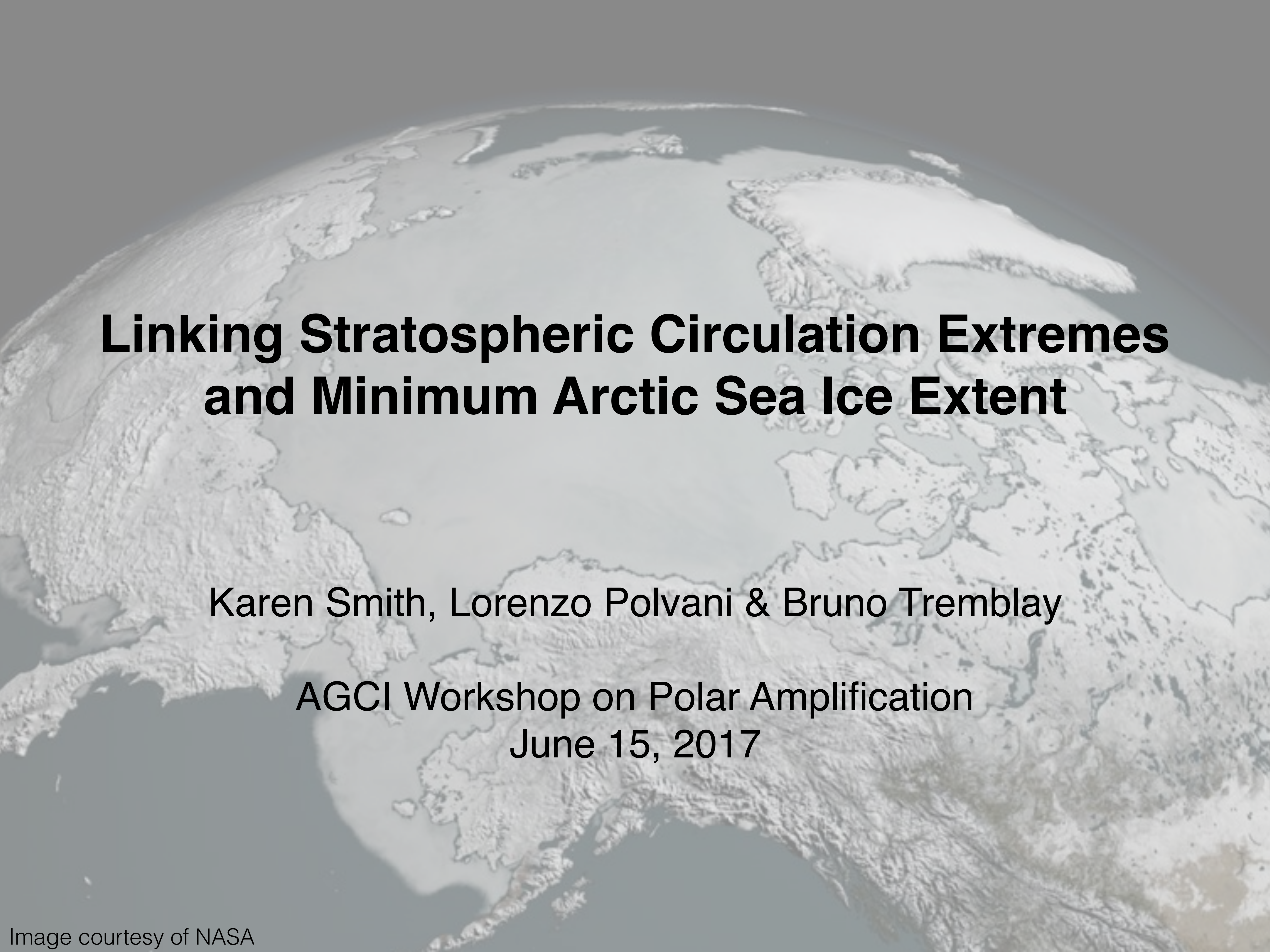


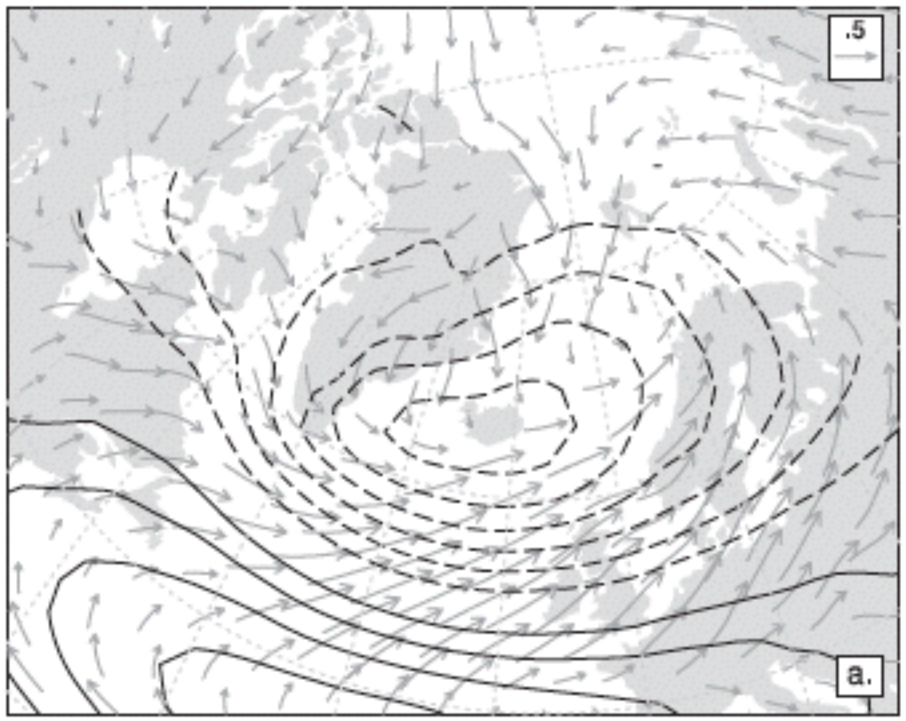
Linking Stratospheric Circulation Extremes and Minimum Arctic Sea Ice Extent

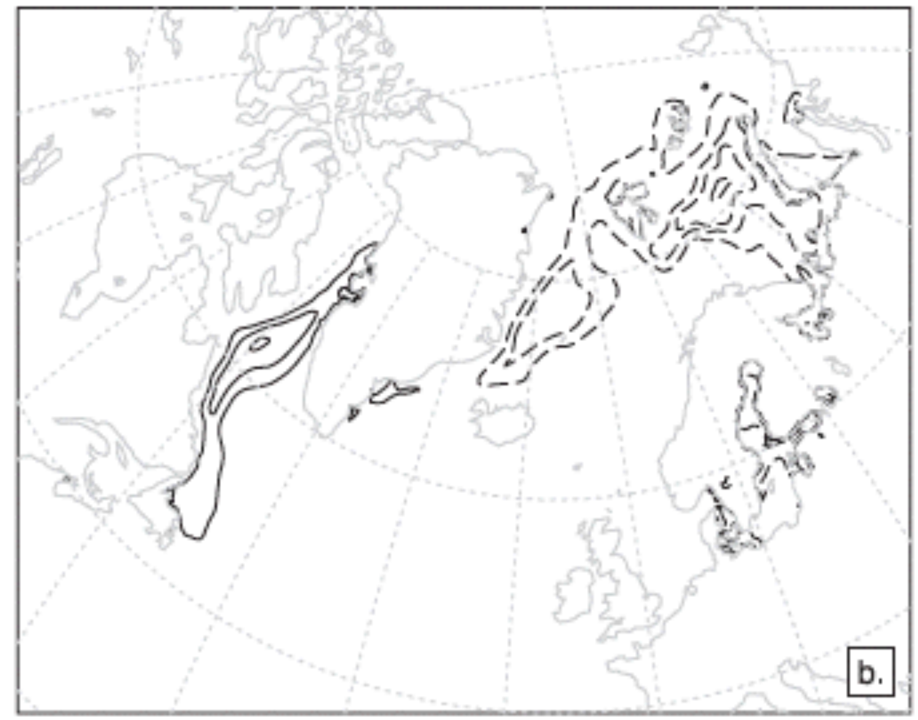
Karen Smith, Lorenzo Polvani & Bruno Tremblay

