EarthWorks Update

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CSU

http://hogback.atmos.colostate.edu/earthworks/

EarthWorks 2.5 Release

- Release “levels up” to cesm3_0_beta06
  - Enables merging EarthWorks with CESM
  - Brings in many km-scale optimizations used in DYAMOND runs.
- Enhanced MPAS Ocean/Sea-Ice support for15 km and finer grids.
- Fixes several software issues.

Blocking issue: NVIDIA memory leaks

- NVIDIA compiler memory leaks
  - EarthWorks and CESM began suffering memory leaks with the September 2024 release.
  - Issue prevents long runs and denies access to a compiler fix to a different restart issue.
- Tool provided, by NVIDIA, and leak is found
  - Ultimately, NVIDIA provided a fix to its memory tracking toolchain.
  - *Using this tool, the largest memory leak was quickly identified.*
  - However, many other smaller leaks exist throughout the code that need to be investigated.
  - Noteworthy: Close teamwork between NCAR & NVIDIA, led by John Dennis of CISL.
- Next Steps
  - Generate reproducers for memory leak issues. Provide these to NVIDIA.
  - Identify which leaks are due to “risky engineering practices” and which are ”compiler bugs”.
  - Patch leaks of the first type and integrate these patches in CESM/EarthWorks codebases.
  - Test latest NVIDIA (25.5) compiler to see what other issues exist.

GPU Components

Atmospheric physics components are running on GPUs

- PUMAS/MG3, RRTMGP, CLUBB
- These are available in standard CAM as well as EarthWorks

Dynamical cores running on GPUs

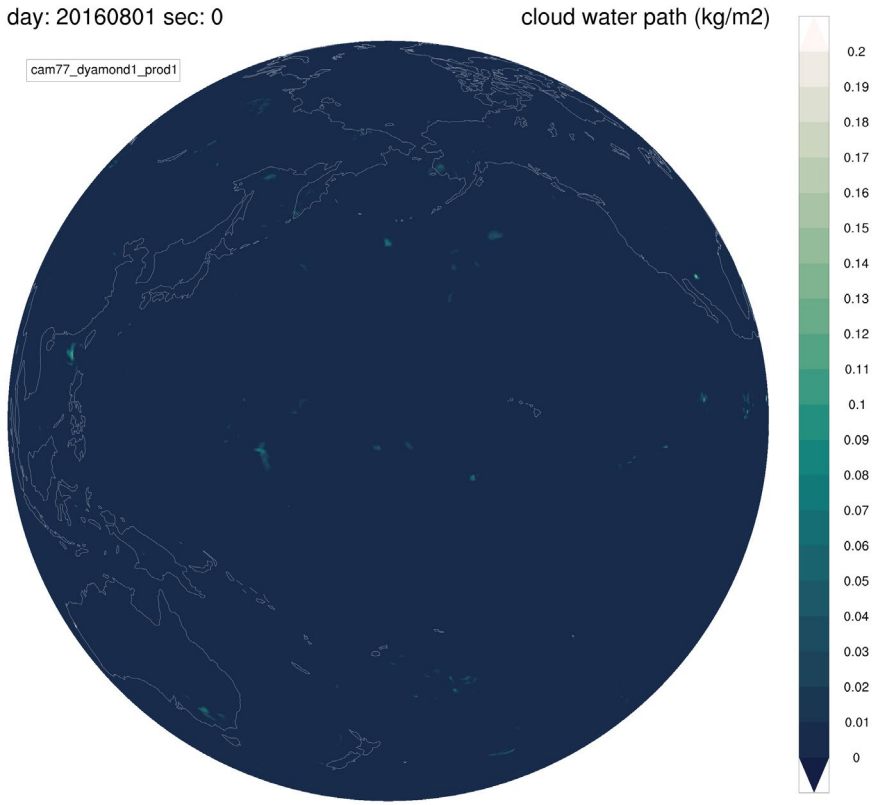
- MPAS-Atmosphere - with simple physics (only available via EarthWorks)
- MPAS-Ocean (available in next release)

DYAMOND Simulations

Special thanks to Brian Dobbins

- DYAMOND 1 summer and part of winter
  - EarthWorks tuning of CAM Physics
  - km-scale CESM scalability fixes from ESMF & PIO
  - Memory footprint reductions
- Efficiency Gains
  - 2.66x faster than originally projected, because
    - Bigger time steps
    - Fewer, faster restarts
    - Lower memory footprint → more ranks per node.
  - Further improvements are coming.

