Remote Sensing Data Products: Uses and Availability

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Topics

- Earth exploration-satellite service
- Missions
- Sensing Allocations
- Data Products and Uses
- Data and Training Resources

Earth exploration-satellite service (EESS)

1.51 ***Earth exploration-satellite service:*** A radiocommunication service between earth stations and one or more space stations, which may include links between space stations, in which:

– information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment, is obtained from *active sensors or passive sensors on Earth satellites;*

– similar information is collected from airborne or Earth-based platforms;

– such information may be distributed to earth stations within the system concerned;

– platform interrogation may be included.

This service may also include *feeder links necessary for its operation.*

- Station Class: EW

Types of Orbits

- Geosynchronous – spacecraft (S/C) follow figure 8's in the sky.
- Geostationary – S/C stay in one place in the sky.
- Polar
  - S/C travel mostly North and South.
  - The Earth rotates under them, and
  - S/C eventually “see” the entire earth's surface.
- Sun-synchronous – Sun-Earth-S/C orbit plane angle is constant (same shadows, more-or-less).
- Equatorial
  - S/C travel mostly Eastward.
  - The Earth wobbles underneath, but
  - S/C don't “see” the poles or high latitudes.

NASA EESS Missions

- ACRIMSAT (1999)
- AIM (2007)
- AQUARIUS on SAC-D (2011)
- AURA (2004)
- CALIPSO (filed by F) (2006)
- EO-1 (2000)
- EOS-AM (a.k.a. Terra) (1999)
- EOS-PM (a.k.a. Aqua) (2002)
- FAST (1996)
- *FIREFLY (2012)*
- *GPM (2013)*
- GRACE (filed by D) (2002)
- ICESAT (2003)
- LANDSAT (1982+)
- *MMS (2015)*
- *OCO-2 (2013)*
- QUIKSCAT (1999)
- SDO (2010)
- *SMAP (2015)*
- SORCE (2003)
- STEREO (2006)
- TIMED (1997)
- TRMM (1997)
- WIND (1994)

Administrations with Notified EESS Satellites

- ALGERIA
- ARGENTINA
- AUSTRALIA
- BELARUS
- CANADA
- CHILE
- CHINA
- EGYPT
- FRANCE (including ESA)
- GERMANY
- INDIA
- INDONESIA
- ISRAEL
- ITALY
- JAPAN
- KOREA
- LIBYA
- LUXEMBOURG
- MALAYSIA
- MEXICO
- MOROCCO
- OMAN
- RUSSIA
- SAUDI ARABIA
- SINGAPORE
- SOUTH AFRICA
- SPAIN
- THAILAND
- TURKEY
- UAE
- UK
- UKRAINE
- USA
- VIETNAM

Types of Sensing - Active

1.182 ***active sensor:*** A measuring instrument in the *earth exploration-satellite service* or in the *space research service* by means of which information is obtained by transmission and reception of radio waves. (RR)

- Active sensing (echoes)
  - Visible/Infrared : LIDAR
  - Microwave : 400 MHz to 94 GHz
  - Synthetic Aperture Radar (SAR) : uses Doppler shift along track and a one-dimensional antenna cross-track; mathematically reconstructs (synthesizes) the “whole” antenna
- Station Class: E3

Types of Sensing - Passive

1.183 ***passive sensor:*** A measuring instrument in the *earth exploration-satellite service* or in the *space research service* by means of which information is obtained by reception of radio waves of natural origin.

- Passive sensing (just listen)
  - Visible/Infrared : Imagers, cameras, spectrometers
  - Microwave : 1 000 MHz to 2 500 000 MHz
- Station Class: E4

Allocations for Emissions[1]

Frequency Band	Radio Service
401-403 MHz	EESS (E-s)
460-470 MHz	[eess (s-E)]
1525-1535 MHz	eess
1690-1710 MHz	[eess (s-E)]
2025-2110 MHz	EESS (E-s) (s-s)
2200-2290 MHz	EESS (s-E) (s-s)
8025-8400 MHz	EESS (s-E)
13.75-14 GHz	eess
25.5-27 GHz	EESS (s-E)
28.5-30 GHz	eess (E-s)
29.95-30 GHz	eess (E-s)(s-s)
37.5-40 GHz	eess (s-E)
40-40.5 GHz	EESS (E-s) / eess (s-E)
65-66 GHz	EESS

Frequency Band	Radio Service
432-438 MHz	eess (active)
1215-1300 MHz	EESS (active)
3100-3300 MHz	eess (active)
5250-5570 MHz	EESS (active)
8550-8650 MHz	EESS (active)
9300-9800 MHz	EESS (active)
9800-9900 MHz	eess (active)
13.25-13.75 GHz	EESS (active)
17.2-17.3 GHz	EESS (active)
24.05-24.25 GHz	eess (active)
35.5-36 GHz	EESS (active)
78-79 GHz	[EESS (active)]
94-94.1 GHz	EESS (active)
130-134 GHz	EESS (active)

[1] CAPITAL LETTERS: Primary Allocation
lower case letters: Secondary Allocation
[Square Brackets]: Allocation by footnote

Allocations for Passive Sensing[2]

Frequency Band	Radio Service
1370-1400 MHz	[eess (passive)]
1400-1427 MHz	EESS (passive)
2640-2655 MHz	[eess (passive)]
2665-2690 MHz	eess (passive)
2690-2700 MHz	EESS (passive)
4200-4400 MHz	[eess (passive)]
4950-4990 MHz	[eess (passive)]
6425-7250 MHz	*[eess (passive)]*
10.6-10.7 GHz	EESS (passive)
14.8-15.35 GHz	[eess (passive)]
15.35-15.4 GHz	EESS (passive)
18.6-18.8 GHz (Rgn 1 & 3)	EESS (passive)
18.6-18.8 GHz (Rgn 2)	EESS (passive)
21.2-21.4 GHz	EESS (passive)
22.21-22.5 GHz	EESS (passive)
23.6-24 GHz	EESS (passive)

Frequency Band	Radio Service
31.3-31.8 GHz	EESS (passive)
36-37 GHz	EESS (passive)
50.2-50.4 GHz	EESS (passive)
52.6-59.3 GHz	EESS (passive)
86-92 GHz	EESS (passive)
100-102 GHz	EESS (passive)
109.5-122.25 GHz	EESS (passive)
148.5-151.5 GHz	EESS (passive)
155.5-158.5 GHz	EESS (passive)
164-167 GHz	EESS (passive)
174.8-191.8 GHz	EESS (passive)
200-209 GHz	EESS (passive)
226-231.5 GHz	EESS (passive)
235-238 GHz	EESS (passive) / [EESS (active)]
250-252 GHz	EESS (passive)
275-1000 GHz	*[eess (passive)]*

[2] *[Italics/square brackets]* : Not allocated but in use.

