Arctic Sea-ice in Climate Scenarios

Kathrin Riemann-Campe

Kathrin.Riemann-Campe@awi.de

Alfred-Wegener-Institut

Bremerhaven

Overview

- Data source: CMIP5 models
  - What are CMIP5 models?
  - Emission scenarios
- The diversity of past sea ice concentration
- How to select the better models?
- Future sea ice concentration
- Summary

What are CMIP5 models?

- **C**oupled **M**odel **I**ntercomparison **P**roject Phase **5**
  standard experimental protocol for studying the output of coupled atmos.-ocean general circulation models (AOGCMs)

- by World Climate Research Programme (WCRP)

- standard experiments:
  - historical simulation (1850-2005)
  - future emission scenarios (2006-2100)
  - etc.

- freely available
  http://pcmdi9.llnl.gov/esgf-web-fe

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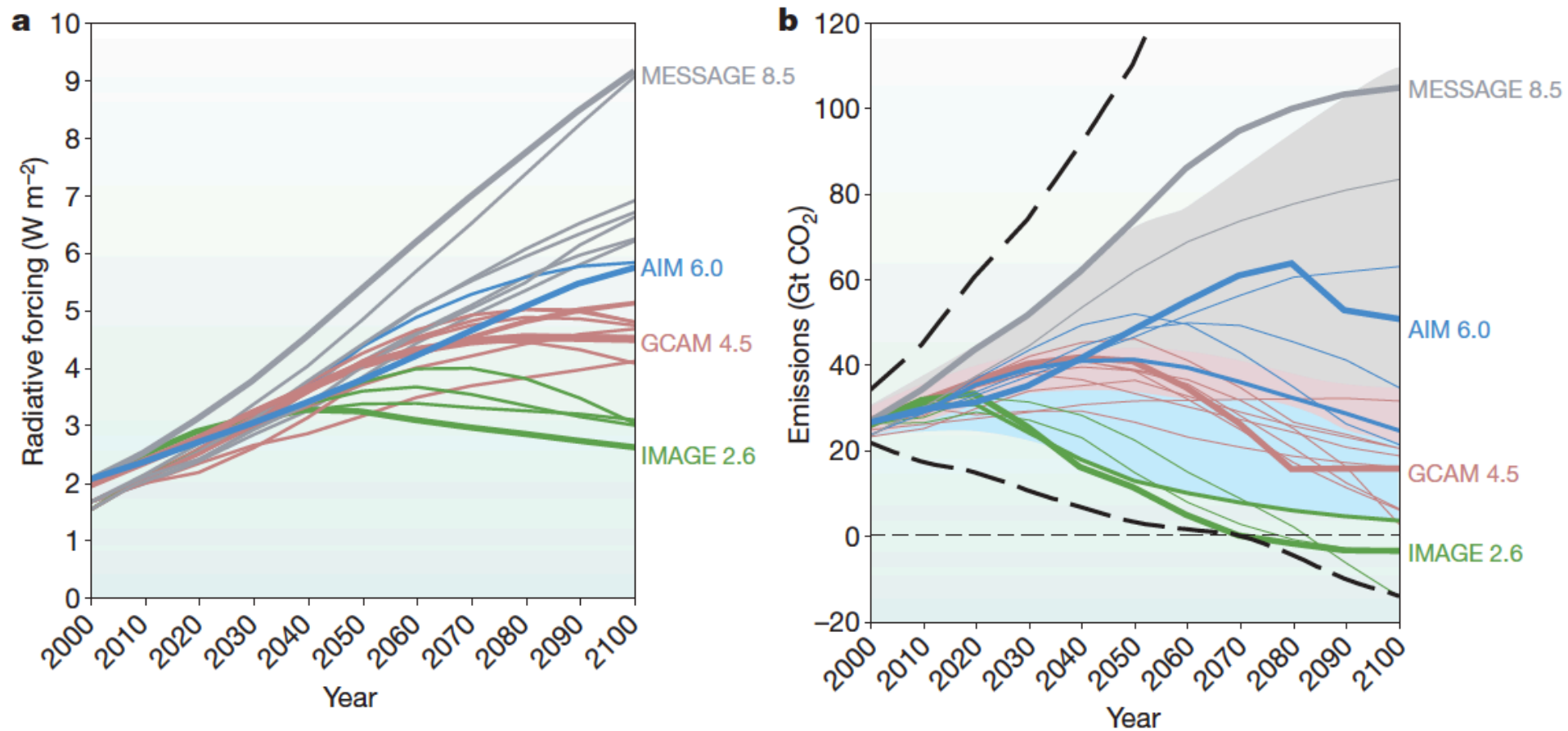 http://pcmdi9.llnl.gov/esgf-web-fe

