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Interannual Arctic sea-ice variability and associated winter weather patterns: A regional perspective for 1979–2014

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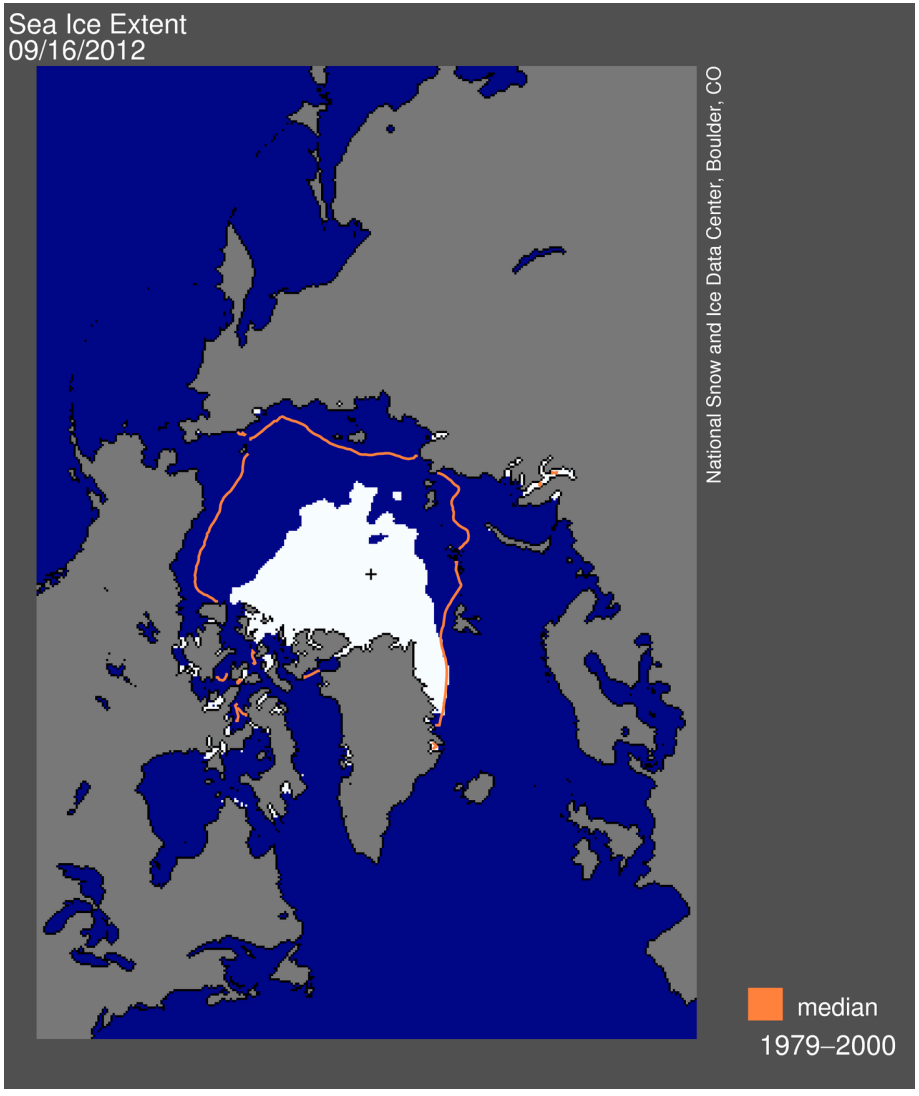
Arctic sea ice is rapidly decreasing



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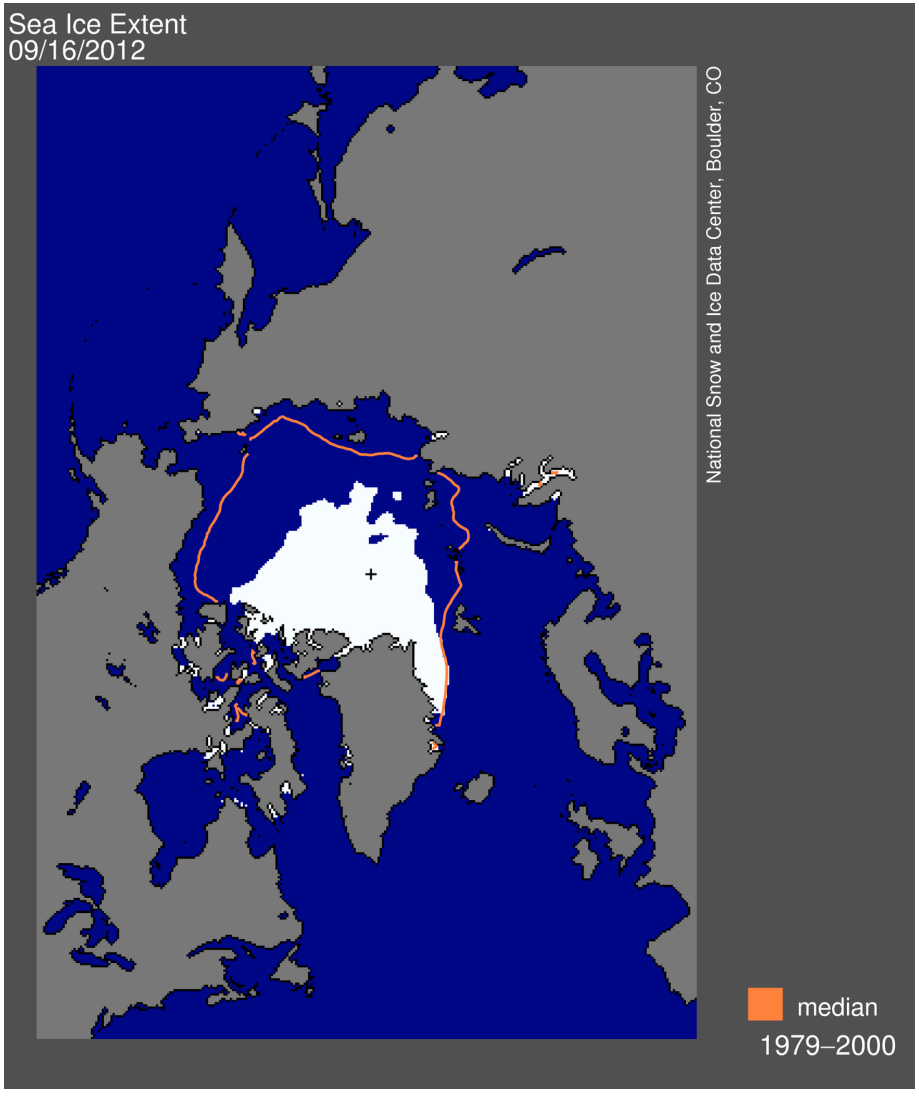
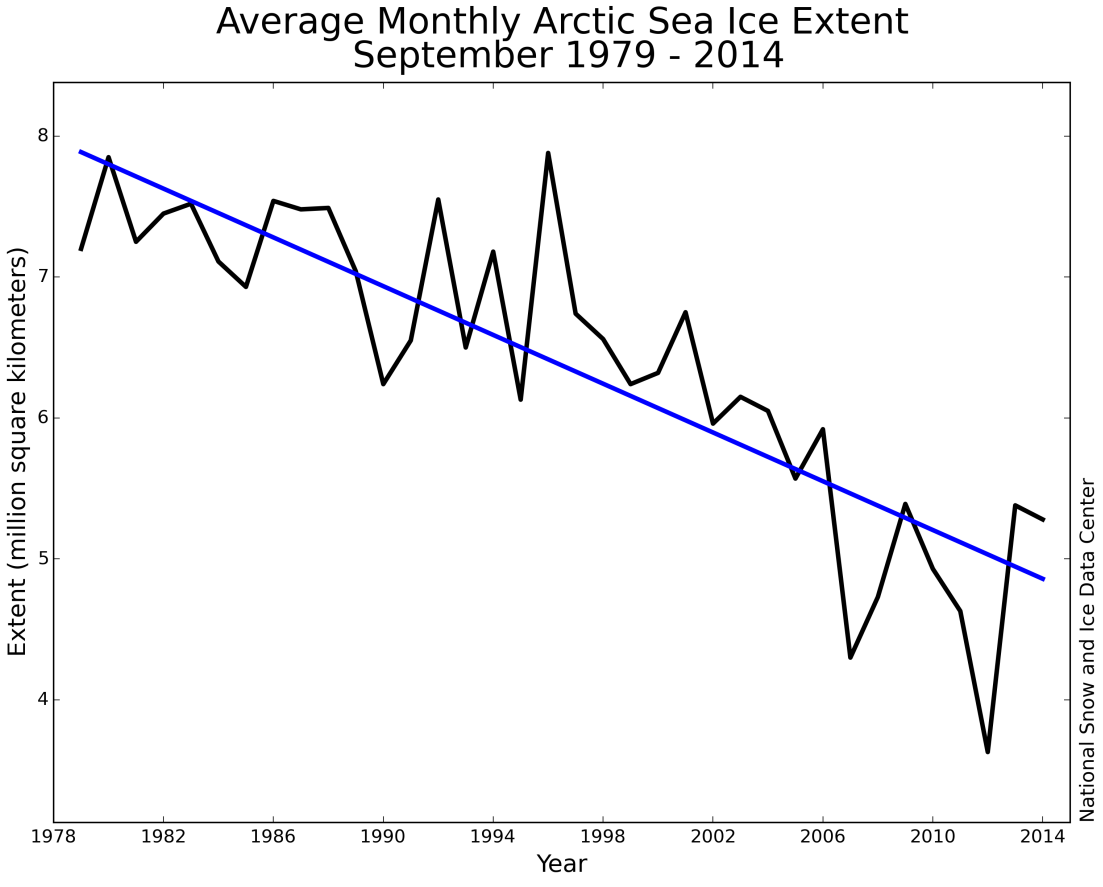
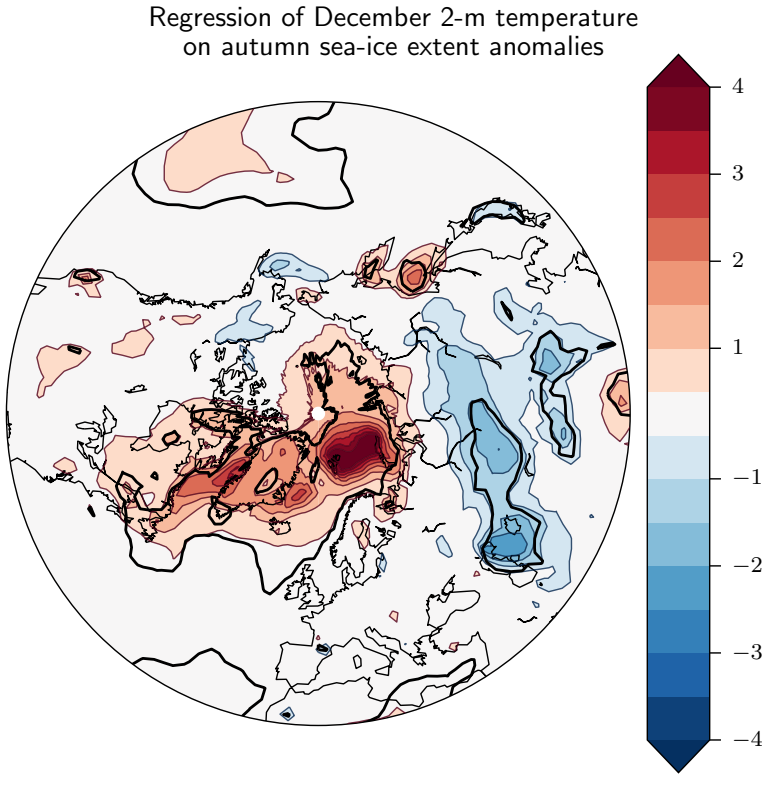


