



**ITU and
Climate
Change**

Remote sensing radio applications/ systems for environmental monitoring

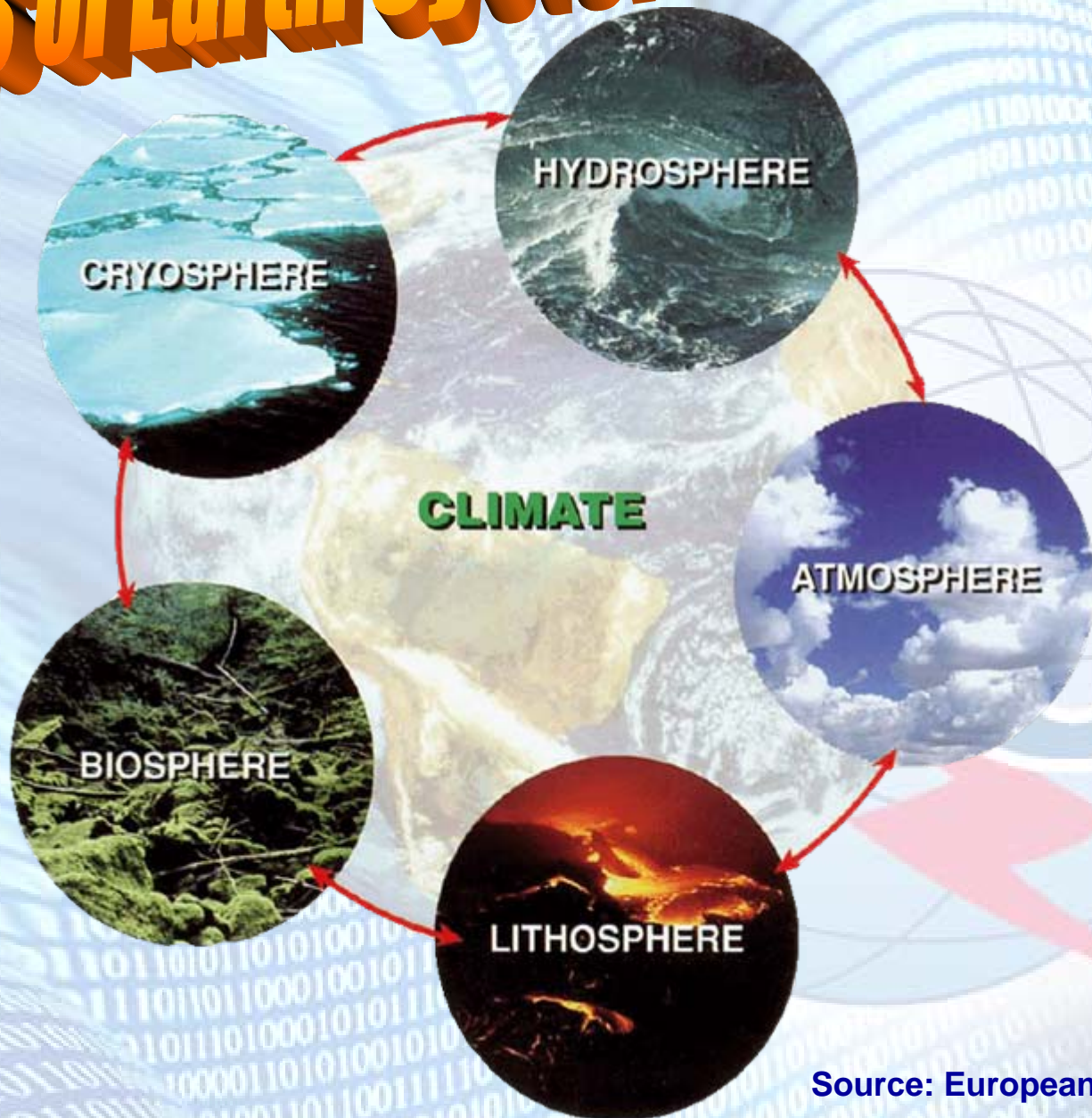
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Elements of Earth Systems



Source: European Space Agency



Radio and Environment Information

Most of people think that the radio frequencies are used for radiocommunications. However, radio emissions are also used for obtaining information about the environment with which they have been in contact.

In the radio frequency spectrum number of frequencies are better suited, due to the physical phenomena, for extracting the environmental information.

Environmental information, including climate monitoring data, is currently being obtained by special measuring instruments called remote sensors.

Remote sensors (passive and active) are radio devices, that derive environmental information by analyzing received radio waves.



Radio and Sensors

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**.

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**.

