ECMWF research progress and plans

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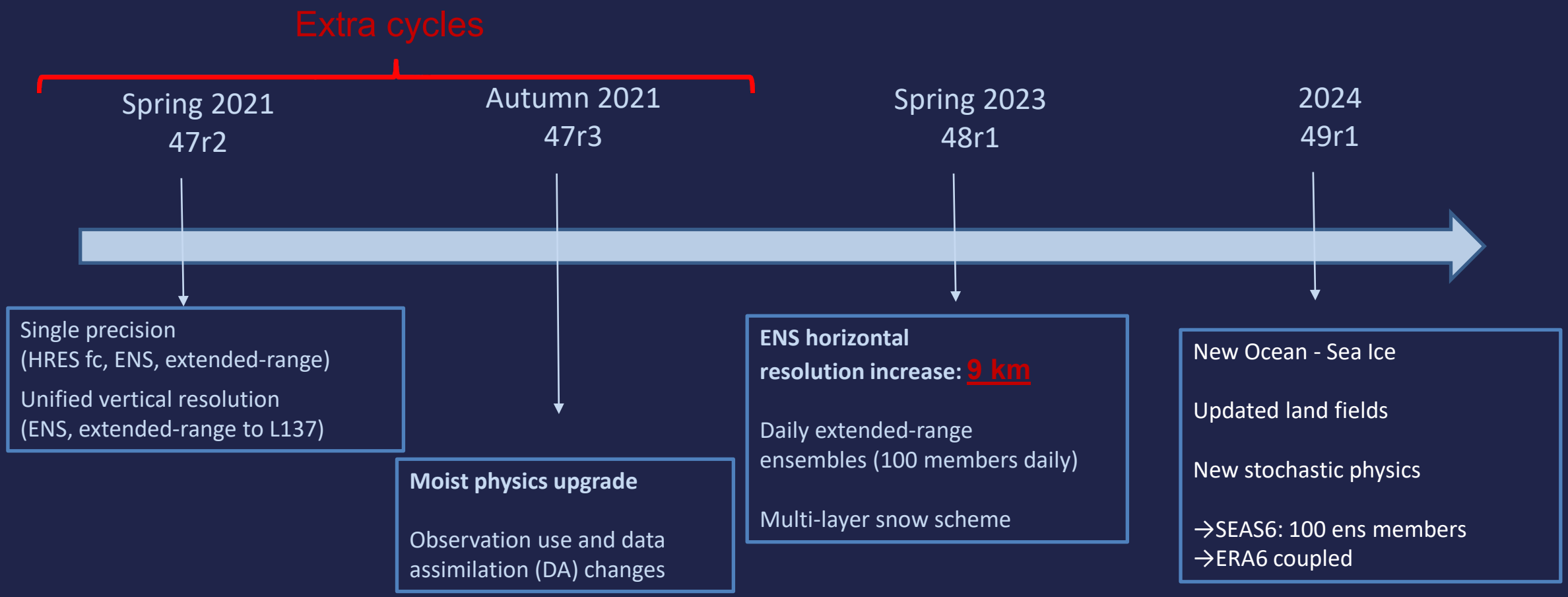
Director of Research

ECMWF

Integrated Forecasting System (IFS) cycle upgrades



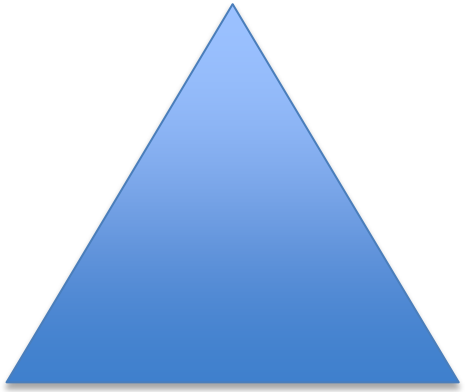
Cycle 47r2

Neutral impact

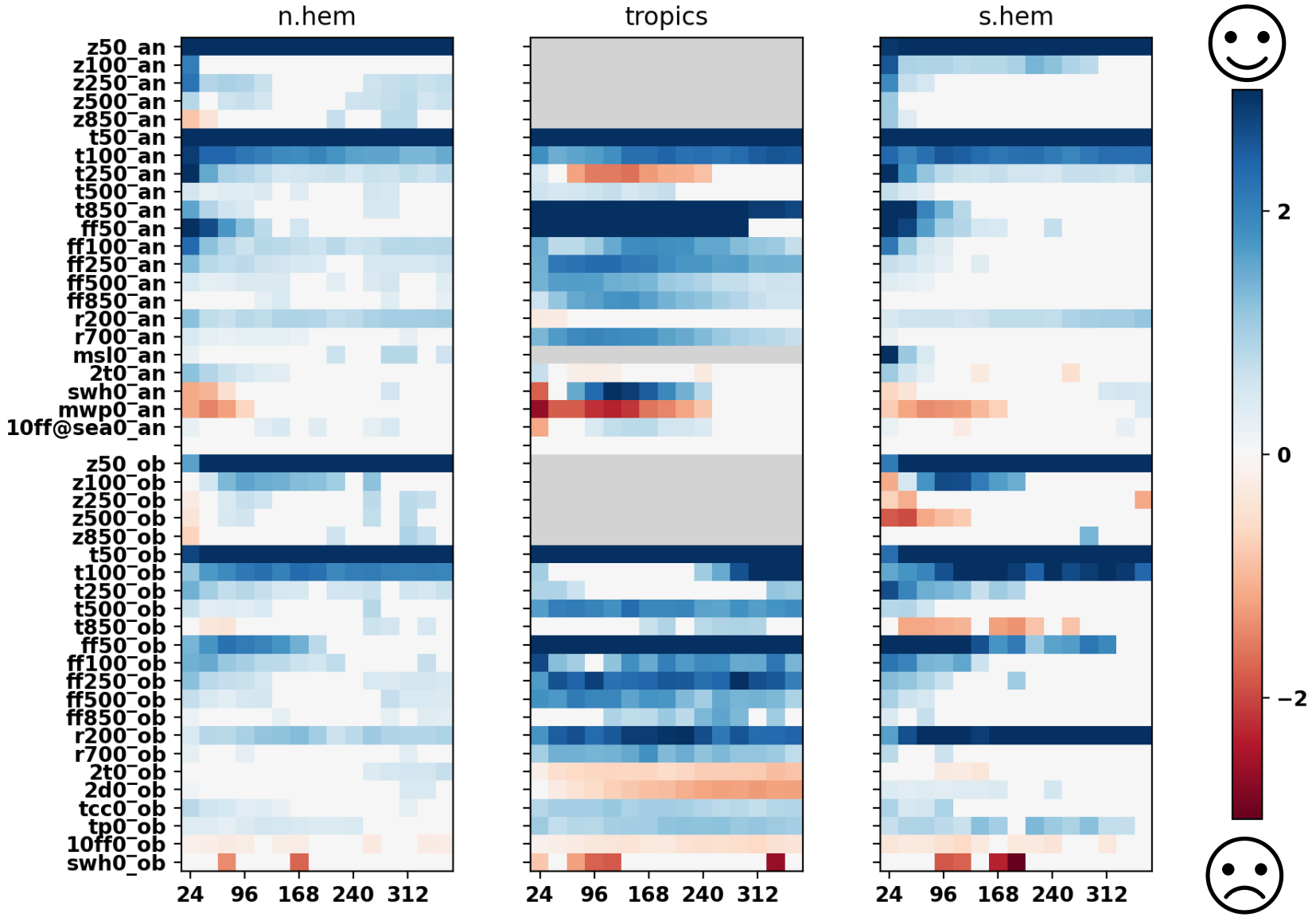
Saving of computational cost through implementation of single precision

Positive impact

Investment to take ENS (medium and extended-range) from L91 to L137



47r2: Impact of single precsion and vertical levels increase

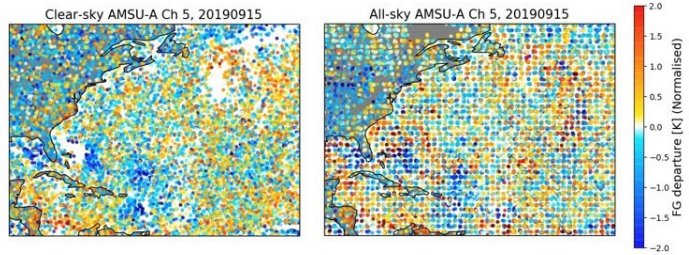


Scorecard, 95% sig. level.

