Relating regional Arctic Sea-Ice and climate extremes over Europe

M. Ionita[1,2] (Monica.Ionita@awi.de), K. Grosfeld[1] , G. Lohmann[1,2] and P. Scholz[1]

[1] Alfred Wegener Institute, Helmholtz Center for polar and marine research, Bremerhaven, Germany

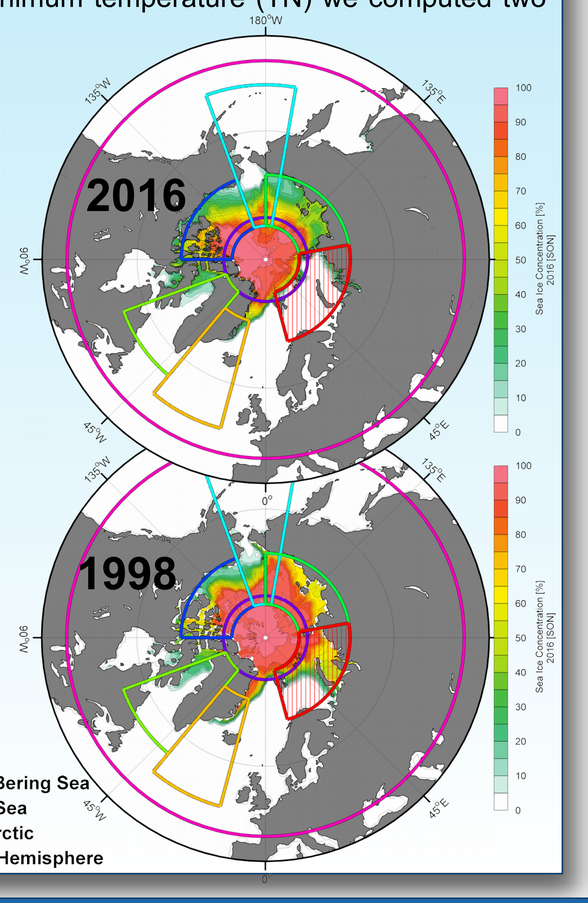
[2] Marum, Bremen University, Bremen, Germany

Introduction

The potential increase of temperature extremes under climate change is a major threat to society, as temperature extremes have a deep impact on environment, hydrology, agriculture, society and economy. Hence, the analysis of the mechanisms underlying their occurrence, including their relationships with the large-scale atmospheric circulation and sea ice concentration, is of major importance. At the same time, the decline in Arctic sea ice cover during the last 30 years has been widely documented and it is clear that this change is having profound impacts at regional as well as planetary scale. As such, this study aims to investigate the relation between the autumn regional sea ice concentration variability and cold winters in Europe, as identified by the numbers of cold days (TX10p) and ice days (ID). We analyze the relationship between Arctic sea ice variation in autumn (September-October-November) averaged over eight different Arctic regions (Barents/Kara Seas, Beaufort Sea, Chukchi/Bering Seas, Central Arctic, Greenland Sea, Labrador Sea/Baffin Bay, Laptev/East Siberian Seas and Northern Hemisphere) and variations in atmospheric circulation and climate extreme indices in the following winter months (December, January, February and March) over Europe using composite map analysis. We also test the robustness of the relationship between reduced sea ice cover and the occurrence of extreme winter over Europe by employing a robust statistical methodology called "stability maps".

