The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2018-27

Winter College on Optics in Environmental Science

2 - 18 February 2009

In-situ measurements, remote sensing monitoring (local, regional, global)

Singh R.P.
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In-situ measurements, remote sensing monitoring (local, regional, global)

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- Environment - Environment around us
- Environment changes frequently due to changes on Land, Hydrosphere and Biosphere
- Changes could be Natural or manmade

Atmospheric Environment is controlled by
Natural (volcano, dust storms, Fires) and Manmade Processes (Industrial, Anthropogenic activities)

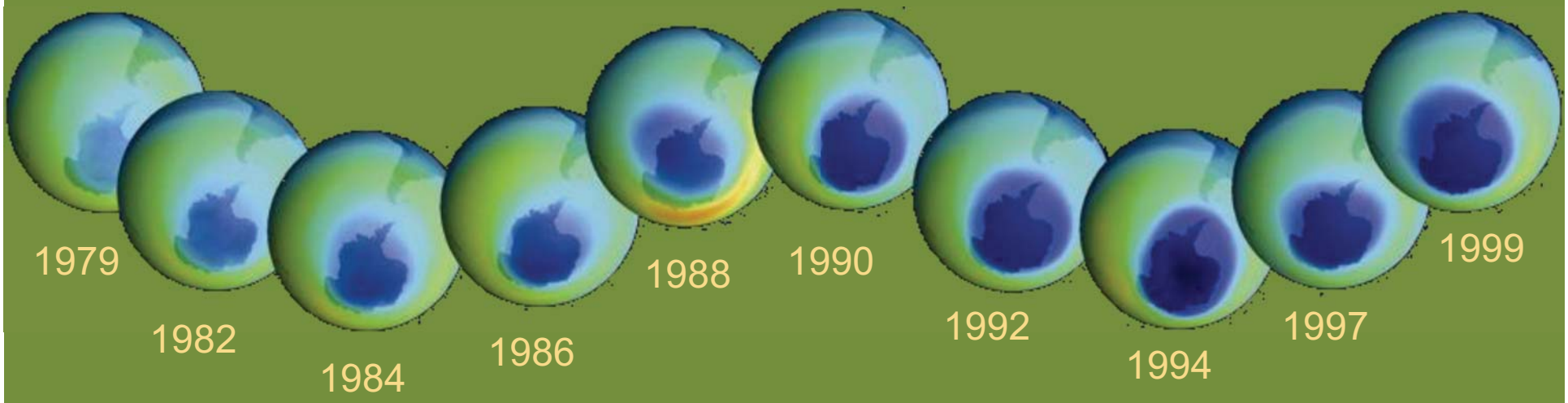
- Changes on Land, Ocean and Atmosphere affect the Global Climate which can affect the earth System Processes

Changes may occur at

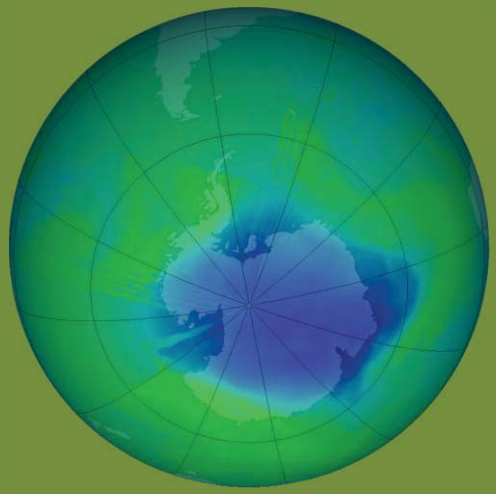
- Local,
- Regional and
- Global scale

- Satellite observation
- Airborne observation
- Tower mount observation
- Ground observation

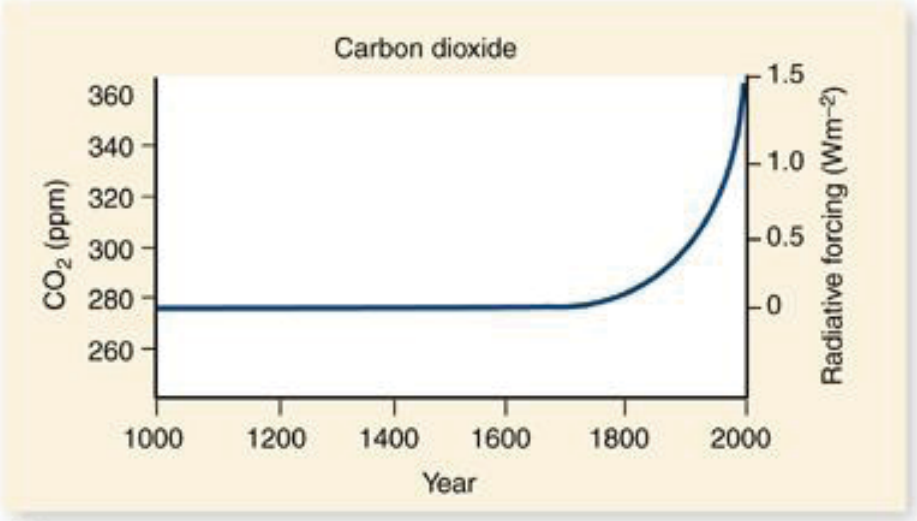
Growth of the Antarctic ozone hole



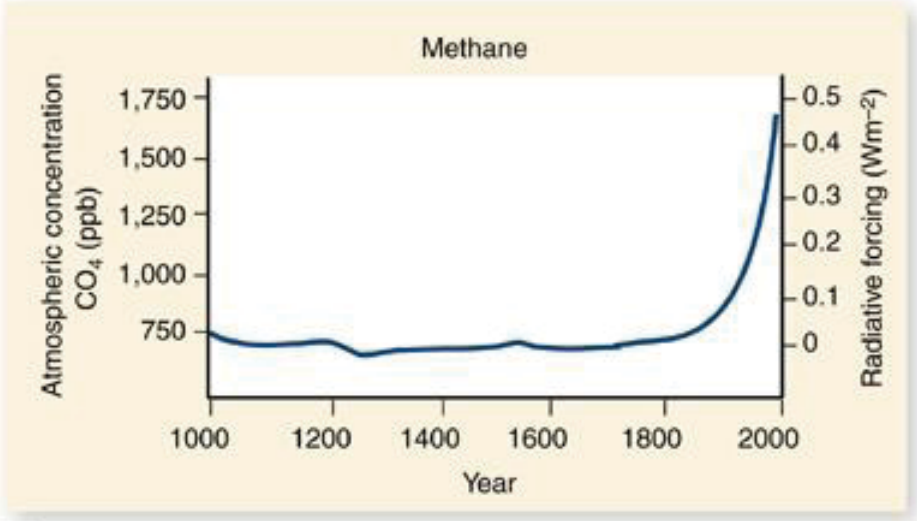
Darkest blue areas represent regions of maximum ozone depletion.



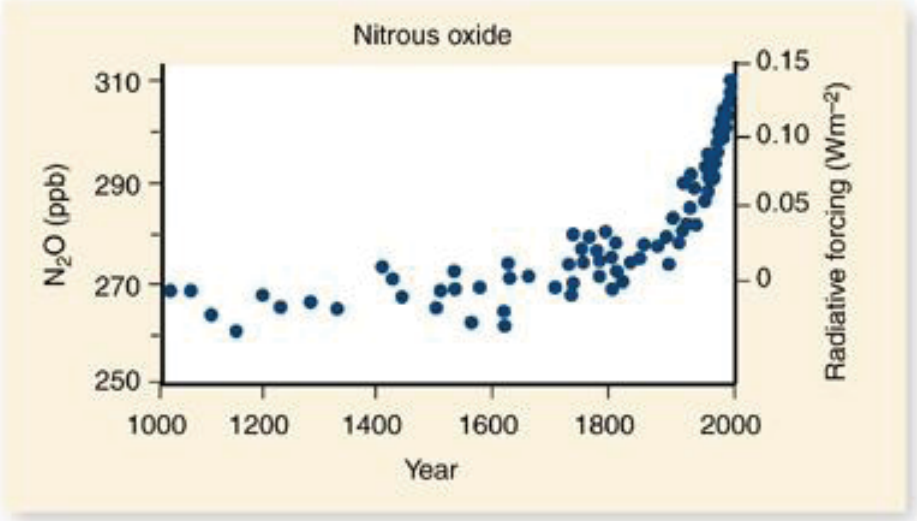
2007



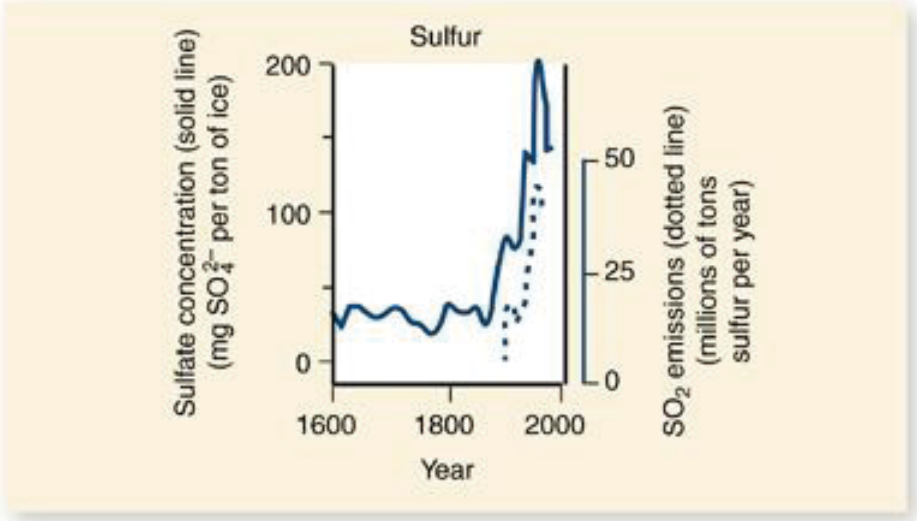
(a)



(b)



(c)

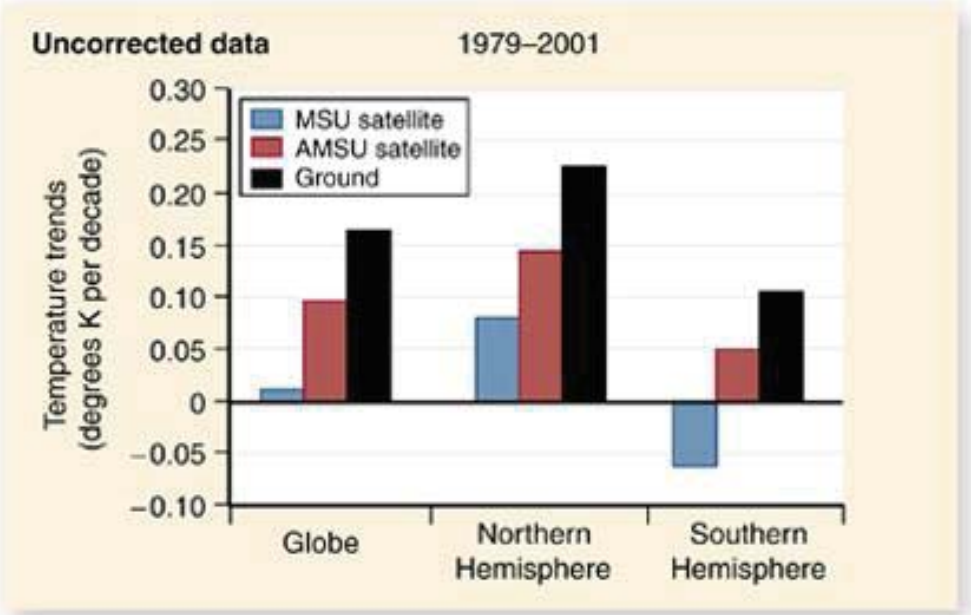


(d)

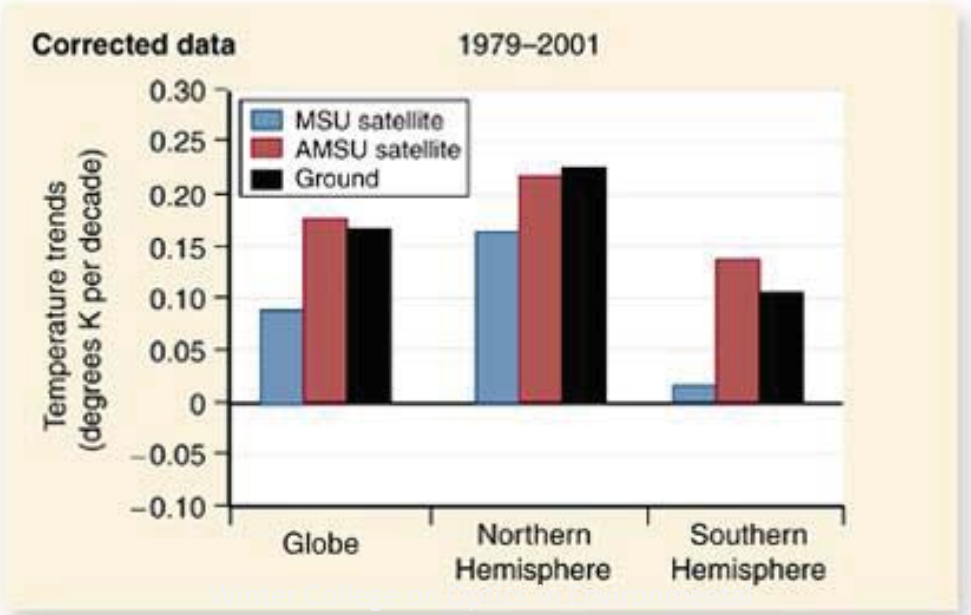
Importance of

•Ground and Satellite Data, and

•where sampling is required



(a)



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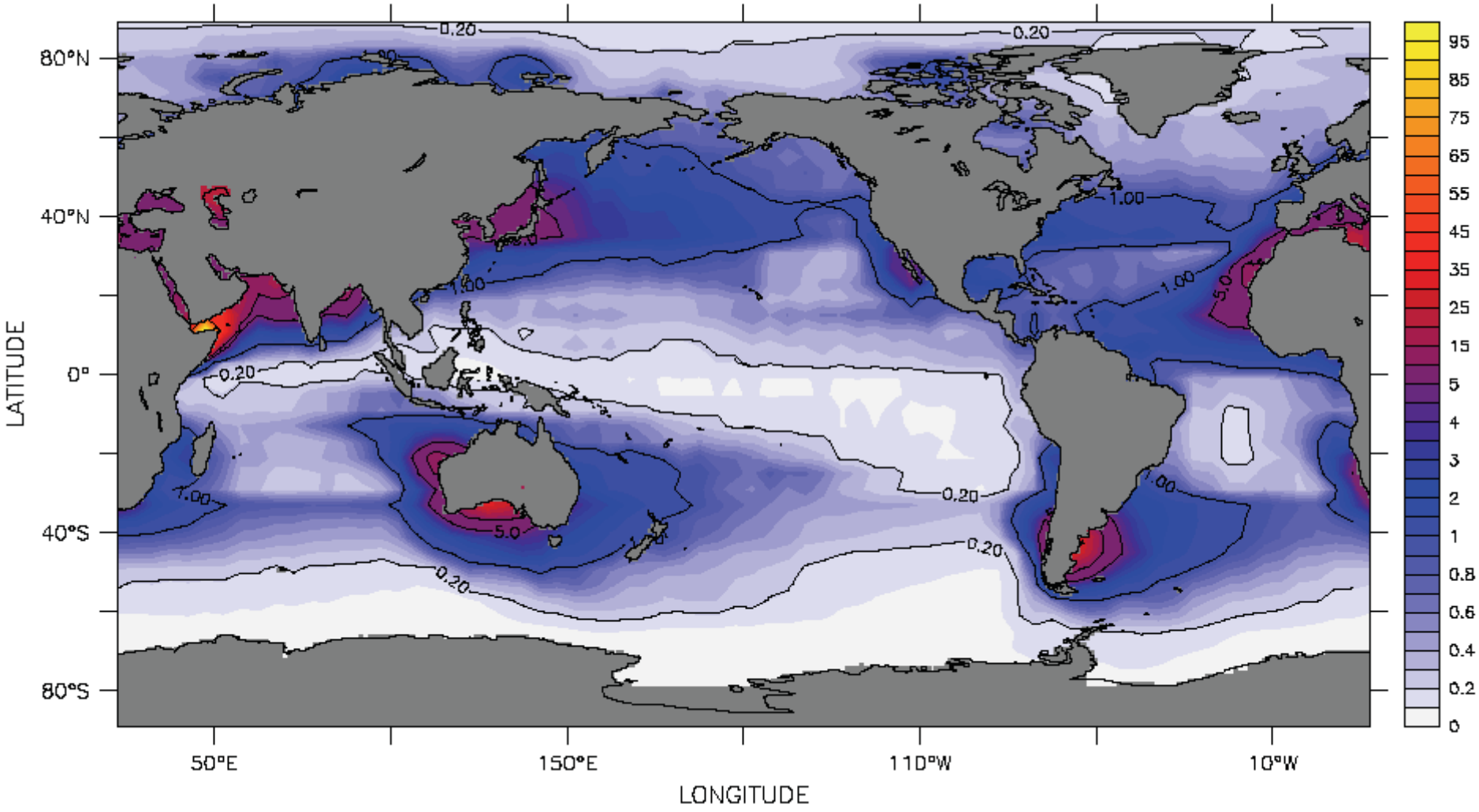
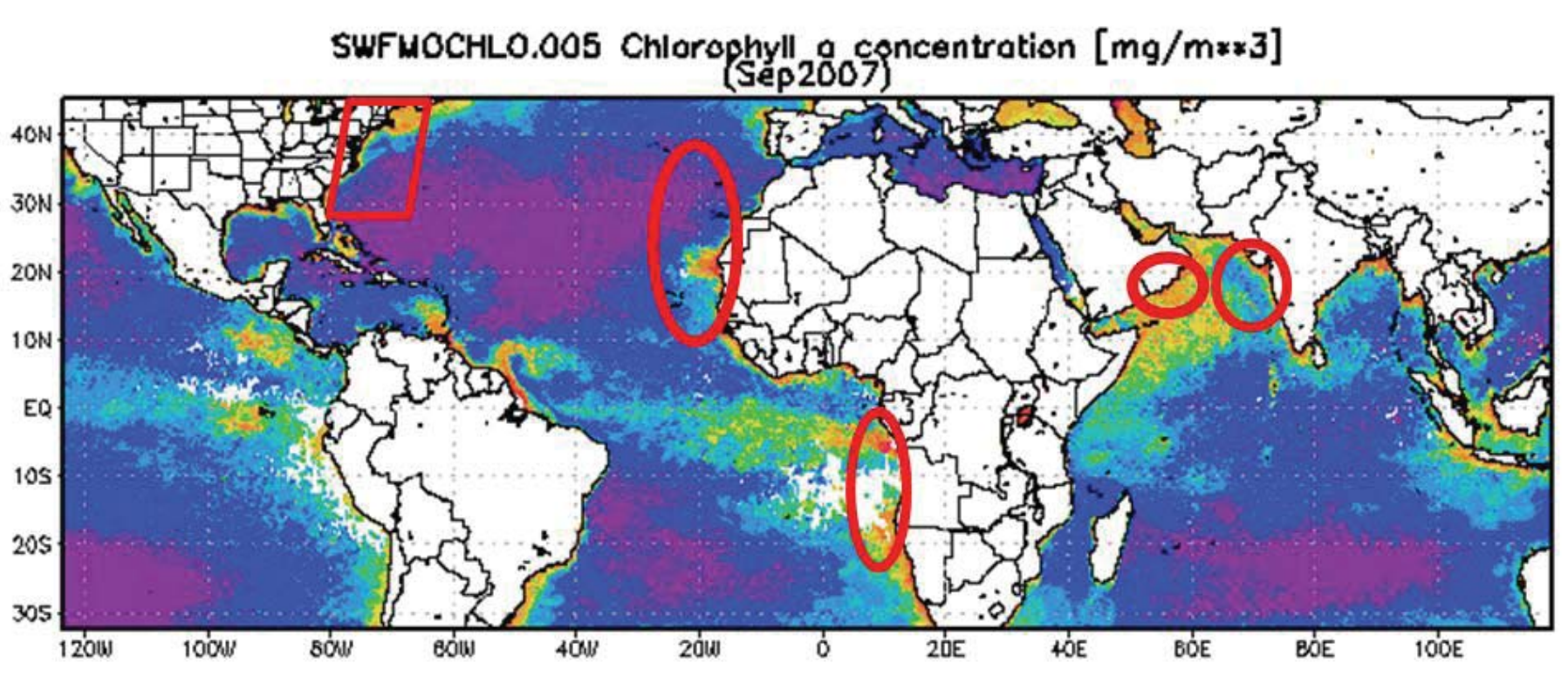


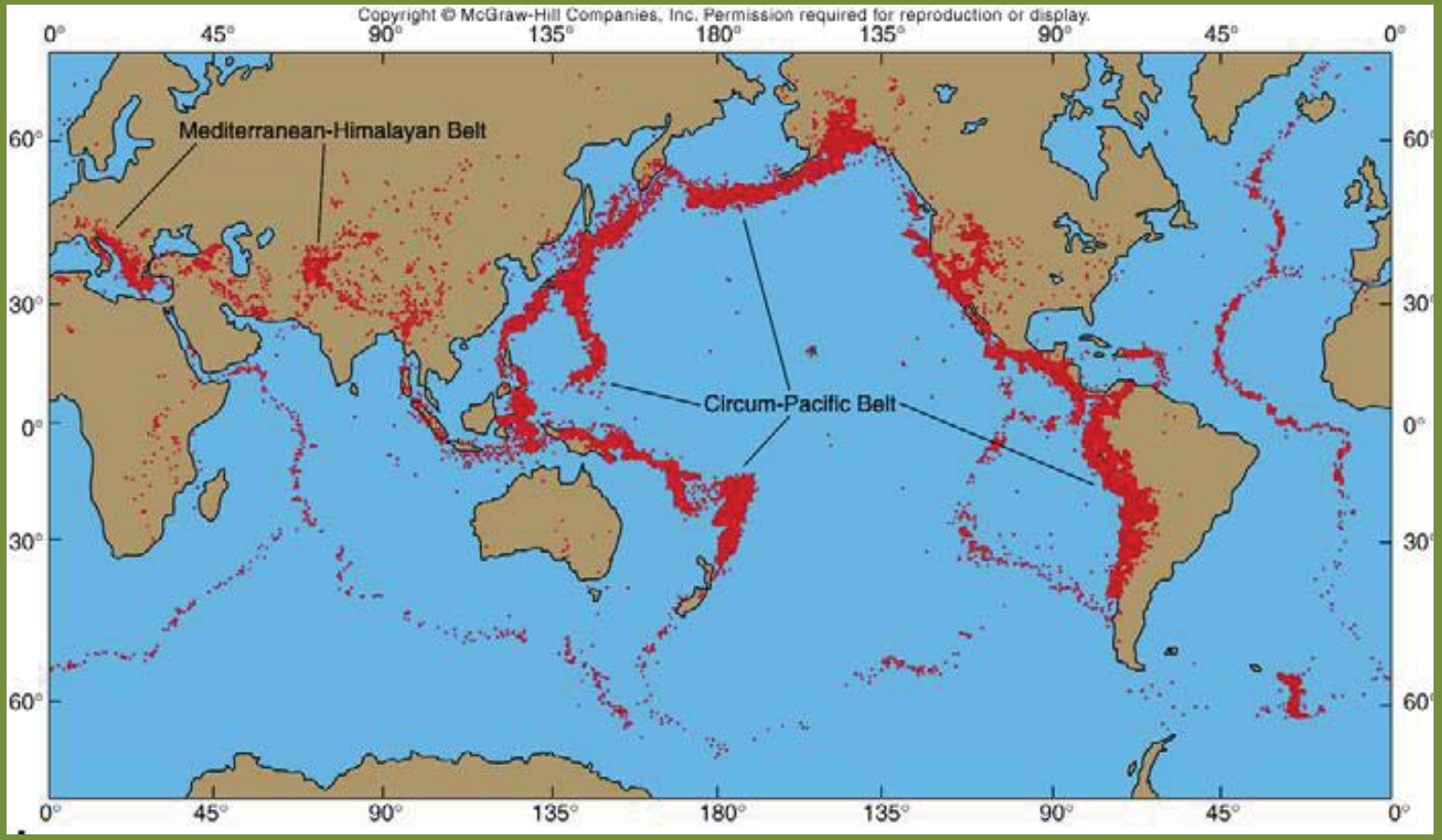
Dust deposition over the ocean:

The input of dust has different impacts in different oceanic environments

(Tegen & Fung 1997)

For our survival and to sustain marine life, environment, and natural resources, observations of Meteorological and Oceanographic Parameters are required. Such observations will provide better understanding of Land-Ocean-Land coupling associated with the Natural Hazards