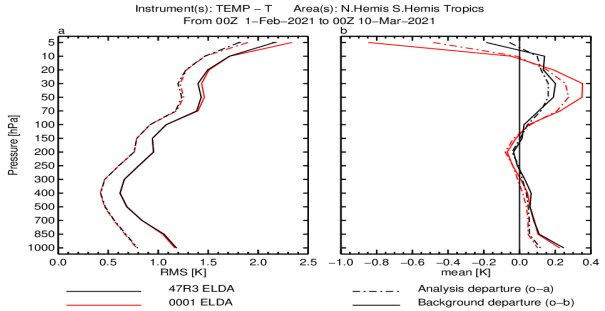
Summer+Winter, 168 ini dates

IFS Cycle 47r3

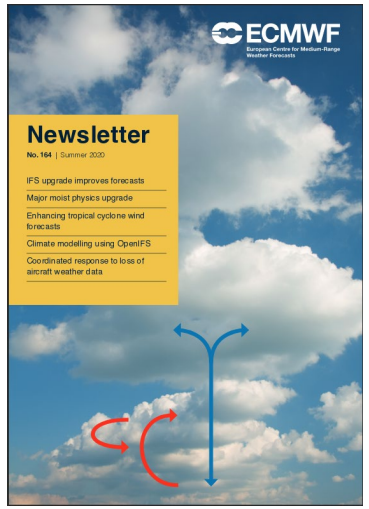
1. Changes to observation usage in the assimilation
   (infra-red, microwave, atmospheric motion vectors, Aeolus winds)



2. Weak constraint 4DVar for stratosphere in EnsembleDA



3. Major revision to improve the physical and numerical basis for moist processes in the IFS



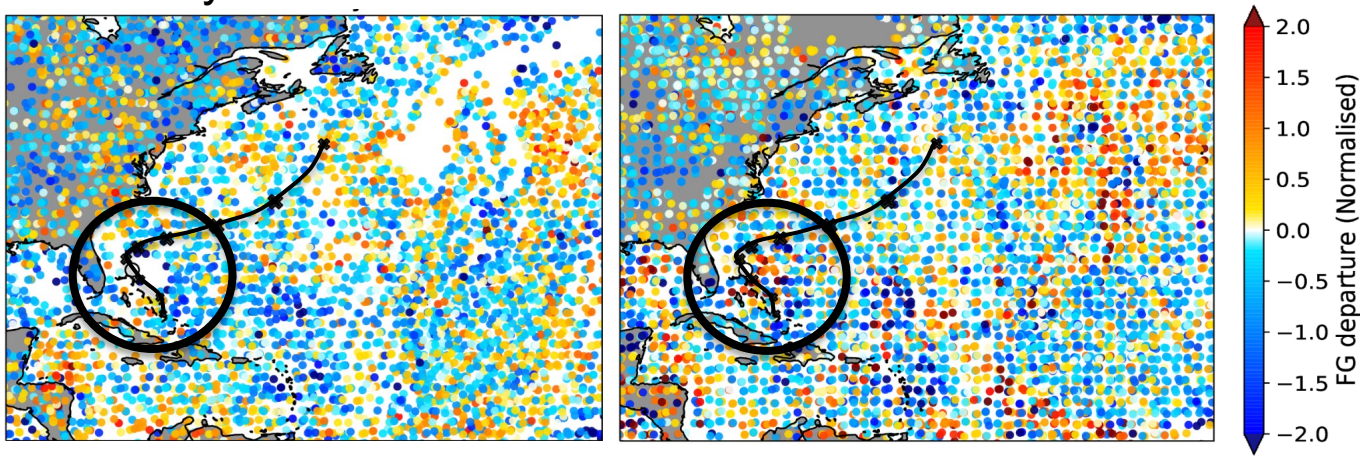
Observations: Assimilation of all-sky AMSU-A

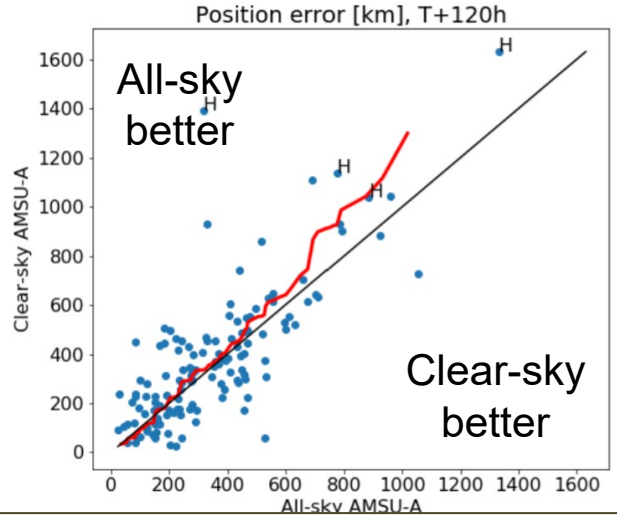
Satellite	Launch	EOL	Broken Channels
NOAA-15	1998	-	6, 11, 14
NOAA-16	2000	2014	8, 9
NOAA-17	2002	2003	N/A
Aqua	2002	-	1, 2, 5, 6, 7, 14
NOAA-18	2005	-	8, 9
Metop-A	2006	2021	7, 8
NOAA-19	2009	-	7, 8
Metop-B	2012	-	15
Metop-C	2018	-	-

AMSU-A channels 5 to 14 are actively assimilated. These are channels with primary sensitivity to temperature from the mid-troposphere through upper stratosphere

In 47r3, **"clear-sky" assimilation is replaced by "all-sky"**, treating satellite radiances in all atmospheric conditions

Clear-sky Hurricane Humberto All-sky





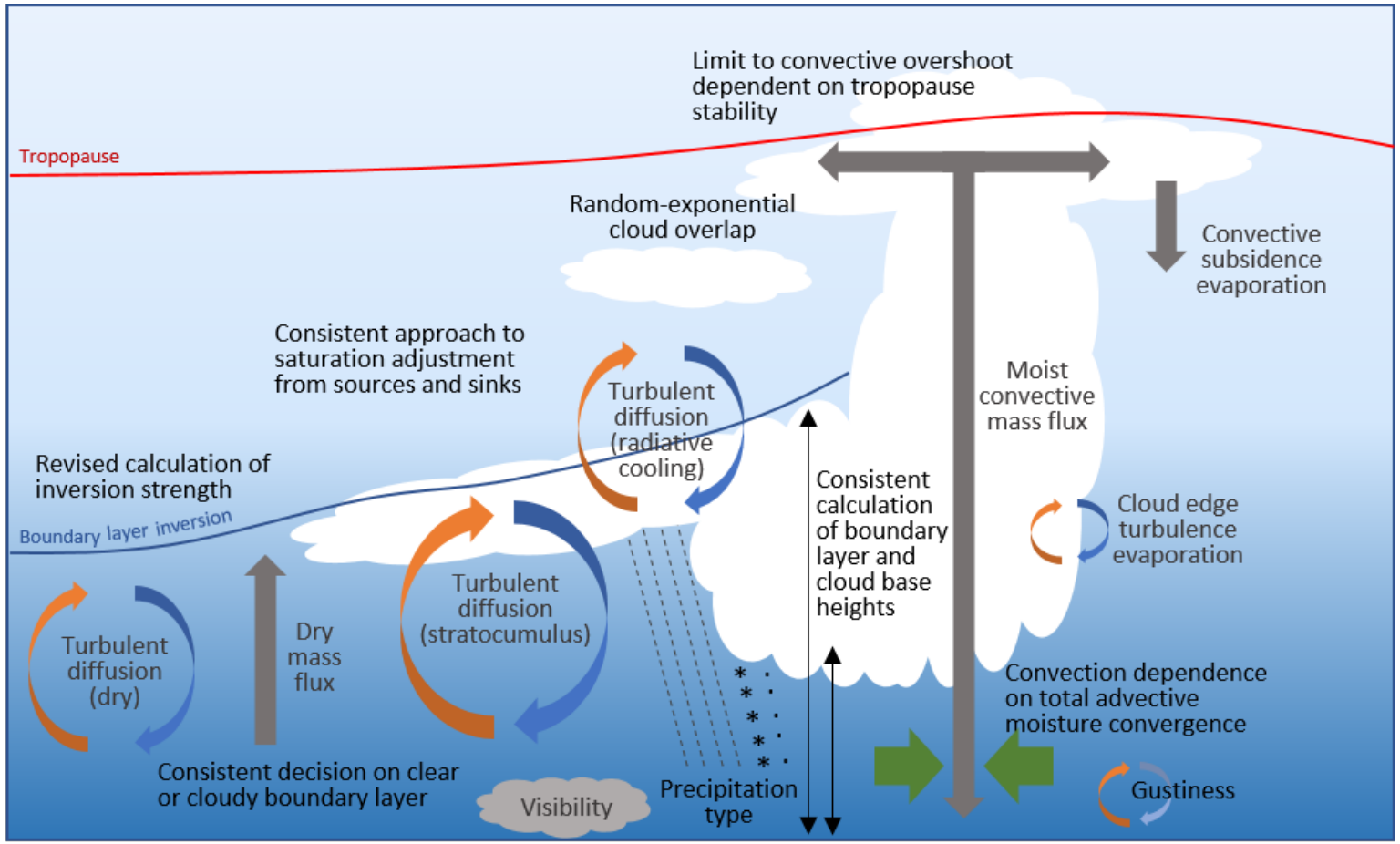
➔ Assimilation of all-sky AMSU-A: Increases use of microwave sounder data in areas of cloud and precipitation (+12% global increase for Channel 5)

➔ Provide critical observations near Tropical Cyclones (example: Hurricane Humberto)

Moist physics upgrade in IFS Cycle 47r3

- Major development to moist physics parametrizations (cloud, convection, turbulent mixing, microphysics)
- **Simpler interactions**, **more consistency**, **improved physical processes**, **better numerics**

Changes to many different aspects of the moist physics…



More details in…

ECMWF Newsletter 164 (Summer 2020)
(www.ecmwf.int/en/publications/newsletters)

47r3 summary - scorecards

HRES
(AnomCorr/RMSE)

