CAM4 with Prognostic Aerosols and MICOM-BCM Ocean Model (NorESM)

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NorClim

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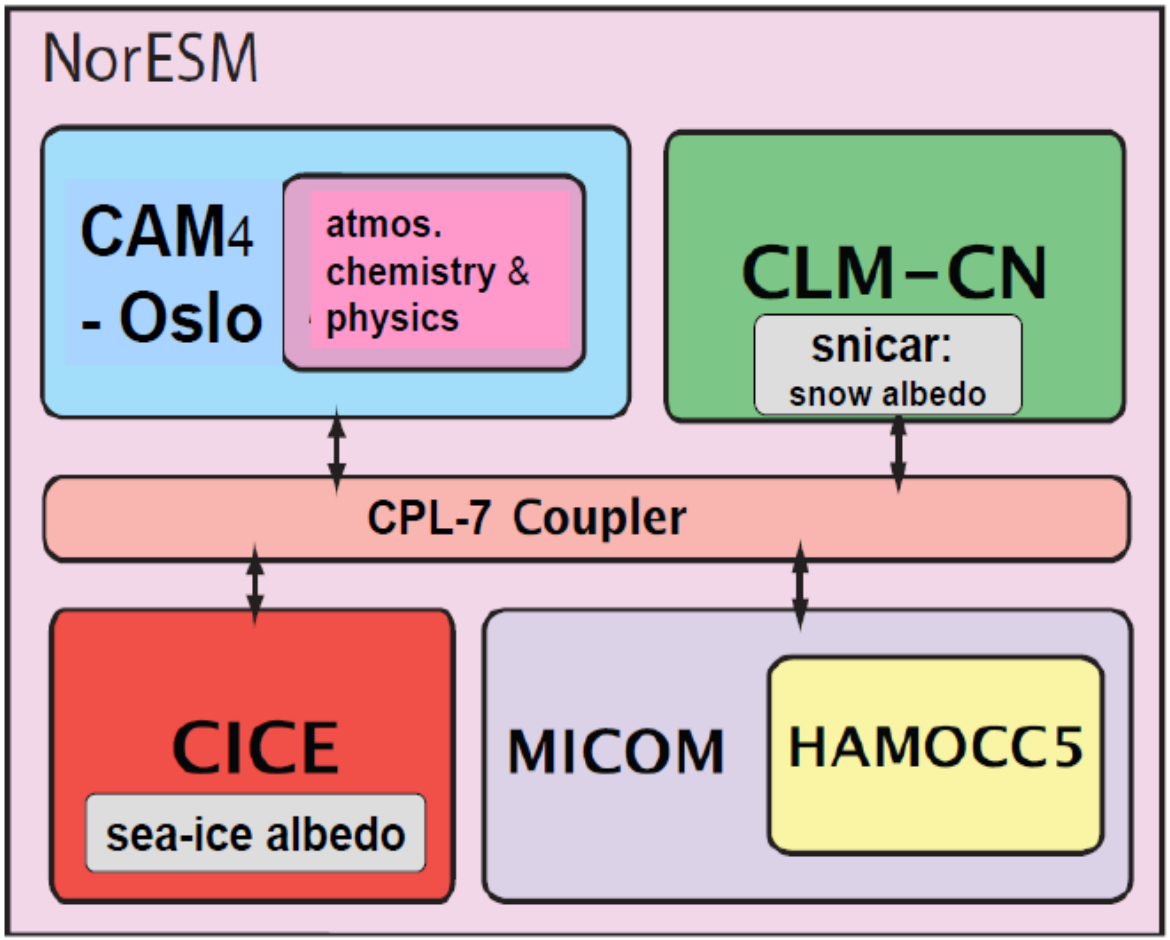
AMWG ,
Boulder, Feb 14- Feb 16. 2011

Overview

- Model description
- NorESM atmospheric chemistry and physics
  - Aerosols, optical properties, and CDNC
  - Radiative forcing
- Results from CMIP spin-up run
- Ongoing and planned CMIP5 simulations

NorESM components and interactions

(based on NCAR CCSM4 and MICOM, with on-line aerosol-cloud-radiation, and on-line ocean carbon cycling)



CAM(4)-Oslo

- NCAR Community Atmosphere Model 4 (CAM4; April 1. 2010) extended with:

  [Seland et al. (2008); Kirkevåg et al. (2008), *Tellus* ***60A***, Storelvmo et al. (2008), *Env. Res. Lett.* ***3***, Hoose et al. (2009), *Geophys. Res. Lett.* ***36.***]

  - Aerosol life-cycling of sulphate (SO_4), black carbon (BC), organic matter (POM and biogenic SOA), sea-salt (SS), mineral dust (DU)
  - Aerosol size distribution and size-resolved composition
    - Aerosol optical properties → direct aerosol forcing
    - Cloud droplet numbers and sizes → 1. & 2. indirect aerosol forcing

- Relevant further upgrades include:
  - IPCC AR5 aerosol and precursor emissions
  - Biogenic ocean POM included; biomass POM & biogenic SOA increased
  - Modified aerosol chemistry
  - Adjusted aerosol processes in convective clouds
  - Online wind- and temp.-dependent sea-salt emis.

