Radio Frequency Earth Science

Overview for

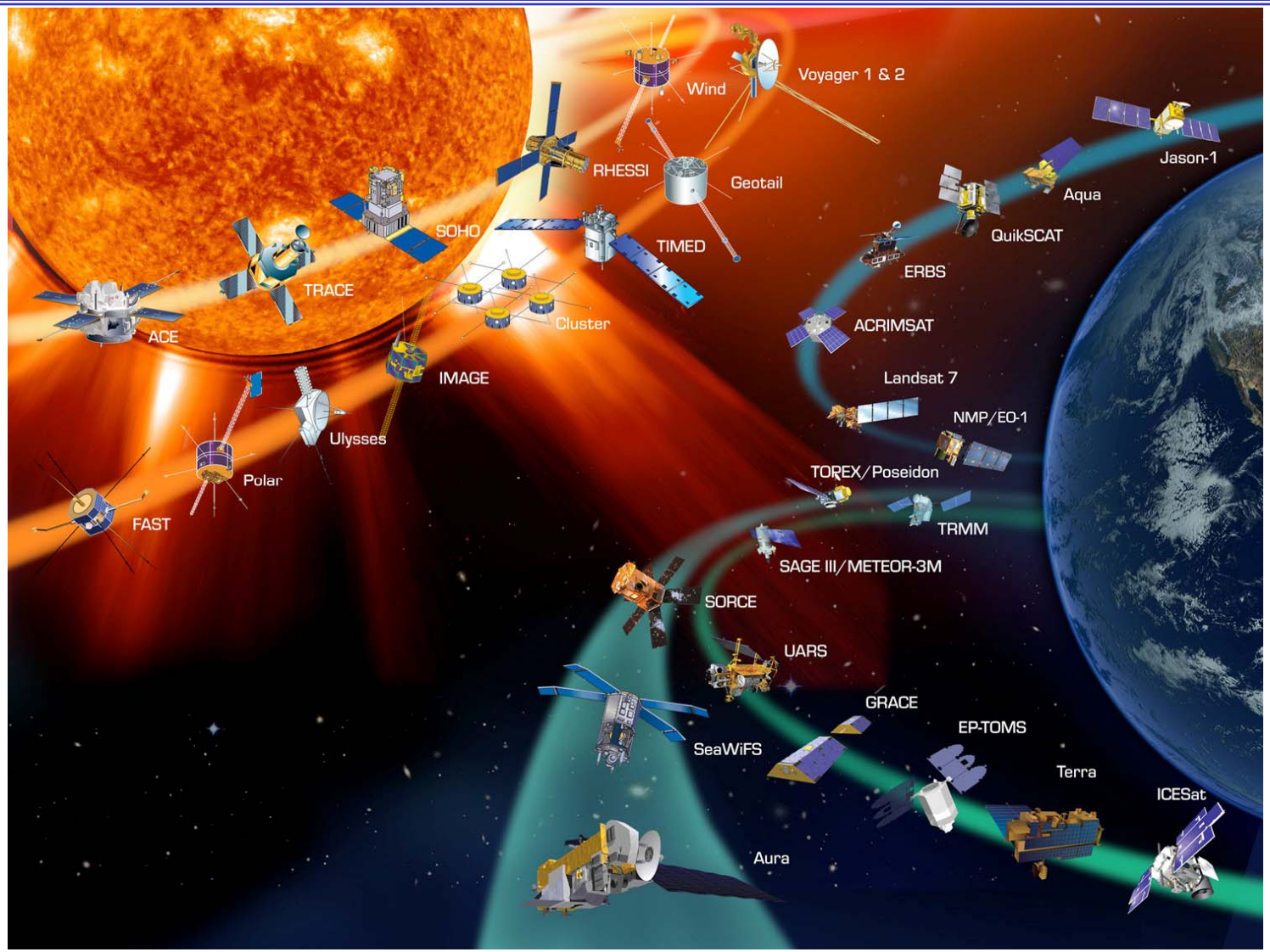
Committee On Radio Frequency (CORF)

National Academy of Science – National Research Council

April 27, 2005

Bill.Watson@NASA.Gov
Program Executive for Ground Networks
Science Mission Directorate

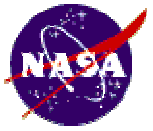
Science Mission Directorate (SMD)



