

# ECMWF forecasting system - Research and development

Erland Källén  
Director of Research  
ECMWF

# Global observation system



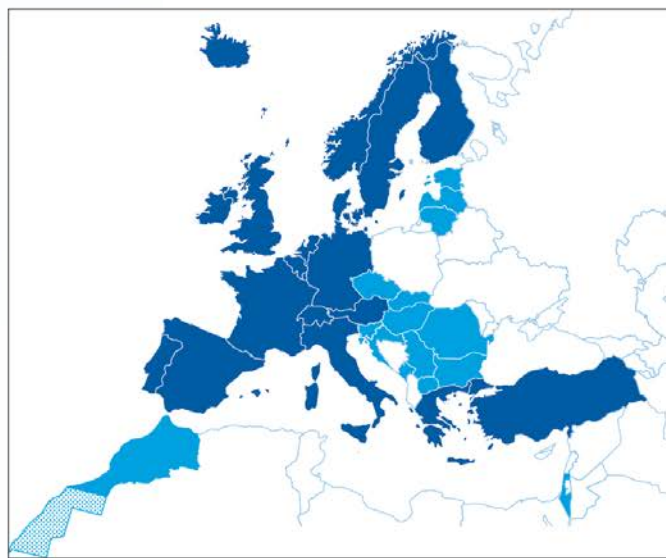
# Global numerical weather forecasts



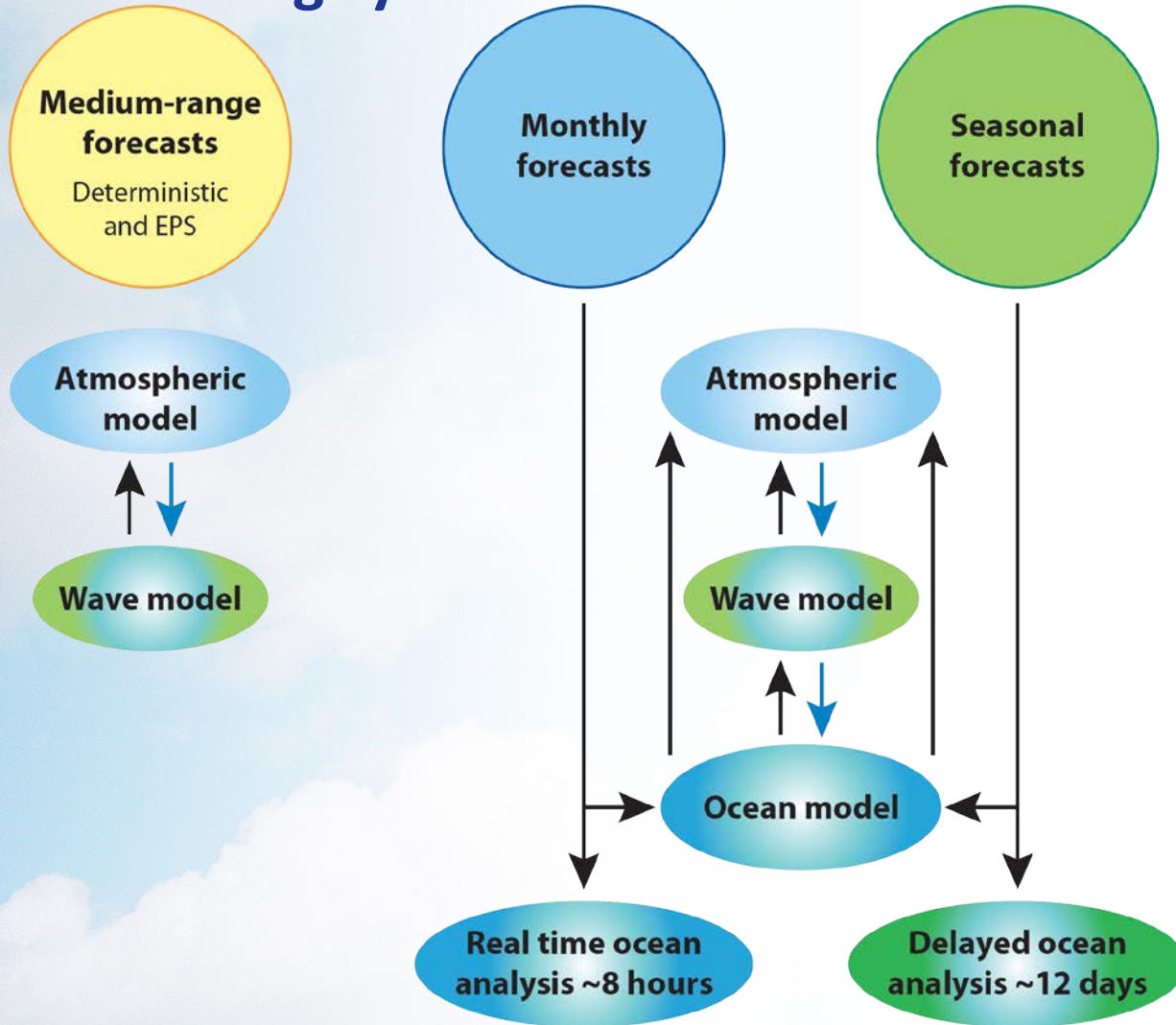
# Users



# National weather services



# ECMWF forecasting systems



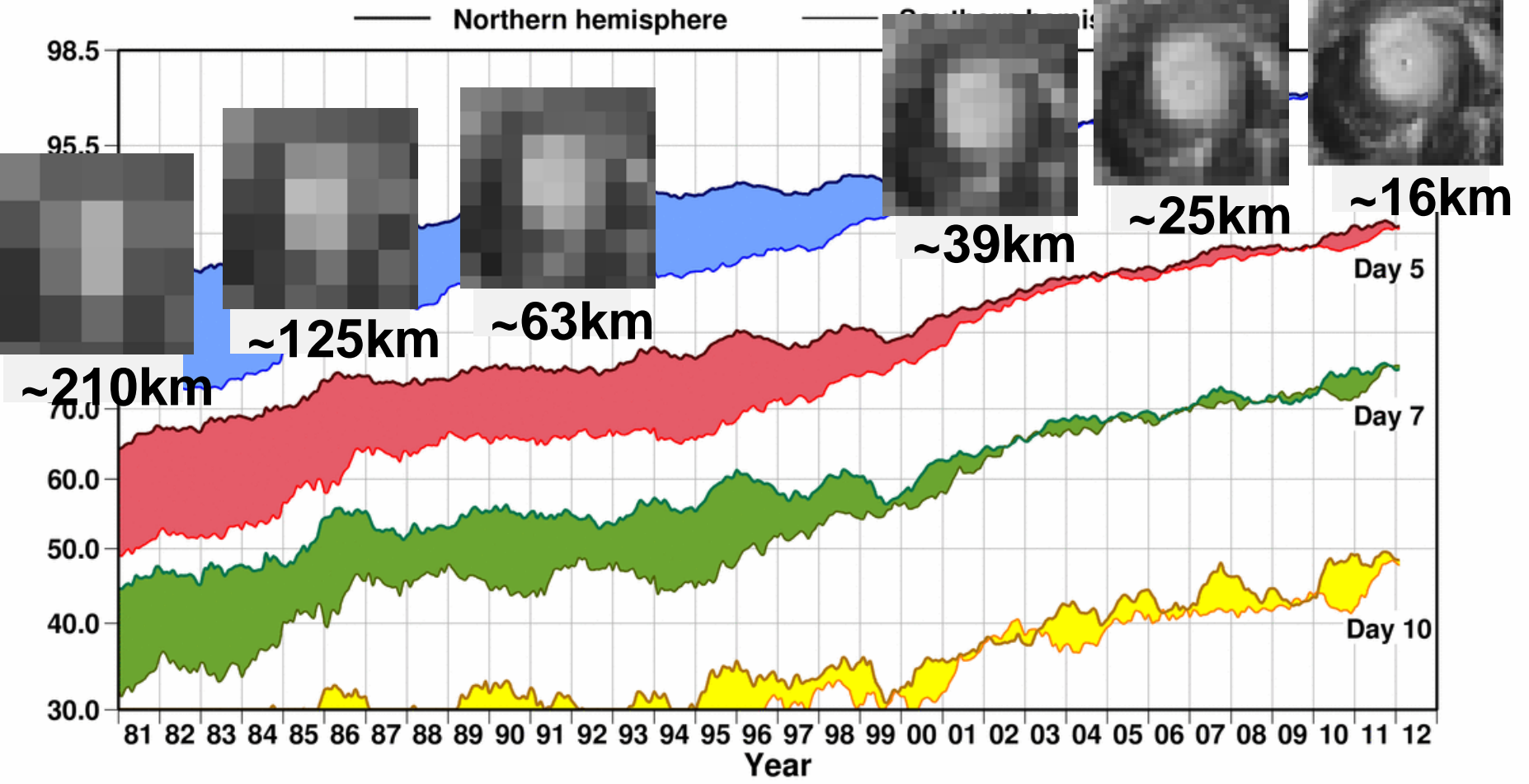
# Present main operational forecast models

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- Global, high resolution forecast model
  - 16 km grid point distance
  - 91 vertical levels
  - Forecast range: 10 days (10 min time steps)
- Ensemble Prediction System
  - 50+1 parallel forecasts
  - Perturbed initial conditions and model error
  - 32 km grid point distance

