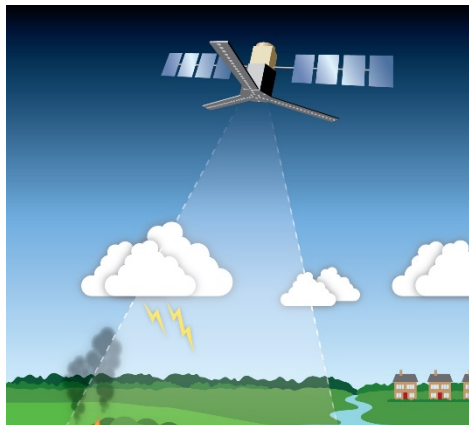
Council 95
10-11 December 2019

The strength of a common goal

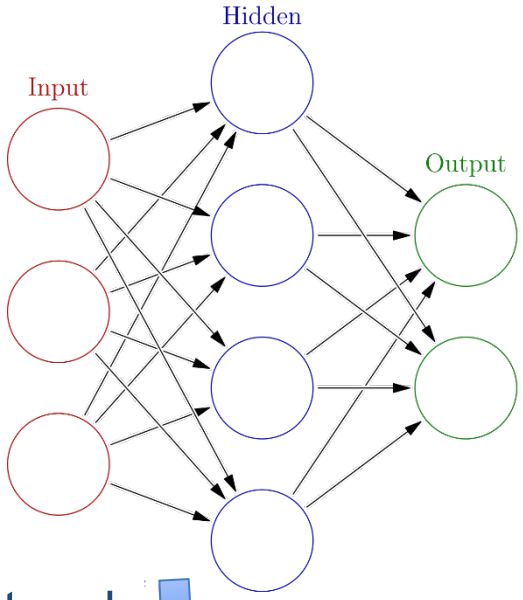
NWP SCIENCE | GLOBAL FORECASTS | SERVING METEOROLOGY | SUPERCOMPUTING | ENVIRONMENTAL SERVICES

Advancing weather science

# SMOS neural network soil moisture assimilation in IFS 46R1

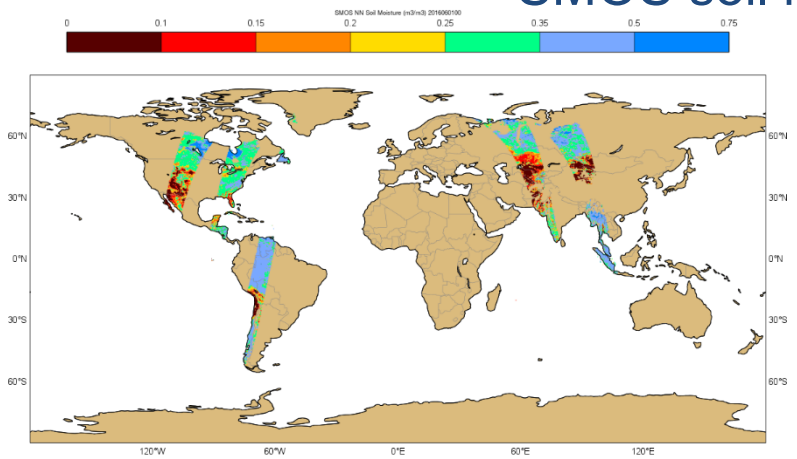


SMOS radiances

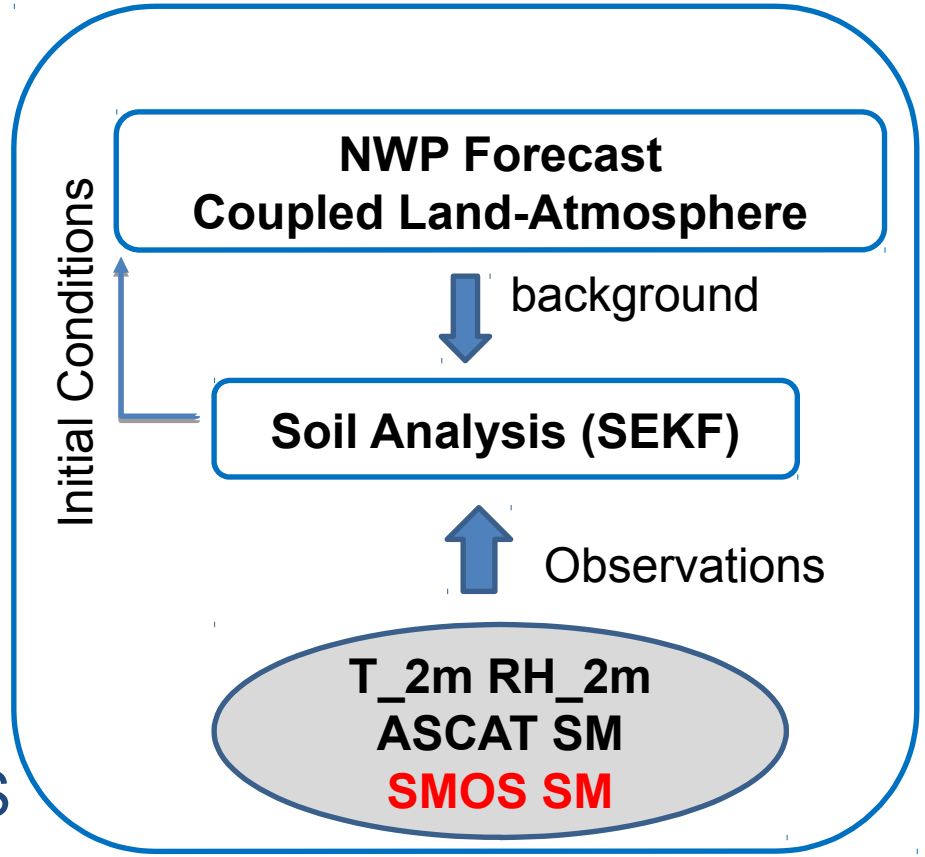



SMOS
neural network

SMOS soil moisture




IFS




ECMWF

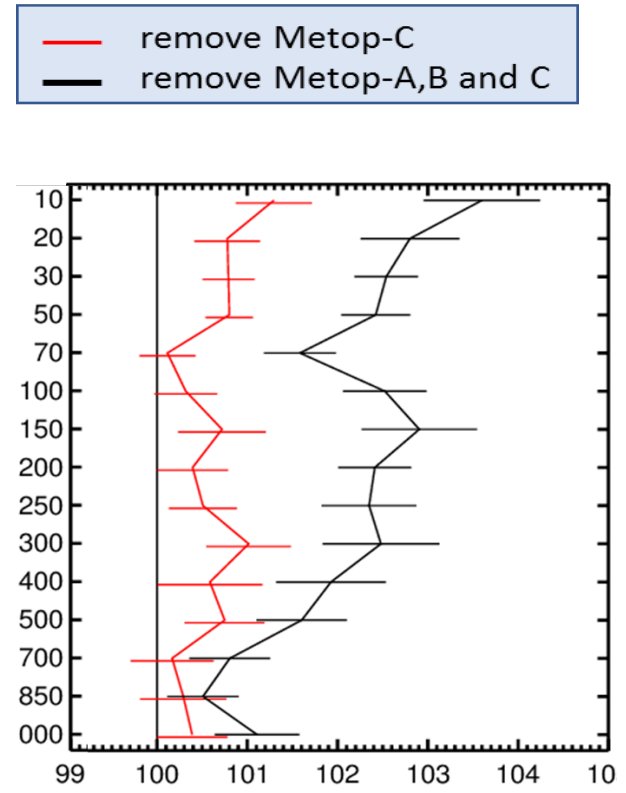
# Status of Metop-C

| SENSOR | Access to CAL/VAL observations (pre-release) | Active use in ECMWF operations (* Expected) | Known data anomalies |
|---|---|---|---|
| **AMSUA** | Nov 2018 | March 2019 | Occasional ch 7 and ch-8 instability ch3 elevated noise |
| **MHS** | Nov 2018 | March 2019 | ch 3 and ch 4 elevated noise |
| **IASI** | May 2019 | July 2019* | Elevated biases between different pixels |
| **GRAS** | Nov 2018 | March 2019 | None |
| **ASCAT** | Jan 2019 | July 2019* | Re-calibration February 2019 |
| **AMV** | Jan 2019 | June 2019 | Different wind bias with dual satellite pairs |
| **GOME (O3)** | pending | pending | |

ECMWF

# Metop-C / EPS impact

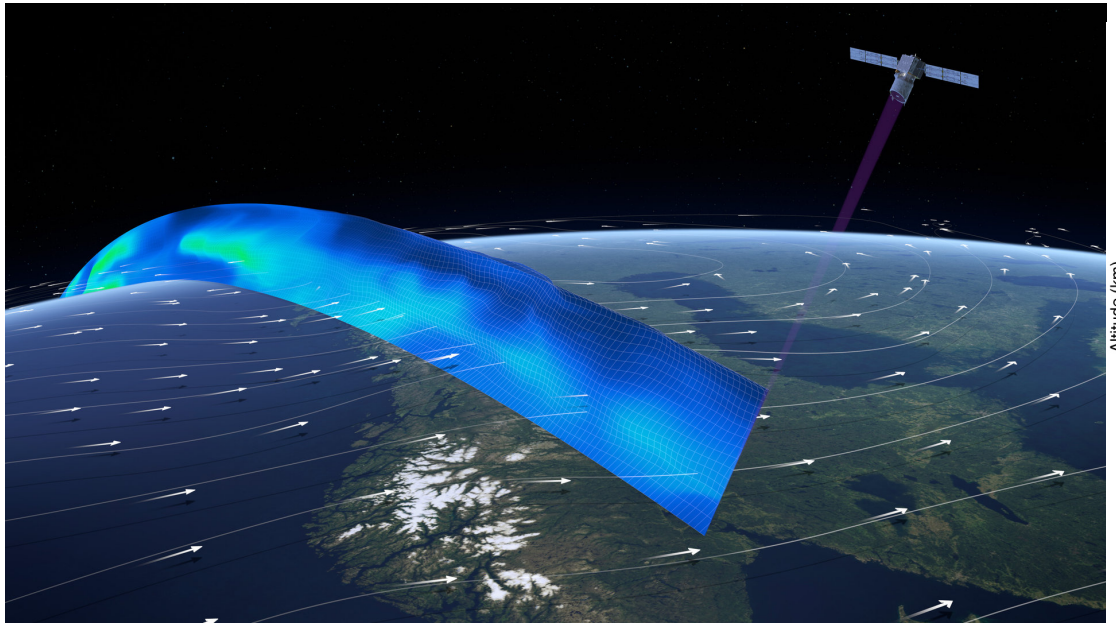
*T-Analysis degradation compared to control (sonde temperatures)*

