Sea ice outlook in 2011: Springtime atmospheric contributions to fall sea ice extent

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Estimate for sea ice extent for September, 2011; comparable to the 2010 minimum in sea ice extent, or 4.60 million square kilometers.

Rationale

Investigation of dynamical atmospheric contributions in spring to sea ice conditions in fall, based on comparison of 2011 and 2007 stratospheric and surface winds and SLP in April and May suggests regional differences in sea ice extent in fall, in a manner consistent with recent studies highlighting the importance of coastal geometry in seasonal interpretations of sea ice cover (Eisenman, 2010). The absence of anomalous features evident in 2007 in SLP and stratospheric and surface winds in spring in 2011 indicates that accelerated decline associated with the former will not be an artifact of dynamical phenomena, although a thinner and more mobile ice cover may lower the wind forcing threshold required for increased ice export. Lower ice concentrations in 2011 relative to 2007 in late May indicate increased sensitivity of the Arctic ice cover to atmospheric dynamical forcing, with implications for ice transport during summer.

Methods

Connections between atmospheric dynamics and summertime sea ice extent in the Arctic are examined in the context of stratospheric and surface winds. Explored in particular are the stratospheric (10 mb) relative vorticity fields during the breakup of the wintertime polar vortex in February, 2007 and 2011. Monthly means of ECMWF ERA-Interim relative vorticity used in this study were obtained from the ECMWF data server.

Stratospheric wind composites for April and May are also presented for 2011, and compared with the 2007 conditions associated with the record minimum in sea ice extent. Stratospheric winds were obtained from the NCEP reanalysis dataset provided by the NOAA/ESRL Physical Sciences Division. Composites based on record minima in sea ice extent in September include the years 2005 – 2010 in accordance with time series for monthly records of sea ice extent (http://earthobservatory.nasa.gov/Features/WorldOfChange/sea_ice.php).

Differences between May, 2011 surface winds and SLP, and composites for years associated with record lows in September ice extent provide an indication of this year's dynamical contributions to ice extent. Surface winds and SLP were also obtained from the NCEP reanalysis dataset provided by the NOAA/ESRL Physical Sciences Division.

Discussion

Investigation of stratospheric relative vorticity fields in winter shows comparable stratospheric conditions in February, 2007 and 2011, with anticyclonic activity located over the western Arctic and cyclonic activity located over the eastern Arctic (Figure 1). Stratospheric winds in spring highlight displacement of the trinodal spatial pattern in April, 2011 relative to April, 2007(Figure 2). In particular, the stratospheric wind maximum in 2007 is located over the North Pole and minima over the Southern Beaufort and Barents Seas, while the stratospheric wind maximum in 2011 is located over the Kara Sea, and minima over Siberia and the Canadian Archipelago, in a manner reminiscent of April SAT anomalies documented in the April NSIDC assessment of Arctic atmospheric and sea ice conditions (http://nsidc.org/arcticseaicenews/2010/092710.html). Previous studies have demonstrated the propagation of stratospheric anomalies to the surface (LeDrew et al., 2009); similarity in difference patterns for 2011 relative to 2007, and 2011 relative to 2005-2010, apparent in maxima over the Kara Sea and minima to the north of Greenland suggests regional differences in stratospheric contributions to surface phenomena, and fall sea ice conditions in particular, in 2011. Comparison of stratospheric wind vector anomalies in May, 2007 and May, 2011 further illustrates regional differences; strong anomalies are observed in subpolar regions in May, 2007, whereas anomalies dominate throughout the Arctic in May, 2011, with implications for stratosphere-surface coupling.

Monthly SLP composites for April, 2007 exhibit patterns conducive to sea ice export out of the Beaufort Sea region and through Fram Strait (Figure 3). By contrast, the SLP composite for April, 2011 demonstrates a displaced SLP high south of the Beaufort Sea region and a dominant SLP low to the east of Greenland that inhibits ice export and results in increased convergence. Differences between April, 2011 and 2007, in addition to the 2005-2010 composite indicate the possibility for increased ice convergence over the Kara and Laptev seas. Incidentally, reduced ice cover in the Barents Sea as outlined in the NSIDC report of April conditions (http://nsidc.org/arcticseaicenews/) suggests increased sensitivity of sea ice to atmospheric forcing conditions in this region. Regional differences in springtime surface atmospheric forcing are further illustrated in a comparison of SLP anomalies for May, 2007 and May, 2011.

