NorESM2 based on CESM2. Preliminary experience based on pre-industrial spin-up and historical simulation

Øyvind Seland, Dirk Olivié, Mats Bentsen, Trond Iversen, Thomas Toniazzo, Alf Kirkevåg

Partners:
Overview

- Possible CMIP6-versions for NorESM2 - based on CESM
- Discuss preliminary results from spin-up and historical runs
The Norwegian Earth System Model (NorESM)

Based on Community Earth System Model (CESM) of NCAR, Boulder, USA.

Specific NorESM additions to CESM:
- Atmospheric chemistry/aerosol/cloud module
- Atmospheric dynamics/physics: Improved conservation of energy and angular momentum
- Parameterization of turbulent air-sea fluxes
- Ocean component with isopycnic vertical coordinate
- Hamburg Model of Ocean Carbon Cycle (HAMOCC) adopted for use with isopycnic ocean model and further developed
## CESM versions tested for preliminary NorESM2

<table>
<thead>
<tr>
<th>Coupled model version</th>
<th>Preferred choice</th>
<th>Back-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CESM2</td>
<td>CESM1.2, configured towards CESM2</td>
</tr>
</tbody>
</table>

### Atmosphere
- **Preferred choice**: CAM6
  - **Back-up**: CAM5.3
    - Ice nucleation from CAM5.4
    - MG1.5
    - 32 vertical layers

### Land
- **Preferred choice**: CLM5
  - **Back-up**: CLM4.5 (5)

### Sea-ice
- **Preferred choice**: CICE 5
  - **Back-up**: CICE4(5)

### Land-ice
- **Preferred choice**: Not included
  - **Back-up**: Not included

### Grid
- **Preferred choice**: f09_tn14; f19_tn14
  - **Back-up**: f09_tn11; f19_tn11
1.125° bipolar grid (every 4th grid line shown):
• NCAR gx1v6 grid.
• 320 × 384 grid cells.
• Used for the NorESM CMIP5 experiments.
• Enhanced meridional resolution near the equator \(f_e = 1/4\).

1° tripolar grid (every 4th grid line shown):
• NorESM tnx1v4 grid.
• 360 × 384 grid cells.
• Used for the NorESM-O CORE2 and CMIP6 experiments.
• Enhanced meridional resolution near the equator \(f_e = 1/4\).

0.25° tripolar grid (every 16th grid line shown):
• 1440 × 1152 grid cells.
• Isotropic grid near equator.
• To be used for CMIP6 experiments (at least OMIP).
Tested versions

- **NorESM based on CESM2beta07-modified as experiment 227 (NorESM2-exp227)**
  - Historical ongoing
  - Tuning as in sandbox but with zmconv_c0_lnd = 0.0300 instead of 0.0075
  - Include AM and energy corrections

- **NorESM based on CESM2beta06 + MG2 bugfix (NorESM2-beta06)**
  - Historical CMIP5 and CMIP6 aerosol pre-cursor emissions
  - Tuning as in original beta06 except modified c0_lnd
  - Start-up run

- **NorESM based on CESM1.2 (NorESM-1.2)**
  - Ice particle formation
  - CLM4.5
  - MG 1.5
  - Vertical levels as in CESM2beta (32)
## Beta07/exp227 – Beta06 – NorESM_c1.2 spinup simulations (1)

<table>
<thead>
<tr>
<th>Model</th>
<th>Experiment</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CESM</td>
<td>B1850</td>
<td>beta07/exp227</td>
</tr>
<tr>
<td>NorESM</td>
<td>N1850</td>
<td>beta07/exp227</td>
</tr>
<tr>
<td>NorESM</td>
<td>N1850</td>
<td>beta06</td>
</tr>
<tr>
<td>NorESM</td>
<td>N1850</td>
<td>noresm_c1.2</td>
</tr>
</tbody>
</table>
Beta07/exp227 – Beta06 – NorESM_c1.2 spinup simulations (2)
Sea-surface temperature compared with PI estimate

NorESM2-beta06
Years: 71-100

NorESM2-exp227
Years: 71-100
Sea-surface temperature compared with PI estimate

NorESM-c1.2
Years: 71-100

NorESM2-exp227
Years: 71-100
Precipitation: Model – Observational estimate

NorESM2-beta06
Years: 71-100

NorESM2-exp227
Years: 71-100
NH Sea-ice concentration compared with PI estimate

NorESM2-beta06
Years: 71-100

NorESM2-exp227
Years: 71-100
NH Sea-ice concentration compared with PI estimate

NorESM2-c1.2
Years: 71-100

NorESM2-exp227
Years: 71-100
Is there a link between an abnormal cooling in the Labrador and Nordic Seas and the strength of AMOC?
Maximum Atlantic meridional overturning circulation.
Sensitivity to missing parameter changes

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CESM</td>
<td>B1850</td>
<td>dust/H₂O</td>
</tr>
<tr>
<td>NorESM</td>
<td>N1850</td>
<td>dust/H₂O</td>
</tr>
<tr>
<td>NorESM</td>
<td>N1850</td>
<td>dust/H₂O</td>
</tr>
<tr>
<td>NorESM</td>
<td>N1850</td>
<td>dust/H₂O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>COARE-flux, alb-avg.</td>
</tr>
</tbody>
</table>

\[
\text{dust: prefactor } \frac{1}{0.4} \rightarrow \frac{1}{0.7}
\]

H₂O: stratospheric H₂O from CH₄ oxidation
Sensitivity to missing parameter changes

Surface air (2m) temperature

2 meter Temperature

Sea-ice extent

Sea-ice extent
Historical simulations based on CESM2-beta06 (Without explosive volcanoes)

- NorESM 1850 spin-up
  - NorESM historical CMIP6 emissions
  - NorESM historical CMIP5 emissions
  - CESM 1850
Summary

- Presented results from NorESM based on CESM2-experiment 227, CESM beta06 and CESM1.2
- Errors in SSTs are considerable in all versions, (beta06-version > 227-version > 1.2-version)
- Positive SST bias dominate in the tropics and the southern oceans
- Negative SST bias dominate in the northern oceans
- Surface air temperature is stable for 1.2, in a cooling spin-up phase for the others
- NorESM based on CESM2 experiments 227 has a reasonable AMOC and the best precipitation distribution
- Sea-ice in the North Atlantic highly sensitive to model version
- Considerable differences between historical temperature development between CMIP5 and CMIP6 emissions (Tested for the version based on CESM2 beta06)
Thank you for the attention.