

Belgian National Committee on Antarctic Research

Modelling recent and future Antarctic sea ice changes

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Arctic

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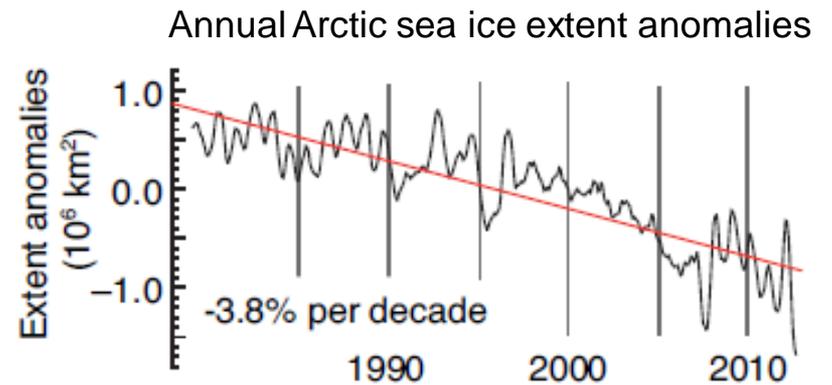
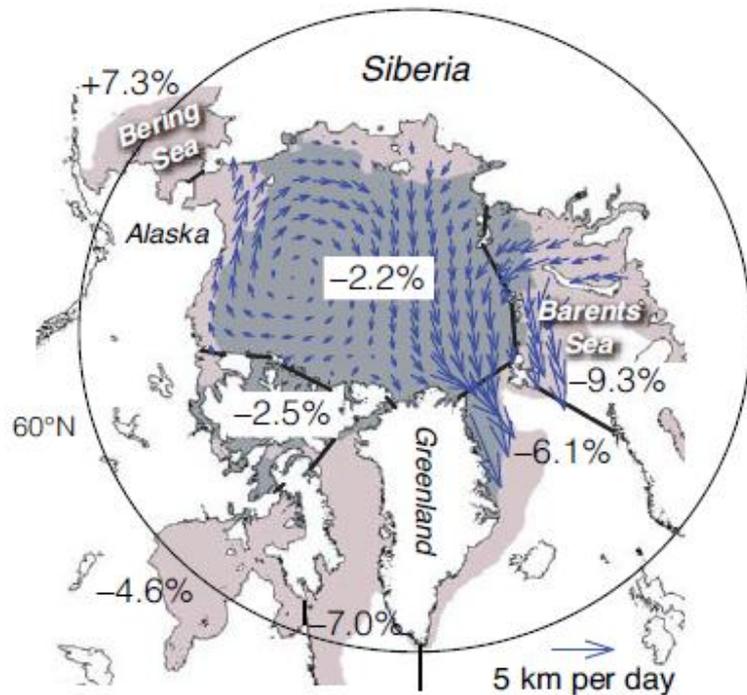
Modelling recent and future ~~Antarctic~~ sea ice changes

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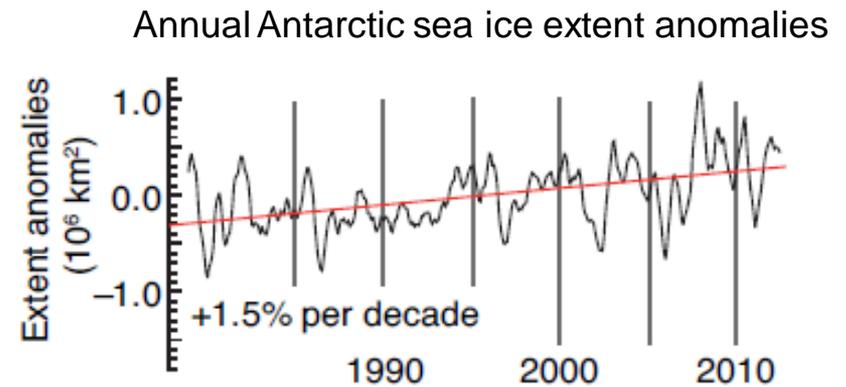
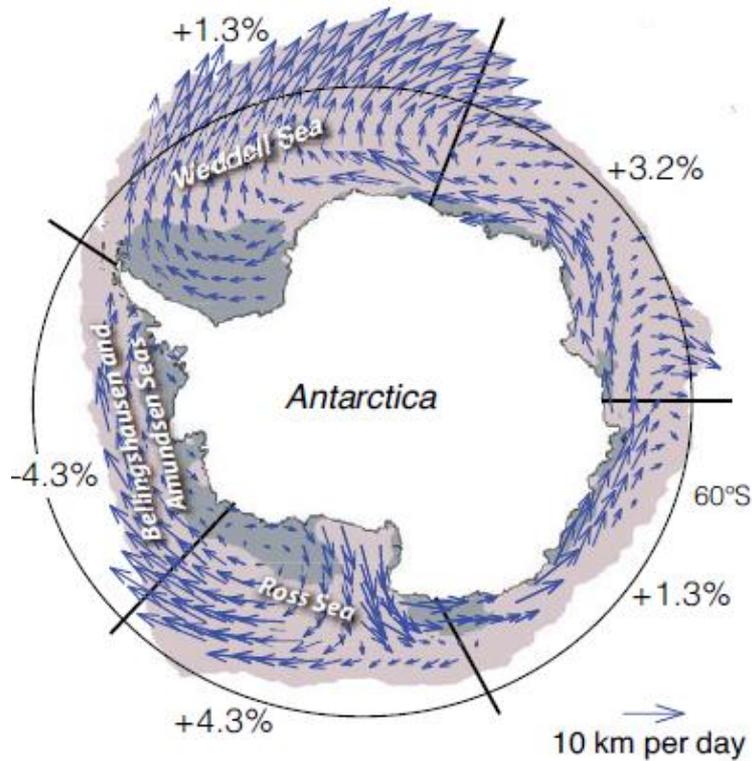
The Arctic sea ice clock is ticking



(IPCC WG1 AR5, 2013)



Antarctic sea ice variability more puzzling than ever



(IPCC WG1 AR5, 2013)

1. Modelling sea ice : from CMIP3 to CMIP5

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2. Sea ice projections

1. Modelling sea ice : from CMIP3 to CMIP5

Interlude Recent Antarctic sea ice increase

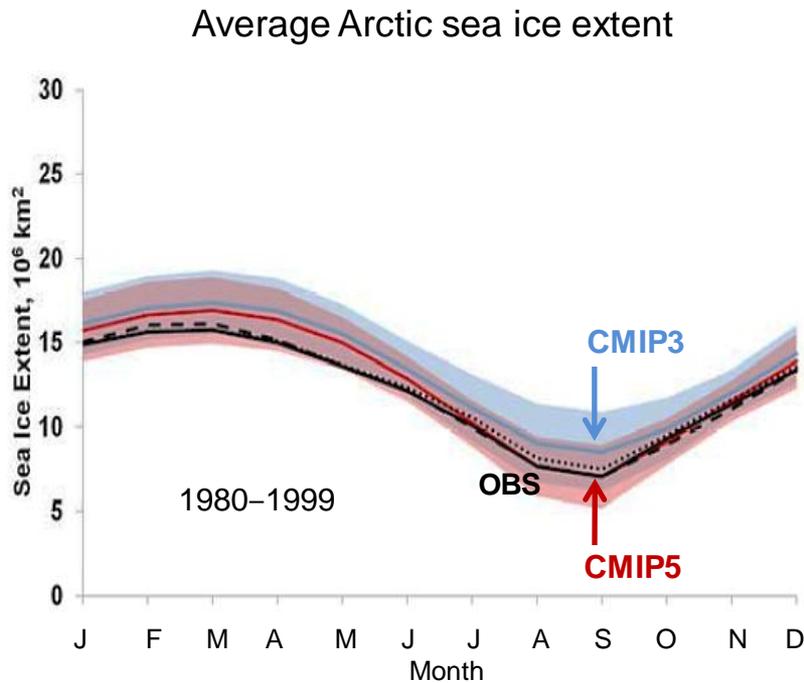
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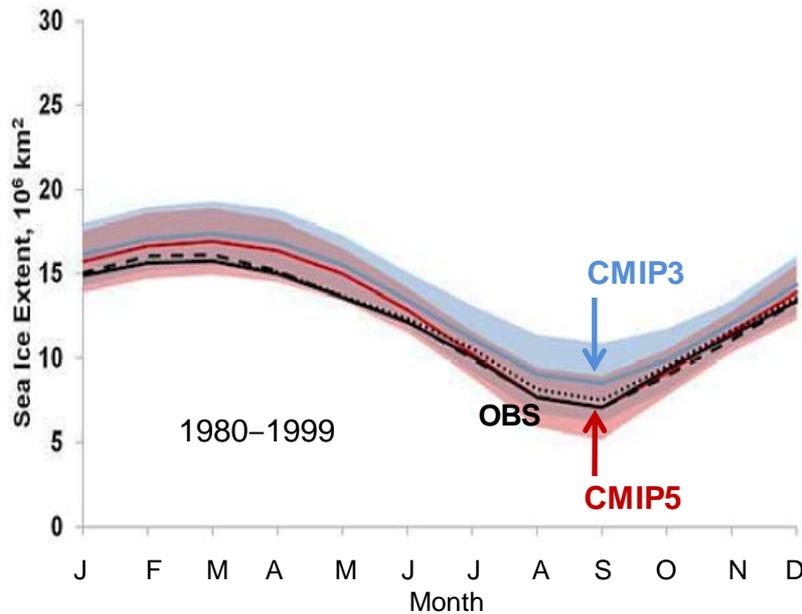
The seasonality of Arctic sea ice extent is better simulated in CMIP5 than CMIP3