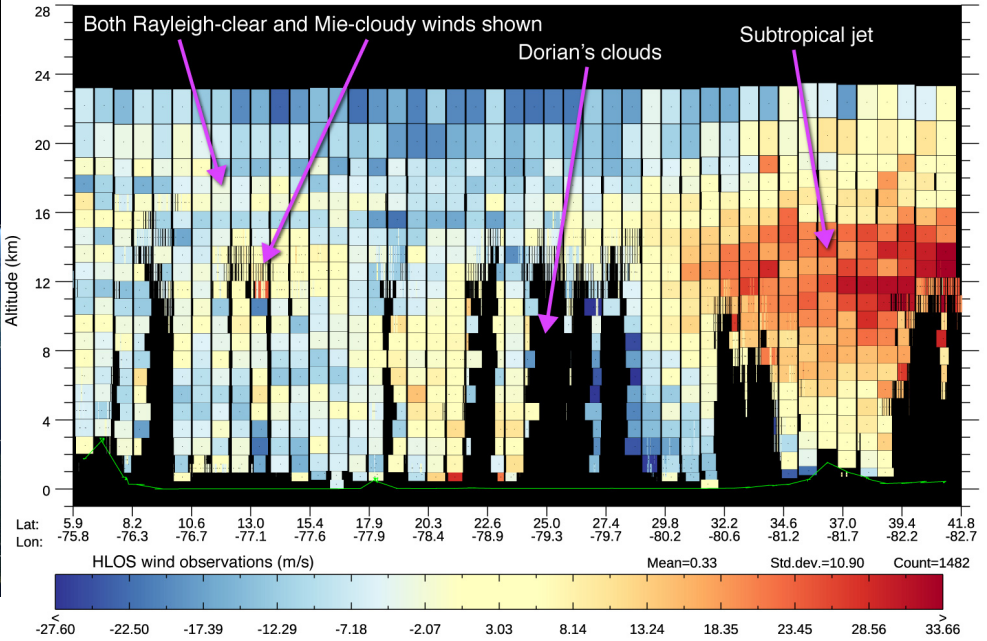



Percentage change

# Collaborating with ESA on Aeolus: **first wind lidar in space**

## Aeolus: impact and preparations for operational usage



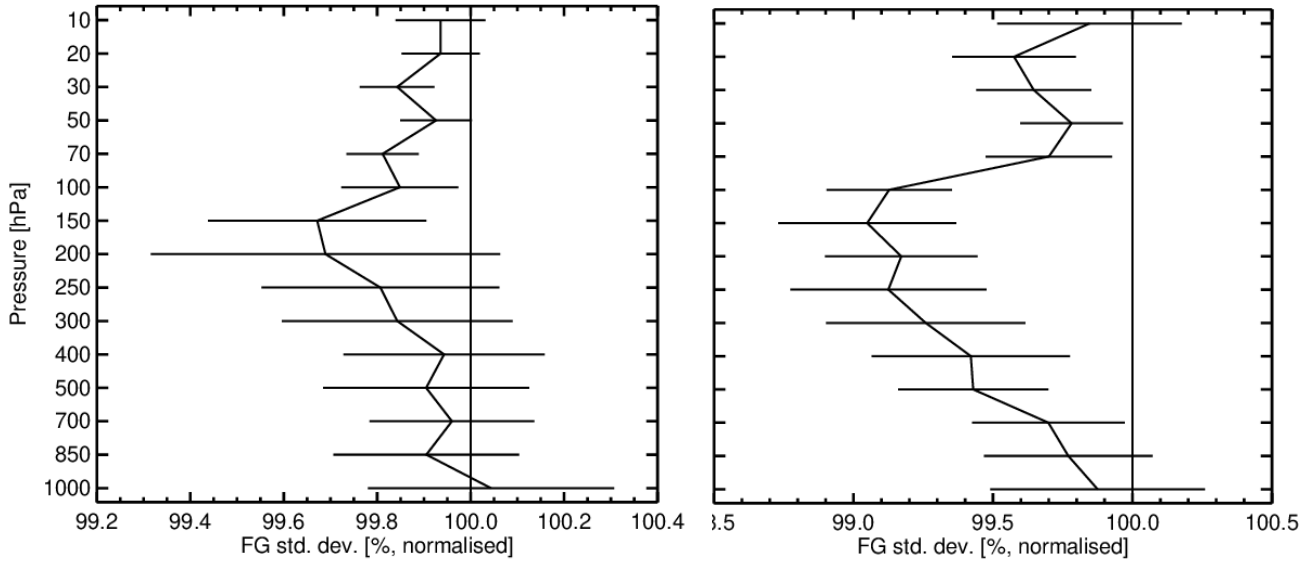



ECMWF

# Collaborating with ESA on Aeolus: **first wind lidar in space**

*Hatched areas are statistically significant (95%)*

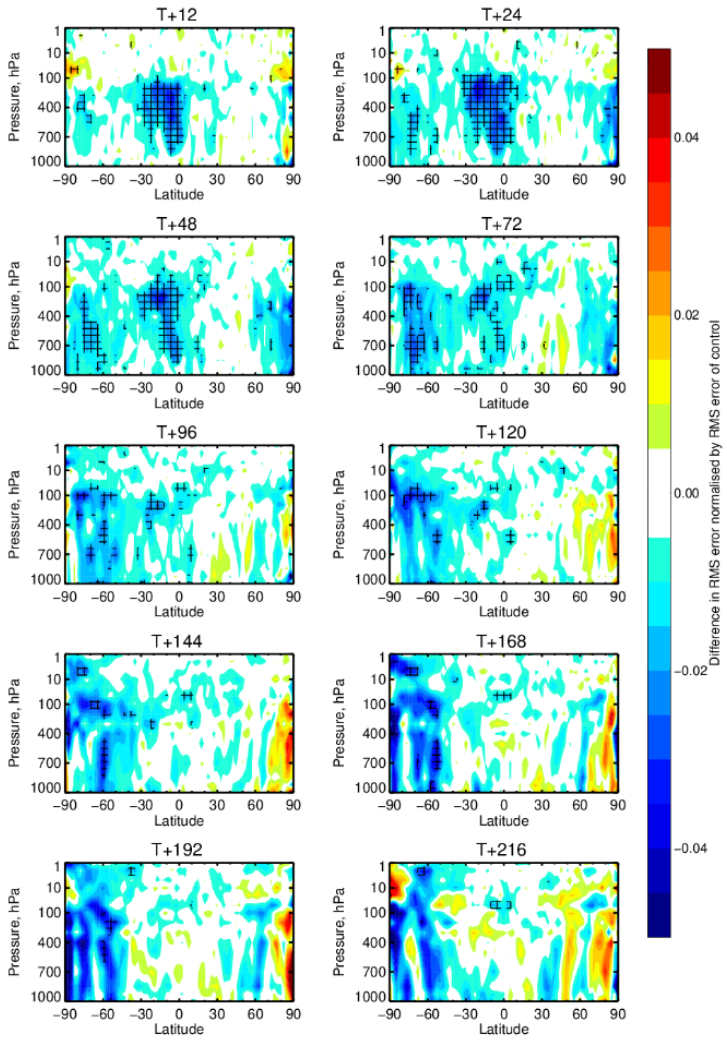
## Conventional **wind** observations




N. Hemi. extratropics

S. Hemi. extratropics

## Temperature




+5%

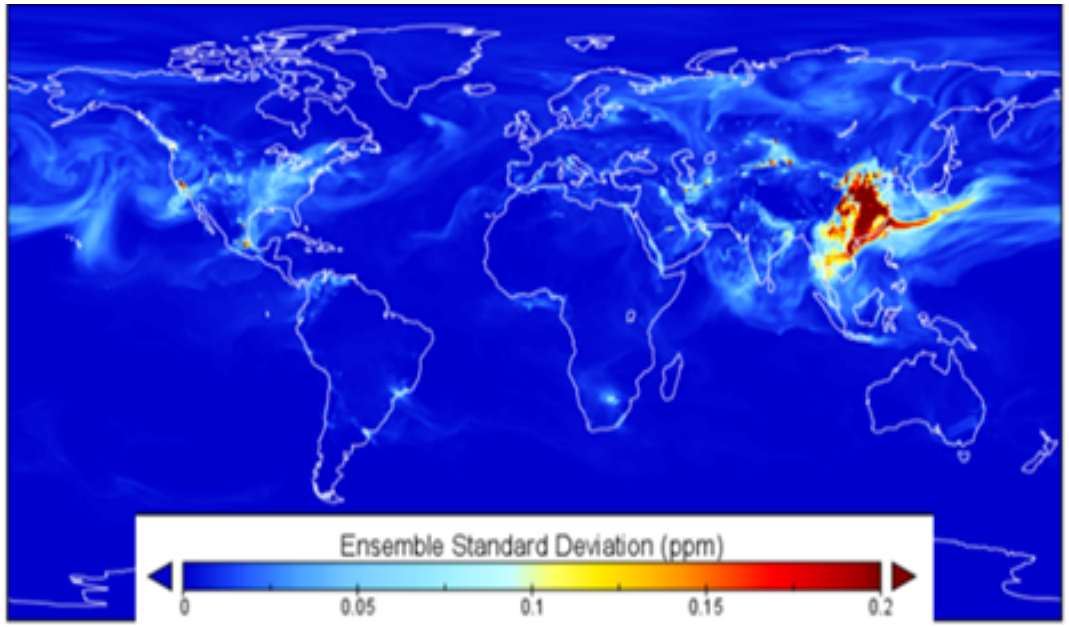
worse

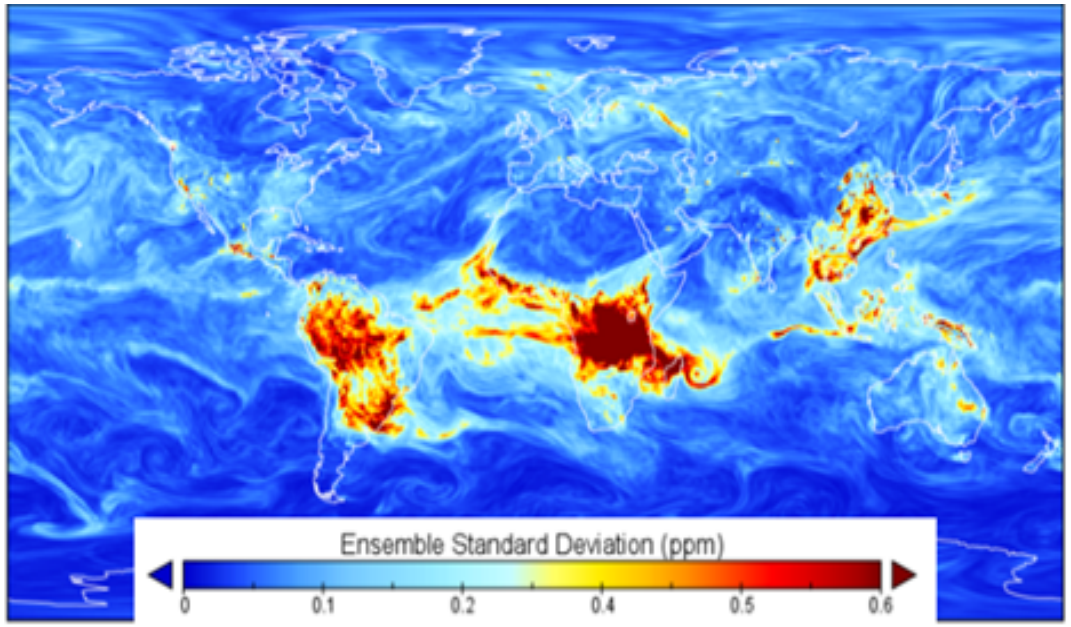
better

-5%

