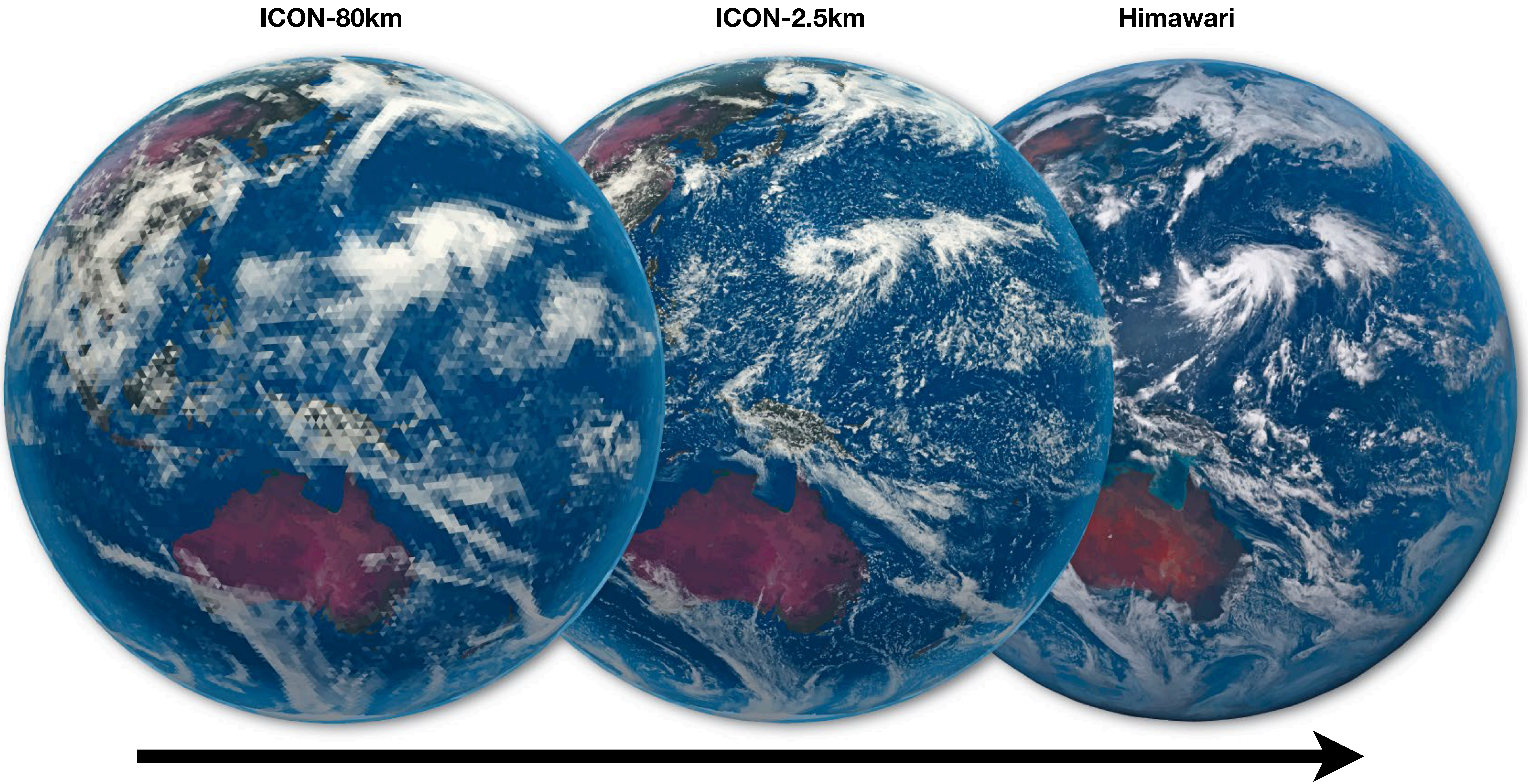
esiwace
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

Max-Planck-Institut für Meteorologie

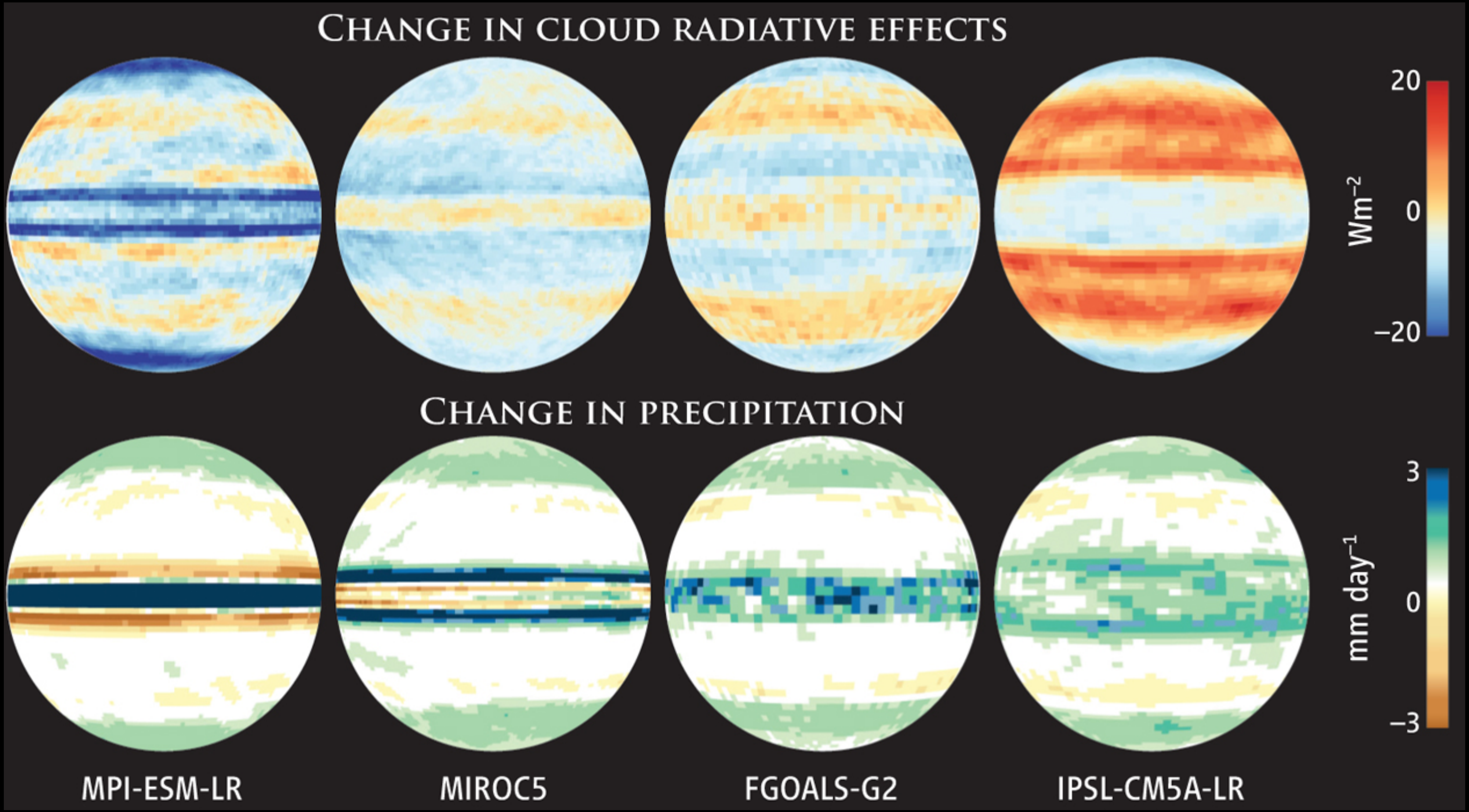
Hans-Ertel-Zentrum für Wetterforschung

Global storm and ocean eddy resolving coupled climate simulations: DYAMOND2

Daniel Klocke, Bjorn Stevens, Cathy Hohenegger, Claudia Stephan, Martin Bergemann, Rene Redler, Florian Ziemen



Hohenegger and Klocke, 2020



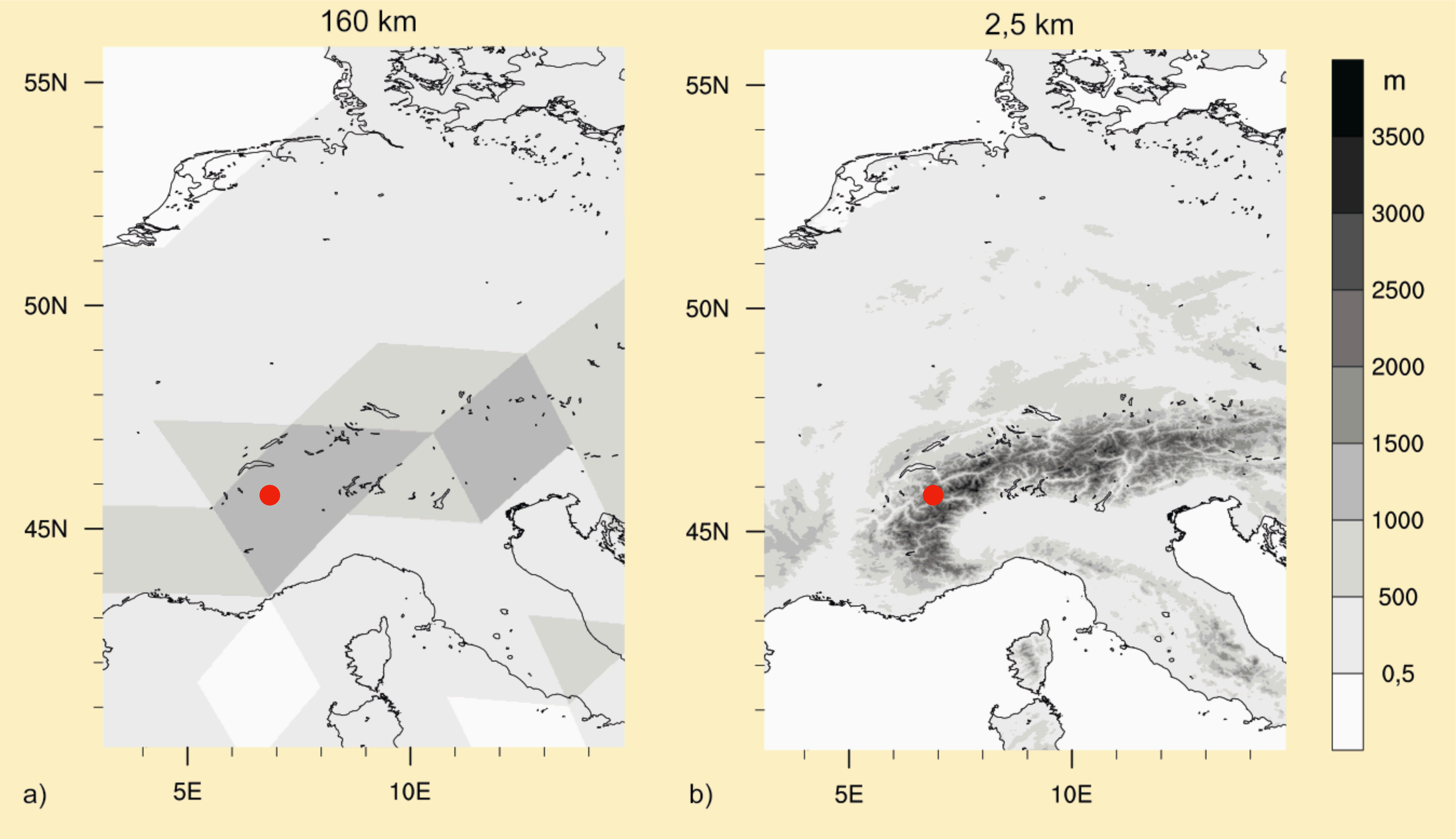
Stevens and Bony, 2013

Advantage: resolving vertical energy transport

- In the tropics, the dominant mode of energy transport is in the vertical.
- The scale is determined by the depth of the tropical troposphere (15-20km)
- Kilometer-scale models can represent those transient dynamics

