Using NASA's Giovanni Web Portal to Access and Visualize Satellite-Based Earth Science Data in the Classroom

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(GES DISC)

Teaching With New Geoscience Tools:
Visualizations, Models and Online Data
Amherst, MA
10-12 February 2008

GES-DISC Interactive Online Visualization and Analysis Infrastructure (Giovanni)

- With Giovanni and a few mouse clicks, one can easily obtain information on the atmosphere around the world.

- There is no need to learn data formats to retrieve and process data.

- You can try various combinations of parameters measured by different instruments.

- All the statistical analysis is done via a regular web browser.

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

Caution: *Giovanni is a constantly evolviong data exploration tool!*
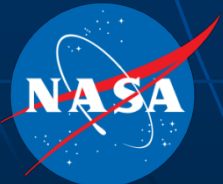
What is Giovanni?

Data Inputs

- MLS **Aura**
- OMI **Aura**
- AIRS **Aqua**
- MODIS **Aqua**
- MODIS **Terra**
- SeaWiFS
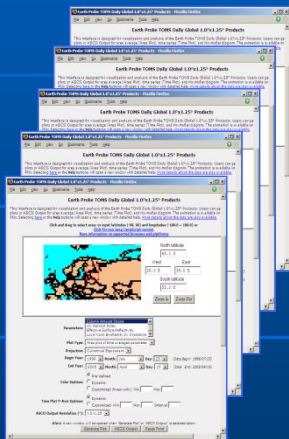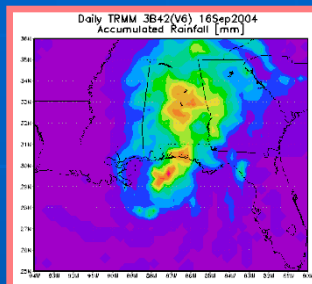- TRMM
- HALOE **UARS**
- TOMS **EP, N7**
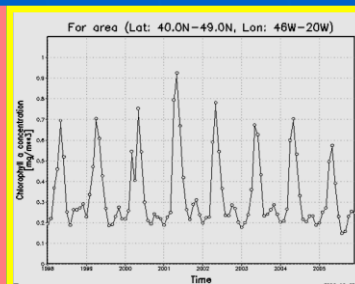- AMSR-E **Aqua**
- MISR **Terra**
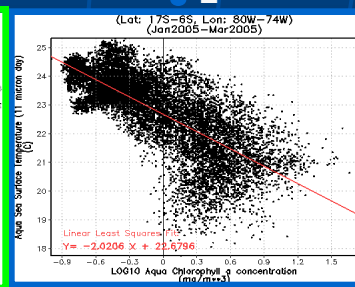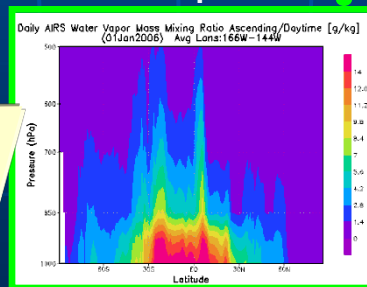- CloudSat
- CALIOP **CALIPSO**

Giovanni Instances

Area Plot — A

Time Series — B

Model Output — C
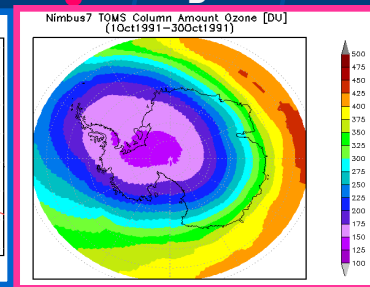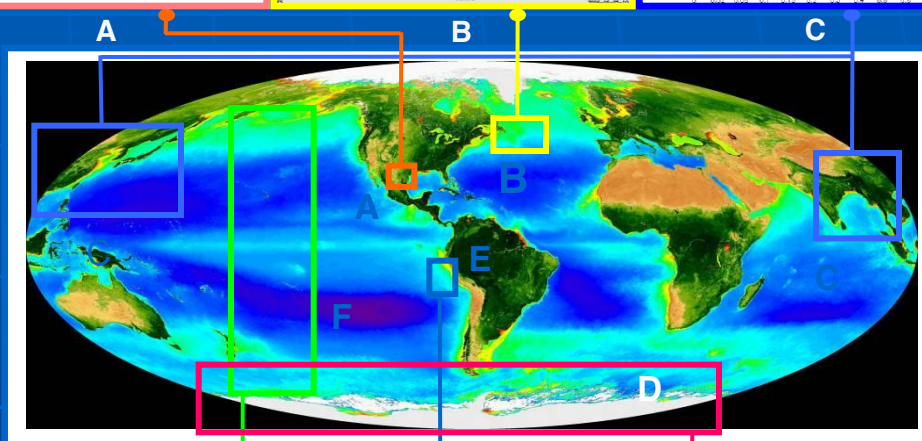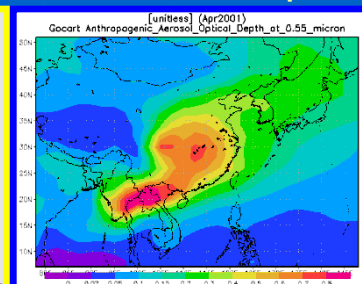
Profile Cross-Section — F

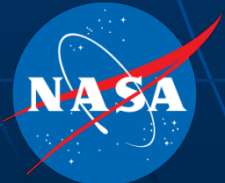**Correlations** — E

Column Densities — D

Giovanni capabilities

Basic (one-parameter):
- **Area plot** – averaged or accumulated over any data period for any rectangular area (various map projections)
- **Time plot** – time series averaged over any rectangular area
- **Hovmoller plots** –longitude-time or latitude-time cross sections
- **ASCII output** – for all plot types (can be used with GIS apps, spreadsheets, etc.)
- **Image animation** – for area plot
- **Vertical profiles**
- **Vertical cross-sections, zonal means**

Beyond basics:
- **Area plot** - geographical intercomparison between two parameters
- **Time plot** - an X-Y time series plot of several parameters
- **Scatter plot of parameters in selected area and time period**
- **Scatter plot of area averaged parameters** - regional (i.e., spatially averaged) relationship between two parameters
- **Temporal correlation map** - relationship between two parameters at each grid point in the selected spatial area
- **Temporal correlation of area averaged parameters** - a single value of the correlation coefficient of a pair of selected parameters
- **Difference plots**
- **Anomaly plots**
- **Acquiring parameter and spatial subsets** in a batch mode through Giovanni

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

Science Questions

You will need to identify *which* specific data products can address your science question.

Data Products

Satellite

Data in Giovanni

Data within GES DISC (Archive)

All Satellite Remote Sensing Data

NASA Earth-Observing Satellites

Direction of Earth's Rotation

North Pole (hidden)

Path of Satellite

Plane of Equator

NASA's "Big Blue Marble"
Photograph taken from Apollo 17
7 December 1972

Sun-Synchronous,
Near-Polar,
Low-Earth Orbit (LEO)

South Pole

NASA Earth-Observing Satellites

Path of Satellite

Low Earth Orbit (LEO): Orbiting at an altitude of 600-1,000 km.

NASA Earth-Observing Satellites

Low Earth Orbit: Orbiting at an altitude of 600-1,000 km.

Path of Satellite

Ascending Orbit: The satellite is moving South to North when that portion of the orbit track crosses the equator.

NASA Earth-Observing Satellites

Low Earth Orbit: Orbiting at an altitude of 600-1,000 km.

Ascending Orbit: The satellite is moving South to North when that portion of the orbit track crosses the equator.

Descending Orbit: The satellite is moving North to South when that portion of the orbit track crosses the equator.

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NASA Earth-Observing Satellites

Low Earth Orbit: Orbiting at an altitude of 600-1,000 km.

Ascending Orbit: The satellite is moving South to North when that portion of the orbit track crosses the equator.

Descending Orbit: The satellite is moving North to South when that portion of the orbit track crosses the equator.

Ascending vs. descending orbits are like night and day!

NASA Earth-Observing Satellites

Low Earth Orbit: Orbiting at an altitude of 600-1,000 km.

Ascending Orbit: The satellite is moving South to North when that portion of the orbit track crosses the equator.

Sun-Synchronous: The satellite is *always* in the *same relative position* between the Earth and Sun.

Descending Orbit: The satellite is moving North to South when that portion of the orbit track crosses the equator.
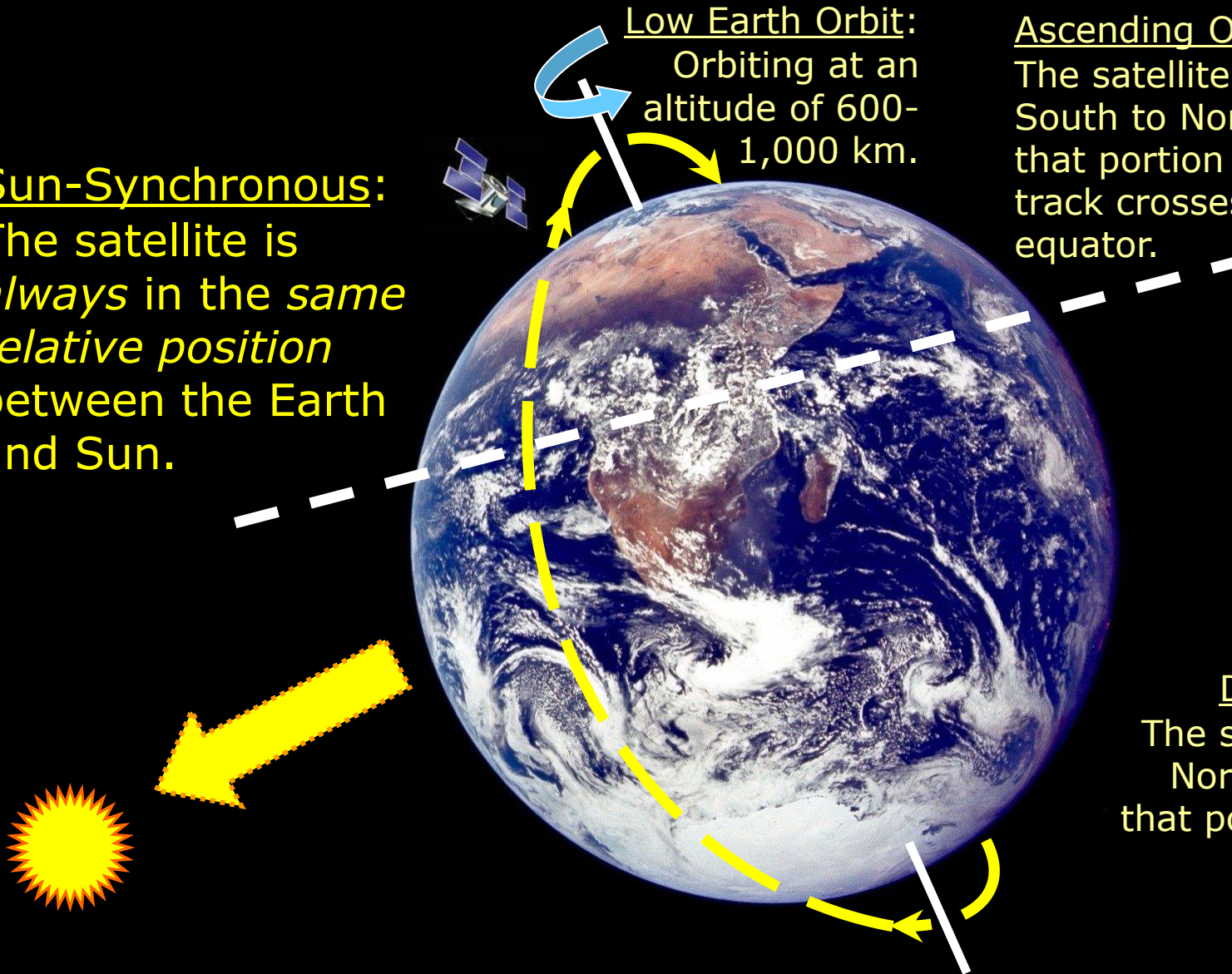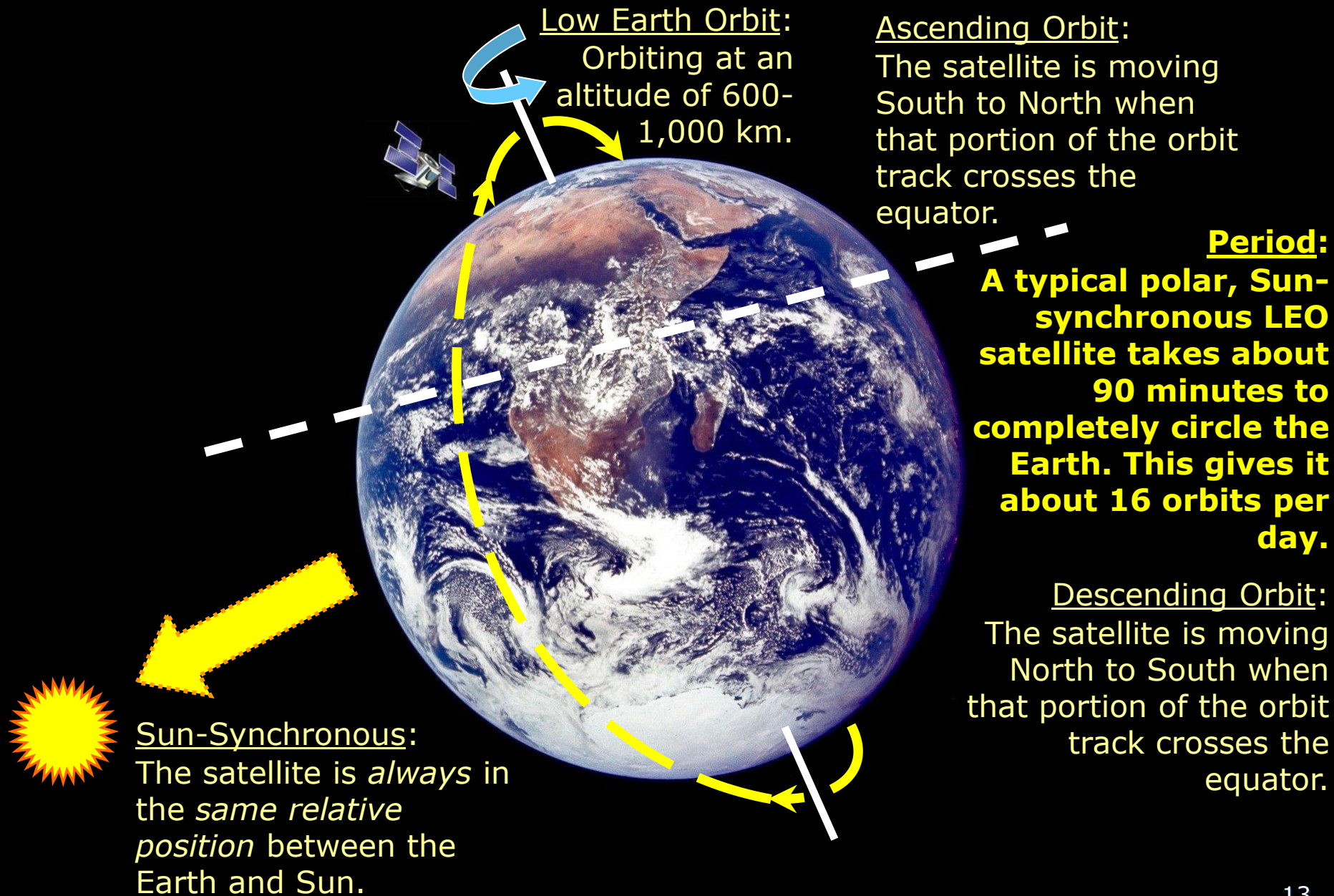
NASA Earth-Observing Satellites