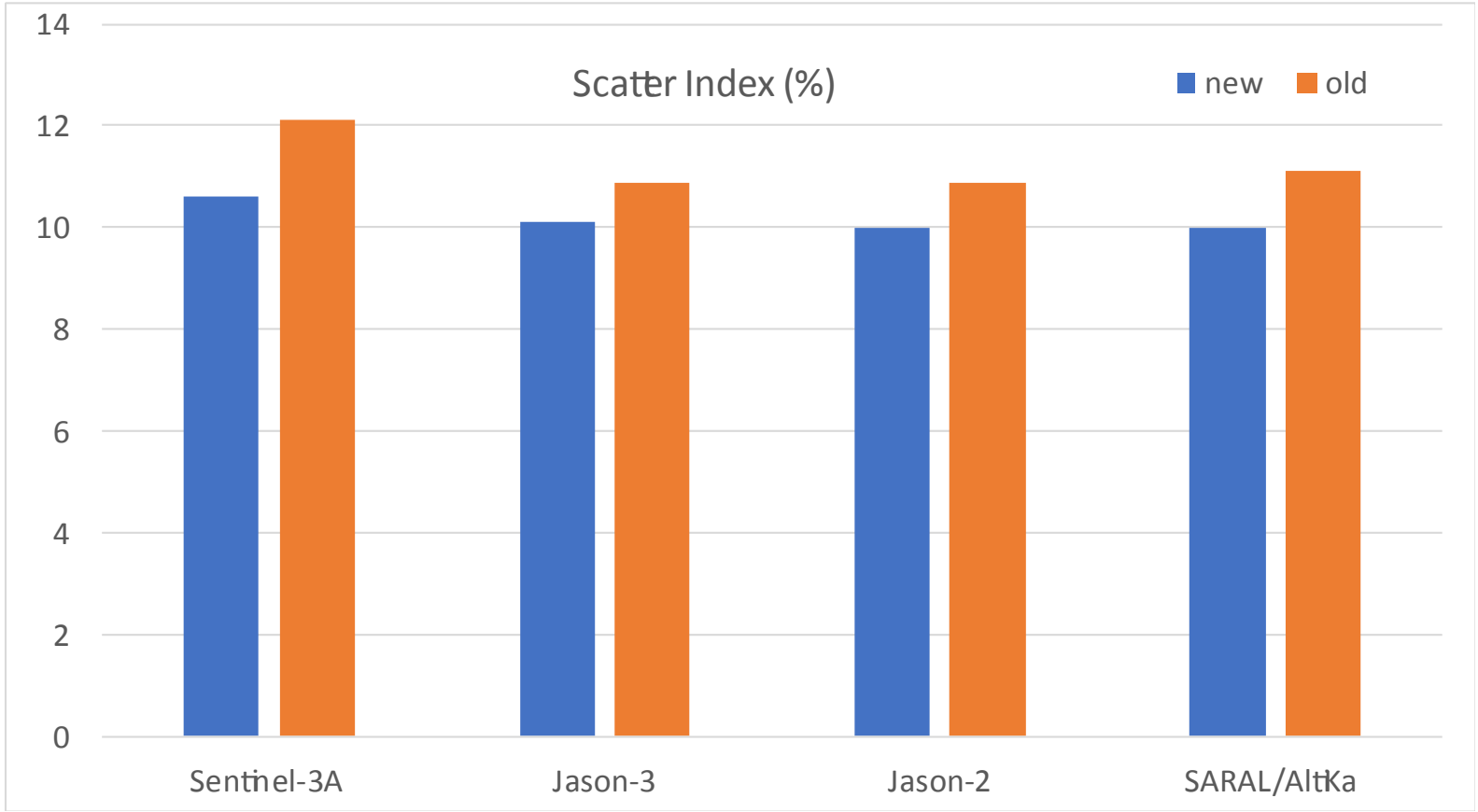
ECMWF

# CO2 Human Emissions, CHE project: Making the most of ECMWF's science



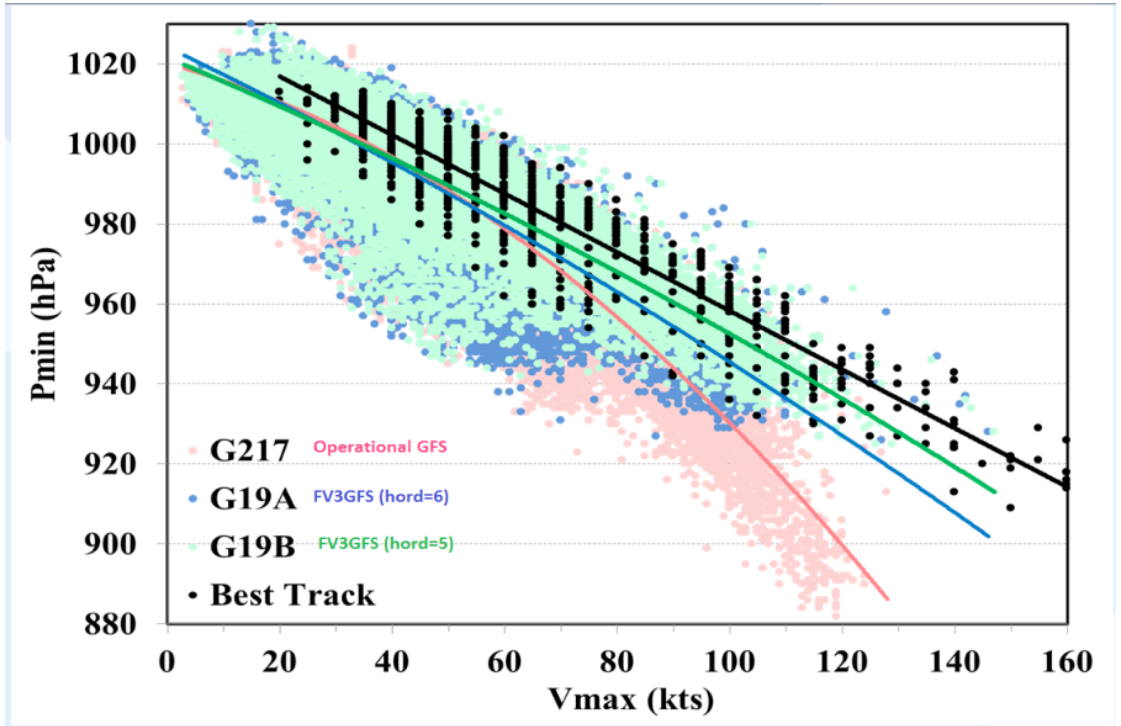
# Wave model hindcast forced with ERA5: **much improved** !

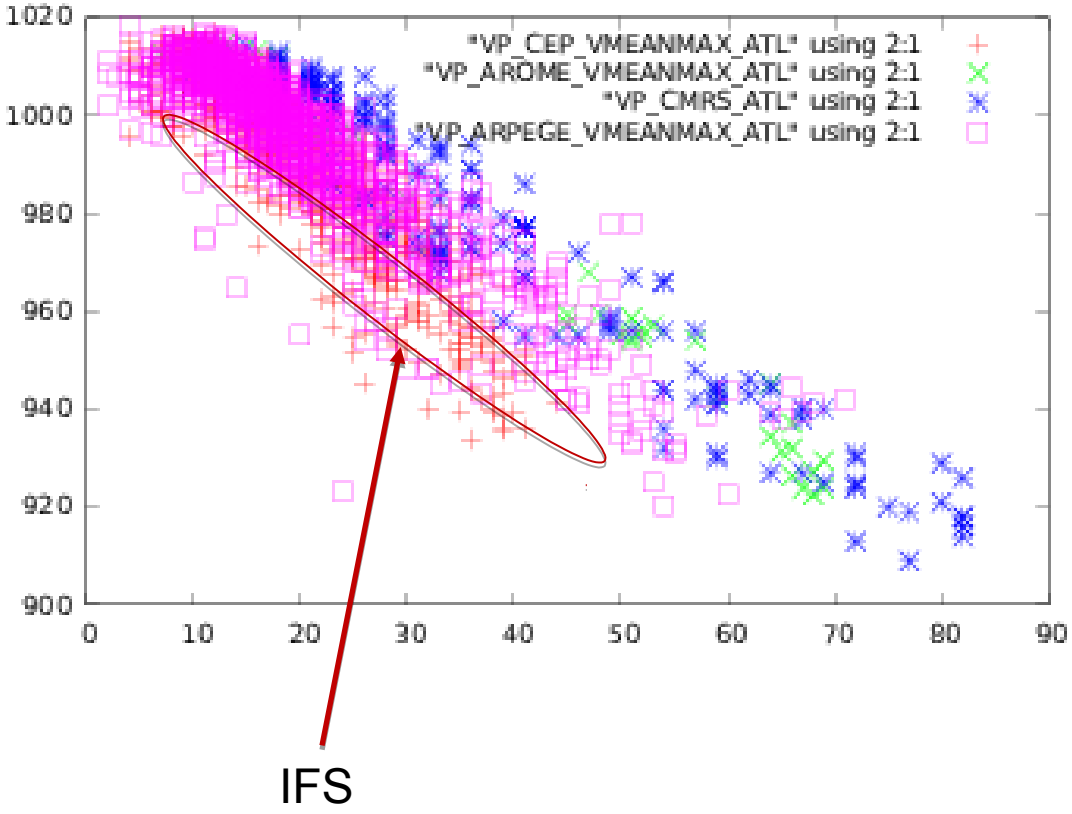



ECMWF FULLY COUPLED SYSTEM

Global verification of significant wave height from the model run with **physics of Ardhuin et al.** and the run with Old Physics **against various altimeters** during the period from 1 July 2017 till 30 June 2018

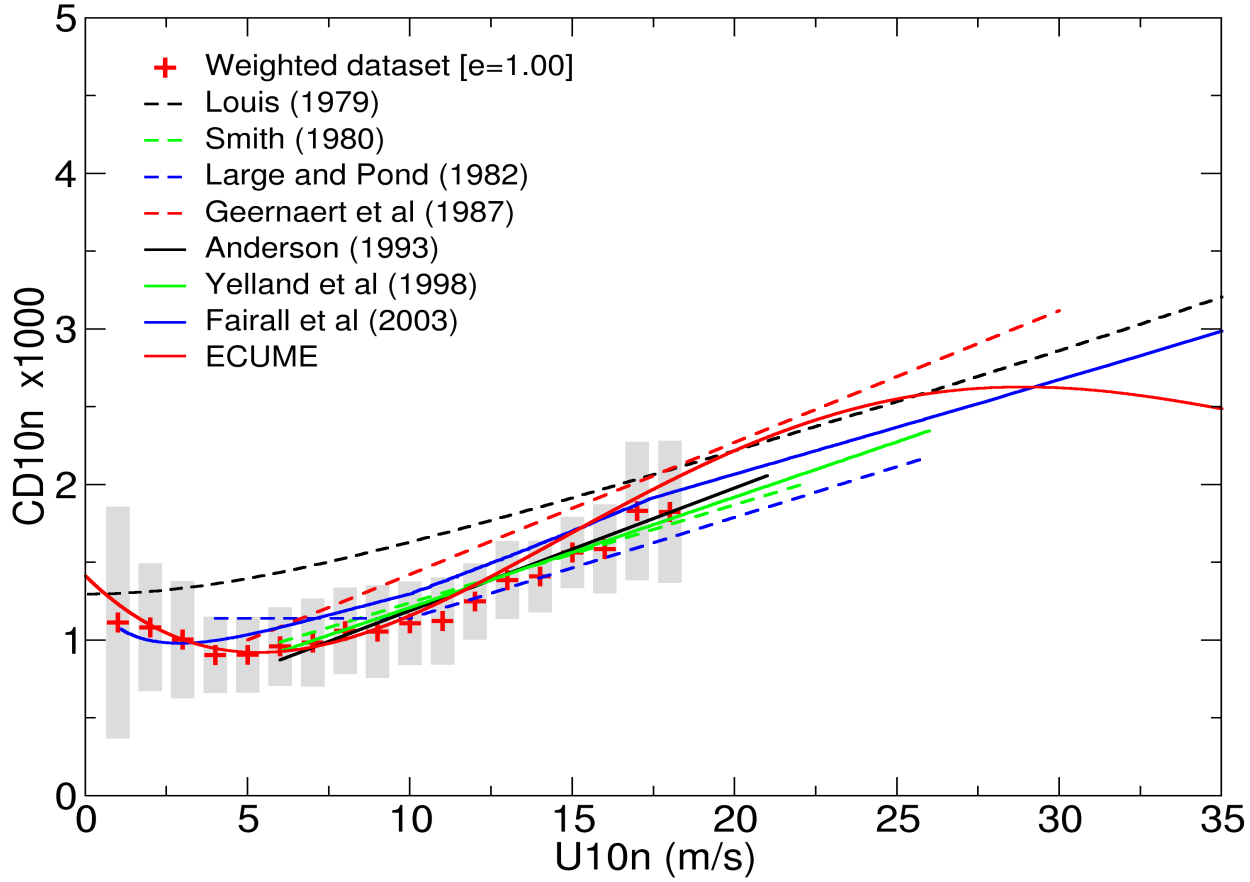
# Wind-pressure relationship IFS, FV3, ARPEGE, AROME in Atlantic Basin



