

# Application and Verification of ECMWF Products 2015

*Centro Operativo per la Meteorologia (COMET)*

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## 1. Summary of major highlights

IFS deterministic model output from both 12 and 00 UTC runs is used at COMET as plotted fields in the forecasting department mainly for the medium range, as input to statistical (PPM type) and physical adaptation schemes, but also as initial and/or boundary conditions for COMET Local Area Models (7km COSMO-ME and very high resolution 2.8km COSMO-IT). Verification of ECMWF products is carried out at COMET for operational model T1279. Surface parameters and forecast ranges mainly used by weather forecasters are considered.

## 2. Use and application of products

### 2.1. Post-processing of ECMWF model output.

#### 2.1.1. Statistical adaptation.

Statistical adaptation is involved in a Perfect Prog application currently being used named ARGO. The model is used to infer surface weather parameters such as precipitation, 2T, humidity, cloudiness, wind etc. over about one hundred geographical sites corresponding to the locations where the Italian network of weather stations is deployed and observations are available.

#### 2.1.2. Physical adaptation.

Physical adaptation is being used within the meteograms generation application. Routines selecting for each geographical site the most likely point among nearest grid points, make use of land/sea mask and elevation comparisons. Correction at all is being performed once the grid point has been chosen on the base of geophysical properties of the site.

#### 2.1.3. 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 mode every 6 hours for the medium range (up to T+72H stepping in time) and every 12 hours for the long range (T+72H 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.

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.

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 (Beaufort Scale). Metgrams (sometime you call them meteograms, others metgrams) over sea geographical sites are being produced too. For each site primary sea swell height, wind wave height, 10 m wind and wave direction behaviours are described from T+12H up to T+96H. 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”.

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

## 2.2. Use of ECMWF products

The ECMWF T1279L137 operational model is being used at COMET. Surface and upper air fields of the 00Z and 12Z runs are routinely downloaded on 0.25° horizontally spaced mesh for surface fields and on a 1.0° horizontally spaced mesh for upper air fields. The time step between two adjacent meteorological fields issued, is 6 hours from T+0h to T+168h and 12 hours between T+168h and T+240h forecast times.

The ECMWF products are classified in two main typologies: primary and secondary. In the first one, parameter fields identified as synoptic tracers are considered, like Potential Vorticity at 300 Hpa and equivalent temperature at 850 hPa as well; they allow to localize and define the path of synoptic configurations, especially in cases where they are not well defined at 500 hPa maps.

In the second category belong all the maps concerning parameters which better summarize the related meteorological conditions (high, medium and low cloudiness, temperature, wind etc.). The fields are generally plotted in an overlapping mode, including satellite images; many combinations are used using proper tools. In this way the forecaster is able to detect the subjects of interest, like Conceptual Models.

Besides these maps, products from EPS and EFI are used for severe weather events detection and issuing of warnings.

Every month, according to the availability of the ECMWF model products, maps from System 3 Seasonal FC (ensemble mean, probability and climagrams) are subjectively analyzed to obtain an outlook for the next quarterly period. Along with a concise

commentary, these maps are shown on the internal intranet website (available on request also for external users).

Finally monthly forecasts system is also used in the Operational Forecasting room even if not routinely.

### 3. Verification of products

#### 3.1. Objective verification

##### 3.1.1. Direct ECMWF model output

###### (i) in the free atmosphere

Some basic (ME, MAE and RMSE) verification statistical indices for the free atmosphere parameters (e.g wind, temperature, RH and geopotential at standard pressure level) are produced and compared to COSMO-ME model output verification results.

###### (ii) of local weather parameters verified for locations

Objective scores are computed for ECMWF 12 and 00 UTC run (d+1 to d+7) after collecting data retrieved from all available Italian Synop stations, using several stratifications. Graphics have been elaborated for a number of parameters: 2m Temperature, 2m Dew Point, 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 2014 to MAM 2015 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 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, optimised 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 CNMCA centre (now named COMET) 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: clear diurnal cycle for all the seasons for ME and MAE, especially during winter and summer. A general small underestimation is shown in ME, less than 1 m/s in absolute value. MAE, around 1.5-2.0 m/s in summer and fall and 2.0-2.5 m/s in winter and spring, with a tendency to slightly increase with forecast step.

2m Temperature: clear diurnal cycle in both ME and MAE. A general underestimation is shown in ME, especially during the night. MAE increases with the forecast time and its values are mainly comprised between 1.5 and 2.5 K (reaching up to 3.5 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 15 mm/12h. About the accuracy (ETS), all seasons exhibit the best results mainly for low thresholds and for the first 3-5 days of integration. For all thresholds there is a gradual decrease in accuracy with integration time.

### 3.1.2 *ECMWF model output compared with COMET COSMO-ME limited area model*

ECMWF 00-UTC scores (ETS, FBI) for 12 hours cumulated precipitation have been calculated and graphically compared to those evaluated for Italian 00-UTC run non-hydrostatic LAM named COSMO-ME (7 km resolution) for d+1 and d+2 on Italian area. These scores are shown in the next pages (see Appendix A).

About FBI scores, COSMO-ME model shows a better distribution and representation than ECMWF for almost all the thresholds and for all the seasons. In general higher thresholds are underestimated with both IFS and COSMO-ME models, whereas the overestimation is less evident in COSMO-ME than in ECMWF model.

Accuracy, represented here through ETS score, tends to be slightly higher for COSMO-ME especially for lower thresholds for all seasons.

### 3.1.3 *Post processed products: none*

### 3.1.4 *End products delivered to users*

Quarterly reports on model verification results are made available to Intranet and Internet users as well as Forecasts and Research division.

