

III WORKSHOP REPORT

1 Introduction

The biennial workshop on Meteorological Operational Systems was held at ECMWF, 14–18 November 2005. It was the tenth workshop in the series. As on previous occasions the workshop reviewed the state of the art meteorological systems, looking at trends and developments in the use of medium- and extended-range forecast products (session 1), operational data management systems (session 2) and applications in meteorological visualisation (session 3). The workshop proved to be very popular with over 100 participants from ECMWF Member States, Co-operating States, from other parts of Europe and beyond.

In session 1 major forecasting centres presented their operational predictive systems and discussed the use and interpretation of medium-range and extended-range forecast guidance. Several presentations from academia and industry were addressing the use of the forecasts in weather risk management: the use of probabilistic forecast information was discussed as was the prediction of severe weather.

In session 2 a wide range of data management systems were presented, focussing on access to distributed data sets through user-friendly application portals and data distribution systems. Such applications will soon be required to support data exchange and access in global scale research activities, such as THORPEX/TIGGE, as well as the emerging future operations information systems of the WMO.

A variety of mature data visualisation systems are now in operational use at several centres. New applications and updates to existing ones were presented in session 3. Several visualisation systems were demonstrated during the exhibition which was arranged for one afternoon.

During the week the workshop split into three working groups to meet twice and to discuss issues relevant to the session topics. The findings of the working groups were presented and discussed in a final plenary session which concluded an informative and successful workshop.

Working group 1 discussed:

- User requirements for forecast information
- Value of forecasts

Forecasters find the ECMWF verification results on the web very useful in their work. Further training on how to use and interpret such verification, in particular the scoring of probabilistic forecasts, would be welcome. ECMWF plans to introduce 15-day forecasts with a variable resolution EPS were discussed. It was noted that the operational post-processing procedures in Member States will require re-forecasts at these variable resolutions for calibration purposes. While it was acknowledged that users will have requirements for deterministic forecasts to help them in their decision-making processes, the workshop recommended ECMWF to be more proactive in explaining forecast uncertainties and the use of probability information as decision support.

ECMWF was encouraged to work with Member States and Co-operating States on forecast evaluation techniques which are closely related to the value and the societal benefit of the products.

Working group 2 on data management systems discussed issues related to:

- Interoperability between centres and disciplines
- Data catalogues
- Discovery mechanisms
- Metadata standards

Systems under development in the research and operational environments aim at implementing standards for accessing data, which would simplify the task of the user but also allows reinforcement of existing data policies. Data discovery will be facilitated through the appropriate use of metadata and related standards.

Working group 3 considered visualisation applications and looked at:

- Output formats for meteorological plots
- Formats suitable for interfacing with Geographical Information Systems (GIS)
- Use of XML to describe a visualisation task

For printing and documents, Postscript and PDF are still dominant, but Encapsulated Postscript (EPS) is now popular in the research community. Interactive graphics formats were discussed in detail. Panning, zooming and toggling of layers, together with the possibility of retrieving geographical co-ordinates at user selected points and load supporting data on demand are the main features required by users.

The workshop programme, and the presentations and the summaries of the working groups presented at the final plenary can be found on the web at:

www.ecmwf.int/newsevents/meetings/workshops/2005/MOS_10/index.html

The Report from the Working Groups are also summarised in this section of the proceedings while the papers from the presentations are given in Section IV.

2 Report of the working group on Use and interpretation of medium-range and long-range forecast guidance

2.1 User requirements for forecast information

- Multi-model systems
 - There are good experiences with operational PEPS systems. There is general consensus that the multi-model ensemble approach can give added value to the forecast system.
 - Weighting of the elements in a multi-model ensemble is an ongoing issue.
 - Objective evaluation of the multi-model ensembles is under development.
- Combined products
 - It was commented that the ECMWF EPS clusters are often very similar. Some tuning is therefore necessary. ECMWF tubes are designed to bring out extreme scenarios. The concept of tubing and clustering need to be addressed when applied to multi-model ensembles of 100+ members.
 - The NAEFS approach toward combining products was noted, i.e.
 - Apply bias corrections to the individual runs from different centres;
 - Compute the suitable weights for combining products but leave the application of coefficients to the user;
 - Provide normalised (anomaly) products
 - The interpretation of multi-mode products in general should be looked into.
- Forecast consistency
 - Inconsistency between consecutive runs and forecasts from different centres is a natural consequence of imperfect predictions. Forecasters tend to use the inconsistency between forecasts as a measure of uncertainty.
 - Looking at consecutive ensemble runs separately (rather than combining them) gives forecasters a good understanding of the uncertainty in the forecast and the probabilistic forecast evolution.
 - A more frequent update of forecasts (e.g. 4x daily) would help forecasters assessing the consistency in the forecast.
- Seamless products
 - Some preference was expressed for forecast products for separate products for the high-resolution (week 1) and reduced resolution (week 2) parts of the VAREPS forecasts.
 - VAREPS resolution change will require adaptations of the Kalman filtering and other PPMs in use in several member states. Any other potential impacts need to be reviewed.
- Verification
 - The verification provided by ECMWF on the web is found to be useful and should be extended for the monthly forecast.
 - Verification over areas (e.g. river basins) would be a useful addition to the standard verification practices.
 - Verification statistics should be complemented with information about the atmospheric variability.
 - Training in how to use and interpret the verification scores is still needed.
 - Verification of severe weather events using corresponding warnings is underway in some countries.
 - As a first step to demonstrate the usefulness of the probabilistic information in the EPS some deterministic verification scores can be used (det. model vs. ensemble mean).