  (Struthers et al., 2010, *ACPD* **10**)

Light-absorption by soot and mineral dust on snow and sea-ice is included in NorESM

In the land model (CLM4 from NCAR):

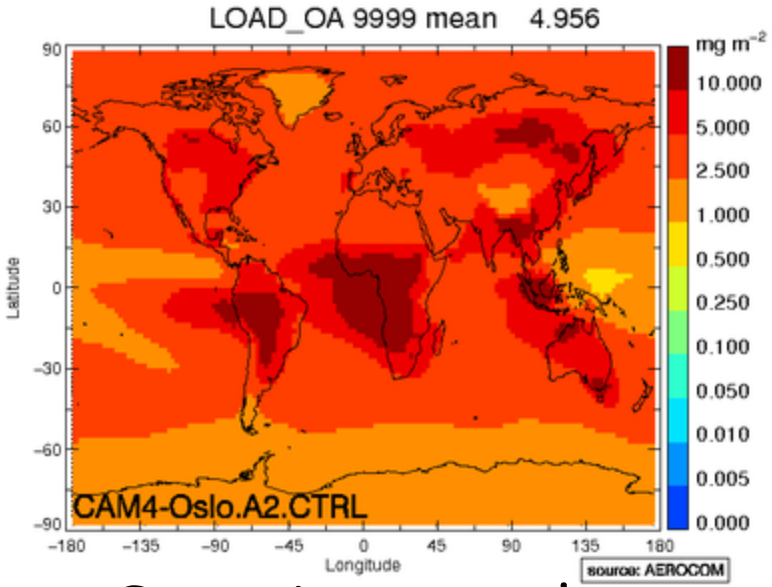
The SNow, ICe, and Aerosol Radiative (SNICAR) model (Flanner et al., 2007; 2009)

- grain-size dep. snow aging
- aerosol deposition (**BC, DU**)
- meltwater scavenging of aerosol
- look-up tables for aerosol optical parameters
- multilayer radiative transfer in the snow

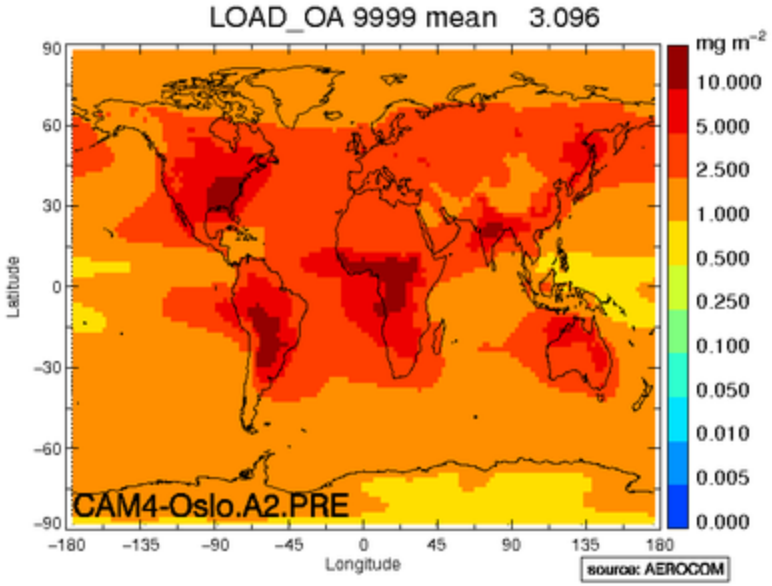
In the sea-ice model (CICE4 from NCAR):

(Holland et al., 2010, draft in preparation)

- aerosol deposition (**BC, DU**)
- BC and DU impact on snow albedo through CICE's own radiation transfer module