Monthly surface wind composites for April, 2007 show that springtime surface wind conditions favored export through Fram Strait, in contrast to April, 2011 surface wind conditions (Figure 4). Regional differences in surface winds in April 2011 and 2007 are evident in the Beaufort Sea region, eastern Greenland and Fram Strait. Surface wind anomalies in May, 2007 highlight dominant contributions to ice advection and export through Fram Strait. Strong anomalies observed in the Beaufort, Chukchi and East Siberian Seas and to the east of Greenland in May, 2011 have the potential to influence summertime sea ice conditions and export. Examination of May, 2011 relative to May, 2007 sea ice concentrations in the Arctic shows reduced ice cover in the Kara and Beaufort Sea and lower ice concentrations throughout the Arctic (Figure 5), providing evidence for increased sensitivity of summer sea ice conditions to atmospheric forcing.

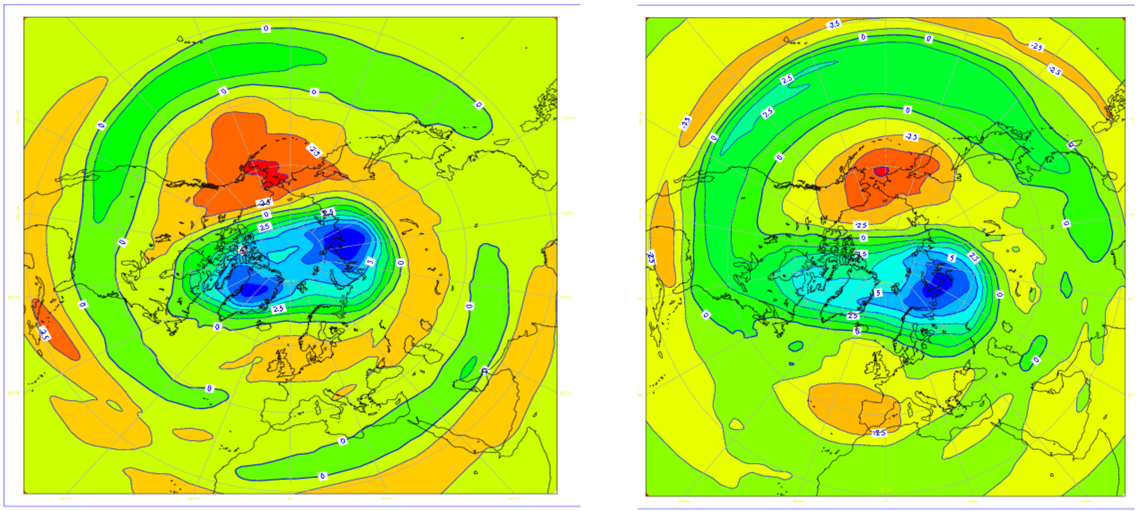

Figure 1. Stratospheric (10 mb) relative vorticity fields for February, 2007 and 2011. Anticyclonic activity (negative relative vorticity) is depicted by red shading. Image provided by the ECMWF ERA-Interim data portal at http://data-portal.ecmwf.int/data/d/interim_moda/levtype=pl/.

