Comparison of ECMWF and NCEP Reanalyses Using Synoptic Classification

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Reanalysis data are now regarded by most atmospheric scientists as the best representation of the large scale dynamical and thermal-dynamical states of the atmosphere. In most of the current reanalysis products cloud properties are not assimilated directly from observed data but produced by cloud parameterizations using assimilated dynamical fields. Radiative fluxes are then computed from the assimilated thermodynamic profiles and the model-generated cloud properties. Thus, the accuracy of cloud properties and radiative fluxes is dependent on model cloud parameterizations and radiative models, rather than on actual data. This research is motivated by the need to understand in different reanalysis products, how the cloud properties and radiation budget, and furthermore the cloud parameterization scheme used to generate them, differ from one another, as well as how these products agree with observation data.

One primary assumption in this study is that in relatively short time scales, the micro-physical and thermal-dynamical properties depends on the dynamical fields as well as the water vapor distributions of the atmosphere, rather than the opposite. Based on this assumption, an objective classification technique that combines reanalyses data and cloud radar observations is used to identify commonly occurring atmospheric states or patterns. The atmospheric states are defined only based on large-scale, synoptic variables from reanalyses, while radar observations of cloud are used to refine states to ensure that each state is statistically meaningful. This classification technique provides a direct link between atmospheric states and the expected statistical distribution of physical and thermal dynamical variables that we anticipate to study, such as cloud properties, surface fluxes and radiation budget.

The reanalysis outputs that are currently being used are the NCEP Climate Forecast System Reanalysis (CFS-R) and the ECMWF Interim Reanalysis (ERA-I). By now, ensemble runs of the classification has been carried out at Southern Great Plain (SGP), USA, using both ERA-I and CFS-R respectively. Theoretically, each state represents a real atmospheric pattern. Therefore, many similar states are expected to be found in most of these independent runs, which are defined as robust states. A rigorous statistical test that combines corresponding time series and radar observations is designed to sort out robust states. We are only interested in robust states because they are expected to be seen in the classification products using different reanalysis datasets.

There are two ways to study the robust states. For each reanalysis, it is used to understand the local synoptic systems in different ways. In the monthly distribution of the states, it can be identified that some states occur mostly in cold seasons while others mostly in warm seasons; in the hourly distribution, there is diurnal variability in the occurrence of the states. The average meteorological fields and progression diagrams show the probability of transitions from one state to any other states and how these transitions may be associated with real atmospheric processes. On the other hand, now that two sequences of robust states are available, we can correlate the state occurrence by time and match the states between two sequences. By comparing the time occurrences, cloud profiles and meteorological fields of corresponding states, it is possible to identify similar patterns in different reanalyses with a

relatively high statistical significance. By associating observation data with classification results, it is possible to obtain the distributions of a number of physical and thermal-dynamical variables, to provide better understanding on how well these reanalysis products simulate atmospheric patterns.

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