3.75-km grid, 40 days and 40 nights



Coupled simulation with 15-km grid

Ocean and sea ice initialization with the OMIP protocol:
120 km (295 years) ➞ 60 km (118 years) ➞ 30 km (1 year) ➞ 15 km (2 mos)

We interpolated to the next finer grid for ocean temperature, salinity, sea surface height, ice area, ice volume, ice temperature, snow-on-ice area, and snow-on-ice temperature. Currents started from rest.

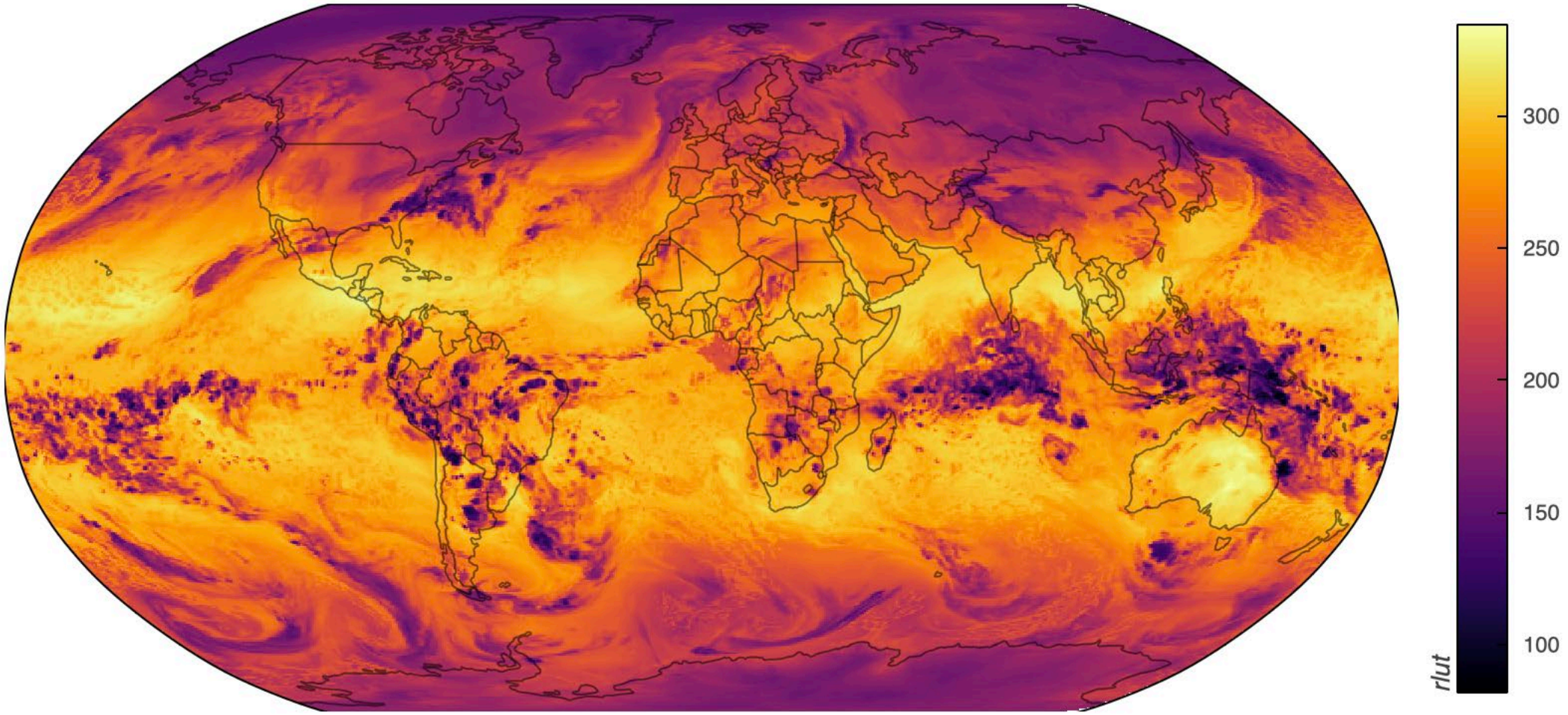
The coupled model was then started from March 1 and run for one year.

