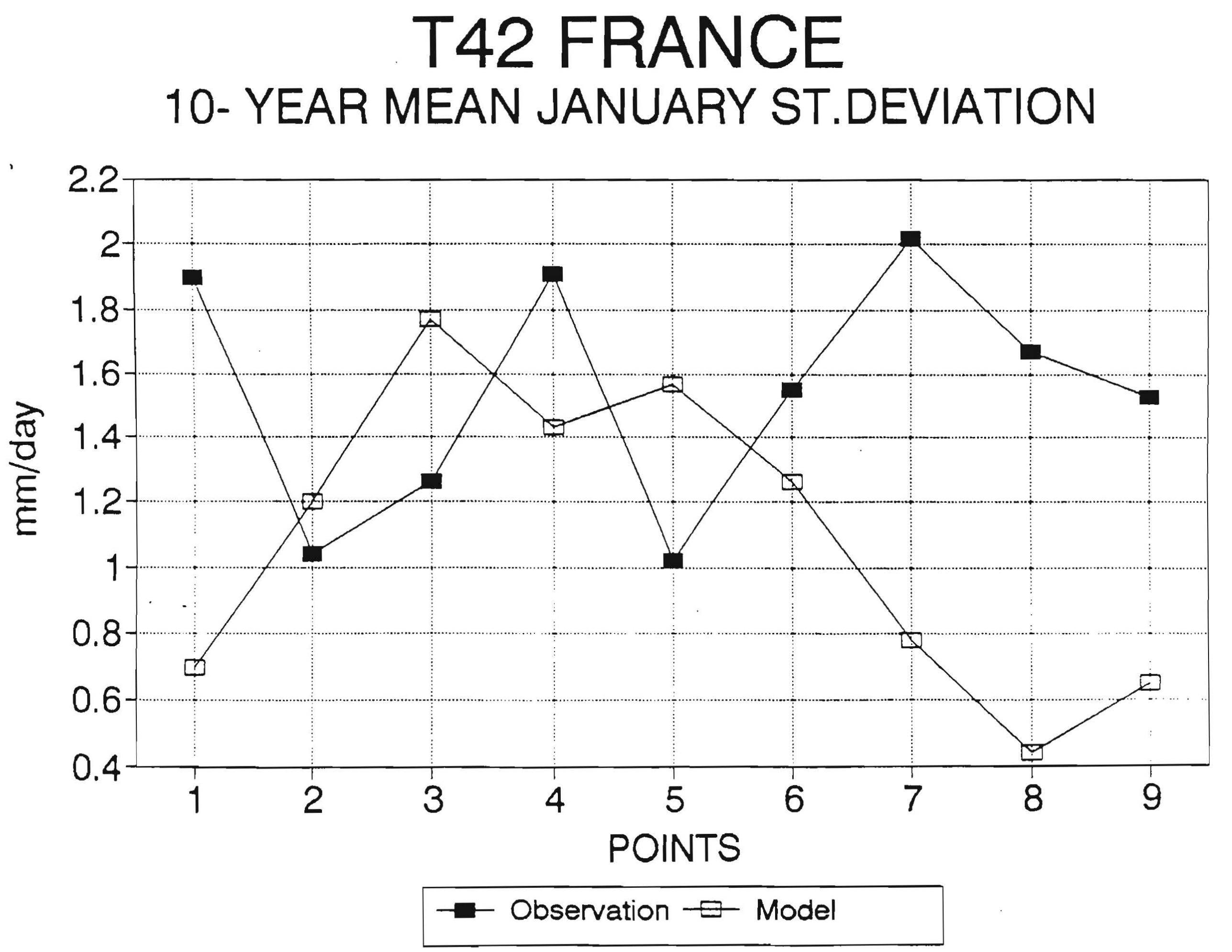


Fig B4.- Evolution of precipitation st.deviation for Emeraude model and observations for January.

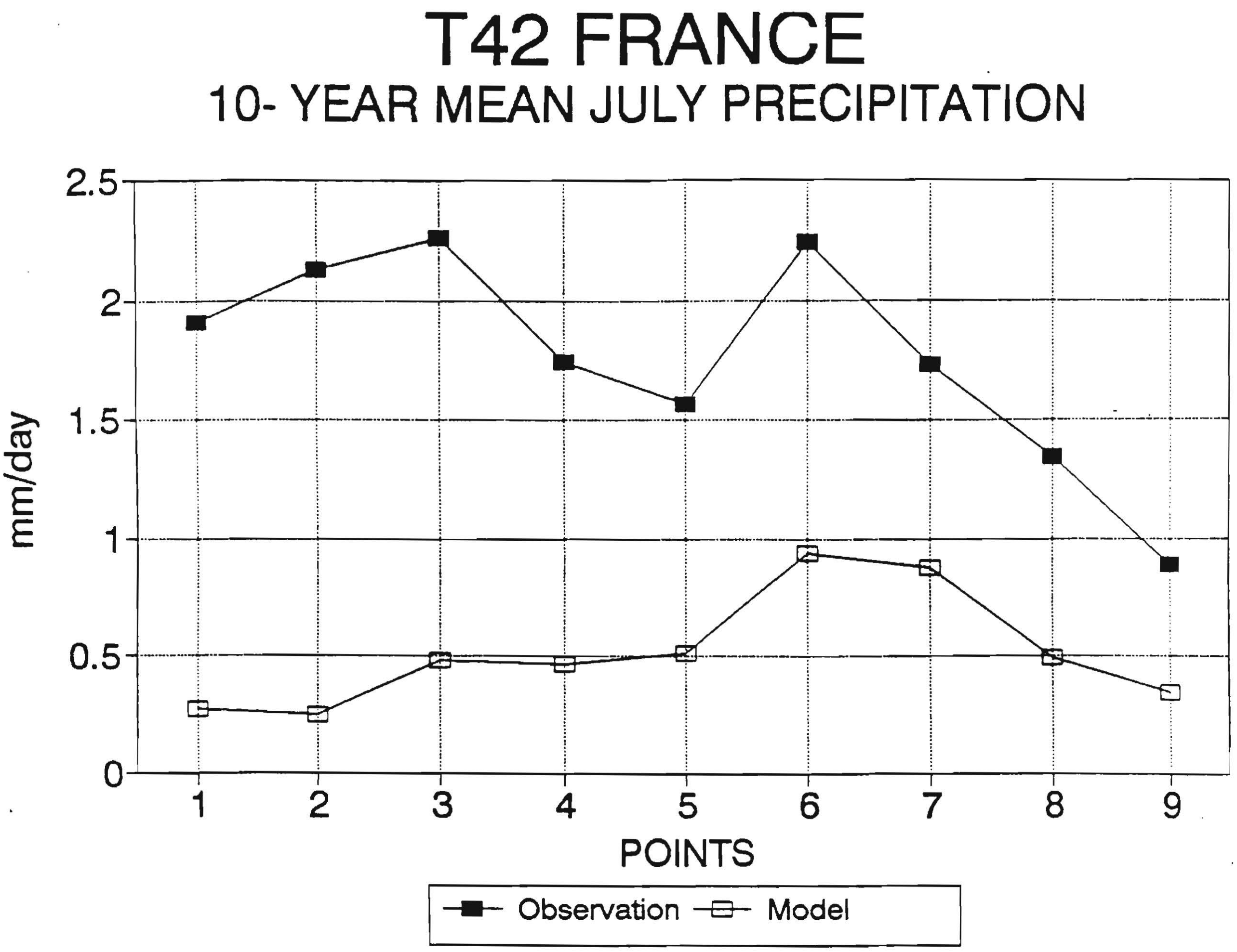


Fig B5 .- Evolution of precipitation for Emeraude model (T42) and observations for July.

