Report to CORF
from the
NASA Office of Earth Science

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Introduction

- The Earth Science Enterprise of NASA uses spectrum for:
  - Remote sensing of the Earth and its atmosphere
    - Passive receiving of natural emissions, and
    - Active sounding (e.g., radar).
  - Communicating with its satellites
    - Transmitting data from its satellites to the scientist-customers, and
    - Commanding satellites.

Agenda:

- Congestion in X-Band - C. Wende
- New 1.4 GHz Missions - C. Wende
- WRC-2003 Booth - C. Wende
- WRC-2003 Issues - J. Zuzek
- Part 15 (UWB, RadioLANs) - J. Zuzek
- Backup Material: NASA Mission Summary

Congestion in X-Band

A large number of new bandwidth-hungry missions are using, or planning to use, the 8025-8400 MHz communications band:

- Some scientific:
  - Earth System Science Pathfinder mission(s).
- Some operational:
  - NPOESS, the next generation weather satellites
- Some commercial Earth remote sensing:
  - Radarsat-2 (-3?)
  - M5 constellation of 4 S/C (DigitalGlobe)
  - Resource 21 (one or more satellites)

Congestion in X-Band

NASA held a “Wideband Downlink Briefing” on July 16:

- To head off future problems as early as possible.
- Targeted at missions being proposed or approaching Preliminary Design Reviews and people leading them.
- To aid in knowledgeable system tradeoffs.
- NOT to provide direction; attendees are responsible for their systems, not the Government.

Congestion in X-Band

A follow-on workshop was held March 25-27 in Orlando, FL:

- Targeted at a broader audience (including all current X-band users, including foreign).
- Presented more detail than the briefing.
- Followed the X-Band Workshops held in the past (1994 at NASA/GSFC, 1995 at Vandenberg Air Force Base).

Congestion in X-Band

Goals of the Workshop:

- To assess of the condition of X-band
  - how usable is it?
- To anticipate the future condition of the band
  - are we heading into trouble?
- To determine what steps, if any, need to be taken to ensure the future (5-10 year) usability of X-band - steps taken
  - either as a group, or
  - as builders of individual missions.
- To set a framework for continuing these assessments at appropriate intervals in the future.

Congestion in X-Band

NASA had a paradigm shift (faster, better, cheaper!) in 1990's:

EOS AM-1	➔TERRA	➔ A fleet of smaller 1- or 2-
EOS PM-1	➔AQUA	➔ instrument spacecraft
EOS CHEM-1	➔AURA	➔ (and at less risk)
Alt	➔ICESAT	➔

Until 1996, larger spacecraft communications were:
- Mostly via the NASA Tracking and Data Relay Satellite System,
- A backup science data link via direct-to-ground X-Band, and
- A direct broadcast service via direct-to-ground X-Band.

Smaller spacecraft forced a change to X-band communications
(TDRSS links require another 26 dB).

Congestion in X-Band

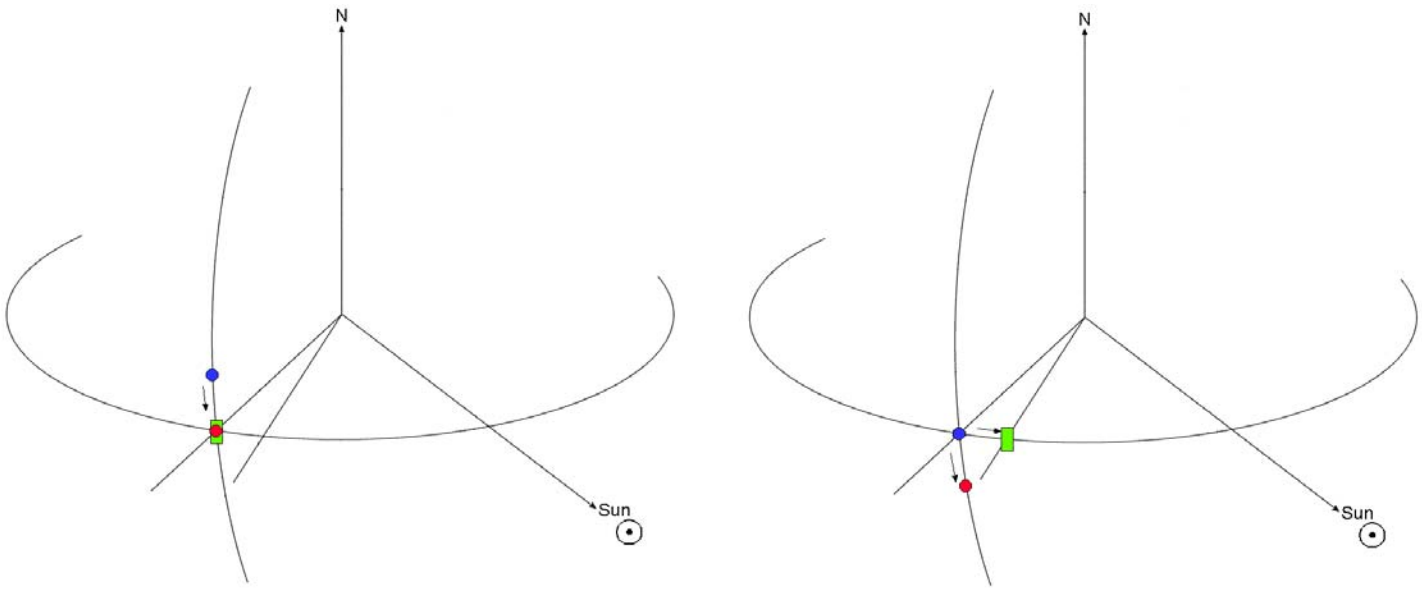
But what about same place, same time imaging?

(This capability was lost when instruments were spread over many satellites.)

Answer – Coordinated observations made by a set of satellites flying in "trains" over the same ground swath . This strategy is sometimes called formation flying, constellations of spacecraft. This strategy results in same place, almost same time imaging.

Congestion in X-Band

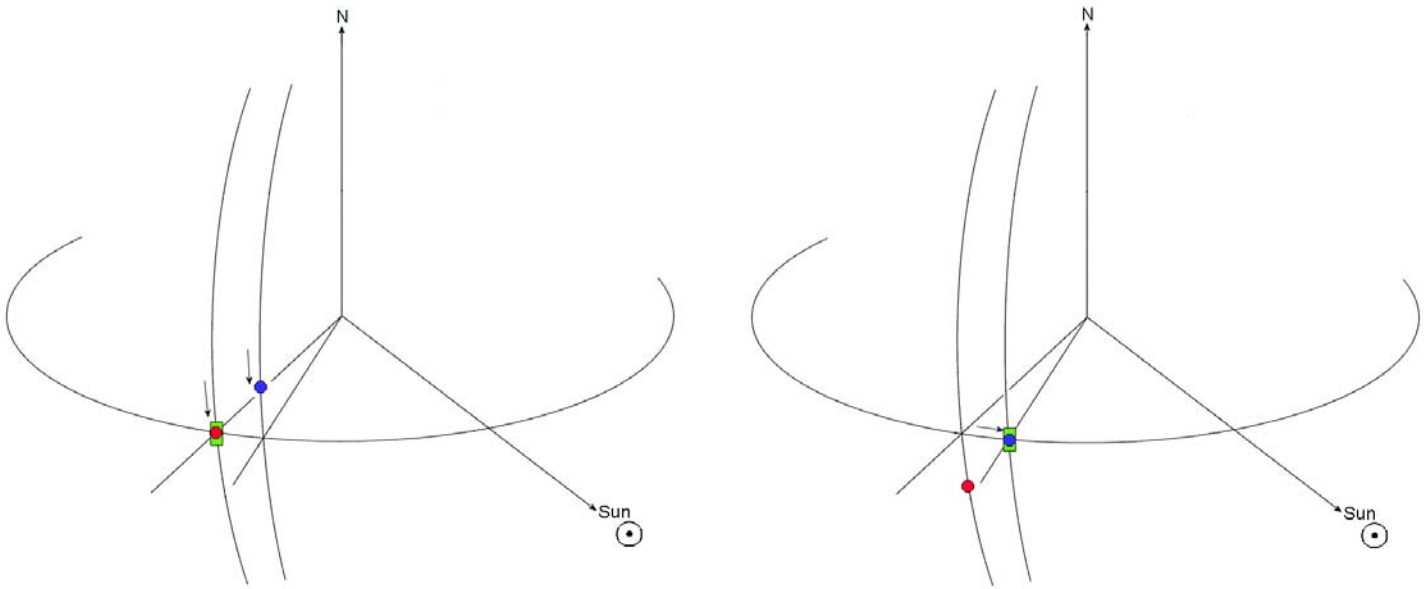
Two Spacecraft, Same Orbit Trajectory



These spacecraft view different scenes on the surface of the earth due to the Earth's rotation under their orbit plane.

