Application and verification of ECMWF products 2016

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1. Summary of major highlights

IFS deterministic model output from both 12 and 00 UTC runs is used as plotted fields in the forecasting department mainly for the medium range, as input to physical adaptation schemes, but also as initial and/or boundary conditions for Italian Air Force 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

None.

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.

The Metview module FLEXTRA is being used to trace contaminant dispersion in case of nuclear, chemical or biological incident/accident.

Meteorological CBRN messages as well are generated and distributed according to NATO directives and other agreements.

The ECMWF model data are also used as boundary conditions in the following components of the operational short-range numerical forecasting system:

- Ensemble Kalman Filter (EnKF) Data Assimilation System based on the COMET-LETKF algorithm and the high-resolution non-hydrostatic model COSMO integrated over the Mediterranean-European region (40+1 members, 10km, 45 vertical levels);
- COSMO-ME EPS short-range ensemble prediction system initialized by the COMET-LETKF ensemble analysis and running twice a day (00 and 12 UTC) up to 72 hours;
- COSMO-ME deterministic model integrated up to 72 hours over the Mediterranean-European region (7km, 40 vertical levels), four times a day.

In the COMET-LETKF assimilation cycle and COSMO-ME EPS system the HRES and ENS ECMWF data are both used to generate the perturbed lateral boundary conditions. In particular, 40 randomly selected perturbations from ENS fields (ensemble member minus ensemble mean) are added to the most recent HRES fields. These HRES data are also used as boundary condition for the COSMO-ME model.

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 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 deterministic IFS 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 assimilated and suitably cropped, regridded and distributed according to agreements with specific users.

2.2 Use of ECMWF products

COMET and CNMCA EcCharts platform and ECMWF web-site currently as dynamic tool as well as classic numerical products are still available as static approach from our operational intranet web-site, where most of the products are plotted for Italian and Mediterranean area to get more details.

CNMCA main mission is to issue severe weather warnings and to support the National Civil Protection Department. Our main warnings usually are issued at 12.00UTC and not before 18-24 hours before the severe weather event begins.

At 10.00 local time the forecaster discuss his decisions about the warnings with the Civil Protection Department, unfortunately between end march to end October without using all the ENS products, because for example EFI are available after 10.00 local time. Anyway at 09.40, just before the discussion only short time is available to see the total precipitation probability maps, which start to be available. Before issuing the warning at 12UTC EFI-SOT (also the new EFI for forecasting severe convection) is usually checked with model climate, CDF, ecChart, to have more detailed information (probe-window) and until July 2016 to see the IFS cycle 41r2, the clickable charts at www.ecmwf.int, that result to be highly useful to have a joint view of both ENS and HRES through ENSgrams and maps.

Highly appreciated is ECMWF web-site cloud cover representation, which is the best way to show three cloud layer in just a single map.

Finally, extended forecasts are also used in the operational forecasting room to issue monthly forecasts available weekly on our public website www.meteoam.it.

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS)

(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 2015 to MAM 2016 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 2.0-3.2 m/s in summer and fall and 2.5-3.5 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 2.0 K (reaching up to 2.3 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 discriminating threshold (i.e. FBI = 1) is around 10 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 to other NWP models

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

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 (including evaluation of confidence indices when available)

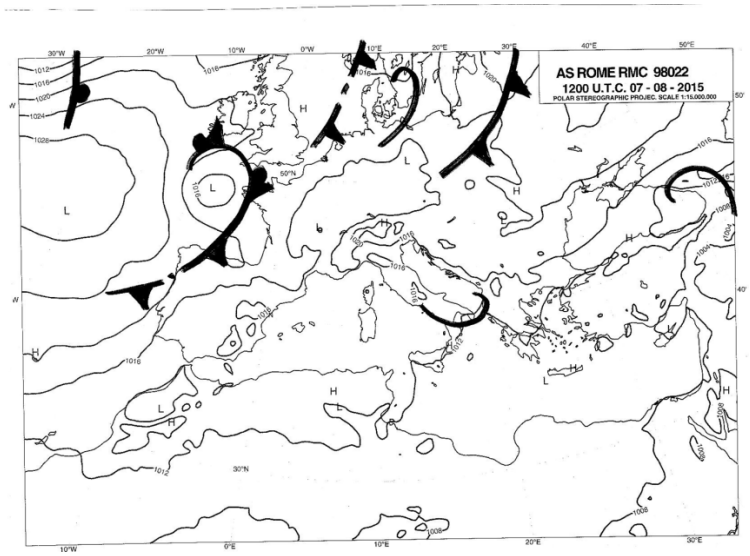
3.2.2 Case studies

***Case Study 1:*An heavy Thunderstorm Cluster Involves Central-Southern Italy**

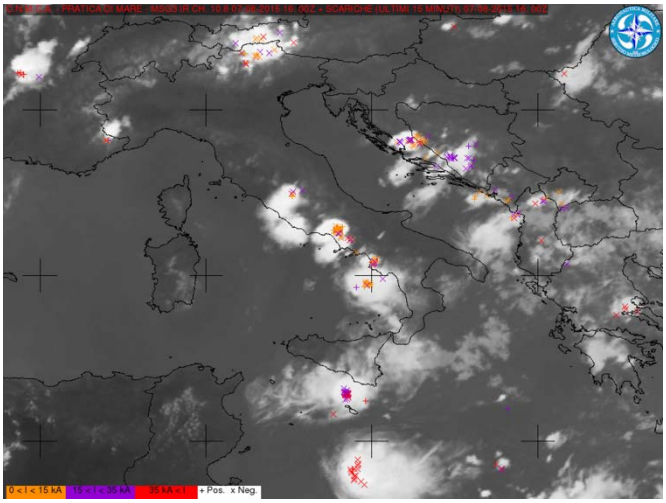
On last August 7th 2015 afternoon and evening, a heavy clustered thunderstorm like cell occurred over Tyrrhenian Central-southern Italian regions as a consequence of a remarkable instability spreading over along the whole coastline area, up to Latium and Umbrian inner part.

Synoptic overview

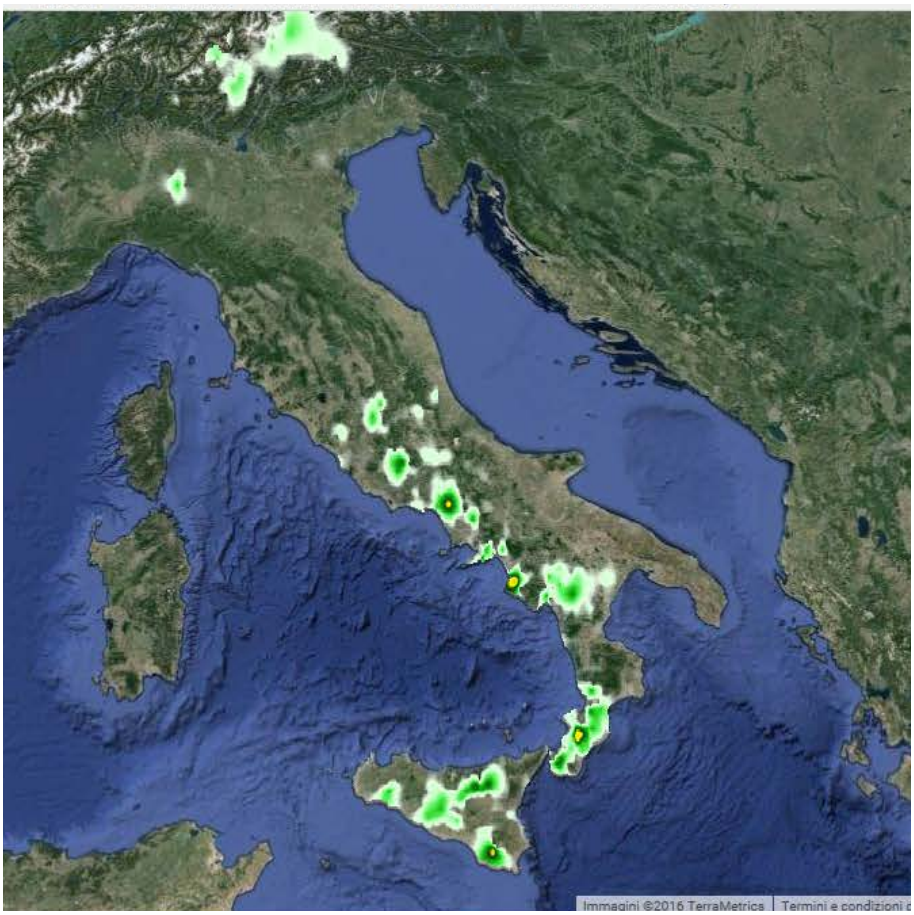
On 7th August the analysis over Europe shows the russian thermal anticyclone that determines levelled high pressure area over western Mediterranean area with relative low (1012 hPa) over central/ eastern basins. An upper level low reported. The main flow, driven by jet stream, moves over northern Europe whilst an anticyclonic area dominates the Mediterranean area. A Warm Conveyor Belt (WBC) following the anticyclone carries warm and moist air mass over Central Mediterranean Sea. The upper level Instability over south eastern Italy, Ionian Sea and eastern Greece is represented by a "Comma".