Data

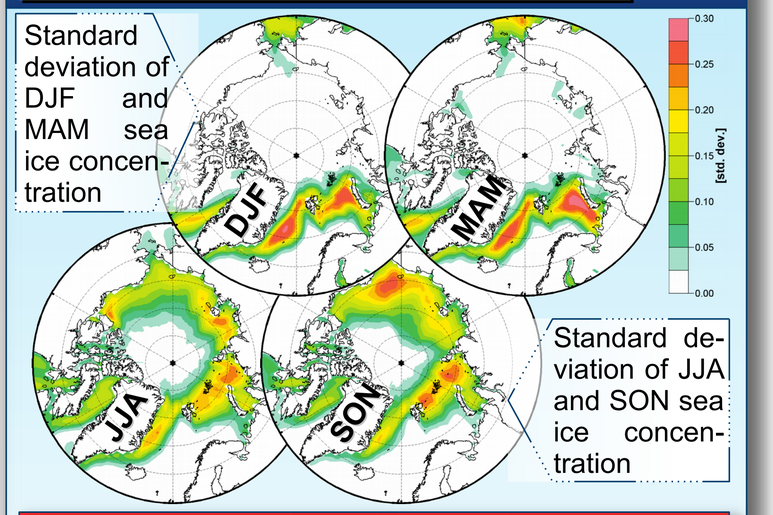
- Daily time series of minimum temperature – E-OBS data set [Haylock et al., 2008]. From the daily minimum temperature (TN) we computed two winter extreme indices:
  - **Cold days (TX10p) - the number of days with T_x < 10th percentile of daily minimum temperature (TX10p) (days)**
  - **Ice days (ID) – the numbers of days when T_n < 0°C (days)**
- Daily and monthly means of sea level pressure, geopotential height, zonal wind and meridional wind from the NCEP/NCAR 40-year reanalysis project (Kalnay et al., 1996) on a 2.5º x 2.5º grid.
- Hadley Centre Sea Ice and Sea Surface Temperature data set (HadISST) (Rayner et al., 2003)



Barents-Kara Sea · Chukchi-Bering Sea · Irminger-Greenland Sea · Beaufort Sea · Labrador Sea · Central Arctic · Laptev-Siberian Sea · Northern Hemisphere

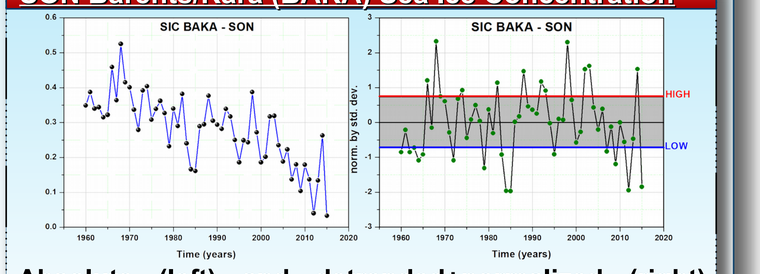
Standard Deviation

Standard deviation of DJF and MAM sea ice concentration



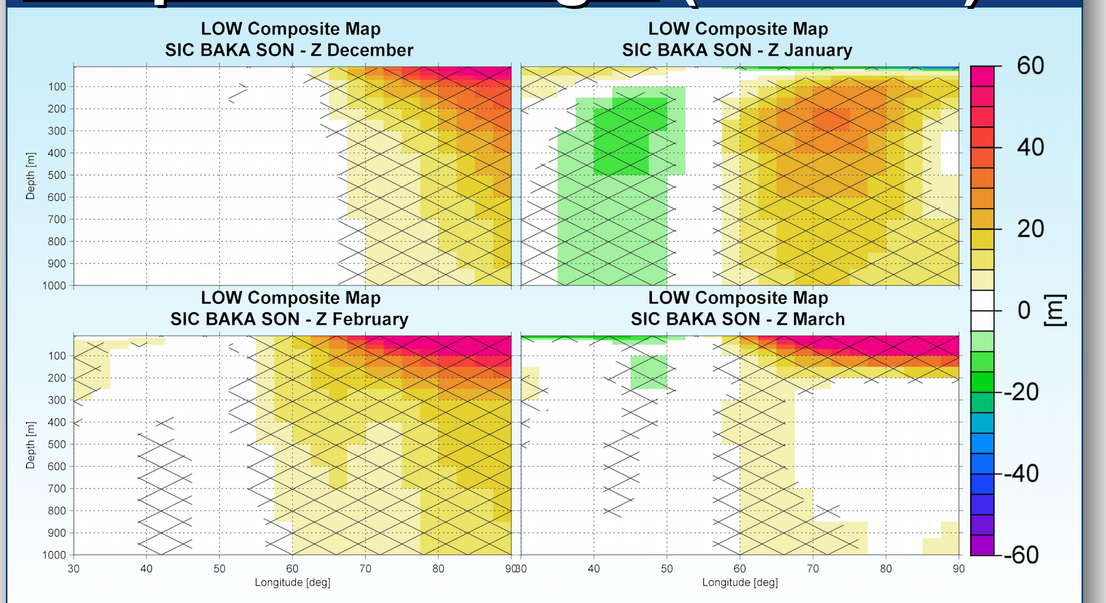
Standard deviation of JJA and SON sea ice concentration

