CONTENTS

PUBLICATION POLICY

The *ECMWF Newsletter* is published quarterly. Its purpose is to make users of ECMWF products, collaborators with ECMWF and the wider meteorological community aware of new developments at ECMWF and the use that can be made of ECMWF products. Most articles are prepared by staff at ECMWF, but articles are also welcome from people working elsewhere, especially those from Member States and Co-operating States. The *ECMWF Newsletter* is not peer-reviewed.

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Guidance about submitting an article is available at www.ecmwf.int/publications/newsletter/guidance.pdf

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Front cover image: Hurricane Irene taken by the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra satellite on August 25, 2011. Courtesy of NASA/NOAA GOES Project

Context for the plans for 2012

Work in 2012 is focussed on delivering the ECMWF Strategy 2011–2020. An important backdrop to these annual plans is the set of decisions taken by ECMWF Council last December regarding: the budget 2012; cooling of the supercomputer; options for relocation; preparing for the procurement of the next supercomputer; procurement of a new telecommunication network (RMDCN).

It is important to remember that ECMWF's success depends on its people. Therefore various developments will be initiated in 2012 that relate to how staff and consultants are managed at ECMWF. These include, as part of refreshing our human resources strategy:

- Devising a new promotions process.
- Developing the staff reporting 'appraisals' process.
- Further work on integration of the terms and conditions for staff and consultants.

Whilst highlighting the plans for 2012, it is also important to be scanning the horizon to develop a picture of what ECMWF and its environment will be like in the longer term. We have started this horizon-scanning process under the banner of 'ECMWF in 2030' and it includes issues such as: external world changes; forecasting system developments; our infrastructure (buildings, supercomputing, location); and staff and career development.

One issue that has emerged as important for the future of ECMWF is referred to as scalability. This means the ability of our computer code to exploit the supercomputer architecture likely to exist for the next decade or more; that is, massively parallel architecture involving hundreds of thousands of cores. We know we will have to do some serious re-design of our computer codes to maximise the efficiency with which we use next generation supercomputers. This is a medium-term activity but the sooner we get started on it the better.

More details about the plans for research, operations and administration are given in the accompanying news item.

ECMWF is an organisation that has clear goals and quantitative measures by which to assess its performance. Last year, 2011, saw continued progress in improving the skill of our weather forecasts. It is with the annual activities planned for 2012 that we aim to continue this progress both by our own efforts but also by collaborating with our many partners, such as the national meteorological services, space agencies, and universities.

Alan Thorpe

ECMWF's plans for 2012

ALAN THORPE

The context for the plans for 2012 has been outlined in the Editorial, so in this brief article we will describe some examples of new or developing activities planned for 2012. These activities are built on the foundations of the ongoing work in administration, operations and research, which is fundamental to ECMWF and to new developments. So this will not be a summary of everything that is happening at ECMWF in 2012 - things that are not mentioned are no less important. These activities have been identified as priority issues, based upon the following criteria: fit to ECMWF Strategy, dependencies and linkages between departments, and availability of human and financial resources. In addition, during 2012 a new framework will be developed to better link and simplify the annual plans, the four-year programme and the Strategy goals - an ECMWF 'balanced scorecard'. Such a scorecard will capture ongoing as well as new and developing areas.

Research

As of 1 January, the Research Department now contains four divisions: data, model, predictability and the newly formed atmospheric composition division. Some examples of new and developing activities in these divisions are as follows.

◆ ***Data Division***: use the Ensemble of Data Assimilations for covariance estimations; improve observation error and bias estimates; produce a coupled ocean-atmosphere reanalysis.

◆ ***Model Division***: improve cloud, boundary layer and surface parametrization schemes; develop a more efficient non-hydrostatic model.

◆ ***Predictability Division***: prepare a perturbation strategy for coupled ocean-surface-atmosphere system; assess predictability in the sub-seasonal forecast range; improve the description of the upper-ocean (including waves and currents).

◆ ***Atmospheric Composition Division***: introduce direct and indirect effect of aerosols on numerical weather prediction; carry out chemical IFS development.

Research developments will feed into the introduction of two new model versions of the Integrated Forecasting System (IFS) in 2012. The first to be implemented around May will introduce a significant number of improvements, notably a major upgrade of the

Honorary degree awarded to Alan Thorpe

On 18 January 2012, Alan Thorpe was awarded the honorary degree of Doctor of Science from the University of Warwick in recognition of his contributions to weather and climate science. He obtained his first degree in Physics from the University of Warwick in 1973 (as did his daughter in 2001).

At the degree congregation the oration by the Head of the Physics Department, Professor Robin Ball, drew attention to Professor Thorpe's research in basic dynamics and predictability of weather and climate at Imperial College, Reading University and the Met Office. Also noted was his leadership of the Natural Environment Research Council (NERC) and ECMWF, and his membership of national and international science committees. Professor Thorpe's involvement in climate change debates was also recognised, with emphasis on his willingness to engage at various levels with the general public and climate change sceptics.

In replying to the oration Alan began by reflecting on what it had been like to be a physics undergraduate at Warwick in 1970, soon after the University had been inaugurated. Alan went on to describe the many diverse opportunities he had experienced because of being involved in weather and climate research.

In describing what lessons he drew from his research career, he referred to the importance of taking a multidisciplinary approach in nearly all areas of science. So, for example, in weather and climate research an understanding of the physical science aspects of the problem is woefully incomplete without taking the human dimension into account.

Alan Thorpe receiving an honorary degree. The Director-General of ECMWF receiving an honorary degree of Doctor of Science from the University of Warwick in recognition of his contributions to weather and climate science.

A second lesson related to the importance of the engagement of researchers with the beneficiaries of research. Ultimately much research is funded by taxpayers and scientists have a responsibility to communicate with the public and others what they are doing and why. Also having such dialogues, even whilst research projects are being formulated, can be beneficial in how the research is pursued. Some academic researchers express a view that this so-called impact agenda is against academic freedom but Alan made the case strongly that on the contrary it represents a real opportunity.

In his closing remarks Alan thanked the University of Warwick both for his education in physics but also for the award of the honorary degree of Doctor of Science.

short-range forecast error statistics. The second upgrade, planned around November, will be devoted to the increase of the number of vertical levels to 137 in our data assimilation and high-resolution forecasts. Following a periodic combining of model versions between ECMWF and Météo-France, the next scientific update (planned for Spring 2013) will incorporate an increase of the number of vertical levels in the Ensemble Prediction System (EPS) as well as a first version of long-window 4D-Var.

Operations

A major planned upgrade to the supercomputer system is in progress leading to the acceptance and migration to IBM Phase 2 (POWER7) in 2012. We hope to migrate the operational suite to Phase 2 before summer and to remove both Phase 1 (POWER6) clusters before the end of 2012. The new model versions arising from research developments will require significant testing associated with the vertical resolution increase and provision of near real-time access to test data.

As well as the development and introduction of additional weather forecast products such as heat/instability indices, we aim to work on a design phase for a new product dissemination system. The need for this new system is to cope with the increase in product recipients.

Further activities planned for 2012 include: the move and modernisation of the Meteorological Operations room; a move of the console area and call desk; several procurements. In this latter category during 2012 ECMWF will have four significant procurement processes running for: RMDCN, dry cooling, mechanical and electrical maintenance contract, and publishing the Invitation to Tender for the next generation high-performance computer facility.

Of note is that early in 2012 the two-year project to re-design and develop the ECMWF external web site - the Web2013 project - began. This is one of several software projects for 2012.

Administration

The new Director of Administration, Nyall Farrell, is focussing on the annual plans for 2012 in the context of a longer-term strategy for the administration at ECMWF. For the Department as a whole this will involve developing the staff, processes and systems to ensure that they are fit-for-purpose and can successfully deliver its mission commitment to ECMWF. Within the main areas of activity in Administration the following will be the main focus in 2012:

◆ ***Finance***: implement International Public Sector Accounting Standards; review our pensions investment strategy; develop funding strategies for HPC and property projects; Navision upgrade.

◆ ***General Services***: prepare property specification and options for relocation; develop a strategy for current premises over the next five years; upgrade catering, library, Met Ops, and console areas; review health and safety policy and business continuity plans.

◆ ***Personnel***: harmonize consultant contracts; prepare a promotions policy and process; introduce on-line recruitment; carry out a staff engagement survey; review performance management processes.

◆ ***Coordinating Committee on Remuneration***: develop further our engagement.

◆ ***Legal Services***: provide procurement support; introduce contract development and tracking.

◆ ***Translation Services***: prepare multilingual requirements for Web 2013; produce a style and communication guidelines.

◆ ***Financial Control / Project Support***: review financial control processes and need for internal audit; further develop the Activity Based Costing system and risks register; manage externally-funded activities and incorporate them into budget and reporting processes.

Final remarks

In this short article it is impossible to reflect all areas of activity that will be vital to ECMWF's success in 2012. A flavour has been given of only some of the new and developing activities in the three Departments - these rely on the bedrock of ongoing operational, research and administrative work that underpins what we do.

Co-operation with EFAS

BOB RIDDAWAY

At the meeting of the ECMWF Council in December 2012 it was agreed that ECMWF should conclude the necessary agreements to operate the computational centre of the European Flood Awareness System (EFAS) for up to four years. This will be the first example at ECMWF of a Third Party Activity. Although Third Party Activities have to be in line with the purposes and objectives of the Centre, they do not necessarily need to contribute to the Centre's core activity. The third party concerned - in this case the European Commission - bears the full cost of these activities.

EFAS is an early flood-warning system complimentary to national and regional systems. It provides the national institutes and the European Commission with information on the occurrence of possible river flooding with a lead-time of up to 15 days. ECMWF provides forecast data that helps drive a hydrological model specifically designed to be used for large-scale catchments.

The European Floods Portal brings together information from ongoing research within the 'Floods' Action at the Joint Research Centre (JRC) of the European Commission, as well as from publicly-available information from EU countries. The portal is available at:

- http://floods.jrc.ec.europa.eu/home.html.

Changes to the operational forecasting system

DAVID RICHARDSON

New cycle – Cy37r3

A new cycle of the ECMWF forecast and analysis system, Cy37r3, was implemented on 15 November. The new cycle contains a collection of improvements to the forecast model, the data assimilation and the ensemble prediction system. It also includes hourly post-processing of model data to 90 hours in support of the Boundary Conditions (BC) Optional Programme, including hourly wave data for all four forecast cycles. Hourly post-processed products will also be introduced for the European limited area wave model. The main meteorological changes included in this cycle are:

- Modification of the entrainment/detrainment of convection.
- Modification of the supersaturation and deposition rate for clouds.
- Modification of the surface roughness.
- Assimilation of accumulated rainfall from NEXRAD radar data from the USA.
- Assimilation of ozone observations from infrared radiances.
- Bias correction of aircraft temperature observations.
- Cycling of stratospheric model error (for the weak-constraint 4D-Var).
- Use of the latest version of the NWP-SAF radiative transfer model (RTTOV-10 including FASTEM-4).
- Retuning of cloud detection for the advanced infrared sounder data.

Changes specifically to the Ensemble Prediction System (EPS) are:

- Use of the NEMO ocean model (instead of HOPE) in EPS and use of the NEMOVAR ocean data assimilation system.
- Coupling of the EPS to the ocean model from day 10 onwards for the forecast from 12 UTC (as already done for the 00 UTC forecast).

Impact of Cy37r3

The impact of the new cycle on the performance of the forecasting system was tested in research mode during the period 1 January to 10 May 2011, and in pre-operational runs from 11 May until the implementation in November (see the news item on page 13 that includes the scorecard comparing Cy37r3 with Cy37r2).

The new cycle shows benefit in terms of objective upper-air scores in the early forecast range in both hemispheres: the geopotential scores are improved throughout the troposphere, with some degradation at the 100 hPa level. Tropical wind scores in the lower troposphere are significantly improved, specifically leading to reduced systematic errors in the strength of the low level inflow to the African and Indian monsoons. The change in surface roughness has led to reduced 10-metre wind speed over land and reduced diurnal amplitude in 2-metre temperature, both of which result in generally reduced bias against observations. Cold biases in 2-metre temperature have been reduced in specific winter-time situations where the amount of super-cooled cloud-water has been increased.

The main impact on the EPS is improved probabilistic scores for the tropical winds throughout the forecast range.

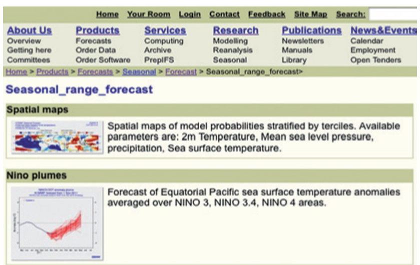
More information on changes to the forecasting system can be found at:

- www.ecmwf.int/products/data/operational_system/evolution/

New items on the ECMWF website

ANDY BRADY

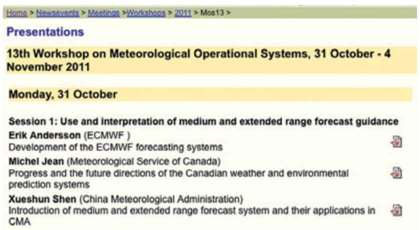
System 4 is now operational



Our next generation 'System 4' seasonal forecasting system became operational in November 2011.

- www.ecmwf.int/products/forecasts/d/charts/seasonal/forecast/

13th Workshop on Meteorological Operational Systems



The 13th Workshop on Meteorological Operational Systems was held at ECMWF from 31 October to 4 November 2011. Presentations and outcome from the plenary are now available on the website.

- www.ecmwf.int/newsevents/meetings/workshops/2011/MOS13/

15th ECMWF Workshop on High Performance Computing in Meteorology

The 15th ECMWF Workshop on High Performance Computing in Meteorology will be held from 1 to 5 October 2012. Note that this workshop is being held earlier than usual.

- www.ecmwf.int/newsevents/meetings/workshops/2012/high_performance_computing_15th/

Diurnal cycles and the stable atmospheric boundary layer

ANTON BELJAARS (ECMWF), BERT HOLTSLAG (WAGENINGEN UNIVERSITY), GUNILLA SVENSSON (STOCKHOLM UNIVERSITY)

Between 7 and 10 November 2011, a workshop was held at ECMWF on 'Diurnal cycles and the stable atmospheric boundary layer'. The workshop was co-sponsored by ECMWF and WCRP/GEWEX/GABLS.

The workshop attracted about 60 participants from Europe and other parts of the world, such as Japan, North and South America, and Australia.

One of ECMWF's strategic goals is to improve the quality of near-surface weather products like temperature, wind and atmospheric composition. It is well known that the diurnal cycles of temperature and wind are strongly influenced by small-scale atmospheric processes in the stable boundary layer, in particular by turbulent diffusion, gravity waves and radiation, but also by the thermal coupling with the underlying soil through vegetation and snow. Most large-scale atmospheric models utilize rather diffusive boundary layer schemes resulting in stable boundary layers that are too thick and show too little wind turning. Climate projections also show strong temperature signals at high latitudes which are affected by the above listed processes.

The purpose of the workshop was to review the on-going research and to make recommendations for future work, particularly about the options for improved parametrization in large scale models.

Many participants of this workshop are active players in the GEWEX Atmospheric Boundary Layer Studies (GABLS; www.gewex.org/gass_panel.html) project, which is the international platform for boundary layer research applied to regional and large-scale models. GABLS started about a decade ago with the study of the stable boundary layer and defined a series of cases that were used for model inter-comparison and model evaluation. LES (large eddy simulation) models and observations were used extensively as reference. It was shown that the spread between models is large and that many models have highly diffusive boundary layers schemes, mainly to avoid 'decoupling' of the atmosphere from the surface in low wind conditions and to maintain sufficient drag at the surface. It was also confirmed that the more research oriented schemes (which tend to be less diffusive) have a better boundary layer structure in terms of profiles of temperature and wind speed and direction. The encouraging news is that the inter-model dispersion between LES models is fairly low within the most recent GABLS inter-comparison and that they show very realistic boundary layer structures. Unfortunately, experience with LES at very low winds is still rather limited.

The presentations focused on all the physical aspects relevant for a realistic simulation of the stable boundary layer. The scientific issues were further discussed in the working groups covering: (i) processes, (ii) tools (like LES) and observations, (iii) parametrization schemes, and (iv) land surface interactions. The working groups were asked to make recommendations for large-scale modellers and for further research in GABLS.

A few conclusions from the workshop are:

- Uncertainty in the formulation of diffusion in stable situations remains high. No clear way forward was identified, but it is clear that the effects of meso-scale variability and terrain heterogeneity are important and need further study.
- It is now accepted that the stable boundary layer is highly interactive with the underlying surface. It was therefore recommended to base further studies on the coupled system. Also for LES it was recommended to have at least a simple representation of the surface energy balance in future simulations.
- The uncertainty in the momentum budget is large in models. Sensitivity experiments show a direct impact of drag over land on the planetary scales. To diagnose this aspect

further, a model inter-comparison study was proposed.

◆ Many models have biases in the long-wave downward radiation even in clear sky situations. Verification studies using, for example the Baseline Surface Radiation Network (BSRN), were recommended.

◆ More diagnostic studies of large-scale models are needed to assess the behaviour of the boundary layer and its interaction with the surface. It was recommended to use super-sites (CEOP, FLUXNET) with a comprehensive set of observations (e.g. in the context of the planned CORDEX-Europe initiative or a possible Arctic activity).

◆ Large-scale modellers should move towards the use of turbulent kinetic energy (TKE) equations to support the turbulence closure.

◆ Recommendations for the land surface include: (i) the use of a shallow top soil to represent fast time scales, (ii) the introduction of a multi-layer snow schemes to replace slab models, (iii) full exploitation of as many observational sites as possible to derive relevant model parameters, and (iv) the use of data assimilation techniques to 'inverse model' land surface parameters.

For presentations and the poster abstracts and (fairly soon) the full working group reports see:

- www.ecmwf.int/newsevents/meetings/workshops/2011/GABLS/index.html

Accession agreement between Croatia and ECMWF

MANFRED KLÖPPEL

On 8 November 2011, Dr Radovan Fuchs, Minister for Science, Education and Sports of the Republic of Croatia, and Professor Alan Thorpe, Director-General of ECMWF, signed the "Agreement between the Government of the Republic of Croatia and ECMWF on the accession of the Republic of Croatia to the ECMWF Convention" in Zagreb. Mr Ivan Čačić, Director of the Meteorological and Hydrological Service of Croatia and President of the Regional Association VI (Europe) of the World Meteorological Organization (WMO), attended the ceremony. Before it will enter into force, the agreement will have to be ratified by the Croatian Parliament.

Minister Fuchs stated: "It is an honour for me to sign the accession agreement with the European Centre for Medium-Range Weather Forecasts, one of the world's leading centres in global numerical weather prediction. The establishment of formal links with this European centre of excellence was one of the key strategic goals for the Government of the Republic of Croatia. Therefore, today's signature was an important milestone. I would also like to express my appreciation to the ECMWF Council for the unanimous decision on the accession of the Republic of Croatia to the ECMWF Convention."

Signing of the accession agreement between Croatia and ECMWF. Dr Radovan Fuchs, Minister for Science, Education and Sports of the Republic of Croatia (right), and Professor Alan Thorpe, Director-General of ECMWF (left) signing the 'Agreement between the Government of the Republic of Croatia and ECMWF on the accession of the Republic of Croatia to the ECMWF Convention' in Zagreb on 8 November 2011

Mr Čačić said: "Since Croatia became a Co-operating State in December 1995, the Meteorological and Hydrological Service of Croatia (DHMZ) has been using ECMWF's products, in particular to improve our forecasts. Above all, the Centre's early warnings of extreme weather events are vital to enable us to prepare for and respond to those events. Based on the Centre's forecasts we contribute to saving lives and reducing damage. I am looking forward to even closer collaboration with our colleagues at ECMWF, the world's leading centre in global medium-range weather prediction."

Professor Thorpe said: "I am pleased that following today's signature of the accession agreement the Republic of Croatia will soon become a Member State. Croatia will then acquire full voting rights at the ECMWF Council. Also a portion of the Centre's computer and archive resources will be allocated to the Republic of Croatia for its own use. Access to all ECMWF products and tools will be granted. We will continue close collaboration with our colleagues at the Meteorological and Hydrological Service of Croatia."

Applying for computing resources for Special Projects

UMBERTO MODIGLIANI

Each year users within one of ECMWF's Member States may apply for computing resources as a 'Special Project'. These are of a scientific or technical nature and are likely to be of interest to the general scientific community. Such projects can be undertaken in co-operation between several institutions, nationally or internationally.

The decision to treat a project request as a Special Project application is made ultimately by the Director of the National Meteorological Service of the project's Principal Investigator. European organisations with which ECMWF has concluded Co-operation Agreements may apply for resources for a Special Project, with such a request to be considered by the Director of ECMWF. The Special Projects that are continuing or starting in 2012 are given in the item starting on page 34 of this edition of the *ECMWF Newsletter*.

