Options for NorESM2 for CMIP6

- with emphasis on the atmosphere

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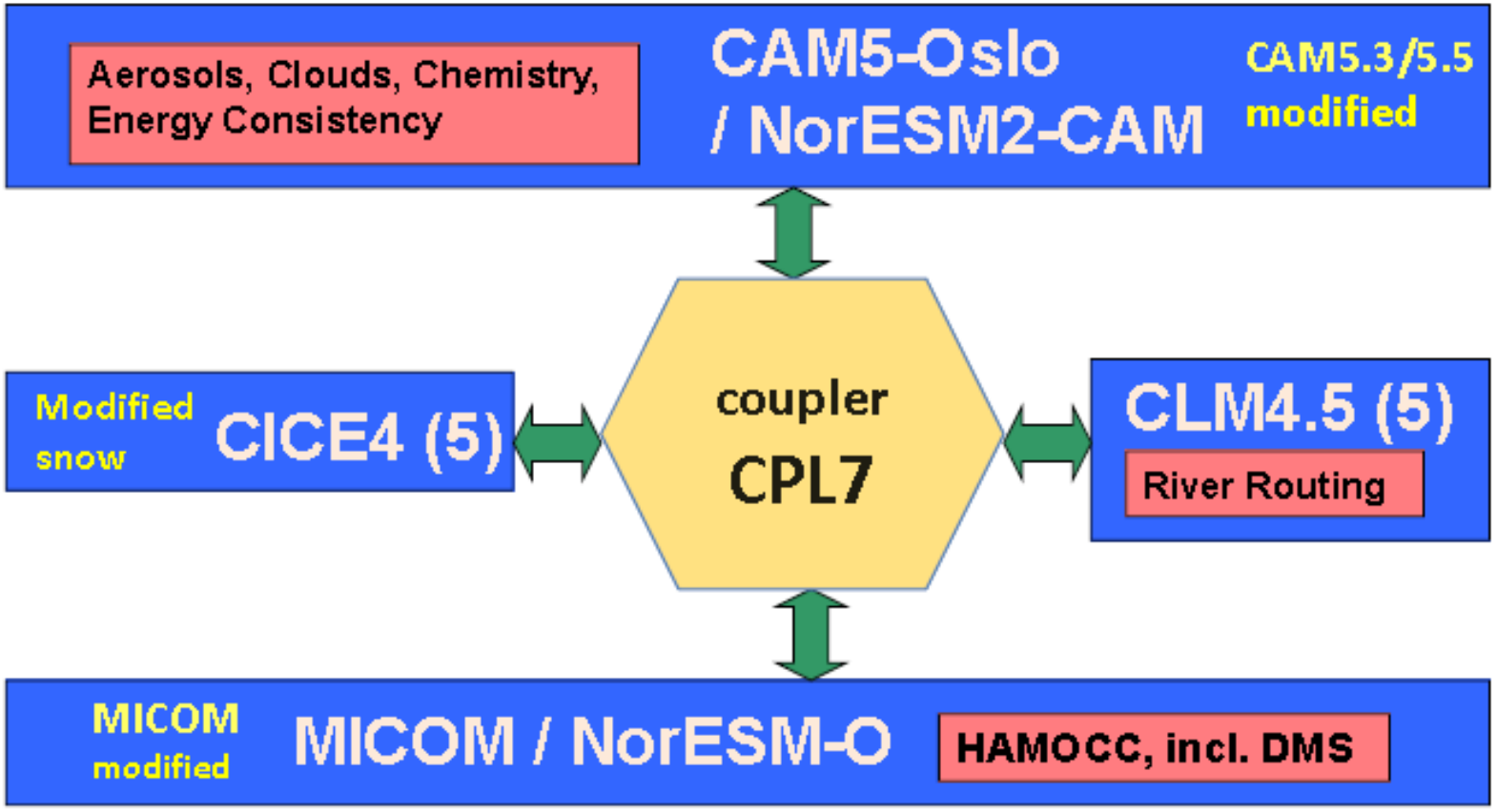
CESM AMWG
NCAR 8-10 Feb. 2016

NorESM belongs to the "family" of models based on the **Community ESMs.**

- **The ocean model** → iso-pycnic co-ordinate, developed from MICOM;
- **Ocean bio-geochemistry** is based on HAMOCC (HAMburg Ocean Carbon Cycle Model);
- **Aerosol life-cycling, physics, and interactions with clouds** (CAM-Oslo);
- Adjusted processing of sea-ice and **snow on sea-ice**.



NorESM2_CAM – the CMIP6-versions

- intended to be based on **CESM1.5 / CAM5.5** or newer.

- **preliminary version** is based on **CESM1.2_CAM5.3.**
  - But: CICE5 and CLM5 are needed in NorESM2

- Alternative:
  - trace-back CAM5.3 / 5.4 from CESM1.5_CAM5.5,
  - e.g. with 48 levels
  - and WACCM stratospheric physics

  (→QBO, SSW possible impacts on tropospheric dynamics)

- A version based on CESM2_CAM6 to be considered later

- The MICOM-based Ocean model can be run with 1x1 deg and 0.25x0.25 deg resolution