(IPCC WG1 AR5, 2013)

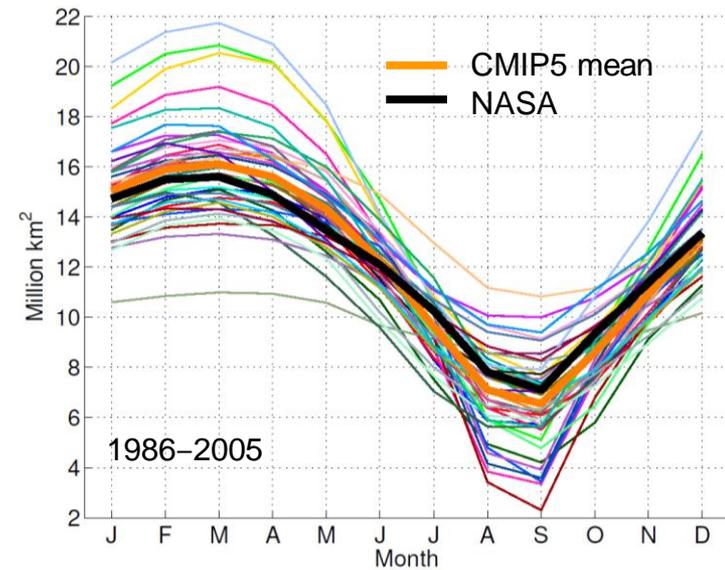
The CMIP5 model spread around the mean is still large

Average Arctic sea ice extent



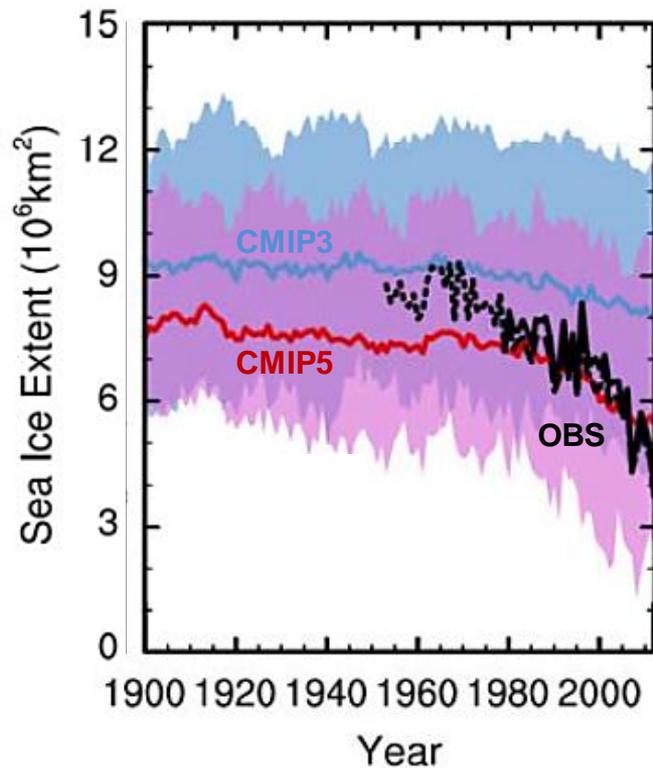
(IPCC WG1 AR5, 2013)

Average Arctic sea ice extent



Trends in September Arctic sea ice extent are better simulated in CMIP5 than CMIP3

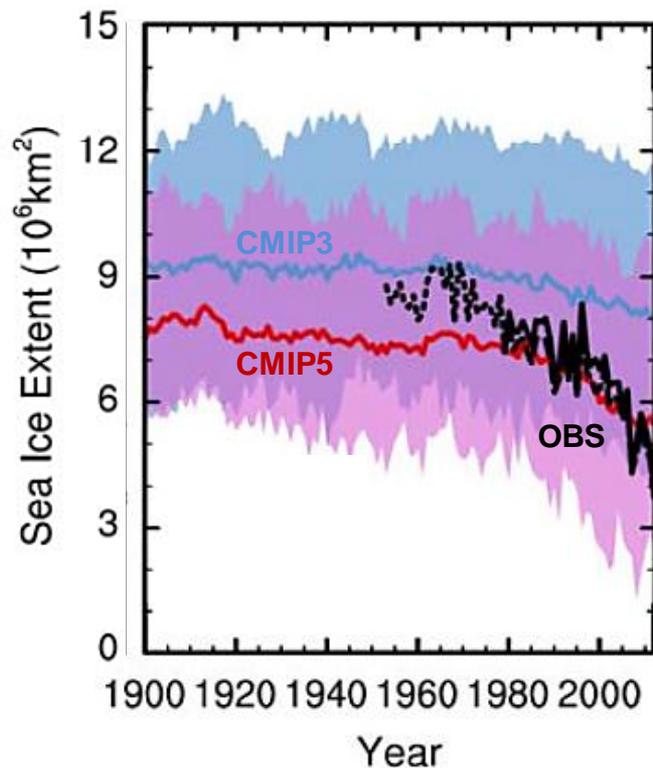
September Arctic sea ice extent



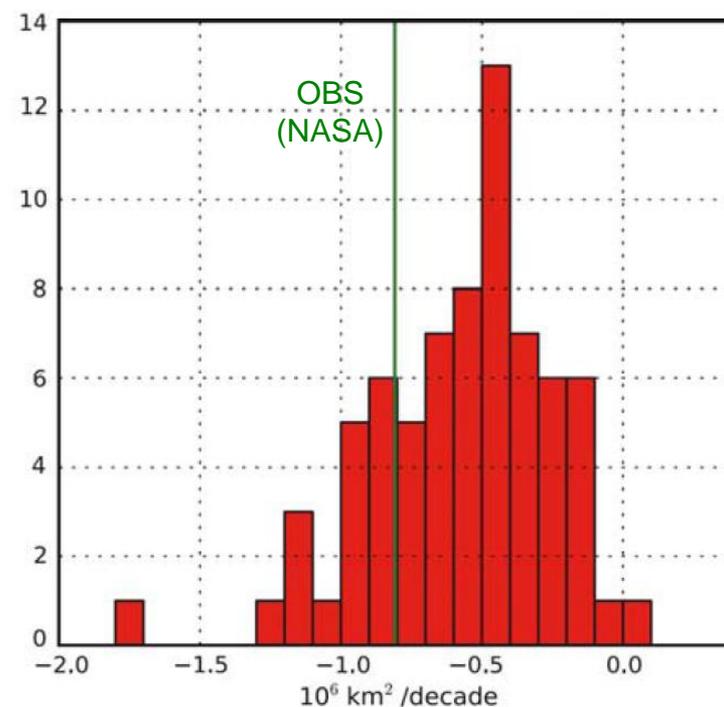
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September Arctic sea ice extent