Emission Scenarios

Representative Concentration Pathways (RCP)

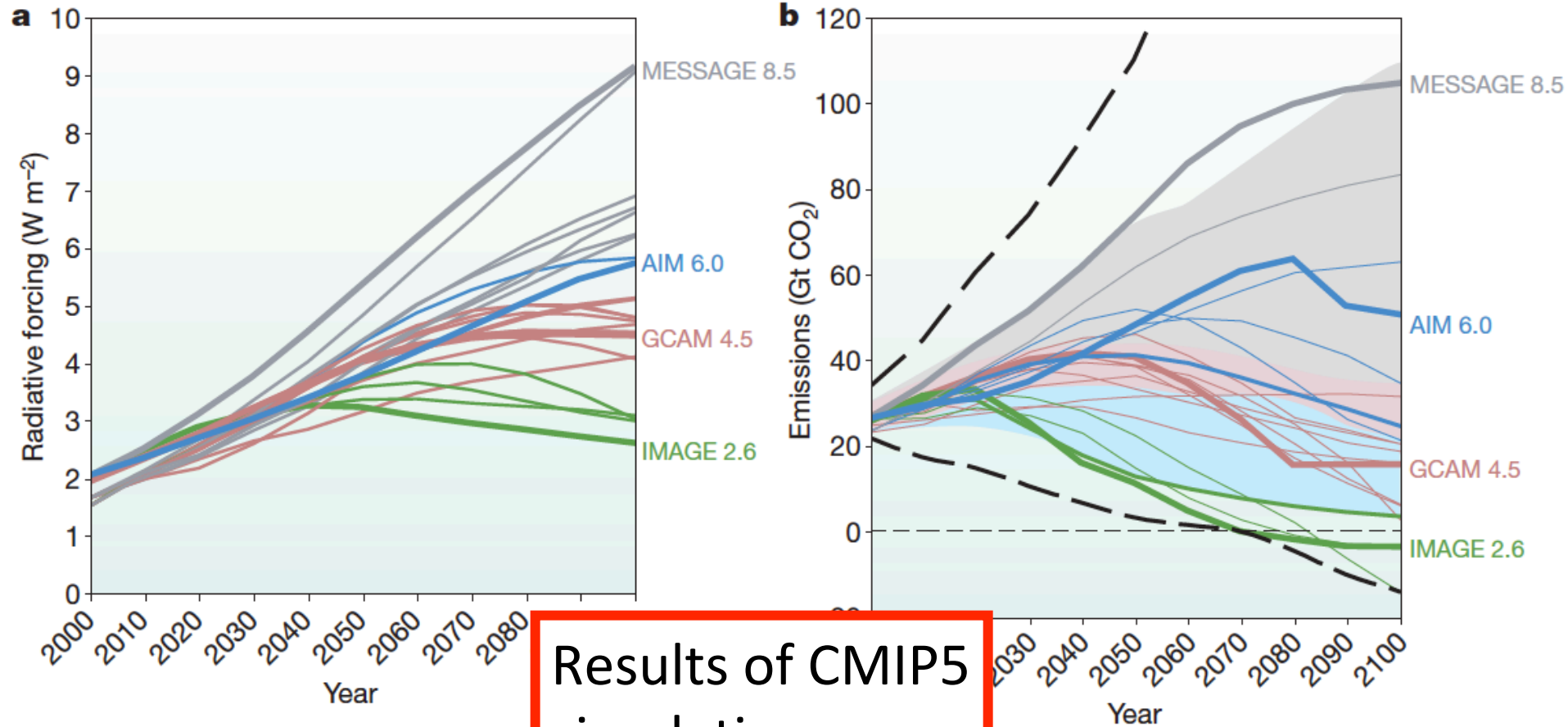| Name	Radiative forcing	Concentration of CO_2-equiv. in ppm	Pathway
RCP8.5	> 8.5 W m^{-2} in 2100	> 1370 in 2100	rising
RCP6.0	~ 6 W m^{-2} at stabilization after 2100	~ 850 at stabilization after 2100	stabilization without overshoot
RCP4.5	~ 4.5 W m^{-2} at stabilization after 2100	~ 650 at stabilization after 2100	stabilization without overshoot
RCP2.6	Peak at ~3 W m^{-2} before 2100 and then declines	peak at ~ 490 before 2100 and then declines	peak and decline

