Constraining projections of summer Arctic sea ice

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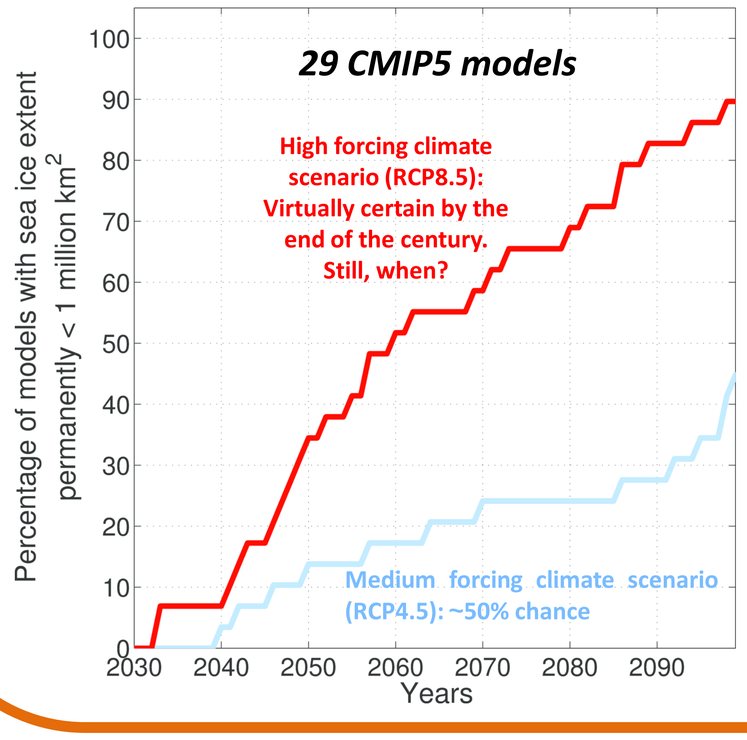
Sea ice-free Arctic in summer

- *Can this happen before 2100 ?*
  YES, according to CMIP5 models
- *When? Of course, scenario-dependent*



Main findings

- *Coupled Model Intercomparison Project, phase 5* (CMIP5) models: **not clear** *a priori* whether or not (and if so, when) **Arctic sea ice-free conditions** could be reached before 2100.
- **Elevated rate of decline** in September sea ice extent at ~2-4 million km²
- **Timing** of summer sea-ice free conditions **well constrained** by current mean sea ice state (extent, volume, trends) for high emission scenario (RCP8.5)
- Constraints have physical *sea ice* bases, but **other factors** (e.g., oceanic meridional heat transport) must be invoked to improve the selection, for example with RCP4.5.

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Supp. info

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References

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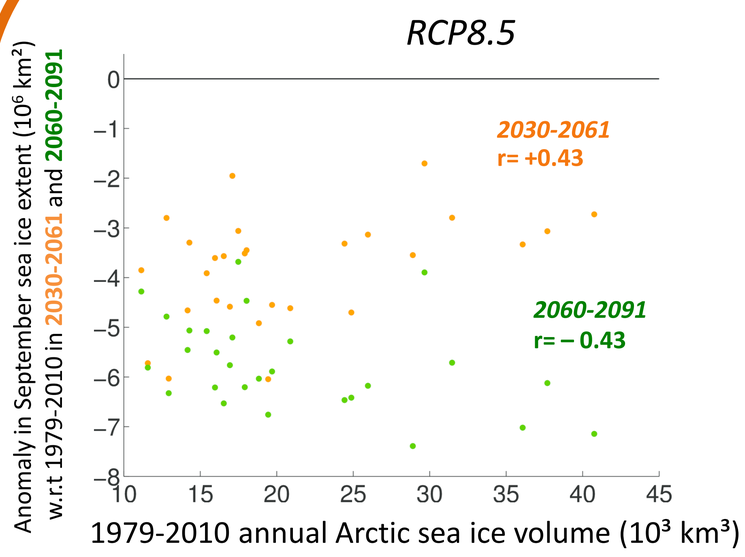
Constraining : *Defining appropriate criteria to reduce uncertainties in sea ice projections*

