Operational and research activities at ECMWF now and in the future

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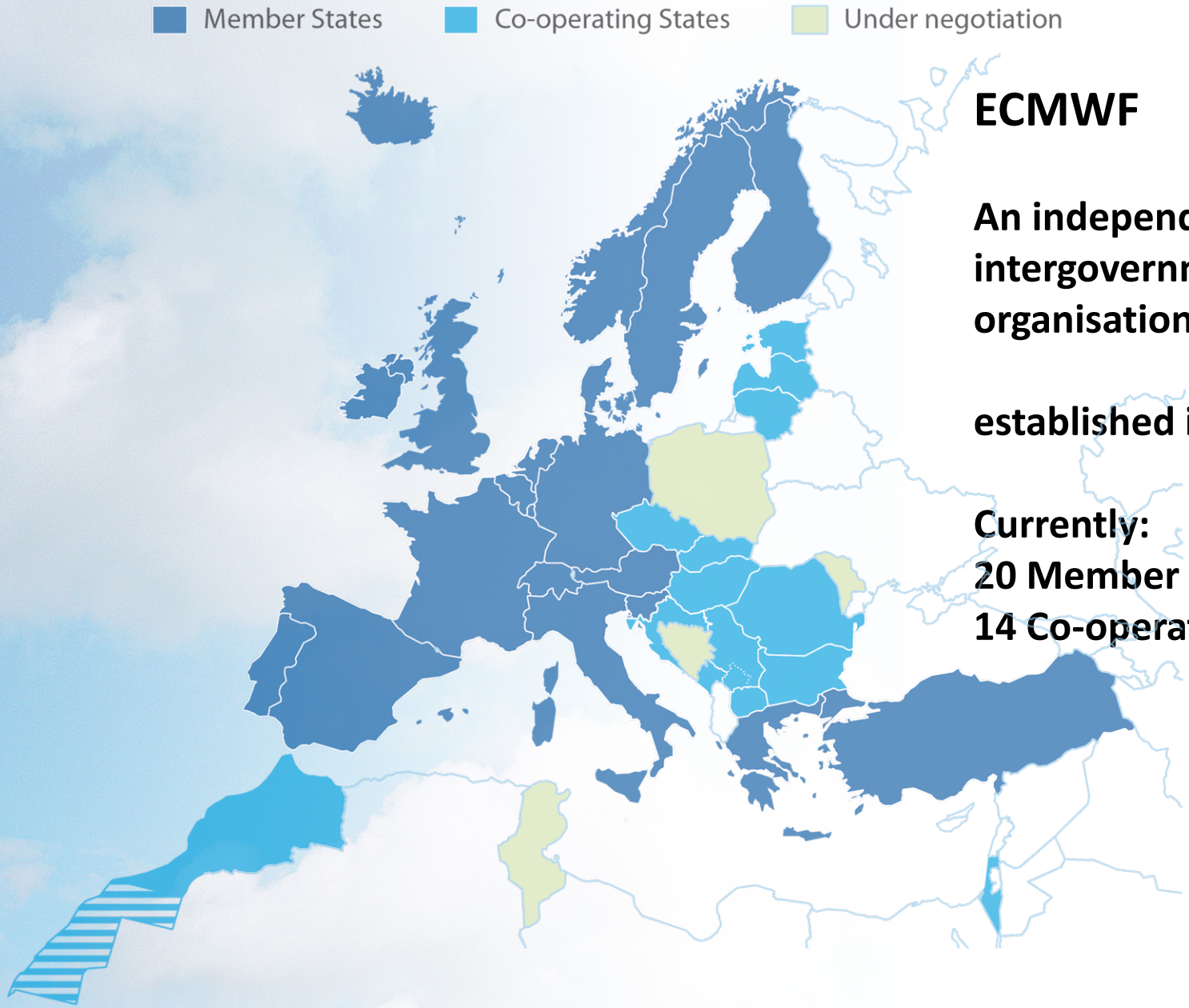


ECMWF

An independent intergovernmental organisation

established in 1975

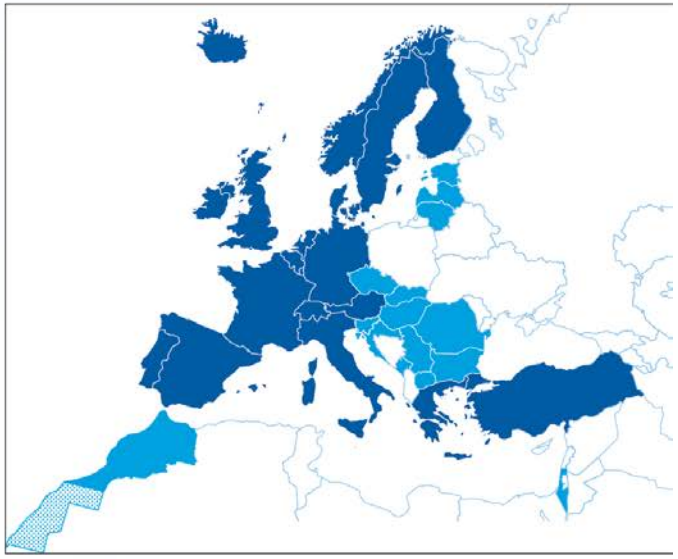
Currently:
20 Member States
14 Co-operating States