Low Earth Orbit: Orbiting at an altitude of 600-1,000 km.

Ascending Orbit: The satellite is moving South to North when that portion of the orbit track crosses the equator.

Period: A typical polar, Sun-synchronous LEO satellite takes about 90 minutes to completely circle the Earth. This gives it about 16 orbits per day.

Descending Orbit: The satellite is moving North to South when that portion of the orbit track crosses the equator.

Sun-Synchronous: The satellite is *always* in the *same relative position* between the Earth and Sun.

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NASA Earth-Observing Satellites

Low Earth Orbit: Orbiting at an altitude of 600-1,000 km.

Ascending Orbit: The satellite is moving South to North when that portion of the orbit track crosses the equator.

Equator-Crossing Time: The local apparent solar time when the satellite crosses the equator.

Example: Terra has an equator crossing time of 10:30 am, and is called an "AM" or morning satellite.
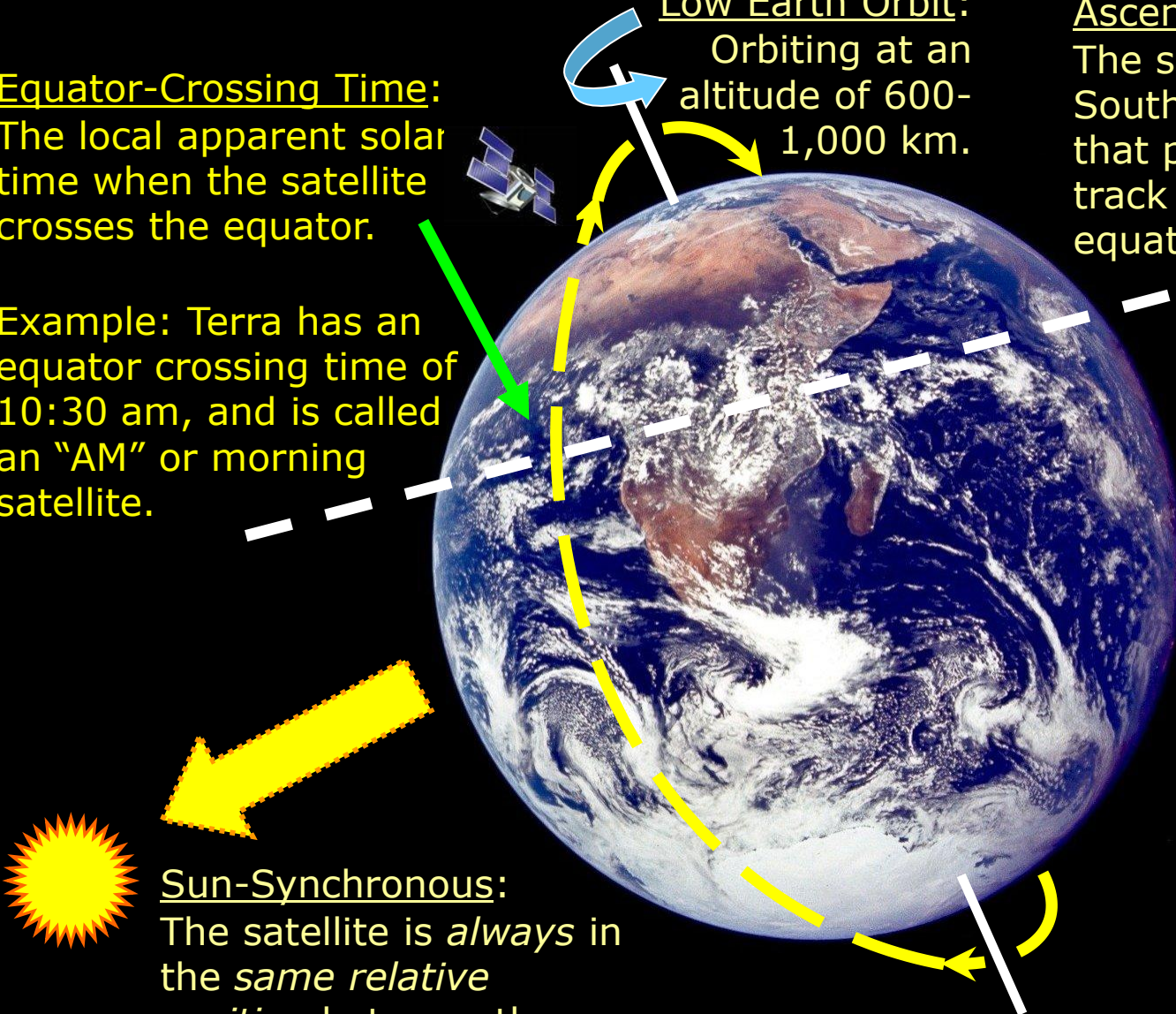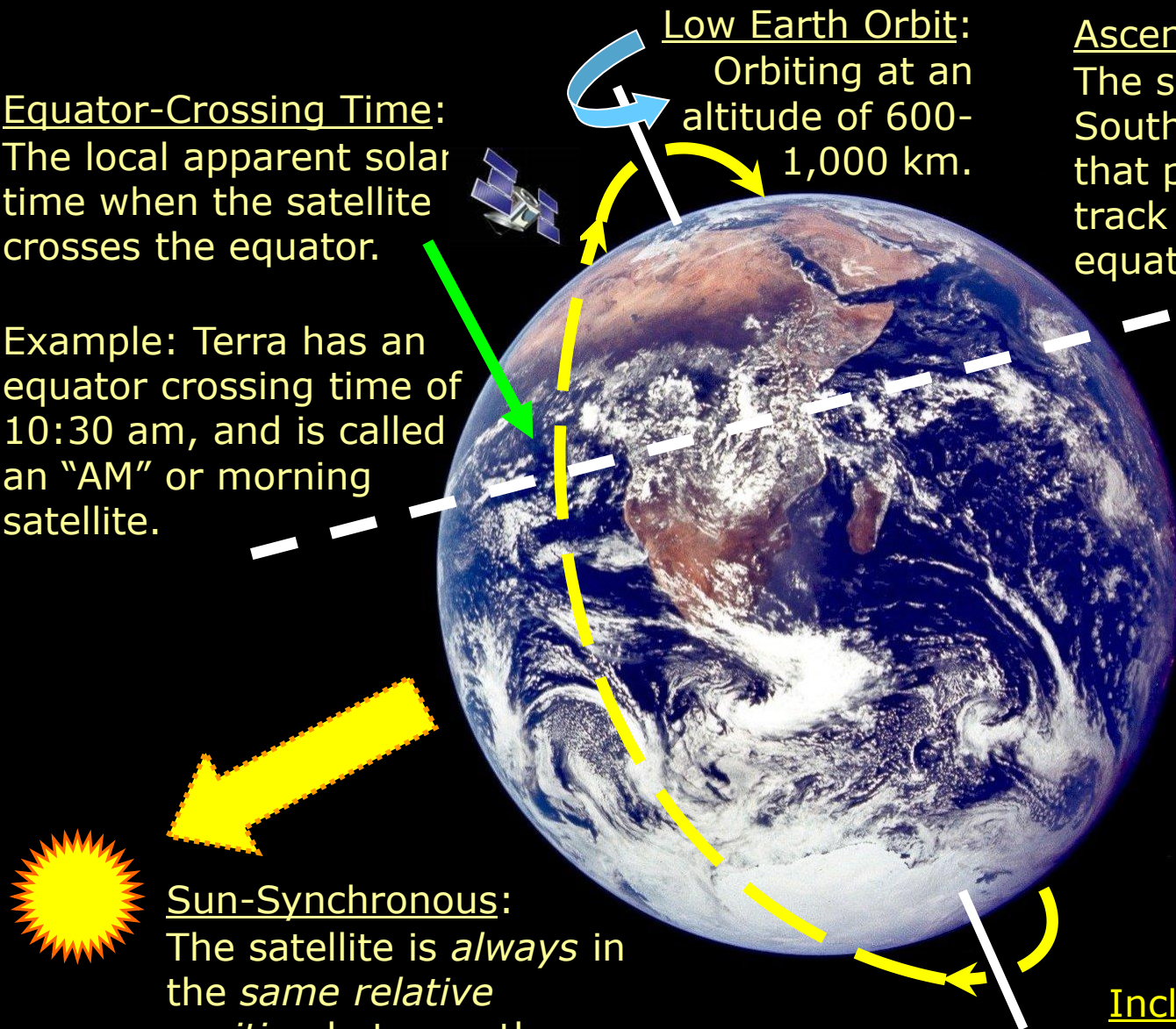
Period: A typical polar, Sun-synchronous LEO satellite takes about 90 minutes to completely circle the Earth. This gives it about 16 orbits per day.

Descending Orbit: The satellite is moving North to South when that portion of the orbit track crosses the equator.

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NASA Earth-Observing Satellites

Low Earth Orbit: Orbiting at an altitude of 600-1,000 km.

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Descending Orbit: The satellite is moving North to South when that portion of the orbit track crosses the equator.

Sun-Synchronous: The satellite is *always* in the *same relative position* between the Earth and Sun.

Inclination: The position of the orbital plane relative to the equator. For near-polar orbits, typically about 97º.

