Norwegian Earth System Model

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Outline

- NorESM overview.
- National computational and storage resources.
- Computational characteristics of NorESM.

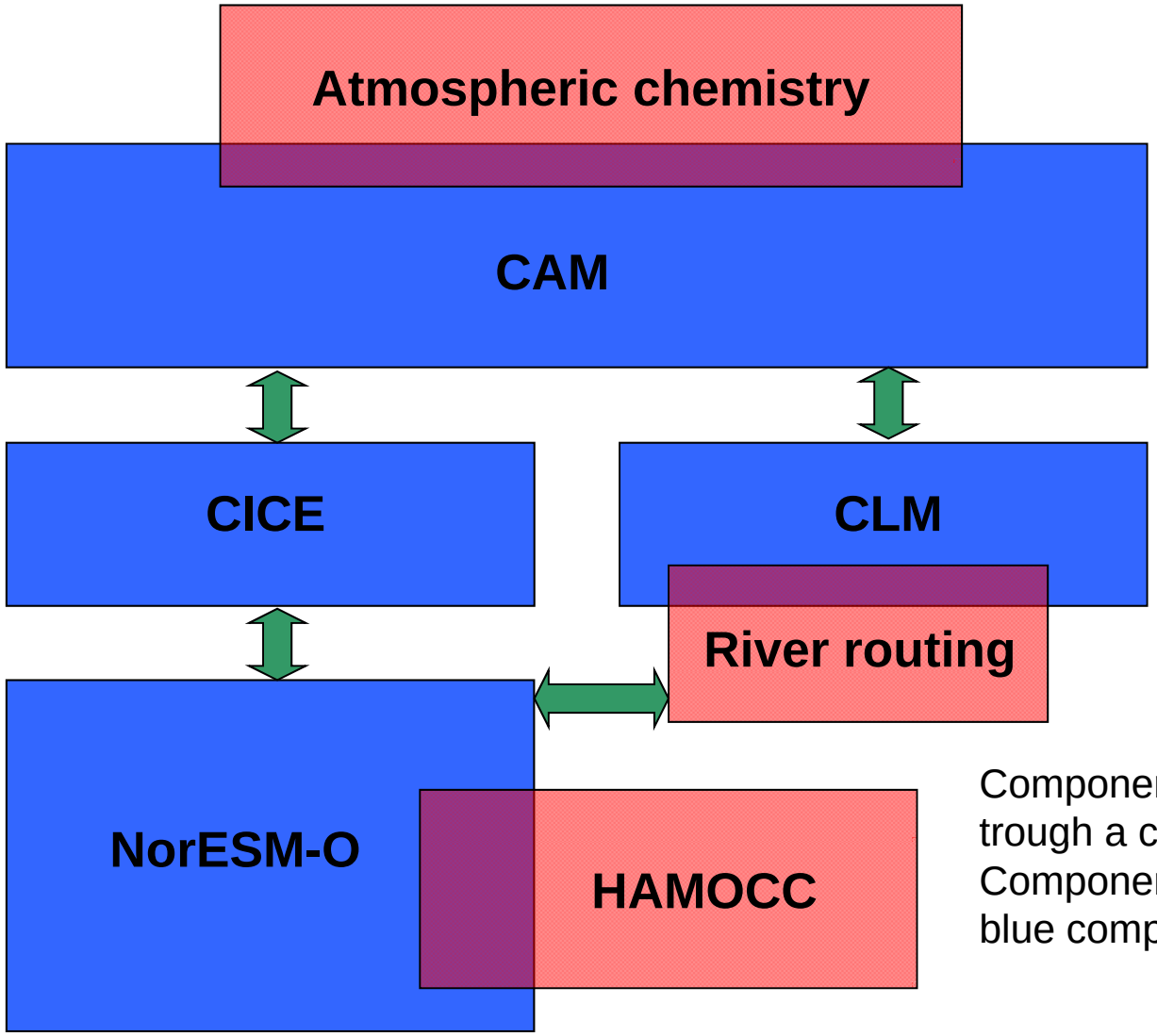
NorESM framework and model components

NorESM is based on version 1 of the Community Earth System Model (CESM1) from the University Corporation for Atmospheric Research and National Center for Atmospheric Research, Boulder, USA.

