Antarctic Sea Ice in the Large Ensemble

Marika Holland
Laura Landrum
Annual cycle generally well simulated
Not enough melt back during summer

Ice thickness climatology:
Overall thickness is reasonable
Distribution is biased – with thickest ice on wrong side of peninsula
Ensemble mean simulates a decrease in Antarctic sea ice, although members span the range of the observed conditions. This is in contrast to observations which show an increase in ice cover.
Observed Antarctic Sea Ice Trends

million sq km per year
Ice Extent Trends

Trend from 1979-2013

OBS

Range across ensemble members
Possible reasons why LE does not simulate increasing ice in late 20th century

- Regional compensation of trends not well expressed
- Anthropogenic warming signal is too large at the surface
  - For example because of inadequate ocean heat uptake
- Influence of ozone loss not well represented
  - E.g., “slow response” may happen too fast or be too large
- Model has missing processes (e.g. associated with ice sheets)
Possible reasons why LE does not simulate increasing ice in late 20th century

- Regional compensation of trends not well expressed
- Anthropogenic warming signal is too large at the surface
  - For example because of inadequate ocean heat uptake
- Influence of ozone loss not well represented
  - E.g., “slow response” may happen too fast or be too large
- Model has missing processes (e.g. associated with ice sheets)
AMJ Observed Trends (1980-2005)
Regional trends

AMJ Trends, 1980-2005

Observed
AMJ Trends (1980-2005)

The simulations with high pattern correlation generally have less ice loss.
CMIP5 simulations

IPCC AR5 Figure 9.22

IPCC AR5 Figure 9.24
Conclusions

• CESM Large Ensemble simulations show reductions in Antarctic sea ice in contrast to observations
• Some members do simulate regional ice trend patterns similar to observations
  – these typically have less ice loss
• CESM-LE has smaller standard deviation in areas of increasing ice trends
  – ongoing work is diagnosing the drivers of this variability
• Other factors that may affect overall Antarctic sea ice loss are also being investigated
Ocean Temperature Change

Ocean TEMP Anomaly: 700–1100M depth, 35–65S
Relative to 1900s

Temperature Change °C

Decade

1920 1940 1960 1980 2000
$1^{\text{st}}$ EOF of AMJ sea ice concentration
Model correctly simulates processes but not correct regional and/or seasonal magnitudes or ratios

Autumn (AMJ) 1992-2010 trends in winds (vectors) and sea level pressure (contours).
Fig. 3 from Holland and Kwok, 2012, Nature Geoscience, 5, 872-875.
Project overview

- Majority of CMIP5 models show decreasing trends (over the satellite era) in SH (summer) sea ice in contrast to observations

- Most CMIP5 models also overestimate SH (winter) sea ice variability (trends vs. natural variability?)

- Ozone changes impact atmospheric circulation in SH – how does this effect sea ice (and can we rely on model projections?)

- Why?
  - Use the CESM Large Ensemble (30 20th-21st Century simulations) to try to tease apart some answers to a complicated question
  - Ocn, atm, ice responses to greenhouse gas and ozone changes
Preliminary figures and first steps

• Use LE simulations individually to look at regional and seasonal processes (regional similarities vs. mean hemisphere differences; seasonality)
Regional trends

AMJ 1992-2010 Trends
Holland and Kwok, 2012