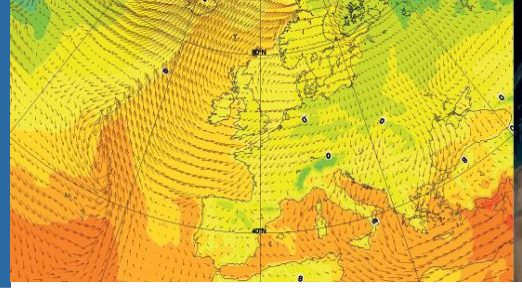




ECMWF's research directions

Andy Brown

ECMWF, Shinfield Park, Reading, UK

THE STRENGTH OF A COMMON GOAL

ECMWF's purpose is to develop a capability for medium-range weather forecasting and to provide such weather forecasts to the Member and Co-operating States

ECMWF is complementary to the National Meteorological Services and works with them in research, numerical weather predictions, supercomputing and training.

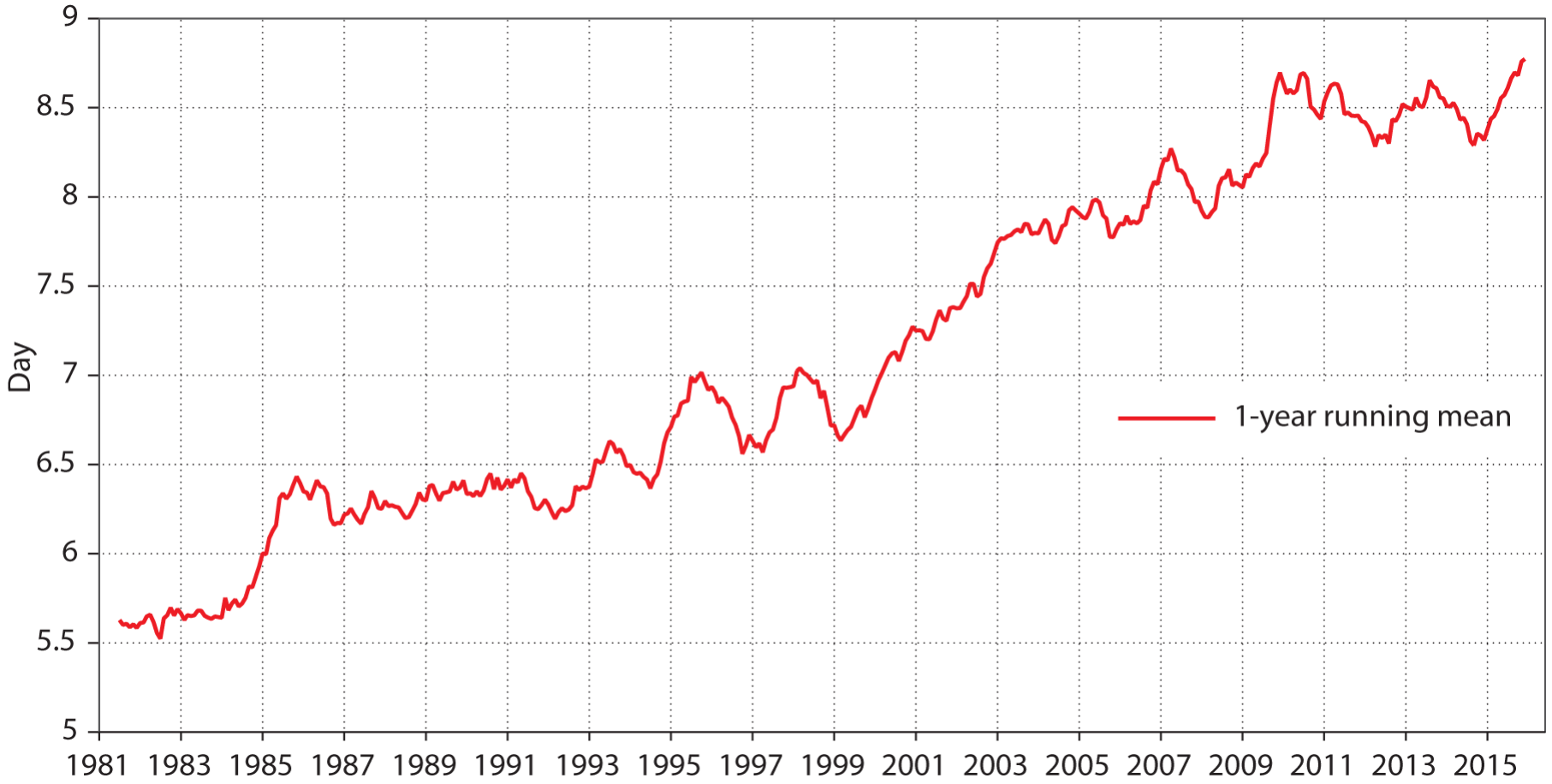
THE STRENGTH OF A COMMON GOAL

Forecast targets by 2025

- Ensemble predictions of high impact weather up to two weeks ahead
- Seamless approach, aiming towards predictions of large scale patterns and regime transitions up to four weeks ahead and global-scale anomalies up to a year ahead

