The earth system modelled at 1km resolution

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Why the earth system at 1km?

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- 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, (better) representation of extremes, information at scales relevant for impact on peoples life (eg. catchment scales) and on scales we observe the Earth -> this workshop

- Scale interactions from local to global scale

- Less equations, less lines of code, less bugs, less assumptions and essentially simpler models, especially easier to understand

- Don’t underestimate: Inspiration , communication and beautiful pictures

What are km-scale earth system models useful for

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- Studies of convergence start to make sense (Angel P. Bravo's talk)
- 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, but very important questions.

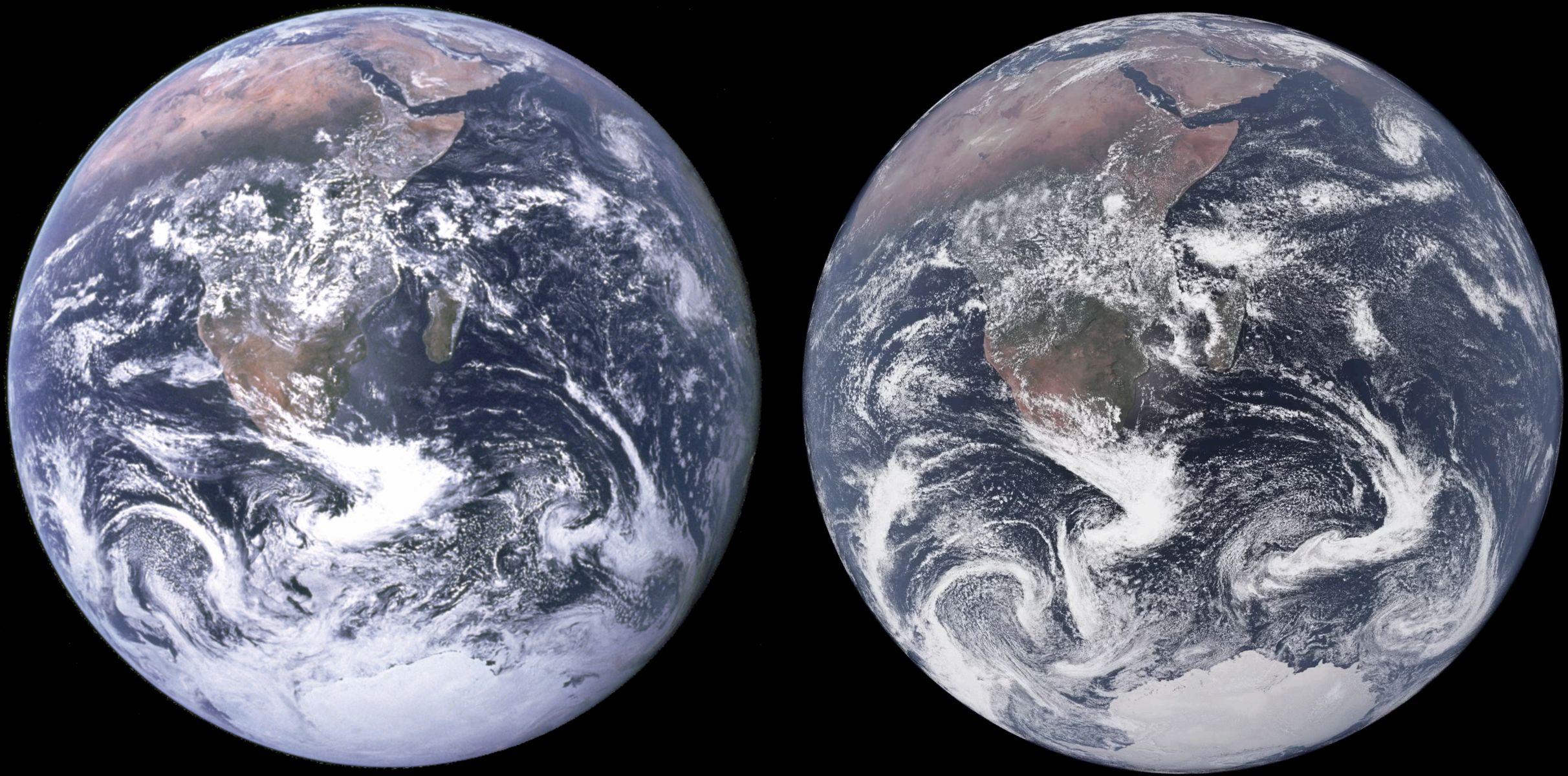
Setup

- Same grid for atmosphere, land and ocean, with a global horizontal resolution of 1.2 km
  - 340 Mio grid points atmosphere
  - 230 Mio grid points ocean
  - 110 Mio grid point land

