

Radio Frequency Sensing from Space

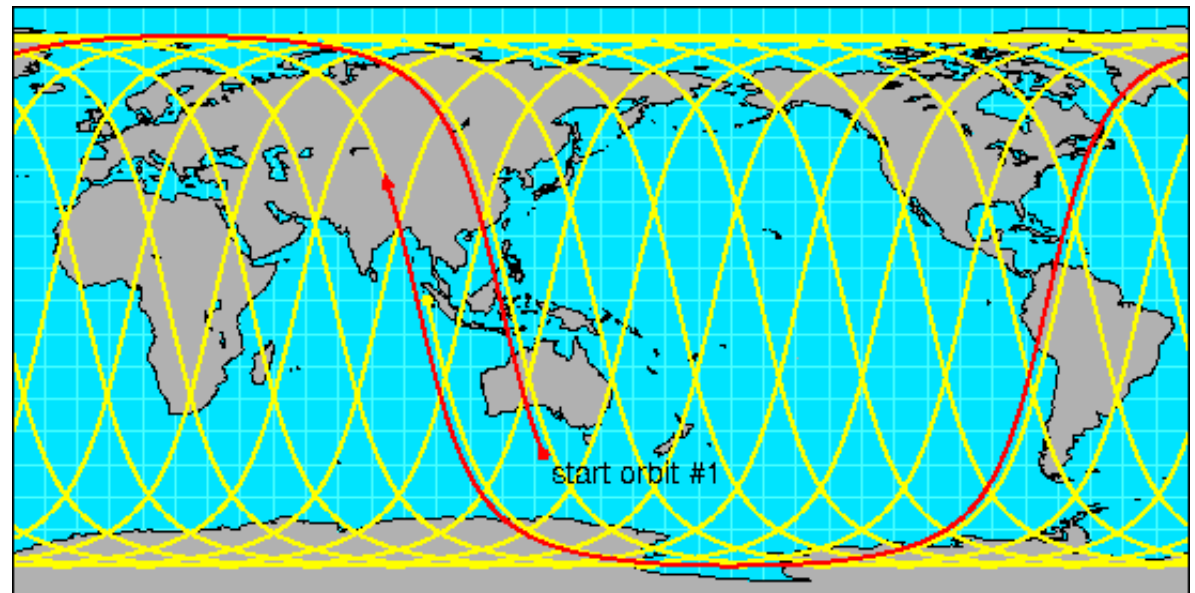
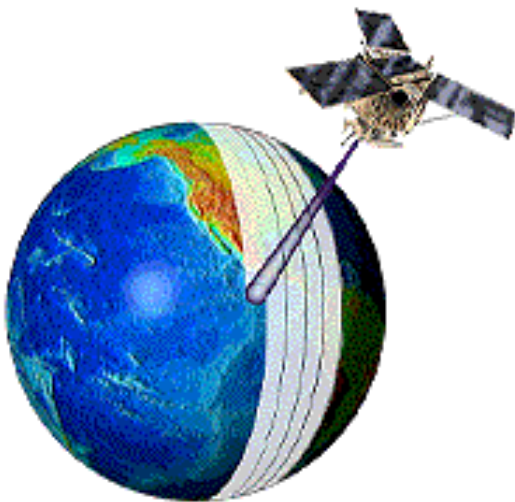
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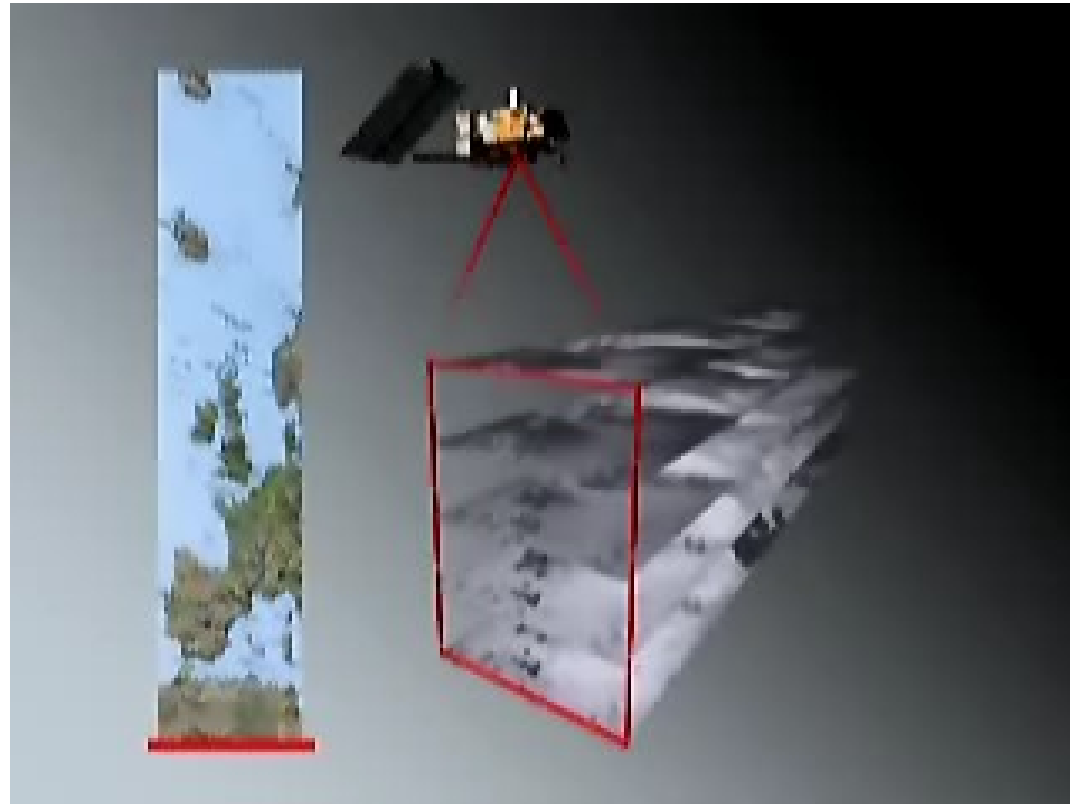
Why observing the Earth from space?