In the afternoon several thunderstorms developed over Alps, central and southern Apennines, Sicily and Ionian Sea.



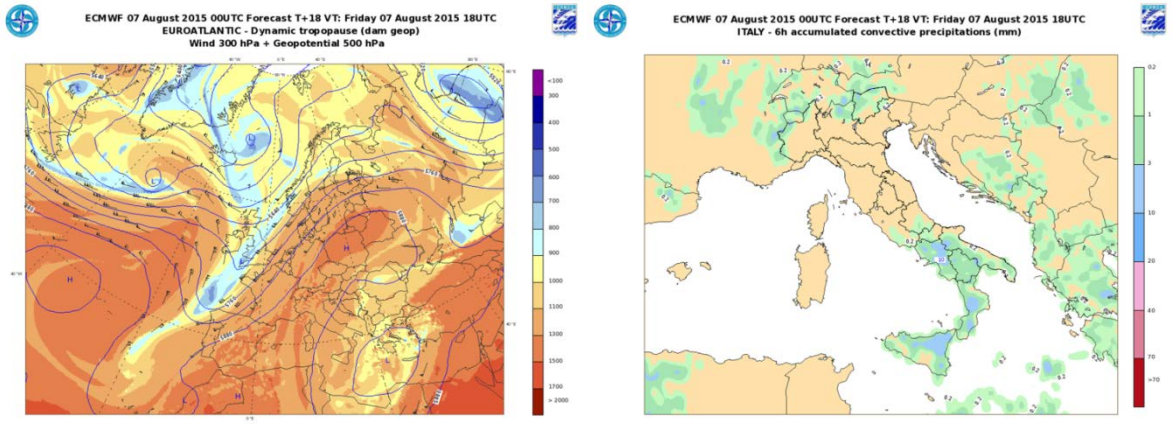
MSG3 IR CH 10.8, aug 07 - 16.00 UTC



Observed Precipitation August 7th 2015: 10.00 am UTC- 10 pm UTC - Courtesy Civil Protection Department

The observed amount of rain has been not excessively high although some clusters had persisted over limited areas. Some severe hail storms have been reported over inner local areas between Latium and Umbria, where no phenomena had been expected (a flight competition was on in Rieti then with most Central Italy as interested air space).

ECMWF FORECAST



ECMWF , run Aug 07 00UTC, T+18

The ECMWF model output slightly underestimates the amount of the summer convective precipitation and does not forecast convective precipitation over central Apennines

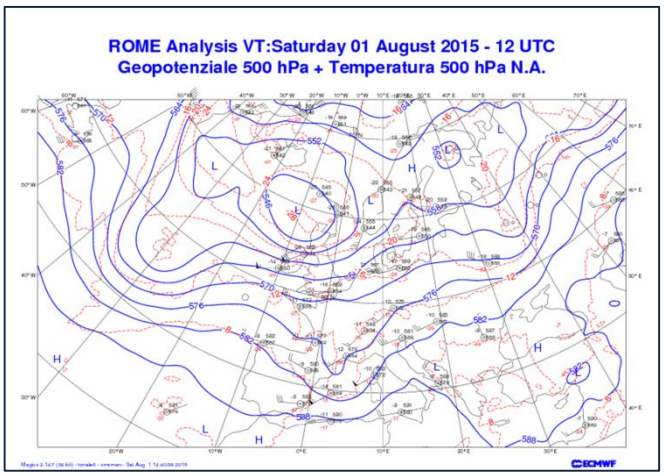
CONCLUSIONS

- Detected synoptic subjects: a comma, wide and not excessively active, within a leveled isobaric ground field (1012 hPa), over Southern Italy by analysis 12.00 UTC;
- Phenomena have been predicted over southern Adriatic and Ionian area, not exclusively convective but kept a dynamical nature as well;
- The rainfall has been quick and not too rich in amount although clustered over some sites;
- Local severe hail storms like incidents are usually connected with such summer typical synoptic subjects.

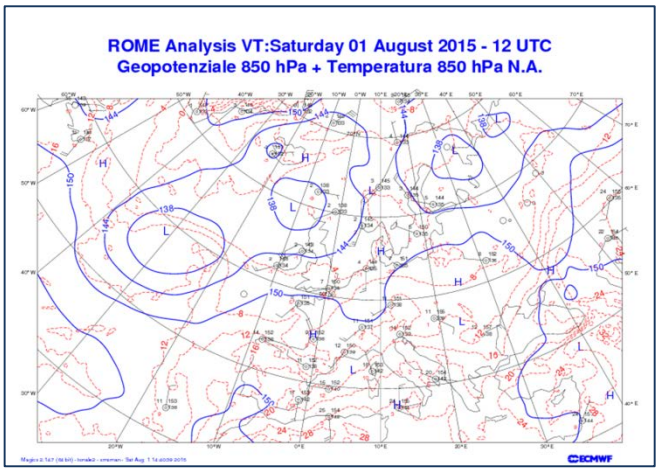
Case Study 2: A Severe Rainstorm with Flood in Florence

A heavy storm occurred over Florence, last August 1st 2015 in the evening, including severe thunderstorms while some tornado-like incident being reported; a remarkable amount of rainfall has been recorded and consequent flood incidents all over the eastern urban sector as well.