*Article 1 of the Radio Regulations
(ITU Radio Regulations is an international treaty regulating
the use of radio-frequency spectrum)*

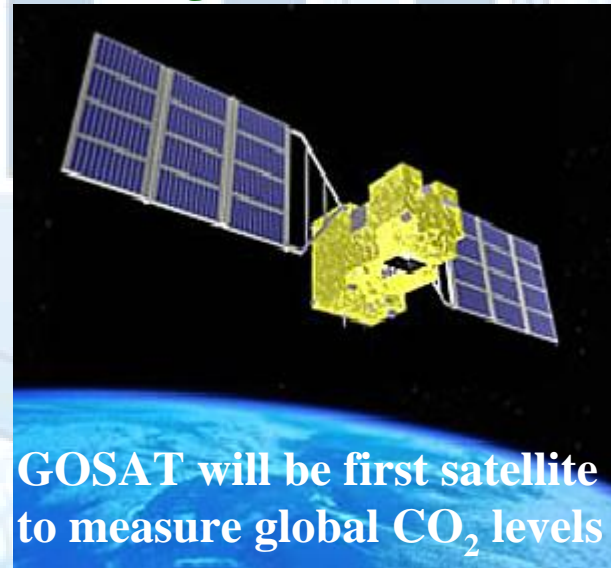


The Role of Radiocommunication Services in Climate Monitoring

- Radiocommunication systems and applications employing remote sensors are the main source of information for climate monitoring, disaster prediction, detection and disaster relief operations
- Space-based remote sensors are the only tools that provide environmental data on a long term, repetitive and global scale.

According to many researchers the increasing release of greenhouse gases (GHG) is the main reason for the global warming. Remote sensors provide global systematic observation of the terrestrial carbon budget.

JAXA Greenhouse gases Observing SATellite "GOSAT"



GOSAT will be first satellite to measure global CO₂ levels

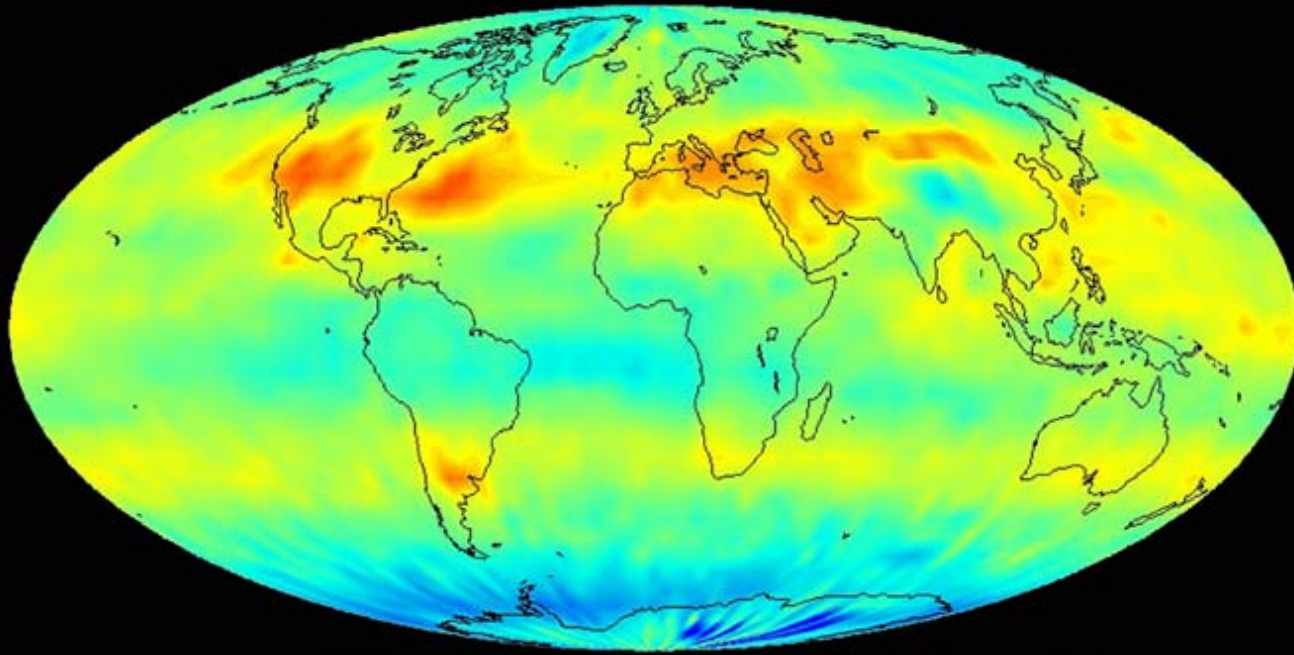


***Samples of space-based
remote sensing radio applications
for monitoring of climate-related
Earth system parameters***



- Atmospheric composition (ozone, **greenhouse gases**, etc.);
- radiation level of UV emissions;
- cloud height and extent;
- wind speed and direction, etc.