If you wish to begin work on a Special Project in 2013 then an application form should be completed and sent to ECMWF via the Director of the appropriate National Meteorological Service. The form needs to reach ECMWF by 30 April 2012. Requests will be reviewed by the Scientific Advisory Committee and Technical Advisory Committee in October and then approved (or not) by the ECMWF Council at its meeting in December 2012. If the 30 April deadline is missed, applications can still be made as limited resources are set aside specifically for ad hoc allocations.

The various application forms and more information about special projects are available from:

- www.ecmwf.int/about/special_projects/

Outcome of Council's 76th session

MANFRED KLÖPPEL

Under the chairmanship of its President, François Jacq (France), the Council held its 75th session on 6 and 7 December 2011.

The Council congratulated the Centre on its main achievements since its last session in June 2011, noting the following in particular.

◆ ***ERA-Interim.*** The ERA-Interim dataset had been extended back to 1979; the extension makes the dataset even more useful for climate-related studies and climate change monitoring, as it now covers a period exceeding three decades.

◆ ***MACC-II project.*** The MACC-II project had started; MACC-II will lead to the operational phase of the GMES Atmospheric Monitoring Service in 2014.

◆ ***Seasonal Forecasting.*** The new seasonal forecasting system has been introduced; it is at higher resolution (80 km grid), represents the full stratosphere as well as the troposphere, the ocean and the land surface, and utilises a slightly larger ensemble (51 members) and longer calibration period (30 years) than the previous system.

◆ ***Computer upgrade.*** The upgrade of the high-performance computer system had started; ECMWF had received the first delivery of 9 frames of computer equipment from IBM.

◆ ***Forecasting system upgrade.*** A new version of the forecasting system has been implemented, containing a collection of improvements to the forecast model, the data assimilation and the ensemble prediction system.

◆ ***Major severe weather events.*** The Centre had provided good early forecasts for several major severe weather events, for instance the torrential rainfall in the area of Genoa, Italy, in early November 2011.

◆ ***Summer skill scores.*** The summer skill scores had been generally very good; comparisons of deterministic and ensemble forecast results with those of other global forecasting centres showed that ECMWF had continued to maintain its lead in the medium as well as in the monthly forecast range.

Besides several decisions made on financial and staff matters (such as adoption of Reports from the Co-ordinating Committee on Remuneration), the main results of this session were as follows.

◆ ***Improving energy efficiency.*** The Council approved use of otherwise surplus funds for the installation of dry coolers into its cooling infrastructure to provide indirect cooling of the chilled water system by ambient air. The installation will result in a 5% reduction in the annual energy consumption at ECMWF and thereby reduce the greenhouse gas emissions associated with the Centre's activities.

◆ ***Co-operation with RIMES.*** The Council agreed that ECMWF should negotiate and conclude a co-operation agreement with the Regional Integrated Multi-Hazard Early Warning System (RIMES), an intergovernmental institution for the generation and application of early warning information which evolved from the efforts of 29 countries in Africa and Asia, in the aftermath of the 2004 Indian Ocean tsunami;

◆ ***Co-operation with Moldova.*** The Council authorised the Director-General to conclude a co-operation agreement with the government of the Republic of Moldova.

◆ ***Co-operation with EFAS.*** The Council agreed that ECMWF should conclude the necessary agreements to operate the computational centre of the European Flood Awareness System (EFAS) for up to four years (see the news item on page 4).

◆ ***Four-year programme of activities.*** The Council unanimously adopted a four-year programme of activities for the years 2012-2015.

◆ ***Budget 2012.*** The Council approved the budget for 2012 with an increase of 1.52% in terms of Member States' contributions compared to 2011.

Other important decisions made were as follows.

◆ ***Members of the Scientific Advisory Committee.*** The Council approved the appointment, in their personal capacity, of three new members of the Scientific Advisory Committee: Prof Sarah Jones, Dr Sonia Seneviratne and Dr Florence Rabier for a first term of office of four years.

◆ ***President and Vice President.*** The Council unanimously re-elected Mr François Jacq (France) as President of the Council, and Mr Ricardo Garcia-Herrera (Spain) as Vice-President of the Council, both for a second term of office of one year.

A lecture was given by Professor Erland Källén, Director of the Research Department, on '*Scientific developments underpinning future high-performance computing provision*'.

Establishment of an Atmospheric Composition Division

ERLAND KÄLLÉN

MACC (Monitoring Atmospheric Composition and Climate) activities, and earlier those associated with GEMS, were integrated within the pre-existing ECMWF management structure. The aim was to achieve a rapid development of a real-time, operational forecasting system for atmospheric composition that builds on the existing NWP system at ECMWF. As we moved into the MACC-II project from 1 January 2012, it was appropriate to reconsider the management structure for research activities concerned with atmospheric composition.

From 1 January a new 'Atmospheric Composition Division' has been formed within the Research Department, with consultants involved in MACC-II activities (or in research activities mainly related to modelling or assimilation for atmospheric composition) regrouped in a 'Chemical Aspects Section'. Also there will remain a core of MACC-II consultants in the Operations Department.

Vincent-Henri Peuch (the new programme manager for MACC) is the Head of Atmospheric Composition Division and he takes on the role of acting Head of Chemical Aspects Section until that position is filled.

The main objectives of the reorganisation are to:

◆ Co-ordinate, manage and carry out the externally-funded activities targeted at developing and operating the GMES Atmospheric Monitoring Service. Activities and tasks for the period November 2011 to July 2014 are described in the Description of Work for MACC-II.

◆ Within the constraints of the funding from the European Commission's Seventh Framework Programme (FP7), carry out research on topics linking atmospheric composition and NWP: modelling, assimilation, medium-to long-range forecasting etc.

◆ Be efficient and resilient over time in anticipation of the GMES full operations phase, by following as much as possible the more general principles of organisation (structures, line management etc.) within ECMWF and the Research Department.

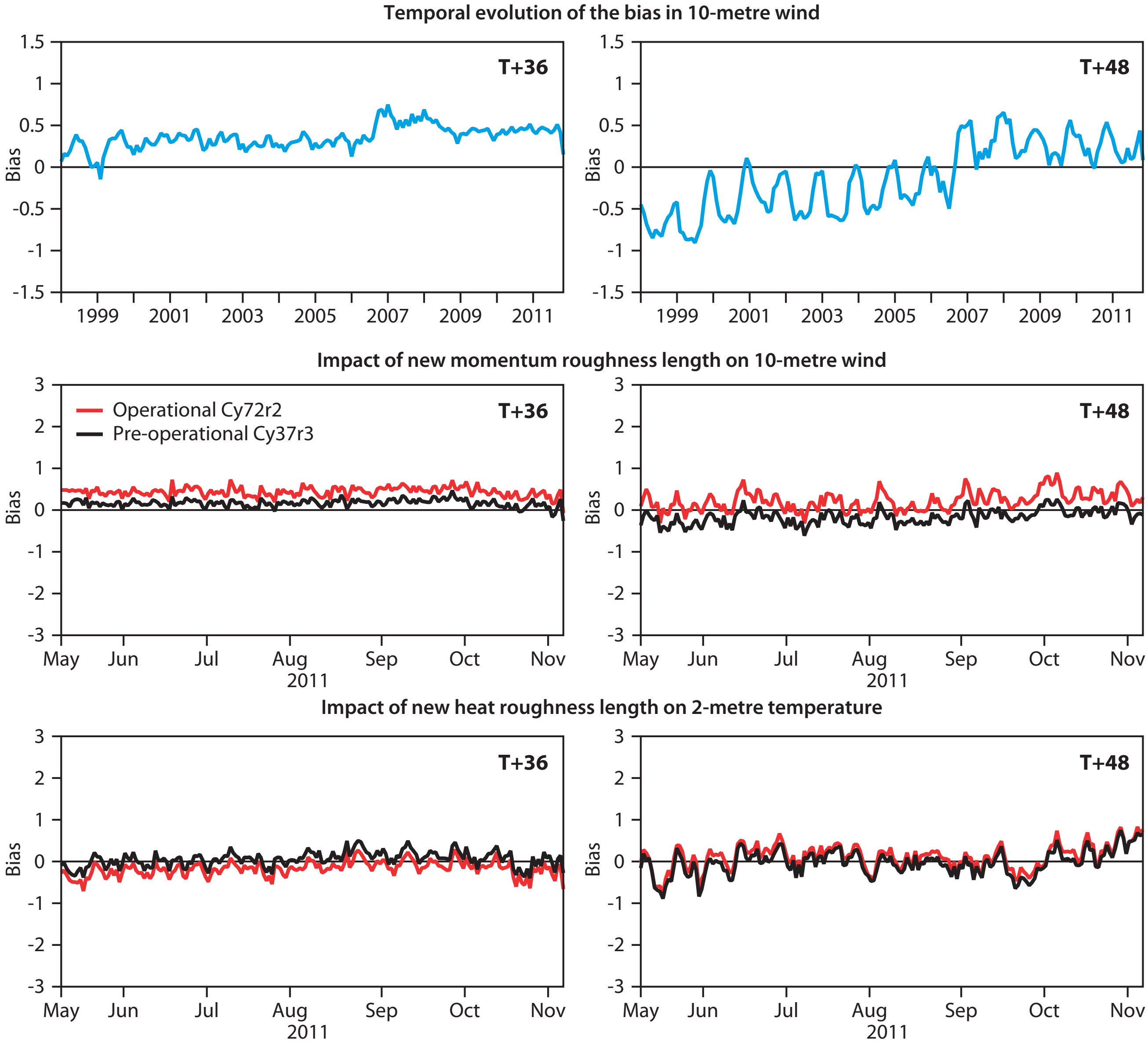
Revision of the surface roughness length table

IRINA SANDU, ANTON BELJAARS, GIANPAOLO BALSAMO, ANNA GHELLI

As users are becoming increasingly interested in near-surface weather products, one of ECMWF's strategic goals is to improve the quality of the forecasts of near-surface winds, temperature and humidity. A step in this direction was achieved with the change of the surface roughness length values, which was implemented in IFS Cycle 37r3 on 15 November 2011. This change improved considerably the representation of near-surface wind speed and corrected to some extent the 2-metre temperature biases.

For many years, the ECMWF forecasts have overestimated the near-surface (10 metre) wind speed over land. It is found that the mean forecast errors, with respect to routine SYNOP observations, range roughly between 0.5 and 1 m/s for various regions/times of the day (see for example the errors for Europe at 00 and 12 UTC during the last 13 years shown in the top panels of the figure). These errors depend on the vegetation type, because the representation of the 10-metre wind speed is mainly controlled by the (constant) value of the momentum roughness length associated with each vegetation type. This parameter is difficult to determine from observations. Consequently the values used so far in the ECMWF model were empirically chosen as 20% of the vegetation height for forests and 10% for the other vegetation types (Mahfouf et al., 1995, *J. Climate*, 8, 2039–2057).

The overestimation of the near-surface wind speed for most of the vegetation types suggests that the values used for the momentum roughness length were too low. This motivated the revision of these values based on theoretical considerations and SYNOP observations of wind speed at 10 metres. The basic idea was to search, for each vegetation



Near-surface wind speed and temperature bias with respect to routine SYNOP observations. All panels show the bias of wind, or temperature, for Europe at 00 (left) and 12 UTC (right) derived from the 36-hour and 48-hour forecasts from 12 UTC for each day. The top panels show the temporal evolution of the 10-metre wind speed bias since 1998. The middle panels show the reduction in the 10-metre wind speed bias when the new roughness length values are used (i.e. test of Cy37r3 compared to Cy37r2). Finally, the bottom panels show the impact of the changes to the roughness length for heat on the 2-metre temperature, namely a warming during nighttime and cooling during daytime.

type, for a new value of the momentum roughness length for which the mean 10-metre wind speed forecast error with respect to SYNOP observations drops to zero. This calibration showed that the momentum roughness length values should be increased for nine and decreased for one of the eighteen vegetation types characterizing land areas.

The need for an increase of the momentum roughness length over land suggested by our calibration method is in agreement with some recent work (**Vautard et al.**, 2010, *Nature Geoscience*, **3**, 756-761). This argues that the surface roughness increased during the last 30 years in the northern hemisphere due to an increase in biomass and to land-use change in Eurasia. The newly-derived values for ten of the vegetation types were therefore introduced in Cy37r3. As the roughness length for momentum was on average increased, the roughness length for heat was decreased in order to account for terrain heterogeneity.

The use of the new momentum roughness length values reduces significantly the 10-metre wind speed forecast errors, especially for the predominant vegetation types, but also on average over continental areas. The improvement for Europe was clear (see middle panels of the figure) in the testing of the new Cy37r3 before becoming operational on the 15 November.

The reduction of the heat roughness length has a positive impact on the 2-metre temperatures, leading to a small warming during the night and cooling during the day over the continental regions for both winter and summer. Thus, the cold night-time bias and the warm daytime bias noticed, for example over Europe, are reduced (see lower panels of the figure). The new roughness length for heat acts thus to damp the amplitude of the diurnal cycle of 2-metre temperature, which is generally too strong in the model. The modification of the roughness length for heat also improves the representation of the daytime skin temperature, and its diurnal cycle. This conclusion is supported by the diminution of the daytime analysis departure for the radiances assimilated from channel 6 of the METEOSAT-9 IMAGER, which are a proxy for the skin temperature.

Use and development of Meteorological Operational Systems

ERIK ANDERSSON, BAUDOUIN RAOULT, DAVID RICHARDSON, STEPHAN SIEMEN

The 13th biennial Workshop on Meteorological Operational Systems was held at ECMWF from 31 October to 4 November 2011. The workshop:

- Reviewed recent developments in the use and interpretation of medium- and extended-range weather forecasts.
- Addressed the data management and visualisation requirements.

This year there was an additional focus on the use of meteorological data in multi-disciplinary applications and international initiatives aimed at making meteorological data readily accessible to wider user communities.

As well as the presentations and discussions there was a session that showcased new meteorological data processing and visualisation systems and updates to existing applications.

The 13th biennial Workshop on Meteorological Operational Systems. The workshop was attended by nearly 60 participants from 24 countries. As well as the presentations and discussions there was a session that showcased new meteorological data processing and visualisation systems and updates to existing applications.

The workshop was attended by nearly 60 participants from Meteorological Services, the World Meteorological Organization (WMO), the United Nations World Food Programme (WFP), research institutions and commercial weather services coming from 24 worldwide countries.

During the week two working groups were established. The following are some of the key points raised by the working groups.

Use and interpretation of medium and extended range forecast guidance

There has been an increase in the amount of data used in the forecasting process (e.g. EPS, multiple models, range of parameters) and more automation in weather forecast production. Consequently, the forecasters cannot manually prepare and assess all data that is available – there is a need to focus on the 'important' aspects. Also there is a trend in the forecaster's role from basic weather forecasting to impact forecasting and decision support. It is therefore important for forecasters not only to account for uncertainty but also to communicate that uncertainty to users.

As a result of the growing range of application areas where weather forecast data is only one element of an integrated multi-disciplinary approach (e.g. civil protection, health, agriculture, energy and transport), there are requirements for data from different sources. The main challenge is the huge (sometimes overwhelming) amounts of data. It may be difficult to find what is required (or what is available). Also it is important to know the quality and the reliability of the data.

In the operational forecasting environment there may be a requirement for traceability of decisions to answer the questions concerning what data was used and the source of that data. Overall uncertainty information needs to be propagated through the production process to all users to assess risks.

Data management and visualization

It is often difficult to find WMS (Web Mapping Services), even for testing purposes. In addition, popular free

WMS services easily get swamped which makes such services unreliable and unsuitable for operational activities. Also it was noted that from January 2012 WIS (WMO Information System) catalogues are available. As these contain lists of datasets and services they can be used to advertise the availability of meteorological data. Meteorological workstations will need a built-in link to these catalogues (SRU/Z39.50).

There was a general feeling that the meteorological community will not drastically change its working practices due to the novel WMS. Current systems are fast and reliable, though users might move to using WMS to get access to new products. It appears , however, that it is worthwhile the meteorological community continuing to invest time and efforts in OGC standards, particularly as their use is mandated by EU's INSPIRE directive.

Public web-services are free, but the products provided are not reliable for operational activities. Achieving operational use of web-services will require service level agreements (SLAs) between parties. High availability can be achieved when multiple centres provide backups of each others' services, but there might be a need to use a dedicated network link in order to guarantee good service.

Data quality work is on-going in WMO. Different providers could have different ways of describing their data quality. Perhaps users could be asked to provide indication of their confidence in the data through user-based rating systems.

Conclusion from the plenary session

The meteorological community needs to continue investing efforts in OGC standards. More volunteers are required to speed up the process and more focus should go to WCS and WFS (Catalogue and Feature Services). This will solve some limitations of WMS and extend the range of possible products.

Operational systems evolve at a slow pace, so more time is needed before we start seeing operational web services. It is expected that most of the current technical difficulties will disappear with time, and solutions will be found by other communities.

Existing data distribution practices will continue to exists as they are (e.g. 'push' methods, in particular for critical data) because they are very reliable. But uptake of web services will really start when new products are only available this way.

Operational web services will require service level agreements (SLAs) and backup procedures. Finding reliable ways of providing users with data quality information is paramount. Also meteorological datasets and services must be publicised in WIS catalogues and forecaster workstations should be provided with access to these catalogues directly.

The final plenary session concluded an informative and successful workshop.

All the presentations and workshop reports can be found at:

- www.ecmwf.int/newsevents/meetings/workshops/2011/MOS13/index.htm

Upgrade of the HPCF

MIKE HAWKINS

ECMWF received the first delivery of nine frames of computer equipment from IBM for the mid-life upgrade of the High Performance Computing Facility (HPCF) in November 2011.

The delivery from IBM consisted of a test system, four compute frames and four frames of disk storage providing over 3 petabytes of usable disk. The four compute frames have more than 12 thousand POWER7® processor cores and will deliver more computational power than one of the current clusters on ECMWF codes. A further thirteen compute frames are expected.

ECMWF's HPCF upgrade will continue the successful design of two independent clusters that can cross-

Part of the mid-life upgrade of the HPCF. A cluster consisting of a management frame with compute and storage frames. The completed system will provide almost three times the sustained performance of the current system.

Each compute cluster will weigh more than 26 tonnes and will comprise:

- 24 super nodes, made up of 32 nodes
- 732 'normal memory' application nodes with 64 GB of memory
- 20 'large memory' applications nodes with 256 GB of memory
- 10 'Availability Plus' spare nodes
- 6 'service' nodes
- 24,576 POWER7 processor cores
- 53 TB of memory

mount storage. Dual clusters add significantly to the resiliency of the system, allowing flexibility in performing maintenance and upgrades and when combined with separate resilient power and cooling systems provide protection against a wide range of possible failures.

The upgrade is based on nodes made up of 4 IBM POWER7 processors each with eight cores. Eight nodes make up a drawer and 4 drawers make a super-node. A low latency high speed network connects each node to every other node in a super-node and each super-node to every other super-node. The bandwidth of this interconnect is 23 terabytes per second per compute cluster.

The completed system will provide almost three times the sustained performance of the current system and have a theoretical peak performance of about 1.5 petaflops. The upgraded HPCF will be made available progressively during 2012.

More information about ECMWF's supercomputer can be found at:

- www.ecmwf.int/services/computing

Progress in ERA-CLIM: First General Assembly

DICK DEE

The first General Assembly for the ERA-CLIM project took place in Lisbon on 15-16 December 2011, marking the end of the first year of the project. This was an opportunity for all ERA-CLIM partners to meet and discuss the work done so far, and to answer questions and take advice from the recently formed Advisory Board for the project.

ERA-CLIM is a three-year European project aiming to prepare a new global climate reanalysis extending back to the early 20th century. ECMWF leads the project and will build the data assimilation systems needed for reanalysis, produce several preliminary reanalysis data sets, and develop the services needed for providing data access to future users of climate data.

The General Assembly reported impressive progress in the area of data rescue, which is a major focus of ERA-CLIM. Several project partners are uncovering large volumes of early weather observations that are not currently available in digital archives. These include highly valuable upper-air observations in tropical and high-latitude regions made in the first half of the 20th century (e. g. from ships, kites, radiosondes, and research aircraft). Numerous new sources, such as logbooks and annual climate reports, have been located and are now being digitized. This laborious and painstaking process is carried out using a variety of tools and techniques, including optical character recognition software and a great deal of human quality control. The data will ultimately be combined into digital collections suitable for reanalysis and will be made available for climate science without restrictions.

While the term data rescue is usually associated with conventional weather observations, the early (pre-1979) satellite record is also in danger of disappearing. Surprisingly, much of this record has not been systematically archived, and in many cases the original measurements exist only on magnetic tape or other perishable media. ERA-CLIM includes a modest effort to safeguard some of these data, such as Nimbus-6 measurements from HIRS and PMR made in the early 1970s, and to make them potentially useful for reanalysis by properly archiving the data and developing the radiative transfer models needed for data assimilation. ERA-CLIM also supports various activities directed at the reprocessing and re-calibration of the more recent satellite data record in order to increase its value for climate reanalysis.

