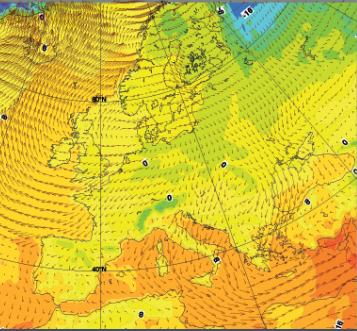
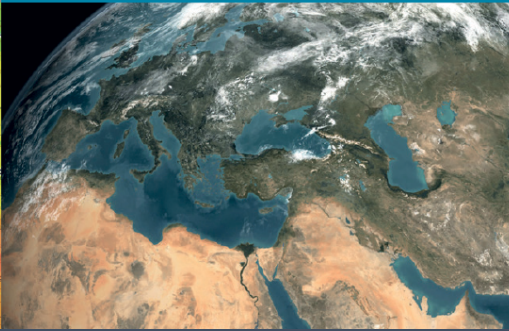


GLOBAL FORECASTS



NWP SCIENCE



ENVIRONMENTAL SERVICES



SERVING METEOROLOGY



SUPERCOMPUTING



Advancing the science to improve global forecasts:

# ECMWF in 2017

Erland Källén



August 11, 2017

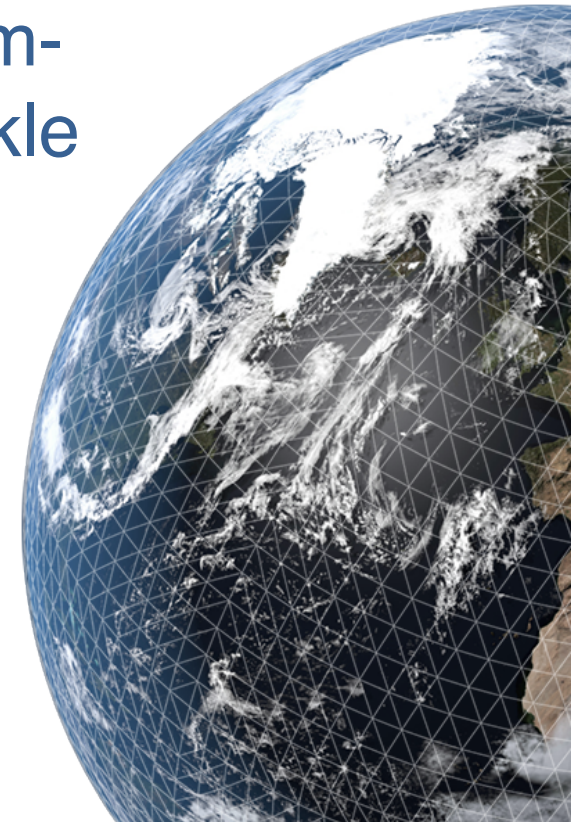
# European co-operation at its best

*our mission*

ECMWF's role is to address the critical and most difficult research problems in medium-range NWP that no one country could tackle on its own



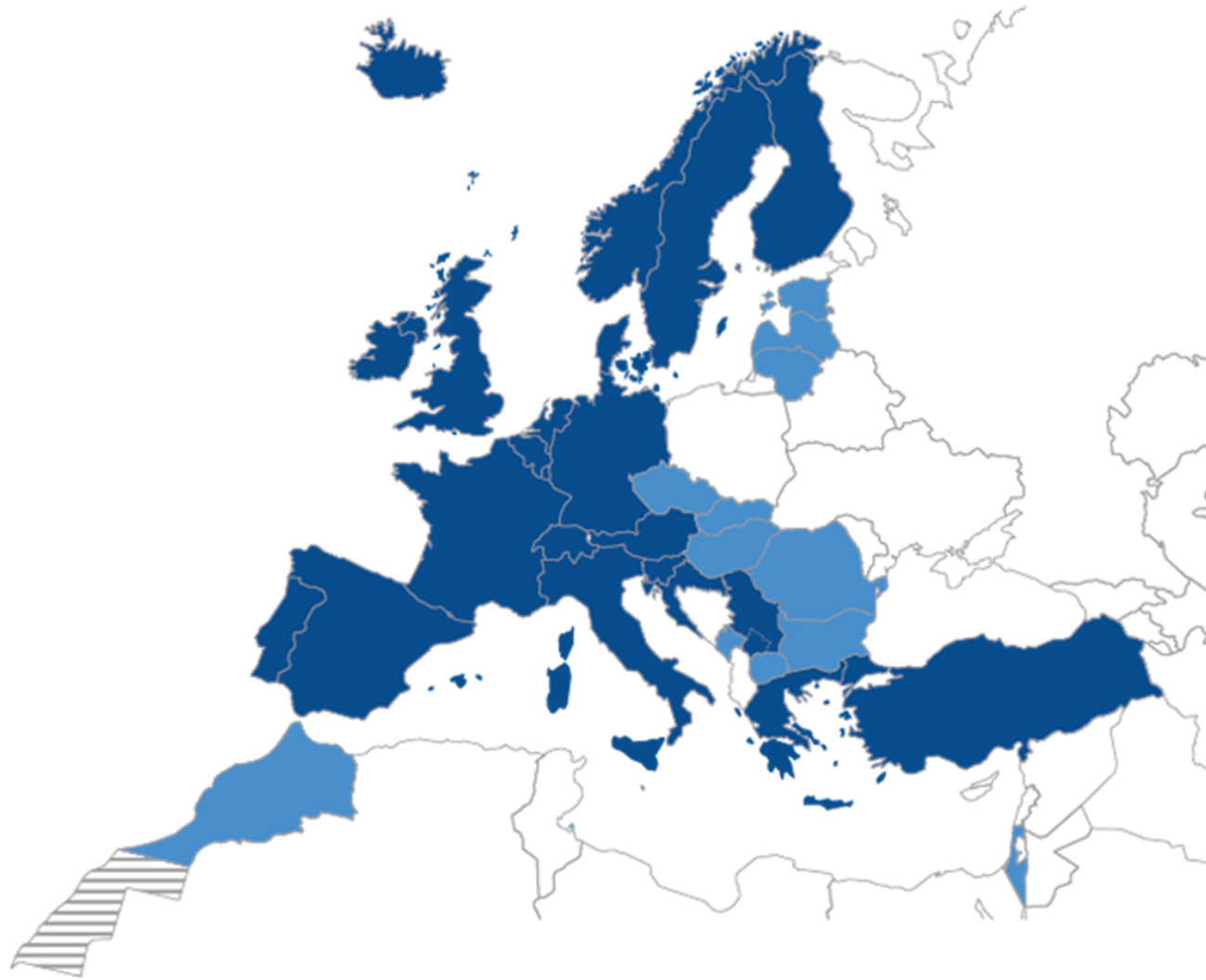
EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS



# European co-operation at its best



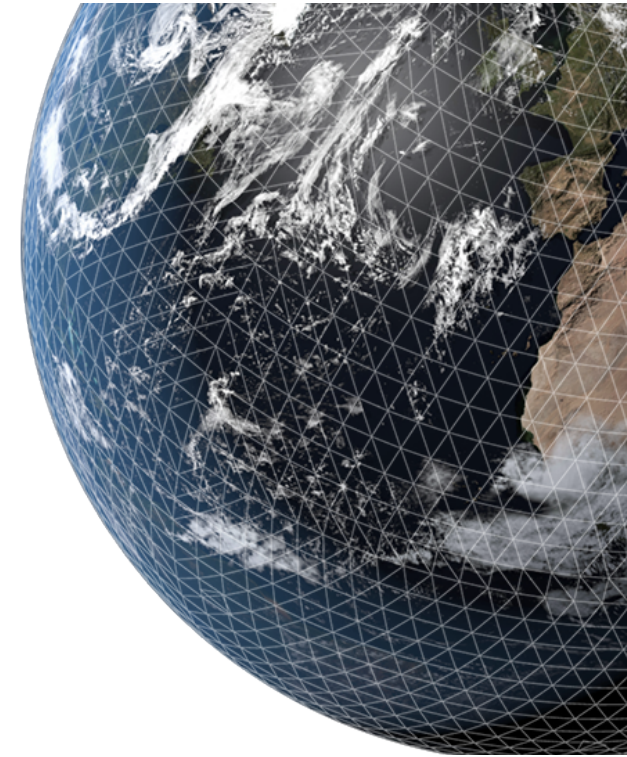
# European co-operation at its best



# European co-operation at its best

## *actoids*

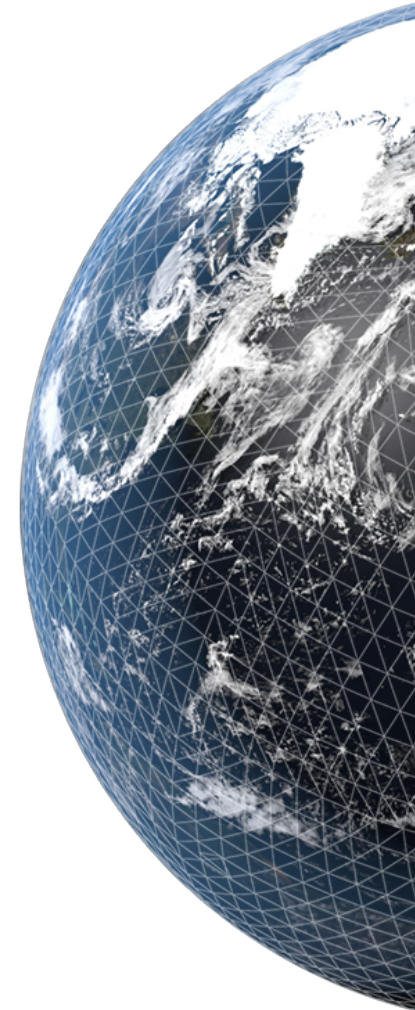
- 34 member and co-operating states
- 341 staff
- 30 countries
- Partnerships around the world ...