SMD Missions in Formulation

	Mission (PI)	Theme	Launch Readiness Date	FY05 Q2 Jan.	FY05 Q2 Feb.	FY05 Q2 March	FY05 Q3 April	FY05 Q3 May	FY05 Q3 June	FY05 Q4 July	FY05 Q4 Aug.	FY05 Q4 Sep.	FY06 Q1 Oct.	FY06 Q1 Nov.	FY06 Q1 Dec.	FY06 Q2-Q4	FY07	FY08	FY09	FY10
Pre-Formulation	Mars Testbed (Lovey)	Solar System	Dec. 2011															PDR / CR	CDR	
	NSR (Lovey)	Solar System	Jan. 2014																CR	PDR / NAR / CR / CDR
	GEC (Fleteren)	Earth-Sun	Mar. 31, 2015																CR	
	Constellation-X (TBD)	Universe	Dec. 1, 2016								PAR									CR
Formulation	Phoenix (McBride)	Solar System	Aug. 9, 2007			PDR / NAR	CR				CDR								PSR	
	OCO (Eldred)	Earth-Sun	Dec. 1, 2007				CR			CDR										PSR
	HST ServiDeorbit	Universe	Dec. 14, 2007							PDR		CDR	CR							
	Glory (Mishchenko)	Earth-Sun	Dec. 31, 2007						PDR / CR							CDR				
	OSTM (Haines)	Earth-Sun	Apr. 1, 2008			PDR / NAR		CR			CDR									
	ST-5 (Kirshner)	Earth-Sun	Apr. 25, 2008								PDR	NAR	CR			CDR			PSR	
	WISE (Eisenhardt)	Universe	Jun. 21, 2008				PSR / NAR	CR							CDR				PSR	
	Aquarius (Lagerloef)	Earth-Sun	Sep. 1, 2008				PSR		CR							CDR				
	MSL (Dott)	Solar System	Oct. 2009						CR							PSR / NAR / CR	CDR			
	MTO (DeFlorio)	Solar System	Oct. 2009													PDR / CR	CDR			
	ST-9 (Kirshner)	Earth-Sun	Feb. 8, 2010													CR	PDR / CR / CDR			
	GPM (Kakar)	Earth-Sun	Jun. 1, 2010											PSR	NAR	CR	CDR			TDM
	HYDROS (Lagerloef)	Earth-Sun	Sep. 3, 2010														PDR	CR / CDR		
	LDCM (Dwyer)	Earth-Sun	2010						PSR	PDR						CDR				
	MMS (Eisbrand)	Earth-Sun	Jan. 30, 2011									CR					PDR / NAR / CR	CDR		
	SIM (LoPresto)	Universe	April 30, 2011												PDR	NAR / CR		CDR		
	JWST (Gardner)	Universe	Aug. 31, 2011													PSR / NAR / CR	CDR			
	GOES-R (Pavlos)	Earth-Sun	Nov. 1, 2012														NAR	PSR	CDR	
	LISA (Gallagher)	Universe	Dec. 1, 2013														SDR		PDR / NAR / CR	CDR