# Evolution of ECMWF forecast skill

Anomaly correlation (%) of ECMWF 500hPa height forecasts

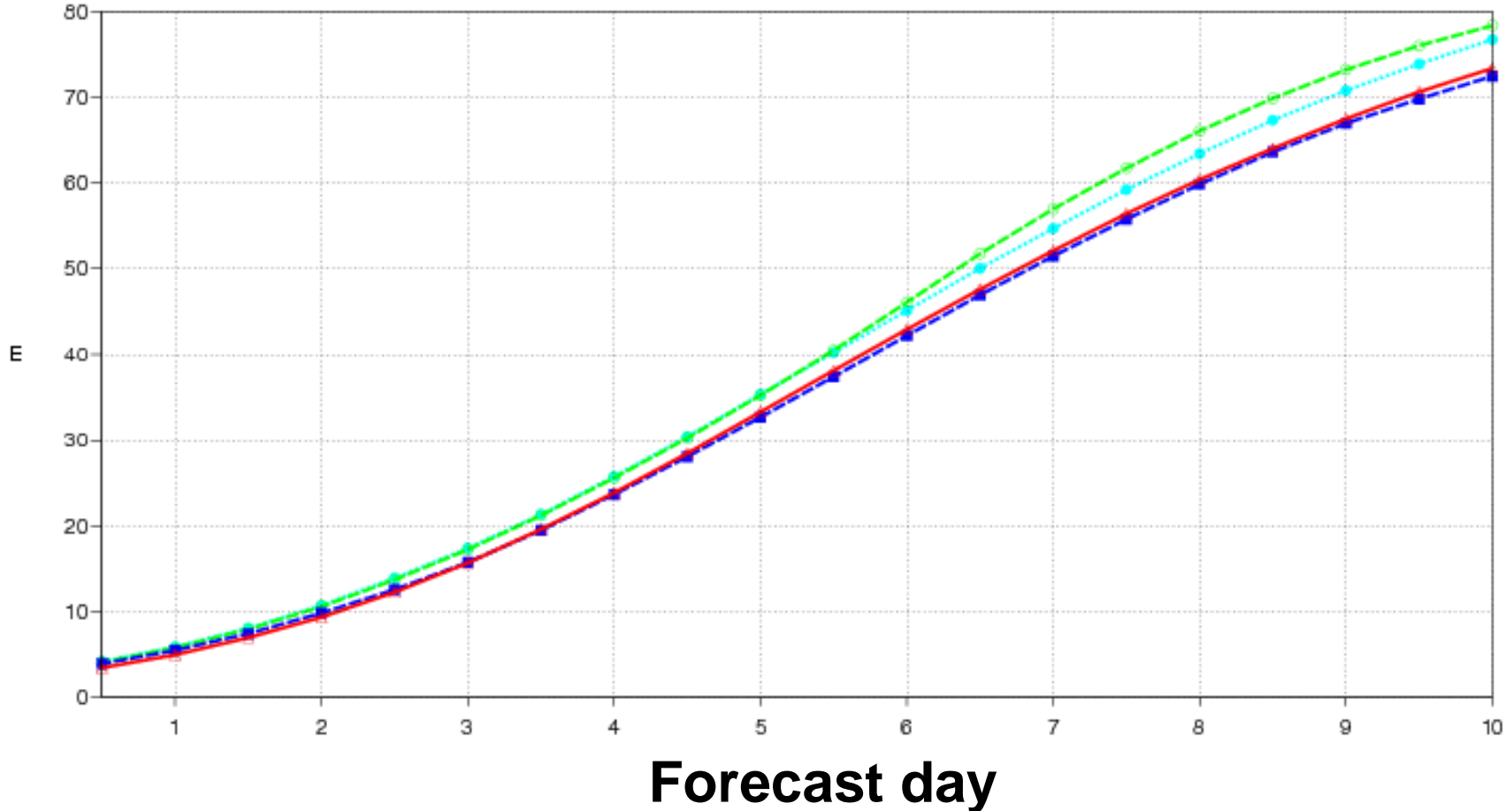


# Root mean square 500 hPa forecast error Northern Hemisphere summer

500hPa geopotential  
Root mean square error  
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)

—△— JunJulAug 2012 **2012**  
- -■- JunJulAug 2011 **2011**  
- -○- JunJulAug 2010 **2010**  
- -●- JunJulAug 2009 **2009**

Mean method: standard



# Comparison with other forecasting centres

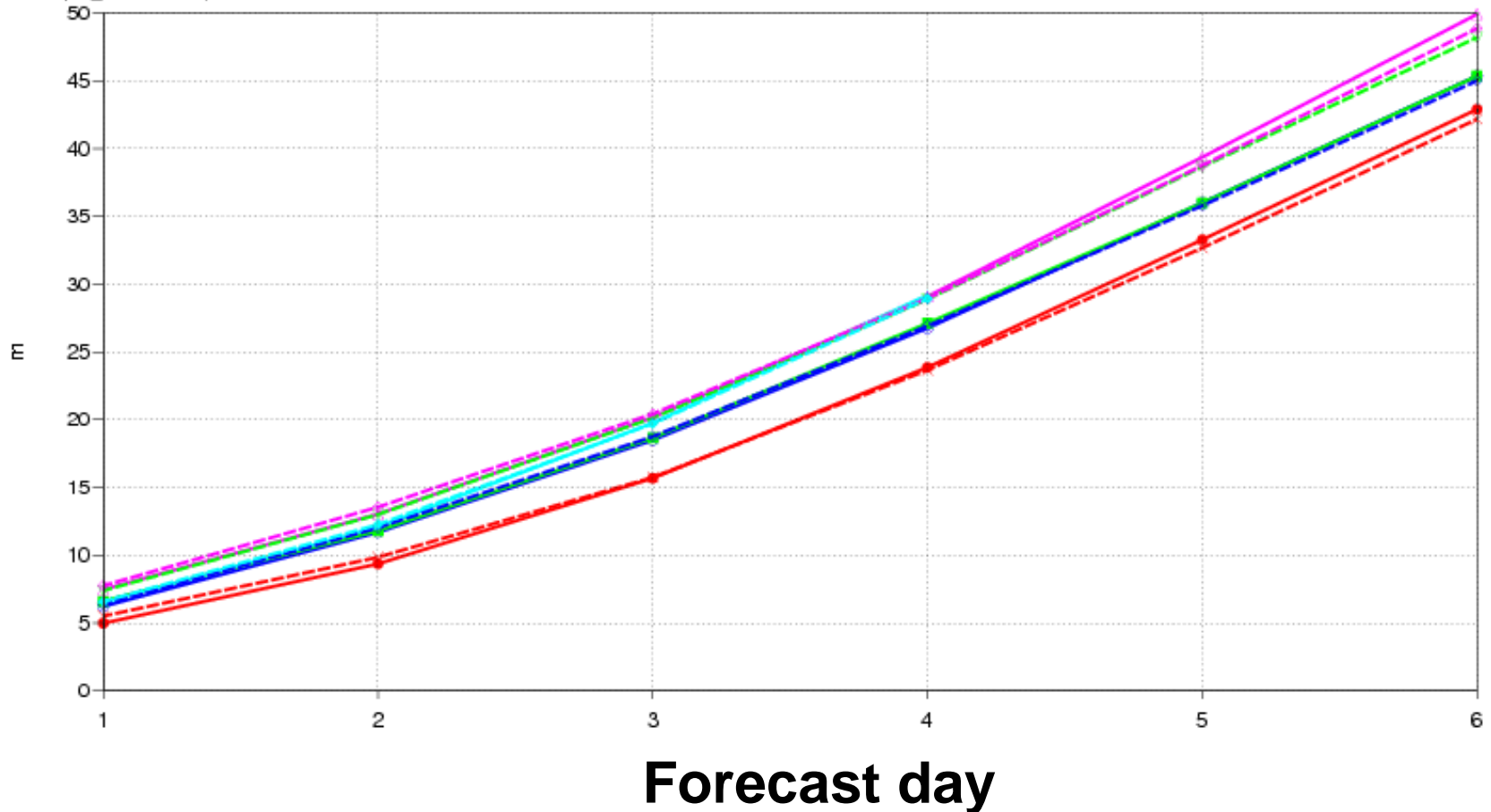
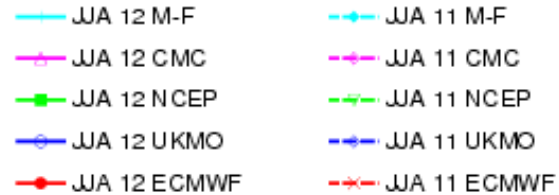
500hPa geopotential

