MAX-PLANCK-INSTITUT
FÜR METEOROLOGIE

# High resolution models

## WCRP Workshop on The Future of Climate Modelling, 21-24 March 2022

**Daniel Klocke**

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# ~~High resolution models~~
# ~~Ultra-high resolution models~~
# ~~Next generation climate models~~

## WCRP Workshop on The Future of Climate Modelling, 21-24 March 2022

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# Storm-resolving models

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**Observation from yesterdays discussions…**

- When we discuss storm-resolving models, people focus on the things still missing, but loose sight of what comes naturally, like bathymetry for through-flow, most of the variance in orography and simple things like resolving water sheds and precipitation intensity.

- Manabe's model had many more limitations than todays models and minimal complexity. It took us a long way…

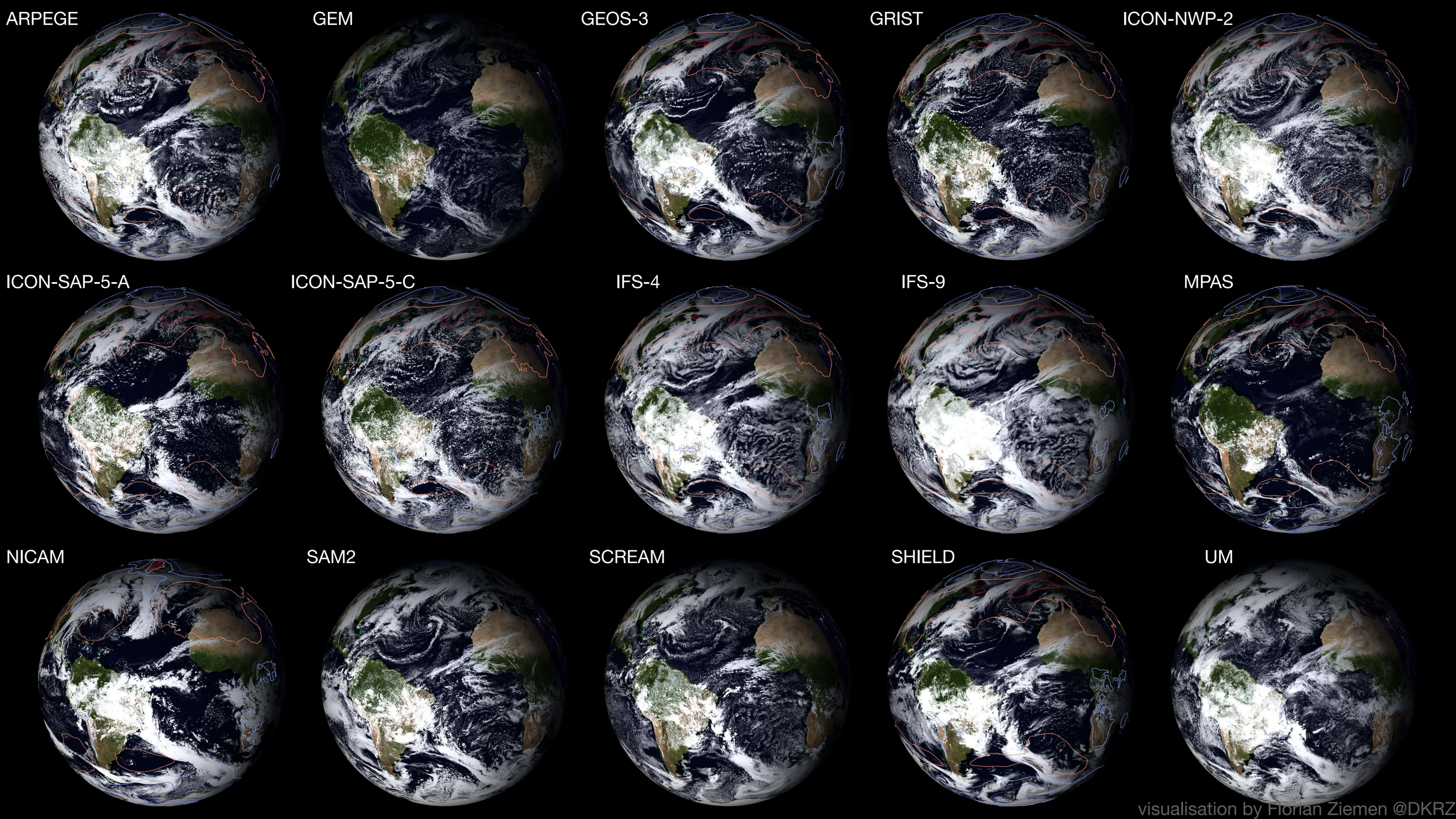
# Why storm resolving models?

