

# Developments of the ECMWF Integrated Forecasting System

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**and colleagues**

# The operational forecasting system

## ➤ High resolution deterministic forecast (HRES):

- twice a day 16 km 137-level, to 10 days ahead

## ➤ Ensemble forecast (ENS):

- twice a day, 32 km (64 km after day 10) 91-level, to 15 days ahead
- 50 perturbed members (account for initial and model uncertainties)
- Monday/Thursday 00 UTC extended to 1 month ahead (Monthly Forecast)

## ➤ Ocean waves: twice a day

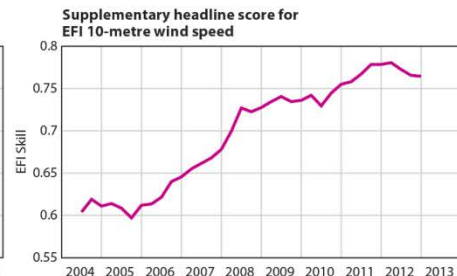
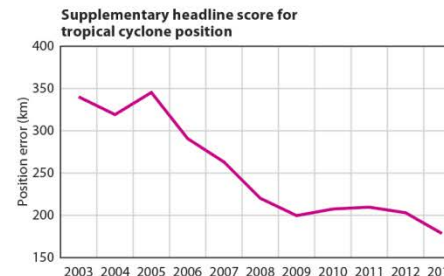
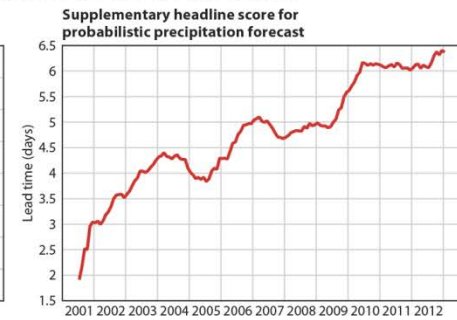
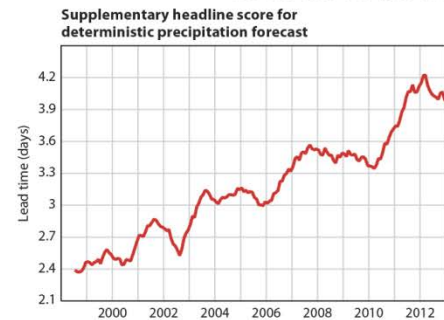
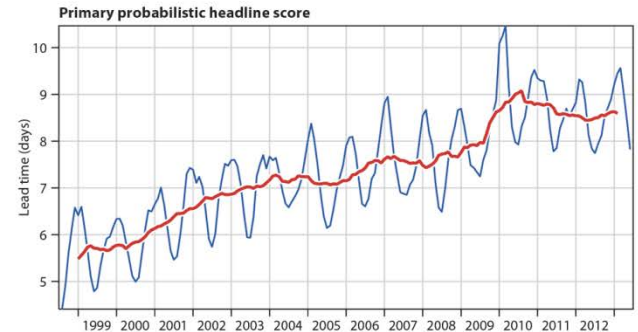
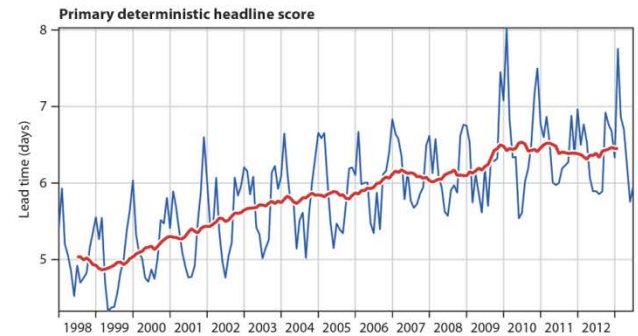
- Global: 10 days ahead at 28 km
- European Waters: 5 days ahead at 10 km
- Ensemble: 15 days ahead at 55 km

## ➤ Seasonal forecast: once a month

- 51 members, 80 km 91 levels, to 7 months ahead

# Forecast performance

- 6 headline scores
  - HRES and ENS upper-air skill
  - HRES and ENS precipitation
  - Severe weather: TC position and EFI for extreme wind
- Wide range of additional verification and in-depth diagnostics
- Comparison with other centres
- Comparison with reference systems
- Evaluation for severe weather



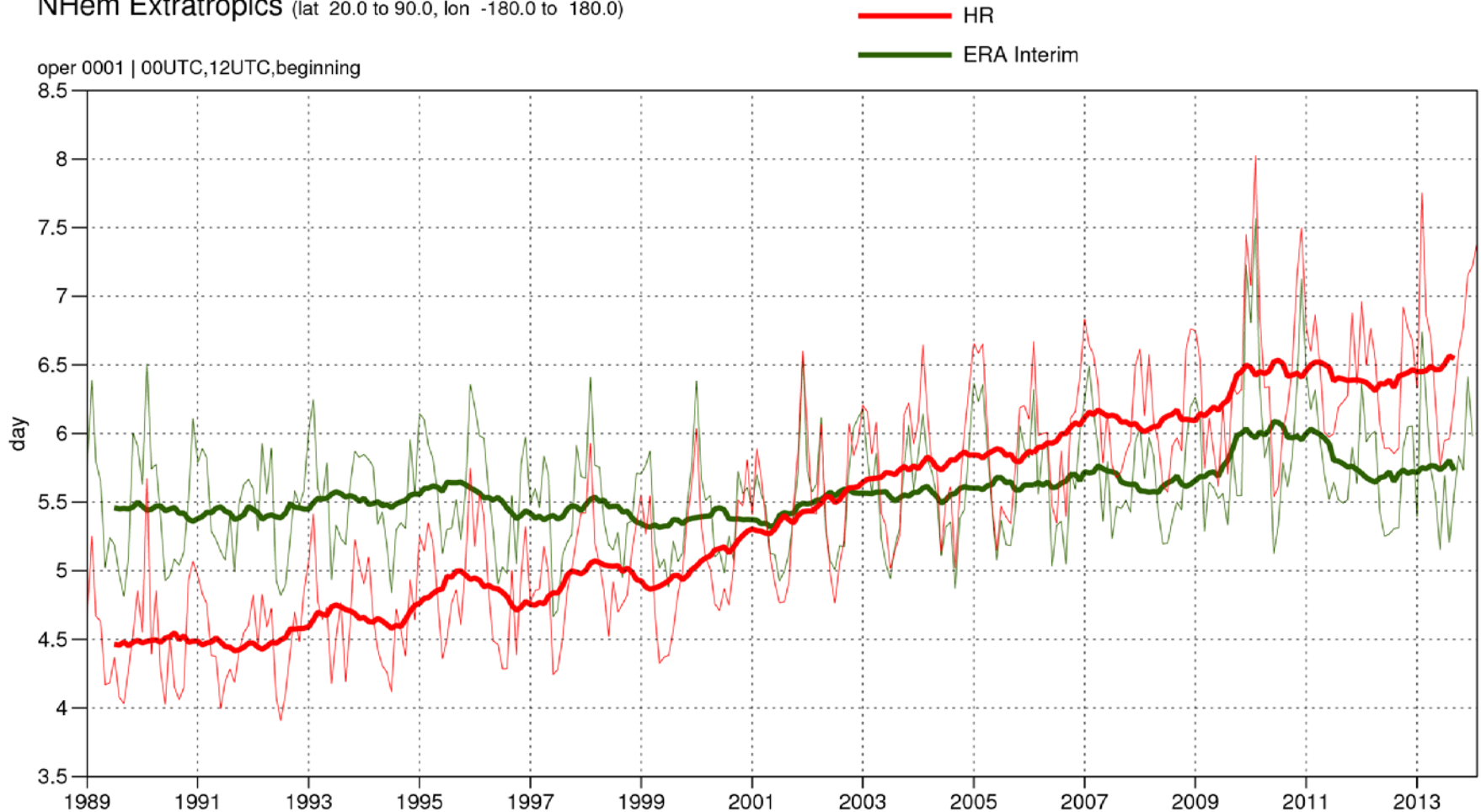
# Z500 Time series of ACC=80% N hemisphere

## HRES and ERA Interim 00,12UTC forecast skill

500hPa geopotential

Lead time of Anomaly correlation reaching 80%

NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)



# Z500 N hemisphere HRES v ERA-I

## HRES - ERA

500hPa geopotential

Anomaly correlation

NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)

T+0 T+12 ... T+240

oper\_an-era\_an od-ei oper 0001 | 00UTC,12UTC,beginning

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## ECMWF Newsletter

Number 137 – Autumn 2013

European Centre for Medium-Range Weather Forecasts  
Europäisches Zentrum für mittelfristige Wettervorhersage  
Centre européen pour les prévisions météorologiques à moyen terme