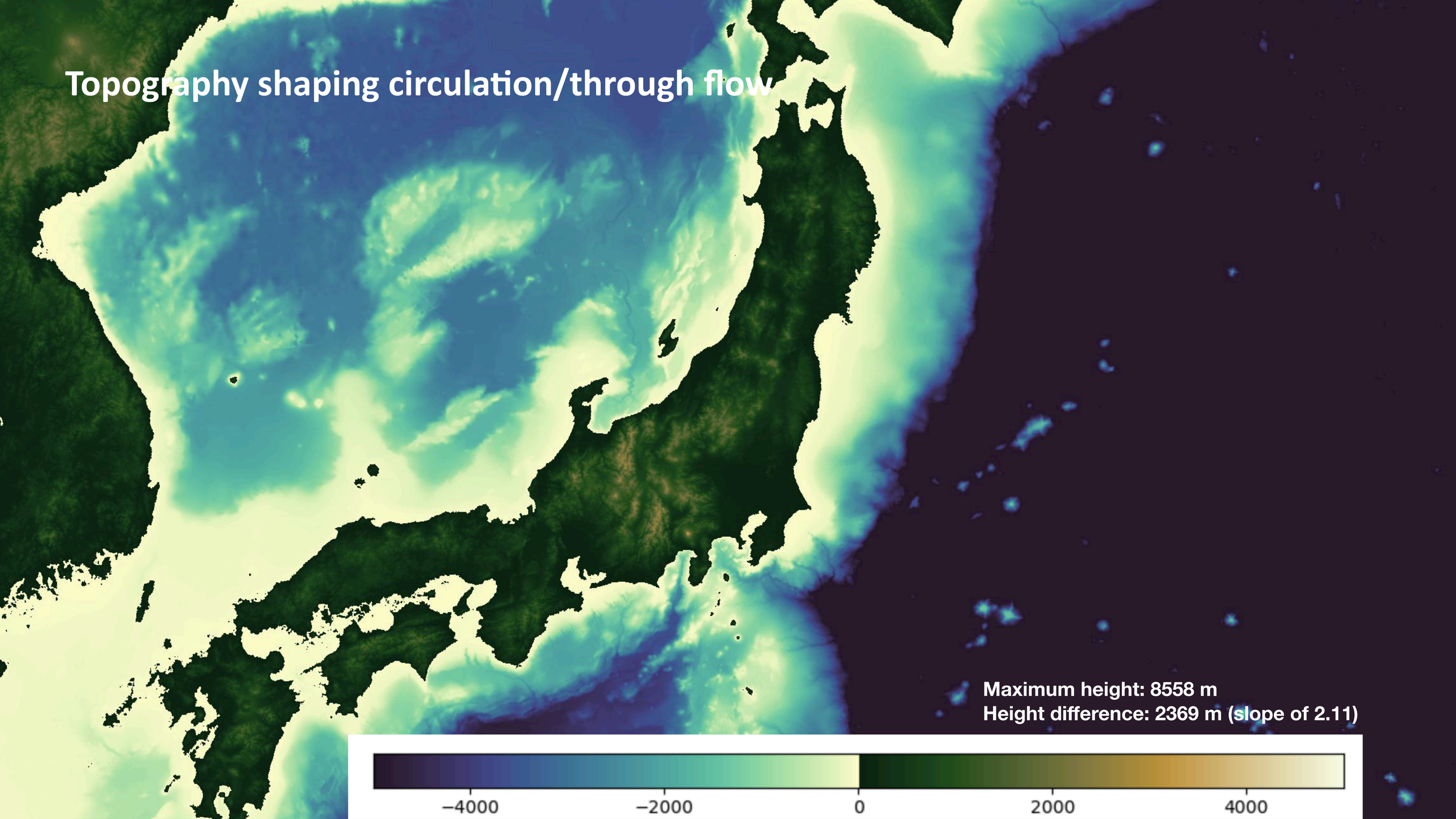
- 90 level in the atmosphere (top at 75), 128 level in the ocean (2m upper layer), 5 level in the soil
- High resolution land maps (topography, bathymetry, soil-types, albedo, root-depth, etc..)