SMD Missions In Implementation



	Mission (PE)	Theme	Launch Readiness Date	FY05 Q2 Jan.	Q2 Feb.	Q2 March	Q3 April	Q3 May	Q3 June	Q4 July	Q4 Aug.	Q4 Sep.	FY06 Q1 Oct.	Q1 Nov.	Q1 Dec.	Q2-Q4	FY07	FY08	FY09	FY10
Implementation	Astro-E2 (Smale)	Universe	May 1, 2005															EOM		EOM
	GOES N-P (Nichols)	Earth-Sun	May 4, 2005 (N)					(N)									(O)		(P)	
	NOAA N-N' (Nichols)	Earth-Sun	May 15, 2005 (N)					(N)									EOM (N)	(N')		EOM (N')
	ST-6 (Krishnan)	Earth-Sun	Jun. 1, 2005							EOM										
	CALIPSO (Volz)	Earth-Sun	June 17, 2005															EOM		
	CloudSat (Volz)	Earth-Sun	June 17, 2005														EOM			
	CINDI (Mackiow)	Earth-Sun	Jul. 31, 2005														EOM			
	MRO (De Paula)	Solar System	Aug. 10, 2005																	
	TWINS-A (Mackiow)	Earth-Sun	Sept. 1, 2005																EOM	
	New Horizons (Lindstrom)	Solar System	Jan. 11, 2006																	
	STEREO (Ekelund)	Earth-Sun	Feb. 11, 2006															EOM		
	ST-5 (Krishnan)	Earth-Sun	Feb. 28, 2006													EOM				
	DAWN (Robinson)	Solar System	Jun. 15, 2006															Encounter 1		Encounter 2
	Solar B (Ekelund)	Earth-Sun	Sep. 1, 2006																	EOM
	TWINS-B (Mackiow)	Earth-Sun	Sep. 1, 2006																EOM	
	AIM (Ekelund)	Earth-Sun	Sep. 30, 2006																EOM	
	THEMIS (Jenkins)	Earth-Sun	Oct. 19, 2006																EOM	
	NPP (Carson)	Earth-Sun	Oct. 31, 2006																	
	GLAST (Blackwood)	Universe	Feb. 27, 2007																	
	Planck (Montemerlo)	Universe	Aug. 3, 2007																	EOM
	Herschel (Montemerlo)	Universe	Aug. 3, 2007																	
	Kepler (Moore)	Universe	Oct. 1, 2007												CDR					
	ST-7 (Krishnan)	Earth-Sun	Mar. 31, 2008																	EOM
	SDO (Brewer)	Earth-Sun	Apr. 30, 2008				CDR													

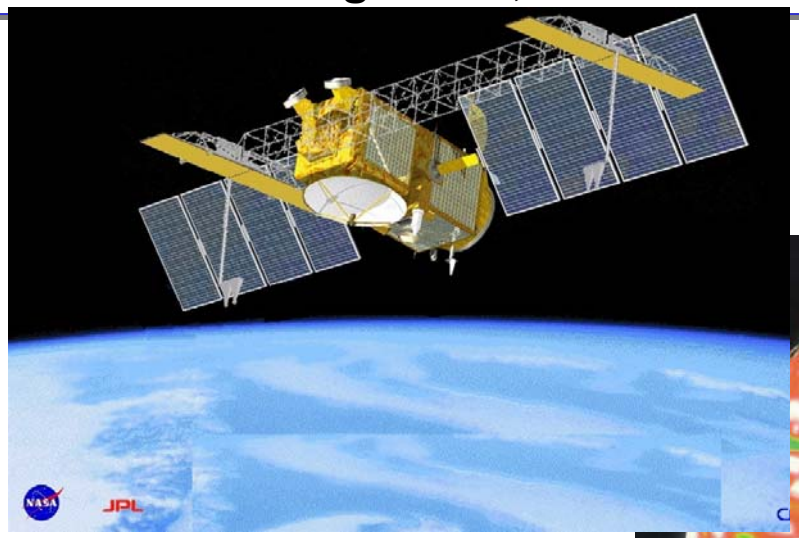
Milestone Key
CDR - Critical Design Review
CR - Confirmation Review (End Phase B)
EOM - End of Prime Mission
FND - Formulation Authorization Document (Beginning Phase A)
EOM - Initial Calibration Review (End Phase C)
NAR - Not Advisable Review (End Phase B)
- Launch Readiness Date
PDR - Preliminary Design Review (End Phase B)

SMD Missions In Operation

	Mission (PE)	Theme	Launch Readiness Date	FY05									FY06				FY07	FY08	FY09	FY10
				Q2			Q3			Q4			Q1			Q2-Q4				
				Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.					
Operations	ACRIMSat (Schueler)	Earth-Sun	Launched			EOM										EOM				EOM
	ICESat (Schueler)	Earth-Sun	Launched			EOM														
	HST (Moore)	Universe	Launched				EOM													
	GP-B (Shafer)	Universe	Launched							EOM										
	Deep Impact (Johnson)	Solar System	Launched							Encounter / Flyby	EOM									
	GALEX (Hayes)	Universe	Launched								EOM									
	Mars Express (Lavery)	Solar System	Launched											EOM						
	Terra (Schueler)	Earth-Sun	Launched												EOM					
	Cluster-2 (Holmes)	Earth-Sun	Launched													EOM				
	Spitzer ST (Hayes)	Universe	Launched													EOM				
	Stardust (Morgan)	Solar System	Launched													EOM				
	SAGE III (Schueler)	Earth-Sun	Launched														EOM			
	Swift (Wentworth)	Universe	Launched														EOM			
	Aqua (Schueler)	Earth-Sun	Launched															EOM		
	Cassini (Dale)	Solar System	Launched	Titan Entry														EOM		
	GRACE (Schueler)	Earth-Sun	Launched															EOM		
	SORCE (Schueler)	Earth-Sun	Launched															EOM		
	Aura (Schueler)	Earth-Sun	Launched																	EOM

JASON-1

Jason-1 is a joint mission between France and the U.S. to monitor global ocean circulation, to improve global climate predictions, and to monitor events such as El Niño Southern Oscillation conditions and ocean eddies. Applications: coastal zone management, disaster management.