- More physics: resolve the dominant mode of energy transport in the tropics (vertical), eddies in the ocean, ice-leads using laws of physics, realistic lower-boundary conditions in topography and land-cover

- Improved large scale circulation, process level air-sea interactions, smaller systematic errors, better representation of extremes, information at scales relevant for impact on peoples life (eg. catchment scales) and on which we observe the Earth

- Less equations, less lines of code, less assumptions and essentially simpler models

- A small code base has less bugs and allows to be agile and adapt to new technologies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SHIELD
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visualisation by Florian Ziemen @DKRZ

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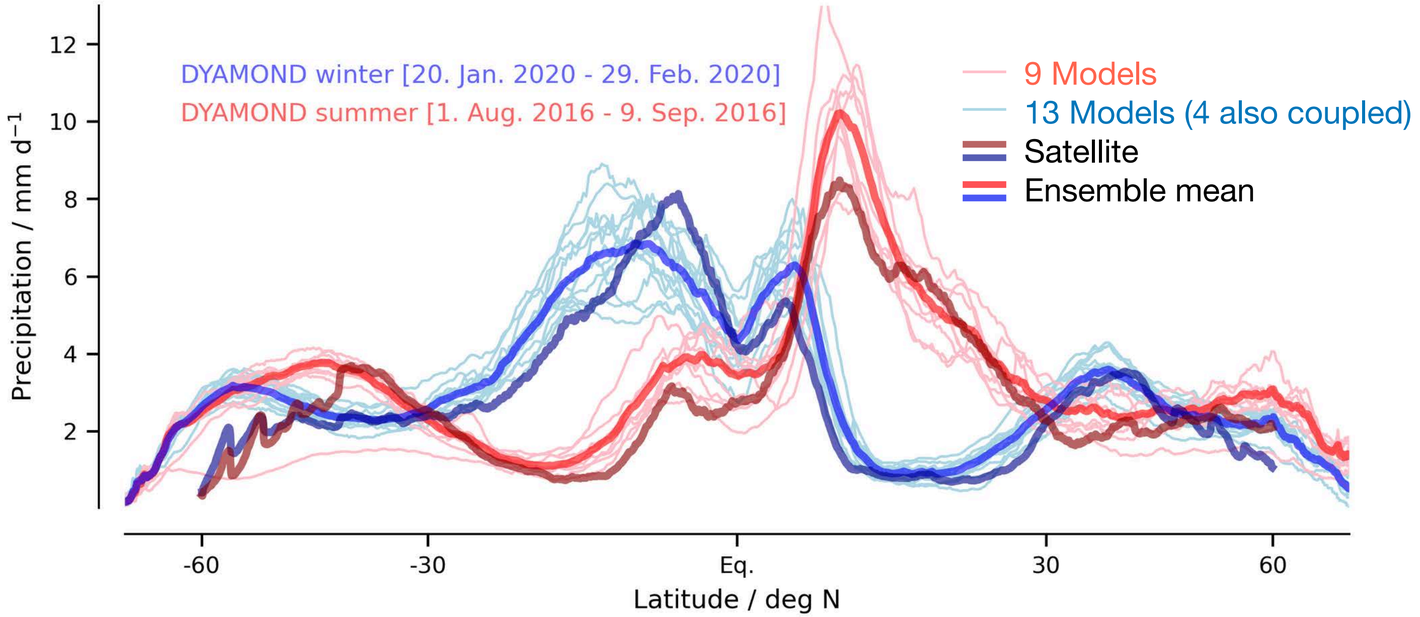