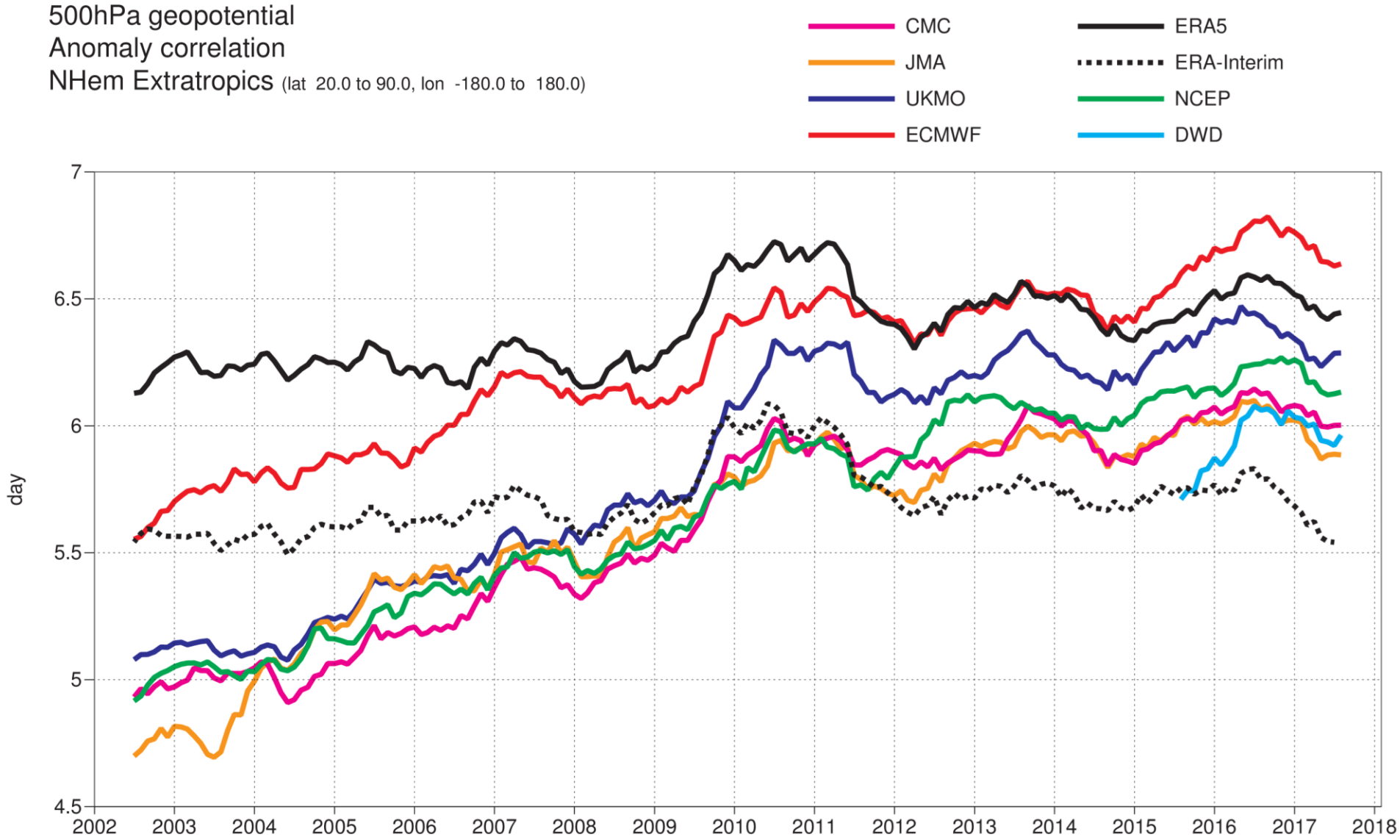
THE STRENGTH OF A COMMON GOAL

Evolution of ECMWF medium-range skill over the past 35 years



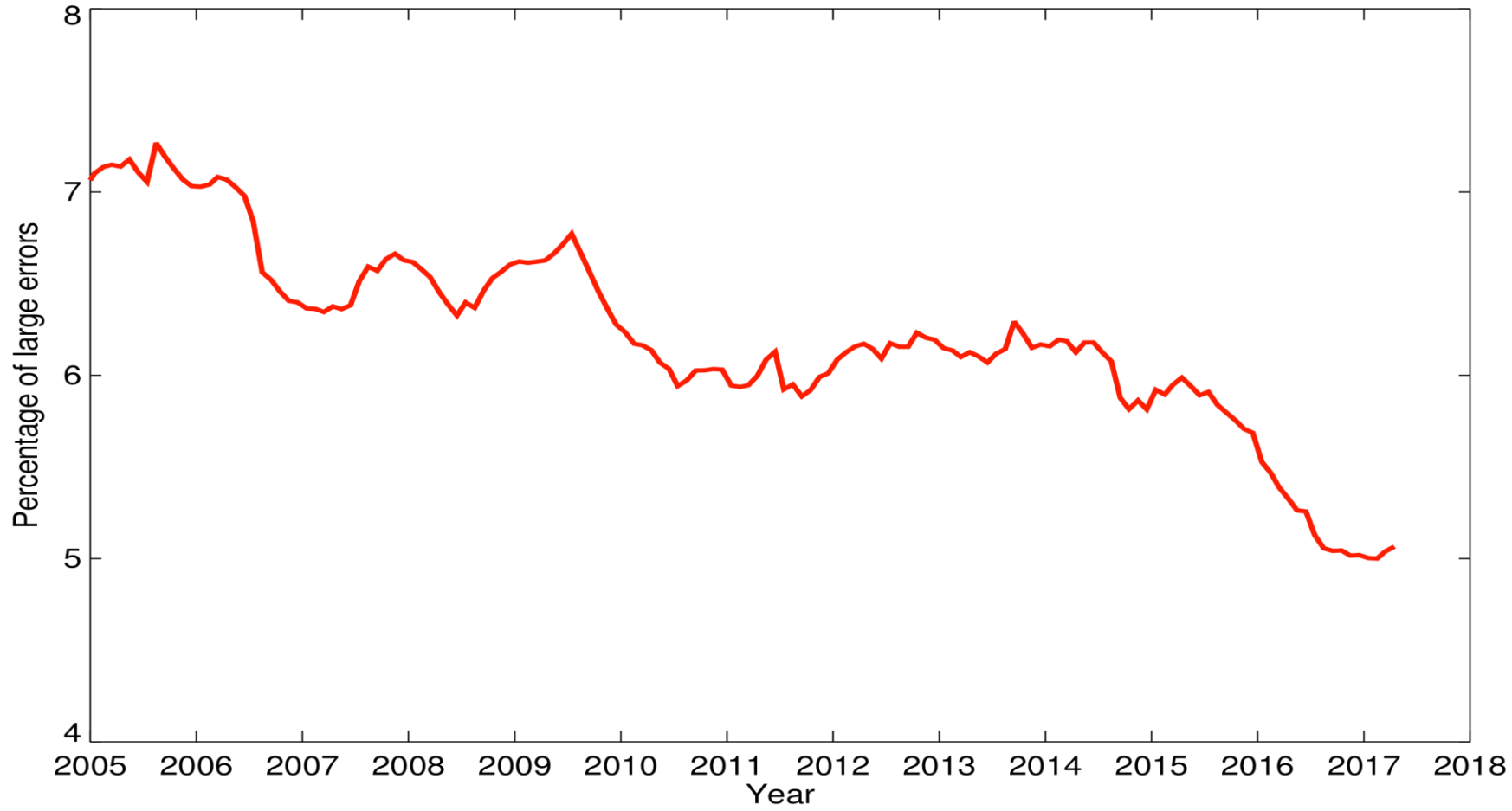
THE STRENGTH OF A COMMON GOAL

Evolution medium-range skill (NH Z500>0.8)



THE STRENGTH OF A COMMON GOAL

New emphasis: Percentage of large 2m temperature errors in the ensemble



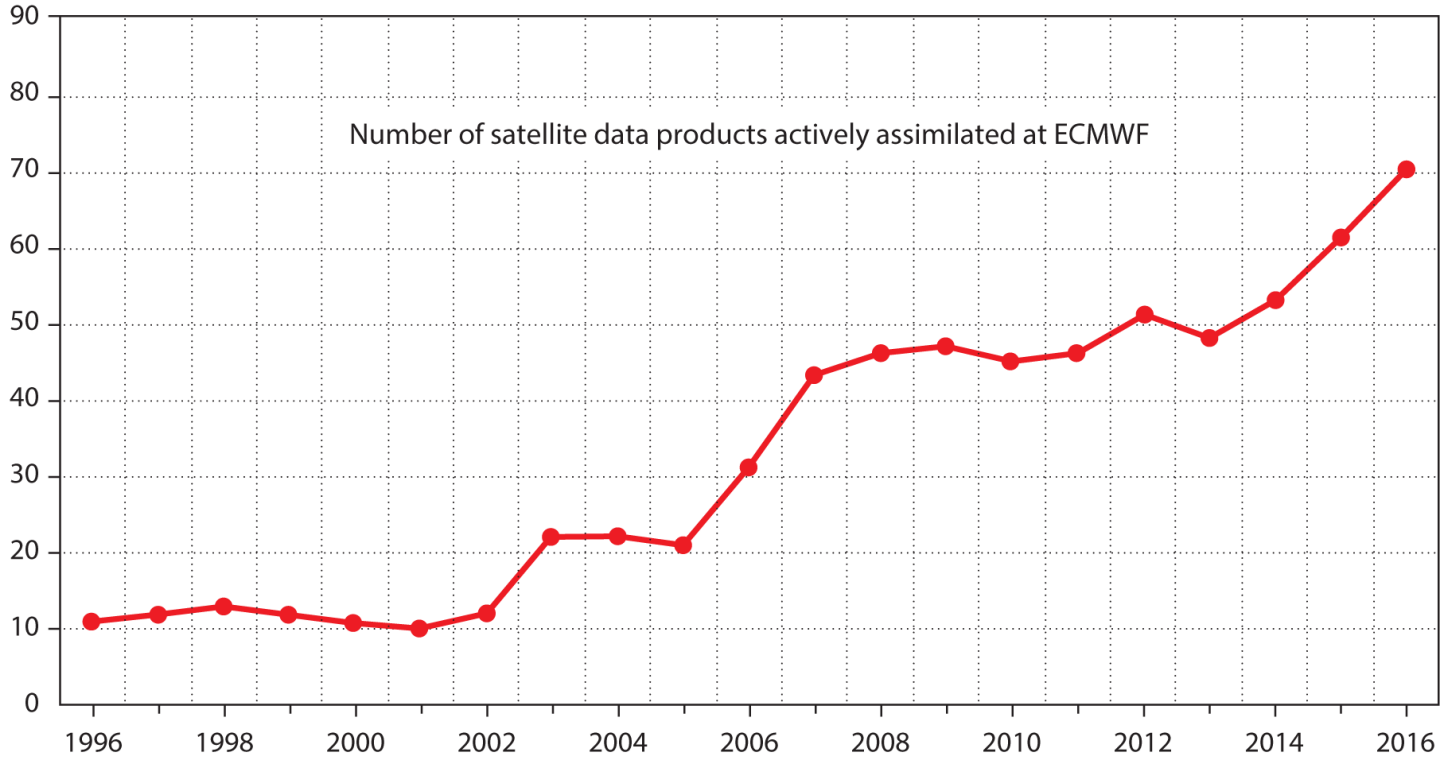
THE STRENGTH OF A COMMON GOAL

How do we achieve these goals?

- Observations
- High resolution ensemble
- Earth-system
- Scalability
- Funding
- People

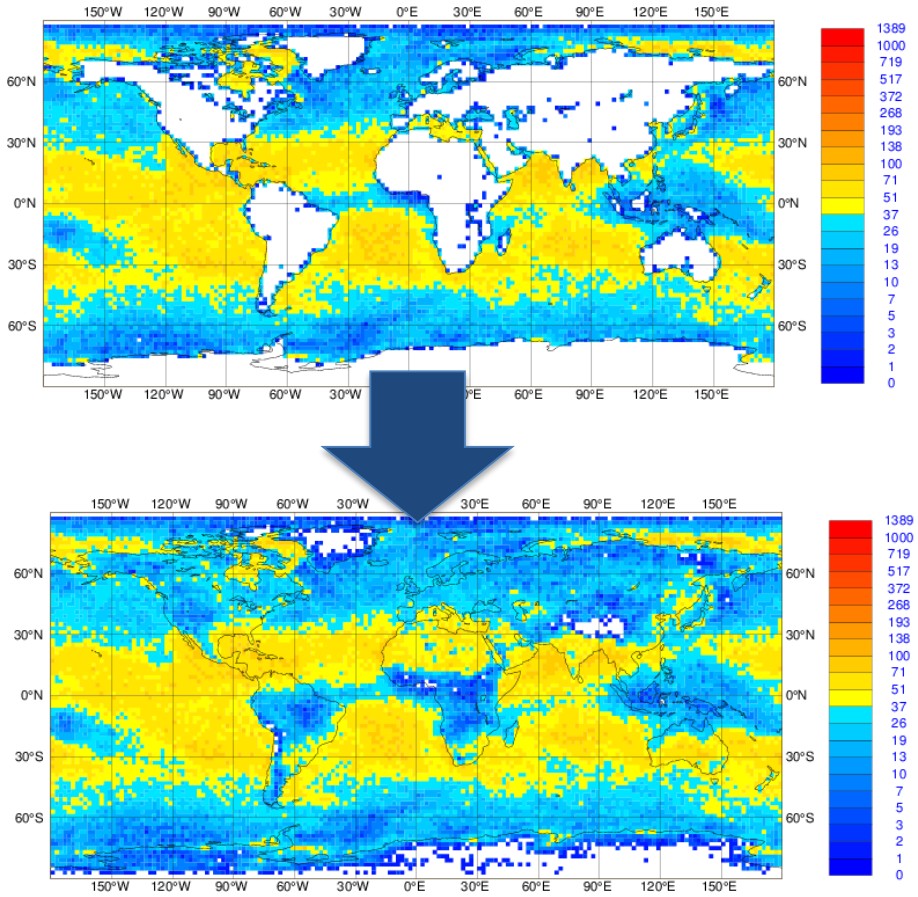
THE STRENGTH OF A COMMON GOAL

Use of satellite data at ECMWF



ECMWF processes an average of 40 million observations every day, from over 70 instruments. Collaboration with sister organisation EUMETSAT, and also ESA, CMA, JMA, NASA, NOAA among others ensures that ECMWF has access to the observations meteorology requires.

