Sea ice outlook in 2013: Summer atmospheric and sea ice dynamical contributions to fall sea ice extent

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Estimate for sea ice extent for September, 2013; comparable to or slightly less than the 2007 minimum in sea ice extent, or 4.0 million square kilometers.

Executive Summary

Sea ice extent is greater on 05 June 2013 than a year ago, however ice thicknesses and volumes are, on average, the lowest on record. While the ice is preconditioned for another record melt the atmospheric and ice conditions observed during May 2013 have not been ideal for rapid melting, evidenced by typical rates of ice decay (*NSIDC*, 2013). Provided that ocean and atmospheric conditions favor rapid melting in June and July, which we feel are still likely, it is therefore hypothesized that the 2013 fall sea ice extent will achieve values comparable to those of 2012, with regional losses governed by local wind and ice conditions and dynamics. This projection is based on a heuristic assessment of sea ice and atmospheric dynamics

Rationale

May 2013 presents a complex setup for the 2013 melt season. Ice concentrations for 05 June 2013 are greater than they were for the same date last year; however ice thicknesses have noticeably declined, particularly around the North Pole and Southern Beaufort Sea. Surface wind forcing and resulting ice drift in May do not appear to favor considerable ice export through Fram Strait. Furthermore, the Beaufort Sea ice gyre is observed to be following a cyclonic rotational pattern on 06 June 2013, [likely responding to wind forcing from an Arctic cyclone that passed over the region a few days prior], in response to a persistent Arctic cyclone. Climatology suggests that anticyclonic circulation should prevail, thereby improving conditions for the export of ice from the East Siberian Sea (*e.g. Serreze and Barry*, 1988). Nowcast data shows a decrease in ice thickness at the pack ice edge indicating increased sensitivity (relative to 2012) of the ice cover to ice melt and sea ice deformation during summer. The impacts of the widespread fracture of the winter ice cover in the Beaufort Sea in spring, 2013 are difficult to assess at this time, however it is probable that dynamic thickening occurred within the first-year ice cover in this region. As 30 – 80% of sea ice volume in given area can be contained in pressure ridges (*Haas*, 2003), the impacts of this event on sea ice mass balance must be considered.

Discussion

Sea ice concentrations are contrasted for 05 June between 2012 and 2013 (figure 1). The 2013 sea ice extent is slightly greater than that of 2012. Most notable is the Kara Sea, which is nearly ice-covered in 2013, compared to nearly ice free conditions in 2012. Also of note are greater amounts of ice in Baffin Bay and in the Southern Beaufort Sea. The SSMI data for 2013 suggests some local areas containing 75% sea ice concentration near the North Pole. This may be indicative of the widespread fracturing of thick multi-year ice floes in the region, observed by the Drifting Russian Polar Research Station SP-40 (presently 82.1°N 130.6°W), which is presently under an emergency evacuation order. Ice floe sizes in and around the station were noted to be 100 – 150 m in diameter, with a mean thickness of 2.5m (http://www.aari.ru/resources/d0014/np40/default.asp?lang=0). Given that it is now June and air temperatures are continuing to climb, it is unlikely that these ice floes will consolidate, and instead may be subject to wind forcing, lateral melting, and further mechanical fracture from wave action (*e.g. Steer et al.*, 2008) and wave-induced melt (*e.g. Wadhams,* 1979).

Ice thickness charts from the HYCOM consortium for Data-Assimilative Ocean Modeling are presented for 05 June 2012 and 2013. The overall thicknesses have notably declined from 2012 to 2013, which is correlated with a record area of first-year sea ice cover during winter 2012-2013 (NSIDC, 2013). There is notably less thick (>2.5m thick) ice in the southern Beaufort Sea and at the North Pole, indicating a predominantly first-year sea ice cover in these areas. There is also a notable decline from 2012 to 2013 in the area of the thick multi-year ice buildup along the coast of the Canadian Archipelago. Decreases in ice thickness at the pack ice edge further suggest increased sensitivity to ice melt and sea ice deformation during summer that will contribute to accelerated loss of sea ice in September.

