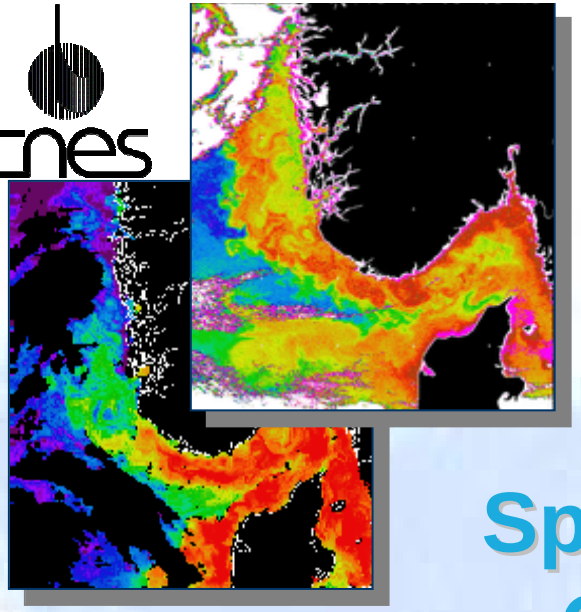
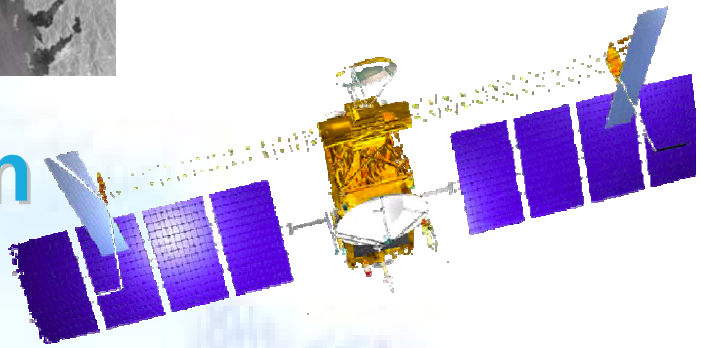
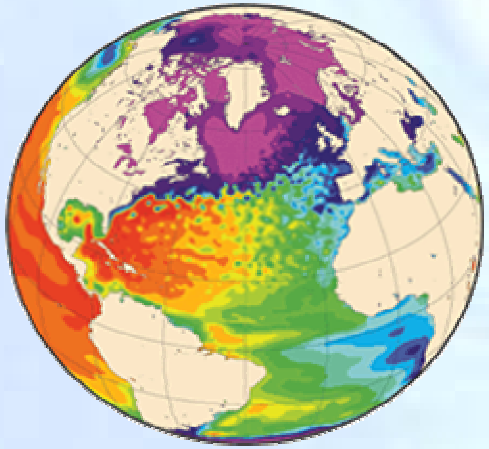


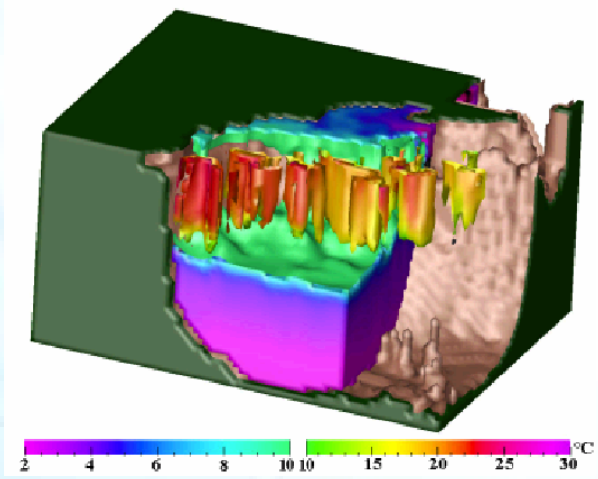
Space Activities in Oceanography



Prepared by Eric Thouvenot

Direction for Strategy and Programs - CNES

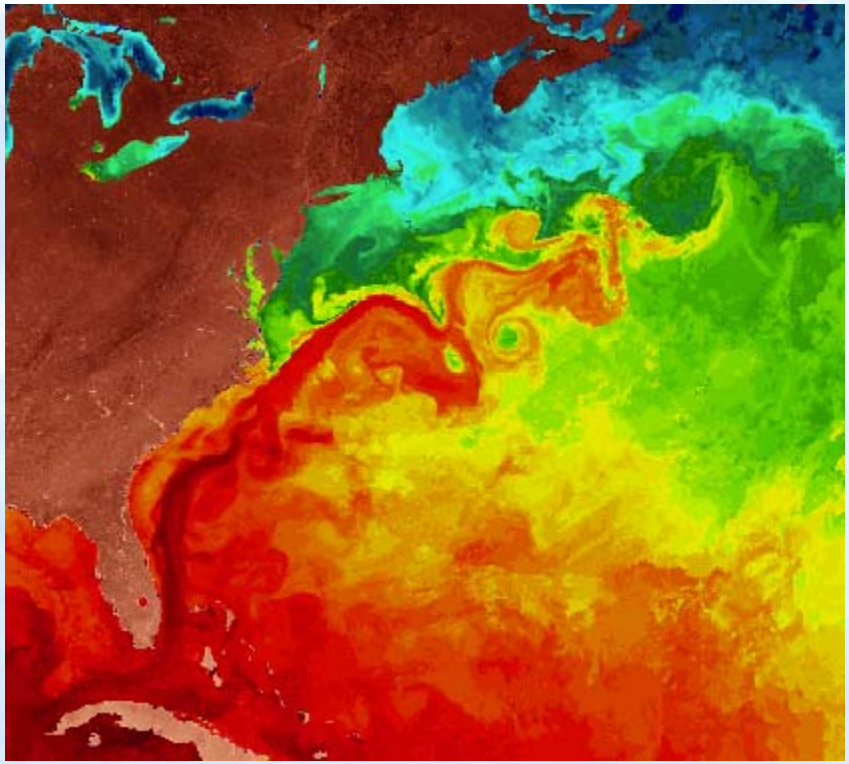




Why Observing oceans ?

- The Ocean covers 70 % of the Earth
- 3.8 km depth in average, 96% of the Earth water
- Major climatic role
  - Thermal exchange with the atmosphere
  - Energy and mass transport
  - CO_2 absorption
- 50 % of the population < 100 km near the coast
- Many activities related to the Ocean
  - Sea transport, Fish industry, Tourism, Pollution, Security, Coast management...
- Coastal observations from space are still a challenge

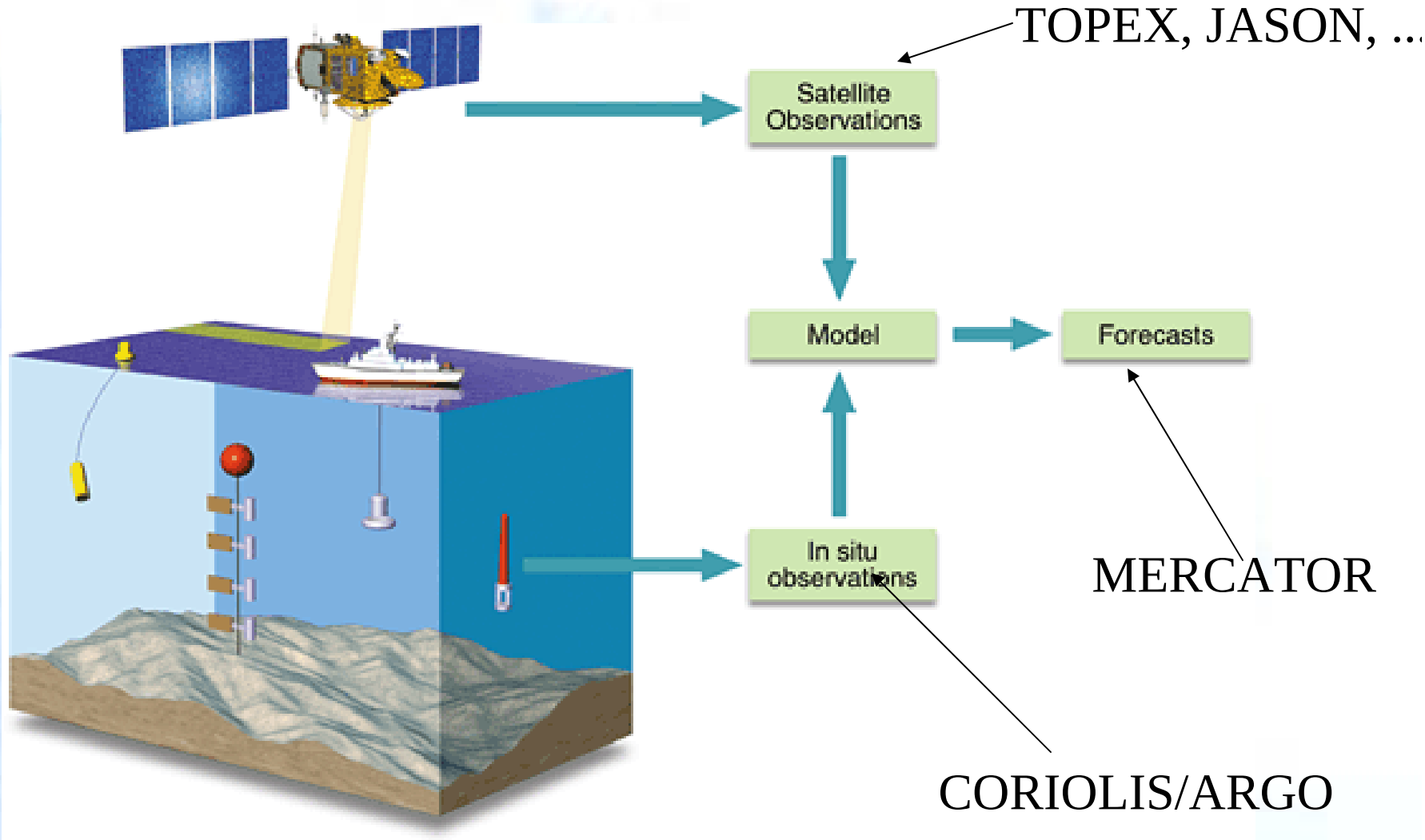
Oceans : a complex, turbulent system to observe



