Application and Verification of ECMWF Products 2019

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1. Summary of major highlights

ECMWF HRES model output from both 12 and 00 UTC runs is used as plotted fields in the forecasting department mainly for the medium range and as input to physical adaptation schemes. ECMWF HRES and ENS are used as boundary conditions for the Italian Air Force NWP Models (COSMO-ME and COSMO-ME-EPS). Verification of ECMWF products is carried out at COMET for HRES model: surface parameters and forecast ranges mainly used by weather forecasters are considered.

2. Use and application of products

Include, as appropriate, high-resolution (HRES) and ensemble (ENS) forecasts, monthly forecasts, seasonal forecasts.

2.1 Direct Use of ECMWF Products

The products are mainly used in the operational forecasting rooms.

2.2 Other uses of ECMWF output

Describe the different ways in which you use ECMWF forecasts indirectly, in the following categories:

2.2.1 Post-processing

The Metview modules FLEXTRA and FLEXPART are being used to download from MARS and code 00 and 12 UTC ECMWF atmospheric model runs and to trace contaminants dispersion in case of nuclear and chemical incident/accident. Procedures feeding from ECMWF dissemination system is planned in order to improve both timing and reliability.
Meteorological CBRN messages as well are generated and distributed according to NATO directives and other agreements.
Thousands of maps are produced every day from both 00 and 12 UTC HRES and WAVE ECMWF models runs.
A Geographical Information System (GIS) platform is being feed with both 00 and 12 UTC HRES and WAVE ECMWF models runs in order to provide GIS services to end users and exchange GIS services with other GIS platforms.

2.2.2 Derived fields

Thousands of meteograms are routinely produced over geographical sites within the 80°N-60°S area. At present meteograms are being produced in PNG graphical format and in text or XML mode every 6 hours for the range T+0H to T+168H stepping in time. Meteograms are produced targeting to a general purpose use and, for this reason, the weather parameters included are numerous; among them: 2m temperature, 2m humidity, mean sea level pressure, total-high-medium-low cloud cover, convective precipitation, grid scale precipitation and 10 m wind. Despite the static mass production a web based system offering dynamic generation services of the same meteograms as above to the registered users is operational since 2011.
Based on the ECMWF models output, several derived parameters are routinely calculated as well. Using the deterministic operational model forecasts, the derived fields produced are for example: freezing level; wet bulb potential temperature; KO and other stability indexes; liquid water content; accumulated precipitation over fixed time interval, heat index (Steadman), wind-chill, tropopause height and maximum wind, 2m relative humidity.
A deterministic post-processing package known as Automatic Weather Interpretation (AWI) is also applied to ECMWF HRES model output fields. A series of multi-parameter decisional tree allows the determination of weather phenomena (drizzle, rain, snow, thunderstorms, fog, etc.) as well as of the cloud type, the risk of icing, strong wind or heat waves. The AWI output are operationally used to establish weather impact over regions of interest.
Derived fields are also calculated using the ECMWF Wave Model output. The most important derived parameter is the sea state code, which is based on the primary wind wave height (Douglas Scale). Meteograms over sea geographical sites are being produced in PNG graphical format and in text or XML mode too. For each site primary sea swell height, wind wave height, 10 m wind and wave direction behaviours are described from T+0H up to T+96H at 6H time resolution. Most of the sites are chosen according to buoys and tide gauges deployment. Some of them do not correspond to any physical instrument deployed and for this reason they are named as “virtual buoys”. As above a web based system offering dynamic generation services of the same meteograms to the registered users is operational since 2011.
The production of some graphical outputs from the EPS forecast system, is carried out directly from ECMWF Servers using “ad hoc” built applications and Metview batch procedures. In particular, the following maps are created on a daily basis:

• Epsgrams and Plumes for 40 main Italian cities

• Probability maps on Europe from t+ 48 to t+168 (precipitation, wind, 850 hPa Temp)

• Tubes on Europe t+96 and t+168

Both ECMWF Wave Model and ECMWF Atmospheric Model outputs are used and suitably cropped, re-gridded and distributed according to agreements with specific users.

2.2.3 Modelling

For the COSMO-ME (Euro-mediterranean domain) deterministic run are currently used the BC from the 6hour older HRES run up to +84hours.

For the COSMO-ME EPS run are currently used 40 randomly selected members from the 6 hours older EPS run up to +84hours.

For the LETKF data assimilation cycle (first guess production) are currently used as BC the 6 hours older HRES run (forecasts up to +12hours) perturbed using 40 randomly selected members from the 12 hours older EPS run (ensemble forecasts up to +18hours).

For the 3DVAR analysis cycle (first guess production) are currently used the 6 hours older HRES run up to +12hours.

The Metview modules FLEXTRA and FLEXPART are currently used to download from MARS and code 00 and 12 UTC ECMWF atmospheric model runs, in order to trace contaminants dispersion in case of nuclear and chemical incident/accident.

3. Verification of ECMWF products

3.1 Objective verification

Describe verification activities and show and discuss related scores.

3.1.1 Direct ECMWF model output (both HRES and ENS), and other NWP models

Local weather parameters verified for locations

Objective scores are computed for ECMWF HRES 12 and 00 UTC run (d+1 to d+7) after collecting data retrieved from all available Italian Synop stations, using several stratifications. Plots have been produced for a number of parameters: 2m Temperature, 2m Dew Point Temperature, 10m Wind Speed, MSLP, Total Cloud Cover (ME, MAE).
Cumulated precipitation quarterly event scores (POD/FAR, FBI, KSS, ETS, ORSS, POD, FAR) with respect to fixed thresholds and for d+1 to d+7 ranges, are computed.
For this report, data covering the 1-year period from JJA 2018 to MAM 2019 have been used for the verification of these parameters and only some selected results are presented in the next pages (see Appendix A), for ECMWF HRES 00 UTC run only.
In order to compute the scores, no interpolation from grid point to observation location is performed. The “nearest point” method is used, optimized by the “smaller” difference in altitude combined with the horizontal distance between a station and the corresponding grid point. The reference software used for verification purposes is called VERSUS (VERification System Unified Survey), i.e. the official software used within COSMO model consortium as Common Verification Suite (CVS). The VERSUS system has been developed at Air Force Met service and it is based on DB architecture with a GUI. Through this tool, Conditional Verifications are also possible (cross conditions on different parameters).
A short note on the results is given below.
10m Wind Speed: a general small underestimation is shown in ME, less than 0.9 m/s in absolute value. MAE, around 1.3-1.7 m/s in summer 2018, 1.5-2.1 m/s in fall 2018 and spring 2019 , 1.6-2.3 m/s in winter 2018-19, with a tendency to slightly increase with forecast step.
2m Temperature: clear diurnal cycle in both ME and MAE especially in winter. A general underestimation is shown in ME, especially during the night. MAE increases with the forecast time and its values are mainly comprised between 1.3 and 2.4 K (reaching up to 2.9 K in winter).
12-h Cumulated Precipitation: regarding the bias (FBI) ECMWF model shows an overestimation for all the seasons for lower thresholds, while tends to underestimate the really higher ones. The discriminant threshold (i.e. FBI = 1) is around 06-20 mm/12h in fall 2018 and spring 2019, 02-07 mm/12h in summer 2018 and around 06-15 mm/12h in winter 2018-19 (with a general worsening above 18-20 mm/12h). About the accuracy (ETS), all seasons exhibit the best results mainly for low thresholds and for the first 3-4 days of integration. For all thresholds there is a gradual decrease in accuracy with the integration time.

ECMWF model output compared to other NWP models

ECMWF HRES 00-UTC scores (ETS, FBI) for 12 hours cumulated precipitation have been calculated and graphically compared to those for the 00 UTC run of COSMO-ME model (5 Km resolution) up to step +72h over the italian synop stations. Results are shown in the Appendix A.

Respect to the FBI scores, COSMO-ME and ECMWF HRES show a similar tendency, with an overestimation for the lower thresholds and a general underestimation for the higher thresholds; COSMO-ME model shows better values that are lower and closer to 1 (for thresholds < 6 mm/12h around 0.5-2.3 in Summer 2018, 0.9-1.4 in Fall 2018, 0.9-1.4 in Winter 2018-19, 0.9-1.5 in Spring 2019) respect to the ECMWF model (for thresholds < 6 mm/12h around 0.4-3.2 in Summer 2018, 1.0-2.0 in Fall 2018, 0.9-2.1 in Winter 2018-19, 0.8-2.0 in Spring 2019) and more costant in function of the thresholds (at least up to 18-20 mm) . Accuracy, represented here through ETS score, tends to be similar, except for lower thresholds, for both models, for all seasons, showing a behaviour similar to that recorded in previous years.
A further comparison between the two models has been done in terms of mean error and root mean square error (ME,RMSE) for 2m temperature and 10m wind speed.
Results show a tendency of COSMO-ME to overestimate the 2m Temperature in Summer 2018 and, for some time steps, in Fall 2018, opposite to the IFS behaviour; for Winter 2018-19 both models have an underestimation attitude, with a counterphased trend, for the mean error; for Spring 2018 COSMO-ME has a ME close to zero, with a slight underestimation attitude, while it is present a negative bias for ECMWF. Looking at the 10m Wind Speed comparison COSMO-ME model seems to slightly outperform the IFS in terms of ME, especially during daytime, except for Winter 2018-19, where the parameter is pretty similar for both models.

3.1.2 Post-processed products and end products delivered to users

e.g. Calibrated ENS probabilities, etc. For lead times up to day 15.

3.1.3 Monthly and Seasonal forecasts

3.2 Subjective verification

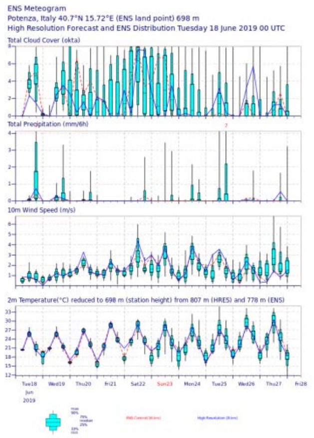
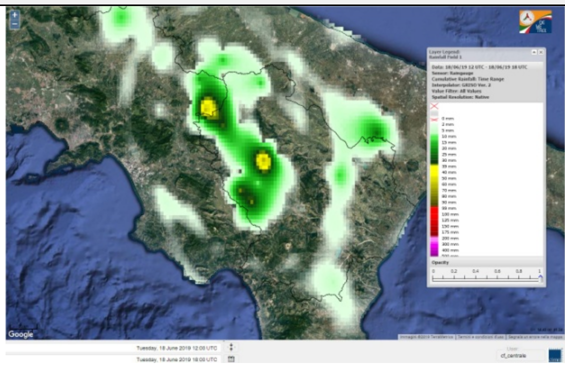
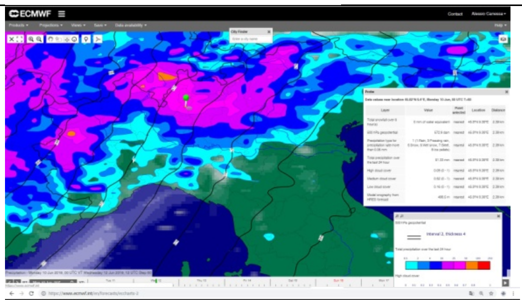
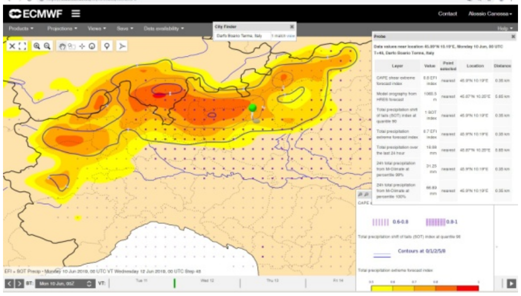
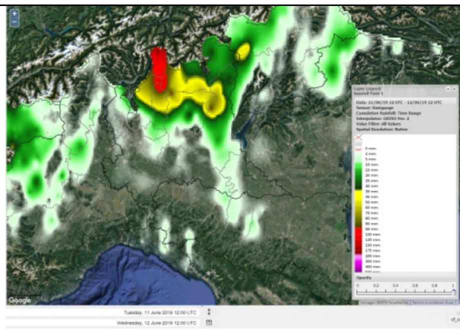
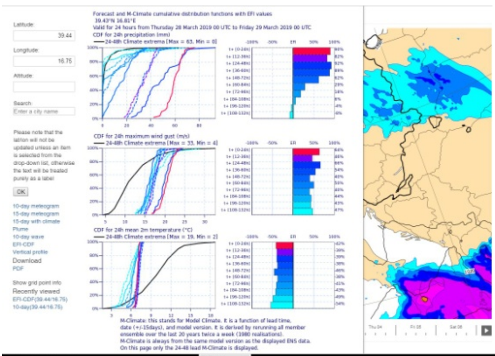
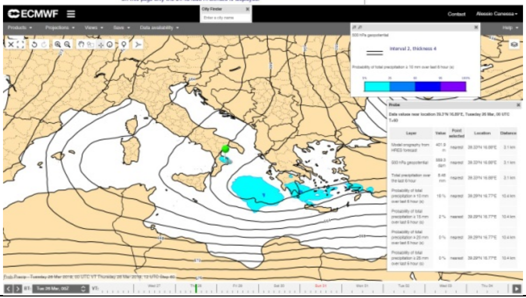
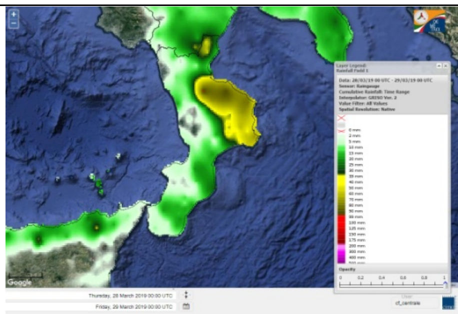
3.2.1 Subjective scores (including evaluation of confidence indices when available)

3.2.2 Case studies

Case Study: Large scale trough over western Europe at the end of October 2018.

