Testing target cy43h surface options in climate mode: First results

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Outline

New Surface options in cy43 (wishlist)

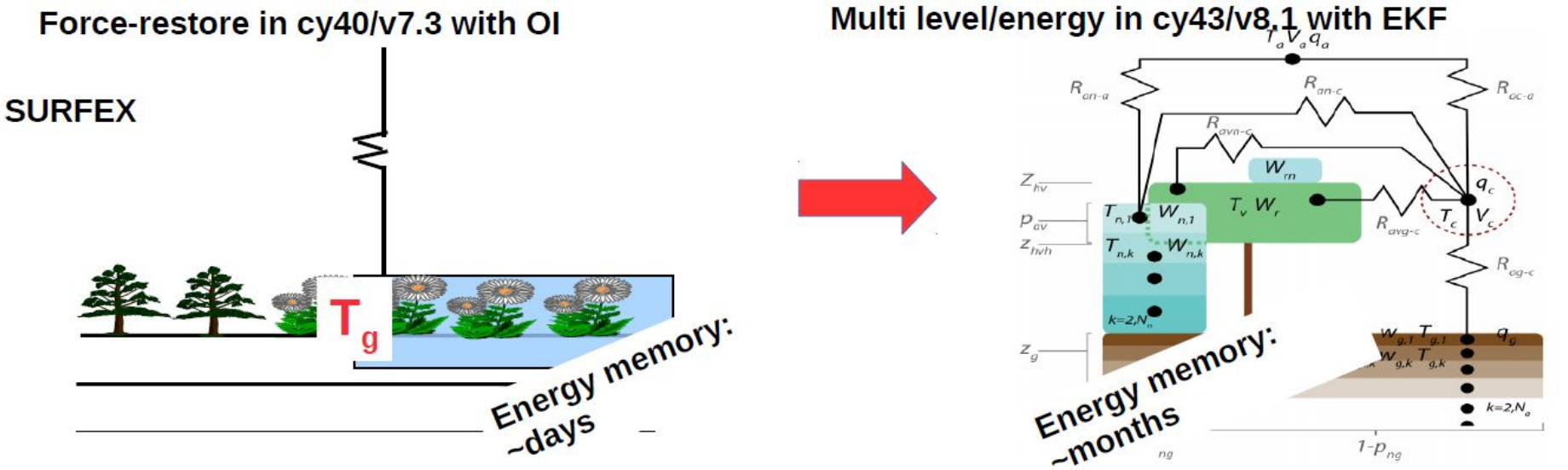
Why climate mode?

Setup of first experiments using the wishlist

Surface bias assessment: First results

Conclusions

New surface options in cy43h



•Most of the development in the HIRLAM's surface group is done now in cy43h since SURFEX8.1 code was introduced there last summer.

•We work in the introduction of a more advanced set of SURFEX land-surface physics: (diffusion soil, explicit snow, Multi-Energy Balance) in combination with SEKF assimilation.

•The first meteorological release of cy43h (harmonie43h2.1) can maybe be expected in autumn 2019. **It will still keep Force-restore and D95 snow** but will include some updates already tested in cy43h or previous releases.

Wishlist of SURFEX 8 namelist options

```
&NAM_ISBA
 CISBA = 'DIF'   ! Activate diffusion soil heat transfer
 YSOC_TOP   = 'soc_top'  ! Read top Soil organic carbon field
 YSOC_SUB = 'soc_sub' ! Read deep Soil organic carbon field
 CPHOTO = 'NON'  ! Jarvis formula is used for plant transpiration (nothing else is available for NPATCH<12)
 LTR_ML = .FALSE.  ! Radiative transfer in vegetation (but see LMEB option below).
 NPATCH = 2-4      ! Number of patches. 2 means separate forest and open land. 3 would mean an additional patch
                   with permanent snow (glaciers). 4 would mean yet an additional patch for bare soil)
 LMEB = .TRUE.   ! Use Multi-Energy Balance (explicit canopy). Automatically sets LTR_ML = .TRUE.
 CPEDO_FUNCTION =  'C084' ! Should be used for DIF
 XUNIF_RUNOFFB = 0.2  ! Used in combination only with CRUNOFF   = 'DT92'. Tunable
/
&NAM_MEB_ISBA
 LMEB_PATCH    = .F., .T.,  ! Use MEB for forest but not for open land (with NPATCH=2)
 LMEB_LITTER   = .TRUE.     ! Use litter on ground in forest.
/
&NAM_ISBAn
 CSCOND = 'PL98'  ! Type of soil thermal conductivity
 CSNOWRES = 'RIL' ! Maximum Richardson number limit for stable conditions ISBA-SNOW3L turbulent exchange option.
 CALBEDO = 'CM13' ! Albedo by cover and vegetation type processed from satellite data.
/
&NAM_SGH_ISBAn
 CRUNOFF   = 'DT92' ! DT92 means Dumenil and Todini (1992) subgrid runoff (should be used in combination with XUNIF_RUNOFFB=0.2).
             SGH means Decharme et al. (2006) Topmodel like subgrid runoff. This was developed for coarser resolution and requires
             subgrid slope information
 CRAIN    = 'SGH'  ! Activate spatial distribution of rainfall.
 CHORT    = 'DEF'   ! DEF=no Horton runoff. SGH activates the Horton surface runoff for intense rain on dry soil with limited infiltration capacity.
                    This option was added in the climate model: it has to be evaluated carefully for NWP applications before taking the decision of its use.
 LSOC = .TRUE.  ! Activate soil organic carbon effect.
/
&NAM_PREP_ISBA_SNOW
 CSNOW  = '3-L'   ! Explicit snow scheme (default 12 layers)
/
```

- New surface physics options: DIF, 3-L Snow scheme, MEB
- Sub-options defined according to past experience in the HCLIM community & with the help of SURFEX staff (Patrick, Aaron)
- New physiography: ECOCLIMAP-SG

Why running “climate mode” for nwp development?

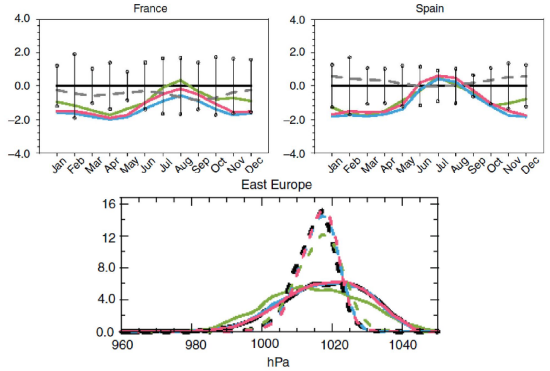
- All NWP forecasting systems have biases.
- In principle, the role of data assimilation should not be to compensate for biases in the system.
- We expect changes in sfc-atm interactions introduced by the new surface components in cy43h.
- So we study the system in climate mode to identify and reduce biases before data assimilation is activated.

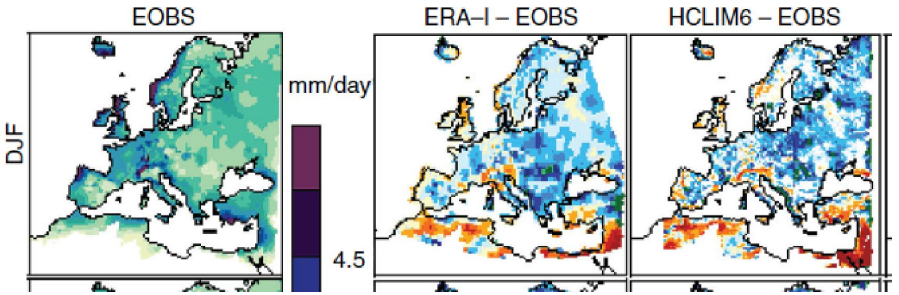
Climate mode status in cy43h

- SURFEX version updated to 8.1 last summer
- Update of SST during the Forecast (LMCC01_MSE=.TRUE.). A solution for updating Sea Ice not yet available (but RC working on it)
- The common CY43 git repository can be used for “climate mode” experiments. Good since we can keep our tests as close as possible to the development branch.
- Progress is slow since we’re early testers of cy43h and we’re trying many new options simultaneously. Also some issues we find are specific to the climate runs.
- We plan to run climate experiments over 2-4 domains to observe the impact of the new surface over different regions. People involved: Samuel Viana, Emily Gleeson, Patrick Samuelsson, RC colleagues.

Evaluation of cy43h model bias in climate mode.

- Methodology inspired by Lindtstedt et al. (2015): Seasonal & yearly PDFs, Annual cycles, maps, etc.



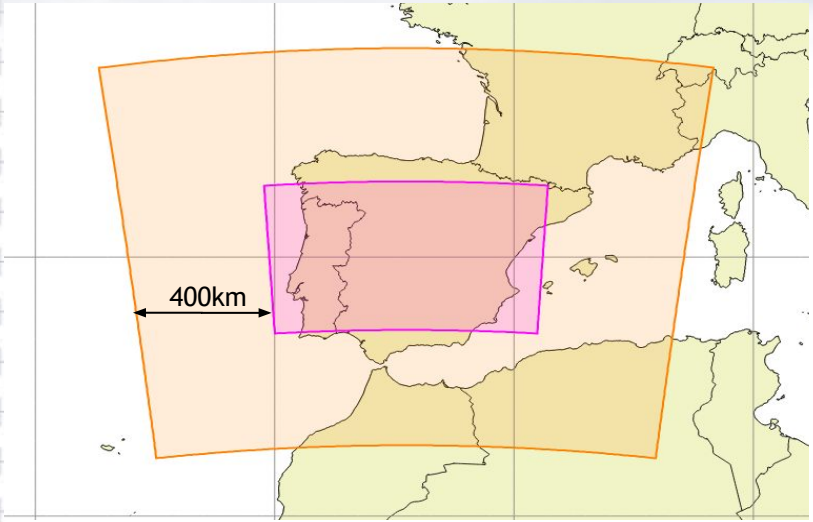


- Need to find a proper reference data for every variable:
  - Atmospheric fields (pcp, T+,T-...) can be compared against HR databases available from the different NWS.
  - Surface fields: ESA CCI Soil moisture, ERA5, etc.
  - Direct validation of surface fluxes when available

First cy43h long runs in climate mode

- Common setup for tests already done (not target sfc configs in **red**):
  - Full wishlist (**except MEB**)
  - ERA5 BCs.
  - **ECOCLIMAP II**
  - LUNBC=OFF (upper level boundary relaxation scheme)
  - LESPCPL=ON: Upper level spectral nudging to constrain the large scales (shorter simulations)
  - NPATCH=2 (Separate energy budgets for open-land & forest)
- So far only tested over domains without sea-ice (IBERIA & IRELAND)

DOMAIN: IBERIAxxm_2.5

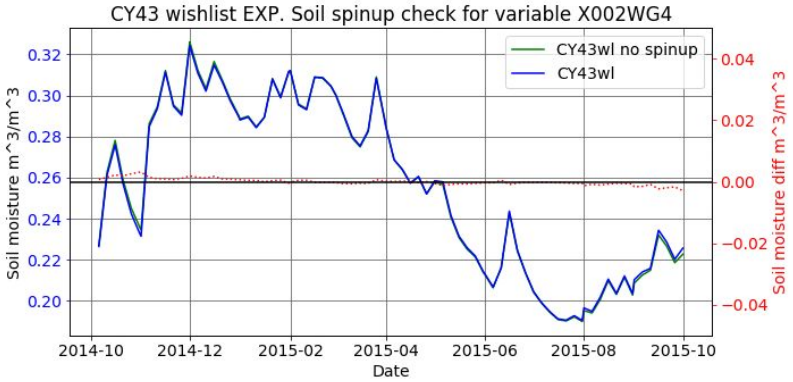


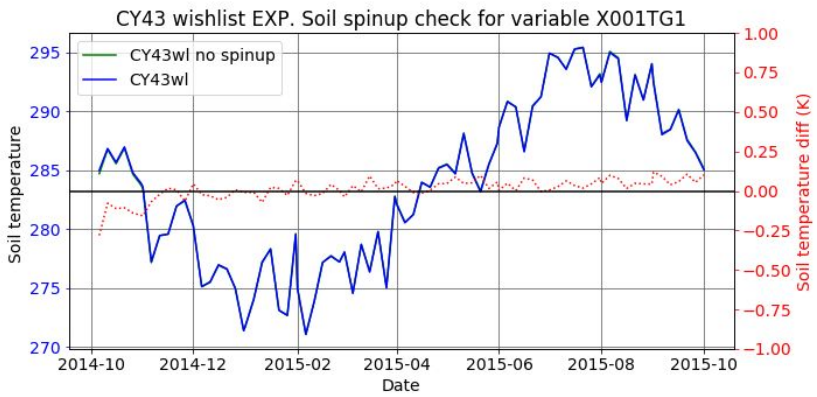
- Medium-sized domain as a compromise
- Assuming ~400km as spin-up distance for precipitation
- Integration time: ~1 week / year when everything works fine.

2 experiments:

1. From 10/2013 to 01/2018. ECOCLIMAPII (4 years).
2. From 10/2014 to 10/2015. ECOCLIMAPII. Purpose: to study surface spin up time.