ECMWF

Global observation system

Global numerical weather forecasts

National weather services



Users

ECMWF

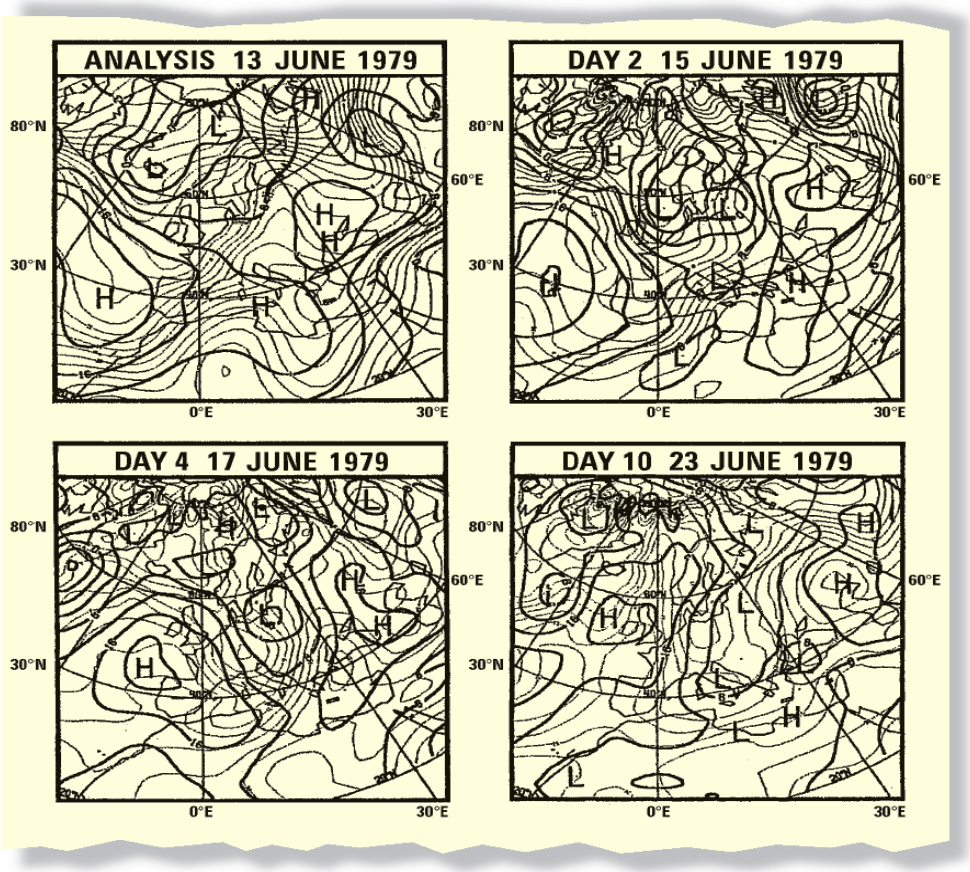
How ECMWF was established

Start of operational activities

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

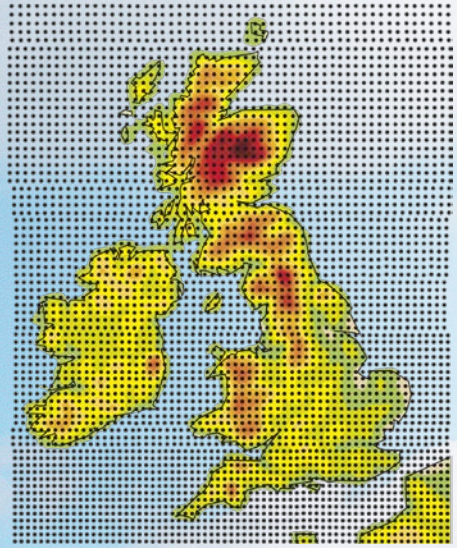
1979 Start of operations

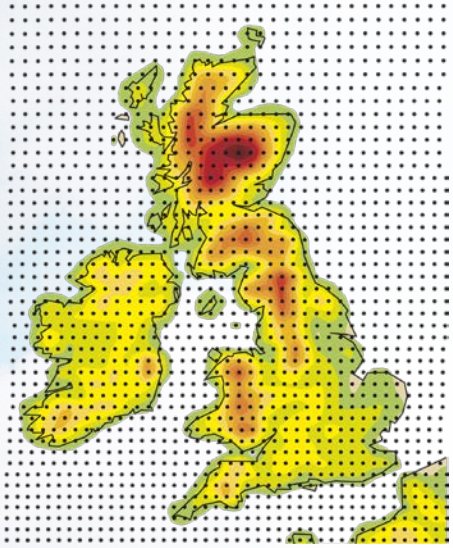
N48 grid point model – 200km

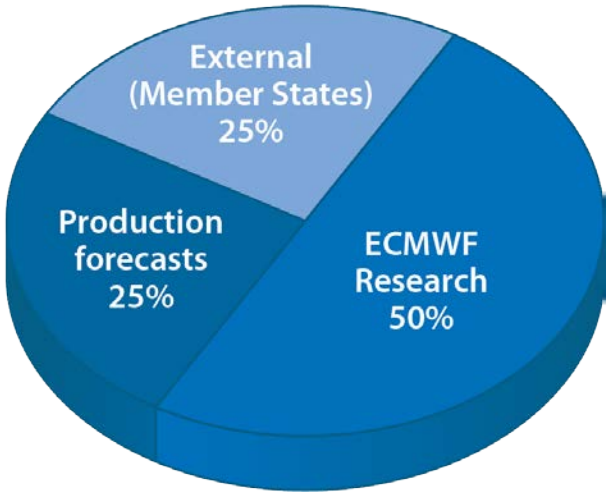


Current system

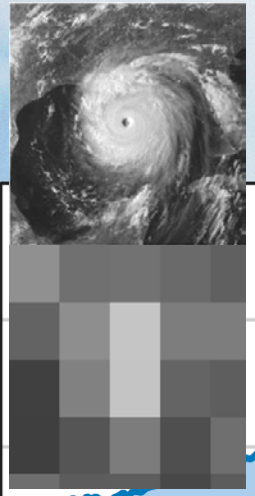
- **IBM Cluster**
  - Two identical systems for resiliency
  - 1.5 Petaflops peak performance (1.5×10^{15})
- Operational Model - T1279 (16km)
- Ensemble Prediction System - T639 (31km)
- Coming soon **Cray XC30**

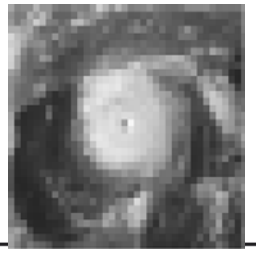






Evolution of ECMWF scores





Anomaly correlation of 500 hPa height forecasts

Northern hemisphere — Southern hemisphere

~210km

~16km

D+3

D+5

D+7

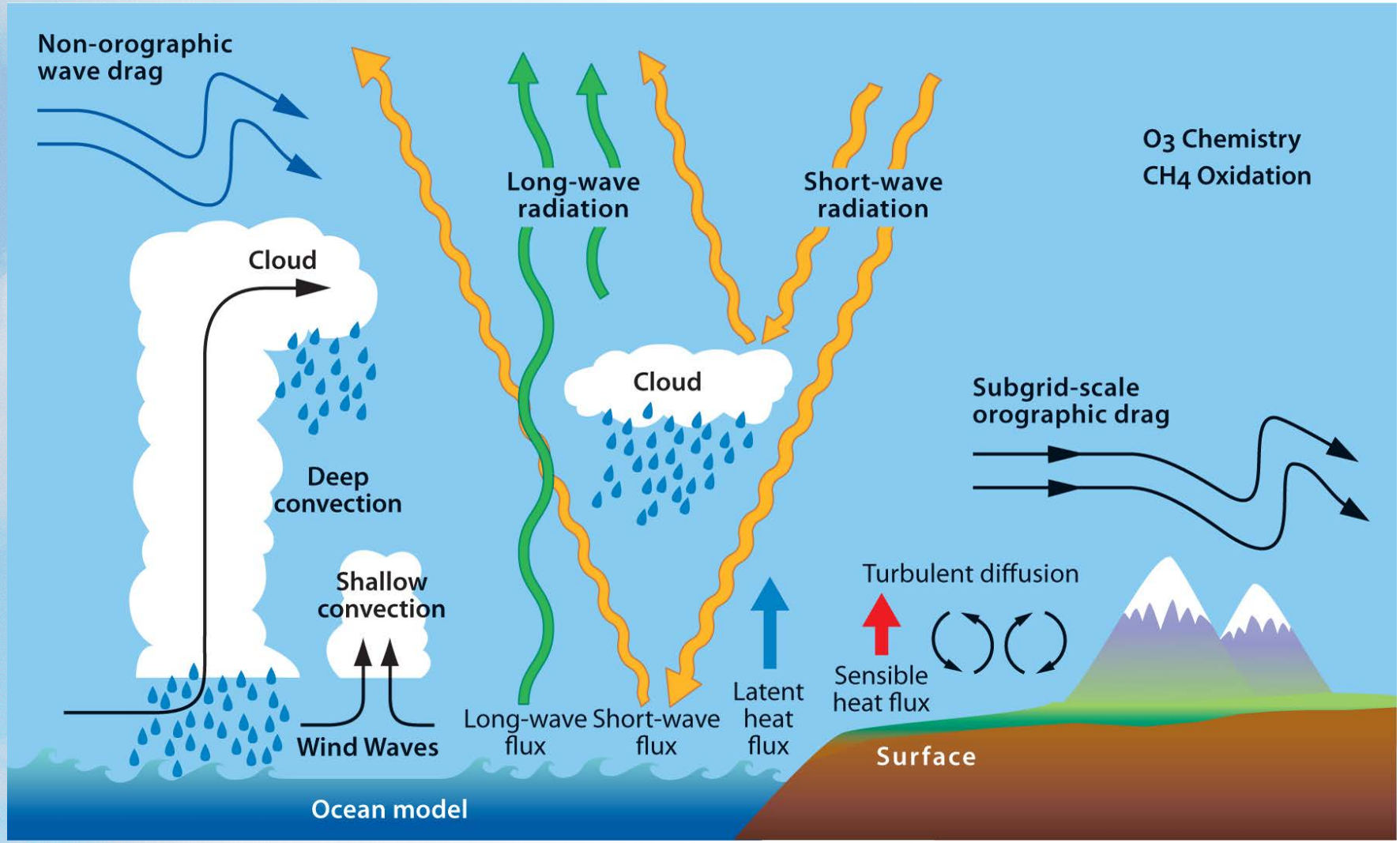
D+10

98.5
95.5
90
80
70
60
50
40
30

1981 1984 1987 1990 1993 1996 1999 2002 2005 2008 2011

Adapted and extended from Simmons & Hollingsworth (2002)

