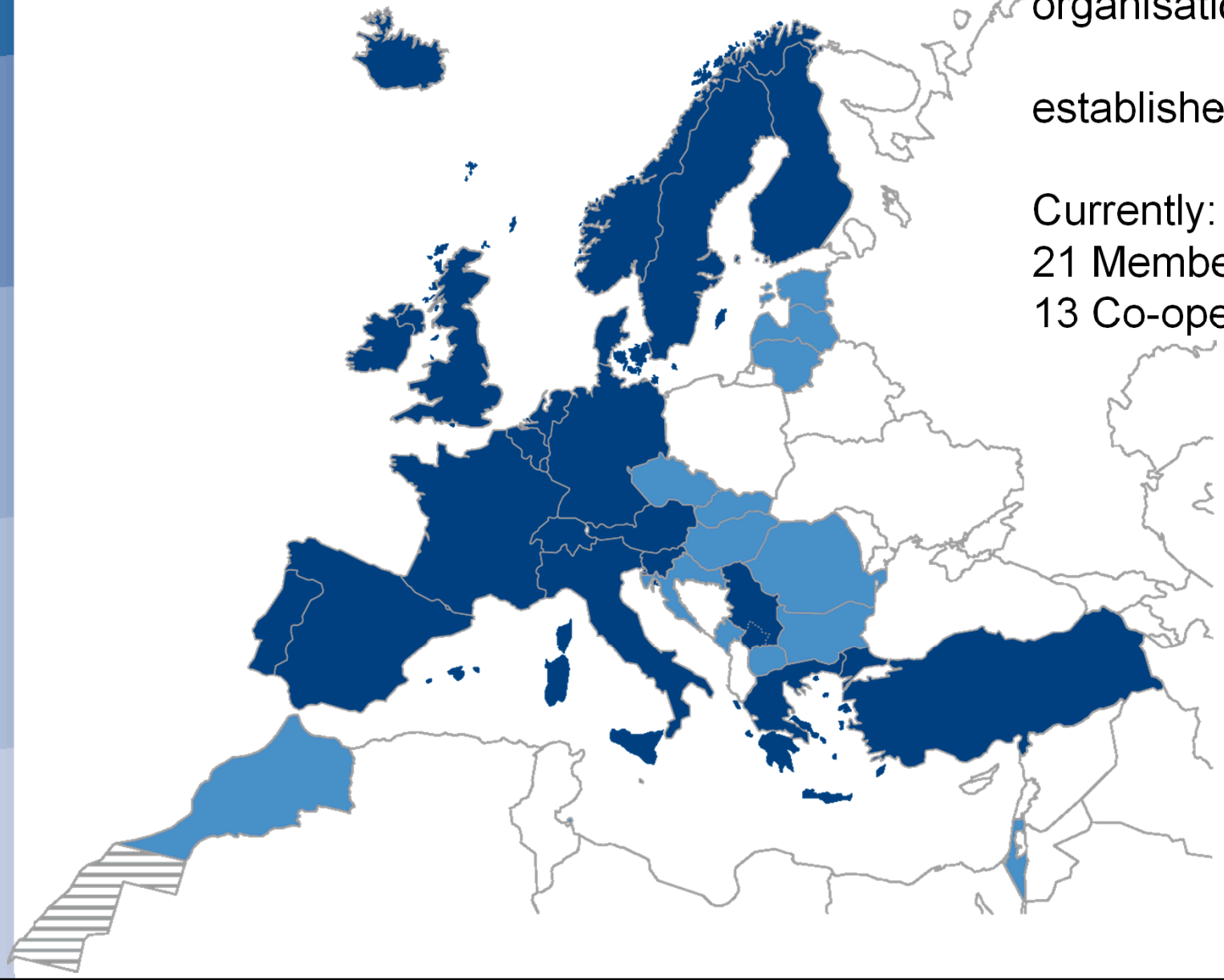
Operational and research activities at ECMWF now and in the future

Sarah Keeley
Education Officer

Erland Källén
Director of Research

ECMWF



An independent intergovernmental organisation

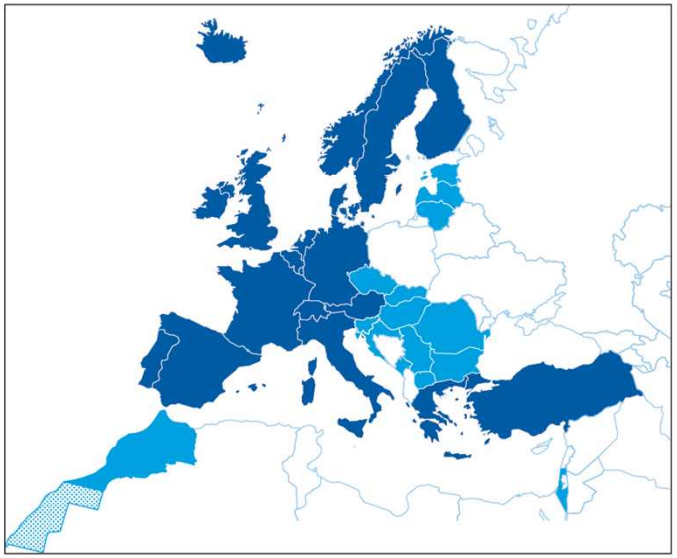
established in 1975

Currently:
21 Member States
13 Co-operating States

Global observation system

Global numerical weather forecasts

National weather services



Users

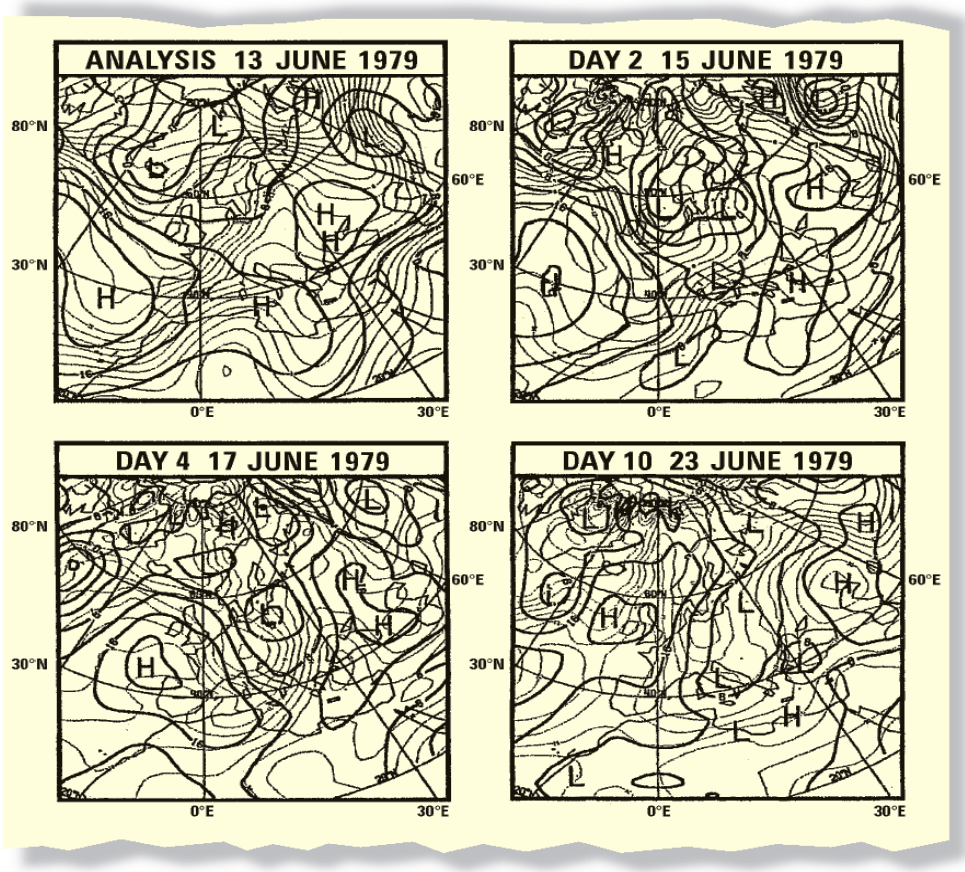
How ECMWF was established

Start of operational activities

1978 Installation of first computer system (CRAY 1-A)

1979 Start of operations

N48 grid point model – 200km



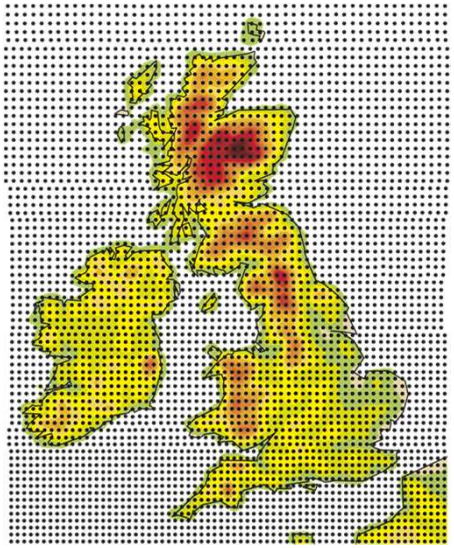
Current system

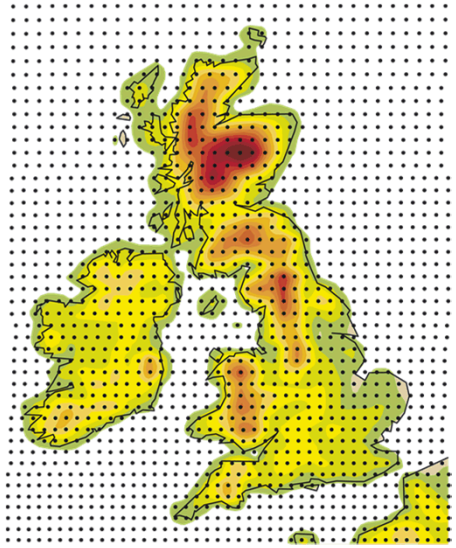
Cray XC30

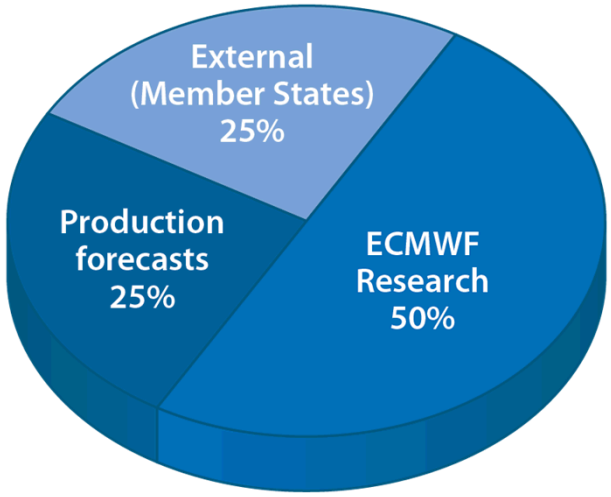
- Two identical systems for resiliency
- 3.5 Petaflops peak performance (3.5×10^{15})

Operational Model - T1279 (16km)

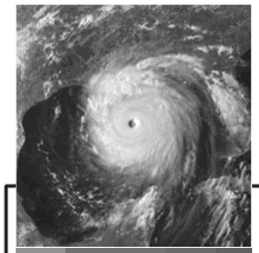
Ensemble Prediction System - T639 (31km)

