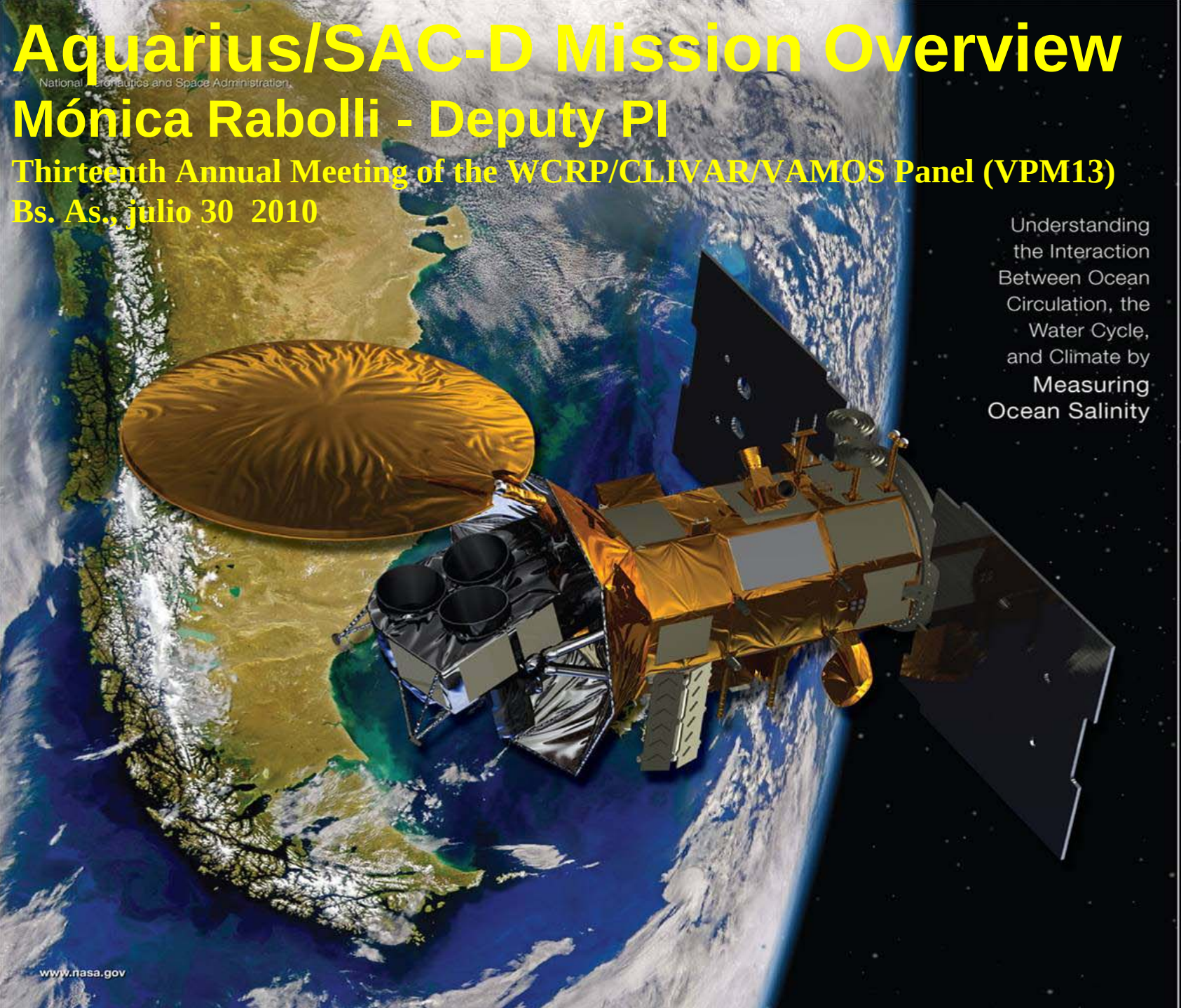
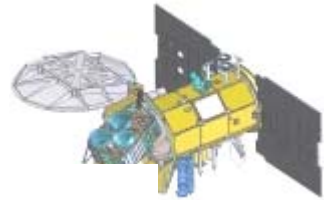
Aquarius/SAC-D Mission Overview

Mónica Rabolli - Deputy PI

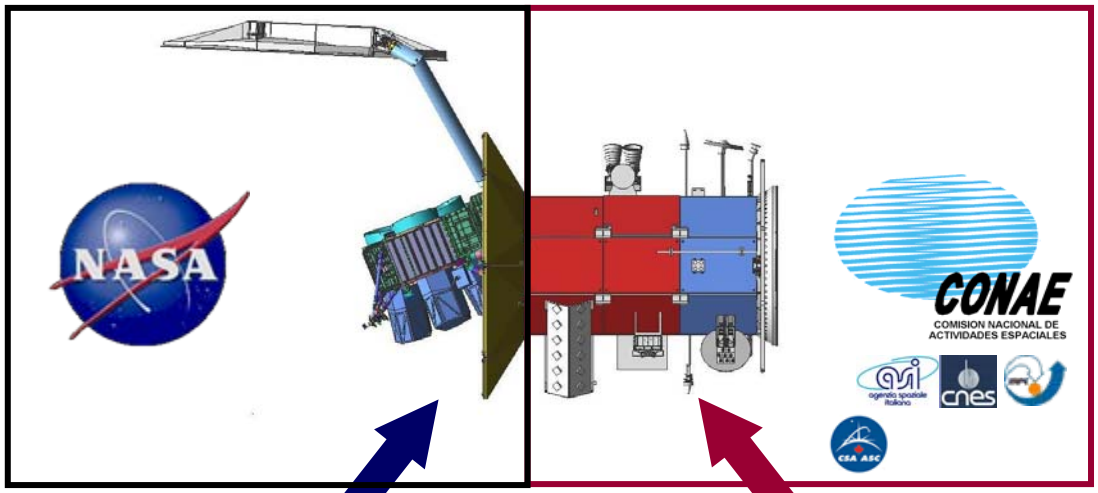
Thirteenth Annual Meeting of the WCRP/CLIVAR/VAMOS Panel (VPM13)

Bs. As., julio 30 2010





International Partnership between United States – Argentina



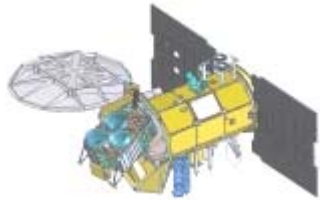
- Aquarius Salinity Microwave Instrument
- Launch Vehicle

- Service Platform and SAC-D Science Instruments
- Mission Operations & Ground System

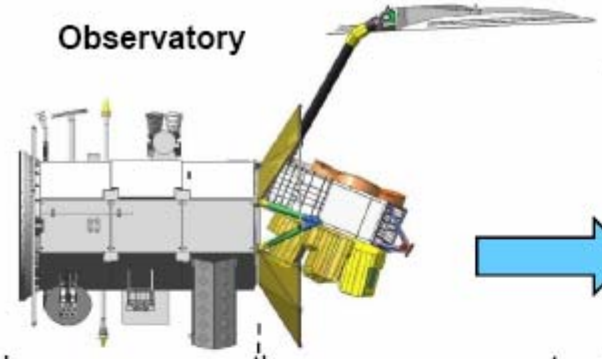
CONAE NASA

AQUARIUS/SAC-D

Mission Overview



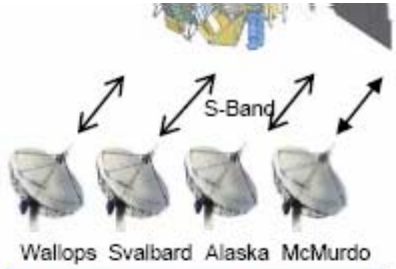
Observatory



S/P & Science Instruments (CONAE)

Aquarius Instrument (NASA JPL & GSFC)

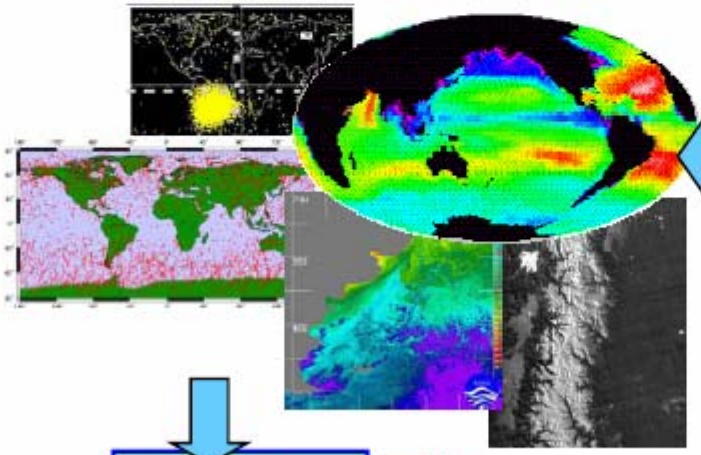
Ground Station & Mission Operations Center (MOC) (CONAE)



ETC (S, X), NGN (S), Matera (X), Malindi (S)

Delta II (NASA)

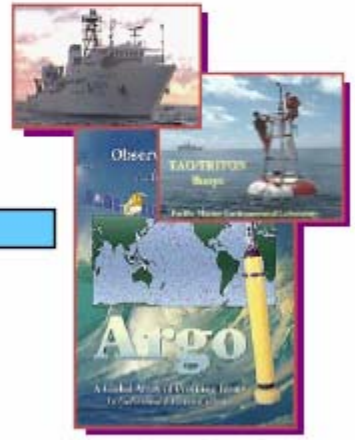
Data Products



Archive (NASA & CONAE)

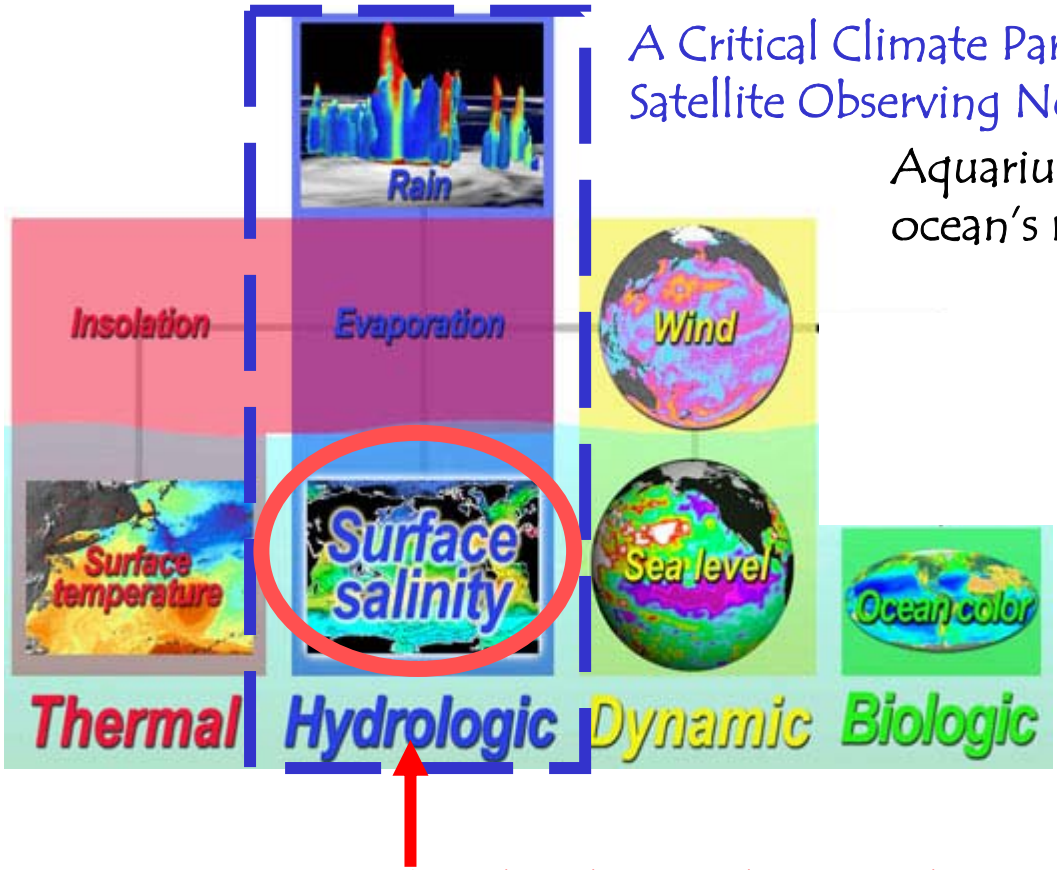
Scientific Community & Data Users

Aquarius Ground System & SAC-D Ground System (Data Processing)



Surface Validation

Mission Objectives



A Critical Climate Parameter Missing from the Present Satellite Observing Network

Aquarius will yield an unprecedented view of ocean's role in climate and weather

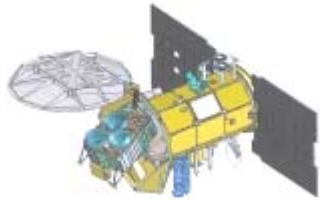
- Investigate the links between the global water cycle, ocean circulation and climate
- Make global, space-based measurements of Sea Surface Salinity (SSS) with high accuracy
- Observe and model seasonal and year-to-year variations of SSS , and how these relate to changes in the water cycle and ocean circulation

A Key to Studying the Global Hydrologic Cycle and Global Change

Understanding the Interactions Between the Global Water Cycle, Ocean Circulation and Climate Through the Measurement of SSS

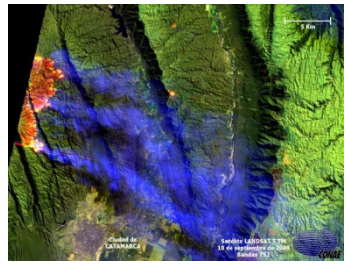
CONAE NASA

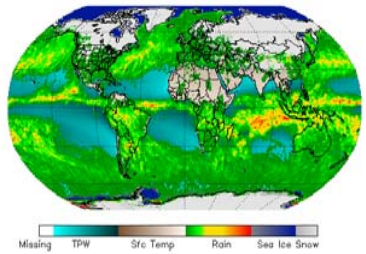
Mission Objectives



SAC-D Science Mission is About Conducting Local Measurements Over Argentina

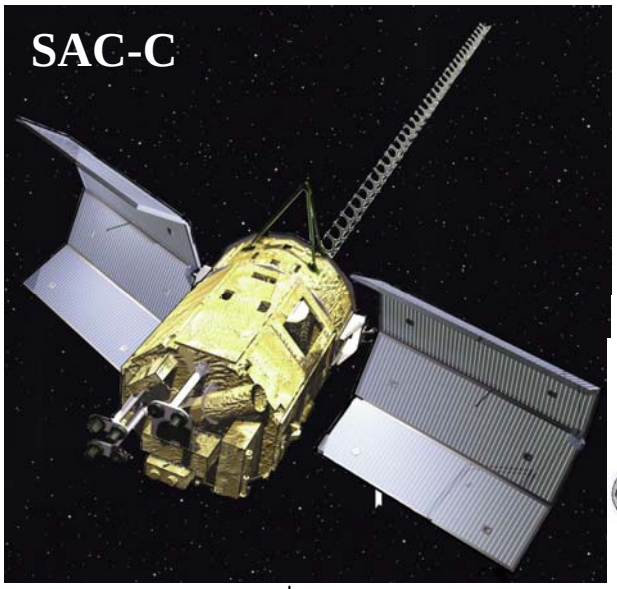
- Understanding ocean circulation, global water cycle and climate interaction
- Monitoring environmental changes, natural hazards and sea ice
- Monitoring atmospheric parameters
- Studying soil moisture
- Studying effect of cosmic radiation on electronic devices and characteristics of space debris
- Validate technology for future CONAE missions





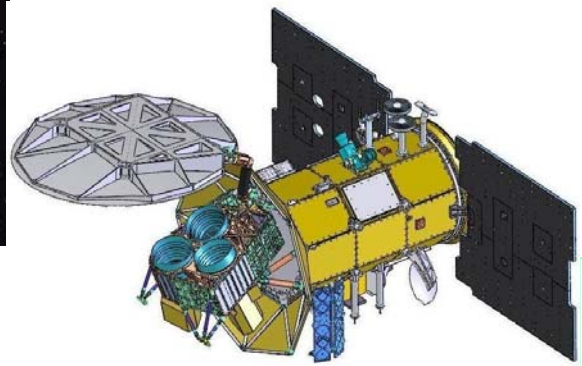
The Aquarius/SAC-D Science Mission is About Conducting Local Measurements Over Argentina and Contributing to Global Investigations of the Atmosphere, the Oceans and the Effects of Human and Natural Processes on the Environment as Defined in the Strategic Plan of the Argentine National Space Program

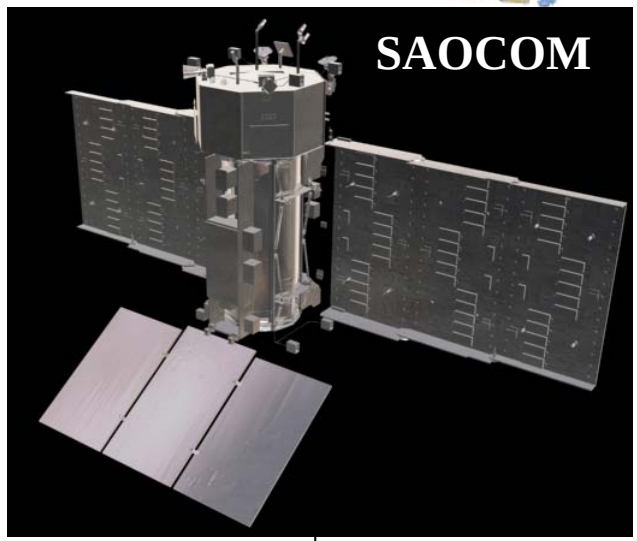
Relationship with Other Satellite Missions of CONAE