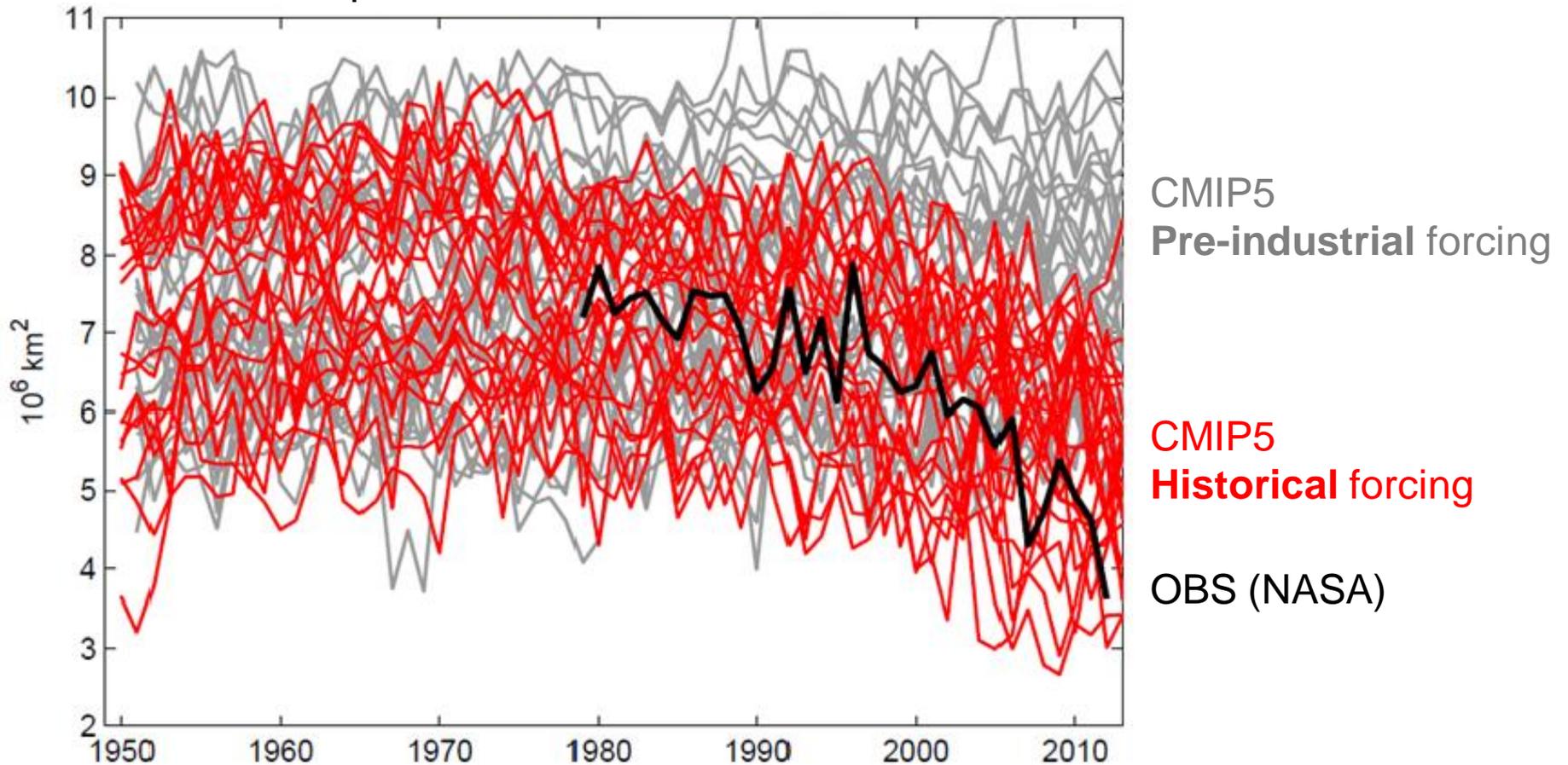


Distribution of CMIP5 September Arctic sea ice extent **trends** (1979-2010, 66 realisations)



Anthropogenic influences have *very likely* contributed to Arctic sea ice loss since 1979

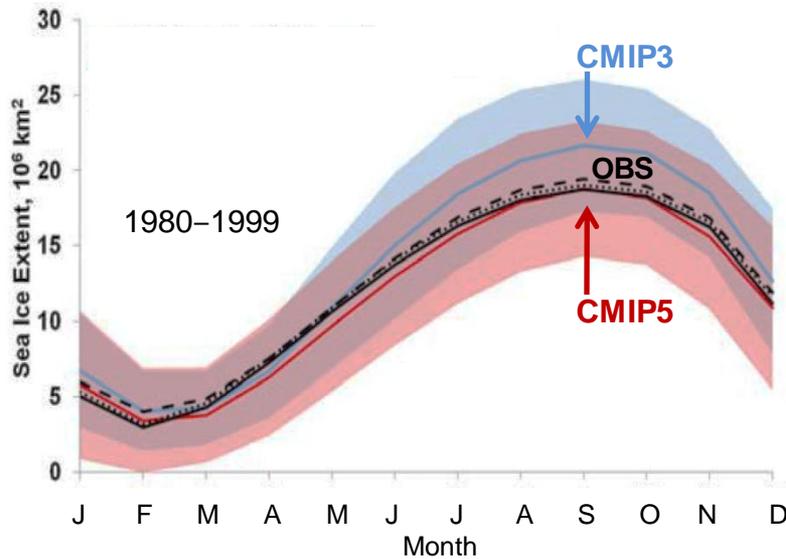
September Arctic sea ice extent



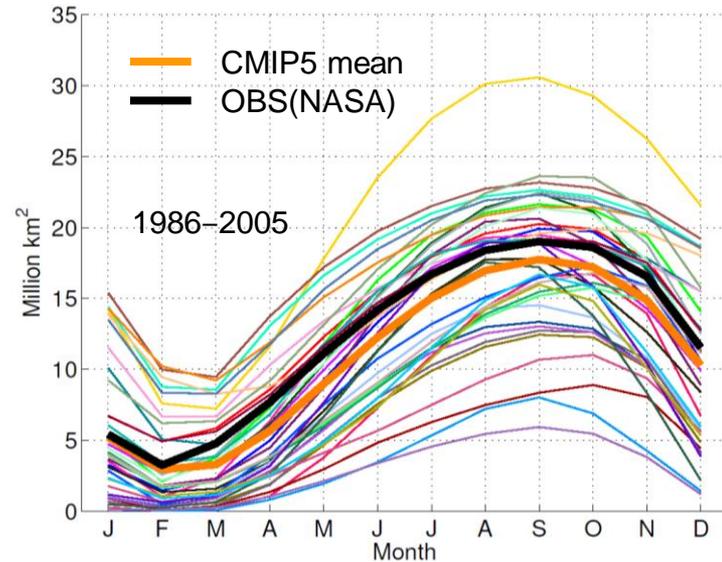
(IPCC WG1 AR5, 2013)

Mean Antarctic sea ice extent: noticeable improvements, but still very large spread

Average Antarctic sea ice extent

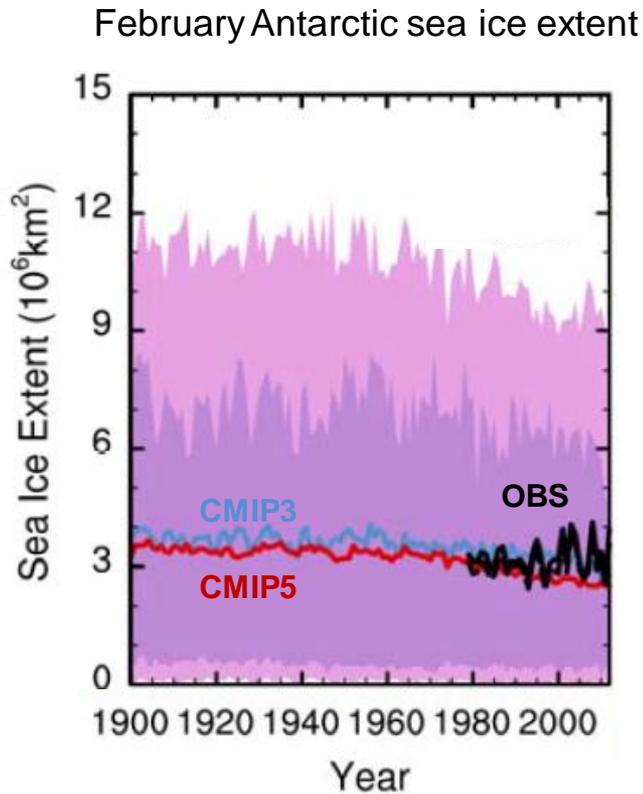


Average Antarctic sea ice extent

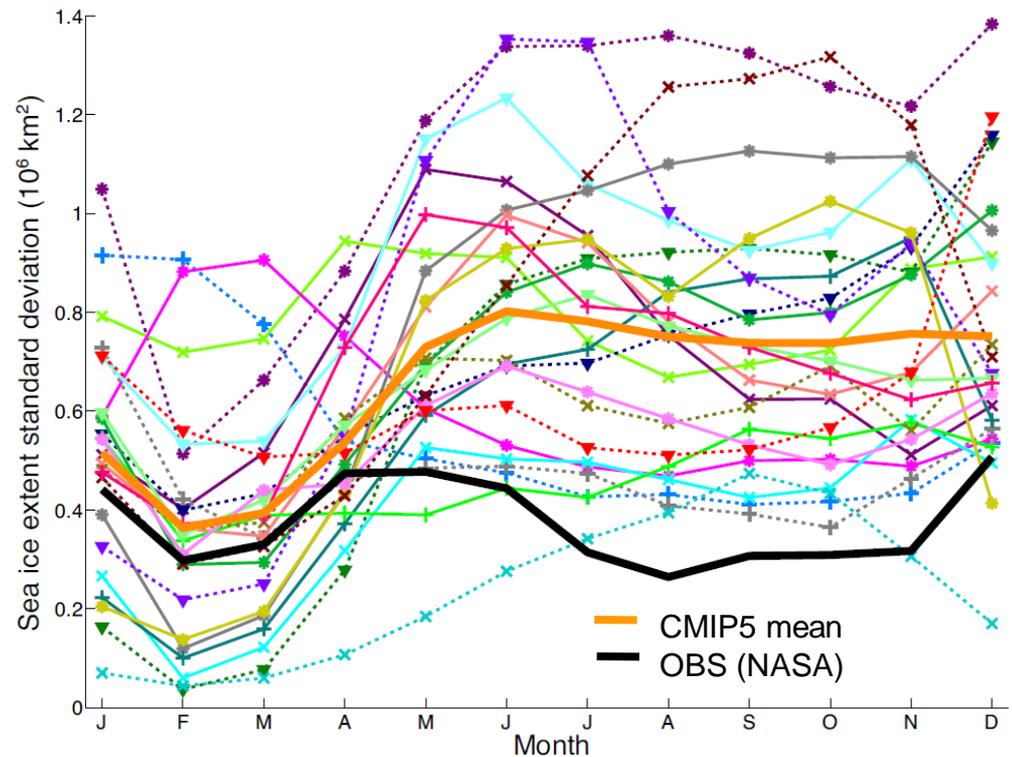


Mismatch between observed and simulated Antarctic sea ice variability

1979-2005 **standard deviation** of the detrended Antarctic sea ice extent



(IPCC WG1 AR5, 2013)



(Zunz et al., The Cryosphere, 2013)

Conclusion 1

CMIP3 → CMIP5: improvements
with persistent uncertainties

	Arctic	Antarctic
Mean state	Improved	Improved
Trends/ variability	Improved	Status quo
Attribution/ Detection	Changes detectable and attributable	Uncertain

1. Modelling sea ice : from CMIP3 to CMIP5

Improvements with persistent uncertainties

Interlude Recent Antarctic sea ice increase

2. Sea ice projections

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Why is **observed** Antarctic
sea ice extent **increasing**?