- Satellites orbiting around the Earth offer an excellent viewpoint from where to sense the Earth surface (land and oceans) as well as the components of the Earth atmosphere.
- Geostationary satellites offer continuous monitoring of a large area, while low orbiting polar satellites cover all the Earth at regular intervals (as shown below)

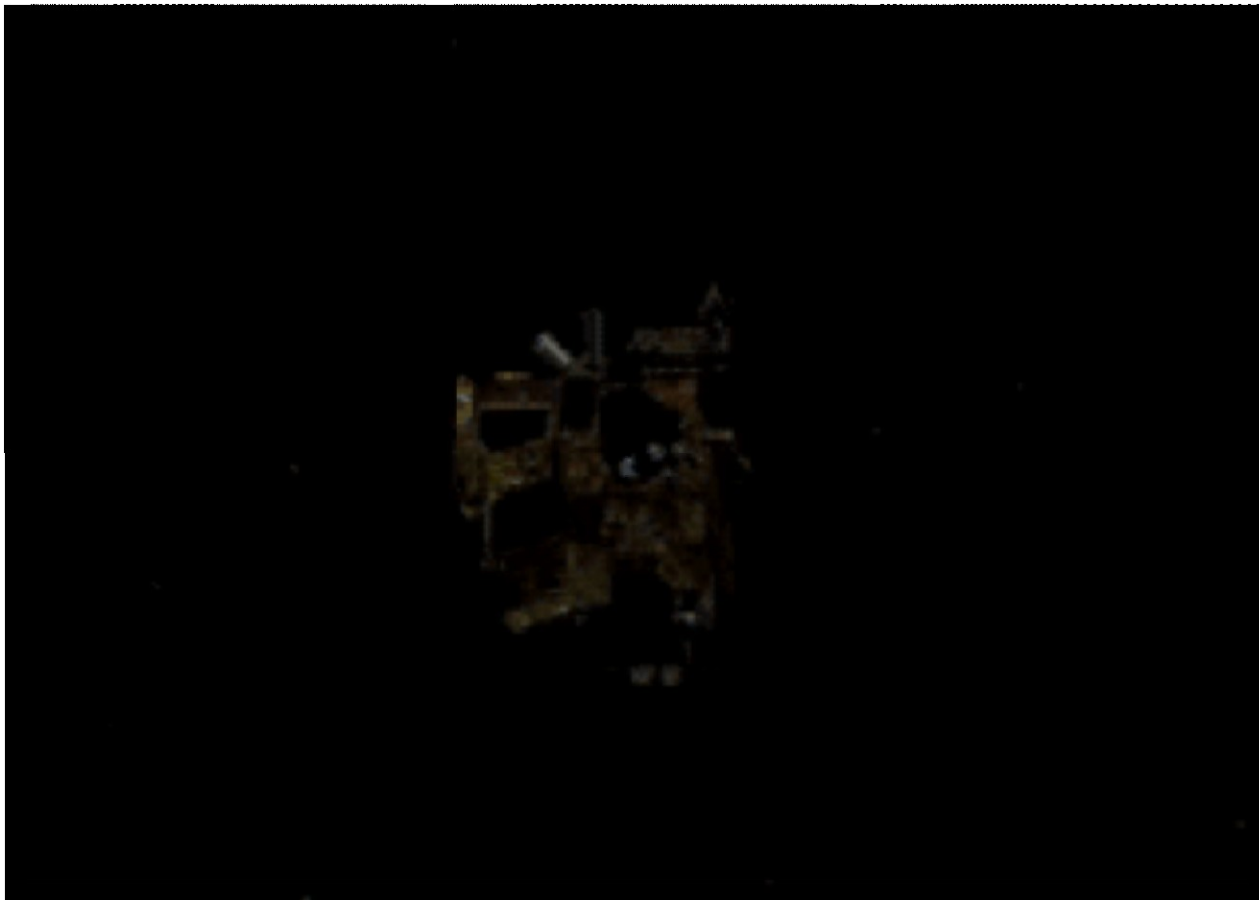


- **Sensing in radio frequency** presents some important advantages wrt optical sensing. While optical instruments are hindered by clouds and can take images in the visible range only during the day, RF sensors provide **continuous coverage (day and night) irrespectively of the clouds coverage**. This is particularly important for **sensing tropical areas**, where cloud coverage is often present.
- **RF passive sensing** is performed by measuring natural emissions produced by the Earth's surface and its atmosphere. The strength of these natural emissions and the frequency at which they are generated characterize the type and status of many important geophysical, which describe the status of the Earth/Atmosphere/Oceans System.
- **RF active sensing** is performed by measuring radio waves transmitted from the instrument itself and reflected by the object under investigation.

Multi-frequency passive measurement.



