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

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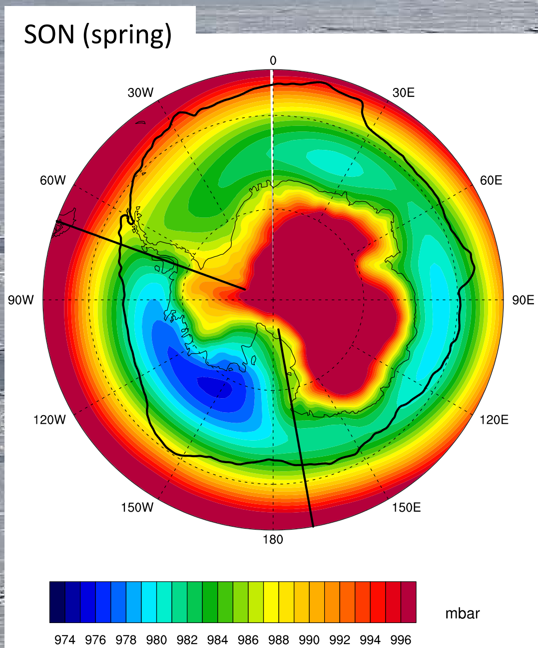
Background: Amundsen Sea Low



1979-2015 climatology

ERAI (PSL)
SSMI (sea ice)

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)

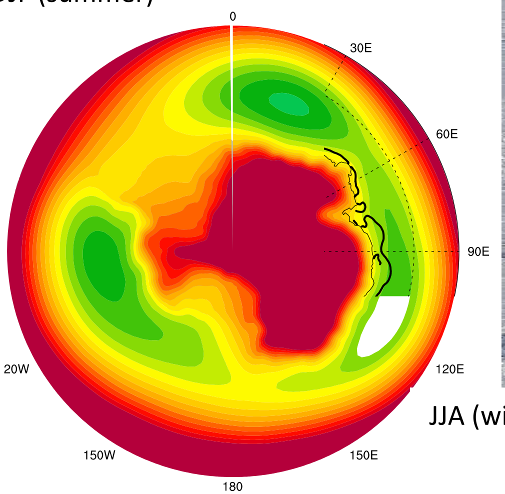
Related to location of maximum cyclone system density in Amundsen-Bellingshausen seas

Tremendous year to year variability

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

Background:
ASL and sea ice extent seasonality

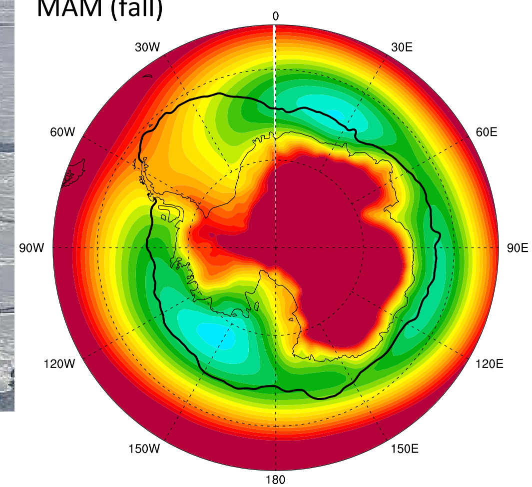
DJF (summer)



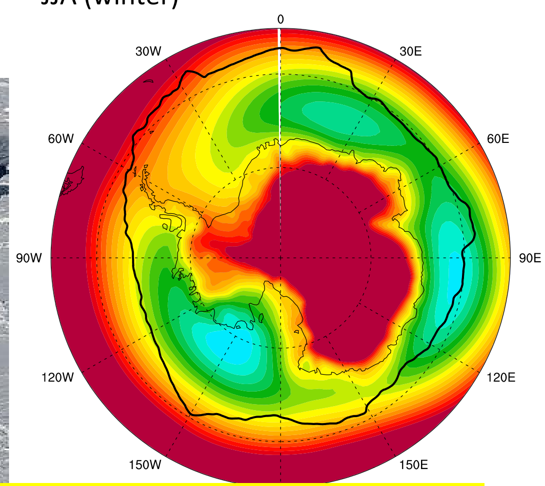
ERAI
1979-2015
climatology

15% ice contour
(black)
SSMI 1979-2015

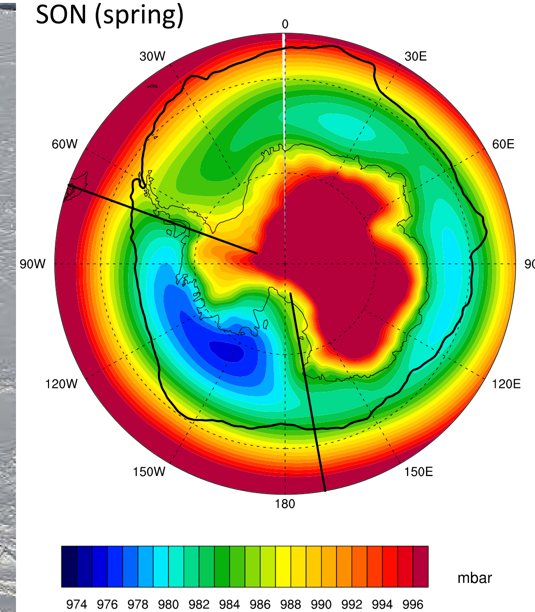
MAM (fall)



JJA (winter)



SON (spring)

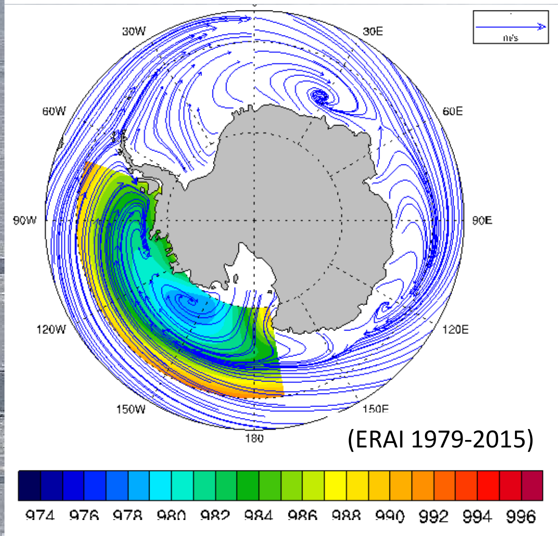


ASL metric:
lowest absolute central pressure in ASL region

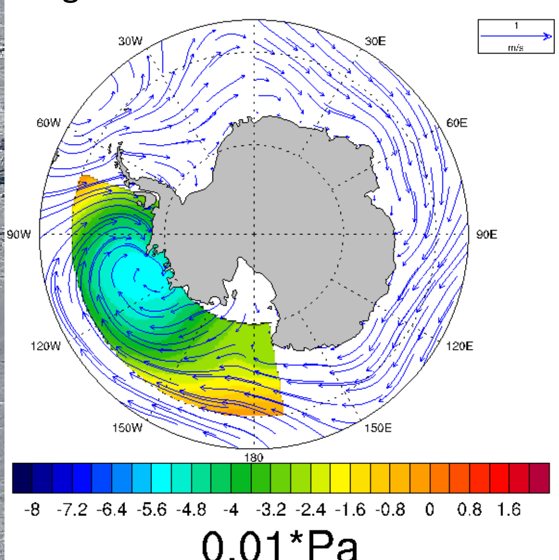
Tremendous year to year variability (depth and location)

