III WORKSHOP REPORT

1 Introduction

The biennial workshop on Meteorological Operational Systems was held at ECMWF on 12 - 16 November 2007. It was the eleventh 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 and interpretation 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 80 participants from ECMWF Member States, Co-operating States, from other parts of Europe and beyond.

The presentations given in session 1 addressed in particular the state of the art post-processing of direct model output to meet user requirements. Extended range forecast out to a month and for the season require model bias corrections before they can be passed to the users. Several presentations were addressing the use of forecasts in weather risk management, mainly using probabilistic forecast information. One afternoon during the week was devoted to applications of severe weather event predictions. The weather alarm and warning system in Europe is now much developed and there is an increasing demand for early warnings of severe weather, mainly in the range of 3-5 days.

In session 2, several presentations discussed the emerging new distributed information systems, such as the WIS (WMO Information System) and the system created to handle the TIGGE (THORPEX Interactive Grand Global Ensemble) data exchange and data service. Providing the users with efficient interfaces for data mining and retrieval and ensuring interoperability were seen as the primary tasks when creating these systems.

Several operational data manipulation and visualization systems were presented in session 3 and also 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 on Severe and high-impact weather events

The working group discussed the requirements for forecasting severe and high-impact weather events, focusing particularly on early warnings from the medium-range.

The Extreme Forecast Index (EFI) was noted to be widely used as alert to forecasters of a potential severe event. A number of suggestions were made for additional EFI parameters to allow alerts to be provided for a wider range of situations, including snowfall and minimum temperature. There was also interest in the ongoing work to develop products to complement the EFI; probabilities of exceeding thresholds relative to the climate distribution and warnings expressed in terms of return periods were considered to be potentially valuable additional information.

The operational ECMWF tropical cyclone tracking was very useful, and development of products showing tropical cyclone genesis during the forecast was encouraged. It was considered useful to investigate corresponding products for extra-tropical cyclones.

The verification of severe weather events was acknowledged to be an important but difficult topic. It was noted that this is an area of active research, but a substantial amount of work remains to be done.

Working Group on Interoperability

Traditionally the meteorological services were very successfully interoperating within their community. Strong governance through WMO allowed the definition of well defined and agreed standards and methods. The need to participate in inter-disciplinary activities, mainly driven by commercial, scientific and humanitarian interests, but also new legal requirements like the European INSPIRE directive, make it necessary to review and adjust these standards in a way that will allow the Meteorological Services to interoperate with a much wider community in the near future.

The working group agreed that discussions about interoperability would have to cover data, software and service issues. By analogy, the Internet was seen as a successful example of the benefit of interoperability. A small set of simple, stable, non-proprietary and accepted standards that connect the information providers to a large, partly unknown user community, leading to unforeseen usage of the published information (see picture).

Similarly, the meteorological community should use a limited number of standards that impose minimal constraints on the users and therefore open up a large variety of information from many different providers to known and unknown user groups who might also find new ways to make use of our data sets.

To continue the analogy, the Internet standards cover data formats (HTML), transfer protocols (HTTP) and requesting mechanisms (URL). Again, the meteorological community must define similar standards:

- Data formats: GRIB, BUFR, CF-NetCDF, (GML_BUFR), GeoTIFF, KML, GIF, PNG, JPG.
- Transfer protocols: (s)ftp, http(s), DVB, OGC Web Services, SMS, VOICE, RSS.
- Requesting mechanisms: WMO file naming convention, OGC Query language.

The working group also discussed the use of XML based data formats. Because of the support by industry and the wealth of available tools these formats are very popular. On the downside, the representation in XML can be bloated and produce very large files, and processing such files can be CPU intensive. Furthermore, the XML format is just an agreed syntax and does not specify any semantics. Such semantics are defined in data schemas that still need to be defined and agreed upon. For these reasons, XML should be limited to the exchange of small data items with other communities. Within the Meteorological community, data exchange should continue to driven by efficiency.

There was general agreement that OGC (Open Geospatial Consortium)/ISO standards will play an important role in the near future. Both the European INSPIRE directive and Eurocontrol for example have decided to define OGC compliant data representations based on GML (Geography Markup Language). Meteorological Services are already in the process of building expertise on OGC but more collaboration is needed. Better coordination of the activities could lead to a common reference implementation of OGC compliant web services for meteorological data, which could be proposed to WMO for standardisation.

Working Group on Visualisation and web applications

The working group discussed the possibility of porting a meteorological workstation from a desktop application to a web application, a so-called rich internet application. The idea was fuelled by many talks at the workshop representing an increasing trend of providing web-based products to forecasters and clients. Also recent developments in web technologies have meant that many web applications have appeared and had much success, increasing the expectations of web users.

Very soon in the discussion it became clear that the time is not yet right for a web-based workstation. The reasons mentioned were:

- Calculations performed using substantial local resources are still required in meteorology
- User interface toolkits are not mature enough - fast changing and not future safe yet
- Download of (initial) application can be a challenge for network bandwidth

In addition there were many questions raised which would need to be addressed before larger web applications could be developed:

- How scalable will the applications be?
- How to deal with demand, and therefore availability, which can be weather dependent?
- Are there any development tools (debugging & profiling)?
- How can a web application be operationally maintained?
- What are the licences and legal issues?
- How can the security be guaranteed?