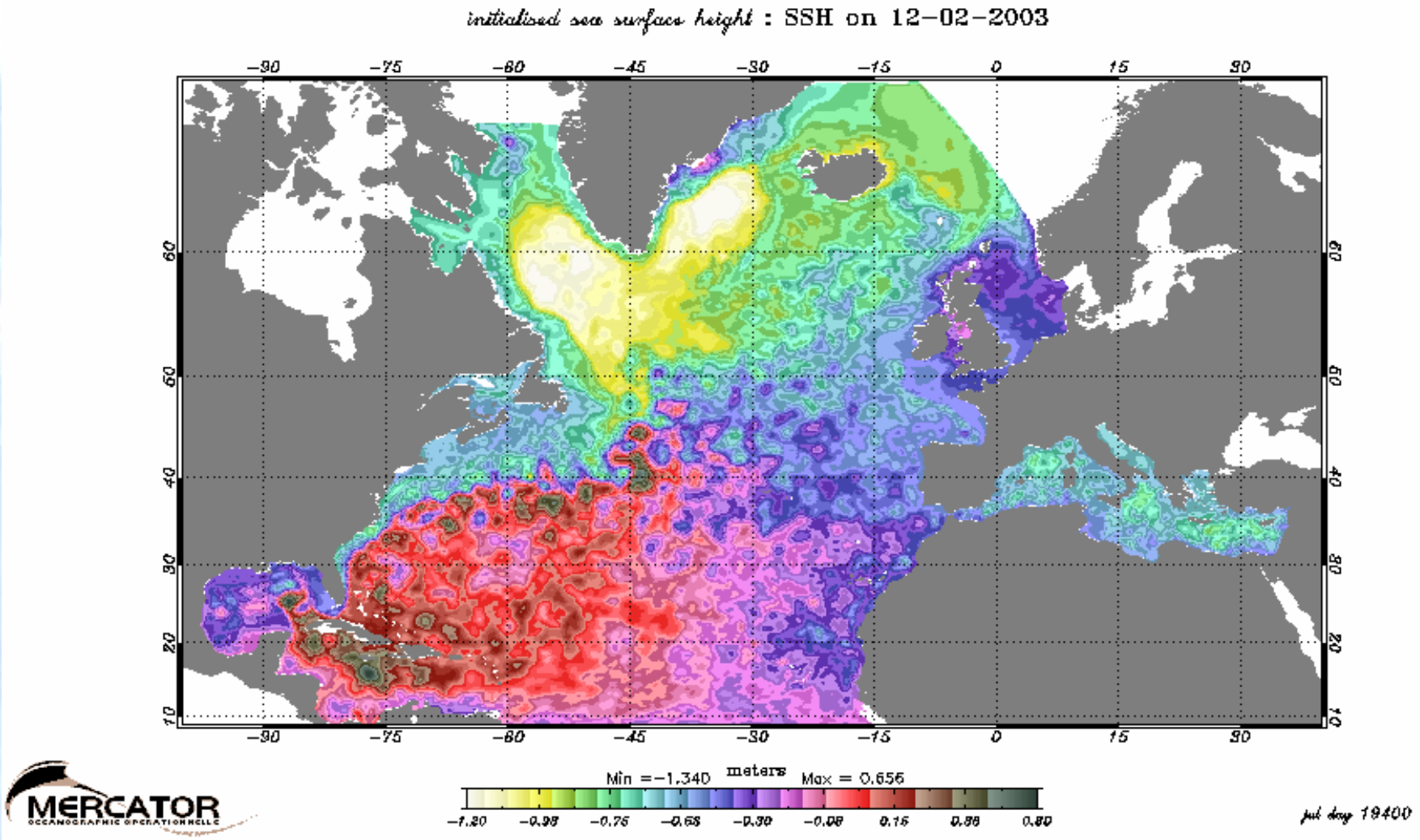
(image AVHRR – NOAA - RSMAS)

Phenomena	Vertical Range (cm)	Spatial Scale (km)	Time Period (days)
Ocean Gyres			
Mean	100	> 1000	
Variations	10	> 1000	> 300
Mesoscale Eddies	25	~ 50	> 30
Western Boundary Currents			
Mean	100	100	
Variations	100	100	> 10
Eastern Boundary Currents			
Mean	20	500	
Variations	10	500	> 10
Equatrorial Currents			
Mean	20	> 500	
Variations	10	> 500	> 50
El Niño Equatorial Response	20	> 500	~ 1000

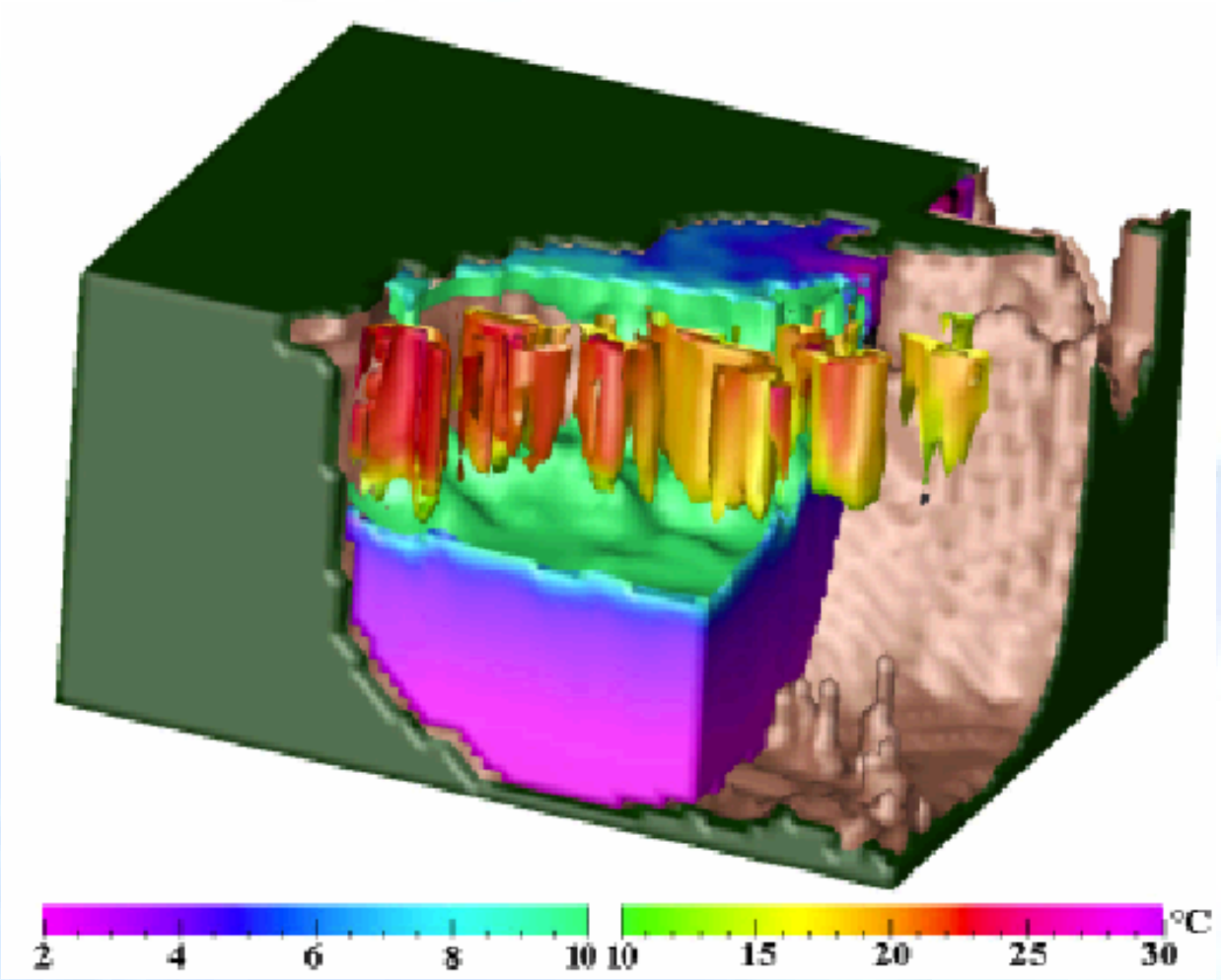
An integrated approach : space segment is only a component of the system



Observing & Forecasting Ocean...

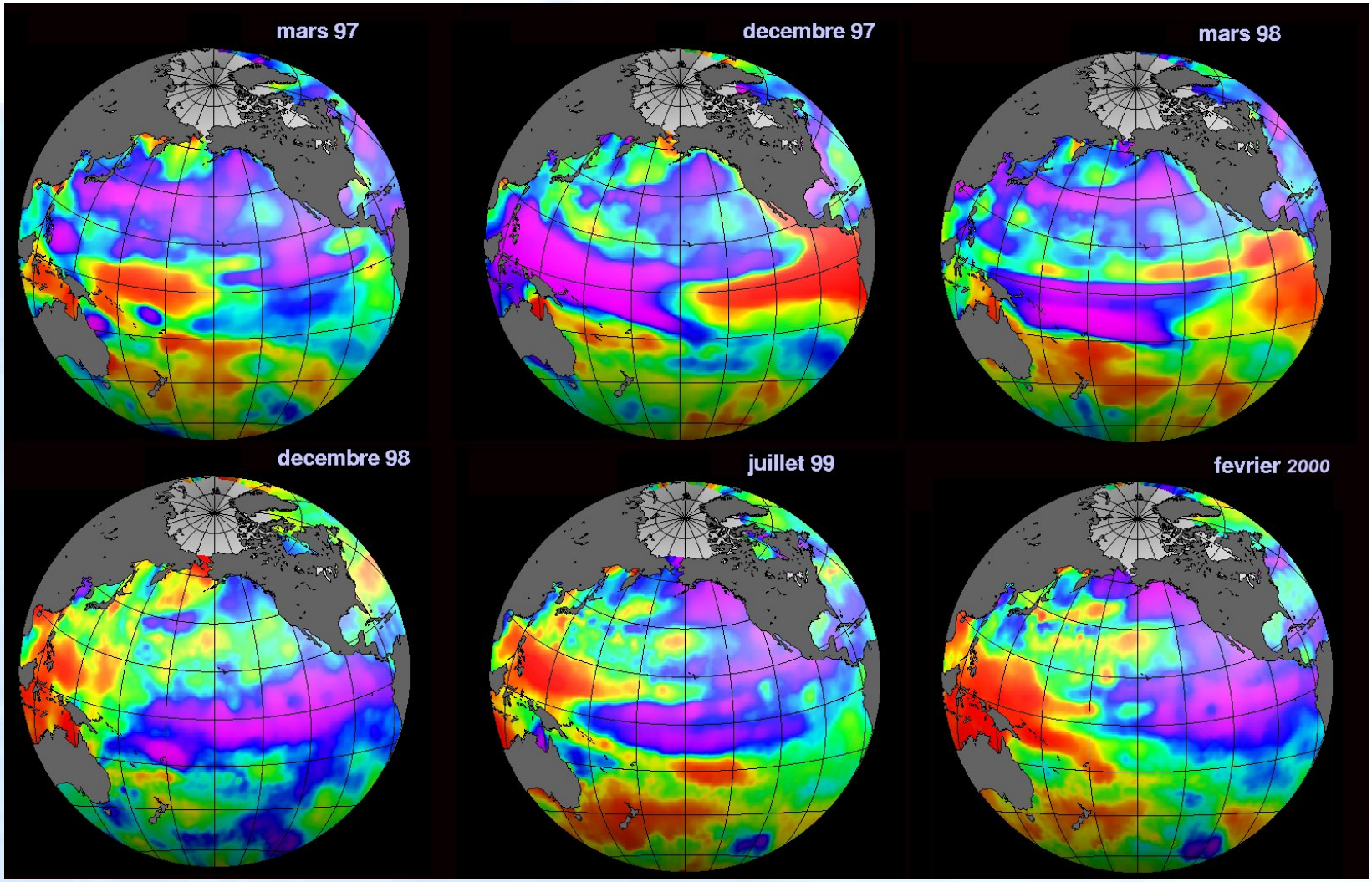


... In 3 (+1) dimensions...

