The CNES Earth Science Program

Objectives, International cooperation and Applications

Aurélie SAND
CNES, France

CNES programs for Earth Science

- Framework : international cooperation
  - European cooperation
    - **bilateral (Belgium, Sweden, Germany, Italy, etc.)**
    - **multilateral (ESA, EUMETSAT, EU)**
  - International cooperation
    - **United States (NASA, NOAA), Japan (JAXA), India (ISRO) etc**
- Satellite and instrument "series" or "families"
  - High resolution imagery satellite series
    - **Optical and radar satellites for science, civilian and defense applications**
  - Meteorological satellite series
    - **Improving operational satellite missions for weather forecast**
  - Research and operational satellite series
    - understanding **the Earth system**
    - **fulfilling the** observational needs **of major international research programs**
    - **fulfilling the GMES objectives**

On-going programs

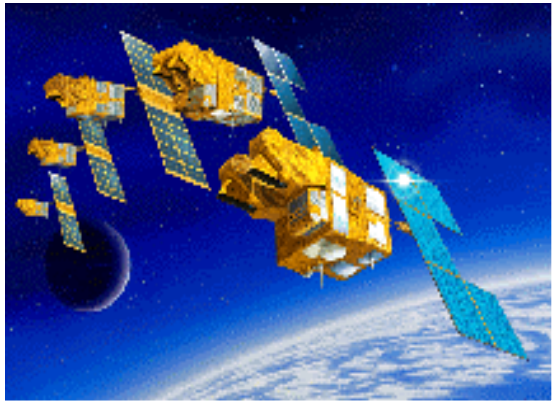
- High resolution imagery satellite series
  - From SPOT-1 to SPOT-5, ERS-1 and 2, ENVISAT
- Meteorological satellite series
  - METEOSAT, MSG
- Research instrument and satellite series
  - Altimetry
    - **TOPEX/POSEIDON, JASON-1, Radar Altimeter/ERS and ENVISAT**
  - Wide field optical imagery
    - **POLDER, VEGETATION, ScaRaB, MERIS**
  - Geophysics
    - **DORIS (SPOT, TOPEX/POSEIDON, JASON, ENVISAT and soon CRYOSAT)**
    - **OERSTED, CHAMP**
    - **DEMETER**
  - Atmospheric chemistry
    - **Airborne instruments (balloons, aircraft),ODIN, ENVISAT (GOMOS, Sciamachy, MIPAS)**

Future programs (decided)

- High resolution imagery satellite series
  - **PLEIADES (ORFEO)**
- Meteorological satellite series
  - **METOP (IASI)**
- Altimetry
  - **JASON-2**
- Geophysics/Oceanography
  - **GOCE (ESA), Cryosat (ESA)**
- Earth radiation budget
  - **CALIPSO (NASA/CNES), PARASOL (POLDER on a microsatellite)**
- Water cycle
  - **SMOS (ESA/CNES/Spain)**
  - **MEGHA-TROPIQUES (CNES/ISRO)**
- Atmospheric Physics and chemistry
  - **STRATEOLE/VORCORE**
  - **AEOLUS (ESA)**
- Continental surfaces
  - **Veμus (with Israel)**

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)

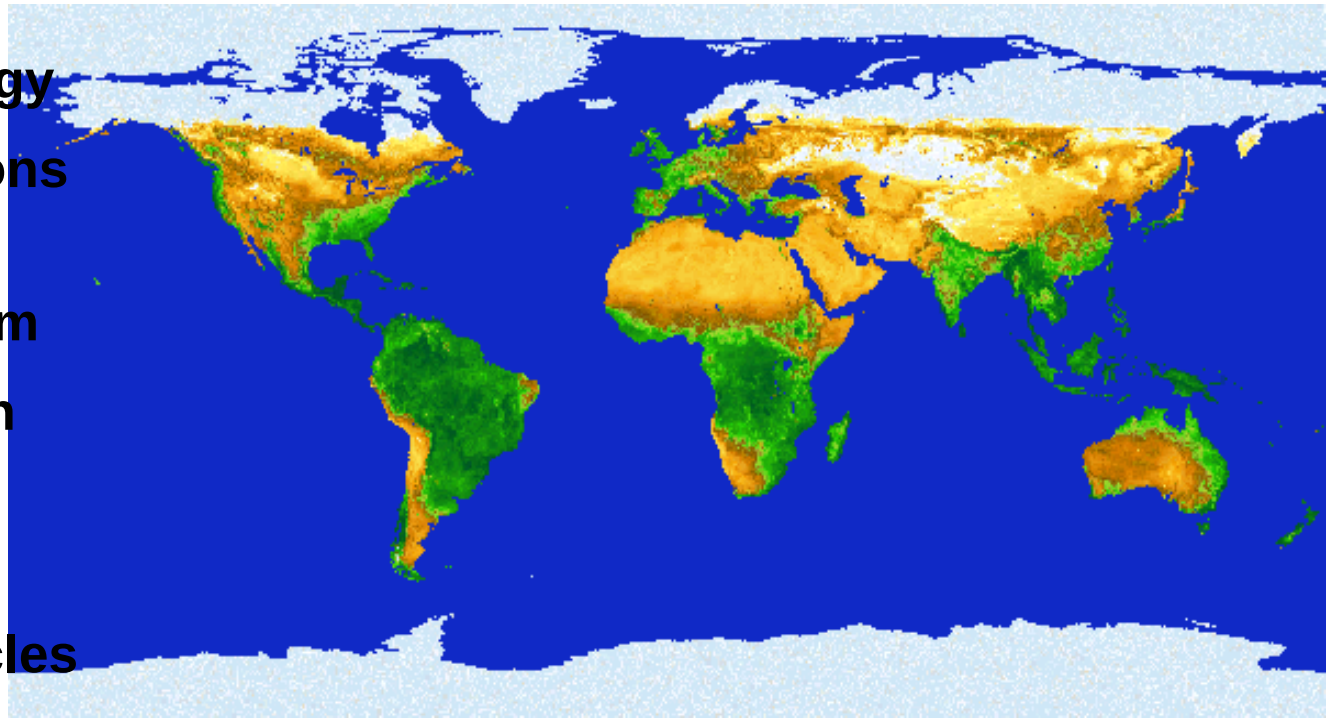


ISIS & OASIS initiatives : access to the SPOT data at a lower cost for the French/European scientific community

SPOT5 2.5m P
Delimitation of types of neighborhood (Centurion, Pretoria)