Specific NorESM additions to CESM1:

- Ocean component: NorESM-O, originates from the Miami Isopynic Coordinate Ocean Model (MICOM) but extensively modified at the Bjerknes Centre.
- Atmospheric chemistry: Chemistry-aerosol-cloud package in CAM4 by University of Oslo and met.no.
- Ocean Carbon Cycle: Hamburg Model of Ocean Carbon Cycle (HAMOCC) adopted for use with an isopycnic ocean model at the Bjerknes Centre.

NorESM framework and model components



Components in blue communicate trough a coupling component.
Components in red are subroutines of blue components.

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NorESM status

- Long-term experiments without carbon cycle made available to CMIP5 through the Earth System Grid (ESG) Gateway in June 2011.
- Many of the proposed CMIP5 long-term experiments with carbon cycle have now been made available through ESG.
- Completed documentation of the CMIP5 version of NorESM and associated experiments.
- Low resolution configuration of NorESM for millennia scale simulations exists.
- A prototype of NorESM for seasonal to decadal prediction has been constructed where the data assimilation for ocean initialization uses EnKF.
- Through IS-ENES2, met.no is involved in establishing a NorESM interface with and access to PRACE resources.

NorESM plans

- Update the atmospheric component so it is based on CAM5 and to explore the potential benefits of the new spectral element dynamical core.
- Enable interactive land ice component.
- Clarify the feasibility of seasonal and decadal prediction.
- Explore higher lateral grid resolution. We are currently investigating 1° resolution for atmosphere/land components and 0.25° resolution for ocean/sea-ice components.
- Adapt to emerging changes in high performance computing.
- Improve physics and numerical methods in all NorESM specific additions to CESM.

National computing and storage resources

- Norwegian metacenter for computational science (Notur).
- Current hardware resources:

	System	Type	Number of nodes	Number of cores	CPU type	Theoretical total peak	Total memory	Total disk capacity
abel	MEGWARE MiriQuid 2600	cluster	630	10080	Intel E5-2670	210 TFlop	40 TiB	400 TiB
gardar	HP BL280cG6	cluster	288	3456	Xeon	35 Tflop	6912 GB	
hexagon	Cray XE6	MPP	696	22272	AMD Interlagos	205 TFlop	22272 GB	540 TB
stallo	HP BL460c Gen8	cluster	304	4864	Intel E5-2670	101 Tflop	12800 GB	2.1 PB
vilje	SGI Altix 8600	cluster	1404	22464	Intel Sandy Bridge	467 Tflop	44 TB	