Optical Spectrum (above 3000 GHz)

- WRC-12 AI 1.6 (Res 955) "…to consider possible procedures for free-space optical-links, taking into account the results of ITU-R studies…"
- ITU-R Rec RS.1804, "Technical and operational characteristics of Earth exploration-satellite service (EESS) systems operating above 3 000 GHz"
- Regulation
  - CS 78 & CV 1005 Note 2: ITU-R Study Groups may conduct studies without limit of frequency range
  - Res 118 (Rev. Marrakesh, 2002): A WRC agenda "can include" issues related to optical spectrum
  - WRC-12 AI 1.6 (Res 955):

Examples of Data Products and Uses

Disaster Management

- Extreme Weather
- Floods
- Coastal Hazards / Tsunamis
- Volcanoes
- Earthquakes
- Landslides/Subsidence
- Droughts
- Dust Storms
- Wildfires

Long Term Management

- Climate Change
- Pollution Monitoring
- Plant Health
- Land Usage
- Population Density
- Deforestation
- Desertification

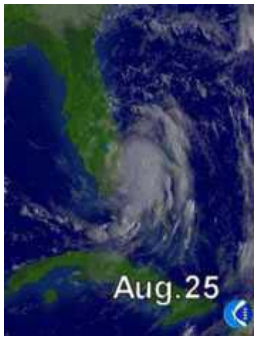
Extreme Weather

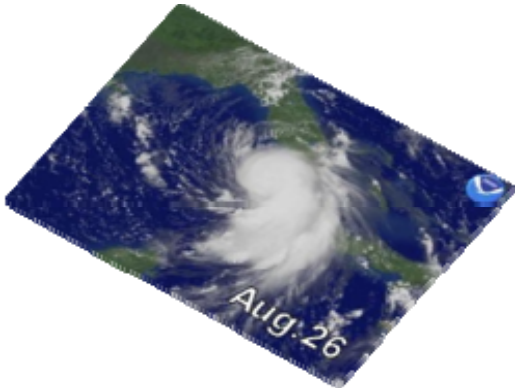
- Atmospheric temperature and water vapor profiles (input to forecasters)
- Sea surface winds, cloud cover (inputs)
- Rainfall and cloud profiles (input)
- Imagery (tracking storms and damage)

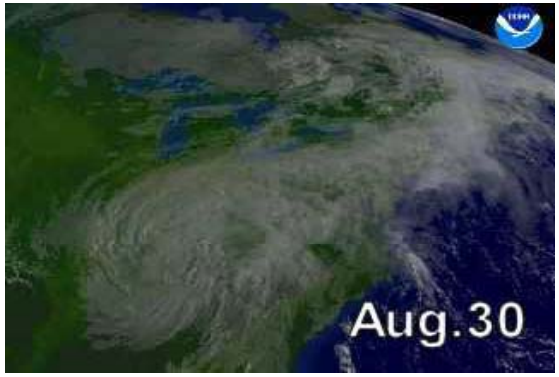
Passive: 10.6, 15.4, 18.7, 21.3, 22.3, 23.8, 31.4, 31.6, 36.5, 50-59, 89, 118, 149, 166, 175-191, 205 GHz

Active: 8.6, 9.6, 13.5, 17.2, 24.1, 35.5, 78, 94 GHz

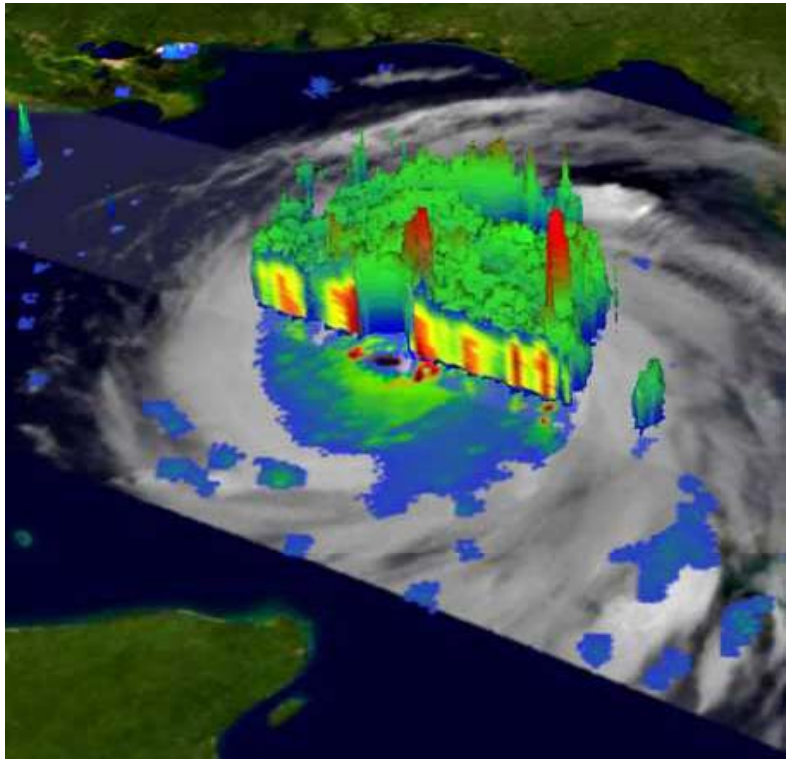
Extreme Weather



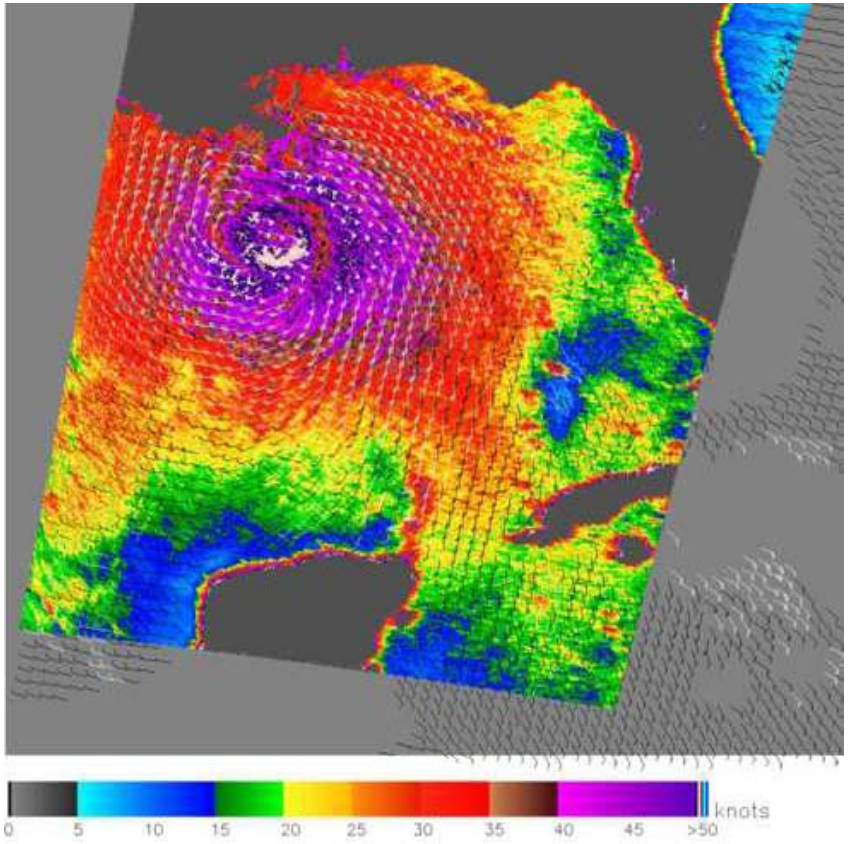




Extreme Weather



TRMM displayed the 3-D character of the hurricane's rainfall.



