Week – 3 – April 02, 2014

Introduction to Satellite Aerosol Products

Pawan Gupta

Introduction to Remote Sensing for Air Quality Applications for the Indian Sub-Continent and Surrounding Regions

Summer 2013

ARSET - AQ

Applied Remote Sensing Education and Training – Air Quality

A project of NASA Applied Sciences

Aerosol Optical Depth

- AOD - Aerosol Optical Depth
- AOT - Aerosol Optical Thickness

These optical measurements of light extinction are used to represent aerosol amount in the entire column of the atmosphere.

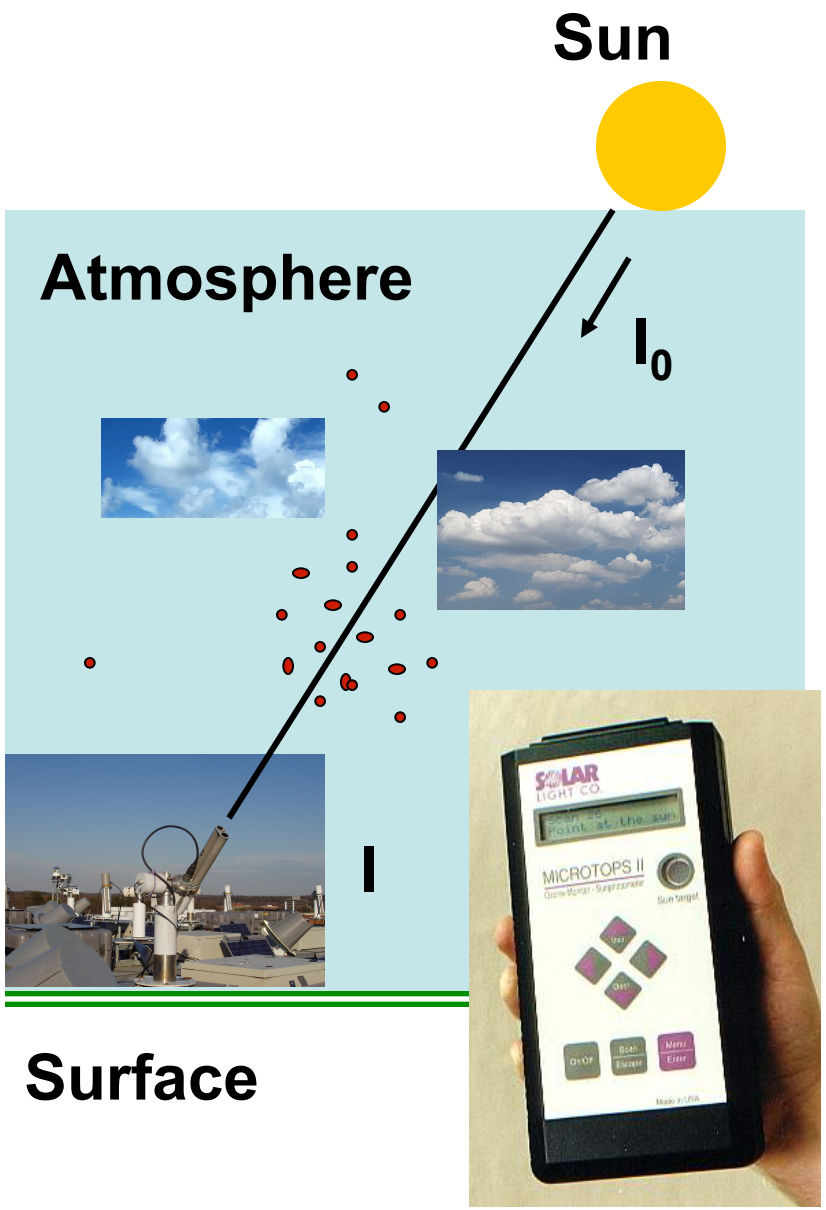
Moderate AOD ~0.40
Near Mt. Abu, India

Photo courtesy of Brent Holben

Visibility and PM2.5

Pictures taken from a same location at same time of day, on two different days

Optical Depth



The optical depth expresses the quantity of light removed from a beam by scattering or absorption during its path through a medium.