"Warm Arctic cold continents"





Objectives

Using observational data,

- Objectively classify Arctic sea ice into regions of similar sea ice concentration variability
- Detrend Arctic sea-ice extent using a nonlinear and adaptive method
- Investigate the winter atmospheric patterns associated with the sea-ice extent variability in each region

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Sea ice and atmospheric data

Sea ice concentration:

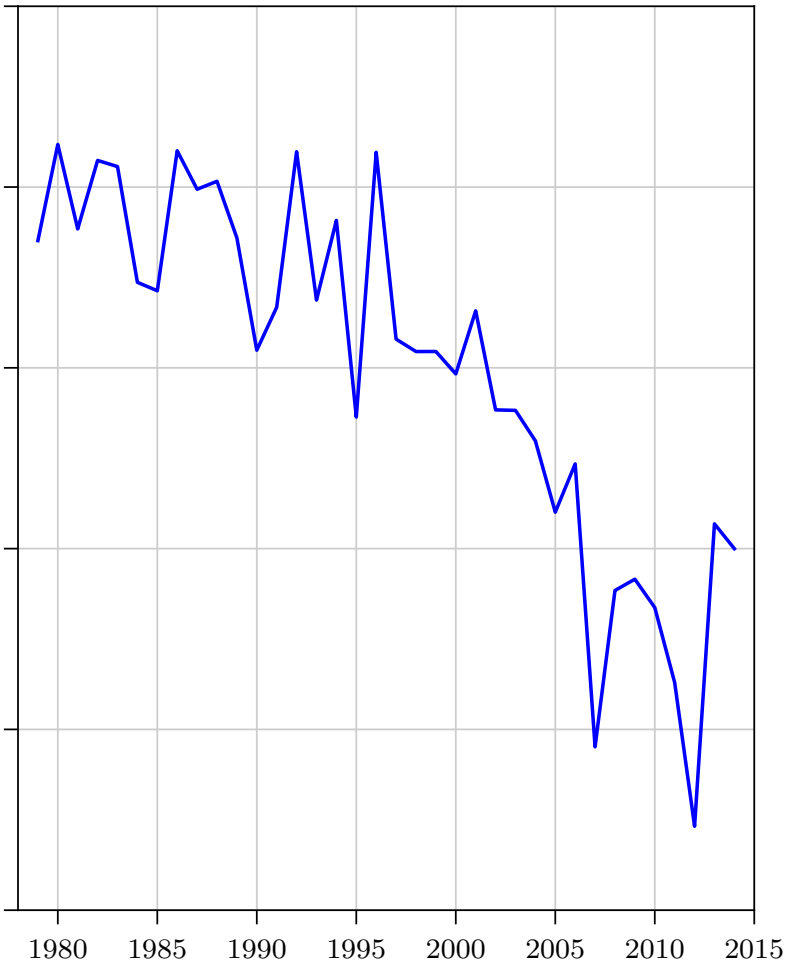
- Nimbus-7 SMMR and DMSP SSM/I-SSMIS passive microwave data
- Daily data from 1979 to 2014
- Horizontal resolution of 25×25 km

Atmospheric data:

- NCEP-DOE Reanalysis 2
- Monthly mean data from 1979 to 2014
- 2-m temperature on a T62 Gaussian grid (192×94)
- Sea-level pressure on a 2.5×2.5 lat-lon grid (144×73)

Detrending with EEMD

Example: Detrending total Arctic sea-ice extent.



Ensemble Empirical Mode Decomposition is an adaptive method to decompose a signal into intrinsic mode functions (IMFs).

EEMD makes no a priori assumptions about the shape of the data.

The method works well with nonlinear and non-stationary data.

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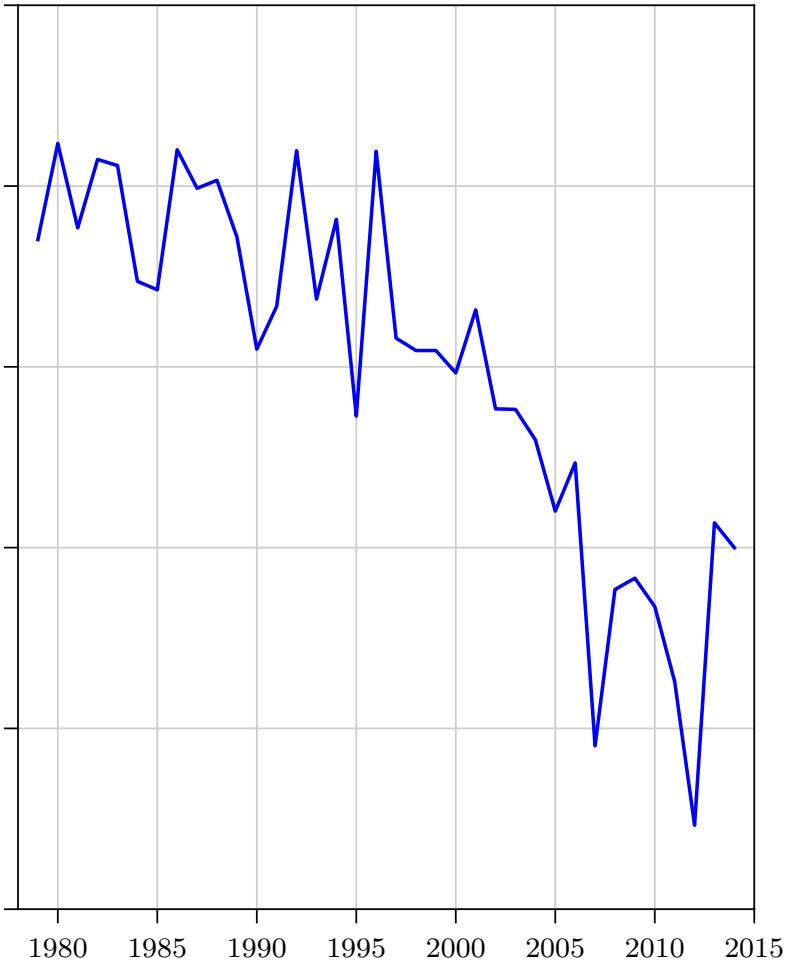

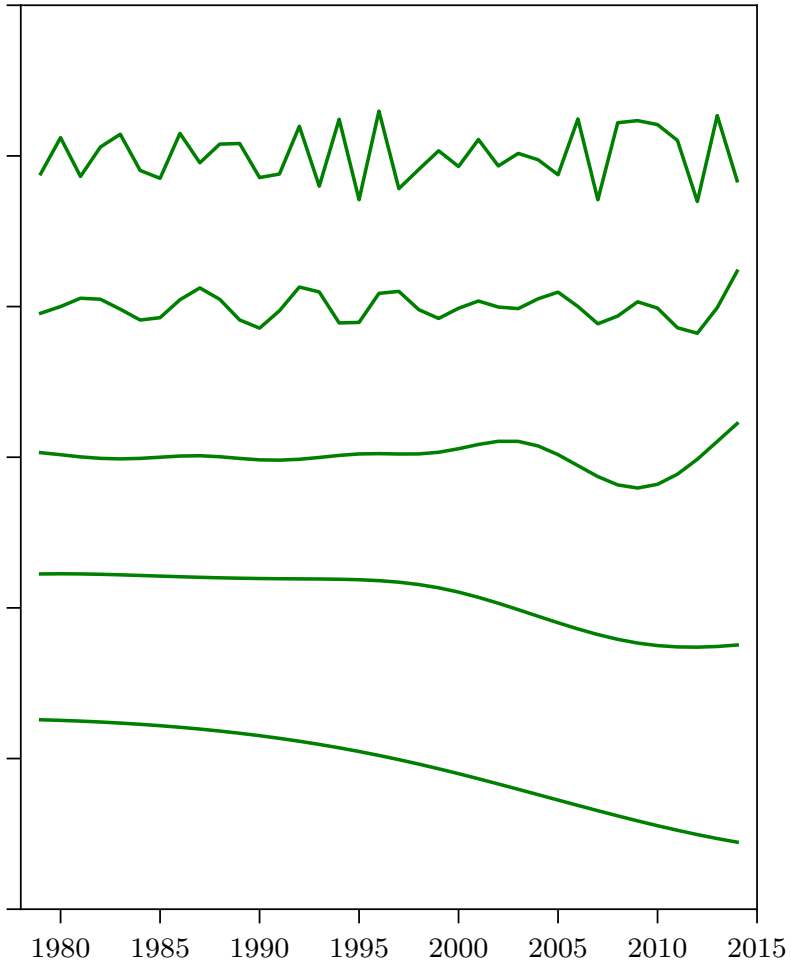

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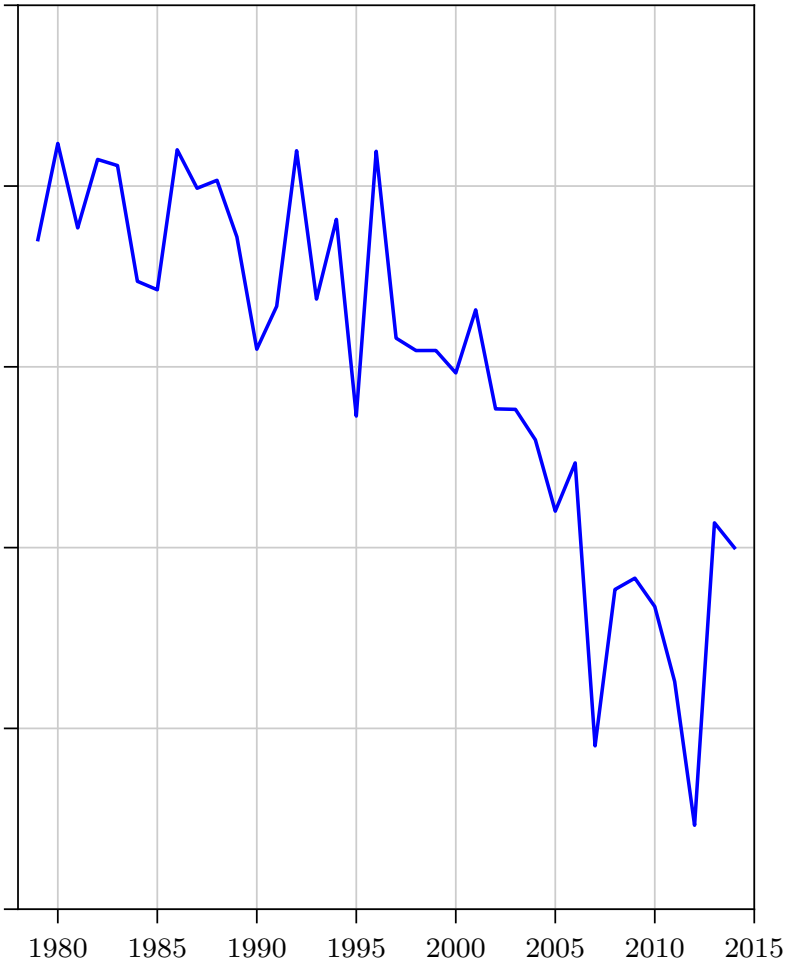