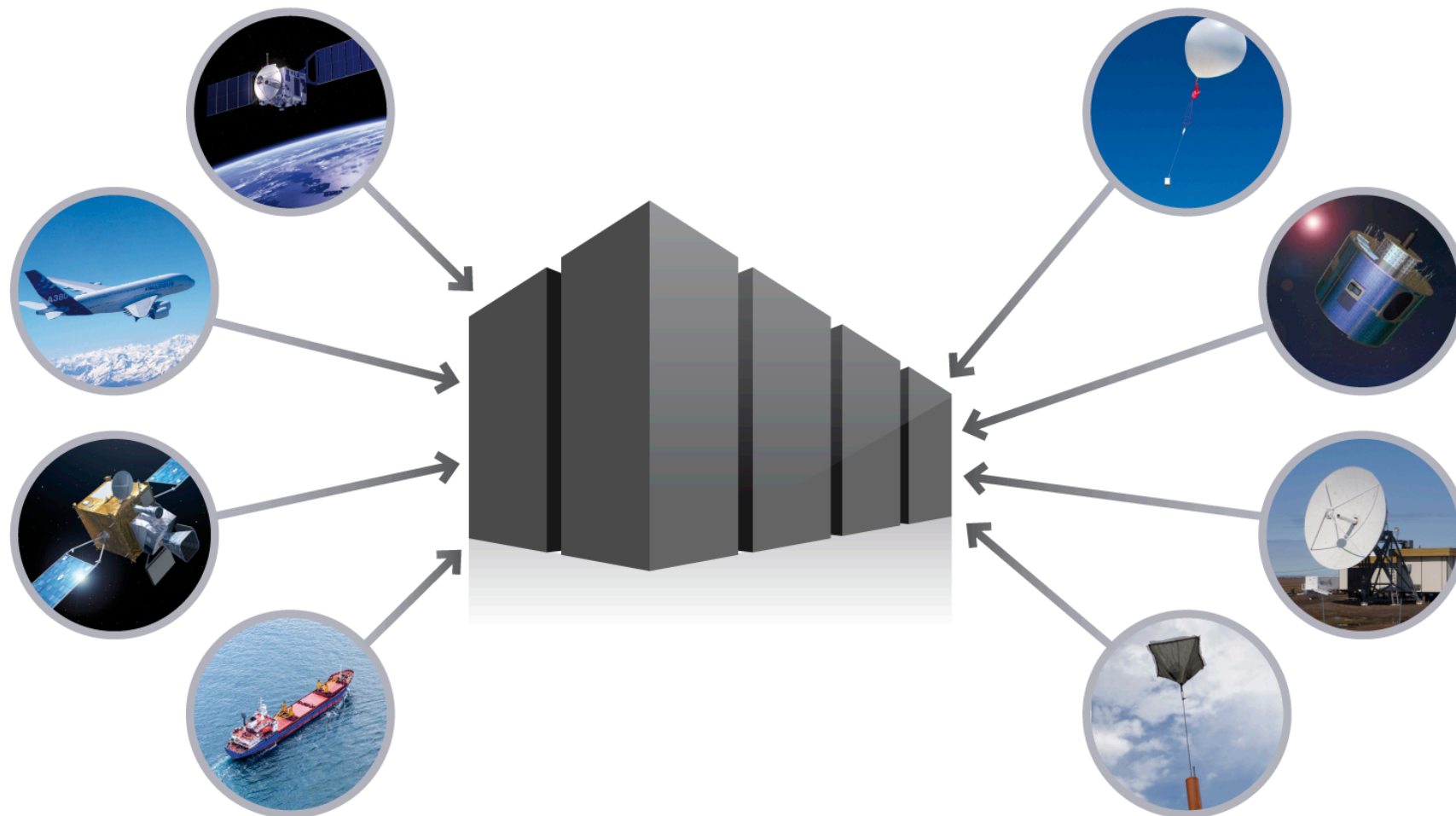
# European co-operation at its best

## *deliverables*

- Research in Earth System modelling
- Global numerical weather forecasts
- Supercomputing & data archiving
- Education & training programme
  