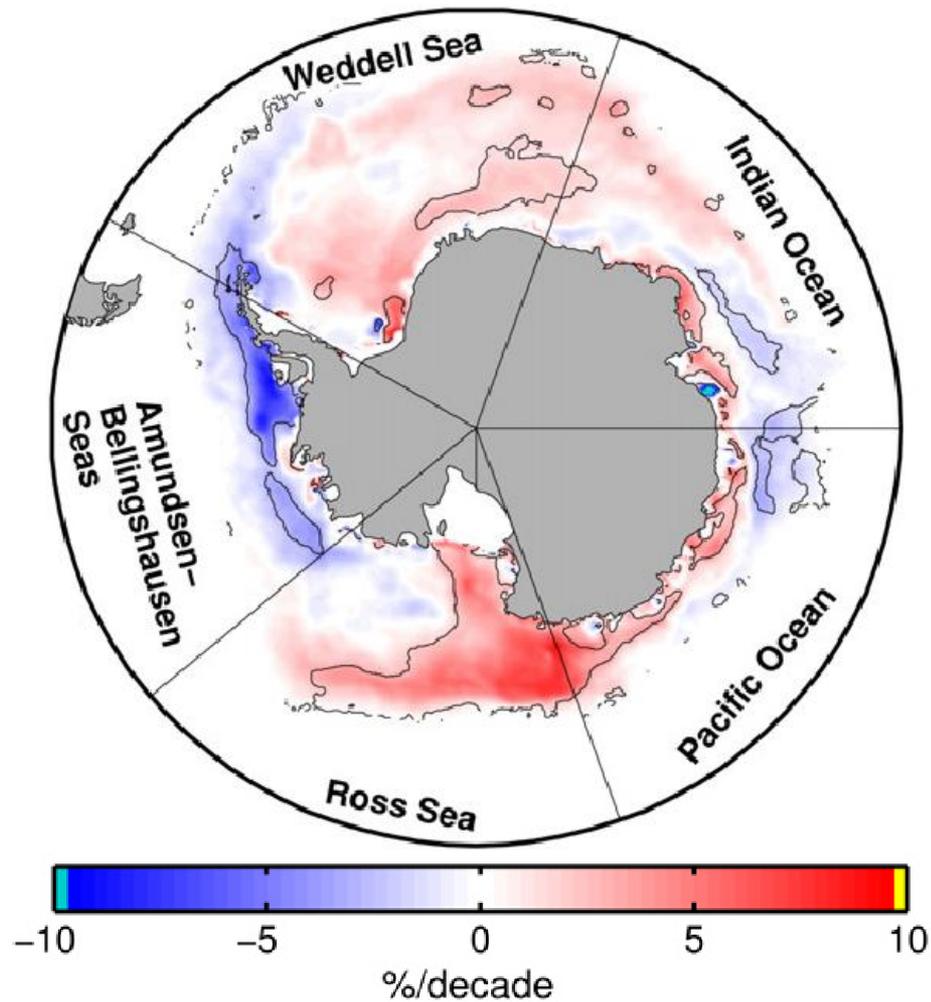
Why is **observed** Antarctic
sea ice extent **increasing**?



Why is **modelled** Antarctic
sea ice extent **decreasing**?

Caution: trends are space-dependent

1980-2008 observed **trends**
in sea ice concentration



Causes for observed Antarctic sea ice increase are unclear

1. Forced signal?

Ice sheet melt, precipitation, winds, (ozone) ...

[Bintanja et al., 2013; Swingedouw et al., 2008;
Holland and Kwok, 2012; Zhang, 2006]



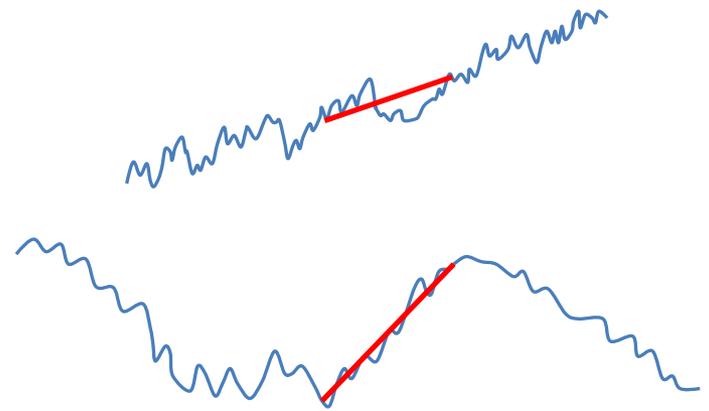
Causes for observed Antarctic sea ice increase are unclear

1. Forced signal?

2. Multi-decadal variability?

Ocean-ice feedbacks, ocean variability

[Goosse and Zunz, 2013; Latif et al., 2013]

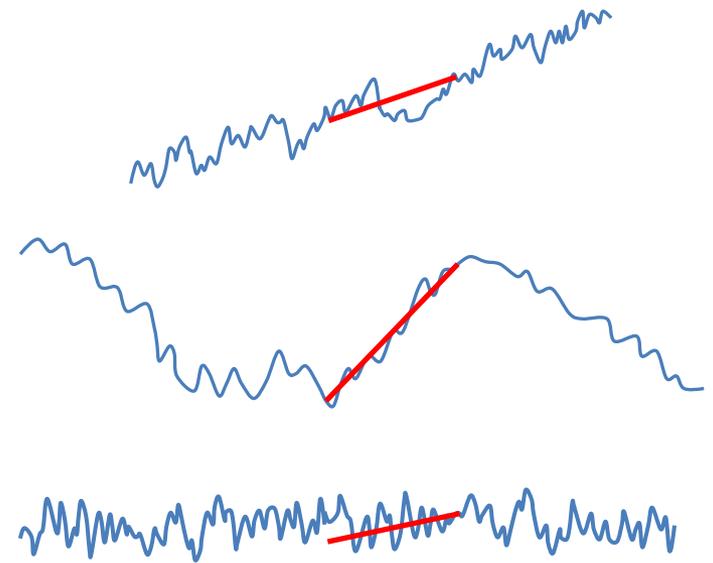


Causes for observed Antarctic sea ice increase are unclear

1. Forced signal?
2. Multi-decadal variability?
3. Statistical noise?

Significance of trends depends on season & region

[e.g., Parkinson and Cavalieri, 2012]



Causes for observed Antarctic sea ice increase are unclear

1. Forced signal?

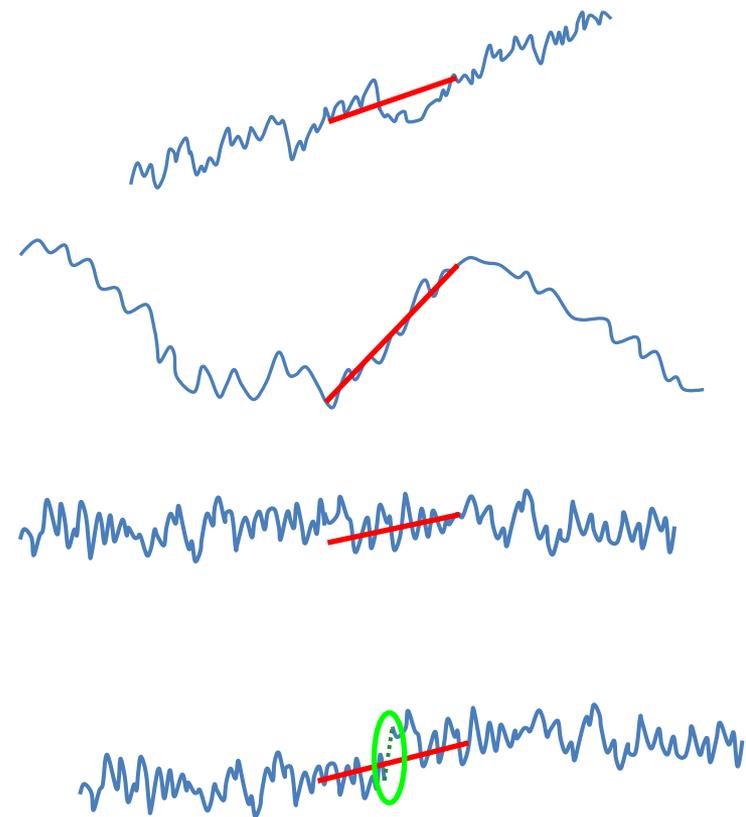
2. Multi-decadal variability?

