



CENTRE NATIONAL D'ÉTUDES SPATIALES

CNES Earth Observation programme

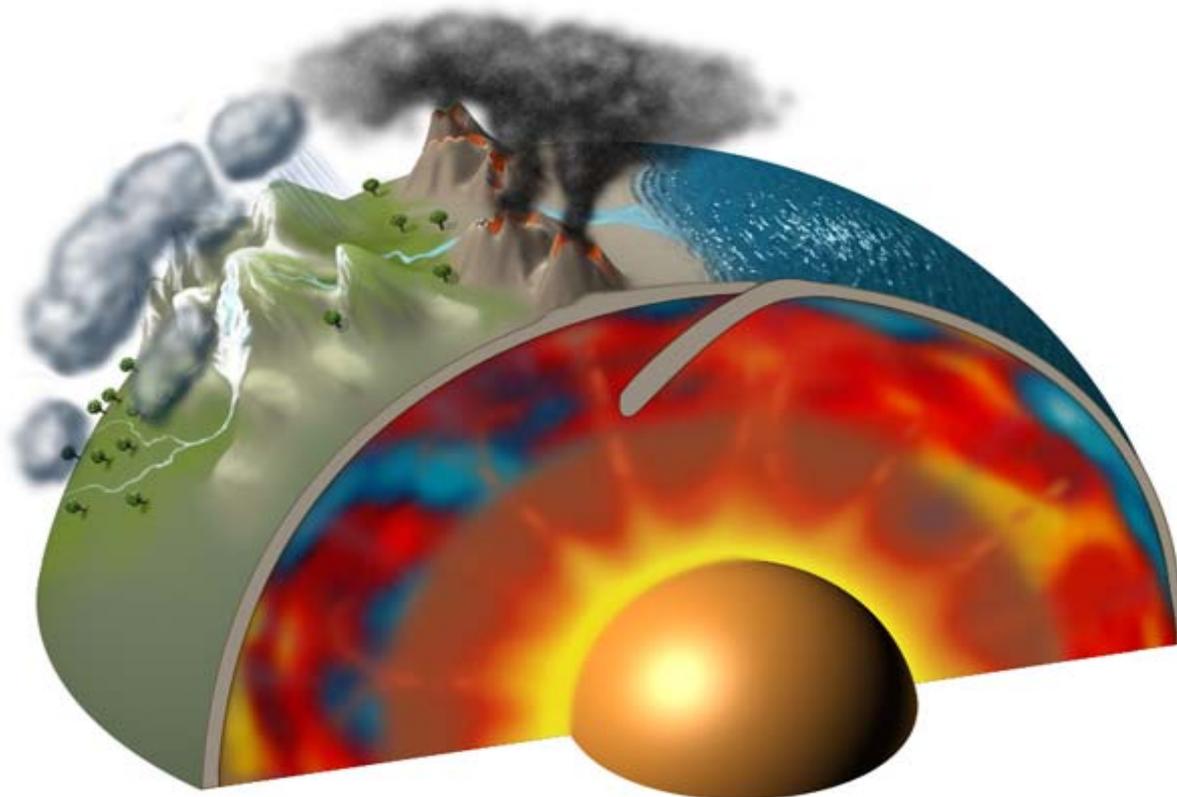
Patrice HENRY

Earth Science main objectives (1/3)

- Scientific knowledge and understanding

- ◆ Earth

Earth

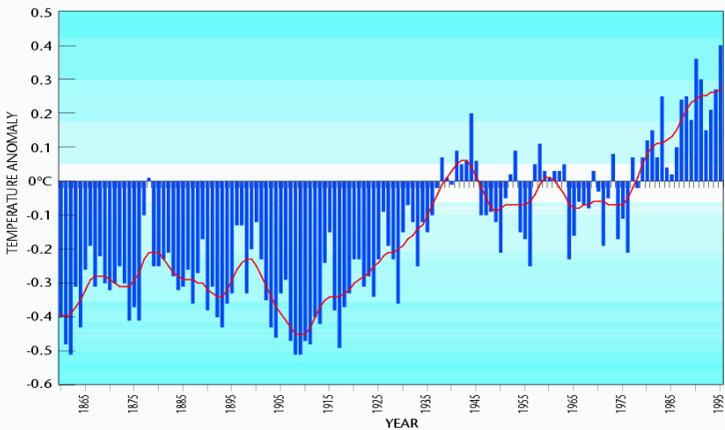


Earth Science main objectives (2/3)

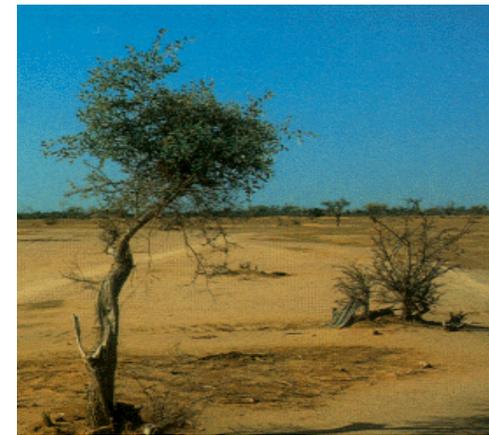
■ Environment and security (GMES - GEO)

- ◆ **Climate and global change (Greenhouse Gases and global warming, El Niño and climate perturbations, Sea level rise, Ozone depletion and atmospheric pollution...)**
- ◆ **Defense**
- ◆ **Hazards**
 - Deforestation, desertification and land degradation
 - Natural and man-made disasters
 - Extreme events
- ◆ **International agreements and Conventions (e.g., Kyoto)**
- ◆ **Development**
 - Renewable resources
 - Non-renewable resources

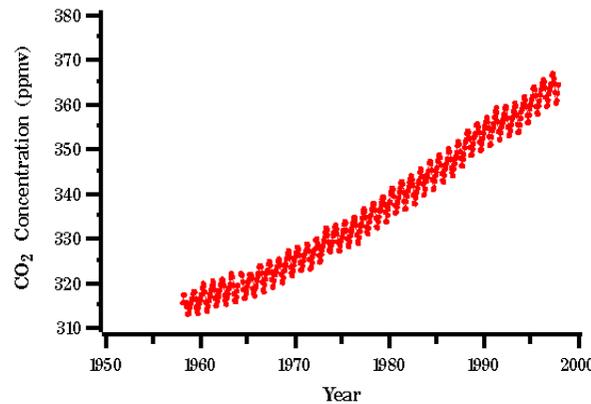
GLOBAL SURFACE TEMPERATURE ANOMALIES



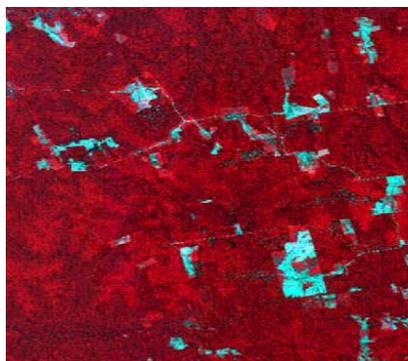
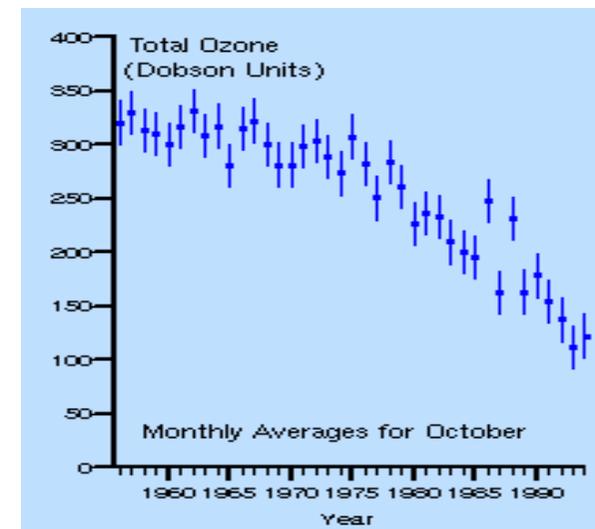
Mauna Loa, Hawaii



