Global Numerical Weather Prediction: Progress and future directions

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8.835 weather related disasters

1.94 million deaths

$2.4 trillion economic loses

WMO figures for 1970 - 2012

How we forecast the weather

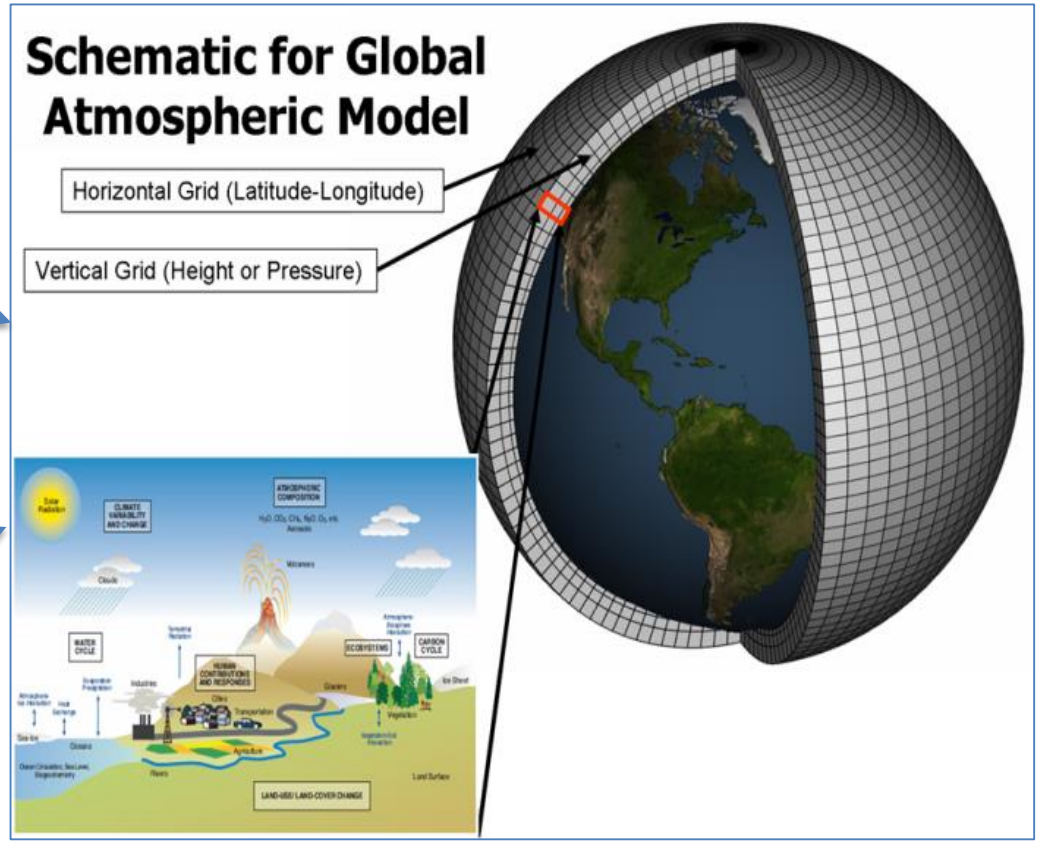
Global Observations

Knowledge

$$\frac{du}{dt} = \frac{\partial p}{\partial x} - fv$$

$$\frac{dv}{dt} = \frac{\partial p}{\partial y} + fu$$

$$\frac{p}{\rho} = RT$$



