P-54

Intercomparison of Surface Heat Transfer in the Arctic for Multiple Reanalyses, Satellite Data and Field Observations

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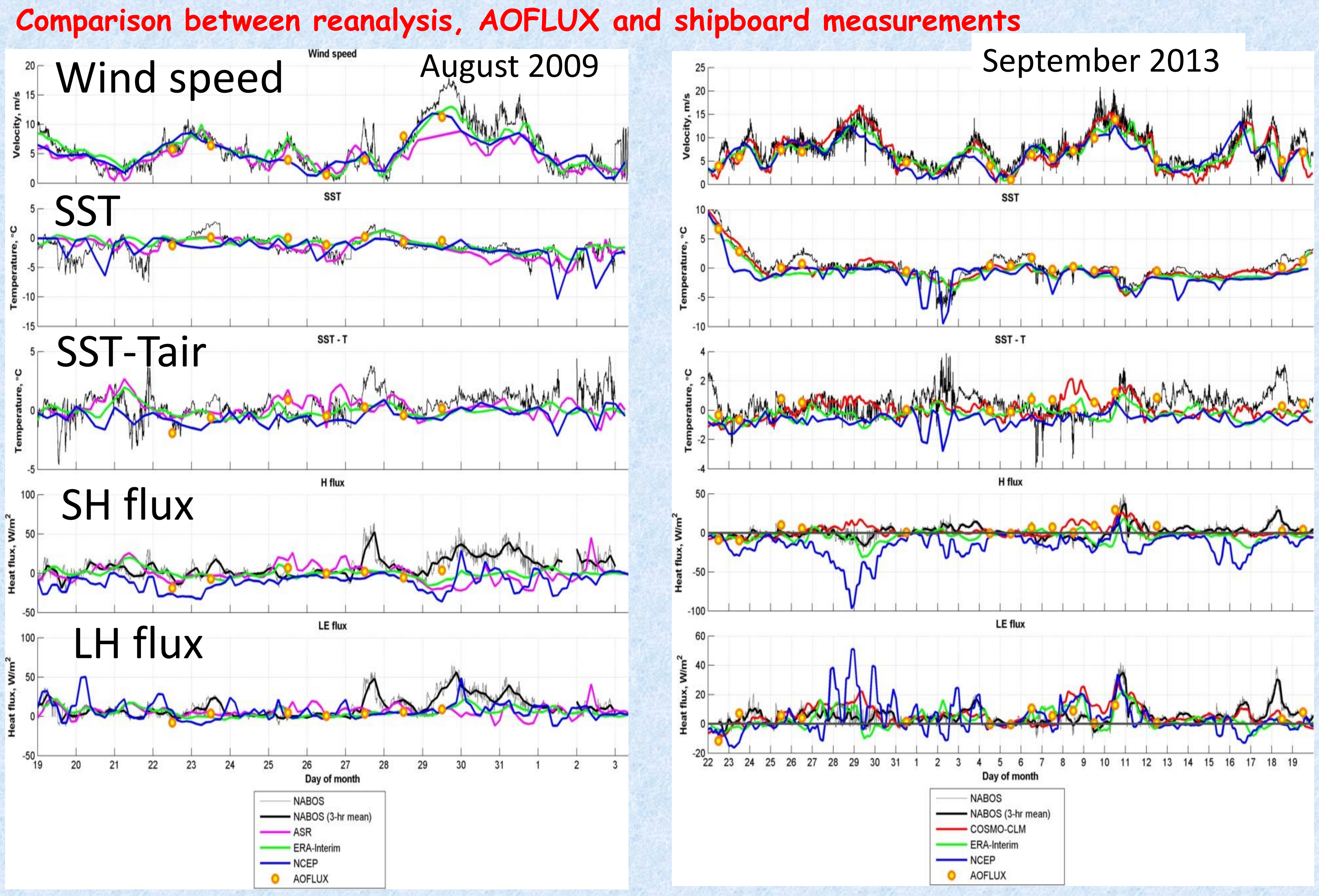
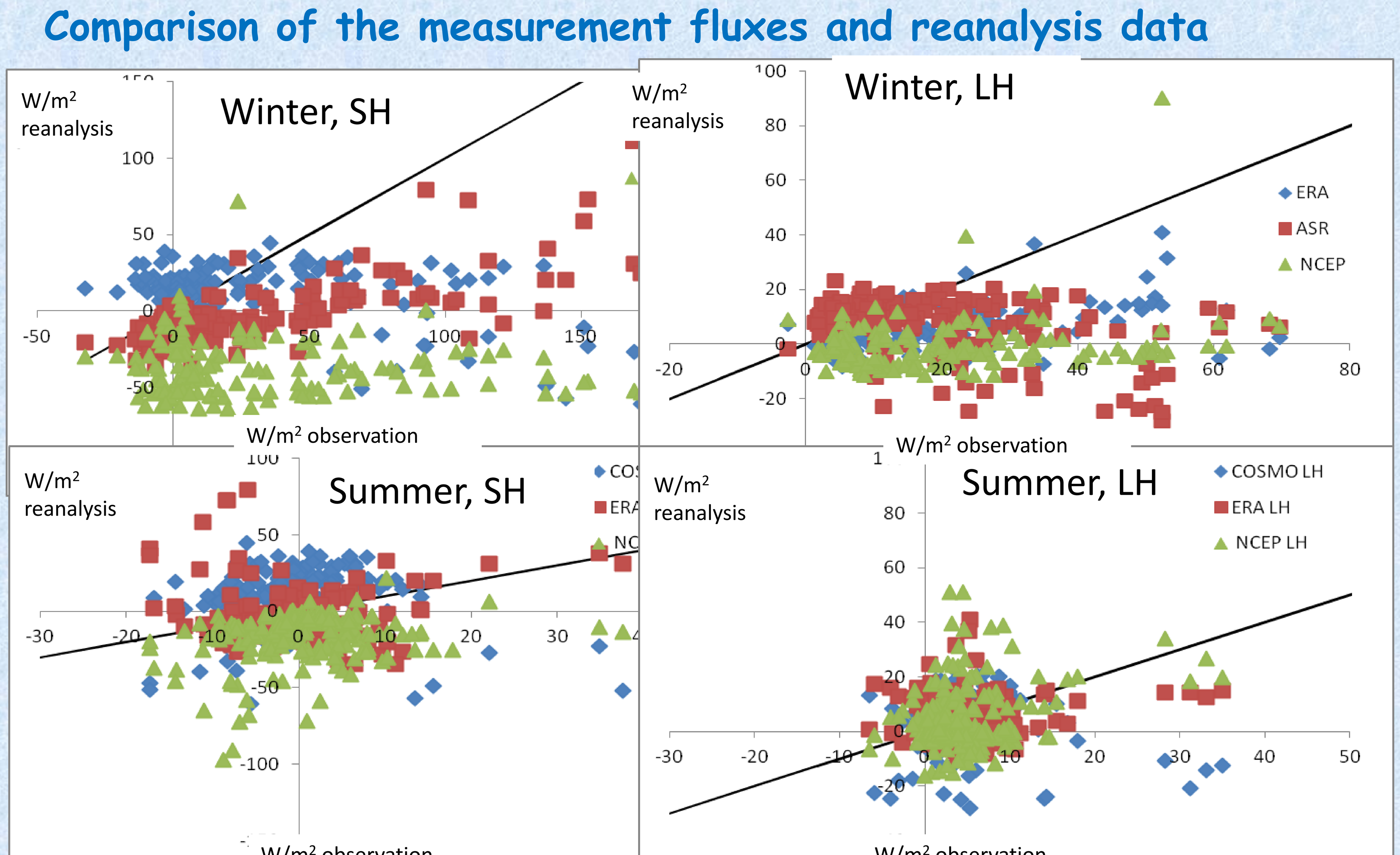
As the performance of the model used in the sea ice simulation in the Intergovernmental Panel on Climate Change (IPCC) for its Fourth Assessment Report (AR4) is an important factor for reproducing the surface air temperature over the Arctic Ocean, reanalyses data have similar problems, at least potentially. Because marginal ice zones are characterized by more complex air-ice-sea interactions, the treatment of the sea ice concentration is a potential source of uncertainty in reanalyses, particularly for surface heat budgets. Accurate turbulent air–sea fluxes (i.e. momentum, latent heat, and sensible heat) are of great interest in regard to a wide variety of air–sea interaction issues. The main sources of such fluxes over the global ocean are numerical weather prediction models, voluntary observing ships, and remotely sensed data. If the heat fluxes over the fractional ice-covered area are calculated implicitly using an ice-concentration cut-off threshold (e.g., 55%, Serreze *et al.* 2009), they are underestimated (overestimated) in a higher (lower) ice-covered area, resulting in misleading surface air temperatures. This study evaluated surface heat fluxes from reanalyses (ERAInterim, NCEP/NCAR, ASR) in the Arctic Ocean during summer and fall. Several types of surface conditions are compared: very new ice cover during a period of low temperature, ice-free conditions, ice with leads and melt ponds, pack ice and marginal ice zone. Meteorological and micrometeorological observations were used to validate the temperature profiles and surface heat fluxes in the major reanalyses.