Instruments:
MMRS, HRTC,
HSTC, DCS
GOLPE, MMP
IST, INES
ICARE

Aquarius/ SAC-D

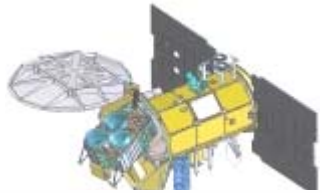




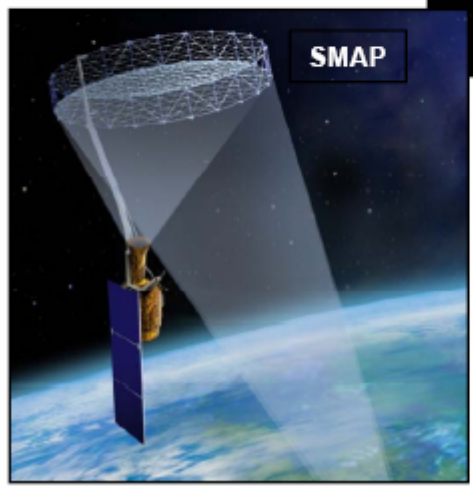
- **Two L Band SAR Satellites.**
- **Transmission in H & V polarizations.**
- **Reception in Single, Dual & Polarimetric modes.**
- **Narrow, Wide and ScanSAR Swath modes.**
- **High, Medium and Low resolution modes. (10 -100 m)**

CONAE NASA

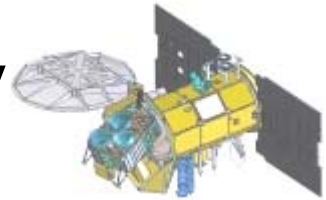
Relationship with Other Satellite Missions of NASA-ESA

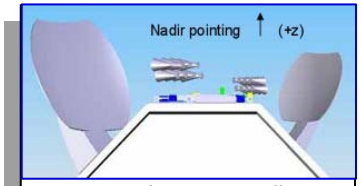


- **Aquarius/SAC-D** is one of two important precursor missions for **SMAP** Soil Moisture science
  - Aquarius will store all Level 1 global data: Land, ice, ocean
  - Aquarius can provide lower resolution (150 km x 7-day) passive/active L-band data to advance SMAP soil moisture algorithm and retrieval science
  - ESA **SMOS** Mission provides passive radiometer (no radar) soil moisture at 40 km x 3-day resolution comparable to SMAP
- SMAP presents an opportunity for follow-on ocean salinity data post-Aquarius/SAC-D



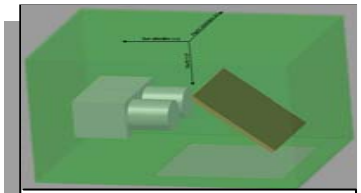
Instruments + S/P → Observatory





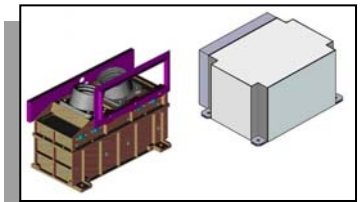
Microwave Radiometer

MWR



New InfraRed Sensor Technology

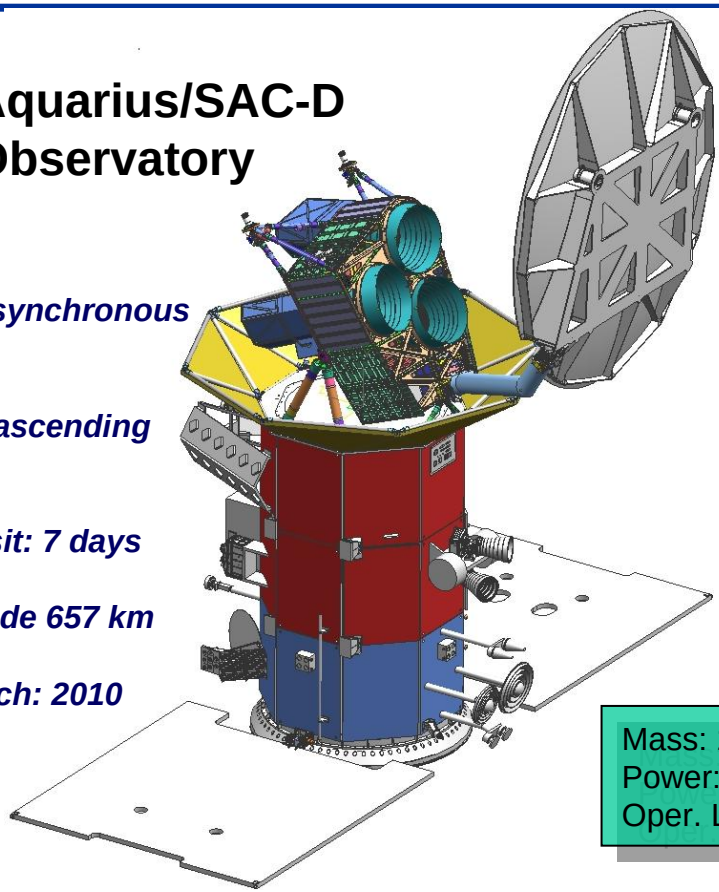
NIRST



High Sensitivity Camera

HSC

Aquarius/SAC-D Observatory



Sun-synchronous orbit

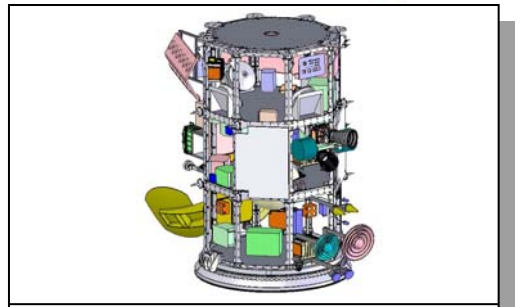
6pm ascending node

Revisit: 7 days

Altitude 657 km

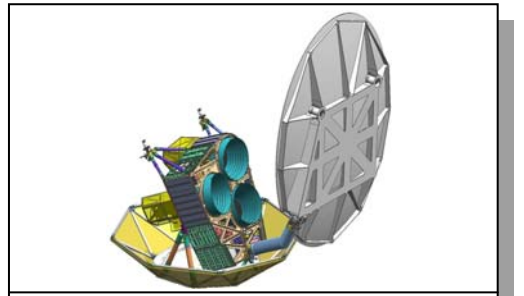
Launch: 2010

Mass: 1675 Kg
Power:1443 W
Oper. Life: 5 yrs

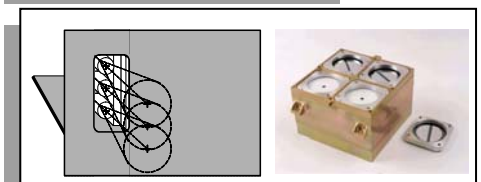


Satélite de Aplicaciones Científicas-D
Service Platform

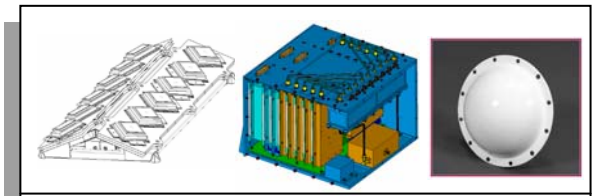
SAC-D S/P



Aquarius
(primary instrument)

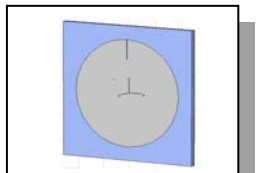


CARMEN-1
(ICARE-NG & SODAD)



Radio Occultation Sounder for the Atmosphere

ROSA



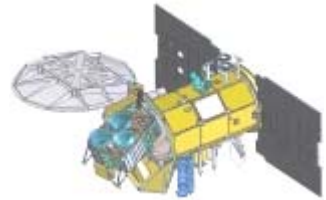
Data Collection System

DCS

Technology Demonstration Package

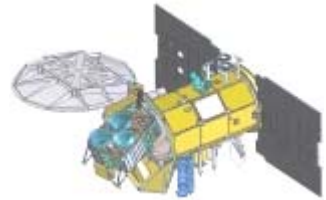
TDP

Specific measurements



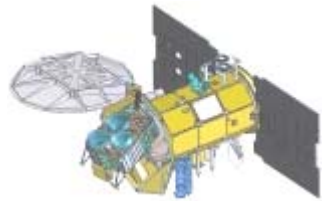
- Global sea surface salinity measurements (Aquarius).
- Retrieval of soil moisture (Aquarius).
- Measurements of precipitable water and sea surface wind speed (which will enhance the results of Aquarius measurements) (Microwave Radiometer-MWR).
- Measurements of water vapor, cloud liquid water and sea ice concentration (Microwave Radiometer-MWR).
- Monitoring of hot spots caused by biomass fires and volcanic eruptions, estimation of fire radiative power (NIRST).
- Measurements of sea surface temperature (NIRST).

Specific measurements

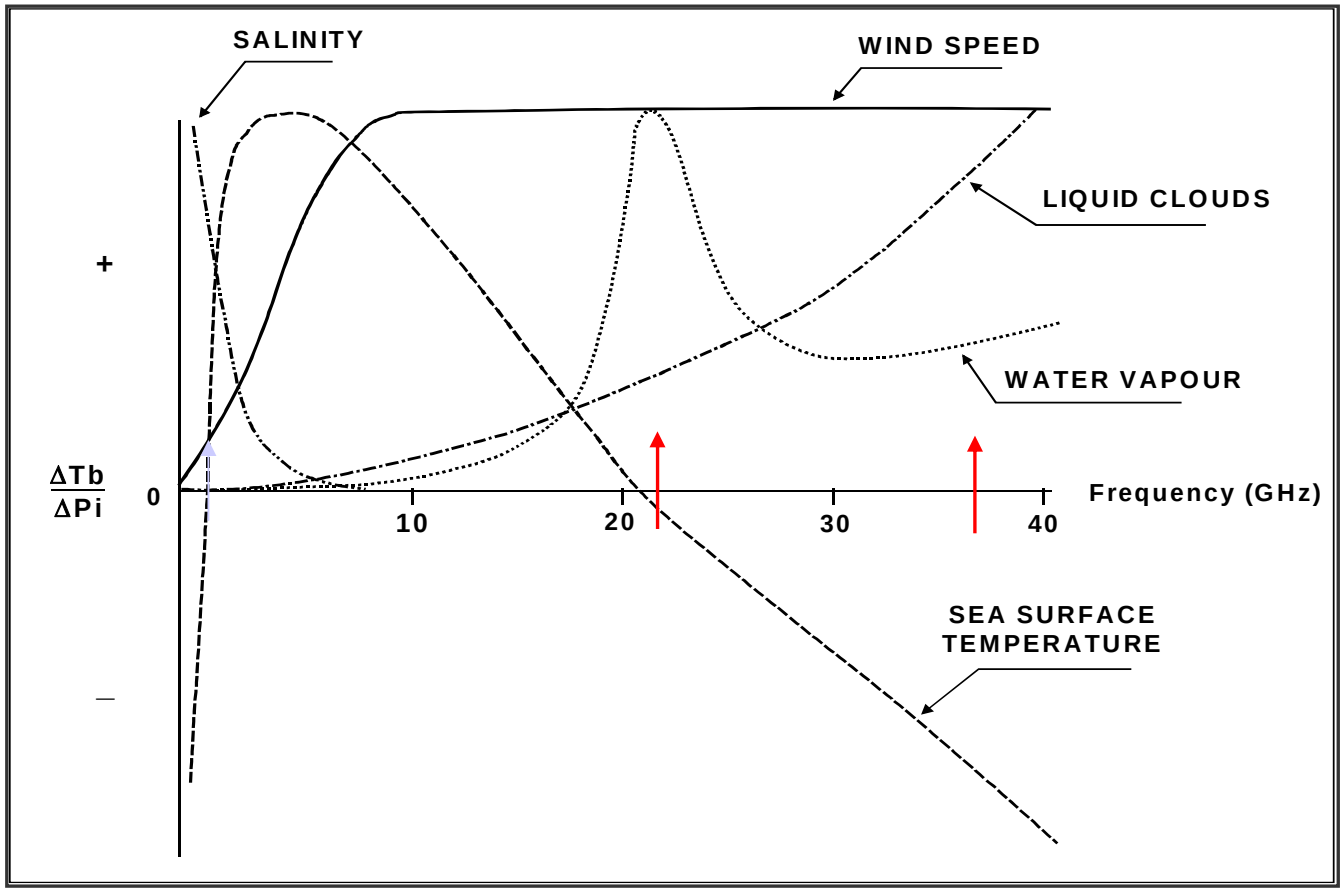


- Measurements of light intensity (urban areas, detection of electric storms, snow coverage, detection of fishing boats and aurora studies) (HSC).
- Measurements of atmospheric temperature, pressure profiles, and water vapor content (ROSA).
- Measure the high energy radiation environment (ICARE).
- Measure the size distribution of micro- particles and space debris (SODAD).
- Collect environmental measured parameters (e.g. meteorological) (DCS)

SAC-D Instruments



Several geophysical parameters are derived by measuring Tb at different bands



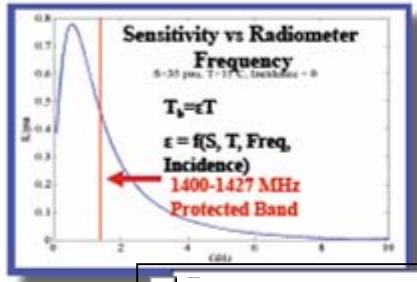
AQUARIUS/SAC-D

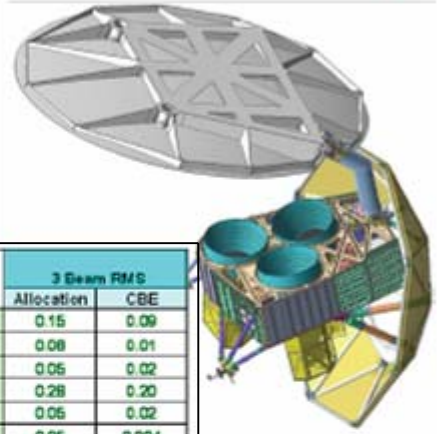
Aquarius

Aquarius/SAC-D will systematically observe the global surface salinity field for ≥3 years to achieve a monthly accuracy that will resolve the seasonal and interannual variability at 150 km scales.

Approach:

- Integrated L-band ultra-stable microwave radiometer-radar, 3 fixed beams, 390 km wide swath, 7-day repeat polar orbit
- Radar scatterometer is required to correct for wind roughness, the largest uncertainty error source
- Monthly averages to reduce measurement noise and achieve 0.2 psu RMS accuracy
- Three year baseline mission to resolve seasonal to interannual variability and robust mean field
- Independent calibration and validation from global *in situ* ocean observing system

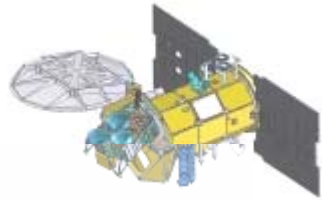




Error Sources	3 Beam RMS Allocation	3 Beam RMS CBE
Radiometer	0.15	0.09
Antenna	0.08	0.01
System Pointing	0.05	0.02
Roughness	0.28	0.20
Solar	0.05	0.02
Galactic	0.05	0.004
Rain (Total Liquid Water)	0.02	0.01
Ionosphere	0.06	0.043
Atmosphere - other	0.05	0.02
SST	0.10	0.07
Antenna gain near land & ice	0.10	0.10
Model Function	0.08	0.07

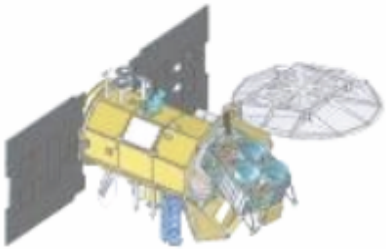
Brighness Temperature Error per Observation			Baseline Mission Allocation	Baseline Mission CBE
		Total RSS (K)	0.38	0.27
		Margin RSS (K)	0.27	
Latitude Range	Mean Sensitivity (dTv/dS)	Mean # Samples in 28 Days	Baseline Mission Monthly Salinity Error (psu) Allocation	Baseline Mission Monthly Salinity Error (psu) CBE
0-10	0.756	10.9	0.15	0.11
11-20	0.731	11.3	0.16	0.11
21-30	0.671	12.1	0.16	0.12
31-40	0.567	13.5	0.18	0.13
41-50	0.455	15.9	0.21	0.15
51-60	0.357	20.3	0.24	0.17
51-70	0.271	30.2	0.26	0.18
Global RMS (psu)			0.20	0.14
Margin RSS (psu)			0.14	

Aquarius

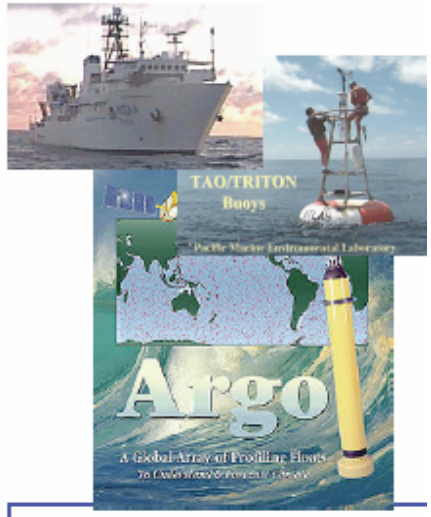


Sun-synchronous exact repeat orbit
6pm ascending node
Altitude 657 km

- **Global Coverage in 7 Days**
- **4 Repeat Cycles per Month**



Beams point toward the night side to avoid sun glint

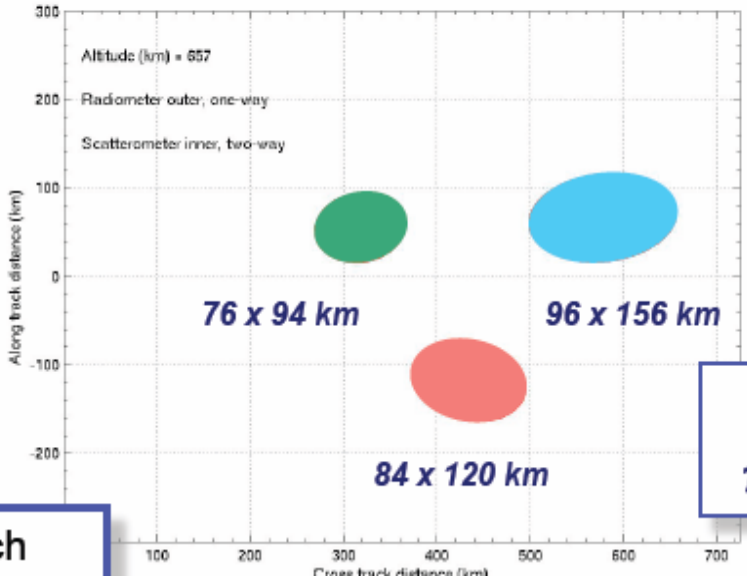


Surface Validation

In Orbit Check out

Launch

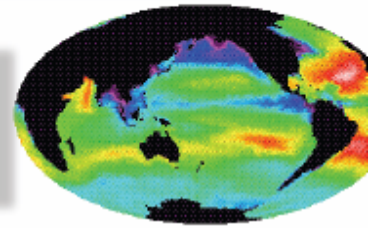
3 beams 390 km wide swath.