Sending pulses and reading the reflected signal

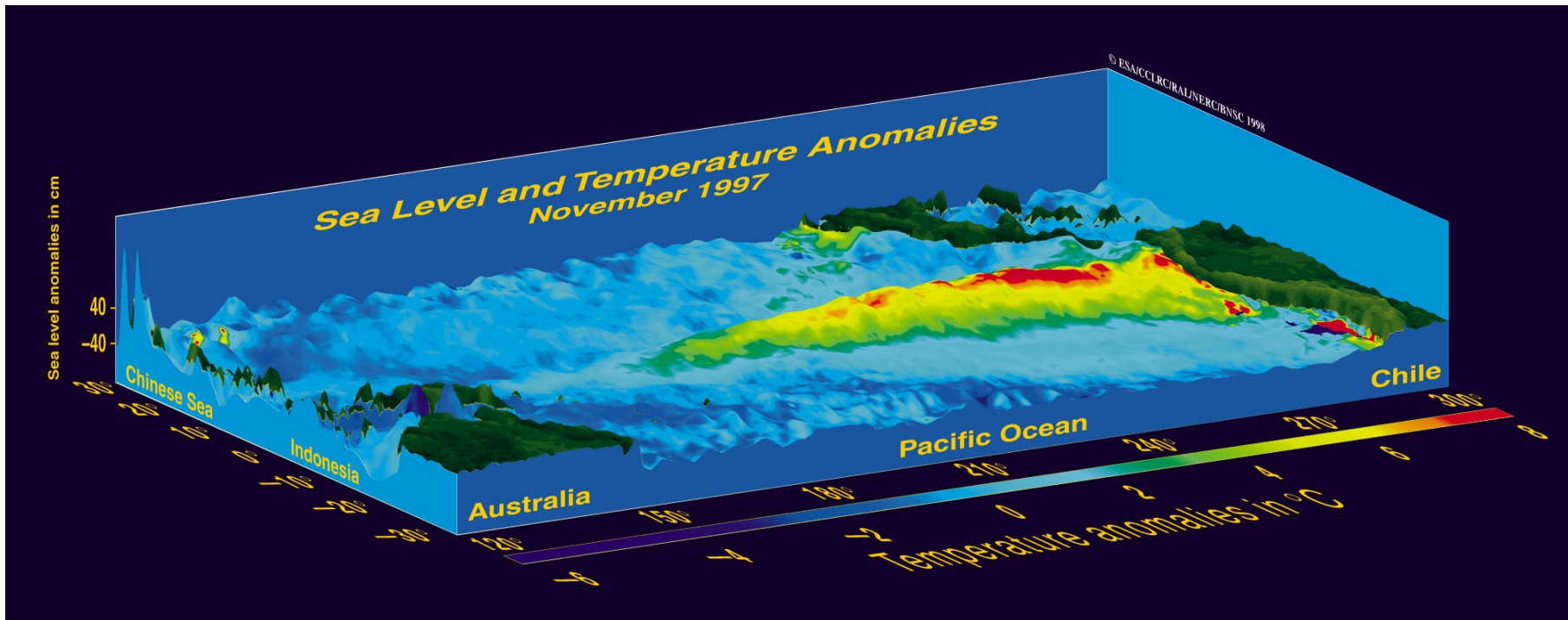


Weather prediction and climate studies:

- Sensing from meteorological satellites → global and continuous coverage → large improvement in the accuracy of **weather predictions** by meteorological offices.
- **Climate change studies** can only be possible thanks to the large wealth of scientific parameters collected by the meteorological satellites over land, oceans and in the various layers of the atmosphere.
- El Niño represents an interesting example that is of particular interest to South America. Better knowledge of ocean circulation is enabling us to better understand and predict climate, especially natural catastrophes such as El *Niño*. This phenomenon, caused by anomalous warm water arrivals on the coast of Peru, brings severe weather patterns, such as drought, flooding, and cyclones. It is now possible to predict El *Niño* from ocean data obtained by satellites.

The main application areas.