QuikSCAT produced wind speed and direction at the ocean surface.

Hurricane Katrina was Category-5 on August 28, 2005

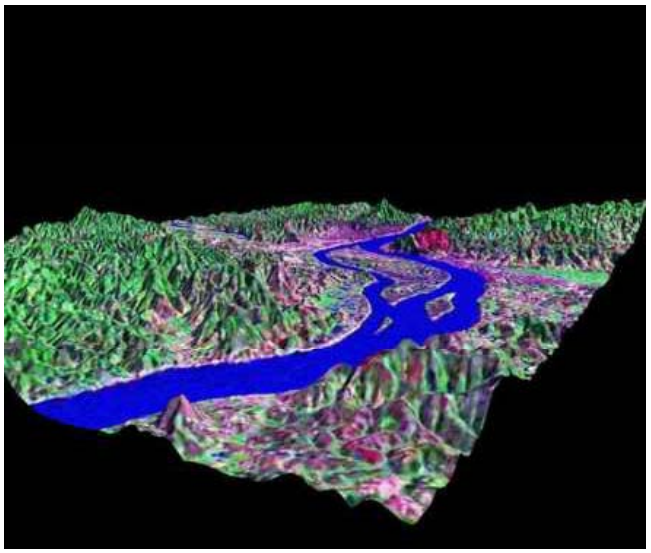
Floods

- SAR-generated Digital Elevation Models, or DEMs (risk areas)
- Weather forecasts (warnings)
- Areal precipitation, water equivalent from snowfall, stream flow, soil moisture (risk)
- Imagery (assess impact, track recovery)

Passive: 1.4, 2.7, 10.6, 15.4, 18.7, 21.3, 22.3, 23.8, 31.4, 31.6, 36.5, 50-59, 89, 118, 149, 166, 175-191, 205 GHz

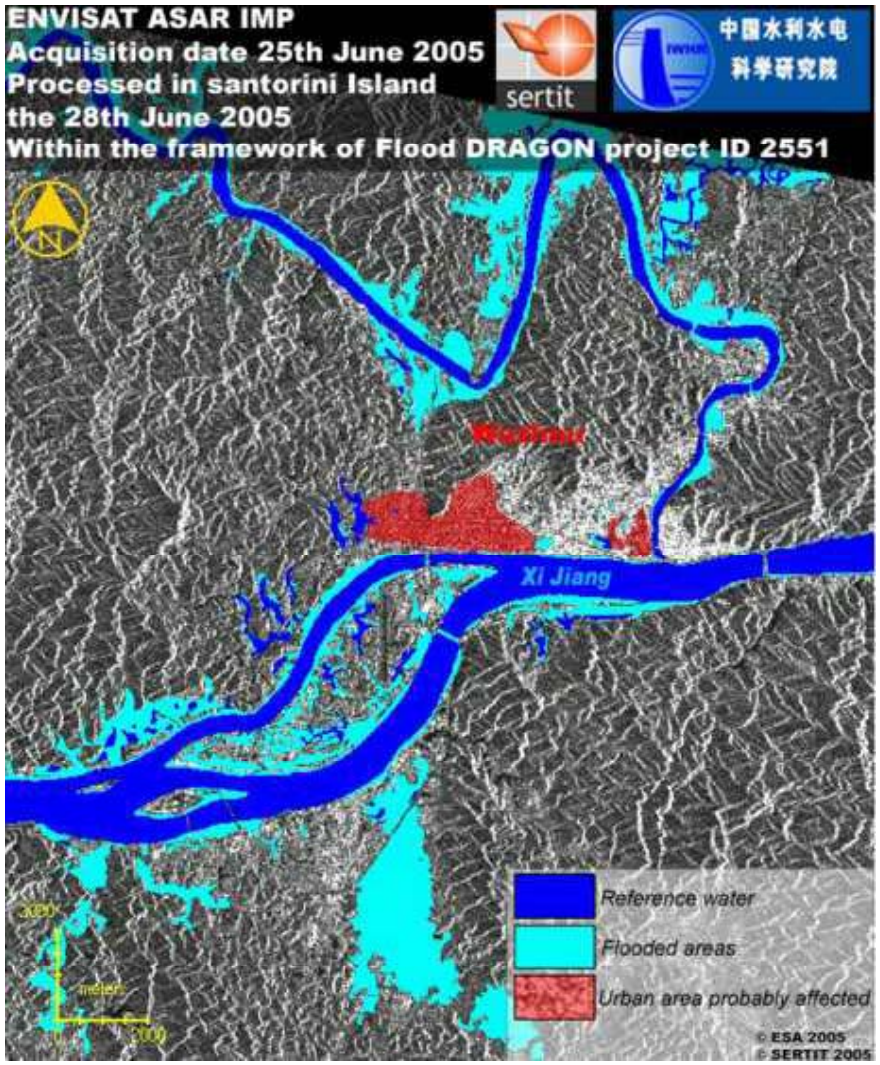
Active: 0.43, 1.25, 5.3, 8.6, 9.6, 13.4, 24.1, 35.5 GHz

Floods



Landsat-7 draped over SRTM DEM

Flooding of the Xi River, affecting the city of Wuzhou in Guangxi Province. Reference data are from Landsat; flood data are from ASAR on Envisat.