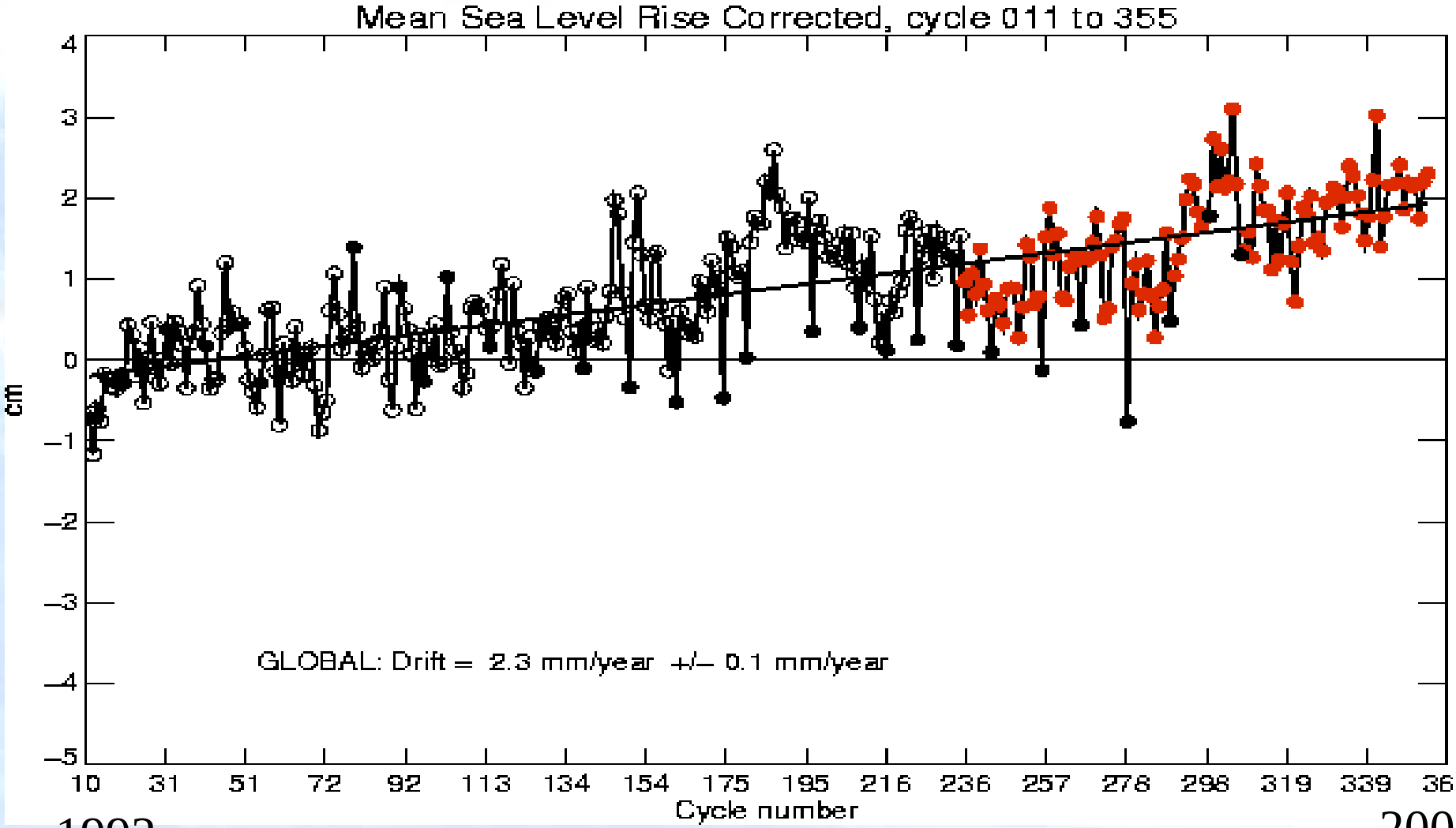


... For years...

El Niño/La Niña (as seen by TOPEX/Poséidon NASA/CNES)



... To decades



1992 2003

What do we measure from Space ?

- Topography/currents : TOPEX/POSEIDON, ERS, GFO, ENVISAT, JASON-1
  (CRYOSAT), JASON-2, NPOESS, (HY-2)...
- Surface winds : ERS, WINDSAT, SEAWINDS/ADEOS-2
  METOP-1, OVWM, NPOESS…
- SST : ERS, (ADEOS 1), Met sats, ADEOS-2, ENVISAT
  Met sats
- Ocean Wave height & spectrum : ERS, ENVISAT, RADARSAT (-1, -2, -3)
  TerraSAR (-L), Cosmo, SWIMSAT, (HY-3), (Cartwheel)
- Ocean-Colour : SeaWIFS, (ADEOS 1), MODIS, ADEOS-2, ENVISAT, HY-1, ...
  NPOESS, …
- (Ocean-Geoid) : CHAMP, GRACE, GOCE, …
- Ocean-Salinity : SMOS, AQUARIUS …

CNES Activities in Oceanography

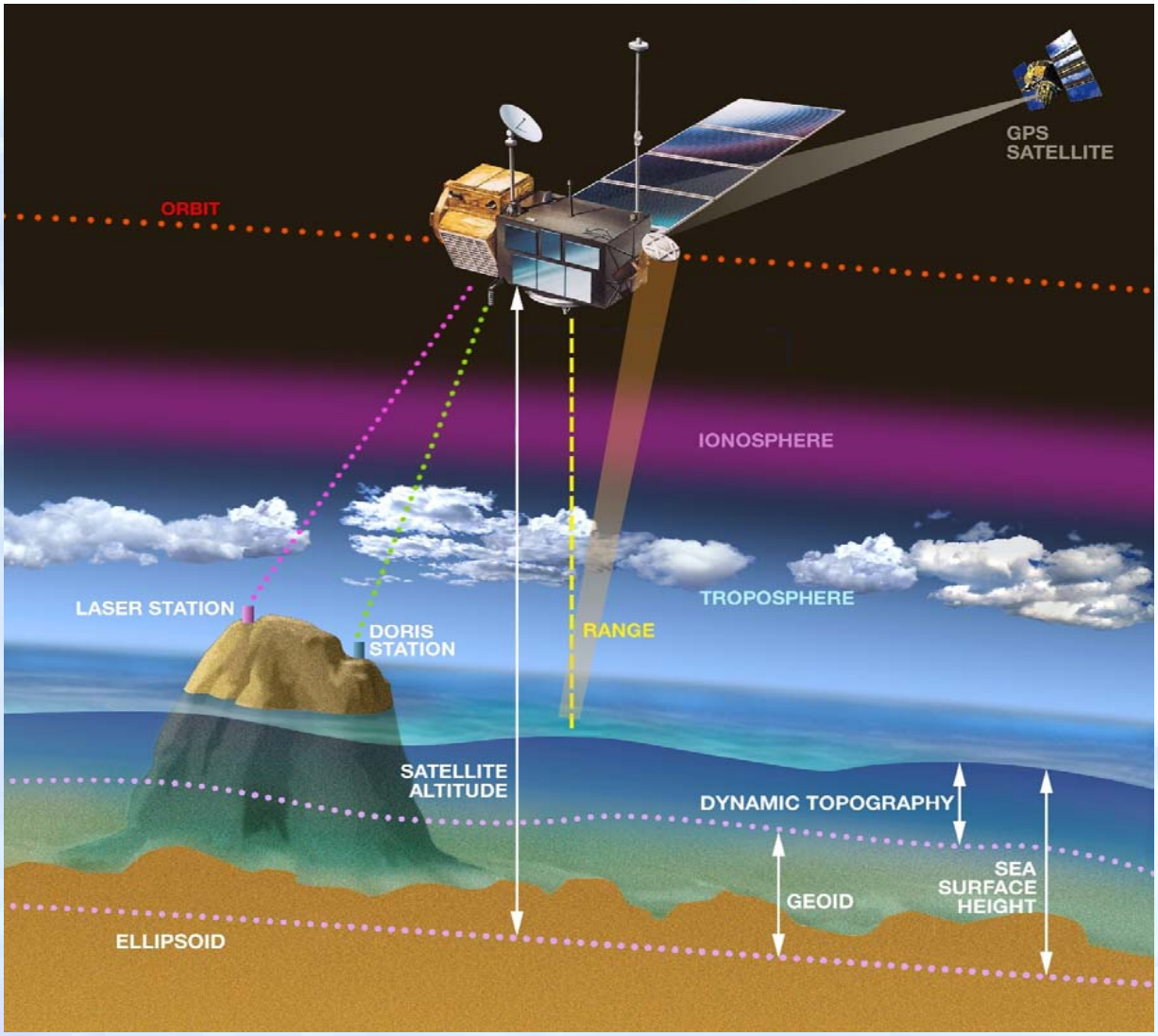
• Contribute to operational outcome of altimetry :
(TOPEX/POSEIDON => JASON1 => JASON2/OSTM =>?)
+ CORIOLIS, MERCATOR/COO/ECOMF, ...

• Continue research activities for future altimetry missions (AltiKa, WSOA, …)

• Contribute to space measurements of other ocean physical parameters :
- salinity (SMOS)
- directional wave spectrum (SWIMSAT)
- ocean colour (VGT1 & 2, POLDER1, 2 & 3, …)

• Prepare ocean applications of ORFEO (Cosmo SkyMed/Pleiades) : mainly coastal applications