Stevens et al., 2020

Advantage: lower boundary conditions



● **Mt Blanc: 4810 m**

‚tradtional‘ climate model : 1394 m

Storm-resolving climate model : 4018 m

Hohenegger and Klocke, 2020

DYAMOND: the DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains

- First inter-comparison of global storm resolving models (<5km grid spacing)
- Never two models did the same experiment before
- Some of the participating models were never applied to these scales
- Start on 1.8.2016, no parametrization for convection, simulate 40 days and 40 nights
- DKRZ and ESiWACE provided support and space for data storage (2 Pb)

- Oct 2017 idea formulated
- Nov 2017 drafted protocol
- Simple protocol in terms of configuration and output requirements
- After one year most models had submitted the simulation
- 2019 Overview paper published (Stevens et al., 2019)
- Groups decided to repeat the exercise for a winter months

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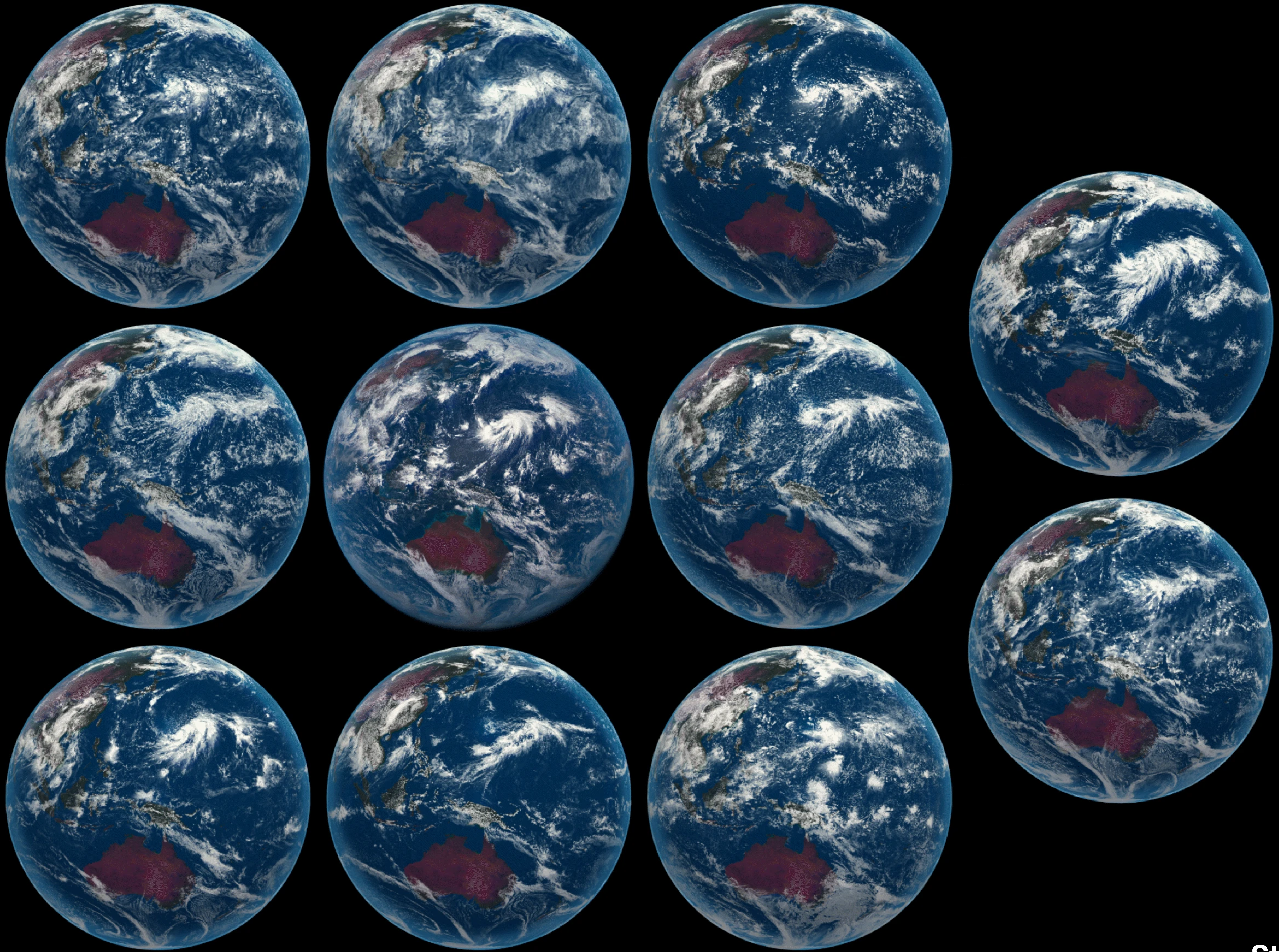
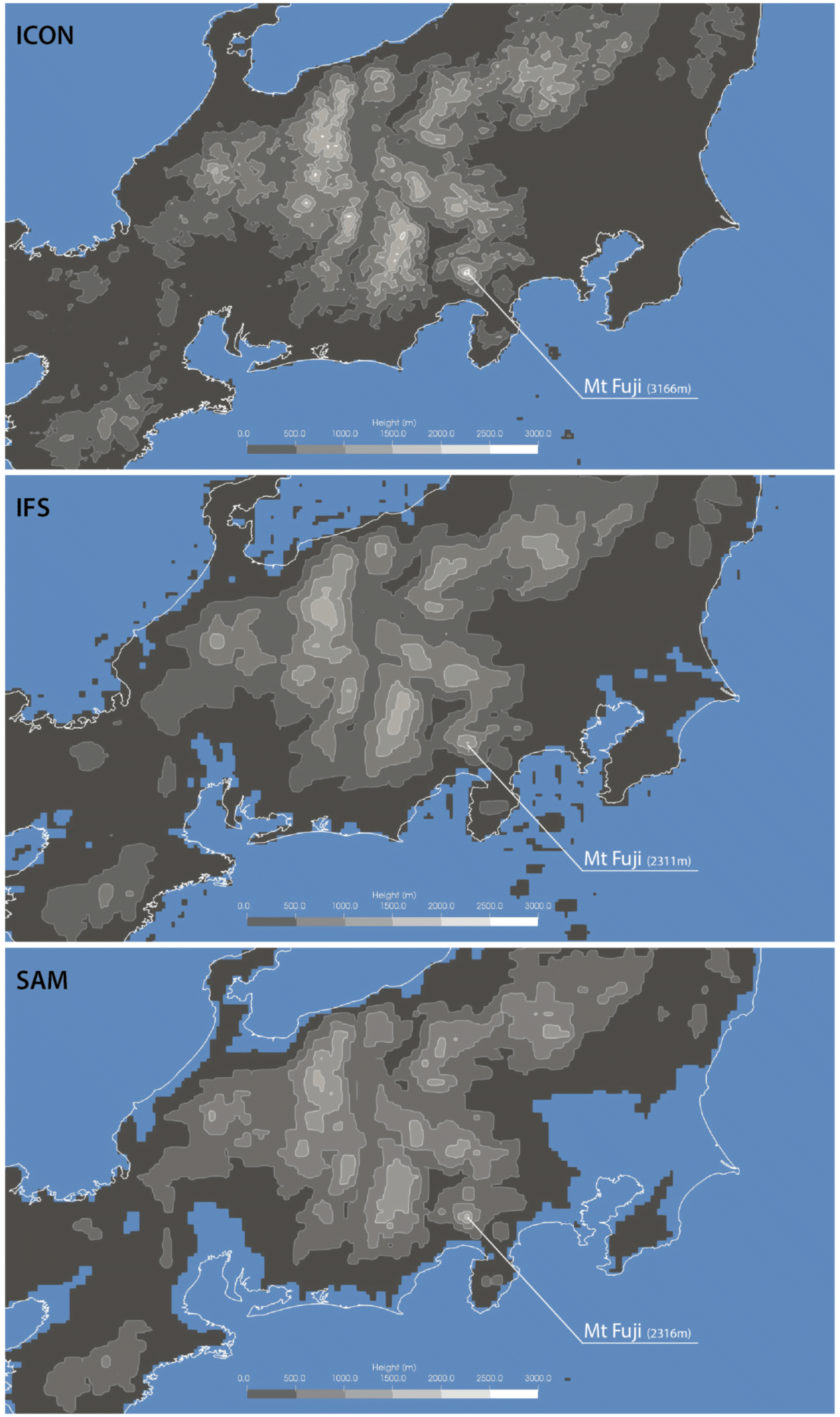
Participating models in DYAMOND

Name	Grid	# Mcol	# lev	# μ	$\sqrt{A_{\max}}$	H top	H spng	CP	BL	FC
ARPEGE-NH	Kurihara	82	75	5	2.5 km	70 km	34 km	N	T	Yes
FV3	Cube	57	79	6	3.3 km	39 km	25 km	S	K	Yes
GEOS	Cube	57	132	5	3.3 km	80 km	75 km	F	K	Yes
ICON	Icoso	84	90	5	2.5 km	75 km	44 km	N	T	Yes
IFS	Octo	26	137	5	4.8 km	80 km	65 km	S	K	Yes
MPAS	Voronoi	42	75	6	3.8 km	40 km	30 km	F	T	Yes
NICAM	Icoso	42	78	5	3.5 km	50 km	25 km	N	K	No
SAM	La-Lo	43	74	5	4.3 km	37 km	22 km	N	S	No
UM	La-Lo	20	85	6	7.8 km	85 km	42 km	S	K	Yes

