Data-adaptive harmonic decomposition and stochastic prediction of regional Arctic sea ice extent

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Decline in the observed Arctic sea ice extent (SIE) conveys profound socio-economic implications and is an area of active scientific research. Of particular interest are reliable methods for SIE forecasting on subseasonal-to-seasonal time scales, from early summer into fall when sea ice coverage in the Arctic reaches its minimum. However, forecasting of SIE is very challenging due to the high variability of ocean and atmosphere over Arctic in summer, as well as shortness of observational data and inadequacies of the physics-based models to simulate sea-ice dynamics. The Sea Ice Outlook (SIO, https://www.arcus.org/sipn/sea-ice-outlook) is a collaborative effort to facilitate and improve prediction of September SIE by physics-based and statistical models.

Here we apply data-adaptive harmonic decomposition (DAHD) and inverse stochastic modeling techniques for the description and prediction of the Arctic SIE. The DAHD identifies narrowband, spatio-temporal data-adaptive modes over four key Arctic regions. The time evolution of these modes can be efficiently modeled and predicted by a set of coupled Stuart-Landau stochastic differential equations. Retrospective forecasts show that resulting multilayer Stuart-Landau model (MSLM) is quite skillful in predicting September SIE; moreover, the DAH-MSLM approach provided accurate real-time prediction that was highly competitive in the submissions into 2016&2017 Sea Ice Outlook. The key success factors are associated with DAHD ability to disentangle complex regional dynamics of SIE by data-adaptive harmonic spatio-temporal patterns that reduce the data-driven modeling effort to elemental inverse models stacked per frequency with fixed and small number of model coefficients to estimate.

References

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