The character of discontinuities in MERRA reanalysis and some preliminary homogenization results

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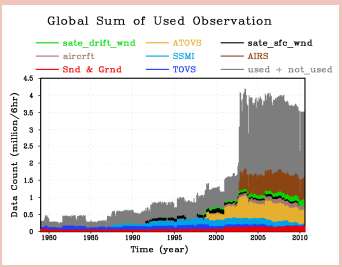
Introduction

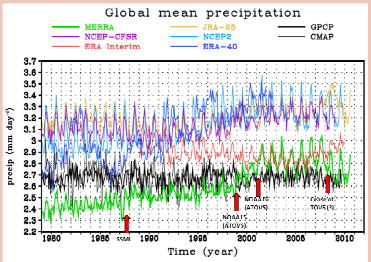
Discontinuities in time series commonly show in reanalysis datasets due to changes in observing system. The resulted temporal inhomogeneity is a major obstacle to apply reanalysis data in climate researches, especially trend studies. In this work, we aim to identify the temporal discontinuities in NASA MERRA reanalysis, and to minimize the discontinuities caused by major changes in the observing system.

Inhomogeneity caused by the changes of observing system

The sequential dramatic increase of observation type and counts is the major character of the evolution of the global observing system in the last 40 years.



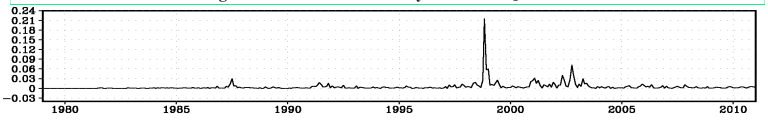
The global mean precipitation time series, which is heavily affected by the bias between simulated and observed moisture field, gives a visualized description of the inhomogeneity of a reanalysis dataset.



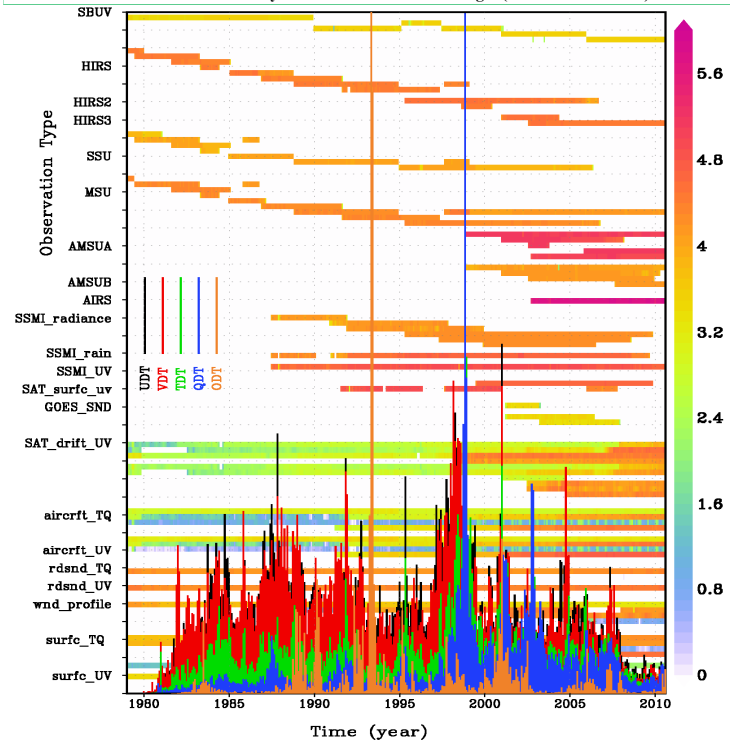
Quantitatively identify the discontinuities

we quantitatively assess the discontinuities in MERRA reanalysis and reveal their connection with the changes in observing system. We use a sequential discontinuity detection method to identify the discontinuities in the grid level time series of major state variables, thus obtaining a comprehensive picture and objective assessment of discontinuity in MERRA. By comparing the discontinuity information with detailed evolution history of the global observing system, the connections between the two are addressed.