AGCI Workshop on Polar Amplification
June 15, 2017

Image courtesy of NASA

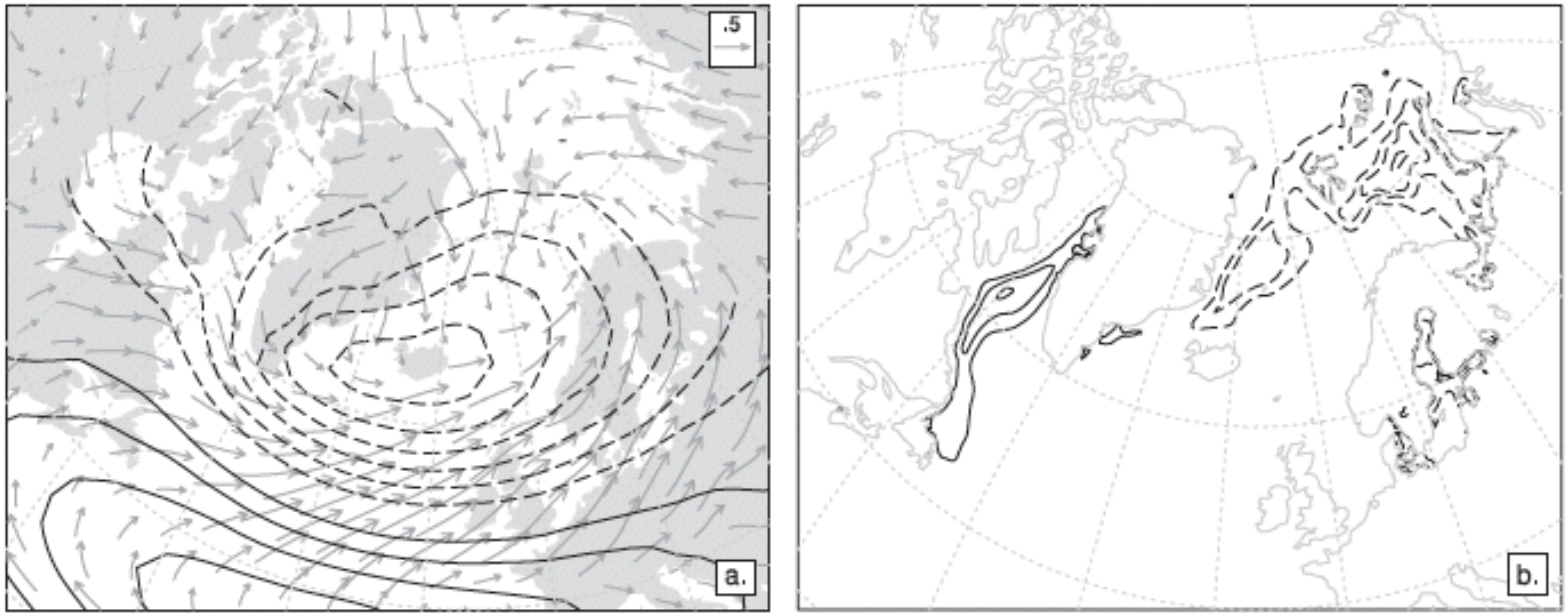
Interannual SIC variability



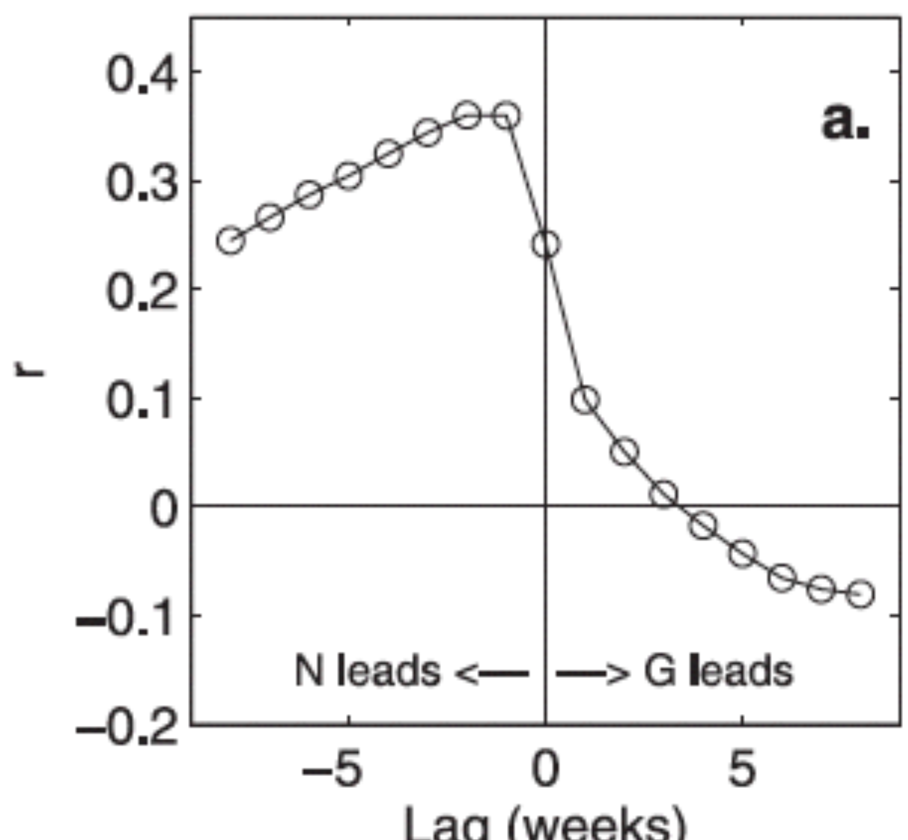


Strong et al. 2009

Interannual SIC variability



NAO Leads

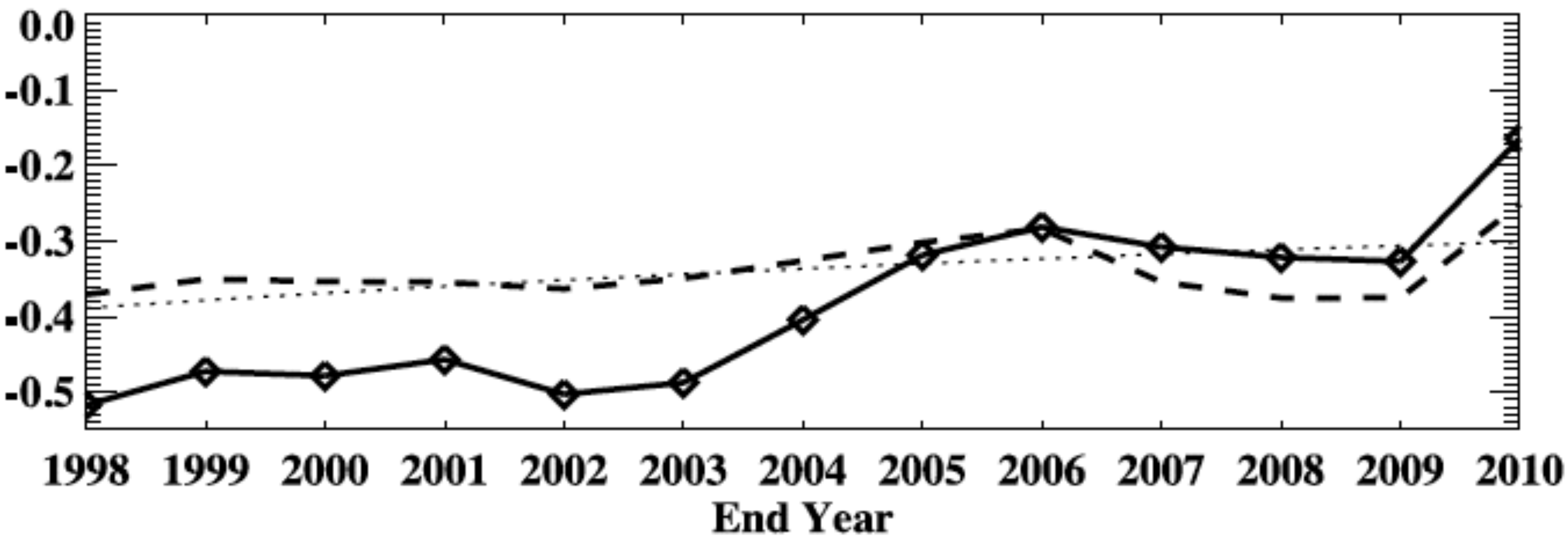


SIC Leads

Strong et al. 2009

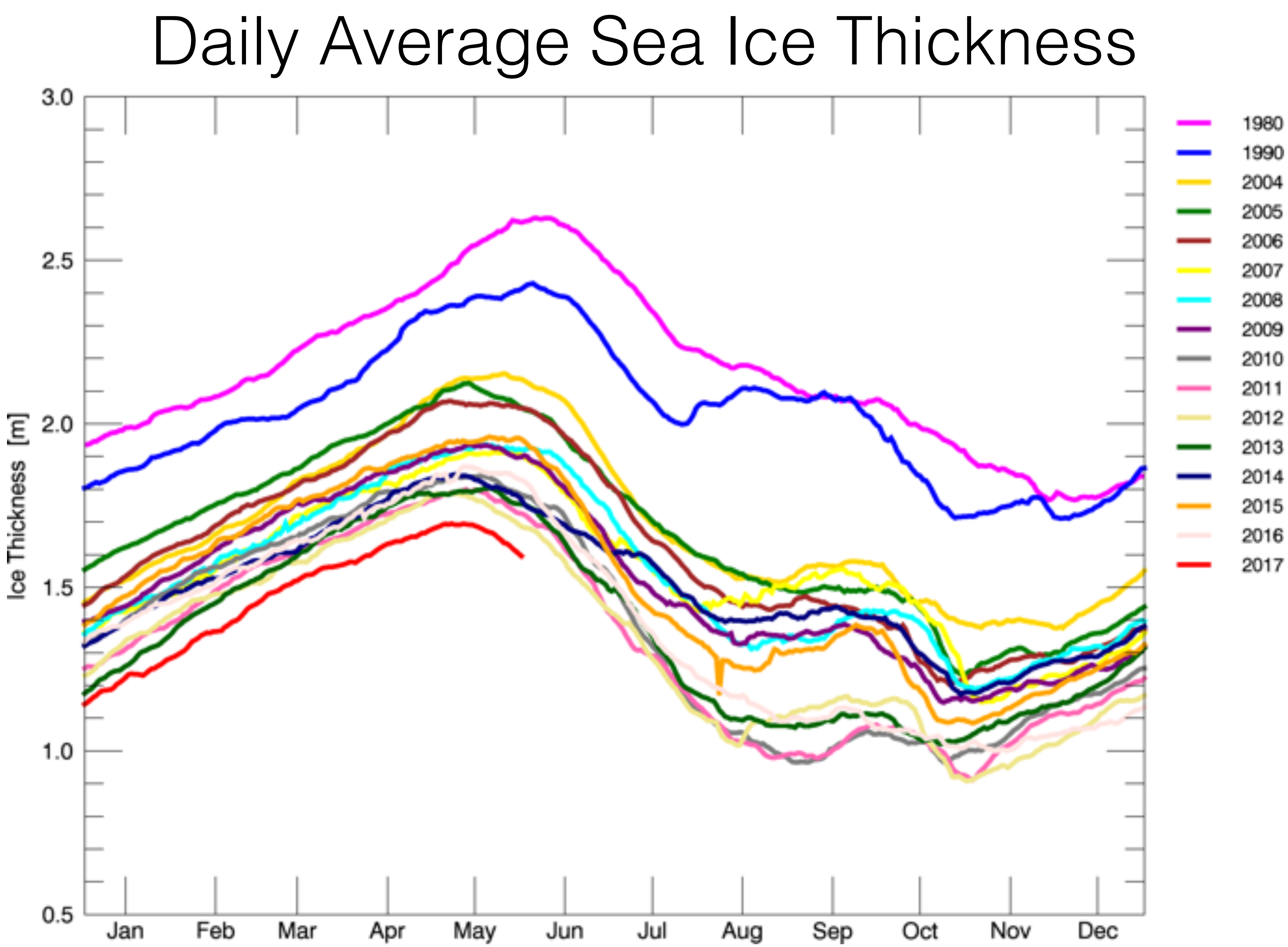
Interannual SIC variability

Correlation between AO and September SIE



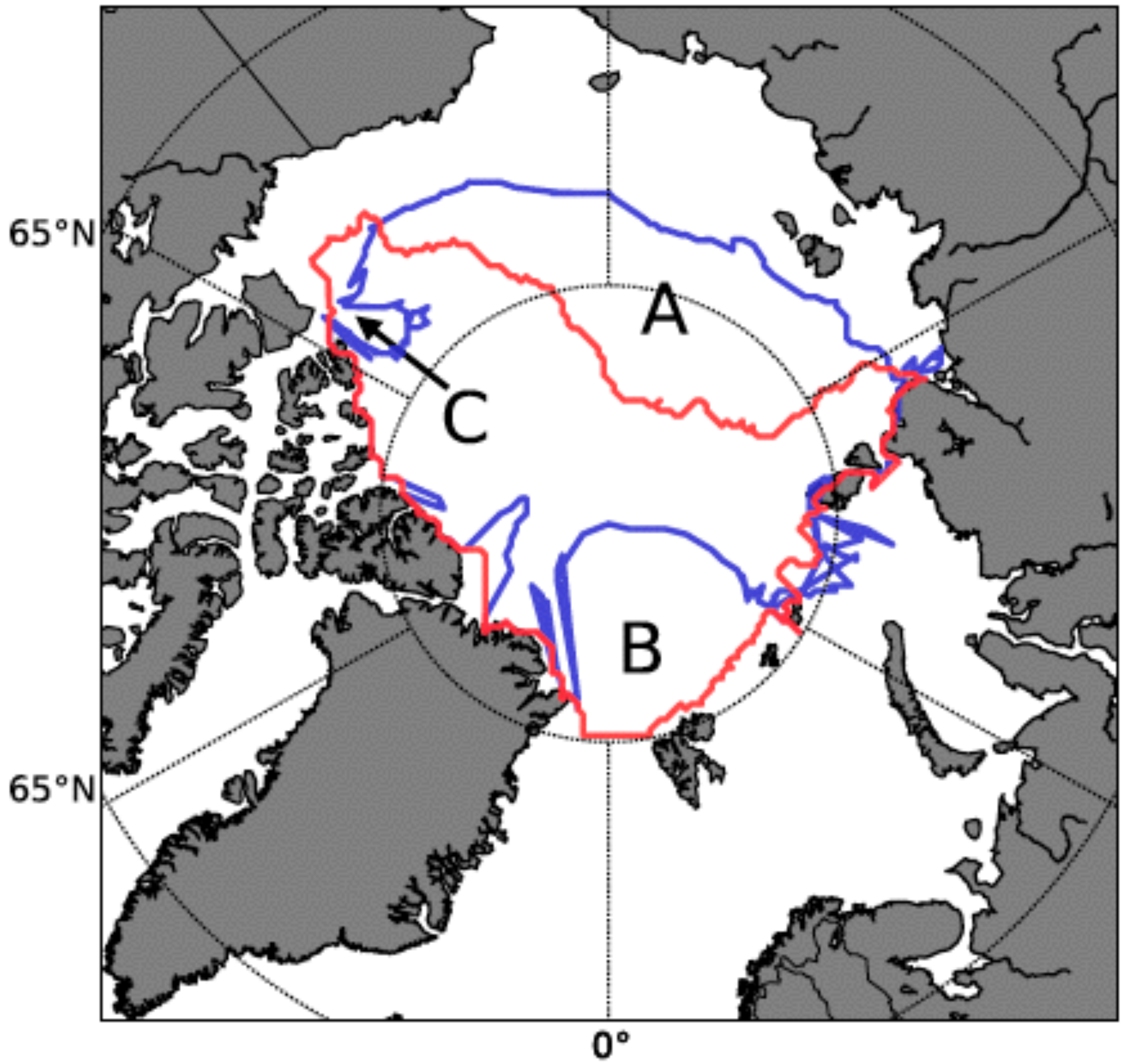
Rigor et al. 2002; Holland & Stoeve, 2011

