Application and Verification of ECMWF Products 2019

Israel Meteorological Service (IMS)

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1. Summary of major highlights

- ECMWF HRES and ENS low clouds (LCC, CBH and Ceiling) were verified using ceilometer --- very poor correlation was found.
- DJF 2018-2019 seasonal precipitation forecast successfully predicted a wet season (89th percentile) based on November model. The forecast model allocated 63% for the above-normal tercile. Seasonal forecast for temperature is skillful. However, the main source of predictability is the warming since 1981 due to climate change.
- Some of the main issues with ECMWF products we experienced during the past year were already reported in last year's report. These are:
    1. Insufficient penetration of precipitation inland
    2. Coastal stratus too low
- New/modified products and tools are requested. The list in sec. 4 covers seasonal forecast, long range forecast climagrams, global radiation forecasts, ERA5, time-lag high spatial resolution ensemble, ecCharts and Dashboard, postage stamps, air parcel trajectory tool, cloud services.

Most of the above highlights are described below. They were presented in much more details at the 2019 ECMWF Liaison Visit to the IMS on April 7-8, 2019. They also were reported in ECMWF's survey in advance of the UEF2019 meeting.

2. Use and application of products

2.1 Direct Use of ECMWF Products

The main use of ECMWF products is to provide guidance for the medium forecast range. The various output fields are made available to the forecaster. EPSgrams are a main tool used routinely by the forecasters in the daily work. EFI and/or probability of crossing thresholds are often used when significant weather event is expected. All of them are very useful. The forecasting aspects that relate to ECMWF model outputs that are of particular concern to us are: 1) Temp. & wind forecasts - used as the main input to our public website; 2) Boundary conditions - used for local area model (COSMO); 3) Rain forecasts -

used to derive the hydrological models; 4) Aviation forecasting - visibility, low ceiling, turbulence, icing, lightning; and 5) Flash floods - especially convective events over small catchments.

2.2 Other uses of ECMWF output

2.2.1 Post-processing

a. Time-lagged-ensemble (TLE) of precipitation is formed from consecutive deterministic forecasts of IFS and COSMO (sec. 2.2.3b). For various thresholds of 6 hourly accumulated precipitation, probability maps are generated. These maps, which represent the forecasted probability to exceed given thresholds, are provided to the forecasters and routinely verified against rain analysis maps (sec. 3.1) using the Fractional Skill Score [Roberts and Lean, 2008]. Verification shows an added value of TLE with respect to most recent deterministic forecast for both IFS and COSMO.

b. IFS global radiation based on accumulated SSRD and STRD fields is being used for calculating UV Index twice a day operationally. Future plans include using CAMS UV Index product.

c. CAMS dust products are used to generate tailored maps and vertical cross section for operational use.

2.2.3 Modelling

a. ECMWF HRES model output is ingested to INCA (Integrated Nowcasting through Comprehensive Analysis) high-resolution (1-km) nowcasting system (Haiden et. al. 2011) together with data from 81 meteorological stations. INCA (from ZAMG) together with automatic station data yield a corrected analysis and nowcasting up to 6 hours.

b. The COSMO (www.cosmo-model.org) short-range non-hydrostatic model is running operationally with a 2.8 km resolution, driven by IFS HRES model as hourly boundary conditions.

3. Verification of ECMWF products

3.1 Objective verification

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

a. Precipitation

ECMWF has recently performed verification of the IFS precipitation fields using the IMS INCA's rain modules analysis maps. Both the HRES operational and the 4-km experimental products were evaluated using several case studies (Fig. 1).

