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Upper-level disturbances over the low-latitude North Atlantic: Forecast quality, predictability and dynamics

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Upper-level disturbances (ULDs) penetrating from the extratropics into low latitudes are a frequent feature of the synoptic-scale circulation over the North Atlantic and can be involved in significant weather events such as heavy precipitation over the western and northern parts of Africa, or Saharan dust outbreaks. While linear Rossby-wave theory successfully explains many climatological characteristics of ULDs, the factors controlling the evolution of individual disturbances are still not well understood. To date work on this matter is mainly based on statistical analysis of observational data or case studies with numerical models.

The present project is the first to systematically explore the huge dynamical information content of long-term data from the European Centre for Medium-Range Weather Forecasts (ECMWF) operational ensemble prediction system (EPS). A potential vorticity (PV) based algorithm adapted from Wernli & Sprenger (2007) is used to detect ULDs. The algorithm is first applied to operational ECMWF analysis fields to identify dates of ULD occurrence. EPS forecasts for these events are then examined at different lead times. The first objective of this study is an evaluation of the EPS forecast quality focussing on latitudinal, but also on longitudinal displacement in the forecasts. The second objective is an assessment of the predictability of ULD systems, which is done on the basis of the ensemble spread (standard deviation of all ensemble members) and the root mean square error between the analysis and the ensemble forecasts at verification time. A comparison of calculations from several areas and variables is done: (A) PV in the area of the analysed streamer only, (B) PV in a rectangular box around the streamer and (C) geopotential height at 500hPa in the defined box. It is shown that for such limited domains forecasts of ULDs are highly underdispersive (RMSE much larger than spread). The dynamical causes of ensemble divergence are investigated with correlations between the ULD-related PV at verification time and several meteorological fields (e.g., upper tropospheric PV, geopotential height at 500hPa and 200hPa, equivalent potential temperature at 850hPa, vertical wind at 700hPa) at various lead times. Since every ensemble member is a physically realistic realization of a possible synoptic evolution, this correlation approach allows a direct assessment of the dynamical prerequisites for ULD development and propagation, which is the third objective of this study.