Application and verification of ECMWF products 2013

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1. Summary of major highlights

- The COSMO local model initialized with IFS deterministic model had the lowest average RMSE for temperature forecast compared with all the other models used by the IMS (GME, GFS, UKMO, IFS, HRM, COSMO and WRF).

- ECMWF deterministic runs are used to issue automatically fire danger indices after 7 day running average bias correction.

- Nowcasting is performed by INCA (Integrated Nowcasting through Comprehensive Analysis) based on IFS forecasts together with automatic station data from Israel.

- The system 4 hit score for DJF precipitation and JJA temperature for Israel is both 57%. For large areas in the Mediterranean basin the hit score is lower than would obtain by a random forecast (33.3%). The DJF 2012/13 forecast indicated above-normal conditions as was truly observed. On the other hand, the JJA temperature forecast indicated above-normal conditions while the observed was around normal.

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

IFS forecasts for 2m temperature, 2m humidity, 10m wind are corrected with the last 7 days running bias. The results together with cloudiness, precipitation amount and duration, are ingested to the US National Fire Danger Rating System (NFDRS). This system is used to provide a measure of the relative seriousness of burning conditions and the threat of fire. We created IC (Ignition Component) and BI (Burning Index) previous 3 years climatology. Then we defined "high" as the highest 10% of the values and "extreme" as the highest 2% of the values. Comparing daily IC and BI forecasts to their "climatic" values provides forecasted maps of fire probability (fig. 1).

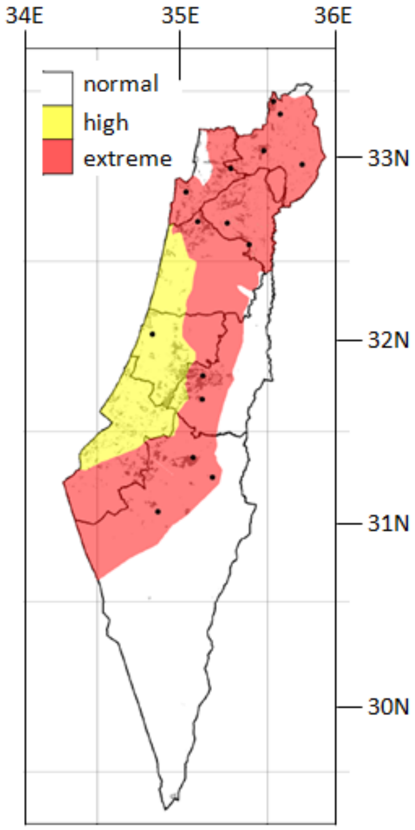


Figure 1 The forecasted fire probability over Israel on May 30, 2013 (extremely hot and dry day). Red indicates extreme risk with weather condition probability that occur less that 2% during the summer time. Yellow indicates high risk with probability of less than 10%. White indicates low fire risk.