Three-dimensional representation of the fully developed 1997 El Niño



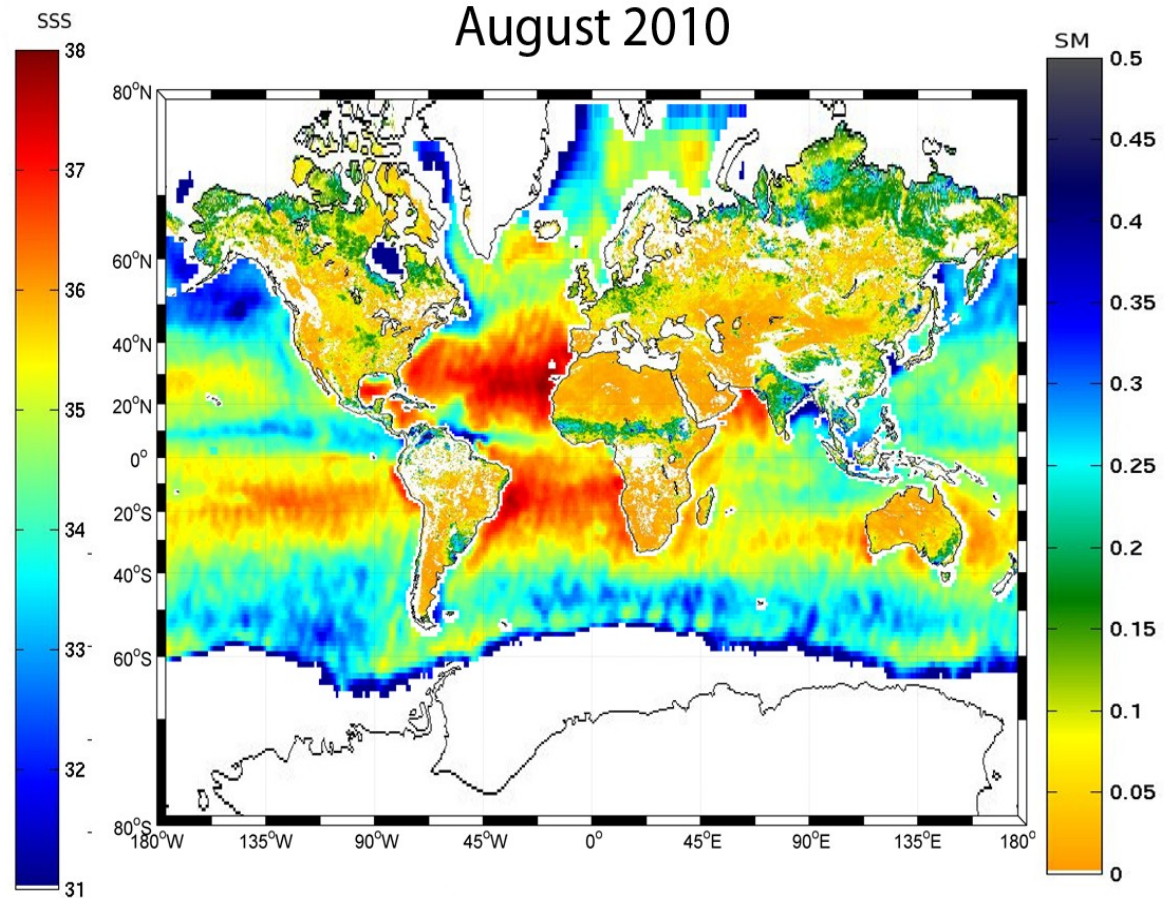
Environmental studies

- Environmental data from Earth observation satellites allow national, regional and world authorities to take informed decisions on what to do about the environment. Examples:
 - Atmospheric chemistry (atmospheric pollution levels)
 - Water temperature/salinity
 - Coastal erosion
 - Forest size and biomass evolution
 - Soil moisture
 - Polar ice extension and depth
 - Land usage
 - Etc...

The main application areas.

Soil moisture and ocean salinity from the satellite SMOS.

RF sensor operating at 1.4 GHz



Commercial and security applications

Satellite data are also used for application of commercial interest like:

- Mining investigation
- Urban planning support
- High resolution mapping
- Fishing stocks localization
- Agricultural productivity
- Etc...