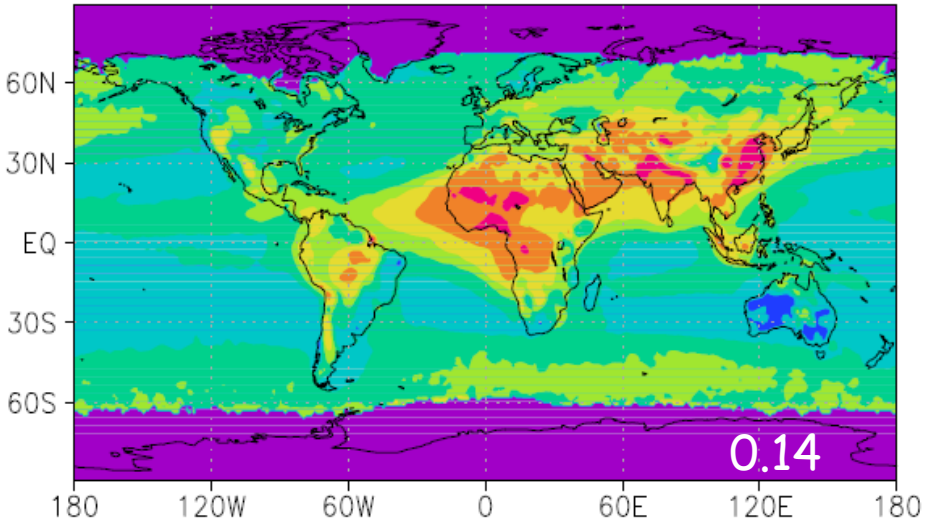


Organic aerosols

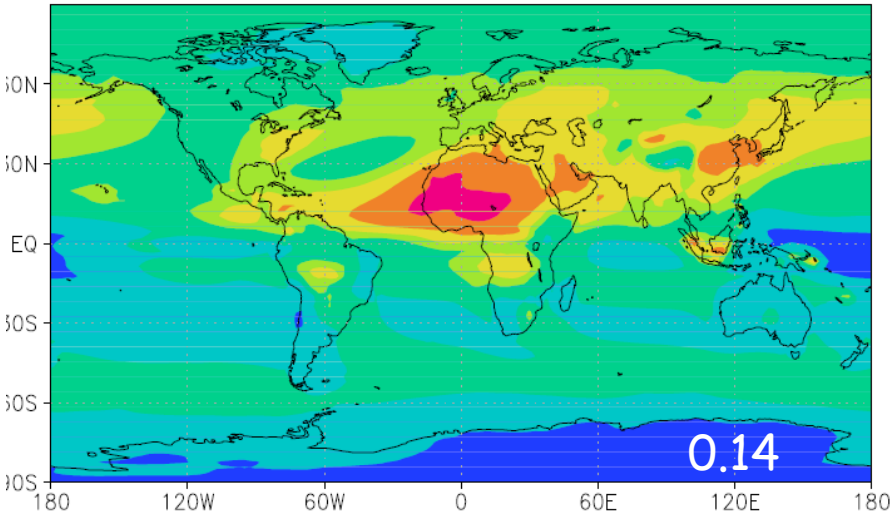


Modeled vs. observed Aerosol Optical Depth

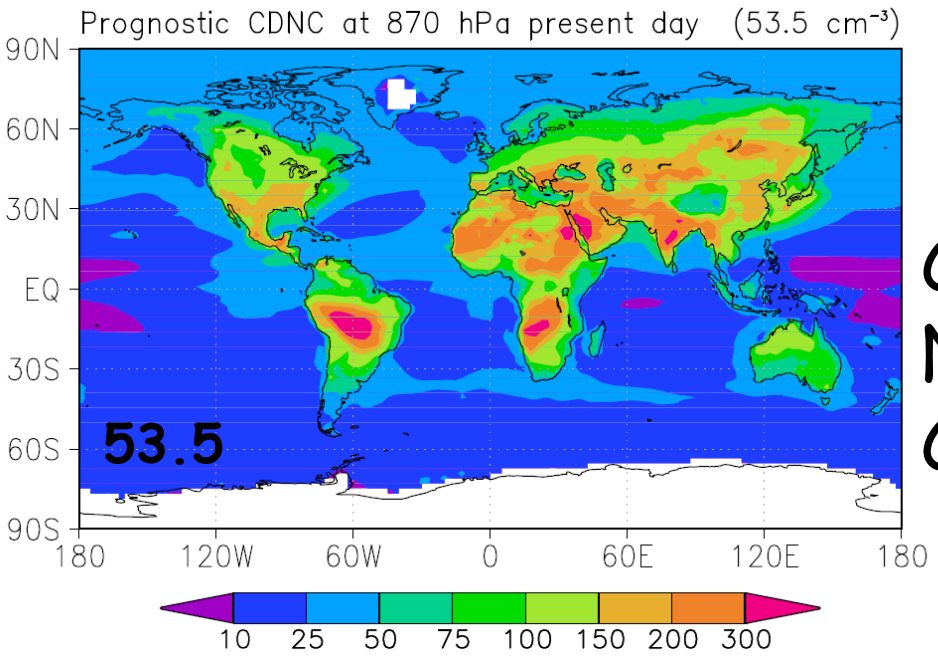
Modis + MISR + AERONET composite

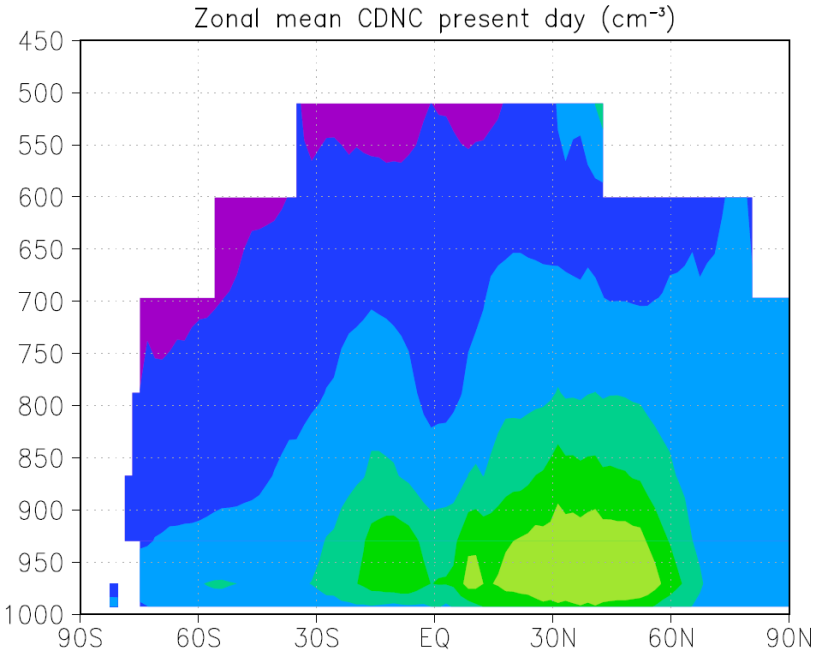


NorESM



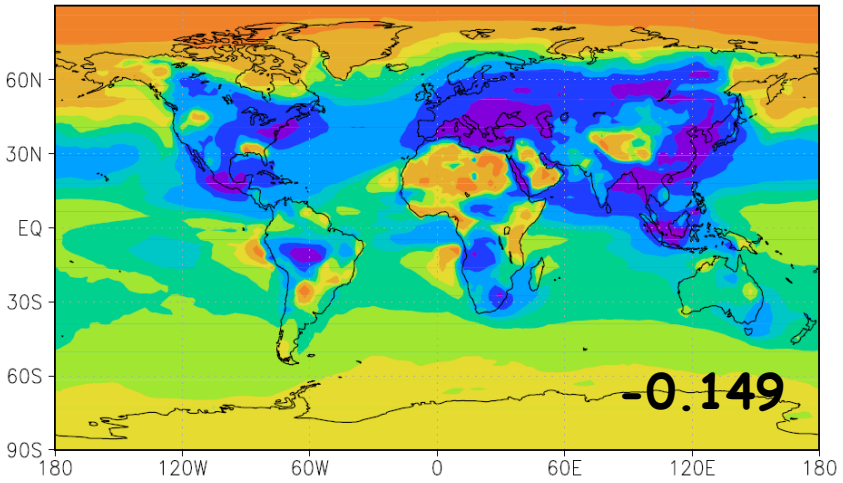
Stefan Kinne, pers. comm.