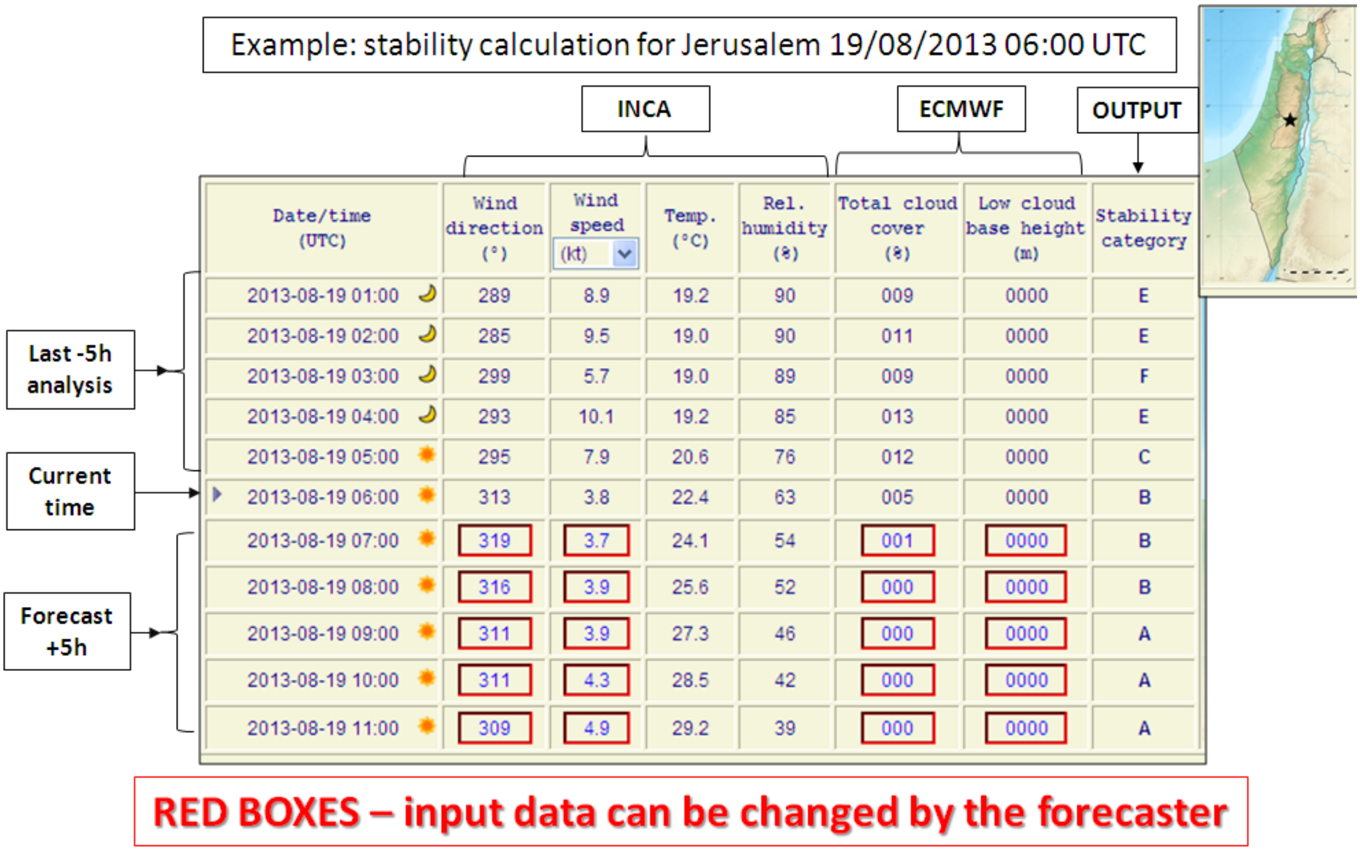
2.1.2 Physical adaptation

a. ECMWF deterministic model output is ingested to INCA (Integrated Nowcasting through Comprehensive Analysis) high resolution (1 km) nowcasting system (Haiden et. al. 2011) together with 81 meteorological stations.

b. The short-range forecasting non-hydrostatic model COSMO (www.cosmo-model.org) is tested with two domains. The first is of 7 km which is driven by the ECMWF global model IFS and second is 2.8 km resolution.

2.1.3 Derived fields

An interface was developed to display meteorological fields for every point in the INCA model domain over Israel. An example of the interface is presented in Fig. 2.0



Date/time (UTC)	Wind direction (°)	Wind speed (kt)	Temp. (°C)	Rel. humidity (%)	Total cloud cover (%)	Low cloud base height (m)	Stability category
2013-08-19 01:00	289	8.9	19.2	90	009	0000	E
2013-08-19 02:00	285	9.5	19.0	90	011	0000	E
2013-08-19 03:00	299	5.7	19.0	89	009	0000	F
2013-08-19 04:00	293	10.1	19.2	85	013	0000	E
2013-08-19 05:00	295	7.9	20.6	76	012	0000	C
2013-08-19 06:00	313	3.8	22.4	63	005	0000	B
2013-08-19 07:00	319	3.7	24.1	54	001	0000	B
2013-08-19 08:00	316	3.9	25.6	52	000	0000	B
2013-08-19 09:00	311	3.9	27.3	46	000	0000	A
2013-08-19 10:00	311	4.3	28.5	42	000	0000	A
2013-08-19 11:00	309	4.9	29.2	39	000	0000	A

Figure 2 Meteorological parameters observed and forecasted for a given location.

2.2 Use of products

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

<u>Introduction</u>

Israel has a Mediterranean climate with long, warm, rainless summers and relatively short, mild, rainy winters. The characteristics of the Israeli Climate are caused by Israel's location between the subtropical arid areas of the Sahara and the Arabian deserts, and the subtropical humid areas of the Levant and Eastern Mediterranean. The climate conditions are highly variable within the state and dependent locally on altitude, latitude, and the proximity to the Mediterranean Sea.

