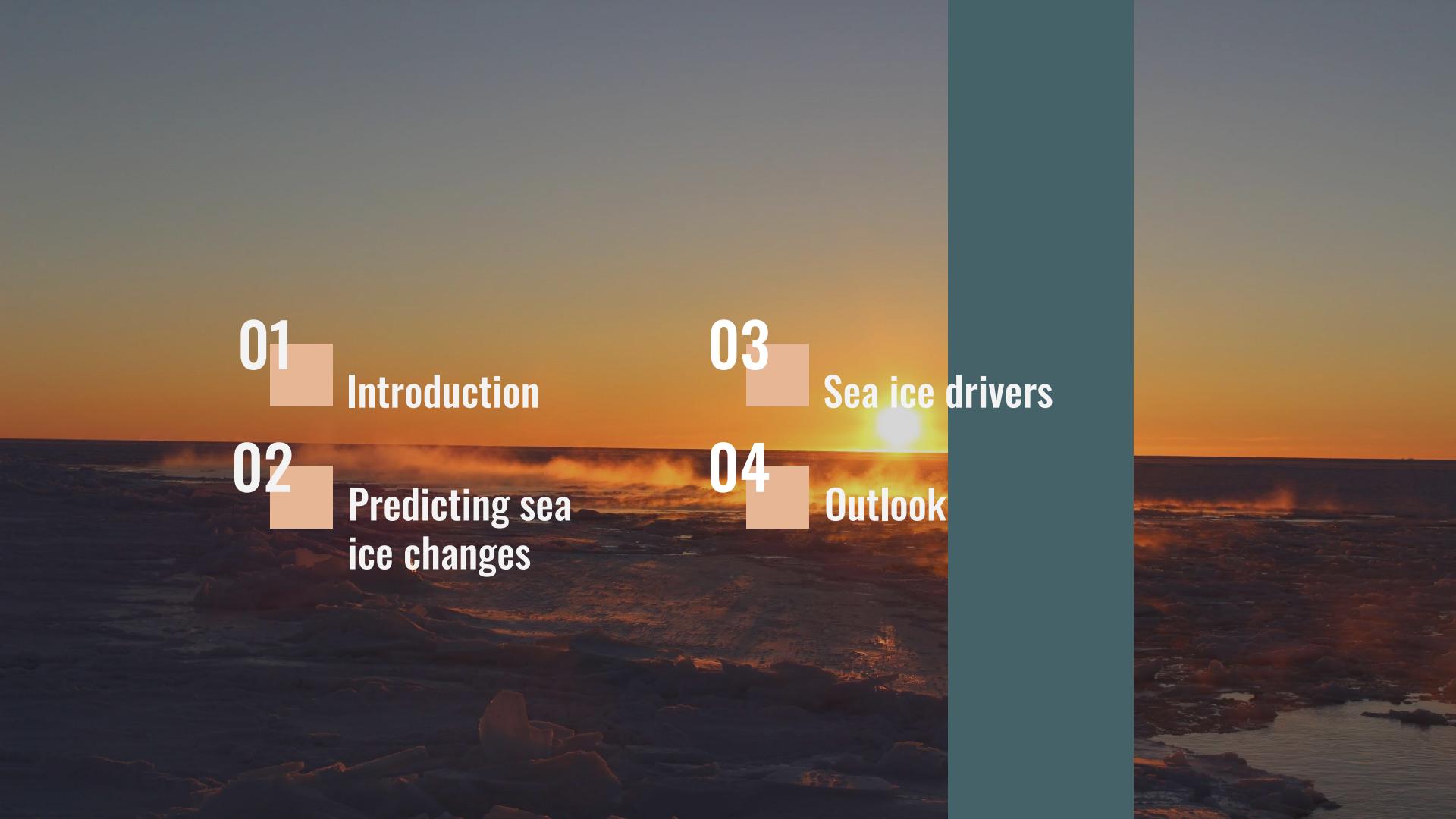


Predicting sea ice extent

Can we beat complex climate models



The background image shows a vast expanse of sea ice at sunset. The sky is a warm orange and yellow, transitioning to a darker blue at the top. The horizon is flat, and the ice floes are scattered across the water, reflecting the light.