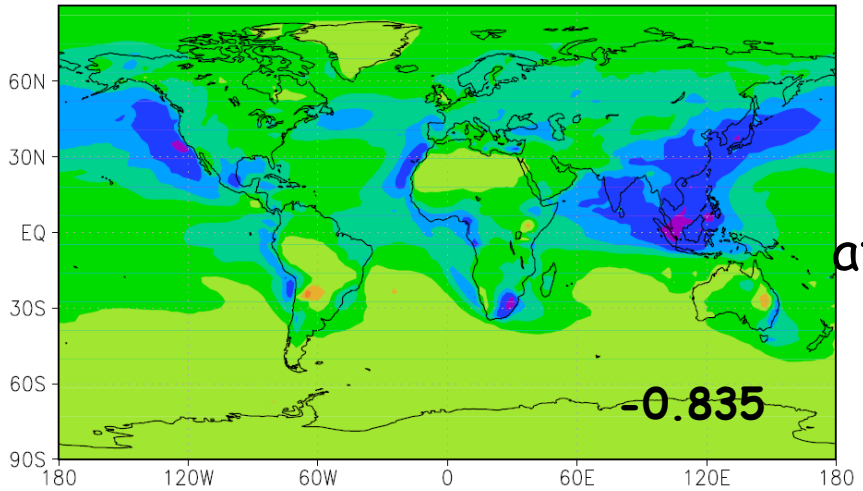


Cloud Droplet Number Concentration

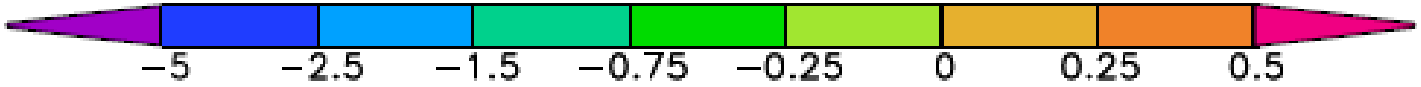
CTRL(2000) – PRE(1850)



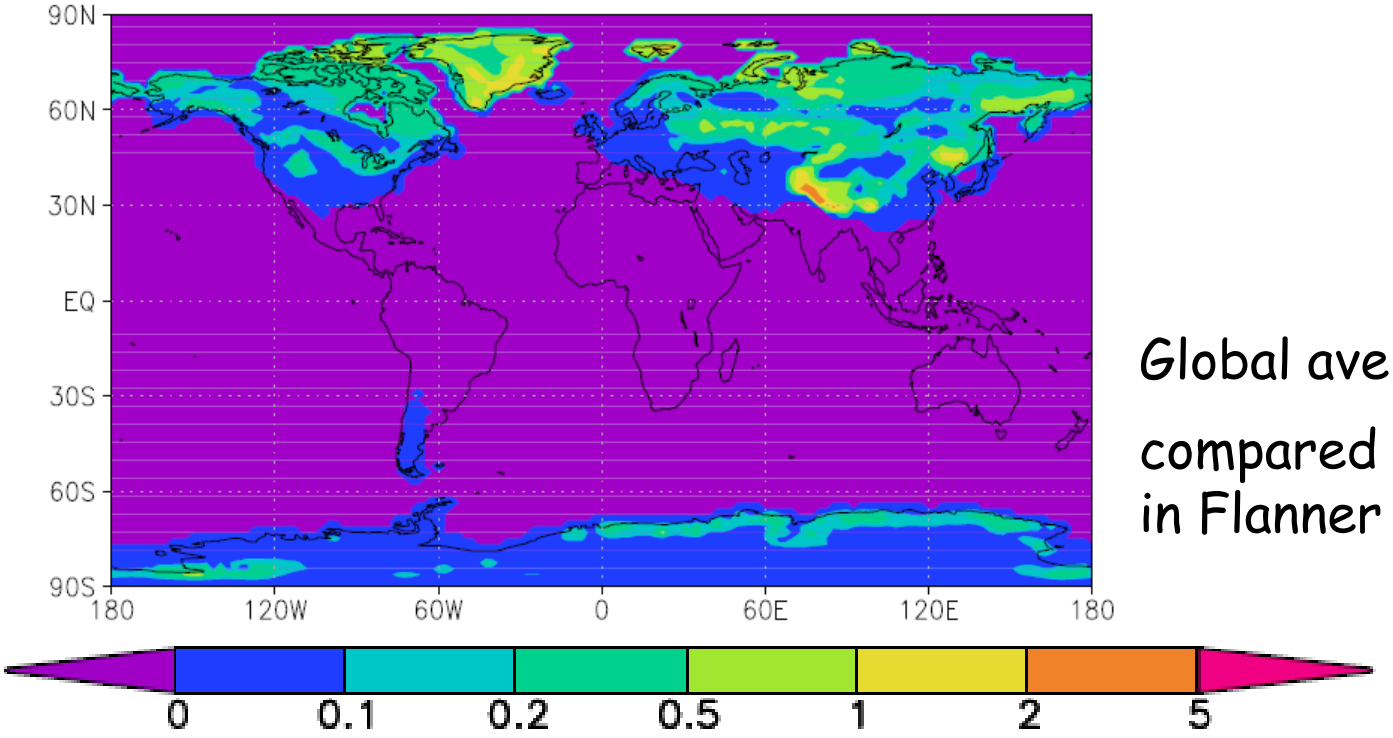
Short wave direct radiative forcing at TOA, **DRF** (W m^{-2})



Short wave indirect radiative forcing at TOA, **IndRF** (W m^{-2})