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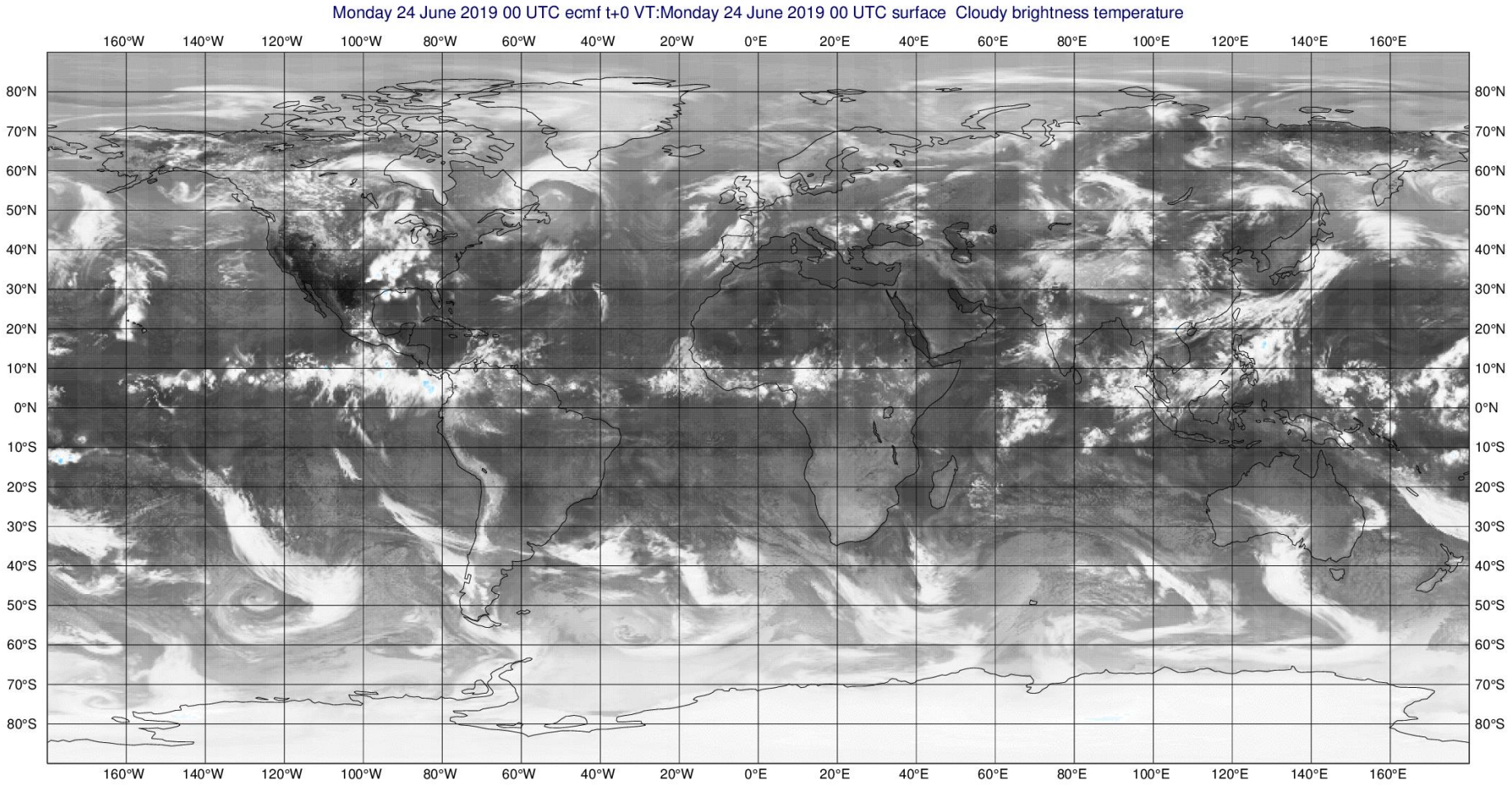
Monday 24 June 2019 00 UTC ecmf t+0 VT:Monday 24 June 2019 00 UTC surface Cloudy brightness temperature
160°W 140°W 120°W 100°W 80°W 60°W 40°W 20°W 0°E 20°E 40°E 60°E 80°E 100°E 120°E 140°E 160°E
80°N 70°N 60°N 50°N 40°N 30°N 20°N 10°N 0°N 10°S 20°S 30°S 40°S 50°S 60°S 70°S 80°S

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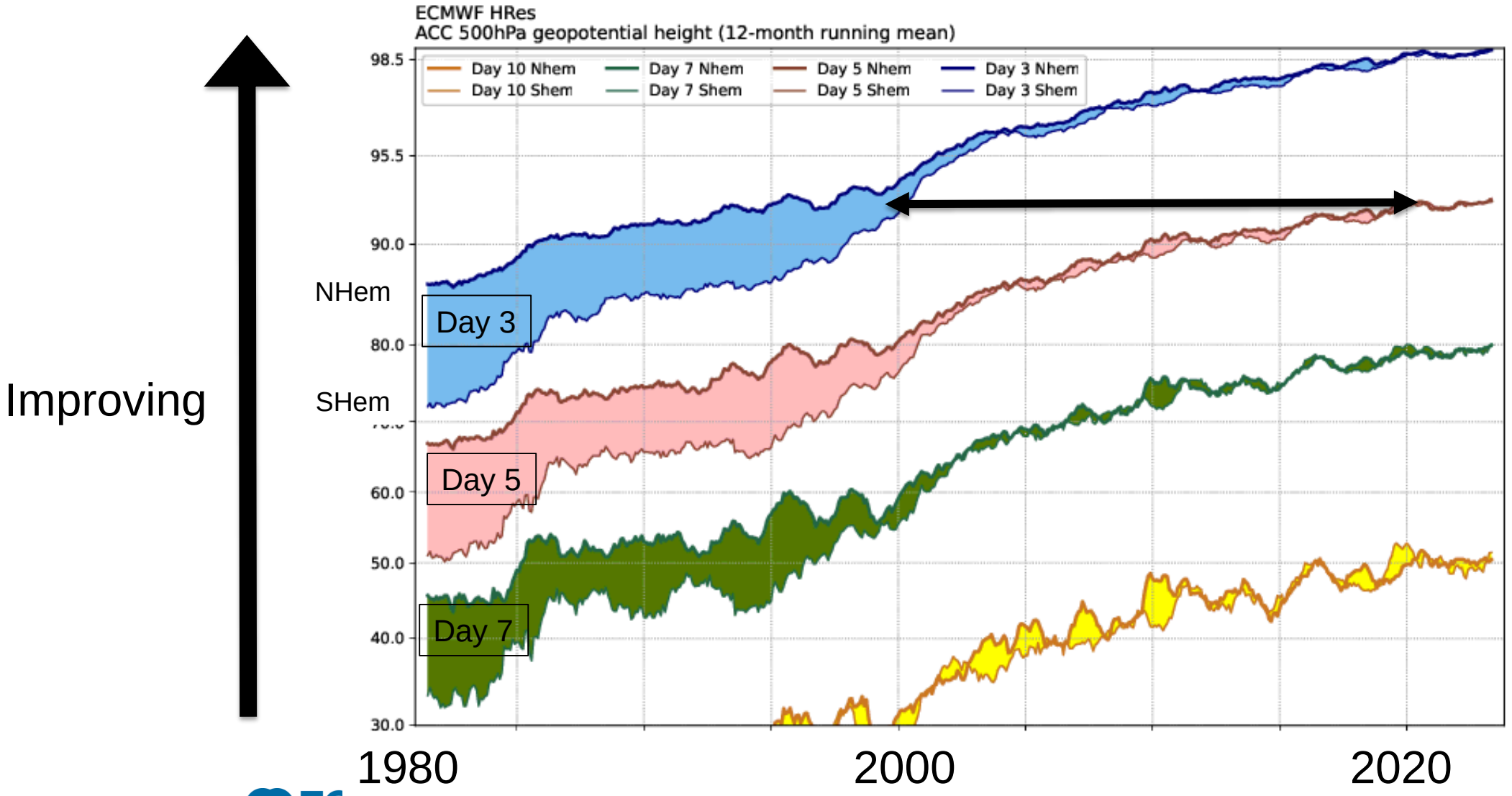
Dramatically improving accuracy……



What has made things better?

