Geophysical Research Abstracts
Vol. 18, EGU2016-280, 2016
EGU General Assembly 2016

Dynamic preconditioning of the September sea-ice extent minimum

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There has been an increased interest in seasonal forecasting of the sea-ice extent in recent years, in particular the minimum sea-ice extent. We propose a dynamical mechanism, based on winter preconditioning through first year ice formation, that explains a significant fraction of the variance in the anomaly of the September sea-ice extent from the long-term linear trend. To this end, we use a Lagrangian trajectory model to backtrack the September sea-ice edge to any time during the previous winter and quantify the amount of sea-ice divergence along the Eurasian and Alaskan coastlines as well as the Fram Strait sea-ice export. We find that coastal divergence that occurs later in the winter (March, April and May) is highly correlated with the following September sea-ice extent minimum ($r = -0.73$). This is because the newly formed first year ice will melt earlier allowing for other feedbacks (e.g. ice albedo feedback) to start amplifying the signal early in the melt season when the solar input is large. We find that the winter mean Fram Strait sea-ice export anomaly is also correlated with the minimum sea-ice extent the following summer. Next we backtrack a synthetic ice edge initialized at the beginning of the melt season (June 1st) in order to develop hindcast models of the September sea-ice extent that do not rely on a-priori knowledge of the minimum sea-ice extent. We find that using a multi-variate regression model of the September sea-ice extent anomaly based on coastal divergence and Fram Strait ice export as predictors reduces the error by 41%. A hindcast model based on the mean DJFMA Arctic Oscillation index alone reduces the error by 24%.