## 3.2 **Subjective verification**

### 3.2.1 *Subjective scores: none*

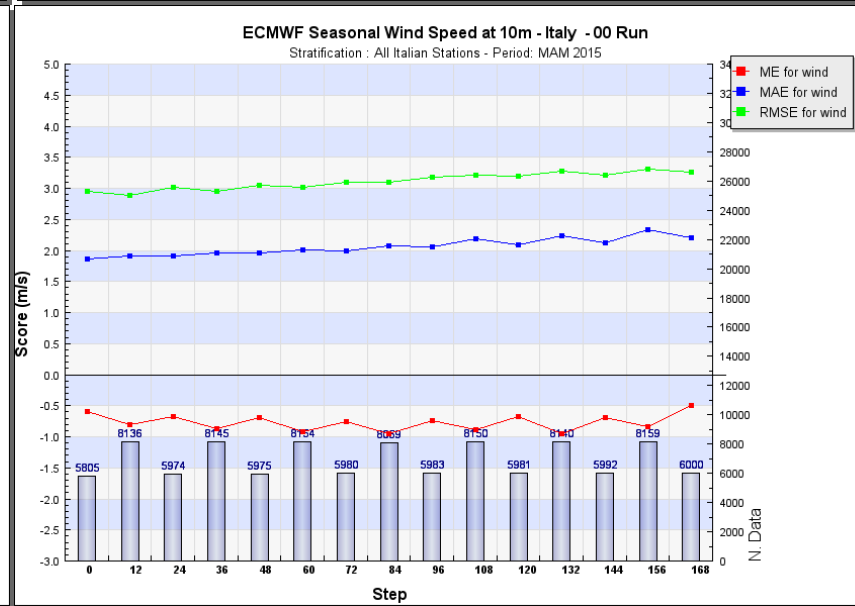
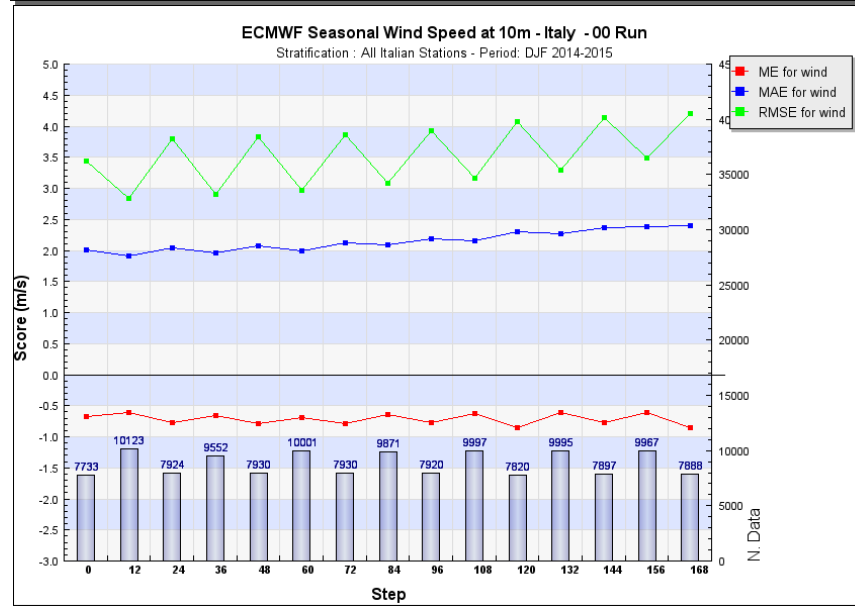
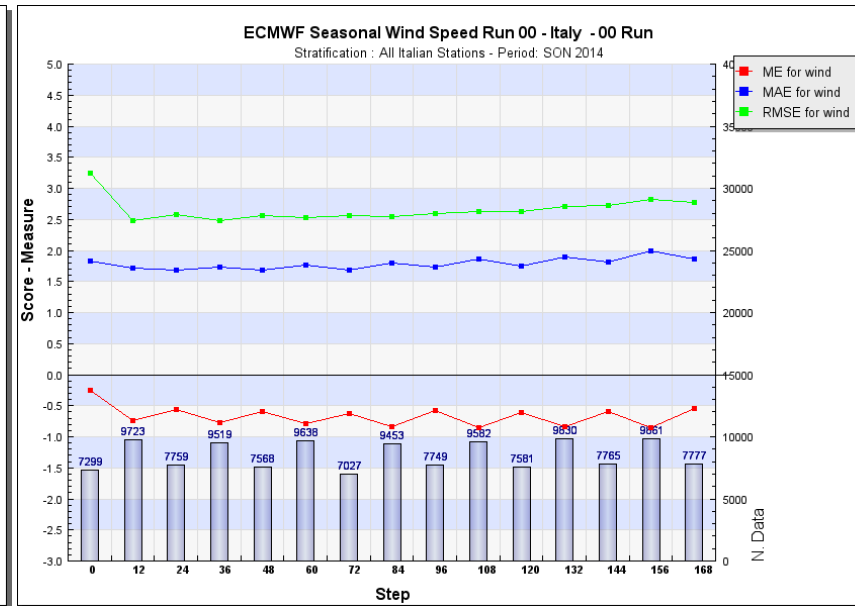
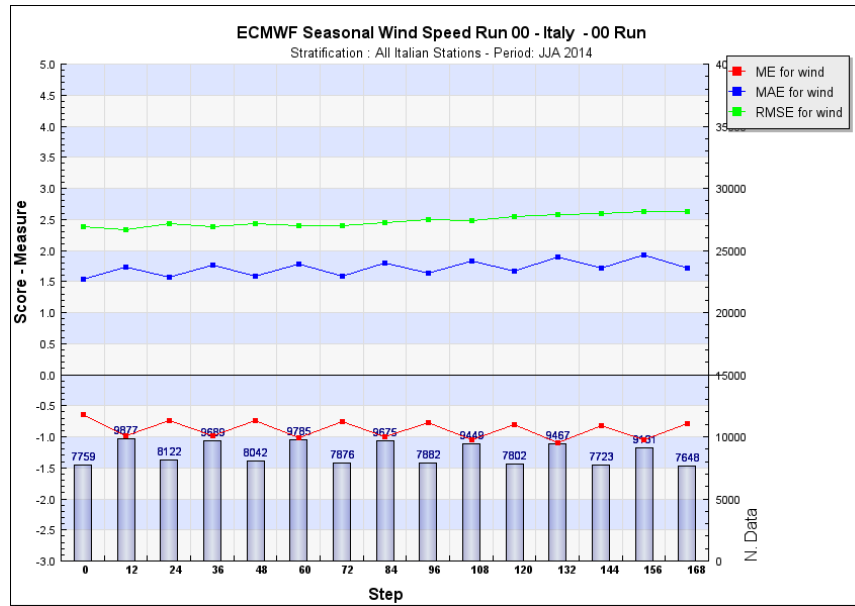
### 3.2.2 *Case studies*

A synoptic study regarding the flood over Marche (Senigallia, Ancona) on 3rd May 2014 has been carried out and the main results are shown in the next pages (see Appendix B).