- EU activities: Copernicus Climate and Atmosphere Services, EFAS contribution

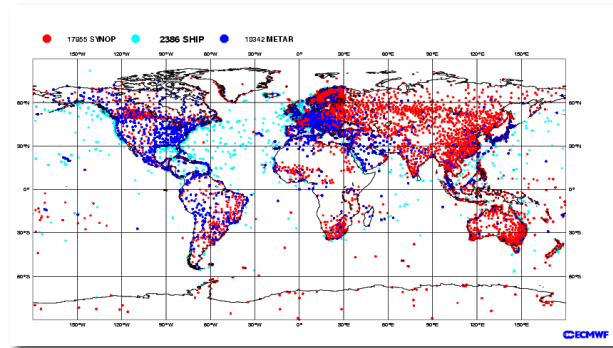


# Observation platforms

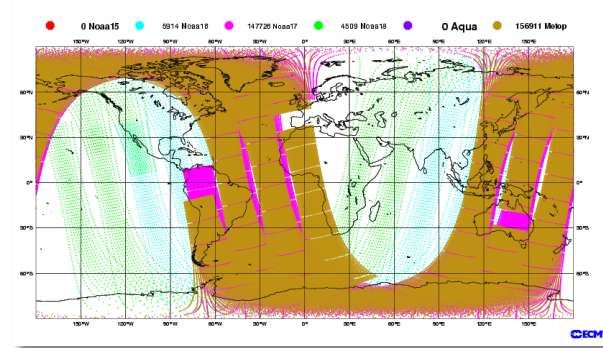


# Geographic coverage

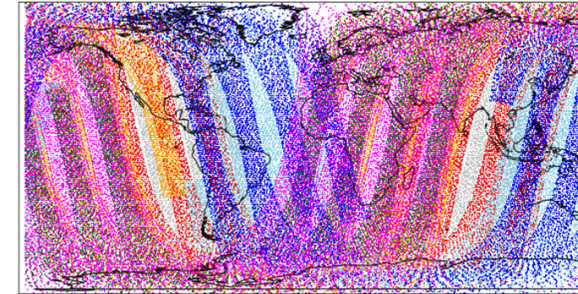
## Surface stations



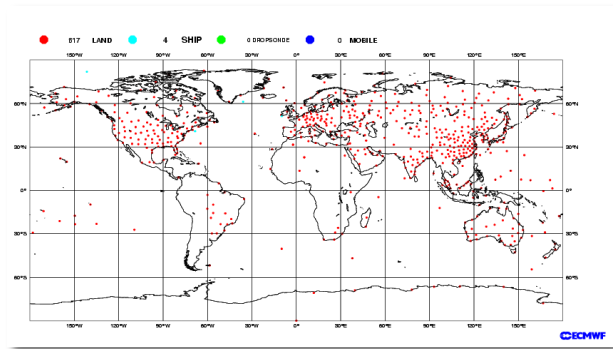
## Polar, infrared



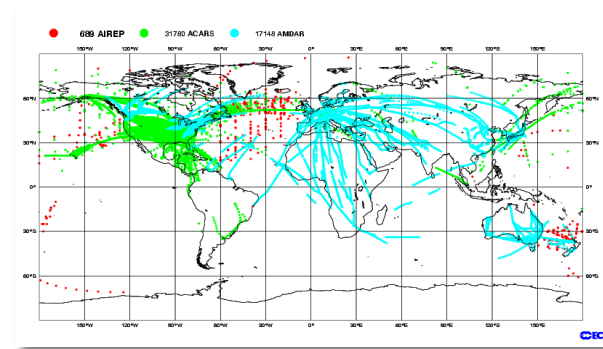
## Polar, microwave



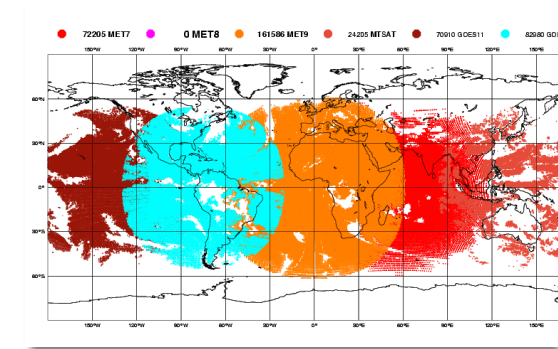