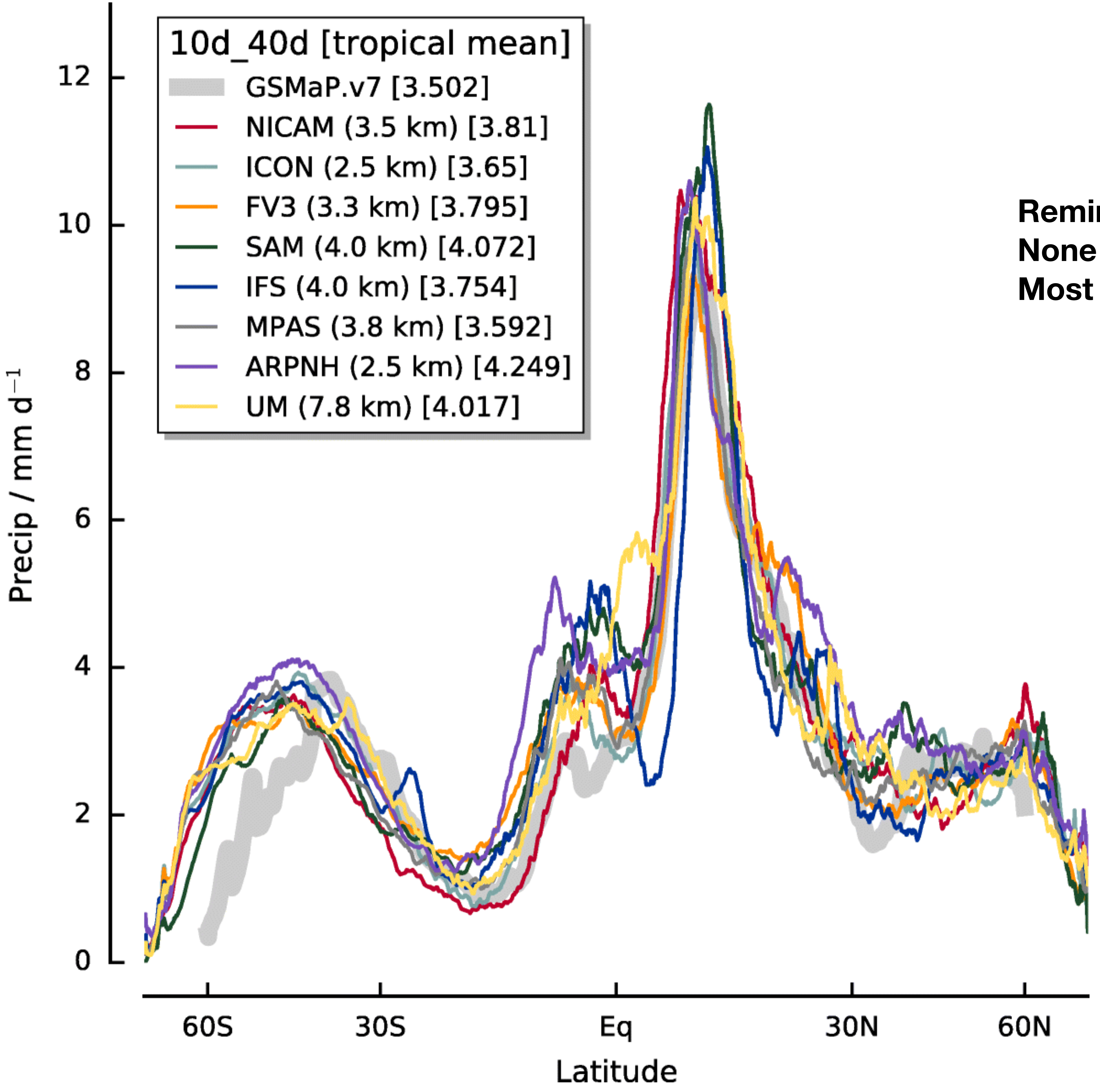


Stevens et al., 2019



Mt Fuji: 3776 m

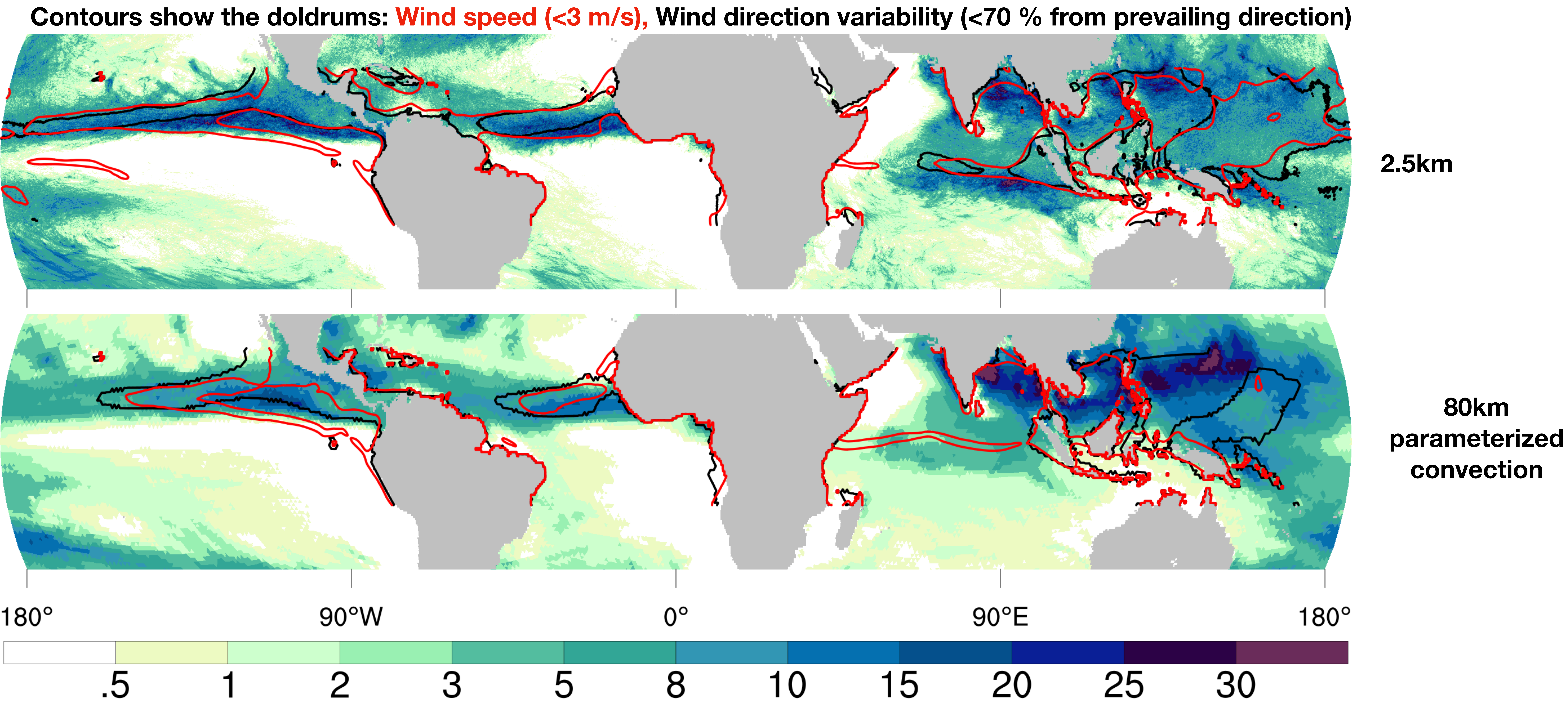
In different DYAMOND models:
3166 m
2311 m
2316 m



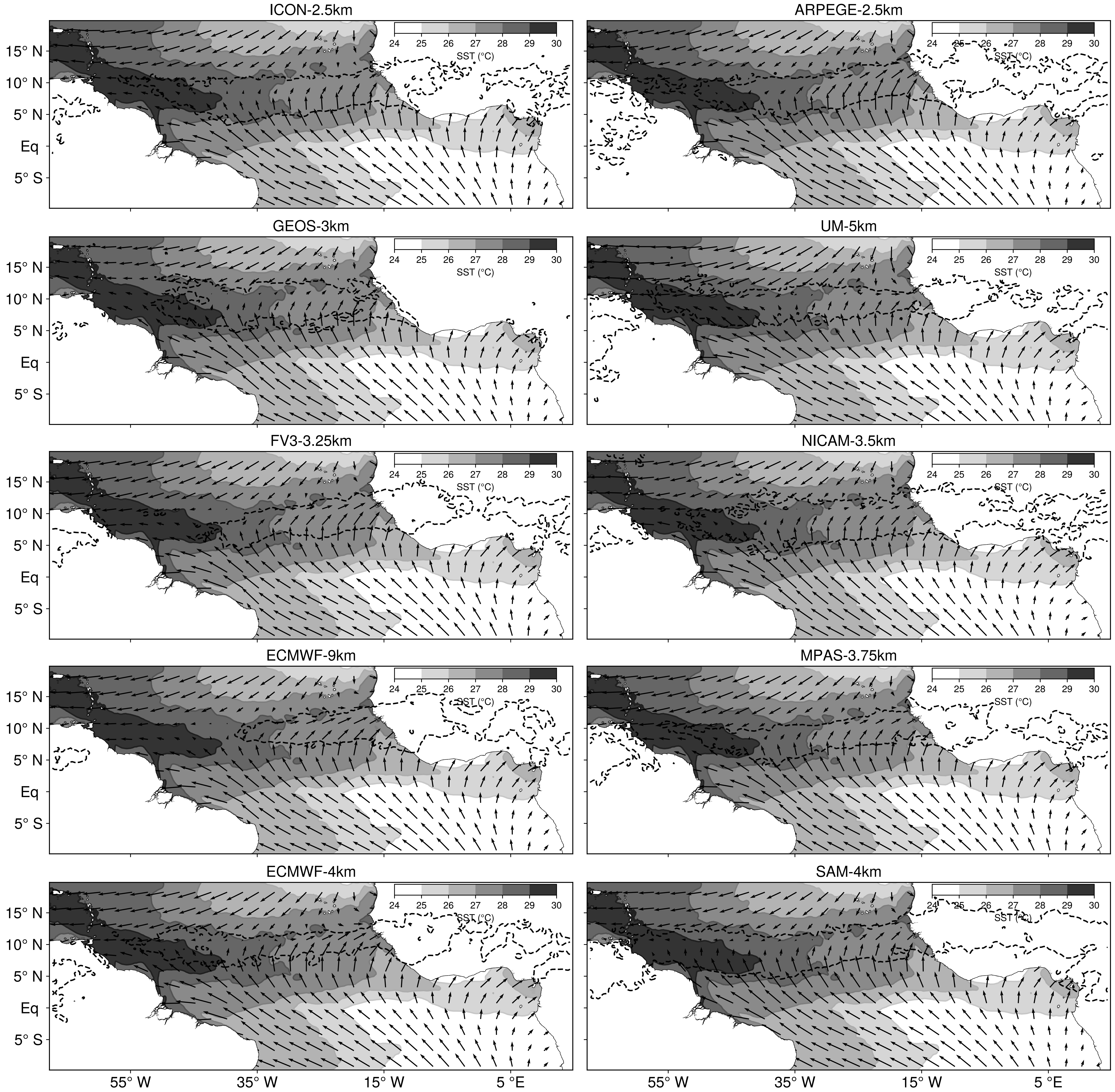
Reminder:
None of the models was tuned
Most were never applied on storm-resolving scales