SON Barents/Kara (BAKA) Sea Ice Concentration



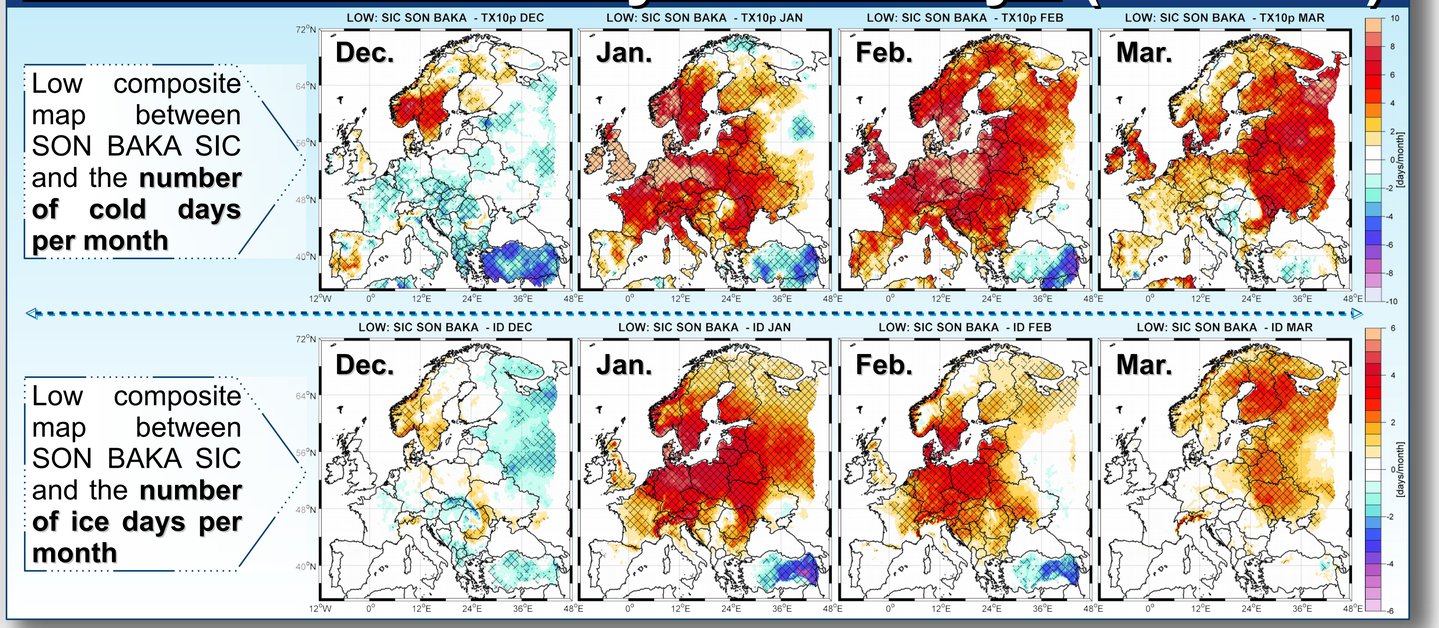
Absolute (left) and detrended+normalized (right) time-series of SON BAKA sea ice concentration (SIC) time-series. Above/below 75% of std. indicated by red/blue line.

Geopotential Height (Low SIC)