Checking the soil spin-up time

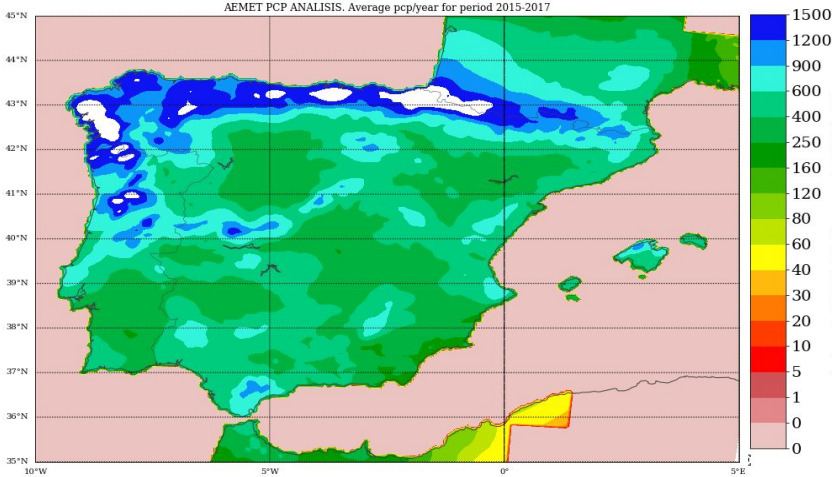


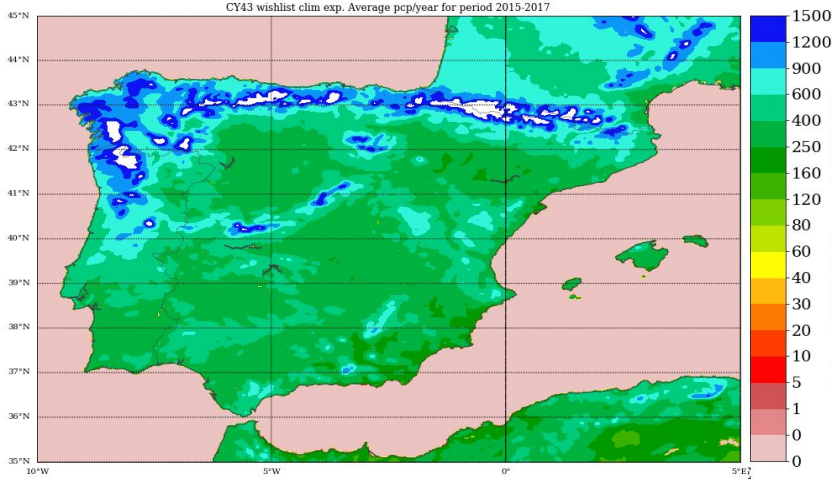


- Upper soil layers up to around 20-cm reach equilibrium in around 3 months (similar to F-R).
- Deep layers: For soil moisture 6-8 months is enough; for soil temperature a difference of 0.5-1 K remains after 1 year.

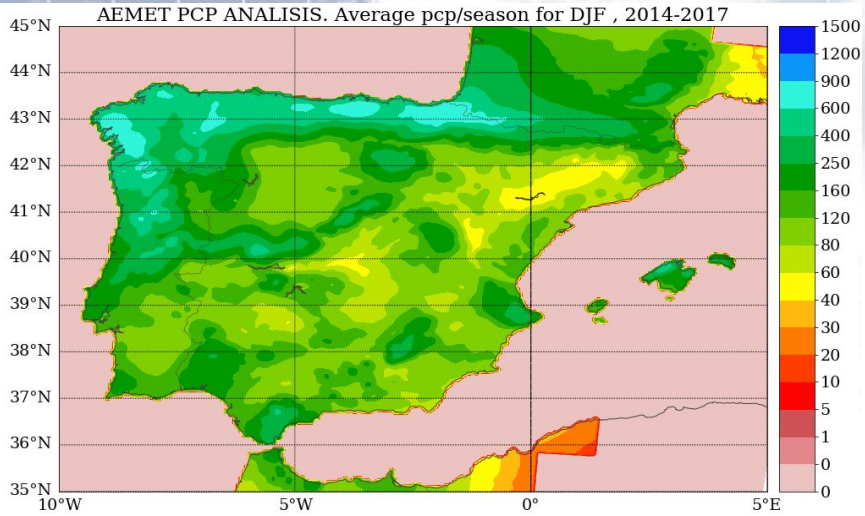
First results for PCP, TMAX, TMIN

- Analysis for years 2015-2017 (1st year left out for spin up)
- Reference: AEMET SPAN objective analysis (5km) for PCP, T2M_max, T2M_min





- Average pcp/year during the period 2015-2017 doesn't look bad, but...


AEMET PCP ANALISIS. Average pcp/season for DJF , 2014-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
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160
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80
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1
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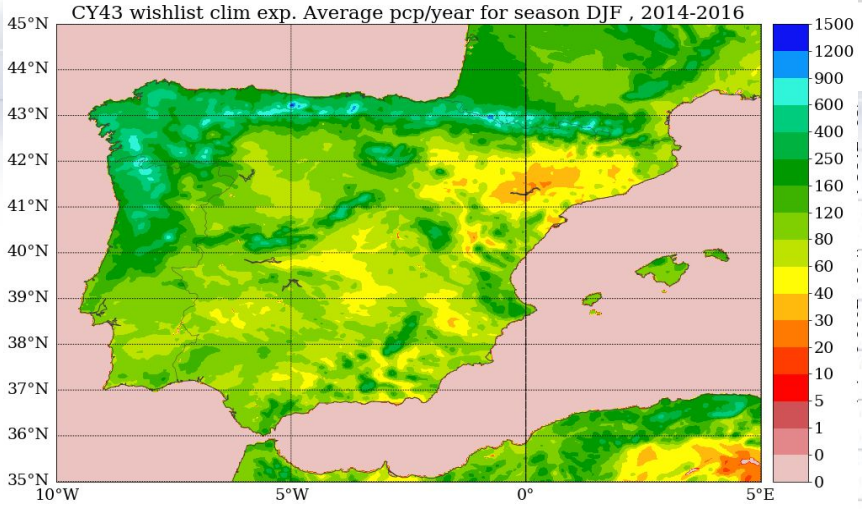
0


CY43 wishlist clim exp. Average pcp/year for season DJF , 2014-2016
45°N
44°N
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42°N
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36°N
35°N
10°W
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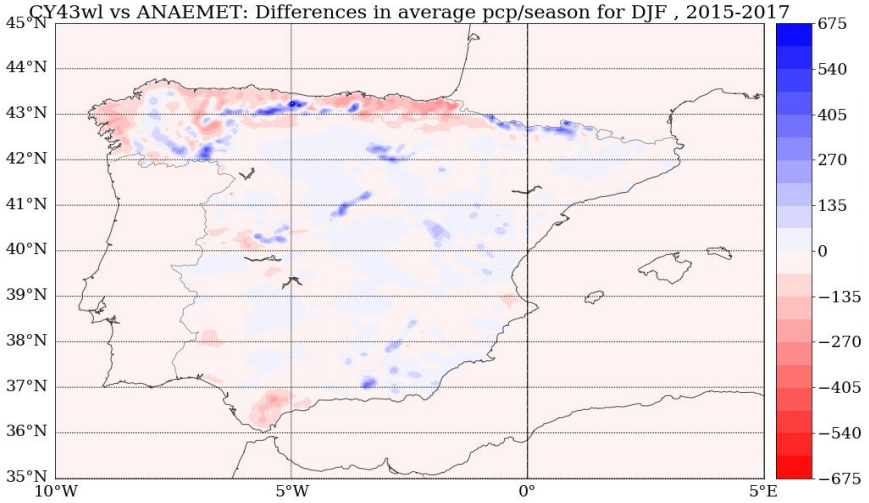
CY43wl vs ANAEMET: Differences in average pcp/season for DJF , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
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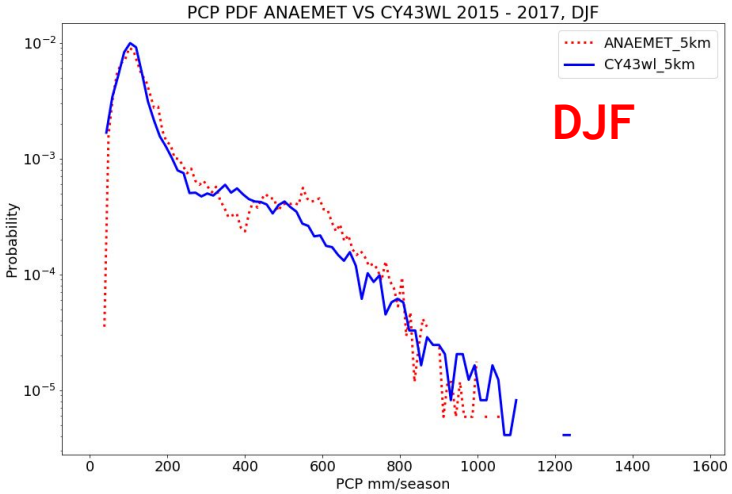
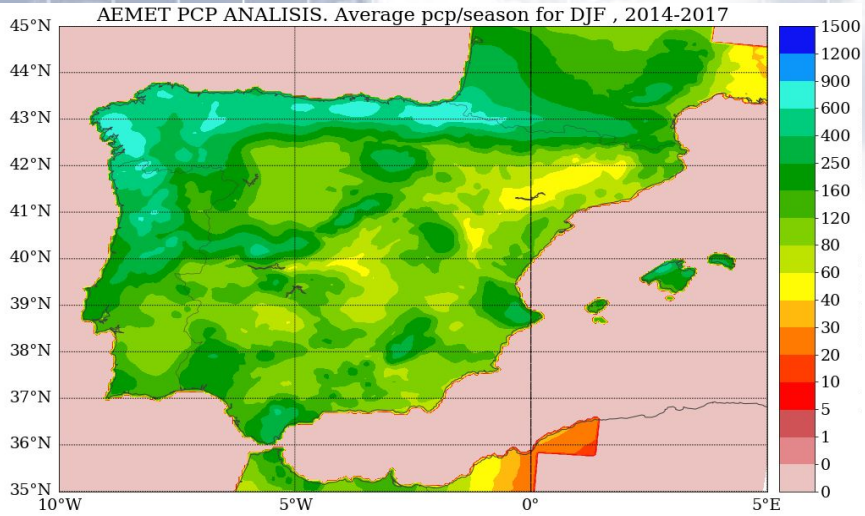
5°W
0°
5°E
675
540
405
270
135
0
−135
−270
−405
−540
−675


PCP PDF ANAEMET VS CY43WL 2015 - 2017, DJF
ANAEMET_5km
CY43wl_5km
DJF
Probability
PCP mm/season
0
200
400
600
800
1000
1200
1400
1600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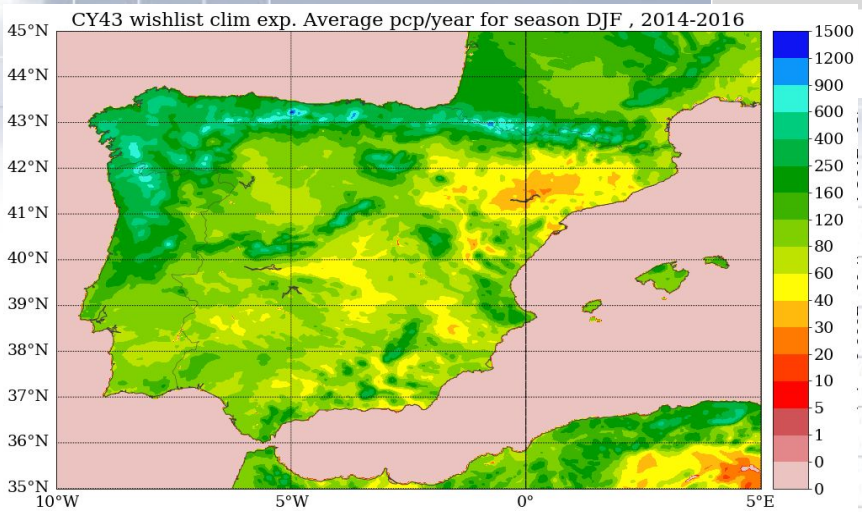
CY43 wishlist clim exp. Average pcp/year for season DJF , 2014-2016
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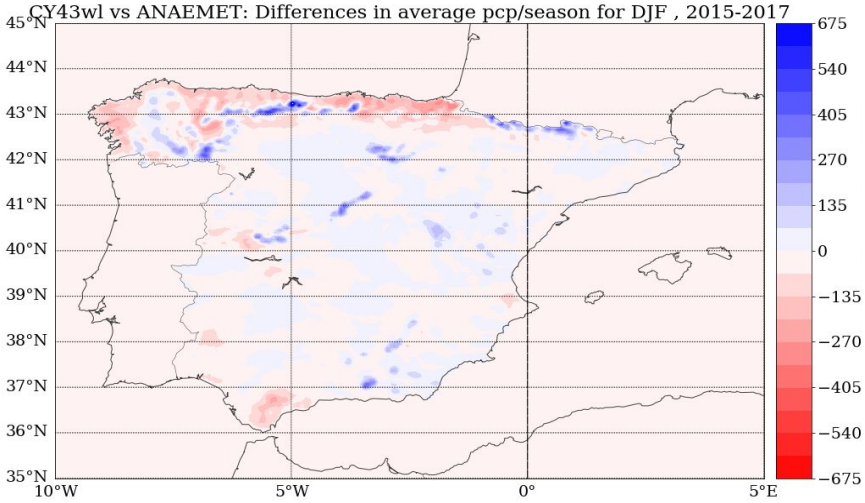
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36°N
35°N
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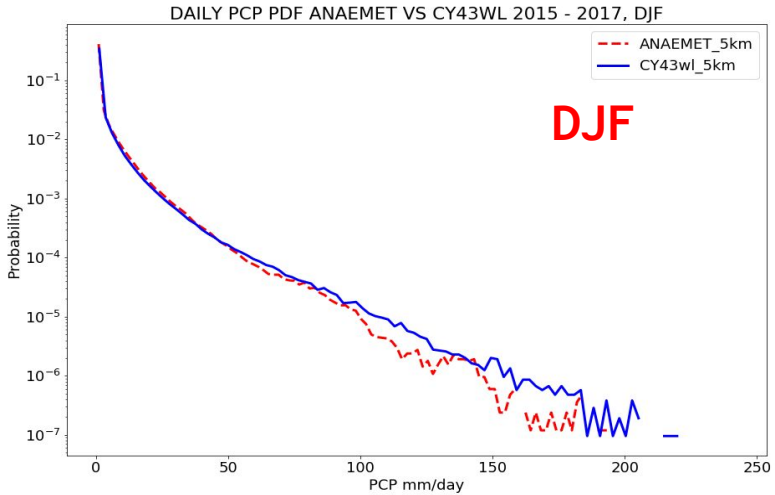
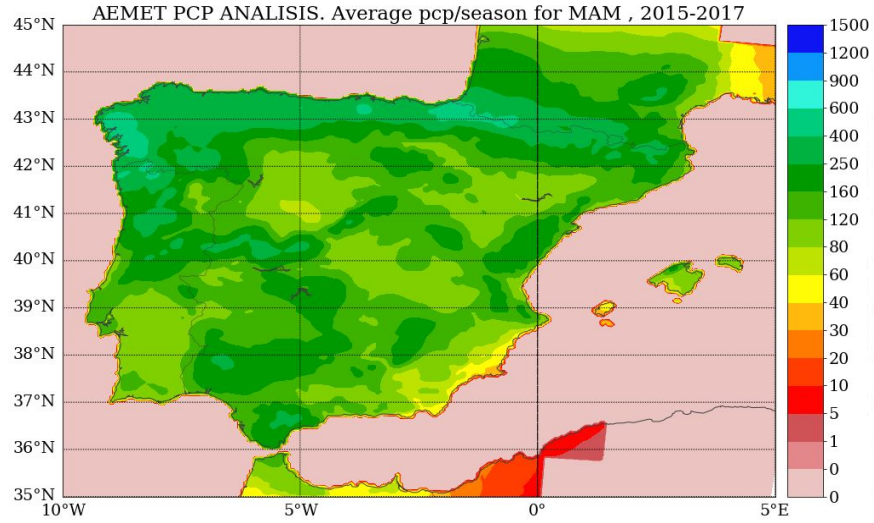
−540
−675