Stevens et al., 2019

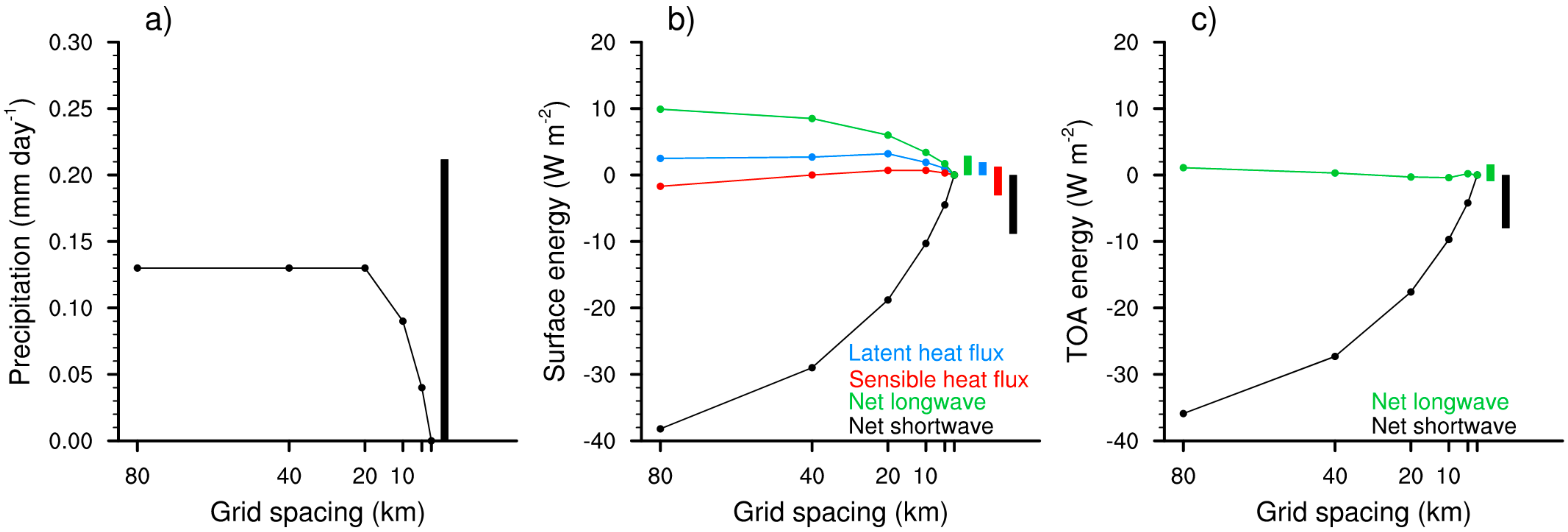
How do the small-scales impact the large scales?



DYAMOND models have doldrums, coarsest model with convection parameterization less pronounced and precipitation remains focused to the east Atlantic



Resolution dependency



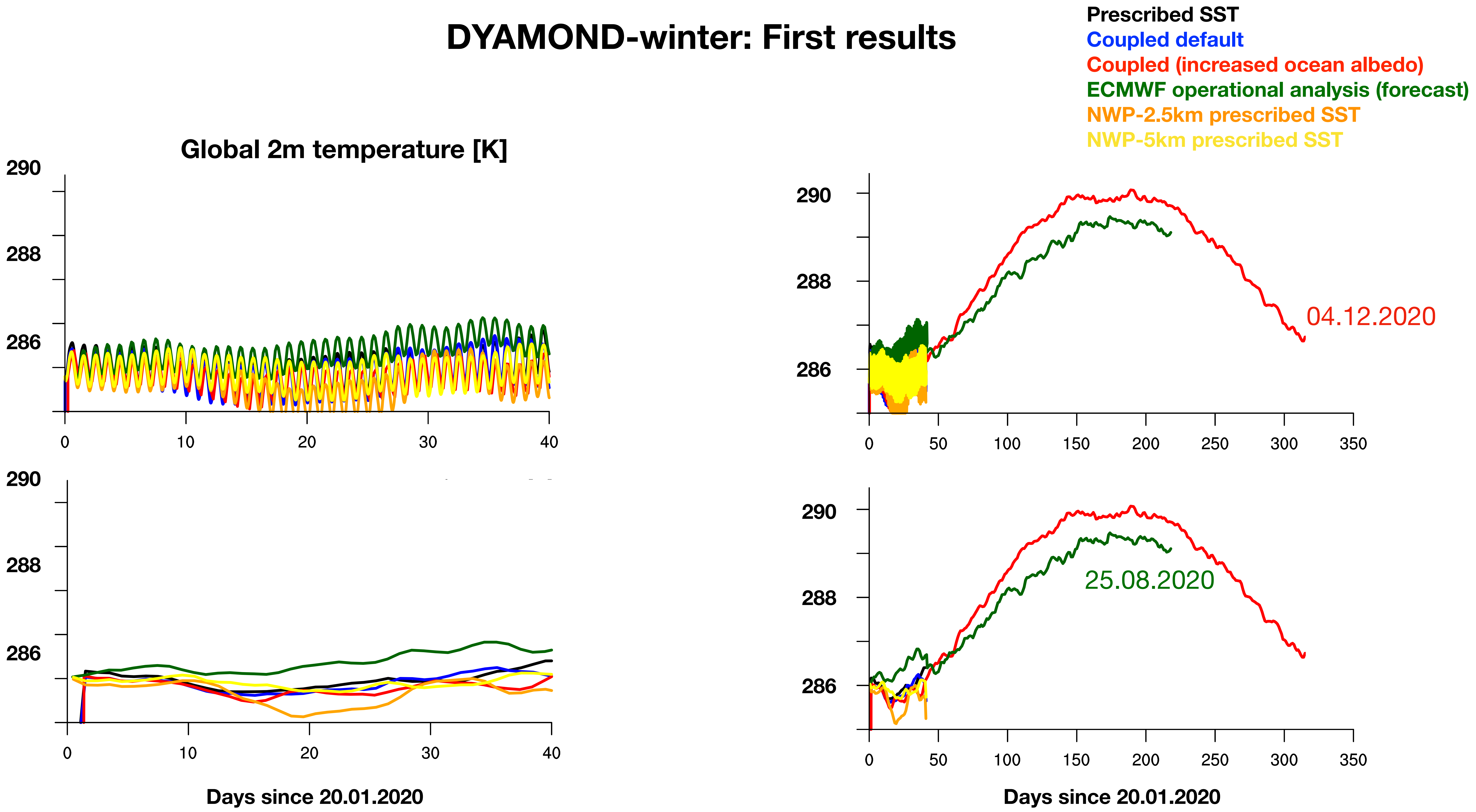
- **Only resolution and time-step are varied in a model**
- **Variables are ‚converged' at 5 km resolution, if the DYAMOND ensemble is considered as the reference**
- **Precipitation only starts to changing at resolutions < 20 km**
- **Short-wave radiation changes most with resolution. This is related to (low) clouds**

Hohenegger et al., 2020

DYAMOND-winter (aka DYAMOND2)

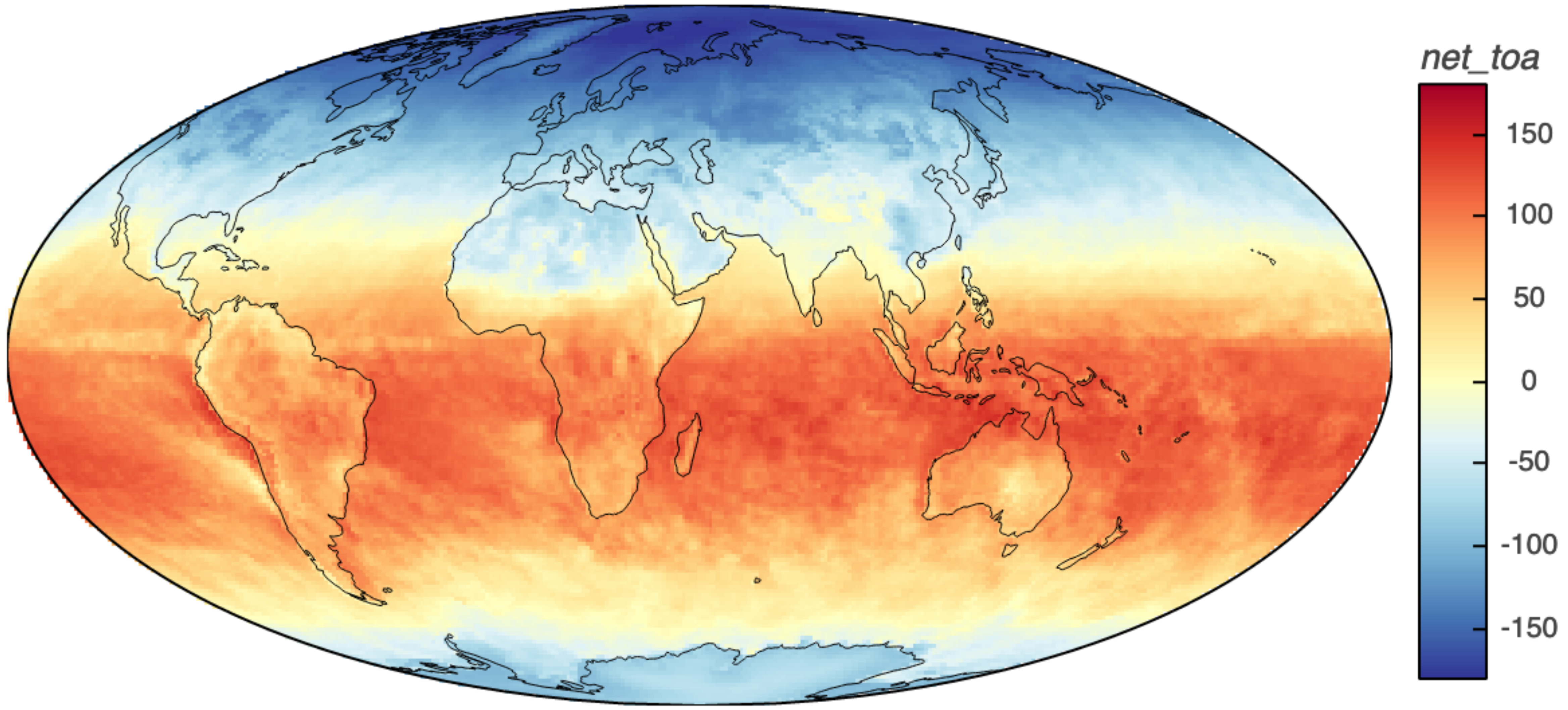
- Repeat exercise, but in winter months (EUREC4A, MJO), starting 20. January 2020
- Add coupled models, if possible, to investigate coupling on the convective scale
- Take the next step towards global coupled storm- and ocean-eddy resolving climate models
- Contributions by other centers expected by the end of 2020