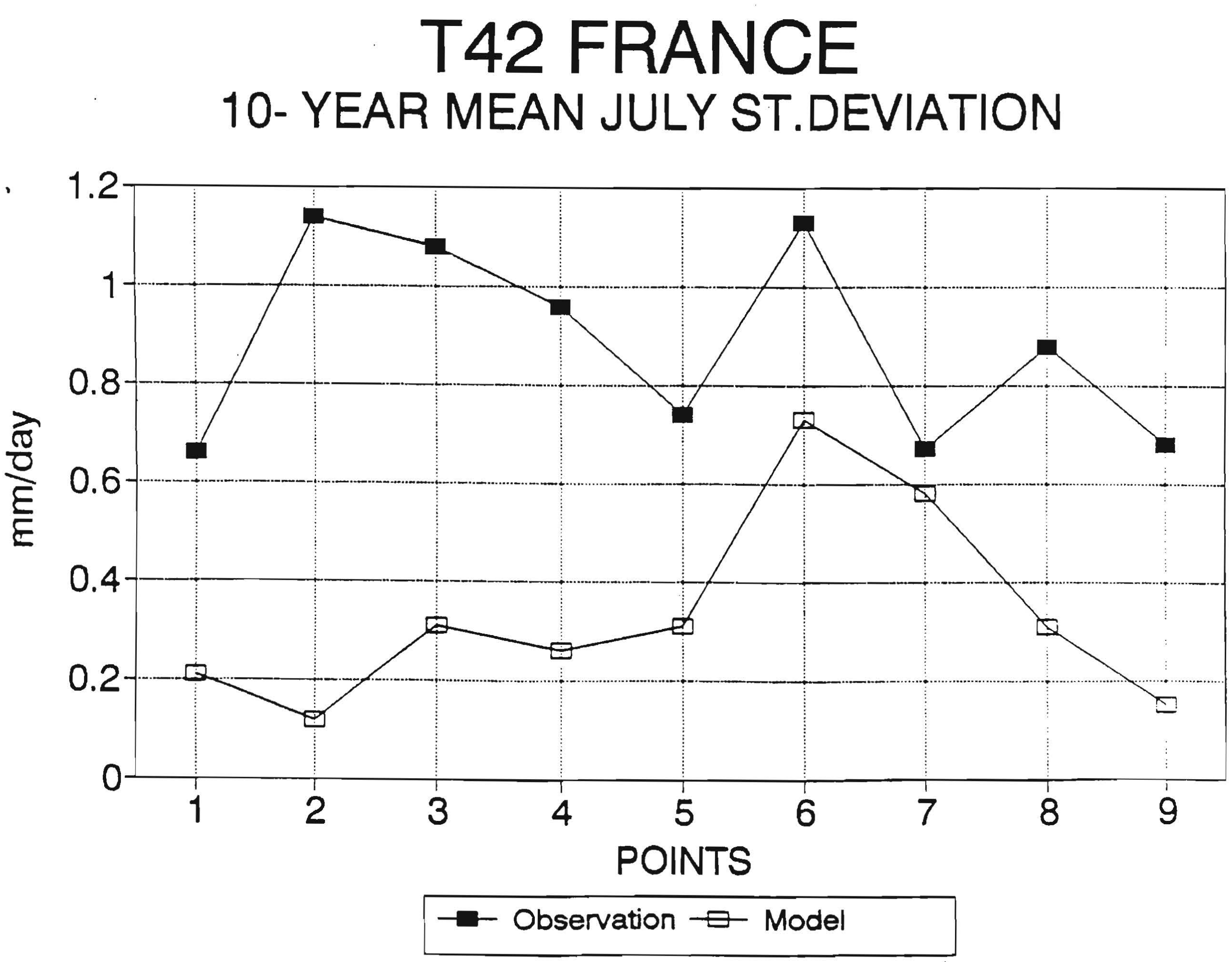


Fig B6.- Evolution of precipitation st.deviation for Emeraude model and observations for July.

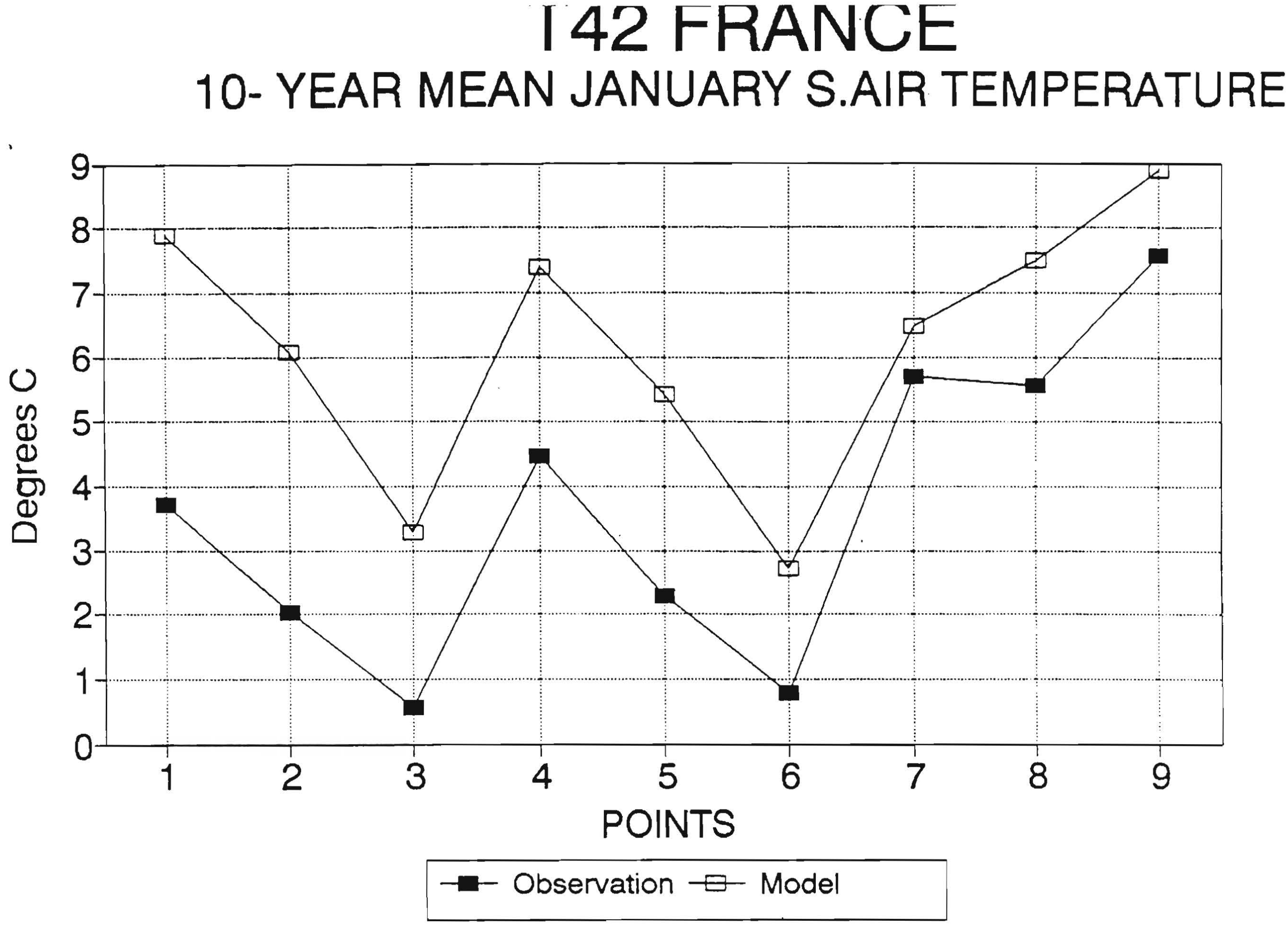


Fig B7 .- Evolution of s.air temperature for Emeraude model (T42) and observations for January.

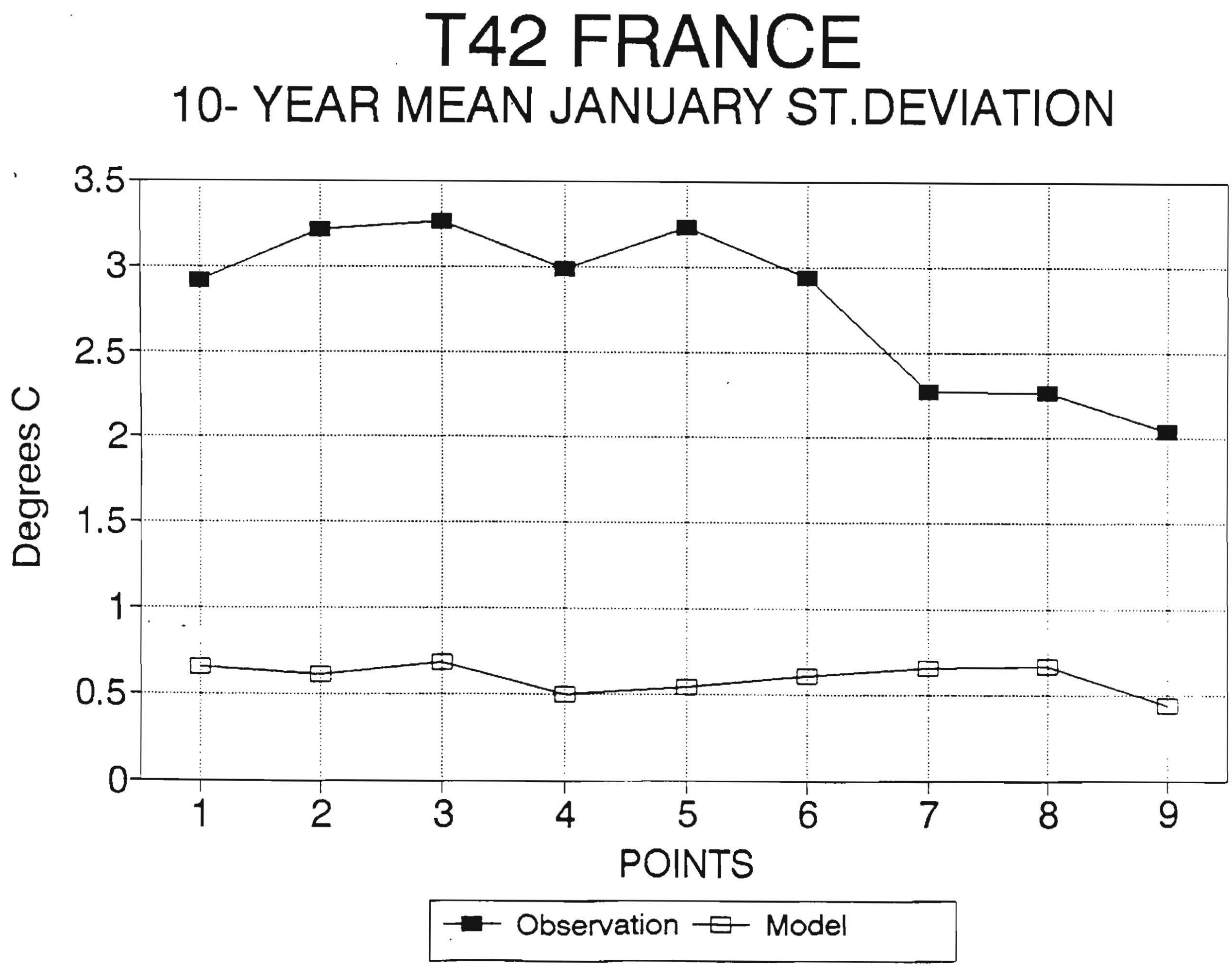


Fig B8 .- Evolution of s.air temperature st. dev for Emeraude model (T42) and observations for January.