## Radiosonde balloons



## Aircraft



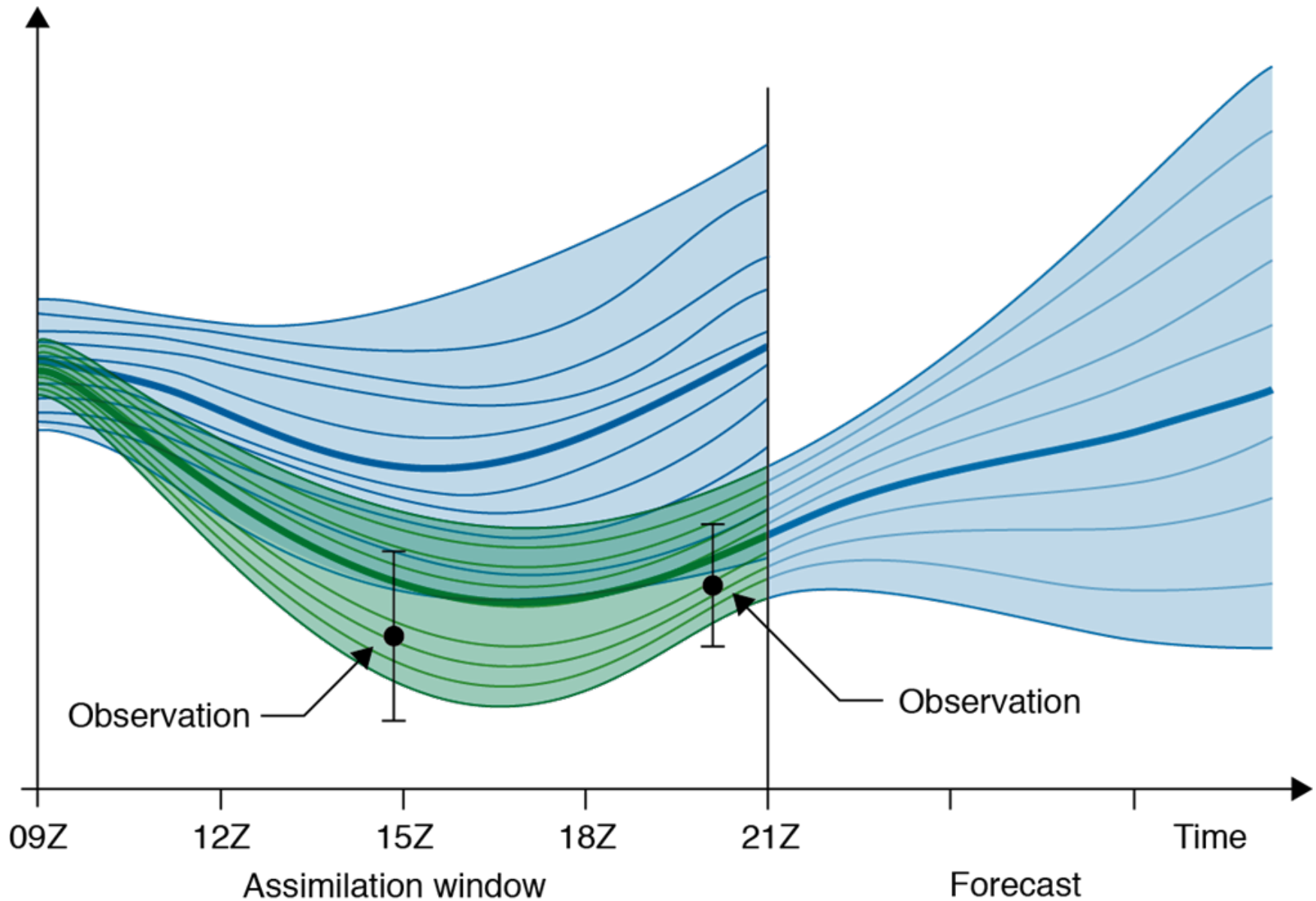
## Geostationary, IR



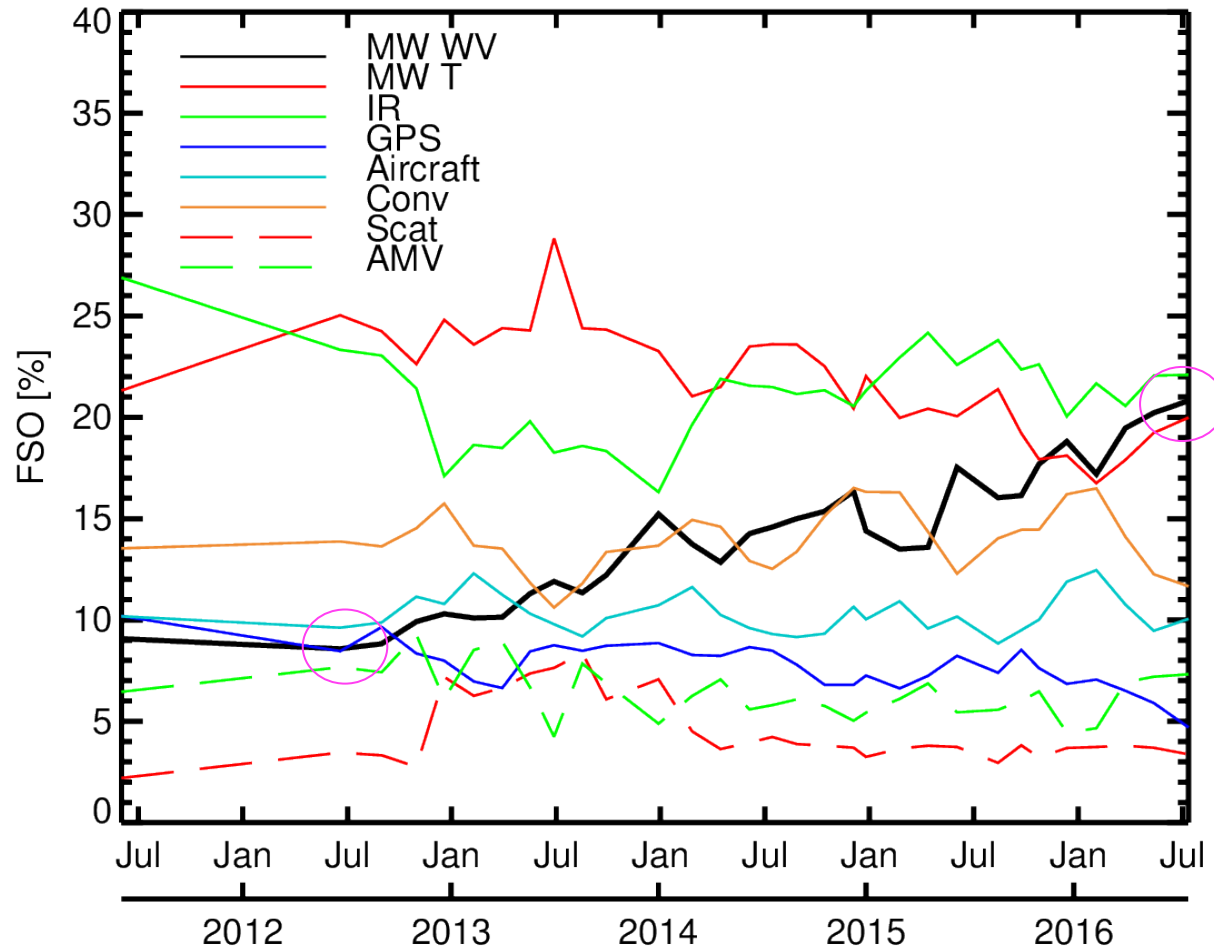


# Ensemble Data Assimilation

# Ensemble Forecast

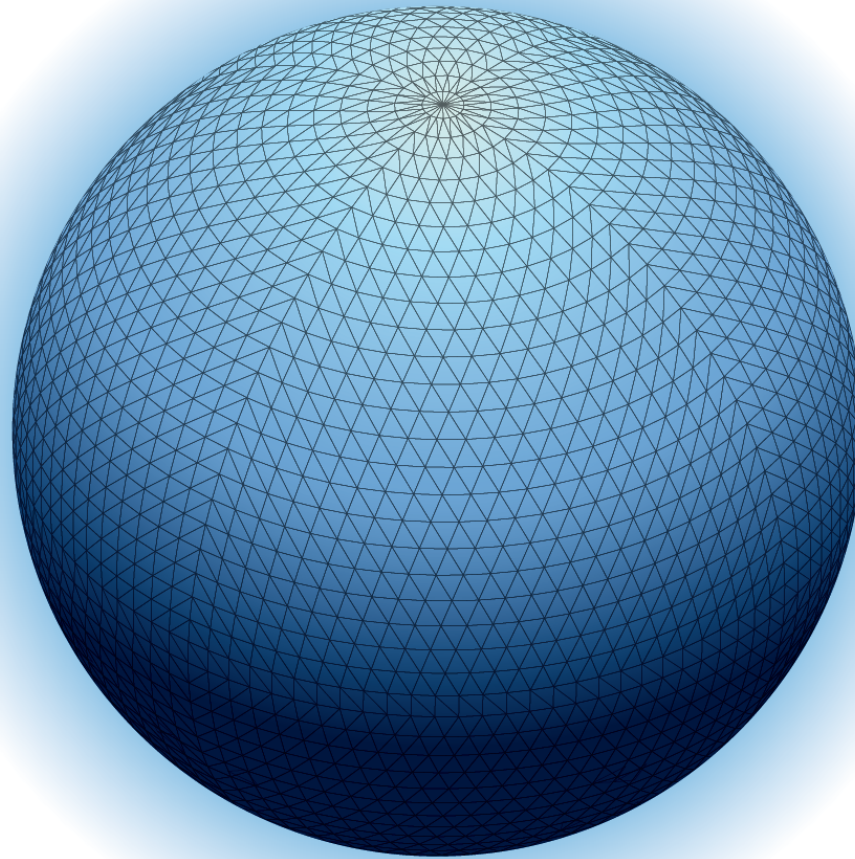


# Forecast sensitivity (FSO) of major observing systems in ECMWF operations

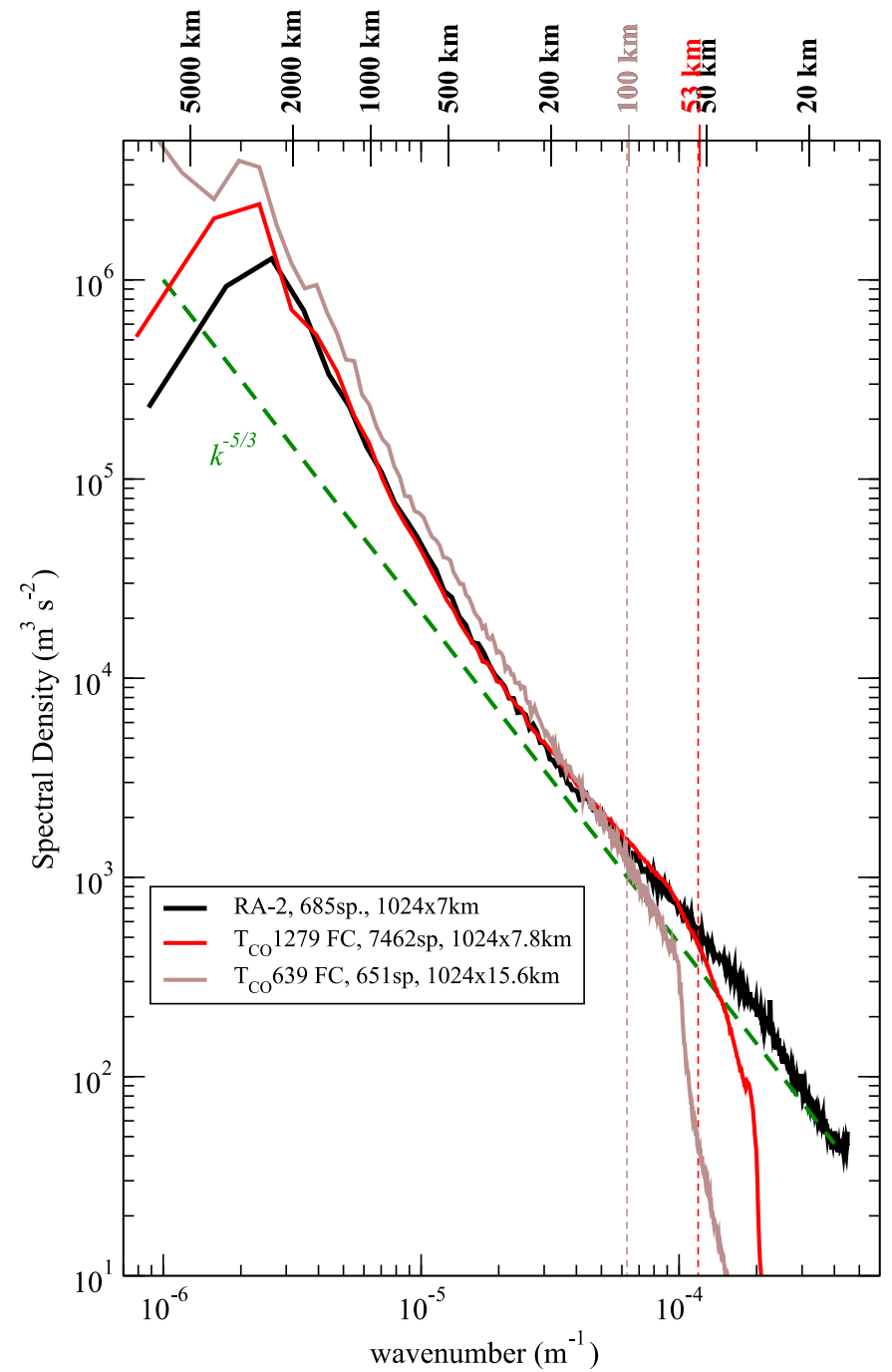


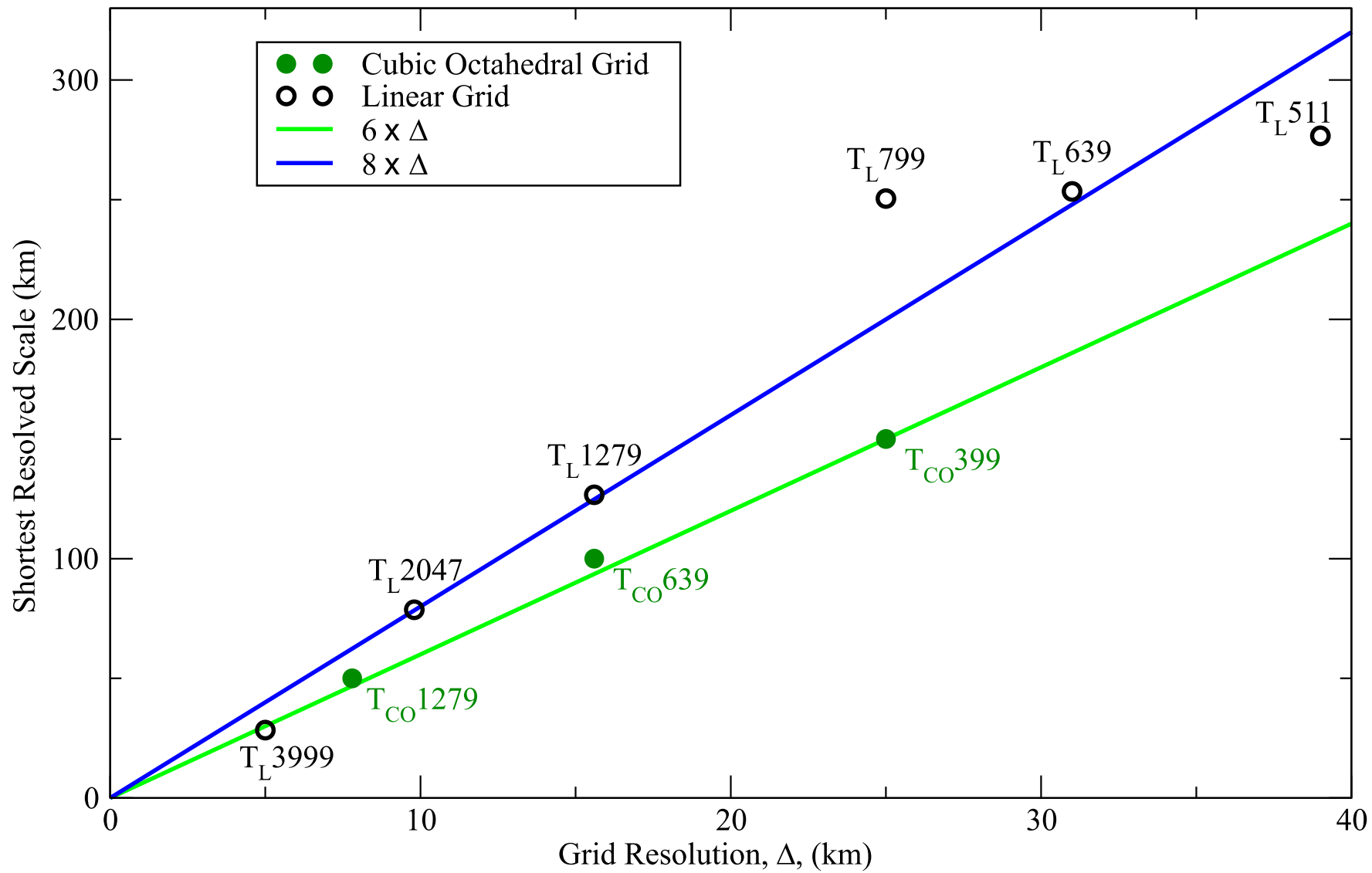
# Forecast model – Octahedral 9 km grid, 137 levels

