

GPS RO Workshop
7-9 April 2009
Pasadena

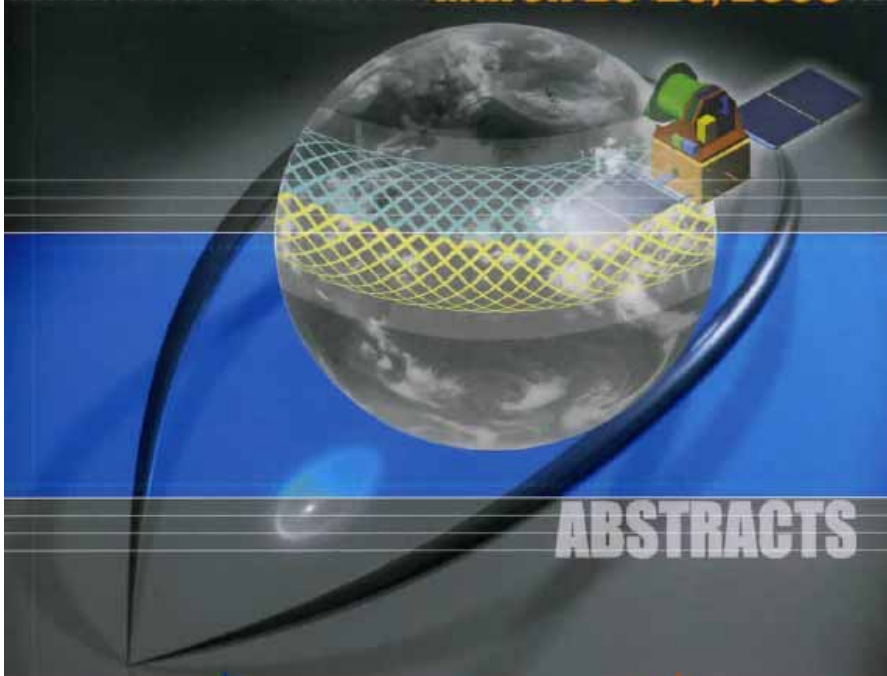
A report on GPS RO mission on board
Megha Tropiques by ISRO
(Indian Space Research Organization)
and related activities

Toshitaka Tsuda
RISH, Kyoto University


Megha Tropiques meeting, 23-25 March 2009, Bangalore, India


International Conference on
MEGHA-TROPIQUES
Science and Applications


March 23-25, 2009



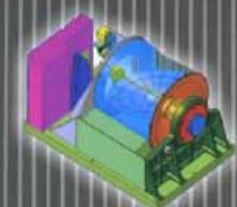
ABSTRACTS

 **Organized by**
Indian Space Research Organisation (ISRO) and
Centre National d'Etudes Spatiales (CNES)


 **Hosted by**
Indian Space Research Organisation (ISRO)
Bangalore, India



MADRAS (Microwave Analysis
and Detection of Rain and
Atmospheric Structures)



SAPHIR (Sondeur Atmospherique
du profil d'Humidite
Intertropicale par Radiometrie)