01 Introduction

02 Predicting sea ice changes

03 Sea ice drivers

04 Outlook

Sea ice extent

Area up to the outer margin of the ice edge

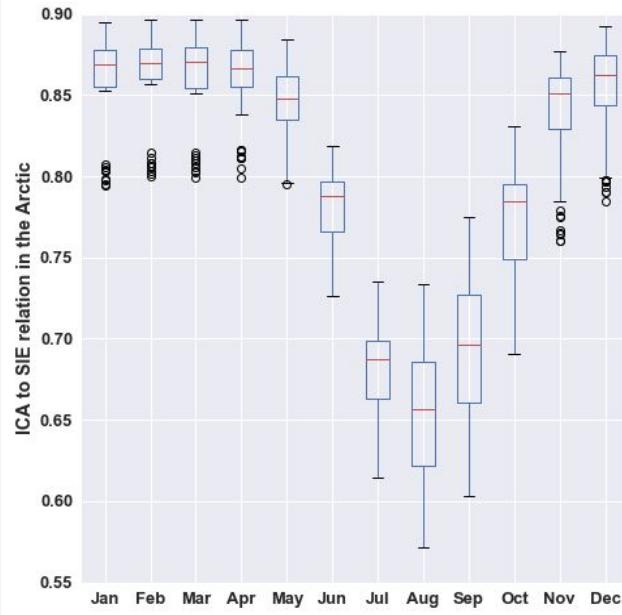


Ice covered area

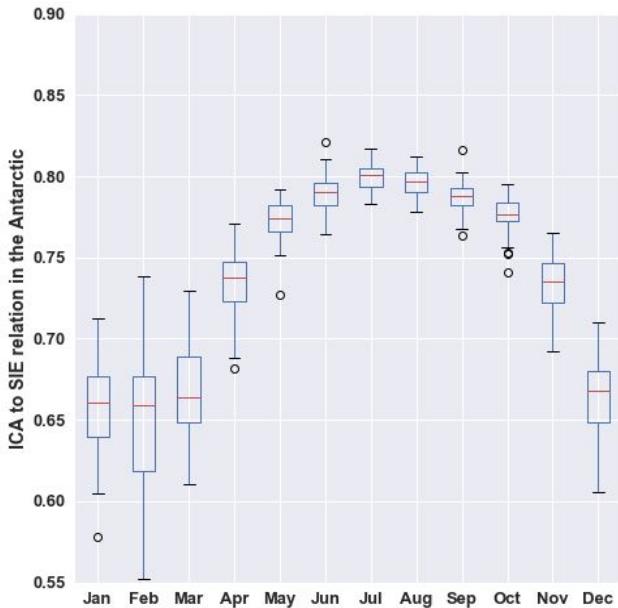
Actual area which is covered by ice



Arctic



Antarctic



Ratios are the lowest in summer and the highest in winter



During summer, variations are higher than in winter

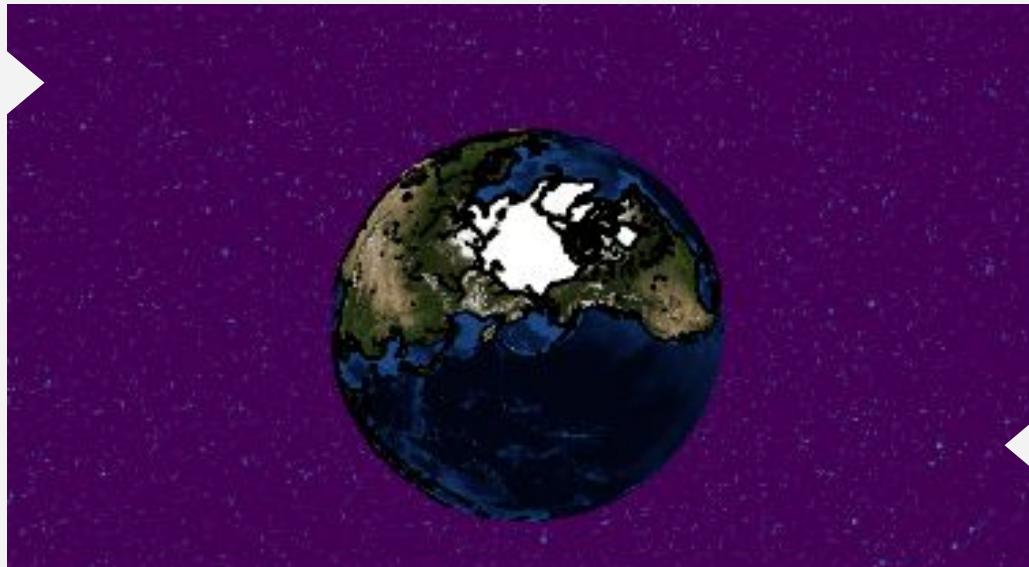


Arctic winter SIE and ICA show higher ratios

Arctic and Antarctic sea ice

Arctic

An ocean
surrounded by
land masses



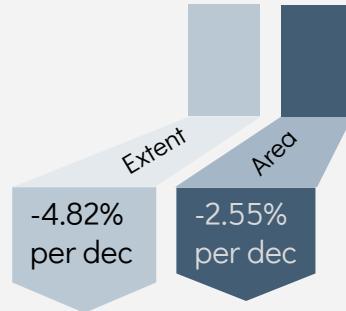
Antarctic

A continent
surrounded by
ocean

Sea ice follows a distinct seasonal cycle and shows a trend over time:

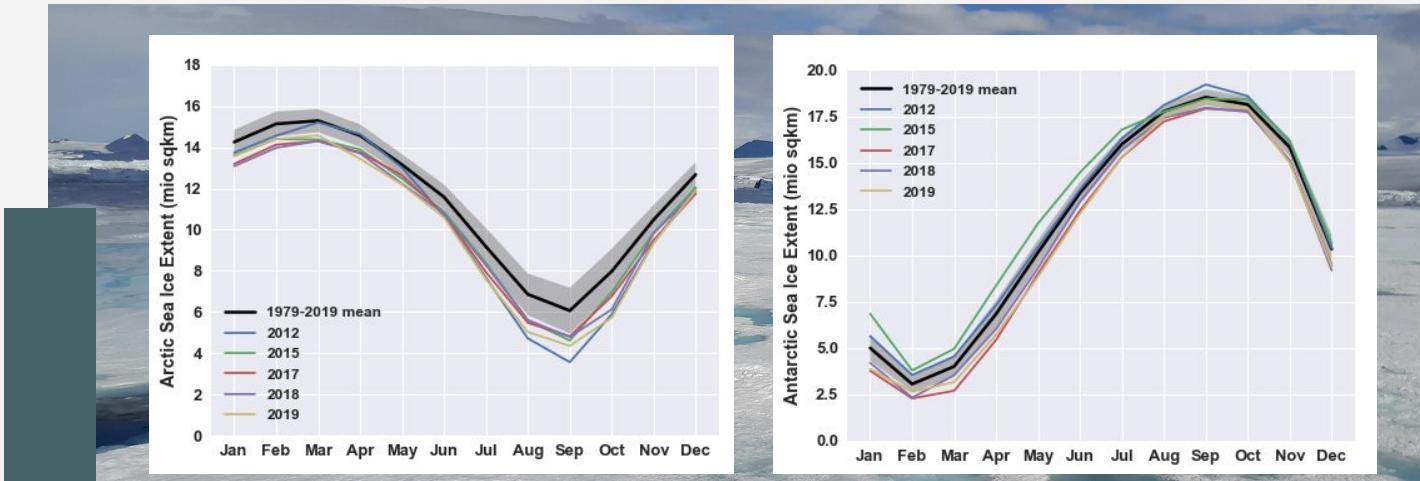
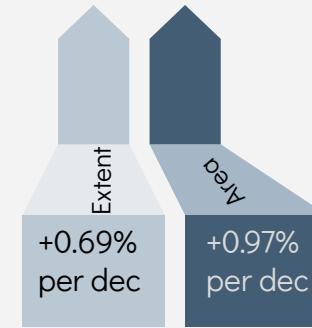
Arctic

Sea ice extent and ice covered area decrease



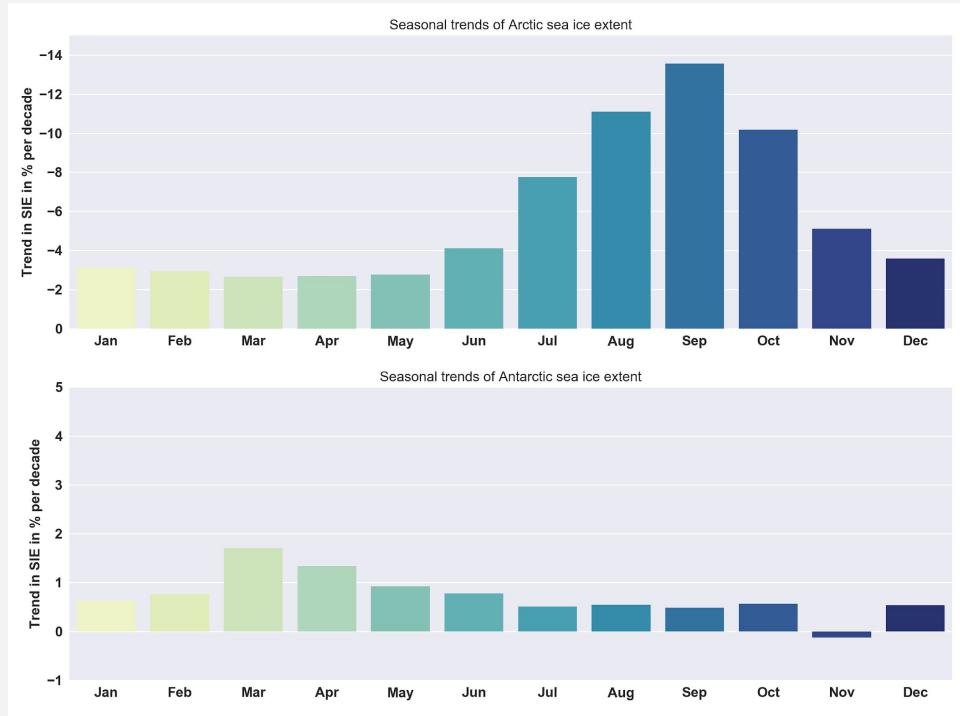
Antarctic

Sea ice extent and ice covered area increase





Do trends show a seasonal pattern?