Further it was questioned whether a full featured web-based meteorological application should be the aim of developments. The desktop based workstation has progressed well over the last decade and gives good services to forecasters.

Instead of heavy rich internet applications, the possibility of using smaller, lighter web applications was discussed. These would be tailored to the need of the users. Accepted standards should be used to exchange information from different disciplines. Standards already considered by many are the web services defined by the OGC. See also the conclusion of the working group on interoperability.

A further workshop to exchange experience on OGC/GML, covering data management and graphics would be beneficial to facilitate such cooperation.

The workshop programme, the presentations and the summaries of the working group discussions, which were presented at the final plenary, can be found at:

http://www.ecmwf.int/newsevents/meetings/workshops/2007/MOS_11/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 extended range forecast guidance

2.1 Products for severe events

- Tropical cyclone tracks and strike probabilities are very useful
  - Extending to include genesis during forecast would be valuable
- Extra-tropical cyclone identification and tracking
  - potentially large benefit
  - Positive response from forecasters to trials at Met Office, but otherwise limited practical experience so far
  - different levels of sophistication in identification/tracking algorithms
  - need to distinguish potential severe storms from general "everyday" cyclones
  - more practical experience required to evaluate benefits
  - Worth pursuing given potential usefulness
- Extreme forecast index (EFI)
  - Seems to be widely used as alert to forecasters (then need to investigate forecast more carefully)
  - Additional parameters would extend the range of situations where these alerts can help
    - Max, min 2m temperature; snowfall; CAPE suggested
  - Noted that new EFI climatology will be introduced with unified EPS/monthly forecast in 2008; parameters and forecast steps can be reviewed
- Interest in information to complement EFI, eg probabilities of quantiles, return period (more intuitive to users)
- Severe events typically rare/extreme – tails of climate pdf
  - Parametrisation of tails (extreme value theory) may be worthwhile – climate and/or ensemble distribution
  - Some encouraging initial results with return period
- Temporal and spatial precision
  - More important to know if something will happen rather than exactly when or where
  - Probabilities for event to occur somewhere within time window over region, not restricted to point probabilities
  - Depends on forecast range
  - Selection of spatial area dependent on user - difficult to do centrally (eg better done by Member States and not ECMWF)
- Precipitation – for flash floods, max precip in short period is more important that totals over fixed period (12h, day); e.g. max rainfall in any 3h period during day; would require additional model output parameter

2.2 Post processing/calibration

- Post-processing and calibration of model data
  - Bias correction is standard practice for monthly and seasonal forecasts (using reforecast data)
    - MOS not commonly used, but can give benefit
  - MOS, KF generally applied to medium-range forecasts in Member States (various methods, using locally available observations)
    - Typical MOS may not be suitable for severe events
    - Calibration using reforecasts not generally done at medium-range; VarEPS/monthly reforecasts will be available for calibration (research shows potential benefit)
- Combining deterministic and EPS output
  - NAEFS plans to make weighted combination for ensemble mean
  - Potential should be explored further
  - Is reforecast needed for T799?

2.3 *Verification*

- Different objective for verification
  - Diagnostic to understand model performance and guide developments
    - Wide range of measures available
    - Still very active discussion and research on methods and tools
    - More work needed on availability and use of observations
  - Administrative to inform users/managers of benefits of forecasts
    - Impossible to summarise in single simple overall measure, especially for severe events where samples are inevitably small
    - Proposals under development for WMO, focus on long-range, but more general applicability should be considered
- Case studies needed (false alarms should be expected; include missed events); complement objective scores

3. Report of the working group on Operational data management systems

What is interoperability?

- Integrate "their data" with "my data"
- Integrate "their software" with "my software"
- Integrate "their service" with "my service

3.1 *Why and with whom do we want to be interoperable?*

- Traditionally successful within Met community
- We try to push our own standards on external users (GRIB, BUFR), which is not what other communities necessarily want
  - XML based formats seems to be what people want
- Reaching people who can assess the societal benefits of our products (e.g. decision makers)
  - They use GIS tools to overlay several sources of information
- Exchange with research to benefit from their activity
- Commercial interest is main driving force
- Some moral obligation
  - Data for NGOs
  - Environmental monitoring
- Force by law (INSPIRE)
- Unknown future usage of our products

3.2 *Interoperability and standards*

- Internet is a good example of interoperability that works, leading to unforeseen usage of published information
- Small set of simple, stable, non-proprietary and accepted standards contributed to success
- The standard imposes minimal constraints