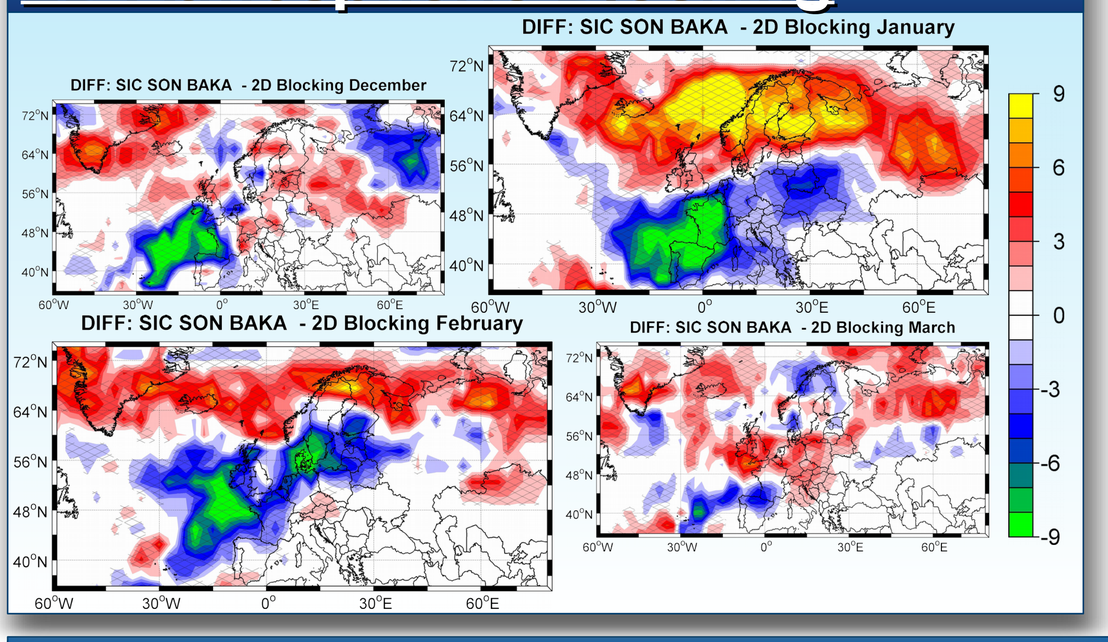
Number of Cold Days & Ice Days (Low SIC)