# Limiting the drag for high wind

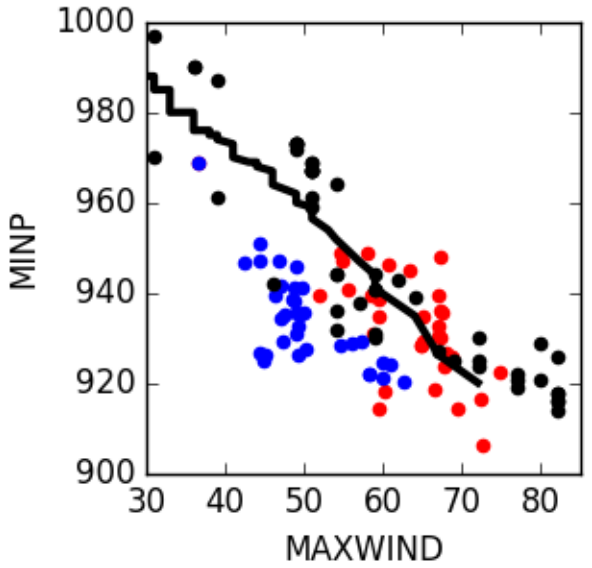
## Cd(U10) MeteoFrance: Arome system




ECMWF FULLY COUPLED SYSTEM

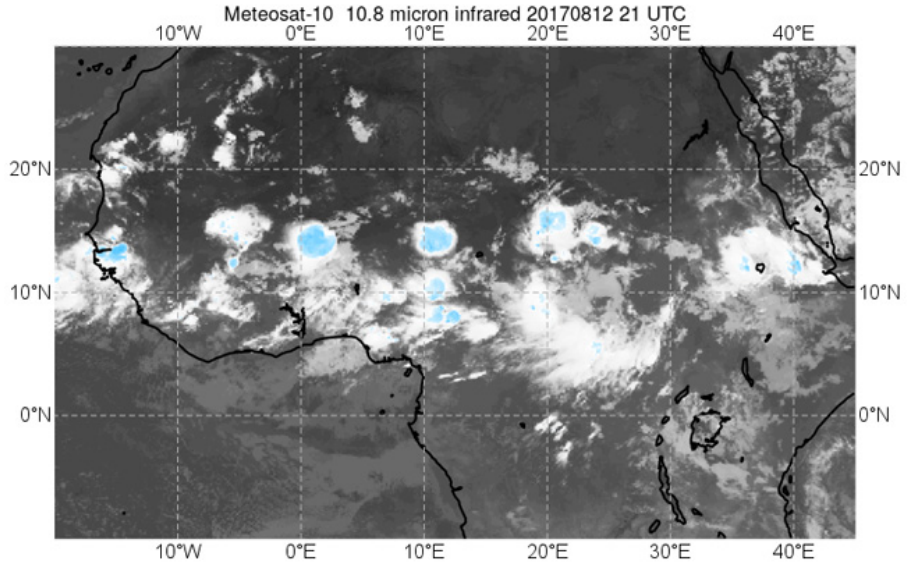
## Irma, forecast from 20170904, 0 UTC

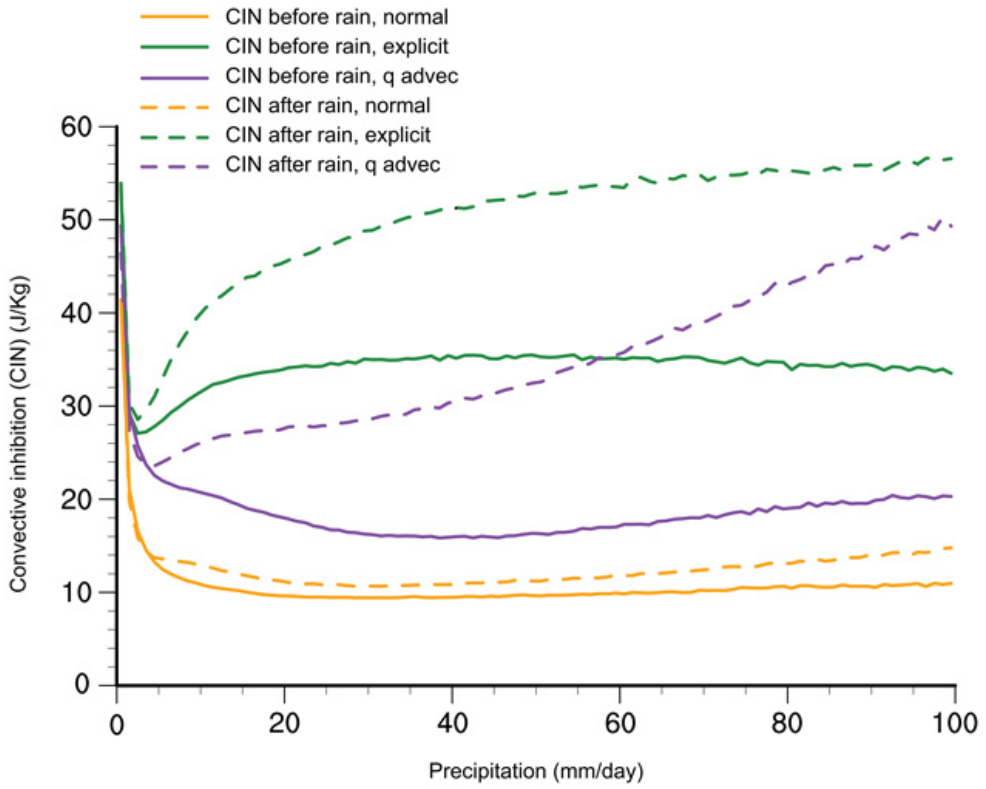
CY46R1 Charnock
limitation on Charnock




Output every 6 hours

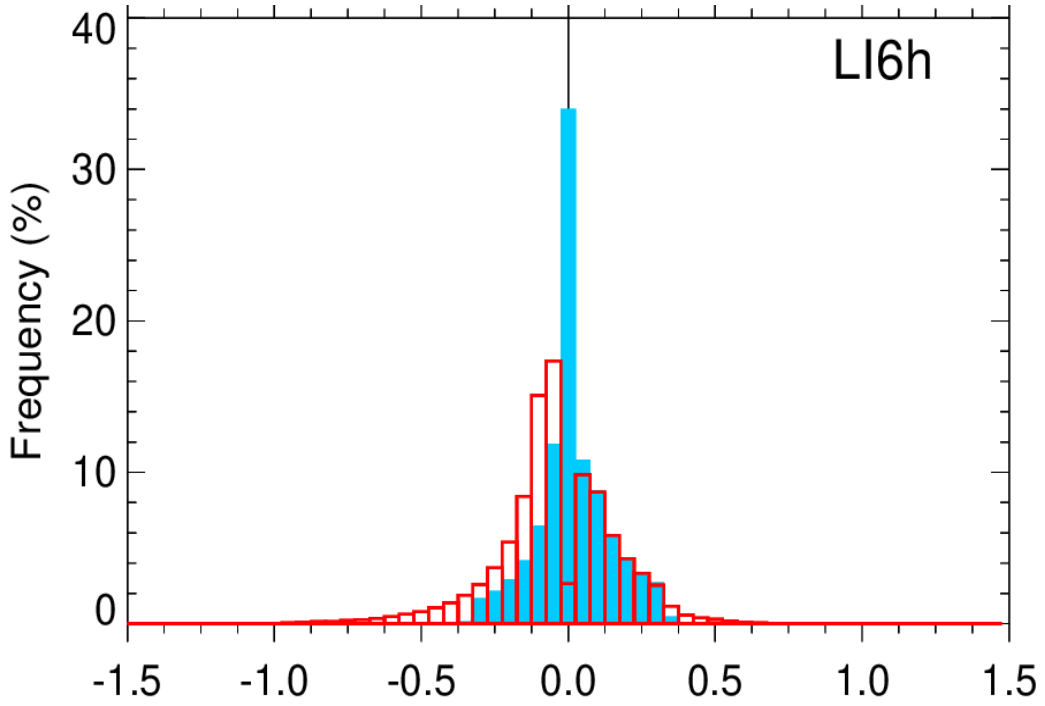
# Modelling convective precipitation: **joining forces with MPI**

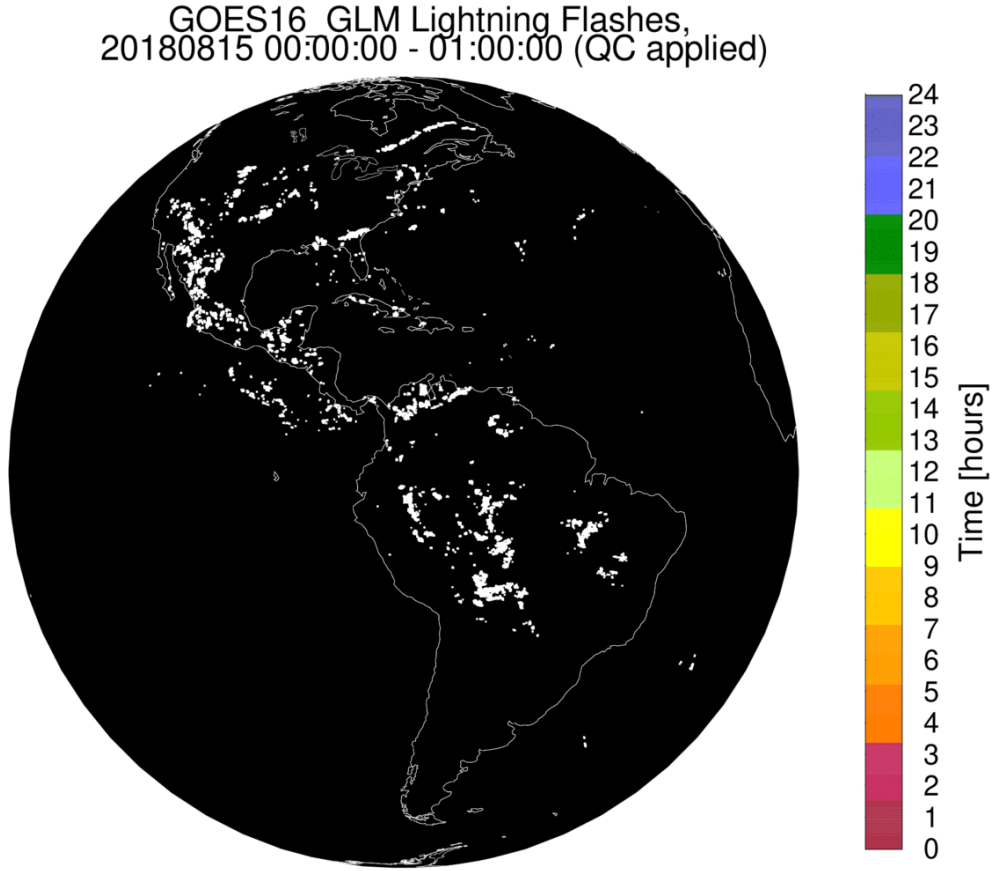




# Lightning assimilation: **preparing for EUMETSAT next generation MTGs**

4D-Var assimilation of GOES-16 lightning data over 3 months




**GOES-16**
15 August 2018

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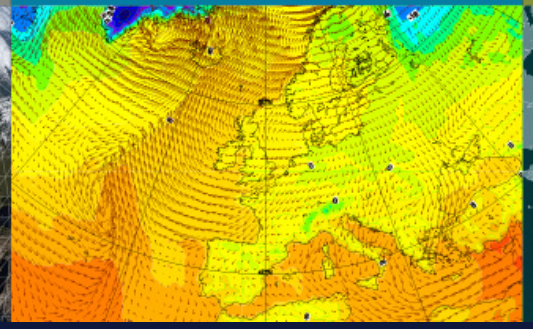