Interannual SIC variability



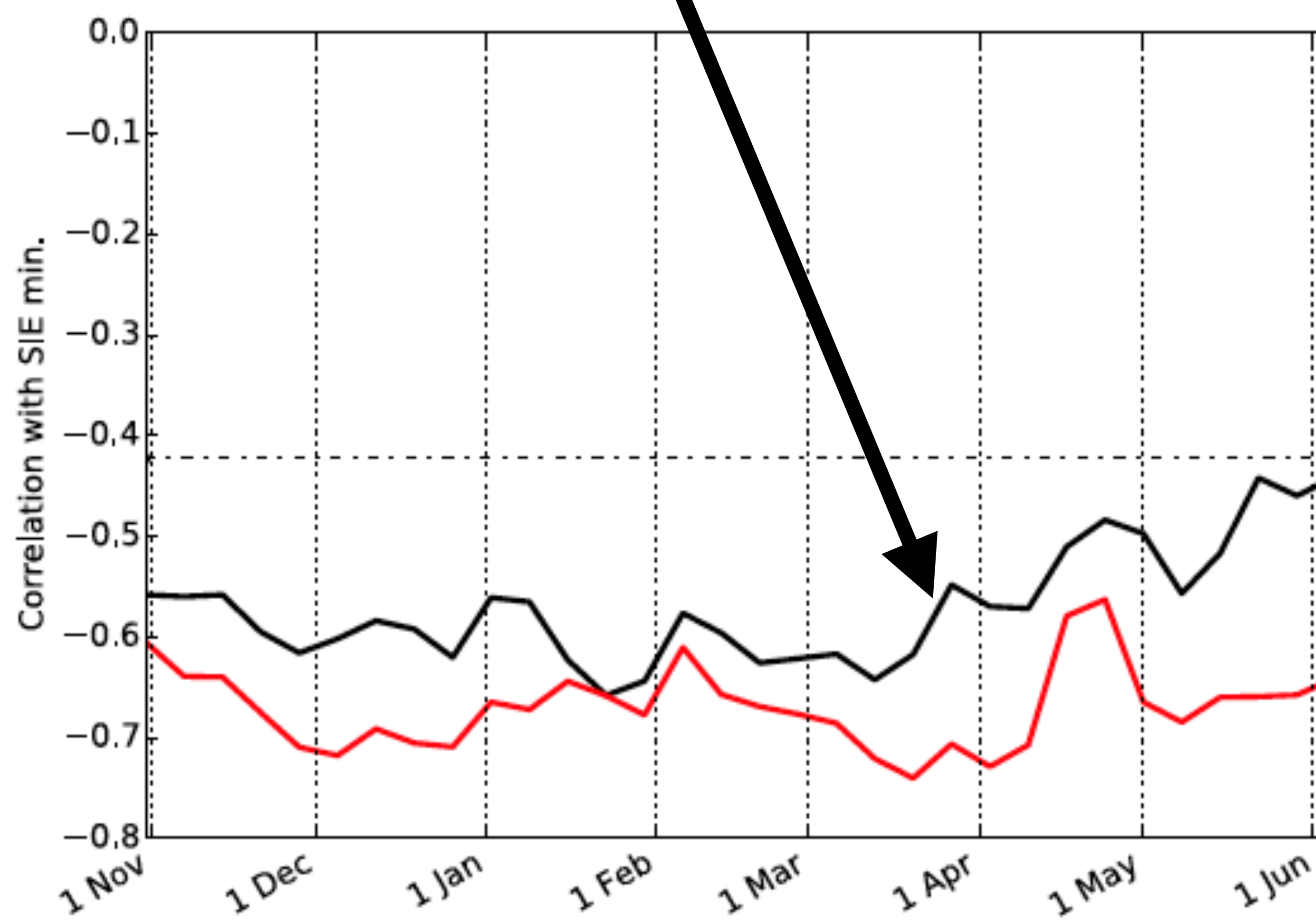
data: PIOMASS

Interannual SIC variability



Data are for 1993-2014

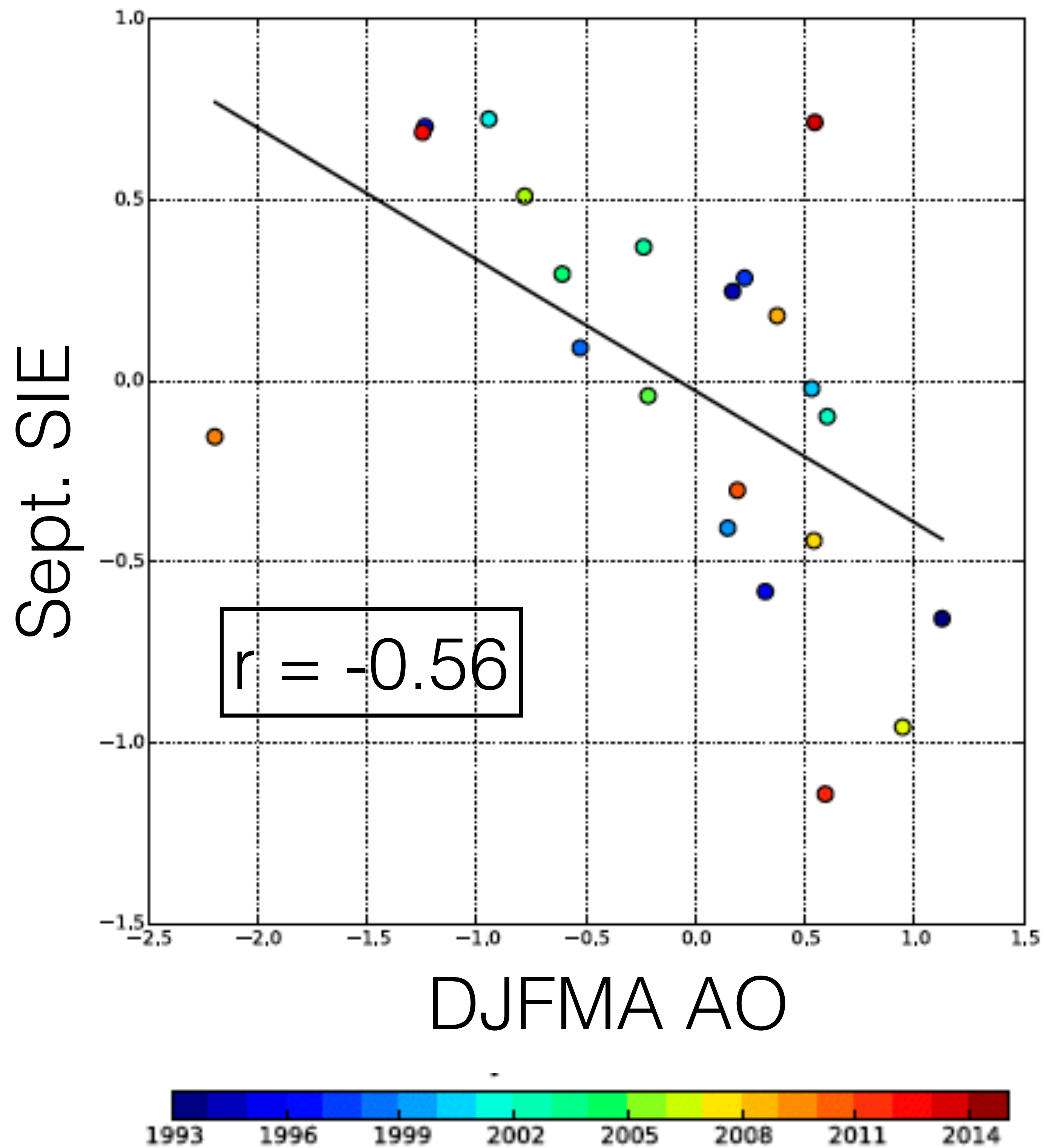
Dynamic Pre-conditioning



Area A - Area C

Rigor & Wallace 2004; Williams et al. 2016

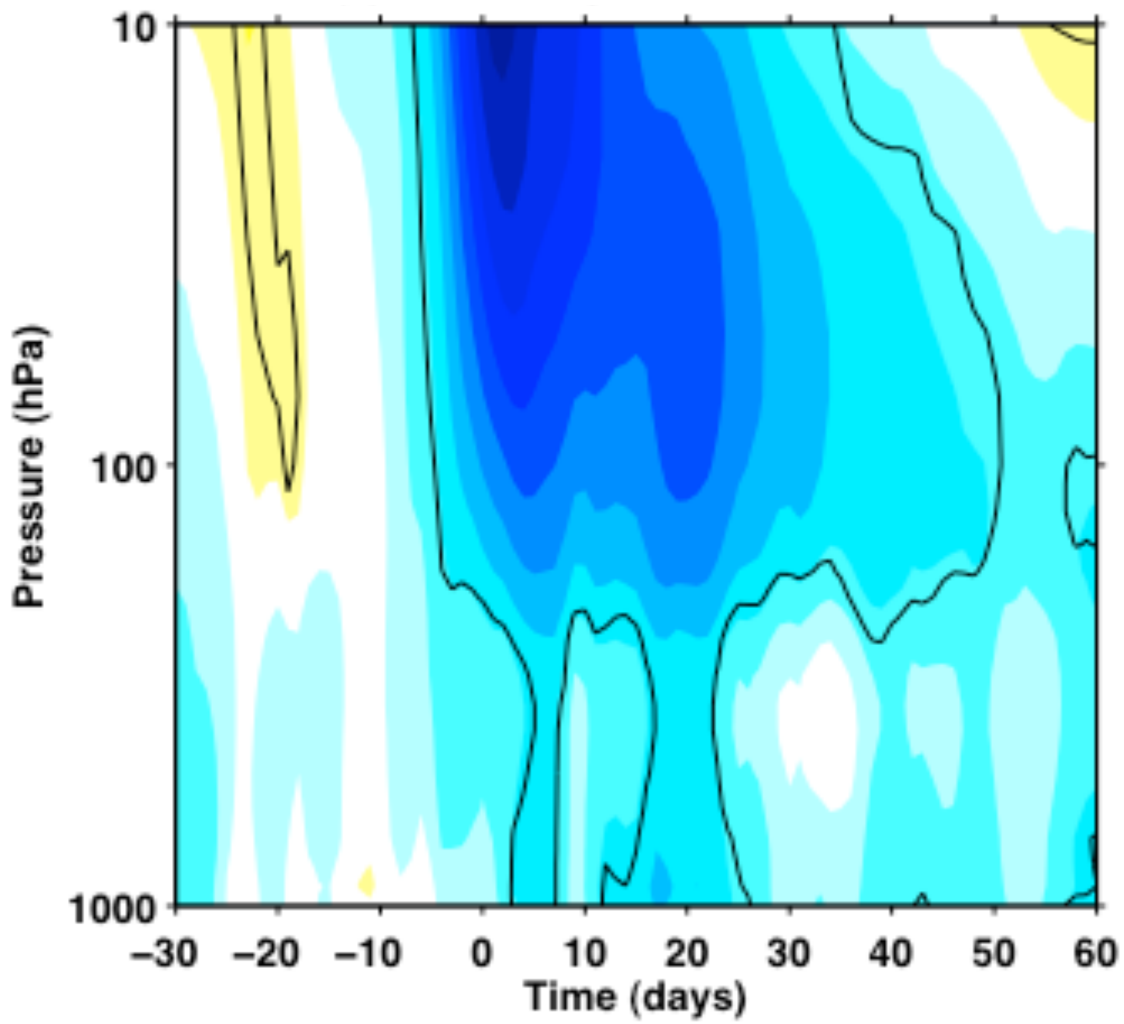
Interannual SIC variability



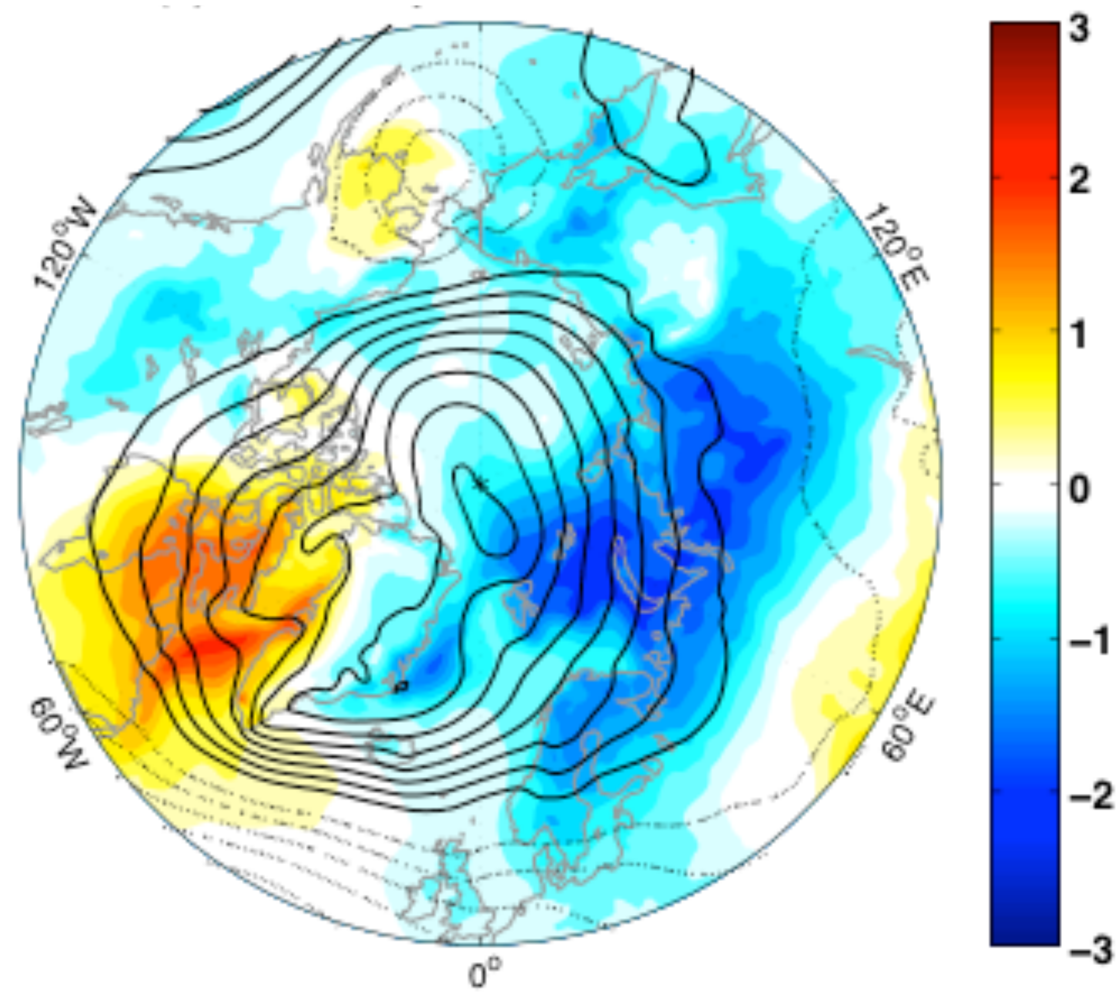
Williams et al. 2016

Stratospheric circulation and the AO/NAO

SSW Composite: AO Index

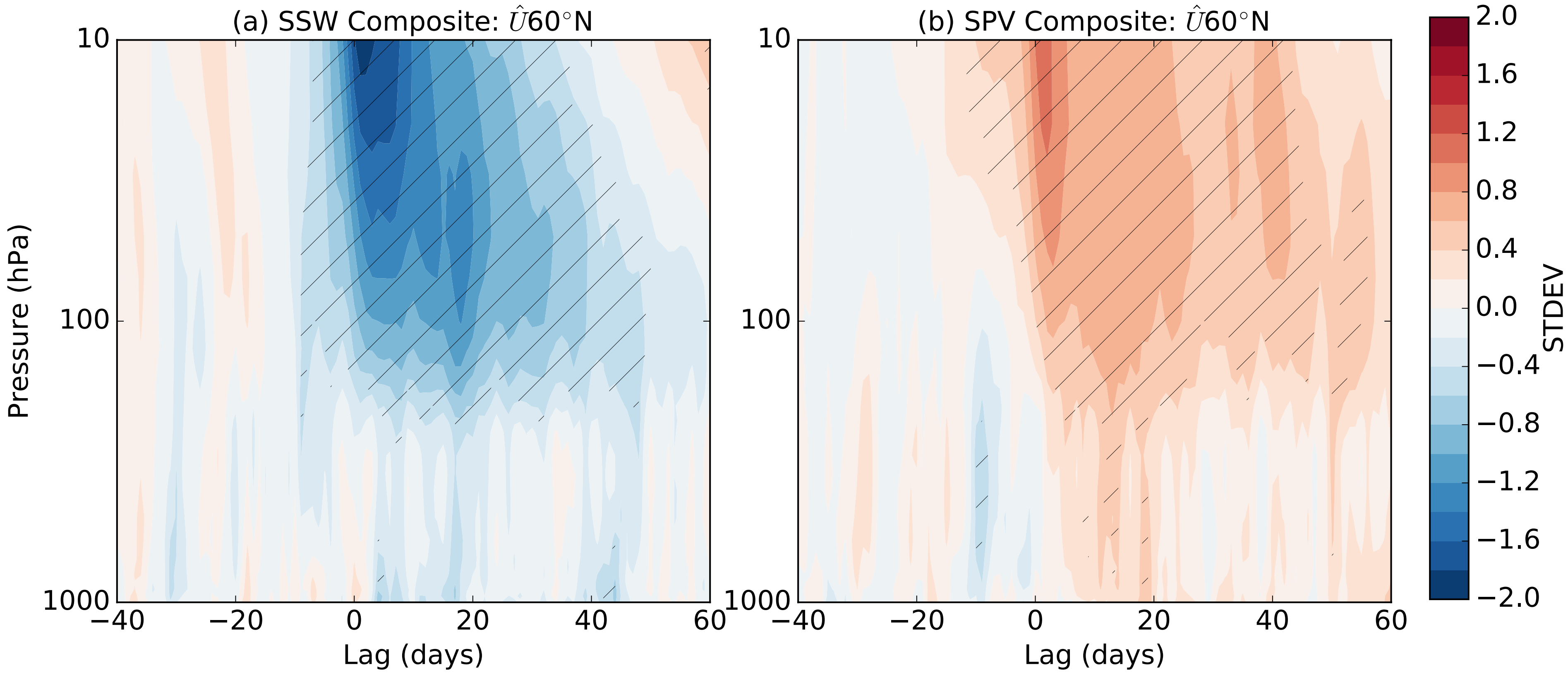


SAT & SLP days 10-60 after SSW



data: ERA-I 1979-2012

SSWs & SPVs - Definitions



ERA-I

- **SSW identification:** Zonal wind reversal at 60°N and 10 hPa
- **SPV identification:** Zonal wind exceeds 48 m/s at 60°N and 10 hPa

Model & Integration

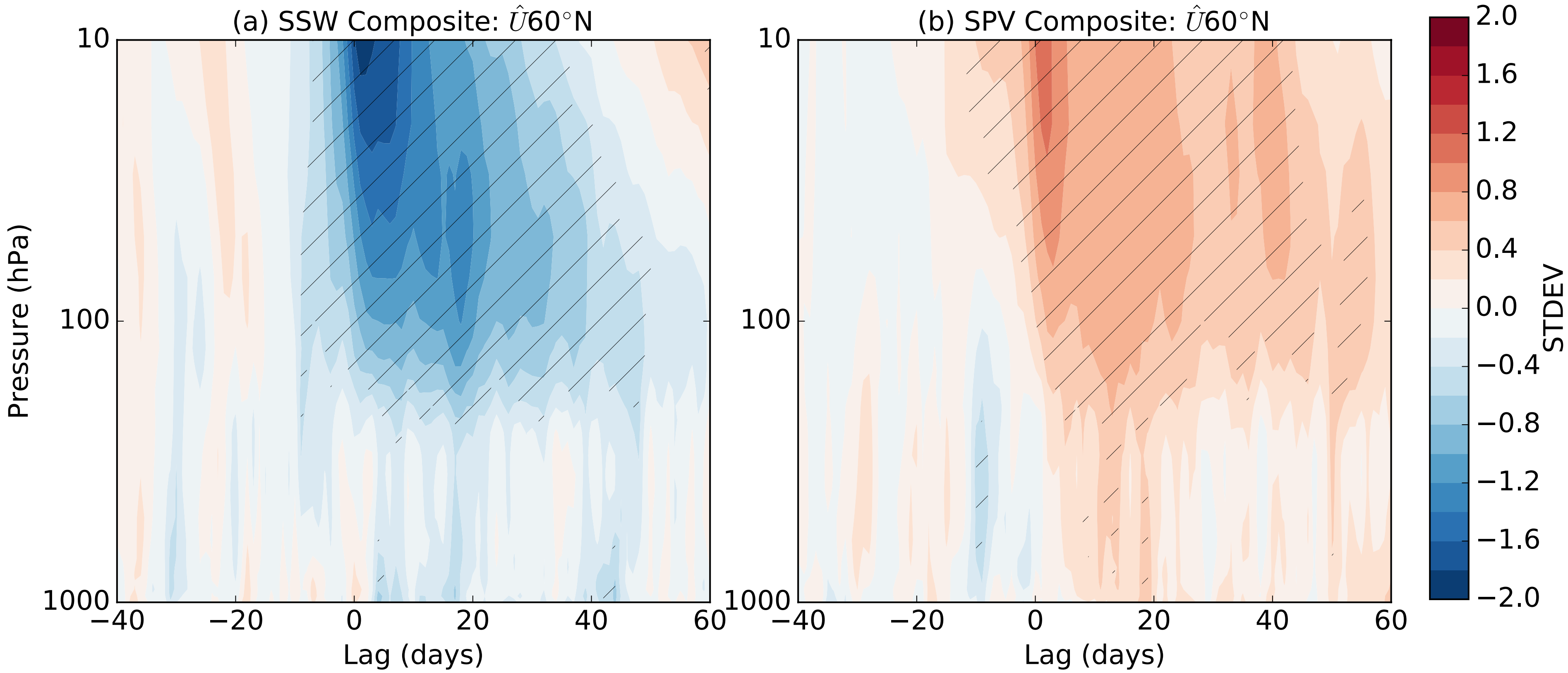
- **Model:** CESM1(WACCM), fully coupled, stratosphere-resolving model.