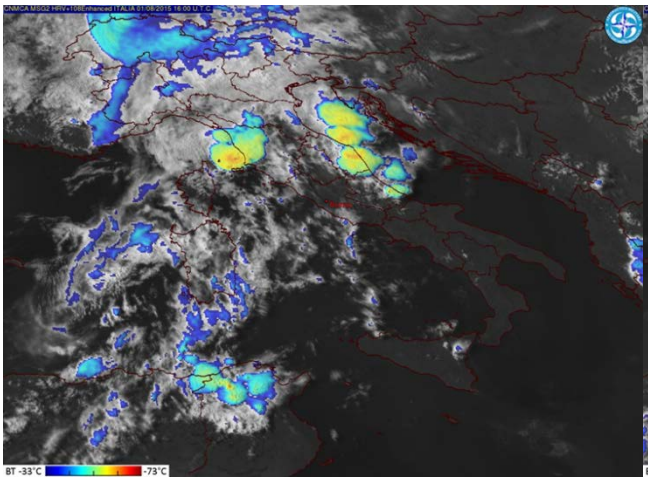
Synoptic overview

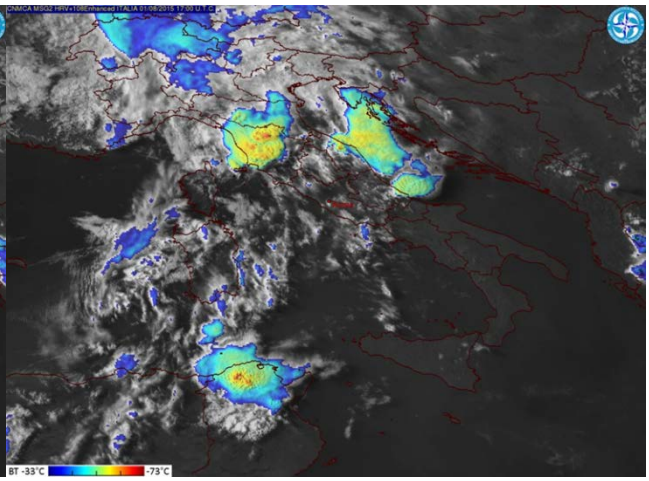


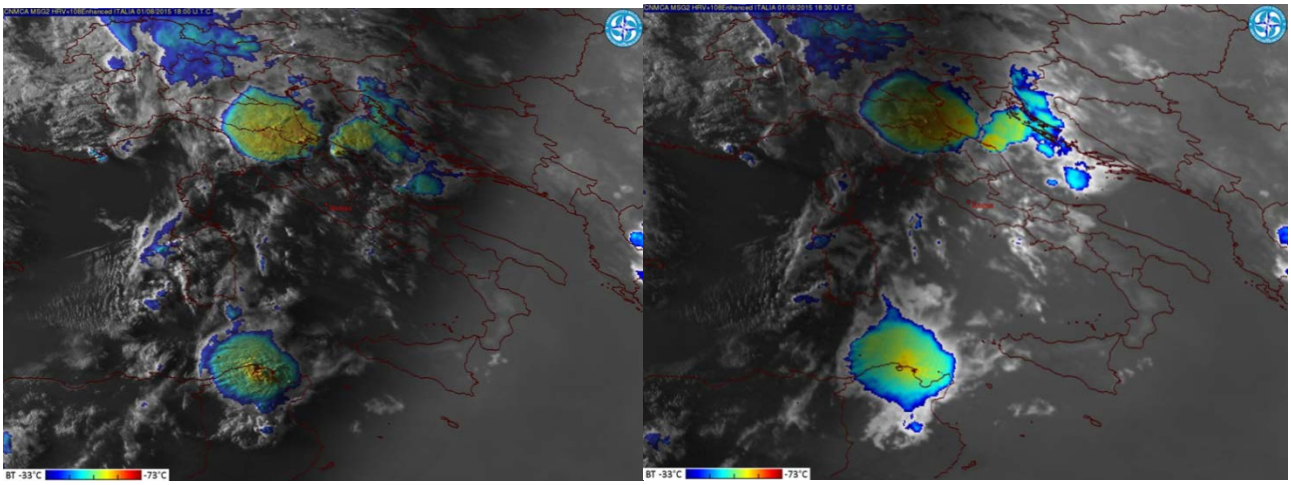
Analysis 12.00 UTC: 588 isoline over Mediterranean area, lowering down after a trough due to classical Atlantic mid latitude cyclone working over northern Europe



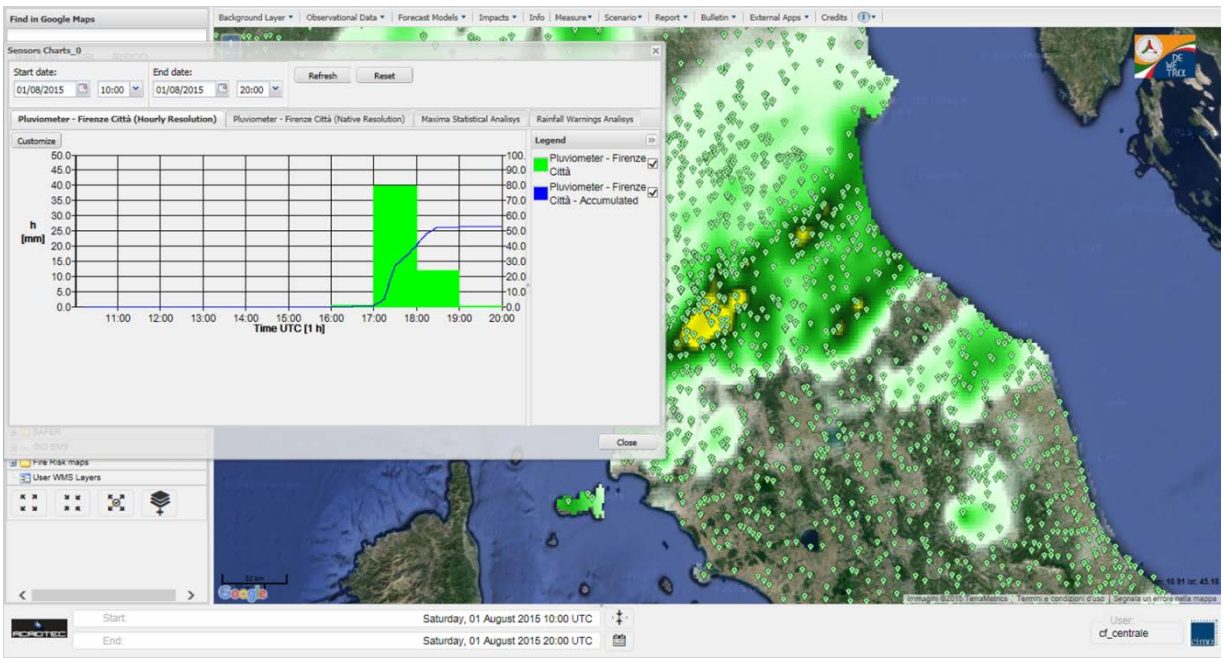
Analysis 12.00 UTC: summer situation with main subjects moving at higher latitudes, jet stream main branches along 50°-55° N parallels, anticyclone over Mediterranean area





