Extreme warming in the NE Atlantic in the winter period 2002-2012 – an analysis with the regional atmospheric model COSMO-CLM and the Arctic System Reanalysis

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Climate change in the Arctic

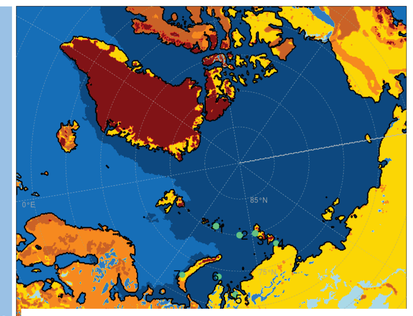
The understanding of the regional climate change in the Arctic is hindered by the fact that long-term measurements do not exist for vast areas of the Arctic. Mesoscale atmospheric models and reanalyses offer the possibility to analyze the temporal and regional development. We use a high-resolution regional climate model and Arctic System Reanalysis data to study 2m-temperature changes with focus on the Barents and Kara Sea.

Regional climate model – CCLM

- forecast mode (30h), nested in ERA-I
- Winter (Nov – Apr), 2002-2015
- 15 km horizontal resolution
- By Environmental Meteorology Group, University of Trier

& Arctic System Reanalysis (ASR)

- 3h data assimilation, Polar WRF, nested in ERA-I
- Jan – Dec, 2000-2012
- 30 km horizontal resolution
- By Meteorology Group, Byrd Polar & Climate Research Center



CCLM domain & OBS (green dots)

Verification using OBS data for the Kara Sea

CCLM and ASR show only slight differences.

Good agreement of CCLM and ASR 2-m air temperatures (T2m) with synoptic observations (OBS/AWS, locations see CCLM domain).

T2m time series are in high accordance, but trend differs strongly depending on the chosen period.

Table 1. Statistical comparison between Station data and CCLM and ASR for all winter periods 2002-2012

Station No	Mean AWS	CCLM	ASR	Bias CCLM	ASR	RMSE CCLM	ASR	r CCLM	ASR
AWS1 200460*	-16.10	-15.41	-16.22	-0.68	0.13	1.66	0.81	0.95	0.99
AWS2 200690	-19.22	-18.53	-18.32	-0.68	-0.9	1.68	1.09	0.97	0.99
AWS3 200870	-21.92	-20.75	-20.96	-1.17	-0.96	2.07	1.32	0.95	0.99
AWS4 202920	-22.77	-23.33	-23.33	0.56	1.30	1.92	1.55	0.96	0.98
AWS5 206740	-19.82	-19.11	-19.11	-0.71	1.54	1.50	1.59	0.97	0.99
AWS6 206670	-17.91	-15.71	-15.71	-2.21	-1.31	2.61	1.54	0.97	0.99
AWS7 207440	-9.43	-11.27	-11.27	1.84	0.71	2.14	0.88	0.97	0.99

* only for the years 2004-2012

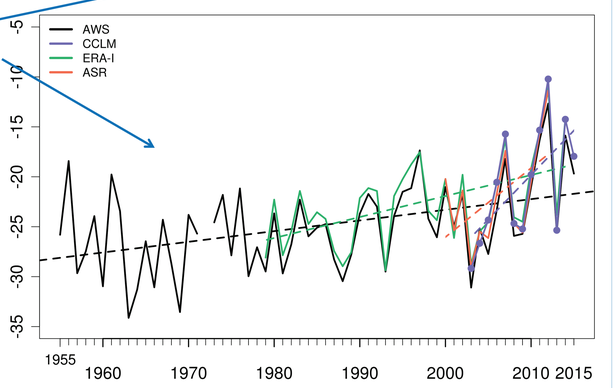


Fig.1: Time series of the 2-m air temperature for AWS2 (black) & related pixel of CCLM (blue), ERA-I (green) & ASR (red) for March. Dotted lines present the trends.