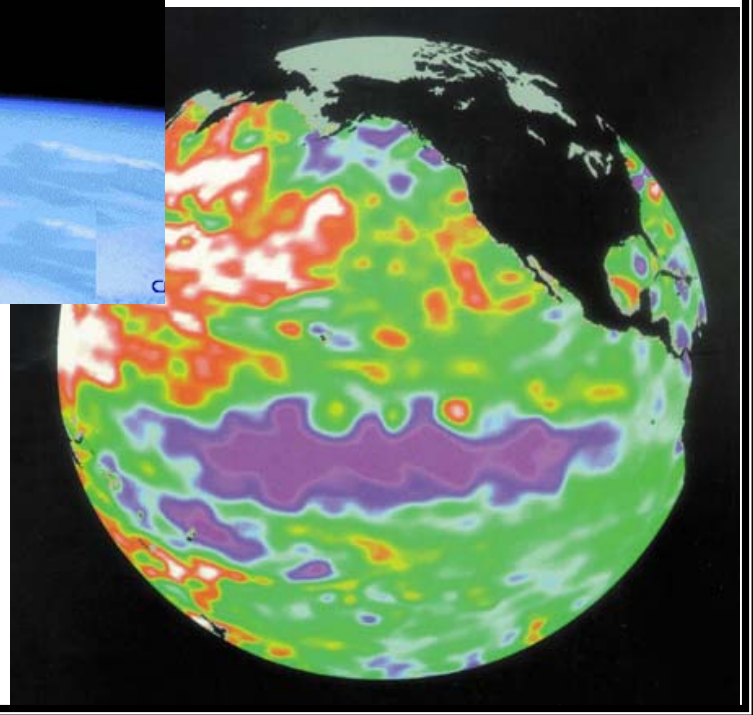
LAUNCH:
- **Date: December 7, 2001**

ORBIT:
- **Altitude: 1,336 km**
- **Inclination: 66 degrees**
- **Period: 122.4 minutes**
- **Repeat Cycle: 10 days**
- **Non-Sun-Synchronous**