Snow BC forcing (W m^{-2}) over land, CTRL



Global average = 0.034 W m^{-2}

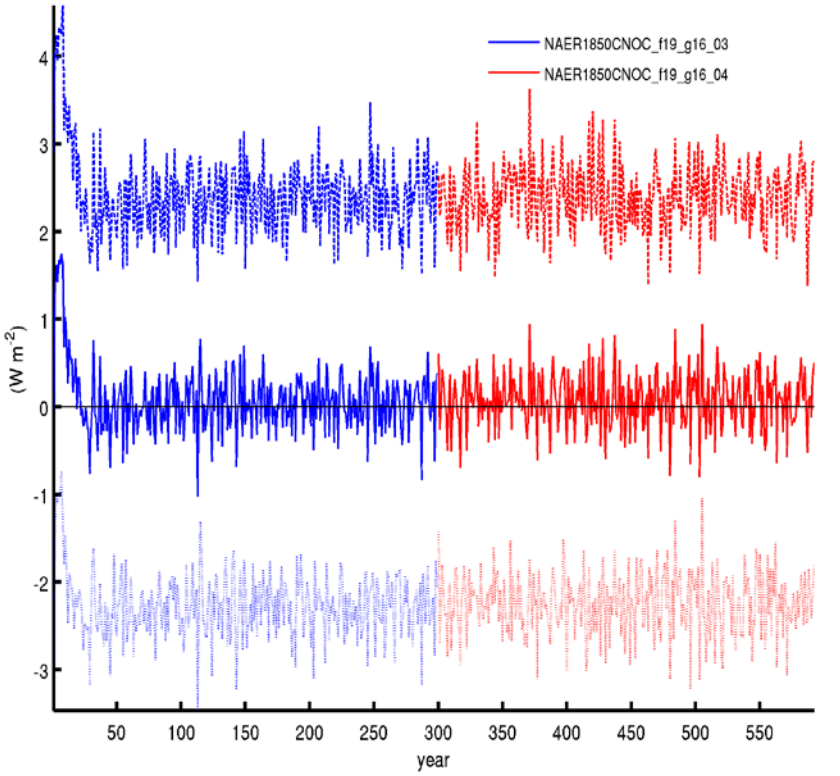
compared to ~ 0.05 W m^{-2} in Flanner et al. (2009)

NorESM spin-up

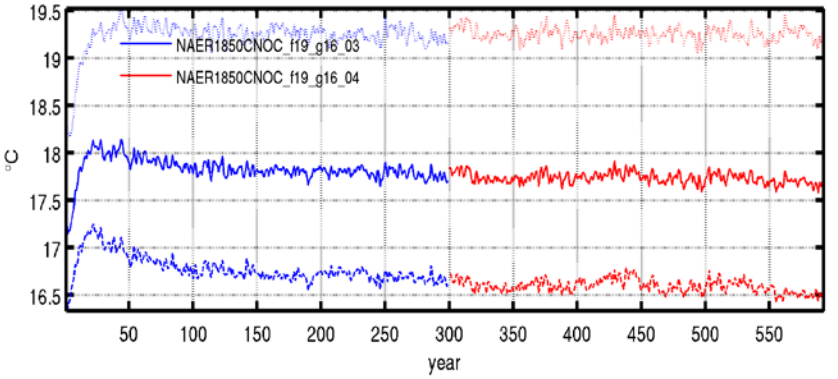
- 700 years of spin-up. Forcing presented from year 450-600.
- CMIP 5 500 year control initialized from year 700.

Energy budget and SSTdevelopment during spin-up

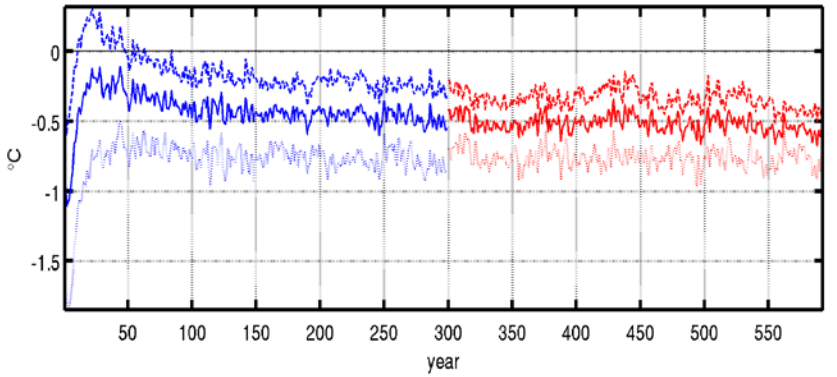
Net heat flux TOA (positive downward).
Solid line: global. Dotted line: Northern Hemisphere. Dashed line: Southern Hemisphere

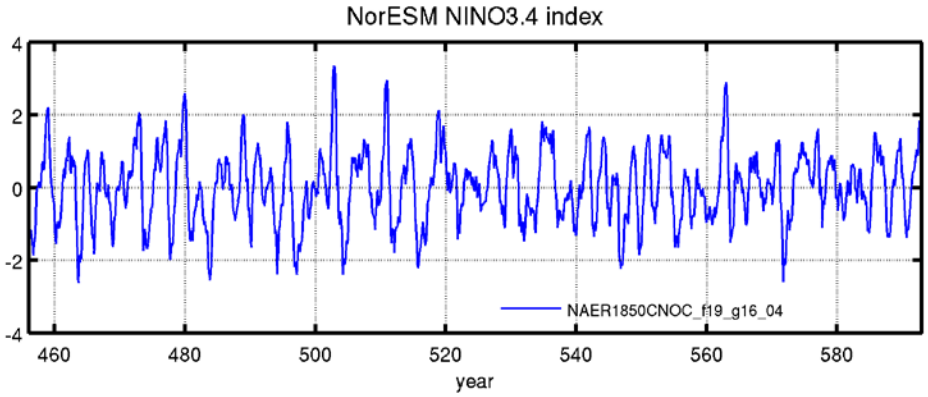


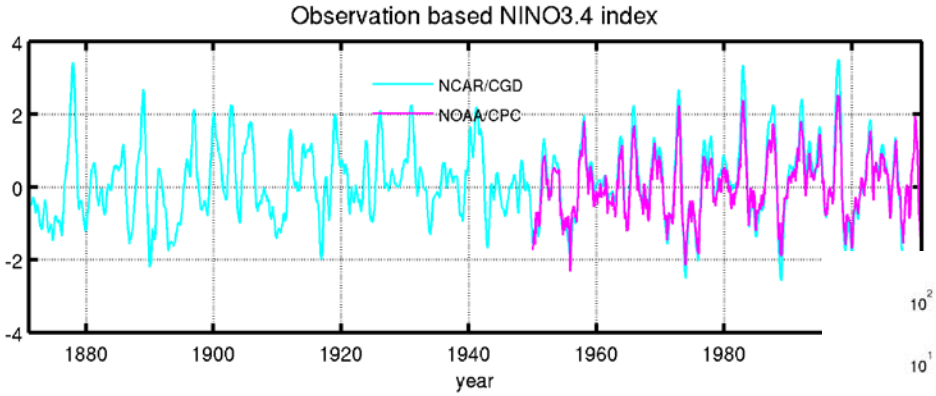
Sea surface temperature (SST).
Solid line: Global. Dotted line: Northern Hemisphere. Dashed line: Southern Hemisphere