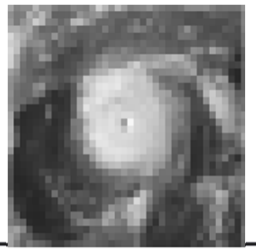






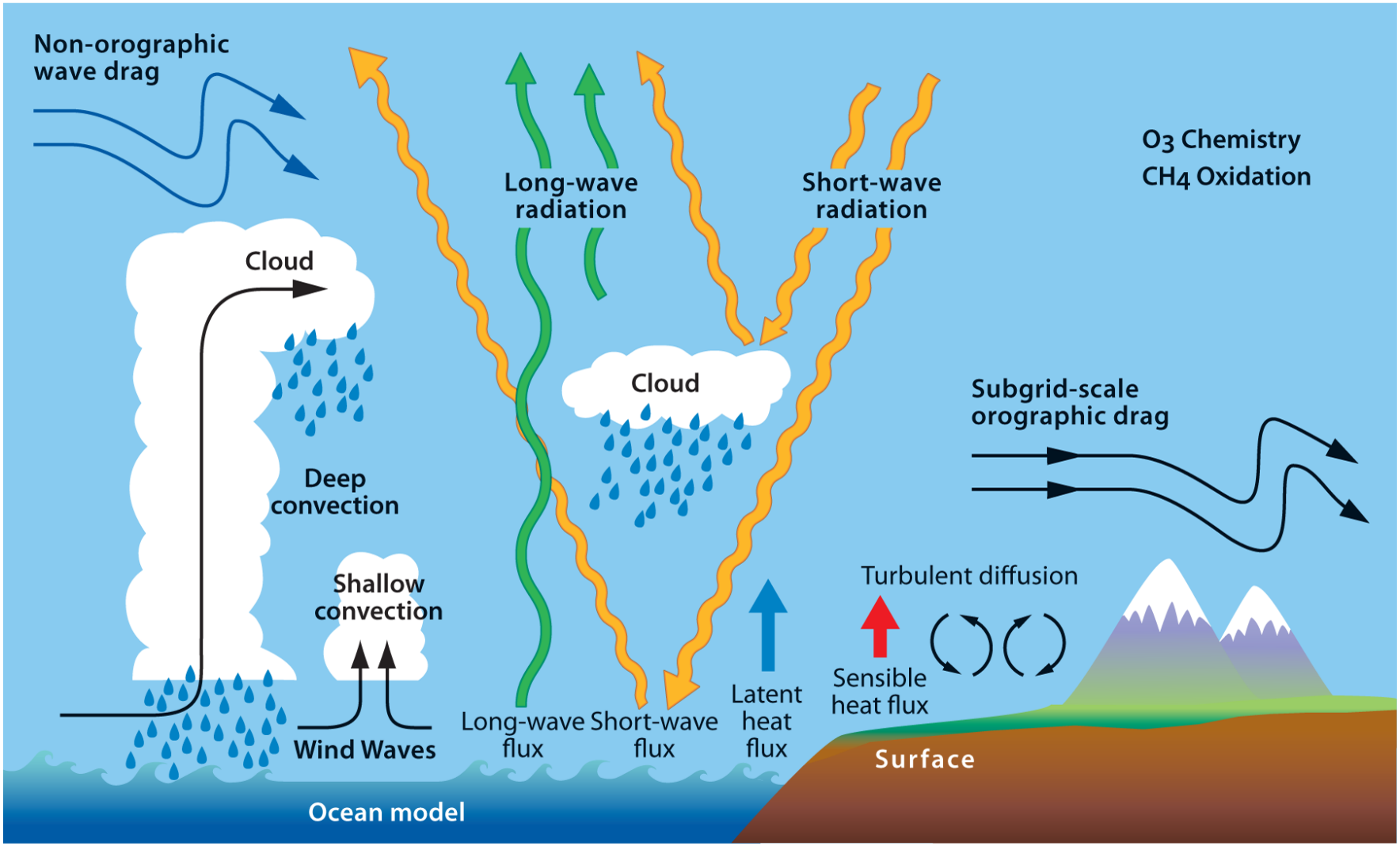
Evolution of ECMWF scores



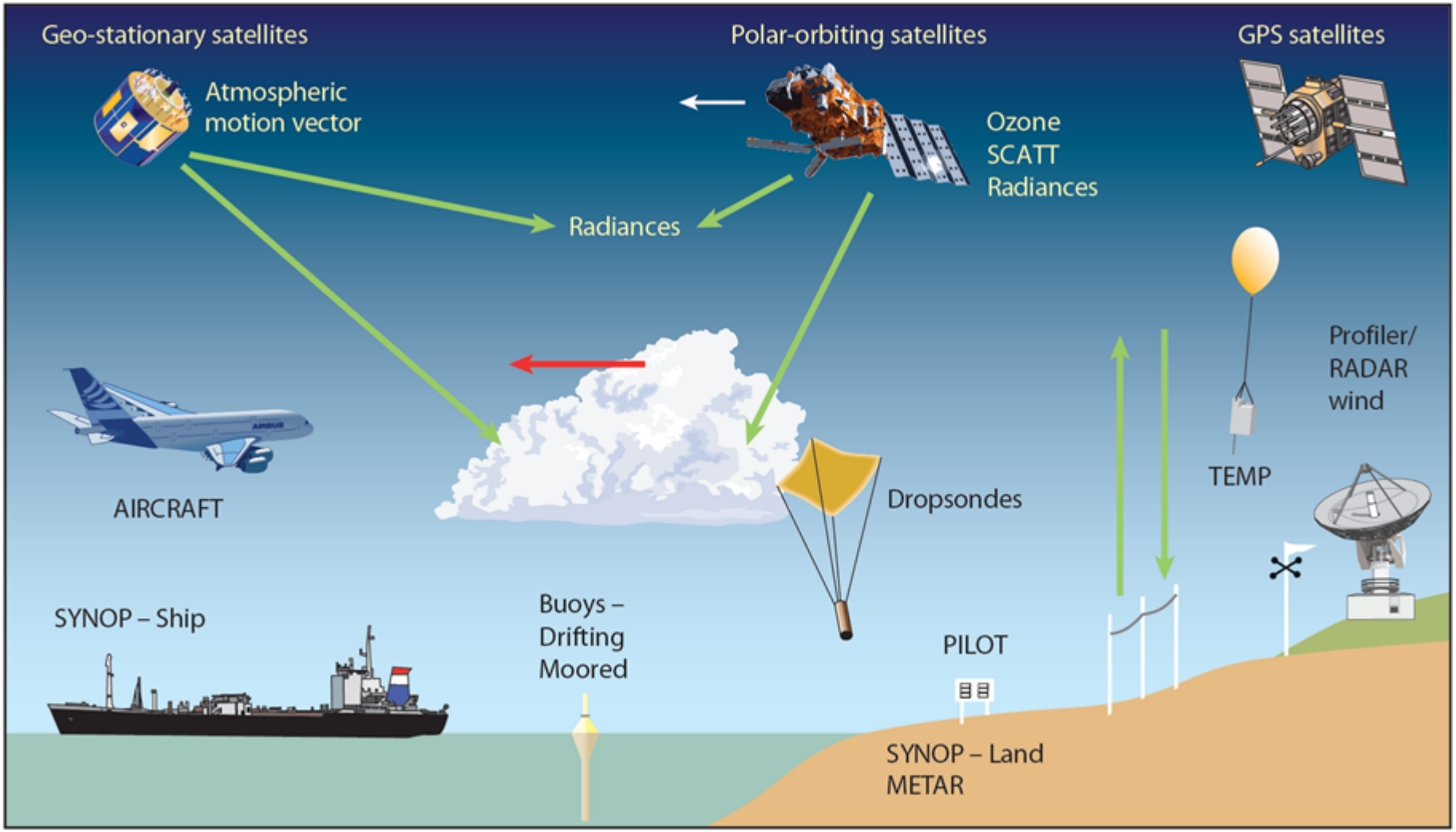


Adapted and extended from Simmons & Hollingsworth (2002)