DYAMOND-winter: First results

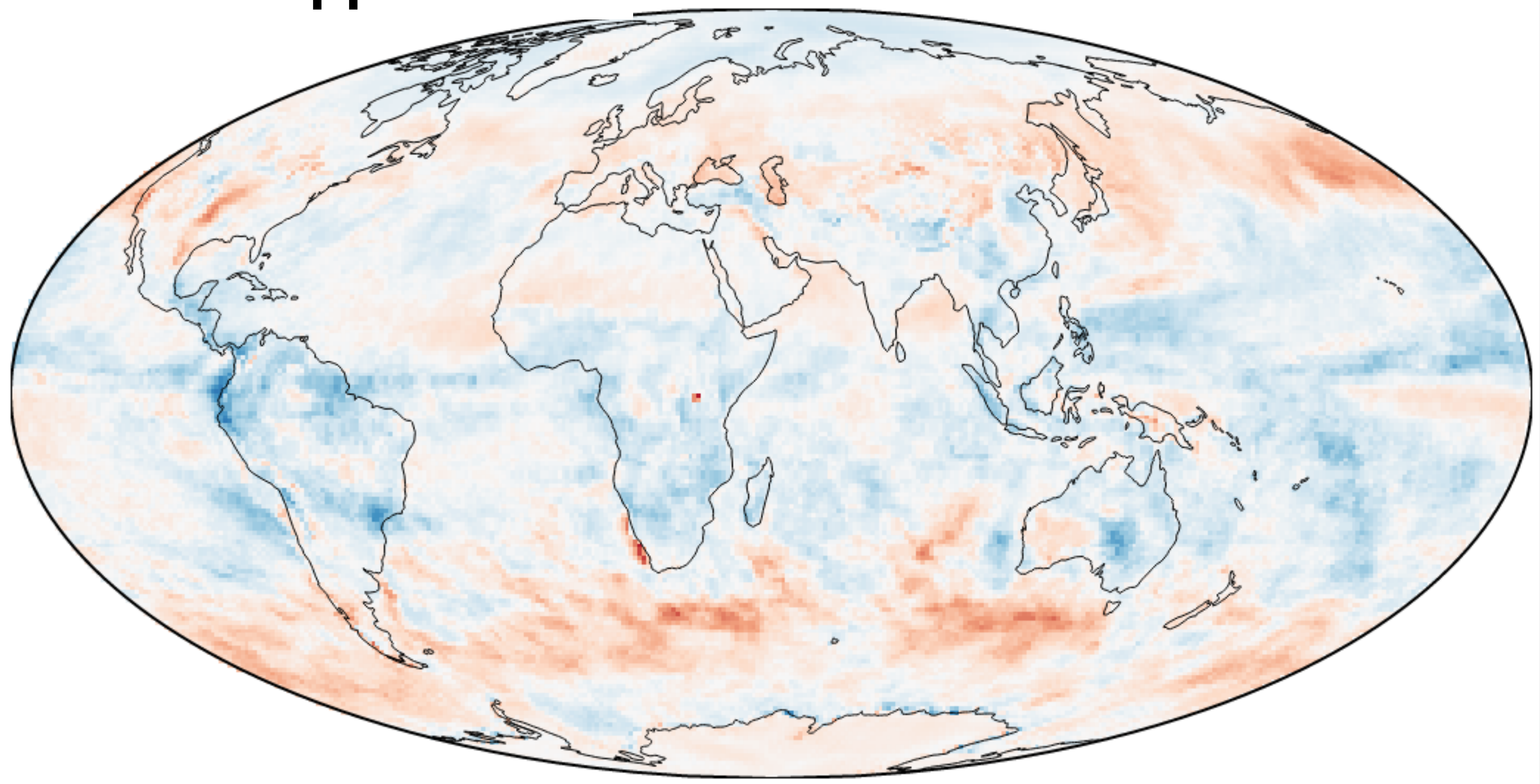


Net TOA radiation flux [W/m²]