**GPS ROS**
(GPS Radio Occultation Sensor)

**SCARAB**
(SCAnner for RAdiative Budget)

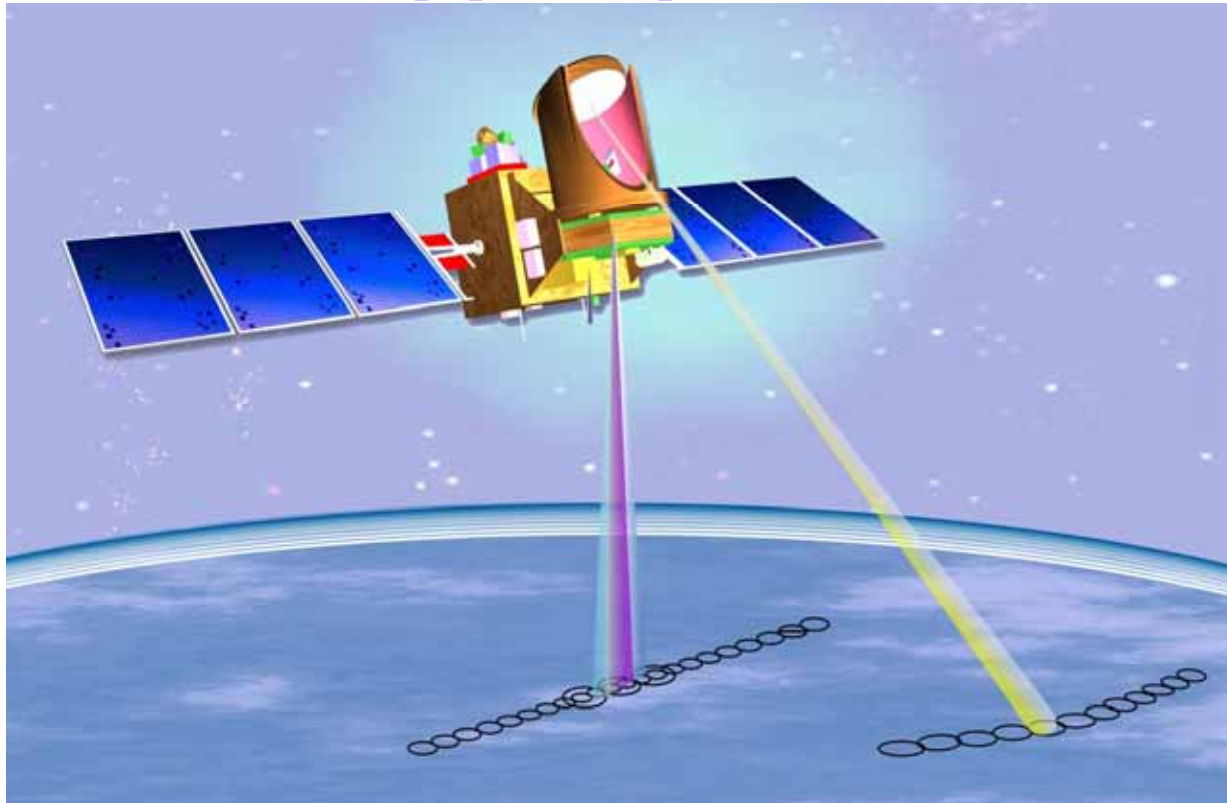
Compiled by : B. M. Rao, B. S. Gohil & Shivani Shah (SAC, Ahmedabad, India)

