Exploring Climatology and Long-Term Variations of Aerosols from NASA Reanalysis MERRA-2 with Giovanni

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Description of Data Access Methods and Examples

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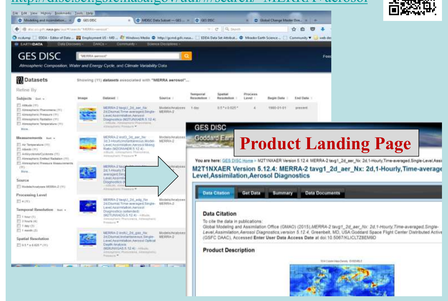
About MERRA-2 Aerosol Products

- **Aerosol Components:** Dust, Black Carbon (BC), Organic Carbon(OC), Sea-salt, Sulfate (SO_4)
- **Aerosol Property:** mixing ratio, column mass density, emission, optical depth, deposition, sedimentation, etc.
- **Model: MERRA-2** (based on MERRAero, aerosol components are fully coupled with meteorological fields)
- **Assimilation Inputs:** MODIS, MISR, AERONET, and AVHRR (pre-EOS period)
- **Temporal Coverage:** 1980-present
- **Temporal Resolution:** hourly, 3-hourly, monthly, and monthly diurnal
- **Spatial Coverage:** Global
- **Spatial Resolution:** 0.5°x0.625°
- **Data Format:** NetCDF-4

Data Services

Finding Data: UUI

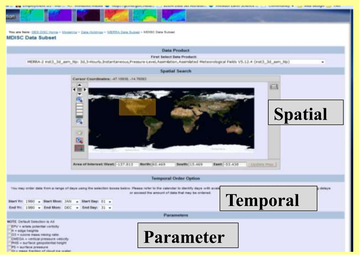
http://disc.sci.gsfc.nasa.gov/uui/#/search/?MERRA+aerosol"



Subsetting: MERRA Subsetter

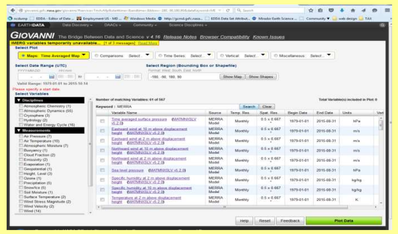
http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset2.pl

- ✓ Parameter, spatial, temporal subsetting
- ✓ Regridding (bilinear interpolation, nearest neighbor, distance-weighted average, …)
- ✓ Resolution (gpcp2.5, cfsr1.0, ERA40, …)
- ✓ Data Format (netCDF4, NetCDF4-classic)



Visualization: Giovanni

http://giovanni.gsfc.nasa.gov/Giovanni/



Other Data Services:

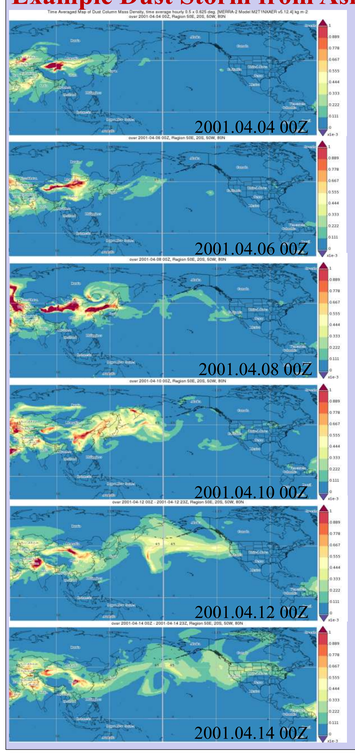
- ✓ HTTP (for direct downloading)
- ✓ OPeNDAP
- ✓ GDS
- ✓ NASA centralized Earth Data search system (http://reverb.echo.nasa.gov)
- ✓ Data Recipes (step-by-step instruction on reading data with varies data tools)

MERRA-2 Aerosol Products

File Specification: http://gmao.gsfc.nasa.gov/pubs/docs/Bosilovich785.pdf

Products Description	Sample Parameters	Temporal Resolution	Product ShortName
Aerosol Diagnostics	SO_2 Column Mass Density Dust Surface Mass Concentration Dust Surface Mass Concentration -PM 2.5 Total Aerosol Extinction AOT at 550nm Total Aerosol Scattering AOT at 550nm	***Hourly*** ***Monthly Diurnal*** ***Monthly***	***M2T1NXAER*** *(tavg1_2d_aer_Nx)* **M2TUNXAER** *(tavgU_2d_aer_Nx)* **M2TMNXAER** *(tavgM_2d_aer_Nx)*
Aerosol Diagnostics (extended)	Dust Dry/Wet Deposition Dust Emission Dust Sedimentation Black Carbon Biomass Burning Emissions SO_2 Biomass Burning Emissions	***Hourly,*** ***Monthly Diurnal*** ***Monthly***	***M2T1NXADG*** *(tavg1_2d_adg_Nx)* **M2TUNXADG** *(tavgU_2d_adg_Nx)* **M2TMNXADG** *(tavgM_2d_adg_Nx)*
Aerosol Optical Depth Analysis	Aerosol Optical Depth Analysis Aerosol Optical Depth Analysis Increment	***3-hourly*** ***Monthly Diurnal*** ***Monthly***	***M2I3NXGAS*** *(inst3_2d_gas_Nx)* **M2IUNXGAS** *(instU_2d_gas_Nx)* **M2IMNXGAS** *(instM_2d_gas_Nx)*
Aerosol Mixing Ratio (3D - L72)	Dust Mixing Ratio SO_2 Mixing ratio Hydrophilic /Hydrophobic Black Carbon Methanesulphonic acid	***3-hourly***	***M2I3NVAER*** *(inst3_3d_aer_Nv)*
Aerosol Mixing Ratio Analysis Increments (3D - L72)	Dust Mixing Ratio Analysis Increments Sulfate Mixing Ratio Analysis Increments Black Carbon Mixing Ratio Analysis Increments	***3-hourly***	***M2I3NVGAS*** *(inst3_3d_gas_Nv)*

Example Dust Storm from Asia to North America



Above: True color image from MODIS, the famous **"Perfect Dust Storm" on April 7 2001** over Northeast China. Courtesy: http://earthobservatory.nasa.gov/IOTD/view.php?id=8341)

Left: MERRA-2 assimilated hourly **column dust mass density**, the dust travels eastward from Asia across the Pacific reaching California and even Maryland in about 6-10 days.
(Images are generated with Giovanni plot function: "Maps: Time Averaged Map". This function is able to plot time averaged map over an interested region.)