The ECMWF verification analysis was performed over the period Jan 1, 2012 – Dec 31, 2012 for two metrological stations: Bet Dagan (near Tel Aviv) and Jerusalem. These two stations represent the Israeli Mediterranean climate region. Bet Dagan climate is highly affected by the sea, whereas Jerusalem climate is affected by both the sea and the topography of the central highlands. At the next table we summarize the characteristics of these two stations:

	Longitude	Latitude	Height (m)	Distance from the coast (km)	Distance from nearest grid point (km)	Height of the nearest grid point (m)
Bet Dagan	34.814E	32.007N	35	7.6	5.81	63.8
Jerusalem	35.197E	31.770N	765	50.6	5.49	544.3

The verification analysis was performed for the meteorological parameters: temperature (at 2 meters), wind (at 10 meters) and precipitation (accumulated over 6 hours). Figures 3,4,5 present the Mean Bias Error (MBE, calculated as Forecast - Observed) and the Root Mean Square Error (RMSE) as function of the forecast range of the ECMWF (12 GMT + 0 hours till 12 GMT + 240 hours, with time steps of 6 hours). MBE and RMSE are presented by dashed and solid lines, respectively.

a. Temperature forecast verification

Temperature forecast verification is presented on Fig. 3.

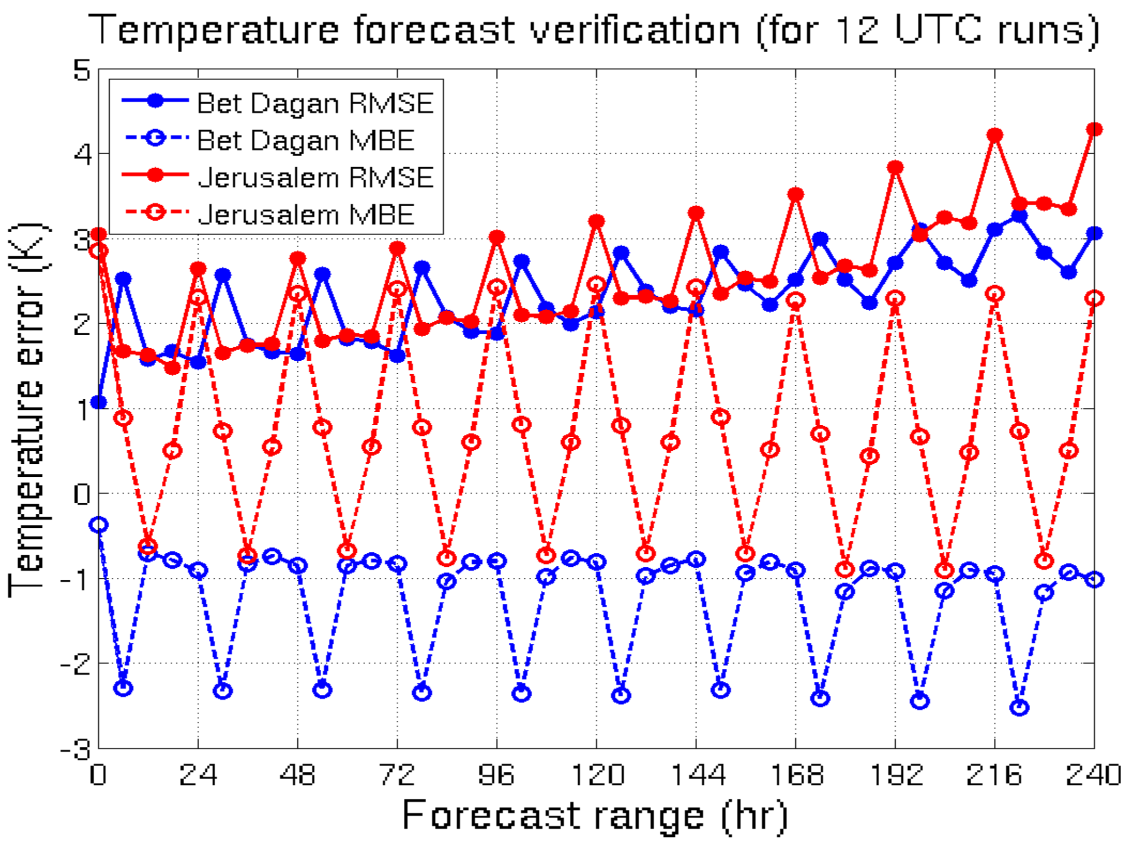


Figure 3 Temperature forecast verification of ECMWF for Bet Dagan (near Tel Aviv) and Jerusalem for period 1.1.2012 –31.12.2012, based on 12Z runs.