OLR

Coupled, 15-km gridd

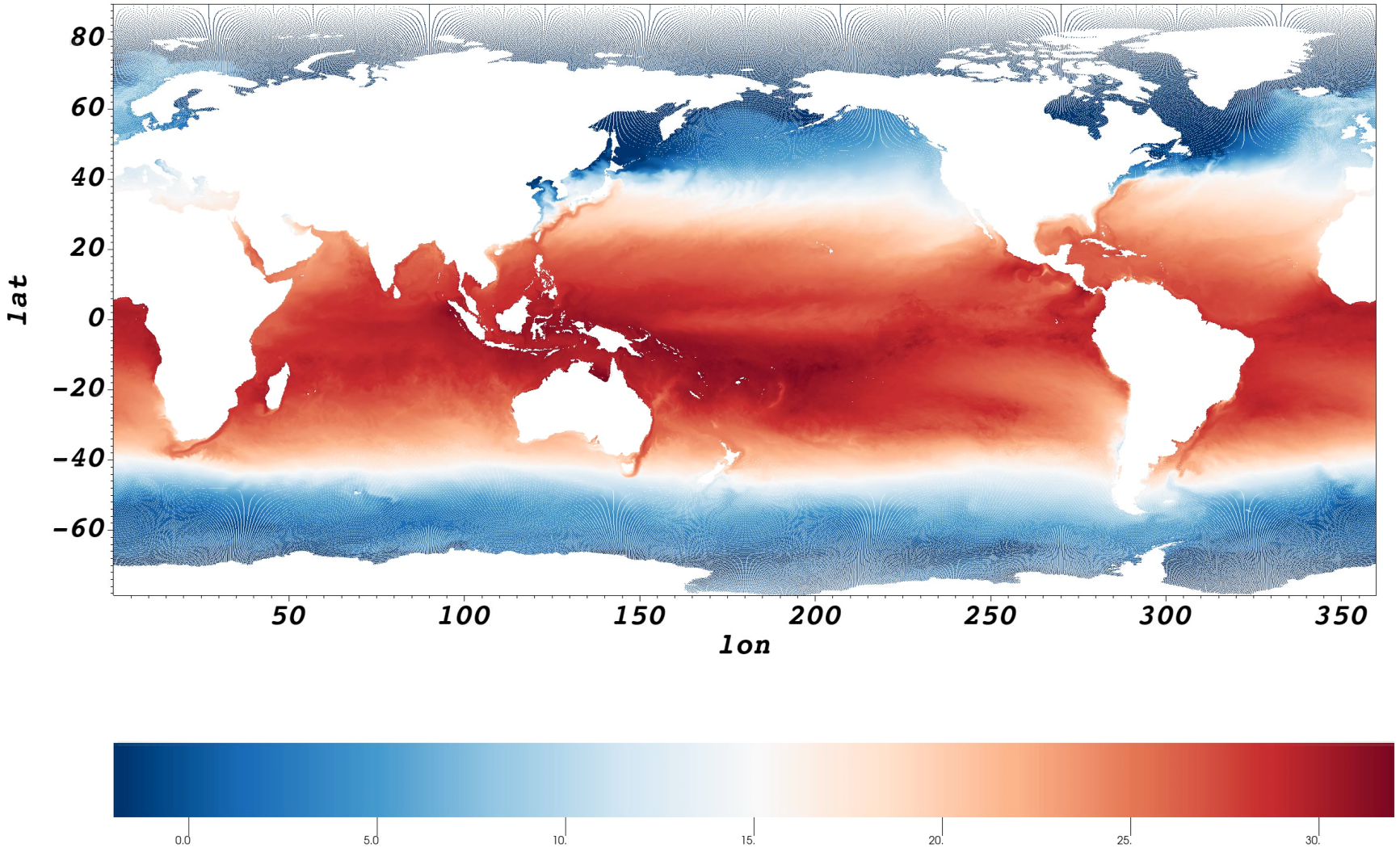
01Z 1 March OLR at HEALPix zoom level 9 (~12km)

This one-year simulation was contributed to the km-scale hackathon.