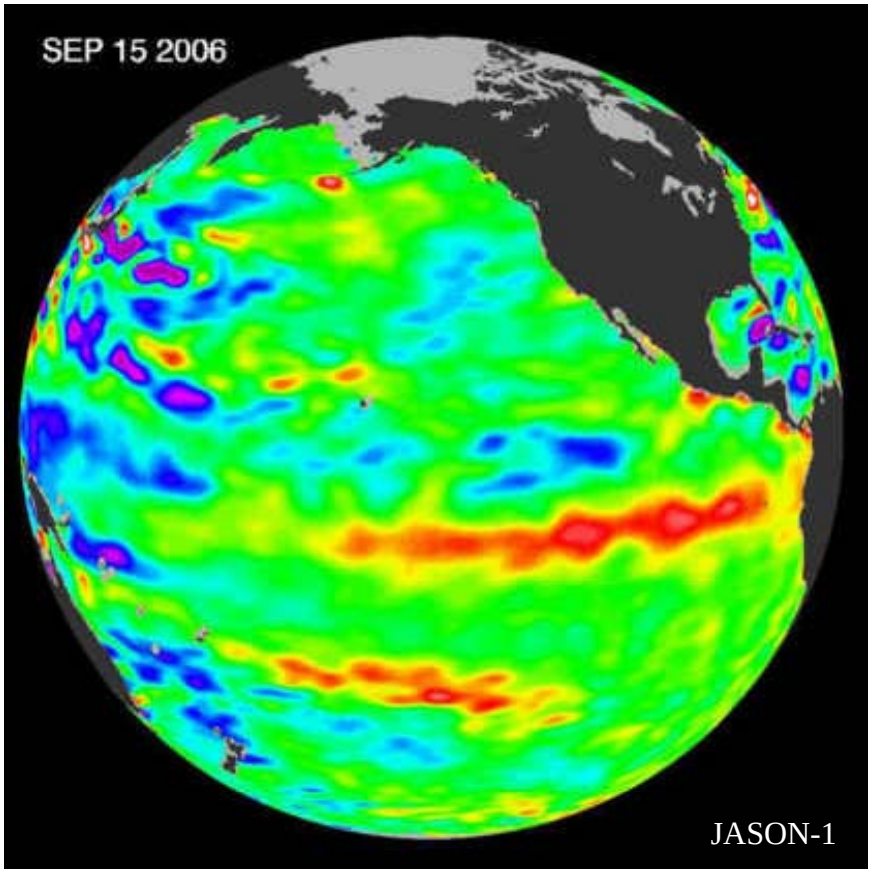
Droughts

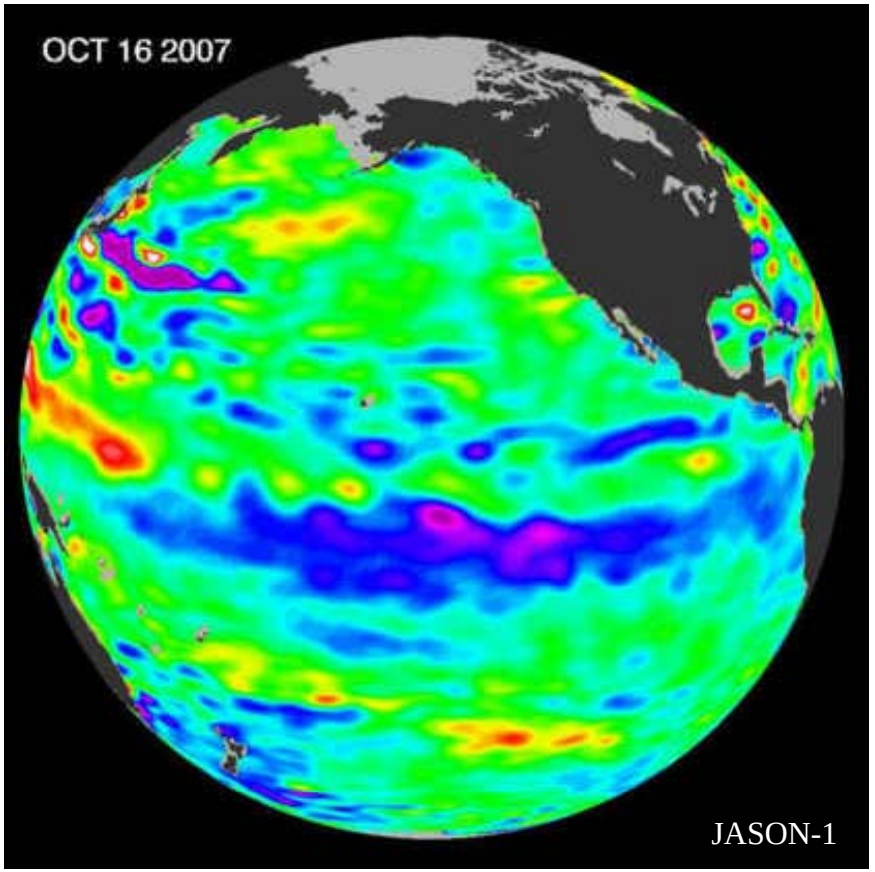
- Sea Surface height, temperature (forecast el Nino)
- Snowcover, surface temperature, rain measurements (forecast available water)
- Soil moisture, rainfall, vegetation health (observe onset, progress)

Passive: 1.4, 2.65, 4.9, 6.7, 7.2, 10.6, 18.7, 21.3, 22.3, 23.8, 31.5, 36.5, 50-59, 89, 118,149, 166, 175-191, 205 GHz

Active: 0.43, 1.25, 5.3, 8.6, 9.6, 13.5, 17.2, 24.1, 35.5 GHz

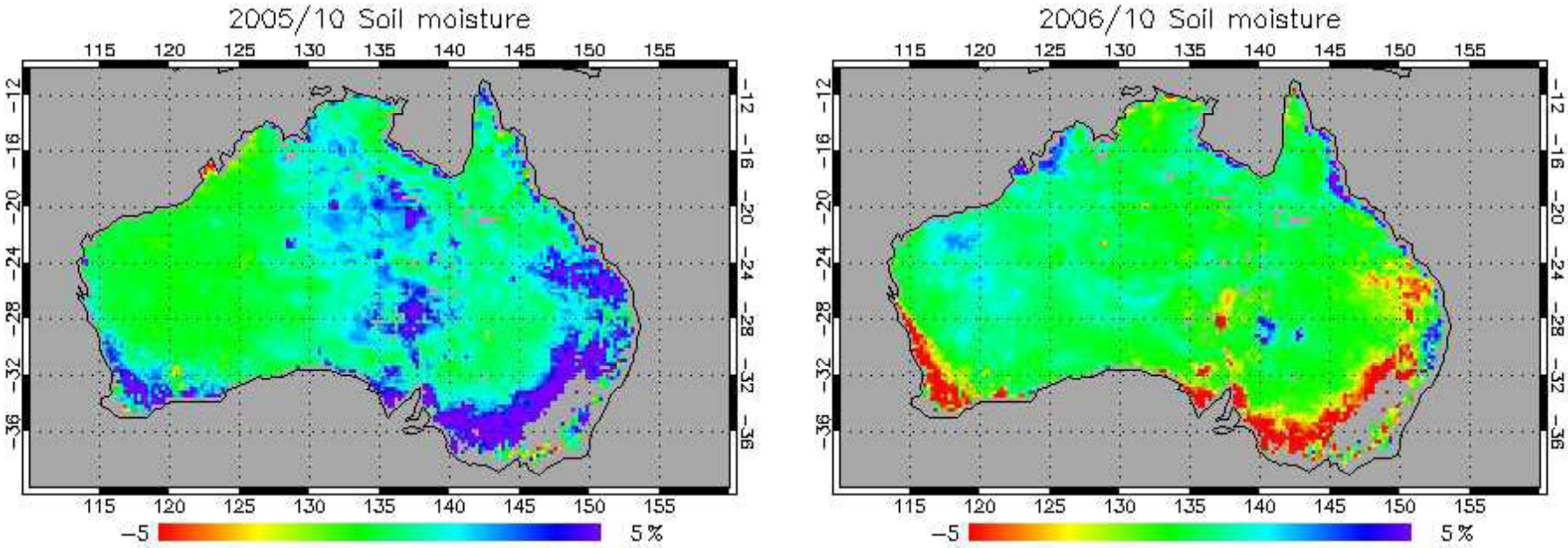
Droughts





El Nino	La Nina
Eastern Pacific: warm, higher (red)	cooler, lower (blue)
Trade winds: weaker	stronger
Drought: Australia, Indonesia	along American coasts