3. Statistical noise?

4. Methodological artefact?

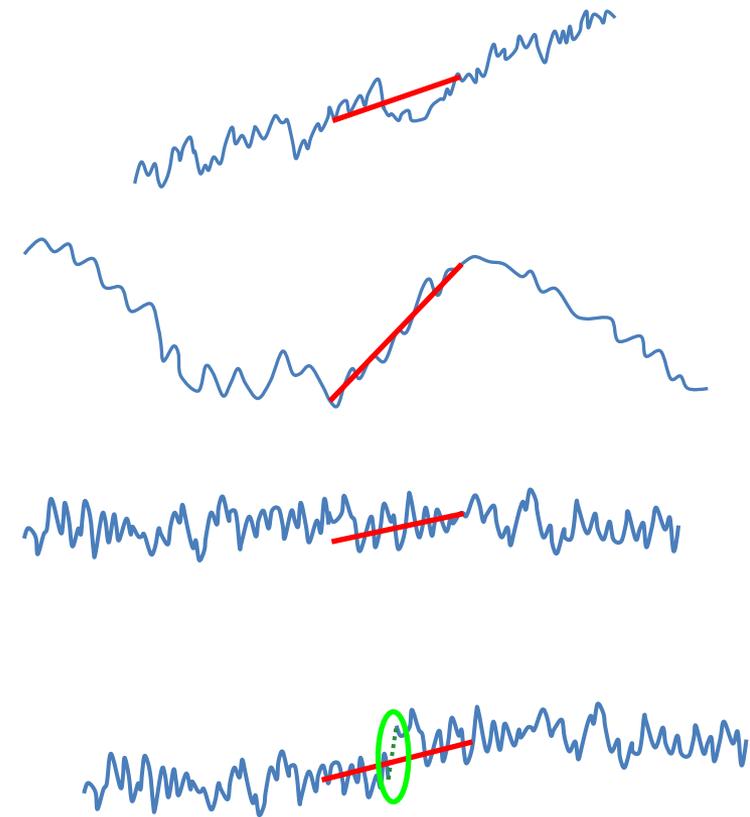
Jump in retrieved sea ice area in 2007-2008

[Screen et al., 2011]



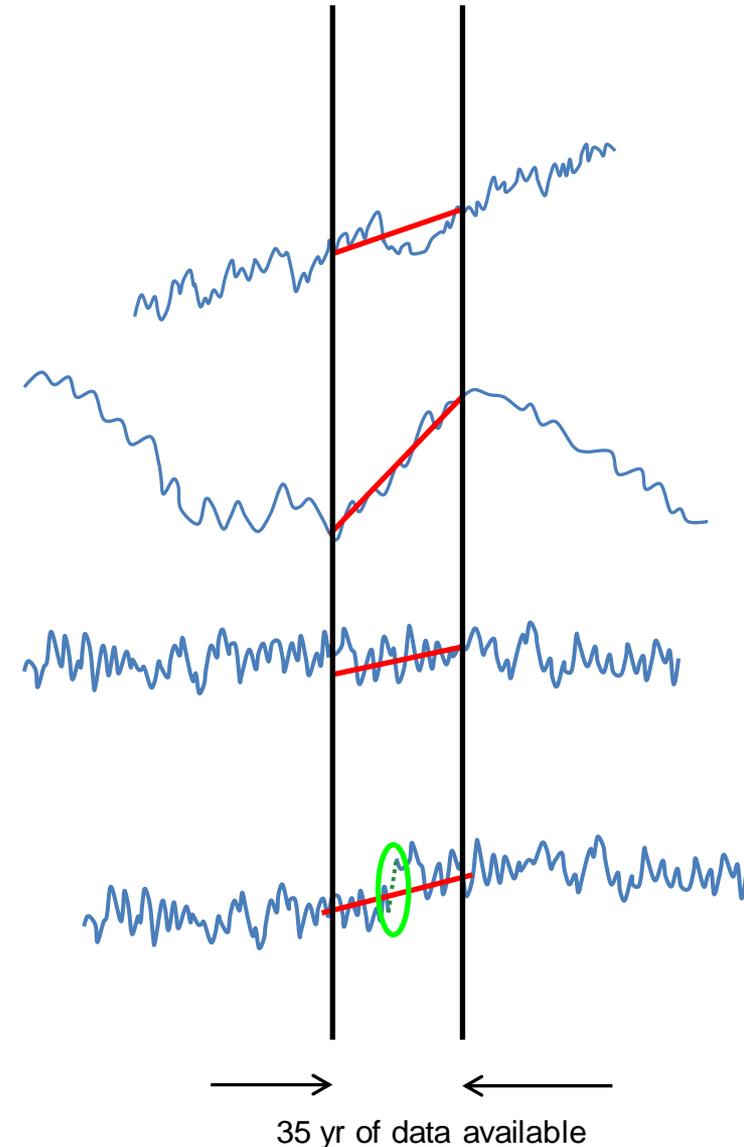
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5. Combination of 1-4?



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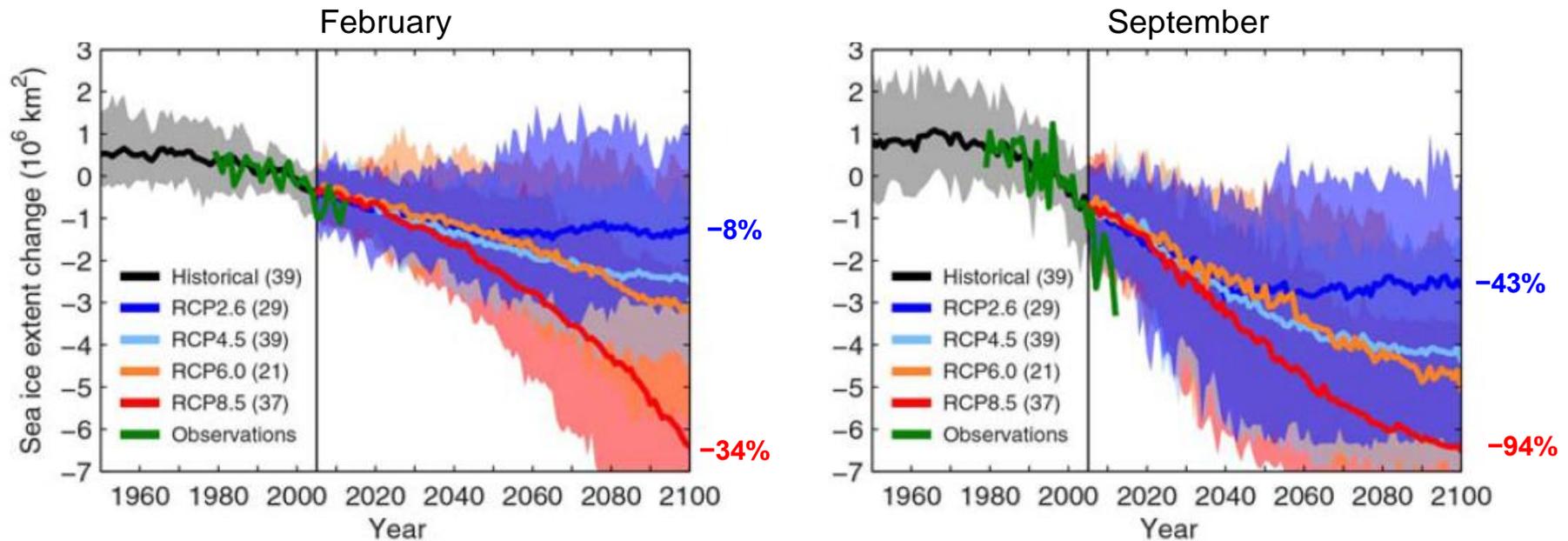
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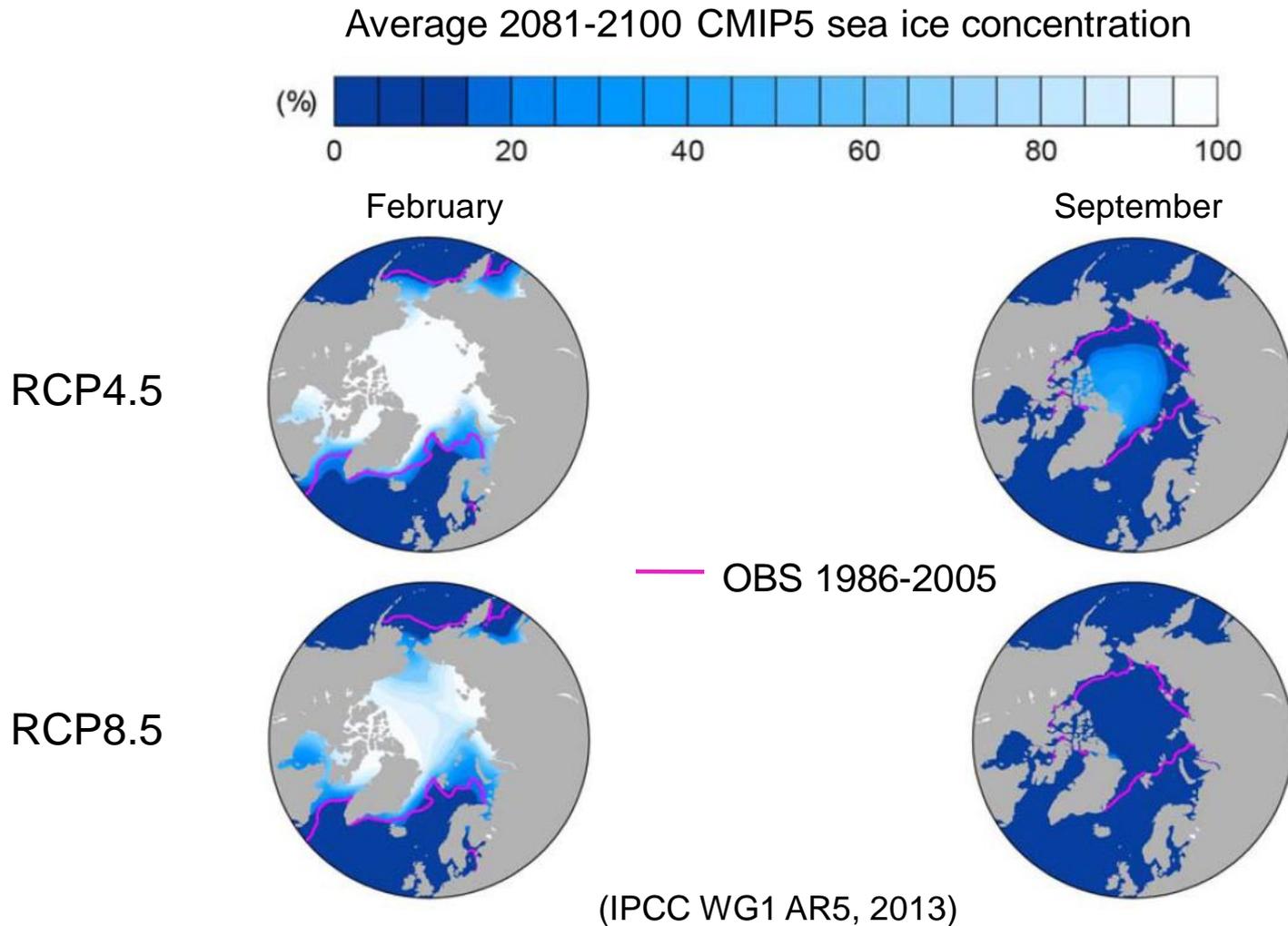
The Arctic sea ice cover will *very likely* continue to shrink as global temperature rises