Better science

- Clever people!
- Partnerships

Bigger supercomputers

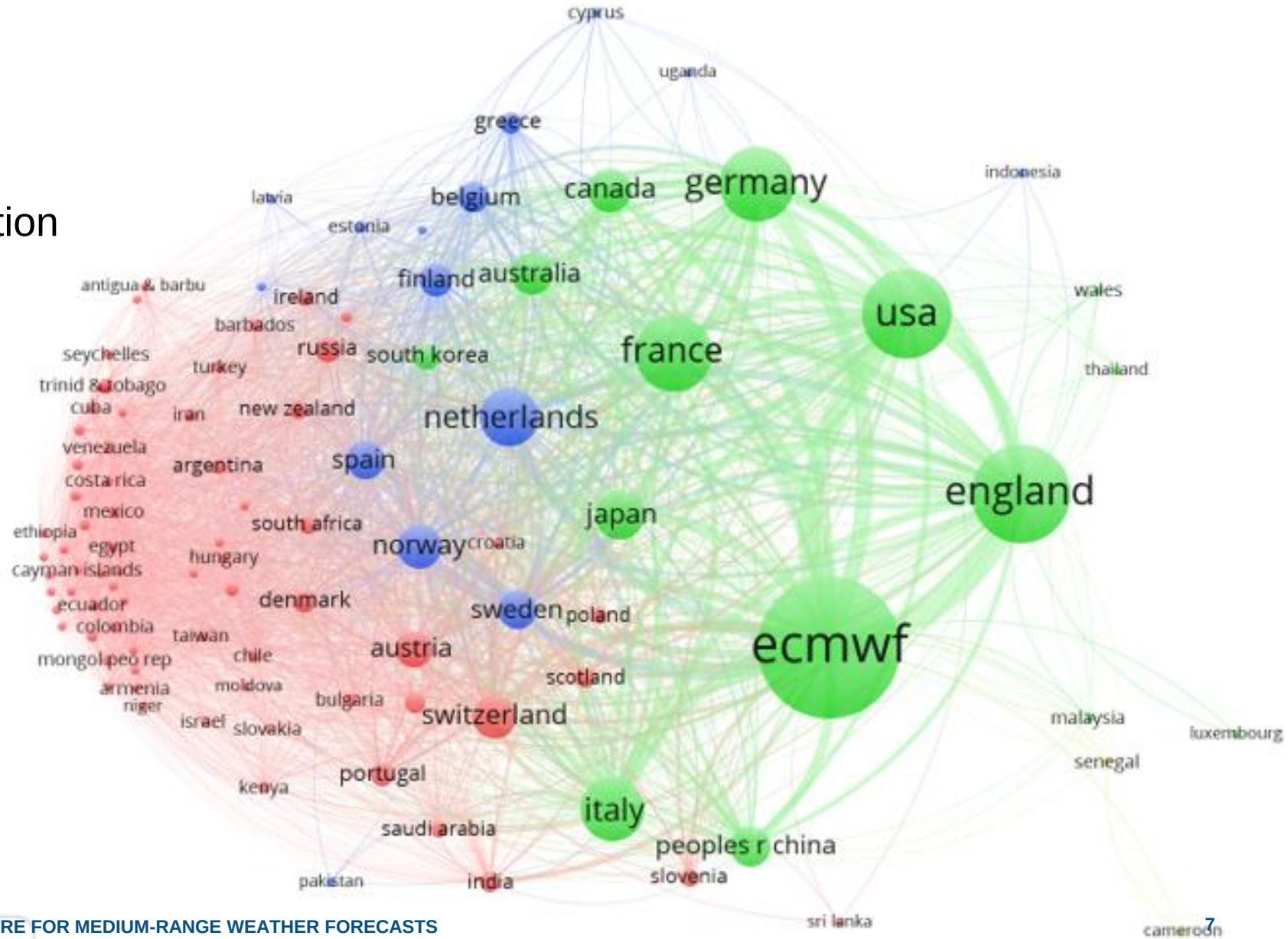
- More expensive choices possible (e.g. model resolution)

