

Explanation of the Morison and Untersteiner Estimate of 2009 Summer Ice Extent

Our forecast of the September arctic sea ice extent was mainly qualitative argument guided by several principles, observations, intuition, and guesswork:

- 1. Complex systems are capable of flipping off the deep end, but they prefer not to.**
- 2. After the extreme 2007 minimum, the ice cover has shown to be capable of a slight recovery, despite the anomalous heat storage in the ocean at the end of summer.**
- 3. The ice export through Fram Strait has shown no significant trend during the past 30 years (Kwok, Spreen et al., and others).**

Thus, the loss of ice during the past decade should be dominated by melting within the Arctic Basin. [This guided Norbert's thinking. Jamie feels that the short-term surges in ice export (e.g., summer 2005 and 2007) can inordinately affect minimum ice concentration, and worked on the estimate under the assumption of no pathological ice drift during the summer of 2009.]

4. Given item 3, above, the energy for causing a negative ice balance must come from radiation, ocean heat flux, or some anomalous distribution of the seasonal snow fall, for instance, more autumn snow to slow down accretion and provide more meltwater and melt ponds in spring. Sporadic snow measurements by NPEO did not indicate increased snow thickness.

5. Snow cover appeared light and temperatures were very cold during the spring 2009 North Pole Environmental Observatory (NPEO) buoy deployment.

6. The NPEO met buoy and web camera buoy (Fig. X) indicated that snow & ice melt was delayed until about July 10, 2 weeks later than usual.

7. Polyakov et al. reported recent cooling of the Atlantic layer in the Eurasian Basin.

For these reasons we expected the ice extent to recover from 2008 to 2009 a similar amount to the recovery from 2007 to 2008 (see 2) plus a little for the added factors of little snow (see 5), late melt (see 6 and Fig. X), and some cooler water (see 7). Our estimate for 2009 was 5.2×10^6 km².

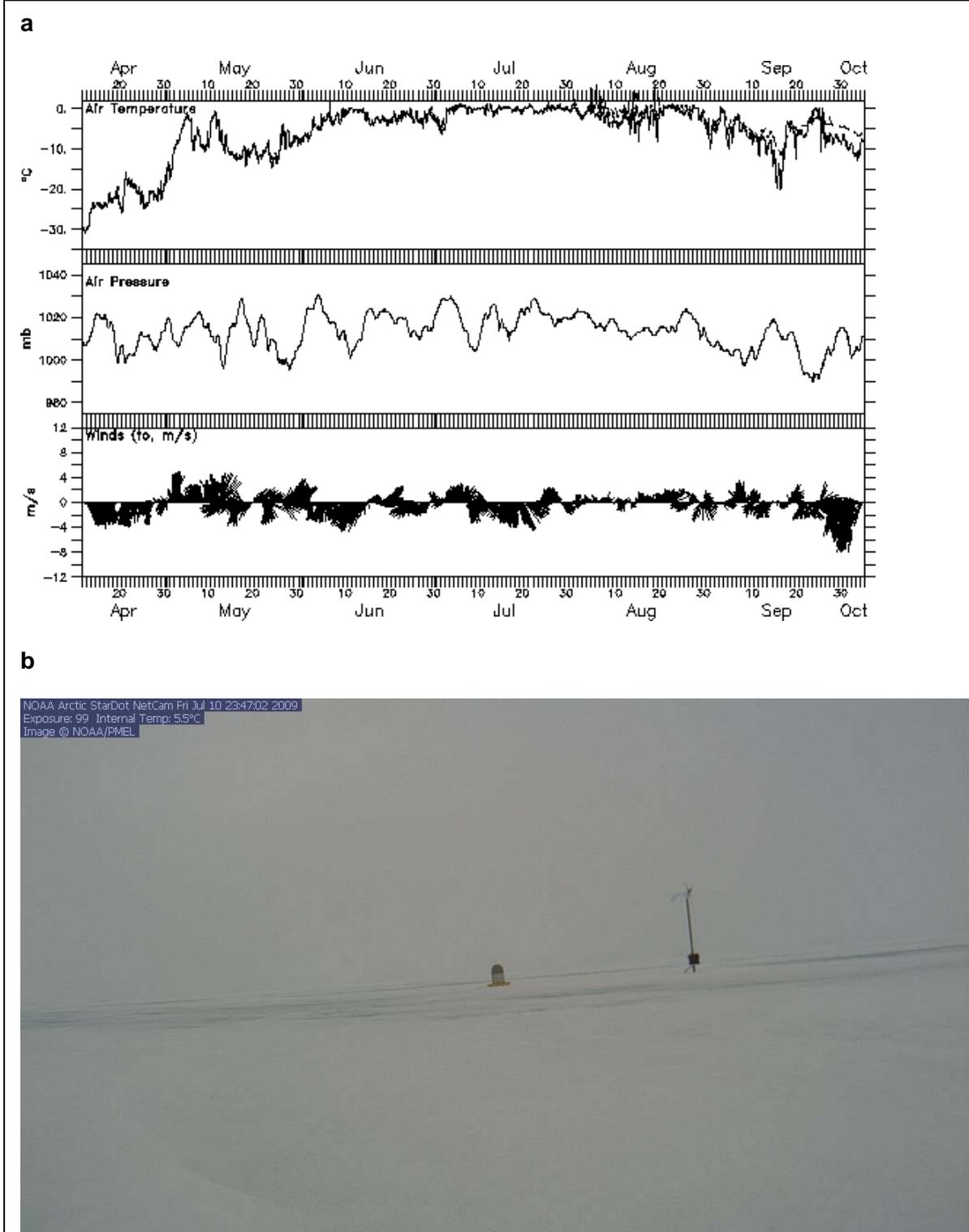


Figure X (a) Air temperature, pressure, and wind from the North Pole Environmental Observatory (NPEO) Automated Drifting Station in the central Arctic Ocean. Except for a short period, air temperature was below freezing until July 1. (b) Web camera image from the NPEO Automated Drifting Station on July 10, 2009, when the first significant melt water appeared.