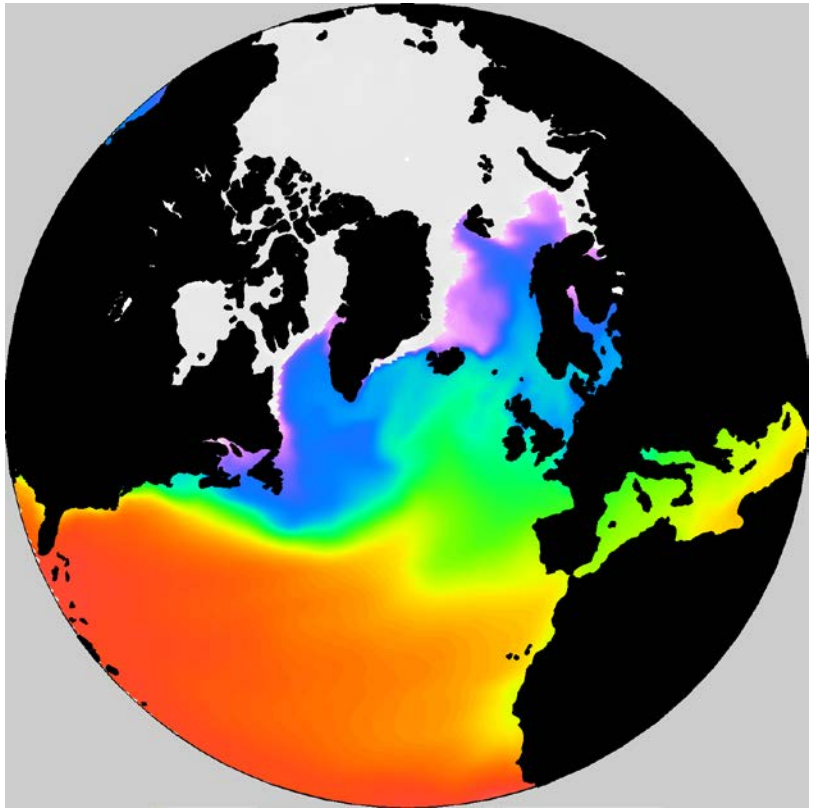
Sea ice component in NorESM2

- **The sea ice component based on CICE5**
  - Most likely with prognostic sea-ice salt.
  - Possibly include changes in the horizontal distribution of snow on sea ice, and a simple parameterization of the effects of wind blowing snow.

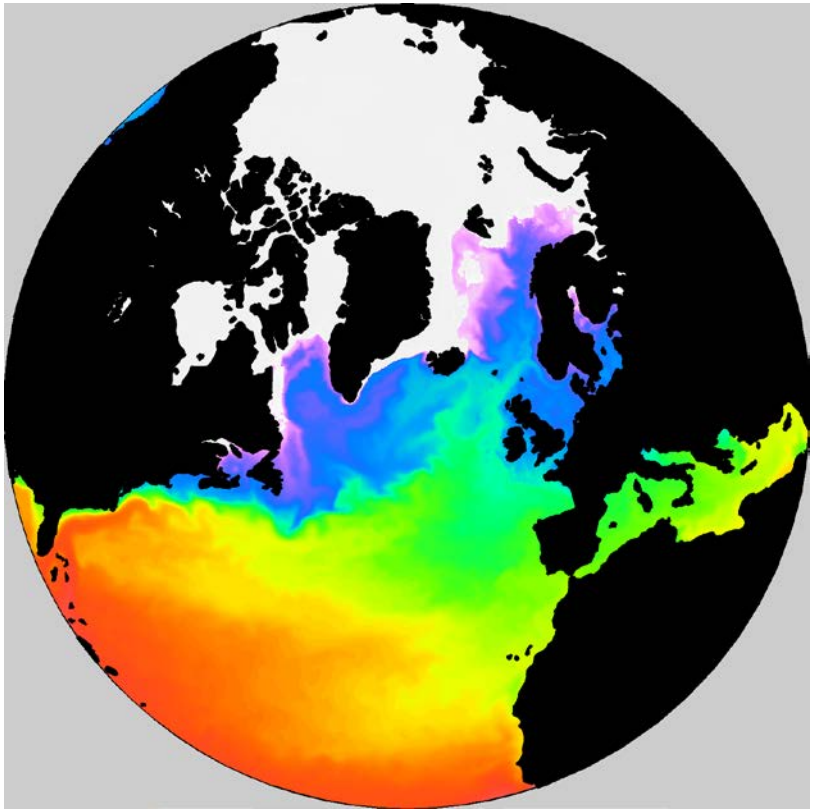
NorESM-Ocean Resolution

Based on monthly snapshots from early NorESM2 tests where NorESM-O was coupled to standard CAM5.3