- **Integration:** 400-year long *Year-2000* Control integration, no QBO, solar average.
  - Daily atmospheric data (+ SSTs & SIC) and monthly data for all other sea ice fields

SSWs & SPVs - Statistics & Composites

	Number of SSWs & SPVs	
	ERA-I	**WACCM**
SSWs	21	193
SSW Years	8	126
SPVs	26	156
SPV Years	14	99

SSWs & SPVs - Definitions



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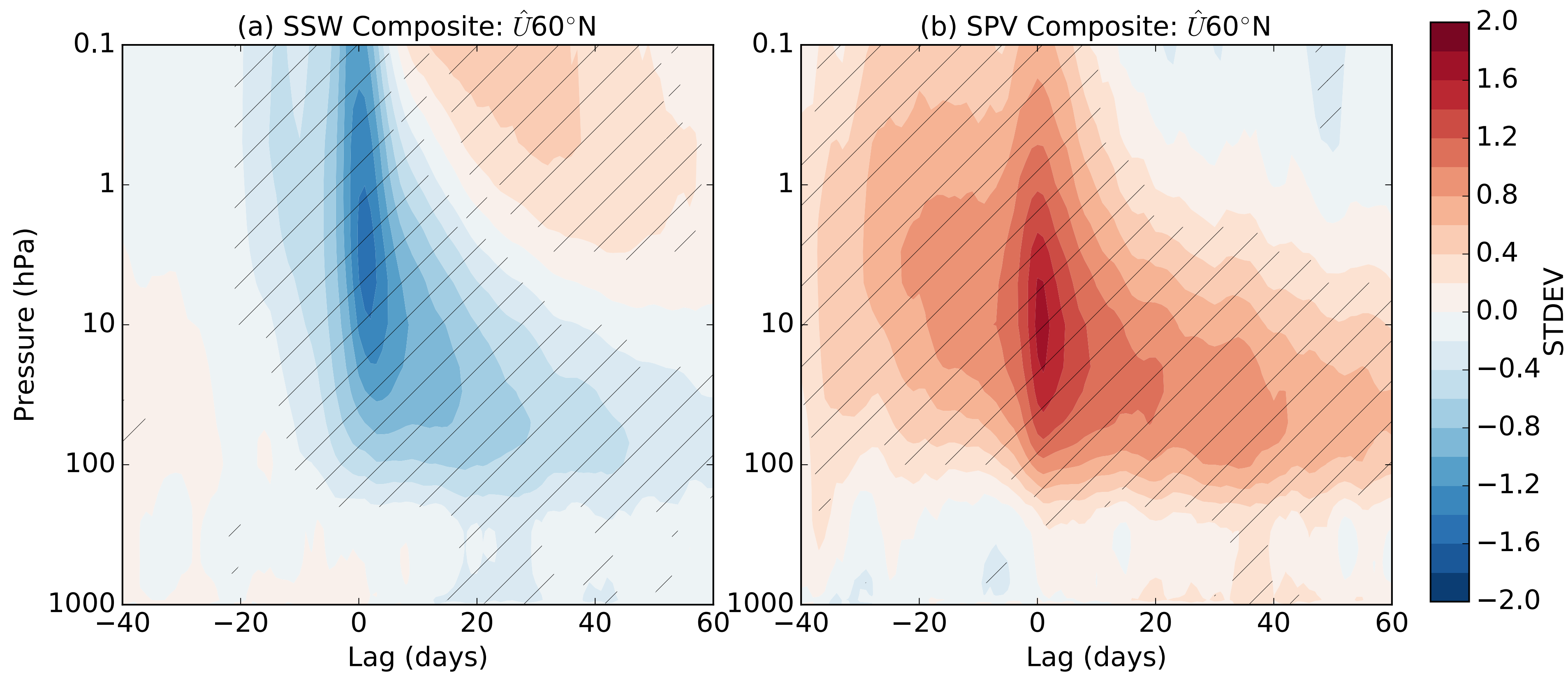
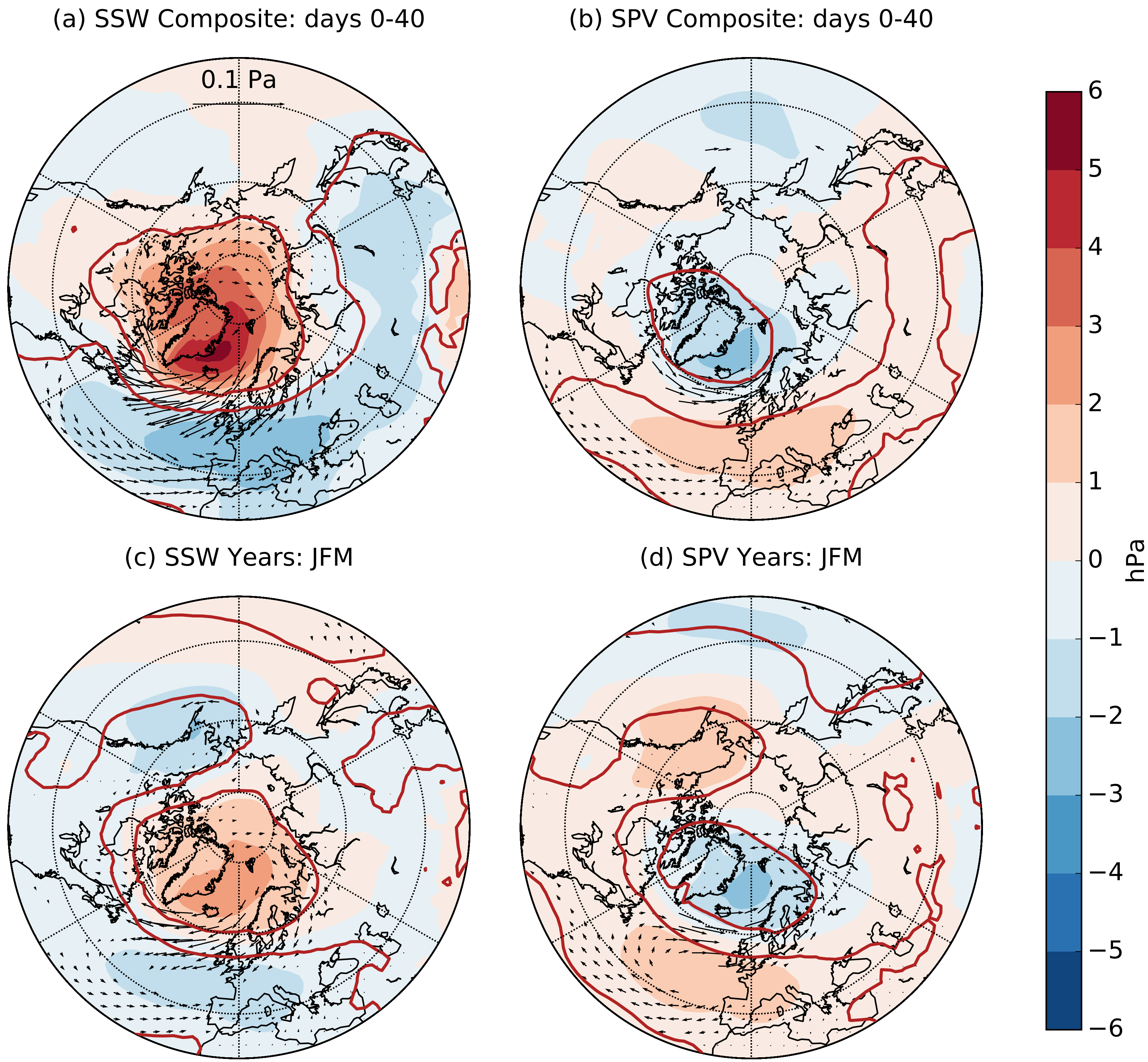
WACCM