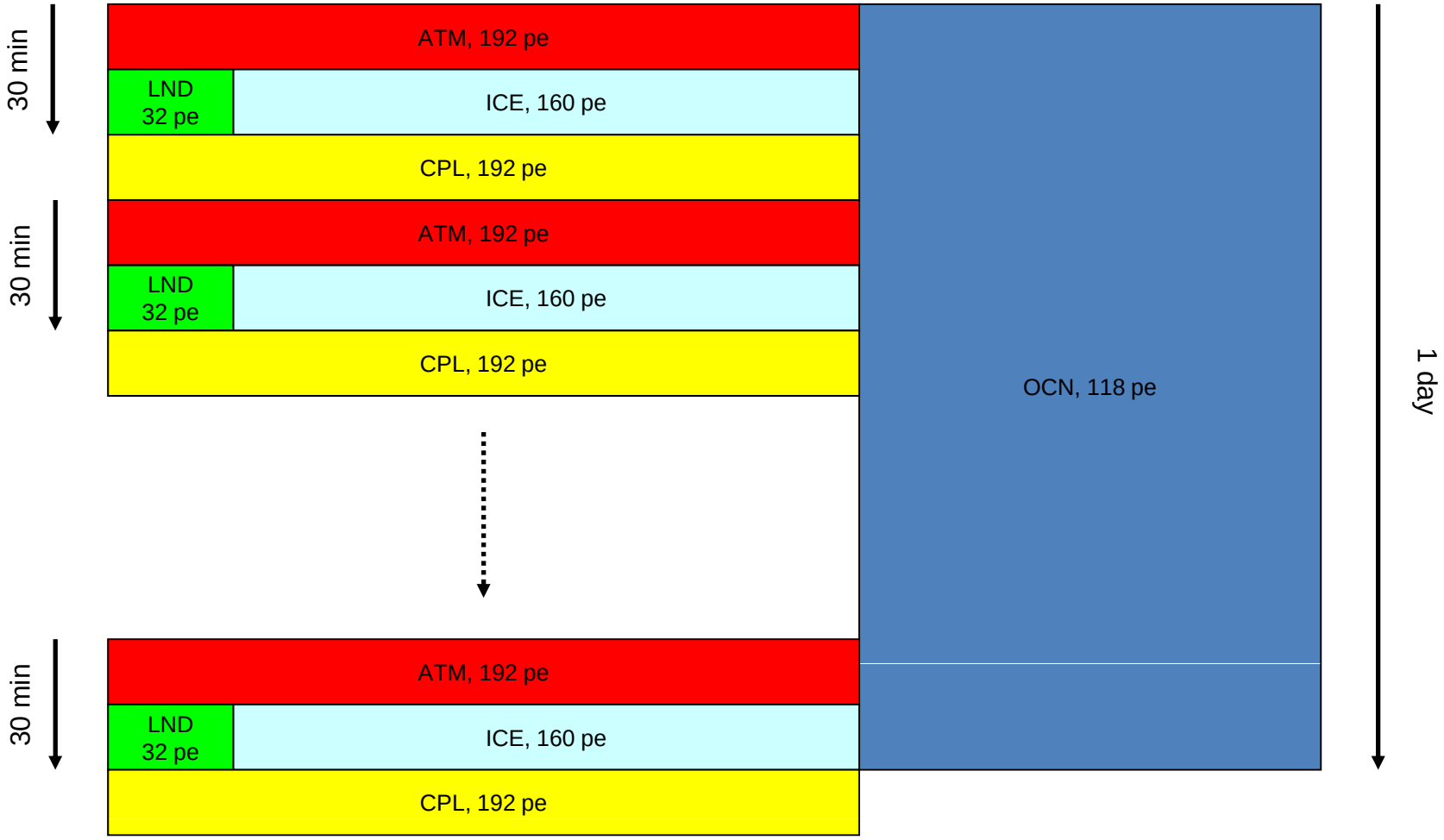
- Norwegian storage infrastructure (NorStore).
- An ESG data node has been established for access to our CMIP5 data.
- Current capacity is ~1 PB and an updated system of ~4 PB will be available March 2013.

Computational characteristics of NorESM

- All model components support hybrid OpenMP/MPI parallelization. No significant improved computational efficiency so far with hybrid parallelization on Cray XT4/XE6.
- All components except the ocean component support parallel I/O through the PIO library included in CESM that again utilizes the parallel netCDF (PnetCDF) library.
- The available computational and storage resources at the time of the CMIP5 experiments limited the horizontal resolution of the atmosphere/land components to 1.9° × 2.5° and the ocean/sea-ice components to ~1°.
- The inclusion of NorESM specific interactive atmospheric chemistry doubles the computational burden of standard CAM.
- Enabling ocean carbon cycle in NorESM increases the computational burden of the ocean component with ~70%.

Execution strategy

Typical NorESM configuration for CMIP5 experiments without interactive carbon cycle, achieving ~10 simulated years pr day on Cray XT4/XE6.