One can see that for Bet Dagan there is a negative bias of about about 1°C for 12Z, 00Z and 6Z. For 18Z the bias is more than 2°C, perhaps due to the rapid change during the sunset. As expected, the RMSE increases with the forecast range, from about 2°C to 3-4°C. For the long forecast range the RMSE for Bet Dagan, is better than for Jerusalem. It might be of an interest to mention that in both scores (MBE and RMSE) there are oscillations as a function of the forecast hour. In Jerusalem these oscillations are more significant, and one can obviously see that at noon (12Z) the errors are larger than at night (0Z).

b. Wind forecast verification

Wind forecast verification is presented in Fig. 4. For each forecast range the wind speed error

$$|\vec{W}|_{forecast} - |\vec{W}|_{obs}$$

was calculated during the entire period. MBE and RMSE were obtained for each of the two stations (Bet Dagan and Jerusalem).

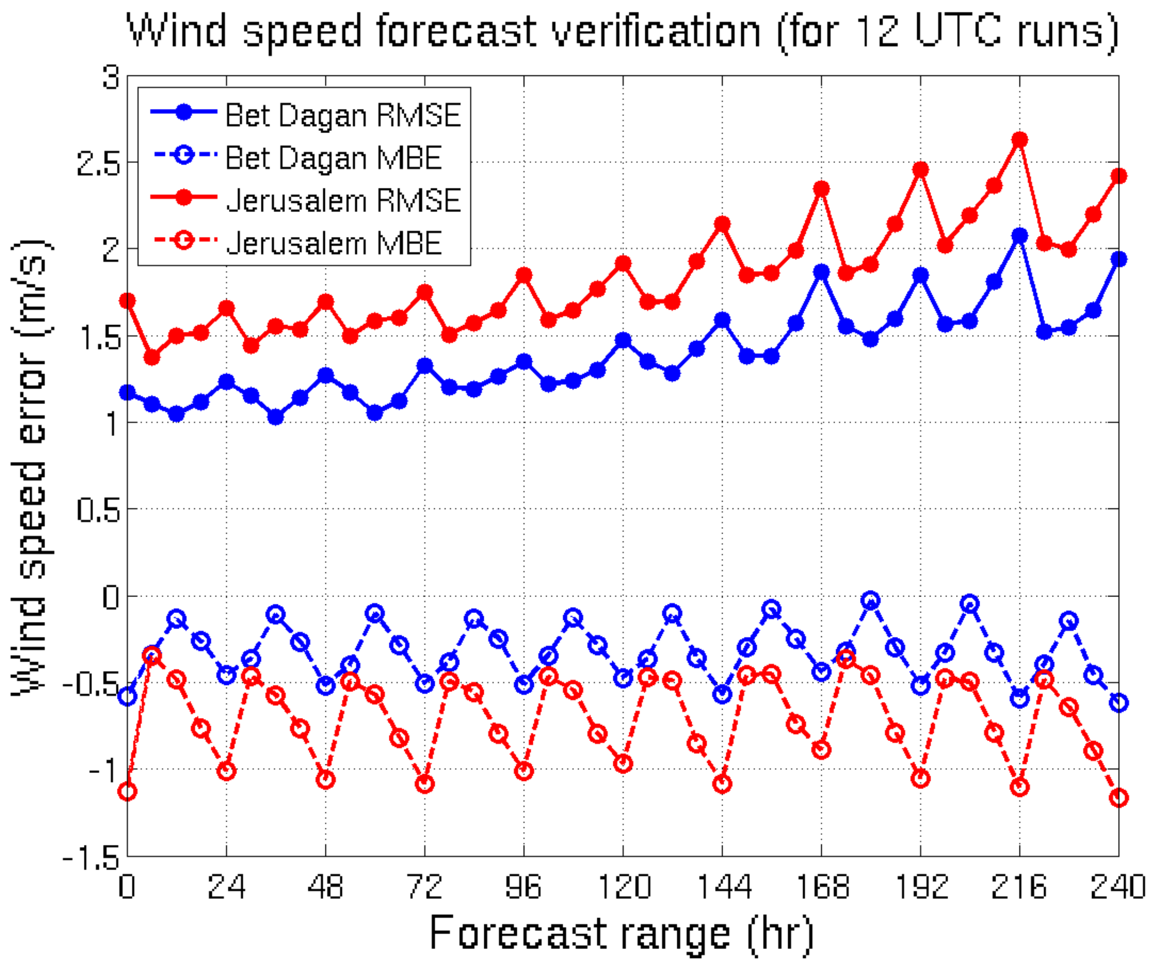


Figure 4 Wind forecast verification of ECMWF over Israel for the period 1.1.2012 –31.12.2012, based on 12Z runs.