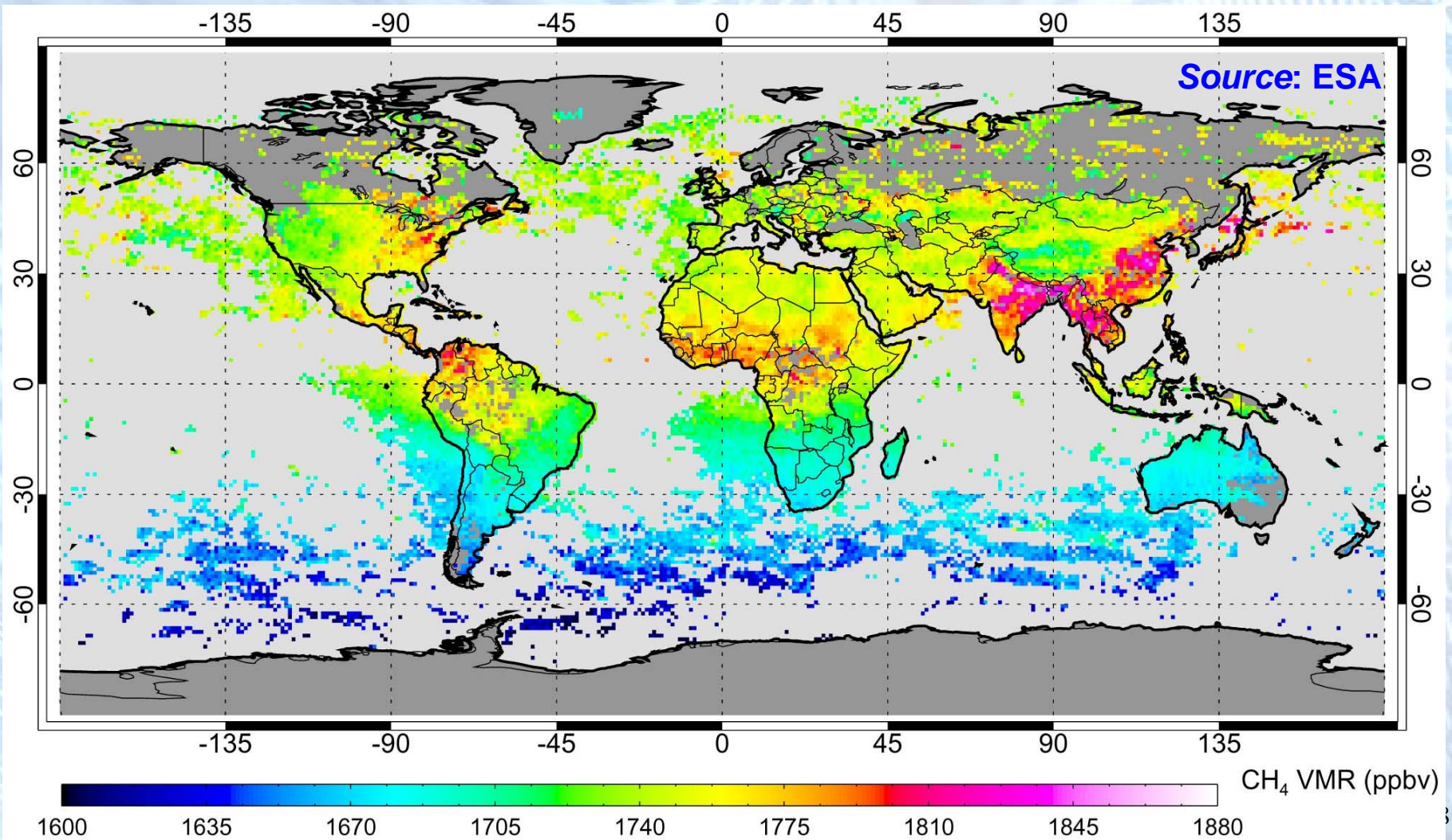
AIRS Retrieved Mid-Tropospheric CO₂ Version 5 July 2003



Source: NASA



Measurements of methane (CH_4) – the second most important “negative” greenhouse gas after carbon dioxide (only few over ocean)