Physical aspects, included in IFS



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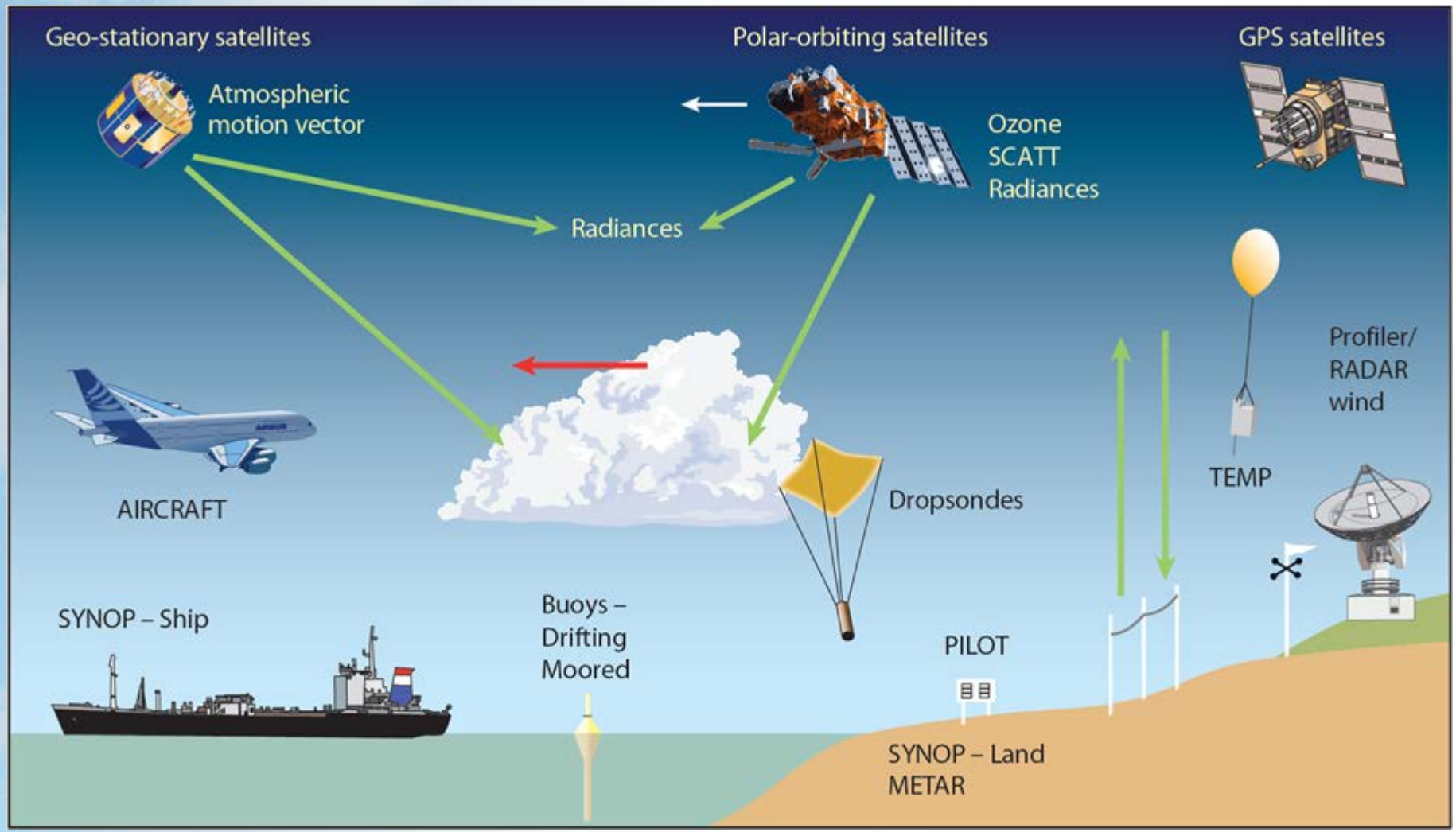
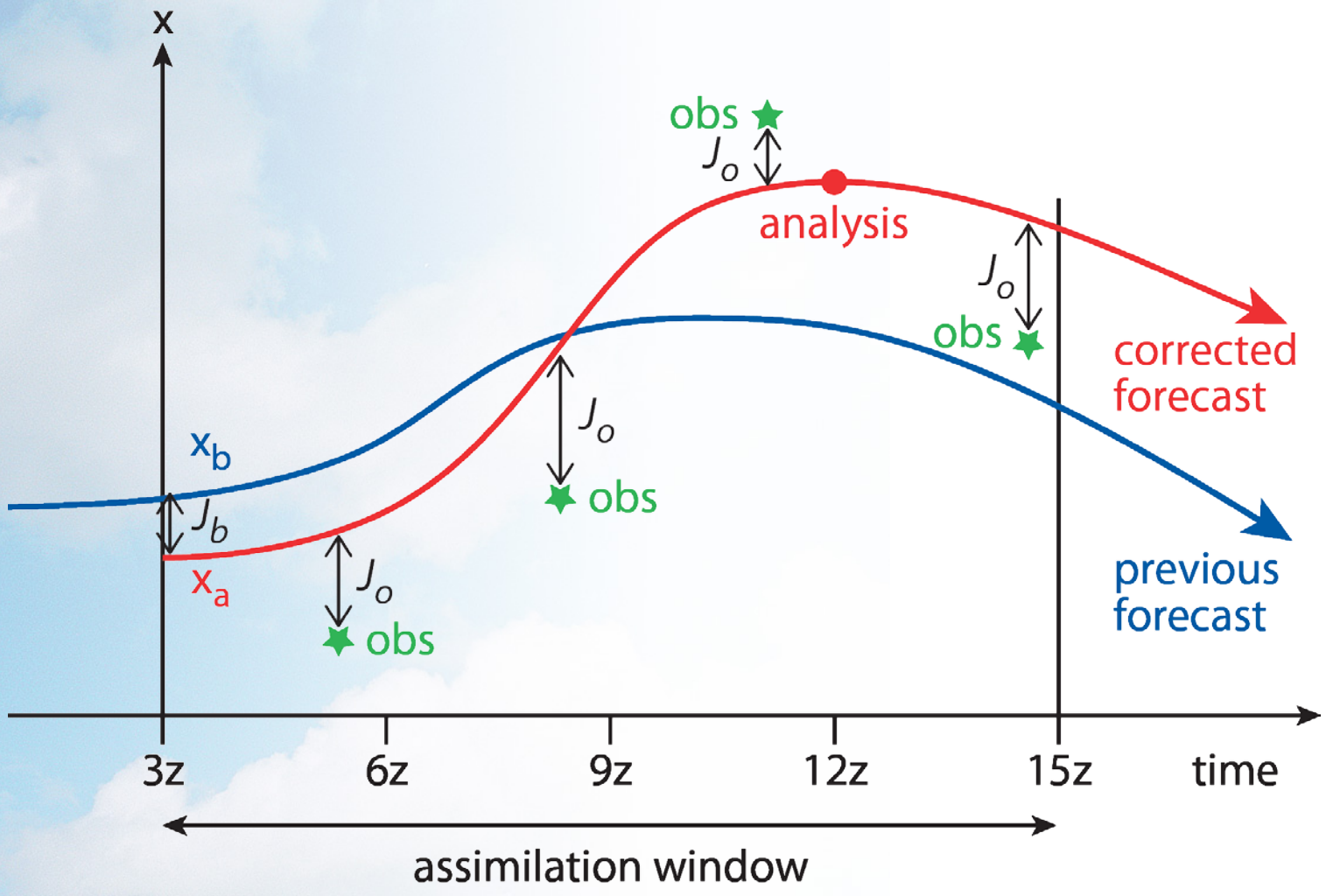
Data assimilation



Variational data assimilation



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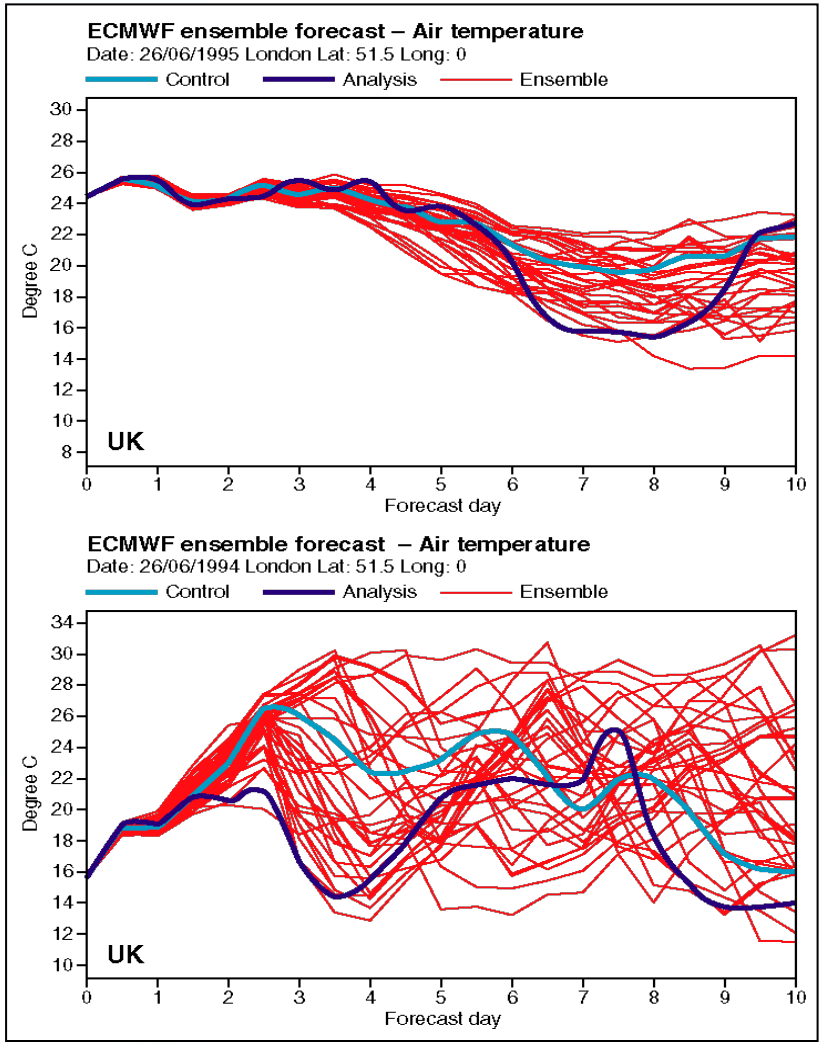
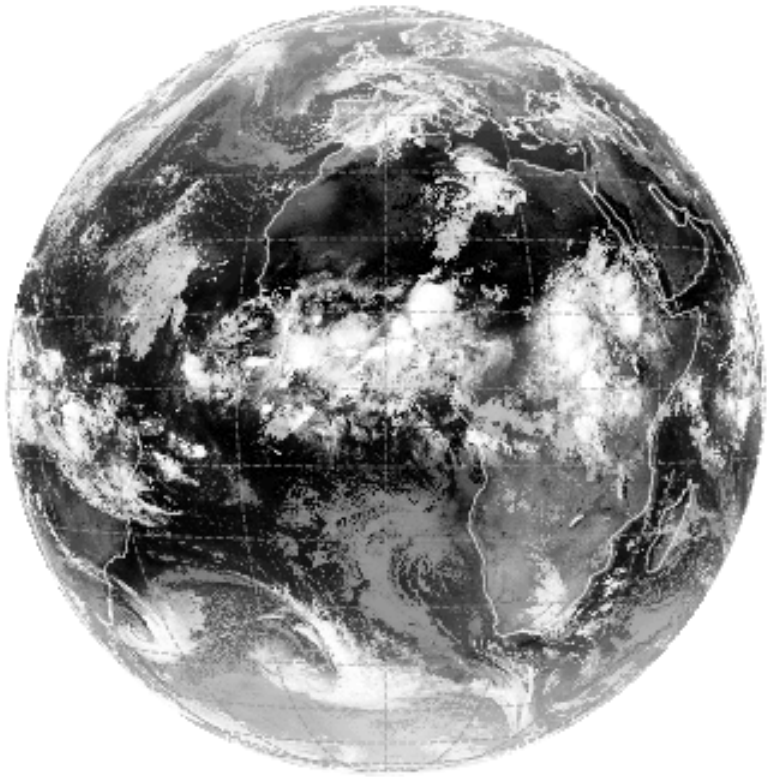
Predictability, diagnostics and extended-range forecasting

