Developments of the ECMWF Integrated Forecasting System

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Evaluation Section
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and colleagues

Contents

- Evolution of scores
- Model cycle 41r1 (12 May 2015)
- Model cycle 42r1 (early 2016)
- High-density observations

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)
- Mon/Thu 00 UTC extended to 46 days ahead (Monthly Forecast)

Ocean waves: twice a day

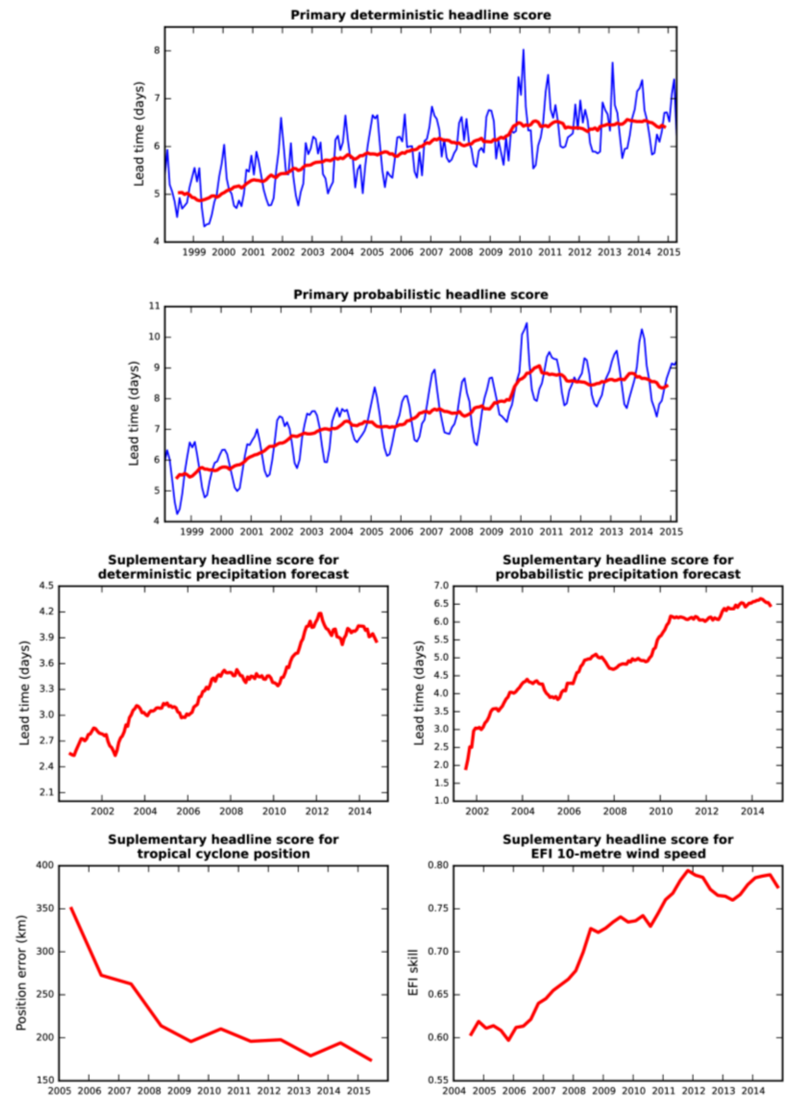
- Global: 10 days ahead at 28 km (fully coupled)
- Global: 10 days ahead at 11 km (stand-alone)
- Ensemble: 15 days ahead at 55 km

Seasonal forecast: once a month

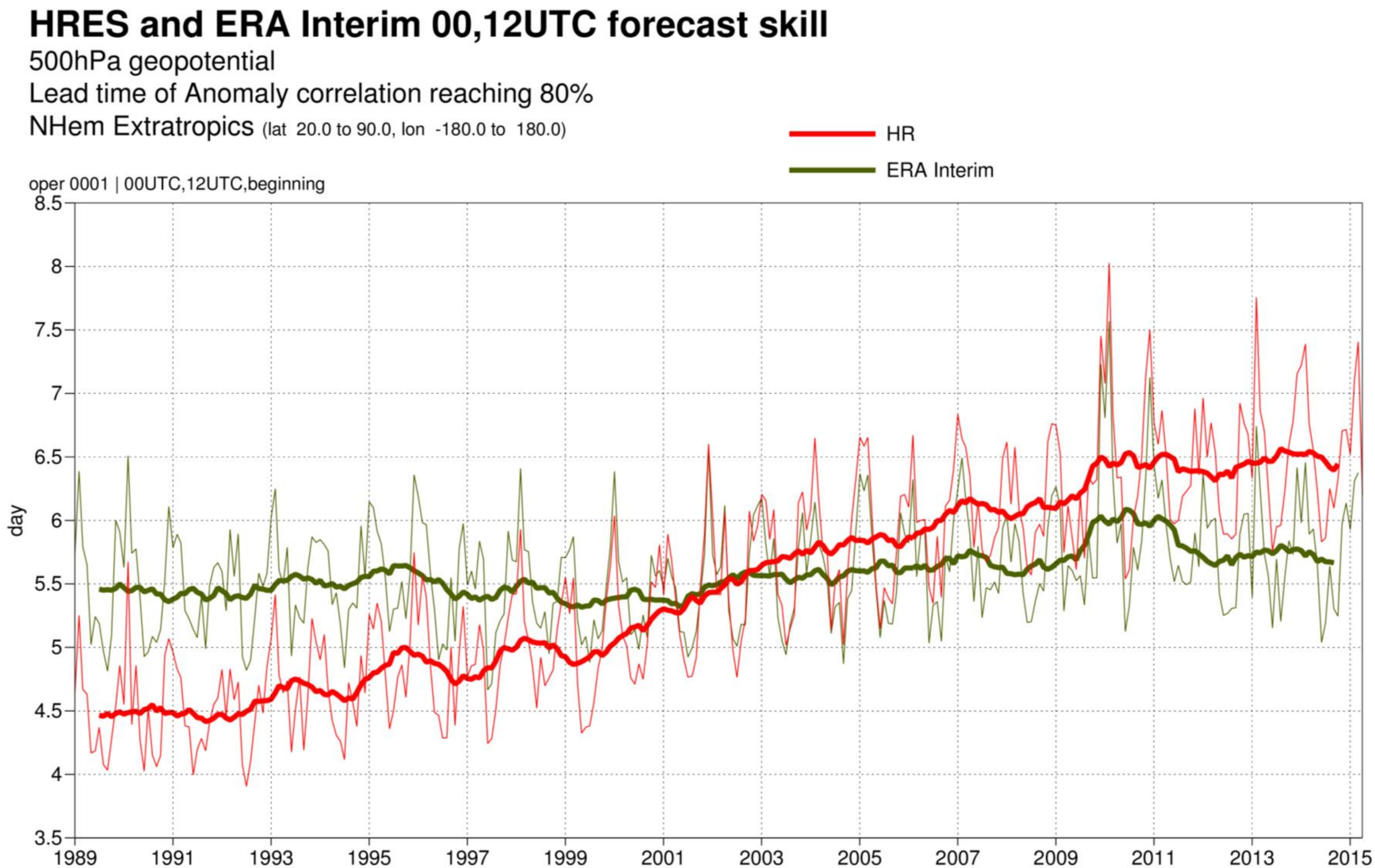
- 51 members, 80 km 91 levels, to 7 months ahead

Forecast performance

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



HRES skill: Z500 NH



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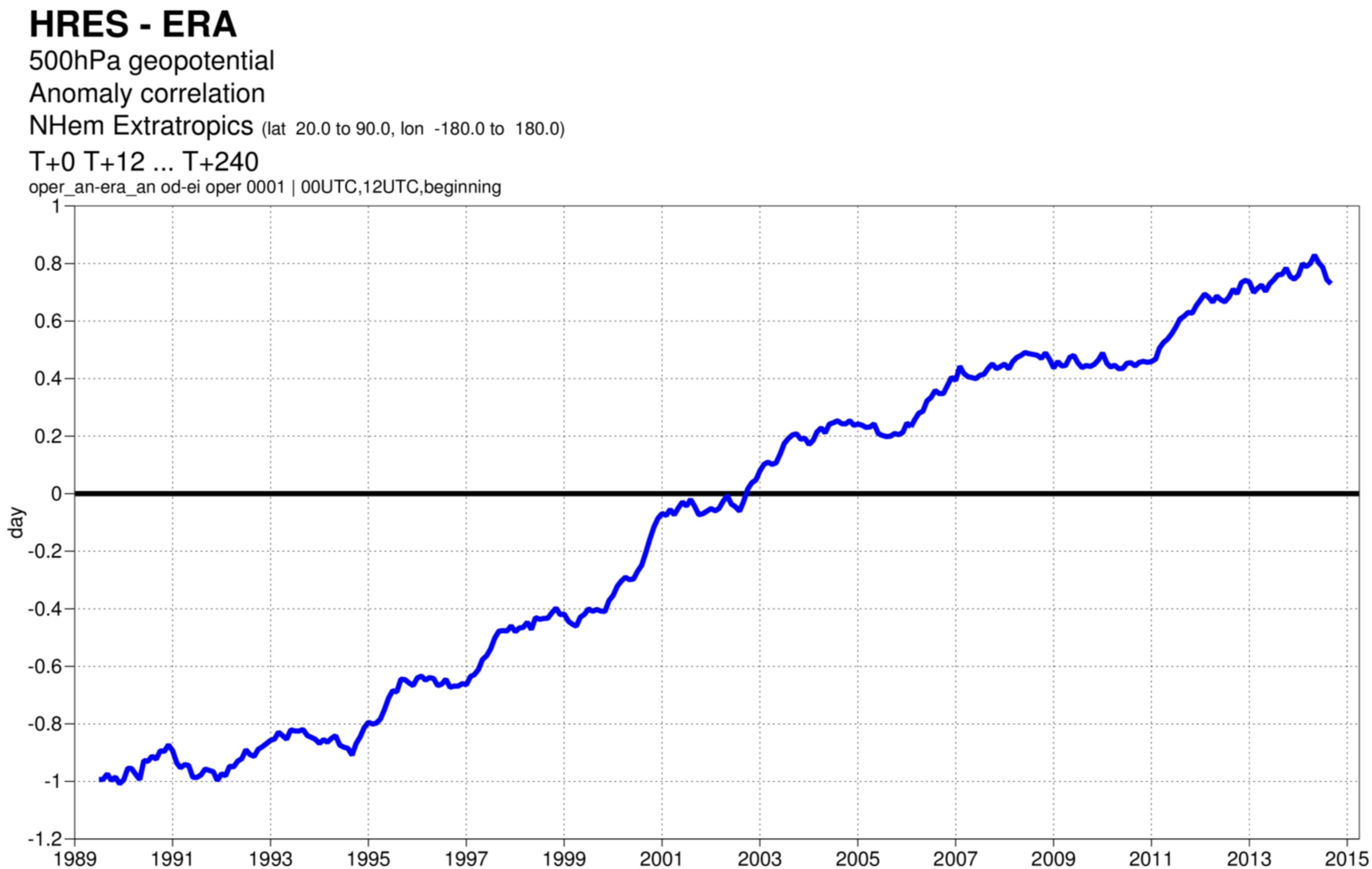
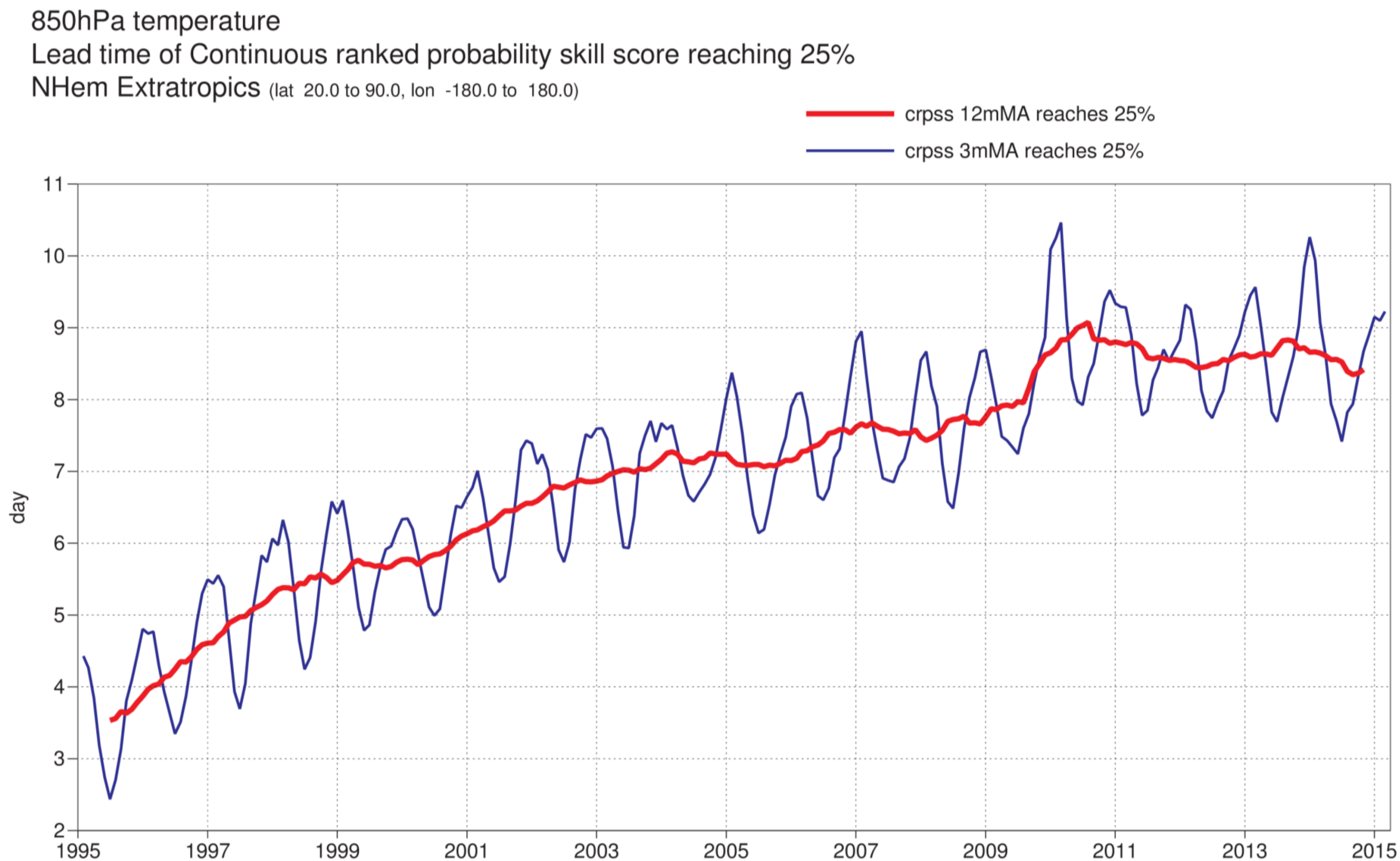