1 degree

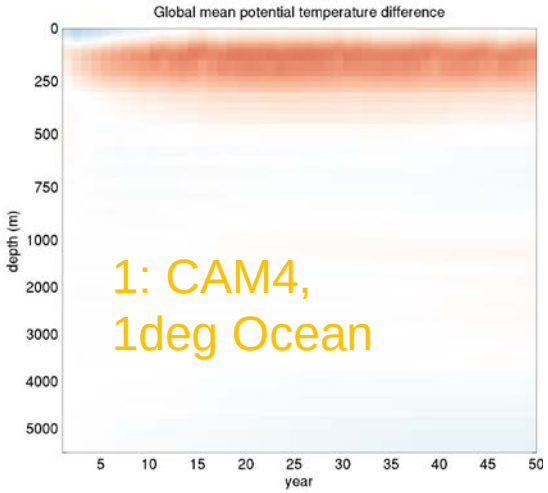


1/4 degree

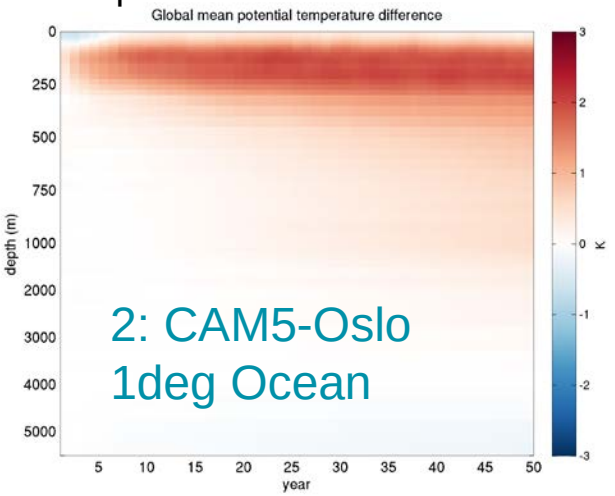


Experience from NorESM2 coupled experiments with 1° and 0.25° ocean resolution

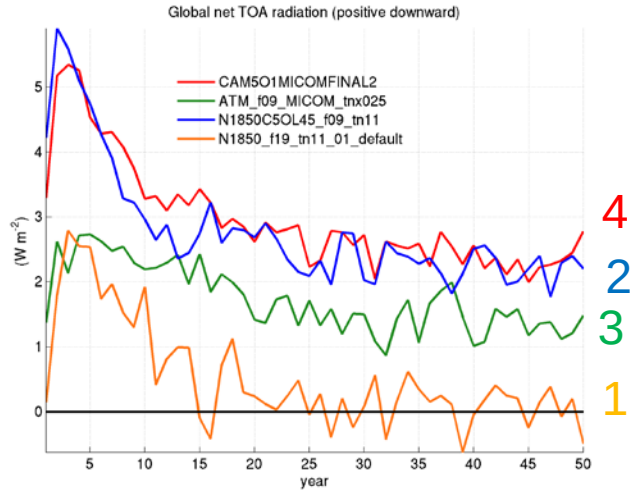
Global Mean Ocean pot. temp. difference.



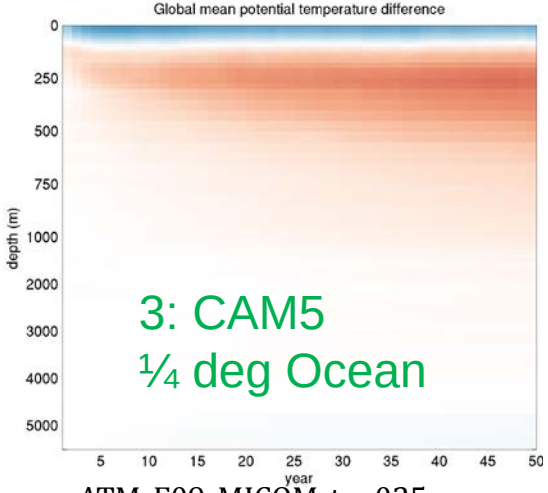
N1850_f19_tn11_01_default
CAM4/CLM4 2°, MICOM/CICE 1°



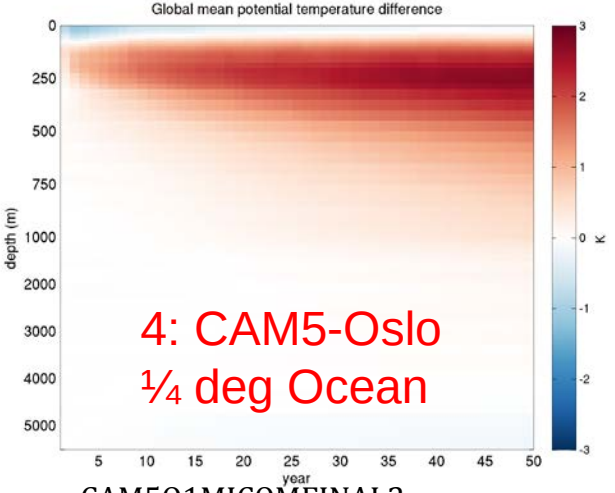
N1850C5OL45_f09_tn11
CAM5-Oslo/CLM4.5 1°, MICOM/CICE 1°