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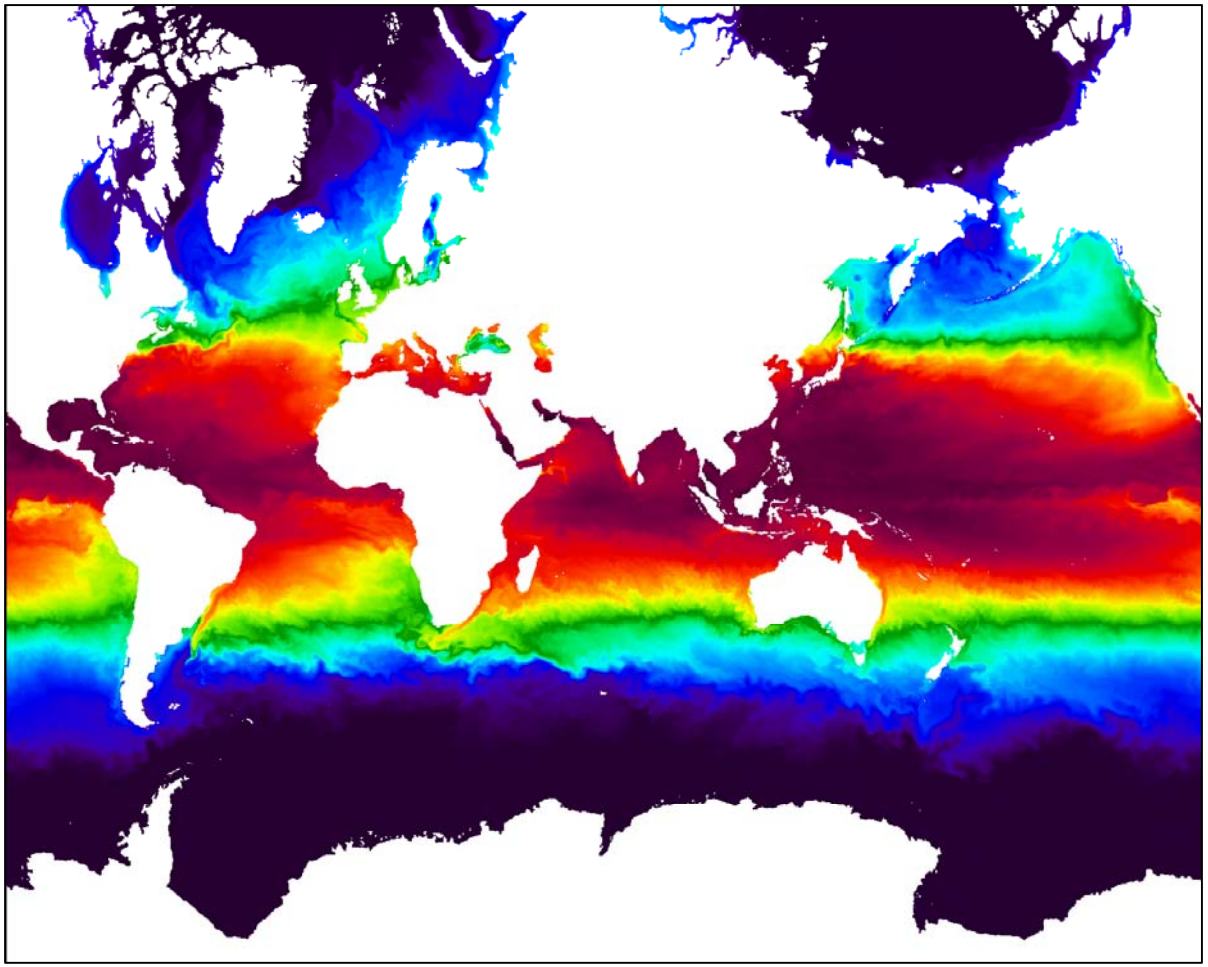
- Testing of 0.25° resolution of ocean/sea-ice components has started.
- For NorESM coupled ocean/sea-ice configuration with CORE atmospheric forcing, 9 simulated years pr day is achieved with 2803 cores on a Cray XE6.



Snapshot of sea surface temperature