Impact of the Metop satellites

Ocean Reanalyses

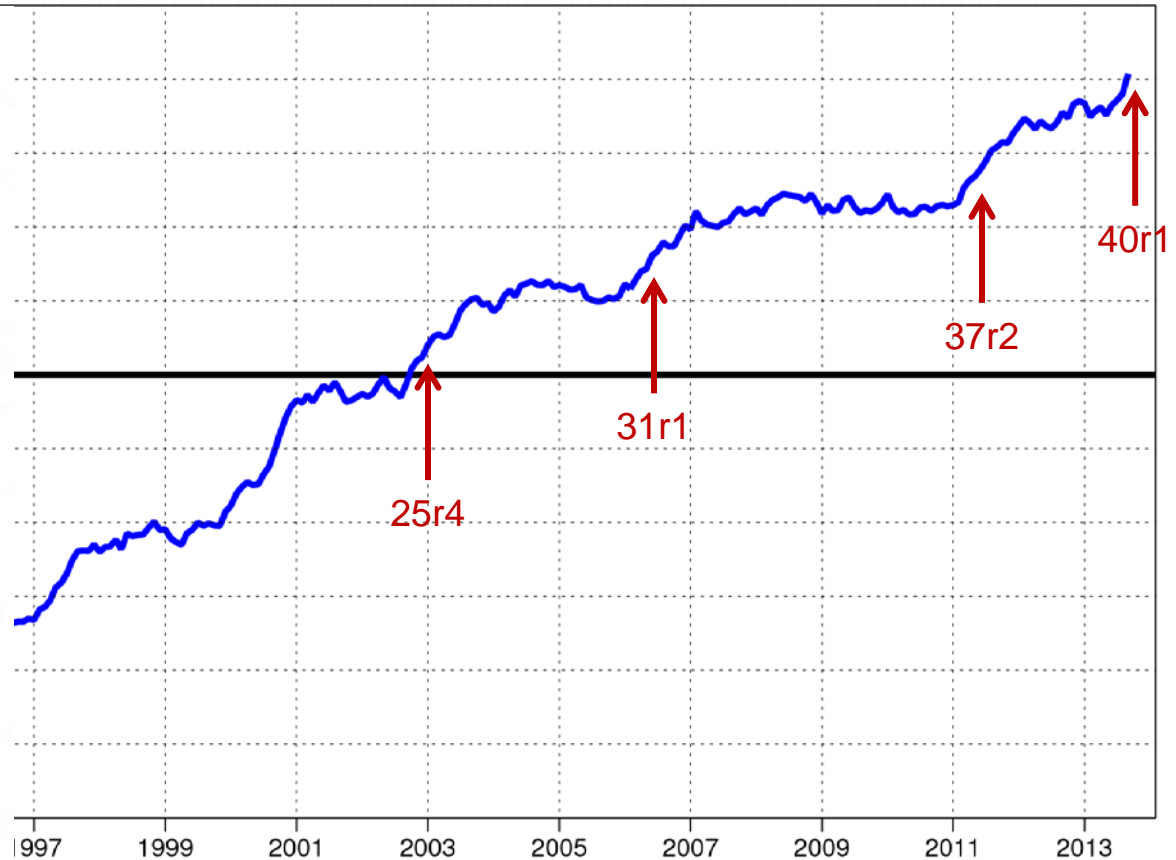
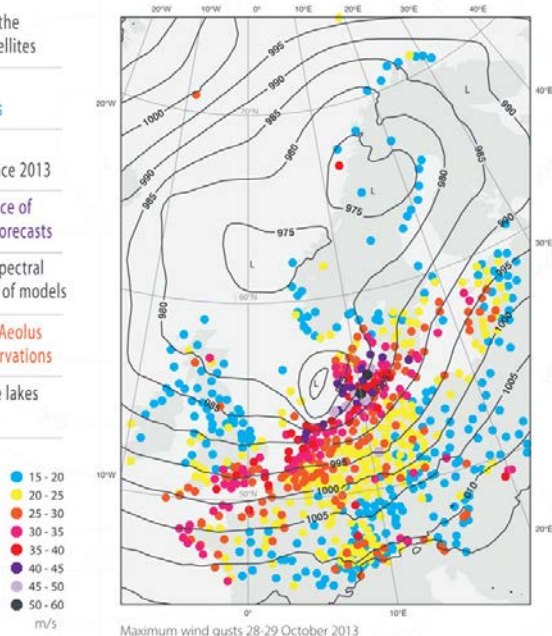
Forecast performance 2013