Late October and beginning November 2018 are identified with some remarkable weather conditions over the whole of Italy. Such meteorological incident has being characterized by two different phases: an initial one with strong destructive winds (somewhere up to 80 kts), sea state 7 (wave height 6-9 m) and isolated rainfall/thunderstorms (only along convergence lines with some tornado like winds; structures damaged, casualties for lightning and trees fall); a second one with heavy and continous rainfalls, sometimes thunderstorm like, with an enormous rain amount within a short time range. The first phase (oct 27th – nov 2nd) has been caused by a very deep baric minimum northwest of Corse, recalling air masses with severe southwesterly winds over all Italian western basins, blowing southeasterly over Adriatic sea regions: the first one determining some convergence lines with thunderstorms and tornado like winds (rain overestimated and spread by Ecmwf model), the second one producing high tides, in Venice for example, up to 1.60 m, which is relevant in the Adriatic sea. The second phase (nov 2nd – nov 5th) has been something like a never stopping southerly flow with warm dry air being unstabilised by humidity from the sea, because of some tear off and then cut off configurations between Sardinia and Sicily. Such incidents affected particularly these regions, but even some Tyrrhenian areas (and Rome itself) with considerable rainfalls, being often underestimated by Ecmwf model. All this “nightmare week” has been one of the most relevant event in the last years for the amount of rain in a short time range, spread over the whole country for its wide scale, involving almost all Italy, with a number of crucial situations (Sicily, Rome, Eastern Alps); affecting population with 32 casualties due to natural weather induced effects. Here attached, in Appendix B, is reported the first described phase of such case study, incidents been occurred last October 28th-29th 2018.

Other Case Studies:

Case studies	**Precipitation forecast**	**Observed precipitation** *(courtesy by data owner: Civil Protection Department)*
18 june 2019 Potenza Flash flood, hail **HRES&ENS** **Deep convective precipitation** **Underestimation** Observed: 54mm/1h 63,4mm/6h		
11 june 2019 Lombardia Flood & Flash flood Large hail **HRES** **Underestimation** Observed: 158mm/24h 42mm/1h Max forecast: 51,33mm/24h EFI&Prob prec OK	 	
28 march 2019 **Very poor predictability:** - Poor +60-168h ENS & EFI - Poor HRES - cyclogenesis, forced by upper PV (IPV-thinking), was not forecast	 	

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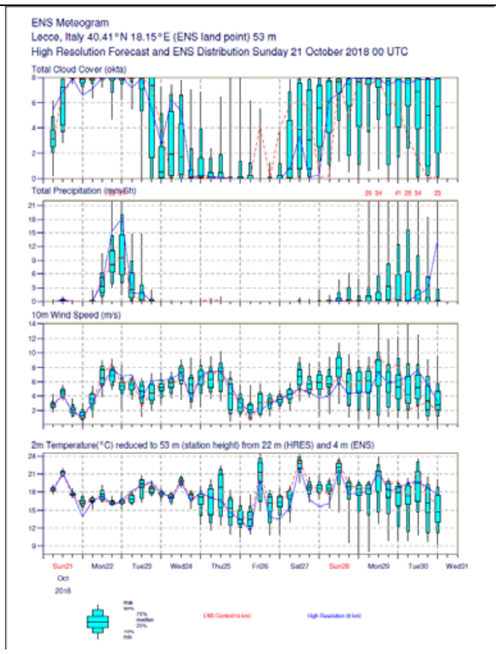
Flash flood in Salento

HRES & ENS Underestimation

max 245mm/24h observed in Lecce</td>
<td>
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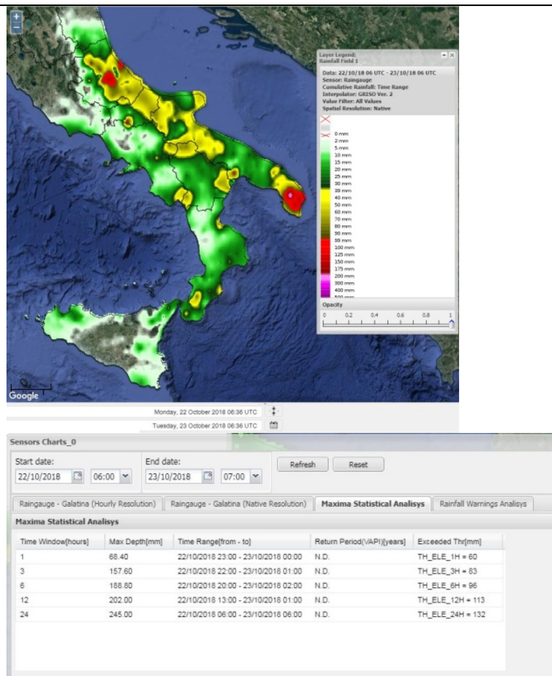
<td>
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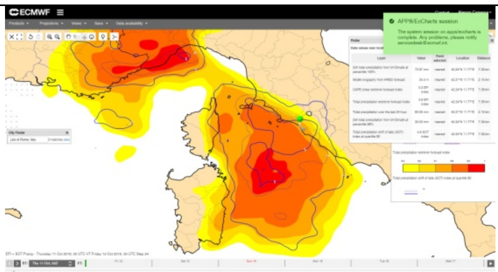
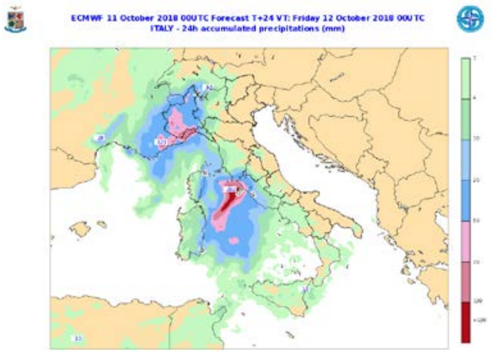
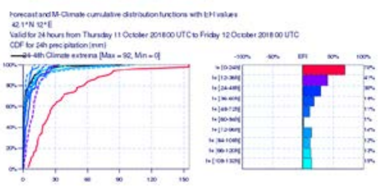
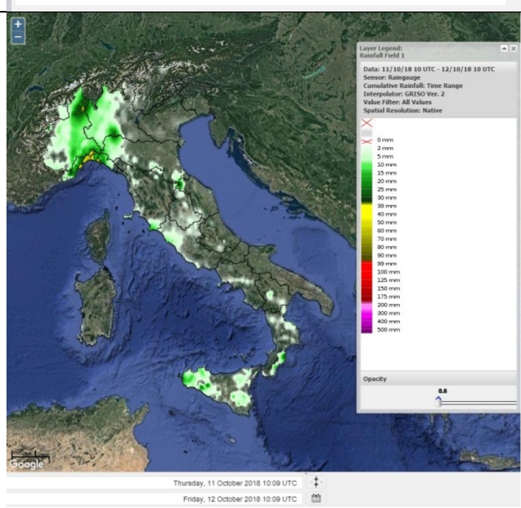
<td>11 october 2018

HRES & ENS Overestimation

False warning issued on central Italy's coasts due to high EFI and high HRES values
- Big EFI jump in the last run (11 00UTC)
- No significant accumulated precipitation observed
- False TLC (Tropical Like Cyclone)
Lesson learned:last run is not always the best</td>
<td>


</td>
<td></td>
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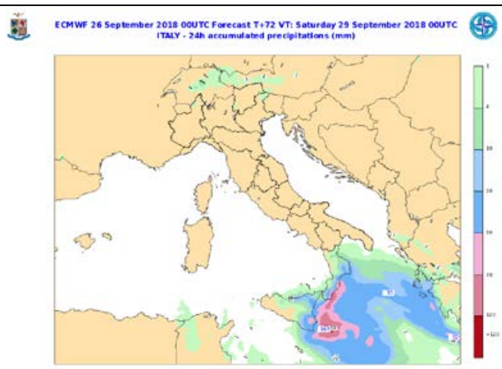
<td>28 september 2018
Medicane "Zorbas"

Sicily
Overestimation

ENS OK (low probability)</td>
<td>
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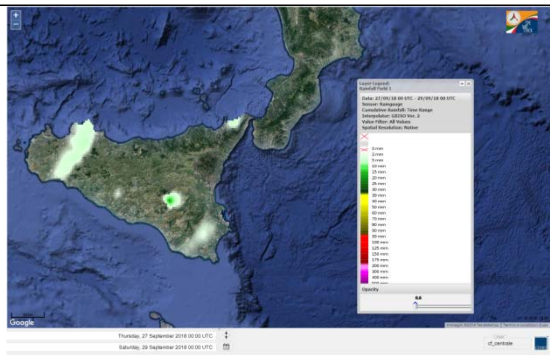
<td></td>
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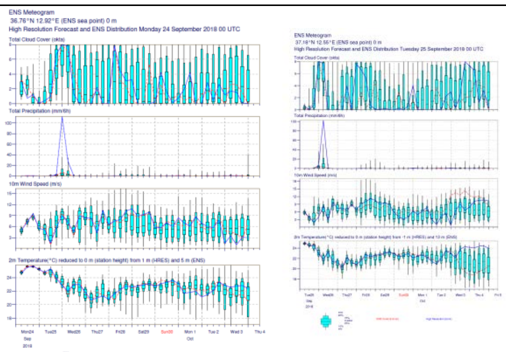
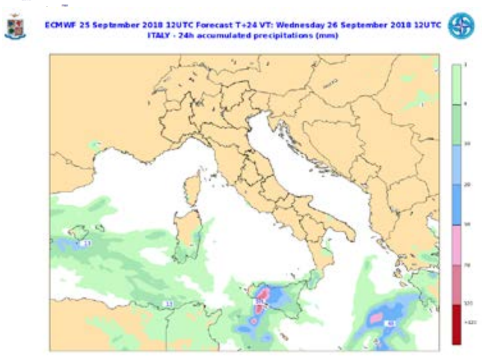
Sicily
HRES
Overestimation</td>
<td>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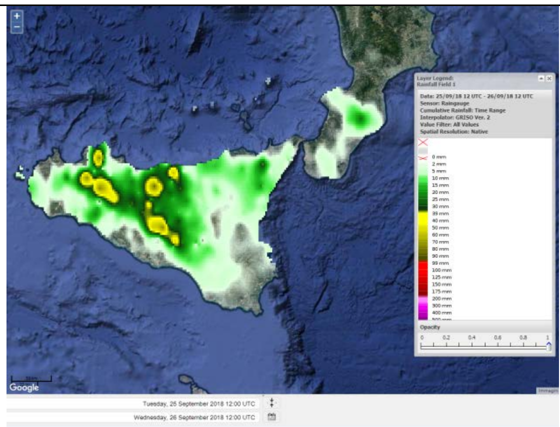
<td>
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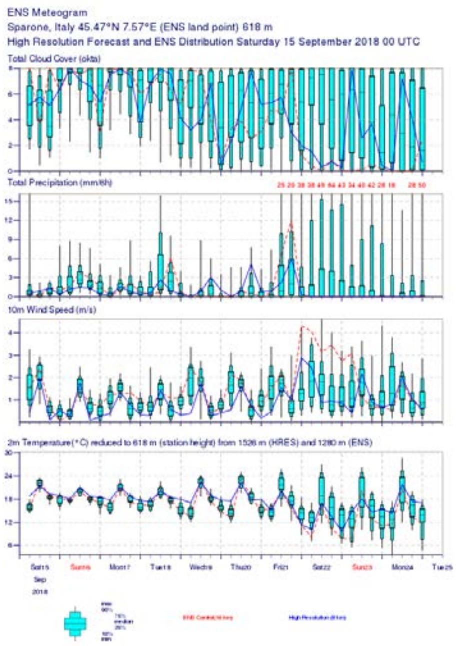
HRES & ENS
Underestimation

In Sparone 100mm/1h observed</td>
<td>
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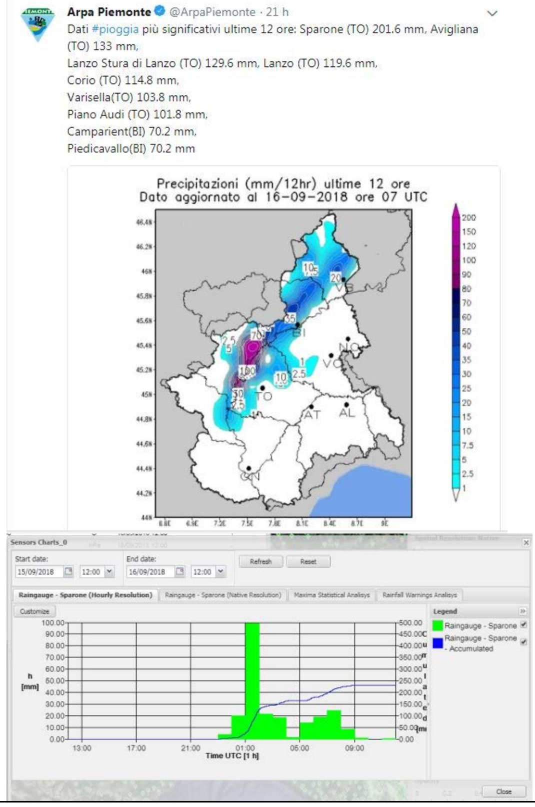
<td>
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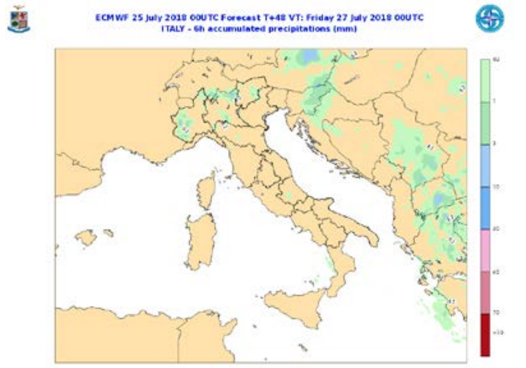
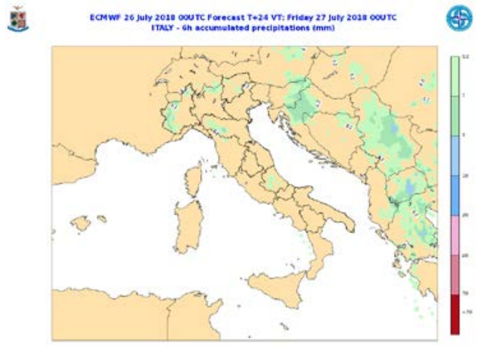
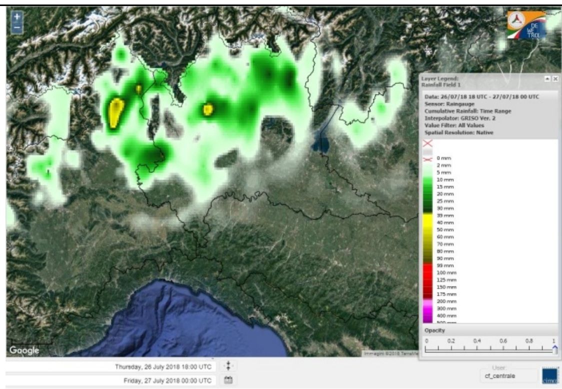
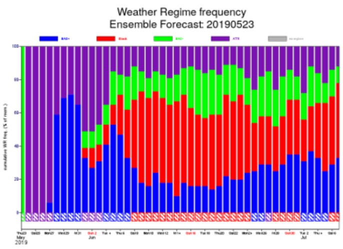
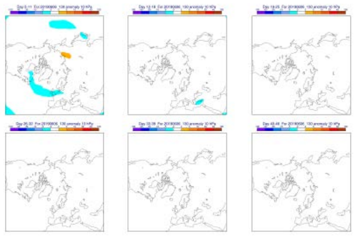
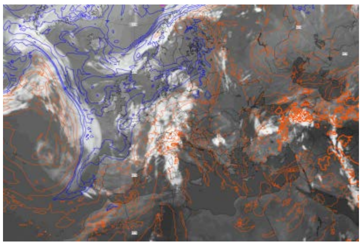
26 july 2018 1800-0000UTC **HRES & ENS Underestimation** 84,2 mm/3h 57,4 mm/1h observed	 	