Drought

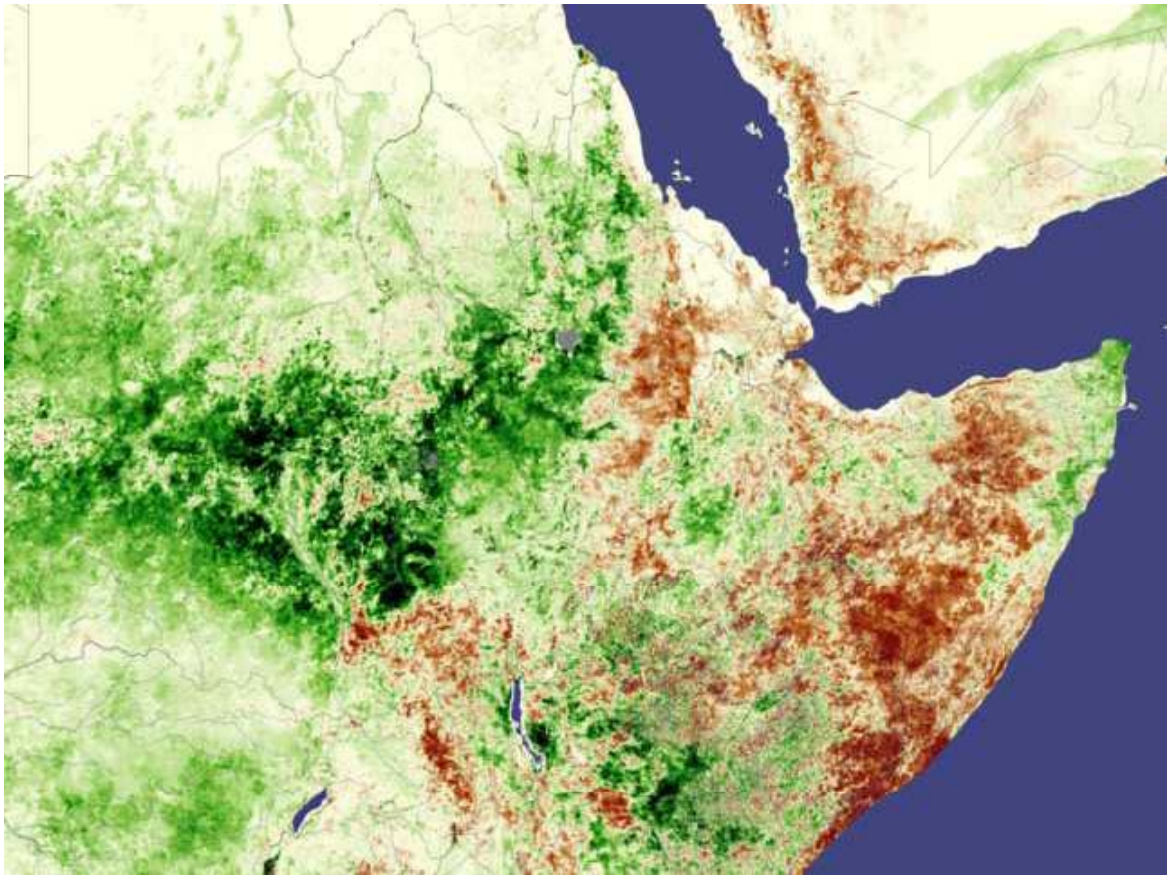


Soil moisture distribution in Australia during October 2005 and 2006.

A drought occurred in south east Australia (Granary area) in 2006.

Data acquired by AMSR-E on Aqua:
Red = low soil moisture (dry); Blue = high soil moisture (wet).

Drought



Data collected by the SPOT Vegetation satellite between May 11 and 20, 2008.
Brown = bad condition; green = good condition.

Pollution

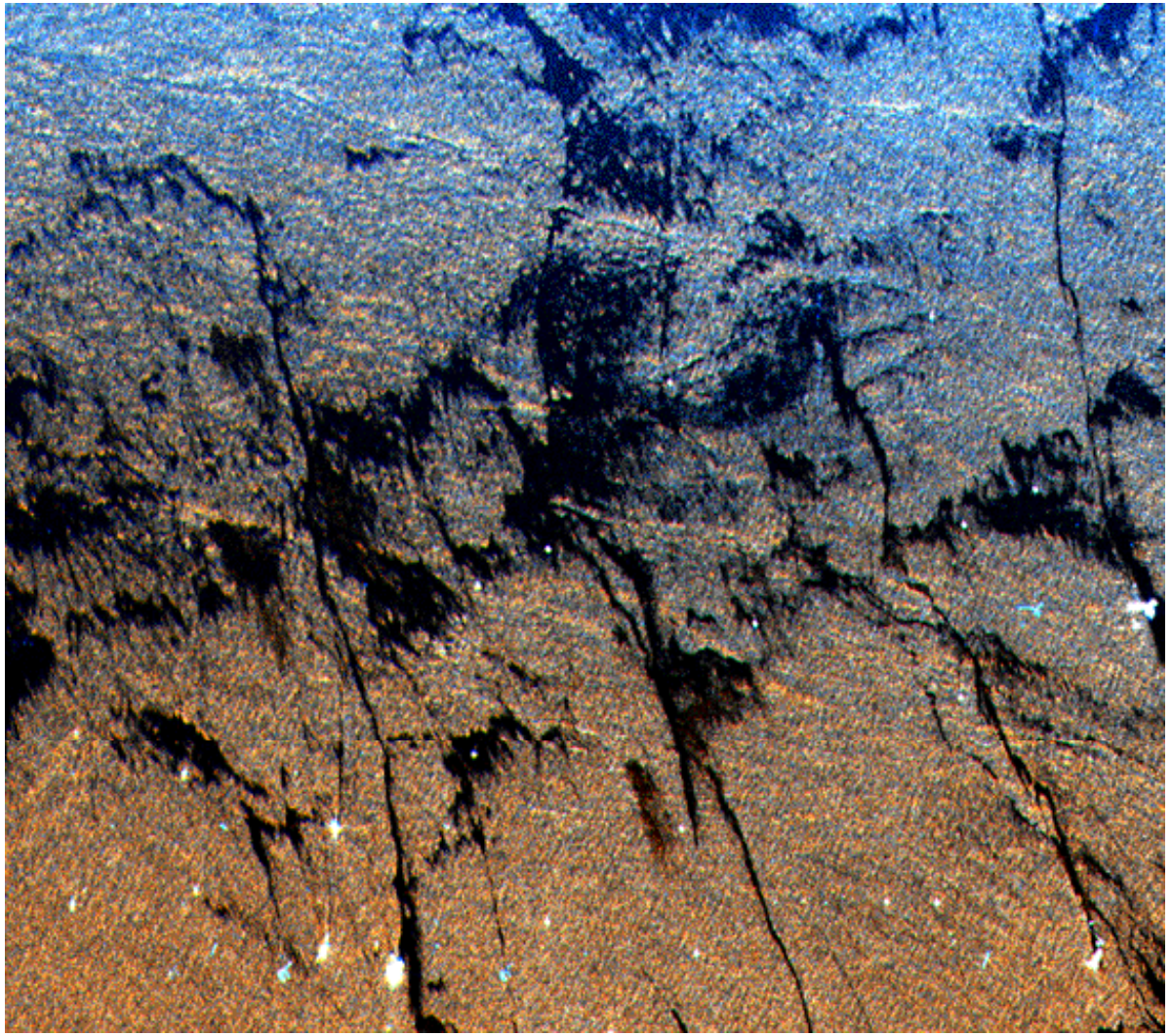
- SAR imagery (detect possible oceanic oil spill, then track it)
- Ocean color to detect red tides.
- Atmospheric pollutants via IR