Seasonal trends



Naive Model

The prediction has the same value as the one of the previous year.



Exponential Smoothing

Holt-Winters approach



Naive with drift

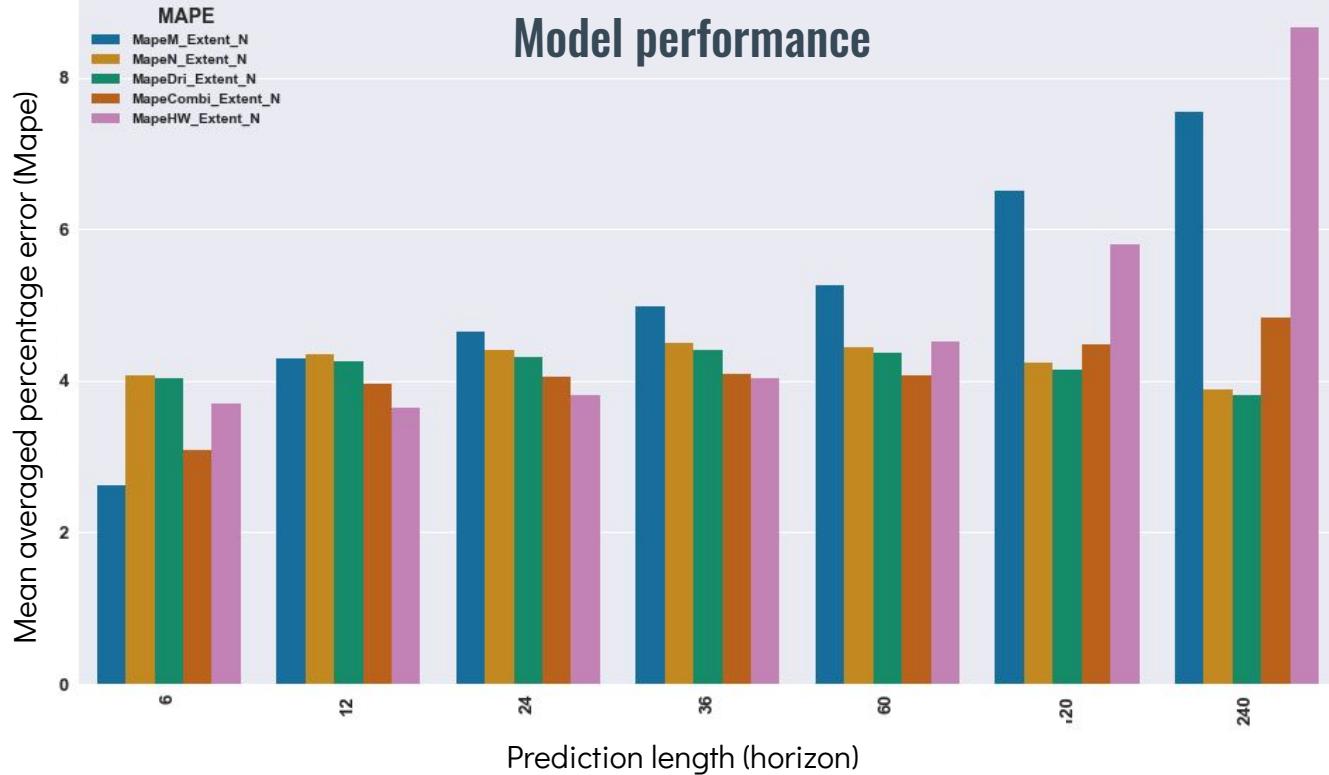
Like naive model but additionally considering a linear temporal trend.