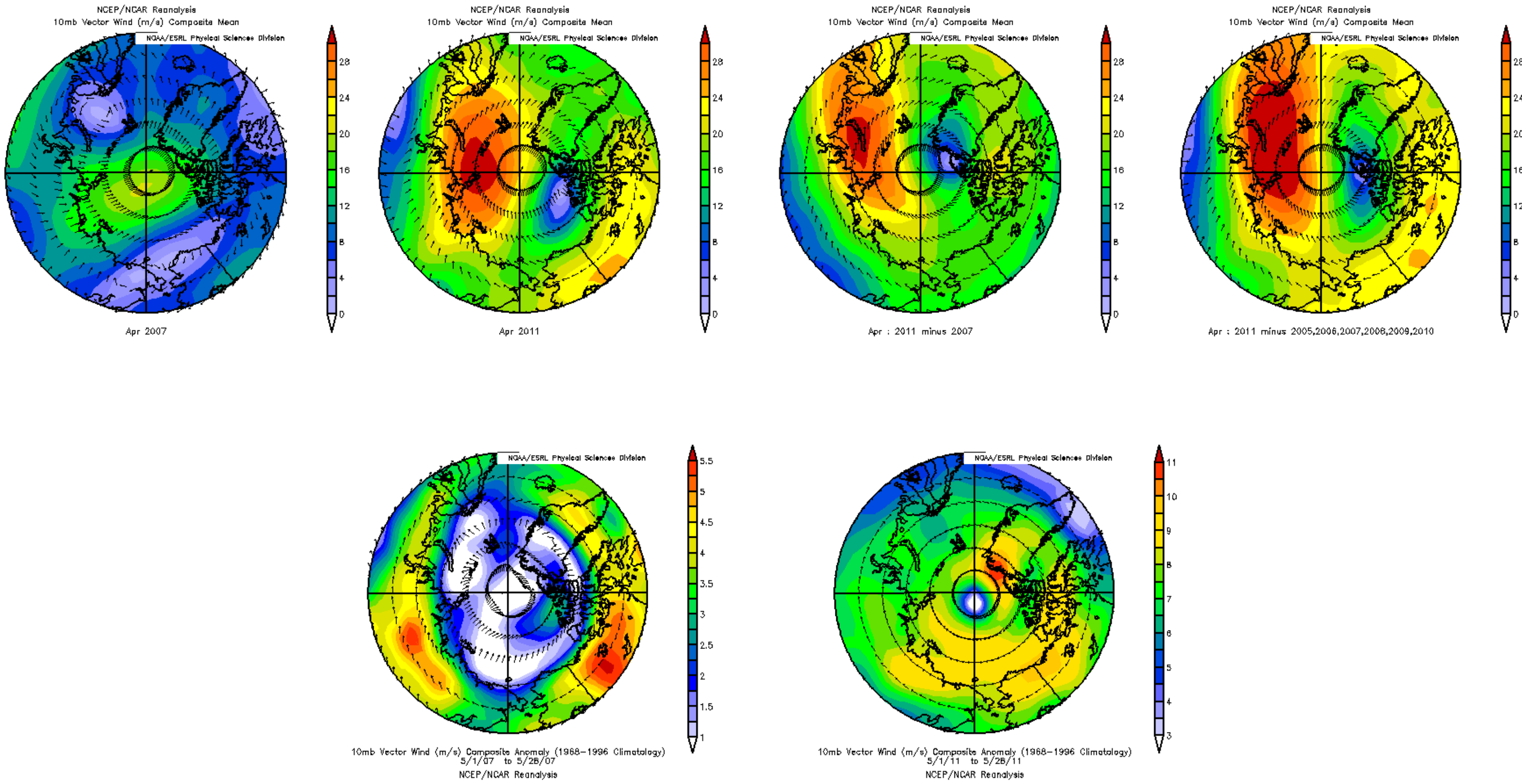

Figure 2. Stratospheric (10 mb) winds for April, 2007, 2011, the difference between 2011 and 2007, and the difference between 2011 and years with record minima in sea ice extent (2005 – 2010) shown in top row. Stratospheric wind anomalies for May, 2007, and May, 2011 shown in second row. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/.