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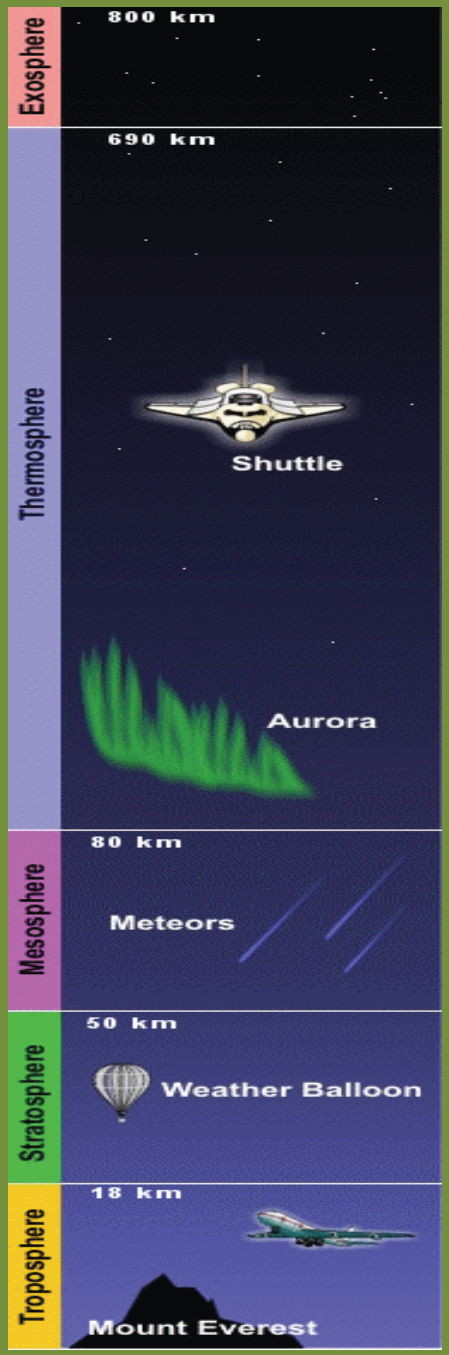
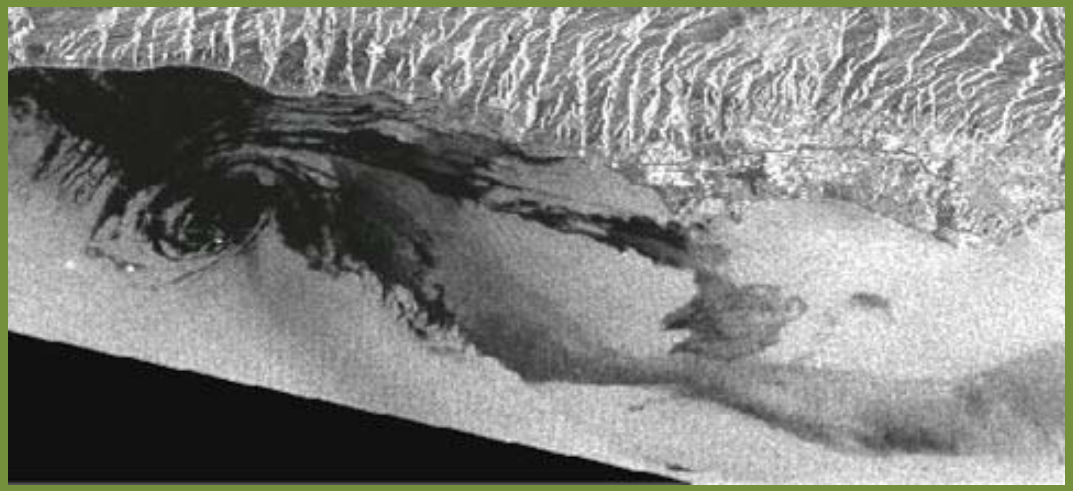
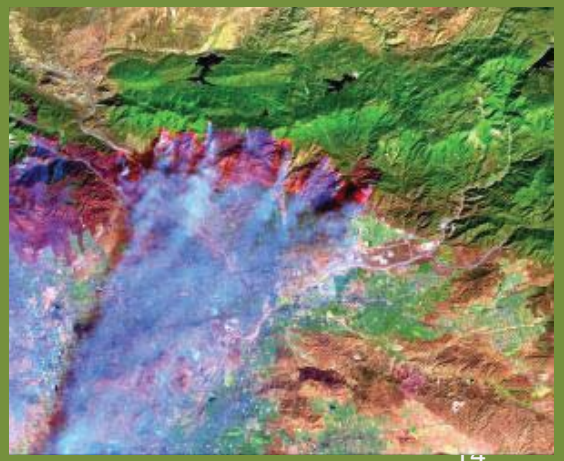
0°
45°
90°
135°
180°
135°
90°
45°
0°
60°
30°
0°
30°
60°
Mediterranean-Himalayan Belt
Circum-Pacific Belt



Increasing Focus on Regional Scale

Increasing number of passive and active instruments can resolve local and regional scale processes





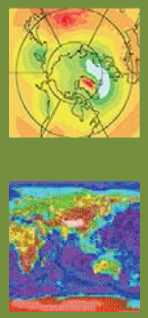
Observing Cycle

Observations

Measurements Areas

- Vegetation
- Biological productivity
- Surface Temp
- Precipitation
- Snow Cover
- Surface Elevation
- Land Use
- Fire Occurrences
- Total Surface Irradiance
- Ice Sheet Elevations
- Ice Volume
- Clouds and Radiation
- Tropospheric Chemistry
- Stratospheric Chemistry
- Aerosols
- Volcano Effects
- Meteorological Variables
- Sea Ice
- Surface Wind Fields
- Ocean Circulation
- Sea Height

Models



Climate variability and Real Life Problems

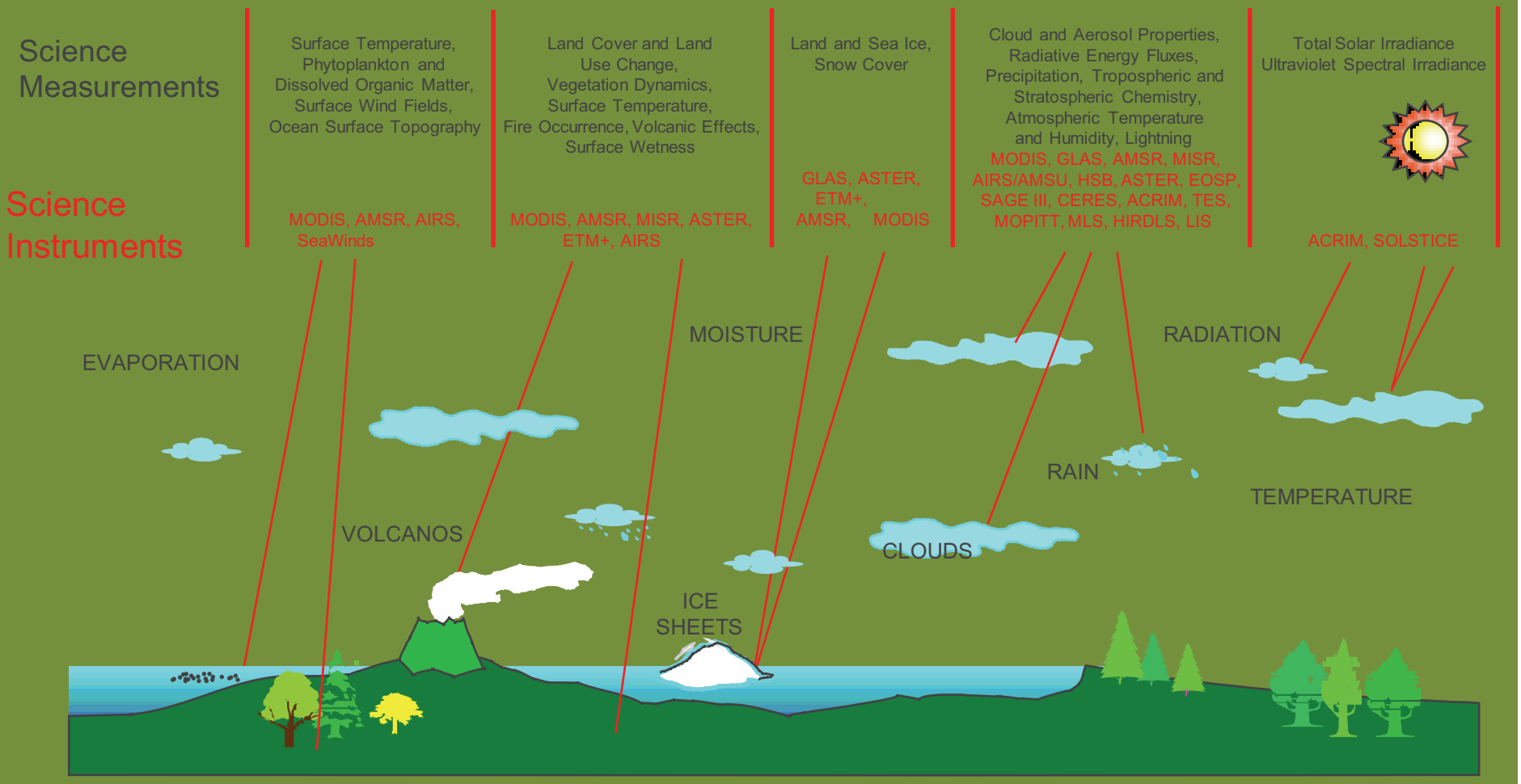
Assessments & Predictions

Risk Management

Products

Leaf area index
Vegetation index
Humidity
Evapotranspiration
Energy Fluxes

Multiple Sensors



Seasonal to Interannual Climate Prediction

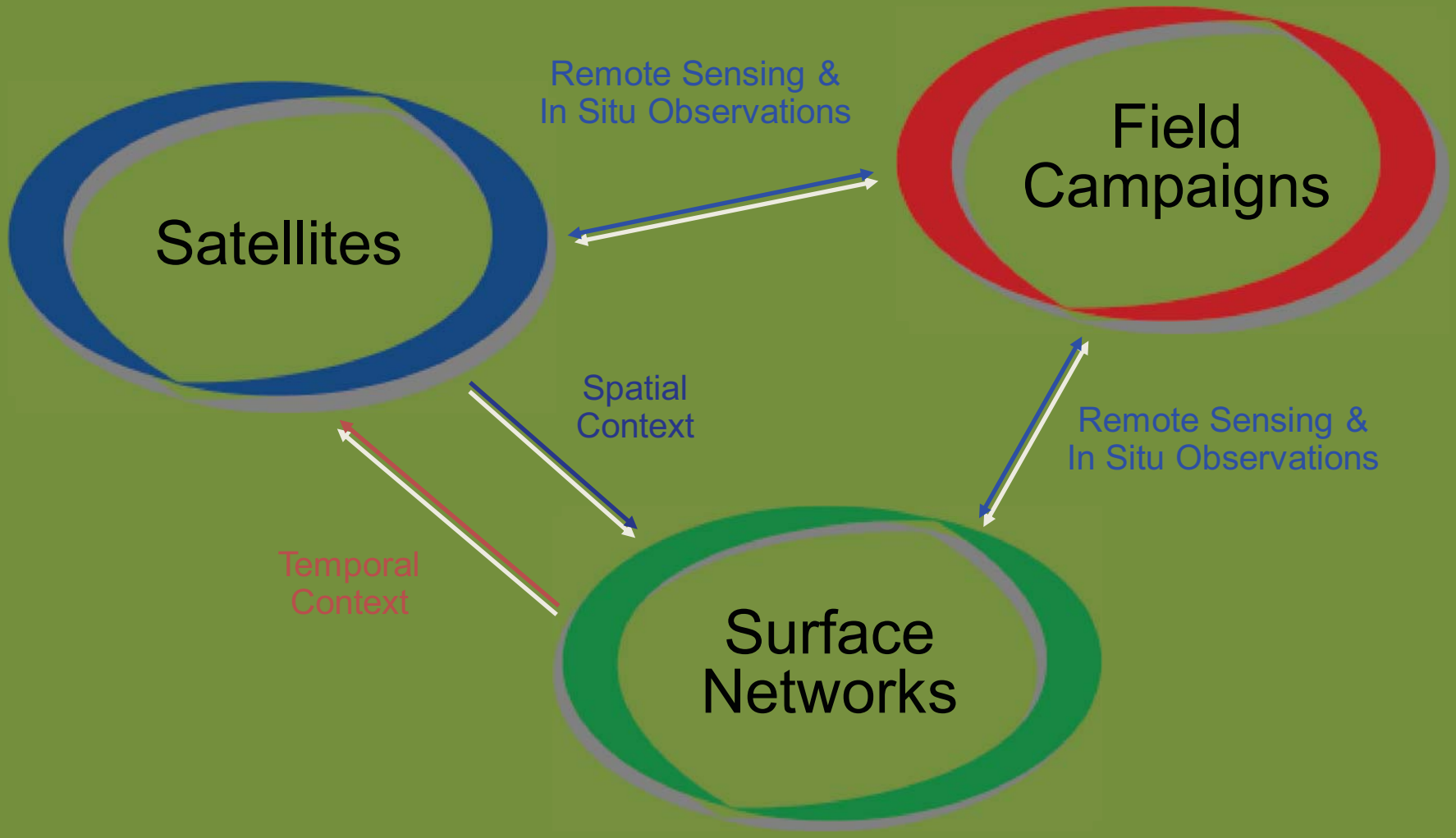
Decadal to Centennial Climate Variability

Atmospheric Chemistry

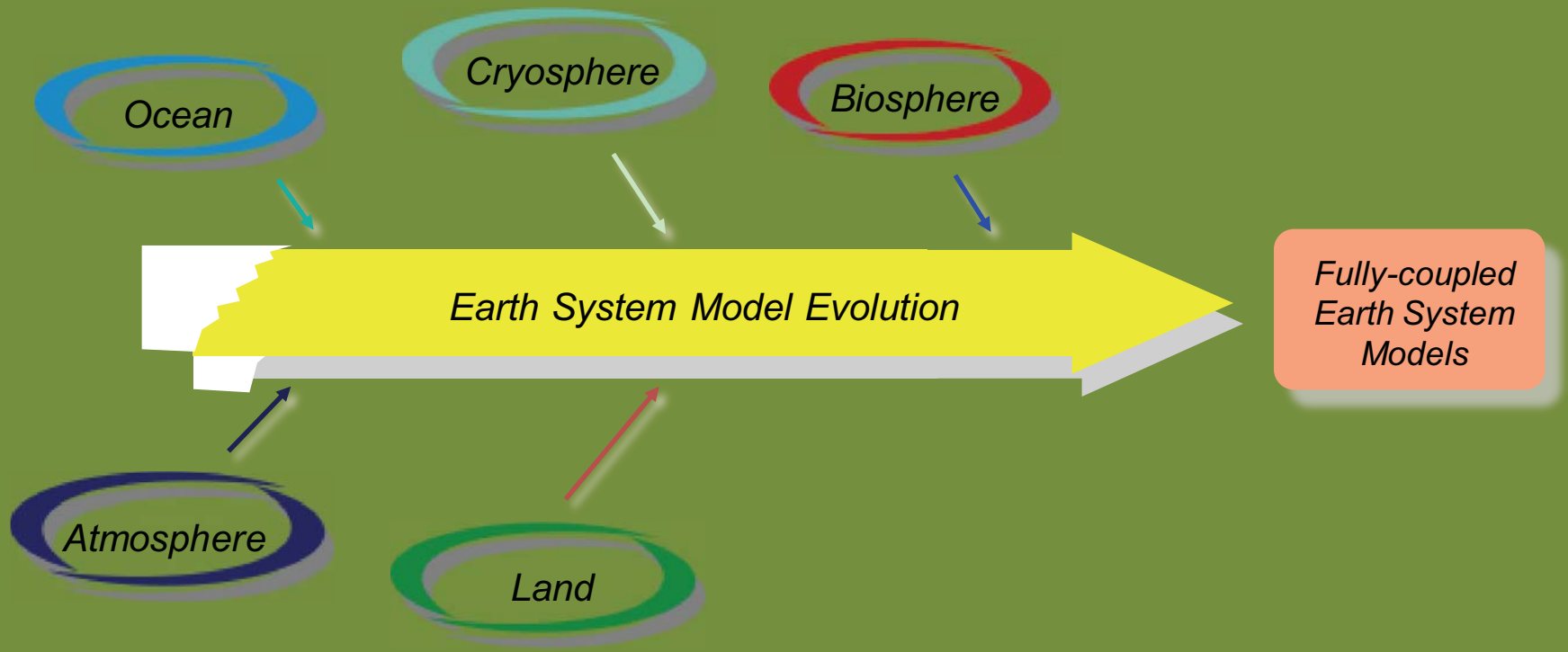
Terrestrial and Oceanic Ecosystems

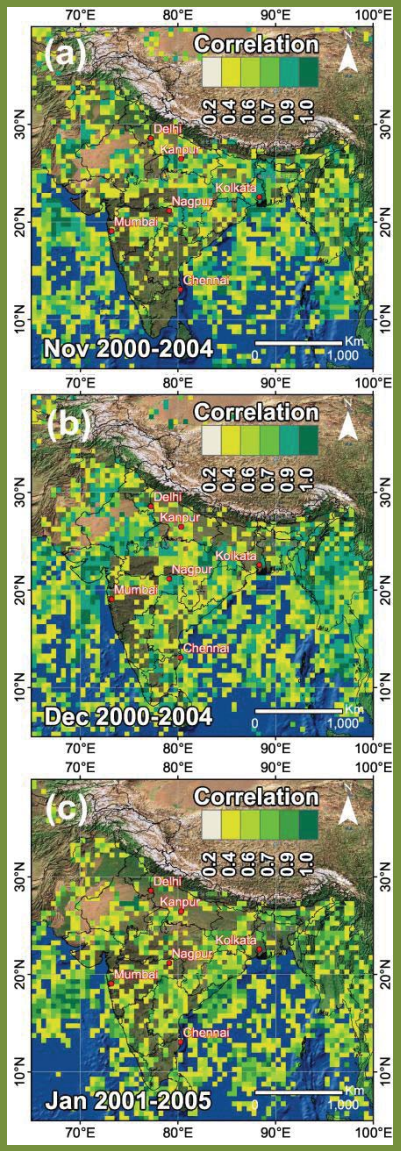
Natural Hazards

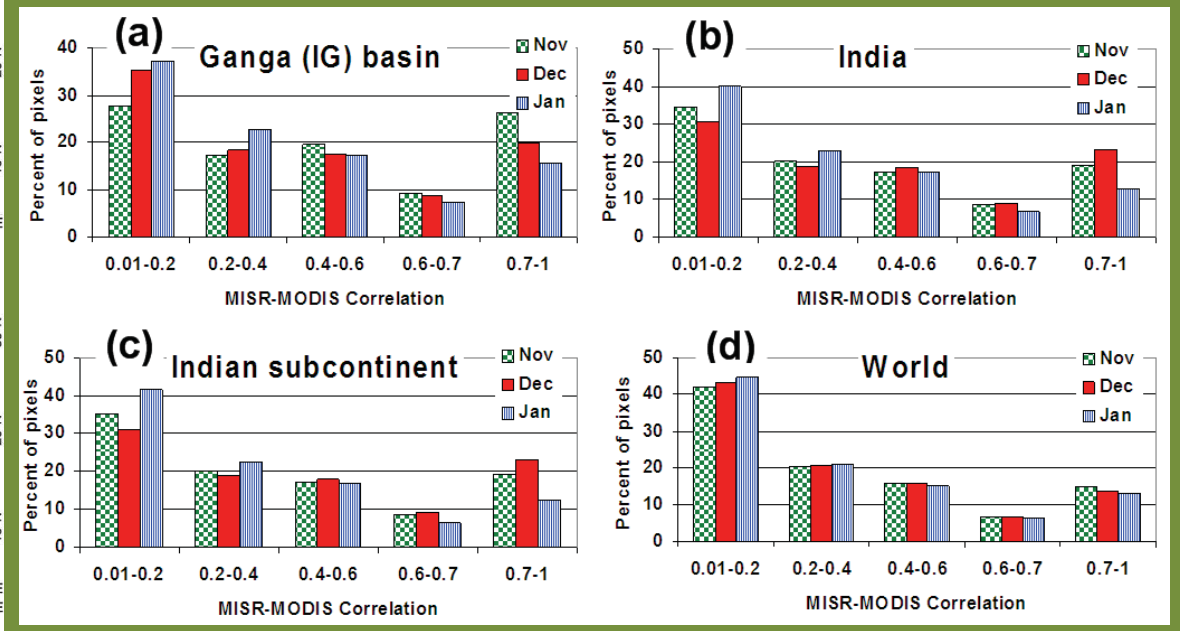
Integrated Observations



Developing Coupled Models







Prasad and Singh, RSE, 2005

- How to Monitor?
- Meteorological Observatories

Meteorological Parameters

- Surface Temperature
- Air Temperature
- Relative humidity
- Rainfall
- Wind velocity and direction
- Evaporation
- Soil moisture
- Water vapor
- Sunshine

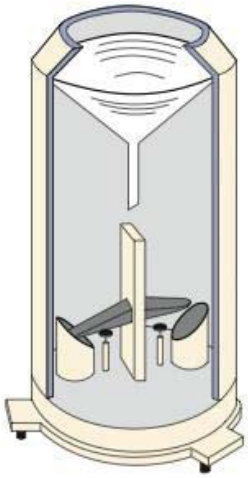
- Lab Measurements


Notausgang

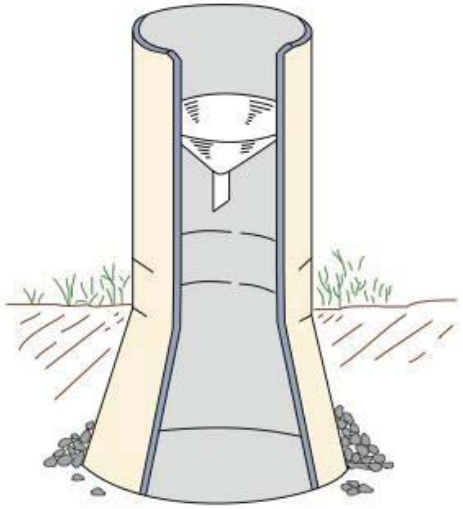
- Location and Weather conditions
- Location – GPS

History of Meteorology

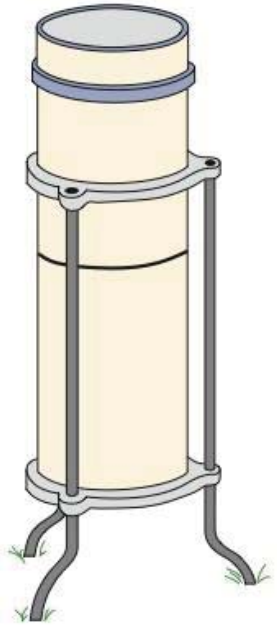
- Invention of weather instruments
  - 1500's Galileo invented water thermometer
  - 1643 Torricelli invented mercury barometer
  - 1667 Hooke invented anemometer
  - 1719 Fahrenheit developed temp scale based on boiling/freezing water
  - 1735 Hadley explained how the earth's rotation influences winds in tropics
  - 1742 Celsius developed the centigrade temp scale



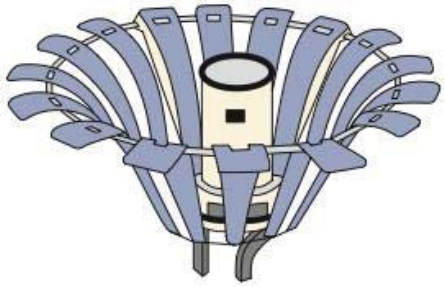
Tipping bucket
rain gauge



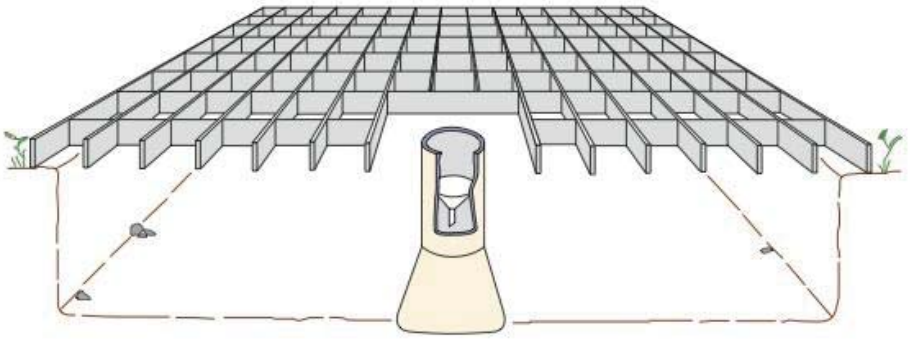
British standard
rain gauge



US Weather Bureau
standard rain gauge



USSR Tretyakov
precipitation gauge

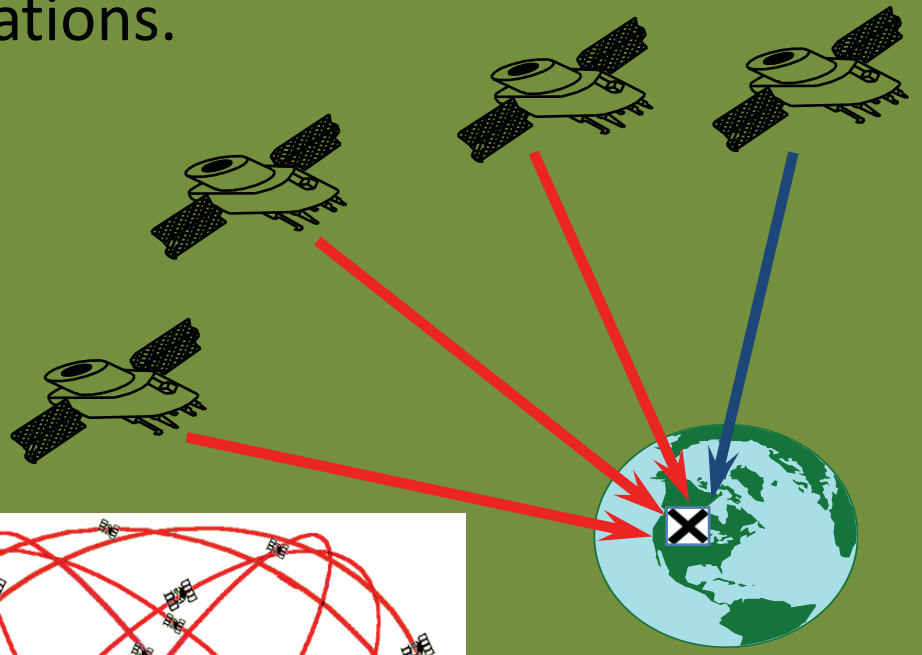


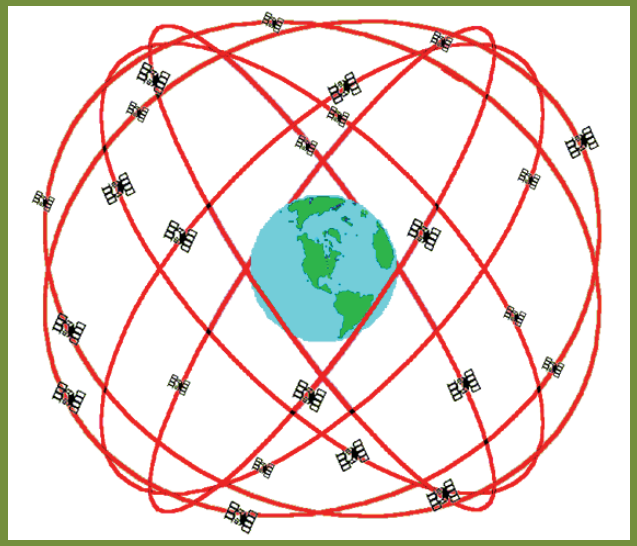
Ground level
rain gauge

GPS

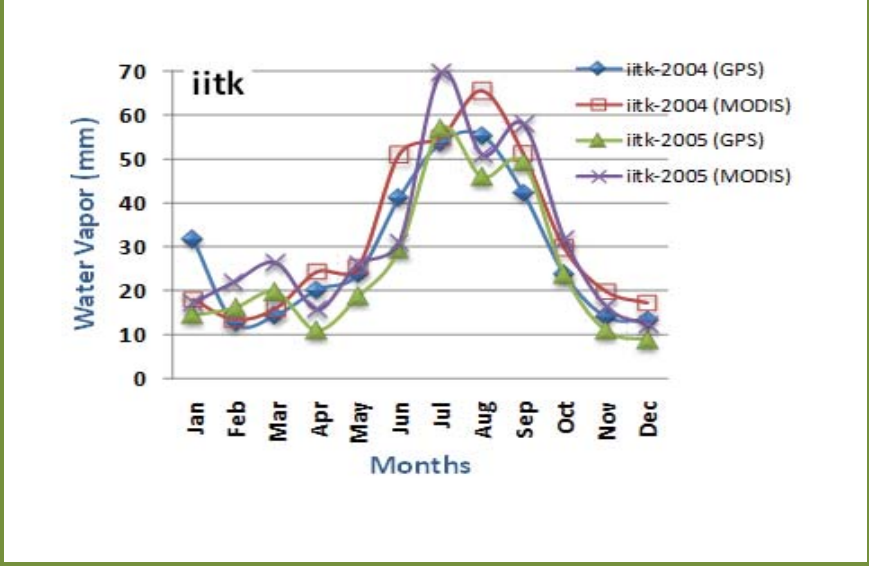
- GPS: Global Positioning System is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations.

