



Norwegian  
Meteorological  
Institute

## Assessing climate states and feedbacks in two versions of NorESM2

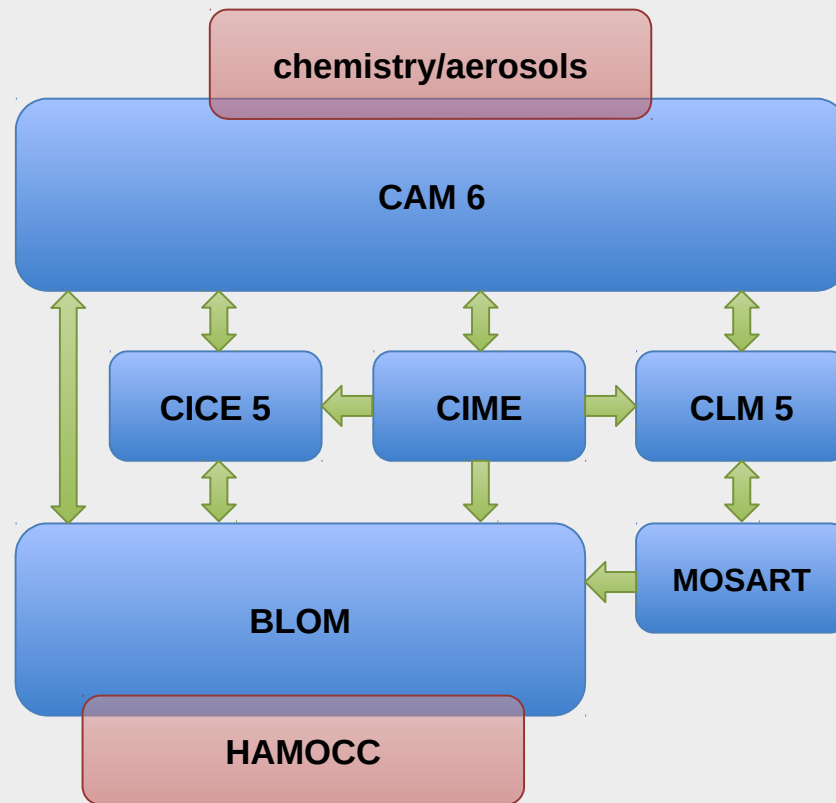
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Jonas Gliss, Alf Kirkevåg, Dirk Olivié, Michael Schulz, Jerry Tjiputra

# Overview

- NorESM2 resolutions and tuning targets
- Selected fields for comparison with measurements:
- Climate sensitivity
- Response to scenarios.

# Overview of NorESM2 within the CESM framework

CESM version: CESM2.1



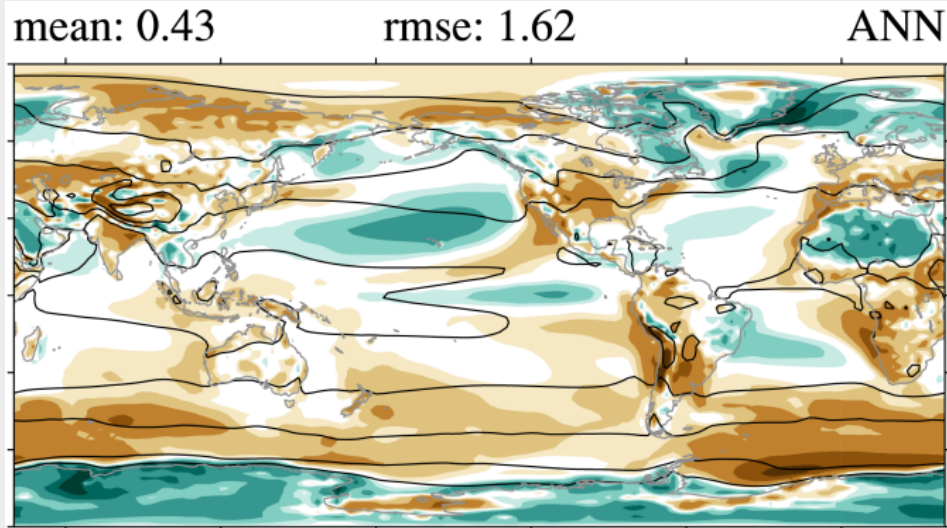
# NorESM2 versions

	atmosphere/land resolution	Ocean/Sea-ice resolution	Compute cost cpuhr/model year
NorESM2-LM	1.9x2.5 degrees	Nominal 1 degree tripolar	1500
NorESM2-MM	0.9x1.25 degrees	Nominal 1 degree tripolar	4000