Root mean square error

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

Date: 20110601 00UTC to 20120831 12UTC

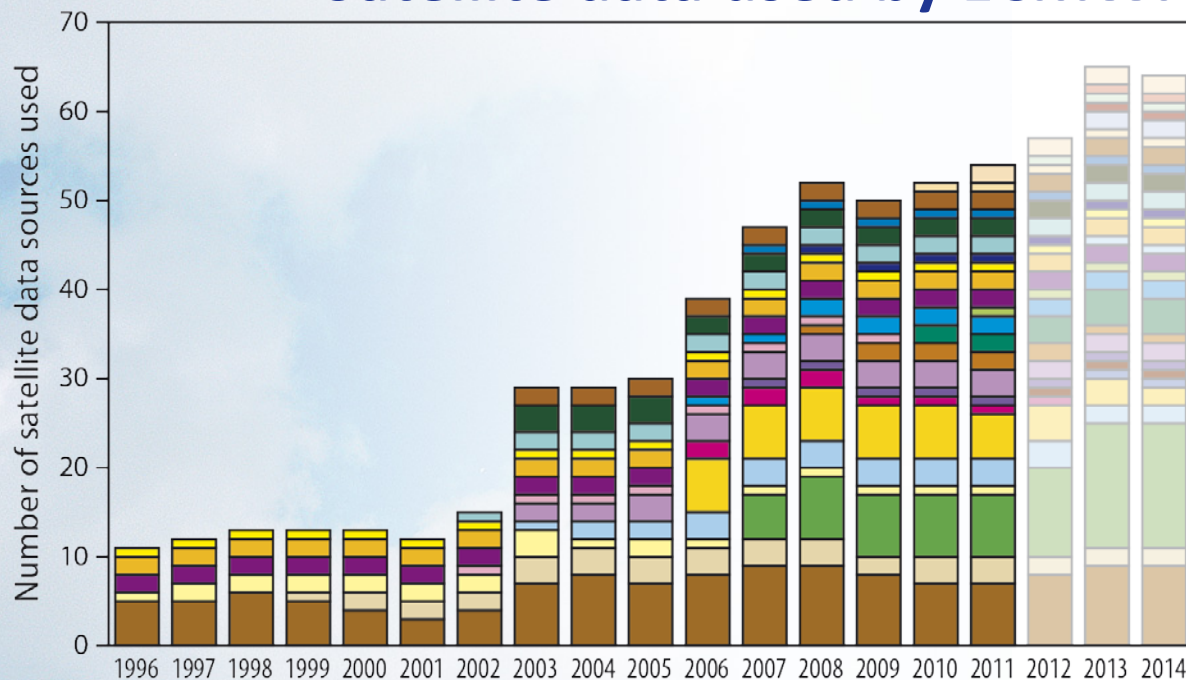
oper\_an od 0001 | Mean method: standard