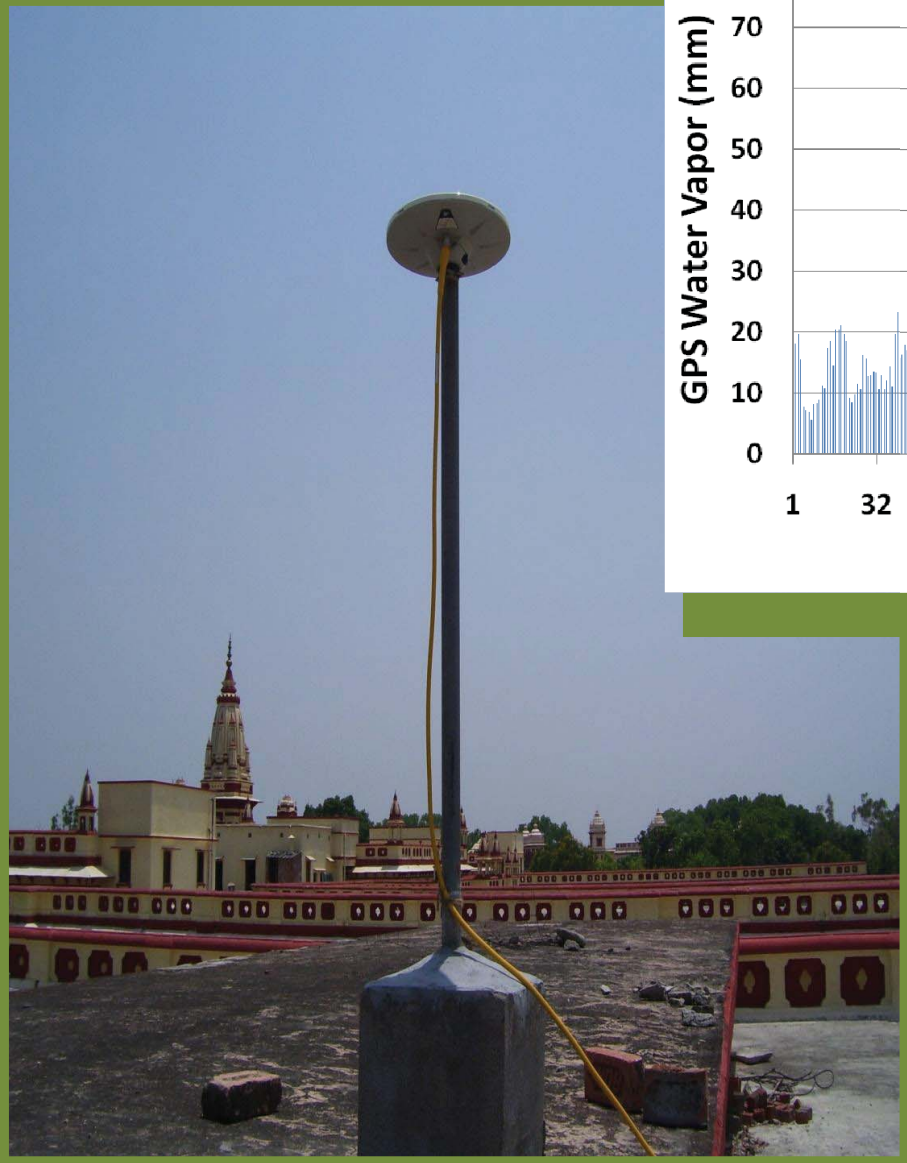
- A simplistic explanation:
  GPS uses these "man-made stars" as reference points to calculate positions accurate to a matter of meters.

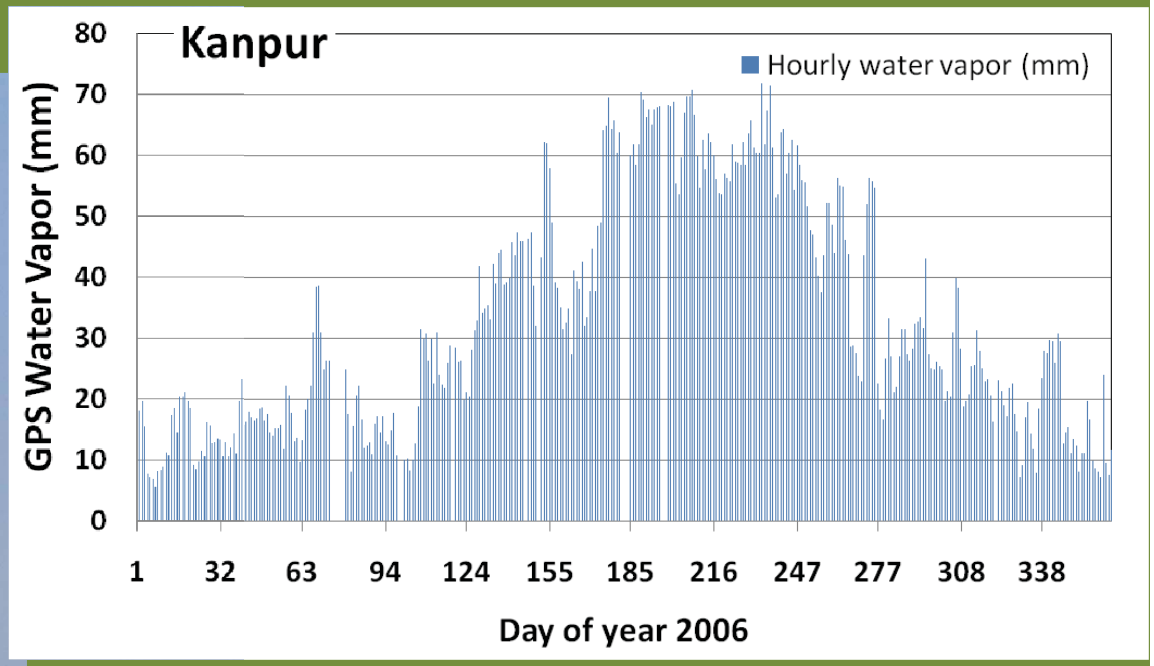




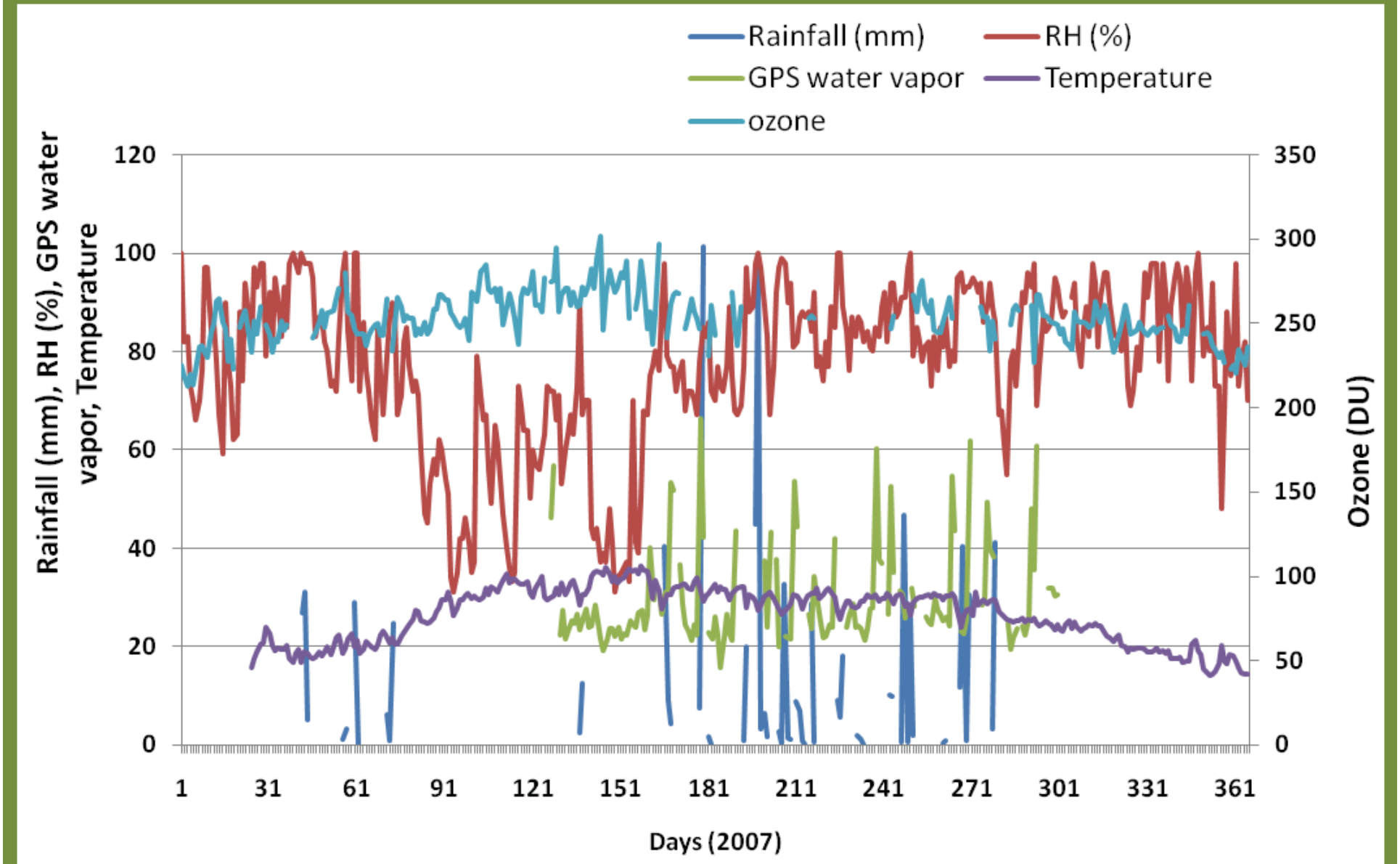

2005 10 13


iitk
Water Vapor (mm)
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months
iitk-2004 (GPS)
iitk-2004 (MODIS)
iitk-2005 (GPS)
iitk-2005 (MODIS)

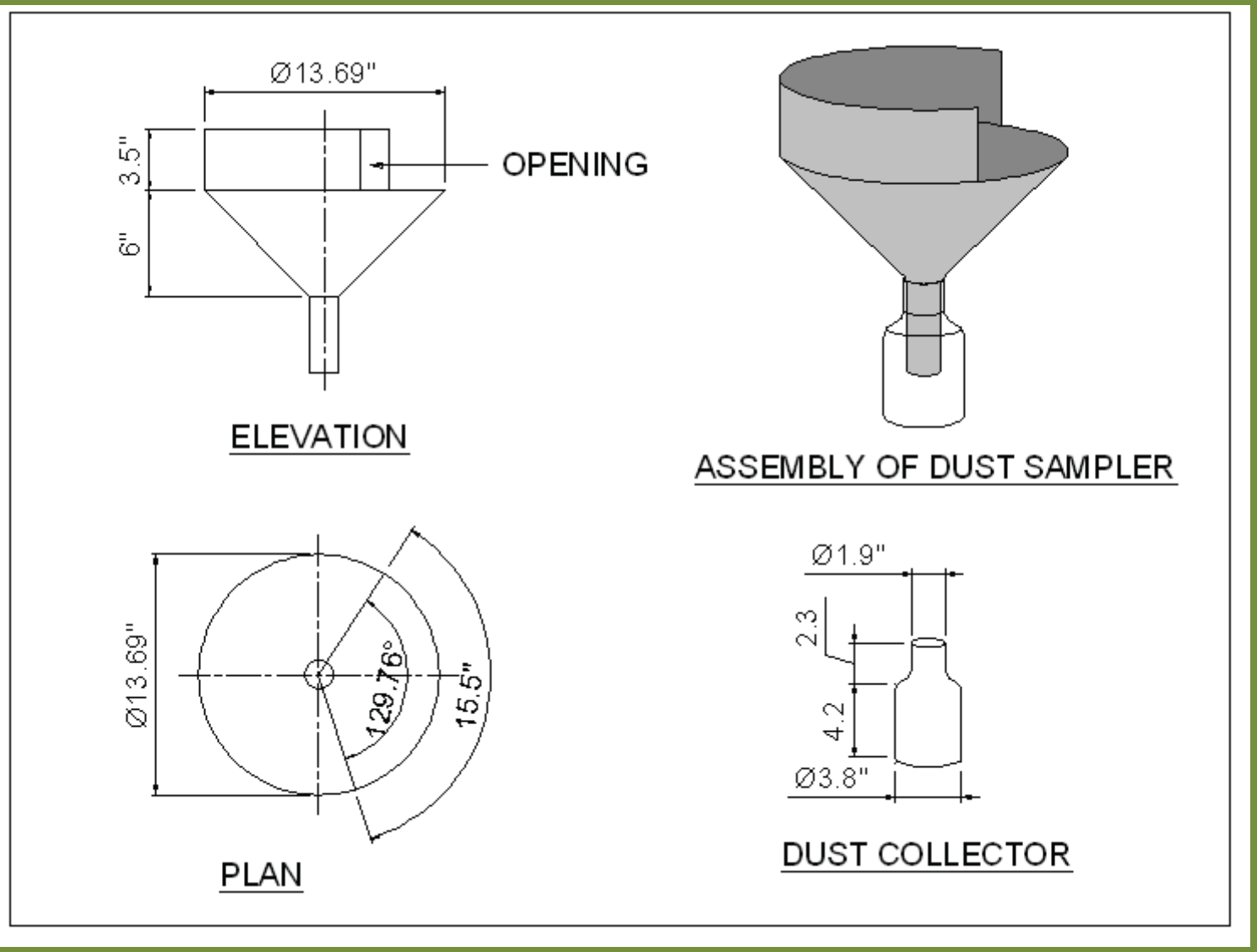




Station over top of Physics building in BHU


Rainfall (mm)
RH (%)
GPS water vapor
Temperature
ozone
Rainfall (mm), RH (%), GPS water vapor, Temperature
Ozone (DU)
120
100
80
60
40
20
0
350
300
250
200
150
100
50
0
1
31
61
91
121
151
181
211
241
271
301
331
361
Days (2007)

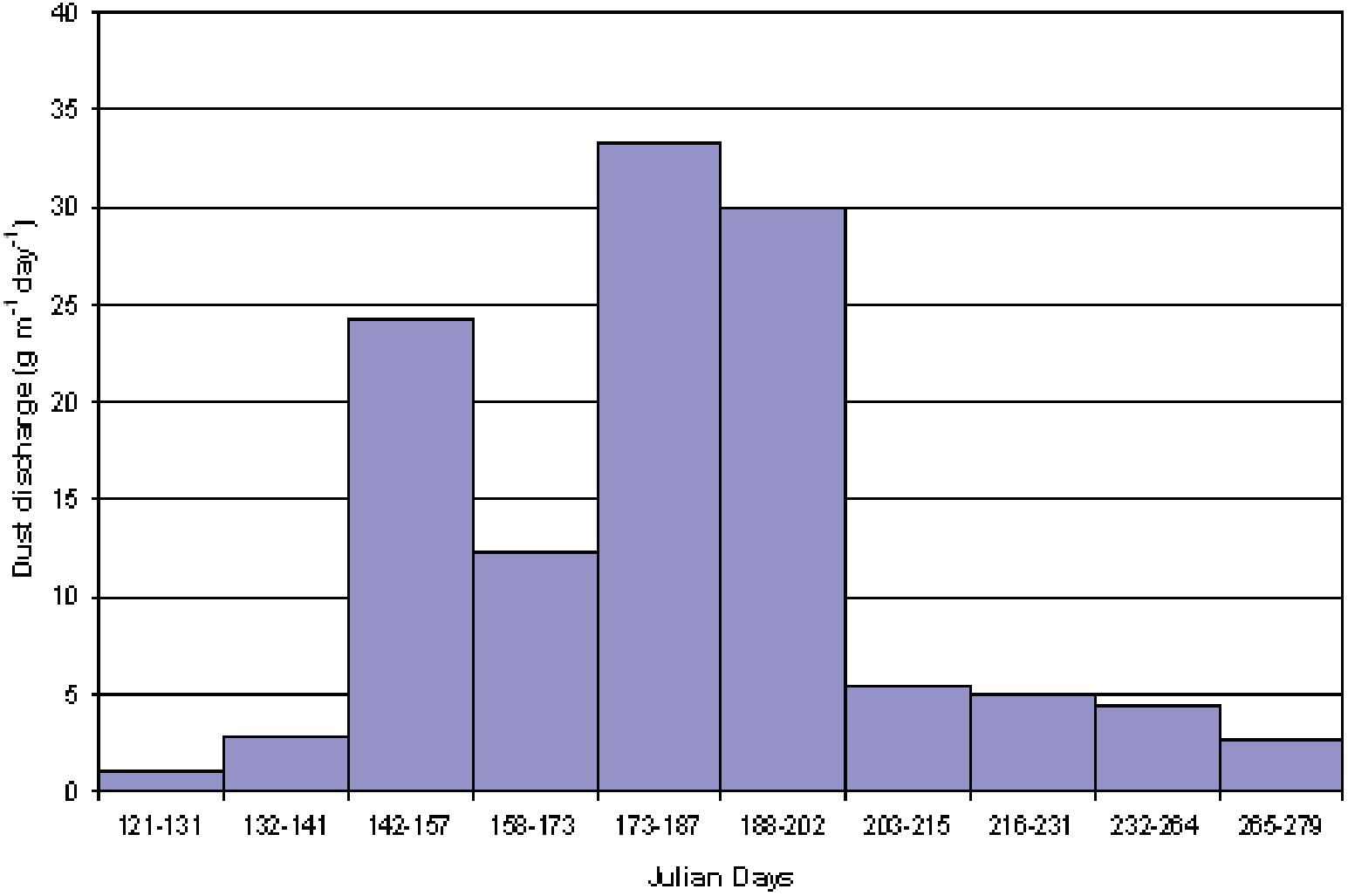
Dust sampler-design



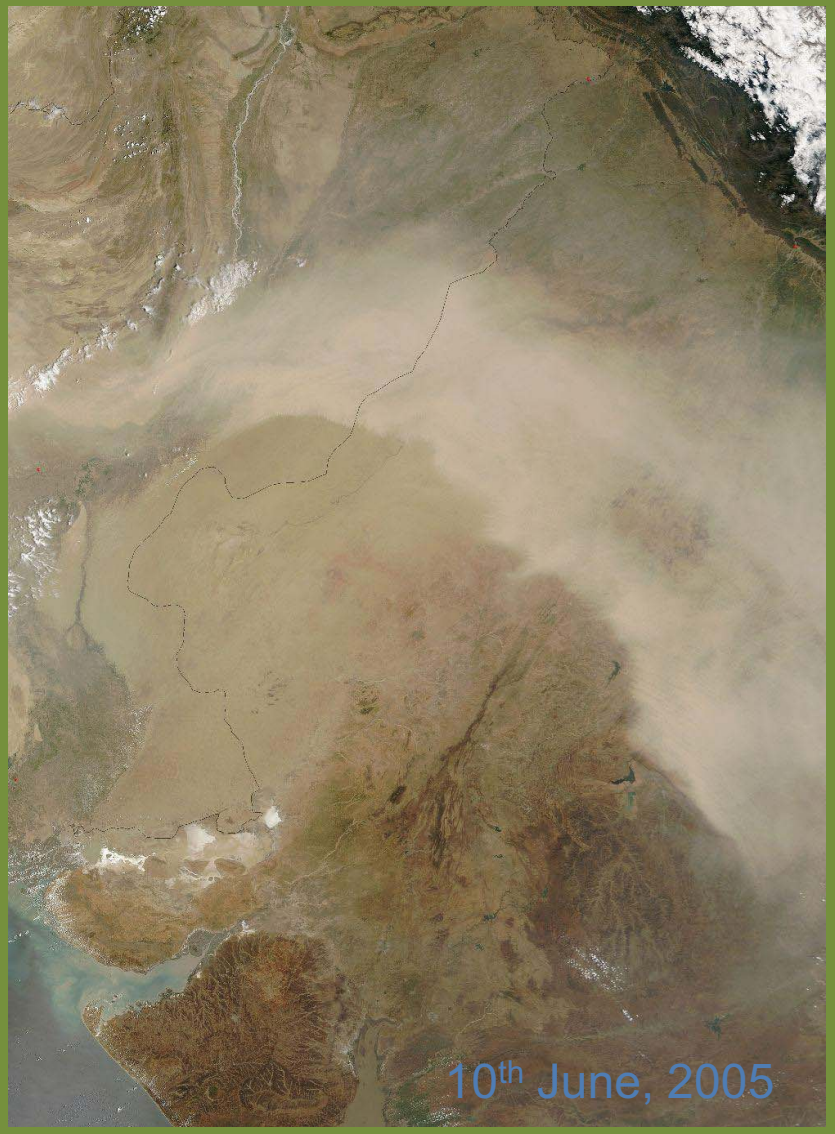
Dust sampler installed in the field

Individual dust sampler

Dust discharge at Jaisalmer



MODIS image of dust aerosol



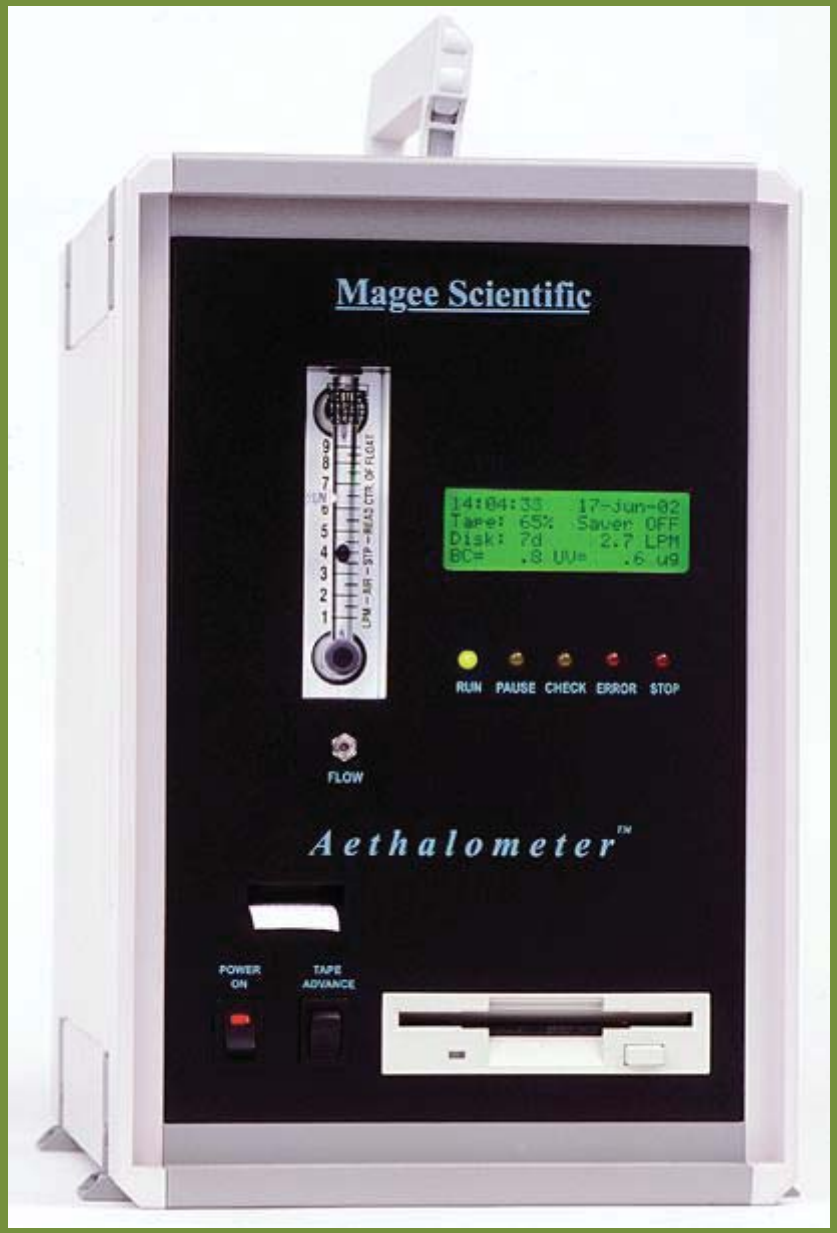
http://www.solarlight.com/products/products.html#mtops2_sun

Optical Particle Counter(OPC)

The particle size analyzer/dust-monitor Model 1.108 also known as Optical Particle Counter (OPC) is a small portable unit, used for the continuous measurement of particles in the air.