1. Is there a significant linear trend? ($p < 0.05$)
2. If yes $\rightarrow$ subtract lowest frequency IMF
3. Do the anomalies have a significant linear trend?
4. If yes $\rightarrow$ subtract next lowest frequency IMF
5. Repeat until there is no significant linear trend

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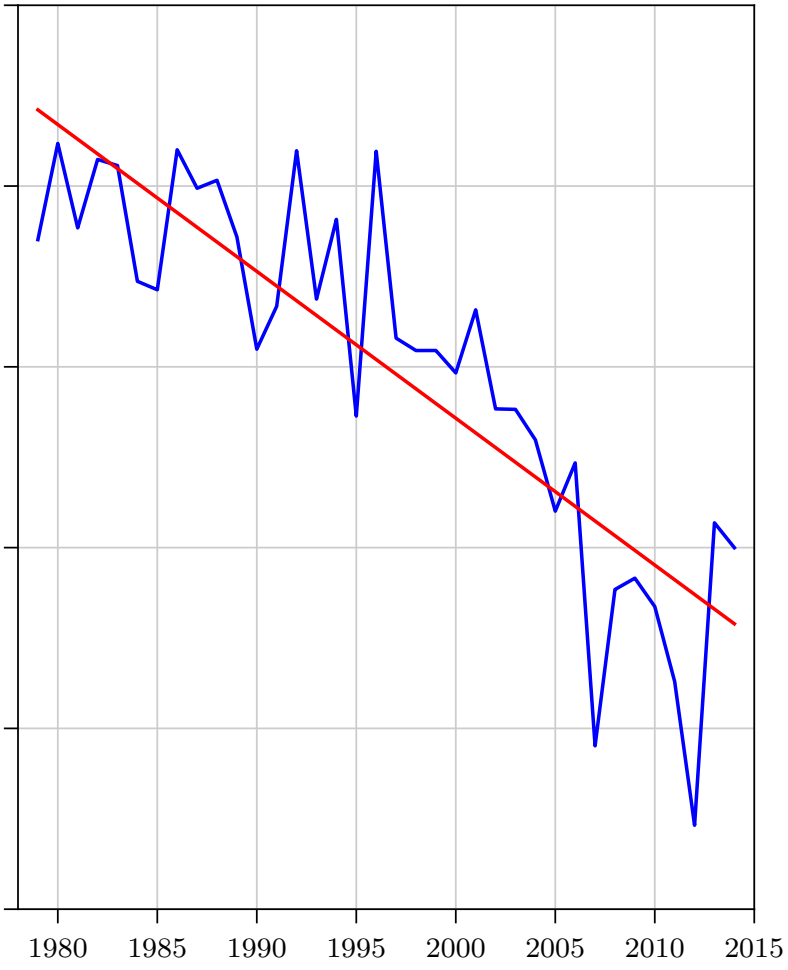

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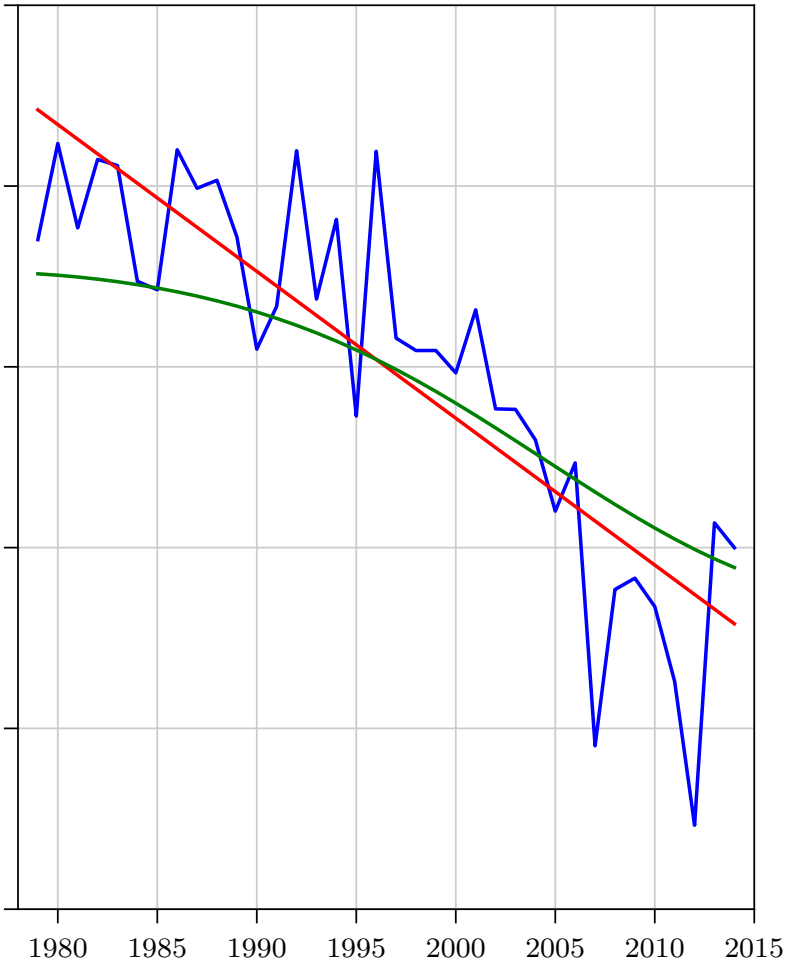

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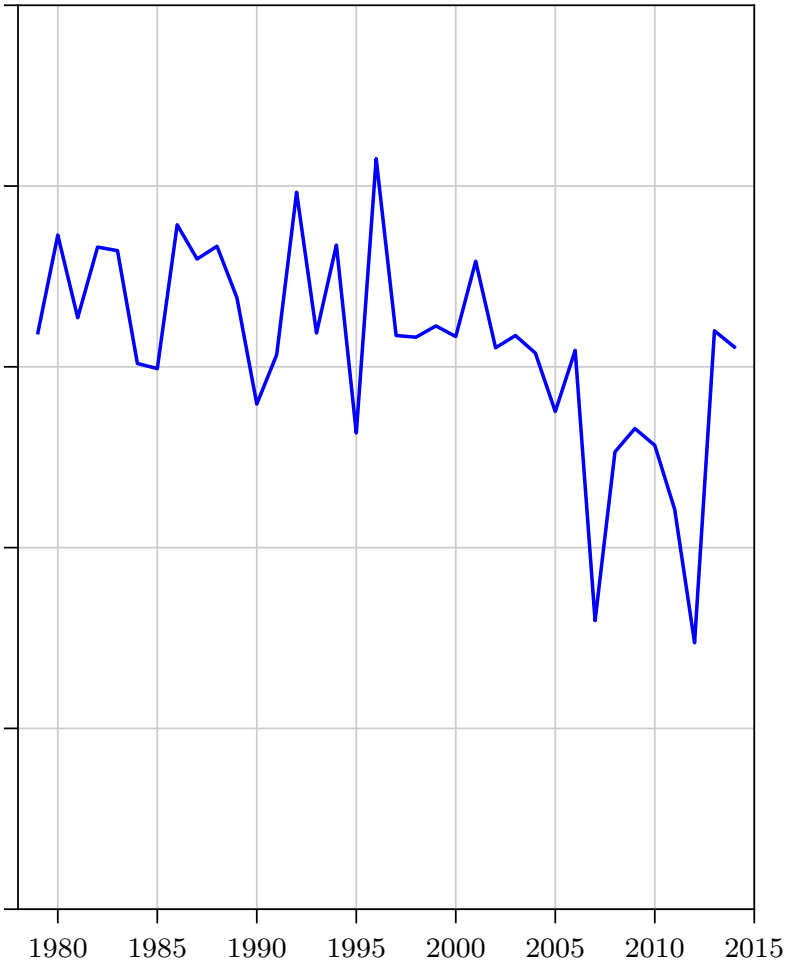

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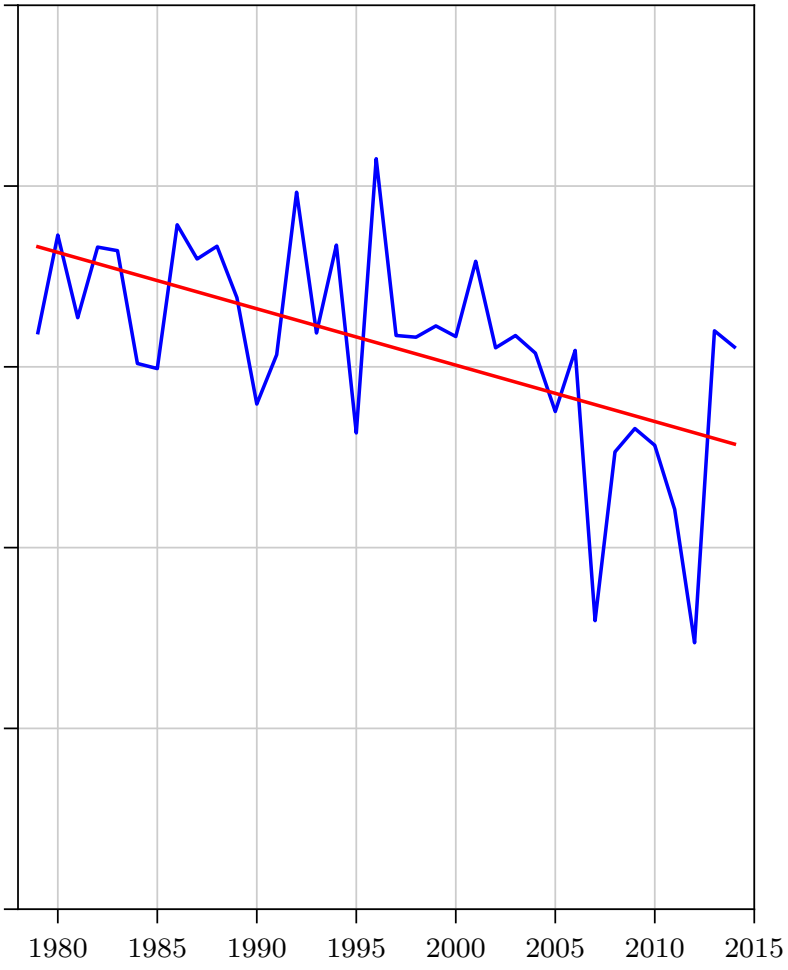