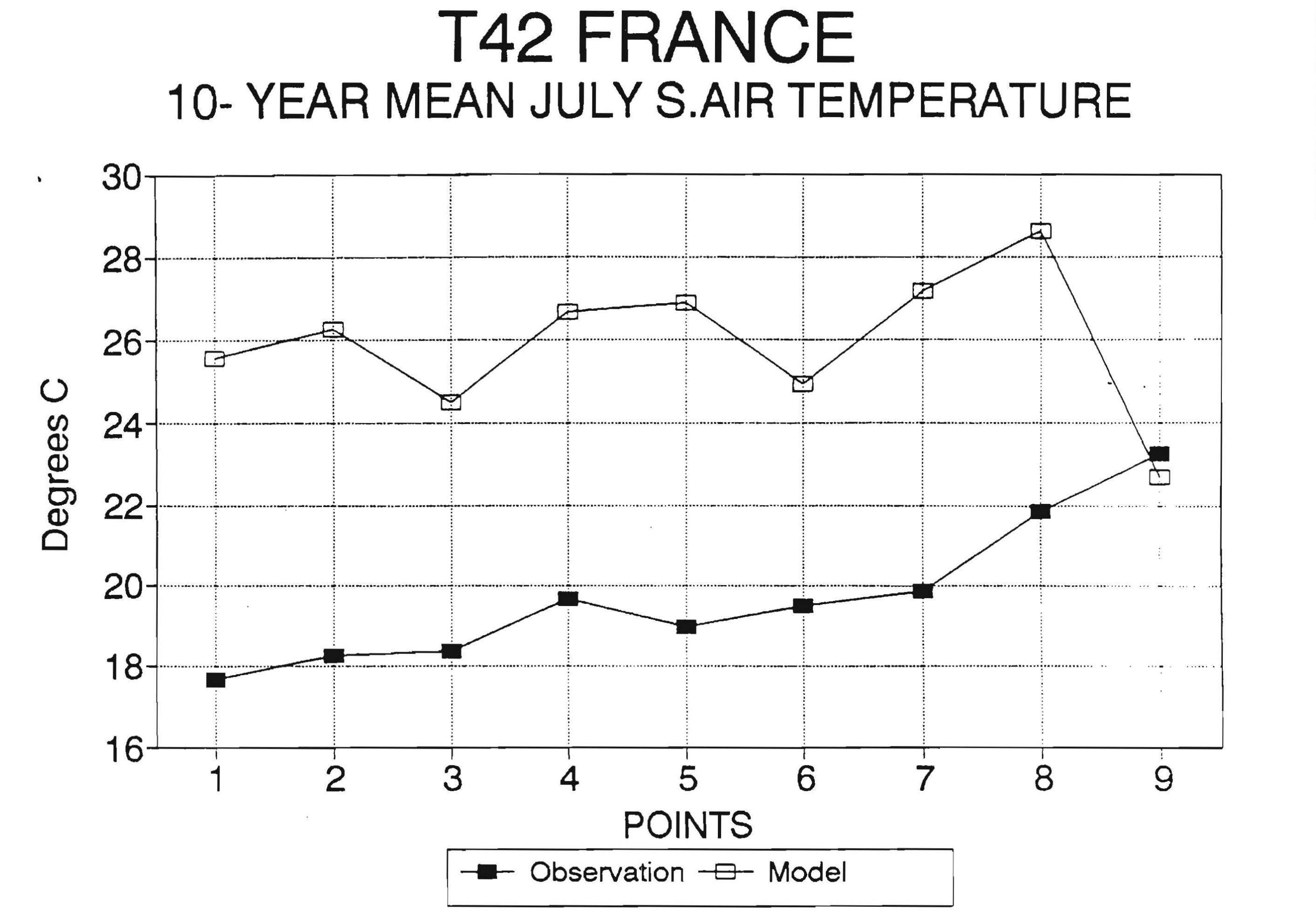


Fig B9 .- Evolution of s.air temperature for Emeraude model (T42) and observations for July.

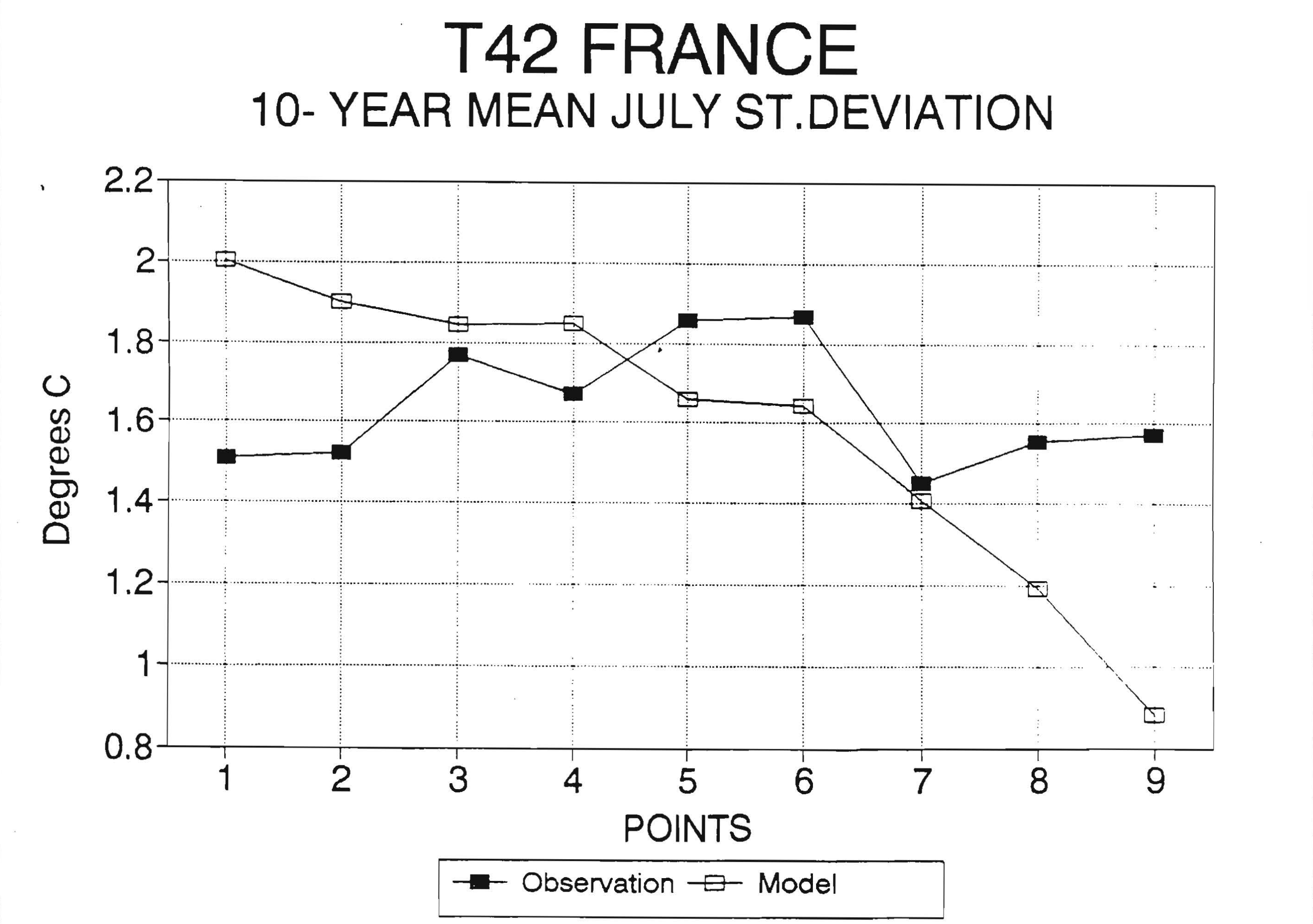


Fig B10 .- Evolution of s.air temperature st. dev for Emeraude model (T42) and observations for July.