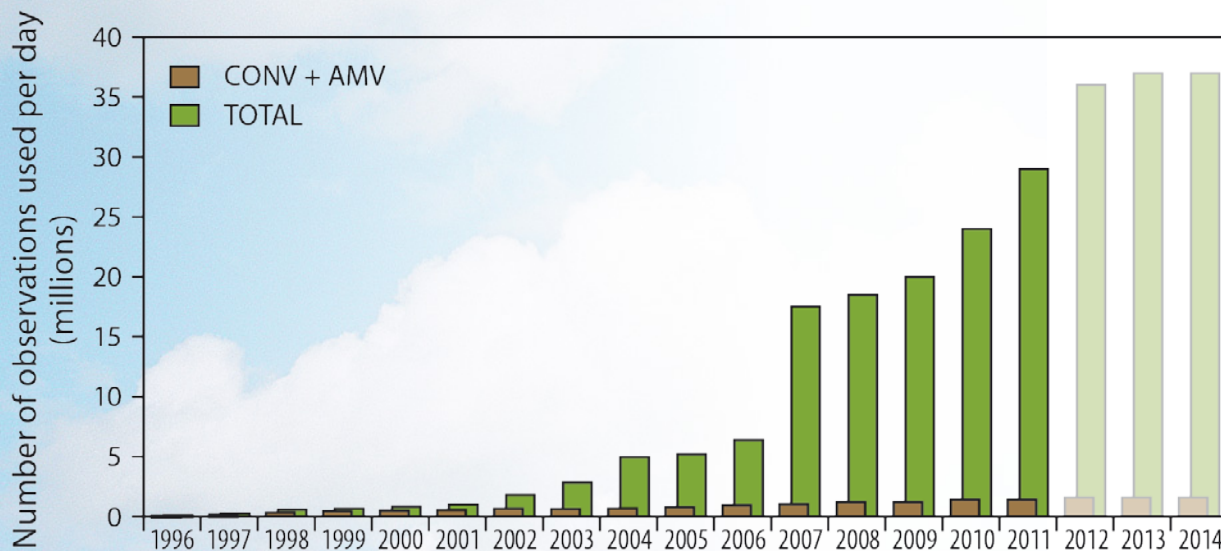




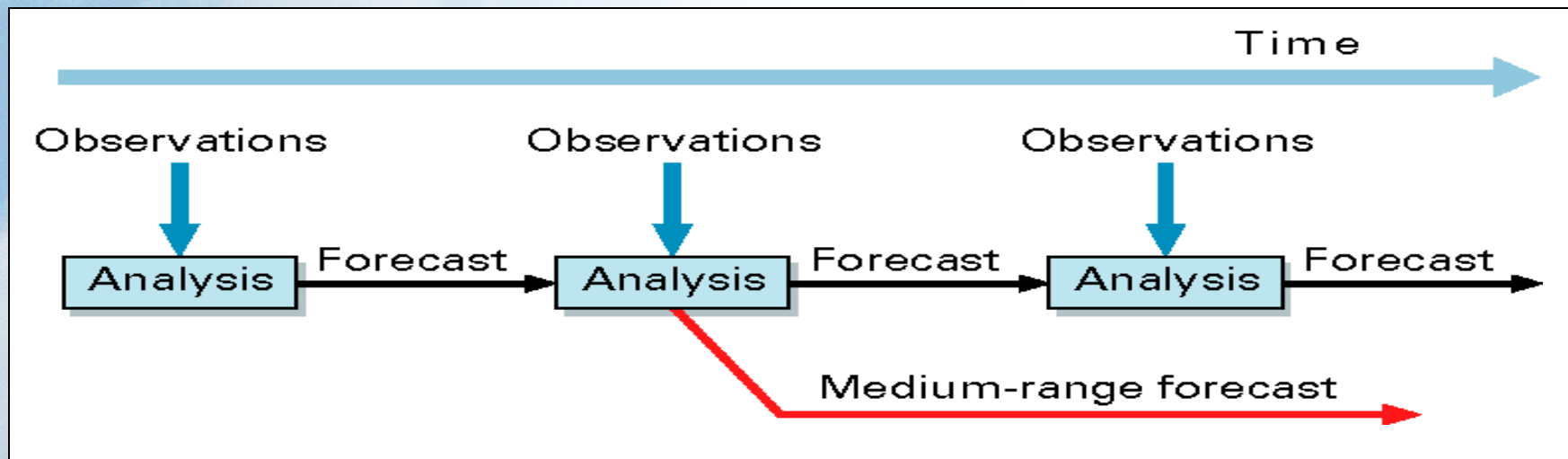
# Satellite data used by ECMWF



- Megha Tropiques
- Sentinel 3
- GOSAT
- ADM Aeolus
- EarthCARE
- SMOS
- TERRA/AQUA AMV
- GMS/MTSAT Rad
- GOES Rad
- METEOSAT Rad
- FY-2C/D AMV
- GMS/MTSAT AMV
- GOES AMV
- HY-2A
- METEOSAT AMV
- Oceansat
- JASON-1/2/3
- QuikSCAT
- FY-3A/B
- AURA
- AQUA
- TRMM
- GCOM-W/C
- CHAMP/GRACE
- TERRASAR-X/SAC-C
- COSMIC
- ENVISAT