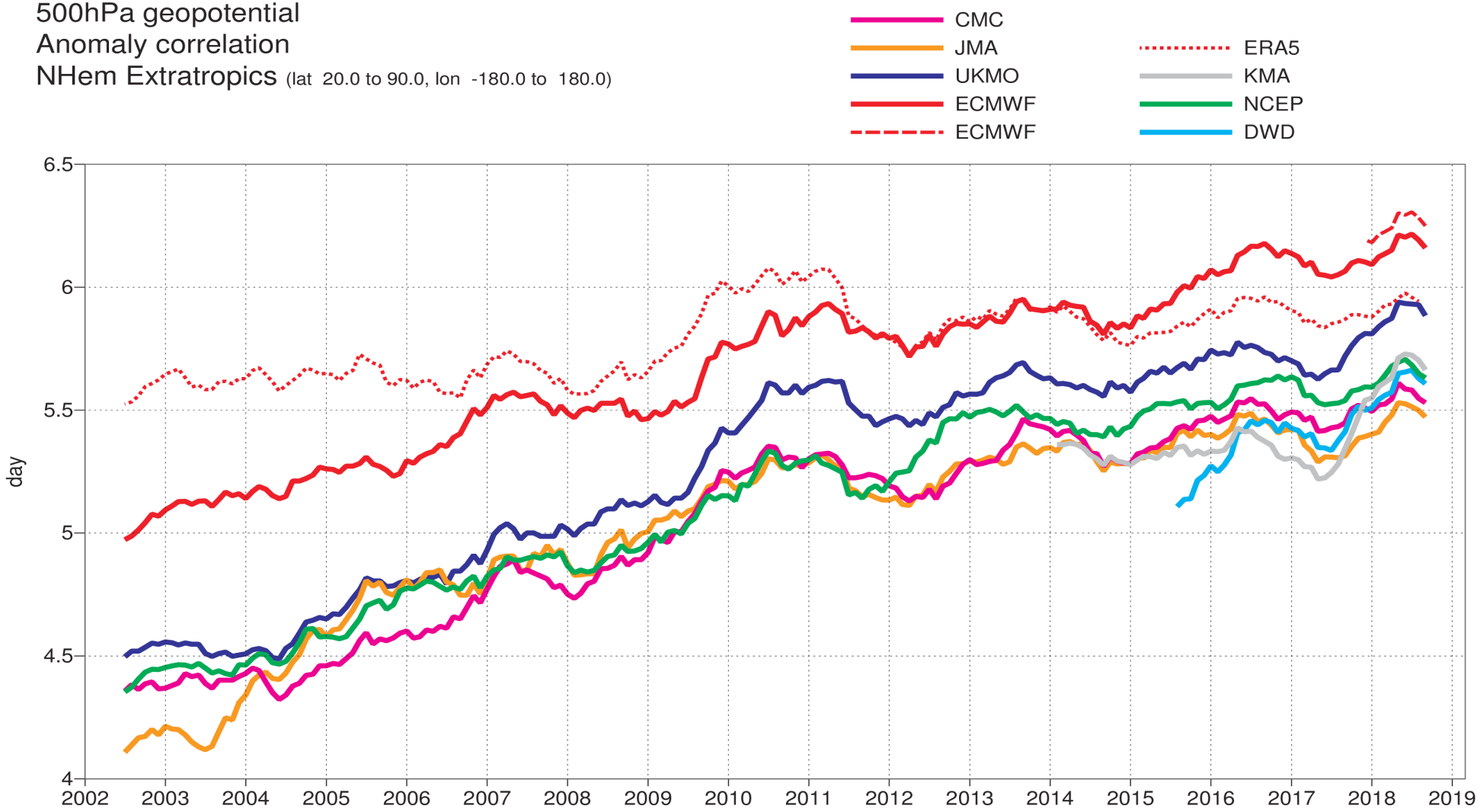
# Delivering global predictions

# 46r1: overview

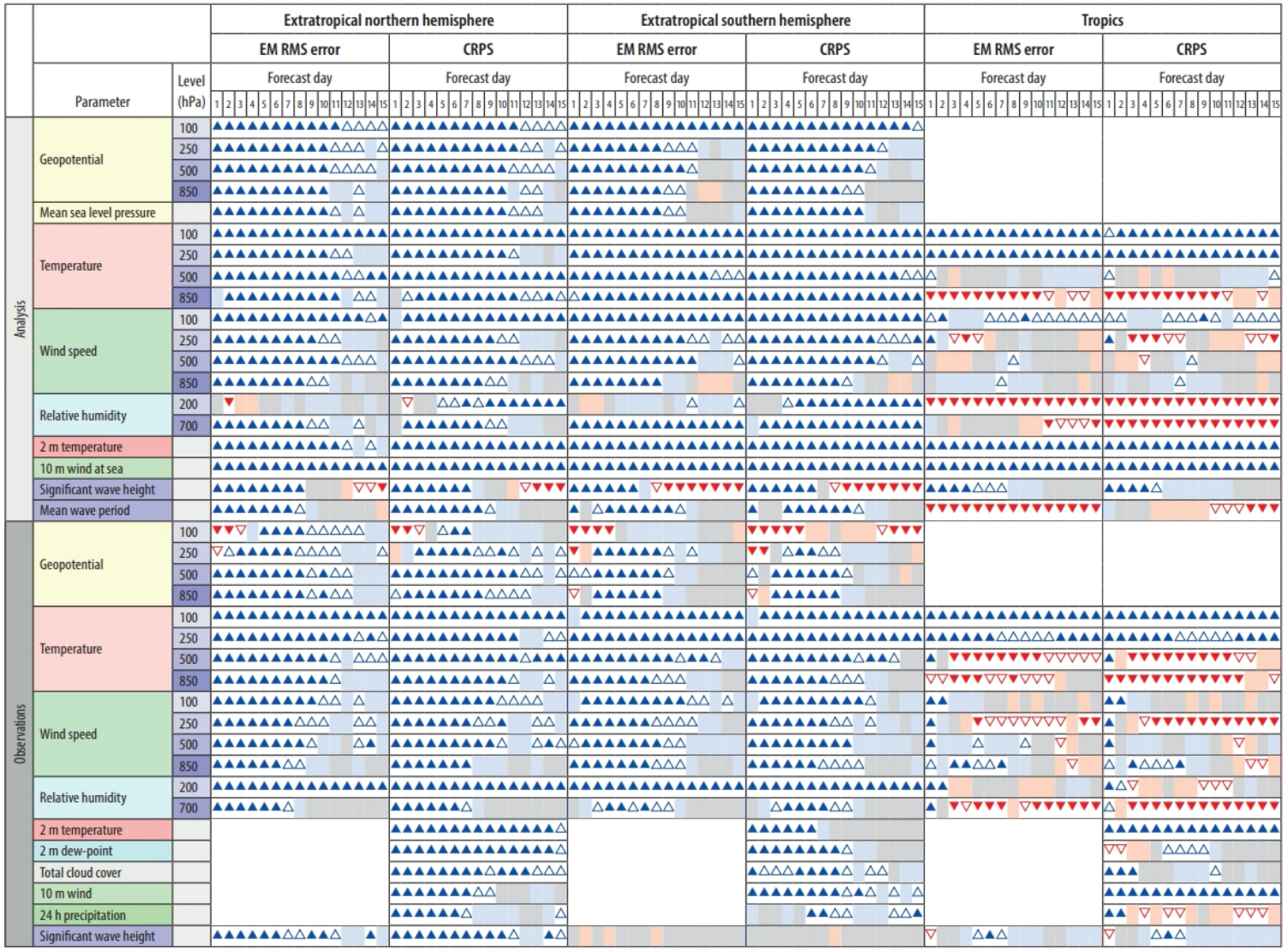
- continuous data assimilation;
- twice the number of members in the ensemble of data assimilations (EDA);
- weakly-coupled data assimilation for sea-surface temperature in the tropics;
- increase in the frequency of the ensemble radiation time step to 1 hour (from 3 hours)
- assimilation of the SMOS neural-network soil-moisture product.
- activation of long-wave scattering in radiation scheme
- activation of wave-current interaction in the wave model

# 46r1: Scores

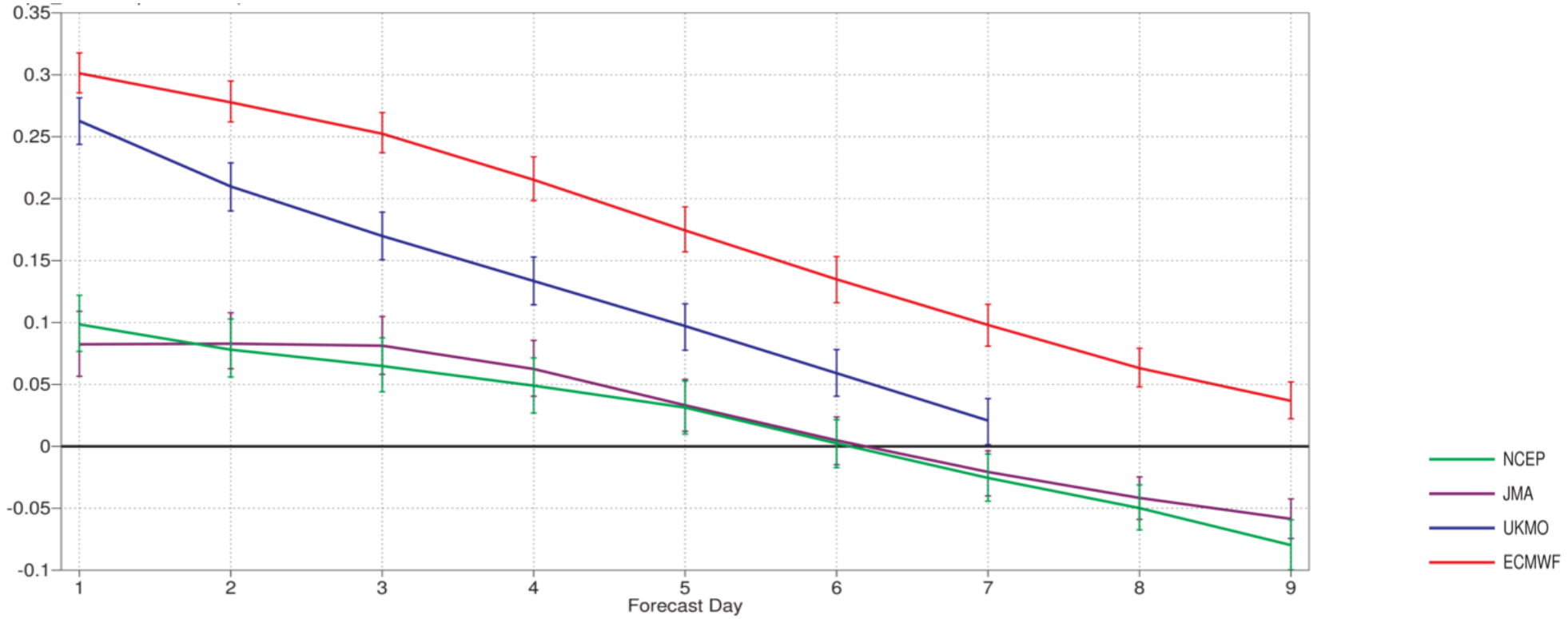
500hPa geopotential
Anomaly correlation
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)



# IFS cycle 46r1 v. cycle 45r1: **delivering significant improvements**



# Comparison with other centres: **precipitation forecast probabilistic skill**

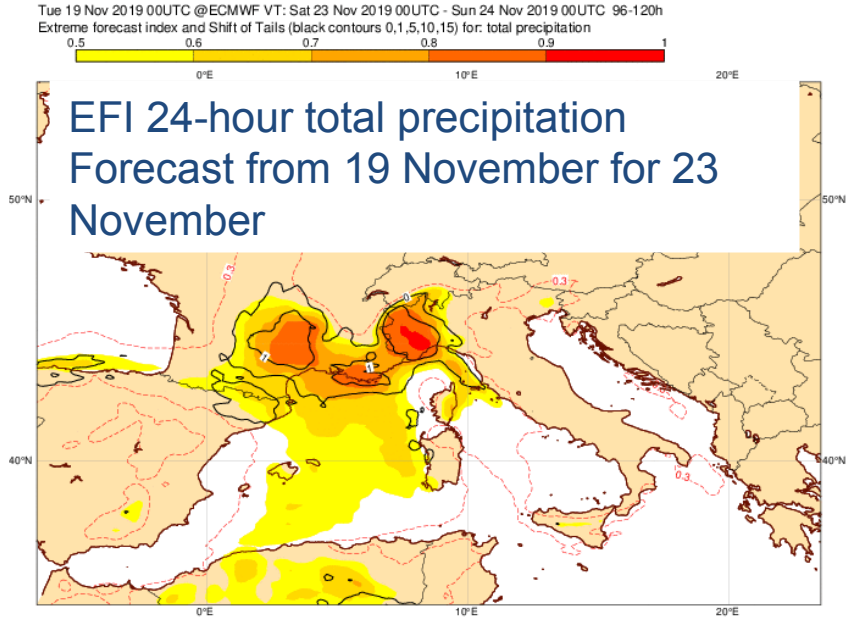


# Pre-Bologna ultimate cycle: **47r1**

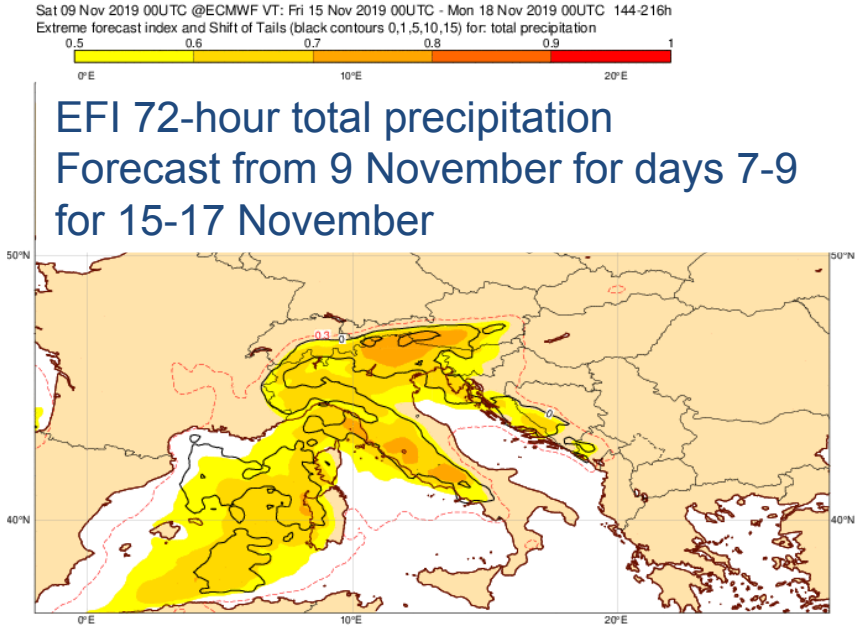
- A new formulation of **weak-constraint 4D-Var**
- Quintic vertical interpolation in the semi-Lagrangian update (which together with the above gives **improvements to stratosphere** in particular)
- MODIS land surface albedo, which is **good for 2 m temperature**
- Shorter, 450-second time-step in last minimisation – bringing consistency with the outer-loop time-step, and thus **removing spurious gravity waves and improves scores**
- Use of the 'first guess' from the most recent early delivery run in the LWDA (long-window data assimilation) analysis – this is a next step along the path to **more continuous data assimilation**
- Changes to high wind drag over the ocean – these **address a long-standing problem with the wind-pressure relationship in tropical cyclones**.

# Extreme rainfall and flooding France, Italy, Austria November 2019

- Extreme precipitation NE Italy and W Austria 15-17 November
  - reaching 50-year return period in Austria (up to 250mm), causing avalanches and landslides
- Intense rainfall S France and NW Italy 23 November
  - Destructive flash flooding
- Consistent signal of extreme in EFI from 1 week ahead