Changes in CMIP5 Arctic sea ice extent (reference: 1986-2005)



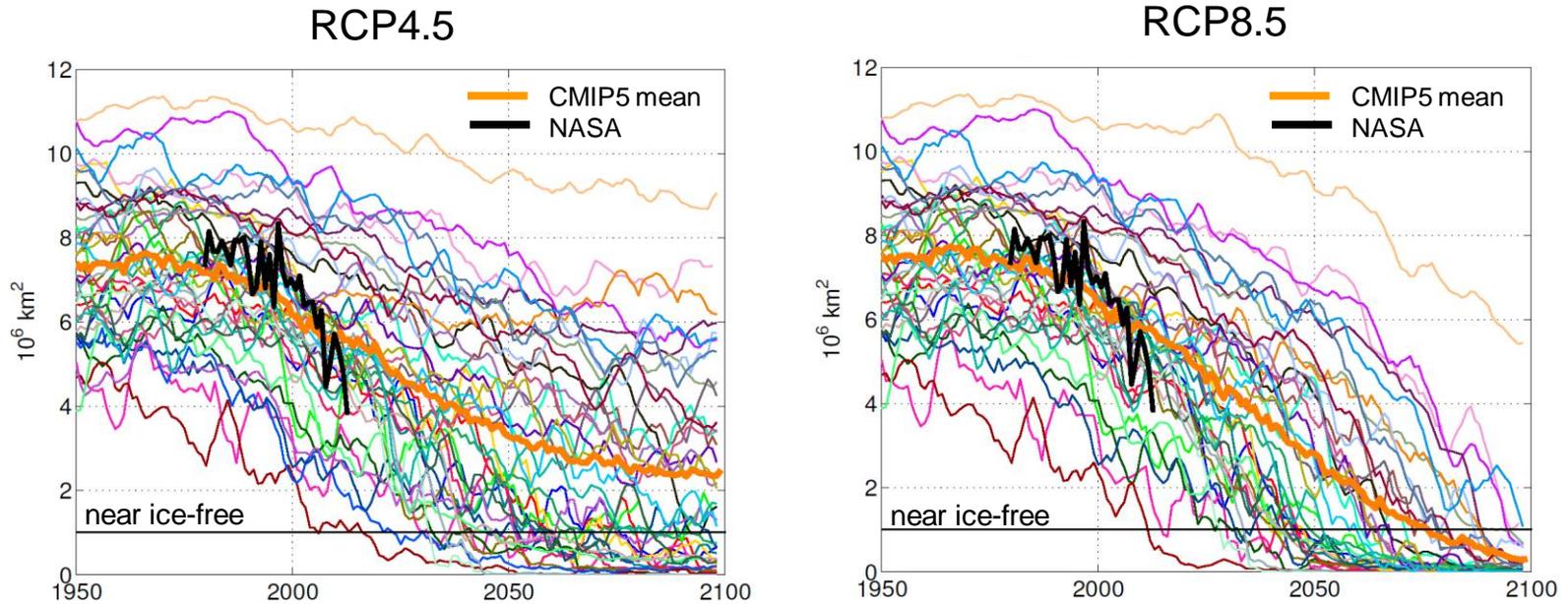
(IPCC WG1 AR5, 2013)

The Arctic sea ice cover will *very likely* continue to shrink as global temperature rises



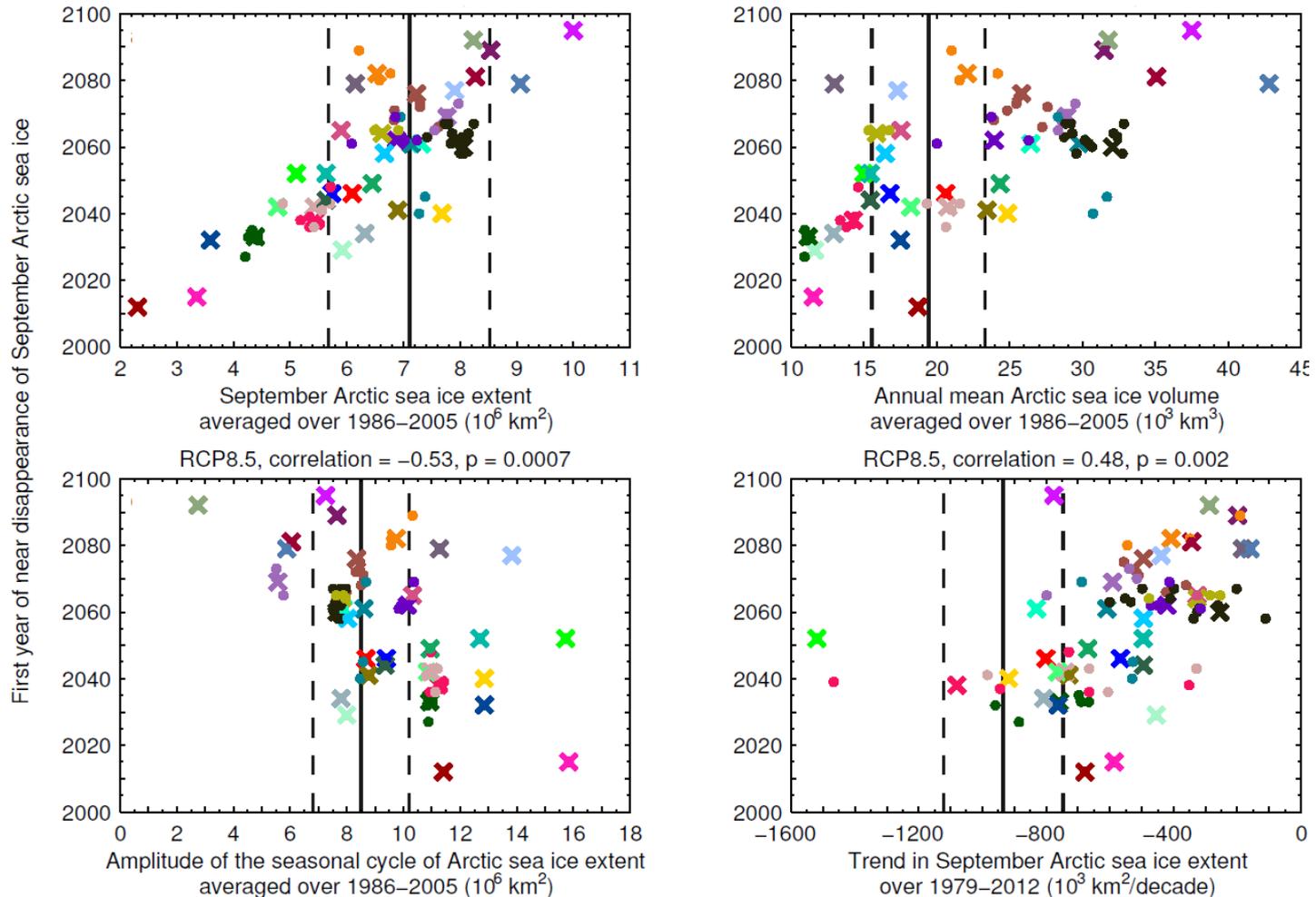
The spread in summer Arctic sea ice projections remains wide

