Atmosphere - sea ice interactions in the Arctic. Non stationarity and implications for predictability

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Outline

• Introduction & Motivation

• Focus on summer season
  
  • Controls on summer sea ice variability: the role of atmospheric heat flux
    
  • Model vs Observations.

• A brief (and incomplete?) history of time. Non stationarity, and implications for seasonal predictability.
September Arctic Sea Ice Extent
1979-2011
September Arctic Sea Ice Extent
1979-2011

• Controls on interannual summer sea ice variability

  • Winds - both summer and winter through preconditioning (e.g. Rigor et al., 2002, Ogi et al 2008, 2010)

  • Ocean currents (Polyakov et al 2005, Shimada et al 2006)

  • Radiative fluxes at the surface (Perovich 2007)

  • Energy redistribution within Arctic (Graversen et al, 2011)

  • Storm tracks (Screen 2012?)
• What (if any) is the role of atmospheric heat flux into the Arctic in summer months? How should one calculate this metric?

Standard deviation of September sea ice concentration
• A little background on Arctic heat fluxes. Overland and Turet (1994)
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In summer, a large part of atmospheric heat flux (at 70N) is radiated downwards.
Summer heat flux into the Arctic

JJA 70N heat flux and September ice extent (normalised)

Mean 70N heat flux = 80 W/m²
StDev of heat flux = 3 W/m²
Spatial patterns

Sept. ice - SLP

JJA heat flux - SLP

(hPa)
Summer heat flux into the Arctic
Summer heat flux into the Arctic

Blue: CCSM control run
\[ r = -0.34 \]
Summer heat flux into the Arctic

In CESM-CAM5, less (more) energy fluxed into surface (space) than in ‘observations’.

Additionally, 9 W/m^2 of heat added to atmosphere throughout summer.
Summer heat flux into the Arctic

In slab ocean - CAM4 experiments with identical ICs in spring, similar mean state.

Also, low coupling heat transport / september sea ice (not shown)

CCSM-CAM4 control shows the same low coupling

(80±3 from reanalysis)

32±2.2
10±1.5
47±2.6
89±2.7
## Energy

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\[ 9_{\pm 2.6} \]

\[ 49_{\pm 4.1} \]

\[ 84_{\pm 3.5} \]

\[ 26_{\pm 3.5} \]
Non-stationarity of heat flux - sea ice coupling

summer heat flux - september ice  \( r = -0.34 \)
Non-stationarity of heat flux - sea ice coupling

May Sep ice – PSL

Heat flux – PSL

Years 1–30

r=-0.33
Non-stationarity of heat flux - sea ice coupling

$r = -0.27$
Non-stationarity of heat flux - sea ice coupling

$r = -0.08$
Non-stationarity of heat flux - sea ice coupling

\[ r = -0.36 \]
Non-stationarity of heat flux - sea ice coupling

$r = -0.15$
Non-stationarity of heat flux - sea ice coupling

$r = -0.40$
Non-stationarity of heat flux - sea ice coupling
Non-stationarity of heat flux - sea ice coupling

$r = -0.19$
Non-stationarity of heat flux - sea ice coupling

$r=-0.09$
Non-stationarity of heat flux - sea ice coupling

$r=-0.45$
Final thoughts...

- Does summer atmospheric heat flux help explain variability of summer sea ice?
  - Observations... strongly
  - Model... weakly
  - But in both cases, negative correlation.

- Are the model fluxes too 'uncoupled'? What is the mechanism heat flux -> sea ice melt? How sensitive is it to mean state?

- Have we just 'observed' an uncommon period of 'coupling' between sea ice variability and heat flux?

- Background variability leads to non-stationary relationships between different fields... not a good thing for statistical predictions

\[ r = -0.45 \]