Megha-Tropiques

Indo-French (ISRO-CNES) Collaboration

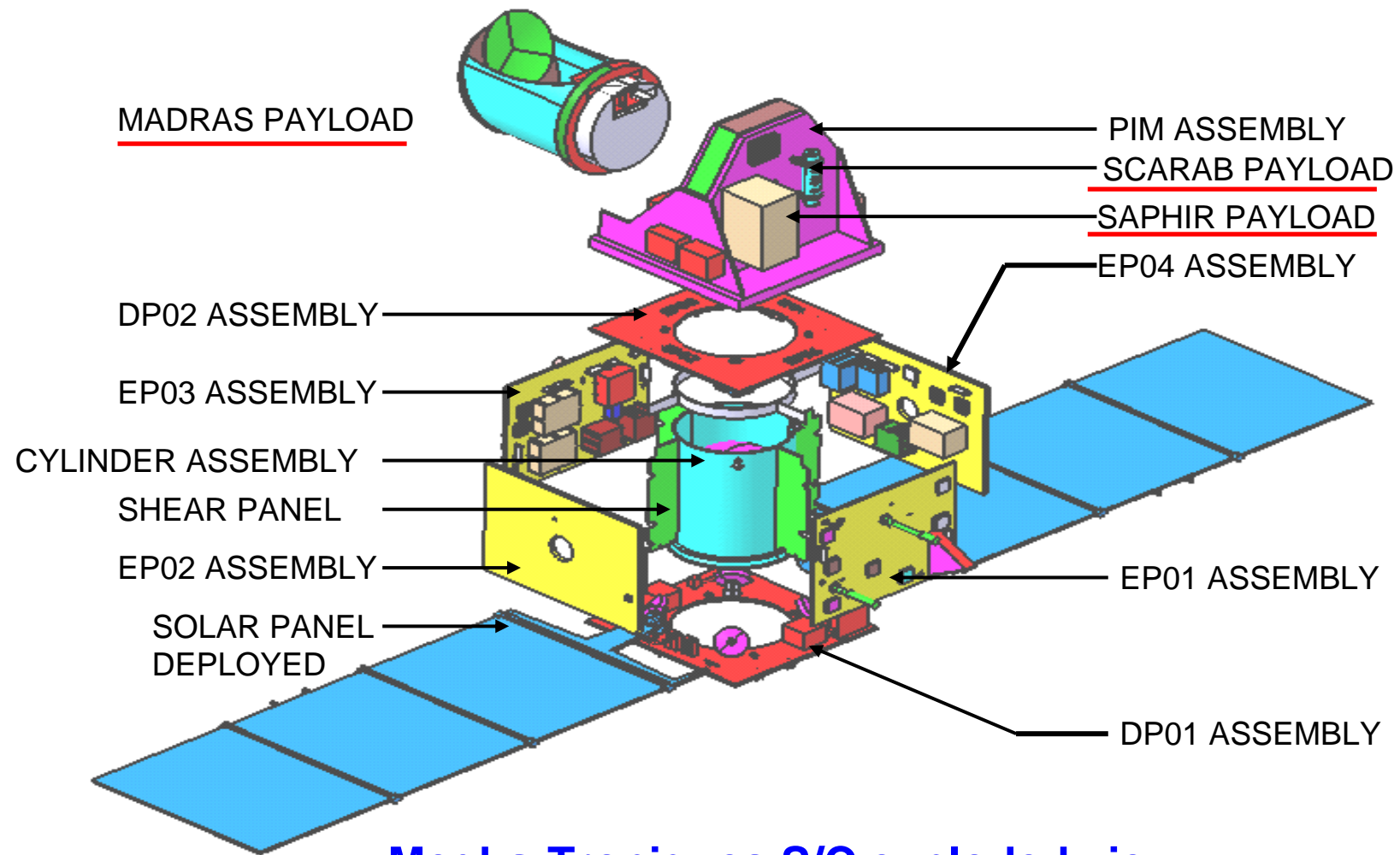
Megha: Cloud in Hindi (Sanskrit)

Tropiques: Tropics in French



G. Raju (ISRO) and Nadia Karouche (CNES)

Modified from Dr. Raju's PPT presented at
the MT conference on 23-25 March 2009



Megha-Tropiques S/C exploded view

Payload

| | | | |
|---|--|---------------|--|
| MADRAS (Microwave Analysis and Detection of Rain and Atmospheric Structures) | Microwave radiometer on 5 frequencies (18.7, 23.5, 36.5, 89 and 157 GHz) | ISRO+ CNES | Brightness temperature Rainfall, atmospheric water parameters and ocean surface winds |
| SAPHIR (Soundeur Atmospherique du Profil d'Humidite Intertropicale par Radiometrie) | Millimeter wave humidity sounder at 6 channels at around 183GHz | CNES | Humidity profile up to 12 km (6 levels) |
| SCARAB (SCAnner for Radiative Budget) | Radiometer in visible (0.5-0.7 μ m) and IR bands (0.2-4, 0.2-200, 10.5-12.5 μ m) | CNES | Radiation budget, Outgoing long-wave and short-wave radiation |
| GPS ROS GPS Radio Occultation Sensor | ROSA with two occultation antennas | ISRO+ ASI | Temperature and humidity profiles |

ISRO (Indian Space Research Organization), India
 CNES (Centre Nationale d'Etudes Spatiales), France
 ASI (Agenzia Spaziale Italiana), Italy

MEGHA - TROPIQUES MISSION

Mission Highlights

- **Indo - French (ISRO-CNES) collaboration**
- **Climate and atmospheric research and applications satellite for studies over the tropics**
- **20-degree Inclined orbit for high temporal sampling**
- **IRS bus –1500-kg class**
- **Shared responsibility of payloads**
- **ISRO's PSLV launcher**
- **Spacecraft control and data reception from ISTRAC, Bangalore**
- **Science data reception at ISTRAC, Bangalore and Kourou (CNES) / HBK (CNES)**
- **Launch from SHAR**
- **Near-real-time (NRT) data availability over the entire globe**