- Role of forecaster
 - Forecasters may be able to add value to numerical models in areas of model weakness.
 - Forecasters will continue to play a role in special events (e.g. media, emergencies)
 - Amongst forecasters there is still a need for training in how to use probabilistic forecasts.

2.2 Value of forecasts

- Benefits to users (societal, financial)
 - The job of the Met Service is to provide the best value to the customers. Some customers require deterministic forecast to be provided by Met Services, even if they know probabilities are available. How should the Met Services respond?
 - Be proactive in explaining uncertainty and use of probability information as decision support. There is evidence that users are becoming more open to the use of probabilities.
 - Work more closely with user to understand their individual needs so it is possible to provide appropriate deterministic guidance from all available information.
 - There will still be users who want deterministic forecasts but whose risk-sensitivity is not known to the forecasters. There will be a need to provide (generic) “best-estimate” deterministic predictions (based on all available information).
- Performance measures for developers/users
 - There are often requests for a single measure to summarise forecast performance (common request from users, management, administrators).
 - Traditionally such measures have been based on synoptic upper air flow (e.g. Z500 error). With higher resolution, improvement in these measures may be small while greater impacts may be seen in fields such as precipitation.
 - Scientifically, a wide range of parameters and scores need to be considered when evaluating effect of change to forecast system.
 - Many users have specific requirements and will only be interested in certain aspects of the forecast (hurricane tracks; temperature and wind for electricity generators). They want verification of relevant parameters with a relevant metric.
 - It is not feasible to develop a simple overall measure to satisfy all these needs. A wide (expanding?) range of verification will be required.
- Relative benefit of different system configurations (e.g. ensemble size v. resolution)
 - What is the benefit of a high resolution deterministic forecast at day 15? Should we run more (lower-resolution) ensemble members? Should the high-resolution run also reduce resolution in a VAREPS configuration? Is there a need for a high-resolution forecast at all?
 - It was noted that doubling ensemble size doubles the cost, while doubling resolution can be closer to a factor of eight times more expensive. A higher resolution run is also useful for development and evaluation potential of future systems.
 - Canada and NCEP will run EPS with the same resolution for days 1–15 NCEP used to truncate after a few days, but now run constant resolution for 16 days). Is it important to maintain resolution in week 2 if the model is to be used to predict severe weather events?
 - Important to consider for which users and for what purposes are more members, or higher resolution, etc. needed. There are likely to be some areas where one option is beneficial, and others where a different configuration is better. There is probably no overall, optimal solution.
 - It was noted that experimentation on the relative benefits of ensemble size and resolution is expensive and cannot be done often. The TIGGE project will provide access to a range of configurations of resolution and ensemble size and will allow significant work to be undertaken.
- Requirements of re-forecasts
 - Re-forecasts (hindcasts) are used (necessary) to calibrate monthly and seasonal forecasts.
 - The potential use of re-forecast data to calibrate medium-range products (including EPS probabilities) was raised at the Workshop.
 - At ECMWF, two sets of re-forecasts are being planned

- Extreme Forecast Index (EFI) climatology: 48-hour forecasts (EPS control) run from ERA-40 reanalyses. Around 900 forecasts will be available to generate the climatology each day. Rolling archive using current model version.
- Ensemble re-forecasts. Plan to investigate benefits for EPS using 15-member ensembles (in VAREPS configuration) run from 20 years of ERA-40 reanalyses
 - It was noted that operational use in Member States (especially as a replacement for current post-processing) would involve extensive testing and operational development work. Re-forecast calibration is not an immediate replacement for current post-processing – continuity of current systems (PP, KF) is required for VAREPS. A T255 control is required (for the first 24 hours at least) to enable these systems to continue.
 - It was suggested that two control runs (T255 & T399) could be run for full 15 days.

