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Assessing the Daily and Radiative Performence of the CFSR, ERA-interim and MERRA

Wesley Ebisuzaki[1], Li Zhang[1, 2], S. K. Yang[1, 2], Arun Kumar[1]

[1]*Climate Prediction Center, NCEP/NWS/NOAA, College Park, MD*
[2]*Wyle Information Systems, McLean, Virginia*

1. Introduction

Uses of reanalyses tend to fall into one of three categories, interest in the instantaneous or daily analyses, interest in the physical cycles diagnosis often conducted through a budget study and interest in the monthly to longer term variability often for climate monitoring.

In the first part, this study uses the procedure of Ebisuzaki and Zhang (2011) to evaluate the performance of the daily analyses from the newer reanalyses (CFSR, ERA-interim and MERRA). Using an ensemble of operational analyses as the reference, the various reanalyses were examined for the year 2007. For the tropospheric variables, the newer reanalyses are better than the previous generation of reanalyses. In comparison with the operational analyses, the ERA-interim was the best of the newer reanalyses for the year 2007.

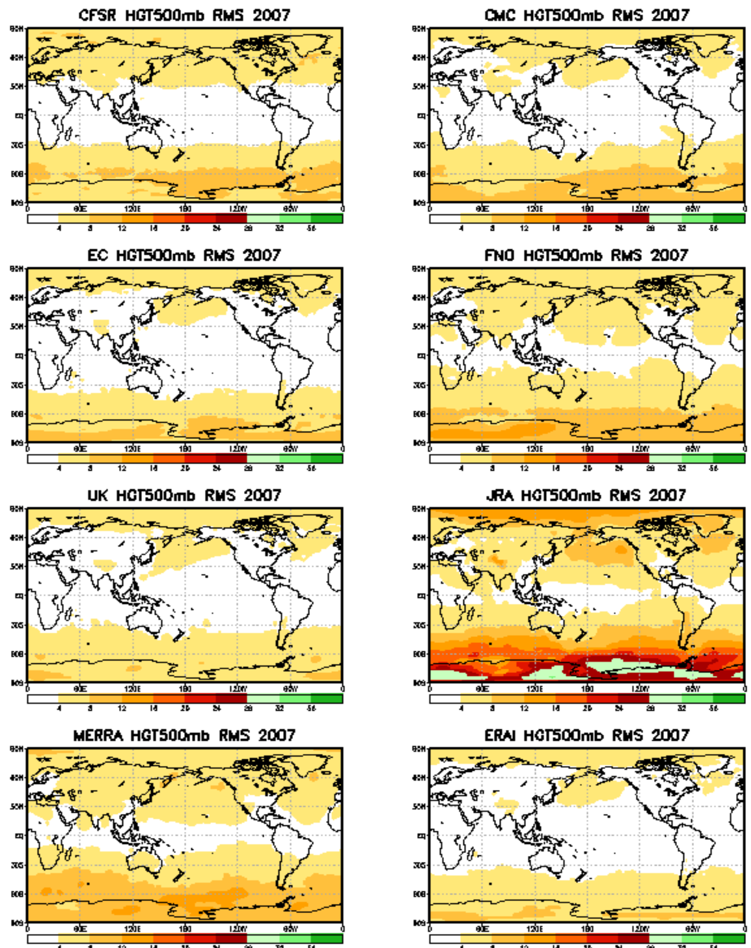

Fig. 1 Analysis of daily 500 mb height variability described by RSM of the various analyses (indicated in each panel's title) from the ensemble mean of operational analyses for 2007.

In the second part of this study we look at the top-of-the-atmosphere (TOA) radiation budget. The TOA radiation is the primary driver behind the atmospheric circulation and can be directly compared with satellite observations. For satellite observations, we use the Clouds and Earth's Radiant Energy System (CERES) level 3 data. The newer reanalyses have a global net upward radiative flux of 0.6 to 1.4 W/m/m (3/2000-2/2009) which is much better than the older reanalyses.

2. Data

i) Ensemble members: twice daily (0000 and 12000 UTC) for 2007 on a 2.5 x 2.5 degree grid

CFSR: Reanalysis from CFS version 2 (used in place of NCEP GDAS/FNL)
CMC: Operational analyses from the Canadian Meteorological Centre

Correspondence to: Wesley Ebisuzaki, Climate Prediction Center, NCEP/NWS/NOAA, 5830 University Research Court, College Park, MD 20740-3818; E-mail: Wesly.Ebisuzaki@noaa.gov.