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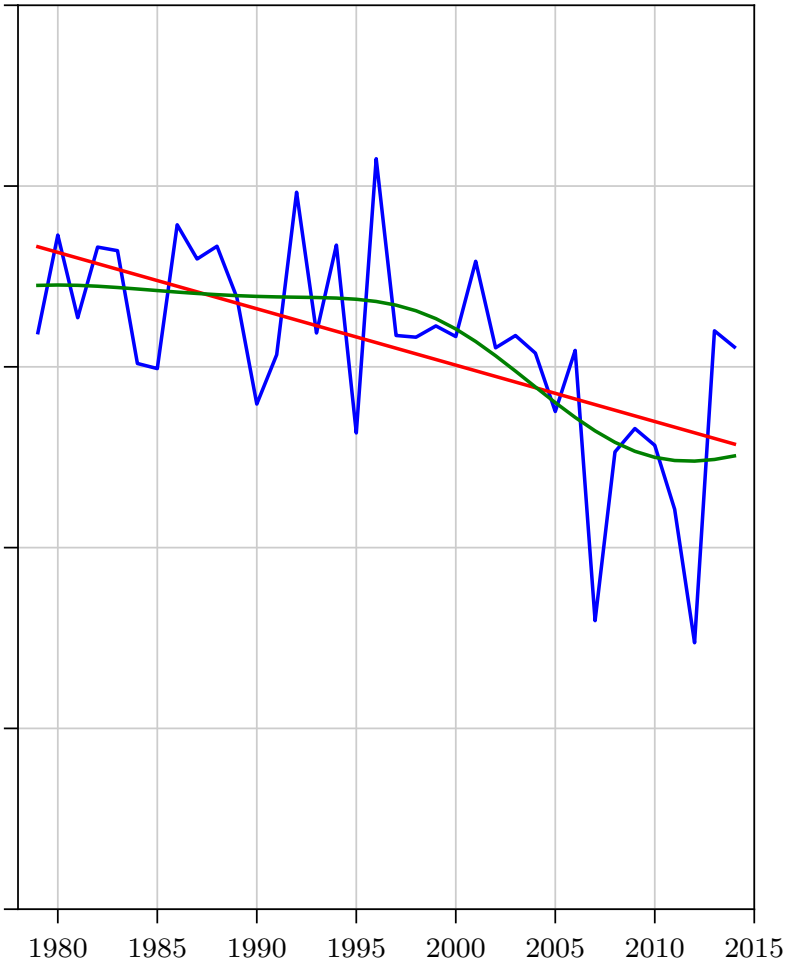

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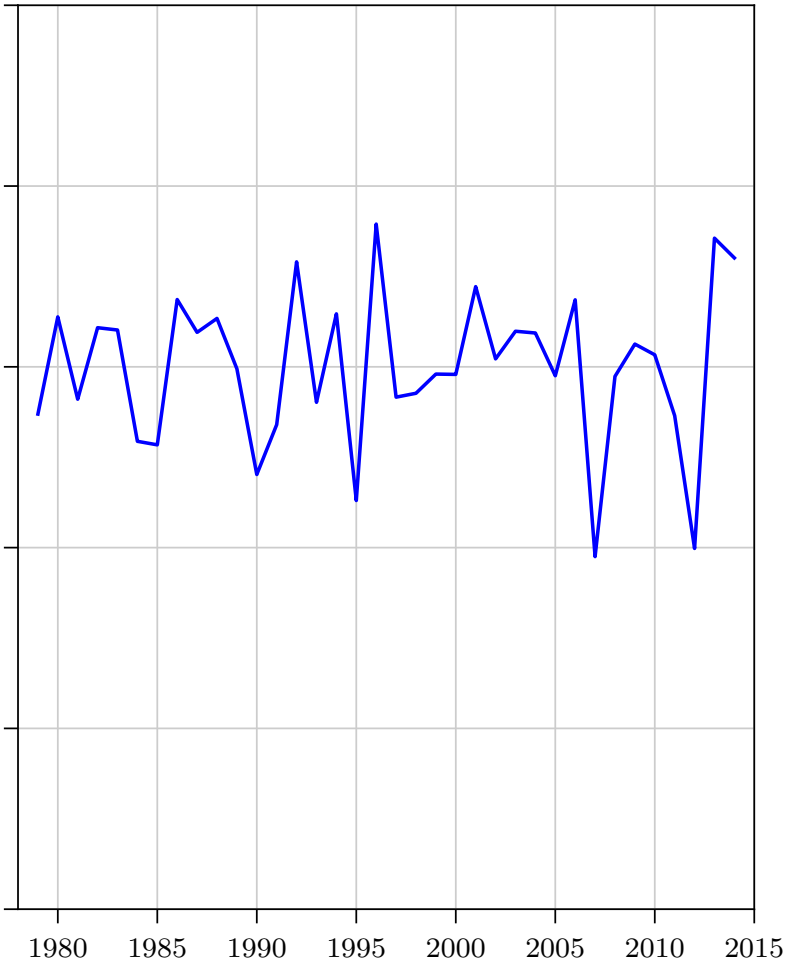

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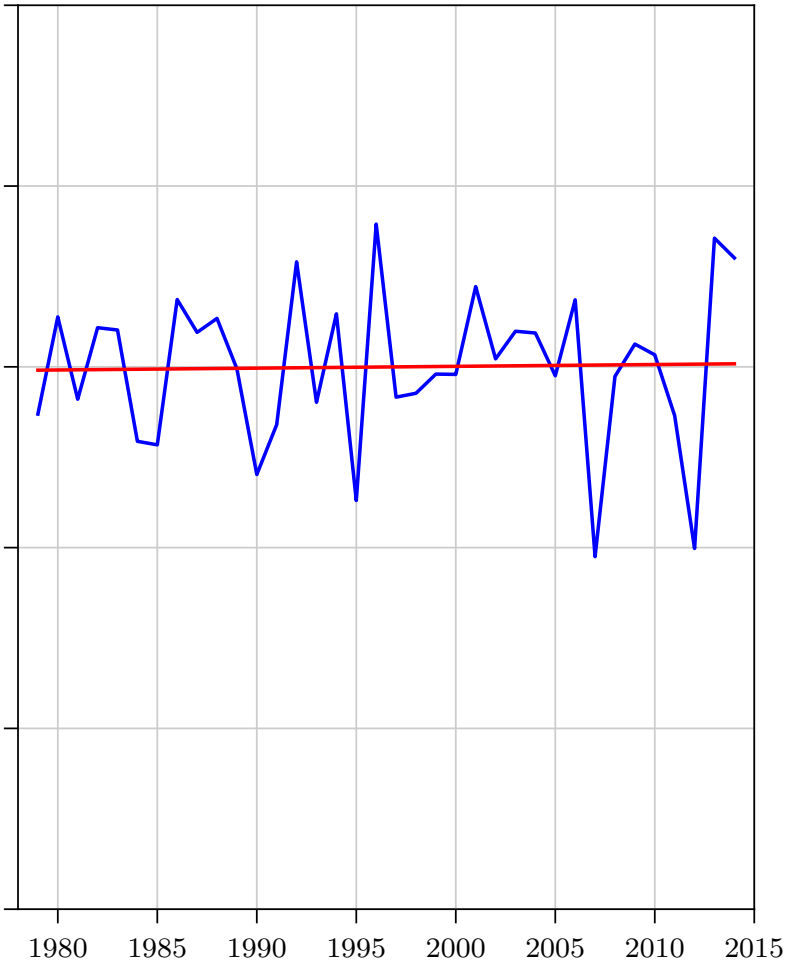

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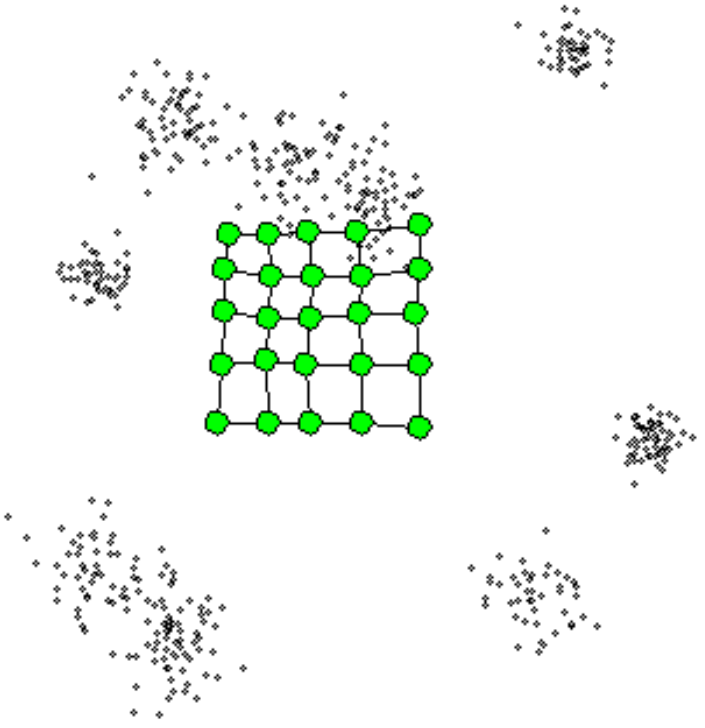
Classification with self-organizing maps

Daily sea ice concentration were averaged into seasonal means. Here we will focus on September-October (autumn).

The time series of sea ice concentrations in each grid point were classified using a self-organizing map.

Our map has 4×3 nodes. Regions that share more than half their variance were merged into one region.