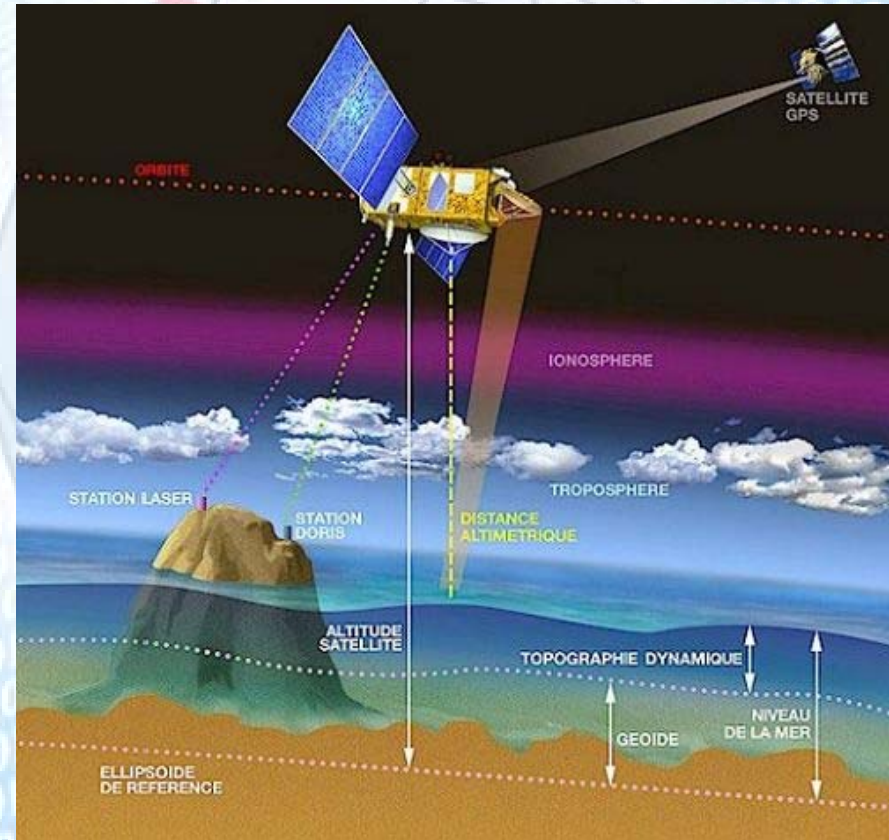




- Ocean topography;
- mapping of ocean circulation;
- sea surface temperature;
- ocean wave structure;
- ocean pollution;
- sea-level rise, etc.

Use of satellites and radio-frequency remote sensing (altimeters) for ice and ocean studies: Can identify a change in sea level with a precision of 2-3 cm.

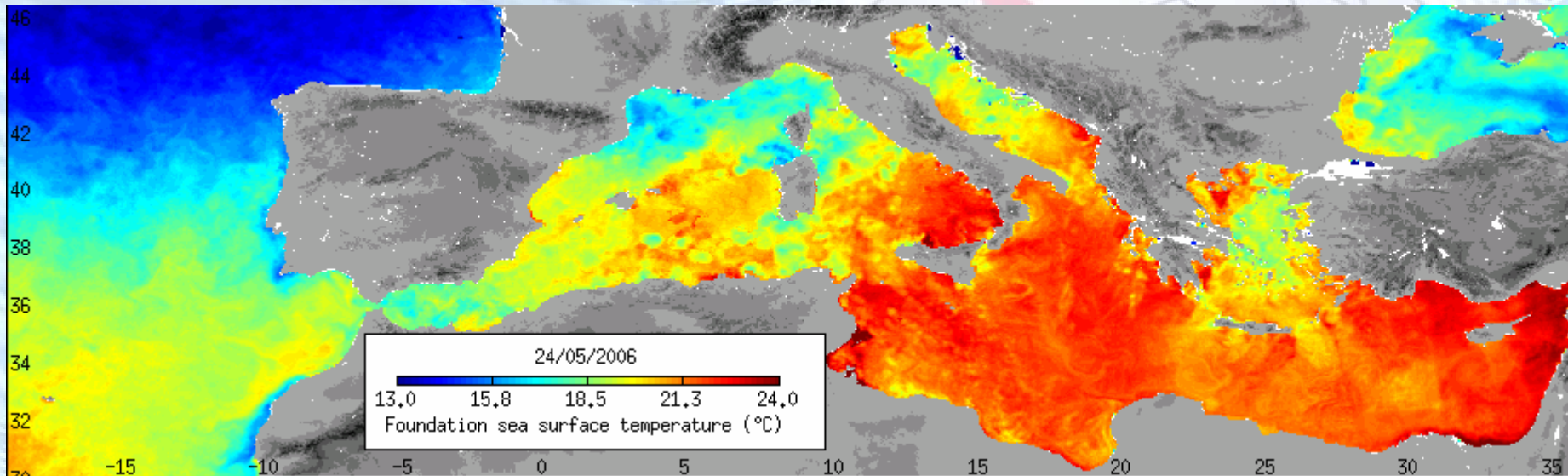
Source: ITU-R Study Group 7 (“Science Services”) and CNES





One of the governing factors influencing hurricanes is increasing ocean surface temperature.

The global control of the ocean temperature is being carried out by remote sensors from satellites with accuracy of up to 0.2°C .