More and better observations

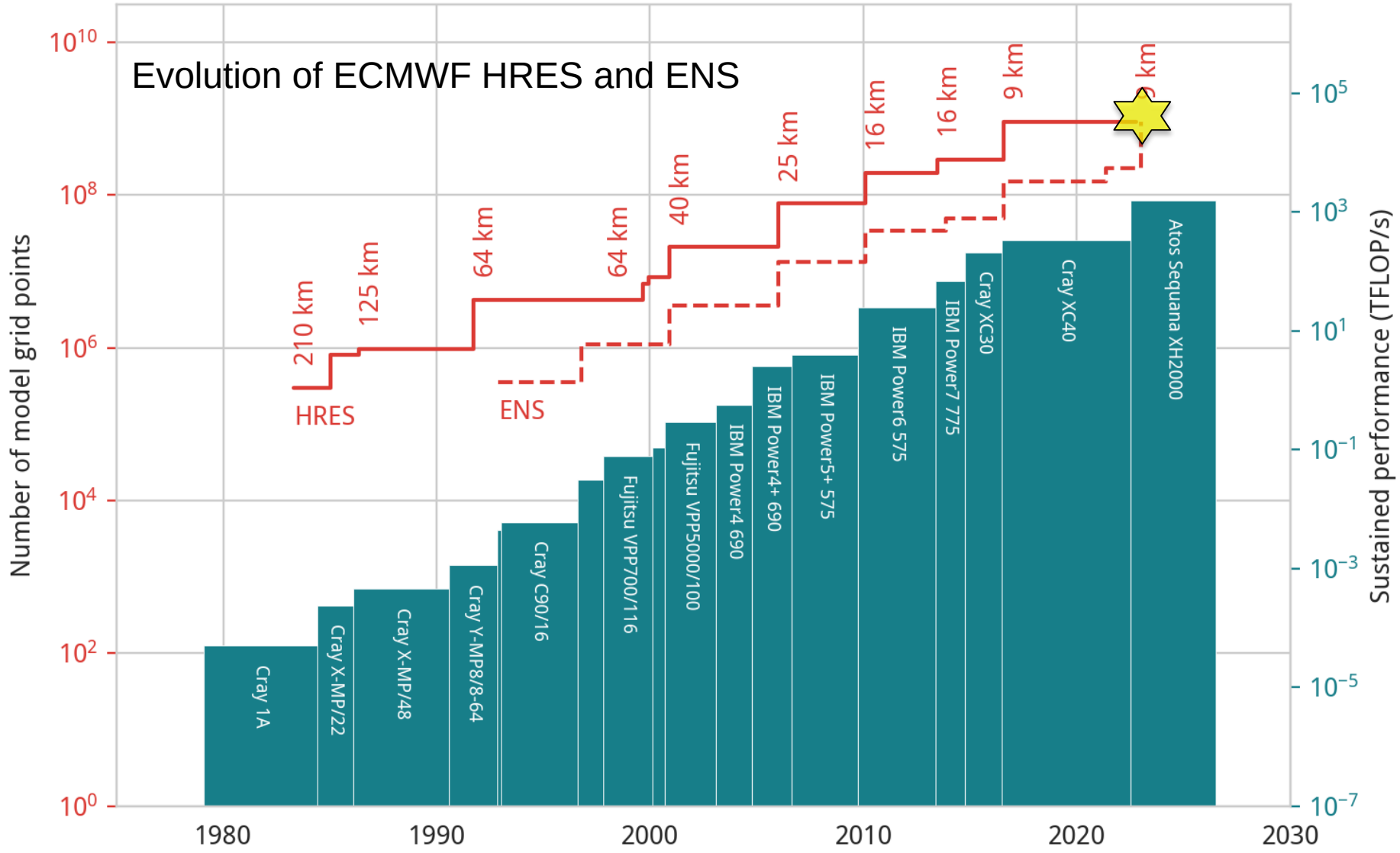
- Number, accuracy, variety

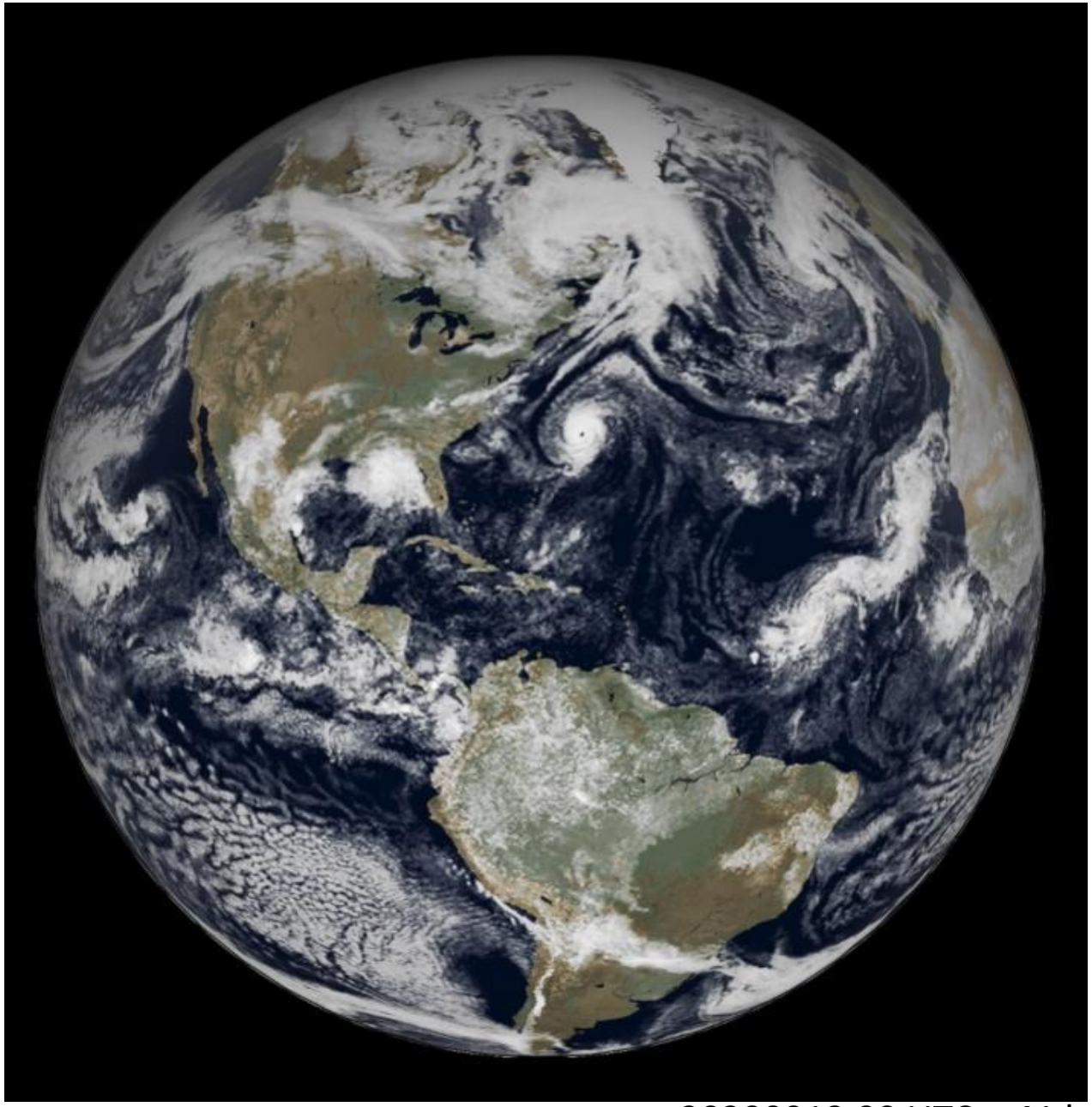
Global collaboration

ECMWF publication co-authorship