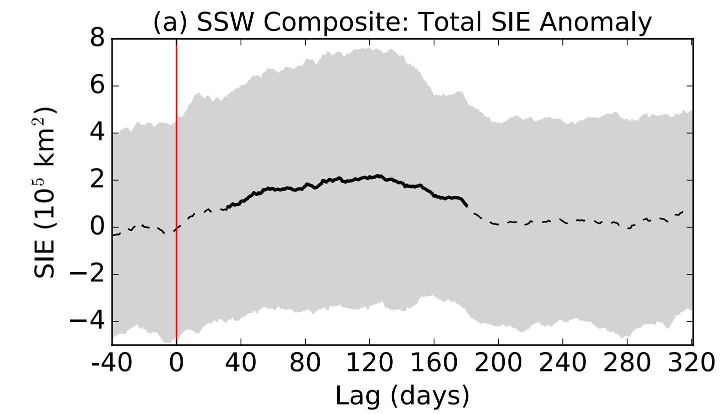


SSWs & SPVs - Surface Signatures

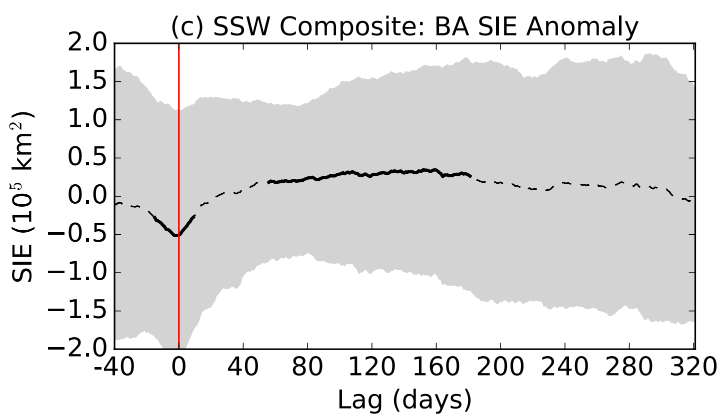


Sea Ice Extent

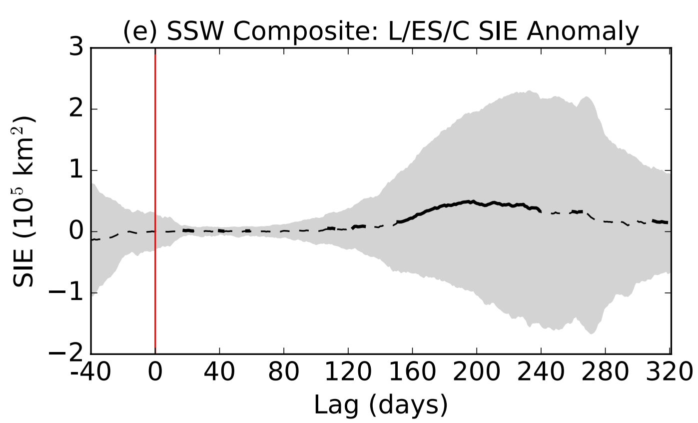
Total



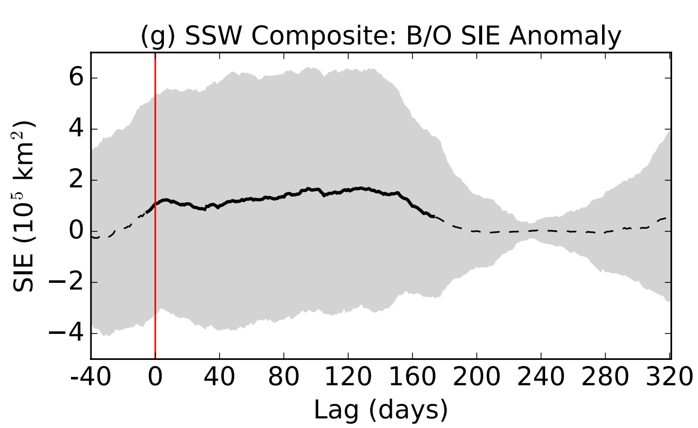
Barents



Laptev/E.Sib/
Chukchi

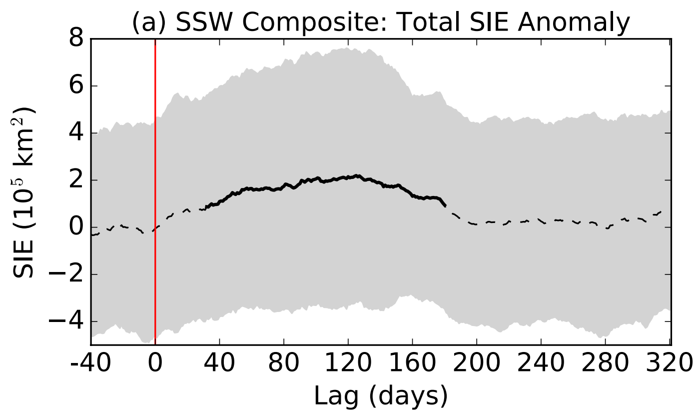


Berring/
Okhotsk

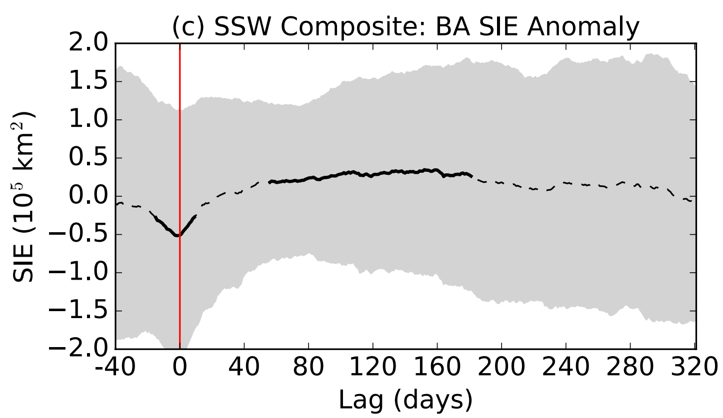


Sea Ice Extent

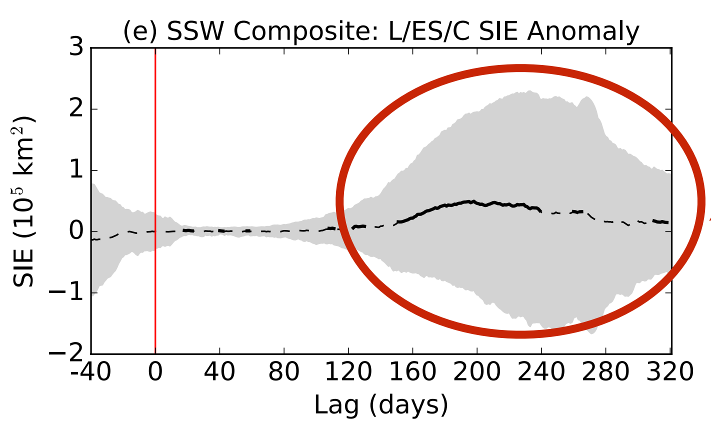
Total



Barents

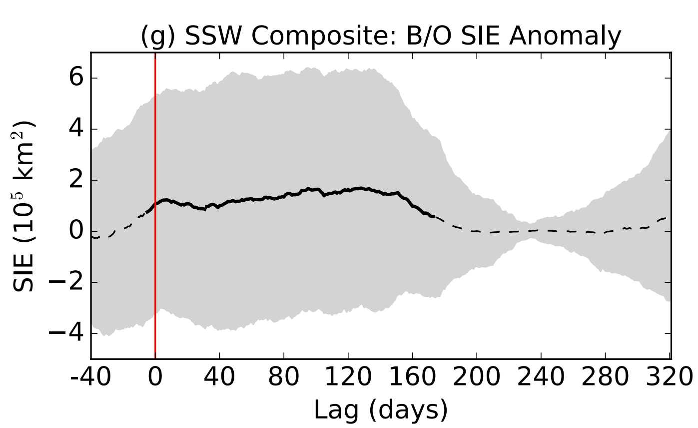


Laptev/E.Sib/ Chukchi

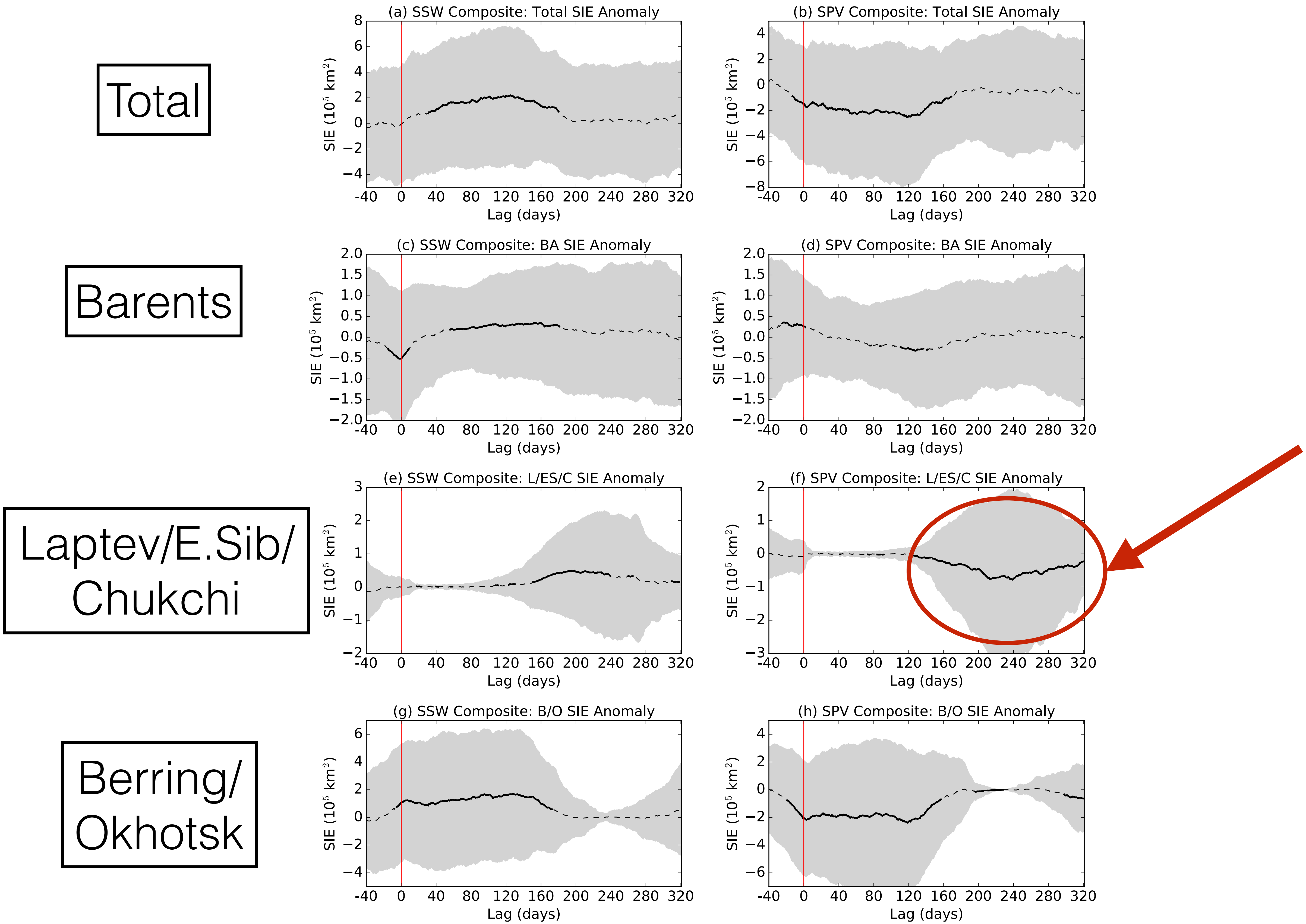


Significant SIE anomalies extending well into late summer

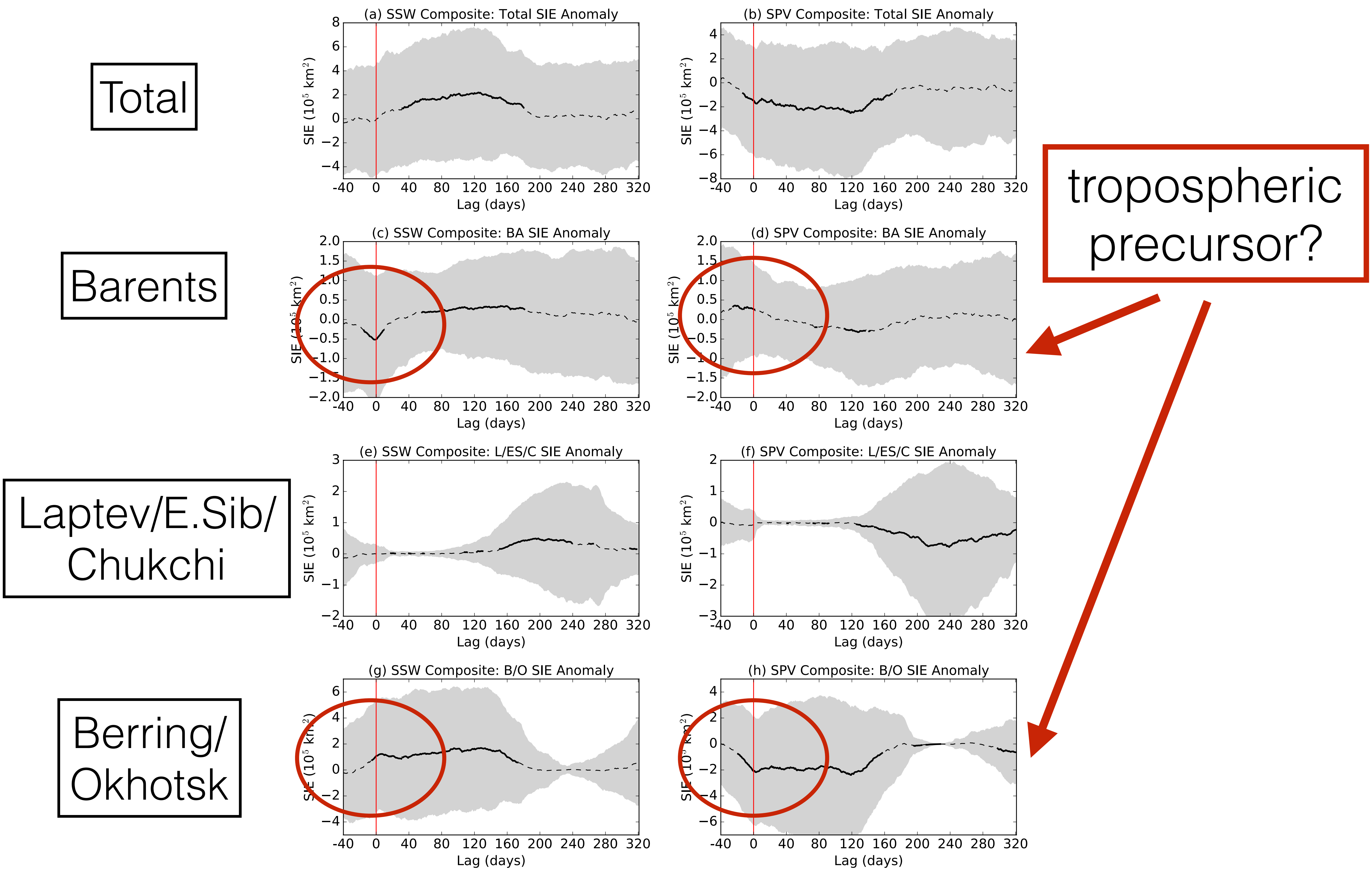
Berring/ Okhotsk



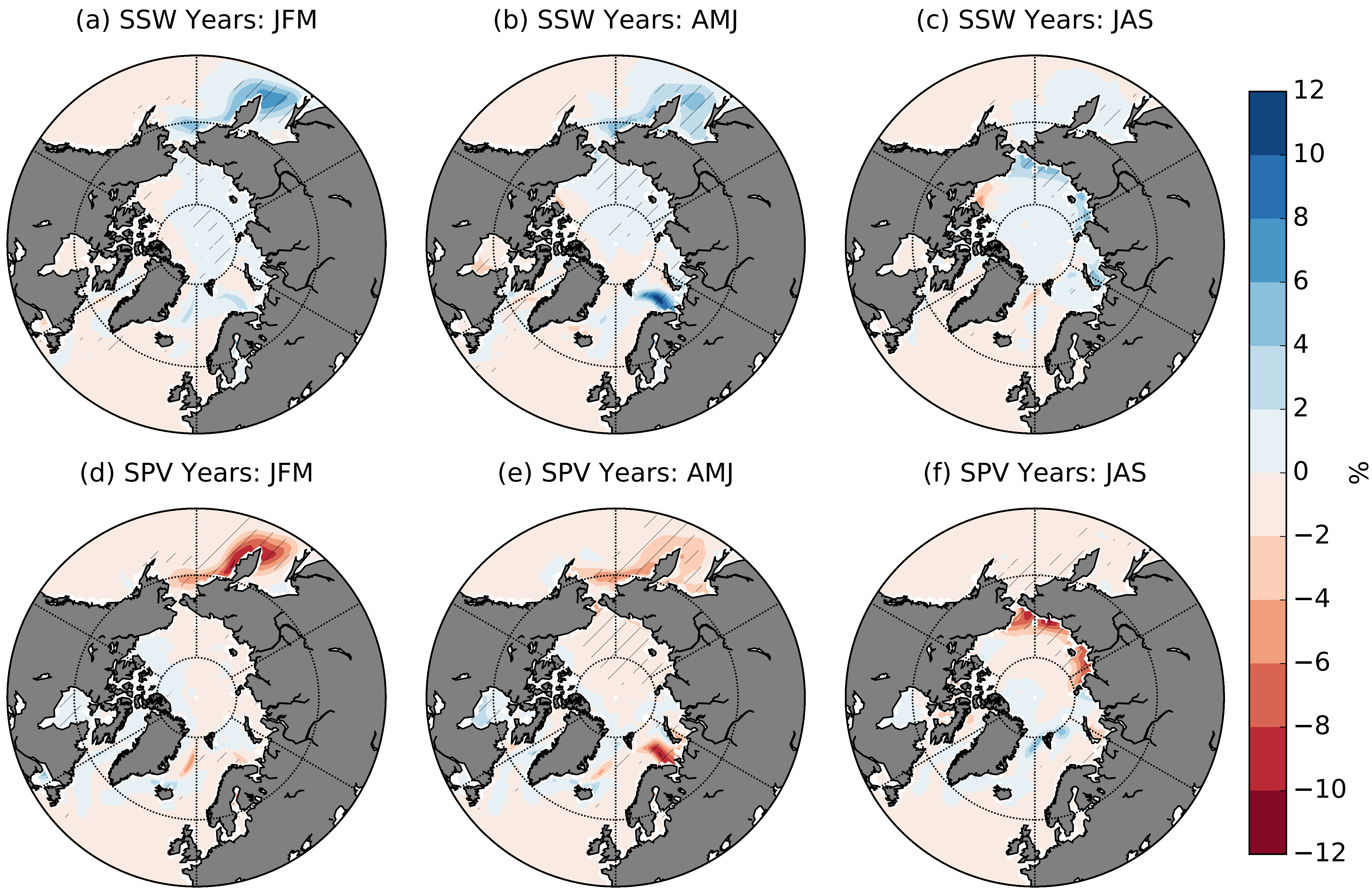
Sea Ice Extent



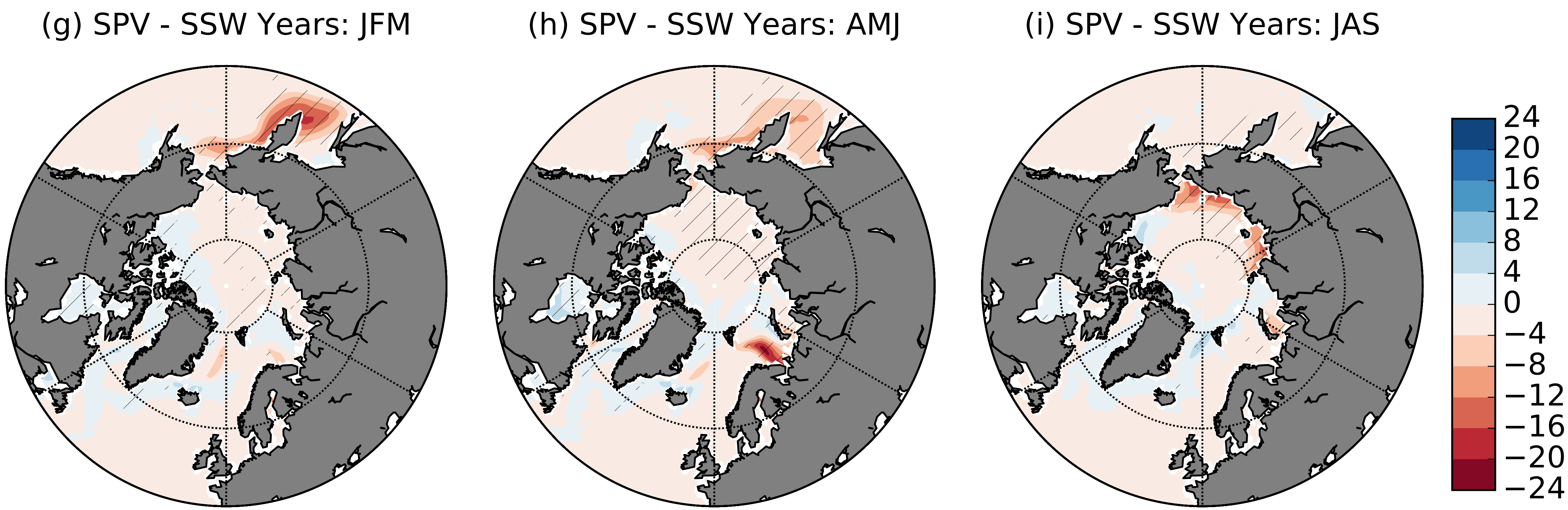
Sea Ice Extent



Sea Ice Concentration



Sea Ice Concentration



- **Barents Sea:** SSW & SPV anomalies are ~25% of a STDEV.
- **Laptev/E. Sib/Chukchi Seas:** SSW anomalies are ~25% of a STDEV and SPV anomalies are ~50% of a STDEV.