Mean surface vector winds and anomalies are presented for May 2007, 2011 – 2013 (Figure 2) and are discussed in context of ice drift (Figure 3). May 2013 is characterized by an anomalous cyclone wind pattern over the Beaufort and Chukchi Sea associated with a persistent low in SLP (Figure 4), as well as strong southerly winds over the Canadian Archipelago. The greater concentrations of sea ice in the Southern Beaufort Sea can likely be attributed to cyclonic wind forcing, thereby causing the Beaufort Gyre's rotation to slow considerably. This is evidenced by the fact that the pack ice has not moved away from the land fast ice in Amundsen Gulf to create the typical spring flaw lead. A reversed Beaufort Sea ice gyre is discernible on the 06 June 2013 ice drift (Figure 3), due to anomalously low and persistent SLP over this region (Figure 4), as noted elsewhere (http://neven1.typepad.com/blog/2013/06/asi-2013-update-2-shaken-and-stirred.html). Comparison of SLP and SLP anomalies for May, 2012 and 2013 highlights distinctions in atmospheric and accompanying sea ice circulation patterns, and in particular increased export through Fram Strait due to the presence of a SLP dipole over the Arctic in 2012, and reversals in the Beaufort Gyre in 2013 due to the presence of a persistent Arctic cyclone over the Beaufort Sea. Also notable in May 2013 is the lack of strong northerly winds over Fram Strait (Figure 2), which is in contrast to 2007, 2011 and 2012 where strong northerly winds drove ice volumes of ice export via Fram Strait these years (Figure 3). Regional differences in ice drift response to surface winds are most likely due to regional differences in ice concentration and thickness.

The effects of the observed large-scale winter fracturing of the Beaufort Sea Ice Gyre during February and March of 2013 (NSIDC, 2013) on the sea ice cover are yet to be fully understood. It appears to have been driven by anomalous easterly wind forcing during this period (Figure 5), evident by a strong pressure gradient over the Beaufort and Chukchi seas in winter (Figure 6). Persistent easterly wind forcing on the relatively thin sea ice cover (Figure 6) induced strain and ice fracture in the vicinity of Pt. Barrow ~31 January 2013, which quickly spread eastward through the ice pack in March 2013. The strong easterly wind forcing was maintained by a strong pressure gradient arising from the interaction of a northward-shifted Beaufort High with a deep Aleutian Low (Figure 6). This event drove large volumes and areal extents of new sea ice formation in the Beaufort Sea. The net impact of this event on ice thicknesses is unknown, but it is likely that this event increased dynamic ice thickening (ridging) during the winter. The relative strength of the ice pack during spring is unknown as wind forcing has not been favorable for driving the normal anti-cyclonic sea ice gyre. It is likely we can further assess this in the July sea ice outlook.