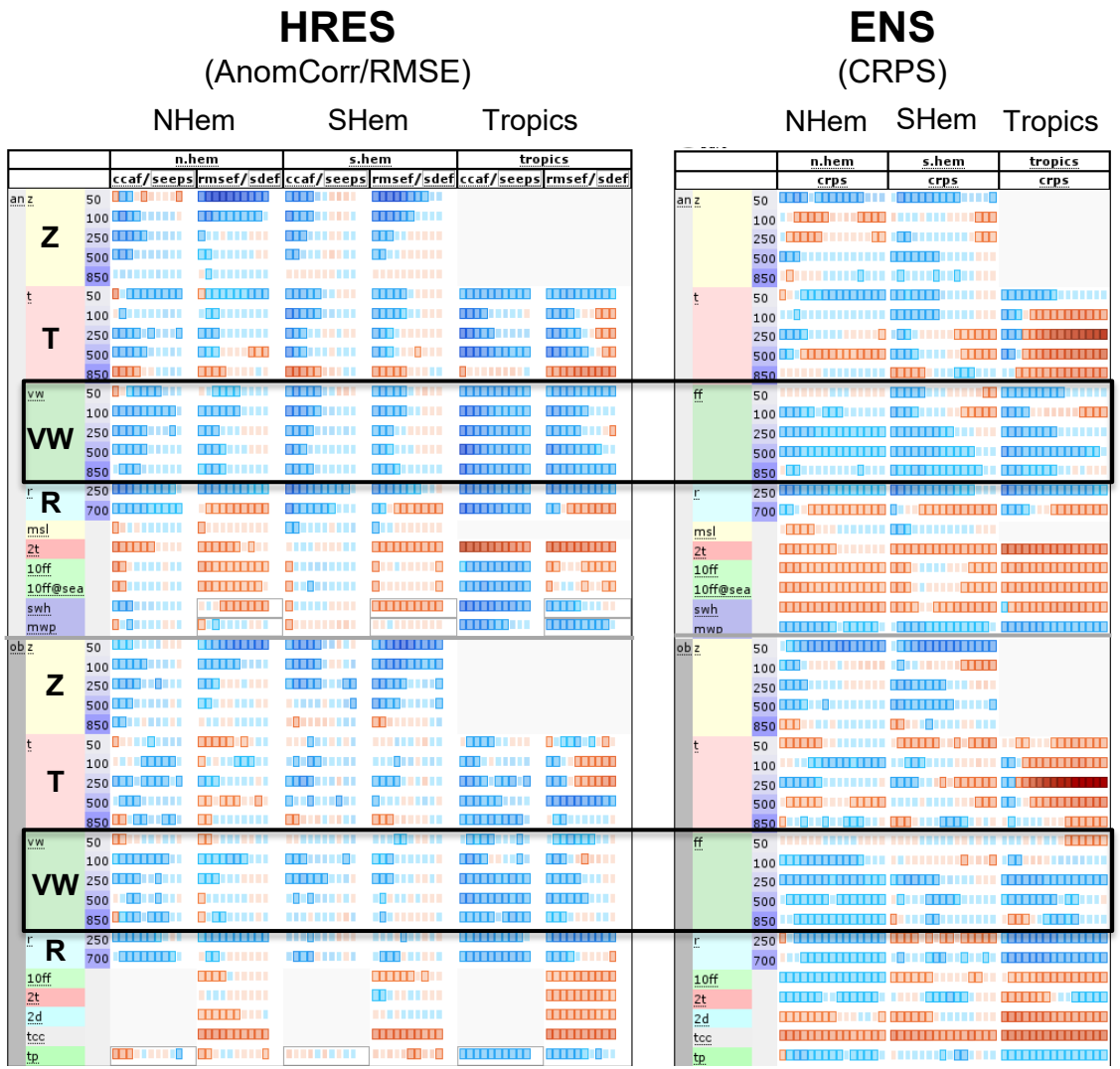
ENS
(CRPS)

Based on 650 forecasts Jun 2020 - Aug 2021

(1) Improved upper air - GEOPOTENTIAL

AC Z500 geopotential NH/SH 1-4% improvement

47r3 summary - scorecards



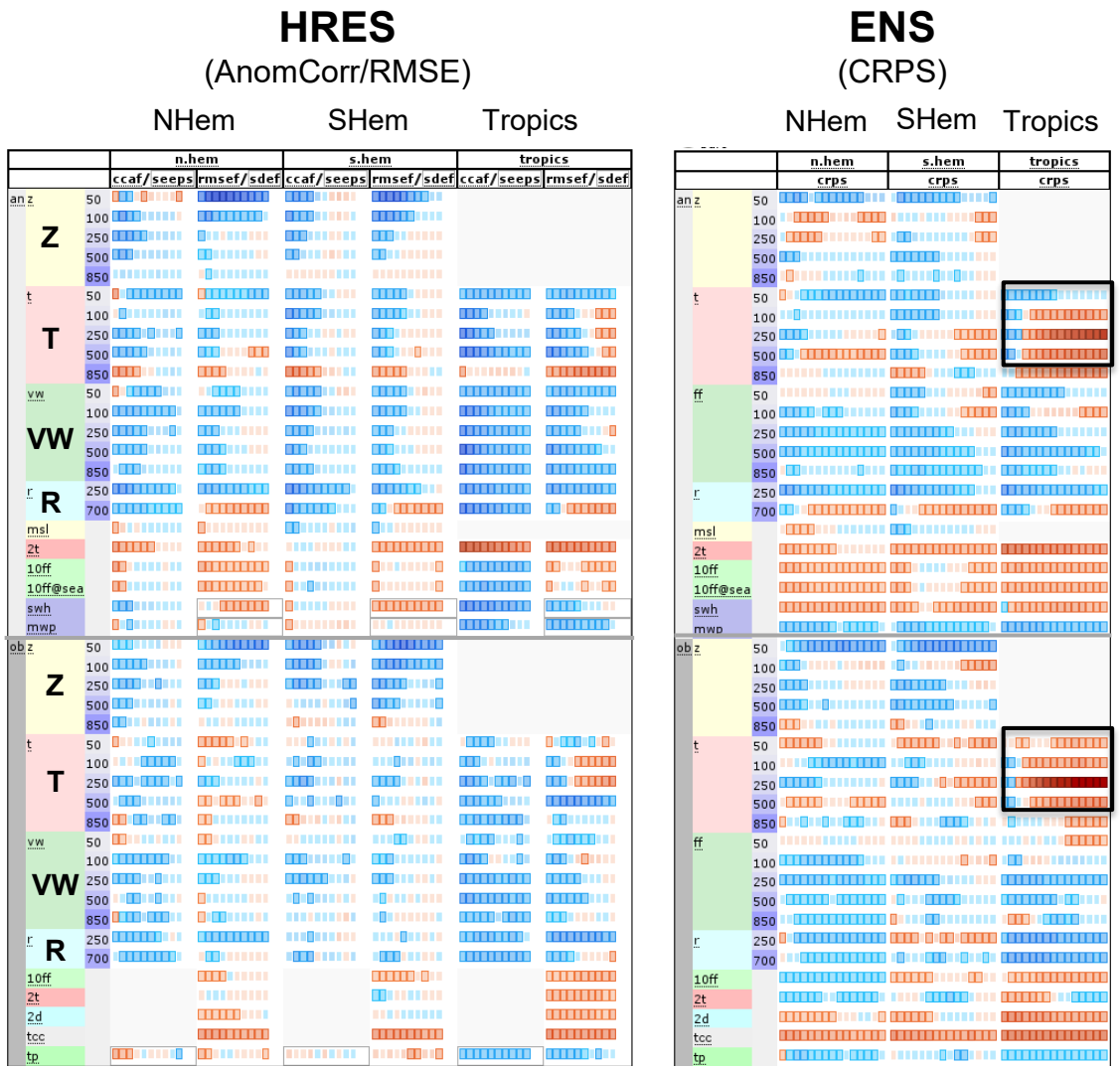
(1) Improved upper air - GEOPOTENTIAL

AC Z500 geopotential NH/SH 1-4% improvement

(2) Improved upper air - WIND

RMSE extratropics 1-2%, tropics 1-7% improvement

47r3 summary - scorecards



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(3) Degraded tropical upper-tropospheric temperature

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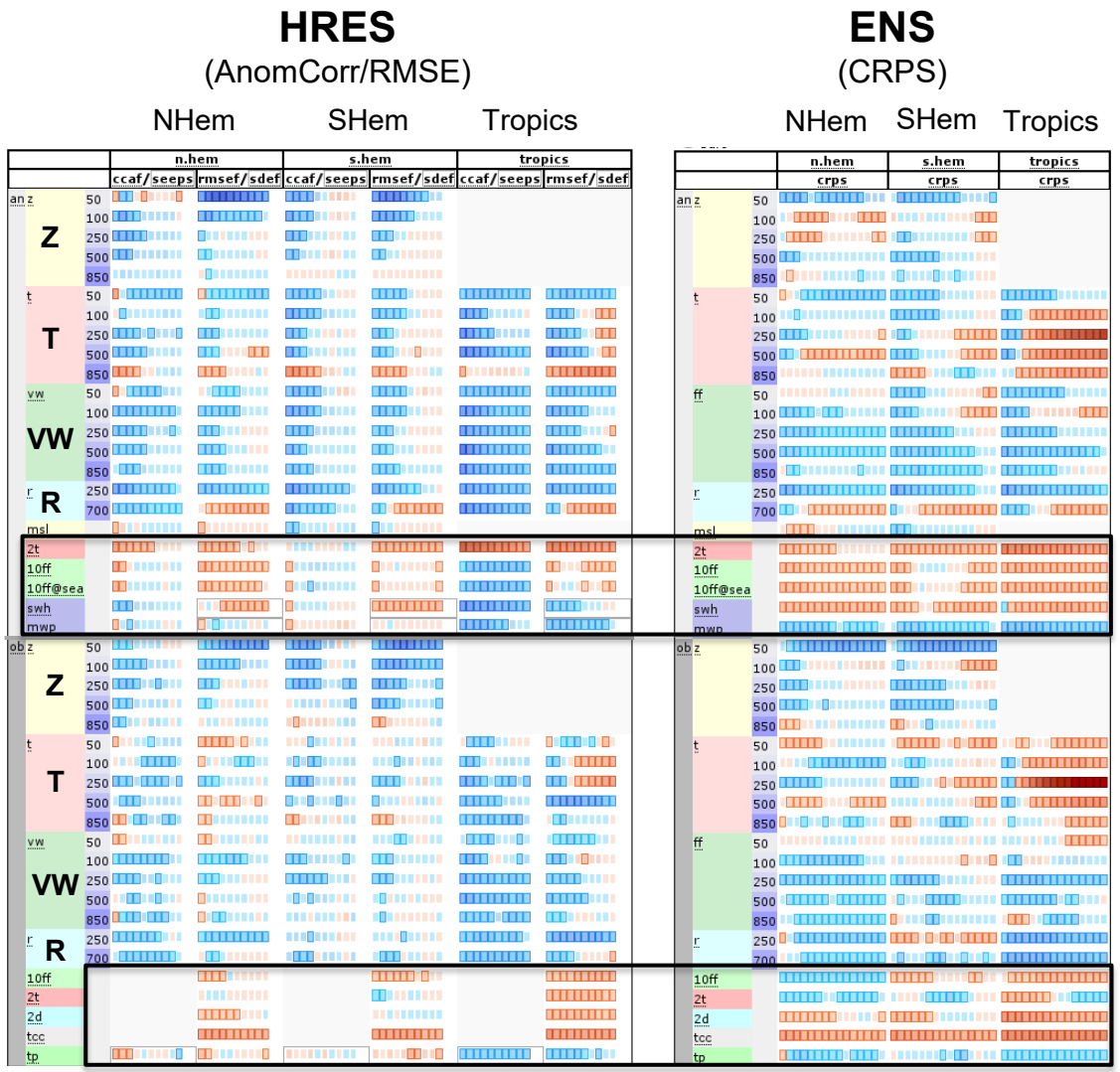

