Interactive 3-D visual analysis of ERA 5 data: improving diagnostic indices for Marine Cold Air Outbreaks

Marcel Meyer¹, Iuliia Polkova², and Marc Rautenhaus¹

¹Regional Computing Center, Visual Data Analysis Group, Center for Earth System Science and Sustainability (CEN), Universität Hamburg, Hamburg, Germany (marcel.meyer@uni-hamburg.de, marc.rautenhaus@uni-hamburg.de)
²Institute of Oceanography, Center for Earth System Science and Sustainability (CEN), Universität Hamburg, Hamburg, Germany (iuliia.polkova@uni-hamburg.de)

We present the application of interactive 3-D visual analysis techniques using the open-source meteorological visualization framework Met.3D [1] for investigating ERA5 reanalysis data. Our focus lies on inspecting atmospheric conditions favoring the development of extreme weather events in the Arctic. Marine Cold Air Outbreaks (MCAOs) and Polar Lows (PLs) are analyzed with the aim of improving diagnostic indices for capturing extreme weather events in seasonal and climatological assessments. We adopt an integrated workflow starting with the interactive visual exploration of single MCAO and PL events, using an extended version of Met.3D, followed by the design and testing of new diagnostic indices in a climatological assessment. Our interactive visual exploration provides insights into the complex 3-D shape and dynamics of MCAOs and PLs. For instance, we reveal a slow wind eye of a PL that extends from the surface up into the stratosphere. Motivated by the interactive visual analysis of single cases of MCAOs, we design new diagnostic indices, which address shortcomings of previously used indices, by capturing the vertical extent of the lower-level static instability induced by MCAOs. The new indices are tested by comparison with observed PLs in the Barents and the Nordic Seas (as reported in the STARS data set). Results show that the new MCAO index introduced here has an important advantage compared with previously used MCAO indices: it is more successful in indicating the times and locations of PLs. We thus propose the new index for further analyses in seasonal climate predictions and climatological studies. The methods for interactive 3-D visual data analysis presented here are made freely available for public use as part of the open-source tool Met.3D. We thereby provide a generic tool that can be used for investigating atmospheric processes in ERA5 data by means of interactive 3-D visual data analysis. Met.3D can be used, for example, during an initial explorative phase of scientific workflows, as a complement to standard 2-D plots, and for detailed meteorological case-analyses in 3-D.