The VEGETATION Program
Observation of the continental biosphere

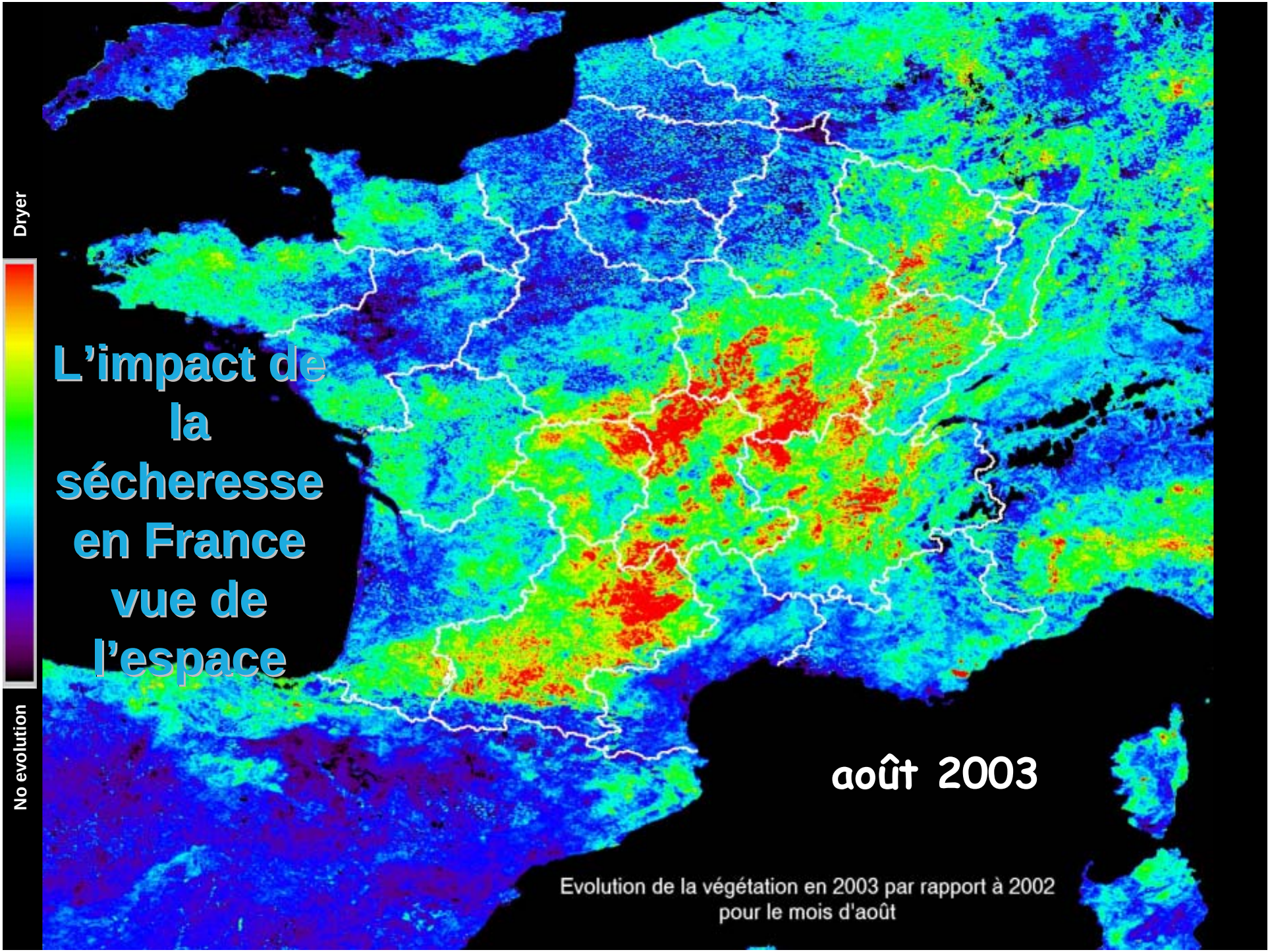
- ⇨ **Vegetation phenology**
- ⇨ **inter-annual variations**
- ⇨ **Crop prevision & early warning system**
- ⇨ **Biomass Production**
- ⇨ **Deforestation monitoring**
- ⇨ **Carbon & Water cycles**



Annual vegetation cycle with SPOT-VEGETATION

Partners : F, B, S, I, European Union
Same spectral bands as SPOT-4
Swath width 2250 km; Resolution 1.1 km
Quasi daily global coverage
Continuous data acquisition of global vegetation cover

Free access to archive data
(3 months)


Dryer
No evolution
L'impact de la sécheresse en France vue de l'espace
août 2003
Evolution de la végétation en 2003 par rapport à 2002
pour le mois d'août

SEAS Guyana Project
Monitoring of Environment assisted by satellite

Technologic payload for the University of Guyana (PUG)
Acquisition & processing of SPOT 5 & ENVISAT satellite images
for research, training and development

IRD
Institut de recherche pour le développement
unité espace s148

SPOT IMAGE

cnes
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A reception station for high resolution data

***Contrat de Plan Etat-Région DocUP Guyane 2000-2006* - (PUG mesure 6.2)**

REGION GUYANE

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
MINISTERE DE LA RECHERCHE

A main tool for cooperation

- The SEAS Guyana station: the only SPOT 2,4,5 and ENVISAT reception station in Amazonia
- A main tool for scientific and technologic regional cooperation with Amazonia and the Cariben
- PUG: A reference center in Latin America and Europe
- A project participating to the european (GMES) and world (GEO) politics of space: Space for citizens

The PLEIADES/ORFEO Program

The ORFEO Program

- ORFEO : Pleiades HR + Cosmo-Skymed in cooperation with Italy
- The dual-use system must meet civil and military requirements for high-resolution optical and radar imagery
- Optical imagery
  - one-metre resolution (20-km swath)
  - other overflight in the next 24 hours -> requires two HR satellites
  - daily acquisition capacity of 250 images per satellite

  Launch : First satellite mid-2008 Second satellite end of 2009

  Lifetime 5 yrs
- Radar imagery (X band SAR)
  - multimode, one-metre resolution, ScanSAR
  - other overflight in the next 12 hours -> requires four SAR satellites
  - daily acquisition capacity of 75 (one-metre) to 375 (wide FOV) images per satellite