September sea ice extent simulated by CMIP5 models



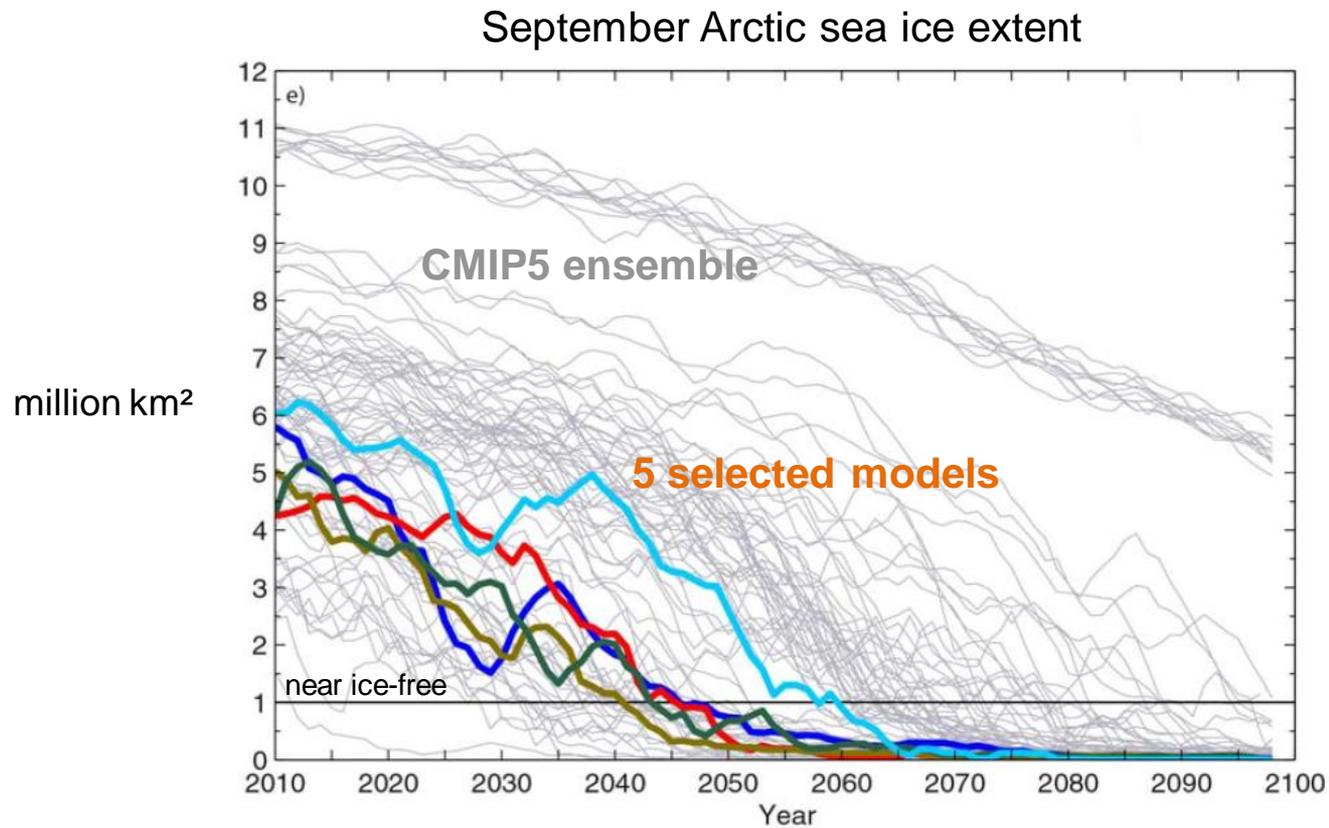
(Massonnet et al., The Cryosphere, 2012)

Year of disappearance of summer Arctic sea ice linked to baseline sea ice state



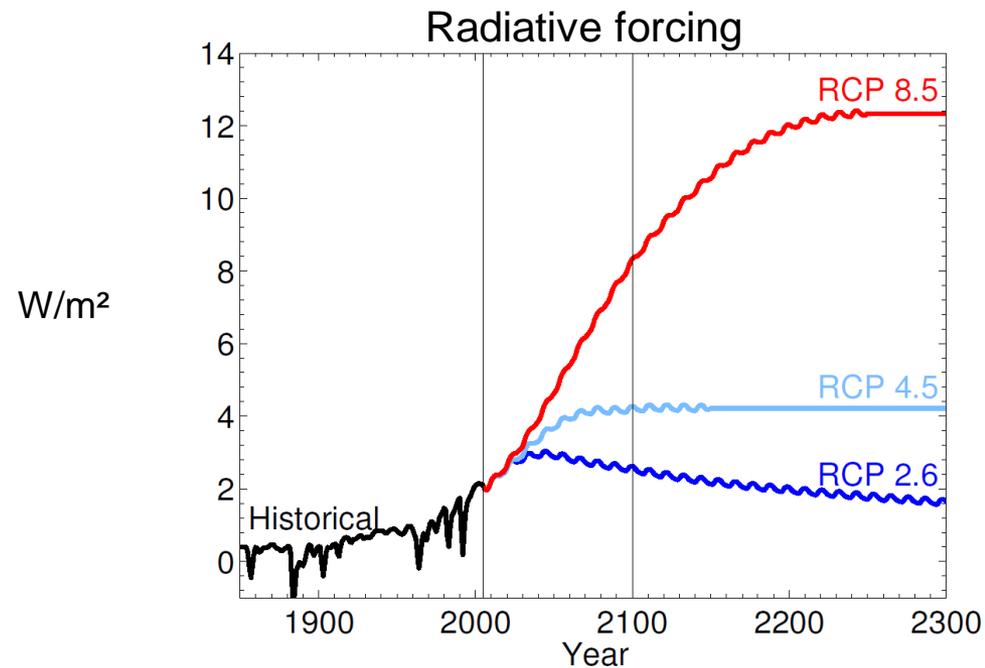
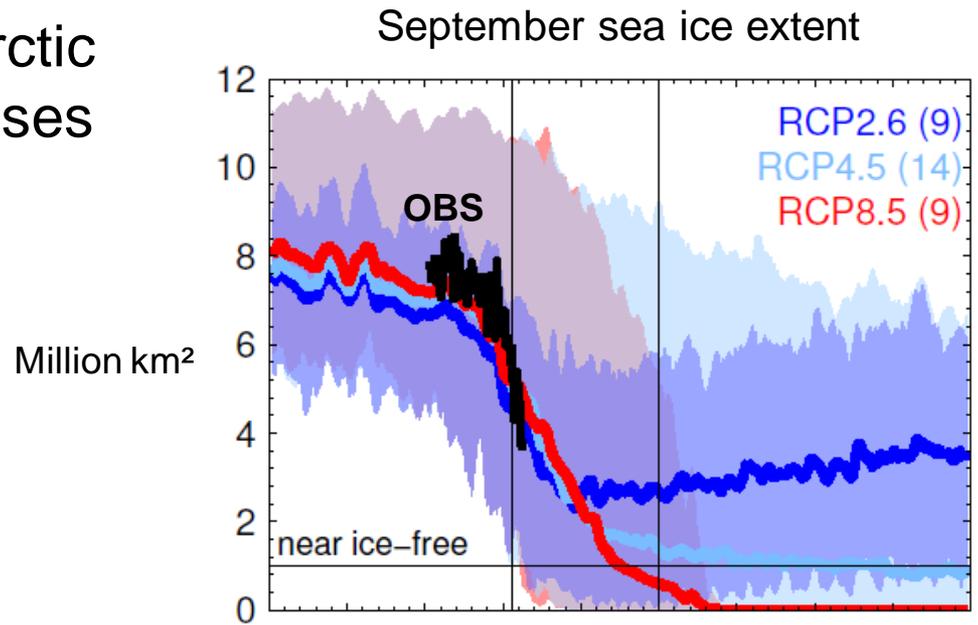
(IPCC WG1 AR5, 2013 ; Massonnet et al., The Cryosphere, 2012)