- Spin-up ocean: initialised from ORAs5, 4 years at with 5 km resolution, another 5 weeks after interpolating to 1.2 km, forced with ERA5 at ocean surface
- Couple and initialise the atmosphere from ERA5, full output at day 7 of the simulation

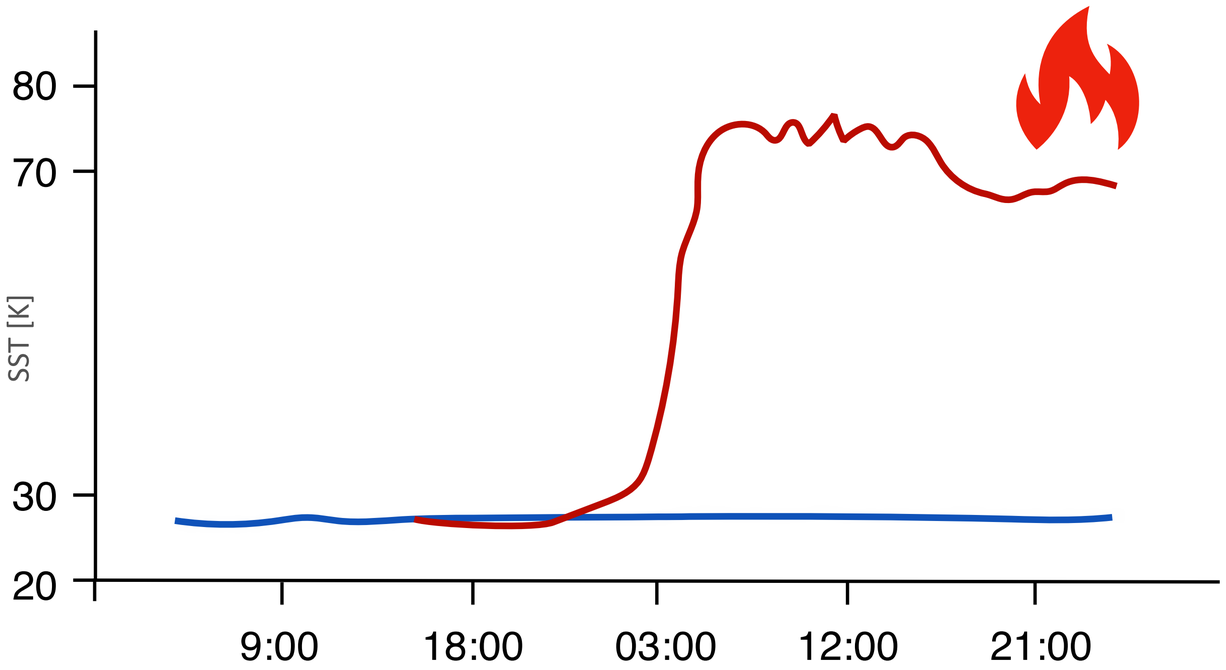
- Throughput: 3 Simulated days per day with 900 nodes on Levante@DKRZ (~25% of a 14 PFlop, CPU)