The atmosphere is a chaotic system

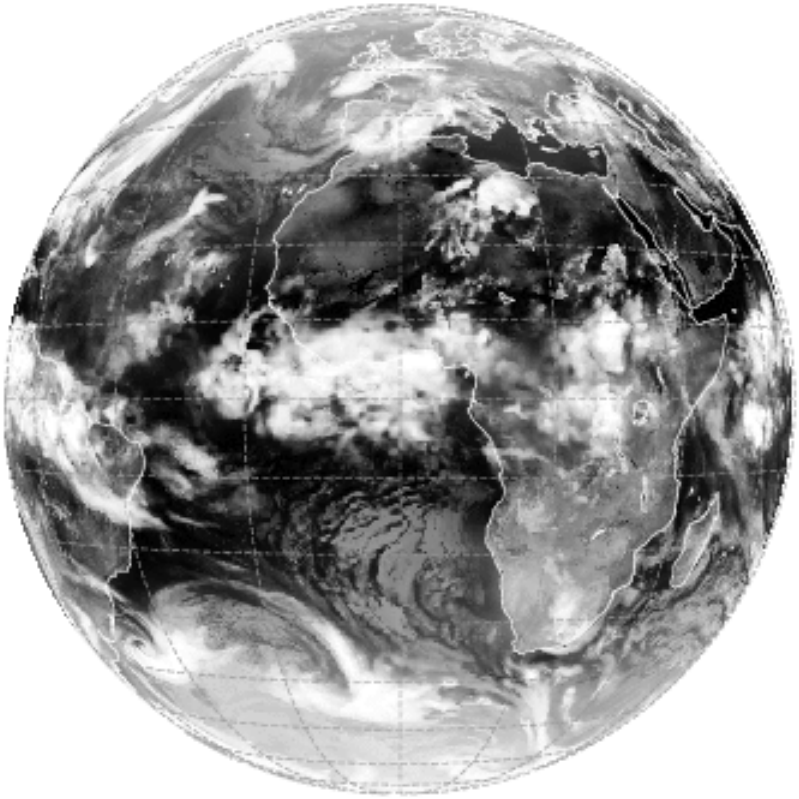
- Small errors can grow to have major impact (butterfly effect)
- This limits detailed weather prediction to a week or so ahead
- Slowly evolving components of the climate system can give predictability at longer timescales



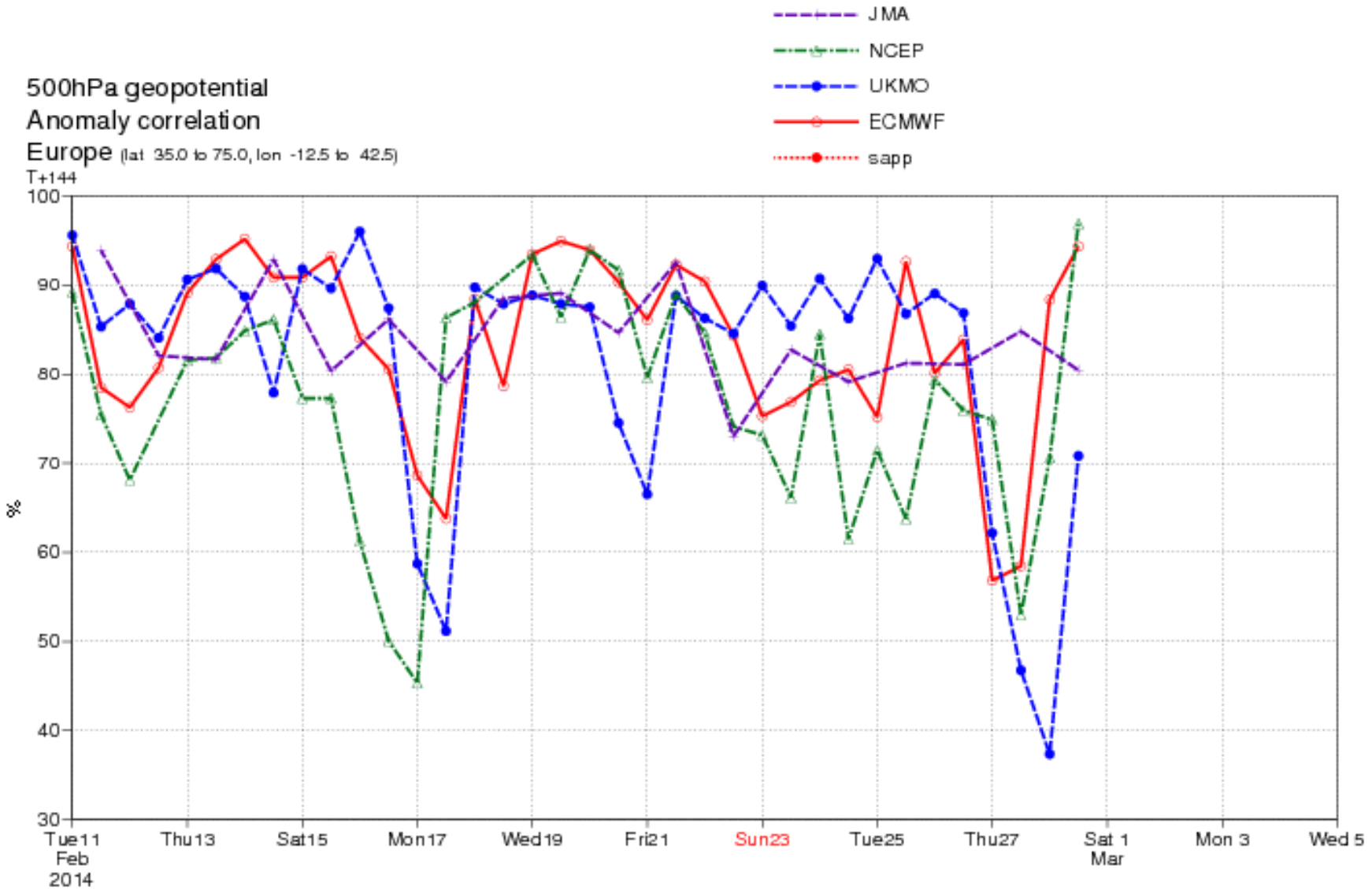
Meteosat 9 IR10.8 20080525 0 UTC



ECMWF Fc 20080525 00 UTC+0h:



Meteorological Operations



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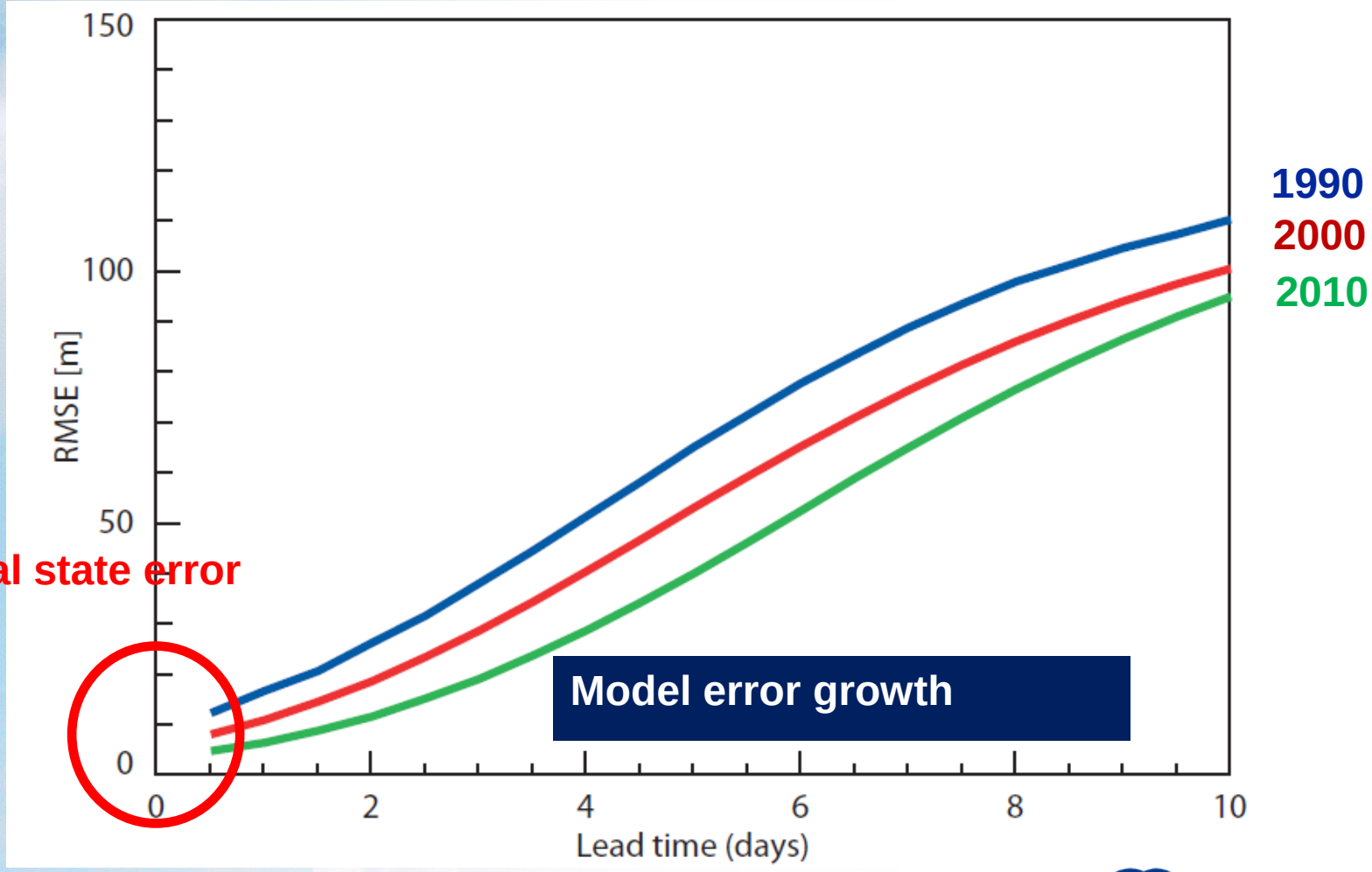
ECMWF Research