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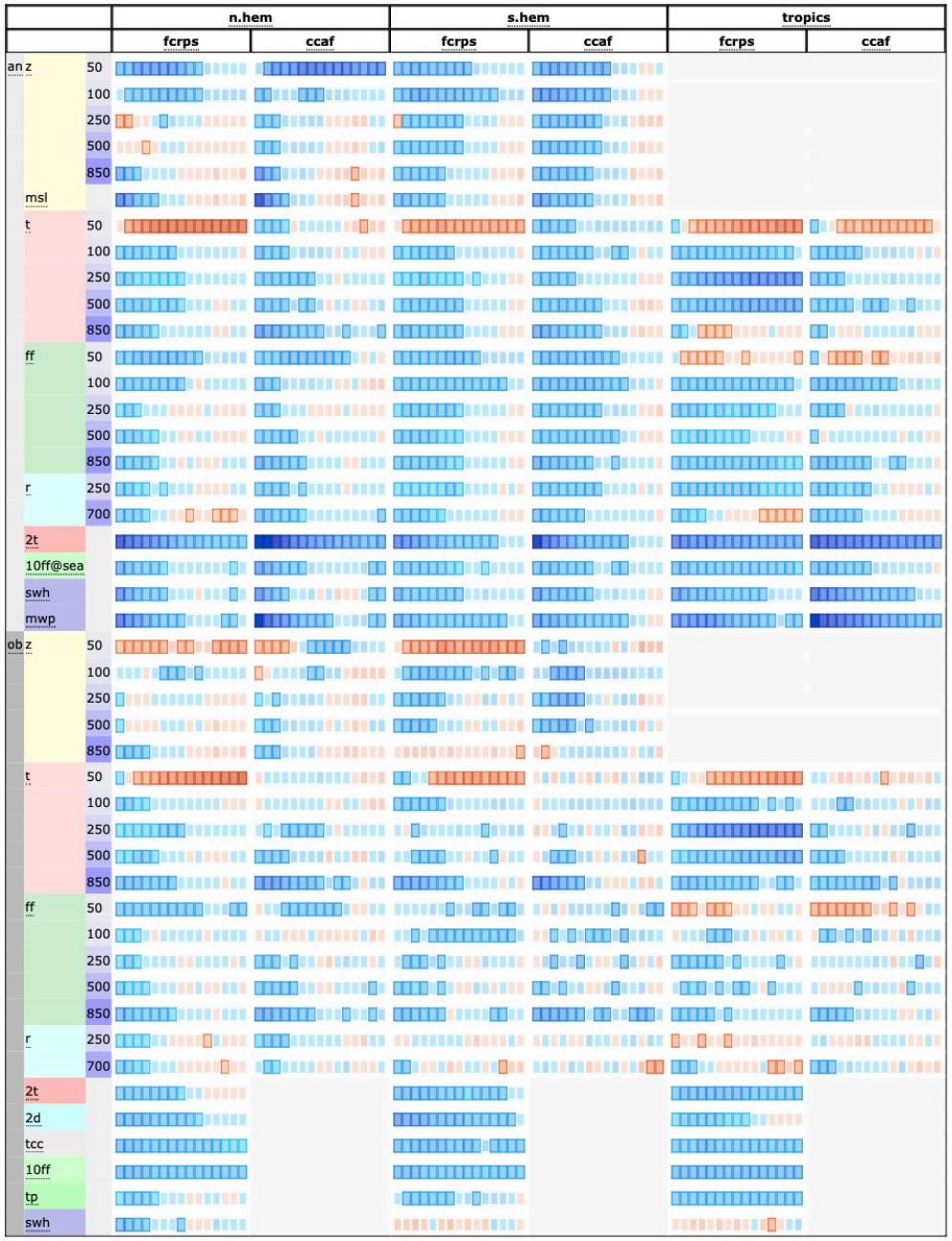
(3) Degraded tropical upper-tropospheric temperature

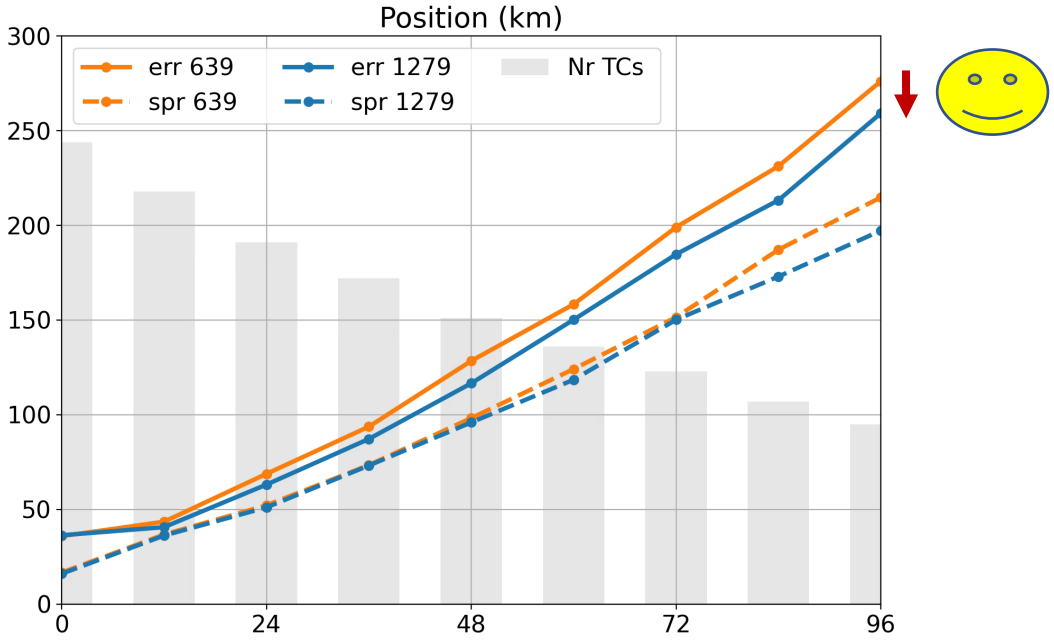
(4) Mixed signal in near surface variables

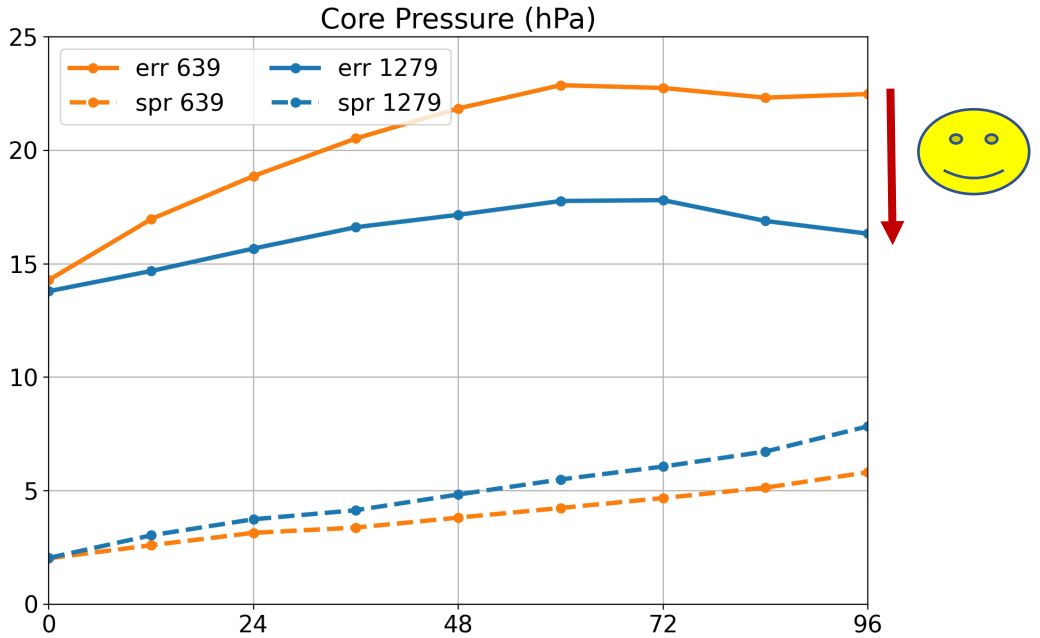
48r1 High resolution ensemble: scorecard and tropical cyclone improvements

8 pert members,
00, 12 UTC
20200602 - 20200724,
20210901 - 20211019,
20201202 – 20210211

9 km (TCo1279)
vs 18 km (TCo639)