Congestion in X-Band

Two Spacecraft, Same Ground Trajectory



The orbit planes are offset so that each spacecraft passes over the same point on the ground at slightly different times.

Congestion in X-Band

NASA already has a morning train (~10:00 AM southbound):

- Landsat-7 (10:00 AM), X-band wideband, EROS Data Center and international cooperators, some Polar Ground Network (Fairbanks, AK and Svalbard).
- EO-1 (10:01 AM), X-band, Polar Ground Network
- SAC-C (10:31 AM), X-band, Argentine ground station
- TERRA (10:34 AM), TDRSS wideband, X-band Direct Broadcast, X-band wideband for backup/proficiency.

Congestion in X-Band

NASA is forming an afternoon train (~1:30 PM northbound):

- AQUA (1:30 PM), X-band, wideband via polar ground network, direct broadcast otherwise.
- Cloudsat (1:32:32 PM), AFSCN S-band
- CALIPSO (1:32:45 PM), X-band, USN in AK, HA
- PARASOL (1:34 PM), S-band (?)
- AURA (1:45 PM), X-band, wideband via polar ground network.

Only AQUA has been launched.

Congestion in X-Band

NASA realized that they had to synchronize the two trains:

- Both are at the same altitude (~705 km) and period.
- Orbits will cross near the poles and in line-of-sight of polar ground stations.
- They could overload the available ground stations (and possibly collide?).

NASA set a minimum of 15 minutes between trains.

- TERRA leads AQUA by ~ 20 minutes
- AURA will lead Landsat-7 by ~ 40 minutes

Congestion in X-Band

However, the two trains are being operated by/for NASA independent of any other band users.

- NASA was forced by the physics to address the contention problem.
- Other users of 705 km orbits are not coordinated with these trains.

There is no central frequency-orbit-ground contact coordination mechanism in place today.

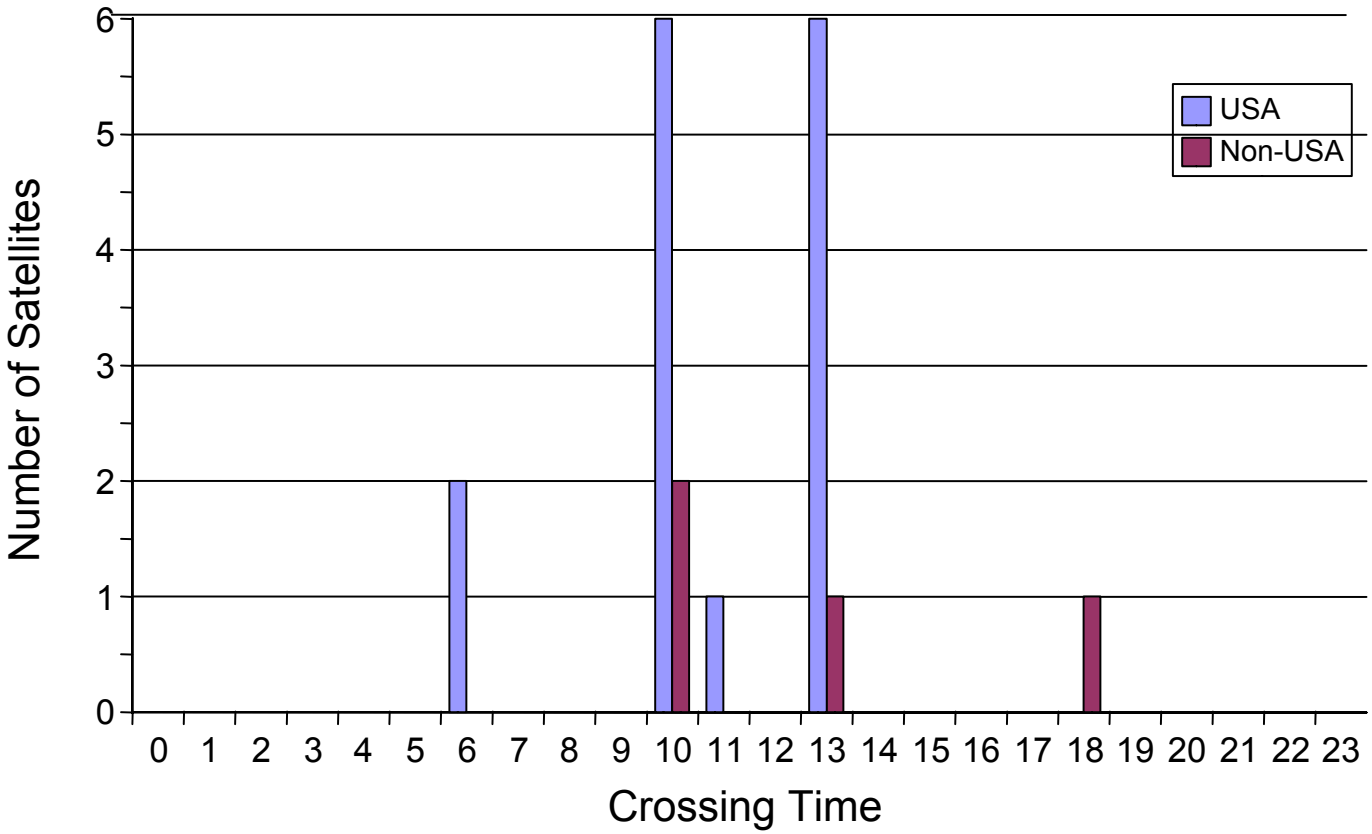
- Something similar is in place for geosynchronous spacecraft (position and frequency are jointly assigned).

Congestion in X-Band

For good reasons, most Earth Science Spacecraft, both public and private, are:

- In sun-synchronous orbits,
- Many at a preferred altitude of ~705 km (~98 minute orbital period),
- With preferred equatorial crossing times (e.g., 6:00 AM, 10:00 AM, and 1:30 PM local satellite time).

Congestion in X-Band



Present and Future Sun-Synchronous Science Satellites

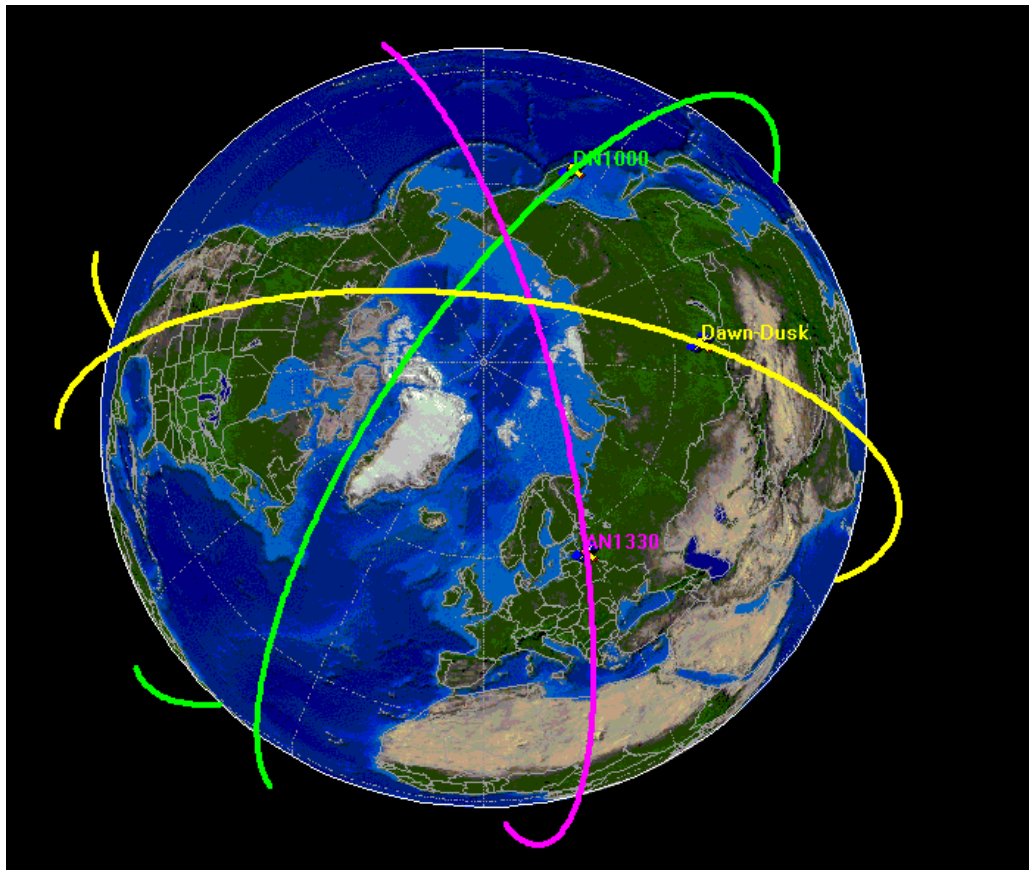
Congestion in X-Band

These good reasons conspire to increase the likelihood of conflicts:

- Sun-synchronous spacecraft with the same equatorial crossing time but different altitudes will “walk” over/under one another.