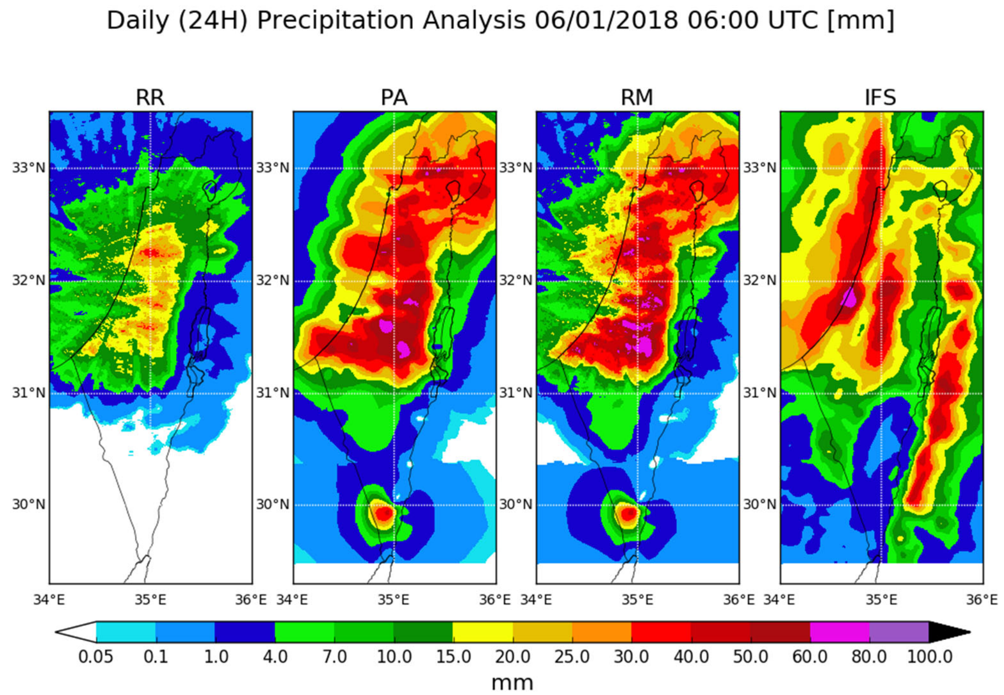

Fig. 1 Comparison of 24-hr rain accumulations over Israel starting on 06-Jan-2018 at 0600UTC. From left to right: Radar-only (RR), IDW interpolated gauge data (PA), gauge-adjusted radar (RM), operational HRES (IFS), and experimental HRES (IFS 4km).

b. Clouds

ECMWF HRES and ENS low clouds (LCC, CBH and Ceiling) were verified using Bet Dagan ceilometer for Jan through May 2018 data. IFS Cycle 43r3 was used. According to ECMWF's Summer 2018 Newsletter, the 45r1 performance got worse for total cloud cover. Lead time between 24 and 83 hours were analyzed. Correlation between the ceilometer ceiling and the model forecast ceiling (HRES and Control) was found to be very poor (e.g., Fig. 2).

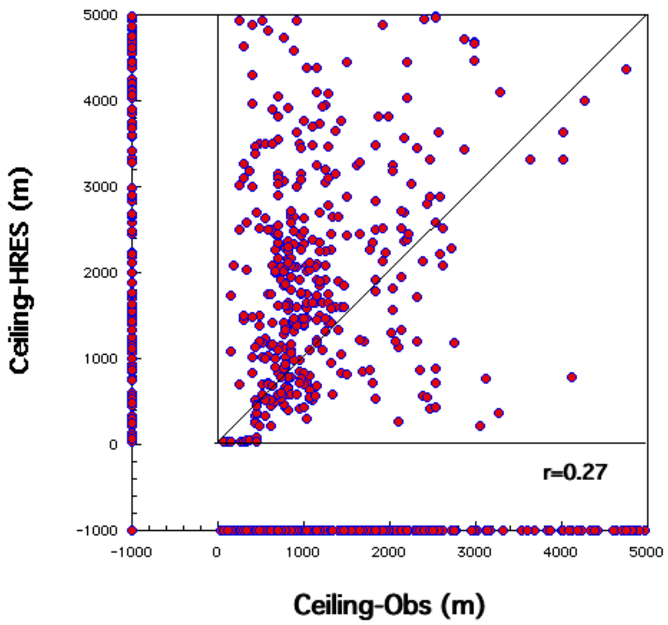

Fig. 2 Comparison of HRES and ceilometer ceiling. Each dot represents an hourly ceilometer data centered at the model forecast time. Period represented: Jan through May 2018. Ceilometer is located near model grid center. Clear sky and values above 5000 meters are represented by a value of -1000m. Correlation coefficient is calculated for positive values.