Passive: (none)

Active: 1.25, 5.3 GHz

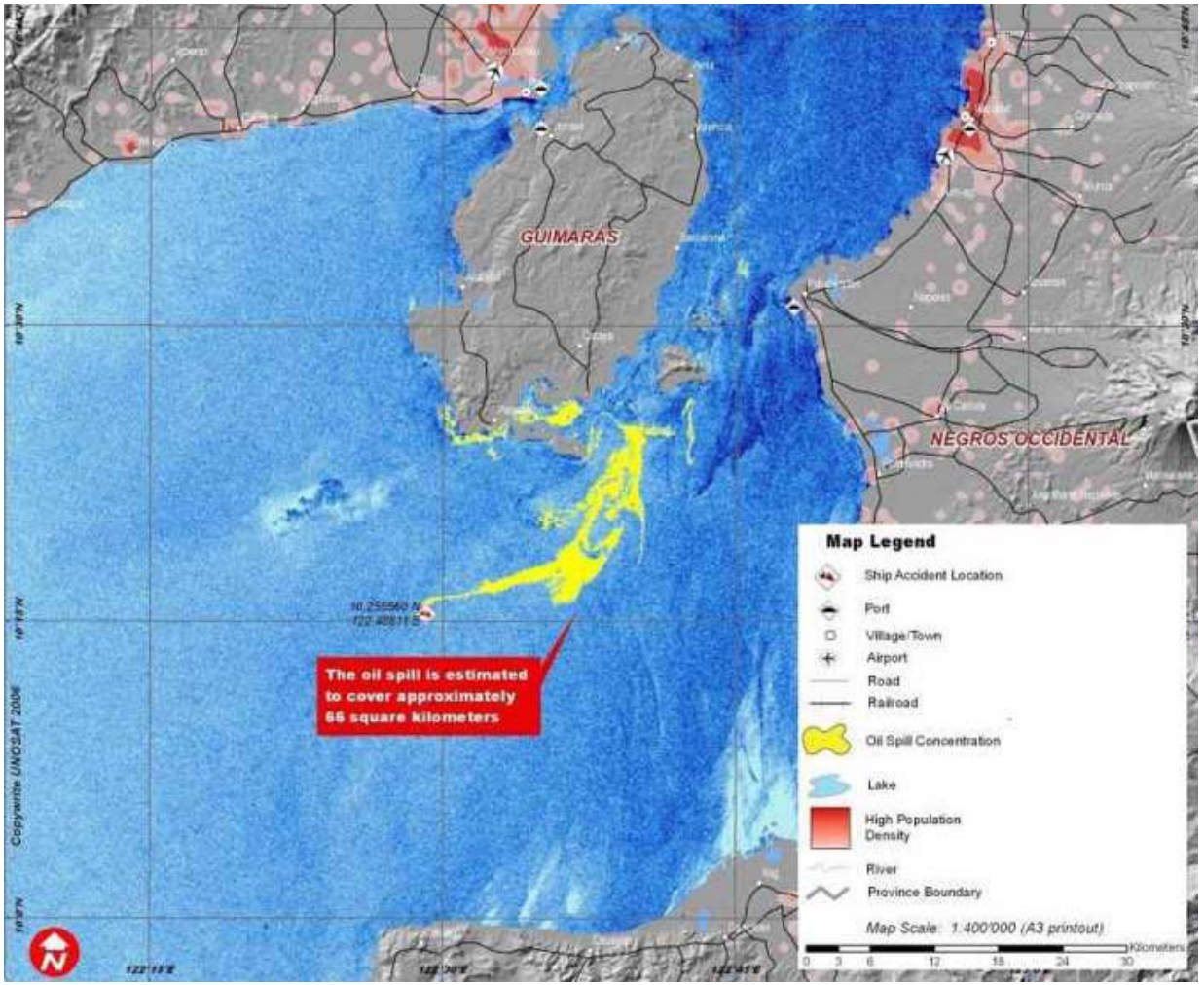
Pollution

- Oil Slicks in the Arabian Sea due to seepage from Oil Platforms
- (Multi-Frequency SIR-C Image)