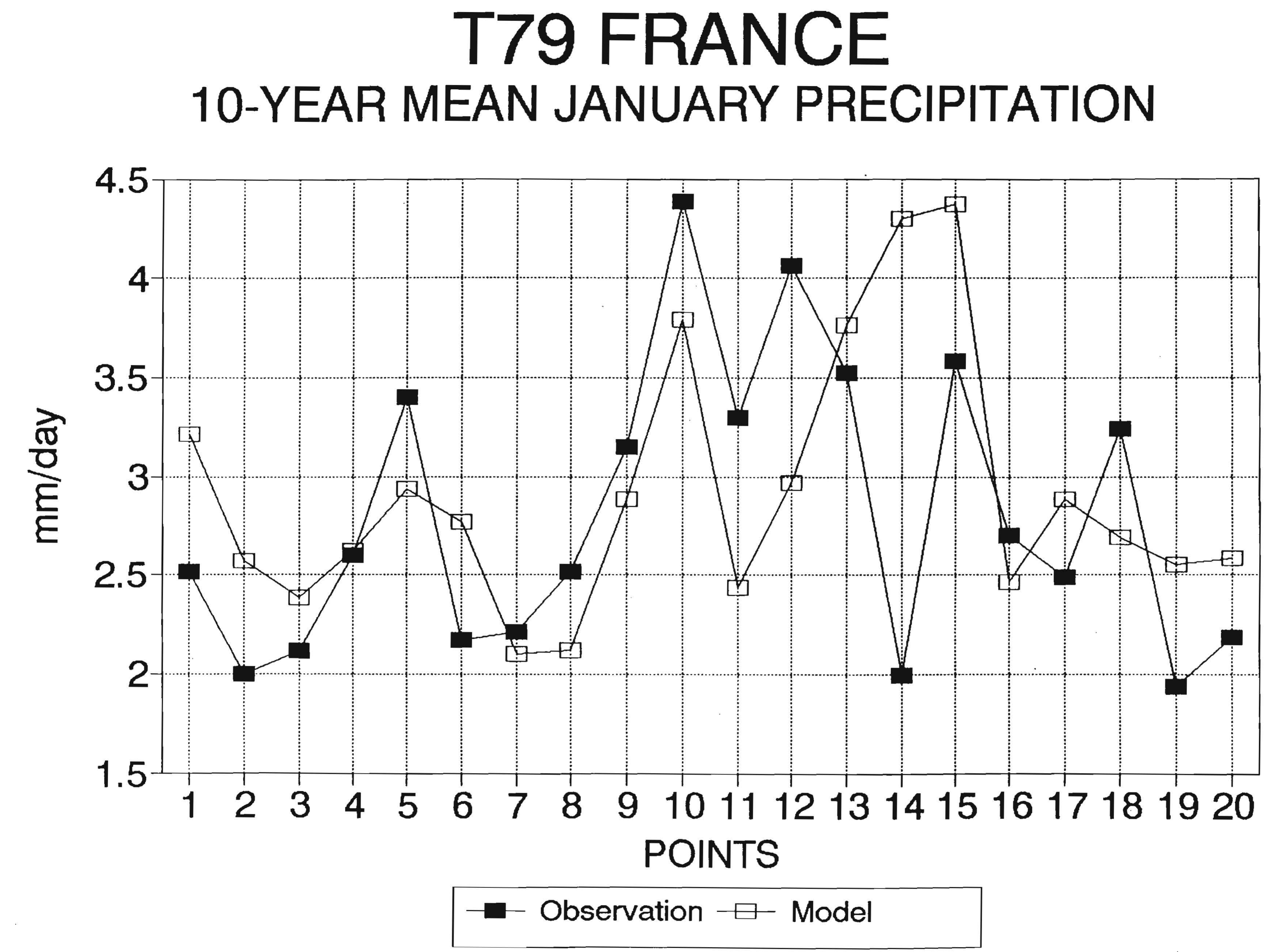


Fig B11 .- Evolution of precipitation for Arpège model (T79) and observations for January.

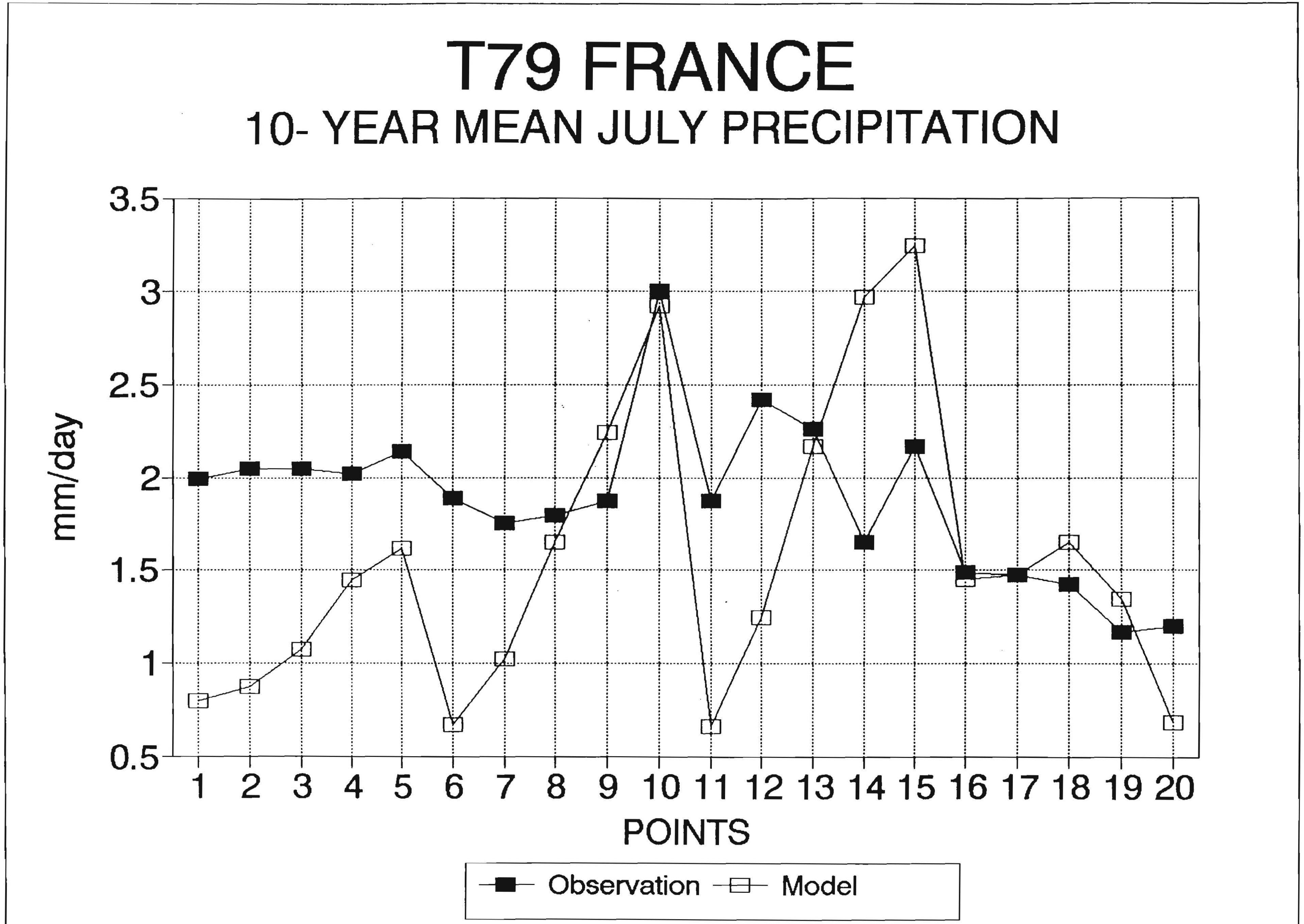


Fig B12 .- Evolution of precipitation for Arpège model (T79) and observations for July.