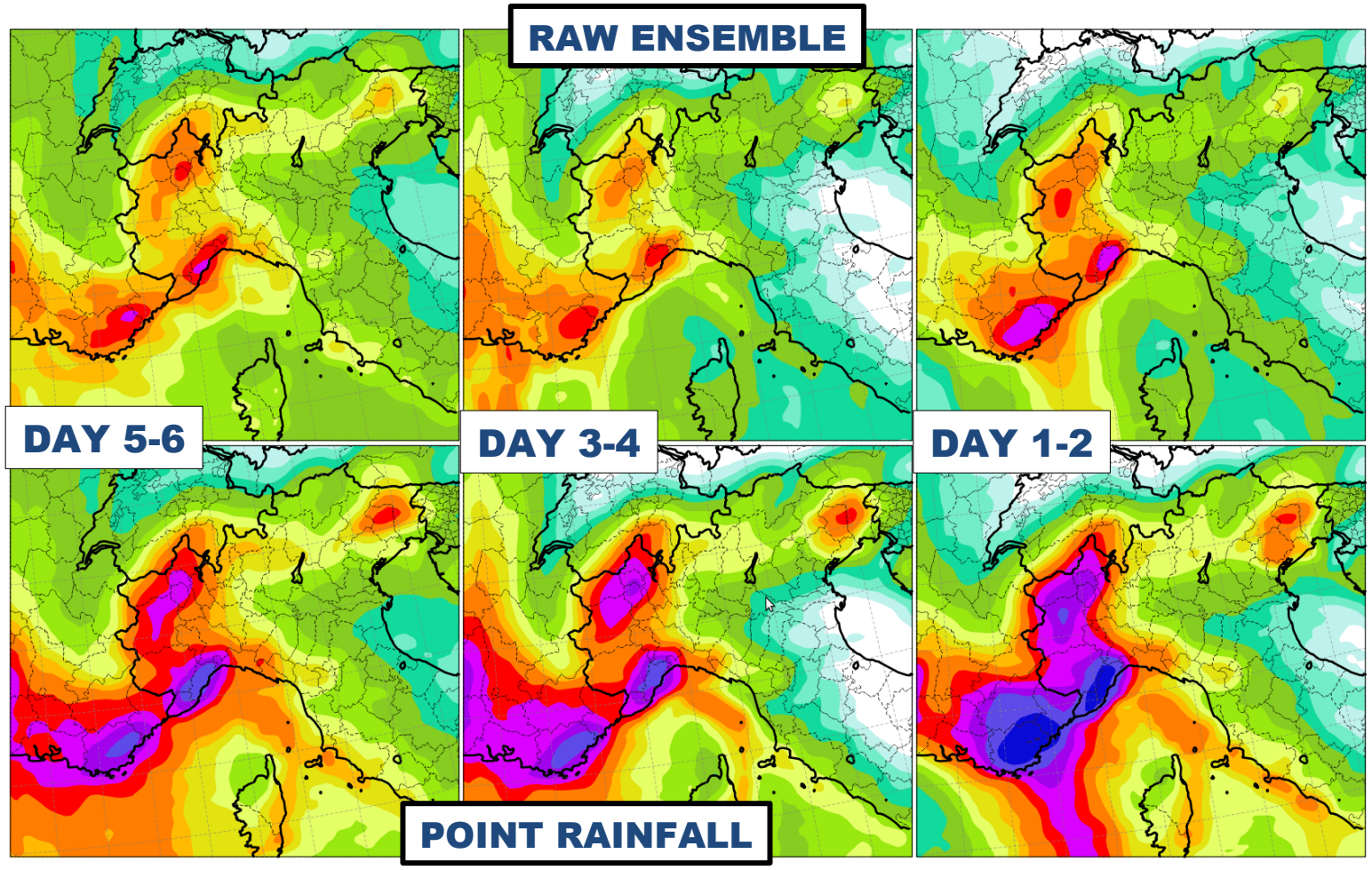


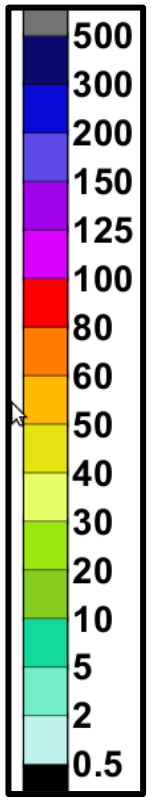

EFI 24-hour total precipitation
Forecast from 19 November for 23 November



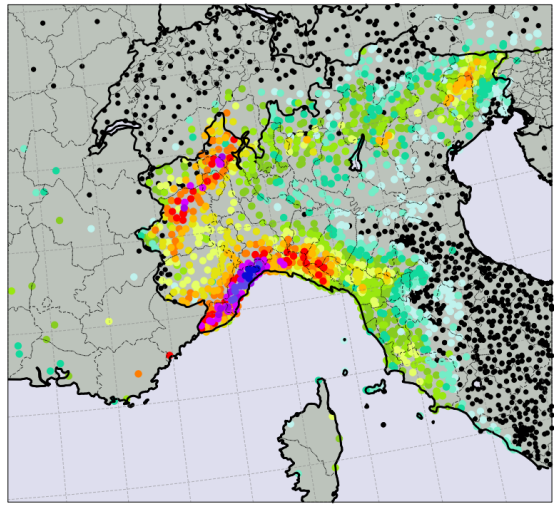

EFI 72-hour total precipitation
Forecast from 9 November for days 7-9 for 15-17 November

# Floods in N Italy / S France – 23 Nov 2019: Forecasts Versus Observations (12h rainfall to 18UTC)

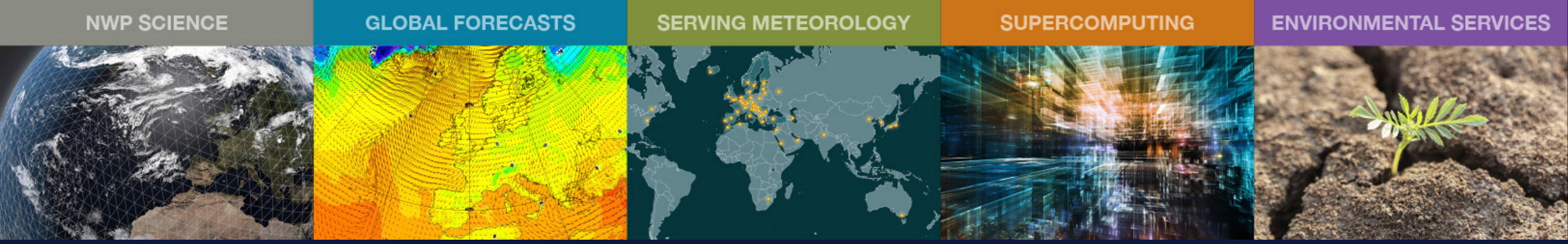



*mm in 12h*



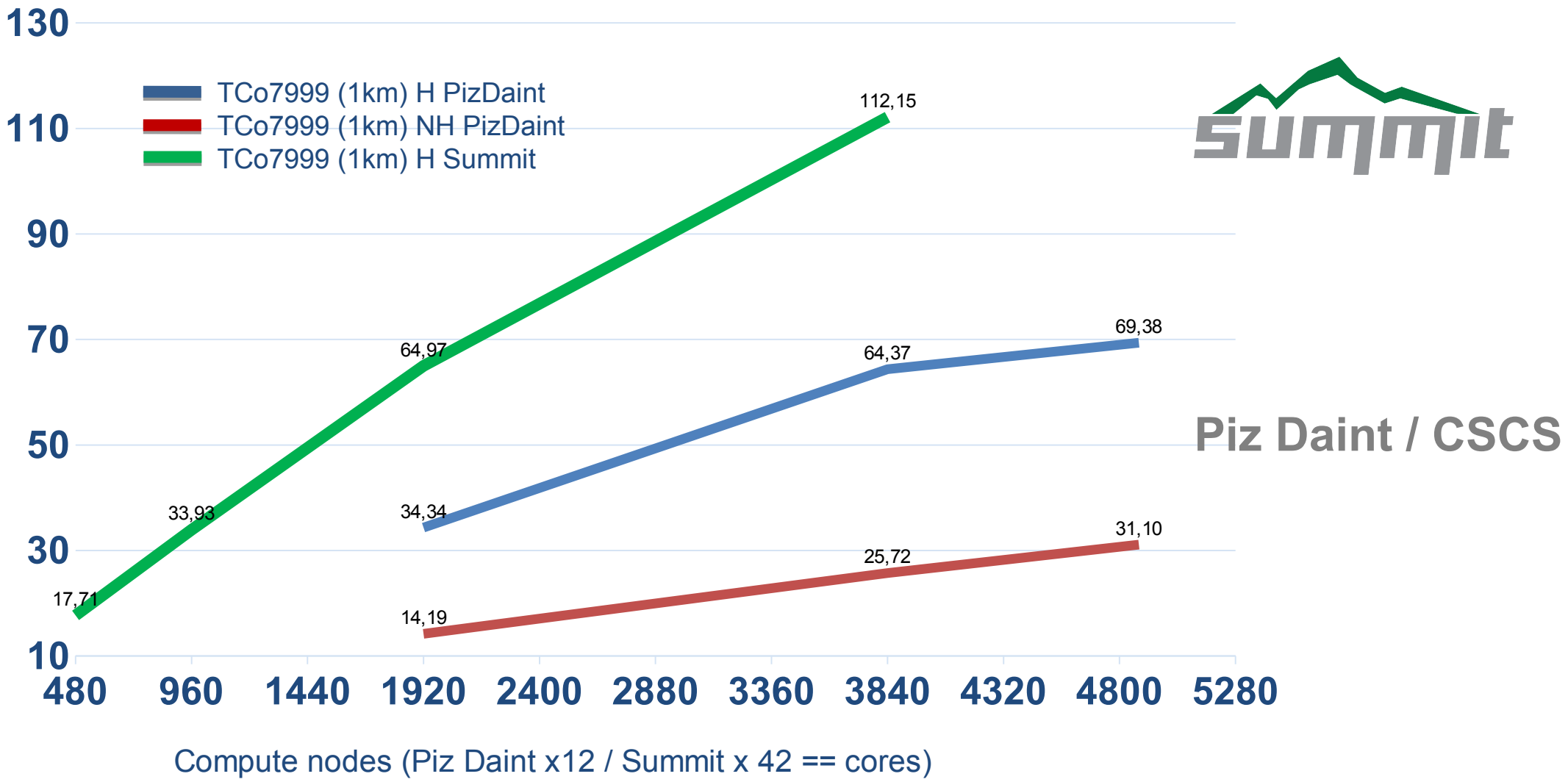
- Forecasts show a "worst case scenario" (99th percentile)
- Point rainfall much better at capturing the extremes




# Sustaining high performance computing

H
IBM
summit
H
IBM
summit

# Optimising the IFS with Summit and Piz Daint

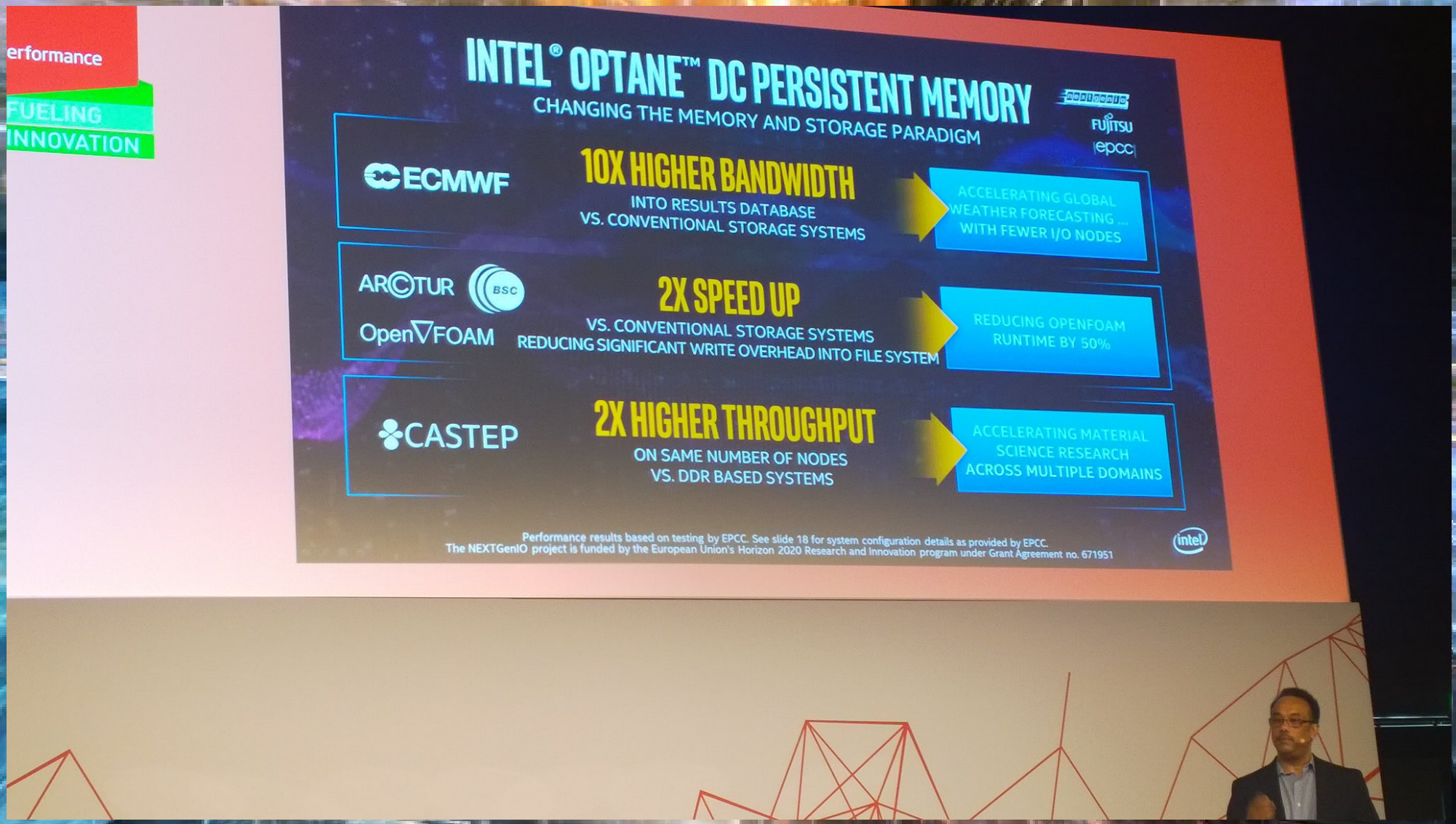



Piz Daint / CSCS

# NextGen IO: **unlocking I/O performance for the exascale**

- Prototype is world first HPC with NVRAM memory
- 30x I/O Performance improvement
- First (experimental) weather forecast run on this hardware
- Developed I/O software is already in ECMWF operations