Comparison between reanalysis, AOFLUX and shipboard measurements

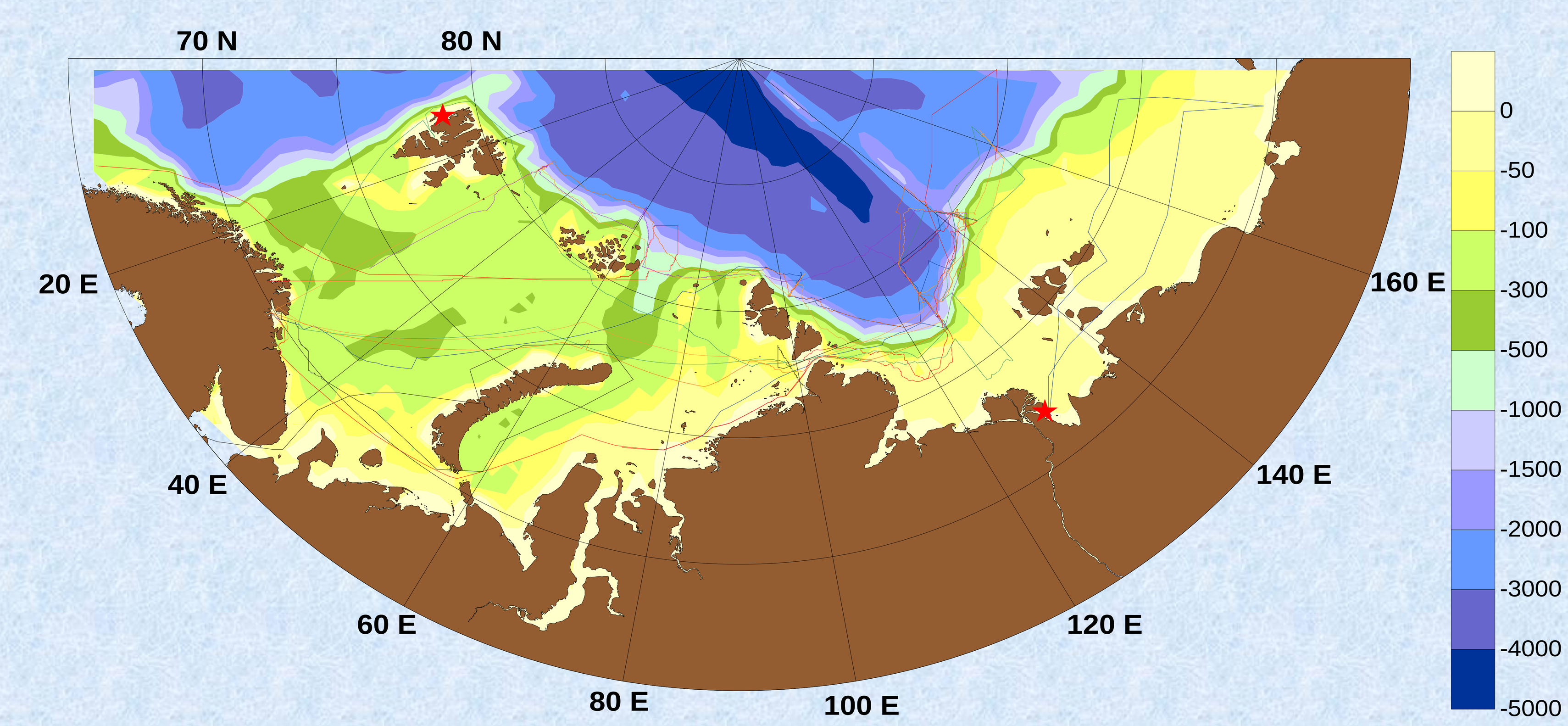


Comparison of the measurement fluxes and reanalysis data



Basic meteorological variables from all reanalyses – i.e., 2m temperature (T_2m), and scalar wind speed (Us) – show reasonable agreement with observations. This means that they generally follow the observed temporal variability. The main contribution to the difference between the data and the reanalysis makes the surface temperature. The largest differences are observed in fall time. At that time, measurements were carried out in the area of consolidated ice cover. The vessel normally takes the route with light ice conditions. Therefore, contribution of turbulence fluxes is substantial. In all compared cases the difference between calculated and measured heat fluxes are large enough, especially in the areas of leads and in the marginal ice zones.

For open water validation of the satellite data is performed through a comprehensive comparison with daily, *in situ* values of LHF and SHF. The satellite-derived daily LHF has bias, RMS, and correlation of 5 W m^{-2}, 27 W m^{-2}, and 0.89, respectively. For SHF, the statistical parameters are –2 W m^{-2}, 10 W m^{-2}, and 0.94, respectively. The main departures are found at marginal ice zone, where satellite latent and sensible heat fluxes are generally larger.



Nansen and Amundsen basins observation system (NABOS)

http://nabos.iarc.uaf.edu/

Correlation between in situ measurements and other data set under different ice condition in the Arctic ocean.