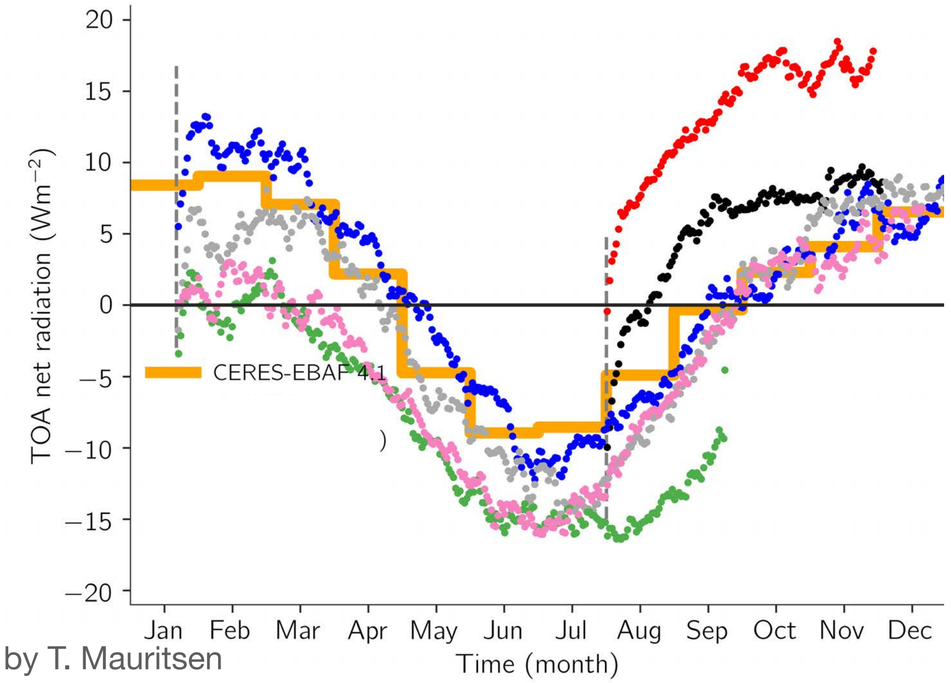

40 days and 40 nights

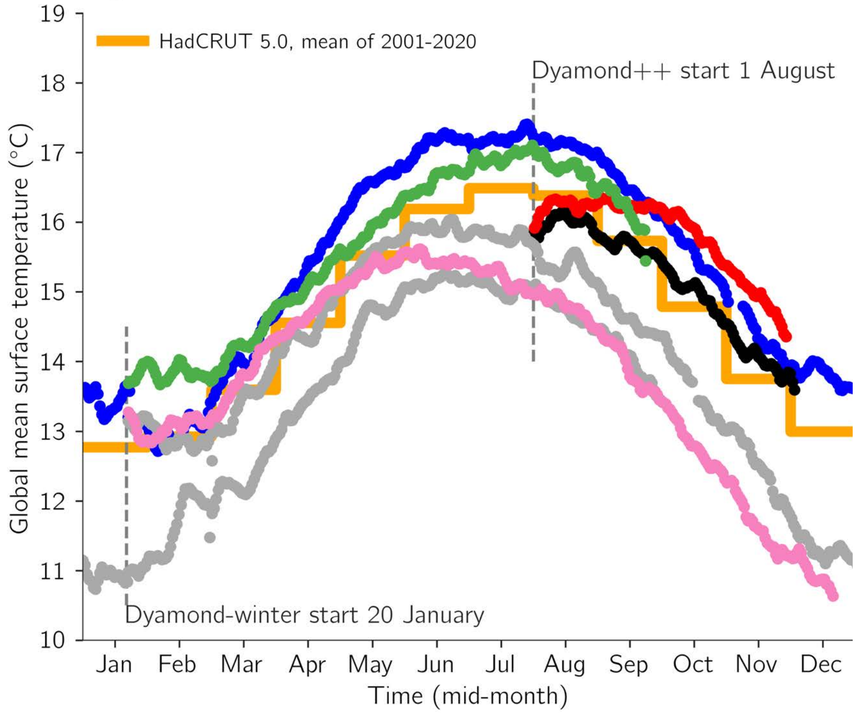
Never before, two models ran the same simulation

Many models ran the first time at those resolutions

Data available to the research community (200+ users)