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Satellite Inclination

Low Inclination Orbit (often near 57º-- Space Shuttle)
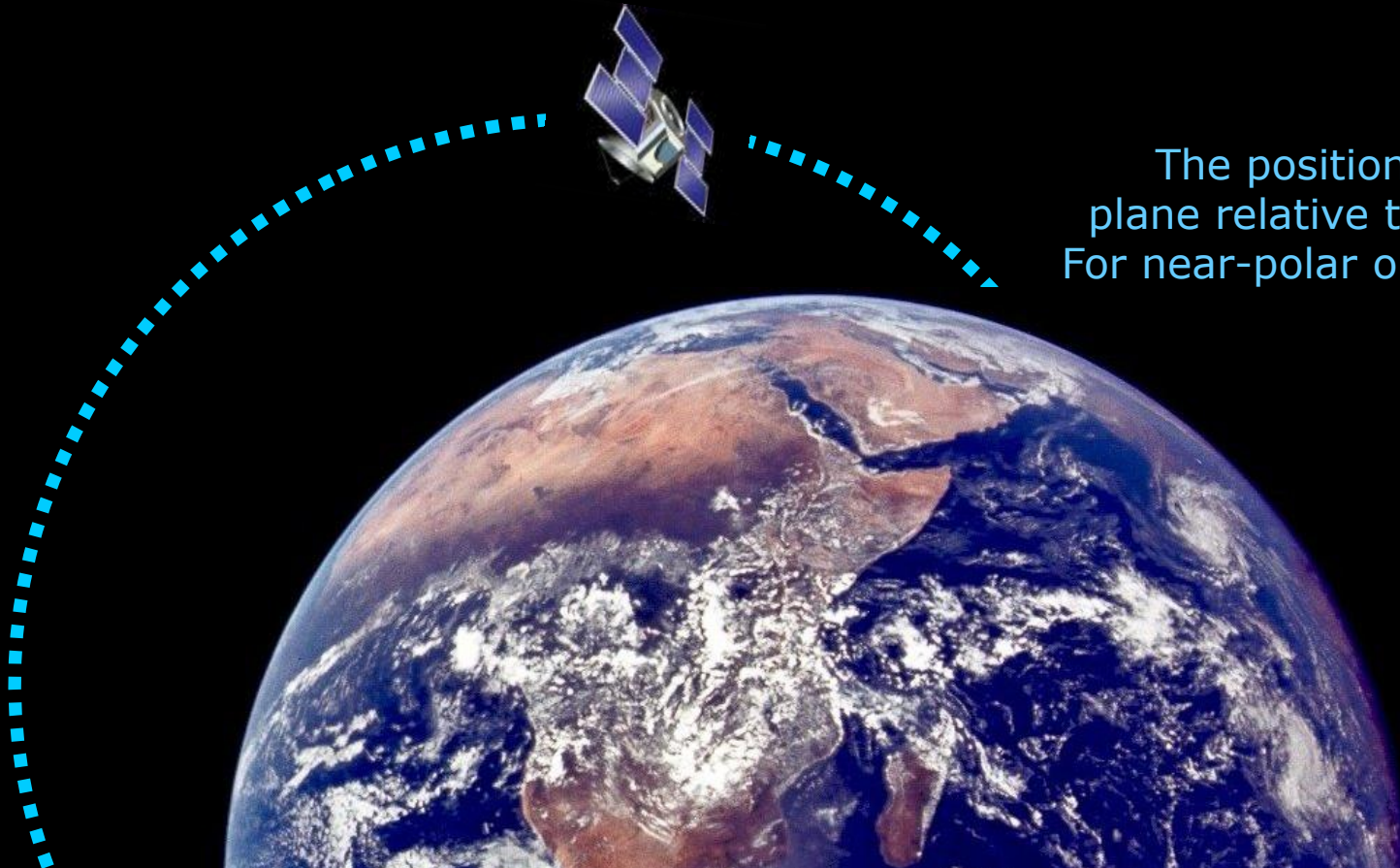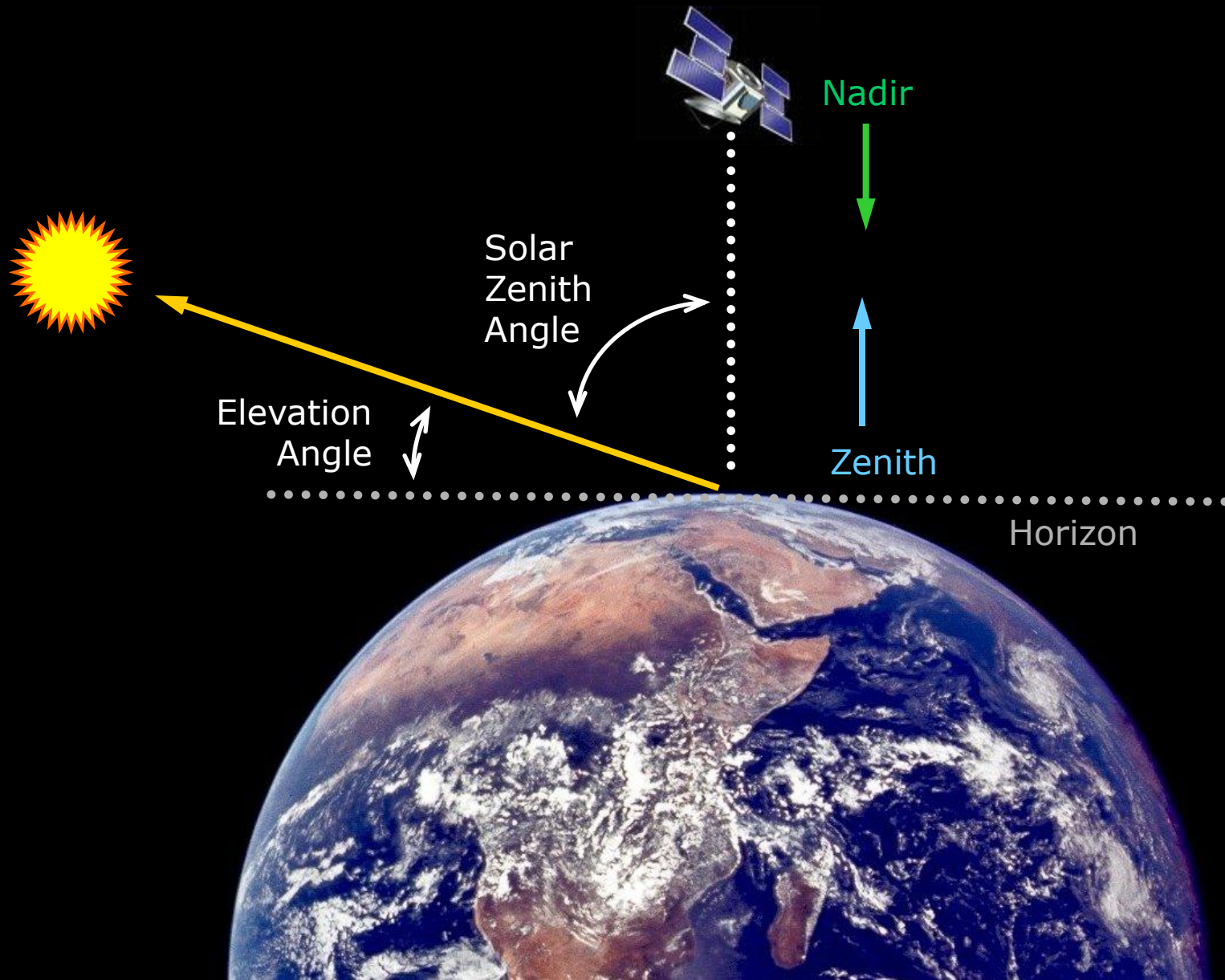
no polar coverage
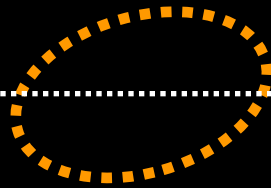
High Inclination or Polar Orbit (near 90º)
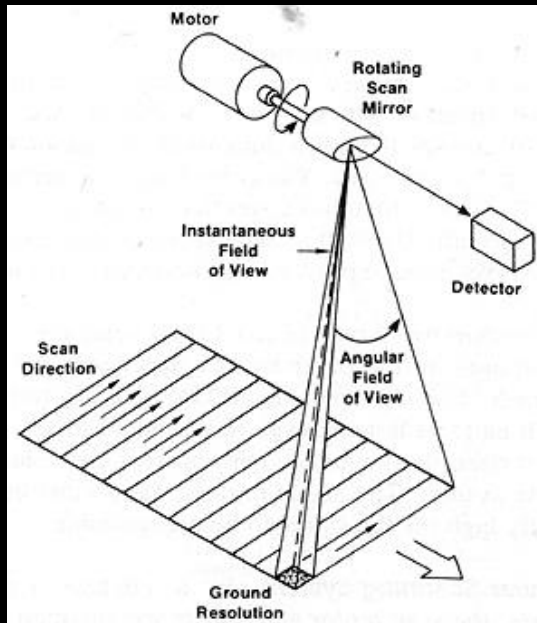
virtually complete global coverage

Equator

Inclination:
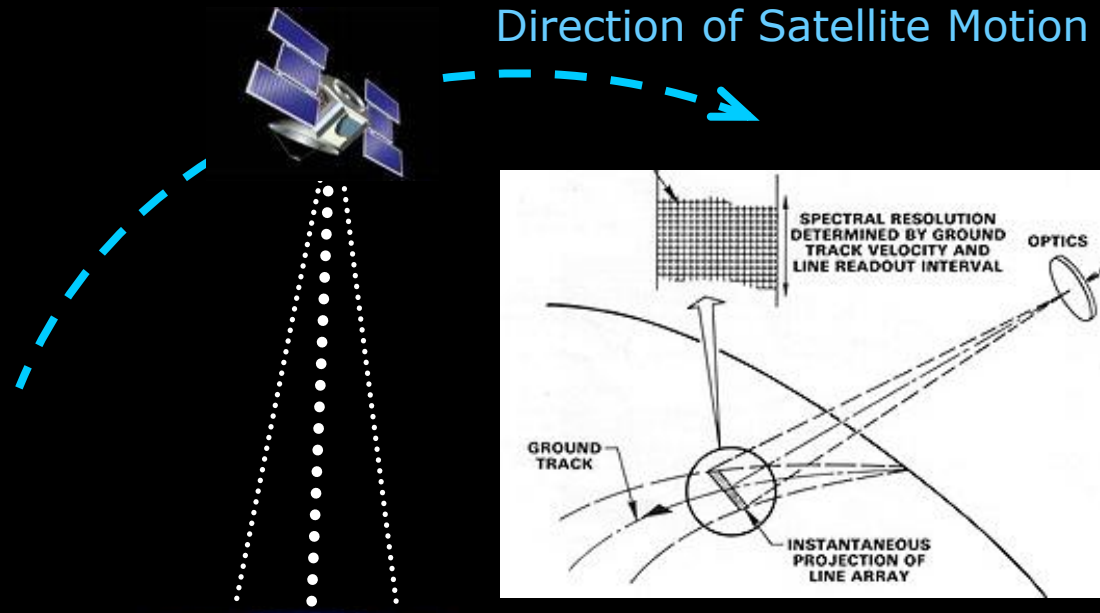The position of the orbital plane relative to the equator. For near-polar orbits, typically about 97º.
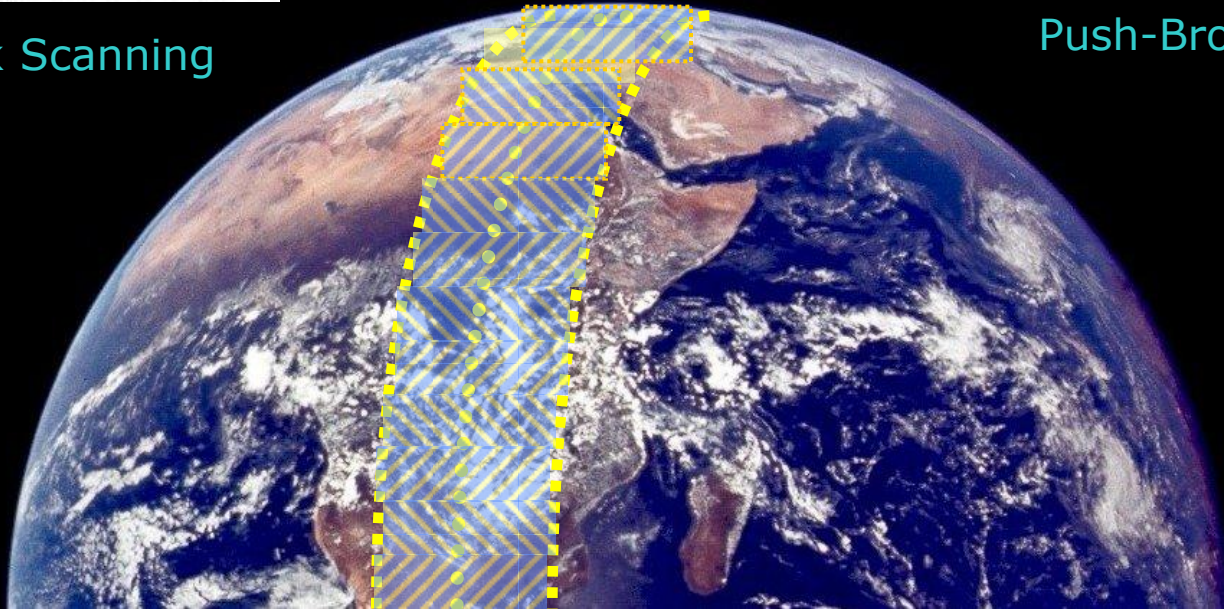
Satellite Viewing Geometry