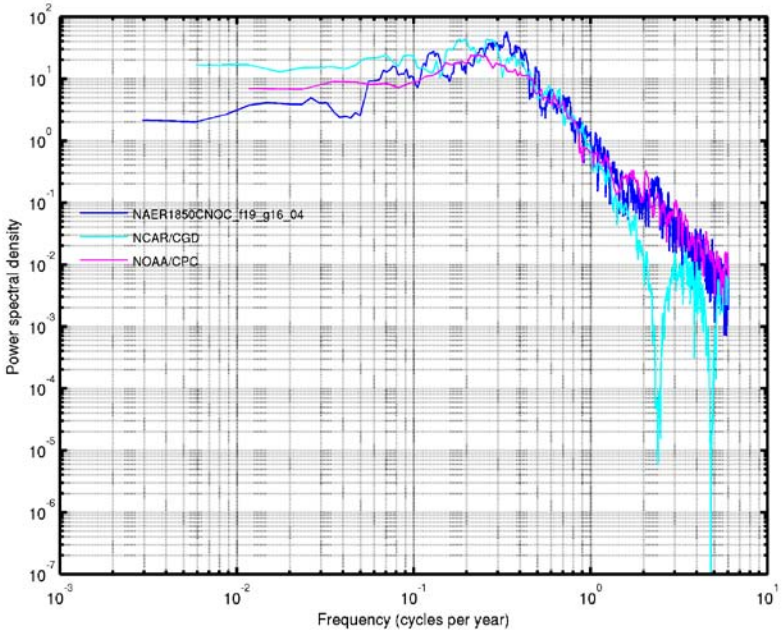


Difference from Levitus/PHC3.0




NorESM NINO3.4 index
NAER1850CNOC_f19_g16_04
year


Observation based NINO3.4 index
NCAR/CGD
NOAA/CPC
year


NAER1850CNOC_f19_g16_04
NCAR/CGD
NOAA/CPC
Power spectral density
Frequency (cycles per year)

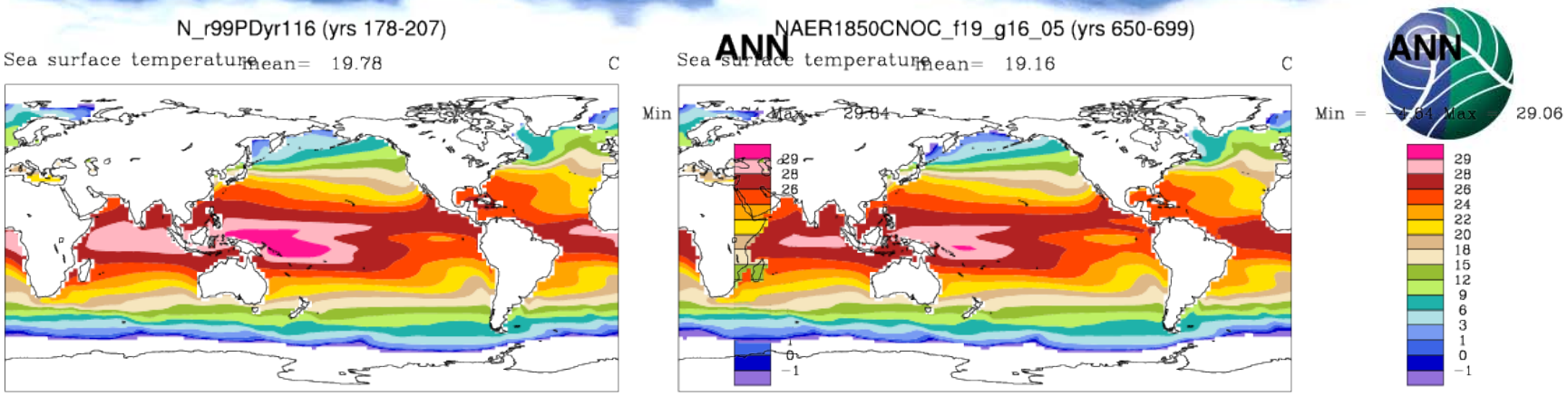
Preliminary comparison with measurements (NCAR diagnostics package)

- 1850 spin-up (Year 650-699)
- 2000 equilibrium run (Year 178-207)

N_r99PDyr116 (yrs 178-207)