UNEP



Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)



French Earth Observation programme

- **It is composed of two main parts:**
 - ◆ **CNES contribution to ESA programme, mainly EOEP, GMES**
 - ◆ **Multilateral programme**

- **The multilateral programme is based on three major components:**
 - ◆ **Scientific missions, undertaken in bilateral or multilateral cooperation (Calipso with the US, Megha/tropiques with ISRO, Venüs with Israel...)**

 - ◆ **Contribution to space observatories of the environment (Jason, with the US and Eumetsat, IASI with Eumetsat)**

 - ◆ **A strong programme on high resolution multispectral mission (SPOT constellation, Pléiades/HR)**

- **The total multilateral civil budget for Earth Observation is around 100 M€/year**

CNES Earth Observation Road Map

■ Missions in operation

- Demeter
- Jason-1
- Jason-2
- SPOT 2-4-5, Végétation 1-2
- Parasol,
- Calipso
- Metop/IASI

■ Missions under development (decided)

- Smos with ESA/CDTI → April 2009
- Megha-Tropiques with ISRO → 2010
- Pléiades 1-2 with EU countries → 2010
- SARAL/Altika with ISRO → 2010
- Venus with ISA → 2010
- Swarm with ESA → 2010
- CFOSAT with CNSA → 2013

■ Phase A

- SIFTI/TRAQ
- SWOT with NASA

Other activities

■ Complementary activities

- ◆ balloons
- ◆ Doris, Argos Systems

■ Contributions

- ◆ GIP Mercator
- ◆ GIP MEDIAS
- ◆ SPOT IMAGE
- ◆ SAFIRE (planes)
- ◆ International Charter “Space and major disasters”

■ Thematic data centres

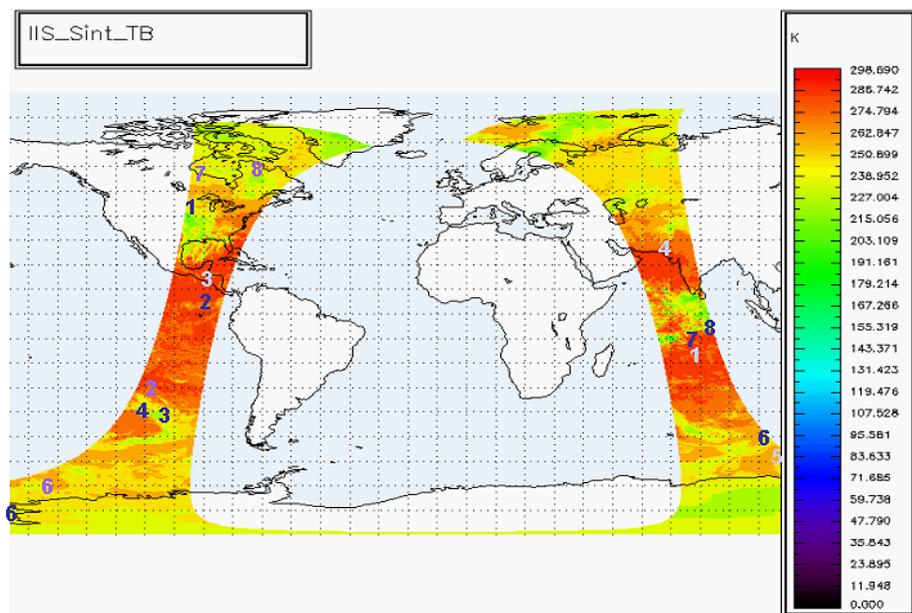
- ◆ ICARE (clouds, aerosols...)
- ◆ ETHER (atmospheric chemistry)
- ◆ POSTEL (land monitoring)
- ◆ SALP (oceanography)

