NWCSAF/HRW-High Resolution Winds use in Aviation forecasting

21 March 2024

EUMETSAT & FMI Expert Testbed in Turbulence

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Description of NWCSAF/High Resolution Winds

➔ AMVs/Trajectories calculated through the displacement of features in successive satellite images.

Use of NWCSAF/High Resolution Winds

➔ Operational forecasting

➔ Aviation forecasting

Case study of 10-11 March 2024

NWCSAF/HRW-High Resolution Winds

In weather forecasting,
conventional observations in different tropospheric levels
are limited, while satellite observations
provide an almost global coverage in regular time intervals.

Among these satellite observations
Atmospheric Motion Vectors (AMVs)

➔ Winds calculated through the displacement of cloud and moisture features in successive satellite images,

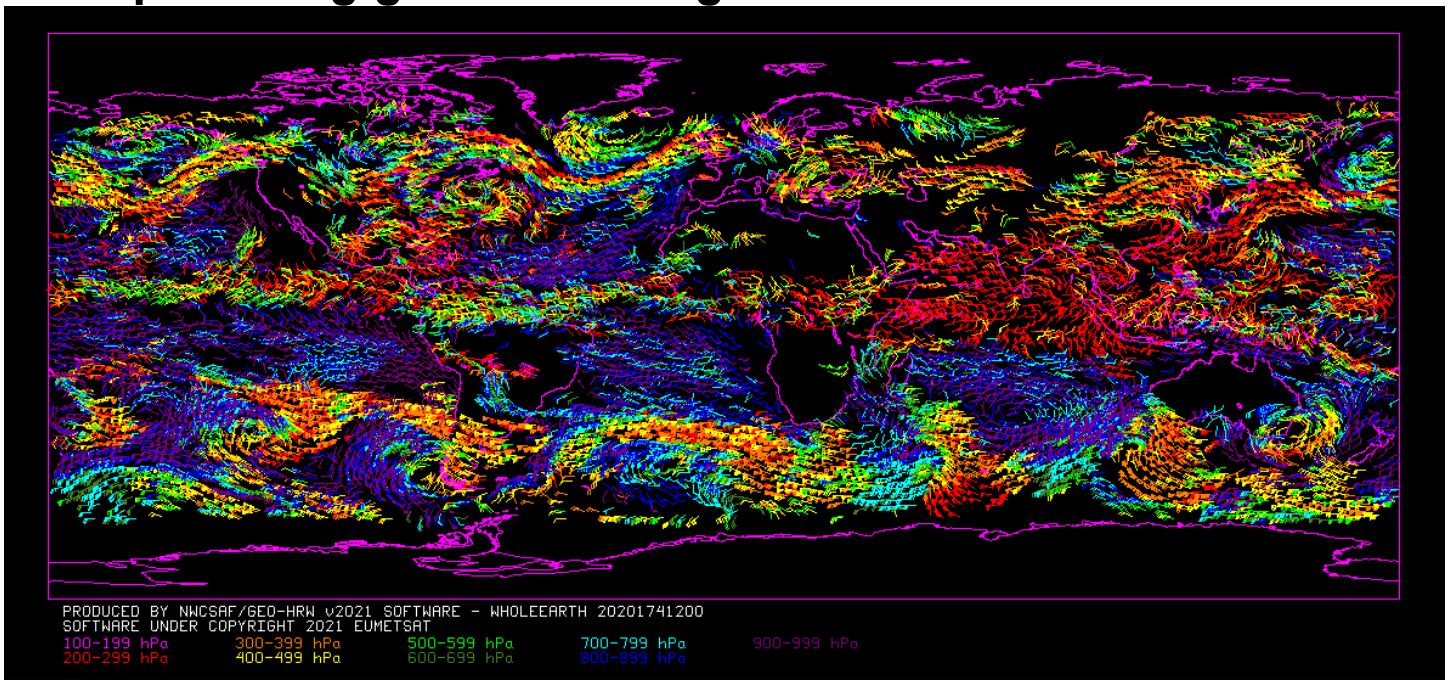
are an important source of wind observations,
especially over oceans and remote areas.

NWCSAF/HRW-High Resolution Winds

In March 2024 the latest version of

NWCSAF/High Resolution Winds is released (NWC/GEO-HRW v2021.3).

➔ AMVs and Trajectories with five geostationary satellites all around the globe (MSG, MSG/IODC, Himawari-8/9, GOES-13/18), so providing global coverage.



(Version for MTG-I satellite ready for release when MTG-I1 satellite becomes operational)

Example of NWC/GEO-HRW throughout the world with GOES-17, GOES-16, MSG, MSG/IODC, Himawari-8 satellites for 22 June 2020, 12:00Z

NWCSAF/HRW-High Resolution Winds

Coverage with NWC/GEO-HRW geostationary software is limited up to latitude ≈ 65º N/S,

not being able to provide information in polar areas.

Due to this,

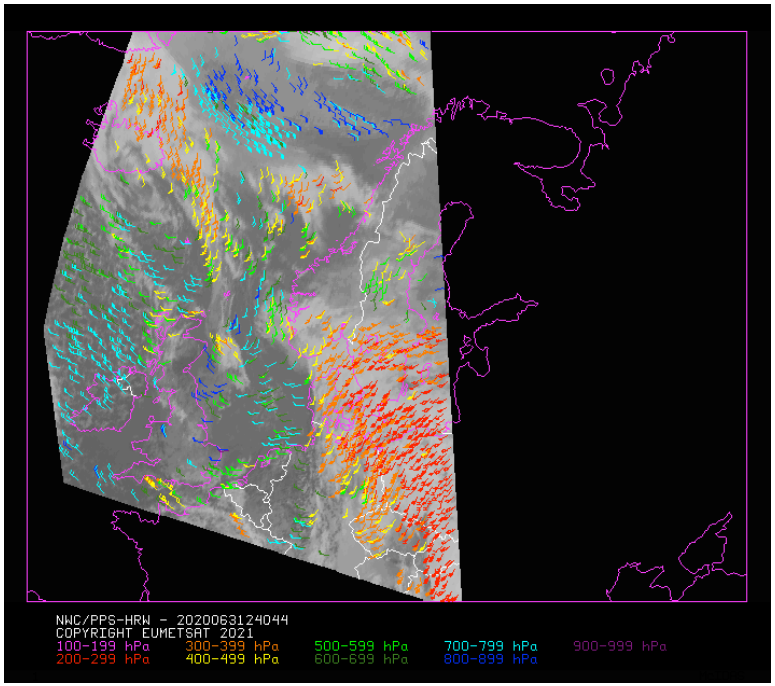
HRW was also extended to polar satellites (16 polar satellites with MODIS, AVHRR/3 VIIRS, MERSI-2 and SLSTR radiometers),

so providing coverage also in polar areas.

Now available in

NWC/PPS-HRW v2021.3 polar software,

released to users in March 2023.



Example of NWC/PPS-HRW in the Scandinavian region, for 3 March 2020, 12:40:44Z (coverage changes from slot to slot)

NWCSAF/HRW-High Resolution Winds

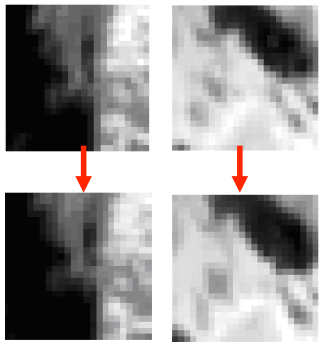
Two slides summarizing the process of AMV/Trajectory calculation in NWCSAF/HRW software:

1. Reading and preprocessing of satellite data

F.ex.: Normalizing visible images to homogenize illumination conditions.

2. Definition of square shaped “tracers” in an initial image

- ➔ In NWC/GEO-HRW, using visible, infrared, water vapour channels.
- ➔ In NWC/PPS-HRW, using visible and infrared channels.
- ➔ Defined by cloud features and clear air moisture features in water vapour images.



3. “Tracking of tracers” in a later image

- Tracers can change their shape and even disappear, but a sufficient number of tracers persists between both images to produce an irregular distribution of AMVs.

NWCSAF/HRW-High Resolution Winds

Two slides summarizing the process of AMV/Trajectory calculation in NWCSAF/HRW software:

4. **Height assignment** to localize the AMVs/Trajectories in a tropospheric level (in hPa / m / ft)

5. **Calculation of the AMVs/Trajectories**, considering the displacement of the tracers between the images.

6. **Quality control** to keep only the best AMVs:
   - **Based on consistency checks** (Temporal/spatial/with NWP wind)
   - **and the Orographic flag**, which removes AMVs affected by orographic influence (blocked by the ground, orographic waves,…)

NWCSAF/HRW-High Resolution Winds

Some elements to notice:

➔ AMV outputs are available ≈ 5-10 minutes
after the reception of the satellite images,
which eases the use in real time applications.

➔ They provide info on
the wind between the ground and 100 hPa (~FL530),
with two observation density maximums
for 300 hPa (~FL300) and 800 hPa (~FL60).

➔ The software is run locally, with many configurable parameters.
Due to this, the running conditions can be specified in many ways.
F.ex.: ➔ Defining up to two scales for the AMV calculation
("basic scale" and "detailed scale"),
➔ Defining the size of the tracers used, etc.

NWCSAF/HRW-High Resolution Winds

But also some limitations:

➔ AMVs are horizontal mean winds

- They provide no direct info on wind gusts or vertical wind.

➔ There is a variability in the amount of available observations
(with the possibility that sometimes
there are no AMVs in a given location)

- It depends on the existence in the area of cloud/moisture tracers.

➔ There is a limitation in the number of AMVs
in different levels of the same location

- There is a limit of two/three AMVs in the same vertical profile,
based on several levels of cloudiness/moisture.

Use of NWCSAF/HRW: Operational forecasting

NWCSAF/HRW software can be used in operational forecasting for:

* Watch and warning of dangerous wind situations.

* Monitoring of the general atmospheric flow.

* Monitoring of small scale circulation and wind singularities.

* Evaluation of low level convergence
  (when and where cumulus start to develop)
  and high level divergence.

* Aviation forecasting.

Use of NWCSAF/HRW: Operational forecasting

Considering "Watch and warning of dangerous wind situations"
the procedure is based on:

1. **Assessing the vertical distribution of NWCSAF/HRW AMVs considering all layers (100 – 1000 hPa) and low level layer (700 – 1000 hPa).**
   - **The opacity of the clouds often avoids that we can observe low level clouds and displacements, so causing observations gaps in the low level AMVs.**
   - **We can try to extrapolate information from higher levels.**

The analysis can be done also in comparison with the NWP model.

We must remember that NWCSAF/HRW AMVs are "mean winds between two satellite images" (f.ex. 15 min. in MSG Nominal mode).