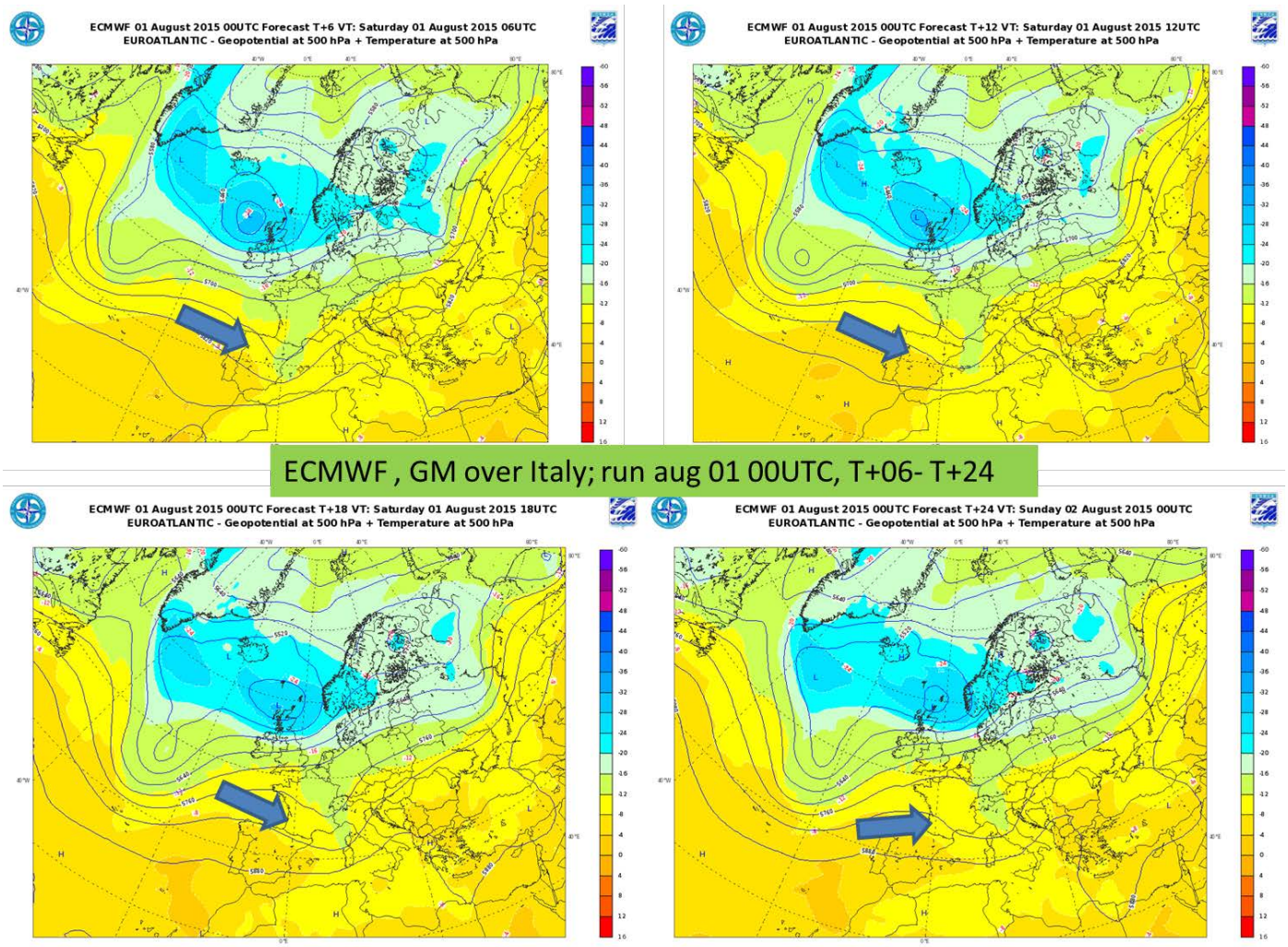


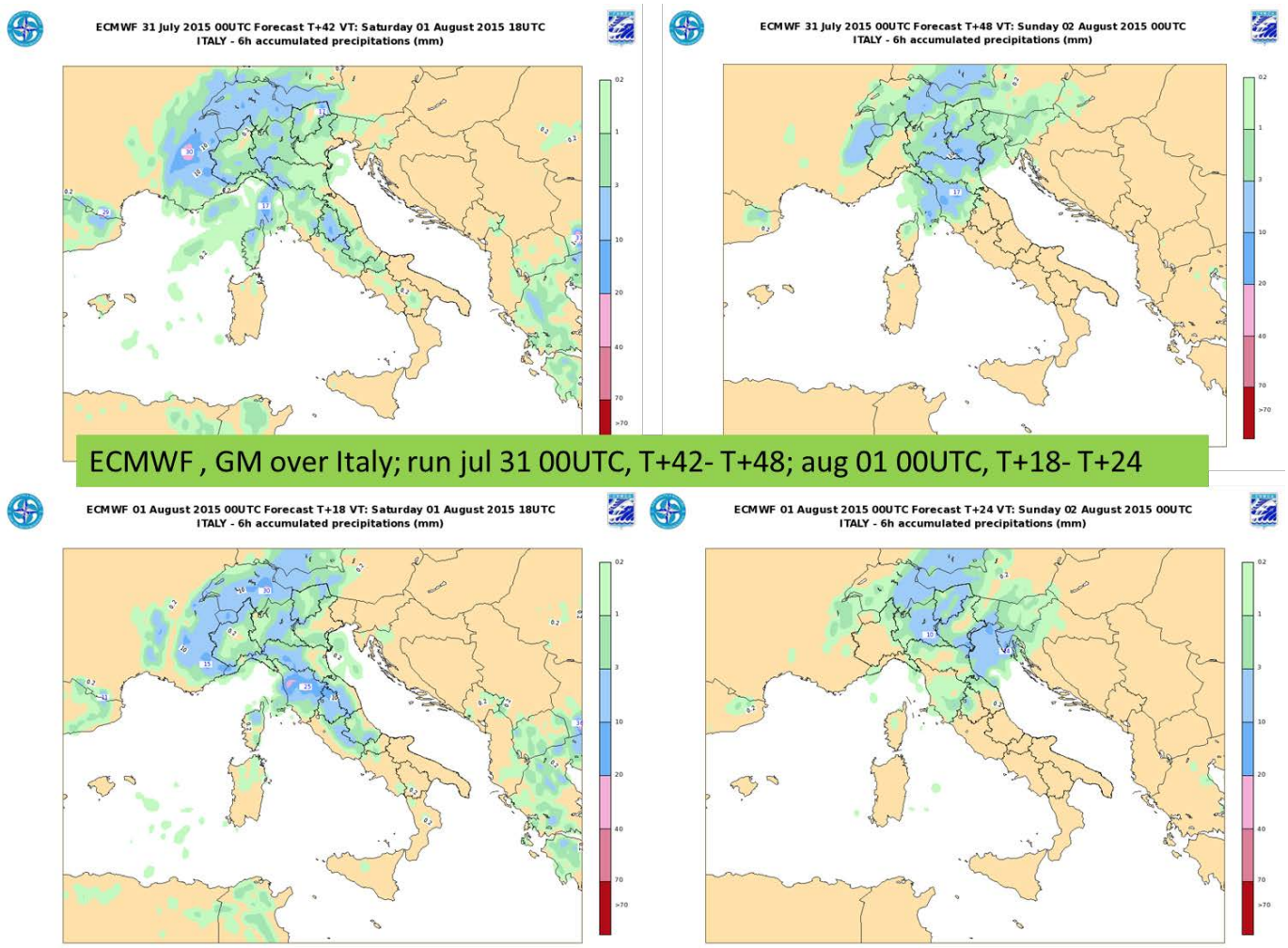
Satellite images, MSG2 HRV + 10.8 Enhanced Aug 01, 16.00 UTC, 17 UTC, 18 UTC, 18.30 UTC



Ground Observations: Locally 52 mm maximum recorded rate within two hours; city gauge (Firenze): 40 mm within 1 hour (Courtesy: Civil Protection Department)