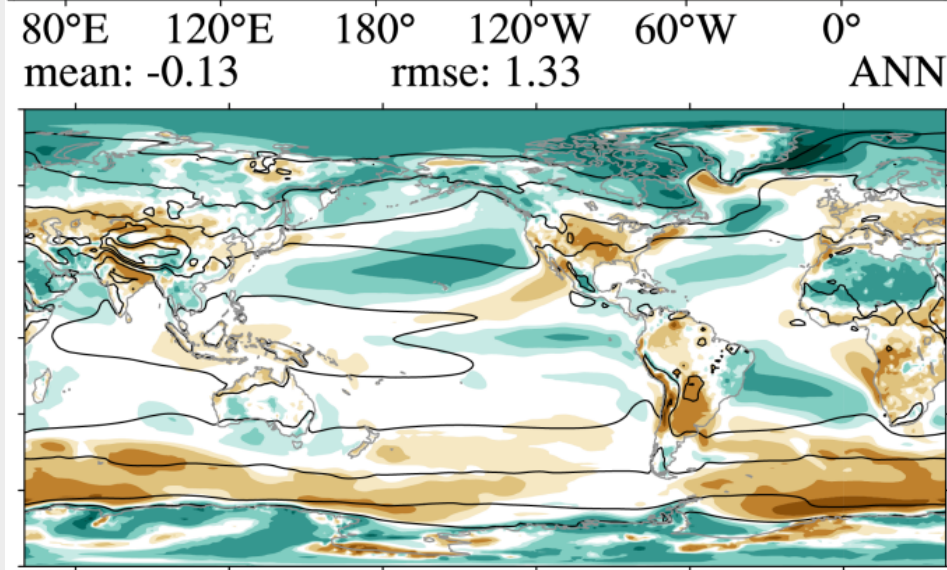
## Keeping the model versions close

- Initialised from the same ocean state (World Ocean Atlas)
- Model versions tuned in tandem as much as possible
  - Similar ocean volume temperature
  - Comparable cloud forcings
- Comparable length of spin-up
  - NorESM2-LM: 1600 years
  - NorESM2-MM: 1200 years

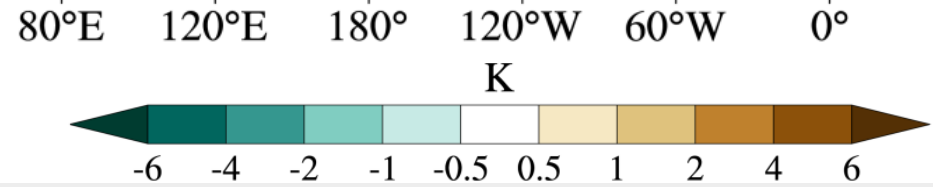
# Near surface temperature bias: Model – ERA-Interim