Very poor correlation coefficients (0.2-0.3) were also found between the model ceiling values and the ceilometer CBH values for different ceilometer-based cloud cover fractions. Special attention was given to low ceiling (500-3000 ft), which are important for aviation. Contingency tables for observing/forecasting ceiling below a given height were generated for HRES, Control and ENS forecasts. Contingency tables for ENS data were generated for several forecast probability thresholds. I.e. an event of ceiling below a given threshold was defined as "forecast yes" if the probability was above a given threshold (e.g., 80%, 60%, 40%, 20% and 0%). Contingency tables for low ceiling yield very low probability of detection (POD) and success ratio (SR) values. POD, SR and critical success index (CSI) values for ceiling<2000ft, as an example, are shown on a Performance Diagram (Fig. 3). The poor ability of the forecast to discriminate between events and non-events is shown by a Resolution Diagram in Fig. 4. Reliability diagrams for testing how well the predicted probabilities correspond to their observed frequencies were generated (not shown). While very low Brier Scores values were derived, forecasting the ceilometer-based climatology yield even lower (i.e., better) values. Results did not improve upon changing lead times. The low values were due to many correct negatives / rare events.

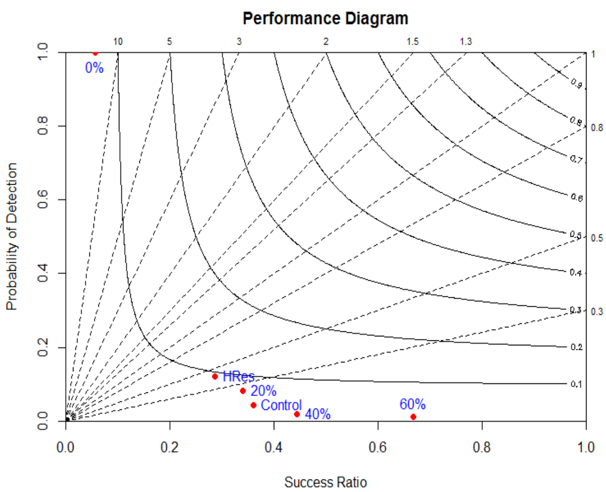

Fig. 3 Performance diagram for ceiling<2000ft. POD, SR (=1-FAR) and CSI values were calculated from HRES, Control and ENS forecasts. An event is defined as "forecast yes" if the ENS probability is above a given threshold (e.g., 80%, 60%, 40%, 20% and 0%). Event observance is based on hourly ceilometer data centered at the model forecast time. Ceilometer is located near model grid center. Period represented: Jan through May 2018.

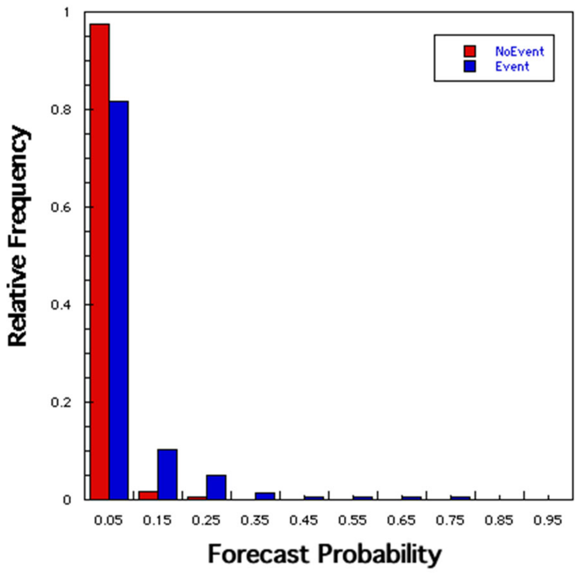

Fig. 4 The distribution of the forecast probability for ceiling<2000ft when events and no-events were observed. Event observance is based on hourly ceilometer data centered at the model forecast time. Ceilometer is located near model grid center. Period represented: Jan through May 2018.