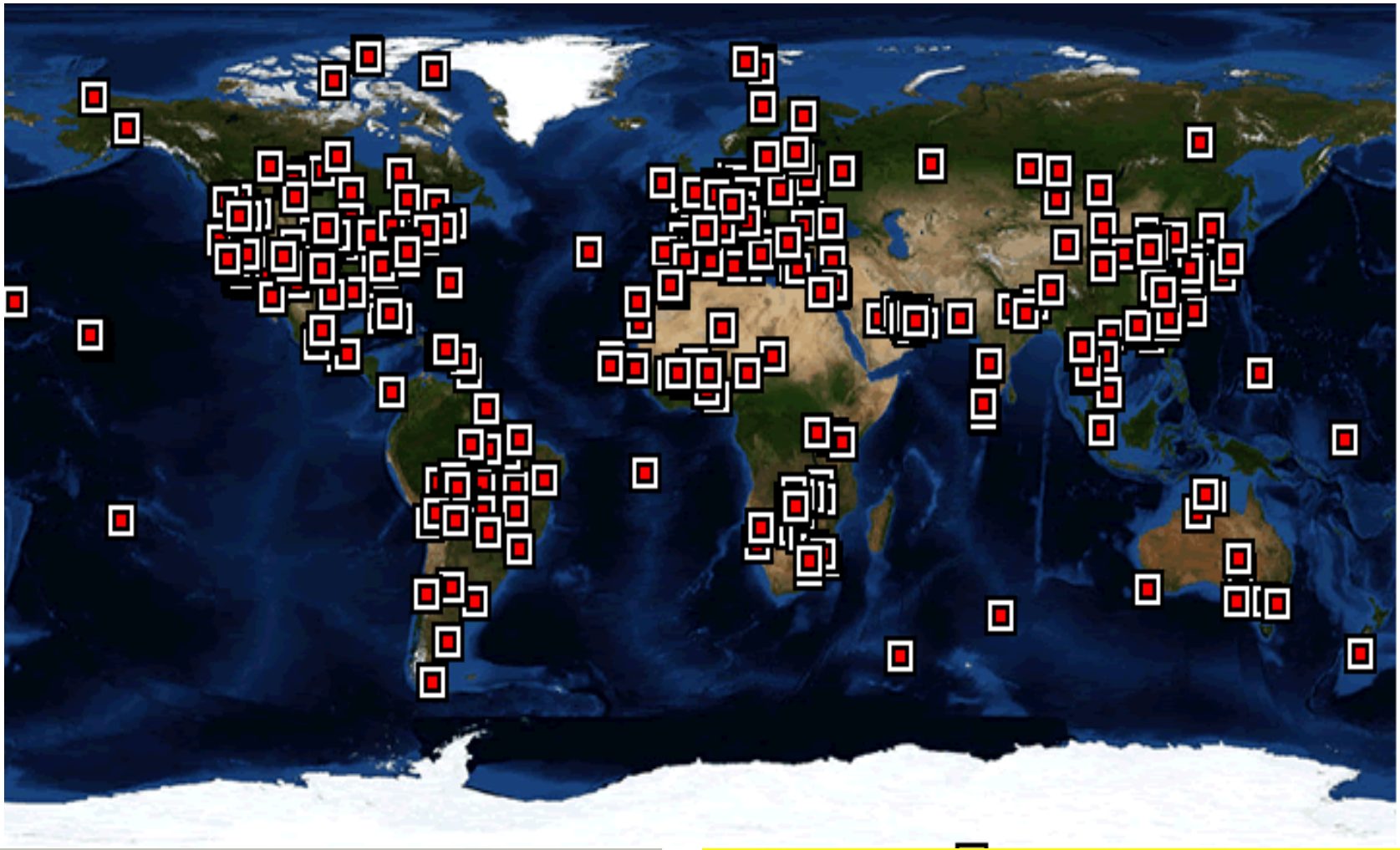
optical depth τ as

$$I = I_0 e^{-m\tau}$$

$$m = \sec\theta_0$$

$$\tau = \tau_{Rayl} + \tau_{aer} + \tau_{gas}$$

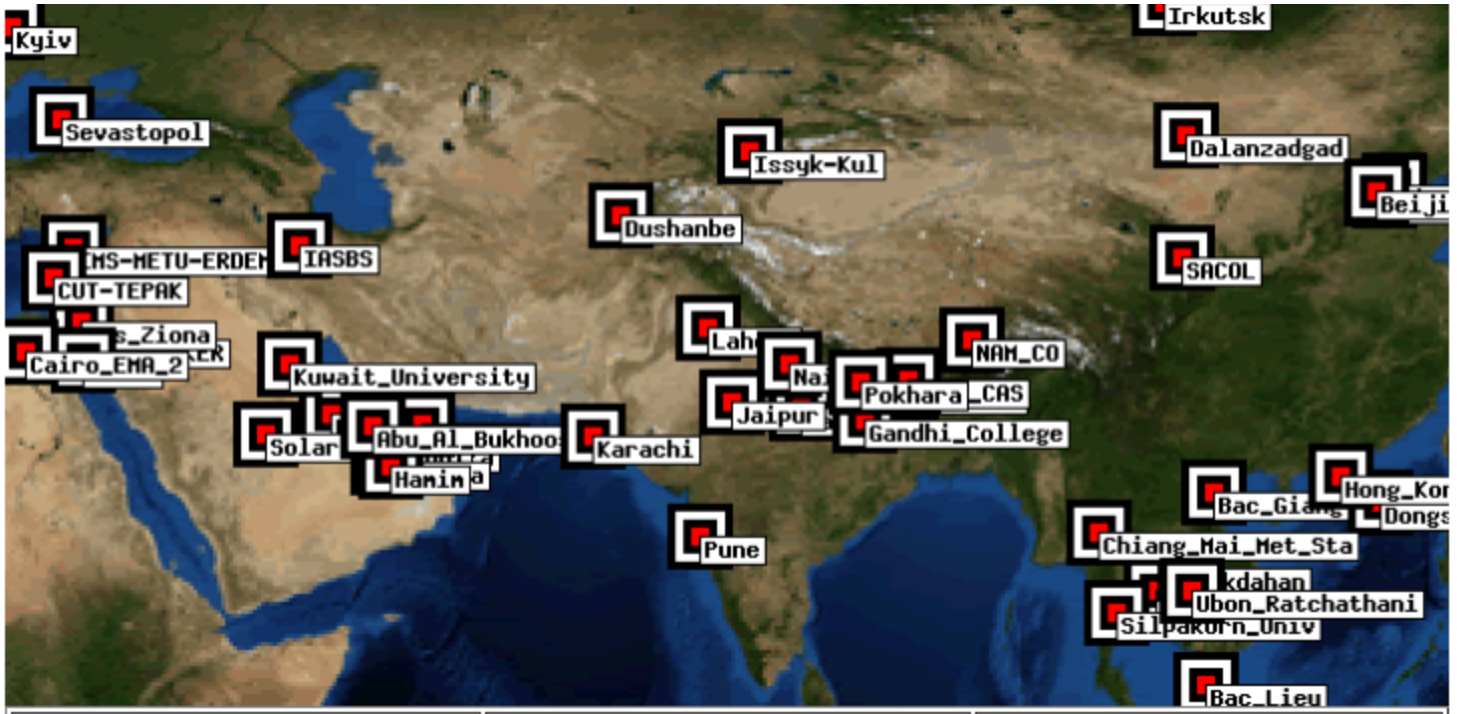
AERONET



Aerosol Robotic Network
http://aeronet.gsfc.nas.gov

AERONET serve as validation tool for satellite aerosol product

Ground based AOD network (AERONET) in the region

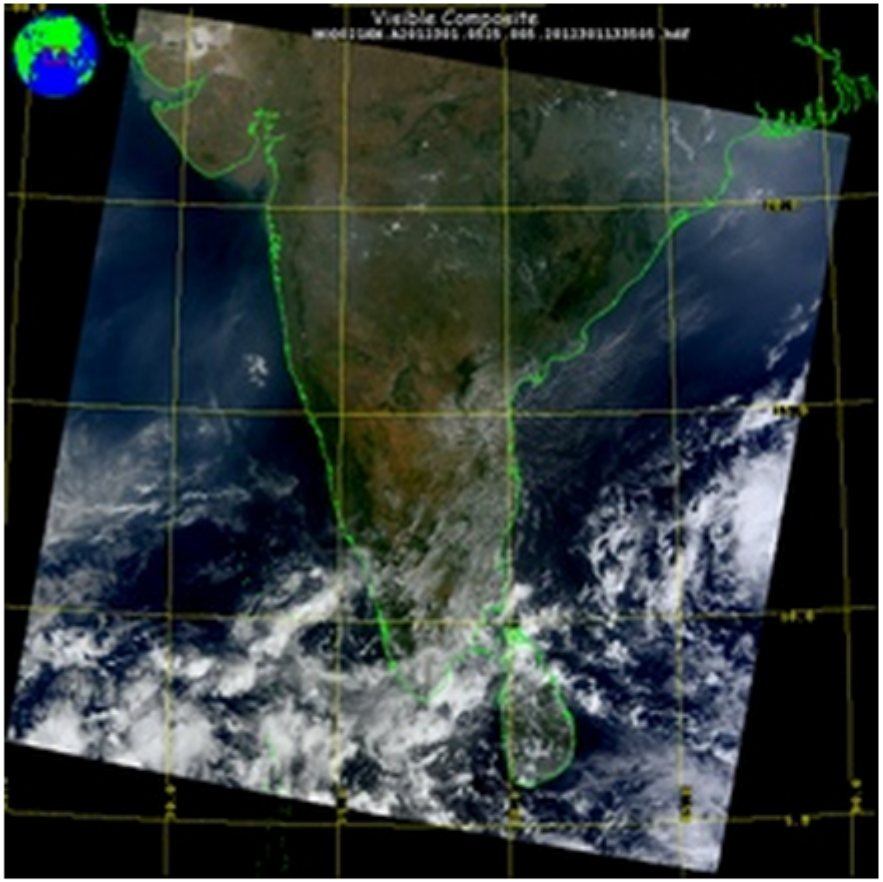


Abu_Al_Bukhoosh (25N,53E)	Bac_Giang (21N,106E)	Bac_Lieu (9N,105E)
Bahrain (26N,50E)	Beijing (39N,116E)	Beijing_RADI (40N,116E)
Cairo_EMA_2 (30N,31E)	Chiang_Mai_Met_Sta (18N,98E)	CUT-TEPAK (34N,33E)
Dalanzadgad (43N,104E)	Dhabi (24N,54E)	Dhadnah (25N,56E)
Dongsha_Island (20N,116E)	Dushanbe (38N,68E)	Eilat (29N,34E)
EVK2-CNR (27N,86E)	Gandhi_College (25N,84E)	Hamim (22N,54E)
Hong_Kong_PolyU (22N,114E)	IASBS (36N,48E)	IMS-METU-ERDEMLI (36N,34E)
Irkutsk (51N,103E)	Issyk-Kul (42N,76E)	Jaipur (26N,75E)
Kanpur (26N,80E)	Karachi (24N,67E)	Kuwait_University (29N,47E)
Kyiv (50N,30E)	Lahore (31N,74E)	Mezaira (23N,53E)
Mukdahan (16N,104E)	Mussafa (24N,54E)	Nainital (29N,79E)
NAM_CO (30N,90E)	Nes_Ziona (31N,34E)	Pimai (15N,102E)
Pokhara (28N,83E)	Pune (18N,73E)	QOMS_CAS (28N,86E)
SACOL (35N,104E)	SEDE_BOKER (30N,34E)	Sevastopol (44N,33E)
Silpakorn_Univ (13N,100E)	Solar_Village (24N,46E)	Ubon_Ratchathani (15N,104E)
XiangHe (39N,116E)	Xinglong (40N,117E)	