Ensemble skill: T850 NH



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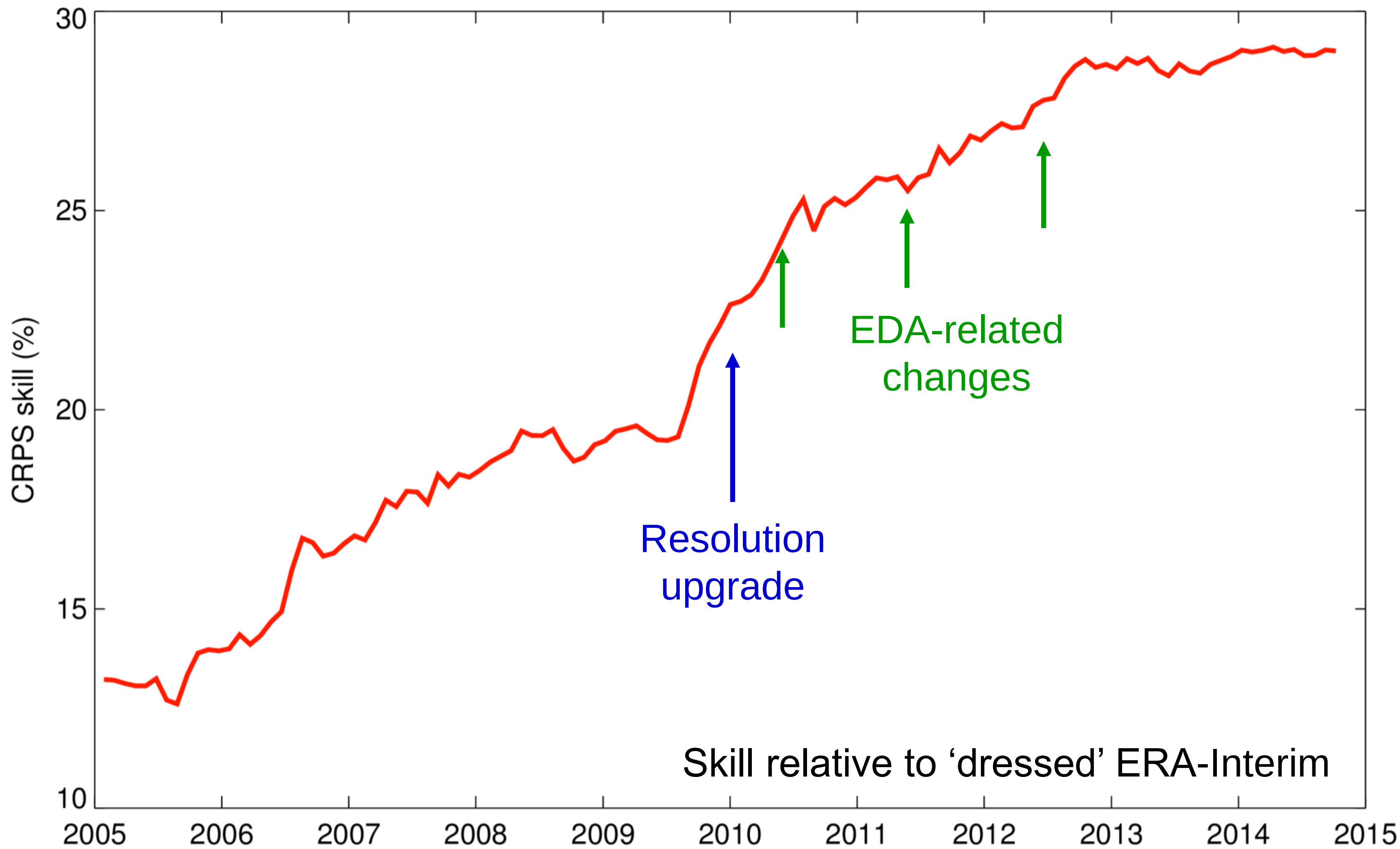

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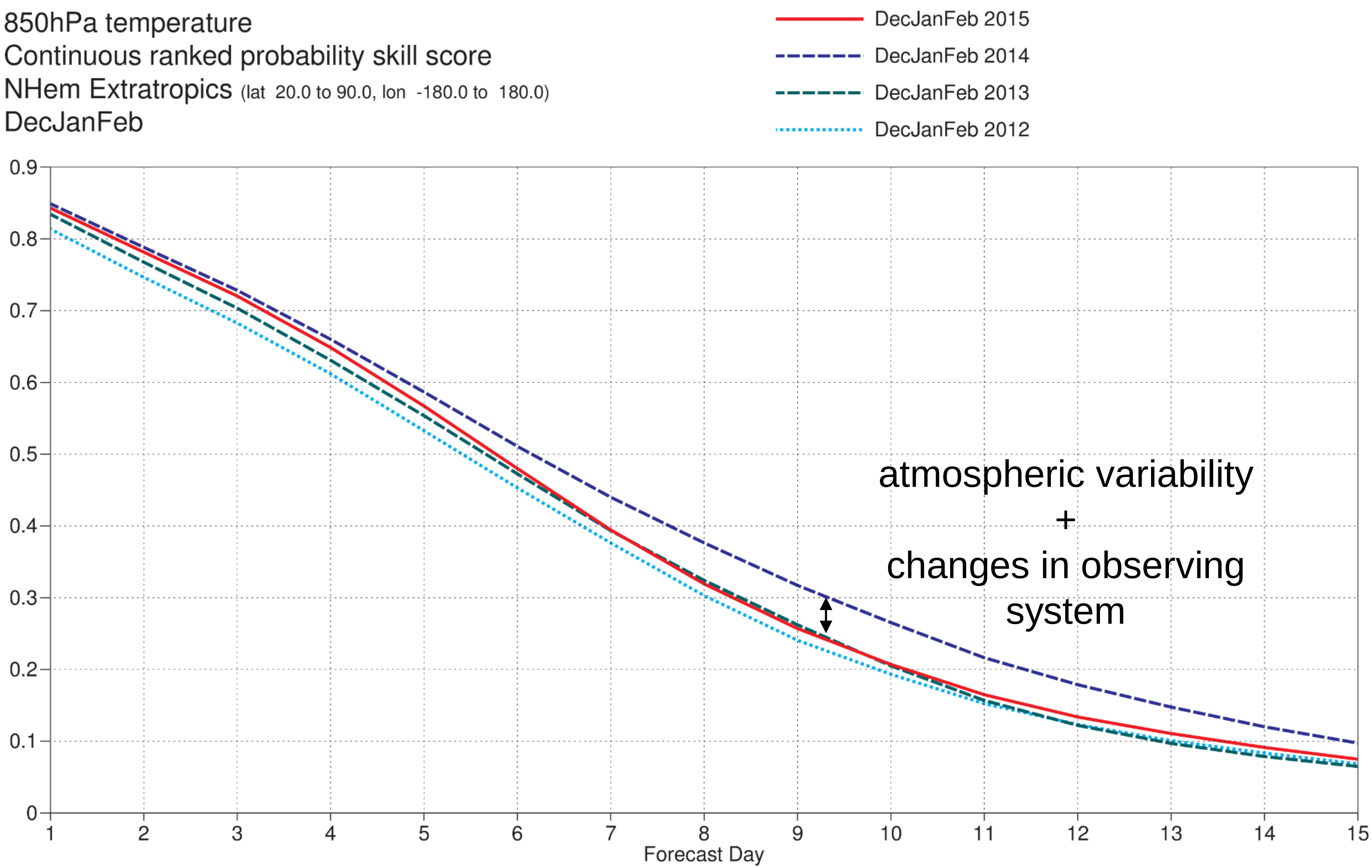

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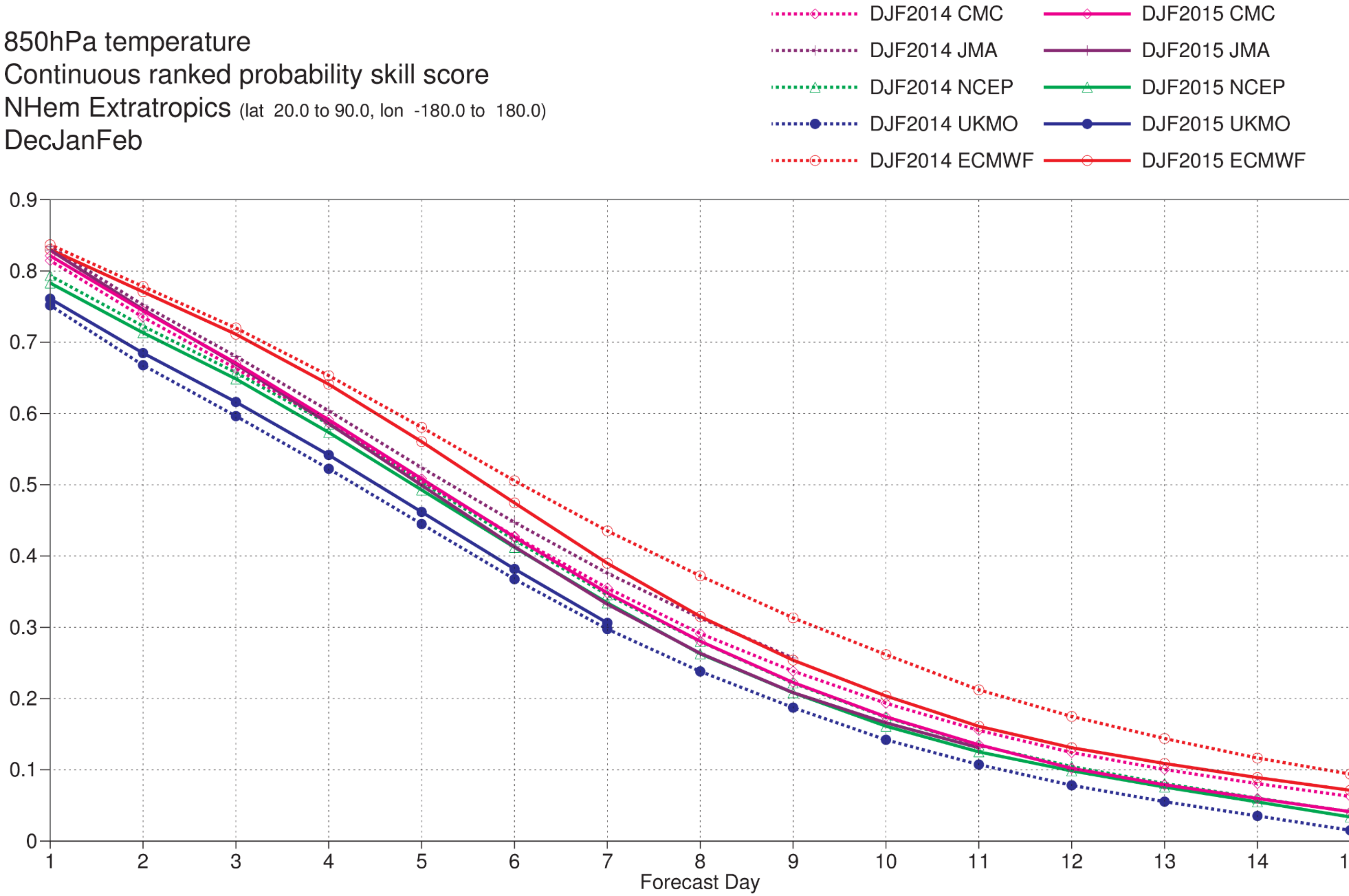
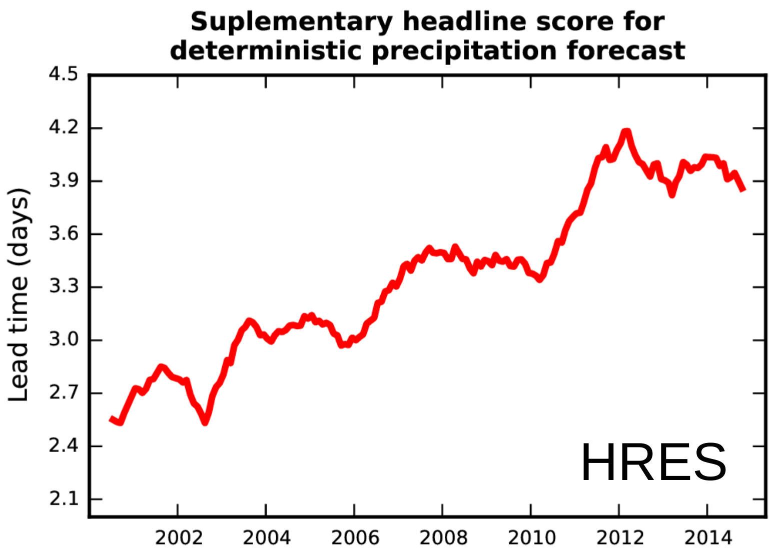
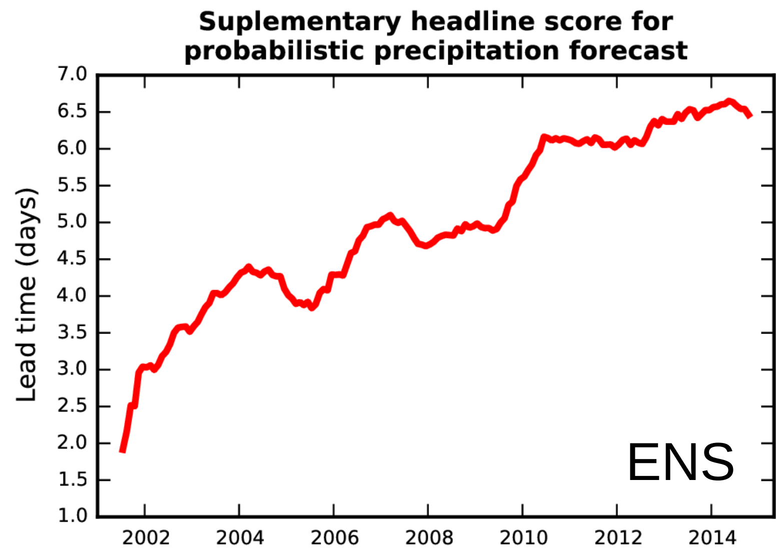
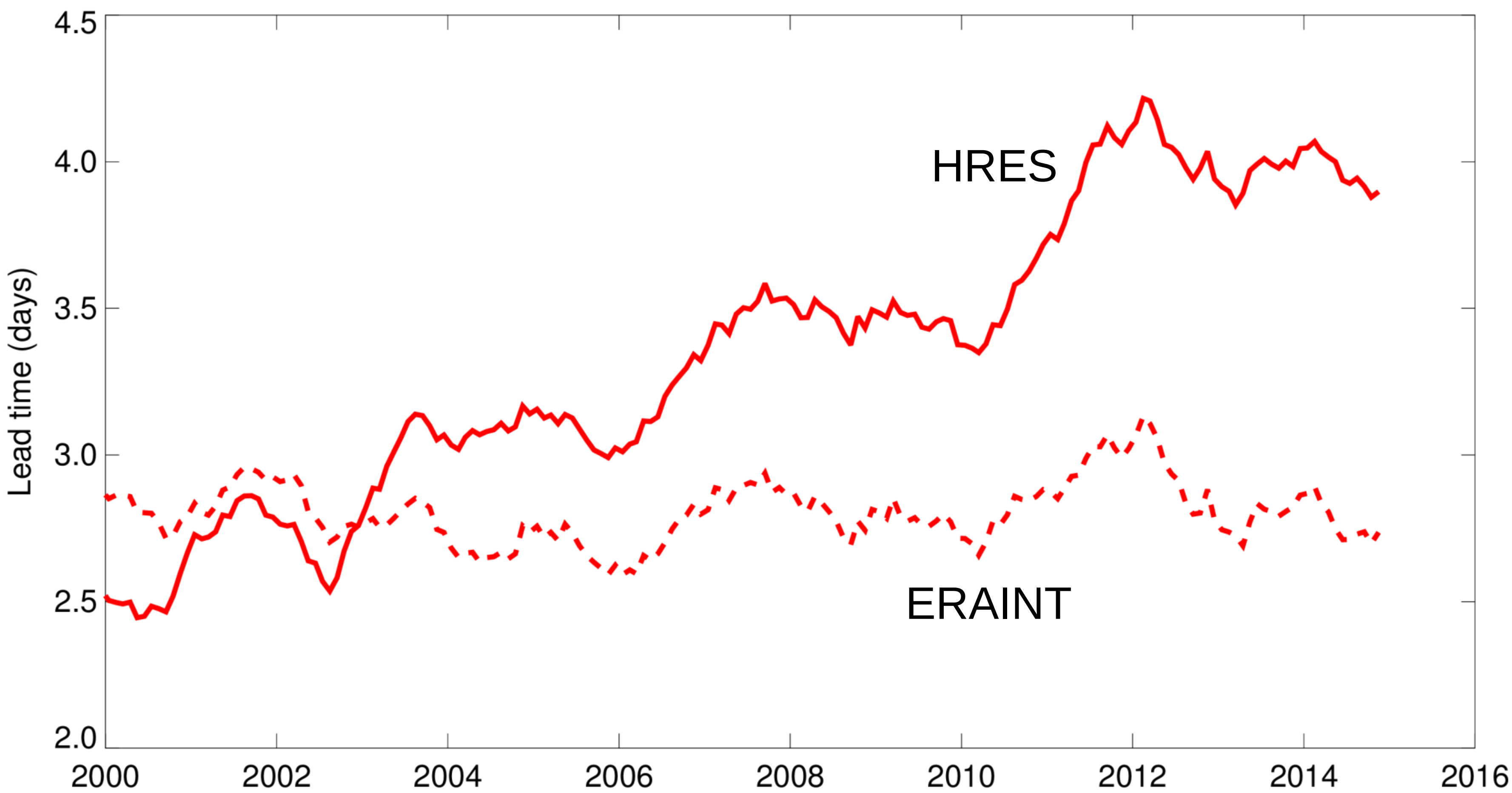