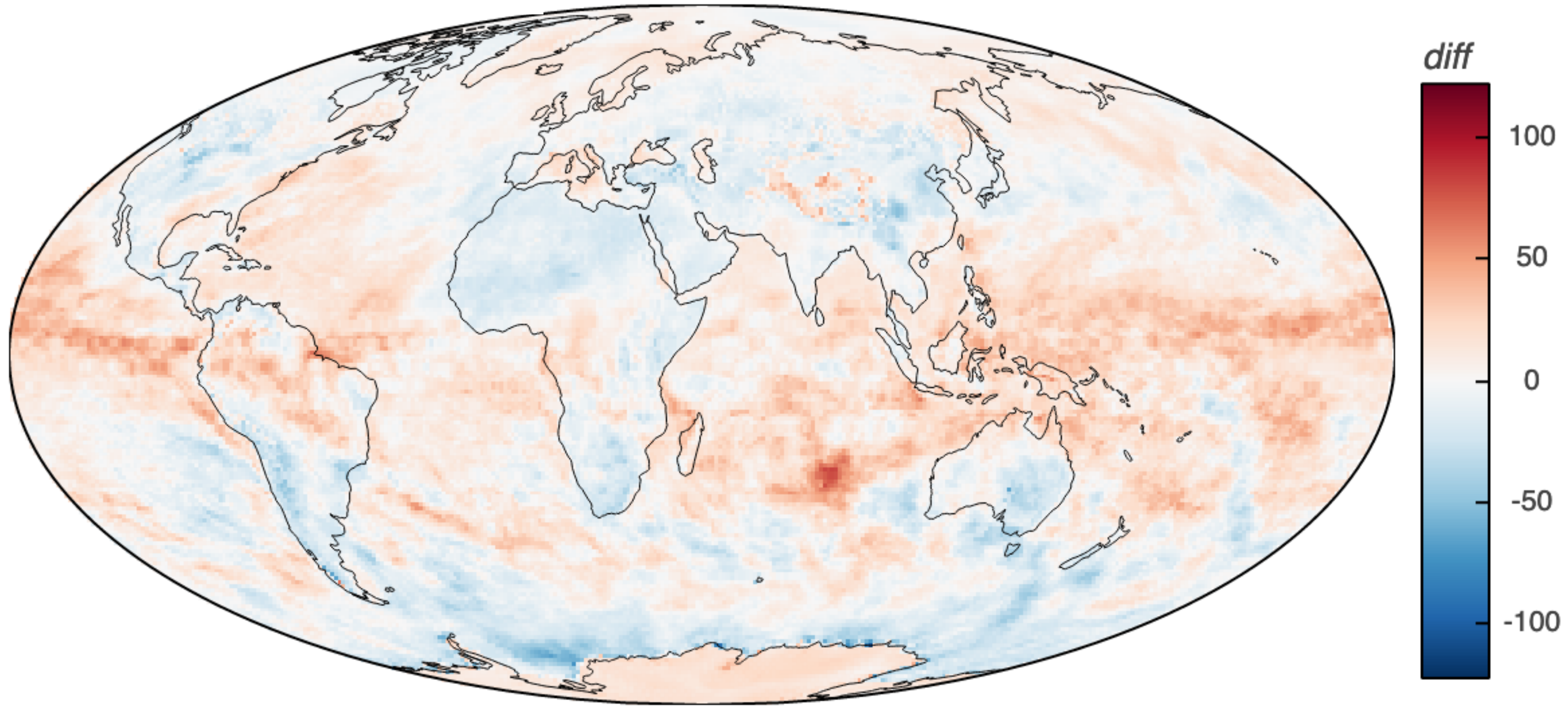
CERES Satellite data



CERES - Sapphire 5km

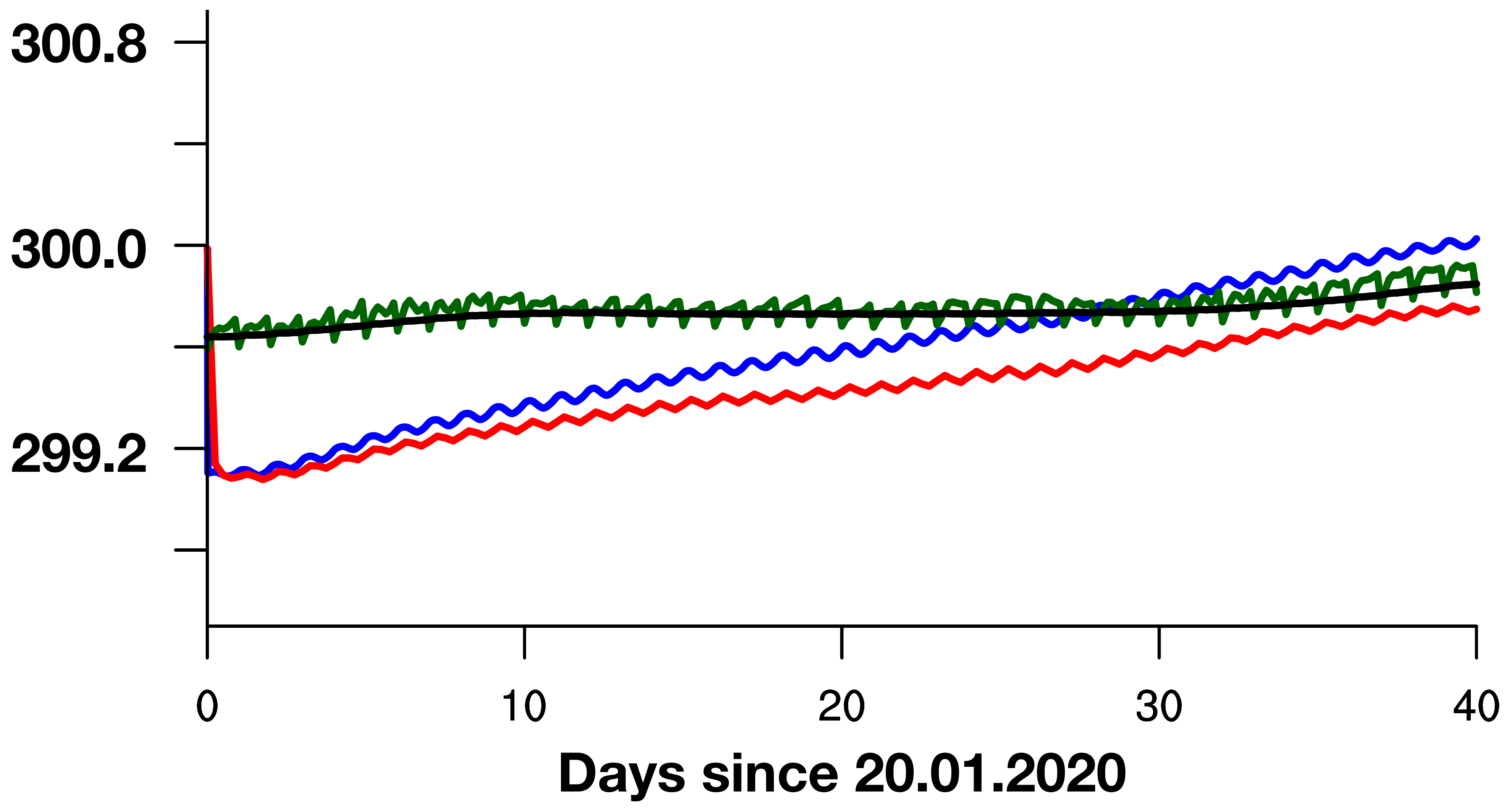


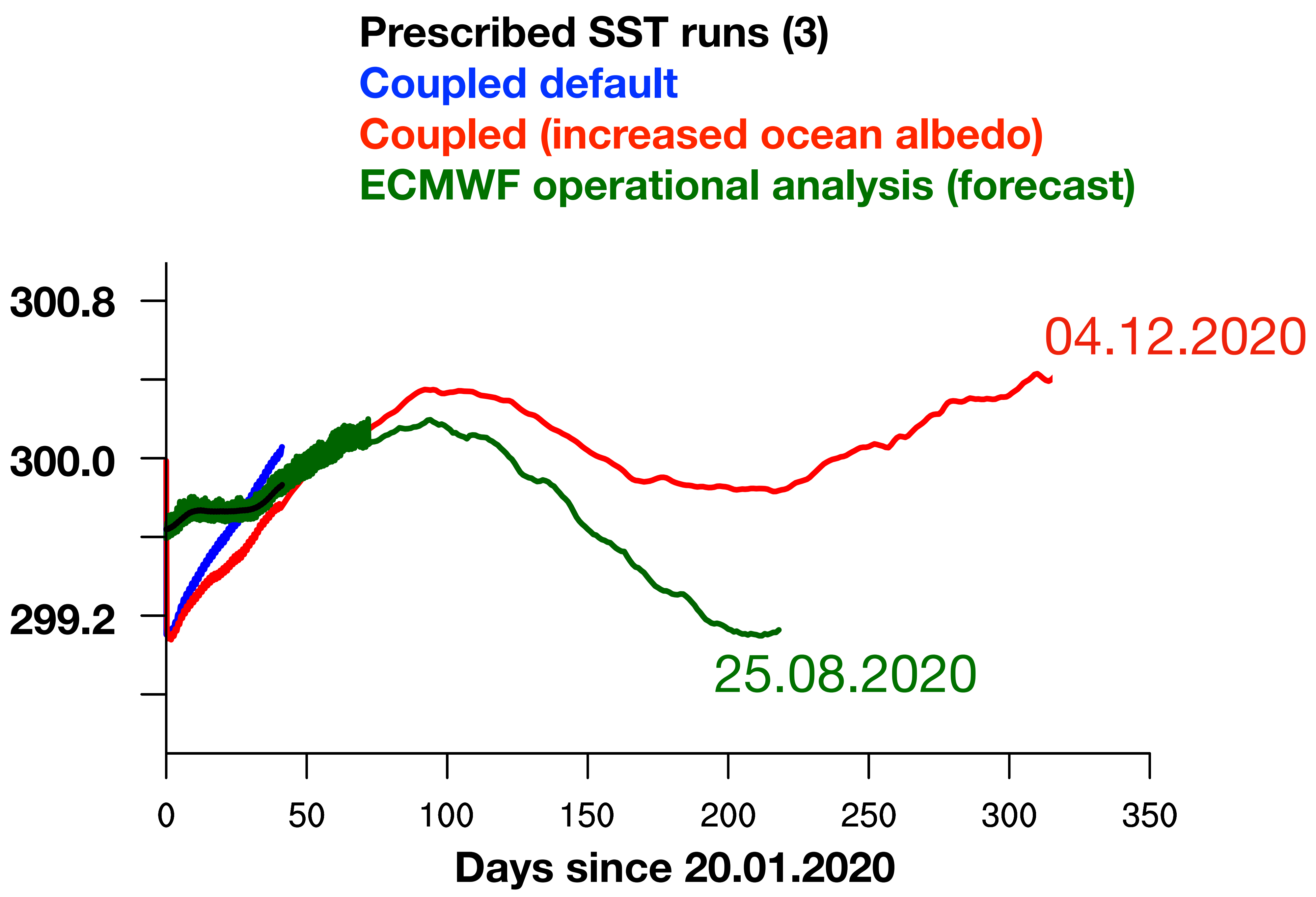
CERES - NWP-2.5km



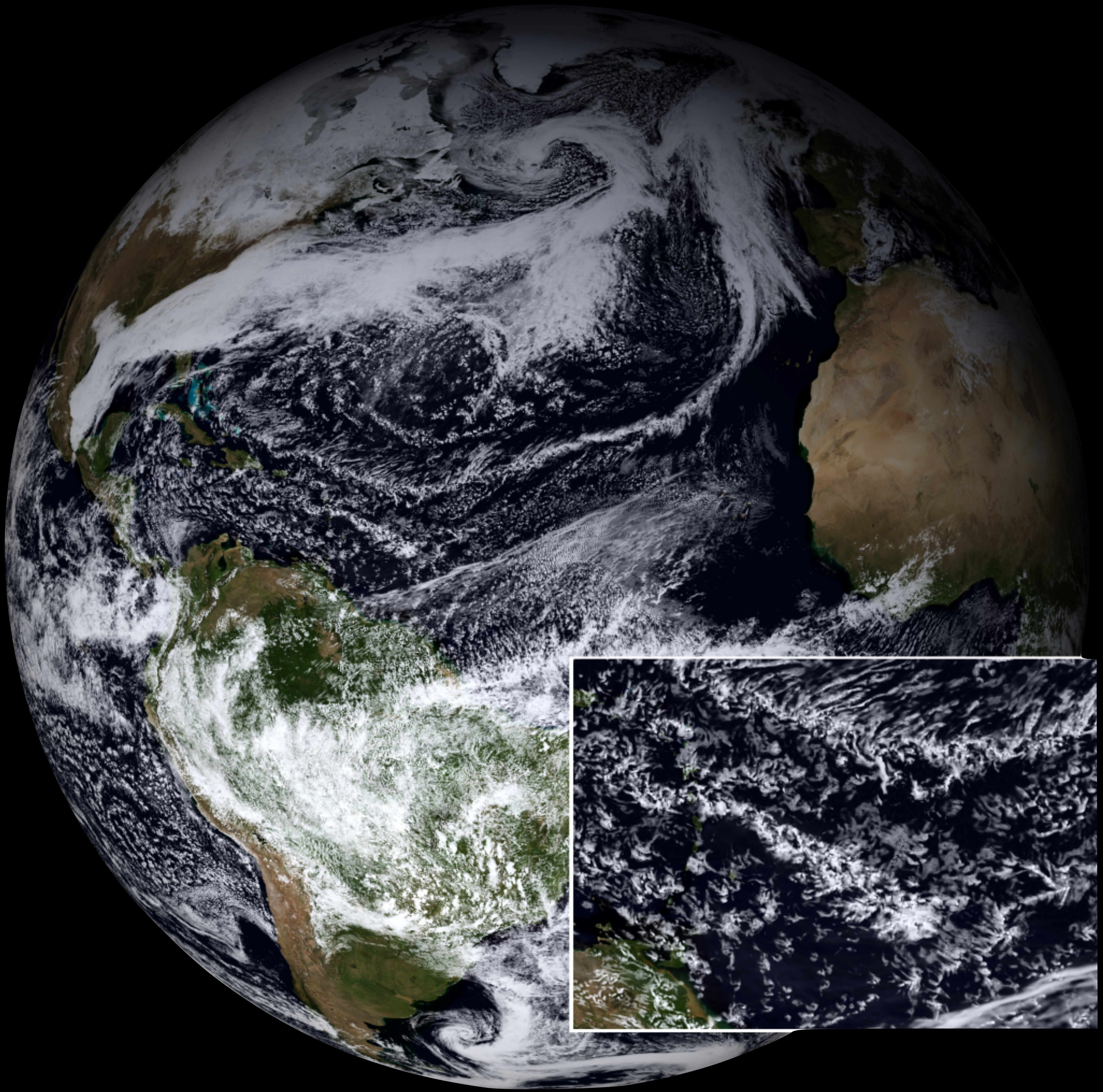
DYAMOND-winter: First results

Sea-surface temperature [K], tropical oceans [30°S - 30°N]





- 5 km resolution in atmosphere and ocean
- Too few tropical clouds
- Nearly one year of coupled integration with increased ocean albedo
- Simulation is warming, but not too badly with increased ocean albedo (about 1K too warm)