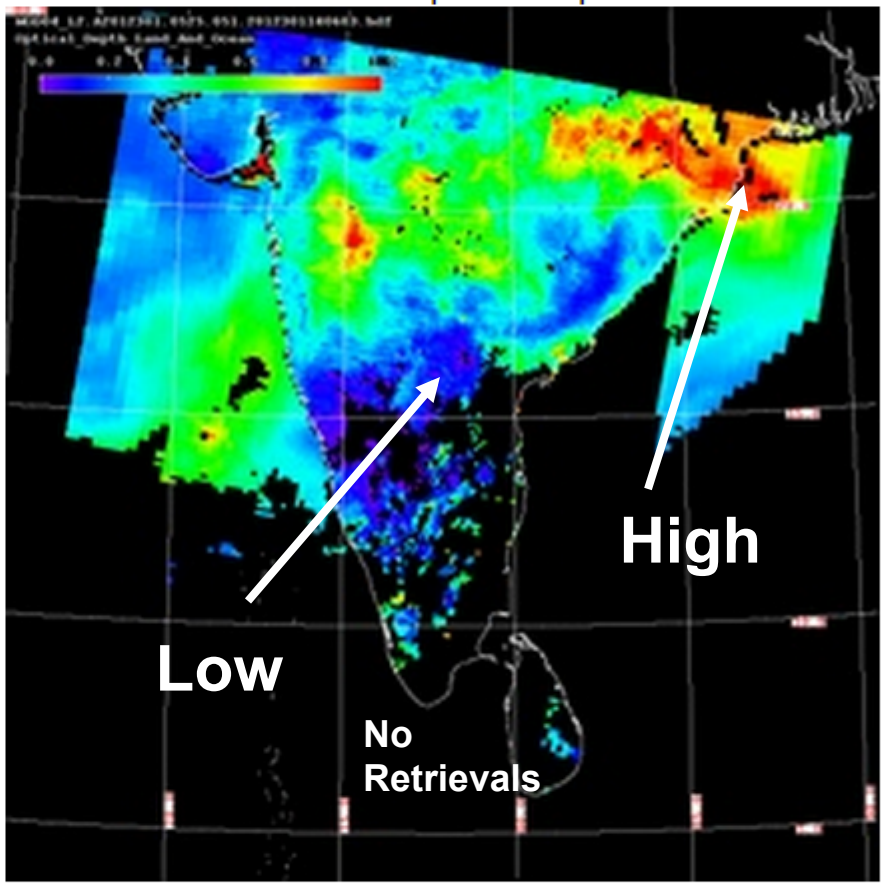
Aerosols from Satellite

Radiance -to- Aerosol Products

RGB



Aerosol Optical Depth

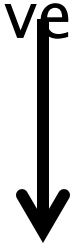


Aerosol Retrieval Algorithm

Data Product Hierarchy

Level 1 Products – Raw data with and without applied calibration.
– **NO AEROSOL DATA**

Level 2 Products – Geophysical Products
– **AEROSOL DATA**



Level 3 Products – Globally gridded geophysical products
– **AEROSOL DATA**

Satellites for air quality data

- **MODIS (Terra and Aqua)**
  - AOD: columnar aerosol loading – can be used to get particulate matter mass concentration

- **MISR (Terra)**
  - Columnar aerosol loading in different particle size bins
  - in some cases aerosol heights

- **OMI (Aura)**
  - Absorbing aerosols
  - Trace gases

- **VIIRS (NPP)**
  - Aerosol Optical Depth, Aerosol Type

Instrument Capabilities for Air Quality

Sensor Measurement Resolution

MODIS –	**250m-1 KM Resolution**
MISR-	**275m- 1.1 KM Resolution**
OMI –	**13 x 24 KM Resolution**
VIIRS –	**750 m**

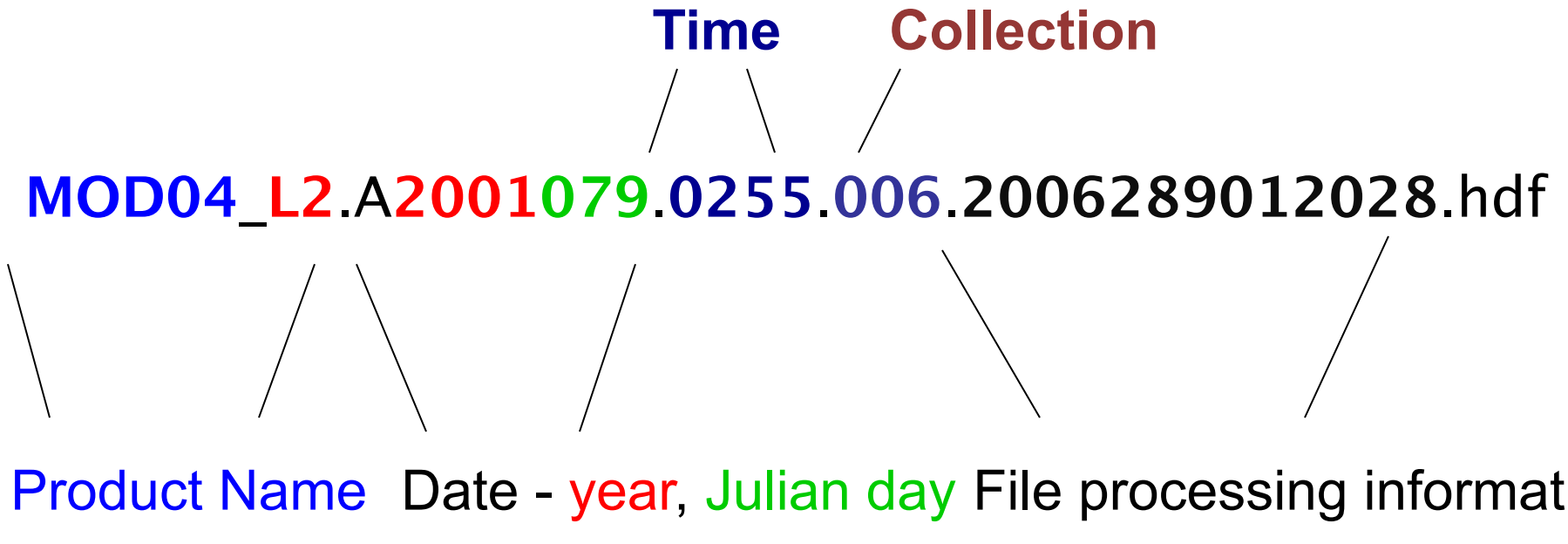
Satellite Aerosol Products

InInI	MODIS	MISR	OMI	VIIRS
Strengths	Coverage Resolution Calibration Accuracy	Calibration Accuracy Particle shape Aerosol height for thick layer or plume	Indication of absorbing or scattering particles	Coverage Resolution Calibration Smaller bow-tie effect
Weaknesses	Bright Surfaces* Ocean glint Non-spherical particles	Coverage	Resolution Cloud contamination	Bright Surfaces* Ocean glint
Main Products	AOD Ocean – 5 wavelengths Land – 3 wavelengths Fine Fraction* *Ocean only	AOD 4 wavelengths Spherical/ Non-spherical ratio Particle Size (3 Bins)	AOD AAOD Aerosol Index	AOD Aerosol Type
Product Resolution (level 2 and at Nadir)	10 Km 3 Km	17.6 Km	13 X 24 Km	0.75 km 6 km
Product Levels	2	2	2	2
Global Level 3 Aggregates	Daily 8 Day 30 Day	Monthly 3 Month Annual	Daily Monthly	Daily Monthly

MODIS

Understanding a MODIS File Name

Terra - MOD04
Aqua - MYD04



HDFLook, Panoply, IDL, Python, Fortran, Mat Lab can be used to read the data

MODIS Aerosol Parameters (SDS)

Optical_Depth_Land_And_Ocean
(with recommended quality flags over land and ocean)

Dark_Target_Deep_Blue_Optical_Depth_550_Combined
(Deep Blue & Dark Target Algorithm merged product)

Dark_Target_Deep_Blue_Optical_Depth_550_Combined_QA
(Quality Flag associated with DD product)