MAIN FEATURES OF THE SATELLITE

| | | |
|------------------------------|---|--|
| Spacecraft bus | : | IRS (ISRO) |
| Spacecraft mass | : | About 1000 kg |
| Orbit height: | : | 866.4 km |
| Orbit inclination | : | 20 degrees |
| Power | : | |
| | | <ul style="list-style-type: none">• Two symmetrical solar array wings on both sides of the spacecraft• Three panels per wing• High-efficiency multi-junction solar cells• Ni-Cd battery |
| Total spacecraft power | : | 694 W |
| Power available for payloads | : | ~ 360 W |
| On-board data storage | : | 16 GB Main + 16 GB Redundant (SSR) – for global coverage |
| Mission Life | : | Design life 5 years |
| Launcher | : | PSLV (ISRO) |

The payloads are ON throughout the mission; data will be recorded on SSR

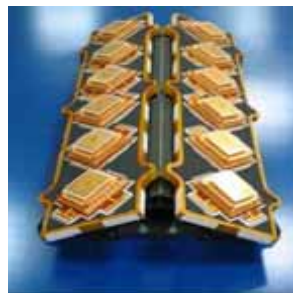
ROSA PAYLOAD

GPS- radio occultation sensor (GPS-ROS)

- ISRO includes a GPS-ROS sensor as the fourth payload on the Megha-Tropiques satellite.
- The ROSA payload (Radio Occultation Sensor for Atmosphere) will be provided by the Italian Space Agency (ASI).
- It consists of accurate measurements of pseudo-range and integrated Doppler (raw data) at dual-frequency from GPS satellites.
- 16 dual frequency channels (equal to 48 single channels)
- The GPS signals are acquired through multiple antennas: a *zenith antenna* is used for navigation purpose, while *two sounding antennas, pointed toward velocity and anti-velocity satellite vectors* respectively, are used for Earth limb rising-setting occultation observations for scientific purpose.