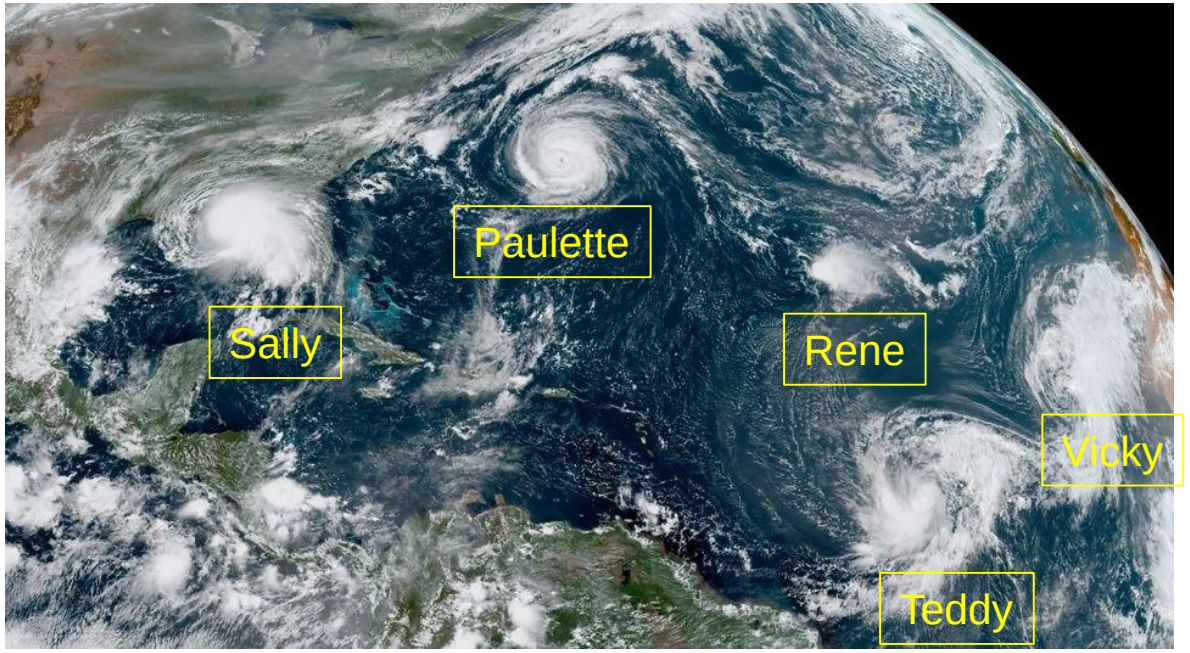


Current and future directions: Focus on ensembles





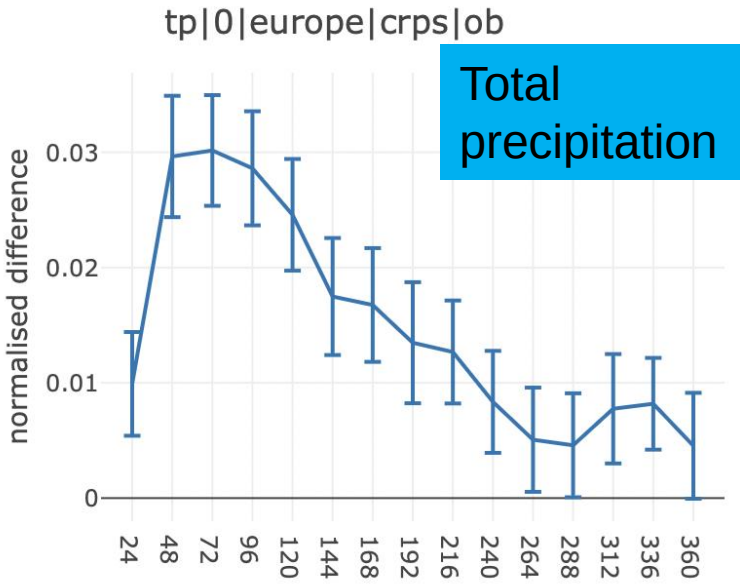
20200913 00 UTC + 41 h



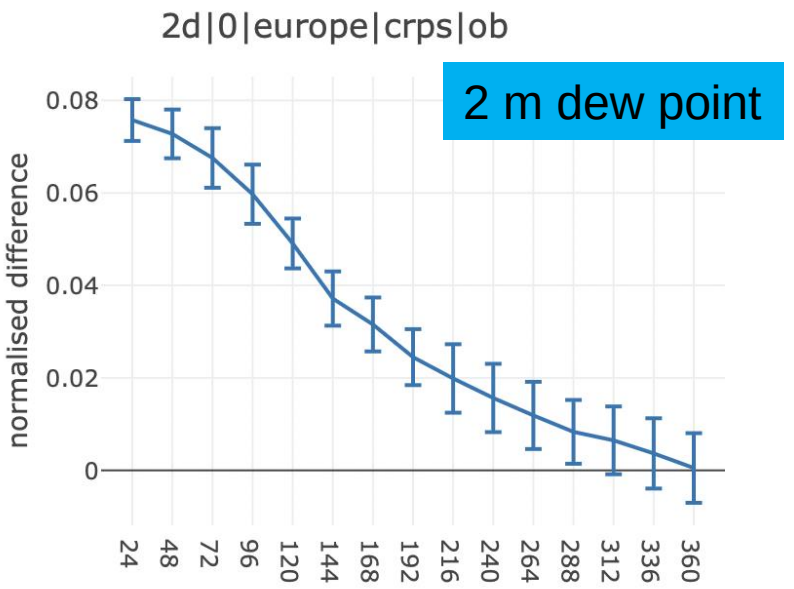