4. Requests for additional output

- We would like to have a cross section tool in ecChart, where we can plot "Equivalent potential temperature" surfaces like for example the cross section at http://eumetrain.org/ePort_MapViewer/index.html
- We would like to have the test products as below:





- We would like to have a better style for the layer "850 hPa wet bulb potential temperature" - Contour (Multi-colour, Interval 2). With some more colours this layer would be more understandable.
    - o 
- We would like to have a new ocean parameter called "storm surge"

5. Feedback on ECMWF "forecast user" initiatives

We invite comments on how useful you find the information provided on ECMWF's "Forecast User Portal", see: (https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home), and on any changes you would like to see. The web-based "Forecast User Guide" was introduced in May 2018 (https://confluence.ecmwf.int/display/FUG/Forecast+User+Guide) and we would particularly welcome feedback on that.

6. References to relevant publications

(Copies of relevant internal papers may be attached)

Smith, W. and **C. Jones**, 2005: Whatever the name of the article is. *Mon. Wea. Rev.*, **20**, 134–148

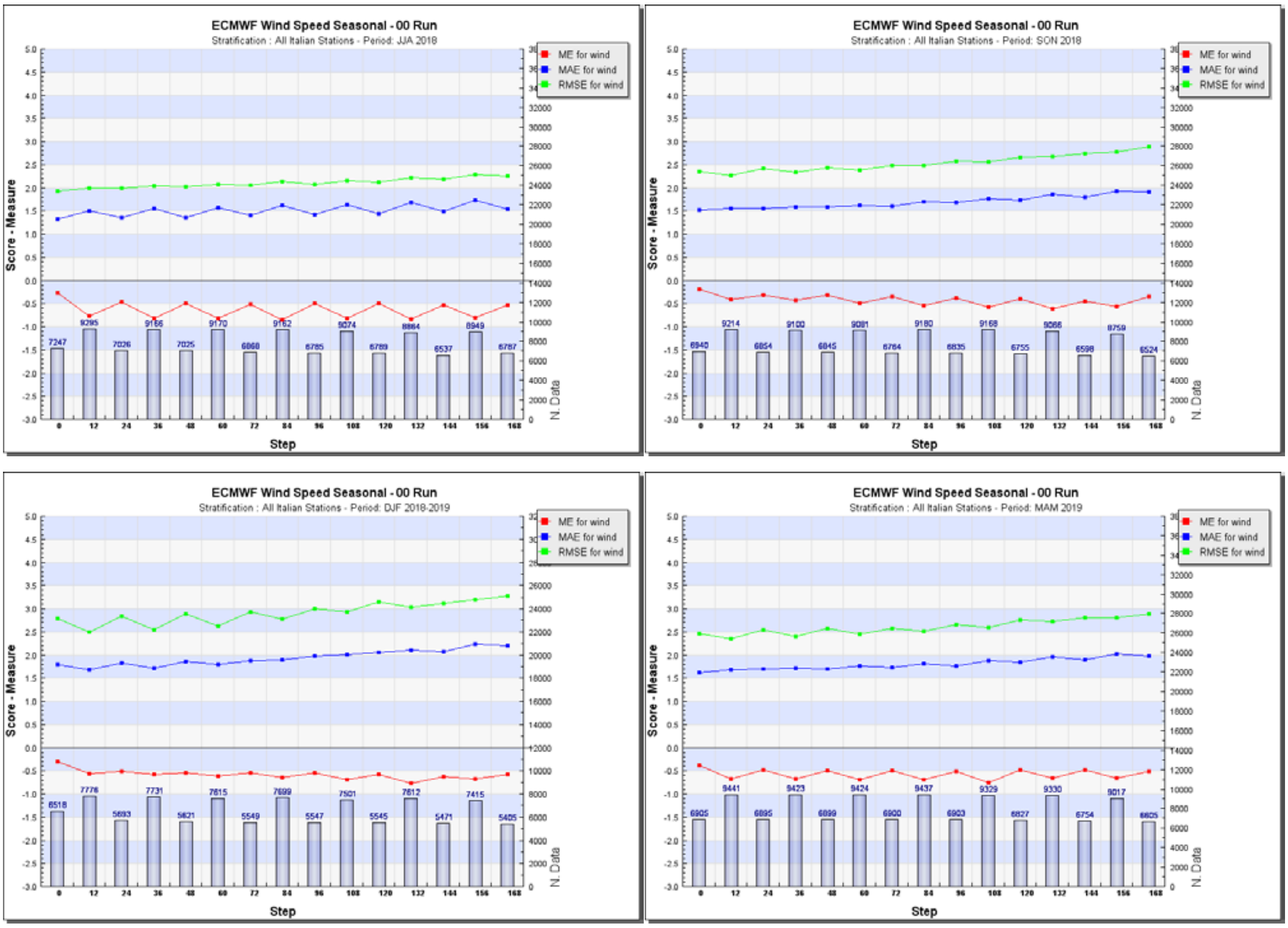
Fig.10 This is just a sample figure caption that shows you how it will look when it is displayed over two or more lines. This is just a sample figure caption that shows you how it will look when it is displayed over two or more lines.

(7. Structure of these Reports)

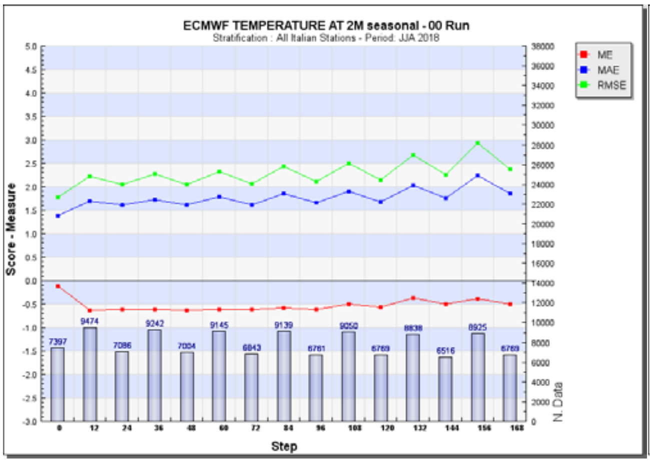
ECMWF is reviewing the way in which contributions such as these are gathered and collated. We have made some simple changes to the structure this year, as can be seen above. Please provide any comments you have on the whole process (e.g. schedule for collecting input, report content, report layout, TAC summary). Comments entered in this section will be examined and used by ECMWF, but will be removed prior to publishing your reports on the ECMWF website.

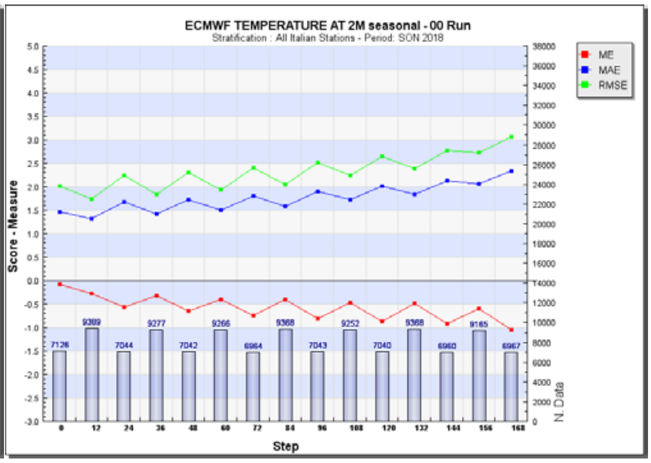
Appendix A of Report ECMWF 2019 -- ITALY

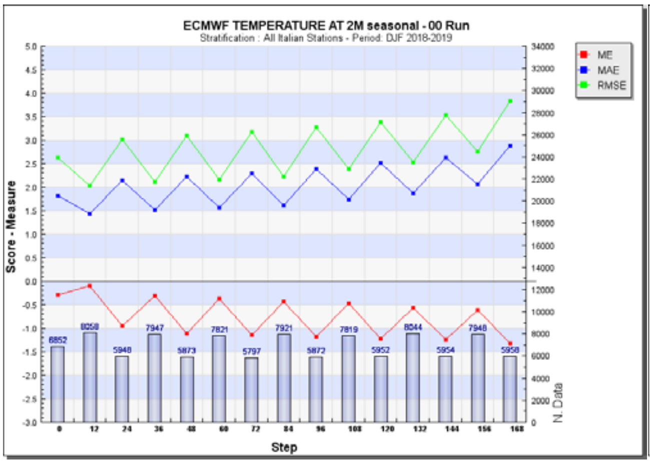
IFS 10m Wind Speed (Mean Absolute Error, Mean Error and Root MSE)

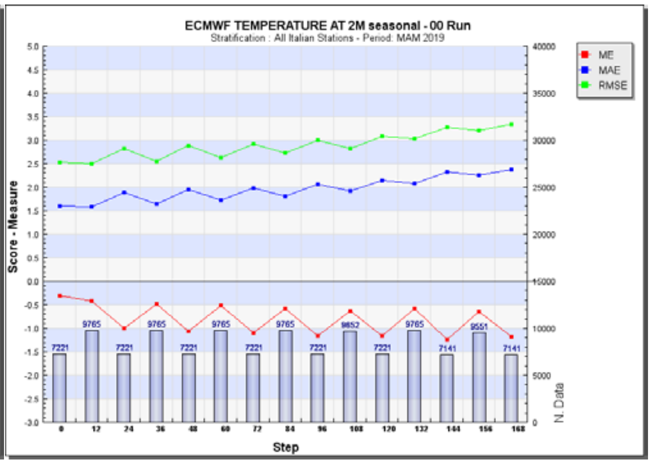


IFS 2m Temperature (Mean Absolute Error, Mean Error and Root MSE)