  Launch : Starting mid 2005 with one satellite every 9 months

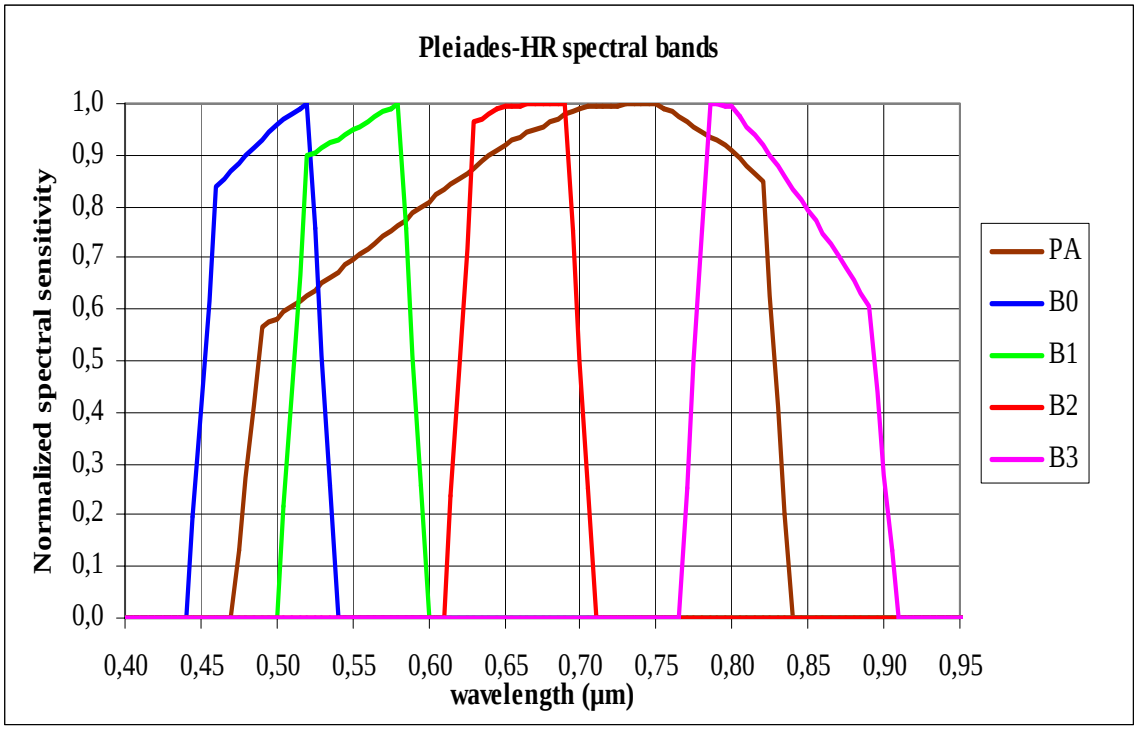
  Lifetime 5 yrs

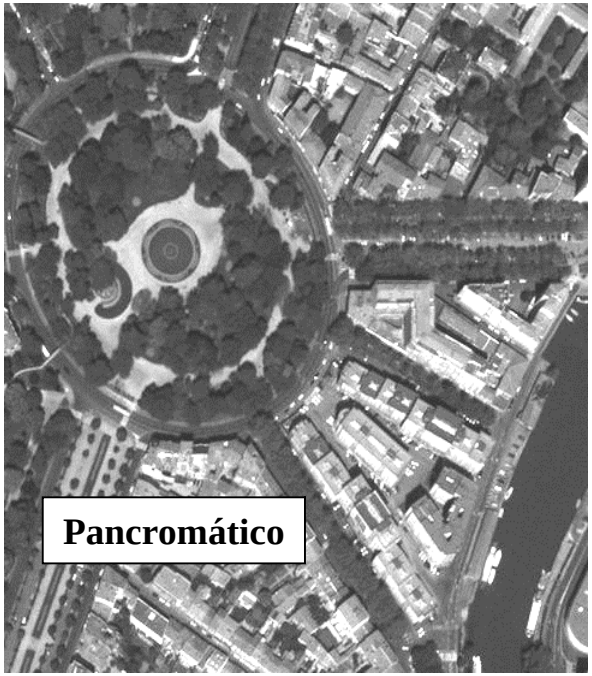
Pléiades-HR

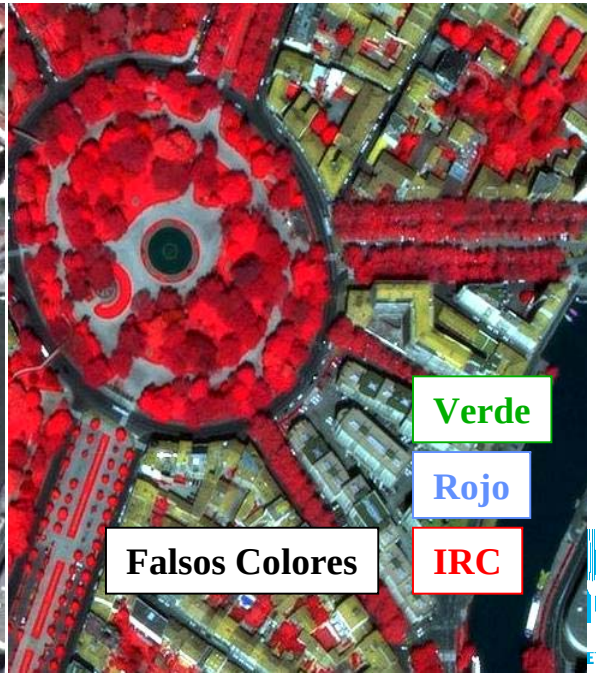
P (Pancromatic): 0.7 m
Wavelenght: 480-830 nm
FTM= 0.2
S/R= 90

XS (Multispectral): 2.8 m

B0 (blue): 430-550 nm
B1 (green): 490-610 nm
B2 (red): 600-720 nm
B3 (NIR): 750-950 nm







Space infrastructures for continental environment

⇨ Current infrastructures

- Optical
  - **SPOT 1 : “desorbited” in November 2003 (17 years in operation !), SPOT 2, 4 and 5 in operation (SPOT 2 in 2 days orbit under investigation : Rhea/Veμus simulation)**
  - **VEGETATION, (POLDER), MERIS, AATSR**
- Radar : ERS, ASAR/ENVISAT, Radarsat