ARIMA class

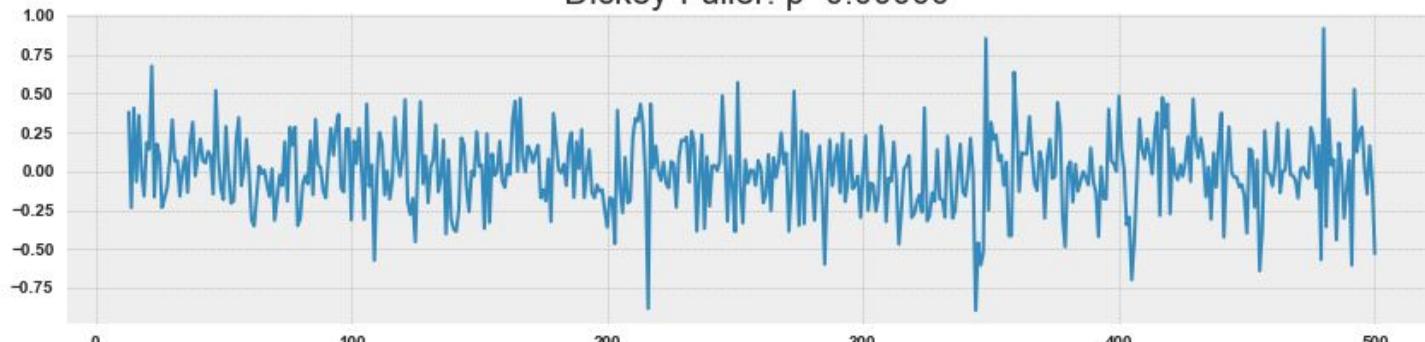
AutoRegressive Integrated Moving Average model (including seasonality).

Model performance

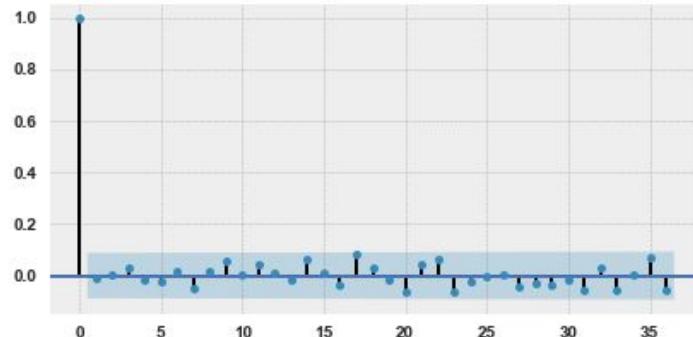


Arctic Sea ice extent: errors for best fit

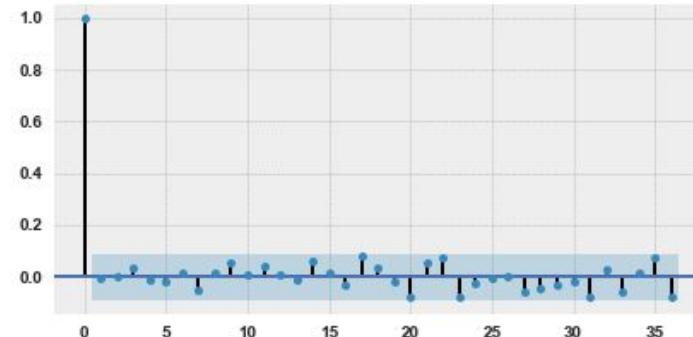
Time Series Analysis Plots
Dickey-Fuller: p=0.00000