At ECMWF, preparations for the production of the first ERA-CLIM test reanalysis, ERA-20C, are nearly complete. ERA-20C will comprise an ensemble of ten reanalyses for the period 1900 to 2012 based on surface

Partner institutions and Advisory Board for ERA-CLIM

The ERA-CLIM project is coordinated by ECMWF.

Partner institutions

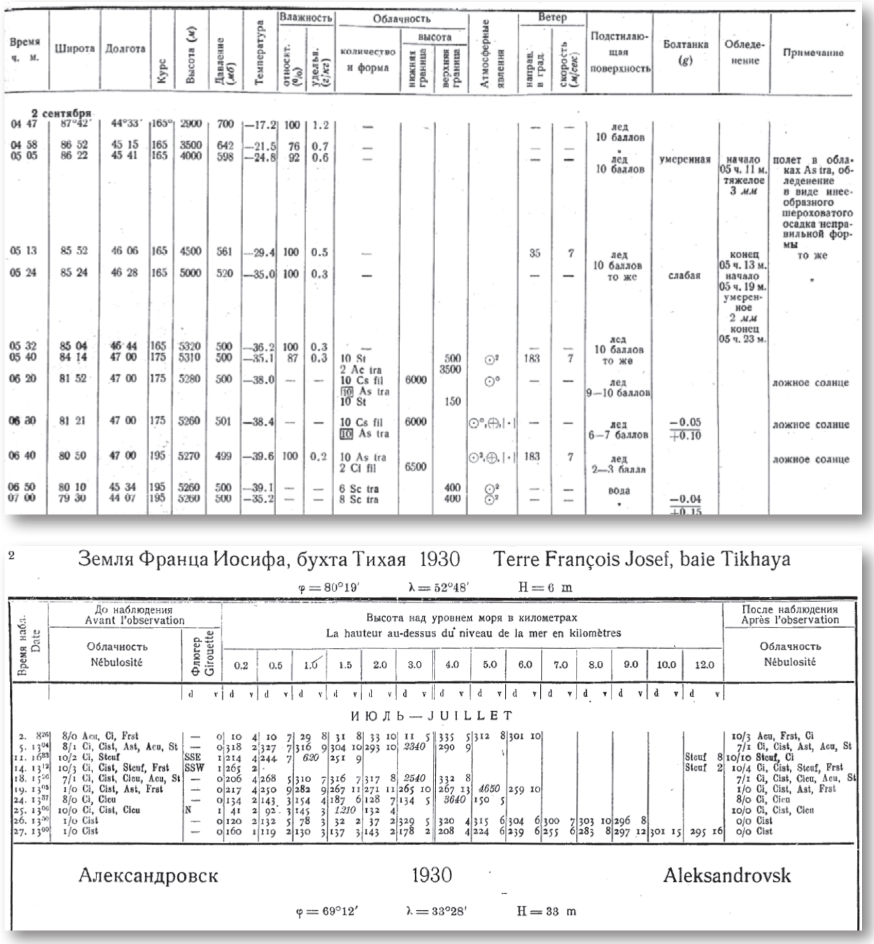
- Met Office Hadley Centre
- Institute for Meteorology and Geophysics at the University of Vienna
- Oeschger Centre for Climate Change Research at the University of Bern
- Russian Research Institute of Hydrometeorological Information - World Data Centre in Oblinsk, Russia
- Faculty of Sciences at the University of Lisbon
- European Organisation for the Exploitation of Meteorological Satellites
- Météo-France
- Universidad del Pacífico in Santiago, Chile

Advisory Board

- Prof Phil Jones, director of the Climatic Research Unit at the University of East Anglia
- Dr Michele Rienecker, head of the Global Modeling and Assimilation Office at NASA's Goddard Space Flight Center
- Dr Mark Serreze, director of the National Snow and Ice Data Center in Boulder, CO
- Dr Sakari Uppala, former head of the reanalysis section at ECMWF
- Dr Robert Vautard, director of the Laboratoire des Sciences du Climat et de l'Environnement and member of the ECMWF Scientific Advisory Committee

observations only. It will be produced with an advanced version of the ECMWF Ensemble Data Assimilation system (EDA; see *ECMWF Newsletter No. 123*, 17-21) at a spatial resolution of T159 (roughly 80 km). Each of the ten members will be constrained by a different evolution of sea-surface temperatures, each considered equally plausible given what is known about observational uncertainties. The ensemble approach to reanalysis, combined with accessible information about the observations used, will provide a great deal of information about uncertainties in the reanalysis products.

After the presentations and discussions at the General Assembly, the Advisory Board offered many useful and constructive comments. The Board emphasized the importance of following an open and transparent data policy. Also it encouraged the project to provide rapid and efficient user access to the data, including the gridded reanalysis products but especially the input observations and associated quality feedback information.


Время ч. м. | Широта | Долгота | Курс | Высота (м) | Давление (мб) | Температура | Влажность | Облачность | Атмосферные явления | Ветер | Подстилающая поверхность | Болтанка (g) | Обледенение | Примечание

2 Земля Франца Иосифа, бухта Тихая 1930 Terre François Josef, baie Tikhaya

φ = 80°19′ λ = 52°48′ H = 6 m

До наблюдения / Avant l'observation — Высота над уровнем моря в километрах / La hauteur au-dessus du niveau de la mer en kilomètres — После наблюдения / Après l'observation

ИЮЛЬ — JUILLET

Александровск 1930 Aleksandrovsk

φ = 69°12′ λ = 33°28′ H = 33 m

Examples of document pages being digitised in ERA-CLIM. Aircraft observations made in the Arctic in 1954 (top) and pilot balloon wind measurements from Franz Josef Land in 1930 (bottom), both supplied with detailed notes in Russian. A vast store of reports and documents held by the Russian Research Institute of Hydrometeorological Information – World Data Centre includes many thousands such pages, in various formats, containing millions of upper-air observations from 1928 to 1964.

New model cycle 37r3

PETER BAUER, ERIK ANDERSSON

On 15 November, a new model cycle of the Integrated Forecasting System (IFS) was implemented. The new cycle (Cy37r3) included the following.

- Significant modifications of the cloud and convection schemes as well as surface roughness in the model physics.
- Active assimilation of NEXRAD rainfall accumulations over the USA.
- Addition of infrared sounder radiances to constrain the ozone analysis.
- Activation of a temperature bias correction for aircraft.
- Use of the NEMO ocean model (instead of HOPE) in the EPS and use of the NEMOVAR ocean data assimilation system.

Cy37r3 also contains many technical changes and contributions with weaker impact on analysis and forecast. These included improvements to satellite data quality control, preparation for new instruments, activation of the RTTOV-10 radiation transfer model, introduction of the CTESSEL land-surface model, use of model error cycling in the stratosphere, and updates to the tangent-linear physics.

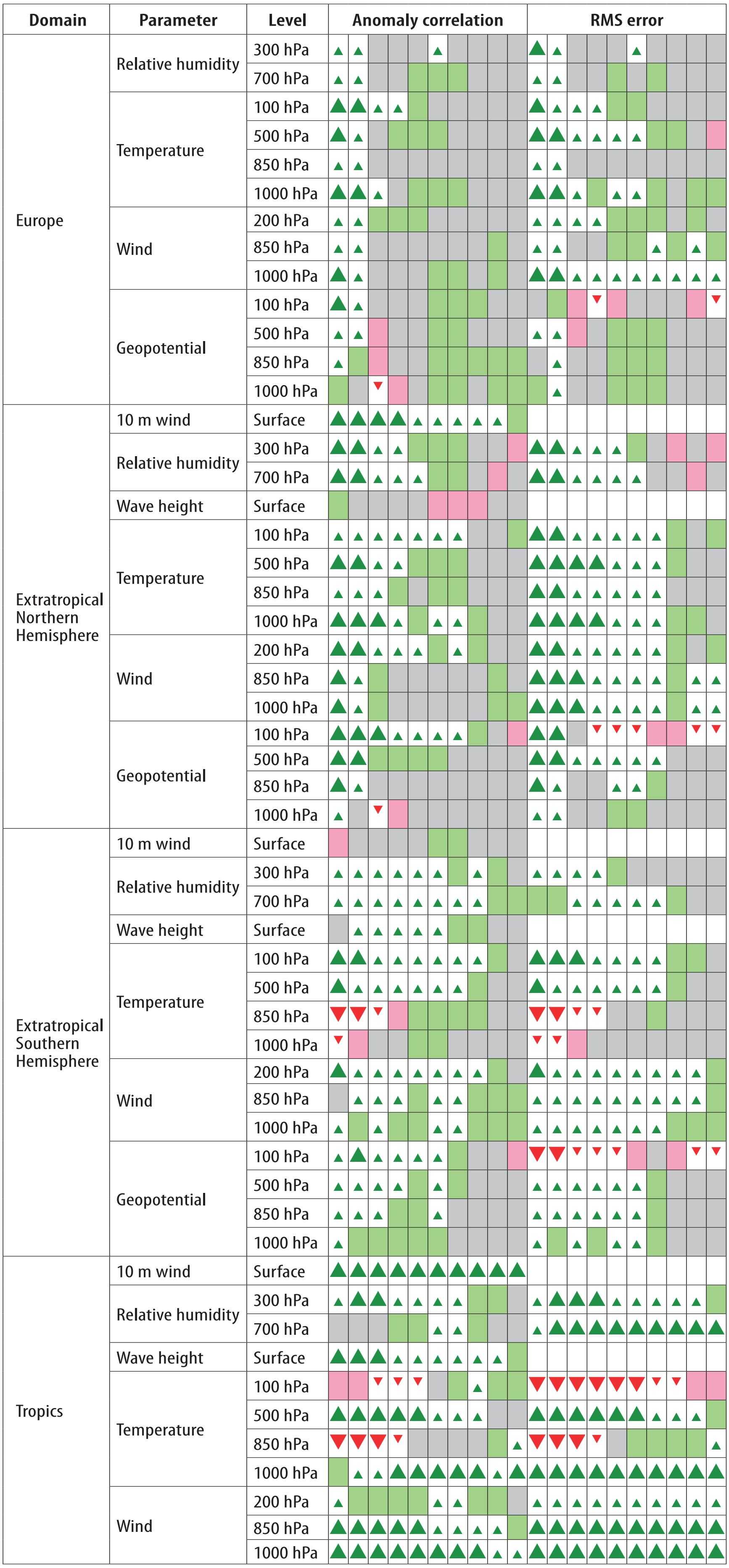
The cloud scheme updates addressed some of the issues related to mixed-phase clouds that had caused excessive negative night-time 2-metre temperature biases over parts of Northern Europe in early 2011 (*ECMWF Newsletter No. 128*, Summer 2011, 10-11). By implementing Cy37r3 in November the cloud scheme revision became active in time for the current winter season (2011/12).

the figure shows the summary score card of the cycle. Symbols and colours indicate better (green) or worse (red) performance of Cy37r3 when compared to Cy37r2 (i.e. the previous operational) as a function of forecast range, both verified with their own analyses. Information on statistical significance has been included as well.

The overall performance is rather good and statistically significant well into the medium range. The main impact of the convection scheme -

humidity dependent detrainment - is a substantial improvement of tropical winds at lower levels. However, cloud and convection schemes change mean temperature structures which produces slightly increased root-mean square errors in geopotential at upper levels. However, anomaly correlation scores are not affected. These errors will be addressed with Cy38r1 that is planned for operational implementation in 2012.

Another feature seen in the scorecard is an increase of lower-level temperature errors over the southern hemisphere. During pre-operational testing the assimilation of all-sky microwave radiances (*ECMWF Newsletter No. 121*, Autumn 2009, 7-8) in areas of low-level super-cooled clouds was identified as the source of excessive temperature analysis increments. This is because the change of the cloud scheme produced larger observation-minus-model departures than before. Prior to implementation it was decided to screen out the all-sky observations in these situations so that this effect was not carried forward into the operational implementation of the cycle.



Symbol legend: for a given forecast step ...
(d: score difference, s: confidence interval width)

▲ Cy37r3 **far better** than Cy37r2 **statistically significant** (the confidence bar above zero by more than its height) (d/s>3)

▲ Cy37r3 **better** than Cy37r2 **statistically significant** (d/s≥1)

Cy37r3 better than Cy37r2, yet not statistically significant (d/s≥0.5)

not really any difference between Cy37r2 and Cy37r3

Cy37r3 worse than Cy37r2 yet not statistically significant (d/s≤–0.5)

▼ Cy37r3 **worse** than Cy37r2 **statistically significant** (d/s≤–1)

▼ Cy37r3 **far worse** than Cy37r2 **statistically significant** (the confidence bar below zero by more than its height) (d/s<–3)

Score card for Cy37r3 against Cy37r2. Verification is against the respective analyses at 00 and 12 UTC for 1 January to 14 November 2011.

Forecast performance 2011

ERIK ANDERSSON, DAVID RICHARDSON

The ECMWF forecasting system produces forecasts of excellent quality. Each year, comprehensive verification statistics are prepared to evaluate the accuracy of the forecasts. A summary of verification results is presented to ECMWF's Technical Advisory Committee. Their views about this year's performance of the operational forecasting system are given in Box A. From this year onwards a new set of six headline scores is being used for the evaluation of long-term trends in forecast performance.

Overall performance in the medium-range

Multi-year time series of verification results reflect the combined impact of all the improvements made to the forecast system over the years: increased resolution, improved forecast model, better data assimilation, and the availability of many more satellite observations.

The forecasting system has performed very well in the last 12 months. In particular, the upper-air performance for the deterministic forecast has been consistently good, with the anomaly correlation of the six-day forecast for the northern hemisphere remaining above 80% for each month.

Headline scores

In the context of ECMWF's Strategy 2011–2020, a set of two primary and four supplementary headline scores has been defined for the evaluation of long-term trends in forecast performance. The aim of the new set of scores is to assess performance for various forecast lead times for surface weather parameters (such as precipitation and wind gusts) as well as for the traditional upper-air fields. These headline scores are shown in Figure 1. Four of the headline scores (two primary and two secondary) are expressed in terms of the lead time at which the score reaches a specific threshold value. The thresholds have been chosen so as to target the verification on the relevant forecast range for each measure of skill.

Figure 1a shows the performance of the high-resolution deterministic forecast as measured by the lead time at which the anomaly correlation of 500 hPa geopotential reaches 80% for the northern hemisphere extratropics; the blue line shows the monthly mean scores and the red line shows the 12-month means. The trend in performance of the Ensemble Prediction System (EPS) is illustrated in Figure 1b. Each point on the curves is the lead time at which the three-month mean (blue lines) or 12-month mean (red line) of the continuous ranked probability skill score of the 850 hPa temperature falls below 25% for the northern hemisphere extratropics. For both the deterministic and EPS forecasts the very high scores achieved during 2010, compared with previous years, have been maintained through 2011.

A — Overall view of ECMWF's Technical Advisory Committee, 6–7 October 2011

In regard to its overall view of the operational forecasting system the Committee:

i congratulated ECMWF on the very high performance level of all the components of its forecasting system and its continued world leading position, while noting a narrowing gap in terms of traditional scores as errors diminish;

ii expressed its appreciation of the imminent introduction of the Monday update run of the monthly extension of the EPS at the request of Member States;

iii acknowledged the value of the EFI for the Member and Co-operating State forecasting services and the high skill of the EFI in predicting severe weather events several days ahead, for instance the strong winds in the UK and Ireland in May 2011 and heavy rainfall in the Balkans in December 2010;

iv congratulated ECMWF for forecasting the genesis and accurately predicting the track and intensification of hurricane Irene in the Caribbean in August 2011;

v noted with satisfaction the removal of temperature bias in the aircraft data used in the analysis;

vi with respect to deterministic forecasts:

- welcomed the recent improvements to the model, in particular the significantly improved skill of precipitation forecasts and the more realistic snow depth forecasts following the introduction of a new snow analysis;
- expressed concern that the current ECMWF forecasting system on occasion in spring gave poor forecasts, linked with strong convective events over the United States;
- noted the tendency for heavy rainfall to be underestimated and light rainfall to occur too often;
- noted the cold temperature bias in winter and spring, particularly in northern Europe;

vii appreciated ECMWF's responsiveness to specific Member State concerns, particularly the revised formulation of cloud microphysics to improve cloud supercooled liquid water layers, which has resulted in better 2 m temperature forecasts;

viii appreciated ECMWF's efforts to continue to improve its deterministic and probabilistic forecast verification system and provide scores reflecting users' needs and usage of ECMWF forecasts, e.g. the on-going development of weather regime-based scores;

ix welcomed the development of web-based facilities to allow forecasters to make better use of ECMWF forecasts (ecCharts);

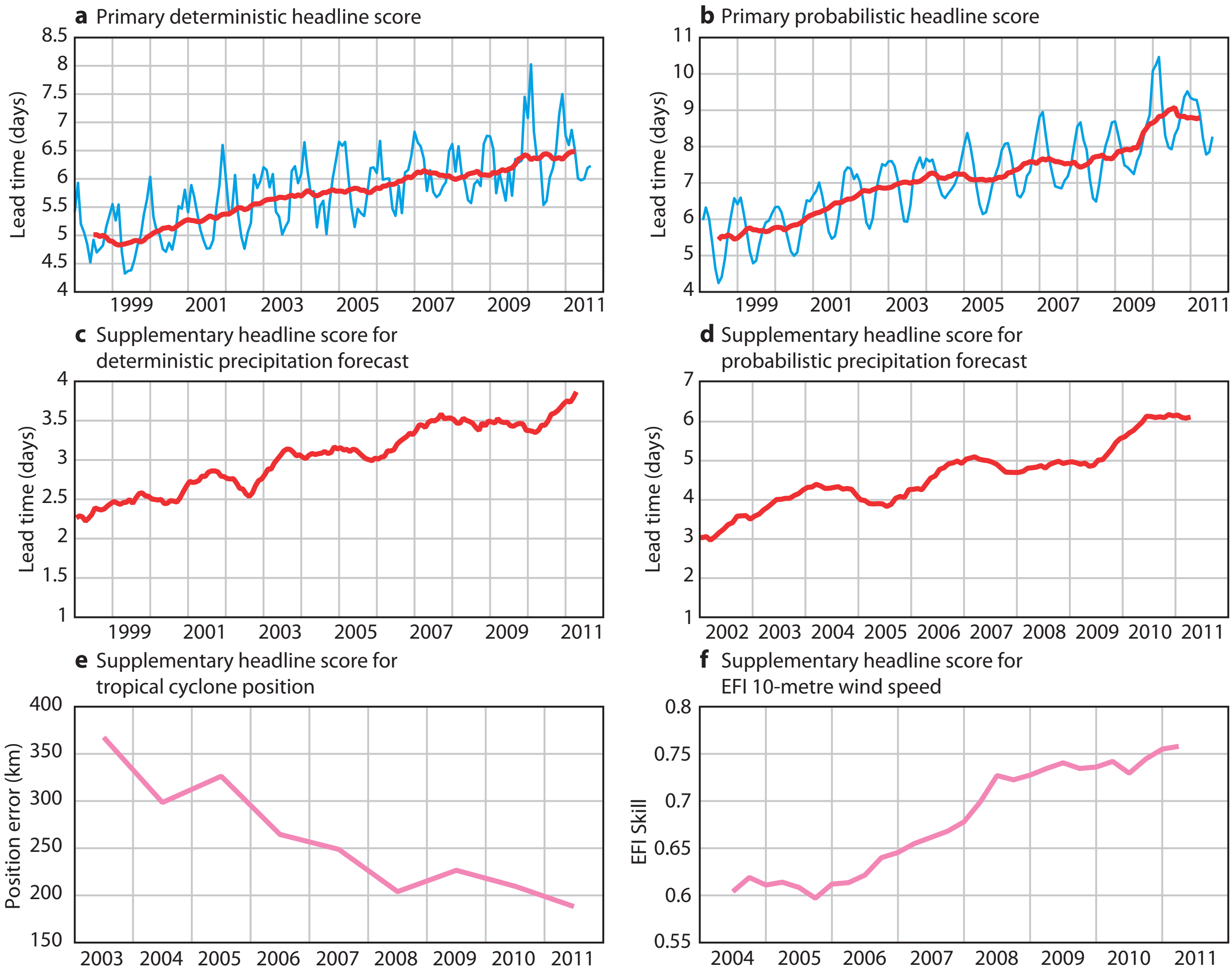


Figure 1 Summary of the two primary and four supplementary headline scores adopted by the ECMWF Council in June 2011 to monitor the trends in forecast performance.

The new supplementary headline scores for deterministic and probabilistic precipitation forecasts are shown in Figures 1c and 1d (they are based on the skill remaining above a specified threshold). The increase in skill of the deterministic forecast in 2010 is associated with the five-species prognostic microphysics scheme introduced in November 2010 (cycle 36r4). For the EPS forecast, the resolution increase on 26 January 2010 (cycle 36r1) is mainly responsible for the improvement in skill between mid-2009 and mid-2010. Due to the time-averaging of the scores, step-wise changes in model skill appear as gradual changes over 12 months in the plots.