DAILY PCP PDF ANAEMET VS CY43WL 2015 - 2017, DJF
ANAEMET_5km
CY43wl_5km
DJF
Probability
PCP mm/day
0
50
100
150
200
250


AEMET PCP ANALISIS. Average pcp/season for MAM , 2015-2017
45°N
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36°N
35°N
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5°W
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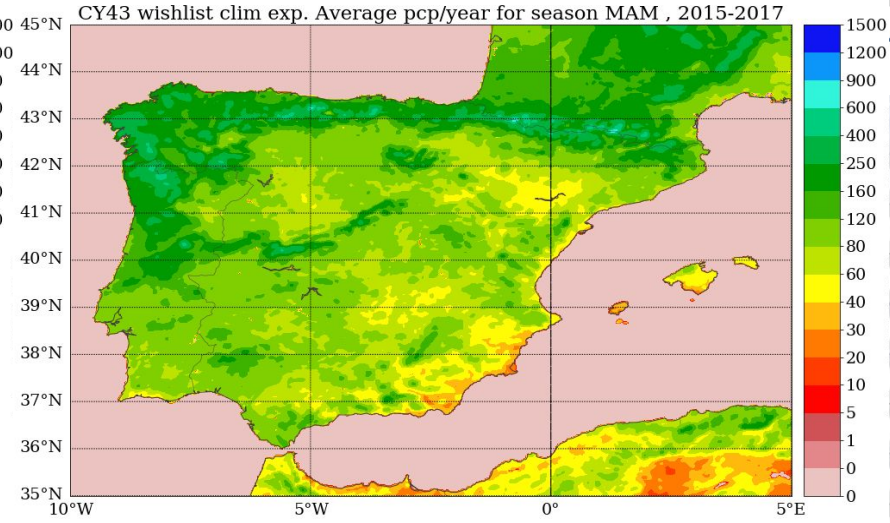
CY43 wishlist clim exp. Average pcp/year for season MAM , 2015-2017
45°N
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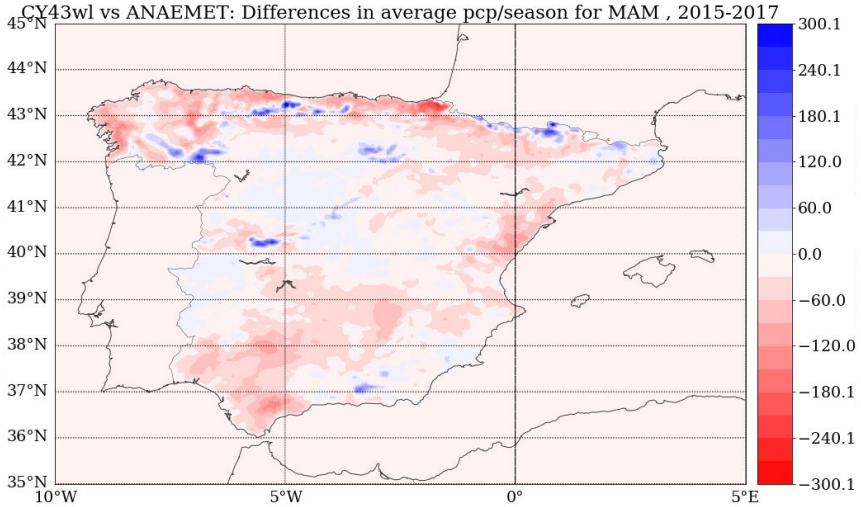
CY43wl vs ANAEMET: Differences in average pcp/season for MAM , 2015-2017
45°N
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5°E
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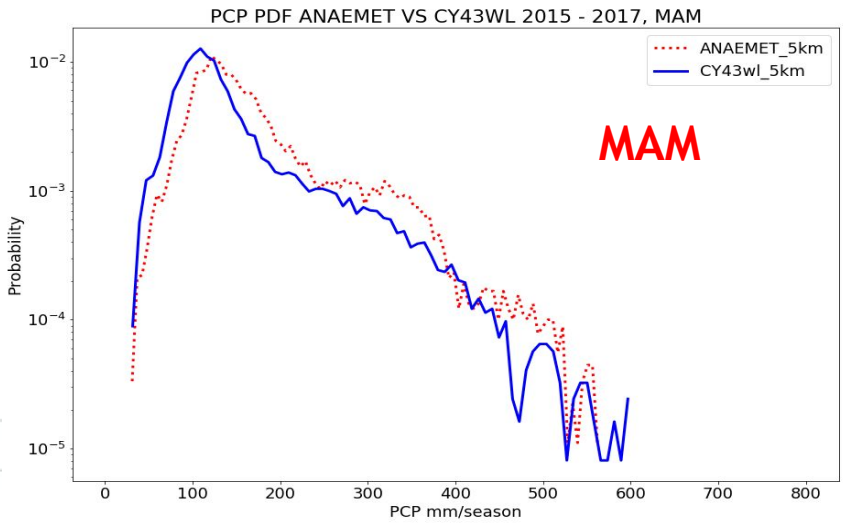
−60.0
−120.0
−180.1
−240.1
−300.1


PCP PDF ANAEMET VS CY43WL 2015 - 2017, MAM
ANAEMET_5km
CY43wl_5km
MAM
Probability
10^{-2}
10^{-3}
10^{-4}
10^{-5}
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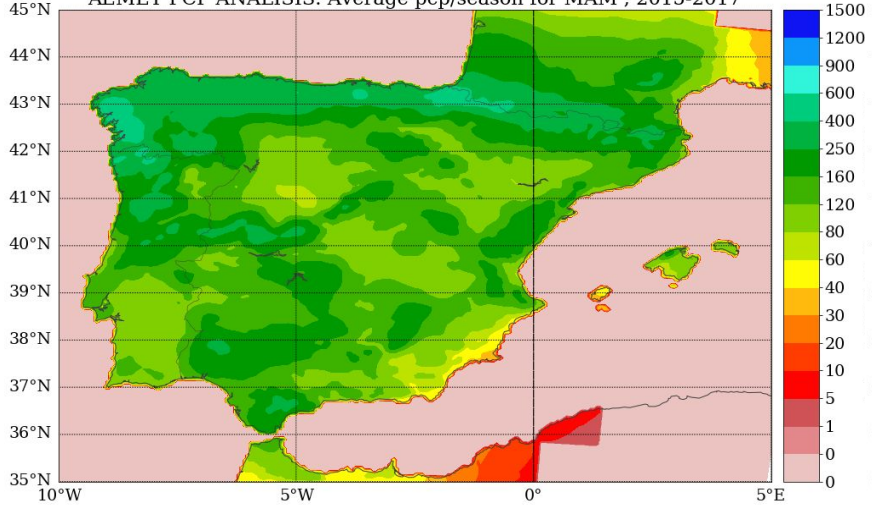
700
800
PCP mm/season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39°N
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35°N
10°W
5°W
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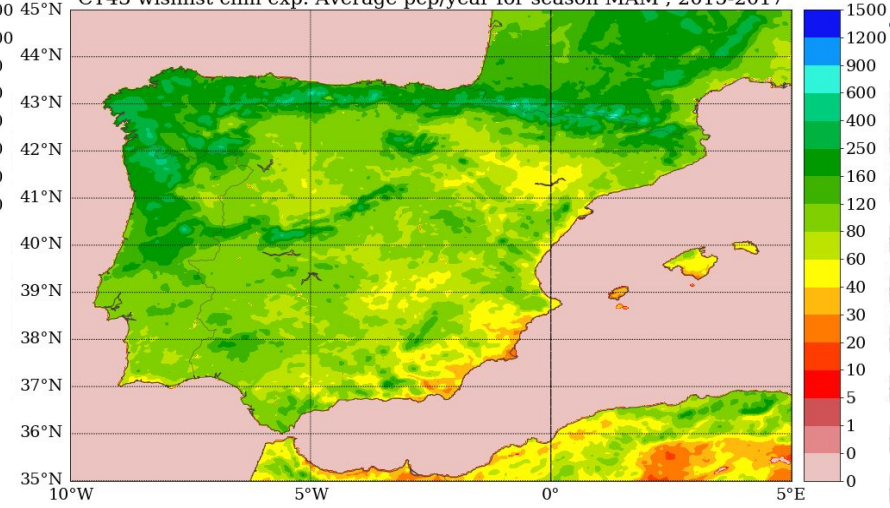
CY43 wishlist clim exp. Average pcp/year for season MAM , 2015-2017
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10°W
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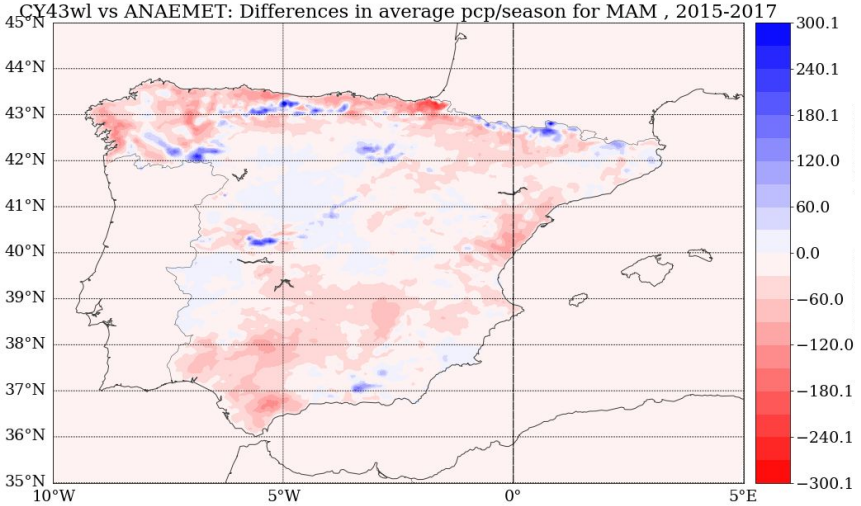
CY43wl vs ANAEMET: Differences in average pcp/season for MAM , 2015-2017
45°N
44°N
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41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
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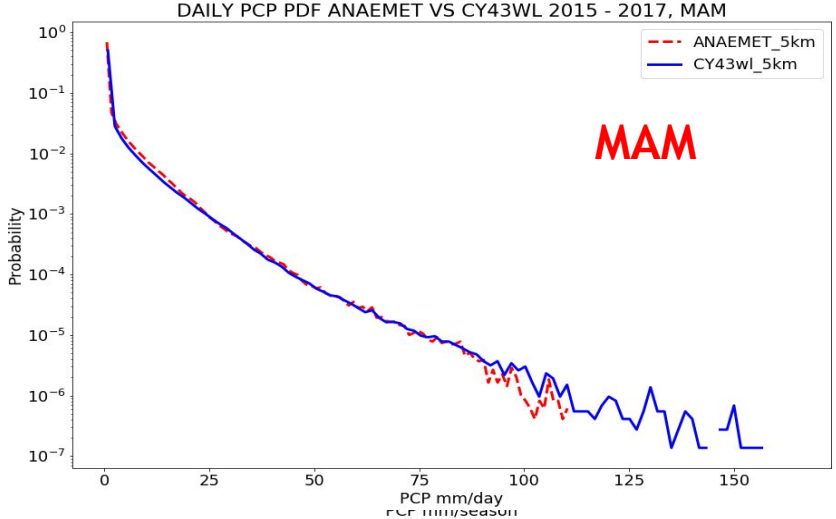
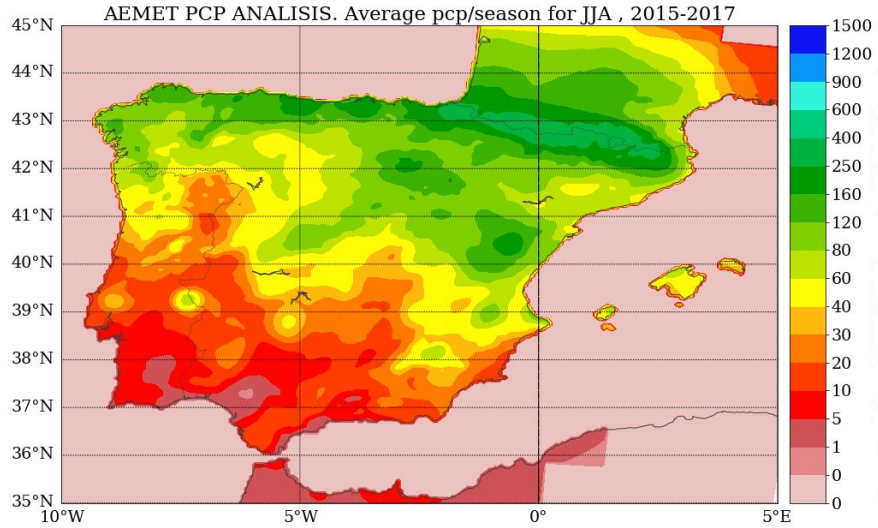
5°E
300.1
240.1
180.1
120.0
60.0
0.0
−60.0
−120.0
−180.1
−240.1
−300.1