Main observing systems : altimetry missions



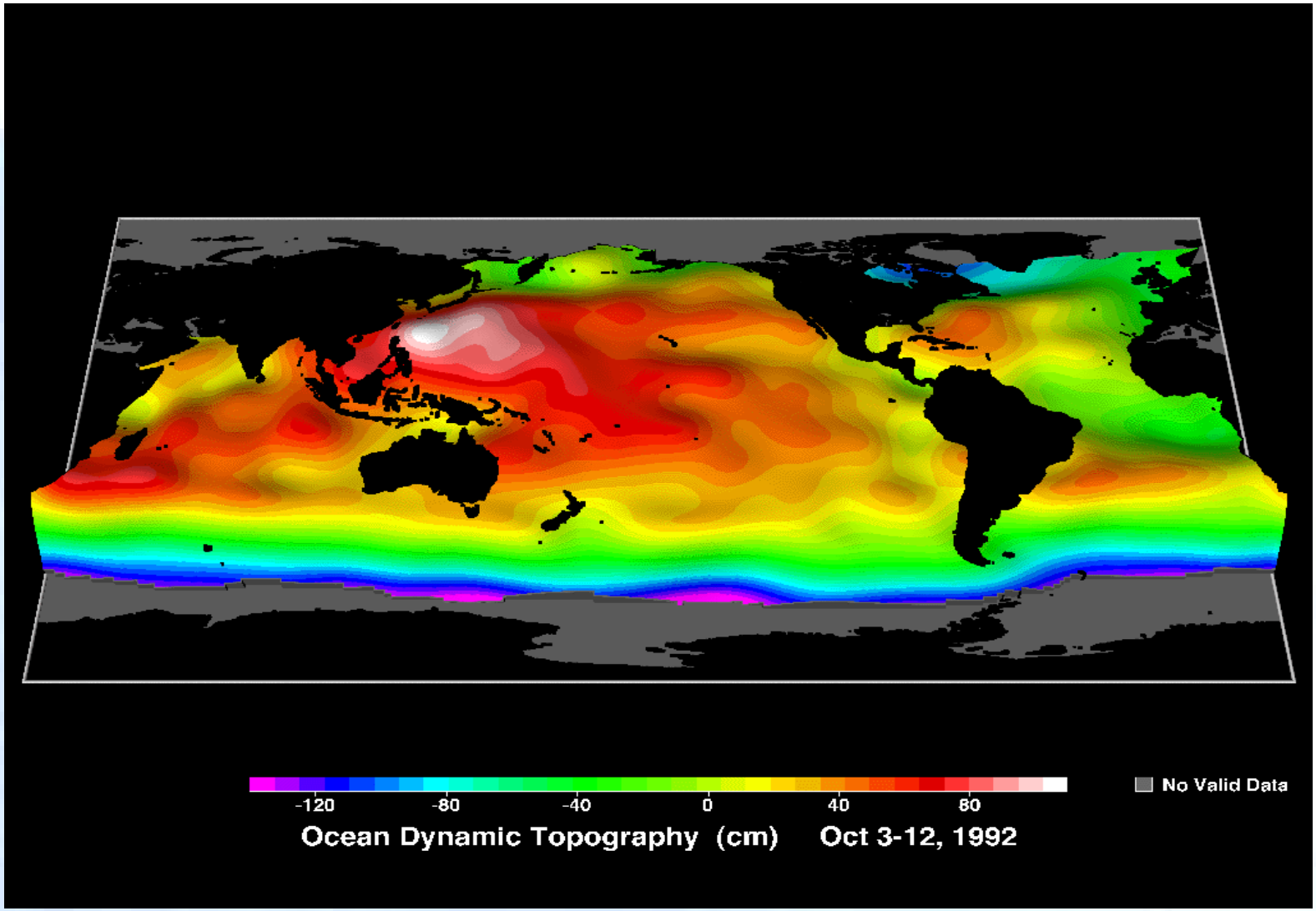
Key components of an altimetric mission:

- precise radar altimeters

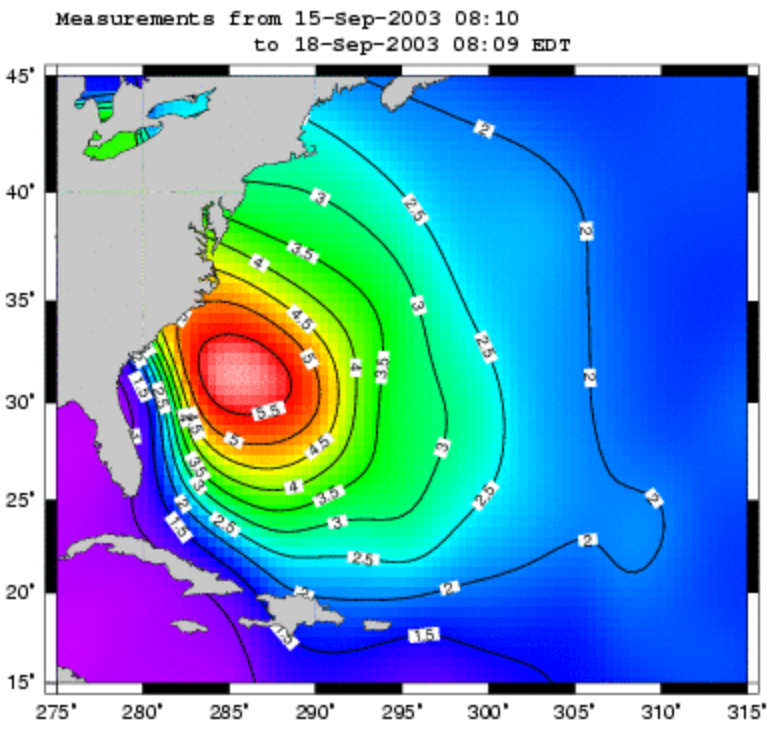
- precise orbit determination systems

- additional systems (e.g. radiometer, LRA,...)

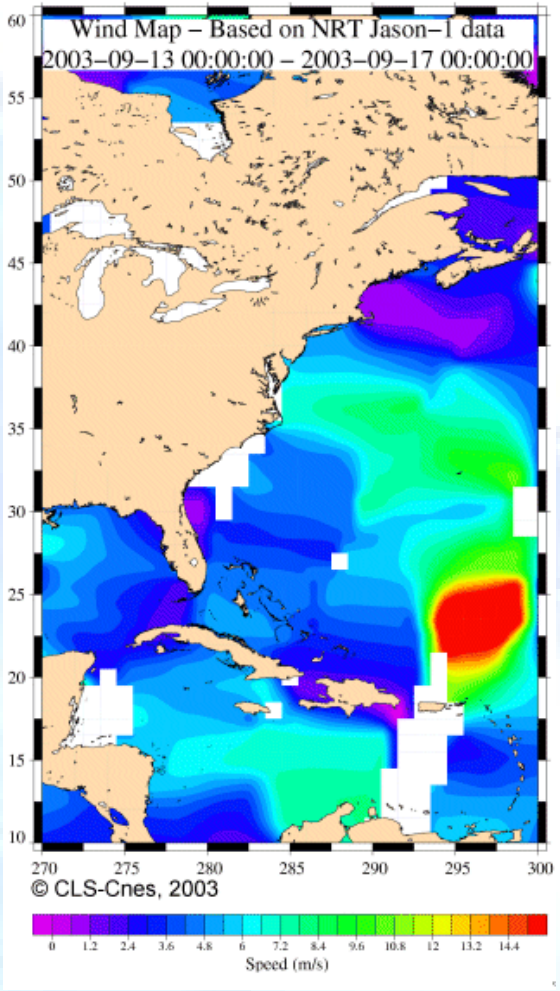
Parameters retrieved from Altimetry missions



Jason-1 Real-time Significant waveheights and windspeed during Hurricane Isabel



(Source: JPL)



CNES involvment in altimetry

experiment

pre-operational

Complementing mission
mesoscale, ice

ERS-1 (ESA)
Altimeter algorithm

ERS-2 (ESA)

ENVISAT (ESA)
DORIS
Altimeter Processing
Archive & distrib.

Reference mission
Ocean Large scale

TOPEX/POSEIDON
(CNES/NASA)
Launcher
DORIS & POSEIDON
Mission Center

Jason-1 (CNES/NASA)
Satellite bus
DORIS & POSEIDON
Control & Mission Center

Jason-2 / OSTM
(CNES/NASA/EUMETSAT/NOAA)
Satellite bus
DORIS & POSEIDON
Control & Mission Center

Earth reference system

SPOT2 (CNES)
DORIS

SPOT3 (CNES)
DORIS

SPOT4 (CNES)
DORIS

SPOT5 (CNES)
DORIS

CRYOSAT (ESA)
DORIS

PLEIADES (CNES)
DORIS

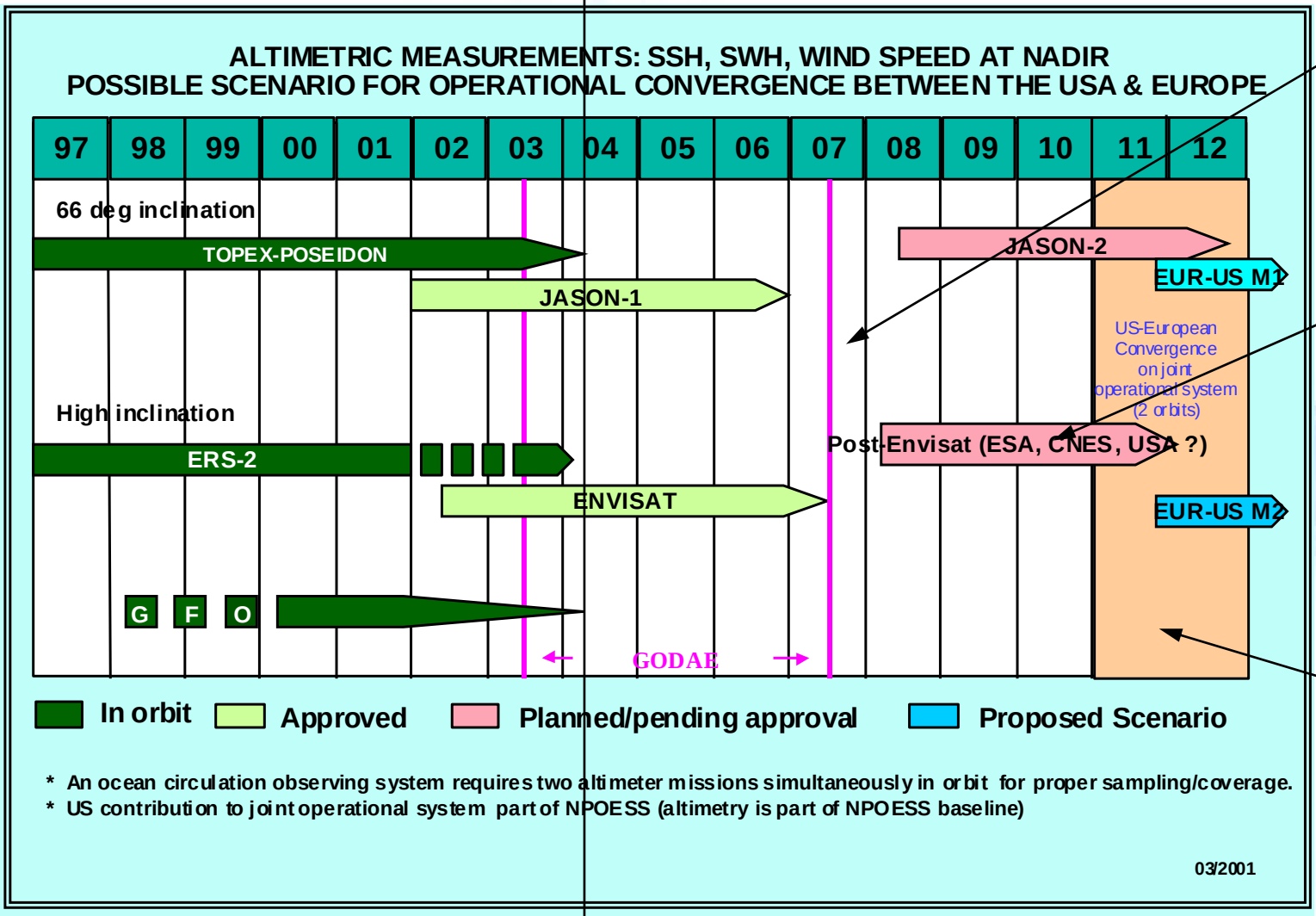
1990

2000

SALP : Altimetry and precise positionning service

MERCATOR : assimilation, forecast
CNES / SHOM / METEOFRANCE / IFREMER / CNRS / IRD