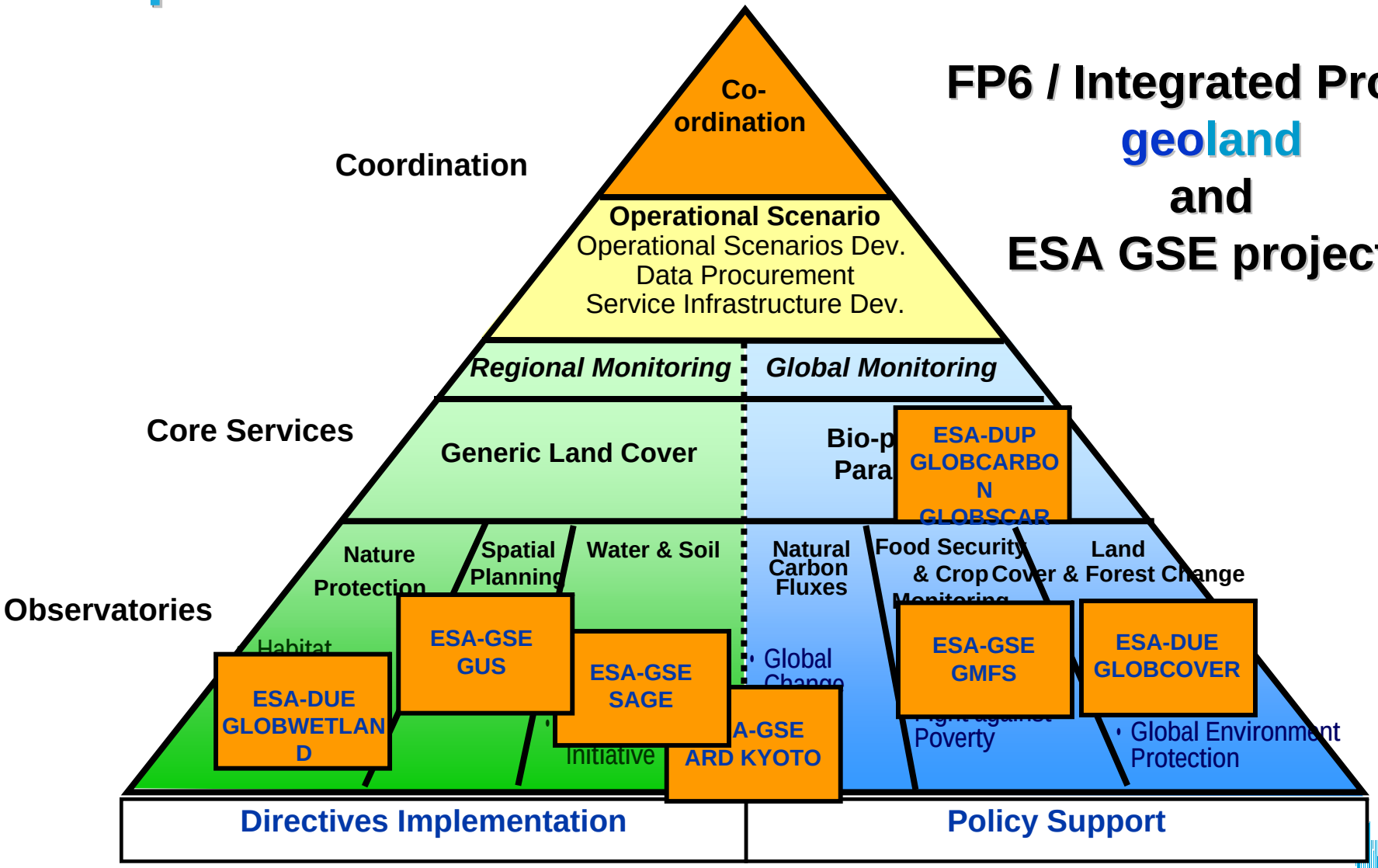
⇨ Future infrastructures

- ORFEO Pleiades /HR & Cosmo Skymed (CNES/ASI)
- **Demonstration / research mission**
  - **Veμus : superspectral microsatellite, 2 days revisit capability, 10m resolution.**
  - **SMOS**
- **Observatories (continuity)**
  - **Constellation for continental environment (GMES services) : superspectral capability, conciliating high spatial and high temporal resolution, phase 0/A launched in 2004;**
  - **SPOT 5 follow-on (HRG+) under study, WFOV sensors**
- Geostationary observation : preliminary study within CNES

Ground infrastructures and services

- At national level : POSTEL (thematic centre)
  - activities centred on biophysical parameters production (LAI, albedo, fAPAR, fCover) extracted from various sensors, e.g. AVHRR, POLDER, VEGETATION, MERIS, MSG;
  - Cooperation between CNES, INSU/CNRS, Météo-France, IRD and INRA
- At European level
  - ESA / DUP-DUE-GSE projects : precursor projects (GLOBCARBON, CYCLOPES…)
  - FP6 / European Commission : GEOLAND (Integrated Project)

Which GMES services to be implemented on land environment ?



FP6 / Integrated Project
geoland
and
ESA GSE projects

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Current/planned projects in Oceanography

- In altimetry :
  - TOPEX-POSEIDON (launched in 1992)
  - JASON1 (launched in 2001)
  - DORIS : radio-positioning system (on board SPOT, TOPEX-POSEIDON, JASON1, ENVISAT) and planned for CRYOSAT, JASON2, Pléiades
  - Use of ENVISAT & GFO data in merged products
  - JASON2 (launch early 2008)
  - ...not forgetting the importance of CHAMP/GRACE/GOCE missions for oceanography through geoid modelling
- Other domains :
  - SMOS (ESA/CNES/CDTI cooperation). Note that France is in charge of the data processing and distribution center for level 3/4 products.
  - POLDER2 : ocean-colour instrument was on MIDORI2 (lost Oct. 2003)
- MERCATOR
  - French center for assimilation of in-situ and space data, modelling and operational forecasting of the ocean.
  - Planned to be integrated into a European center in the 2006-2008 timeframe

Future plans in oceanography

- ALTIKA : Ka-Band altimetry for oceanography at meso-scales
  - Payload : Altimeter Ka + radiometer + DORIS (compatible with microsatellite)
  - Products : sea level products which complements the products derived from Topex-Poseidon and Jason + potential applications for coastal area and inland water bodies
  - Strong support of the research community
- SWIMSAT : real aperture Ku-Band radar with multi-beams
  - Objectives : determine the wave spectrum and sea surface roughness
  - Strong support of the research community
- Geostationnary observation for coastal areas.