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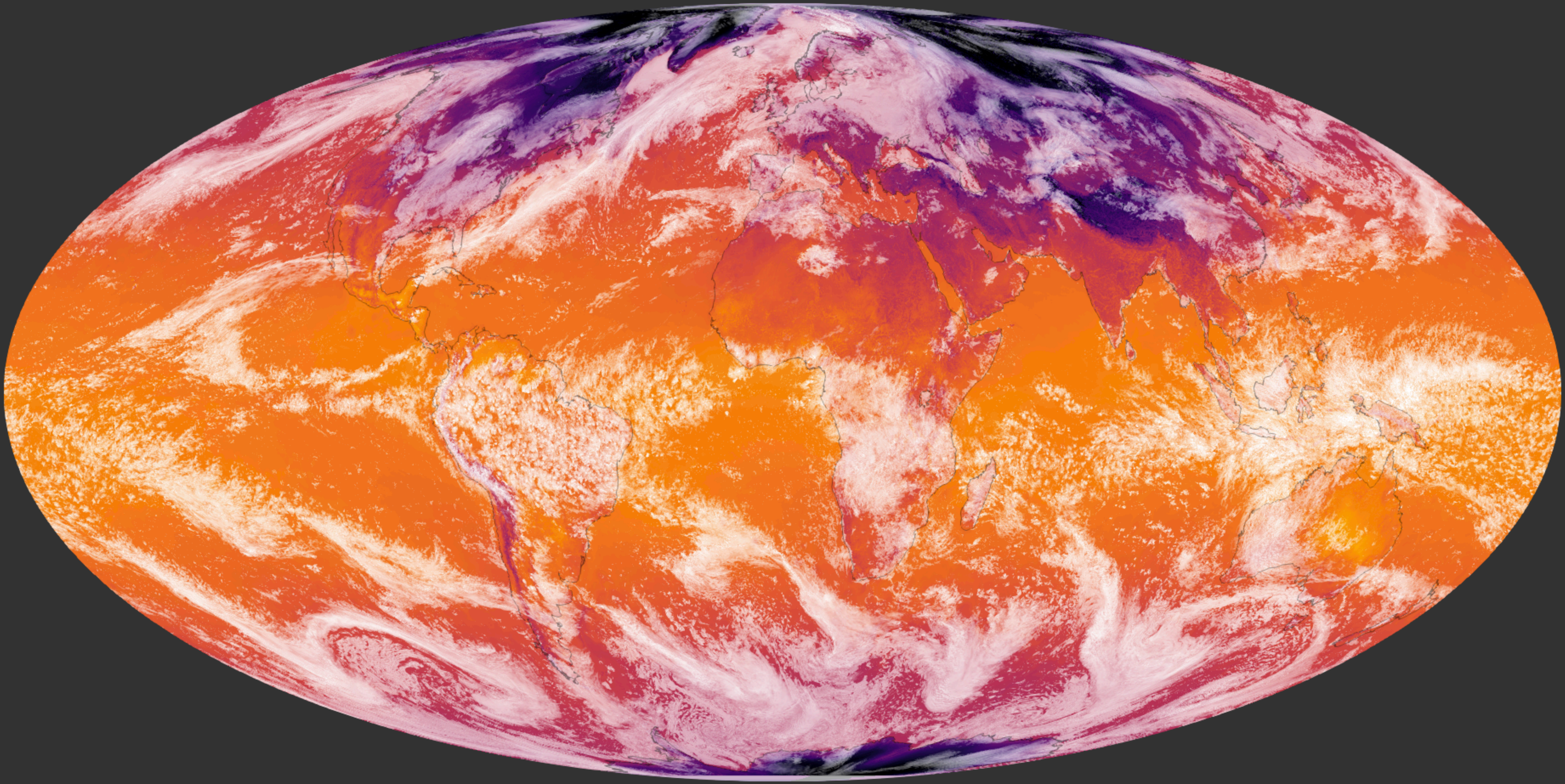
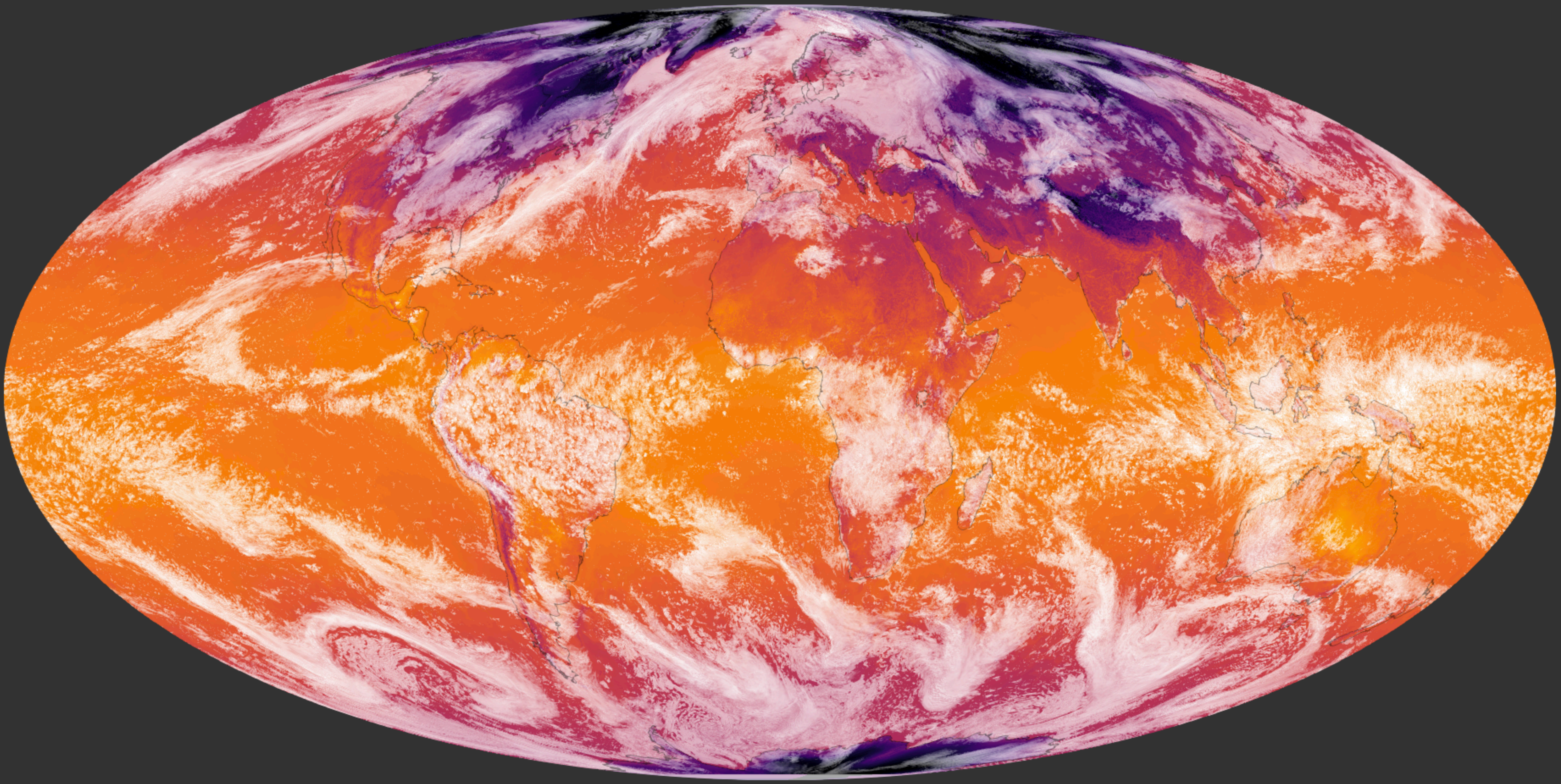


