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Interactive detection and visual analysis of 3-D fronts in ECMWF forecasts

Atmospheric fronts are a widely used conceptual model in weather forecasting, most encountered as two-dimensional (2-D) front lines, e.g., on surface analysis charts. The three-dimensional (3-D) dynamical structure of fronts is commonly sketched in 3-D illustrations of idealized weather systems in atmospheric science textbooks. Only recently the feasibility of objective detection and visual analysis of "real"3-D frontal structures within numerical weather prediction data has been proposed, and such approaches are not yet widely known in the atmospheric community. In our work, we investigate the benefit of objective 3-D front analysis for research and forecasting. Our technique builds on a recent gradient-based detection approach, combined with modern 3-D interactive visual analysis techniques, all integrated into the open-source meteorological visualization framework Met.3D. In our presentation, we show case studies of extratropical cyclones and their frontal dynamics. Examples include joint interactive visual analysis of 3-D fronts and warm conveyor belt trajectories, and development of the 3-D frontal structure of the characteristic stages of a Shapiro-Keyser cyclone. We also demonstrate the benefit of our technique for comparative analysis of frontal dynamics in different model simulations provided by the ECMWF, e.g., of different resolution. We argue that the presented approach has large potential to be beneficial for complex studies of atmospheric dynamics and for operational weather forecasting.

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