Ice condition	Sensible heat, H			Latent heat L		
	NSEP	ERA	AOFLUX	NSEP	ERA	AOFLUX
Open water	0.42	0.46	0.63	0.39	0.42	0.6
ice	0.47	0.53		0.45	0.5	
Margin ice zone	0.24	0.28		0.22	0.26	

CONCLUTION

The results from in situ observations indicate that leads, polynyas, and puddled surfaces can play a significant role in the balance of the Arctic energy budget and climate change, through the turbulent fluxes from the ice free area plus ice mixed regions of the Arctic Ocean.

A computation of sensible heat flux at the surface is formulated on the basis of spatial variations of the surface temperature estimated from satellite data. Based on the comparison of field experiments data, satellite-derived data and reanalysis the causes of underestimation of the values of turbulent heat fluxes in the Arctic modern reanalysis are investigated. Obtained differences are related to the temperature and structural inhomogeneity of the surface and the development of space-organized convection fields. Reanalyses data are sometimes used to calculate the surface heat budgets over polynyas and to estimate ice production in polar/sub-polar oceans. In particular, the near-surface air temperature and wind fields, which are difficult to observe using satellites or with in-situ measurements are key parameters for estimating turbulent heat fluxes. If the sea-ice concentration and SST in reanalyses are not treated appropriately, careful attention is needed when using the resultant air temperature for such calculations.

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