Regional, seasonal and lagged influences of the Amundsen Sea Low on Antarctic Sea Ice

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Background: Amundsen Sea Low

ASL:

Climatological low pressure region in high latitude South Pacific
(60°-75°S, 170°-290°E)

Significantly correlated with:
Southern Annular Mode (SAM)
(all seasons although not as strongly in austral winter)

Nino3.4 (DJF)

Related to location of maximum cyclone system density in Amundsen-Bellingshausen seas

Tremendous year to year variability

e.g. Fogt et al., JGR, 2012; Hosking et al., J. Clim, 2013

1979-2015 climatology

ERAI (PSL)
SSMI (sea ice)
Background:
ASL and sea ice extent seasonality

ASL metric:
lowest absolute central pressure in ASL region

Tremendous year to year variability (depth and location)
ASL: interannual variability

April (example)

ASL impacts Sea Ice through winds

Largest observed SIC trends in region of ASL influence
Background motivation: ozone, ASL and sea ice

ASL attributed SIC changes, 1955-2005

Observed SIC changes, 1979-2015

DJF ASL deepening over ozone depletion time period (1955-2015)

Deepening summertime ASL does not explain observed MAM sea ice trends

Mechanisms explaining observed fall (MAM) trends in sea ice remain uncertain

e.g. England et al., GRL, 2016; Landrum et al., GRL, 2017
ASL-Sea Ice Concentration

3 examples of ASL influence on SIC

1. April (sea ice advance)
2. July (mid-winter)
3. October (sea ice retreat)
April ASL

Deepening ASL: 
↑ SIC in Ross, Amundsen
April (austral fall) ASL

- Deepening ASL → increased SIC in Ross, Amundsen
- Anomaly increases then persists (1 – 3 months)

- Ice advancing
- Ice edge close to ASL lat
- Mean ice motion: meridional (V) > zonal (U)
- ASL impacts primarily meridional ice motion
Deepening ASL:

↓ SIC in Ross (outer), Bellingshausen

↑ SIC in Amundsen

July ASL - July SIC correlation
July (austral winter) ASL

- Deepening ASL → tripole anomaly pattern:
  - decreased SIC in Ross, Bellingshausen
  - increased SIC in Amundsen
- Anomaly grows (1-3 months) and persists (~7 months in Ross-Amundsen)

- Ice nearing maximum
- ASL within ice pack
- Mean ice motion: meridional (V) ~ zonal (U)
- ASL impacts primarily zonal ice motion (U)
October ASL

Mean SLP, ice motion

R: ASL-SLP, ice motion

Deepening ASL: Relatively little lag-0 influence

Oct ASL - Oct SIC correlation
October ASL

2 different processes:
- **Zonal ice motion (outer Ross)** – similar to July

- **Seasonal ice retreat (inner Ross)** opposite to July
  - Ice thinning
  - Earlier melt out
  - Higher solar radiation
  - Warmer ssts
  - *delayed ice advance 5 months later*

(Holland et al., Nature Communications, 2017)
October (austral spring) ASL

- Deepening ASL $\rightarrow$ decreased SIC in Ross, Bellingshausen, increased SIC in Amundsen
- ASL influence on ice motion similar to July
- Oct ice retreating (unlike July)
- Lagged relationships stronger than coincident relationships

- Ice retreating (Ross Sea no longer producing ice)
- ASL within ice pack
- Mean ice motion: meridional ($V$) $\sim$ zonal ($U$)
- ASL impacts primarily zonal ice motion ($U$)
- ASL also increases ice transport out of inner Ross Sea ($U$ and $V$), thinning the ice pack (initially little impact on sea ice concentration)
Summary

April ASL
Meridional ice motion
Anomaly persists ~3 months

July ASL
Zonal ice motion
Very persistent anomalies (7+ months)

Oct ASL
Zonal ice motion
Thinning of ice in inner Ross sea
Earlier melt out
Highest correlations at 5 months lag
Oct ASL: Mar SIC relationships stronger than Mar ASL: Mar SIC
Summary

“Generally accepted” view deepening ASL (↓ PSL) leads to:

↑ SIC Ross (western flank)
↓ SIC Bellingshausen (eastern flank)

Sometimes right, sometimes wrong

it’s complicated

(ice motion: mean and ASL influence; location of ice edge & ASL, ice retreating vs. advancing)
Extra slides
Ice motion convergence

Regional climatological ice motion convergence

Regional climatological regressed ice convergence
Climatology ASL
(mean and regressed)