- Wind
- Temperature
- Pressure
- Humidity
- Clouds
- Precipitation

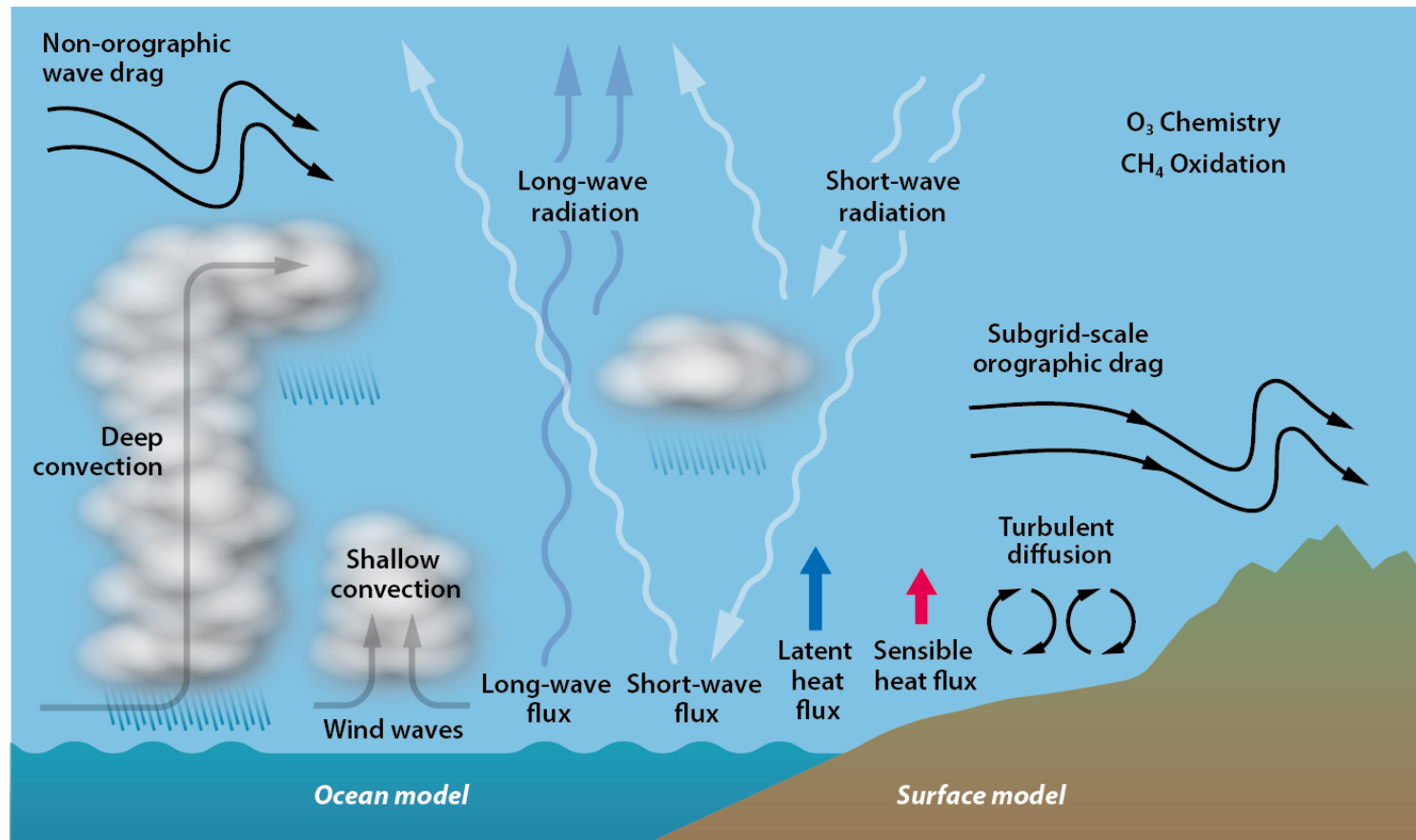


# Wind Speed Spectrum of operational T<sub>CO</sub> resolutions





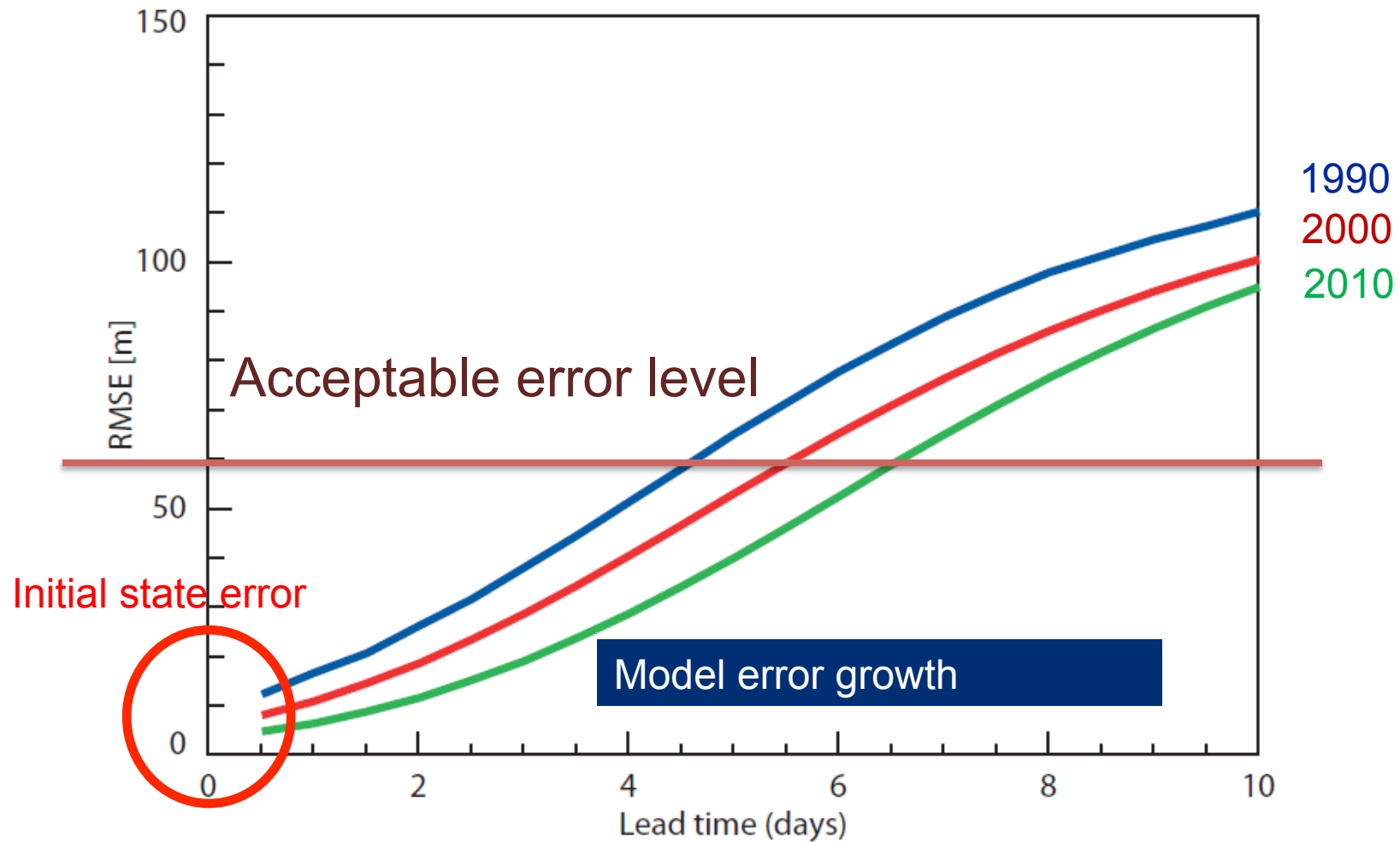
# Physical processes in the ECMWF model



# Open IFS

- Provide IFS for research and education
- Make scientists familiar with IFS code
- Provide feedback to ECMWF developments
  - Single precision coding
  - Super parameterisation of convection
  - PBL research
- NWP training at universities and met services