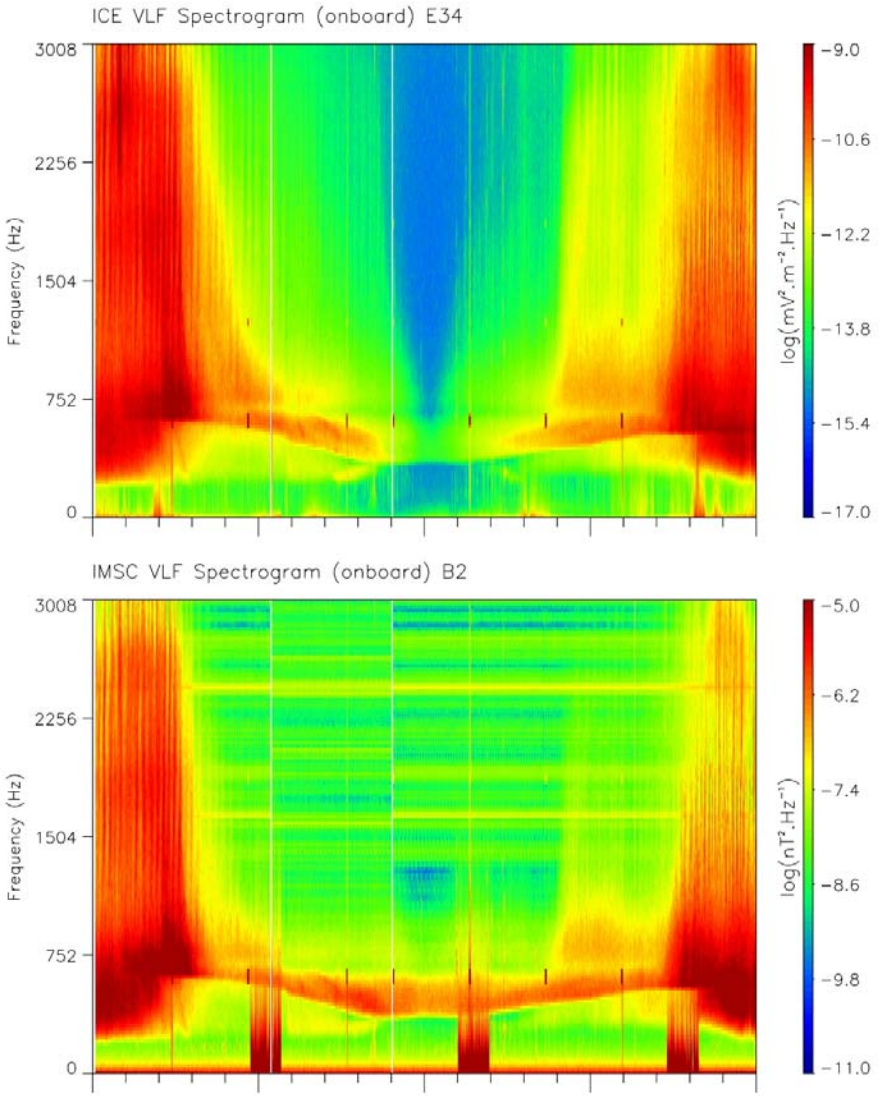
Earth surface dynamics and Geohazards

- On-going and decided programs :
  - SPOT, ERS, ENVISAT for the study of Earth Surface dynamics
  - Pleiades/Orfeo Program
  - International Charter for Natural disasters
  - DEMETER launched in june 2004,
    - **First microsatellite of the Myriade family developped by CNES**
    - **International call for proposals for associated experiments**
    - **Demeter first results : instruments OK**

- Next steps :
  - Interferometric Carthwheel : cluster of 3 microsatellites with radar receivers for DEM
  - ISIS : cluster of 3 satellites (one bi-frequency radar and 2 receivers) to do seismology from space

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

DEMETER Date (m/d/y): 09/01/2004 Orbit: 00883_0



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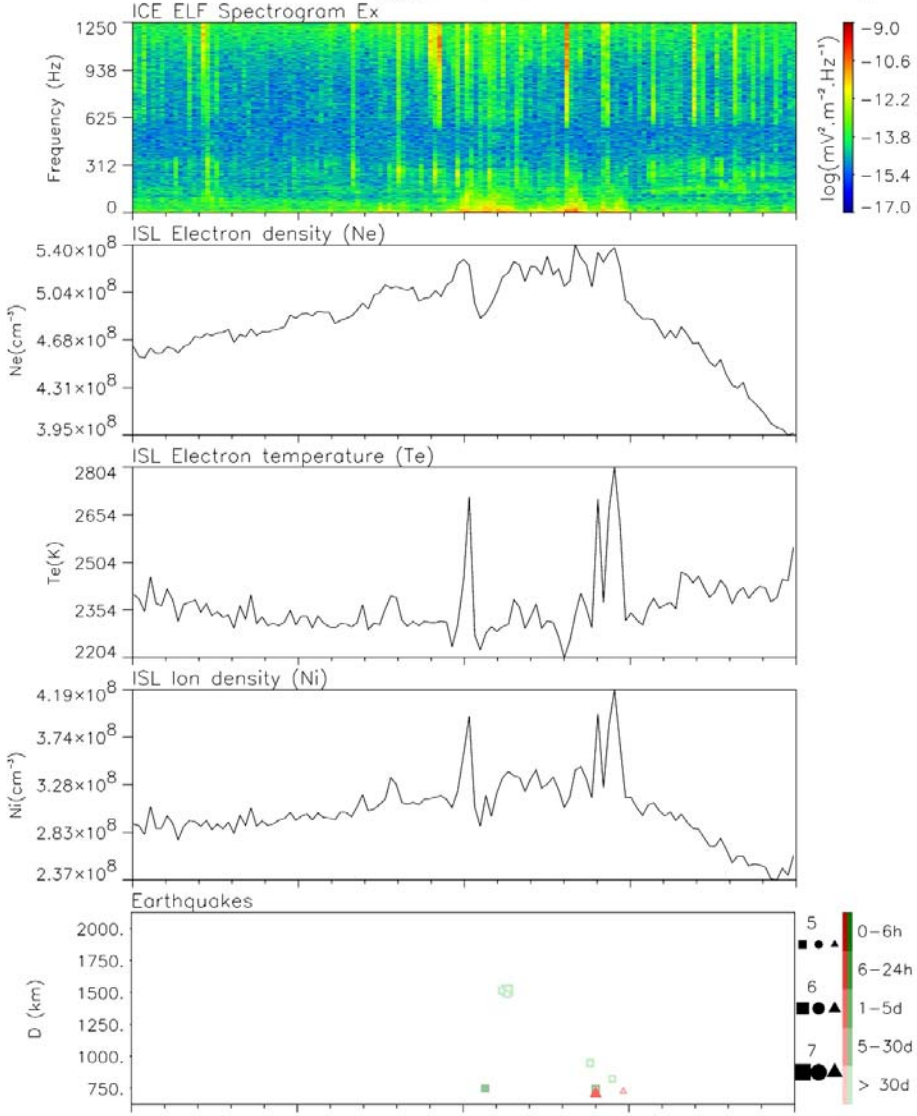
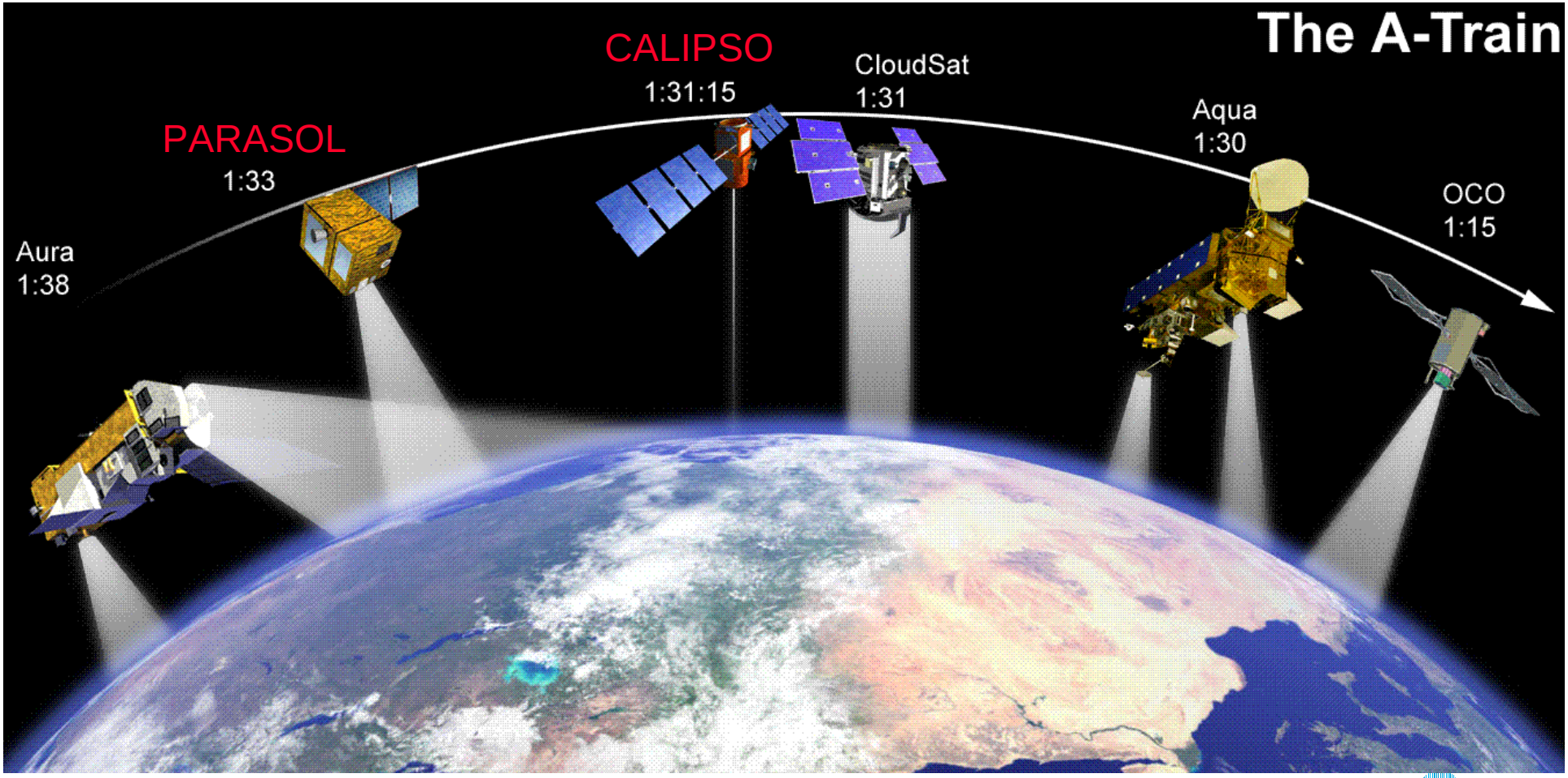
Lat.	72.19	41.26	9.40	-22.44	-53.94
Inv. Lat.	66.41	36.59	6.05	-36.39	-65.04
Alt.	709.03	708.41	712.57	726.45	743.89