NOAA

Cycle 48r1:
Delivering an operational 9 km medium-range global ensemble!

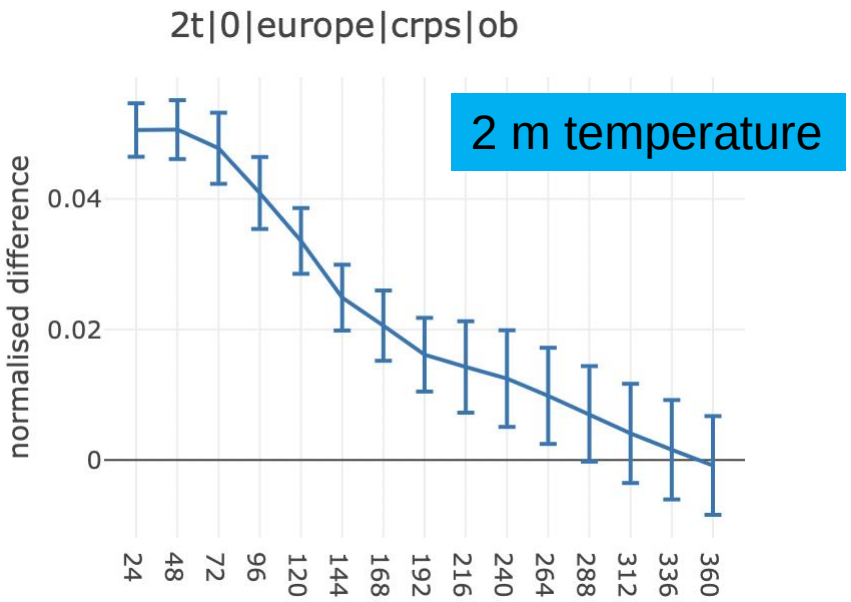
Current and future directions: Focus on user-relevant quantities