DAILY PCP PDF ANAEMET VS CY43WL 2015 - 2017, MAM
ANAEMET_5km
CY43wl_5km
MAM
Probability
PCP mm/day
0
25
50
75
100
125
150


AEMET PCP ANALISIS. Average pcp/season for JJA , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
1500
1200
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250
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120
80
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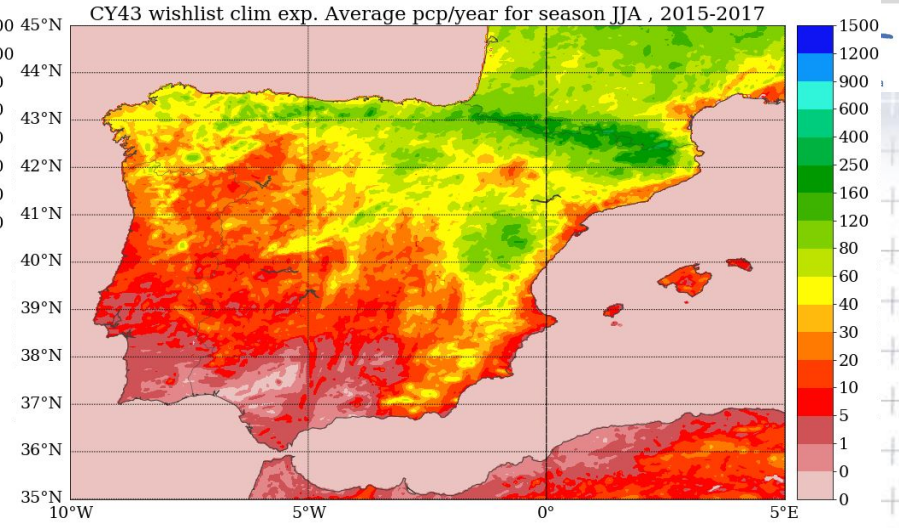
20
10
5
1
0
0


CY43 wishlist clim exp. Average pcp/year for season JJA , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
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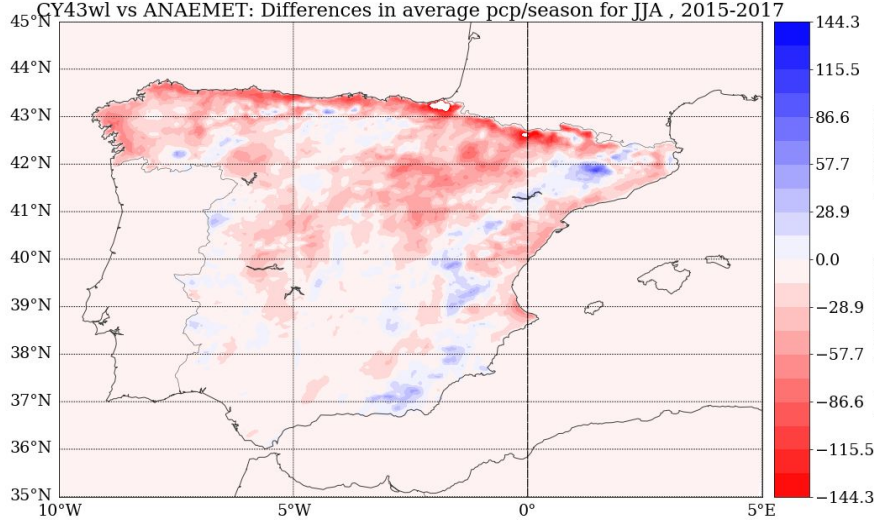
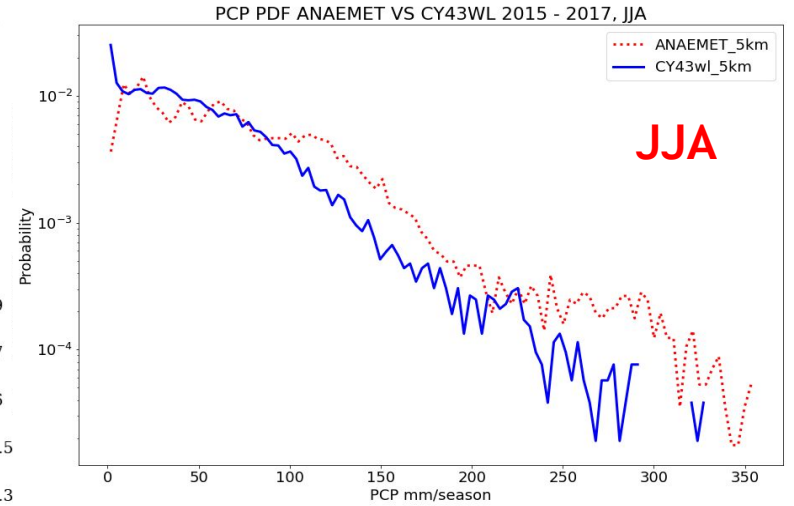
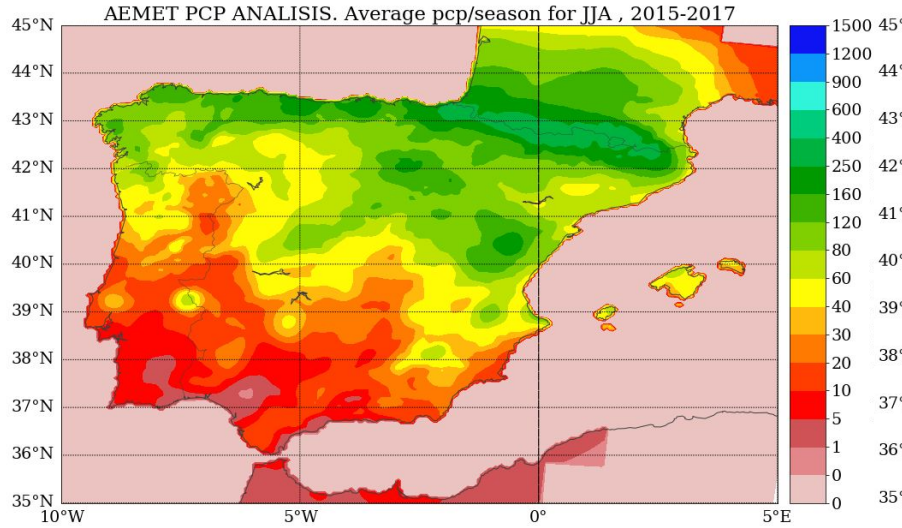
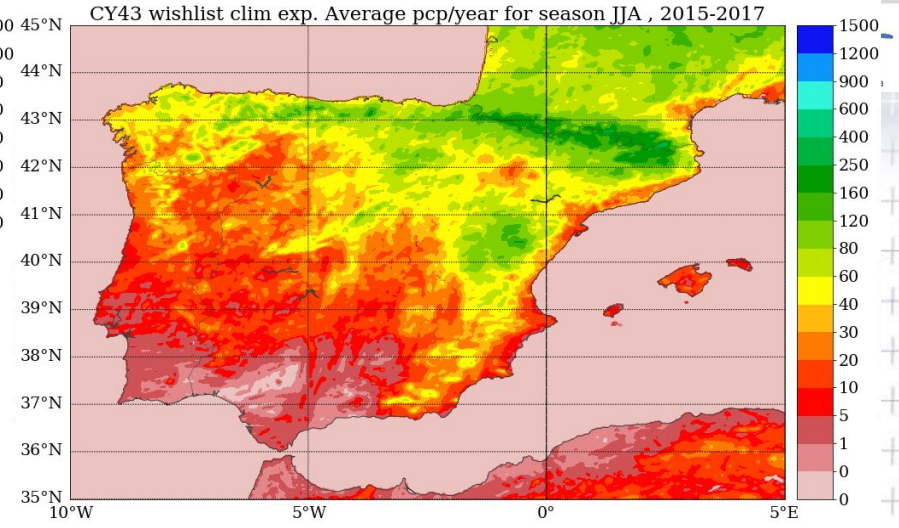
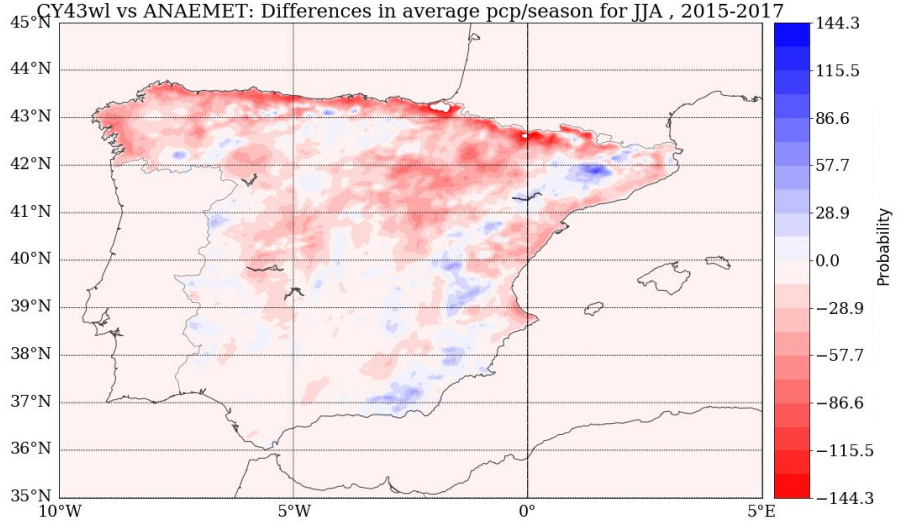
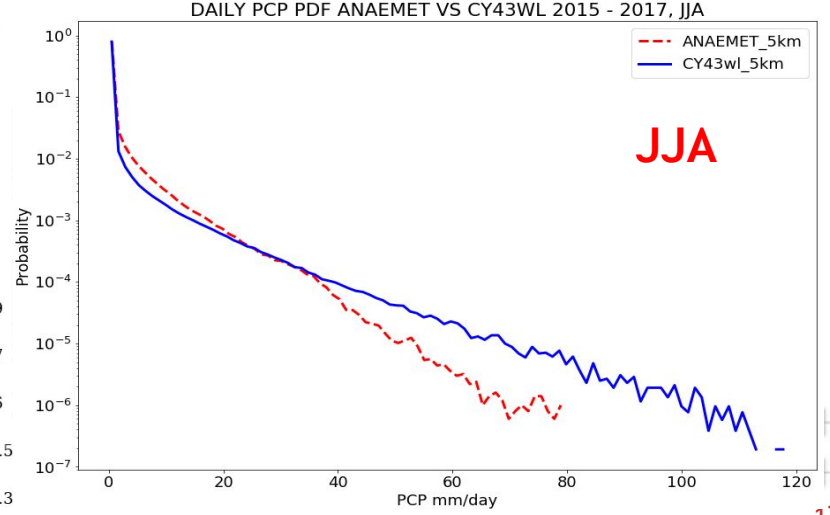

CY43wl vs ANAEMET: Differences in average pcp/season for JJA , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
144.3
115.5
86.6
57.7
28.9
0.0
−28.9
−57.7
−86.6
−115.5
−144.3

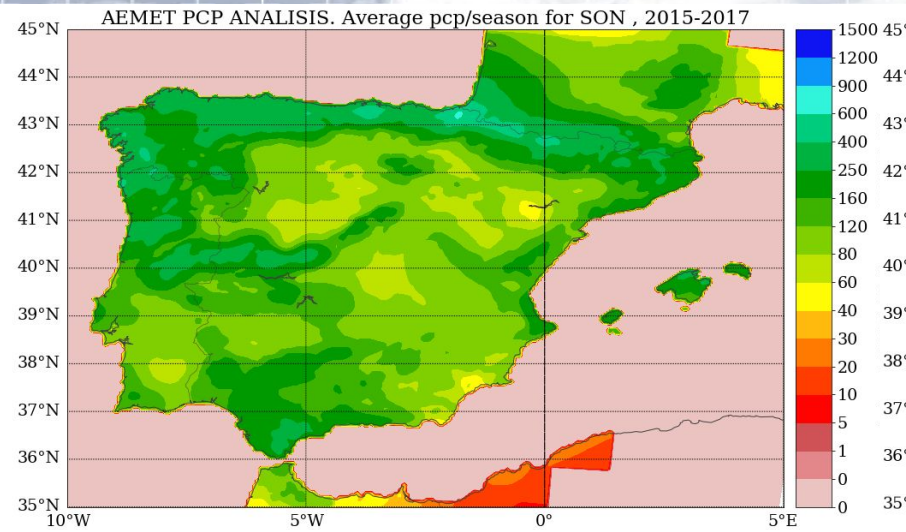

PCP PDF ANAEMET VS CY43WL 2015 - 2017, JJA
ANAEMET_5km
CY43wl_5km
JJA
Probability
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200
250
300
350
PCP mm/season