Mediterranean sea surface temperature map from Envisat's Advanced Along Track Scanning Radiometer (AATSR) instrument
Source: European Space Agency (<http://www.esa.int/>)



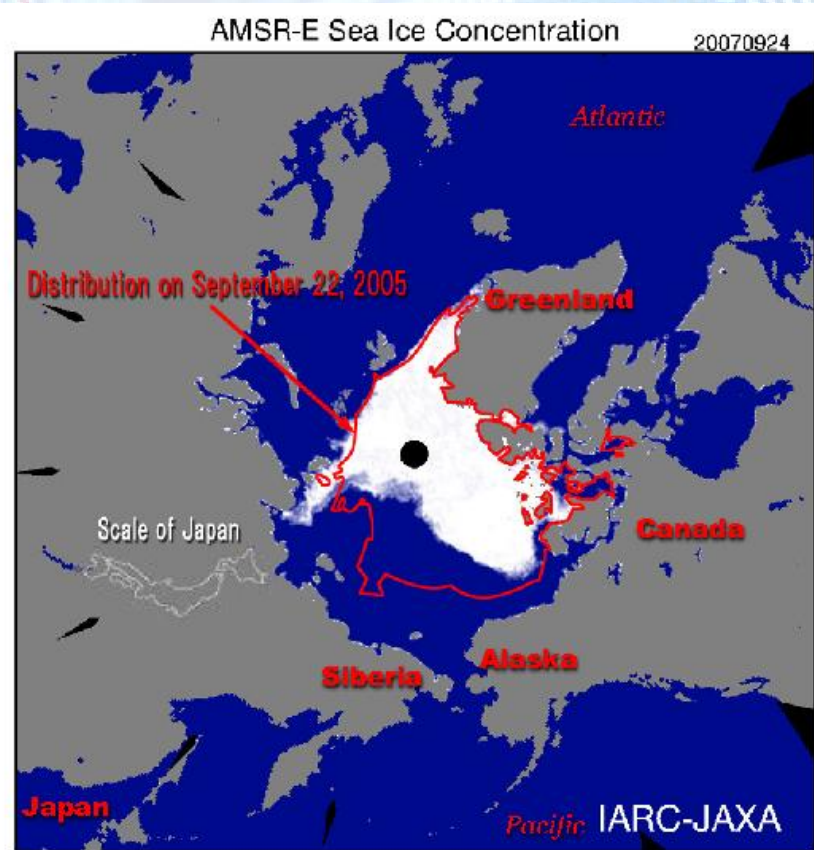
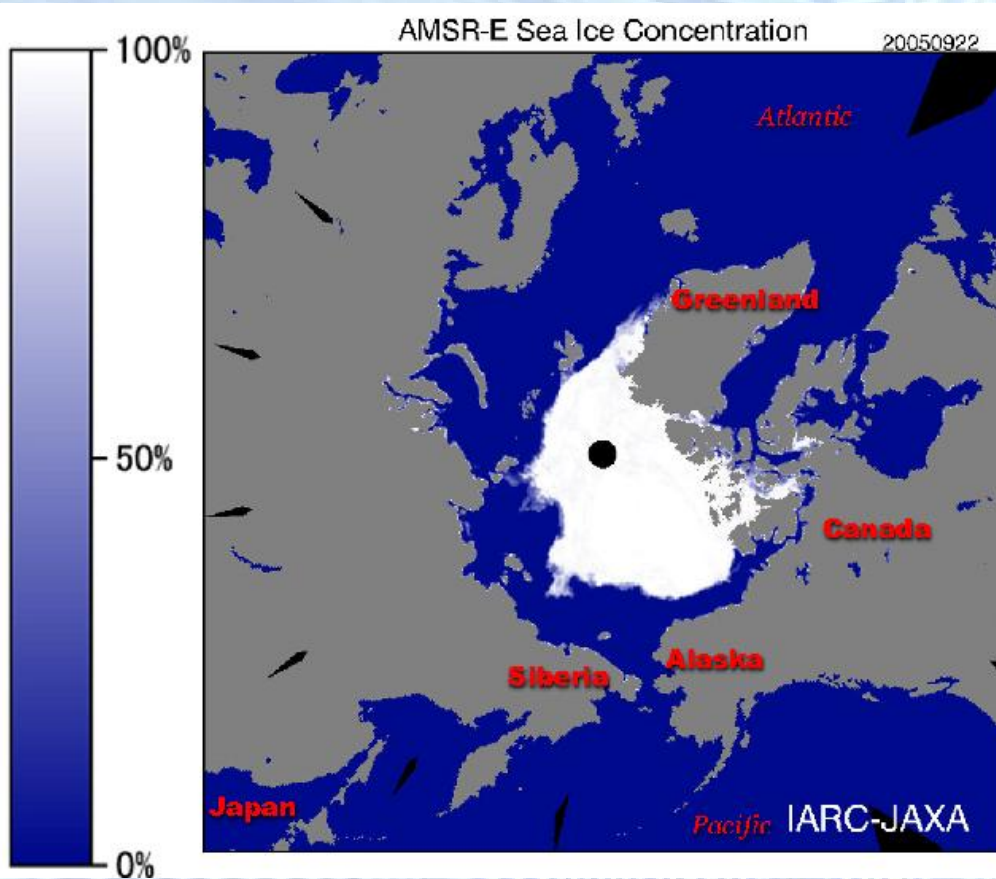
- Vegetation mapping;
- biomass measurements;
- crop cover and status;
- forest cover and status;
- land use mapping;
- soil moisture, etc.