Anderson Sampler is used routinely from 1-29 December 2004 for air sampling to monitor the population of airborne particles near the surface. The air inlet is uniform on all sides of the sampler to provide an effective particle capture air velocity between 20-35 cm/sec. at the recommended flow rate between 40-60 ft^3/min. The gable roof design of the sampler allows the sampled air to be evenly distributed over the surface of a downstream filter, where sample is collected.

The High Volume Sampler (HVS) samples ambient particles on a filter, operated from 1-29 December 2004 everyday from 9am 5pm. Air is drawn into a covered housing and through a filter by a high flow rate blower at 1.1 to 1.5 m^3/ min that allows total suspended particulate matter with diameter of less than 100 m (stokes equivalent diameter) to collect on the filter surface. Particles with diameter 0.1-100 m are ordinarily collected on glass fiber filters.

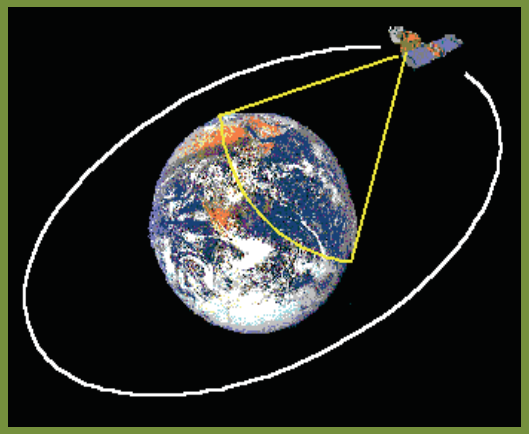


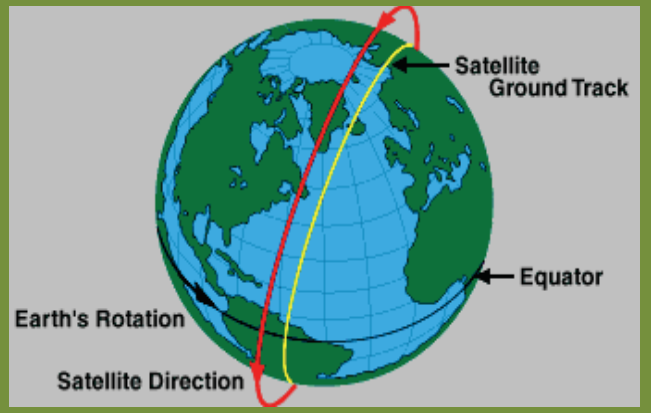
The *Aethalometer* (AE-42) is an instrument that measures suspended carbonaceous particulates, an important species of air pollutant. Wavelength-dependent absorption (at 7 wavelengths: 0.37, 0.45, 0.571, 0.615, 0.66, 0.88, and 0.95 nm)

Three-stage size fractioning fog water collector (SF-FWC 3) deployed at IIT Kanpur, an urban-Industrial city in Ganga basin, for the collection of fog water. Fog collector is capable of simultaneous collection of fog in three independent sizes (D_{50}: for 1st, 2nd and 3rd stages are 21, 15 and 4 m respectively) for chemical analysis. It works on inertial impaction technique. Altogether nine fog episodes were observed during winter of December 04-January 05.

Major Programs

- Geostationary (Met satellites)
  - Meteosat (Europe)
  - GOES (US)
  - GMS (Japan)
  - INSAT (India)
- Polar Orbiting
  - SPOT (France)
  - NOAA (US)
  - ERS-1 & 2, Envisat (Europe)
  - ADEOS, JERS (Japan)
  - Radarsat (Canada)
  - EOS/NPOESS, Landat, NOAA (US)

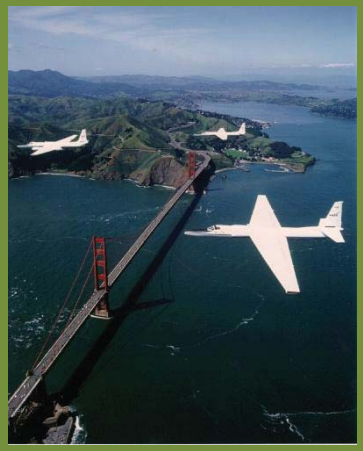




Remote Sensing: examples

upscale

upscale



upscale

- Platform depends on application
  - What information do we want?
  - How much detail?
  - What type of detail?

http://www-imk.fzk.de:8080/imk2/mipas-b/mipas-b.htm

A Remote Sensing System

- Energy source
- platform
- sensor
- data recording / transmission
- ground receiving station
- data processing
- expert interpretation / data users

Physical Basis

- measurement of EM radiation
  - scattered, reflected
- energy sources
  - Sun, Earth
  - artificial
- source properties
  - vary in intensity AND across wavelengths

EM radiation

- emitted, scattered or absorbed
- intrinsic properties (emission, scattering, absorption)
  - vary with wavelength
  - vary with physical / chemical properties
  - can vary with viewing angle

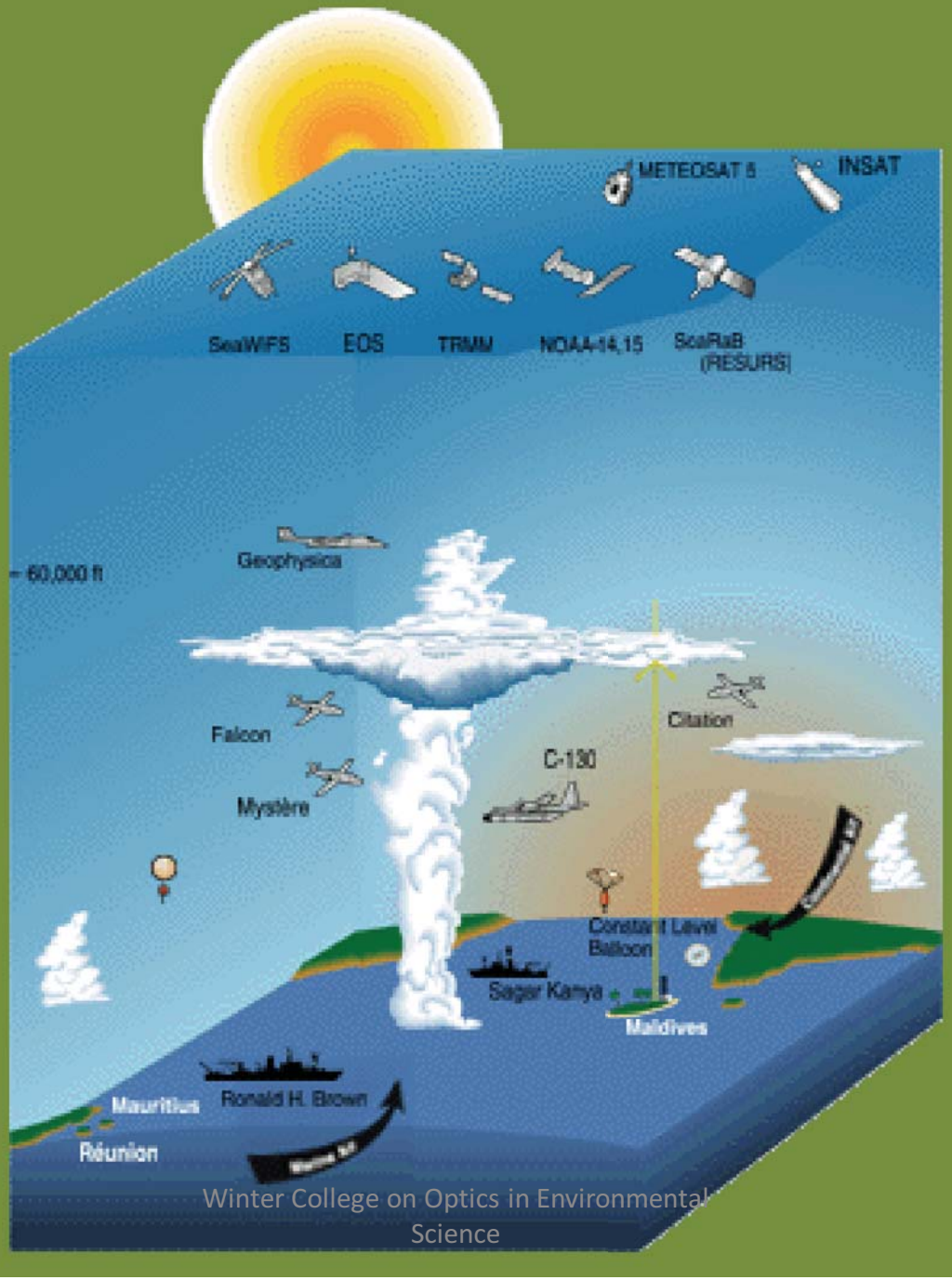
Data Acquisition

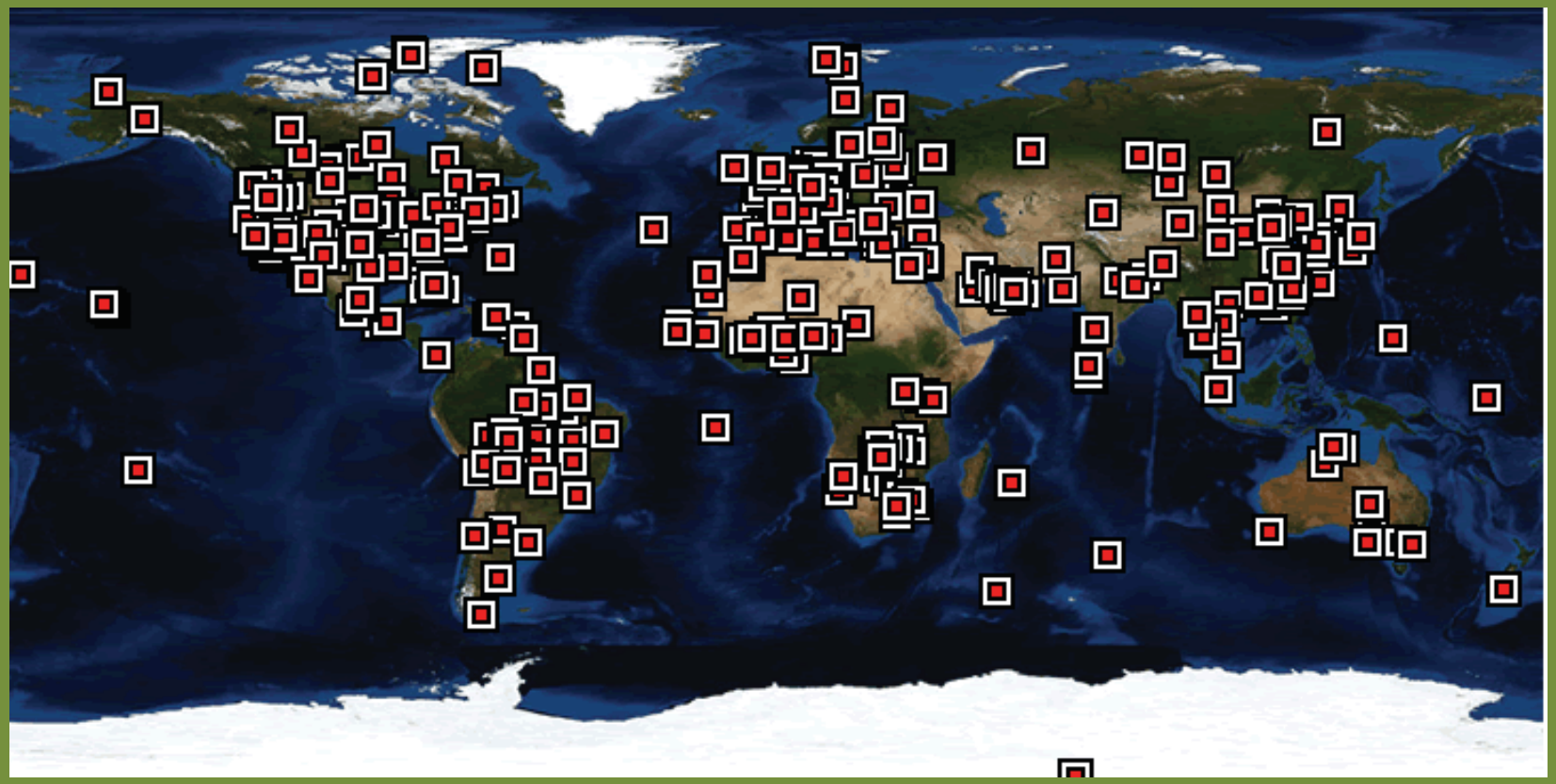
- RS instrument measures energy received
  - 3 useful areas of the spectrum:-

1) *Visible / near / mid infrared*
   - **passive**
     - solar energy reflected by the surface
     - determine surface (spectral) reflectance
   - **active**
     - LIDAR - active laser pulse
     - time delay (height)
     - induce florescence (chlorophyll)

2) *Thermal infrared*
   - energy measured - temperature of surface and emissivity

3) *Microwave*
   - **active**
     - microwave pulse transmitted
     - measure amount scattered back
     - infer scattering
   - **passive**
     - emitted energy at shorter end of microwave spectrum

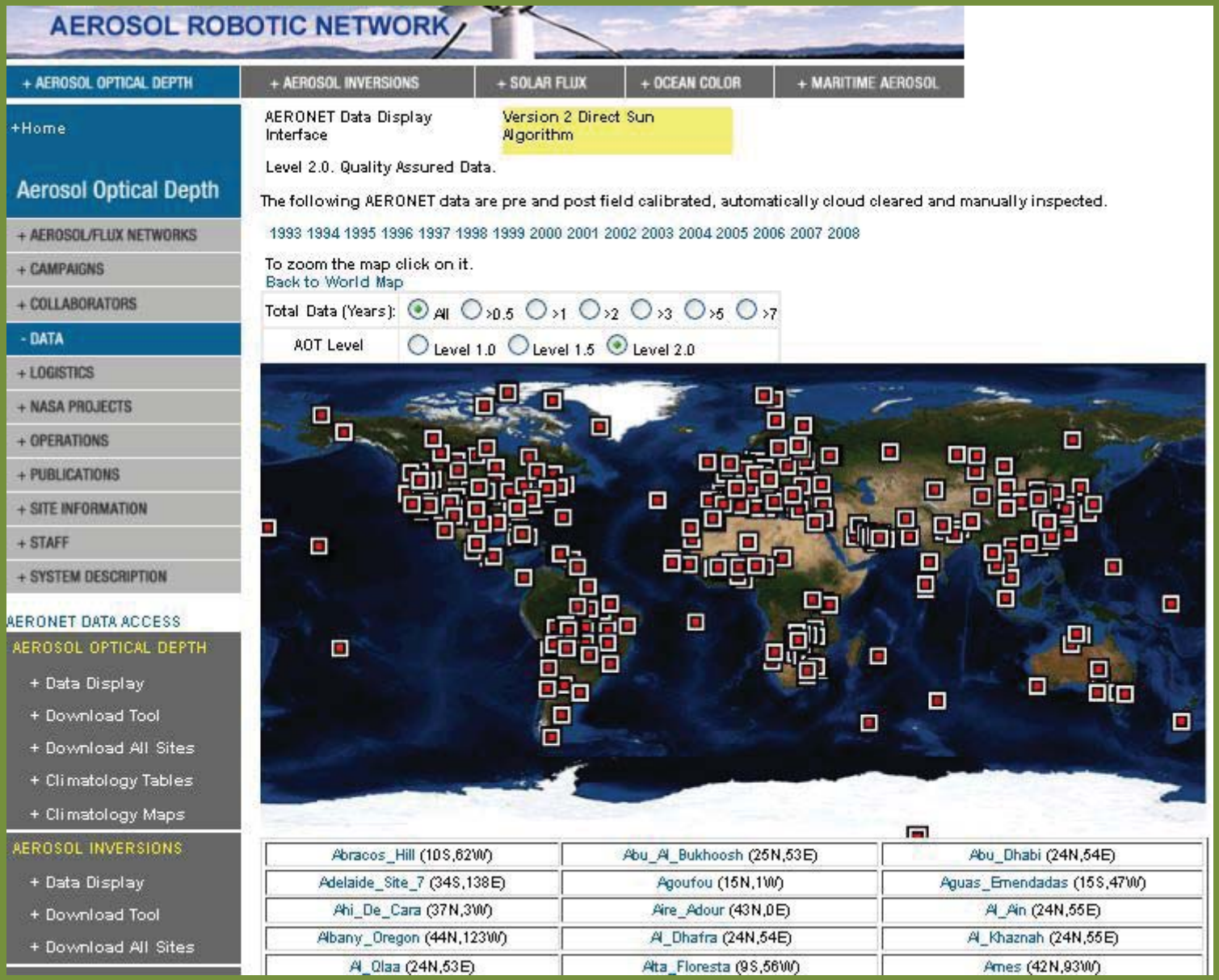

METEOSAT 5
INSAT
SeaWIFS
EOS
TRMM
NOAA-14,15
ScaRaB
(RESURS)
~ 60,000 ft
Geophysica
Falcon
Mystère
C-130
Citation
Constant Level
Balloon
Sagar Kanya
Maldives
Ronald H. Brown
Mauritius
Réunion

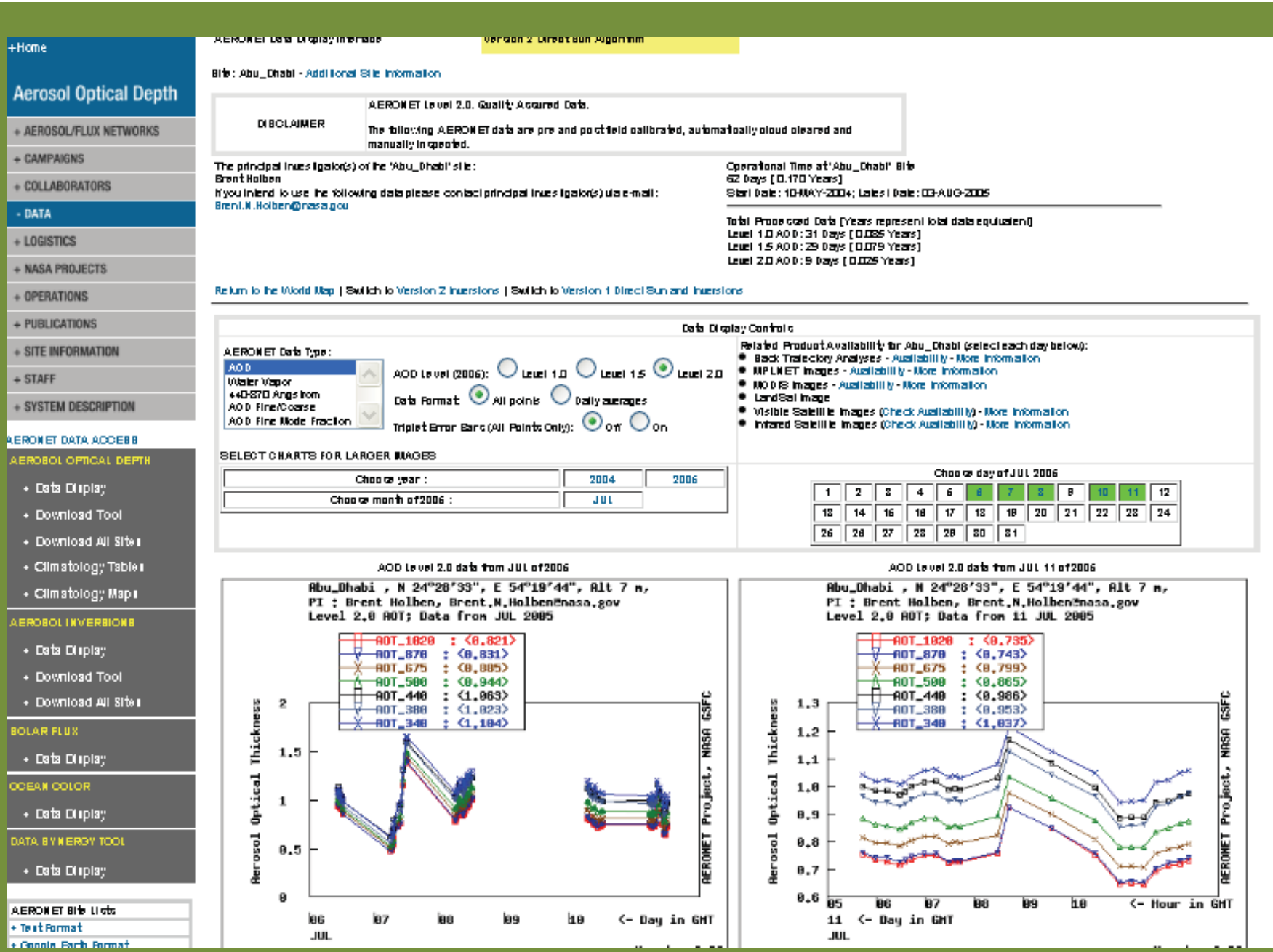


- http://aeronet.gsfc.nasa.gov/

- http://aeronet.gsfc.nasa.gov/


AERONET
AEROSOL ROBOTIC NETWORK
+ AEROSOL OPTICAL DEPTH
+ AEROSOL INVERSIONS
+ SOLAR FLUX
+ OCEAN COLOR
+ MARITIME AEROSOL
Web Site Feature Announcement
AERONET Data Synergy Tool - Access Earth Science data sets for AERONET sites
+ 2008 AERONET Review - 6 November 2008
-Home
Home
+ AEROSOL/FLUX NETWORKS
+ CAMPAIGNS
+ COLLABORATORS
+ DATA
+ LOGISTICS
+ NASA PROJECTS
+ OPERATIONS
+ PUBLICATIONS
+ SITE INFORMATION
+ STAFF
+ SYSTEM DESCRIPTION
AERONET DATA ACCESS
AEROSOL OPTICAL DEPTH
+ Data Display
+ Download Tool
+ Download All Sites
+ Climatology Tables
+ Climatology Maps
AEROSOL INVERSIONS
MISSION
The AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks established by NASA and LOA-PHOTONS (CNRS) and is greatly expanded by collaborators from national agencies, institutes, universities, individual scientists, and partners. The program provides a long-term, continuous and readily accessible public domain database of aerosol optical, microphysical and radiative properties for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases. The network imposes standardization of instruments, calibration, processing and distribution.
AERONET collaboration provides globally distributed observations of spectral aerosol optical depth (AOD), inversion products, and precipitable water in diverse aerosol regimes. Aerosol optical depth data are computed for three data quality levels: Level 1.0 (unscreened), Level 1.5 (cloud-screened), and Level 2.0 (cloud-screened and quality-assured). Inversions, precipitable water, and other AOD-dependent products are derived from these levels and may implement additional quality checks.
The processing algorithms have evolved from Version 1 to Version 2.0 (fully released in July 2006) and are available from the AERONET and PHOTONS web sites. Version 1 data may be downloaded from the web site through 2006 and thereafter upon special request. New AERONET products will be released as new measurement techniques and algorithms are adopted and validated by the AERONET research community. The AERONET web site also provides AERONET-related news, a description of research and operational activities, related Earth Science links, and an AERONET staff directory.
+ Read More
NEWS


AEROSOL ROBOTIC NETWORK
+ AEROSOL OPTICAL DEPTH
+ AEROSOL INVERSIONS
+ SOLAR FLUX
+ OCEAN COLOR
+ MARITIME AEROSOL
+Home
Aerosol Optical Depth
+ AEROSOL/FLUX NETWORKS
+ CAMPAIGNS
+ COLLABORATORS
- DATA
+ LOGISTICS
+ NASA PROJECTS
+ OPERATIONS
+ PUBLICATIONS
+ SITE INFORMATION
+ STAFF
+ SYSTEM DESCRIPTION
AERONET DATA ACCESS
AEROSOL OPTICAL DEPTH
+ Data Display
+ Download Tool
+ Download All Sites
+ Climatology Tables
+ Climatology Maps
AEROSOL INVERSIONS
+ Data Display
+ Download Tool
+ Download All Sites
AERONET Data Display Interface
Version 2 Direct Sun Algorithm
Level 2.0. Quality Assured Data.
The following AERONET data are pre and post field calibrated, automatically cloud cleared and manually inspected.
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
To zoom the map click on it.
Back to World Map
Total Data (Years): All >0.5 >1 >2 >3 >5 >7
AOT Level Level 1.0 Level 1.5 Level 2.0
Abracos_Hill (10S,62W)
Abu_Al_Bukhoosh (25N,53E)
Abu_Dhabi (24N,54E)
Adelaide_Site_7 (34S,138E)
Agoufou (15N,1W)
Aguas_Emendadas (15S,47W)
Ahi_De_Cara (37N,3W)
Aire_Adour (43N,0E)
Al_Ain (24N,55E)
Albany_Oregon (44N,123W)
Al_Dhafra (24N,54E)
Al_Khaznah (24N,55E)
Al_Qlaa (24N,53E)
Alta_Floresta (9S,56W)
Ames (42N,93W)