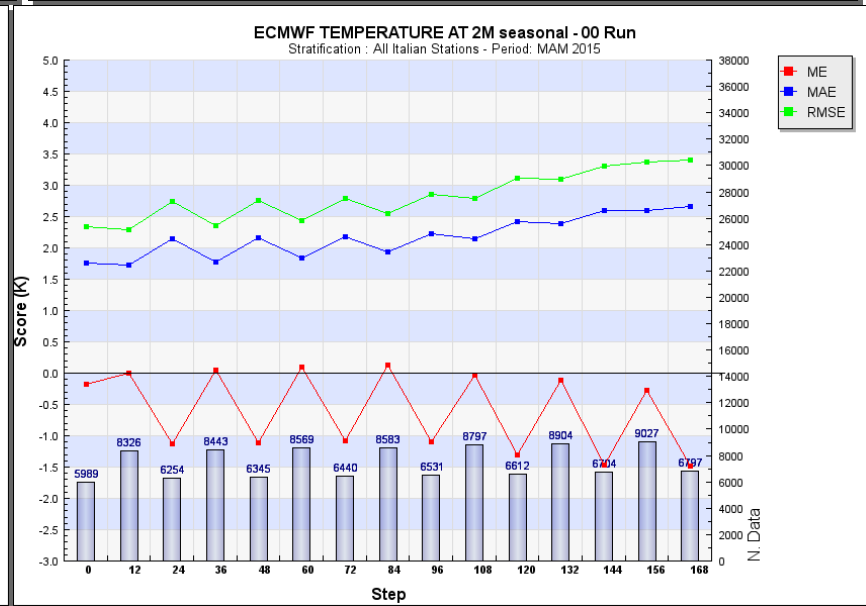
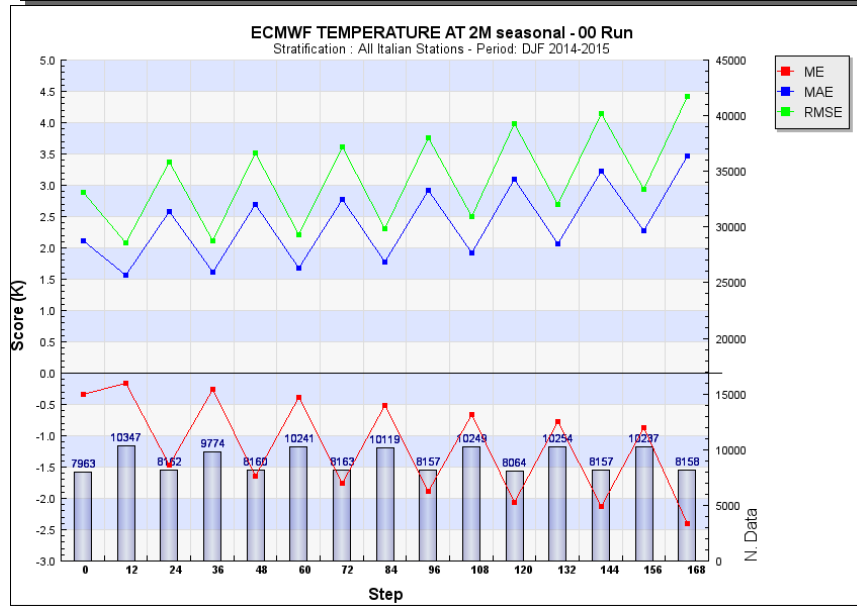
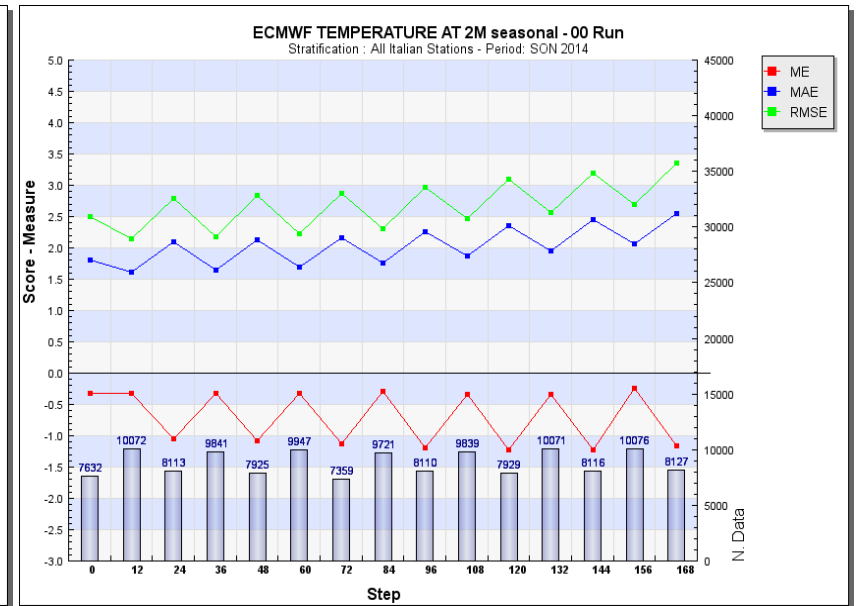
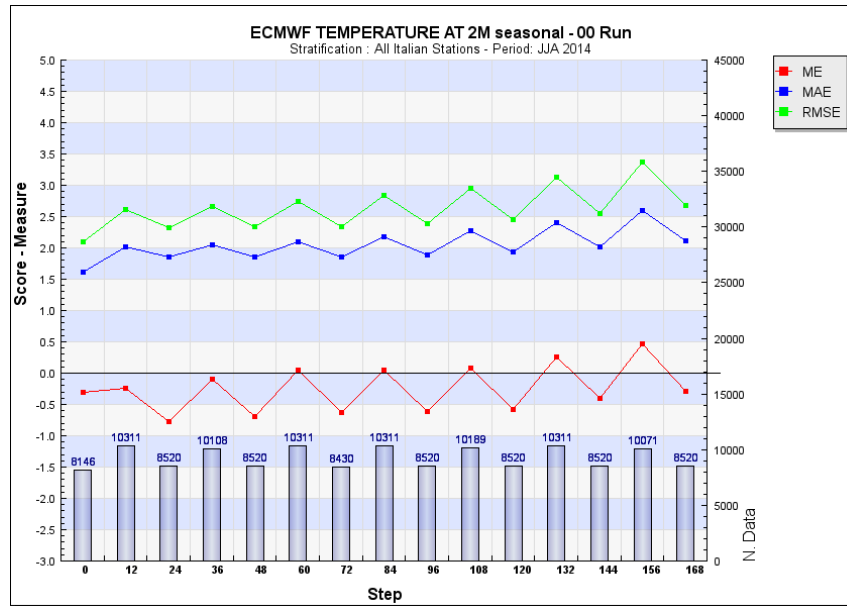
## 4 **References**