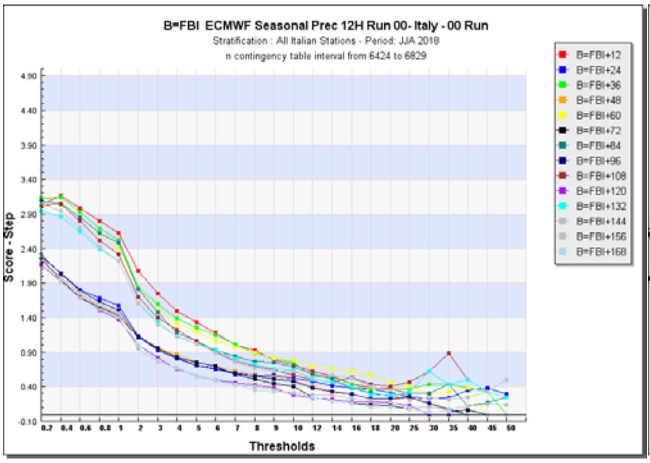


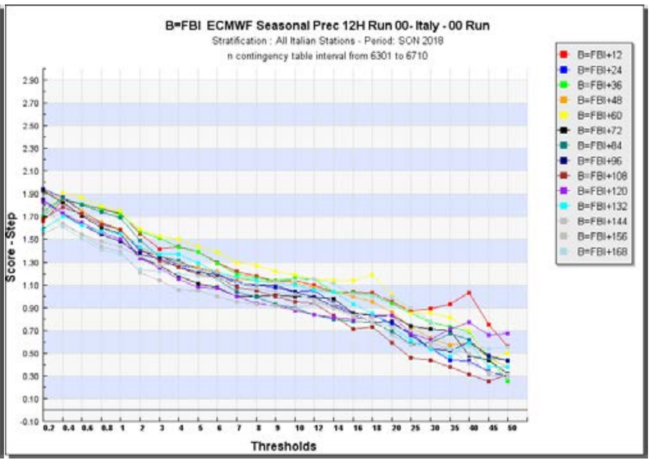


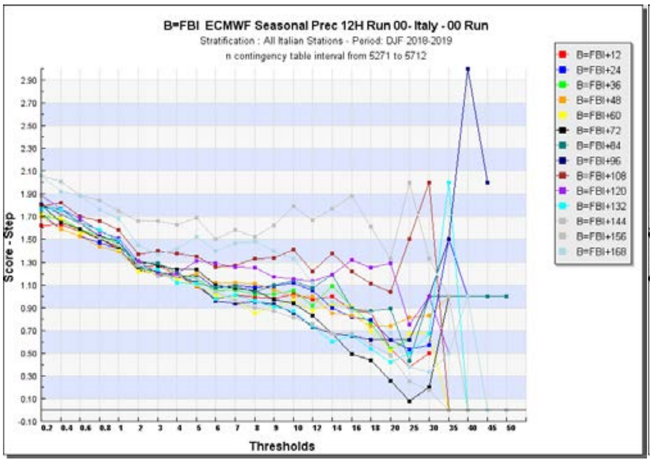


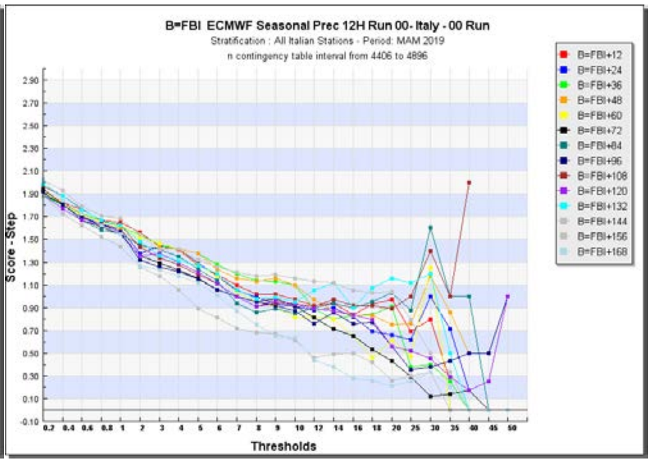


IFS Precipitation in 12 hours - FBI score

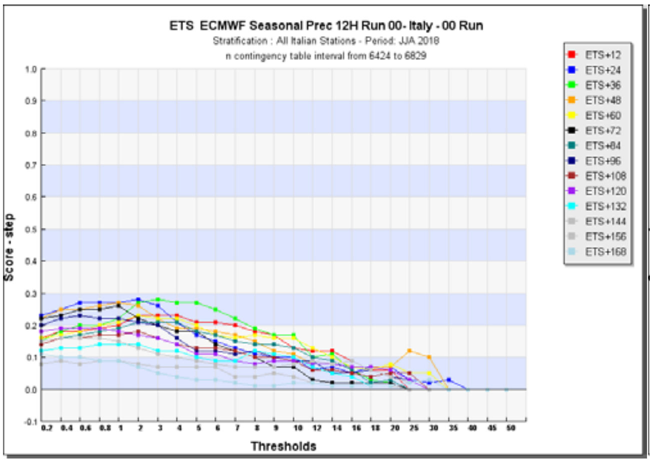


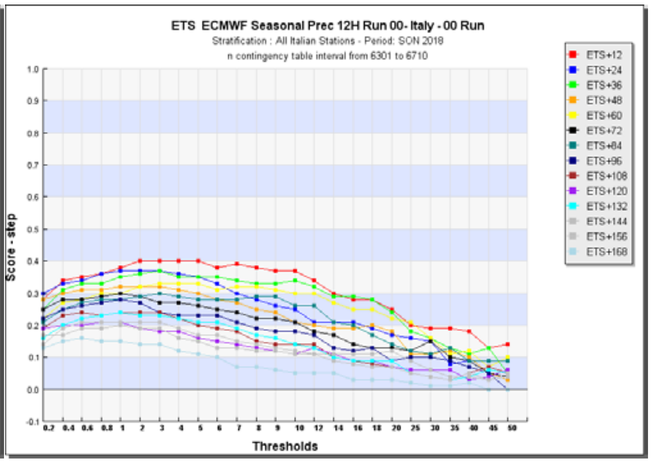


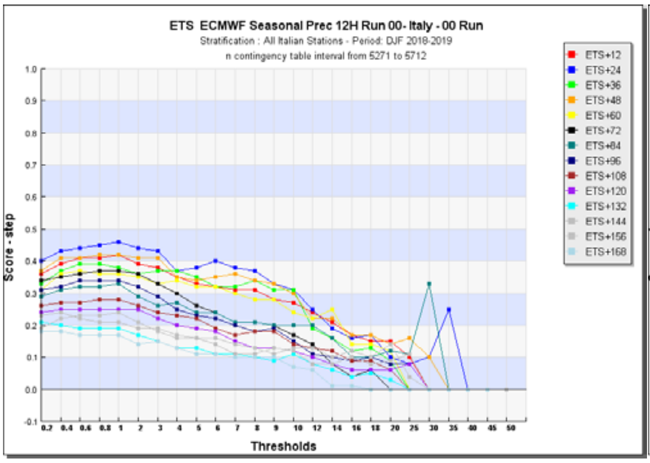


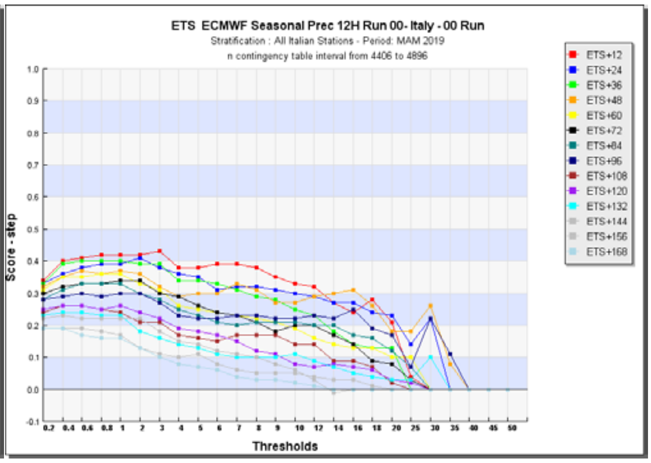


IFS Precipitation in 12 hours - ETS score

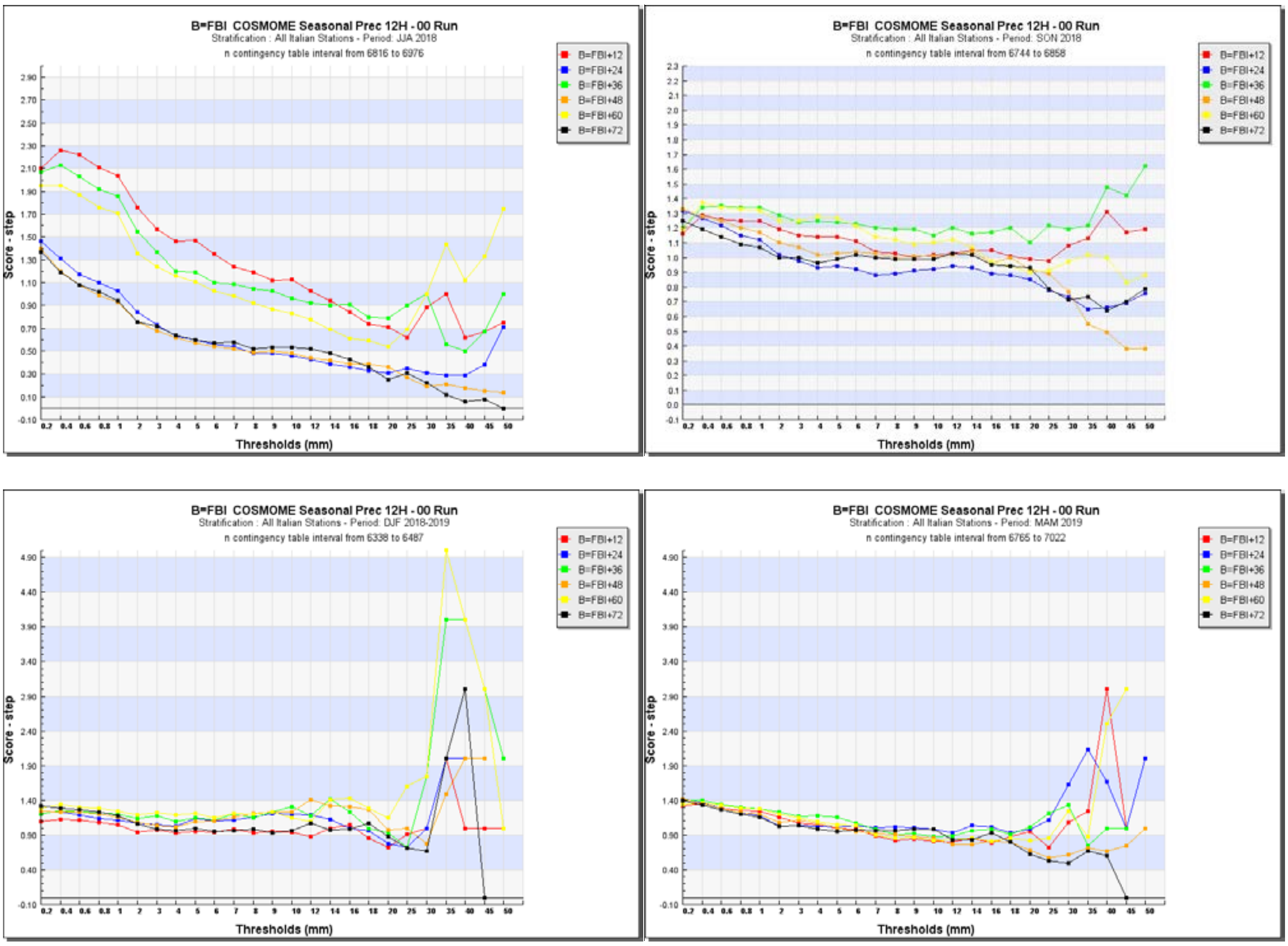




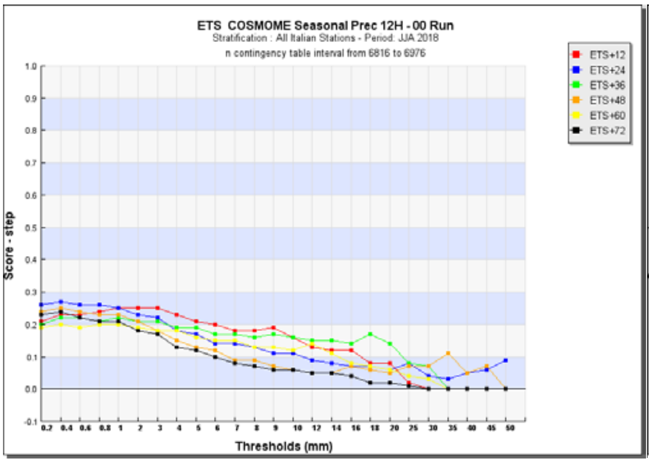


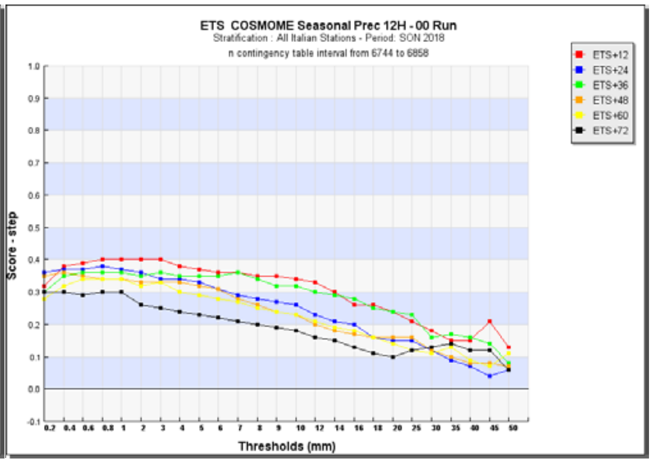


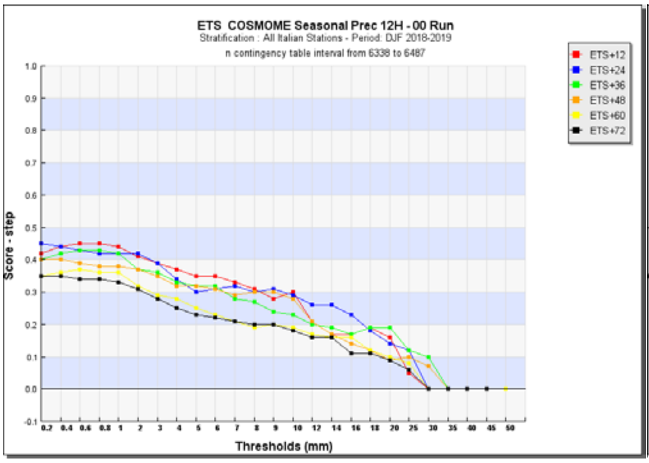
COSMO-ME Precipitation in 12 hours - FBI score