Applications development

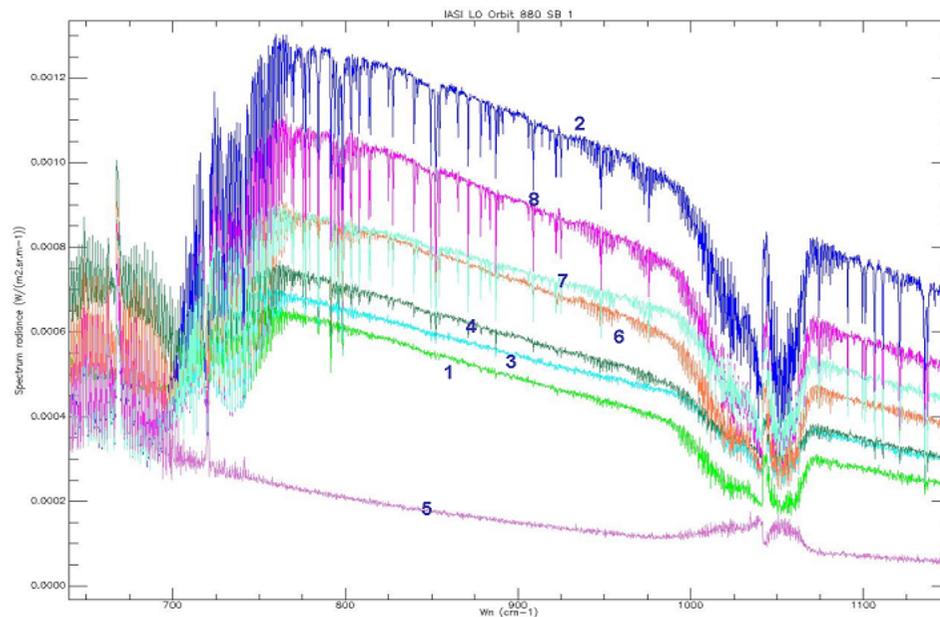
IASI on board METOP satellite



IASI : Preliminary results

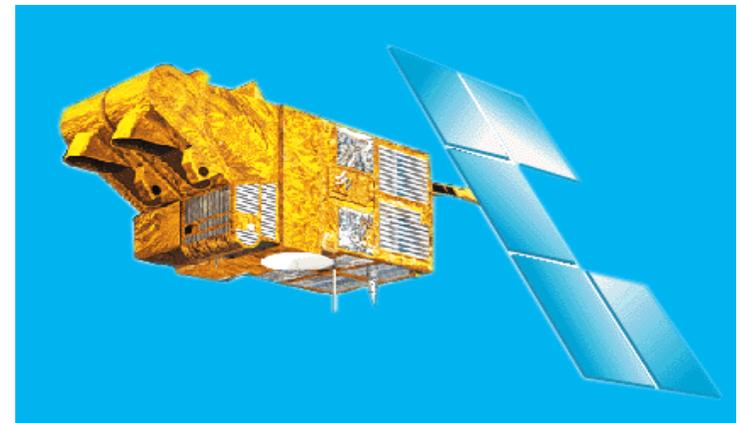
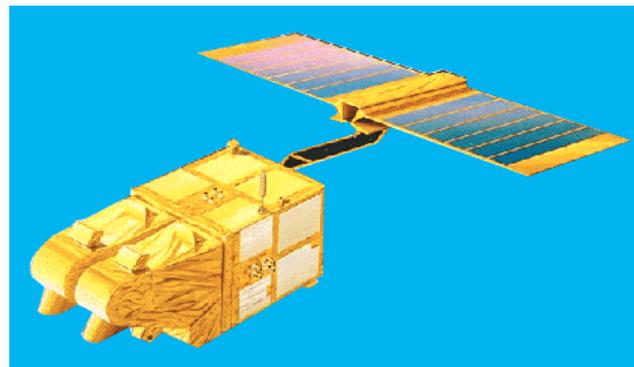
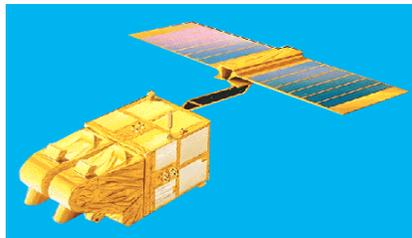
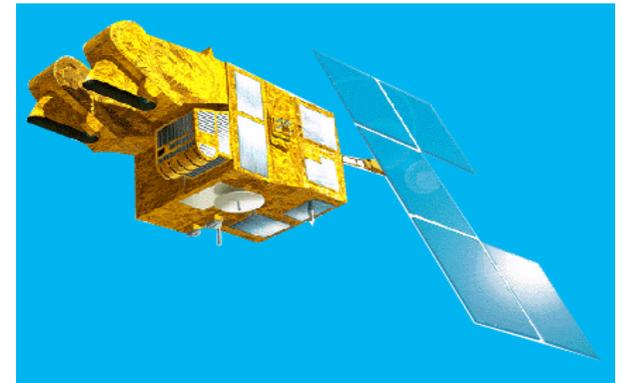
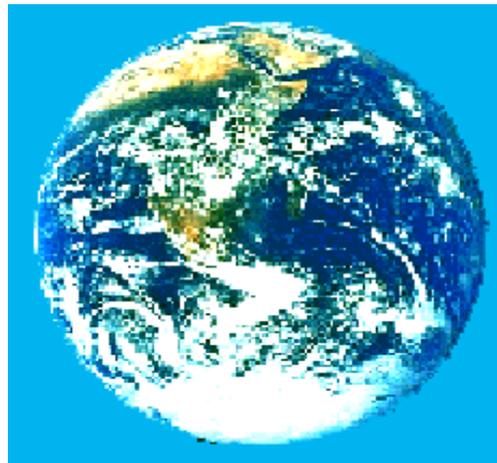
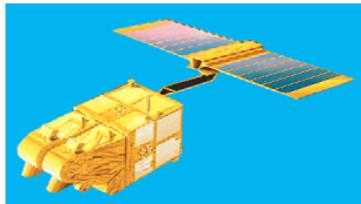


IASI orbit (convolution with the filter of the IIS imager (bandwidth 10,5 -12,5 μm , corresponds to the surface temperature)



IASI spectrum (bandwidth 650-1150 cm^{-1}) corresponding to the blue dots on the left side

The SPOT series



The SPOT program

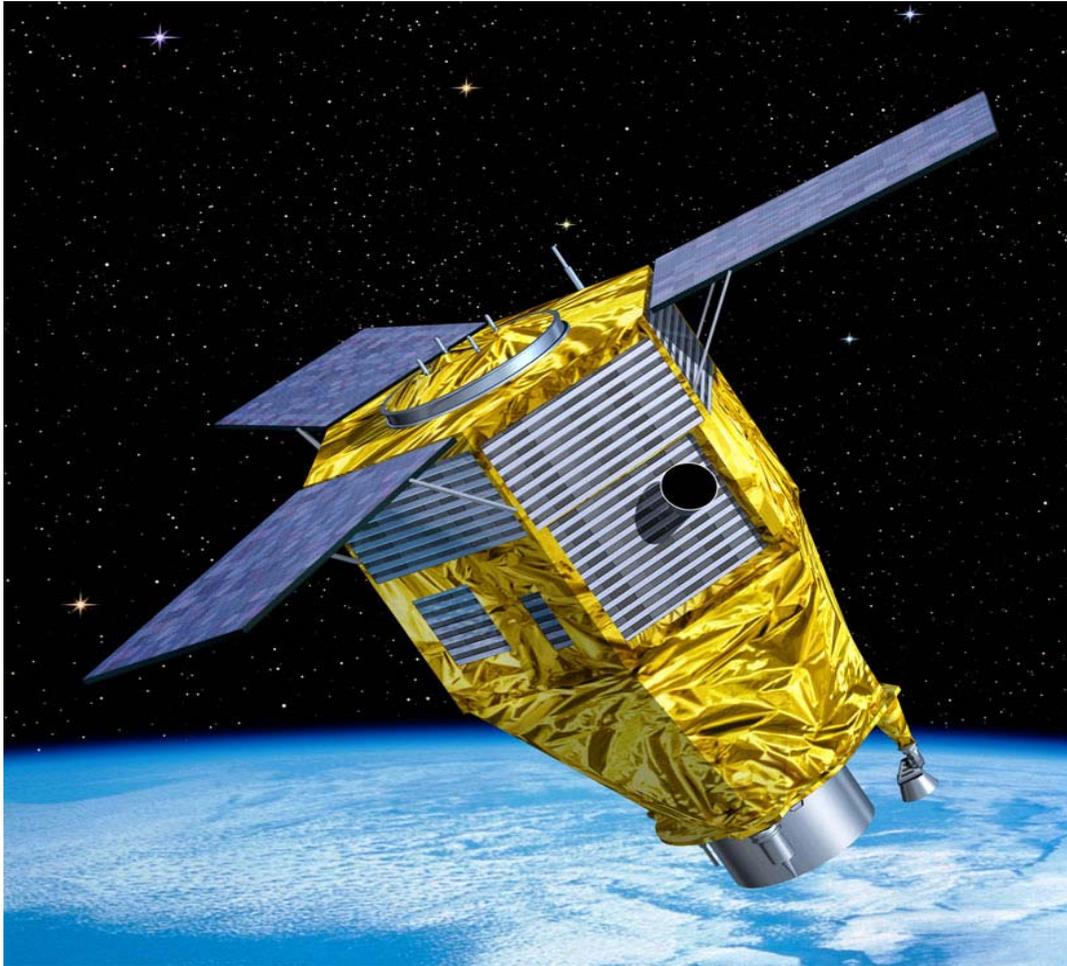
- **SPOT 1** : launched 22 February, 1986
 - ◆ put on a lower orbit in 2003
- **SPOT 2** : launched 22 January, 1990
 - ◆ no more on-board recording since October, 1993
- **SPOT 3** : launched 26 September, 1993
 - ◆ failed on 14 November, 1996
- **SPOT 4** : launched 24 March, 1998
 - ◆ New platform, same resolution
 - ◆ New middle IR band, VEGETATION payload
- **SPOT 5** : launched 4 May 2002
 - ◆ Resolution : 5 m in panchromatic mode, 10 m in spectral mode
2,5 m in panchromatic mode through processing
 - ◆ Passengers: VEGETATION-2 and HRS (High resolution stereo camera)



ISIS & OASIS initiatives : access to the SPOT data at a lower cost for the European scientific community