- ERS-1/2
- METOP
- DMSP
- NOAA

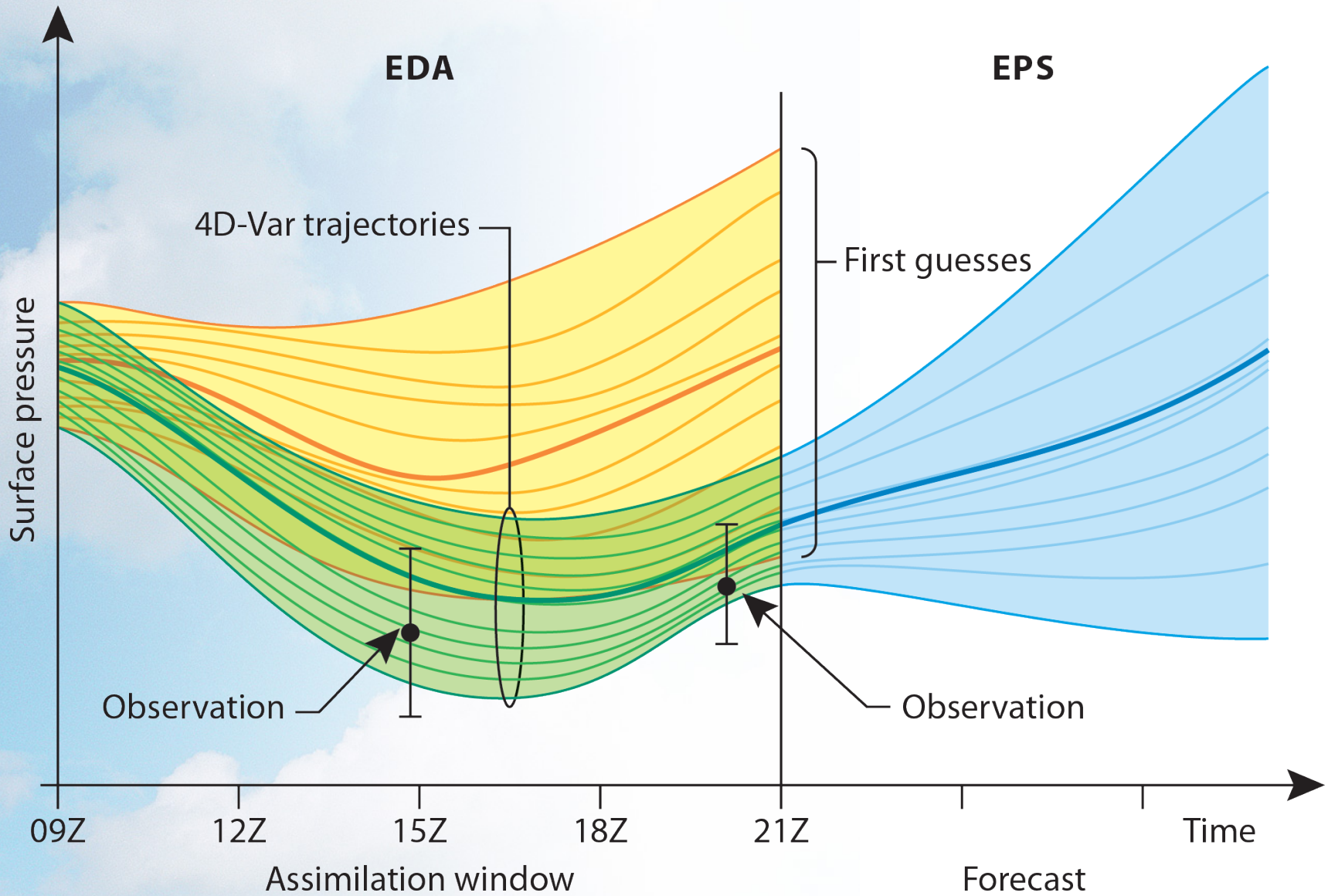


## Data assimilation system (4D-Var)



- The observations correct errors in a short range forecast from the previous analysis time.
- Every 24 hours we assimilate  $3 \cdot 10^7$  observations to correct the model's virtual atmosphere ( $2 \cdot 10^9$  variables).
- 4-dimensional interpolation in space and time, 4D-Var; takes as much computer power as the 10-day forecast.