GPS Receiver



Occultation antenna



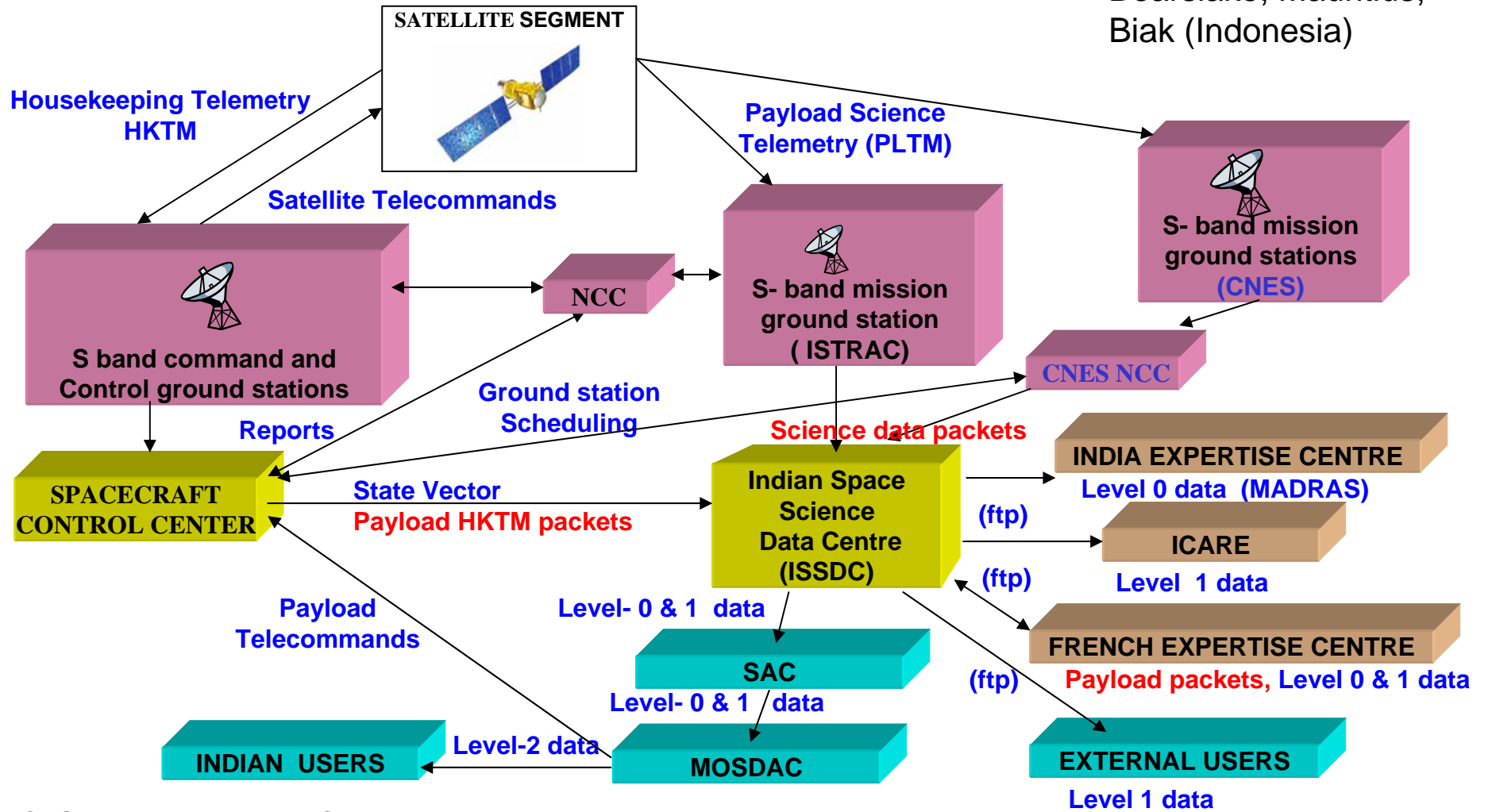
POD antenna

Modified from
Dr. Raju's PPT

MT Ground Segment Plan

Agreed by both ISRO & CNES Project teams

ISTRAC ground stations
Bangalore, Lucknow, Bearslake, Mauritius, Biak (Indonesia)



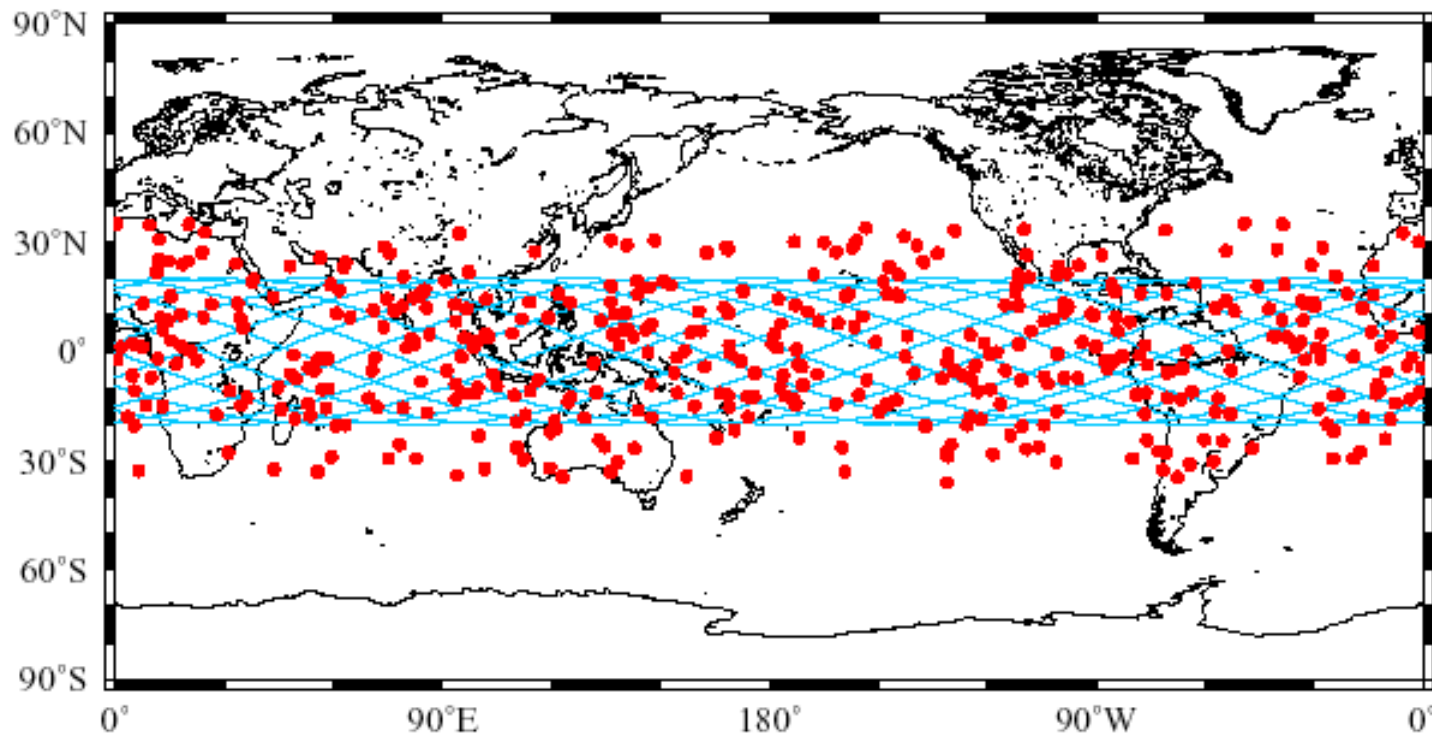
SAC: Space Applications Center, Ahmedabad