Precipitation skill





HRES precipitation skill



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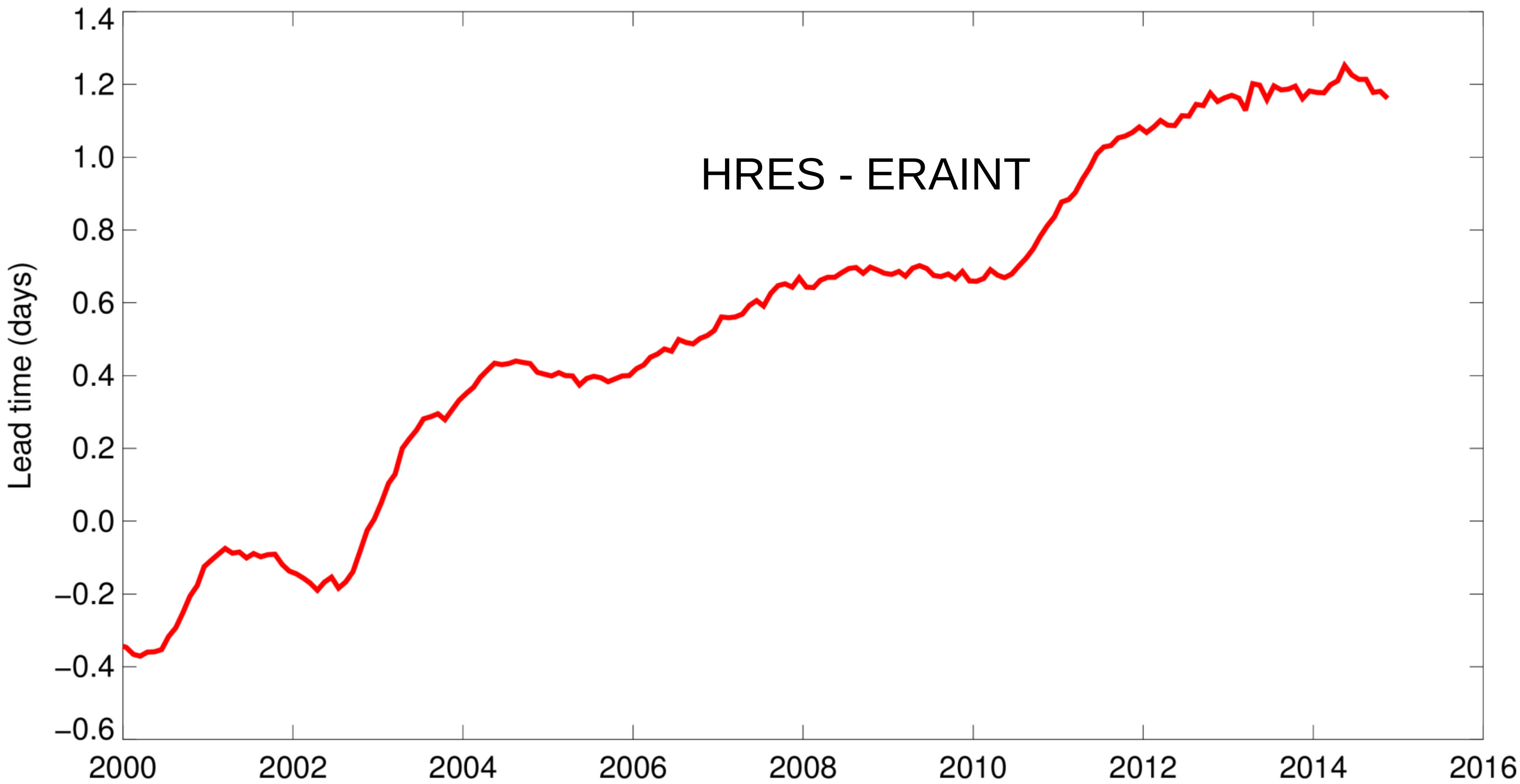
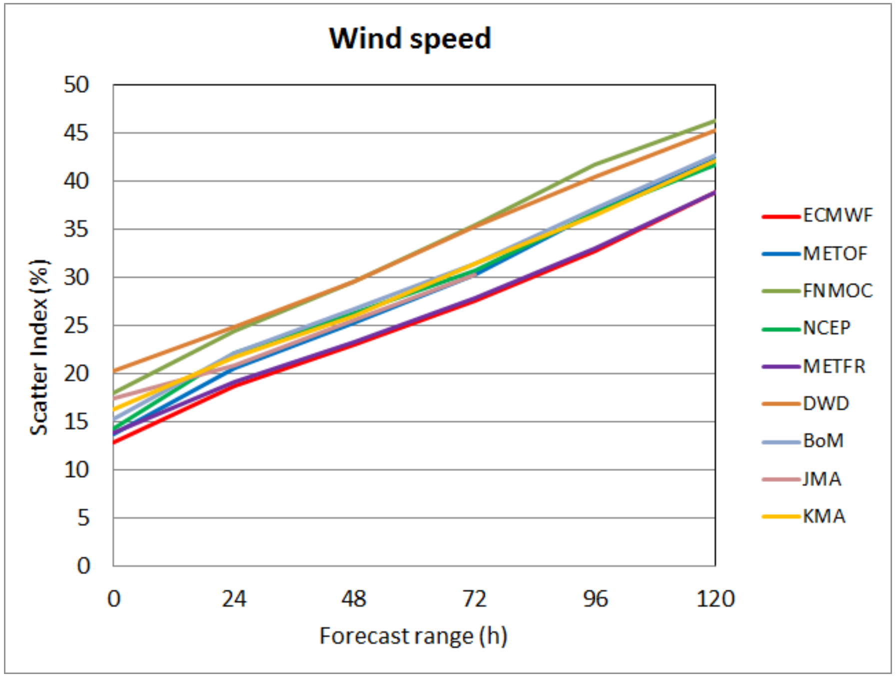
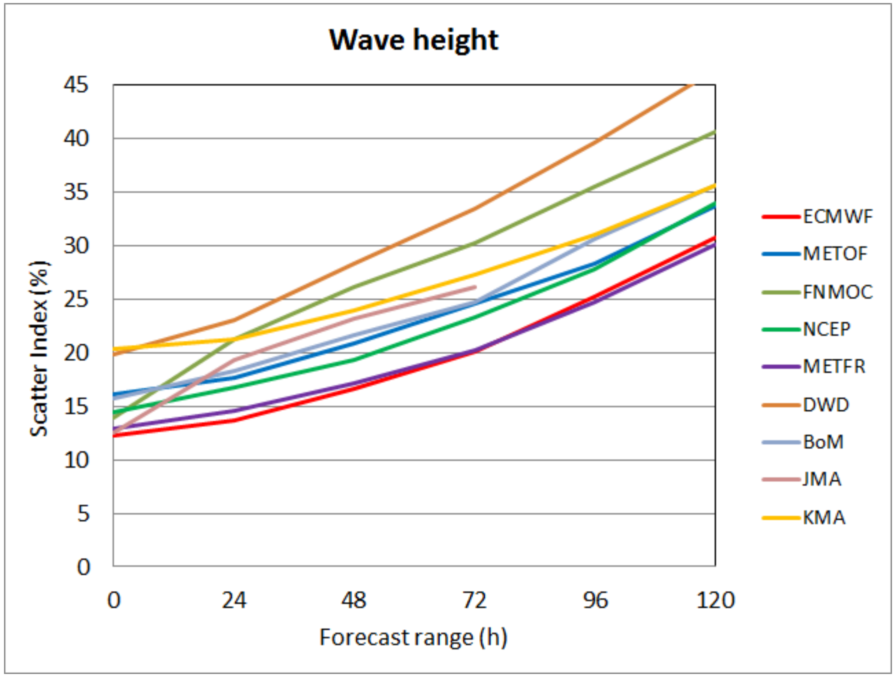