# Ensemble assimilation and prediction



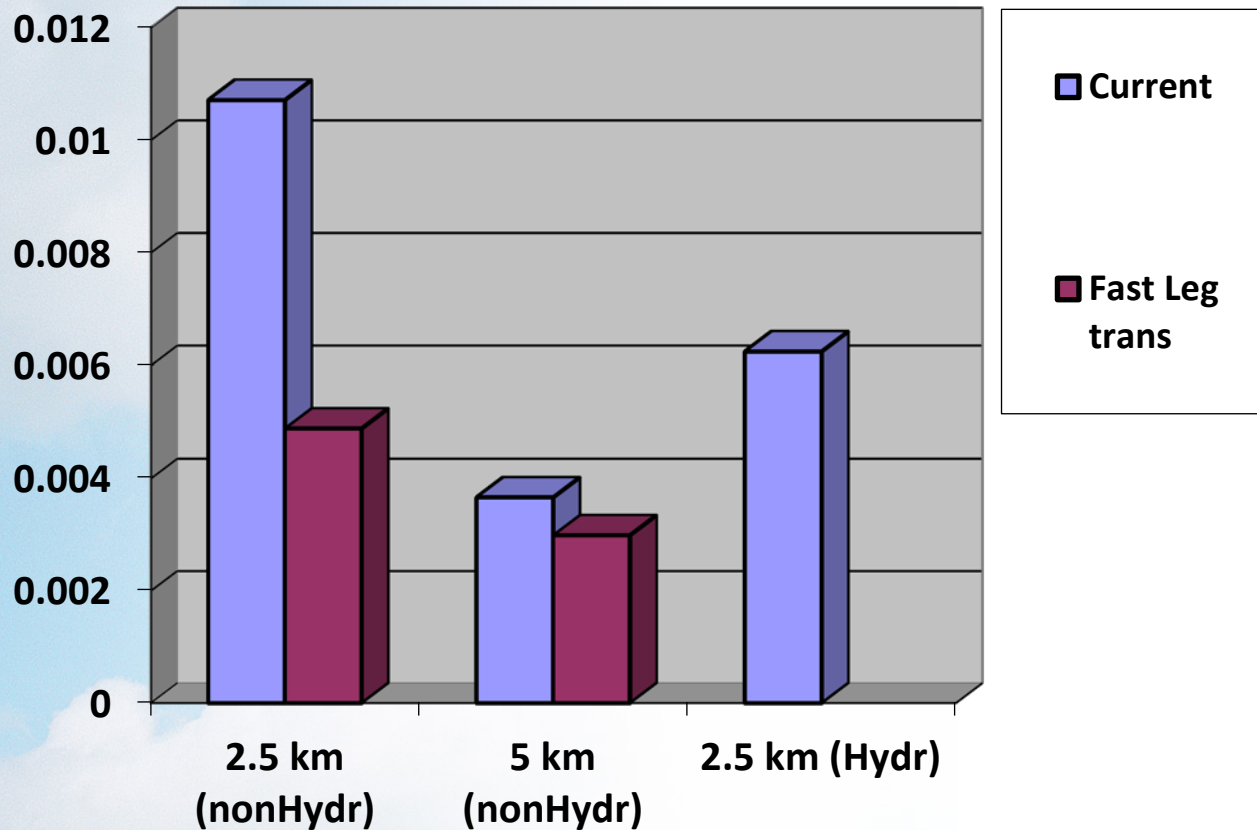
# Increasing resolution

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- Vertical resolution
  - 91 → 137 levels by year 2012
- Horizontal resolution
  - 16 → 10 km by year 2015
- Beyond 2015
  - 10 km → 5 km ( $\approx$  year 2020)
- Non-hydrostatic model formulation
- Fast Legendre transforms

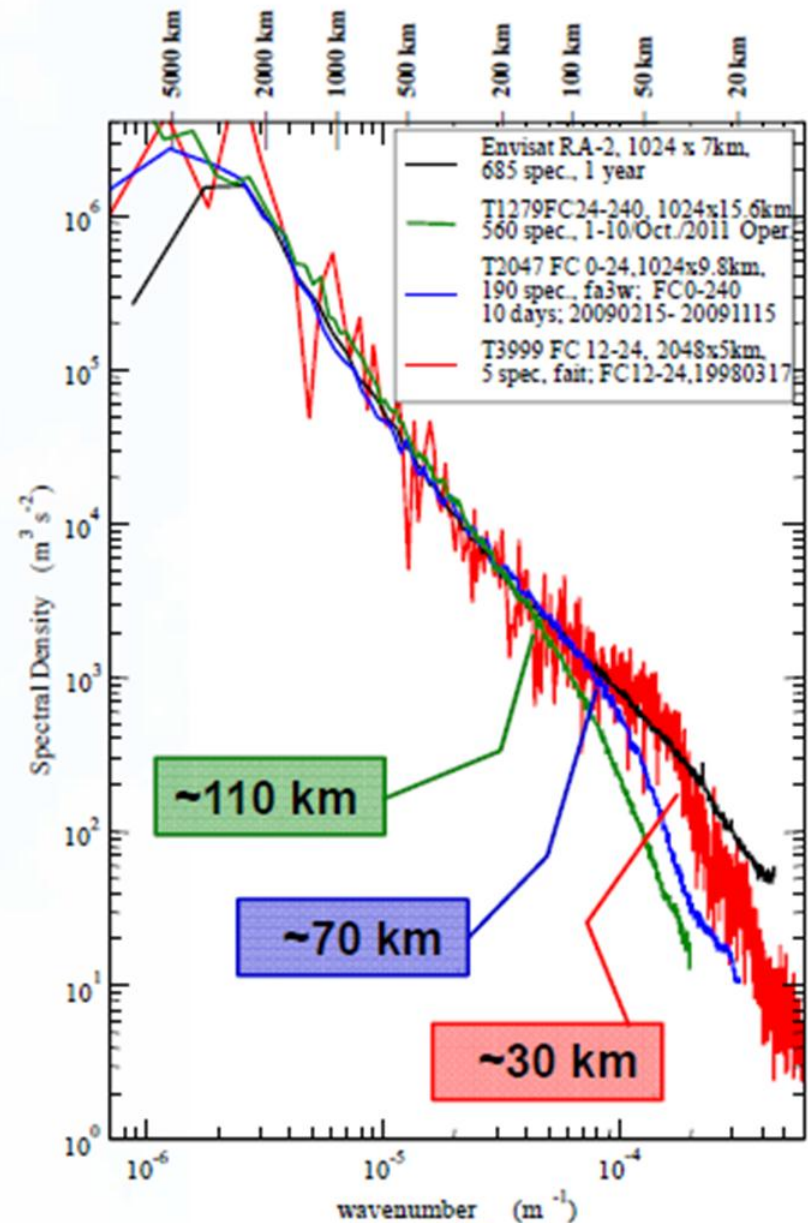
# (Wall-clock comp cost)/N<sup>2</sup> in ms