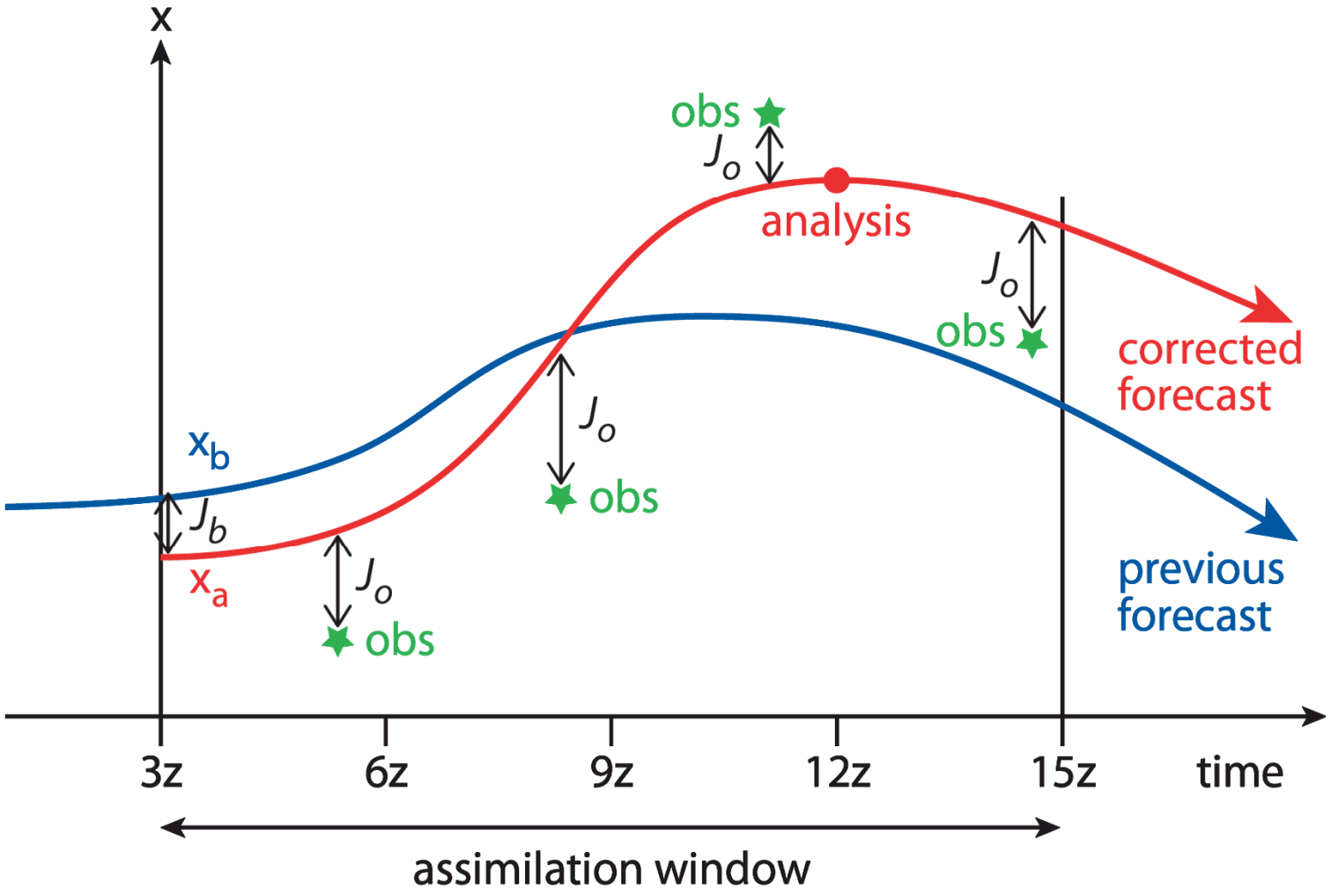
Physical aspects, included in IFS



Data assimilation



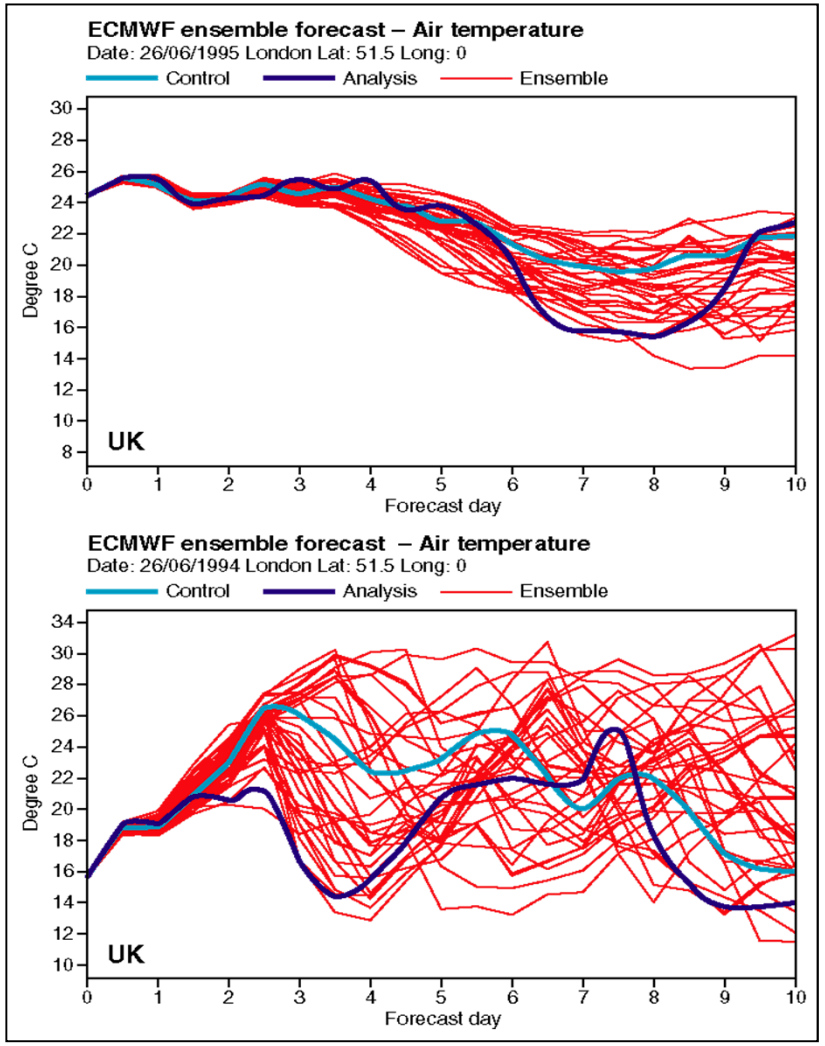
Variational data assimilation



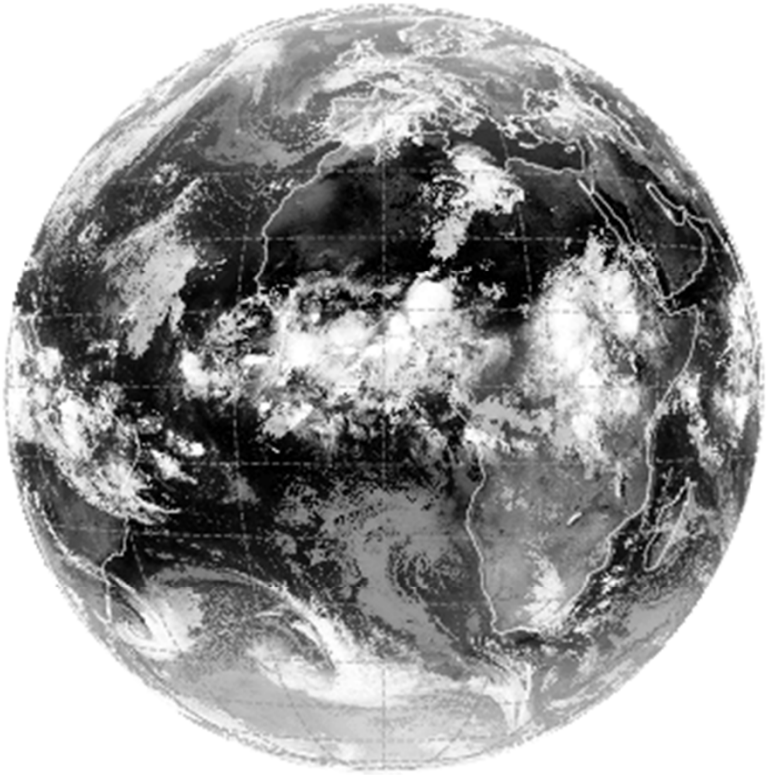
Predictability, diagnostics and extended-range forecasting

The atmosphere is a chaotic system

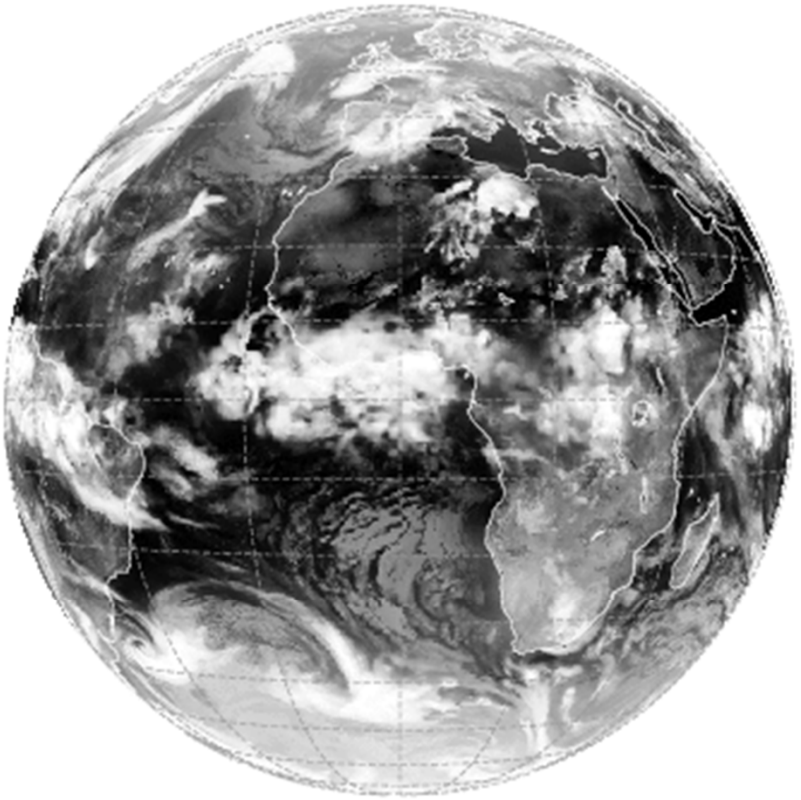
- Small errors can grow to have major impact (butterfly effect)
- This limits detailed weather prediction to a week or so ahead
- Slowly evolving components of the climate system can give predictability at longer timescales



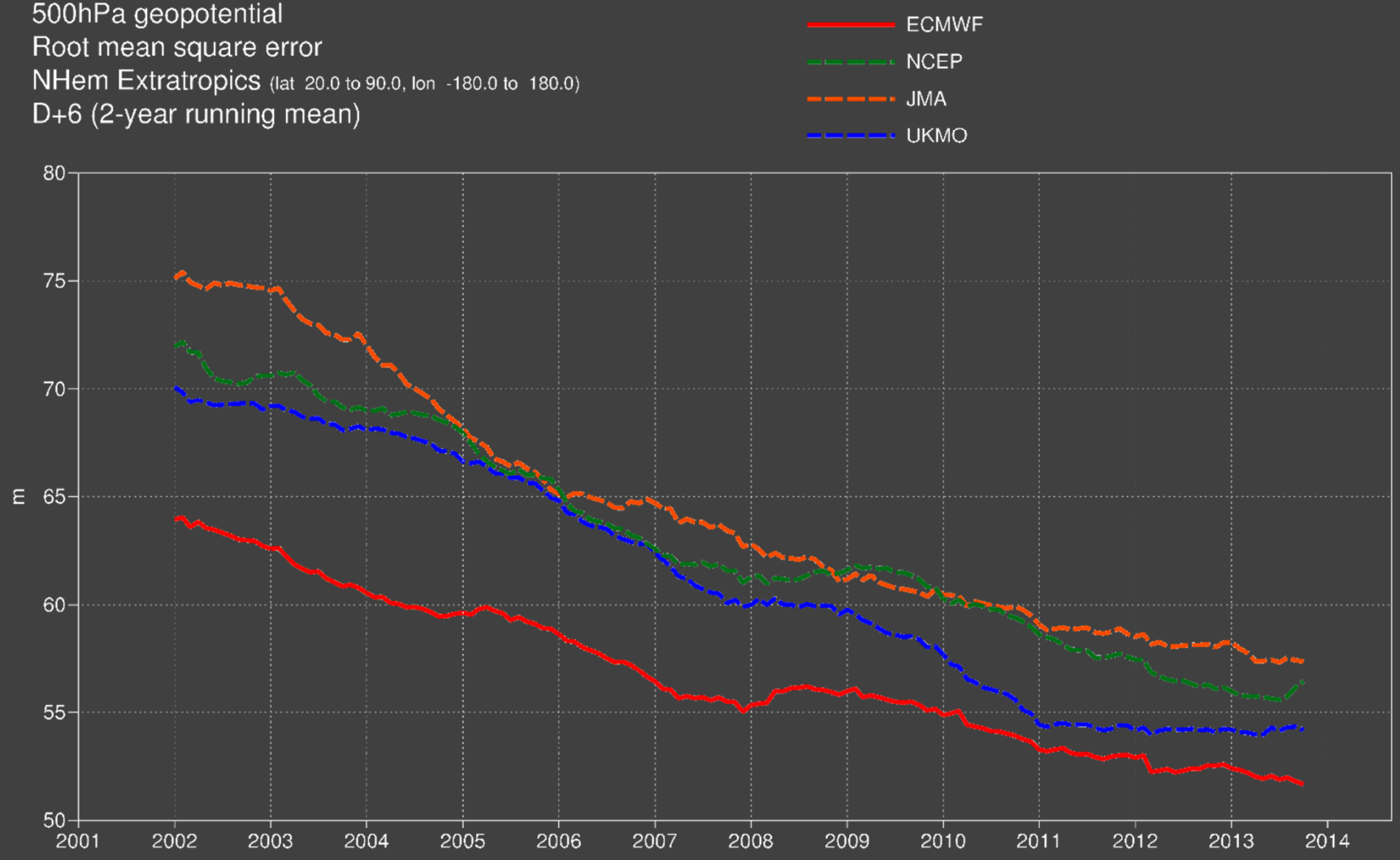
Meteosat 9 IR10.8 20080525 0 UTC



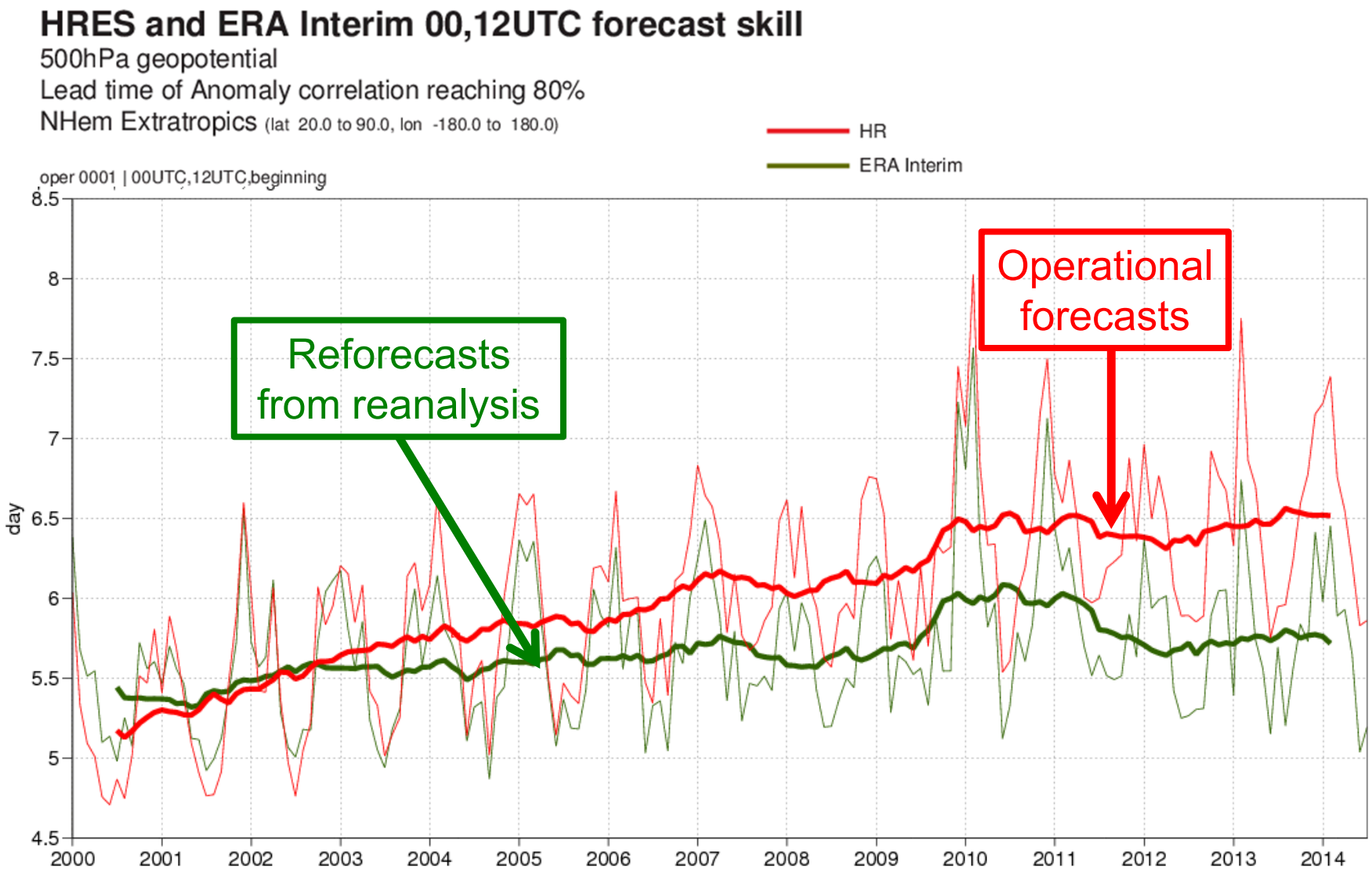
ECMWF Fc 20080525 00 UTC+0h:



Forecast skill and improvement

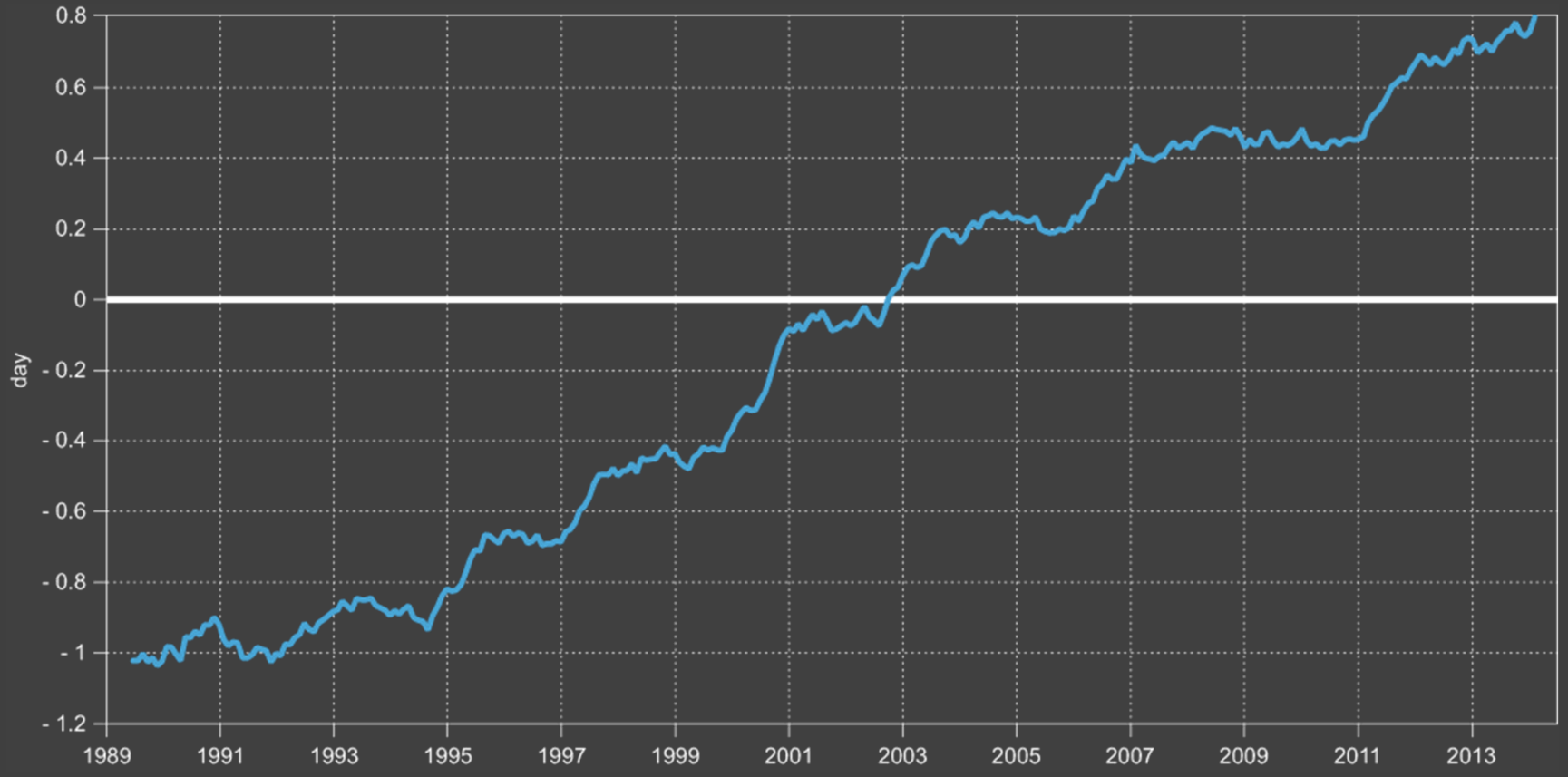


Z500 Time series of ACC=80% N hemisphere

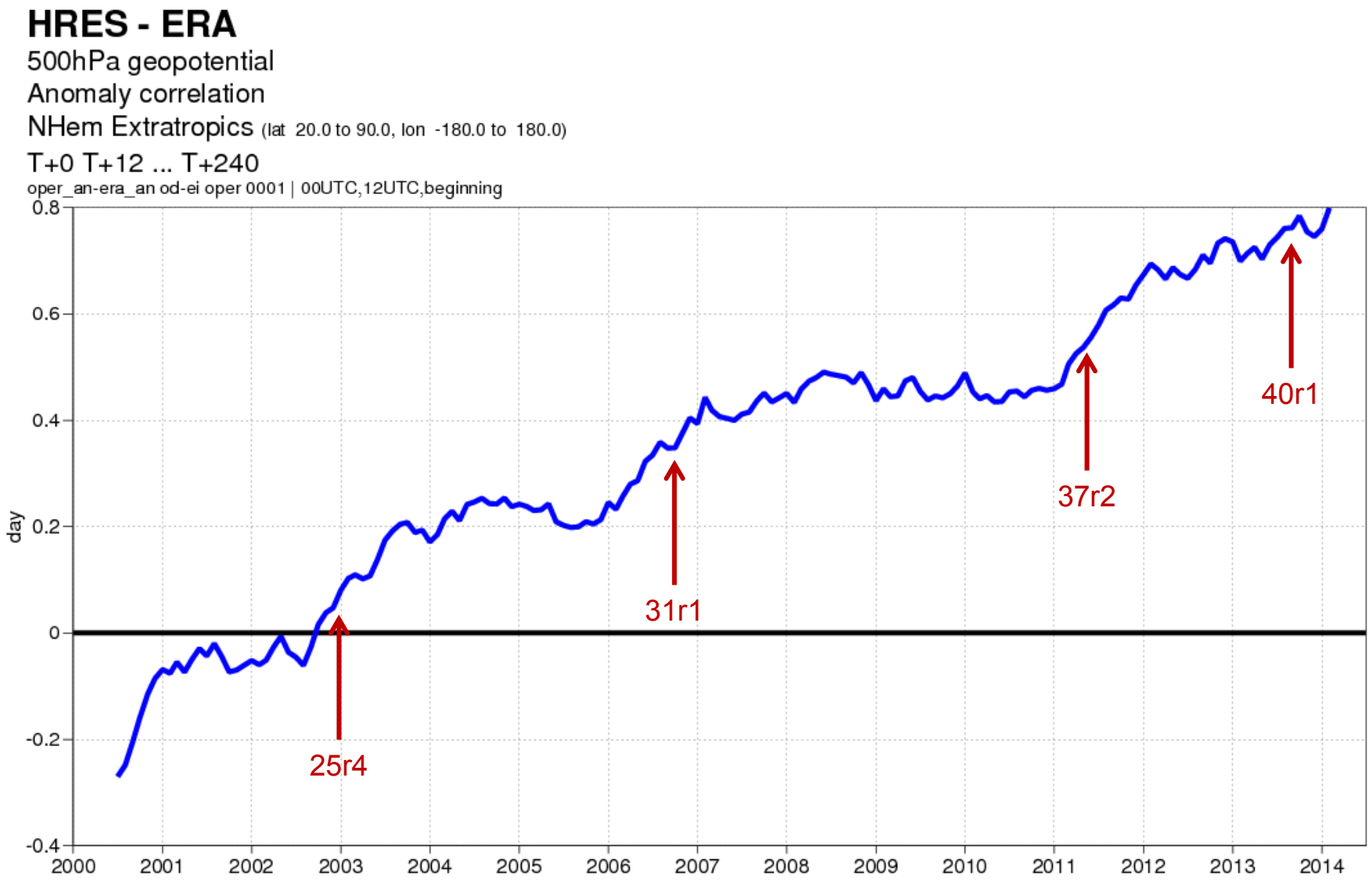


Forecast skill and improvement

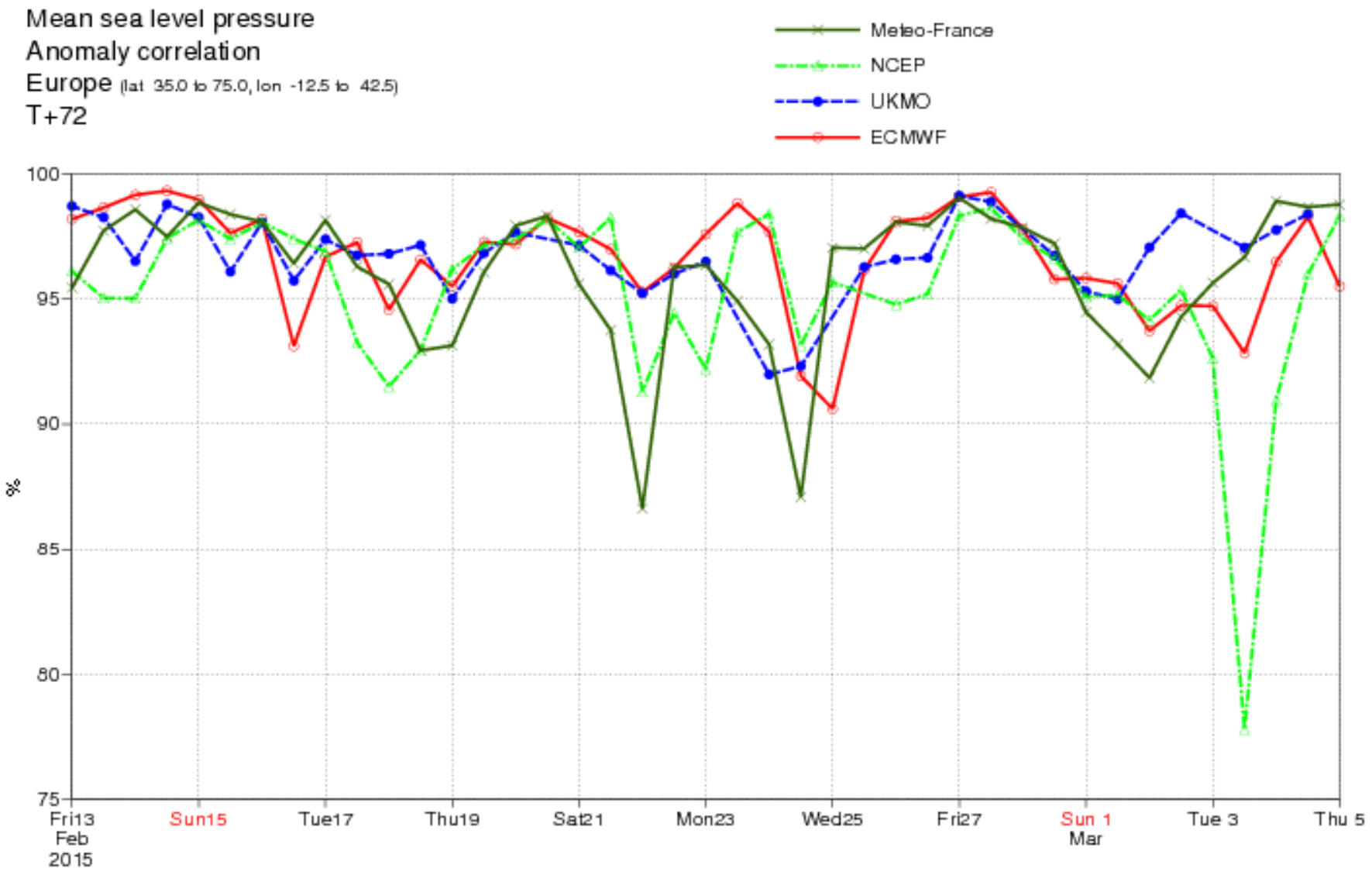
Change in the range of skilful forecasts compared to using the operational system of ten years ago