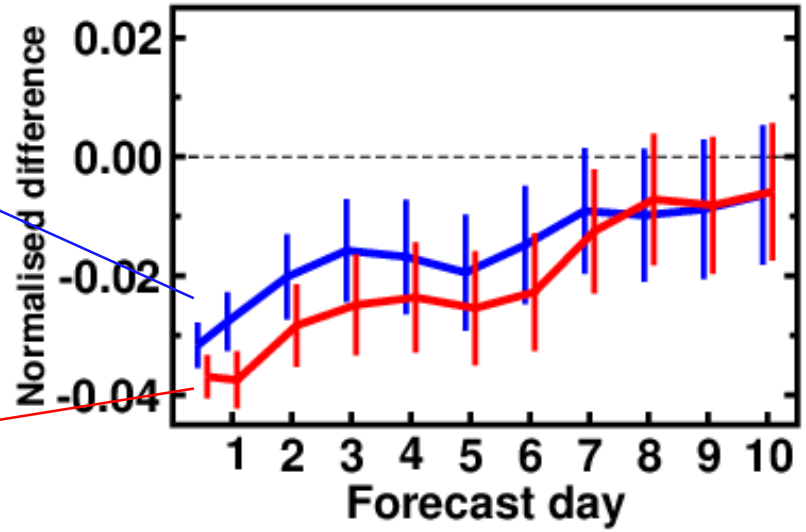
Increased used of hyperspectral infrared sounders over land



Current impact of IR radiances in ***Cy43r3***

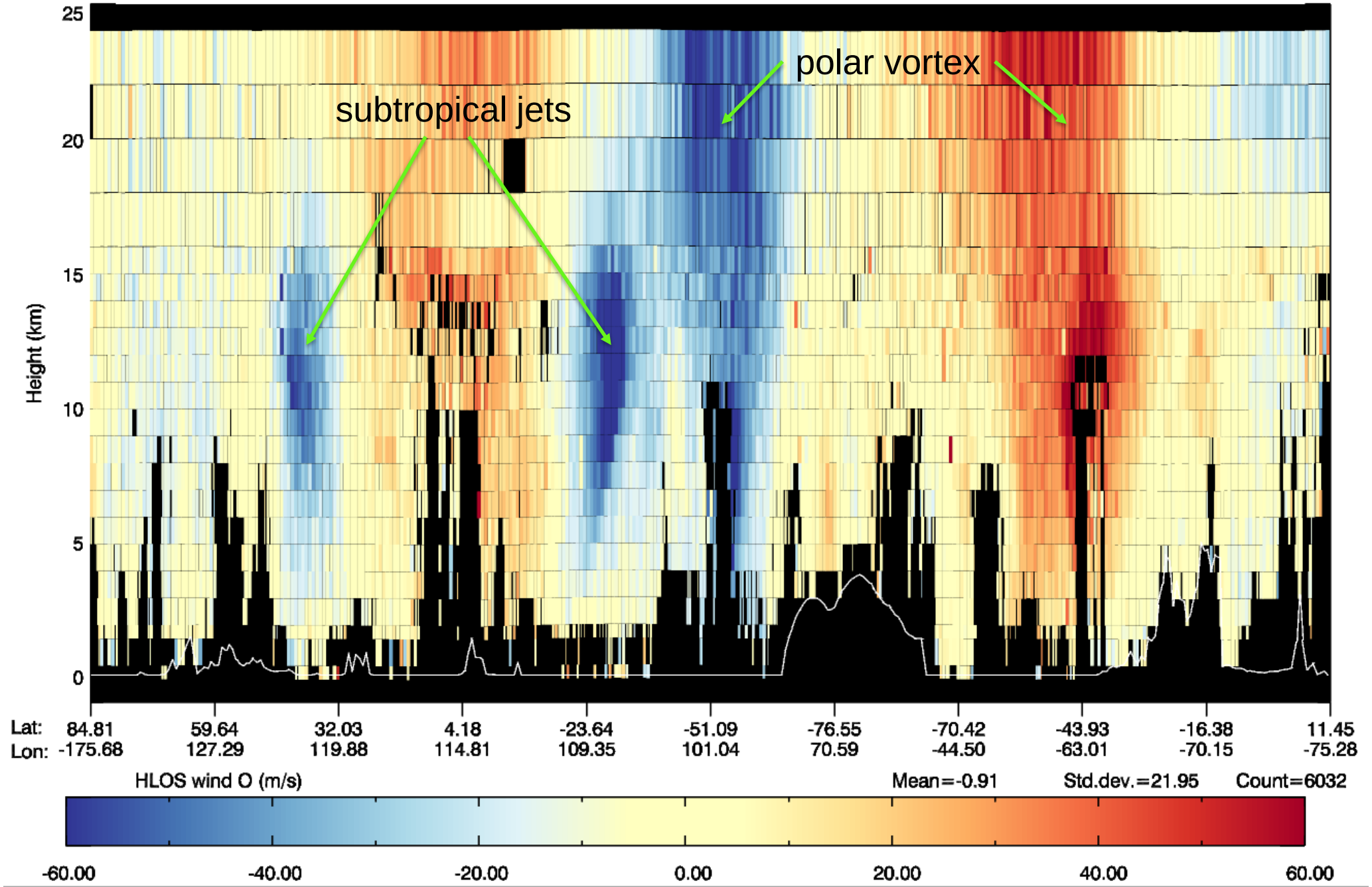
Expected impact of IR radiances in ***Cy45r1***

N.Hem. Z500 (RMSE)

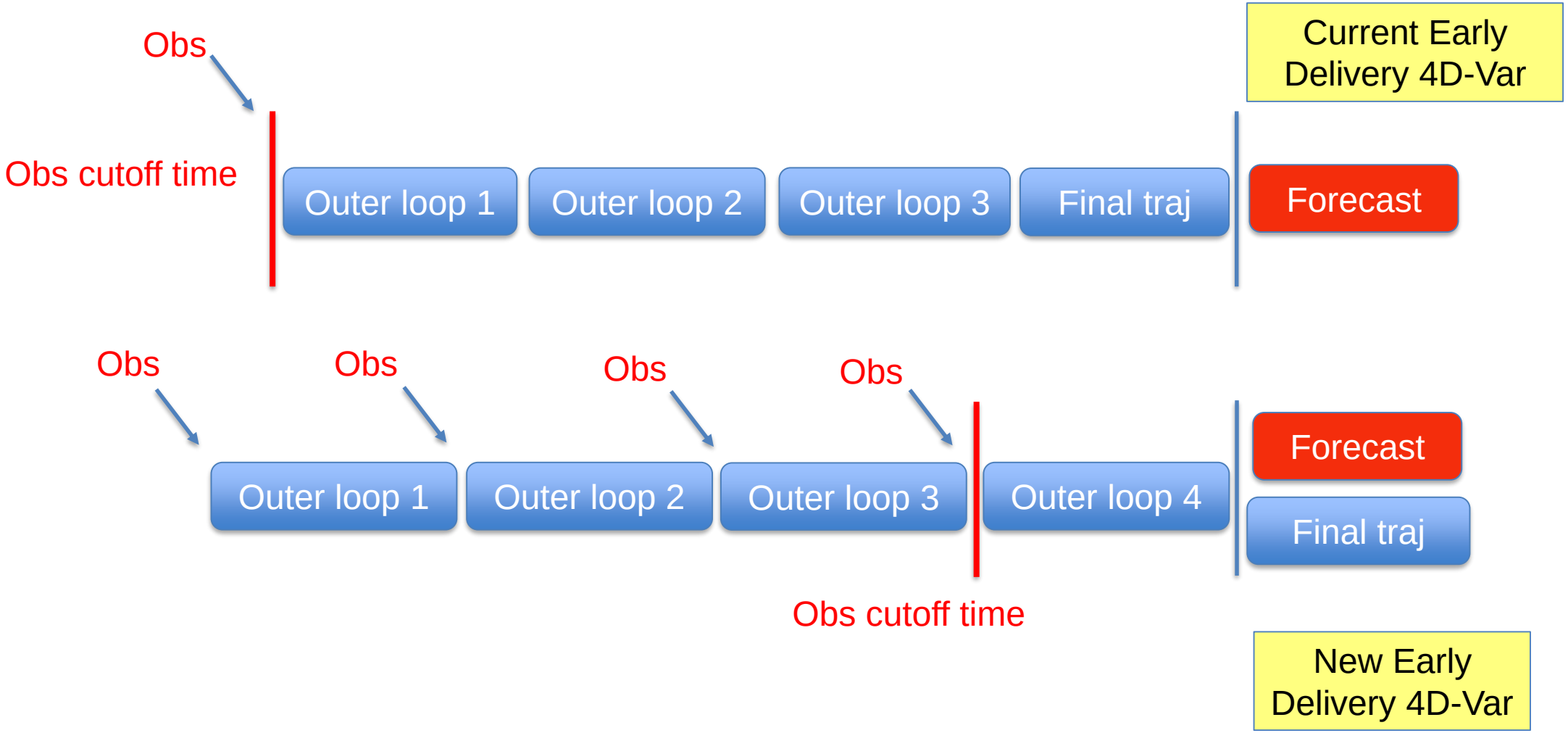


Activation of tropospheric IR data over land increased magnitude of forecast error reduction due to IR sounders by 50%