DESIGN LIFE:
- **5 years**

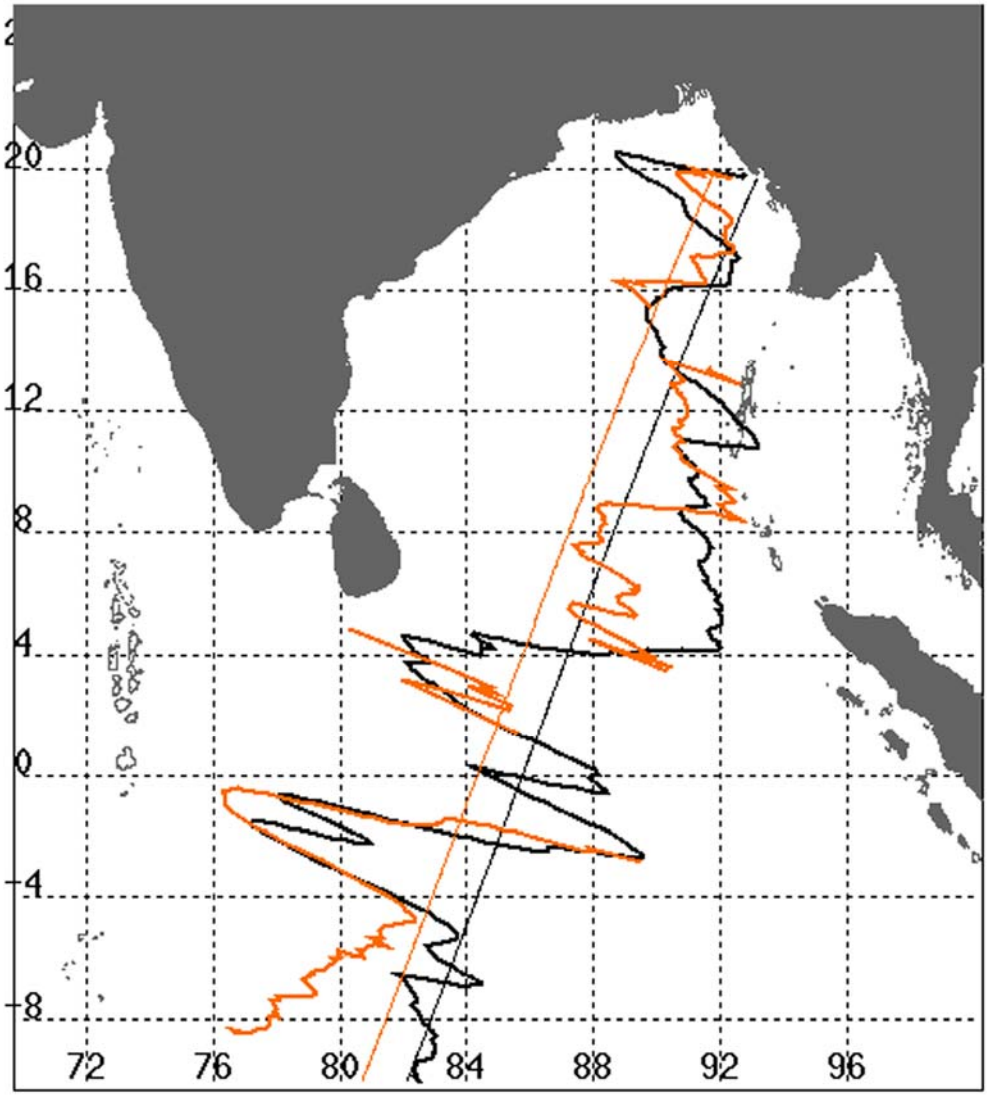
INSTRUMENTS:
- **Laser retroreflector array**
- **TOPEX radar altimeter 13.6 and 5.3 GHz**
- **Poseidon-2 radar altimeter 13.65 GHz**
- **DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) receiver**
- **Jason Microwave Radiometer**
- **Turbo Rogue Space Receiver GPS tracking system**

MEASUREMENTS:
- **Brightness temperature**
- **Water vapor content**
- **Liquid water content**
- **Ocean topography**



http://topex-www.jpl.nasa.gov/mission/jason-1.html

Tsunami - Jason data



Aura

Aura hosts a suite of scientific instruments designed to make the most comprehensive measurements of atmospheric trace gases ever undertaken. The mission measures ozone, aerosols, and several key atmospheric constituents that play an important role in atmospheric chemistry, air quality, and climate. The United Kingdom and The Netherlands are providing some of the instruments for this mission. Applications: air quality management, carbon management, energy forecasting, public health.

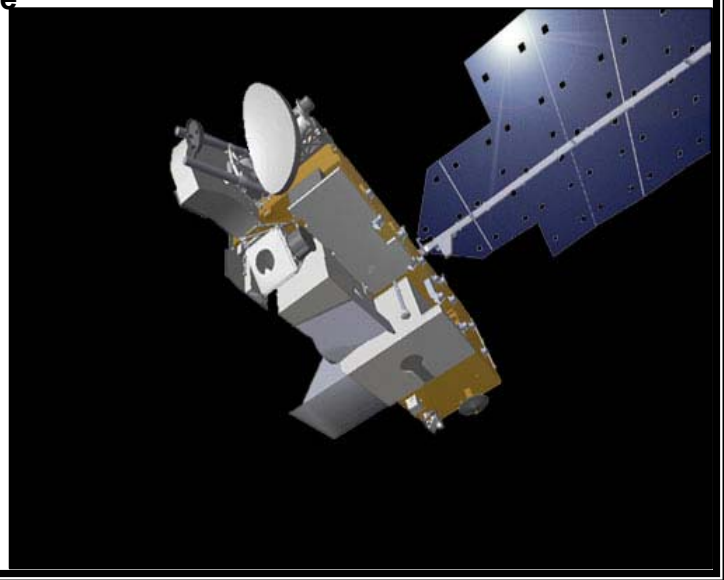
LAUNCH:
- Date: Summer, 2004

ORBIT:
- Altitude: 705 km
- Inclination: 98.2 degrees
- Period: 100 minutes
- Repeat Cycle: 16 days
- Sun-Synchronous, Polar