There is a negative bias in the wind speed for Bet Dagan 0-0.5 m/s and for Jerusalem 0.5-1 m/s. The RMSE is increasing with the forecast range: in Bet Dagan from ~1 m/s to ~2 m/s after 10 days; in Jerusalem from ~1.5 m/s up to 2.5 m/s after 10 days. Again, it could be explained by the coarse representation of the height of Jerusalem. Interesting to mention, that as in Fig. 3, in both scores (MBE and RMSE) there are diurnal oscillations. During the day (12Z) there is a systematic bias as the modelled wind is about 0.5-1 m/s weaker than the observed one. During the night (00Z) the bias is smaller, and the RMSE is smaller as well.

c. **Precipitation forecast verification**

Precipitation forecast verification is presented on Fig. 5. For each forecast range we have calculated the error $P_{forecast} - P_{obs}$ of the accumulated precipitation over the last 6 hours (from the previous forecast range to the current), during 2012. Note that over Israel, most of the year there is no precipitation, and the precipitation forecasts show zeros. Therefore, in order to reflect the precipitation forecasts quality, we have ignored periods where both $P_{forecast}$ and P_{obs} are less than 0.5mm/6hr.

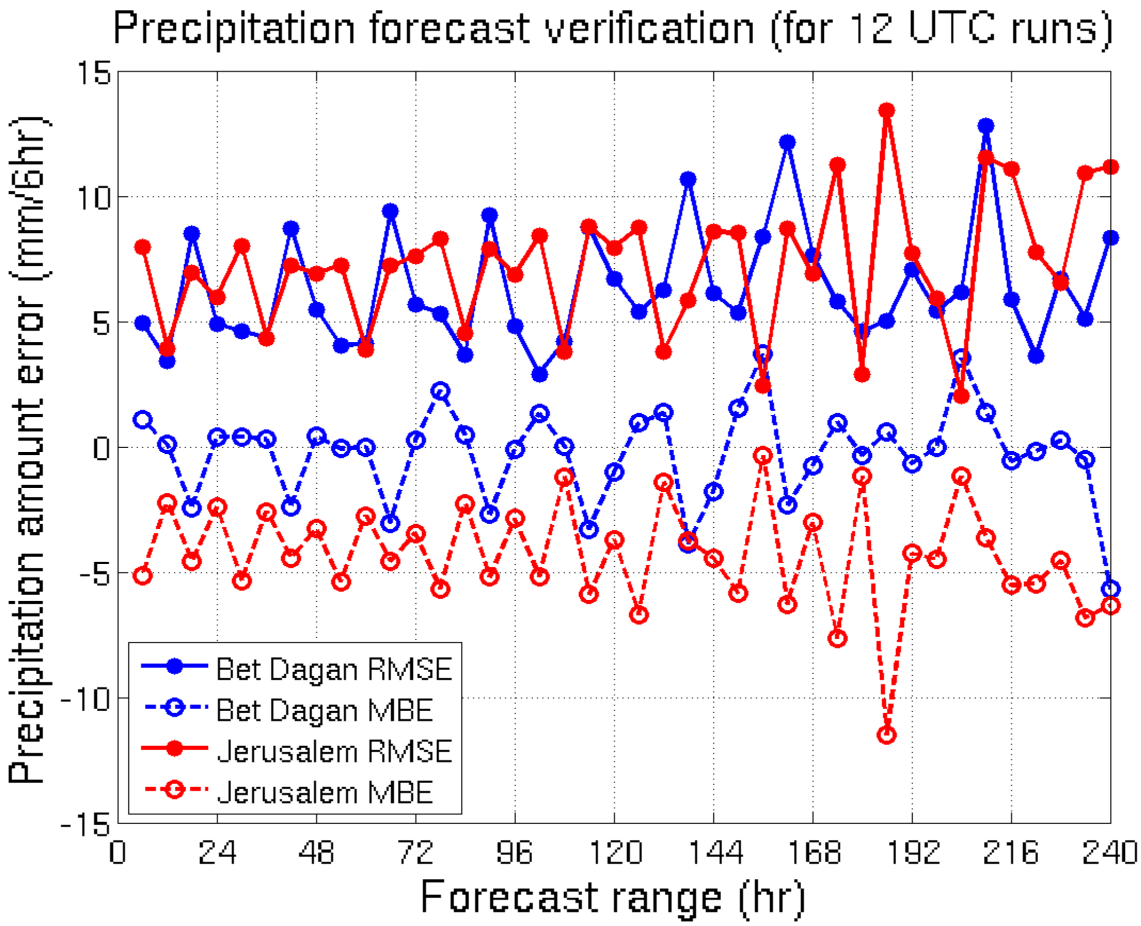


Figure 5 Precipitation forecast verification of ECMWF over Israel for the period 1.1.2012 –31.12.2012, based on the 12Z runs.

The total precipitation predicted by ECMWF at Bet Dagan for the 2012 was 690 mm, and the measured value was 641 mm, which is rather similar. On the contrary, over Jerusalem, the total predicted value was 320 mm while the measured value was 583 mm. The under-prediction of ECMWF precipitation over Jerusalem could be again explained by the coarse resolution. Moreover, major part of the cloudiness over Israeli central and north highlands as Jerusalem are orographic. Unfortunately, orographic convection is forecasted as a sub-grid process in ECMWF so that the current resolution may be too coarse.

d. System 4 Seasonal verification

Fig. 6 shows DJF precipitation hit score of ECMWF system 4 hindcast (1981-2010), in the Mediterranean basin. The hit score is the percentage of correct tercile forecasts as compared to the observed tercile obtained from the ERA-interim dataset. Comparing the results of the prediction to the 33.3% value of a random forecast reveals large areas without skill. Nevertheless, there are islands of significant positive hit score (i.e. > 42%) as the South-East Mediterranean and Adriatic coast.