Use of NWCSAF/HRW: Operational forecasting

2. Checking if the wind speed is near or over the "warning thresholds".

Operational examples for AEMET/Spain are here provided:

➔ **In the sea**, thresholds defined considering the **mean wind**:

> **Moderate gale (F7, 50 km/h wind)**: yellow warning

> **Storm (F10, 90 km/h wind)**: red warning

➔ **Over land**, thresholds defined considering the **wind gusts**:

> **70-80-90 km/h gust**: yellow warning

> **130-140 km/h gust**: red warning

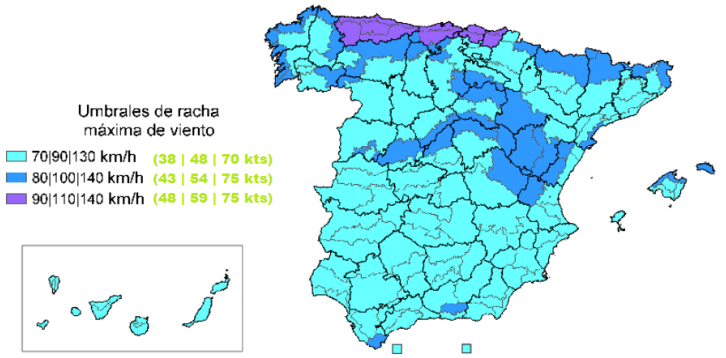
FENÓMENOS COSTEROS F7 = 52km/h, 28kts F8 = 63km/h, 34kts F10 = 89 km/h, 48kts

Zonas	Amarillo	Naranja	Rojo
CANTÁBRICAS ATLÁNTICAS	F7, mar combinada o compuesta que provoque oleaje de 4 a 5 metros	F8 y F9, mar combinada o compuesta que provoque oleaje de 5 a 8 metros	A partir de F10, mar combinada o compuesta que provoque oleaje de más de 8 metros
MEDITERRÁNEAS	F7, mar combinada o compuesta que provoque oleaje de 3 a 4 metros	F8 y F9, mar combinada o compuesta que provoque oleaje de 4 a 7 metros	A partir de F10, mar combinada o compuesta que provoque oleaje de más de 7 metros

GALERNAS

GALICIA ASTURIAS CANTABRIA PAÍS VASCO	AMARILLO	Mar: Cambio brusco del viento, arreciando y rolando al Noroeste con fuerza 7. Tierra: Giro brusco del viento al noroeste, aumentando repentinamente con rachas fuertes, superiores a 60 km/h en el litoral.
	NARANJA	Mar: Cambio brusco del viento, arreciando y rolando al Noroeste con fuerza 8 a 9. Tierra: Giro brusco del viento al noroeste, aumentando repentinamente con rachas muy fuertes de 90 a 120 km/h en el litoral.
	ROJO	Mar: Cambio brusco del viento, arreciando y rolando al Noroeste con fuerza 10 o superior. Tierra: Giro brusco del viento al noroeste, aumentando repentinamente con rachas huracanadas, superiores a 130 km/h en el litoral.

UMBRALES DE RACHA MÁXIMA DE VIENTO (km/h) POR ZONAS PROVINCIALES SEGÚN LOS COLORES ASIGNADOS EN EL MAPA, NIVELES AMARILLO | NARANJA | ROJO



Use of NWCSAF/HRW: Operational forecasting

2. Checking if the wind speed is near or over the “warning thresholds”.

➔ For this,
AMVs in the layer 850-1000 hPa
define a good representativity
of the ground conditions.

➔ If not available,
AMVs in the layer 700-1000 hPa
provide additional data,
taking into account that
winds are stronger at higher levels.

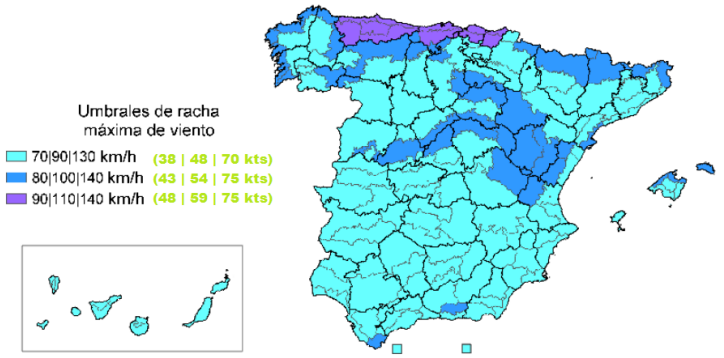
FENÓMENOS COSTEROS F7 = 52km/h, 28kts F8 = 63km/h, 34kts F10 = 89 km/h, 48kts

Zonas	Amarillo	Naranja	Rojo
CANTÁBRICAS ATLÁNTICAS	F7, mar combinada o compuesta que provoque oleaje de 4 a 5 metros	F8 y F9, mar combinada o compuesta que provoque oleaje de 5 a 8 metros	A partir de F10, mar combinada o compuesta que provoque oleaje de más de 8 metros
MEDITERRÁNEAS	F7, mar combinada o compuesta que provoque oleaje de 3 a 4 metros	F8 y F9, mar combinada o compuesta que provoque oleaje de 4 a 7 metros	A partir de F10, mar combinada o compuesta que provoque oleaje de más de 7 metros

GALERNAS

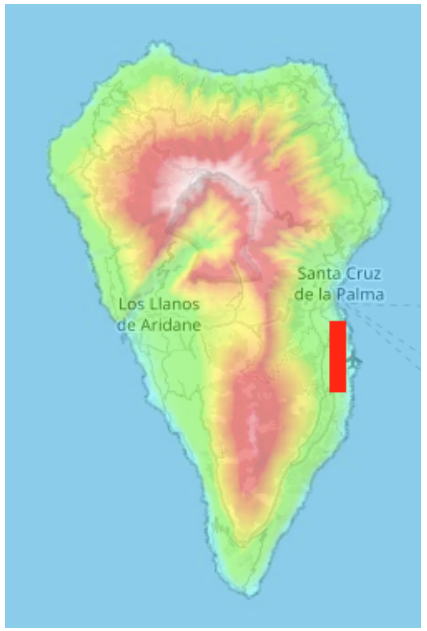
GALICIA ASTURIAS CANTABRIA PAÍS VASCO	AMARILLO	Mar: Cambio brusco del viento, arreciando y rolando al Noroeste con fuerza 7. Tierra: Giro brusco del viento al noroeste, aumentando repentinamente con rachas fuertes, superiores a 60 km/h en el litoral.
	NARANJA	Mar: Cambio brusco del viento, arreciando y rolando al Noroeste con fuerza 8 a 9. Tierra: Giro brusco del viento al noroeste, aumentando repentinamente con rachas muy fuertes de 90 a 120 km/h en el litoral.
	ROJO	Mar: Cambio brusco del viento, arreciando y rolando al Noroeste con fuerza 10 o superior. Tierra: Giro brusco del viento al noroeste, aumentando repentinamente con rachas huracanadas, superiores a 130 km/h en el litoral.

UMBRALES DE RACHA MÁXIMA DE VIENTO (km/h) POR ZONAS PROVINCIALES SEGÚN LOS COLORES ASIGNADOS EN EL MAPA, NIVELES AMARILLO | NARANJA | ROJO



Use of NWCSAF/HRW: Operational forecasting

Considering
"the monitoring of small scale circulation and wind singularities":



1. There can be interest to check
   the behaviour of the wind in a specific location
   F.ex.: for the operations of an airport,…
   - ➔ Sometimes operations have to be cancelled
     if the wind blows from a specific direction,
     or the wind force is higher than a given threshold.
   - ➔ Example: La Palma airport/SPC (Canary Islands)
     has to close operations with "west wind"
     due to turbulence (frequently and for long periods of time)
     due to 1500m mountain height differences around the airport.
   - ➔ This causes the closure of the only airport in the island
     and an important civil impact.

Use of NWCSAF/HRW: Operational forecasting

Considering
“the monitoring of small scale circulation and wind singularities”:

2. NWCSAF/HRW AMVs can be used for this,
verifying especially the differences with other forecast tools
(like NWP models).
> The wind direction is checked
considering directly NWCSAF/HRW AMVs.
> To check the wind speed,
some knowledge about the relationship between
NWCSAF/HRW AMVs and the local winds/gusts might be needed.

Use of NWCSAF/HRW: Operational forecasting

Considering
“the monitoring of small scale circulation and wind singularities”:

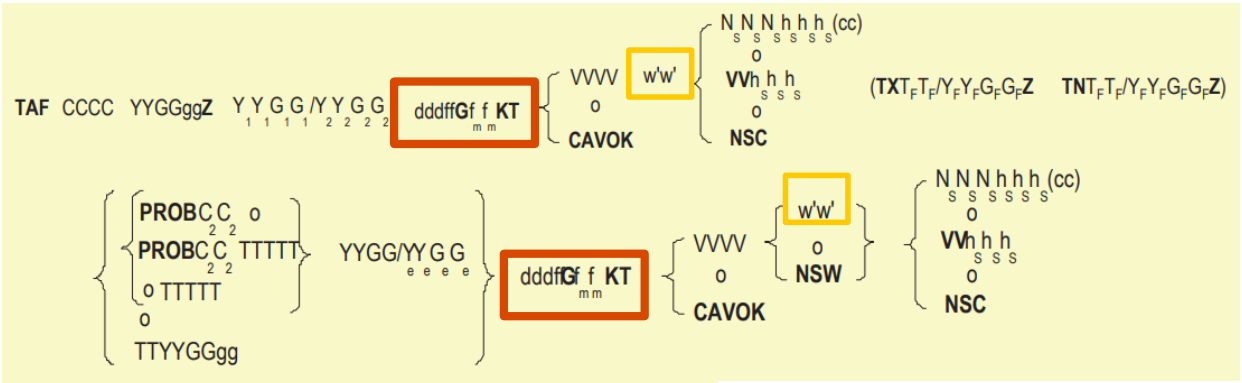
3. In longer time forecast periods (> 3 hours)
the forecast depends on other forecast tools like NWP model

However, NWCSAF/HRW AMVs can still be used
to check the validity of the NWP model outputs in each moment.

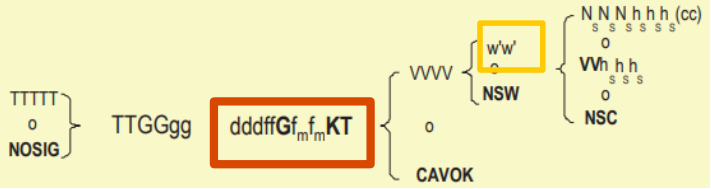
Use of NWCSAF/HRW: Aviation forecasting: TAF/TREND

Prognosis of TAF & TREND for an airport:

- TAF:



- TREND:



* Usable for "wind" (formally defined as 10 min. mean wind) and "wind gusts".
* Also for some related "weather descriptors":
  DR/BL: "drifting/blowing"

  And related "weather phenomena":
  PO: "dust devil" SS: "sand storm" DS: "dust storm"

Use of NWCSAF/HRW: Aviation forecasting: TAF/TREND

Prognosis of TAF & TREND for an airport:

* Use of NWCSAF/HRW in interaction with METAR observations
  (which provide real observations every 30/60 minutes).

* Relating in a given moment and throughout an event:
  - ➔ "Wind" and related "Weather phenomena" provided by METAR
  - ➔ The temporal evolution in the vicinity of the airport of NWCSAF/HRW product in low levels:
    - HRW winds in 850-1000 hPa (<FL50)
      (good representativity of winds above the ground).
    - HRW winds in 700-1000 hPa (<FL100)
      (more data, but taking into account stronger winds with height).

a good prognosis of "wind" and related "weather phenomena" can be done up to 2-3 hours
(useful for TREND and shortest term of TAF).