Autocorrelation



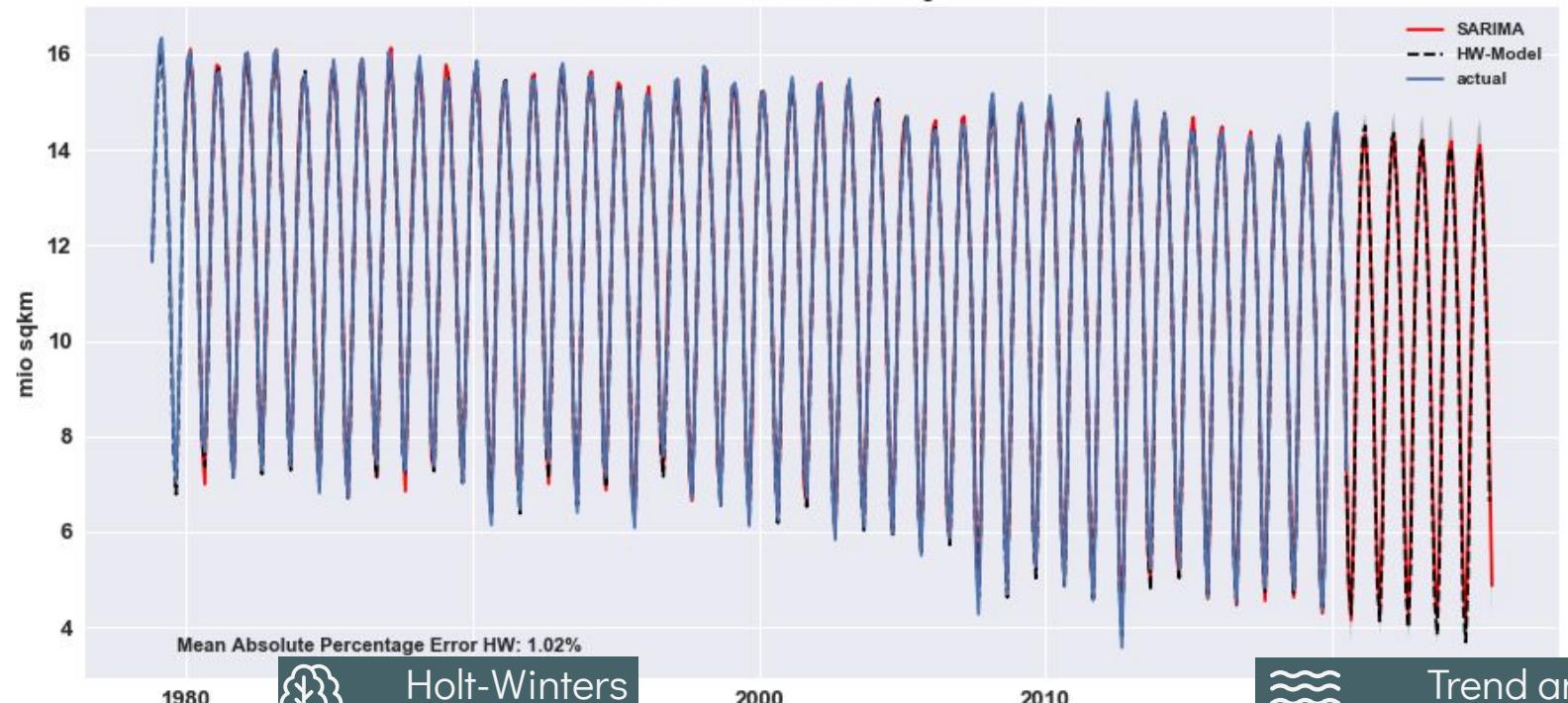
Partial Autocorrelation





Model fit close
to observed
data

Arctic SIE Mean Absolute Percentage Error: 1.95%



Sea ice prediction

11



Holt-Winters
mostly lower
than SARIMA

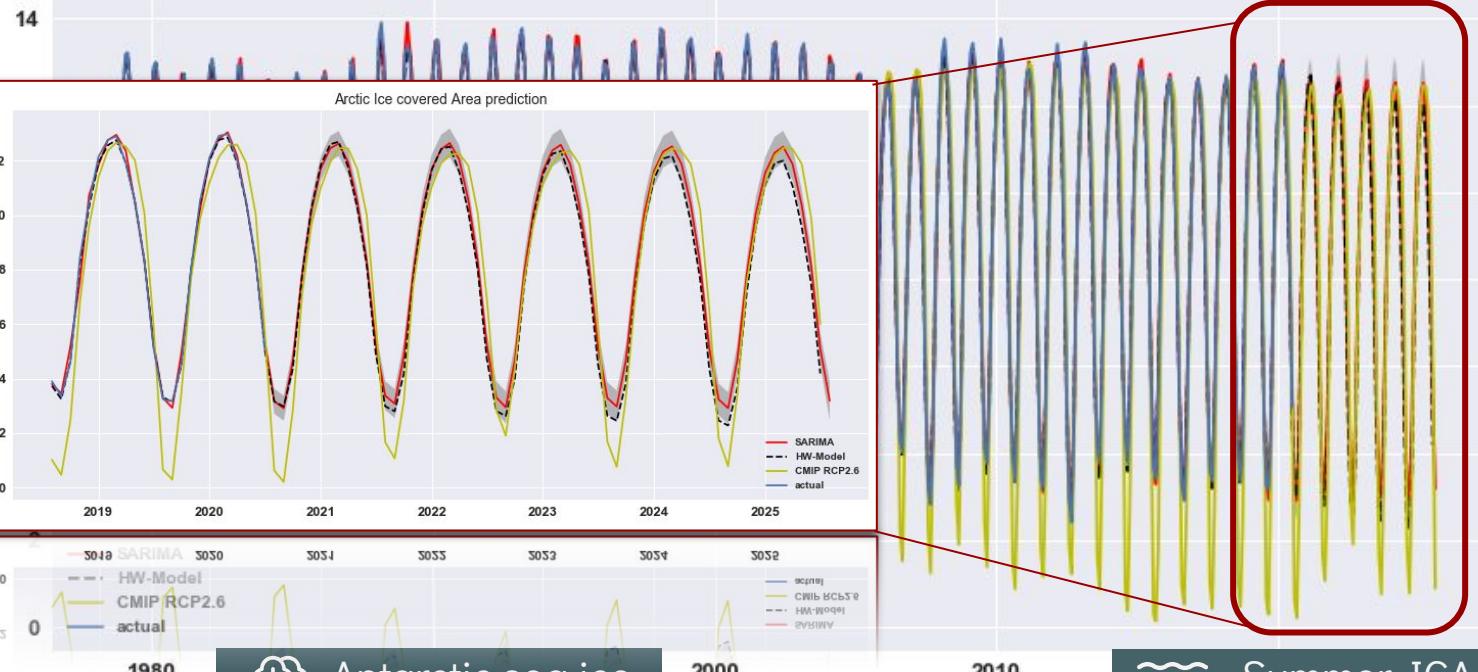


Trend and
seasonal cycle
kept with models



CMIP5 winter ICA close to obs and other models

Arctic Ice covered Area Mean Absolute Percentage Error: 2.45%



Antarctic sea ice
for all models
more difficult



Summer ICA better
represented in ML