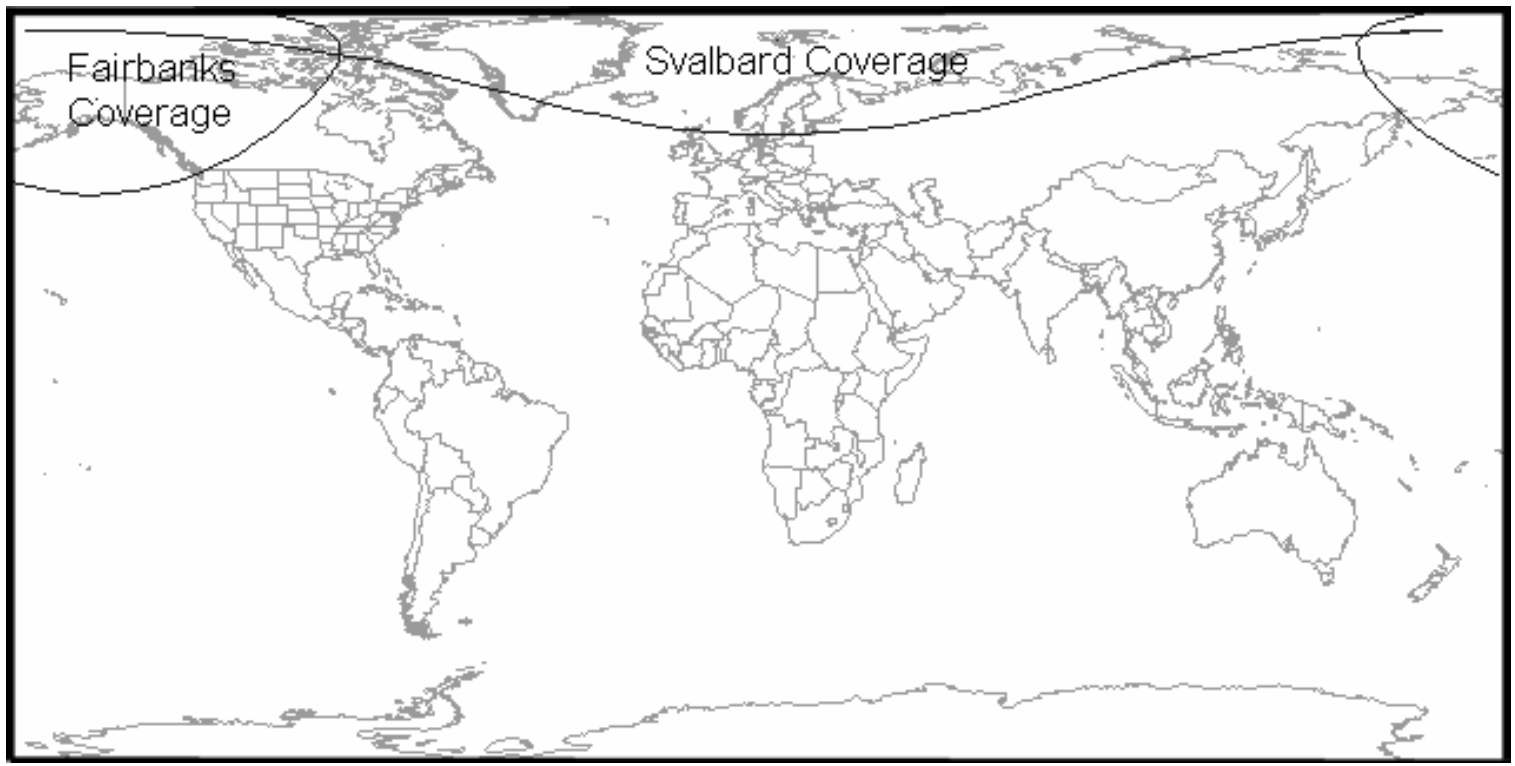
- Sun-synchronous satellites at the same altitude but different equatorial crossing times will cross their orbits at high latitudes – where the prime ground stations are located.

Congestion in X-Band



Congestion in X-Band

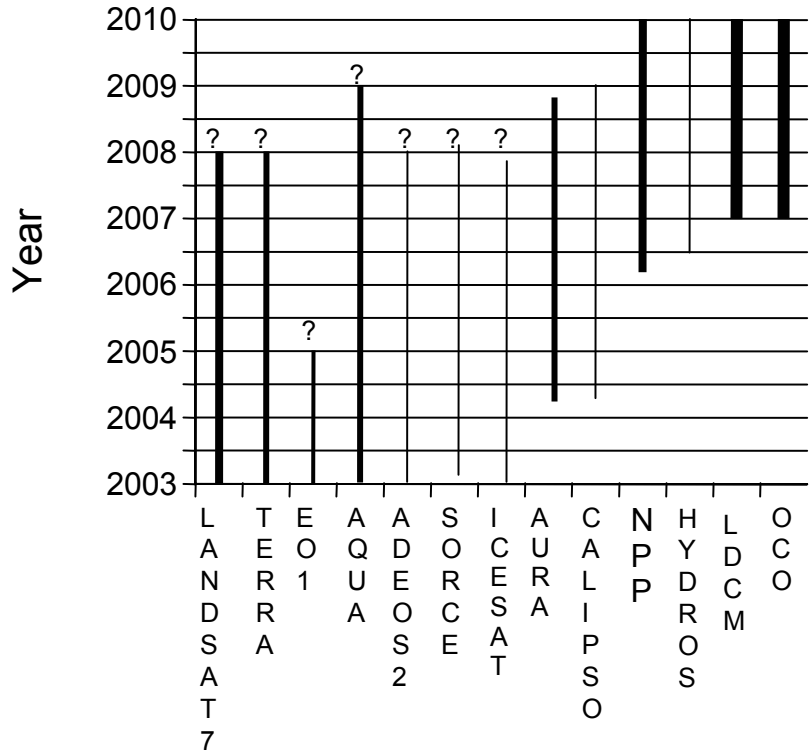
Add in the highly desirable polar ground stations, and conflicts are likely.



Congestion in X-Band

	NASA Missions & Collaborators	Other Affiliated Missions
Present number	23	3
Present sun-synch	11	3
Present X-Band	6	3
Present Data rates	40-150 Mb/s	105 Mb/s
Future number	12	1
Future sun-synch	8	1
Future X-band	5-7	?
Future Data rates	30-300+ Mb/s	?

Congestion in X-Band



Science Satellites Using X-Band

Congestion in X-Band

Do the math:

- At 705 km, the orbit period is ~98 minutes.
- A 4-satellite constellation will space satellites every 24.5 minutes along the orbit.
- A 30-minute long train must overlap at least one satellite in the constellation.

Congestion in X-Band

- Frequency dispersion won't work if too many users each require too much bandwidth (despite the technology).

- Geographic dispersion won't work if the ground stations and/or satellites are too close together.

- Temporal dispersion won't work – the time over ground stations is driven by orbital mechanics (can't stop a satellite).

- Operational coordination may become necessary to resolve the time place-frequency dilemma. Operational coordination is the procedure invoked when spacecraft operations have to be modified by one or more parties to avoid a radio frequency conflict which would result in the loss of communications.

Congestion in X-Band

Other workshop discussions:

- Band users shared their plans:
  - Foreign and domestic, and
  - Space and ground system operators.
- A major licensing issue surfaced:
  - Ka-band is secondary for commercial operators in the USA.
- Applicable techniques and technologies were presented
  - Government and private sector assessments.
- Preliminary models of the operational environment were presented.

Congestion in X-Band

Results of Workshop:

- General recognition that the situation would probably become difficult in 5-10 years; more work is needed now.

- The Space Frequency Coordinating Group agreed to take on the job of quantifying the future situation.
  - Input data was being provided as people left.
  - Next meeting: 12-18 months in the future (i.e., 6-12 months after next SFCG meeting).

