2013 SIO Post-Season Report, Global Modeling and Assimilation Office

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1. The NSIDC value for average September 2013 ice extent was 5.35 million square kilometers. How would you characterize the success of Outlook predictions this year, including relative strengths or weaknesses of different methodologies?

From the June report, it is apparent that model contributions diverged, with six models indicating values ranging from 4.1 to 5.0×10^6 km^2, and two models indicating values of 3.5×10^6 km^2 or less. While all of these forecasts were less than the observed extent, the majority suggested a modest recovery over the 2012 minimum. The GMAO seasonal forecast indicated regional recovery in ice cover for the Beaufort Sea, which in fact validated over most of the summer. A more rigorous assessment of dynamical predictability for this summer remains to be performed, but it appears that models were able to forecast differences in circulation over the previous year, and that these differences had significant influence on the Arctic ice cover. The primary limitations for these forecasts are in model biases, as indicated by the use of bias corrections, and in the forcing fields and the model representation of physical processes in the transition from spring to summer conditions. For example, there was little improvement in forecasts for the July report.

2. What were the main factors driving the minimum extent this year, in contrast to 2012 or 2011?

In the comparison of this year's conditions with the previous two, the most accessible evidence of differences is in the atmospheric circulation. As may be seen through anomalies in sea level pressure (Fig. 1), the late summer period of 2011 was distinguished by high pressure over the central Arctic and low pressure anomalies over surrounding subpolar land masses. This pattern is characteristic of anomalies observed over the 21st Century, and results in southerly wind patterns over the Pacific side of the basin, clear-sky conditions, and the consolidation of the ice cover via Ekman drift.

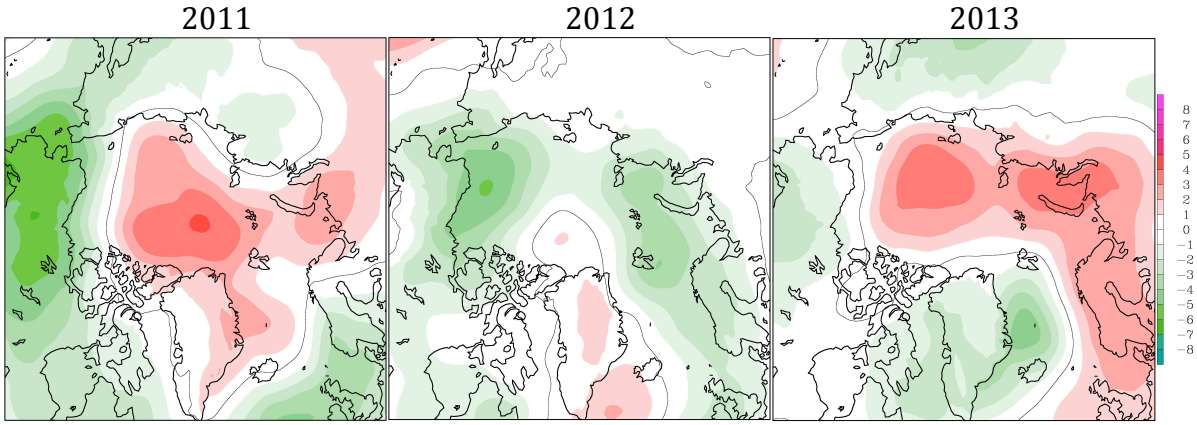

FIG. 1. *Sea level pressure anomaly for July-August-September of the last three years from MERRA, in hPa. The anomaly is taken with respect to the period 1979-2000.*

The summer period of 2012 represented a significant departure from this pattern, with low pressure anomalies extending into Arctic Ocean basin. Nevertheless it may be seen that both circulation patterns lead to enhanced poleward atmospheric energy transport from the North American continent into the Pacific side of the basin (Fig. 2). The introduction of warmer air from lower latitudes may be one factor that modifies the summer melt season. This year's atmospheric circulation patterns represented a return to high pressure anomalies in the central Arctic. But in contrast to 2011, the high pressure anomaly was centered more to the Eurasian side of the basin, and subpolar low pressure anomalies were generally weaker than in recent years. Poleward atmospheric energy transport anomalies were more focused on the Atlantic side of the basin, and energy transport anomalies over the Beaufort Sea area were diminished. Analyses of near-surface air temperature anomalies (Fig. 3) further suggest a moderation of atmospheric forcing over the Beaufort Sea in comparison to prior years.