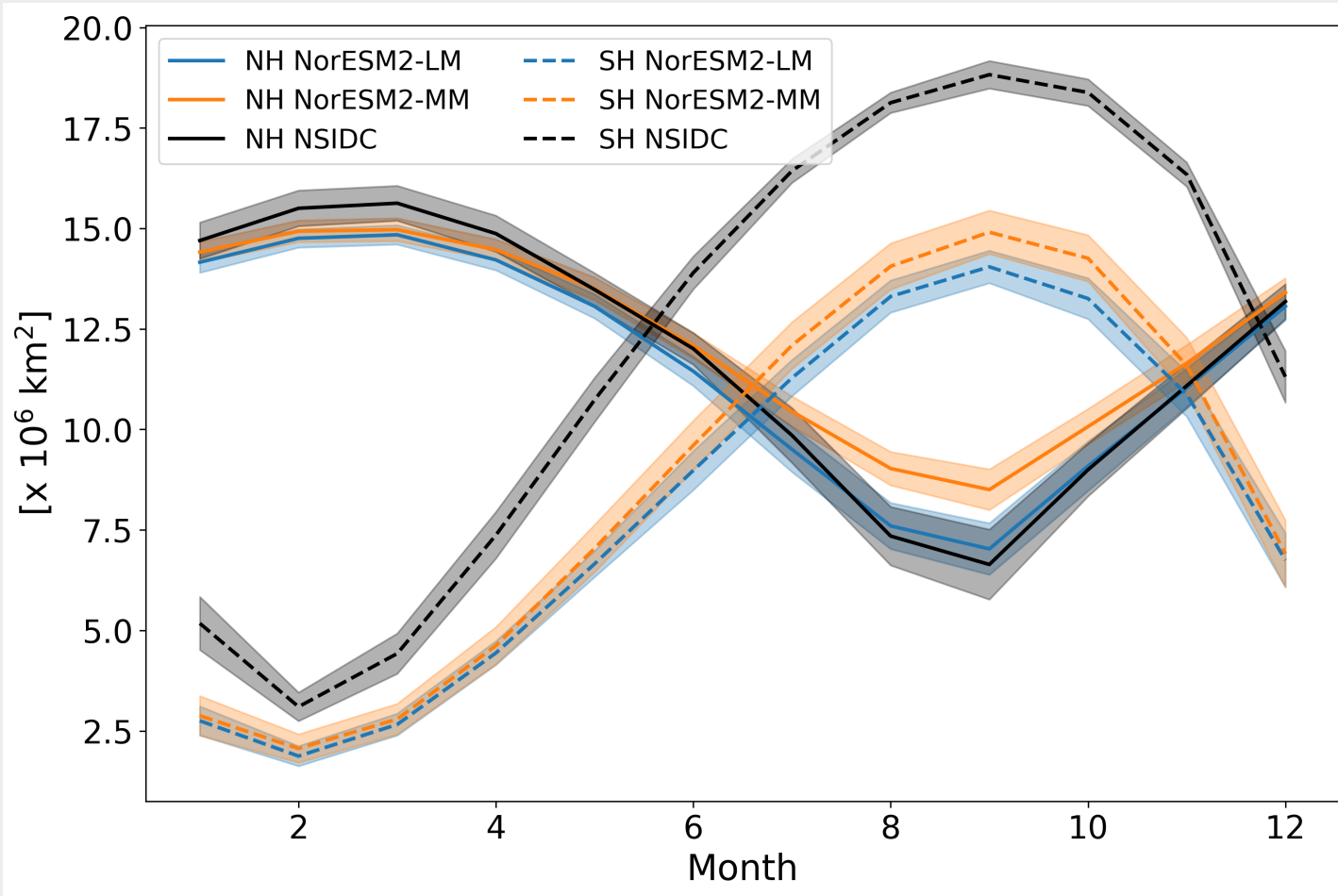
NorESM2-LM



NorESM2-MM



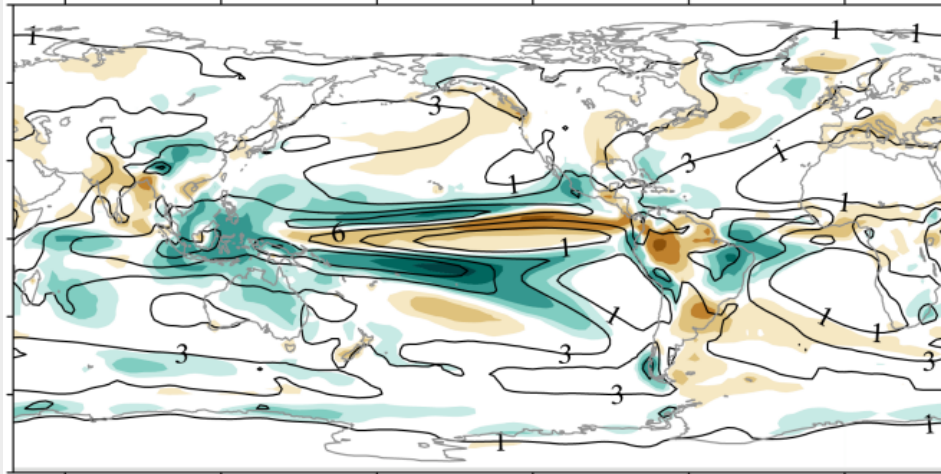
# Seasonal cycle of sea-ice extent.