ISTRAC: ISRO Telemetry Tracking and Command Network, Bangalore

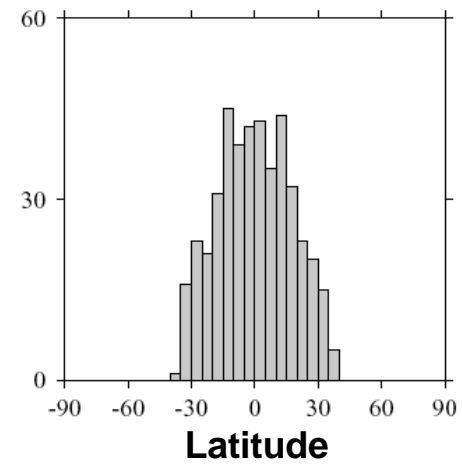
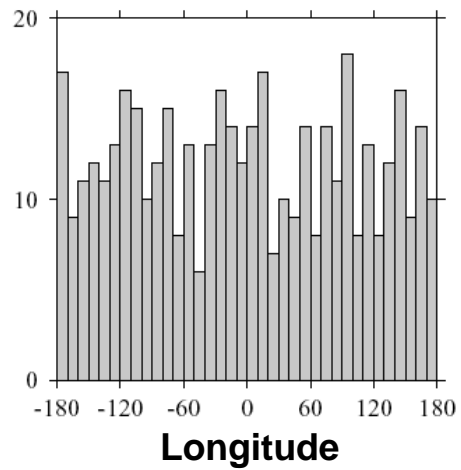
MOSDAC: Meteorological and Oceanographic Satellite Data Archival Center, Ahmedabad

Modified from Dr. Raju's PPT

GPS RO Data with a LEO satellite on low inclination angle in 24 hours

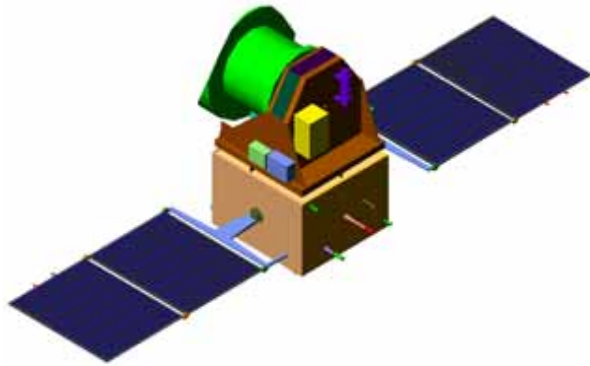


■ Location of occultation at 15km altitude
--- Satellite orbit



Orbit altitude: 700km
Inclination angle: 20.0 deg
Eccentricity: 0.0
Right ascension: 0.0
Argument of perigee: 0.0
Number of occultation events: 435
(Available data: more than 300)
Latitude Range: 36.1S - 35.3 N