Performance of ECMWF's forecasts

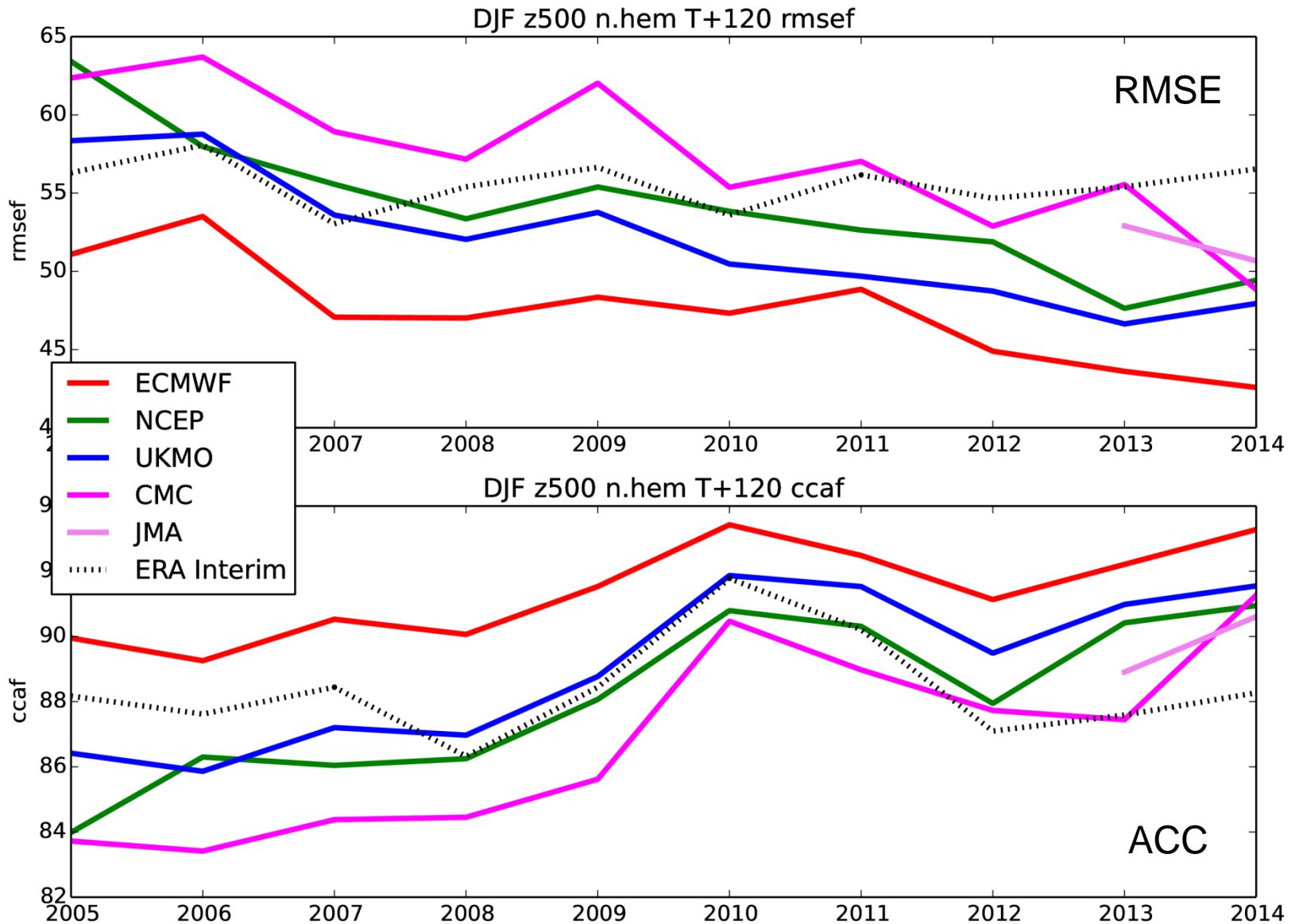
Effective spectral resolution of models

Impact of Aeolus wind observations

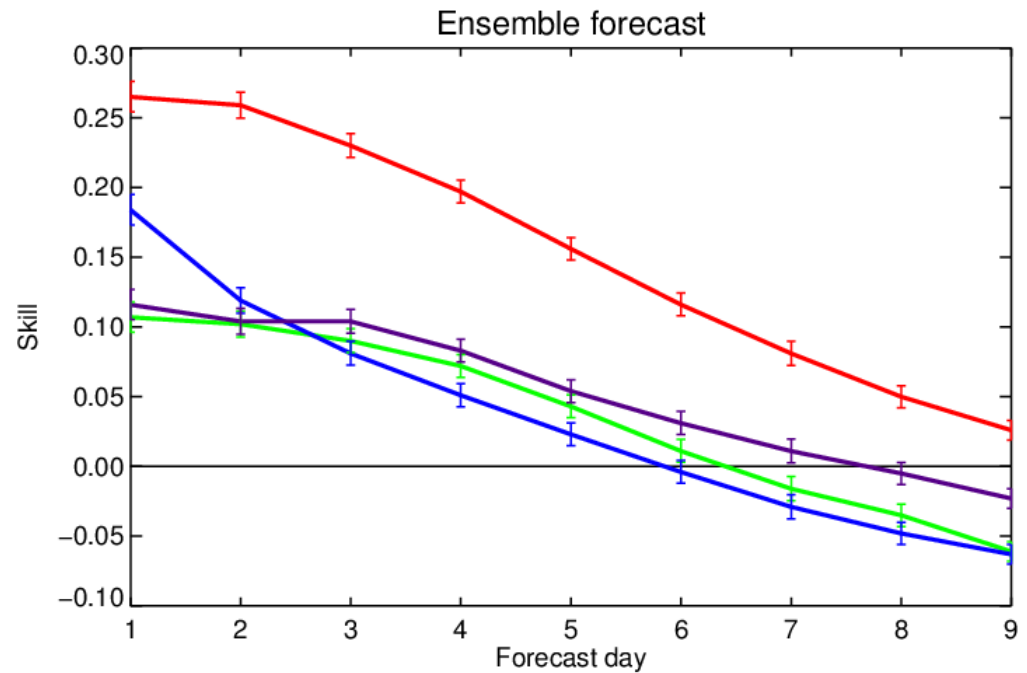
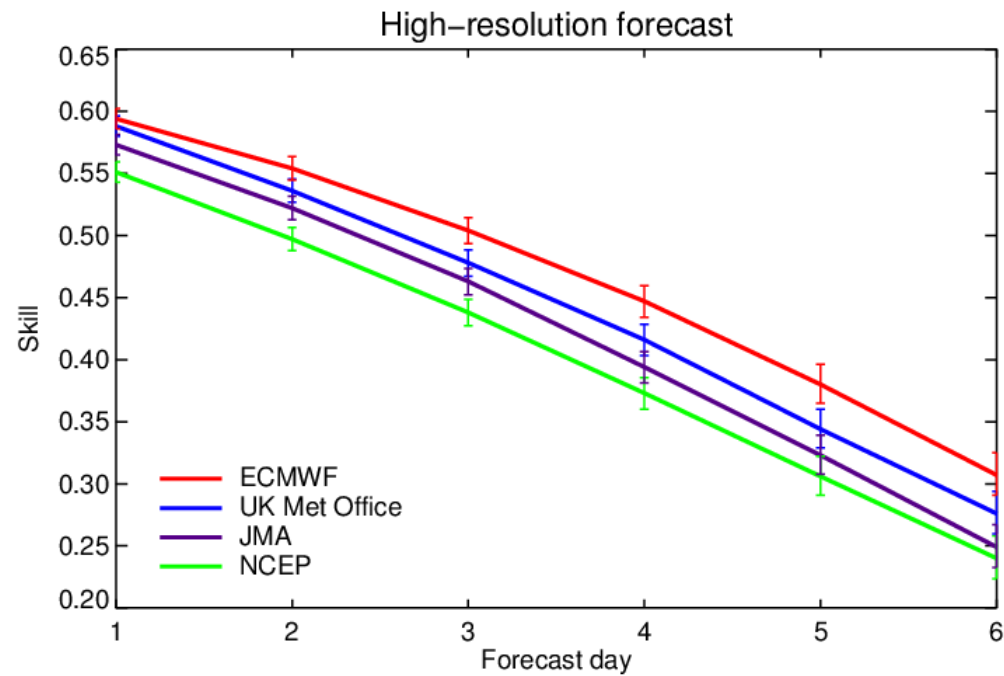
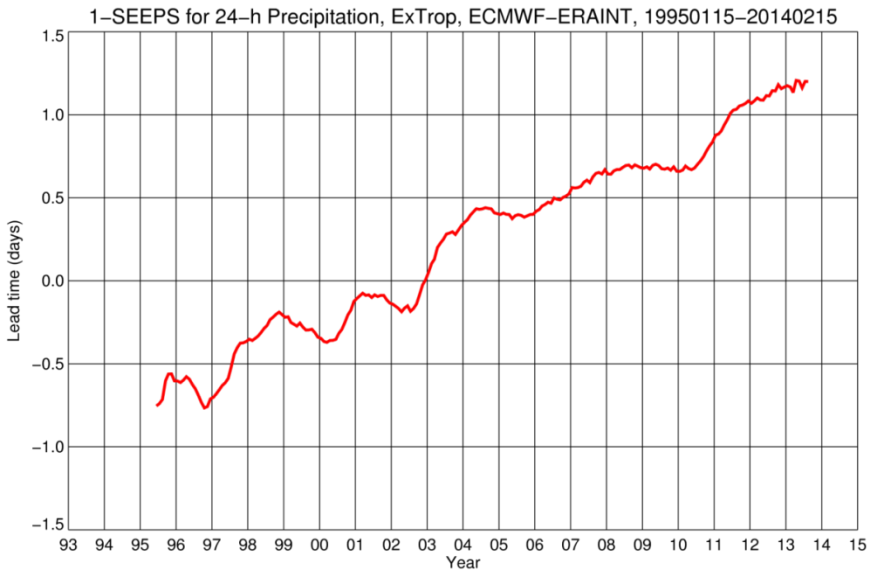
Interactive lakes in the IFS



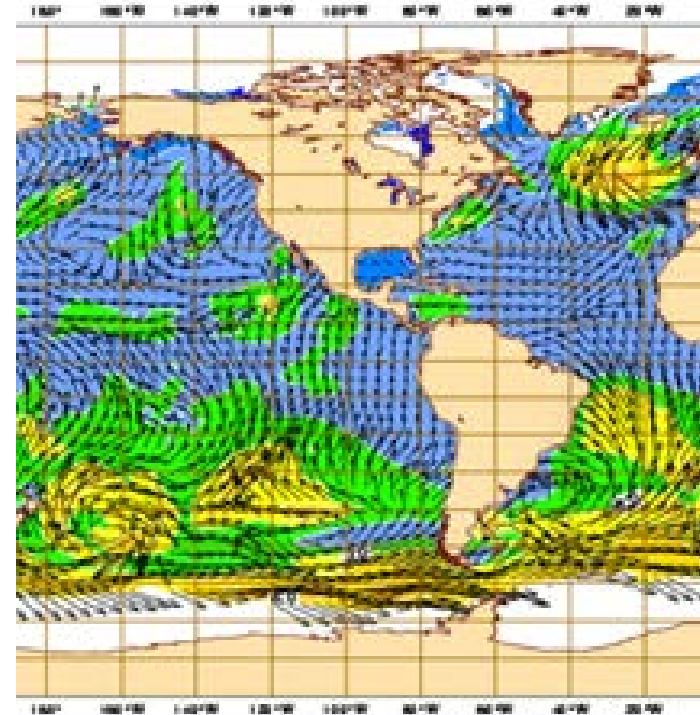
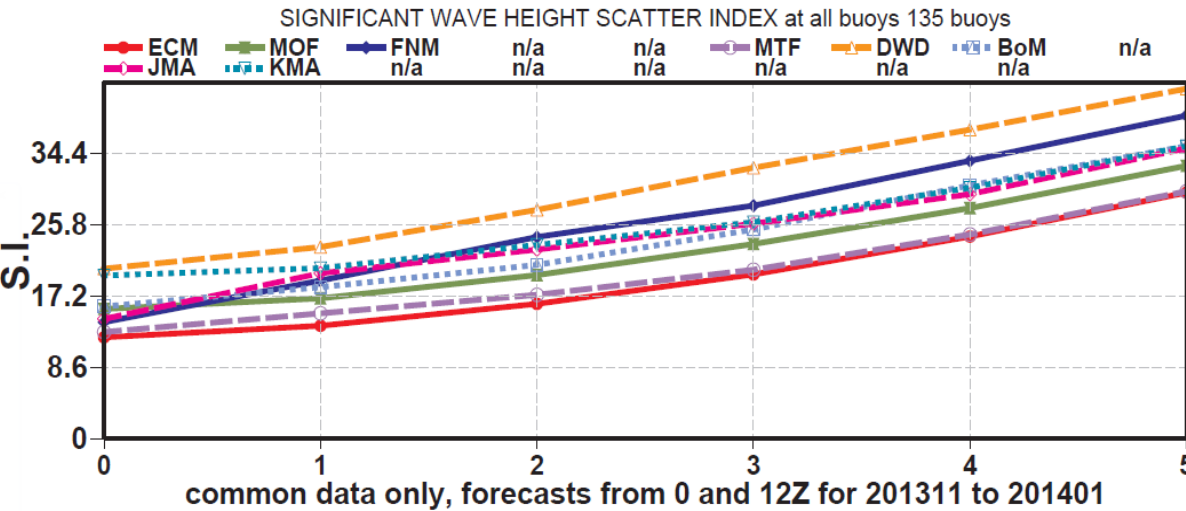
# Other centres N hemisphere, D+5



# Precipitation skill



# The errors of the ECMWF wave height forecasts (red) compared to other major global centres



The scores for all centres are computed for a fixed set of ocean buoys in a verification project for the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology. The error score is the scatter index (SI – the standard deviation of error normalised by the mean observed value) for forecasts of significant wave height out to five days ahead for the period January - March 2013.



# New model cycles

- Typically 2 per year
- Fax announcement
- Web page for information on operational model changes
  - Technical details
  - Meteorological changes
  - Verification results
- Test data

The screenshot shows a web browser window displaying the ECMWF website page for the implementation of IFS cycle 40r1. The page title is "Implementation of IFS cycle 40r1 - M". The browser address bar shows the URL "old.ecmwf.int/products/changes/ifs\_cycle\_40r1/". The page features a navigation menu with links for Home, Your Room, Login, Contact, Feedback, Site Map, and Search. Below the menu, there are sections for "Operational Upgrades" and "Related" links. The main content area is titled "Implementation of IFS cycle 40r1" and contains a detailed description of the changes, including a list of two major changes: 1. The vertical resolution and the vertical extent used for the medium-range and monthly ensemble forecasts will change: the number of levels of the ENS will increase from 62 to 91 with the model top raised from 5 hPa to 0.01 hPa. The pressure levels remain unchanged. 2. The atmosphere-ocean coupling of the ENS will be active from initial time of the forecast using a new version of the NEMO ocean model. The page also mentions that these changes do not apply to the Long-range (SEAS) forecast and that the first operational run using IFS cycle 40r1 was on 19 November 2013. A footer section highlights the latest changes, stating that IFS cycle 40r1 was implemented successfully on 19 November 2013 and that updates to meteorological impact of IFS cycle 40r1 are available. The page was last changed on 02.12.2013.