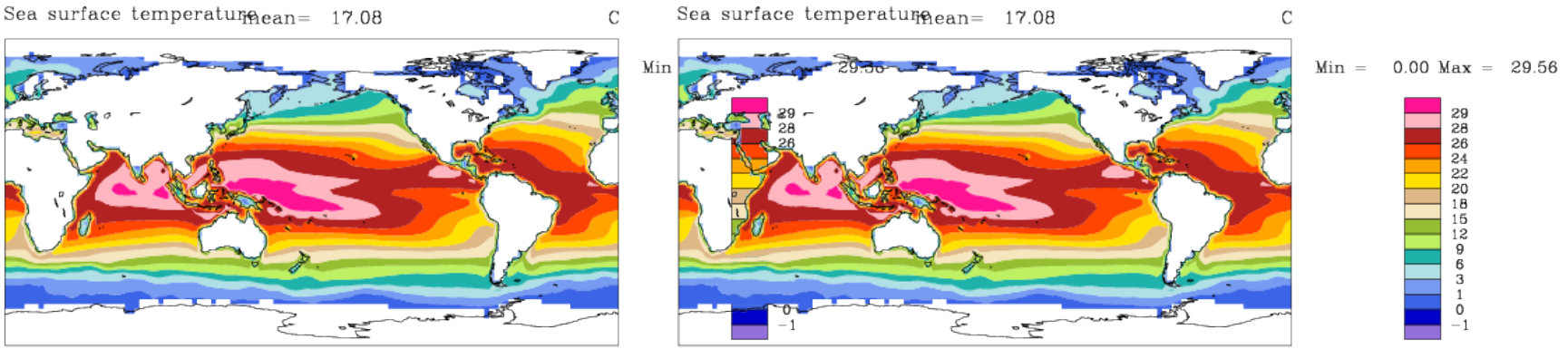
ANN

NAER1850CNOC_f19_g16_05 (yrs 650-699)



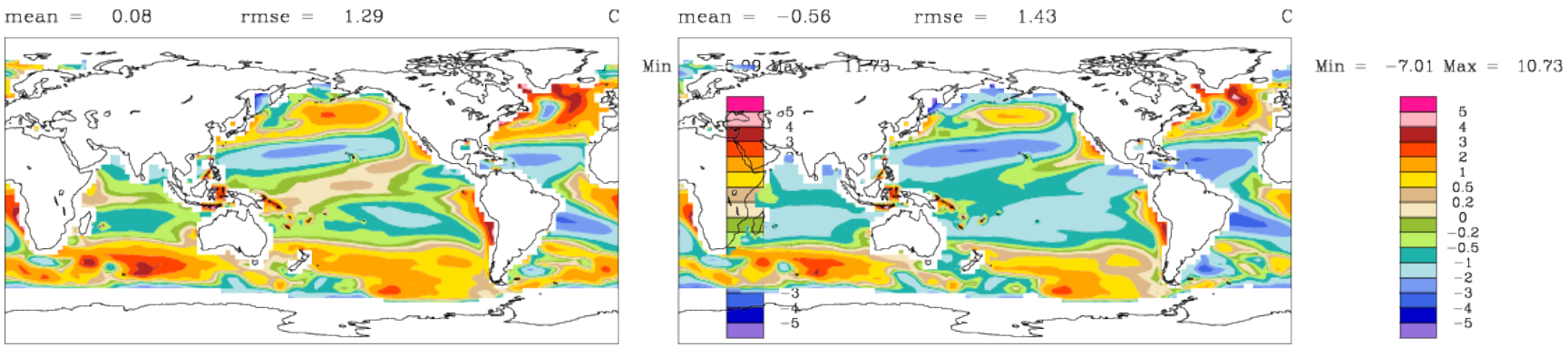
HadISST

HadISST



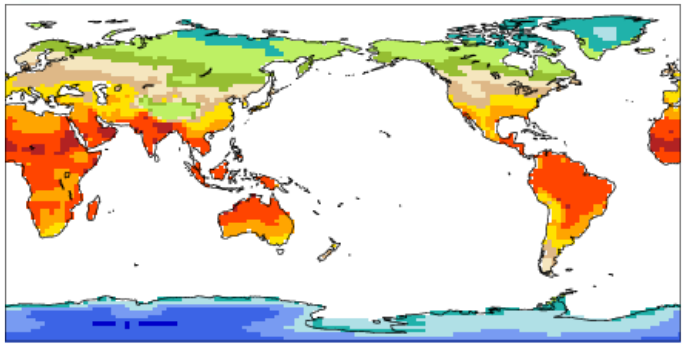
N_r99PDyr116 - HadISST

NAER1850CNOC_f19_g16_05 - HadISST



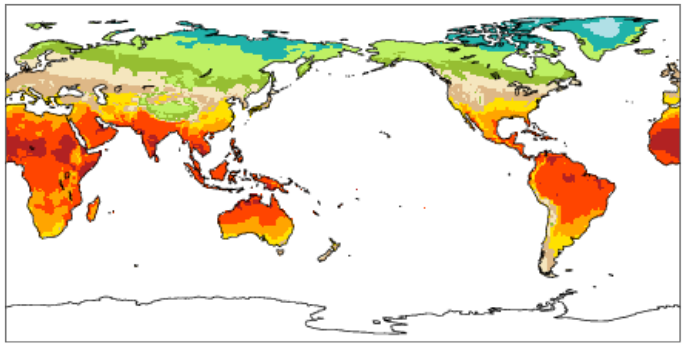
N_r99PDyr116 (yrs 178-207)

2−meter Temp (land) mean= 281.69 K



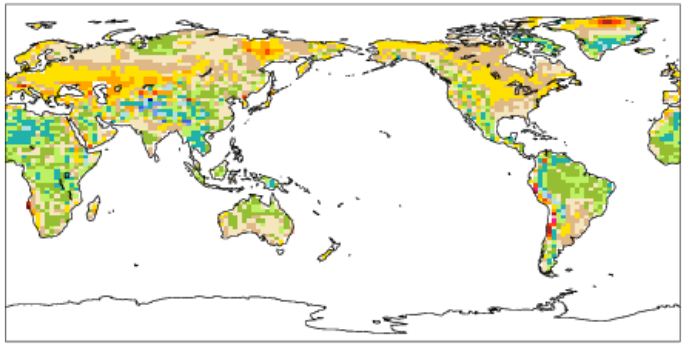
IPCC/CRU

2−meter Temp (land) mean= 286.04 K



N_r99PDyr116 - IPCC/CRU

mean = 0.37 rmse = 2.21 K



NAER1850CNOC_f19_g16_05 (yrs 650-699)