Nadir

Solar Zenith Angle
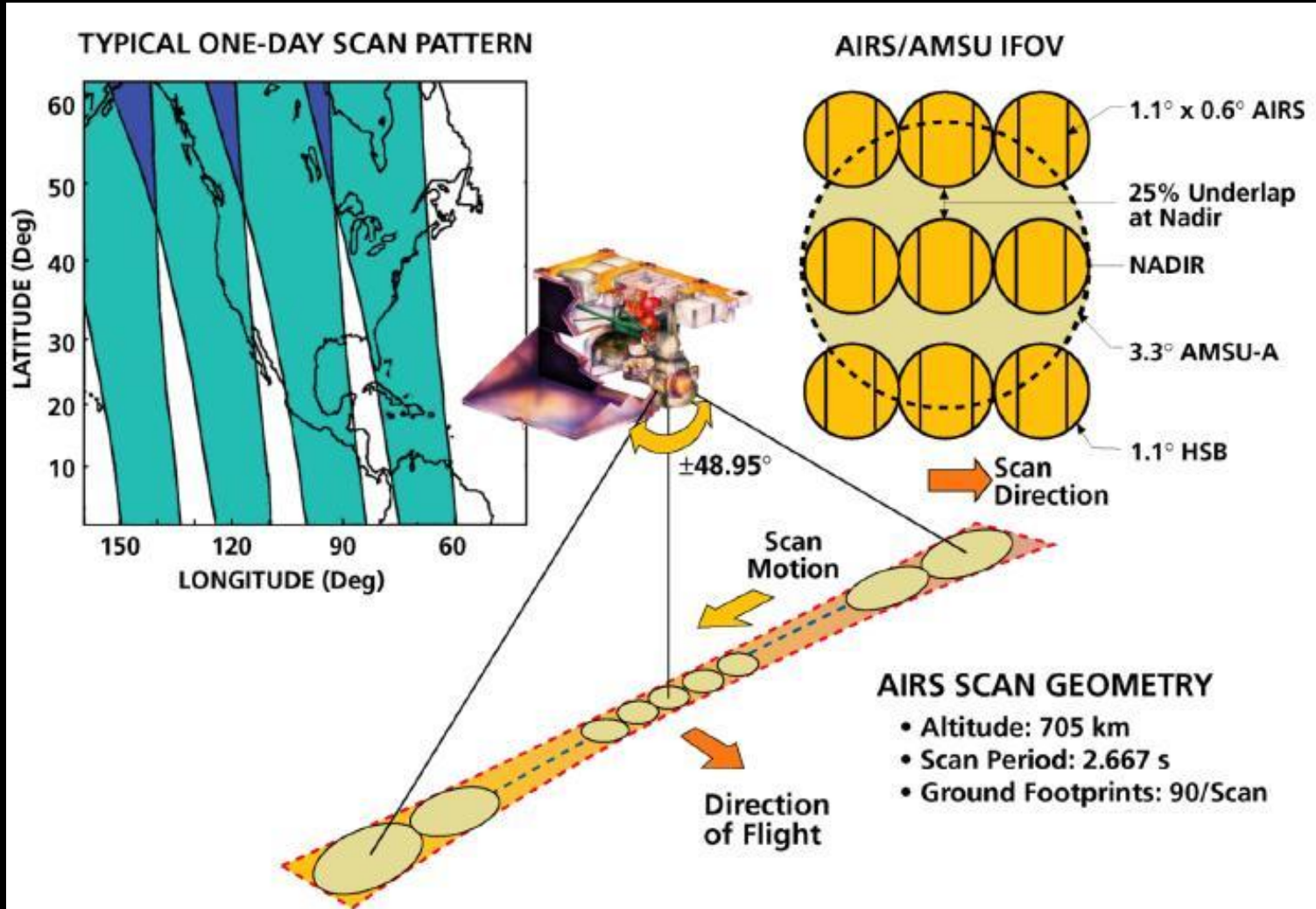
Elevation Angle

Zenith

Horizon

Satellite Viewing Geometry

Direction of Satellite Motion

Cross-Track Scanning

Push-Broom

Satellite Viewing Geometry

TYPICAL ONE-DAY SCAN PATTERN

AIRS/AMSU IFOV

- 1.1° x 0.6° AIRS
- 25% Underlap at Nadir
- NADIR
- 3.3° AMSU-A
- 1.1° HSB

Scan Direction

±48.95°

Scan Motion

Direction of Flight

AIRS SCAN GEOMETRY
- Altitude: 705 km
- Scan Period: 2.667 s
- Ground Footprints: 90/Scan

Cross-track scanning results in individual observations ("pixels") of varying size, and can leave gaps between successive orbits if the scan angle is not wide enough.

NASA Earth-Observing Satellites

UARS

Nimbus-7

SORCE

TRMM

Earth Probe

Aura

Aqua

CloudSAT

CALIPSO

SeaWIFS

Terra
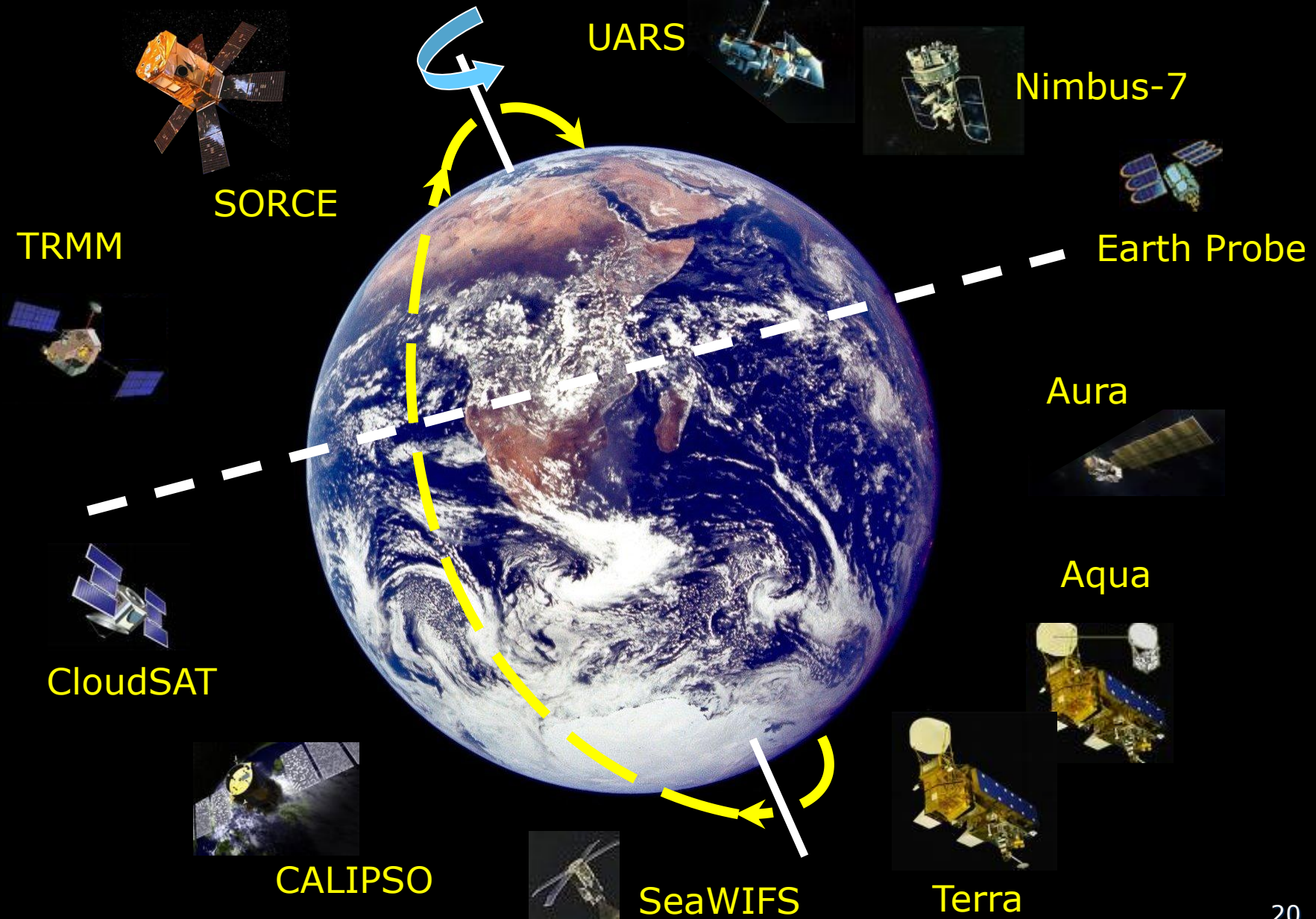
NASA's A-Train:

A Constellation of Near-Simultaneous Afternoon-Viewing Satellites

CALIPSO
1:31:15

CloudSat
1:31

Parasol
1:33
(ESA)

Aqua
1:30

OCO
1:15
(2009
launch)

Aura
1:38

Near-Coincident A-Train Observations

- Modis (Aqua)
- AIRS (Aqua)
- CloudSat
- Calipso
- OMI (Aura)
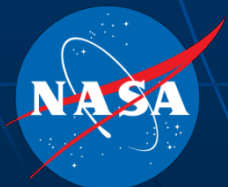
Scientific Instruments on NASA Satellites

TRMM: Tropical Rainfall Measuring Mission

Instruments:

- Precipitation Radar (PR)
- TRMM Microwave Imager (TMI)
- Visible and InfraRed Scanner (VIRS)
- Cloud and Earth Radiant Energy Sensor (CERES)
- Lightning Imaging Sensor

Data Products at GES DISC:

- 3-hourly, daily and monthly rainfall
- Surface rainfall rate
- Accumulated rainfall
- Latent heating
- Cloud liquid water content
- Cloud ice content

in cooperation with:

JAXA Japan Aerospace Exploration Agency

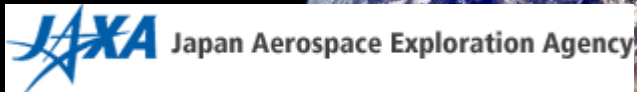# Scientific Instruments on NASA Satellites

SORCE: Solar Radiation and Climate Experiment

Instruments:

- Total Irradiance Monitor (TIM)
- Solar Stellar Irradiance Comparison Experiment (SOLSTICE)
- Spectral Irradiance Monitor (SIM)
- XUV Photometer System (XPS)

Data Products at GES DISC:

- Daily spectral solar irradiance
- 6-hr and daily total solar irradiance

Scientific Instruments on NASA Satellites

EOS Terra

Instruments:

- Adv. Spaceborne Thermal Emission and Reflection Radiometer (ASTER)
- Moderate Resolution Imaging Spectroradiometer (MODIS)
- Multi-angle Imaging SpectroRadiometer (MISR)
- Measurement of Pollution In The Troposphere (MOPITT)
- Cloud and Earth Radiant Energy Sensor (CERES)

Data Products at GES DISC:

- Aerosol optical depths
- Cloud fraction
- Cloud top pressure
- Aerosol parameters
- Water vapor
- Cirrus cloud reflectance
- etc.

Scientific Instruments on NASA Satellites

EOS Aqua

Instruments:

- Atmospheric Infrared Sounder (AIRS)
- Advanced Microwave Sounding Unit (AMSU-A)
- Humidity Sounder for Brazil (HSB)
- Advanced Microwave Scanning Radiometer for EOS (AMSR-E)
- Moderate-Resolution Imaging Spectro-radiometer (MODIS)
- Clouds and the Earth's Radiant Energy System (CERES)

Data Products at GES DISC:

- Aerosol optical depths
- Cloud fraction
- Cloud top pressure
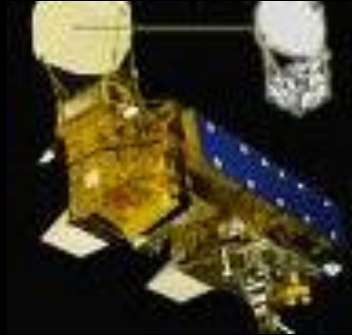- Aerosol parameters
- Water vapor
- Cirrus cloud reflectance
- Surface pressure
- Temperature profiles
- H_2O and O_3 profiles

Scientific Instruments on NASA Satellites

EOS Aura

Instruments:

- High Resolution Dynamic Limb Sounder (HIRDLS)
- Microwave Limb Sounder (MLS)
- Ozone Monitoring Instrument (OMI)
- Tropospheric Emission Spectrometer (TES)

Data Products at GES DISC:

- Atmospheric profiles of H_2O, O_3, CO, ClO, HCl, HCN, OH and HNO_3
- Temperature profiles
- Geopotential height
- Total column O3 and NO2
- Aerosol index
- Cloud reflectivity
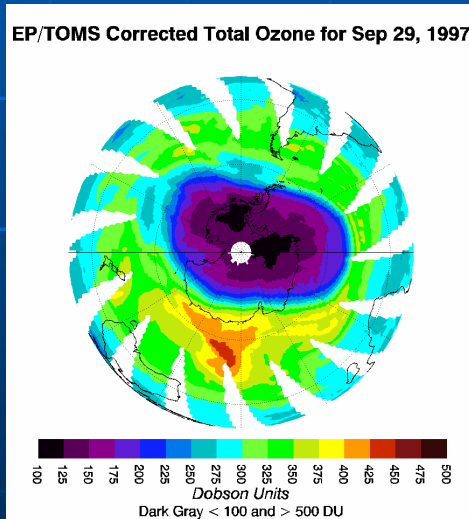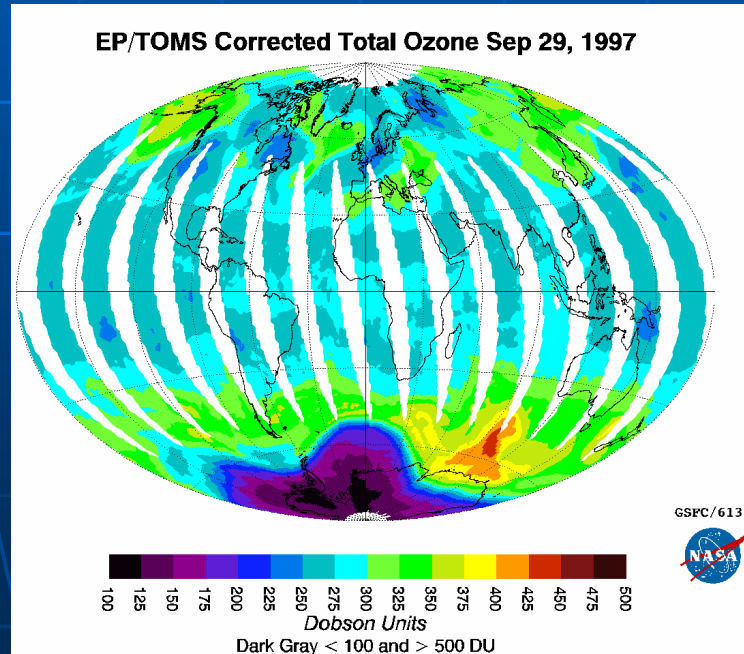- Surface UV irradiance