T79 FRANCE

10- YEAR MEAN JANUARY TEMPERATURE

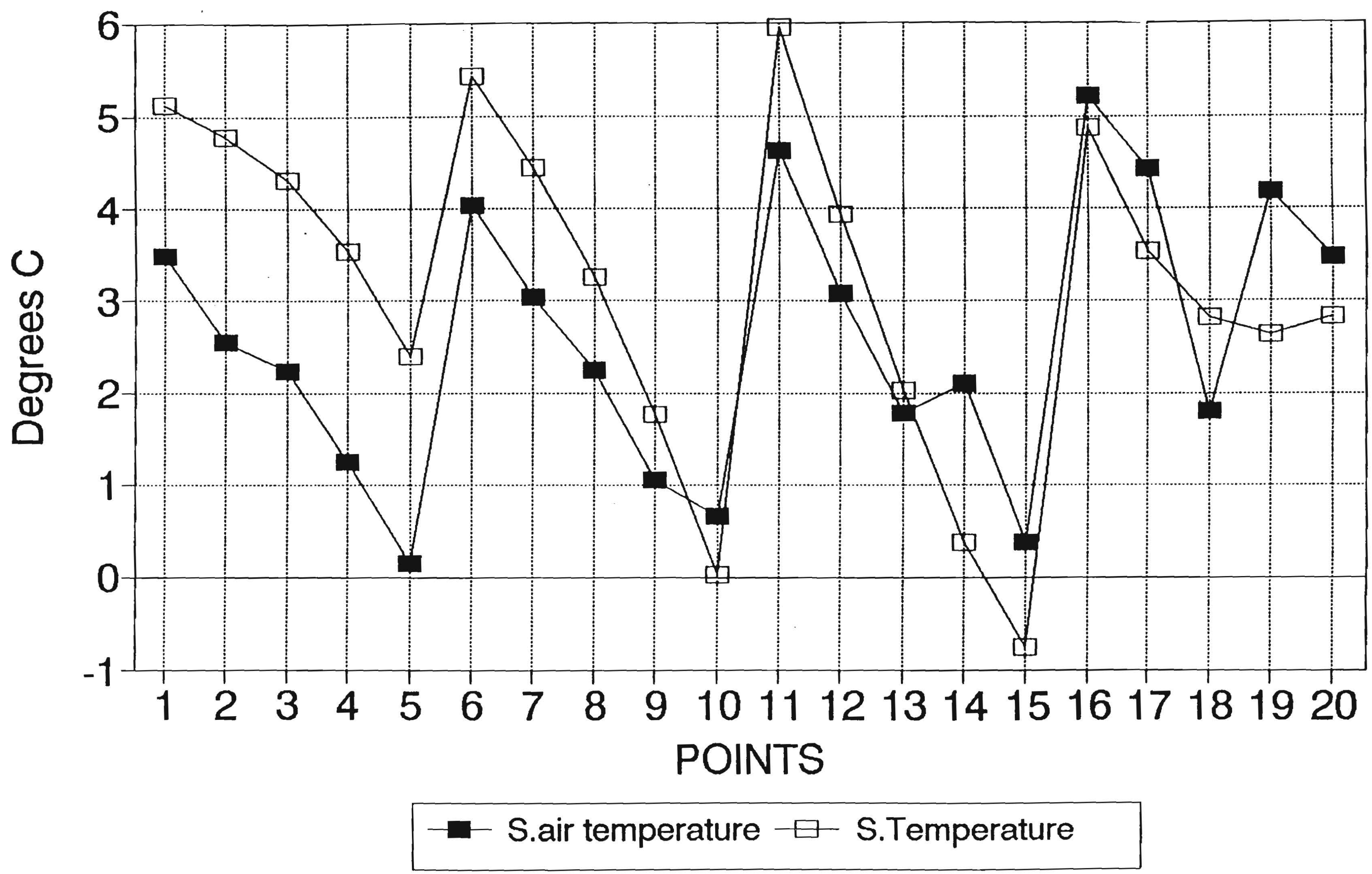


Fig B13 .- Evolution of s.temperature for Arpège model (T79) and s.air temperature (obs) for January.

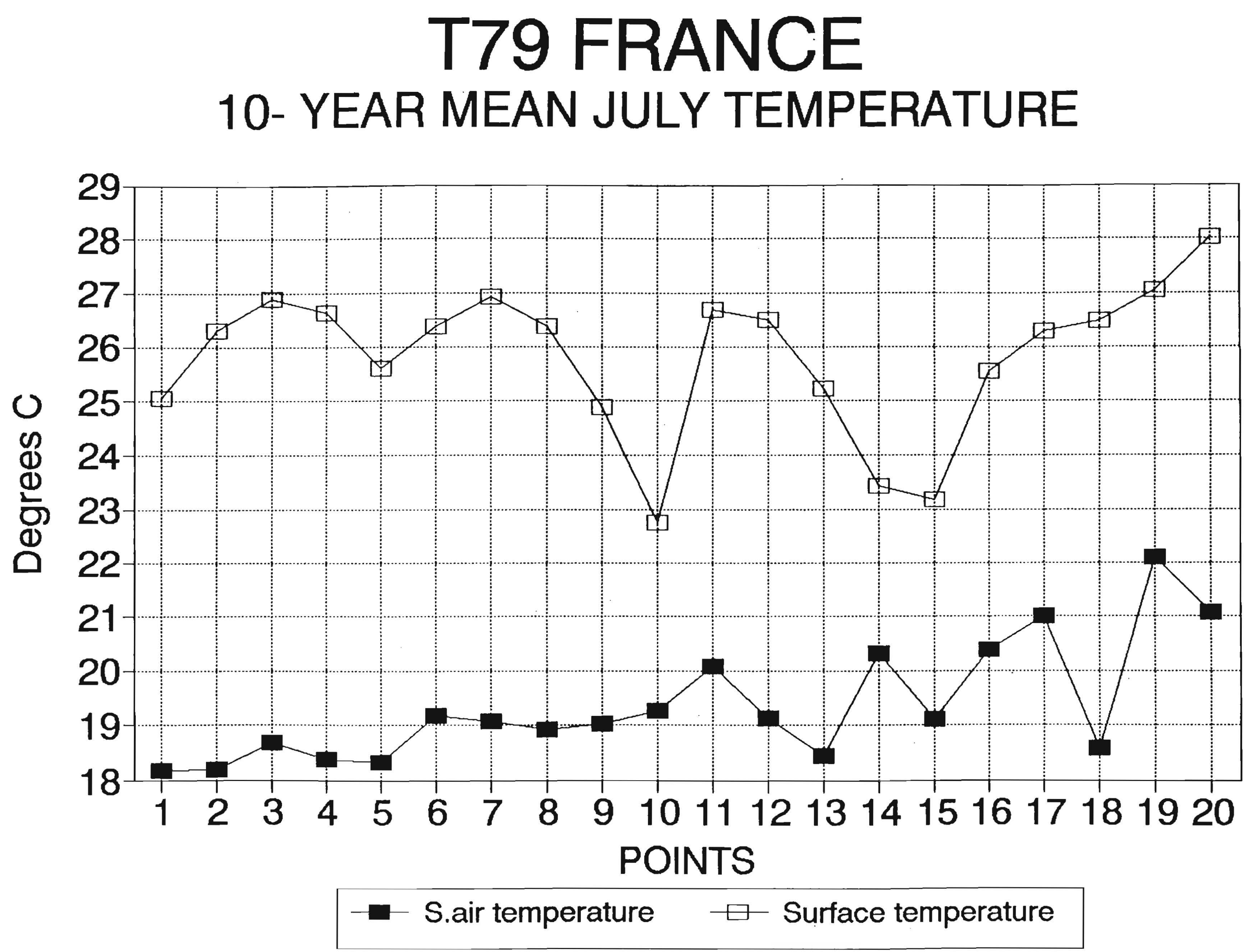


Fig B14 .- Evolution of s.temperature for Arpège model (T79) and s.air temperature (obs) for July.

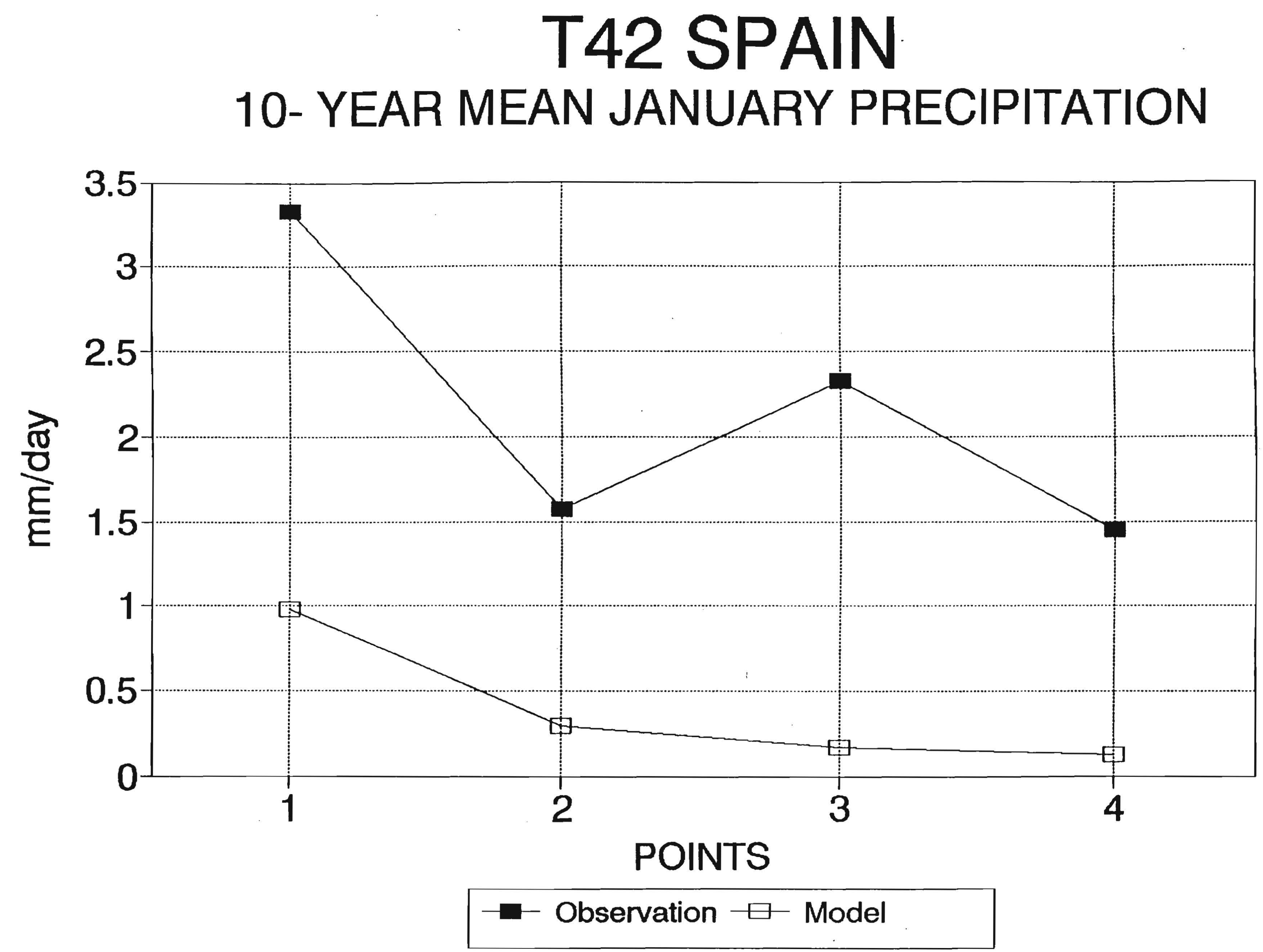


Fig B15 .- Evolution of precipitation for Arpège model (T42) and observations for January.