Reference:

http://www.atmos-meas-tech.net/6/2989/2013/amt-6-2989-2013.html

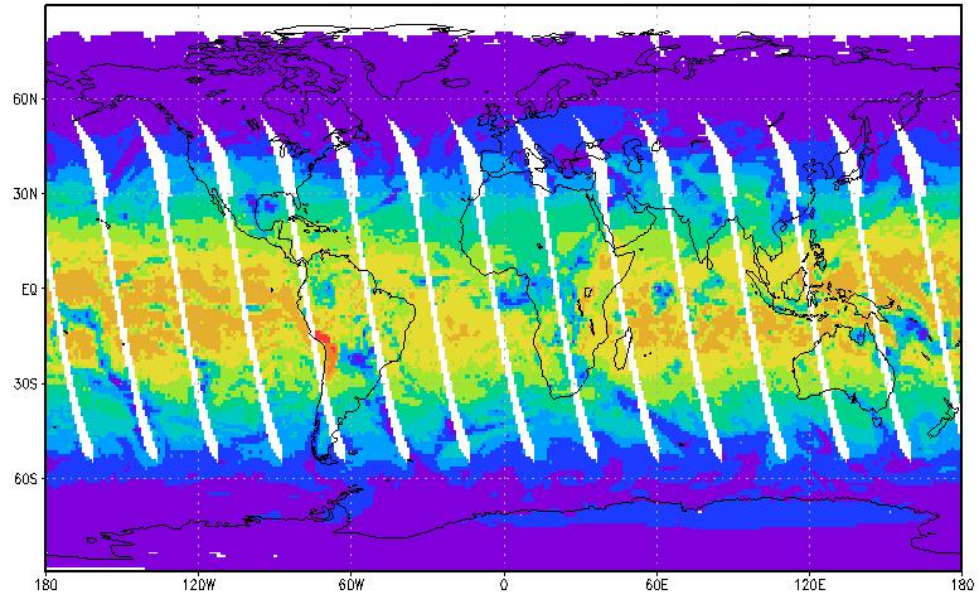
Access to MODIS Aerosol Products

- **NASA LAADSWEB. Searchable data base, FTP access**
  http://ladsweb.nascom.nasa.gov/index.html
- **MODIS-Atmos Site: Complete RGB archive and Level 3 product imagery.**
  http://modis-atmos.gsfc.nasa.gov/
- **Giovanni – web tool for imagery visualization and analysis**

  http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=MODIS_DAILY_L3

OMI

Ozone Monitoring Instrument (OMI)



One of four sensors on the EOS-Aura platform (OMI, MLS, TES, HIRDLS)

An international project:
Holland, USA, Finland
Launched on 07-15-04

Instrument Characteristics

- **Nadir solar backscatter spectrometer**
- **Spectral range 270-500 nm (resolution~1nm)**
- **Spatial resolution: 13X24 km footprint**
- **Swath width: 2600 km (global daily coverage)**

Retrieval Products

Column Amounts
- **Ozone (O_3)**
- **Nitrogen Dioxide (NO_2)**
- **Sulfur Dioxide: (SO_2)**
- **Others**

Aerosols

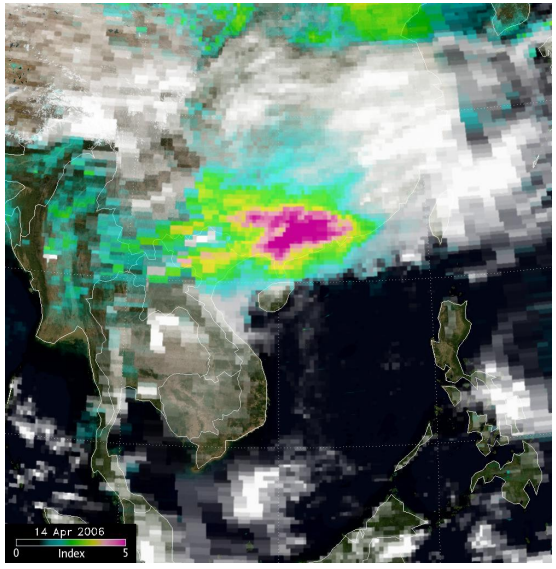
Applications of the Aerosol Index

-Validation tool for transport models

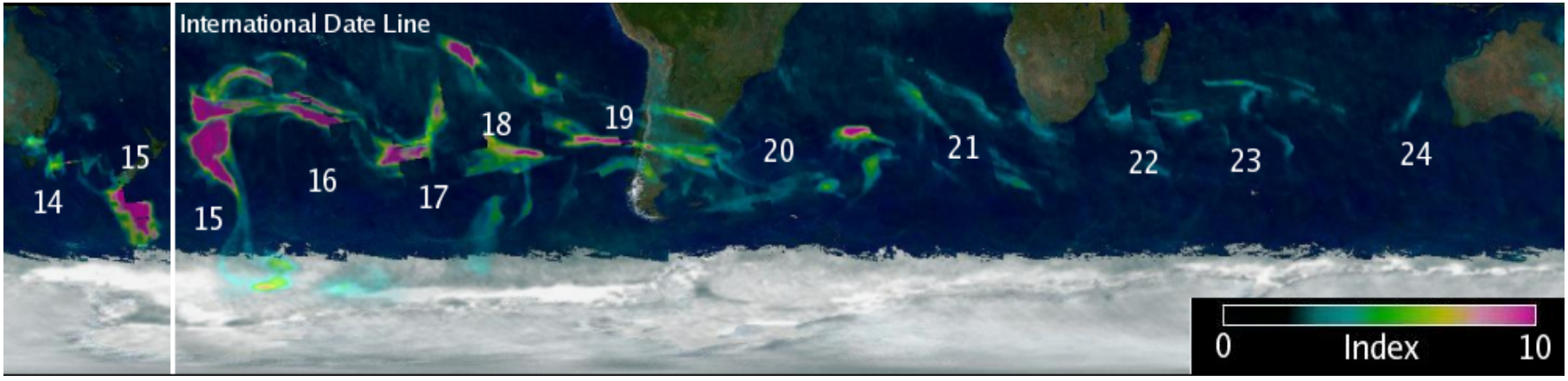
-Separation of carbonaceous from sulfate aerosols

-Identification of aerosols above PBL (i.e., PBL aerosols are not detectable by AI)

-Tracking of aerosol plumes above clouds and over ice/snow



Aerosol s over clouds:
April 14, 2006



Transport around the globe of a high altitude smoke layer generated by the Australian fires in December 2006. Numbers indicate the day of the month.

OMI data site

http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI

Version 003 OMI Level 2, Level 2G, Level-3 and Climatology Products			
Short Name & Data Access			Product Description
Level-2 Orbital Swath (Nadir pixels 13x24 km)	Level-2G Global Binned (0.25x0.25 or 0.125x0.125 deg)	Level-3 Global Gridded (0.25x0.25 or 1x1 deg)	
Aerosols			
OMAERUV	OMAERUVG	OMAERUVd	OMI/Aura Near-UV Aerosol Optical Depth and single Scattering Albedo
OMAERO	OMAEROG	OMAEROe	OMI/Aura Multi-Wavelength Aerosol Optical Depth and single Scattering Albedo