The PLEIADES/ORFEO Program



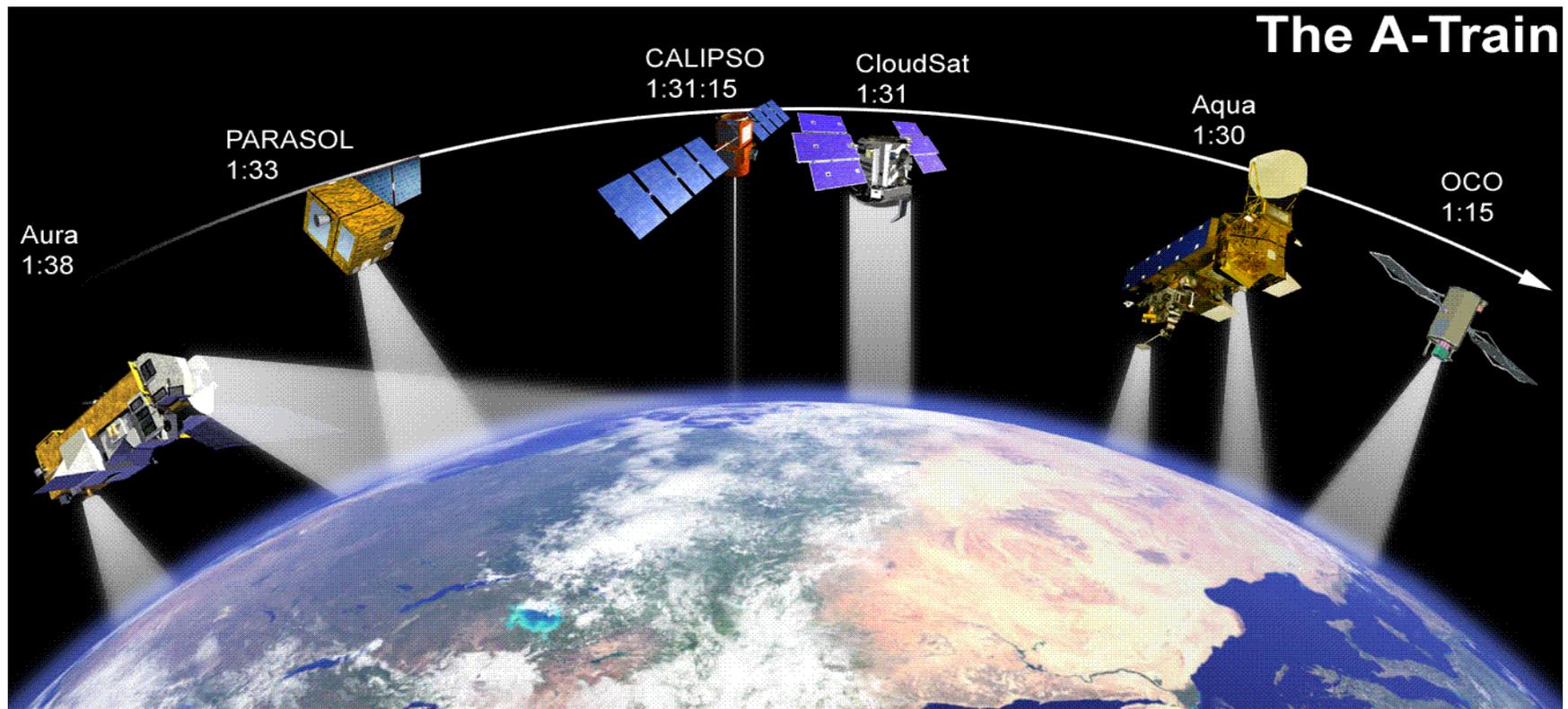


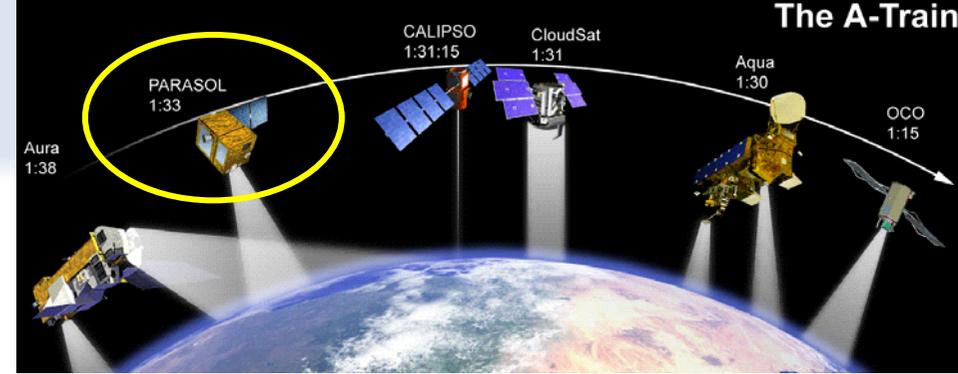
3D
navigation
over
Toulouse
city

Airborne
Simulation
And
Toulouse
City urban
data base

CNES Activities in Physical Atmosphere

Earth radiation budget, aerosols and clouds

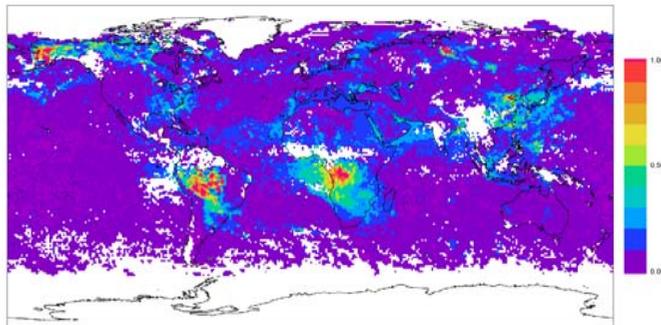




Parasol: measuring aerosol and cloud properties

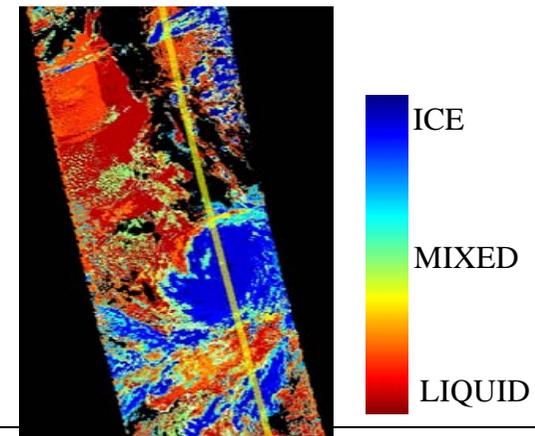
- Parasol (Myriade microsatellite) with the Polder radiometer : launch in December 2004, inside the A-Train.
- More than 2 years of data and products (LOA, LSCE, CNES and Icare).
- Spectral, polarization and directionality measurements of light reflected (490-1020 nm) to determine radiative and microphysical properties of aerosols and clouds.
- Synergy with other A-Train measurements (Modis on Aqua, Caliop on Calipso).
- The goal: a better understanding of the radiative impact of aerosol and clouds on climate.

