AN OVERVIEW OF MERRA: VALIDATION AND CHALLENGES FOR FUTURE REANALYSES

Presented by Michael Bosilovich

with contributions from many in the GMAO
NASA’S MODERN ERA RETROSPECTIVE-ANALYSIS FOR RESEARCH AND APPLICATIONS (MERRA)

- 2002 Proposed Objective: Improving the water and energy cycle representation in a reanalysis
- GEOS5 system development including NASA global climate model with NCEP GSI data assimilation
- Production began in May 2008
- Provisional release of 9 yrs. data in Dec 2008
- Began realtime production in Apr 2010
- Currently 1979 through May ‘10 are available
NASA’S MODERN ERA RETROSPECTIVE-ANALYSIS FOR RESEARCH AND APPLICATIONS (MERRA)

- 1979-present (continuing as it is feasible)
- $\frac{1}{2}^\circ$ horizontal resolution (72 model levels, sfc-strat)
- 1 hourly surface and 2D diagnostic data
  - Including complete budgets and extensive meteorology, lowest model level states
- 6 hourly 3-Dimensional atmospheric analysis
- 3 hourly 3-D model background including diagnostics, coarse resolution
- >70 Tbs online storage, many portals (incl. subsetter) up to realtime processing > 31 years of data
CHALLENGE AND ADVANTAGE OF REANALYSIS

1973 – 77K Obs every 6hrs
07-Jan-1973 12UTC All data: 77098 observations

1987 – 550K Obs every 6hrs
02-Aug-1987 12UTC All data: 550602 observations

1979 – 325K Obs every 6hrs
07-Jan-1979 12UTC All data: 325765 observations

2006 – 4.2M Obs every 6hrs
07-Jan-2006 12UTC All data: 4217655 observations
ASSESSING PRECIPITATION SKILL

Taylor Diagram of Global Annual precipitation skill of existing reanalyses e.g. Bosilovich et al (2008)
http://gmao.gsfc.nasa.gov/ref/merra/atlas/
Calculating Budgets

\[ \frac{\partial q v}{\partial t} = E - P - \nabla \cdot q v + \frac{\partial q v}{\partial t} \_{AN} \]

- Complete budgets are available including all tendencies and analysis increments
- Water (all phases), Ozone, KE, Enthalpy, Included
- Also, land-only budgets
- Tremendous effort by Max Suarez, Larry Takacs and Randy Koster
Global P trend mostly over Ocean
Land, taken together, are comparable with little apparent trend
\[
\frac{\partial \bar{w}}{\partial t} = -\nabla \cdot (\bar{v} \bar{w}) + E - P + \left[ \frac{\partial \bar{w}}{\partial t} \right]_{ANA} + F
\]
Global surface net imbalance is improving in time, mostly changing over Ocean.

The Ocean net imbalance is decreasing in incoming SW radiation and increasing LE.
Increases in SH midlatitude and Indian Ocean
SPCZ increase is also related to moist convergence
African decrease needed more attention
Many analyses can help understanding/validation/development

CORRECTING THE TIME SERIES

Analysis increments contain the information to remove trend artifacts induced by step function changes in observing system input.

From Robertson et al (2010)

MERRA dQv analysis increment eof
(variance %)

Increment Change (mm day⁻¹)
2000-08 minus 1990-97

MERRA smth3 global RA-corrected P-[dQv-ana(black)]; GPCP(green)
BASIN-SCALE PRECIPITATION

- CPC US ¼ gridded gauge data
- Daily, Jan 1 2003 – Dec 31 2004
- Area average over the Mississippi River Basin domain
Figure 10.30. Cross section through a tropopause fold for 0000 GMT, 13 March 1978. Potential temperature (K) is indicated by thin solid lines; wind speed (m s$^{-1}$) by thick dashed lines; Sabreliner flight track by thin dashed lines; tropopause defined in terms of potential vorticity (100 x 10$^{-7}$ K mb$^{-1}$ s$^{-1}$) by thick solid line. The troposphere is stippled. (From Shapiro, 1980.)
TROPOPAUSE FOLD

MERRA 12Z13MAR1993, 90.625 W: Wind Sp (Black), EPV (color)
ERS observations overlay
MERRA Obs (including O-F and O-A) to be available for user access soon
BEGINNING RESEARCH

- MERRA Precipitation shows skill compared to GPCP, relative to other reanalyses
- Trends are on the order of other reanalyses, but the bias is much improved
- Energy balance smallest in the recent period, ~8Wm\(^{-2}\) imbalance

- Remaining issues in reanalyses: model bias appears as trends in conjunction with the changing observing system, can affect many aspects of the reanalysis
- Researchers must evaluate the processes important to their project; Analyzed observations should help
THANK YOU

- Data - http://disc.sci.gsfc.nasa.gov/MDISC/
- Discussion – http://merra-reanalysis.blogspot.com/
- merra-questions@listserv.gsfc.nasa.gov
- Michael.Bosilovich@nasa.gov
850mb specific humidity from Bangui (64650), compared to MERRA grid point, monthly mean anomalies
- Amazon precipitation generally increases, but there is also a phase shift in the annual cycle.
- More water in the soil, after AMSU assimilation.
Global Heating Rates (W m\(^{-2}\))

- Moist Processes
- Analysis