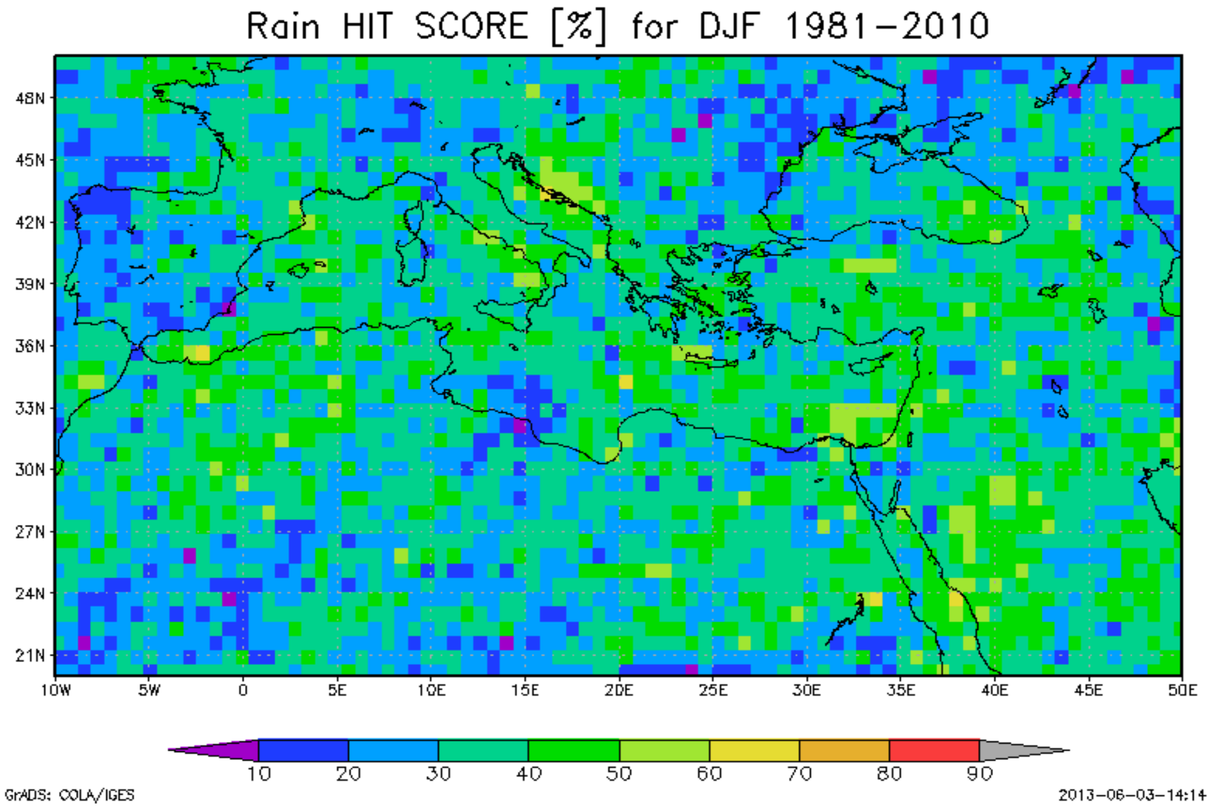


Figure 6 DJF precipitation hit score of ECMWF system 4 hindcast, based on ERA-interim data in the Mediterranean basin. The forecast lead-time is one month (from November).

3.1.2 ECMWF model output compared to other NWP models

Here we present the temperature (at 2m) verification analysis of 8 models run/received at IMS:

- IFS 0.125NX0.125E degrees resolution,
- UKMO 0.833NX0.555E degrees resolution (as received in IMS),
- COSMO-ME (Italy) 0.0625NX0.0625E resolution (boundary and initial conditions – ECMWF)
- GFS 1NX1E degrees resolution (as obtained in IMS),
- WRF 0.11NX0.11E degrees resolution (boundary and initial conditions - GFS),
- COSMO-IL 0.0625NX0.0625E degrees resolution (boundary and initial conditions - GME),
- HRM 0.125NX0.125E degrees resolution (boundary and initial conditions - GME),
- GME 0.36NX0.36E degrees resolution (as obtained in IMS).

Figs. 7 and 8 present the 2012 Root Mean Square Error (RMSE) as function of the diurnal time, for Bet Dagan and Jerusalem stations, respectively. The 4 time groups, are:

00Z - averaging RMSE obtained for 12UTC + 12h and 12UTC + 36h forecasts

06Z - averaging 12UTC + 18h and 12UTC + 42h results,

12Z - averaging 12UTC + 24h and 12UTC + 48h results,

18Z - averaging 12UTC + 30h and 12UTC + 54h results.

The higher resolution of the COSMO model is reflected in a lower average RMSE compared to the IFS especially is the mountainous station of Jerusalem. The COSMO-ME model which is initialized with IFS and includes data dissimilation has a better average RMSE score compared to the COSMO_IL initialized with GME data.