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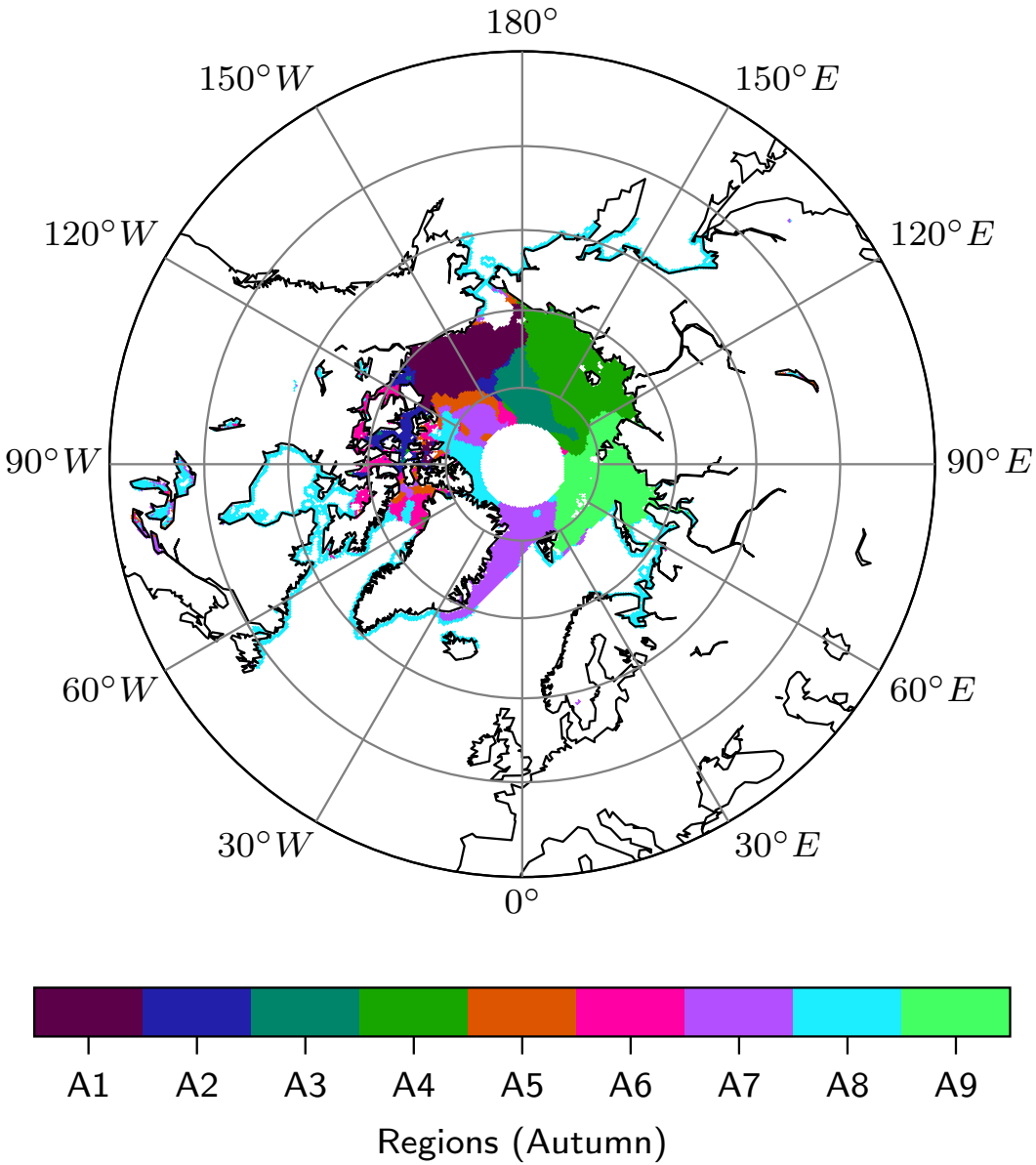
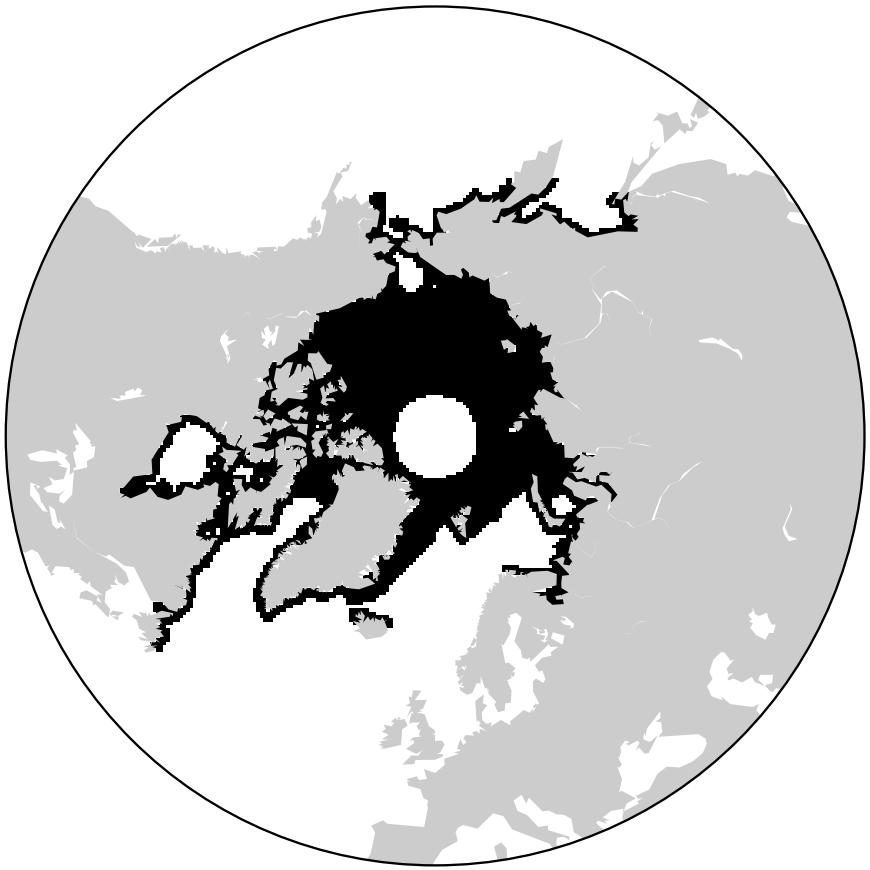
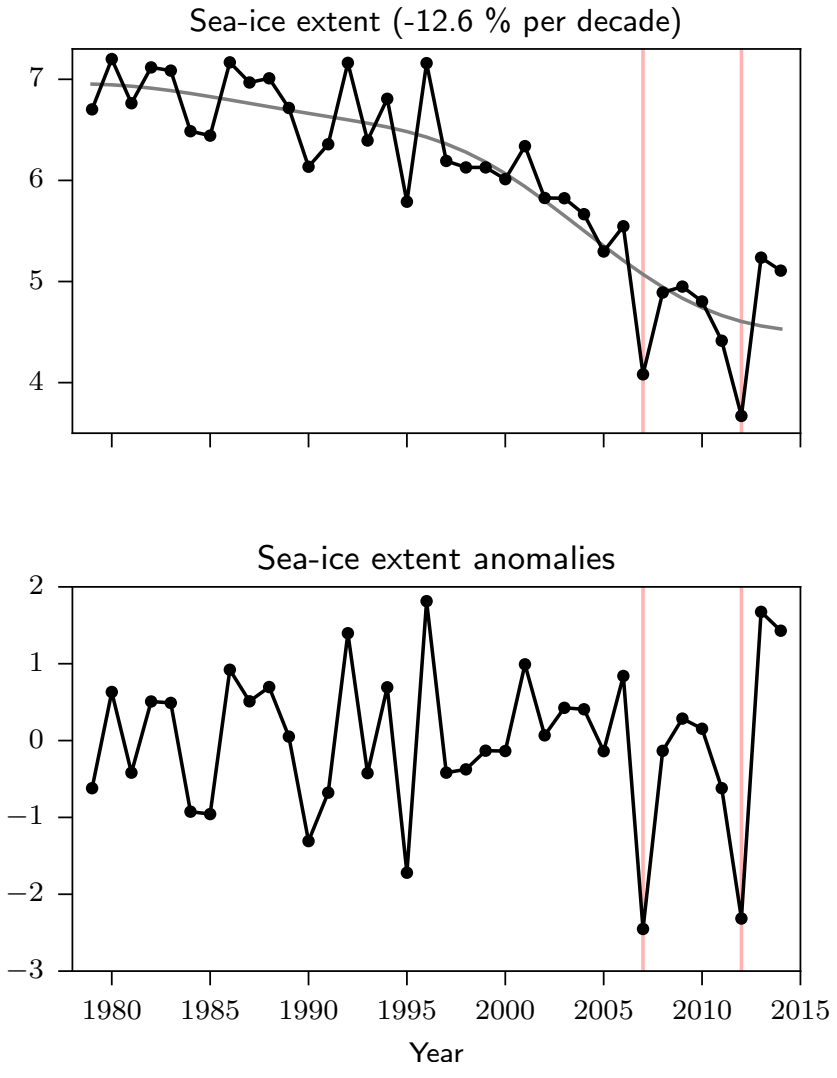
Classification of sea ice regions



