Observations for Climate:
Measuring the Upper Layer Temperature of the Arctic Ocean (UpTempO)

http://psc.apl.washington.edu/UpTempO/

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ABSTRACT

The surface layer (0-50 m) of the Arctic Ocean has in recent years experienced unprecedented summertime warming. The causes are still under investigation, but are undoubtedly related to extreme summer sea ice retreat (Figure 1), which allows more atmospheric heating and northward advection of warm subarctic waters.

Warming surface waters in turn melt more sea ice ("ice-albedo feedback") and delay fall ice growth. They also affect marine ecosystems, atmospheric boundary layer characteristics, and water mass formation. Presently, we can observe ocean surface temperatures by satellite (Figure 1), although these data need more validation and do not tell us about the vertically integrated heat content of the upper ocean. Hydrographic cruise data can measure sub-surface warming, but provide only a "snapshot" view of the warming at one time during summer. Ice-based buoys exist that can measure temperature profiles, but these are not optimized for observing the open sea.

Thus our objective is to fill this gap in the Arctic Observing Network measurement strategy, i.e., to measure the time history of summer warming and subsequent fall cooling of the seasonally open water areas of the Arctic Ocean. We will focus on those areas with the greatest ice retreat, i.e., the northern Beaufort, Chukchi, East Siberian, and Laptev Seas. We plan to maintain an array of inexpensive ocean thermistor string buoys in the seasonally ice-free regions of the Arctic Ocean (e.g. Figure 2).