Implementation of IFS cycle 40r1 - M

File Edit View History Bookmarks Tools Help

Implementation of IFS cycle 40r1

old.ecmwf.int/products/changes/ifs\_cycle\_40r1/

Most Visited ECMWF ECMWF CEPMMT EZ... Meteorological Operati... Google Met Office: Weather

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**About Us** Overview Getting here Committees  
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**Services** Computing Archive PrepiFS  
**Research** Modelling Reanalysis Seasonal  
**Publications** Newsletters Manuals Library  
**News&Events** Calendar Employment Open Tenders

Home > Products > Operational Upgrades > IFS cycle 40r1 >

## Implementation of IFS cycle 40r1

**Operational Upgrades**

[IFS cycle 40r1](#)  
[Other](#)

**Related**

[User guide of ECMWF products](#)  
[History of ECMWF model's cycle changes](#)  
[Full scientific and technical documentation of the IFS](#)

IFS cycle 40r1 introduces significant changes to the assimilation and forecast model, as detailed [below](#), and two major changes to the [ensemble forecast](#) (ENS).

1. The vertical resolution and the vertical extent used for the medium-range and monthly ensemble forecasts will change: the number of levels of the ENS will increase from 62 to 91 with the model top raised from 5 hPa to 0.01 hPa. The pressure levels remain unchanged.
2. The atmosphere-ocean coupling of the ENS will be active from initial time of the forecast using a new version of the NEMO ocean model.

These changes do not apply to the Long-range (SEAS) forecast.

With the implementation of cycle 40r1:

- ensemble forecast tube products are no longer be offered in dissemination: see [Impact on users - Dissemination](#);
- some MARS streams are discontinued: see [Impact on users - MARS](#)

The first operational run using IFS cycle 40r1 was the 06 UTC analysis and forecast in the Boundary Conditions optional programme on 19 November followed by the 12 UTC main assimilation and forecast. The monthly forecast extension to the ensemble was run with the new IFS cycle for the first time the following Thursday, 21 November 2013.

In order to manage the transition, changes to dissemination requirements were suspended from 12:00 UTC on 18 November 2013 until 12:00 UTC on 19 November 2013.

**The page will be updated as required. It was last changed on 02.12.2013.**

**Latest changes:**

- IFS cycle 40r1 was implemented successfully on 19 November 2013
- Updates to meteorological impact of IFS cycle 40r1

ECMWF thanks all users that used the IFS cycle 40r1 test data to prepare their systems for the change.

# Cycle 38R2 (June 2013): Main contents

## Number of levels increased from 91 to 137 in high-resolution forecast model (HRES), the ensemble of data assimilations (EDA), the main assimilation (4DVAR) and the Boundary-Conditions (BC) optional programme

- Revised background error variances at 137 levels based on IFS cycle 38r1
- Revised EDA calibration and filtering for 137 levels
- Flow dependent, unbalanced errors in EDA
- Modification of surface drag
- Modified test parcel entrainment in boundary layer and shallow convection, auto-conversion
- Adjustment of non-orographic gravity wave drag to be consistent with System-4
- SV retuning in ENS

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Model Cycle 38r2:  
Components and Performance

Peter Bauer, Anton Beljaars,  
Maike Ahlgrimm, Peter Bechtold,  
Jean-Raymond Bidlot, Massimo Bonavita,  
Alessio Bozzo, Richard Forbes,  
Elias Hölm, Martin Leutbecher,  
Philippe Lopez, Linus Magnusson,  
Fernando Prates, Mark Rodwell,  
Irina Sandu, Agathe Untch,  
Frédéric Vitart

Research Department

July 2013

This paper has not been published and should be regarded as an Internal Report from ECMWF.  
Permission to quote from it should be obtained from the ECMWF.

TECHNICAL MEMORANDUM

 European Centre for Medium-Range Weather Forecasts  
Europäisches Zentrum für mittelfristige Wettervorhersage  
Centre européen pour les prévisions météorologiques à moyen terme

# Cycle 40R1 (November 2013) includes:

## ➤ ENS:

- **Vertical resolution and extent increased: from 62 to 91 levels, with the model top raised from 5 hPa to 0.01 hPa**
- **Atmosphere-ocean coupling from initial time of the forecast using a new version of the NEMO ocean model**
- **perturbation of land surface initial conditions**

## ➤ HRES and ENS

- **Convection: improved diurnal cycle of precipitation**
- **A package of changes introduced to stable boundary layer diffusion, turbulent orographic drag, orographic gravity wave drag and surface-atmosphere coupling over forests, which improves boundary layer winds (e.g. at wind turbine hub height) and improves northern hemisphere winter scores**

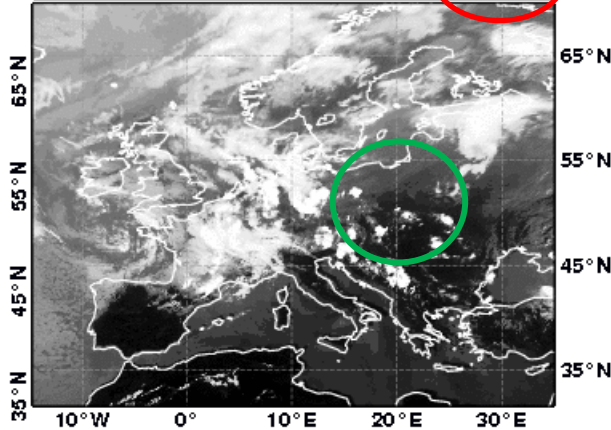
# Cycle 40R1: Diurnal cycle convection

## Observations

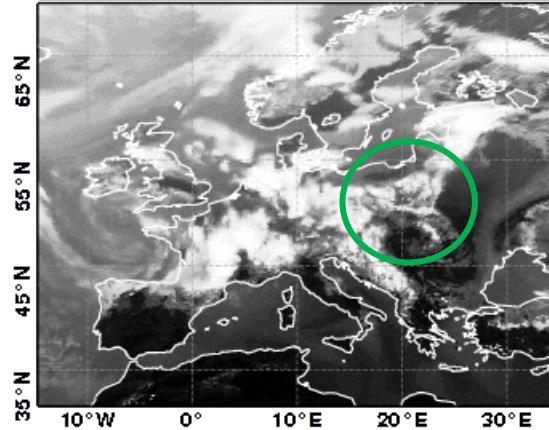
## Current scheme

## New scheme

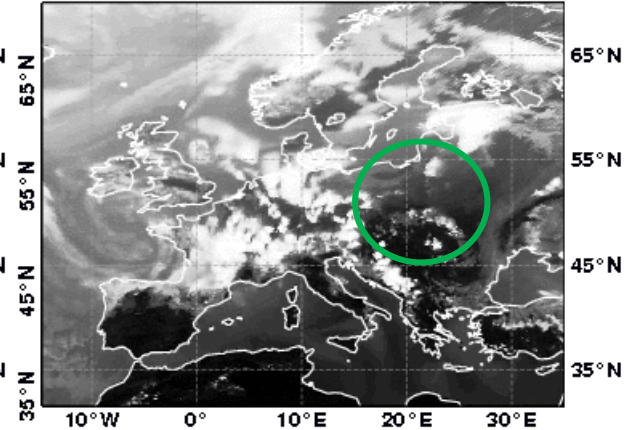
Meteosat 9 IR10.8 20120705 12 UTC



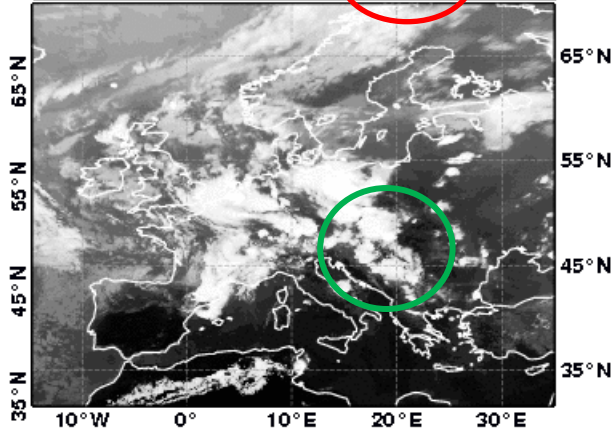
b CTL 20120705 00 UTC+12h:



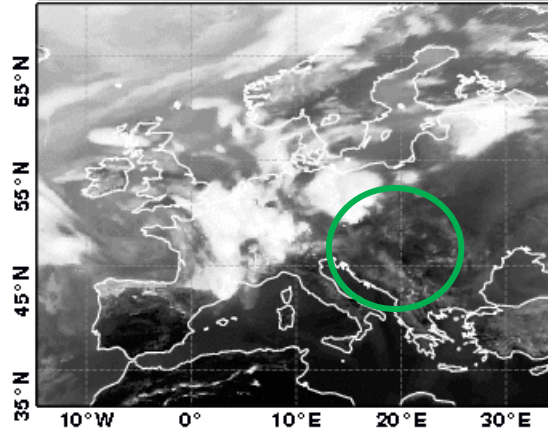
c NEW 20120705 00 UTC+12h:



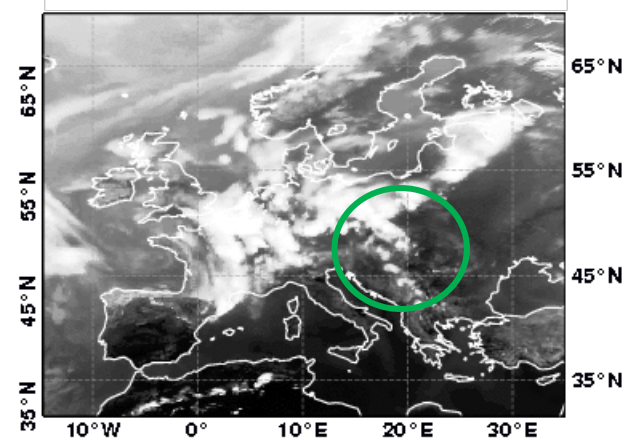
a Meteosat 9 20120705 18 UTC



b CTL 20120705 00 UTC +18h

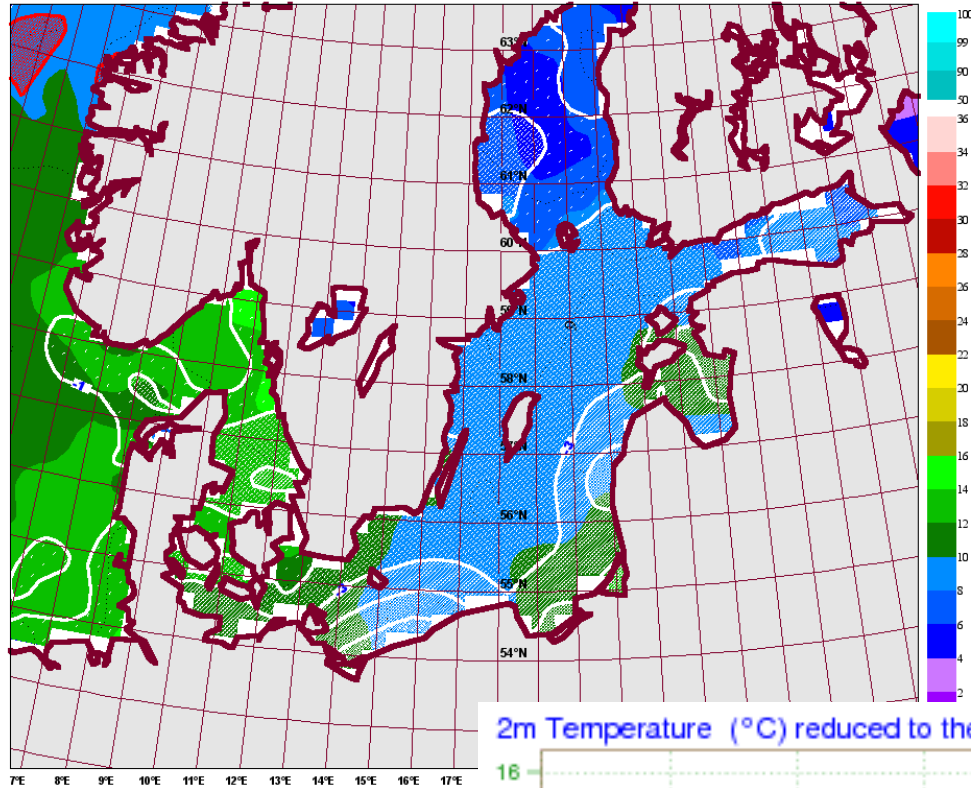


c NEW 20120705 00 UTC +18h:



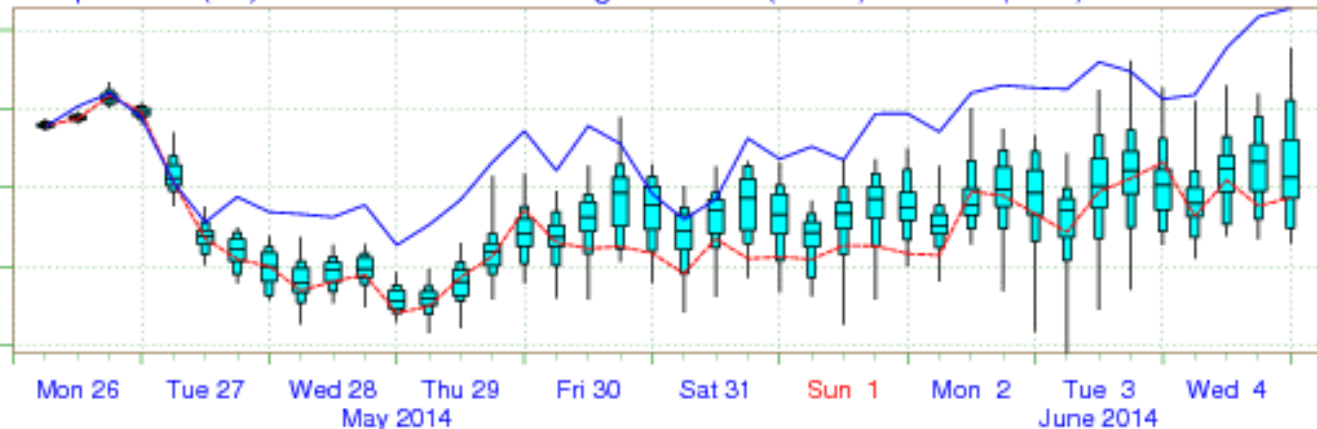
# Coupled ocean from beginning of forecast

ECMWF (coupled) Control run: Monday 26 May 2014 00UTC T+132 VT: Saturday 31 May 2014 12 UTC  
Sea Surface Temperature (C, bottom legend) and Sea Ice Fraction (%), top legend) in coupled Control run  
Stippling shows SST difference, Coupled minus Uncoupled (red for >+1c, white for <-1C)



**ENS coupled throughout  
HRES not coupled**

2m Temperature (°C) reduced to the station height from 0 m (T1279) and -1 m (T639)



Using ECMWF Forecasts

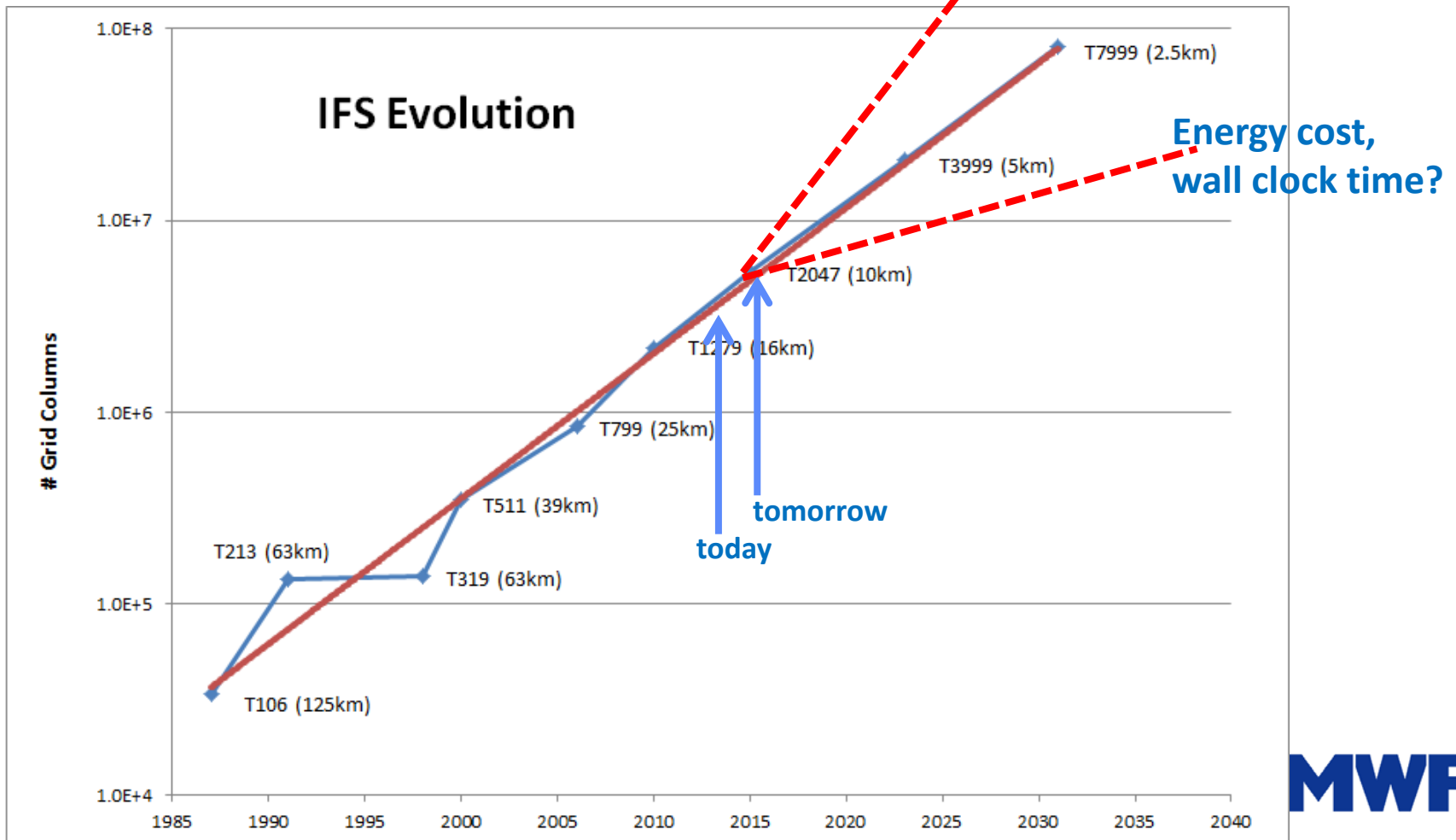
# Cycle 40R3 (autumn 2014) includes:

- cloud scheme: rain evaporation/autoconversion/accretion, riming (less drizzle, reduced T-bias)
- instantaneous precipitation rates, max/min total precipitation rate in a period, precipitation type, "instantaneous" wind gust and visibility
- lake model (FLAKE) (better surface-atmosphere interaction)
- twice weekly 11-member reforecasts (more frequent updates of calibration)
  
- 3x T255 inner loops in DA (higher res. first inner loops, more smaller scale increments)
- weighted sampling from more recent EDA (more day-to-day variability in background errors)
- Wave modified stress in coupled mode (more interaction between waves and ocean)
- MACC-II CO<sub>2</sub>/O<sub>3</sub>/CH<sub>4</sub> climatologies (latest trace gas climatologies)
- new surface climate fields (land-sea mask, sub-grid orography, albedo)
- improved SL-trajectory (reduced noise in SSW events)
- RTTOV-11 (new IR spectroscopy) MHS in all-sky assimilation mode (improved moisture analysis)
- assimilation of GPS-RO with 2D operator (better representation of lower tropospheric variability)

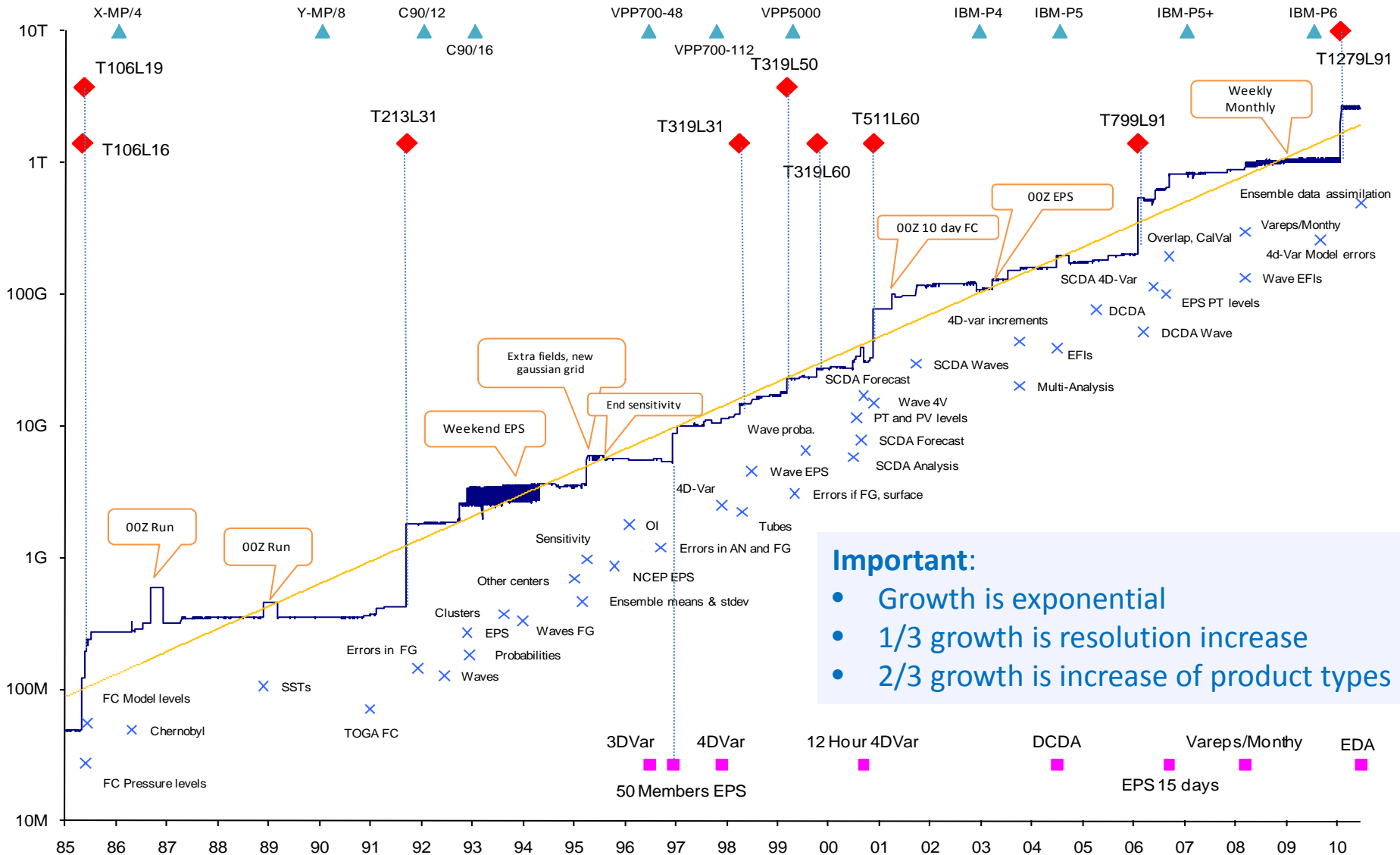
# 2015: increase in horizontal resolution

➤ HRES/EDA/4DVAR: ~10 km grid (T2047)

➤ ENS: ~20 km grid (T1023)



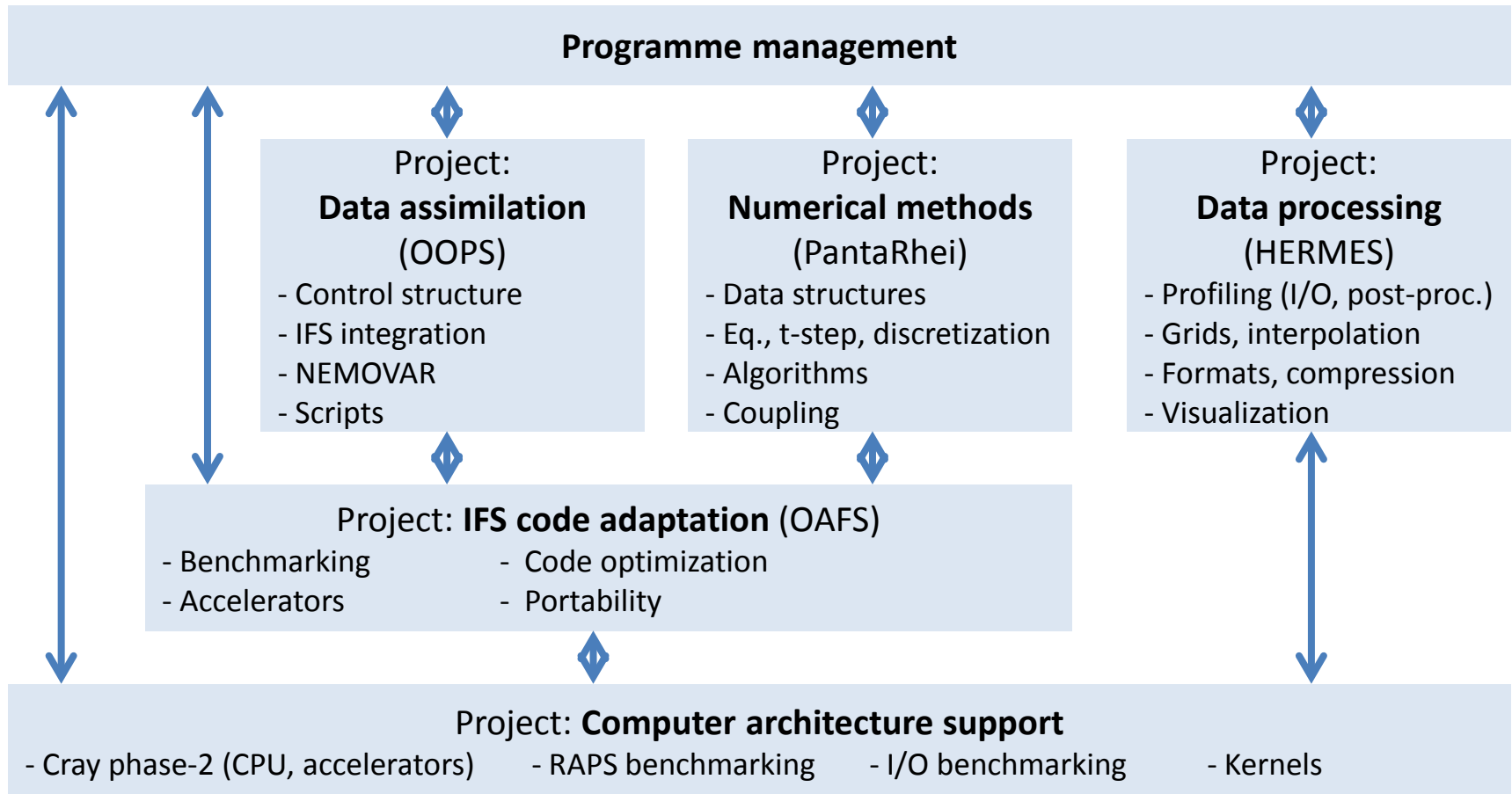
# MARS archive volume





# Scalability Programme

- Implement a formal structure at ECMWF to coordinate science & software activities across departments for efficient exa-scale computing/archiving
- Coordinate activities with Member States, European HPC facilities, research centres, academia, vendors & international NWP centres



# Scalability Project: Workshop

## ➤ Scientific flexibility/choices:

- E.g. which are the priorities between complexity, resolution, ensembles given scalability limitations?