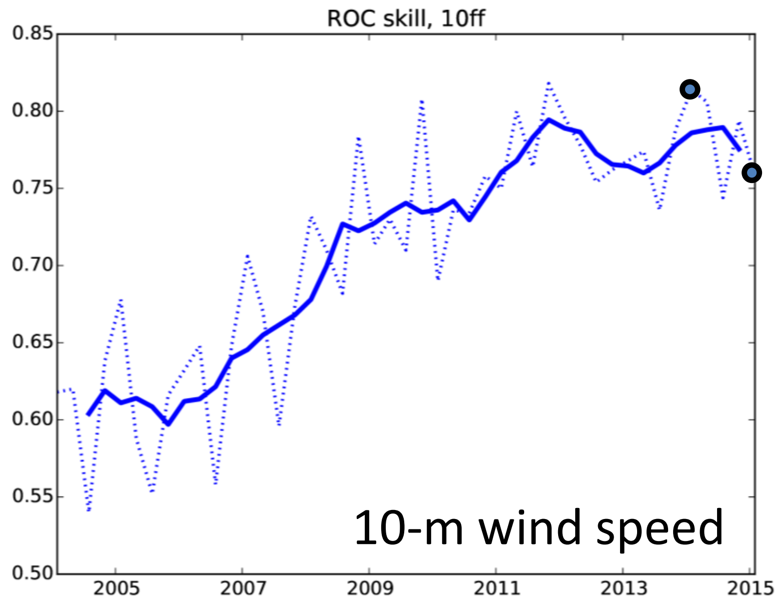
Wave height forecasts

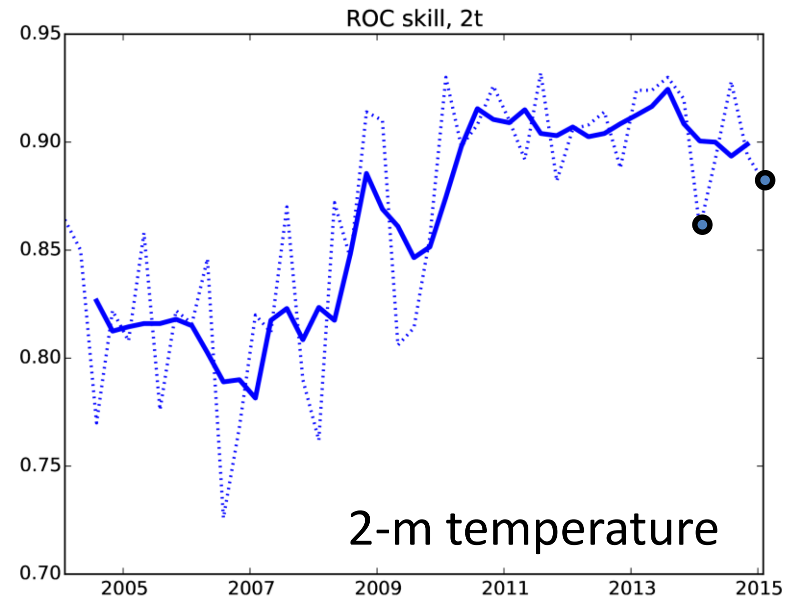
DJF 2015, verification against buoys





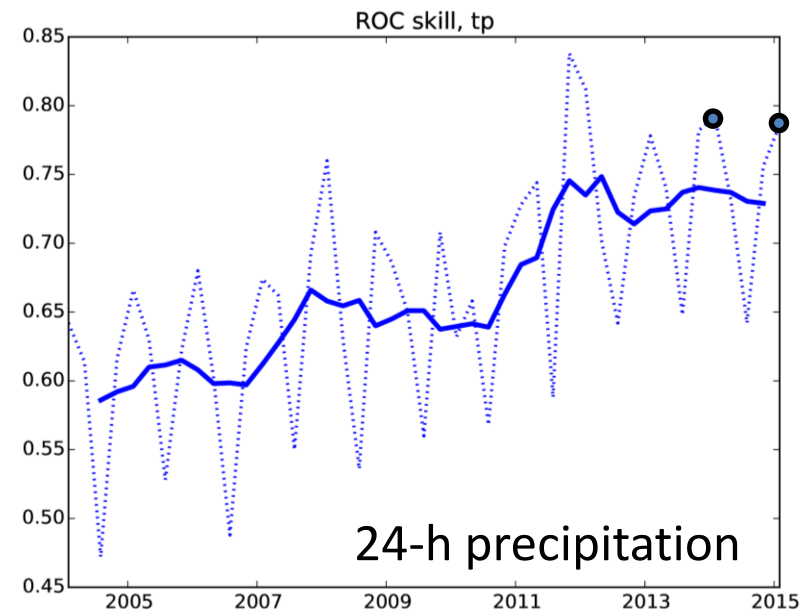
Extreme Forecast Index (EFI) – Day 4



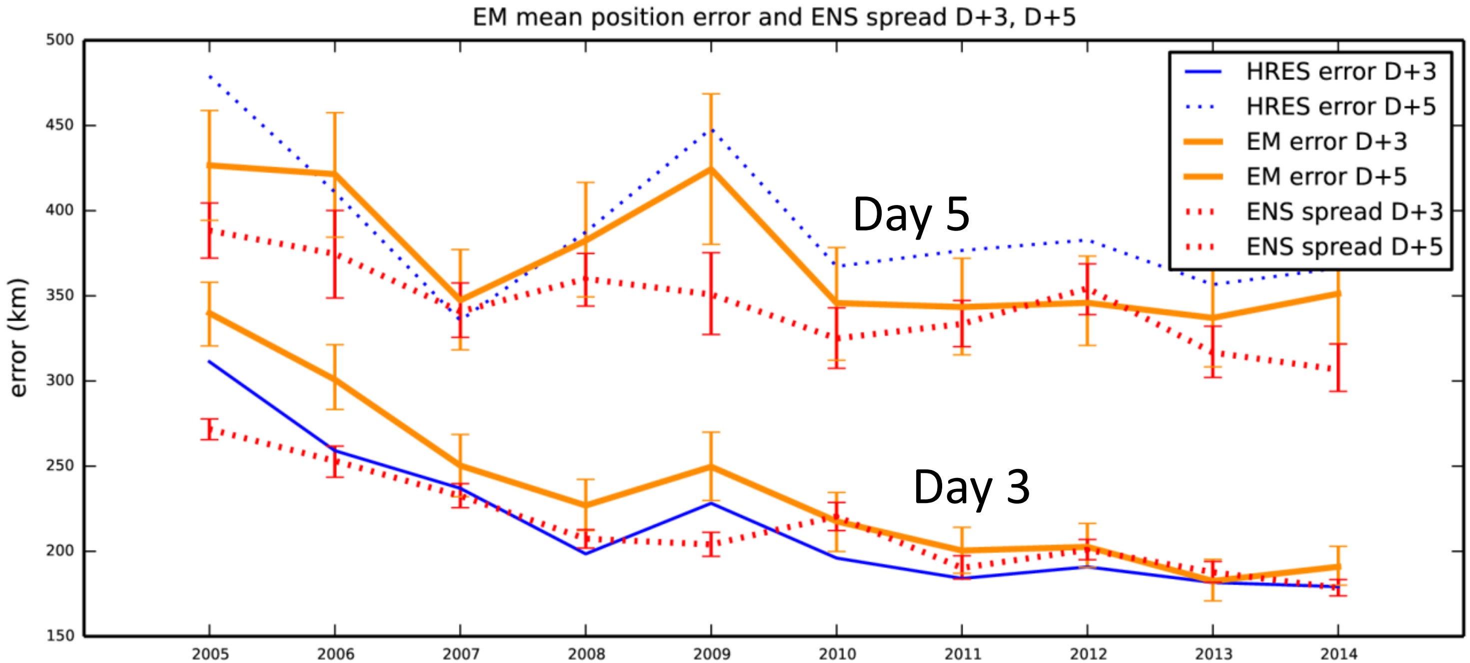


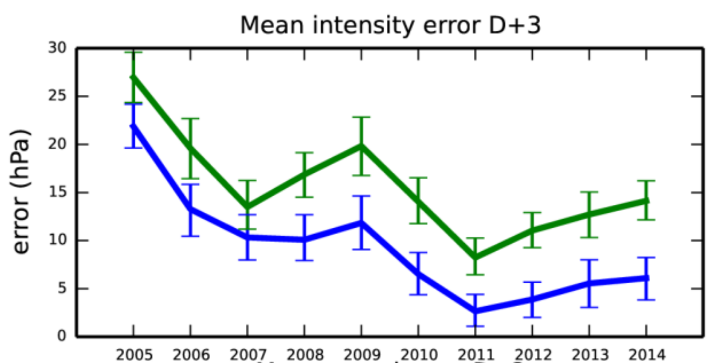
EFI skill = 2*ROC-1

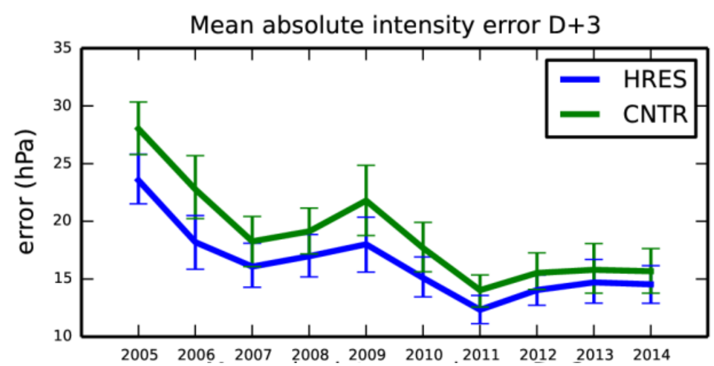
Events defined by 95th percentile



Tropical cyclone forecast







New model cycle – 12 May 2015

ECMWF | World leader in global medium-range numerical weather prediction - Mozilla Firefox

www.ecmwf.int/en/forecasts/documentation-and-support/changes-ecmwf-model/cycle-41r1

ECMWF About Forecasts Computing Research Learning Thomas Haiden Search site Go

- Charts
- Datasets
- Quality of our forecasts
- Software and tools
- Documentation and support
  - Medium range
  - Extended range
  - Long range
  - Monitoring
  - FAQs
  - Key characteristics of the forecasting system
  - Changes in ECMWF model
    - **Cycle 41r1**
    - Cycle 40r1
  - Severe Weather Forecast Demonstration Projects (SWFDPs)
- Accessing forecasts

Cycle 41r1

Description of the upgrade

IFS cycle 41r1 includes a large number of changes affecting all components of the forecasting system. Significant changes to the model physics, assimilation, observation usage and the ensemble configuration have been shown to deliver significant analysis and forecast benefit.

The domain of the high-resolution limited-area wave model will be extended to the entire globe, and will no longer be 'limited-area'.

The page will be updated as required. It was last changed on 19.05.2015.

For a record of changes made to this page please refer to Document versions .

Further information and advice regarding the upgrade can be obtained from User Support.

Timetable for implementation

Date	Event
13 Mar 2015	Initial announcement to Member States
16 Mar 2015	Availability of test data in dissemination
12 May 2015	Implementation date

News

19 May 2015

IFS Cycle 41r1 implemented a revised set of forecast output fields for the ocean waves. These were based on a new method to split the 2d ocean wave spectrum into its principal components. The new scheme splits the wave spectrum into one wind waves and up to three swell partitions. The parameters characterising the three swell partitions (significant height, mean wave direction and mean wave period of first, second and third swell partitions) are new, supplementing the total swell parameters already produced.

The previous wave products split the spectra into just two components (wind waves and total swell).

Cycle 41r1 – Meteorological changes

Forecast

- New surface climate fields (land-sea mask, sub-grid orography), also affecting number of land and sea points.
- New $CO_2/O_3/CH_4$ climatologies from latest MACC-II reanalysis produced at ECMWF.
- Revised semi-Lagrangian extrapolation reducing stratospheric noise.
- Cloud scheme change of rain evaporation, auto-conversion/accretion, riming, precipitation fraction.
- Improved representation of supercooled "freezing" rain.
- Modified convective detrainment.
- Activation of the lake model (FLAKE).
- Active use of wave modified stress in coupled mode.
- Revised sea-ice minimum threshold, sea-ice roughness length and consistency between SST and sea ice concentration.

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Cycle 41r1 – Meteorological changes

Data assimilation

- Upgrade of inner loop resolutions of 4D-Var to TL255 for each of the three iterations of the outer loops.
- Reduction of number of iterations in 1st inner loop and use of full linear physics package.
- Changed calculation of background error covariances from using EDA samples of perturbations from last cycle (1/3) and climatology (2/3).
- Active use of:
  - SSMIS moisture sounding channels over land and sea-ice;
  - surface-sensitive ATMS channels over land;
  - ASCAT in soil moisture analysis;
  - Altika and Cryosat altimeter wave height data.
- Upgrade of radiance observation operator with RTTOV-11.
- Assimilation of GPS-RO with two-dimensional observation operator.
- Assimilation of high-resolution radiosondes.