Moss et al., 2010

Emission Scenarios
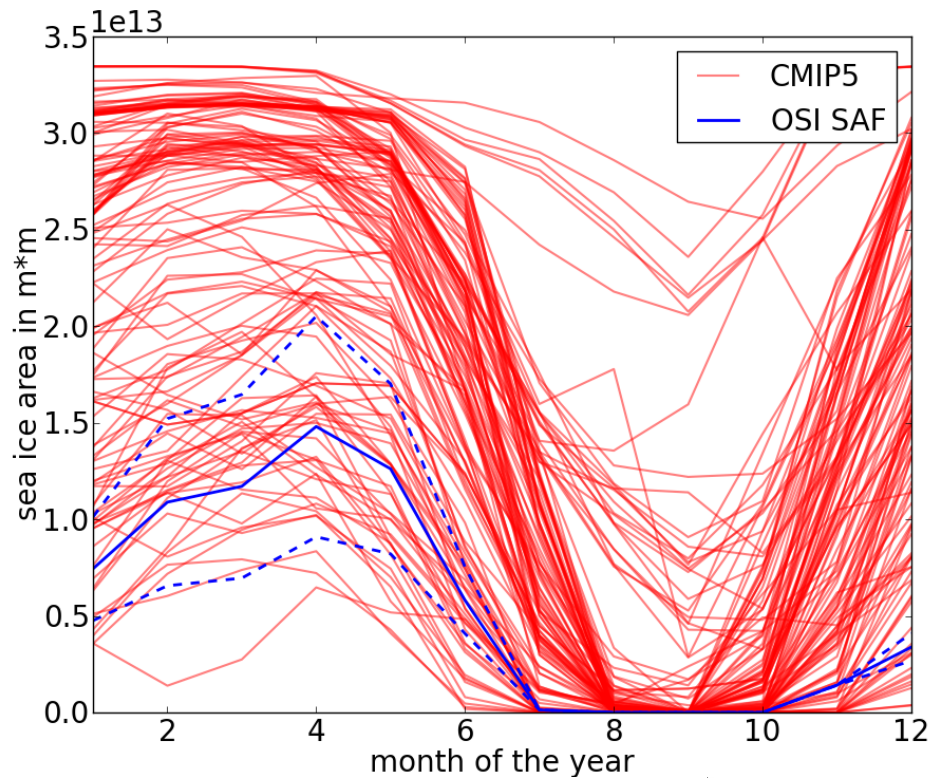

Moss et al., 2010

Emission Scenarios

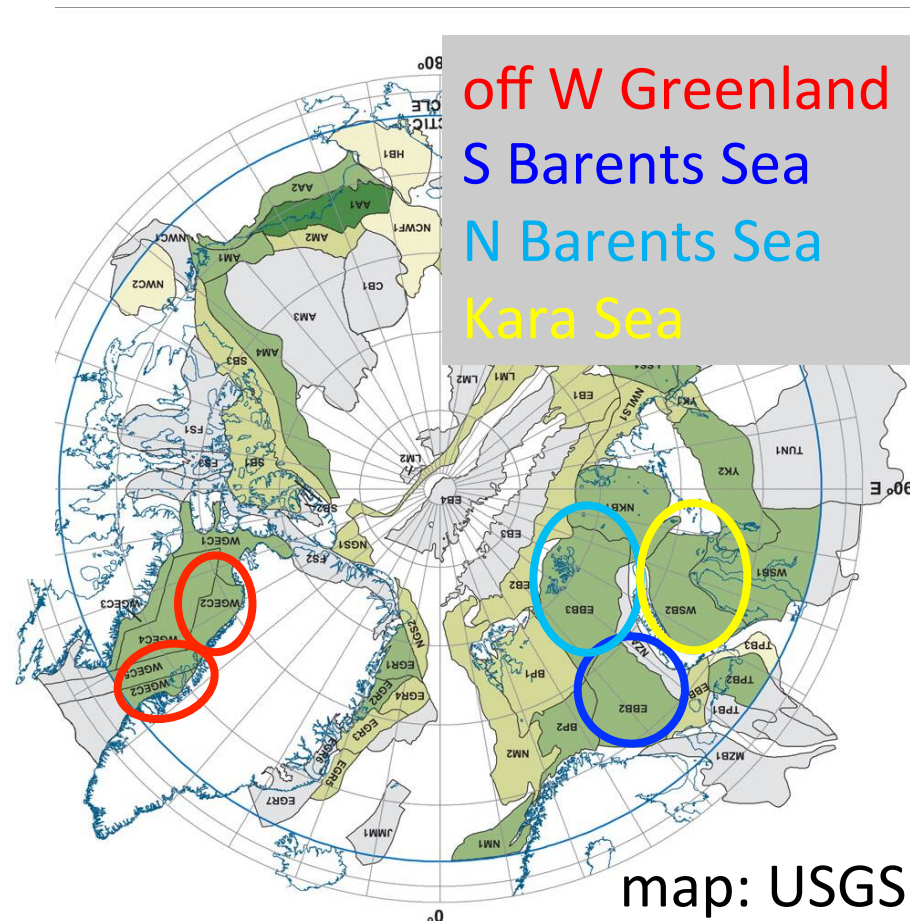Moss et al., 2010

Results of CMIP5 simulations are discussed in the IPCC reports.