The supplementary headline scores for severe weather are shown in Figures 1e and 1f. The mean position error of the 3-day deterministic forecast for all tropical cyclones occurring globally in 12-month periods ending on 31 October is shown in Figure 1e; verification is against the position reported in real-time via the Global Telecommunication System (GTS). The position error reached its lowest ever value this year. Figure 1f shows the skill of the extreme forecast index (EFI) for 10-metre wind speed at forecast day 4 (final point includes summer, June to August 2011). It shows a continually improving trend.

The complete set of annual results is available in *ECMWF Tech. Memo. No 654* on '*Verification statistics and evaluations of ECMWF forecasts in 2010-2011*', downloadable from:

- www.ecmwf.int/publications/library

This document presents recent verification statistics and evaluations of ECMWF forecasts (including weather, waves and severe weather events) along with information about changes to the data assimilation/forecasting and post-processing system. Also the performance of the monthly and seasonal forecasting systems is assessed.

FURTHER READING

Verification pages have been created on the ECMWF web server and are regularly updated. Currently they are accessible at the following addresses:

Medium range: www.ecmwf.int/products/forecasts/d/charts/medium/verification/

Monthly range: www.ecmwf.int/products/forecasts/d/charts/mofc/verification/

Seasonal range: www.ecmwf.int/products/forecasts/d/charts/seasonal/verification/

Note: All forecasting system cycle changes since 1985 are described and updated at:
www.ecmwf.int/products/data/operational_system/index.html

New tropical cyclone products on the web

FREDERIC VITART, FERNANDO PRATES, AXEL BONET, CIHAN SAHIN

The ECMWF tropical cyclone (TC) products are designed to provide probabilistic information to the users. Those products comprise, amongst others, the strike probability forecast of a TC up to 5 days ahead based on data from the Ensemble Prediction System (EPS) and seasonal forecasts of the tropical storm activity.

The continuous development of the forecasting systems at ECMWF has improved the ability to predict the formation of TCs in the medium and extended ranges. Following user requests, a new range of products has been designed to display TC activity (including genesis) throughout the EPS forecast range up to a month ahead. The tracking of existing (named) TCs has been extended from 5 to 10 days into the forecast. The TC identification and tracking algorithms for all forecast ranges have been unified (up to now medium-range and seasonal forecasts used different tracking software). In addition, technical changes made last July allow the TC track forecasts for the deterministic model to be disseminated about one hour earlier than previously.

This article introduces the new products and illustrates these with some examples. Also some results concerning the verification of TC forecasts during the testing period are presented. The dissemination of the new TC products is planned to commence in the first quarter of 2012.

Tropical cyclone tracker

Previously, TC products at ECMWF included only the prediction of tracks of TCs already present in the initial conditions for the medium-range deterministic and EPS (*van der Grijn et al.*, 2005) forecasts and for seasonal forecasts of tropical storm activity (*Vitart et al.*, 2007). These two products used different TC trackers.

It is desirable to have a single TC tracker at ECMWF for predictions at various time ranges (medium-range, monthly and seasonal) and for various types of products (genesis location and tropical cyclone track). Consequently a new tracker has been developed which is a combination of the previous two trackers – see Box A for more details. All the TC products described in this article use this new tracker.

Tropical cyclone products for existing storms

Whenever a tropical cyclone is observed and is present in an EPS forecast, a set of products is generated automatically using the observed position reported via the Global Telecommunications System (GTS) in near real time. The current TC products are being replaced at ECMWF. To date, these products are available from the web at:

- http://nwmstest.ecmwf.int/products/forecasts/d/tccurrent

The new tracker

A

At ECMWF, the medium-range prediction of tropical storm tracks has used the tracker described in *van der Grijn et al.* (2005) to detect features with characteristics of TCs in the analysis and forecast whenever a storm is observed. However, the seasonal forecasts of tropical storms are based on the *Vitart et al.* (1997) algorithm, which not only identifies low pressure systems, but also checks the presence of a warm core above the centre of the storm in the upper troposphere. The presence of a warm core is an important criterion, particularly for genesis detection, since it helps to distinguish tropical cyclones from extra-tropical cyclones.

In order to have a single TC tracker at ECMWF for predictions at various time ranges and for various types of products, the *Vitart et al.* (1997) tracker has been modified so that the detection of cyclones for each model time step remains the same as before. But the trajectory building now uses the same algorithm as in *van der Grijn et al.* (2005), which was more accurate than the one that was used in *Vitart* (2007). Therefore, the new tracker is a combination of the previous two trackers and can be used for seasonal forecasting as well as for the medium-range. For the deterministic forecast and EPS, the maximum wind speed criteria for a tropical storm are set to 17 m/s as for observations, but the criterion is set to a lower value for seasonal forecasts (about 13 m/s) because of the lower horizontal resolution of System 4, the seasonal forecasting system.

This tracker is applied to model output every 6 hours and allows a tropical cyclone to 'disappear' for 24 hours (a tropical cyclone may weaken for a short period of time when crossing an island for instance). The presence of a warm core is required only once during the full tropical cyclone lifetime, so that the trajectory contains the early part of the life of the cyclone, when it is a tropical depression, and also the later part (extra-tropical transition, after landfall). This tracker can detect any tropical storm that develops during the forecast even though it might not be present in the initial conditions. To be detected a storm needs to be present for a minimum of two time steps. The tracker is applied to each individual EPS and seasonal forecast member.

The next generation of products includes the extension of the tracking and strike probability maps from 5 to 10 days ahead and probabilistic information of the storm intensity. The definition of a TC 'strike' was introduced by the National Weather Service in early 1980s (Sheets, 1985): a strike occurs whenever the centre of a storm moves through an area represented by a circle with radius of 62.5 nautical miles.

An approximate threshold (120 km) has been used to construct the strike probability maps at ECMWF since 2003. This is computed using the EPS forecast tracks which are present in the forecast up to 10 days.

Strike probabilities and tracks

Figure 1 shows the strike probability map for Irene from the 10-day EPS forecast from 00 UTC on 22 August, one day after being named a tropical storm. The high-resolution model (T1279) and the ensemble mean tracks are represented by solid and dotted lines respectively, with the symbols placed at 24-hour intervals. With this type of information the forecaster gets valuable guidance of the timing of a hit, especially for the storm to make landfall at a particular location. The forecaster might also want to look at the full set of tracks as well as the derived strike probabilities.

Figure 2 shows the individual tracks based on the same forecast as depicted in Figure 1. The tracks are identified with different colours at 24-hour intervals to emphasize the uncertainties of the motion of the storm with forecast lead time. This can be particularly useful when landfall is expected to occur at a particular location.

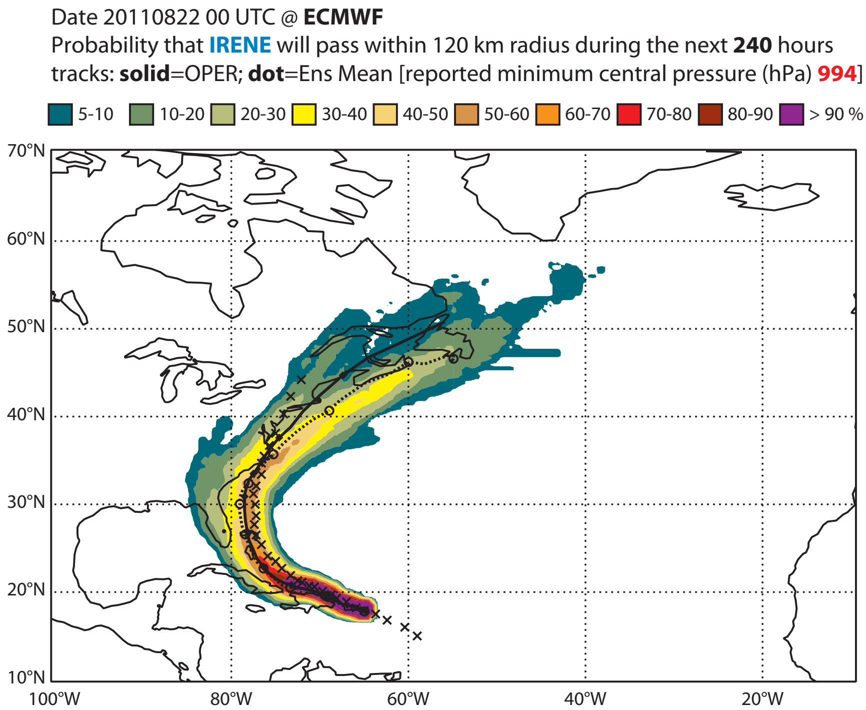


Figure 1 Strike probability (%) that TC Irene will pass within 120 km for the next 10 days for the EPS forecast starting at 00 UTC on 22 August 2011. The lines correspond to T1279 (solid) and ensemble means (dot) tracks with symbols placed at 24-hour intervals. Cross symbols correspond to observed positions of hurricane Irene during the same period.

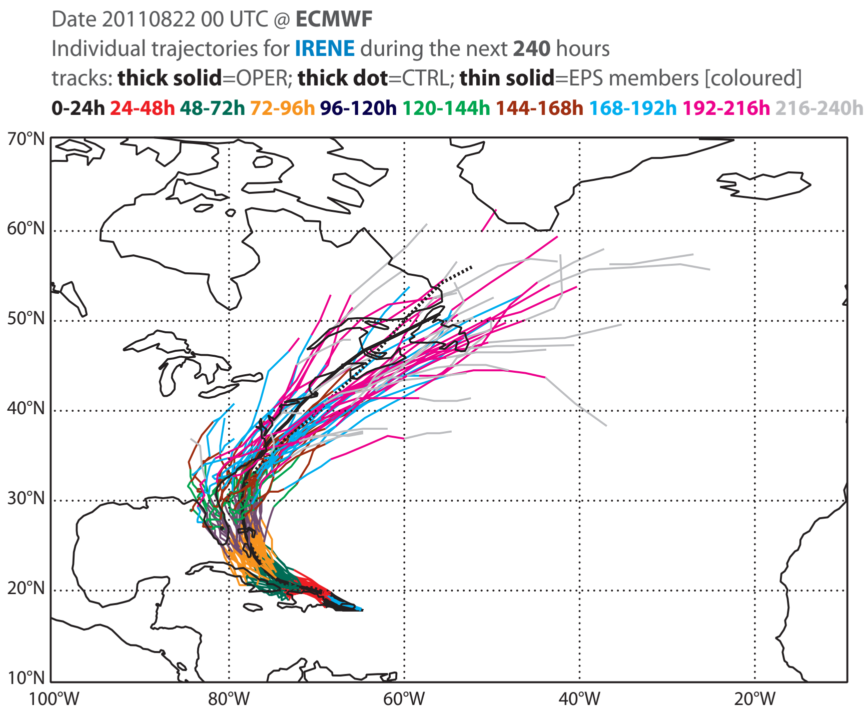


Figure 2 As Figure 1 but for the individual tracks from the EPS for TC Irene using various colours to indicate tracks over 24-hour intervals out to 240 hours. Black lines represent the T1279 (solid) and T699 control (dot) model tracks.

List of ensemble members numbers forecast Tropical Cyclone
Intensity category in colours: **TD**[up to 33] **TS**[34-63] **HR1**[64-82] **HR2**[83-95] **HR3**[>95 kt]

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Figure 3 Numbers of ensemble members that tracked TC Irene at 24-hour intervals up to 10 days based on the same EPS forecast used for Figures 1 and 2. Each ensemble number is coloured accordingly with the strength of the storm in the forecast at the same time intervals.

Ensemble members

To have a clear perception how the EPS forecast is handling the feature during the forecast, a list of the EPS members in which the storm was tracked, together with intensity, can be viewed at 24-hour intervals. An example is shown in Figure 3 for Irene. The first column indicates the forecast interval; subsequent columns show the intensity for the high-resolution 'hr' and EPS control 'ct' forecasts followed by the list of ensemble members. They are coloured according to one of the five predefined intensity categories: tropical depression, tropical storm, and hurricane categories 1, 2 and 3. The attribution is made using the maximum 10-metre wind speed assigned to each member. If the storm disappears from the forecast a blank space replaces the number of the member in that list. Those gaps are not necessarily permanent. Note that the storm is missing in members 6 and 37 at 192 hours but not at 216 hours. This behaviour is quite common in the new tracker because it can stop and then restart the tracking of the same feature some hours later in the forecast, under specific circumstances (see the main characteristics of the tracker described in Box A).

Despite of the continuous improvement in the EPS forecasts in the last few years, the ensembles still have difficulties representing rapid intensity changes. This could be explained by the lack of spatial resolution and description of the inner-core processes in TCs (long-term statistics for intensity forecast errors show differences between the high-resolution and EPS control models with the later showing worse results). Even so, the current forecast system offers a far better distribution of the intensity probability when compared with the previous model configurations.

Intensity probabilities

With the new TC product, it is feasible to represent the uncertainty of strength of a TC during the forecast especially when a rapid development is under way. The intensity probability forecast represents the number of EPS members falling into five predefined categories (as described earlier), each one having equal weight.

Figure 4 shows the probability of storm intensity forecast at 6-hour intervals up to 10 days for hurricane Irene. The most likely category is 'tropical storm' for the whole forecast period. Note that there is a small chance of Irene becoming 'hurricane 1' force on 27 August, which coincides with landfall of the storm accordingly to the position from the ensemble mean (see Figure 1).

Other developments

The traditional Lagrangian meteograms (i.e. following the centre of the storm as it moves in the forecast) for the 10-metre wind speed and minimum mean sea level pressure were kept in the new product. However, the time series for the control model was replaced by the ensemble mean in the new meteograms.

The observed TC position and minimum central pressure (when available) are also included in the new TC product. With this the user can have a perception of the position and 'intensity' errors at the analysis time.

Probability (%) of Tropical Cyclone Intensity falling in each category
TD [up to 33] **TS** [34-63] **HR1**[64-82] **HR2** [83-95] **HR3** [> 95 kt]

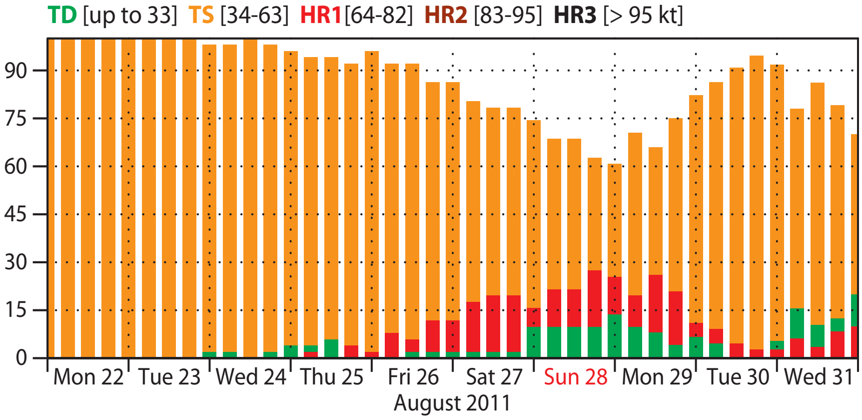

Figure 4 Intensity probability forecast (%) for TC Irene for the next 10 days based on the same EPS forecast used for Figures 1, 2 and 3. The landfall was predicted to occur during 27 August.

Tropical cyclone activity (including genesis)

With the new tracker running (pre)-operationally, a set of new products has been designed to synthesize the information in the EPS forecasts for TCs. These products are available in graphical form at:

- www.ecmwf/products/forecasts/d/charts/medium/eps/genesis/ta_genesis/

for the twice daily EPS integrations.

- www.ecmwf.int/products/forecasts/d/charts/mofc/forecast/tcyc/

for the 32-day extension of the EPS every Thursday and Monday.

Strike probabilities from the medium-range forecasts

Figure 5 shows the strike probability for the occurrence of TCs (storms with maximum wind speeds >8 m/s) that will pass within 300 km of a given location in the two-day period 20–22 August for the EPS medium-range forecast from 00 UTC on 17 August 2011. No observed TCs were present at the analysis time. Using this product, forecasters would immediately notice a very active period predicted for the Caribbean Sea and West Atlantic regions; more than 70% probability that a tropical storm may develop for the next days can be seen over Honduras and the region northeast of the islands of Antigua and Barbuda. Verifying data is shown in the same figure.

Tropical cyclone Harvey formed on 19 August offshore of Honduras and made landfall in Belize the following day, whilst Irene materialized east of the Lesser Antilles on 21 August. Irene became the first hurricane of the 2011 Atlantic season reaching category 3 (>49 m/s). It moved north-westward towards Florida before turning northwards on the 25 August. Landfall occurred two days later in North Carolina as hurricane category 1 (>33 m/s), crossing New York the next day; heavy floods caused widespread disruption in some east coast states. For both storms the observed initial positions were not far from the location of the maximum forecast probability of tropical cyclone genesis given in Figure 5. Equivalent strike probability maps are also generated for cyclones with maximum wind strength above tropical storm (>17 m/s) or hurricane (>33 m/s) thresholds. This allows the forecaster to evaluate the potential activity for more intense systems. All these TC activity products are available as global maps and for seven ocean basins for forecast ranges up to 12 days ahead.

Strike probabilities from the monthly forecasts

Equivalent activity products are produced for monthly forecasts twice a week using exactly the same methodology as for the medium-range forecasts. For these longer lead times,

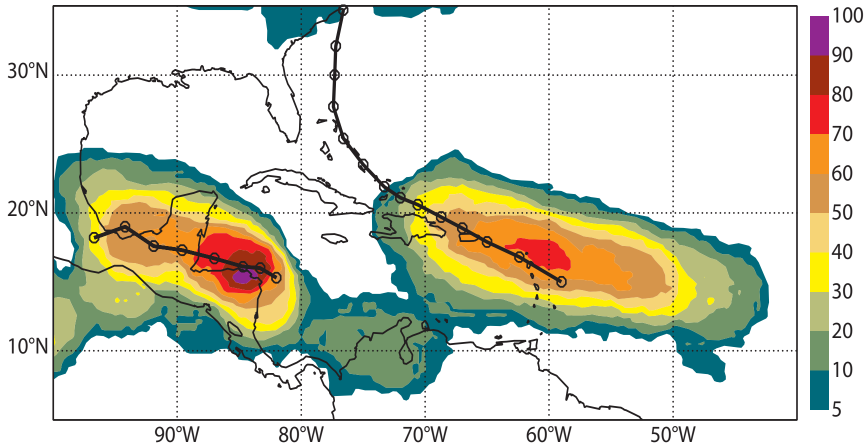

Figure 5 Strike probability (%) for tropical cyclone activity within 300 km (systems with maximum wind speed >8 m/s) for the two-day period 20–22 August based on the EPS forecast from 00 UTC on 17 August 2011. Solid lines and open circles represent the observed tracks of tropical storm Harvey (to west) and hurricane Irene (to east) between 20 and 24 August.

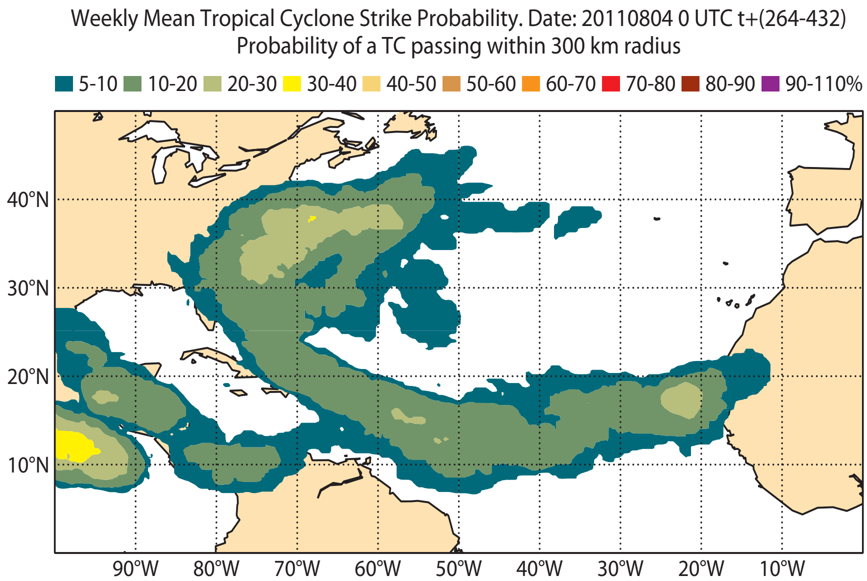

Figure 6 Strike probability (%) for tropical cyclone activity (>8 m/s) for the seven-day period 16–22 August (time range: day 12–18) based on the EPS forecast from 00 UTC on 4 August 2011.

