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Maintenance of Baroclinicity in the Atlantic Storm Track and its Relation to the Sea Surface Temperature Gradient along the Gulf Stream

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The maintenance of baroclinicity along mid- and high-latitude storm tracks is a matter of ongoing debate. We devise a diagnostic based on the tendency equation for the slope of isentropic surfaces – a measure of the baroclinicity. The tendency comprises contributions from dynamic processes, latent heat release, radiation and subgrid-scale turbulence, which incorporates the effect of sensible heat fluxes. We present a climatology (for winter 2009 and 2010) of these tendencies over the North Atlantic and discuss the relevance of the SST gradient associated with the Gulf Stream.

We find that adiabatic tilting flattens the isentropic surfaces, reflecting the action of growing baroclinic cyclones. This tendency is balanced climatologically by the generation of isentropic slope by diabatic processes. In the lower troposphere, the most intense diabatic increase of slope is found along the oceanic frontal zone associated with the Gulf Stream and at higher latitudes in the Labrador Sea, the Nordic Seas and the Barents Sea. Latent heat release and sensible heat fluxes both contribute substantially in these regions. A quantitative analysis of cold-air outbreaks emphasizes their important role in restoring the slope in the lower troposphere over the Gulf Stream region and off the sea-ice edge at high latitudes. We also present composites of strong events of slope tendency and latent heating as well as surface fluxes, pinpointing the relative contribution of the cold or warm sector of a cyclone to the slope tendency in the Gulf Stream region. In the upper troposphere, latent heat release due to cloud microphysical processes is the dominant mechanism maintaining the slope.