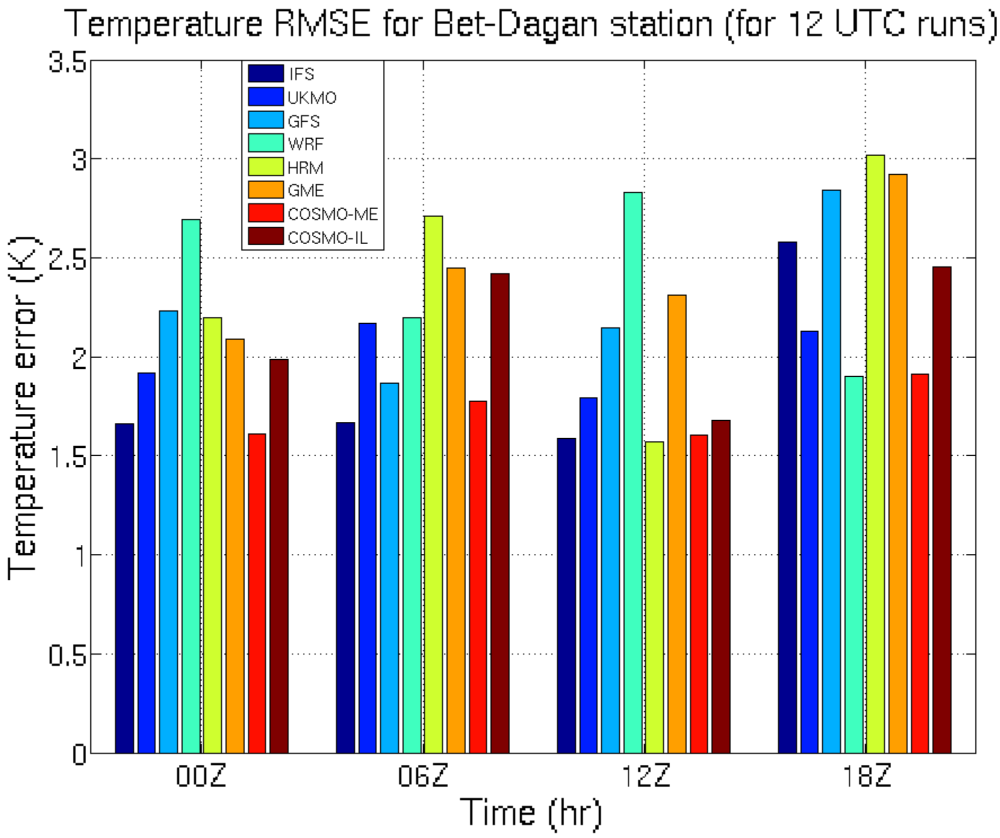


Figure 7 Temperature RMSE verification of 8 IMS models at Bet Dagan (near Tel-Aviv) for the period 1.1.2012 –31.12.2012, based on the 12 UTC runs.

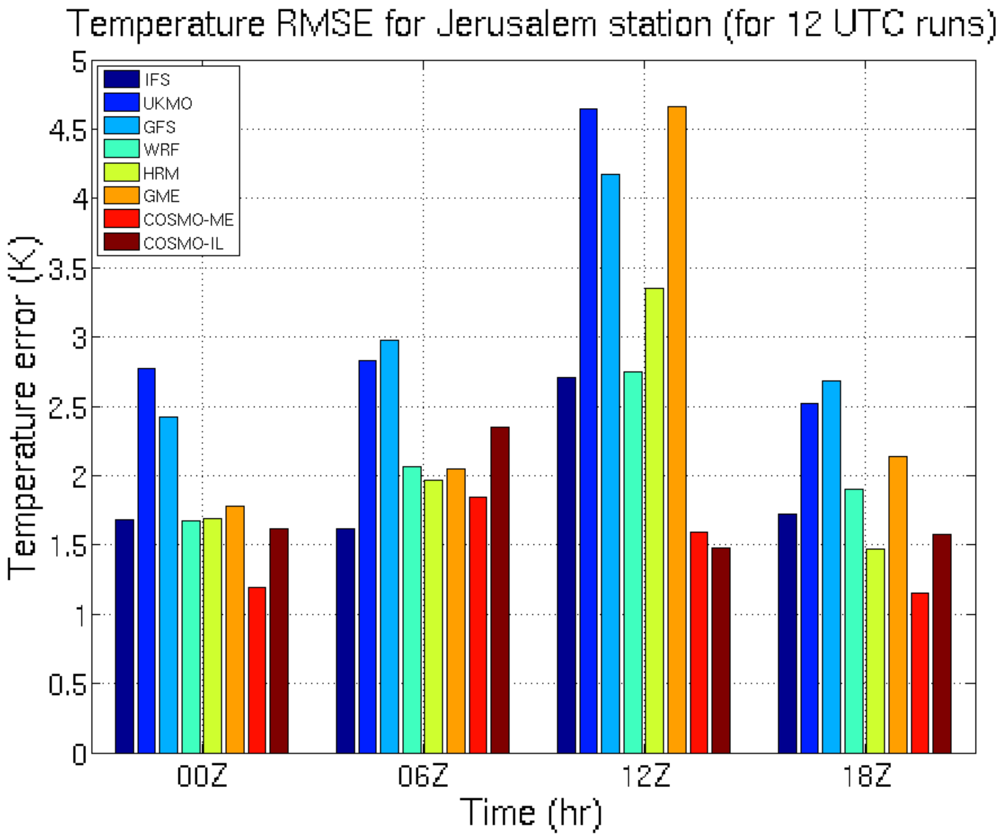


Figure 8 Temperature RMSE verification of 8 IMS models at Jerusalem for the period 1.1.2012 –31.12.2012, based on the 12 UTC runs.

3.1.4 End products delivered to users

3.2 Subjective verification

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

3.2.2 Synoptic studies

4. References to relevant publications

Haiden, T., A. Kann, C. Wittmann, G. Pistotnik, B. Bica, C. Gruber, 2011: The Integrated Nowcasting through Comprehensive Analysis (INCA) System and Its Validation over the Eastern Alpine Region. *Wea. Forecasting*, **26**, 166–183.