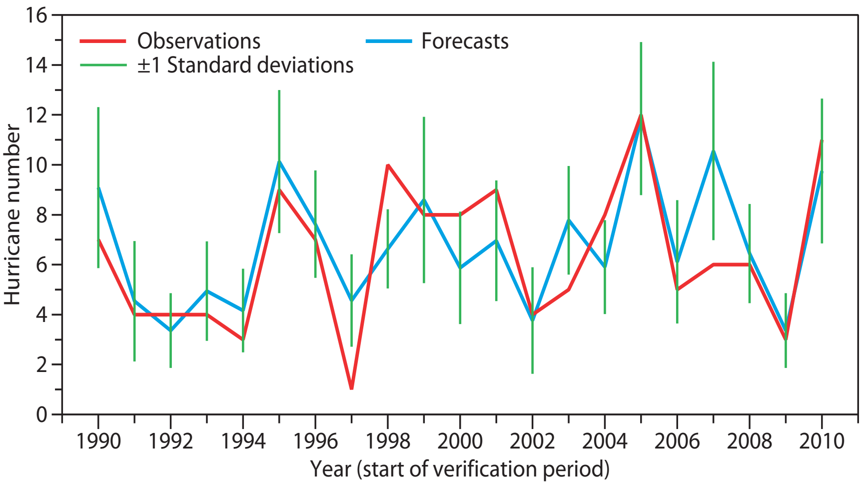

Figure 7 Interannual variability of the number of hurricanes from August to January predicted by System 4 hindcasts starting on 1 July for each year from 1990 to 2010 (blue line) and observed (red line). The vertical green bars represent 2 standard deviations from the model ensemble distribution.

the strike probabilities are computed for the standard 7-day periods corresponding to the calendar weeks (for instance days 5–11, days 12–18, days 19–25 and days 26–32 for the Thursday forecasts) used for monthly forecast products.

Figure 6 shows an example of the monthly forecast strike probabilities. The starting date is 4 August 2011 and the forecast range is days 12–18 (same case as for Figure 5). At this time range, the probabilities are much lower than in the medium-range, but this forecast indicates probabilities up to 30% for a tropical cyclone to occur in the areas that were affected by Irene and Harvey. These probabilities are higher than in other areas of the North Atlantic basin and also higher than climatology.

Seasonal forecast products

The new tracking algorithm is also used to track TCs in the seasonal forecasts (System 4). At this time range, the TC products include the number of tropical storms, number of hurricanes, accumulated cyclone energy (ACE) over a basin (North Atlantic, eastern North Pacific, western North Pacific, South Indian Ocean, Australian Basin and South Pacific), tropical storm density anomaly and standardized tropical storm density for a six-month period. The seasonal forecasts of TCs are available at:

- www.ecmwf.int/products/forecasts/d/charts/seasonal/forecast/seasonal_range_forecast/

Figure 7 shows an example of the verification of the hurricane frequency over the North Atlantic for past forecasts from System 4 starting on 1 July for each year from 1990 to 2010. This shows that, overall, the System 4 has some skill in predicting the in the Atlantic basin for this period. On the seasonal time scale, the predictability of tropical storms comes mostly from the predictability of sea surface temperatures and vertical wind shear in the tropics, which are strongly modulated by the El Niño and La Niña phenomena.

Verification

Verification is performed routinely to assess the performance of both the deterministic and EPS forecasting systems. This is of major importance, particularly when there is an important model development to be implemented in operations such as the increase of resolution or changes in the physical

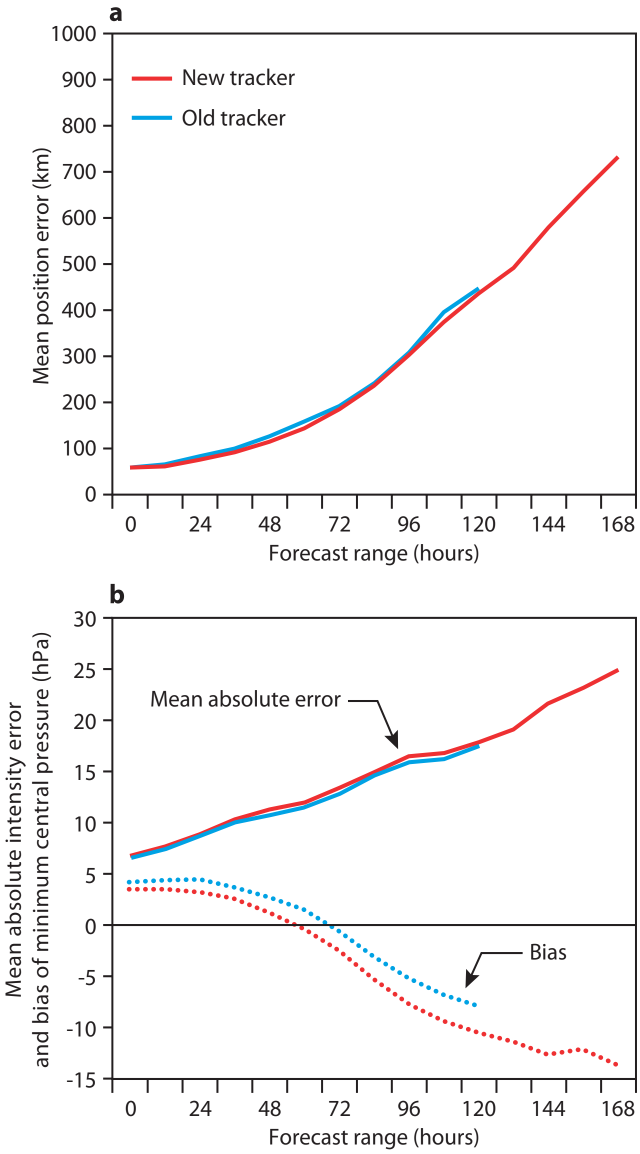

Figure 8 Verification of tropical cyclone forecast from the T1279 model. (a) Mean position errors based on the new (red) and old (blue) trackers for a period of 10 months starting in mid-November 2010. (b) As (a) but for the mean absolute intensity errors and bias of minimum central pressure; solid lines for the mean absolute error and dotted lines for the bias.

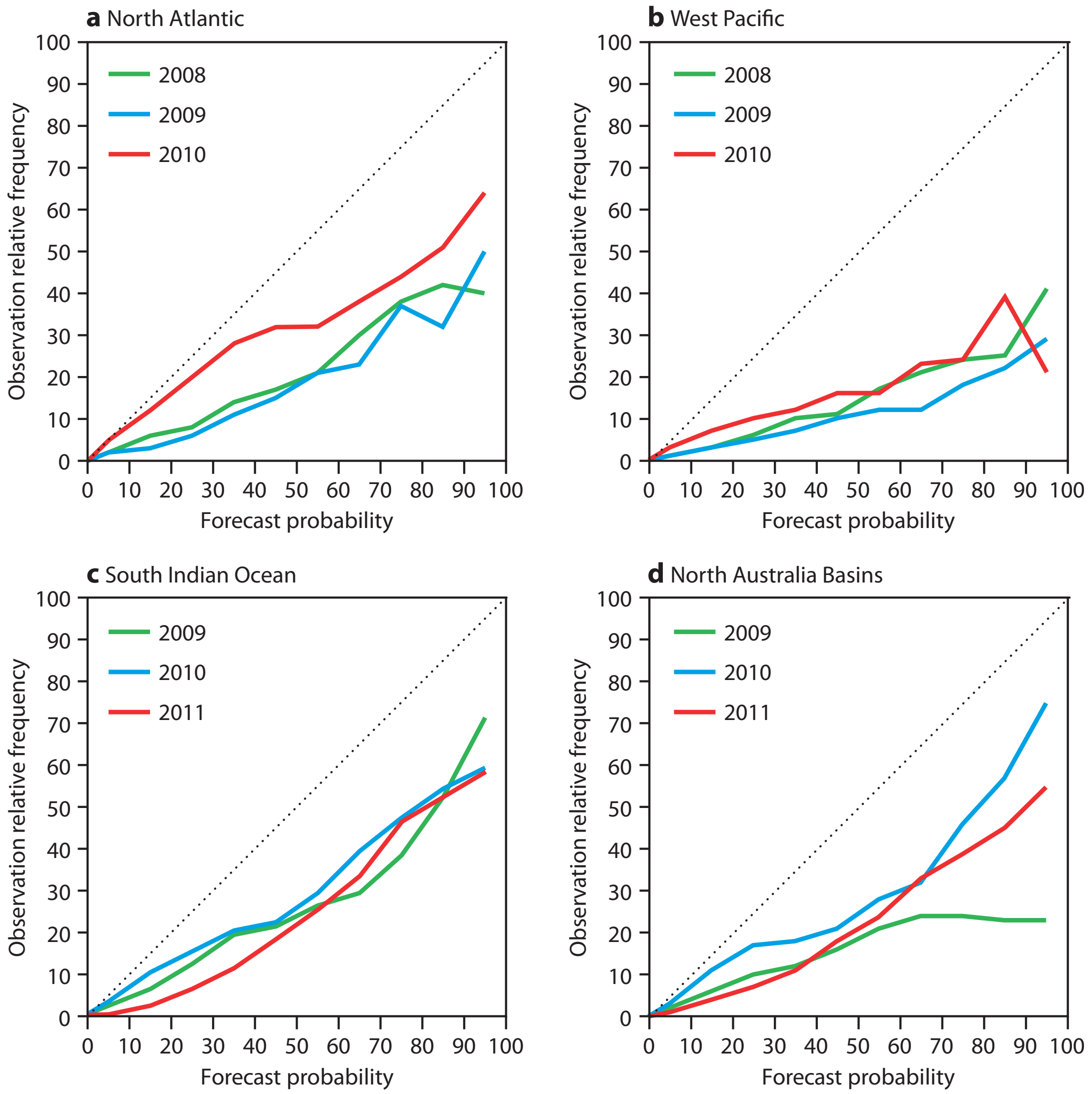

Figure 9 Reliability diagrams for the strike probability of tropical storm strength (and above) activity within 300 km in two-day period for the forecast range 48–96 hours for the last three hurricane seasons for (a) North Atlantic, (b) West Pacific, (c) South Indian Ocean and (d) North Australia basins.

parametrizations, both of which are known to have a significant impact on the quality of TC forecasts.

Deterministic forecasts

The extension of the forecast tracks beyond five days has permitted, for the first time, the assessment of the model's ability to track TCs out to 10 days. To evaluate the forecast accuracy, the observed position and minimum central pressure of the storm (available from the bulletins disseminated via the GTS) are used as independent data.

Figure 8 shows the mean position and intensity errors as a function of the forecast time range up to 7 days for a period of ten months starting on 11 November 2010. For comparison the statistics are given for both the new and old trackers. Out to 120 hours the position errors of the new tracker are similar to those of the old tracker (Figure 8a): the position error is around 450 km and almost double this value 2½ days later. Thereafter position errors increase linearly with the forecast time range between 72 and 168 hours. However, the verification period is still too short to provide enough cases to compute scores with sufficient statistical significance for longer forecast lead times (up to 10 days).

For the mean absolute intensity errors of the minimum central pressure (Figure 8b) the results are similar, but slightly better for the old tracker. The mean absolute error obtained from the new tracker increases linearly with the forecast lead time up to 168 hours. Differences are more significant for the bias. With the new tracker the bias is smaller in the first 72 hours whilst, for longer lead times, the tracker tends to emphasise the systematic negative bias in the forecast system for tropical storms (i.e. the forecast tends to predict too strong storms, on average, when compared with observational data).

Probabilistic forecasts

The verification of probabilistic products is also part of the verification package developed at ECMWF. Recently this has been expanded to include the assessment of the new product – the strike probability of TC activity during the forecast.

Figure 9 shows the reliability curves for the probability forecast that a tropical storm or hurricane will pass within

300 km during a 2-day period for two basins in the northern hemisphere and two for the southern hemisphere. The forecast does not perform equally well in all basins. This result is expected since the number of storms per season and basin can vary significantly from year-to-year which in turn is influenced by the main sources of predictability for TCs (e.g. Madden-Julian Oscillation and El Niño).

Overall, the probability forecasts tend to indicate too high confidence at all probability levels. In the northern hemisphere the forecasts are more reliable in the North Atlantic than in the West Pacific. In the Atlantic basin the forecast reliability has improved in the last year, particularly for low probability forecasts. The forecast reliability for the South Indian Ocean is higher than in the North Australia region. In the South Indian basin the reliability curve for the 2011 season has deteriorated when compared with the previous seasons, especially for low probabilities. This might be related with the fact that the 2011 season was the least active since the records began in 1923.

The skill of the ECMWF 32-day EPS to predict tropical storm strike probabilities over weekly periods has been evaluated from a research experiment because there was not a big enough sample from real-time monthly forecasts. In this experiment, 15-member ensemble forecasts using the same configuration as the operational monthly forecasts, but with a version of the IFS which was operational from November 2010 to May 2011, have been produced starting on the first day of each month from 1989 to 2008. The probability of a tropical storm strike has been computed over a 10°×5° box for each forecast and compared to the observations from the National Hurricane Center (NHC) over the North Atlantic and eastern North Pacific and to observations from the Joint Typhoon Warning Center (JTWC) for the other ocean basins. The dimension of the tropical storm strike domain (10°×5°) for the verification was chosen so that it is large enough to make the verification statistically robust. The Brier skill score has been computed for the northern and southern hemisphere seasons.

Figure 10 shows that the 32-day EPS displays skill in predicting tropical storm strike probabilities for the first three-weekly periods (positive Brier skill score). It also indicates that the model shows more skill over the southern hemisphere than over the northern hemisphere in the sub-seasonal time range. This could be explained by the major role the Madden Julian Oscillation (MJO) plays in modulating TC activity. Since the MJO is more intense during the southern hemisphere tropical cyclone season (winter and spring) than during that of the northern hemisphere (summer and autumn), it is expected that the predictability of TC activity should be higher over the southern hemisphere than over the northern hemisphere in the sub-seasonal time range.

Concluding remarks

A new set of probabilistic products for TCs for the medium-range and monthly forecasts has been introduced. For the medium range the strike probability forecast product for

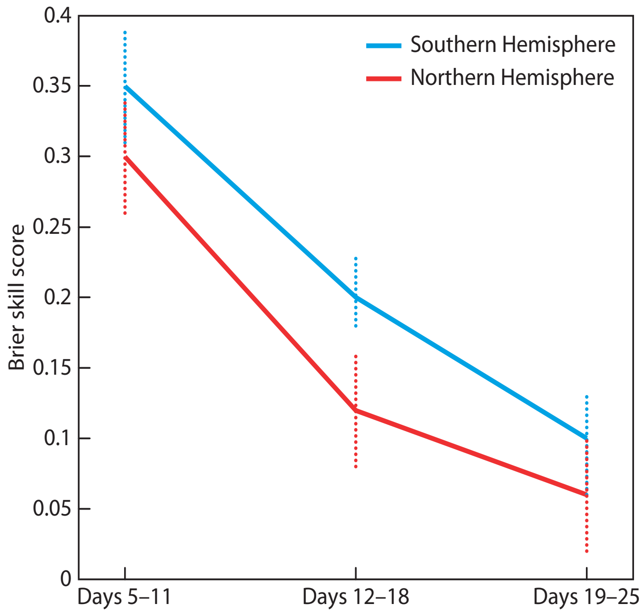

Figure 10 Brier skill scores of the strike probability of tropical storms in the ECMWF monthly forecasts for days 5–11, days 12–18 and days 19–25 for all the tropical storm basins over the northern (red line) and the southern (blue line) hemispheres. The dotted line represent the level of confidence computed using a 10,000 re-sampling bootstrap technique.

existing TCs has been extended from 5 to 10 days. The new TC product, also represents the uncertainty in the strength of a TC during the forecast which is especially of interest when a rapid development is under way. Also, the strike probability for the TC activity (including genesis) during the forecast for the medium and extended ranges is now available to the users via the web.

The accuracy of the new tracking algorithm has been confirmed as being at least as good as the current operational one and will soon replace it. In addition, this new tracking algorithm is being used for the detection of TCs at all time ranges (medium-range, monthly and seasonal). Graphical products are available via the web. There are plans to make the corresponding binary products available to users through the MARS archive in the first quarter of 2012. Recent technical changes in the operational suite have allowed the TC track forecasts from the deterministic model to be disseminated one hour earlier.

FURTHER READING

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Use of EDA-based background error variance in 4D-Var

MASSIMO BONAVITA, LARS ISAKSEN, ELÍAS HÓLM

Atmospheric data assimilation schemes work by combining a 6–12 hour forecast (the background) with observations. The background essentially contains the information from all previous observations propagated by the forecast model. To a large extent, the skill of an assimilation system is determined by how accurately we can describe the errors in the background and the observations. The weight given in the analysis to observations depends on the ratio of background error and observation error variance. In addition, the spatial and temporal structures of the background error covariance are very important for the assimilation scheme.

4D-Var is the four-dimensional variational data assimilation technique used at ECMWF. It performs a statistical interpolation in space and time between observations and an estimate of the model state (i.e. the background). Standard 4D-Var implicitly evolves the background error covariance over a (12 hour) assimilation window, but is not able to use this information in the next analysis. This implies that the background error covariance at the beginning of the assimilation window is almost isotropic and the background error variance is largely homogeneous. It has long been recognised, however, that the spatial and temporal variability of the background errors can be large. This implies that background error estimates need to be flow-dependent and evolving in order for the assimilation system to be able to extract the maximum amount of information from the observations.

It is possible to estimate flow-dependent background error covariance. This can be done through an ensemble of perturbed data assimilations (Ensemble of Data Assimilations, EDA; *Isaksen et al.*, 2010); i.e. an ensemble of independent data assimilations where the main error sources (observation, model and boundary conditions errors) are properly represented. The EDA has been used in two main ways.

- *Integrated Forecasting System (IFS)*. To specify the static background error statistics for 4D-Var and, since May 2011 (cycle 37r2), to provide flow-dependent estimates of background error variances.
- *Ensemble Prediction System (EPS)*. To provide EDA analysis variances that have been used since June 2010 (cycle 36r2) for the estimation of the initial errors (*Isaksen et al.*, 2010, *Buizza et al.*, 2010).

A schematic representation of the EDA and its interaction with 4D-Var and the EPS is shown in Box A.

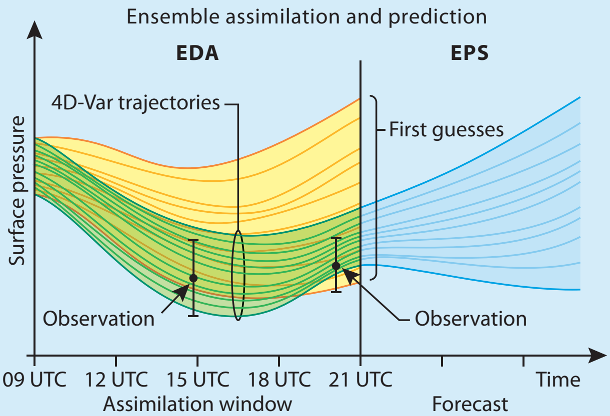
In this article we describe the scientific issues involved in the implementation of flow-dependent background error variance derived from the EDA, and their impact on the ECMWF deterministic analysis and forecast. This is the first step towards a fully flow-dependent representation of background errors where the correlation structures will also be estimated from the latest available EDA.

How the EDA works — A

The EDA is an ensemble of independent 4D-Var data assimilations where the main analysis error sources (observation, model and boundary conditions errors) are represented by perturbing the relative quantities (observations, forecast model and sea surface temperature, respectively) according to their estimated accuracy.

In the idealized schematics below, one can see how the 4D-Var 12-hour assimilation window (left part of the diagram) modifies the initial trajectories of the EDA members (in yellow) to reflect the information from the assimilated observations (black dots with error bars). The analysis trajectories (in green) show the impact of the new observations on the ensemble: the spread of the ensemble has been reduced and the centre of mass of the ensemble has been shifted.

At the end of the assimilation window the EDA is used to provide (a) background error information for the successive deterministic analysis update and (b) the initial perturbations of the Ensemble Prediction System (EPS) around the control analysis.



Controlling sampling noise in the EDA variances

The background error estimates derived from the EDA are themselves affected by estimation errors which have to be dealt with, and if possible reduced.