References

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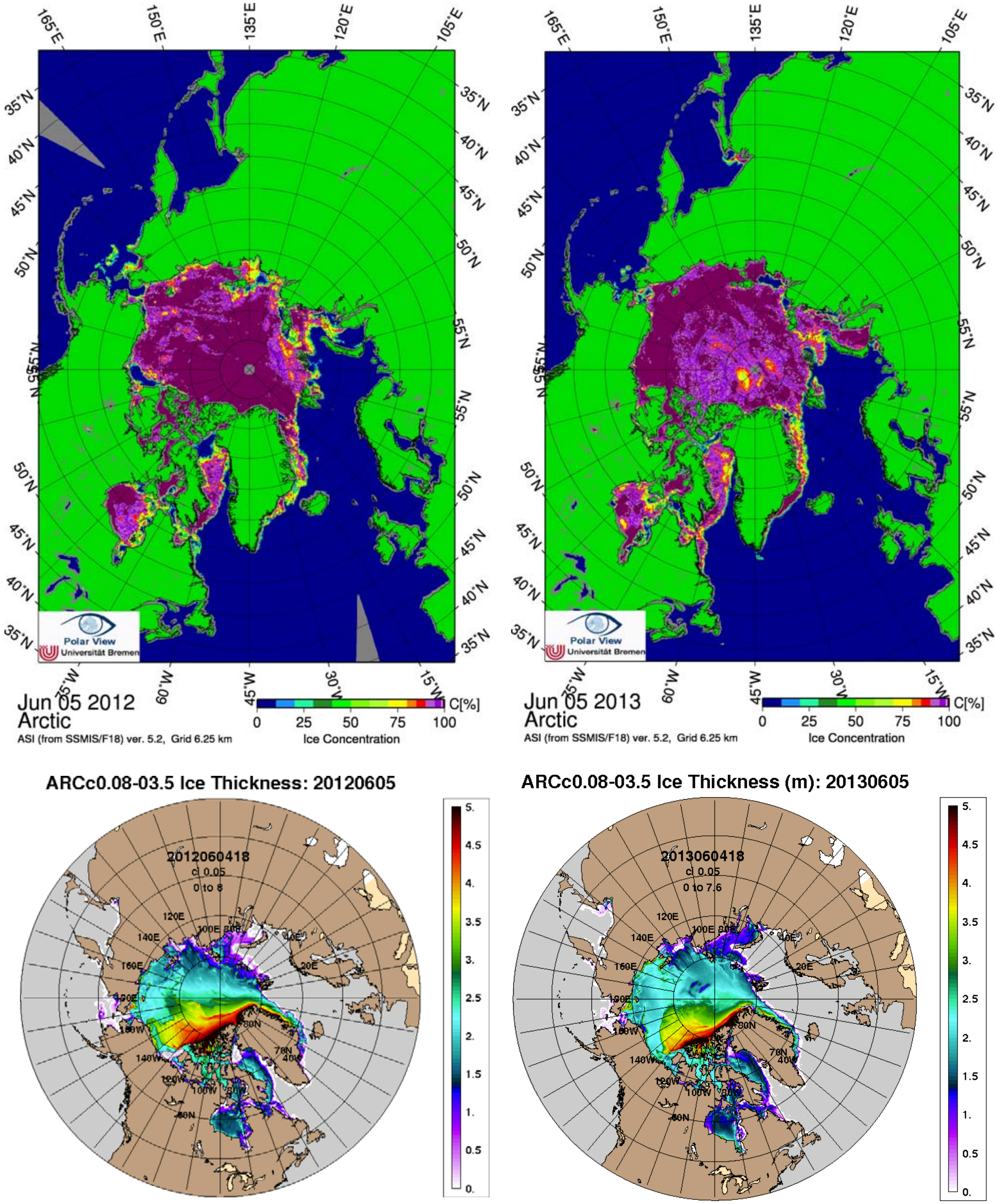

Figure 1. Upper row: SSMI sea ice maps of sea ice concentrations in the Arctic for 05 June 2012 and 2013. Image provided by the University of Bremen at http://www.iup.uni-bremen.de:8084/ssmisdata/ (note: AMSR-2 was not yet publically available in June 2012). Lower row: Arctic sea ice thickness nowcast from the Naval Research Laboratory (NRL) – HYCOM Consortium for Data-Assimilative Ocean Modeling. Image provided by the Naval Research Laboratory at http://www7320.nrlssc.navy.mil/hycomARC/navo/arcticictn/nowcast/.