- Recognition that industry needed to ask FCC for a primary allocation in Ka-Band.

New NASA Missions using

1.2 and 1.4 GHz

(At least one is likely to fly)

New 1.4 GHz Missions

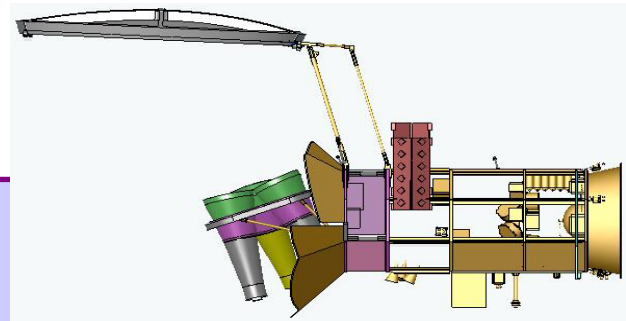
Aquarius

Science

- ***First global, space-based observations of Sea Surface Salinity (SSS)***
- ***Produce global salinity maps (0.2 psu) on a monthly basis***
- ***Chart seasonal and year-to-year variations of SSS***
- ***Observe & model the process that relate salinity variations to climate changes in the global cycling of water. Understand how these variations influence ocean circulation***
- ***Aquarius will provide an unprecedented view of ocean's role in climate and weather***

New 1.4 GHz Missions

Aquarius



Salient Features

- *L-band Radiometer / Scatterometer*
- *Argentine (CONAE) Provided Spacecraft (SAC-D) & MOC*
- *Dedicated Delta II launch vehicle*
- *Launch date: September 2008*
- *Operational life: 3 years*
- *Science Partnership with CONAE*
- *Aquarius Principal Investigator: Dr. Chet Koblinsky, GSFC*
- *SAC-D Principal Investigator : Dr. Raul Colomb, CONAE*
- *Project Manager: Amit Sen, JPL*
- *Aquarius Project Scientist: Dr. Yi Chao, JPL*
- *Aquarius Mission Manager: Neal Barthelme, GSFC*
- *ESSP Formulation Program Manager: Dr. Steven Bard, JPL*

New 1.4 GHz Missions

QUARIUS

ensor types: Radiometers at 1.413 GHz Scatterometer at 1.26 GHz

3 antenna feeds, 3 polarimetric radiometers, 1 polarimetric scatterometer

00% duty cycle, 50 W standby

ata rate with contingency 5 kbps, 0.5 kbps standby

ptical layout 3 antenna beams at 23.3¡, 33.7¡, 41.7¡ incidence angles to shadow side of orbit

ootprint sizes: 62 _ 68 km, 68 _ 82 km, 75 _ 100 km

adiometer NEDT 12 sec integration: 0.05 K

New 1.4 GHz Missions

HYDROS

Science

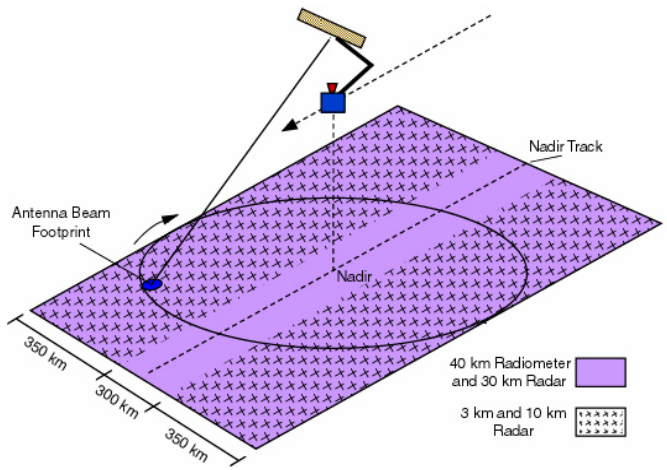
- ***New data product provides first global view of Earth's soil moisture & freeze-thaw state***
- ***Answers open questions on cycling water, energy & carbon and linking processes***
- ***Extends water resource projections through improved climate models***
- ***Provides boreal surface detailed carbon source-sink maps***
- ***Improves numerical weather prediction by initializing land surface state***
- ***Provides three-day knowledge of trafficability for military applications***
- ***Provides all-weather daily ice edge & ice quality detection at 10X existing resolution***

New 1.4 GHz Missions

HYDROS

Salient Features

- ***Rotating 6-m L-band reflector in 670-Km polar orbit***
- ***1000 Km radar & radiometer swath width***
- ***3 Km to 40 Km resolution on 1 to 3 day revisits***
- ***2 year mission after Sept 2007 Taurus launch***
- ***Partnerships with CSA, IPO, and DoD***
- ***Principal Investigator: Dara Entekhabi, MIT***
- ***Project Management: Joel Smith, JPL***
- ***ESSP Mission Manager: Neal Barthelme , GSFC***



New 1.4 GHz Missions

INSTRUMENT:

- L-band active/passive system
- Wide swath (1000 km) with constant look angle (39°)

	Radar		Radiometer
Polarization	VV, HH and HV		V, H and U
Resolution	3 km	10 km	40 km
Relative Error	1.0 dB	0.45 dB	0.64º K

New 1.4 GHz Missions

HYDROS

LAUNCH:
- **Vehicle: Taurus 2210**

MISSION DESIGN:
- **Orbit: 6 am/pm sun-synchronous at 670 km**
- **Bus: Spectrum Astro SA-200HP**
- **Mission Ops: Spectrum Astro**
- **Power: 1283 Watts EOL**
- **Launch Mass: 627 kg**
- **Data Rate: 31 Mbps peak; 26 Mbps average**
- **Telecom: S- and X-band**
- **Data Processing: MIT, GSFC, JPL, U-MT**
- **Launch Date: June 2006**

WRC 2003 Booth

The NASA Administrator asked the NASA Enterprises to support an educational booth in Geneva during WRC 2003.

NASA has provided such a booth on past occasions.

WRC 2003 Booth

The booth will be supported during the first 3 weeks of WRC 2003:

- June 9-13, Space Science
- June 16-20, Manned Flight
- June 23-27, Earth Science

The booth will have a different backdrop each week, with an HDTV screen to display data, short informational videos, etc.