<http://www.meteoam.it/page/verifiche-modelli>

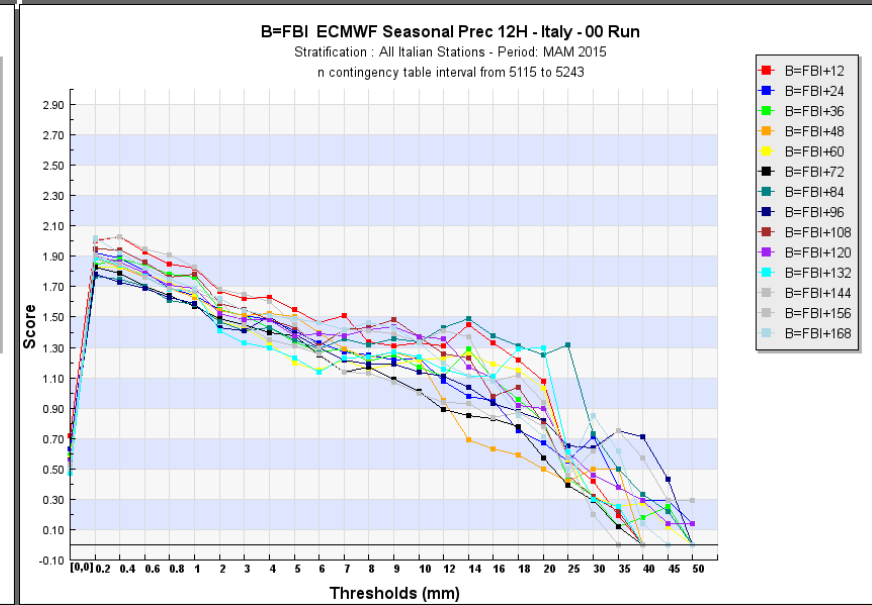
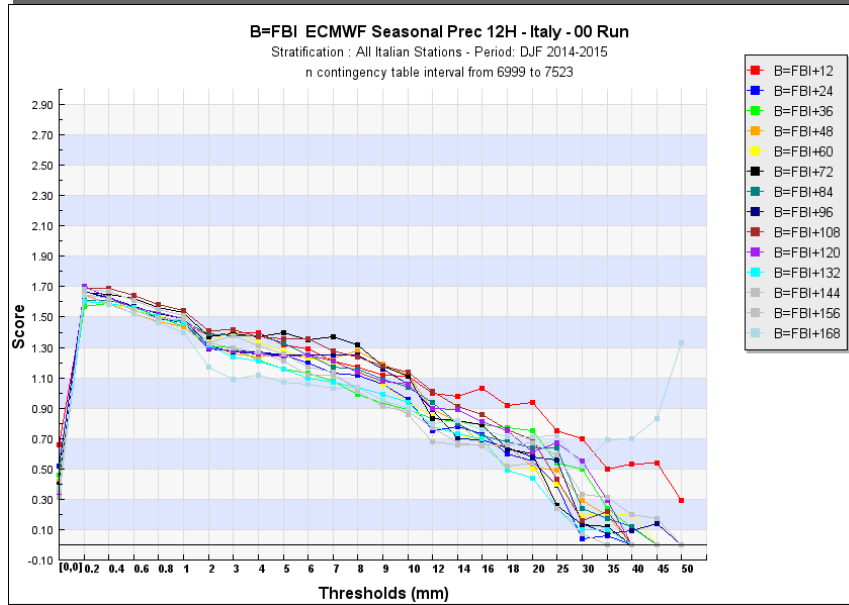
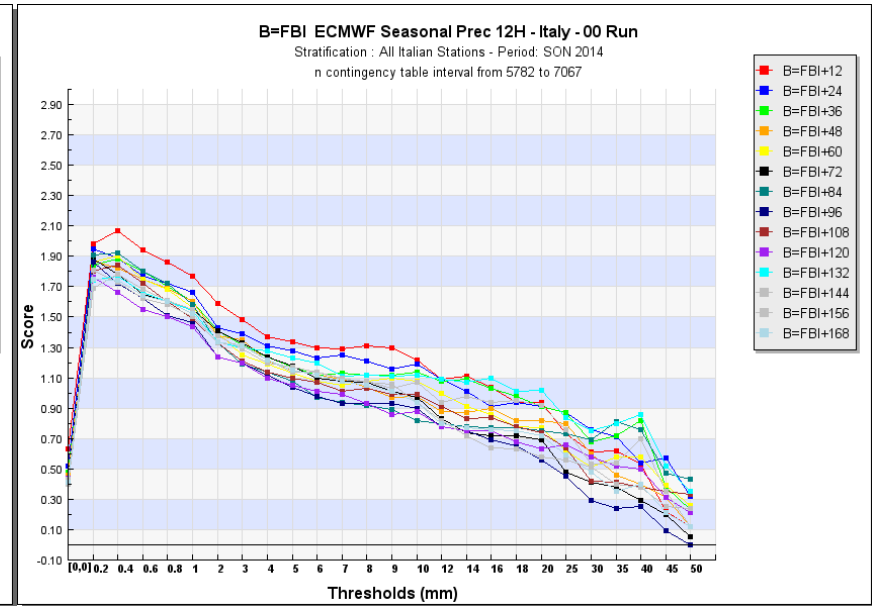
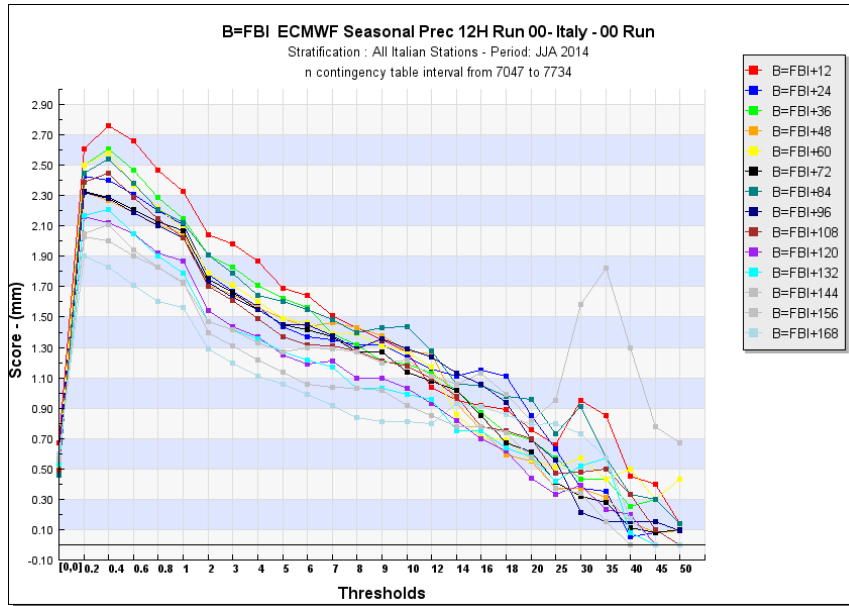
for quarterly reports on model verification (in Italian only).