Altimetry missions : from research to operational

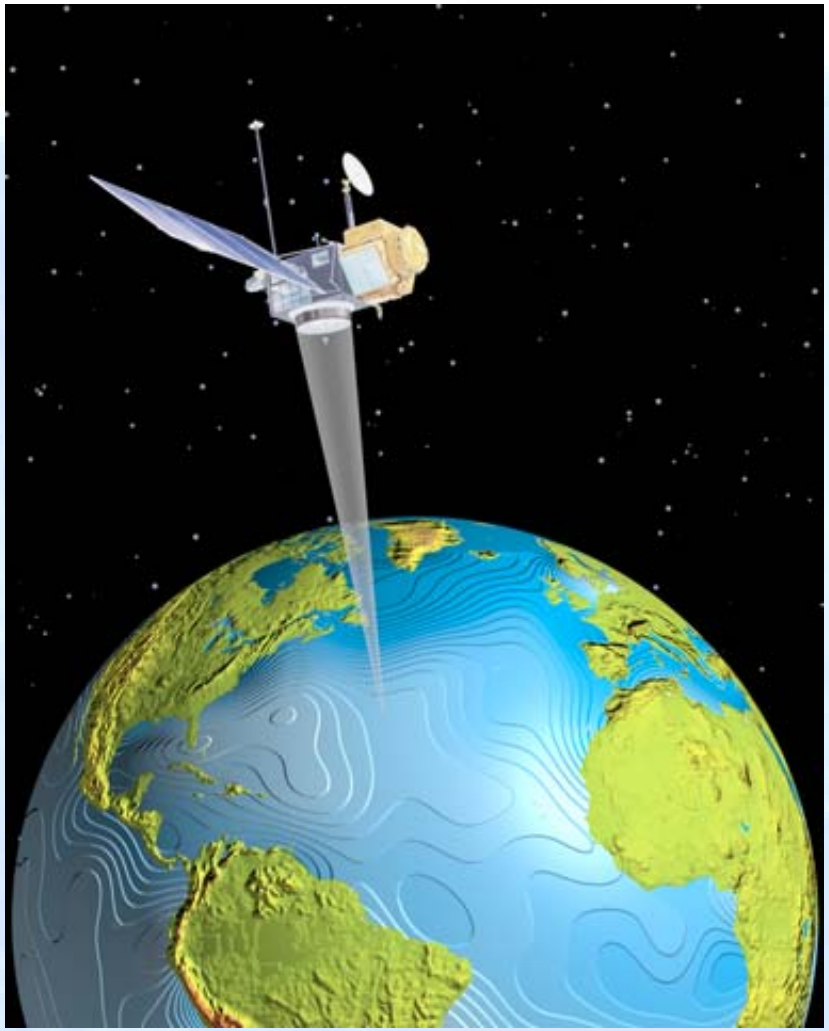


Possible gap in 2007

???

NPOESS, GMES

To-day : very good situation ! (5 satellites)



TOPEX/POSEIDON

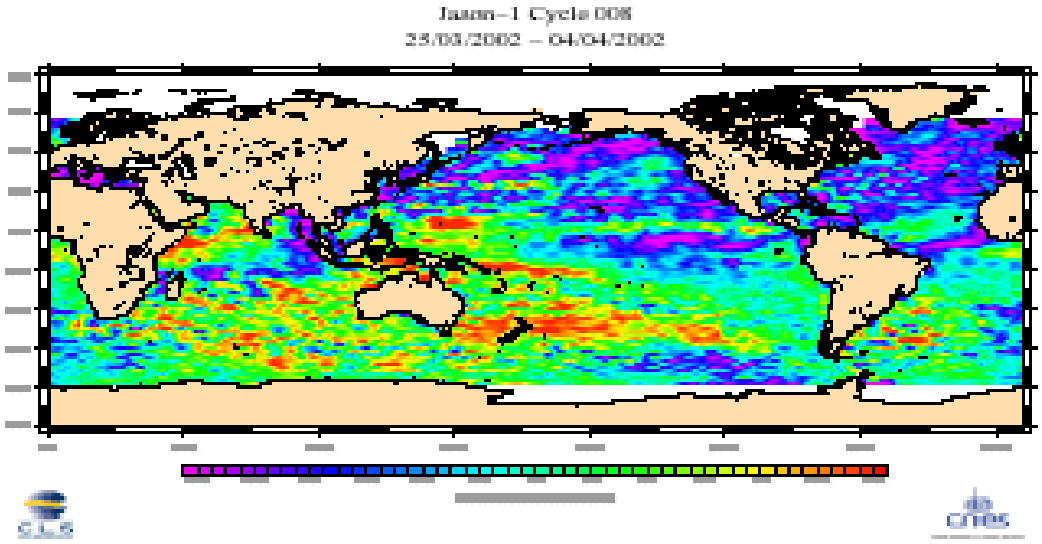
Status of TOPEX/POSEIDON

- 12 years in orbit !
- Close tandem mission with JASON-1 successful
- Transfer to new orbit in september/october 2002
- Now in coupled mission with JASON-1

JASON-1

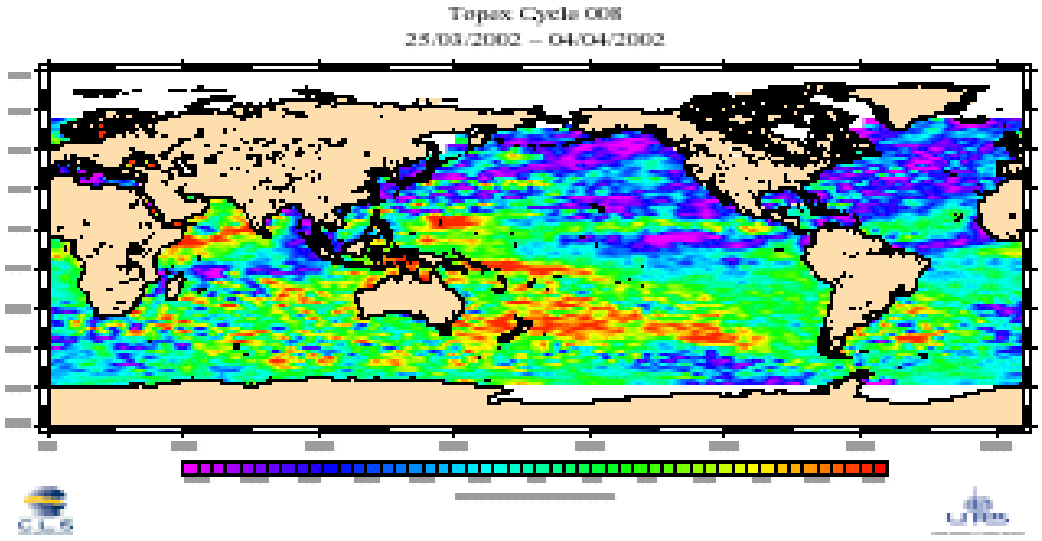
Jason1 Status

- Launched on December 7, 2001
- Qualified in orbit
- Routine mode for research and application use
  - required lifetime : 3 years
  - expected lifetime : > 5 years