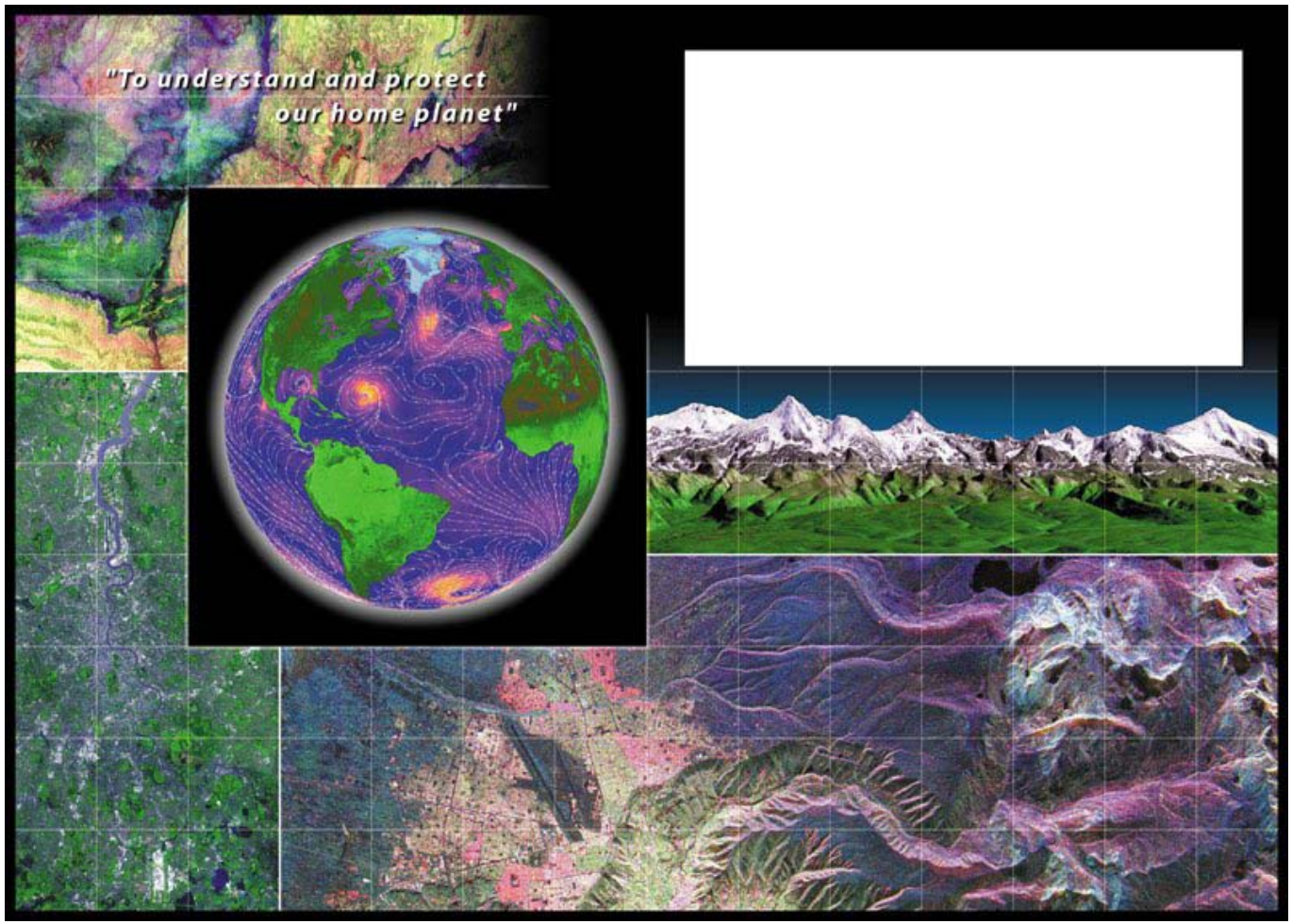
WRC 2003 Booth

Staffing:

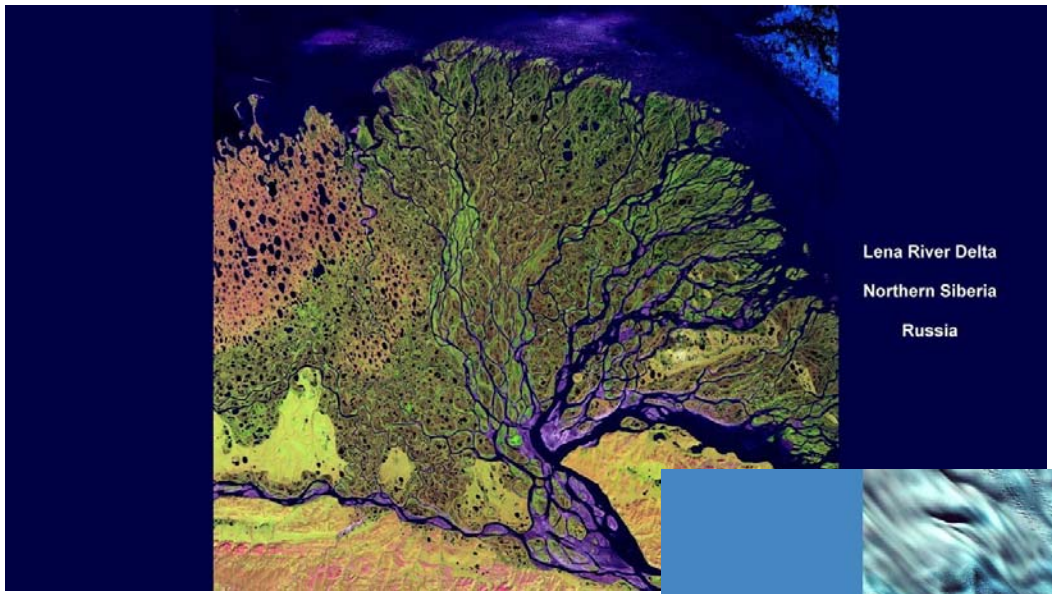
- Chuck Wende, HQ (Lead)
- Bryan Huneycutt, JPL (active sensing)
- Ed Kim, GSFC (passive sensing)
- Karen Yuen, JPL (Outreach)

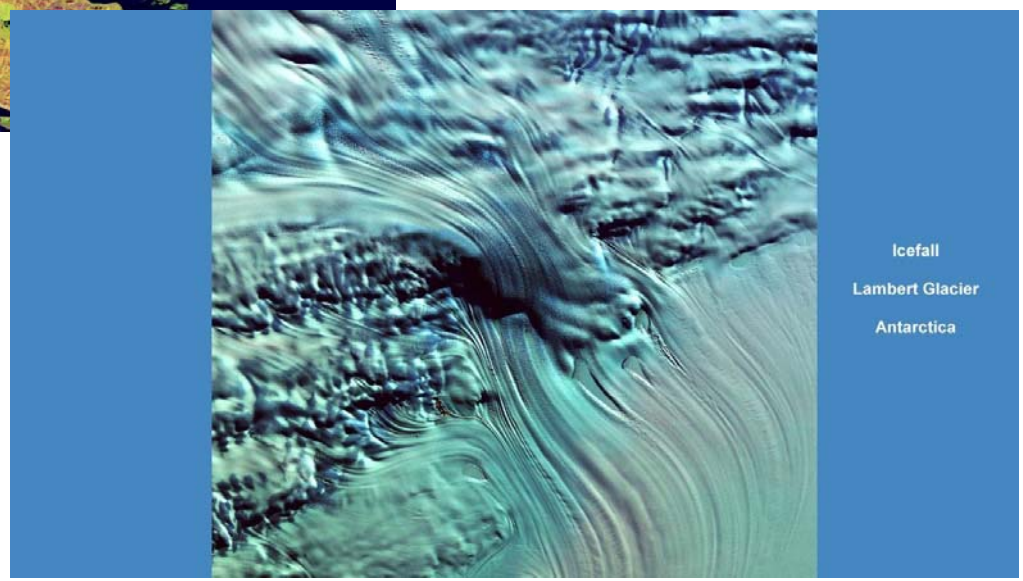
A combination of animations (zoom-ins, etc), slide shows, and handouts will be available.