for spectral transforms, 1h simulation  
N truncation limit



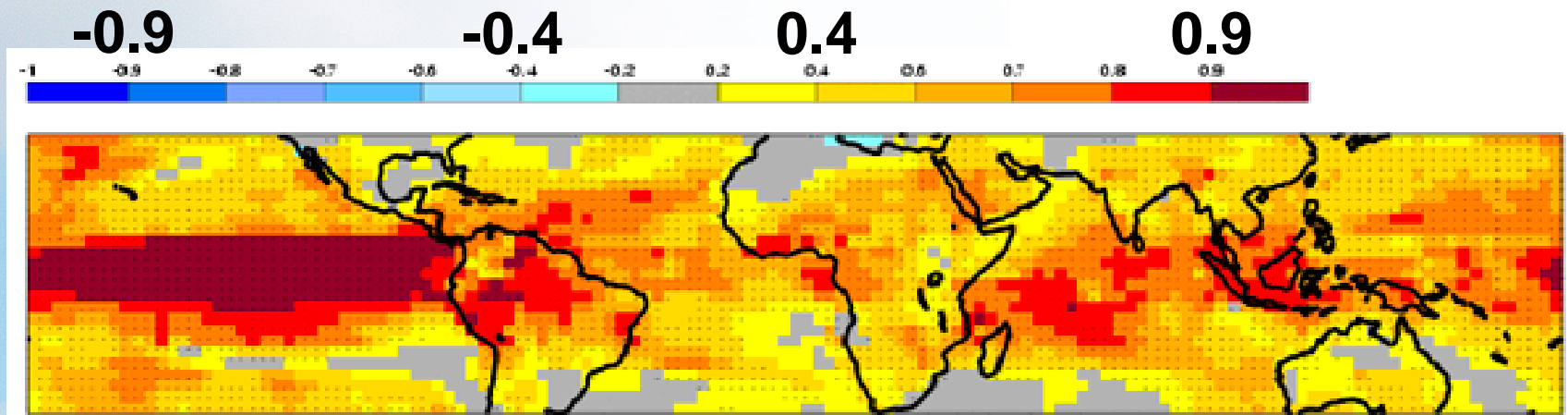
## Impact of Model Resolution

- **Black line:**  
“REFERENCE” RA-2 data.
- **Green line: Resolution ~16 km**  
T1279, Current ECMWF operational model resolution.
- **Blue line: Resolution ~10 km**  
T2047, Next ECMWF model resolution ~2014.
- **Red line: Resolution ~5 km**  
T3999, ECMWF model resolution ~2020.  
(not yet fully spun-up from low resolution).



# Seasonal prediction: System 4 introduced November 2011

- Anomaly correlation of surface temperature
  - Hindcast period: 1981-2010
  - Forecast lead time: 2-4 months



