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Extratropical cyclone induced sea surface temperature anomalies in the 2013/14 winter

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The 2013/14 winter averaged sea surface temperature (SST) was anomalously cool in the mid-North Atlantic region. This season was also unusually stormy with extratropical cyclones passing over the mid-North Atlantic every 3 days. However, the processes by which cyclones contribute towards seasonal SST anomalies are not fully quantified. In this paper a cyclone identification and tracking method is combined with ECMWF atmosphere and ocean reanalysis fields to calculate cyclone-relative net surface heat flux anomalies and resulting SST changes. Anomalously large negative heat flux is located behind the cyclones cold front resulting in anomalous cooling up to 0.2K/day when the cyclones are at maximum intensity. This extratropical cyclone induced 'cold wake' extends along the cyclones cold front but is small compared to climatological variability in the SST's. To investigate the potential cumulative effect of the passage of multiple cyclone induced SST cooling in the same location we calculate Earth-relative net surface heat flux anomalies and resulting SST changes for the 2013/2014 winter period. Anomalously large winter averaged negative heat flux occurs in a zonally orientated band extending across the North Atlantic between 40-60 ^{o}N. The 2013/2014 winter SST cooling anomaly associated with air-sea interactions (anomalous heat flux, mixed layer depth and entrainment at the base of the ocean mixed layer) is estimated to be -0.67 K in the mid-North Atlantic (68% of the total cooling anomaly). The role of cyclones is estimated using a cyclone masking technique which encompasses each cyclone centre and its trailing cold front. The environmental flow anomaly in 2013/2014 sets the overall tripole pattern of heat flux anomalies over the North Atlantic. However, the presence of cyclones doubles the magnitude of the negative heat flux anomaly in the mid-North Atlantic. Similarly, the environmental flow anomaly determines the location of the SST cooling anomaly but the presence of cyclones enhances the SST cooling anomaly. Thus air-sea interactions play a major part in determining the extreme 2013/2014 winter season SST cooling anomaly. The environmental flow anomaly determines where anomalous heat flux and associated SST changes occur and the presence of cyclones influences the magnitude of those anomalies.