Estimation errors can formally be separated into random and systematic components. The random component is the part of the estimation error which will tend to zero if aver-

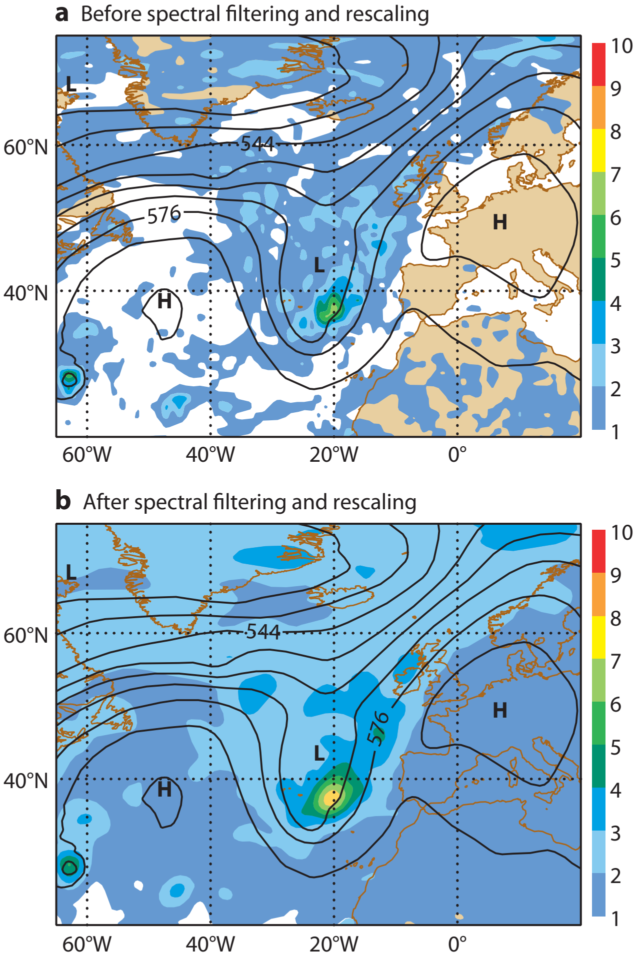


Figure 1 (a) The EDA background ensemble spread for vorticity at model level 64 (shaded, units 10^{-5} s^{-1}) superimposed on the 500 hPa geopotential height analysis verifying 1200 UTC on 1 October 2011 at. (b) As (a), but after the application of the spectral filter and the calibration step, superimposed on the 500 hPa geopotential height analysis verifying on at 1200 UTC on 1 October 2011. Note that the rescaling changes the average values of the errors. Consequently the colour scale used for (b) is slightly different to that for (a) so as to highlight the main differences in the patters.

aged over a very large sample of EDA members. In practice, for affordable ensemble sizes (10 in the current EDA configuration), this type of error is present and has to be addressed. It has been found that the size of the ensemble directly determines the range of spatial scales that can be robustly estimated from the EDA (*Bonavita et al.*, 2011).

Figure 1a shows the spread of the EDA background of the vorticity field at model level 64 (close to the 500 hPa isobaric surface), superimposed on the verifying 500 hPa geopotential height analysis, valid at 1200 UTC on 1 October 2011. The EDA estimates increased uncertainties in the accuracy of the background forecast on the cyclonic side of the 500 hPa trough approximately centred at (45°N, 22°W). This looks reasonable since this is an active weather system over an oceanic area which is not as well observed as Europe or North America. It is also apparent from Figure 1a that the EDA spread is spatially noisy and the significance of the small-scale details is doubtful.

The noisiness of the raw EDA spread is not surprising. The accuracy of error estimates sampled from the EDA can be expected to only increase proportionally to the square root of the ensemble size. Because only a small ensemble is currently affordable, the application of statistical post-processing techniques that allow the filtering of the sampling noise is required.

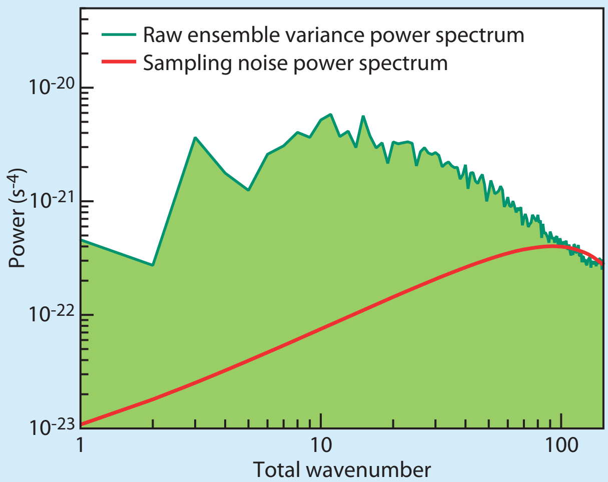
The filtering algorithm which has been implemented in the operational ECMWF analysis closely follows the pioneering work of *Raynaud et al.* (2009) at Météo-France, with the modifications described in *Bonavita et al.* (2011). This consists of applying different low-pass spectral filters for all the variables used in the analysis. The basis for this method is outlined in Box B.

The application of these low-pass filters in spectral space is similar to a weighted spatial averaging technique in grid-point space, which enables the large-scale signal of interest to be extracted while filtering out the small-scale sampling

The basis for using a spectral filtering technique

B

There should be a significant scale separation between sampling noise and signal and this provides the basis for using a spectral filtering technique to separate the two components. In the figure the green line is the raw power spectrum of the 10-member EDA background forecast variance and the continuous line is the estimated power spectrum of the climatological sampling noise for vorticity at model level 64 (~500 hPa). The separation in spectral space of the signal (the EDA variance) from the random error power spectrum is clear up to approximately total wavenumber 80. This naturally leads to the definition of a low-pass spectral filter based on the signal-to-noise ratio defined by the two curves. The filters are separately computed for all the variables used in the analysis.



Basis of the definition of a low-pass spectral filter. Power spectrum of the 10-member EDA short-range (9-hour) forecast variance (green line) and power spectrum of the climatological sampling noise (red line) for vorticity at model level 64 (~500 hPa), as a function of total wavenumber.

noise. This is apparent from Figure 1b (to be compared with Figure 1a) which shows the spread of the EDA background of the vorticity field at model level 64 (~500 hPa) after the application of a spectral filter and calibration step (that will be described below).

Systematic errors in the EDA variances

The systematic error component is the part of the estimation error representing how much the EDA error estimates deviate, on average, from the truth. As such it reflects the deficiencies in the representation of the main sources of uncertainties in the analysis and background fields.

Errors in the deterministic background forecast can be considered to arise from three different sources: errors in the initial conditions, errors in the boundary conditions and errors in the model formulation. The ECMWF EDA tries to represent these sources of errors through the use of perturbed observations, perturbed sea surface temperature (SST) fields and perturbed model physical tendencies. Consequently any deficiencies or approximations in these errors will cause the sampled EDA variances to be sub-optimal estimates of the analysis and background errors. This type of estimation error will not be alleviated by an increase in ensemble size and will translate into systematic differences between the EDA sampled variances and the true analysis/forecast errors. This situation had been recognised at an early stage during the development of the ECMWF EDA (*Isaksen et al.*, 2007): globally averaged EDA spread values were diagnosed to be underestimated by approximately a factor of two, so that a global inflation factor of the same magnitude was applied to minimise the under-estimation of errors. However the systematic errors of the EDA variances have a complex spatial and statistical structure which cannot be adequately represented by a global multi-plicative inflation factor.

The relationship between EDA spread and analysis/background errors can be investigated in a quantitative manner by the use of spread-error plots, an example of which is given in Figure 2. For a statistically reliable EDA the spread-error curves (separately computed for the northern and southern hemispheres and the tropics) should lie on the diagonal (dashed black line). Their distance to the diagonal shows that the ensemble is under-dispersive (i.e. the root mean square error exceeds the spread) while their slope gives an indication of the bias of the ensemble spread. The slope of the calibration curves with respect to the diagonal suggests that different rescaling factors should be applied to the sampled EDA spread distribution. It is also apparent how tropical regions have, on average, different reliability characteristics than extra-tropical regions.

The rescaling does not change significantly on daily to weekly timescales. However it can be shown to have an appreciable seasonal drift (*Isaksen et al.*, 2010). This temporal drift is linked to time-varying model error characteristics and the ability of the current model error parametrization to properly describe their statistical effects. Irrespective of the physical causes of the drift of the rescaling factors, it is obvious that any statistical correction we might want to apply to the

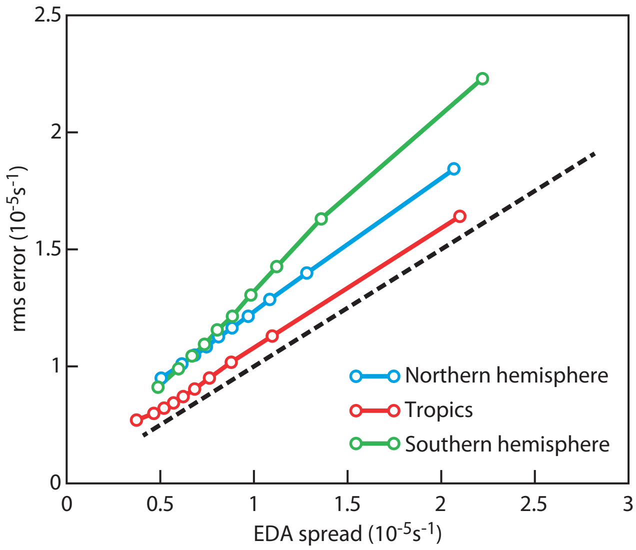


Figure 2 The spread-error diagram for vorticity at model level 81 (~900 hPa). Averaged over one month (August 2009). For a well balanced system all curves should be close to the diagonal indicated by the dashed line.

EDA spread must have a time-varying component.

In light of the above diagnostic findings, a rescaling step is currently applied to the raw (unfiltered) EDA estimates of background error variances. This is aimed at enforcing approximate statistical consistency between the EDA variance estimates and the mean squared errors of the ensemble mean background (in the present case, the operational ECMWF analysis is taken as 'truth'). This statistical balance is enforced separately for each spread-error bin, variable and latitude band (northern hemisphere, tropics, southern hemisphere). The time-varying component is taken into account in the ECMWF implementation by computing a running mean of the scaling factors over the previous 5 days (e.g. the last available ten analysis cycles) from the nominal analysis date.

EDA variances in action: a case study

We illustrate the mechanisms through which the use of EDA variances impacts the ECMWF 4D-Var analysis with a case study. Tropical cyclone Aere affected the north-eastern part of the Philippines on the 8–9 May 2011, causing loss of lives and extensive damage due to the accompanying floods and landslides.

Figure 3 shows the mean sea level pressure evolution of the storm from the then operational ECMWF analysis (which at the time was still using climatological background error estimates) in the left column and from an experiment making use of the EDA error estimates in the right column. The diamond symbol locates the estimated position of the storm according to the Joint Typhoon Warning Center (JTWC) of the U.S. Air Force and Navy (Pearl Harbour, Hawaii). The experiment which makes use of the EDA variances is clearly more accurate in analysing the cyclone position.

What is more interesting in this case is the different use of the information from available observations (mainly surface pressure observations from land stations, shown as

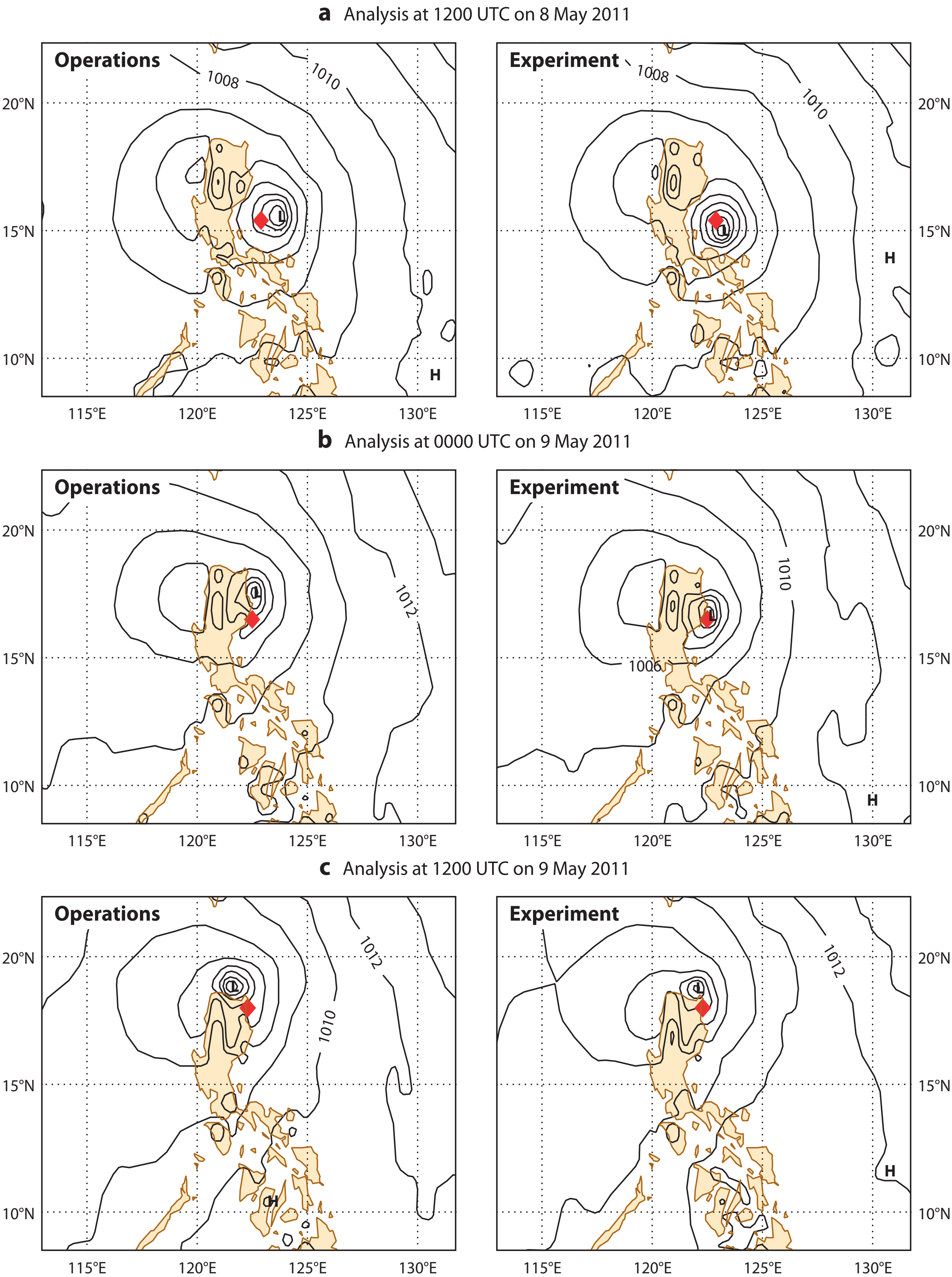


Figure 3 Analysed mean sea level pressure valid at (a) 1200 UTC on 8 May 2011, (b) 0000 UTC on 9 May 2011 and (c) 1200 UTC on 9 May 2011. Left column shows fields from the then operational ECMWF analysis and the right column has those from an experiment using EDA error estimates. The red diamond symbol denotes the independent best estimate of the position of Tropical Storm Aere.

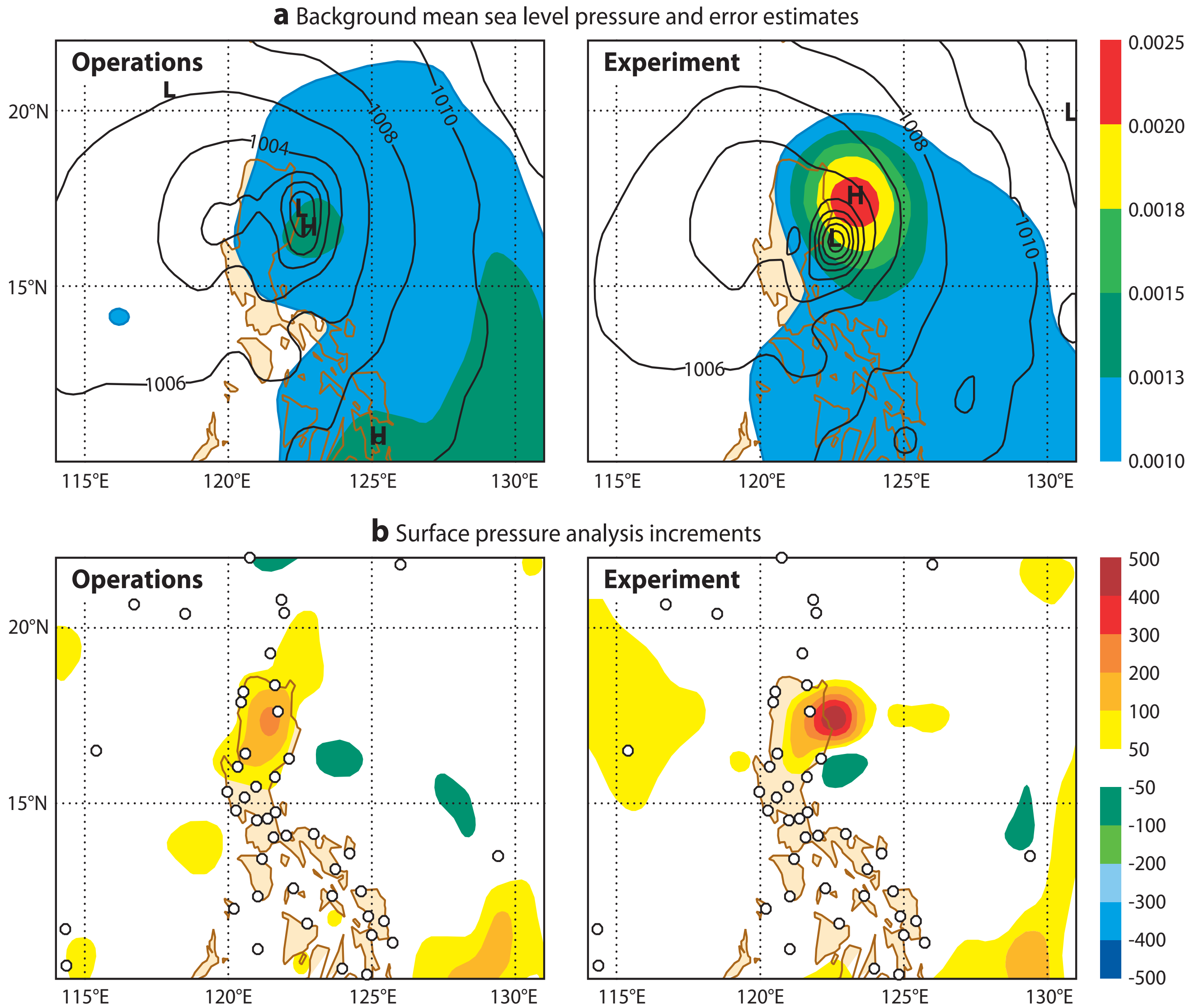


Figure 4 (a) Background mean sea level pressure valid at 0000 UTC on 9 May 2011 (solid line, units: hPa) superimposed on background error estimates for the logarithm of surface pressure (shaded contours). (b) Surface pressure analysis increments valid at 0000 UTC on 9 May 2011 (yellow-red shades indicate positive increments, green-blue shades negative increments, isolines of 50 Pa). Left column shows fields from the then operational ECMWF analysis cycle and the right column those from an experiment using EDA error estimates.

filled circles in bottom row of Figure 4). The top row of Figure 4 shows the estimated uncertainty of the background forecast of the logarithm of surface pressure and the background mean sea level pressure field. The bottom row shows the analysis increments for the mean sea level pressure field. As in Figure 3, the left column shows fields from the then operational ECMWF analysis and the right column has the corresponding fields from the experiment using EDA error estimates. It is clear that the estimated uncertainty in the then operational background is much smaller than in the EDA experiment and tends to be axis-symmetric with the predicted position of the cyclone. This reflects the limited flow-dependent effect in the old background error formulation. Besides, errors in the background state estimate will affect the background errors estimate. This is a fundamental limitation of the previous formulation of the background error variances.

On the other hand the errors diagnosed by the EDA are, by design, constructed to sample the real analysis errors, thus implicitly taking into account the observation network distribution and the model instabilities. In the present case they act to extrapolate the observational information from the land based stations into the more uncertain areas to the north-east of the cyclone, thus helping achieve a better positioning of the analysed storm.