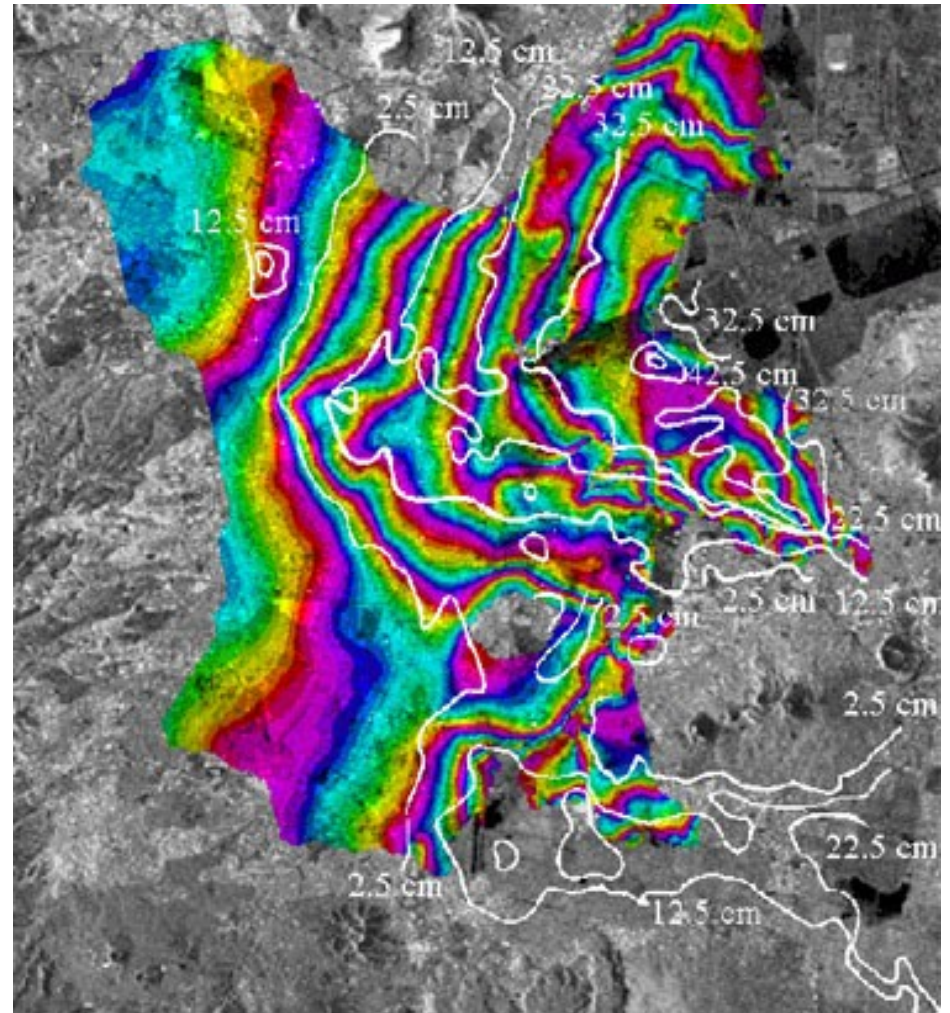
As well as security applications.

The main application areas.

Mexico City subsidence map.

Interferometric image
from Synthetic Aperture Radar
on ERS-1 (ESA).

This kind of information (with
centimetres accuracy) allows the
local authority to plan the urban
developments.



Disaster management:

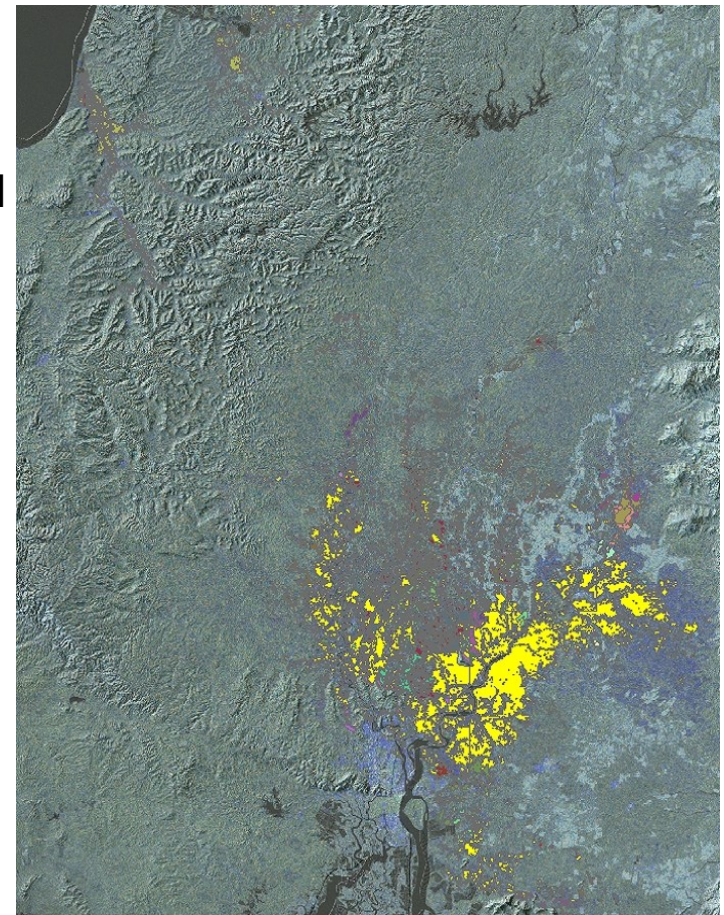
- Coastal hazards/tsunamis
 - Drought
 - Earthquakes
 - Extreme weather/tornados
 - Flooding
 - Landslides
 - Pollution (e.g. oil spills)
 - Sea and lake ice
 - Volcanoes eruptions
 - Wild land fires.
-
- In many cases the satellite observations can help **detecting signs** of the incumbent disaster.
 - In all these cases remote sensing can be used for the **global monitoring and evaluation** of the effects/scale of the disaster (all-weather observations) and consequent planning of the rescue operations. (Disaster Management Charter: free satellite support in case of natural disaster: see <http://www.disasterscharter.org/web/charter/home>)