Use of NWCSAF/HRW: Aviation forecasting: WW

Observation and prognosis of several phenomena in "Aerodrome warnings (WW)":

- **SFC WIND/SFC WSPD**
  (when thresholds defined for each aerodrome are exceeded)

- **[HVY] SS: "sand storm"**
  [HVY] DS: "dust storm"
  SA: "swirling sand"
  DU: "swirling dust"

Phenomenon (1)	Template (2)
Mean wind speed with maximum wind gust	SFC WSPD nn[n]KT MAX nn[n]
Mean surface wind (direction and speed) and maximum wind gust	SFC WIND nnn/nn[n]KT MAX nn[n]
Accumulated precipitation in 1 or 12 hours	RAINFALL IN 1HR MORE THAN nnMM RAINFALL IN 12HR MORE THAN nn[n]MM
Thunderstorm	[HVY] TS
Squall (3)	SQ
Hail	GR
Frost (4)	FROST T MSnnC
Snow (5) (including the expected or observed snow accumulation)	[PROB30, PROB40, PROB70][HVY] SN nnCM
Freezing precipitation	[HVY] FZRA o [HVY] FZDZ
Hoar frost or white rime	RIME
Sandstorm	[HVY] SS
Duststorm	[HVY] DS
Swirling sand or dust	SA (sand), DU (dust)
Volcanic ash [volcanic ash deposition]	VA [DEPO]
Tsunami	TSUNAMI
Toxic chemicals substances	TOX CHEM

Use of NWCSAF/HRW: Aviation forecasting: SIGMET

Observation and prognosis of several phenomena in "en-route SIGMET warnings" (up to 4 hours):

- **SEV MTW**
  (severe mountain wave)
- **SEV TURB**
  (severe turbulence)

- **HVY SS**
  (heavy dust storm)
- **HVY SS**
  (heavy sand storm)

Description of phenomenon causing the issuance of SIGMET	Observed and/or forecast phenomenon	Location and flight level or altitude	Movement (direction and speed)	Changes in intensity
OBSC[2] **TS**: obscured thunderstorms **EMBD**[3] **TS**: embedded thunderstorms **FRQ**[4] **TS**: frequent thunderstorms **SQL**[5] **TS**: squall line thunderstorms **OBSC TSGR**[6]: obscured thunderstorms with hail **EMBD**[3] **TSGR**: embedded thunderstorms with hail **FRQ**[4] **TSGR**: frequent thunderstorms with hail **SQL**[5] **TSGR**: squall line thunderstorms with hail **TC** (+name): tropical cyclone **SEV TURB**[7]: severe turbulence **SEV ICE**[8]: severe icing **SEV ICE (FZRA**[9]**)**: severe icing due to freezing rain **SEV MTW**[4]: severe mountain wave **HVY DS**: heavy duststorm **HVY SS**: heavy sandstorm **VA**(+name of volcano): volcanic ash **RDOACT CLD**: radioactive cloud	1. **OBS** is used when the phenomenon is observed and expected to continue. Time of observation is included, if known. 2. **FCST** is used when the phenomenon is forecast. Time of forecast is included, if known	**Location**, referring to latitude and longitude (in degrees and minutes)) and flight level or altitude, ENTIRE FIR: if the phenomenon is forecast for the entire FIR	**Direction** with reference to one of the sixteen points of compass, **Speed** in kt or in km/h. Or stationary (**STNR**)	1. **WKN**: weakening 2. **NC**: no changes 3. **INTSF**: intensifying

Use of NWCSAF/HRW: Aviation forecasting: AIRMET

Observation and prognosis of several phenomena in "AIRMET warnings" (below FL150/~570 hPa, up to 4 hours):

- **SFC WIND**
  (surface wind > 30 kt)
- **MOD MTW**
  (moderate mountain wave)
- **MOD TURB**
  (moderate turbulence)

Description of phenomenon causing the issuance of AIRMET	Observed or forecast phenomenon	Location and flight level or altitude	Movement (direction and speed)	Changes in intensity
* Widespread areas where mean surface wind speed > 30 kt (60 km/h): **SFC WIND** (+ wind speed, direction and units) * Widespread areas affected by reduction of visibility to less than 5000 m: **SFC VIS** (+ visibility in m + weather phenomena) * Thunderstorms: **ISOL TS**, **OCNL TS** (without hail) **ISOL TSGR**, **OCNL TSGR** (with hail) * Mountains obscured: **MT OBSC** * Widespread areas of BKN or OVC cloud with height of base less than 1000 ft above ground level: **BKN CLD** or **OVC CLD** (+ height of the base and top + units) * Cumulonimbus: **ISOL CB**, **OCNL CB**, **FRQ CB** * Towering cumulus clouds: **ISOL TCU**, **OCNL TCU**, **FRQ TCU** * Moderate icing: **MOD ICE** * Moderate turbulence: **MOD TURB** * Moderate mountain wave: **MOD MTW**	1. **OBS** is used when the phenomenon is observed and expected to continue. Time of observation is included, if known. 2. **FCST** is used when the phenomenon is forecast. Time of forecast is included, if known	**Location**, referring to latitude and longitude (in degrees and minutes)) and flight level or altitude	**Direction** with reference to one of the sixteen points of compass **Speed** in kt or in km/h Or stationary (**STNR**)	1. **WKN**: weakening 2. **NC**: no changes 3. **INTSF**: intensifying

Use of NWCSAF/HRW: Aviation forecasting: SIGMET/AIRMET

In both SIGMET and AIRMET,
the temporal evolution of NWCSAF/HRW in successive images
also helps to define
the labels attached to these phenomena:

- OBS: Observation
- FCST: Forecast

- MOV: Moving
- STNR: Stationary

- WKN: Weakening
- NC: No change
- INTSF: Intensifying

Observed or forecast phenomenon	Location and flight level or altitude	Movement (direction and speed)	Changes in intensity
1. **OBS** is used when the phenomenon is observed and expected to continue. Time of observation is included, if known. 2. **FCST** is used when the phenomenon is forecast. Time of forecast is included, if known	**Location** referring to latitude and longitude (in degrees and minutes)) and flight level or altitude	**Direction** with reference to one of the sixteen points of compass **Speed** in kt or in km/h Or stationary (**STNR**)	1. **WKN**: weakening 2. **NC**: no changes 3. **INTSF**: intensifying

Use of NWCSAF/HRW: Aviation forecasting: GAMET

Observation and prognosis of several phenomena in "GAMET area forecasts" (below FL150/~570 hPa, up to 6 hours):

Section I:

- **SFC WIND** (surface wind > 30 kt)
- **HVY SS** (heavy sand storm)
- **HVY DS** (heavy dust storm)
- **MOD/SEV MTW** (mountain waves)
- **MOD/SEV TURB** (turbulence)

SECN I: Information on en-route weather phenomena hazardous to low-level flights (see note 1)

(1) **SFC WIND:** *[G_1G_1 /G_2G_2]* (See note 2) [Location] [Direction] [Speed (kt)]: Widespread surface wind > 30 kt (see note 6).

(2) **SFC VIS:** *[G_1G_1 /G_2G_2]* [Location] [Visibility in metres] [weather phenomena causing the reduction]: Widespread surface visibility < 5000 m (see note 6)

(3) **SIGWX:** *[G_1G_1 /G_2G_2]* [Location] [Significant weather condition]: Any of the following significant weather conditions included: ISOL TS, OCNL TS, ISOL TSGR, OCNL TSGR, FRQ TS, OBSC TS, EMBD TS, HVY SS, HVY DS, SQL TS, FRQ TSGR, OBSC TSGR, EMBD TSGR, SQL TSGR, VA

(4) **MT OBSC**: *[G_1G_1 /G_2G_2]* [Location]: Mountain obscuration.

(5) **SIG CLD:** *[G_1G_1 /G_2G_2]* [Location] [Amount (BKN or OVC)] [CB and/or TCU with ISOL, OCNL, FRQ or EMBD] [Altitude of cloud base and top (ft)]: Only clouds with height of base less than1000 ft above ground level, and/or CB or TCU at any height, are included.

(6) **ICE:** *[G_1G_1 /G_2G_2]* [Location] MOD or SEV [Altitude of cloud base and top (FL)]: Moderate or severe icing.

(7) **TURB:** *[G_1G_1 /G_2G_2]* [Location] MOD or SEV [Altitude of cloud base and top (FL)]: Moderate or severe turbulence.

(8) **MTW:** *[G_1G_1 /G_2G_2]* [Location] MOD or SEV [Altitude of cloud base and top (FL)]: Moderate or severe mountain wave.

(9) **SIGMET APLICABLES:** n.º of applicable message SIGMET to the FIR concerned or a sub-area thereof, for which the area forecast is valid.

When no elements are included in SECN I next message is included:

(10) **HAZARDOUS WX NIL:** No weather phenomena hazardous to low level flights and no applicable SIGMET are forecast.

NOTES:

1: Elements of points 1 to 10 will only appear in GAMET when the phenomena is forecast during the validity period.

2: G_1G_1 /G_2G_2 . Optional group. Starting and end time of the weather phenomena forecast.

3: Vertical distances are altitudes, so they are referenced to the mean sea level (MSL) and the unity is the feet (ft).The AMSL abbreviation is used after FT. For some elements level flights (FL) are used.

4: For each element more than one line could be used. Only approved ICAO abbreviation are allowed.

5: These notes are complemented by AIRMET notes.

6: The term "**areas extensas**" (widespread surface) is used to indicate a spatial coverage of more than 75% of the affected area.

SECN II: Additional information required by low-level flights

(11) **PSYS**: Data in abbreviated language on pressure centres and fronts and their expected movements and developments at the central hour of validity period of forecast.

(12) **WIND/T**: Upper wind (in kt) and upper-air temperature (in ºC) forecast for altitudes 02000, 05000, 10000, 15000 ft, for given locations at the central hour of validity period of forecast.

(13) **CLD**: Cloud information not included in Section I on clouds amount (BKN or OVC) between 1000 ft of height and FL150, showing the cloud type if known: ST, SC, CU, AS, AC and NS.

(14) **FZLVL**: Height indication of t = 0ºC level(s) for given locations at the central hour of validity period of forecast.

(15) **MNM QNH**: Forecast lowest QNH at the central hour of validity period of forecast (hectopascal).

(16) **VA**: Volcanic eruptions and name of volcano.

Use of NWCSAF/HRW: Aviation forecasting: GAMET

Prognosis of several phenomena in "GAMET area forecasts" (below FL150/~570 hPa, up to 6 hours):

Section II:

- **WIND**

  (wind for levels FL20, FL50, FL100, FL150 at central hour of forecast)

SECN I: Information on en-route weather phenomena hazardous to low-level flights (see note 1)

(1) **SFC WIND:** *[G_1G_1 /G_2G_2]* (See note 2) [Location] [Direction] [Speed (kt)]: Widespread surface wind > 30 kt (see note 6).

(2) **SFC VIS:** *[G_1G_1 /G_2G_2]* [Location] [Visibility in metres] [weather phenomena causing the reduction]: Widespread surface visibility < 5000 m (see note 6)

(3) **SIGWX:** *[G_1G_1 /G_2G_2]* [Location] [Significant weather condition]: Any of the following significant weather conditions included: ISOL TS, OCNL TS, ISOL TSGR, OCNL TSGR, FRQ TS, OBSC TS, EMBD TS, HVY SS, HVY DS, SQL TS, FRQ TSGR, OBSC TSGR, EMBD TSGR, SQL TSGR, VA

(4) **MT OBSC**: *[G_1G_1 /G_2G_2]* [Location]: Mountain obscuration.

(5) **SIG CLD:** *[G_1G_1 /G_2G_2]* [Location] [Amount (BKN or OVC)] [CB and/or TCU with ISOL, OCNL, FRQ or EMBD] [Altitude of cloud base and top (ft)]: Only clouds with height of base less than1000 ft above ground level, and/or CB or TCU at any height, are included.

(6) **ICE:** *[G_1G_1 /G_2G_2]* [Location] MOD or SEV [Altitude of cloud base and top (FL)]: Moderate or severe icing.

(7) **TURB:** *[G_1G_1 /G_2G_2]* [Location] MOD or SEV [Altitude of cloud base and top (FL)]: Moderate or severe turbulence.

(8) **MTW:** *[G_1G_1 /G_2G_2]* [Location] MOD or SEV [Altitude of cloud base and top (FL)]: Moderate or severe mountain wave.

(9) **SIGMET APLICABLES:** n.º of applicable message SIGMET to the FIR concerned or a sub-area thereof, for which the area forecast is valid.

When no elements are included in SECN I next message is included:

(10) **HAZARDOUS WX NIL:** No weather phenomena hazardous to low level flights and no applicable SIGMET are forecast.

NOTES:

1: Elements of points 1 to 10 will only appear in GAMET when the phenomena is forecast during the validity period.