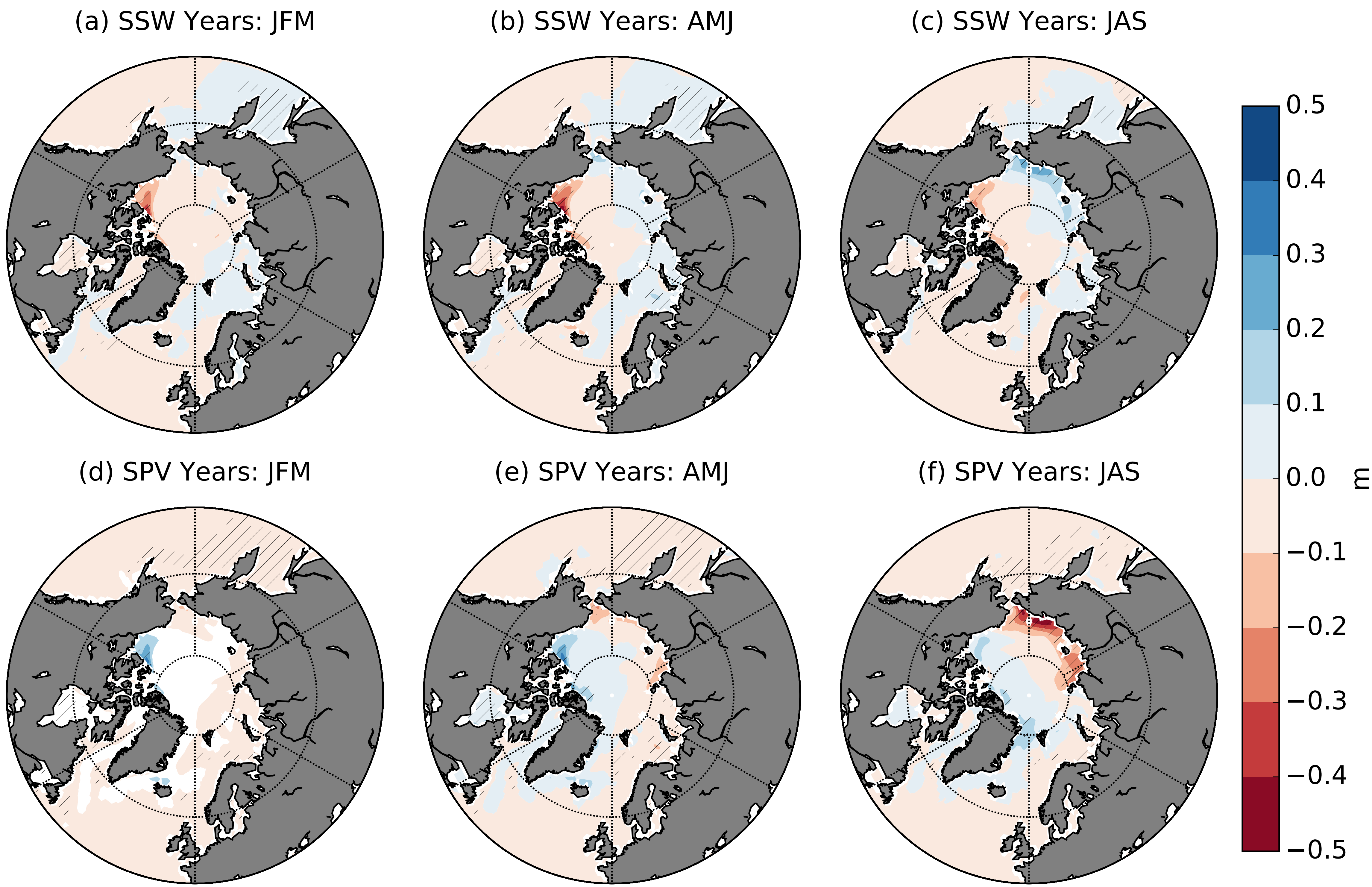
Story so far:

1. SSWs and SPVs are followed by SIC anomalies in the Barents Sea in spring and the Laptev/E. Siberian/Chukchi Seas in summer

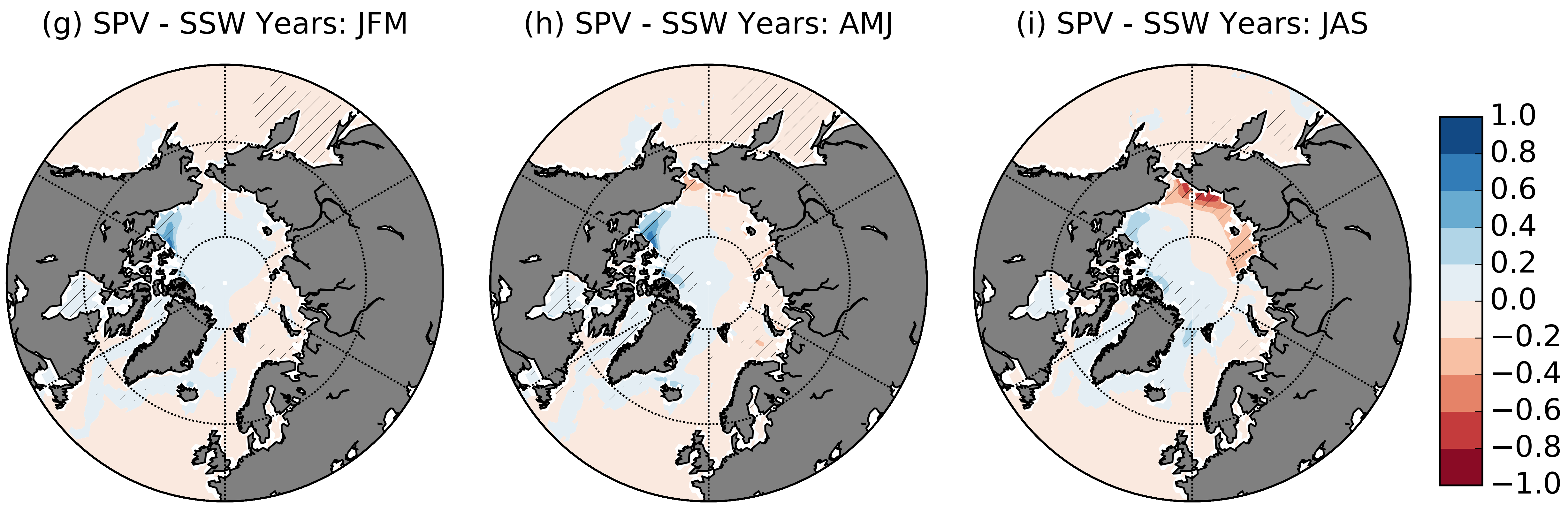
2. Anomalies appear to be consistent with the interannual relationships between AO/NAO and SIC in literature

Are the mechanisms also consistent?

Sea Ice Thickness

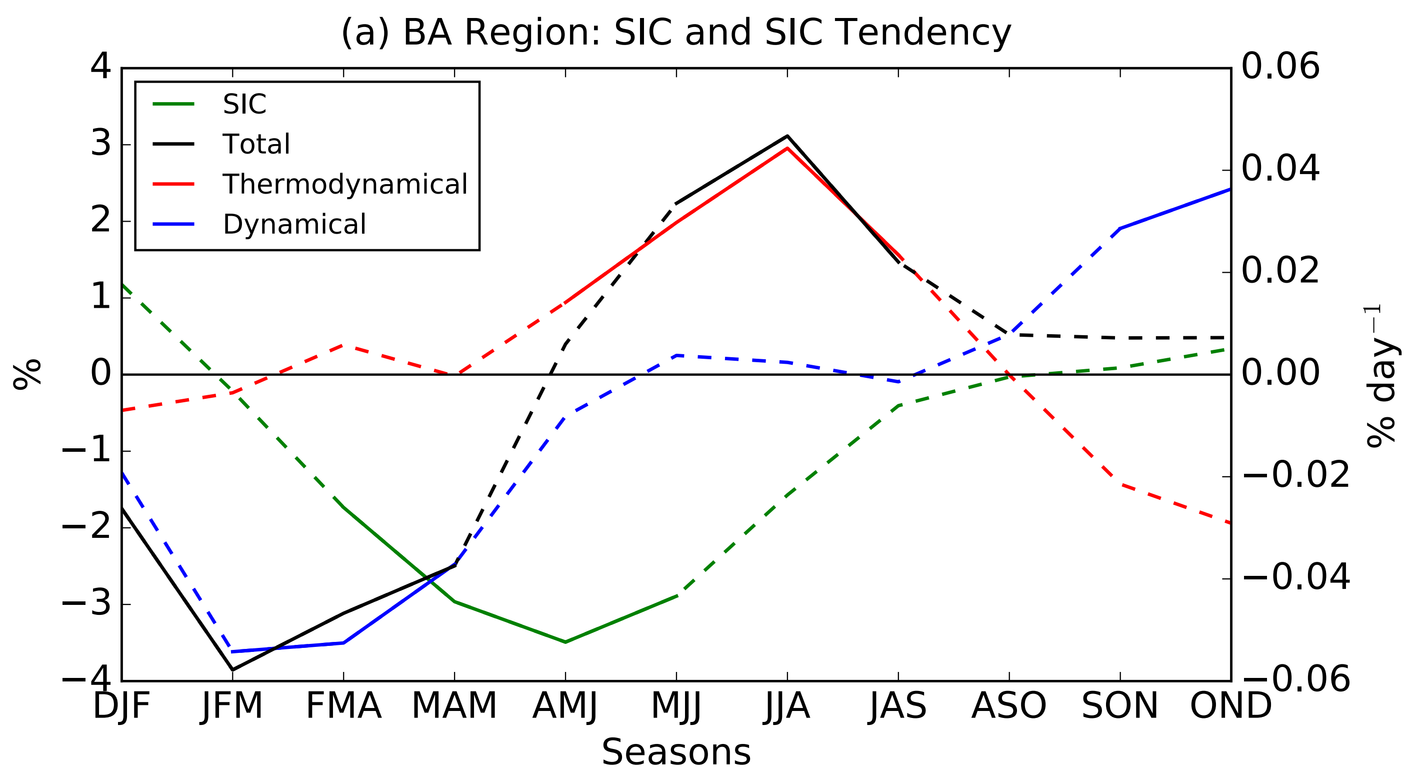


Sea Ice Thickness

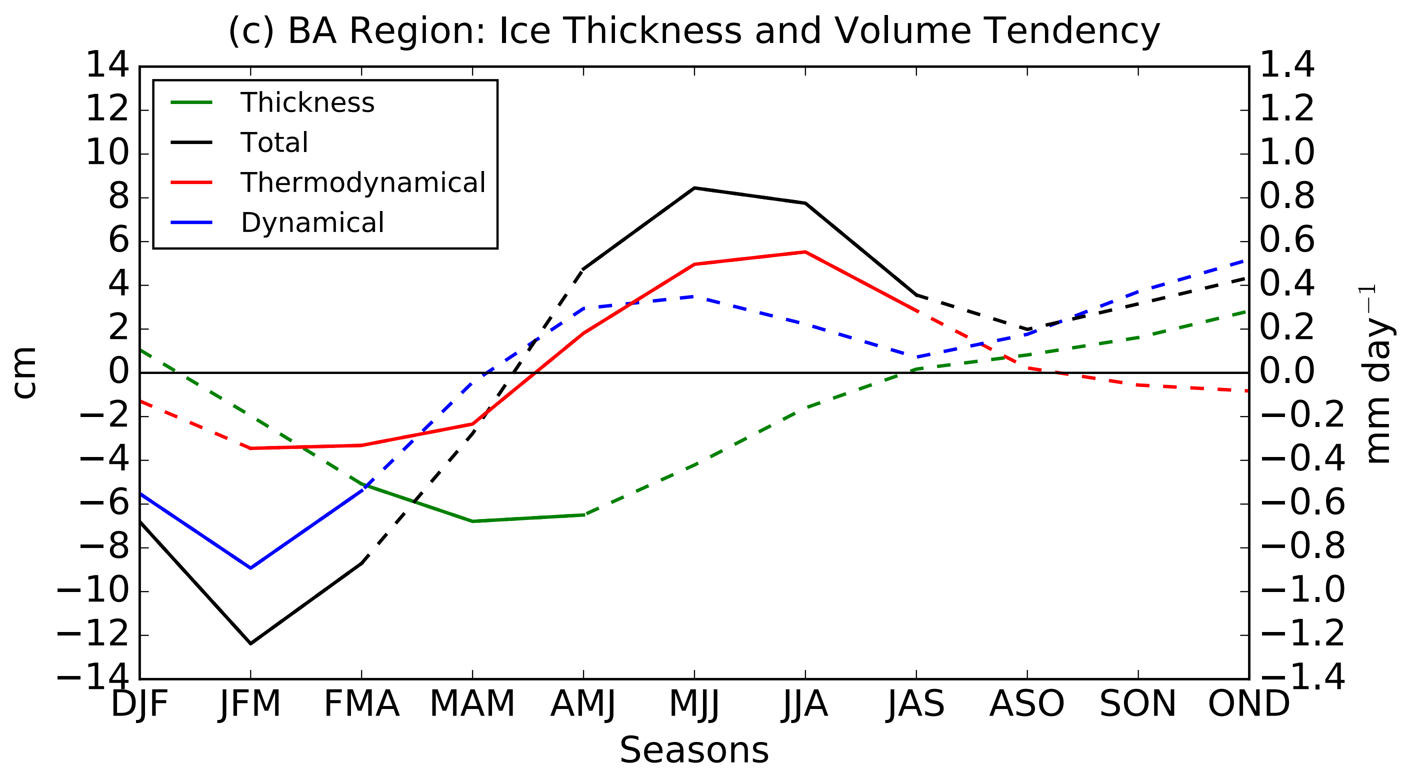


- **Laptev/E. Sib/Chukchi Seas:** SSW anomalies are ~16% of a STDEV and SPV anomalies are ~32% of a STDEV.