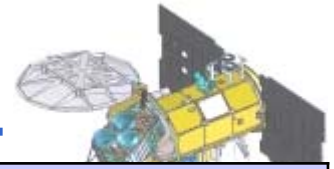
Aquarius Ground System

Salinity Data

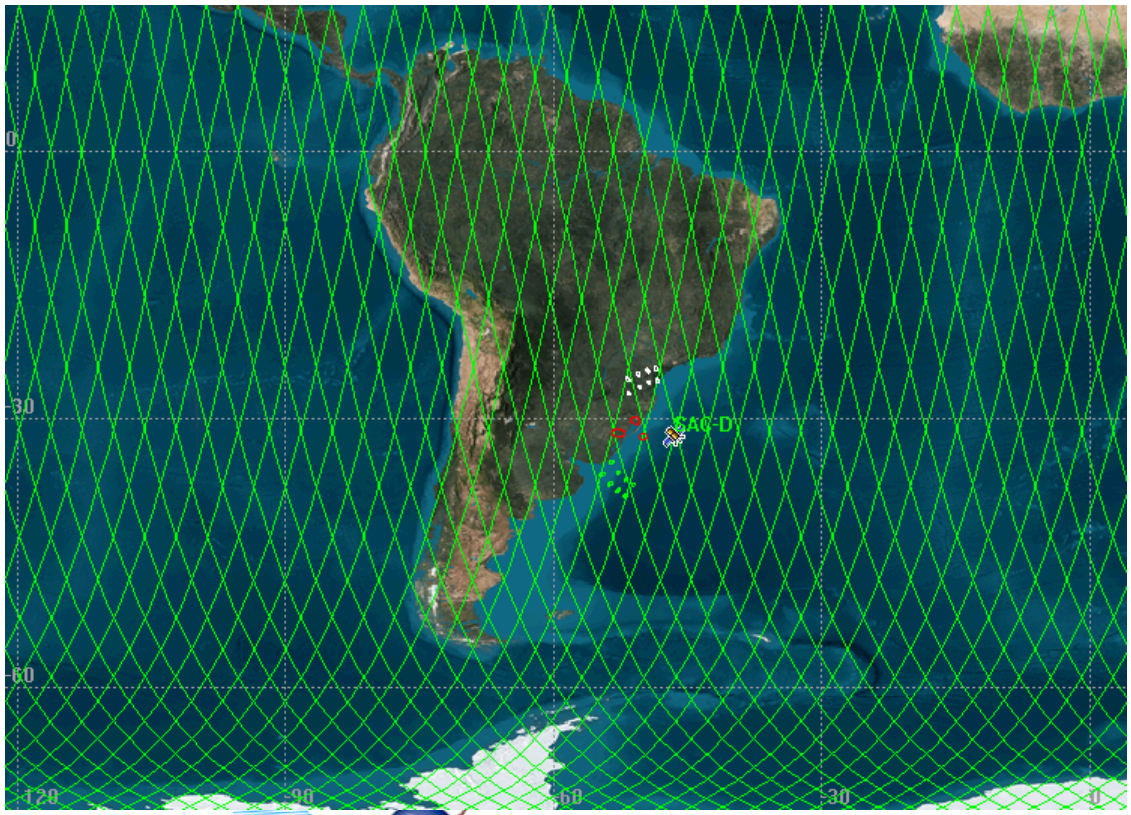
150km, Monthly, 0.2 (pss)



MWR: SCIENCE REQUIREMENTS

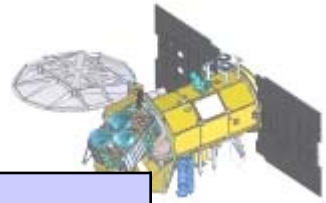


Science key-Requirements (L2)
The MWR shall be operated in an orbit which is in agreement with the Aquarius Orbit
The orbit was chosen to provide weekly global coverage measurements over the Earth
The MWR shall be continuously operating and return ocean and land surface data.

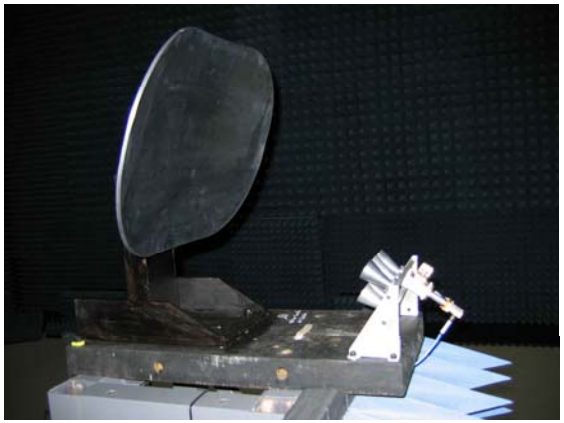


Power and Mass memory allocation was also took into account for a 100% operation over sea and land

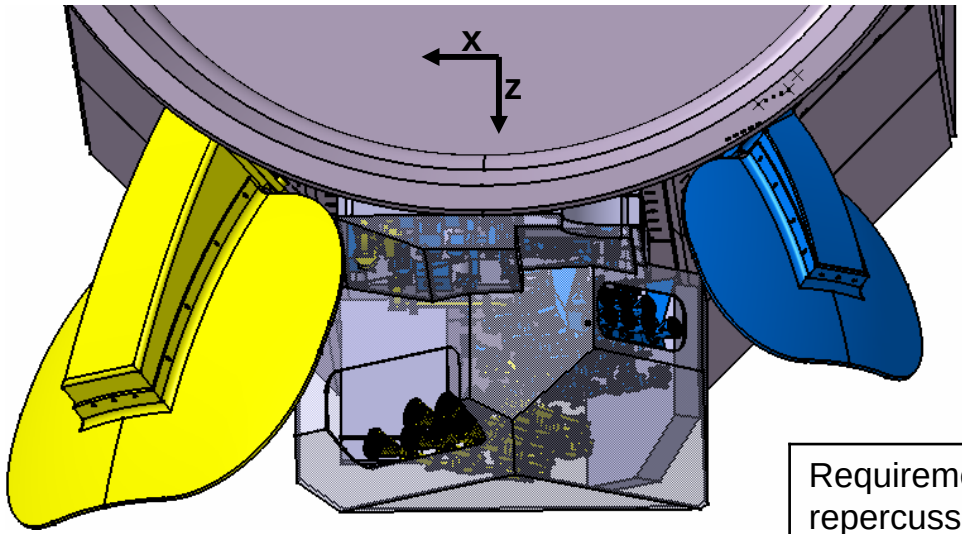
MWR: SCIENCE REQUIREMENTS



Science key-Requirements (L2)
The MWR has a multi-beam configuration in each frequency
The MWR shall be pointed towards the shadow side of the orbit to reduce the solar reflection and be coincident with Aquarius beams
Elapse time between MWR and Aquarius observations < 150 sec.
The MWR incidence angles shall be between 52º and 58º

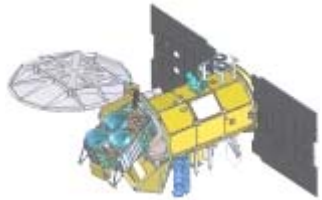


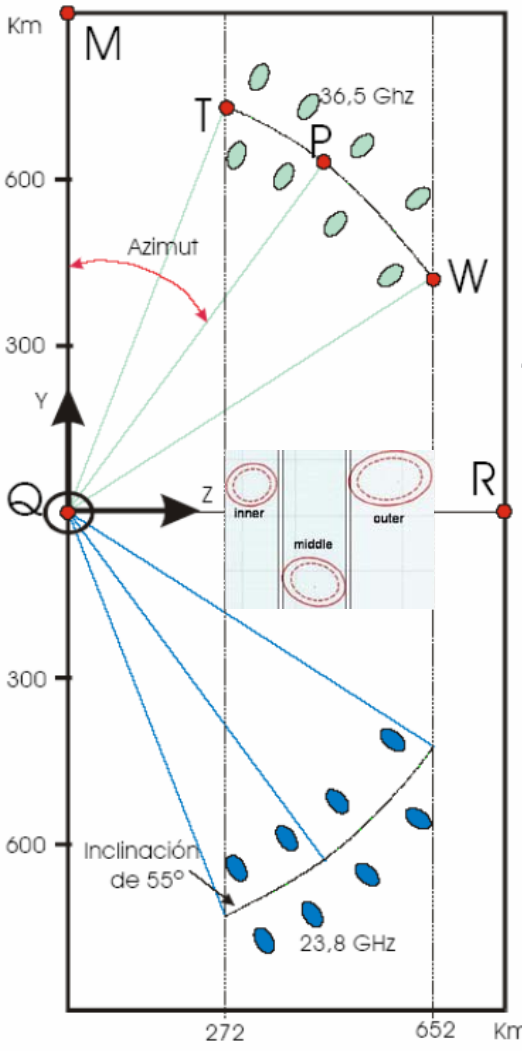
36.5 GHz 8-beam antenna provides a half power angle of 1.7º that produces a < 54 km across-track footprints in our pointing conditions