## ➤ Numerical techniques/libraries:

- E.g. what is the trade-off between accuracy and energy efficiency (e.g. double vs single precision)?

## ➤ Hardware/compiler:

- E.g. how will the other components of an exa-scale system cope, e.g. Operating System, resource scheduler, workflow management, file system?

## ➤ I/O:

- E.g. what needs to be archived/disseminated, what can be post-processed on the fly or recalculated?

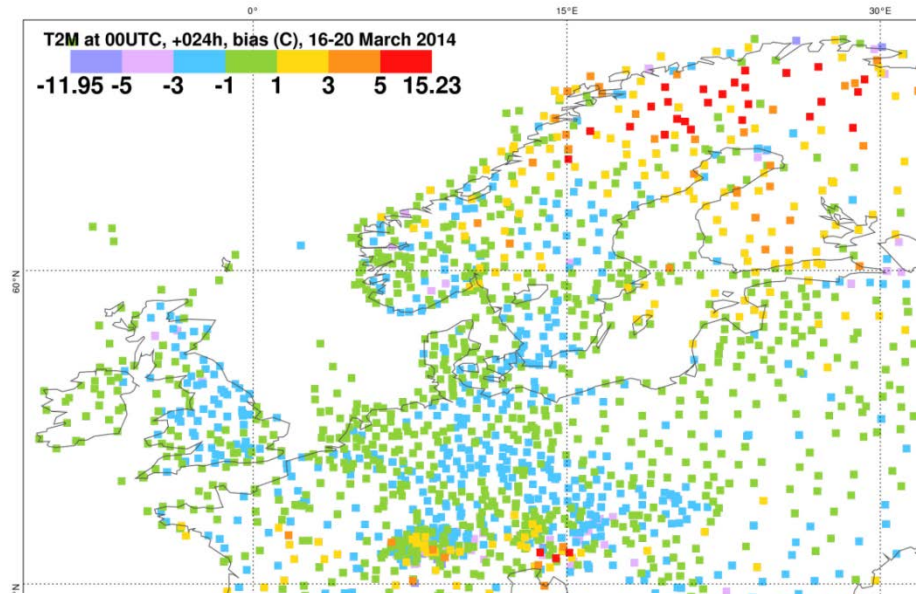
## ➤ Benchmarking:

- E.g. which components of the workflow should be benchmarked separately and how?

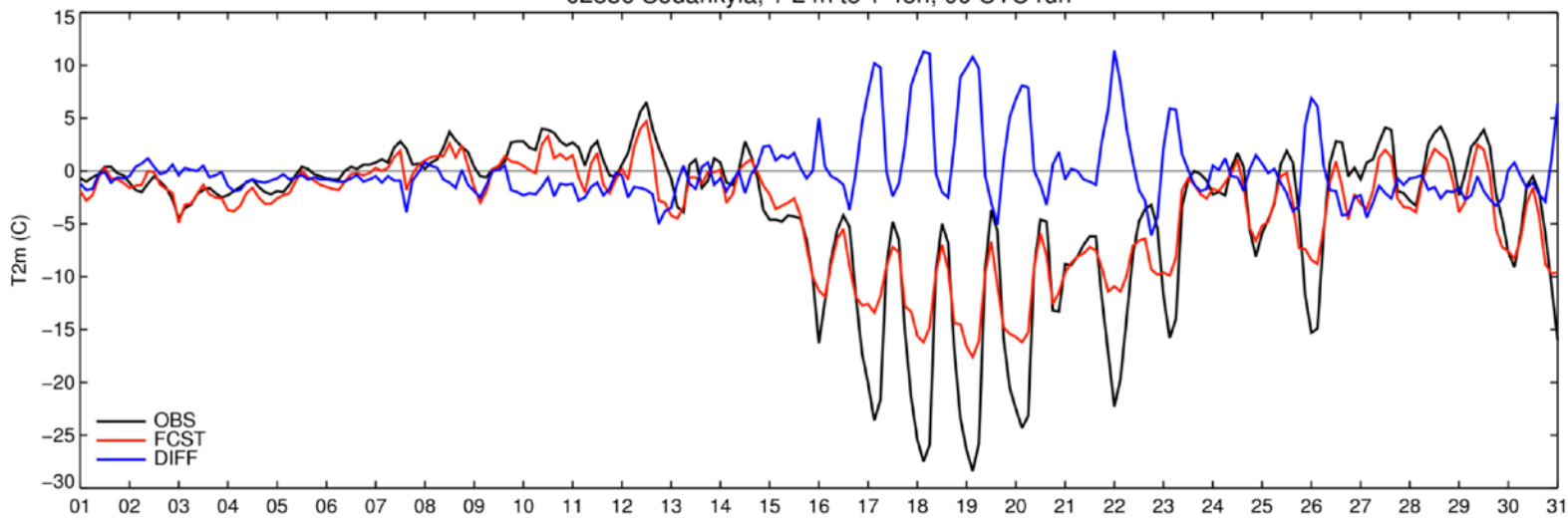
<http://old.ecmwf.int/newsevents/meetings/workshops/2014/Scalability/index.html>

# 2m temperature errors

**Positive 2m temperature bias in cases of strong surface inversions and very weak wind, may reach 10 K  
Especially over snow, nighttime**

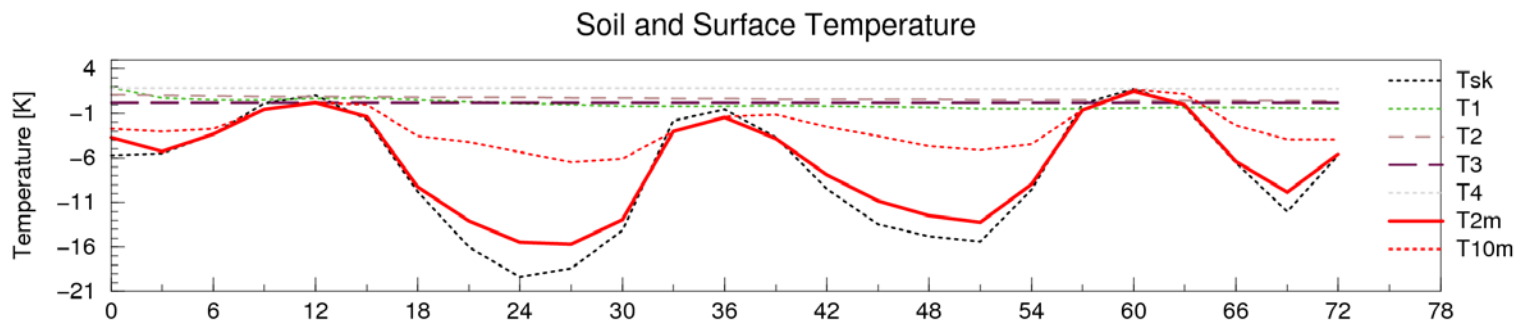
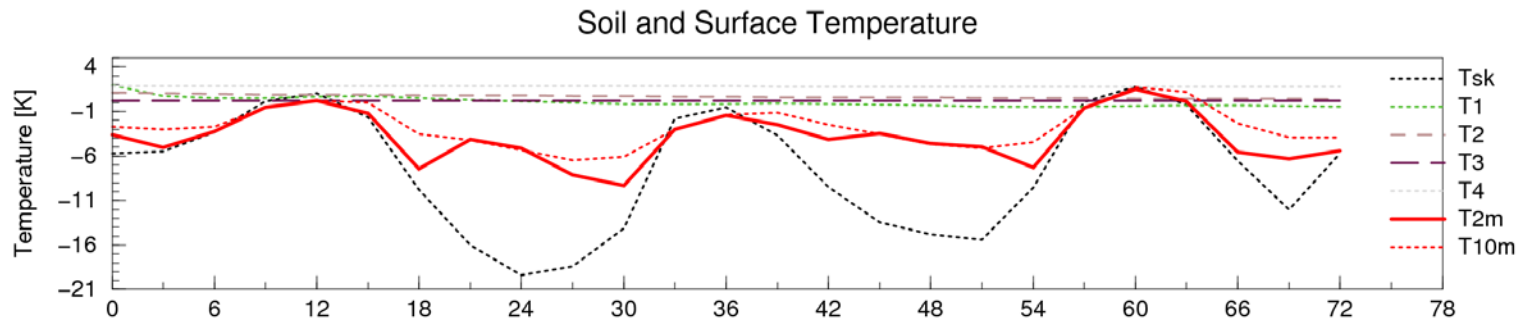


02836 Sodankyla, + 24h to + 45h, 00 UTC run



Mar 2014

# 2m temperature errors



# New forecast users web space

<https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home>

The image shows a browser window displaying the ECMWF Forecast User Home page. The page is titled "Forecast User Home" and is created by Daniel Varela. It includes a welcome message and a sidebar with navigation links. The main content area features a "Severe Event Catalogue" section with a featured image of a lightning storm and a "Known IFS forecasting issues" section with a table of common forecast errors.