ECMWF FORECAST

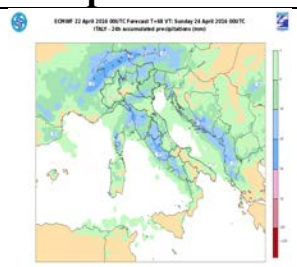
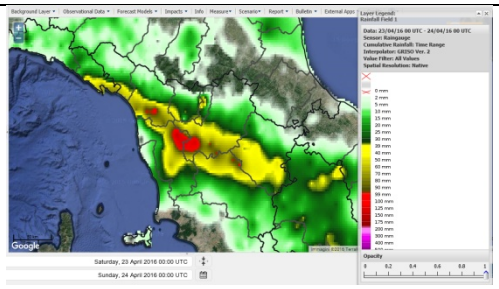
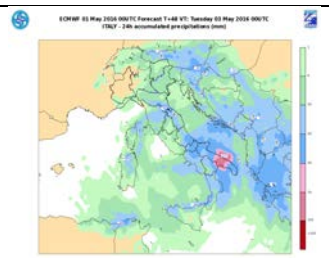
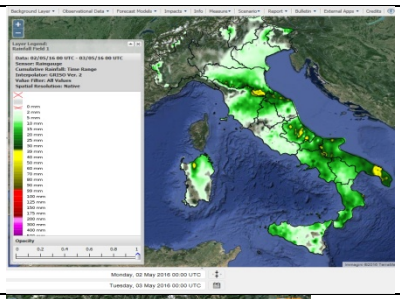
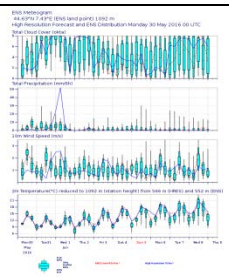
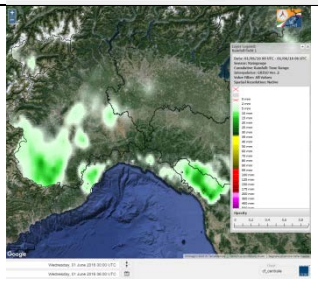
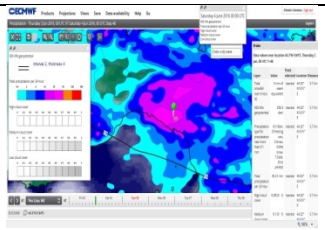
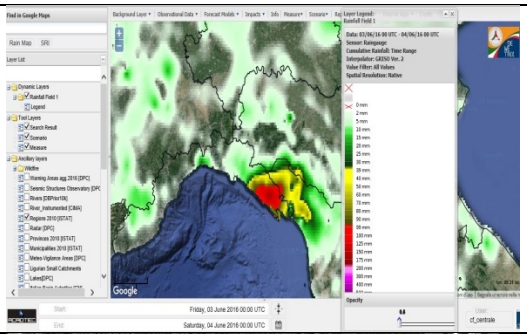
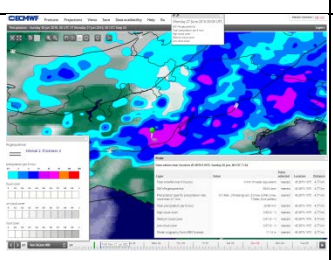
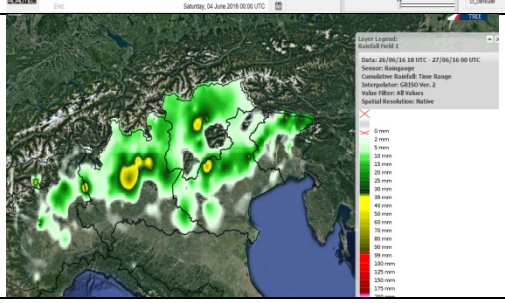


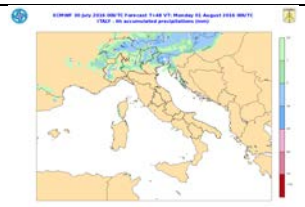
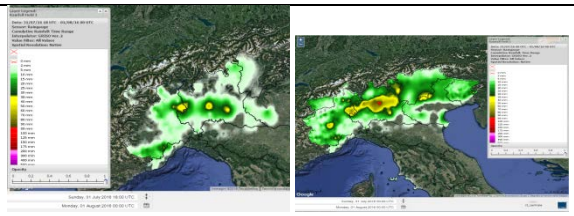


CONCLUSIONS

- Detected synoptic subjects: a warm front, not excessively active, within a well organized classic frontal system and a comma-like cold upper level low, being charged by the high sea temperature (SST) and humidity rate.
- 2. Phenomena have been not exclusively convective but kept a dynamical nature as well.
- 3. The rainfall has been quick, rich in amount though. As a typical summer convective phenomenon, this incident looks detectable although in a general qualitative way, not emphasizing the top rainfall amount locally occurring.
- 4. Possible tornado-like incidents are usually connected with such powerful summer subjects.

Since the new model with 9km resolution is available, in many case of severe weather it has been noticed that the total precipitation's maxima per 6 hours are much higher in values compare to the past, sometimes with peaks closer to the observed precipitation maxima. The following 6 cases of severe weather events show a big difference between forecast and observed precipitation.

Case studies	Forecasted Precipitation	Observed precipitation
23 april 2016 Toscana (Castelfiorentino) HRES underestimation 45,21mm/24h forecast 148mm/<24h observed		
2 may 2016 Puglia HRES and ENS overestimation 117mm/24h forecast 50mm/24h observed		
1 June 2016 Piemonte HRES overestimation 50mm/6h forecast 20-25mm/6h observed		
3 June 2016 Liguria HRES underestimation 45,21mm/24h forecast 178mm/24h observed		
26 June 2016 Lombardia (Bergamo) HRES underestimation 21mm/6h forecast 78,4mm/6h observed		

31 July 2016 Lombardia HRES&ENS underestimation 3mm/6h forecast 50mm/6h observed 59mm/24h forecast 100mm/24h observed		

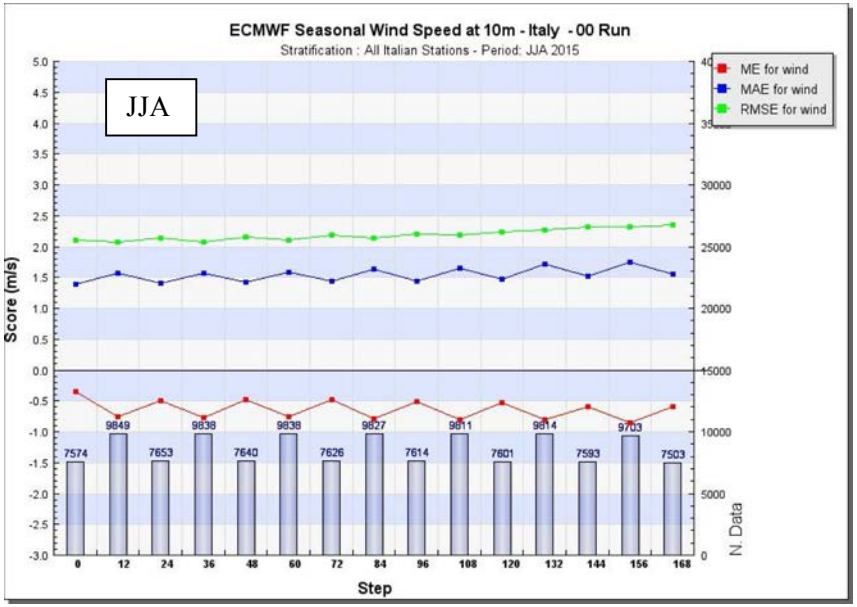
4. Feedback on ECMWF "forecast user" initiatives

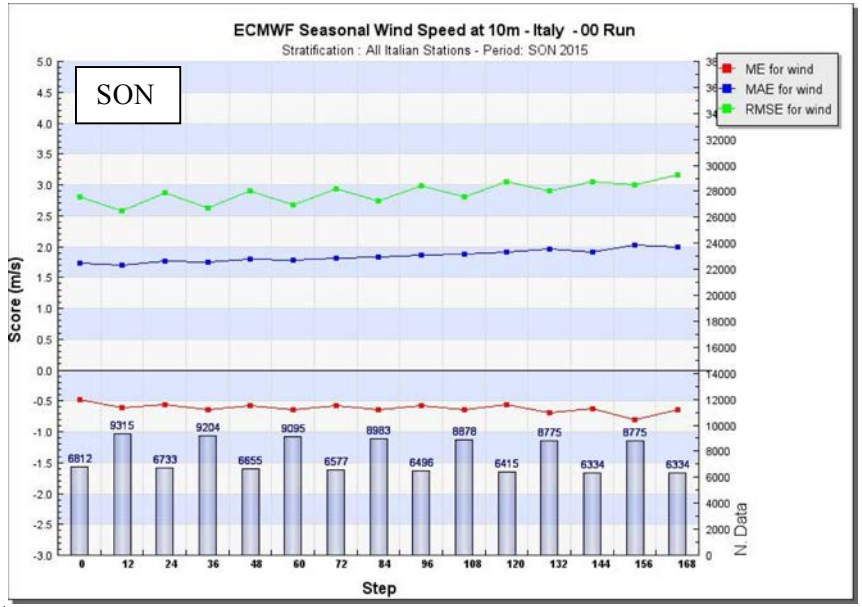
Please comment on whether you use the following, on how useful you find them, and on any changes you would like to see. The "known IFS forecast issues" page –(see: https://software.ecmwf.int/wiki/display/FCST/Known+IFS+forecasting+issues) and the "severe event catalogue" (see: https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue).