+Home
Aerosol Optical Depth
+ AEROSOL/FLUX NETWORKS
+ CAMPAIGNS
+ COLLABORATORS
- DATA
+ LOGISTICS
+ NASA PROJECTS
+ OPERATIONS
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AERONET DATA ACCESS
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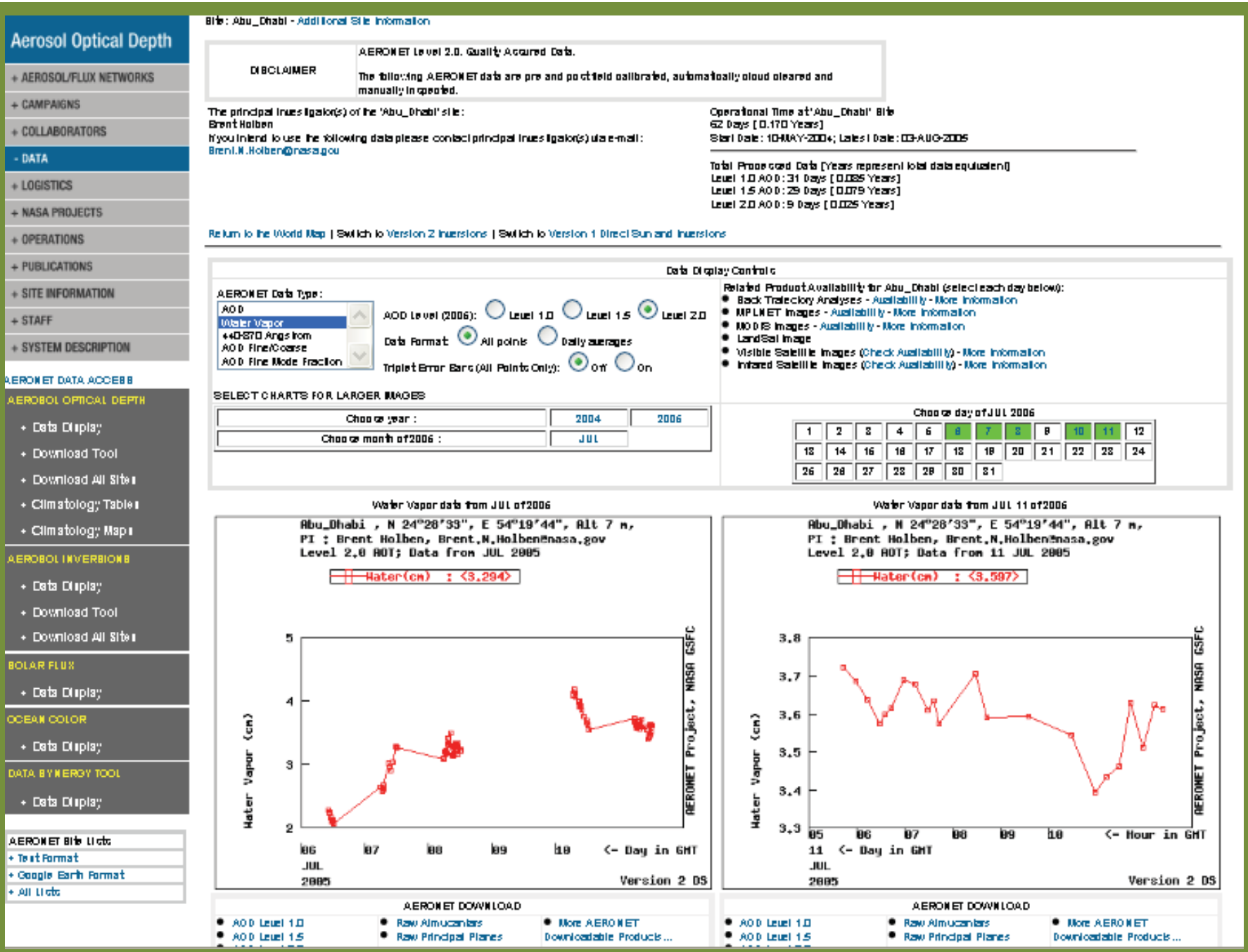
+ Data Display
+ Download Tool
+ Download All Sites
SOLAR FLUX
+ Data Display
OCEAN COLOR
+ Data Display
DATA SYNERGY TOOL
+ Data Display
AERONET Site Lists
+ Text Format
Site: Abu_Dhabi - Additional Site Information
DISCLAIMER
AERONET Level 2.0. Quality Assured Data.
The following AERONET data are pre and post field calibrated, automatically cloud cleared and manually inspected.
The principal investigator(s) of the 'Abu_Dhabi' site:
Brent Holben
If you intend to use the following data please contact principal investigator(s) via e-mail:
Brent.N.Holben@nasa.gov
Operational Time at 'Abu_Dhabi' Site
62 Days [0.170 Years]
Start Date: 10-MAY-2004; Latest Date: 03-AUG-2005
Total Processed Data (Years represent total data equivalent)
Level 1.0 AOD: 31 Days [0.085 Years]
Level 1.5 AOD: 29 Days [0.079 Years]
Level 2.0 AOD: 9 Days [0.025 Years]
Return to the World Map | Switch to Version 2 Inversions | Switch to Version 1 Direct Sun and Inversions
Data Display Controls
AERONET Data Type:
AOD
Water Vapor
440-870 Angstrom
AOD Fine/Coarse
AOD Fine Mode Fraction
AOD Level (2006): Level 1.0 Level 1.5 Level 2.0
Data Format: All points Daily averages
Triplet Error Bars (All Points Only): Off On
Related Product Availability for Abu_Dhabi (select each day below):
Back Trajectory Analyses - Availability - More Information
MPLNET Images - Availability - More Information
MODIS Images - Availability - More Information
LandSat Image
Visible Satellite Images (Check Availability) - More Information
Infared Satellite Images (Check Availability) - More Information
SELECT CHARTS FOR LARGER IMAGES
Choose year : 2004 2006
Choose month of 2006 : JUL
Choose day of JUL 2006
1 2 3 4 5 6 7 8 9 10 11 12
13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31
AOD Level 2.0 data from JUL of 2006
Abu_Dhabi , N 24°28'33", E 54°19'44", Alt 7 m,
PI : Brent Holben, Brent.N.Holben@nasa.gov
Level 2.0 AOT; Data from JUL 2005
AOT_1020 : <0.821>
AOT_870 : <0.831>
AOT_675 : <0.885>
AOT_500 : <0.944>
AOT_440 : <1.063>
AOT_380 : <1.023>
AOT_340 : <1.104>
Aerosol Optical Thickness
AERONET Project, NASA GSFC
<- Day in GMT
JUL
AOD Level 2.0 data from JUL 11 of 2006
Abu_Dhabi , N 24°28'33", E 54°19'44", Alt 7 m,
PI : Brent Holben, Brent.N.Holben@nasa.gov
Level 2.0 AOT; Data from 11 JUL 2005
AOT_1020 : <0.735>
AOT_870 : <0.743>
AOT_675 : <0.799>
AOT_500 : <0.865>
AOT_440 : <0.986>
AOT_380 : <0.953>
AOT_340 : <1.037>
Aerosol Optical Thickness
AERONET Project, NASA GSFC
<- Hour in GMT
<- Day in GMT
11
JUL


Aerosol Optical Depth
+ AEROSOL/FLUX NETWORKS
+ CAMPAIGNS
+ COLLABORATORS
- DATA
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+ NASA PROJECTS
+ OPERATIONS
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SOLAR FLUX
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OCEAN COLOR
+ Data Display
DATA SYNERGY TOOL
+ Data Display
AERONET Site Lists
+ Text Format
+ Google Earth Format
+ All Lists
Site: Abu_Dhabi - Additional Site Information
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Brent Holben
If you intend to use the following data please contact principal investigator(s) via e-mail:
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Data Display Controls
AERONET Data Type:
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Water Vapor
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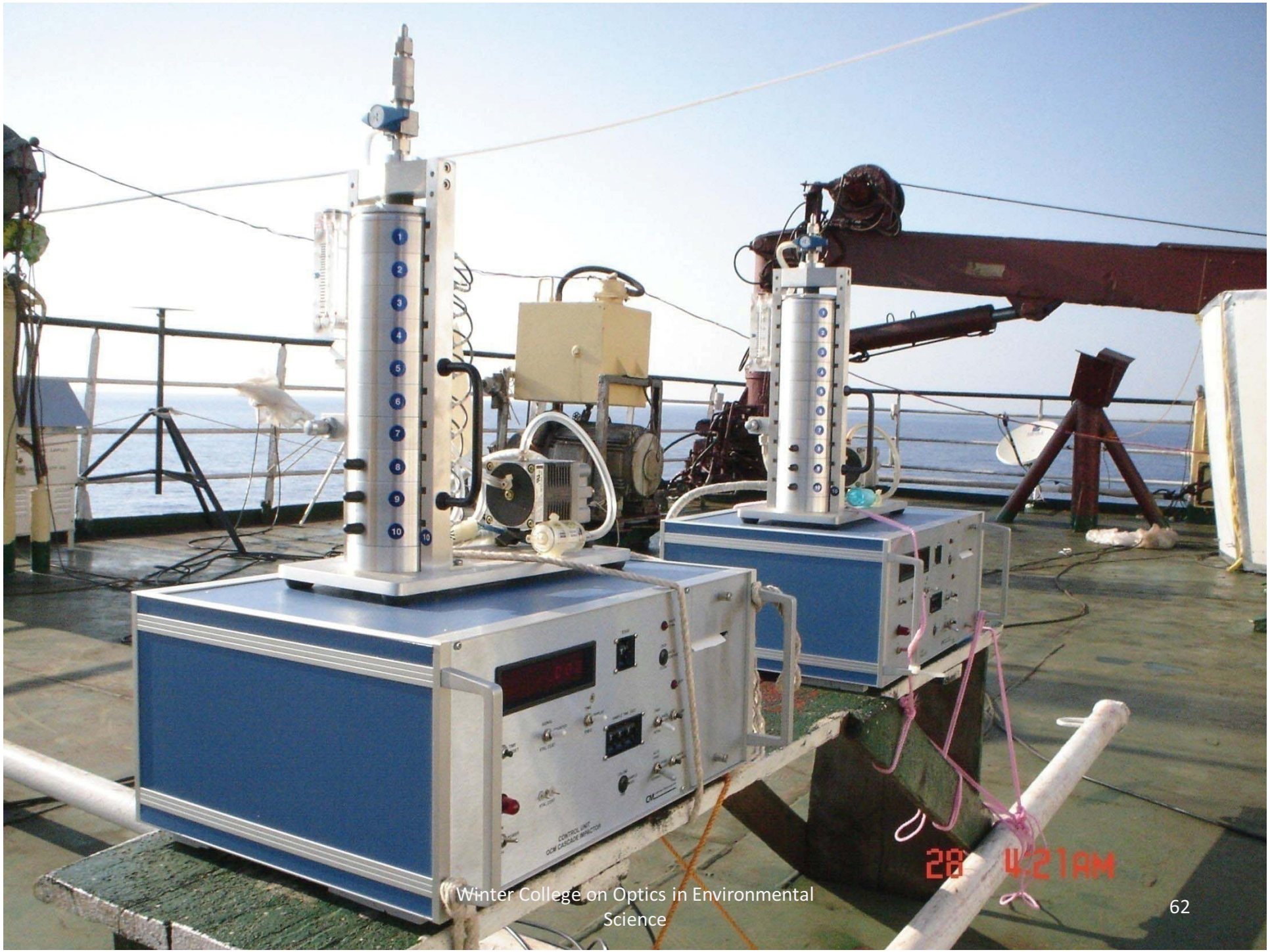
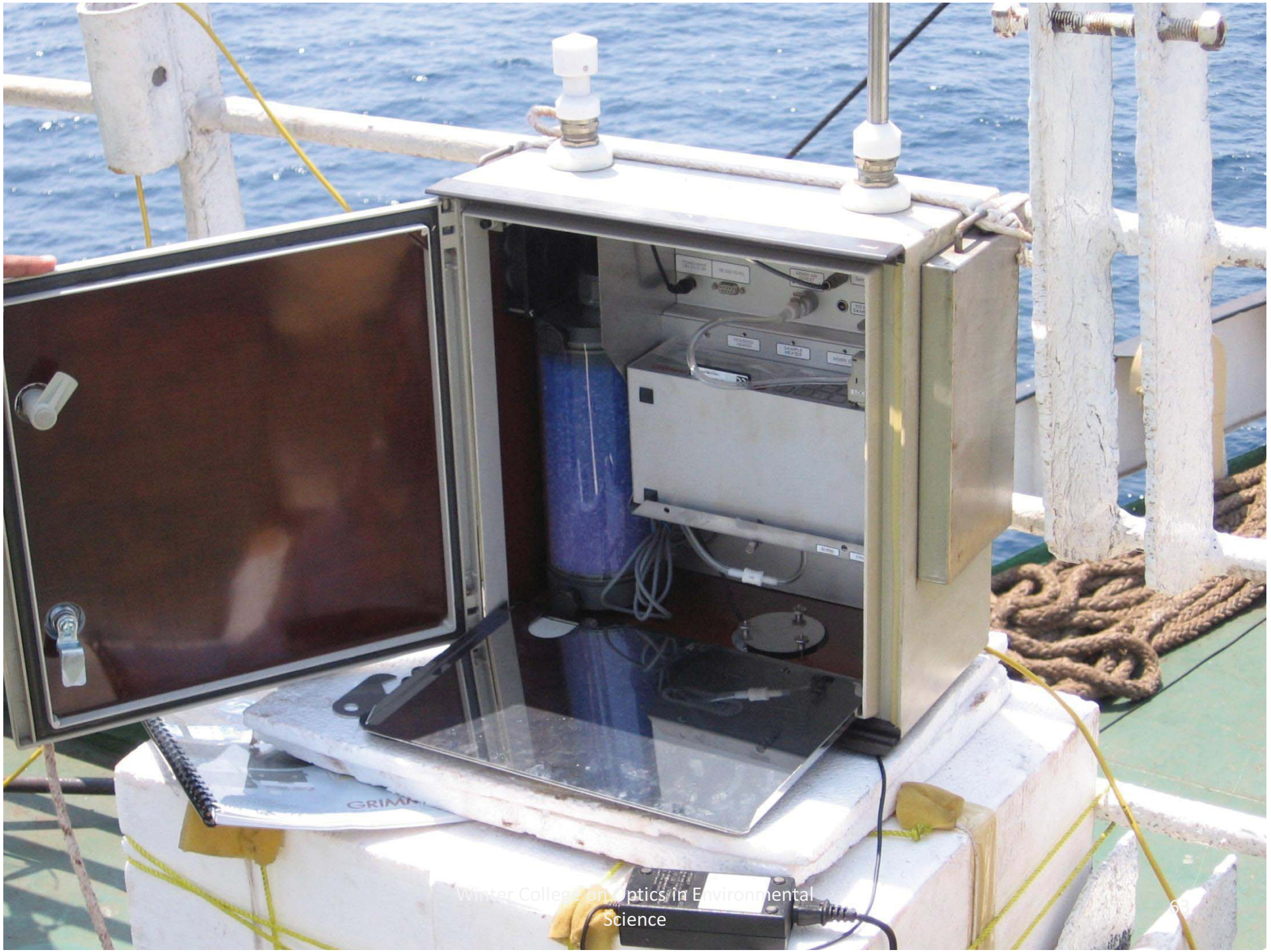
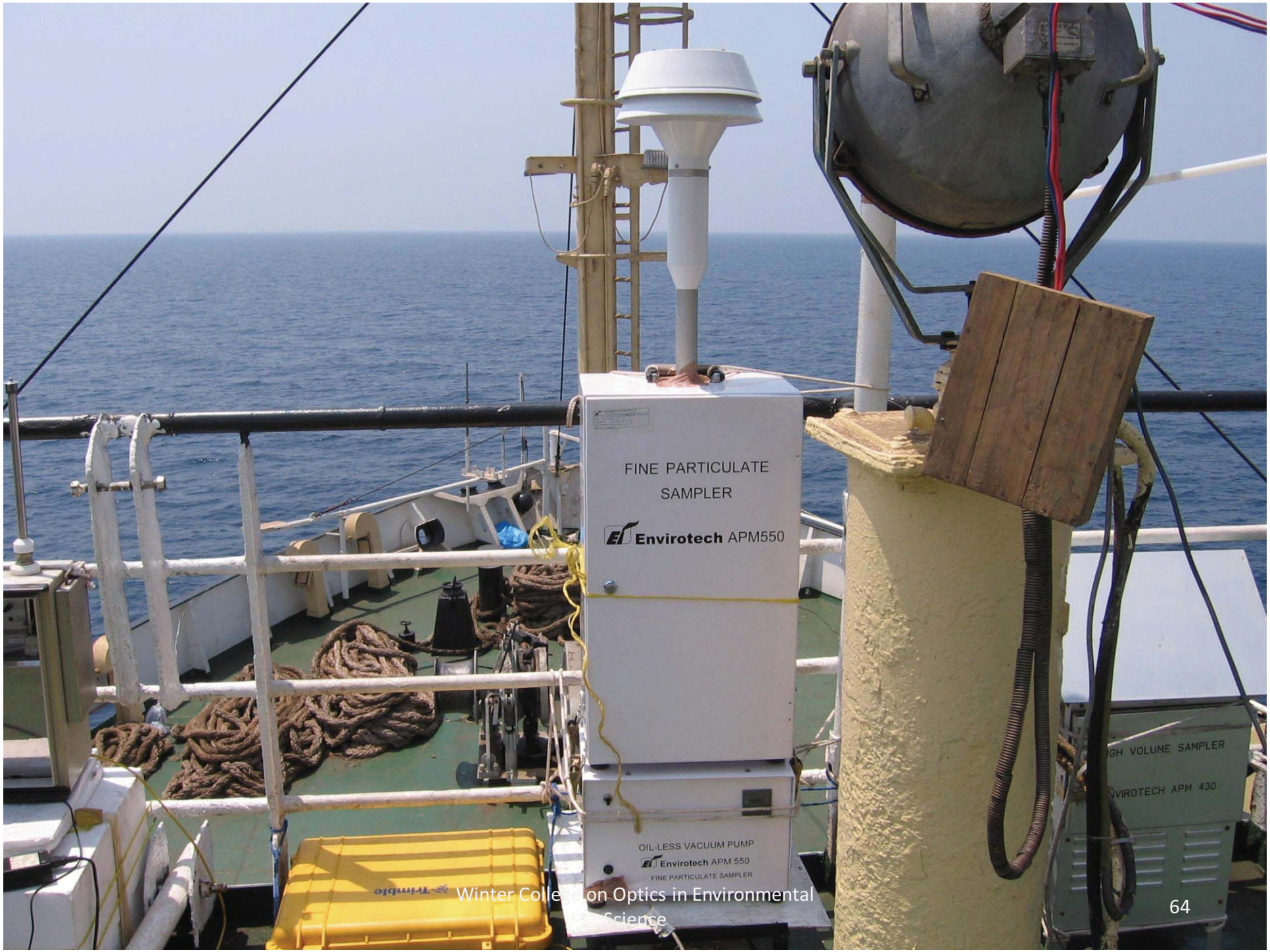
Data Format: All points Daily averages
Triplet Error Bars (All Points Only): Off On
Related Product Availability for Abu_Dhabi (select each day below):
Back Trajectory Analyses - Availability - More Information
MPLNET Images - Availability - More Information
MODIS Images - Availability - More Information
LandSat Image
Visible Satellite Images (Check Availability) - More Information
Infrared Satellite Images (Check Availability) - More Information
SELECT CHARTS FOR LARGER IMAGES
Choose year : 2004 2005
Choose month of 2005 : JUL
Choose day of JUL 2005
1 2 3 4 5 6 7 8 9 10 11 12
13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31
Water Vapor data from JUL of 2005
Abu_Dhabi , N 24°28'33", E 54°19'44", Alt 7 m,
PI : Brent Holben, Brent.N.Holben@nasa.gov
Level 2.0 AOT; Data from JUL 2005
Water(cm) : <3.294>
Water Vapor (cm)
<- Day in GMT
JUL
2005
Version 2 DS
AERONET Project, NASA GSFC
AERONET DOWNLOAD
AOD Level 1.0
AOD Level 1.5
Raw Almucantars
Raw Principal Planes
More AERONET Downloadable Products ...
Water Vapor data from JUL 11 of 2005
Abu_Dhabi , N 24°28'33", E 54°19'44", Alt 7 m,
PI : Brent Holben, Brent.N.Holben@nasa.gov
Level 2.0 AOT; Data from 11 JUL 2005
Water(cm) : <3.597>
Water Vapor (cm)
<- Hour in GMT
11 <- Day in GMT
JUL
2005
Version 2 DS
AERONET Project, NASA GSFC
AERONET DOWNLOAD
AOD Level 1.0
AOD Level 1.5
Raw Almucantars
Raw Principal Planes
More AERONET Downloadable Products ...

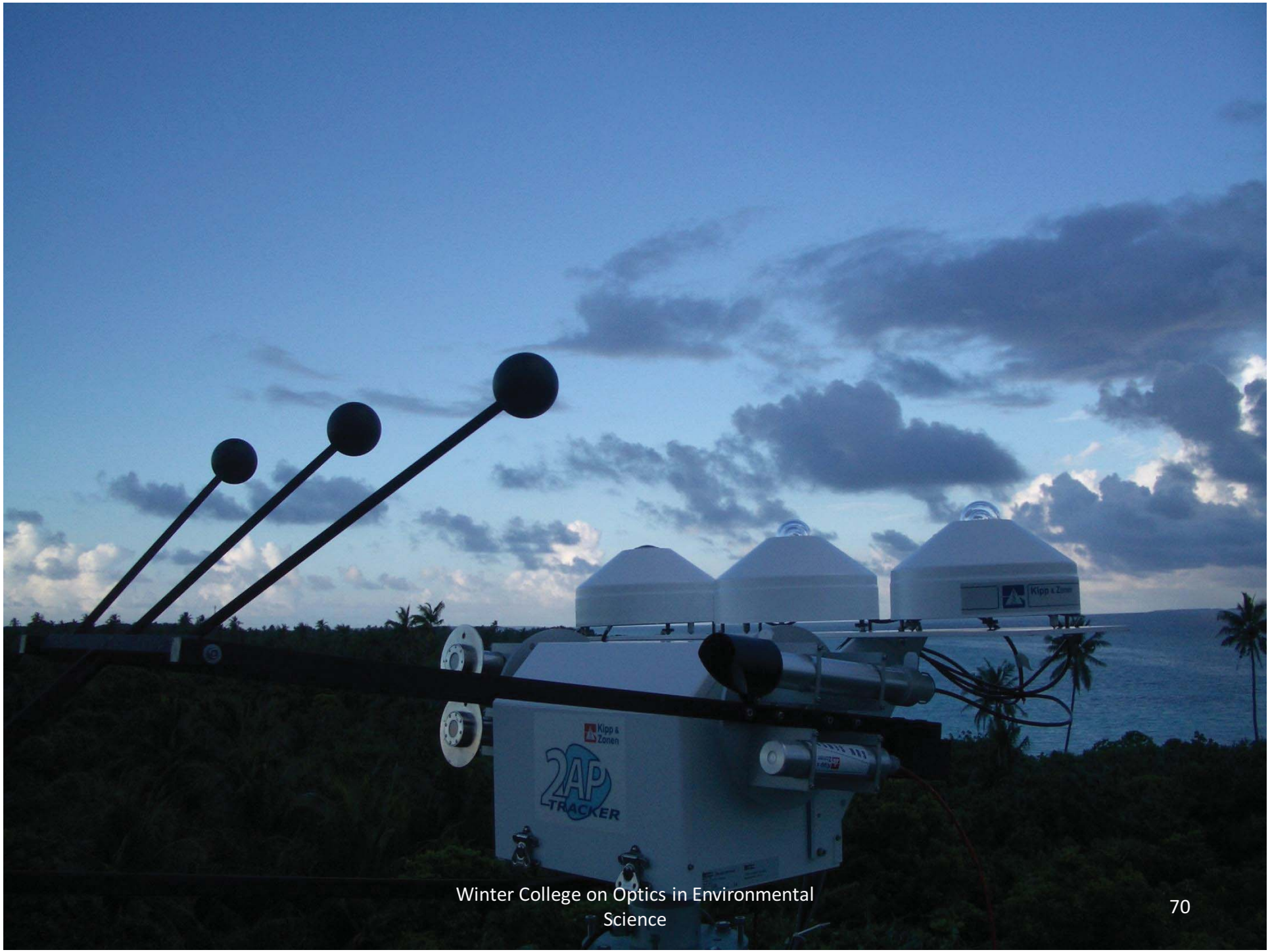

AREA
2006 3 18


28 4:21AM



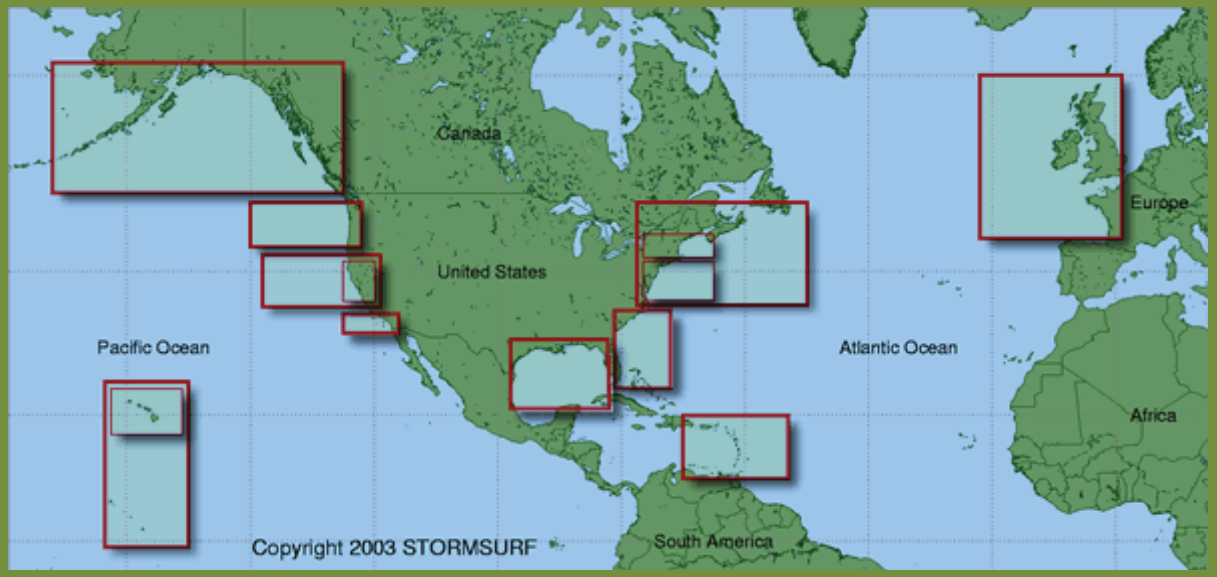

FINE PARTICULATE
SAMPLER
Envirotech APM550
OIL-LESS VACUUM PUMP
Envirotech APM 550
FINE PARTICULATE SAMPLER
GH VOLUME SAMPLER
NVIROTECH APM 430