SSTs

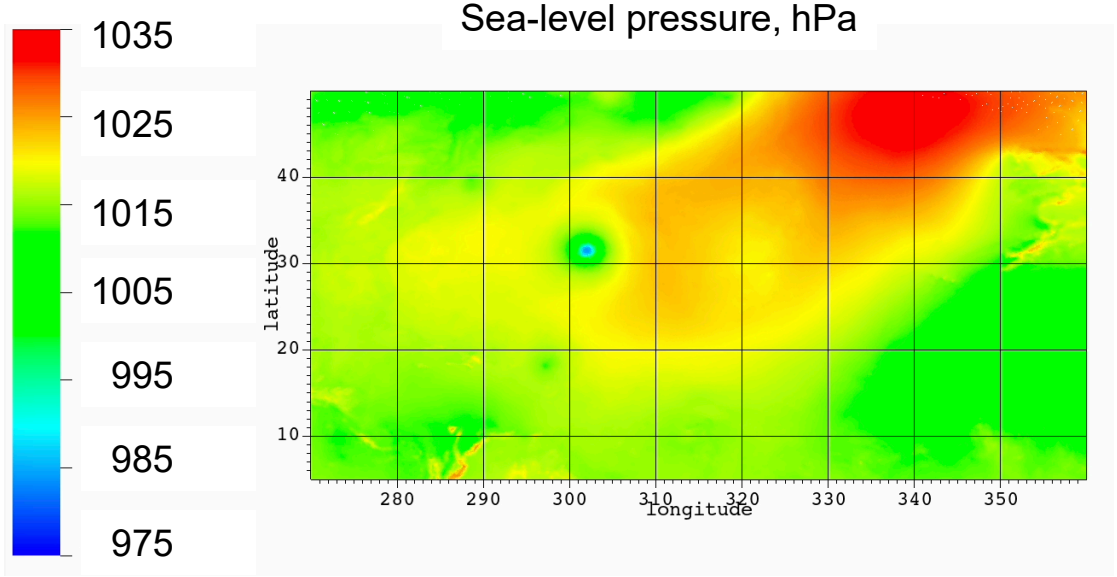
Coupled 15-km grid, March 1 - February 28