Global vegetation cover from Nov. 1, 2007,
to Dec. 1, 2007 Source: NASA





- Ice boundaries, depth, type and age;
- snow distribution;
- snow depth;
- snow water content, etc.

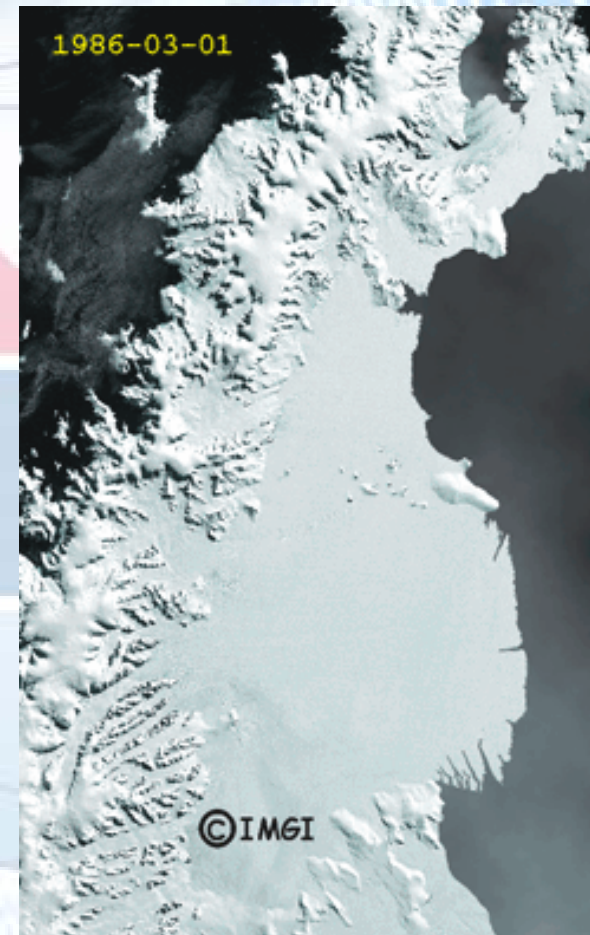


Distribution of Arctic sea ice in 2005 and 2007 acquired by AMSR-E
Source: JAXA



Advanced Synthetic Aperture Radar (ASAR) allows Envisat to produce high-quality images of ice sheets in Greenland and Antarctica through clouds and darkness.