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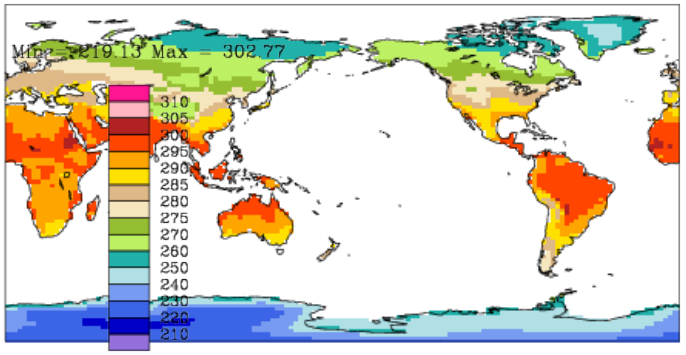
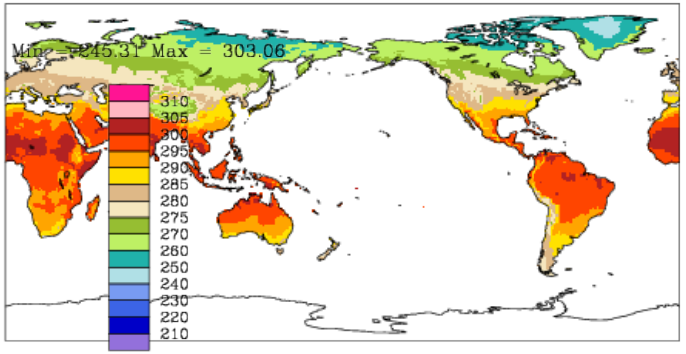
2−meter Temp (land) mean= 279.96 K



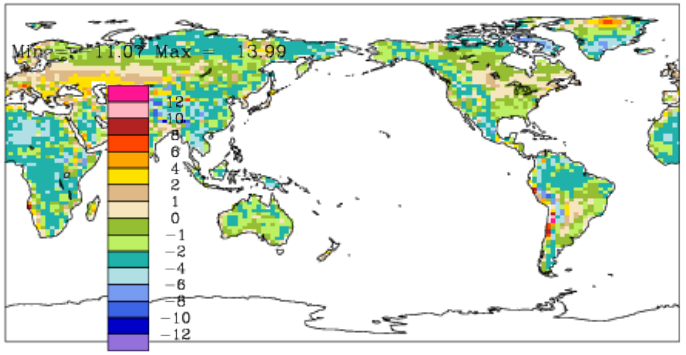
IPCC/CRU

2−meter Temp (land) mean= 286.04 K



NAER1850CNOC_f19_g16_05 - IPCC/CRU

mean = −1.45 rmse = 2.65 K



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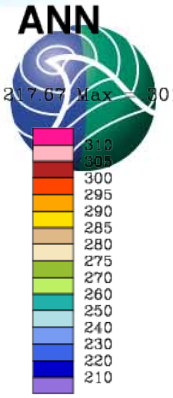

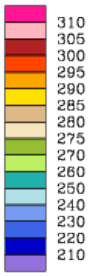

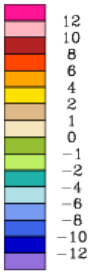

Planned NorESM coupled CMIP5 experiments without carbon cycle

Experiment	No.	Tier	Years	Ens. size	Type
Pre-industrial control	3.1	core	>500	1	CPL
Historical (1850-2005)	3.2	core	156	1	CPL
Ensemble of historical runs	3.2-E	tier 1	156	2	CPL
RCP4.5 (2006-2100)	4.1	core	95	1	CPL
RCP4.5 (2100-2300)	4.1-L	tier 1	200	1	CPL
RCP8.5 (2006-2100)	4.2	core	95	1	CPL
RCP8.5 (2100-2300)	4.2-L	tier 2	200	1	CPL
RCP2.6 (2006-2100)	4.3	tier 1	95	1	CPL
1% per year CO2	6.1	core	140	1	CPL
Abrupt 4xCO2	6.3	core	150	1	CPL
Historic with natural forcing only	7.1	tier 1	156	1	CPL
Historic with GHG forcing only	7.2	tier 1	156	1	CPL
Historic with other individual forcing	7.3	tier 1	156	1	CPL

started Feb 1.
After 700 yr spin-up

started Feb 2.

Started Feb 9.

Planned NorESM atmosphere only CMIP5 experiments

Experiment	No.	Tier	Years	Ens. size	Type
2030 time-slice	2.1	core	10	1	A
AMIP (1979-2008)	3.3	core	30	1	A
Ensemble of AMIP runs	3.3-E	tier 1	30	3	A
Control SST climatology (from exp 3.1)	6.2a	core	>30	1	A
CO2 forcing	6.2b	core	>30	1	A
Aerosol forcing	6.4	core	>30	1	A
4xCO2 AMIP	6.5	tier 1	30	1	A

Planned NorESM coupled CMIP5 experiments with carbon cycle

Experiment	No.	Tier	Years	Ens. size	Type
ESM pre-industrial control	5.1	core	>250	1	ESM
ESM historical	5.2	core	156	1	ESM
ESM RCP8.5 (2006-2100)	5.3	core	95	1	ESM
ESM fixed climate 1	5.4-1	tier 1	140	1	ESM
ESM fixed climate 2	5.4-2	tier 1	251	1	ESM
ESM feedback 1	5.5-1	tier 2	140	1	ESM
ESM feedback 2	5.5-2	tier 2	251	1	ESM

Possible NorESM coupled CMIP5 experiments with lower resolution

(Only standard CAM4)

Experiment	No.	Tier	Years	Ens. size	Type
mid-Holocene	3.4	tier 1	>100	1	CPL
Last glacial maximum	3.5	tier 1	>100	1	CPL
Last millennium	3.6	tier 2	1000	1	CPL

Historic simulation 1850-1943

T 2m