3.1.3 Monthly and Seasonal forecasts

Analysis of DJF 2018/19 and JJA 2018 seasons

The SEAS5 (Sys5) DJF 2018/19 averaged precipitation forecast over Israel (five grid points in Northern Israel) assigned 63% chance for the "above normal" tercile, 27% for the "normal" tercile, and 10% for the "below normal" tercile, and was located in the 99.9th percentile of 1981-2010 distribution.

DJF 2018/19 average precipitation for the Mediterranean climate region in Israel (above 200 mm/yr) was 459.6 mm. This value is above the 1981/82-2010/11 average by 38.4%, above the median by 55.1%, and resides in the 89.3 percentile of the precipitation distribution. Hence, DJF 2018/19 resides in the "above normal" tercile, yielding a positive Rank Probability Skill Score (RPSS = 0.74), (Table 1).

The Temperature forecasts are skillful. However, the main source of predictability is the warming since 1981 due to climate change.

Table 1: Verification summary of the seasonal forecast for Israel

	temperature			**precipitation**		
	Observed	ECMWF forecast	RPSS	Observed	ECMWF forecast	RPSS
DJF 2018/19 (SEAS5)	above normal	59% above normal 33% ~normal 8% below normal	0.69	above normal	63% above normal 27% ~normal 10% below normal	0.74
JJA 2018 (SEAS5)	above normal	71% above normal 27% ~normal 2% below normal	0.85	Dry season		

4. Requests for additional output

- Seasonal forecast - Once a month update is not good enough. Often, the forecast is not consistent with the previous forecast and hence there is no confidence in the result. Sometimes after a week, a long-range run yields a totally different scenario then the previous run. Thus, one should consider the possibility of running the extended weekly runs to 4 months range (instead of only 1.5 month). In order not to consume too much computer resource, these runs can be run with a smaller ensemble size after day 45.

- Long range forecast climagrams - Additional geographic area is required: Eastern Mediterranean (or alternatively: South-East Europe).

- Global radiation forecasts - More frequent calls to radiation scheme, dissemination of both instantaneous value of incoming radiation and of hourly average for the entire range of the IFS run (not only for the first 90hr).
- ERA5 reanalysis for the years 1950-1979 will be of great value for climate change research.
- Resolution of the ensemble is rough relative to the abrupt changes in topography and coast line in Israel. Most population lives very close the sea shore and influenced by the sea breeze and the exact location of the coast is of high importance. The Judea hills are short distance (20km) to the dead sea with a drop from +900 to -400m. The strategic plan of ECMWF to reach an ensemble of 5km runs is highly supported by us. And yet, due to our country very small geographic scale, we find value in higher resolution models. A time-lag high spatial resolution ensemble may be of higher value than lower resolution coarser model.
- ecCharts – Request for 1) an option to remove the probe (once it is selected, it cannot be removed), 2) an option to manually change the contour spacing in all parameters, 3) an option to change the contour-label size, 4) an option for generating vertical cross section between two user defined coordinates for different parameters (e.g., temp, humidity, wind vectors), and 4) adding extra-tropical frontal features (fronts, cyclone centers etc.). See also last year report for a list of EcCharts interface modification requests, and for new web tool/interface requests.
- Dashboard - Animation control is too small, and should appear near Validity time (e.g., currently, in new vertical profile widget, animation control is located in the bottom while forecasted time is located at the top).
- Postage stamps - Geographic domain should cover Israel.
- New tools - A tool for forward/backward air parcel trajectory (e.g., NOAA HySplit tool).
- Cloud services/European Meteorological cloud - Would be obliged if a supercomputer ability (enabling running of local models) be provided as a service.

6. 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.