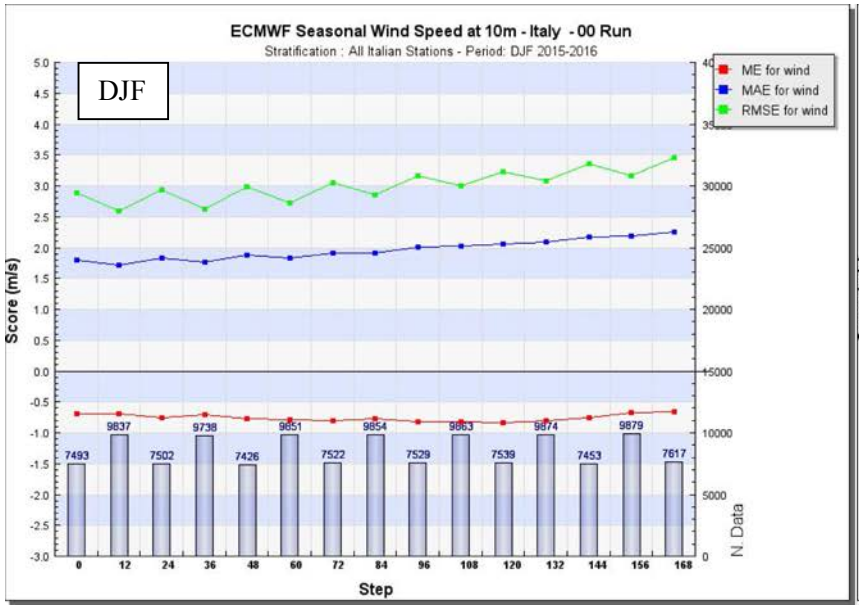
Both pages are very interesting and useful, but it is not so easy to find them on the website www.ecmwf.int.

