Autumn Arctic Predictors for Winter Marine Cold Air Outbreaks (MCAOs) over the Barents Sea

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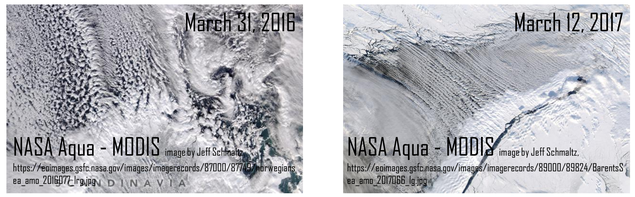
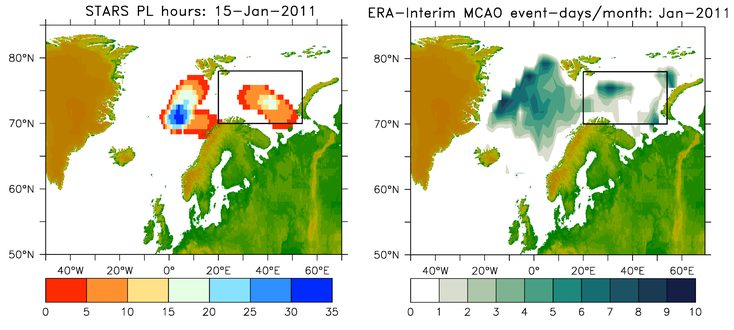
What are marine cold air outbreaks (MCAOs) and why are we concerned with them?

Societal and economic impact: MCAOs are transports of cold air from over *cold* sea ice or land toward *warm* ocean. They create conditions favorable for development of severe weather over land and open ocean. Associated with them extreme weather events – polar lows, sometimes called as Arctic hurricanes, pose a threat to marine operations and municipal infrastructure.



An example of satellite image for a MCAO with (left) and without (right) polar low

MCAOs are large scale proxies for polar lows. Such large-scale phenomena might be simulated and predicted in state-of-the-art Earth System Models. This is what we are aiming to figure out in Work Package 1, EU Horizon 2020 Blue-Action project, www.blue-action.eu.



An example of the monthly statistics for polar lows (hours/month; King, 2020) and for MCAOs (anomalous number of event-days per month; from ERA-Interim).

Methodology to predict MCAOs

Detection via static instability condition in the lower troposphere:
MCAO index = potential skin temperature minus potential air temperature @ 850 hPa.

- Daily MCAO index as well as monthly MCAO statistics: strongest outbreak values per month (90th percentile) and frequency of event-days per month.

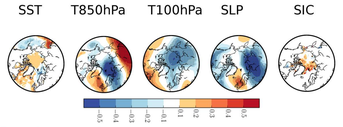
Seasonal prediction system

- MPI-ESM-MR (atmosphere: 1.9°L95, ocean: 0.4°L40),
- initialized with full fields from ERA-Interim and ORAS4 reanalyses,
- every November for 1980-2016,
- 30-member ensembles generated with bred-vectors,
- verification data set: ERA-Interim (atmosphere: 0.75°L60).

Potential predictors for MCAOs

- Established climate indexes: blocking patterns (Papritz et al, 2018, GRL), NAO (Kolstad et al, 2009, ClimDyn), and conditions during the positive phase of the Arctic Oscillation (Polkova et al, in preparation). 33% of sudden stratospheric warming events cause strong MCAOs over the Barents Sea (Afargan-Gerstman et al, WCD, in review),
- Large-scale patterns detected via composite analysis and lagged cross-correlation: For the Barents Sea, northerly winds, low SLP over Scandinavia and high SLP over Greenland.