Data Distribution of GPS RO Events with Megha Tropiques (2 antennas) in 24 hours

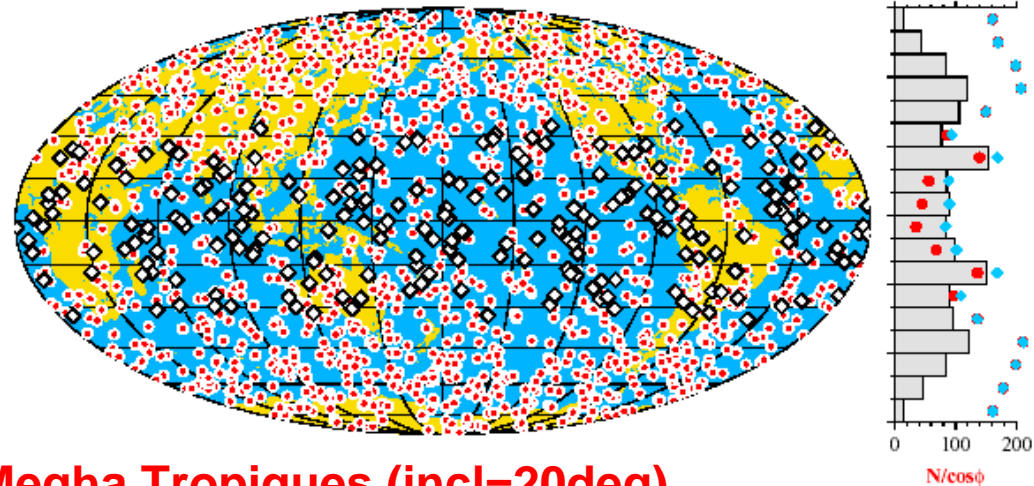
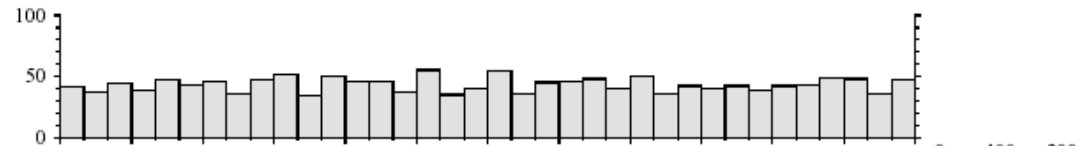
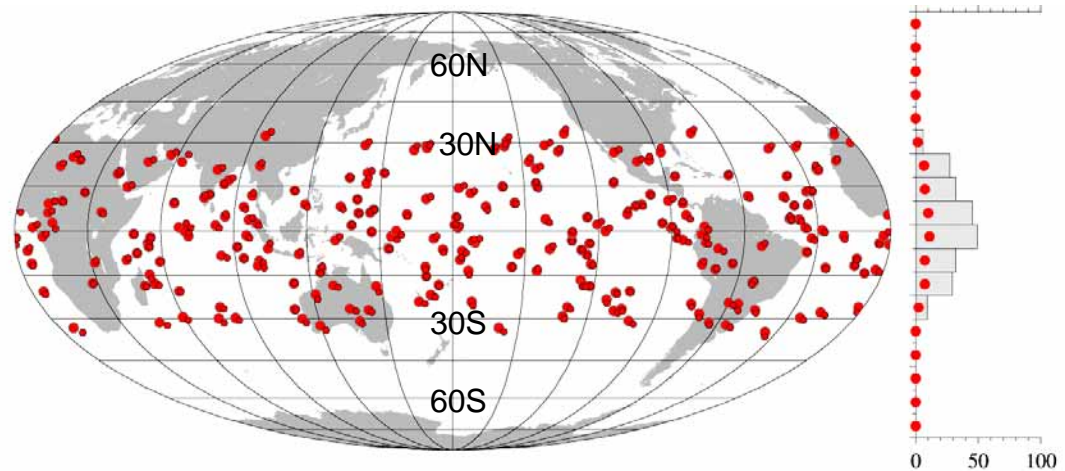