Total sea-ice extent variability





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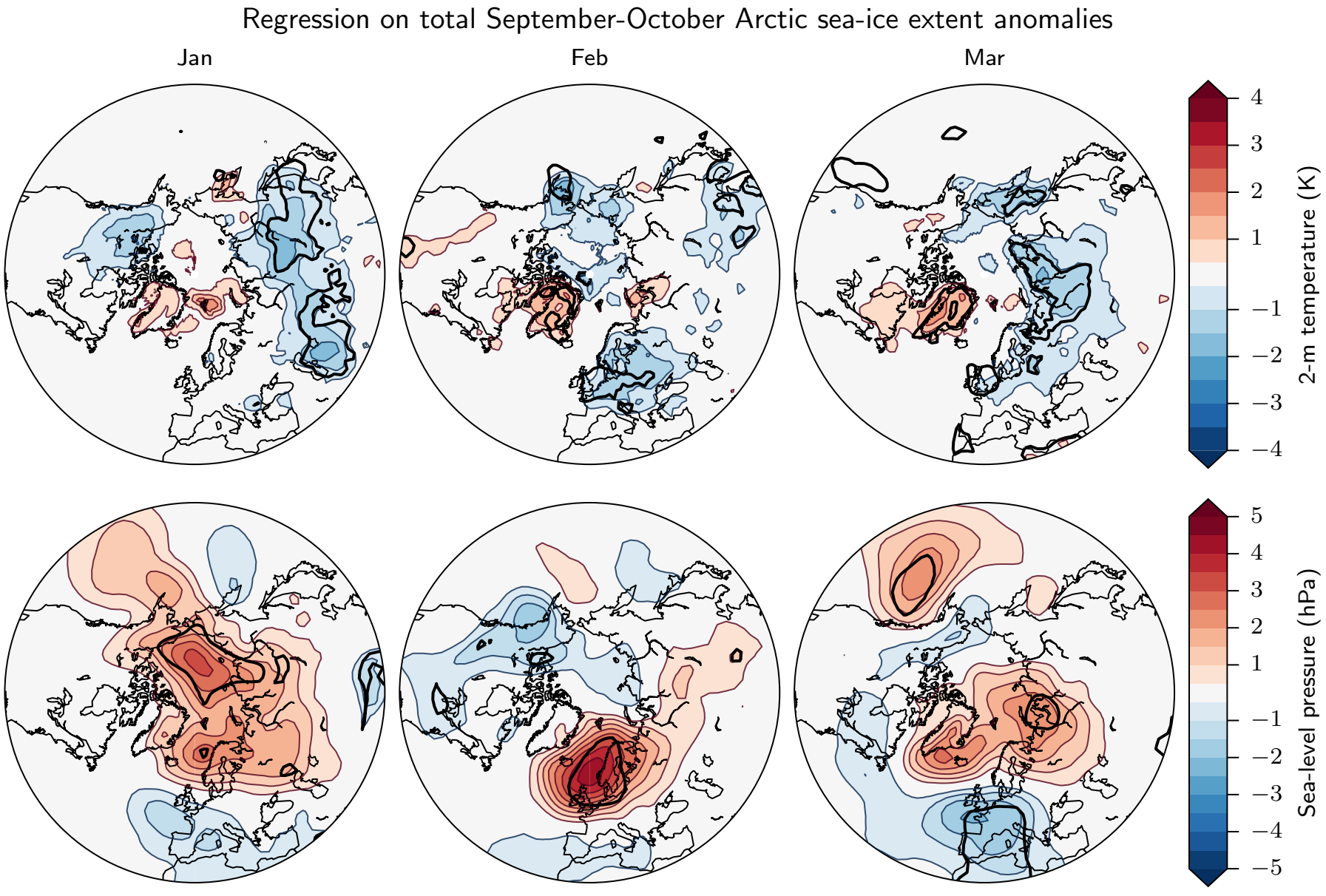
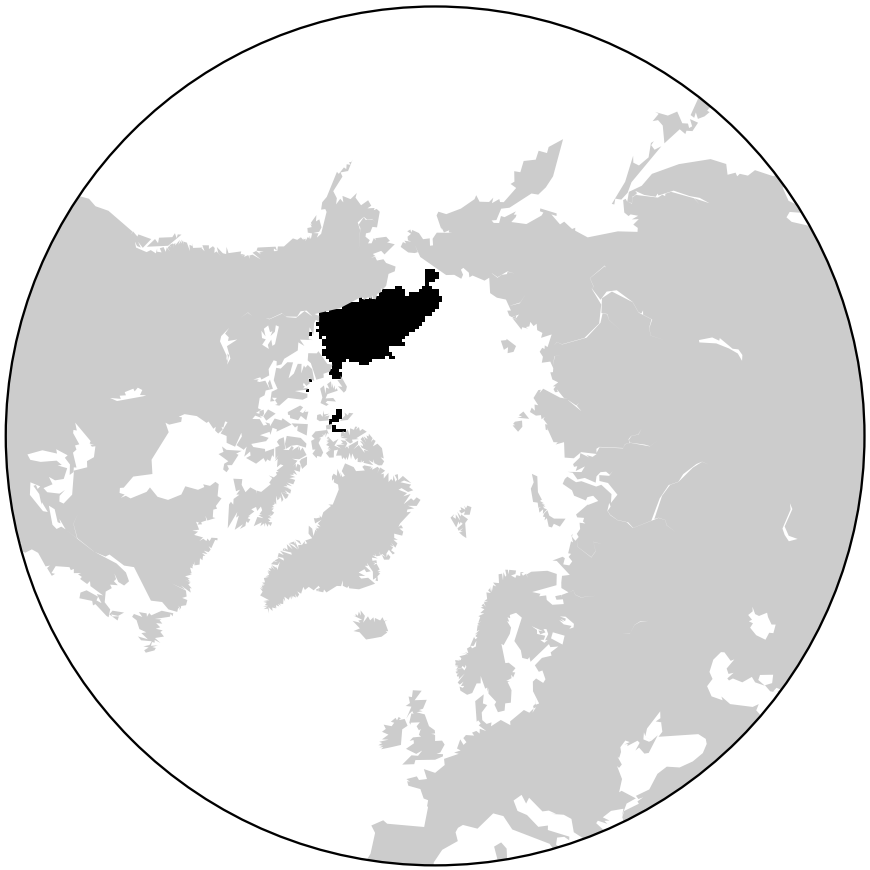
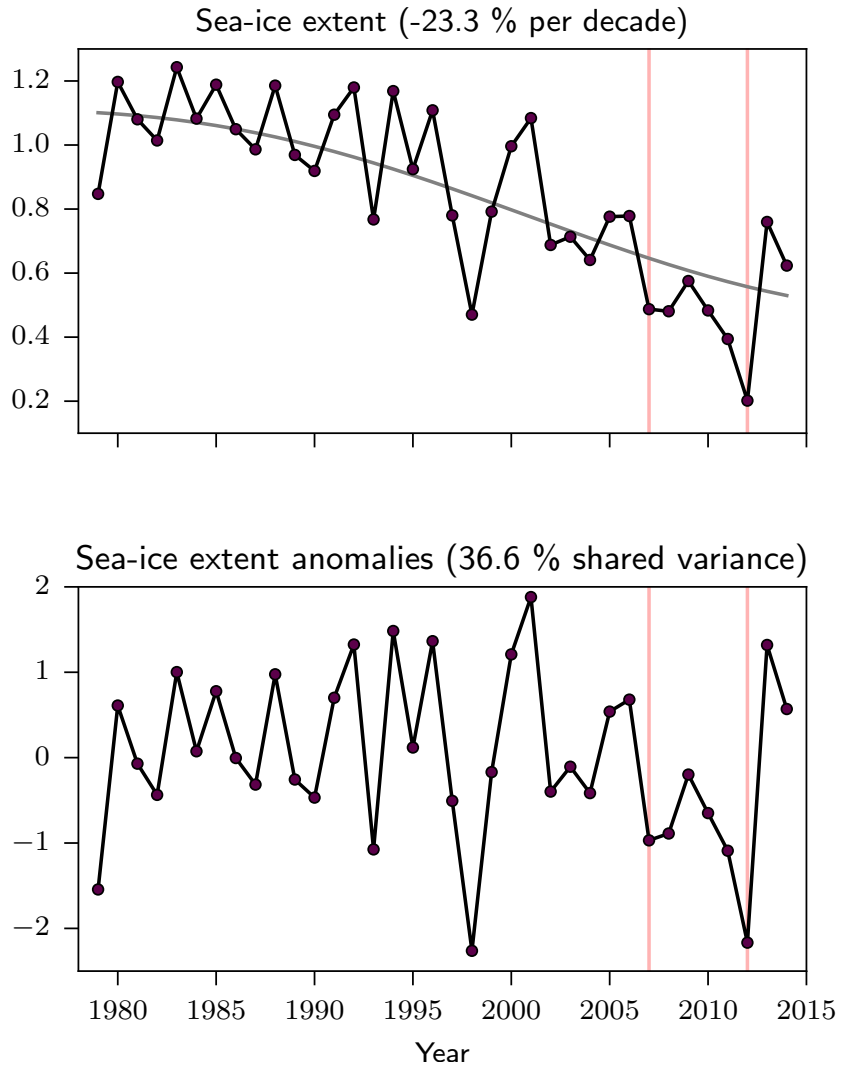
Weather patterns associated with total



A1 region and sea-ice extent variability





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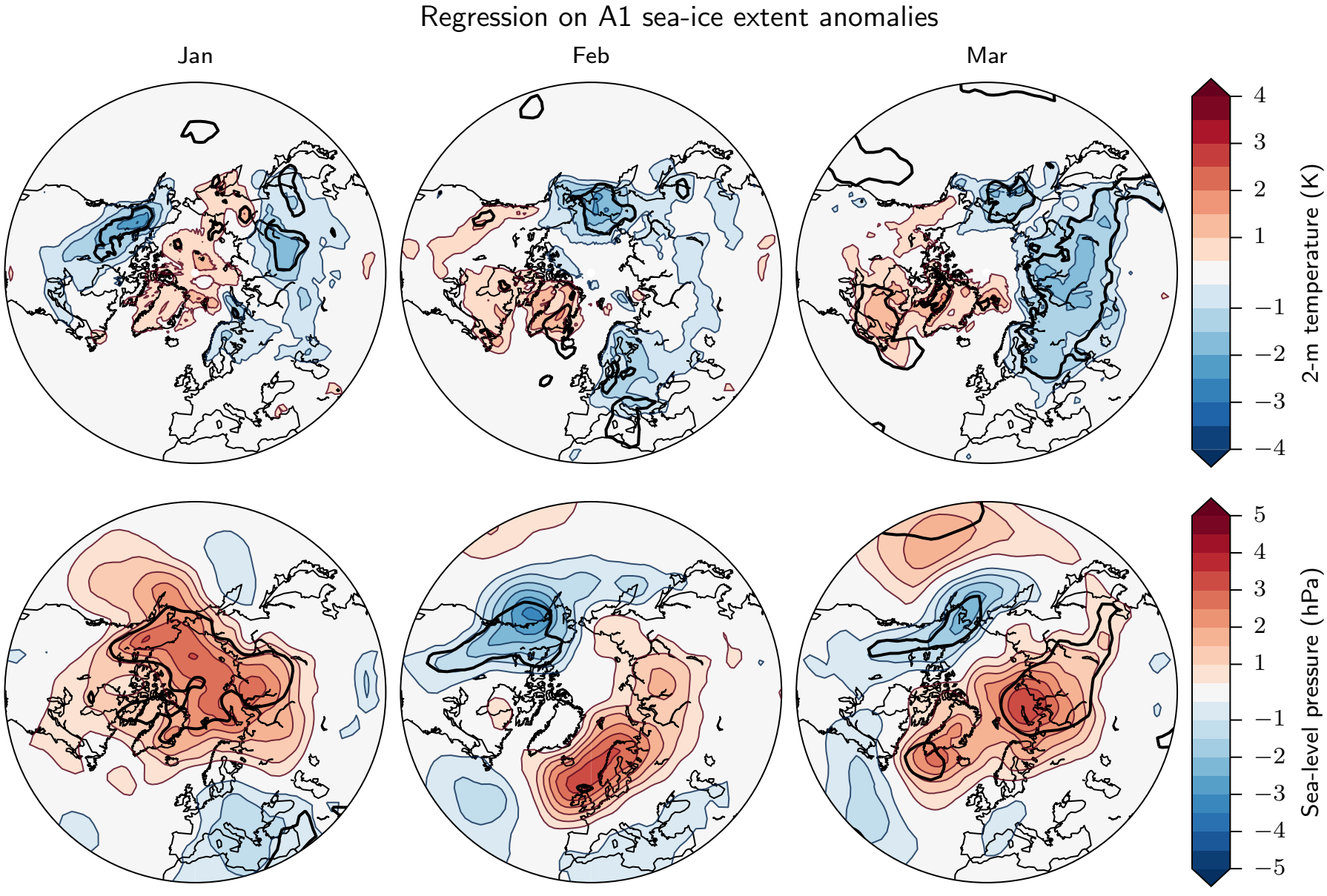
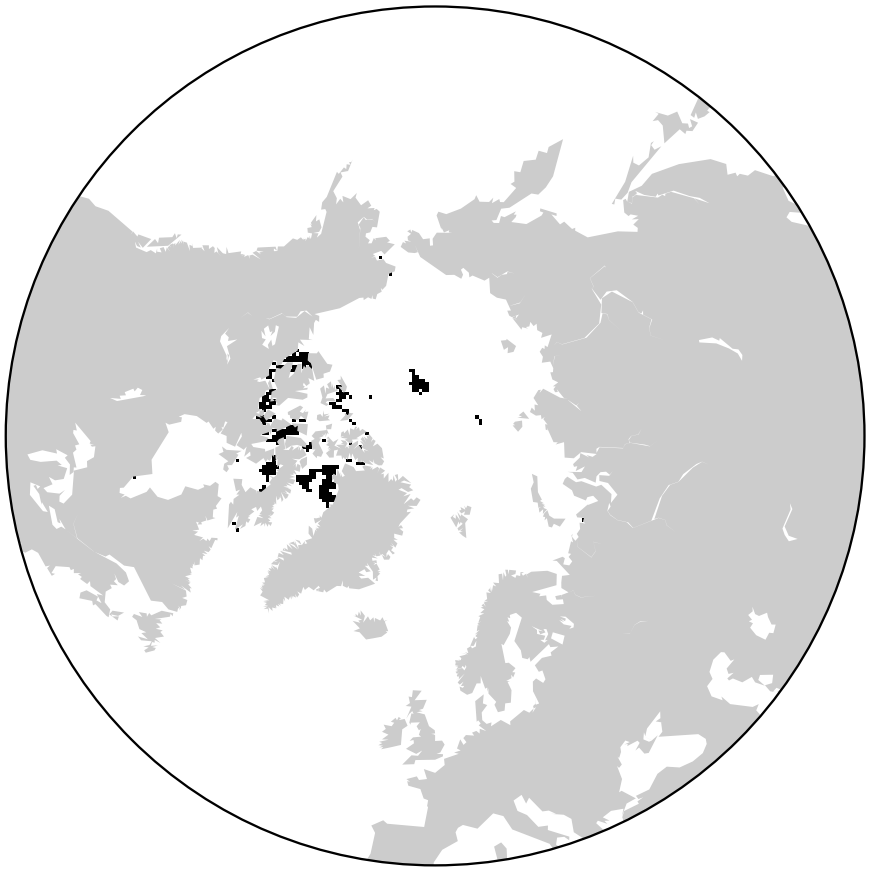
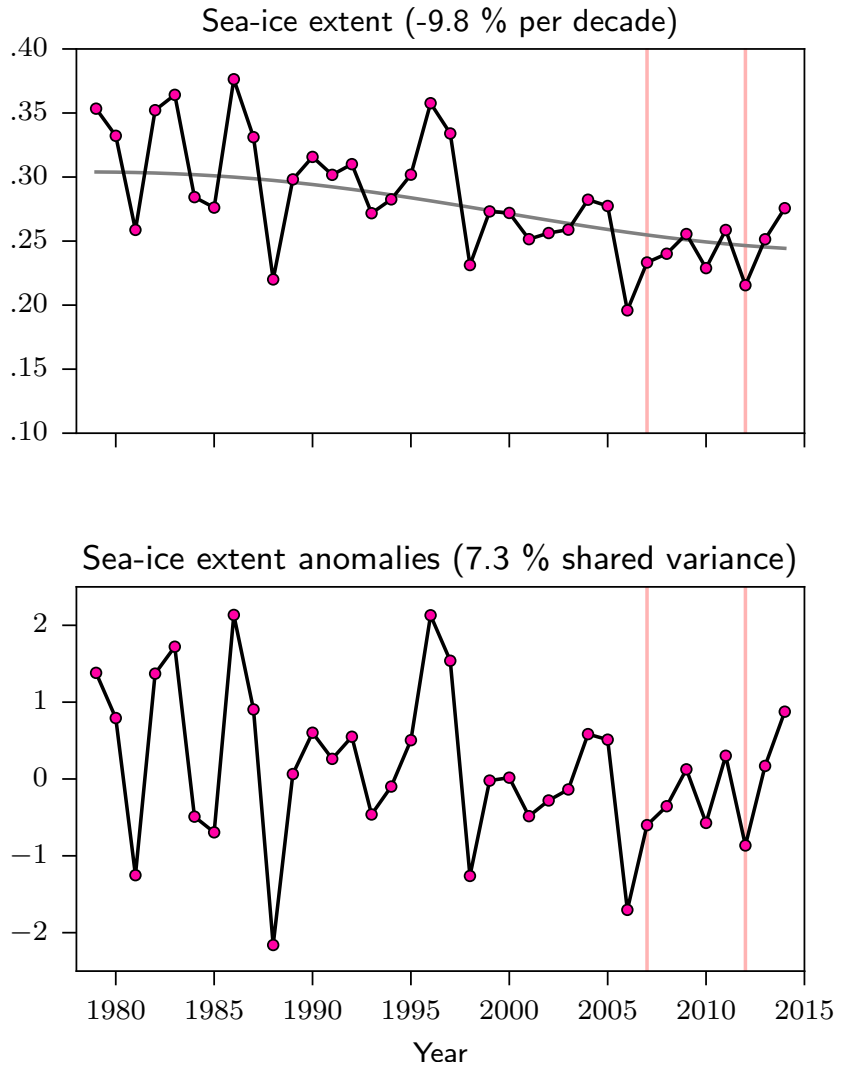