Erland Källén
Director of Research
ECMWF

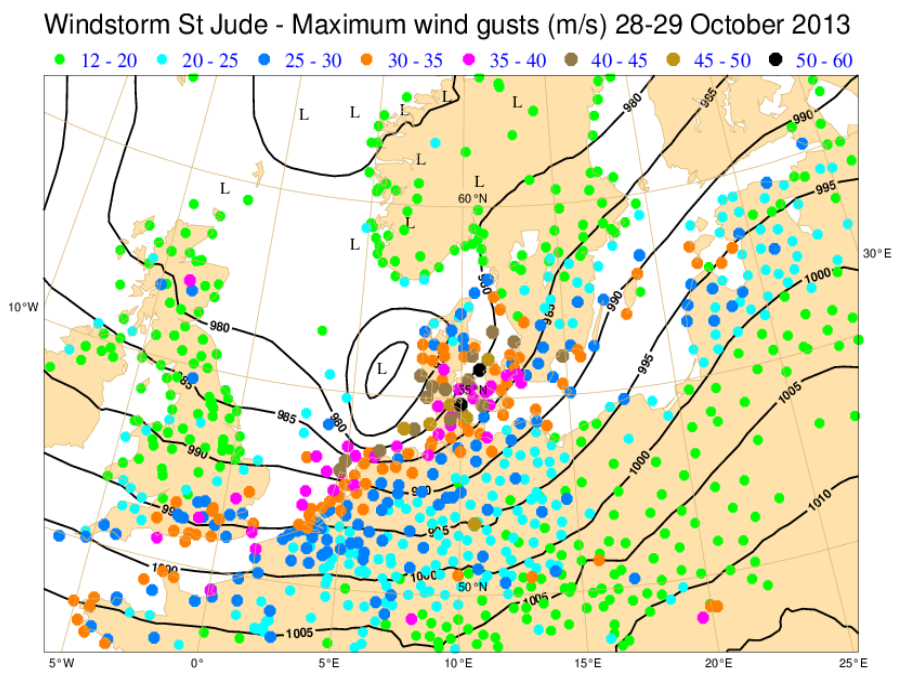
RMS error of 500 hPa height field Northern Hemisphere

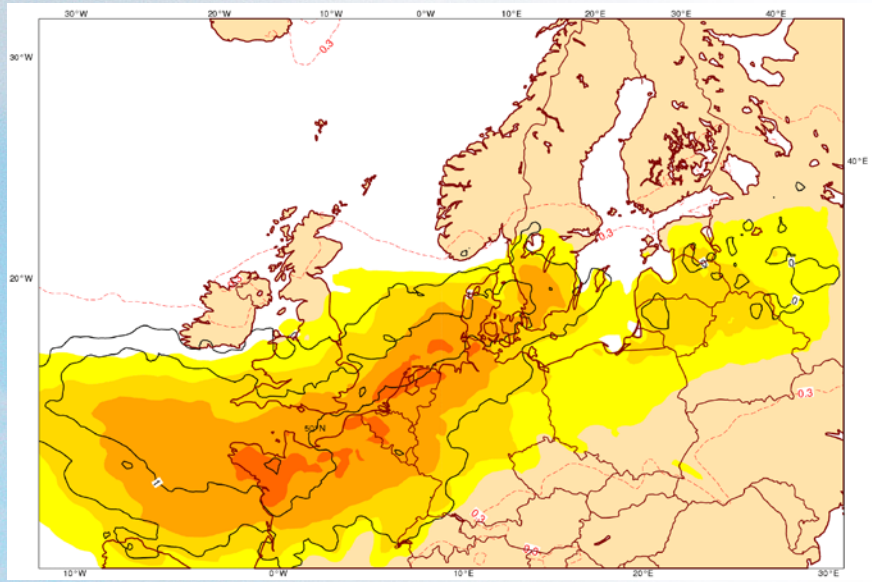


Outline

- Operational scores
- Clouds and surface processes
- Increasing resolution
- Ensemble prediction
- Data assimilation
- Reanalysis
- Chemical modelling and assimilation

Wind storm NW Europe 28 October 2013





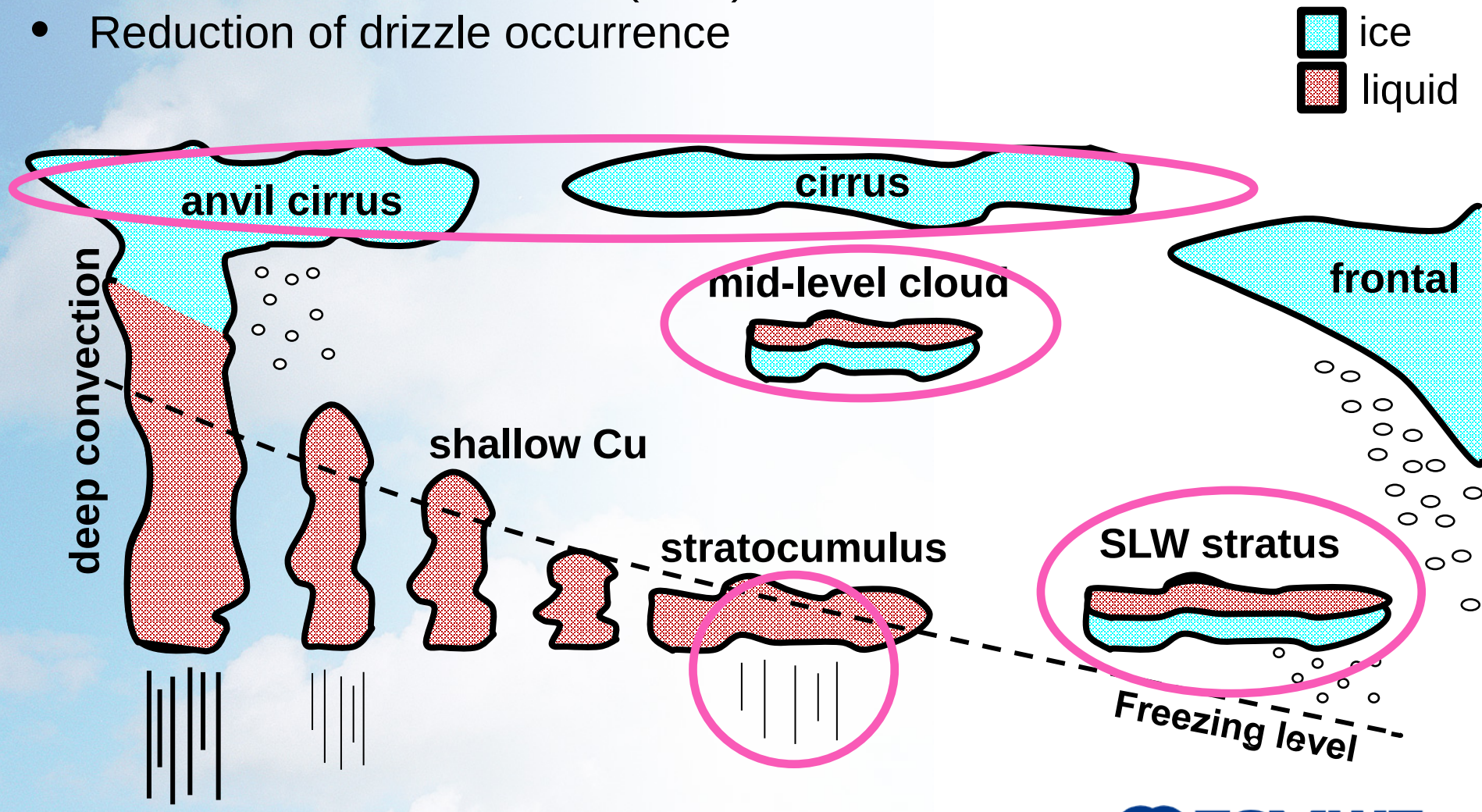
Signal from 4-5 days ahead in the Extreme Forecast Index (EFI)

Model: Physical aspects

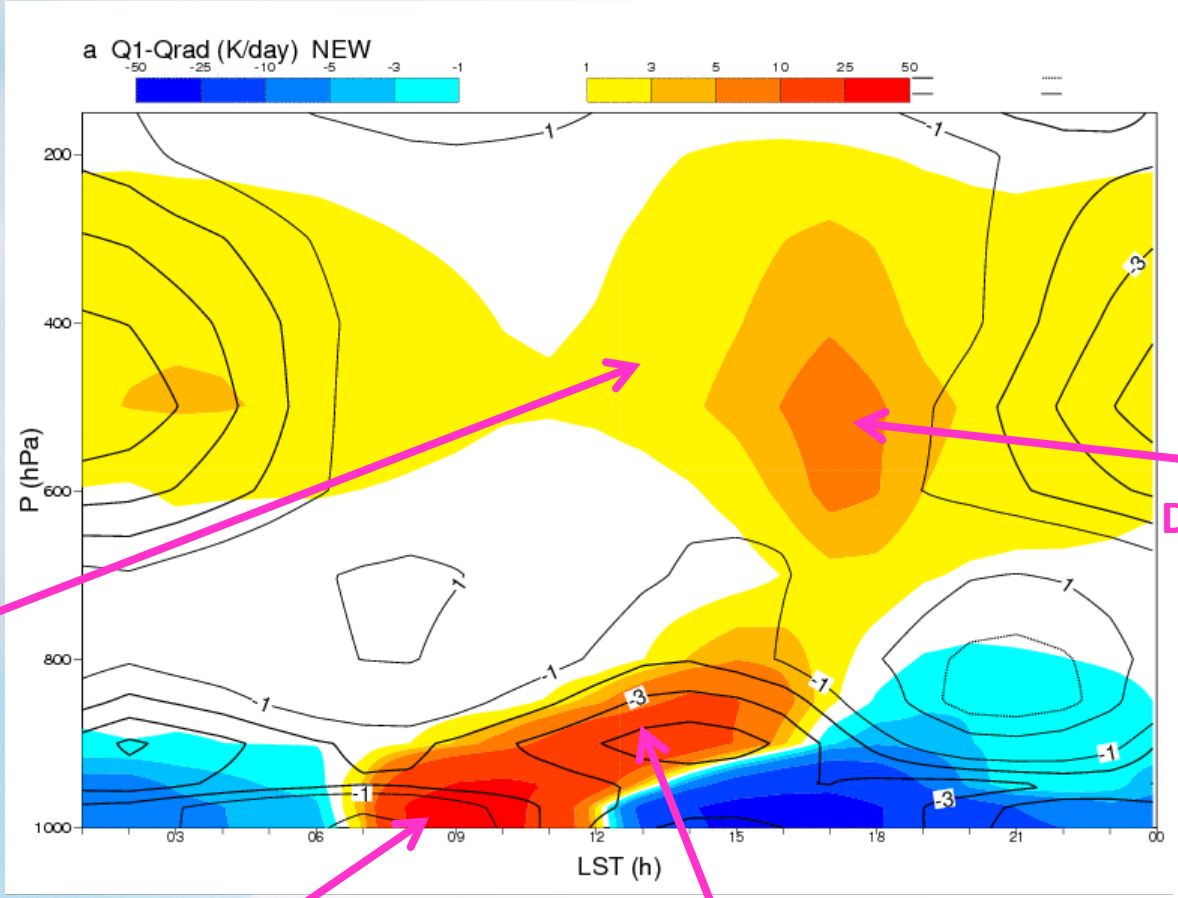
- Cloud microphysics
- Convection scheme revisions
- Stable boundary layer – roughness lengths
- Radiation and aerosols