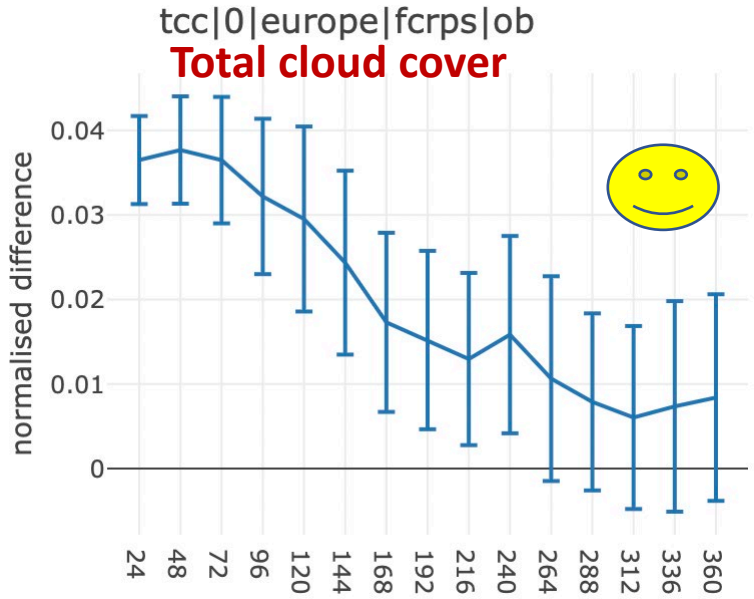




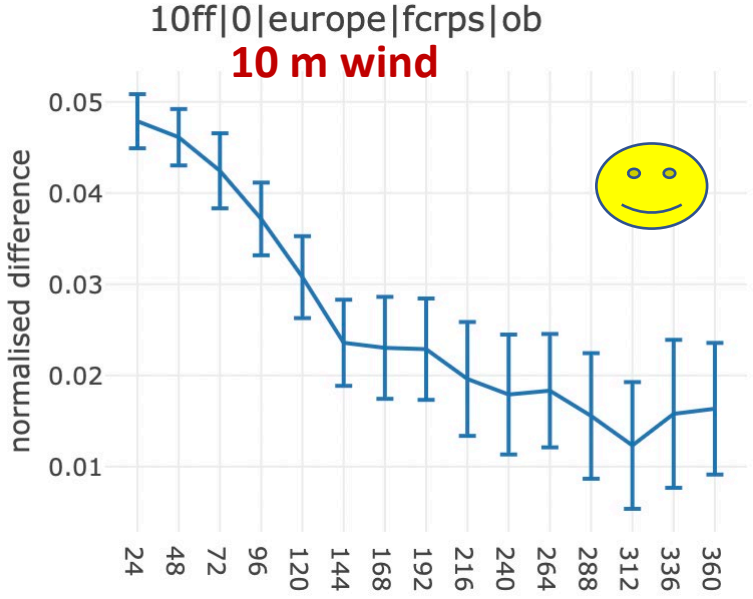


48r1 High resolution ensemble: near-surface weather improvements

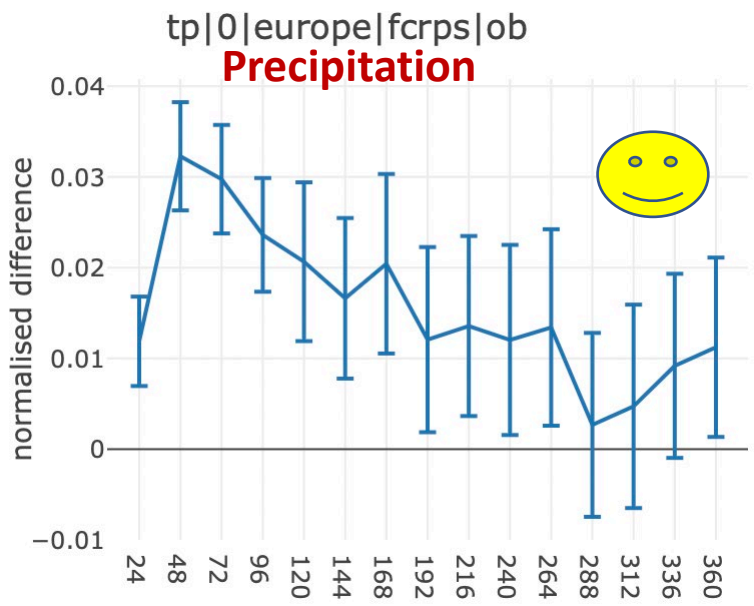
4%



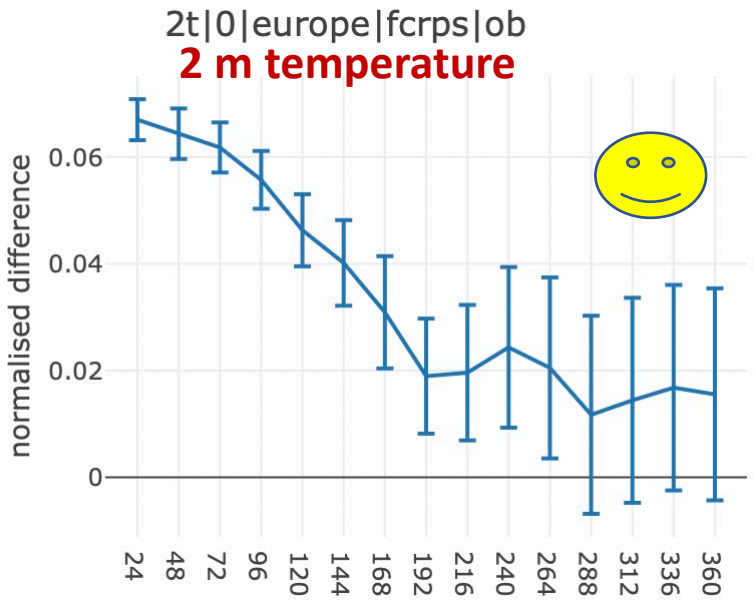
5%



4%

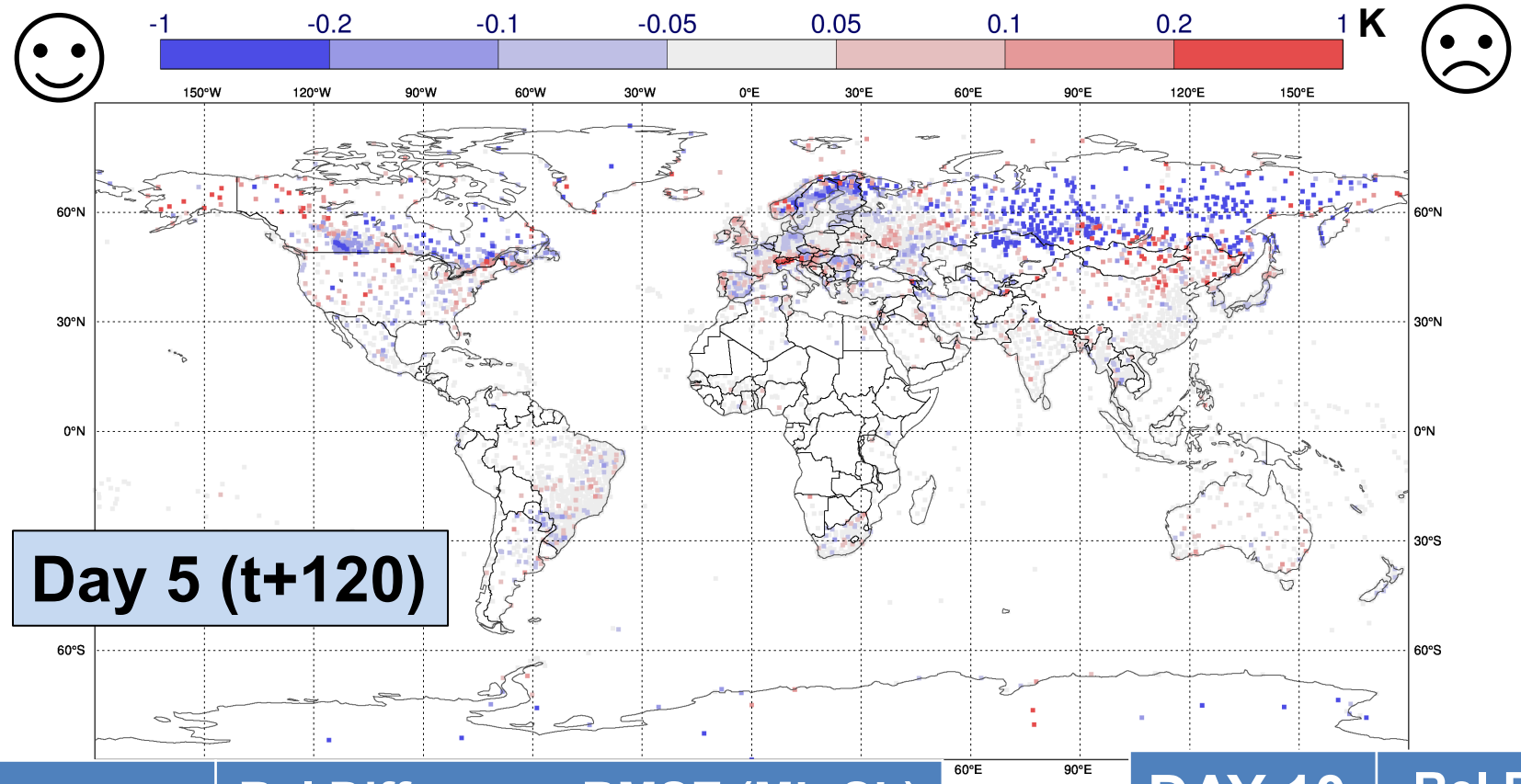


6%



48r1: Impact of multi-layer snow

Winter, 47r1.3, DJF 2019/2020 Impact on 2-metre temperature ensemble CRPS (TCo399; L137)