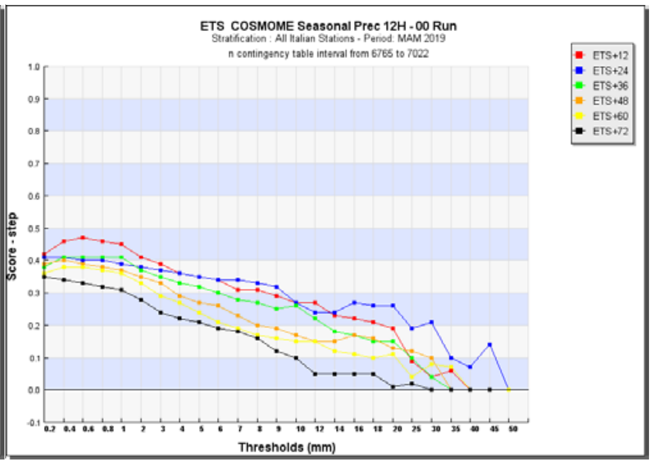


COSMO-ME Precipitation in 12 hours - ETS score

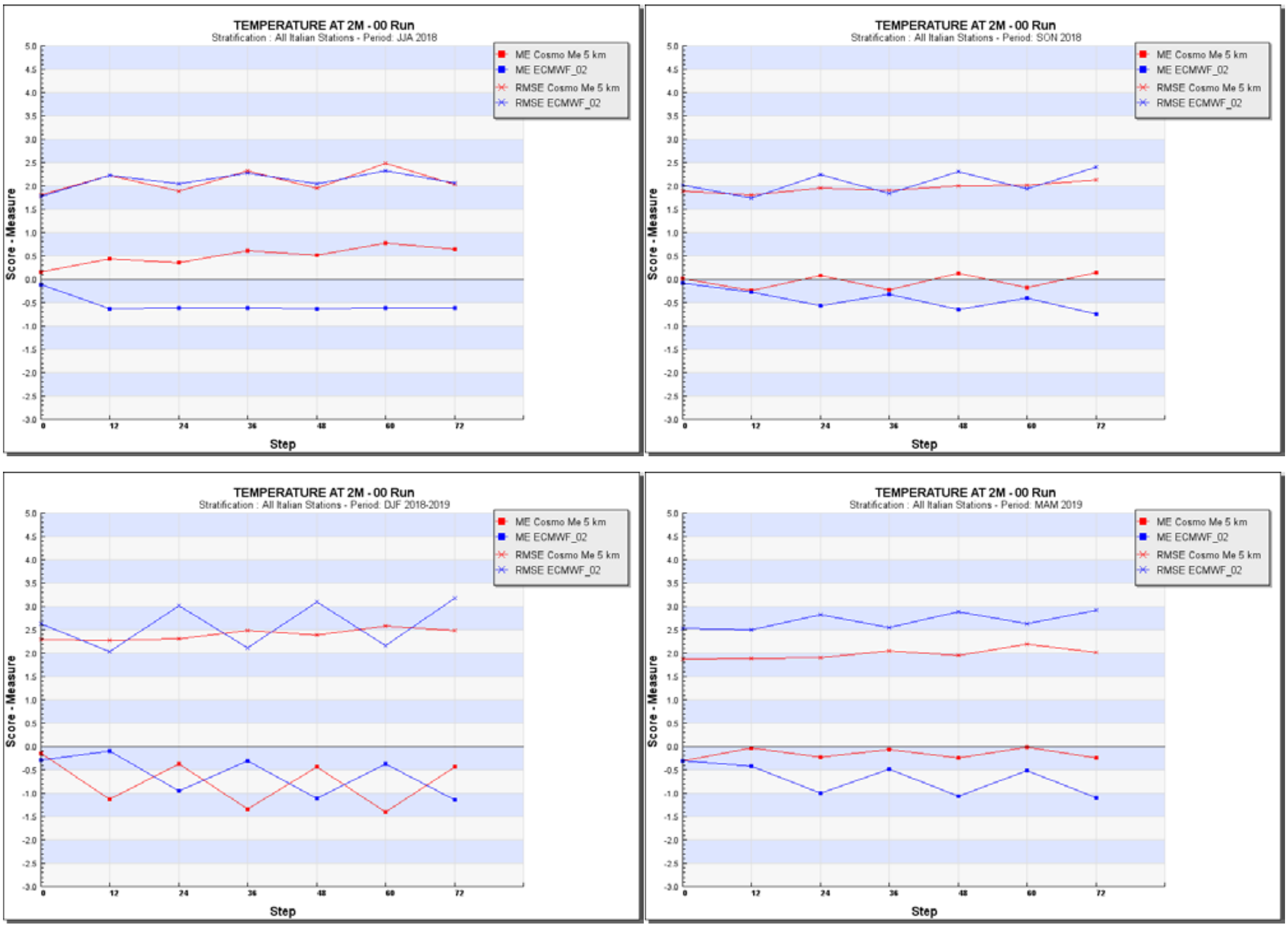




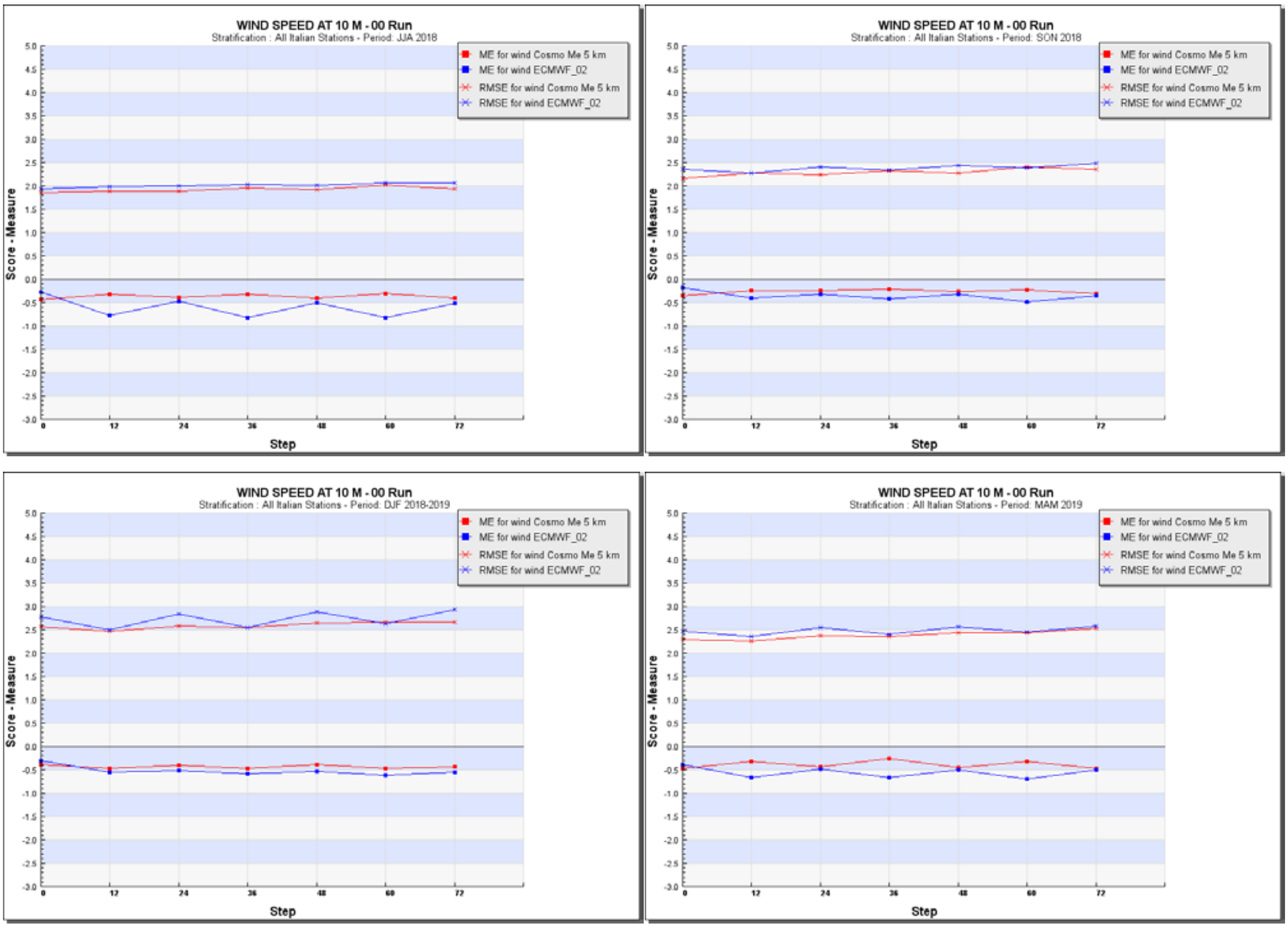




IFS – COSMO-ME comparison: 2m Temperature



IFS – COSMO-ME comparison: 10m Wind Speed



Appendix B of Report ECMWF 2019 -- ITALY

Case Study: Large scale trough over western Europe at the end of October 2018.

The last days in October 2018 are identified with some remarkable weather conditions over the whole Italy. Such meteorological incident has being characterized by two different phases: an initial one with strong destructive winds (somewhere up to 80 kts), sea state 7 (wave height 6-9 m) and isolated rainfall/thunderstorms (only along convergence lines with some tornado like winds; structures damaged, casualties for lightnings and trees fall); a second one with heavy and continous rainfalls, sometimes thunderstorm like, with an enormous rain amount within a short time range. The first phase (oct 27^{th} – nov 2^{nd}) has been caused by a very deep baric minimum northwest of Corse, recalling air masses with severe southwesterly winds over all Italian western basins, blowing southeasterly over Adriatic sea regions: the first one determining some convergence lines with thunderstorms and tornado like winds (rain overassessed by Ecmwf model and spread), the second one producing high tides, in Venice for example, up to 1.60 m, which is relevant in the Adriatic sea.

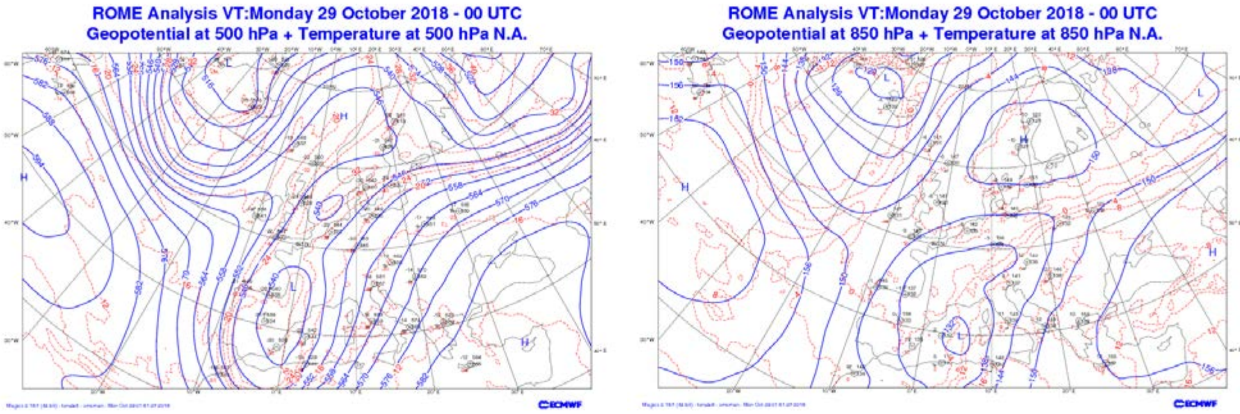


Figure 1: ECMWF analysis ZT 500 hPa and 850 hPa at 29/10 00Z

Figure 1 shows situation on October 29^{th}, 00.00 Z, by 500 hPa geopotential and 850 hPa analysis plot, as a deep elongated depression convoys cool oceanic air masses down into Saharian area and Mediterranean basins, creating a minimum near Balearic islands and making it quite unstable and kicking off a regime of south westerly winds over Italy. Such configuration is remarked by numerical Ecmwf model (figure 2), showing a tropopause anomaly, becoming more accentuated over southern Thyrrenian area.

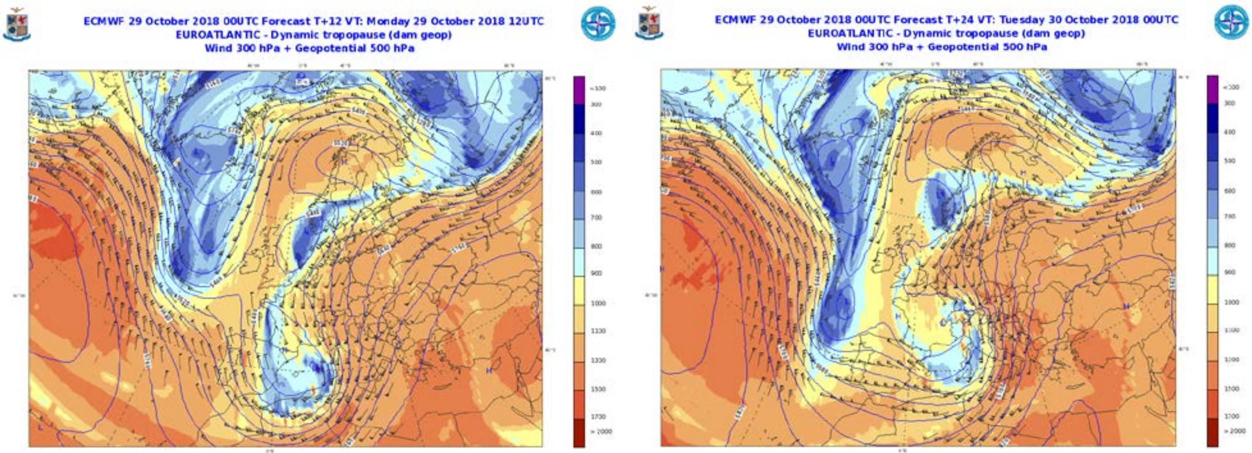


Figure 2: ECMWF forecast Dynamic Tropopause (dam geop), Wind 300 hPa, Geopotential 500 hPa, 00 z run 29/10

The same model detecting, in Figure 3, 850 hPa air masses over interested areas in evolution involve Italian area and eastern Alpine regions.