Cross-correlation at lag 0 for the Barents Sea MCAOs

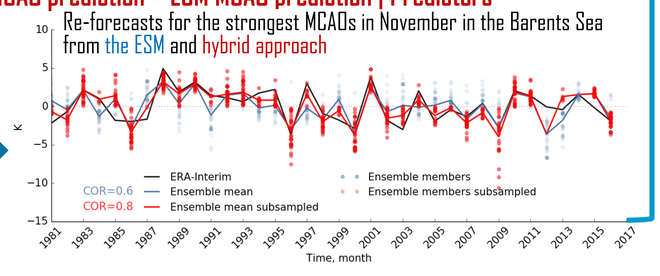


Statistical MCAO prediction = function(Predictors)

We use predictors mentioned above for a statistical model based on multi-linear regression model, for which causal MCAO drivers are identified using the causal effect network algorithm (following Kretschmer et al, 2016, JClim.)

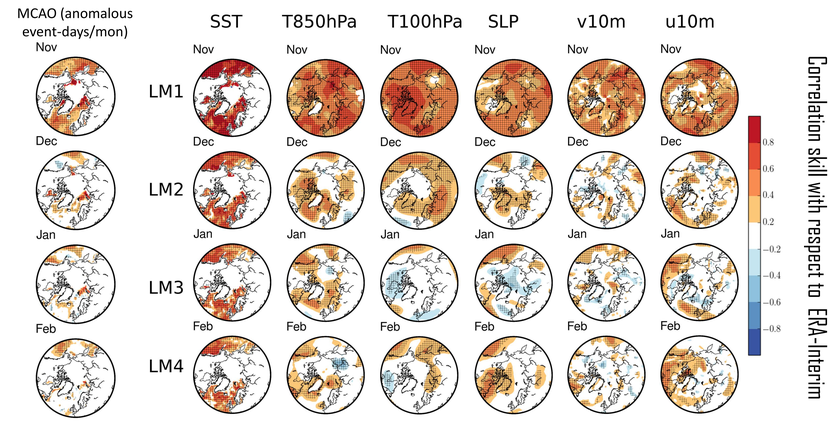
Hybrid MCAO prediction = ESM MCAO prediction | Predictors

Re-forecasts for the strongest MCAOs in November in the Barents Sea from the ESM and hybrid approach

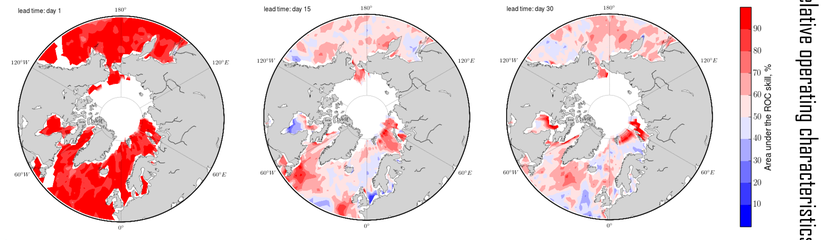


Prediction skill for MCAOs and their predictors

Can the seasonal prediction system skillfully predict the historical evolution of MCAO predictors? – Yes, for 1-2 months and a bit longer for SST and T850.

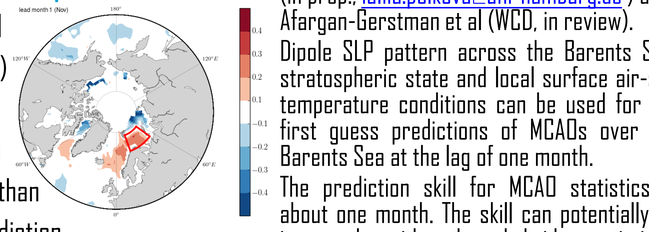


Can the seasonal prediction system distinguish between MCAO-events and non-events? – For daily output, the skill is about 2,5 weeks.



Does the hybrid statistical-dynamical prediction approach improve skill?

– Correlation skill difference (in red) shows that the hybrid prediction has a better skill than the seasonal prediction.



Summary: More details are in Polkova et al (in prep., iuliia.polkova@uni-hamburg.de) and Afargan-Gerstman et al (WCD, in review).
Dipole SLP pattern across the Barents Sea, stratospheric state and local surface air-sea temperature conditions can be used for the first guess predictions of MCAOs over the Barents Sea at the lag of one month.
The prediction skill for MCAO statistics is about one month. The skill can potentially be improved with the hybrid statistical-dynamical prediction approach.

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