Small aerosols (<0.35 μm) in August 2005



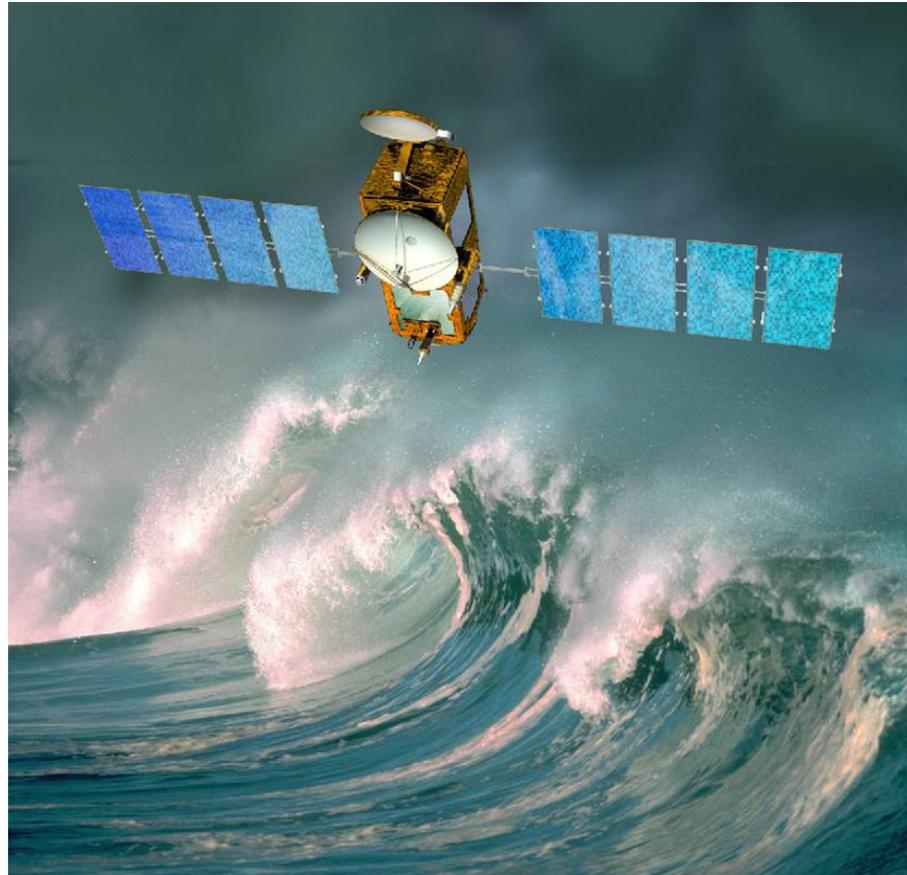
@ LOA

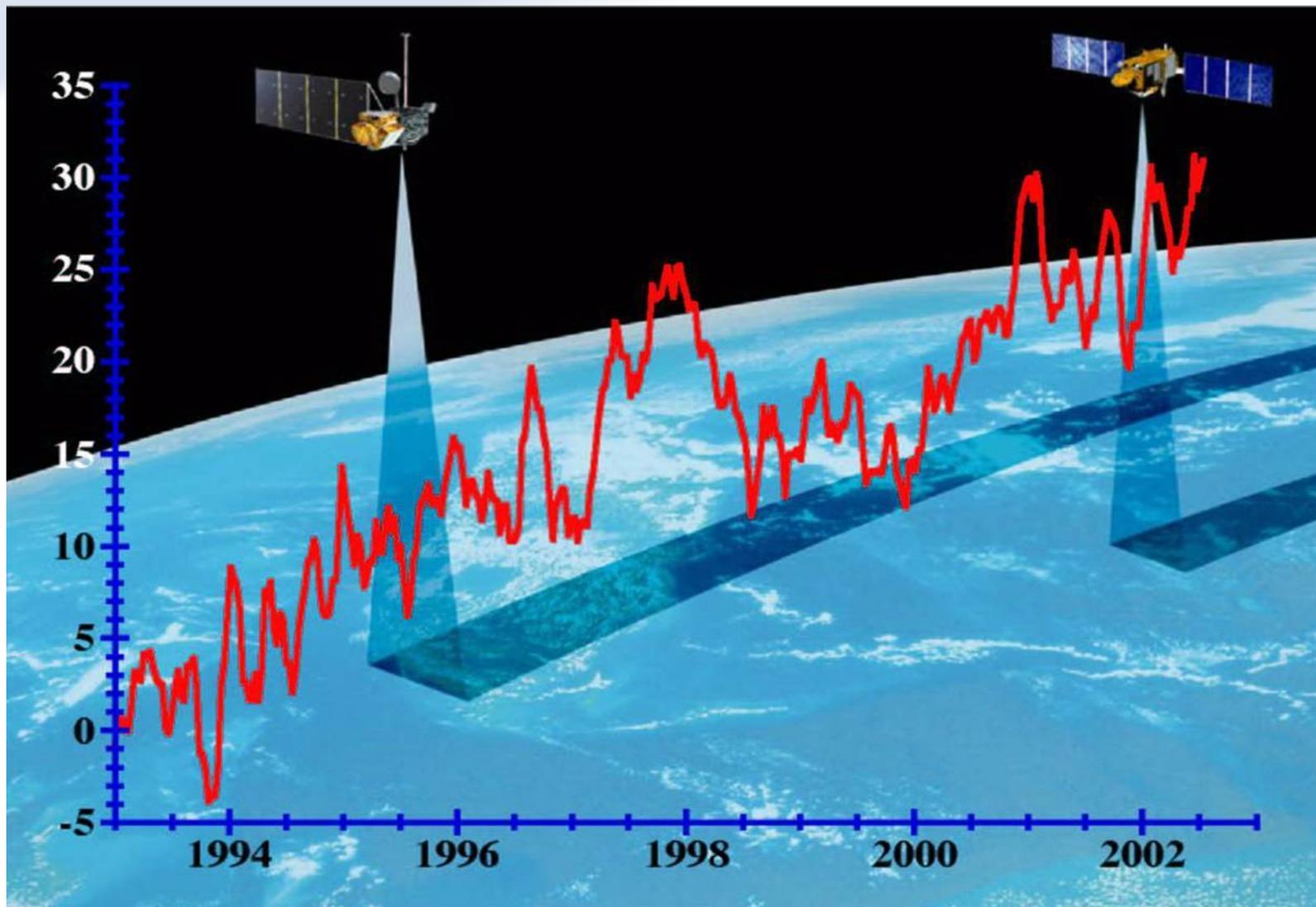
Hurricane Ileana (August 2006). Cloud phase inferred from a Modis-Parasol algorithm