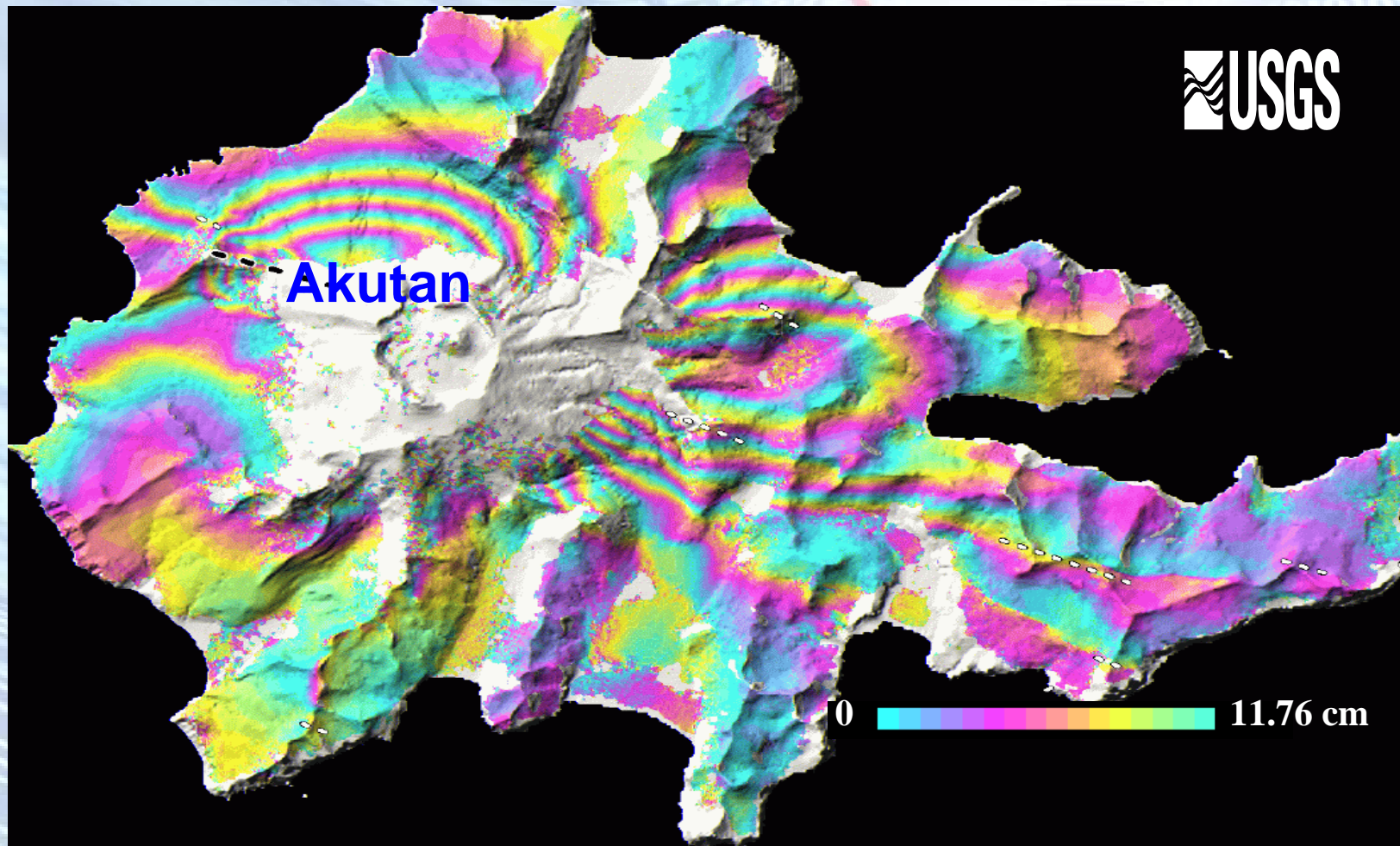
Animated picture





- Overall shape of Earth;
- regional variations of gravity;
- land displacement from earthquakes;
- changing shape of volcanoes during eruptions, etc.

Surface deformation over Akutan Island, Alaska, during the 1996 seismic swarm mapped by JERS (L-band, $\lambda = 23.53$ cm) InSAR





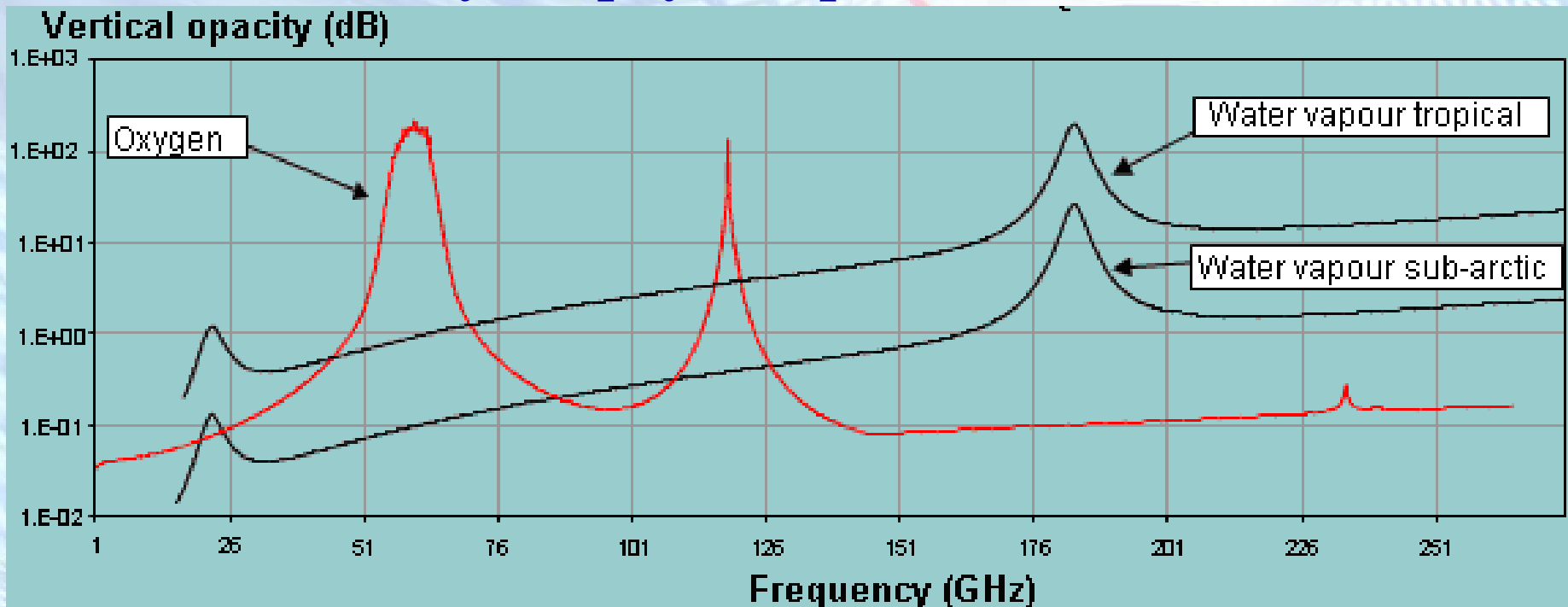
Frequency Bands for Remote Sensing

- Microwave observations at frequencies below 100 GHz enable studies of the Earth's surface and its atmosphere from spaceborne instruments **even in the presence of clouds**, because clouds are almost transparent at these frequencies. This "all-weather" observing capability has been very important for EESS (*Earth-exploration satellite service*) in achieving the repetitive global coverage mandatory for *meteorological, climatological, and environmental monitoring and surveying*.
- The impressive progress made in recent years in weather analysis, warning and forecasts, especially for dangerous weather phenomena that affect all populations and economies is largely attributable to the spaceborne observations and their assimilation in numerical models.
- Play a major role in the prediction and detection of disasters.