EC: Operational analyses from the European Centre for Medium Range Weather Forecasts
FNO: NOGAPS analysis from the Fleet Numerical Ocean and Meteorological Center
UK: Operational analysis from the UK MetOffice

ii) Observed TOA radiation: CERES level 3 (v2.6r, 12/2011) March 2000-Dec 2011, monthly means

iii) Reanalyses: CFSR (NCEP), ERA-interim (ECMWF), MERRA (GMAO/NASA), JRA-25 (CRIEPI, JMA), R1 (NCEP/NCAR), R2 (NCEP/DOE)

3. Results

a) Analyses of daily 500 mb height variability (2007)

Using the ensemble of operational analyses as the "truth", the RMS of the various analyses from the ensemble mean for the 500 mb Height RMS are plotted for 2007. Figure 1 shows the modern analyses have less land-sea contrast, indicating that the newer systems are making a better use of satellite data. The ERA-interim is the best reanalysis for this statistic.

b) Analysis of daily 200 mb zonal wind variability (2007)

The RMS of the 200 mb zonal wind (UGRD) analyses from the mean of the operational ensemble is shown by Figure 2. Again the land-sea contrast is stronger in the older reanalyses. Of the newer reanalyses, the ERA-interim is best for this variable followed by CFSR and MERRA. The eastern tropical Pacific was a region of higher uncertainty.

Many tropospheric fields were checked using the same procedure. The general result was that ERA-interim was best of the three newer reanalyses in capturing the daily variability.

c) January OLR climatologies (2001-2011)

The observed Outgoing Long-wave Radiation (OLR) from CERES is compared with the various reanalyses on

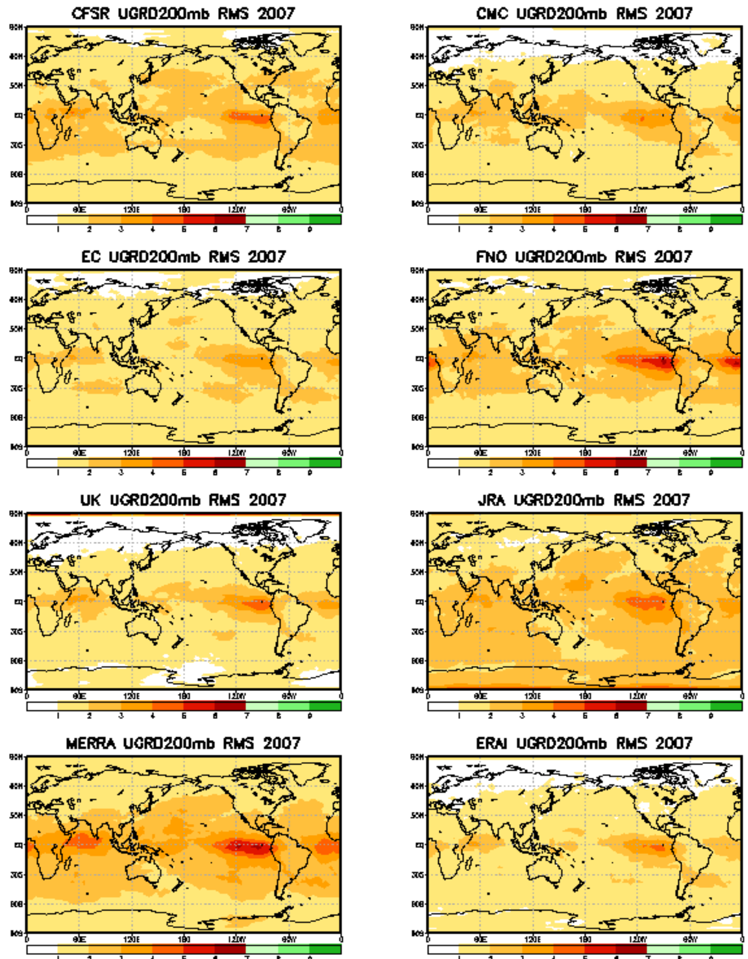

Fig. 2 Same as Figure 1 except for 200 mb zonal wind.

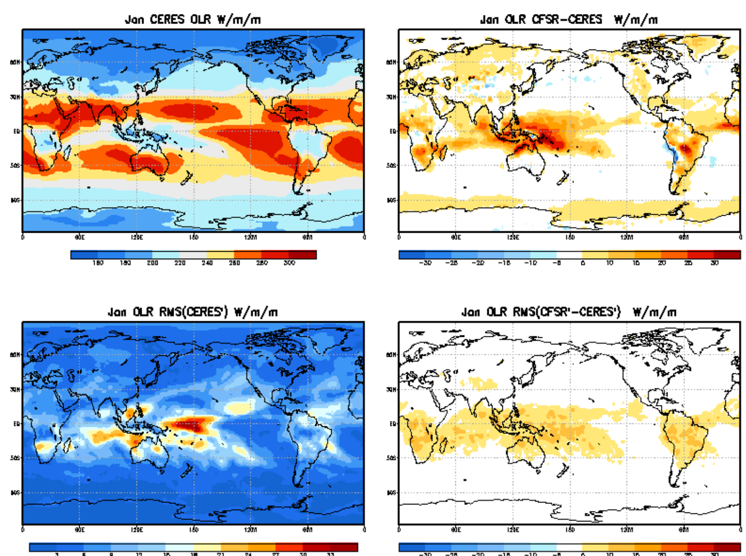

Fig. 3 Left column: observed January OLR (top) and RMS (bottom). Right column: the differences between CFSR and the observed January OLR (top) and the RMS of (CFS-OBS) anomalies.