AEOLUS: Level-2B Rayleigh-clear HLOS wind

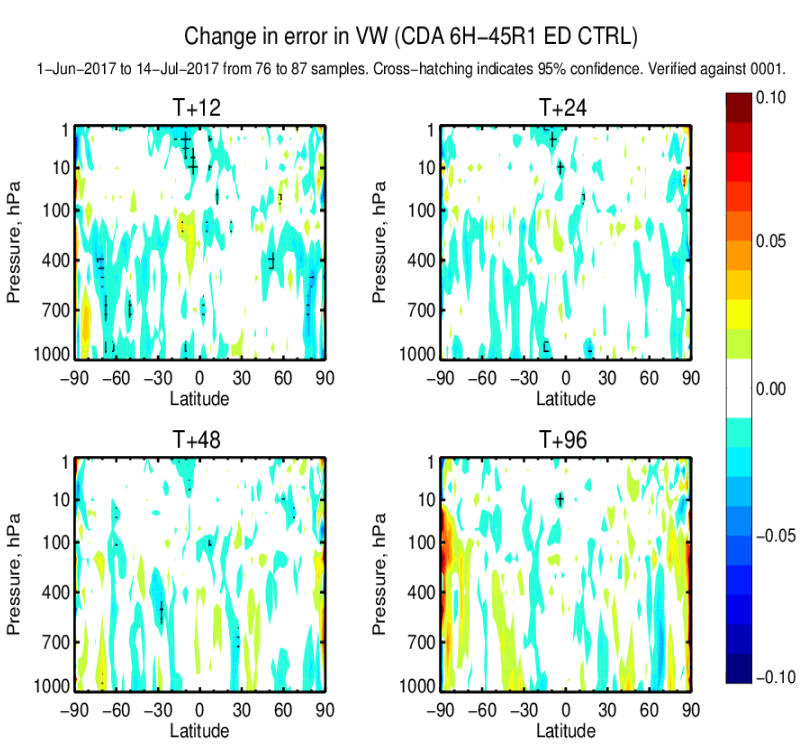


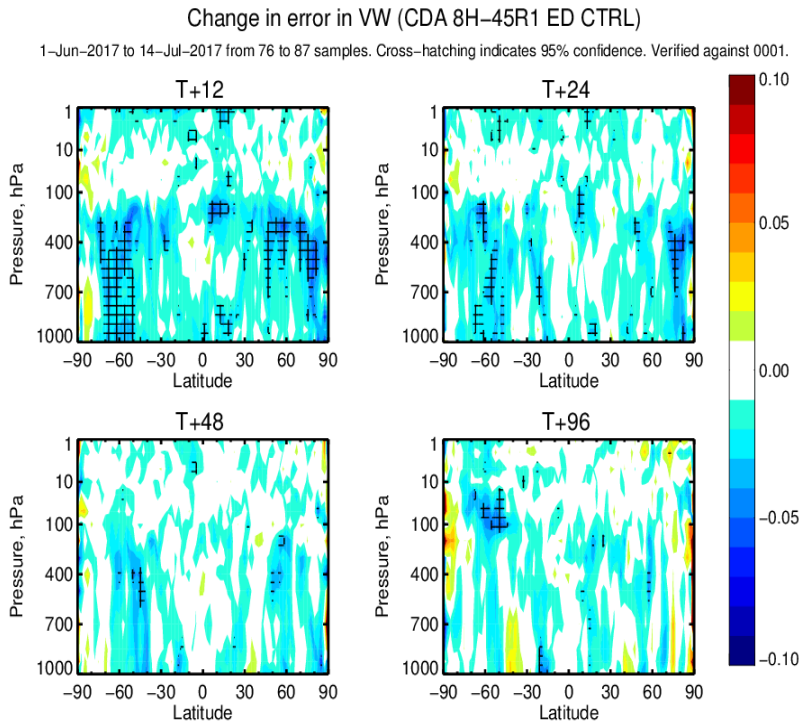
46r1: Continuous data assimilation

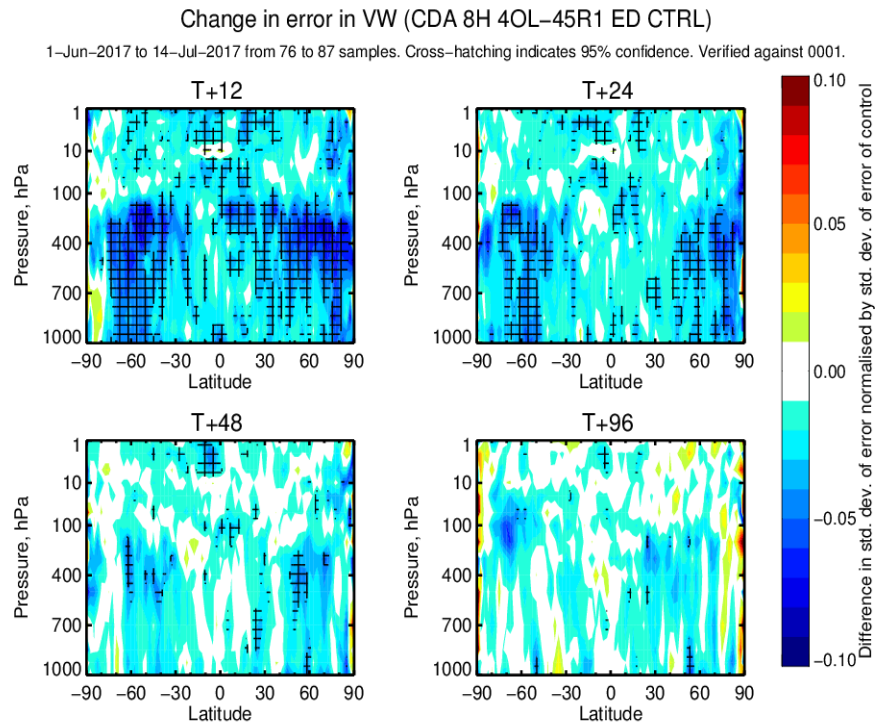


Continuous DA

- **Preliminary results (Wind Vector error stdev, 1/6/17 – 14/7/17)**





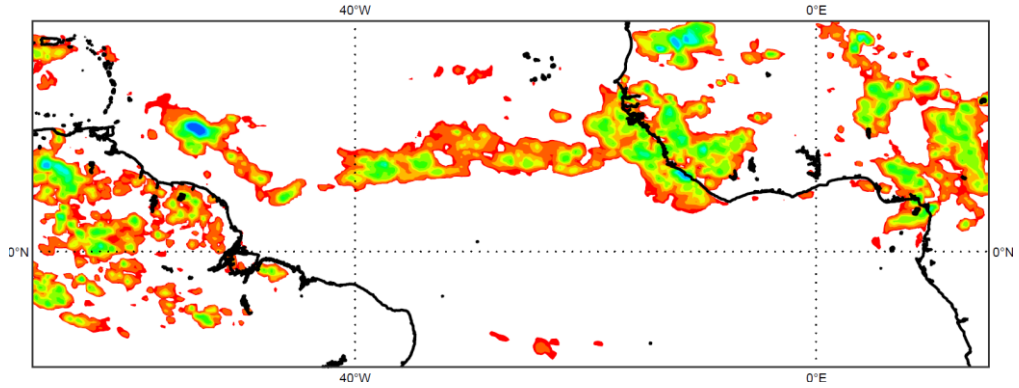


A: Late obs – 6h window

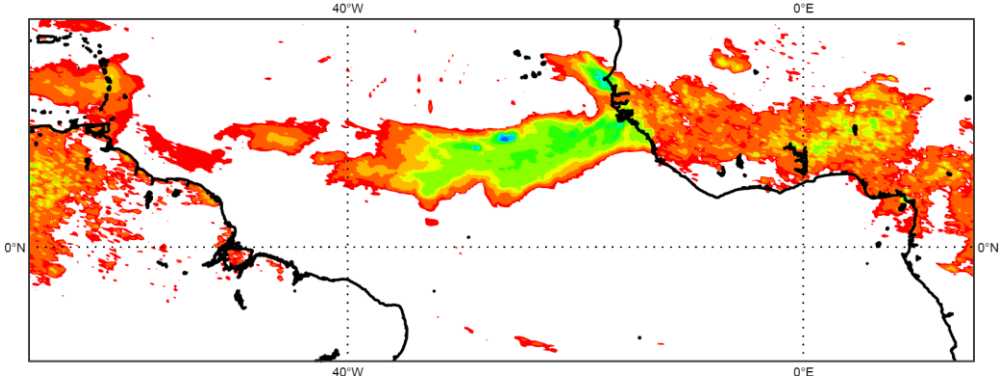
B: Late obs – 8h window

C: B + 4 outer loops

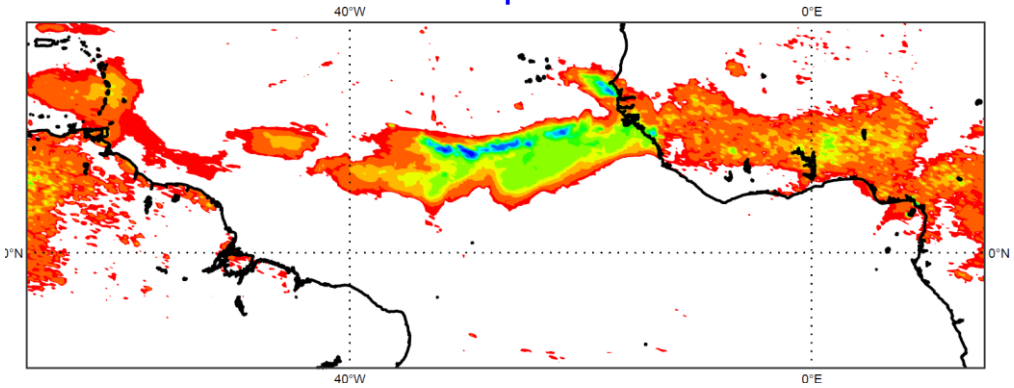
Observed 24h precipitation (TRMM)