DEMETER Date (m/d/y): 09/13/2004 Orbit: 01063_1



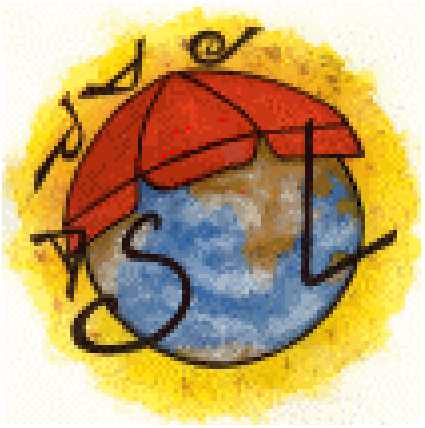
UT/LT	13:58:10/22:08	13:58:40/22:07	13:59:10/22:06	13:59:40/22:05	14:00:10/22:04
Lat.	9.47	11.28	13.08	14.89	16.69
Long.	122.49	122.10	121.70	121.29	120.88
Inv. Lat.	9.65	10.07	10.85	11.79	12.97

CNES Activities in Physical and Chimical Atmosphere



POLARIZATION &
ANISOTROPY of
REFLECTANCE for
ATMOSPHERIC
SCIENCES coupled with
OBSERVATIONS from a
LIDAR

PARASOL



⇨ Microsatellite CNES mission

- **Objective:**
  study of microphysic and radiative properties of clouds and aerosols
- **Payload: MYRIADE**
- **Instrument: POLDER**
- **Ariane V Launch**

Launch with Hélios-II and 4 micro-satellites
Essaim planned on Decembre 10th, 2004

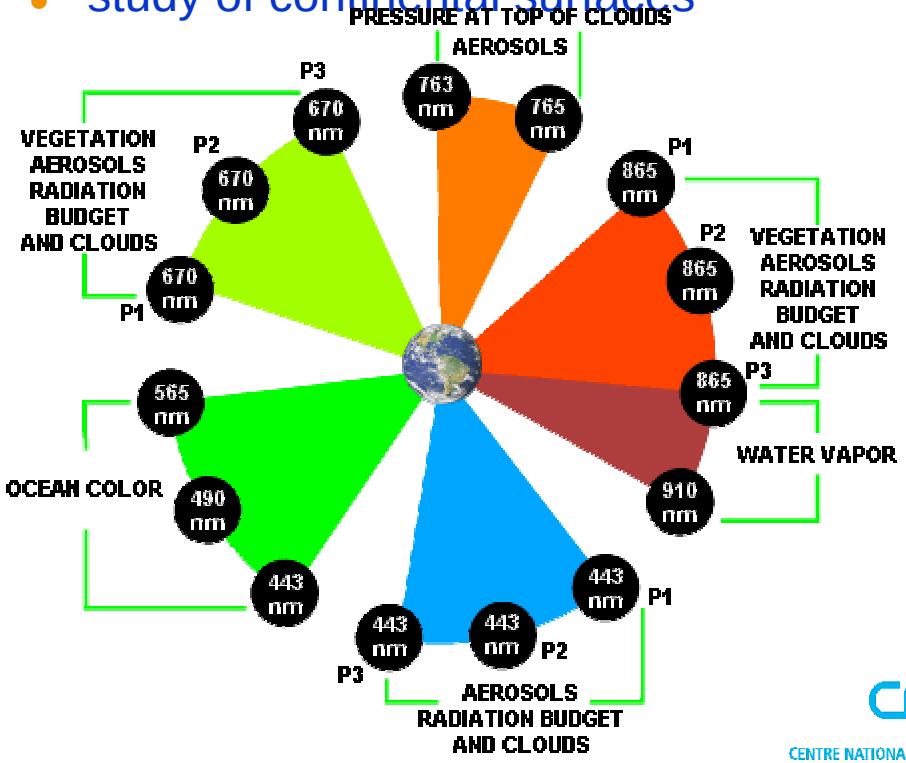
Polder Missions

POLarisation and Directionality of the Earth Reflectance

Polder 1 (August 1996 - 30 June 1997)
Polder 2 (14 December 2002 - 25 Octobre 2003)
on satellites ADEOS/MIDORI