Processes: Barents Sea

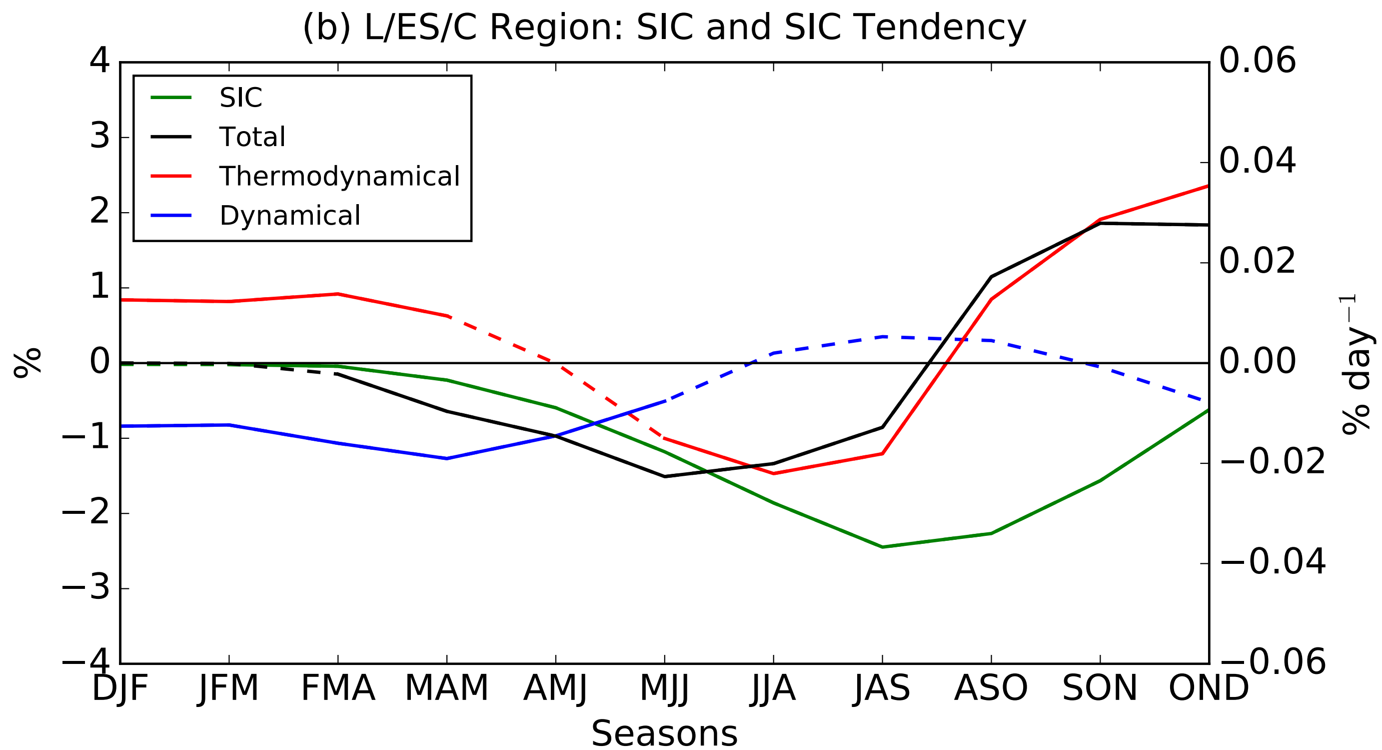


SIC Tendencies

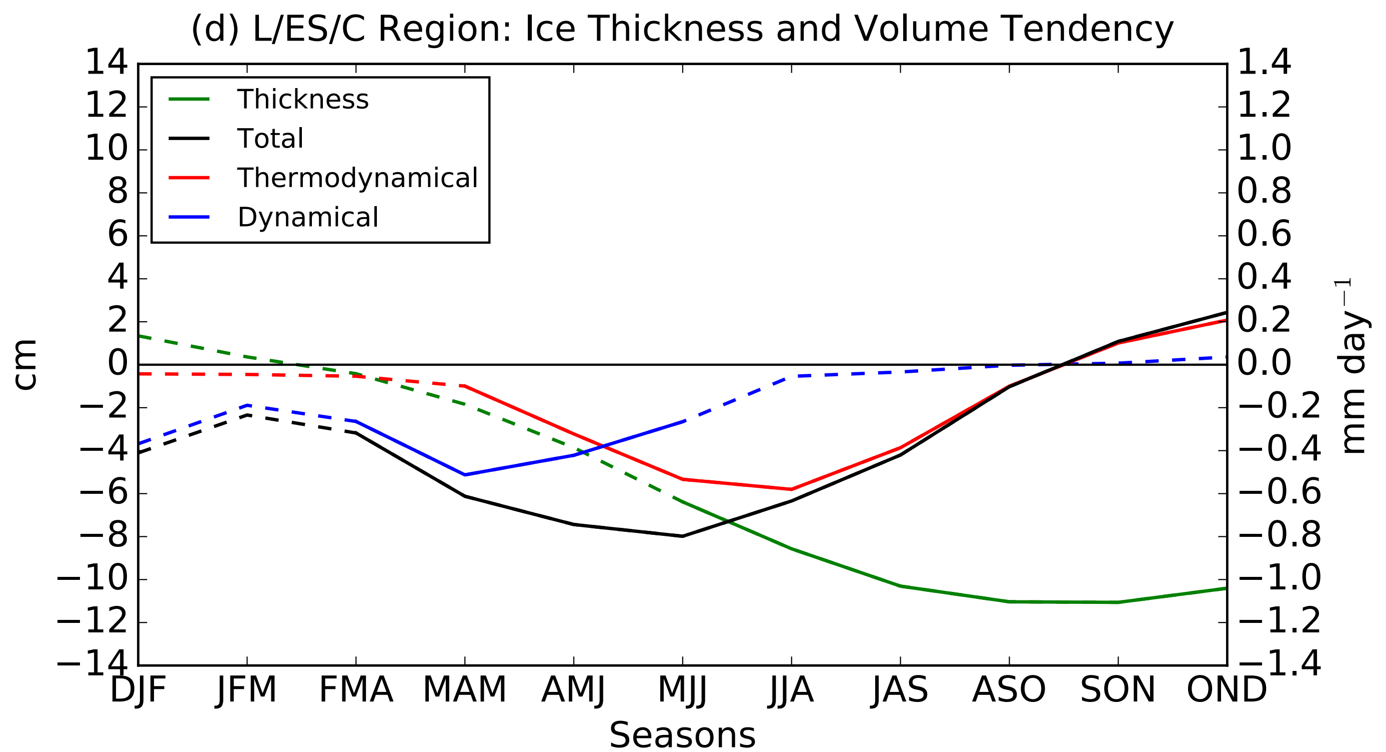


SIT Tendencies

Processes: Laptev, E. Siberian & Chukchi Seas

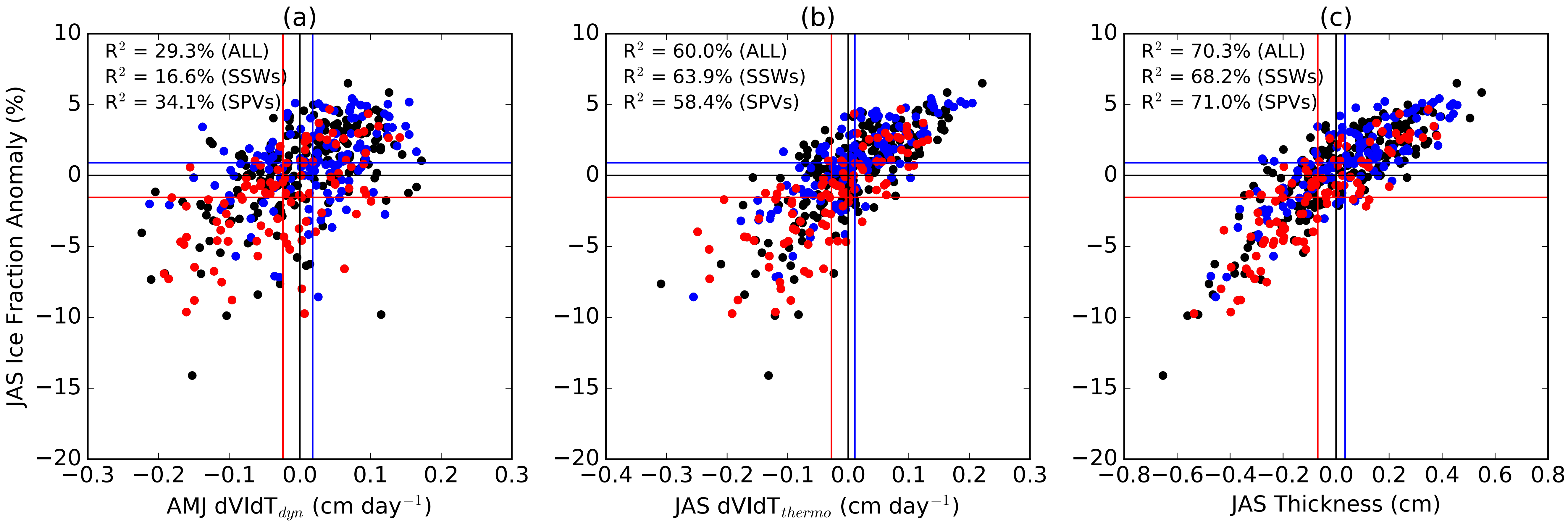


SIC Tendencies

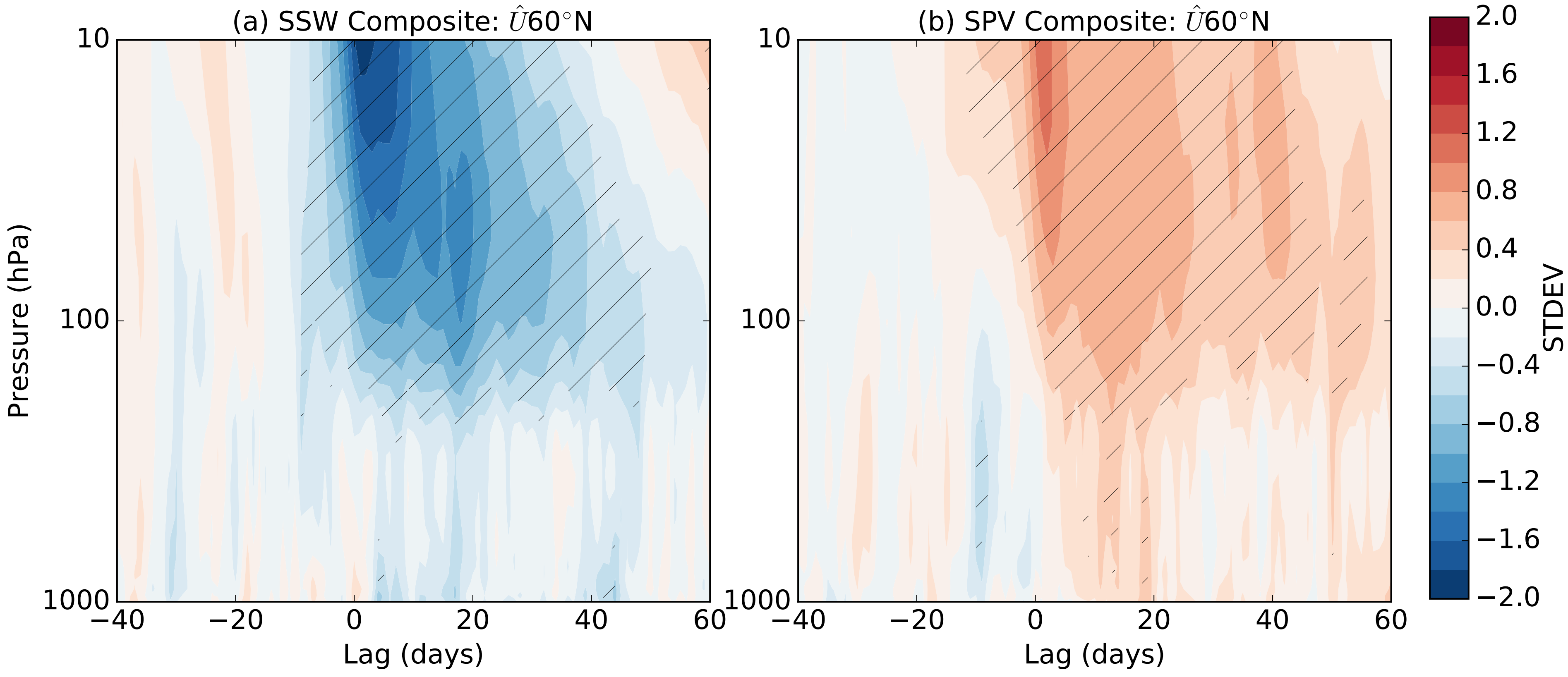


SIT Tendencies

Processes: Laptev, E. Siberian & Chukchi Seas



SSWs & SPVs: Reanalysis



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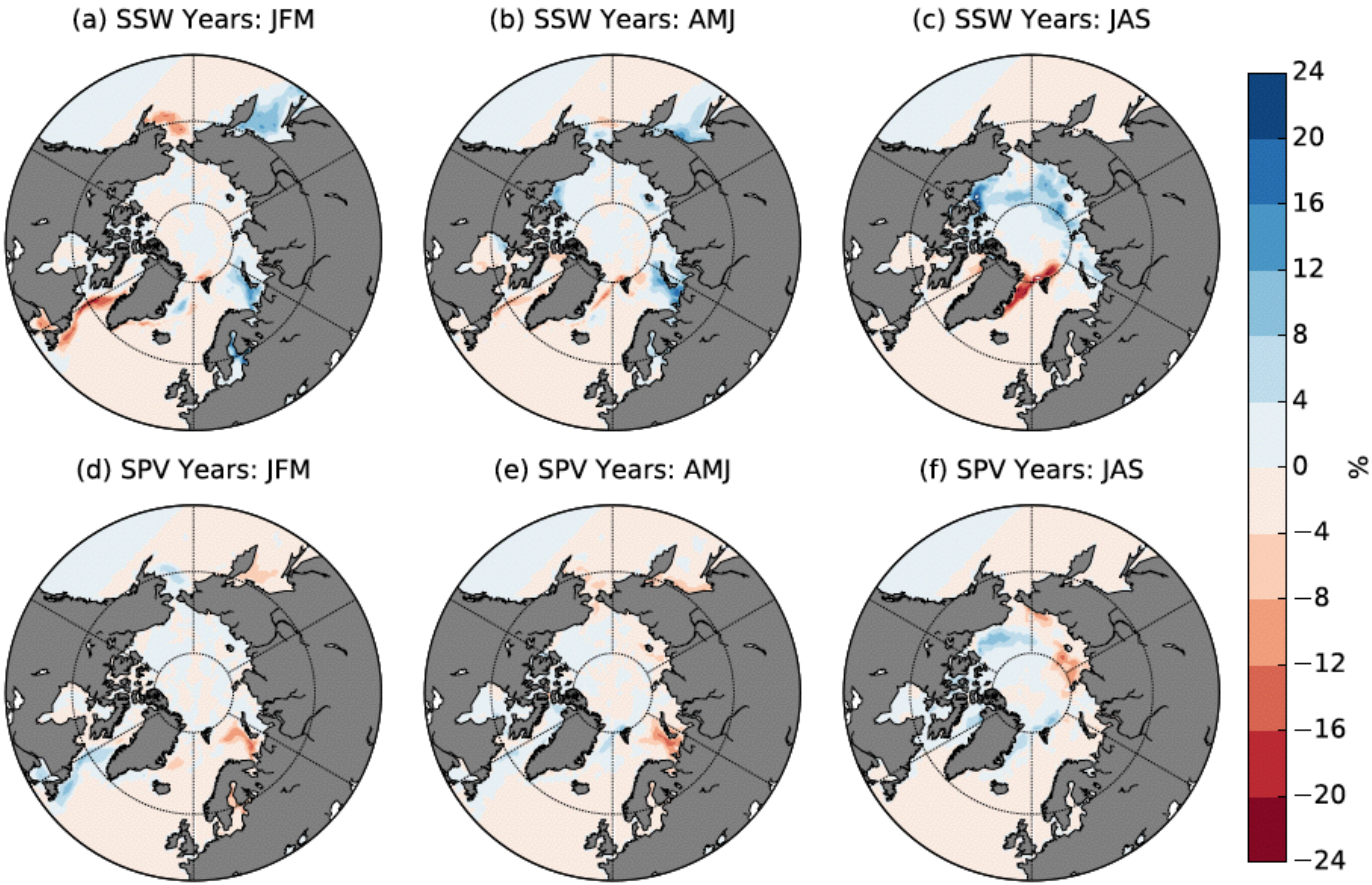
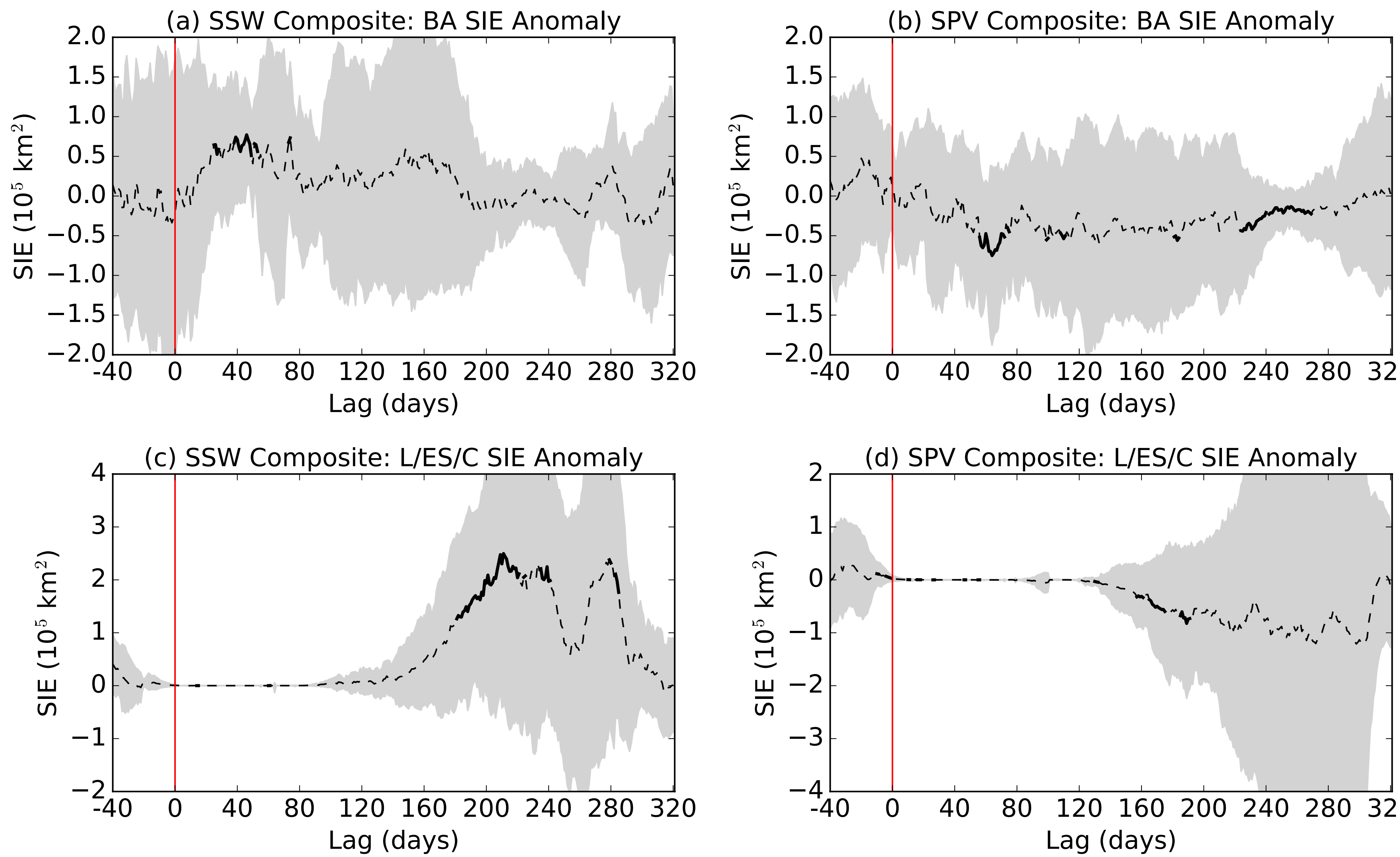
Sea Ice Concentration: NSIDC