The diversity of past sea ice concentration (sic)

Mean seasonal cycle 1979-2005 area integrated sic Southern Barents Sea

off W Greenland
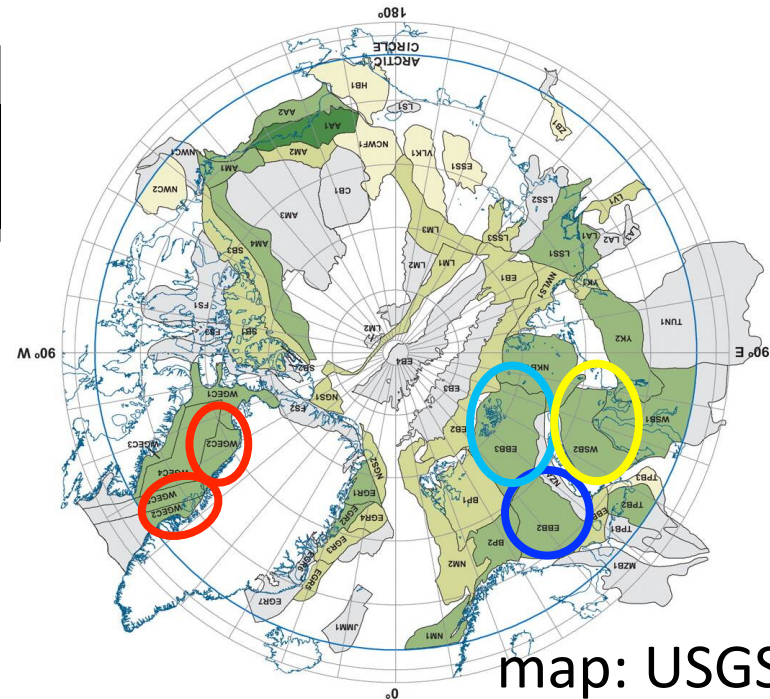S Barents Sea
N Barents Sea
Kara Sea

map: USGS

How to select the better models?