Nimbus-7

Earth Probe

EOS Aura

Nimbus-7 Total Ozone Mapping Spectrometer (TOMS)
Earth Probe Total Ozone Mapping Spectrometer (TOMS)
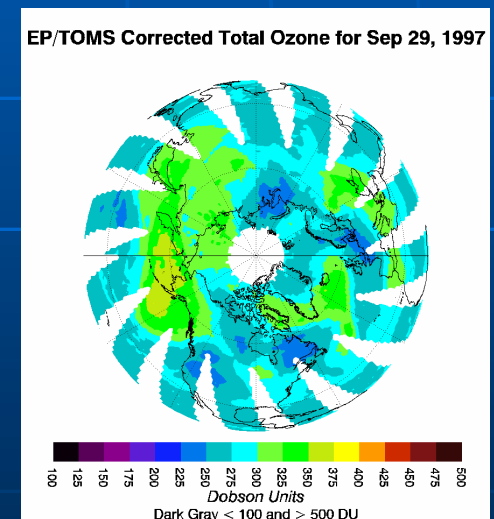# Aura Ozone Monitoring Instrument (OMI)
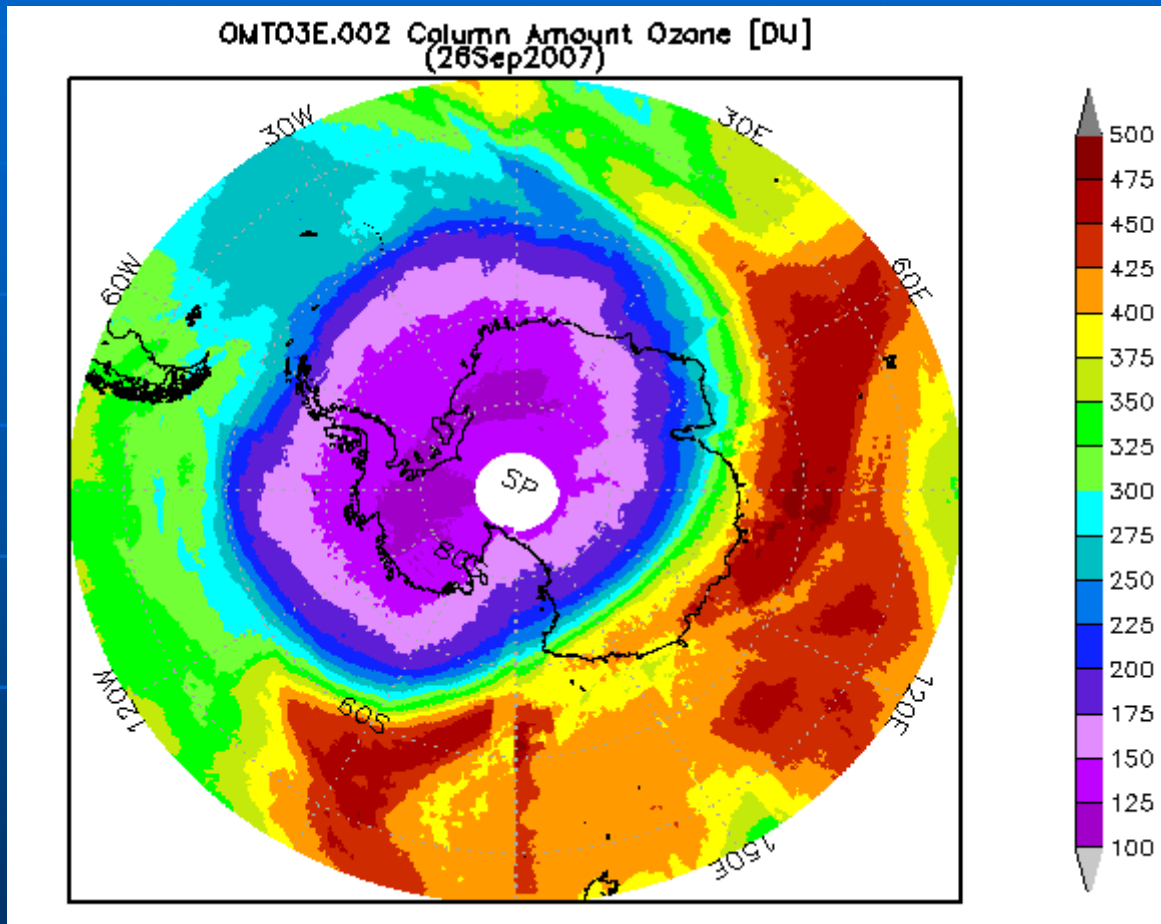
South Polar View

Global View

North Polar View

EP/TOMS Corrected Total Ozone for Sep 29, 1997

Dobson Units
Dark Gray < 100 and > 500 DU

EP/TOMS Corrected Total Ozone Sep 29, 1997

Dobson Units
Dark Gray < 100 and > 500 DU

GSFC/613.3

EP/TOMS Corrected Total Ozone for Sep 29, 1997

Dobson Units
Dark Gray < 100 and > 500 DU

29 September 1997

2007 Antarctic Ozone Hole
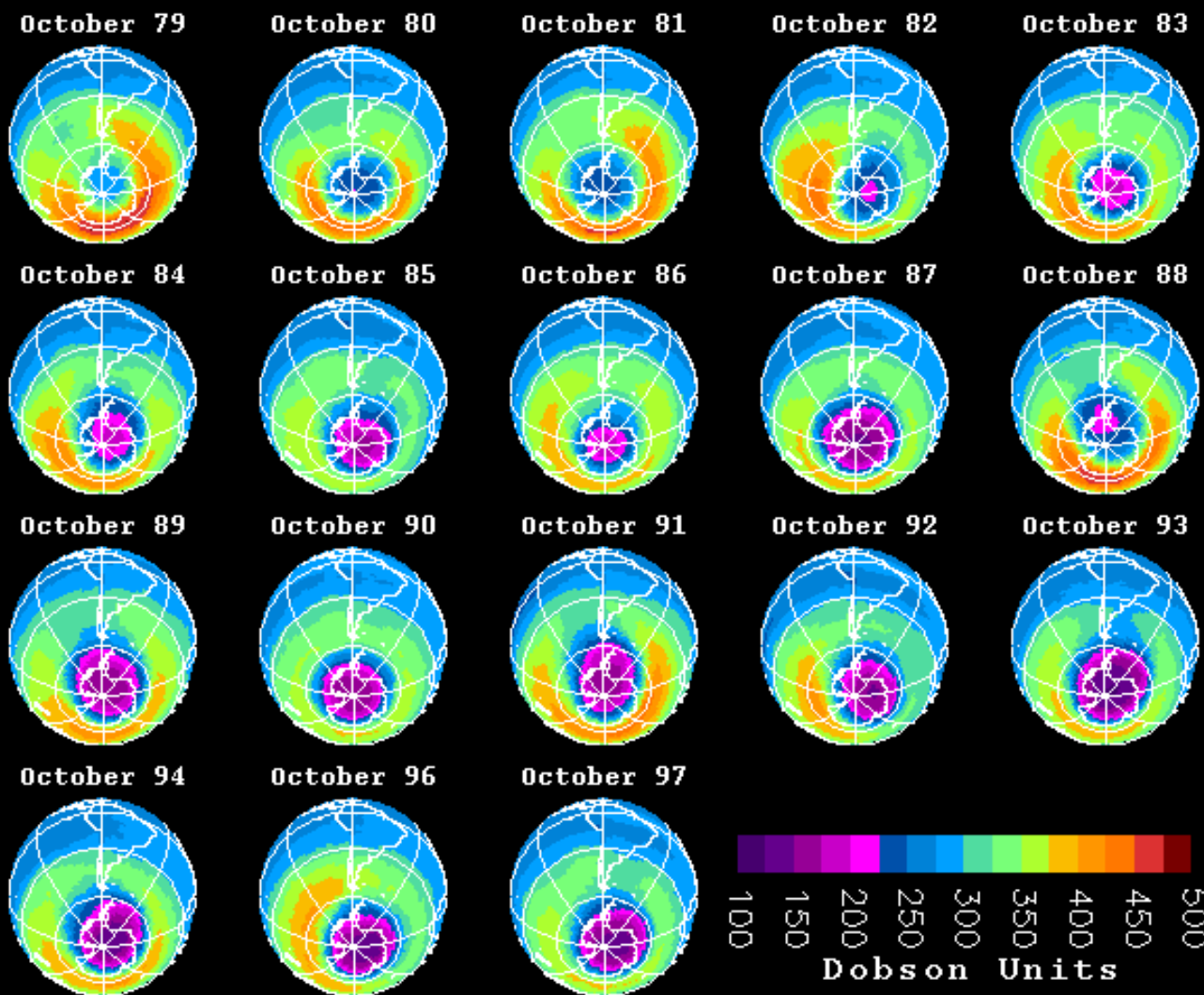

OMTO3E.002 Column Amount Ozone [DU]
(26Sep2007)

26 September 2007

- Orientation
- Size
- Shape
- Collar
- Polar Vortex
- Wind Speed
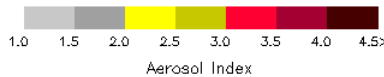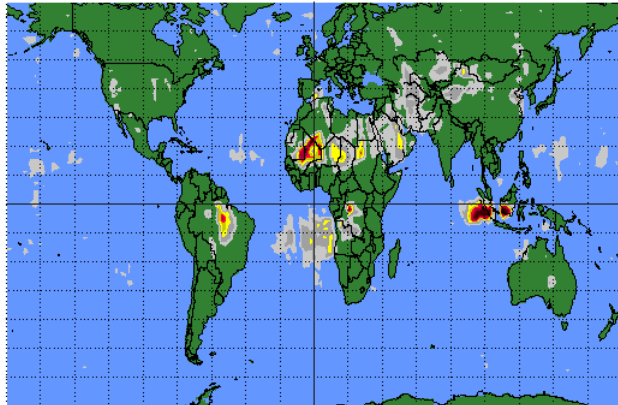- Discontinuity
- "Polar Blank"

TOMS Total Ozone October Monthly Averages

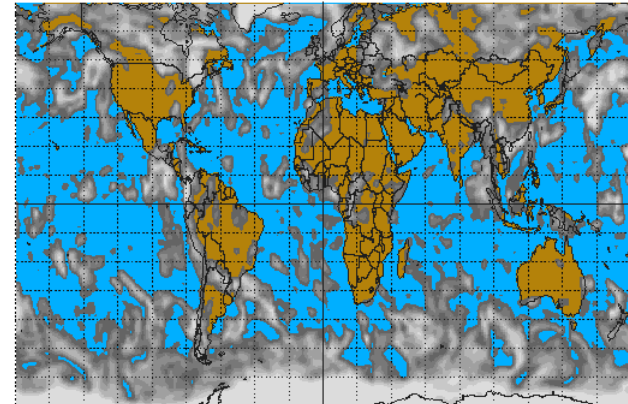# Other Useful TOMS/OMI Data Products

UV Aerosol Index

UV Effective Reflectivity

Noon-time Erythemal UV Irradiance
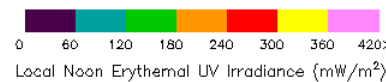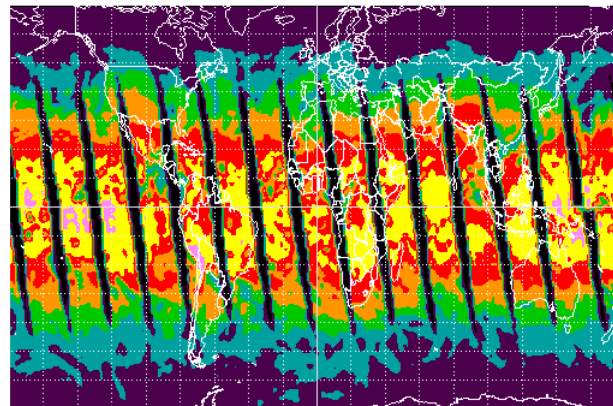
29 September 1997