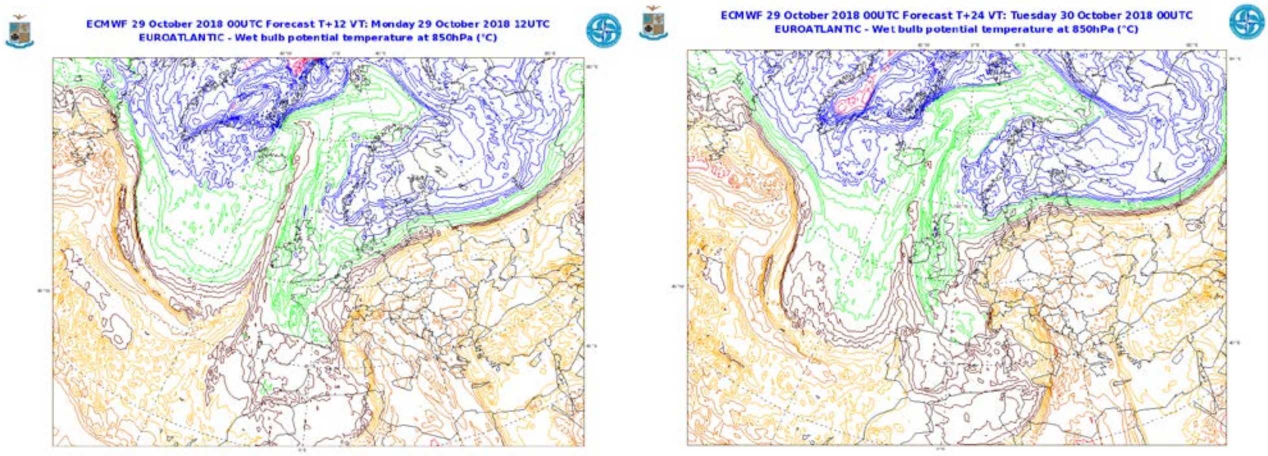


Figure 3: ECMWF forecast Wet Bulb Potential Temperature at 850 hPa (°C), 00Z run 29/10

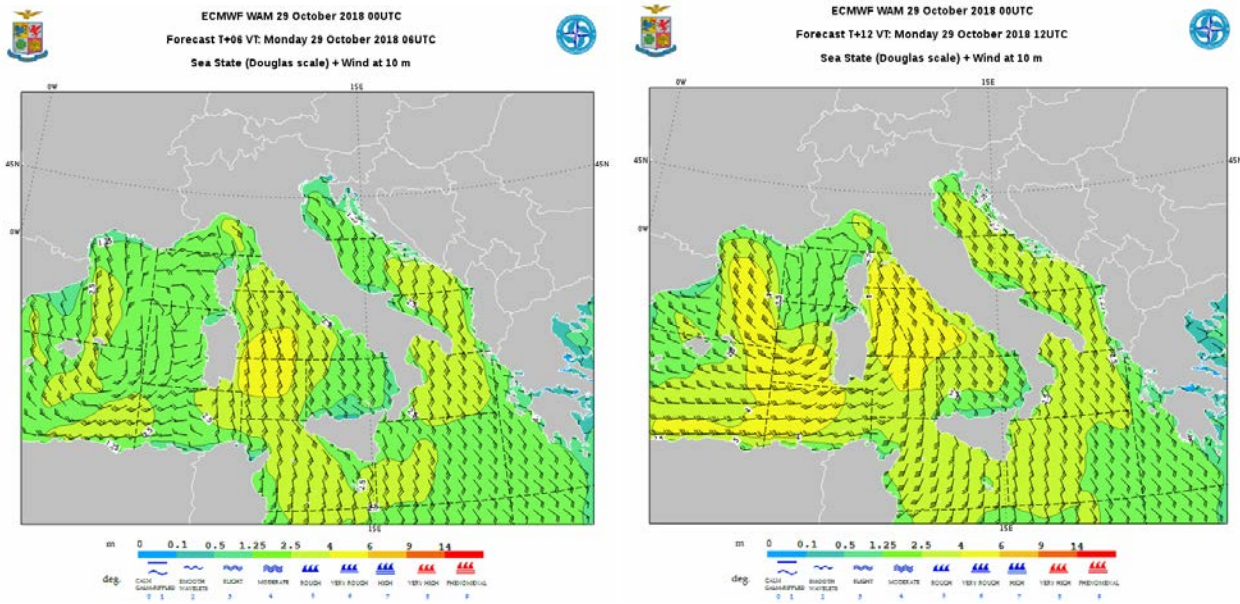


Figure 4: ECMWF WAM forecast Sea State (Douglas Scale), Wind at 10 m, 00Z run 29/10

Ecmwf-Sea model (Figure 4) is confirming minimum baric producing heavy winds rotating from northwest to southwest and agitated sea basins, in intensification during the day.

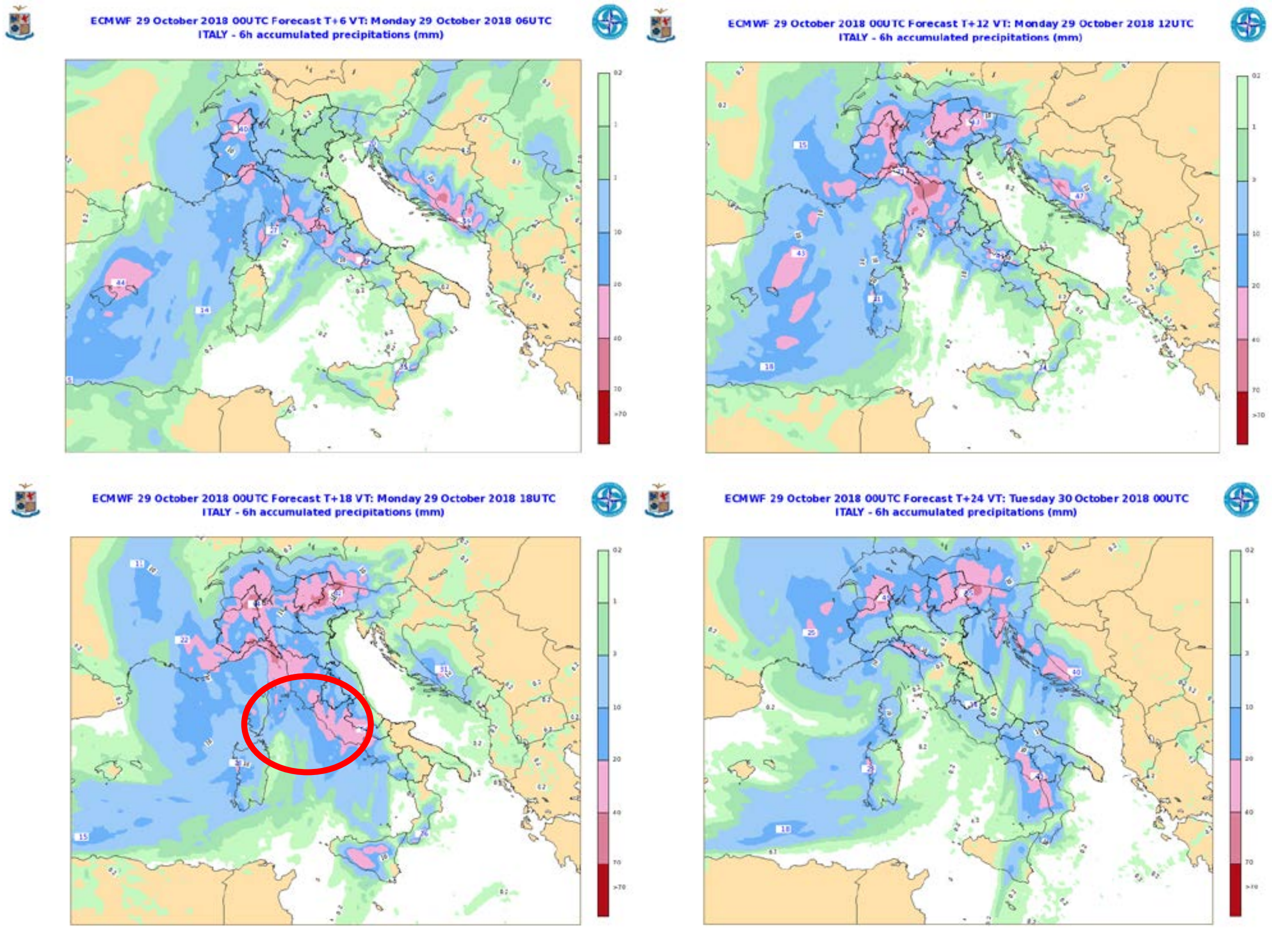


Figure 5: ECMWF forecast 6h Accumulated Precipitations (mm), 00Z run 29/10

The expected rainfall amount (Figure 5) and distribution let imagine a very severe weather, which is going to involve all western sectors, in the first part of October 29th, and then even all Alpine areas. Due to heavy wind it is not easy to justify such an amount of precipitation, unless, as it is going to be shown, its action may create some convergence lines.

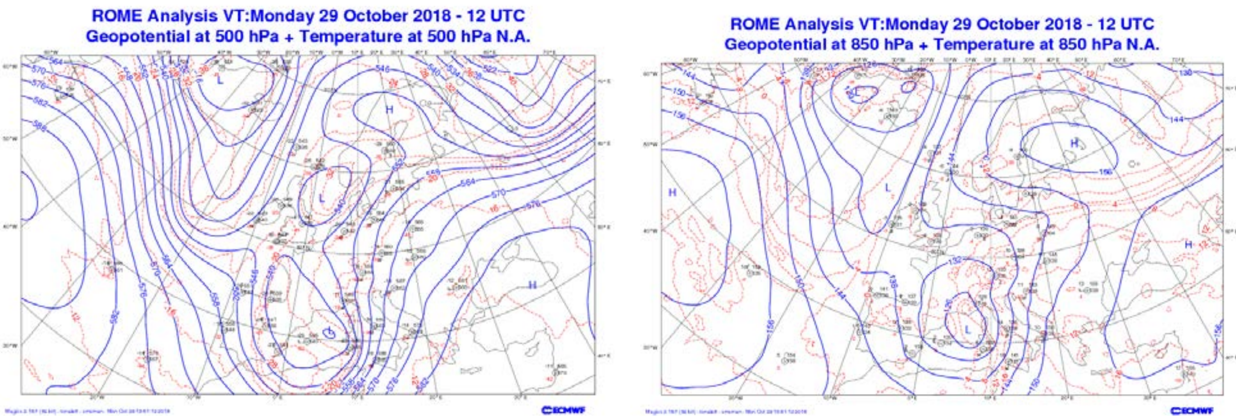


Figure 6: ECMWF analysis ZT 500 hPa and 850 hPa at 29/10 12Z

At 12.Z the minimum has pregressed towards western Italian coasts with all that baric gradient associated, to justify intense predicted winds (Figure 6). This depression looks like associated as well with a complex frontal structure, as is going to be clarified further on.

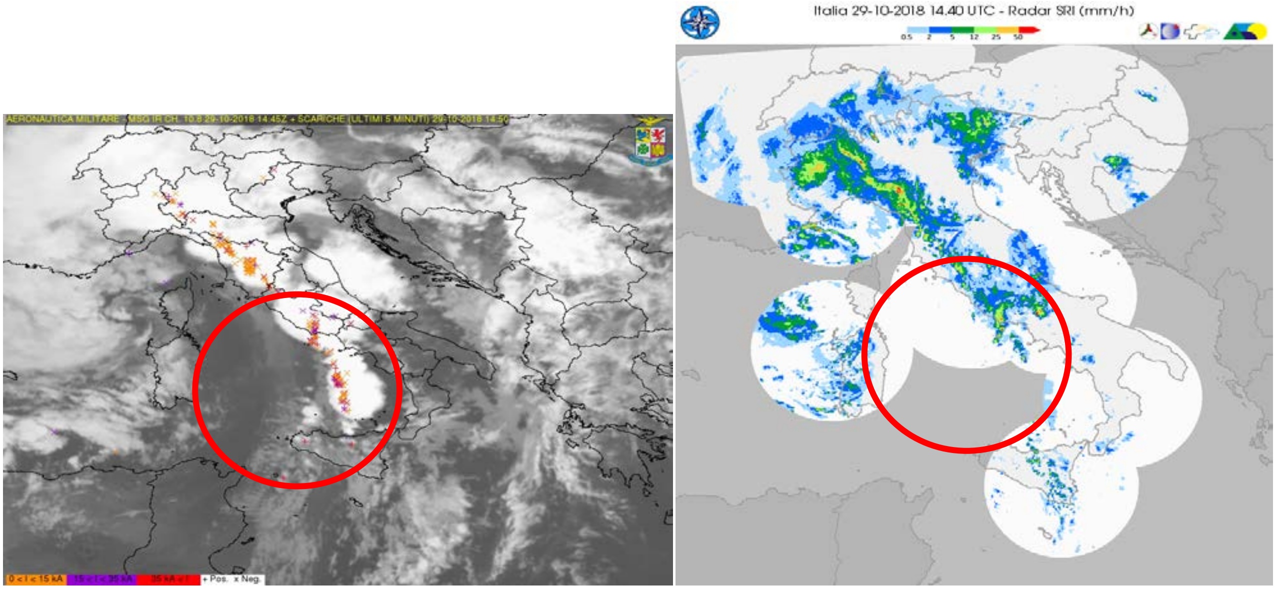


Figure 7: AM Observed Lightnings last 5 minutes, 29/10 14.55Z (above left), Italy radar SRI (mm/h), 29/10 14.40Z (above right): Terracina Tornado-like Wind in evidence

How it is shown in Figure 7, observative network for lightnings clarifies that all that amount of rainfall, predicted by model as spread all over, was really concentrated along some convergence lines at low levels which produced thunderstorm like events over the sea and across some coastline. Figure 7 refers to some specific accidents which provoked casualties and damages.

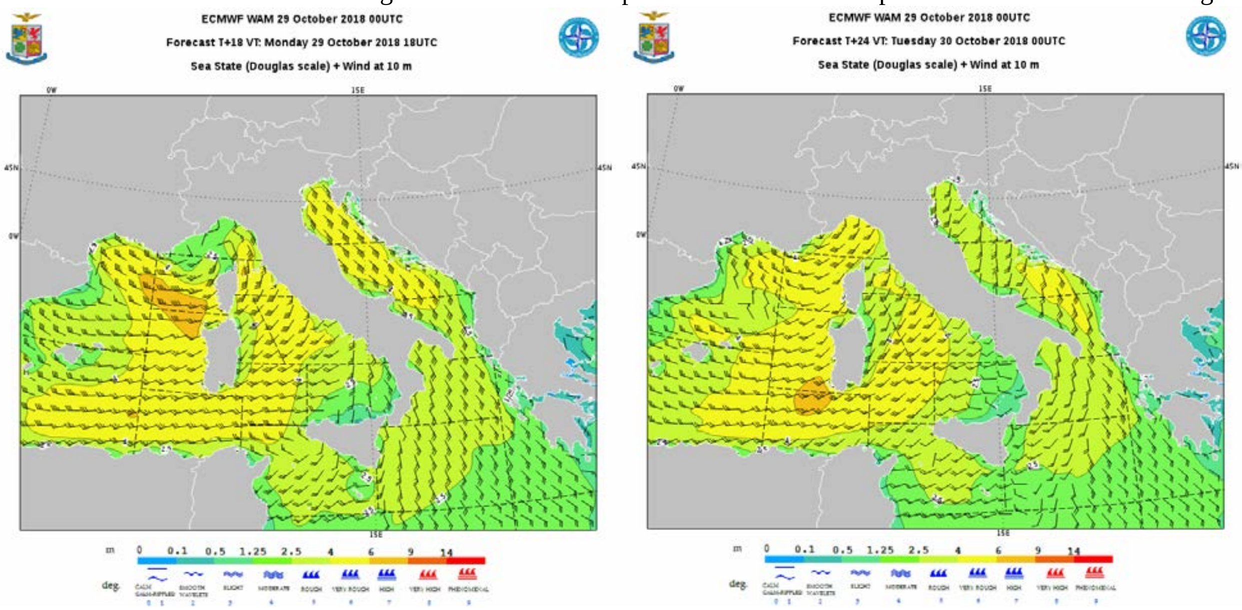


Figure 8: ECMWF WAM forecast Sea State (Douglas Scale), Wind at 10 m, 00Z run 29/10

ECMWF WAM shows how wide was the portion of Italy affected by severe winds, with rough sea associated. Very unusual tides have been reported all wide over Adriatic sea, including Venice.

