

Validation of Water Depth Measurements at the Mass Balance Site, 2009 and 2010

Preliminary comparison with NOAA offshore sea level data

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Executive Summary

Water depth measurements at the SIZONet Mass Balance Site, seasons 2009 and 2010, are compared with water level measurements at an offshore buoy operated by NOAA. Preliminary comparisons show excellent agreement until 25 May 2009 and 23 May 2010, respectively, the absence of phase lag, and a systematic amplitude error of approximately 5% and 2%, respectively. Assuming NOAA measurements are error-free, the deviation might be due to errors in the speed of sound of water or damped movement of landfast sea ice with respect to the open ocean. Starting at the end of May, the acoustic sounder of the Mass Balance probe shows signs of vertical slip toward the bottom that reveal themselves as a systematic underrepresentation of the true water level. This is consistent with observations of slip performed directly at the instrument.

Instruments

Water depth at the mass balance probe is measured with a downward-looking acoustic sounder moored in landfast sea ice, landward of potentially grounded pressure ridges. Water depth is inferred from the arrival time of an acoustic echo. This method depends on accurate knowledge of the speed of sound of seawater. Mass balance data are recorded in 15-minute intervals. The sounder was deployed from January 2009 to June 2009, and again from January 2010 to June 2010.

Water depth at the NOAA offshore mooring “Barrow Offshore, AK”, ID: 9494935 (which actually consists of two independent moorings) was measured from August 2008 until August 2009 and again from August 2009 until August 2010. Location 71° 21.6' N, 156° 43.7' W, approx. 4 to 5 km NW of NARL. Water depth was inferred from data acquired by a high-stability pressure sensor (Paroscientific 100 psi sensors in a Seabird SBE26+, logging every 6 minutes, averaging 3 minutes of measurements, specified to about 3 mm equivalent water depth. Water density is derived from salinity and temperature measurements at the mooring (personal communications, Mike Zieserl, April 2011). I will assume in the following that NOAA data are error-free). Water temperatures ranged from -1.8 °C in winter to +6 °C in August (2008/9-season). Quality-controlled water depth data are available in 6-minute intervals and are used for the analysis below.

Wind speed and direction used below are extracted from the METAR record of the Barrow airport, PABR. Wind direction is reported in steps of 10 degrees.

Methods

For the purpose of the following comparisons, water depth data of both the Mass Balance Probe and the NOAA depth gauge were reduced by an arbitrarily chosen offset to be comparable.

Water depth estimates based on the wind speed were calculated as follows:

$$\text{estimated_depth} = -0.04 \text{ s} \times \text{wind_speed} \times \cos(\text{wind_direction} - 45^\circ),$$

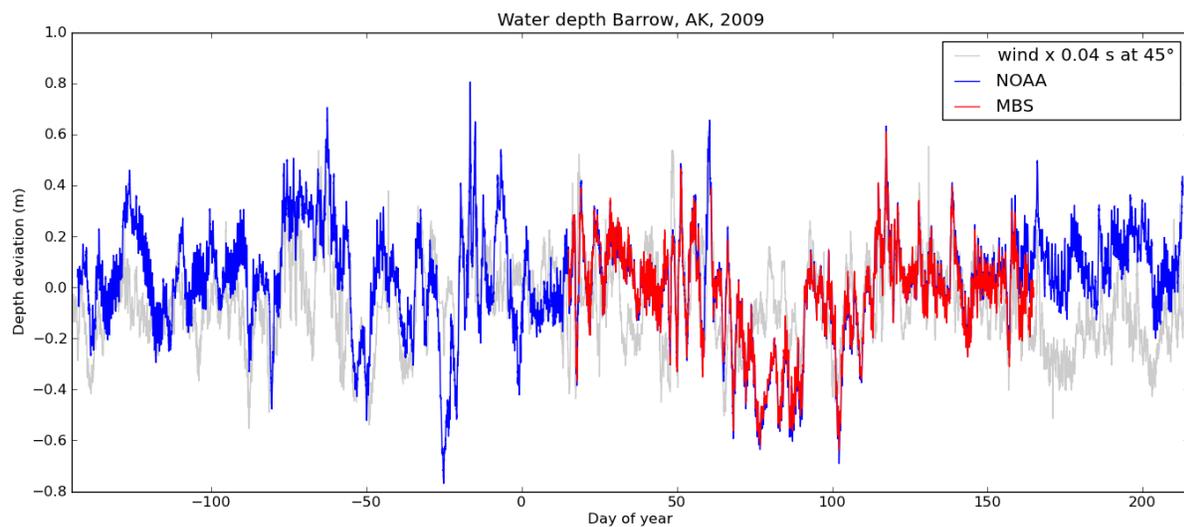
where *estimated_depth* is in meters, *wind_speed* in m/s and *wind_direction* is the direction the wind comes from. The cosine function and the offset of 45° are used to calculate the component of the wind parallel to the coast.