climatological mean and variability of anomalies. The comparison with the January means is shown (Figs. 3-5). Overall there is no clear best reanalysis for January OLR. “Best” depends on the region of interest. The newer reanalyses are much better than the older R1, R2 (not shown) and JRA-25.

d) January outgoing short-wave radiation

The comparison of observed January outgoing short-wave radiation (OSR) with that of the reanalyses is shown in Fig. 6. It revealed the OSR wasn't as well represented as the OLR. However, the OSR showed a similar feature. The systematic error was larger than the error in the anomalies.

e) Trends in the OLR and OSR

The global mean OLR, OSR and the net radiation at the top of atmosphere (TOA) are inspected. OLR shows CFSR, ERA-interim and MERRA are 2-6 W/m/m more than CERES (Fig. 7a). OSR shows CFSR, ERA-interim and MERRA are clustered about CERES. The newer reanalyses display some trends (Fig. 7b). The net global radiation shows the March 2000 - February 2009 (net) upward flux is 0.6 (CFSR), 1.4 (ERA-interim), and 0.7 (MERRA) W/m/m. The older R1 and R2 have a 13 and 7 W/m/m (respectively) net radiative upward flux (Fig. 7c).

4. Summary

The CFSR was very good representing

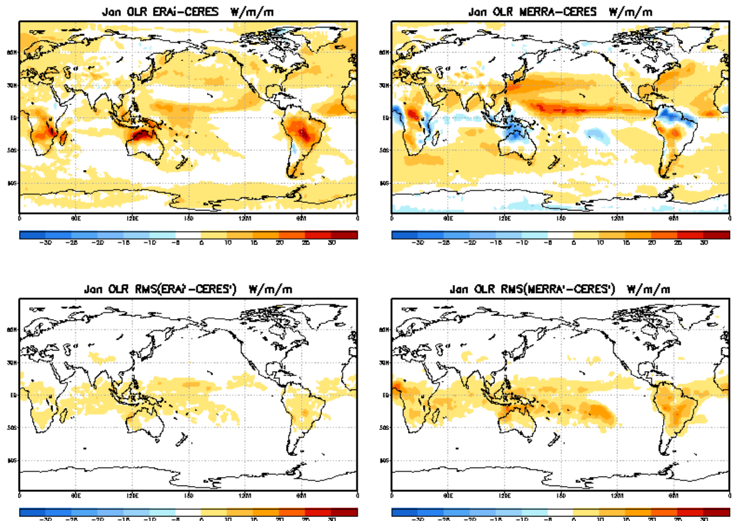

Fig. 4 Same as the right column of Figure 3 but for ERA-interim (left) and MERRA (right).

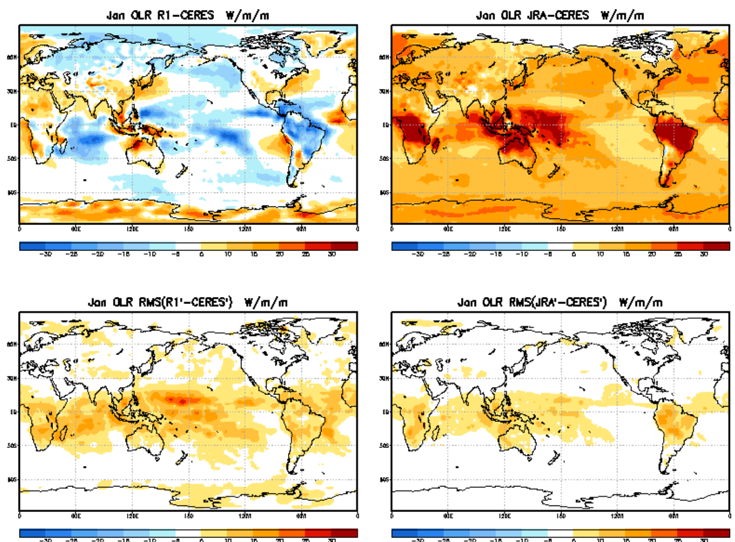

Fig. 5 Same as the right column of Fig. 3 but for R1 (left) and JRA-25 (right).