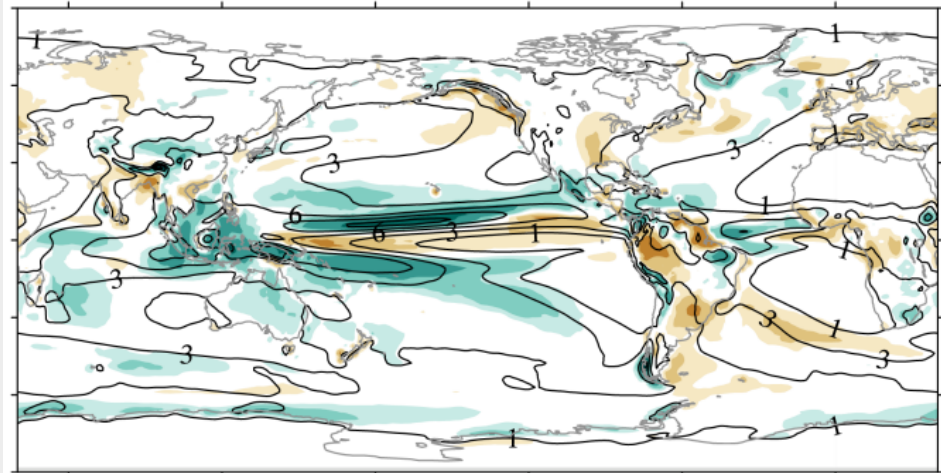
# Precipitation rate: Model - GPCP

mean: 0.16      rmse: 1.04      ANN

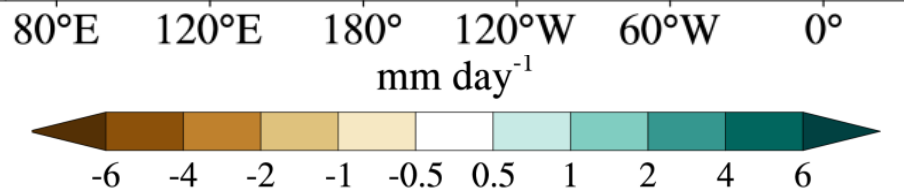


NorESM2-LM

80°E 120°E 180° 120°W 60°W 0°  
mean: 0.15      rmse: 0.86      ANN



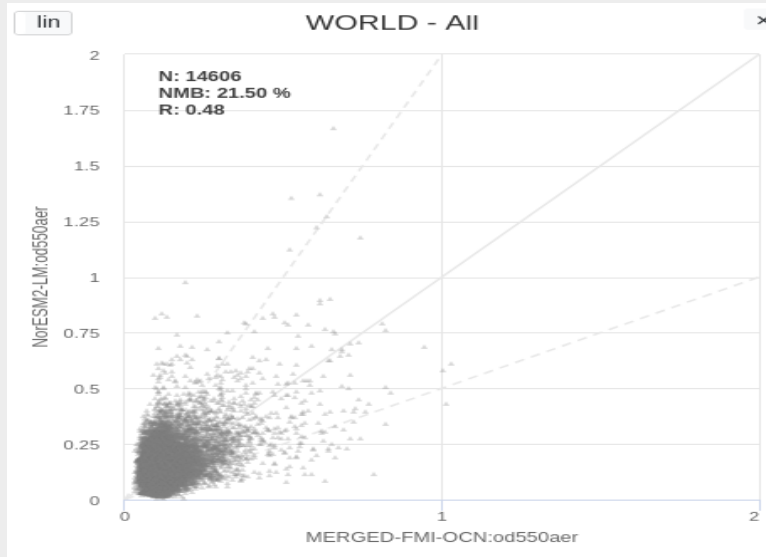
NorESM2-MM





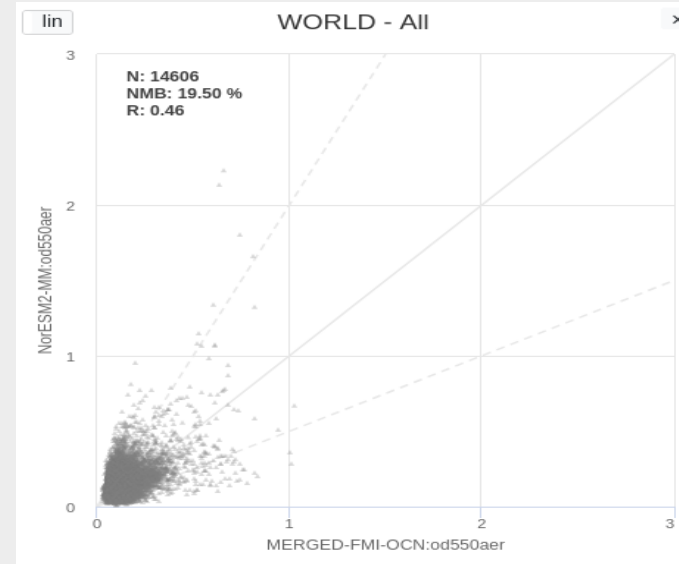
Aerosol optical depth (Model year 2010, 1 ensemble member)  
Effective radiative forcing (2014-1850, 3 ensemble members)