DESIGN LIFE:
- 3 years

MEASUREMENTS:
- Molecular species distribution
- Aerosol index, ozone content, reflectivity, erythemal UV exposure, surface radiance
- Temperature and the locations of polar stratospheric clouds and cloud tops

INSTRUMENTS:
- OMI (Ozone Monitoring Instrument)
- MLS (Microwave Limb Sounder)
  - 118 GHz Primarily for temperature and pressure
  - 190 GHz Primarily for H_2O, HNO_3,
  - 240 GHz Primarily for O_3 and CO
  - 640 GHz Primarily for N_2O, HCl, ClO, HOCl, BrO, HO_2, and SO_2
  - 2.5 THz Primarily for OH
- TES (Tropospheric Emission Spectrometer)
- HIRDLS (High Resolution Dynamics Limb Sounder)



http://eos-chem.gsfc.nasa.gov/

CloudSat

CloudSAT, a cooperative mission with Canada, will use advanced radar to "slice" through clouds to see their vertical structure, providing a completely new observational capability from space. CloudSAT will look at the structure, composition, and effects of clouds and will be one of the first satellites to study clouds on a global basis. Applications: air quality management, aviation safety, disaster management, energy forecasting, water management and conservation.

LAUNCH:
- Date: 2005

ORBIT:
- Altitude: 705 km
- Inclination: 98.2 degrees
- Period: 99 minutes
- Sun-Synchronous

DESIGN LIFE:
- 2 years

INSTRUMENTS:
- CPR (Cloud Profiling Radar- 94 GHz)

MEASUREMENTS:
- Cloud properties

http://cloudsat.atmos.colostate.edu/

NPOESS - National Polar-orbiting Operational Environmental Satellite System

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) will provide the U.S. with an enduring capability to measure atmospheric, land, and oceanic environmental parameters globally. The system will provide timely and accurate weather and environmental data to weather forecasters, military commanders, civilian leaders, and the scientific community. The current plan is for the NPOESS constellation to consist of three polar-orbiting satellites. Each satellite will be designed for a 7-year lifetime and will host 10 to 12 sensor payloads. Applications: agricultural competitiveness, air quality management, disaster management, energy forecasting, homeland security, public health, water management and conservation.

LAUNCH:
- Date: September 1, 2010

ORBIT:
- Altitude: 833 km
- Inclination: 98.75 degrees
- Period: 101 minutes
- Sun-Synchronous

DESIGN LIFE:
- 5 years

MEASUREMENTS:
- Atmospheric temperature and water vapor profiles
- Electron density and ionospheric profiles
- Vertical and horizontal distribution of ozone
- Total solar irradiance and solar spectral irradiance
- Earth radiation budget, land/water and sea surface temperature, ocean color, and low light imagery
- Characteristics of auroral boundary

INSTRUMENTS:
- VIIRS (Visible/Infrared Imager/Radiometer Suite)
- CMIS (Conical Microwave Imager/Sounder 6.6, 18.7, 36.5, 60.4 GHz)
- CrIS (Crosstrack Infrared Sounder)
- GPSOS (Global Positioning System Occultation Sensor)
- OMPS (Ozone Mapping and Profiler Suite)
- SESS (Space Environment Sensor Suite)

http://www.ipo.noaa.gov/index2.html

Aquarius

Aquarius is a focused satellite mission to measure global sea surface salinity (SSS). Aquarius will resolve missing physical processes that link the water cycle, the climate, and the ocean. The Aquarius science goals are to observe and model the processes that relate salinity variations to climatic changes in the global cycling of water and to understand how these variations influence the general ocean circulation. One application of the Aquarius mission data will be to benefit coastal zone management.