# Next Gen IO: end of a successful project



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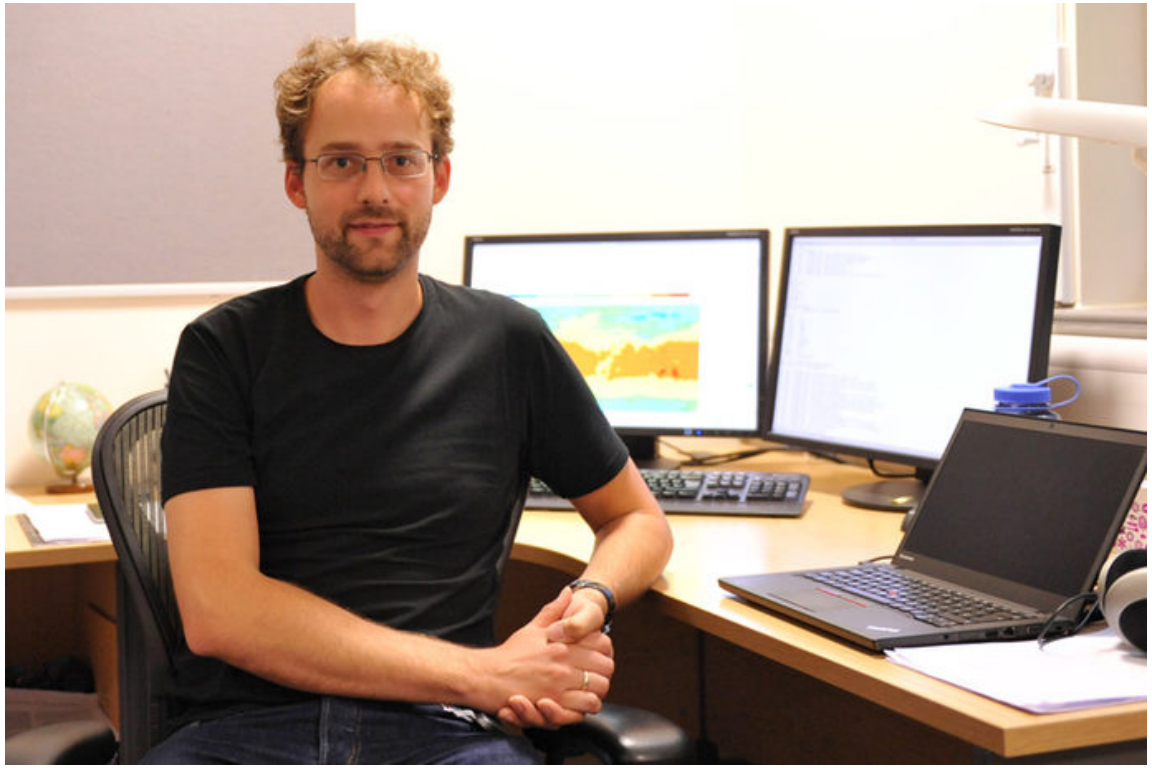
# Serving Member & Co-operating States

# Artificial Intelligence in NWP: **investigation stage**

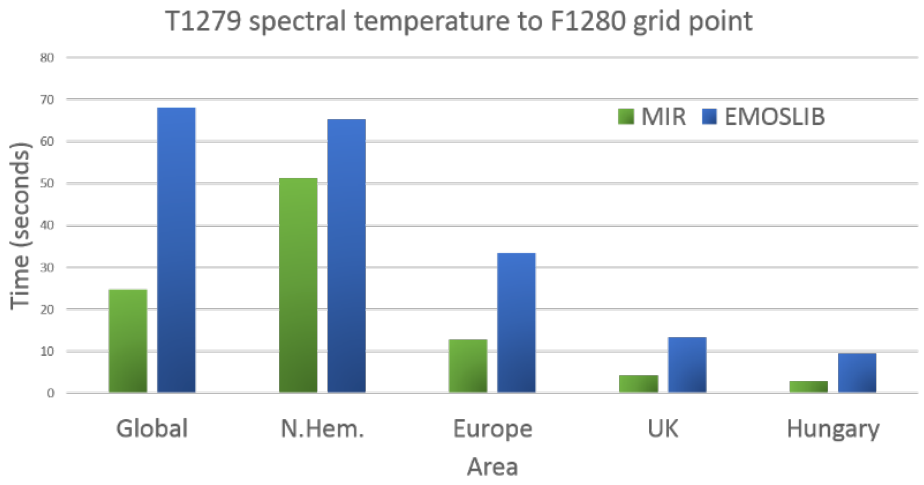
So far:

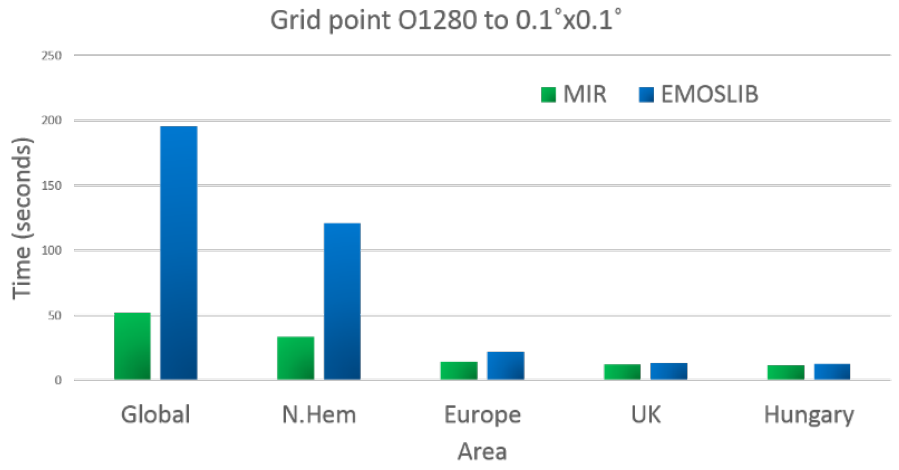
- A workshop run in collaboration with Oxford University
- A workshop run by ECMWF Copernicus Services
- Appointment of a coordinator across ECMWF
- Council Lecture!



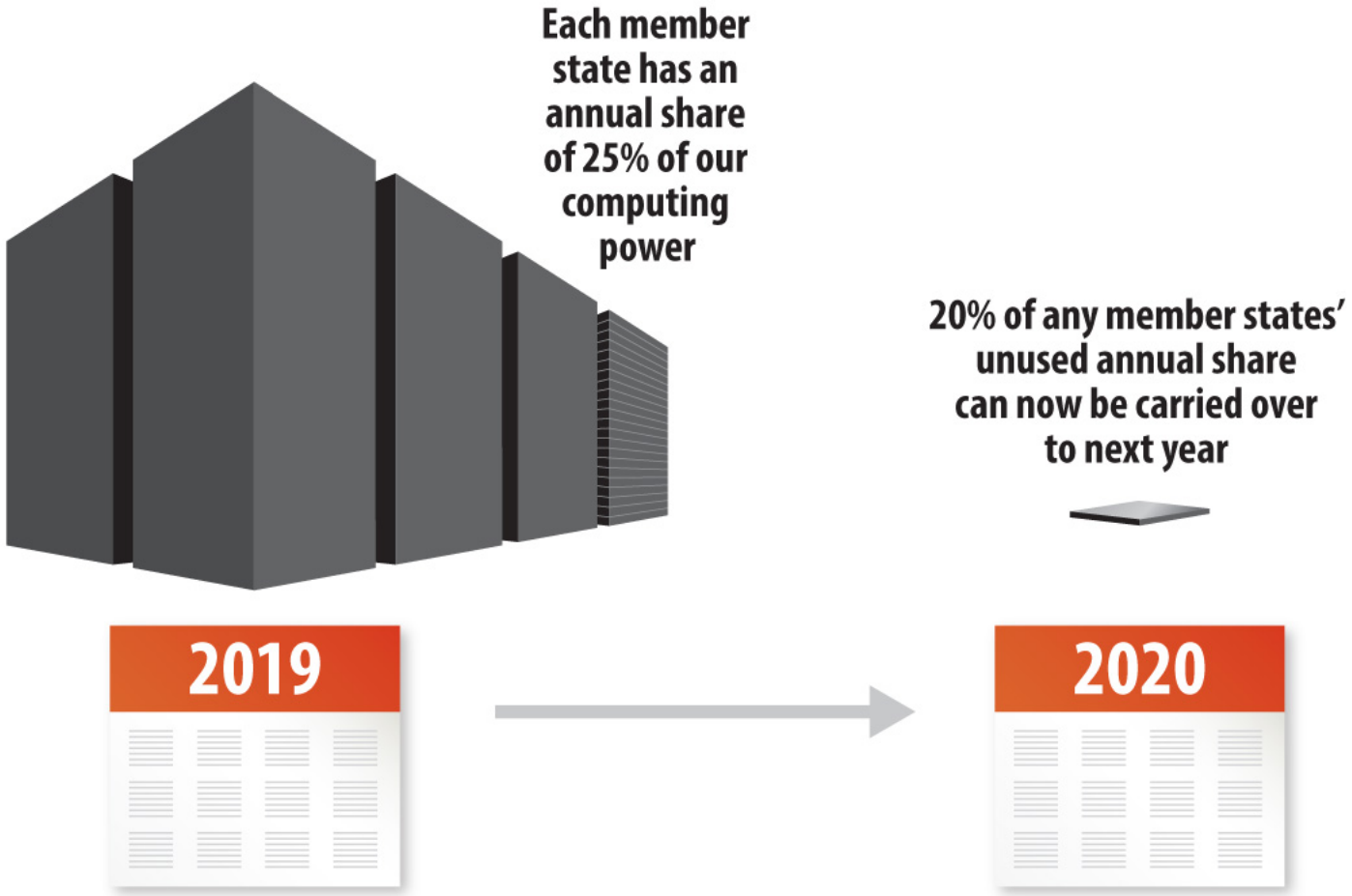
# New Meteorological Interpolation and Regridding (MIR) library

- Spectral transforms are faster (up to 3×)
- Global-to-global interpolations 2× – 3× faster in operational env. (caching + plan optimizations)



# Carrying over computing power

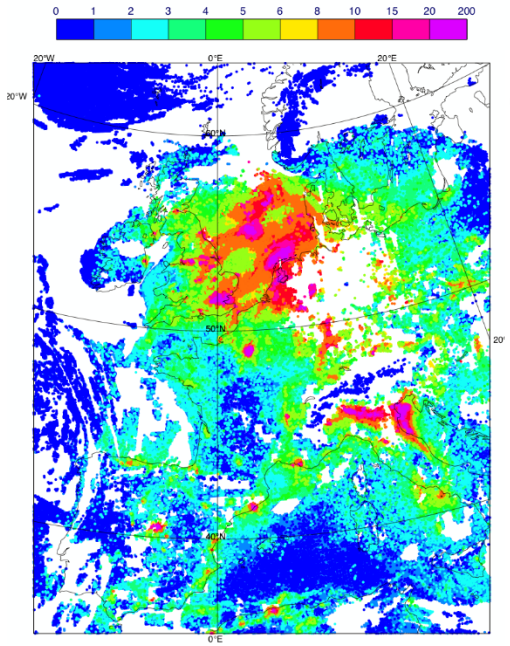


# Uptake of Sentinel 5-P in CAMS: **making the most of the IFS**

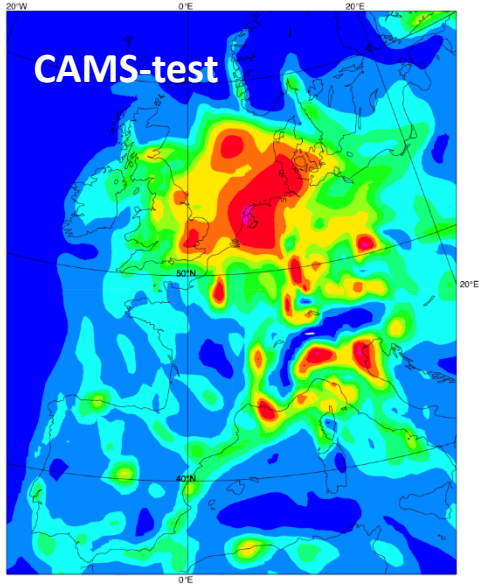
Operational monitoring and assimilation tests performing very well, especially for $NO_2$.
Assimilation on track to be activated in the next few months.

