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Extreme Events and the General Circulation of the Atmosphere: Dynamics and Observations

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This study explores the dynamical role of non-Gaussian potential vorticity variability (extreme events) in the zonally averaged circulation of the atmosphere in a stochastic framework. First the zonally averaged skewness and kurtosis patterns of relative and potential vorticity anomalies from NCEP/NCAR reanalysis data are presented. In the troposphere, midlatitude regions of near zero skewness coincide with regions of maximum variability. Equatorward of the northern hemisphere stormtrack positive relative/potential vorticity skewness is observed. Poleward of the same stormtrack the vorticity skewness is negative. In the southern hemisphere the relation is reversed, resulting in negative relative/potential vorticity skewness equatorward, and positive skewness poleward of the stormtrack.

The dynamical role of extreme events in the zonally averaged general circulation is then explored in terms of the potential enstrophy budget by linking eddy enstrophy fluxes to a stochastic representation of non Gaussian potential vorticity anomalies. The stochastic model assumes that potential vorticity anomalies are advected by a random velocity field. The assumption of stochastic advection allows for a closed expression of the meridional enstrophy flux: the potential enstrophy flux is proportional to the potential vorticity skewness. This key result is confirmed by observations. That is, potential enstrophy fluxes are induced by non-Gaussian potential vorticity variability. In a Gaussian atmosphere the enstrophy fluxes disappear. Thus extreme events play an important role in the potential enstrophy budget and the related general circulation of the atmosphere.