AEMET PCP ANALISIS. Average pcp/season for JJA , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
1500
1200
900
600
400
250
160
120
80
60
40
30
20
10
5
1
0
0


CY43 wishlist clim exp. Average pcp/year for season JJA , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
1500
1200
900
600
400
250
160
120
80
60
40
30
20
10
5
1
0
0


CY43wl vs ANAEMET: Differences in average pcp/season for JJA , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
144.3
115.5
86.6
57.7
28.9
0.0
−28.9
−57.7
−86.6
−115.5
−144.3


DAILY PCP PDF ANAEMET VS CY43WL 2015 - 2017, JJA
ANAEMET_5km
CY43wl_5km
JJA
Probability
PCP mm/day
0
20
40
60
80
100
120


AEMET PCP ANALISIS. Average pcp/season for SON , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
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900
600
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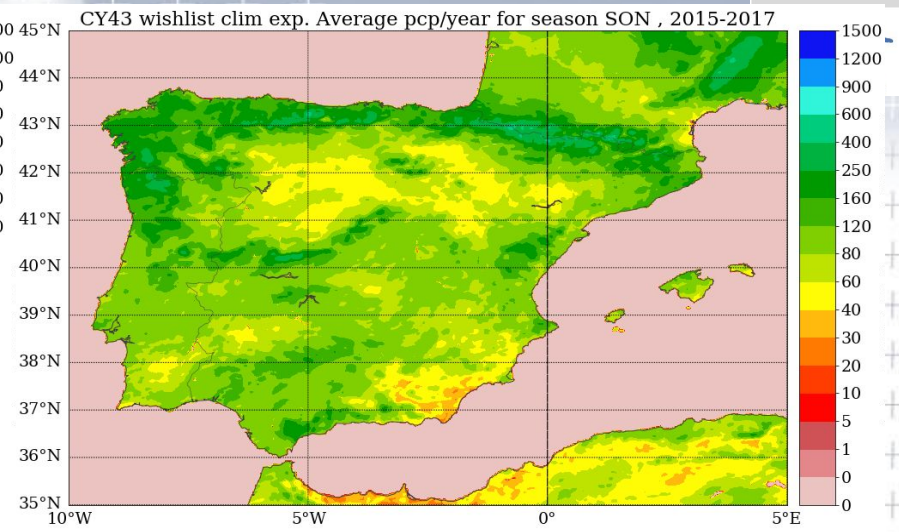
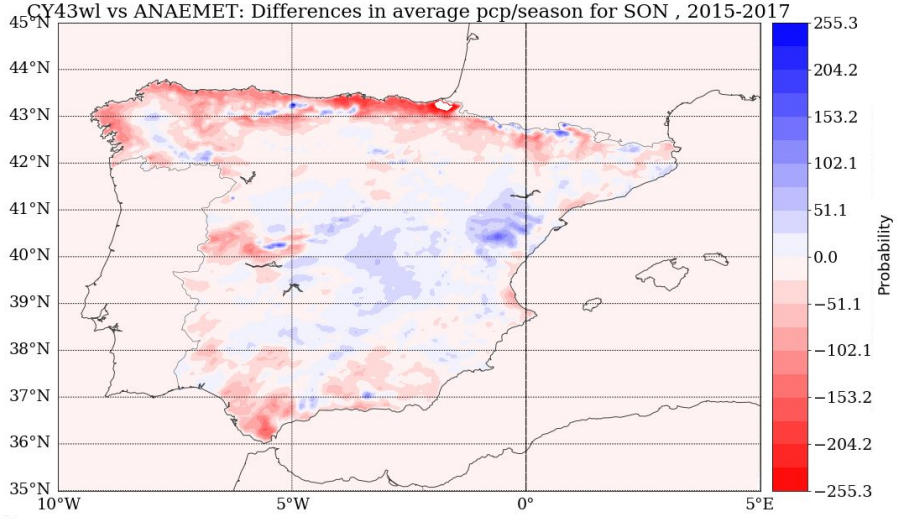
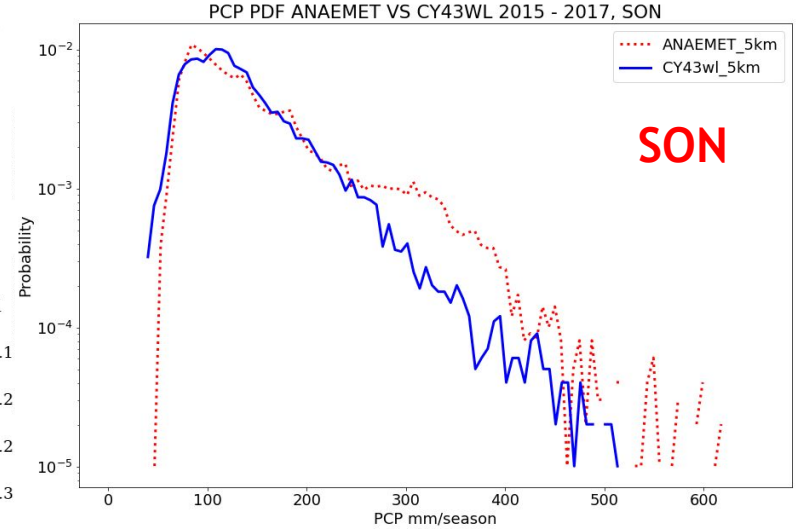
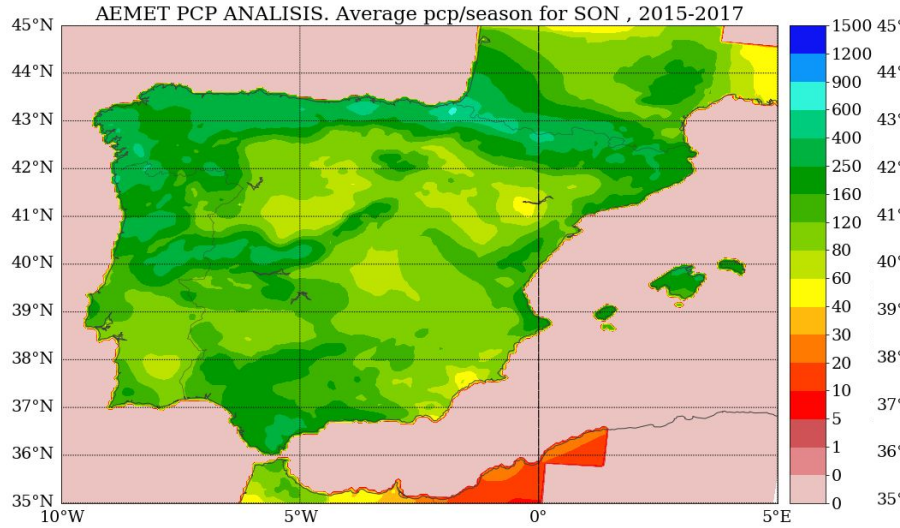
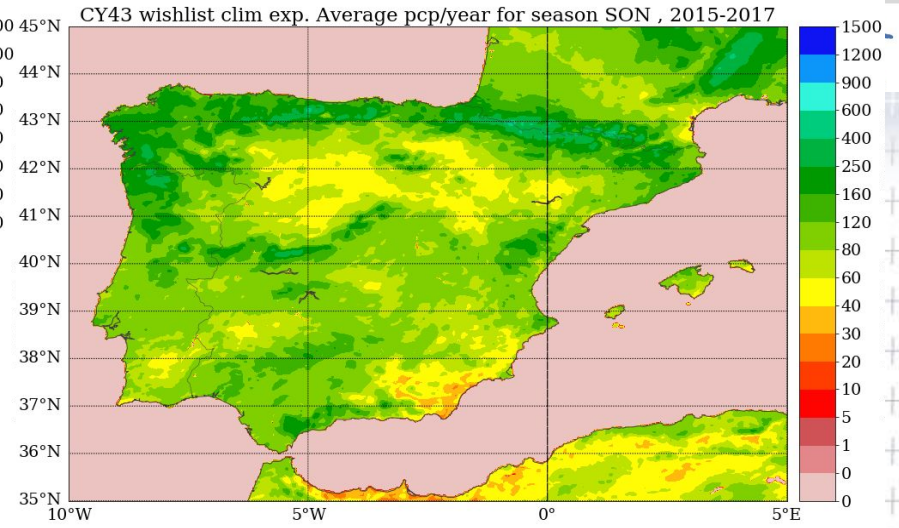
120
80
60
40
30
20
10
5
1
0

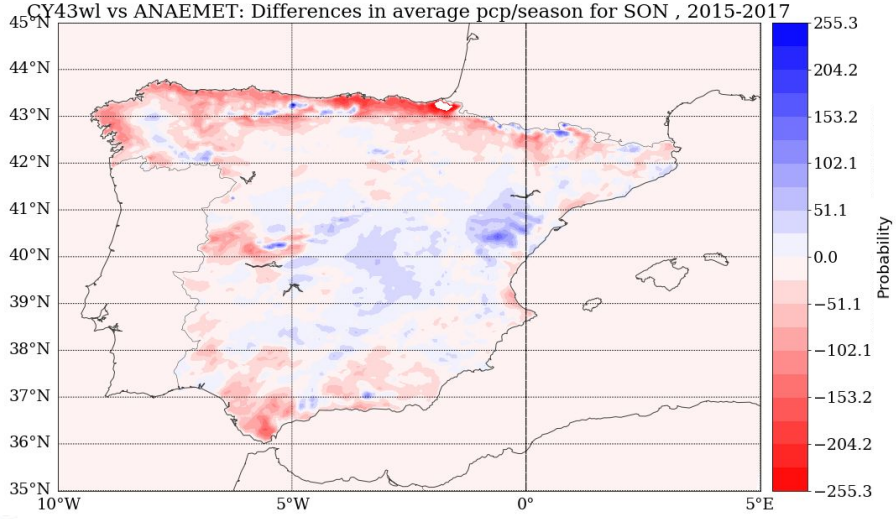

CY43 wishlist clim exp. Average pcp/year for season SON , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
1500
1200
900
600
400
250
160
120
80
60
40
30
20
10
5
1
0

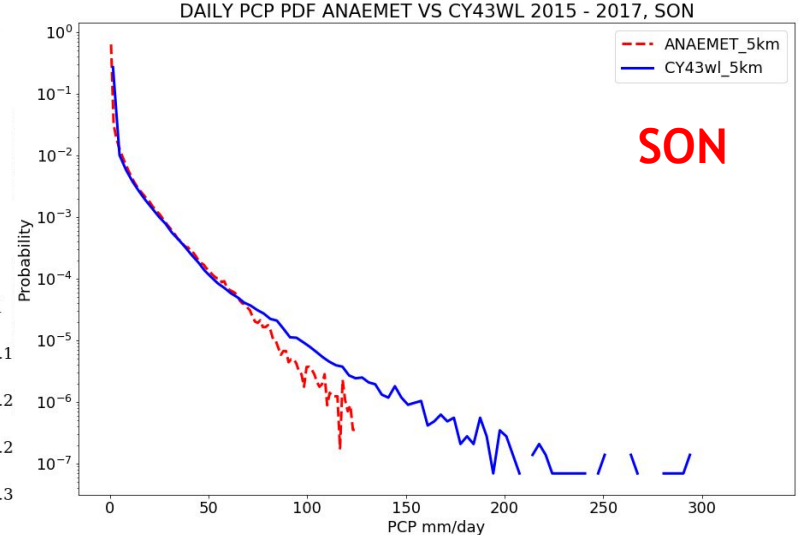

CY43wl vs ANAEMET: Differences in average pcp/season for SON , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
255.3
204.2
153.2
102.1
51.1
0.0
−51.1
−102.1
−153.2
−204.2
−255.3


PCP PDF ANAEMET VS CY43WL 2015 - 2017, SON
ANAEMET_5km
CY43wl_5km
SON
Probability
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
100
200
300
400
500
600
PCP mm/season


AEMET PCP ANALISIS. Average pcp/season for SON , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
1500
1200
900
600
400
250
160
120
80
60
40
30
20
10
5
1
0


CY43 wishlist clim exp. Average pcp/year for season SON , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
1500
1200
900
600
400
250
160
120
80
60
40
30
20
10
5
1
0


CY43wl vs ANAEMET: Differences in average pcp/season for SON , 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
255.3
204.2
153.2
102.1
51.1
0.0
−51.1
−102.1
−153.2
−204.2
−255.3

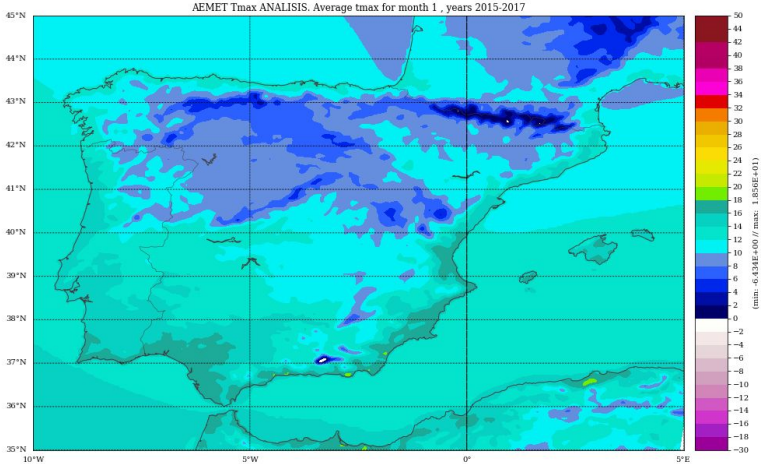

DAILY PCP PDF ANAEMET VS CY43WL 2015 - 2017, SON
ANAEMET_5km
CY43wl_5km
SON
Probability
PCP mm/day
0
50
100
150
200
250
300