EDA variances in action: Impact on deterministic forecast scores

An assessment has been made of the impact of using online EDA variances in the deterministic analysis using an operational configuration of the ECMWF IFS (cycle 36r4), run at the operational resolution (T1279L91). The evaluation is performed for two long (~3 months) assimilation periods over the winter (11 January to 30 March 2010) and summer/

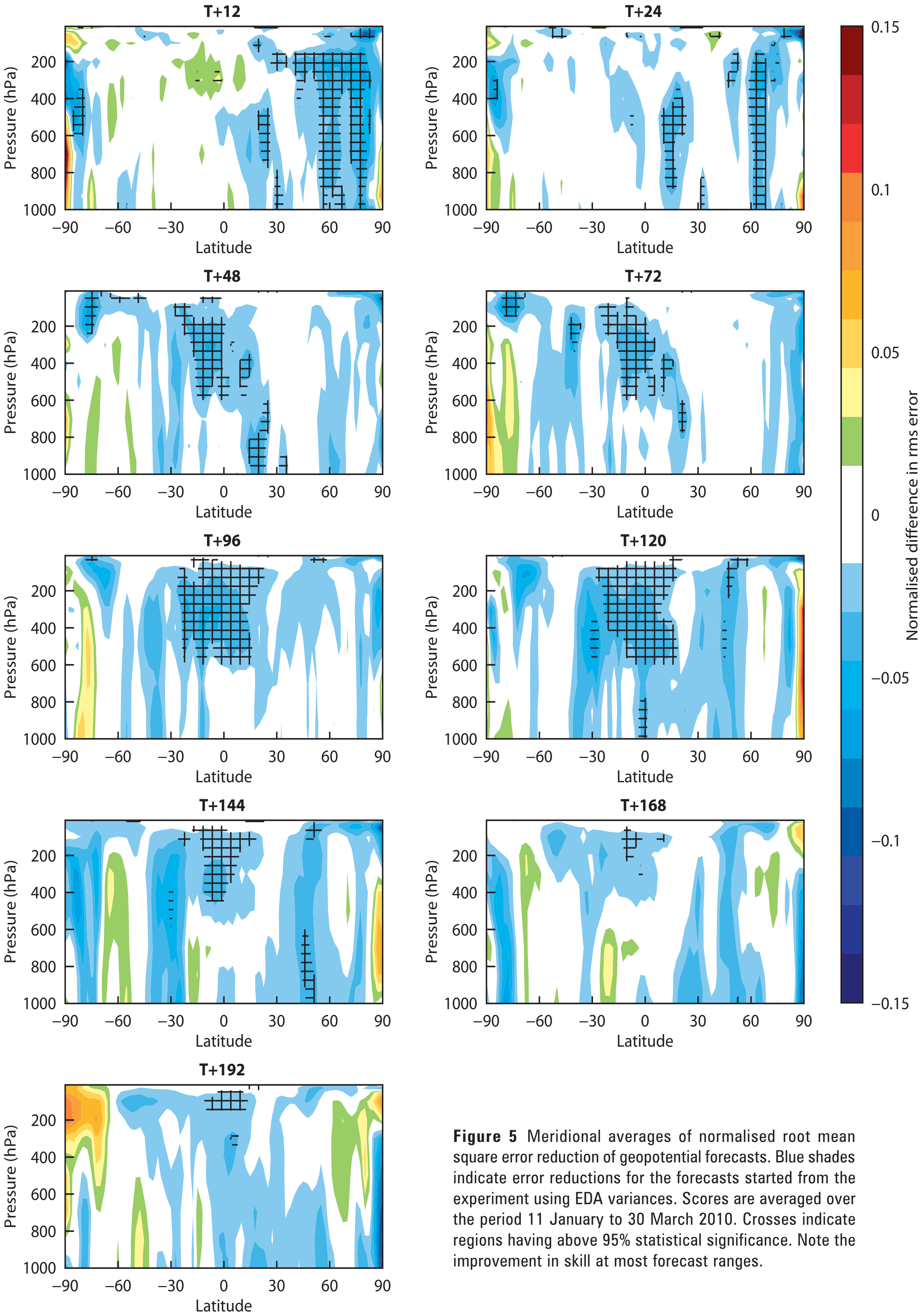


Figure 5 Meridional averages of normalised root mean square error reduction of geopotential forecasts. Blue shades indicate error reductions for the forecasts started from the experiment using EDA variances. Scores are averaged over the period 11 January to 30 March 2010. Crosses indicate regions having above 95% statistical significance. Note the improvement in skill at most forecast ranges.

autumn (2 August to 30 October 2010) seasons. In these experiments use is made of the variances computed from the ten member operational ECMWF EDA (as described in detail by *Isaksen et al.*, 2010), and the sample variances are filtered and rescaled as discussed above. Also the EDA error variance estimates are used as proxies of the background errors both in the 4D-Var minimization step (for vorticity and the balanced part of the other control variables) and in the observation background quality control check (for all variables). The controls differ from the experimental runs only in that they use the then operational quasi-static background errors estimates derived from the 'randomization' technique (*Fisher*, 2003).

Figure 5 presents vertical cross-sections of the twelve hours to eight days root mean square reduction of geopotential height errors for the winter EDA variance experiment against the control. The forecast experiment is verified against its own analysis. The improvement in forecast skill is apparent at most forecast ranges, latitude bands and pressure levels. It is interesting to note that improvements tend to be larger in the winter hemisphere. This is consistent with our understanding of the effect of EDA variances on the deterministic analysis as illustrated in the case study: in regions and times of the year where weather conditions are more active the impact of the use of EDA variances will be more significant.

Future developments

The use of background error variance estimates sampled from an EDA was successfully implemented in the ECMWF 4D-Var (Cy37r2, May 2011), resulting in significant improvements in the skill of the ensuing deterministic forecast. This is the first important step towards the final goal of a hybrid assimilation system with a fully flow-dependent representation of background error covariance.

As explained above, filtering of sampling noise in the EDA variances is required. This has been implemented using a method developed at Météo-France. A refinement of the current spectral filter has been successfully tested and will be implemented in the next IFS release. Systematic estimation errors reflect, on the other hand, basic inadequacies of our modelling of the error sources in the EDA. An adaptive statistical rescaling technique is used to mitigate their impact. A more fundamental solution needs to be based on an improved representation of observation errors and model errors. In this respect it has already been shown (*Bonavita*, 2011) that more advanced model error parametrizations than the one currently used in the EDA, can provide more realistic and statistically consistent error estimates.

A number of further improvements and extensions to the current use of EDA variances in 4D-Var are envisaged. The increase of the EDA size has been shown by Bonavita et al. (2011) to be beneficial. Other developments currently pursued include the use of EDA variances for the first-guess check of radiances from satellite borne sensors, and the use of EDA variances to estimate the error variance of the unbalanced components of the ECMWF 4D-Var (along the lines discussed in *Raynaud et al.*, 2011).

The next big step will be directed towards the use of EDA information in the estimation of background error correlations. Being a much larger-dimensional problem, sampling issues will play an even bigger role than for the estimation of background error variance. This will probably imply the need to make use of a larger ensemble and to apply local spatial averaging techniques similarly to what has been implemented for the sampled EDA variances. This will be based on an extension of the wavelet approach (*Fisher*, 2003) already used in the ECMWF analysis.

FURTHER READING

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(Available from: www.ecmwf.int/publications/)

Bonavita, M., **L. Raynaud** & **L. Isaksen**, 2011: Estimating background-error variances with the ECMWF Ensemble of Data Assimilations system: the effect of ensemble size and day-to-day variability. *Q. J. R. Meteorol. Soc.*, **137**, 423–434.

Buizza, R., **M. Leutbecher**, **L. Isaksen** & **J. Haseler**: 2010: The use of EDA perturbations in the EPS. *ECMWF Newsletter No. 123*, 22–27.

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Isaksen, L., **M. Fisher** & **J. Berner**, 2007: Use of analysis ensembles in estimating flow-dependent background error variance. In *Proc. of ECMWF Workshop on 'Flow-dependent aspects of data assimilation'*, ECMWF, Reading, UK.
(Available from: www.ecmwf.int/publications/)

Isaksen, L., **J. Haseler**, **R. Buizza** & **M. Leutbecher**, 2010: The new Ensemble of Data Assimilations. *ECMWF Newsletter No. 123*, 17–21.

Raynaud, L., **L. Berre** & **G. Desroziers**, 2009: Objective filtering of ensemble-based background-error variances. *Q. J. R. Meteorol. Soc.*, **135**, 1177–1199.

Raynaud, L., **L. Berre** & **G. Desroziers**, 2011: An extended specification of flow-dependent background-error variances in the Météo-France global 4D-Var system. *Q. J. R. Meteorol. Soc.*, **137**, 607–619.

A new framework to handle ODB in Metview 4

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ANNE FOUILLOUX, PIOTR KUCHTA

The ODB (Observational DataBase) is bespoke software developed at ECMWF to manage very large volumes of observational data. It uses SQL (Structured Query Language) to enable fast and flexible post-processing of observational data produced during the data assimilation system runs of the Integrated Forecasting System (IFS).

The main motivation behind the developments presented in this article was to provide users with a comprehensive framework for working with ODBs. There was a need for a system that could operate both in interactive and batch mode and enable users to retrieve, filter and visualise ODB data and perform computations on it. As a design goal the visualisation had to be flexible enough to be able to generate a wide range of graphical products out of ODB such as map-based plots, histograms, scatter plots and graphs. In addition, the capability of overlaying displays of ODB content with other data types, especially with numerical model fields was an important requirement.

All these goals were achieved within the Metview meteorological workstation whose latest version (4.1) includes a redesigned ODB interface. This article gives an overview of the new interface and highlights how users can benefit from working with ODB in Metview 4.

Data access, inspection and filtering

The basis of all the ODB-related operations in Metview 4 is the *ODB Database* icon (Figure 1a), which represents an ODB database residing on the file system. Analysts and researchers can inspect an ODB by right clicking on its icon and selecting 'examine' from the context menu. The ODB examiner will appear, as illustrated in Figure 2, to show both the meta-data and the data values of the database. A command line version of the ODB examiner is also available by typing: metview4 -e odb *database-path*.

One of the most commonly used and popular features of Metview is its interface to the MARS archive. The *MARS Client* in Metview 4 is now ODB-enabled so users can retrieve ODB data from MARS in a similar way to that used for GRIB or BUFR, but of course an ODB-specific set of MARS parameters has to be used to define the request.

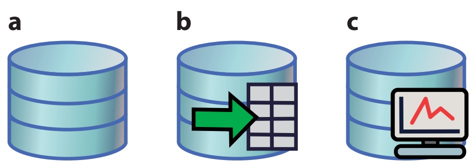
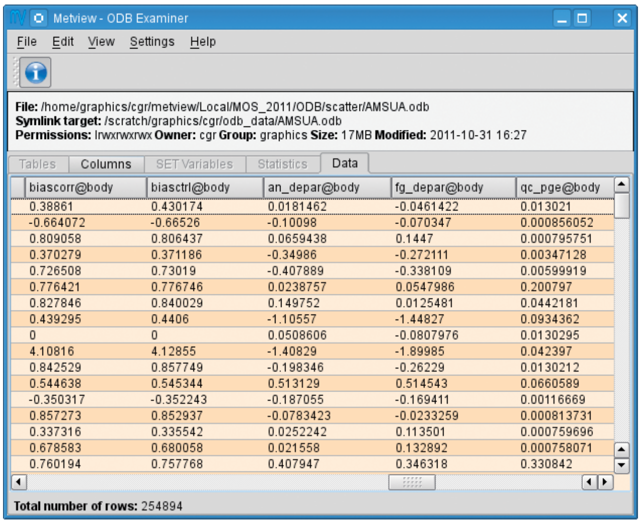


Figure 1 The icons representing the ODB Database, ODB Filter and ODB Visualiser in Metview 4.



biascorr@body	biasctrl@body	an_depar@body	fg_depar@body	qc_pge@body
0.38861	0.430174	0.0181462	-0.0461422	0.013021
-0.664072	-0.66526	-0.10098	-0.070347	0.000856052
0.809058	0.806437	0.0659438	0.1447	0.000795751
0.370279	0.371186	-0.34986	-0.272111	0.00347128
0.726508	0.73019	-0.407889	-0.338109	0.00599919
0.776421	0.776746	0.0238757	0.0547986	0.200797
0.827846	0.840029	0.149752	0.0125481	0.0442181
0.439295	0.4406	-1.10557	-1.44827	0.0934362
0	0	0.0508606	-0.0807976	0.0130295
4.10816	4.12855	-1.40829	-1.89985	0.042397
0.842529	0.857749	-0.198346	-0.26229	0.0130212
0.544638	0.545344	0.513129	0.514543	0.0660589
-0.350317	-0.352243	-0.187055	-0.169411	0.00116669
0.857273	0.852937	-0.0783423	-0.0233259	0.000813731
0.337316	0.335542	0.0252242	0.113501	0.000759696
0.678583	0.680058	0.021558	0.132892	0.000758071
0.760194	0.757768	0.407947	0.346318	0.330842

Figure 2 The ODB examiner in Metview 4 offers a powerful way to inspect both the meta-data and data values of ODBs.

To run ODB/SQL queries Metview 4 offers the *ODB Filter* module, whose icon is shown in Figure 1b. The output of ODB Filter is a new ODB database storing only the selected subset of the original data. The main goal of using ODB Filter is to provide a smaller subset of ODB data better suited for visualisation and further data processing in Metview 4.

Visualisation

Metview 4 introduced the concept of *visualisers* to allow the quick and easy visualisation of particular data types in various ways. The ODB Visualiser, whose icon can be seen in Figure 1c, provides a high-level interface for selecting a subset of ODB data and visualising it in the desired plot type. With this icon Metview users can easily generate maps with symbol or wind plotting. Also scatter plots and graphs can be produced.

Both symbol and wind plotting in Metview 4 now benefit from the improved functionalities of Magics. Probably the most important feature is that the colour palette can be automatically generated for the plots, just like it has been available for the *Contouring* icon. Another exciting novelty is that the legend can contain a colour-coded histogram showing the distribution of the visualised data values as illustrated in Figure 3.

The control area on the right of the Display Window was also renewed. Here the Layer Data tab was added to display statistics and a histogram complemented with a data count table. In addition, the Cursor Data tool, which shows data values at the cursor position in the plot, has been redesigned to be able to display ODB data values as well. Figure 3 illustrates both these features. Note that ODB data can be overlaid with any other data types in Metview as shown in Figure 4.

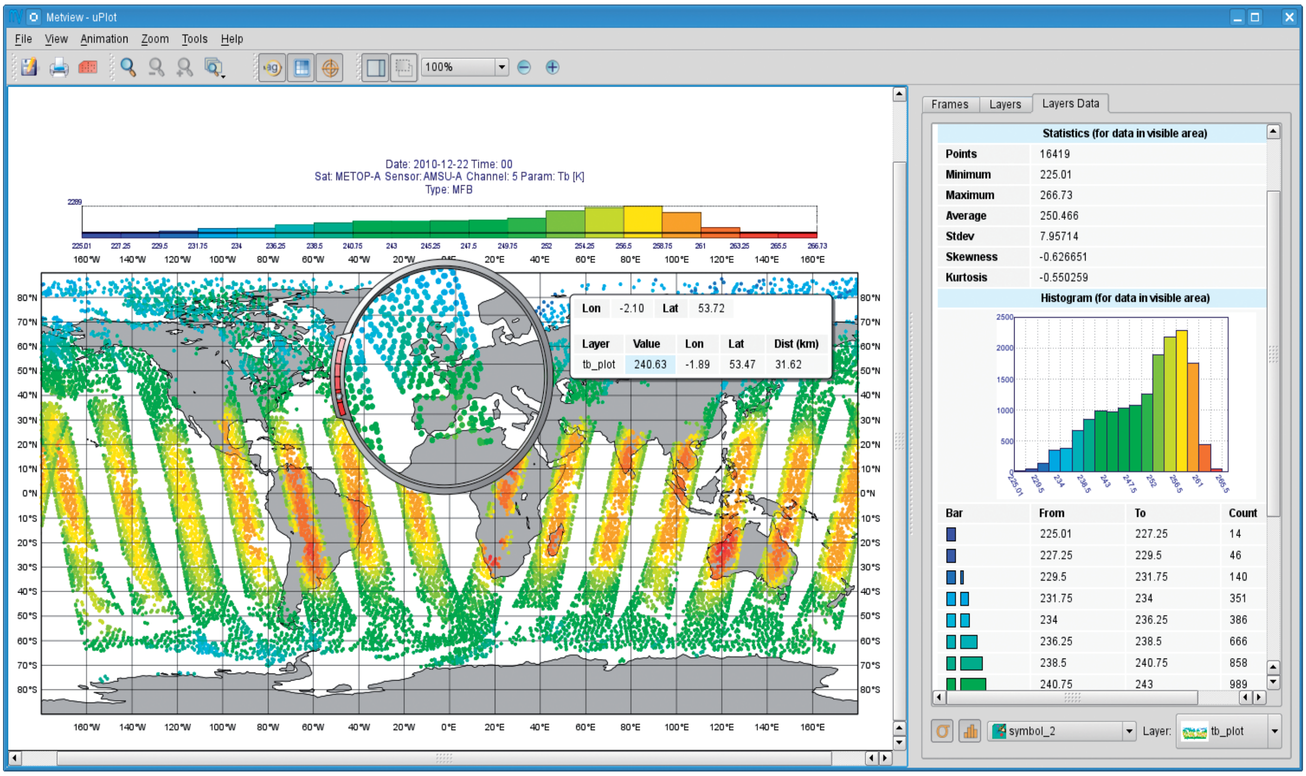


Figure 3 Brightness temperature values from an ODB visualised using an automatically-generated colour palette. Another interesting feature is the cursor data (next to the magnifier) showing the ODB values nearest to the current cursor position in the plot. The legend features a histogram showing the data distribution within the visualised value range. The sidebar on the right-hand side of the window displays detailed statistics about the visualised data together with a histogram.

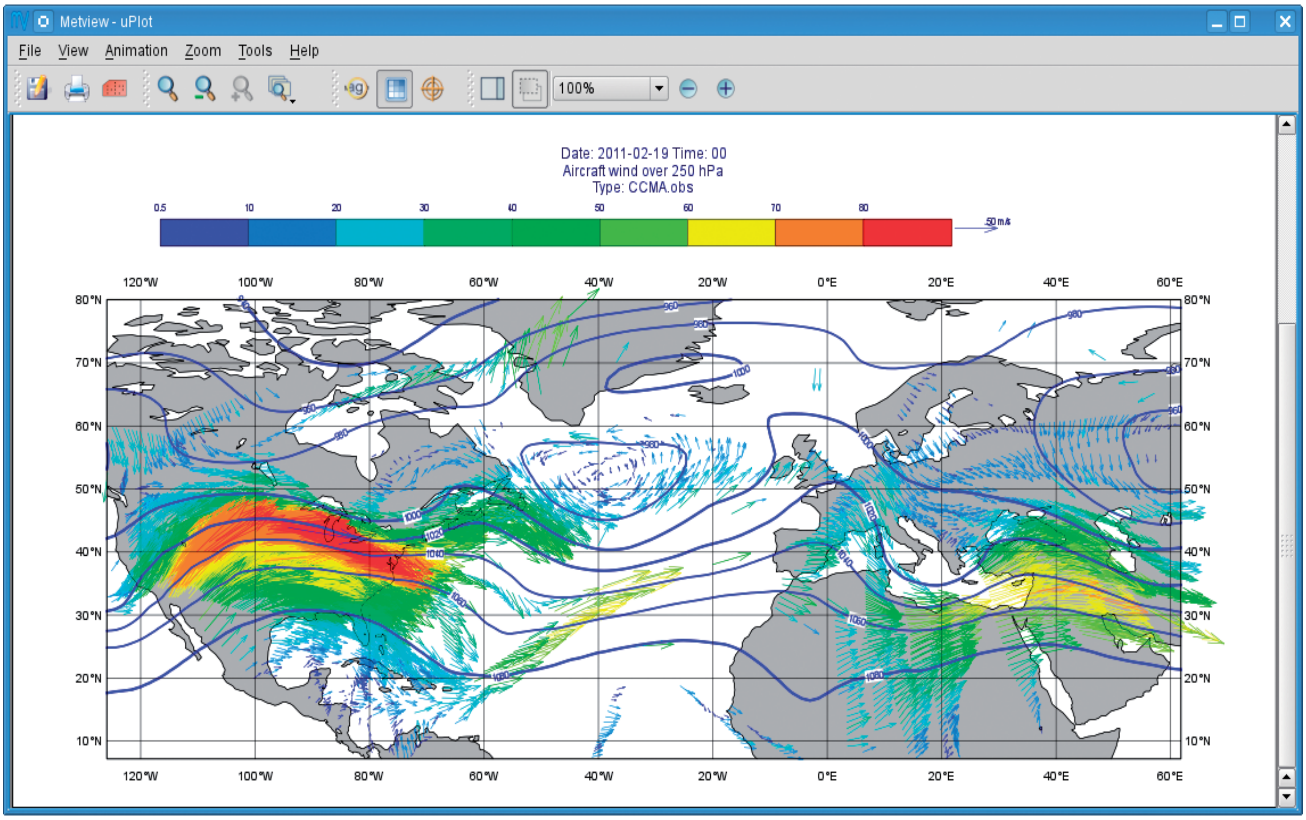


Figure 4 Wind data from an ODB overlaid with isolines of geopotential from GRIB data.

Figure 5 illustrates the ability of Metview 4 to generate scatter plots for ODB data.

Metview Macro

Metview's macro scripting language offers a powerful framework for incorporating all the functionality provided by the ODB icons. The usage of the **values()** macro function is particularly useful because it can read ODB data into a built-in **vector** data structure. Vectors are optimised to store a large number of numerical values and it is easy to derive new datasets and generate new plots out of ODB data stored in vectors.

More information

Metview users will find a tutorial that goes into more detail about how to use the ODB interface on the Metview documentation web page at:

- www.ecmwf.int/publications/manuals/metview/documentation.html

User feedback is important for improving Metview, and users are encouraged to send their suggestions by e-mail to:

- metview@ecmwf.int.