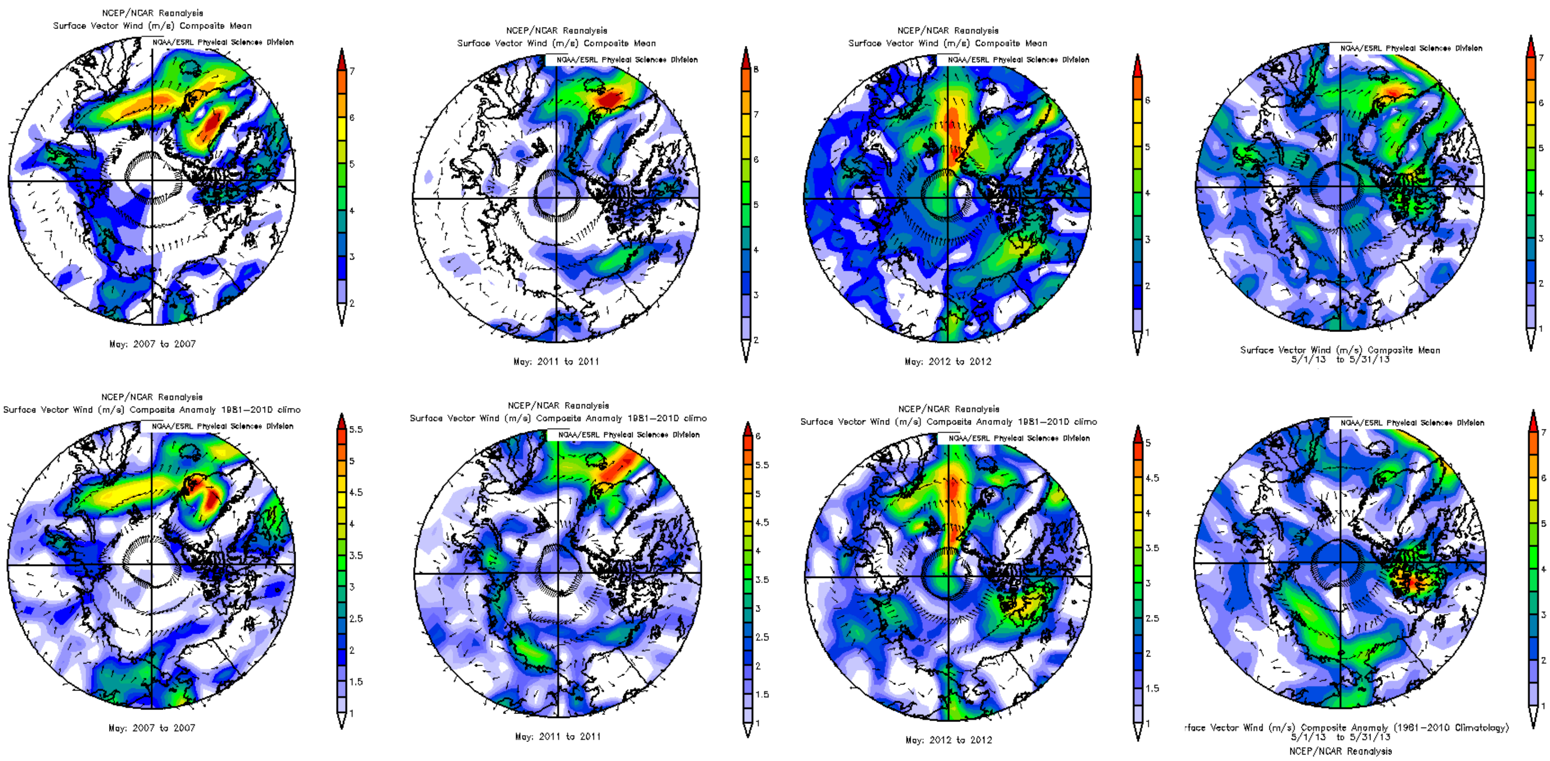

Figure 2. Surface winds and anomalies for May 2007 and 2011 – 2013. Images provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/.