Sea Ice Extent: NSIDC

Barents

Laptev/E.Sib/Chukchi



Conclusions

- **SSWs: Positive** SIC anomalies in Barents Sea in spring and Laptev/E. Siberian/Chukchi Seas in summer

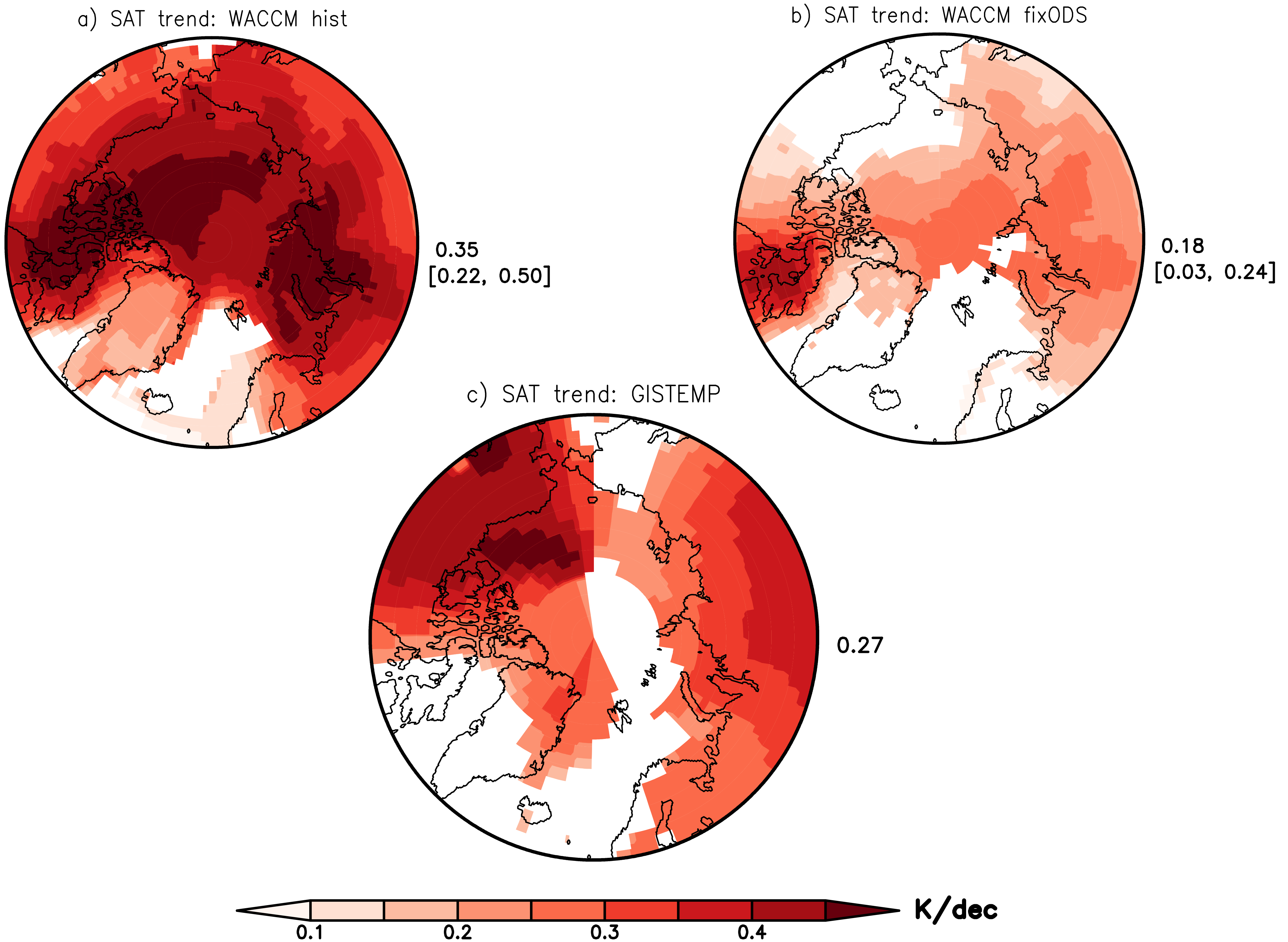
- **SPVs: Negative** SIC anomalies in Barents Sea in spring and Laptev/E. Siberian/Chukchi Seas in summer

- In the BA region, SIE anomalies are driven by winter ice advection, while SIE anomalies in the L/ES/C region arise due to ice thickness anomalies, generated by coastal sea ice divergence in late winter and enhanced by thermodynamical feedbacks in spring and summer.

- Because stratospheric anomalies precede AO anomalies in the troposphere, there is the potential to extend the period over which skillful prediction of Arctic SIE may be achieved if knowledge of stratospheric conditions is known.

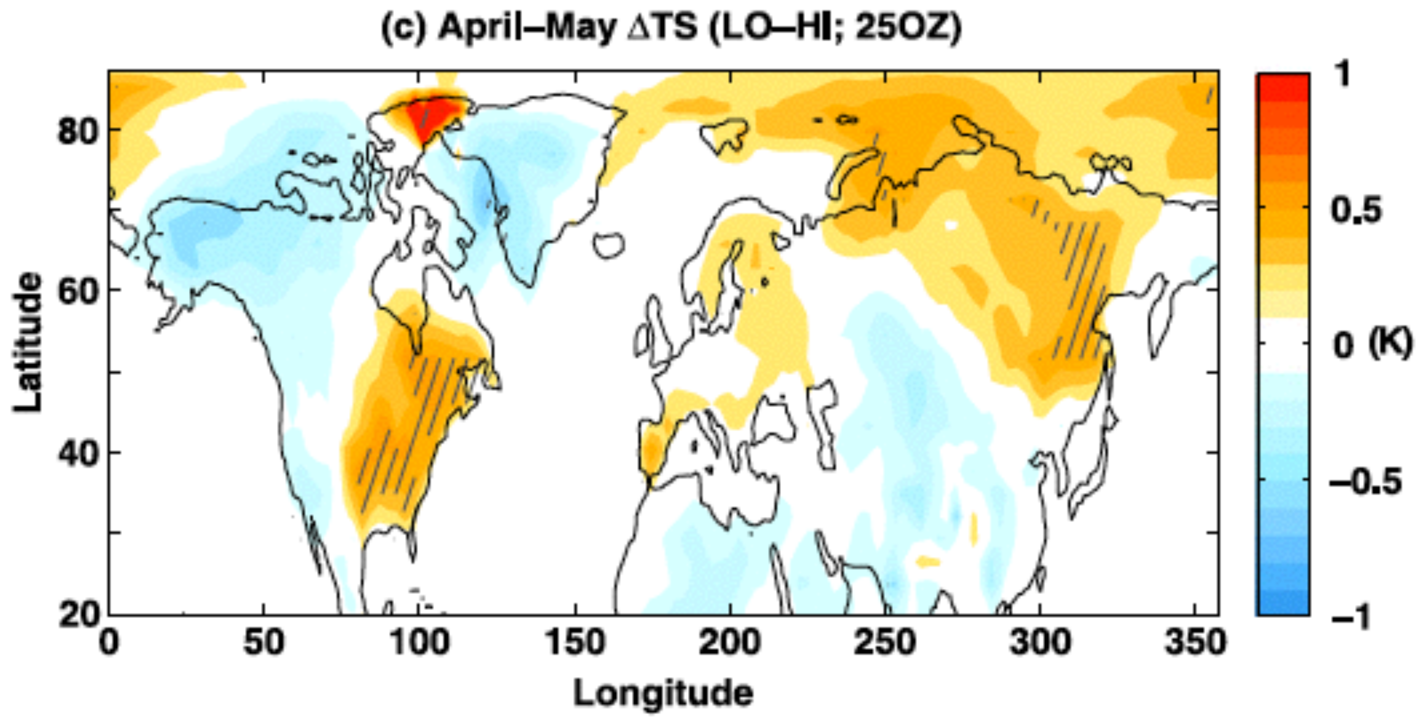
Multi-decadal stratospheric influence on Arctic

Multi-decadal stratospheric influence on Arctic

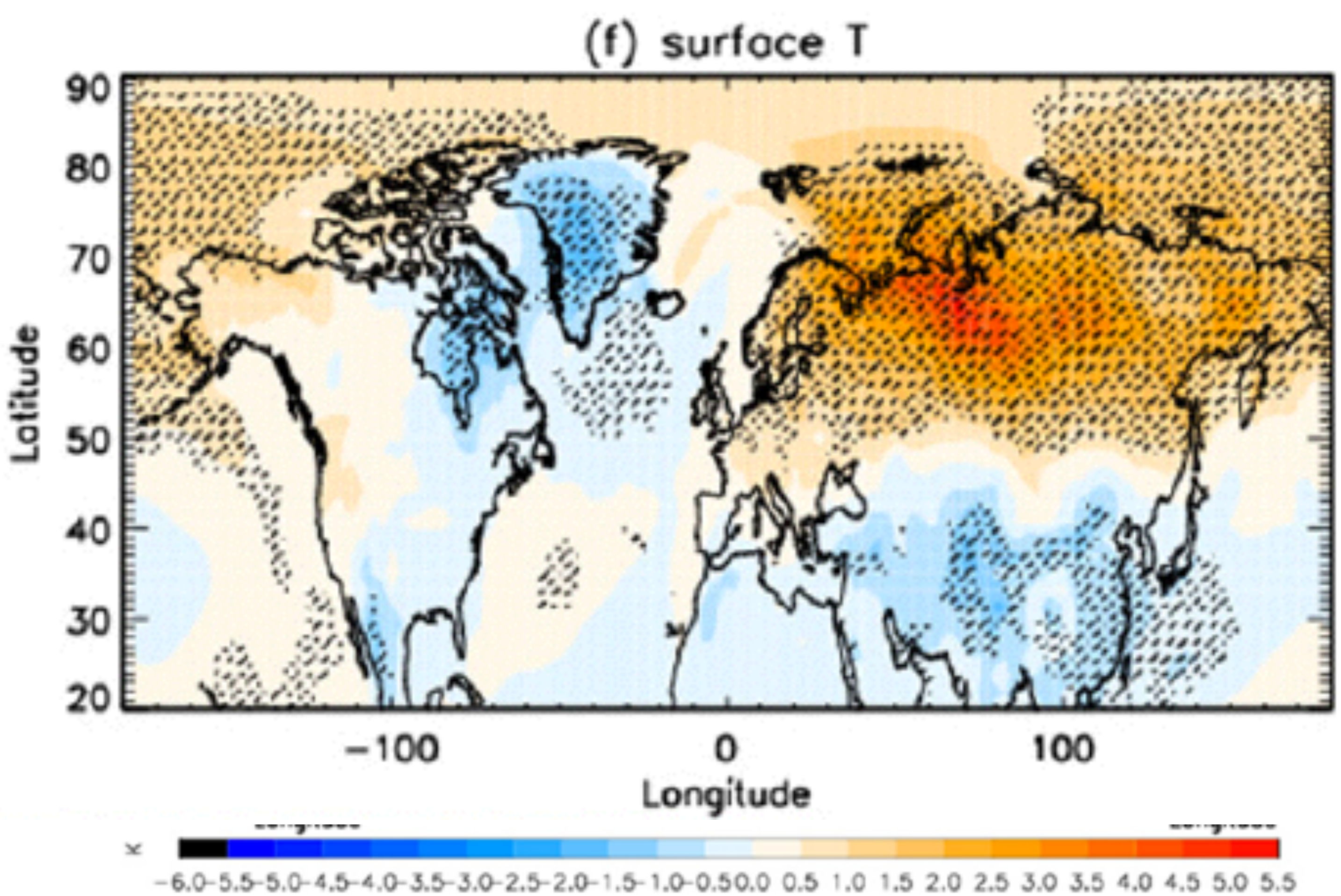


Polvani, Previdi, Smith (in prep)

Multi-decadal stratospheric influence on Arctic



CAM4



WACCM4

Smith & Polvani 2014
Calvo et al. 2015

Multi-decadal stratospheric influence on Arctic

Historical - FixODS