NCEP Reanalysis Status and US National Reanalysis Program Plan

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1. Introduction

The first part of this presentation reports current status of Reanalysis activities at NCEP. Two Reanalyses were completed and are now continuing as Climate Data Assimilation Systems (CDAS). The third reanalysis is the high resolution Regional Reanalysis covering US, Canada, Mexico and a part of South America. This reanalysis is still in the pilot stage but its production run will start in a few months.

In the second part of this presentation, the US National Reanalysis Program Plan is presented. This somewhat ambitious plan is based on the reanalysis user's demands that was not satisfied by the existing reanalyses. Basically, the inherent problem of Reanalysis is that it is based on the data assimilation for short-medium range weather forecasts, which do not satisfy several basic requirements for the climate studies the user places on the reanalysis data. The program addresses the need for basic research and execution of the reanalysis with a collaborative activity among various agencies throughout the US.

2. NCEP/NCAR and NCEP/DOE Reanalysis status

The NCEP/NCAR 50-year reanalysis is completed and is continuing as a Climate Data Assimilation System with a few days delay. Recently, a discontinuity in the tropical upper tropospheric temperature was found in the analysis around 1996. The cause was traced to the small change in the satellite data processing, and the analyses were redone for this period to correct the problem. For the original NCEP/NCAR Reanalyses, data-decoding problems were discovered. These errors affected surface pressure analyses in the early years. Several diagnostics were performed and found that the effect seems to be not negligible. The analysis was not repeated due to lack of resources. Detailed are described in the Reanalysis web page.

3. NCEP/DOE AMIP-II Reanalysis status

The NCEP/DOE reanalysis for the period 1979 to current is now complete (Kanamitsu et al., 2002). This analysis is unique in the sense that it uses observed precipitation for land hydrology. The analyzed soil wetness is compared against actual soil wetness observation over US (Illinois and Ohio) and over China. The correspondence is not excellent but considering the uncertainties in the observation, the reanalysis soil wetness is reasonable. Using this soil wetness, several seasonal summertime hindcasts experiments were performed. The near surface temperature over continental US improved significantly with the use of the analyzed soil wetness. Comparisons of the anomaly correlation skill scores between the two forecast; one starting from climatological soil wetness (CTL), and the other from NCEP/DOE reanalysis (ISM) is presented in Figure 1. More detailed is presented in Kanamitsu et al. (2002). It is now planned that the NCEP/DOE reanalysis to be extended to the near real time for the use in the operational real time seasonal prediction.