DAY 5	Rel.Difference RMSE (ML-SL)
ExTrop	-2.2%
Arctic	-3.9%
Europe	-0.7%

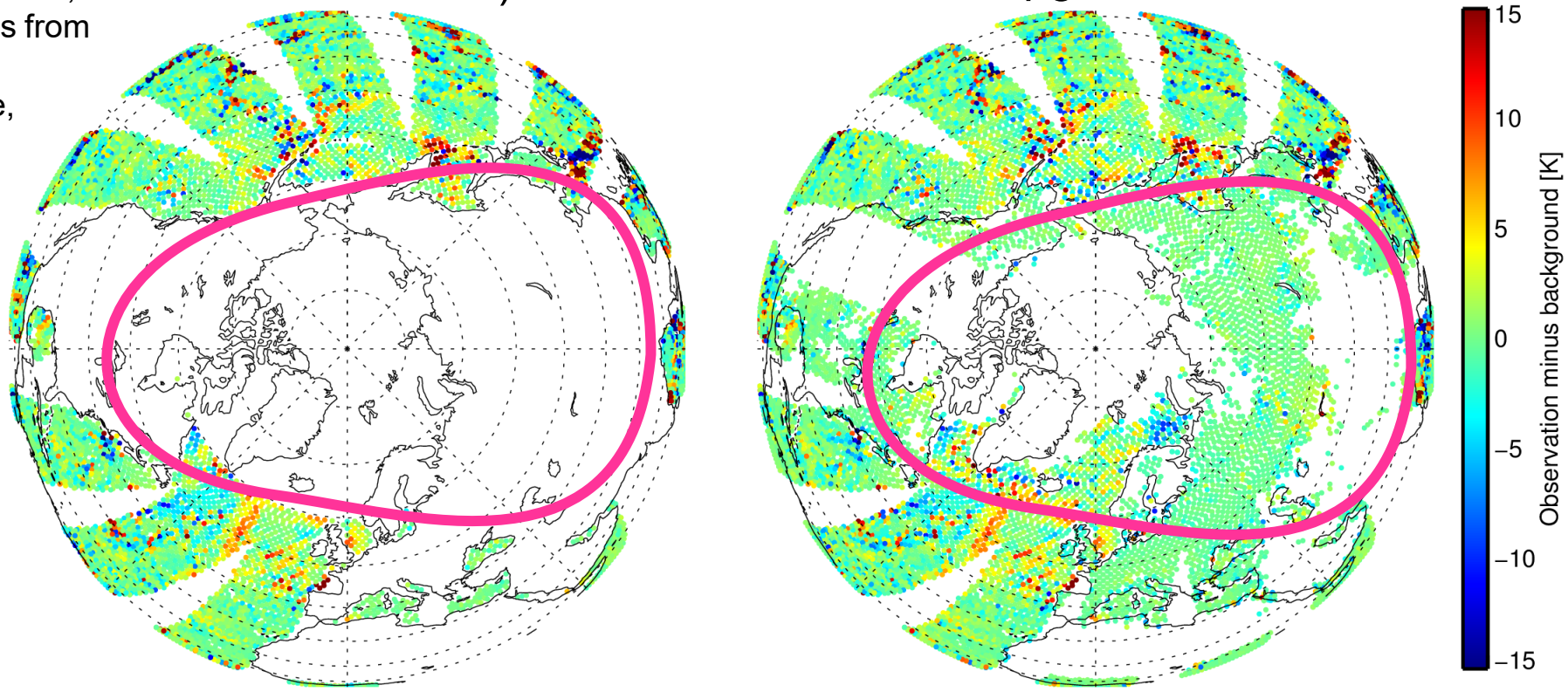
DAY 10	Rel.Difference RMSE (ML-SL)
Ex.Trop	-0.6%
Arctic	-1.0%
Europe	+0.5%

48r1: increased use of surface-sensitive microwave channels

Active channel 10 (36.5 GHz, v-polarised) observations from AMSR2 during 00 UTC analysis cycle, 26th June, 2019

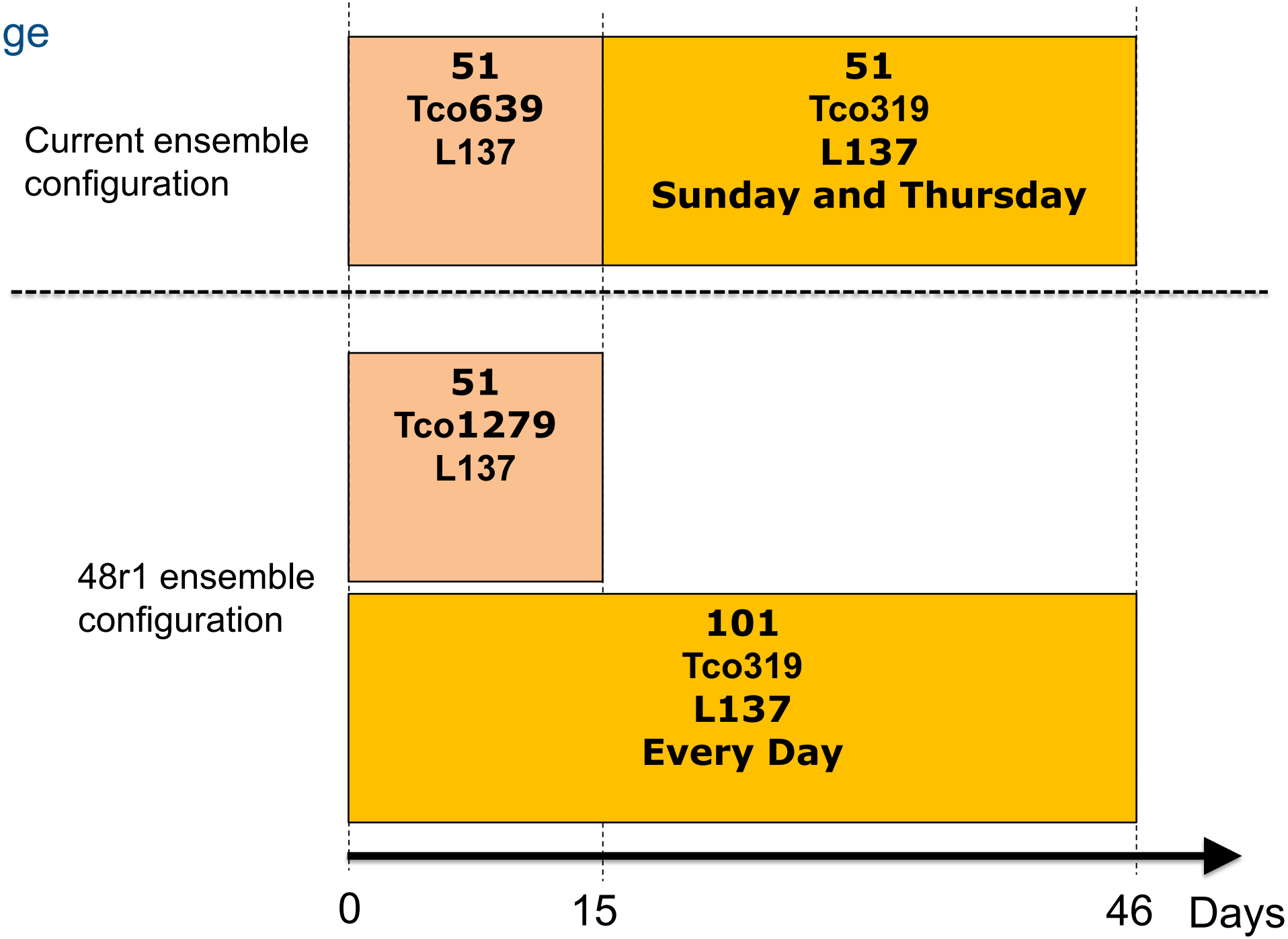
now (all-sky but not all-surface)