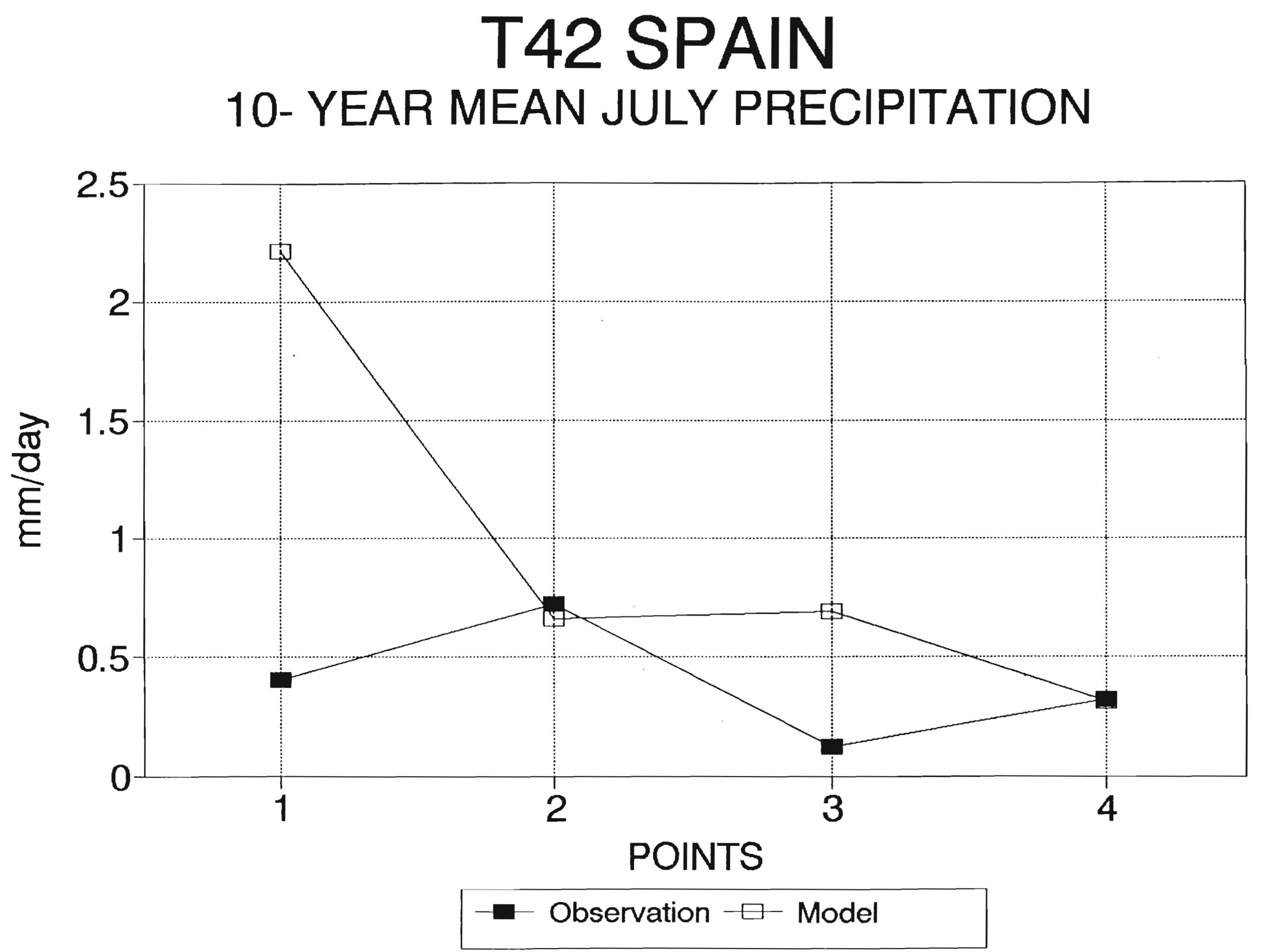


Fig B16 .- Evolution of precipitation for Arpège model (T42) and observations for July.

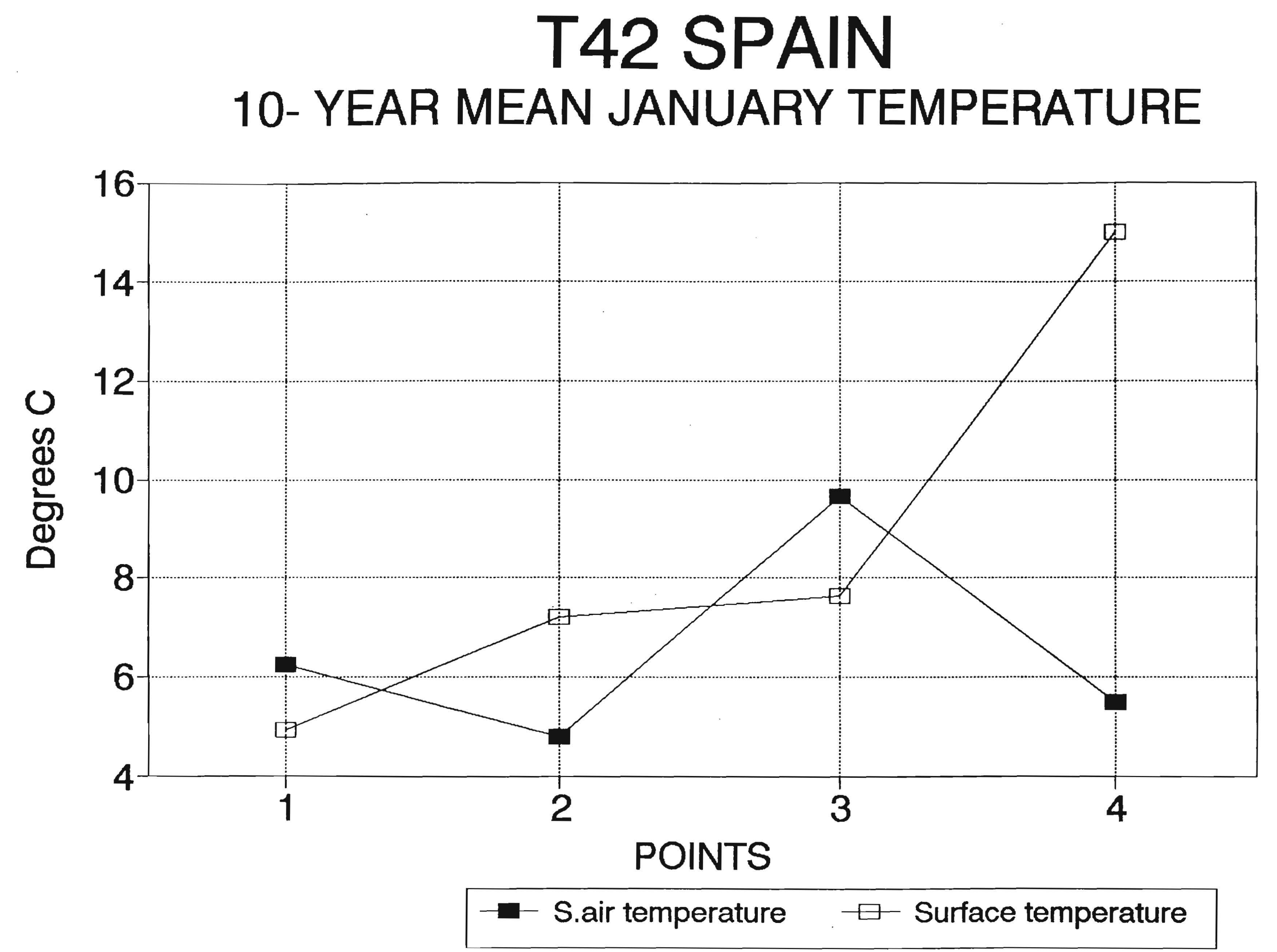


Fig B17.- Evolution of s.temperature for Arpège model (T42) and s.air temperatures for January.