## NorESM2-LM



ERF:  $1.36 \text{ W m}^{-2}$

## NorESM2-MM

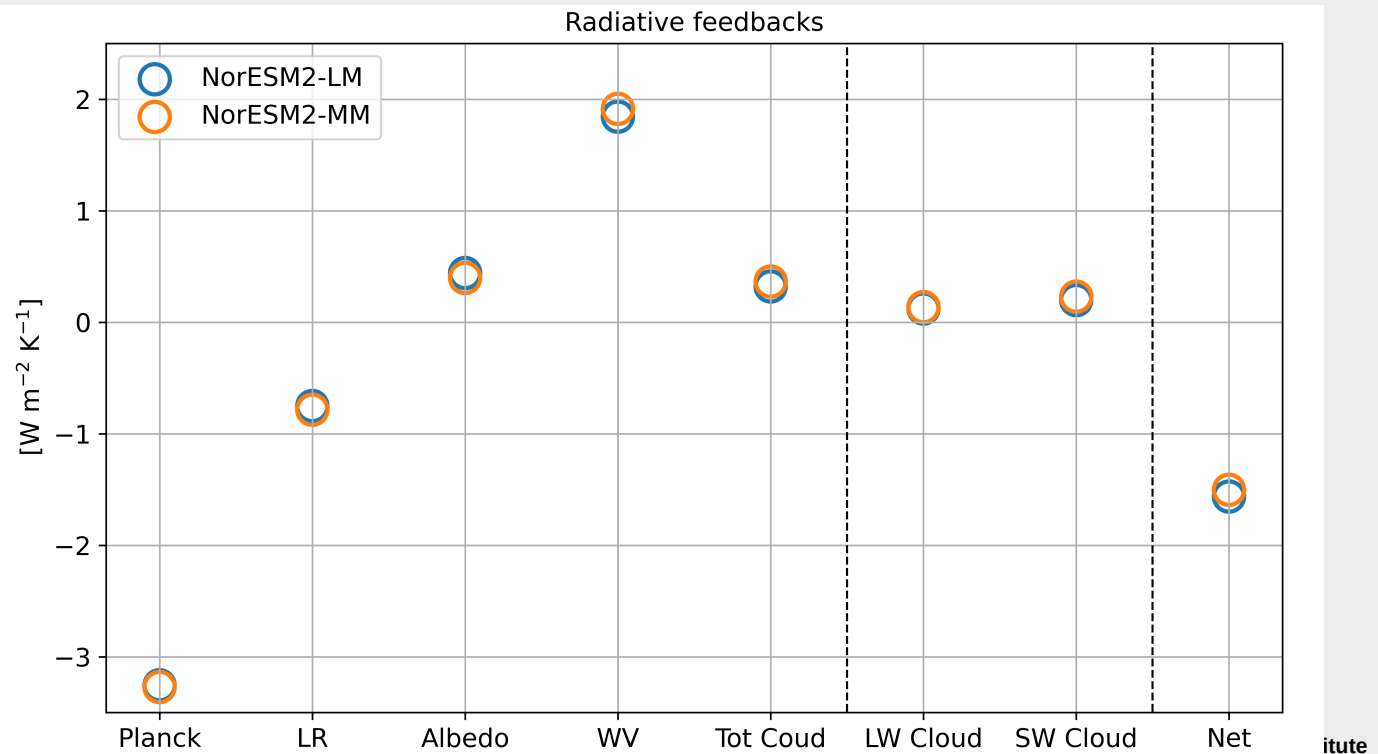


ERF:  $-1.26 \text{ W m}^{-2}$

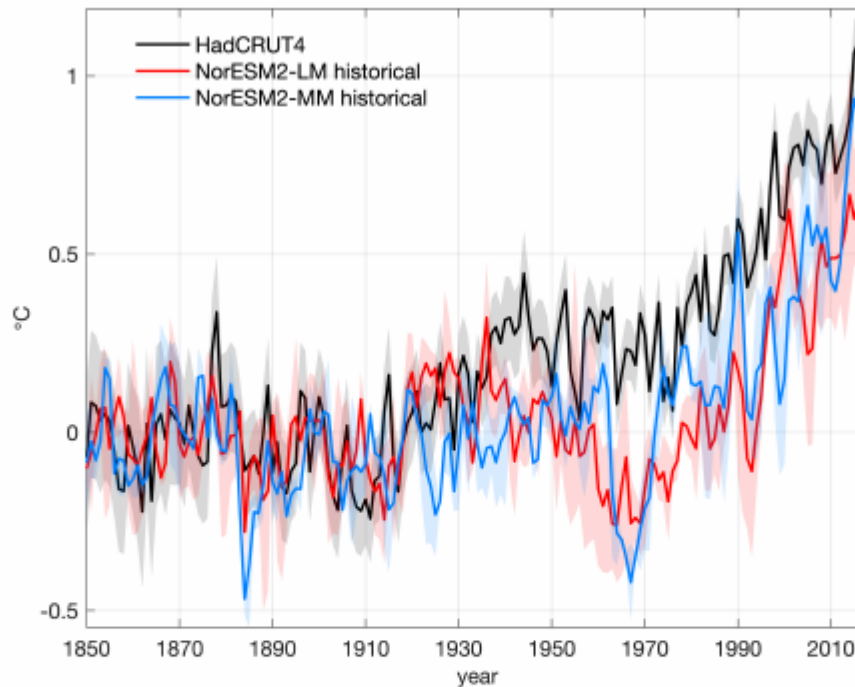
# Climate response

	ECS(K)	TCR(K)	TCRE (K Eg C <sup>-1</sup> )
NorESM2-LM	2.54	1.48	1.36
NorESM2-MM	2.50	1.33	1.21