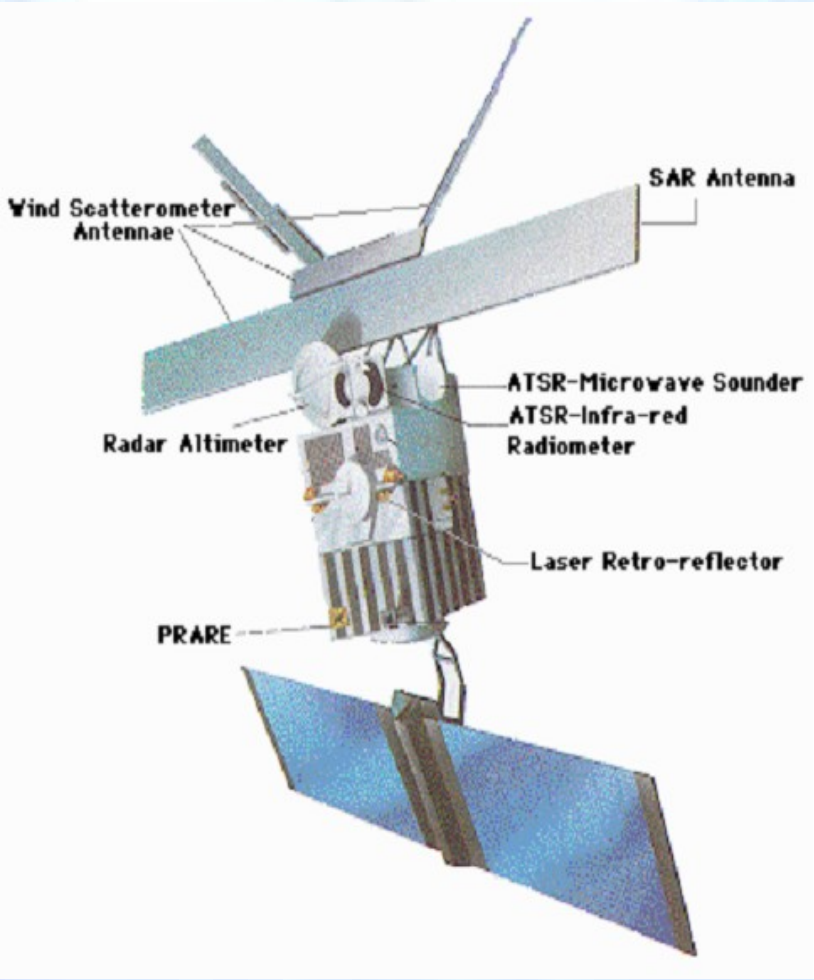
Jason-1 SLA

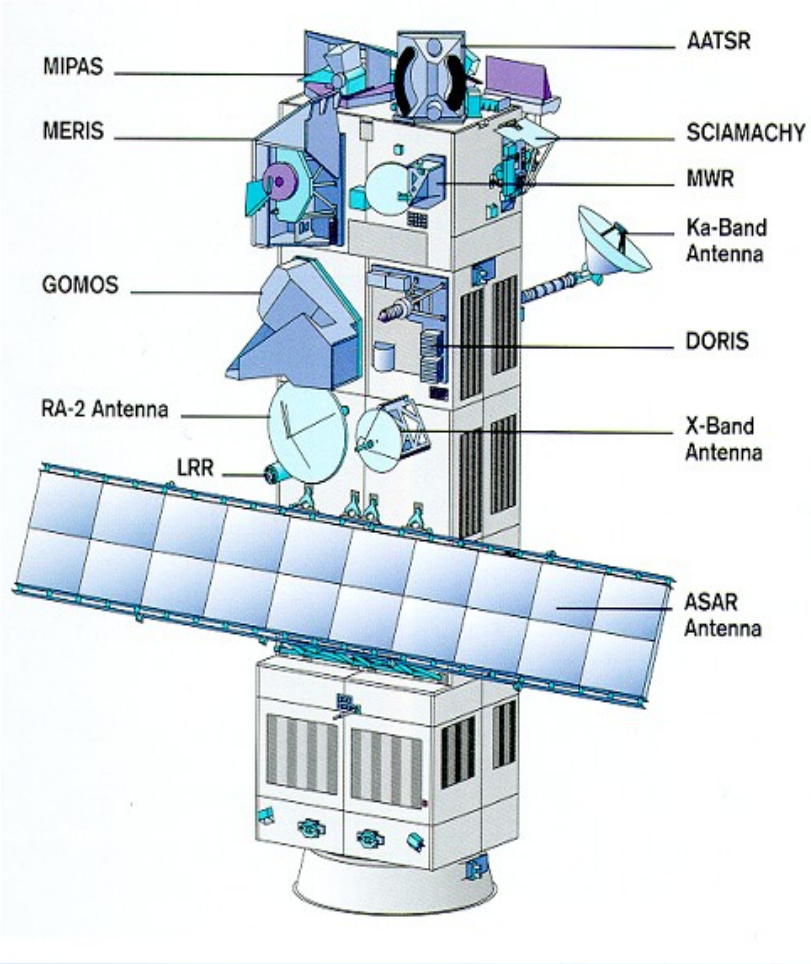
March 25
to April 04 2002



Topex SLA

ESA contribution to altimetry : ERS, ENVISAT



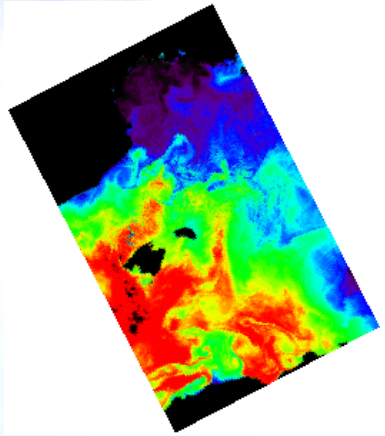


ENVISAT for Oceanography applications

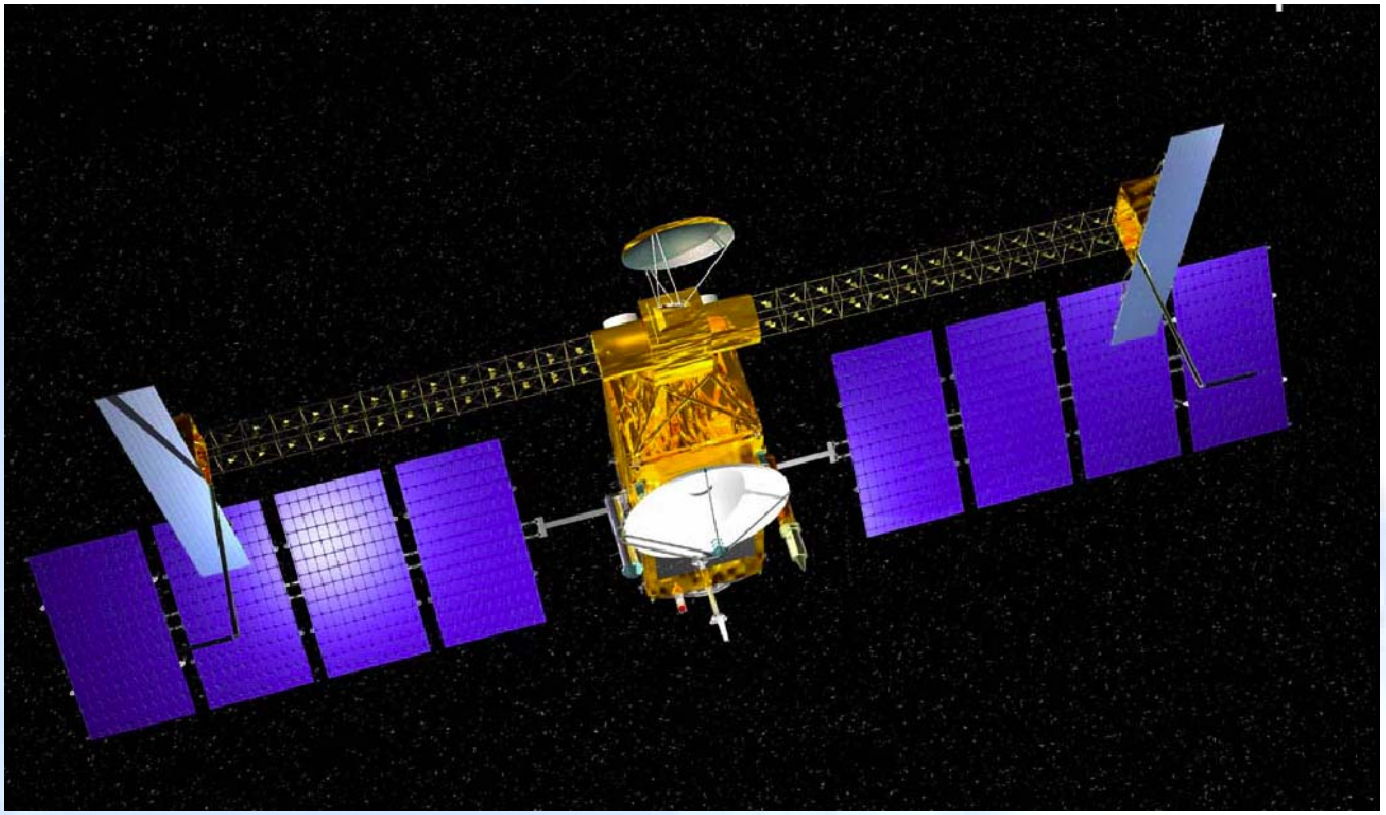
- Synergy /complementarity with Jason1 :
  - following ERS / TOPEX/POSEIDON
  - optimised for mesoscale and high latitude
  - same earth reference system : DORIS
  - same off line processing center : F-PAC / SALP

    improvements for ocean applications

  - cryosphere and earth applications (adaptive tracker)
  - synergy with other ENVISAT ocean sensors
    - **SST : AATSR,**
    - **ocean color : MERIS**

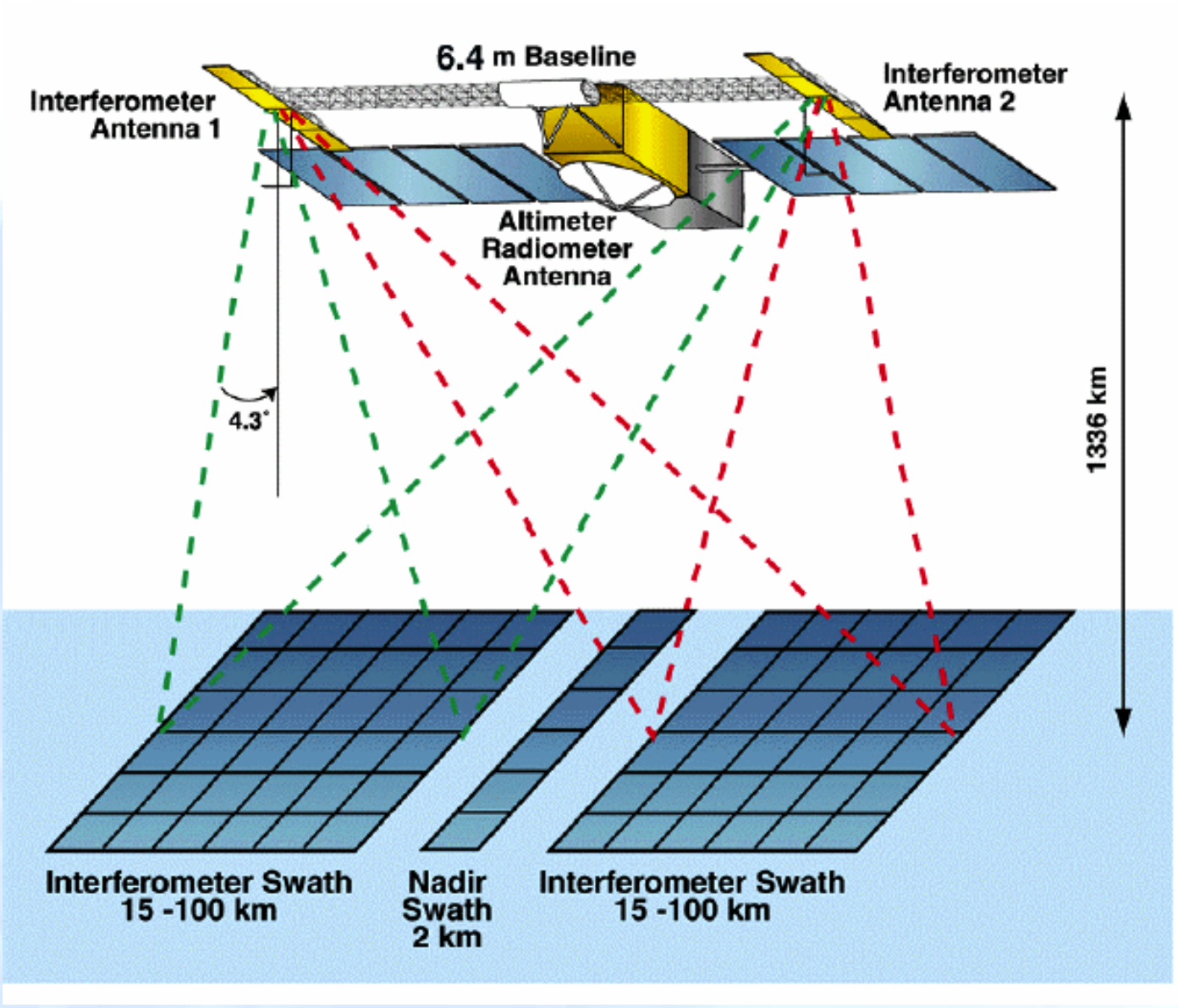


OSTM/Jason-2



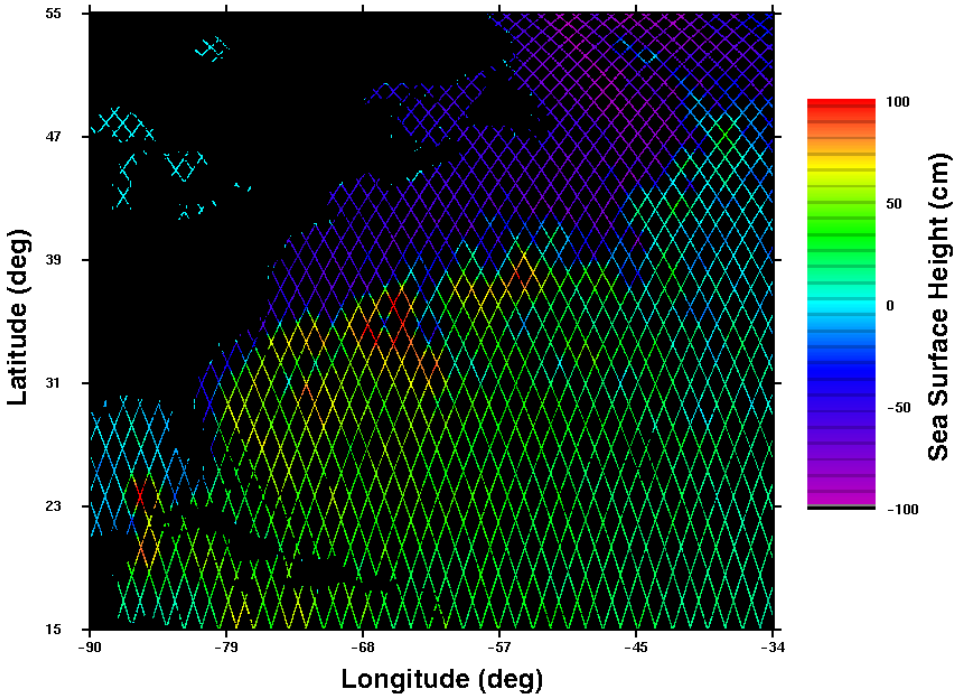
JASON-2 = JASON-1 + technological experiment : WSOA
Launch : April, 2008