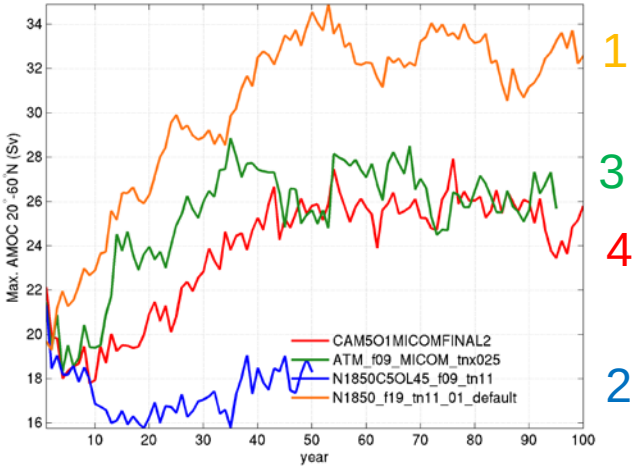
TOA heat balance



ATM_F09_MICOM_tnx025
CAM5/CLM4 1°, MICOM/CICE 0.25°



CAM5O1MICOMFINAL2
CAM5-Oslo/CLM4.5 1°, MICOM/CICE 0.25°



Max. AMOC

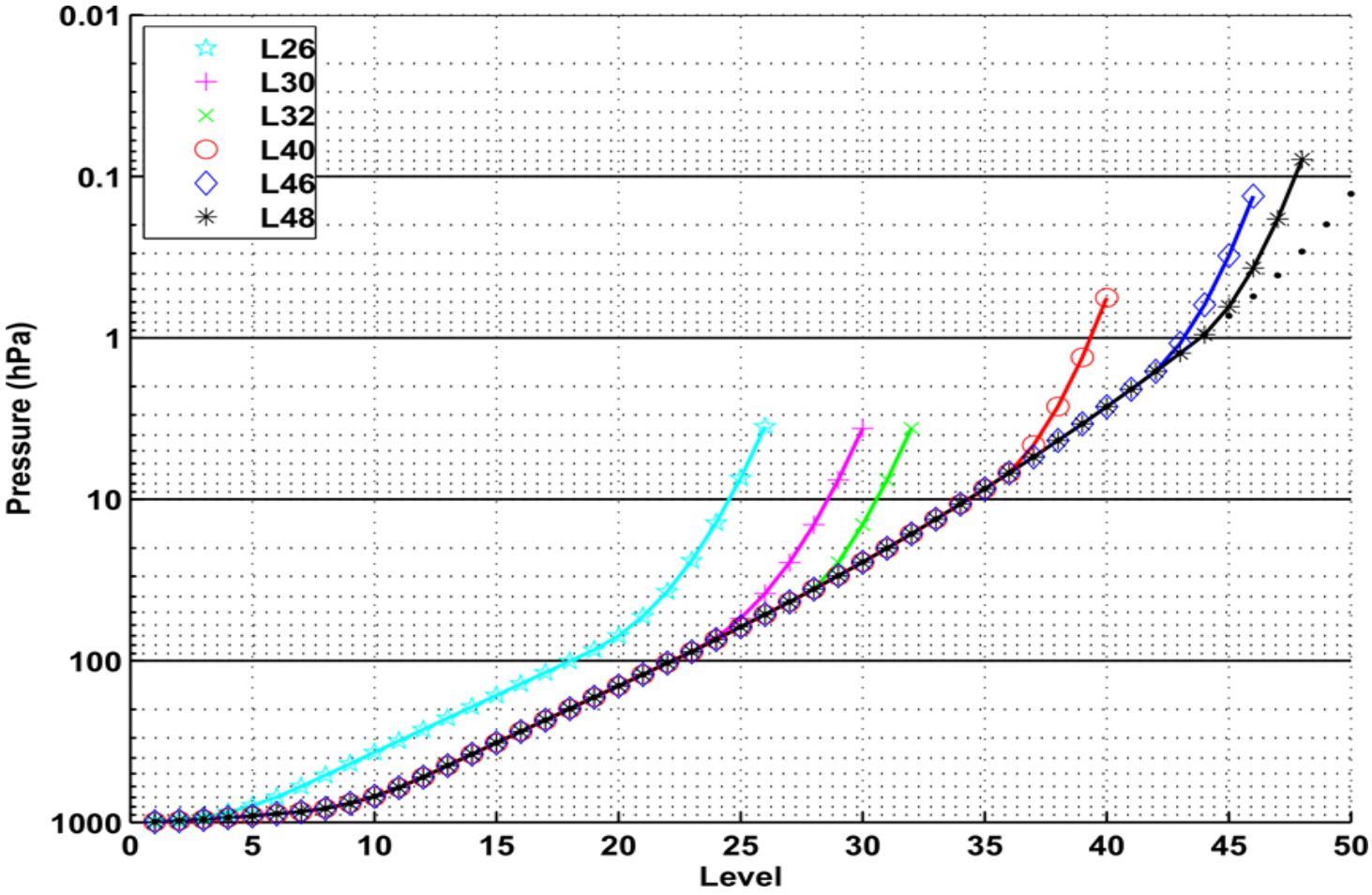
Increase no. of levels

Inspired by Yaga Richter's work

Two CAM5.3-OSLO test simulations planned,

- one with 32 layers and standard gravity wave drag parametrisation
- one with 48 levels and WACCM gravity wave drag parametrisation.

1 deg resolution with prescribed SST/sea-ice climatology; 50 years.



Six possible configurations of NorESM2 for CMIP6.

Low, Medium, or High atmospheric and oceanic resolution; Preliminary: 53 ocean & 32 atmos. levels.
Process complexity: Emission-driven GHG and atmospheric Chemistry.

NorESM2		_MH	_HH	*_MM*	_LM	_LME	_LMEC
RESOLUTION	Atmos. – Land	M: 0.9x1.25 deg.	H: 0.23x0.31 deg.	*M: 0.9x1.25 deg.*	L: 1.9x2.5 deg.	L: 1.9x2.5 deg.;	L: 1.9x2.5 deg.
	Ocean - Sea-Ice	H: 0.25 deg.	H: 0.25 deg.	*M: 1 deg.*	M: 1 deg.	M: 1 deg.	M: 1 deg.
PROCESSES	GHG	Concentration-driven	Concentration-driven	*Concentration-driven*	Concentration-driven	E: Emission-driven	E: Emission-driven
	Aerosol	Emis-driven, Compl physics	Emis-driven, Simple physics	*Emis-driven, Compl physics*	Emis-driven, Compl physics	Emis-driven, Compl physics	Emis-driven, Compl physics
	Atmos. Chem.	Simplified;	Simplified;	*Simplified;*	Simplified;	Simplified	C: Complex
	Ocean BioGeoC.	OFF	OFF	*OFF*	OFF	E: ON	E: ON
CMIP-DECK + CMIP6 Hist		ALL	Only AMIP	*OPTIONAL: ALL if _MH fails*	AMIP, PreInd, Historic	ALL except AMIP	Only AMIP
MIPs		•AerChemMIP •CFMIP •RFMIP •DAMIP •OMIP •ScenarioMIP •SIMIP	HighResMIP	*OPTIONAL. If _MH fails:* *AerChemMIP* *•CFMIP* *•RFMIP* *•DAMIP* *•OMIP* *•ScenarioMIP* *•SIMIP*	•AerChemMIP •CFMIP •DAMIP •DCPP •LS3MIP •LUMIP •OMIP •PMIP •RFMIP •ScenarioMIP •VolMIP •SIMIP	•C4MIP •LUMIP • LS3MIP •OMIP	•AerChemMIP •VolMIP