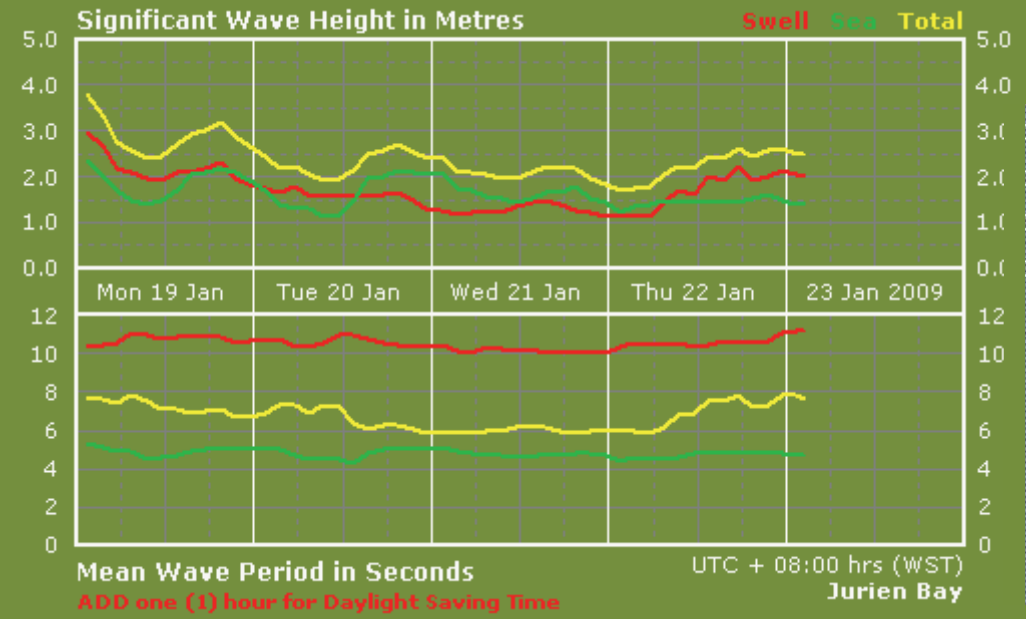

8 2:40PM


Kipp & Zonen
2AP
TRACKER


ZAP
TRACKER


YOUNG





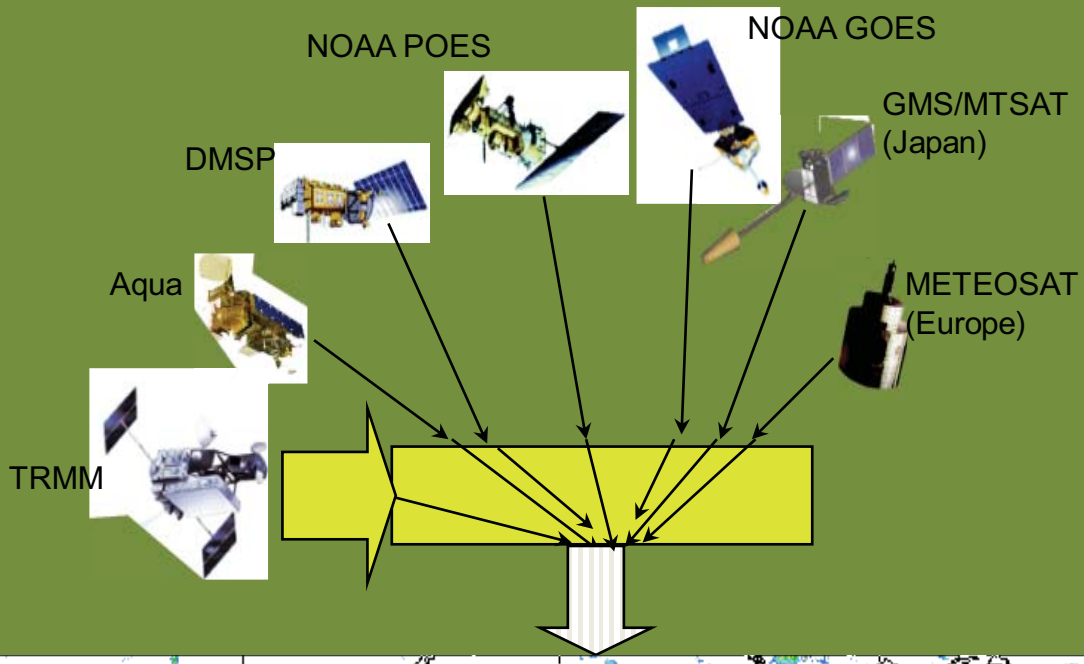
http://www.stormsurf.com/page2/links/wozbuoy.html

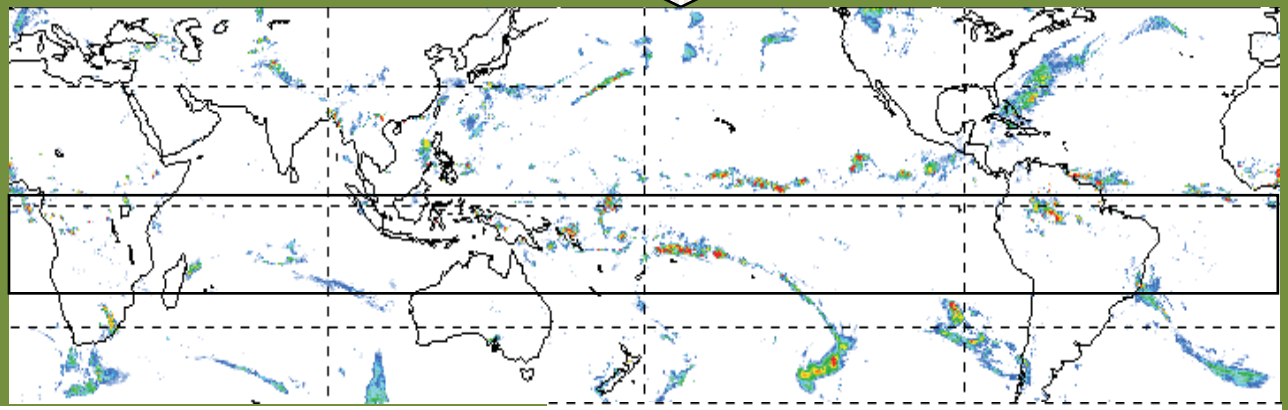

ATLAS


kkom
CLEAR


TSUNAMI

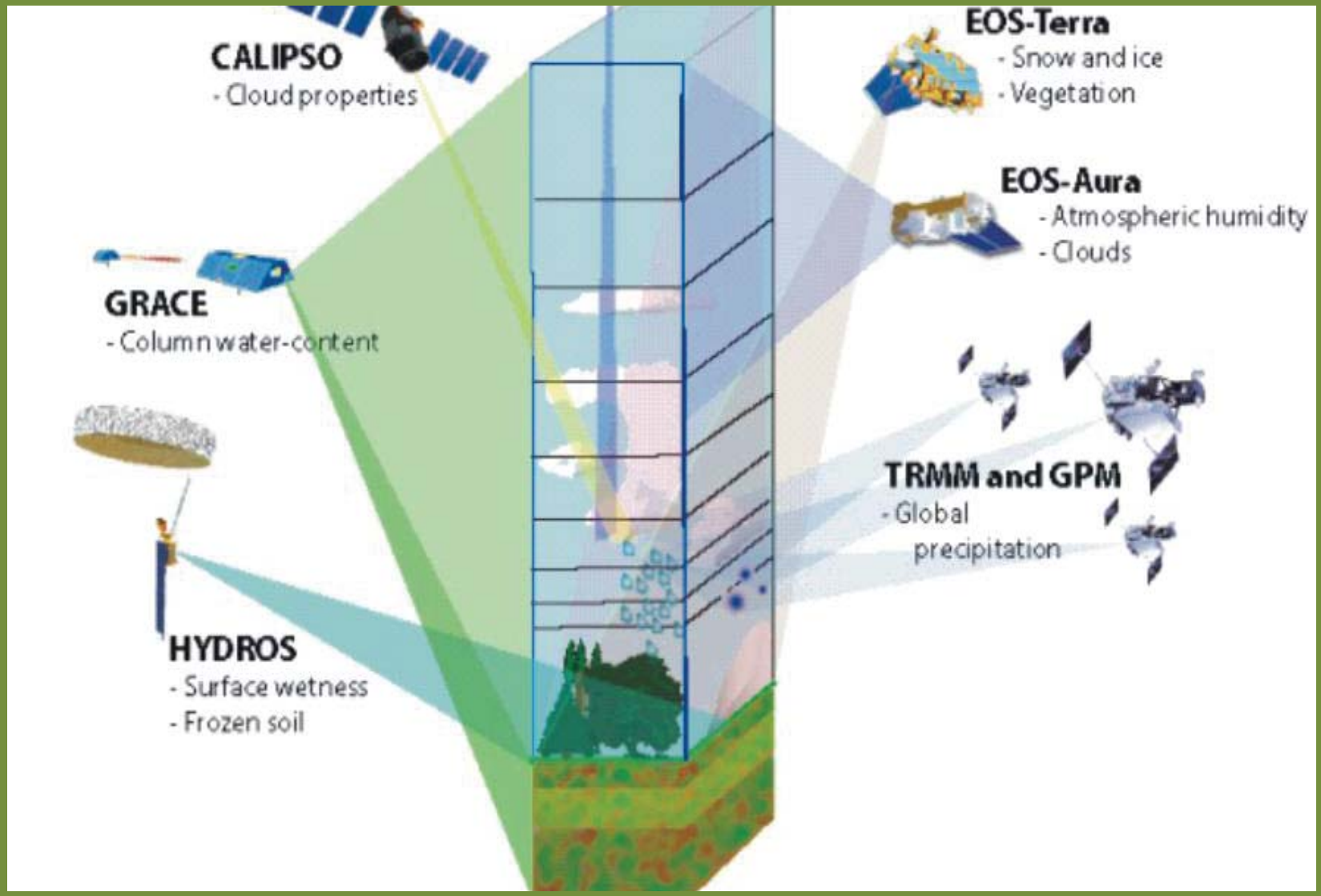
Near Real Time ***Rainfall Measurements***

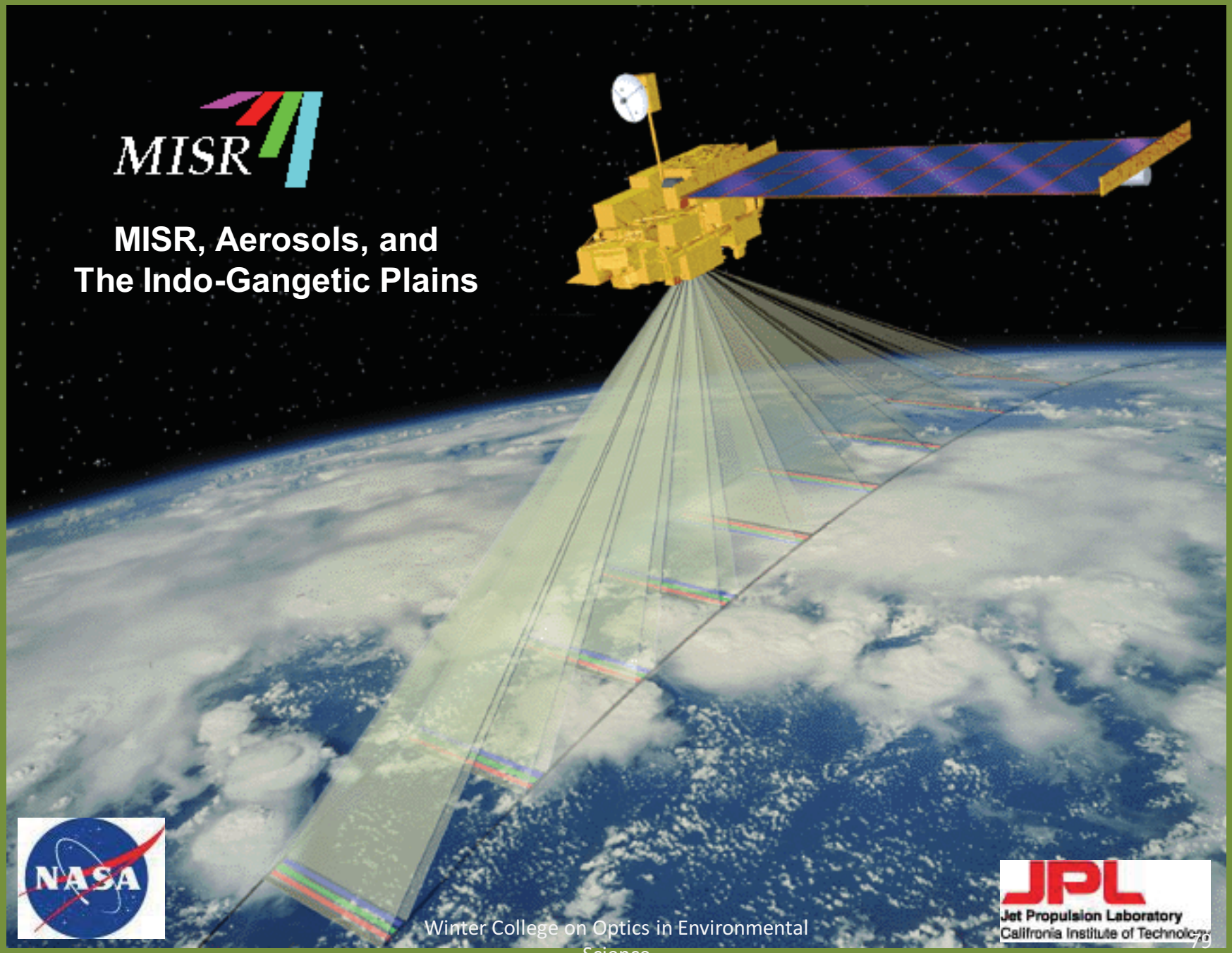


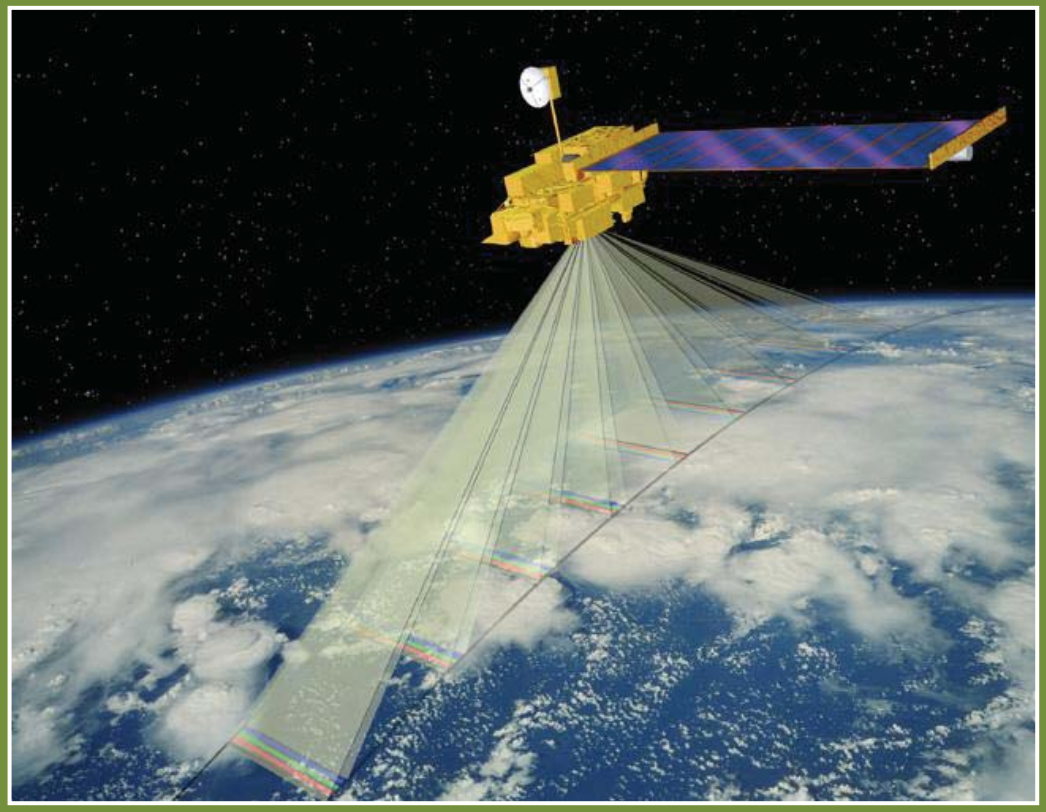


1. TRMM used to calibrated all other satellites
2. 25-km grid precipitation, every 3 hours, 1998-present,
3. http://trmm.gsfc.nasa.gov

In search of water using Multi-sensors




MISR
MISR, Aerosols, and
The Indo-Gangetic Plains
NASA
JPL
Jet Propulsion Laboratory
California Institute of Technology



Nine view angles at Earth surface: 70.5º forward to 70.5º aft

Four spectral bands at each angle: 446, 558, 672, 866 nm

Seven minutes to observe each scene at all 9 angles

400-km swath

Global coverage about once per week

275 m - 1.1 km spatial sampling

Air mass factors from 1 (nadir) to 3

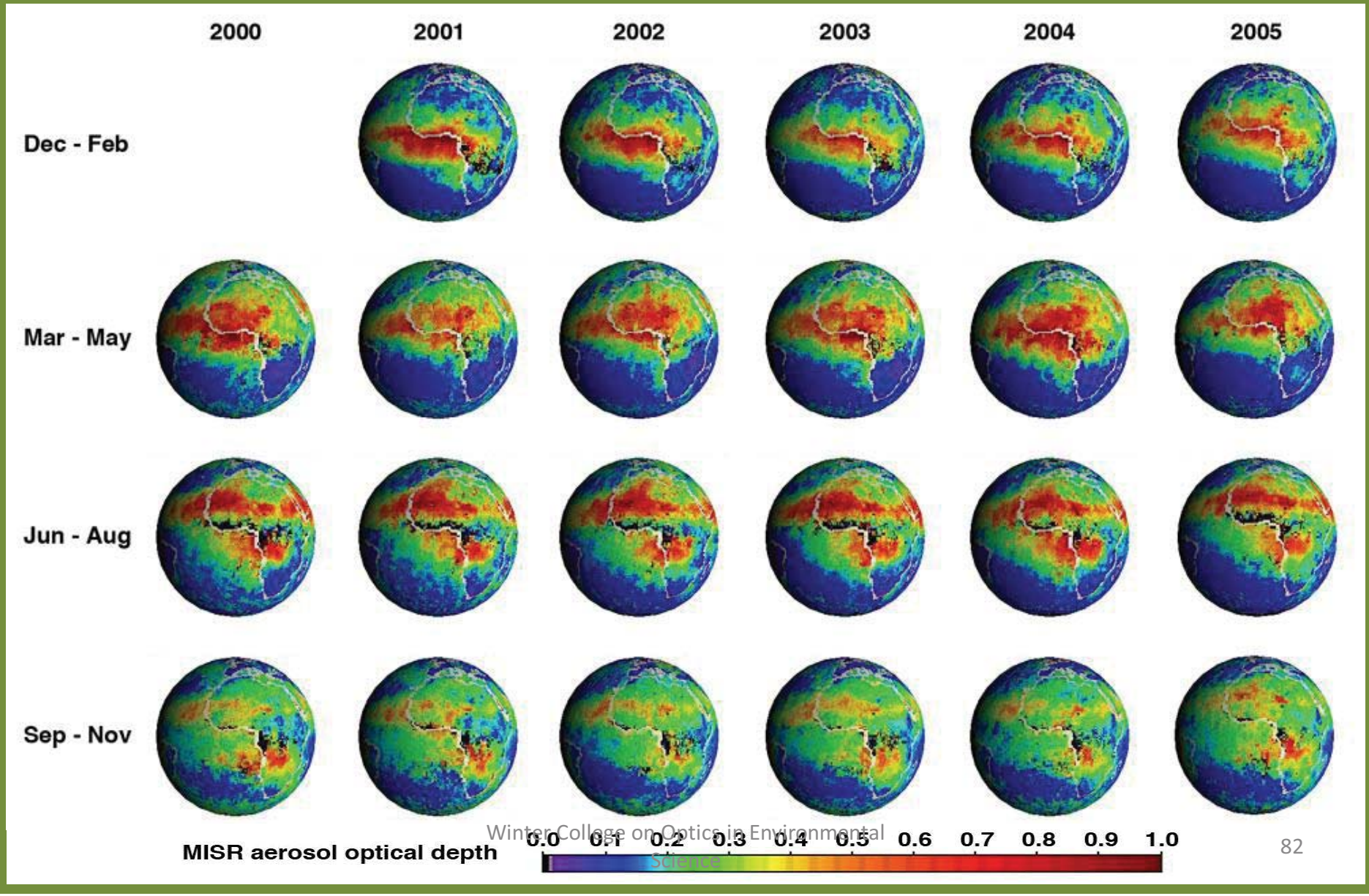
Scattering angles from ~60˚ to ~160˚ in mid-latitudes

MISR MULTI-ANGLE AEROSOL RETRIEVAL STRENGTHS -

- Ability to retrieve Aerosol Optical Thickness (AOT) over Land
- Ability to retrieve AOT over Very Bright Surfaces (e.g., Desert)
- Ability to retrieve AOT for Optically Thin hazes over land and water
- Ability to retrieve Particle Sphericity at least over dark water
- Ability to retrieve Three-to-Five Size Groupings at least over dark water
- Crude Sensitivity to Single-Scattering Albedo [~ 1.0 vs. 0.88 vs. 0.80 over dark water]
- Ability to retrieve Bi- and even Tri-modal Distributions in some cases
- Ability to retrieve Plume Height; mainly useful in Aerosol Source Regions

Six Years of MISR Global Aerosol Products

Mid-vis AOT: • Land & Water • Bright Surfaces • Globe ~ weekly • ~ 10:30 AM + particle size, shape



MODerate-resolution Imaging Spectroradiometer [MODIS]

- NASA, Terra & Aqua
  - launched 1999, 2001
  - 705 km polar orbits, descending (10:30 a.m.) & ascending (1:30 p.m.)
- Sensor Characteristics
  - 36 spectral bands ranging from 0.41 to 14.385 μm
  - cross-track scan mirror with 2330 km swath width
  - Spatial resolutions:
    - 250 m (bands 1 - 2)
    - 500 m (bands 3 - 7)
    - 1000 m (bands 8 - 36)
  - 2% reflectance calibration accuracy
  - onboard solar diffuser & solar diffuser stability monitor

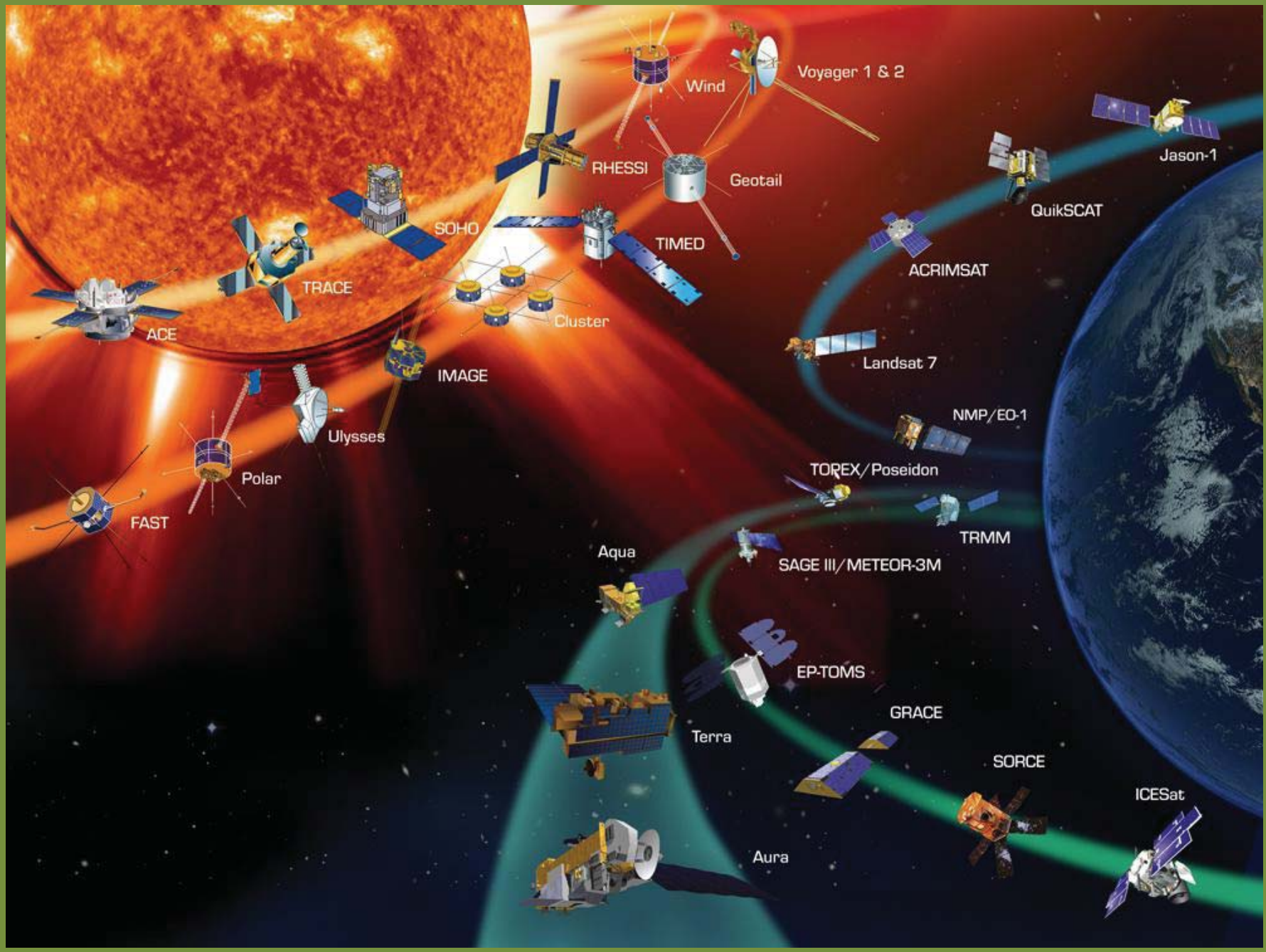
Improved over AVHRR:
- Calibration
- Spatial Resolution
- Spectral Range & # Bands

Source: MODIS Team, NASA/GSFC

Japan's GOSAT heads for the heavens.