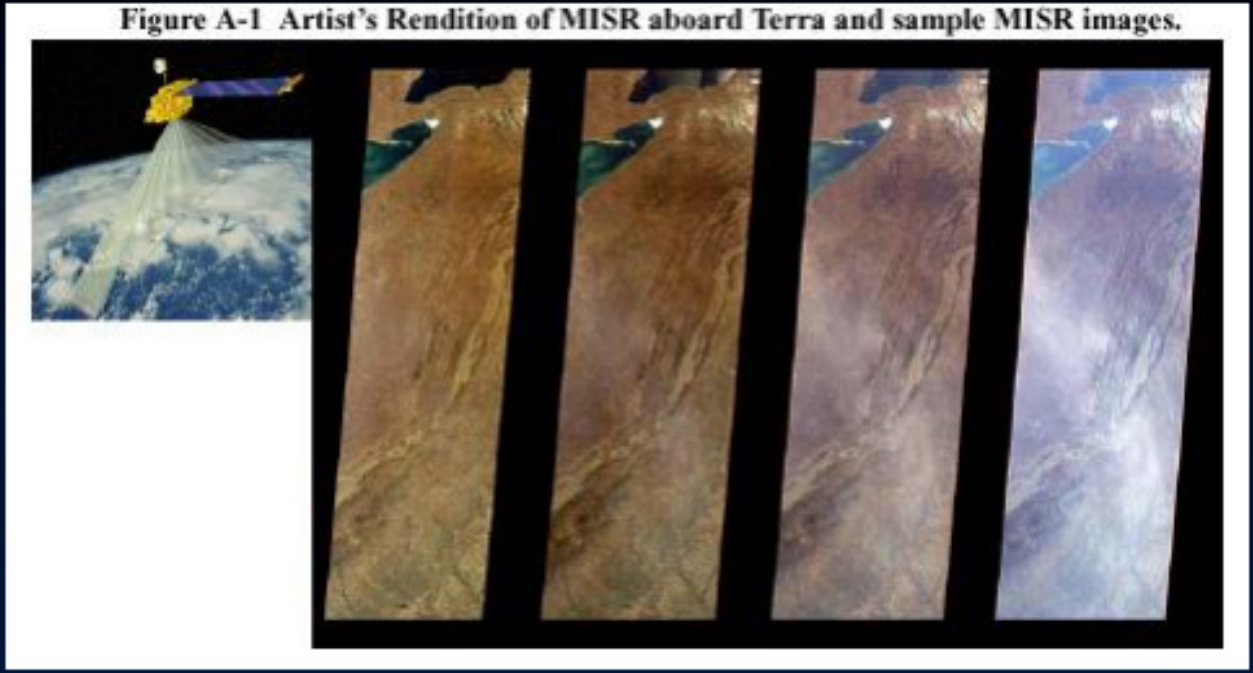
OMI-Aura_L2-OMAERUV_2011m1024t0521-o38692_v003-2011m1024t115317.he5

Product name

YYYYmMMDDtHHMM

MISR

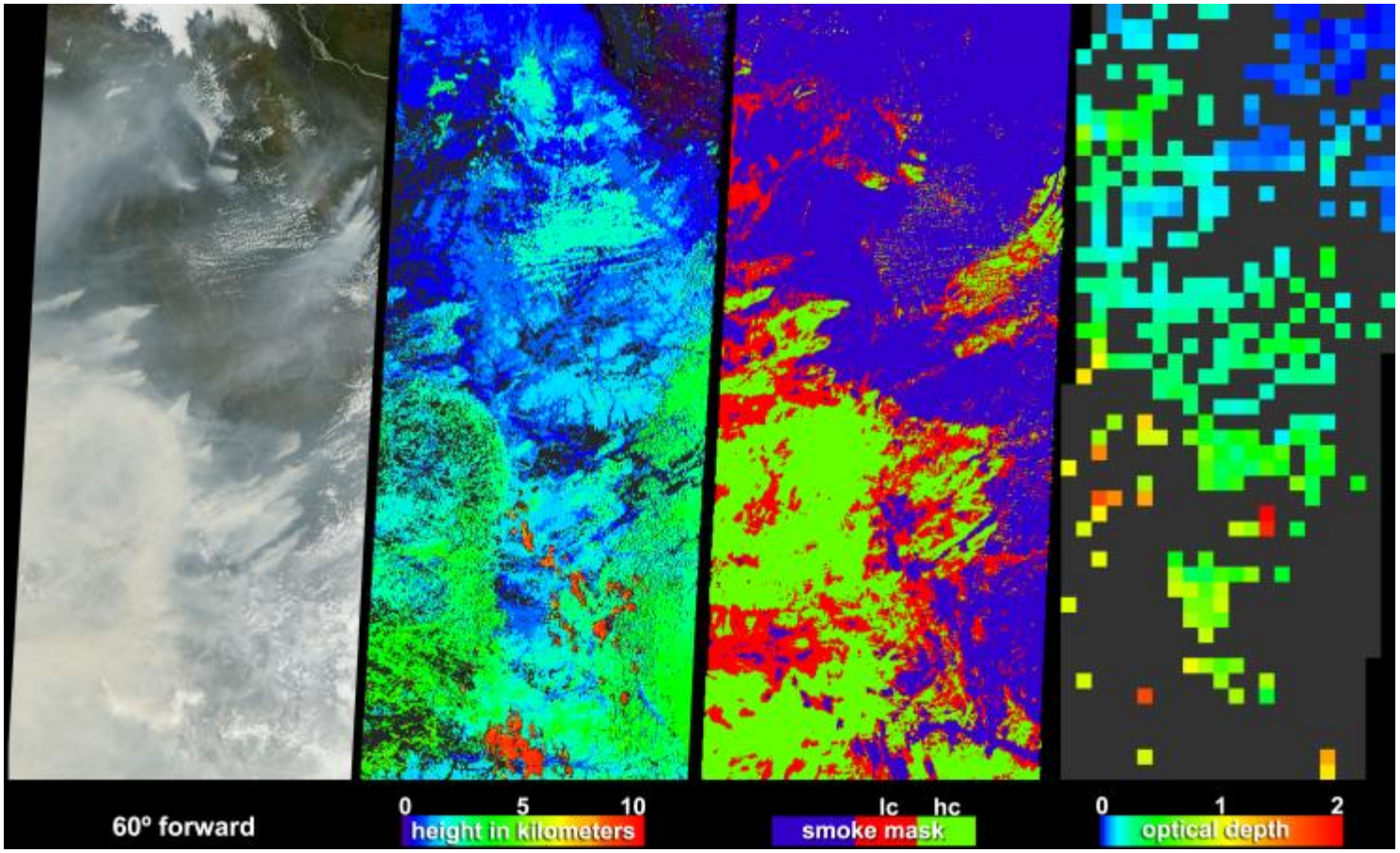
MISR Background



Four MISR images over Appalachain Mountains
Nadir, 45.6 deg, 60.0 deg, 70.5 deg forward viewing cameras