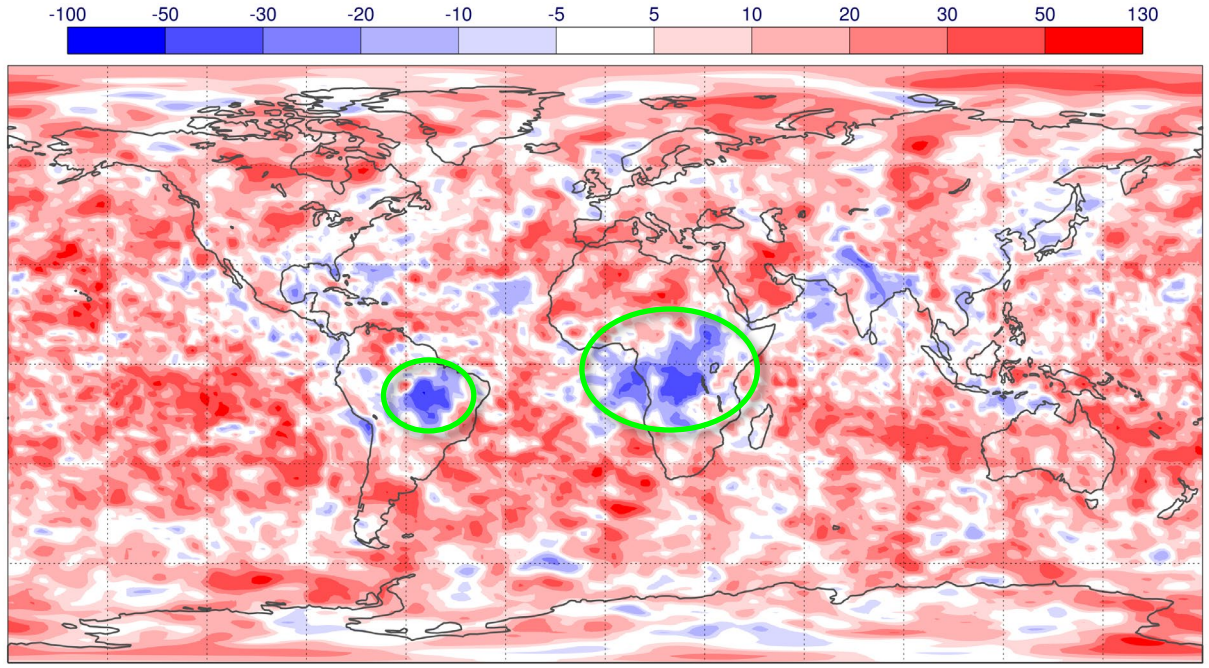
upgrade

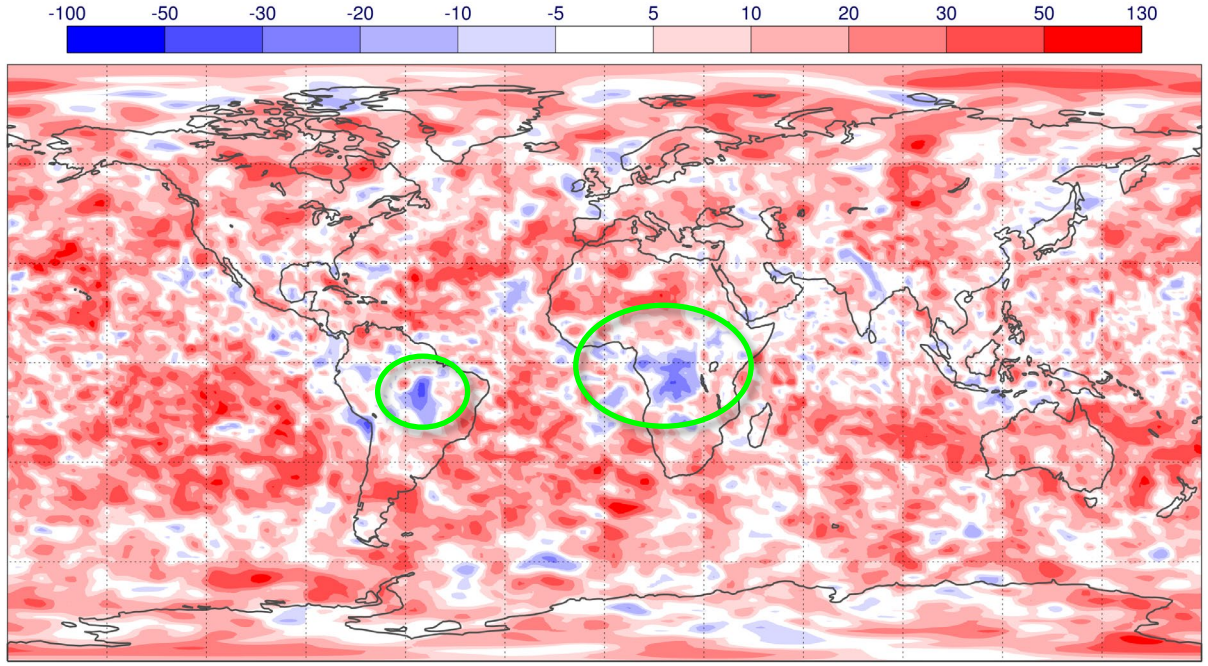


adding higher latitudes, land surfaces, mixed scenes (land – water)
(but excluding sea-ice, snow, high altitudes, desert soils)

48r1: Extended range







Looking further ahead: Impact of prognostic aerosols

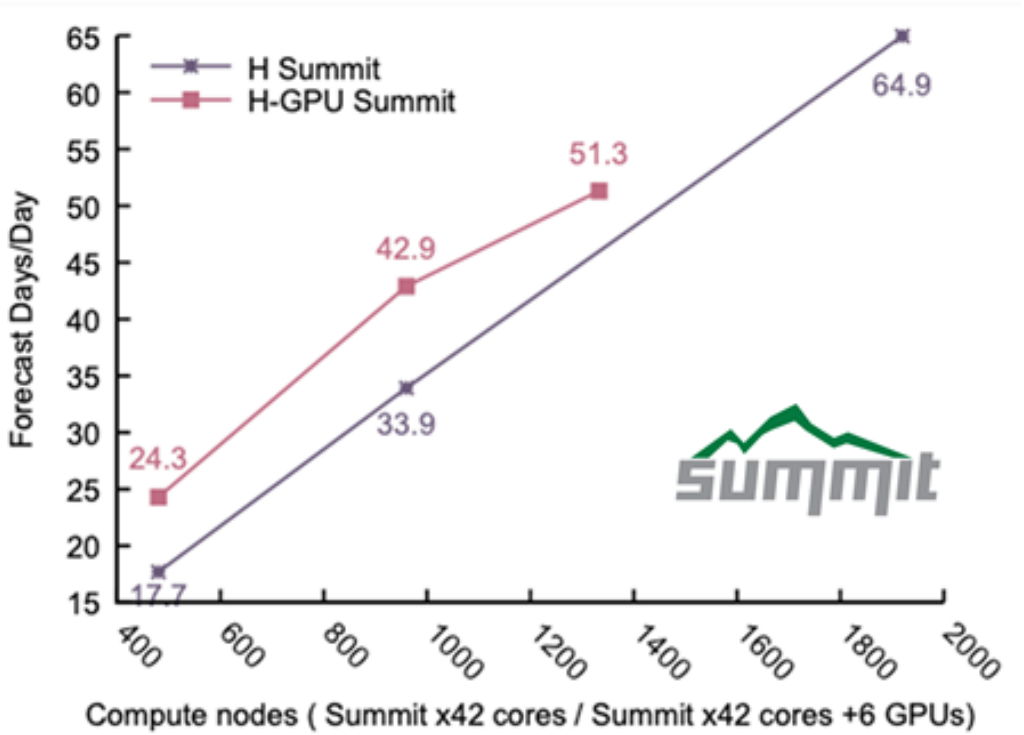
CAMS (prognostic) vs HRES (climatology)

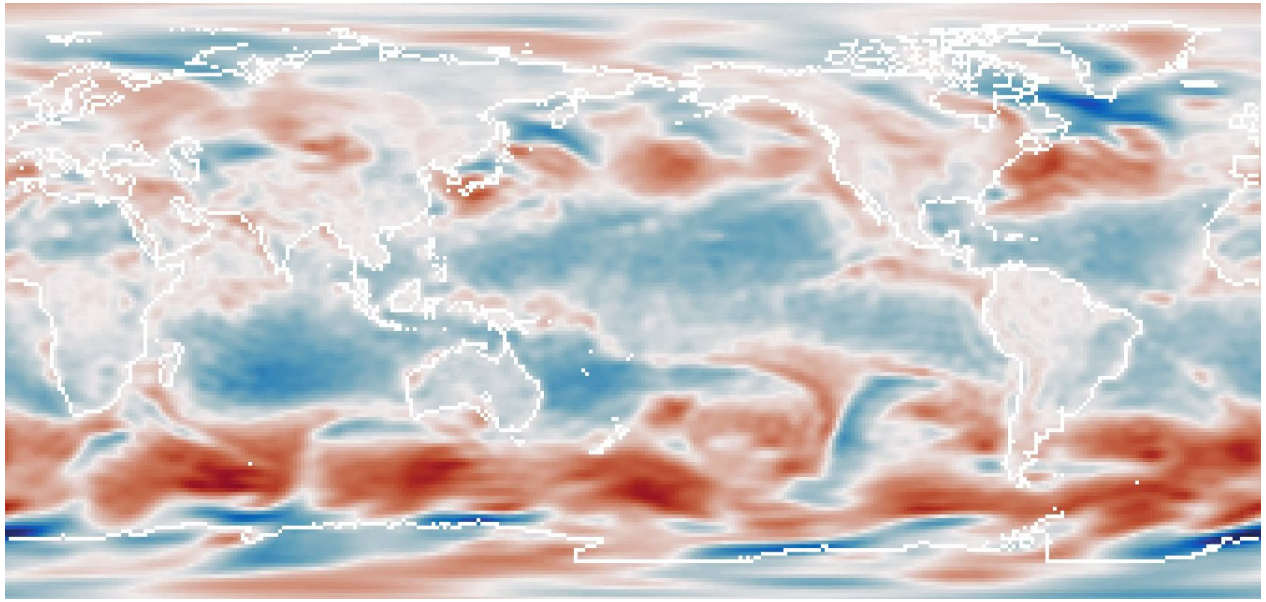
JJA 2021, T850 at 5 days

- RMS error: CAMS – HRES (%)
  - CAMS appears better in southern Africa and Amazonia

- Error standard deviation: CAMS – HRES (%)
  - Some improvement still remains in both locations!
  - Also T2m Siberia stddev reduced (not shown)