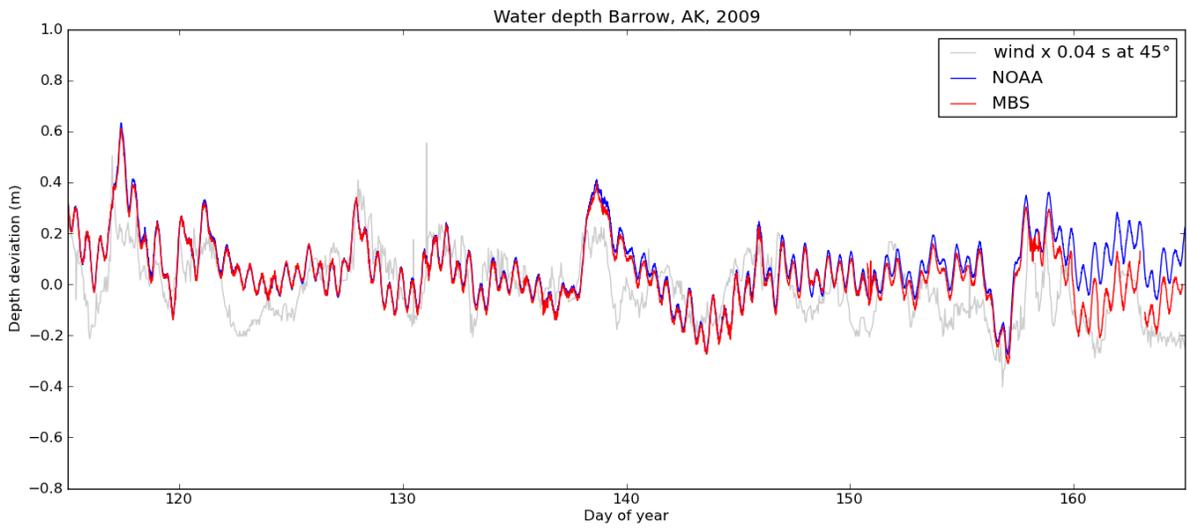
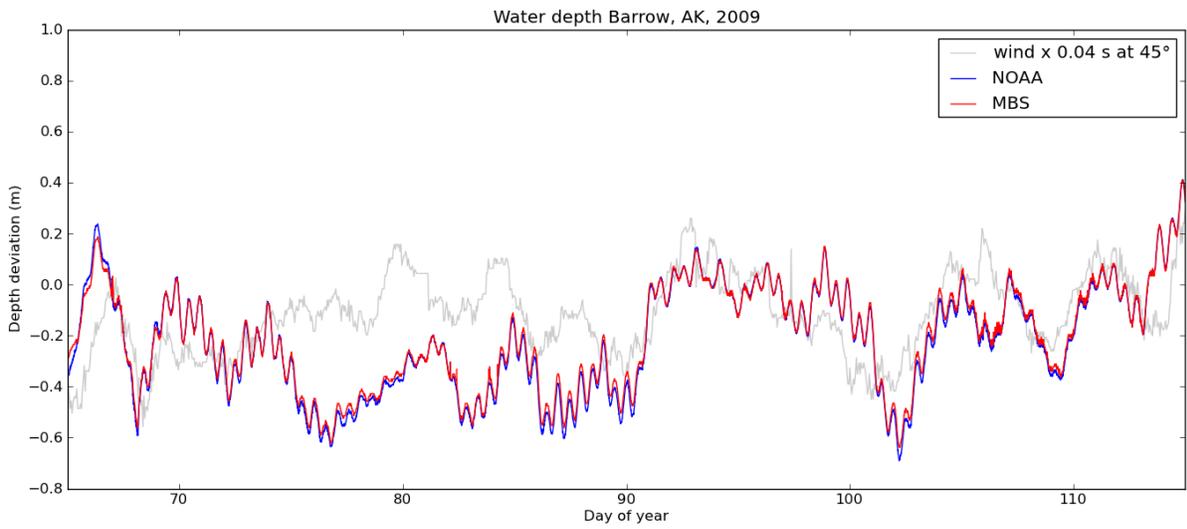
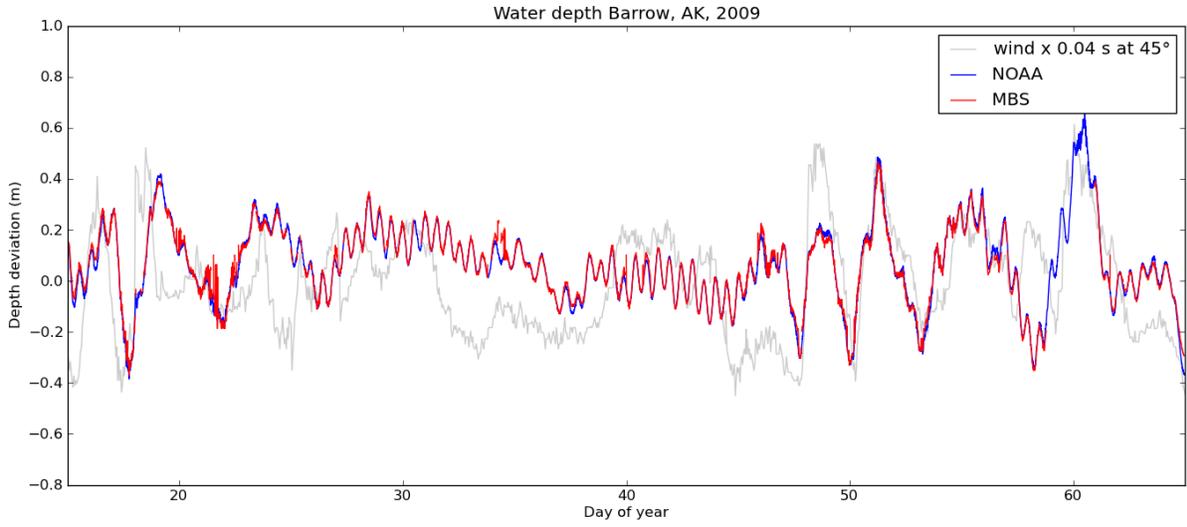
Data are plotted unsmoothed. However, the scatter plots comparing NOAA mooring and MBS data use 1-hour averages (the afore-mentioned 5% error is independent of the bin size).