ASL: interannual variability

April PSL, winds: climatology



Regression on ASL



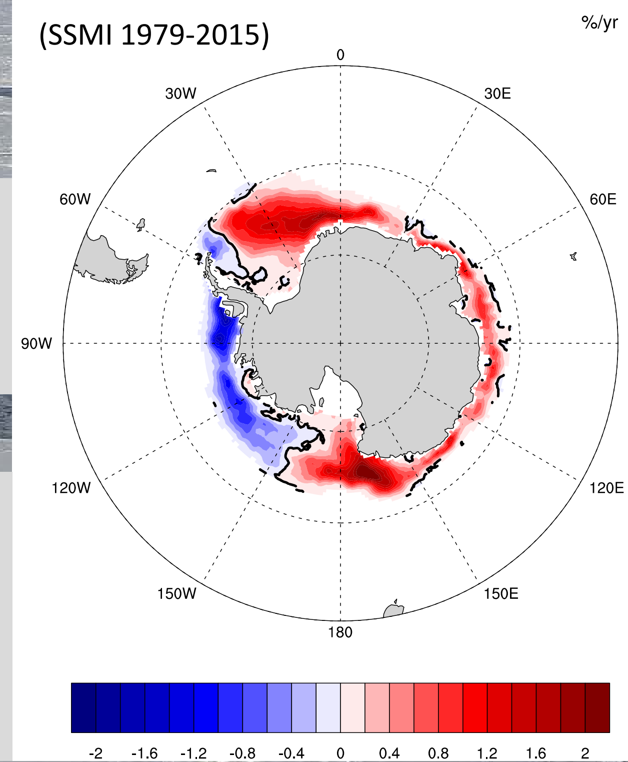
April (example)

ASL impacts Sea Ice through winds

Largest observed SIC trends in region of ASL influence

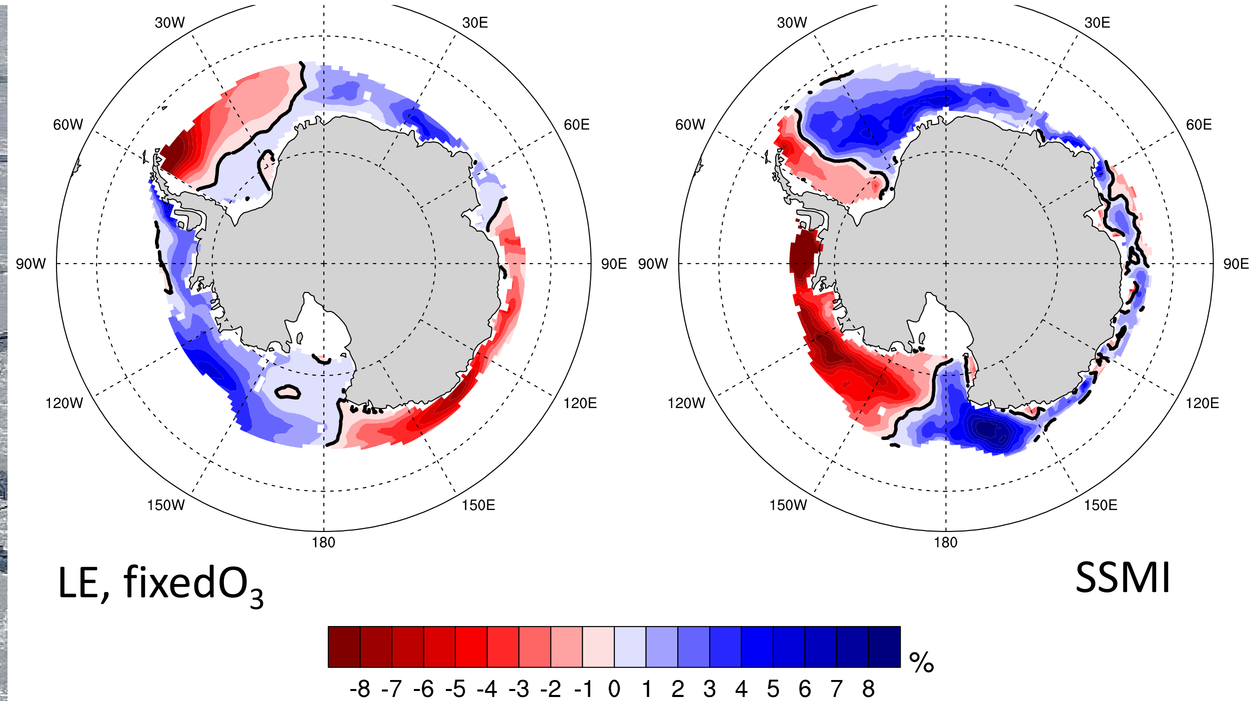
April SIC trends

(SSMI 1979-2015)



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

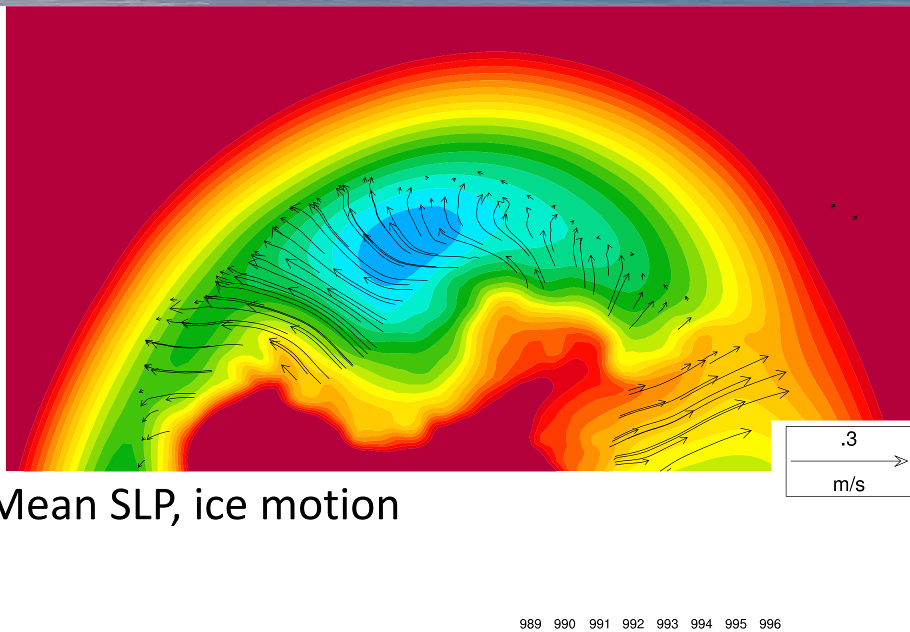
e.g. England et al., GRL, 2016; Landrum et al., GRL, 2017