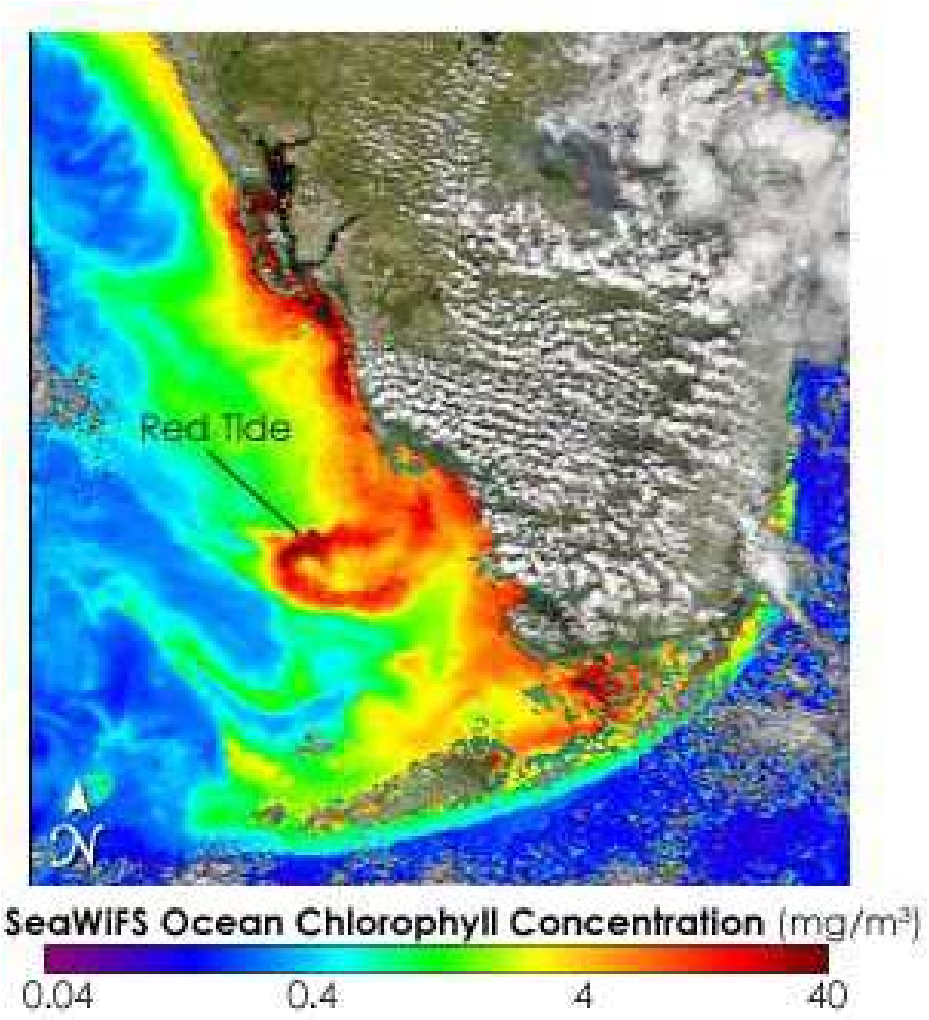
Pollution

- On 11 August 2006, an oil tanker sank in the Philippines.
- ENVISAT SAR located the extent of the oil slick on 24 August 2006.

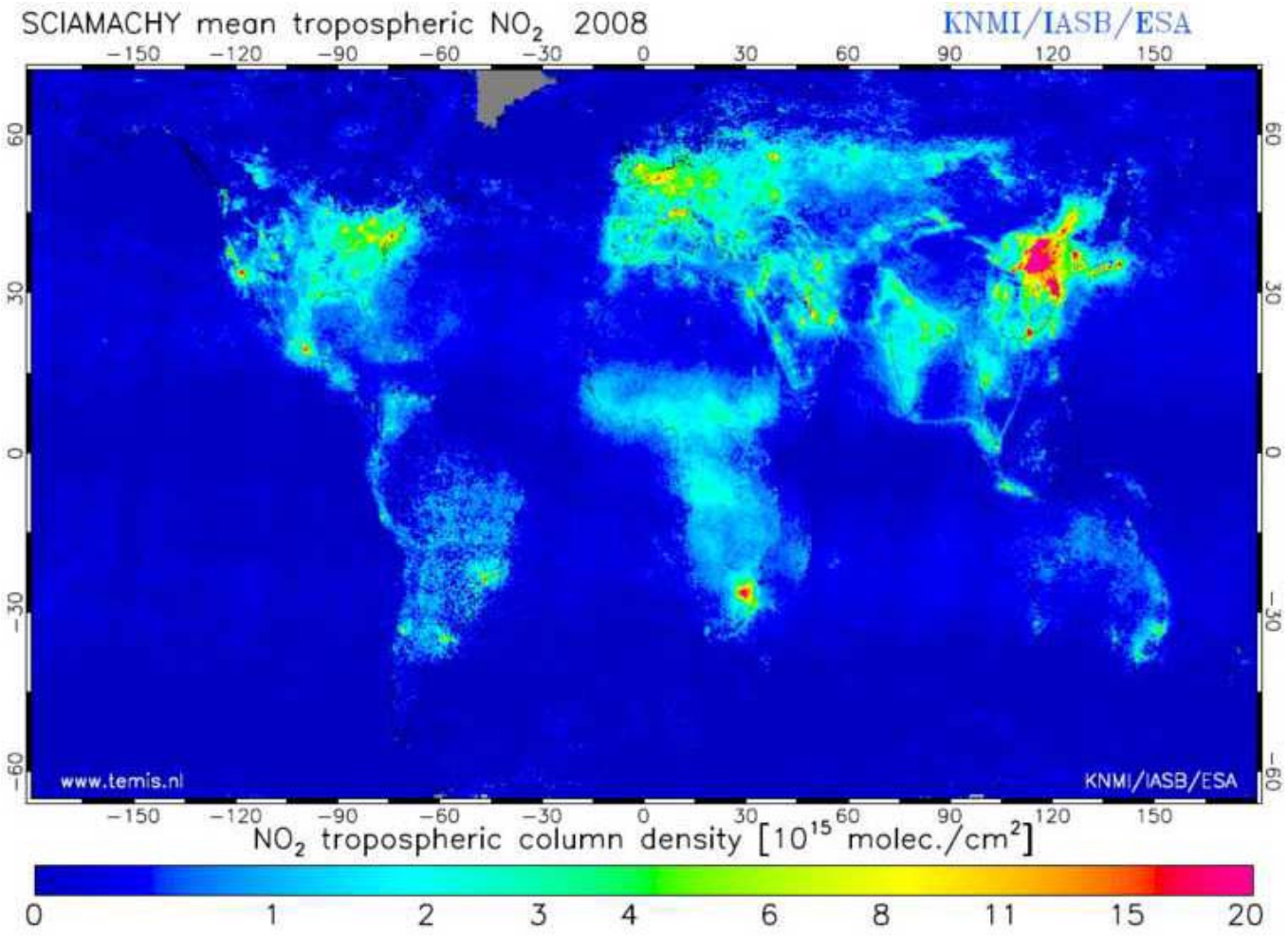


Pollution

- "Red Tide" Observed off Florida (USA) by SeaWiFS November 21, 2004
- Red Tides
  - Due to "algal bloom" or a rapid increase in concentrations of micro-organisms in coastal water
  - Associated with die offs of fish, birds, marine mammals, and other organisms.
  - Mortalities are caused by exposure to a potent neurotoxin called brevetoxin which is produced naturally