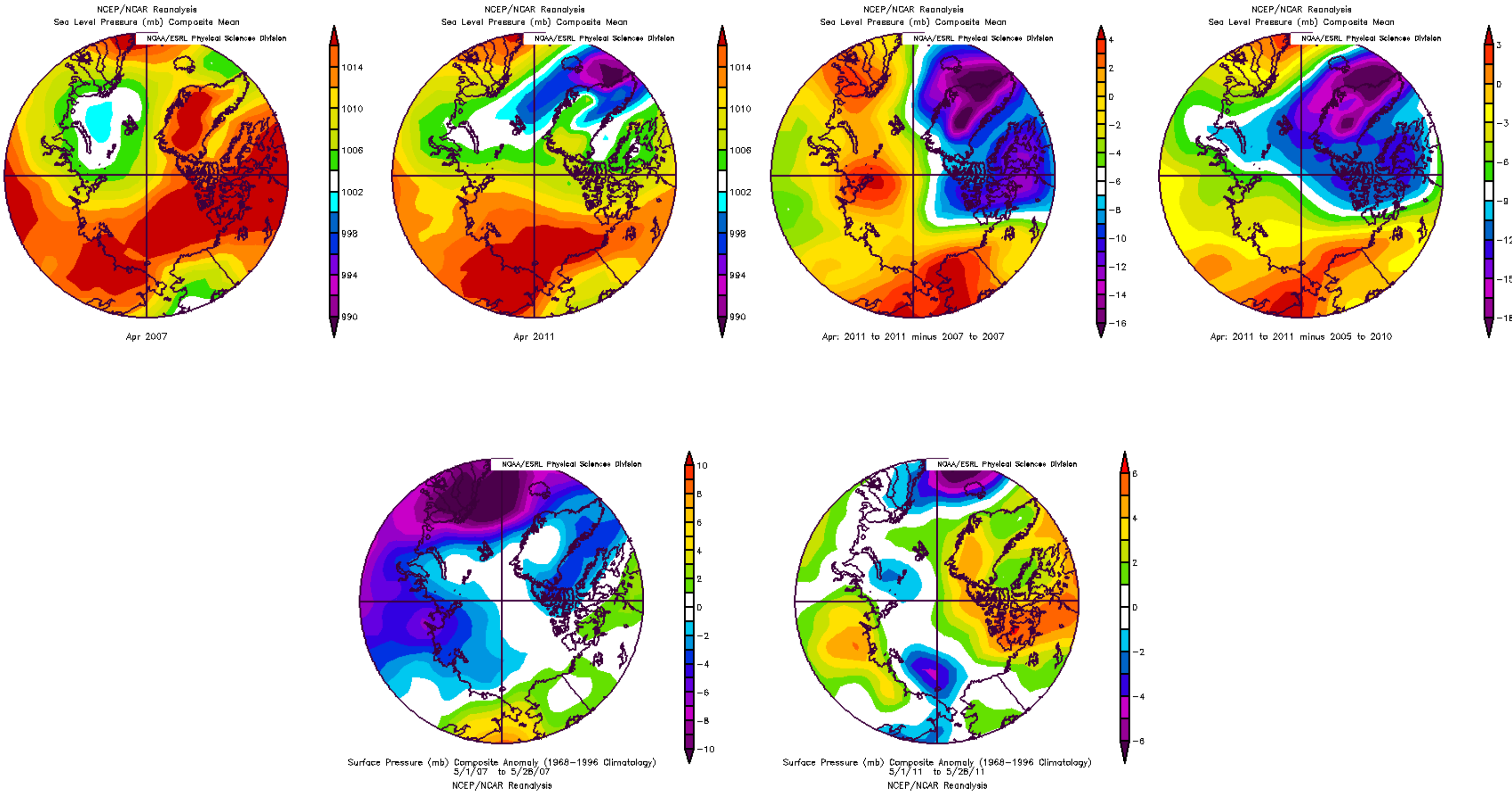

Figure 3. SLP for April, 2007, 2011, the difference between 2011 and 2007, in addition to the difference between 2011 and years with record minima in sea ice extent (2005 – 2010), shown in top row. SLP anomalies for May, 2007, and May, 2011, shown in second row. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/.