Z500 N hemisphere HRES v ERA-I



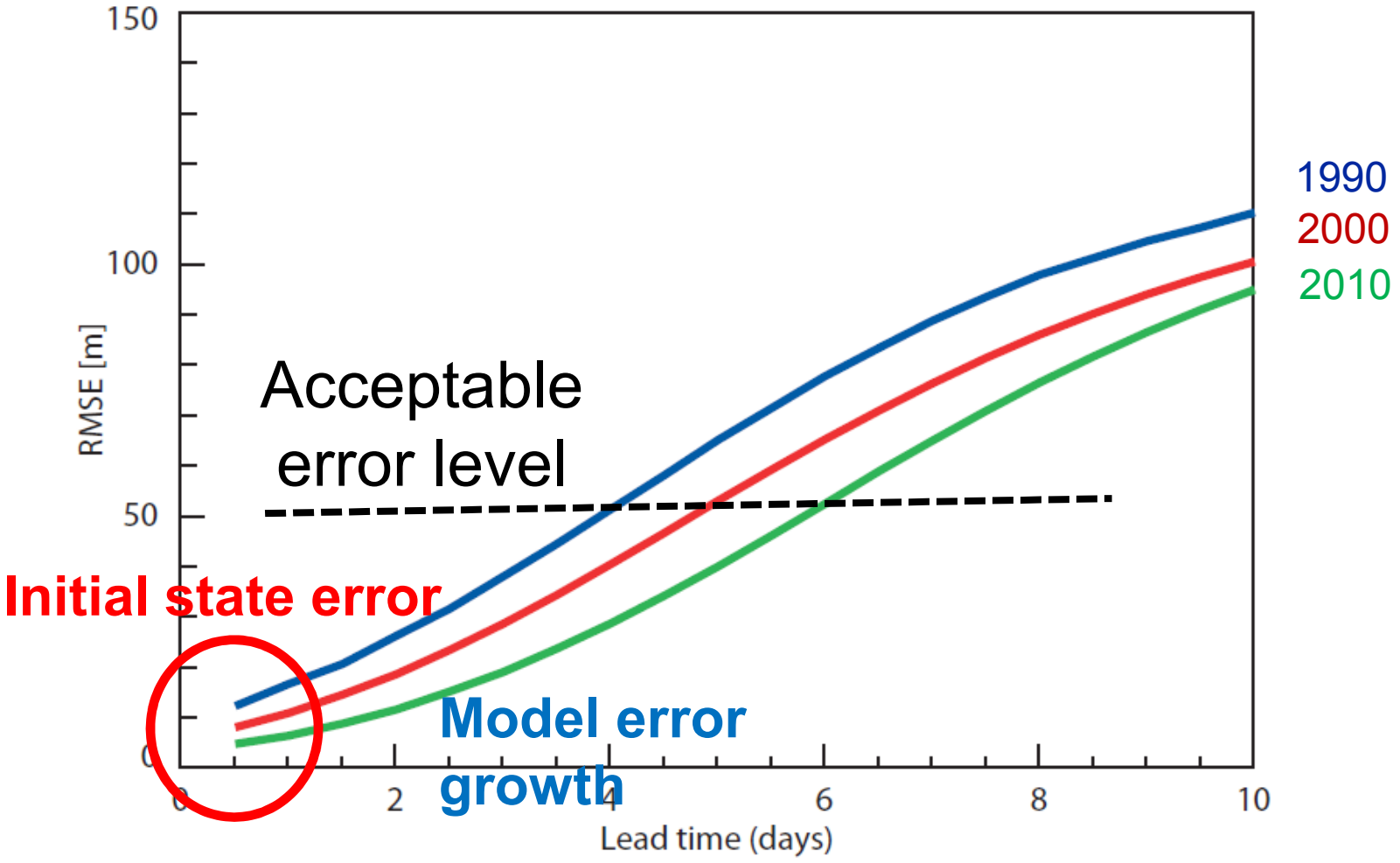
Meteorological Operations



Future Research Activities

Erland Källén
Director of Research

RMS error of 500 hPa height field Northern Hemisphere

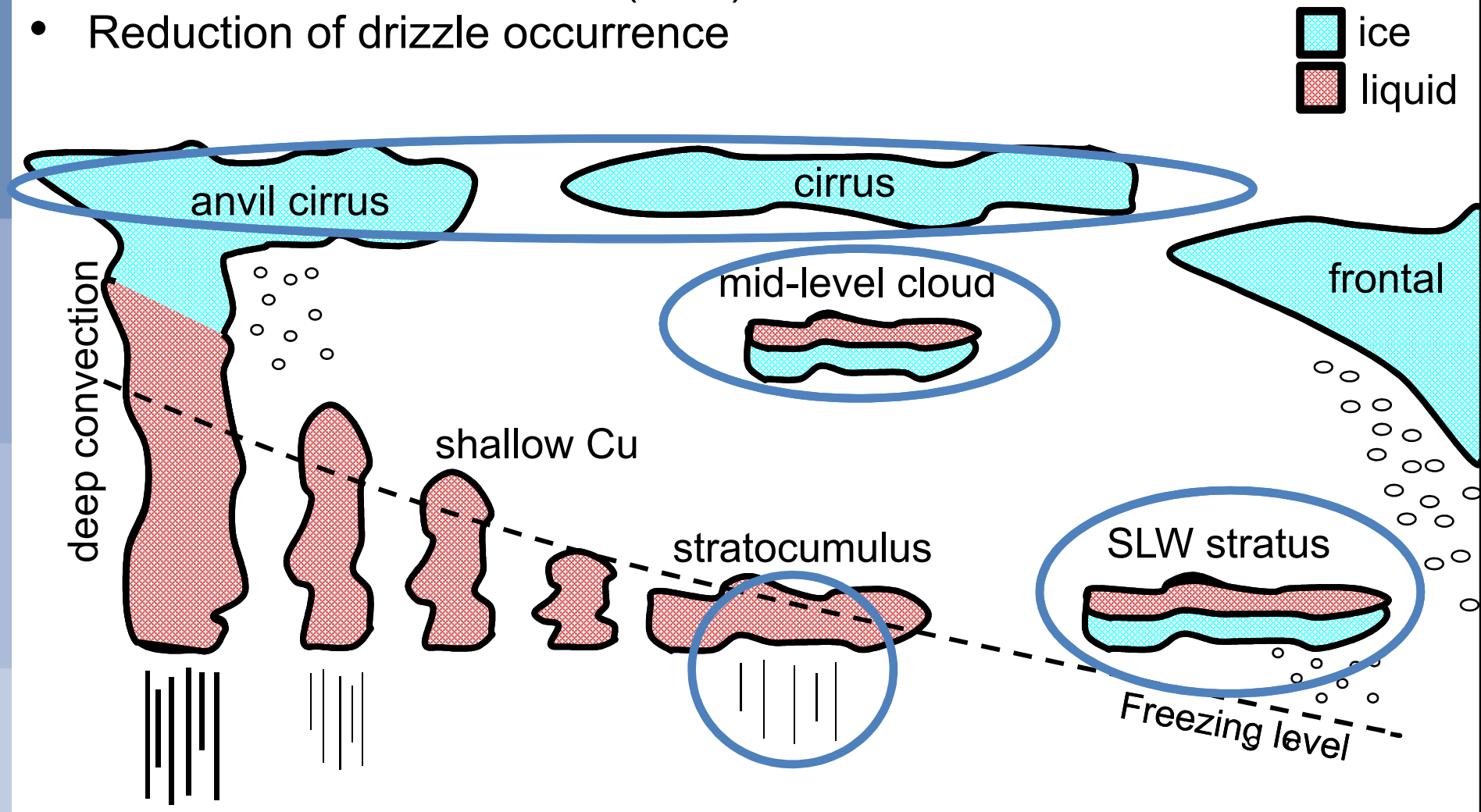


Outline

- Model physics
- Increasing resolution
- Ensemble prediction
- Data assimilation

Focus on improved cloud parametrization:

- Super-cooled liquid layers in mixed phase stratiform cloud (37r3)
- Ice water content in cirrus (38r1)
- Reduction of drizzle occurrence



Horizontal resolution

Atmosphere:

- Vertical: 91 → 137 levels in 2013
- Increased resolution in 2015
  - 16 km → 8-10 km
- Cubic octahedral grid

Ocean:

- 1º → ¼º
- 42 vertical levels → 75 levels

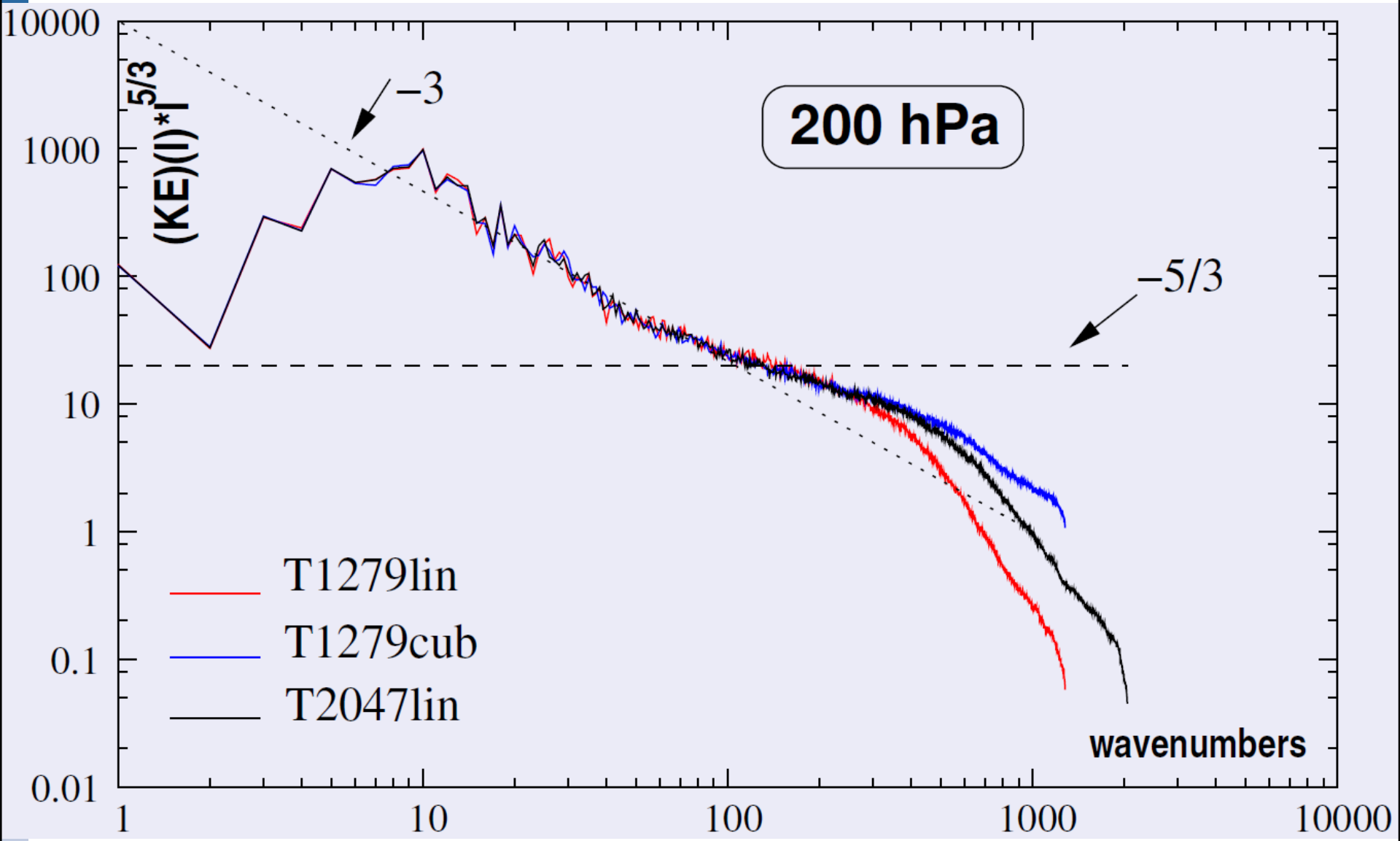
In the future:

5 km ensemble prediction system (2025)