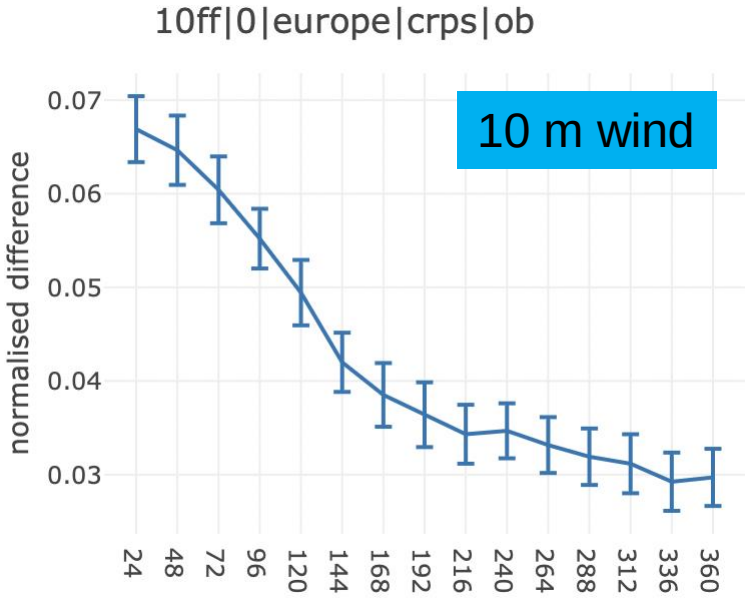
Total precipitation



2 m dew point



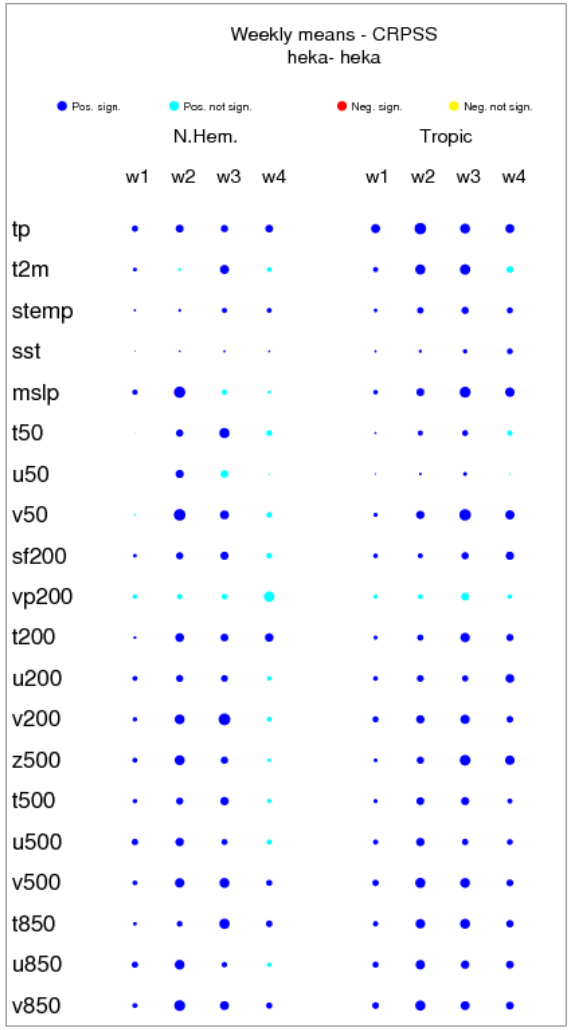
2 m temperature



10 m wind

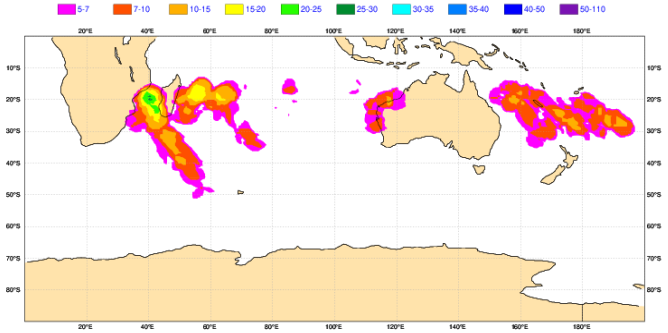
Current and future directions: Focus on extended-range forecasts

Impact of increase of ensemble size

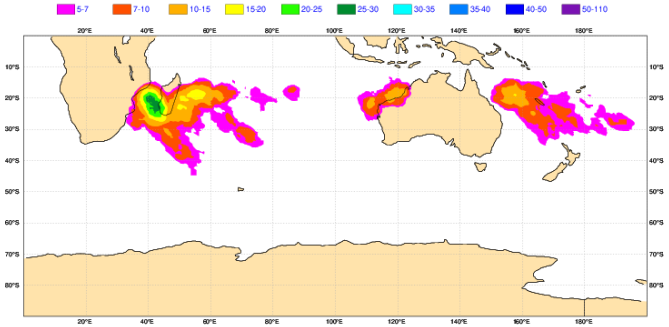


Tropical storm strike probability week 4 forecast
Start date:7/1/2021 – verification 1-7 Feb. 2021