Radiative feedback: Instantaneous 4XCO<sub>2</sub>



# NorESM2 global temperature trend 1850-2015

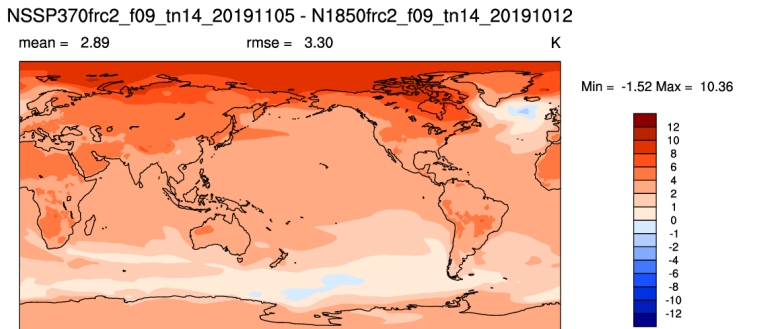
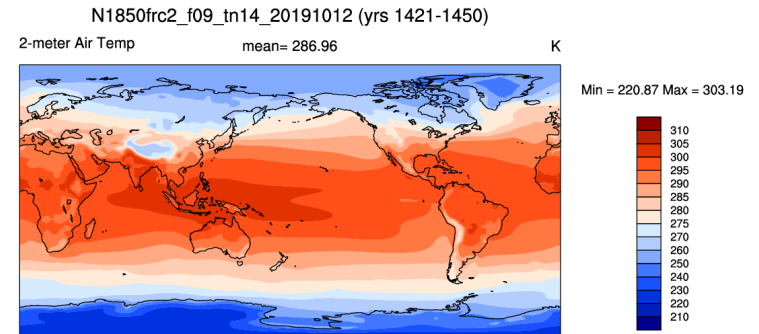
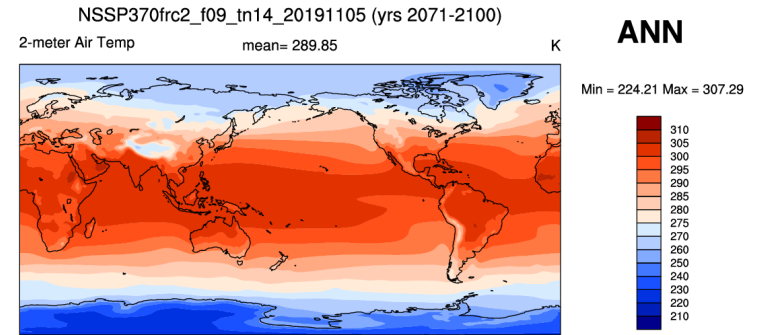
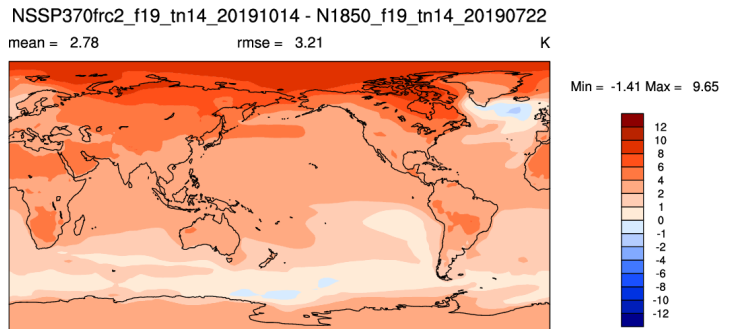
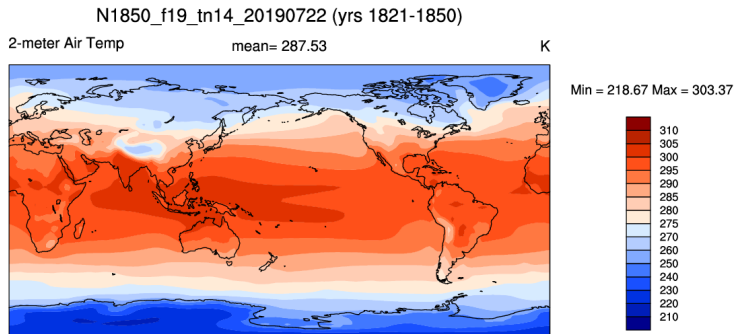
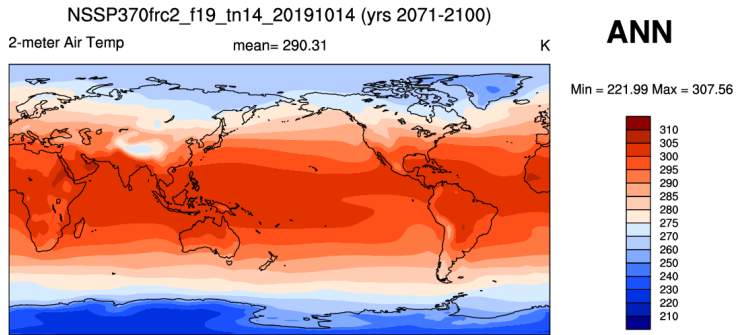