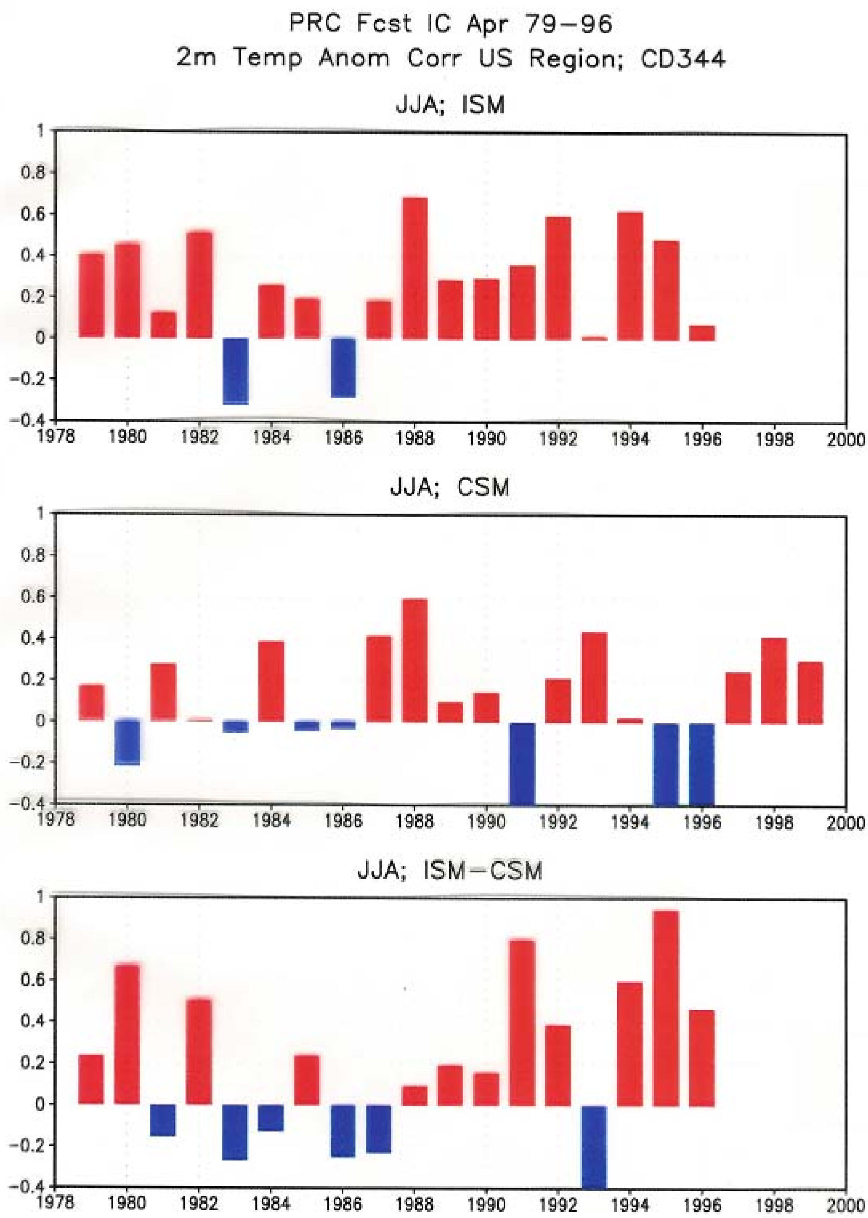

Figure 1 Comparison of 2 m air temperature anomaly correlation scores of ISM and CTR experiments verified against independent 344 climate division data. The scores for ISM is shaded light and those of CTR is shaded dark. The skill score is computed for 10-member ensemble average of 3-month mean for June-July-August period.

4. NCEP Regional Reanalysis status

This is a successor project to the NCEP/NCAR Reanalysis. The plan is to make 1982-2002 high-resolution analyses over the continental US. The major focus of this analysis is the detailed regional analysis and hydrology. The unique aspect of the analysis is the use of observed precipitation in the data assimilation, in addition to the advanced 3-Dimensional variational analysis. The method to use the observed hourly precipitation is a nudging of latent heating during the assimilation period. The heating profile is taken from the model heating profile. Figure 2 a and b presents the comparison of the monthly averaged precipitation. The observed precipitation is very well assimilated in to the analysis. The advantage of the use of higher resolution analysis is demonstrated by examining the fit of the analysis and guess to the radiosonde observation. The fits to both fields are found to be better than those of the global reanalysis (not shown). So far, one pilot analysis with 80km resolution is complete. Two more 80km resolution for 1988 and 1992 will be performed and is followed by the full 32km resolution analysis. After carefully examining these analyses and obtaining the advisory committee's approval, the project will advance to the production mode. This is expected to occur in 3-6 months.