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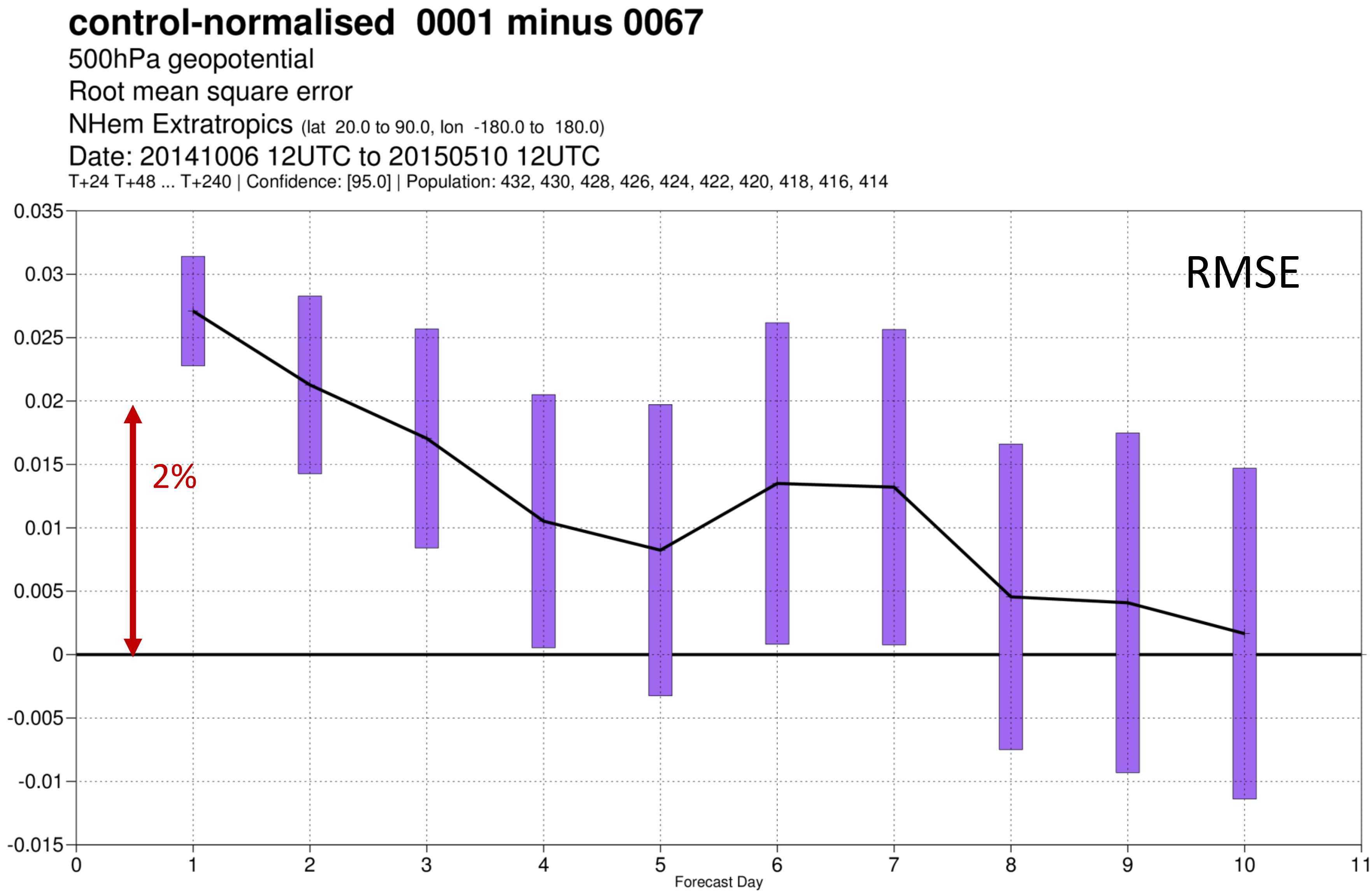
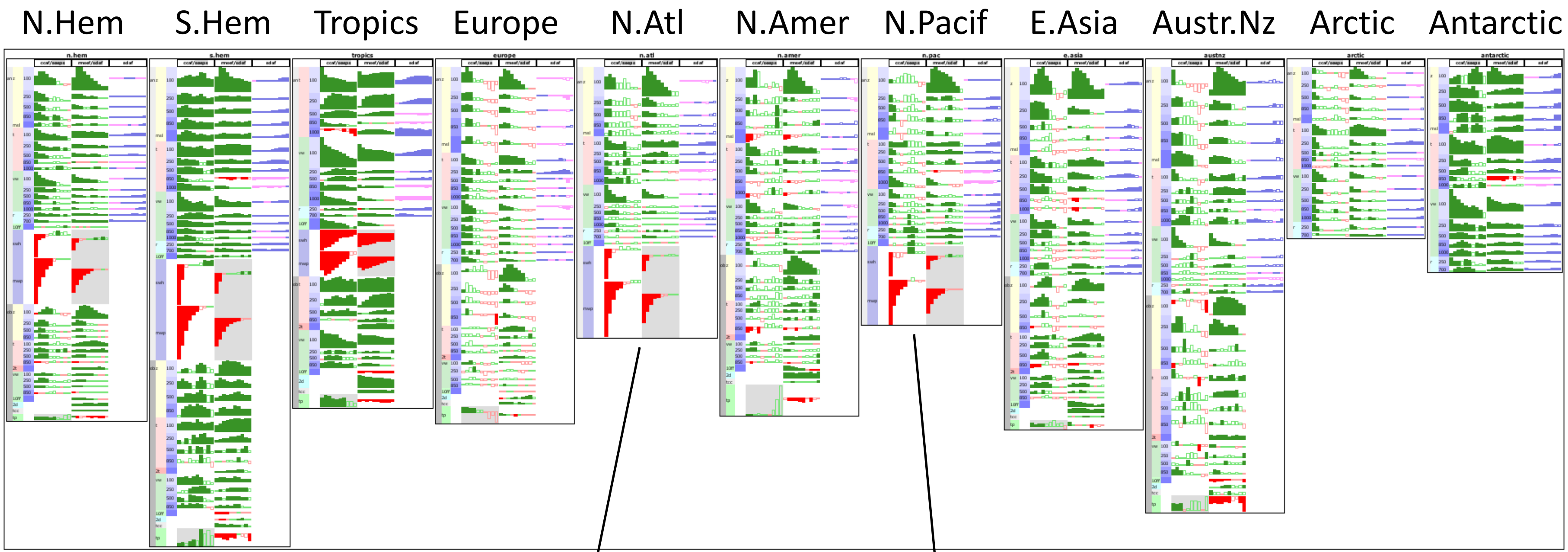
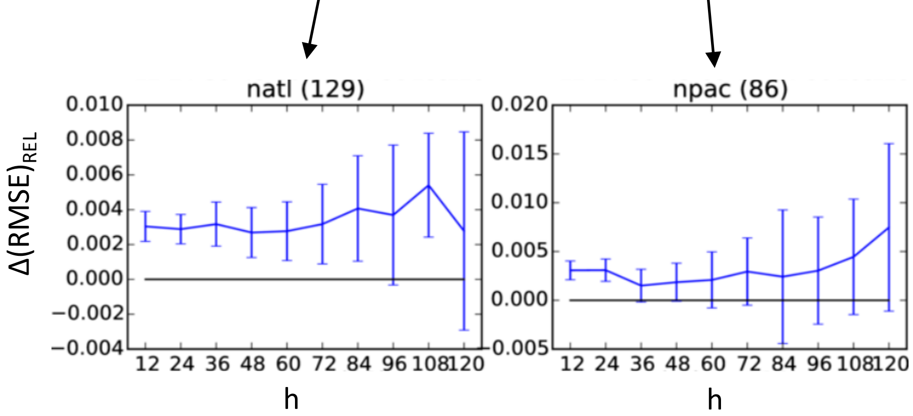
41r1 - HRES



control-normalised 0001 minus 0067
500hPa geopotential
Root mean square error
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
Date: 20141006 12UTC to 20150510 12UTC
T+24 T+48 ... T+240 | Confidence: [95.0] | Population: 432, 430, 428, 426, 424, 422, 420, 418, 416, 414
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
0 1 2 3 4 5 6 7 8 9 10 11
Forecast Day
RMSE
2%

41r1 - Scorecard



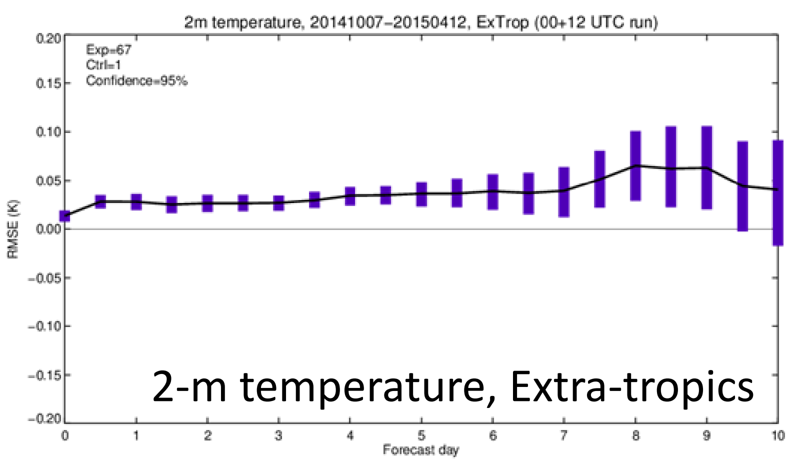


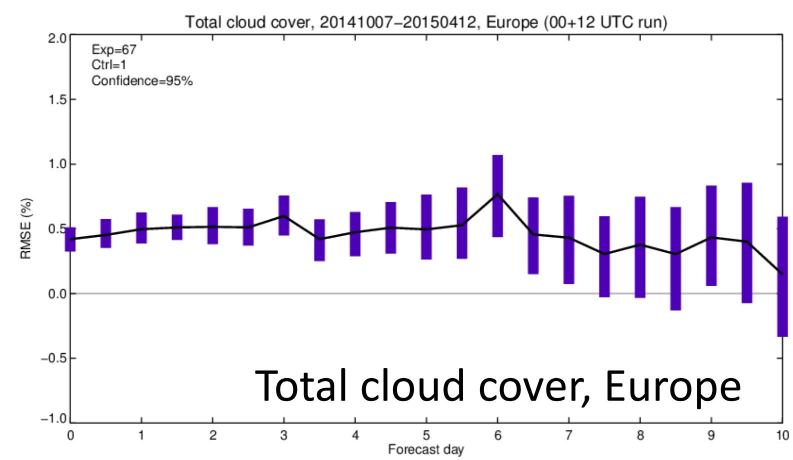
Significant wave height verified against satellite obs

EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

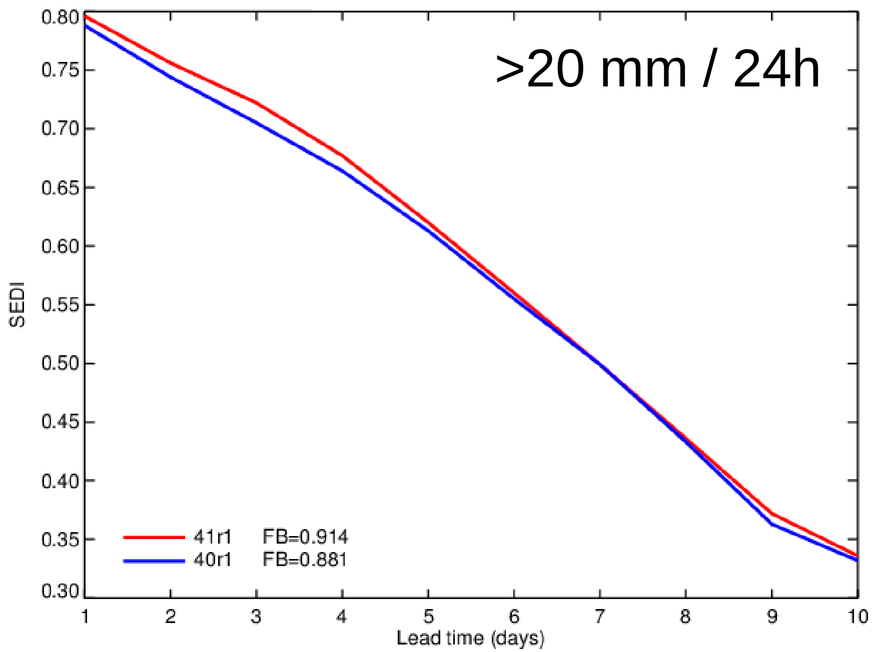
41r1 – Surface parameters

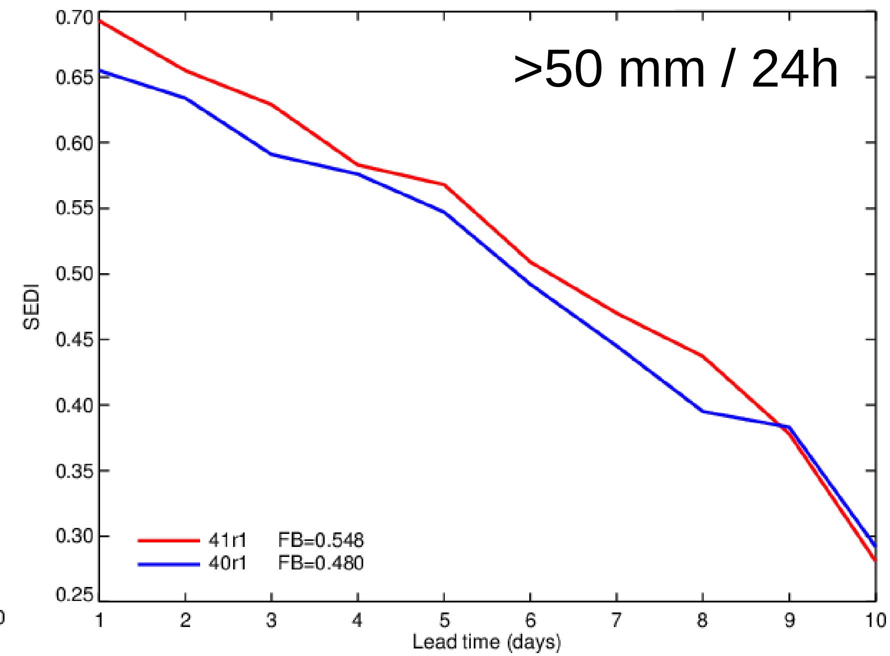
	2-m temperature	2-m dewpoint	10-m wind speed	Total cloud cover	24-h precipitation
Extratropics					
Europe					
Tropics					





41r1 – Heavy precipitation





Oct 2014 – Apr 2015, Europe

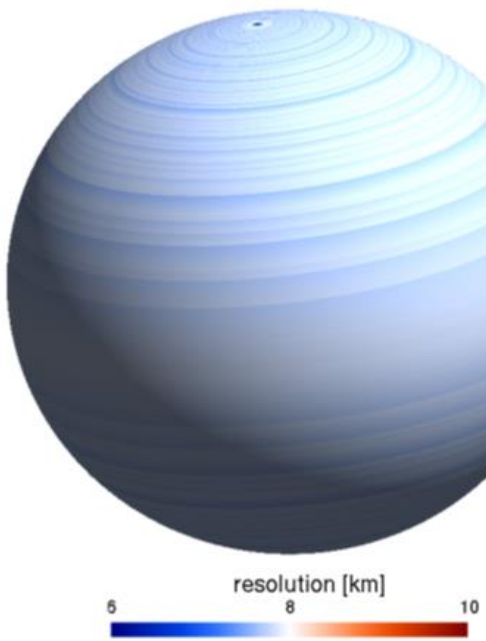
The future – 42r1 (early 2016)