2: G_1G_1 /G_2G_2 . Optional group. Starting and end time of the weather phenomena forecast.

3: Vertical distances are altitudes, so they are referenced to the mean sea level (MSL) and the unity is the feet (ft).The AMSL abbreviation is used after FT. For some elements level flights (FL) are used.

4: For each element more than one line could be used. Only approved ICAO abbreviation are allowed.

5: These notes are complemented by AIRMET notes.

6: The term "**areas extensas**" (widespread surface) is used to indicate a spatial coverage of more than 75% of the affected area.

SECN II: Additional information required by low-level flights

(11) **PSYS**: Data in abbreviated language on pressure centres and fronts and their expected movements and developments at the central hour of validity period of forecast.

(12) **WIND/T**: Upper wind (in kt) and upper-air temperature (in ºC) forecast for altitudes 02000, 05000, 10000, 15000 ft, for given locations at the central hour of validity period of forecast.

(13) **CLD**: Cloud information not included in Section I on clouds amount (BKN or OVC) between 1000 ft of height and FL150, showing the cloud type if known: ST, SC, CU, AS, AC and NS.

(14) **FZLVL**: Height indication of t = 0ºC level(s) for given locations at the central hour of validity period of forecast.

(15) **MNM QNH**: Forecast lowest QNH at the central hour of validity period of forecast (hectopascal).

(16) **VA**: Volcanic eruptions and name of volcano.

Use of NWCSAF/HRW: Aviation forecasting: SIGWX maps

Prognosis of phenomena in "SIGWX maps" (below FL150/~570 hPa, up to 6 hours):

- Surface wind > 30 kt
- Mountain waves
- Moderate/severe turbulence
- Severe sand/dust
- Widespread blowing snow
- Widespread sand/dust storm

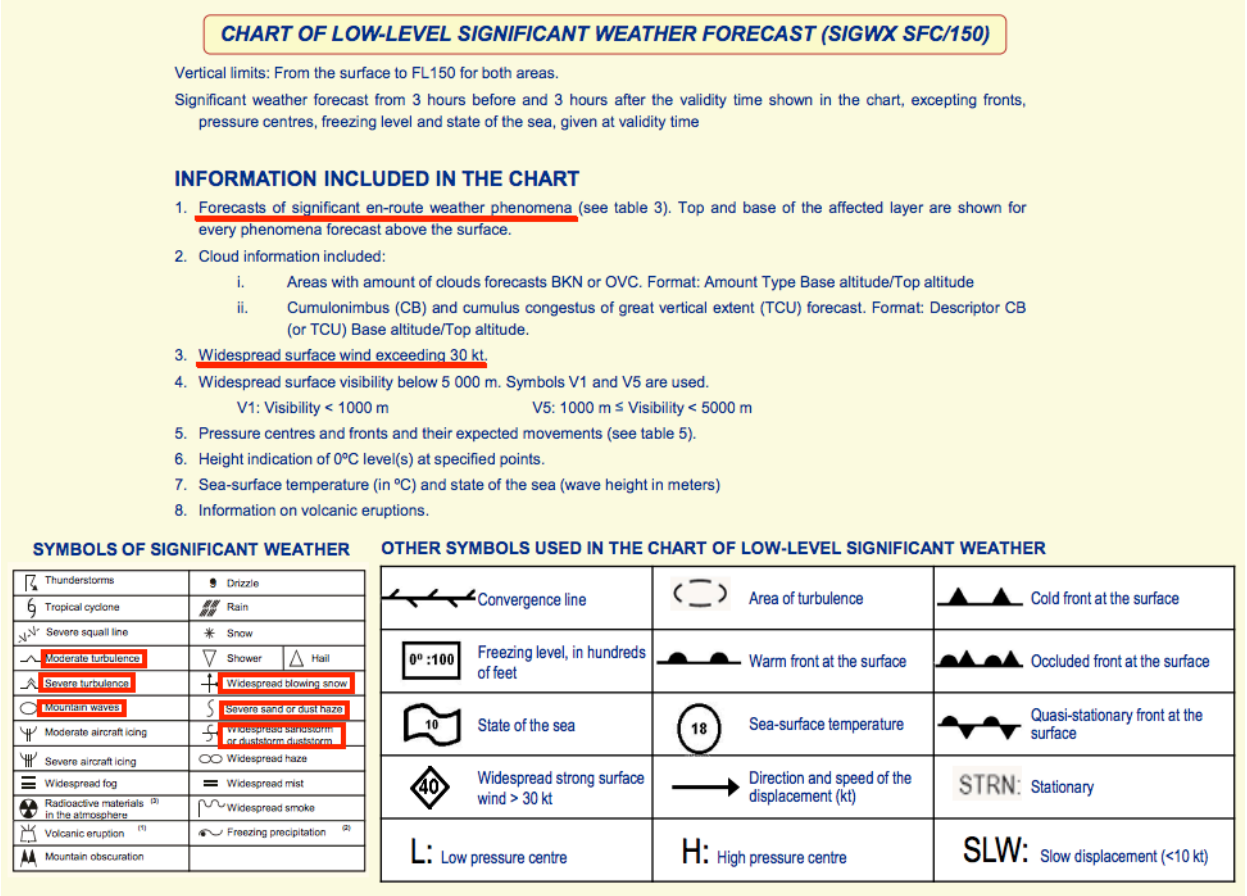


CHART OF LOW-LEVEL SIGNIFICANT WEATHER FORECAST (SIGWX SFC/150)

Vertical limits: From the surface to FL150 for both areas.

Significant weather forecast from 3 hours before and 3 hours after the validity time shown in the chart, excepting fronts, pressure centres, freezing level and state of the sea, given at validity time

INFORMATION INCLUDED IN THE CHART

1. Forecasts of significant en-route weather phenomena (see table 3). Top and base of the affected layer are shown for every phenomena forecast above the surface.
2. Cloud information included:
   - i. Areas with amount of clouds forecasts BKN or OVC. Format: Amount Type Base altitude/Top altitude
   - ii. Cumulonimbus (CB) and cumulus congestus of great vertical extent (TCU) forecast. Format: Descriptor CB (or TCU) Base altitude/Top altitude.
3. Widespread surface wind exceeding 30 kt.
4. Widespread surface visibility below 5 000 m. Symbols V1 and V5 are used.
   V1: Visibility < 1000 m V5: 1000 m ≤ Visibility < 5000 m
5. Pressure centres and fronts and their expected movements (see table 5).
6. Height indication of 0ºC level(s) at specified points.
7. Sea-surface temperature (in ºC) and state of the sea (wave height in meters)
8. Information on volcanic eruptions.

SYMBOLS OF SIGNIFICANT WEATHER

Thunderstorms	Drizzle
Tropical cyclone	Rain
Severe squall line	Snow
Moderate turbulence	Shower / Hail
Severe turbulence	Widespread blowing snow
Mountain waves	Severe sand or dust haze
Moderate aircraft icing	Widespread sandstorm or duststorm duststorm
Severe aircraft icing	Widespread haze
Widespread fog	Widespread mist
Radioactive materials in the atmosphere	Widespread smoke
Volcanic eruption	Freezing precipitation
Mountain obscuration	

OTHER SYMBOLS USED IN THE CHART OF LOW-LEVEL SIGNIFICANT WEATHER

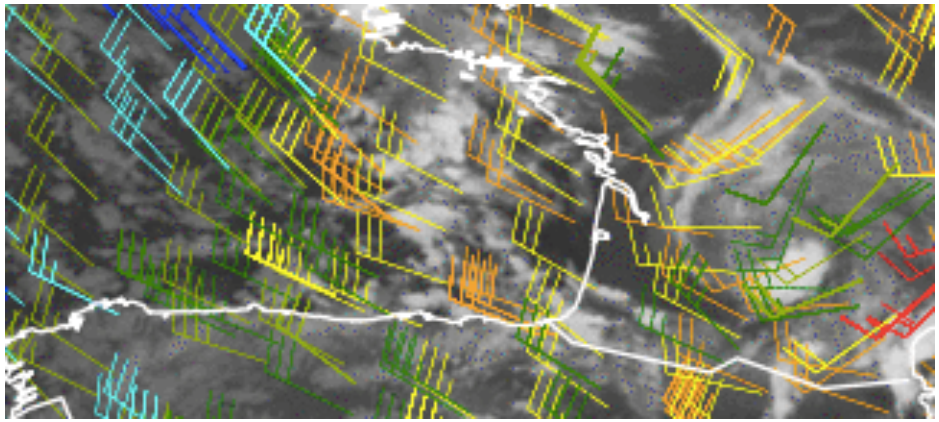
Convergence line	Area of turbulence	Cold front at the surface
0º :100 Freezing level, in hundreds of feet	Warm front at the surface	Occluded front at the surface
10 State of the sea	18 Sea-surface temperature	Quasi-stationary front at the surface
40 Widespread strong surface wind > 30 kt	Direction and speed of the displacement (kt)	STRN: Stationary
L: Low pressure centre	H: High pressure centre	SLW: Slow displacement (<10 kt)

Aviation forecasting: SIGMET/AIRMET/GAMET/SIGWX maps

Considering WIND at different levels and SURFACE WIND > 30 kt:

NWCSAF/HRW to be used directly for the forecast.

- ➔ As already said, cloud opacity often prevents the observation of winds at the lowest levels.
- ➔ In this case, we can try to extrapolate information from slightly higher levels.



Considering SURFACE WIND GUSTS:

- ➔ Reported when at least 9kt higher than the mean wind.
- ➔ Caused by wind shear, friction turbulence, ground heating differences.
- ➔ The forecast can be specific for every location.
  (Knowledge of the local relationship between the surface mean wind and the wind gusts is needed).

Aviation forecasting: SIGMET/AIRMET/GAMET/SIGWX maps

Considering DUST/SAND/SNOW STORMS:

➔ Dependent not only on turbulent gusty wind,
but also on the soil properties, moisture and vegetation.

➔ ICAO guidelines based on weather:

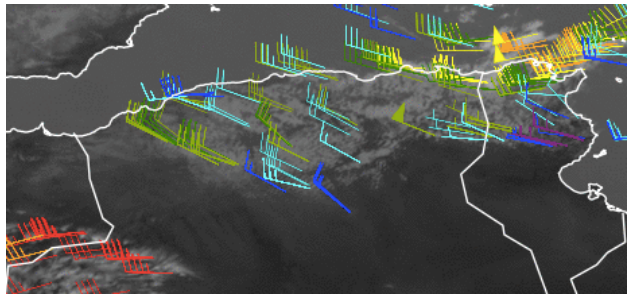
- VIS < 1500m & GUSTS > 30kt for “moderate storms”.
- VIS < 500m & GUSTS > 40kt for “heavy storms”.

Considering MOUNTAIN WAVES:

➔ A specific NWC/GEO-ASII-GW product detects this.

➔ However, NWC/GEO-iSHAI stability + NWC/GEO-HRW winds
at ridge level, perpendicular to the mountain chain, also helpful for this.