Choice of Frequency Bands – Rather Limited!

There is no free choice of frequency bands used for environmental measurements; the choice of the frequency band is dictated by the physical phenomena to be observed.



As shown in Figure it is not possible to use frequency bands from 75 to 100 GHz for measuring the oxygen level in atmosphere.

Source: [Radiocommunication Study Group 7 \(Science Services\)](#)

ITU/MIC Japan Symposium "ICTs and Climate Change", Kyoto, Japan, 15-16 April 2008



Frequency Band and Precision

In many cases remote sensing precision depends on the radio spectrum available for a remote sensing application.

For example, to achieve 1 meter resolution at 30° incidence angle an Advanced Synthetic Aperture Radar (ASAR) needs 300 MHz.

(ASARs provide Earth's images (through clouds too) for monitoring ice, flooding, estimate the effect of different disasters, etc.)

The radio frequency spectrum is a very limited natural resource and the ITU has to find a proper balance between spectrum provided for environment monitoring and for other radiocommunication needs.



Radiocommunication Services Involved in Climate Monitoring

- Meteorological-satellite, Earth exploration-satellite and meteorological aids services are the main users of remote sensors employed for climate monitoring;
- Fixed-satellite service, broadcasting-satellite service, broadcasting, fixed, mobile services are used for dissemination of remote sensing data;
- All above-mentioned services are also employed for planning relief operations and mitigating of local effects of climate change and related natural disasters.



World Radiocommunication Conference 2007 (WRC-07) and Climate Monitoring

WRC-07 was the biggest forum in ITU history with participation of more than 2'800 participants from 164 ITU Member States and 104 observer organizations.

The World Radiocommunication Conferences are empowered to modify the Radio Regulations - an international treaty regulating the use of radio-frequency spectrum.



WRC-07 Treaty Status Decisions

WRC-07:

- **Extended spectrum allocations and adopted protection criteria for the services involved in environment monitoring in general, and climate monitoring.**
- **Adopted several Resolutions on studies and actions by Radiocommunication Sector (ITU-R) related to the services involved disaster prediction, detection and relief.**
- **included several items in the draft of WRC-11 Agenda concerning the use and further development of radicomunication systems involved environment monitoring.**



Radiocommunication Assembly 2007

Radiocommunication Assembly has the same status in radio matters as the World Telecommunication Standardization Assembly (WTSA) in telecommunication standardization matters.

RA-07 approved 2 resolutions related to studies to be carried out by the Radiocommunication Study Groups concerning development and operation of remote sensing:

- Resolution ITU-R 53 “The use of radiocommunications in disaster response and relief”**
- Resolution ITU-R 55 “ITU studies of disaster prediction, detection, mitigation and relief”**



Conclusion

- Remote sensing is the essential tool for climate monitoring, prediction, detection and relief from natural and man-made disasters;
- Remote sensing systems are key global assets that serve the world as a whole;
- It is very important to protect non-interference operation of remote sensors, and provide radio and telecommunication infrastructure, for obtaining and disseminating remote sensing data;
- *As the steward of the global framework for spectrum, ITU provides for the necessary radio-frequency spectrum and orbit resources for satellites for climate monitoring and remote sensing, as well as promoting their use for the interests of all countries, ...*



Web resources

ITU and Climate Change page

<http://www.itu.int/themes/climate/>

ITU Radiocommunication Sector (ITU-R) page

<http://www.itu.int/ITU-R/index.asp?category=information&rlink=rhome&lang=en>

ITU Radiocommunication Sector (ITU-R) emergency telecommunications page

<http://www.itu.int/ITU-R/index.asp?category=information&rlink=emergency&lang=en>

ITU-R Publications page

<http://www.itu.int/publications/sector.aspx?sector=1&lang=en>

Remote Sensing Workshop (during ITU Global Forum on Effective Use of Telecommunications/ICT for Disaster Management) http://web.itu.int/ITU-D/emergencytelecoms/events/global_forum/rs_present.html

List of some Remote Sensors (provided at ITU Global Forum on Effective Use of Telecommunications/ICT for Disaster Management – produced by ITU-D) **see at:** <http://www.itu.int/ITU-D/emergencytelecoms/doc/Remote%20Sensing%20Sensors%20for%20Disaster%20Type%20and%20Phaseweb.pdf>