WRC 2003 Booth



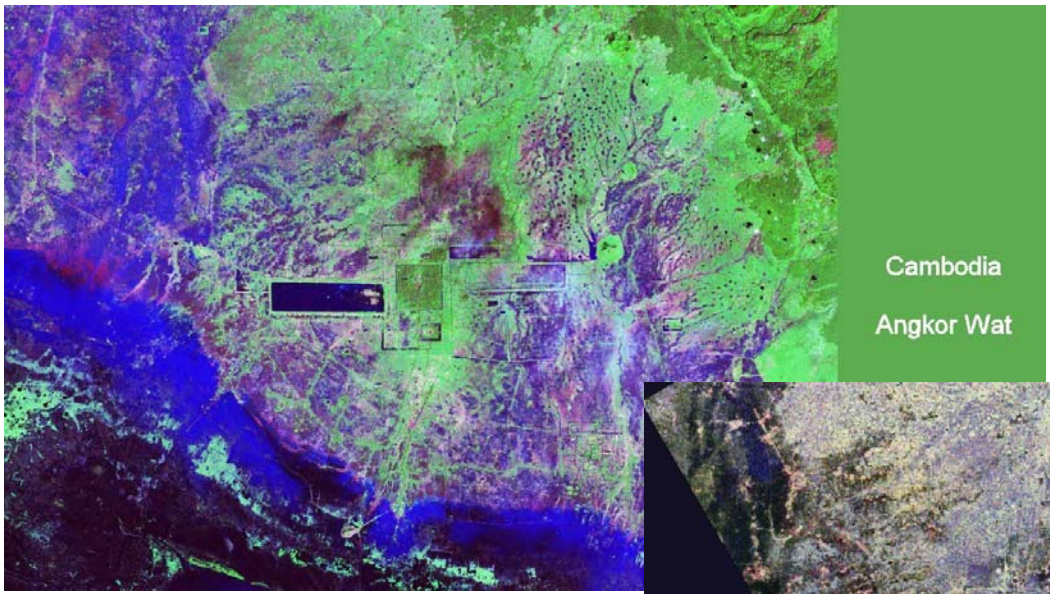
WRC 2003 Booth



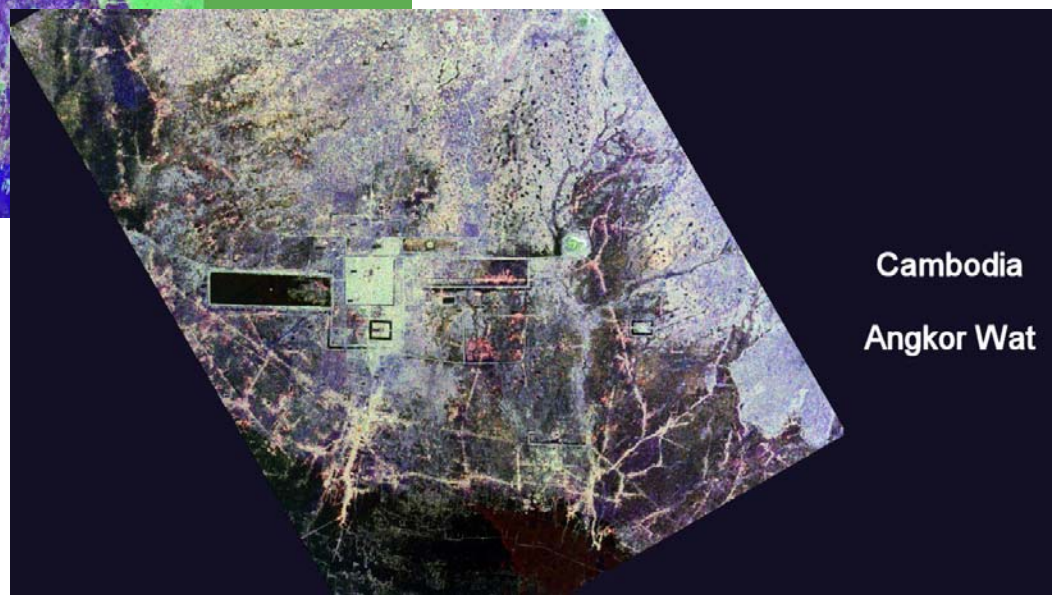


Landsat 7 Images
From the USGS
Earth-as-Art series

WRC 2003 Booth



Landsat 5 image
(Green-NIR-SWIR)