The global mean of discontinuity index of DQVDTANA



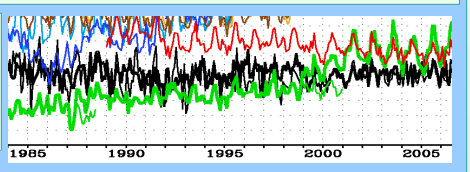
Crosscheck Discontinuities and Observing System Changes
Vertical: Discontinuity Indices Horizontal: Log10(observation counts)



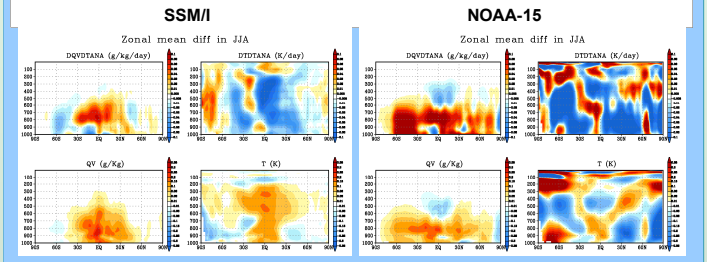
Homogenization method

The MERRA data is augmented with several reanalysis segments each being performed for a period of a few months to two years when a major observing system change happens. Each of these reanalysis segments will be similar to the corresponding segment of original MERRA, except that the newly introduced observation data type is excluded. By comparing these Observing System Experiments (OSE) with original MERRA streams, impacts of the changes in observing system will be investigated and identified for many physical and dynamical parameters, and corrections to minimize the impacts will be produced. The corrections or patches could be constructed with variety methods, including simple offset method, more sophisticated statistical methods, for example, cumulative distribution function matching in one or more dimensions, and biases correction in model side. With the patches, the MERRA data before each ROSS run will be adjusted to offset the difference caused by the change of observing system. That is, MERRA data will be homogenized to match the latest MERRA data, which obtains the best quality with most recent advanced observations.

Two OSEs withholding NOAA-15 ATOVS and SSM/I data have been produced to address the impact of the introduction of ATOVS data in late 1998 and SSM/I data in 1987, respectively.

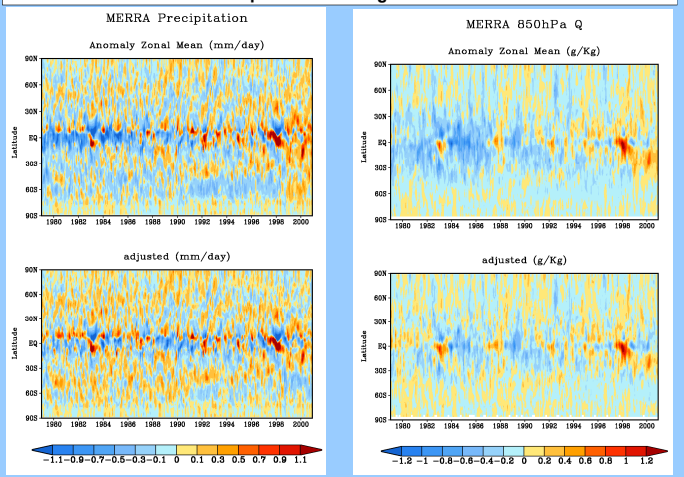


The impacts of SSM/I and NOAA-15 ATOVS are largely different



How to understand the relationship between the changes in state parameters and the corresponding observation induced analysis increment? In differences between MERRA and SSM/I OSE, DQVDT_Analysis and Q have same sign, but DTDT_Analysis and T have opposite sign. Implying cause and effect relationship? Except the different spatial distribution from SSM/I, the NOAA-15 associated temperature and its increment appear to be positively correlated. Implying the temperature increment is not just passively changing? Hypothesis: does the opposite or same signs between a state parameter and the corresponding analysis increment indicate the cause and effect relationship between them?

Simple offset homogenization



Conclusion and future work

- Historical changes of observing system cause inhomogeneity in MERRA and also other reanalyses.
- A homogenization effort is ongoing for MERRA. Preliminary results are encouraging.
- More OSEs are being generated. Ongoing patch generation methods include posterior statistical process and prior model bias correction.

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