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



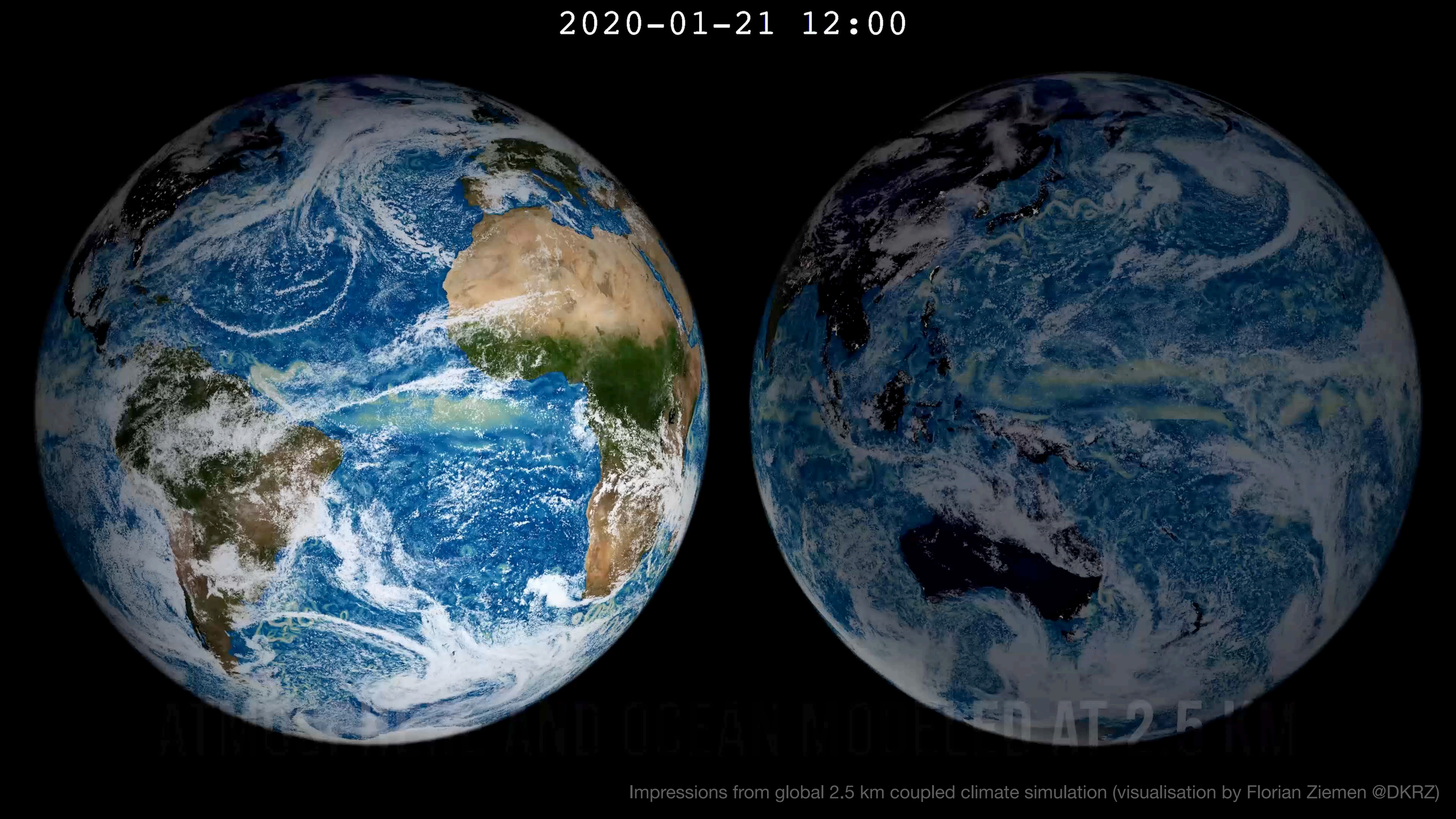

Development cycles towards multi-decade climate simulations (with two coupled storm-resolving models)

Plots by T. Mauritsen

next GEMS

# What to do with storm resolving models?

- Studies of convergence start to make sense
- Do we get consistent responses to perturbations - at least in sign, on climate regime scale?
- Ensembles: do we really sample uncertainty right with a large sample of structurally similar models? Out of sample trajectories?
- Are current models overfitted and react too stable to perturbations?
- Fundamental questions: Will the rain forests collapse, will we see major circulation shifts, is the ITCZ structure stable, how will the monsoon margins change.. all hard to answer with current models.




Impressions from global 2.5 km coupled climate simulation (visualisation by Florian Ziemen @DKRZ)

# Look into the (near) future

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- In 2018, we (and not only us) simulated for the first time at 2.5 km resolution for one months
- We (and not only us) can simulate years coupled at this resolution now….
- … and months at 1.2 km horizontal resolution
- Fully exploiting new technologies by being able to run on GPUs
- Simulations are done using fractions of todays machines (~25%)
- This bodes well for the future of storm-resolving climate modelling
- We aim at running the 1 km climate model at 100 simulated days per day within the next 3 years and routinely the 2.5 km climate model for decades simulations

Today: Destination Earth put out the invitation to tender for the operationalisation of two (or more) storm/eddy resolving climate models for climate adaptation twins of the Earth in two years!!!

Impressions from global 2.5 km coupled climate simulation (visualisation by Niklas Röber @NVIDIA)