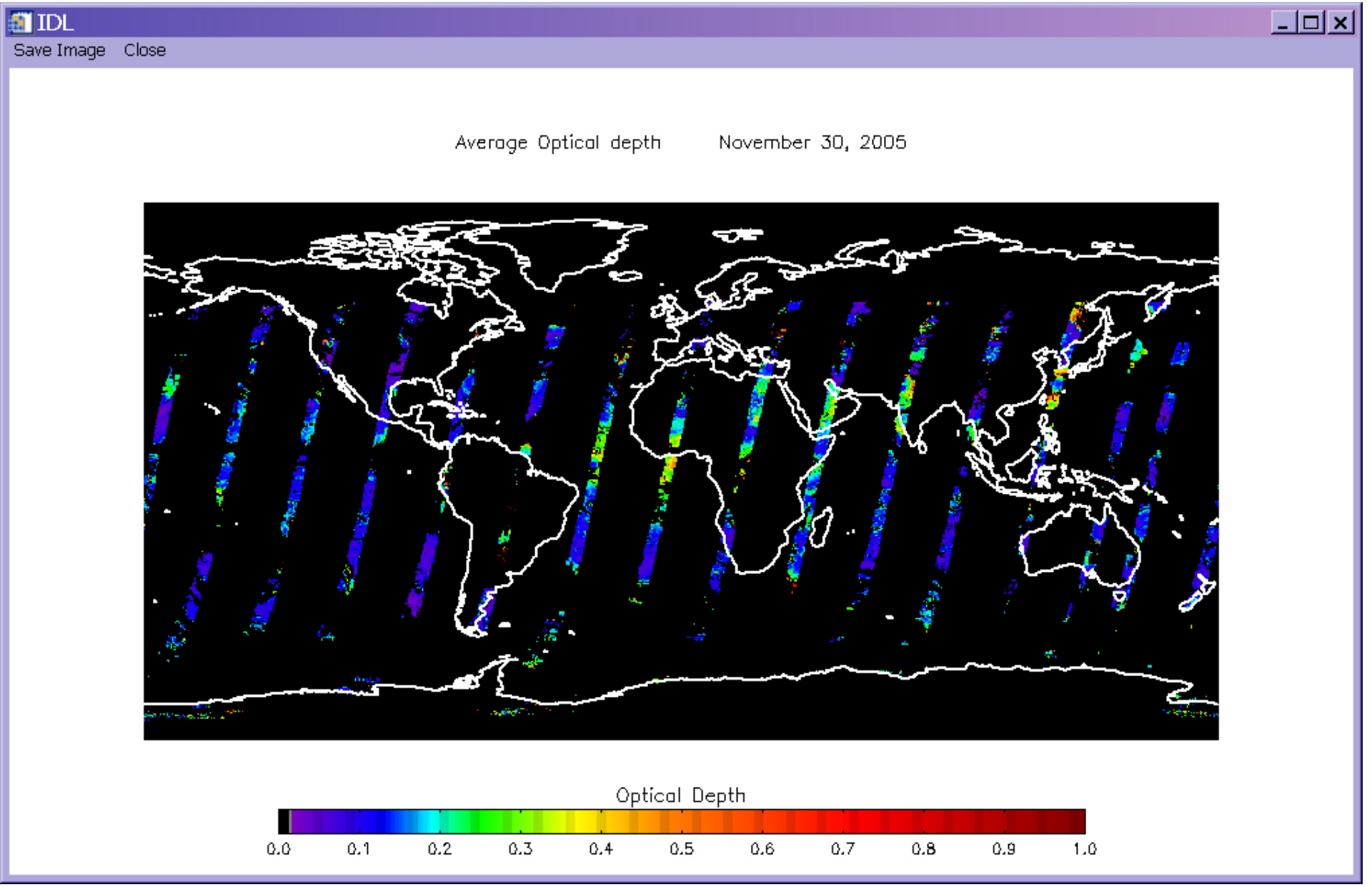
Angular observations (which are not available in MODIS) makes MISR capable of providing additional information on particle size, shape and aerosol height under specific cases

Aerosol Heights from MISR



Smoke Signals from the Alaska and Yukon Fires - July 2004

MISR Level 3 Tool



Level 2 & 3 aerosol

1 file = one orbit - about 98 min Data

17.6x17.6 km^2 , 0.5x0.5, and 1x1deg, daily, monthly, seasonal

MISR_AM1_AS_AEROSOL_P028_O002510_F12_0022.hdf

RegBestEstimateSpectralOptDepth (AOD – 4 wavelengths)
RegBestEstimateSpectralOptDepthFraction (AOD fraction for small, medium, large, spherical, and non-spherical particles)

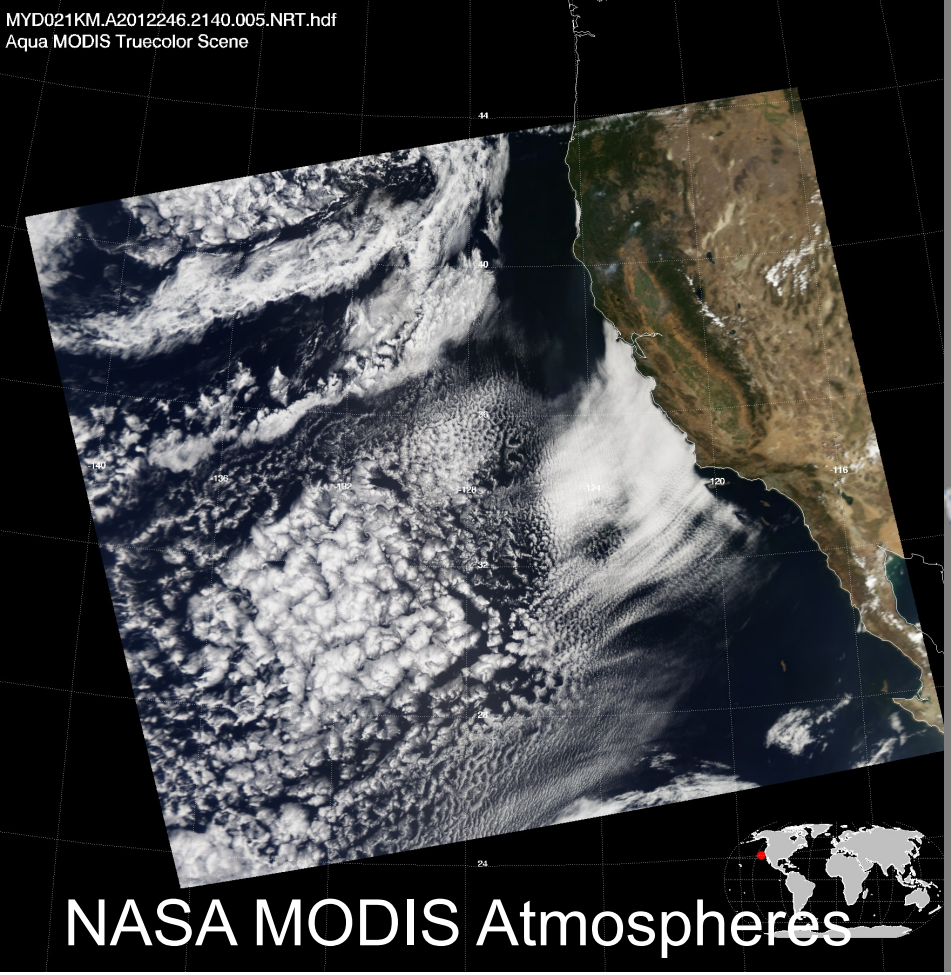
Data access and handling tutorial

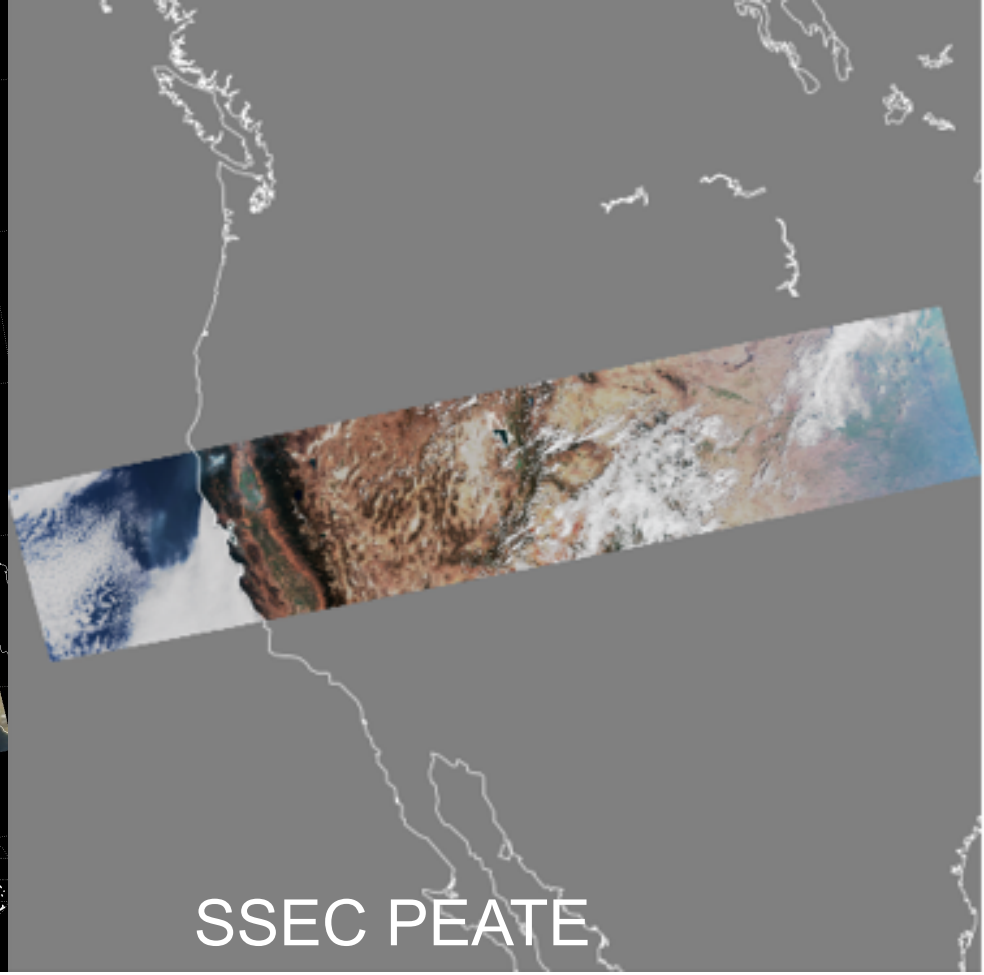
http://eosweb.larc.nasa.gov/PRODOCS/misr/workshop/ppt/2010_lcluc/misr_tutorial.pdf