Low composite map between SON BAKA SIC and the **number of cold days per month**

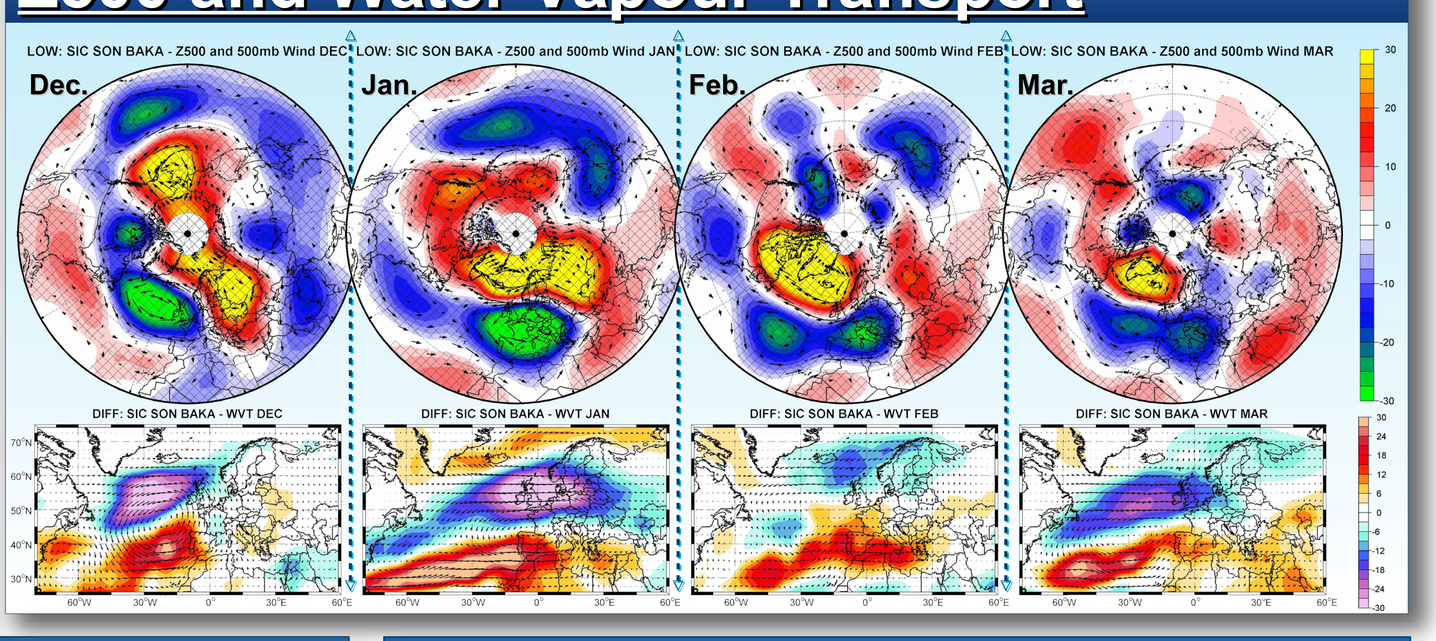


Low composite map between SON BAKA SIC and the **number of ice days per month**

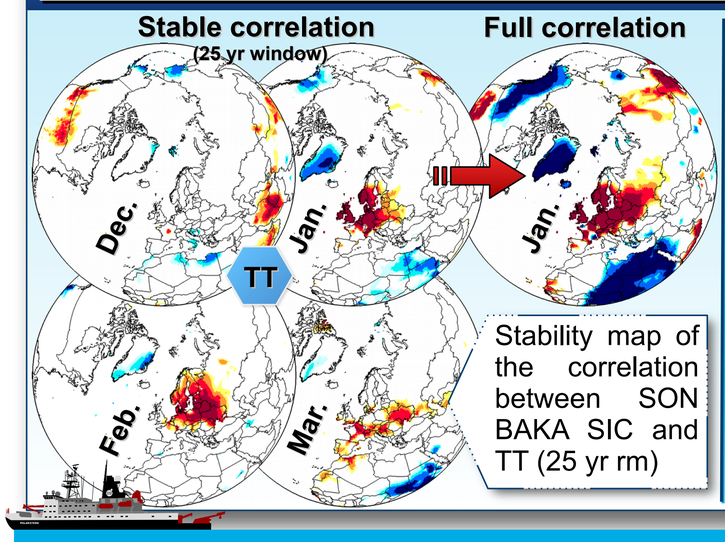
2D Atmospheric Blocking



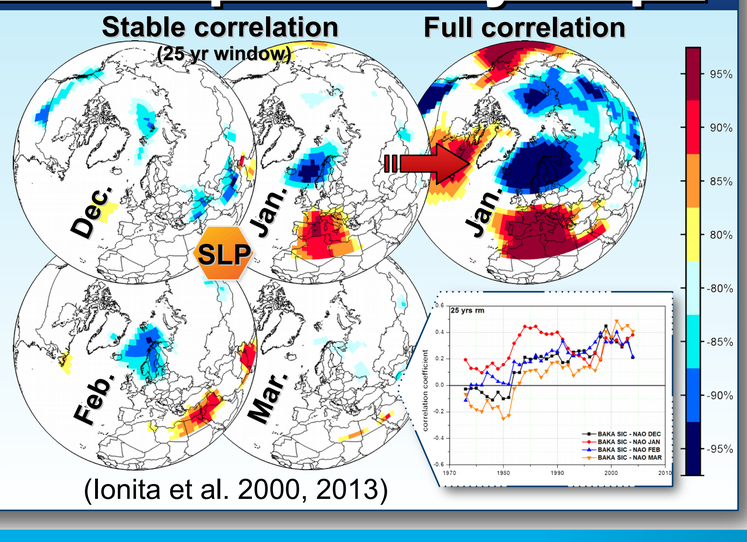
Z500 and Water Vapour Transport



Robustness of the relationship-Stability Maps



Stability map of the correlation between SON BAKA SIC and TT (25 yr rm)



(Ionita et al. 2000, 2013)

Conclusions

- Barents/Kara sea ice cover plays the most important role in the occurrence of extreme (cold/warm) winter months over Europe.
- Reduced sea ice cover over BAKA sea, in autumn, weakens the stratospheric Polar Vortex in January and February.
- The early winter mid-tropospheric response to reduced sea ice cover over BAKA resembles the negative phase of NAO/AO.
- Reduced sea ice cover over BAKA, in autumn, triggers the occurrence of more blocking-like events over the Norwegian Sea and Fennoscandia in January and February.
- A weekend Polar Vortex and the increased occurrence of blocking-like events over the Norwegian Sea and Fennoscandia are associated with an increased frequency of cold and ice days in January and February over Europe.
- The influence of BAKA sea ice cover is restricted, from a statistical point of view, to Europe and Greenland.

References

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REKLIM Helmholtz-Verbund Regionale Klimaänderungen

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