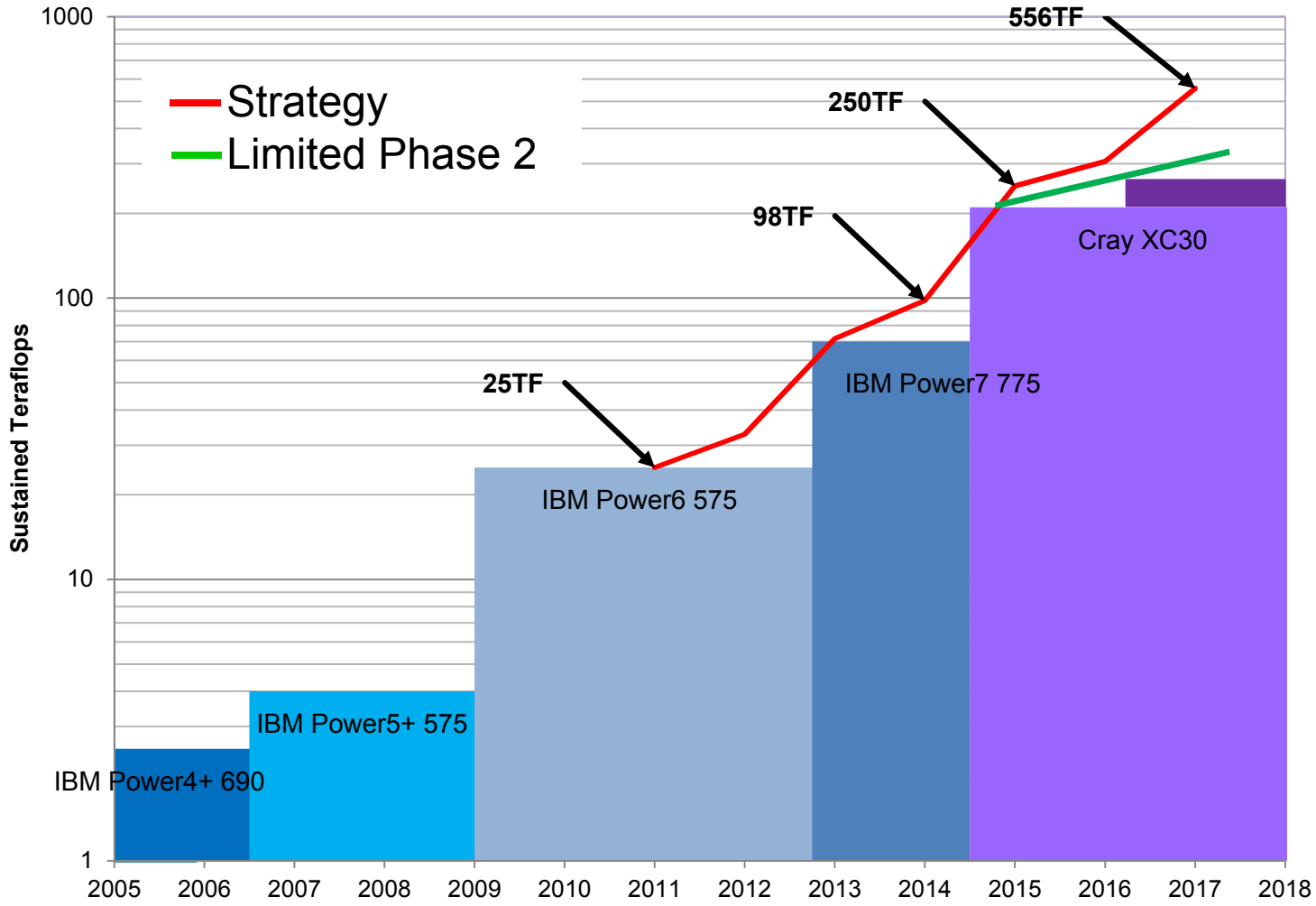
Computing requirements:

60 MW!! (scalability)

Kinetic energy spectra at 200 hPa



HPCF performance vs Strategy

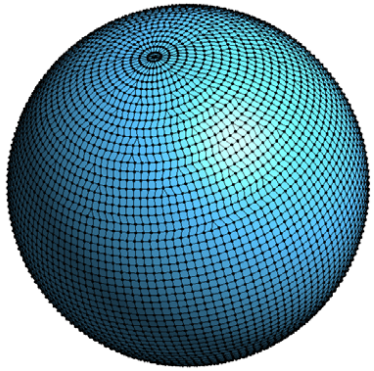


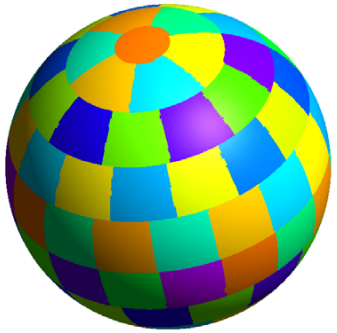
Scalability activities

- Preparation for future HPC architectures (2018 onwards)
  - Data assimilation (OOPS)
  - IFS dynamical core
  - Model code optimisation
  - Other code optimisations (observation handling)

Strategy for IFS dynamical core

- Fully compressible equations
- Retain semi-implicit, semi-Lagrangian schemes
- Retain spectral transform technique
- Improve parallelisation/scalability by implementing unstructured grids

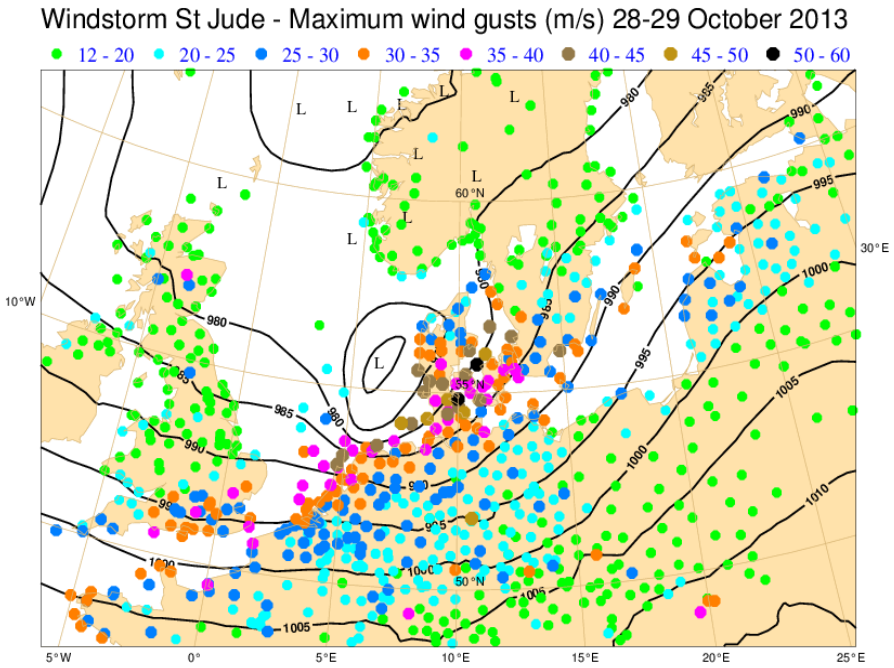


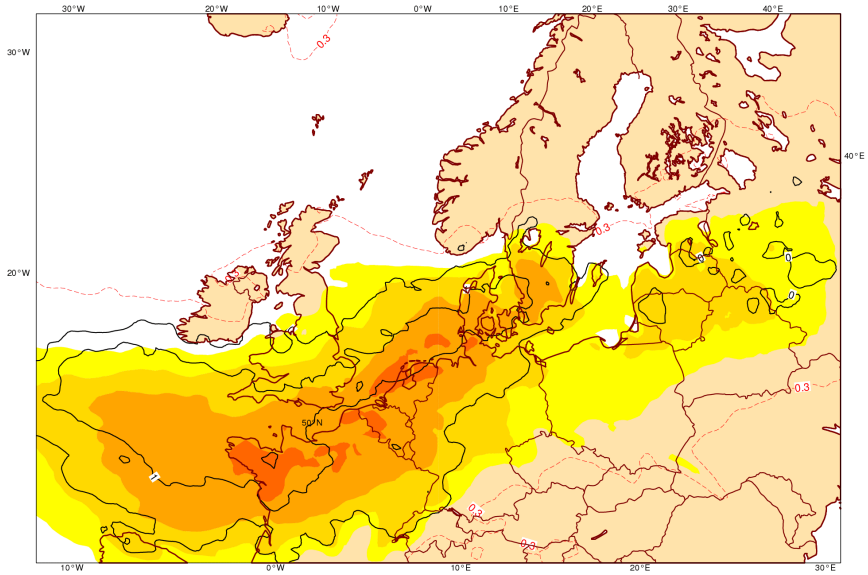


ENsemble prediction System (ENS)

- EDA, singular vectors and ENS
- Stochastic physics
- 91 levels in the vertical T639
- Coupled to the ocean model from the start of the forecast
- Monthly forecasting
  - MJO skill scores
- Seasonal forecast System 4
  - EUROSIP including NCEP
- Applications of ENS

Wind storm NW Europe 28 October 2013

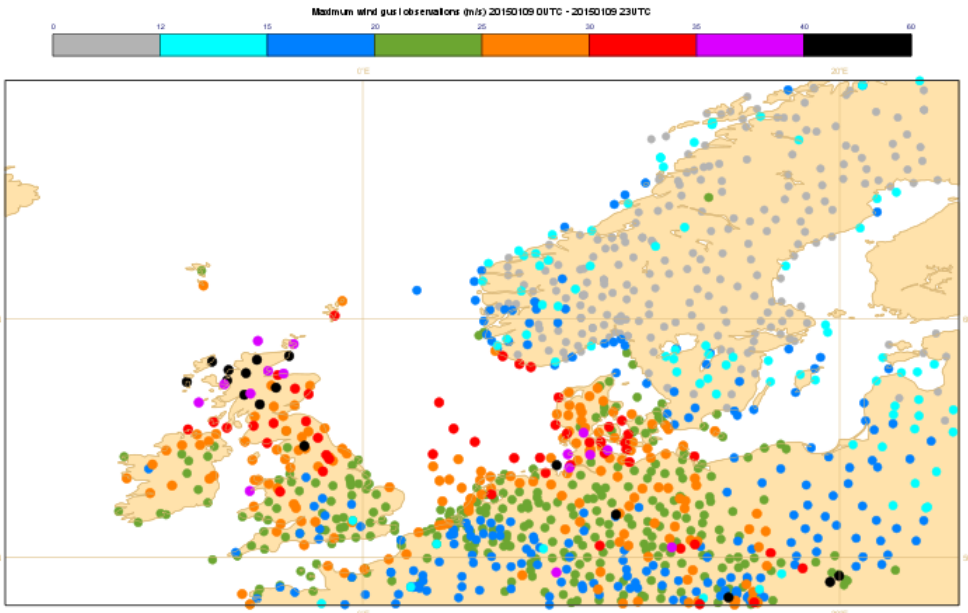


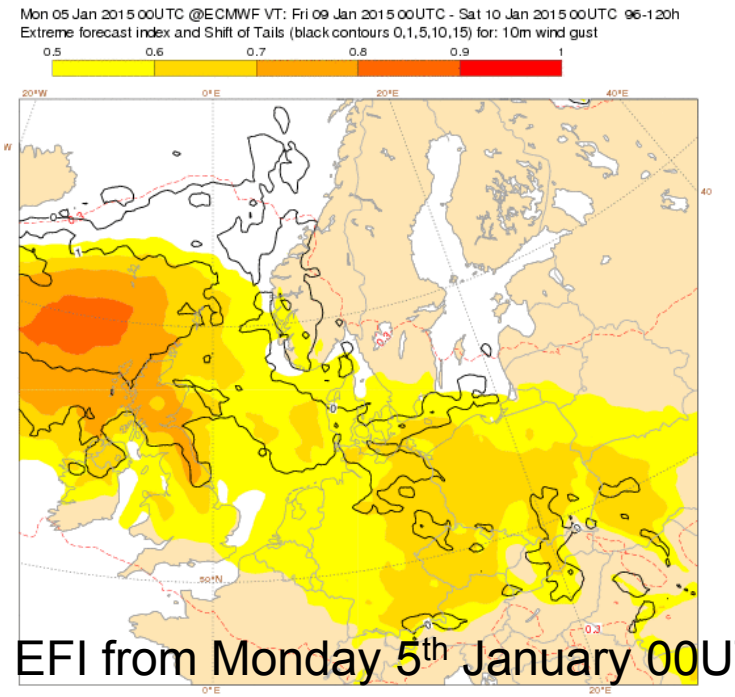


Signal from 4-5 days ahead in the Extreme Forecast Index (EFI)