Remarks on Status for NorESM2

CMIP DECK:

NorESM2_MH (or _**MM**) should be ready by end 2016/early 2017
ScenarioMIP, AerChemMIP, DAMIP

NorESM2_LM & LME should be ready before summer 2017.
ScenarioMIP, C4MIP, DAMIP, LUMIP, LS3MIP, AerChemMIP

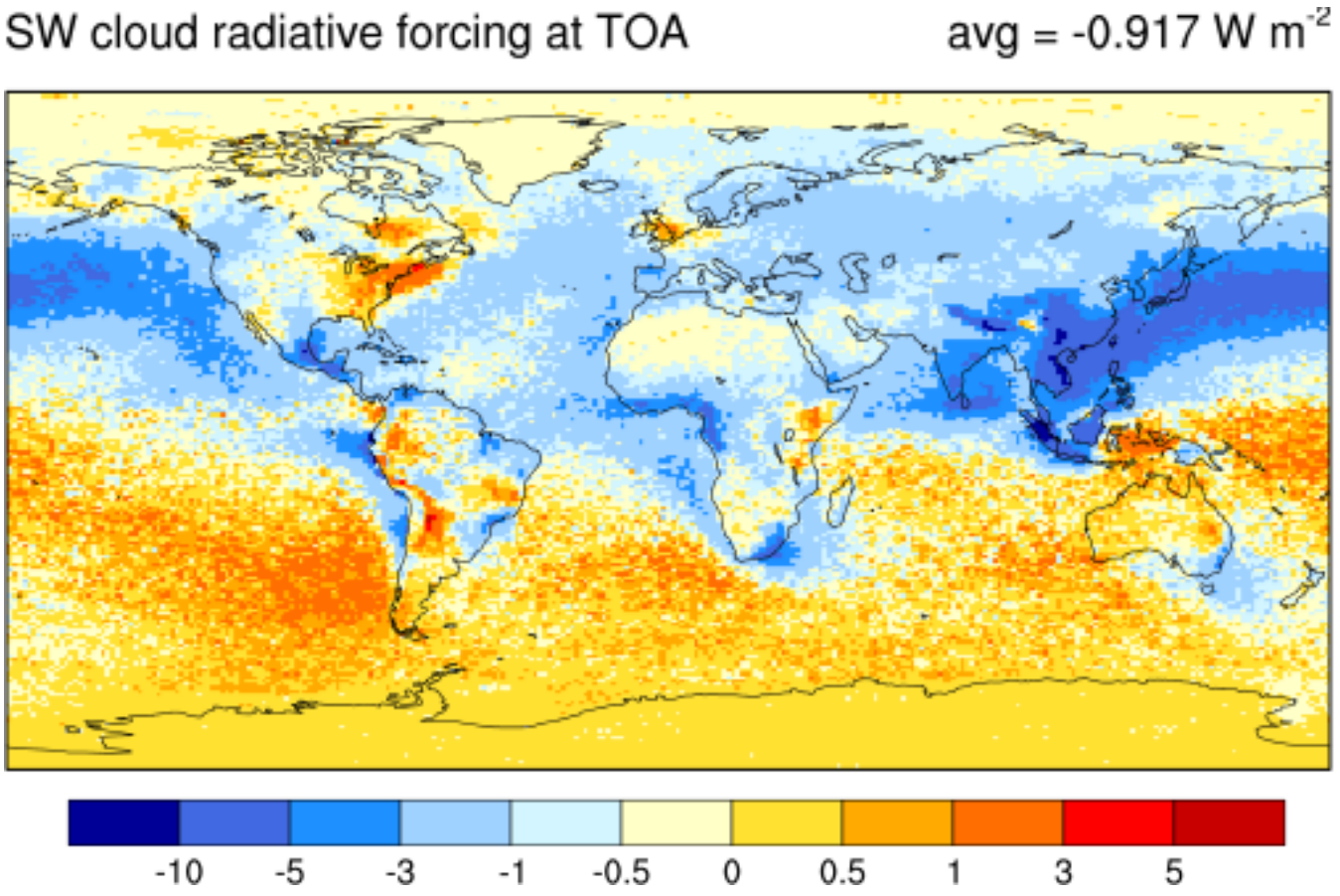
Important aerosol related updates: CAM4-Oslo → CAM5-Oslo:

1) "Oslo aerosols" as an option alongside CAM5's MAMx
2) Explicit treatment of aerosols in cloud-water
3) New sea-salt emission parametrization (Salter et al., 2015)
4) Terrestrial BVOC-emissions from CLM4.5 →SOA
5) Explicit aerosol nucleation of H2SO4 + SOA
6) Online oceanic biogenic POM and DMS emissions
7) Improved heterogeneous ice nucleation treatment
8) Conservation of energy-consistency – fix implemented
9) Several bug fixes since CAM4-Oslo (alas!)
10) Nitrate aerosols: in progress

Indirect RF in CAM4-Oslo vs. **ERF ACI** in CAM5-Oslo (W m^{-2}):

(Only minor changes in direct radiative forcing, ca. -0.1 – 0.0 W m^{-2})