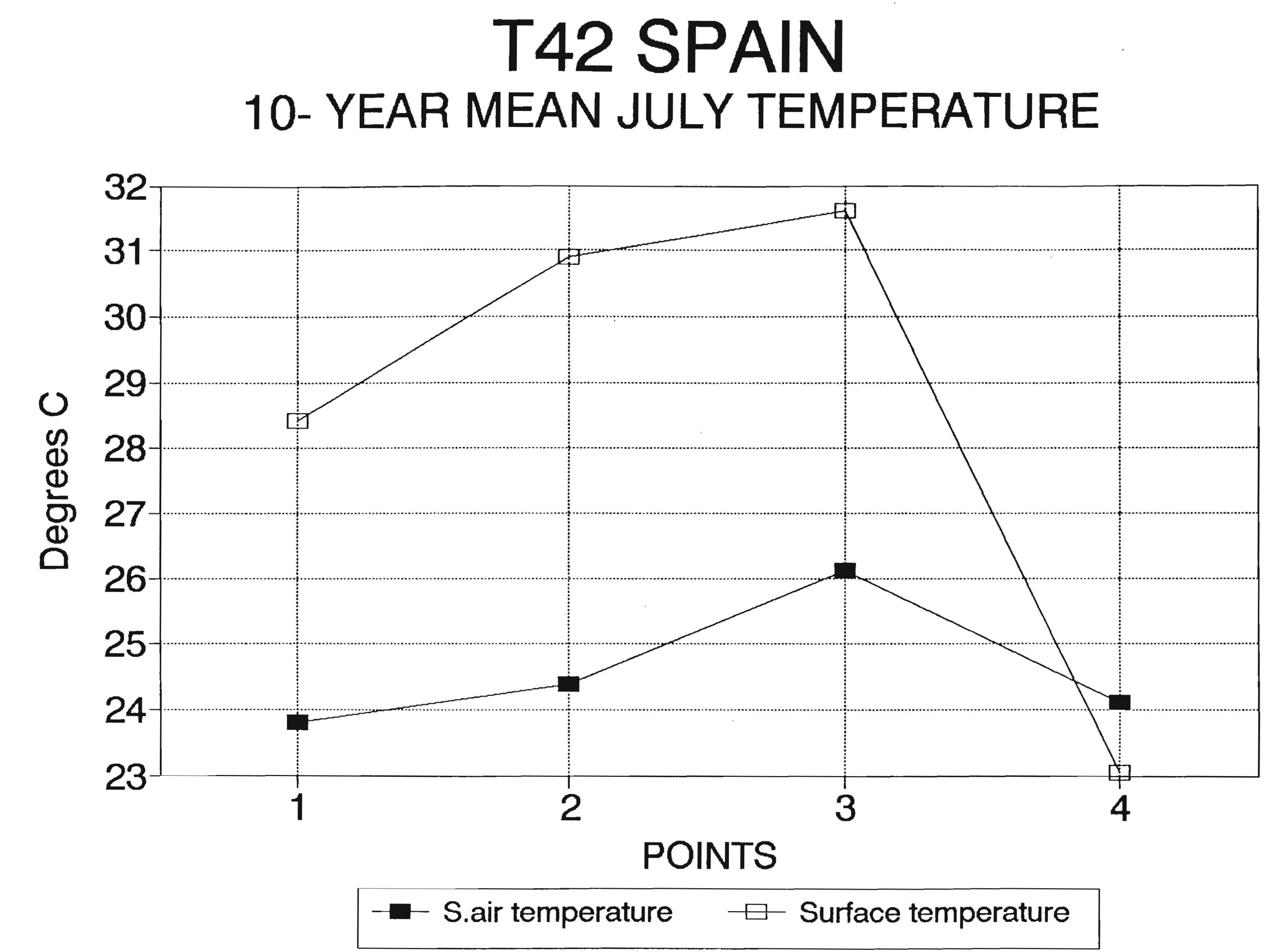


Fig B18 .- Evolution of s.temperature for Arpège model (T42) and s.air temperature (obs) for July.

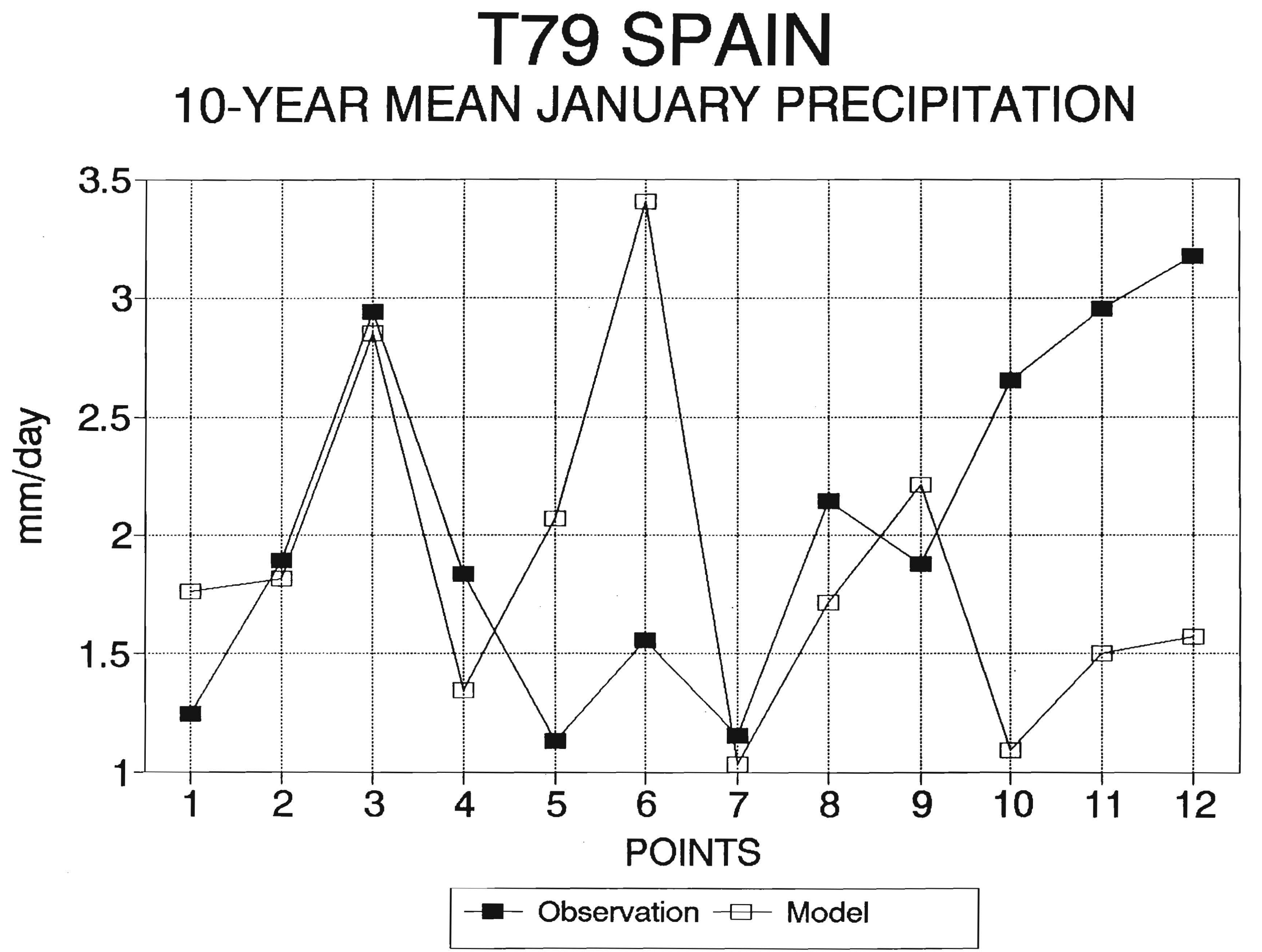


Fig B19.- Evolution of precipitation for Arpège model (T79) and observations for January.