**High pollution case 27/02/2019**

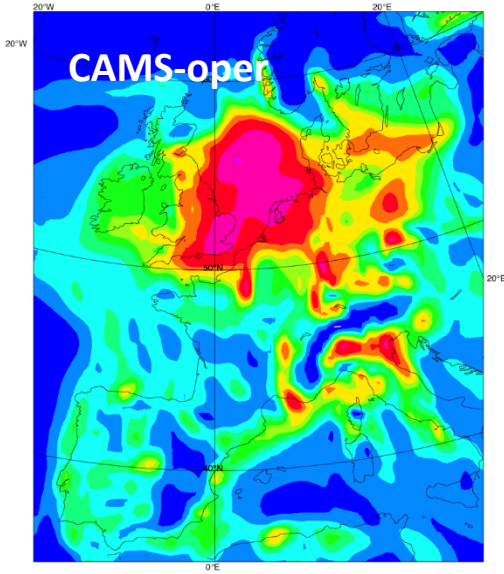
**S-5P observation**




**Assimilation GOME2-A,B+OMI+S-5P**




**Assimilation GOME2-A,B+OMI**



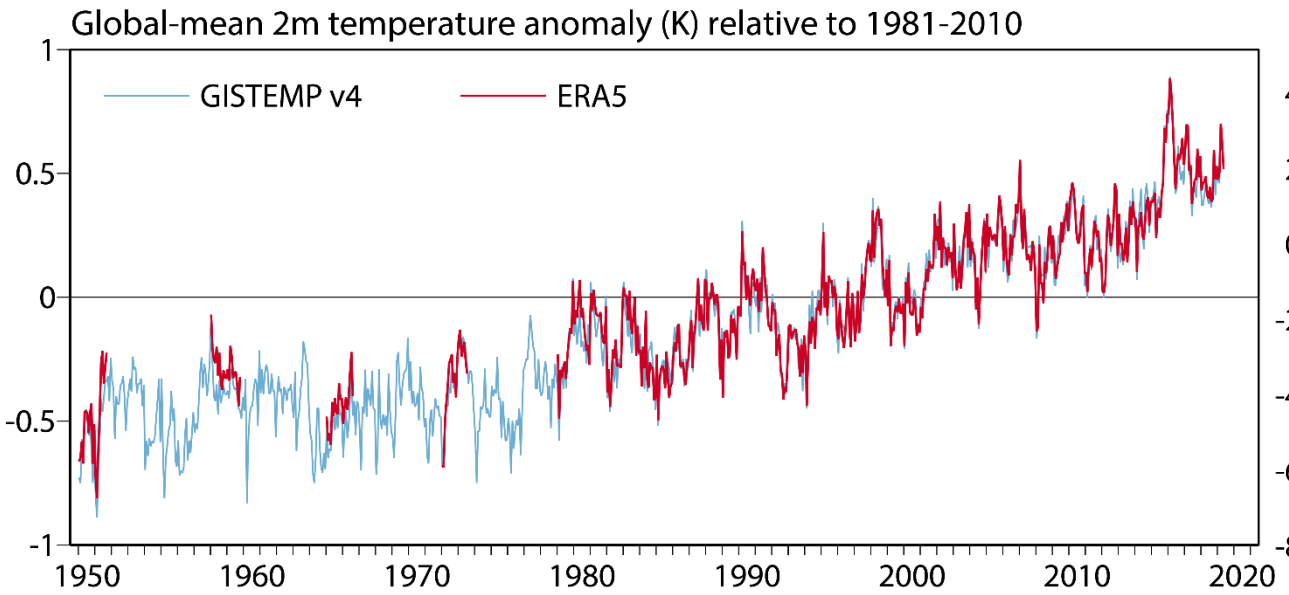

Tropospheric column $NO_2$

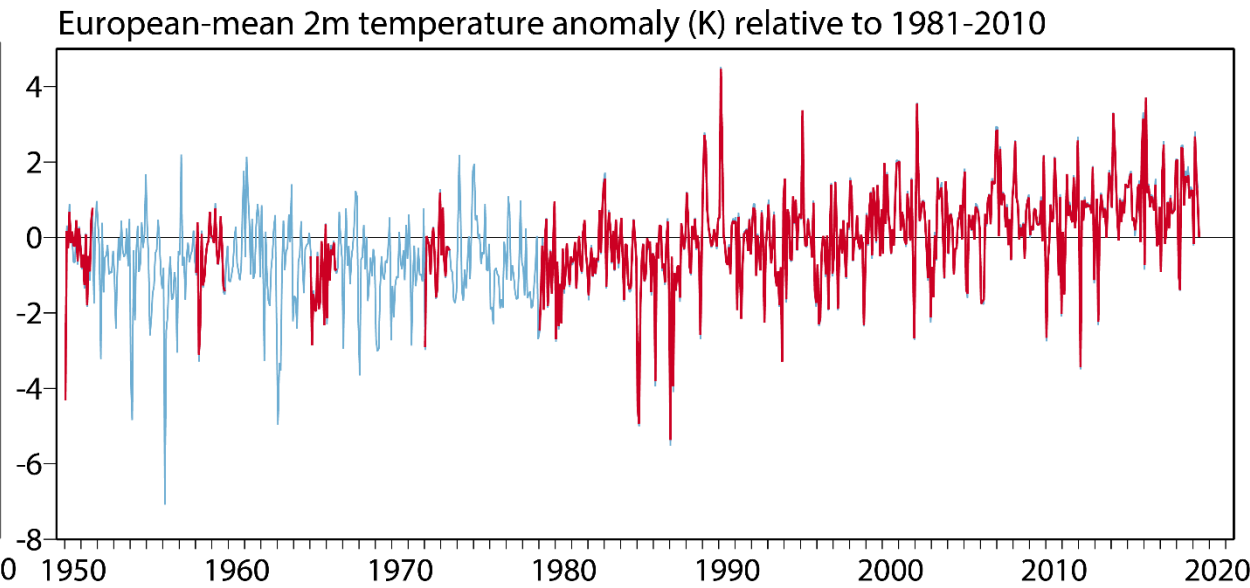
*On that situation, the addition of Sentinel-5P data on top of the observations operationally assimilated (parallel test) had a visible impact impact, reducing in that case the amount of $NO_2$.*

ECMWF

Copernicus Europe's eyes on Earth

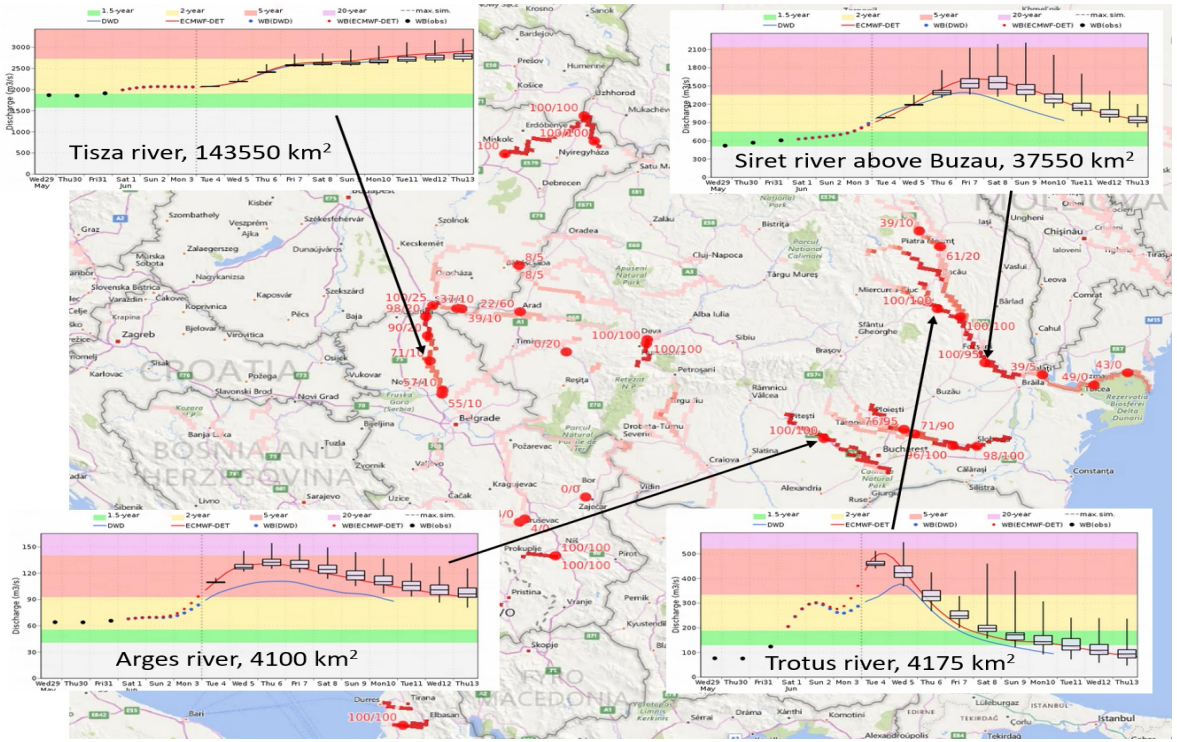
# The synergies of ERA5: **a tool for weather and climate**




ECMWF

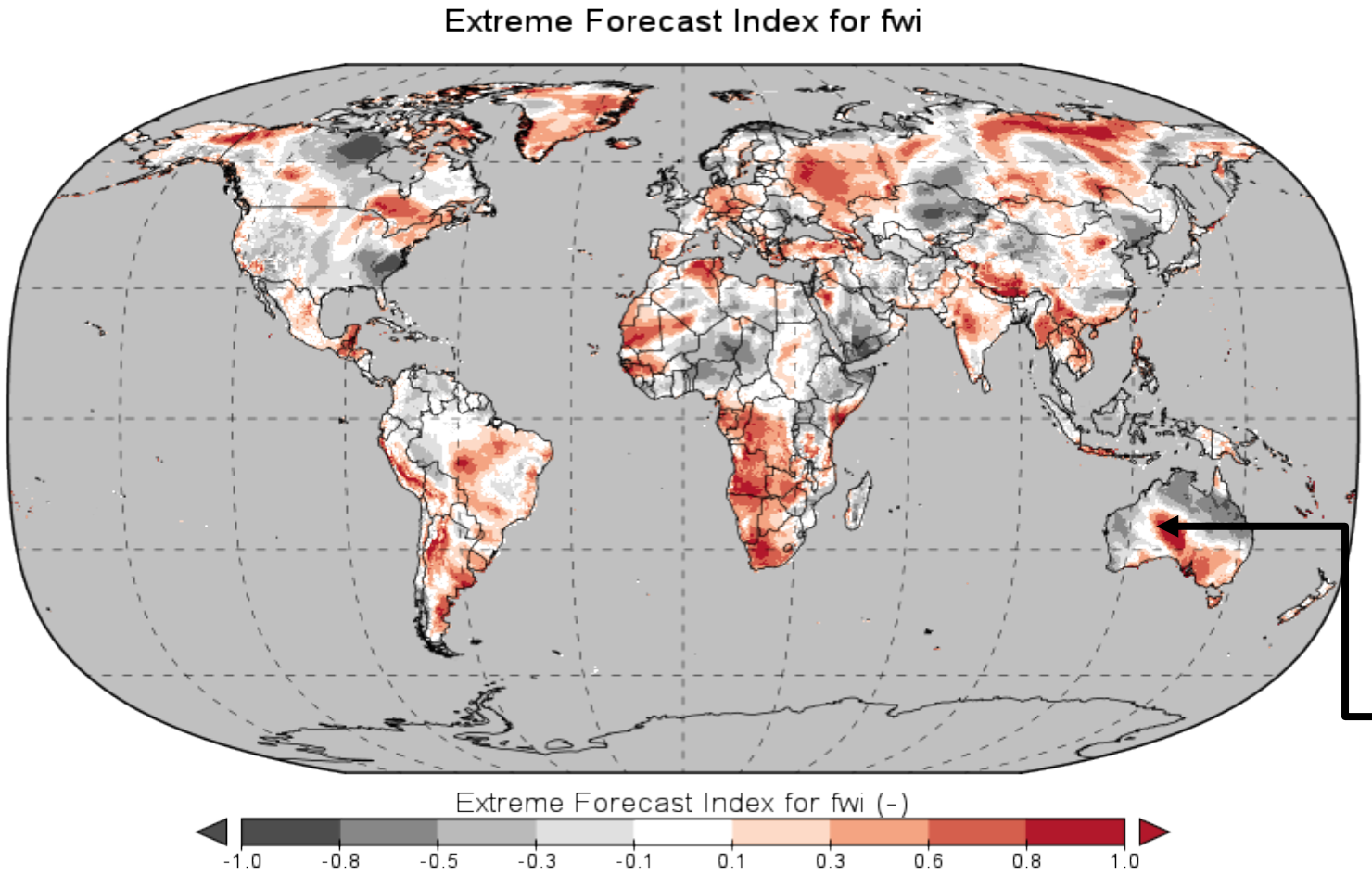
Copernicus
Europe's eyes on Earth



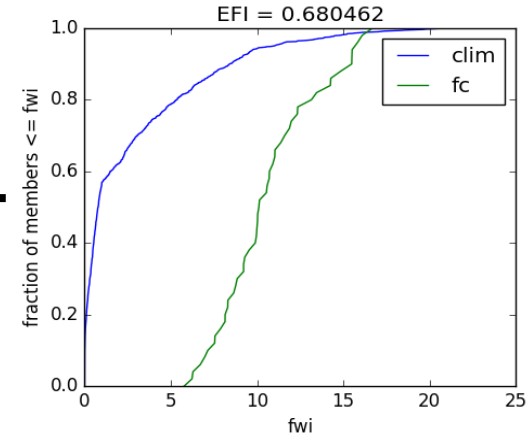

**ARISTOTLE2 Partnership with MS** as part of multi-hazard advice capability Aristotle2 to the **Emergency Response Coordination Centre of EU**

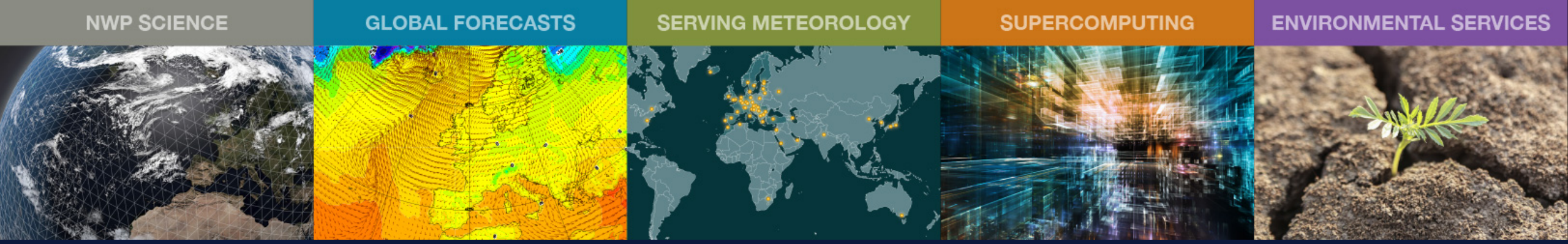
**ECMWF, SMHI and UK MO** provides flood forecast briefs for Europe (Global as pilot)

# FIRE: First **probabilistic** fire forecast product released to JRC




Positive anomaly

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# Thank you