SIR-C Image

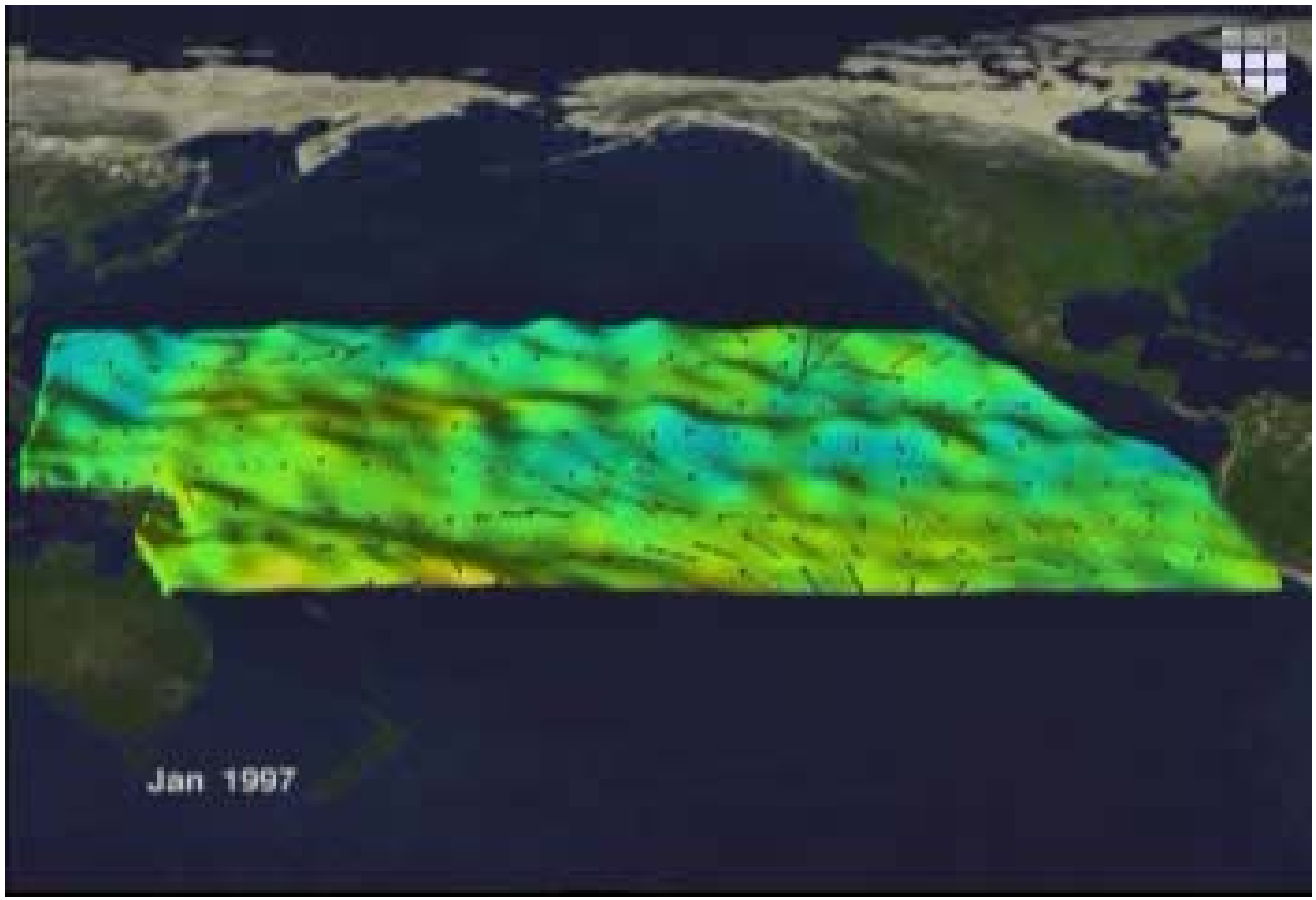
WRC 2003 Booth

European Capitols
Landsat 5
Circa 1990

WRC 2003 Booth

Ozone

WRC 2003 Booth

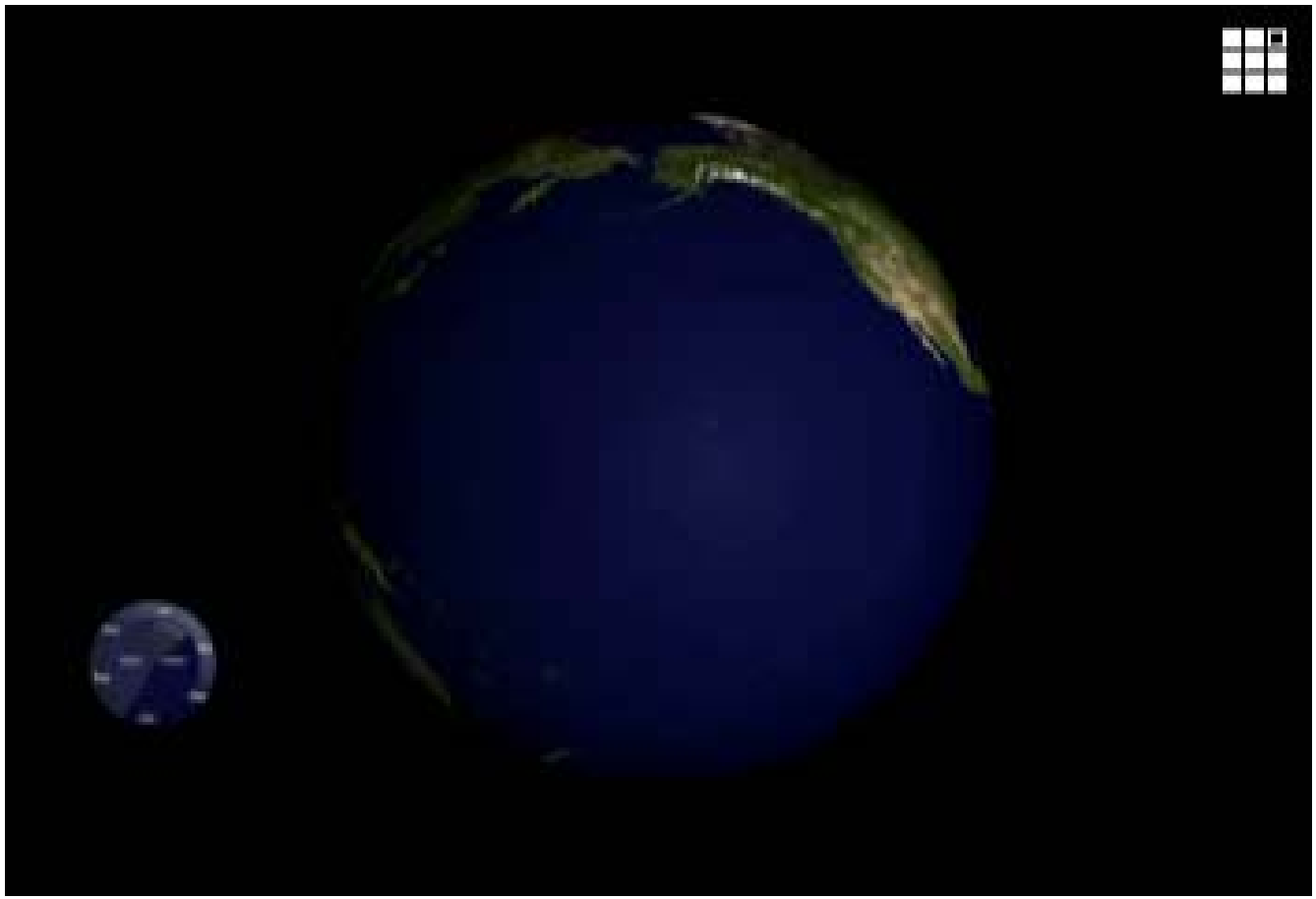


El Nino-La Nina 1997-1999

WRC 2003 Booth

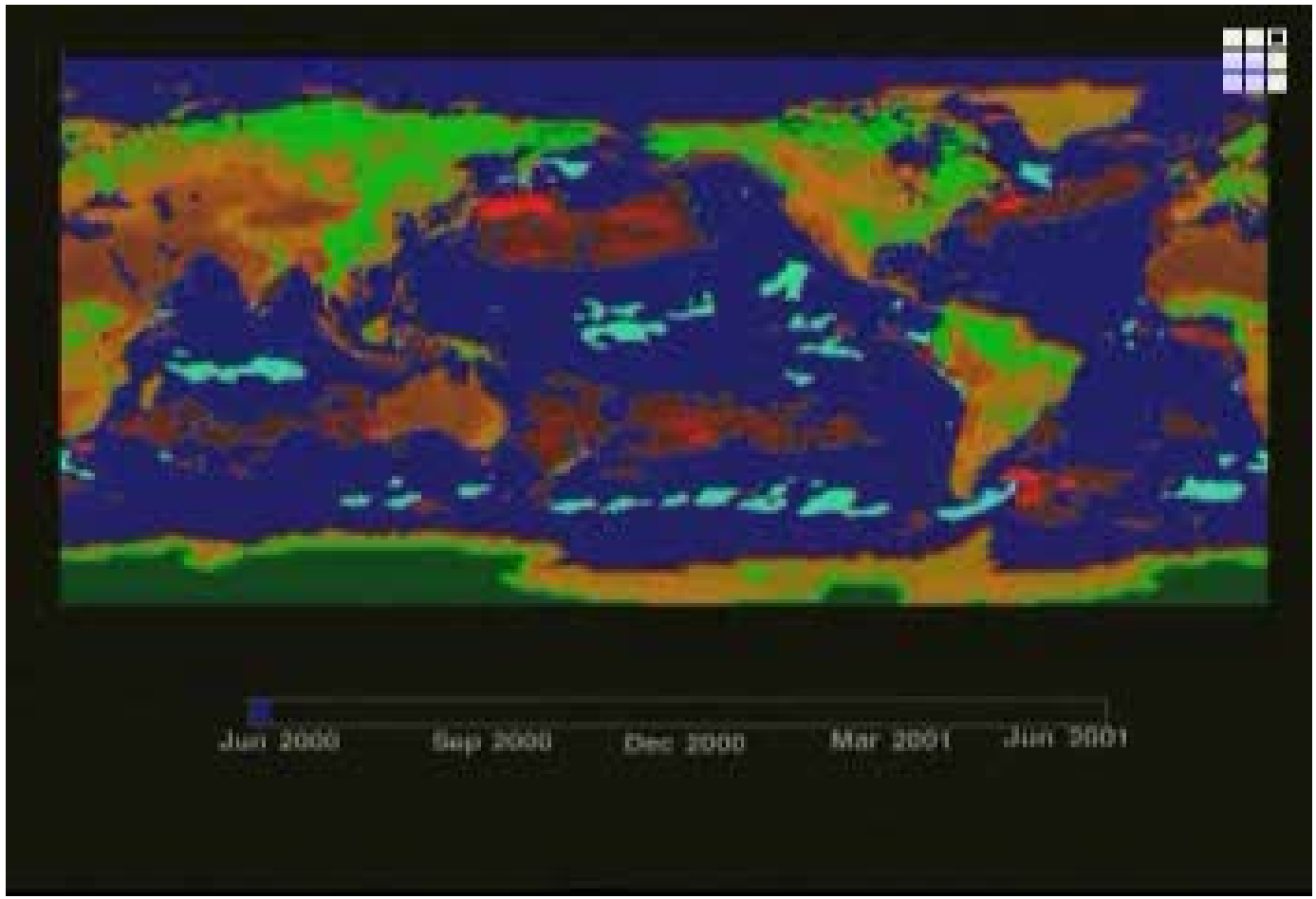
Arctic Ice from Nimbus-7 SSMR and DMSP SSMI

WRC 2003 Booth



Fires seen by MODIS, Global and Chediski

WRC 2003 Booth



Global SST and Soil Moisture from a Climate Model

WRC 2003 Booth

Credits/sources:

Landsat 7 – Earth as Art: http://landsat7.usgs.gov/gallery/

Landsat 5 data: https://zulu.ssc.nasa.gov/mrsid/

SIR-C/X-SAR images: http://www.jpl.nasa.gov/radar/sircxsar/

Animations: http://svs.gsfc.nasa.gov

WRC 2003 Issues

John Zuzek, NASA/Glenn Research Center

Backup Material

NASA Mission Summary

Mission	Launch	Altitude	Incl.	Crossing	Rept	X-Band	Comment
	mm/dd/yy	km	deg.	LT-SunSy	days	Mb/s	
ERBS	10/05/84	585	57				Earth Radiation Budget Satellite
UARS	09/15/91	585	57				Upper Atmosphere Research Satellite
TOPEX/Poseidon	08/10/92	1336	66				Oceanography mission, preceeded JASON-1
TOMS-EP	07/02/96	740	98.4	11:10A		none?	Total Ozone Measurement
TRMM	11/27/97	402	35				Tropical Rainfall Measuring Mission
LANDSAT-7	04/15/99	705	98.2	10:00D	16	3x150	Multispectral imagery for Land cover/Land use
QuikSCAT	06/19/99	803	98.6	06:00A			Replaced SeaWinds instrument after ADEOS-1 failed.
TERRA	12/18/99	705	98.2	10:30D	16	150	Observes state of atmosphere, land, and oceans.
ACRIMSAT	12/20/99	716	98.13	22:44D			Measures total solar irradiance
SRTM	02/11/00	233	57				Mission competed, duration 11 days
GOES-L	05/03/00	36000	0				For NOAA
CHAMP	07/15/00	450	87				gravity, geomagnetic field, and atmospheric sounding
NOAA-L POESS	09/21/00	833	98.8	13:54A			For NOAA
EO-1	11/21/00	705	98.2	10:01D	16	105	Technology demo-advance land imager and hyperspectral
GOES-M	07/23/01	36000	0				For NOAA
SAGE-3 (Meteor)	12/10/01	1018	99.6	09:25A		none?	Russian vehicle, Russian downlinks
GRACE	03/17/02	300-500	89				Gravity Recovery and Climate Experiment
AQUA	05/04/02	705	98.2	13:30A	16	150	…precise atmosphere and oceans measurements
NOAA-M POES	07/24/02	833	98.8	10:00D			For NOAA
JASON-1	12/07/02	1336	66		10		Oceanography mission
Seawinds(ADEOS-2)	12/14/02	803	98.6	10:03D	4	60	Instrument on MIDORI-2 (ADEOS-2) Japanese Spacecraft
ICESat	01/12/03	600	94		183	40	Ice, Clouds, and Land Elevation Satellite
SORCE	01/25/03	600	40				Solar irradiance and spectrum measurements

