Reassessing the Role of Sea Ice Drift in Arctic Sea Ice Loss

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Tandon et al., in prep.
CESM PCWG Meeting, February 2017
Rampal et al. 2011: Apparent Sea Ice Drift Issues in CMIP3

- Rampal et al.: CMIP3 models have unrealistic ice drift speeds, seasonal cycle and trends.
- The apparently sluggish thin ice in models ice suggests that trends in Arctic sea ice export (Fram Strait) might be underestimated.
- Was this bias a source of reduced sea ice thinning and loss in CMIP3?
Key Points Today

When using appropriate temporal sampling, ice drift in climate models agrees better with observations.

However, in the forced model response, drift acceleration is not necessarily associated with ice loss.

Instead, spread in ice loss is more closely related to differences in climatological sea ice thickness.

Ice drift feedbacks might play a role in internal variability of Arctic sea ice.
Methods

- 22 CMIP5 models
  - Historical + RCP8.5
  - Daily sea ice drift and winds.
  - Models with multiple ensemble members: IPSL-CM5A-LR, MIROC5, CESM1.


- Arctic domain shown to left
  - North of 68°N for 103°E –124°W
  - North of 79°N elsewhere.

Tandon et al. in prep.
Rampall et al (2011): Seasonal cycle of drift speed in buoys (black) and model (colored)

- Observed drift is large when ice is thin, in September-October
- Rampall et al: CMIP3 drift speed strong in December, when winds are strong.
• Observed drift is large when ice is thin, in September-October

• Rampall et al: CMIP3 drift speed strong in December, when winds are strong.
• We find CMIP5 maximum drift typically occurs in September-October.
• But we use daily model drift components, while Rampal et al. used monthly model drift components!
Rampall et al (2011): Seasonal cycle of drift speed in buoys (black) and CMIP3 (colored)

Tandon et al. (in prep): Seasonal cycle of drift speed (solid) and wind speed (dashed)

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• But we use daily model drift components, while Rampal et al. used monthly model drift components!
Time Sampling Has a Big Impact

Annual Mean CMIP5 Drift Speeds (away from coasts)

Computed from daily means

Computed from monthly means
Let’s pick out models with drift acceleration ...

20-Year Mean Drift Speeds

IABP Buoys
Let’s pick out models with drift acceleration ...

20-Year Mean Drift Speeds

(We don’t have 1950-2100 daily drift time series for CCSM4 or CESM1.)
Sea Ice Thickness Feedback Dominates

Sea Ice Area

Sea Ice Volume

Annual Mean

September Mean

NSIDC

PIOMAS
When we sample CESM1’s internal variability, more drift acceleration is associated with stronger volume trends.
Exploring a Range of Drivers for Volume Trends

Sea Ice Volume Loss ($10^{12}$ m$^3$ dec$^{-1}$)

Drift acceleration (km day$^{-1}$ dec$^{-1}$)

Sea ice volume climatology ($10^{12}$ m$^3$)

Sea Ice Volume Loss ($10^{12}$ m$^3$ dec$^{-1}$)

Fram Strait southward acceleration (km day$^{-1}$ dec$^{-1}$)

Arctic volume export ($10^{12}$ m$^3$ dec$^{-1}$)
To Recap...

- Models are better at producing realistic ice drift than previously claimed – appropriate time sampling is key!
- For intermodel spread, any effect of ice drift acceleration is overwhelmed by effects due to initial sea ice climatology.
- For internal variability, a drift acceleration effect might be at work.
- As model climatologies converge, we can expect ice drift effects to play a more prominent role, but they may still be overwhelmed/obscured by other effects.
- **Bottom line:** improving sea ice dynamics on its own will not drastically improve the skill of the forced component of Arctic sea ice loss projections. Much attention needs to be given to the initial climatology of sea ice.
- In addition, drift feedbacks could still be important for seasonal prediction of sea ice.