	SW	LW	Main new features/bug-fixes
CAM4-Oslo (Ind. RF)	**-0.91**	**+0.01**	**(Indirect RF; NorESM1 for CMIP5)**
CAM5.3-Oslo ERF ACI	**-0.92**	**+0.14**	**Most recent CAM5.3-Oslo version**
	-1.27	+0.22	New emissions, chemistry and aerosol cloud interactions, assumed hygroscopicity for CCN activation, and b.b. OM/OC=1.4 (reduced from 2.6)
	-1.16	+0.22	New sea-salt parameterization
	-1.46	+0.26	Bug-fixes for aerosol condensation, halved dust emissions
	-1.82	+0.34	On-line terrestrial BVOC → SOA life-cycling
	-1.71	+0.41	New Ice-Nucleation scheme and daily oxidants
	-1.20	+0.33	On-line DMS & oceanic biogenic POM



Hypotheses studied:

- Nucleation over oceans is high in PI due to inefficient condensation combined with large BVOC emissions upwind.
    - In NH, this is compensated by large PD SO2-emissions.
- Organic aerosols influence sea salt hygroscopicity
- Feedback to DMS emissions
- Different oxidant levels in PD and PI

Norwegian
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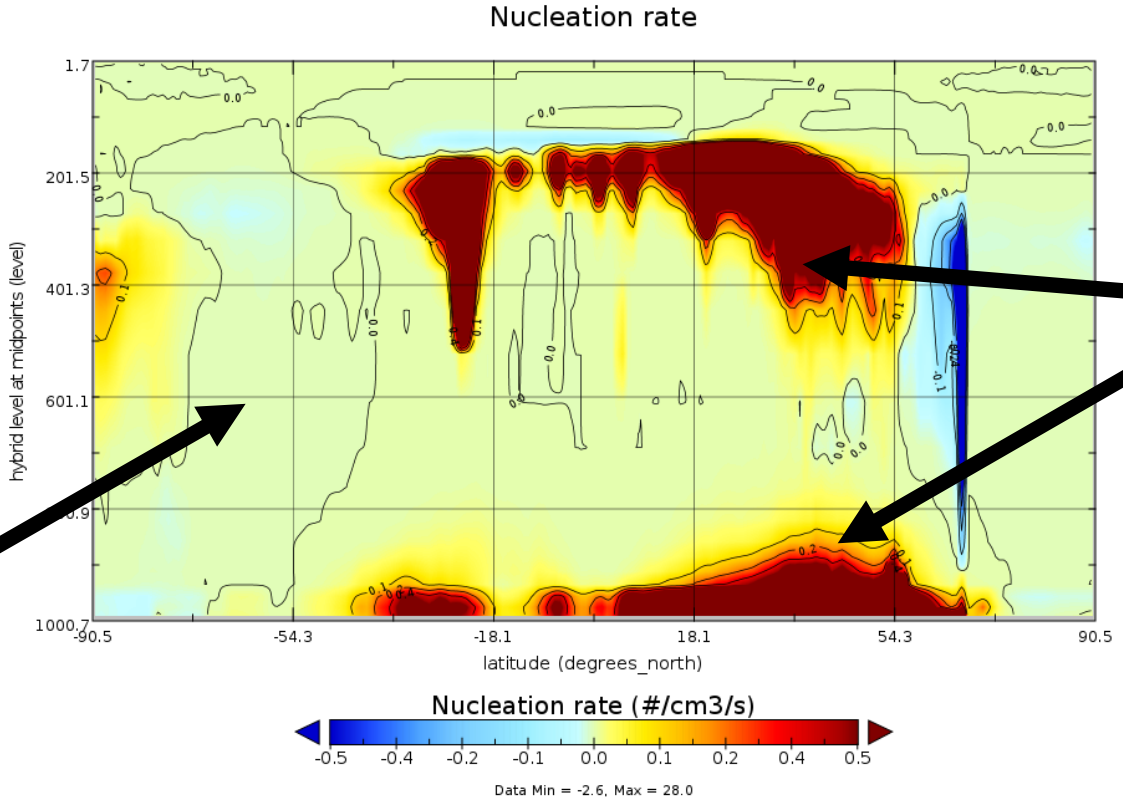
Thank you for the attention.