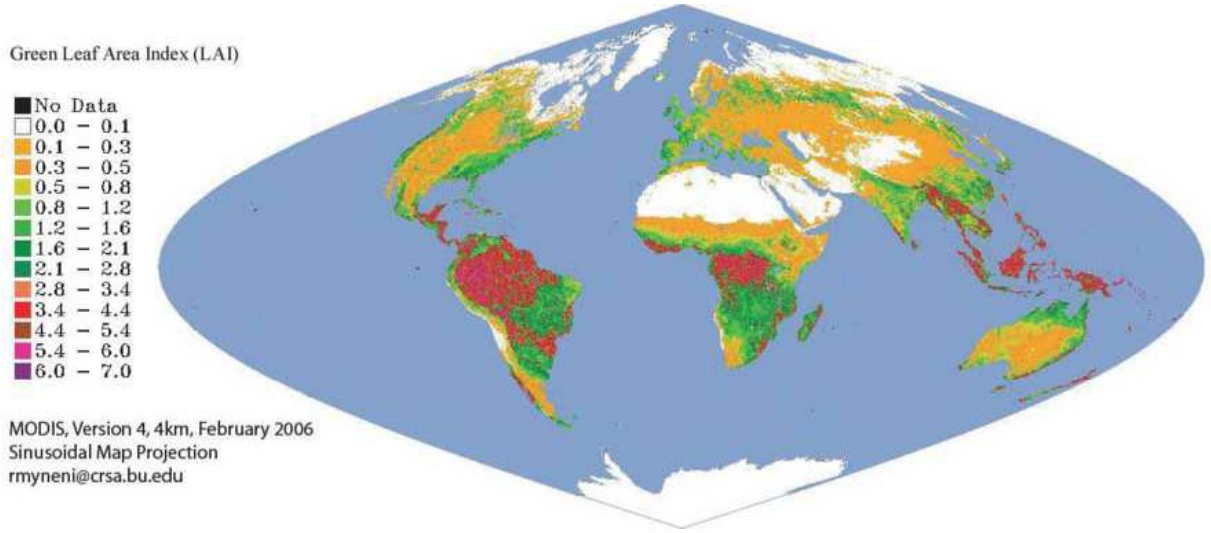
Pollution



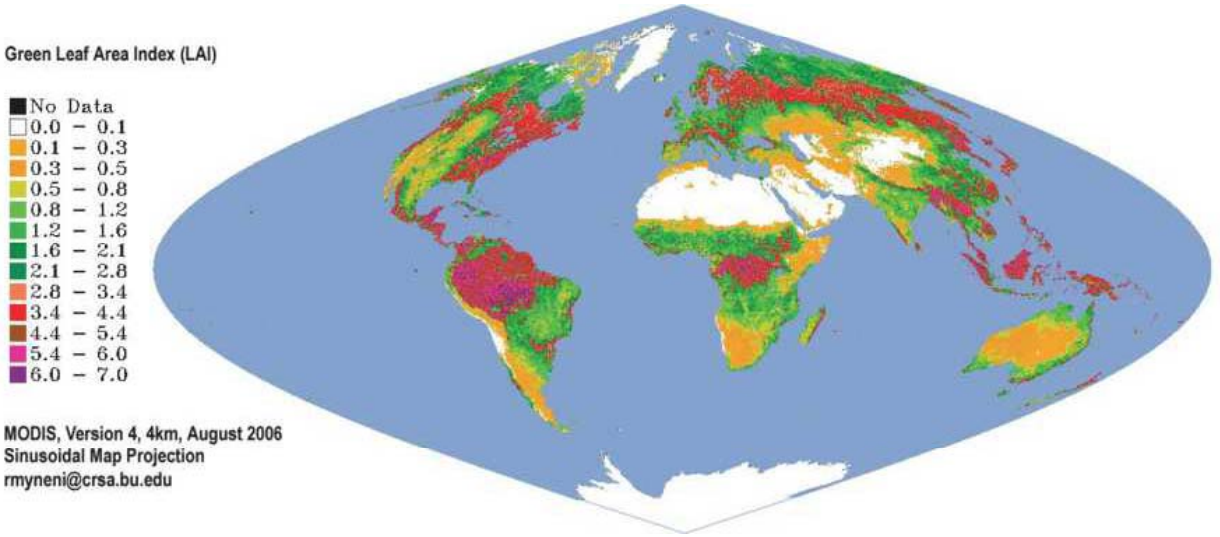
Nitrogen Dioxide Measured Worldwide in 2008

Climate Change - Plant Health

February 2006



August 2006



Climate Change - Population Monitoring

Night lights visible from space indicate populated areas

Organizations Providing Data & Training

- SERVIR: Spanish for “To Serve”: Regional Visualization and Monitoring System integrating earth observations (e.g. satellite imagery) and forecast models together with in situ data and knowledge.
- UNOSAT: The United Nations Institute for Training and Research (UNITAR) Operational Satellite Applications Programme (UNOSAT)
- UN-SPIDER: United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER)

SERVIR

- Joint NASA, NOAA, USGS, USAID program with regional offices
  - Clayton, Panamá (2005)
  - Nairobi, Kenya (2008)
  - Kathmandu, Nepal (2010)
- Uses
  - Monitoring: Air quality, extreme weather, biodiversity, land cover
  - Used over 35 times in response to natural disasters and environmental threats
    - Wildfires, Floods, Landslides, Alga Blooms
  - Emphasis on analyzing impacts of climate change
- www.servir.net

UNOSAT & UN-SPIDER

- UNOSAT:
  - Specializes in analyzing data from a vast array of sources and providing custom data products and reports
  - Provides hands-on training with geographic information systems (GIS) equipment
  - Has specific modules in training and education curricula up to post-university Master level
- UN-SPIDER:
  - "Ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle“
  - Links space-based remote sensing and disaster management communities
  - Conducts workshops

Other ITU-R and ITU-D resources

- Report ITU-R RS.2178 “The essential role and global importance of radio spectrum use for Earth observations and for related applications”
- Recommendation ITU-R RS.1859 “Use of remote sensing systems for data collection to be used in the event of natural disasters and similar emergencies”
- Recommendation ITU-R RS.1883 “Use of remote sensing systems in the study of climate change and the effects thereof”
- ITU/WMO Handbook on “Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction” (Edition 2008)
- ITU-R Handbook on “Earth Exploration-Satellite Service” (Edition 2011)
- ITU-D Report “Question 22/2 - Utilization of ICT for disaster management, resources, and active and passive space-based sensing systems as they apply to disaster and emergency relief situations” - Final Report

Other resources

- United States Telecommunications Training Institute (USTTI) : Disaster Management and Communications course, October/November 2011 in Washington, DC, USA
- ITU-R responsible for keeping spectrum used by remote sensing satellites free from interference
- ITU-D Study Group 2: Has invited the UNOSAT, UN-SPIDER, and SERVIR to establish liaison relationships with the ITU-D
- Space Frequency Coordination Group (SFCG) Disaster Management Database
  - https://www.sfcgonline.org/Remote%20Sensing/default.aspx

* Many Thanks to Dr. Chuck Wende

Thank You!