VIIRS

VIIRS is a multiwavelength imager, like MODIS with similar wavelength bands in the aerosol rang

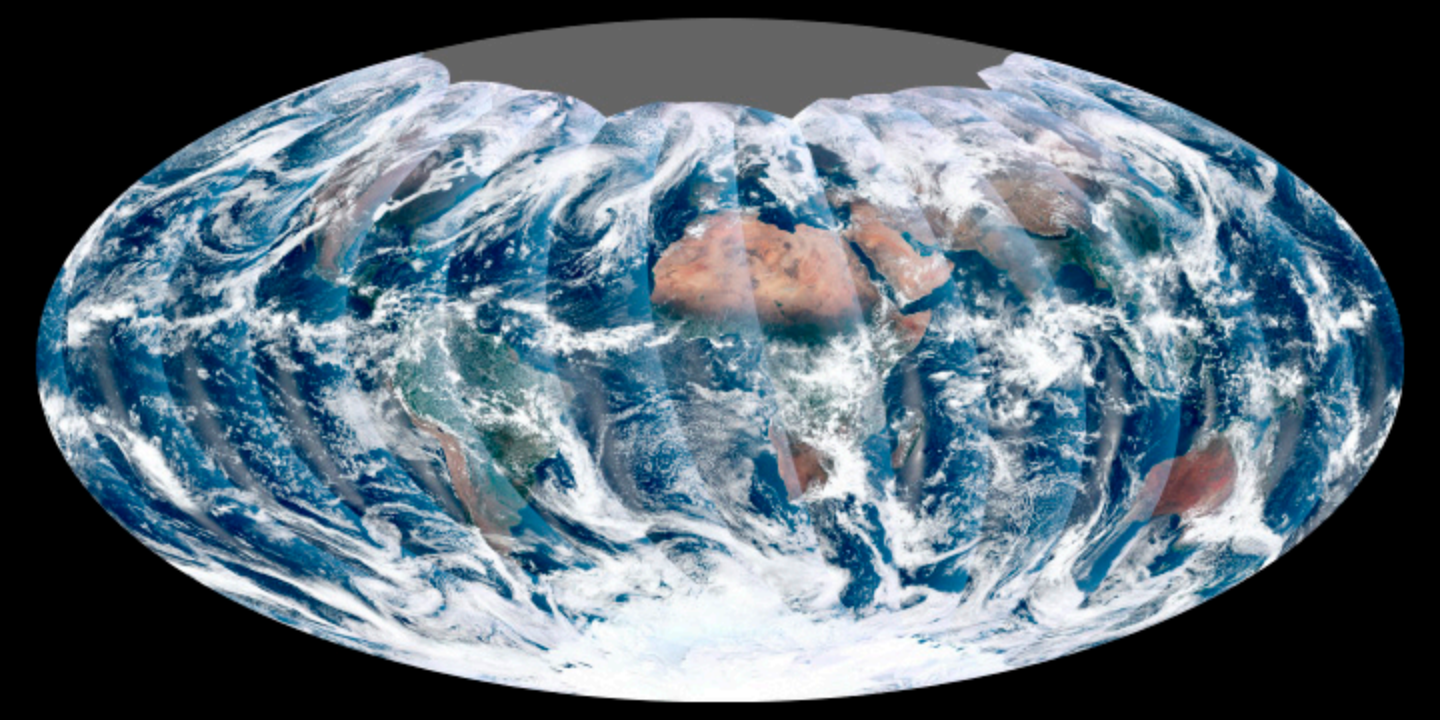
	MODIS	VIIRS
Orbit altitude	690 km	824 km
Equator crossing time	13:30 LT	13:30 LT
Granule size	5 minutes	86 seconds
swath	2330 km	3000 km
Pixel nadir	0.5 km	0.75 km
Pixel edge	2 km	1.5 km





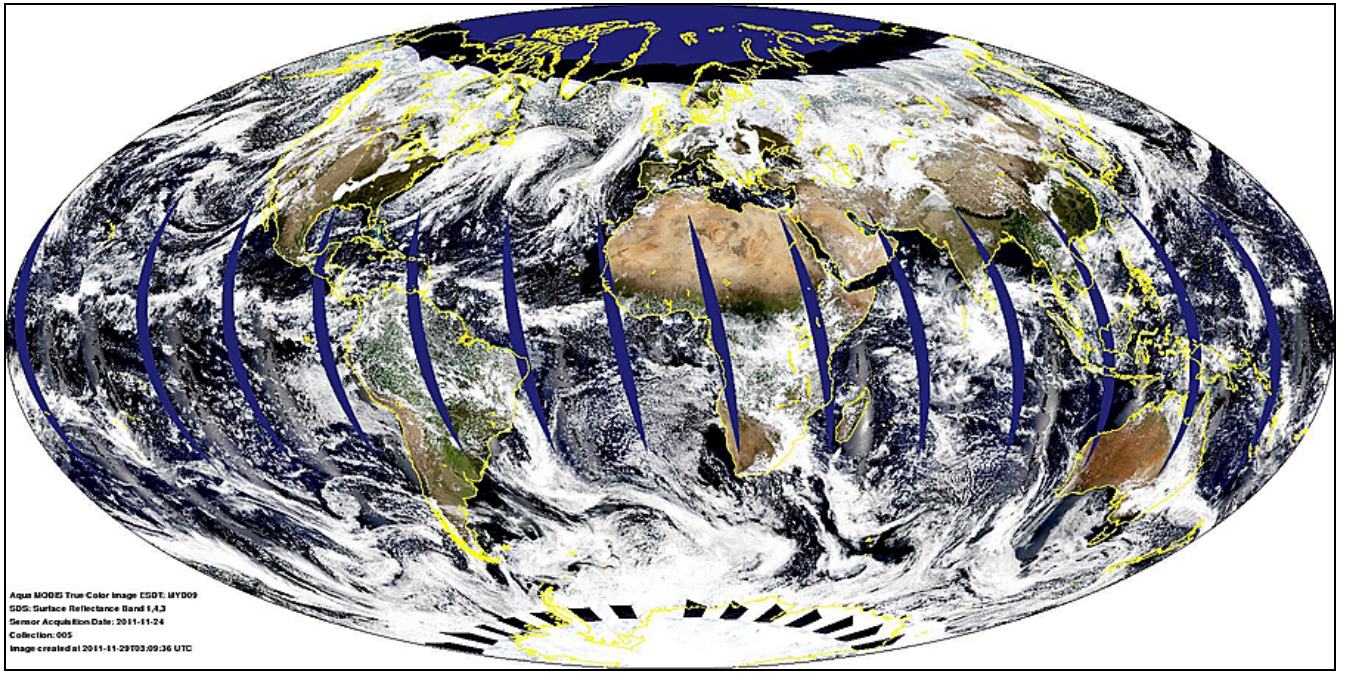
MODIS
0.66 – 0.55 – 0.47 µm
2 Sep 2012
21:40 UTC

VIIRS
0.67 – 0.55 – 0.49 µm
2 Sep 2012
20:24:27.8 UTC



VIIRS
Nov 24, 2011

MODIS - AQUA
Nov 24, 2011



VIIRS Level 2 & 3 Aerosol Data

Level 2, VIIRS Data

http://www.class.ngdc.noaa.gov/saa/products/search?sub_id=0&datatype_family=VIIRS&submit.x=26&submit.y=6