**Figure 4.** Time evolution of globally averaged surface temperature in the historical simulations of NorESM2-LM (red line) and NorESM2-MM (blue line) shown with the observations (black line) from HadCRUT4 (Morice et al., 2012) updated to version HadCRUT4.6.0.0. Temperatures are computed as anomalies from the time-mean over years 1850–1880. For NorESM2-LM and NorESM2-MM, the solid lines show the mean and the shading of corresponding colour the spread from three ensemble members. For HadCRUT4, the solid black line shows the median and the grey shading indicates the lower and upper bounds of the 95% confidence interval of the combined effects of all the uncertainties described in the HadCRUT4 error model (measurement and sampling, bias, and coverage uncertainties).

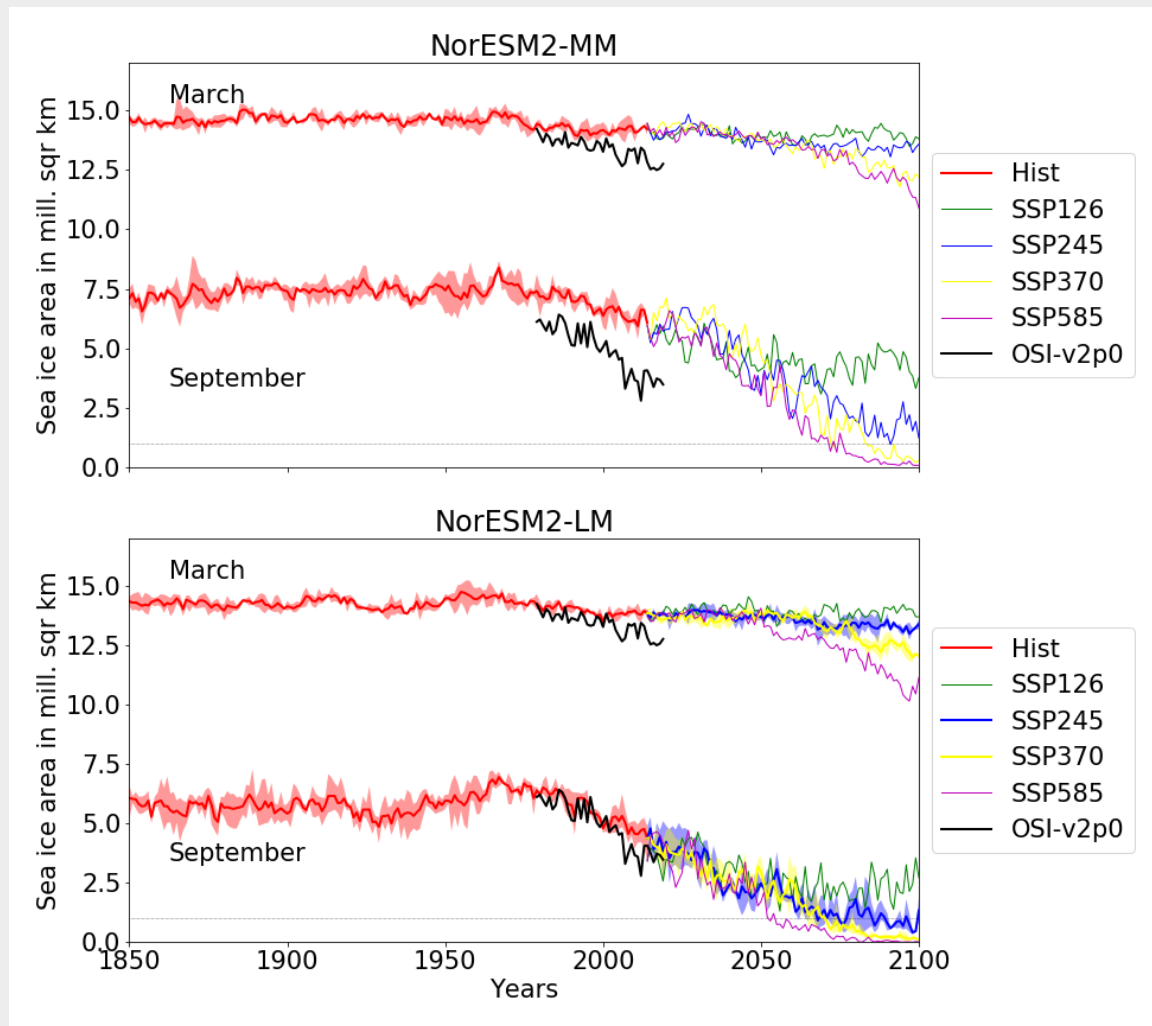
# Change in near surface temperature

## Scenario SSP3-7.0 2071-2100 - pre-industrial

### NorESM2-LM NorESM2-MM

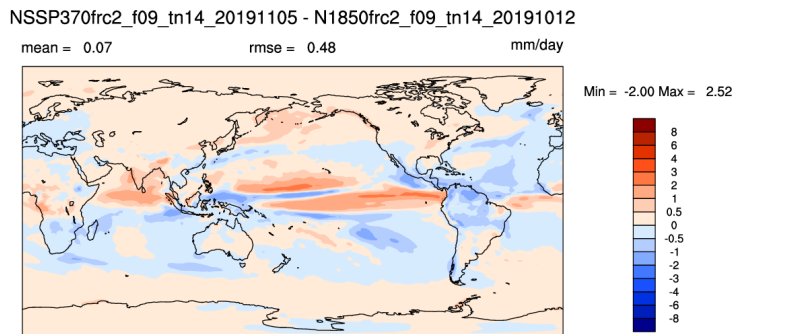
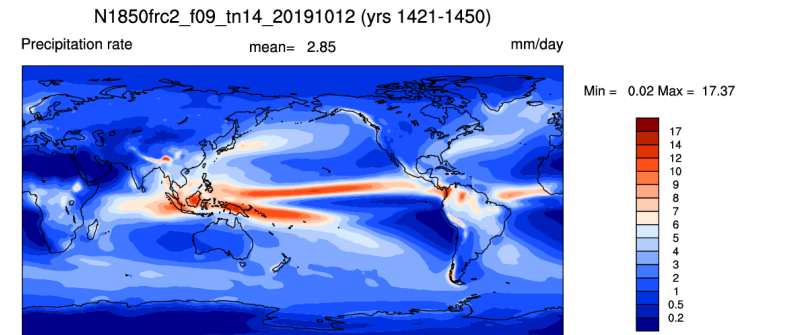
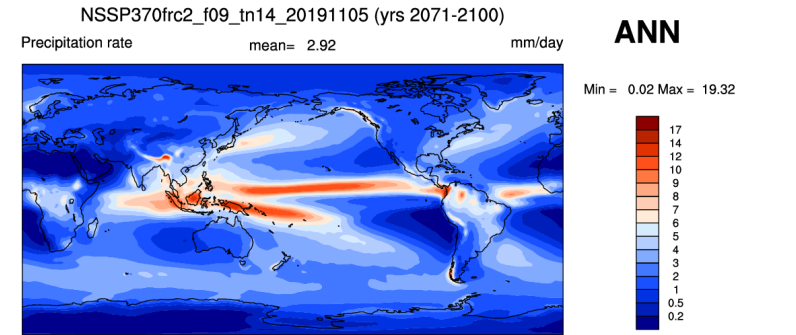
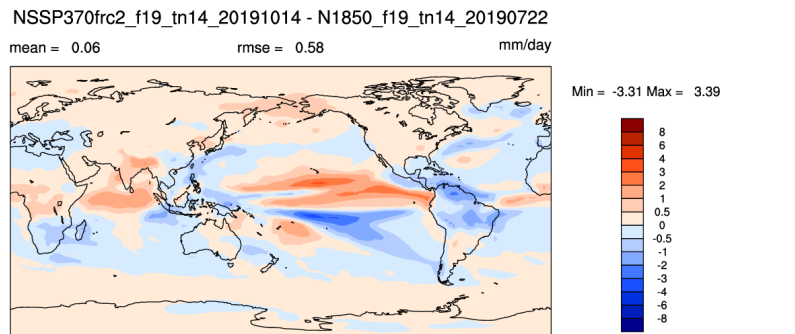
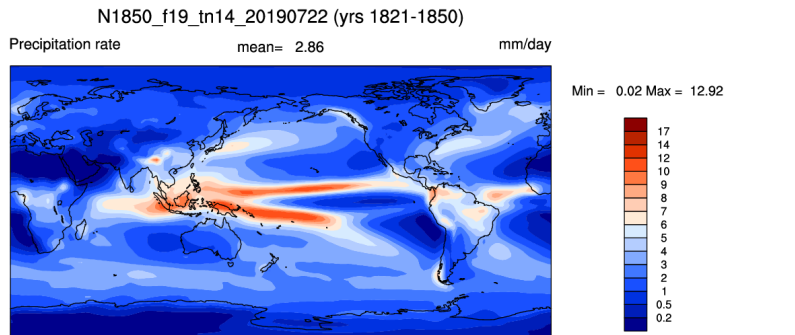
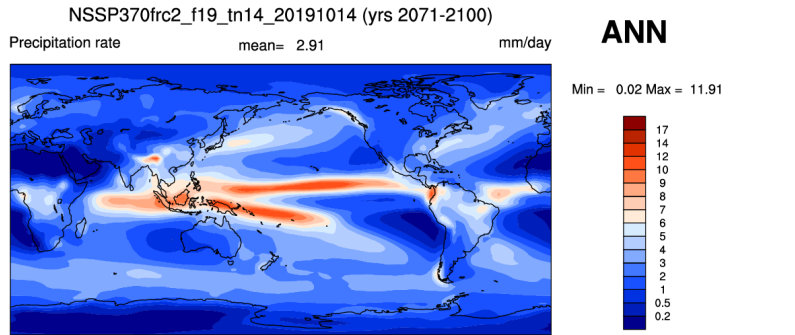