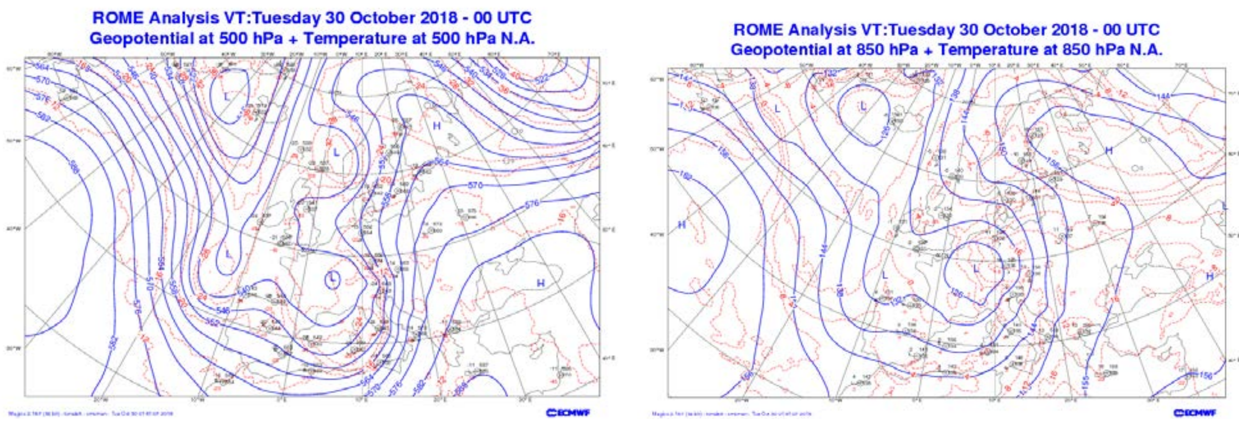


Figure 9: ECMWF analysis ZT 500 hPa and 850 hPa at 30/10 00Z

Analysis October 30th, 00Z underlies the minimum low northeastward movement with associated southwesterly severe wind. Dynamic tropopause anomalies over such regions (Figure 10) justify IPV supplying into lower layers increasing air mass triggering

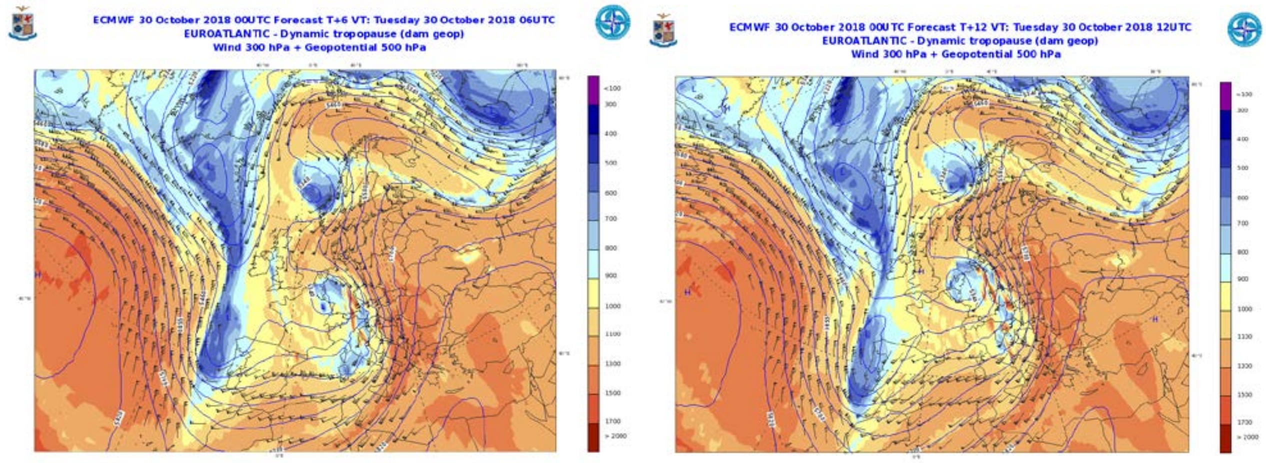


Figure 10: ECMWF forecast Dynamic Tropopause (dam geop), Wind 300 hPa, Geopotential 500 hPa, 00 z run 30/10.

As shown in Figure 11, the cold core synoptic subject, which was responsible of such described situation, is moving northwards on October 30th, going to affect central Europe but still driving severe winds from southern regions, mostly across Ionian and Adriatic basins.

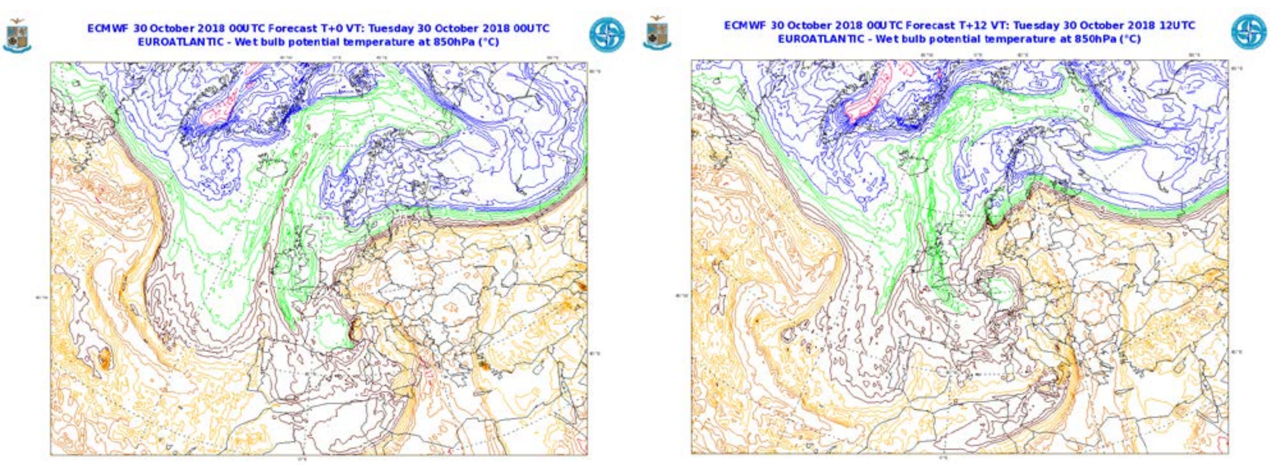


Figure 11: ECMWF forecast Wet Bulb Potential Temperature at 850 hPa (°C), 00Z run 30/10.

In fact, 500 hPa and 850 hPa analysis, October 30th 12Z (Figure 12) it it is visible the cold core moving away with consequent southwesterly circulation and orographic induced rainfall expected by model for the beginning of the day (Figure 13).

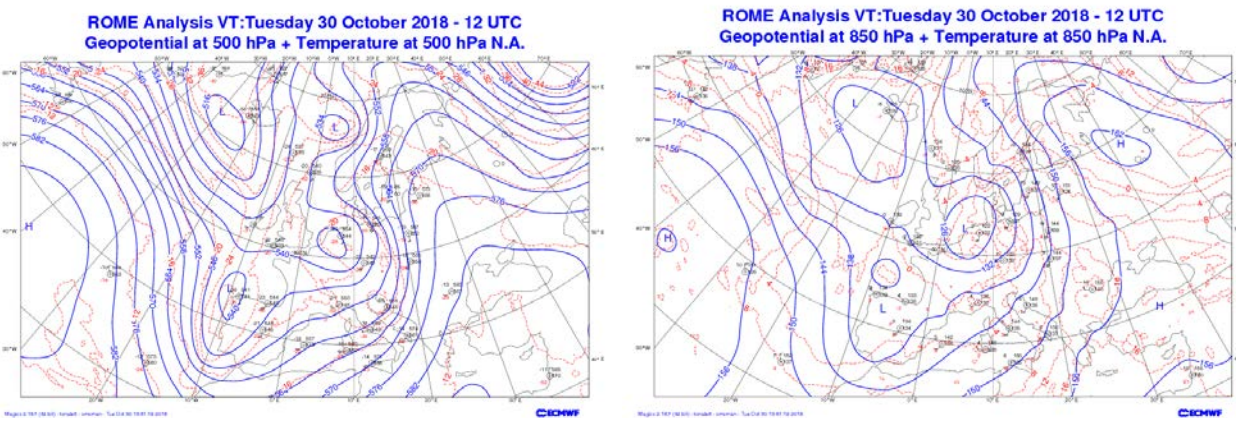


Figure 12: ECMWF analysis ZT 500 hPa and 850 hPa at 30/10 12Z.

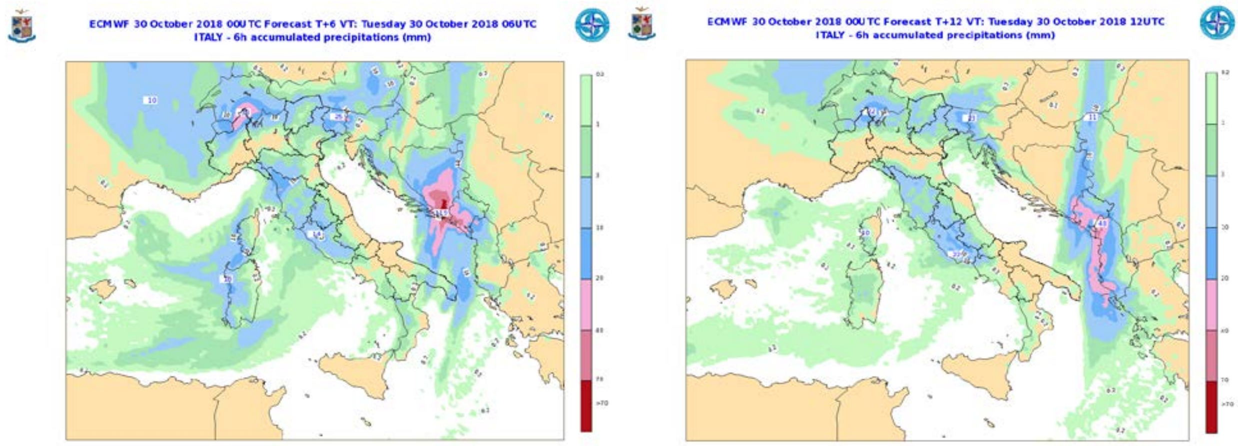


Figure 13: ECMWF forecast 6h Accumulated Precipitations (mm), 00Z run 30/10.

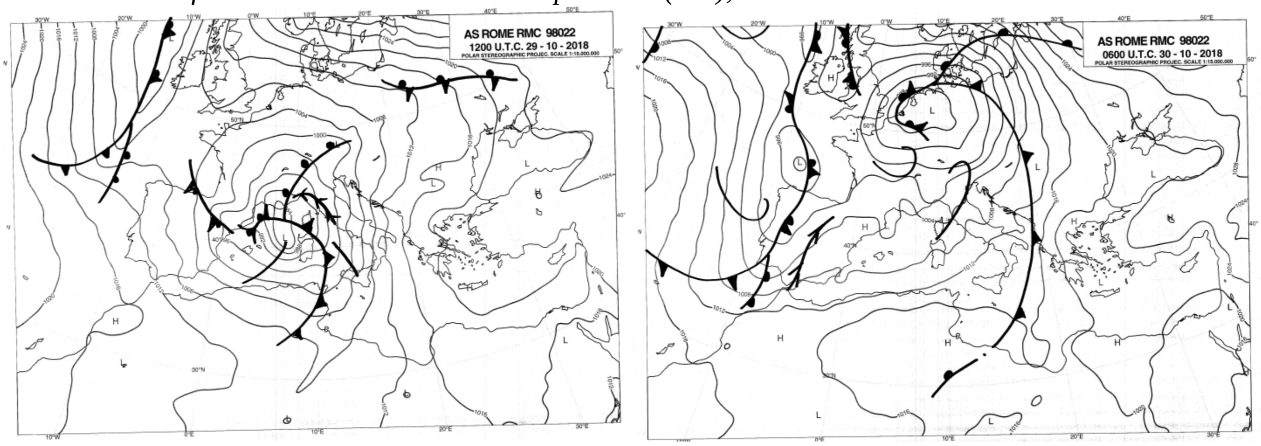


Figure 14: ROME analysis ground level at 29/10 12Z (left), 30/10 06Z (right)

Figure 14, representing ground analysis at the end of October 29th, underlines the complexity for such a synoptic subject, now moving far away to north, being composed of different conceptual models all together.