models

General atmospheric patterns

like Arctic/Antarctic oscillation Index,
North Atlantic oscillation a.o.

Wind speed

Are speeds or directions important?

Regional air temperatures

Is it important to consider whole Arctic/Antarctic temperatures or those at the marginal ice zone only



Global atmospheric carbon dioxide

measured on Hawaii, influencing global temperature

Global temperatures

Land only and Land-and-Ocean



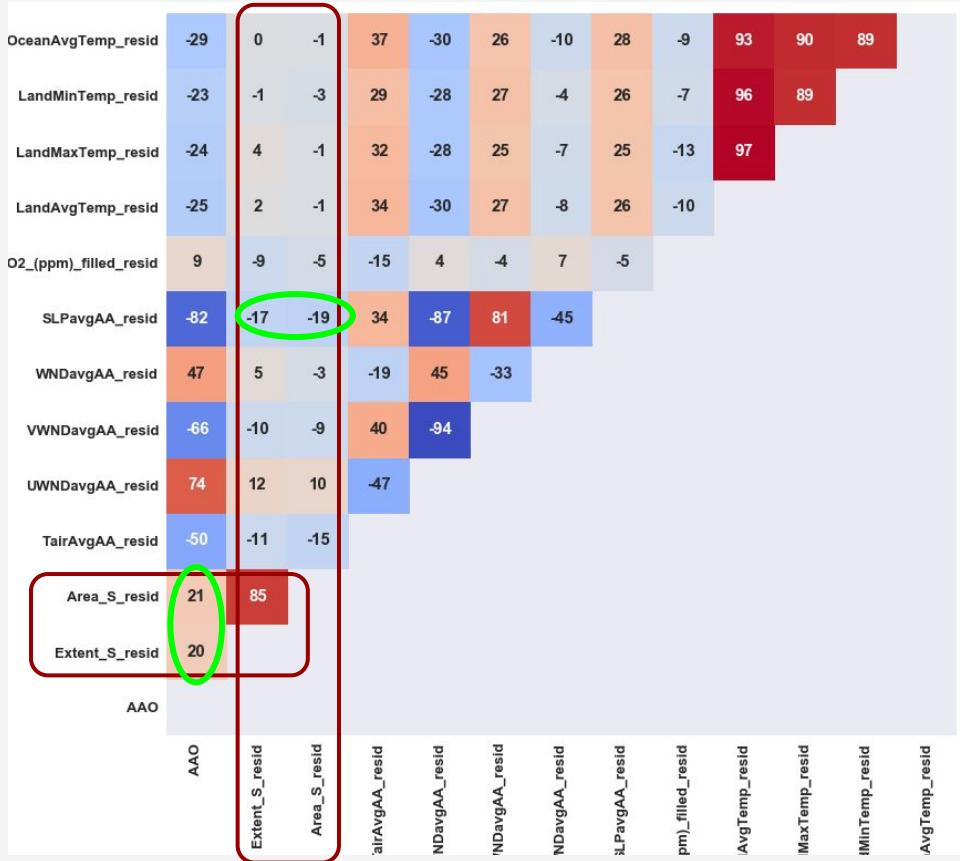
Main drivers of sea ice variability: Arctic