Southern California Wildfires

MOD08_D3.005 Aerosol Optical Depth at 0.55 micron [unitless]
(25Oct2007)
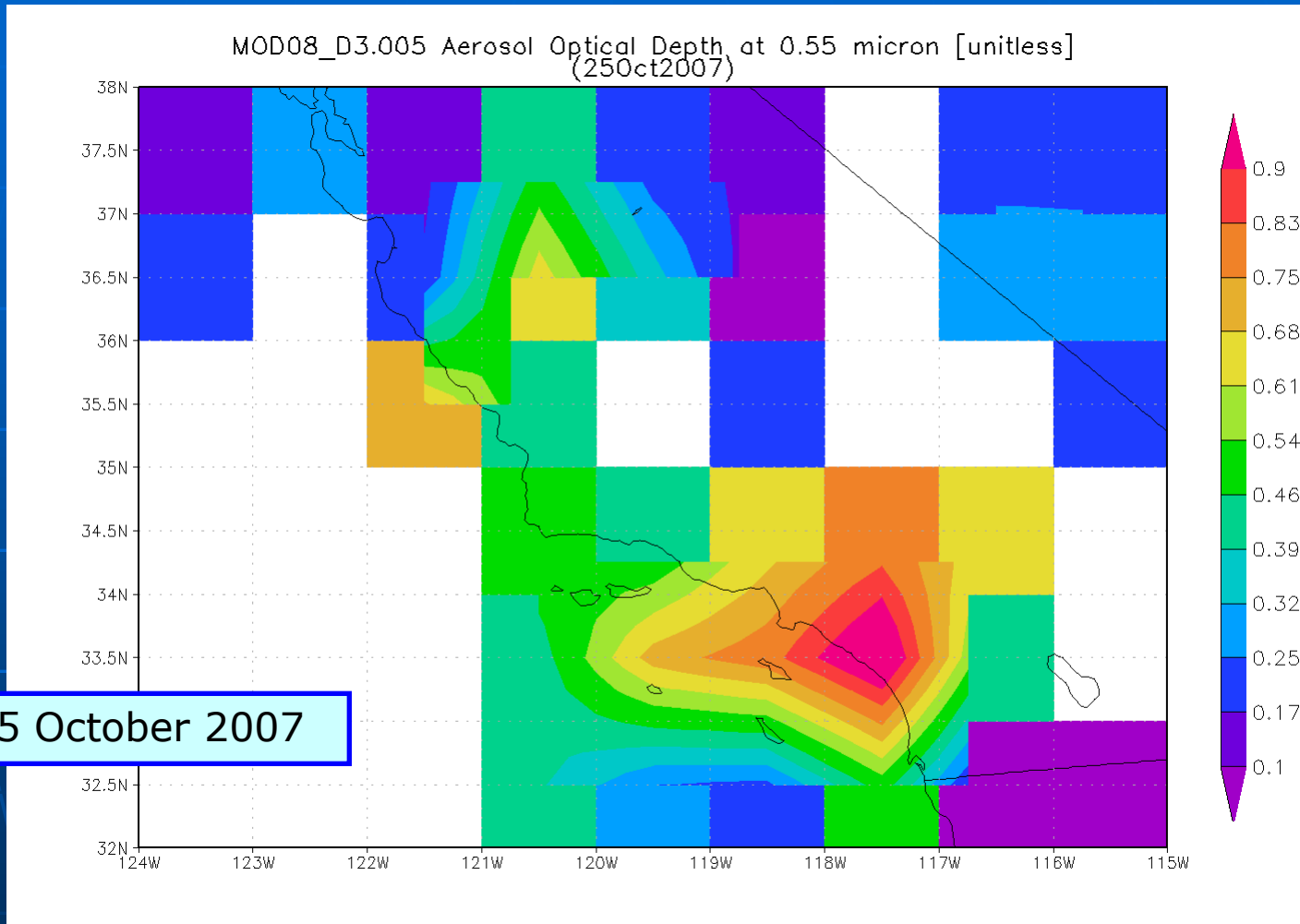
25 October 2007
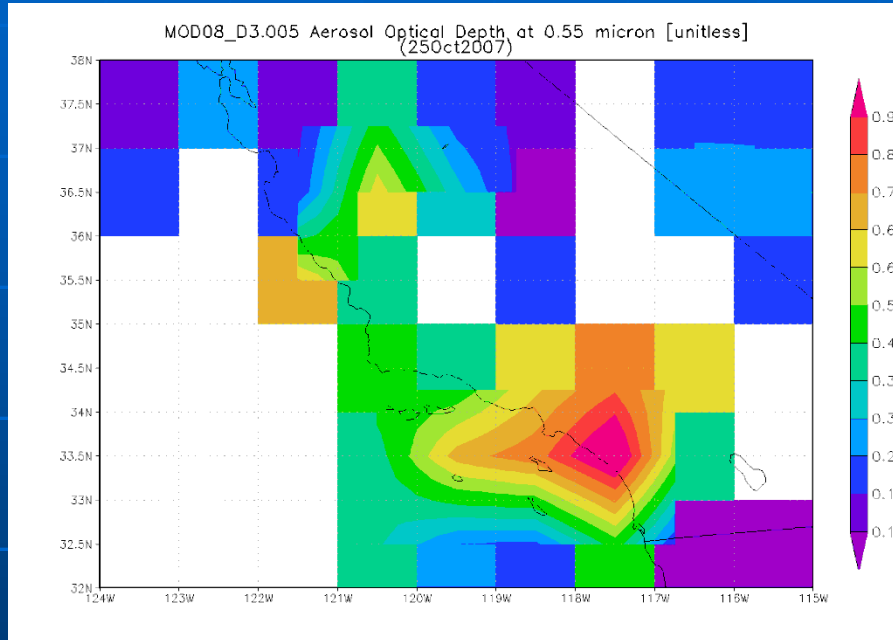
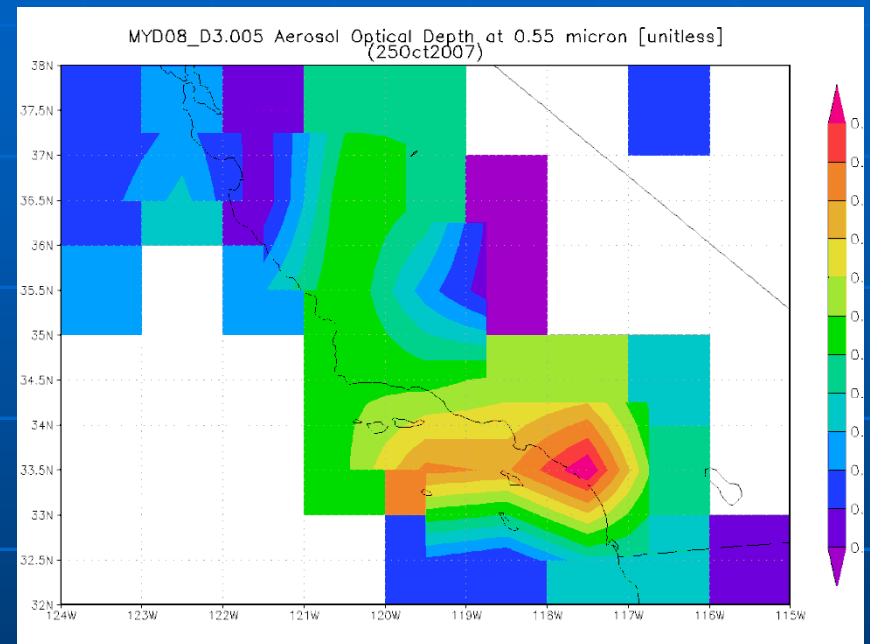Aerosol Optical Depths at 0.55 μm (550 nm- red) from the MODIS instrument on the Terra satellite
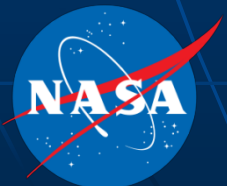
Southern California Wildfires

25 October 2007

MODIS on Terra
~10:30 am

MODIS on Aqua
~1:30 pm
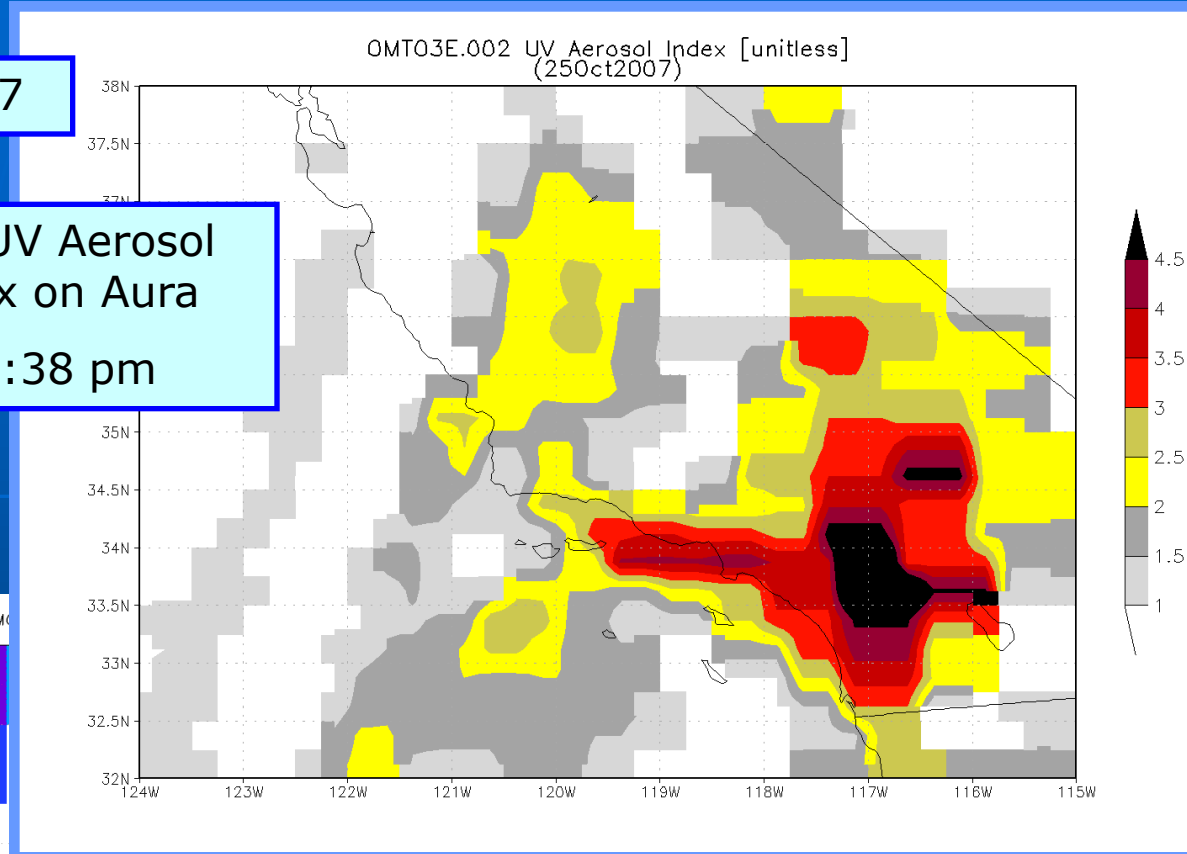
Aerosol Optical Depths at 0.55 μm (550 nm- red)

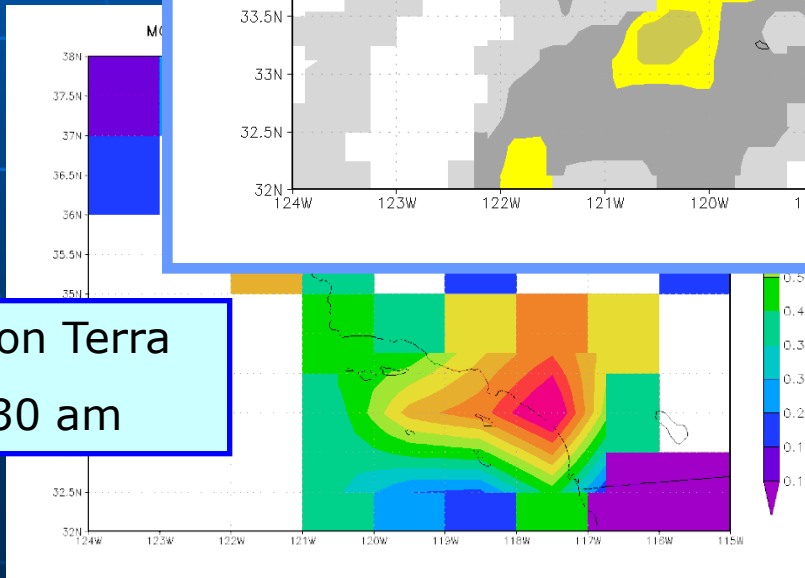# Southern California Wildfires

25 October 2007

OMI UV Aerosol
Index on Aura

~1:38 pm

MODIS on Terra

~10:30 am
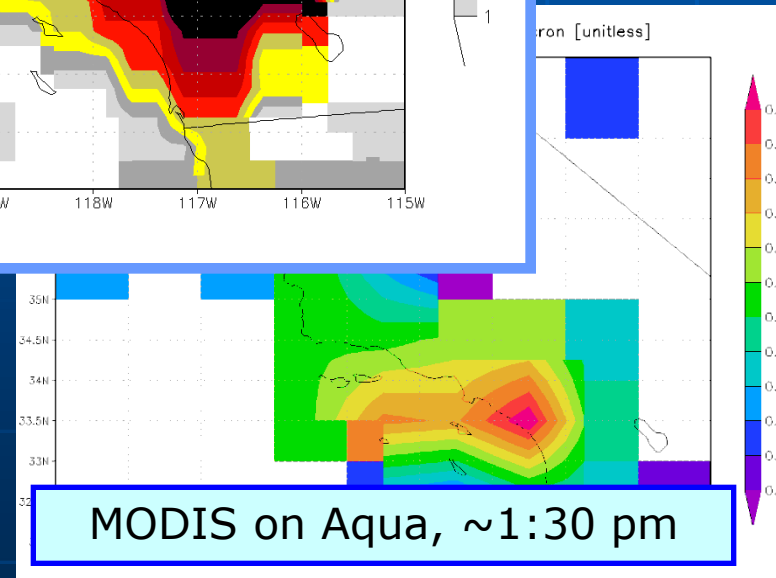
MODIS on Aqua, ~1:30 pm

OMTO3E.002 UV Aerosol Index [unitless]
(25Oct2007)

Southern California Wildfires
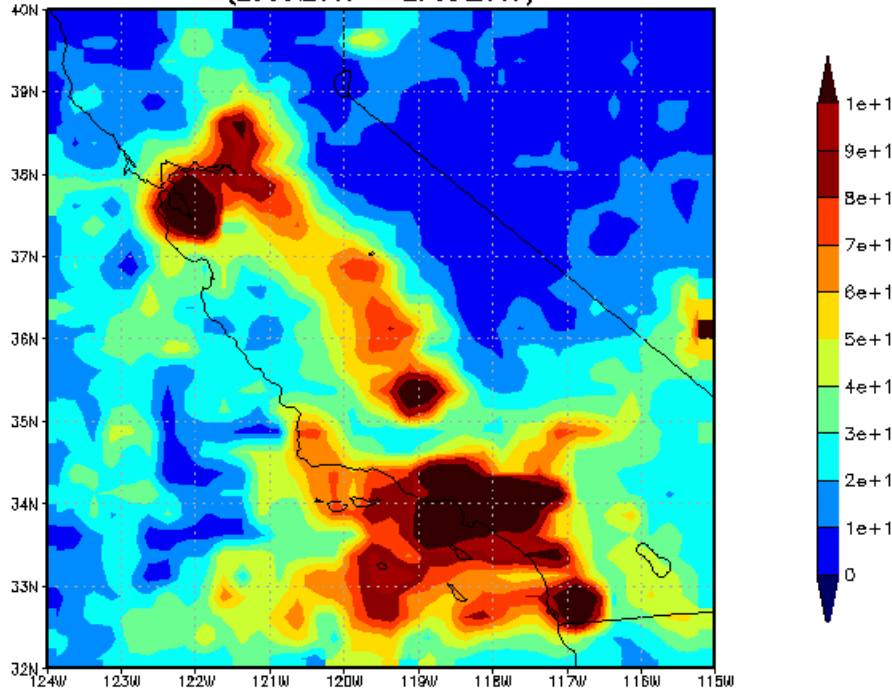
OMI Tropospheric NO_2