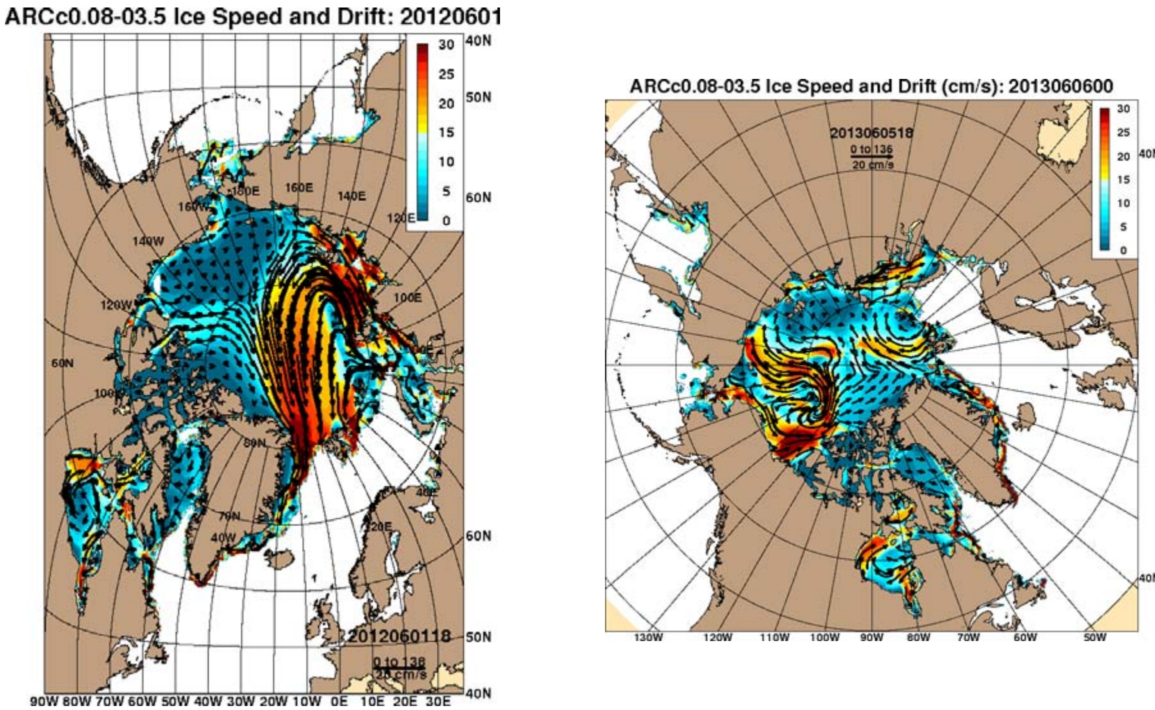

Figure 4. Ice speed and drift for June, 2012 and 2013 obtained from the Naval Research Laboratory (NRL) – HYCOM Consortium for Data-Assimilative Ocean Modeling at http://www7320.nrlssc.navy.mil/hycomARC/navo/arcticictn/nowcast/.

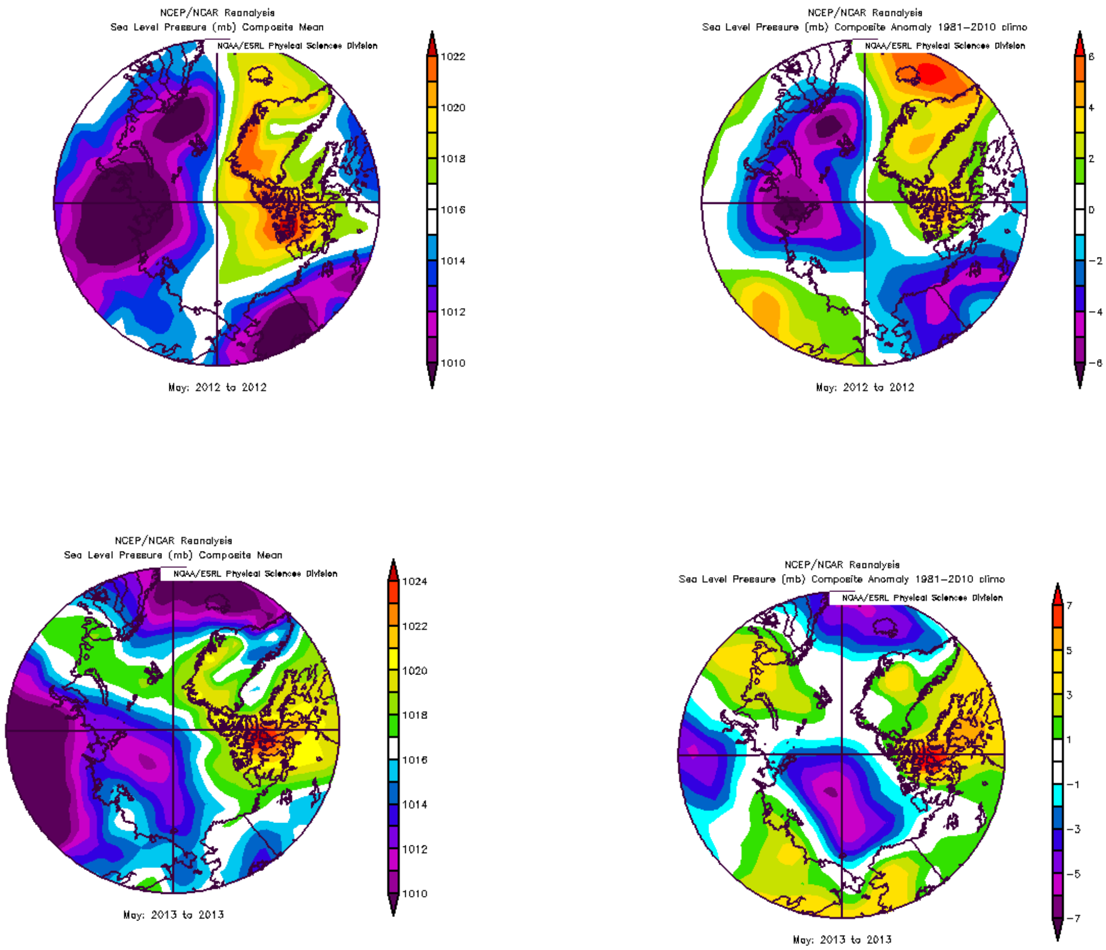

Figure 4. SLP and anomalies relative to the 1981-2010 climatology for May, 2012 and 2013. Images provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/.