LAUNCH:

- **Date: 2008**

ORBIT:

- **Altitude: 600 km**
- **Repeat Cycle: 8 days**
- **Sun-Synchronous**
- **DESIGN LIFE:**
- **3 years**

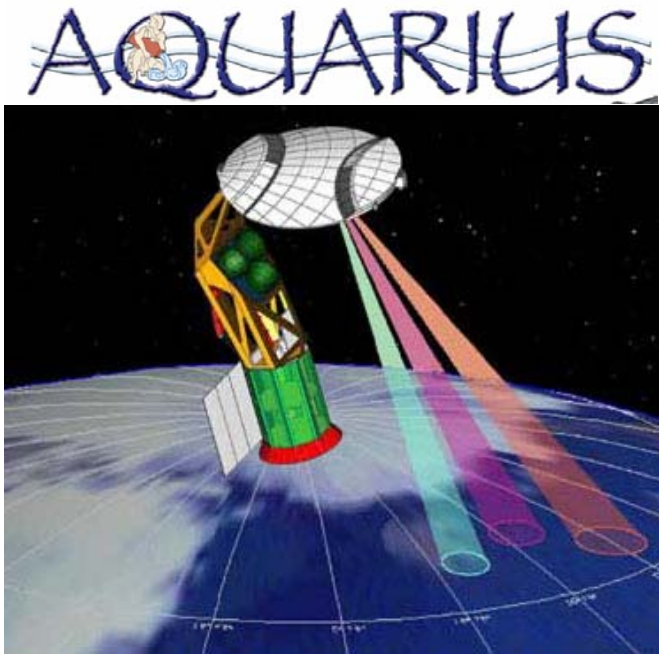
INSTRUMENTS:

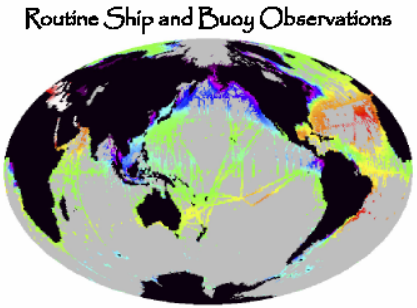
- **Radiometer/Scatterometer**

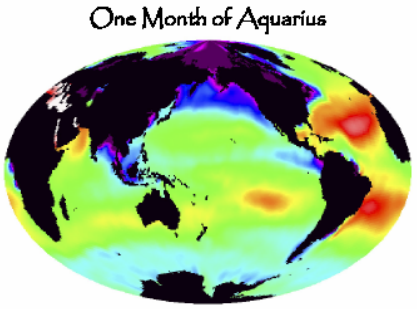
  Radiometers at 1.413 GHz
  Scatterometer at 1.26 GHz

MEASUREMENTS:

- **Seawater emissivity sensitive to salinity**







http://essp.gsfc.nasa.gov/aquarius/

GPM – Global Precipitation Mapper

GPM is a joint mission with the National Space Development Agency (NASDA) of Japan and other international partners. Building upon the success of the Tropical Rainfall Measuring Mission (TRMM), GPM will initiate global precipitation measurement, a key climate factor. Its science objectives are to improve ongoing efforts to predict climate by providing near-global measurement of precipitation, its distribution, and physical processes; to improve the accuracy of weather and precipitation forecasts through more accurate measurement of rain rates and latent heating; and to provide more frequent and complete sampling of the Earth's precipitation. Applications: agricultural competitiveness, disaster management, water management and conservation.

MEASUREMENTS:

- Cloud structure and precipitation characteristics including rain rate, cloud type, 3D cloud structure, and drop-size distribution
- Global precipitation

LAUNCH:

•Date: November 2007

ORBIT:

•Altitude: 400 km

•Inclination: 65 degrees

•Sun-Synchronous

DESIGN LIFE:

•3 years

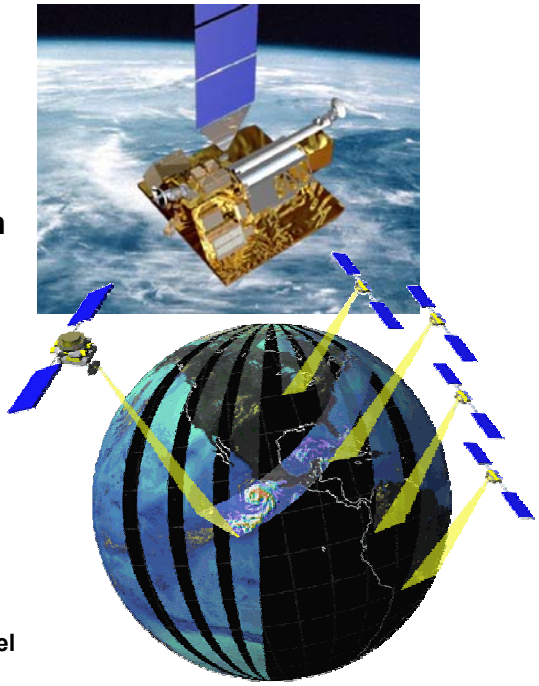
INSTRUMENTS:

- DPR (Dual-frequency Precipitation Radar)
  - KuPR 13.597 & 13.603 GHz
  - KaPR 35.547 & 35.553 GHz
- GMI (GPM Microwave Imager)

Ch #	Center Freq (GHz)	Pass-band Bandwidth
1	10.65	100
2	10.65	100
3	18.7	200
4	18.7	200
5	23.80	200
6	36.5	1000
7	36.5	1000
8	89.0	4000
9	89.0	4000

(150 or 166 GHz and 183 GHz are TBD high frequency channel enhancement options)

- Constellation of passive microwave radiometers



http://gpm.gsfc.nasa.gov

Hydros - The Hydrosphere State Mission

Hyrdros is expected to provide the first global view of the Earth's changing soil moisture and land surface freeze/thaw state. It will conduct hydroclimatology of the soil moisture at 40 km, hydrometerology of the soil moisture at 10 km, and observe freeze/thaw conditions at 3km during a 2 year mission. Science appilcations from Hydros include an enhanced understanding of processes that link water, energy, and carbon cycle, and improved weather and climate prediction.

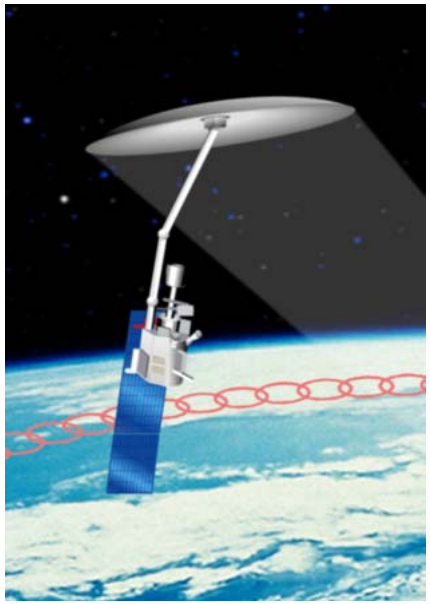
LAUNCH:
- **Date: 2007**

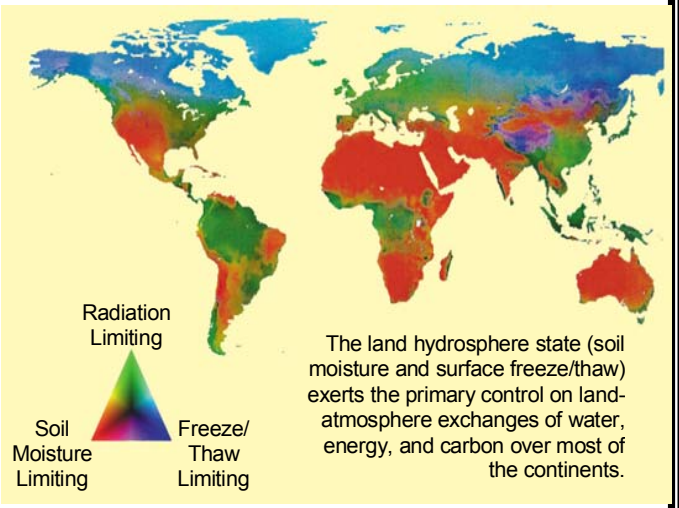
ORBIT:
- **6AM/6PM sun-synchronous orbit at km, for a 2 year mission**
- **Altitude: 670 km**

DESIGN LIFE:
- **2 years**

INSTRUMENTS:
- **L-band radar 1.24 GHZ and radiometer 1.41 GHz using one deployable antenna;**
- **Radiometer from GSFC**
- **Radar from ASI (Italian)**
- **Antenna from CSA**

MEASUREMENTS:
- **Hydroclimatology of the soil moisture at 40 km**
- **Hydrometerology of the soil moisture at 10 km**
- **Observe freeze/thaw conditions at 3km**





The land hydrosphere state (soil moisture and surface freeze/thaw) exerts the primary control on land-atmosphere exchanges of water, energy, and carbon over most of the continents.

http://essp.gsfc.nasa.gov/oco/

Integrated Observations