23-27 October 2007

Multi-day means "smear out" some spatial features, but allow for more complete coverage for data-sparse mapping

OMI UV Aerosol Index

Southern California Wildfires

OMI Tropospheric NO_2

OMI UV Aerosol Index

AIRS Carbon Monoxide (CO)

MODIS Cloud Optical Thickness
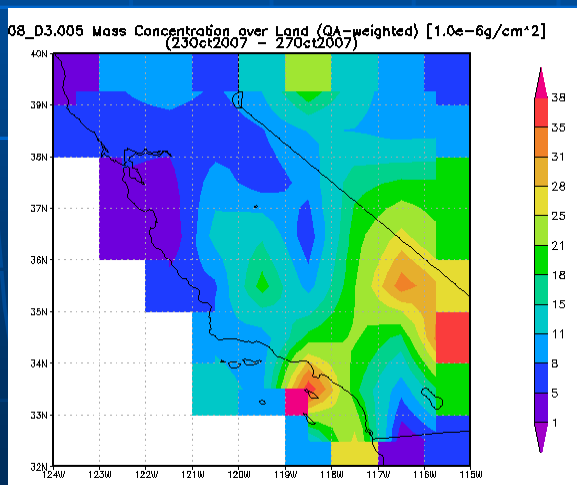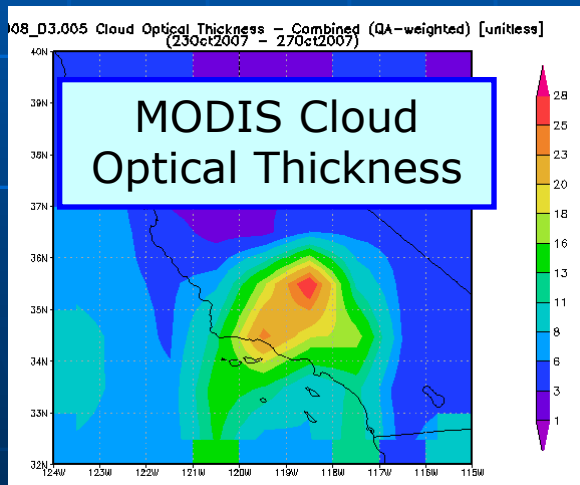
MODIS Aerosol Mass over Land
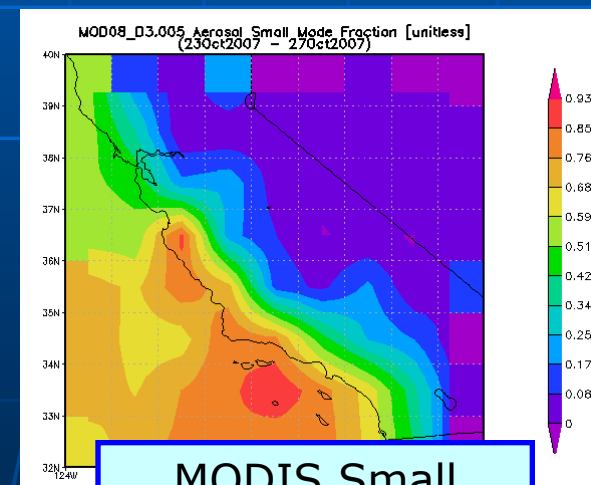
MODIS Small Aerosol Fraction

Access to current Giovanni interfaces:

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

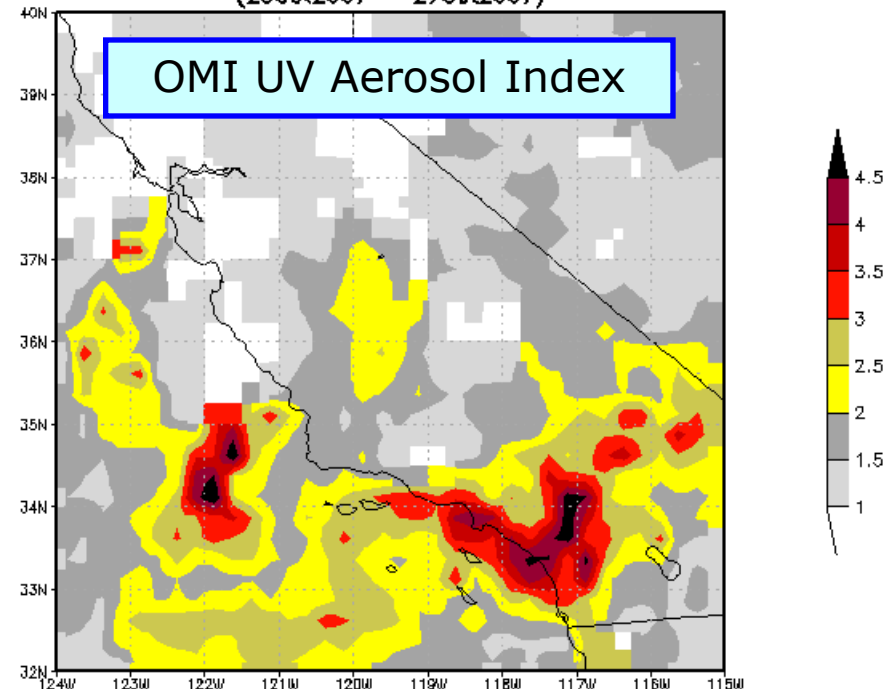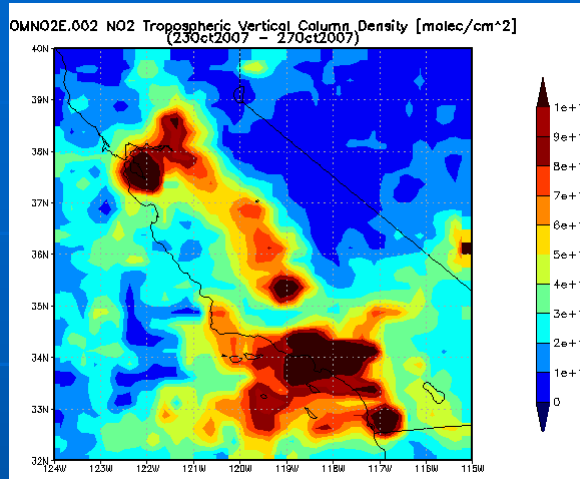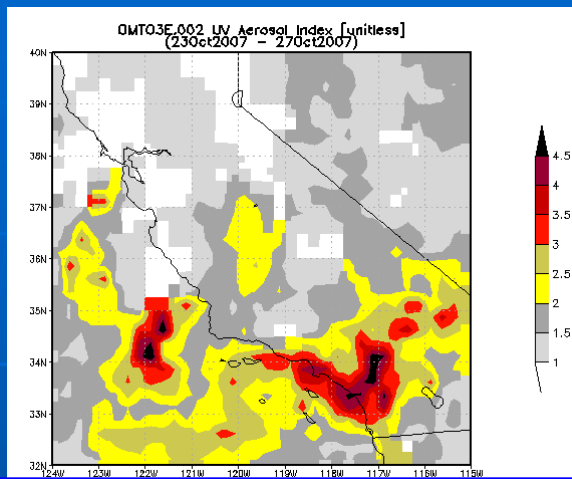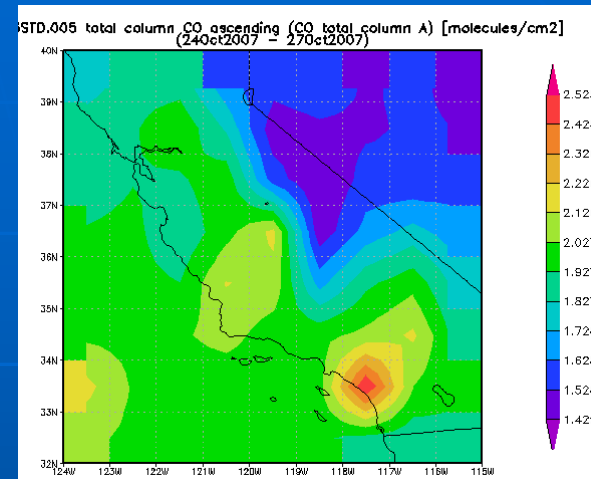| |
|---|
| TRMM rainfall products, near-real-time 3-hourly, Multi-Satellite Precipitation Analysis, and rainfall ground observation data |
| Aqua and Terra MODIS daily and monthly global aerosol data, GOCART model data, and MISR monthly global aerosol data |
| A-Train Along CloudSat Track featuring CloudSat cloud and MODIS Aqua temperature and humidity data |
| NEESPI (Northern Eurasia Earth Science Partnership Initiative) monthly products |
| Aura MLS version 2.2 daily near-global profile data |
| Aura MLS version 1.5 daily near-global profile data |
| Aura OMI Level 3 hi-res and TOMS-like daily global data |
| Aura OMI Level 2G derived data (BETA) |
| TOMS daily global from Earth Probe and Nimbus-7 |

Access to current Giovanni interfaces:

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

Ocean Color monthly global Aqua MODIS data and monthly and 8-day SeaWiFS data

Agriculture-oriented TRMM and other derived precipitation data

Aqua AIRS version 5 and 4 daily global maps and profile data (BETA)
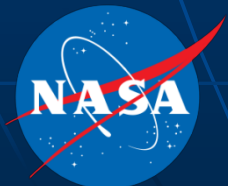
Aqua AIRS version 5 and 4 monthly global maps and profile data (BETA)

Aqua AIRS version 4 daily and monthly global maps and profile data

UARS HALOE atmospheric profiles

Sample Science Questions

1. How has rainfall changed in the Sudan?

- http://disc.gsfc.nasa.gov/techlab/giovanni

- click on TRMM rainfall products (TOVAS)

- click on monthly global precipitation (GPCP), non-Java version

- 5-22 N Lat, 23-35 E Lon, Accumulated Rainfall, Time Series (area-averaged), Jan 1979-Dec 2006, Generate Plot

- A plot shows up in another browser window

- From the plot it is difficult to see a dramatic trend...

Monthly GPCP (Lat: 5N–22N, Lon: 23E–35E)
Accumulated Rainfall [mm]

GrADS: COLA/IGES   2008-02-10-05:23

Generated by NASA's Giovanni (giovanni.gsfc.nasa.gov)
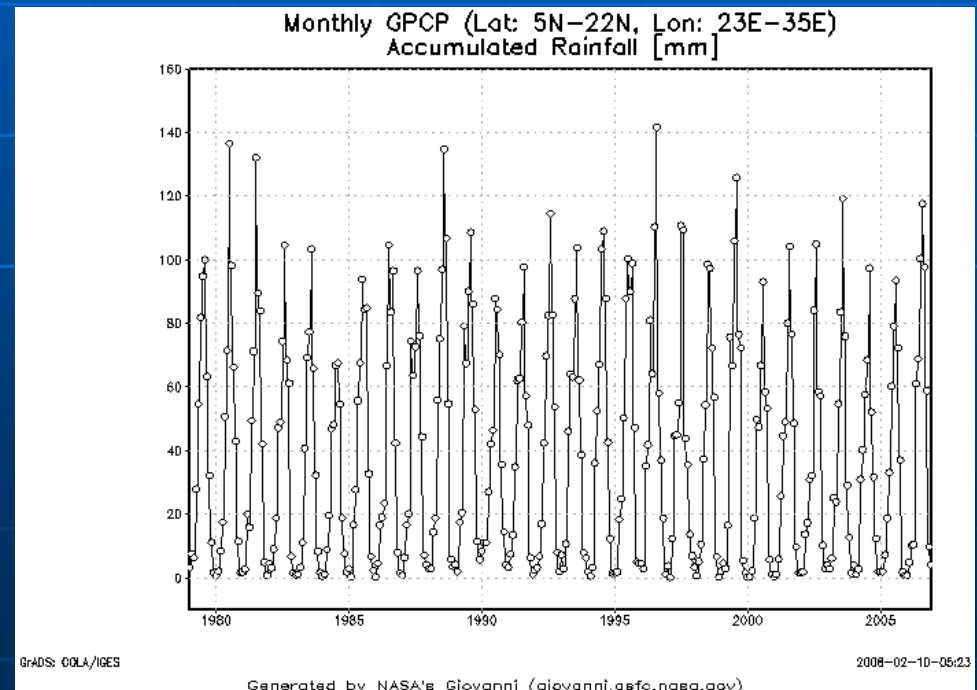
Sample Science Questions

1. How has rainfall changed in the Sudan?

- Return to main window and click on ASCII Output button at bottom
- ASCII output pops up in separate browser window, save as text file
- Open text file in Excel, sort by month and plot up Jan. and July