Case in Algeria,
11/Mar/2024 at 12000Z

Aviation forecasting: SIGMET/AIRMET/GAMET/SIGWX maps

Considering TURBULENCE:

Main causes of turbulence:

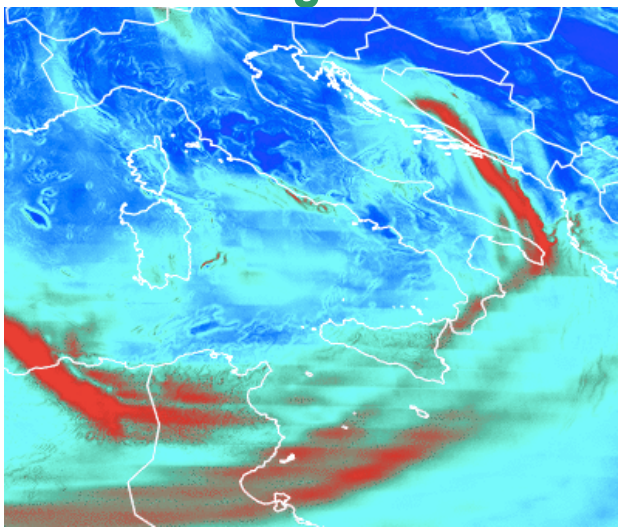
1. **Mountain waves (already seen).**

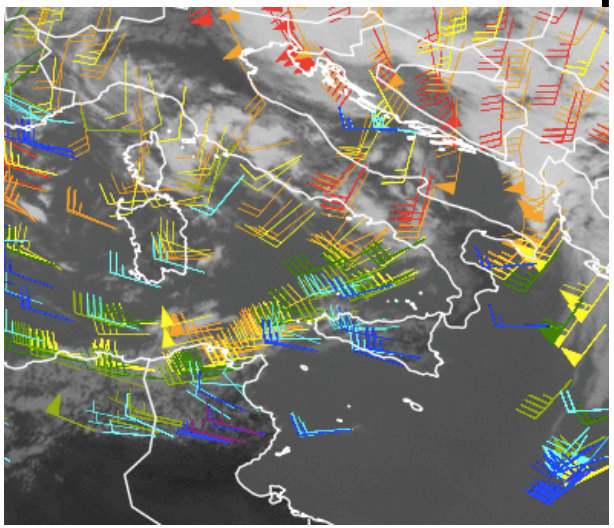
2. **Frontal turbulence and wind shear in troughs and lows**

   (lifting of warm air + opposition of air masses, with ΔT>5K, displ. > 30kt)

➔ **Again, a specific NWC/GEO-ASII-TF product detects this turbulence.**

➔ **Satellite images + NWCSAF/HRW winds are also helpful for this.**





Case in Italy,
11/Mar/2024 at 12000Z

Aviation forecasting: SIGMET/AIRMET/GAMET/SIGWX maps

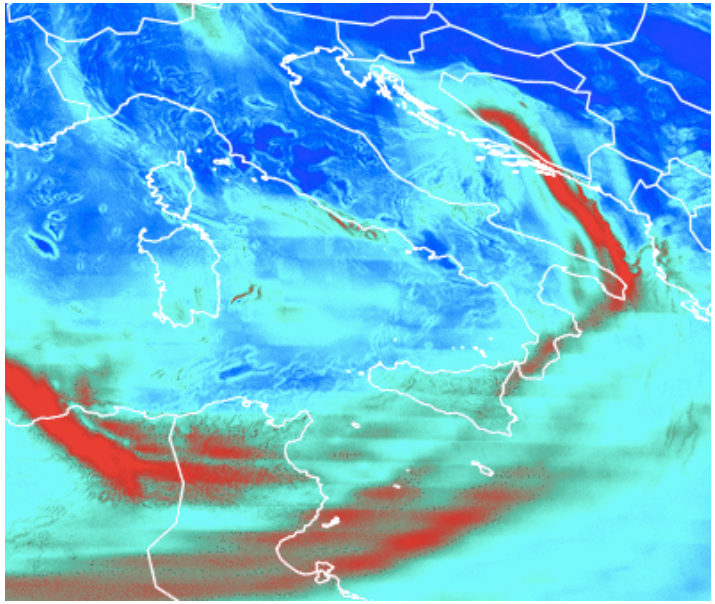
Considering TURBULENCE:

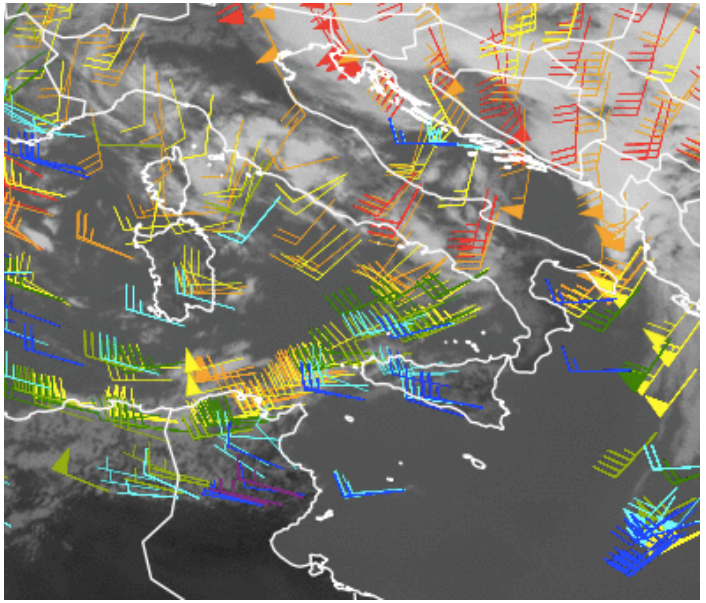
Main causes of turbulence:

3. Wind shear in jet streams.

➔ **NWC/GEO-ASII-TF product also detects this turbulence.**

➔ **Satellite images + NWCSAF/HRW winds are also helpful for this.**





Case in Italy,
11/Mar/2024 at 12000Z

Aviation forecasting: SIGMET/AIRMET/GAMET/SIGWX maps

Considering TURBULENCE:

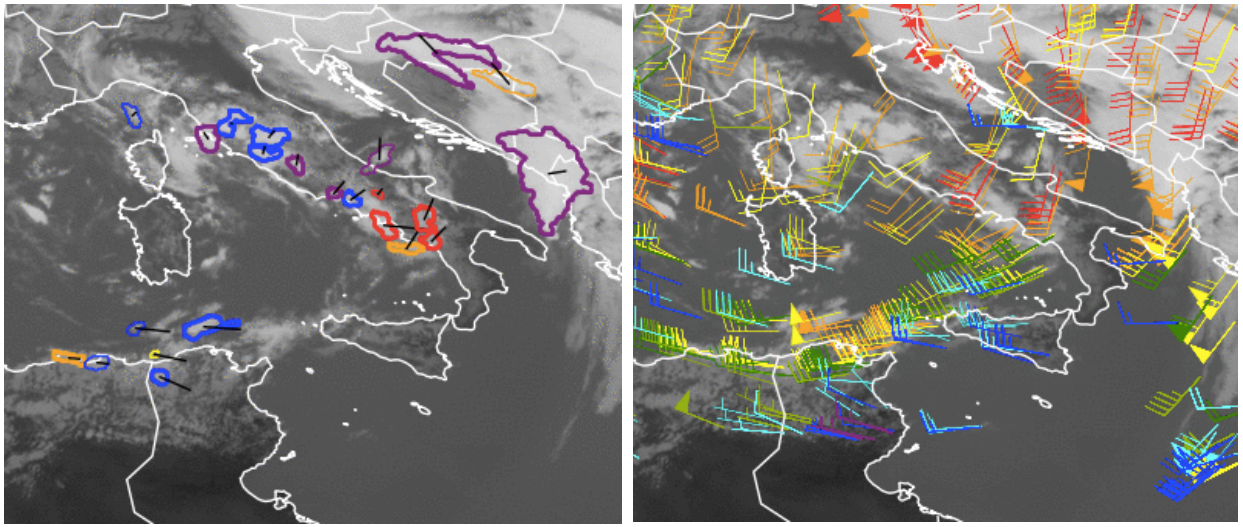
Main causes of turbulence:

4. Convective turbulence (due to ground heating differences), evolving in:

5. Thunderstorm turbulence.

➔ **A specific NWC/GEO-RDT-CW product detects related storms.**

➔ **Satellite images + NWCSAF/HRW winds are also helpful for this.**



Case in Italy, 11/Mar/2024 at 12000Z

Aviation forecasting: SIGMET/AIRMET/GAMET/SIGWX maps

Considering TURBULENCE:

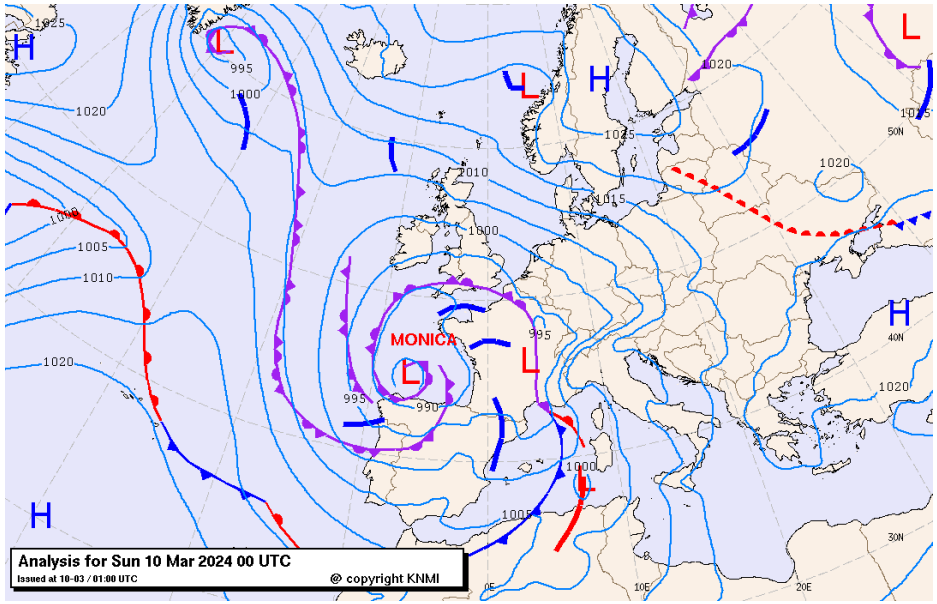
Main causes of turbulence:

6. Wind shear in temperature inversion areas
(due to night cooling).

7. Mechanical friction of air with the ground
(irregular terrain, obstacles).

➔ **Cases not detectable with NWCSAF/HRW.**

Case study of 10-11 March 2024



Storm Monica affects

Central and Southern Europe with widespread rain and wind

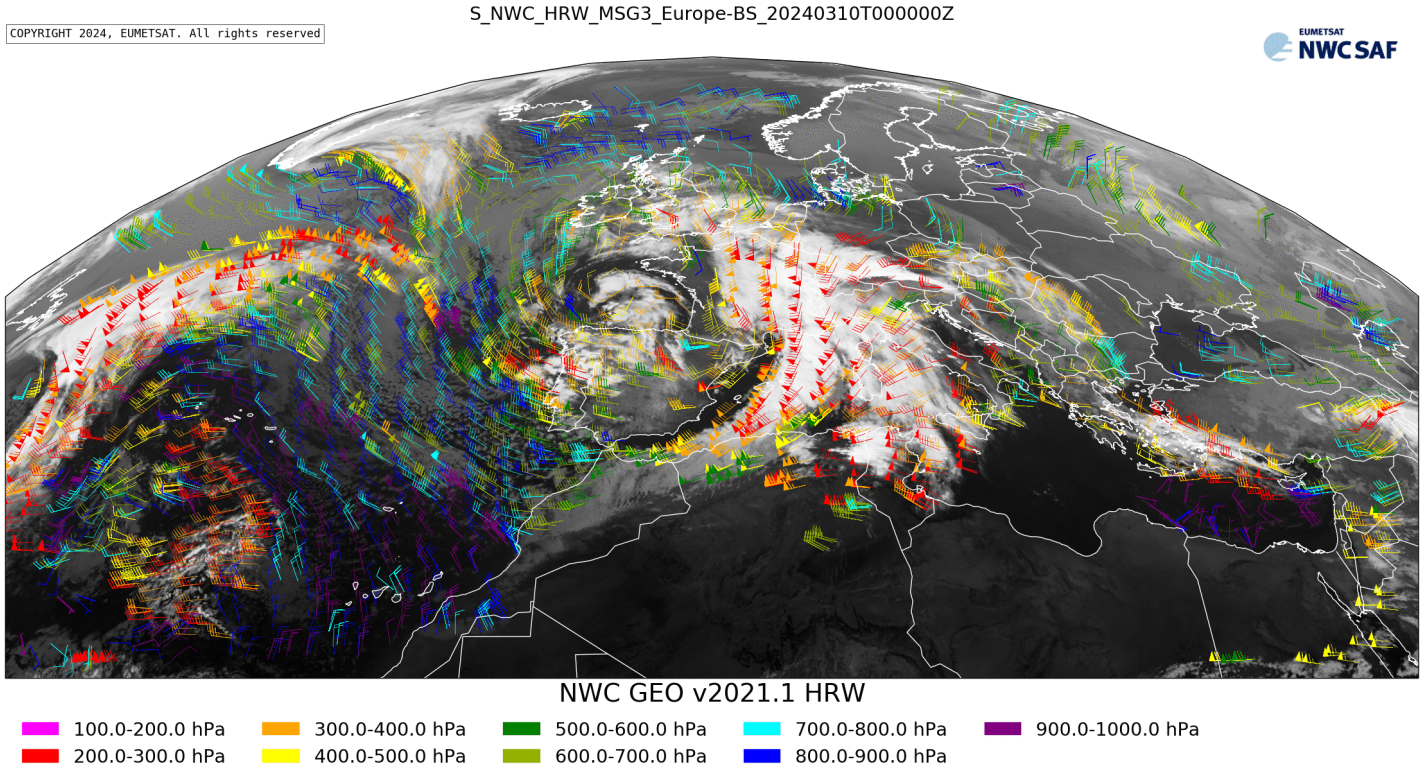
(and snow in the mountains).

It moves East

from the Gulf of Biscay to the Northern Balkans, while it weakens

(min. surf. pressure from 985 hPa to 1005 hPa throughout the period).

Case study of 10-11 March 2024

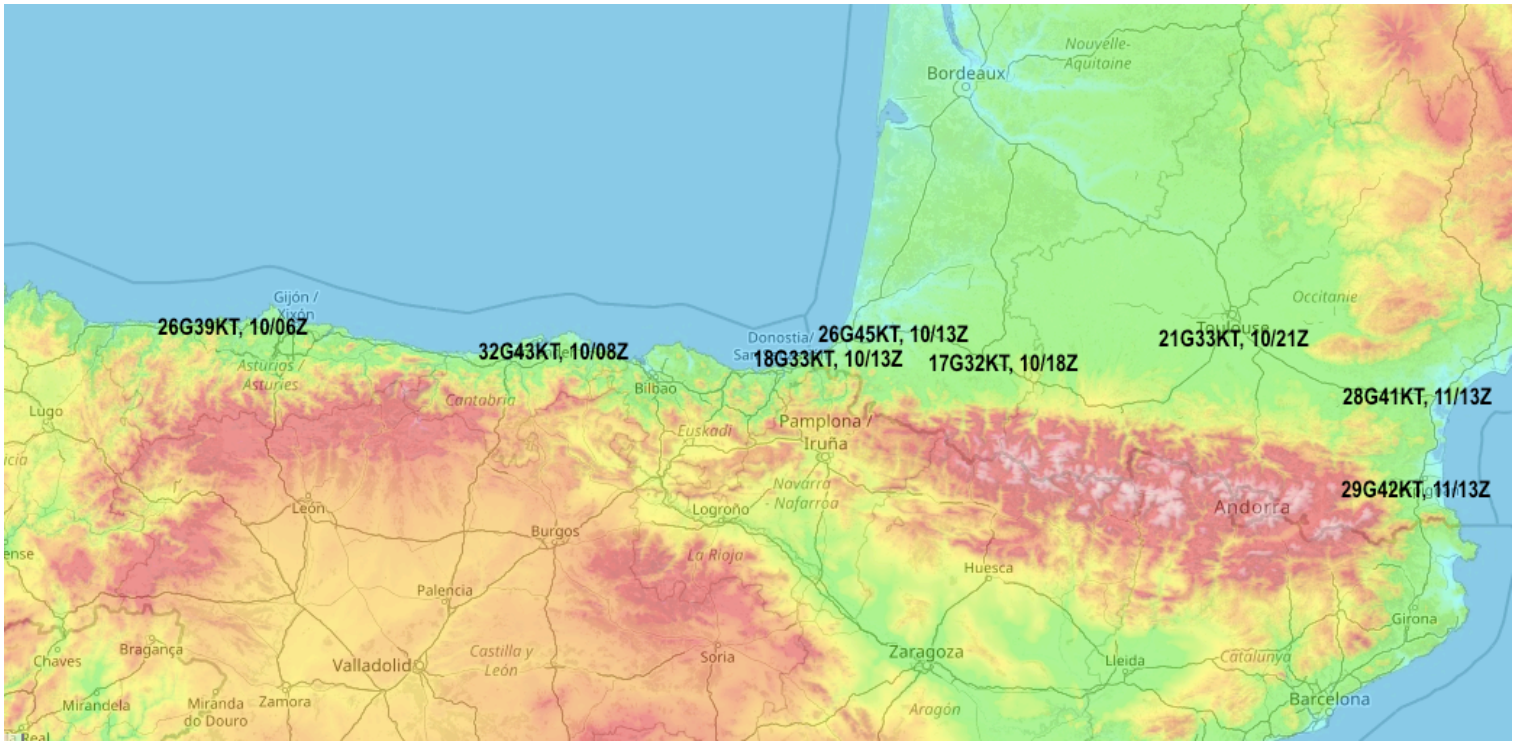


There is big density of NWCSAF/HRW AMVs in all layers, which allows a quick analysis of the circulation and dynamics of the low in the whole period.

Let's check the aviation forecasting for North Spain/South France!

Case study of 10-11 March 2024

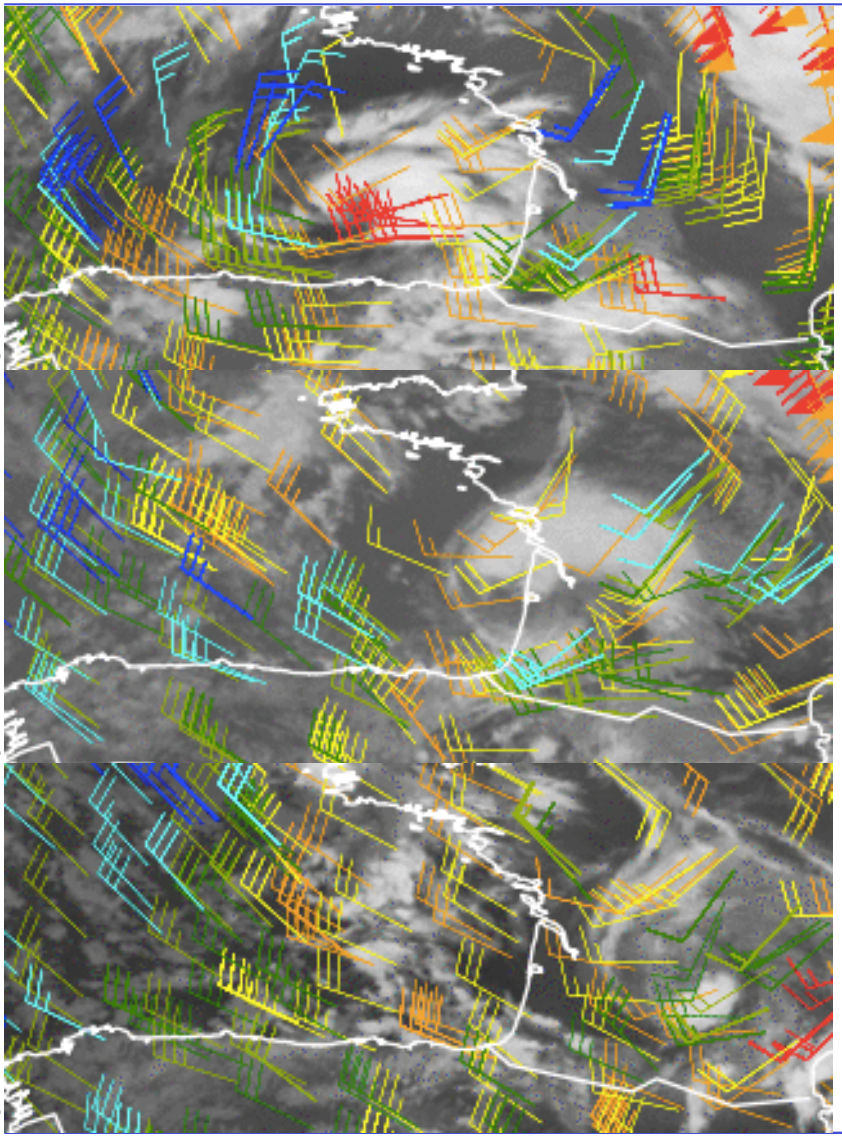
METAR wind gusts over 30kt in Northern Spain/Southern France:



Wind maximums move progressively East with:

- **Maximum mean winds of 32kt in Santander.**
- **Maximum wind gusts over 40kt in several airports.**

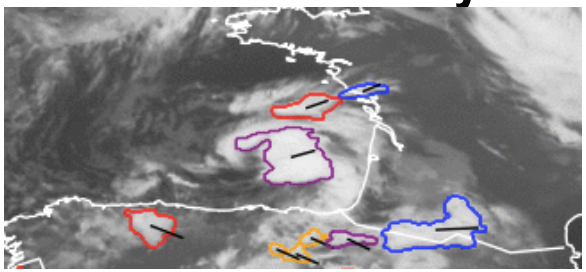
Case study of 10-11 March 2024



NWCSAF/HRW product specially useful at the start of the forecasting period:

- Many 25-30kt low level AMVs (below 800hPa)
- Wind shear causing turbulence

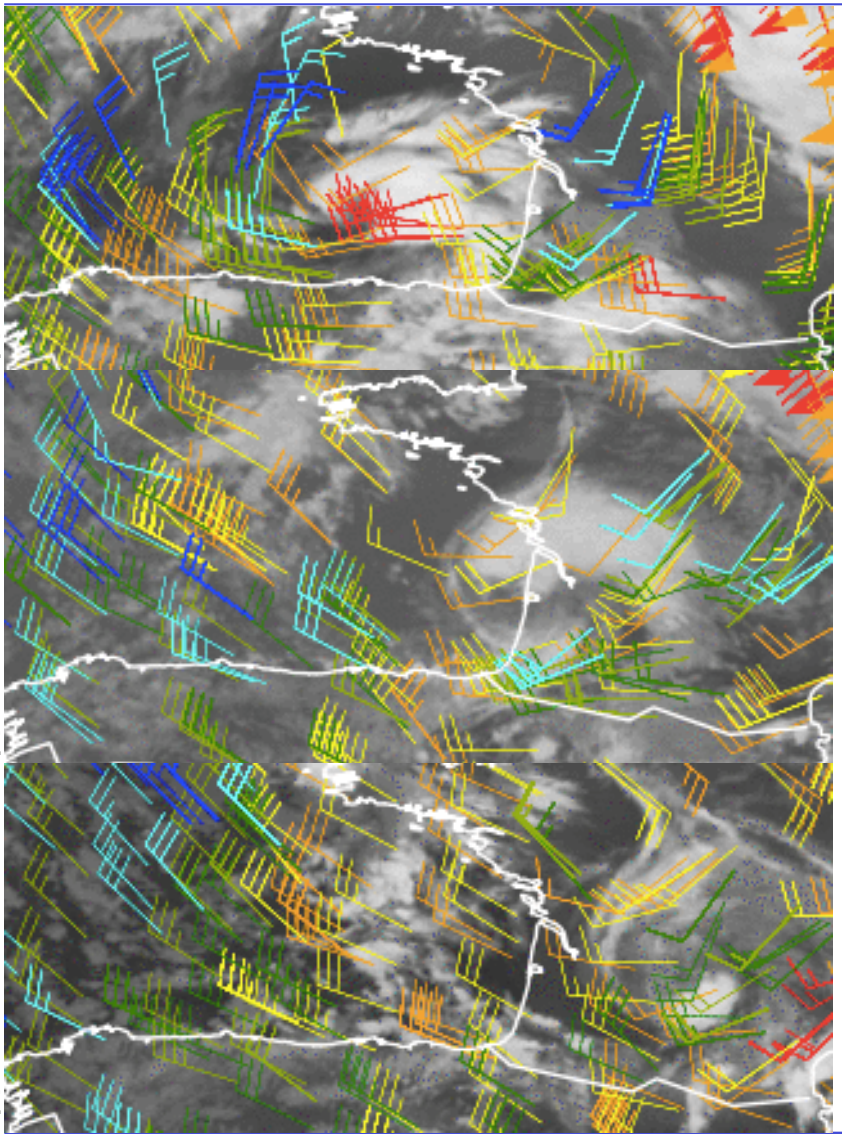
(together with: - mountain waves
- 2000m heights near the coast
- convection shown by RDT)



The information is smaller at later stages (dependence on existing tracers!):

- Less low level AMVs
- Less wind shear

Case study of 10-11 March 2024



This way, NWCSAF/HRW product helps to define places/moments for:

➔ "surface winds > 30KT warnings" in AIRMET/GAMET/SIGWX.