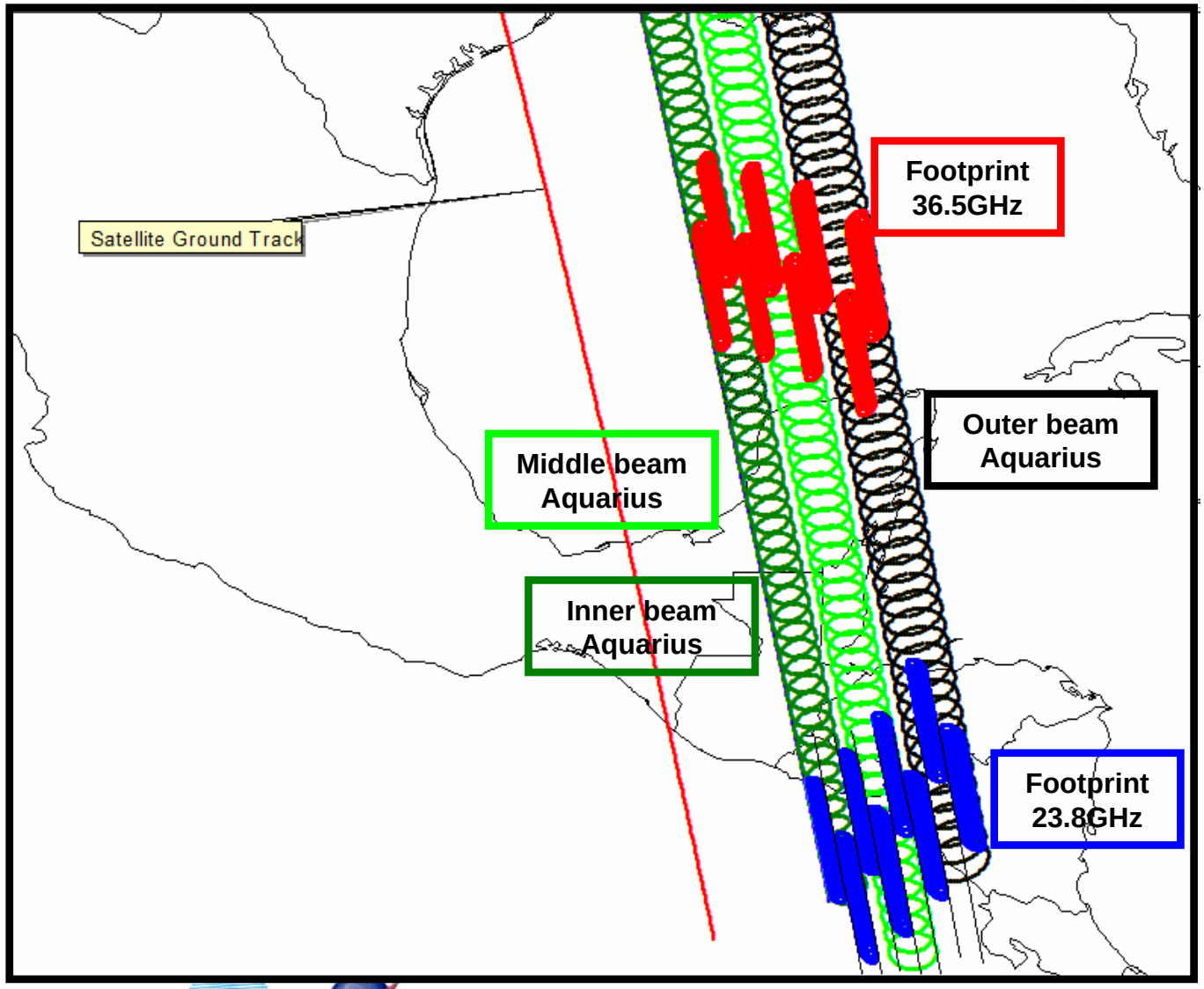


Requirements repercussion on the MWR physical configuration

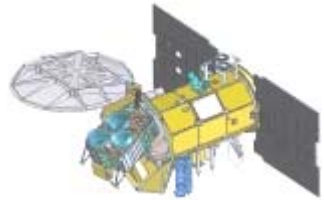
Footprints MWR & Aquarius

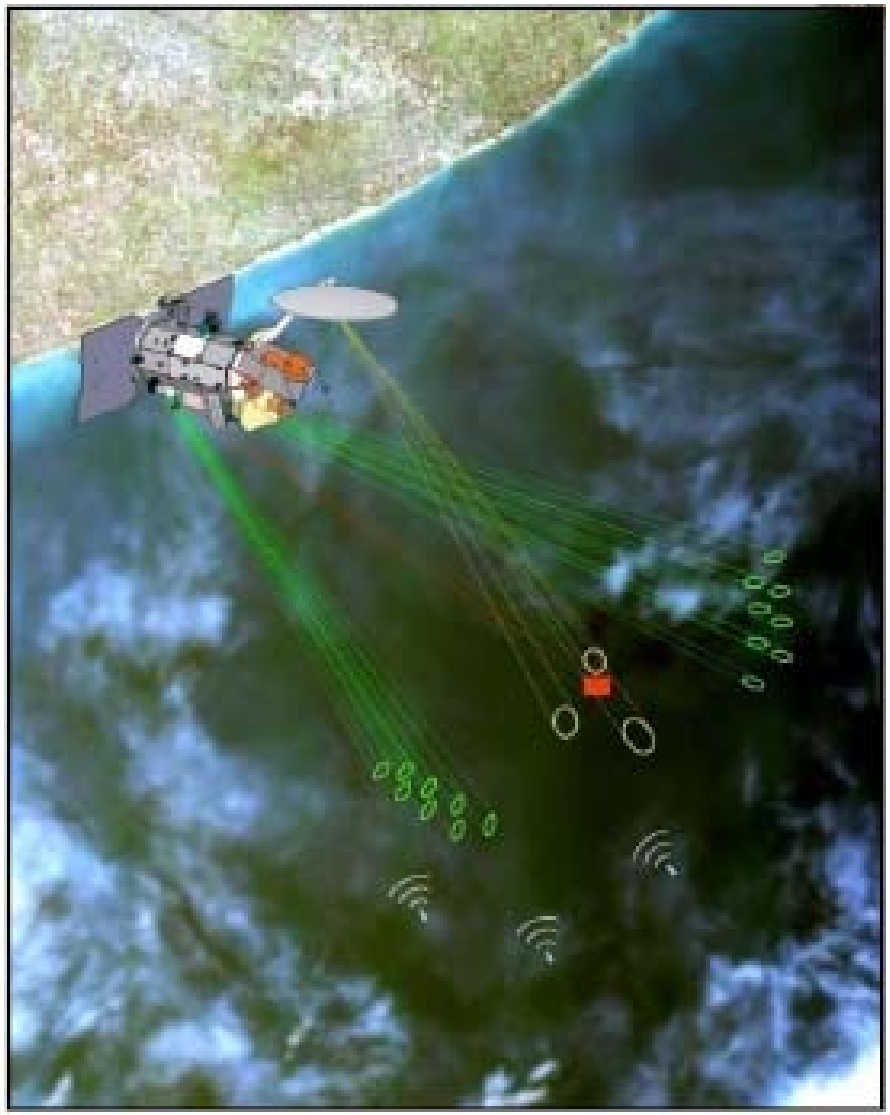




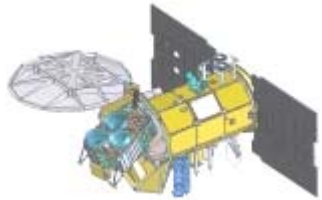


Geometry: Aquarius-MWR-NIRST



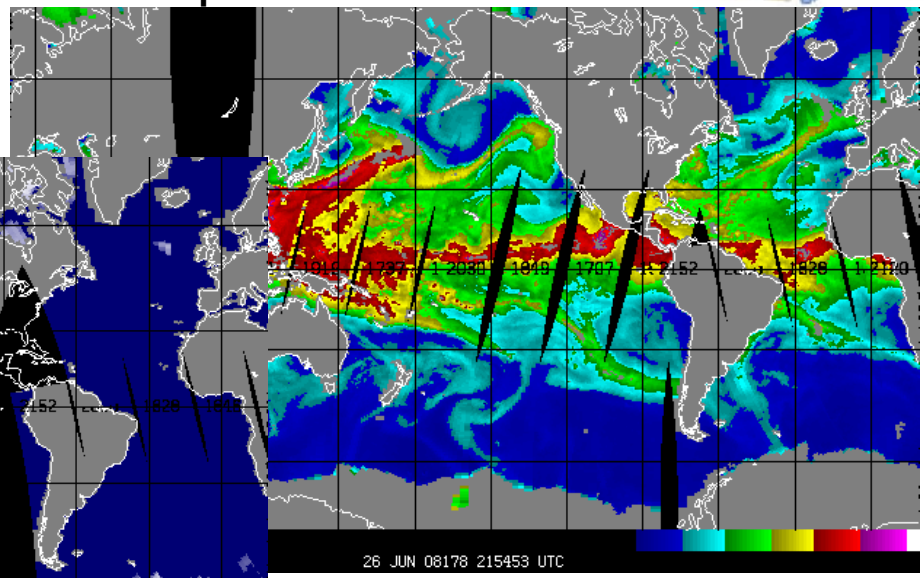


MWR

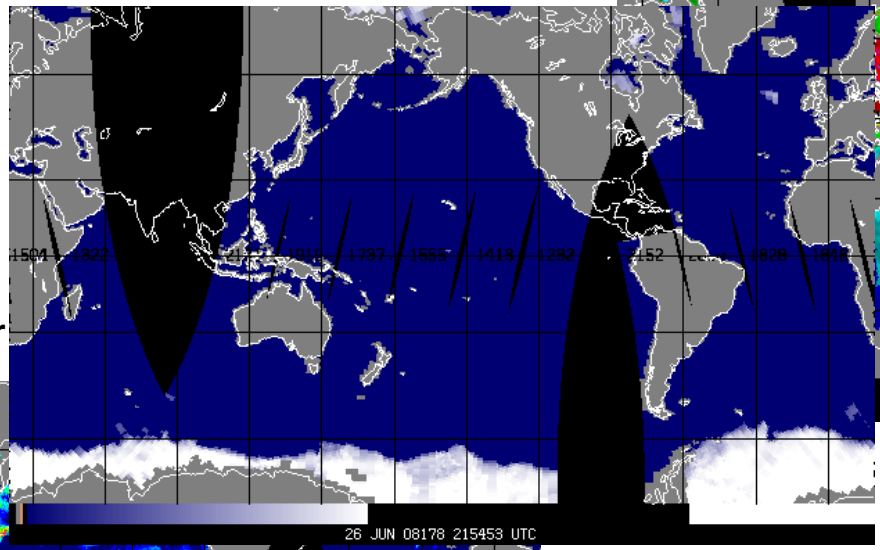


AMSU (Advanced Microwave Sounder Unit) Product NOAA Satellite

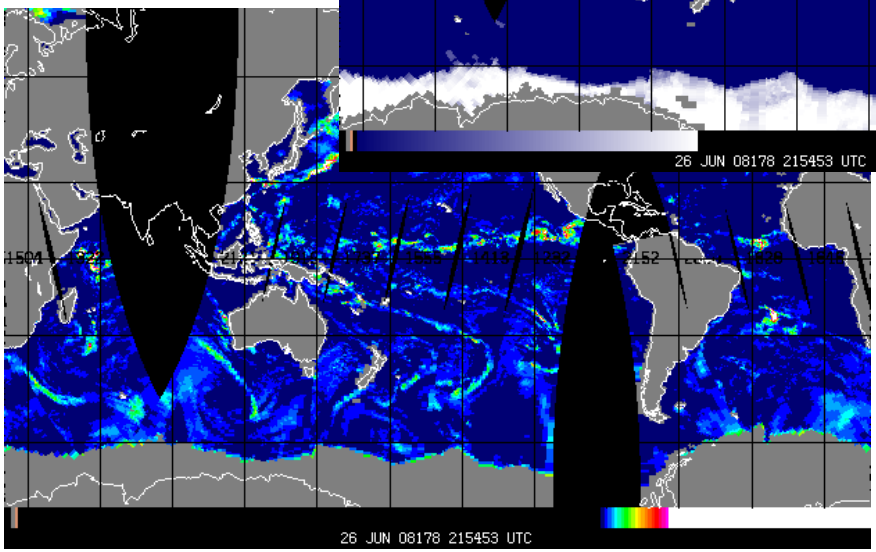
Total Precipitable Water



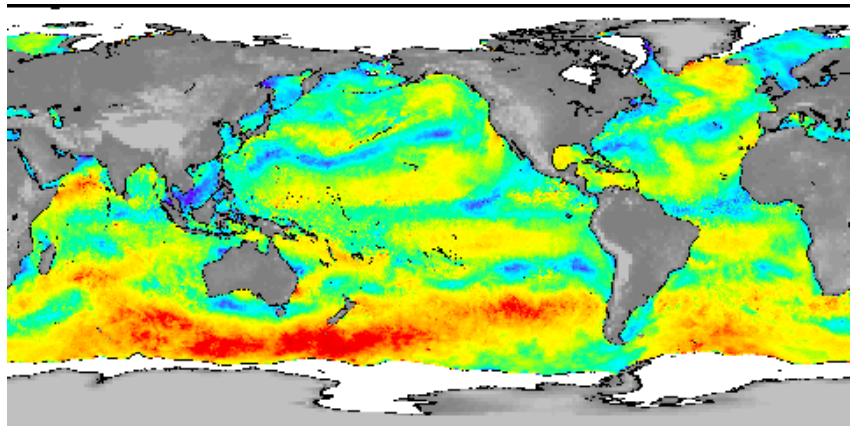
Sea Ice

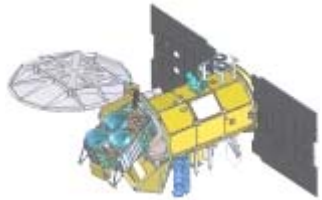


Cloud Liquid Water

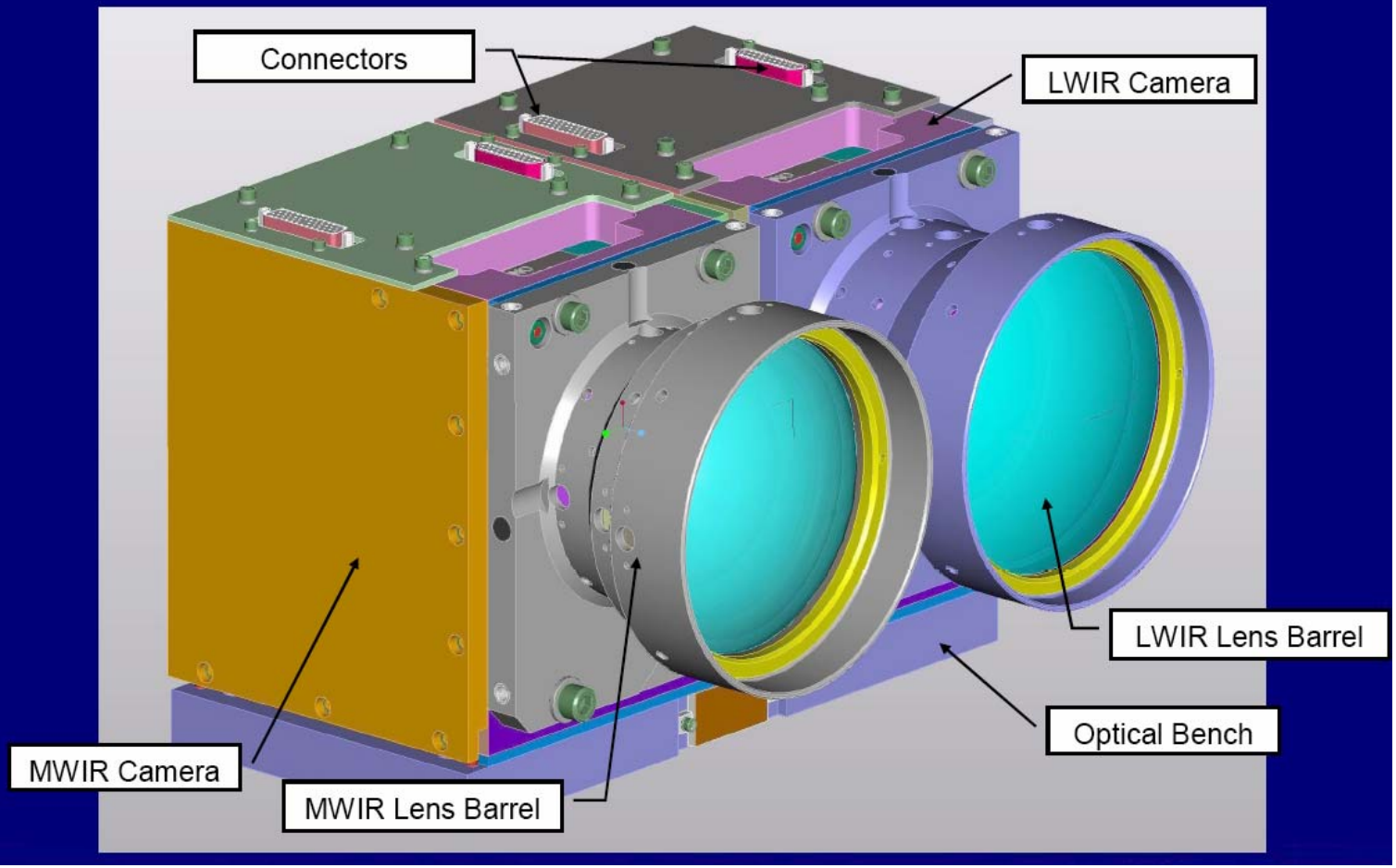


SSMI on DMSP - Surface Wind Speed





Design Overview

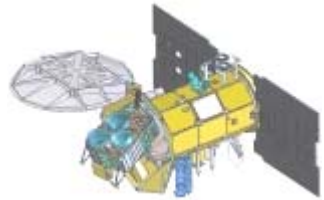


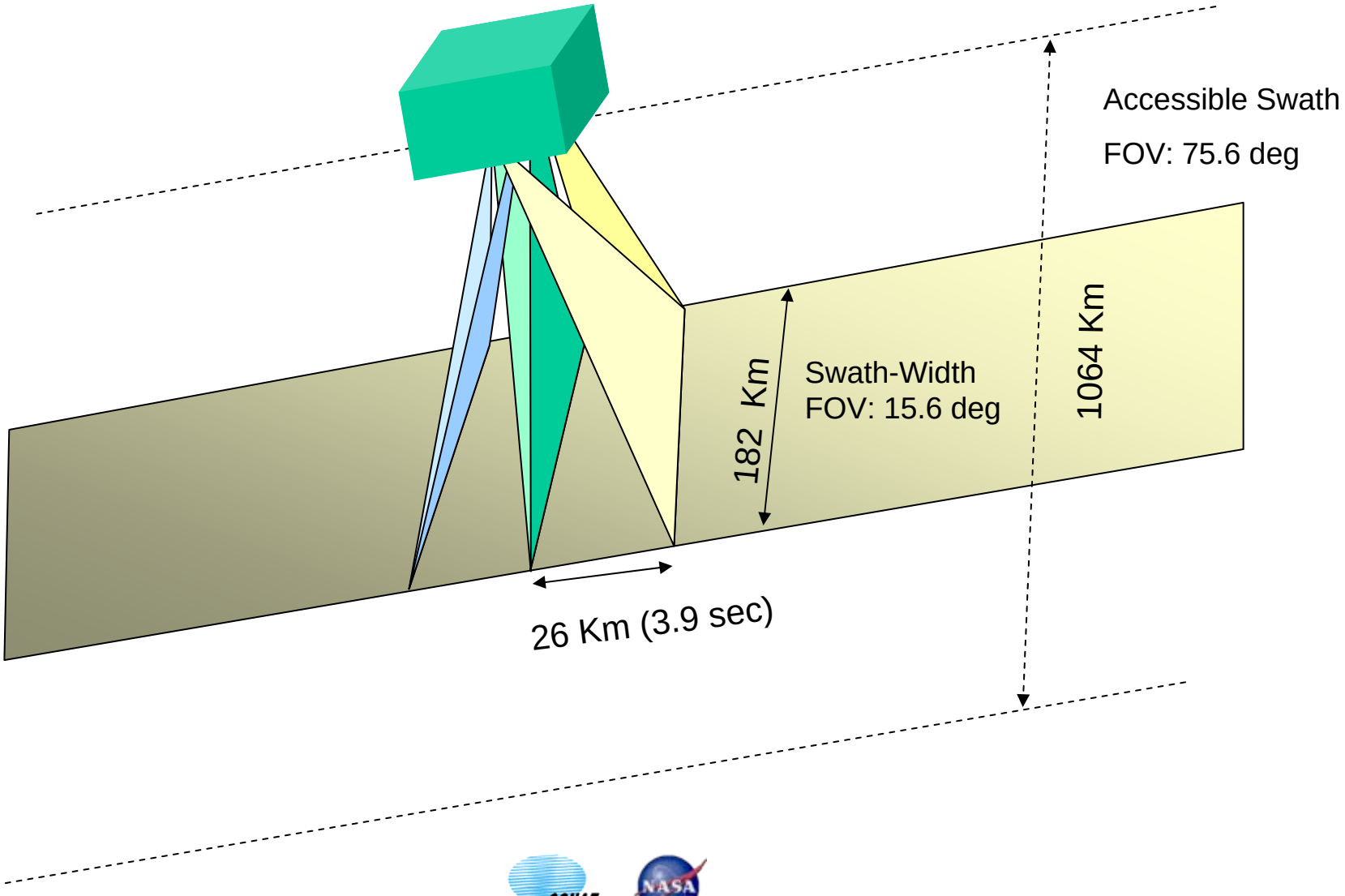
MWIR: 3.8 µm

LWIR1: 10.8µm

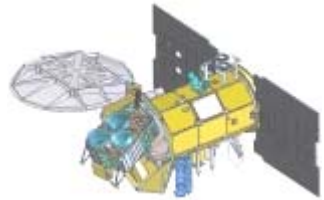
LWIR1: 11.8µm

NIRST Fields of View



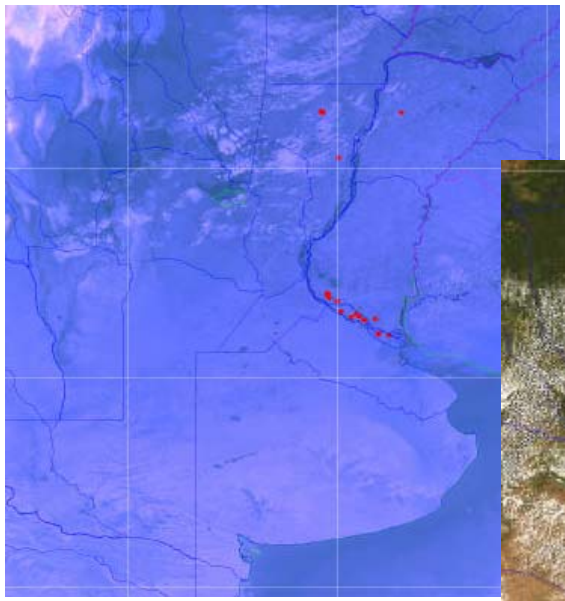


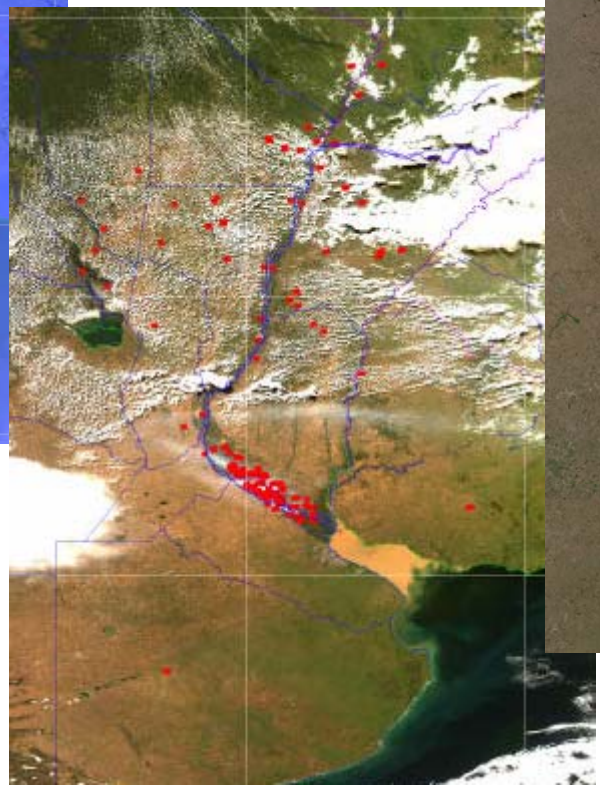
NIRST



NIRST: High Temperatures Events (HTE)