Level 3, Quarter Degree Gridded VIIRS Data

http://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/products_gridded.php

References & links

. ARSET-AQ webpage

http://airquality.gsfc.nasa.gov/index.php?section=11

. MODIS ATMOS

http://modis-atmos.gsfc.nasa.gov/mod04_l2/

. MISR DATA

http://eosweb.larc.nasa.gov/PRODOCS/misr/Quality_Summaries/L2_AS_Products.html

. OMI DATA

http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI

. IDEA

http://www.star.nesdis.noaa.gov/smcd/spb/aq/

. SMOG BLOG

http://alg.umbc.edu/usaq/

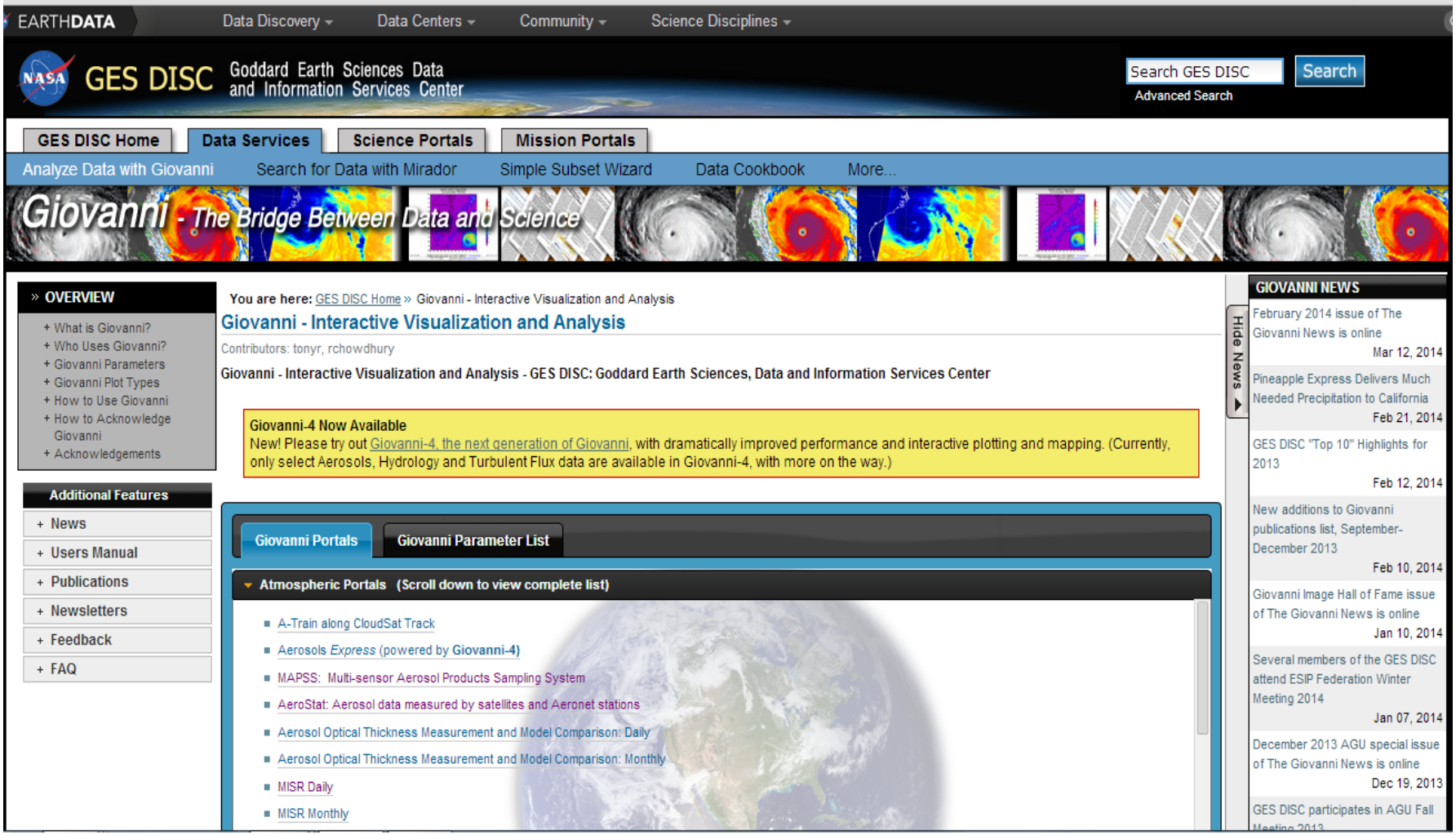
For Today's Material click here

http://airquality.gsfc.nasa.gov/IntroWebinar/

GIOVANNI

Interactive Visualization and Analysis

http://disc.sci.gsfc.nasa.gov/giovanni

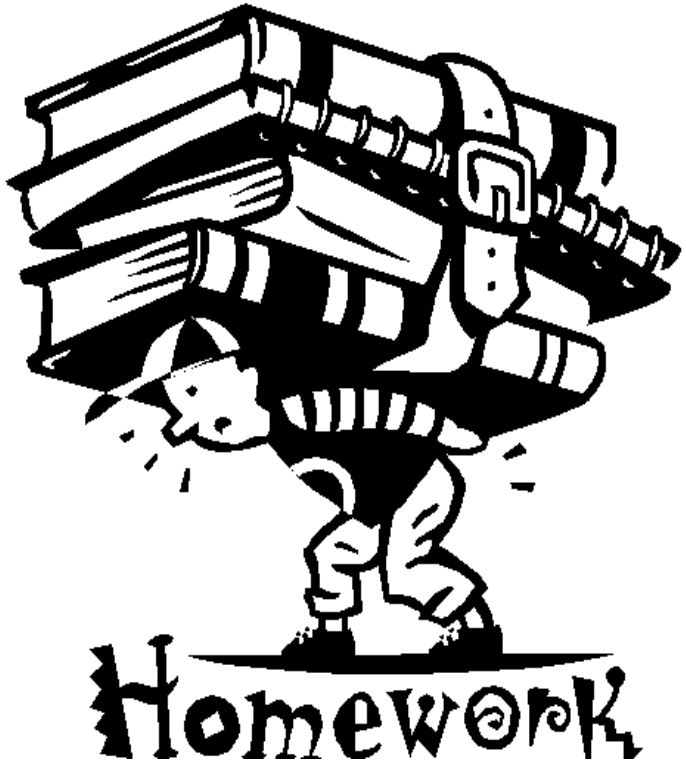


GIOVANNI

Atmospheric Portal

- A-Train along CloudSat Track
- **Aerosols *Express* (powered by Giovanni-4)**
- **MAPSS: Multi-sensor Aerosol Products Sampling System**
- **AeroStat: Aerosol data measured by satellites and Aeronet stations**
- **Aerosol Optical Thickness Measurement and Model Comparison: Daily**
- **Aerosol Optical Thickness Measurement and Model Comparison: Monthly**
- **MISR Daily**
- **MISR Monthly**
- Aqua/AIRS Global: Daily
- Aqua/AIRS Global: Monthly
- **Terra and Aqua MODIS: Daily**
- **Terra and Aqua MODIS: Monthly**
- **Aura OMI Level 3**
- **Aura OMI Level 2G**
- Aura Microwave Limb Sounder (MLS)
- Aura High Resolution Dynamics Limb Sounder (HIRDLS)
- Aura Tropospheric Emission Spectrometer (TES)
- Earth Probe and Nimbus-7 TOMS
- Upper Atmosphere Research Satellite (UARS) Halogen Occultation Experiment (HALOE)
- **SeaWiFS Deep Blue Level 3 Long-Term Aerosol Data: Daily**
- **SeaWiFS Deep Blue Level 3 Long-Term Aerosol Data: Monthly**

Assignment – Week 3



Due on
April 8, 2014

https://docs.google.com/forms/d/1NuOEEChZUfNpf-WDUuKbFtRohXJF6nHch--3qgRMW7U/viewform