3.3 *What infrastructure should be used?*

- Internet analogy:
  - Format: HTML
  - Protocol: HTTP
  - Requesting: URL
- We need to agree on formats, protocols and requests
  - Formats: GRIB, BUFR, CF-NetCDF, (GML_BUFR), GeoTIFF, KML, GIF, PNG, JPG, ...
  - Protocols
    - Low: (s)ftp, http(s), DVB, ...
    - High: OGC Web Services, ...
    - Other: SMS, VOICE, RSS, ...
  - Requesting ?
    - File naming convention, OGC Query language,...
- Internet, Private Network (e.g. RMDCN)
  - P2P technologies only efficient if data is used by multiple users. Issue: when can data be removed from network (e.g. when does everyone have a copy)
  - Web Services do not support asynchronous data requests/delivery. Something is needed for large/off-line data sets.
    - Two solutions: polling, notification (no standards seem to exist).
    - OGC Galeon project is looking into an asynchronous mechanism for Web Coverage Services (UNIDATA, BADC, ...)
- Satellite Broadcasting (e.g. GEONetcast, RETIM2000, ...)
  - Global reach with limited local infrastructure
  - Cheap (for the user)

3.4 *Access control, Data policy and security*

- (Digital) right management: data has to be traceable to owner to protect intellectual property and prevent misuse.
- Difficult to implement and enforce (especially across national boundaries)
- Issue of controlling access to Web Services need to be addressed

3.5 *What rules should be followed?*

- INSPIRE will define rules on how serve and present geo-reference data.
  - Rules rely on still evolving standards (ISO19109, rules for application schema)
  - Chosen standards will certainly be OGC (Open Geospatial Consortium).
- Eurocontrol has also chosen OGC as standard for aviation met information.

3.6 *Data formats*

- Standardising on data formats is not sufficient. Difficulty comes from semantics/ schemas.
- Meteorological schemas might be too complicated for non-meteorological users
- Formats should not be exposed to users.
- Success of formats is depended on availability and user-friendliness of tools that support the format (e.g NetCDF)
  - Users don't really care about the format, as long as they can use the data
- Initiative (Eurocontrol WXCM) to define GML schema for meteorological data based on BUFR schema (GML-BUFR)

3.7 *Thoughts on XML*

- There are mixed feelings on XML
- XML is pushed by the industry
- Many XML tools exists
  - Most programming languages have XML parsers
- XML can be bloated
  - Usage of XML should be limited to small data exchanges with other communities
  - Within the Met community, data exchange should continue to driven by efficiency.
  - XML processing is CPU intensive
- XML is a syntax, does not provide semantics

3.8 *Conclusion*

- OGC/ISO Standards are coming (INSPIRE, Eurocontrol)
- Met services seem to have or are building expertise on OGC.
- Need for more collaboration and creation of common reference implementation of OGC compliant web services for met data which can be proposed to WMO.
  - Workshop to exchange experience on OGC/GML, covering data management and graphics

4. Report of the working group on Meteorological visualisation applications

Web-based meteorological workstation

- Is the time right to develop web-based meteorological workstations?
- What are the current limits of web applications?

Interactive file formats

- How much use are interactive formats for the web?
- Should one use formats such as SVG, Flash or animated GIFs, or are static formats using JavaScript better for interactivity?
- How can overlapping layers be best displayed?

4.1 *What has changed?*

- Web 2.0 with its (new) emerging technologies opens possibilities to implement new interactivities
- More demands on visualisation on the web
  - Scalable plots → vector graphics
  - Interaction → select further information
  - Operational → High availability
- Fast changing world with high expectation through successful services (e.g. Google, Yahoo)
- Cheap hardware might solve the availability issue
- Role of forecaster and demands of end-user changed: Information from different fields of science are required

4.2 *Meteorological user interface*

Classical desktop

- Many advanced toolkits (e.g. GTK, Qt)
- Lots of tested and optimised code → mature development tools
- Make use of all system resources
- Platform dependent

Web applications

- New emerging user interface APIs (e.g. jQuery, YUI)
- Lots of new developments and experience needed
- Different opinions on how heavy / rich the applications should be
- Can not use full advantage of local computer resources
  - Adobe AIR (FLEX), Mozilla PRISM, Microsoft Silverlight could change this in future

4.3 *Meteorological rich internet applications (RIA)*

- Time for meteorological RIA not ready yet
  - Calculations performed using lots of local resources still required in meteorology
  - User interface toolkits not mature enough – fast changing and not future safe yet
  - Download of (initial) application can be a challenge
- Many open questions:
  - Scalability
  - Availability (weather dependent)
  - Development tools (debugging & profiling)
  - Maintainability
  - Licences / legal issues
  - Security
- First step: Restructuring into services (WFS & WMS)

4.4 *Mash-up of services*

- Standardised services (from OGC) such as WFS (geo features), WMS (maps) and WCS (coverage)
  - These can be used to "mash-up" thin web applications
- To enable exchange of services between meteorological institutions standards should be agreed
  - Co-ordination is required
- The big idea: a user in one organisation can overlay own products with products from other inter-disciplinary organisations independent of which software packages were used to produce these products

4.5 *Summary*

- It is too early (if desired at all) to develop web-based rich meteorological workstations
- Not to forget: Desktop is successful → do we need to change?
- BUT the recent developments on the web (new technologies and standards) should allow to develop interactive web services which can improve the communication to the end-user
- One way might be to follow standards from the GIS world to enable exchange information