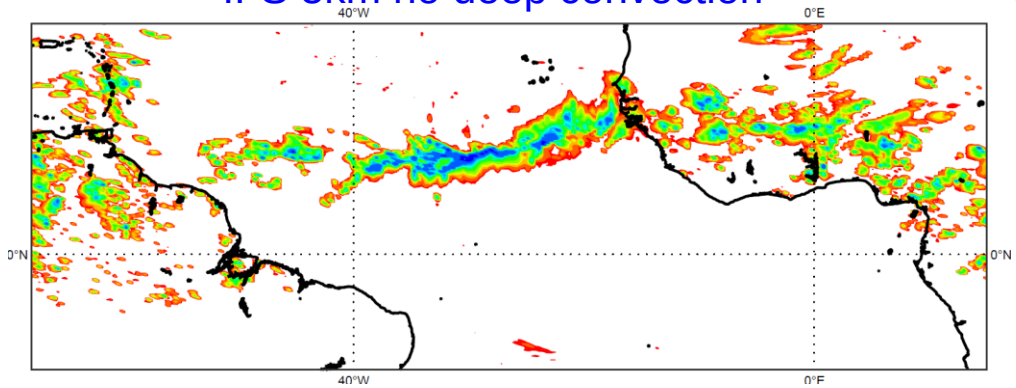
IFS 9km deep convection



IFS 5km deep convection



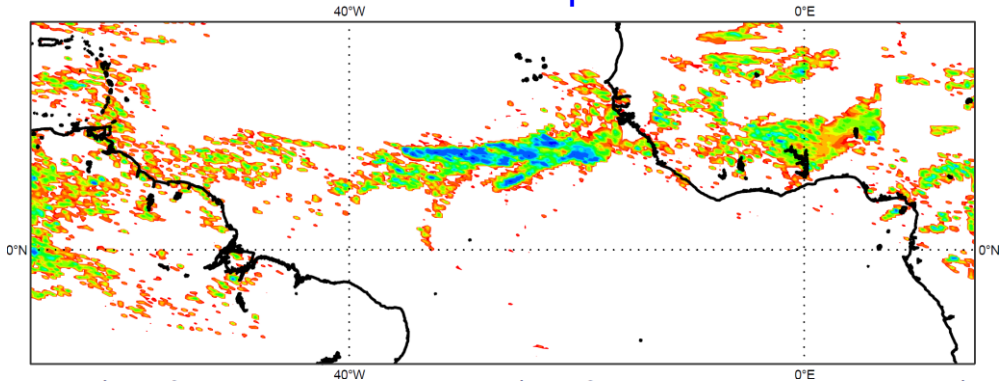
IFS 5km no deep convection

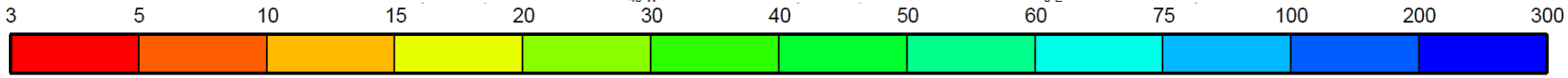


ECMWF

DWD

ICON 5km no deep convection

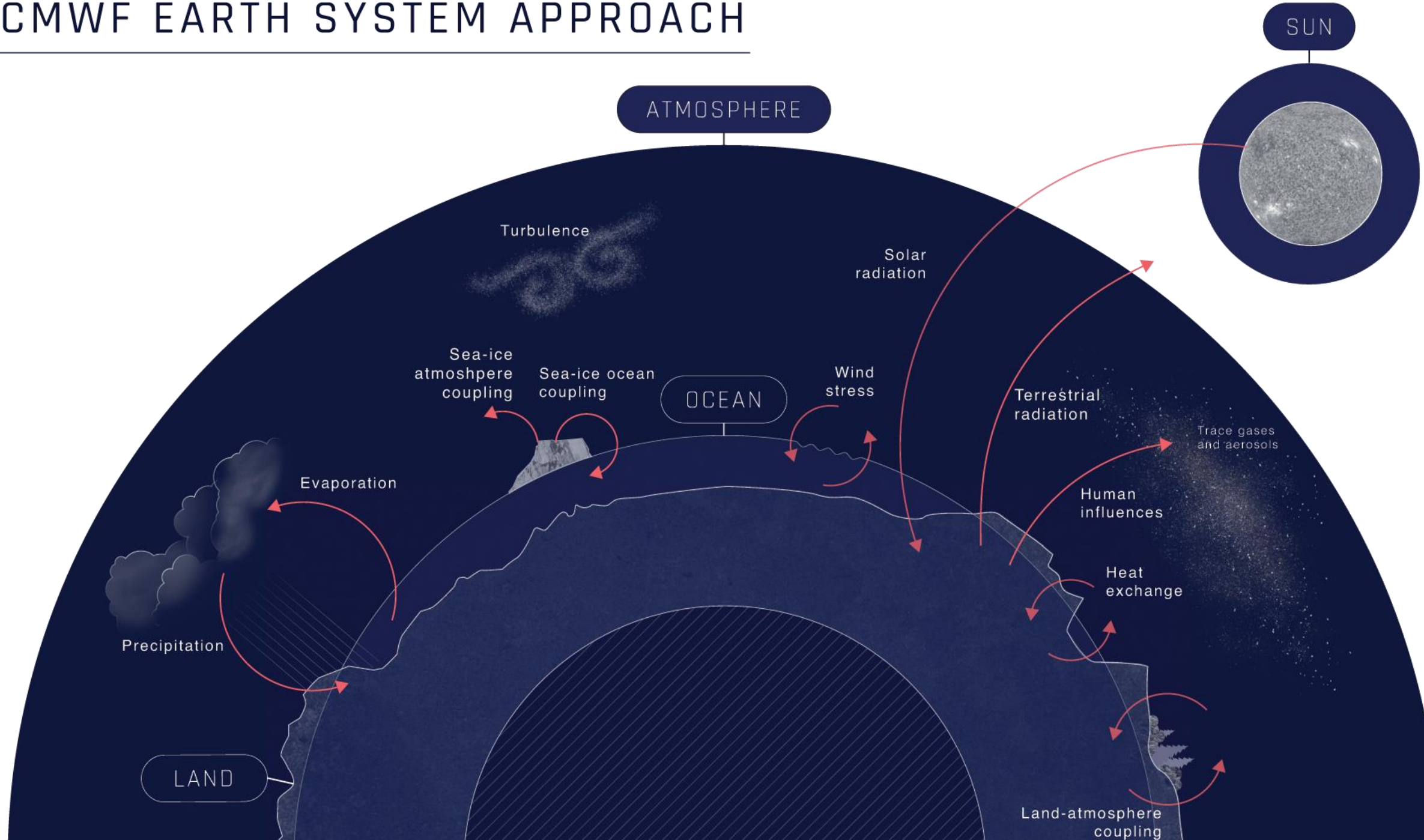




Work needed on moist physics and physics-dynamics coupling

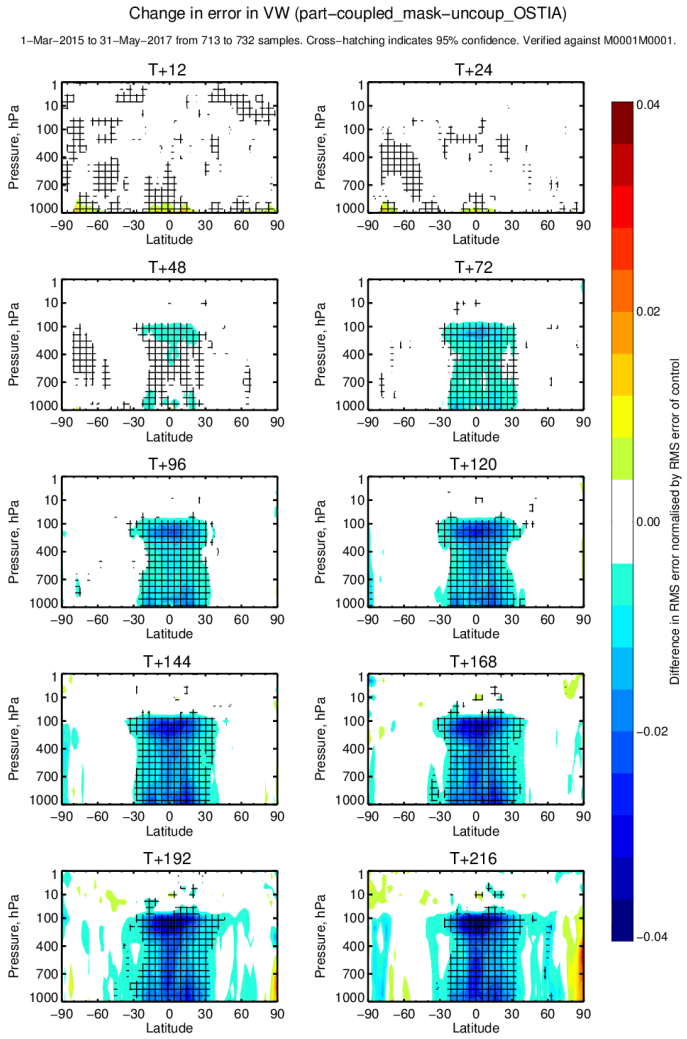
P. Dueben, P. Bechtold, D. Klocke

ECMWF EARTH SYSTEM APPROACH

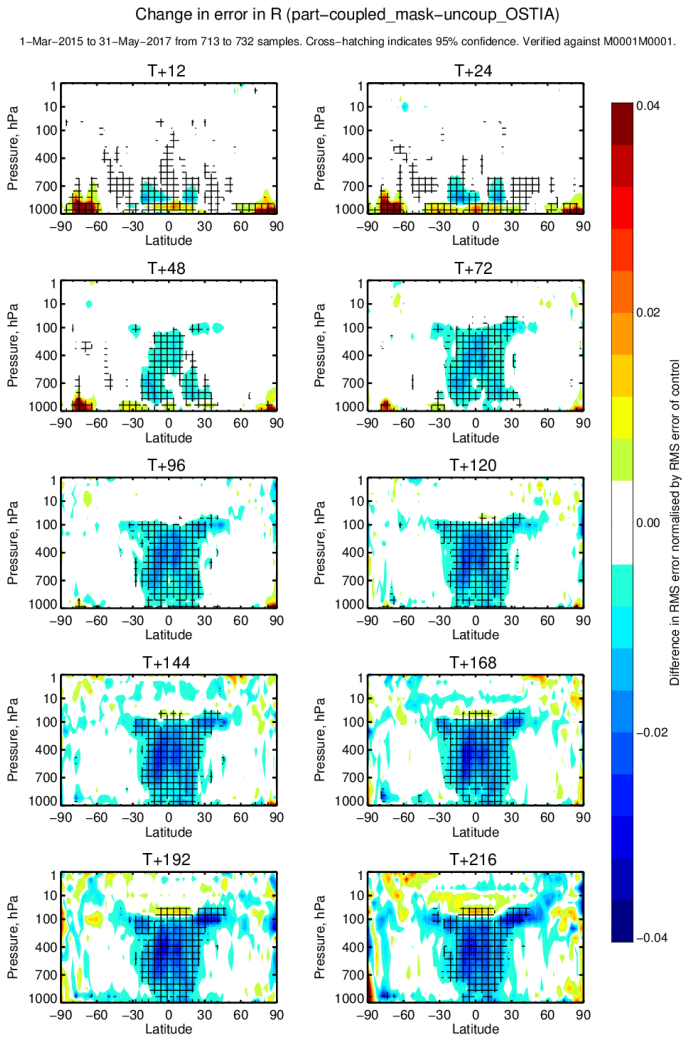


Impact of coupling (2 years combined scores. TCo1279)