- histor. experiment: monthly mean sic
- mean seasonal cycle 1979-2005
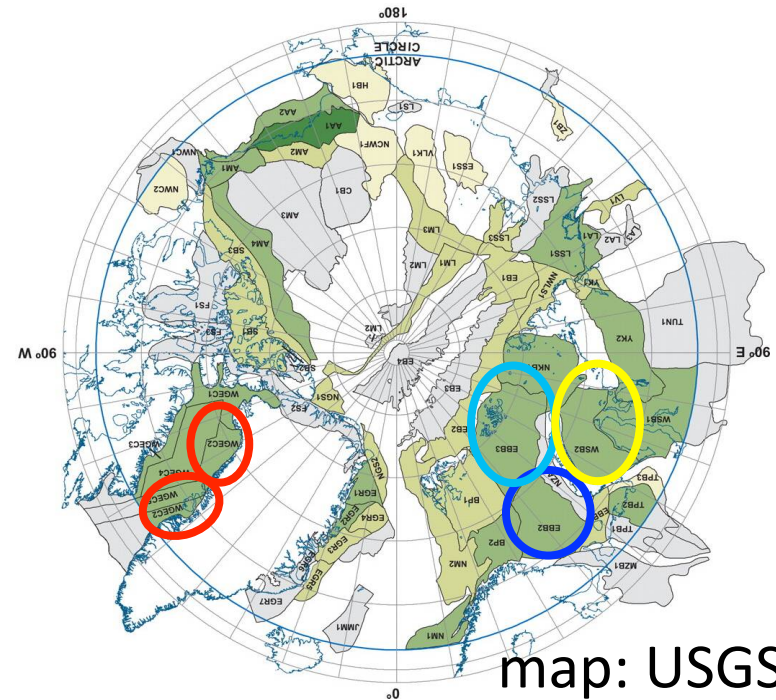- difference to satellite derived sic
  - OSI SAF by EUMETSAT

- $\text{costfunction} = \dfrac{1}{2} \sum \left[\dfrac{(\text{model-satellite})^2}{\text{weights}} \right]$

- for each grid point,
  integrate over regions
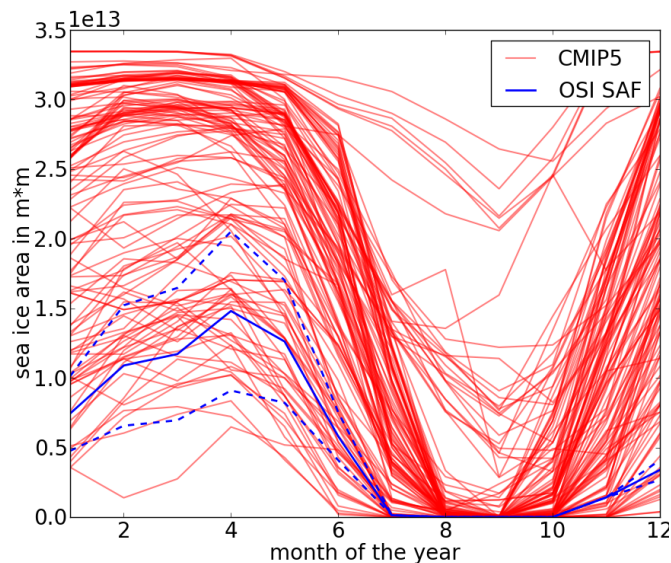
map: USGS

How to select the better models?

rank	OSI SAF WP4.1 regions	norm. costfunction sum over WP4.1 regions
1	MPI-ESM-LR	1.000
2	MIROC4h	0.998
3	MPI-ESM-MR	0.997
4	GFDL-CM3	0.988
5	NorESM1-M	0.979
6	MPI-ESM-P	0.966
7	ACCESS1-0	0.926
8	NorESM1-ME	0.882
9	inmcm4	0.878
10	CCSM4	0.859

map: USGS

How to select the better models?

rank	OSI SAF WP4.1 regions	norm. costfuction sum over WP4.1 regions	OSI SAF whole Arctic	norm. costfunction sum over whole Arctic
1	MPI-ESM-LR	1.000	MPI-ESM-LR	1.000
2	MIROC4h	0.998	MPI-ESM-P	0.984
3	MPI-ESM-MR	0.997	MPI-ESM-MR	0.980
4	GFDL-CM3	0.988	NorESM1-M	0.930
5	NorESM1-M	0.979	NorESM1-ME	0.890
6	MPI-ESM-P	0.966	CCSM4	0.888
7	ACCESS1-0	0.926	GFDL-CM3	0.853
8	NorESM1-ME	0.882	IPSL-CM5A-MR	0.853
9	inmcm4	0.878	MIROC-ESM	0.847
10	CCSM4	0.859	MIROC-ESM-CHEM	0.840

