MERRA - NASA’s Reanalysis Overview & Status

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&
GMAO

http://gmao.gsfc.nasa.gov/merra

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The Modern Era Retrospective-analysis for Research and Applications is a reprocessing of atmospheric observations from 1979 to present using the GEOS-5 Data Assimilation System.

The focus of MERRA is the hydrological cycle.

Assimilation of the historical data stream: consistent Climate Data Records for several Essential Climate Variables concurrently.
AGCM

- Finite-volume dynamical core
- Integrated set of physics packages
- Physics integrated under the Earth System Modeling Framework (ESMF)
- Generalized vertical coord to 0.01 hPa
- Catchment land surface model
- Prescribed aerosols
- Interactive ozone
- Prescribed SST, sea-ice

Analysis

- Grid Point Statistical Interpolation (co-dev. with NCEP)
- Direct assimilation of satellite radiance data using JCSDA Community Radiative Transfer Model (CRTM)
- Variational bias correction for radiances

Assimilation

- Apply Incremental Analysis Increments (IAU) to reduce shock of data insertion
- IAU gradually forces the model integration throughout the 6 hour analysis period
- Provides a “replay” capability

\[
\left( \frac{\partial q^n}{\partial t} \right)_{total} = \text{dynamics (adiabatic)} + \text{physics (diabatic)} + \Delta q
\]
MERRA Production

- 1979 – present
- \(1/2^\circ \times 2/3^\circ \times 72L\)
- 2-year spin up at 2-degree resolution
- 1-year spin up at \(1/2\) degree

*Preview/Validation runs:*
- Jan, Apr, Jul, Oct 2004
- July-August 1987
- Jan, Jul 2001
- Jul 2006

*2 degree (scout) runs* ⇒ preliminary look at data and spin-up of satellite bias estimates.
Validation Foci:

• Climate (comparisons with NCEP R1&R2, ERA-40, EC-Ops, JRA-25, CERES/ERBE TOA fluxes, GPCP precipitation, ..)
• Comparisons with satellite observations (CloudSAT, TRMM, SSMI, …)
• Hydrological cycle (comparisons with GPCP, CEOP, …)
• Land surface hydrology and energy balances
• Climate variability: Diurnal cycle, monsoons, …
• Stratosphere, constituent transport, QBO
• Marine surface fluxes
• Budgets

Note: little attention to NWP skill scores in system tuning
MERRA External User Group

Phillip A. Arkin  ESSIC, UMD  Moderator
Alan K. Betts  AER  Land, Planetary Boundary Layer
Robert X. Black  Georgia Inst. Tech.  Synoptic Dynamics
David H. Bromwich  Byrd Polar Research Ctr.  Arctic
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Steven W. Running  U. Montana  Land Biophysics
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Kevin E. Trenberth  NCAR  Climate
Glenn H. White  NOAA/NCEP  Ocean Flux, Reanalysis
John Roads  SIO  Regional energy budgets

GMAO POCs

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MERRA FILE COLLECTIONS

• Distributed through a modeling data portal at the Goddard DISC:
  http://disc.sci.gsfc.nasa.gov/MDISC/

• MERRA products are organized into 24 collections in HDF
• All distributed data products have slightly degraded precision and are compressed with gzip.

• Data are produced on three horizontal grids:
  • Native --------- (1/2 by 2/3 w/ FV conventions)
  • Reduced ------- (1½ by 1½ Dateline-edge, Pole-edge)
  • Reduced FV -- (1 by 1¼ w/ FV conventions)

• In the vertical, 3-D data are on:
  • 72 model layers
  • 42 pressure levels

• Diagnostics temporal resolution:
  • 3D products are 3-hourly
  • 2D products are hourly

• Total online collections ~70TB

MERRA products are from both Analysis and Assimilation
# MERRA File Collections

**Analyzed Fields** $(u,v,t,q,O_3,p)$ [2]
- Native, instantaneous, 6-hourly model and pressure levels

**Assimilated Fields** [1]
- Reduced, instantaneous, 3-hourly pressure levels

**3-D Diagnostic Fields** [8]
- Reduced, time-averaged, 3-hourly pressure levels

**2-D Diagnostic Fields** [5]
- Native, time-averaged, hourly

**Products for Offline Chemistry Transport Models** [6]
- Various resolutions frequencies and grids

**Invariants** [2]
Summary

- Results from validation runs:
  - GEOS-5 analysis improves upon many features of existing reanalyses
  - Biases generally smaller than climate signals
  - Precipitation issues remain: trends; diurnal cycle

- Comprehensive output suite

- Expect to complete processing to end of 2007 by August 2009
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• SIVO for help with performance issues

• GES DISC for the MDISC and support in online product distribution

• External User Group for evaluation of early products and guidance on products

• Don Anderson & Tsengdar Lee for programmatic and moral support
And next.....

- The hydrological cycle - Michael Bosilovich
- Climate validation of MERRA - Siegfried Schubert
- The stratospheric analysis and chemistry transport - Steven Pawson
- Accessing MERRA online - Michael Bosilovich
- Questions??