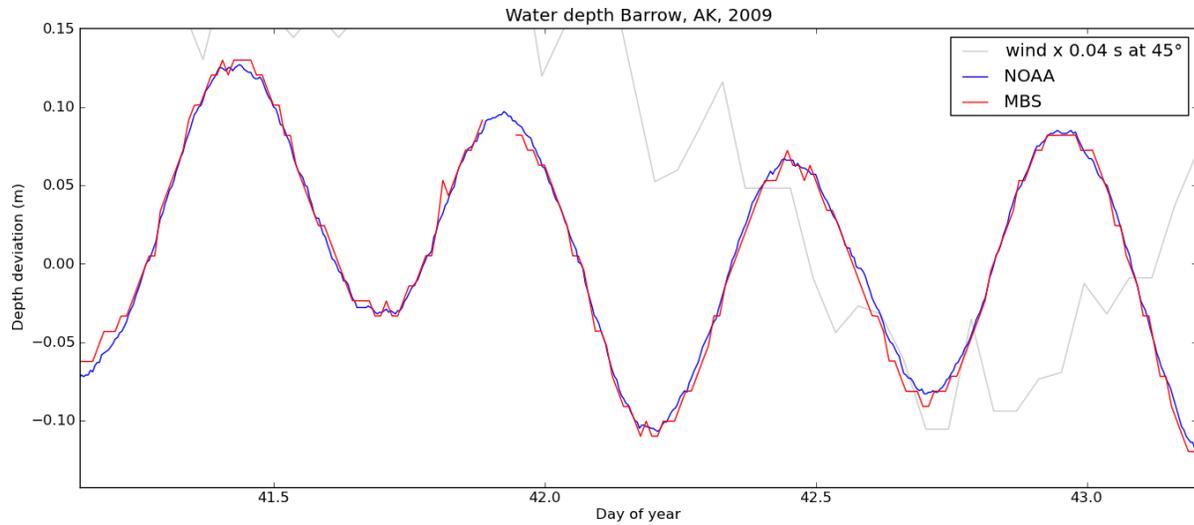
Results 2009

Time Series

The following plots show the time series of water depth measurements and expectations from wind speed parallel to the coast.







Scatter Plots

Comparison between mass balance and NOAA water level measurements.

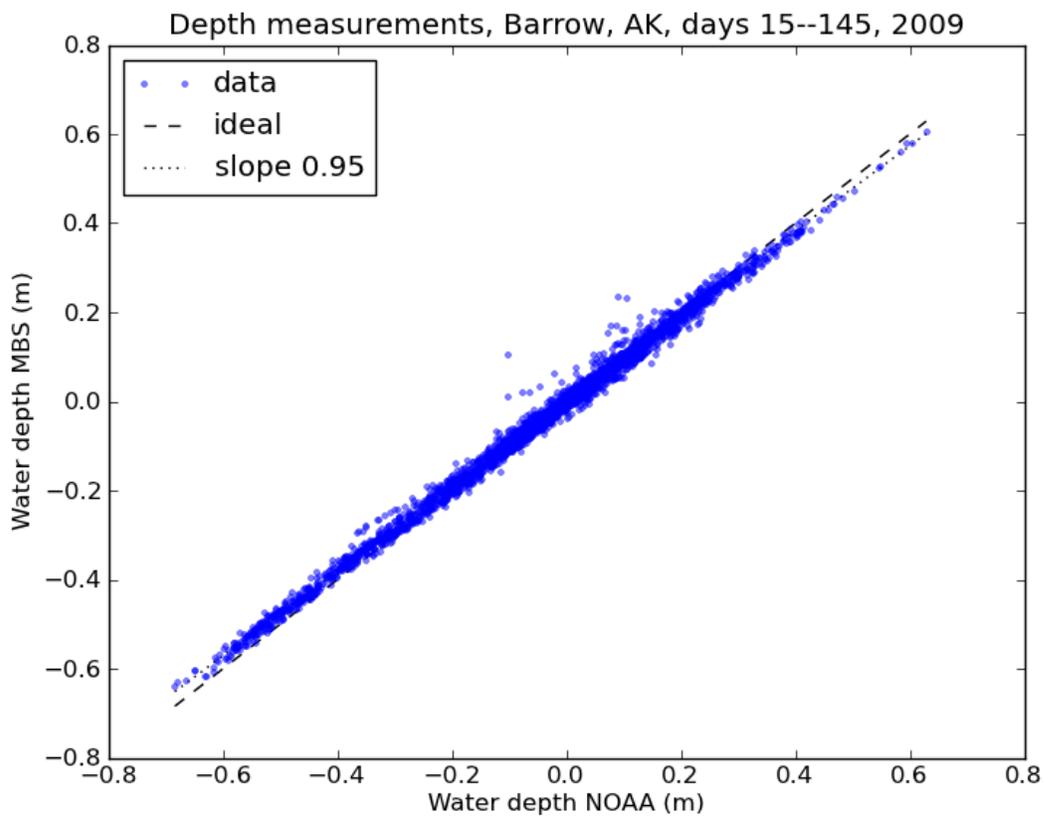


Figure. Comparison of depth measurements. The dotted line is fitted and indicates that the Mass Balance measurements underestimate the deflection amplitude by 5%.