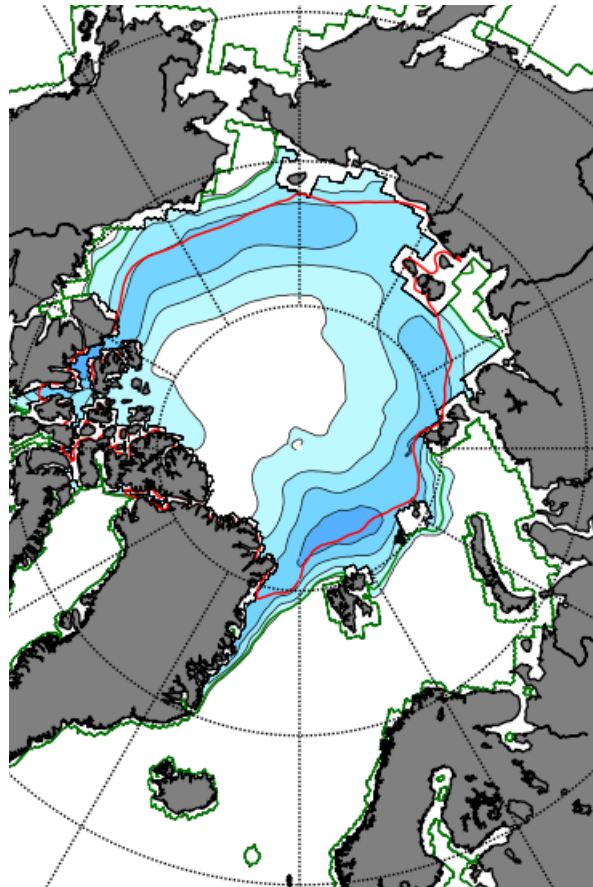# The diversity of past sea ice concentration (sic)

Mean seasonal cycle 1979-2005
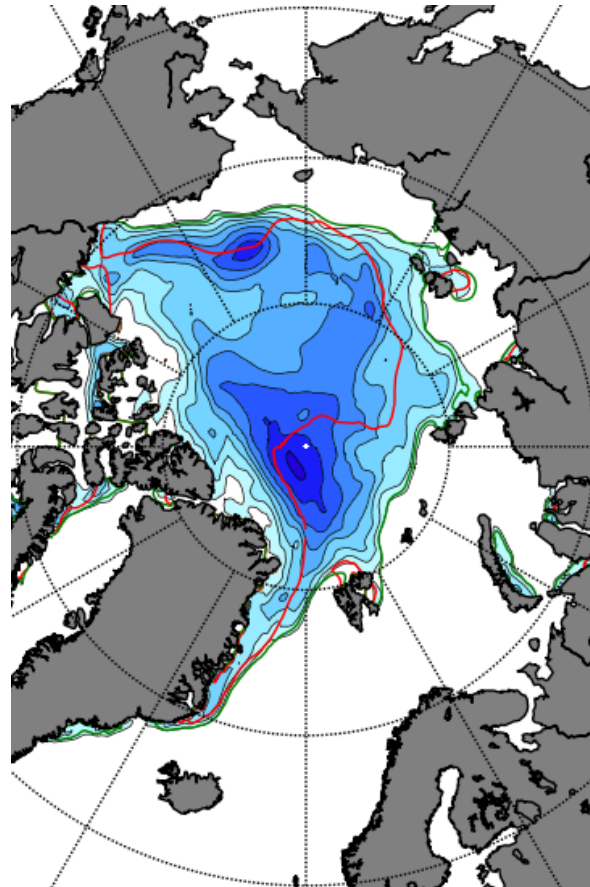area integrated sic Southern Barents Sea