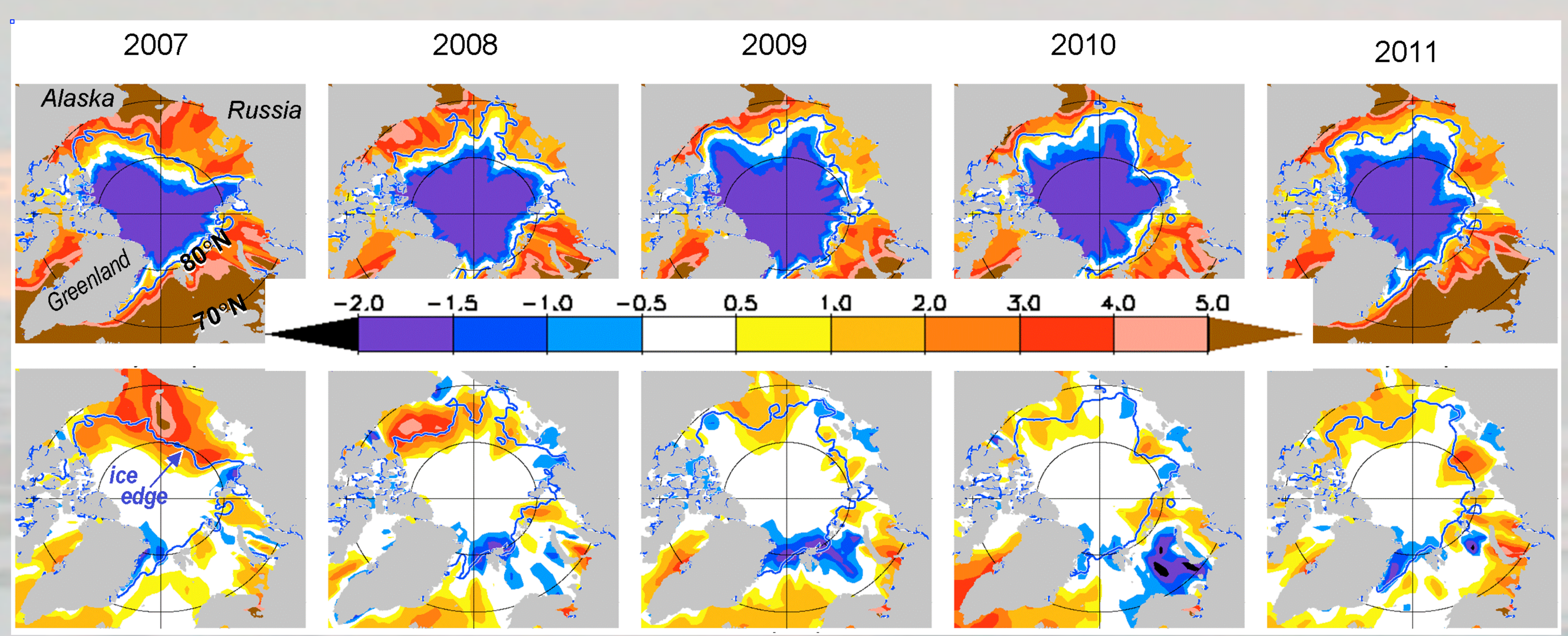

Figure 1. Satellite-derived August Sea Surface Temperature (SST) in upper panels, and anomalies (relative to the 1982-2006 August mean) in lower panels from the past 5 years (color bar in °C applies to all panels). These plots use monthly average data from the Advanced Very High Resolution Radiometer [Reynolds, et al., 2002]. Also shown is the passive microwave – derived August-mean ice edge (15% concentration contour, blue) from the Reynolds product.

Acknowledgements

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The UpTempO Buoy

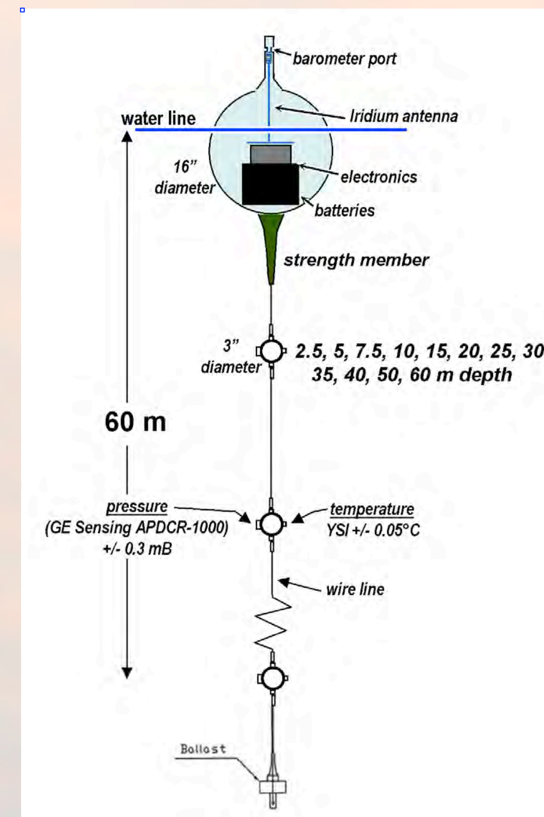

Figure 2. UpTempO buoy schematic. Standard nominal thermistor depths are shown, with ocean pressure sensors at 20 m and 60 m. The buoy is shipped in a box 2 foot cubed and 100 pounds (including pallet). Deployment is in open water using a small boat, or lowered from the side of an icebreaker, or placed in a small hole drilled in an ice floe (with the hull resting at the top of the hole).