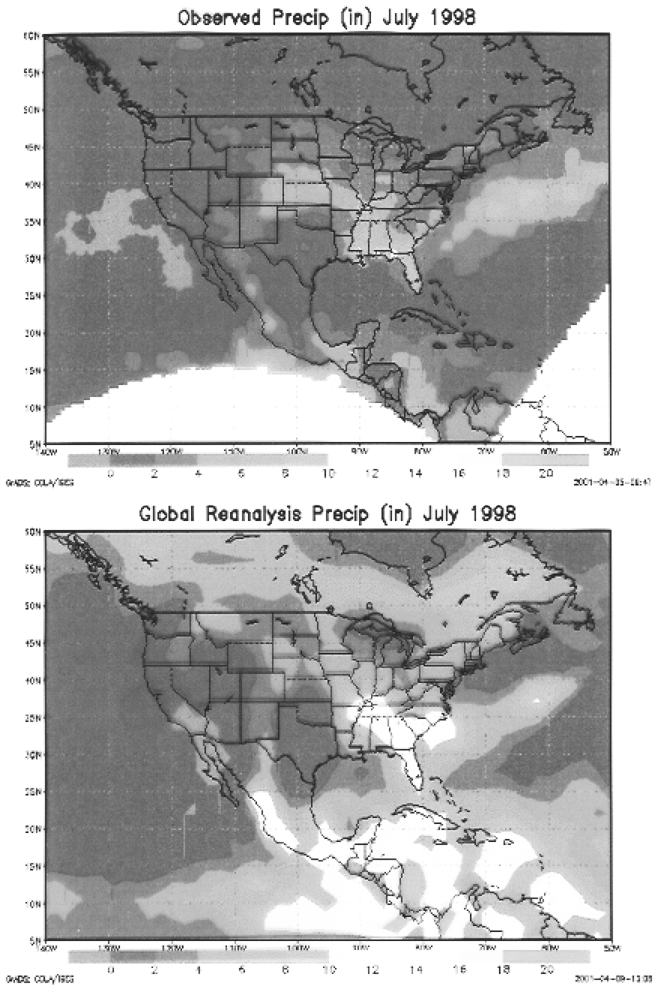

Figure 2a Observed (top) and Global reanalysis (bottom) precipitation for July 1998

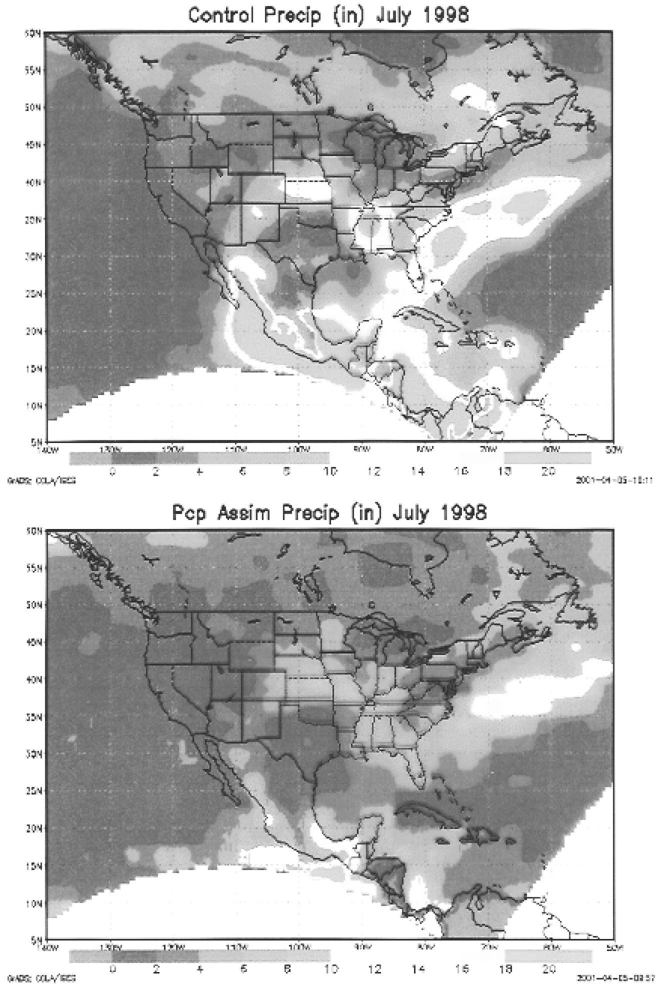

Figure 2b. Precipitation from Eta regional reanalysis without (top) and with (bottom) precipitation assimilation