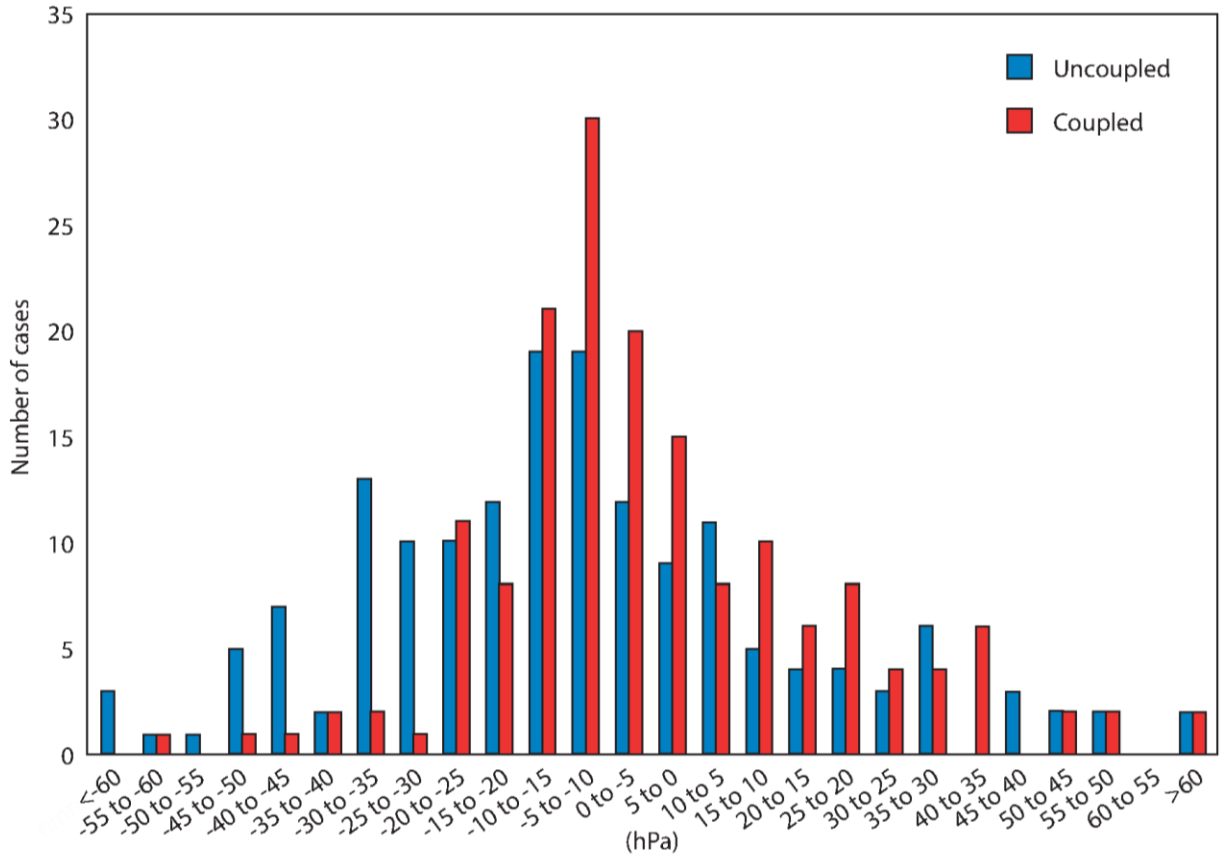
Wind



Humidity



Does the ocean coupling actually matter for a large sample of TC's?



- Distribution of 7-day TC intensity forecast errors for coupled and uncoupled high-resolution forecast experiments.
- The experiments cover the period of March 2015 to June 2017 and were carried out over all basins for a total of 163 TCs.
- The number of over predictions is reduced in the coupled forecasts compared to the uncoupled forecasts.

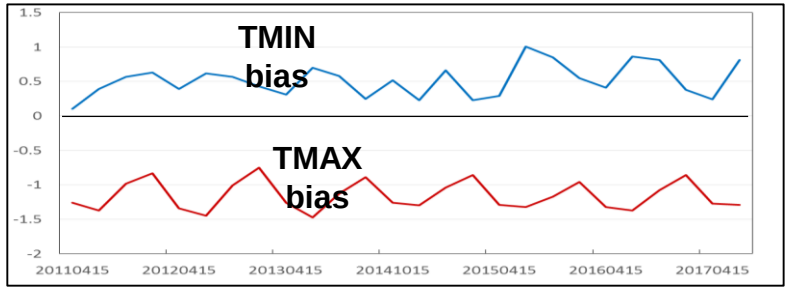
New snow model and enhanced vertical discretization of the soil

- Increased vertical discretization

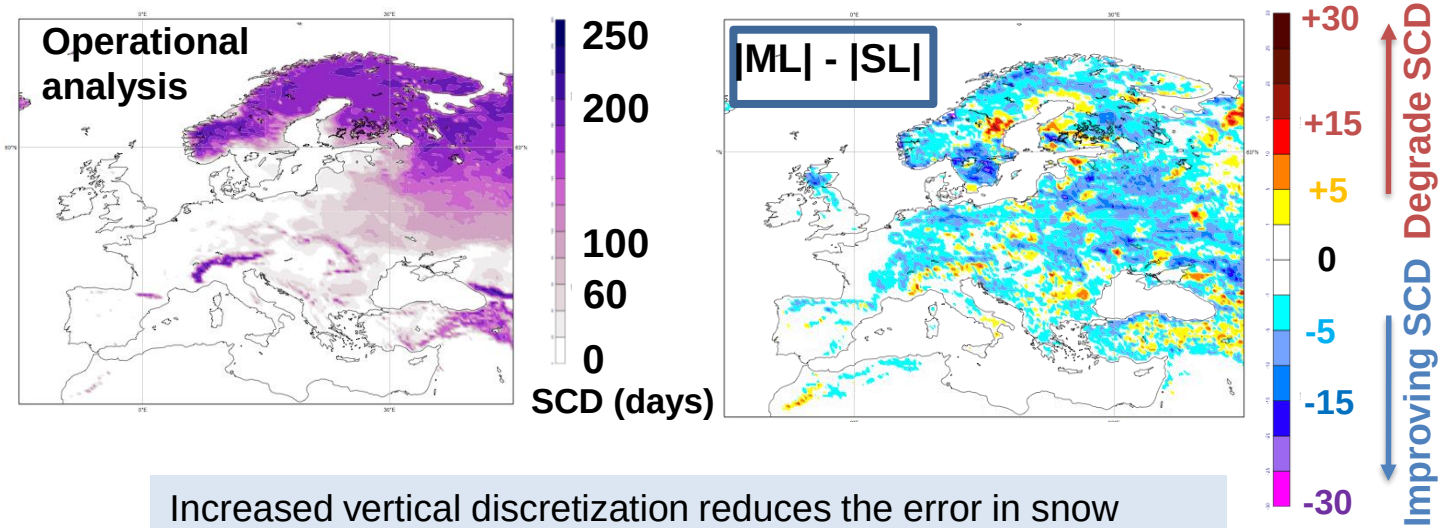
➔ of the snowpack (**up to 5 layers**)

➔ of the soil (**from 4 to 9 layers**)

- better physical processes representation



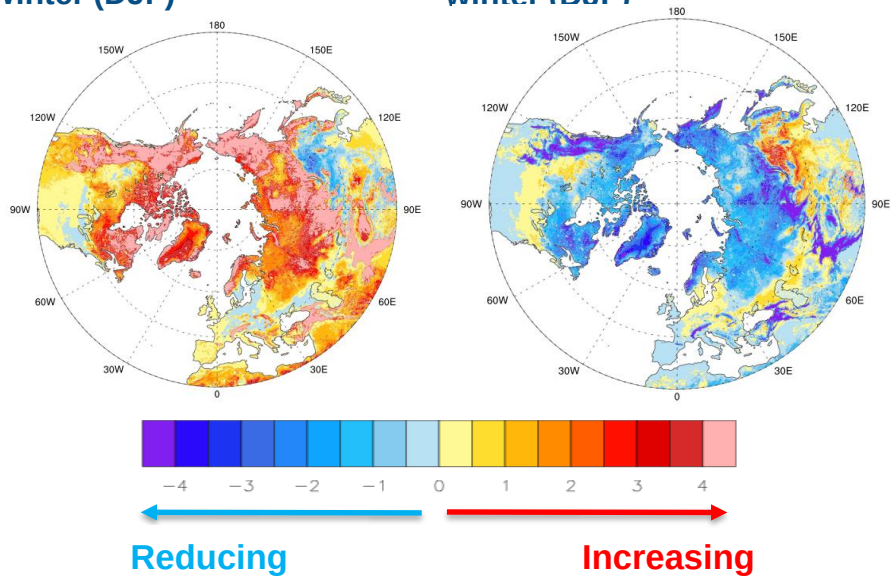
Snow cover duration (SCD) over Europe 2016/2017



Increased vertical discretization reduces the error in snow cover duration by 5 to 15 days

Difference in T_{skin} amplitude winter (DJF)