50 members

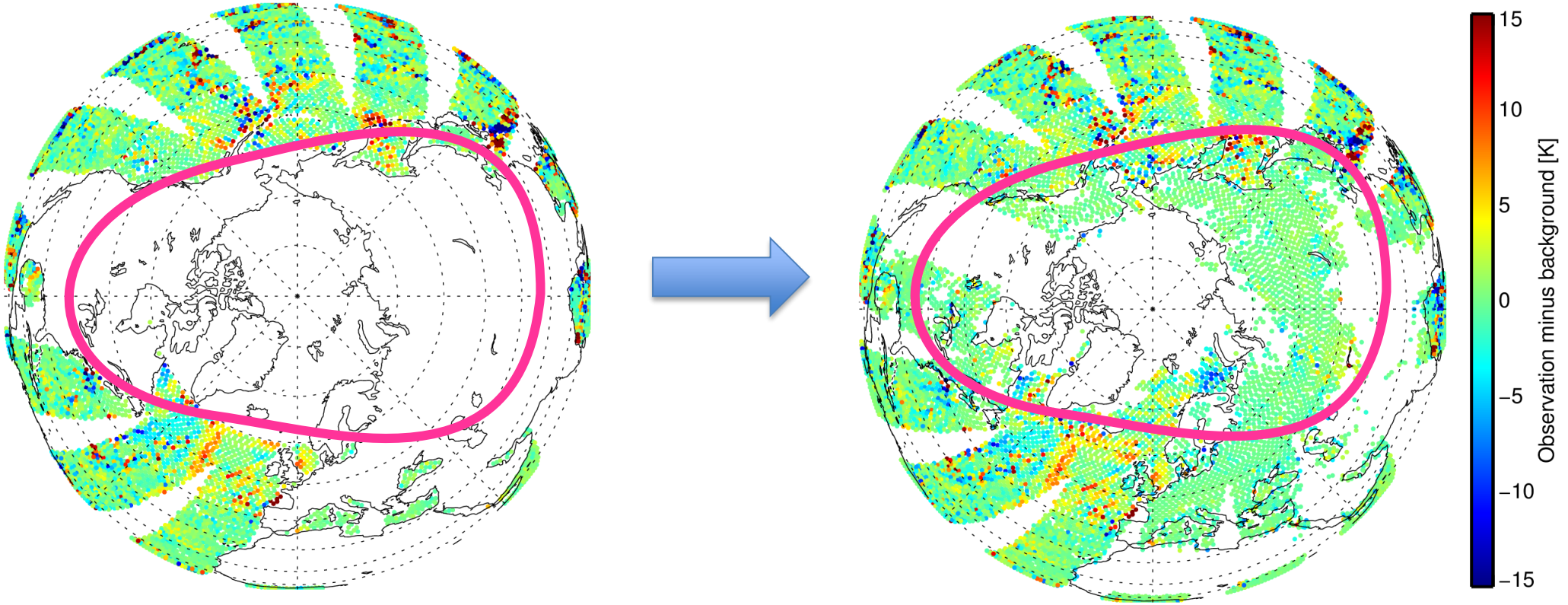


100 members



Cycle 48r1:
From a 50 member ensemble twice per week to a 100 member ensemble every day

Current and future directions: Learning to use more difficult observations

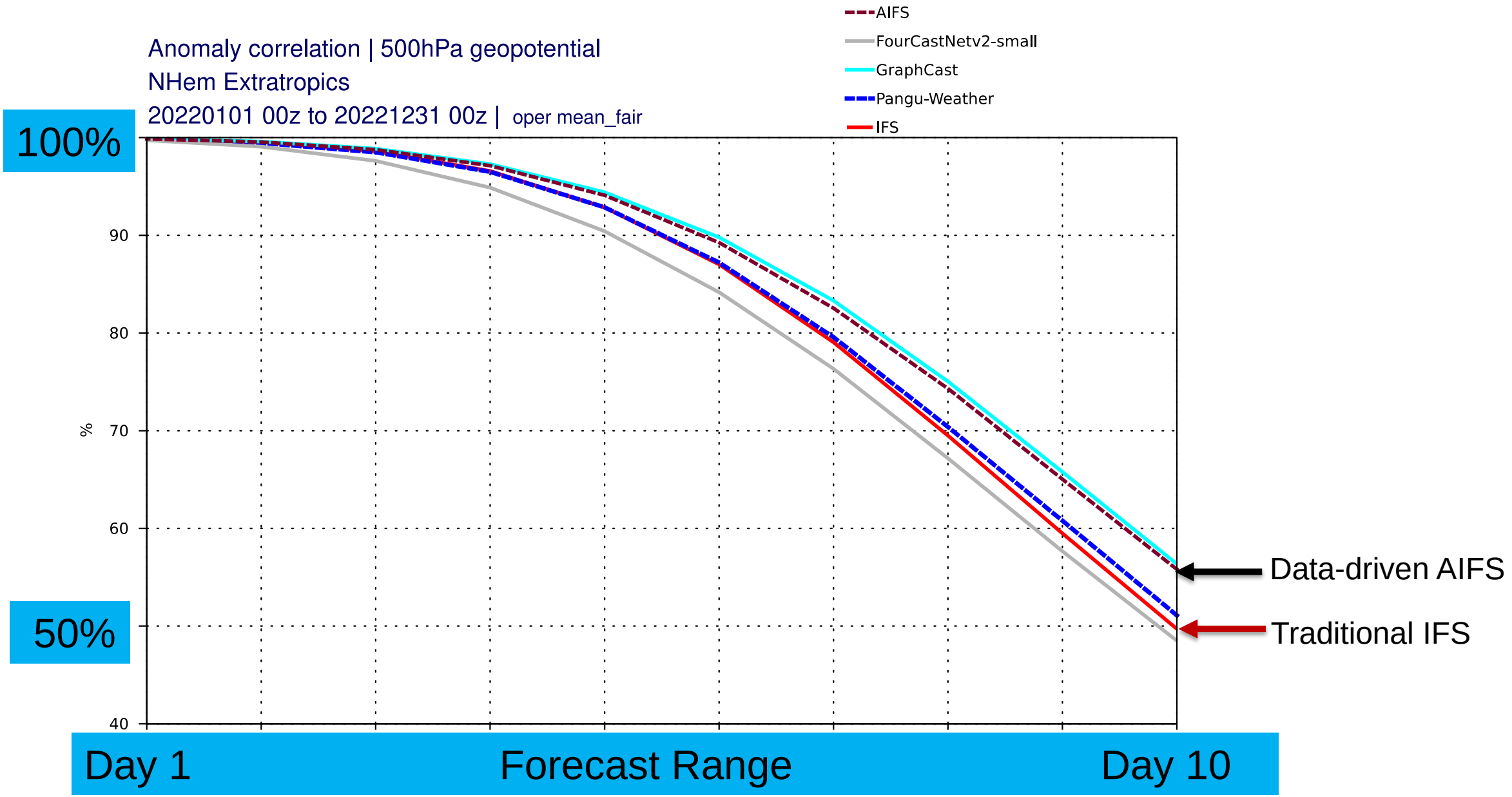


Current and future directions: The rise of machine learning

Post-processing and calibration of traditional models

Hybrid modelling (e.g. online correction of learned errors)

Complete model replacement


Anomaly correlation | 500hPa geopotential
NHem Extratropics
20220101 00z to 20221231 00z | oper mean_fair
AIFS
FourCastNetv2-small
GraphCast
Pangu-Weather
IFS
100%
90
80
%
70
60
50%
40
Data-driven AIFS
Traditional IFS
Day 1
Forecast Range
Day 10

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