ASL-Sea Ice Concentration

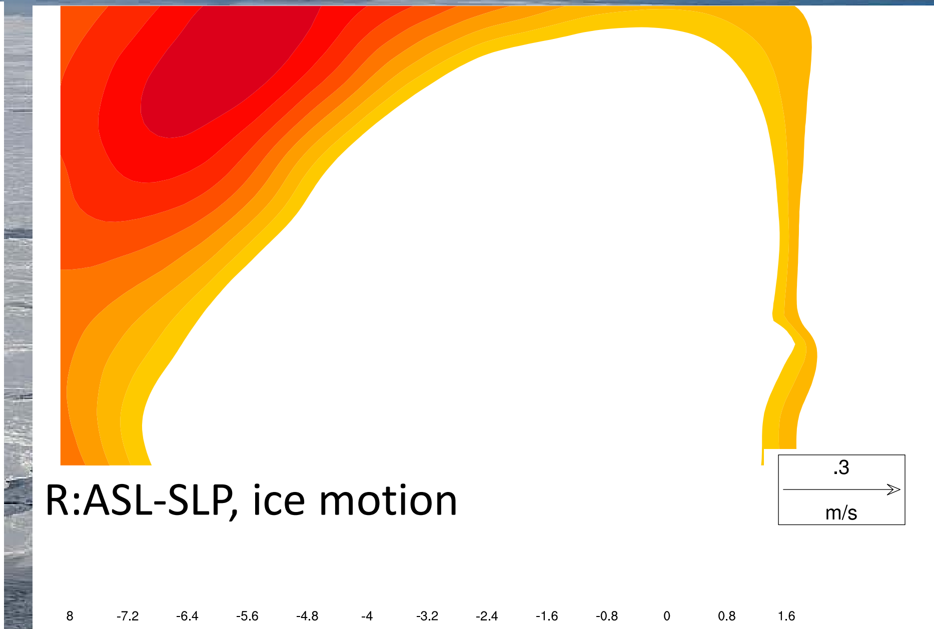
3 examples of ASL influence on SIC

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

April ASL



Mean SLP, ice motion

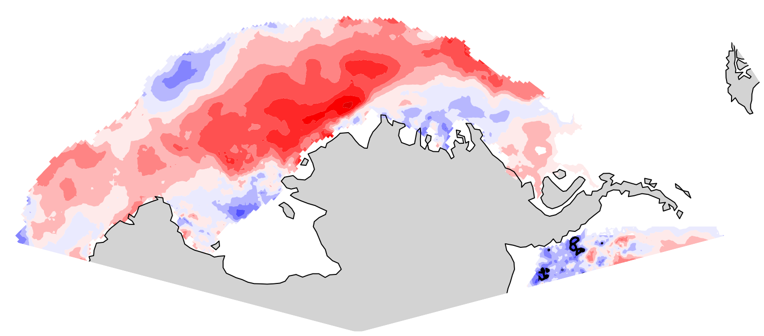


R:ASL-SLP, ice motion

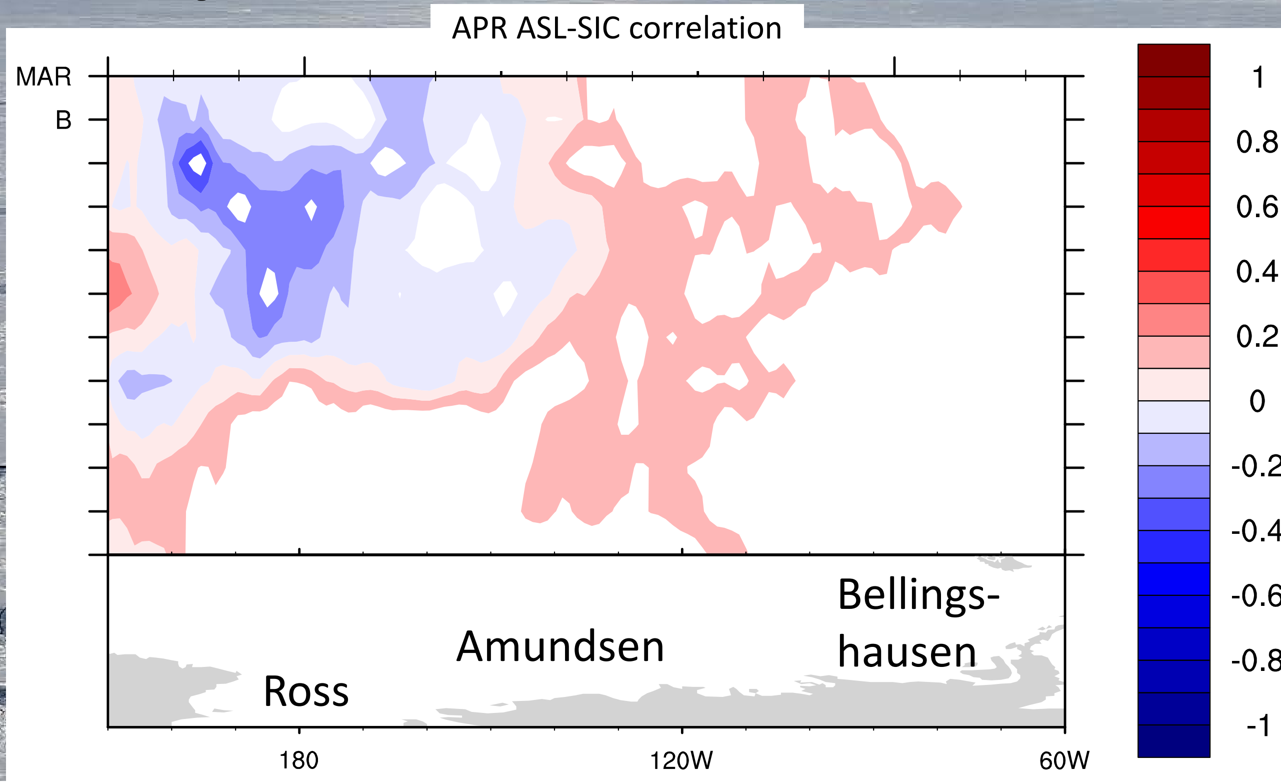
Deepening ASL:

↑ SIC in Ross, Amundsen

April ASL - April SIC correlation



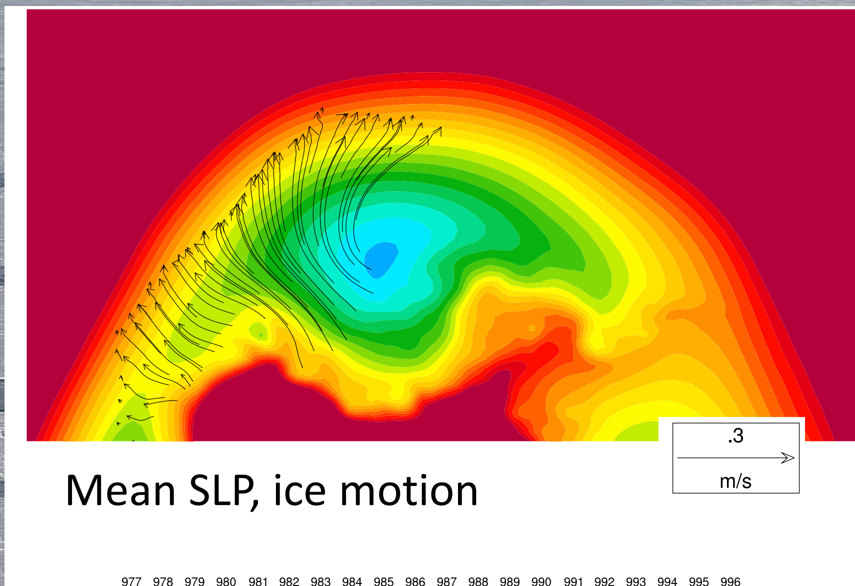
April (austral fall) ASL

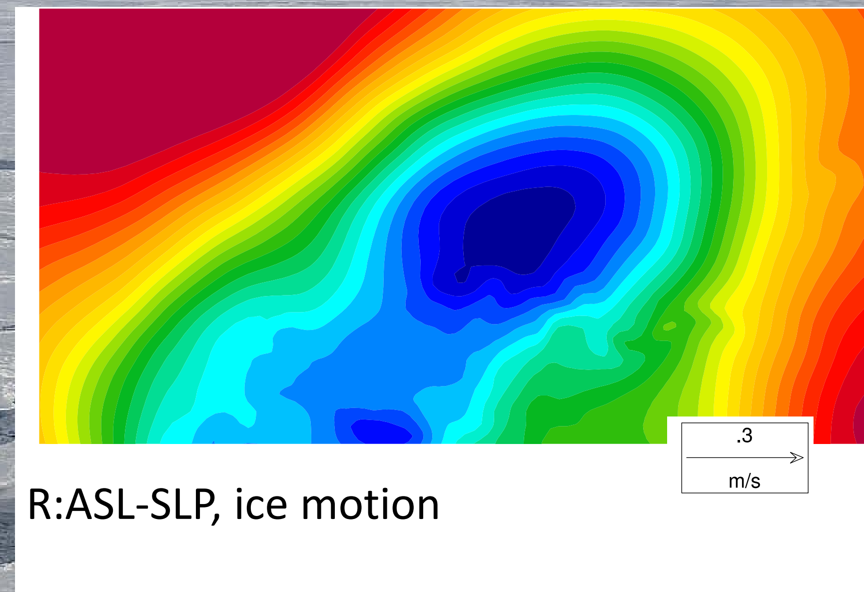


- Deepening ASL → increased SIC in Ross, Amundsen
- Anomaly increases then persists (1 – 3 months)

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

July ASL



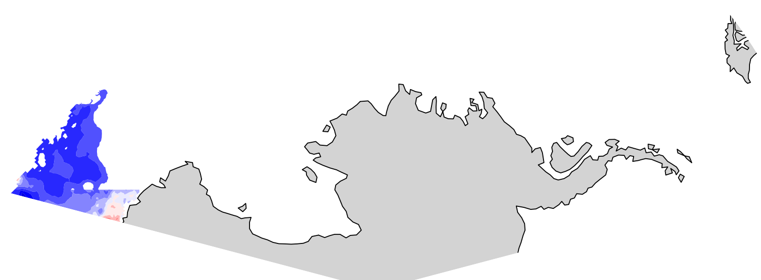


Deepening ASL:

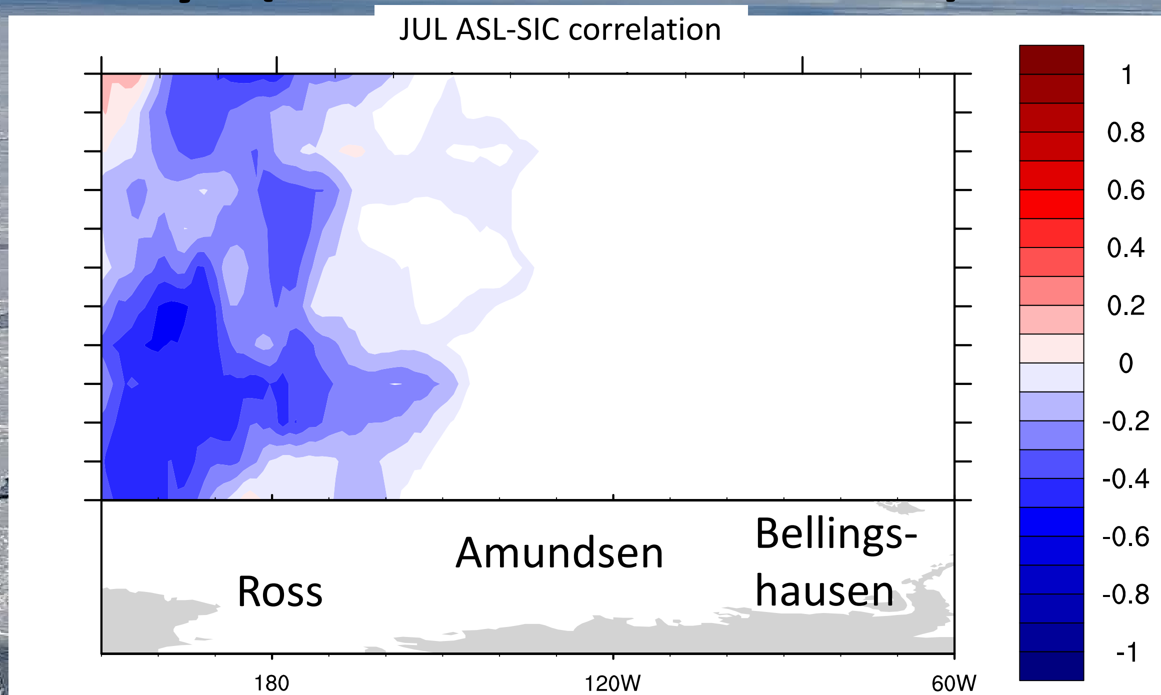
↓ SIC in Ross (outer), Bellingshausen

↑ SIC in Amundsen

July ASL - July SIC correlation



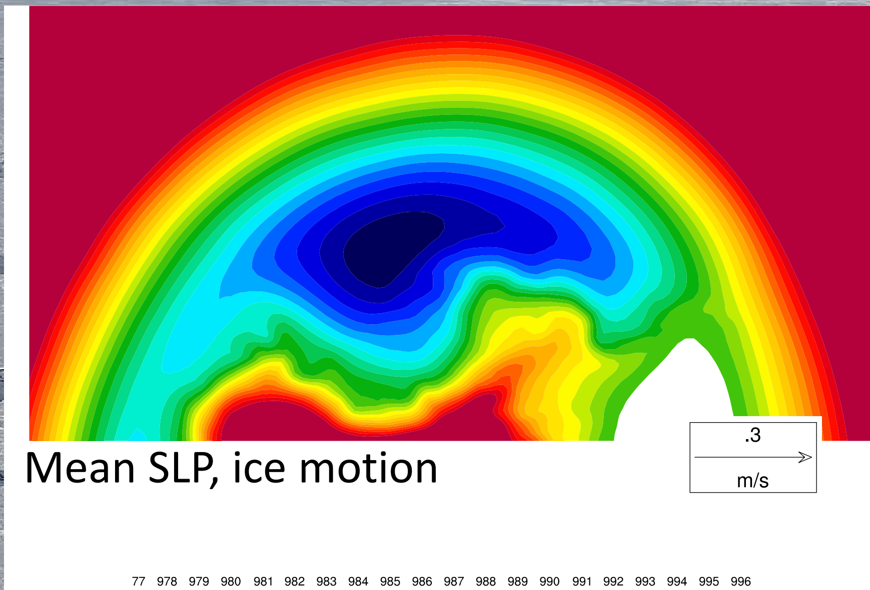
July (austral winter) ASL

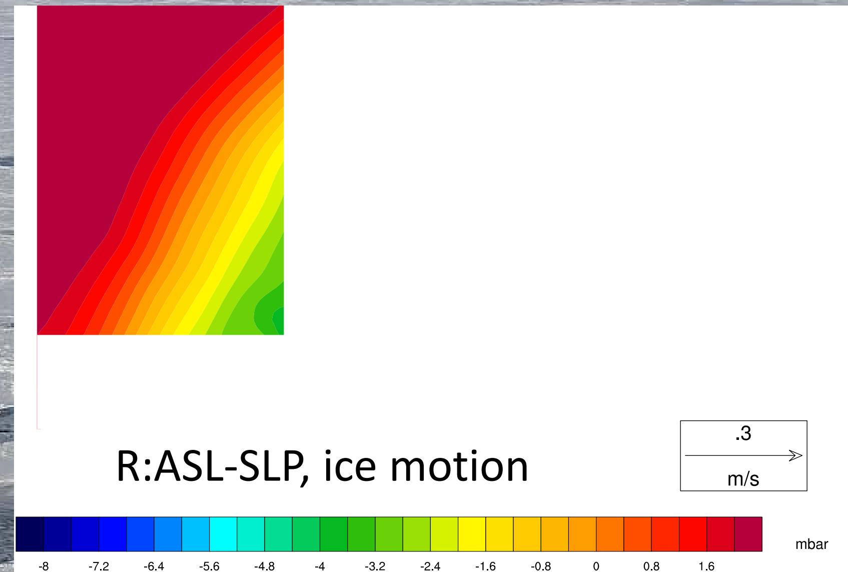


- Deepening ASL → tripole anomaly pattern:
  - decreased SIC in Ross, Bellingshausen
  - increased SIC in Amundsen
- Anomaly grows (1-3 months) and persists (~7 months in Ross-Amundsen)