@ LOA

Jason 2



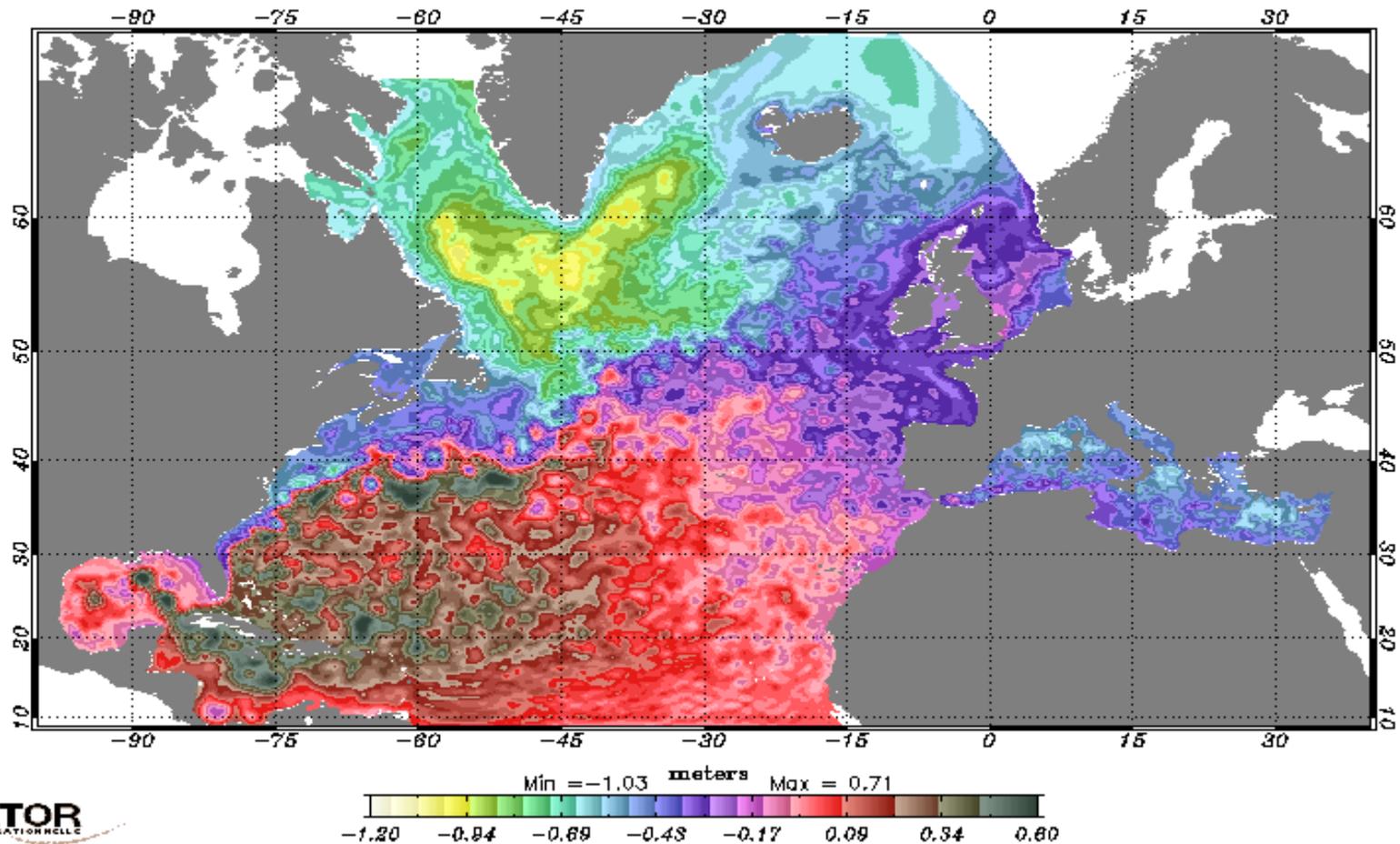


Mean sea level rise 1992-2005 : ~3.0 mm/yr

Operational oceanography

Mercator : Sea state forecast...

2 weeks forecast sea surface height : SSH on 14-12-2005



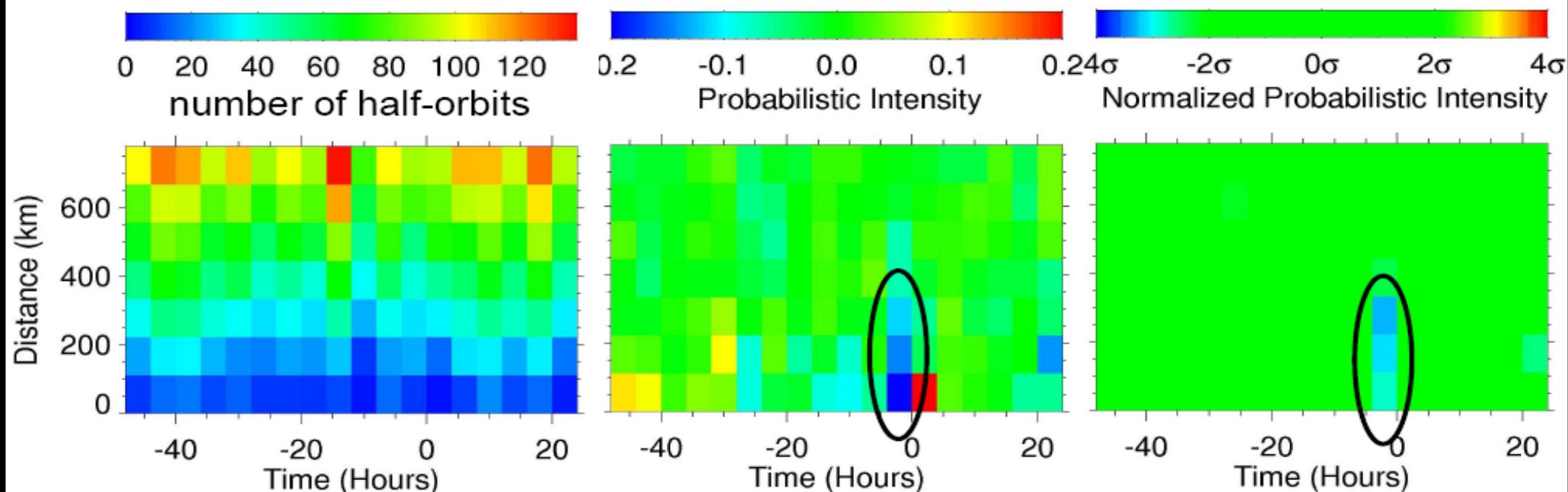
The DEMETER (Detection of ElectroMagnetic Emissions Transmitted from Earthquake Regions) micro-satellite



(c) CNES novembre 2003, ill. D. Ducros

Distance-Time Plot

mag > 5.0, electric field night-time data, frequencies 1055 – 2383 Hz



- the effect seems to be located at distances less than ~ 350 km (3°)
- Dobrovolsky et al. (1979) for the size of earthquake preparation zone gives $\sim 140 - 380$ km
- a decrease was observed also in the corresponding magnetic field data, but it is much weaker and statistically not very significant: average probabilistic intensity ~ -0.06 ($\sim -1.8 \sigma$)

...and the future with phase 0 activities

- **Meteosat Third Generation (MTG)** : completed. Discussion with ESA and Eumetsat on CNES participation for the IR sounder
- **Post EPS Infrared Sounder** (coop. Eumetsat) : in progress (mid 2009).
- **Trade Off LEO-GEO** for ocean colour and disaster monitoring (coop. JAXA) : in progress.
- **TIR MISTIGRI** (coop. Spain) : just started (June 2008).
- Spectro imager / Hyperspectral (coop. schemes fully open) : start delayed in 2008 (working group in progress)
- 3MI (Multiviewing Multichannel Multipolarization Imager) as Polder F/O (interest NOAA): in progress.
- Lidar altimetry (cf Nasa DesDynI): start delayed in 2009
- Micromega (formation flying = F/O of Goce or NASA Grace) : start delayed end 2008
- VGT-Gap Filler with ESA/DTEC : Belgium request. Completed.
- e-Corce (constellation of 1 m satellites for covering the globe in 1 day) : completed.

- **Two new studies planned in 2008-09**
 - ◆ Minicarb for CO2 measurement
 - ◆ Air pollution monitoring from geostationary orbit.

Note : scientific prospective seminar in March, 2009

Phase A : TRAQ/SIFTI

- Proposed at ESA for a research mission dedicated to air quality and science issues related to tropospheric composition and global change. It should deliver high quality, height resolved information on tropospheric composition with small ground footprints.
- 3 complementary instruments:
 - ◆ a UV-Vis_NIR nadir grating imaging spectrometer (TROPOMI)
 - ◆ a novel static infrared (TIR+SWIR) Fourrier Transform interferometer (SIFTI) with an embedded cloud imager
 - ◆ a multi-viewing polarization-resolving imaging radiometer (OCAPI).
- CNES started a Phase A study on SIFTI end 2006. The idea is to measure O3 profile with 5 independant vertical informations (in BL, Troposphere, stratosphere), CO profile with 3, and CO and CH4 columns.
- At nadir the pixel goal is 10 km.
- Combined with the 2 other instruments, TRAQ is designed to be able to monitor pollution
- CNES started also in 2008 a phase 0 on OCAPI (3MI) mainly in order to demonstrate the pixel resolution up to 4*4 km.
- If selected by ESA, launch planned in 2014
- If not : backup scenario to be envisaged (with European partners, with USA?)