NASA Mission Summary

Mission	Launch	Altitude	Incl.	Crossing	Rept	X-Band	Comment
	estimated	km	deg.	LT-SunSy	days	Mb/s	
AQUARIUS	2006	600	97.8	06:00?		?	Measures ocean salinity, L-band scatterometer and radiomete
AURA	winter 2004	705	98.2	13:45A	16	150	to study the chemistry and dynamics of Earth's atmosphere
CALIPSO	spring 2004	705	98.2	13:33A	16	80	key aerosol and cloud properties
CloudSAT	spring 2004	705	98.2	13:33A	16		topside cloud radar
DSCVR	spring 2020	1000000	N/A				Sun-Earth libration point observatory, formerly TRIANA
EO-3	2005	geosyn.	0				GIFTS instrument
GPM	fall 2007	400	65			TBD	Global Precipitation Mission: Improve weather forecasting
HYDROS	2006	670	97.8	600		31	Measures soil moisture, L-band radar and radiometer
LDCM	2006	705	98.2	10:00D	16	TBD	Continues supply of Landsat data via commercial vendor
NPP	winter 2006	824	98.8	10:30D		300	Joint NASA-NOAA-DoD, bridge from AQUA to NPOESS
OCO	2006	705	98.2	13:15A	16	150	Orbiting Carbon Observatory
VCL	spring 2020	400	67			?	Vegetation Canopy Lidar
Related Missions	Launch	Altitude	Incl	Crossing	Rept	X-Band	Comment
	mm/dd/yy	km	deg.	LT-SunSy	days	Mb/s	
ADEOS-2	12/14/02	803	98.6	10:03D	4	60	Japanese; Downlinks to ASF - see SeaWinds
ERS-2	04/21/95	785	98.5	10:30D	35	105	ESA; Downlinks to ASF
Parasol		705	98.2	13:40?	16	none?	French; In afternoon train
Radarsat-1	11/04/95	798	98.6	18:00A	24	105	Canadian; Downlinks to ASF
SAC-C	11/21/00	705	98.2	10:21D	16	yes	Argentinian; In morning train; Downlinks in Argentina

NASA Mission Summary

	BAND (GHz)	1.25	1.42	1.67	2.65	3.2	4.3	4.9	5.3	6.7	7.15	8.6	9.65	10.65	13.5	15.3	15.4	17.25	18.7	21.3	22.3	23.8	24.1	31.5	35.55	36.5	50.3	55	64.5	78.5	89.	94	101	110	118	150.5	157	166	175.5	183	201	224	236	251	276	301
	ALLOC.	A	P	P	p	a	p	p	A	p	p	A	A	P	A	p	P	A	P	P	P	P	A	P	A	P	P	P	A	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
INSTR.	MISSION																																														
ALT	TPX/POS								1						1																																
AMSR-E	AQUA									1				1					1			1				1				1																
AMSU	AQUA																				1	1		1			1	12			2								4						
AMSU-A	NOAA K+																					1		1			1	1			1														
AMSU-B	NOAA-K+																														1						1			3						
ATMS	NPP, NPOESS																					1		1			3	9			1							1		5						
HSB	AQUA																														1									3						
JMR	JASON																		1			1																			1					
MHS	NOAA-N																														1						1		1	3						
MLS	EOS-CHEM																																								1					1
MLS	UARS																												1										1	1					
MSU	NOAA-9 - NOAA-14																										1	3																	
NSCAT	ADEOS														1																															
PR	TRMM														1																															
QuikSCAT	QuikSCAT														1																															
Radiometer	Proposed		1																														1											
SAR	RADAR-SAT								1																																			
SEAWINDS	ADEOS-2														1																															
SIRC/XSAR	Shuttle	1							1				1																																
SRTM/XSAR	Shuttle								1				1																																
SSALT	JASON								1						1																															
TMI	TRMM													1						1						1					1														
TMR	TPX/POS																		1	1						1																			

NASA Mission Summary

Acronym/ Abbreviation	Name/Title	MISSION	COUNTRY
ADEOS	Advanced Earth Observation Satellite(s)		JAPAN
ALOS	Advanced Land Observing Satellite		JAPAN
ALT	Altimeter	TOPEX/ POSEIDON	USA/ FRANCE
AMI	Active Microwave Instrument	ERS-1, -2	ESA
AMSR	Advanced Microwave Scanning Radiometer	ADEOS-2	JAPAN
AMSR-E	Advanced Microwave Scanning Radiometer-EOS	EOS-PM	JAPAN/ USA
AMSU	Advanced Microwave Sounding Unit	AQUA	USA
AMSU-A	Advanced Microwave Sounding Unit - A	NOAA K+ METOP1	USA ESA
AMSU-B	Advanced Microwave Sounding Unit - B	NOAA-K+	USA
ASAR	Advanced Synthetic Aperture Radar	ENVISAT	ESA
ASCAT	Advanced Scatterometer	METOP	ESA
ATMS	Advanced Technology Microwave Sounder	Bridge, NPOESS-C	NASA, NPOESS
ATSR, -2	Along Track Scanning Radiometer (& Microwave Sounder)	ERS-1, -2	ESA
CLOUD RADAR	Cloud radar	FUTURE	ESA
CSR	Commonwealth of Soviet Republics		
DELTA-2		OKEAN	CSR
DORIS	Doppler Orbitography & Radio Positioning Integrated by Satellite	TOPEX/ POSEIDON	USA/ FRANCE
ENVISAT	Environmental Satellite		ESA
EOS	Earth Observing System (-AM, morning equator crossing; -PM afternoon crossing; -CHEM afternoon crossing)		USA
ERS	Earth Resource Satellite(s)		ESA
ESA	European Space Agency		
ETM	Enhanced Thematic Mapper	LANDSAT	USA
HSB	Humidity Sounder, Brazil	AQUA	USA/Brazil
IKAR		PRIRODA	CSR
JERS	Japanese Earth Resources Satellite		JAPAN
JMR	Jason Microwave Radiometer	JASON-1	USA/France
MASTER		FUTURE	ESA
MHS	Microwave Humidity Sounder	AQUA NOAA-N METOP	USA USA ESA
MIMR	Multifrequency Imaging Microwave Radiometer	METOP	ESA
MIRAS	Microwave Imaging Radiometer with Aperture Synthesis	MIRAS	ESA
MIVZA	(humidity sounder)	METEOR	CSR
MLS	Microwave Limb Sounder	UARS, AURA	USA
MSR	Microwave Scanning Radiometer	MOS-1B	JAPAN
MSU	Microwave Sounding Unit	NOAA-9-14	USA

NASA Mission Summary

Acronym/ Abbreviation	Name/Title	MISSION	COUNTRY
MTZA		METEOR	CSR
MWR	Microwave Radiometer	ENVISAT	ESA
NASA	National Aeronautics and Space Administration		USA
NOAA	National Oceans and Atmospheres Administration		USA
NSCAT(US)	NASA Scatterometer	ADEOS	JAPAN
PR	Precipitation Radar	TRMM	JAPAN
R-225	2.25 cm radiometer (?)	OKEAN-O	CSR
R-400	4 cm radiometer (?)	PRIRODA	CSR
R-600	6 cm radiometer (?)	OKEAN-O	CSR
RA	Radar Altimeter	ERS-1,-2	ESA
RA-2	Radar Altimeter	ENVISAT	ESA
RADIOMTR	Radiometer	ODIN	SWEDEN
RLSBO	Imager	OKEAN-O, SICH-1	CSR
RM-0.8	0.8 cm imaging radiometer	SICH	CSR
SAR	Synthetic Aperture Radar	RADARSAT	CANADA
SAR	Synthetic Aperture Radar	JERS-1	JAPAN
SAR	Synthetic Aperture Radar	SICH	CSR
SAR-10	Synthetic Aperture Radar - 9.6 cm	ALMAZ	CSR
SAR-3	Synthetic Aperture Radar - 3.5 cm	ALMAZ	CSR
SAR-70	Synthetic Aperture Radar - 70 cm	ALMAZX	CSR
SIRC/XSAR	Shuttle Imaging Radar -C, X-Synthetic Aperture Radar	Shuttle	USA
SMR	Scanning Microwave Radiometer	SICH	CSR
SEAWINDS (USA)	Scatterometer	ADEOS-2	JAPAN
SLR-3	Side Looking Radar	ALMAZX	CSR
SOPRANO	Sub-millimeter Observation of Processes in the Absorption Noteworthy for Ozone	FUTURE	ESA
SSALT	Solid State Altimeter	TPX/POS, JASON	USA, FRANCE
TDRSS	Tracking and Data Relay Satellite System		USA
TMI (USA)	TRMM Microwave Imager	TRMM	JAPAN
TMR	TOPEX Microwave Radiometer	TPX/POS, JASON	USA, FRANCE
TPX/POS	TOPEX/POSEIDON		USA, FRANCE
TRMM	Tropical Rainfall Measurement Mission		USA, JAPAN
TRVRS SAR	Transverse-Synthetic Aperture Radar	PRIRODA	CSR
TT&C	Tracking, Telemetry, and Command		
UARS	Upper Atmosphere Research Satellite		USA
USA	United States of America		
VSAR	? Synthetic Aperture Radar	ALOS	JAPAN