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

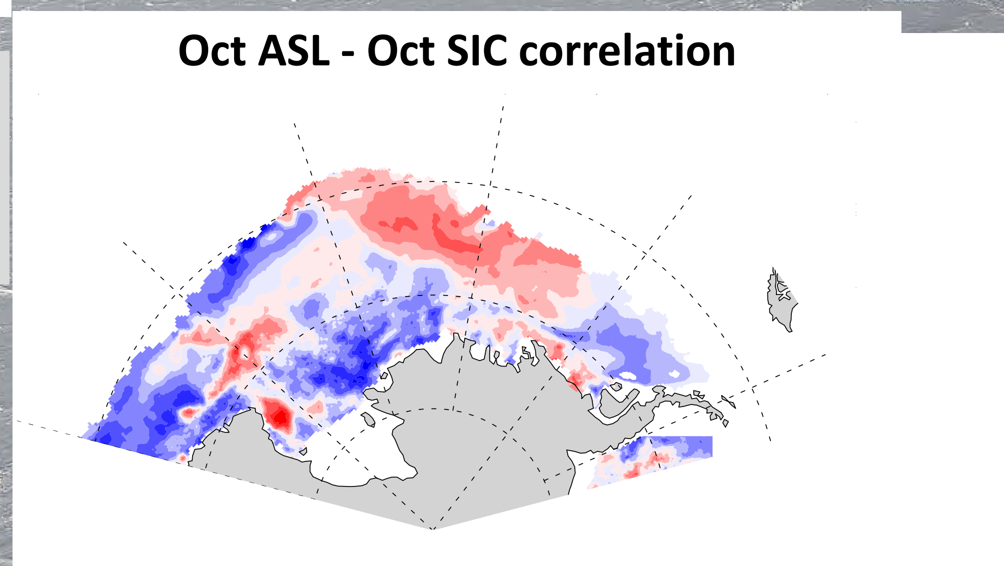
October ASL



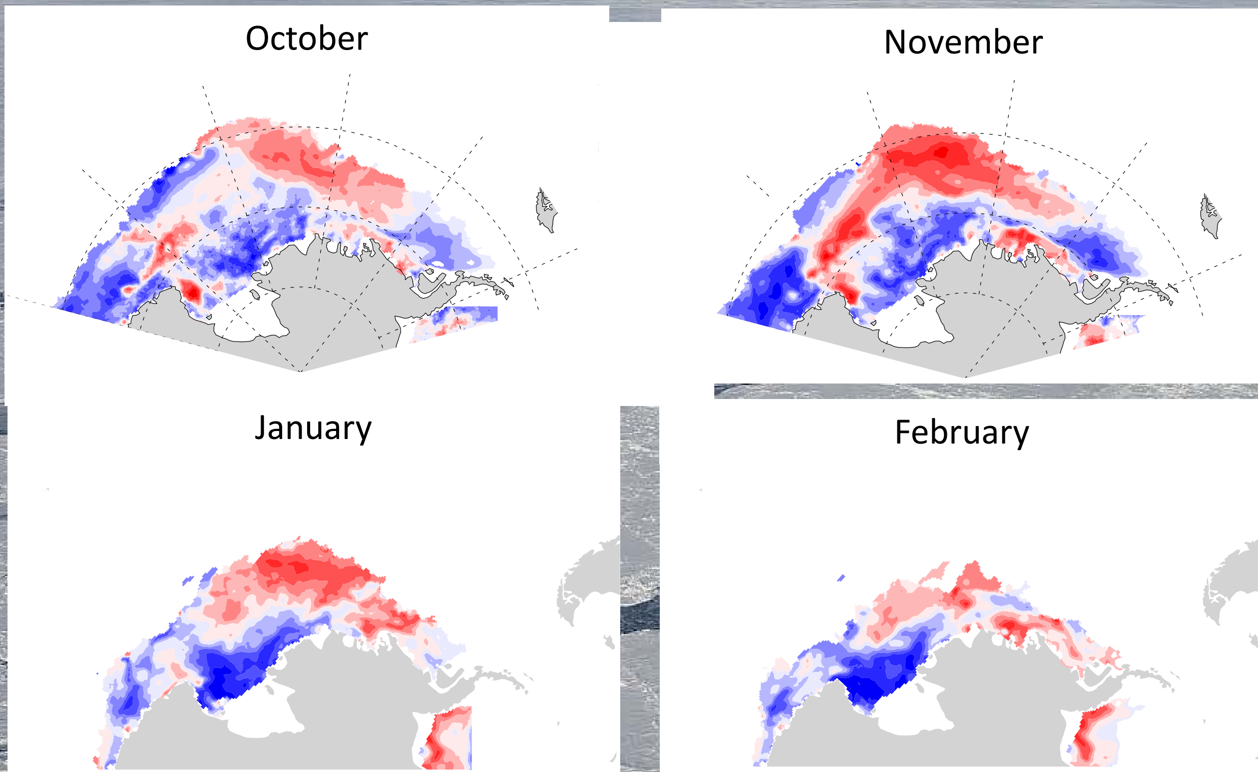


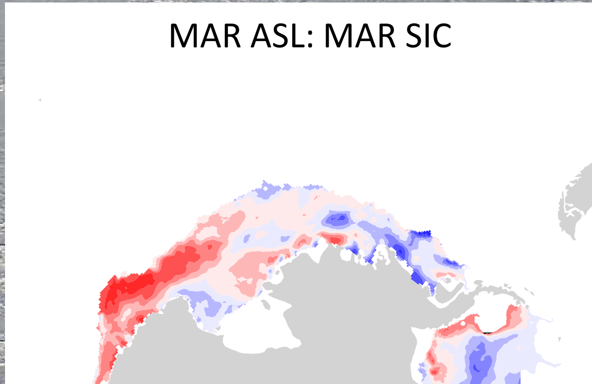
Deepening ASL:

Relatively little lag-0 influence



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

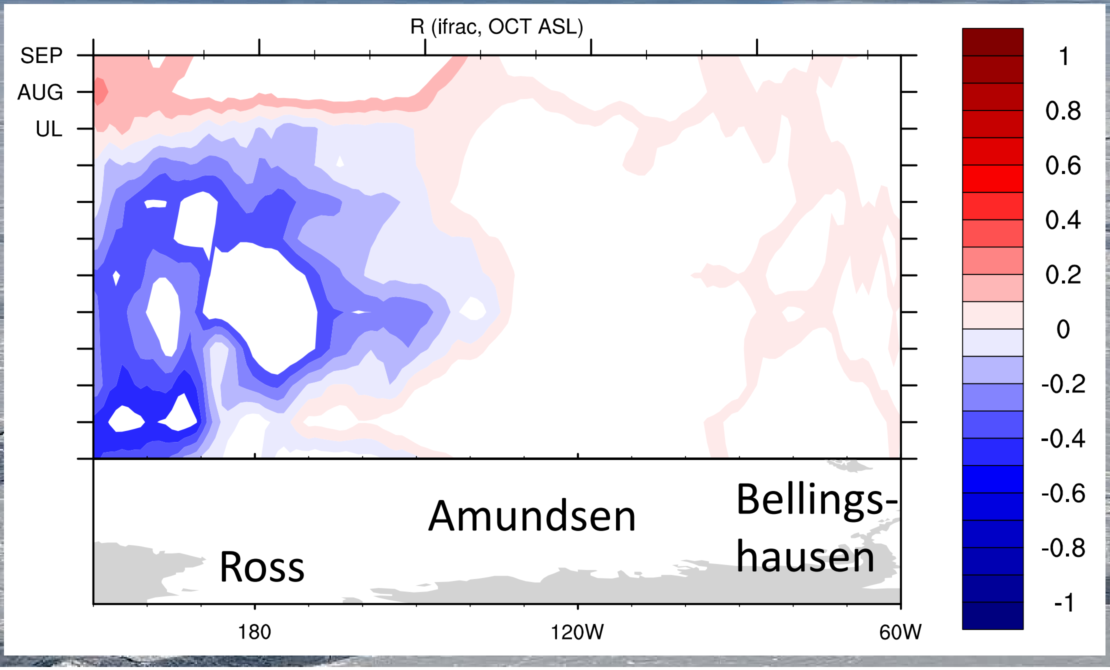
Higher solar radiation

Warmer ssts

delayed ice advance 5 months later

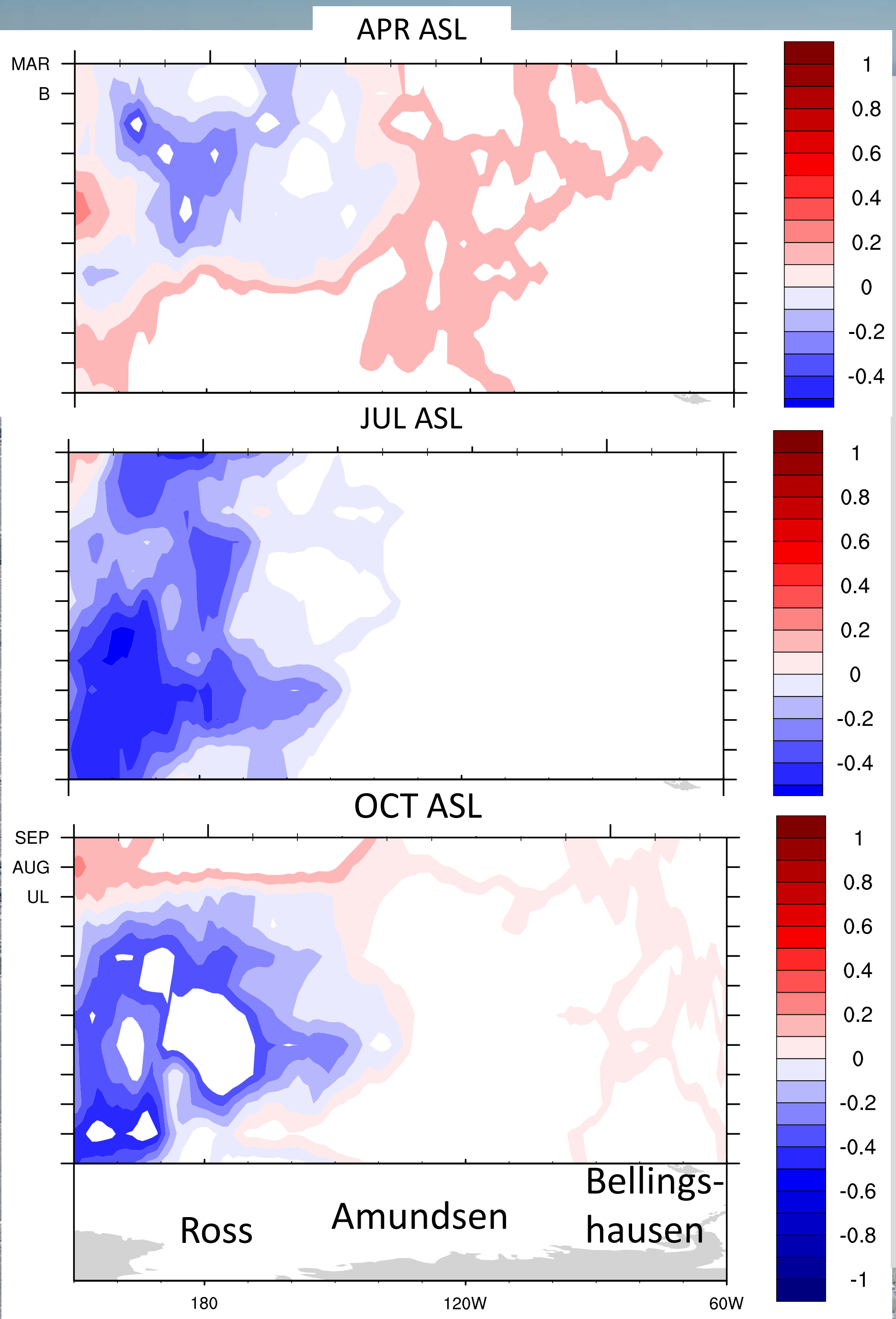
(Holland et al., Nature Communications, 2017)