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



Diurnal evolution of total heating profile -radiation



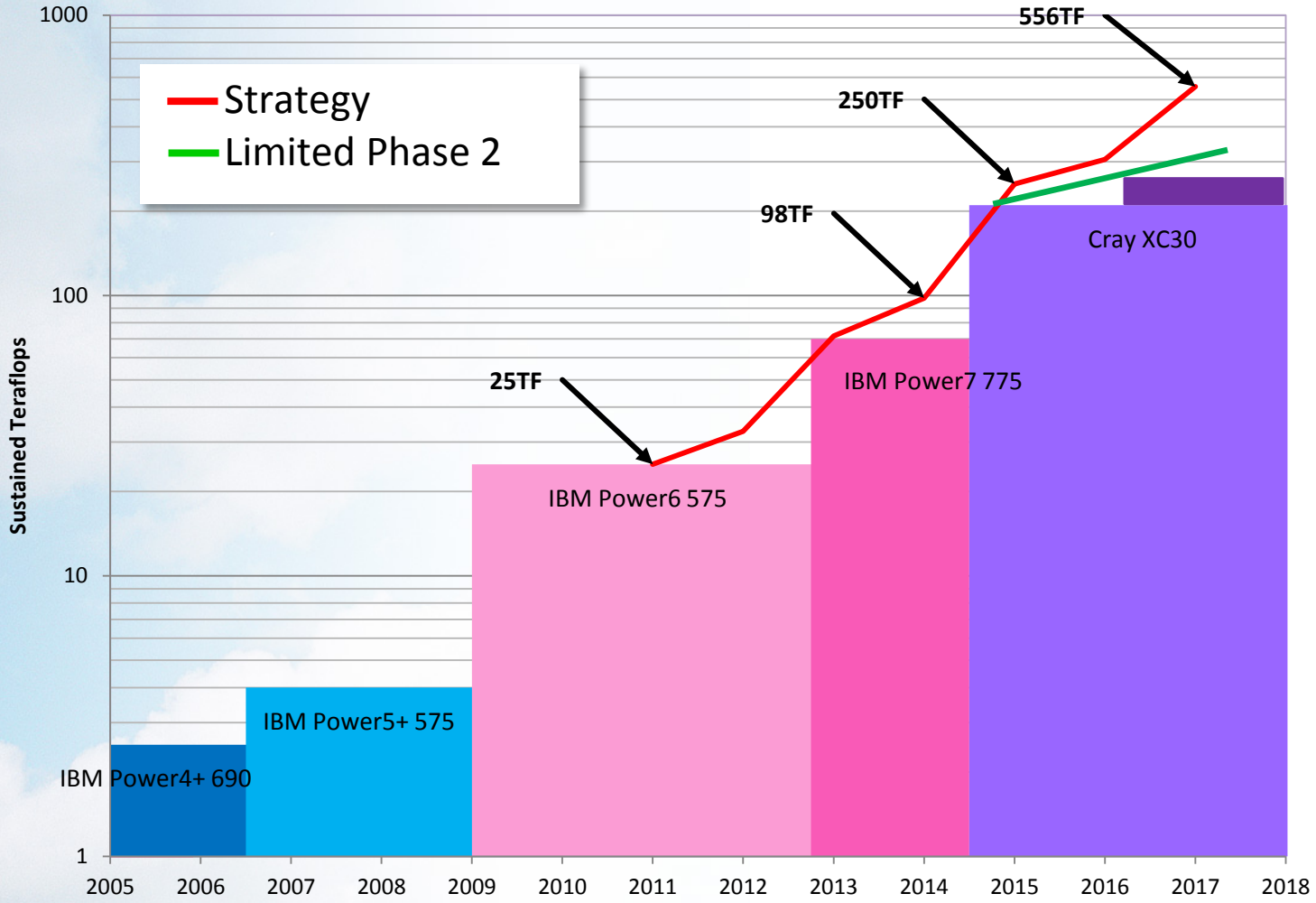
congestus

Deep convection

Turbulent heat flux

Shallow convection

HPCF performance vs Strategy



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Scalability activities

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

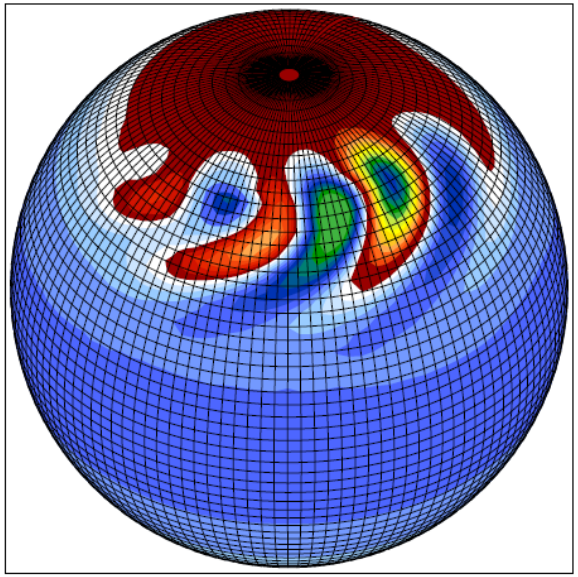
Model: Numerical aspects

- Resolution increases
  - Horizontal: 16 km in 2010 →10 km in 2015 → ≈5 km in 2020
  - Vertical: 91 → 137 levels in 2013
- Fast Legendre transforms
- Non-hydrostatic model
- Mass conservation

Strategy for IFS dynamical core

- Unified hydrostatic-anelastic equations
- Extend to nonhydrostatic formulation
- Retain semi-implicit, semi-Lagrangian schemes
- Retain spectral transform technique
- Improve parallelisation/scalability by implementing unstructured grids

EULAG on full Gaussian grid



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
  - Flooding/drought prediction
  - Health

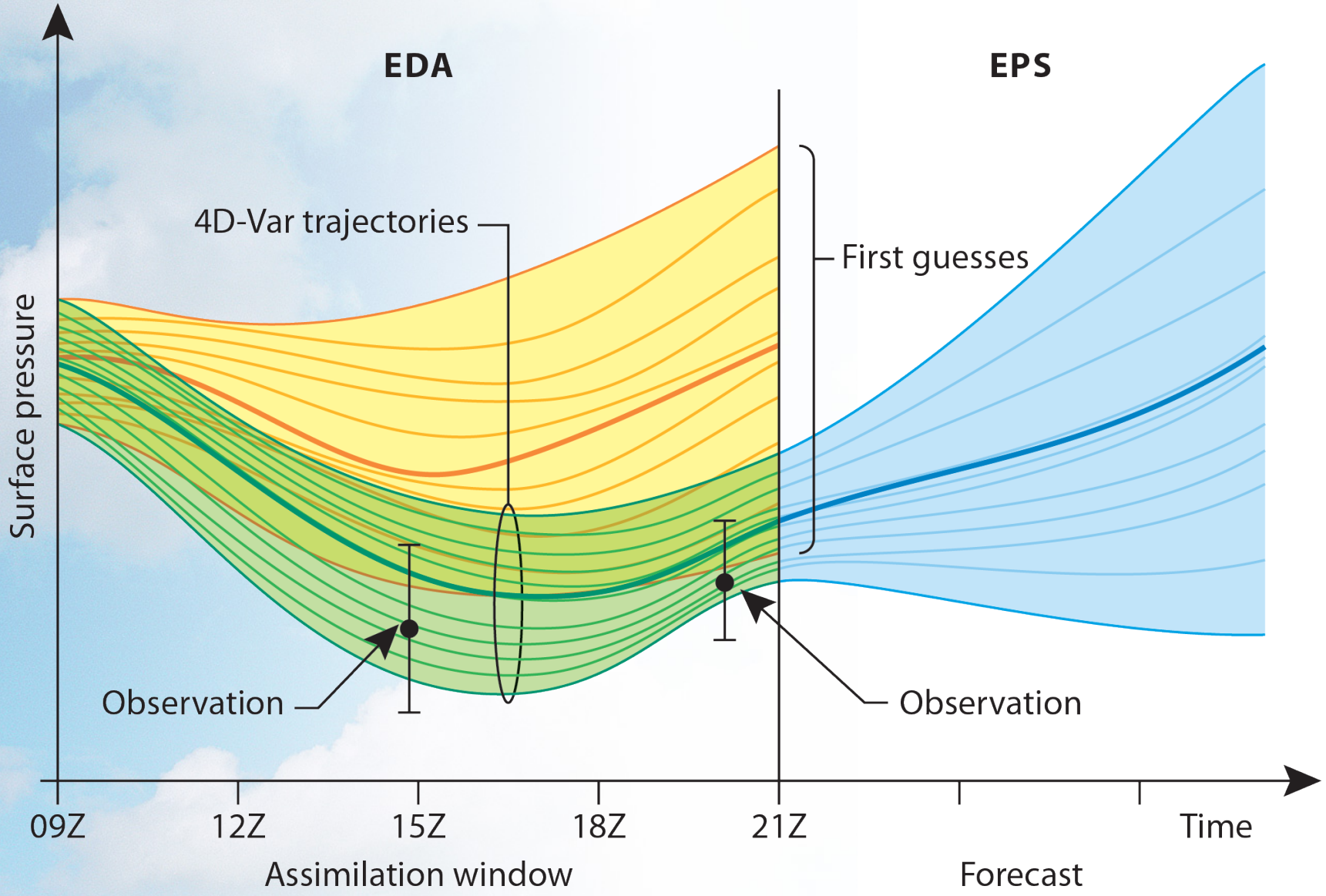
Performance of the monthly Forecasts since 2002