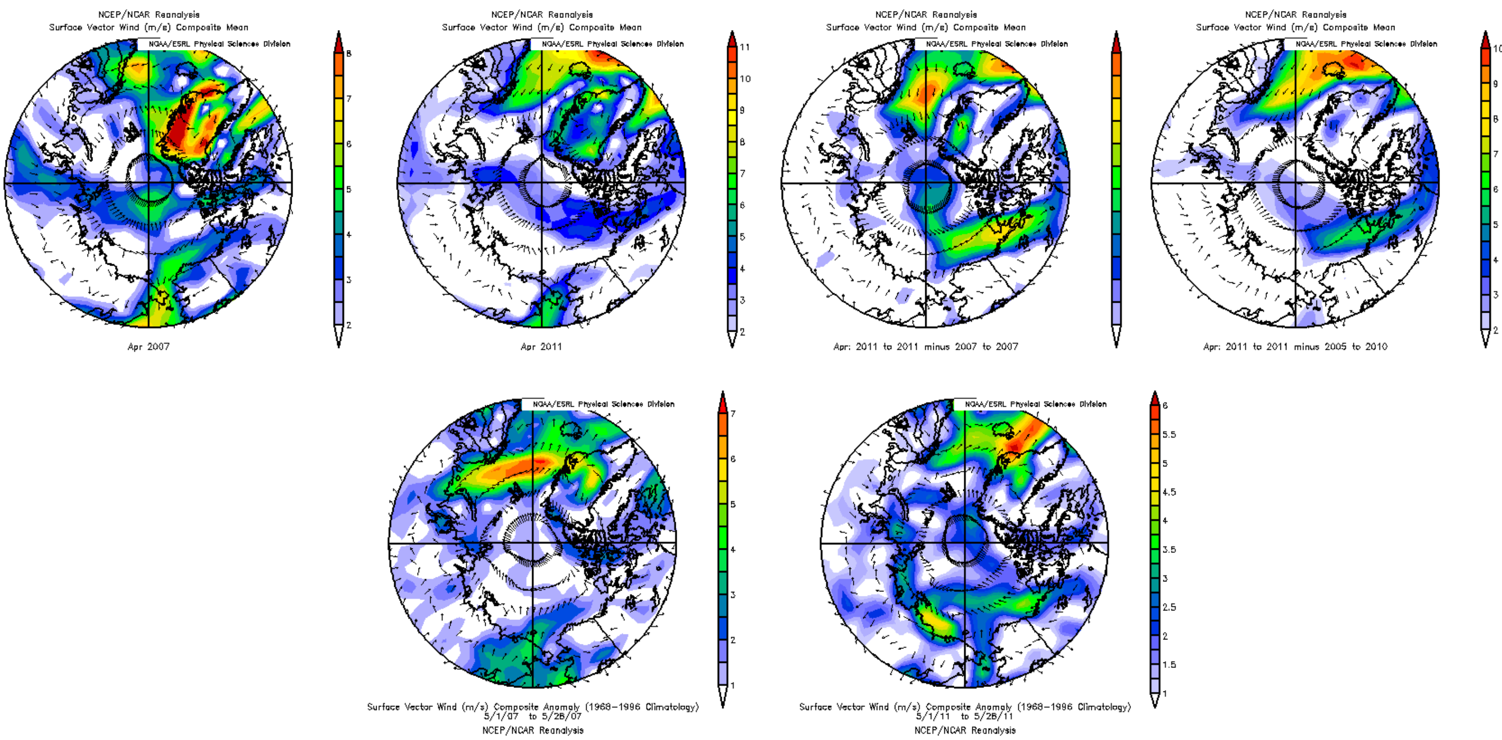

Figure 4. Surface winds for April, 2007, 2011, the difference between 2011 and 2007, in addition to the difference between 2011 and years with record minima in sea ice extent (2005 – 2010), shown in top row. Surface wind anomalies for May, 2007, and May, 2011, shown in second row. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/.