October (austral spring) ASL



- Deepening ASL → 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) ~ 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

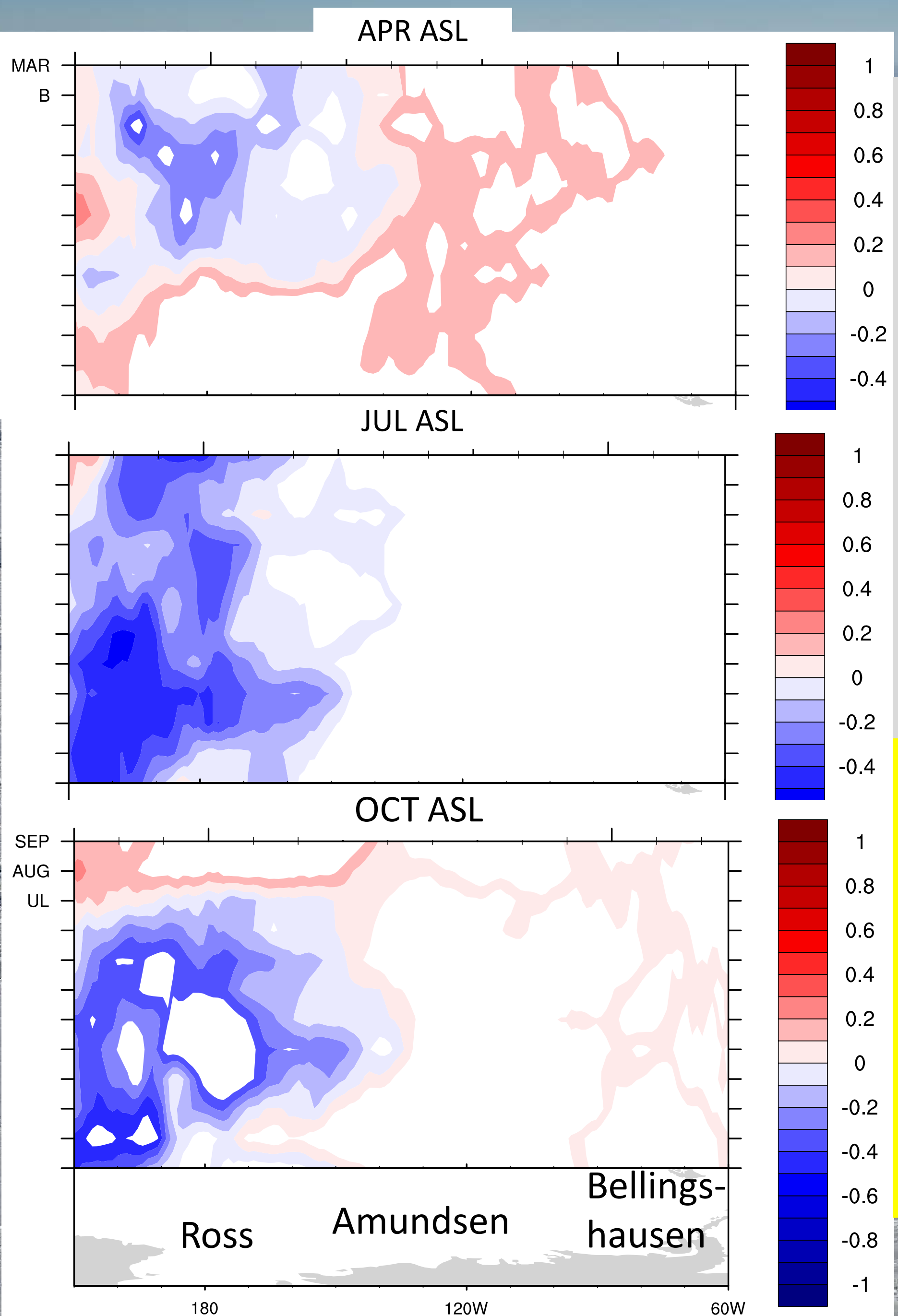
Zonal ice motion

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)