A6 region and sea-ice extent variability





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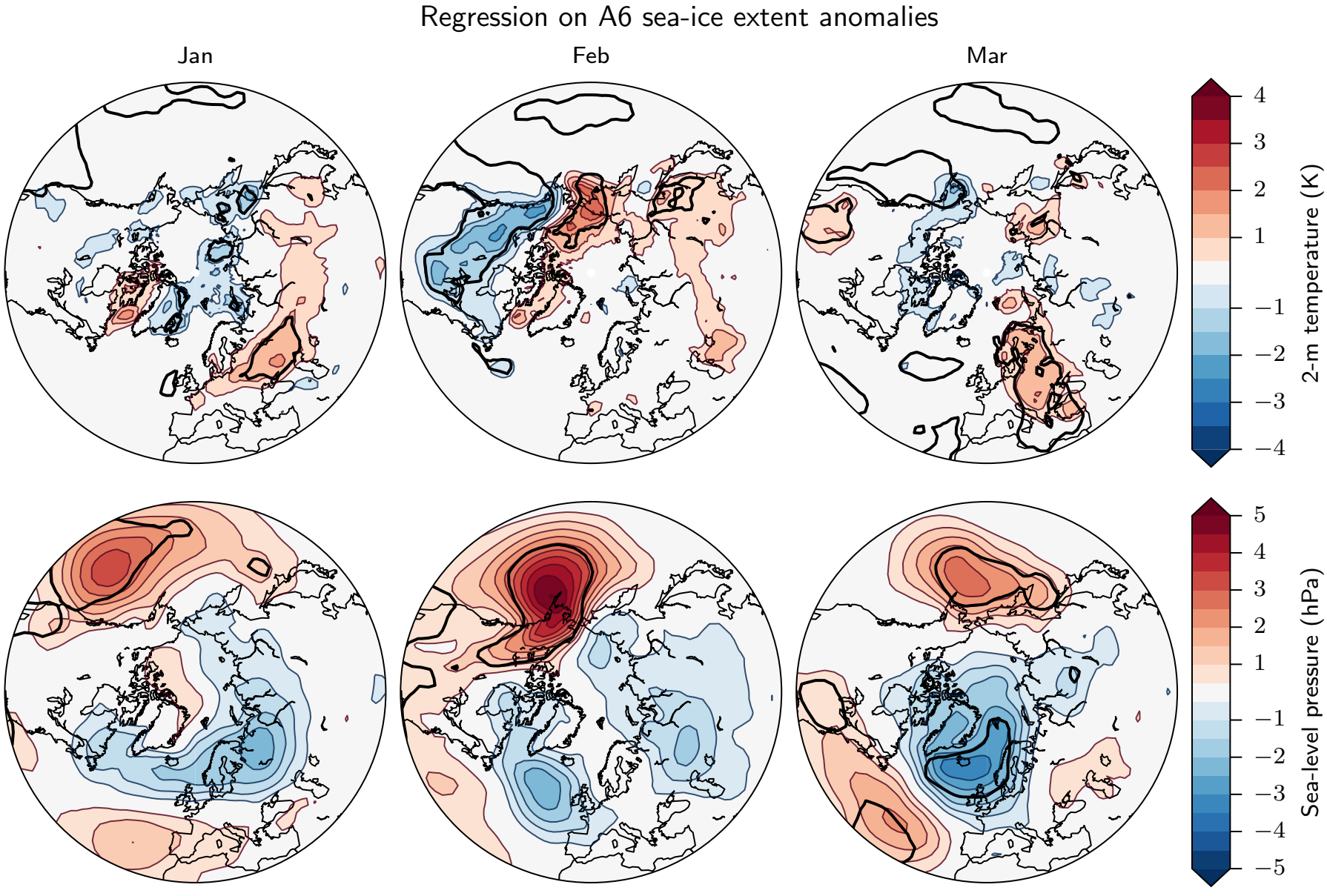
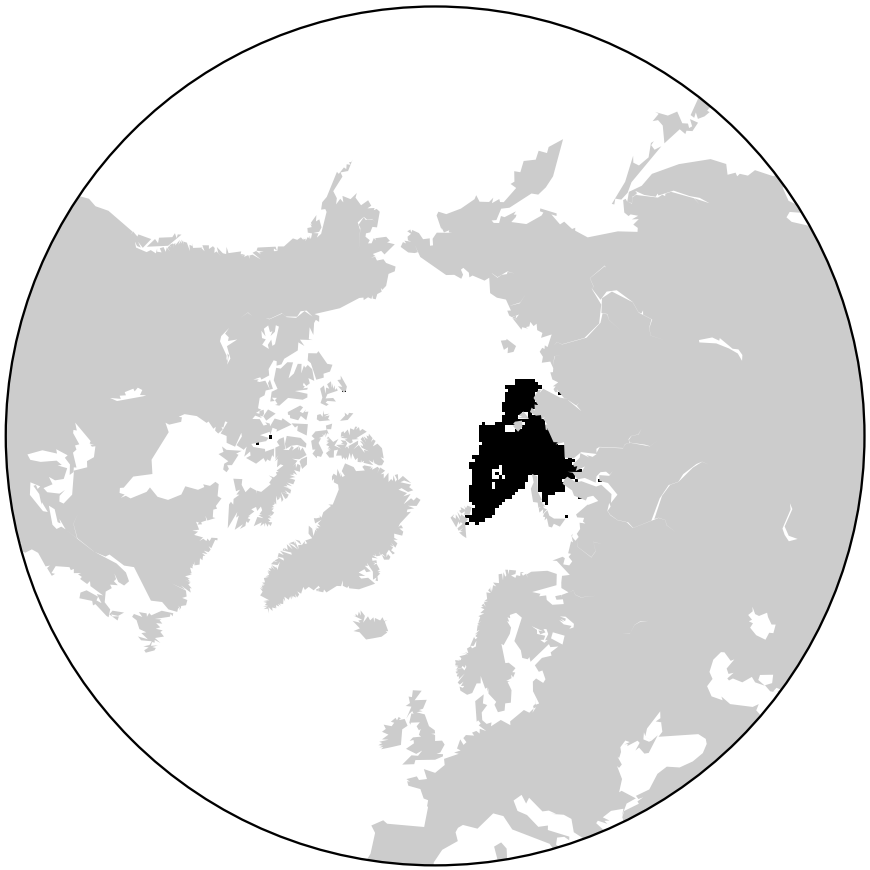
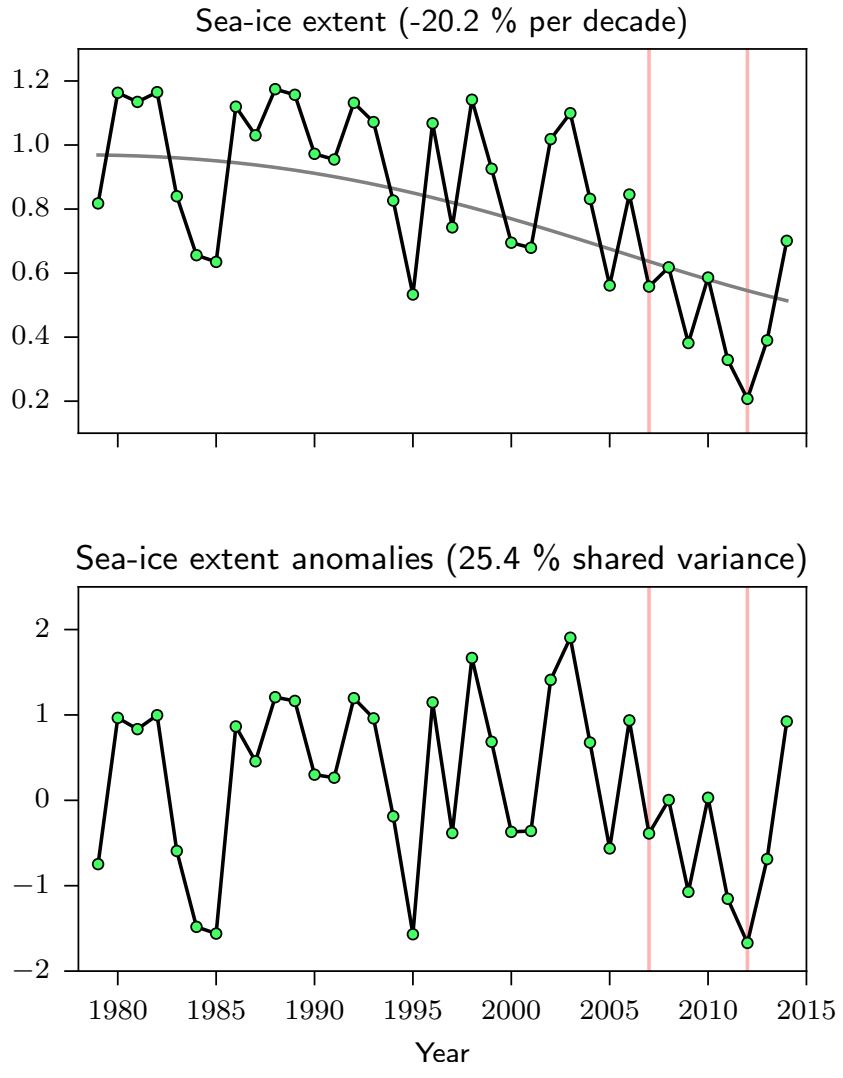