Different effect of nucleation NH/SH

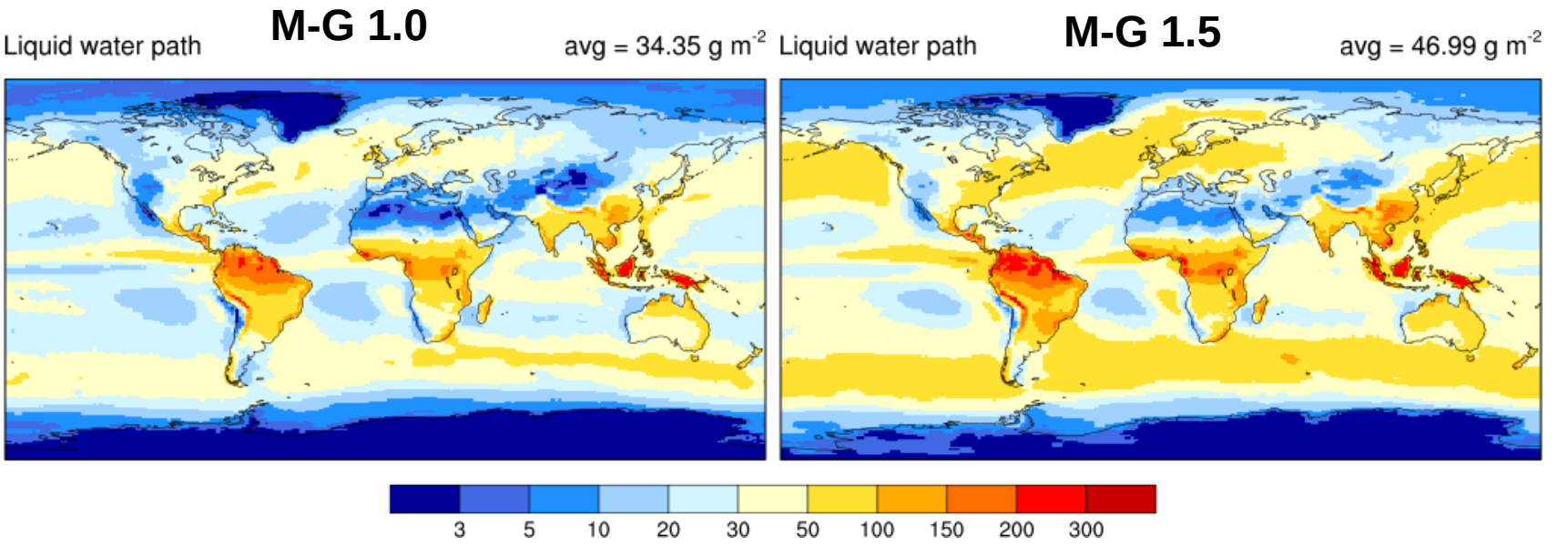


Positive values

Negative values

Difference in nucleation-rate PD – PI in REF-simulation. Increased nucleation in NH (due to larger SO2 I guess), but decreased nucleation over the areas where there are mostly sea-salt. (Due to more pulluted atmosphere in PD acting as “condensation sink for H2SO4(g))

Cloud water and ice

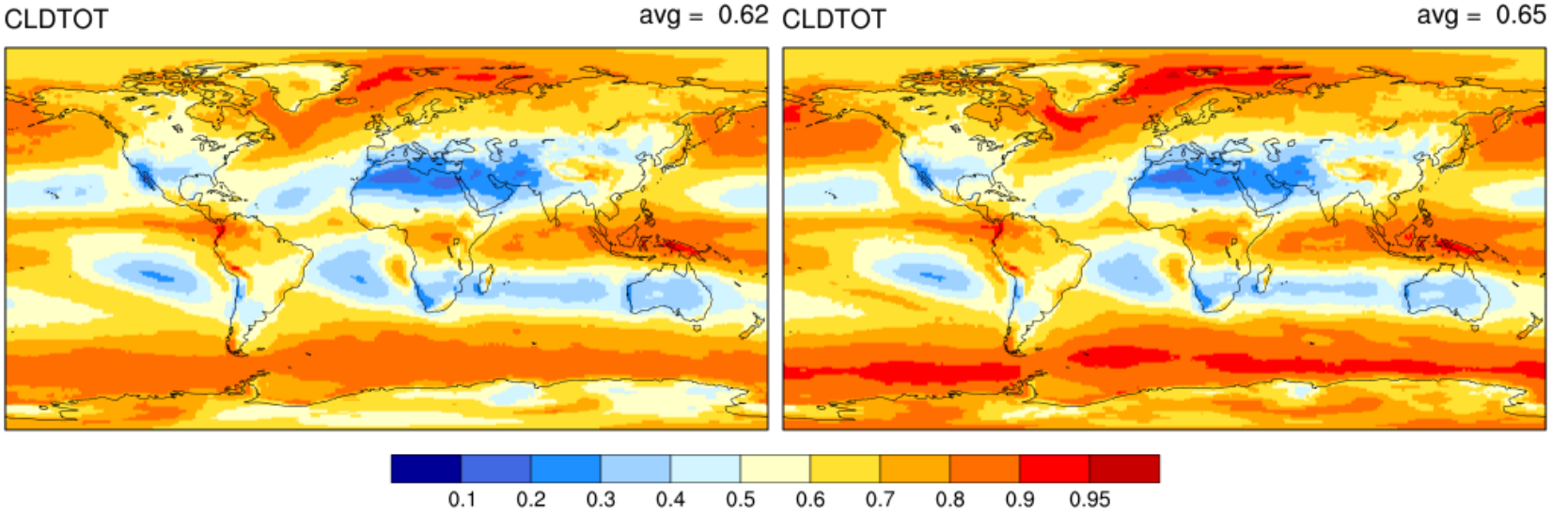


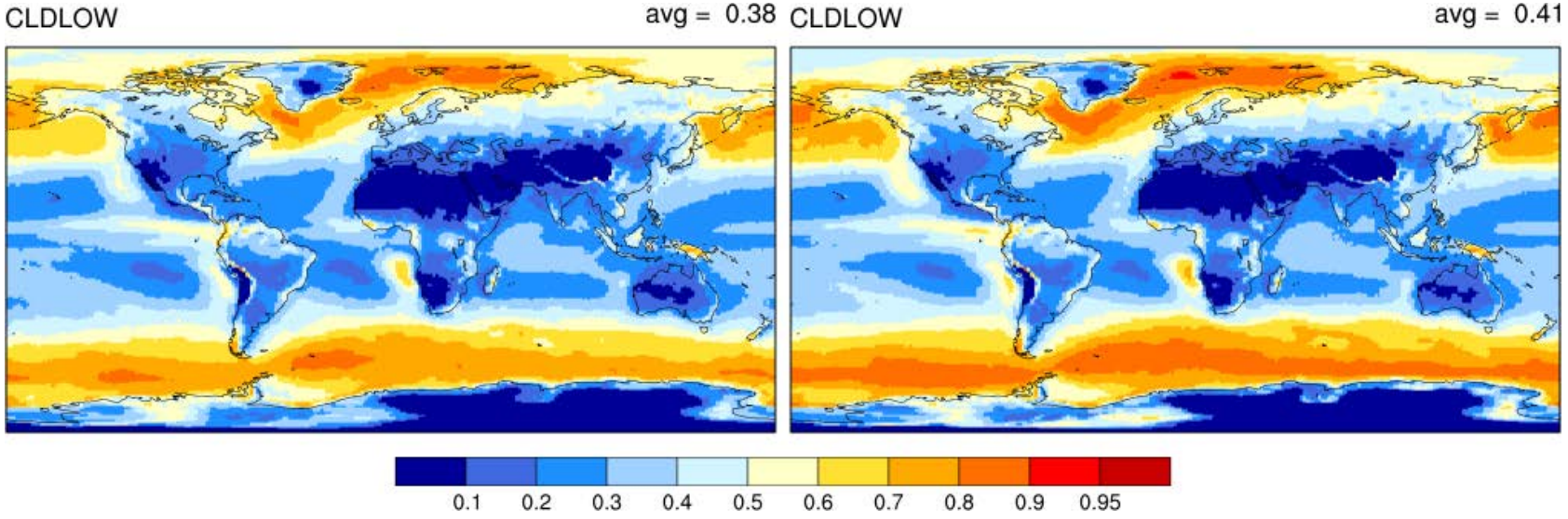
Free-running model has 10 % higher LWP than the nudged version