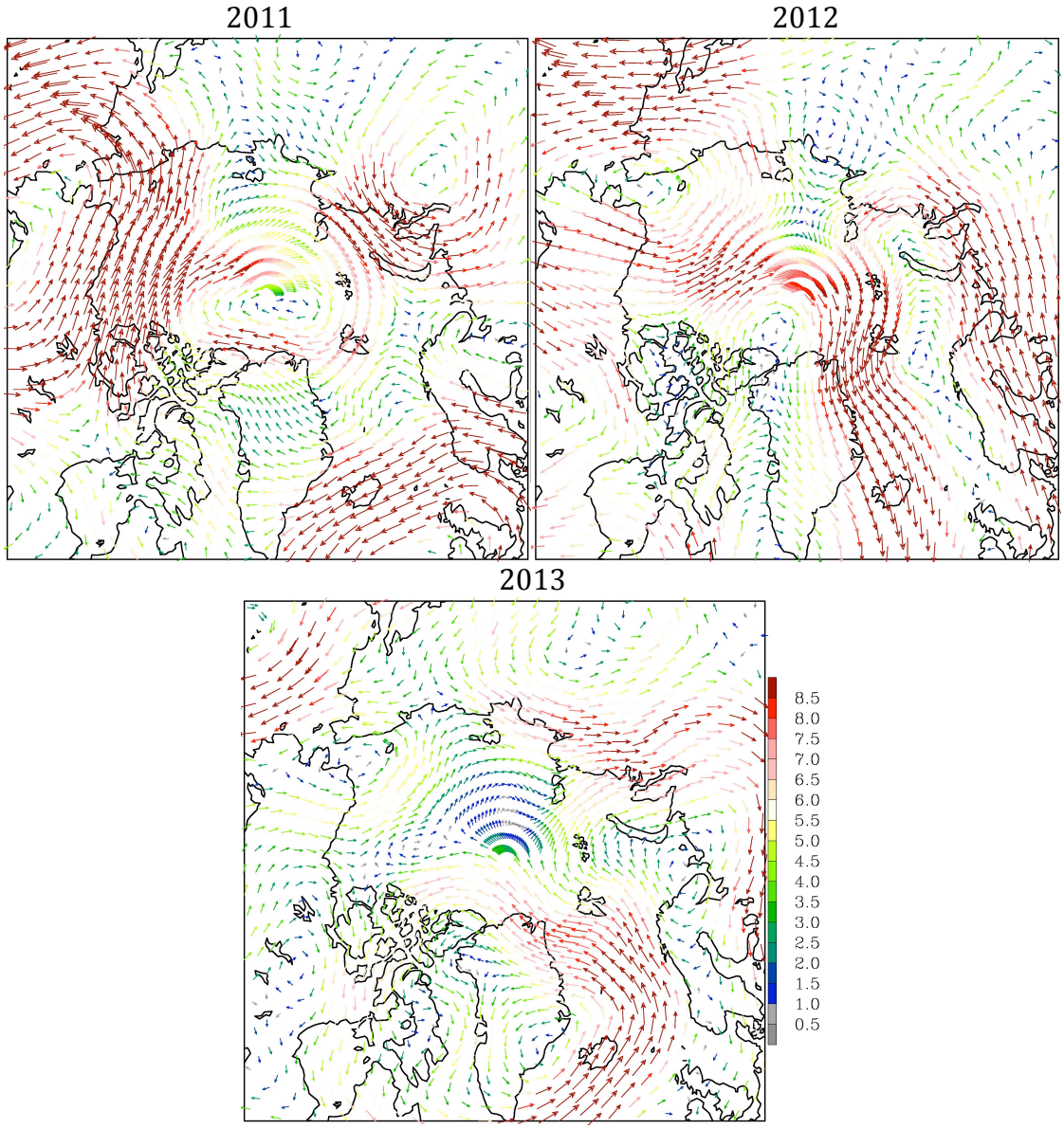

FIG. 2. *Vertically-integrated total atmospheric energy transport anomaly vectors for July-August-September for three years, from MERRA. The color interval is every* 0.5×10^{9} *J* m^{-1} s^{-1}.

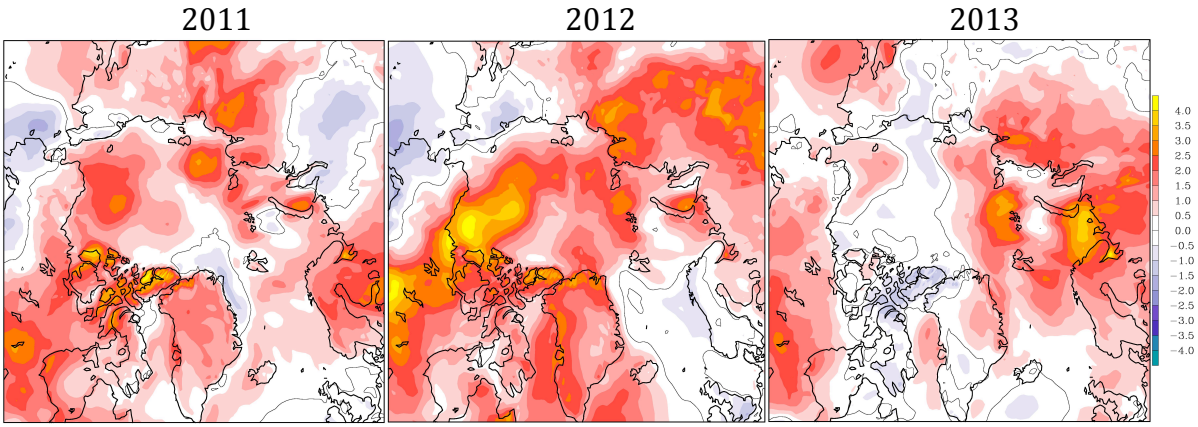

FIG. 3. *Two-meter temperature anomaly for July-August-September for the last three years, from MERRA. The shading interval is every 0.5 °C.*

3. What are the implications of this year's minimum (or regional patterns) for sea ice extent in the future?

The NSIDC indicates that this year's September ice extent was the sixth lowest in the satellite record, and that extent losses were most notable in the Barents and Kara Seas in comparison to the median ice extent climatology. The presence of open waters may restrict the growth of ice in these areas in the following season. It is possible that the loss of ice volume may precondition the Arctic for the further loss of perennial sea ice in the future.

4. What is needed to improve future predictions of seasonal sea ice extent (e.g., observational data, model simulations, coordination)? If more observations are needed, where and what type of data would be most helpful?

The GMAO forecast model appears to be unfavorably affected by atmospheric forcing conditions during the onset of the melt season, and further analysis is being conducted. The GMAO model is currently not initialized with observed ice thickness, and this is a topic for future work. As ocean circulation is thought to be a dominant influence on the current trend in sea ice cover, additional analysis is required to assess and understand the model performance.

5. What are the key lessons learned from this year?

This year included the first contribution to the SIO from the NASA GMAO. Preliminary results suggest a degree of seasonal predictability for conditions at high latitudes, which may be further exploited after some assessment and revision.