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On the causes of systematic wind turning biases in numerical weather prediction models

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Biases in wind turning across the boundary layer are among the most longstanding and resilient systematic errors of numerical weather prediction models. The wind turning is typically underestimated by 5-10 degrees or even more in short range weather forecasts, both over land and over oceans. In this study we discuss the evolution and possible causes of the wind turning errors in the Integrated Forecasting System of the European Centre for Medium Range Weather Forecasts. We show that these biases are very robust, being confirmed by comparison with synoptic station observations over land and with scatterometer data over the ocean, and have changed little over past 20 years despite the remarkable improvements to the forecasting system. Traditionally it is assumed that most of these errors are due to fact that too much mixing is artificially maintained in stable conditions in global NWP models in order to control NWP skill in the large-scale circulation, and to prevent too cold near-surface temperatures at night. In this study, a wide range of sensitivity experiments is performed to explore to what extent the errors in wind turning are related to mixing in stable boundary layers, and to what extent they are due to other factors such as mixing in unstable layers, top entrainment, cloudy or clear situations, convective momentum transport, or roughness over the oceans.