Polarimetric radiometer with wide swath

- study of the ocean colour
- study of aerosols and clouds
- study of continental surfaces



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CNES Programs for Physical Atmosphere

Operational Meteorology

- MSG and METOP (EUMETSAT)
- IASI
- Preparatory studies for MTG

Radiative Budget

- SCARAB with India (M/T)
- POLDER
- A-Train : IIR CALIPSO + PARASOL
- EARTHCARE (ESA)

ICARE

Water Cycle

- SMOS (ESA)
- MEGHA-TROPIQUES with ISRO
- E-GPM (ESA)

Wind Measurements

- AEOLUS (ESA)
- VORCORE (Pressurised Stratospheric Balloons)

- AMMA (International Campaign West Africa 2006)

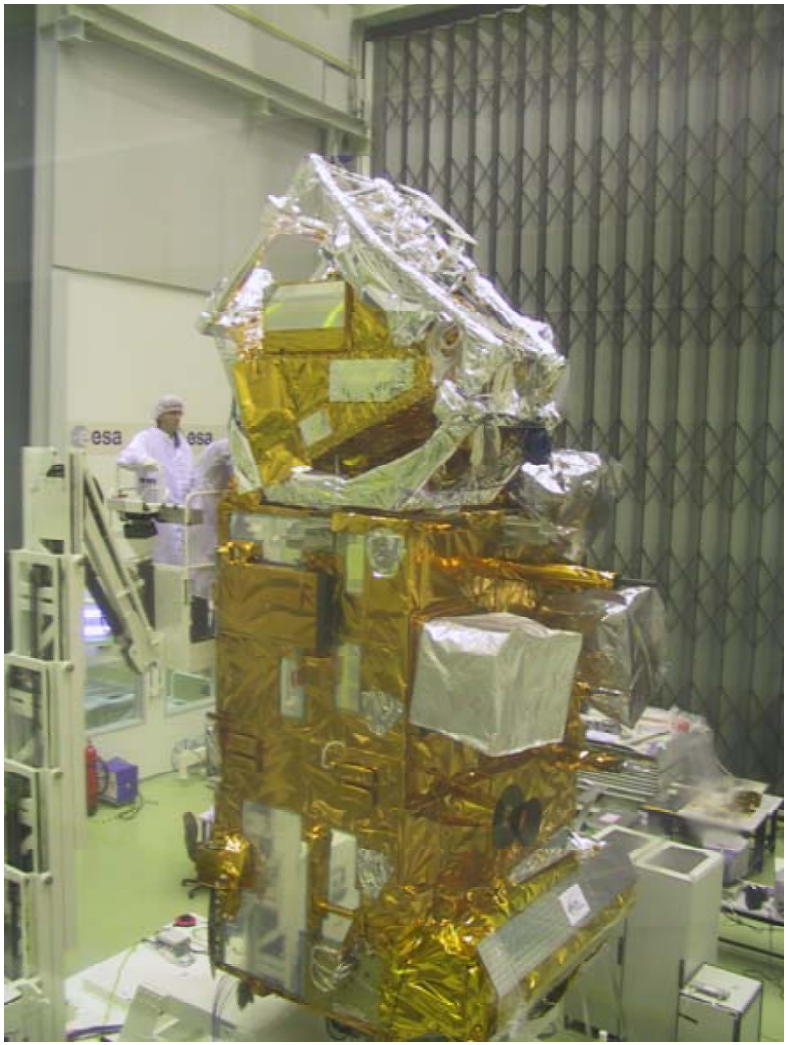
IASI

⇨ Atmospheric Interferometer for Infrared Soundings

- development of 3 flight models on board the METOP satellites in cooperation with EUMETSAT