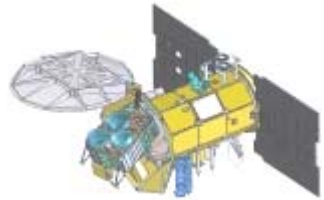
Fires in Paraná Delta-Fall 2008



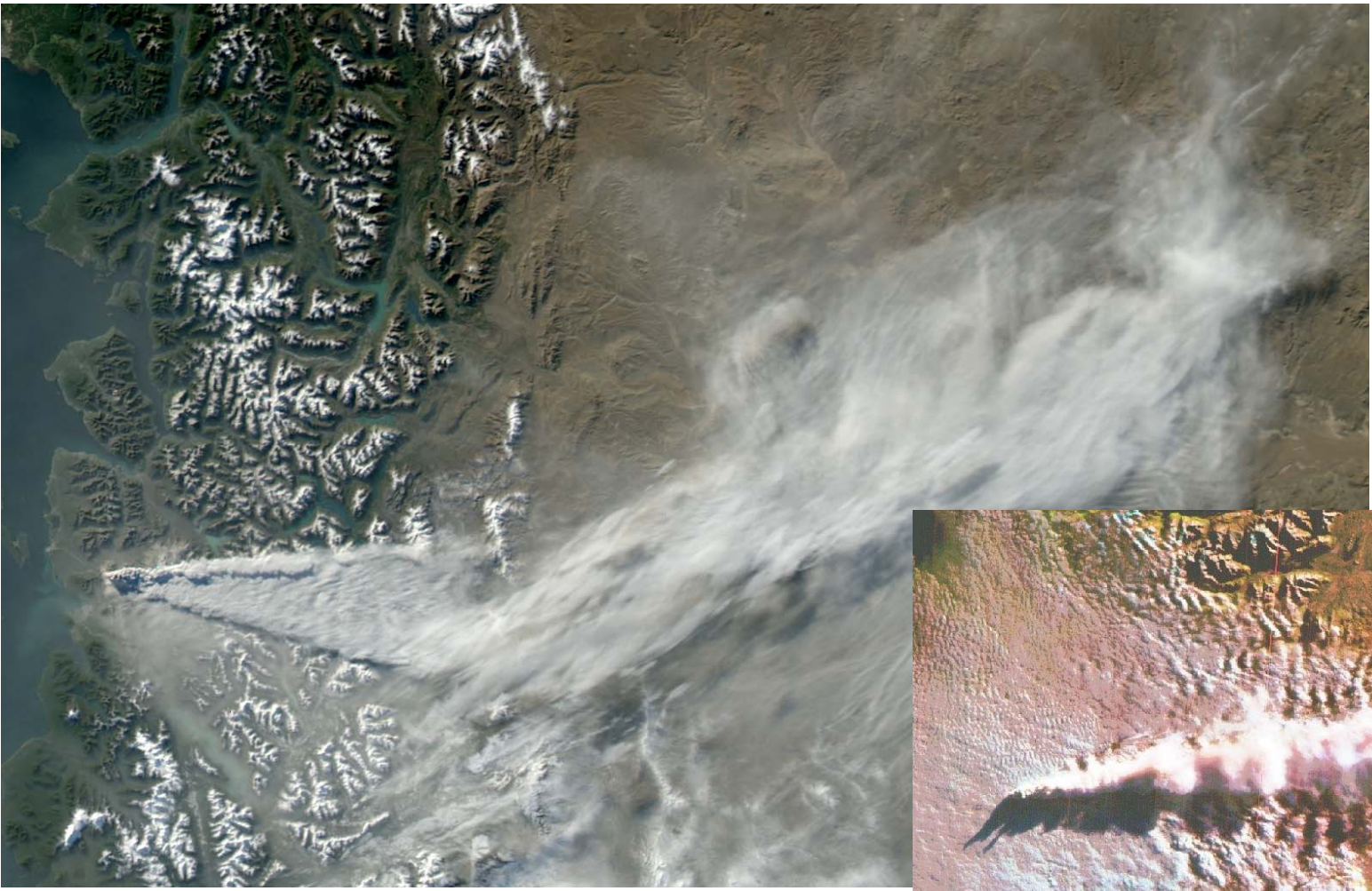


From MODIS Data

NIRST

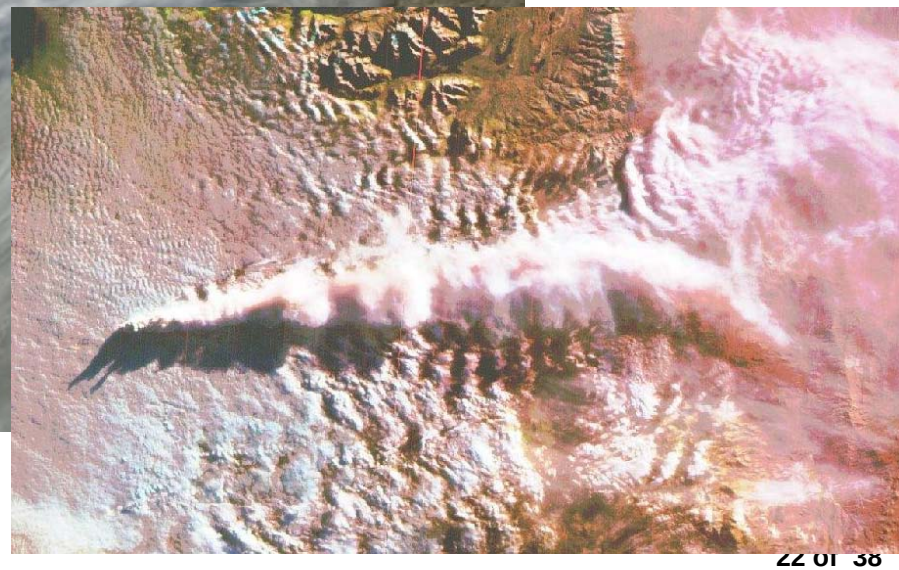


Volcanoes: El Chaiten Eruption- Fall 2008

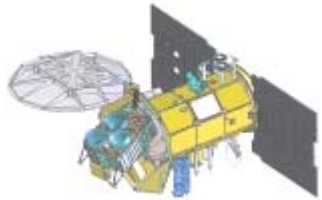


MODIS

SAC-C

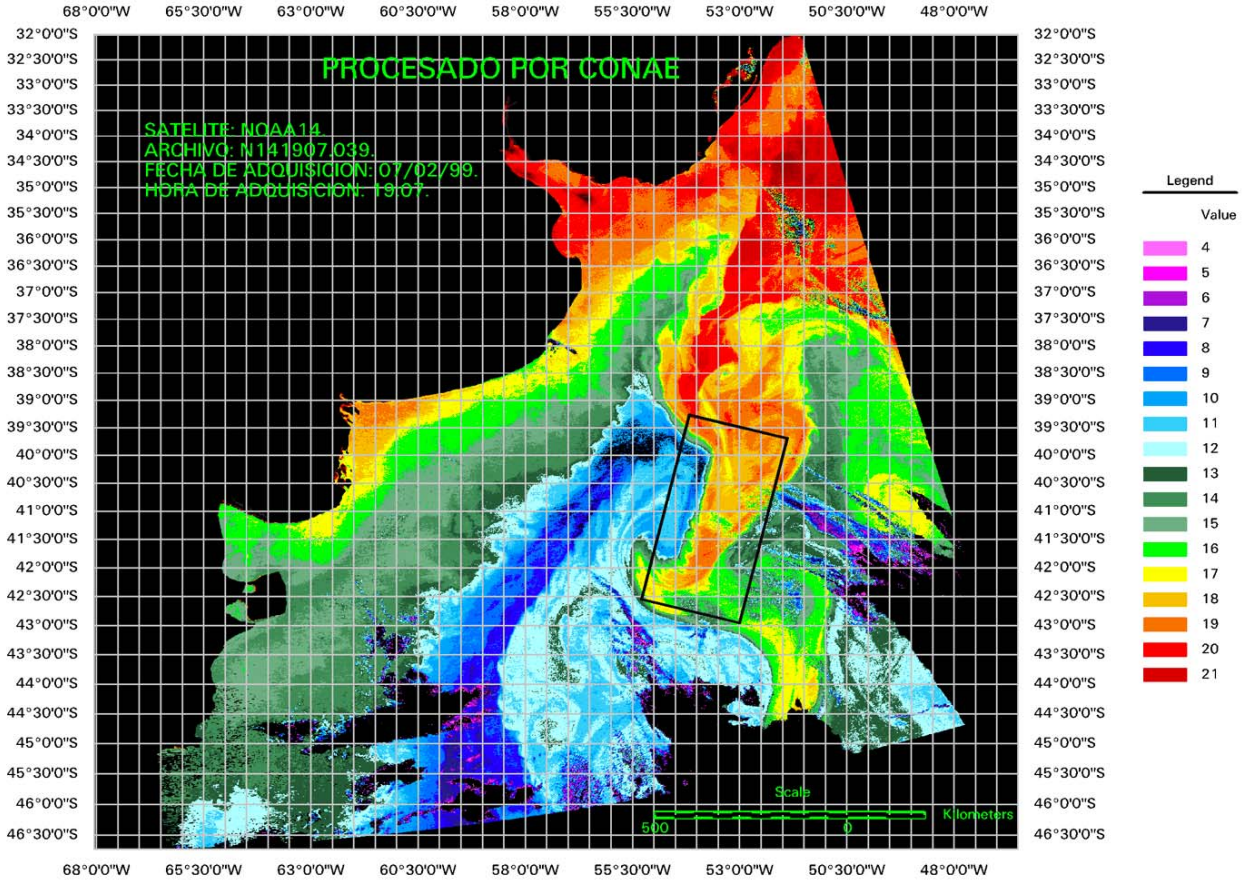


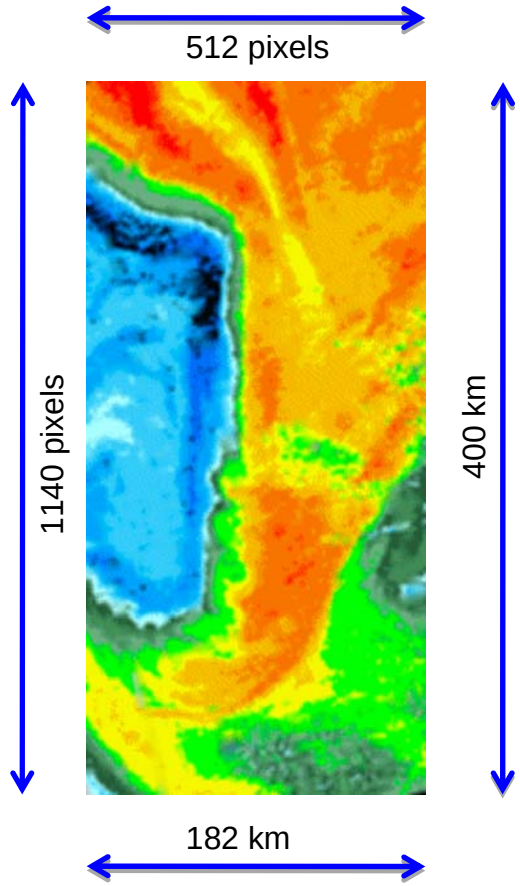
NIRST



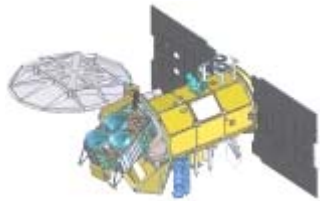
SST

NIRST almost 1 minute long nadiral scan over the Malvinas-Brazil eddies

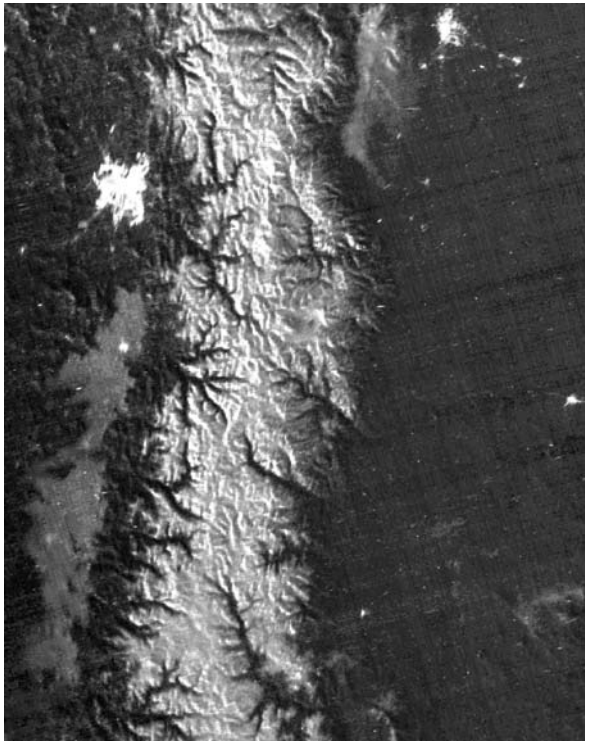




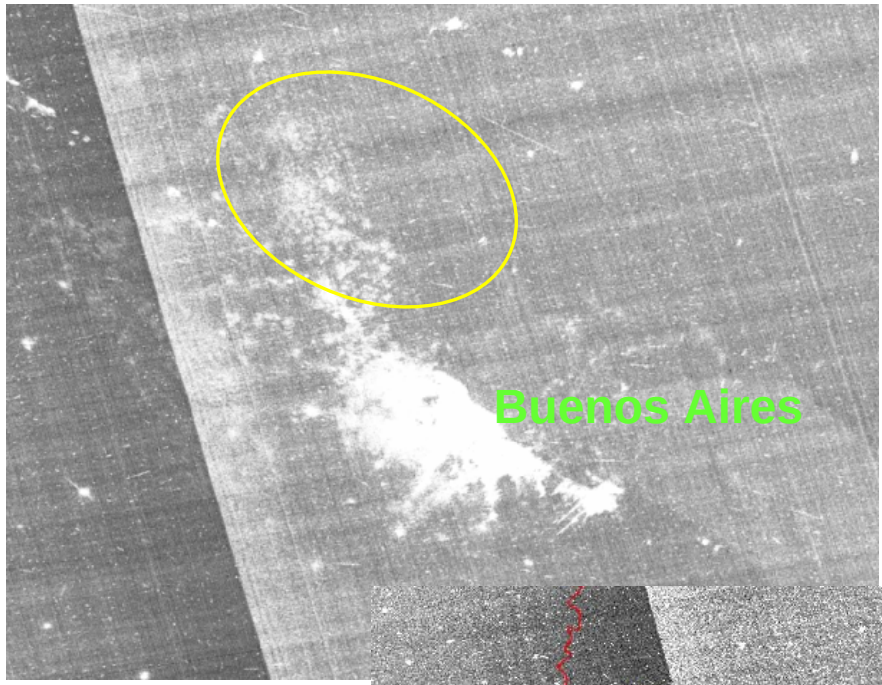
HSC



HSTC

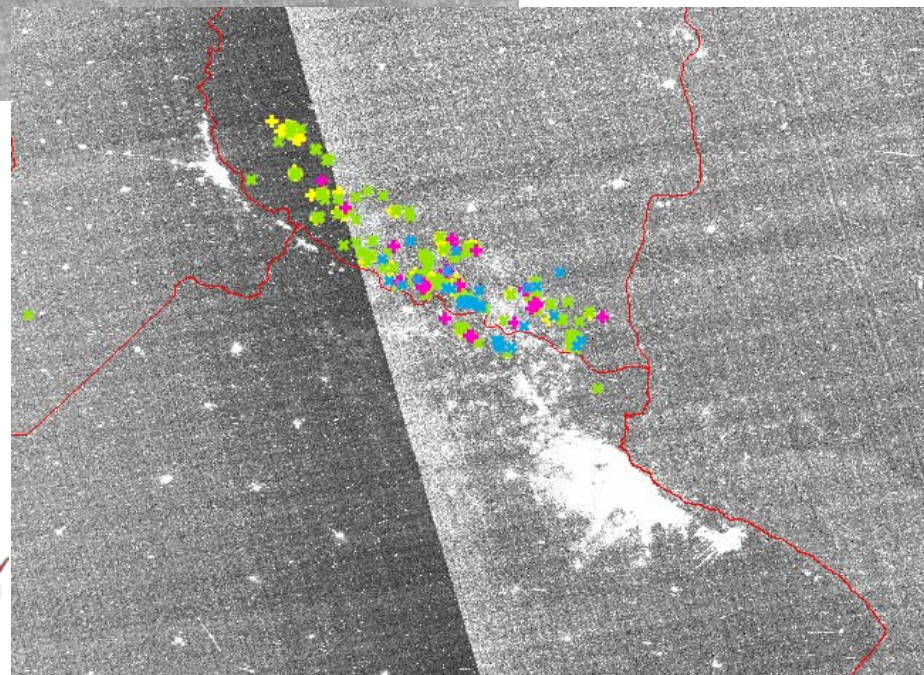


Snow Coverage



Fires Detection

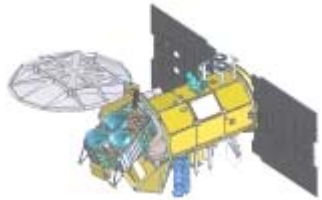
Urban Lights



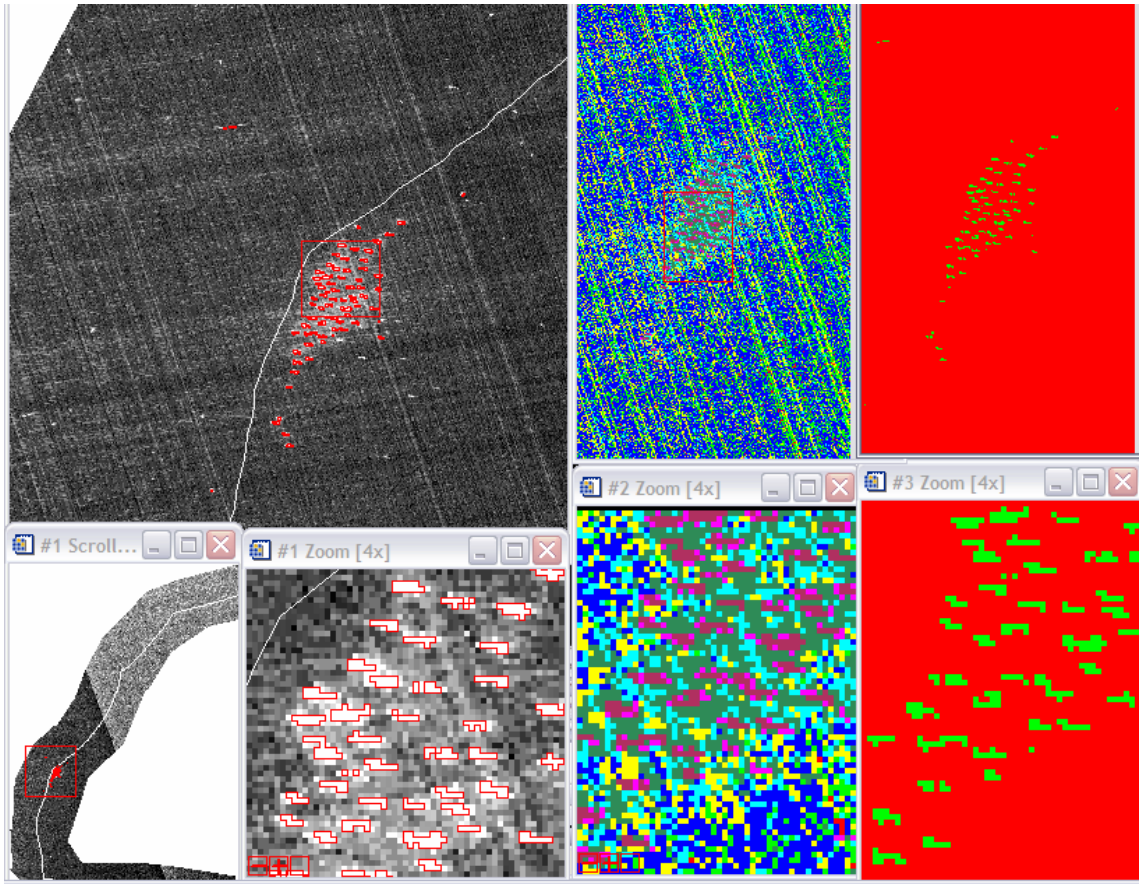
CONAE

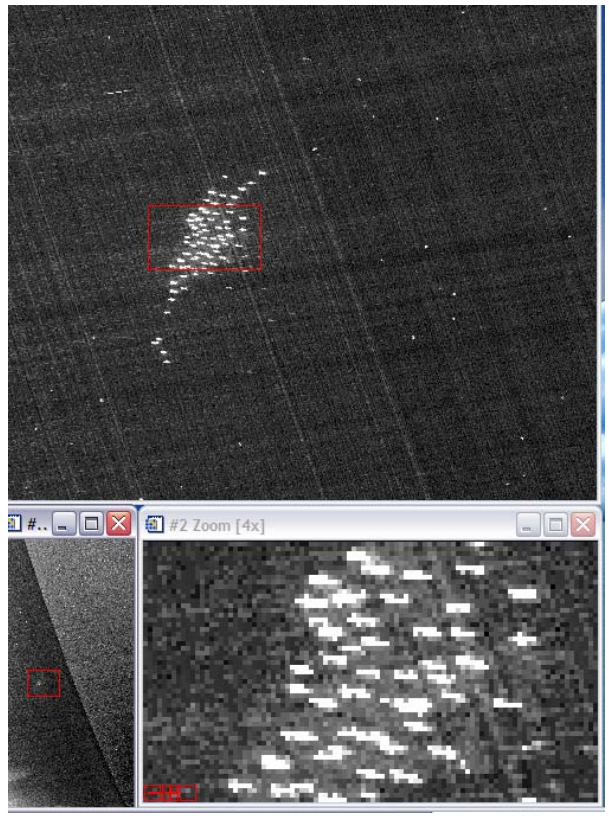
NASA

HSC

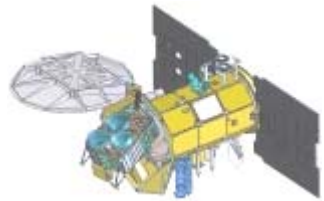


HSC: Surveillance (fishing boat).