Arctic 2m air temperature trend 2002-2015

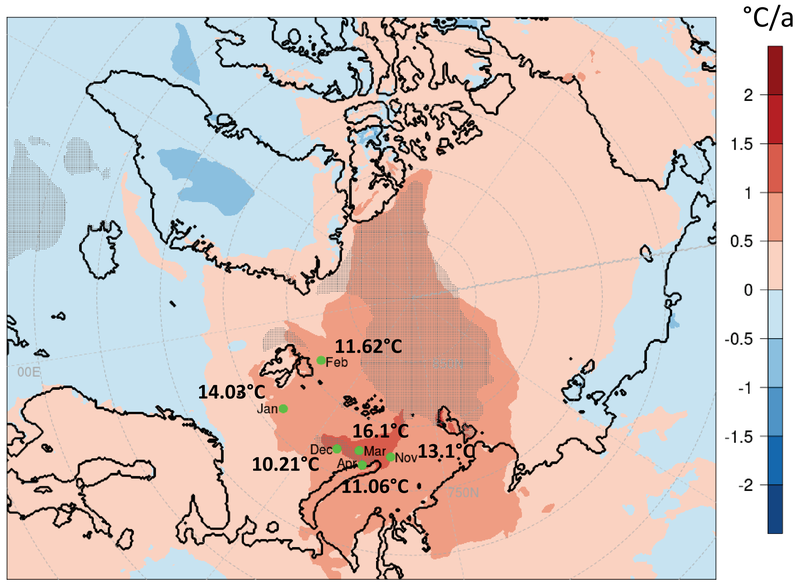


Fig.2: Spatial trend of the 2-m air temperature of CCLM for March 2003-2015. Green points show grid points of maximal T2m increase for particular months, inclusive T2m change for 2002-2015. Gray dots: significant at the 95% level.

Spatial trends winter 2002-2012

CCLM & ASR have **significant trends** in the Barents & Kara Sea with different strengths & spatial patterns for the winter months (**Fig.3**).

Strongest trends occur in **March: maximal increase 2°C/a**, which corresponds to a **T2m rise** of up to **20 °C** for **2003 to 2012.**

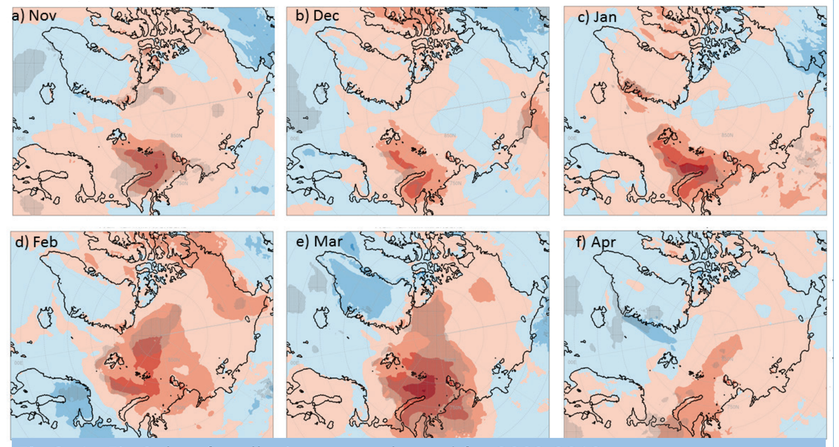


Fig.3: As Fig.2, but for all winter months and for 2002-2012.

Sea ice retreat → 2-m air temperature increase

The high correlations between sea ice coverage (SIC) and T2m changes cover the regions of the Barents & Kara Sea for the same period: Correlation max. 0.8 (**Fig.4**).

The reduced sea ice in late autumn and winter leads to an enhancement of ocean-to-atmosphere sensible heat flux. The contribution of the heat flux to the warming depends on the seasonal cycle (Deser et al., 2010).

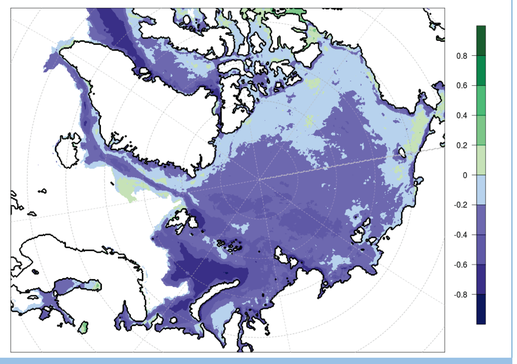


Fig.4: Correlation T2M & AMSR-E SIC for 2002-2012

Conclusions

- CCLM is in a good agreement to ASR and observational data → realistic results
- CCLM & ASR show an enormous 2-m air temperature increase (more than 15K for March) in the Barents & Kara Sea regions for 2002 - 2012. Similar results are found for 2002-2015
- Reason for this rise is the sea ice decline and an intensified sensible heat flux

Literature

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Deser, C., Tomas, R., Alexander, M. & Lawrence, D. (2010) The seasonal atmospheric response to projected Arctic sea ice loss in the late twenty-first century. J. Clim. 23, 333–351.
Rockel, B., Will, A., and Hense, A (2008): The Regional Climate Model COSMO-CLM (CCLM), Meteorologische Zeitschrift 17, 70 347–348.

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