An Intercomparison of Stratospheric Variables from the Recent Reanalyses

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The stratosphere plays a vital role in the earth-climate system. Phenomena such as the Quasi-Biennial Oscillation (QBO), Arctic Oscillation (AO), and sudden stratospheric warmings (SSW) all contribute to climate variability on various time scales. However, long term analysis of the stratosphere remains much more difficult than analysis of the troposphere for several key reasons. (1) Half as many radiosonde observations are made in the lower stratosphere than in the troposphere. The number of radiosonde observations decreases further by an order of magnitude above 10 hPa. (2) Satellite observations of stratospheric temperatures, which began in 1979 with the Stratospheric Sounding Unit (SSU), were made without consideration of overlapping observations, making intersatellite calibration very challenging for climate analysis purposes. (3) Ground-based ozone measurements of the stratosphere via ozonesondes are even fewer in number and frequency than radiosondes. Ozonesondes, like radiosondes, are only capable of observing the lower stratosphere. Ozone profile measurements via satellite are taken mostly in the nadir and are thus limited spatially. Satellite observations of ozone also suffer from intersatellite calibration due to multiple satellite systems. (4) Humidity observations in the stratosphere are inconsistently measured via research satellites and hence have not been assimilated in the reanalyses. In order for the reanalyses to have humidity above the tropopause the analysis and forecast models either must parameterize humidity or must derive it by monitoring the transport across the tropopause and via water vapor budget processes in the stratosphere. (5) There was a major change in the quality and density of satellite measurements when the TOVS system was replaced by the ATOVS system in 1998. In the stratosphere this meant that the three vertically broad channels on the SSU and Microwave Sounding Unit Channel 4 measurements were replaced by 6 narrower channels on the Advanced Microwave Sounding Unit (AMSU-A).

These issues posed significant problems for accurate stratospheric representation in the earlier NCAR/NCEP and ERA-40 reanalyses. Only recently, in the preparation of the current set of reanalyses, have these issues been addressed and to some extent resolved. To show how well these new reanalyses represent the stratosphere, we will present an intercomparison of the most recent reanalyses: CFSR, MERRA, ERA-Interim, and JRA-25, focusing upon the temperatures, winds, ozone, and humidity in the stratosphere. Comparisons of the reanalyses' stratospheric variables against non-assimilated observations where ever and whenever possible will be presented. An examination of how well these reanalyses capture the Quasi-Biennial Oscillation will also be presented. We will examine the agreement between these reanalyses below and above 10 hPa. How the SSU to AMSU-A transition impacted some reanalyses more than others will be presented. Finally, we compare how well the reanalyses capture dynamics, including wave driving, stratospheric sudden warmings, and the impact of El Nino Southern Oscillation (ENSO) on the stratosphere.

NCEP is in the process of producing a lower resolution coupled reanalysis called CFSR-Lite (CFSRL). CFSRL contains many improvements upon the CFSR. An early examination of how the CFSRL compares against CFSR, MERRA and ERA-Interim will be presented.

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