A9 region and sea-ice extent variability





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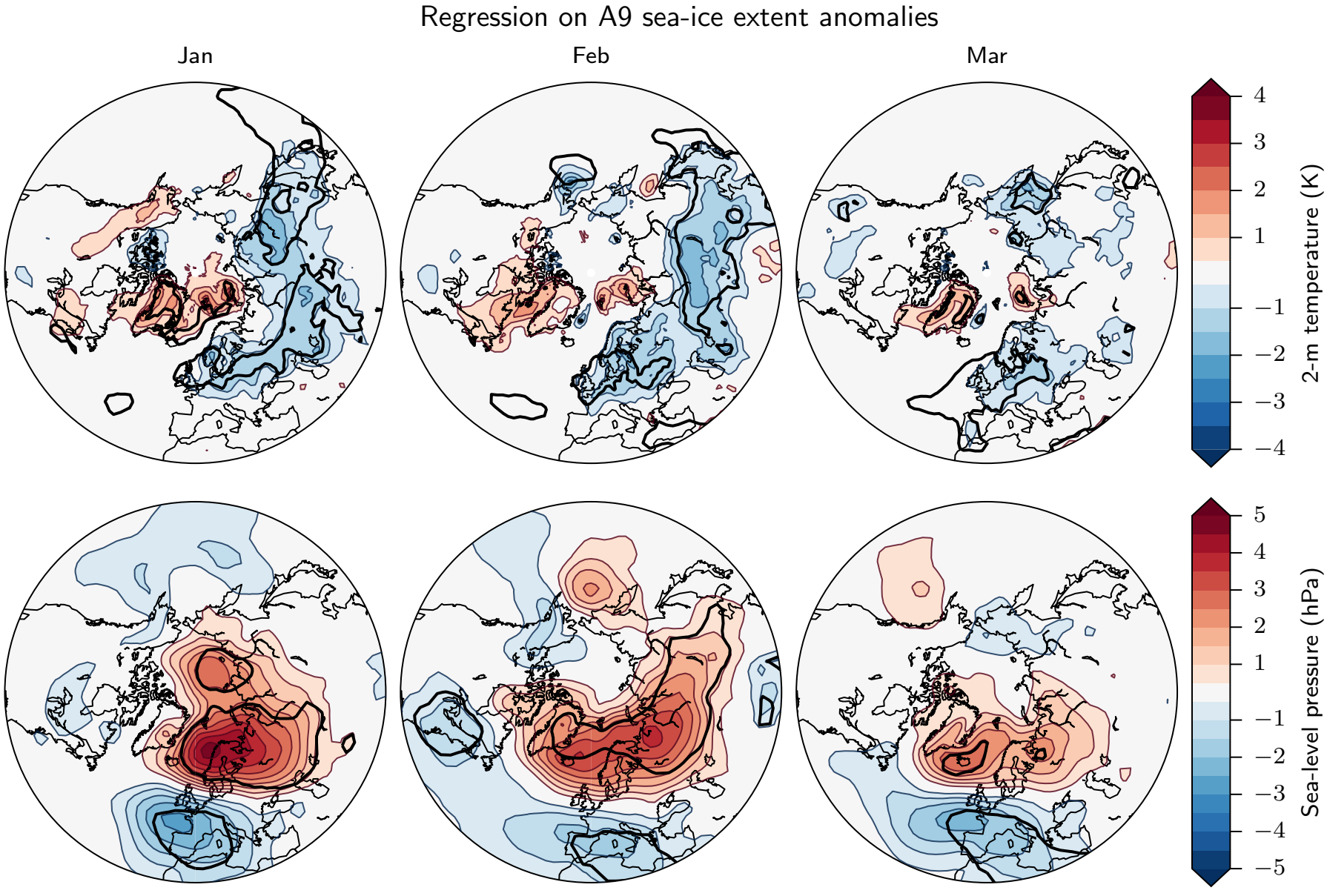
Weather patterns associated with A9



Conclusions

- Arctic sea-ice extent shows clear patterns of regional variations and trends
- The trends in sea-ice extent are largely nonlinear and are well described by EEMD analysis
- Sea-ice extent variability in different regions are associated with distinct atmospheric patterns in winter

Take home message

Just like global warming, the total Arctic sea-ice extent tells an important story, but the regional variations are also important to consider.

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Extra material

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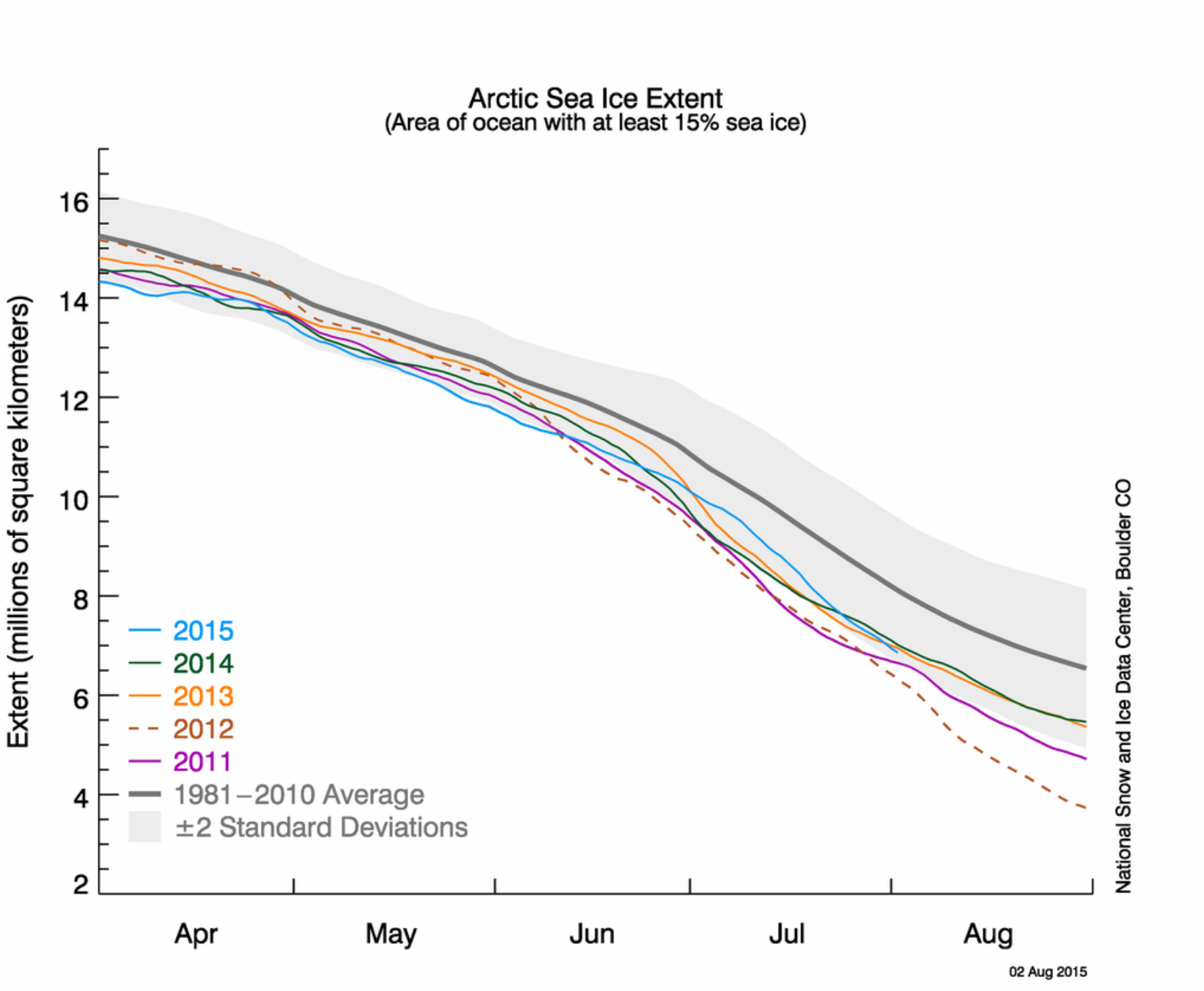
Correlation between regions

	Tot	A1	A2	A3	A4	A5	A6	A7	A8
A1	**0.60**								
A2	**0.51**	**0.51**							
A3	**0.59**	0.28	**0.41**						
A4	**0.66**	0.27	0.26	**0.50**					
A5	**0.38**	**0.46**	0.15	-0.00	0.09				
A6	0.27	0.12	**0.52**	0.13	0.17	**0.37**			
A7	-0.08	-0.02	**-0.37**	-0.32	**-0.39**	**0.35**	-0.13		
A8	0.02	-0.14	-0.19	0.01	-0.07	**0.40**	**0.45**	0.03	
A9	**0.50**	0.03	0.22	0.11	0.08	-0.09	-0.03	0.06	-0.17


Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
16
14
12
10
8
6
4
2
2015
2014
2013
2012
2011
1981–2010 Average
±2 Standard Deviations
Apr
May
Jun
Jul
Aug
National Snow and Ice Data Center, Boulder CO
02 Aug 2015