Main parameters thought to be *constraining* sea ice projections*:*

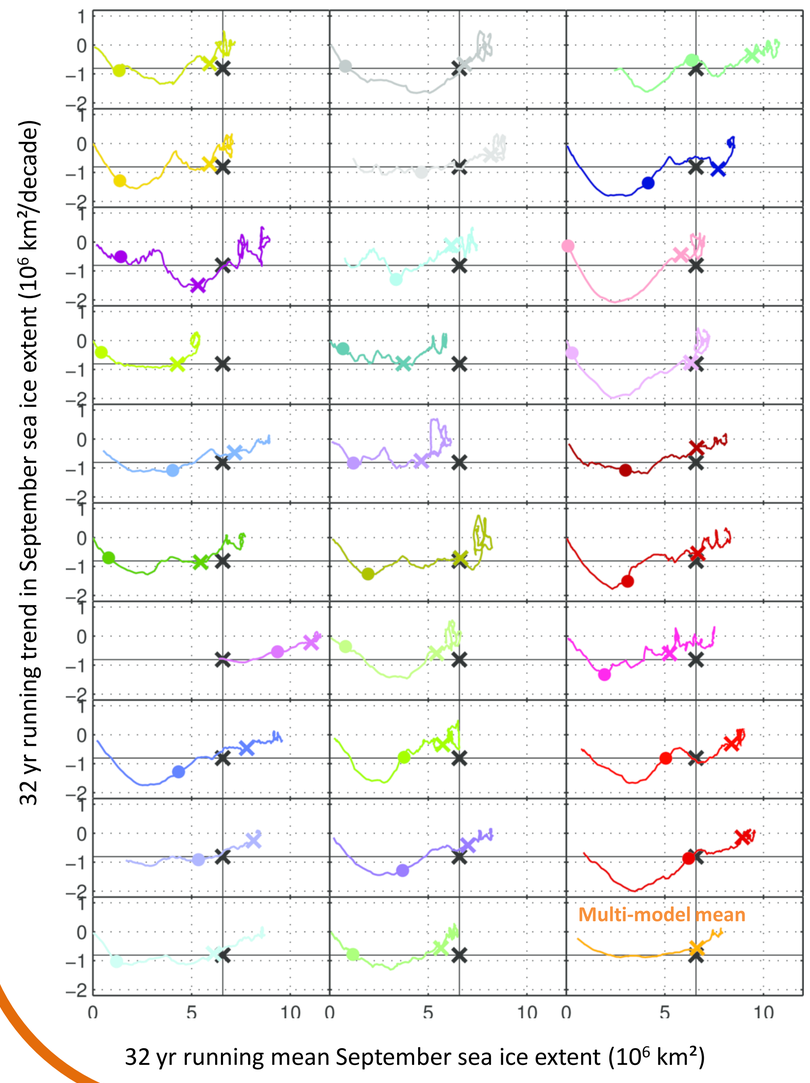
Type of climate scenario, ***current sea ice state****, sea ice sensitivity to temperature rise, oceanic heat transport to high latitudes, …*

Boé et al., 2009; Stroeve et al., 2007,2012; Wang and Overland 2009,2012 — Mahlstein and Knutti, 2012; Gregory et al., 2002 — Mahlstein and Knutti, 2011

1. Constraining future sea ice extent *anomalies*?



Example
Current sea ice volume is not a good constraint on simulated September sea ice extent anomalies:
- Moderate correlations
- Sign of relationship sensitive to time periods



Constraining anomalies seems not to be a good strategy.

It appears that the **trends (rate** of decline**)** in September sea ice extent achieve a maximum when the mean sea ice extent is at ~2-4 million km²
(is this what the real sea ice cover is undergoing currently?)

➡ With CMIP5 models, future sea ice losses (i.e., *x*-distance between the cross and the dot) depend in a nonlinear manner to the current sea ice state.

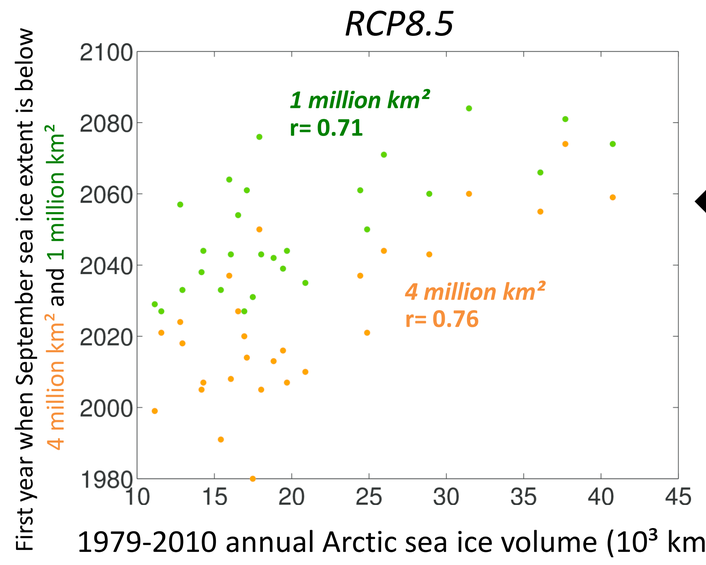
Legend

OBS **1979-2010 (NSIDC)**

… CMIP5 models **1979-2010**

… CMIP5 models **2030-2061**

2. Constraining *year of disappearance* of summer Arctic sea ice?



Example
Current sea ice volume is a good constraint on the first year during which September sea ice extent drops below a given value

Outcome of a **model selection** based on (1) mean 1979-2010 September sea ice extent, (2) 1979-2010 trend in September sea ice extent, (3) amplitude of 1979-2010 mean seasonal cycle and (4) 1979-2010 annual mean sea ice volume. All four criteria impact the timing when ice-free conditions are reached in the Arctic (relationship shown above for sea ice volume). A model is selected if it simulates all four criteria within 20% of the observations (NSIDC sea ice index for sea ice extent; PIOMAS (Schweiger et al., 2012) for sea ice volume).