Greenhouse-gas satellite heads into orbit

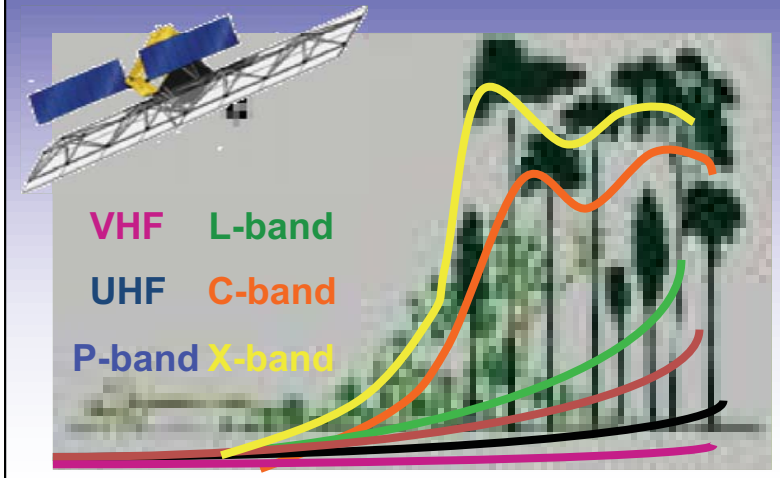
Japan successfully launched its Greenhouse
Gases Observing Satellite (GOSAT) on
23 January, to monitor levels of methane,
water vapor, ozone and carbon dioxide.


Voyager 1 & 2
Wind
RHESSI
Geotail
Jason-1
QuikSCAT
SOHO
TIMED
ACRIMSAT
TRACE
Cluster
ACE
IMAGE
Landsat 7
NMP/EO-1
Ulysses
TOPEX/Poseidon
Polar
TRMM
FAST
SAGE III/METEOR-3M
Aqua
EP-TOMS
GRACE
Terra
SORCE
ICESat
Aura

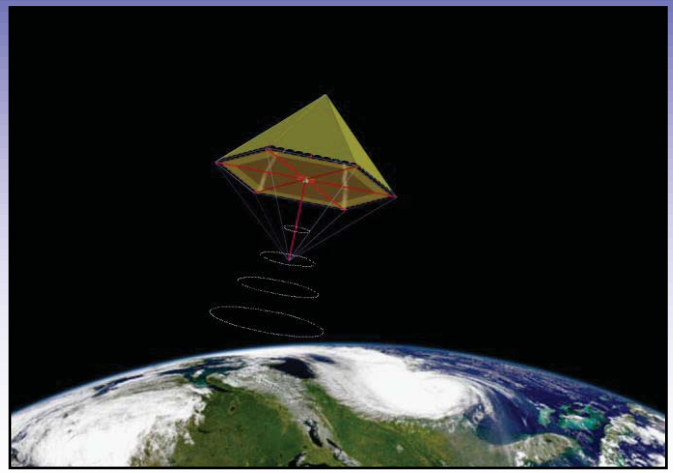
Tuesday January 22, 2002 Mount Nyiragongo erupts: The lava cut off routes into Goma and divided the town in two, complicating the aid effort to 350,000 people

Restless Planet Initiative: Geodetic Imaging Development

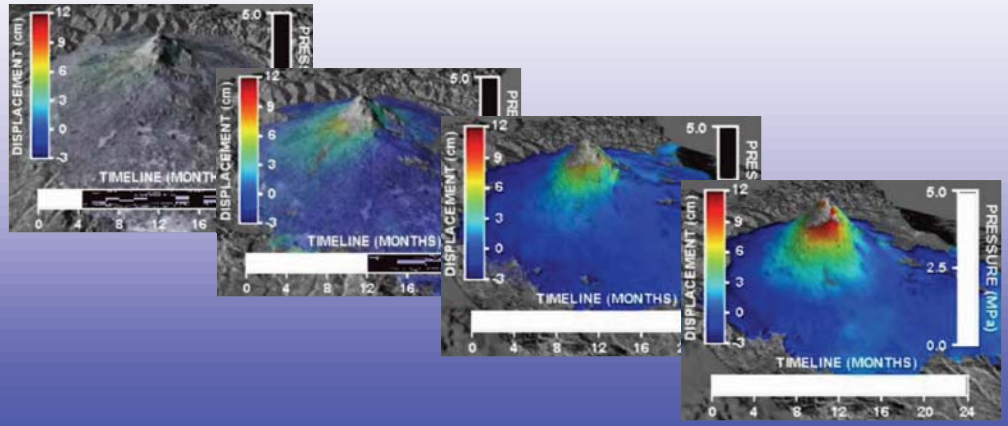
Build the InSAR we need today



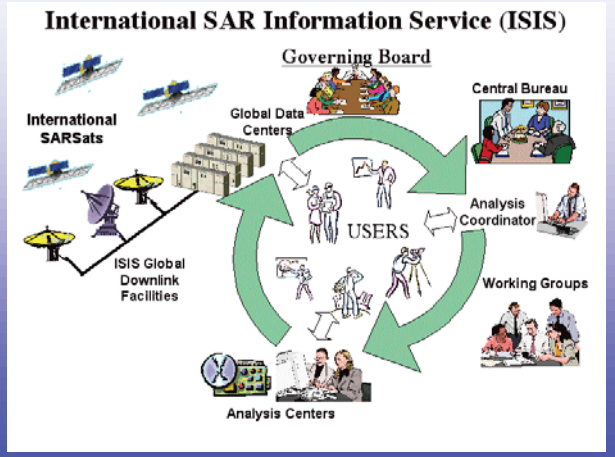
Develop the technology for tomorrow



Accelerate development of data handling and modeling capacity



Enable an international collaboration on civilian SAR data and applications



Restless Planet Initiative:The Development of Geodetic Imaging:InSAR

3-D Displacement Accuracy (mm)

0.1
5
10
20
50

GeoSynchronous InSAR

2025

- Continuous observations
- Understanding earthquake physics and prediction
- Precise hazard maps continuously updated

UAVSAR

Technology & Modeling

2008

- **Repeat pass InSAR - EarthScope and A-PANL**
- **Advanced concept testbed**

Low Earth Orbit- (DESDynI) InSAR

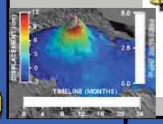
2010-13

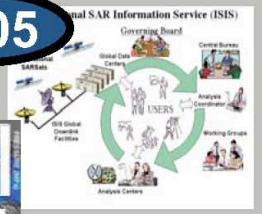
- Systematic data acquisition
- Modeling of faults in crust/mantle system
- Fine resolution hazard maps

Int'l SAR Constellation GEOSS

Foreign Satellites/National Partnerships

2005

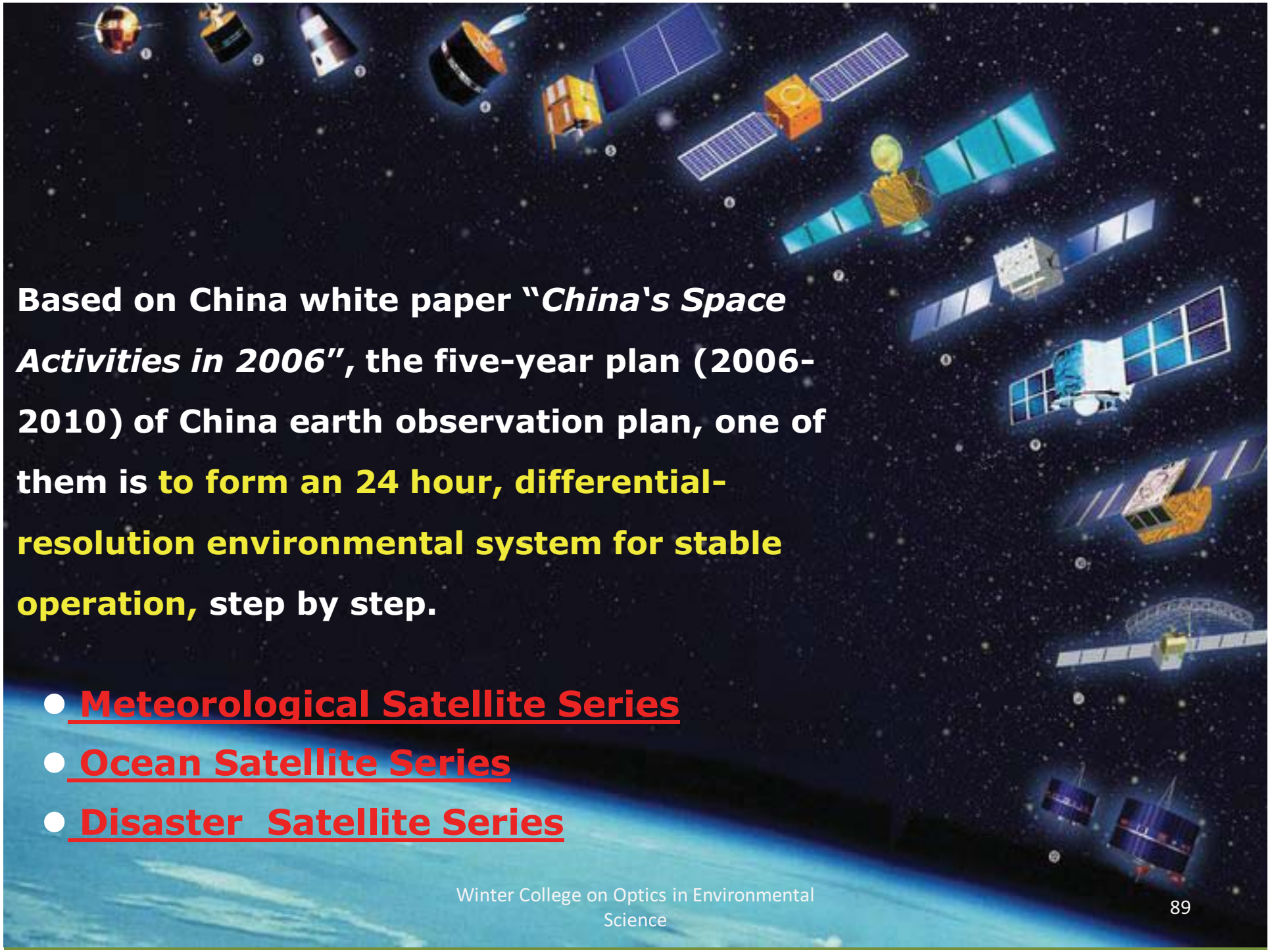




- Community Based Data System-WinSAR/ISIS AADN/ASF//CSTARS
- Geohazards Natural Laboratories
- Modeling-Project Columbia
- National/ International Partnerships-GEO/ GMES/ IGOS

100 10 1 0.1 0.01

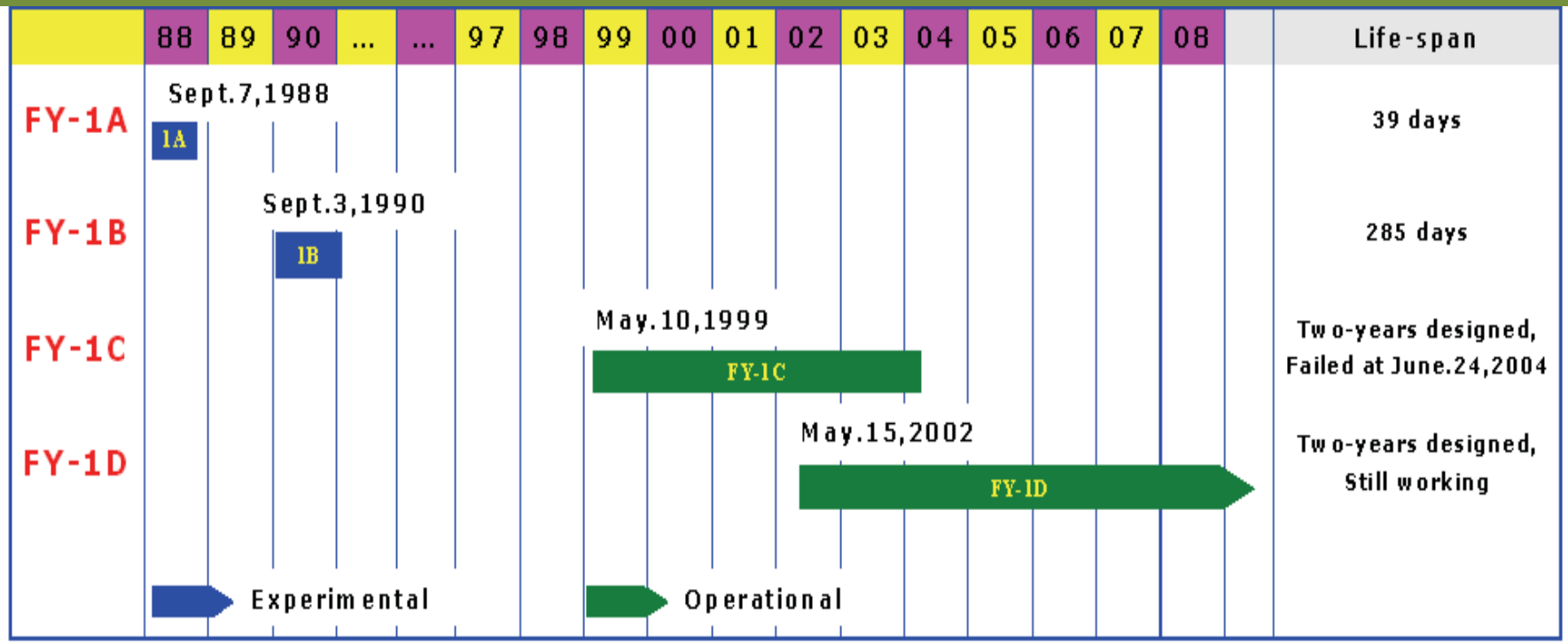
Revisit Frequency (days)



Based on China white paper "*China's Space Activities in 2006*", the five-year plan (2006-2010) of China earth observation plan, one of them is to form an 24 hour, differential-resolution environmental system for stable operation, step by step.

- Meteorological Satellite Series
- Ocean Satellite Series
- Disaster Satellite Series

FY-1 series—China's 1st Generation of Polar Orbit Meteorological Satellites

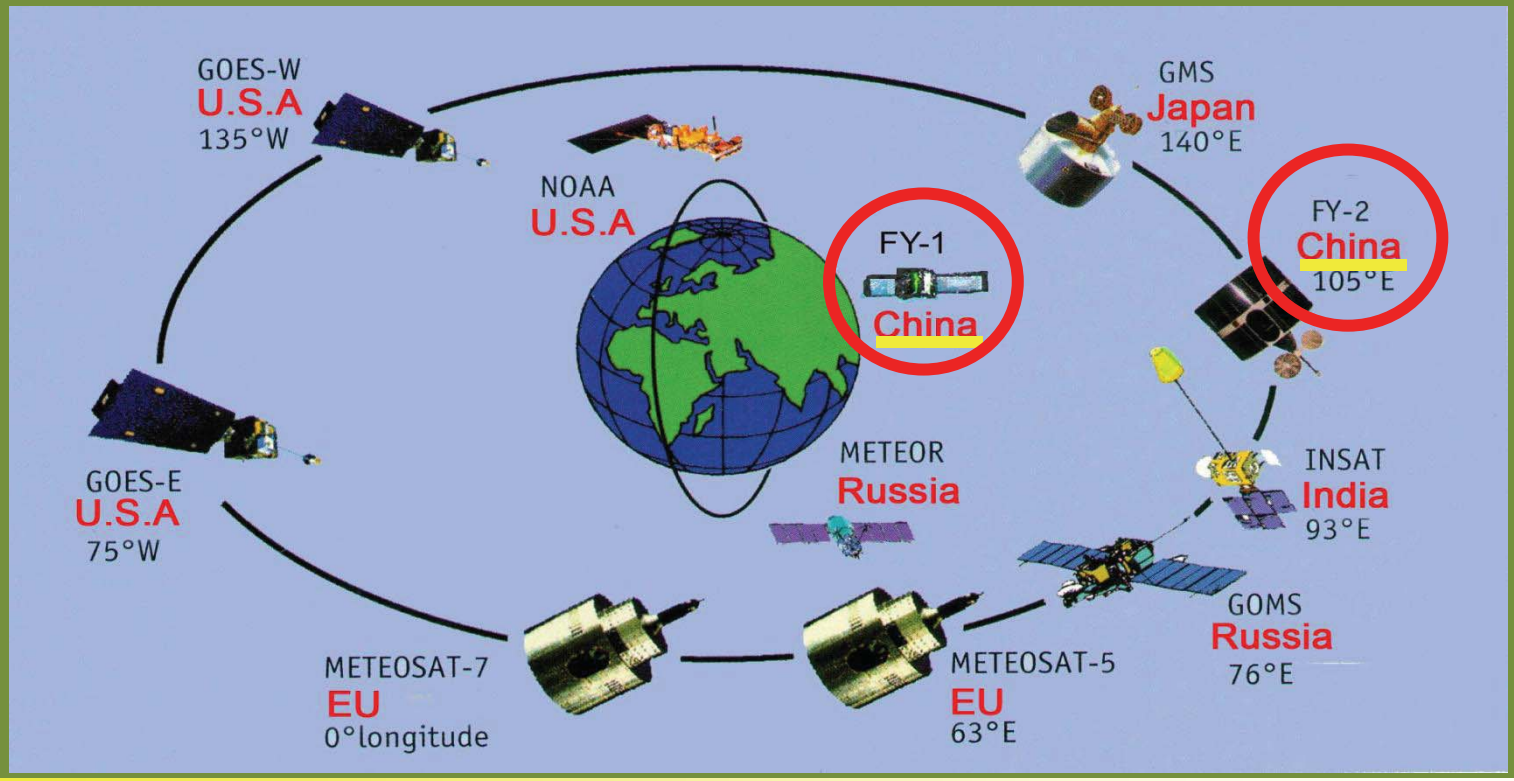


FY-1A, FY-1B with 5 Channel Visible and Infrared Radiometers.

FY-1C, FY-1D with 10 Channel Visible and Infrared Radiometers.

World Meteorological Organization

International Operational Meteorological Satellite Net



At present, the FY-1D, FY-2 C / D and FY-3A satellites are in-orbiting operationally. WMO has accepted the FY-1, FY-2 and Fy-3 into the international operational meteorological satellite net. And China is one of the few countries who has the polar and geostationary satellites series at the same time.

REMOTE SENSING SERIES

IRS-1C (1995) LISS-3 (23/70M,
STEERABLE PAN (5.8 M);
WiFS (188M)

IRS-1D (1997) LISS-3 (23/70M,
STEERABLE PAN (5.8 M);
WiFS (188M)

RESOURCESAT-1 (2003)
LISS3 - 23 M; 4 XS
LISS4 - 5.8 M; 3-XS
AWIFS - 70 M; 4-XS

IRS-P2 (1994)
LISS-2

IRS-P3 (1996)
WiFS MOS
X-Ray,

IRS-P4 (1999)
OCEANSAT OCM, MSMR

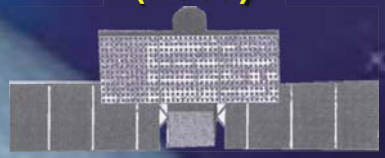
CARTOSAT – 1 (2004)
PAN - 2.5M, 30 KM,
F/A

IRS-1A & 1B (1988 & 91) LISS-1&2 (72/36M,
4 BANDS; VIS & NIR)

TES (2001)

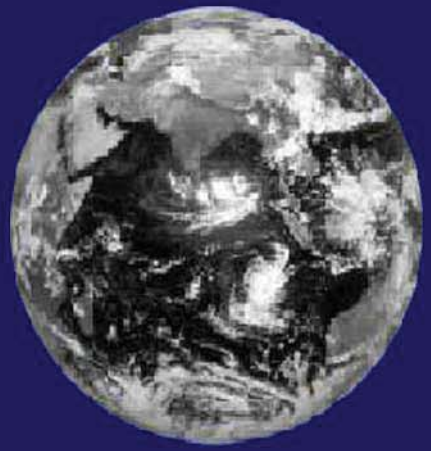
CARTOSAT-2 (2005)
PAN - 1M

MEGHA-TROPIQUES
(2007)

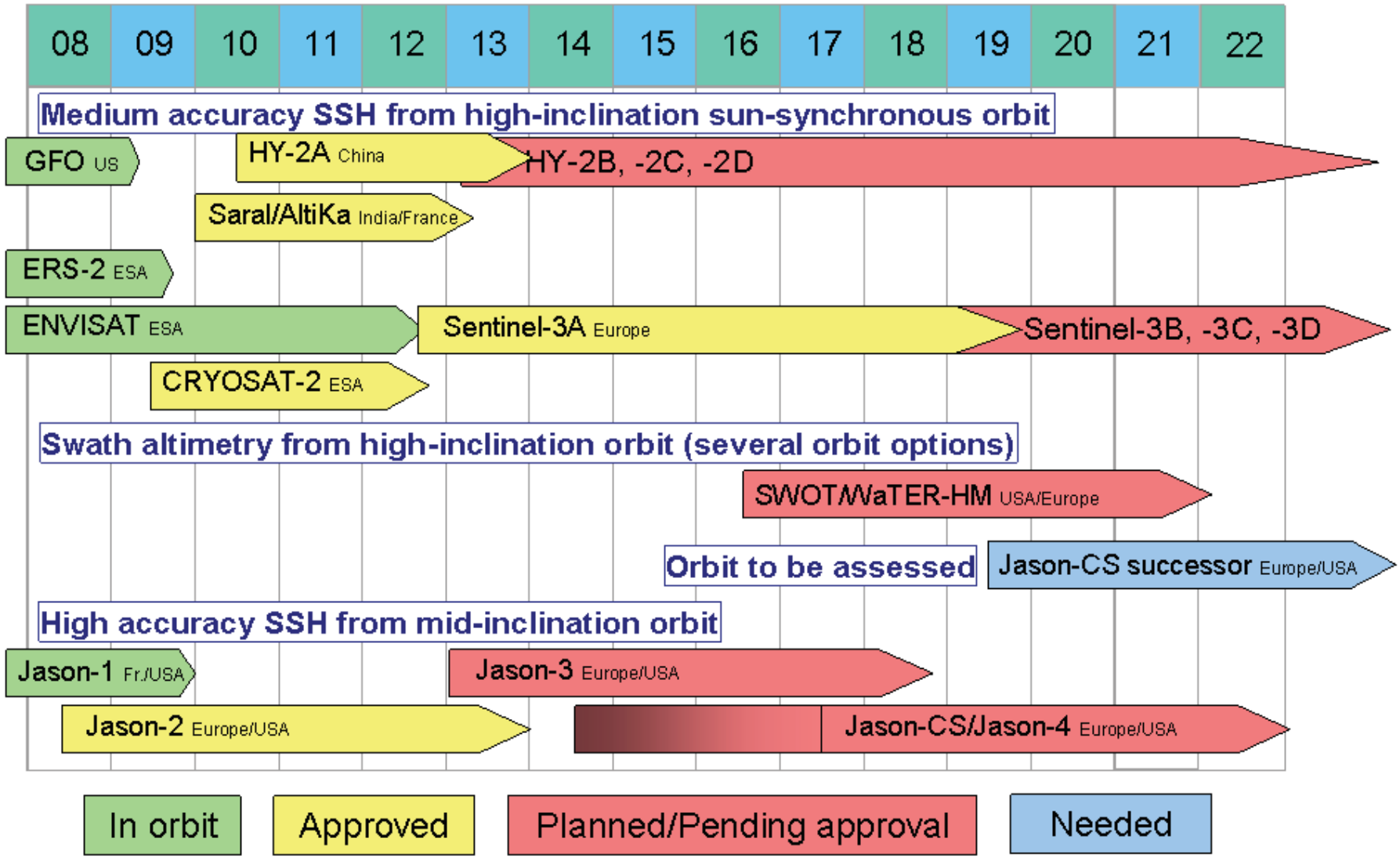


RISAT SAR (2007)

