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Extreme air-sea surface turbulent fluxes in mid latitudes - estimation, origins and mechanisms

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Extreme turbulent heat fluxes in the North Atlantic and North Pacific mid latitudes were estimated from the modern era and first generation reanalyses (NCEP-DOE, ERA-Interim, MERRA NCEP-CFSR, JRA-25) for the period from 1979 onwards. We used direct surface turbulent flux output as well as reanalysis state variables from which fluxes have been computed using COARE-3 bulk algorithm. For estimation of extreme flux values we analyzed surface flux probability density distribution which was approximated by Modified Fisher-Tippett distribution. In all reanalyses extreme turbulent heat fluxes amount to 1500–2000 W/m2 (for the 99th percentile) and can exceed 2000 W/m2 for higher percentiles in the western boundary current extension (WBCE) regions. Different reanalyses show significantly different shape of MFT distribution, implying considerable differences in the estimates of extreme fluxes. The highest extreme turbulent latent heat fluxes are diagnosed in NCEP-DOE, ERA-Interim and NCEP-CFSR reanalyses with the smallest being in MERRA. These differences may not necessarily reflect the differences in mean values. Analysis shows that differences in statistical properties of the state variables are the major source of differences in the shape of PDF of fluxes and in the estimates of extreme fluxes while the contribution of computational schemes used in different reanalyses is minor. The strongest differences in the characteristics of probability distributions of surface fluxes and extreme surface flux values between different reanalyses are found in the WBCE extension regions and high latitudes.

In the next instance we analyzed the mechanisms responsible for forming surface turbulent fluxes and their potential role in changes of midlatitudinal heat balance. Midlatitudinal cyclones were considered as the major mechanism responsible for extreme turbulent fluxes which are typically occur during the cold air outbreaks in the rear parts of cyclones when atmospheric conditions provide locally high winds and air-sea temperature gradients. For this purpose we linked characteristics of cyclone activity over the midlatitudinal oceans with the extreme surface turbulent heat fluxes. Cyclone tracks and parameters of cyclone life cycle (deepening rates, propagation velocities, life time and clustering) were derived from the same reanalyses using state of the art numerical tracking algorithm. The main questions addressed in this study are (i) through which mechanisms extreme surface fluxes are associated with cyclone activity? and (ii) which types of cyclones are responsible for forming extreme turbulent fluxes? Our analysis shows that extreme surface fluxes are typically associated not with cyclones themselves but rather with cyclone-anticyclone interaction zones. This implies that North Atlantic and North Pacific series of intense cyclones do not result in the anomalous surface fluxes. Alternatively, extreme fluxes are most frequently associated with blocking situations, particularly with the intensification of the Siberian and North American Anticyclones providing cold-air outbreaks over WBC regions.