5. US National Reanalysis Program Plan

After the successful NCEP/NCAR Reanalysis and the NCEP/DOE analysis, majority of the reanalysis producers felt that discussion among wider community is necessary to plan for the next phase of global reanalysis. Based on this the Workshop on Global Reanalysis took place on June 5-6, 2000 at the University of Maryland. The key message of this workshop was the need to embrace the idea of reanalysis as a continuing program of technology and data integration. This program apparently requires a variety of new researches keyed to the reanalysis itself that have not performed in the past. The most urgent requests made by many Reanalysis users can be summarized as follows:

- More accurate analysis of basic variables where direct observation is scarce.
- More accurate analysis of derived variables (such as surface fluxes, radiation fluxes, …)
- More accurate estimate of global and regional long term trend

- More accurate analysis of the low frequency modes
- Closure of the budget calculations
- More accurate estimate of land surface parameters

The first two items and the last item are the problem of the quality of the data assimilation system, namely the objective analysis scheme and the forecast model. 3-D var or 4-D var and the good quality forecast model is essential for this, and continuing development and improvement of the model and the analysis system at various operational center is essential and should continue. The use of observed precipitation, radiation fluxes, clouds, liquid water distributions, snow depth, soil wetness and vegetation from satellite should benefit both operational forecast as well as the reanalysis users.

More accurate estimate of trend and low frequency modes is a unique problem to the reanalysis and has never been seriously considered in the data assimilation research. There are three components to this particular problem. The first is the strict monitoring and bias correction of observations. This requires tedious search of the history of the evolution of instruments at various locations over the globe. For some instruments and countries, there is a record of simultaneous measurement with the two different instruments to calibrate/verify the new instruments. In some other place, old instruments were kept for future calibration. These records need to be painstakingly corrected, examined and verified. This is a huge task to be done before any sensible trend analysis is performed. The second is the use of fixed observation system to avoid climate change due to change in observation system. This is not a very difficult task, but limiting the observation to a handful of radiosonde observation will significantly degrade the resulting analyses. In fact, some preliminary analysis showed that the analysis over data void area becomes so uncertain that no credible long-term global trend information is obtained. This situation can be improved by using the 4-dimensional data assimilation, which 4-dimensionally propagates the observation information into data void areas. This may require use of longer time window for the 4-D var data assimilation, which is a challenging problem. The third is a method to find the best observational array for the detection of global trends, under the 4-D variational data assimilation system.

Closure of the budget calculation is a problem of systematic increment in the analysis. This is the result of model systematic error, or the systematic spin-up/spin-down of the model that occurs by the insertion of observation into the forecast guess. This term is still quite significant compared to other terms in the budget equation. Particularly, when the budget residual is the target of the problem, this systematic increment term makes it impossible to find the target quantity. For the closure of the budget equation, it is of course essential to reduce the model error such that the systematic increment is minimized, however, we cannot expect such improvement in the model for a very long time. Therefore, some other method needs to be sought. One possibility is to use 4-Dimenstional data assimilation to fit the observation tendency as closely as possible. Or, it may be possible to add constraints of long time mean such that the systematic increment is minimized. By doing so, it is not necessarily true that the resulting analysis will produce the best forecast, but it will certainly produce the best analysis for budget studies. Whether one is actually closer to the truth is a big question, but the discrepancy between the two analyses should become small as the assimilation system truly improves. These developments in the data assimilation apparently require new research that may not be urgently important for the data assimilation of the operational forecast centers.

Finally, the historical atmospheric observation can go back to 1800's for surface observations. It is of a great interest to see whether it is possible to dynamically reconstruct the three-dimensional structure of atmosphere from surface observation only. Again, the use of 4-D variational analysis system comes into mind, but special research may be needed to work on such problem. Another thought is to analyze the monthly mean fields, rather than the daily fields for very long reanalysis. This also requires special research.

References

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