WSOA

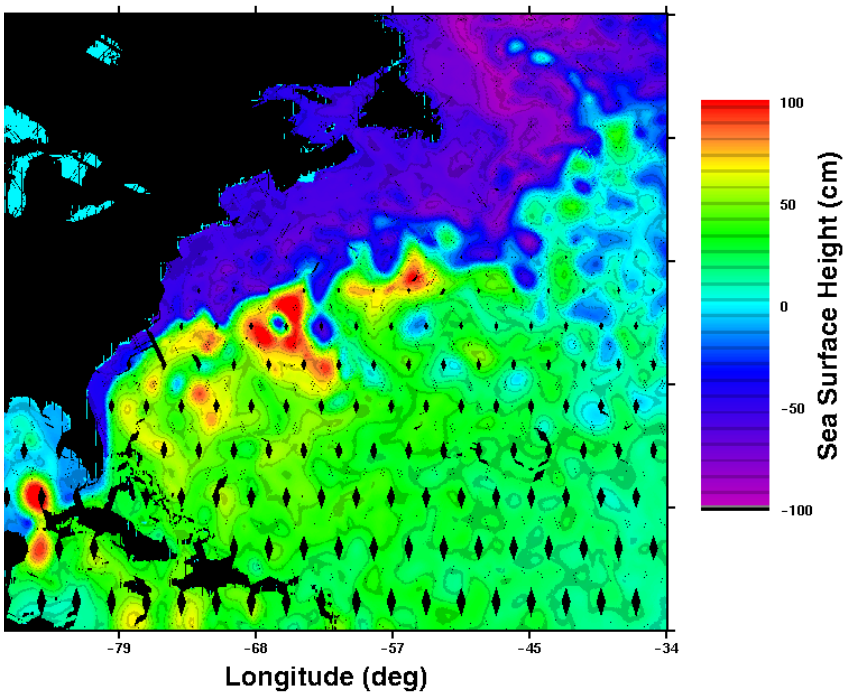

6.4 m Baseline
Interferometer Antenna 1
Interferometer Antenna 2
Altimeter Radiometer Antenna
4.3°
1336 km
Interferometer Swath 15 -100 km
Nadir Swath 2 km
Interferometer Swath 15 -100 km

WSOA Science Rationale

Topex Orbit, 2 Altimeters:
150km equatorial spacing, 10 day repeat

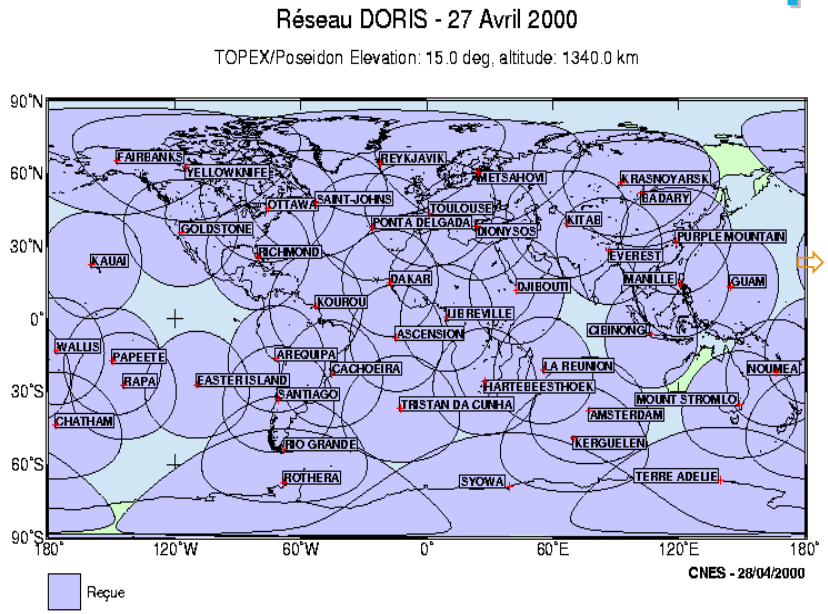


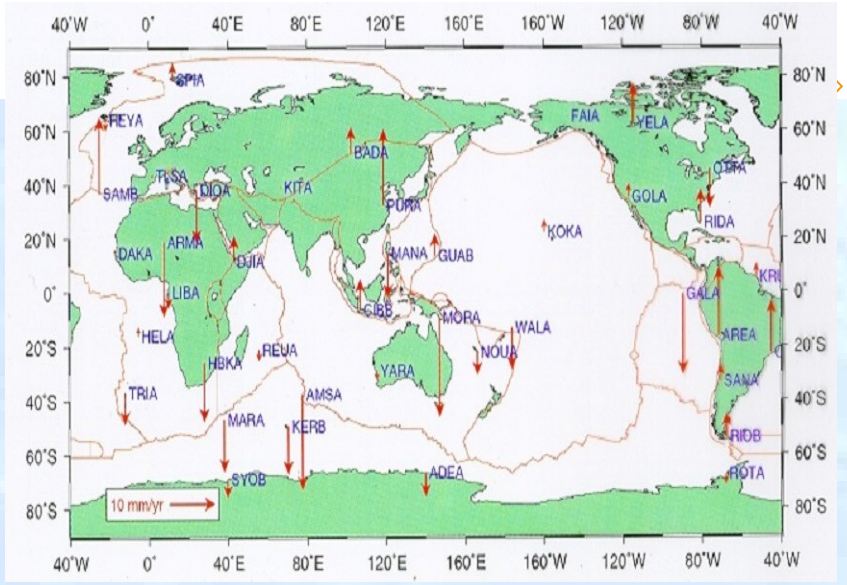
Topex Orbit, 1 satellite, fixed yaw coverage
Wide-Swath altimeter, 10 day repeat



High resolution ocean topography measurements requires several coordinated nadir altimeters. A better coverage from a single platform can be obtained using an instrument which can image a swath instantaneously.

DORIS: an essential component of the SYSTEM





Was conceived to fulfill altimetry requirements for precise orbitography (TOPEX/POSEIDON)

- In-Flight Performance: 3 cm for the T/P altitude
- Key element for the science achievements of the T/P mission,
- **Performance already assessed for Jason is 2 cm**
- **Goal for Jason is 1 cm**

Capability of accurate autonomous navigation with DORIS demonstrated onboard SPOT4, ENVISAT and Jason-1

DORIS Applications

1. Precise Orbit Determination

=> Altimetry missions

TOPEX-POSEIDON (1300 km): < 3 cm

SPOT (800 km) : < 6 cm

ENVISAT (800 km) : <10 cm (objective = 5 cm)

JASON-1 (1300 km): < 3 cm (objective = 1 cm)

2. Positioning

DORIS is a technique recognised by ITRF

absolute positioning within 1 to 10cm

=> geodesy, survey, ...

3. Modeling

Gravity Field **Geoïd** **Ionosphere**

4. Real time on-board orbit DIODE

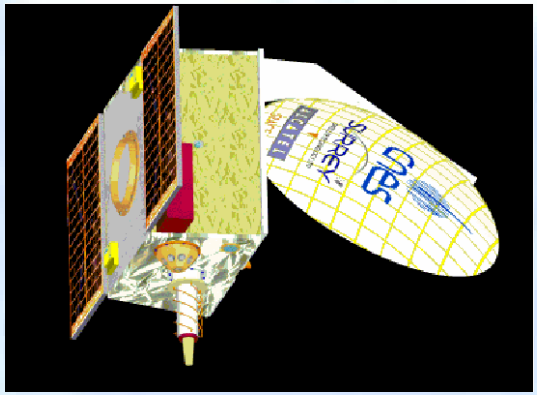
Since 1998, SPOT4 orbit within 3 to 5m accuracy

JASON and ENVISAT within 15cm on radial component

30cm on other components

Future altimetry missions

- *What Mission to complement JASON-2 ?*



Example : AltiKa
(cooperation CNES/SHOM/
UK/JPL/...)

- Post-2010 missions : to be decided/funded by **operational** agencies
  - NPOESS (IPO)
  - OCEANWATCH (EUMETSAT/ESA ??)
  - JASON3 (EUMETSAT/CNES ??)

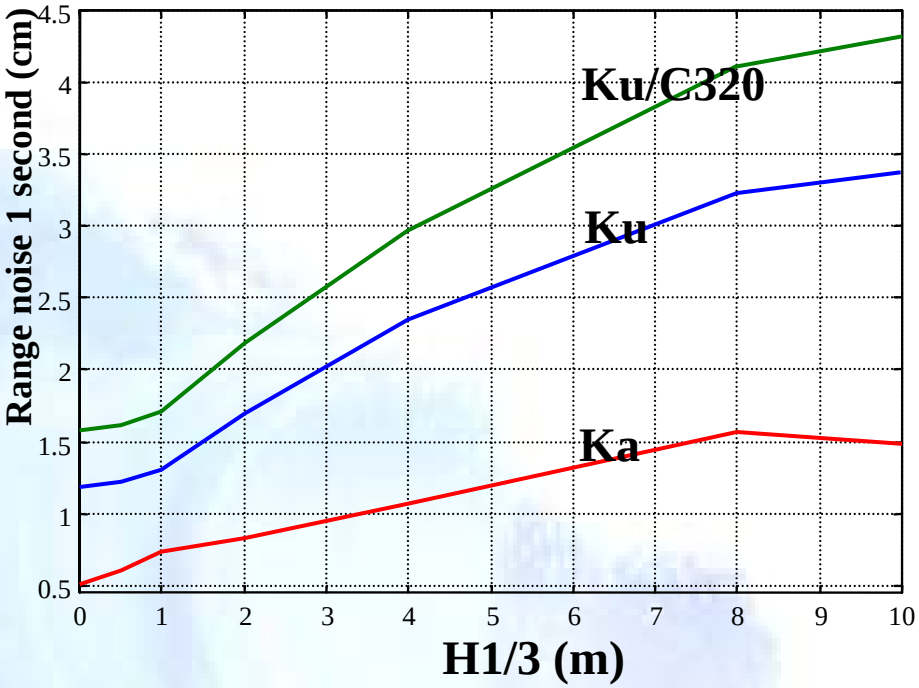
(note : some of those missions might merge into a single one…)