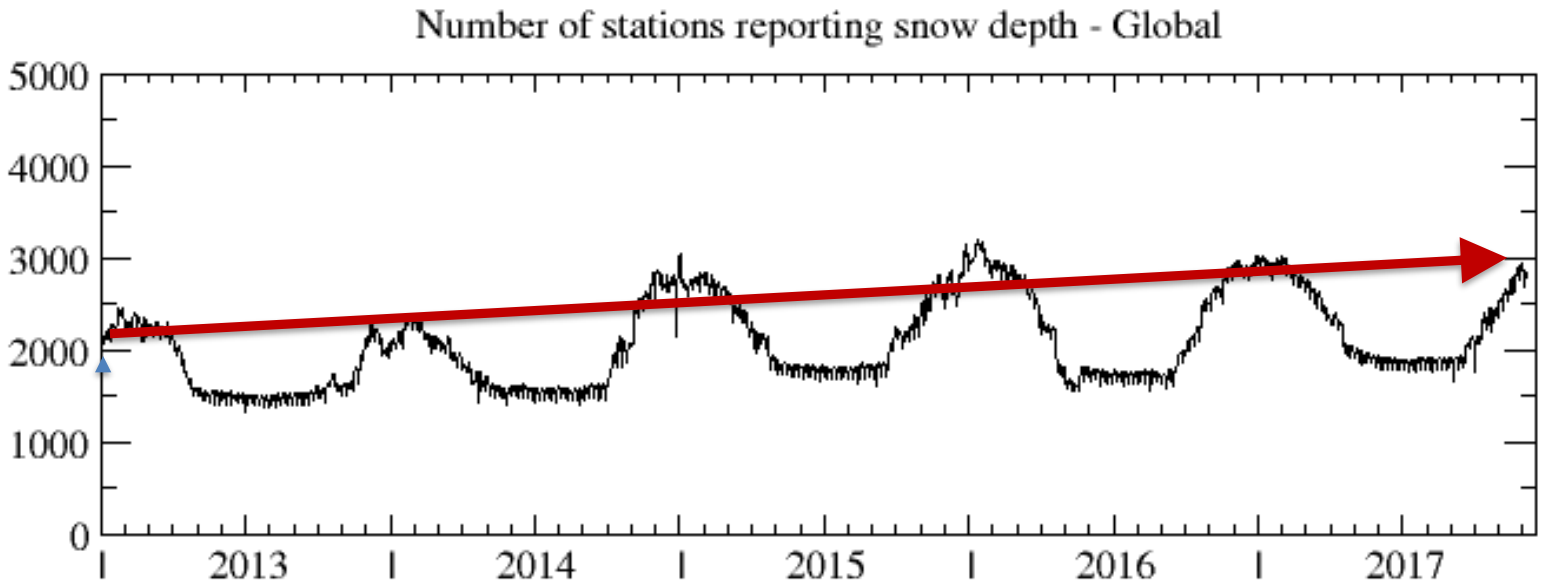
Difference in T_{skin} minimum winter (DJF)



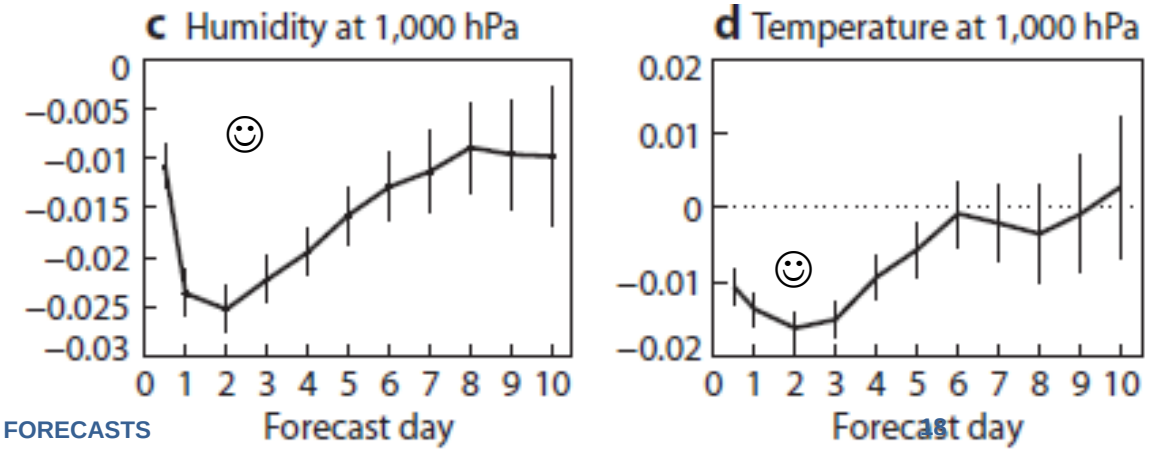
Potential for reducing the 2m temperature diurnal-cycle bias

THE STRENGTH OF A COMMON GOAL

Availability and use of GTS snow depth information



Impact of revised IMS snow cover assimilation on rms 1000hPa temperature and humidity errors



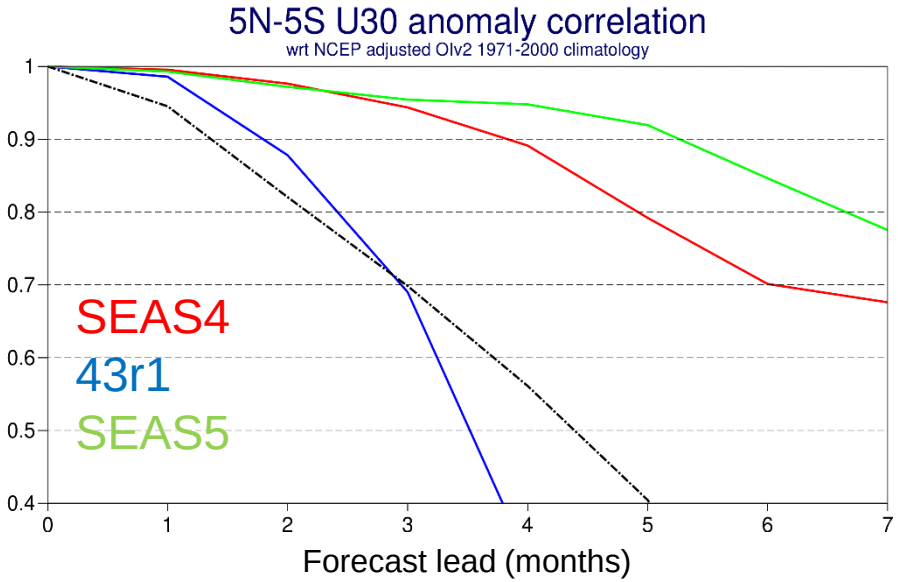
THE STRENGTH OF A COMMON GOAL

Seamless modelling systems

- Scientific and infrastructure advantages of convergence of approaches across timescales

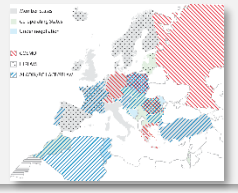
- Seasonal SEAS5 only differs from the 43r1 ENS extended (monthly) system when testing demonstrated clear improvement in forecast skill or mean state
  - Horizontal (Tco319/ORCA25) and vertical resolution (L91/L75) identical

- Improvements found on one timescale applicable for others
  - Decreasing non-orographic gravity wave drag ameliorates the effect of stratospheric temperature and winds biases on the QBO
  - Preferred seasonal setting now found suitable for adoption for medium-range to monthly



ECMWF Scalability Programme

Governance: ECMWF, Member states, Regional consortia



Projects:

Observation processing:
- Lean workflow in critical path
- Object based data store
- Screening/bias correction

Data assimilation:
- Flexible algorithms (C++)
- IFS integration
- Coupling with ocean and sea-ice
- Parallel minimization

Numerical methods:
- Numerical methods
- h/v/t-discretization, multiple grids
- Prognostic variables, coupling

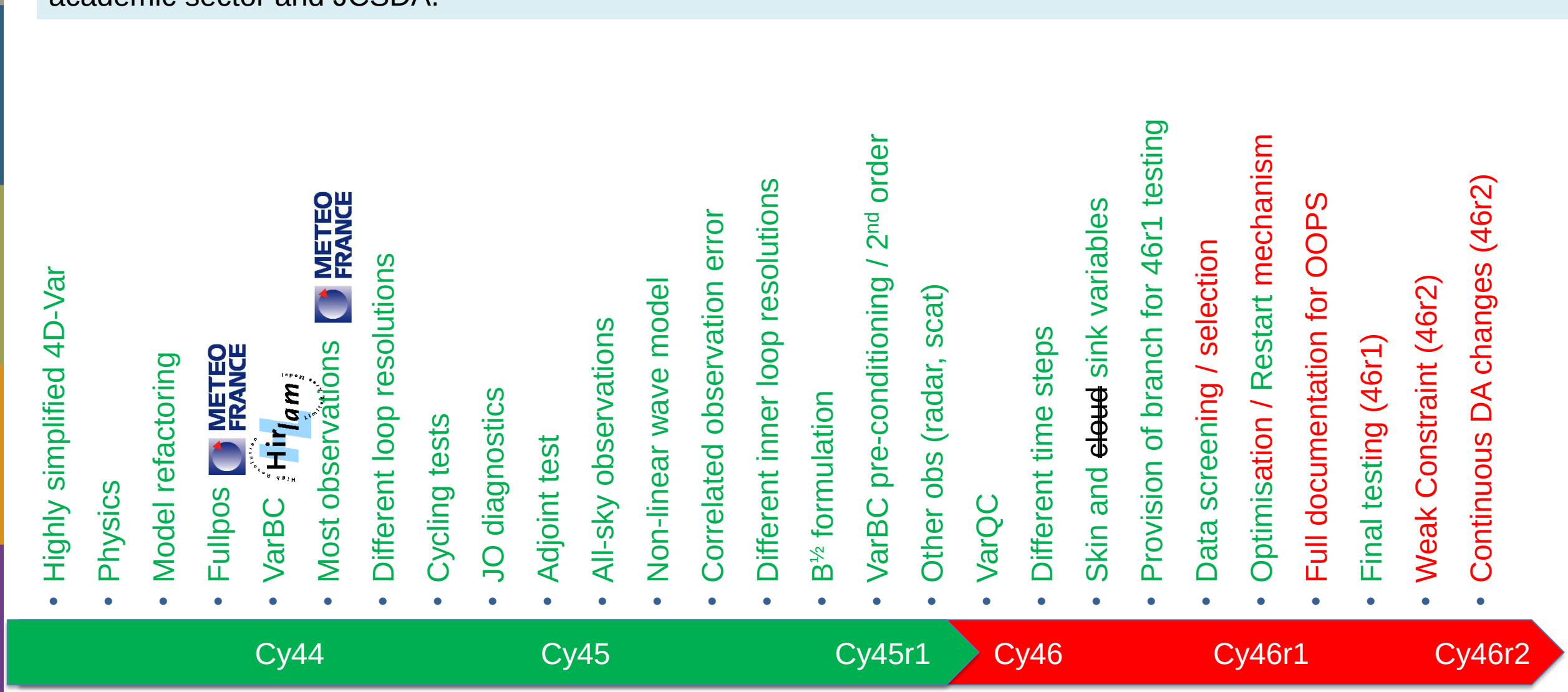
Model output processing:
- Broker-worker workflow
- Near-memory processing
- Data compression