# Atmospheric composition and forest fires

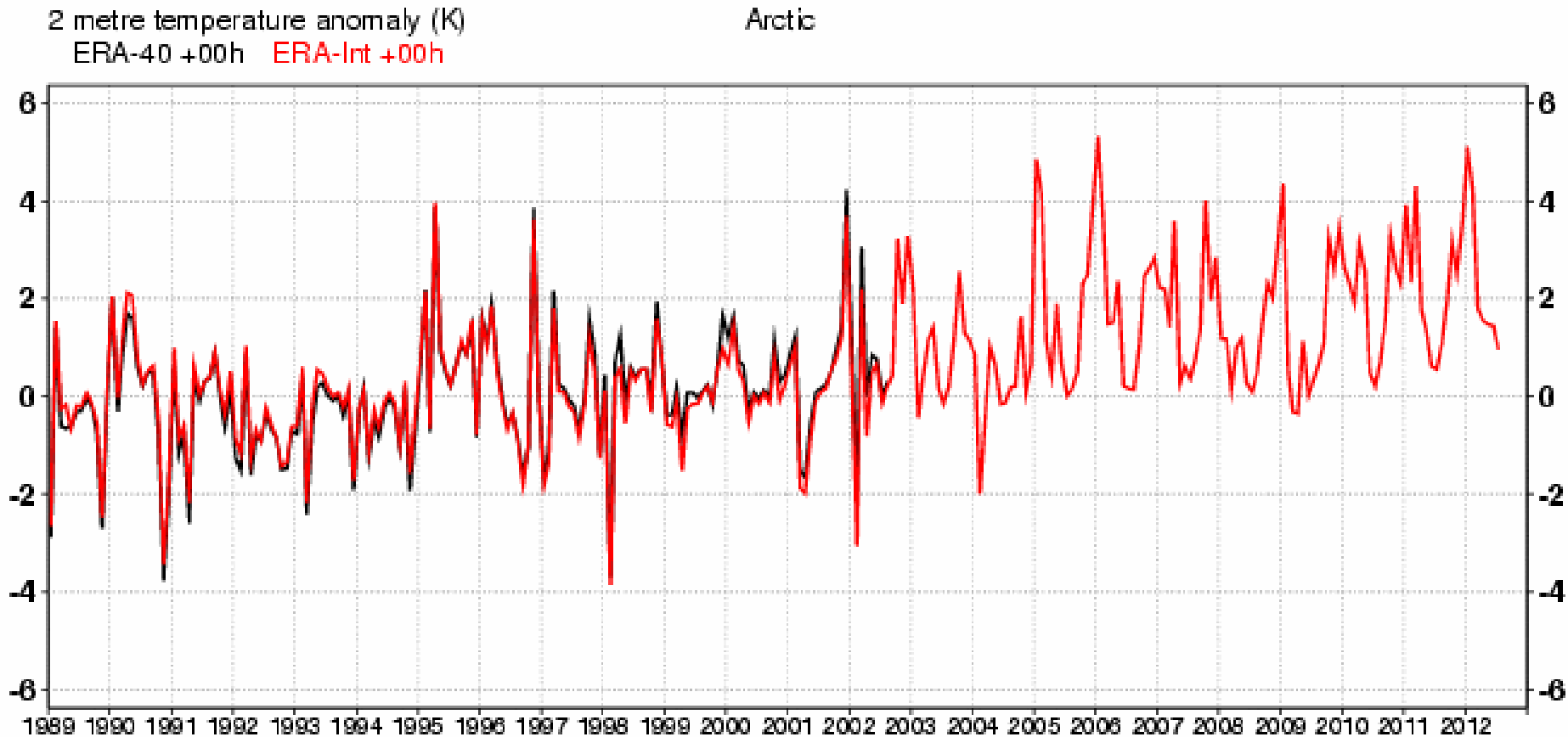


**Simulated smoke transport from fires over Greece and Algeria.**

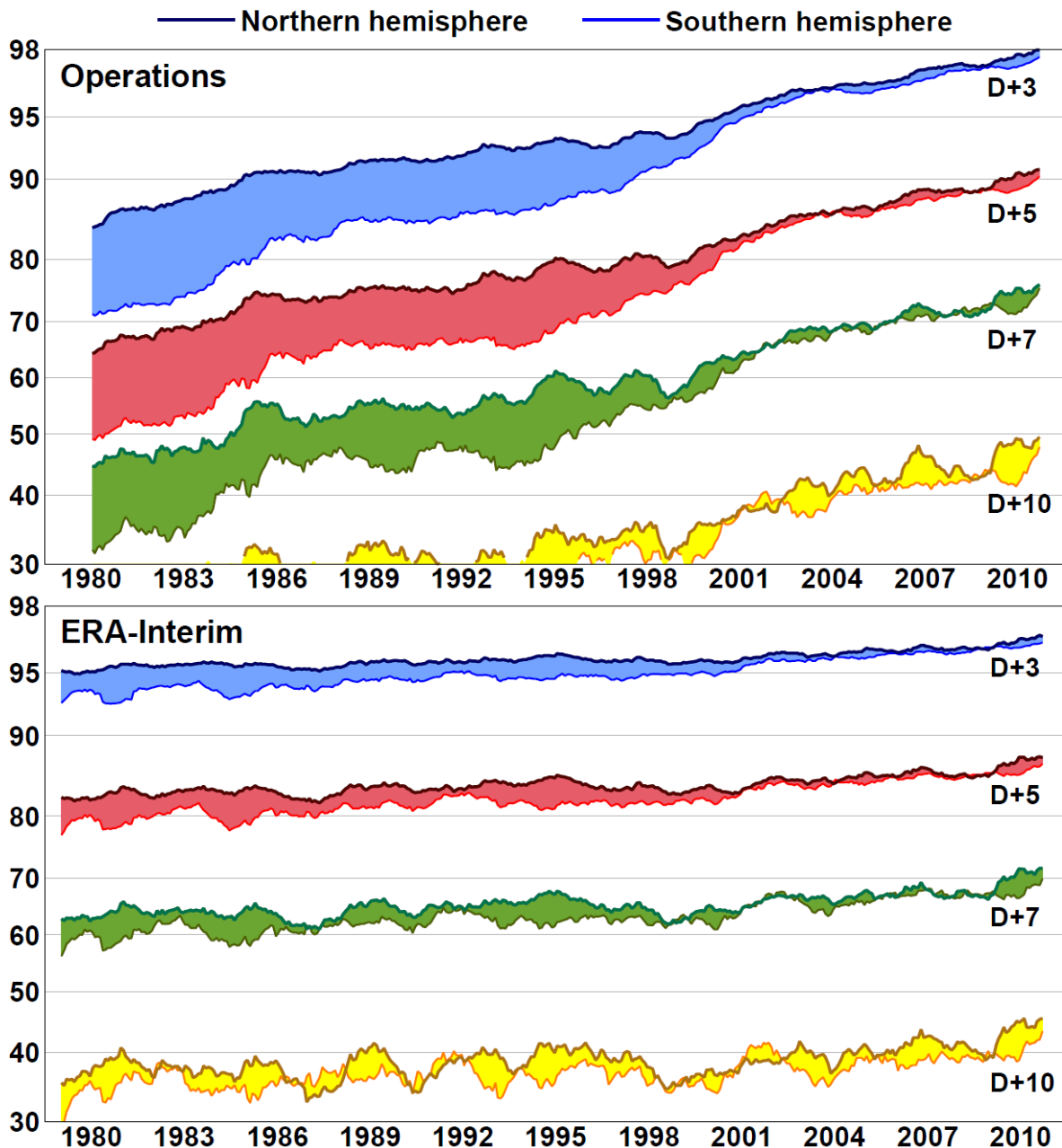
**From global model run at 25km resolution, with smoke flux derived from satellite fire observations.**



## Arctic temperature anomaly



# Anomaly correlation of 500hPa height forecasts



- The **principal goal** is to improve global medium-range weather forecasts, at the current rapid rates, in order to provide:
  - **Reliable** forecasts of **severe weather**
  - **High quality near-surface** weather products
- **Secondary goals**
  - **Extended range** forecasts
  - Forecasts of **atmospheric composition**
  - Reanalyses for **climate monitoring**

# Summary

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- Scalability
  - Data assimilation
  - Forecast model
- Spatial resolution 16 → 10 → ≈5 km in ten years
- Increased ensemble size
- Atmospheric composition
- Seasonal forecasts
- Reanalysis – climate monitoring