	AOI	NAO	PNA	SCAND	AOI	Extent_N_resid	Area_N_resid	TairAvgA_resid	SLPavgA_resid	WNDavgA_resid	WNDavgA_resid	SLPavgA_resid	pm1_filled_resid	AvgTemp_resid	MaxTemp_resid	MinTemp_resid	AvgTemp_resid
OceanAvgTemp_resid	13	-6	10	-22	-6	-6	7	-1	-5	12	-26	-9	93	90	89		
LandMinTemp_resid	17	-2	9	-24	-1	-3	13	1	-4	19	-28	-7	96	89			
LandMaxTemp_resid	12	-7	9	-23	1	1	3	-2	-7	11	-24	-13	97				
LandAvgTemp_resid	15	-5	9	-25	1	-0	6	-1	-6	14	-27	-10					
O2_(ppm)_filled_resid	1	-3	-1	-0	9	13	2	-1	-2	-6	1						
SLPavgA_resid	-79	-43	5	18	-6	-6	0	-77	-77	-25							
WNDavgA_resid	25	21	12	-21	2	0	23	10	8								
VWNDavgA_resid	59	37	-16	3	8	4	2	98									
UWNDavgA_resid	61	38	-17	-3	10	8	1										
TairAvgA_resid	-3	4	14	-10	-25	-30											
Area_N_resid	11	4	-15	-11	90												
Extent_N_resid	8	0	-16	-9													
SCAND	-30	-3	2														
PNA	-24	4															
NAO	61																
AOI																	

Which are the main drivers?



Main drivers of sea ice variability: Antarctic



Which are the main drivers?

Take home messages

Hemispheric bi-pol

Sea ice extent and area:

- Arctic 
- Antarctic 

Strongest trends occur in summer months



Predictions

SARIMAX: 6 months

Holt-Winters: >6 months

SARIMAX-Naive models
Combi: best choice > 6 months

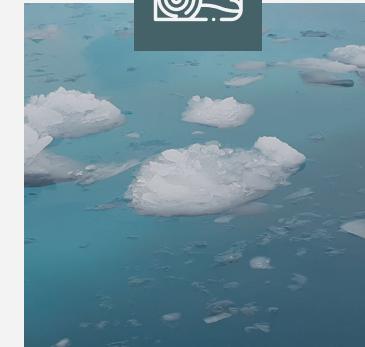


Main drivers

Air temperature

SLP

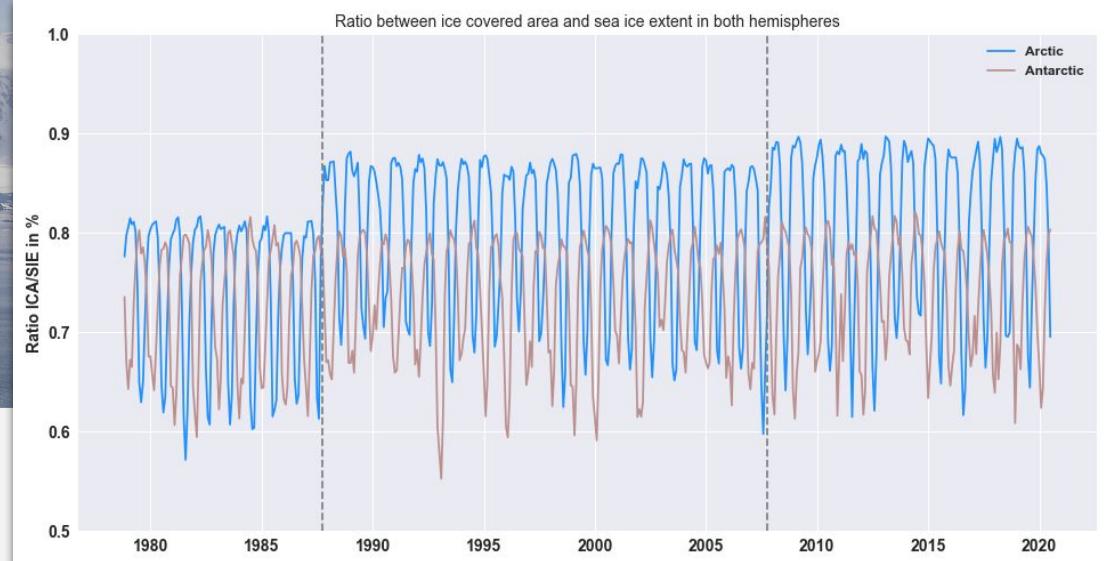
Climate indices



Outlook



More data cleaning: study possible inconsistencies in the data





Outlook



More data cleaning: study possible inconsistencies in the data



Prediction of sea ice using Neural Networks approach



Consider exogen variables for more precise prediction



Predict sea ice extent for subregions in the Arctic



Increase regional investigation by predicting sea ice concentration



THANKS!

Does anyone have any questions?

Sandra.Schwegmann@gmx.net

www.linkedin.com/in/sandra-schwegmann-36414596

<https://orcid.org/0000-0002-3102-7279>

<https://github.com/skrutzky>

THANKS!

CREDITS



- ◀ Presentation template by [Slidesgo](#)
- ◀ Icons by [Flaticon](#)
- ◀ Infographics by [Freepik](#)
- ◀ The space image has been provided by [Pixaby](#)
- ◀ I acknowledge the World Climate Research Programme's Working Group on Coupled Modelling, which is responsible for CMIP, and we thank the climate modeling groups for producing and making available their model output.