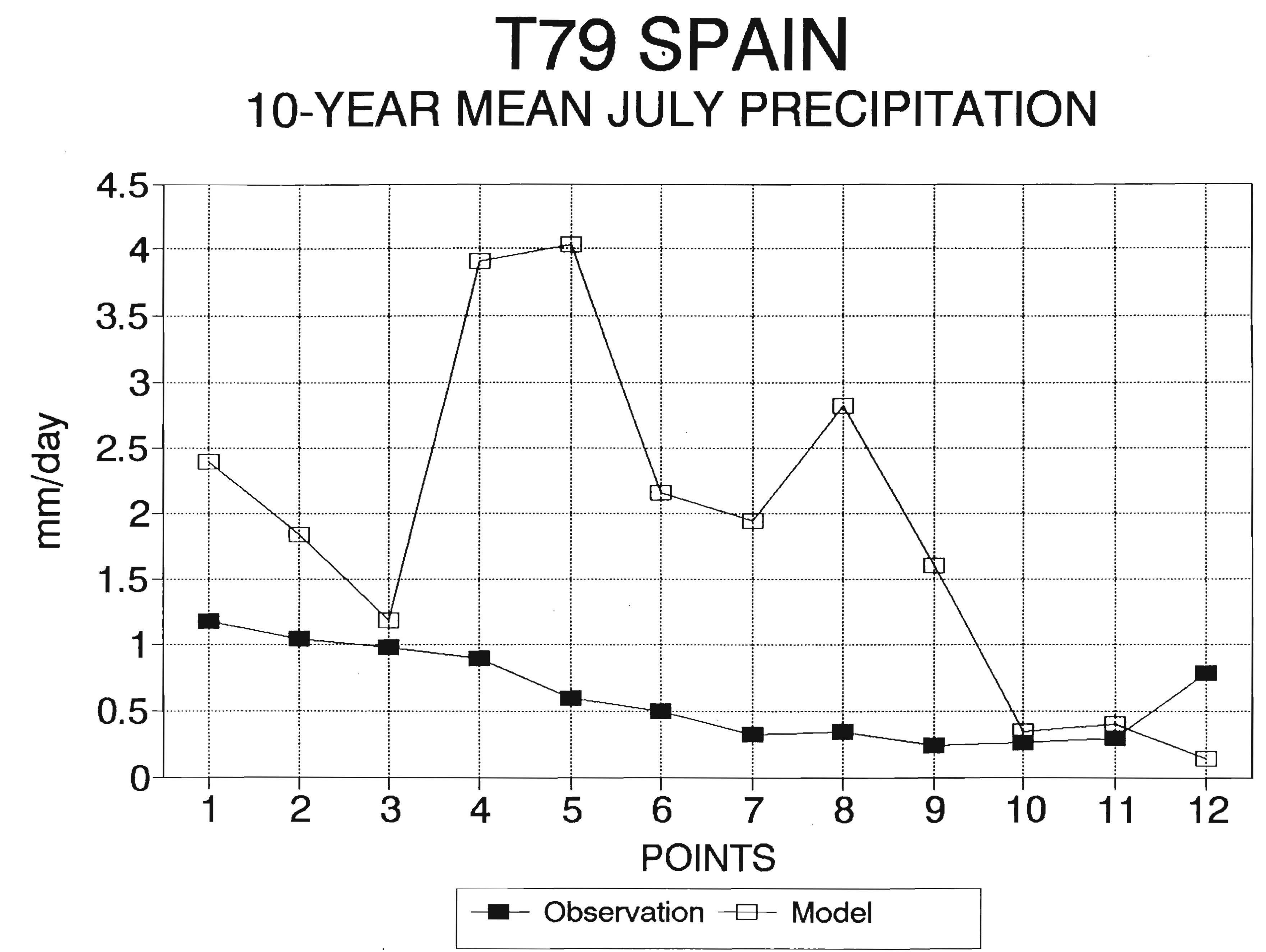


Fig B20 .- Evolution of precipitation for Arpège model (T79) and observations for July.

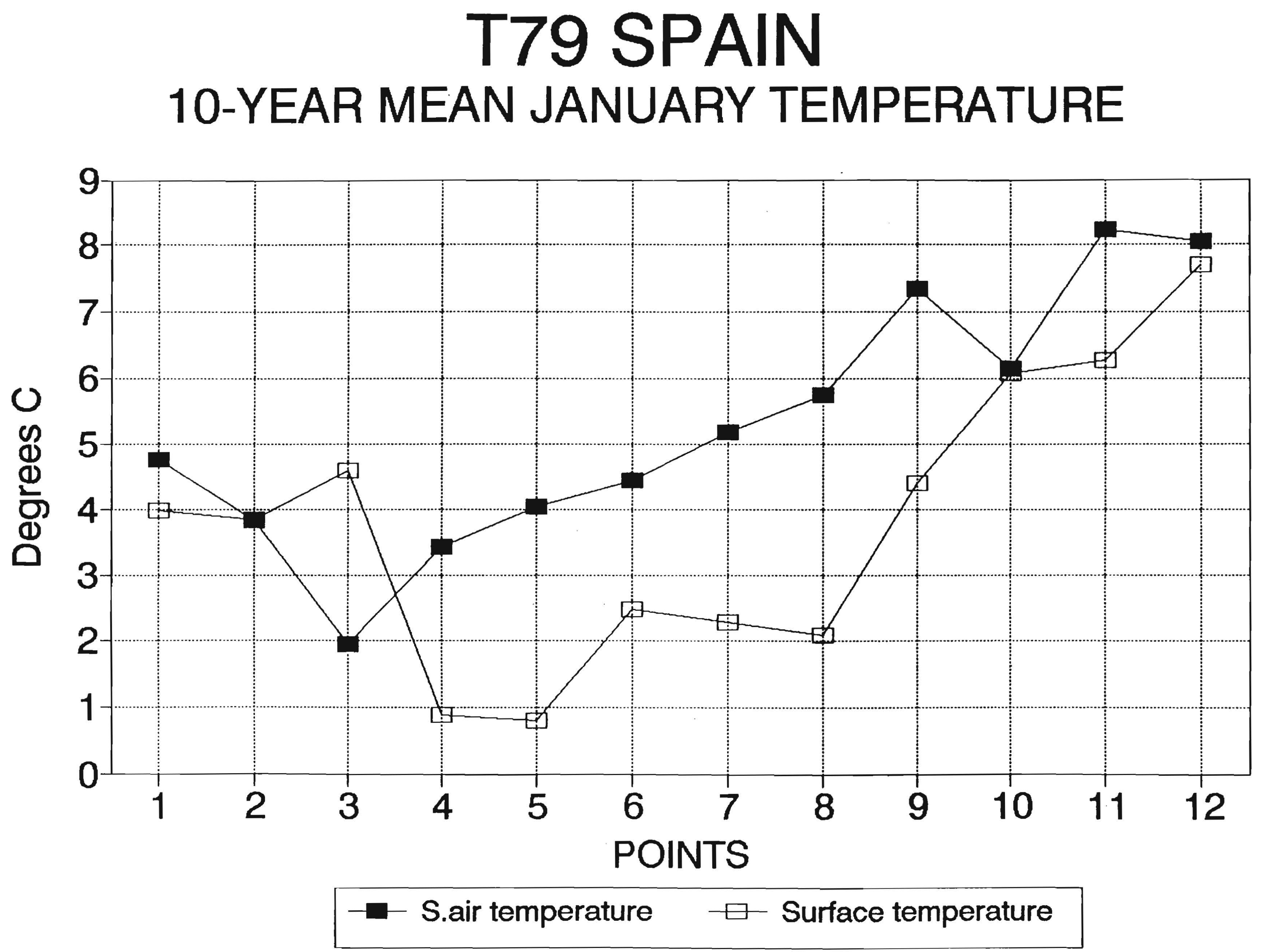


Fig B21 .- Evolution of s.temperature for Arpège model (T79) and s.air temperature (obs) for January.

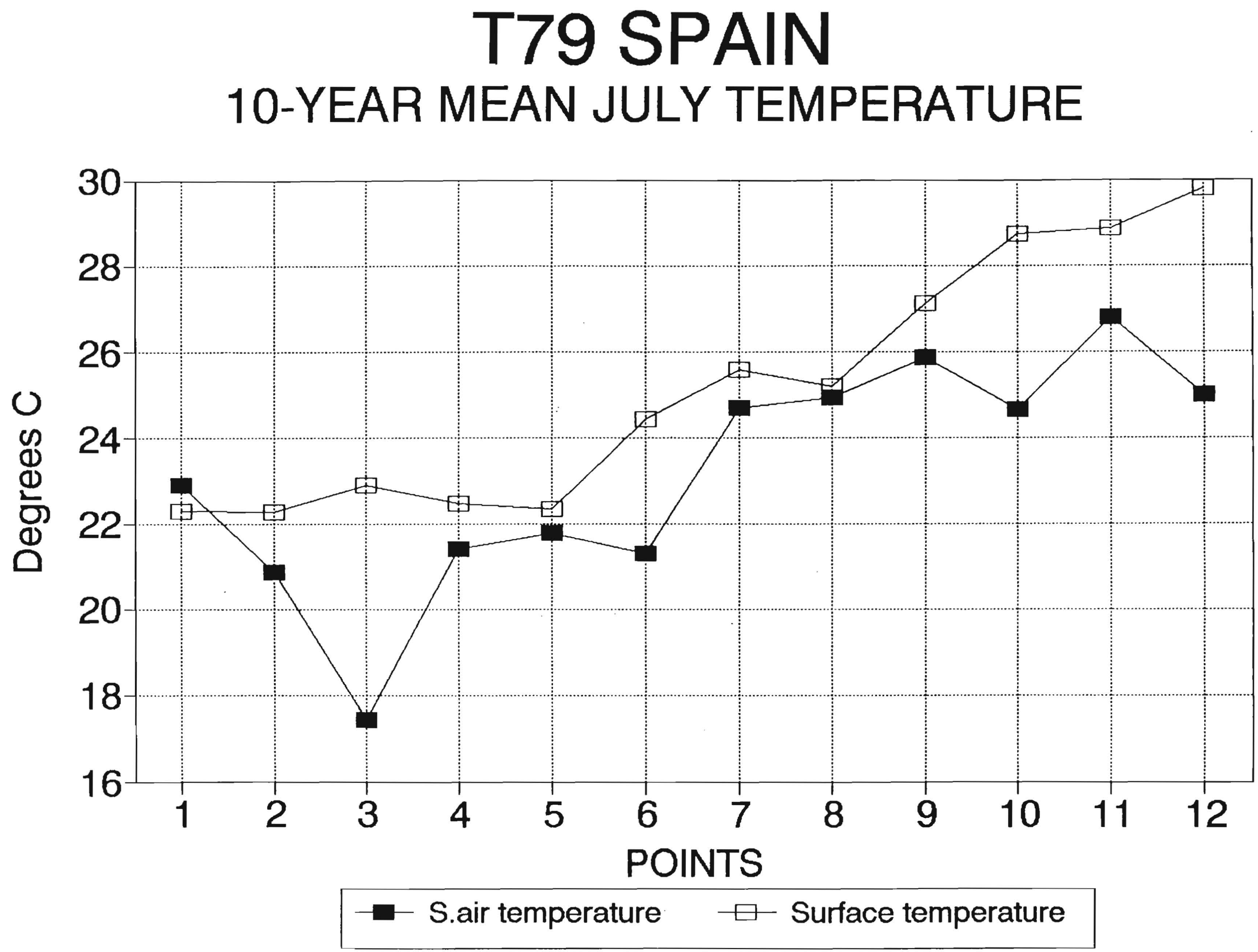


Fig B22 .- Evolution of s. temperature for Arpège model (T79) and s.air temperature (obs) for July.

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