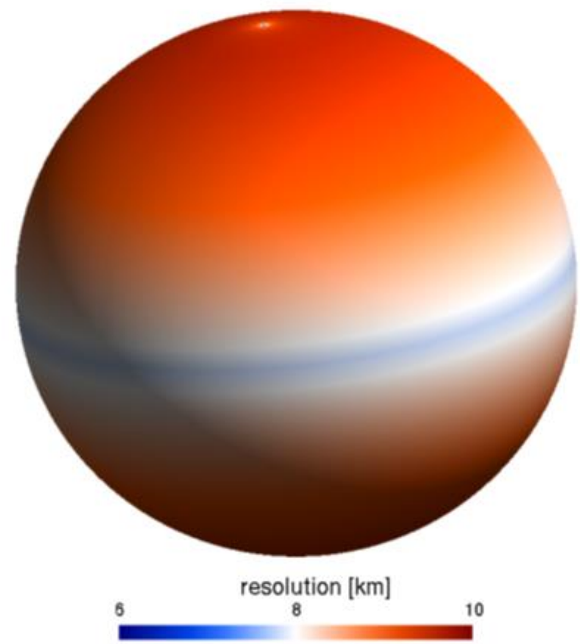
Increased resolution

Atmosphere: 16 km → 9 km (32 km → 18 km)

Ocean: 1→¼ deg

Grid T1279 → TCo1279 (‘cubic octahedral’)





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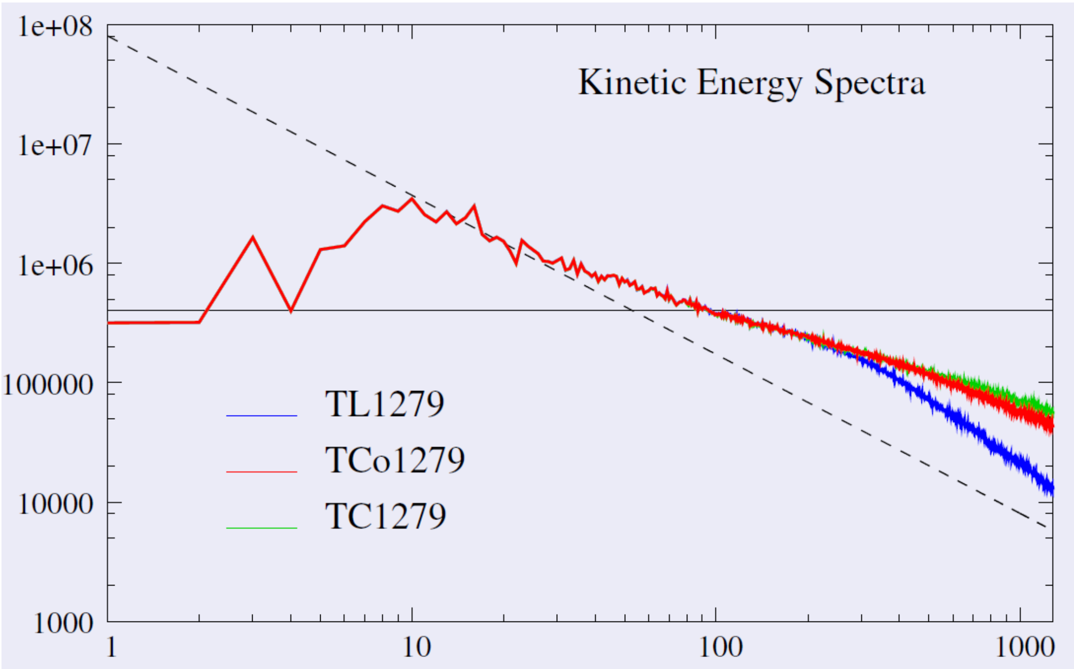


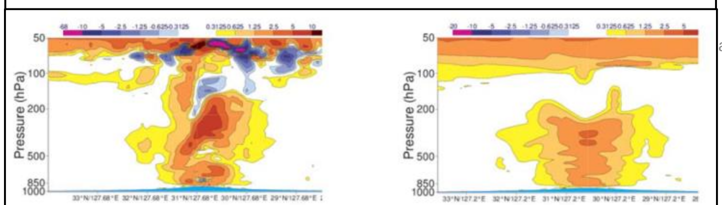
41r2 – List of changes

Data Assimilation

EDA configuration:
Resolution TL639 forecast/outer loop, TL191/TL191inner loops.
Timesteps 900s outer loop, 1800s inner loops.
Simplified linear physics used in first inner loop.
New climatological B's evenly sampled from ~41R1 TL399 EDA's every 5.5 days Jan-Oct 2014.
Compute hybrid B by adding samples from latest EDA forecast (weight 0.3) to static
climatological B (weight 0.7).
Cycling flow-dependent errors and B =>
=> Saving on iterations in first minimization (70 down to ca. 3
Background error covariance calculation 5 times faster due to h
and code optimizations.
4DVAR configuration:
Inner loop resolutions TL255/TL319/TL399.
Timesteps inner loops 1200s/1080s/900s.
Conventional data:
Implementation of Sonntag saturation vapour equation in observation operators.

Inner loop resolutions TL255/TL319/TL399

Increase from 3 to 5 iterations for SL departure points



al if Aeolus off.

Passive code updates to allow all-sky ATMS
RTTOV coefficient files for microwave instruments: move to 54 levels
and improved 22 GHz spectroscopy
AMSU-A sensor & situation dependent observation errors (v I)
AMSU-A sensor & situation dependent observation errors (v II)
CRIS activation - g98u g98v
Improved IASI aerosol screening -
GPSRO observation error increased 25%
Preparations for passive AMV monitoring
AMV blacklist relaxation
Extend acceptable GEO zenith angle from 60 to 64 degrees (greater high latitude coverage)
Allow Meteosat mid-height IR winds
Hourly time-window shift for GOES
Additional bit-reproducible changes
RTTOV v11.2 technical upgrades (but not v11.2 changes that induce numerical differences)
Meteo France / L-F Meunier technical upgrades including performance fix to RTTOV coef reading
Minor change to MWRI thinning parameters (not active unless MWRI is monitored)
Preparations for all-sky infrared
AMSU-A new obs errors tidied up and read from file

Ensemble Prediction

Prepare SKEB for horizontal resolution upgrade and spectral viscosity (passive)
Enable computation of singular vectors on cubic grid (technical/passive)
New ozone scheme (Monge-Sanz et al., 2011, ACP) (passive)
Changes for relaxation and multi-year runs (technical)
Revised options for vertical diffusion in stratosphere (passive except for type longrange)

Optimisations for the input/output.
Technical changes to move wave data assimilation in a different trajectory
Ocean model:
IFS-NEMO coupled model changes + NEMOVAR assimilation changes

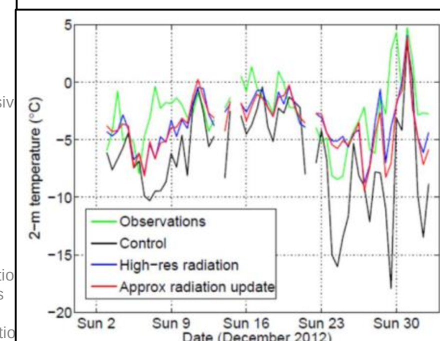
Numerical Aspects

Increase 3 to 5 iterations for SL departure points
Redefine convective adjustment timescale by grid area
Algorithmic and structural improvements in the mass fixing package.

Physical Aspects

Radiation-surface LW/SW updating
Radiation-surface LW tiling
Surface snow fixes
New freezing rain physics and additional diagnostic for accumulation
VDF/convection cleaning and detrainment of snow
Resolution dependent non-orog GWD
Increased erosion rate for convective points
TL/AD non-orog GWD
TL/AD snow fix
Updates for Single Column Model
TL/AD surface & VDF
New snowfall sublimation and ice deposition physics options (passiv
New MACC aerosol climatology (passive as switched off)
Lake fractional ice + update lake "soil" T
Increased roughness over snow/veg
Option for CRM superparametrization
Changes to allow Single precision

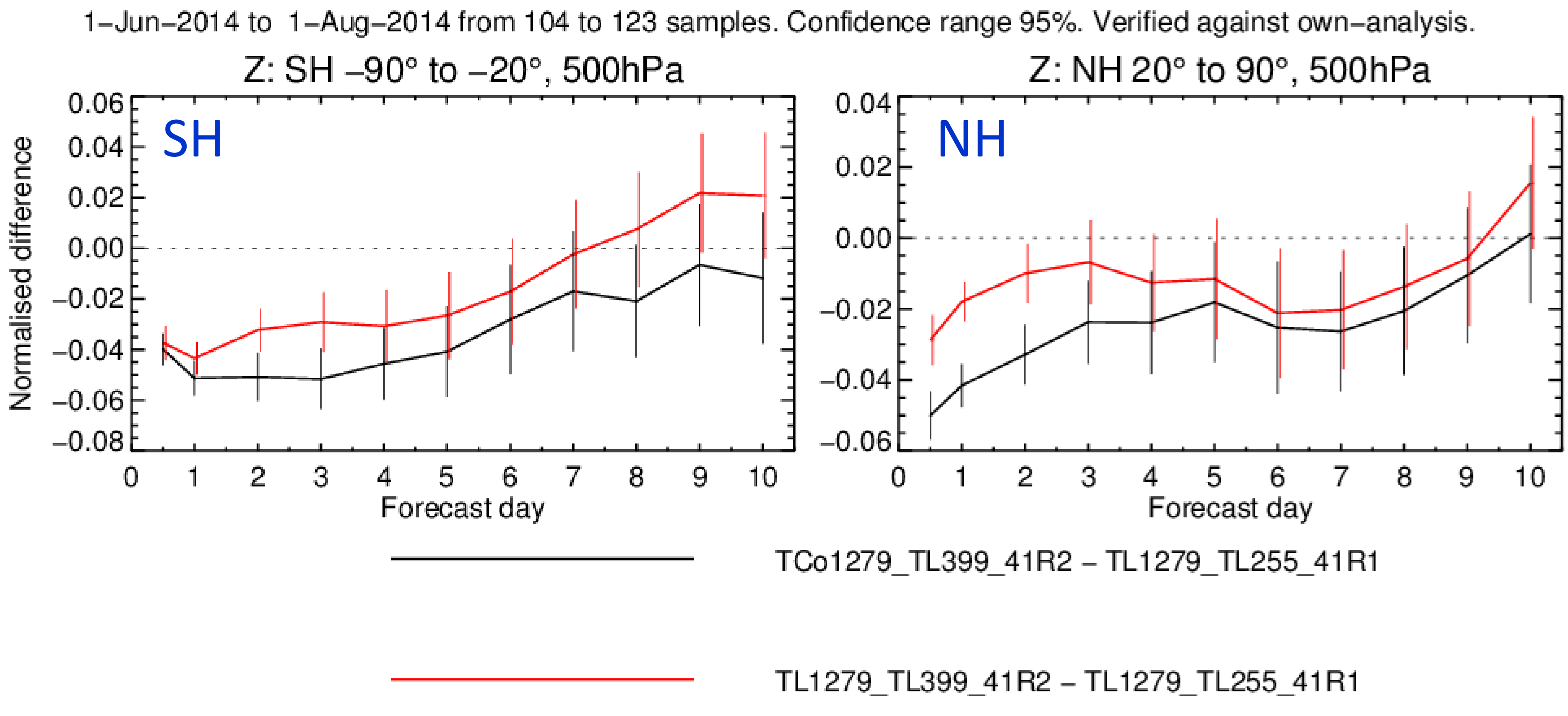
Radiation-surface LW/SW updating



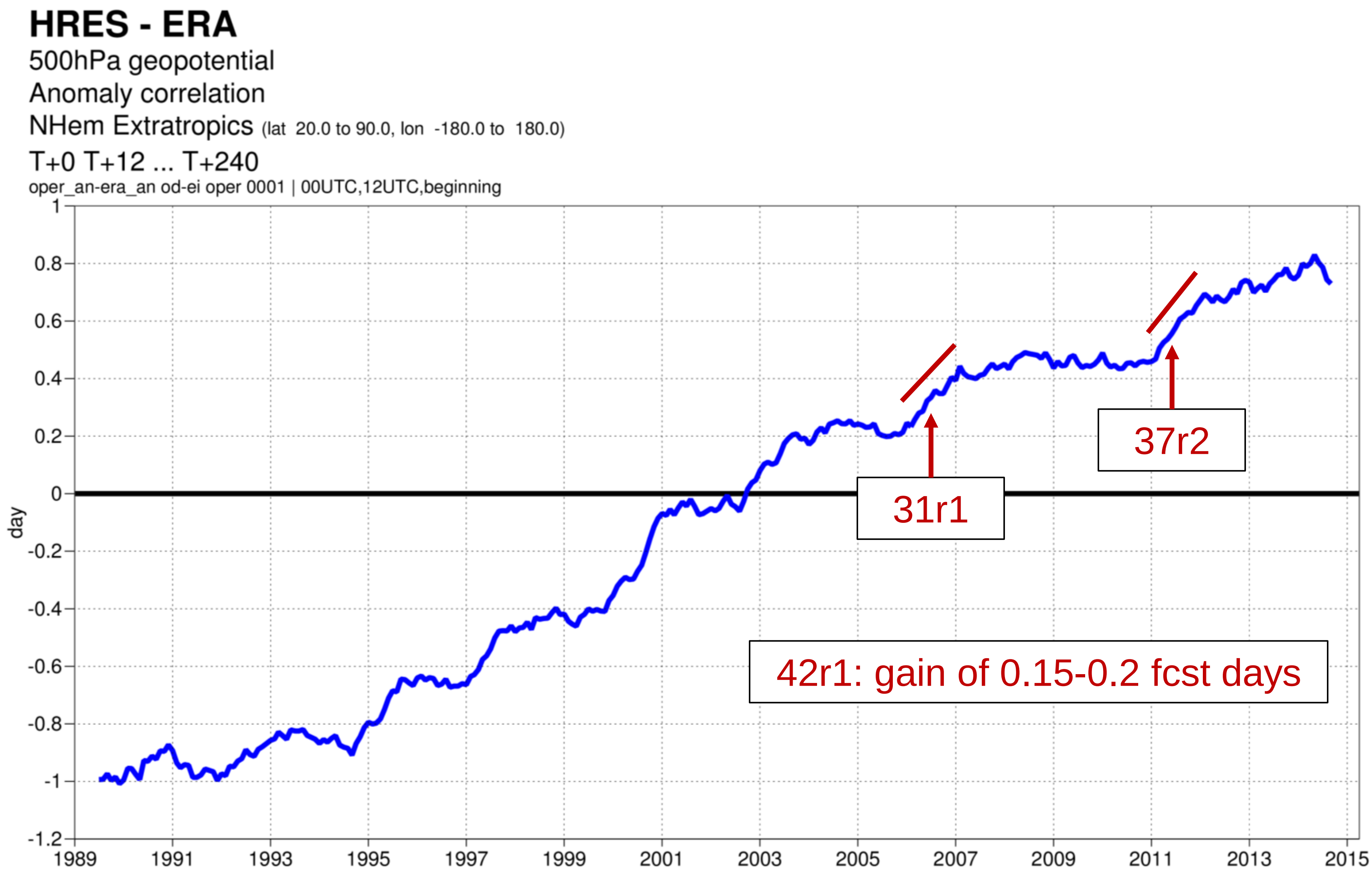
Chemical Aspects:

Removal of all code related to coupled chemistry set-up; Compositio
Implementation of new UV processor providing better UV forecasts
Various model improvements for C-IFS
Assimilation of new satellite data (GOME-2 SO2 (for volcanic eruptio
AOD (being monitored), MODIS Deep Blue AOD, AATSR AOD)
Improvements to aerosol model (mass fixer introduced, better use of fire
emissions, SO2 emissions same as for chemical model)

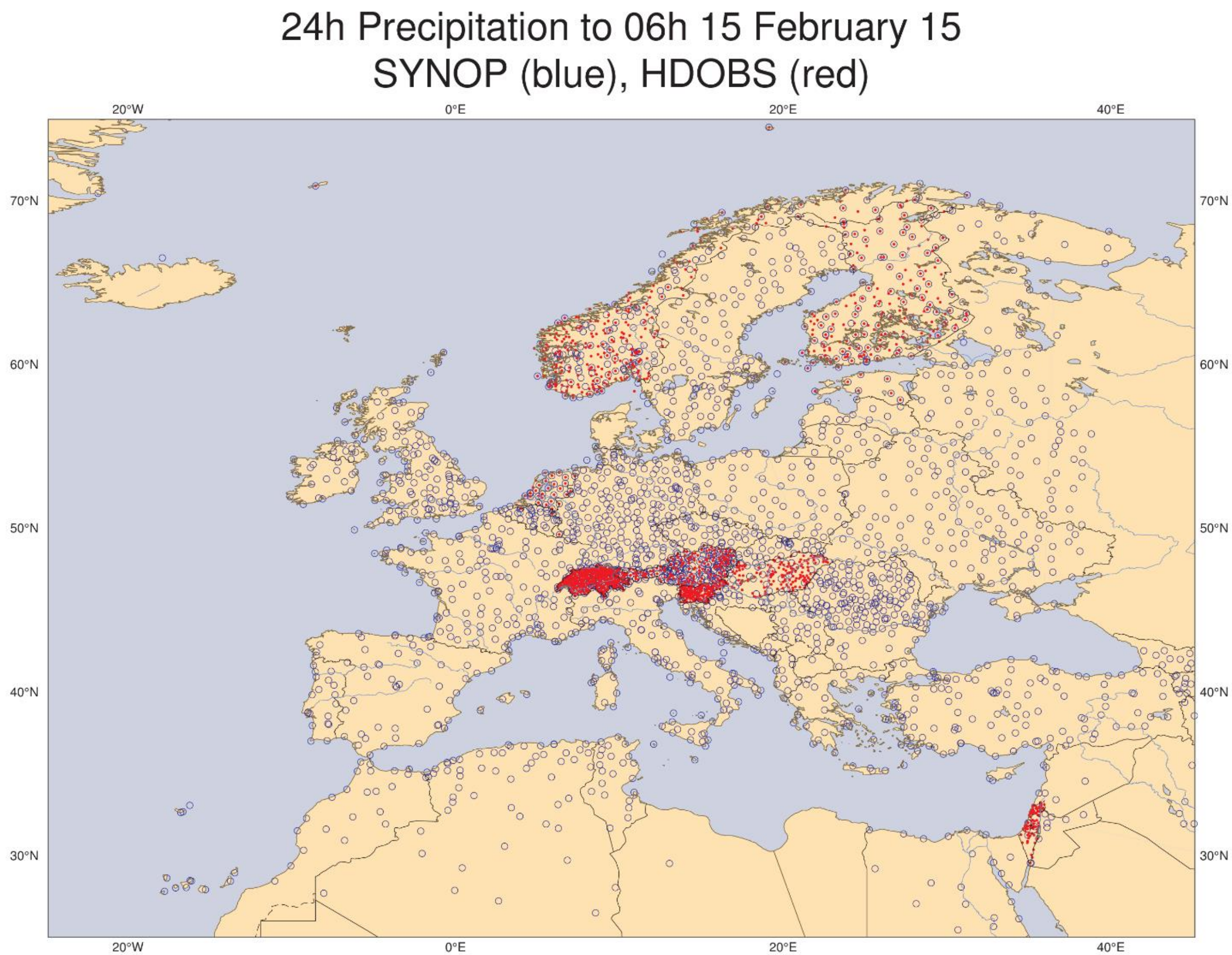
41r2 – evaluation results



HRES skill: Z500 NH



High-density observations for verification



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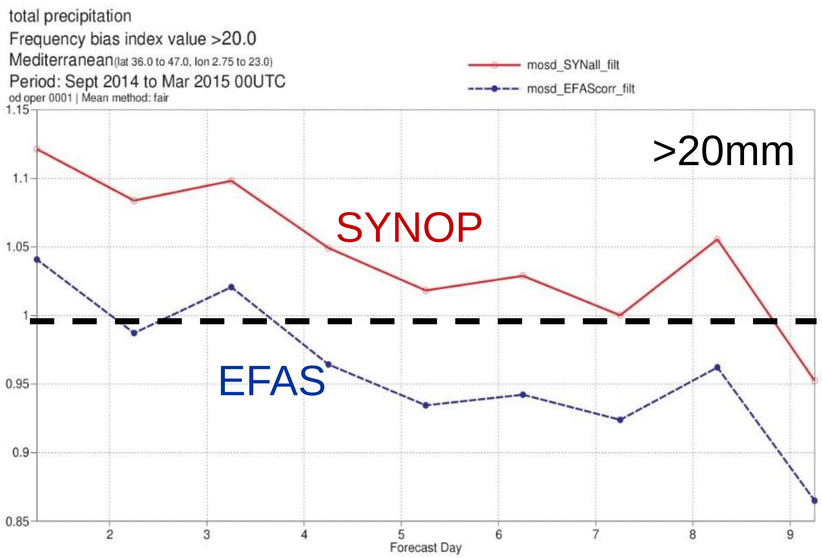
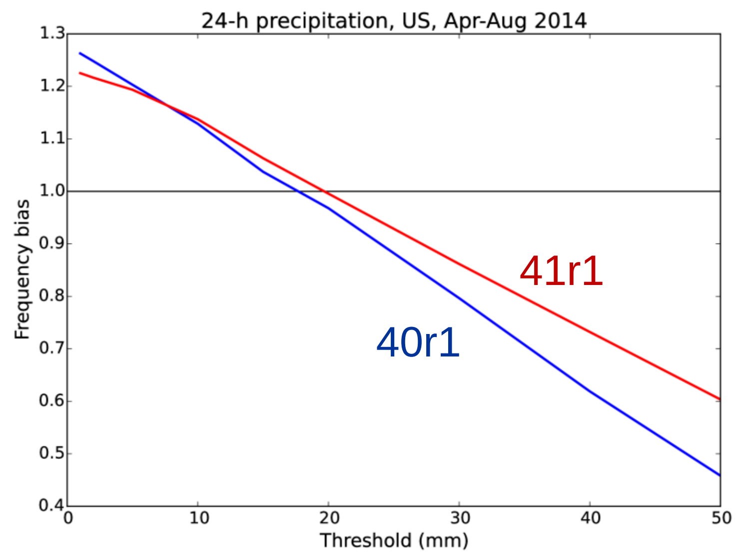


Verification against different datasets



Verification against up-scaled observations (NEXRAD)

Forecast users web space

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

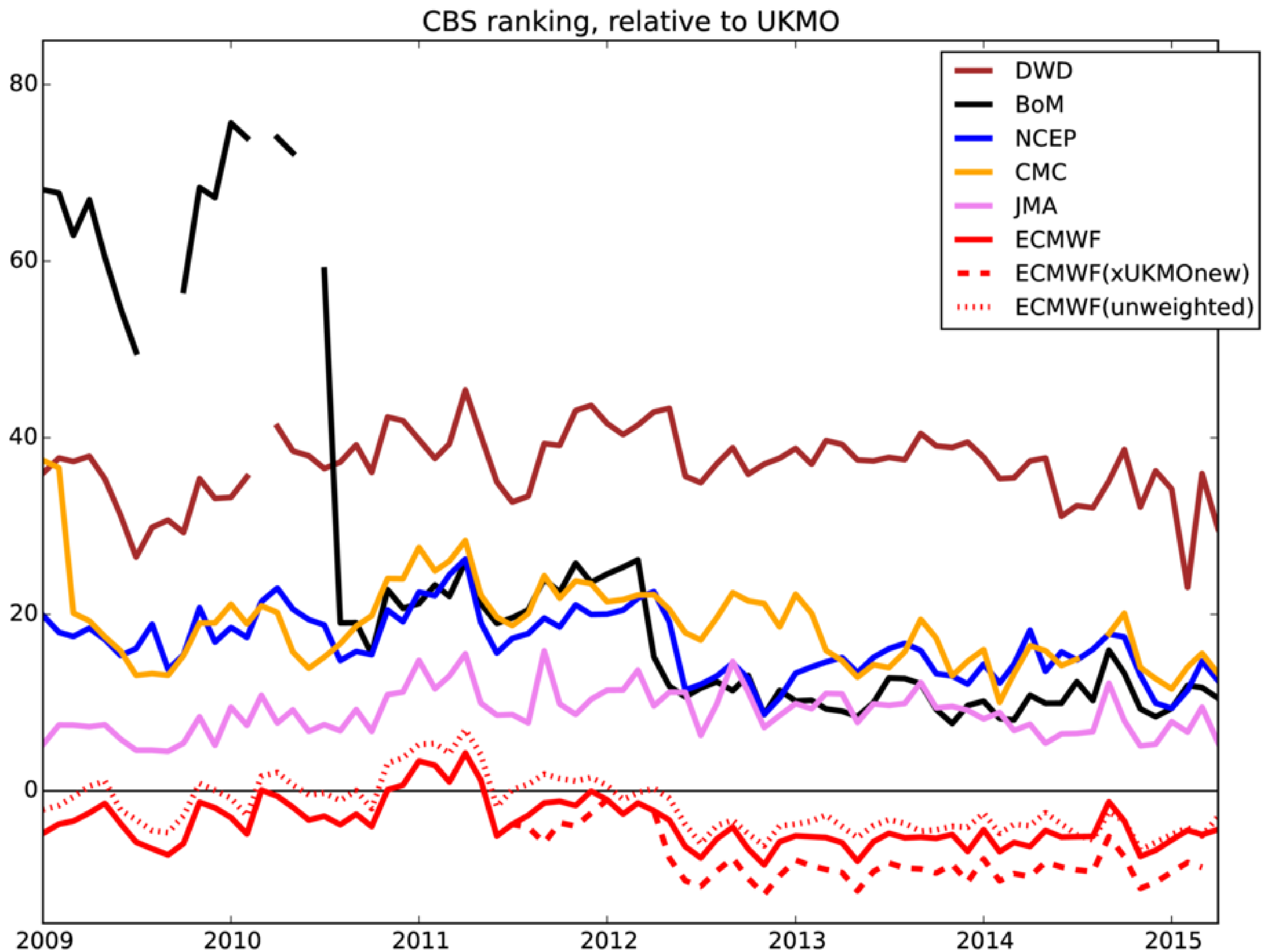
- Severe Event Catalogue
- Known IFS forecasting issues
- Planned changes to the forecasting system
- Forecast evaluation (main ECMWF web site)