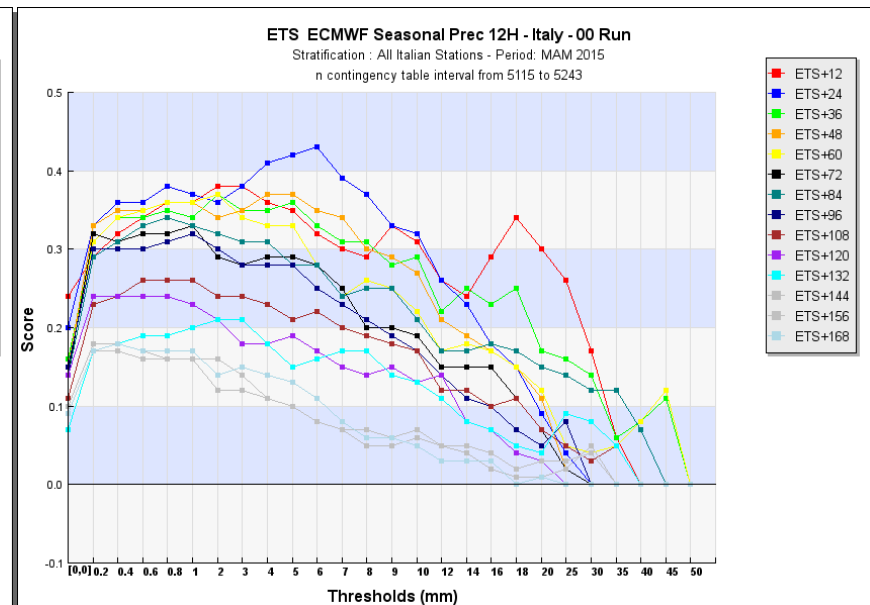
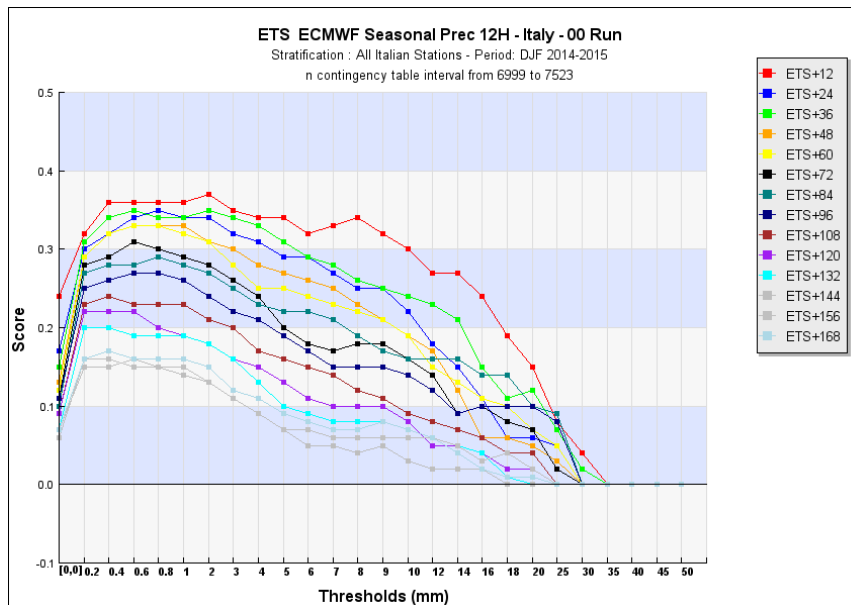
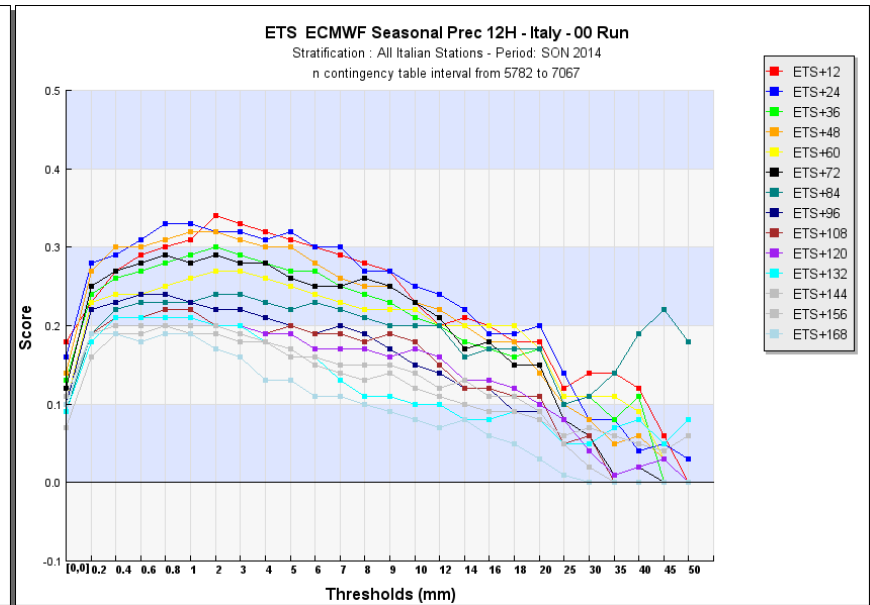
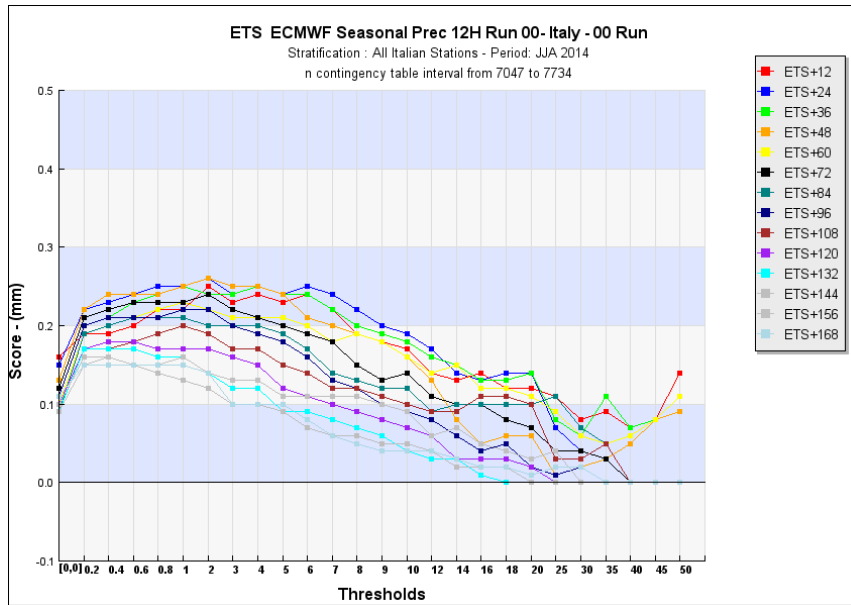
**IFS 10m Wind Speed (Mean Absolute Error, Mean Error and Root MSE)**



IFS T2m (Mean Absolute Error, Mean Error, Root MSE)