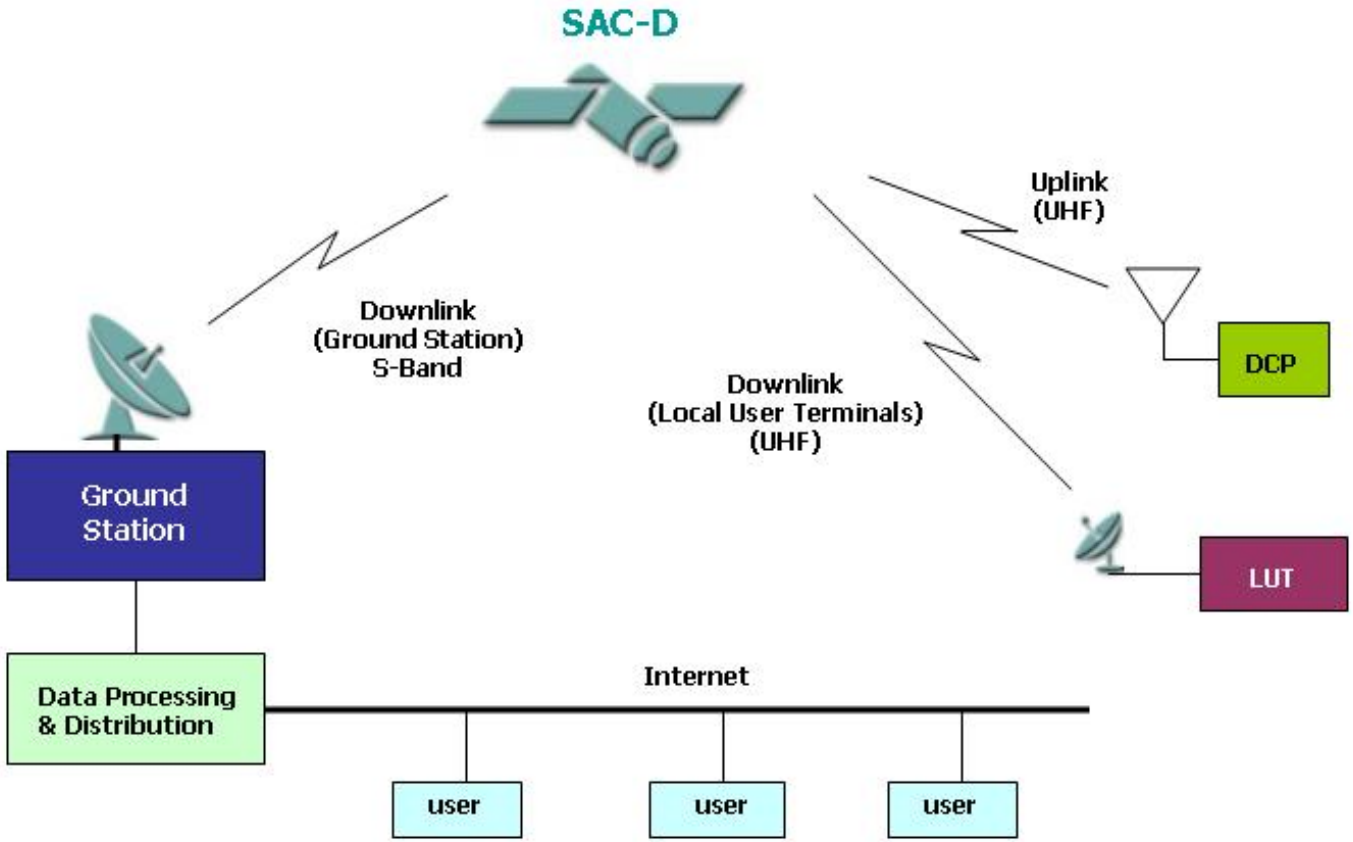




DCS

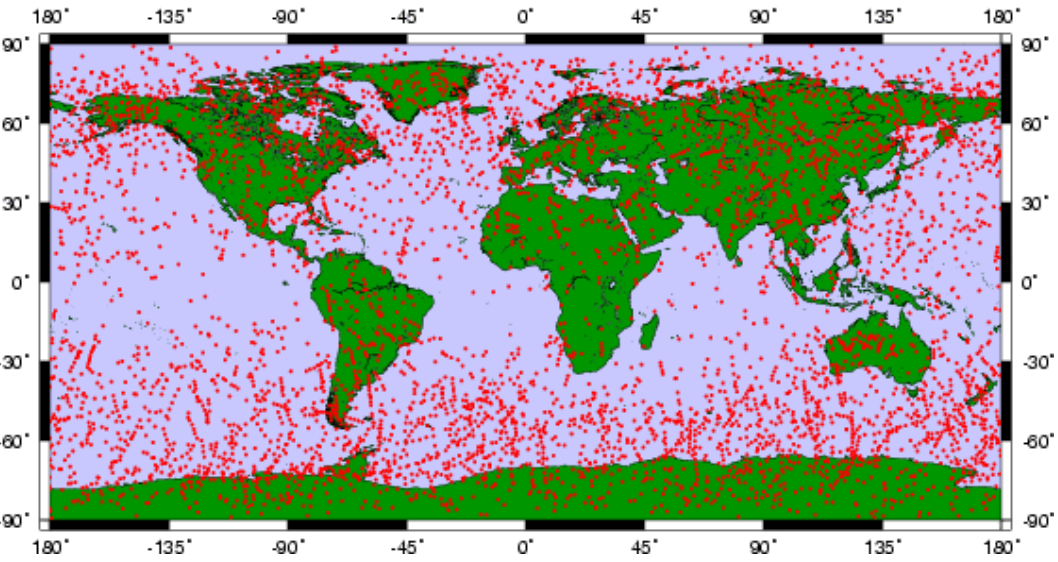


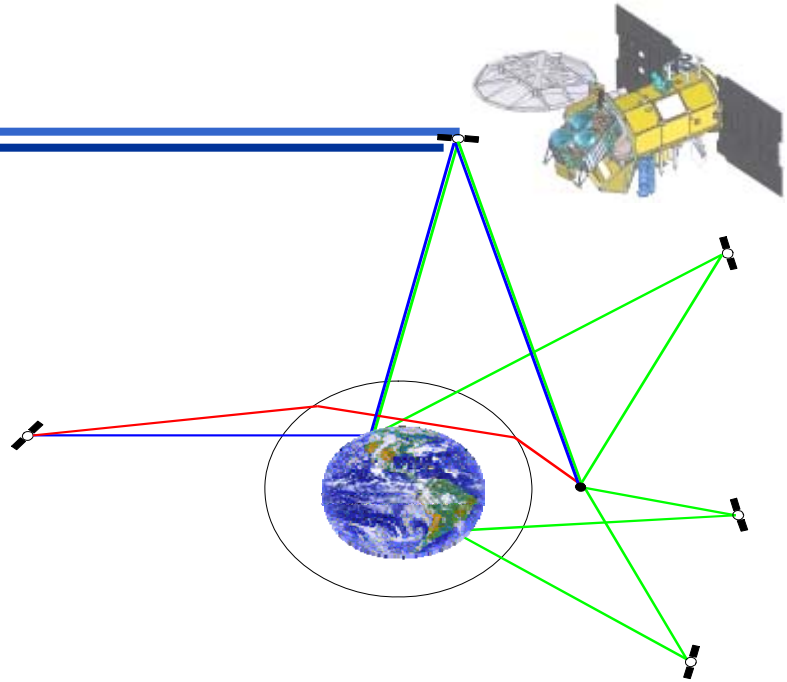
Data Collection System (DCS)

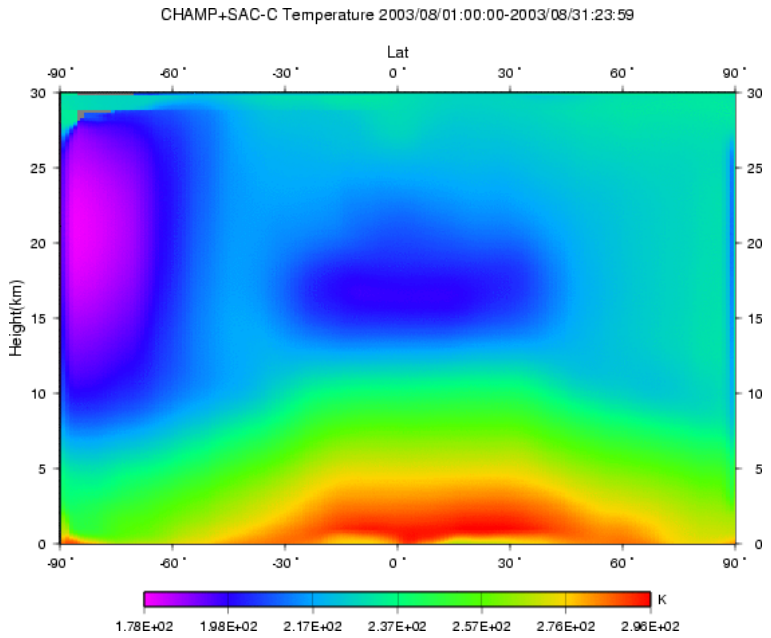


ROSA

Radio Occultation Sounder for the Atmosphere







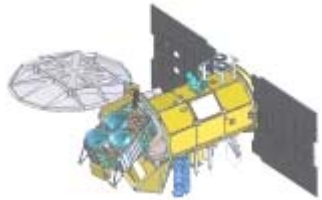
Frequency bands:

1575.42 MHz

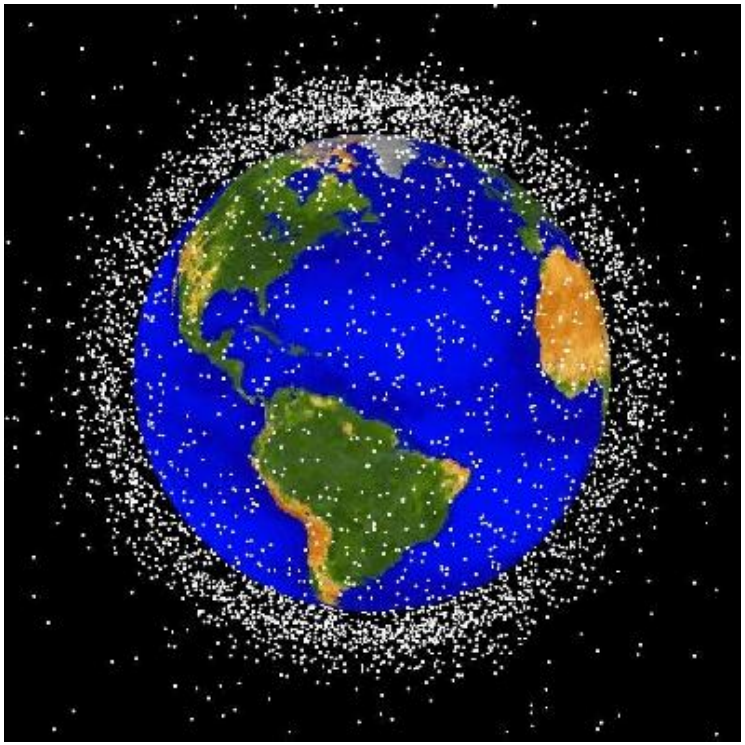
1227.6 MHz

CONAE NASA

CARMEN-1



ICARE/SODAD



Computer simulation of space debris distribution

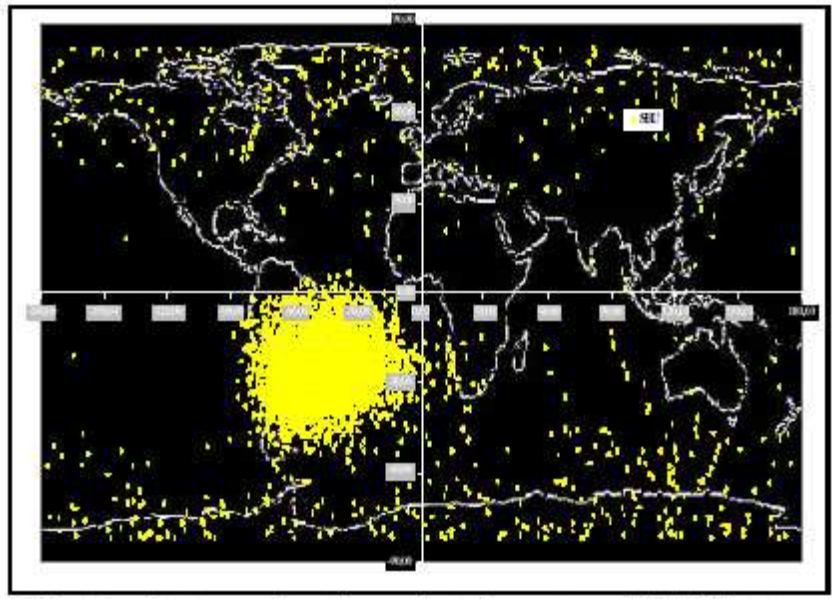
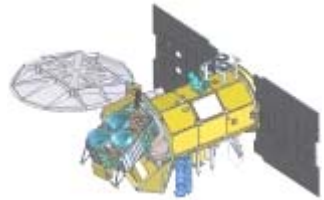


Fig. 5 : Cartography of cumulated upsets on ICARE test board from November 2000 to May 2001 (7416 upsets)

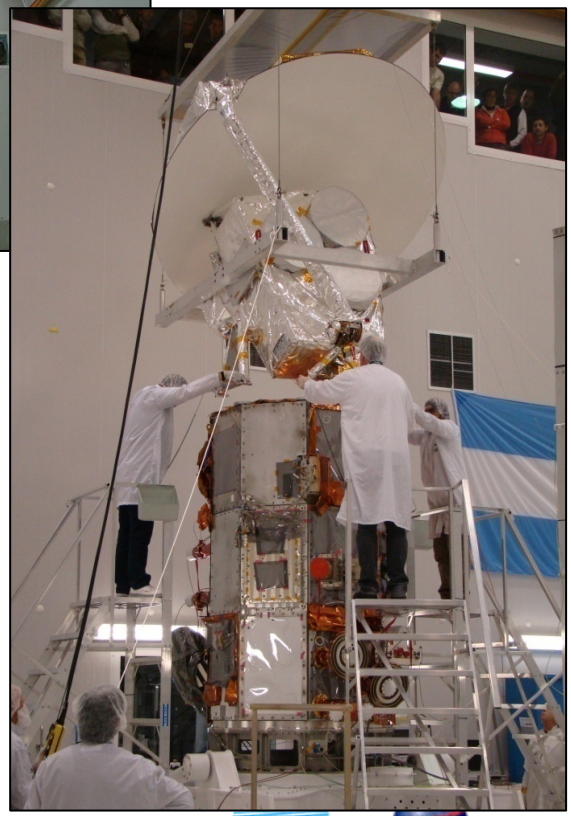
Results from ICARE on SAC-C

Science Programe Status



- **First Announcement of Opportunity (NASA & CONAE/MinCyT) in order to select an International Science Investigating Team for the Aquarius/SAC-D Observatory.**
- **30 proposal selected in june 2009.**
- **5th Aquarius/ SAC-D Science Meeting- October 2009**
- **6th Aquarius/ SAC-D Science Meeting- July 2010**