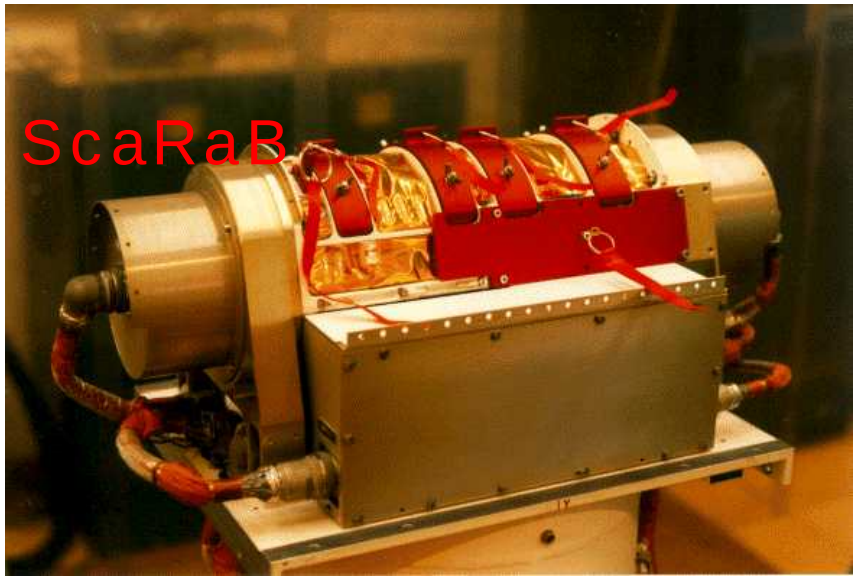
⇨ Objectives

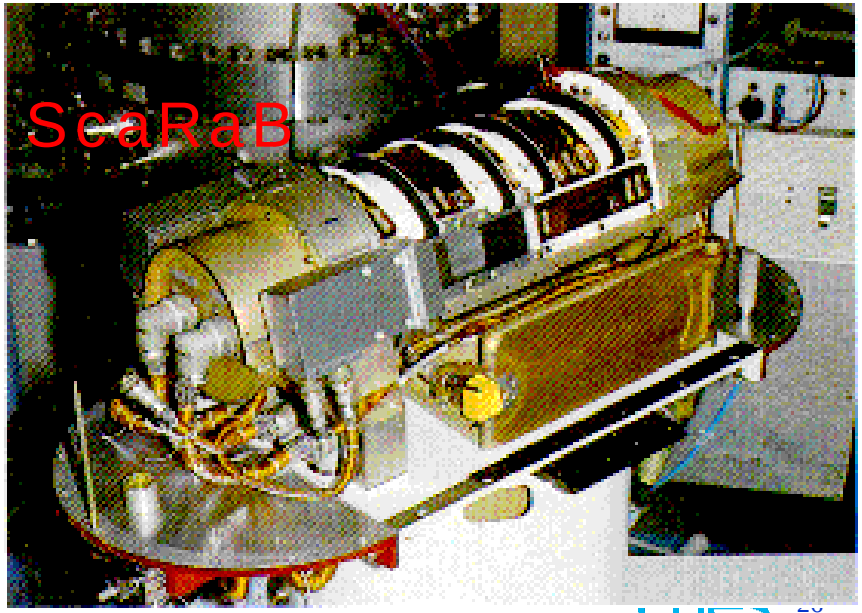
- to satify the need of operational meteorology in soundings
  - **temperature 1K/km**
  - **humidity 10%/km**
  - **ozone**
- climate surveillance and study
- research in atmospheric chimie
  - **CO**
  - **CH4**
  - **N2O**
  - **...**



Earth Radiative budget missions

- ERB/ ERBE (1978-89)
- SCARAB
  - METEOR march 94 to feb. 95
  - RESURS nov. 98 a march 99
  - MEGHA-TROPIQUES
- CERES
  - TRMM dec. 97
  - TERRA march 00
  - AQUA april 02

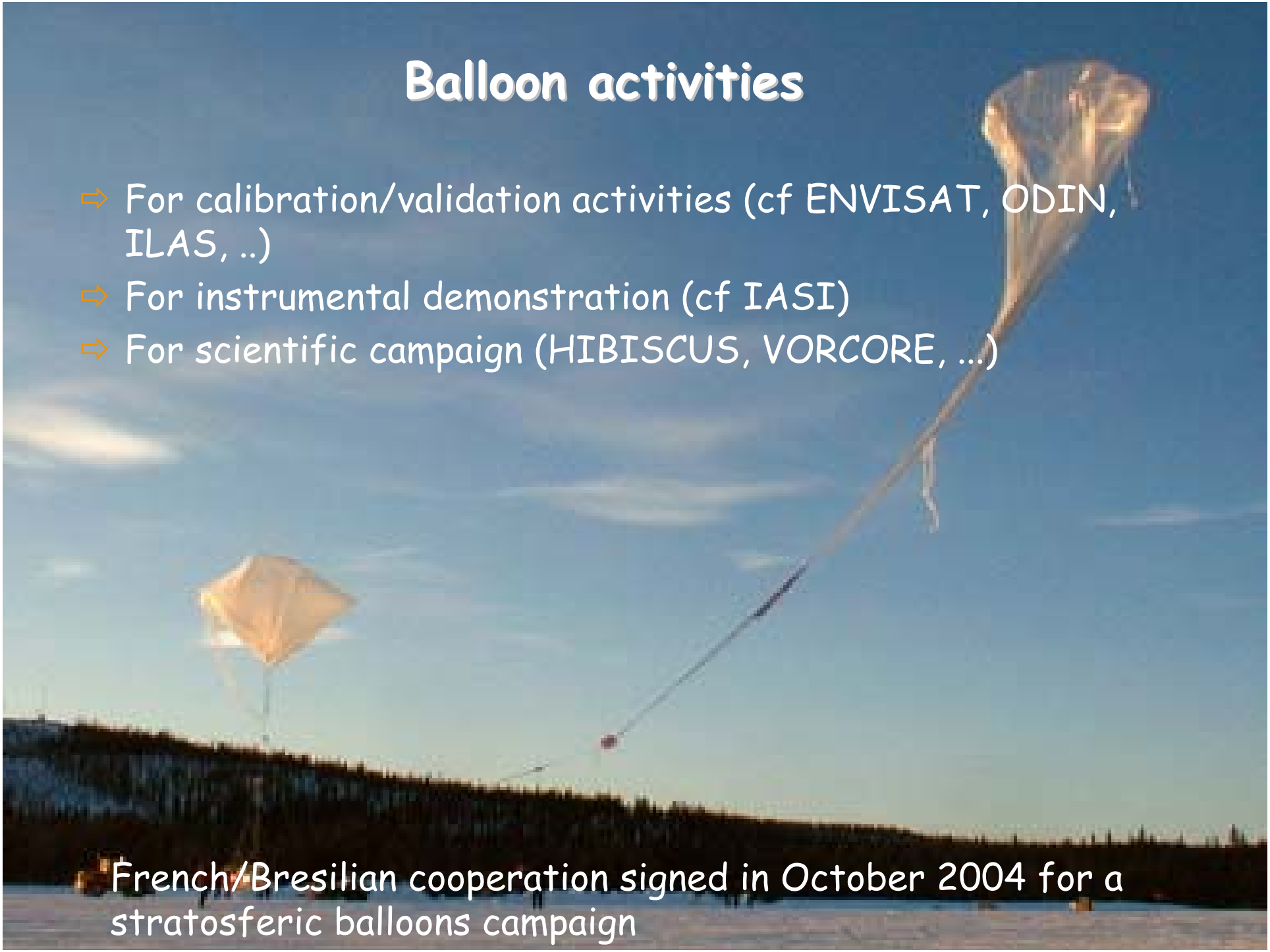




MEGHA-TROPIQUES
MOU signed en novembre 2004
CNES contribution:
- radiometer SCARAB
- microwave sounder SAPHIR
- microwave radiometer MADRAS (element MARFEQ)

Balloon activities

- For calibration/validation activities (cf ENVISAT, ODIN, ILAS, ..)
- For instrumental demonstration (cf IASI)
- For scientific campaign (HIBISCUS, VORCORE, ...)



French/Bresilian cooperation signed in October 2004 for a stratosferic balloons campaign

The Earth Observation at CNES

- Instruments and payloads
  - cooperation bilateral and multilateral for programs realization
  - Active presence in all EO themes:

  geophysic, oceanography, continental surfaces and atmosphere
- ground segments and thematic poles for data processing and production of dedicated information
  - SSALTO, ETHER, ICARE, POSTEL
- Applications development
  - A CNES team dedicated to support the EO data users and to develop new applications
- Active participation to the European programme GMES and to international programs
  - Integrated projects, GMES services and future missions
  - GEO, CEOS, …,
  - actor of the « International charte for natural desasters »