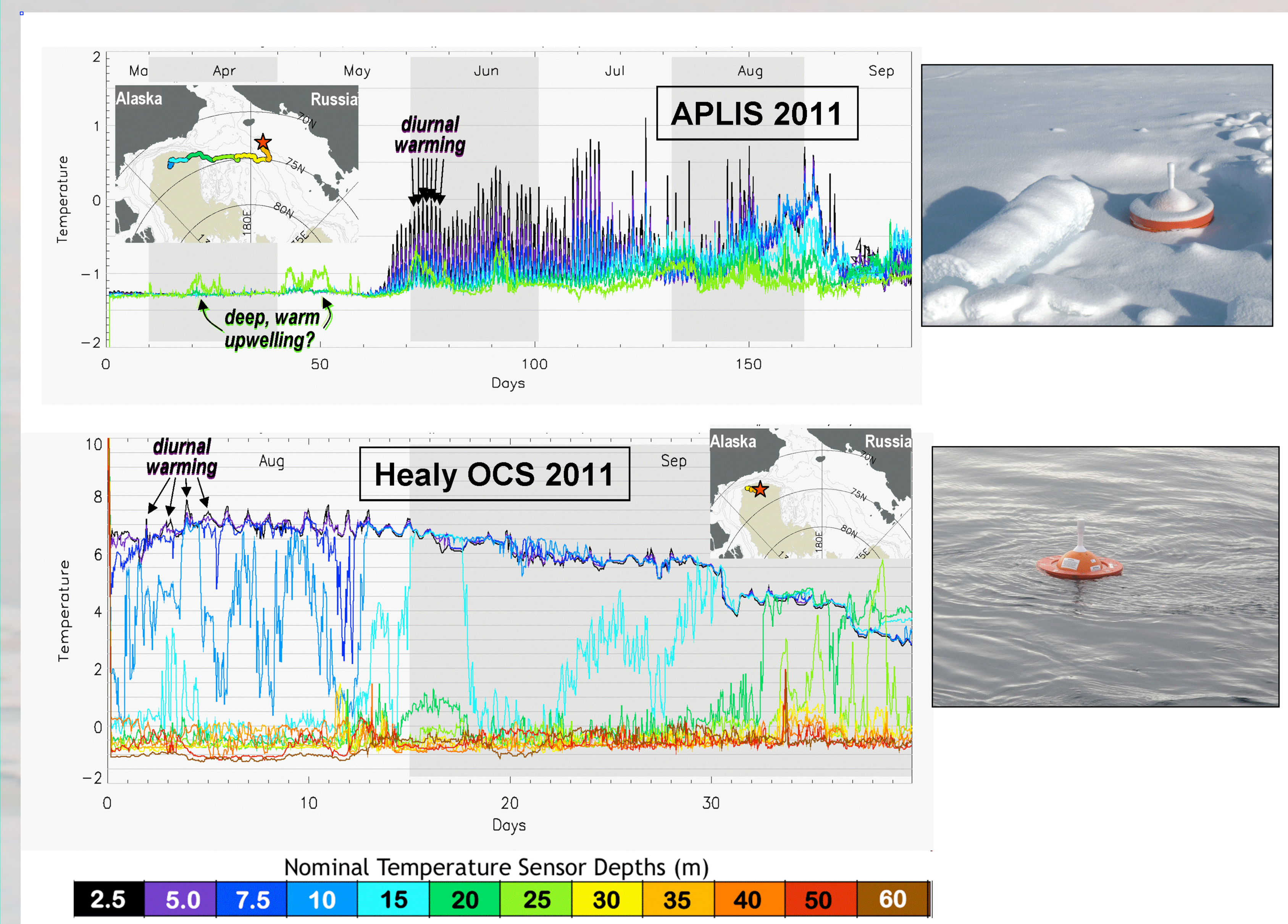

Figure 3. UpTempO buoy temperature time series at each thermistor through September 25 from two 2011 deployments. Colors represent different depths, from uppermost (black) through deepest (green for APLIS, brown for Healy OCS. Deepest values are overplotted on top of shallow values (i.e, an isothermal layer is colored by its deepest value). (top) A "short" 28 meter model deployed on March 22 at the U.S. Navy APLIS ice camp, which drifted generally westward over the summer (see map inset; red star denotes position on September 25). (bottom) A "standard" 60 m long model deployed on August 17 in open water in nearly the same location as the APLIS camp (see map inset) during the Outer Continental Shelf (OCS) cruise of the U.S. Coast Guard icebreaker Healy. Photos at the right were taken shortly after deployment of each buoy.