Feedback on cases or issues: forecast_user@ecmwf.int

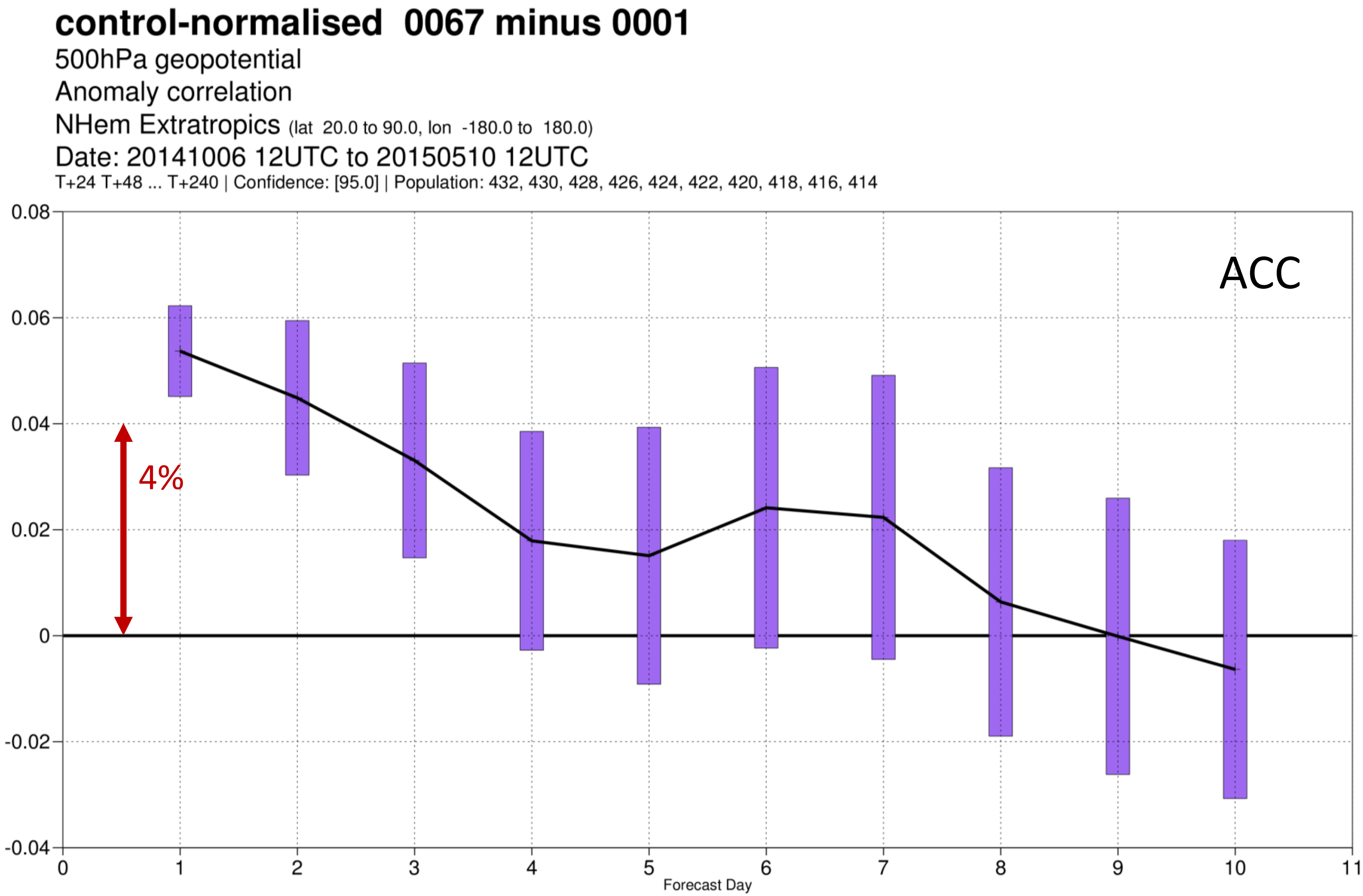
Summary

- IFS further improved, both HRES and ENS
- Maintaining overall lead among global models
- Increasing focus on high-impact weather in the medium-range
- New cycle in 2016 (16 km → 9 km and many other changes) a major step in forecast skill

Met Office Index (WMO exchange of scores)

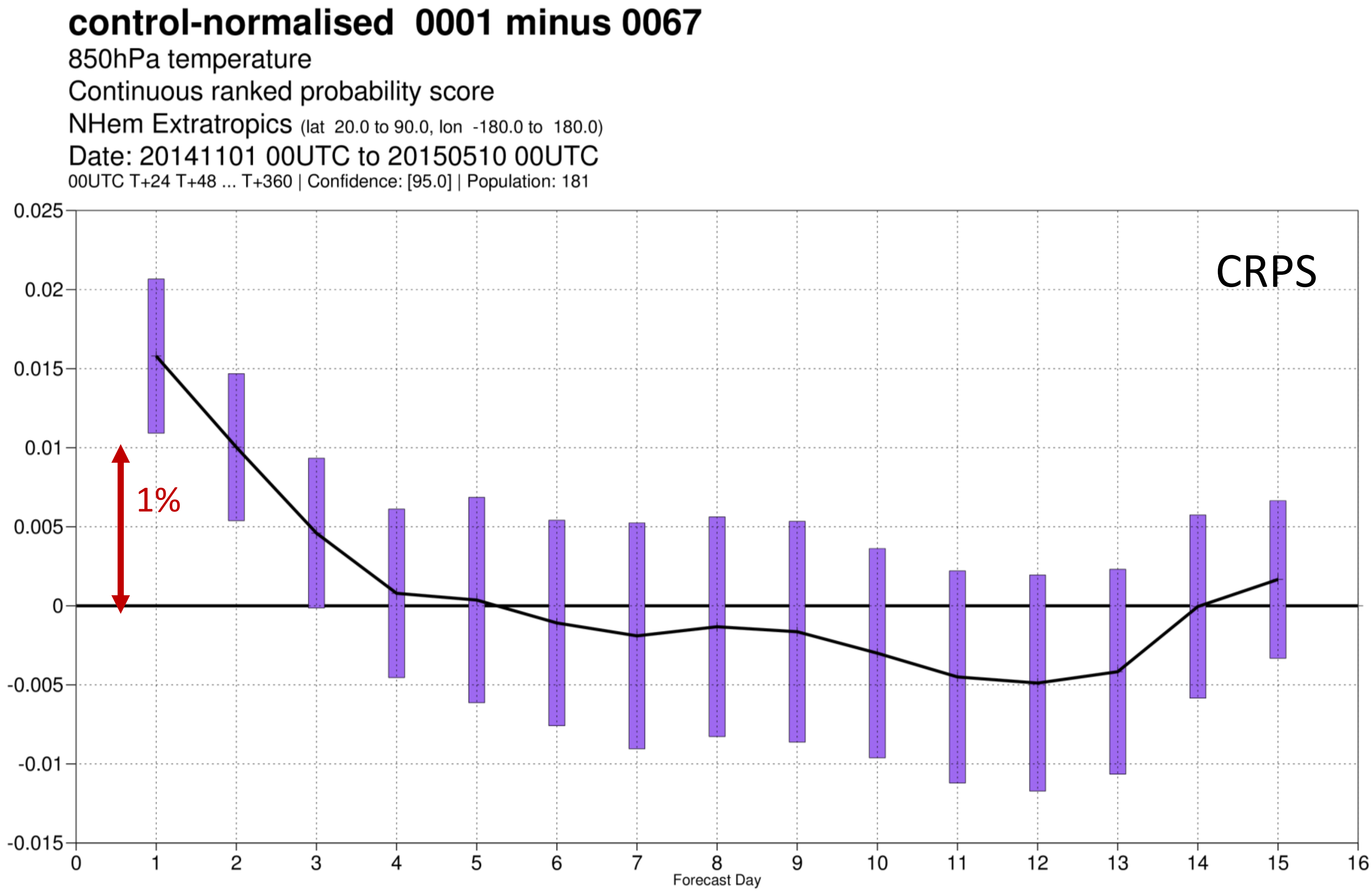


41r1 - HRES



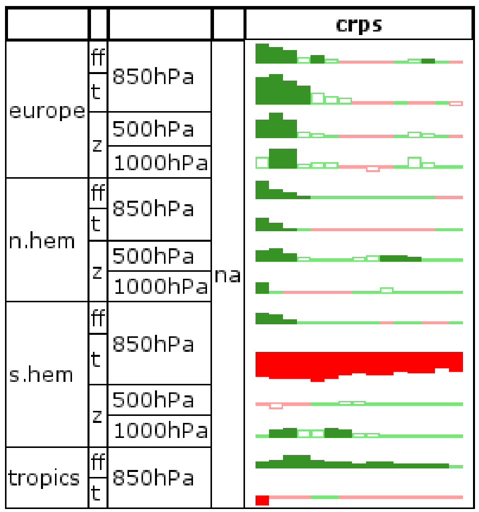
control-normalised 0067 minus 0001
500hPa geopotential
Anomaly correlation
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
Date: 20141006 12UTC to 20150510 12UTC
T+24 T+48 ... T+240 | Confidence: [95.0] | Population: 432, 430, 428, 426, 424, 422, 420, 418, 416, 414
ACC
4%
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0
1
2
3
4
5
6
7
8
9
10
11
Forecast Day

41r1 - ENS

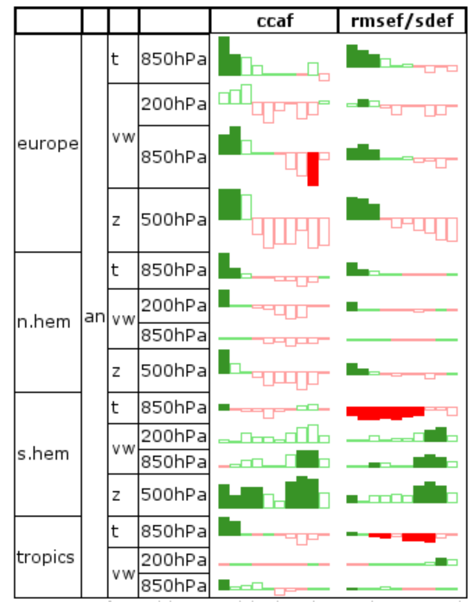

control-normalised 0001 minus 0067
850hPa temperature
Continuous ranked probability score
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
Date: 20141101 00UTC to 20150510 00UTC
00UTC T+24 T+48 ... T+360 | Confidence: [95.0] | Population: 181
CRPS
1%
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Forecast Day

41r1

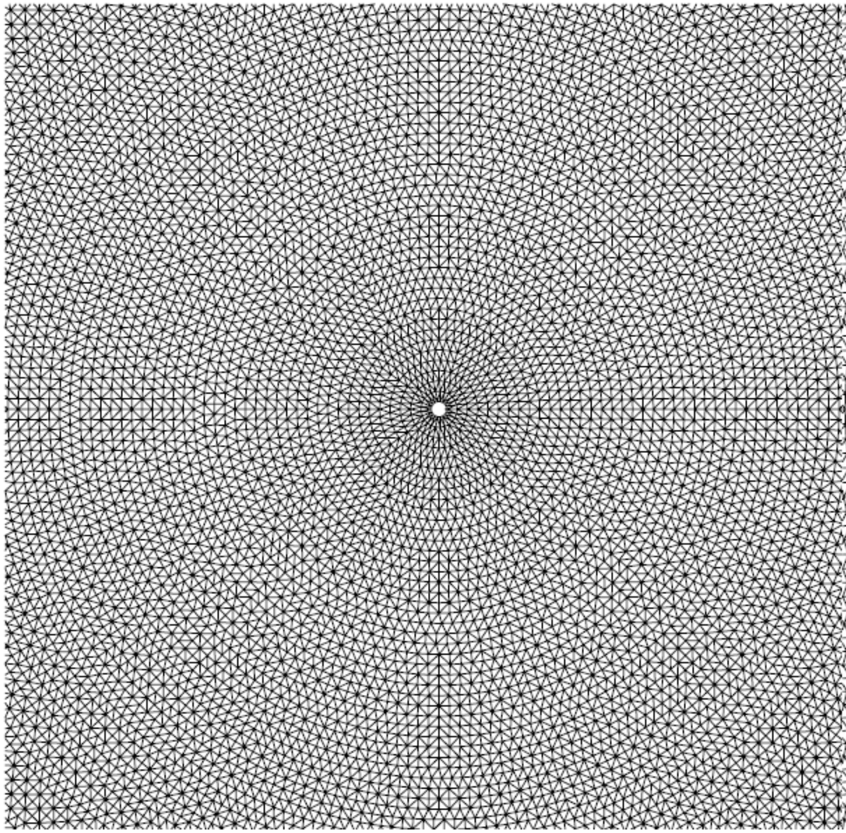
ENS scorecard



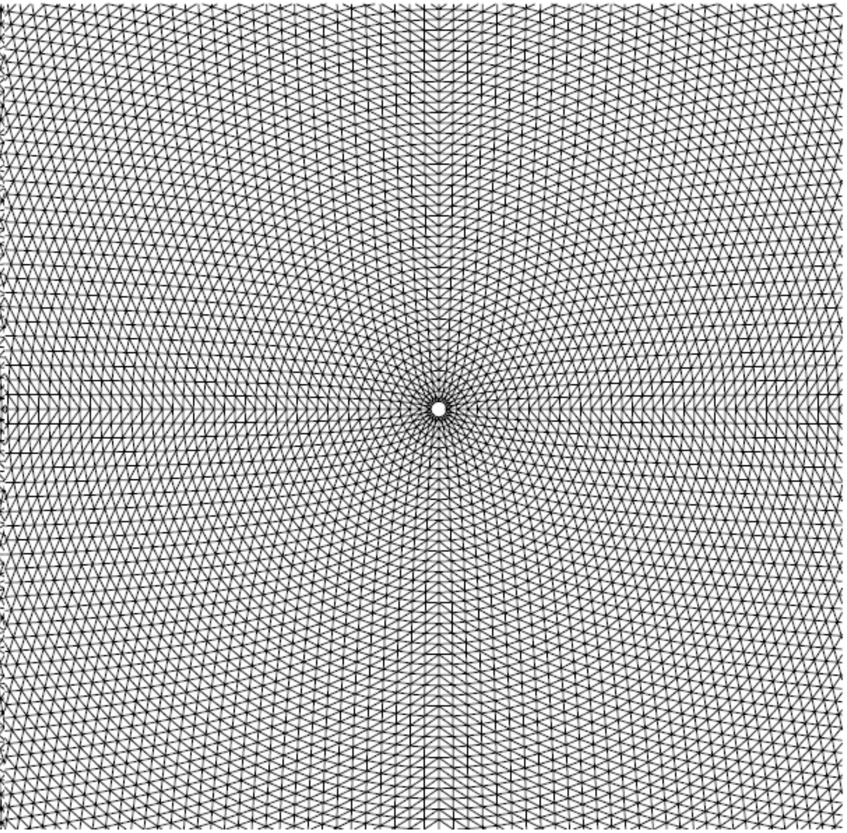
CF scorecard



Smoother distribution of gridpoints



Standard reduced Gaussian grid



Octahedral reduced Gaussian grid

41r2 – evaluation results