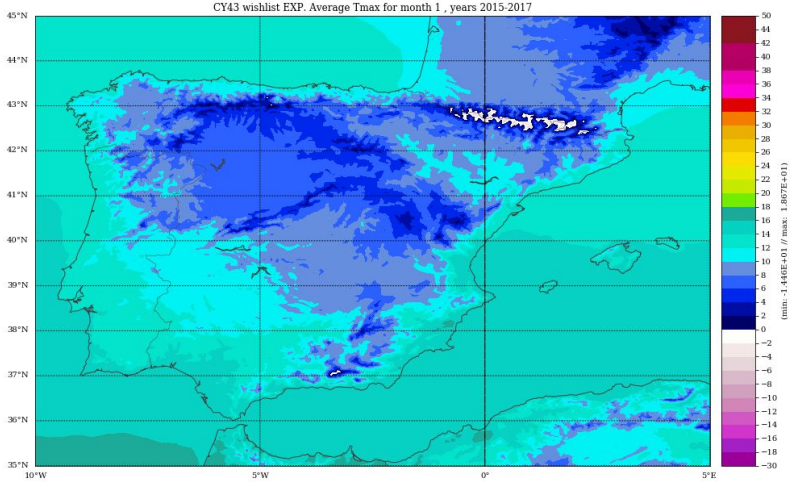
- The model tends to underestimate pcp (seasonally).
- Over complex orography (where model appears to “overestimate” pcp), the reference data (coarser) is probably too dry.
- Worst results during the convective season. Very little precipitation over the east coast & Balearic islands.
- Daily & seasonal PDFs reproduce correctly the reference data in winter & spring.
- Daily & seasonal PDFs show opposite biases during the convective season: better to compare station vs gridpoint data there.

AEMET ANALYSIS

CY43wishlist

T+





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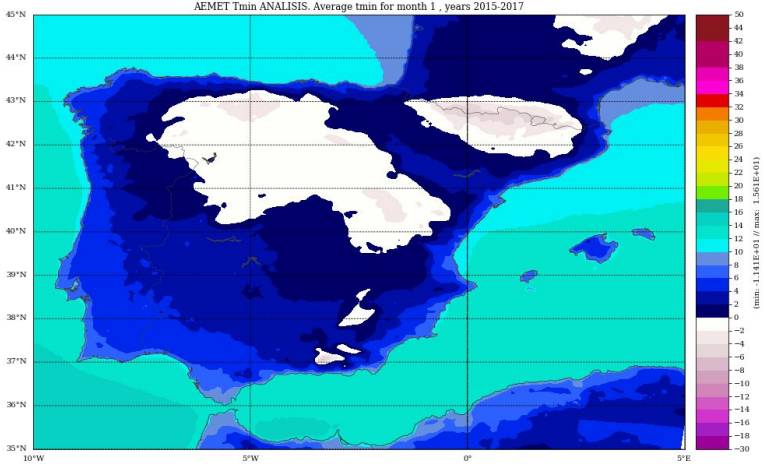
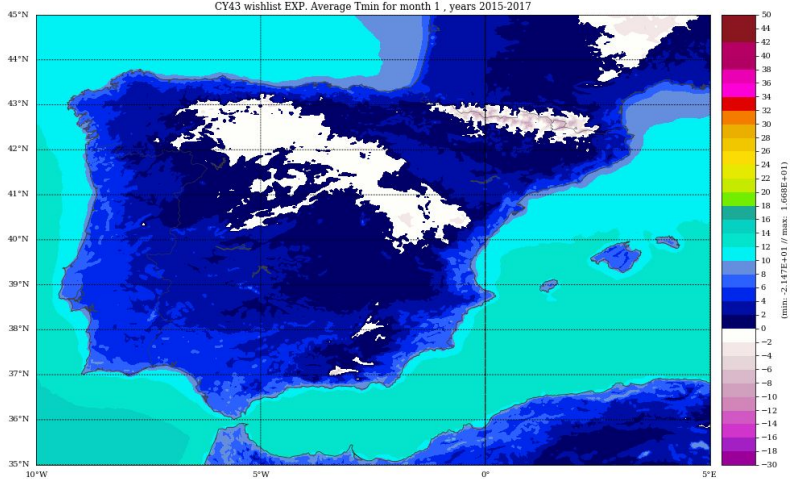
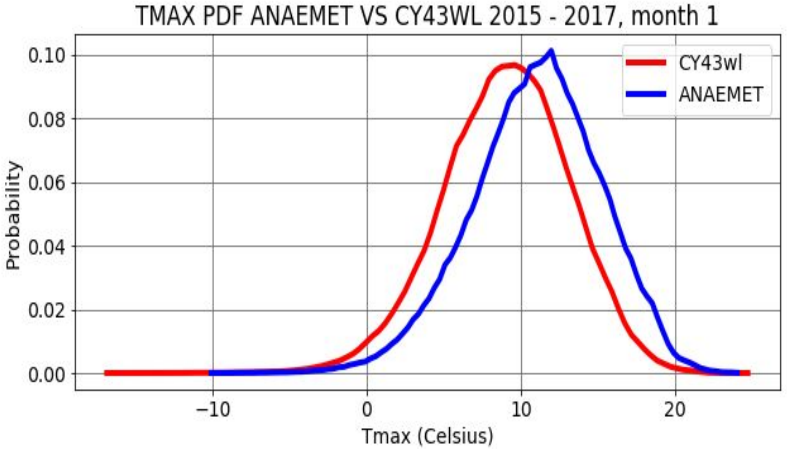
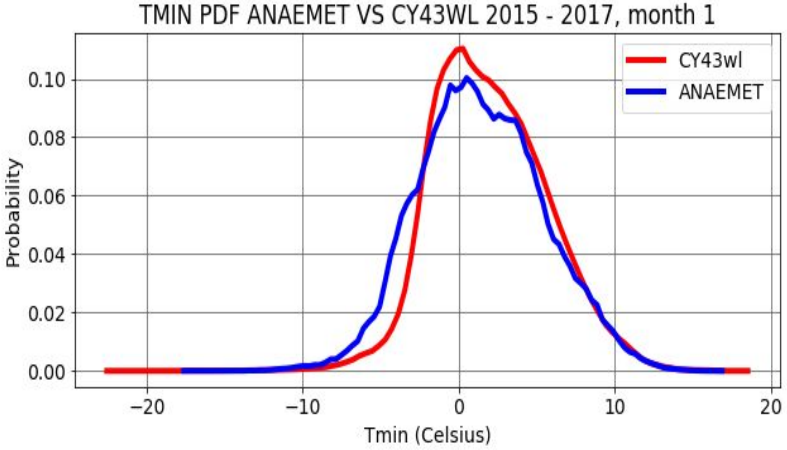
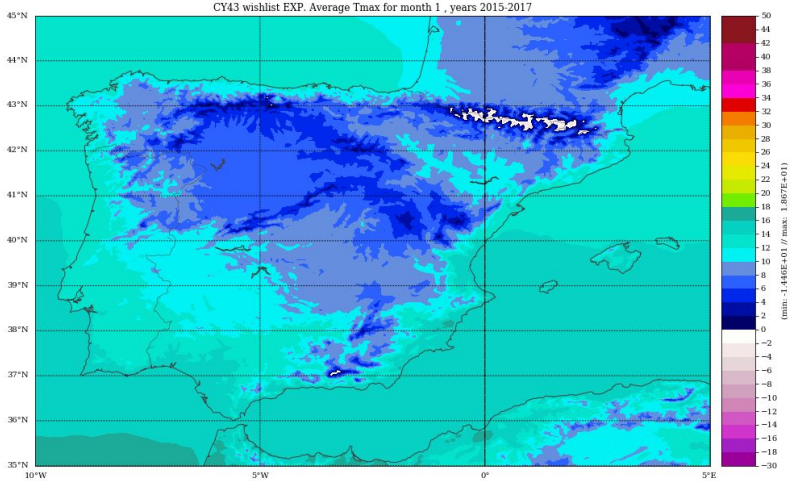