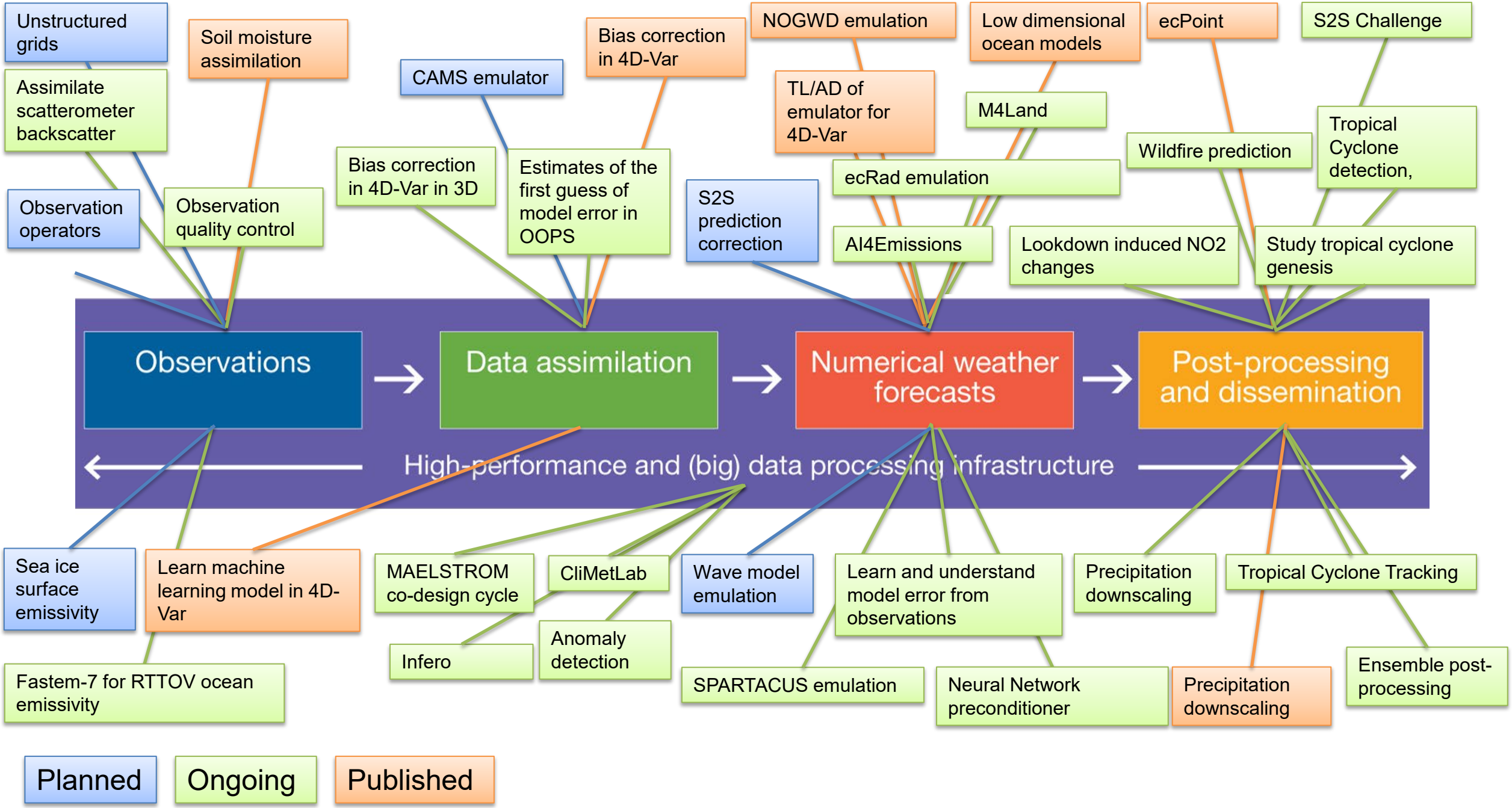
Performance of IFS at 1 km on Summit and first tests on Fugaku

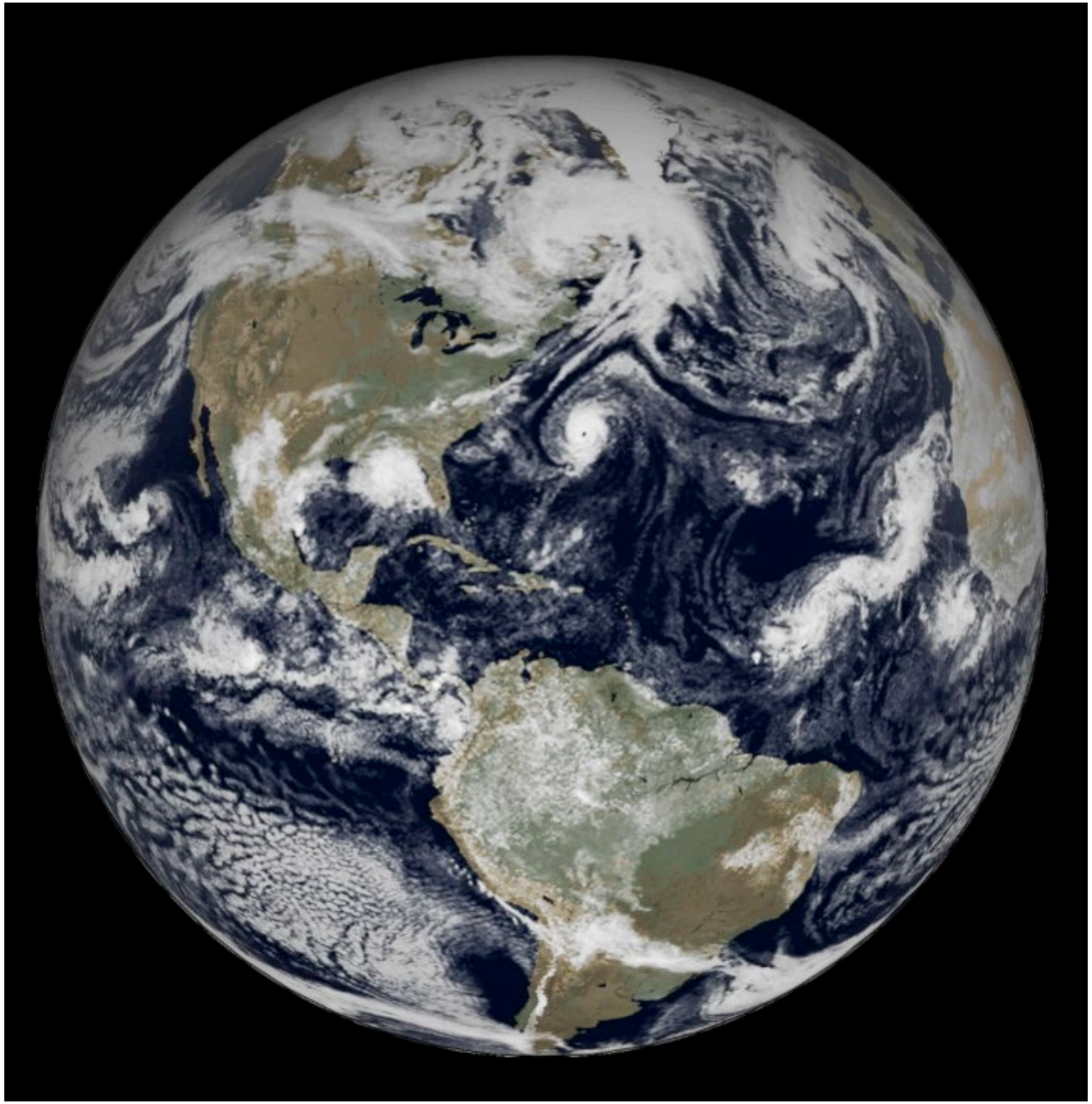


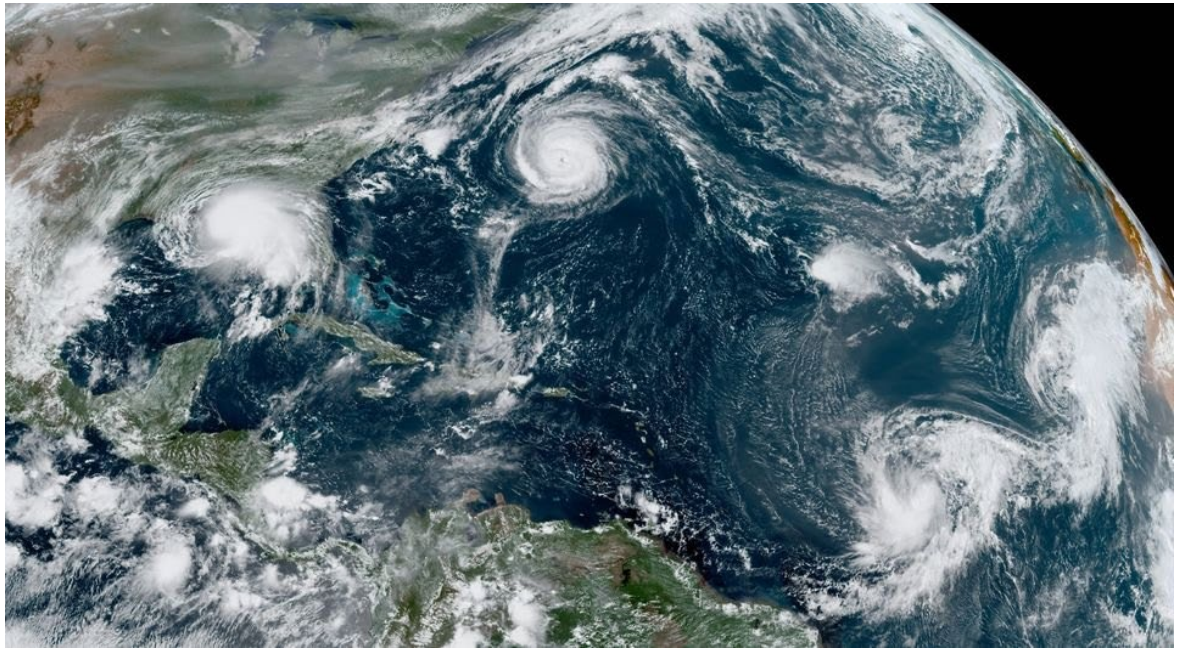


Fugaku, RIKEN Center for Computational Science

Status of machine learning at ECMWF







NOAA

TCo1279L137 ENS, 51 members,
20200913 00 UTC + 41 h

THE STRENGTH OF A COMMON GOAL