Hindcasts covering the period 1995-2001

Data assimilation

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

Ensemble assimilation and prediction



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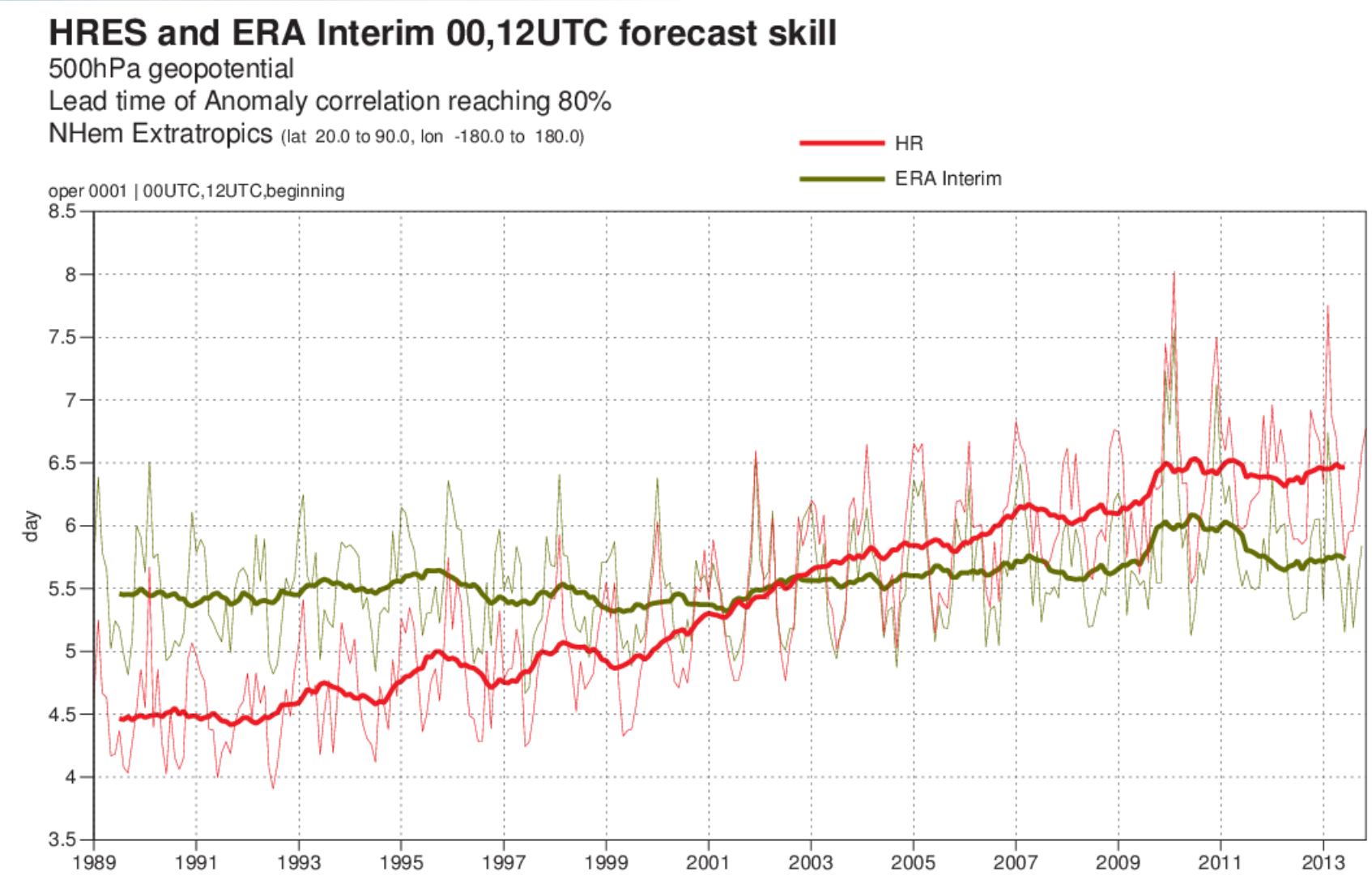
Z500 Time series of ACC=80% N hemisphere

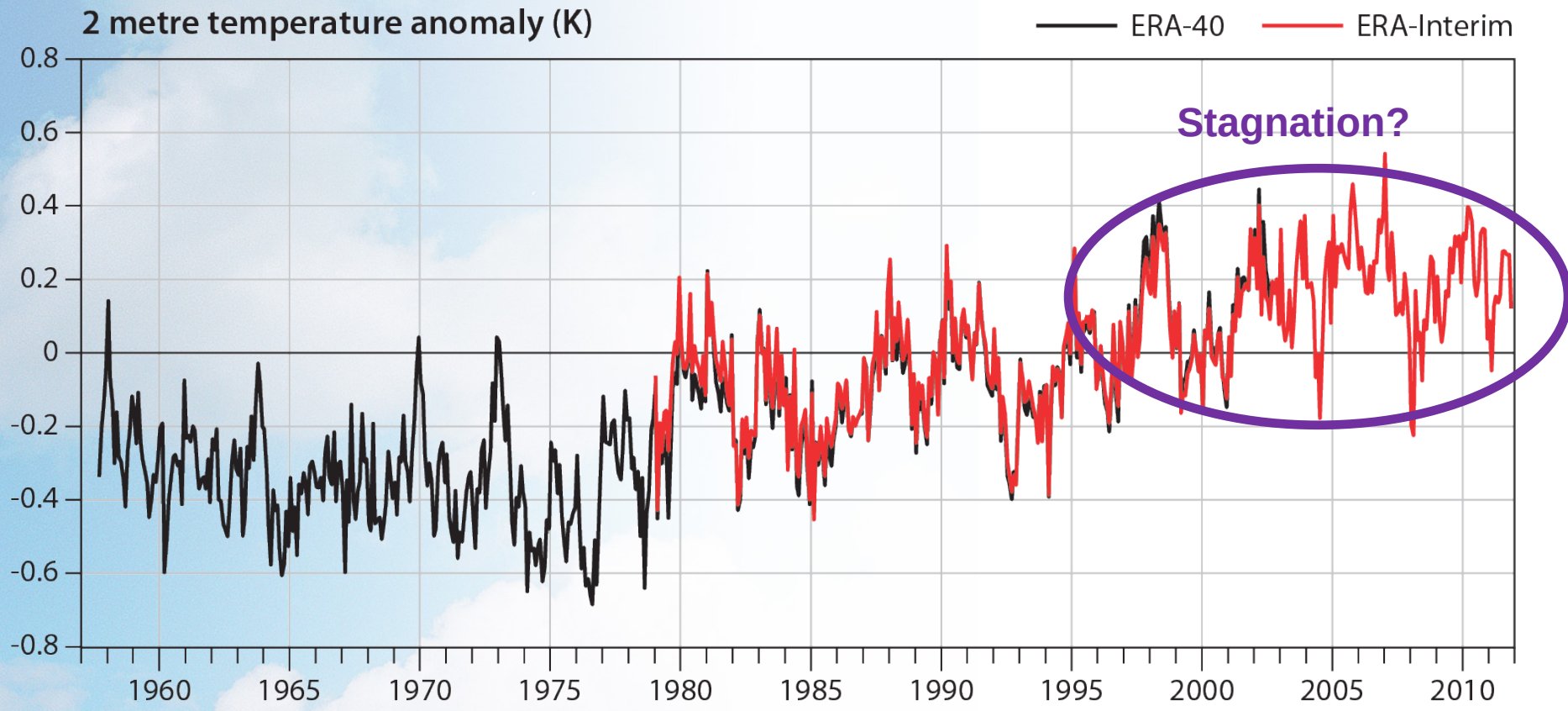


Reanalysis (ERA)

- Climate monitoring in near real time
- ERA-20th century reanalysis in preparation
- Ocean reanalysis