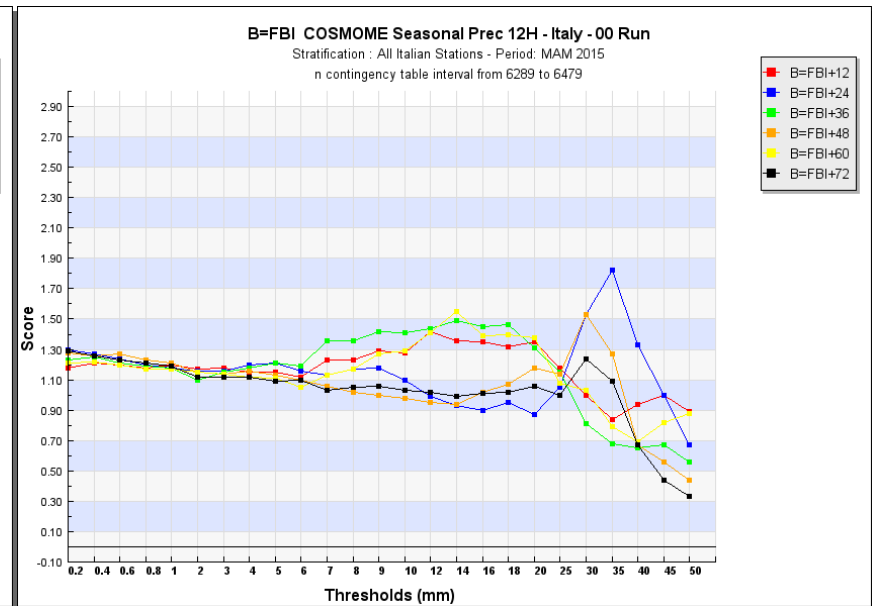
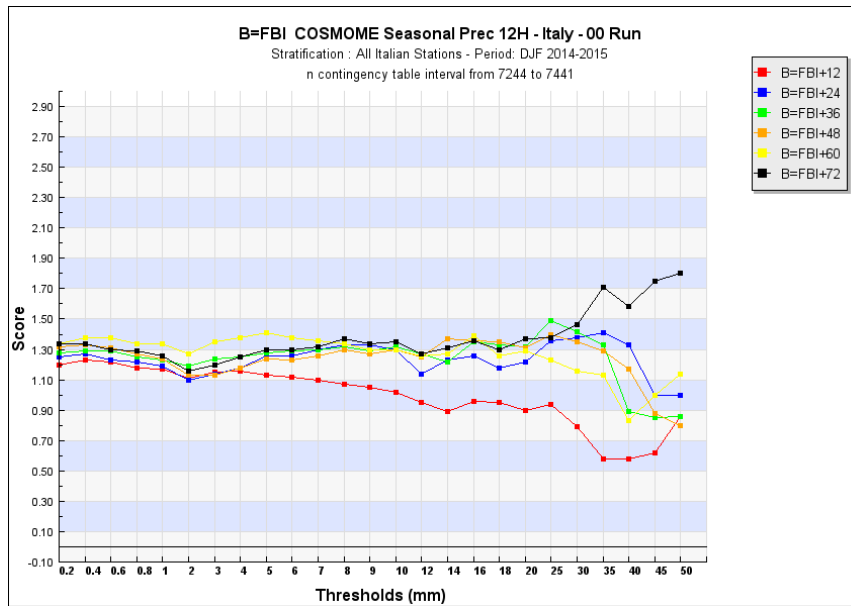
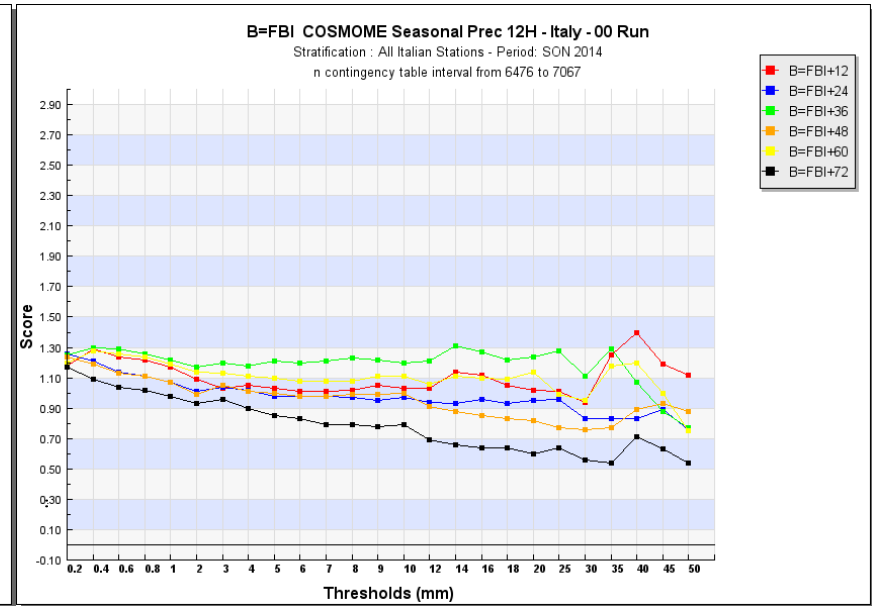
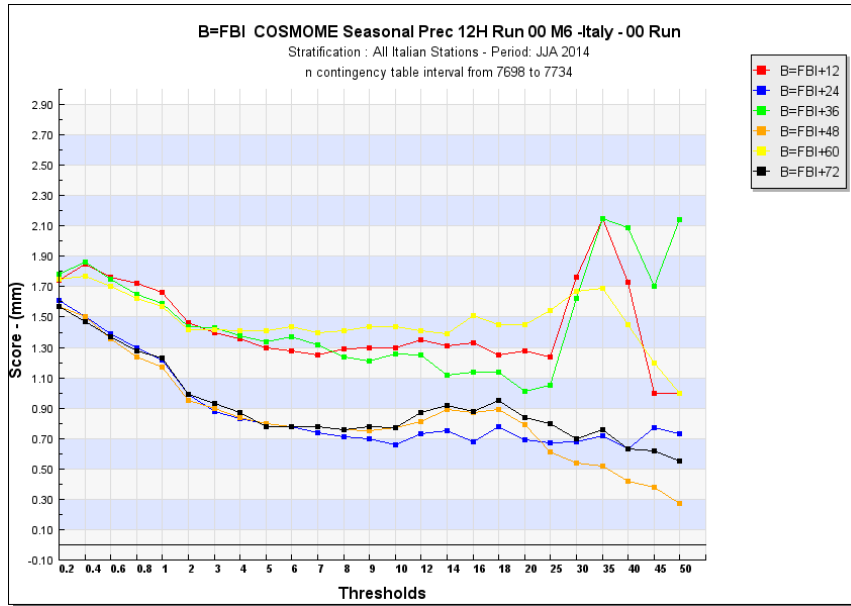