➔ "mean wind and wind gusts" in TAF/TREND forecasts and Aerodrome warnings (WW).

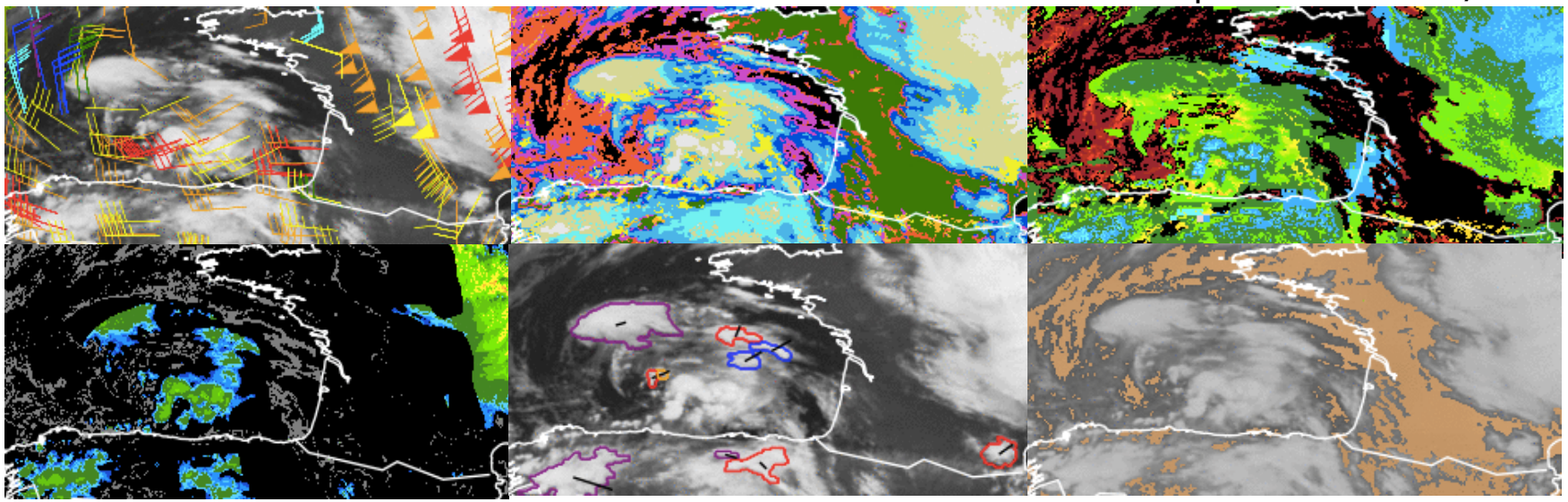
➔ "wind in FL20/FL50/FL100/FL150 levels" in GAMET forecasts.

Case study of 10-11 March 2024

TAF forecast for Santander airport for 10 March:

```
TAF COR LEXJ 100231Z 1003/1103 20009KT 9999 FEW025 SCT040
             TEMPO 1003/1010 22019G32KT
             BECMG 1008/1011 28012KT
             TEMPO 1007/1103 29019G33KT 3000 SHRA BKN010 SCT025TCU
             PROB30 TEMPO 1006/1021 TS SCT030CB
             PROB40 TEMPO 1009/1021 29025G43KT=
```

NWCSAF products for 10MAR/0230Z



➔ **NWCSAF/HRW AMVs help to fine-tune the wind information (beyond the one provided by the NWP model)**

➔ **Other NWCSAF products (Clouds, precipitation, convection, instability) can also be used for corresponding information in the forecast.**

Case study of 10-11 March 2024

SIGMET warnings for Madrid/Barcelona FIRs in the first half of 10 March:

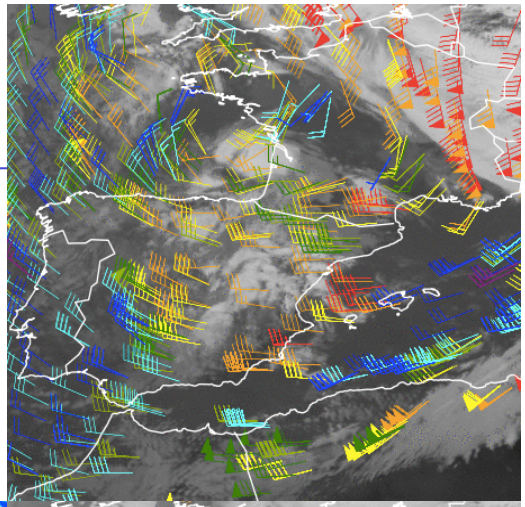
```
TWSSP31 LEMM 100924
LECM SIGMET 3 VALID 100925/101300 LEVA-
LECM MADRID FIR SEV TURB OBS AT 0923Z WI N4420 W00436 - N4322 W00433 - N4310 W002 - N4342 W00216 -
    N4420 W00436 SFC/FL060 MOV E 20KT WKN=NNNN

WSSP31 LEMM 100948
LECM SIGMET 4 VALID 101000/101400 LEVA-
LECM MADRID FIR/UIR SEV MTW FCST WI N3842 W00126 - N3816 W00250 - N3645 W00318 - N3703 W00148 -
    N3842 W00126 SFC/FL400 STNR NC=NNNN

WSSP32 LEMM 100947
LECB SIGMET 2 VALID 101000/101400 LEVA-
LECB BARCELONA FIR/UIR SEV MTW FCST WI N3843 W00118 - N3844 E00018 - N3729 E00003 - N3706 W00142 -
    N3706 W00142 - N3843 W00118 SFC/FL400 STNR NC=NNNN
```

Case study of 10-11 March 2024

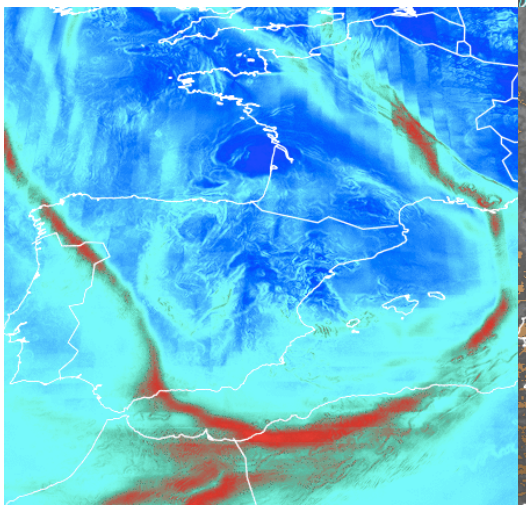
NWCSAF products for 10MAR/0900Z

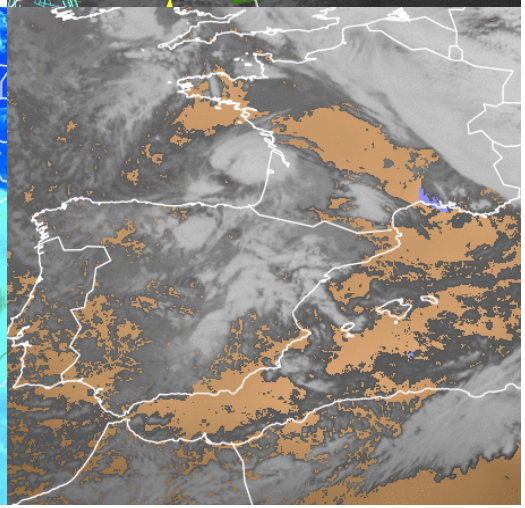


TWSSP31 LEMM 100924
LECM SIGMET 3 VALID 100925/101300 LEVA-
LECM MADRID FIR SEV TURB OBS
SFC/FL060 MOV E 20KT WKN

WSSP31 LEMM 100948
LECM SIGMET 4 VALID 101000/101400 LEVA-
LECM MADRID FIR/UIR SEV MTW FCST
SFC/FL400 STNR

WSSP32 LEMM 100947
LECB SIGMET 2 VALID 101000/101400 LEVA-
LECB BARCELONA FIR/UIR SEV MTW FCST
SFC/FL400 STNR





➔ **NWCSAF products (HRW AMVs, Tropopause folding, iSHAI instability) help to fine-tune turbulence/mountain wave information in SIGMET warnings**

