Aspects of Arctic sea ice decline in CMIP5

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Recent and future Arctic summer sea ice loss from the perspective of a Rapid Ice Loss Event (RILE)

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Summary

Rapid Ice Loss Events were identified in CMIP3 models as periods of ~5 years of rapid Arctic summer sea ice extent loss that is greater than the background rates of loss (Holland et al., 2006). We use the CMIP5 archive to show that:

- the probability of RILEs increases dramatically after 1990;
- the observations have undergone a RILE in the last decade;
- linear interpolation of a RILE trend underpredicts SIE after a RILE

Thus we find that the September sea ice extent rate of decline is not likely to continuously accelerate in the coming decades.

1. RILE example (ACCESS-1.0 model)

RILE definition used:
1. Use 5 year running mean time series of Sept. SIE.
2. Define RILE threshold as 3-
3. Bound RILE at 1-

By the numbers...

- 84 ensemble members
- 73 with at least 1 RILE
- 227 RILEs identified
- Length: median: 5 years, mean 6.0 years
- Mean threshold -0.33±0.12 x 10^6 km^2 / year
- Observed RILE threshold -0.27 x 10^6 km^2 / year

2. RILE in observations

A RILE is found for 2002-2009 in the observations using the same definition. Observations are from Meier et al. (2012).

3. RILE probabilities by decade

Probability of RILE calculated as number of RILEs starting in each decade divided by total number of ensemble members.

4. Role of trend in forcing versus change in variability

Monte-Carlo simulations estimate the relative role of the forced trend and increase in variability, as well as the non-linear combination of the two, in increasing the probability of a RILE.

5. Linear extrapolations using RILE trend

Linear extrapolation of the RILE trend to 10 years (and more) increasingly underestimates the SIE compared to the CMIP5 model evolution.

Arctic sea ice evolution through 2300 in CMIP5 extended RCPs


Summary

We examine sea ice extent and volume in the extended RCP scenerios to 2300. We find the following:

- September SIE begins to recover in RCP2.6 in all models, as expected from the decrease in radiative forcing. Timing of multi-model mean matches time in change in forcing.
- Temperature at which sea ice extent disappears is broadly consistent across models.
- Winter sea ice disappears in 7 out of 9 models.

1. Global temperature response reflects forcing changes

The global surface temperature response reflects changes in forcing in the RCP scenarios.

2. Sea ice response follows forcing changes, RCP2.6 SIE shows increases

Multi-model mean Arctic SIE rates of decline change with changes in forcing. All RCP2.6 models show some recovery of summer SIE.

3. Global temperature increase at ice-free Arctic

Global mean temperature increases at which sea ice extent disappears (RCP8.5) are broadly consistent across models. (Exceptions GISS-E2-H, GISS-E2-R, CSIRO-MK3.6.0). These are also consistent with RCP4.5 (not shown).

4. RCP8.5 both summer and winter sea ice disappear

Sea ice disappears in both summer and winter in 7 of 9 models (8 shown here).

September

RCP8.5 (9) RCP4.5 (14) RCP2.6 (9)

March

RCP8.5 (9) RCP4.5 (14) RCP2.6 (9)