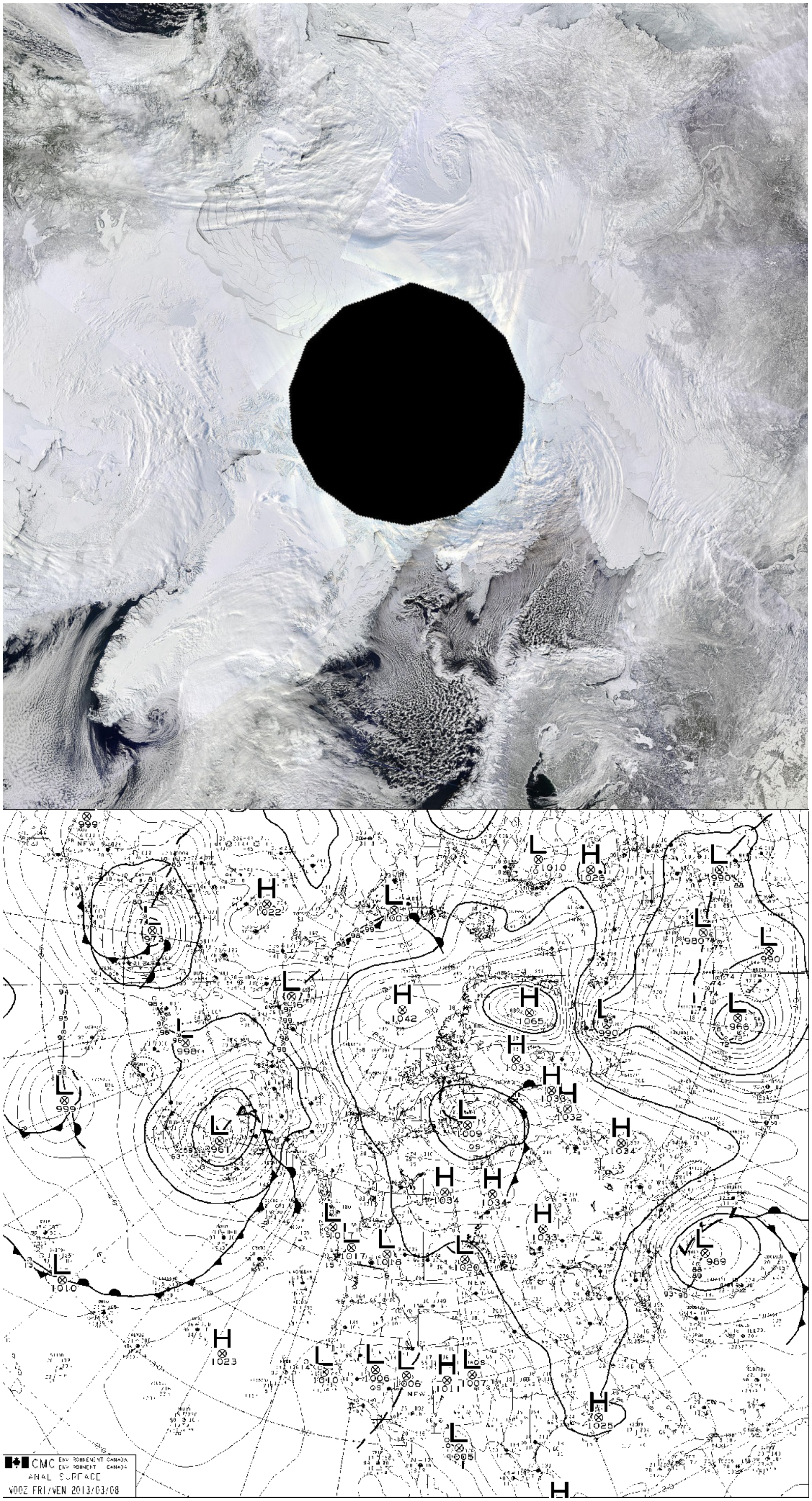

Figure 5. Top) MODIS Terra Arctic Mosaic image for 08 March 2013 found at: http://rapidfire.sci.gsfc.nasa.gov/imagery/subsets/?mosaic=Arctic.2013067.terra.4km.jpg Bottom) Sea level pressure analysis for the northern hemisphere (http://weather.gc.ca) for 00Z 08 March 2013.