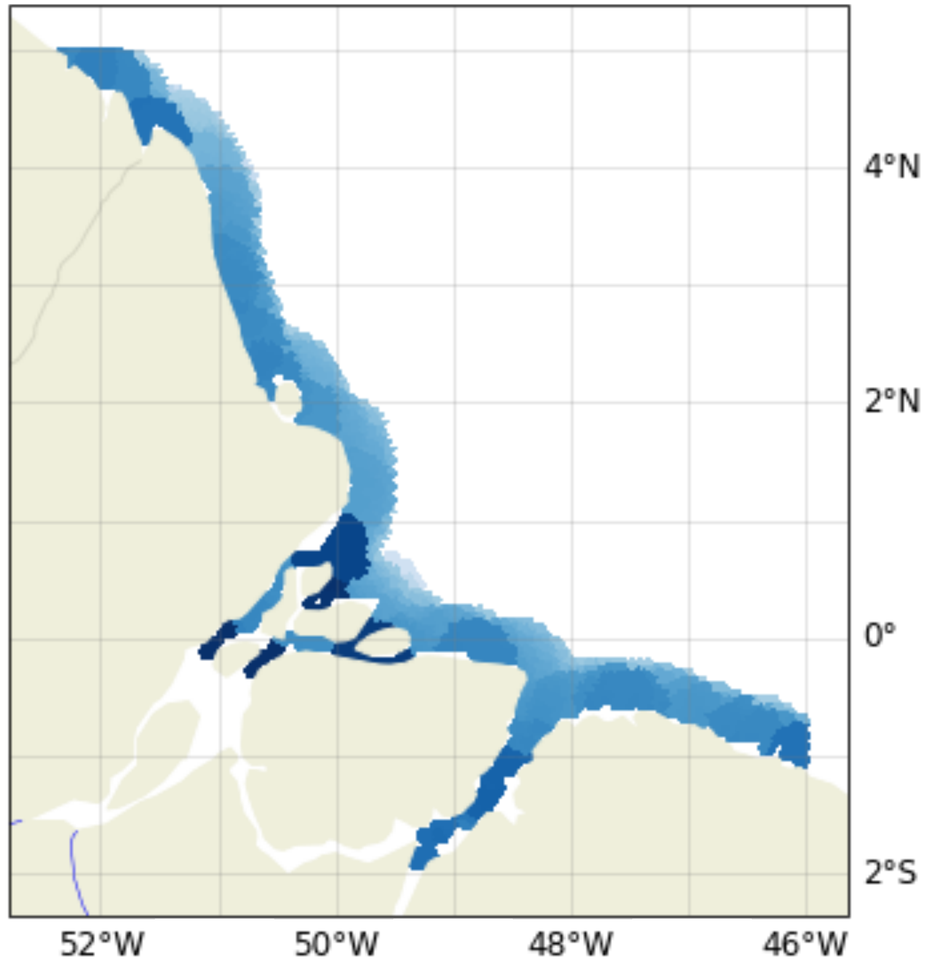


Topography shaping circulation/through flow



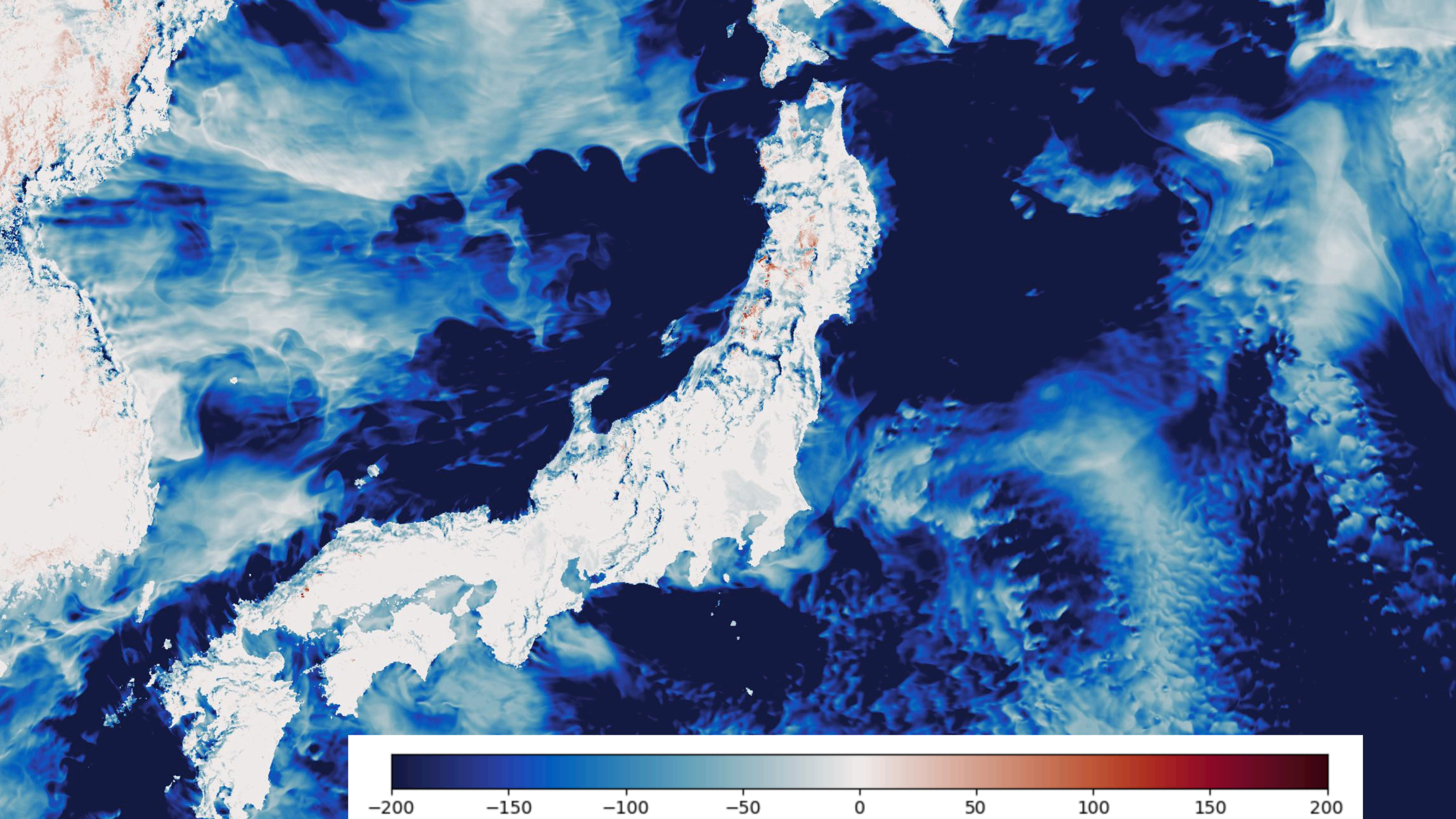
River discharge needs distribution





Bifurcation of large river mouths and