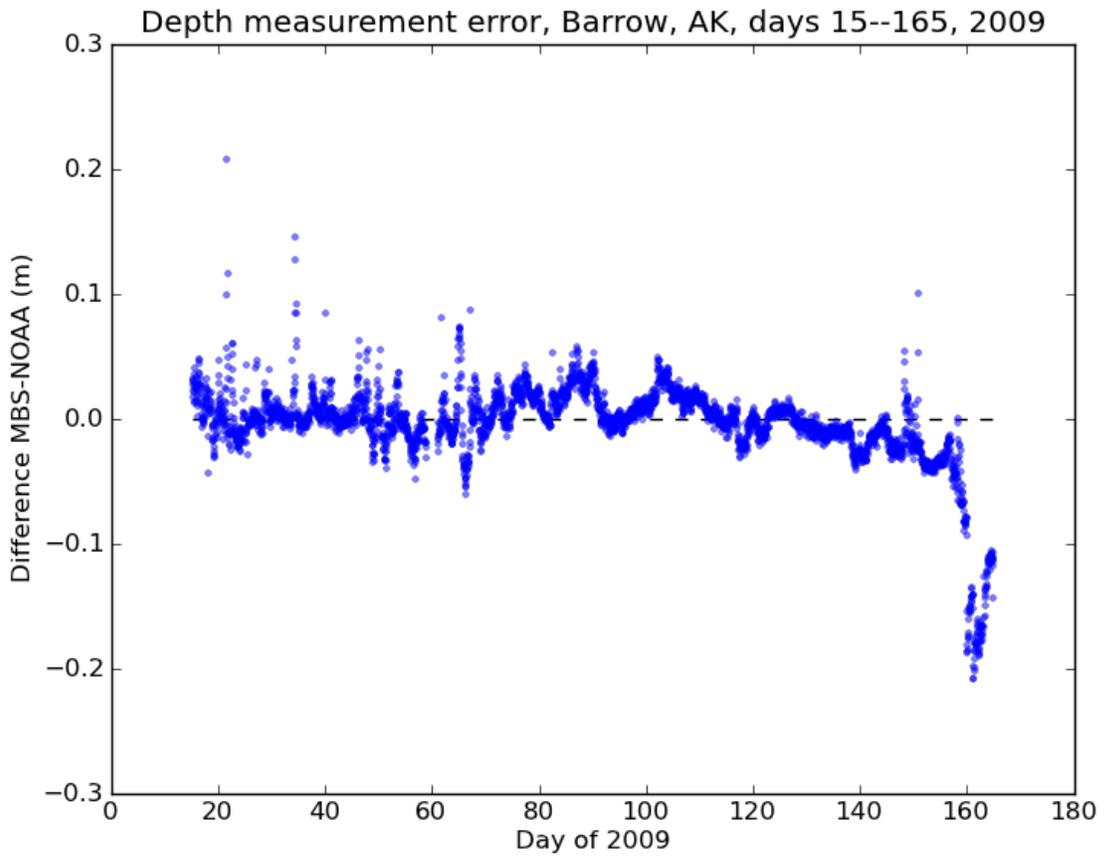
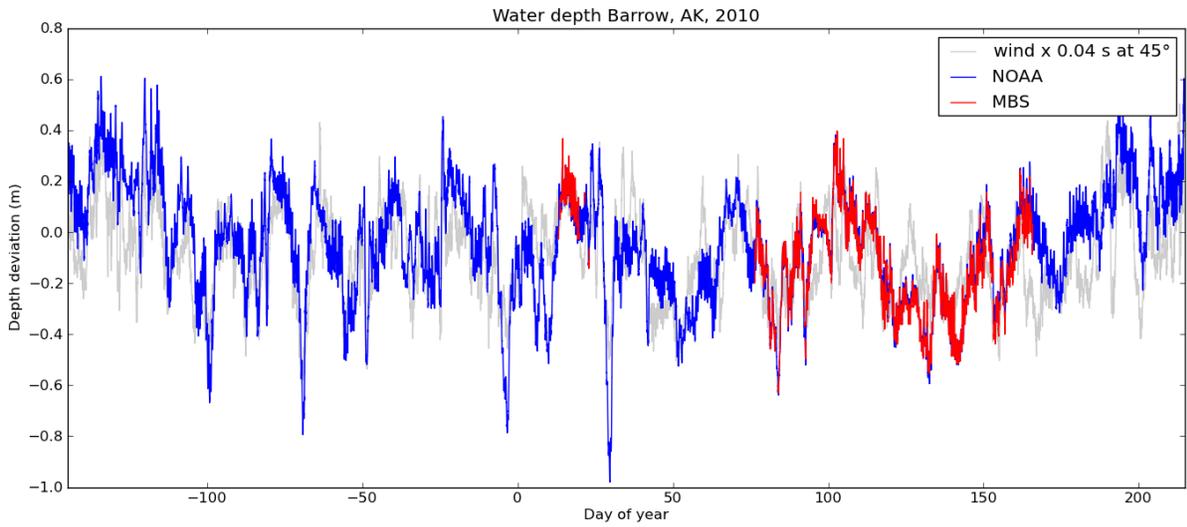
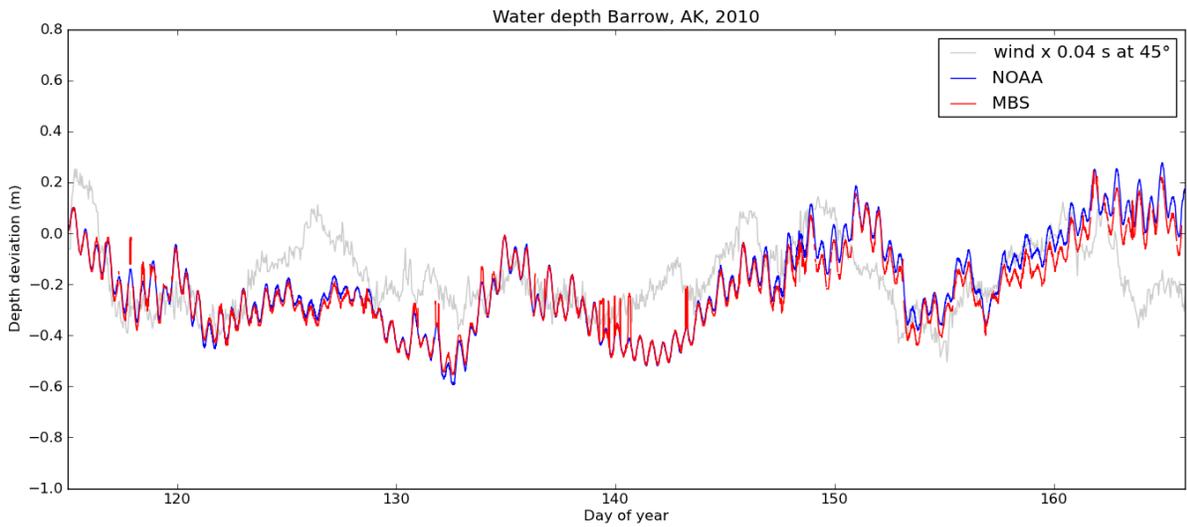
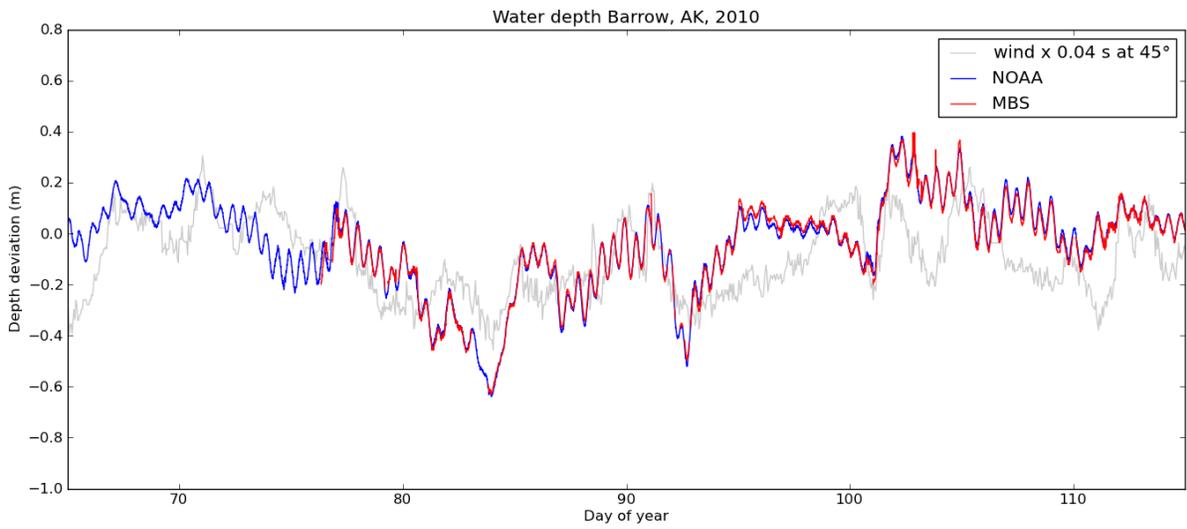
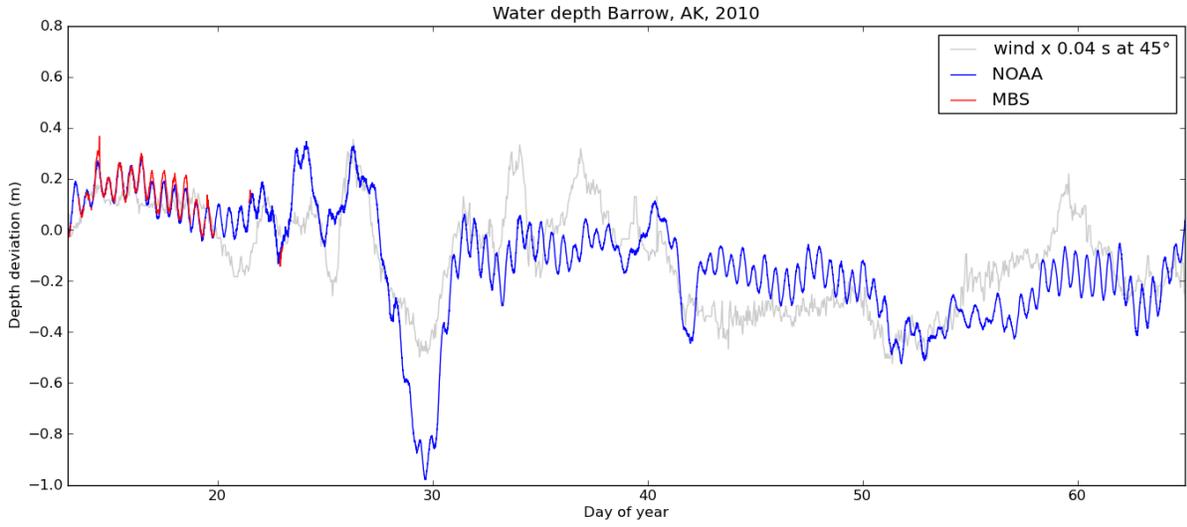
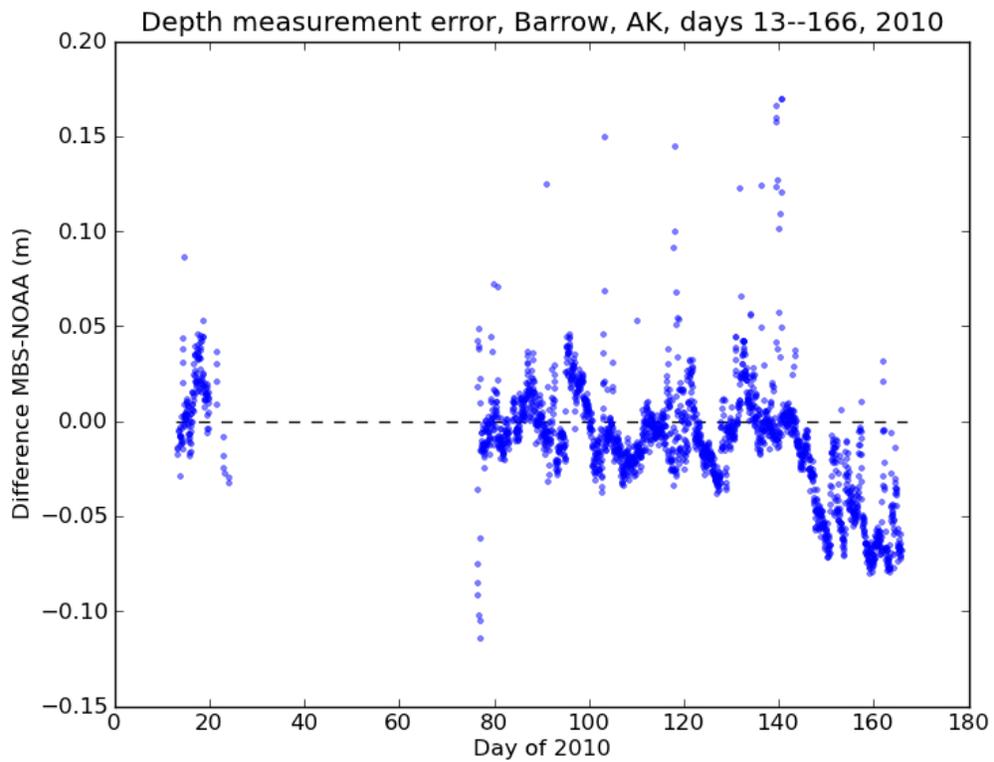
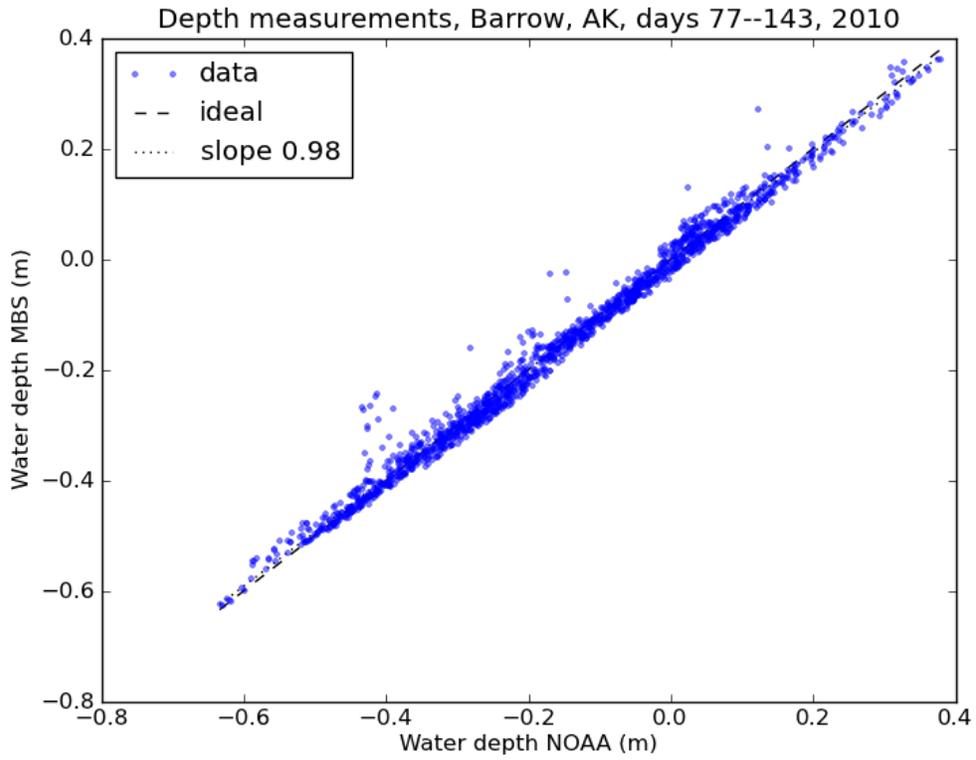


Figure. Overestimate of water depth at the Mass Balance Site with respect to the NOAA offshore mooring.

Results 2010







Summary and Conclusion

Sea level data obtained by the Mass Balance Probe moored in landfast sea ice in 2009 and 2010 are comparable to moored measurements in the open ocean performed by NOAA. The systematic underestimate of deflection could be due to an incorrectly assumed speed of sound or possibly due to some form of damping in the presence of ice. However, nothing is known about systematic errors of the mooring. No systematic phase shift in the measurements is apparent visually. I conclude that, for all but precision measurements and measurements during the melt season, the water depth recorded at the mass balance probe in 2009 and 2010 is an adequate representation of the sea level fluctuations in the Chukchi Sea.