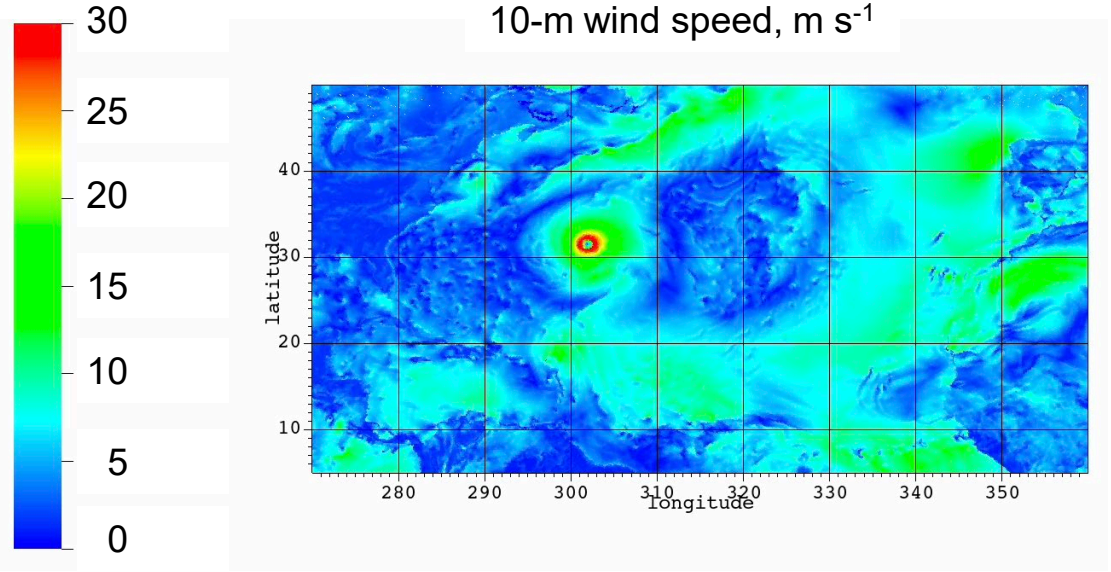
Atlantic tropical storm

Coupled 15-km grid

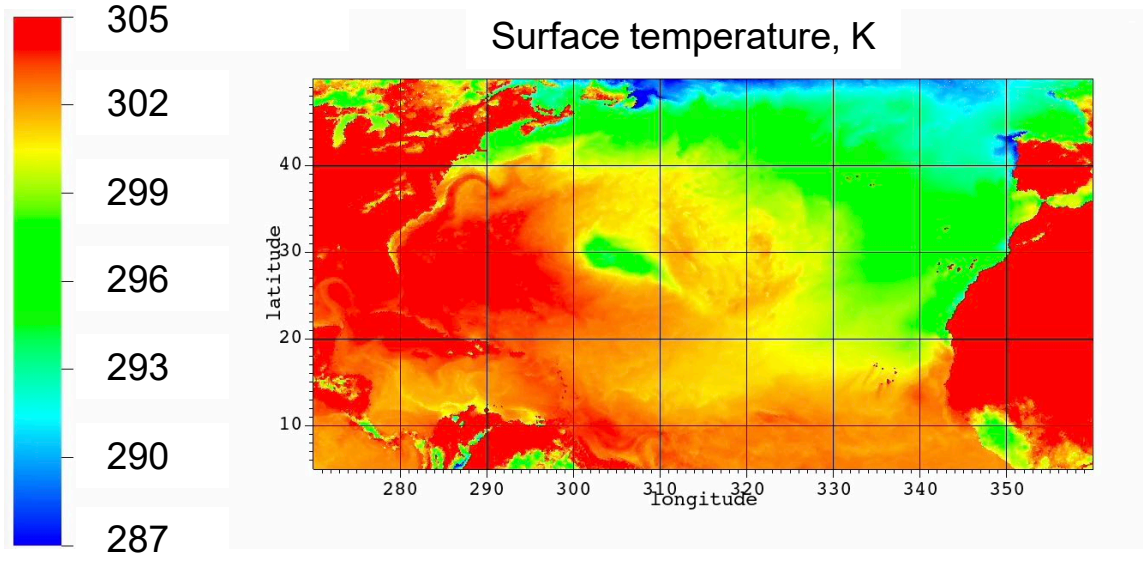
Sea-level pressure, hPa



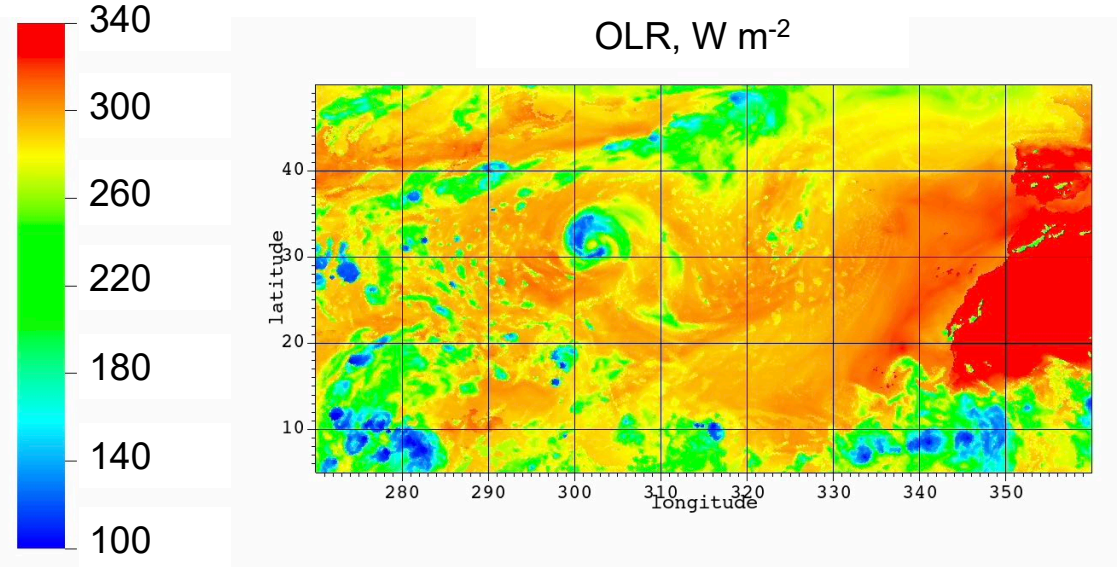
10-m wind speed, m s^{-1}



Surface temperature, K



OLR, W m^{-2}



Conclusions

- EarthWorks is in production mode.
- We have completed a DYAMOND 1 run for summer, and part of a winter, both on the 3.75-km grid.
- We have also done a one-year coupled simulation on the 15-km grid.
- The 15-km coupled run was submitted to the km-scale hackathon.
- A DYAMOND 2 simulation is planned for the near future.
- Further code improvements and optimization are being worked on.