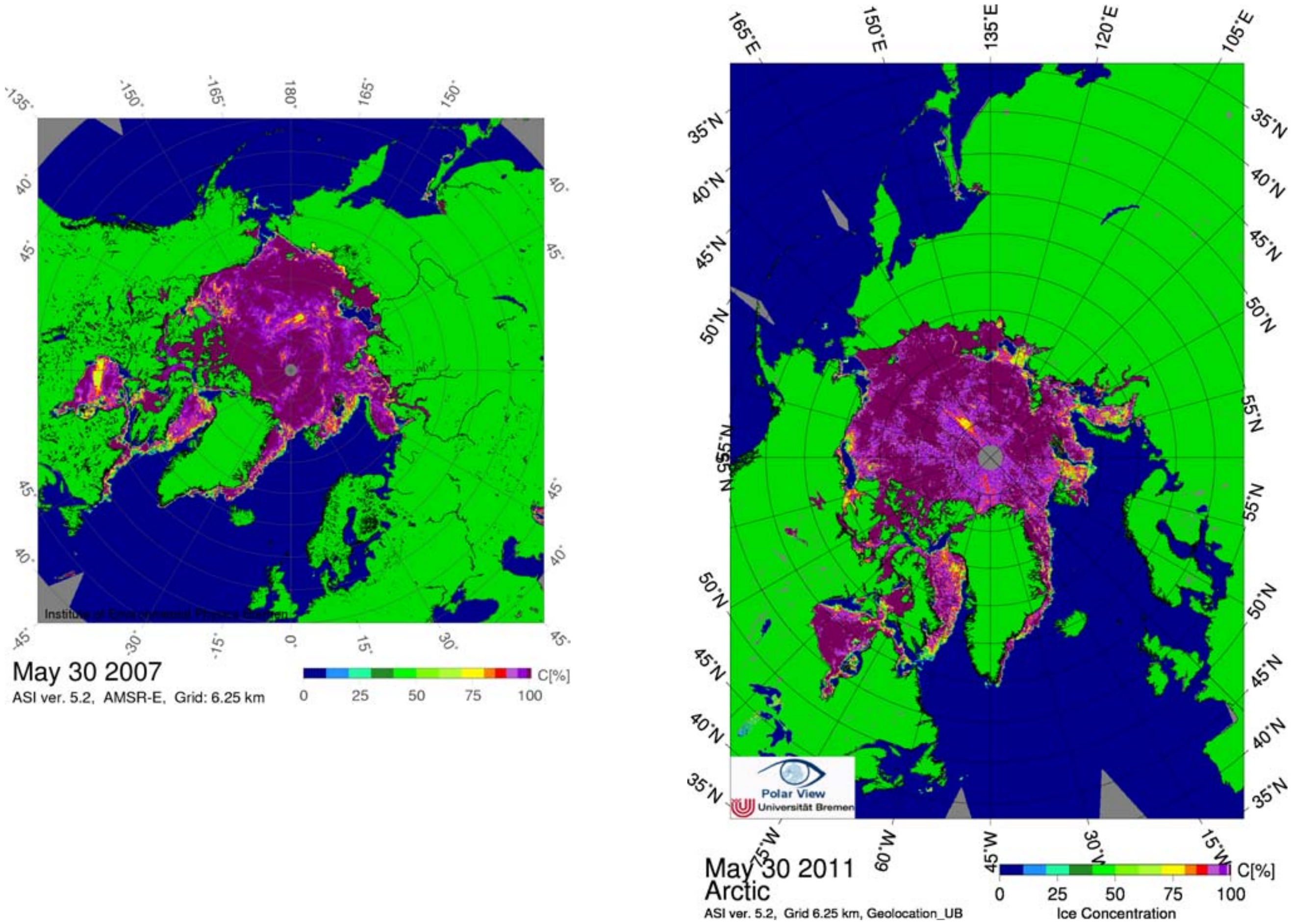

Figure 5. AMSR-E sea ice maps of sea ice concentrations in the Arctic for May 30, 2007 and May 30, 2011. Image provided by the University of Bremen at http://www.iup.uni-bremen.de:8084/amsr/.