Wind storm 9-11 January 2015

Observations Friday 9th January





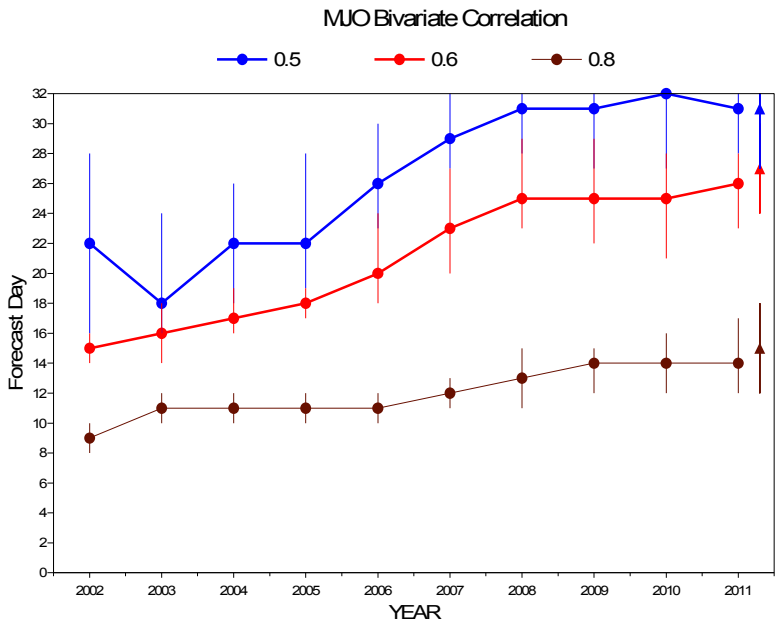
Signal from 4-5 days ahead in the Extreme Forecast Index (EFI)

EFI from Monday 5th January 00UTC

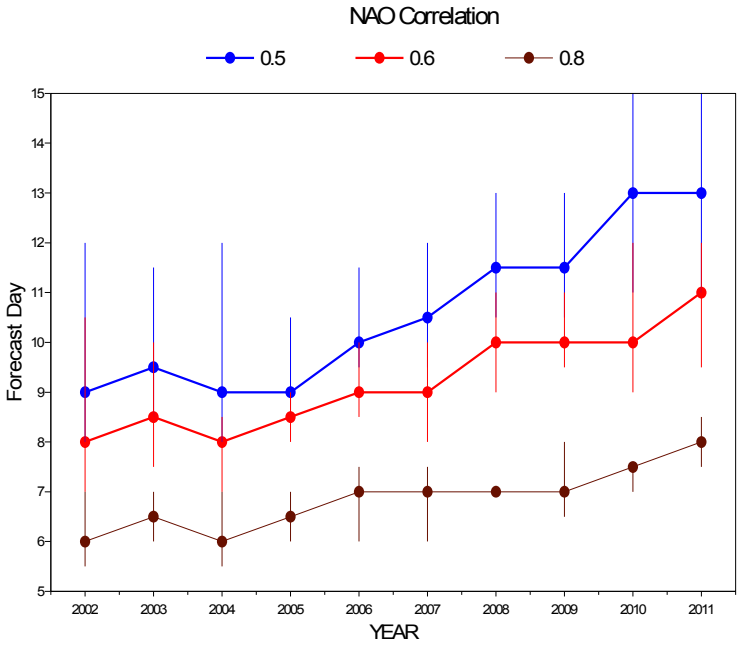
Performance of the monthly Forecasts since 2002

Hindcasts covering the period 1995-2001

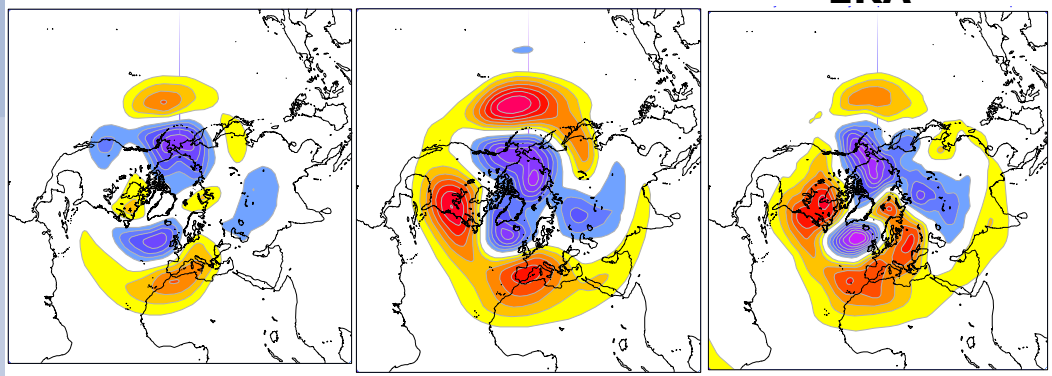
Tropics

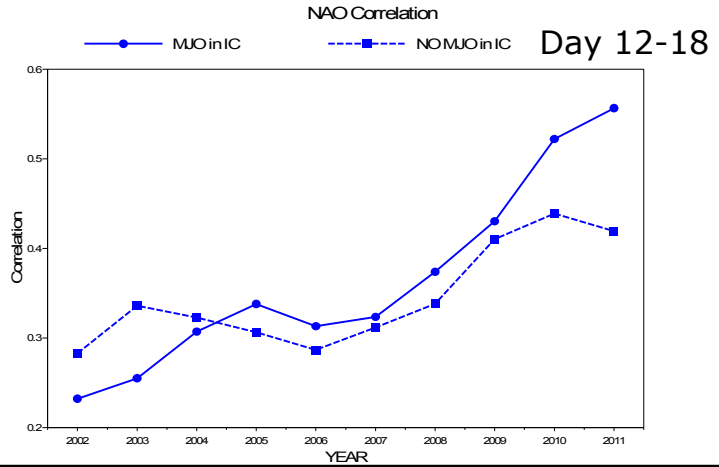


N. Extratropics



2002 **2011** **ERA**

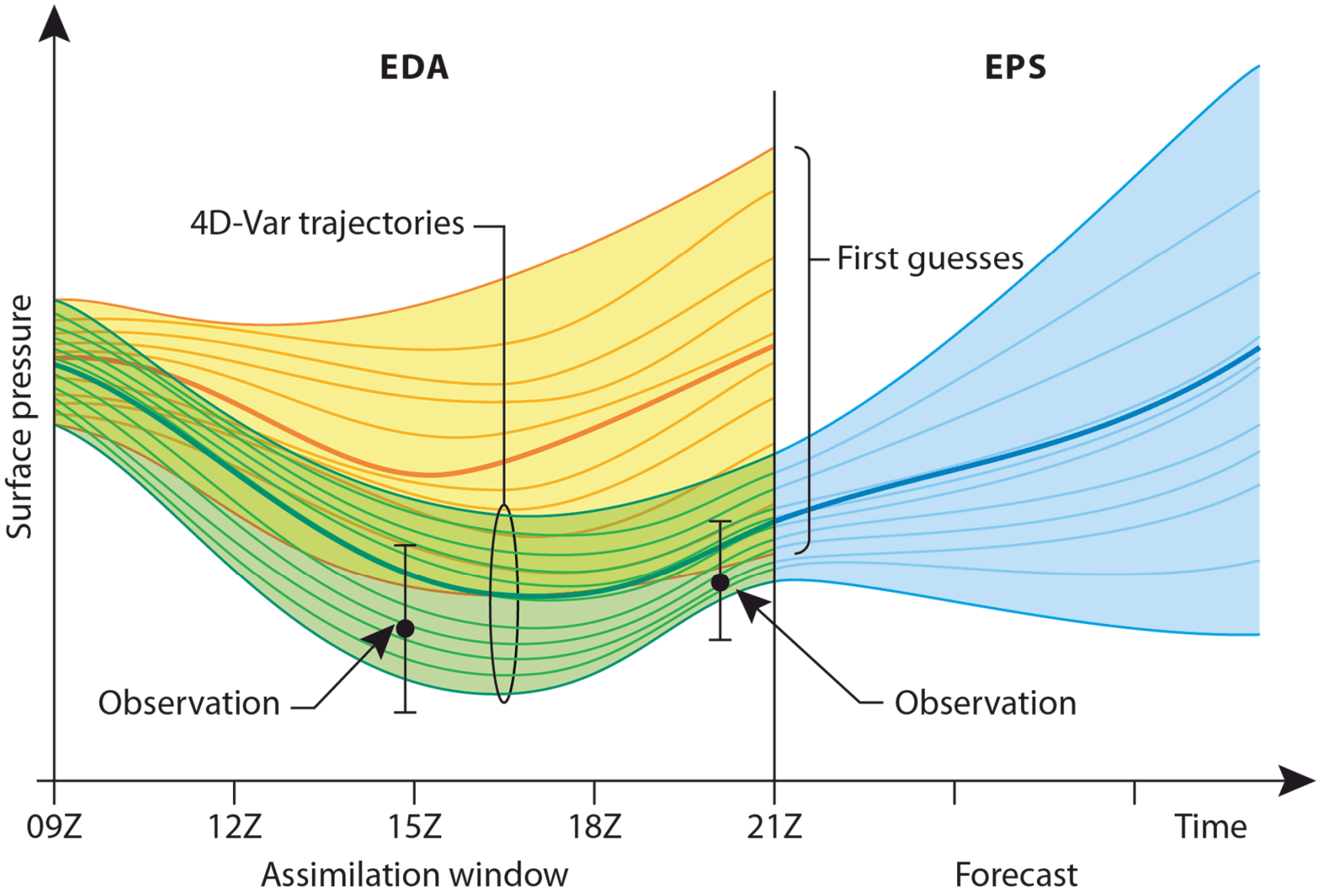




Data assimilation

- Variational assimilation
- Ensemble of Data Assimilations (EDA)
- Ensemble Kalman Filter (EnKF)
- Surface analysis

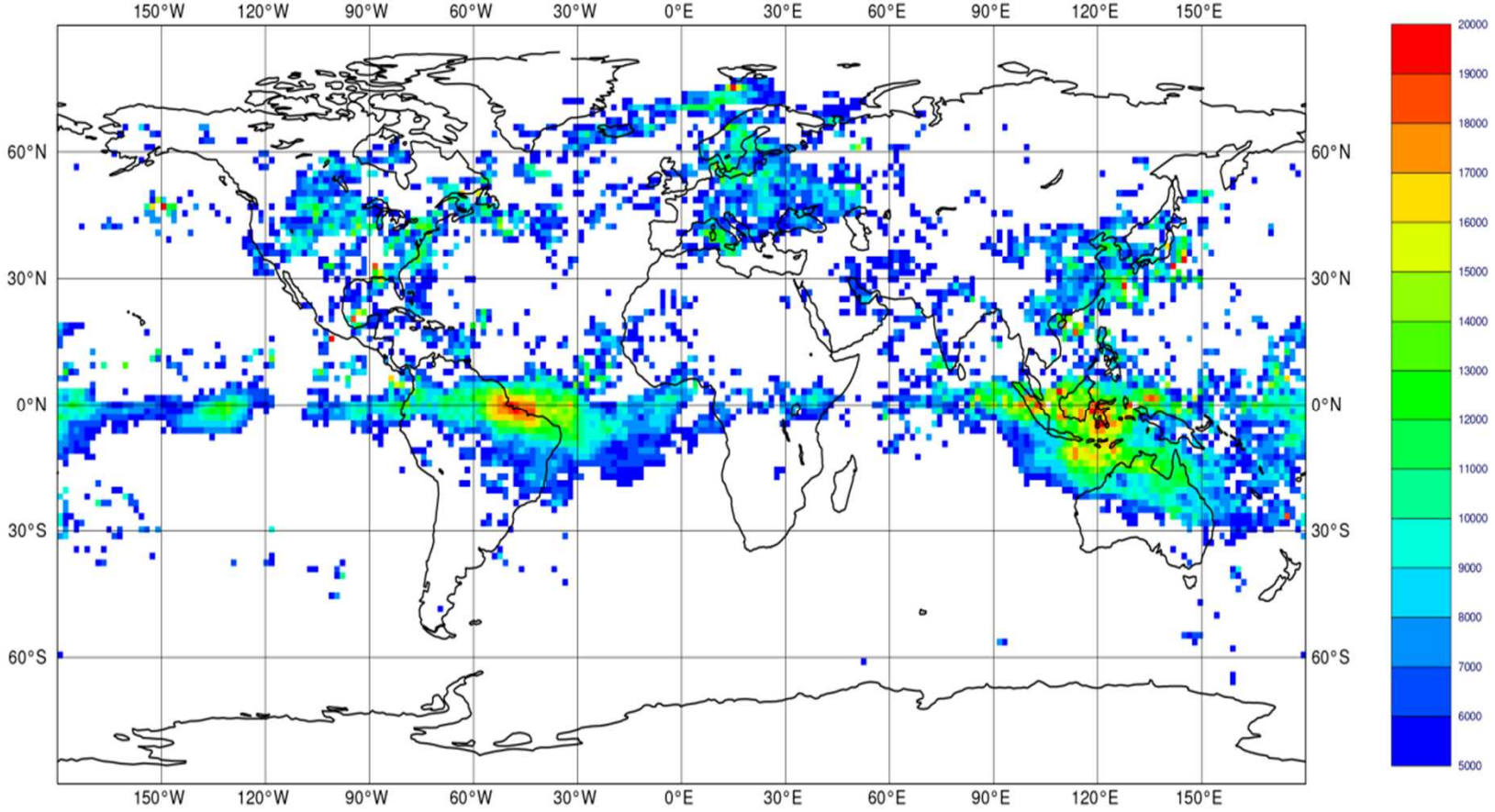
Ensemble assimilation and prediction



Aeolus Doppler wind Lidar (launch 2017) (ESA Earth Explorer Mission)