3 Report of the working group on Operational data management systems

More and more datasets are made available to large user communities using web technologies. This raises several issues:

- i. Interoperability
 - Between centres
 - Between disciplines
- i. Data catalogues
- ii. Discover mechanisms
- iii. Metadata standards

Interoperability, defined in ISO:

- ii. Discovery
- iii. Access
- iv. Use

3.1 *Discovery*

- What is discovery? Browsing, searching.
- There does not seem to be much experience with publishing data/metadata catalogues for the outside world.
- Waiting for the outcome of SIMDAT/WIS.
- Experience: rather than publishing full feature catalogues, just list of products are available.
- Metadata should be in a form that can be used for automated discovery (ISO19115 for WIS).
- Granularity: Different levels of catalogues ? hierarchical catalogues.
- Different levels of catalogues for different access groups (with possible redirection to other sites).
- The motivation to publish data on the web is either commercial interest or the wish to help research, which should eventually lead to better applications.
- GISC will provide discovery mechanisms for global data sets for all WMO programs.
- WMO are working on Metadata standards for data discovery (and catalogues).
- INSPIRE is EU legal initiative which will enforce (GIS) standards for metadata (for discovery, access and use) in Europe.
- Multi-language support:
 - Use XML-XSLT
 - WIS supports multi-language approach through standardised XML metadata tags
 - Centres who publish data for global exchange will have to make the extra effort to translate metadata

3.2 *Access*

- Access method must be part of metadata. Users should not have to know how to get to the data.
 - One possible solution: service catalogues (also with service guarantees)

- Access policy should be part of metadata.
- Standardisation of access interfaces (web services (XML/GML)).
- Web services probably not feasible for real-time data exchange.
- Automated batch approach might not work well for (large) archive data sets.
- Different transport mechanisms have to be offered.
- Subscription service is useful for real-time data exchange (but problematic for archive data sets (you need to discover future datasets)).

3.3 *Use*

- ISO standards (profile of series 191xx for WIS) should allow the exchange and use of data across disciplines (or XML based solution (OGC standard)).
- Who knows all the standards?
 - It is quite difficult to keep an overview
 - Every institute will need 1–2 persons who knows the standards
 - Profile of ISO standards reduces effort. So does the provision of software written for the standards
 - Conversion experts are needed to convert different standards
- There is metadata that is not needed for discovery but only for use (e.g. documentation of data gaps).
- Users need to receive this and other metadata together with the data to make sense of it

4 **Report of the working group on Meteorological visualisation applications**

4.1 *Output formats as they relate to meteorological plots*

- On-screen graphics formats were discussed.
 - Care must be taken.
 - Apart from GIF and PNG, TIFF is also used for publication-quality plots. A georeferenced raster format, GeoTIFF, is becoming better supported.
- Graphics formats for printing and documents were discussed.
 - PostScript and PDF still dominate, but PDF is popular on Windows platforms because of lack of default PostScript support there.
 - Newspapers prefer Encapsulated PostScript (EPS) files which are also popular in the research community. It can be a good idea to produce files directly for the printing house so that the newspaper cannot inadvertently degrade the image quality.
 - The Windows Metafile (WMF) format has been used in order to support Chinese characters. This is being superseded by Microsoft's new EMF format.
 - It was noted that some firms are now requiring data in OpenDocument format as this is not tied to one software vendor.
- Interactive graphics formats were discussed.
 - SVG has been considered for, and even used in, some visualisation packages. However, its limitations and lack of support and development have made it less attractive.
 - Flash was suggested, as it is well supported and installed on most web browsers. However, Flash is not necessarily suitable for high-quality images.
 - Google Maps shows what can be done on the web without using a desktop package or seeing actual files. This application illustrates the power of available web technologies such as AJAX, loading a large raster image piece by piece as needed; vector graphics can be overlaid. This approach works well with all browsers. Panning, zooming and toggling of layers, for example, are possible. It is also possible to retrieve the geographical coordinates of a point selected by the user and load relevant data on demand.
 - These features were noted as the main interests of interactive plots.

4.2 *Formats suitable for interfacing with GIS*

- Geographical Information Systems (GIS) were discussed.
 - GIS systems store various kinds of georeferenced data and are used primarily by end users, not meteorologists.
 - Most GIS software cannot import data in the standard meteorological data formats. Data can be converted to a GIS format, but reprojecting gridded data onto a rectangular grid can degrade the quality.
 - Better solution is to import GIS data into meteorological visualisation software. Information that might be imported includes locations and names of cities, roads, railways and also population figures.
 - The Shapefile format is popular and well-supported, but is proprietary (ESRI). GML and CSML are examples of XML-based formats which may come to dominate.
 - One problem with GIS data is a lack of standardisation with no central repository, making local changes (e.g. country borders) slow to propagate.
- Use of XML to describe a visualisation task
 - XML is text-based and easy to read/write by humans and computers.
 - One advantage of XML formats is that validation tools exist and can be used as long as a proper schema is defined.
 - XML-based files can become very large; defining a separate schema for each dataset can help reduce the file size.
 - Attribute-based XML can be easier for humans to read, but harder to validate as it is less structured.
 - Different organisations have used different XML-based formats.
 - GML was tentatively advocated as a way of encoding metadata.
 - GML can encode geospatial vector data, but raster data is generally described with a reference to an external file.
 - WMO is investigating standards for describing meteorological data in XML - could this lead to widely-adopted standards? This issue will be examined by appropriate WMO expert teams.