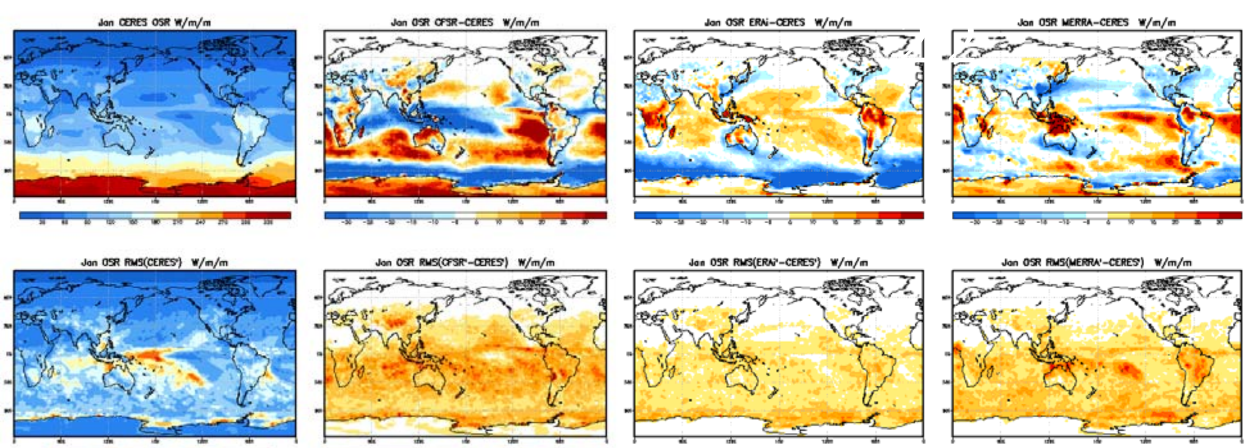

Fig. 6 January OSR (top left) and RSM of anomalies (bottom left) for 2001-2011 from CERES in comparison with counter-parts of CFSR (2nd column), ERA-interim (3rd column) and MERRA (last column on right).

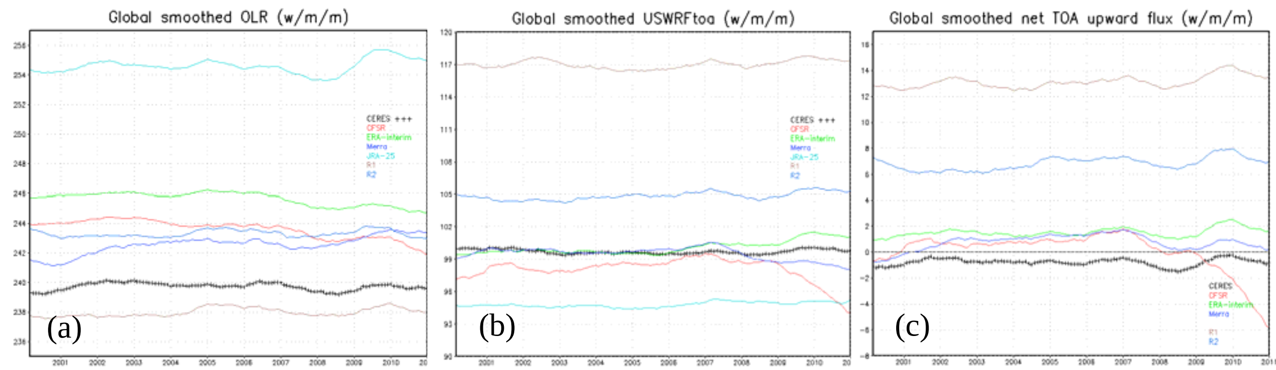

Fig. 7 Global OLR (a), OSR (b) and the net radiation (c) with a 12-month running mean.

the daily variability in the current environment. For various fields examined, the CFSR did well and was comparable to the operational models *circa* 2007. Compared with the older R1 and R2, the CFSR did better at capturing the daily variability. The biggest improvements were over the oceans which were the result of improved satellite instruments and the improved data assimilation of the satellite data. Over the well observed land areas, the improvements over R1 and R2 were smaller. Overall, the ERA-interim did the best on the primary tropospheric fields.

The newer reanalyses have improved their OLR in both the systematic and the time varying components with the systematic error being larger than the errors in the anomalies. The OSR was not as well represented as the OLR.

The global TOA radiation budget was better simulated in the recent reanalyses. The net global flux averaged 0.6 (CFSR), 1.4 (ERA-interim) and 0.7 (MERRA) W/m/m upward for the period March 2000-Feb 2009.

All the newer reanalyses showed trends in the TOA fluxes, some larger than others.

References

Ebisuzaki, W., and L. Zhang, 2011: Assessing the performance of the CFSR by an ensemble of analyses. *Clim. Dyn*., **37**, 2541-2550.