Aeolus Doppler wind lidar

Aeolus wind profile impacts



Conclusions

Forecasts will continue to improve

Initial error reduction

Model improvements

By 2025:

Ensemble prediction at 5km resolution

High impact weather up to two weeks ahead

Large scale patterns and regime transitions up to four weeks ahead

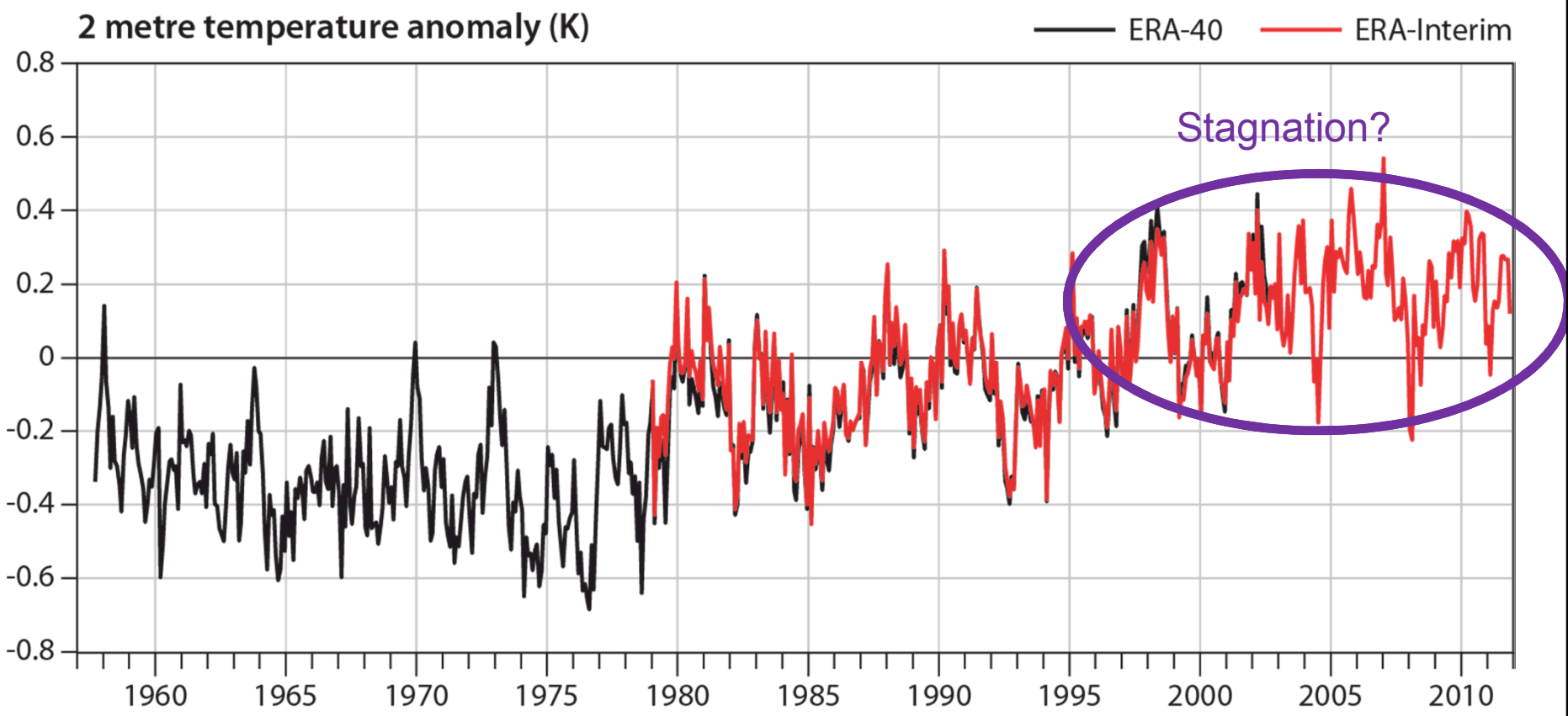
Global scale anomalies up to a year ahead

Reanalysis (ERA)

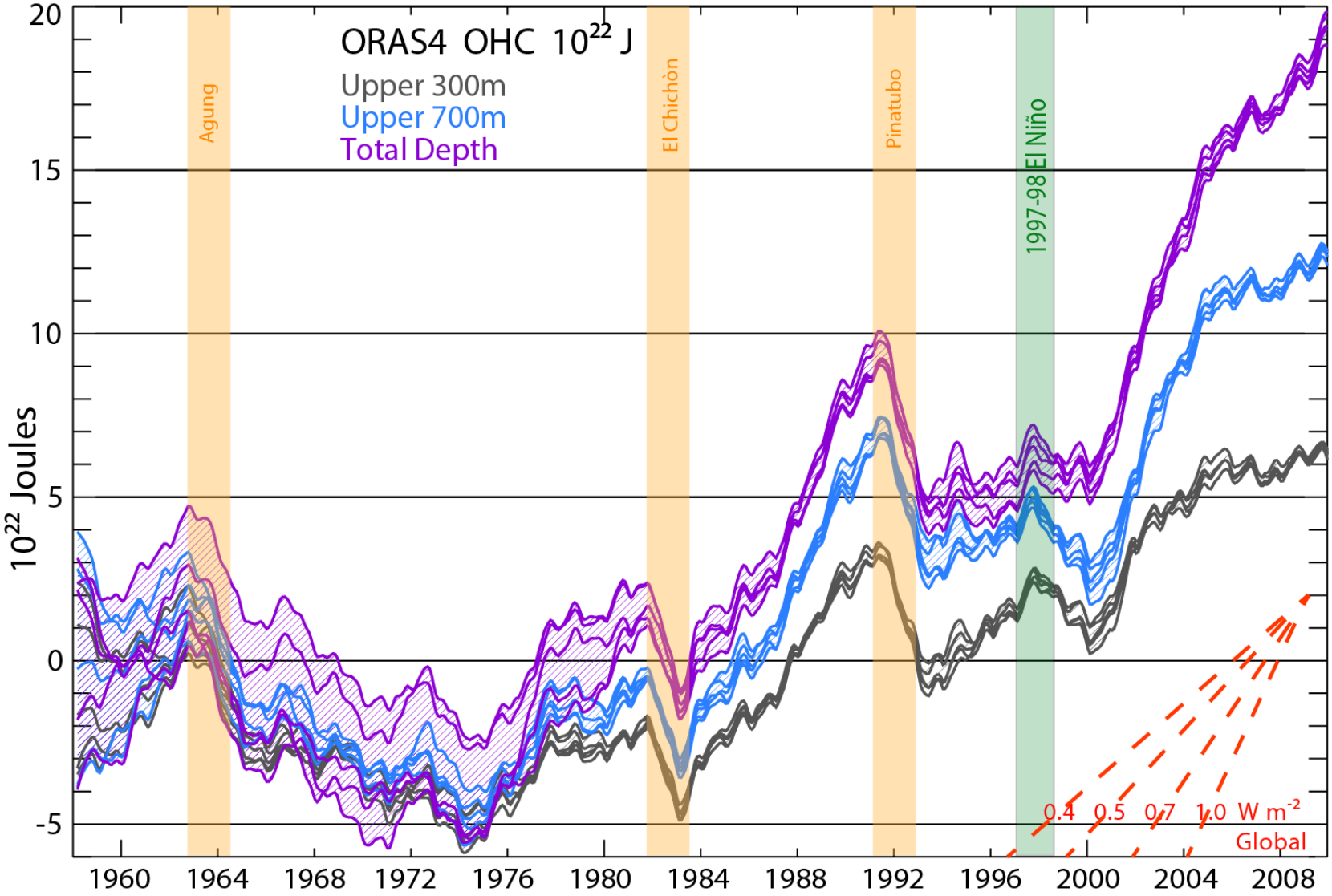
- Climate monitoring in near real time
- Verification data set for reforecasts
- ERA-20th century reanalysis in preparation
- Ocean reanalysis

Global Warming since 1957

Anomalies of monthly-means relative to 1989 – 2001 average



Time evolution of ocean heat content



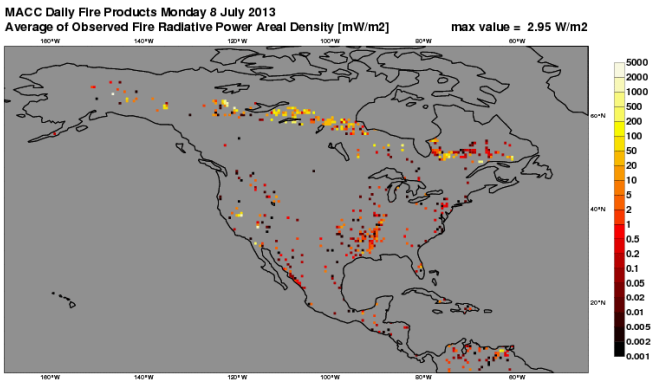
Atmospheric composition

Modelling and data assimilation

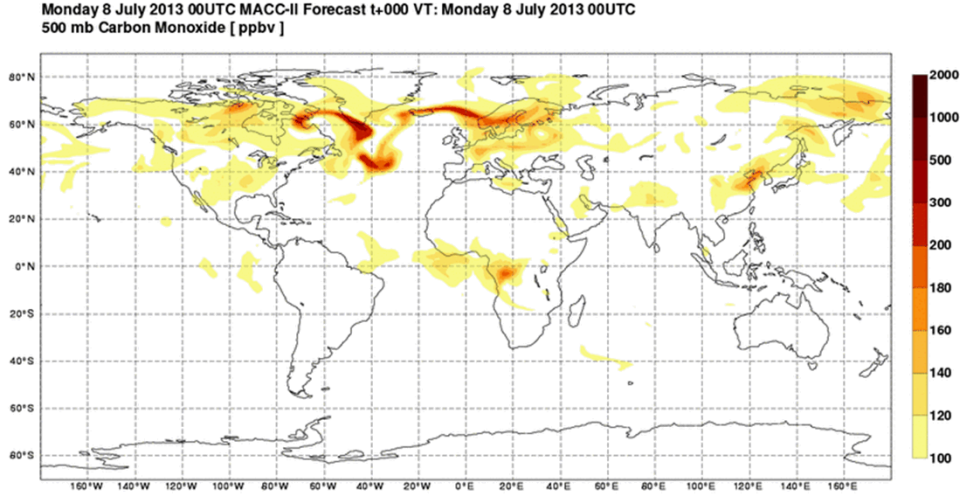
Monitoring and evaluation

Impact on NWP – aerosols


July
2013
Canadian smoke over
Europe



GFAS



Ceilometer, obs. & simul.

CO @ 500 hPa