Case study of 10-11 March 2024

GAMET forecast for Madrid FIR in the first half of 10 March:

```
FASP40 LEMM 100500
     LECM GAMET VALID 100900/101500 LEVA-
     LECM MADRID FIR/1 BLW FL150
     SECN I
     SFC WIND:
     SFC VIS:  LCA N OF LINE N44 W009 - N42 W003 - N43 W001 3000M RA/SHRA

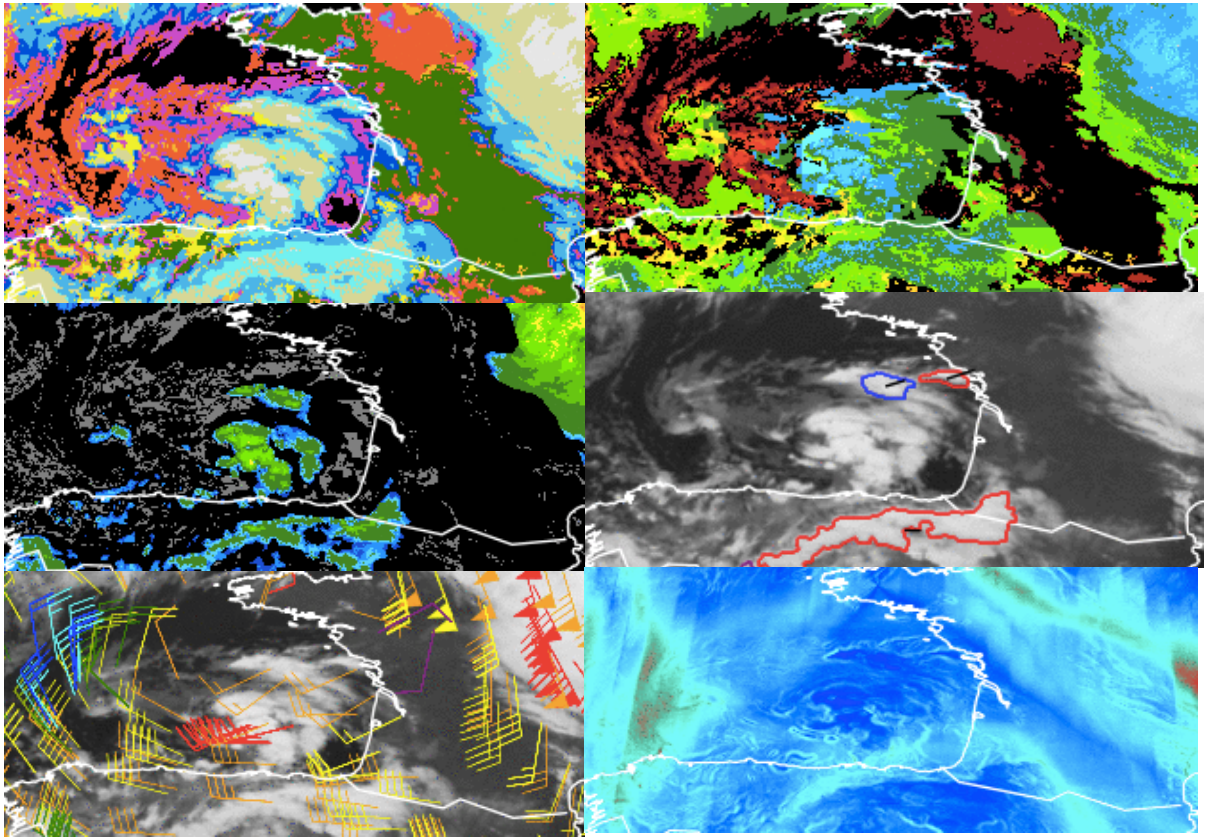
     SIGWX:    N OF LINE N44 W009 - N42 W003 - N43 W001 ISOL/EMBD TS
               PIRIN, VAL EBRO, S IBER ISOL/EMBD TS
     MT OBSC:  C CATABR, PIRIN, S IBER, S CENTRAL
     SIG CLD:  N OF LINE N44 W009 - N43 W001 ISOL/EMBD CB TCU 02000-04000/15000-ABV15000FT AMSL
               PIRIN, VAL EBRO, S IBER ISOL/EMBD CB TCU SFC-03000/15000-ABV15000FT AMSL
     ICE:      S CENTRAL, S IBER MOD FL070/090 PIRIN, C CANT MOD FL070/120
     TURB:     M CANT MOD/SEV SFC/FL050-070
               C CANT, S IBER, VAL EBRO, S CENTRAL MOD SFC/FL060-090
     SECN II
     PSYS:     12 OCCLUDED FRONT N45 W009 - N44 00000
     WIND/T:   LA CORUNA         MADRID          SANTANDER       ZARAGOZA
               N4330 W00838      N4049 W00359    N4342 W00382    N4166 W00101
               02000FT 305/026KT PS06 259/013KT PS10 289/038KT PS06 254/025KT PS09
               05000FT 310/027KT MS01 274/028KT PS01 300/038KT MS01 273/019KT PS00
               10000FT 314/027KT MS10 304/038KT MS09 309/043KT MS10 287/025KT MS10
               15000FT 319/039KT MS19 291/043KT MS21 316/045KT MS22 264/029KT MS21
     FZLVL:    04800FT AMSL      05300FT AMSL    04600FT AMSL    05200FT AMSL
     MNM QNH:1014 HPA=NNNN
```

Case study of 10-11 March 2024

NWCSAF products for 10MAR/0500Z

```
FASP40 LEMM 100500
     LECM GAMET VALID 100900/101500
     LECM MADRID FIR/1 BLW FL150
     SECN I
     SFC WIND:
     SFC VIS:   RA/SHRA
     SIGWX:     ISOL/EMBD TS
     MT OBSC:
     SIG CLD:   ISOL/EMBD CB TCU
                ISOL/EMBD CB TCU
     ICE:
     TURB:      MOD/SEV

     SECN II
     PSYS:      OCCLUDED FRONT
     WIND/T:
                02000FT
                05000FT
                10000FT
                15000FT
     FZLVL:
     MNM QNH:
```



➔ **NWCSAF/HRW AMVs** help again to fine-tune the wind information in this forecast (beyond the one provided by the NWP model)

➔ **Clouds/Precipitation/Convection/Tropopause folding NWCSAF products** can also be used for corresponding information in the forecast.

How to reach NWCSAF/HRW-High Resolution Winds

All National Meteorological Services within EUMETSAT

can be users of NWCSAF & NWCSAF/HRW software.

Any other Organisation may also apply, considering conditions defined in

www.nwcsaf.org/web/guest/software-delivery-conditions

All applicants have become users up to now without restrictions:

around 400 institutions from all around the world.

- **For institutions: software delivery authorized according to a Licence Agreement, signed by EUMETSAT (represented by AEMET) and the applicant user.**
- **For individuals: software delivery authorized after filling a registration form.**

After this, access credentials to NWCSAF Helpdesk Restricted Area are provided,

where NWCSAF software can be downloaded:

nwc-saf.eumetsat.int

How to reach NWC/GEO products

Real time visualization of NWC/GEO products

is available for MSG satellite in Europe,

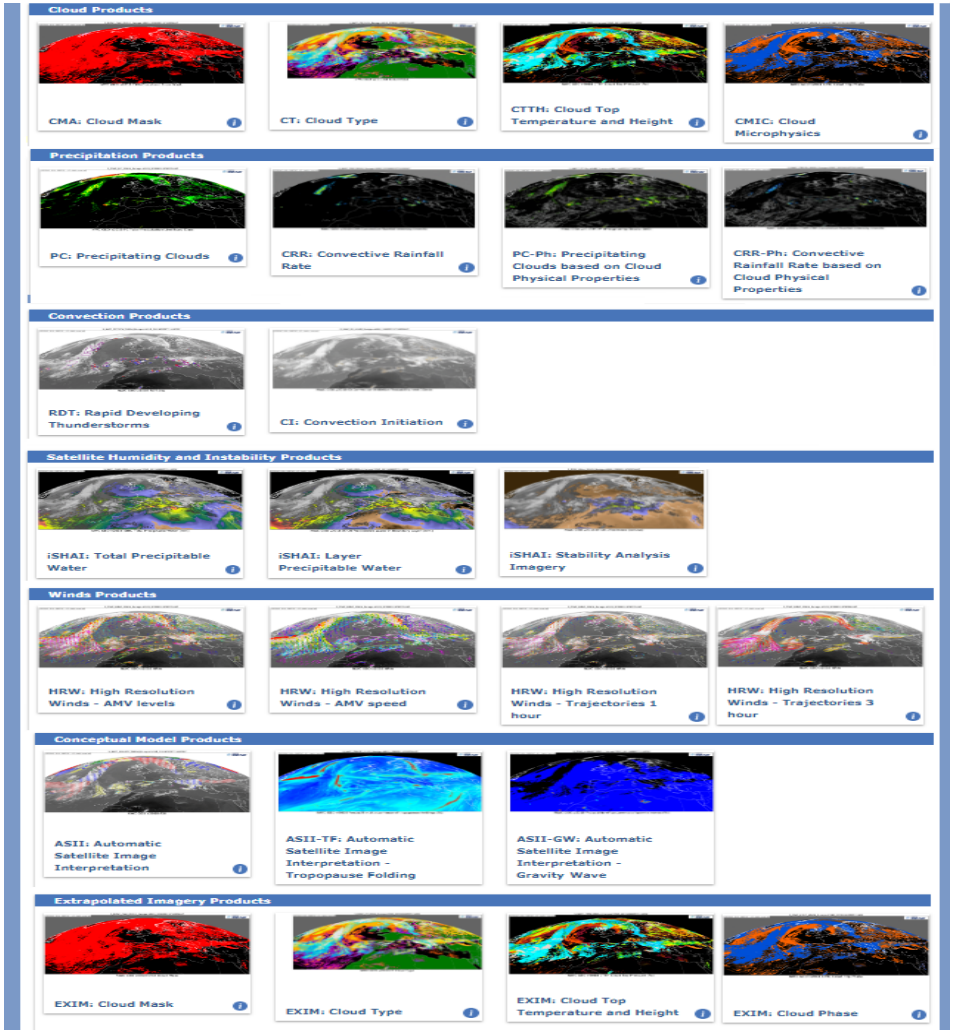
with update every 15 minutes,

in NWCSAF Helpdesk

nwc-saf.eumetsat.int

> Running the latest version of the software with the default configuration.

> The update for MTG-I is already prepared, for the moment when the satellite becomes operational



How to reach NWC/GEO products

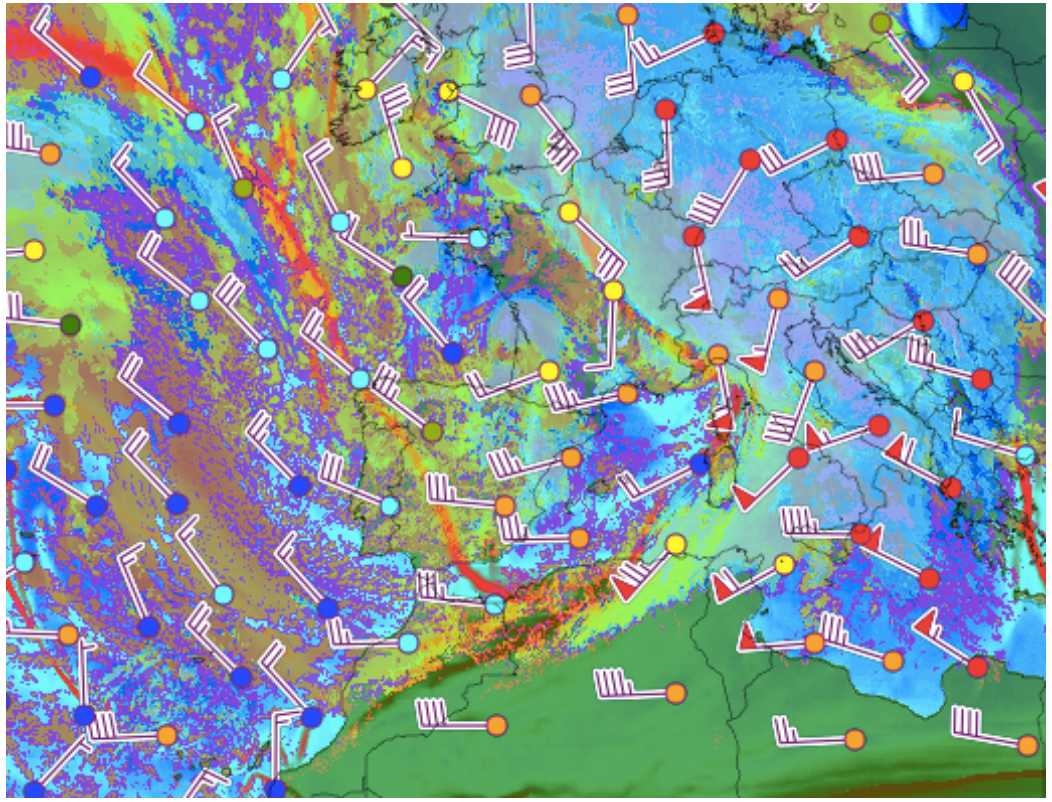
A Full Disk visualization for Europe and Africa

is also available in the following link:

https://adaguc.nwcsaf.eumetsat.ewcloud.host

> **Option to superpose different NWC/GEO products in a dynamic way, for big and small scales in any location.**

> **The case study (10-11 March 2024) is today available in the webpage for your own testing of NWCSAF products!**



Thank you very much for your attention!

Questions?

Contact:
jgarciap@aemet.es