horizontal distribution of river outflow

R. Redler, H. Haak, T. Riddick (MPI-M)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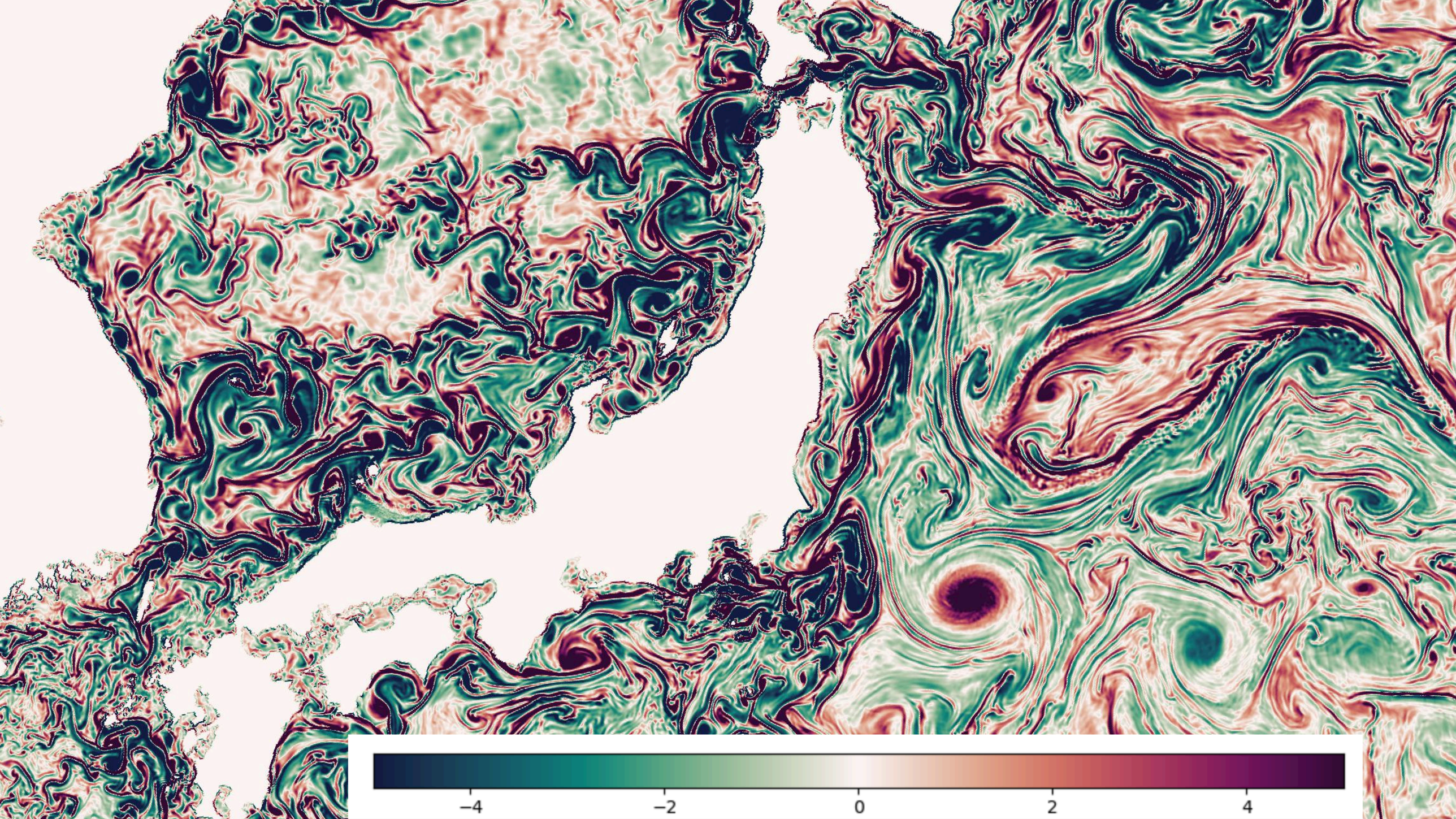
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