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The role of cloud diabatic processes in the life cycle of Atlantic-European weather regimes

Christian M. Grams
Institute of Meteorology and Climate Research (IMK-TRO), Department Troposphere Research, Karlsruhe Institute of Technology (KIT), Germany (grams@kit.edu)

The large-scale midlatitude flow is dominated by Rossby wave activity along the upper-level midlatitude wave guide and jet stream. This activity often occurs in preferred quasi-stationary, persistent, and recurrent states, so-called weather regimes (e.g. Vautard, 1990). Many of these regimes are dominated by a blocking anticyclone. In the Atlantic-European region, weather regimes explain most of the atmospheric variability on sub-seasonal time scales. From a forecasting perspective, the onset, persistence, and transition of weather regimes present a severe challenge in current numerical weather prediction models (Ferranti et al., 2015).

Recently, Pfahl et al. (2015) showed that transport of air mass into the upper troposphere driven by latent heat release in ascending air streams is a first-order process in blocking onset and maintenance. This study systematically investigates the role of such diabatic outflow in the life cycle of all European weather regimes.

An extended definition of 7 year-round Atlantic-European weather regimes from 37 years of ERA-Interim reanalysis data is used (Grams et al. 2017). This is based on an EOF analysis and k-means clustering of normalized low-pass-filtered 500hPa geopotential height anomalies. The weather regime index of Michel and Rivière (2011) is used to further objectively define important life cycle stages such as the regime onset, mature stage, decay, or transition. The role of cloud-diabatic processes in European weather regimes is assessed based on time lagged analysis of warm conveyor belt (WCB) activity at these life cycle stages.

Results indicate that the period prior to regime onset is characterized by important changes in location and frequency of WCB occurrence. These changes persist during the early stage of a regime life cycle and weaken thereafter. Most importantly, prior to the onset of regimes characterized by blocking, a statistically significant increase in WCB activity occurs upstream of the evolving blocking anticyclone even before blocking is detectable. This suggests that the injection of air mass into the upper troposphere by diabatic WCB outflow helps to establish the blocking anticyclone. Furthermore, diabatic WCB outflow helps maintaining the blocking anticyclone later during the life cycle.

This study corroborates the importance of correctly representing cloud-diabatic processes in numerical weather prediction (NWP) models across multiple scales in order to predict the large-scale circulation accurately.

Further reading:
Ferranti, L., et al., 2015: Flow-dependent verification of the ECMWF ensemble over the Euro-Atlantic sector. doi:10.1002/qj.2411.
Grams, C. M., et al., 2017: Balancing Europe’s wind-power output through spatial deployment informed by weather regimes. doi:10.1038/nclimate3338.
Michel, C., and G. Rivière, 2011: The Link between Rossby Wave Breakings and Weather Regime Transitions. doi:10.1175/2011JAS3635.1.
Pfahl, S., et al., 2015: Importance of latent heat release in ascending air streams for atmospheric blocking. doi:10.1038/ngeo2487.
Vautard, R., 1990: Multiple weather regimes over the North Atlantic: analysis of precursors and successors. doi:10.1175/1520-0493(1990)118<2056:MWROTN>2.0.CO;2.