Global Warming since 1957

Anomalies of monthly-means relative to 1989 – 2001 average



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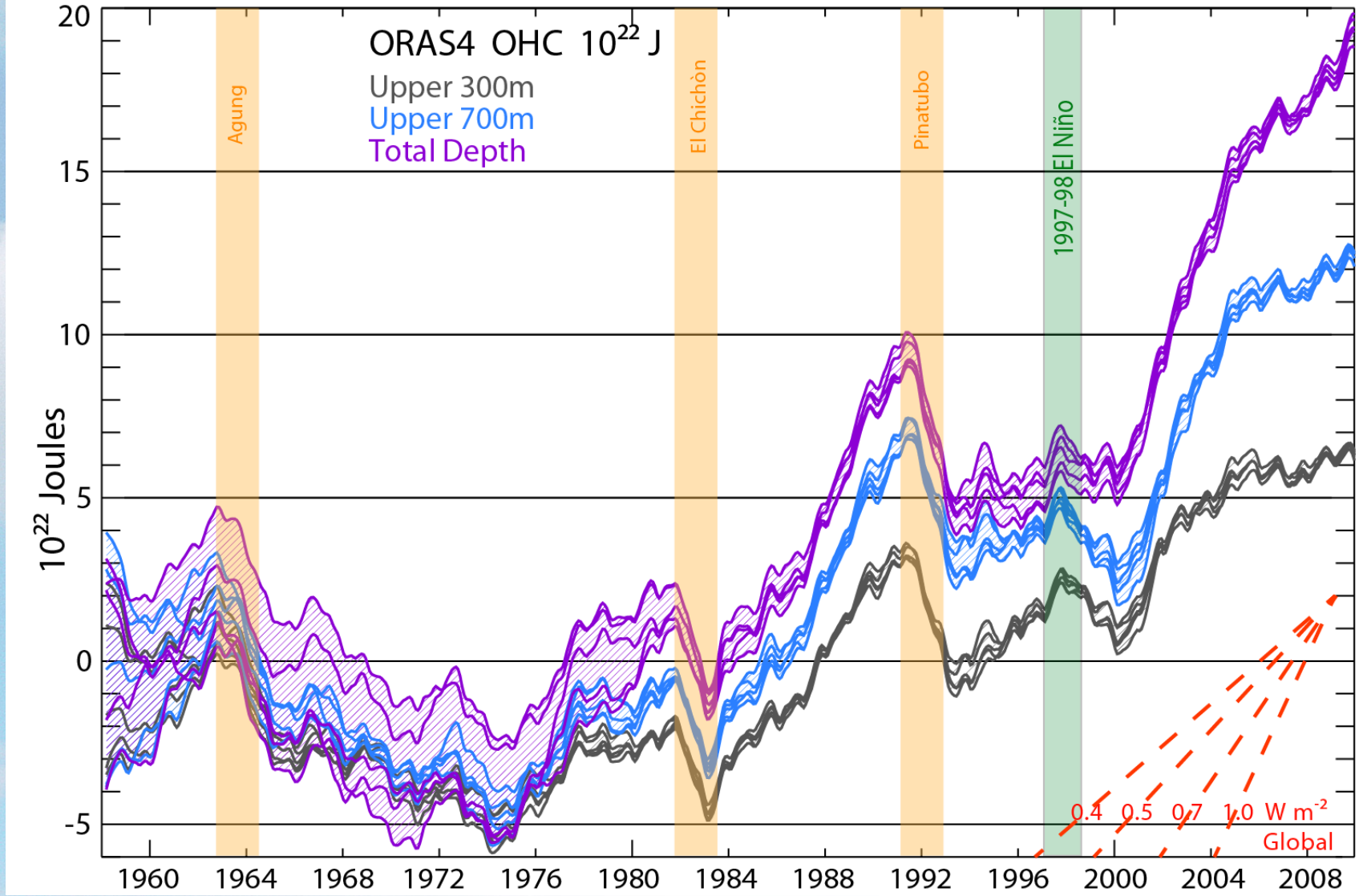
Time evolution of ocean heat content



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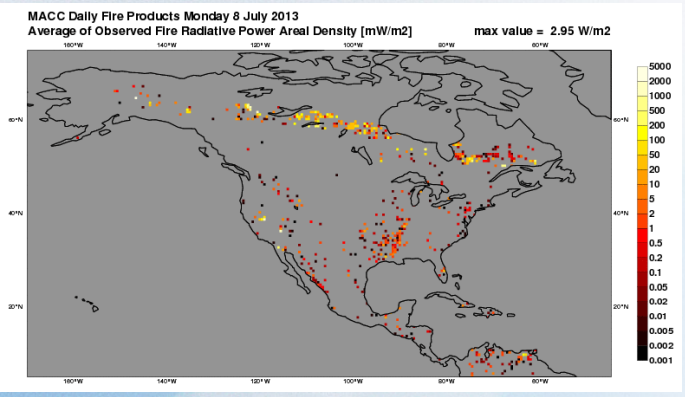
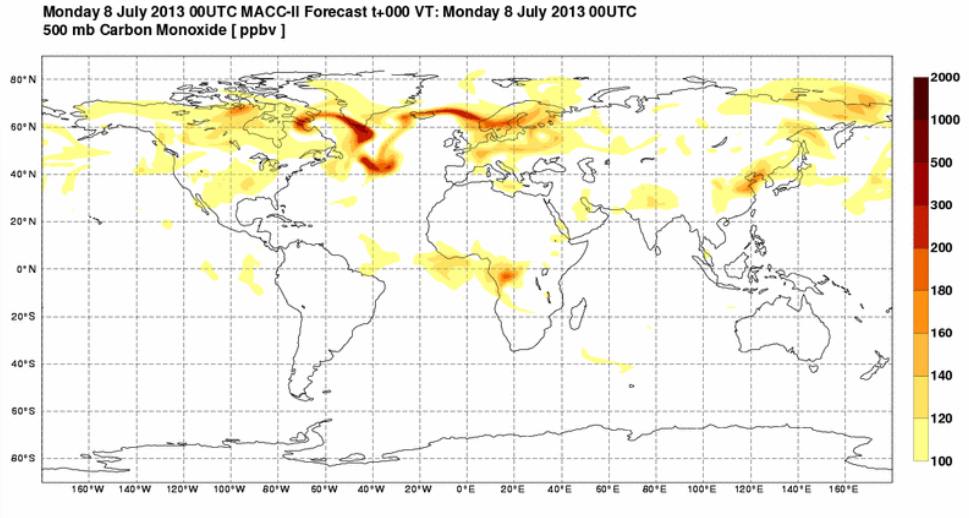
Atmospheric composition

- Modelling and data assimilation
- Monitoring and evaluation
- Impact on NWP – aerosols


July 2013
Canadian smoke over Europe

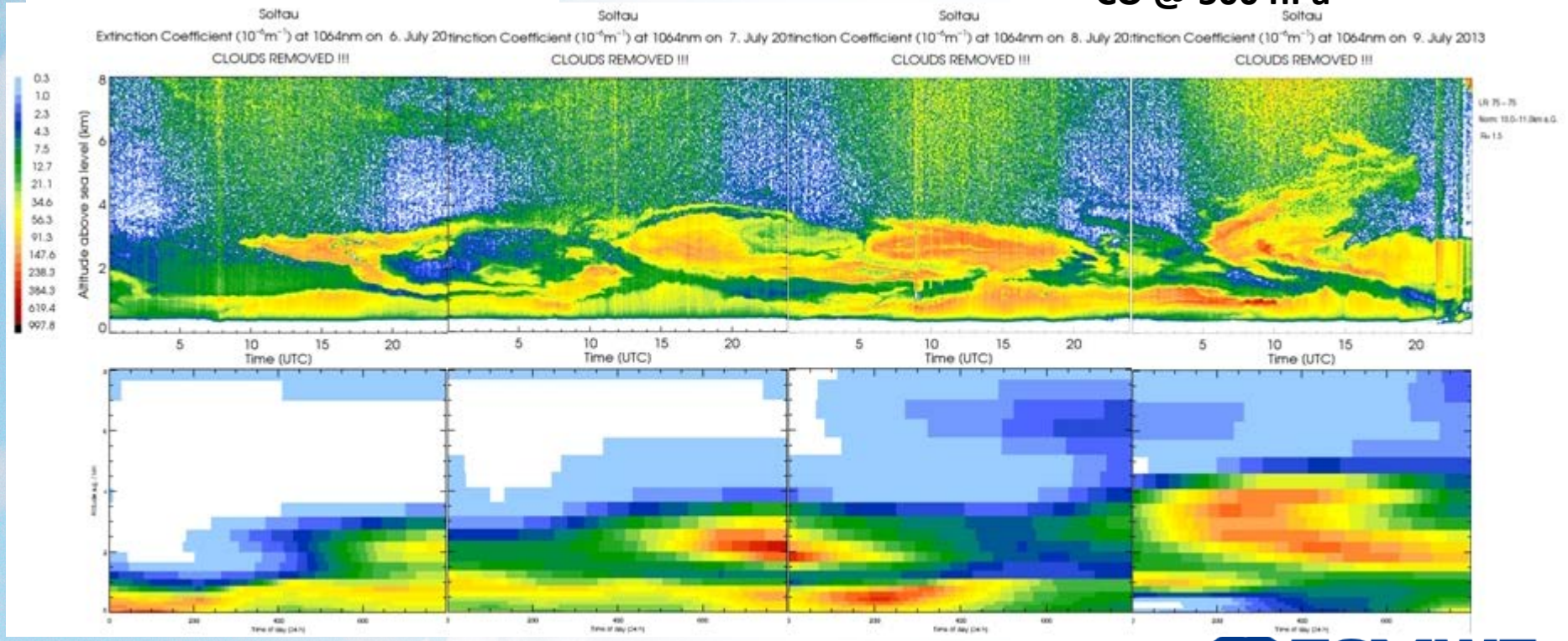


GFAS



CO @ 500 hPa

Ceilometer, obs. & simul.



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Summary

- ECMWF world leader medium range weather forecasting
- Variational and ensemble data assimilation
- Very high resolution possible
- Atmospheric composition
- Reanalysis