**Forecast User Home**  
Created by Daniel Varela

Welcome to the Forecast User Home. These pages are for new users and provide information on how to use the forecast services. Your feedback is welcome and there is the opportunity to already a brief report on forecast\_user@ecmwf.int. For any general feedback, please contact forecast\_user@ecmwf.int. These pages complement the following pages:

- Severe Event Catalogue
- Forecasting issues
- Forecast evaluation

**Severe Event Catalogue**  
Created by Florian Pappenberger, last modified by Lin...

**Known IFS forecasting issues**  
Created by Timothy Hewson, last modified by Daniel Varela Santoalla on May 16, 2014

Please note that numbering/ordering does *not* indicate/imply any sort of priority.

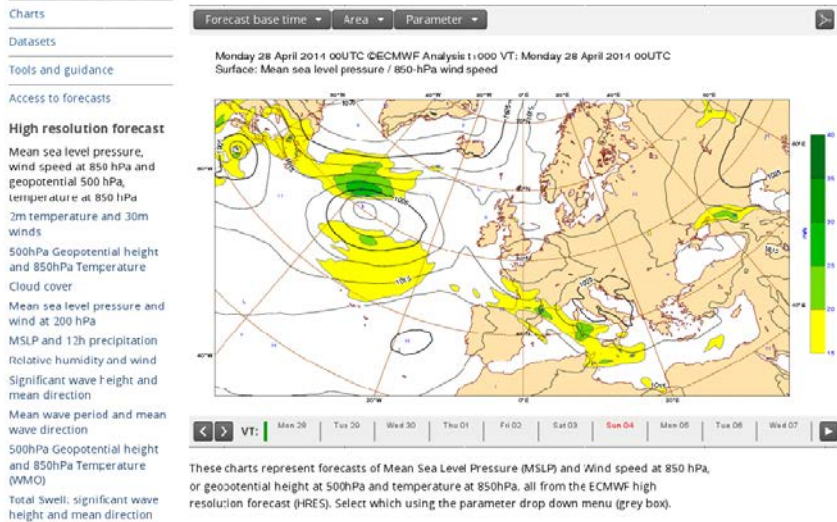
Topic / title	Description	Related activities
<b>2m Temperature</b>		
1. 2m temperature in the presence of inversions	In common with all models, 2m temperature forecasts from the IFS tend to have much larger errors, on average, during low level inversion situations, which are particularly common at high latitudes in winter. The basic physical explanation is that a set change in atmospheric energy content has a much larger impact on screen temperature in inversion situations than in unstable situations, because the energy change is commuted through a much smaller depth of the atmosphere (e.g. metres rather than kilometres). The lower the inversion, the larger is the potential error. There is also sensitivity here to the method we use to interpolate between air temperature at the lowest model level (~10m) and skin temperature (2m temperature is a diagnostic, not direct model output).	
2. City temperatures too low	Due to the urban heat island effect not being represented, screen temperatures in large urban areas, particularly cities, are commonly too low compared to observations. The problem can be accentuated in winter by snow cover.	'Urban tiles' due in land surface scheme in 2016/17
3. Screen temperatures fall too much near coasts	As a consequence of the radiation grid being larger than the model grid (due to computational constraints) night-time radiative cooling over land near to the coast is often too rapid. This is because cooling progresses according to $T^4$ , and at near-coast points $T$ is approximately the average temperature of the land and (warmer) ocean. As a result screen temperatures drop too much - related errors can sometimes exceed 10C. The problem is enhanced (i) when there is snow cover, (ii) at high latitudes, and (iii) where coasts have a convex shape (land-relative).	2-year goal to improve radiation code efficiency so that grids match. Shorter term fixes also being considered.
4. Meteogram	In addition to the normal problems of representing screen temperatures in complex topography in current-	Resolution upgrade in

**Using ECMWF Forecasts June**

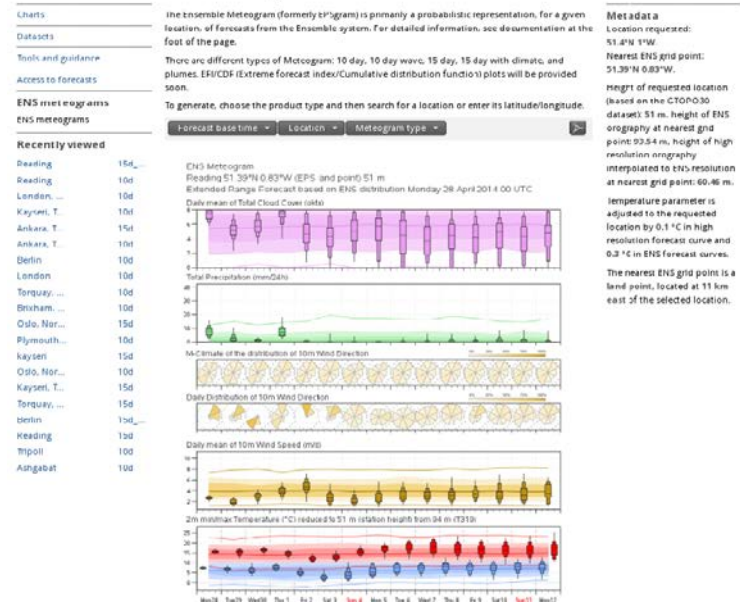
# Charts on the new web site

- Modernize the look in the context of web2013 project
- New software infrastructure to allow new products & features
- Migration of essential products (~140) is completed
- New user interfaces for charts and meteograms

Mean sea level pressure, wind speed at 850 hPa and geopotential 500 hPa, temperature at 850 hPa



## ENS meteograms



# Navigation and discovery

- Hierarchical navigation replaced with faceted navigation based on search facility
- Faceted navigation provides list of all products based on pre-defined facets (eg: Display all tropical cyclone products, display all temperature products ...)
- An improved search facility

Charts catalogue

Showing 1-10 of 10 results for **Tropical cyclones** ✕

**Tropical cyclone activity (including genesis)**

ecCharts service

**Extended range tropical storm activity**

**Long range tropical storms**

Charts  
Datasets  
Tools and guidance  
Access to forecasts

**Filter charts**  
Filter charts

- ▼ Range
  - Medium (15 days) (3)
  - Extended (30 days) (2)
  - Long (Months) (5)
  - Analysis (1)
- ▼ Type
  - Forecasts (10)
- ▼ Component
  - Atmosphere (10)
  - Surface (3)
  - Geography (1)
- ▼ Product type
  - ENS (10)
  - Combined (1)
  - Extreme forecast index (1)
  - HRES (1)
  - Meteograms (1)
- ▼ Parameters
  - ✓ Tropical cyclones
  - Temperature (40)
  - Wind (39)
  - Precipitation (32)
  - Ocean waves (28)
  - Geopotential height (20)

Search results

Site: **Charts** Datasets FAQs

Showing 1-10 of 54 results for **"temperature"** ✕

**Search charts**  
temperature

Sort by

▼ Range

- Medium (15 days) (36)
- Extended (30 days) (7)
- Long (Months) (12)
- Analysis (11)

▼ Type

- Forecasts (47)
- Verifierator (7)

▼ Component

- Atmosphere (33)
- Surface (2)
- Geography (4)

▼ Product type

- ENS (39)
- HRES (15)
- Extreme forecast index (14)
- Combined (7)
- Meteograms (4)

Parameters

- 2m temperature**  
Two metre temperature probabilities ...
- 2m temperature**  
2m temperature probabilities The plot shows probability information derived from the ensemble ... (ENS), specifically: Probability of 2 metre temperature being below 0C at the validity time (colour ... member is assigned an equal probability of 1/50). The 2m temperature is a post-processed product, derived ...
- 2m temperature and 30m winds**  
2m temperature and 30m winds On this page you can visualise the high-resolution forecasts (HRES) ... Arrow length is proportional to wind speed. Two metre temperature (colour shading, 4C intervals). The 2m ... temperature is a post-processed product, derived by non-linear interpolation between temperatures ...
- 2m temperature and 30m winds**  
Two metre temperature and 30m winds over Africa ...
- 500hPa Geopotential height and 850hPa Temperature**  
These charts show 500 hPa geopotential height (contours) and temperature at 850 hPa (shading) from ... troposphere whilst high heights indicate ridges and anticyclones. 850 hPa Temperature Colour shading indicates ... temperature at the 850 hPa level in degrees Celsius to 0 in 1.0 C colour ...

# Future plans for web charts

- **Complete the migration of products (ie: Observation monitoring, tropical cyclone tracks, EUROSIP plots, Special projects ...)**
- **Implementation of more advanced features such as “Your room”**
- **Start building interactive products (basic zoom and pan and click functionalities as in clickable EFI)**
- **Receive/revise/implement user feedbacks**
- **Most modern browsers are supported.**
- **Retirement of old web site and application framework.**



# ecCharts updates

## ➤ June 2014 focuses on content:

- Additional EFI parameters: wind gust, snowfall, significant wave height, 2m max temperature, 2m min temperature
- EFI parameters extended up to 7 days, 1-day ranges
- 250 hPa geopotential/temperature/relative humidity/wind/wind speed (HRES)
- Relative humidity at 1000 and 925 hPa (HRES)
- K-index

## ➤ November 2014 (content and software):

- Revision and addition to combined probabilities
- Total totals index, CIN
- Zero degree level
- Shift of tails
- Specific humidity at 1000 hPa and 925 hPa,
- Divergence at 1000 hPa, 925 hPa, 500 hPa and 300 hPa
- Usability improvements

