# Application and verification of ECMWF products in Member States and Co-operating States

## Report 2008 - Summary

## 1. Introduction

In May 2008 Member States and Co-operating States were invited to contribute to the 'Report on application and verification of ECMWF Products, 2008'. Contributions have been received from 24 States and have been made available on the ECMWF web site, as recommended by the Committee at its 36th session (October 2006):

http://www.ecmwf.int/products/greenbook/2008/

This document presents a summary of the information and results given in the contributions, which were invited under the following headings:

1. Summary of major highlights
2. Use and application of products
3. Verification of products (objective and subjective)
4. References to relevant publications

At its 36th session, the Committee requested Member States and Co-operating States to include information on the use of ECMWF products in each annual report. Verification was requested to focus on surface weather parameters to complement the comprehensive upper-air verification carried out operationally at ECMWF. The recommendations to Member States for the verification of local weather forecasts are given in ECMWF Technical Memorandum No 430 by P. Nurmi, available on the ECMWF website:

http://www.ecmwf.int/publications/library/do/references/list/14

This summary notes comments that have been made about verification results, when methods (e.g. subjective verification) differ from those used operationally at ECMWF. ECMWF objectively verifies a wide range of direct model output (DMO): upper air parameters verified against analyses and observations, weather elements verified against observations or 0-24h forecasts. Various statistics, such as area means, time averages, etc., are produced. The EPS verification is included in this system. These results are available in a separate document on verification statistics and evaluations of ECMWF forecasts (ECMWF Tech. Memo. 578).

The detailed contributions from Member States and Co-operating States complement the presentations on applications and verification made at the ECMWF Product Users' Meeting, 11-13 June 2008. Some of the findings from this meeting are included in the following summary. The programme for the Users' Meeting, together with the presentations and the conclusions from the final discussion, can be found on the ECMWF website:

http://www.ecmwf.int/newsevents/meetings/forecast_products_user/Presentations2008/index.html

## 2. Use and application of products

### 2.1. Post-processing of model output

Most countries apply statistical procedures to post-process ECMWF products, especially to make forecasts of surface weather parameters for specific station locations. The main methods are Model Output Statistics

or MOS (reported this year by Austria, Croatia, France, the Netherlands, Romania and Slovenia) and Kalman filtering (France, Greece, Iceland, Norway, Slovenia, Sweden, Turkey). Perfect prognosis is also used (Austria, Italy). Iceland reported on statistical downscaling of ECMWF precipitation, using high resolution precipitation climate to account for complex terrain.

Equivalent statistical adaptations are also applied to EPS products, either the ensemble mean (France, Germany) or individual ensemble members (France). In the Netherlands, MOS is based on input from both deterministic and EPS forecasts. In addition, calibration methods for the ensemble distribution are being employed, including use of rank histograms (France). Calibration of the EPS is an area of ongoing development in several countries (including Finland, France, Norway); Bayesian model averaging is one of the new methods under investigation. Hungary is testing the use of the new EPS reforecast data to calibrate EPS products.

Austria reported on the statistical combination of ECMWF and limited area model ALADIN for short-range precipitation forecasts, which reduces systematic errors and provides improved input to hydrological models.

Several countries perform additional post-processing to provide tailored versions of the more general products available from ECMWF. Examples using EPS products include automatic probability forecast (Denmark), clustering for specific areas or variables (Hungary, the Netherlands, Spain), and probability maps for different thresholds and parameters, e.g. CAPE (Spain, Norway).

ECMWF model output is post-processed to generate derived fields, often for use in severe weather warnings, such as freezing level, stability indices (Italy, Germany, Portugal, Sweden), sea state (Italy), heat index (Italy, Romania), wind chill (Romania), temperature and vorticity advection and fronts (Portugal).

ECMWF forecasts provide the boundary conditions for limited area models run in national weather services (Denmark, Finland, France, Greece, Hungary, Iceland, Ireland, Lithuania, the Netherlands, Norway, Portugal, Romania, Serbia, Slovenia, Sweden, Turkey) and for limited area ensemble prediction systems (Italy, Norway, Portugal).

ECMWF model fields are used to drive a number of application models including trajectory and dispersion models (Austria, Czech Republic, France, Greece, Hungary, Portugal, Slovenia), ocean wave models (Portugal, Sweden, Turkey), ocean circulation and ice models (Sweden) and hydrology models (Austria, Czech Republic, Sweden ). Sweden, Finland, France and the Czech Republic also use EPS ensemble data as input to river discharge models.