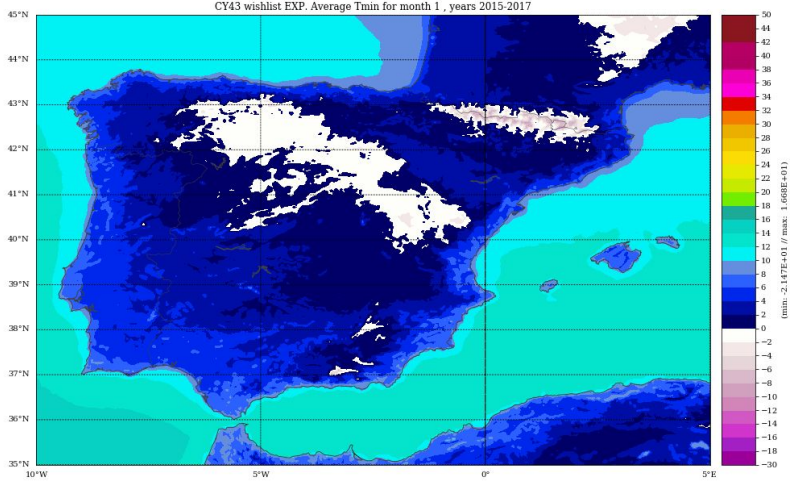


CY43wishlist

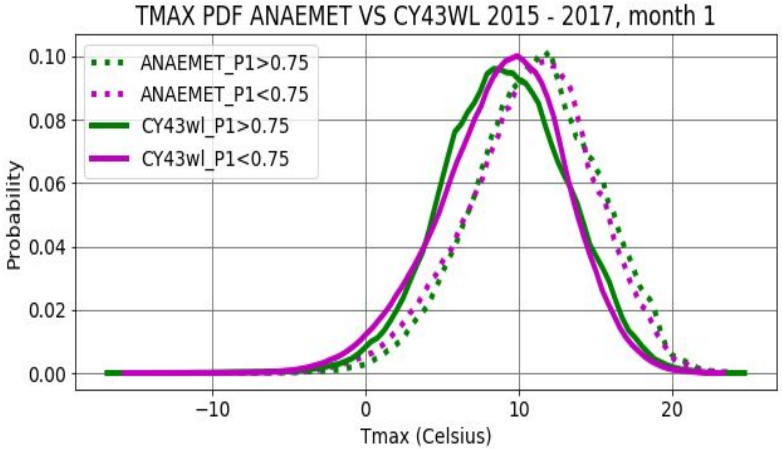


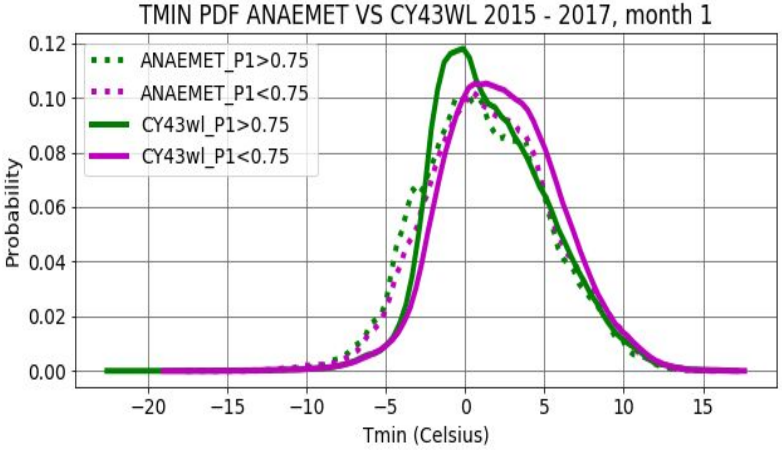


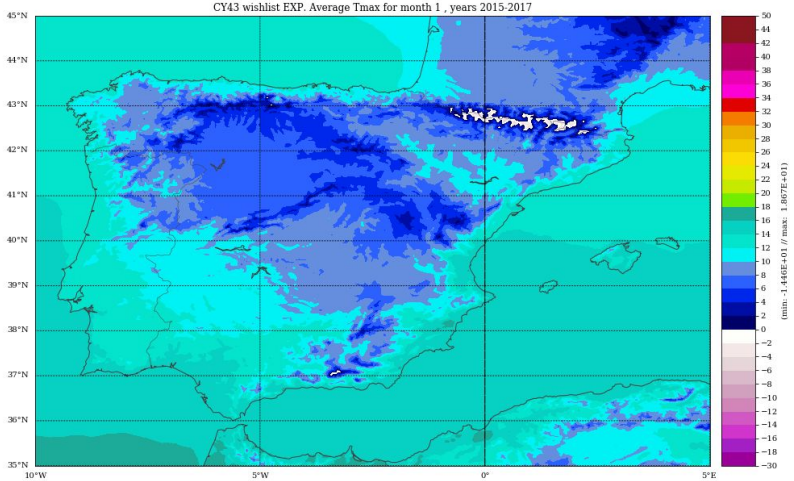


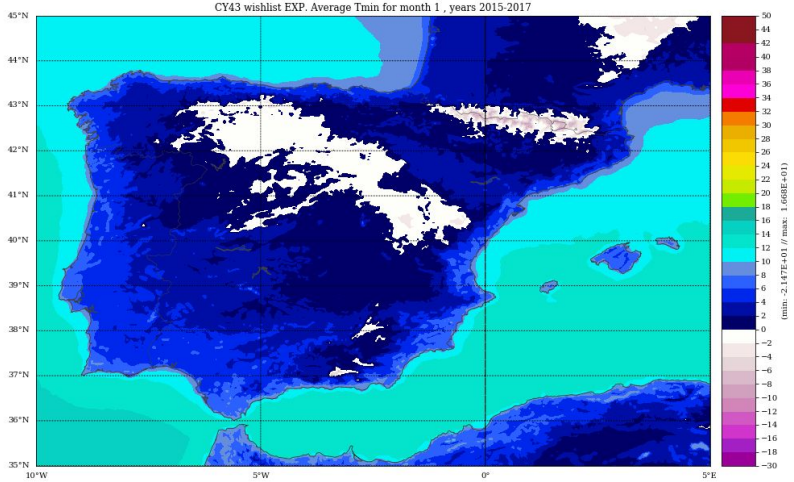


CY43wishlist

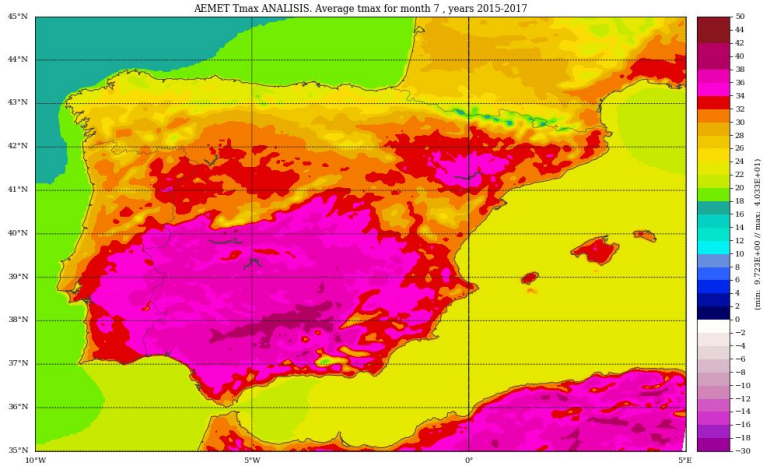


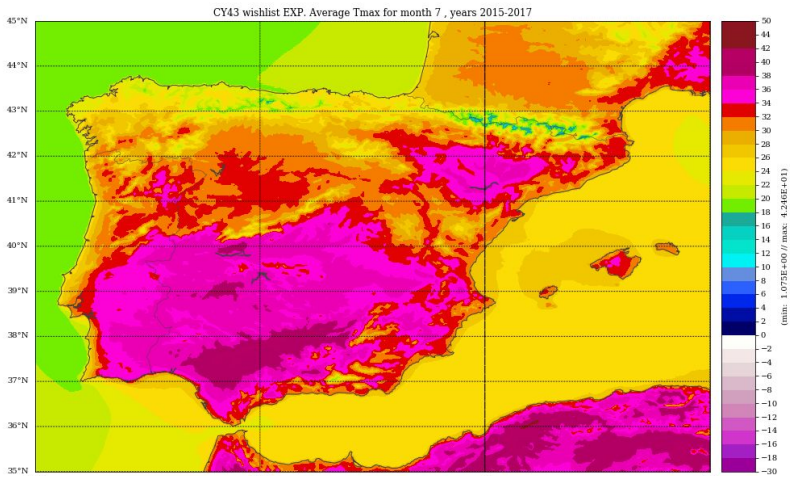




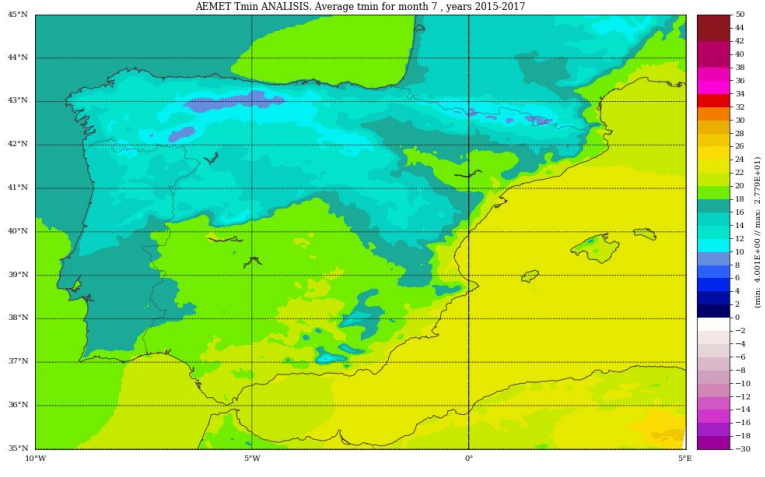


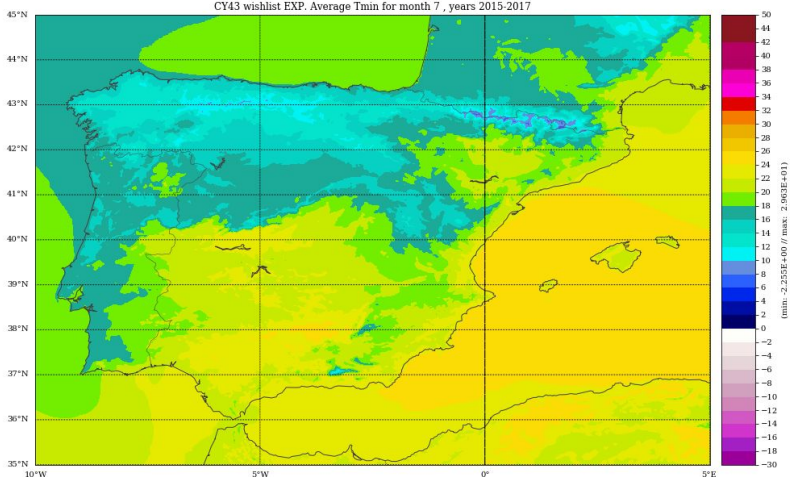
T+

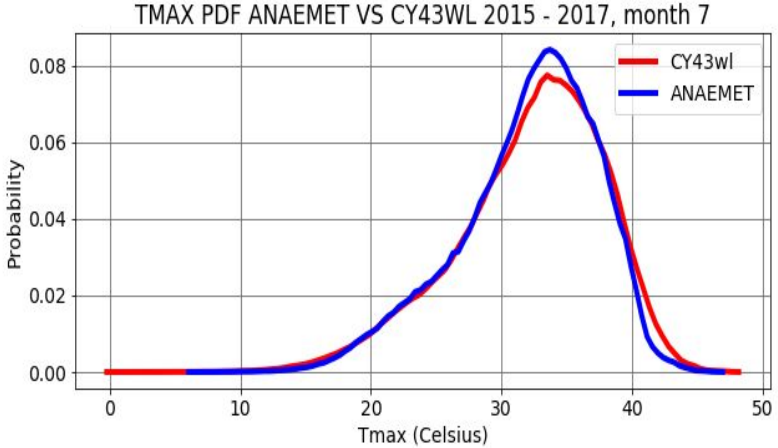

AEMET Tmax ANALISIS. Average tmax for month 7 , years 2015-2017
(min: 9.723E+00 // max: 4.033E+01)

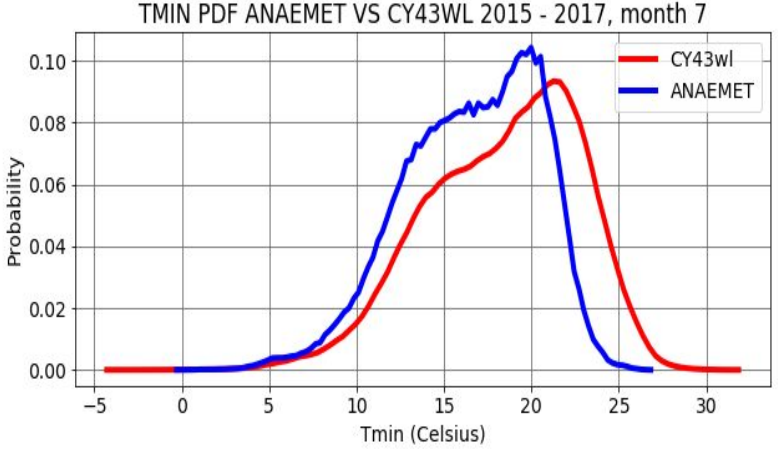

CY43 wishlist EXP. Average Tmax for month 7 , years 2015-2017
(min: 1.075E+00 // max: 4.246E+01)

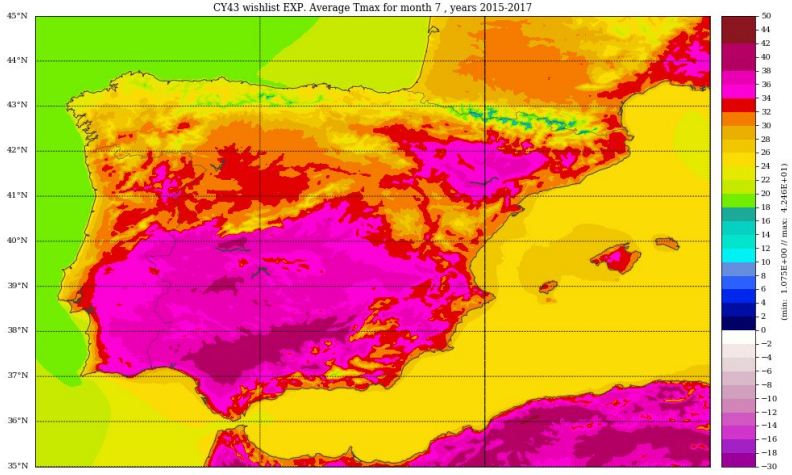
T-

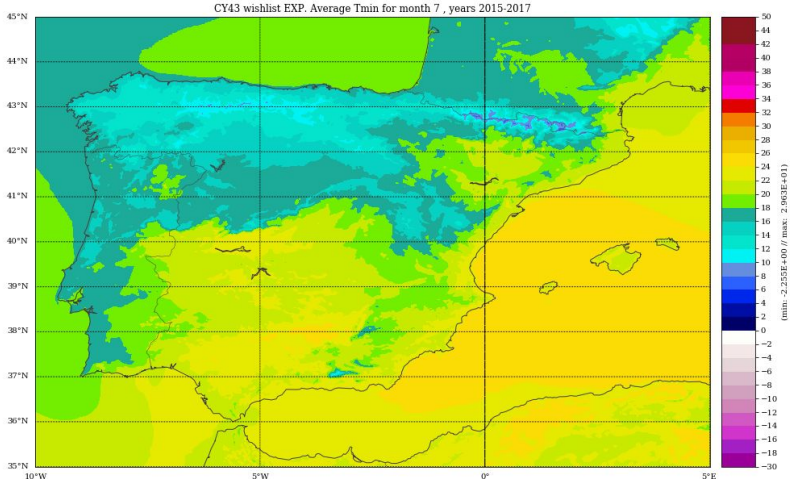

AEMET Tmin ANALISIS. Average tmin for month 7 , years 2015-2017
(min: 6.001E+00 // max: 2.779E+01)

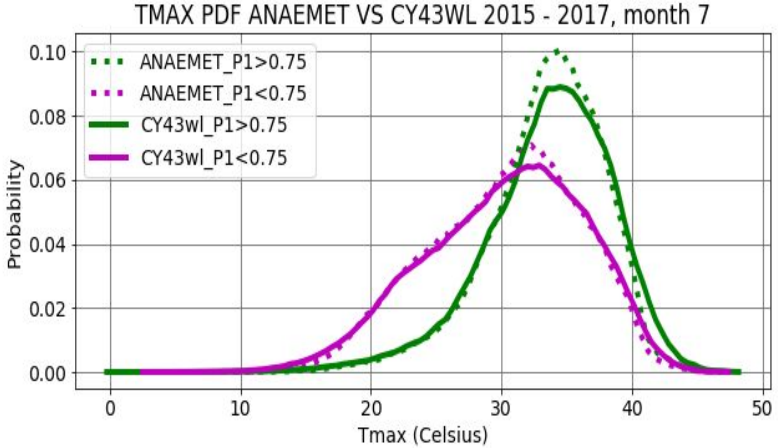

CY43 wishlist EXP. Average Tmin for month 7 , years 2015-2017
(min: -2.255E+00 // max: 2.903E+01)

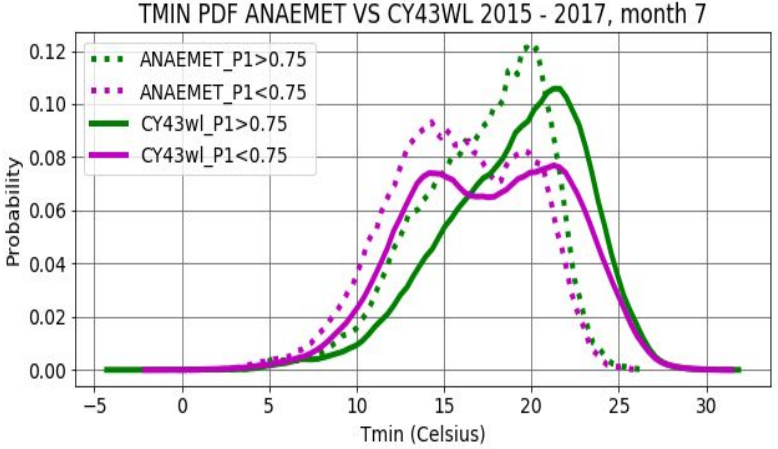

TMAX PDF ANAEMET VS CY43WL 2015 - 2017, month 7
CY43wl
ANAEMET
Probability
0.00
0.02
0.04
0.06
0.08
0
10
20
30
40
50
Tmax (Celsius)