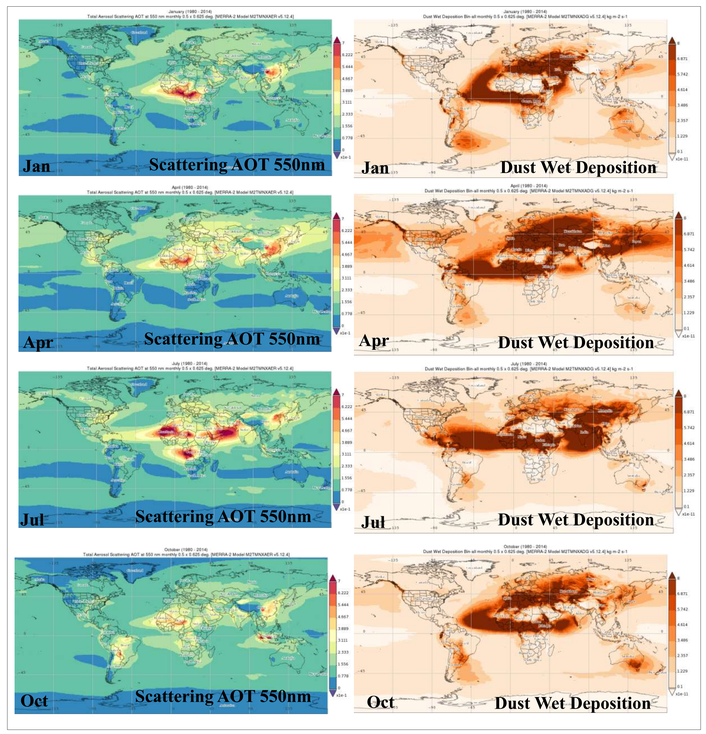
Monthly Climatology of Aerosols

(Base period: 1980-2014)

Right: Example monthly climatology: aerosol scattering AOT at 550 nm and Dust wet deposition for Jan, Apr, Jul, and Oct, respectively. The average is made for 35 years period from 1980-2014.

The dust depositions are available as dry and wet at five dust particle size bins in the range from 0.1 to 10 (μm) in radius.

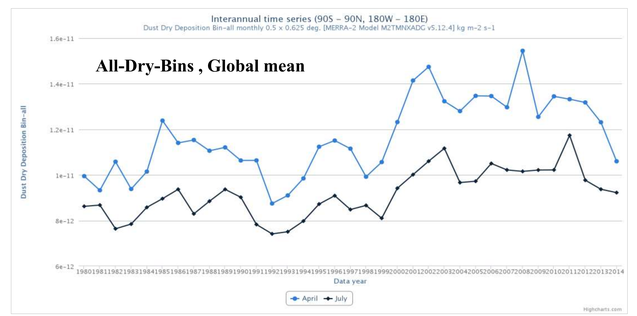
(Images are generated with Giovanni plot function: "Maps: User Defined Climatology". This function enables monthly climatology calculation of user selected base-periods.)

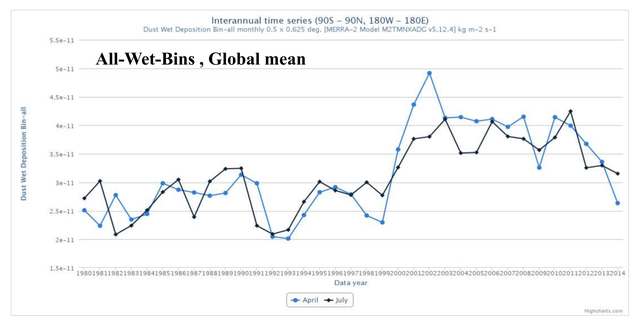


Interannual Variations of Aerosols

Right: Time series of global mean dust deposition for April (blue line) and July (black line) from 1980 to 2014. Both Wet and Dry dust deposition show systematic difference before and after about year 2000. More studies are needed to investigate if it is a real signal or the artifact due to different input satellite data.

(Plots are generated with Giovanni function: "Time Series: Seasonal". This function is able to plot time series for an interested month or season over a desired region.)





Acknowledgements:

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References:

Bosilovich, M. G., R. Lucchesi, and M. Suarez, 2015. **MERRA-2: File Specification**. *GMAO Office Note No. 9*, http://gmao.gsfc.nasa.gov/pubs/docs/Bosilovich785.pdf

Colarco, P., A. Da Silva, M. Chin, and T. Diehl (2010), Online simulations of global aerosol distributions in the NASA GEOS-4 model and comparisons to satellite and ground-based aerosol optical depth, J. Geophys. Res., 115, D14207, doi:10.1029/2009JD012820

da Silva, A. M., C. A. Randles, V. Buchard, A. Darmenov, P. R. Colarco, and R. Govindaraju, 2015. File Specification for the MERRA Aerosol Reanalysis (MERRAero). GMAO Office Note No. 7