IFS Precipitation in 12 hours - FBI score

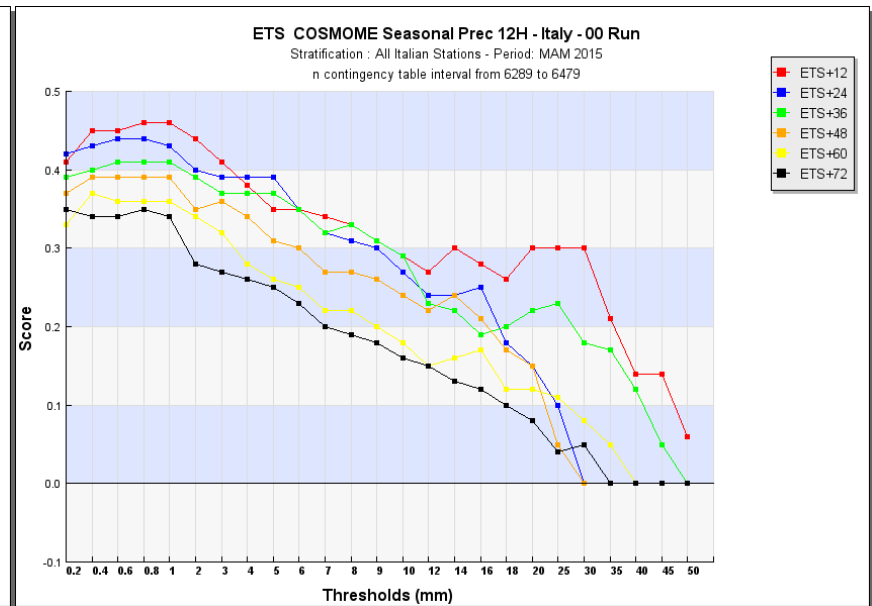
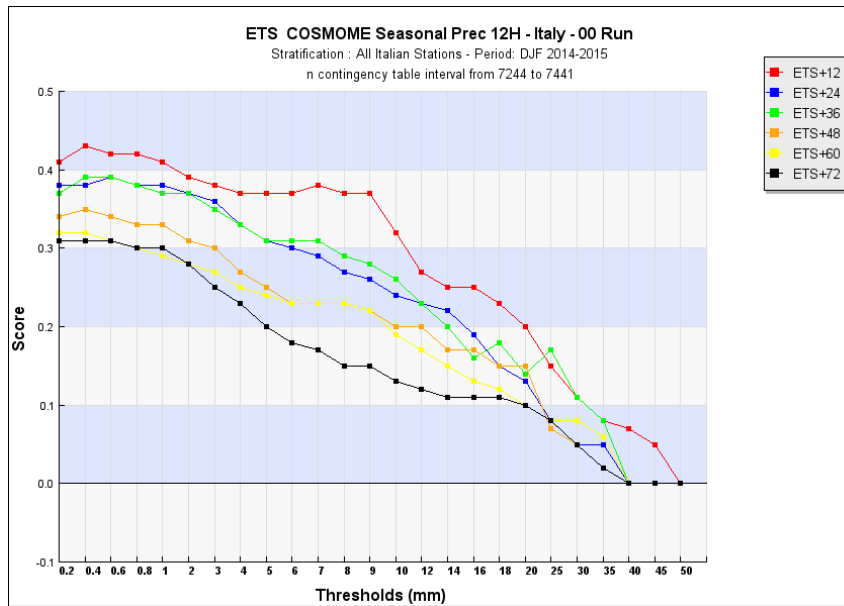
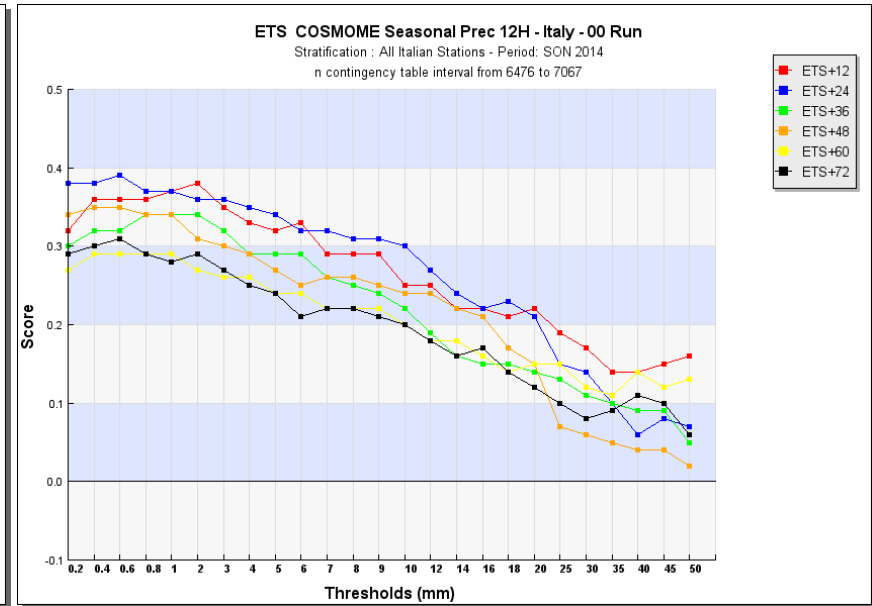
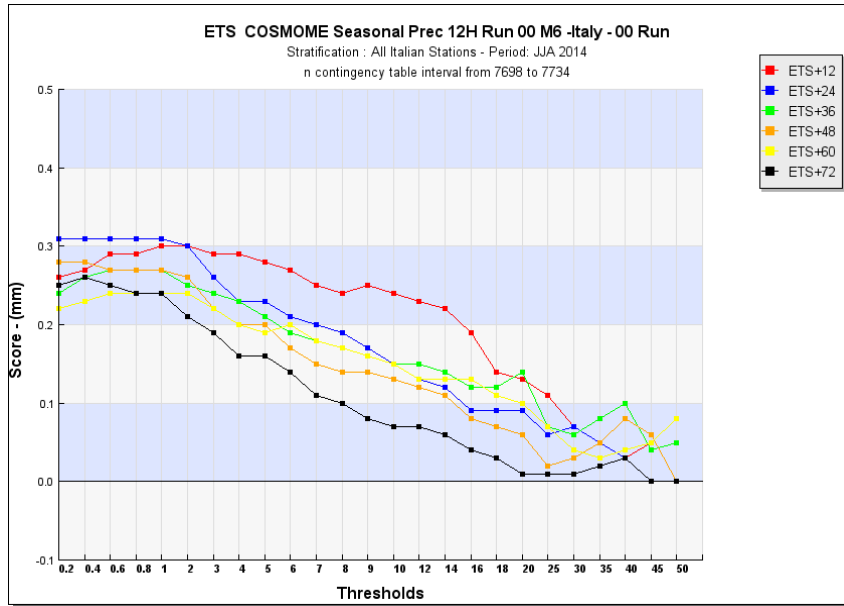


IFS Precipitation in 12 hours - ETS score





COSMO-ME Precipitation in 12 hours - FBI score



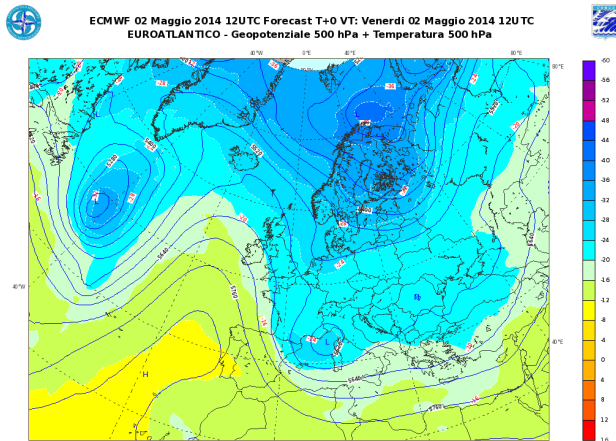
**COSMO-ME Precipitation in 12 hours - ETS score**

## Case study : rain flood over Marche in Senigallia

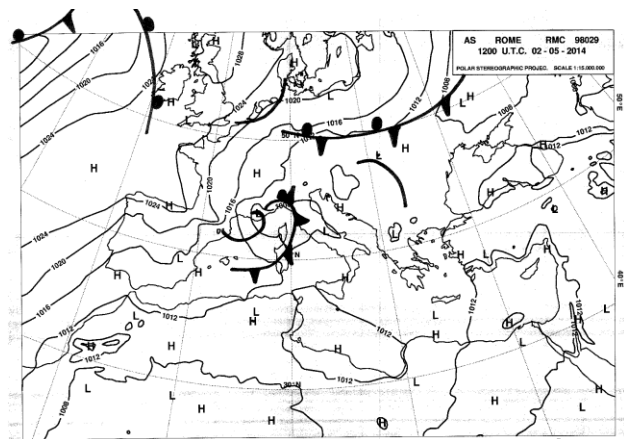
At early morning 3<sup>rd</sup> May 2014 in Senigallia,(AN) heavy and persistent rainfall occurred causing channel overflow and many more incident.

### Synoptic overview

On 2<sup>nd</sup> May the European scenario was characterized by Azores High extending poleward up to 60°N and by a widespread trough over central Europe evolving into a cut-off (“coldcore” of -24°C at 500hPa)over central Mediterranean Sea and Italy. The frontal system associated to the aforementioned trough was active over Sardinia and north-western regions.