Jocai (**Ecuador**) February 2012. **Floodings**

Radarsat-2 image (Canadian Space Agency and Ecuadorian Remote Sensing Center (CLIRSEN))

By intersecting the water surface layer with other socioeconomic and infrastructure layers it was possible to map the impacts of floods on civil population, agriculture, education, health, energy, housing, road network and society.

This product shows **crops affected** →



For more details about the various applications associated to sensing from space, please refer to:

- The ITU-R Handbook on : “Earth Exploration Satellite Service”(2011).
- The ITU-R and WMO Handbook on : “Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction”(2008).
- The ITU-D Report on: “The Use of Remote Sensing for Disaster Prediction, Detection and Mitigation”(2008).

WRC recognition of the importance of remote sensing from space

- Extracts from **WRC-12 Resolution 673** (The importance of Earth observation radiocommunication applications)

“

i) that, although meteorological and Earth observation satellites are currently operated by only a limited number of countries, the data and/or related analyses resulting from their operation are **distributed and used globally**, in particular by national weather services **in developed and developing countries** and by climate change-related organizations;

h) that Earth observations are performed **for the benefit of the whole international community** and the data are generally made available at no cost,

....”

Two kinds of passive bands (allocated also to Radioastronomy):

1) Purely passive bands (footnote No 5.340) « All emissions are prohibited in the following bands (only the main ones are shown) :

1400-1427 MHz

10.68-10.7 GHz

23.6-24 GHz

31.3-31.5 GHz

50.2-50.4 GHz

86-92 GHz»

2) Passive bands shared with other active services, in general terrestrial services (Fixed and Mobile Service). In most of these passive bands limits apply to the active services to allow sharing.

- Relevant frequency bands are mainly determined by fixed physical properties (molecular resonance) that cannot be changed. These frequency bands are, therefore, an important natural resource.
- Satellite remote sensors have instrumentation that is significantly more sensitive than that used by other active radiocommunication services. They measure naturally-occurring radiations at very low power levels.
- Passive sensors cannot discriminate between natural and man-made radiation, so data errors often cannot be detected and/or corrected. Maintaining data integrity therefore depends upon the prevention of man-made interference. The imposition of strict limitations on such interference and maximum power on a global basis currently appears as the only solution.
- Attention should be paid in particular to:
 - the combined effect of multiple terrestrial transmitter whose **aggregate signal** may result in severe interference to the sensor. Typical problem: high numbers of low-power devices (e.g. Short Range Devices)
 - the uncontrolled **unwanted emissions** from active transmitters operating in adjacent bands

- The active sensors read the echo of their own signal. This allows some filtering of signals from other similar sources (e.g. terrestrial radars in the radiolocation service).
- But in those bands shared with terrestrial active services problems may arise. The aggregate effect of a large number of devices gives an increase of the noise floor that cannot be filtered by post-processing. This results in harmful interference with wrong data being obtained.
- It is therefore important to avoid introducing high density outdoor terrestrial devices in the bands used by EESS (active), even when these devices are low-power (what matters is the aggregate power seen by the sensor).

Key elements

- RF remote sensing from space is a service providing data of high societal and economical value (local data and global phenomena: weather forecast, climate change, disaster management, etc...).
 - Protection of these sensors needs to be ensured in the interest of all administrations.
 - No national decisions impacting these highly sensitive systems should be taken independently from the ITU. Agreement with the other administrations in ITU is necessary, since the data obtained from these systems serve international and not simply national interest.
- ➔ **ITU Radio Regulations and Recommendations must be carefully followed!**

**Thanks for your attention.
Question time.**