## 2.2. Use of ECMWF products including for severe weather prediction

ECMWF products form the basis of medium-range forecasts in most countries. In the short range, ECMWF products are often used in combination with other sources, especially limited area models, (Austria, Croatia, Czech Republic, Germany, Greece, Hungary, Iceland, Portugal, Romania, Serbia, Sweden). As a new Co-opertating State, Slovakia has adjusted all its medium-range forecasts to use ECMWF products and has been able to extend the range of forecast products provided to its customers.

Use of the ECMWF web site is becoming widespread as part of day-to-day activities in the forecast offices. It was also confirmed at the Users Meeting that the web pages are often an integral part of the forecasters' daily routine and that it becomes a problem, if the web products are unavailable.

The usefulness of the EFI for alerting to severe weather events was mentioned in particular (Czech Republic, Germany, Greece, Italy, the Netherlands, Romania, Serbia, Slovenia, Spain). The EPS probability products are often used to provide additional information, especially the probability charts for precipitation and wind gusts. EPSgrams are widely used; clusters and tubes are also used by forecasters considering alternative scenarios. The EPS is used to provide confidence indices (France, the Netherlands). The UK has integrated

internally produced graphics from the EPS and the Met Office short-range EPS to develop "seamless" products for the short to medium range.

Specific uses of ECMWF forecasts that are mentioned include the energy sector, road maintenance, heating, agriculture (Ireland,), ship routing (Denmark), aviation (Greece) avalanche, land-slide risk (Iceland), and flood risk (Netherlands).

The Netherlands have introduced a heat and health warning system based on EPS products. This has been developed as a close collaboration between KNMI and the National Institute of Health (RIVM). Warnings are issued to the institute when there is a 20% probability for a sustained period of high temperatures to allow internal planning.

It was also noted that ECMWF data are used for research and verification.

## 3. Verification of products

Most countries include results from the verification of ECMWF forecasts, generally by comparison to observations in the local area of interest.

Several countries regularly compare the performance of their limited area models (LAMs) with the ECMWF forecasts in the short range (Denmark, Finland, Greece, Hungary, Italy, Norway, Portugal, Romania, Slovenia, Turkey). In general, the higher resolution LAMs provide more accurate short-range wind forecasts, but ECMWF gives better temperature forecasts. The skill of precipitation forecasts is similar in most comparisons.

Countries that include post-processing of direct model output noted that this improves results considerably for verification against station observations. Kalman Filters can be efficient at removing systematic differences (biases) between model and station (Iceland, Sweden, Turkey), but is less useful where biases are not present.

Subjective verification is also reported. Forecasters noted useful guidance in the outlook to days 5-7 of weather parameters. Some problems with cloud cover in particular situations (e.g. strong winter inversions) were reported (Hungary). Luxembourg reported a general cold bias in the predicted 2m-temperature.

UK reported continued improvements in ECMWF tropical cyclone track forecasts, especially at 72 hours and beyond. Met Office tracks are better in the analysis and in short-range forecasts, although in 2007 ECMWF model track errors were, for the first time, lower than those of the Met Office model at 48 hours. The ECMWF model is better at predicting strengthening of tropical cyclones while the Met Office model is better at representing the weakening phase.

Italy reported a case study for the western Alpine region during the period 26-30 May 2008, when very persistent and abundant rainfall led to significant damage.

## 4. Monthly and seasonal forecasts

Use of the monthly and seasonal forecast products continues to increase. Applications include the energy sector (France), civil protection briefings (Italy, Portugal), public and media (Denmark, Sweden), input to crop models using soil moisture (Switzerland, Romania), and research or consultancy (Greece). The ECMWF website is often used to view the monthly and seasonal forecasts. Some countries are now developing their own products for internal use (France, Norway, Switzerland), including statistical adaptation (France). A statistical-analogue forecast method is in use by the Czech Republic. ECMWF fields are used for initial conditions for seasonal forecast modelling (France). The 15-day EPS forecasts are used in some countries as additional input to the preparation of monthly forecast products (Italy).

Some verification of monthly forecasts has begun (Hungary, Switzerland, Czech Republic). Temperature forecasts can be useful out to week 2 or in some cases even to week 3; the level of skill varies with season and region. Evaluation of the monthly precipitation forecast by the Czech Republic demonstrated usefulness in the 5-11 day range, and mostly no signal in the 12-18 day range.