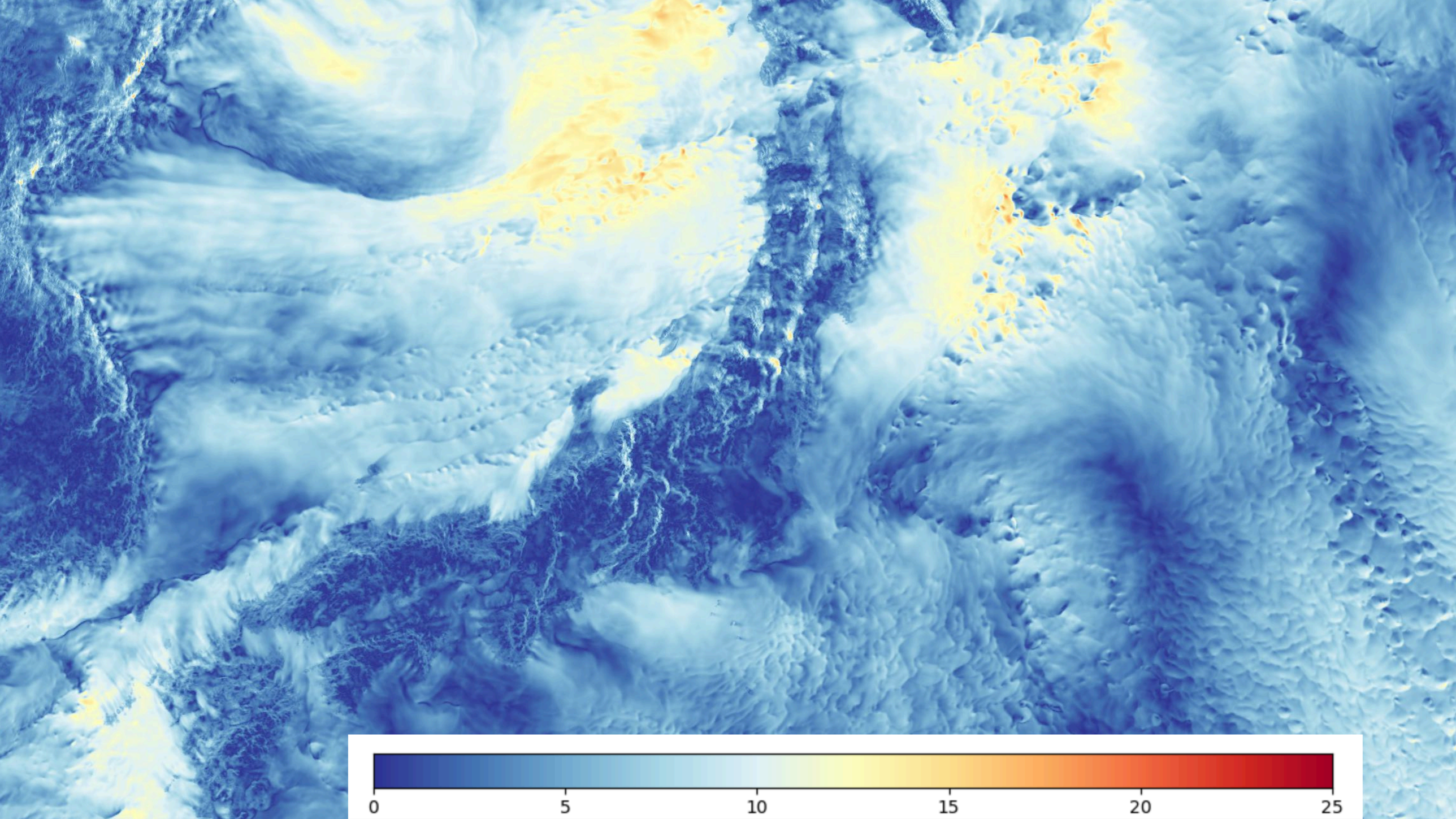
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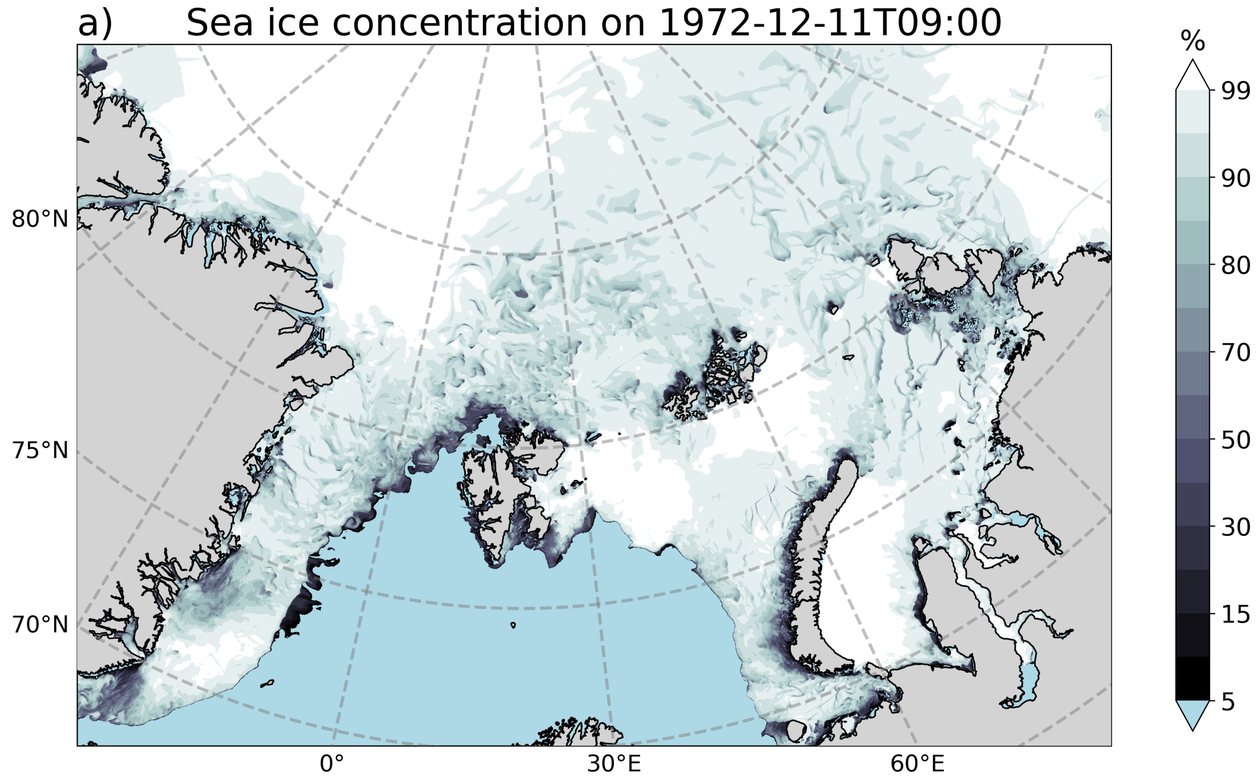
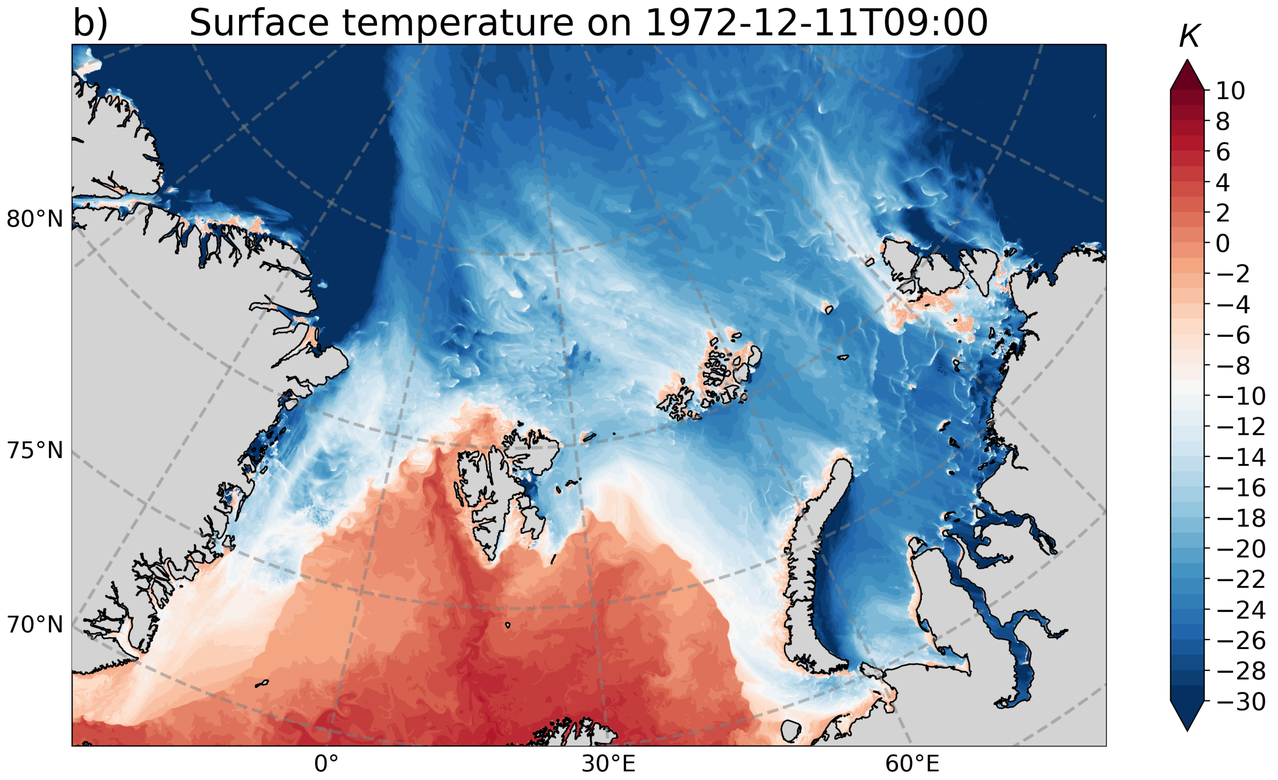
25

Polynyas and sea-ice leads





O. Gutjahr (MPI-M)

Conclusion

- Km-scale earth system modelling is possible, soon also on climate time-scales (-> see SCREAM group)
- Earth-system component interactions are sensitive at the meso-scale
- We (obs and models) start to speak the same language
- Full “Apollo17” data available for 1 day (hourly)… because: “innovation is endless” (R. Pincus)
- Exiting times, a lot to learn…. (and issues to fix)