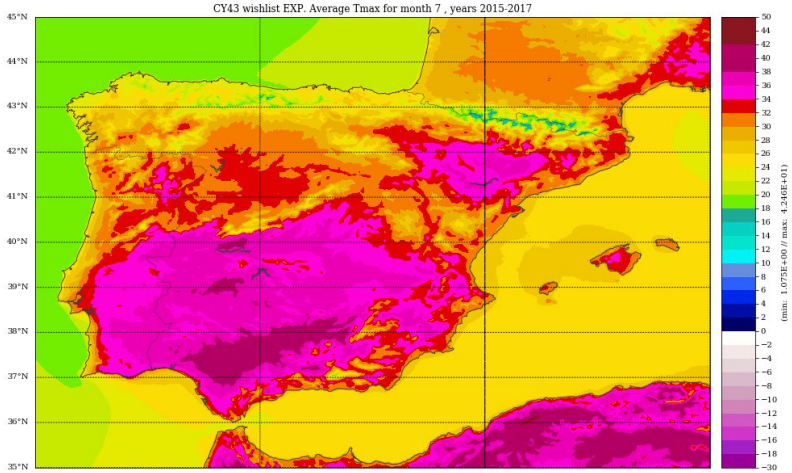

TMIN PDF ANAEMET VS CY43WL 2015 - 2017, month 7
CY43wl
ANAEMET
Probability
0.00
0.02
0.04
0.06
0.08
0.10
−5
0
5
10
15
20
25
30
Tmin (Celsius)

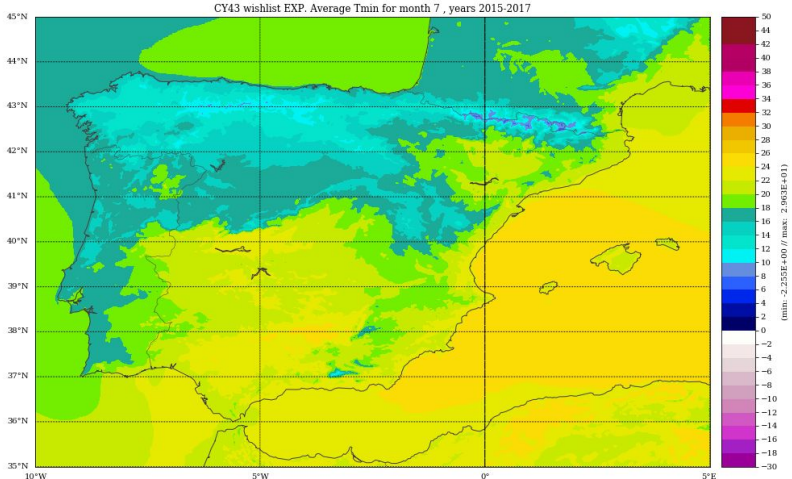

CY43 wishlist EXP. Average Tmax for month 7 , years 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
(min: 1.075E+00 / max: 4.240E+01)


CY43 wishlist EXP. Average Tmin for month 7 , years 2015-2017
45°N
44°N
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
35°N
10°W
5°W
0°
5°E
(min: -2.250E+00 / max: 2.903E+01)


TMAX PDF ANAEMET VS CY43WL 2015 - 2017, month 7
ANAEMET_P1>0.75
ANAEMET_P1<0.75
CY43wl_P1>0.75
CY43wl_P1<0.75
Probability
Tmax (Celsius)


TMIN PDF ANAEMET VS CY43WL 2015 - 2017, month 7
ANAEMET_P1>0.75
ANAEMET_P1<0.75
CY43wl_P1>0.75
CY43wl_P1<0.75
Probability
Tmin (Celsius)


CY43 wishlist EXP. Average Tmax for month 7 , years 2015-2017


CY43 wishlist EXP. Average Tmin for month 7 , years 2015-2017

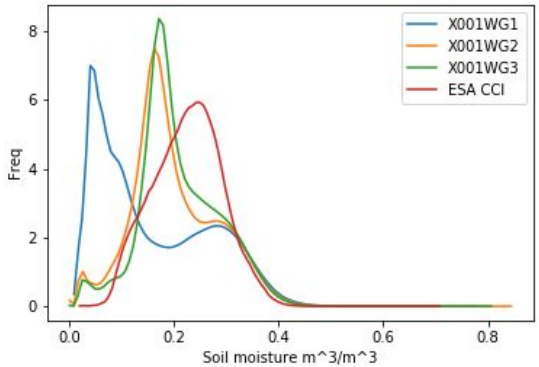
- T2M_max: Good results in general, cold bias in winter
- T2M_min: Warm bias, larger in summer
- T2M_min: Problems to reproduce frost conditions in wintertime linked to open-land patch (P1) physics

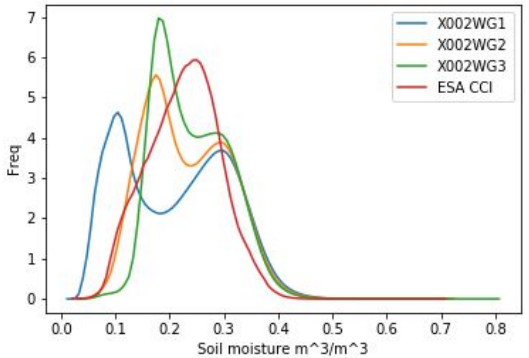
Direct soil moisture validation: Is it possible?

- Soil moistures in LSMs are highly model-dependent quantities and therefore they're difficult to validate i.e. against in-situ or satellite derived data. In addition, satellite products ussually have their own LSMs.

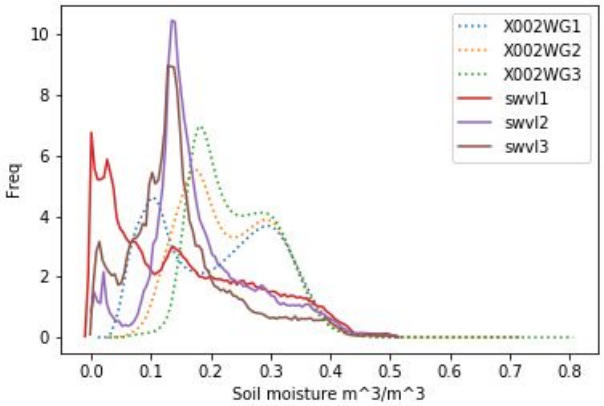
- Nevertheless, different model/observations tend to show similar temporal variability when scaled conveniently (for instance through long-time average & standard deviation) Koster, R.D., Z. Guo, R. Yang, P.A. Dirmeyer, K. Mitchell, and M.J. Puma, 2009: On the Nature of Soil Moisture in Land Surface Models. J. Climate, **22**

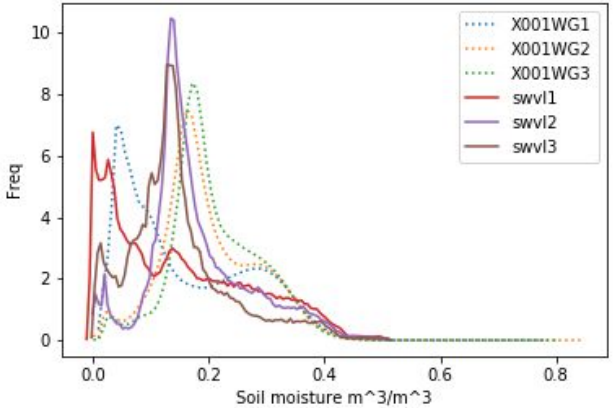
- Example: ESA CCI Soil moisture (0.25°) product doesn't look comparable to any of the first soil layers from DIF scheme.

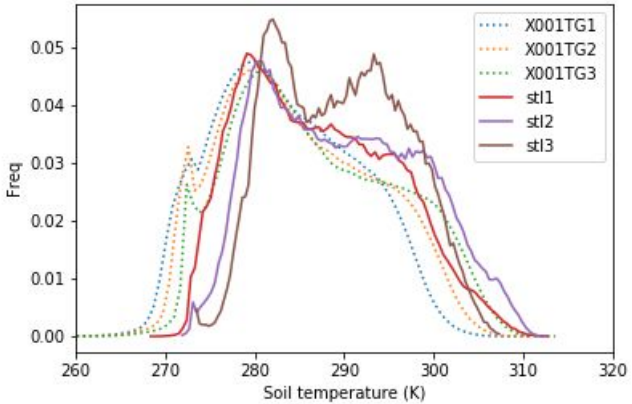


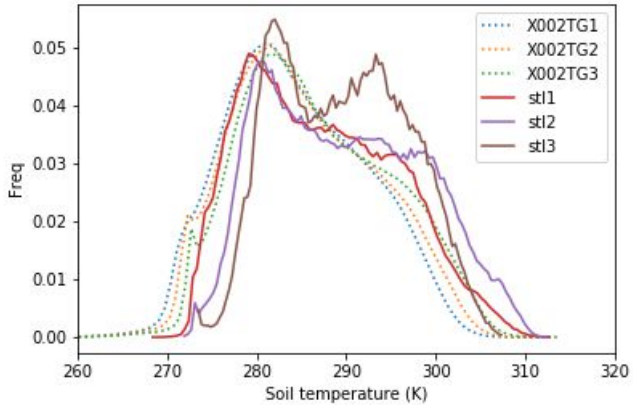


CY43h soil moistures & temperatures against first soil layers in ERA5









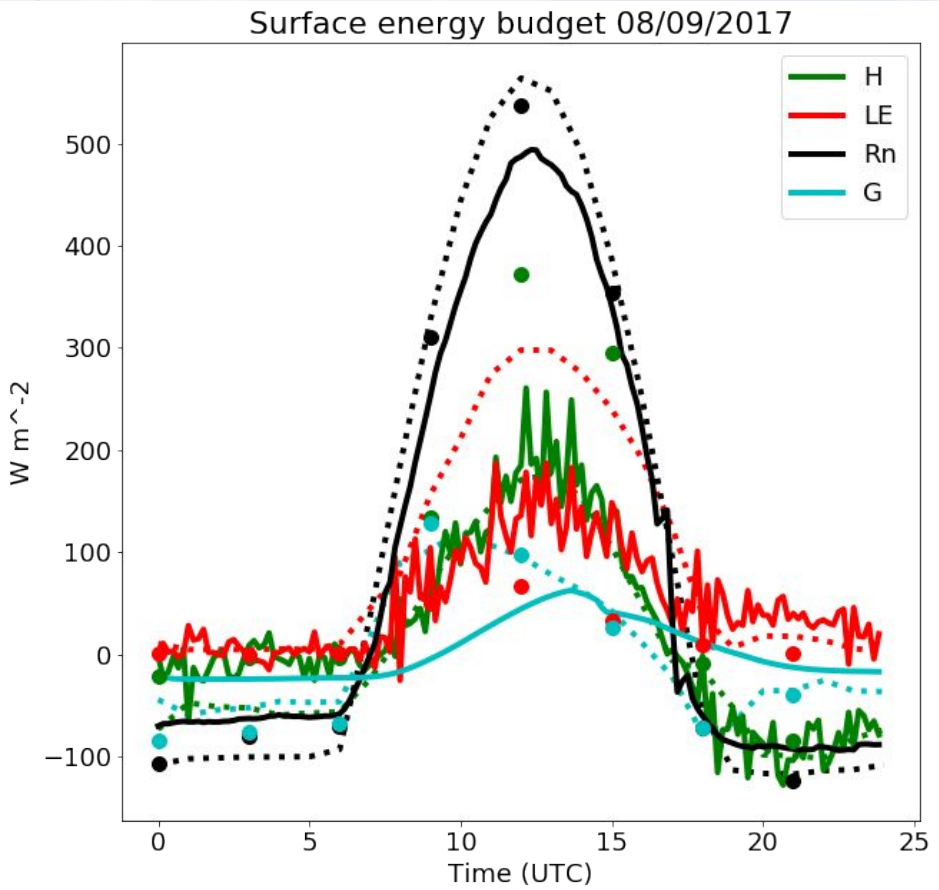
Validation of surface fluxes

- In principle, direct validation through surface fluxes would be the “ideal” way to evaluate a LSM for NWP purposes.
- We expect impacts in the surface energy balance (SEB) caused by the new surface components/settings in the system (DIF, ES, MEB, ECOCLIMAP-SG, OROTUR, increase of Ri_max...).
- Problems:
  - Direct observations are scarce (eddy covariance sites)
  - Observations through long periods are not frequent
  - There’s usually question marks over the representativity of point data
- Ok, but at least we should make sure that the SEB is modified in the right direction.

Flux sites / domains under consideration

- CESAR site (Cabauw, Netherlands). All SEB components, 2000-2019 coverage, public data
- ICOS Sweden stations. All SEB components
  Forest: Hyltemossa, Norunda, Svartberget
  Open land (crop): Lanna
  2014-2017 public data, more recent data on request.
- La Herreria site from GUMNET (Spain). All SEB components, data from 06/2016, public data available on request.

SEB example for a single day



- Solid lines: SEB data from a experimental site in northern Spain
- Dotted lines: CY43wishlist experiment (acting as a downscaling tool)
- Points: AEMET's Operational run

Conclusions

- We try to reduce the biases by new surface physics before DA is applied
- A first multi-year simulation over IBERIA is studied for:
  - A general overview of the model performance with new surface
  - Testing methods for surface analysis
- Better results for temperature than for precipitation. Need to further investigate possible surface connections.
- More tests will follow after all the target surface components become available in cy43h (sea-ice update, MEB…)

Thank you!