Phase A : SWOT Surface Water & Ocean Topography

- Mission combining research needs associated to hydrology and oceanography :
 - Global mapping of water level for rivers, lakes, and oceans (including coasts)
- Principle : Wide-swath interferometric, Ka-band altimeter (KaRIN)
- Cooperation scheme : NASA/CNES
- Phase 0 in 2007
- Launch possible in ~2014



Phase 0 : « Infrared sounder for Post-EPS »

➤ Goals

- **Post-EPS is the 2nd generation Eumetsat polar satellite, scheduled to take the place of Metop in 2018-2020. The phase 0 study deals with a new infrared sounder to take the place of IASI.**
- **Main objectives :**
 - **better knowledge of possible mission scenarios for a new infrared sounder in terms of performances, risks, cost and schedule**
 - **elements for CNES to decide its involvement in the infrared sounder development.**

➤ Schedule

- **1st part: Definition of the initial scenarios' specifications with the users' (Météo-France, Eumetsat, scientists) - end 2007**
- **2nd part: First evaluation of the different scenarios. Until December 2008**
- **3rd part: Scenarios selection, users' workshop, consolidation and conclusions. Until mid-2009**

➤ Perspectives

- **Would allow CNES to decide phase A studies, and then to decide to develop this post-IASI sounder for Eumetsat, as it was done for IASI.**
- **Would allow to keep CNES' excellence in infrared hyperspectral sounding.**
- **Would allow to continue strong cooperation with French meteorologists and atmospheric chemists.**



MISTIGRI



Phase 0

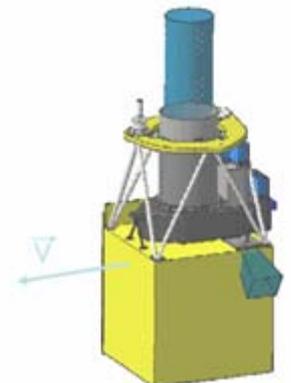
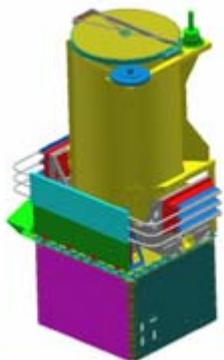
FOR A LOW COST DEMONSTRATOR IN TIR

DEDICATED TO

THE MEASUREMENT OF THE WATER & ENERGY FLUXES

BETWEEN VEGETATION & THE ATMOSPHERE

AND FOREST FIRE MONITORING



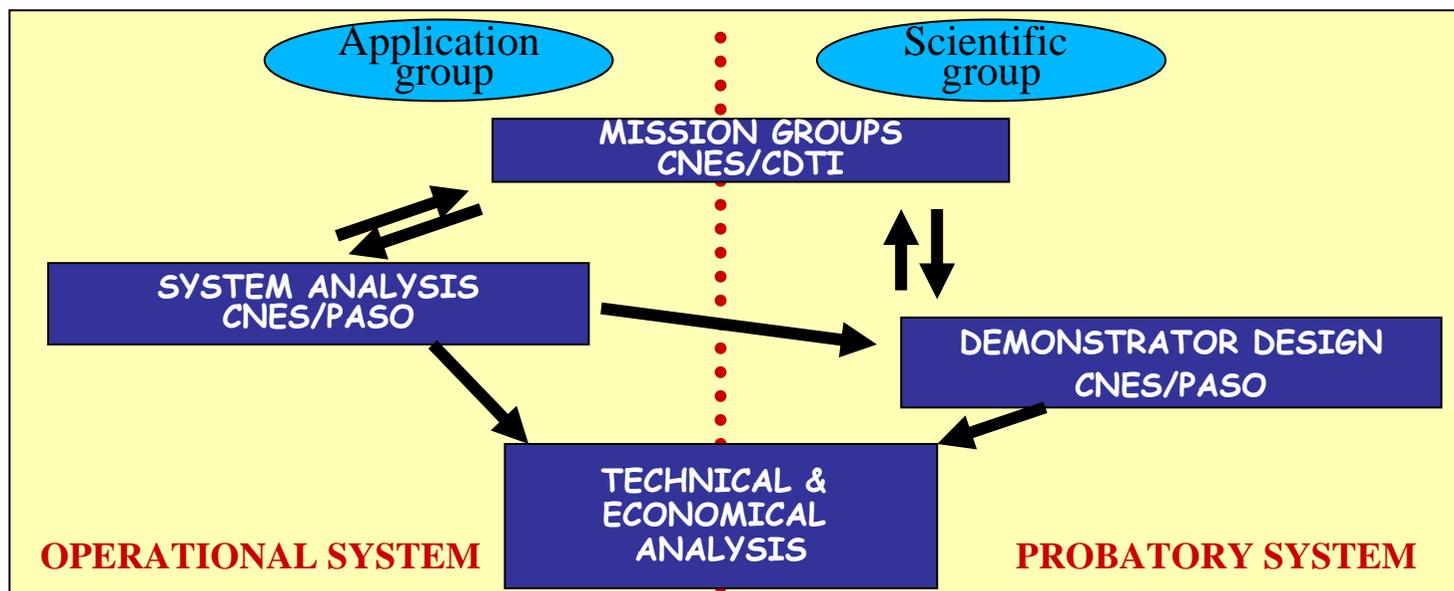
MISTIGRI

■ Schedule

- ◆ Phase 0 started end of September 2007
- ◆ Preliminary results in July 2008
- ◆ End of the study : beginning 2009
- ◆ Launch : 2013-2015 (interest for flying together with ESA/Sentinel2)

■ Organisation

- ◆ Cooperation with Spain under investigation (CDTI)
- ◆ Mission group to be established with European scientific community



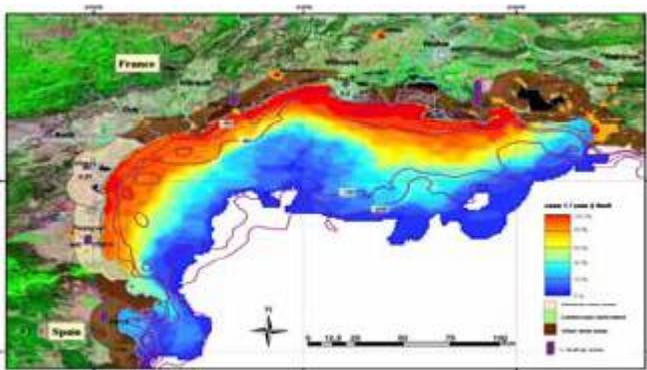
Phase 0 : Trade-off LEO GEO

■ Context : how to offer a permanent observation for two main applications

- ◆ 1- coastal monitoring : water colour, turbidity, quality, biomass production
- ◆ 2- natural disasters monitoring : fires, floods, land slides...

■ Objectives

- ◆ Evaluation and comparison of LEO vs GEO solutions by a complete technical & economical analysis
- ◆ Identification of critical technologies → R&T needs