# RMS error of 500 hPa height field Northern Hemisphere





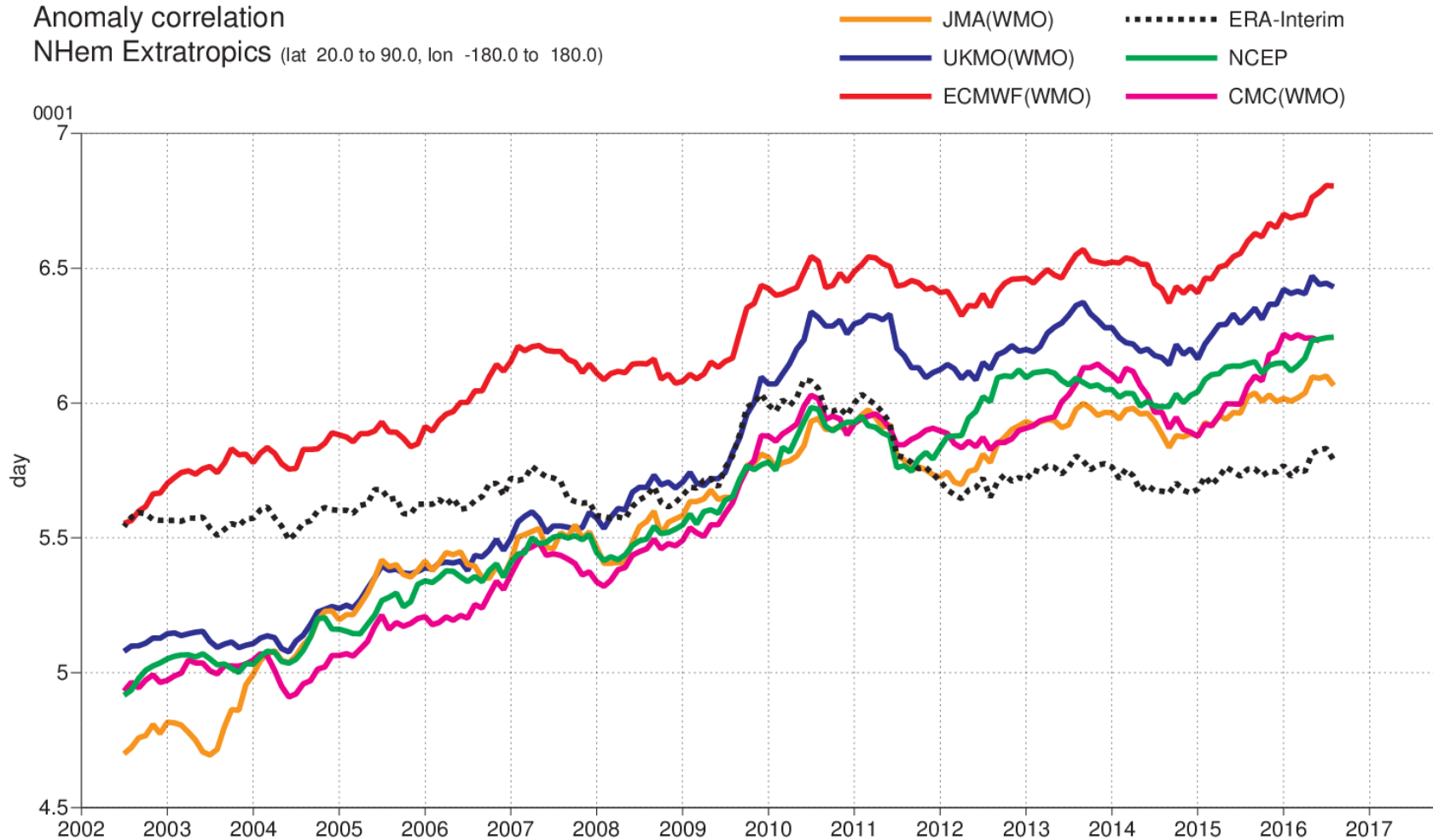
# Comparison to other centres

## Lead time of ACC=80%

500hPa geopotential

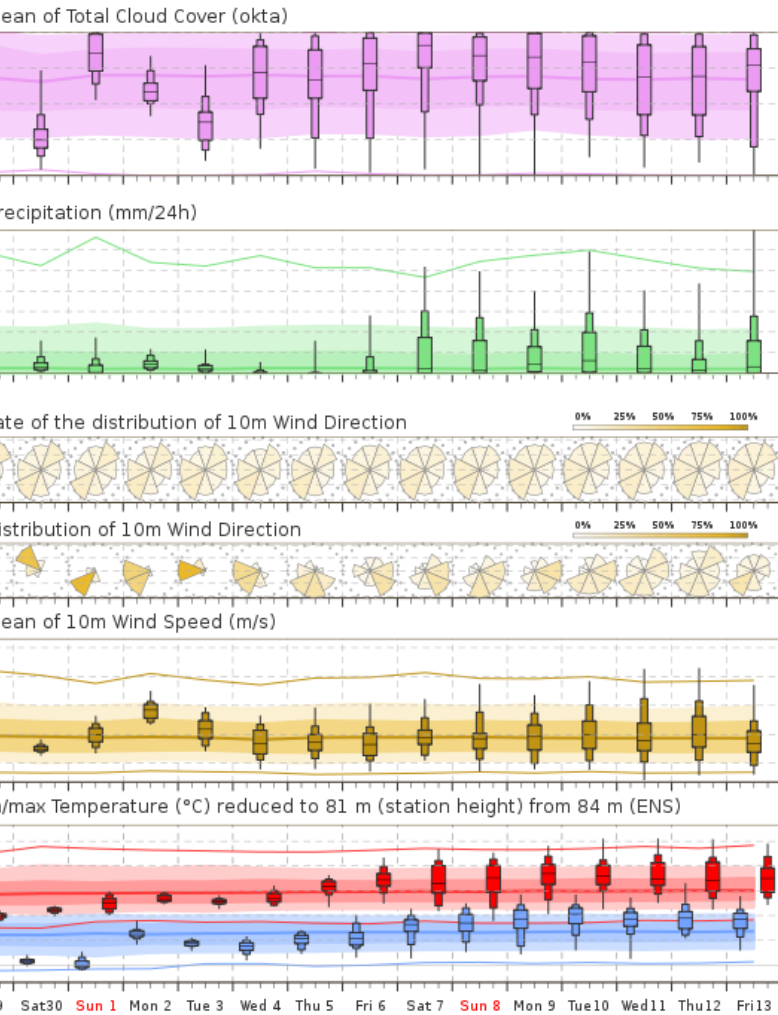
Anomaly correlation

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

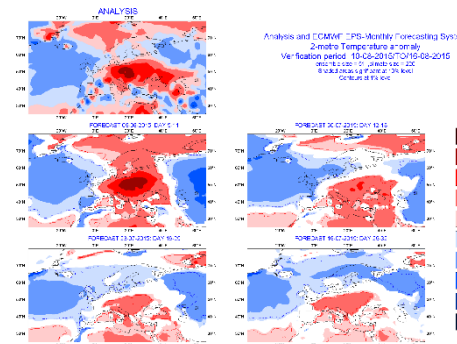


# Deliverables: a few examples

## Medium-range

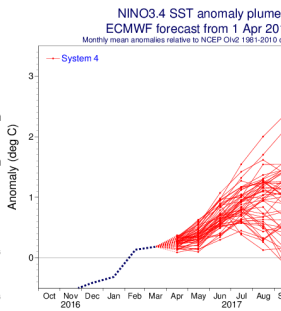
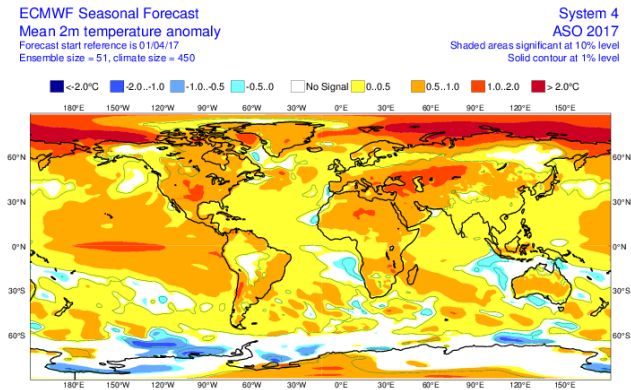


## ENS-Monthly Forecasting System 2mt anomaly

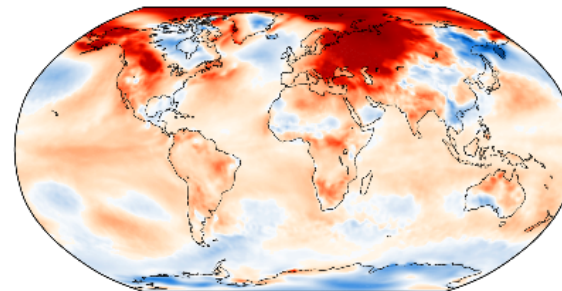


ECMWF Seasonal Forecast  
Mean 2m temperature anomaly  
Forecast start reference is 01/04/17  
Ensemble size = 51, climate size = 450

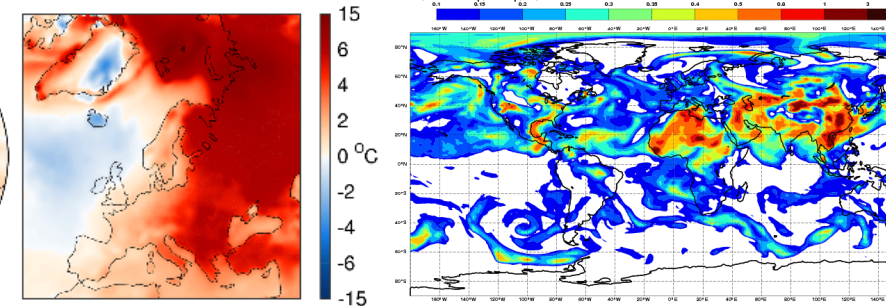
## Seasonal Forecast



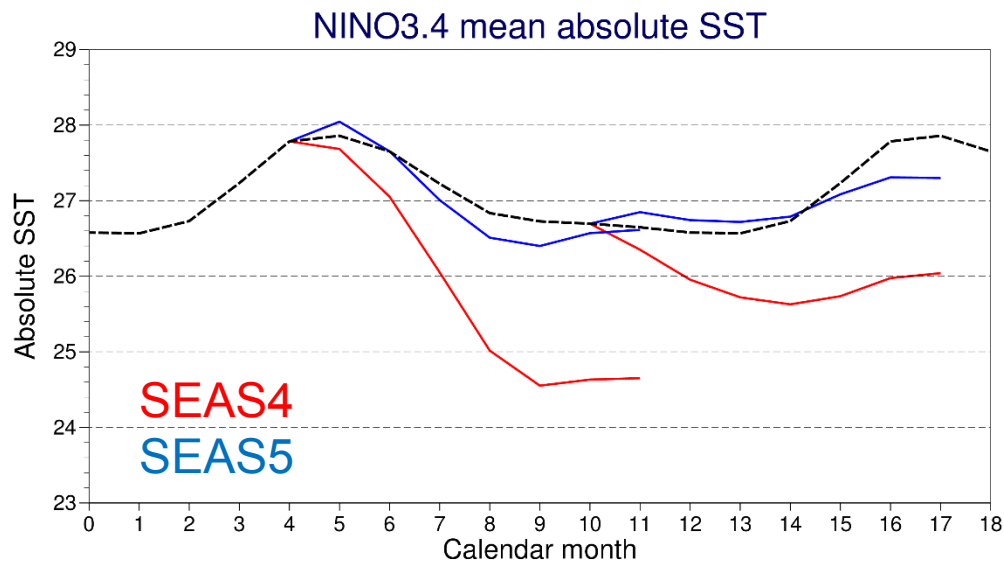
## Global average temperatures



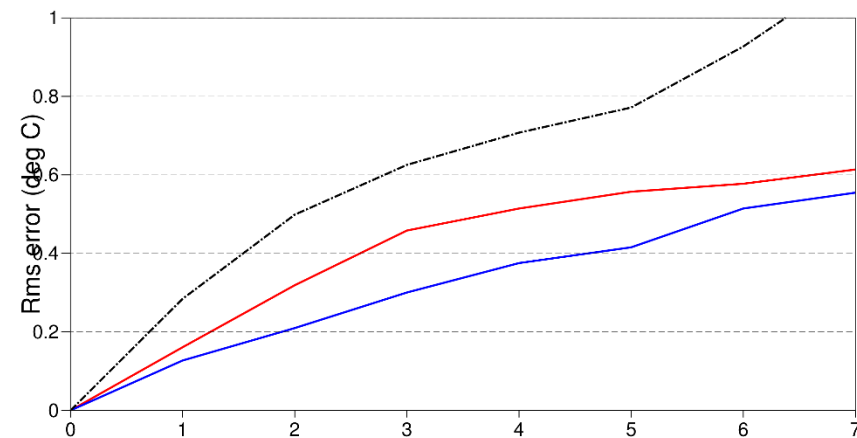
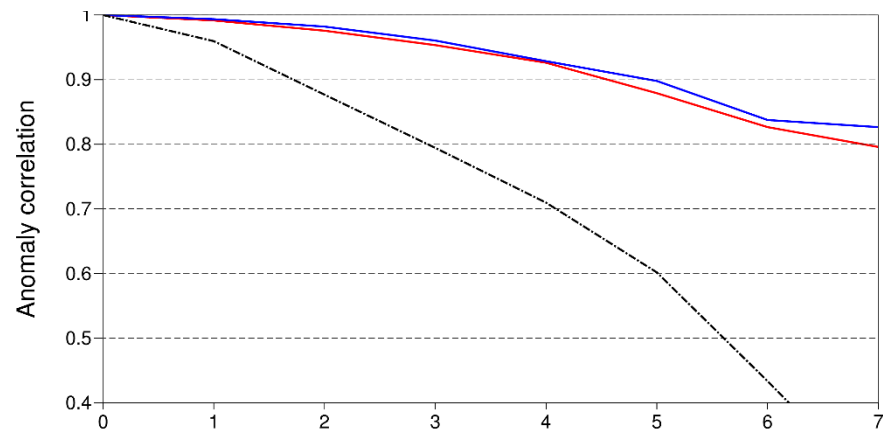
## Forecast of Aerosols Optical Depth