Sudan Rainfall Rate (mm/month)
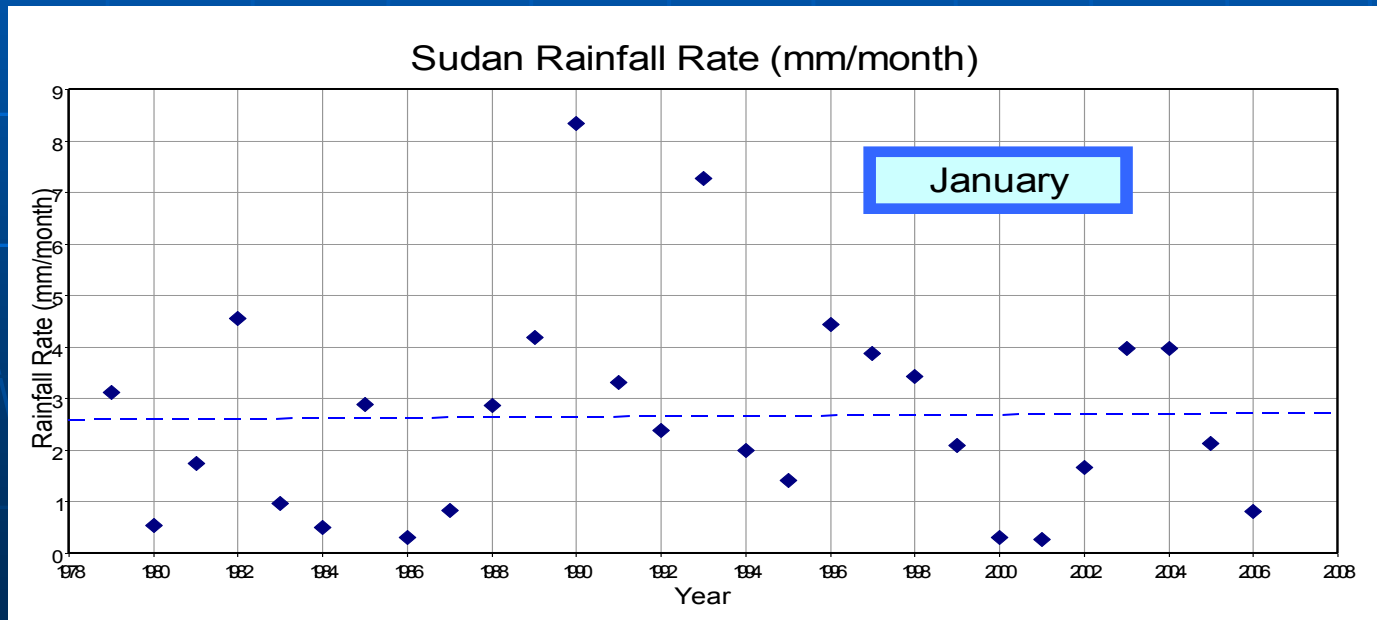
Sample Science Questions

1. How has rainfall changed in the Sudan?

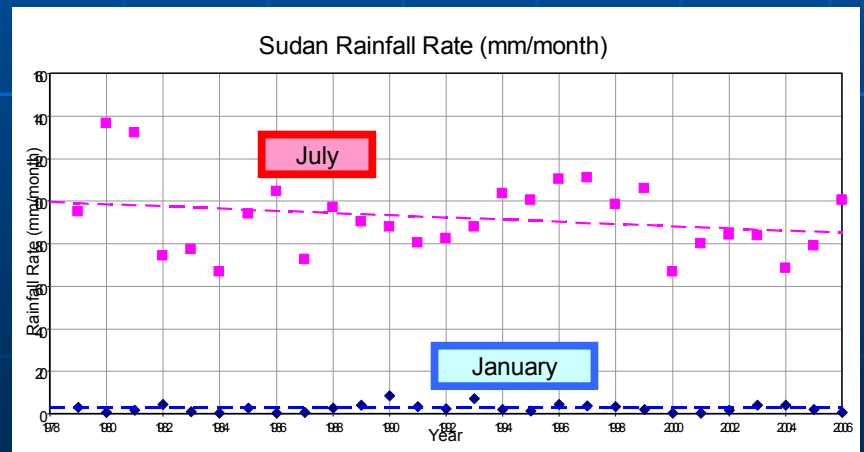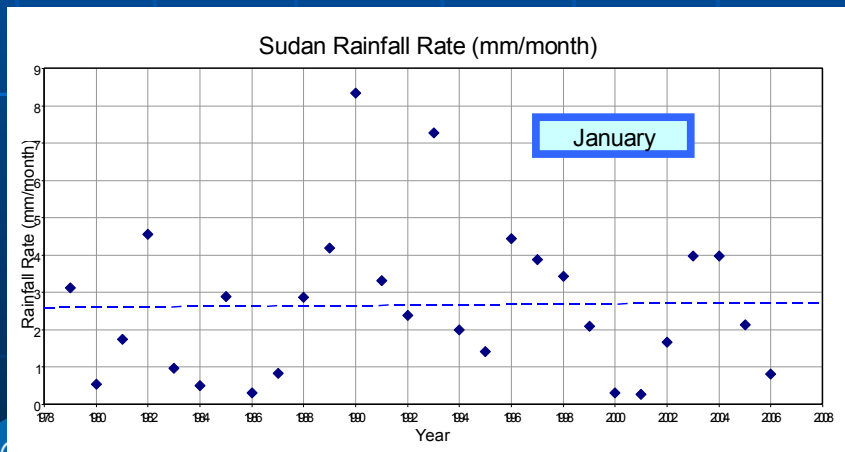- While winter (January) rainfall rates are flat, summertime rates (July, the "rainy season") have fallen 18% over the past three decades

- This is a contributing factor in the current crisis in Darfur.

- You can't do everything in Giovanni alone, but sometimes a simple spreadsheet program can provide all the additional computational power to address complex issues.

Sample Science Questions

2. How has rainfall changed in Wyoming?
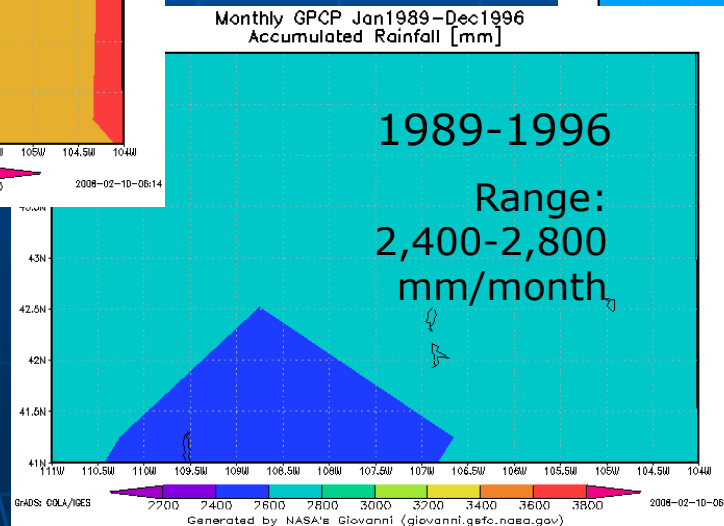
- http://disc.gsfc.nasa.gov/techlab/giovanni
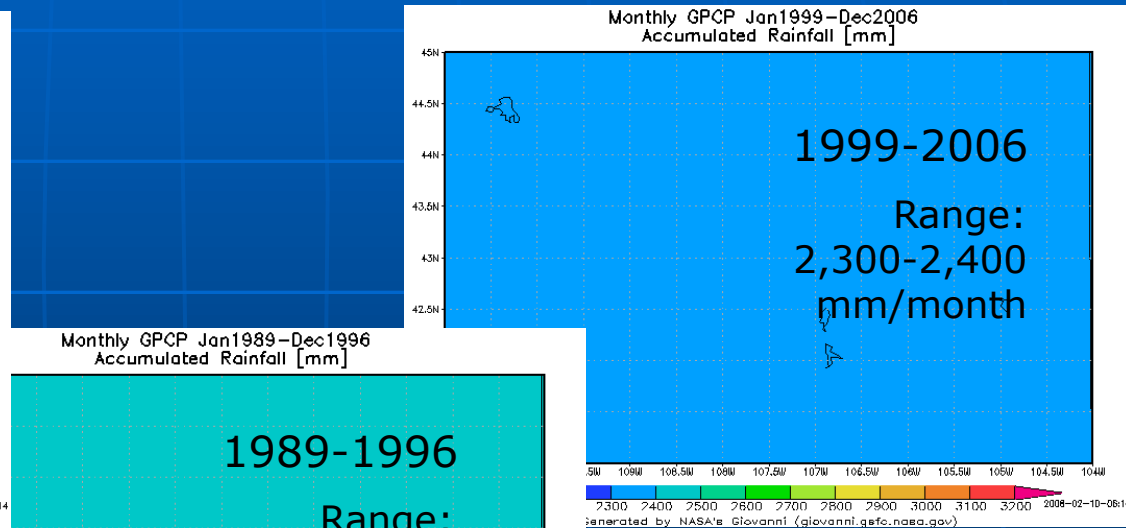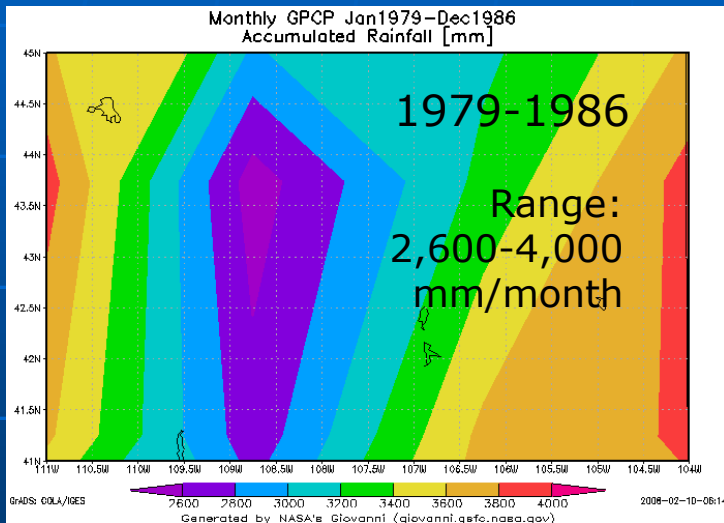
- click on TRMM rainfall products (TOVAS)

- click on monthly global precipitation (GPCP), non-Java version

- 41-45 N Lat, 111-104 W Lon, Accumulated Rainfall, Lat-Lon Map, Jan 1979-Dec 1986, custom y-axis: min 2000, max 4000, interval 200, Generate Plot

- A plot shows up in another browser window

- Save plot as gif file

Monthly GPCP Jan1979–Dec1986
Accumulated Rainfall [mm]
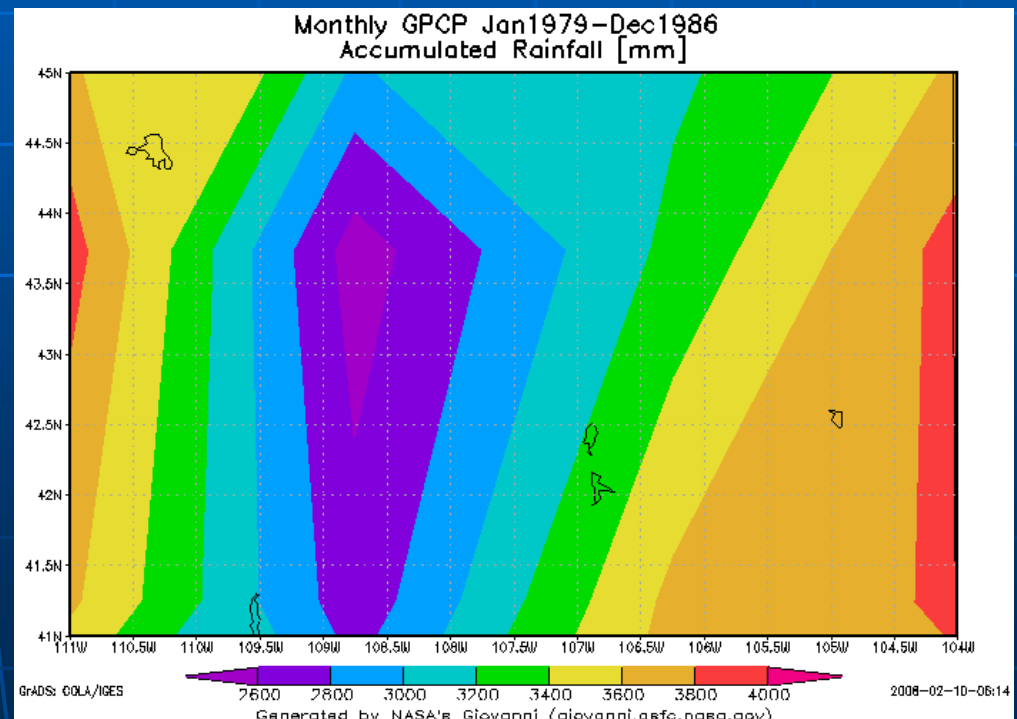
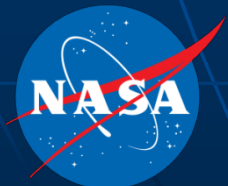# Sample Science Questions

2. How has rainfall changed in Wyoming?

- Do the same plots for 1989-1996 and 1999-2006

1979-1986

Range:
2,600-4,000
mm/month

1989-1996

Range:
2,400-2,800
mm/month

1999-2006

Range:
2,300-2,400
mm/month

Large portions of the American plains, Rockies and West are becoming more uniformly dry.

Sample Science Questions

3. Is there an "ozone hole" in the Arctic?   TOMS

4. What does the El Niño look like?   AIRS

5. Is there a connection between central Atlantic sea temperatures and hurricanes?   Hurricane Portal

6. Is the surface temperature changing differently in the two hemispheres?   AIRS

7. Can one detect Canadian summertime boreal forest fires from space?   MODIS

8. How do wildfires in the Western US differ from urban smog?   OMI, MODIS, AIRS