RASP

Towards a Reliable Arctic Sea ice Prediction using ensemble-based multivariate data assimilation

Principal investigator

Jiping Liu

jiping.liu07@gmail.com

Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP/CAS), Beijing, China

Areas of contribution

Oceanic processes

Modelling and forecasting

Sea ice processes

Data assimilation

Summary

This project aims to advance understanding of different assimilation methods for sea-ice forecast initialization, improve coupled prediction systems and the data assimilation capability of newly developed satellite datasets, and enhance predictability and prediction of Arctic sea ice through the collaboration between Chinese and German scientists.

The following targeted activities provide a framework for the project: The coupled prediction systems of the Chinese partners will be augmented by assimilating satellite-retrieved sea-ice parameters developed by the German partners (including sea-ice concentration, ice types, sea-ice thickness, and melt pond fraction) with an ensemble-based Kalman filter (LESTKF). To assimilate melt ponds, the coupled prediction systems of the Chinese partners will be extended to include a prognostic melt pond parameterization. Additionally, sea-surface temperature and sea level anomaly data will be assimilated to constrain the state of the ocean. More importantly, the impact of observational errors of the assimilated sea-ice parameters on Arctic sea-ice prediction will be assessed. As sea-ice thickness distribution is not Gaussian, and sea-ice dynamics are nonlinear, new non-linear
data assimilation methods will be developed and implemented in the coupled prediction systems of the Chinese partners, and their assimilation impacts on Arctic sea-ice prediction will be studied and compared with the linear-based LESTKF. Finally, the predictability of Arctic sea ice and its relationship with the representation of the internal variability in the coupled prediction systems will be investigated.

Description

Summary
Recent changes in Arctic sea-ice extent and thickness have captured attention and posed significant challenges to a wide range of stakeholders, including maritime safety and security, resource management and development, coastal communities, climate change researchers, politicians, and general public. Thus there is a rising demand for Arctic sea-ice prediction at both short- and long-term time scales. This project aims to advance understanding of different assimilation methods for sea-ice forecast initialization, improve coupled prediction systems and the data assimilation capability of newly developed satellite datasets, and enhance predictability and prediction of Arctic sea ice through the collaboration between Chinese and German scientists. The following targeted activities provide a framework for the project: The coupled prediction systems of the Chinese partners will be augmented by assimilating satellite-retrieved sea ice parameters developed by the German partners (including sea-ice concentration, ice types sea-ice thickness, and melt pond fraction) with an ensemble-based Kalman filter (LESTKF). To assimilate melt ponds, the coupled prediction systems of the Chinese partners will be extended to include a prognostic melt pond parameterization. Additionally, sea-surface temperature and sea level anomaly data will be assimilated to constrain the state of the ocean. Impacts of different tuning options in the LESTKF on Arctic sea-ice prediction will be examined, including ensemble size, localization settings, and the length of integration to generate initial ensembles. More importantly, the impact of observational errors of the assimilated sea-ice parameters on Arctic sea-ice prediction will be assessed. As sea-ice thickness distribution is not Gaussian, and sea-ice dynamics are non-linear, new non-linear data assimilation methods will be developed and implemented in the coupled prediction systems of the Chinese partners, and their assimilation impacts on Arctic sea-ice prediction will be studied and compared with the linear-based LESTKF. Finally, the predictability of Arctic sea ice and its relationship with the representation of the internal variability in the coupled prediction systems will be investigated.

The project will be performed through an active collaboration using exchange visits between the Chinese and German project partners. As the project partners have different expertise in data assimilation, satellite remote sensing, and sea-ice and climate modeling and prediction, these visits will enrich the skills and experiences of the researchers from the participating groups.

Objectives
The main objective of the project is to improve predictability and prediction of Arctic sea ice at both short-term (daily to subseasonal) and long-term (seasonal to decadal) time scales by assimilating recently developed satellite remote sensing of sea-ice parameters and improving coupled predictive models' representation of melt ponds, advancing our understanding of processes controlling changes of sea ice. To achieve this, we aim at understanding of different assimilation methods for sea-ice initialization, in particular those that take account of the non-linearity of sea-ice dynamics, and provide improved sea-ice initial conditions for coupled predictive models. Forecast skills will be tested in the framework of the Year of Polar Prediction (YOPP, 2017-2020, www.polarprediction.net) and the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC, 2019-2020, www.mosaic-expedition.org). A strong aim is also the exchange of experience between the German and Chinese partners. The German partners are specialized in data assimilation and satellite remote sensing of sea ice, and the Chinese partners are specialized in sea-ice and climate modeling and prediction.
Thus, an added value of the cooperation will be to enhance the understanding of particularities of data assimilation, uncertainties of satellite retrieved sea-ice data, and their impacts on sea-ice and climate simulation and prediction. The planned research visits will train young researchers in data assimilation, satellite remote sensing of sea ice, and modelling and prediction of sea ice.

Work programme
WP1 Development and assessment of new nonlinear data assimilation methods
WP2 Advancing data assimilation of new sea ice and ocean parameters and optimizing data assimilation system
WP3 Satellite data development and extension of multivariate data assimilation system
WP4 Merge developments and study predictability
WP5 Dissemination

Timeline
2019-01-01 - 2021-12-31

Regional emphasis
Northern hemisphere: Yes
Southern hemisphere: No

Key project deliverables
- Sea ice-ocean prediction based on satellite data assimilation on daily to seasonal time scales
- Advanced data assimilation methods in the the Parallel Data Assimilation Framework (PDAF)
- Melt pond fraction dataset from Sentinel-3 satellite data and uncertainty estimates for assimilated satellite data products

Data management
pangaea.de

Is data provided to WMO Global Telecommunication System
No
Other information

This project will start late in the YOPP time line. It would be very useful for this project if the tentative Special Observing Period in Feb/March 2020 in connection to MOSAiC would be executed. Nevertheless, we think that in any case our project can contribute to the YOPP Consolidation Phase and will for sure use data collected during the YOPP Core Period.