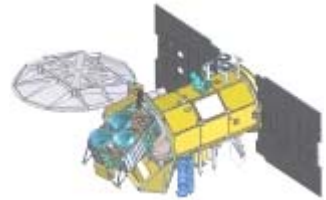
Observatory Flight Model I&T

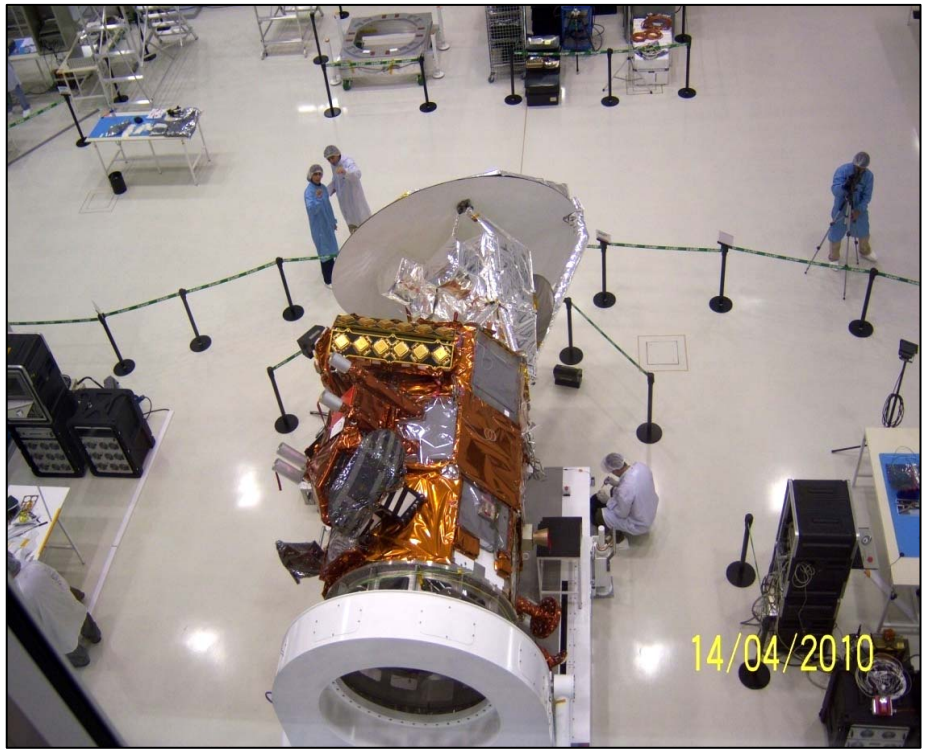


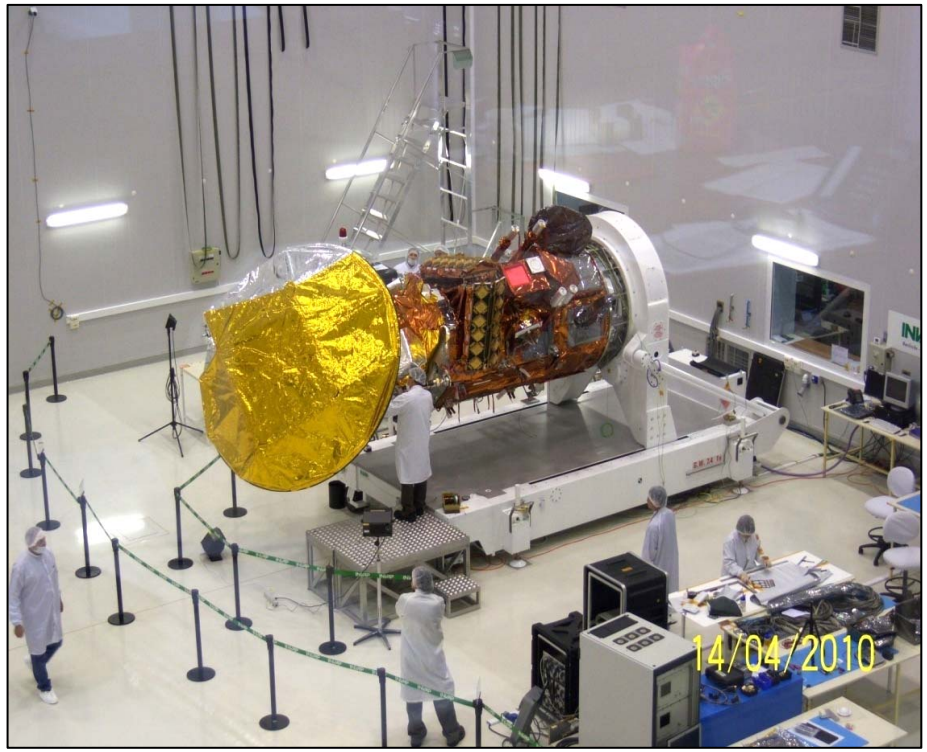
Aquarius Mechanical Integration

CONAE NASA

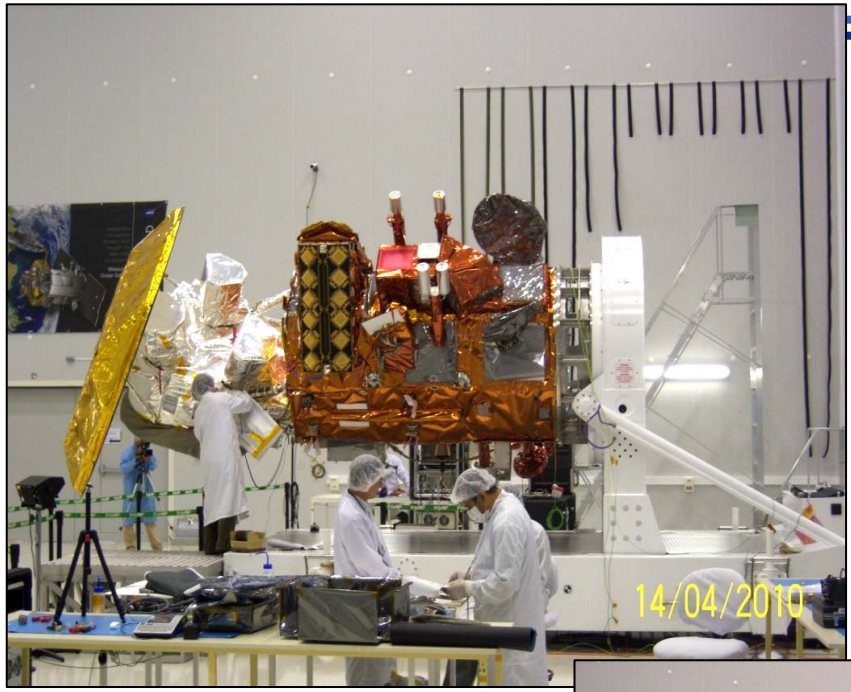
Observatory Flight Model I&T

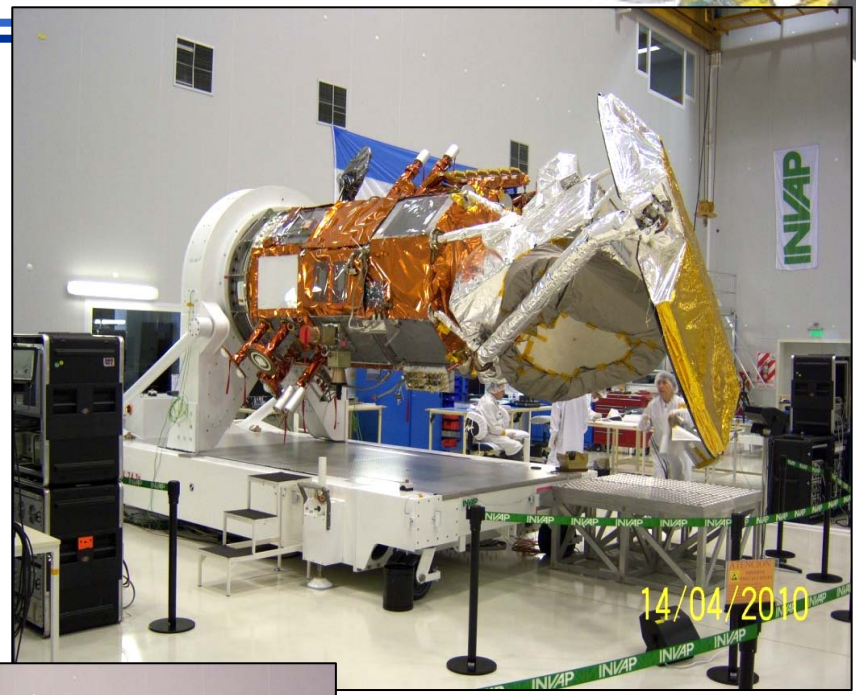


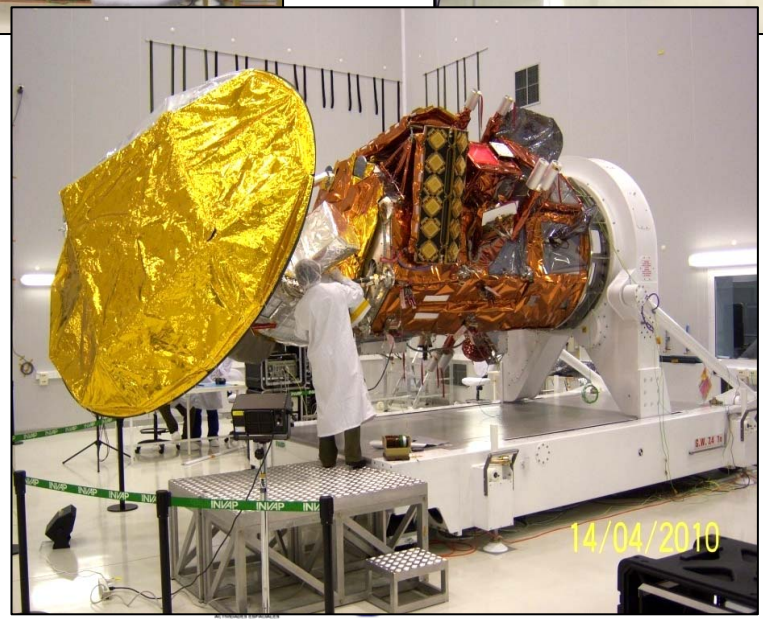


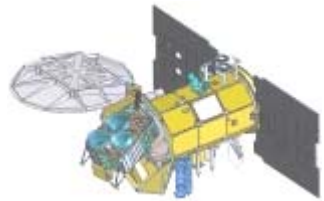


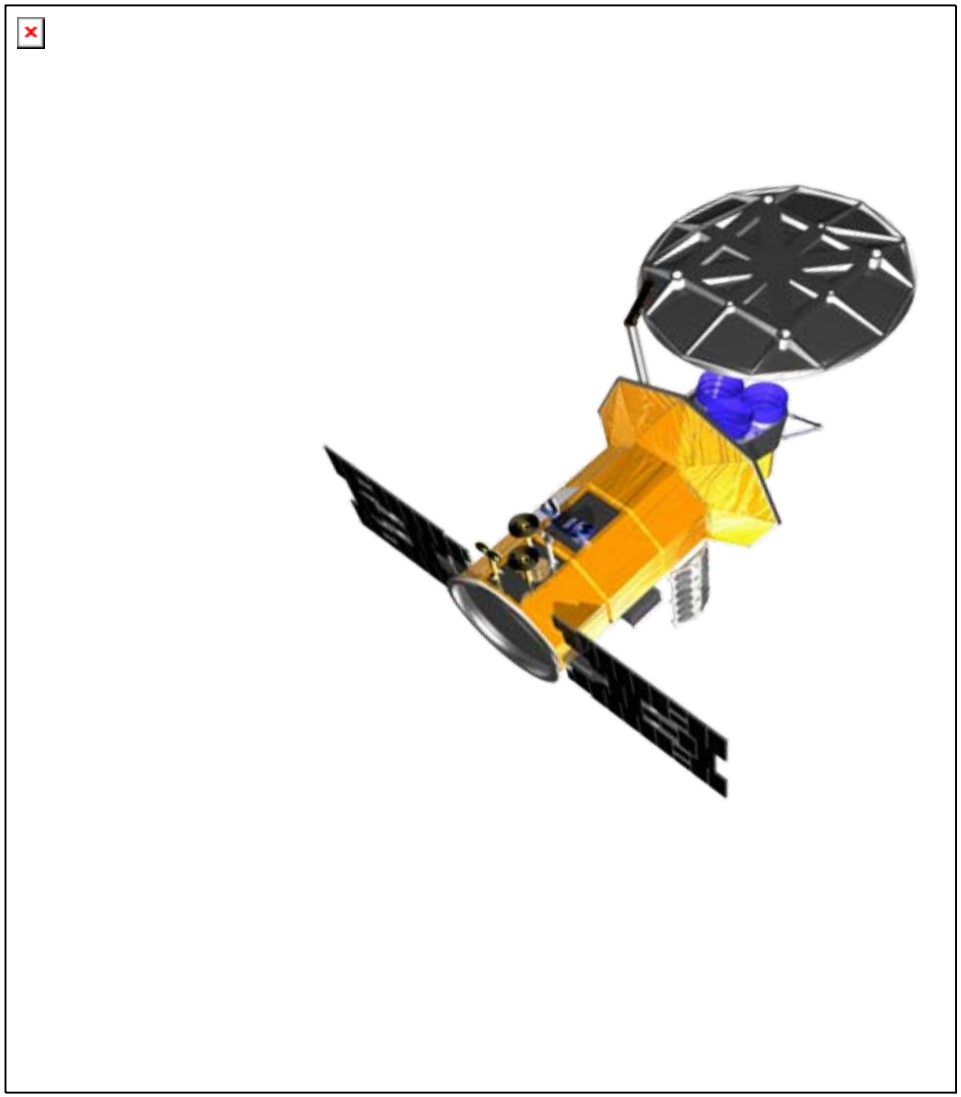
Observatory Flight Model I&T



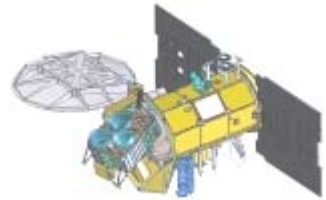






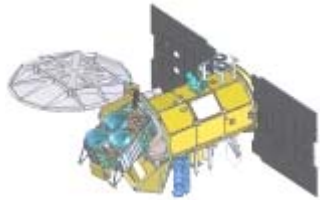


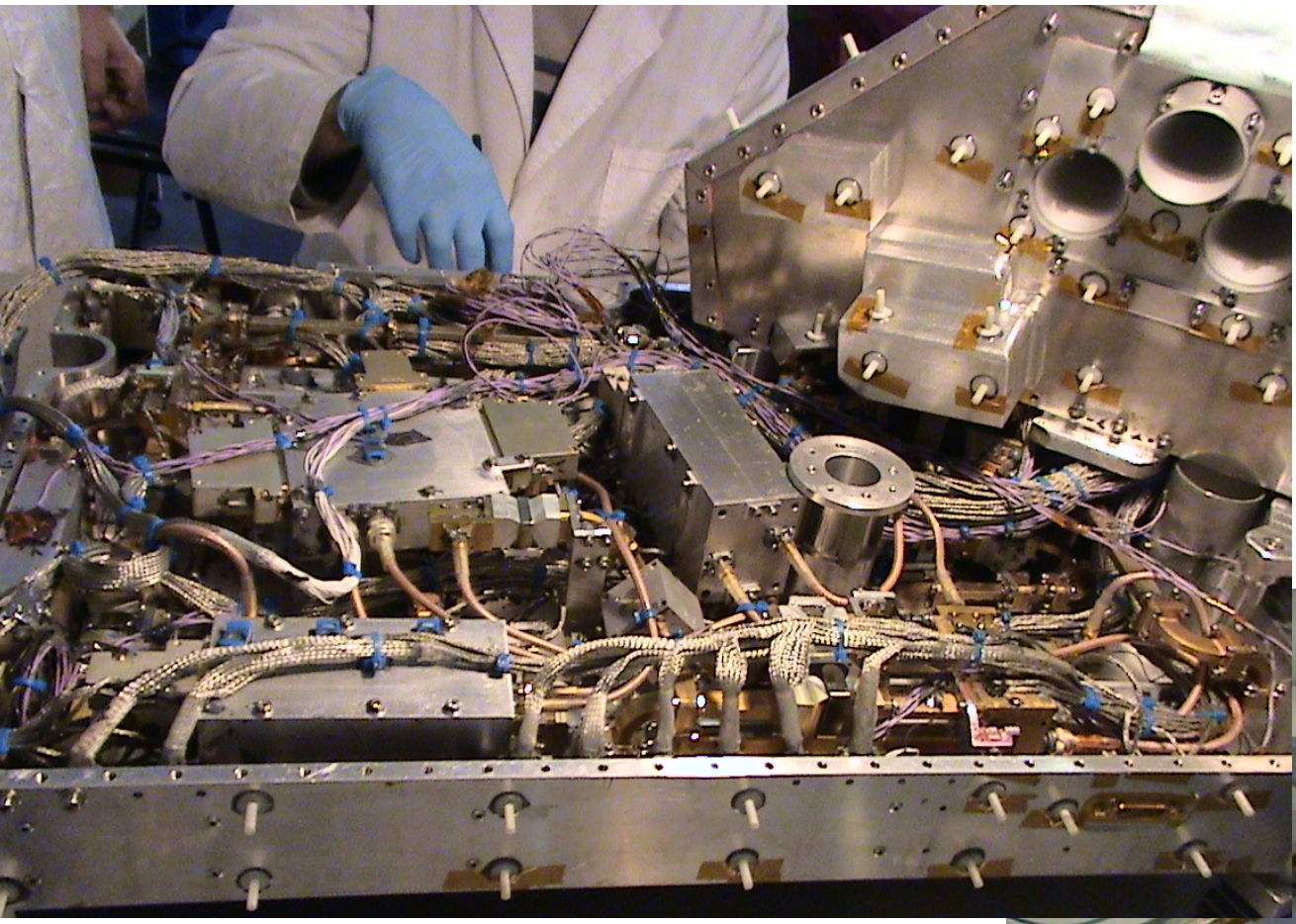
mrabolli@conae.gov.ar



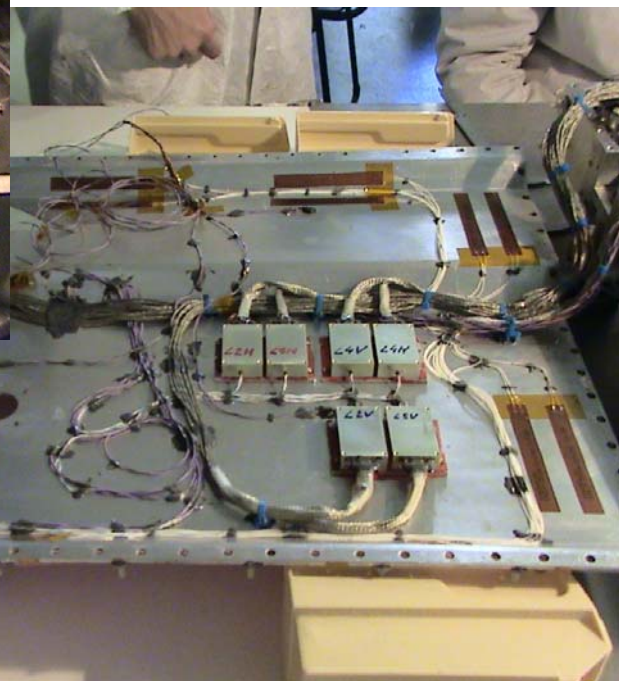
- **Back-up slides**

Some pictures: Front-end & Back-end





Now the environmental tests are in progress

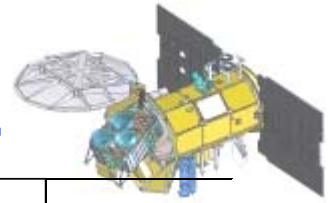


CONAE

NASA

AQUARIUS/SAC-D

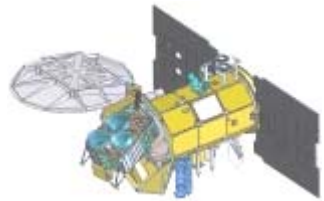
Aquarius SAC-D Instruments Overview



INSTRUMENT	OBJECTIVES	SPECIFICATIONS	RESOLUTION	AGENCY
Aquarius	Understanding ocean circulation, global water cycle and climate interaction. Soil moisture over Argentina	Integrated L- Band radiometer (1.413 Ghz) and scaterometer (1.26 Ghz) swath: 390 km	Three beams:76 x 94, 84 x 120, 96 x 156 km	NASA
MWR Microwave Radiometer	Rain rate, winds speed, sea ice concentration, water vapour, cloud liquid water	Bands: 23.8 Ghz V Pol. & 36.5 Ghz H and V Pol. Band widht: 0.5 and 1 Ghz Swath: 380 km	Sixteen beams < 54 km	CONAE
NIRST New Infrared Sensor Technology	Hot spot events, sea surface temperature measurements	Bands: 4, 11 y 12 um Instantaneous swath 182 Km extended swath 1000Km Pointing: ±30°	Space resolution: 350 m in temperature: 0.5°C smallest burning detectable area 200 m²	CONAE CSA
HSC High Sensitivity Camera	Urban lights, electric storms, polar regions, snow cover	Pancromatic: 450-610 nm Swath: 700 Km	200-300 meters	CONAE
DCS Data Collection System	Data Collection System	401.55 Mhz uplink	2 contacts per day with 200 platforms	CONAE
ROSA Radio Occultation Sounder for Atmosphere	Atmospheric properties	GPS Occultation Techniques	Horiz: 300 Km Vert: 300m	ASI
CARMEN I ICARE & SODAD	Effects of cosmic radiation in electronic devices, distribution of micro-particles and space debris	I: three Si detectors, Si/Li S: four MOS sensors	I: 256 channels spectra S: Sensitivity: 0.5 u part. at 10Kkm/sec	CNES
TDP Technological Demostration Package	Position, velocity and time inertial angular velocity determination	GPS receiver Inertial Unit Reference	Position: 20m, velocity:1m/sec Angular Random Walk: 0.008 deg/sqrt h	CONAE