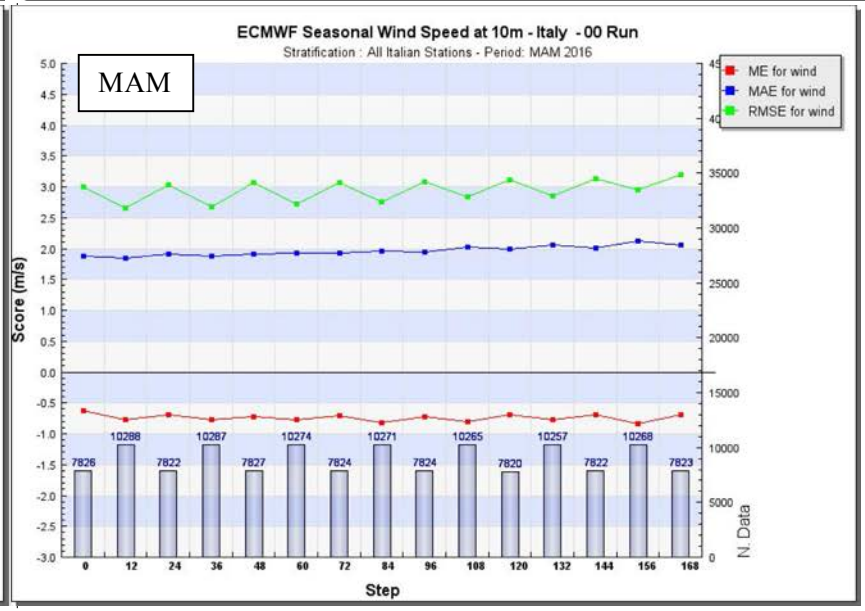
5. References to relevant publications

APPENDIX 1

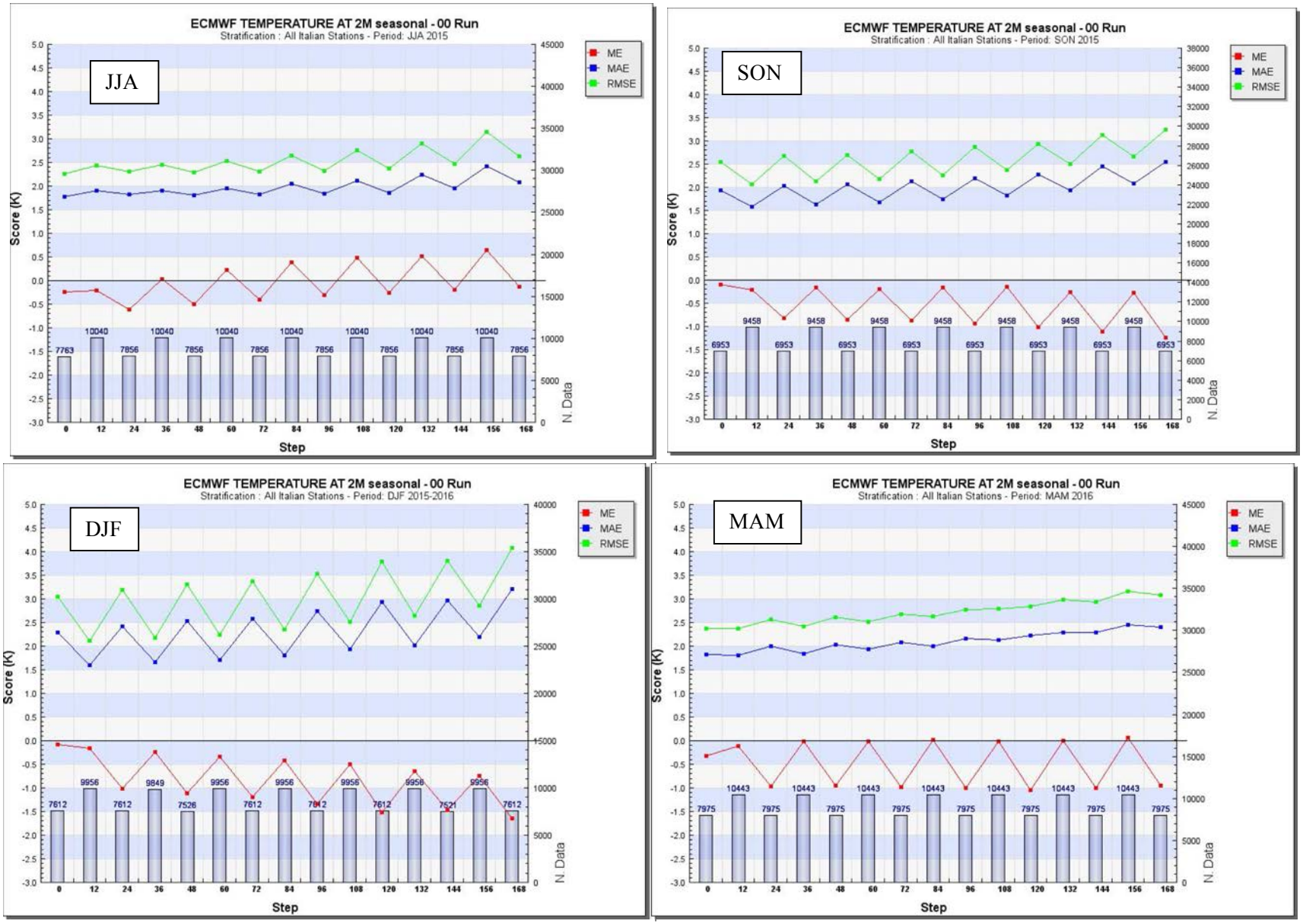




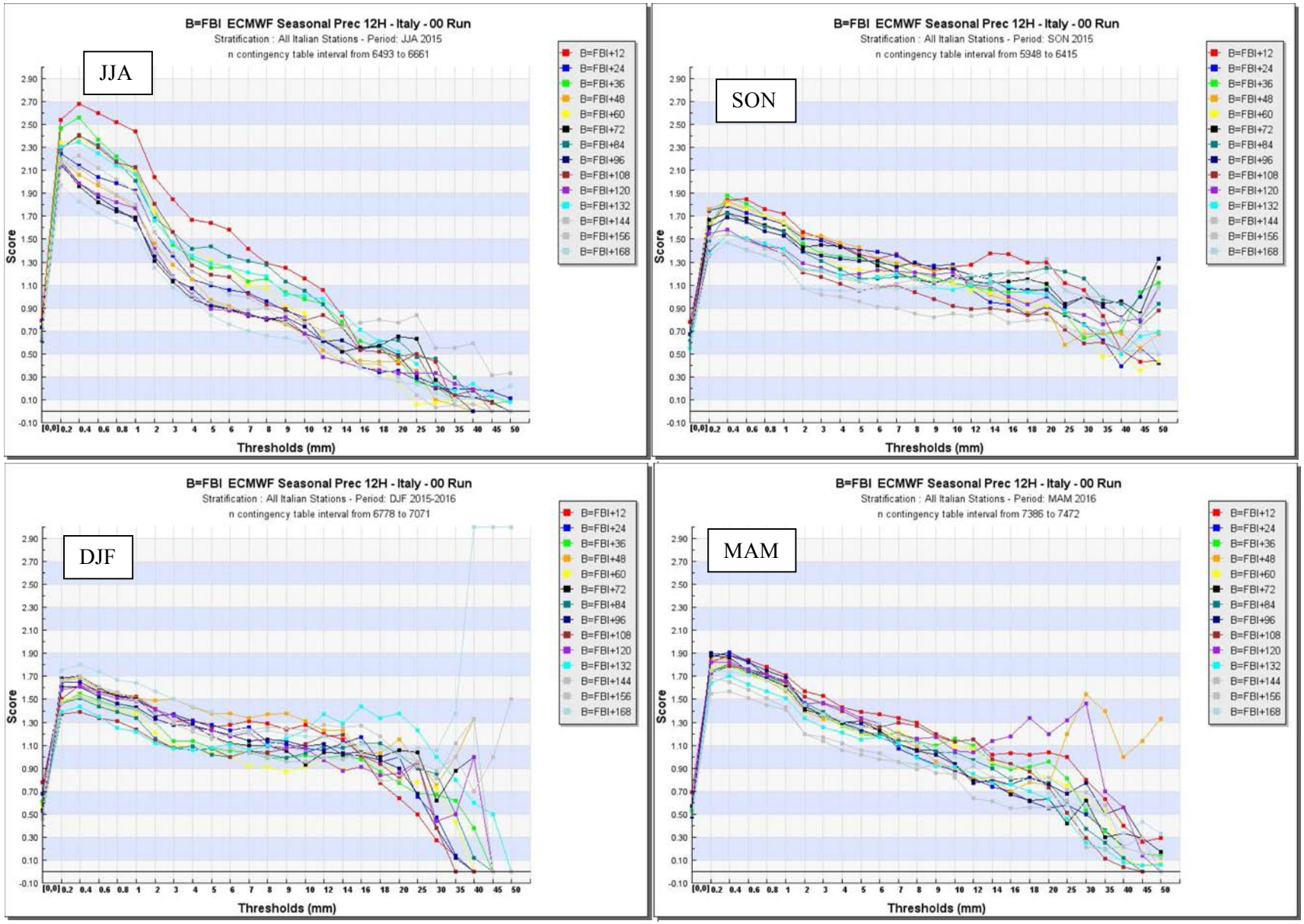




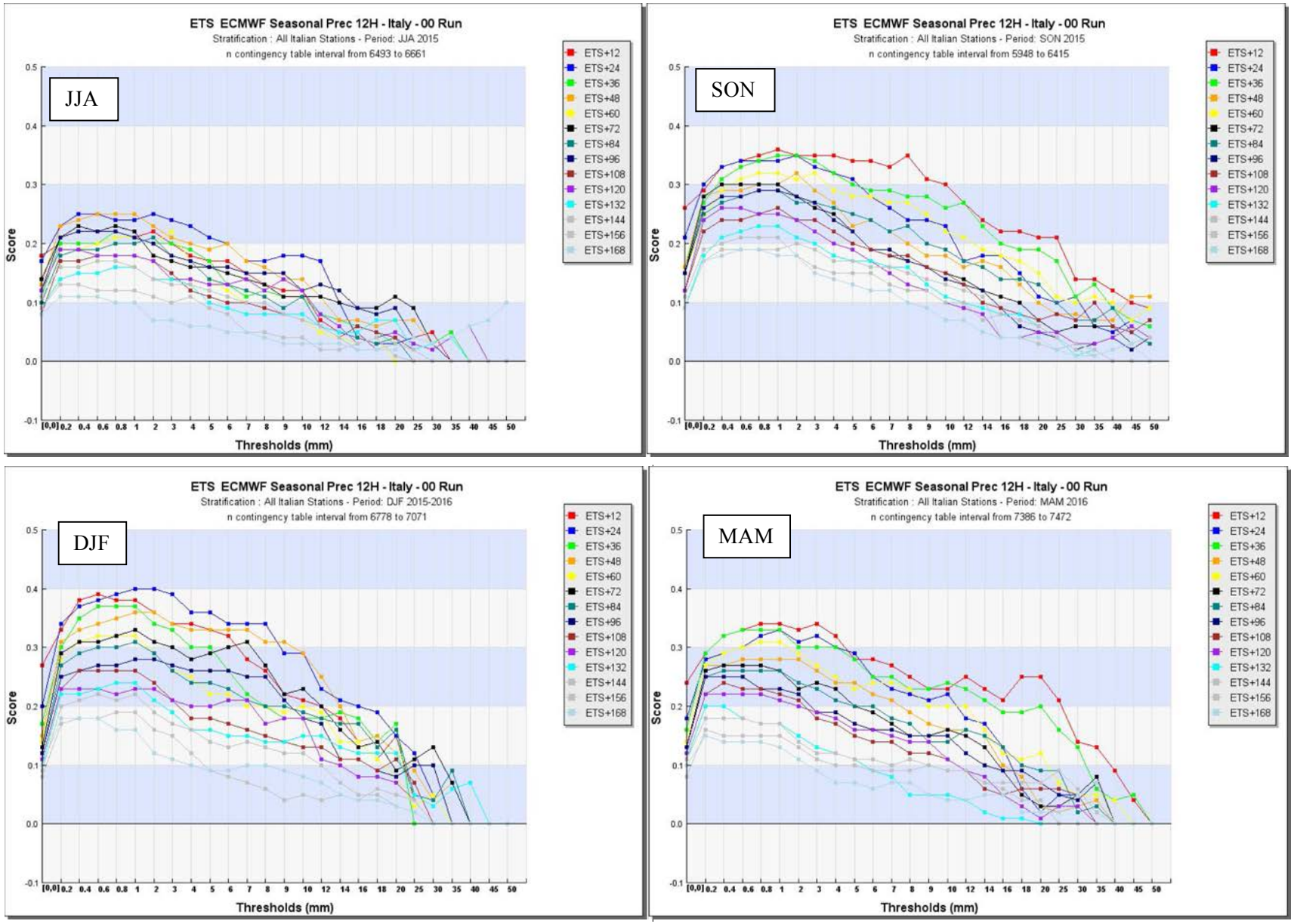
IFS 10mWindSpeed(Mean AbsoluteError,Mean Errorand Root MSE)