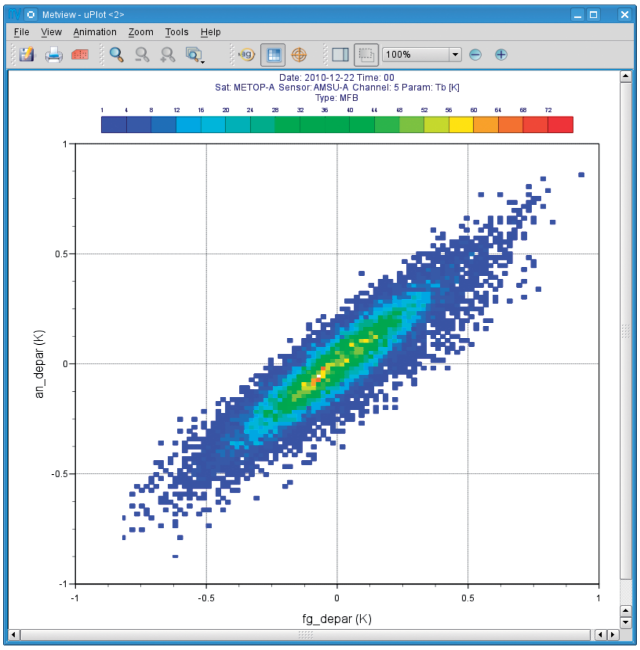


Figure 5 Scatter plot for the first-guess and analysis departures read from an ODB.

ECMWF publications

(see www.ecmwf.int/publications/)

Technical Memoranda

662 **de Rosnay, P., M. Drusch, D. Vasiljevic, G. Balsamo, C. Albergel & L. Isaksen**: A simplified Extended Kalman Filter for the global operational soil moisture analysis at ECMWF. *January 2012*

661 **Lopez, P.**: Experimental 4D-Var assimilation of SYNOP rain gauge data at ECMWF. *January 2012*

660 **Morcrette, J.-J., A. Benedetti, A. Ghelli, J.W. Kaiser & A.M. Tompkins**: Aerosol-cloud-radiation interactions and their impact on ECMWF/MACC forecasts. *December 2011*

659 **Morcrette, J.-J., A. Benedetti, P. Lopez, L. Jones, J.W. Kaiser, M. Razinger & M. Suttie**: Prognostic aerosols in the ECMWF IFS: MACC vs. GEMS Aerosols. *December 2011*

658 **Magnusson, L., M. Alonso-Balmaseda & F. Molteni**: On the dependence of ENSO simulation on the coupled model mean state. *December 2011*

656 **Molteni, F., T. Stockdale, M. Balmaseda, G. Balsamo, R. Buizza, L. Ferranti, L. Magnusson, K. Mogensen, T. Palmer & F. Vitart**: The new ECMWF seasonal forecast system (System 4). *November 2011*

654 **Richardson, D.S., J. Bidlot, L. Ferranti, A. Ghelli, T. Haiden, T. Hewson, M. Janousek, F. Prates & F. Vitart**: Verification statistics and evaluations of ECMWF forecasts in 2010-2011. *December 2011*

653 **Benedetti, A., J.W. Kaiser, J.-J. Morcrette, R. Eresmaa & S. Lu**: Simulations of volcanic plumes with the ECMWF/MACC aerosol system. *December 2011*

Proceedings

Workshop on Representing Model Uncertainty and Error in Numerical Weather and Climate Prediction Models, 20–24 June 2011

ERA Report Series

1 **Berrisford, P., D. Dee, P. Poli, R. Brugge, K. Fielding, M. Fuentes, P. Kållberg, S. Kobayashi, S. Uppala & A. Simmons**: The ERA-Interim archive. Version 2.0. *November 2011*

EUMETSAT/ECMWF Fellowship Programme Research Reports

23 **Salonen, K. & N. Bormann**: Atmospheric Motion Vector observations in the ECMWF system: 1-year report. *October 2011*

ESA Contract Reports

Munoz Sabater, J., M. Dahoui, P. de Rosnay & L. Isaksen: Tech Note – Phase II – WP1100 SMOS monitoring report number 2: Nov 2010–Nov 2011. *December 2011*

Munoz Sabater, J. & P. de Rosnay: Tech Note – Phase-II – WP1300: SMOS report on noise filtering. *November 2011*

Special Project computer allocations for 2012–2013

Member State	Institution	Project title	2012		2013	
			HPCF (units)	Data storage (Gbytes)	HPCF (units)	Data storage (Gbytes)
Continuation Projects						
France	Mercator Ocean (Chanut)	High resolution ocean modelling over Iberian, Biscay and Irish seas	10,400,000	20,000	12,000,000	35,000
	Mercator Ocean (Garric)	The freshwater representation in the Mercator Ocean global ocean reanalysis	10,400,000	15,000	12,000,000	20,000
	CNRM/GAME, Meteo-France (Marecal)	Modelling the impact on atmospheric chemistry of very short-lived species and volcanic emissions of halogens	850,000	150	500,000	150
Germany	Univ. Munich (Groenemeijer, Craig)	Large-scale and local control of severe weather: towards adaptive ensemble forecasting	300,000	500	300,000	0
	LMU Munich (Schulz)	Statistical downscaling of ERA interim data using spatial distributed land surface characteristics and novel tools from machine learning and pattern recognition for hydrological applications	30,000	500	30,000	0
Italy	ISMAR-CNR (Bertotti)	Effect of rain on the growth and evolution of sea waves	250,000	200	250,000	0
	ARPA-SIM (Marsigli)	Testing the impact of model perturbations applied to the COSMO model at a convection-permitting scale over Italy	450,000	100	X	X
	INAF (Masciadri)	Optical turbulence modelling for astronomical applications: towards the Extremely Large Telescopes (ELTs)	400,000	150	400,000	150
Netherlands	KNMI (Haarsma)	Decadal predictions	2,400,000	2,000	2,400,000	2,000
	KNMI (Onvlee)	The Hirlam-B project	3,750,000	10,000	4,500,000	12,000
	KNMI (Selten)	The role of clouds in model bias and climate sensitivity	300,000	600	300,000	600
Norway	DNMI (Gauss)	Meteorological data for EMEP	1,000,000	4,000	X	X
Sweden	SMHI (Undén)	European regional re-analysis for monitoring and observations	2,500,000	12,000	2,500,000	15,000
ICTP	ICTP (Kucharski)	Interactions between the Atlantic Ocean, African monsoon, the Indian and Pacific Oceans using the EC-Earth and IFS modelling systems	500,000	1,000	X	X
	ICTP (Tompkins)	Use and value of ECMWF short-range and seasonal forecast products for developing countries in terms of end-user impact variables	500,000	500	X	X
JRC	JRC (Dosio)	Climate change impacts on the European ecosystems and assessment of forest fires risk	300,000	200	300,000	200

Member State	Institution	Project title	2012 HPCF (units)	2012 Data storage (Gbytes)	2013 HPCF (units)	2013 Data storage (Gbytes)
New Projects						
Austria	Univ. Vienna (Haimberger)	Homogenization and uncertainty estimation of historic in situ upper air data	10,000	500	10,000	1,000
	Univ. Vienna (Serafin)	Numerical modelling of boundary layer processes over complex terrain	230,000	1,800	230,000	1,800
Belgium	RMI (Deckmyn)	Boundary conditions for ALADIN, ALARO and AROME based on IFS, ECMWF EPS and ERA-Interim data	130,000	800	130,000	800
Denmark	DMI (Baklanov)	EnviroChemistry on ECMWF	4,000,000	8,500	4,000,000	9,000
Finland	FMI (Ollinaho)	Model parameter perturbations in ensemble prediction	450,000	8,000	450,000	8,000
France	IPSL (Lapeyre)	Using Lyapunov covariant modes for atmospheric predictability	10,000	100	10,000	100
	CERFACS (Weaver)	Ensemble variational data assimilation with NEMOVAR	1,000,000	10,000	1,000,000	10,000
Germany	KIT, Karlsruhe (Anwender)	Impact of blocking and tropical-extratropical interactions on predictability in the Atlantic-European sector	400,000	3,000	420,000	4,000
	Univ. Hohenheim (Bauer, Wulfmeyer)	Validation and improvement of high-impact weather process understanding in Europe with the aid of high-resolution WRF simulations and sophisticated data assimilation (VALPUDA)	300,000	3,000	300,000	3,000
	FU Berlin (Cubasch, Kirchner)	Analysis of the coupling between the ocean and atmosphere large scale circulation regimes from annual to decadal time scales	20,000	3,000	20,000	4,000
	DLR (Doernbrack)	Mission Support System for HALO research flights	100,000	80	100,000	80
	DLR (Doernbrack)	Source spectra for convectively generated gravity waves – adaptive numerical simulations	200,000	80	200,000	80
	Univ. Cologne (Elbern)	Monitoring Atmospheric Climate and Composition – Interim Implementation (MACC-II)	2,250,000	14,600	2,250,000	14,600
	KIT, Karlsruhe (Gantner, Kalthoff)	Convection-permitting ensemble simulations for West Africa based on different soil moisture fields	350,000	500	350,000	800
	DLR (Gierens)	The impact of fluctuations of temperature, humidity and wind on cirrus clouds	300,000	100	300,000	200
	DLR (Hoinka)	The global circulation in various coordinate systems	500	10	500	10
	Alfred Wegener Institute, Bremerhaven (Jung)	The global impact of explicitly resolving small-scale processes: A model study with the finite element sea ice-ocean model FESOM	490,000	5,000	490,000	5,000
	FU Berlin (Langematz)	Simulations with an atmosphere-ocean-chemistry-climate model for the development of a decadal climate prediction system	2,750,000	8,000	550,000	2,000
	FZ Juelich (Stein)	Global atmospheric chemistry modelling	610,000	30,000	610,000	35,000
Italy	ARPA-SIMC, DWD, MeteoSwiss (Montani, Majewski, Steiner)	Implementation of a limited-area ensemble prediction system for Sochi Olympic Games	1,620,000	50	2,700,000	70
	ARPA-SIMC, CNMCA (Montani, Torrisi)	Experimentation of different strategies to generate a limited-area ensemble system over the Mediterranean region	1,000,000	90	1,200,000	110
	ARPA-SIMC, ISAC-CNR (Pavan, Buzzi)	Multi-model monthly ensemble	490,000	100	490,000	100
	CNMCA (Torrisi, Marcucci)	Data assimilation and short-range forecast with a limited area ensemble Kalman filter	3,000,000	1,000	3,500,000	1,000

Member State	Institution	Project title	2012		2013	
			HPCF (units)	Data storage (Gbytes)	HPCF (units)	Data storage (Gbytes)
Netherlands	KNMI (Attema)	Evaluation of model precipitation for the current climate when using imperfect (GCM) boundaries	499,000	3,000	499,000	3,000
	KNMI (Hazeleger)	EC-Earth: developing a European Earth System model based on ECMWF modelling systems	10,400,000	20,000	15,000,000	40,000
	KNMI (Huijnen)	Inline chemistry for reactive trace gases within IFS	200,000	250	300,000	250
	KNMI (van den Hurk)	Land use change in the 21st century	500,000	1,000	500,000	1,000
	KNMI (van Meijgaard)	Contribution of the great ice sheets to sea level rise: assessments with a polar regional climate model	499,000	5,000	499,000	5,000
	KNMI (van Noije)	Modelling interactions between atmospheric composition and climate changes with the Earth system model EC-Earth	3,500,000	6,000	3,800,000	6,500
	KNMI (Verkley)	Implementation and validation of radar data-assimilation in the HARMONIE mesoscale weather prediction model	300,000	400	300,000	400
	KNMI (Williams)	Investigation of aerosol feedbacks on decadal timescales	200,000	100	200,000	100
Norway	NILU (Eckhardt)	FLEXPART transport simulations of volcanic ash clouds and gas tracer for the Norwegian community Earth System Model	50,000	150	50,000	150
	DNMI (Frogner)	High-resolution ensemble forecasts	450,000	2,000	450,000	2,000
	DNMI (Frogner)	Hirlam - Aladin Probabilistic Systems	8,000,000	43,200	8,000,000	50,000
Spain	Univ. Illes Balears (Cuxart)	Atmospheric boundary layer processes in complex terrain	150,000	200	150,000	200
	Institut Catala de Ciencies (Doblas-Reyes)	Seasonal climate forecast quality with EC-Earth: role of initialization and stochastic physics	3,795,000	5,060	3,960,000	3,300
Sweden	MISU, Stockholm (Körnich)	Aeolus' impact estimation for different sampling scenarios using EDA experiments	10,400,000	13,500	X	X
Switzerland	Institute for Atmospheric and Climate Science, ETH Zurich (Böttcher, Joos)	Diabatic effects in mid-latitude weather systems	90,000	3,500	70,000	3,000
United Kingdom	King's College London (Cloke)	IFS water cycle verification using river discharge observations	250,000	3,000	250,000	6,000
	Univ. of Birmingham (Leckebusch)	Investigation of large scale precursor conditions for extreme cyclone development in the extra-tropics	5,000	2,000	5,000	2,000
	Oxford Univ. (Palmer)	Representing uncertainty in ocean observations and the ocean model for extended-range ensemble prediction	2,500,000	3,000	5,000,000	6,000
	Oxford Univ. (Palmer)	Representing uncertainty in weather and climate prediction	2,500,000	3,000	5,000,000	6,000
	Keele Univ. (Shrira)	New kinetic equations and their modelling for wind wave forecasting	100,000	100	100,000	100
JRC	JRC-IES (Bergamaschi)	Global and regional inverse modelling of atmospheric CH_4 and N_2O	500,000	400	500,000	400
	JRC-IES (Dentener)	Pollution in world regions: analysis of past-trends with sensitivity simulations	180,000	450	200,000	470
Total Requested			**99,108,500**	**280,520**	**99,623,500**	**322,920**

TAC Representatives, Computing Representatives and Meteorological Contact Points

Member States	TAC Representatives	Computer Representatives	Meteorological Contact Points
Austria	Dr G. Kaindl	Mr M. Langer	Dr A. Schaffhauser
Belgium	Dr D. Gellens	Mrs L. Frappez	Dr J. Nemeghaire
Denmark	Mr L. Laursen	Mr T. Lorenzen	Mr G. Larsen
Finland	Dr J. Damski	Mr M. Aalto	Mr P. Nurmi
France	Mr J.-M. Carrière	Mr D. Birman	Ms N. Girardot
Germany	Dr D. Schroeder	Dr E. Krenzien	Mr T. Schumann
Greece	Mr A Emmanouil	Mr M Manousakis	Ms T Tzeferi
Iceland	Mr T. Hervarsson	Mr V. Gislason	Mrs K. Hermannsdóttir
Ireland	Mr P. Halton	Mr P. Halton	Mr G. Fleming
Italy	Dr M. Ferri	Mr A. Vocino	Dr T. La Rocca
Luxembourg	Mr J. Santurbano	Mr J. Santurbano	Mr J. Santurbano
Netherlands	Mr T. Moene	Mr H. de Vries	Mr J. Diepeveen
Norway	Dr R. Skålin	Ms R. Rudsar	Dr B Røsting
Portugal	Mrs T. Abrantes	Mr L. Cardoso	Mr N. M. Moreira
Spain	Mr E. Monreal	Mr R. Corredor	Mrs F. Aguado
Sweden	Mr F. Linde	Mr R. Urrutia	Mr F. Linde
Switzerland	Dr S. Sandmeier	Mr P. Roth	Mr E. Müller
Turkey	Mr M. Fatih Büyükkasabbaşi	Mr F. Kocaman	Mr A. Guser
United Kingdom	Dr A. Dickinson	Mr R. Sharp	Mr I. Forsyth
Co-operating States			
Bulgaria	Ms I. Etropolska	Ms I. Etropolska	Mrs A. Stoycheva
Croatia	Mr I. Čačić	Mr V. Malović	Mr Č. Branković
Czech Republic	Ms A. Trojakova	Mr K. Ostatnický	Mr F. Sopko
Estonia	Mr T. Kaldma	Mr T. Kaldma	Mrs M. Merilain Mrs T. Paljak
The former Yugoslav Republic of Macedonia	Mr V. Dimitriev	Mr B. Sekirarski	Ms N. Aleksovska
Hungary	Dr Z. Dunkel	Mr I. Ihász	Mr I. Ihász
Israel	Mr I. Rom	Mr V. Meerson	Mr N. Stav
Latvia	Mr A. Bukšs	Mr A. Bukšs	Ms A. Niznika
Lithuania	Mrs V. Auguliene	Mr M. Kazlauskas	Mrs. V. Raliene
Montenegro	Mr A. Marčev	Mr A. Marčev	Ms M. Ivanov
Morocco	Mr H. Haddouch	Mr M. Jidane	Mr K. Lahlal
Romania	Dr A. Bell	Mr R. Cotariu	Ms M. Georgescu
Serbia	Ms L. Dekic	Mr V. Dimitrijević	Mr B. Bijelic
Slovakia	Mr J. Vivoda	Mr O. Španiel	Dr M. Benko
Slovenia	Mr J. Jerman	Mr P. Hitij	Mr B. Gregorčič
Observers			
EUMETSAT	Mr M. Rattenborg	Dr S. Elliott	
WMO	Mr M. Jarraud		

ECMWF Council and its committees

The following provides some information about the responsibilities of the ECMWF Council and its committees. More detail can be found at:

- www.ecmwf.int/about/committees

Council

The Council adopts measures to implement the ECMWF Convention; the responsibilities include admission of new members, authorising the Director to negotiate and conclude co-operation agreements, and adopting the annual budget, the scale of financial contributions of the Member States, the Financial Regulations and the Staff Regulations, the long-term strategy and the programme of activities of the Centre.

President: Mr François Jacq (*France*)

Vice President: Mr Ricardo Garcia-Herrera (*Spain*)

Policy Advisory Committee (PAC)

The PAC provides the Council with opinions and recommendations on any matters concerning ECMWF policy submitted to it by the Council, especially those arising out of the Four-Year Programme of Activities and the Long-term Strategy.

Chair: Mr Juhani Damski (*Finland*)

Vice Chair: Mr Arni Snorrason (*Iceland*)

Finance Committee (FC)

The FC provides the Council with opinions and recommendations on all administrative and financial matters submitted to the Council and shall exercise the financial powers delegated to it by the Council.

Chair: Mr Detlev Frömming (*Germany*)

Vice Chair: Mr Marco Viljanen (*Finland*)

Scientific Advisory Committee (SAC)

The SAC provides the Council with opinions and recommendations on the draft programme of activities of the Centre drawn up by the Director and on any other matters submitted to it by the Council. The 12 members of the SAC are appointed in their personal capacity and are selected from among the scientists of the Member States.

Chair: Dr Heikki Järvinen (*Finnish Meteorological Institute*)

Vice Chair: Dr Jan Barkmeijer (*KNMI*)

Technical Advisory Committee (TAC)

The TAC provides the Council with advice on the technical and operational aspects of the Centre including the communications network, computer system, operational activities directly affecting Member States, and technical aspects of the four-year programme of activities.

Chair: Mr Leif Laursen (*Denmark*)

Vice Chair: Mr Roar Skålin (*Norway*)

Advisory Committee for Data Policy (ACDP)

The ACDP provides the Council with opinions and recommendations on matters concerning ECMWF Data Policy and its implementation.

Chair: Mr Klaus Haderlein (*Germany*)

Vice Chair: Mr Frank Lantsheer (*Netherlands*)

Advisory Committee of Co-operating States (ACCS)

The ACCS provides the Council with opinions and recommendations on the programme of activities of the Centre, and on any matter submitted to it by the Council.

Chair: Mr Milan Dacić (*Serbia*)

Vice Chair: Mr Pavol Nejedlík (*Slovakia*)

ECMWF Calendar 2012

April 16 – May 31	Training Course – Numerical Weather Prediction
April 16 – 20	*Numerical methods, adiabatic formulation of models and ocean wave forecasting*
April 23 – May 2	*Data assimilation and use of satellite data*
May 9 – 18	*Predictability, diagnostics and extended-range forecasting*
May 21 – 31	*Parametrization of subgrid physical processes*
April 23 – 24	Advisory Committee for Data Policy (*13th Session*)
April 24 – 25	Finance Committee (*90th Session*)
April 26 – 27	Policy Advisory Committee (*33rd Session*)
May 21 – 22	Security Representatives' Meeting
May 22 – 24	Computer Representatives' Meeting
June 13 – 14	Council (*77th Session*)
June 20 – 22	Forecast Products Users' Meeting
June 25 – 27	Workshop on 'Ocean wave modelling'
September 4 – 7	Annual Seminar on 'Seasonal prediction: Science and Applications'
October 1 – 5	15th Workshop on 'High performance computing in meteorology'
October 8 – 12	Training Course – Use and interpretation of ECMWF products for WMO Members
October 15 – 17	Scientific Advisory Committee (*41st Session*)
October 18 – 19	Technical Advisory Committee (*44th Session*)
October 22 – 23	Finance Committee (*91st Session*)
October 24 – 25	Policy Advisory Committee (*34th Session*)
October 29	Advisory Committee of Co-operating States (*18th Session*)
November 6 – 9	Workshop on 'Parametrization of clouds and precipitation across model resolution'
December 4 – 5	Council (*78th Session*)

Index of newsletter articles

This is a selection of articles published in the *ECMWF Newsletter* series during recent years.
Articles are arranged in date order within each subject category.
Articles can be accessed on the ECMWF public website – www.ecmwf.int/publications/newsletter/index.html