# Change in NH sea-ice area. Historical simulation and selected scenarios



# Change in precipitation rate: Scenario SSP3-7.0 2071-2100 - pre-industrial NorESM2-LM

# Scenario SSP3-7.0 2071-2100 - pre-industrial NorESM2-MM



## Summary of results

- Climate responses and feedbacks similar for both atmospheric resolutions
- Overall absolute biases similar in the two model versions, although the spatial patterns usually improves with higher resolution.
- Too slow melt of Arctic sea-ice in NorESM2-MM due to an Arctic cold bias
- Question: Are the conclusions valid also for higher resolutions
  - 100 --> 50 km resolution: Known to give better representation of extratropical cyclones and blocking
  - 50 --> 25 km: Resolves tropical cyclones and other large scale convective systems.





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**Thank you for the attention.**





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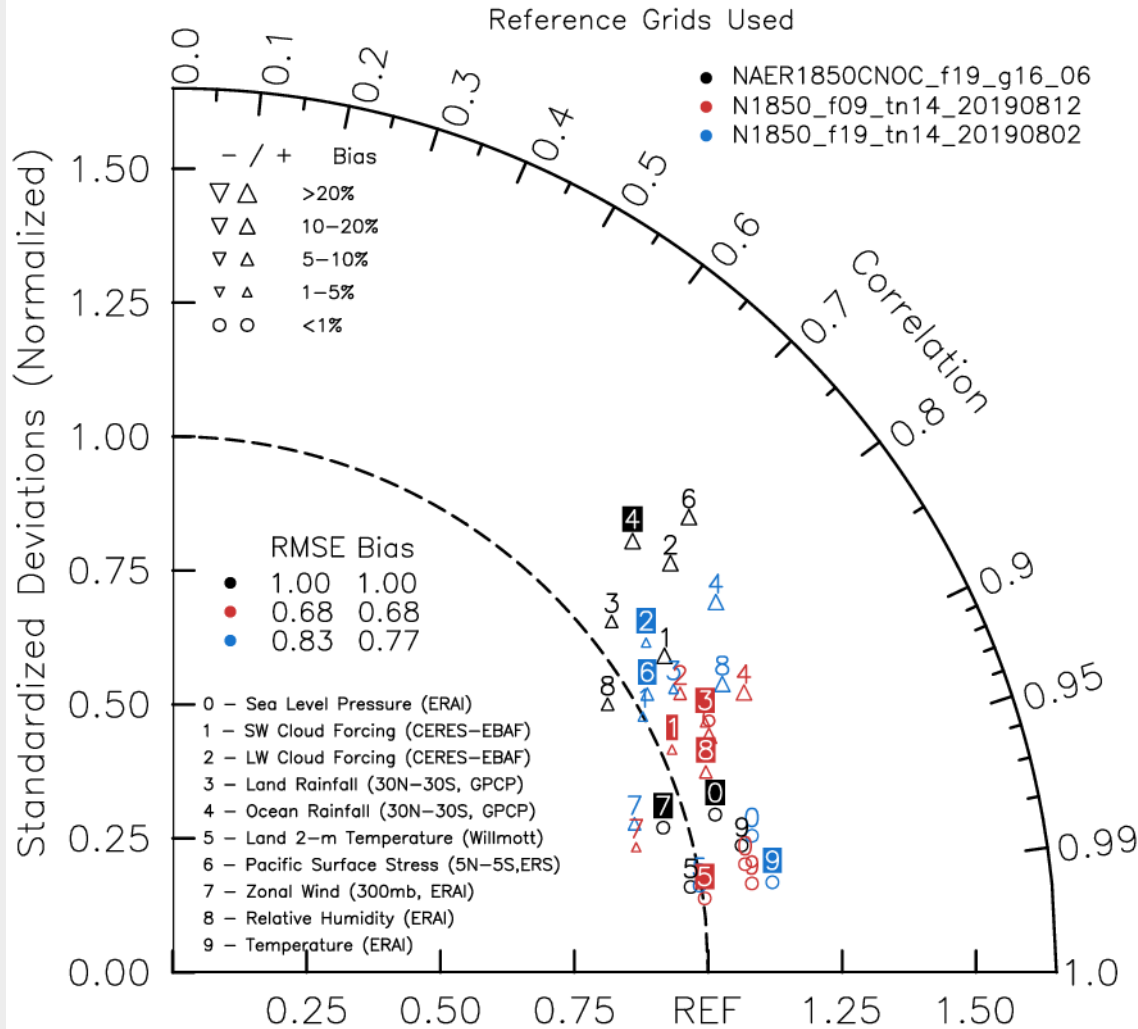
EXTRAS



# Difference in tuning parameters: NorESM2-LM and NorESM2-MM

Parameter	Purpose of parameter Main effect in tuning	LM	MM
Clubb gamma	Govern entrainment at PBL top Change in low cloud cover	0.264	0.286
MG Dcs	Converting of cloud ice to snow Shift in LW/SW ratio	5.5e-4 /	5.0e-4
CLDFRC2M	Ambient RH dependence of ice-cloud fraction on/off Change in high cloud cover	off	on

# ANN: SPACE-TIME



## Statistical comparison with observations

- NorESM1-M
- NorESM2-MM
- NorESM2-LM

# Change near surface temperature. Historical simulation ensemble member 1 and selected scenarios