Here are some of the most relevant Gale warning, for sea state, thunderstorms and winds having been issued previously and during phenomena development (here main sea state according to the case study evidenced):

GALE WARNING ISSUED AT 0000/UTC ON OCTOBER 29. SOUTHERLY GALE **FORCE EIGHT** IN THE SOUTHERN ADRIATIC SEA, SOUTHERN TYRRHENIAN SEA WEST SIDE, SARDINIAN CHANNEL. SOUTHEASTERLY GALE **FORCE SEVEN** IN THE CENTRAL ADRIATIC SEA, SICILY STRAIT, SOUTHERN TYRRHENIAN SEA EAST SIDE, NORTHERN TYRRHENIAN SEA, JONIAN SEA, CENTRAL TYRRHENIAN SEA AND CONCERNING COASTAL REGIONS. GALE GRADUALLY INTENSIFYING TO **FORCE NINE** IN THE SARDINIAN CHANNEL AND CENTRAL AND SOUTHERN TYRRHENIAN SEA WEST SIDE. GALE GRADUALLY

INTENSIFYING TO **FORCE EIGHT** IN THE CENTRAL TYRRHENIAN SEA EAST SIDE AND NORTHERN TYRRHENIAN SEA. SOUTHEASTERLY EXPECTED GALE **FORCE SEVEN** IN THE LIGURIAN SEA AND CONCERNING COASTAL REGIONS. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS OVER SOUTHERN ADRIATIC SEA, NORTHERN JONIAN SEA, CORSICAN SEA, LIGURIAN SEA, OTRANTO CHANNEL, SARDINIAN SEA AND CHANNEL, CENTRAL AND SOUTHERN TYRRHENIAN SEA WEST SIDE. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS EXPECTED OVER CENTRAL TYRRHENIAN SEA EAST SIDE AND NORTHERN TYRRHENIAN SEA

GALE WARNING ISSUED AT 0600/UTC ON OCTOBER 29. SOUTHEASTERLY GALE **FORCE NINE** IN THE LIGURIAN SEA AND THYRRENINAN SEA. SOUTHEASTERLY GALE **FORCE EIGHT** IN THE SOUTHERN ADRIATIC SEA, NORTHERN JONIAN SEA, SICILY STRAIT, OTRANTO CHANNEL AND CONCERNING COASTAL REGIONS. GALE GRADUALLY INTENSIFYING TO **FORCE EIGHT** IN THE SARDINIAN CHANNEL. SOUTHWESTERLY GALE **FORCE SEVEN** IN THE SARDINIAN SEA. SOUTHEASTERLY GALE **FORCE SEVEN** IN THE NORTHERN ADRIATIC SEA, CENTRAL ADRIATIC SEA, SOUTHERN JONIAN SEA AND CONCERNING COASTAL REGIONS. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS OVER SICILY STRAIT, CORSICAN SEA, LIGURIAN SEA, THYRRENINAN SEA, SARDINIAN SEA AND CHANNEL. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS EXPECTED OVER NORTHERN ADRIATIC SEA AND CENTRAL ADRIATIC SEA. THUNDERSTORMS CEASED OVER SOUTHERN ADRIATIC SEA, NORTHERN JONIAN SEA, OTRANTO CHANNEL. –

GALE WARNING ISSUED AT 1200/UTC ON OCTOBER 29. SOUTHEASTERLY GALE **FORCE NINE** IN THE LIGURIAN SEA AND THYRRENINAN SEA. SOUTHEASTERLY GALE **FORCE EIGHT** IN THE SICILY STRAIT, OTRANTO CHANNEL, ADRIATIC SEA, JONIAN SEA AND CONCERNING COASTAL REGIONS. SOUTHWESTERLY GALE **FORCE EIGHT** IN THE SARDINIAN SEA AND CORSICAN SEA. SOUTHWESTERLY GALE **FORCE TEN** IN THE SARDINIAN CHANNEL AND CONCERNING COASTAL REGIONS. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS OVER SICILY STRAIT, CORSICAN SEA, SARDINIAN SEA AND CHANNEL, SOUTHERN TYRRHENIAN SEA, CENTRAL TYRRHENIAN SEA. ACTIVE THUNDERSTORM AREA WITH GUSTS OVER NORTHERN TYRRHENIAN SEA AND LIGURIAN SEA. COASTAL REGIONS AFFECTED: NORTHERN TOSCANA AND EASTERN LIGURIA. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS EXPECTED OVER SOUTHERN ADRIATIC SEA, OTRANTO CHANNEL, JONIAN SEA

GALE WARNING ISSUED AT 1800/UTC ON OCTOBER 29. SOUTHWESTERLY GALE **FORCE NINE** IN THE SOUTHERN TYRRHENIAN SEA WEST SIDE, NORTHERN TYRRHENIAN SEA, BONIFACIO STRAIT, CENTRAL TYRRHENIAN SEA AND CONCERNING COASTAL REGIONS. SOUTHEASTERLY GALE **FORCE NINE** IN THE NORTHERN ADRIATIC SEA AND CENTRAL ADRIATIC SEA AND CONCERNING COASTAL REGIONS. SOUTHEASTERLY GALE **FORCE EIGHT** IN THE SOUTHERN ADRIATIC SEA, OTRANTO CHANNEL, JONIAN SEA. WESTERLY GALE **FORCE NINE** IN THE SARDINIAN CHANNEL AND CONCERNING COASTAL REGIONS. SOUTHWESTERLY GALE **FORCE SEVEN** IN THE SICILY STRAIT AND SOUTHERN TYRRHENIAN SEA EAST SIDE AND CONCERNING COASTAL REGIONS. WESTERLY GALE **FORCE NINE** IN THE CORSICAN SEA AND CONCERNING COASTAL REGIONS. SOUTHWESTERLY GALE **FORCE EIGHT** IN THE LIGURIAN SEA AND CONCERNING COASTAL REGIONS. SOUTHWESTERLY GALE **FORCE EIGHT** IN THE SARDINIAN SEA AND CONCERNING COASTAL REGIONS. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS OVER NORTHERN TYRRHENIAN SEA, CORSICAN SEA, LIGURIAN SEA, SARDINIAN SEA AND CHANNEL, CENTRAL AND SOUTHERN TYRRHENIAN SEA WEST SIDE AND CONCERNING COASTAL REGIONS. ACTIVE THUNDERSTORM AREA WITH GUSTS OVER SOUTHERN TYRRHENIAN SEA EAST SIDE AND CENTRAL TYRRHENIAN SEA EAST SIDE. COASTAL REGIONS AFFECTED: TYRRHENIAN BASILICATA AND CAMPANIA.

GALE WARNING ISSUED AT 0000/UTC ON OCTOBER 30. SOUTHWESTERLY GALE **FORCE NINE** IN THE SOUTHERN TYRRHENIAN SEA WEST SIDE, SARDINIAN CHANNEL, LIGURIAN SEA, CENTRAL TYRRHENIAN SEA AND CONCERNING COASTAL REGIONS. SOUTHWESTERLY GALE **FORCE EIGHT** IN THE SOUTHERN TYRRHENIAN SEA EAST SIDE, NORTHERN TYRRHENIAN SEA, SARDINIAN SEA, BONIFACIO STRAIT AND CONCERNING COASTAL REGIONS. WESTERLY GALE **FORCE EIGHT** IN THE CORSICAN SEA AND CONCERNING COASTAL REGIONS. SOUTHWESTERLY GALE **FORCE SEVEN** IN THE SICILY STRAIT AND CONCERNING COASTAL REGIONS. SOUTHERLY GALE **FORCE EIGHT** IN THE NORTHERN ADRIATIC SEA AND NORTHERN JONIAN SEA AND CONCERNING COASTAL REGIONS. SOUTHERLY GALE **FORCE NINE** IN THE CENTRAL ADRIATIC SEA. SOUTHEASTERLY GALE **FORCE NINE** IN THE SOUTHERN ADRIATIC SEA. COASTAL REGIONS AFFECTED: SOUTH-EASTERN APULIA. SOUTHEASTERLY GALE **FORCE EIGHT** IN THE OTRANTO CHANNEL. SOUTHERLY GALE **FORCE SEVEN** IN THE SOUTHERN JONIAN SEA. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS OVER CENTRAL ADRIATIC SEA, SOUTHERN ADRIATIC SEA, CORSICAN SEA, LIGURIAN SEA, BONIFACIO STRAIT, OTRANTO CHANNEL, JONIAN SEA, THYRRENINAN SEA, SARDINIAN SEA AND CHANNEL AND CONCERNING COASTAL REGIONS.

GALE WARNING ISSUED AT 0600/UTC ON OCTOBER 30. SOUTHWESTERLY GALE **FORCE EIGHT** IN THE SOUTHERN TYRRHENIAN SEA WEST SIDE, CENTRAL TYRRHENIAN SEA EAST SIDE, NORTHERN TYRRHENIAN SEA, SARDINIAN CHANNEL, LIGURIAN SEA AND CONCERNING COASTAL REGIONS. SOUTHWESTERLY GALE **FORCE SEVEN** IN THE SICILY STRAIT, SOUTHERN TYRRHENIAN SEA EAST SIDE, CENTRAL TYRRHENIAN SEA WEST SIDE, SARDINIAN SEA, CORSICAN SEA, BONIFACIO STRAIT AND

CONCERNING COASTAL REGIONS. SOUTHERLY GALE **FORCE SEVEN** IN THE NORTHERN ADRIATIC SEA, CENTRAL ADRIATIC SEA, NORTHERN JONIAN SEA. COASTAL REGIONS AFFECTED: VENEZIA GIULIA, VENETO, JONIAN APULIA. SOUTHEASTERLY GALE **FORCE EIGHT** IN THE SOUTHERN ADRIATIC SEA AND OTRANTO CHANNEL. COASTAL REGIONS AFFECTED: SOUTH-EASTERN APULIA. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS OVER SOUTHERN ADRIATIC SEA, SOUTHERN TYRRHENIAN SEA WEST SIDE, NORTHERN TYRRHENIAN SEA, LIGURIAN SEA, BONIFACIO STRAIT, SARDINIAN SEA AND CHANNEL, CENTRAL TYRRHENIAN SEA AND CONCERNING COASTAL REGIONS. ISOLATED THUNDERSTORMS WITH LOCAL GUSTS EXPECTED OVER NORTHERN ADRIATIC SEA.

From observations (Figure 15) here is a verification about cumulated precipitations. This shows how October 29th afternoon Ecmwf numerical model overassessed rainfalls over Central Italy (Figure 5). It is evident as well how such precipitations, thunderstom like, were concentrated all along low level convergence lines being detected in Figure 7.

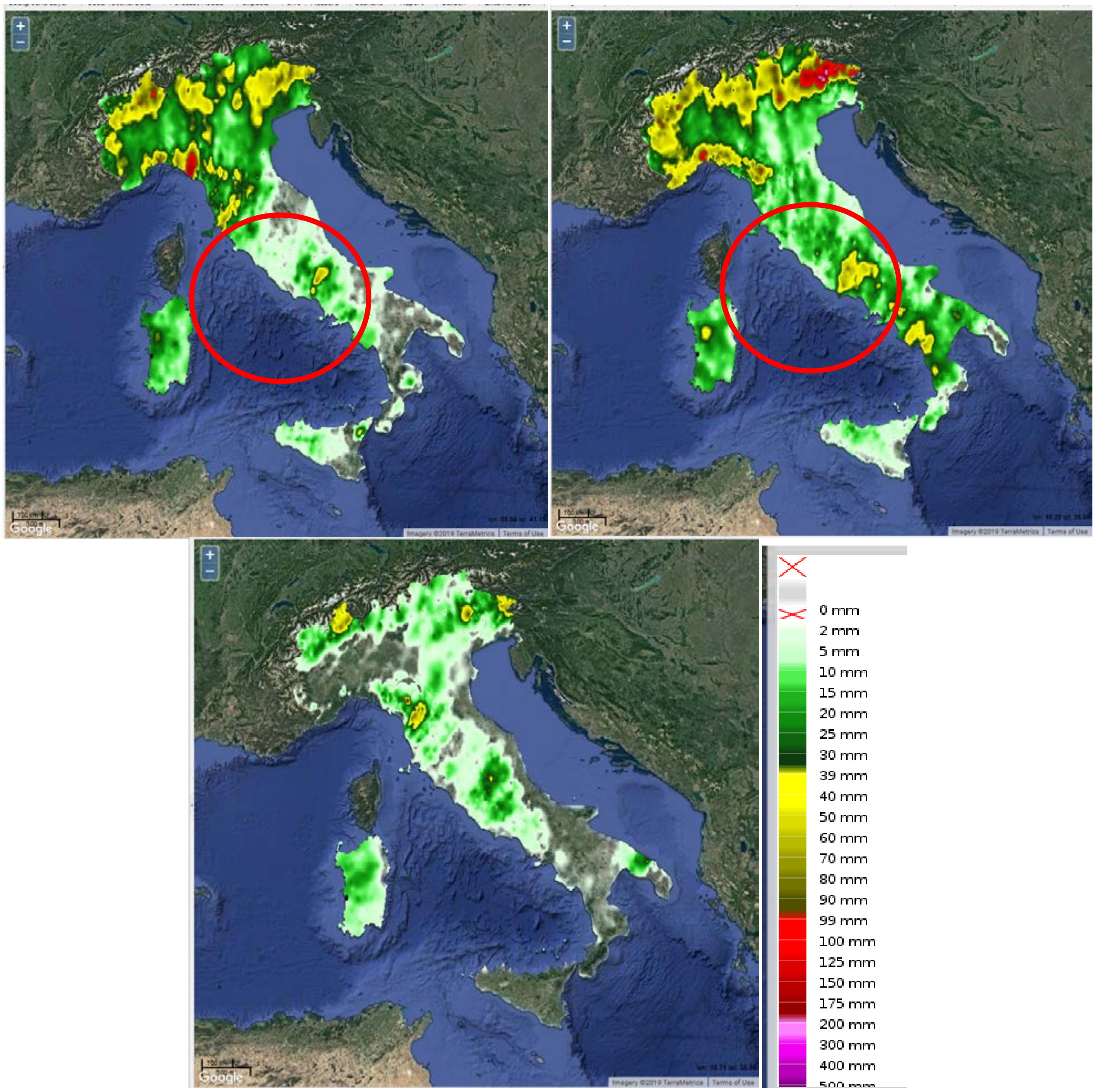


Figure 15: ProCiv 12h Observed Accumulated Precipitations (mm): 29/10 00Z-12Z (above left), 29/10 12Z- 30/10 00Z (above right), 30/10 00Z-12Z (below) (courtesy by data owner: Civil Protection Department)

Such an overassessment occurred also during the first part of the day, October 30th, as in Figure 13. This behavior is probably due to model attitude to spread amounts of rain, not detecting real main cores.

During this exceptional event, 32 casualties have been reported although all the possible warning procedures have been performed, mainly due to accidents (floods, fallen trees, lightnings, tornado like winds, rivers overflow). Because of red vigilance, all public services (schools, airport, maritime transports, etc.) were closed by the responsible communes. A relevant amount of material damages have been reported, including destruction of roofs, structures, and a number of Ligurian ports and coast roads by sea strength.

GENERAL REMARKS TO BE REPORTED ABOUT HIGH RESOLUTION MODEL

- Amount of rain at the smallest thresholds (0.2 mm) affecting forecasts as in not corresponding to real rainfall but often to low cloudiness;
- Spread of rainfall all over wide area instead of configuring real affected points (low level convergence lines, as in the first case study);
- Convective phenomena unappropriate detection (summertime or daily cycle thunderstorms);
- Light rainfall unappropriate detection (confusion by 0.2 mm overspread).