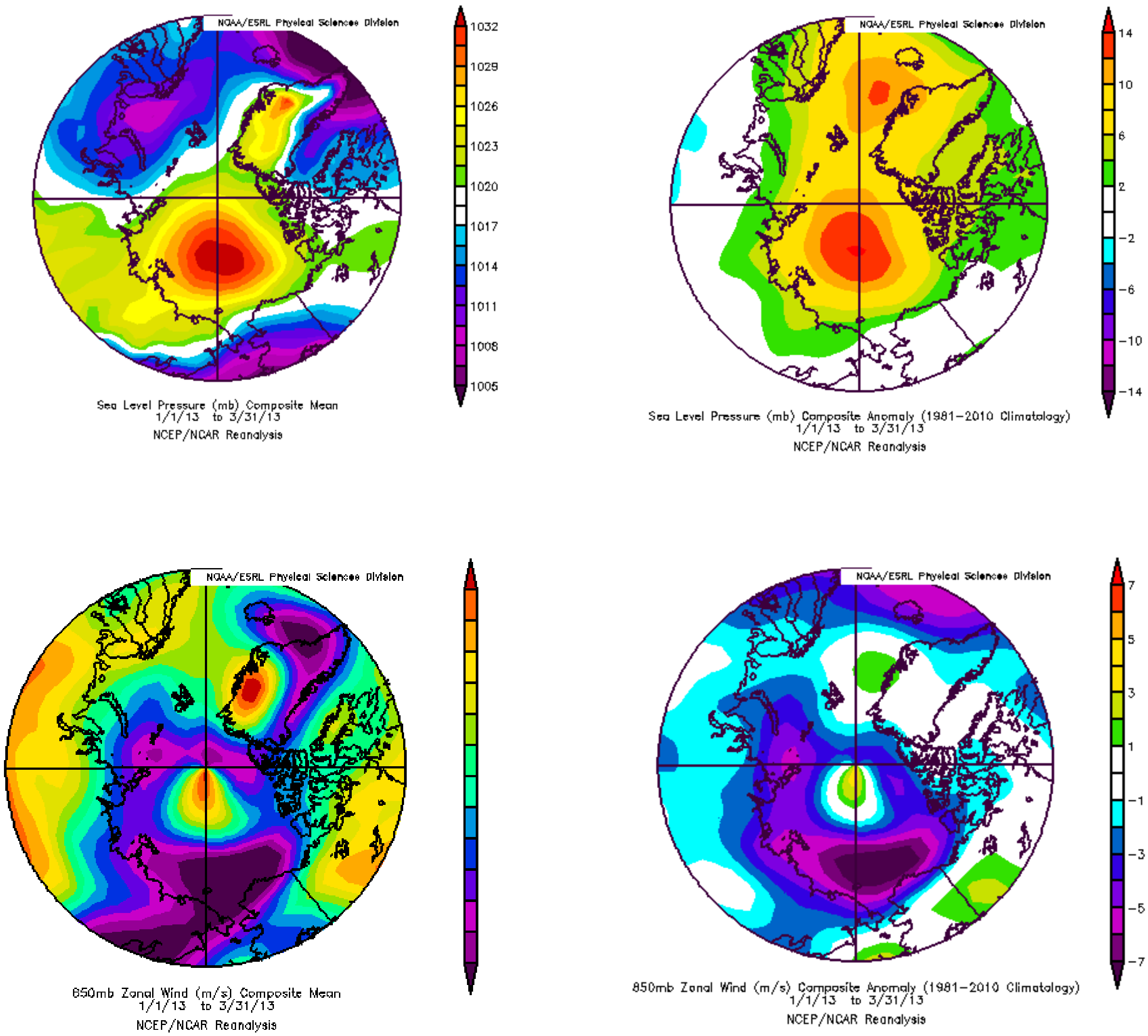

Figure 6. Top left) Mean sea level pressure for JFM 2013, top right) Sea level pressure anomaly for JFM 2013 versus 1981 – 2010 climatology. Bottom left) Mean zonal winds for JFM 2013, bottom right) Zonal winds anomaly for JFM 2013 versus 1981 – 2010 climatology.