Future change in September sic mean(2025-2040)-mean(1991-2005)
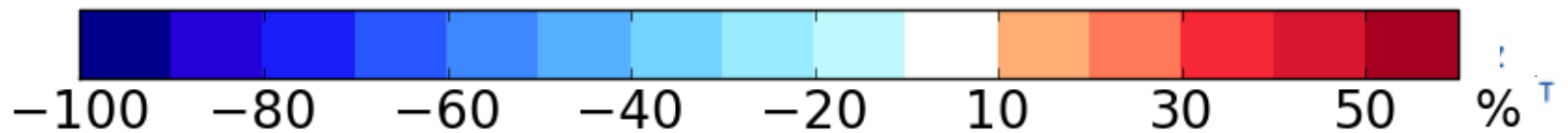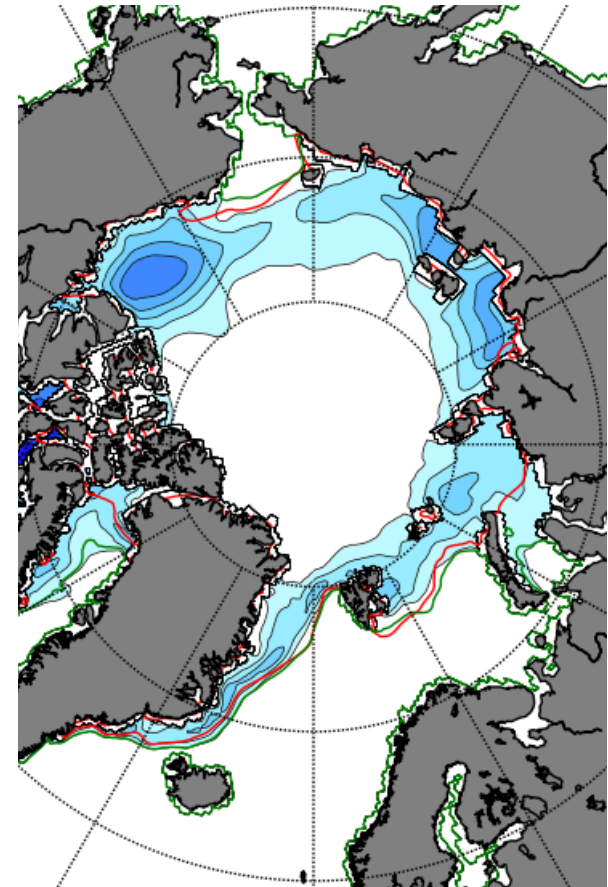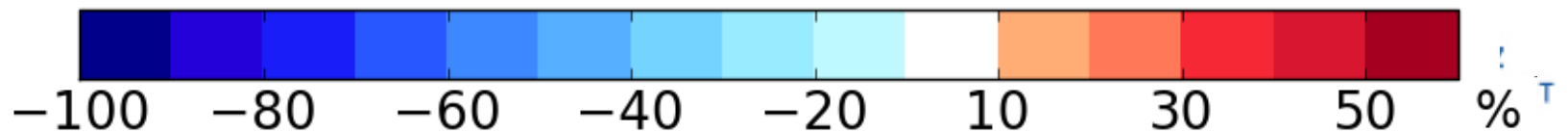
Future change in April sic mean(2025-2040)-mean(1991-2005)
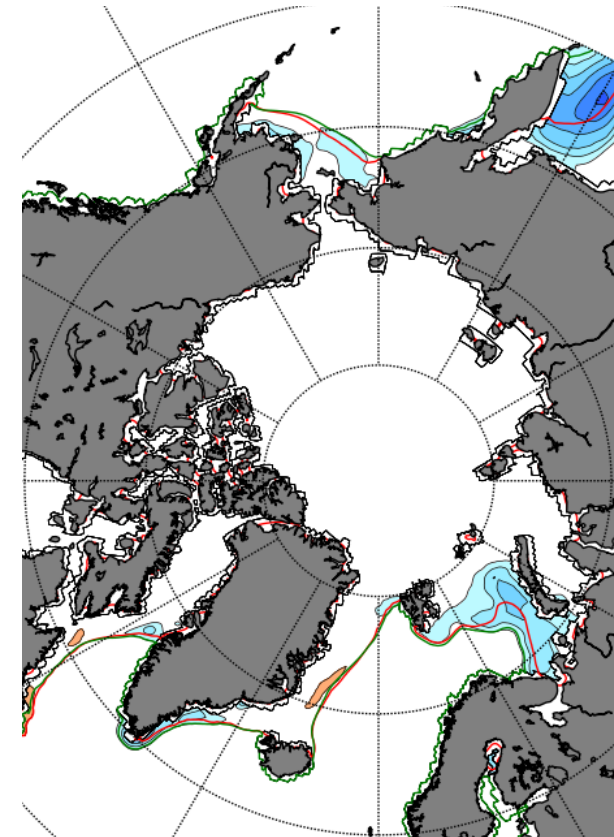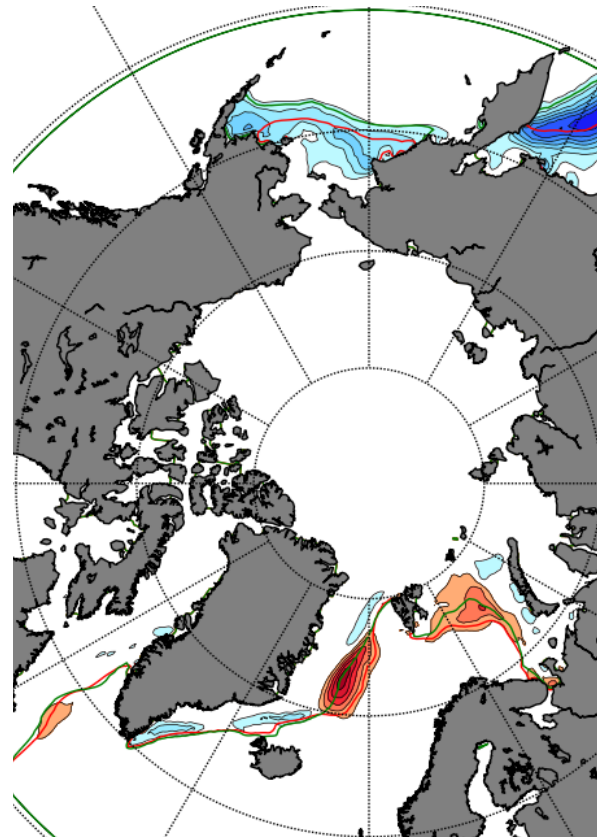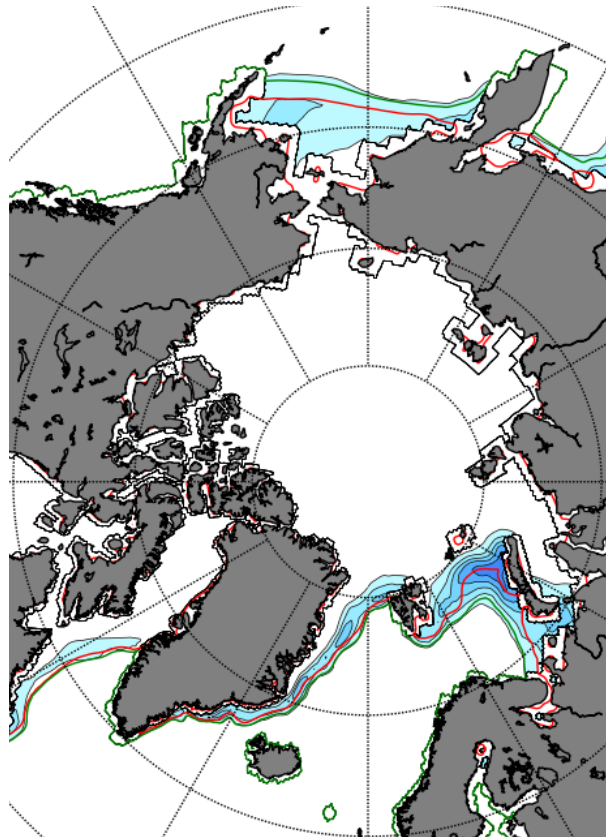
MPI-ESM-LR   ACCESS1-0   NorESM1-ME

Summary

- summer sea-ice extent
  - general reduction
  - hardly Reduction in WP4.1 regions

- winter sea ice extent
  - general reduction along Pacific ice edge
  - reduction and increase along 'Atlantic' ice edge

- most models agree on decreasing sic
- models do **NOT** agree on region of decreasing sic