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Reconstruction of observationally-based 130-year (1880-2010) time series of surface turbulent fluxes in the North Atlantic: prospects for studying North Atlantic climate variability on decadal to centennial time scales

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Surface turbulent fluxes are critically important for understanding the mechanisms driving ocean-atmosphere coupling on all time scales. At the same time, inhomogeneous sampling does not allow for development of observational time series of surface fluxes for the periods longer than several last decades. We present the methodology for reconstruction of long-term time series of surface turbulent fluxes in the North Atlantic using exclusively Voluntary Observing Ship (VOS) data available from the ICOADS data set. The main idea of the reconstruction is the extensive use of probability distributions of surface fluxes and censored sample theory for minimization and homogenization of time dependent sampling errors. Using this concept we developed 130 year reconstruction of gridded monthly air-sea heat flux anomalies over the North Atlantic (20S - 80N) ocean and analysed the potential of this outstanding product for estimation of long-term variability of air-sea exchanges and the role of air-sea fluxes in forming climate variability and change. Reconstructed time series reveal statistically significant centennial and longer trends in surface fluxes over the North Atlantic mid latitudes and subtropics (up to 2-3 W/m2 per decade). These trends become several times stronger over the last several decades. Furthermore, reconstructed time series allow for the effective analysis of multidecadal climate variability. Long-term time series of surface fluxes in the North Atlantic were used to analyse the links between sea-air heat exchange and SST taken from the latest updates of HadSST. De-trended time series of surface fluxes and SST have shown that on multidecadal time scale there is a clear positive correlation between surface heat fluxes southeast of Newfoundland (positive fluxes are directed from the ocean to the atmosphere) and the North Atlantic SST averaged over the latitudinal band from 35N to 50N (used as Atlantic Meridional Overturning Circulation, MOC index). At the same time, at interannual time scales there has been identified quite strong negative correlation between surface fluxes and SST over the mid latitudinal North Atlantic. Thus, on interdecadal time scale, increasing/decreasing SST results in the increase/decrease of the heat flux from the ocean to the atmosphere, implying the impact of MOC on the atmosphere through surface flux anomalies (the Bjerknes mechanism). However, on a shorter interannual time scale SST is likely to passively react to the changes in surface fluxes showing the decrease/increase under the influence of the positive/negative surface flux anomalies.