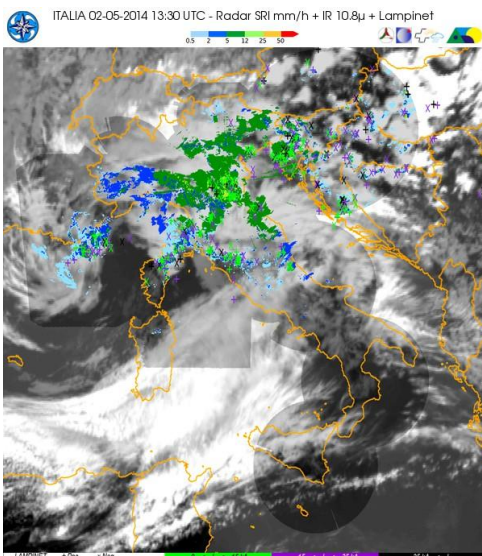


500 hPa Geopotential and Temperature (ECMWF,02/05/2014 12.00 UTC)

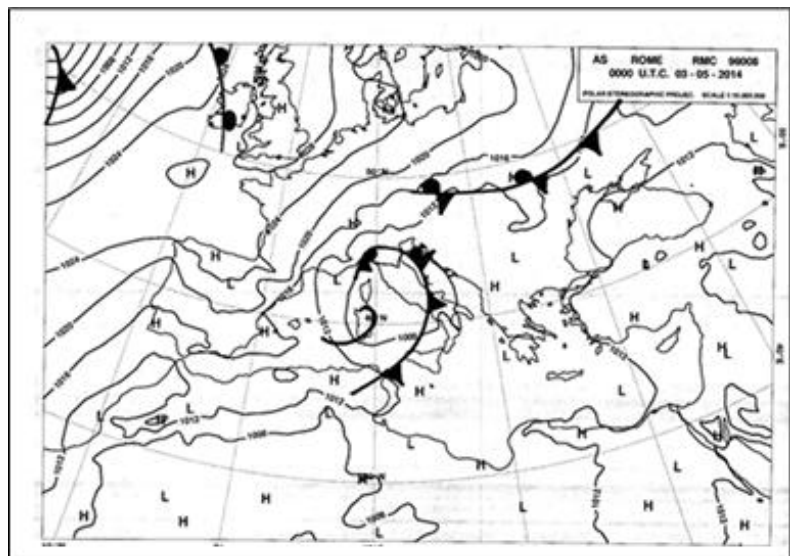


Surface Analysis with fronts(02/05/2014 12.00 UTC)

The cold front affected western side of the peninsula with thunderstorms while the Adriatic regions, lied in warm sector, were involved in Warm Conveyor Belt (WCB) prefrontal flux that brought heavy convective rainfall.

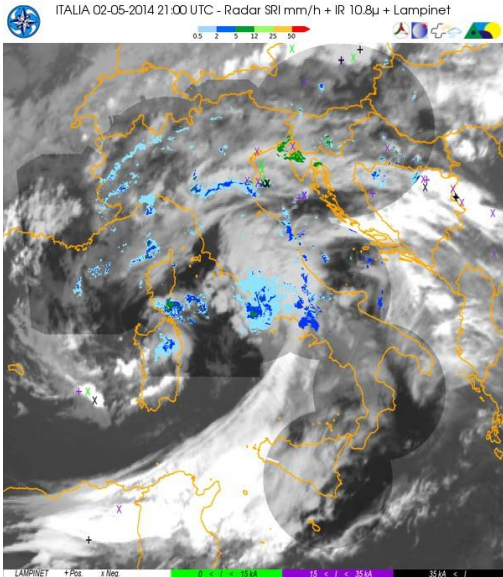


Composite Image (IR10.8μm+radar rain rate+lightning) 02/05/2014 13:30UTC. It is worth of notice thunderstorm activity over northern and central Tyrrhenian due to the cold front and WCB convective rainfall over Marche and northern Adriatic Sea still with lightnings.

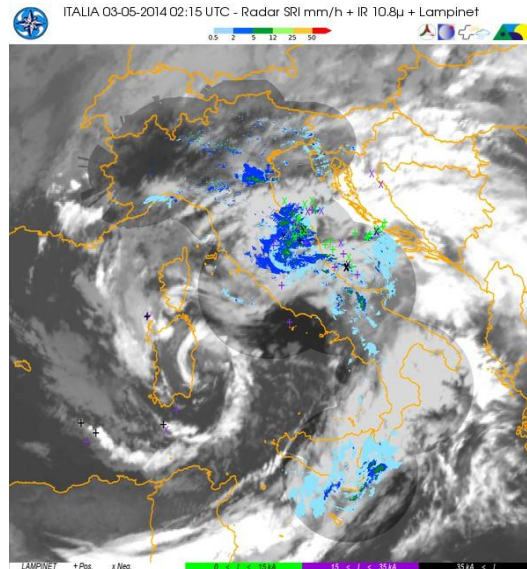


Surface analysis 03/05/2014, 00 UTC

In the evening the cold front moved towards southern Italy with the occlusion twisting over central Italy affecting northern Adriatic with weak or moderate rainfalls up to midnight. After midnight the intensity of the phenomena increased due to the incoming occlusion. Thunderstorms originated over marine surface affected persistently northern Marche until dawn. The intensification of the occlusion branch is stark evident in the following image.



**Composite Image (IR10.8µm+radar rain rate+lightning) 02/05/2015 21.00UTC. The occlusion affected Marche and eastern Emilia-Romagna with light rain.**



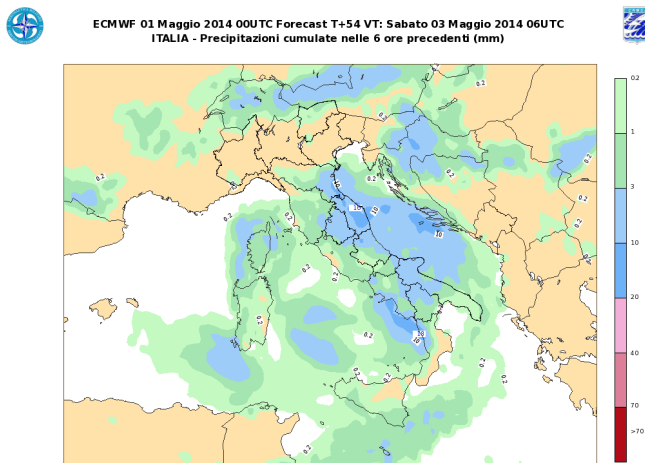
**Composite Image (IR10.8µm+radar rain rate+lightning) 03/05/2015 02.15UTC.**

Observations from Civil Protection Department recorded 48 h total rainfall of about 150 mm in Senigallia (AN) from 02/05/2014 to 03/05/2014.

## ECMWF FORECAST

On 1<sup>st</sup> may 2014, an heavy rainfall warning was issued over Marche and Emilia-Romagna for persistent and thunderstorm like precipitation starting from 02/05/2014 late morning up to 03/05/2014. The model output showed the convective rainfalls over Marche however the amounts were quite underestimated, in fact, the peaks over Marche were around 10 mm/6h.

The subsequent model outputs still continued to under assessed the rainfall amounts over Marche because the forecast accumulated rainfall ranged between 10mm/6h and 20mm/6h against an observed value around 60 mm/6h in Senigallia (AN).



**Forecast 6h accumulated rainfall 03/05/2014 06 UTC (run: ECMWF01/05/2014, 00 UTC)**