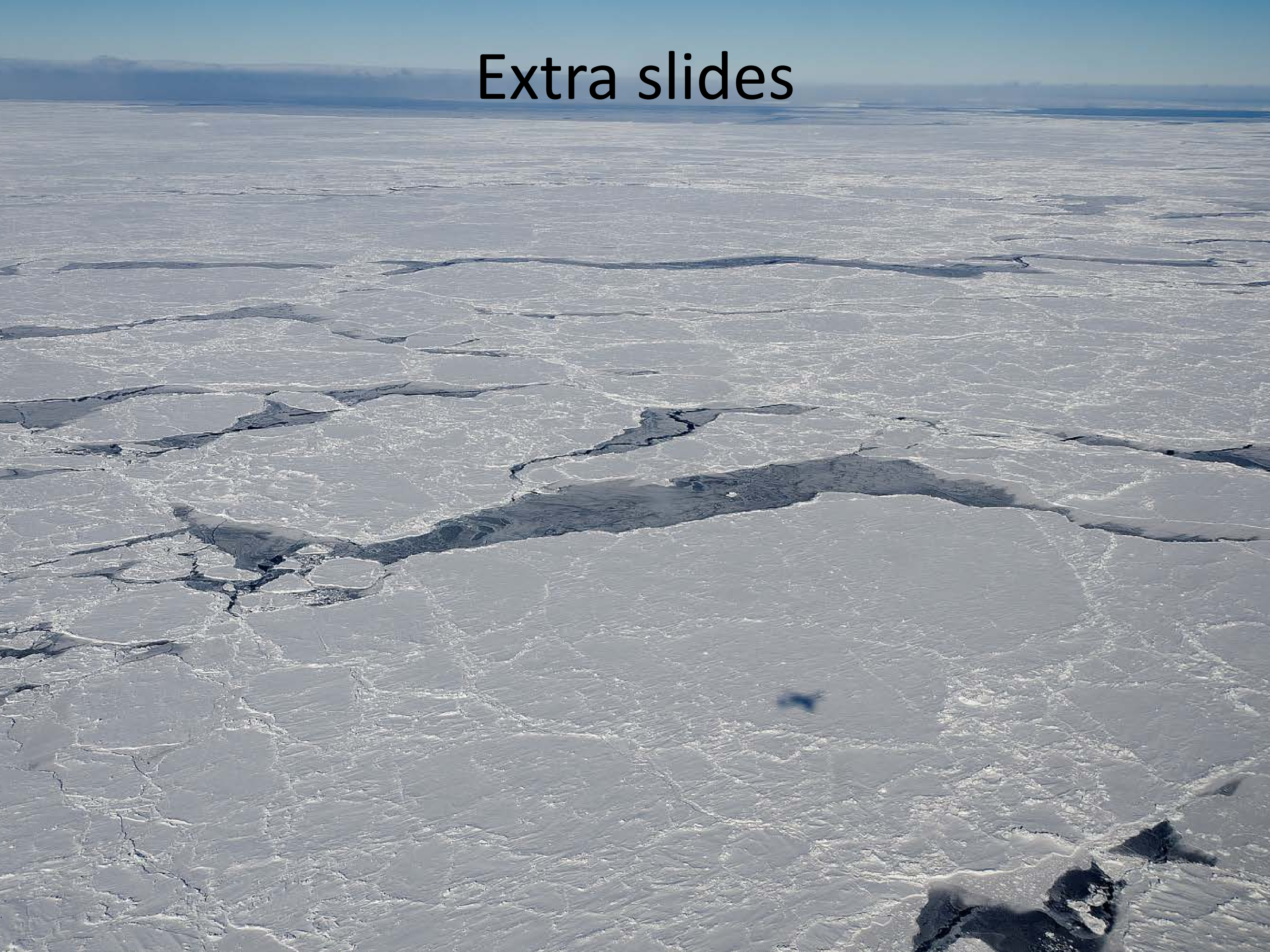
↓ SIC Bellingshausen (eastern flank)

Sometimes right, sometimes wrong

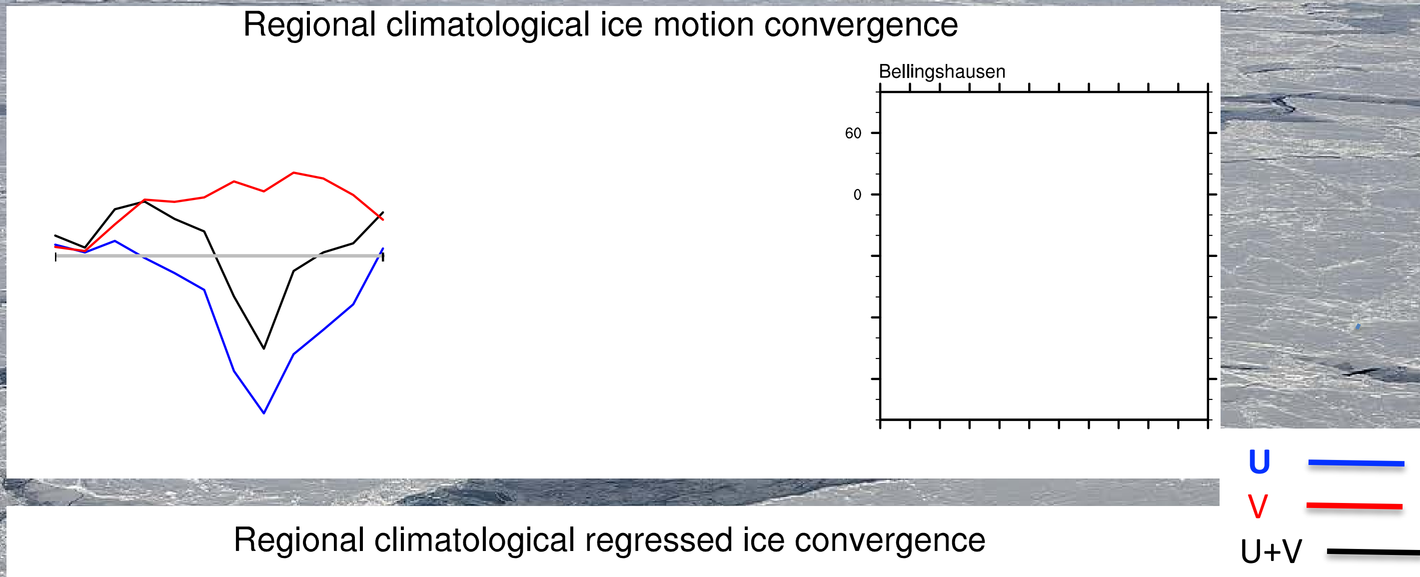
it’s complicated

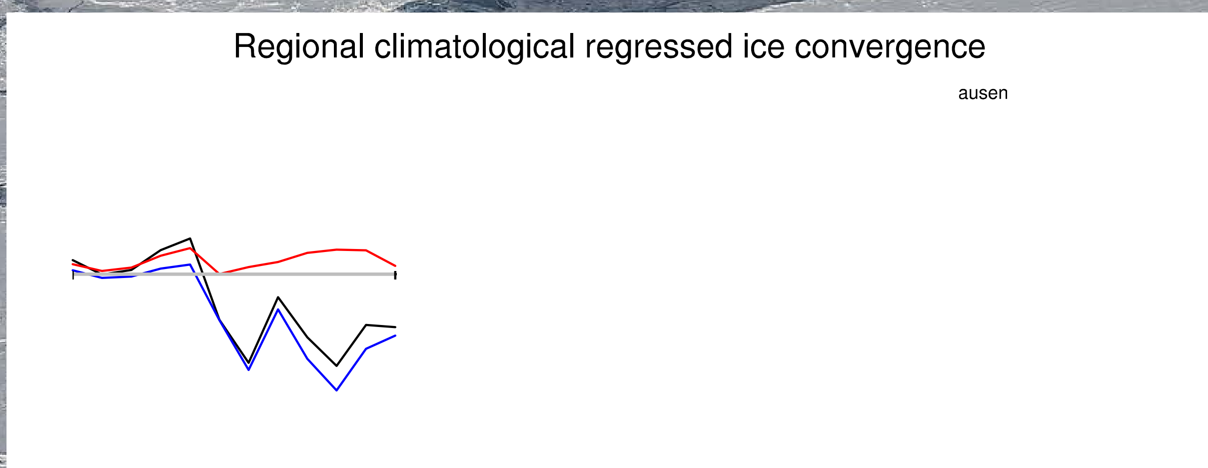
(ice motion: mean and ASL influence; location of ice edge & ASL, ice retreating vs. advancing)

Extra slides



Ice motion convergence





Climatology ASL (mean and regressed)