CONAE NASA

MWR: DEVELOPMENT TEAM



1. **National Institute of Radioastronomy (IAR)**

   Responsible for the radiometer receivers

   Collaborating with the Antennas tests & additional calculations

2. **University of La Plata, Faculty of Engineering (UNLP), Department of Aeronautics (GEMA)**

   Responsible for the thermal analysis and the structural design

3. **Crux**

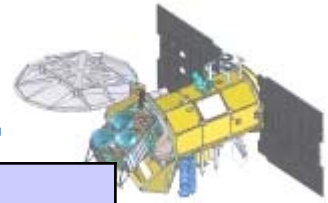
   Responsible for the PDU and the Thermal Control Subsystem

MWR: SCIENCE REQUIREMENTS

Mission key-Requirements (L1)
Microwave Radiometer (MWR) will measure the surface brightness temperature in the frequency range sensitive to geophysical **parameters over the ocean such as water vapor, wind speed, rain rate, cloud liquid water and sea ice.**

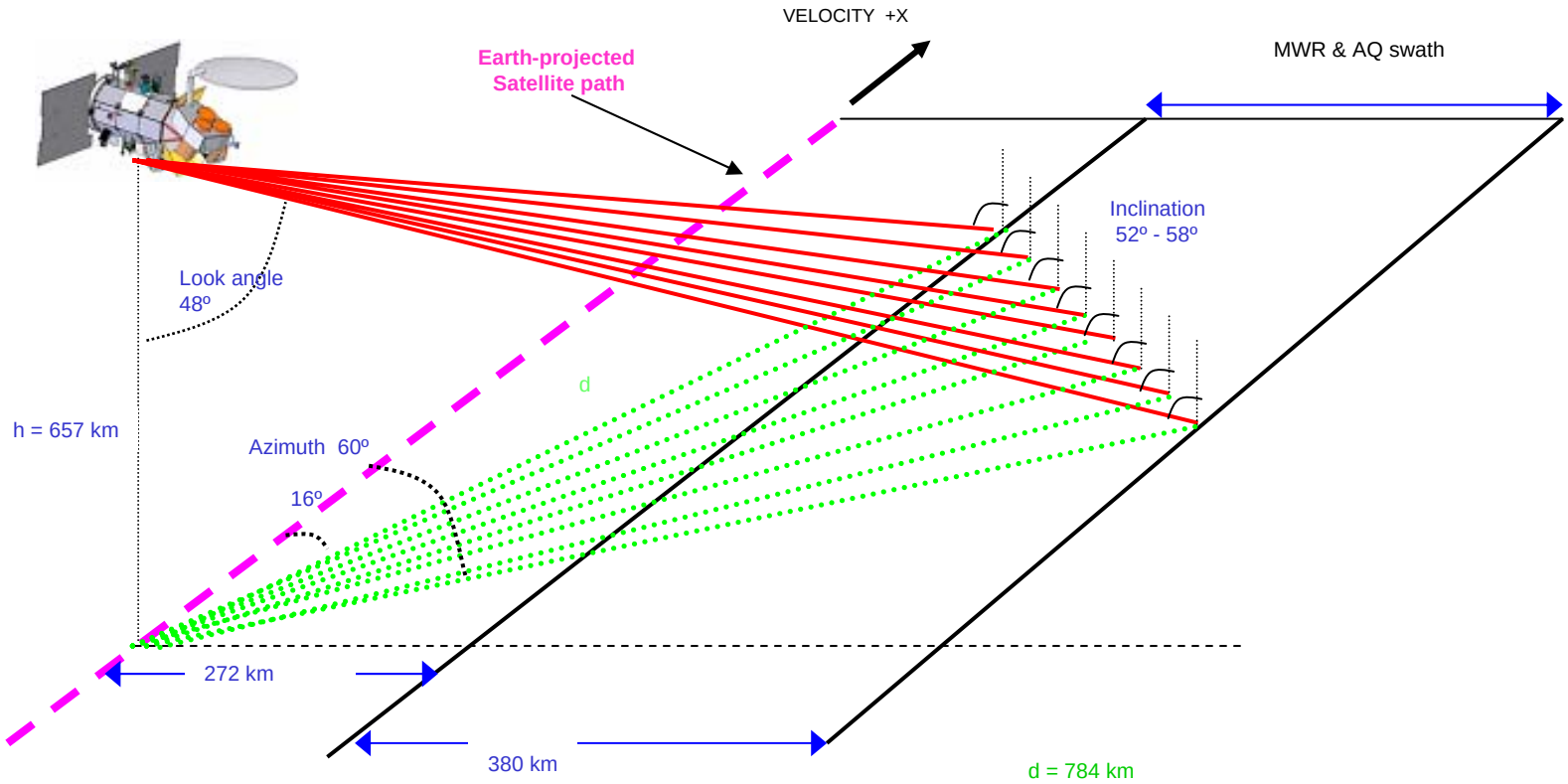
Science key-Requirements (L2)
The **23.8 GHz** channel **(V polarization)** The **36.5 GHz** channel **(H and V polarizations)**
The band widths: 400 MHz @ 23.8 GHz & 1 GHz @ 36.5 GHz
The brightness temperature RMS error: **0.5 K**
The brightness temperature stability: **1 K**

MWR: SCIENCE REQUIREMENTS

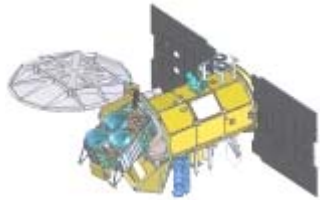


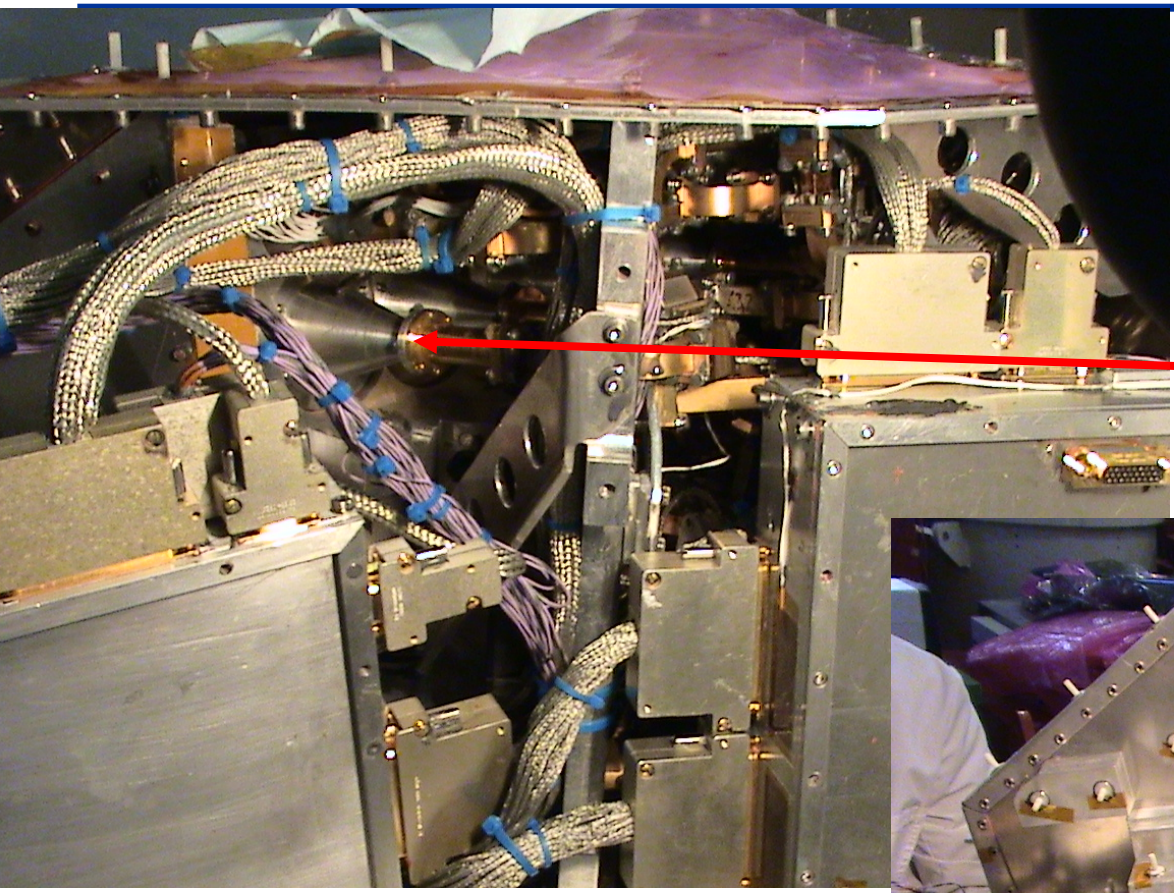
Science key-Requirements (L2)
The MWR spatial resolution: 54 Km or less
Same swath scene observation than Aquarius with an overlap of at least 95%

Swath width shall be 380 km minimum

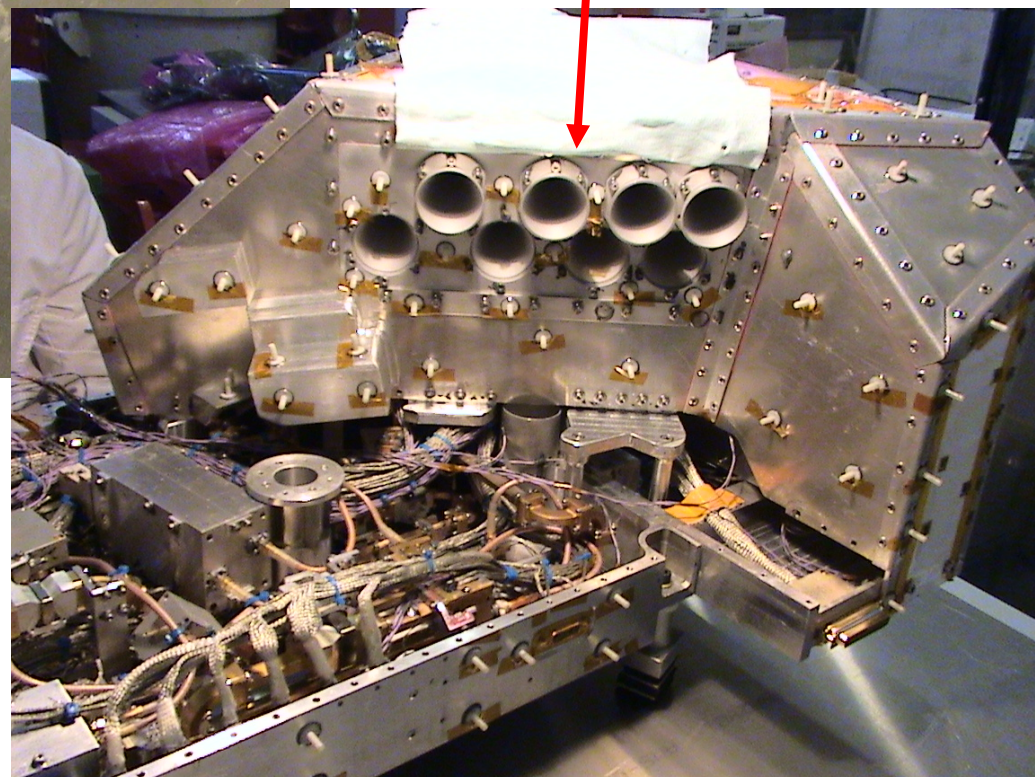


Some pictures: MWR Front-end



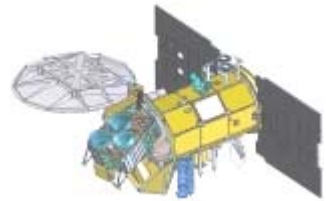


Feed horn



CONAE

Potential Users in Argentina

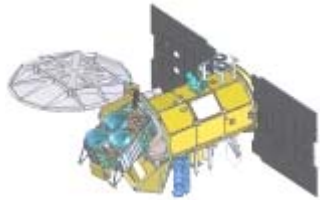


Some Institutions.....

- **Universidades Nacionales**
- **Universidades Privadas**
- **Instituto Argentina de Oceanografía (IAO)**
- **INIDEP**
- **Secretarías de Pesca Provinciales**
- **Instituto Antártico**
- **CENPAT**
- **CADIC**
- **SHN**
- **SMN**
- **Servicio Meteorológico de la Armada**
- **Prefectura Argentina**
- **Plan Nacional de Manejo del Fuego**
- **Parques Nacionales**
- **SIFEM**
- **SENASA**

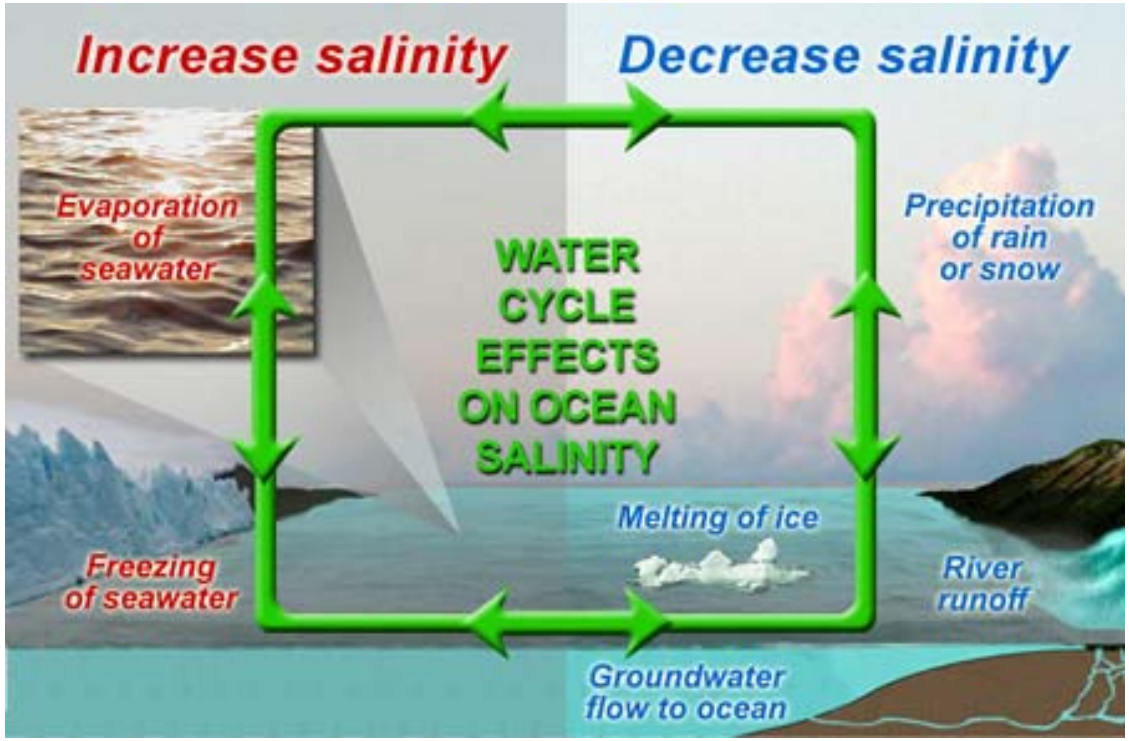
- **Latin-American Teams.**

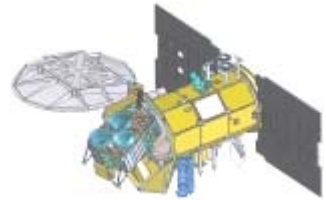
Mission Objectives



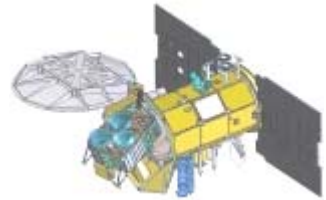
The **primary objective** of this Joint Mission AQUARIUS/SAC-D is:

To contribute to a better understanding of ocean circulation, the prediction of changes in this circulation, and its impact on Earth's climate and water cycle.





Mission Objectives

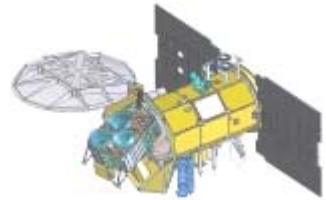


Other important mission goal:

• To study the relationship between the different measurements performed by the observatory in the framework of:

- Oceanography
- Coastal Environment
- Climate
- Hydrology
- Natural Resources and
- Environmental Monitoring

Mission Objectives



Continue...

- To provide information to help in the studies of the relationship between regional soil moisture and essential climate variables (ECV) on the appearance and spread of diseases as malaria, hantavirus, dengue, chagas.

- To study the relationship between measurements (as soil moisture and high temperature events) and natural hazards, as flooding and fires.

- Monitoring atmospheric parameters.

- Studying effect of cosmic radiation on electronic devices and characteristics of space debris.