The Annular Modes in reanalyses: The value of conventional and surface-observation only based reanalyses in the Northern Hemisphere

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We assess the representation of annular mode variability across all available reanalysis products, contrasting "reanalysis uncertainty" associated with our ability to constrain the circulation with available observations (i.e., the inter-reanalysis spread) with "sampling uncertainty" associated with the finite length of the reanalysis records. The annular modes characterize the dominant variability of the extratropical circulation in each hemisphere, quantifying vacillations in the position of the tropospheric jet stream and strength of the stratospheric polar vortex. They provide a metric for assessing the coupling between these jets across time scales, from intraseasonal (associated with Sudden Stratospheric Warmings; SSWs) to decadal, where the formation of the ozone hole drove a poleward shift in the jet stream.

We find that the annular modes are extremely consistent across all modern reanalyses during the satellite era (1979 onward). Consequently, uncertainty in annular mode variability, e.g., the coupling between the stratosphere and troposphere and the variation in amplitude and time scale of jet variations throughout the annual cycle, is dominated by sampling uncertainty. Comparison of reanalyses based on conventional or surface observations alone with those using all available observations confirm that we have limited ability to characterize Southern Hemisphere in the pre-satellite era. In the Northern Hemisphere, however, there is evidence that conventional observations are sufficient, at least from 1958 onward. The addition of two additional decades substantially reduces uncertainty in our ability to quantify the dominate variability of the stratosphere-troposphere system and so demonstrates the value of historic reanalyses.

Implications for the assessment of models, and the strength of coupling between the surface and upper atmosphere will be discussed. In particular, the ERA-20C reanalysis suggests that much of the variability of the stratosphere (e.g., 50 percent of the variance at 10 hPa — such that the reanalysis accurately identifies half of all SSWs since 1958) can be captured in a reanalysis based on surface observations alone. This does not imply that the surface "drives" the variability of the stratosphere, but that the circulation of the atmosphere is tightly coupled across the tropopause.

Key words: annular modes, reanalysis, stratosphere-troposphere coupling