A nearly ice-free Arctic Ocean in September is *likely* by mid-century (high-emission scenario)



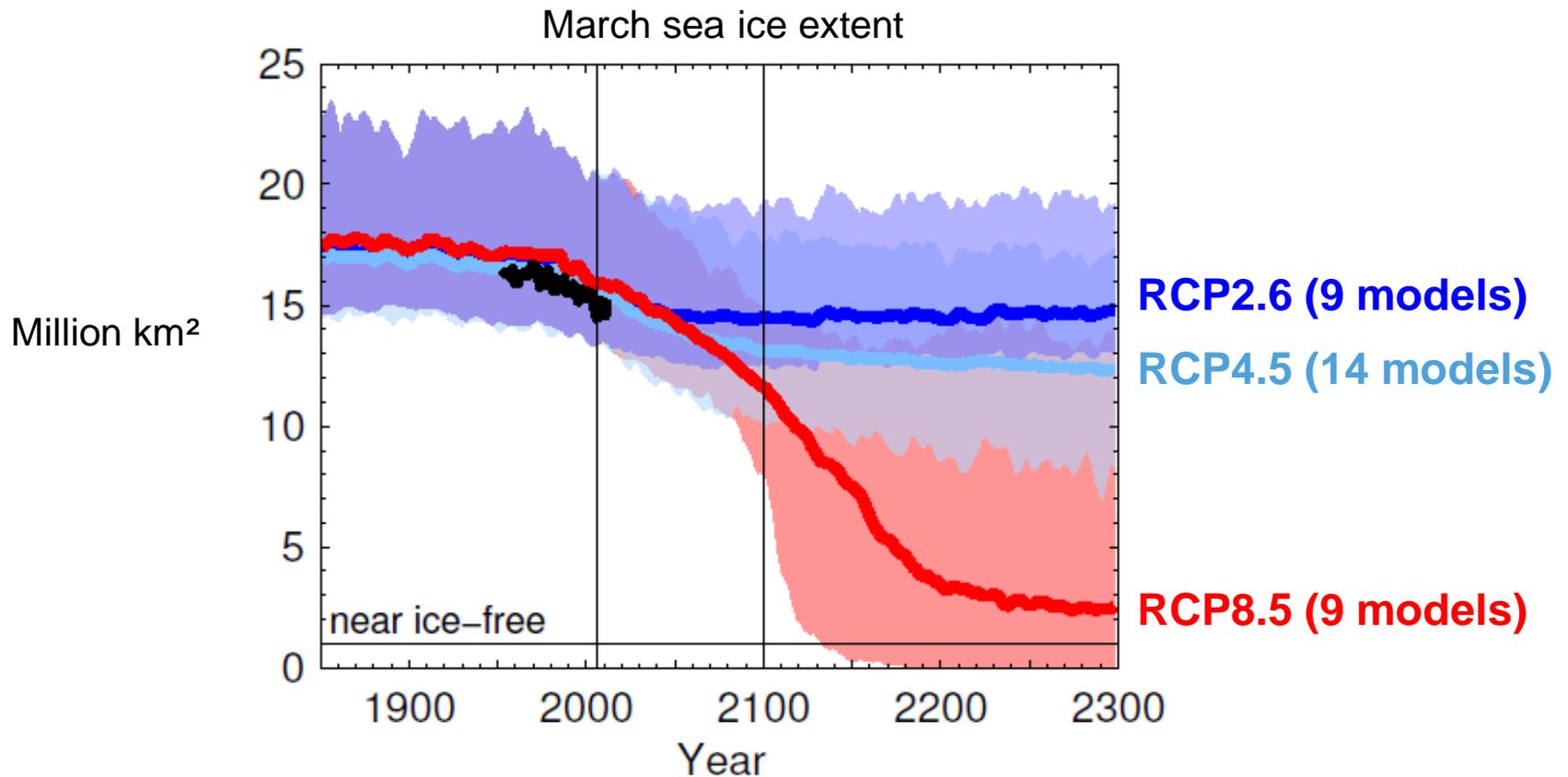
(IPCC WG1 AR5, 2013 ; Massonnet et al., The Cryosphere, 2012)

Possible recovery of summer Arctic sea ice if radiative forcing decreases



(Hezel et al., in prep.)

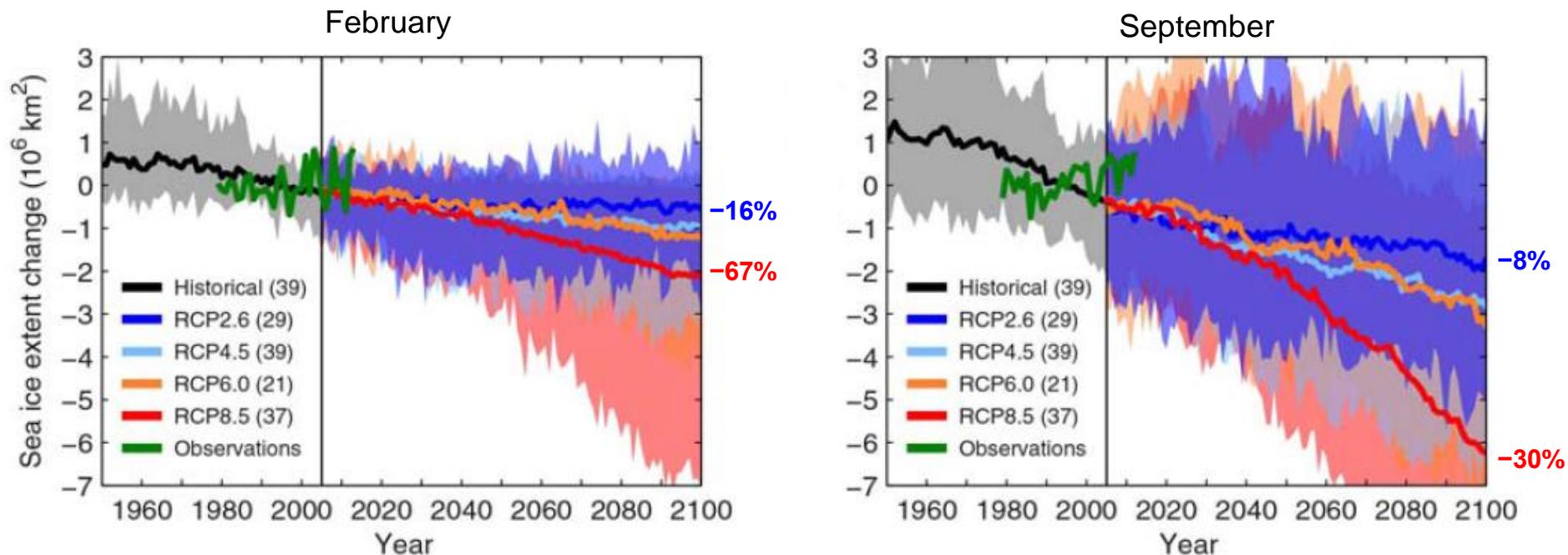
7 out of 9 CMIP5 models reach ice-free conditions in winter by 2300 under a high-emission scenario



(Hezel et al., in prep.)

A decrease in Antarctic sea ice extent is expected during the 21st century, but with *low confidence*

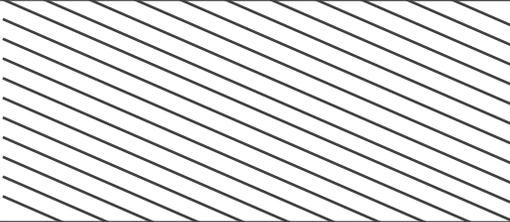
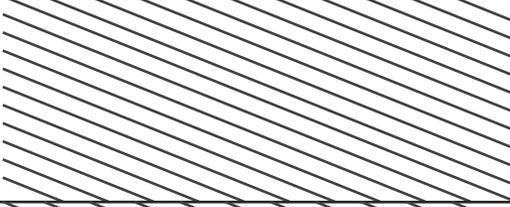
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(IPCC WG1 AR5, 2013)

Conclusion 2

CMIP5 offers the possibility to investigate Arctic sea ice projections, caution has to be taken for Antarctic

	Arctic	Antarctic
Projected sea ice extent	 <i>very likely</i>	 <i>low confidence</i>
Ice-free conditions in September	by mid-century if high-emission scenario <i>likely</i>	
Ice-free conditions in March	clear possibility by 2300 if high-emission scenario	
Recovery of sea ice in September	possible if low-emission scenario	

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Possible analyses for the Arctic,
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A satellite view of Earth from space, showing the Antarctic continent and the surrounding Southern Ocean. The continent is covered in a thick layer of white sea ice, which extends into the surrounding dark blue waters. The curvature of the Earth is visible at the bottom and sides of the frame.

Antarctic sea ice A priority for CMIP6?

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`www.climate.be/u/fmasson`

IPCC report: `www.climatechange2013.org`