# Global SST biases improve, especially in the ENSO regions



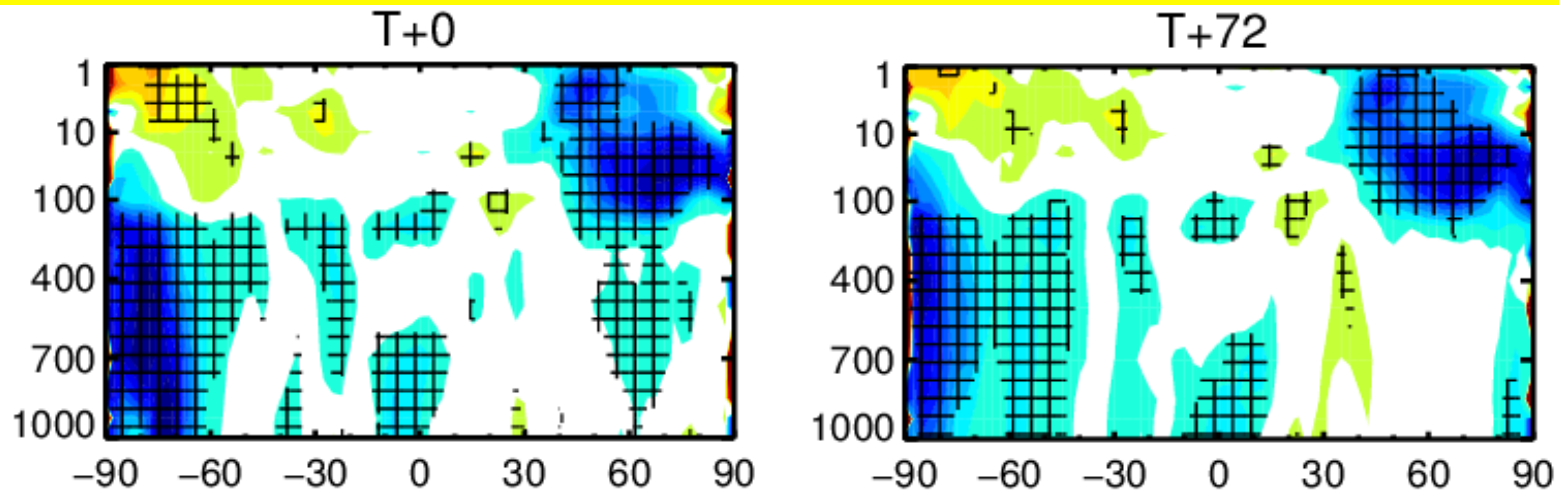
ENSO SST drift improves markedly. Also a small increase in ENSO correlation scores, an improvement in ENSO variance, and a decrease in RMS error (after bias correction).



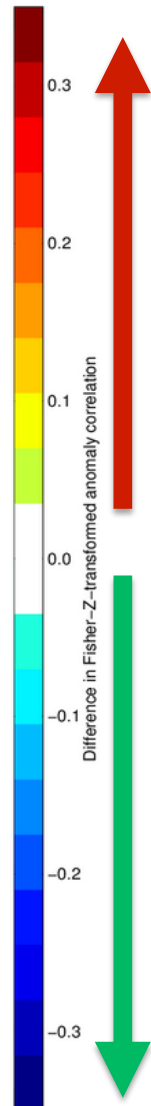
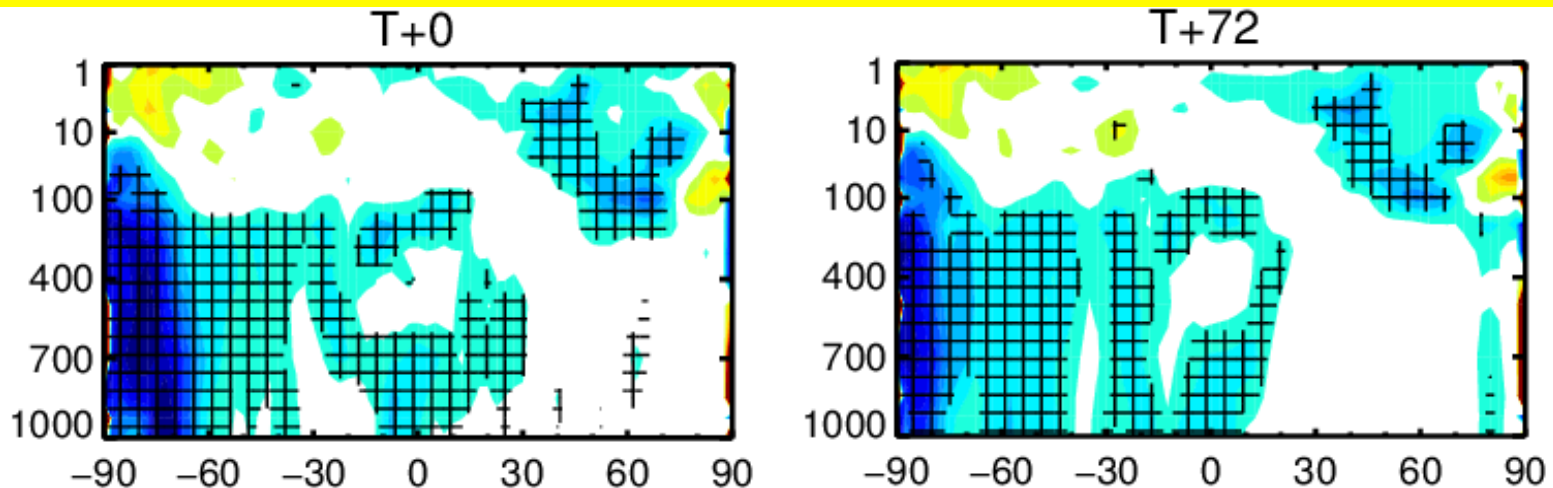
# Impact of ocean coupling and ocean observations

CERA-20C compared to extra experiments for geopotential height in MAM 2010

Ocean coupling in CERA improves atmospheric analysis and forecast (comparison with an atmospheric-only system)

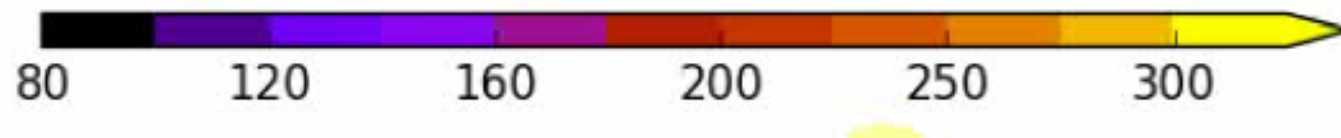


Ocean observations in CERA improve atmospheric analysis and forecast (comparison with a CERA system withholding all ocean observations)