OCEAN-COASTAL MONITORING



QUICK RESPONSE FOR DISASTER MONITORING

Horizon 2020



Soils, Environmental monitoring,
Coastal zones, Desertification



Low cost
hyperspectral
sensor

Objectives

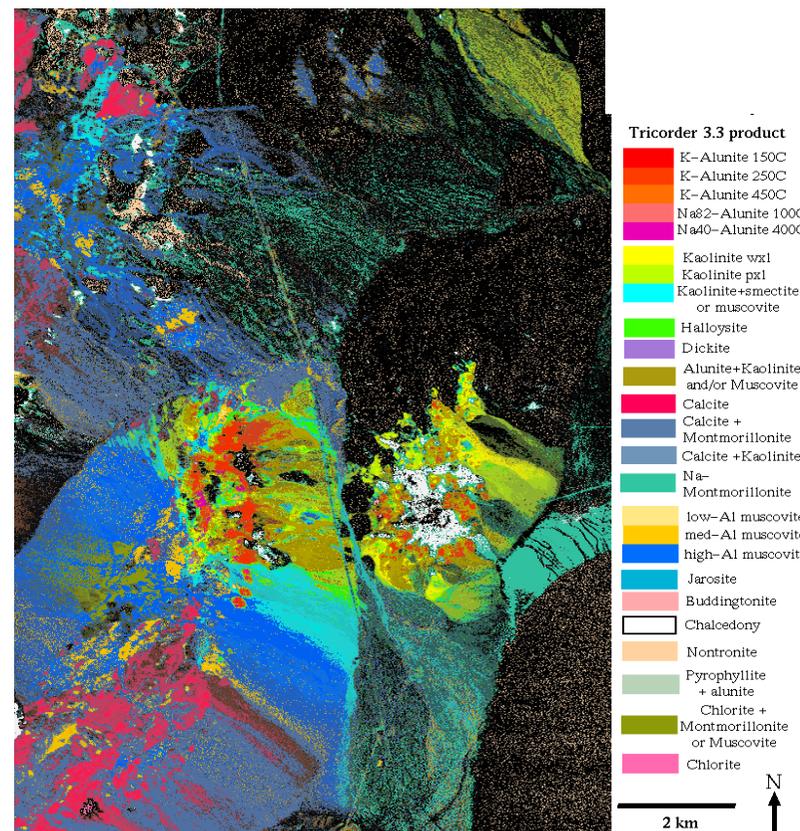
- Clarify the science needs through the CNES hyperspectral working group
- Analyse potential future mission that would be complementary to Enmap
- Identify critical technologies

Outputs

Provide some idea of

- cost
- complexity,
- technical maturity
- performances

Feed the outputs through into the R&T programme where necessary.



Phase 0 : « 3MI: Multiviewing Multichannel Multipolarization Imager »

➤ Goals

- Preliminary study of an advanced radiometer-polarimeter, which would be a Polder-Parasol follow-on.
- To give the necessary elements to prepare the realization of an operational aerosol-cloud monitoring mission on Post-EPS (2nd generation Eumetsat polar satellite, scheduled to take the place of Metop in 2018-2020).

➤ Schedule

- Not yet defined. Must begin in 2008.

➤ Perspectives

- Polder follow-on instrument with extended capacities, in cooperation with the Laboratoire d'Optique Atmosphérique (Lille).
- First demonstration possible on TRAQ mission (2014 ?), in connection with French atmospheric chemists.
- Possible future cooperation with Eumetsat (Post-EPS).
- Interactions with NOAA for the NPOESS programme (APS on NPOESS ?).

Horizon 2020



*Mapping of the gravity field @100km &
Analysis of temporal variations*

**Gravimeters
formation flying**

Scientific requirements:
continental hydrology, solid earth

Study Outputs:

General idea of the cost, complexity, performance and technical maturity of potential technologies.

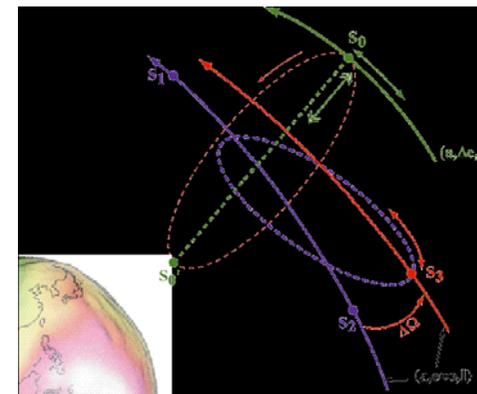
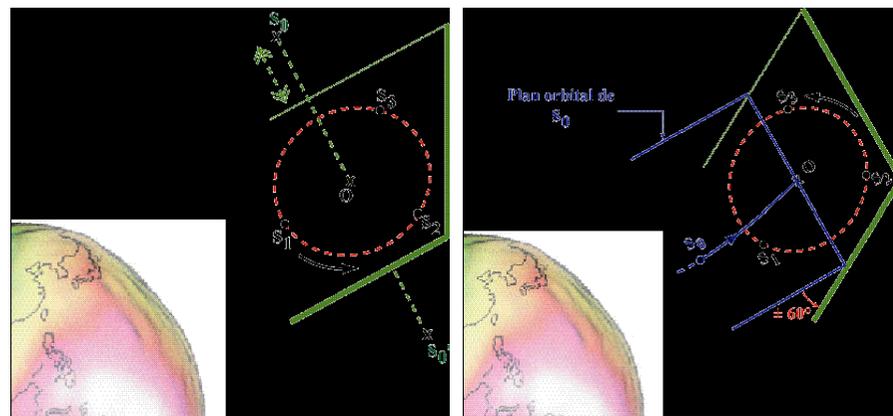
Comparison of different scenarios :

GRACE-2 (2 satellites) : Laser interferometry,
Precision : 10 nm

MICROMEGA (2x2 satellites in 2 orbital plans)

K-band distance measurements

Precision: 1 micron or better

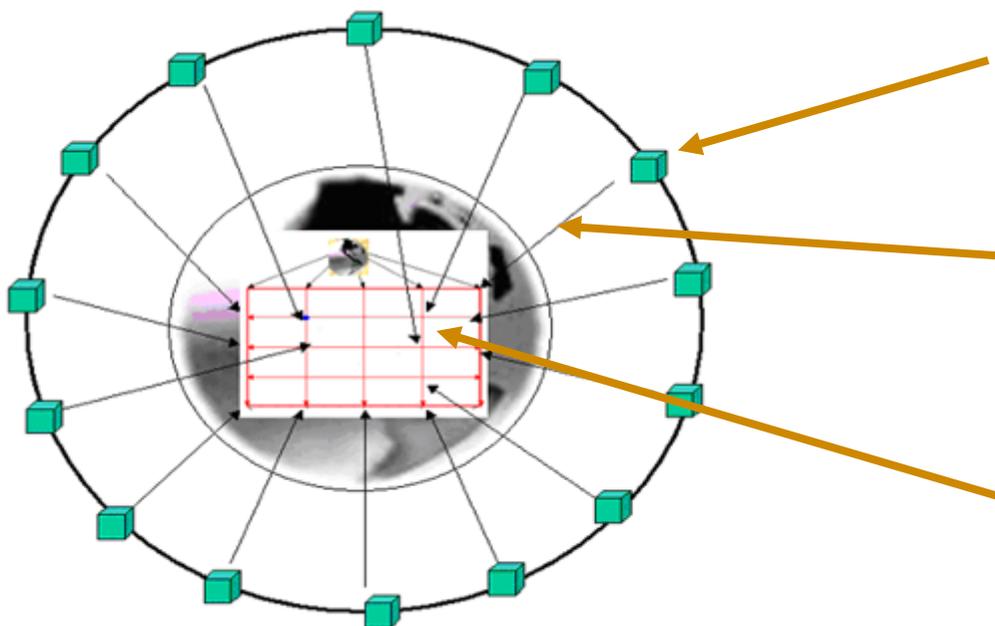


The e-Corce concept

e-Constellation of Observations Recurrent CELLular

■ Questions :

- ◆ Is it possible to imagine a geo portal able to distribute high resolution imagery (~ 1 m) over the entire globe with a daily refreshing capacity ?
- ◆ Is there a technical solution for designing such a system and for manufacturing all components at acceptable recurrent cost for a “mass” market ?



Association / inter operability of 3 distributed layers

- **Spatial layer**
 - ◆ « cellular » observation
 - ◆ Constellation of EO satellites by saturation
- **Telecom layer**
 - ◆ « cellular » communication
 - ◆ Distributed Telecom board-board, board-ground, ground-ground
- **Ground layer**
 - ◆ « cellular » processing
 - ◆ Grid, networks