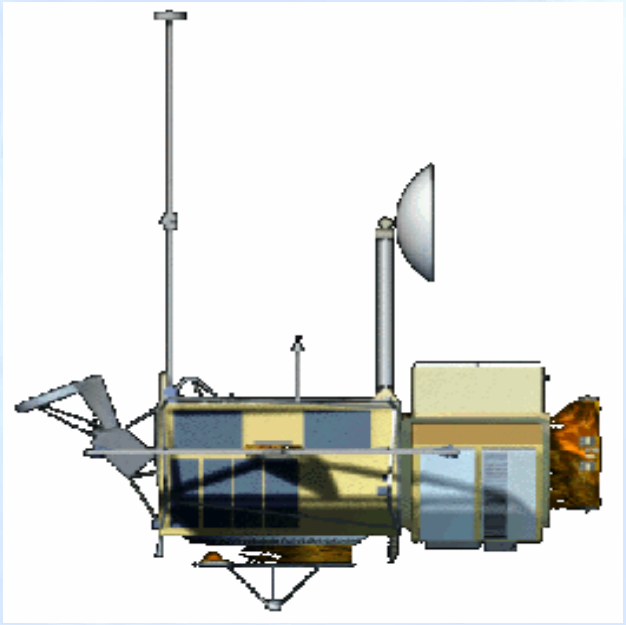
- European context for those missions is GMES

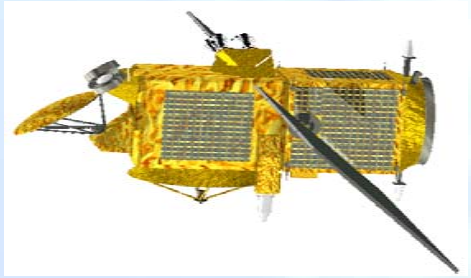
Future altimetry mission : AltiKa ?

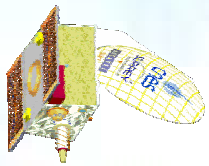
- **Ka-band altimeter with enhanced bandwidth**
  - ionospheric effects are negligible
  - better vertical resolution
  - error budget improvement
- **Dual-frequency radiometer (24/37 GHz)**
  - required for tropospheric correction
- **Laser Retro-reflector Array**
  - minimum for orbitography and system calibration
- **DORIS**
  - required for achieving adequate orbitography performances in low earth orbit (oceanography need)
  - enable to have similar mission than reference missions like T/P, JASON, ENVISAT
  - required for sea mean level analysis

Evolution of performance and weight of altimetry satellites







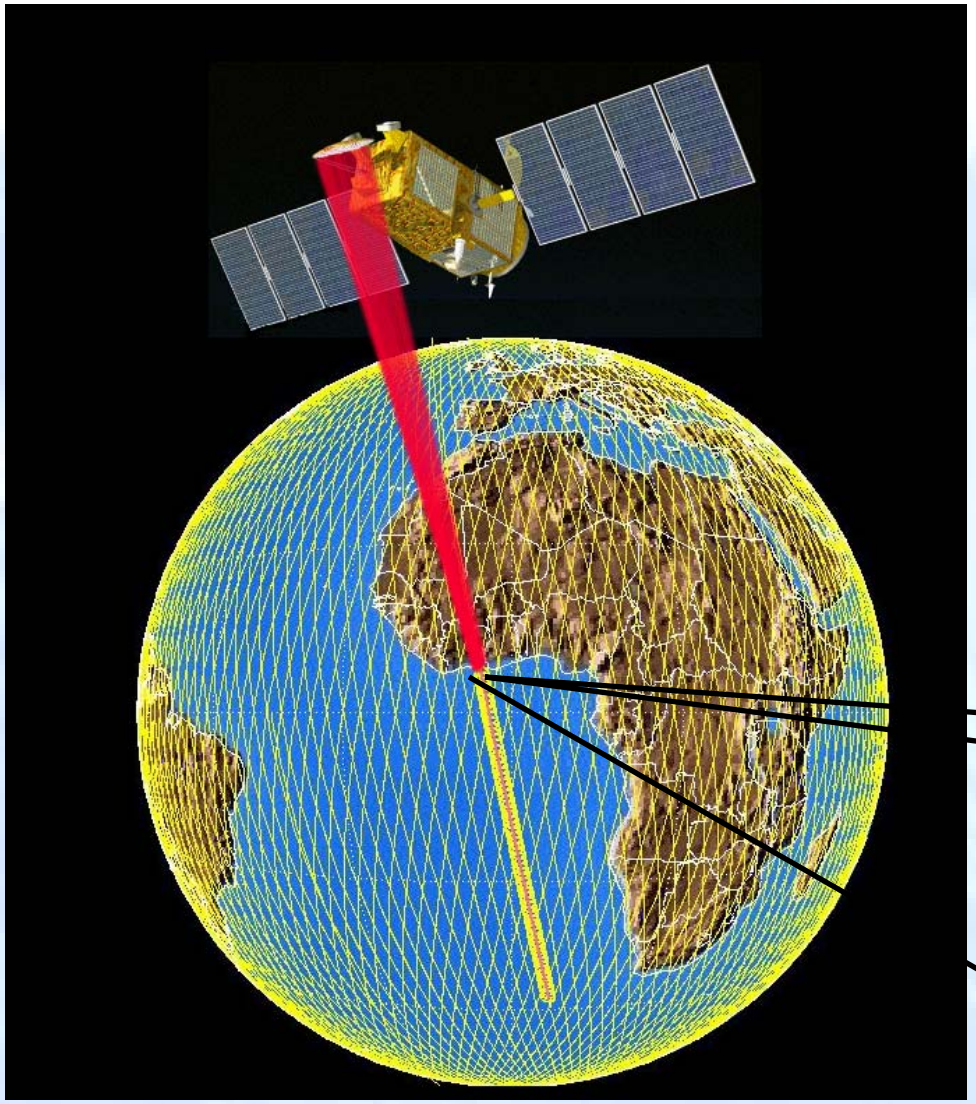


TOPEX/Poseidon
2500kg

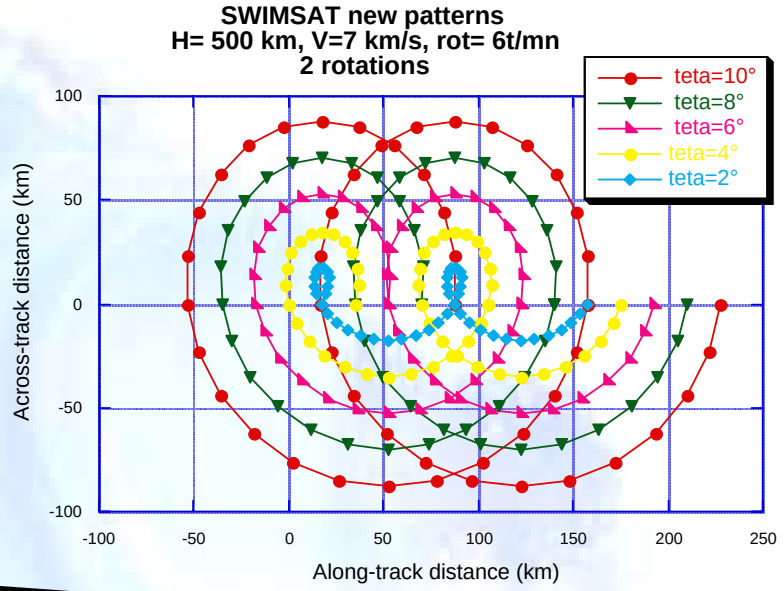
Jason
500 kg

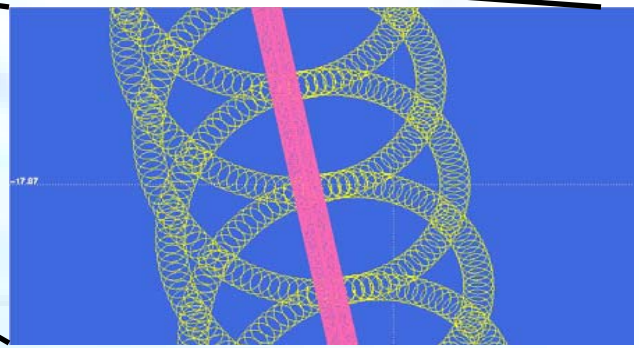
AltiKa
120 kg

Future altimetry mission : SWIMSAT ?



SWIMSAT





SWIMSAT(Surface Waves Investigation and Monitoring from SATellite)

- Measurement of wave directional spectra

- Instrument : Ku-band scatterometer with 6 rotating beams

- Objectifs :

- Improve sea state forecasting through assimilation of wave directional spectra
- Contribute to climate monitoring of sea state at global scale
- Contribute to studty of coastal phenomena
- Quantify influence of sea state on ocean/atmosphere interaction
- Quantify influence of waves on ocean circulation
- Improve inversion of other ocean physical parameters (altimetry for ocean topography, radiometry surface salinity) through independent measurement of surface parameters (wind, waves)

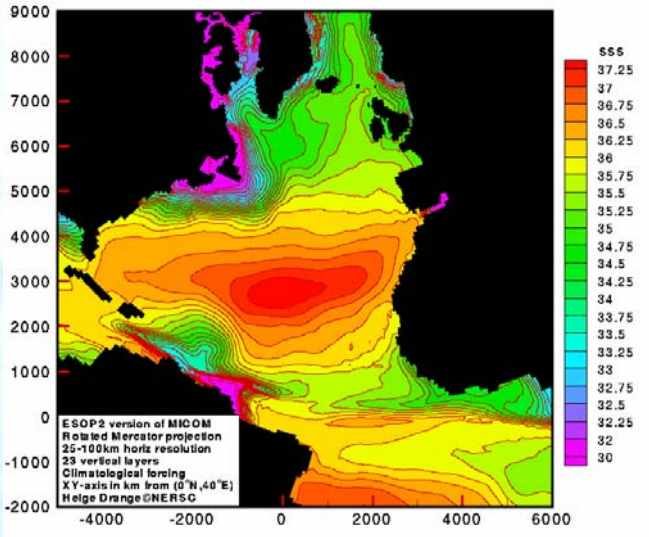
- Status : proposed as EEOM (Research-class mission at ESA)

Future mission with a new parameter measured from Space :

SMOS : Soil Moisture and Salinity Mission

SMOS : Soil Moisture and Salinity Mission

- ESA Mission [Earth Explorer Opportunity Mission]
- Cooperation between ESA / CDTI / CNES
- Science Objectives:
  - Soil Moisture
  - Ocean surface salinity
- Phase B in progress
- Launch Feb. 2007



Conclusions

• Oceanography will soon (within 10 years) be transfered to operational activities & agencies

• CNES is involved in many aspects of programmes & activities in :

- Altimetry & Precise Orbit Determination
- Ocean colour
- Data processing, modelling, assimilation & forecasting
- Interface with end users

• CNES will maintain R&D instrumental/mission activities in cooperation with other partners/agencies