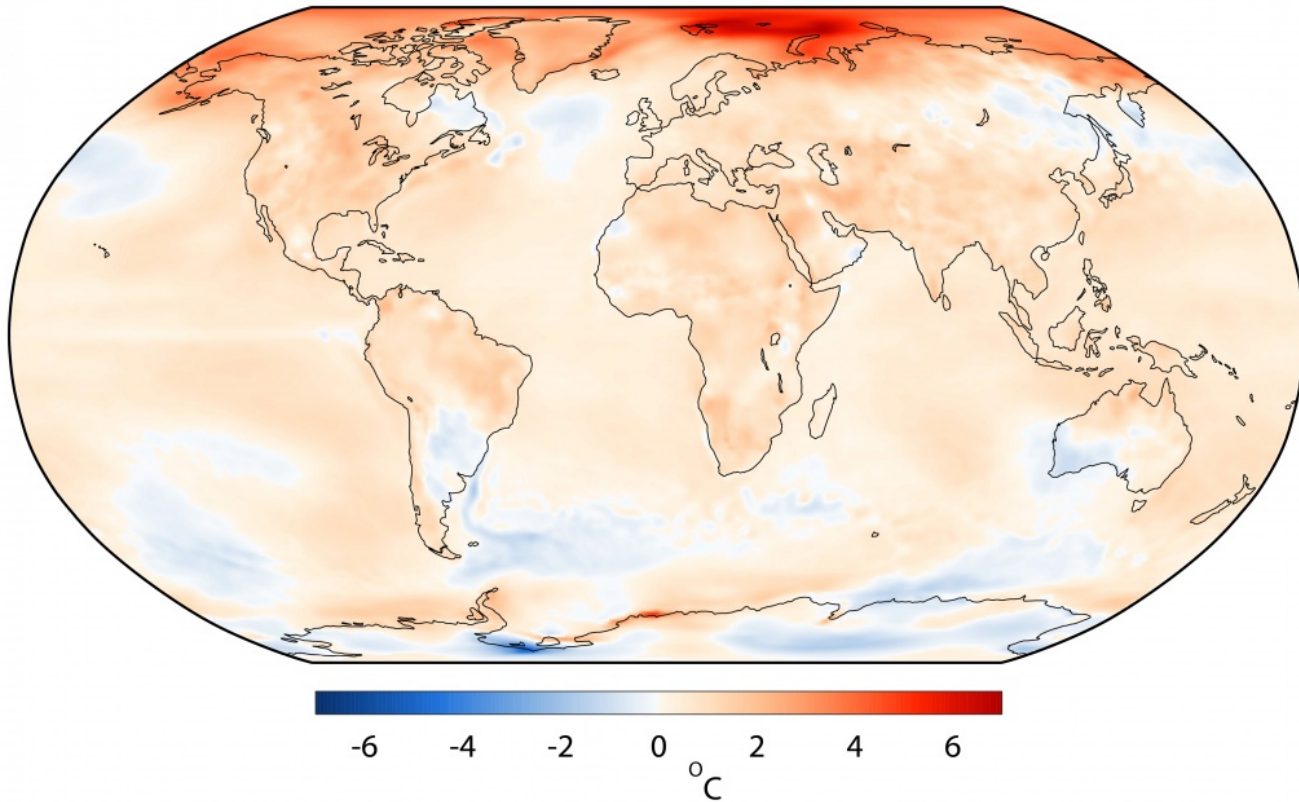
# Monitoring atmospheric composition (MACC)

CO concentration at 500 hPa in ppm - 24 Jun 2015 00:00

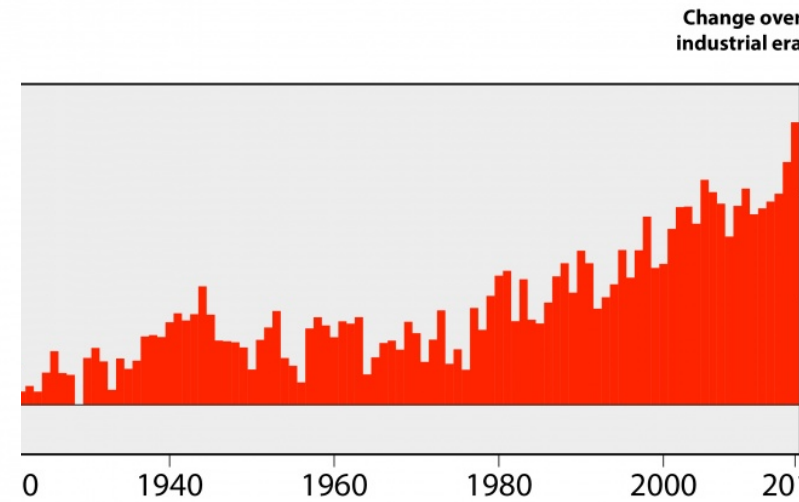


# Reanalysis results for climate change

## AVERAGE SURFACE AIR TEMPERATURE FOR 2016



## GLOBAL SURFACE AIR TEMPERATURE FROM 1880 TO 2016



Source: Copernicus Climate Change Service, ECMWF.

Copernicus  
Europe's eyes on Earth

Climate  
Change Service  
climate.copernicus.eu

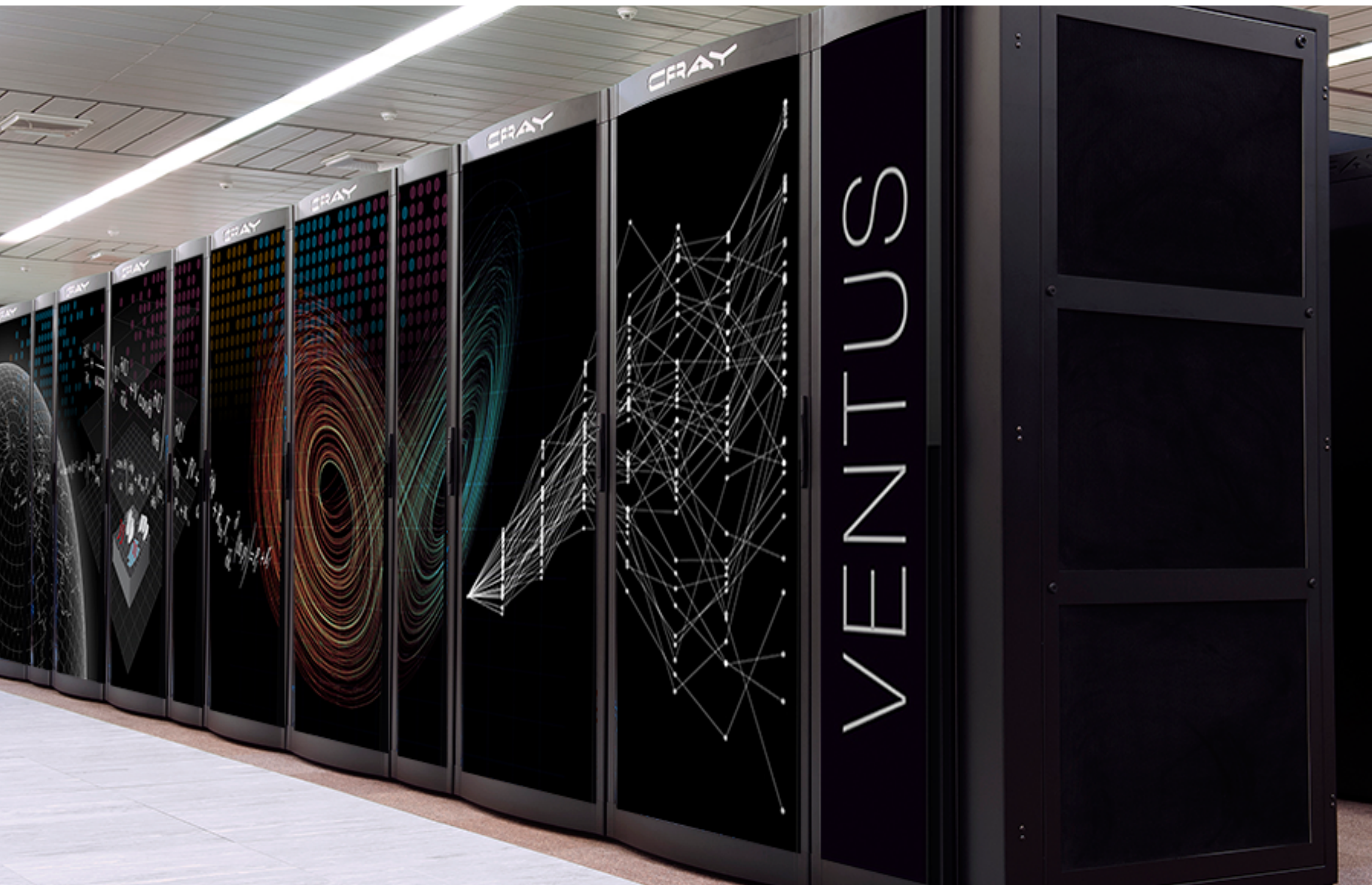
from 1979;  
to 1979.

Copernicus  
Europe's eyes on Earth

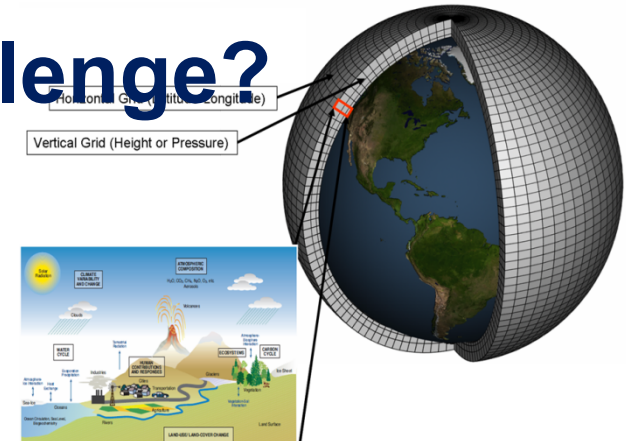


ECMWF

EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS



# What is the scalability challenge?



**Today:**

	Observations	Models
Volume	40 million = $4 \times 10^7$	10 million grid points 100 levels 10 prognostic variables = $1 \times 10^{10}$
Type	98% from 60 different satellite instruments	physical parameters of atmosphere, waves, ocean

**Tomorrow:**

	Observations	Models
Volume	100-200 million = $1-2 \times 10^8$	500 million grid points 200 levels 100 prognostic variables = $1 \times 10^{13}$
Type	98% from 80 different satellite instruments	physical and chemical parameters of atmosphere, waves, ocean, ice, vegetation

**Factor 5**

**Factor 1000**



# The strength of a common goal

## *the Strategic Goals 2016-2025*



- Earth system approach to modelling and analysing
- Ensemble prediction at 5km
- Scalability across the NWP chain

# Conclusions

- Weather forecasts require
  - Observations and data assimilation
  - Earth System model
- Open IFS
- ECMWF is a world leading provider of weather and environmental forecasts based on research developments



The strength of a common goal