Cloud-fraction

M-G 1.0

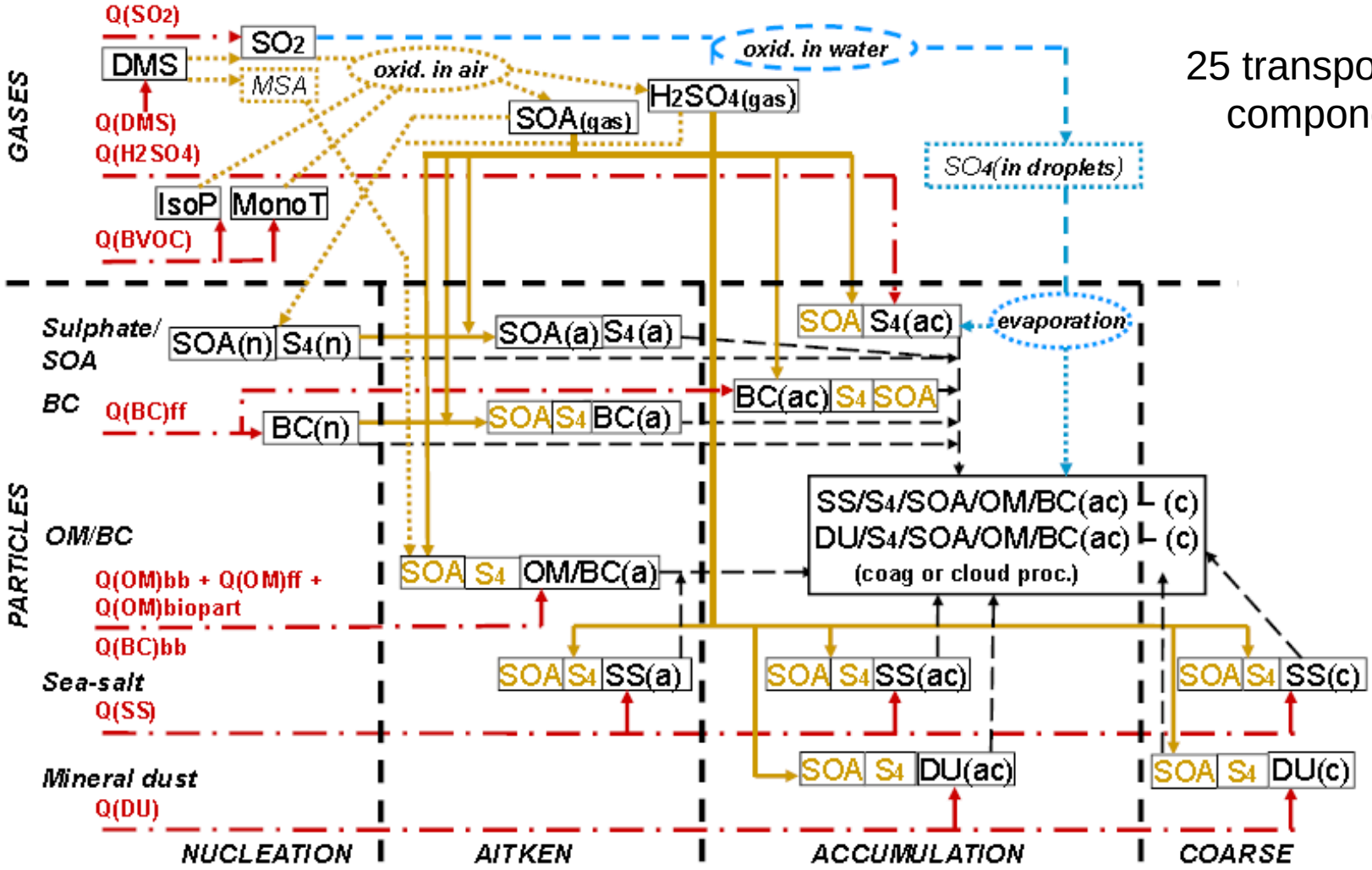
M-G 1.5





Complex aerosol-scheme extended since NorESM1 (CMIP5):

- Improved treatment of SOA/SO_4 nucleation and condensation.
- BVOC-->SOA explicit.
- Interactive marine DMS, bio-particles, sea-salt, and dust.
- Explicit concentrations in cloud droplets.



25 transported components

CAM5.3-Oslo

with nudging towards CAM5.3-AMIP U,V,T-fields

6 year simulations PD and PI, 2 final years used for statistics.

- M-G 1.0

  NorESM2-version 18. January 2016

- M-G 1.5

  Morrison-Gettelmann 1.5 is used instead of MG