F. Ziemen, DKRZ

2020-02-29 23:30 UTC

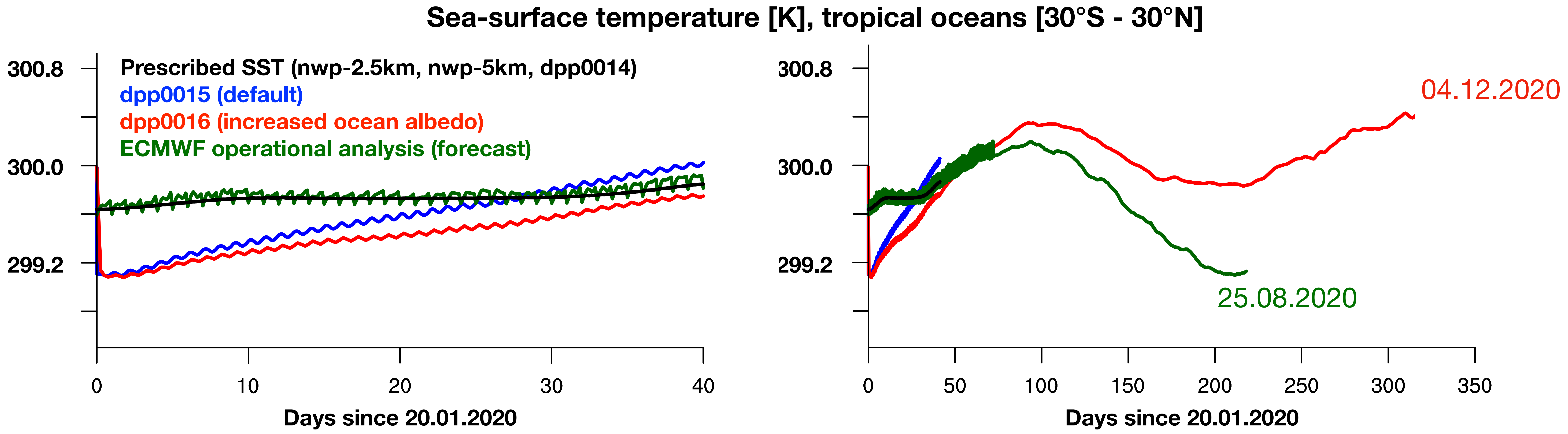


F. Ziemen, DKRZ


2020-01-20 00:00 UTC
F. Ziemen, DKRZ

Summary

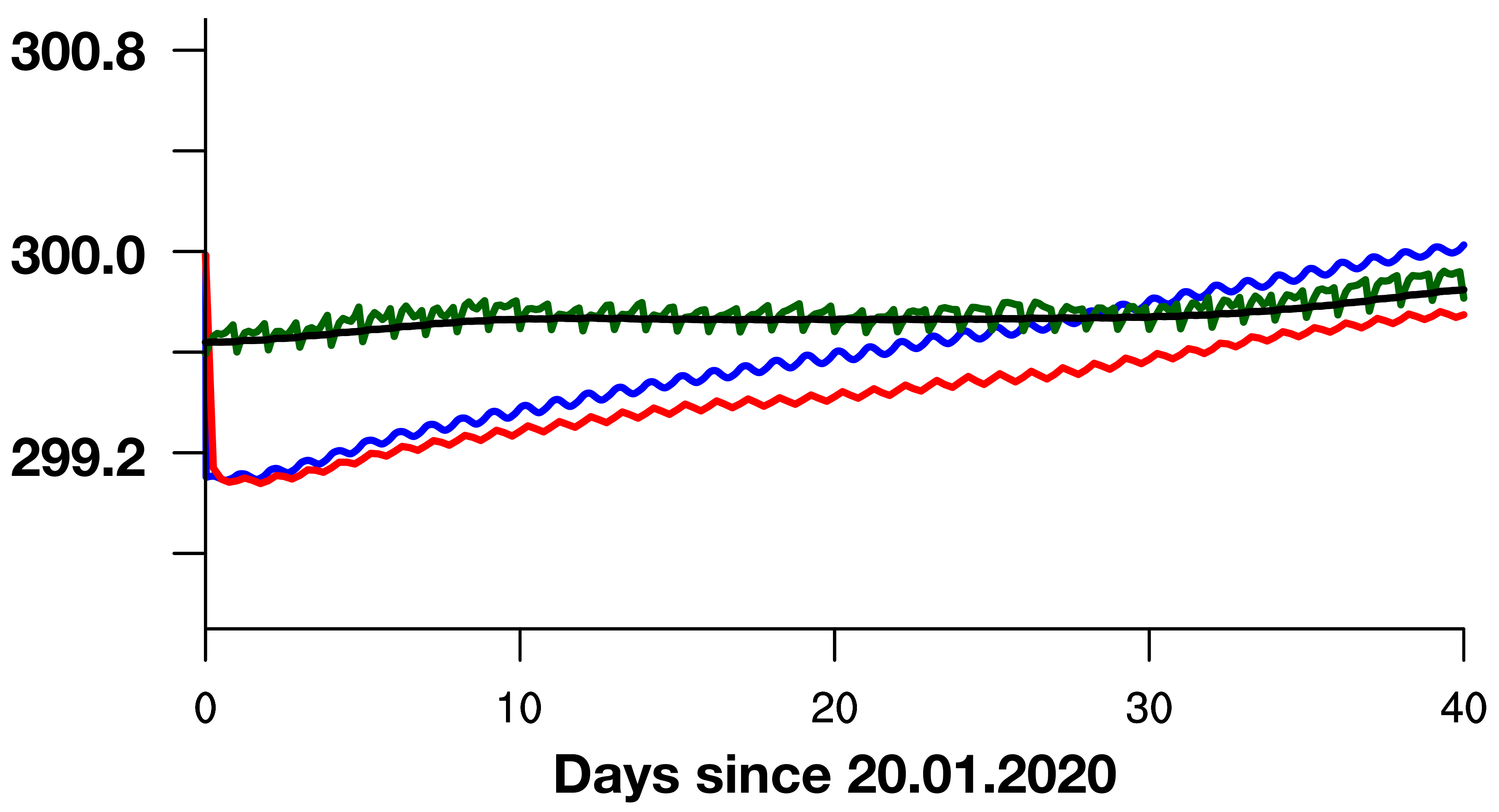
- Global coupled storm and ocean-eddy resolving climate simulations are becoming possible and increasingly feasible. Even on todays computers
- They are a new and exciting tool (even simpler tool)
- They are here to stay and will help us to gain new insides and address old questions with new tools
- Linking to observation communities becomes easier
- Data is available to the community

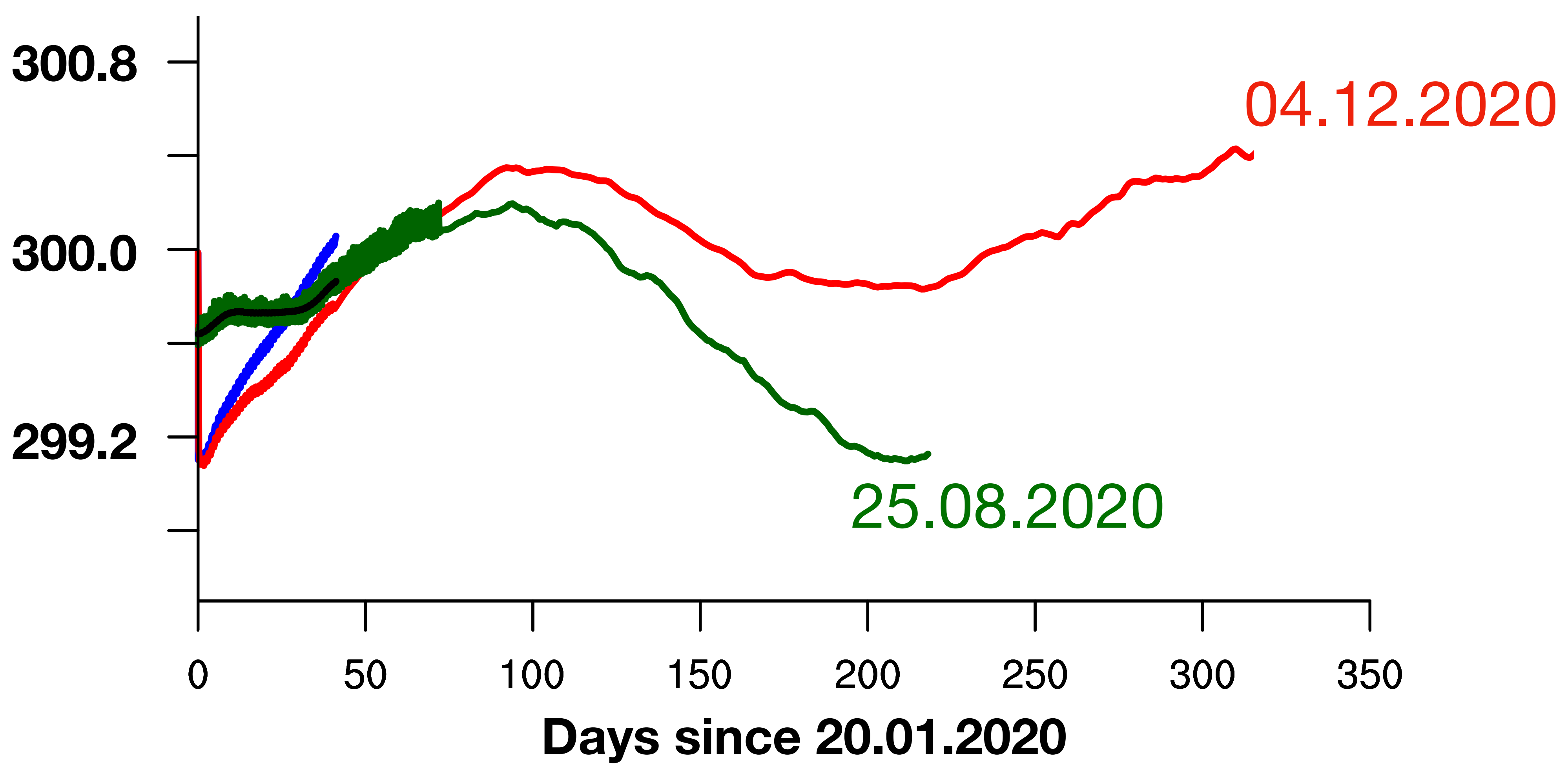

Sea-surface temperature [K], tropical oceans [30°S - 30°N]
Prescribed SST (nwp-2.5km, nwp-5km, dpp0014)
dpp0015 (default)
dpp0016 (increased ocean albedo)
ECMWF operational analysis (forecast)
300.8
300.0
299.2
0
10
20
30
40
Days since 20.01.2020
04.12.2020
25.08.2020
0
50
100
150
200
250
300
350
Days since 20.01.2020

DYAMOND-winter: First results

Sea-surface temperature [K], tropical oceans [30°S - 30°N]

Prescribed SST runs (3)
Coupled default
dpp0016 (increased ocean albedo)
ECMWF operational analysis (forecast)





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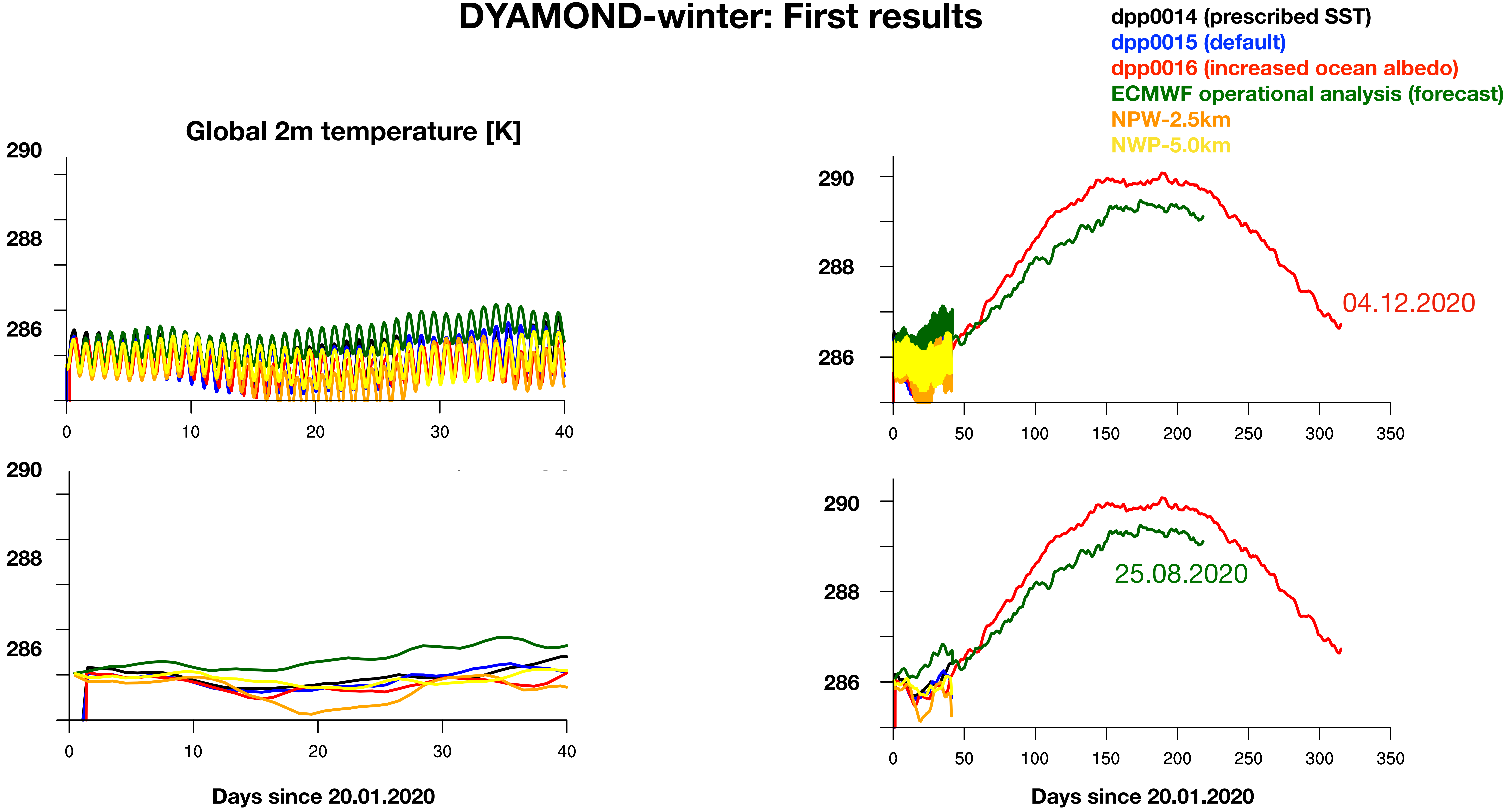

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