Code adaptation:
· Benchmarking · Vectorization · Programming models · Precision · DSL/libraries · Transition to operations

Computer architecture support:
· Benchmarking · Novel architectures · Compilers · Vendor support · Transition to operations

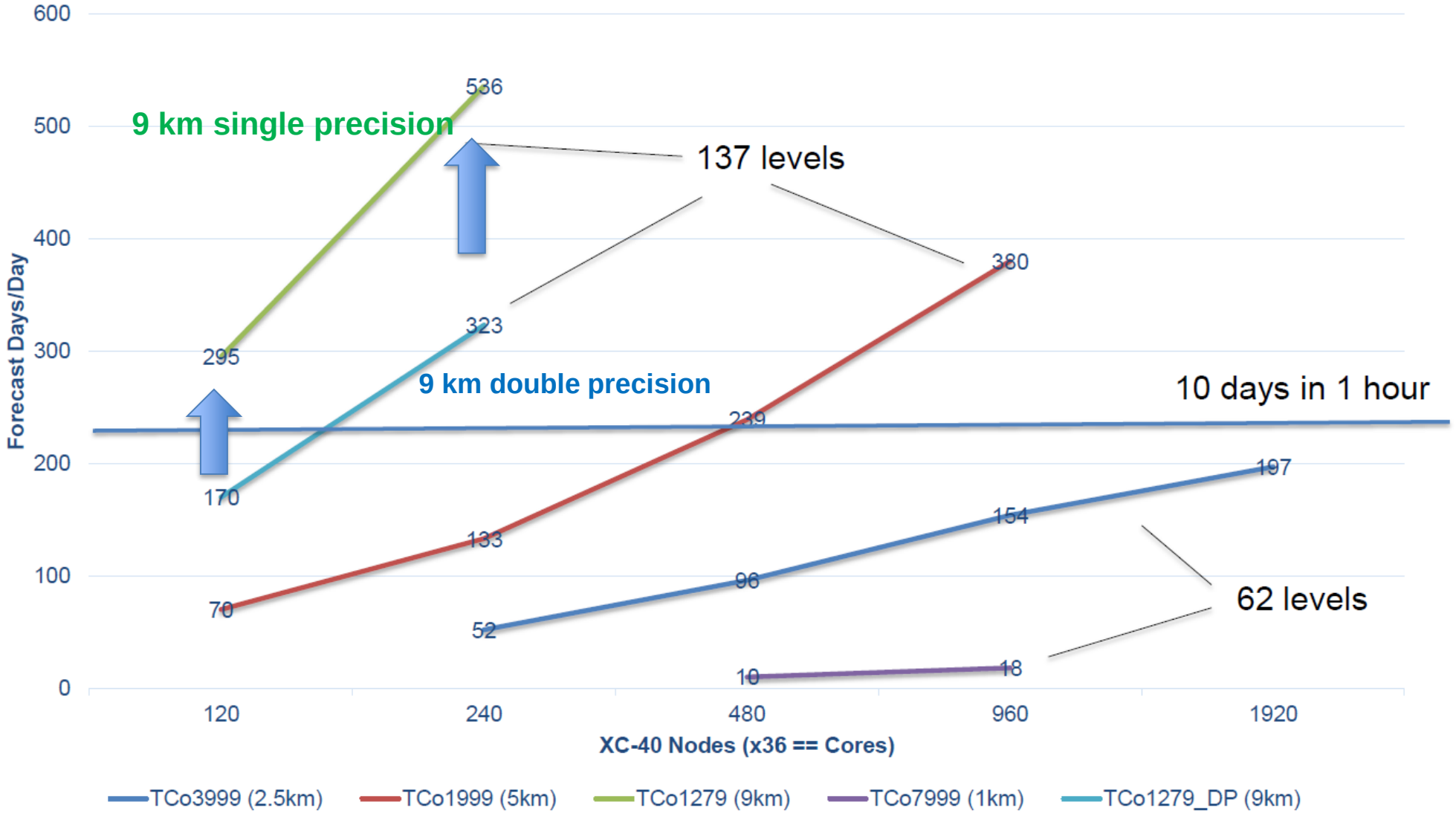
OOPS Progress 2016-18 and plans 2018-19

OOPS enables Flexibility, new DA methods, time parallelisation in DA, reduced inter-dependency in code, code sharing by Earth System components, engagement with Member States (Météo-France, HIRLAM, ALADIN), academic sector and JCSDA.



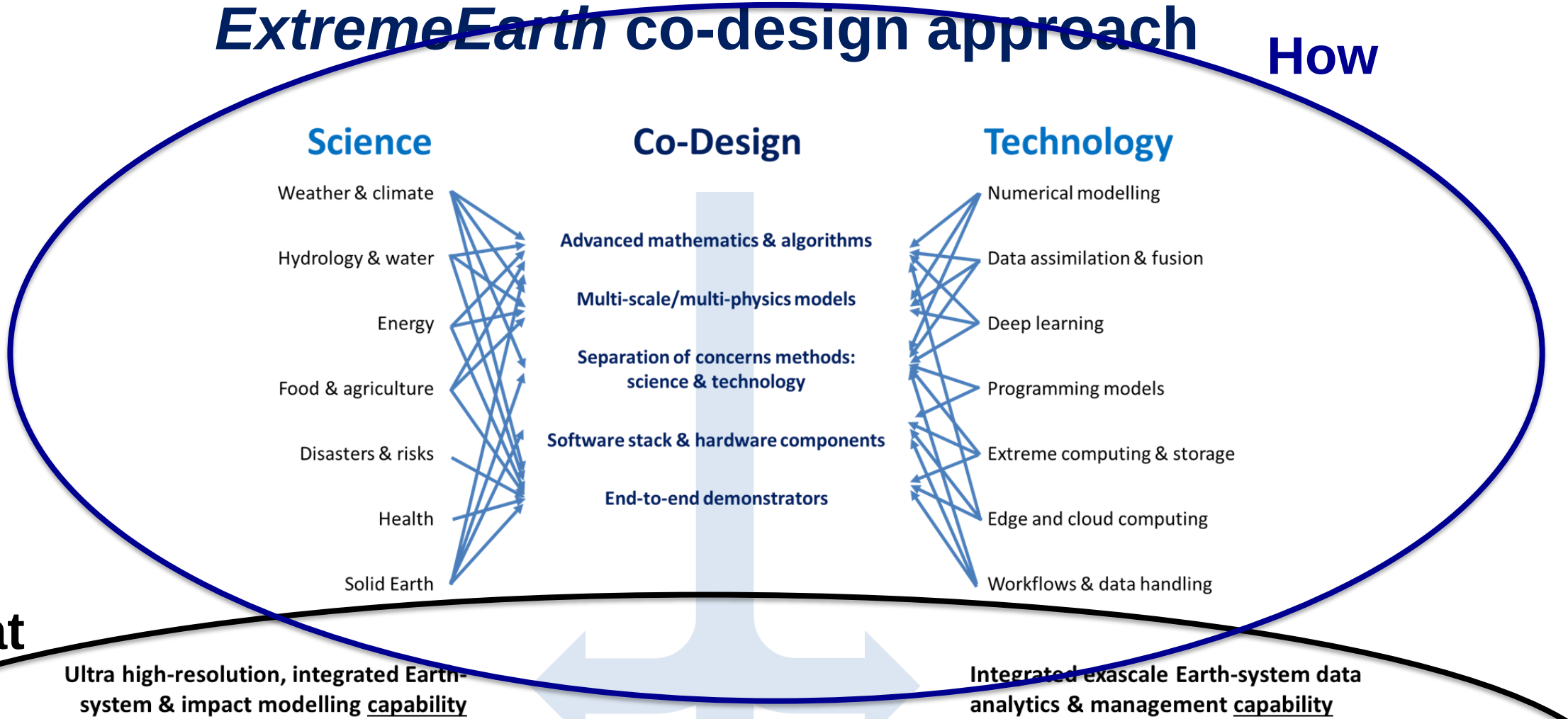
Funded by the
European Union

ESiWACE: Single precision IFS



ExtremeEarth co-design approach

How



What

Ultra high-resolution, integrated Earth-system & impact modelling capability

Integrated exascale Earth-system data analytics & management capability

Earth-system HPC technology and exascale capability

Integrated Earth-system information system capability

THE STRENGTH OF A COMMON GOAL

In summary

- Operational forecasts AND Research
- High-impact weather, regime transitions and global-scale anomalies
- Integrated ensemble at 5km resolution by 2025
- Earth-System model and analysis
- Scalable computation
- Collaboration

IRMA operational v. **5km**