INDIAN IMAGING CAPABILITY

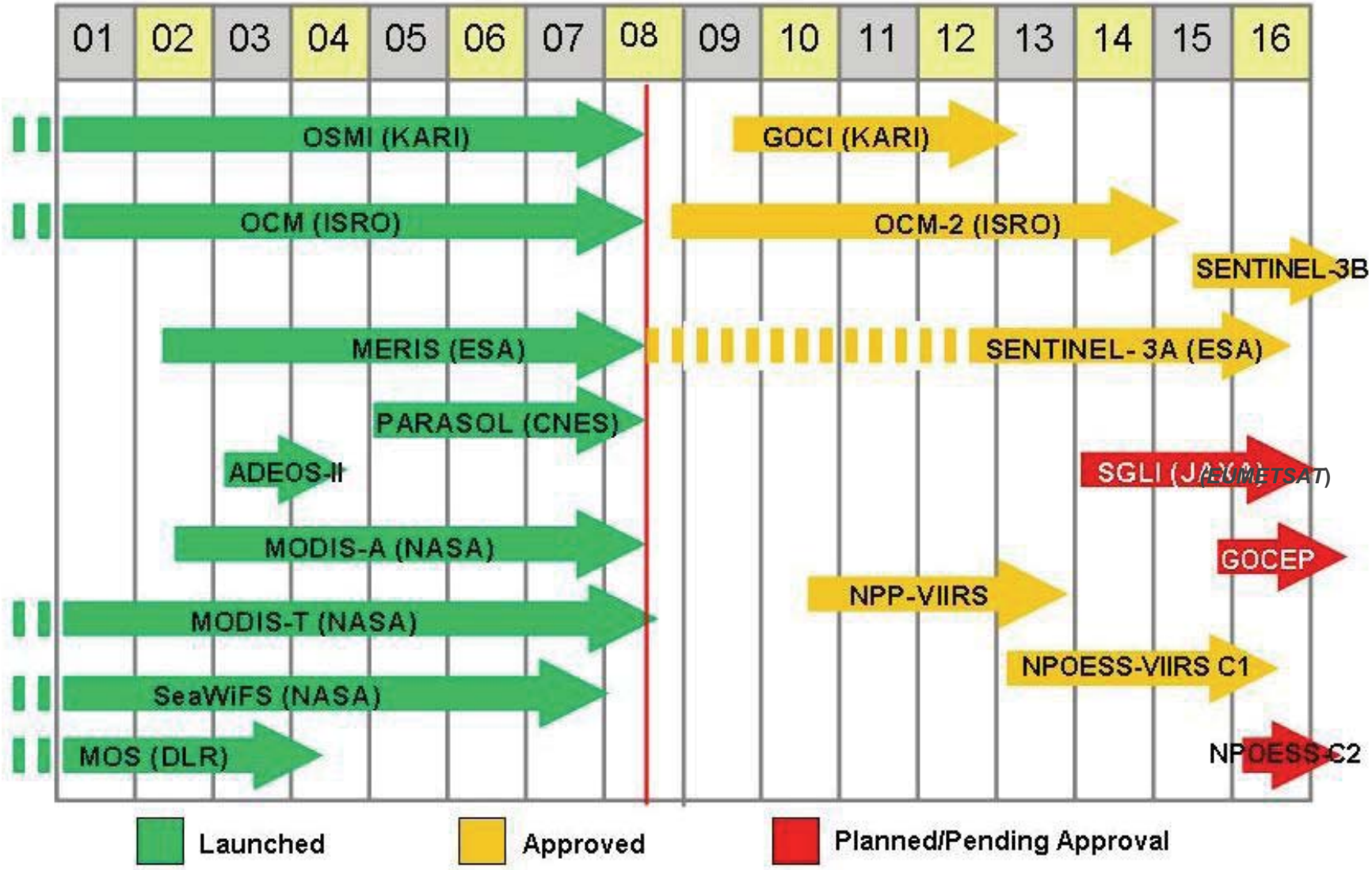


Ocean Surface Topography Constellation Roadmap



From OST Strategic Planning Workshop, Assmannshausen, 29-31 Jan 2008

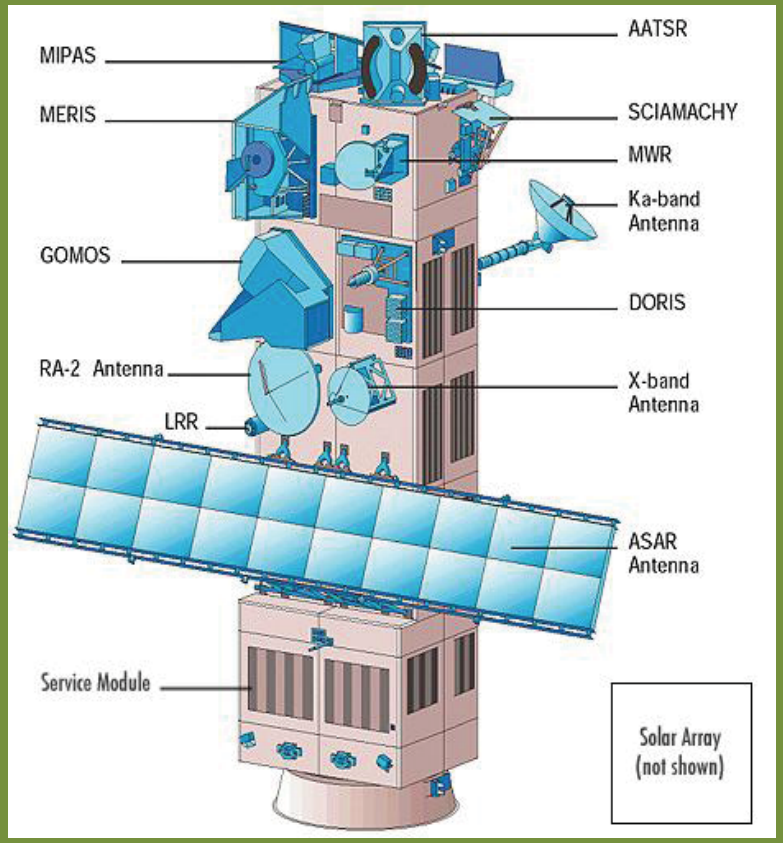
Ocean Color Missions



ENVISAT

ESA Envisat:

- **Mission objective: to make a significant contribution to environmental studies, notably in the area of atmospheric chemistry and ocean studies**
- **Launch: 2002**
- **5 year mission**
- **Extension to 2014**

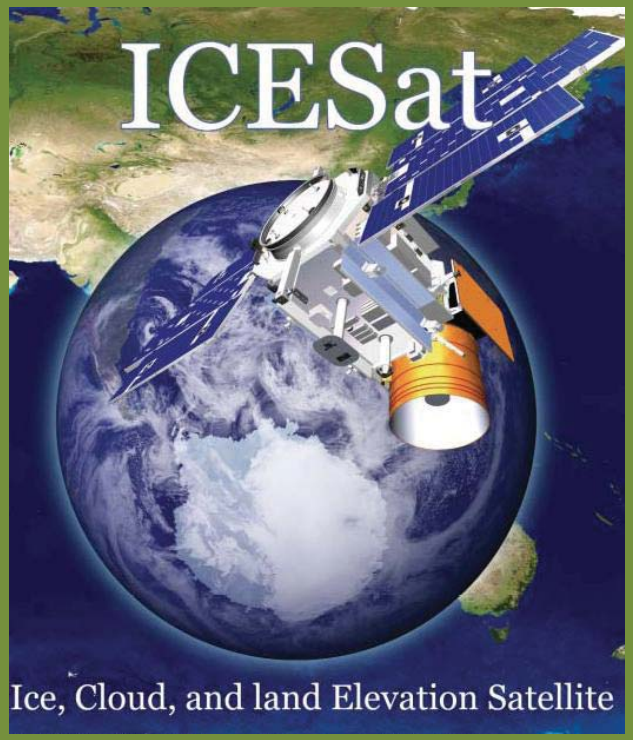


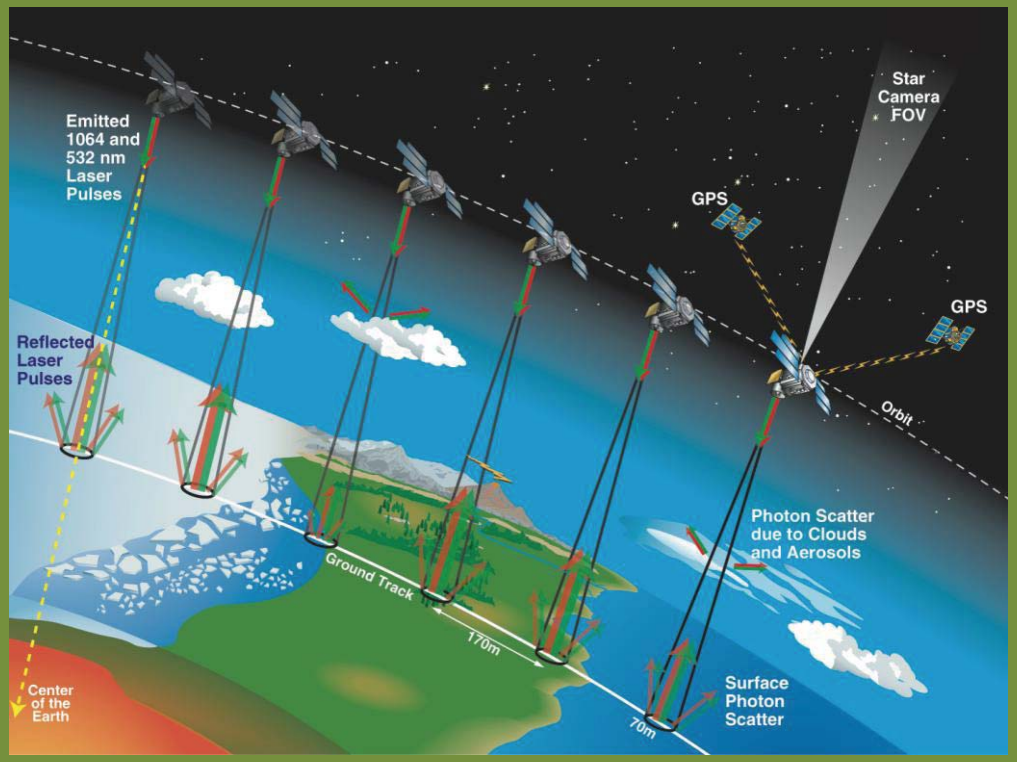
Band	Wavelength (μm)	Bandwidth (nm)	Resolution (m)	Swath Width (km)	Revisit time (days)
Band 1 (VIS)	0.4125	10	300 (1200)	1150 (575)	3
Band 2 (VIS)	0.4425	10	300 (1200)	1150 (575)	3
Band 3 (VIS)	0.49	10	300 (1200)	1150 (575)	3
Band 4 (VIS)	0.51	10	300 (1200)	1150 (575)	3
Band 5 (VIS)	0.56	10	300 (1200)	1150 (575)	3
Band 6 (VIS)	0.62	10	300 (1200)	1150 (575)	3
Band 7 (VIS)	0.665	10	300 (1200)	1150 (575)	3
Band 8 (VIS)	0.68125	7.5	300 (1200)	1150 (575)	3
Band 9 (VIS)	0.705	10	300 (1200)	1150 (575)	3
Band 10 (VIS)	0.75375	7.5	300 (1200)	1150 (575)	3
Band 11 (VIS)	0.76	2.5	300 (1200)	1150 (575)	3
Band 12 (VIS)	0.775	15	300 (1200)	1150 (575)	3
Band 13 (NIR)	0.865	20	300 (1200)	1150 (575)	3
Band 14 (NIR)	0.89	10	300 (1200)	1150 (575)	3
Band 15 (NIR)	0.9	10	300 (1200)	1150 (575)	3

Geoscience Laser Altimeter System (GLAS)

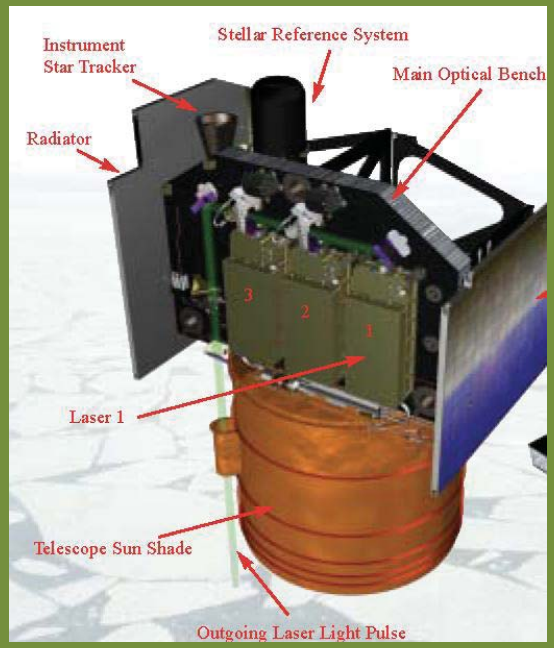
Launched onboard ICESat in 2003 as part of NASA's Earth Observing System (EOS).

The *main objective* of the GLAS instrument is to measure ice sheet elevations and changes in elevation through time. *Secondary objectives* include measurement of cloud and aerosol height profiles, land elevation, **vegetation cover**, and sea ice thickness.





Geoscience Laser Altimeter System (GLAS)



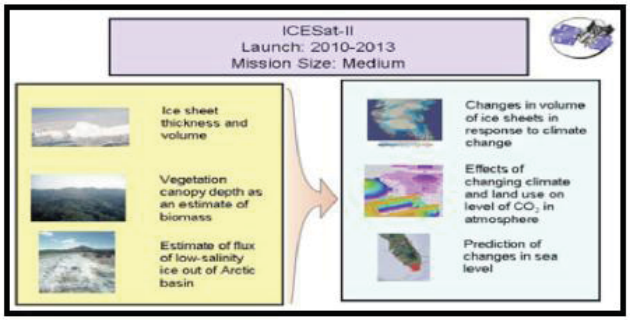
Laser campaign	Year	Season	Start Date	End Date	Repeat Orbit (days)	Footprint major axis (m)
L3a	2004	Fall	3-Oct	8-Nov	91	55
L3b	2005	Winter	17-Feb	24-Mar	91	55*
L3c	2005	Spring	20-May	23-Jun	91	55
L3d	2005	Fall	21-Oct	24-Nov	91	52
L3e	2006	Winter	22-Feb	28-Mar	91	52
L3f	2006	Spring	24-May	26-Jun	91	51

Technical characteristics

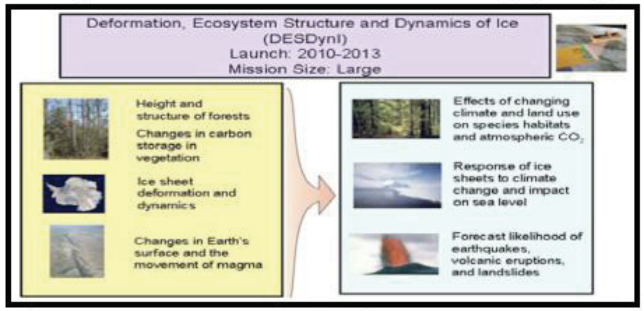
- Status: launched Jan. 2003
- Platform: space-borne
- Wavelength: 1064 nm (vegetation)
- Pulse frequency: 40 Hz
- Pulse width: 5 ns
- Pulse form: Gaussian
- Footprint diameter: 60-70 m
- Transmit energy: 5 mJ
- Along-track separation: 170 m
- Cross-track max: 15 km
- Cross-track min: 2.5 km
- Repeat cycle: 183 days
- Life-time: 3 years

Nasa future Lidar missions

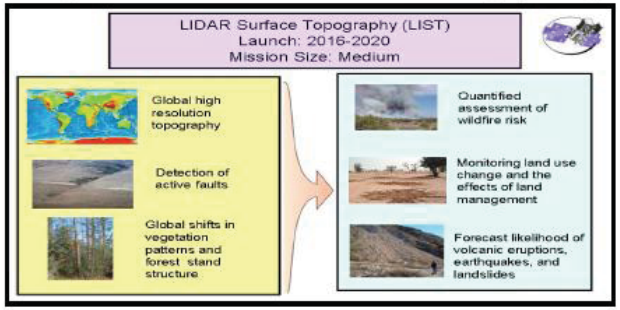
ICESat-II
Profiling Lidar for
Ice Sheet Mass Balance, Sea Ice &
Vegetation Structure Sampling



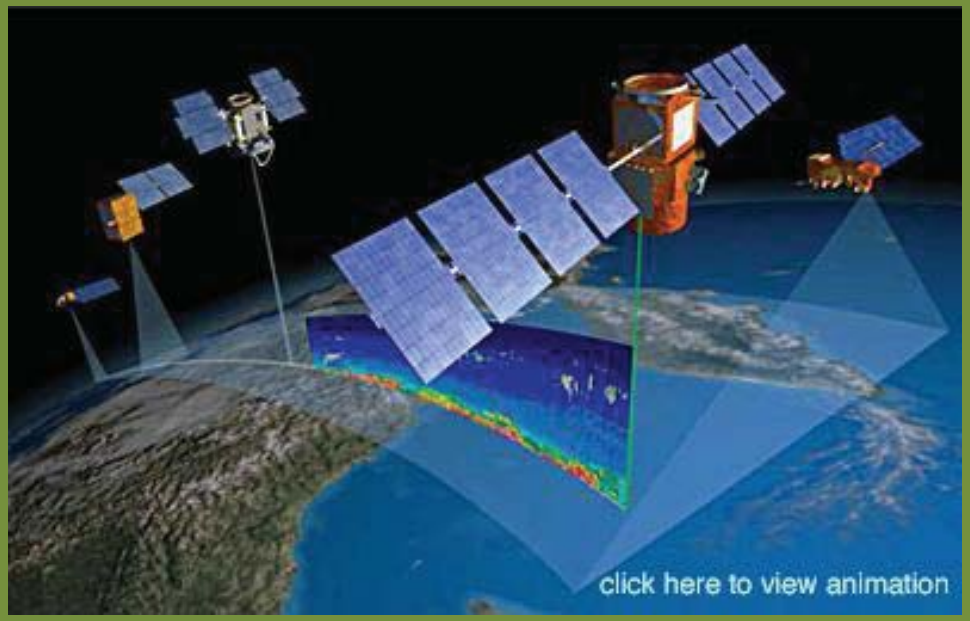
DESDynI
Multi-beam Lidar
& L-band Polarimetric InSAR
for Surface Deformation &
Vegetation Structure Mapping

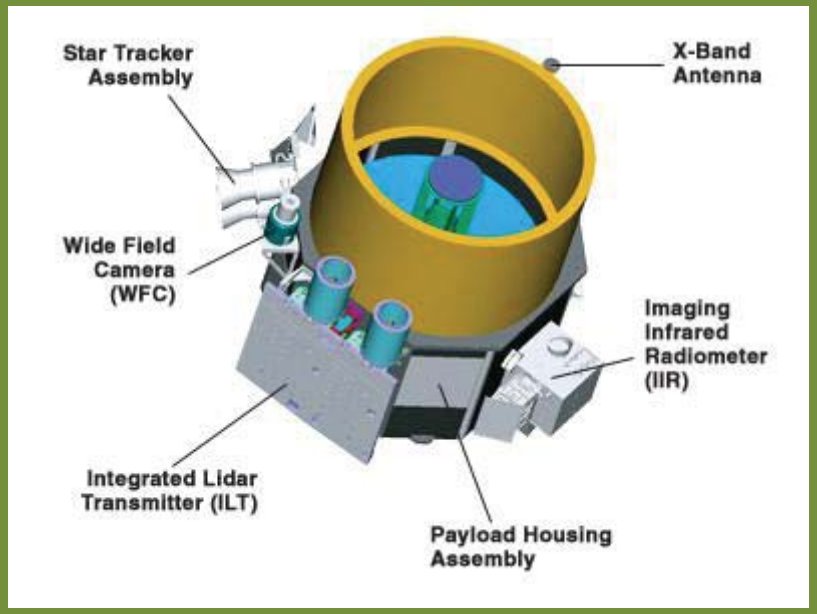


LIST
Swath Imaging Lidar for
High-Resolution Topography &
Vegetation Structure Mapping



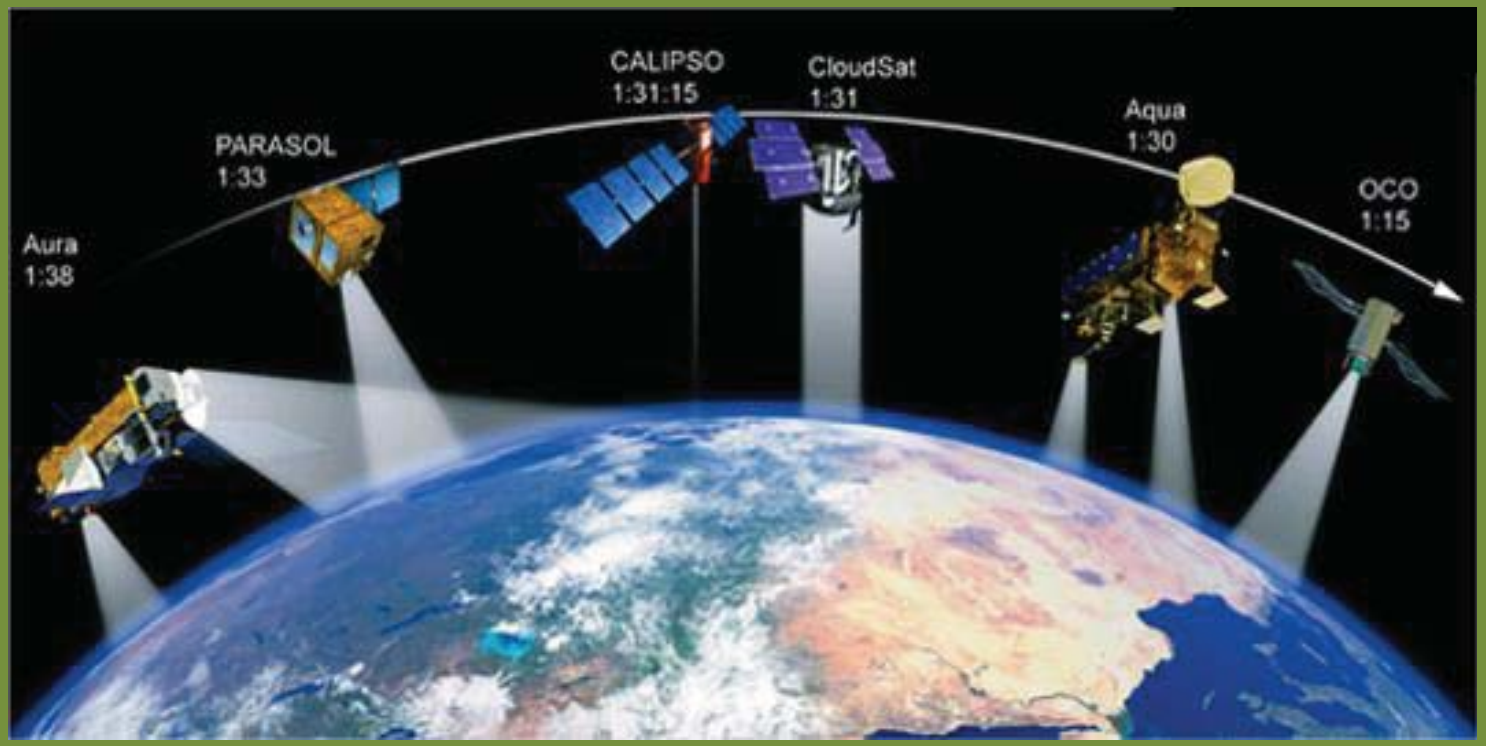
2010 **2014** **2018** **2022**





CALIPSO

http://www-calipso.larc.nasa.gov/about/constellation.html



CALIPSO flies as part of the Aqua satellite constellation (or A-Train), which consists of the Aqua, CloudSat, CALIPSO, PARASOL, and Aura satellite missions. The constellation has a nominal orbital altitude of 705 km


International Charter
Space and Major Disasters
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About The Charter
Following the UNISPACE III conference held in Vienna, Austria in July 1999, the European and French space agencies (ESA and CNES) initiated the International Charter "Space and Major Disasters", with the Canadian Space Agency (CSA) signing the Charter on 20 October 2000.
The following agencies subsequently joined the Charter as members:
September 2001
National Oceanic and Atmospheric Administration (NOAA) and Indian Space Research Organization (ISRO)
July 2003
Argentine Space Agency (CONAE)
February 2005
Japan Aerospace Exploration Agency (JAXA)
2005
United States Geological Survey (USGS) as part of the U.S. team
November 2005
BNSC/DMCii
May 2007
China National Space Administration (CNSA).
The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorized Users. Each member agency has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property.
The International Charter was declared formally operational on November 1, 2000.