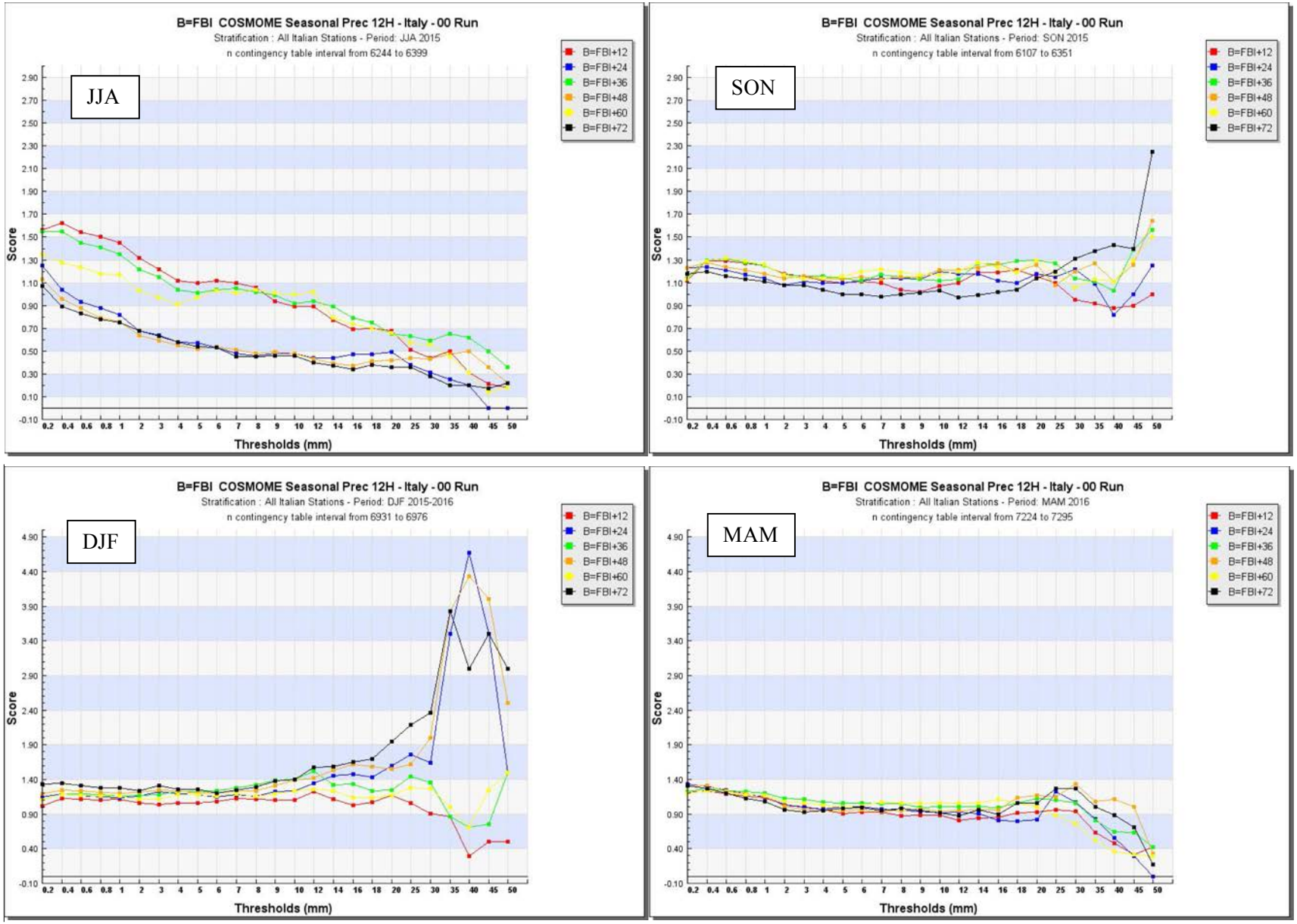
IFS T2m(Mean AbsoluteError,Mean Error,RootMSE)



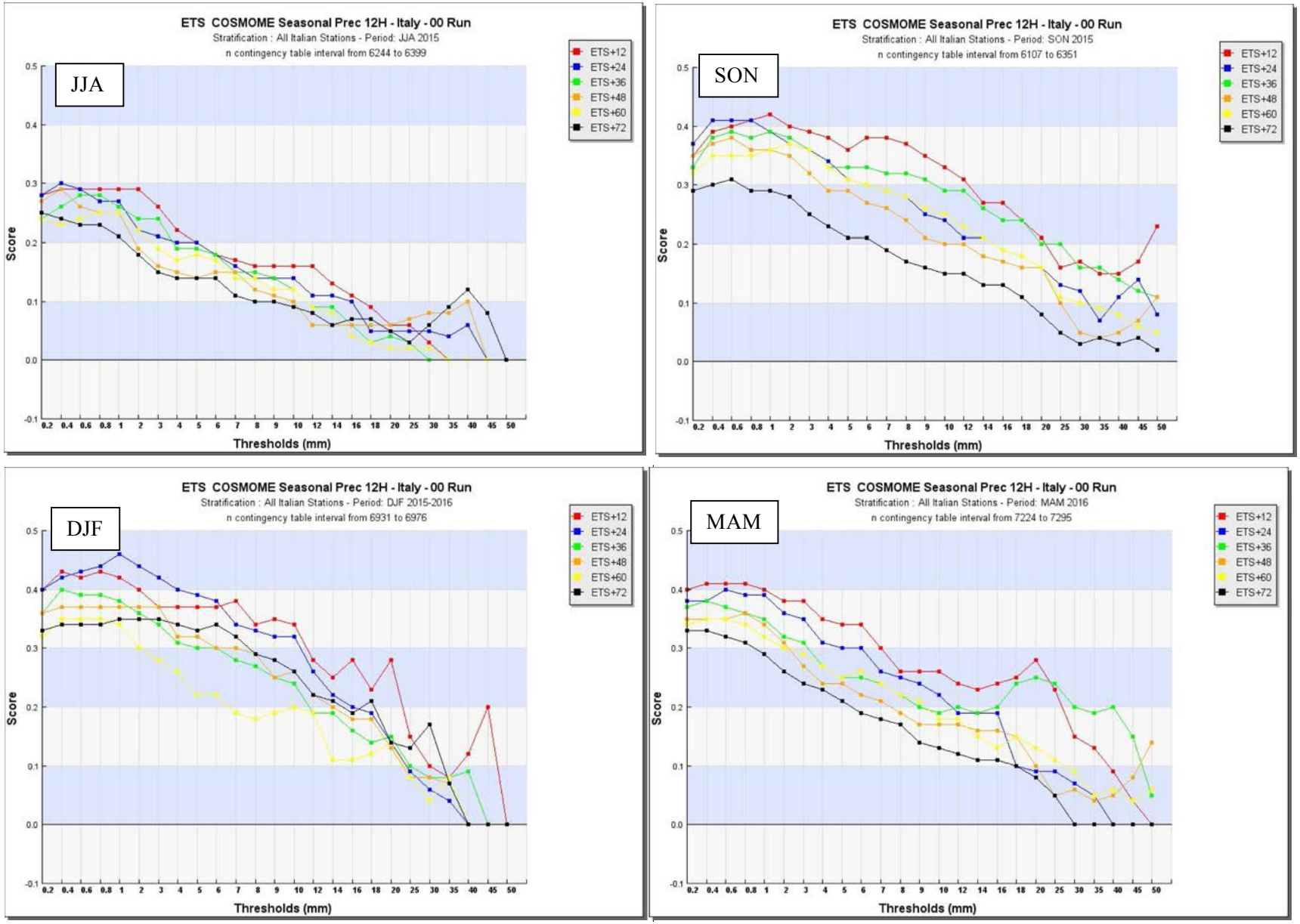
IFSPrecipitationin12 hours -FBI score



IFSPrecipitationin12 hours -ETS score



COSMO-ME Precipitationin12hours -FBI score



COSMO-ME Precipitationin12hours -ETS score