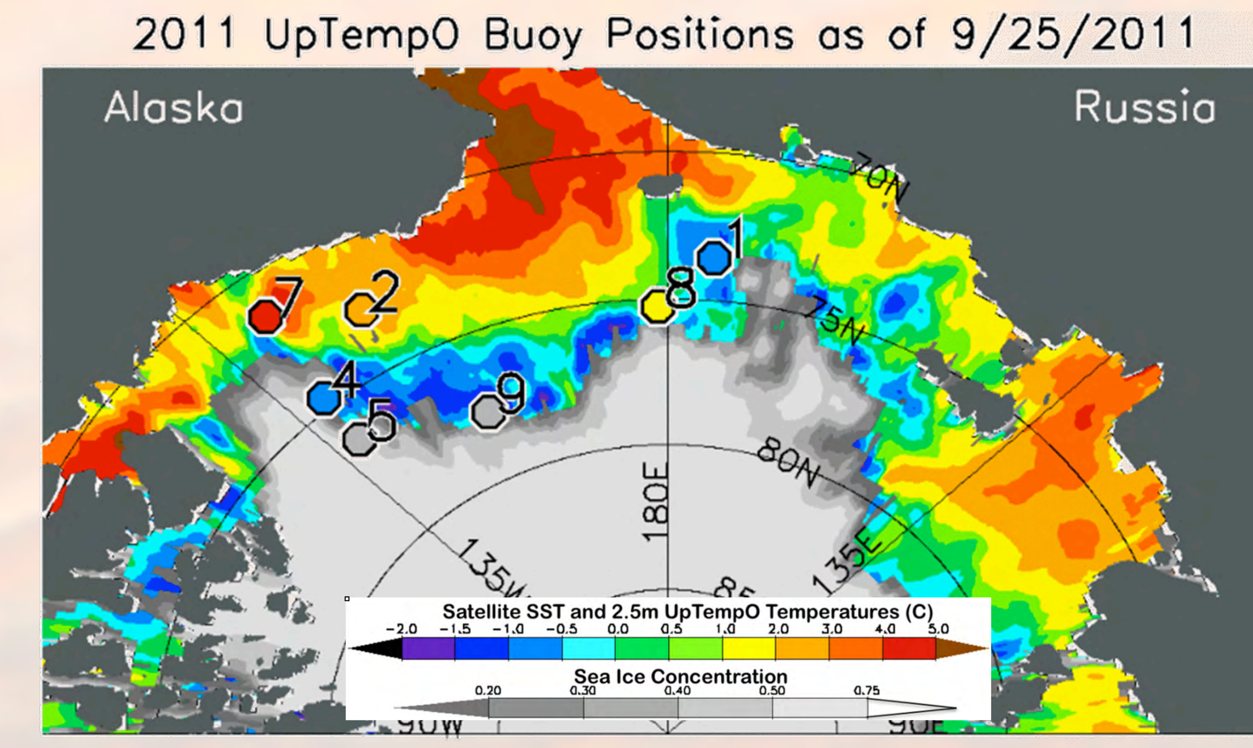

Figure 4. September 25, 2011 sea surface temperature (SST) from a daily version of the satellite product shown in Figure 1 (contours) and the 2.5 meter depth temperature from UpTempO buoys (dots) using the same color scale. Also shown is sea ice concentration provided by the SST product. APLIS 2011 is "1" and Healy OCS 2011 is "2." Buoys with 2.5 m thermistors not reporting are colored gray.

Preliminary Results

Figure 3 shows results from two buoys deployed in 2011. The first buoy (APLIS 2011) was deployed in March in an ice floe at the U.S. Navy ice camp in the southern Beaufort Sea. A cold isothermal layer initially extends from the surface to 25 m, although occasionally warmer water is seen at 25 m depth that may be a signature of sub-surface warm layer upwelling events [Shaw, et al., 2009]. Ocean surface layers start to warm in early May, when the snow cover in nearby Barrow, Alaska was observed to disappear (H. Eicken, pers. comm.). This may indicate that solar radiation is penetrating through the bare ice at this time, although temperatures quickly rise above zero at 2.5 meters depth, indicating that the buoy eventually melted out into open water. We also note a remarkable diurnal cycle of > 1°C amplitude that has just recently been described using buoy data from the southern Barents Sea [Eastwood, et al., 2011], but has never before been reported for the Arctic Ocean.

The second buoy in Figure 3 (Healy OCS 2011) was deployed in August in open water at nearly the same location as the APLIS 2011 deployment in March. Upper ocean temperatures approached 8°C, but this extraordinarily warm water was generally confined to an isothermal layer of only ~7.5-15 meters thick, below which lay a very sharp thermocline and much colder waters. Again, a diurnal cycle of roughly the same amplitude as at APLIS 2011 is, although its signal may be swamped by strong winds and it is clearly weakening toward the end of the time series as fall approaches.

Figure 4 shows UpTempO buoy positions and 2.5 meter depth ocean temperature, with contours of satellite SST and sea ice concentration. There is general agreement between the satellite product and the buoy data, although a cold bias in the satellite data is seen that will be further investigated.

As the extent of the seasonal ice zone continues to grow, upper ocean data will become even more crucial to a variety of scientific and applied fields.