Megha Tropiques

Altitude: 800 km

Inclination angle: 20 deg

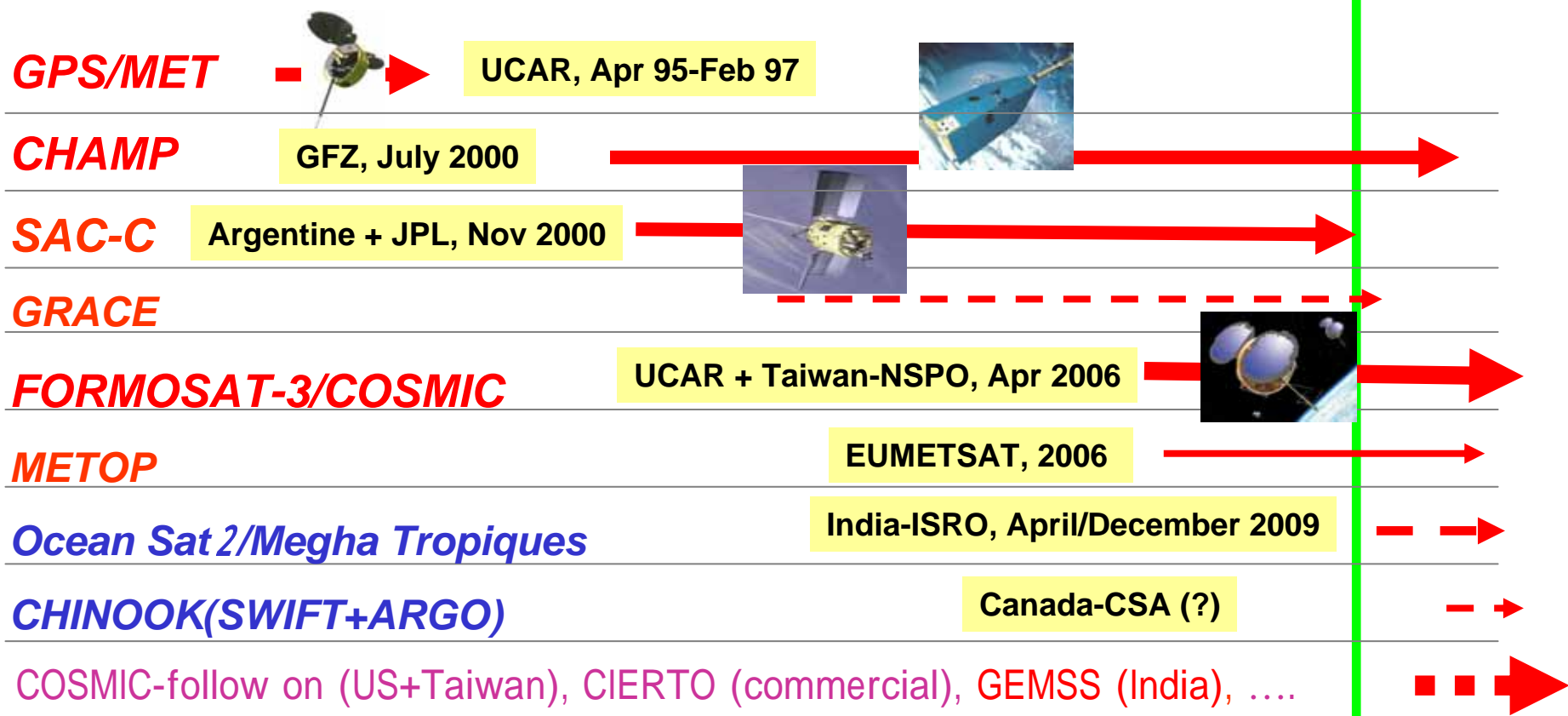
High data density at low latitudes is very useful to complement the CSOMIC GPS RO data distribution, which is denser at mid- and high latitudes.



**Megha Tropiques (incl=20deg)
+ COSMIC (incl=72deg)**

GPS radio occultation (RO) missions

1995 - 1997 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

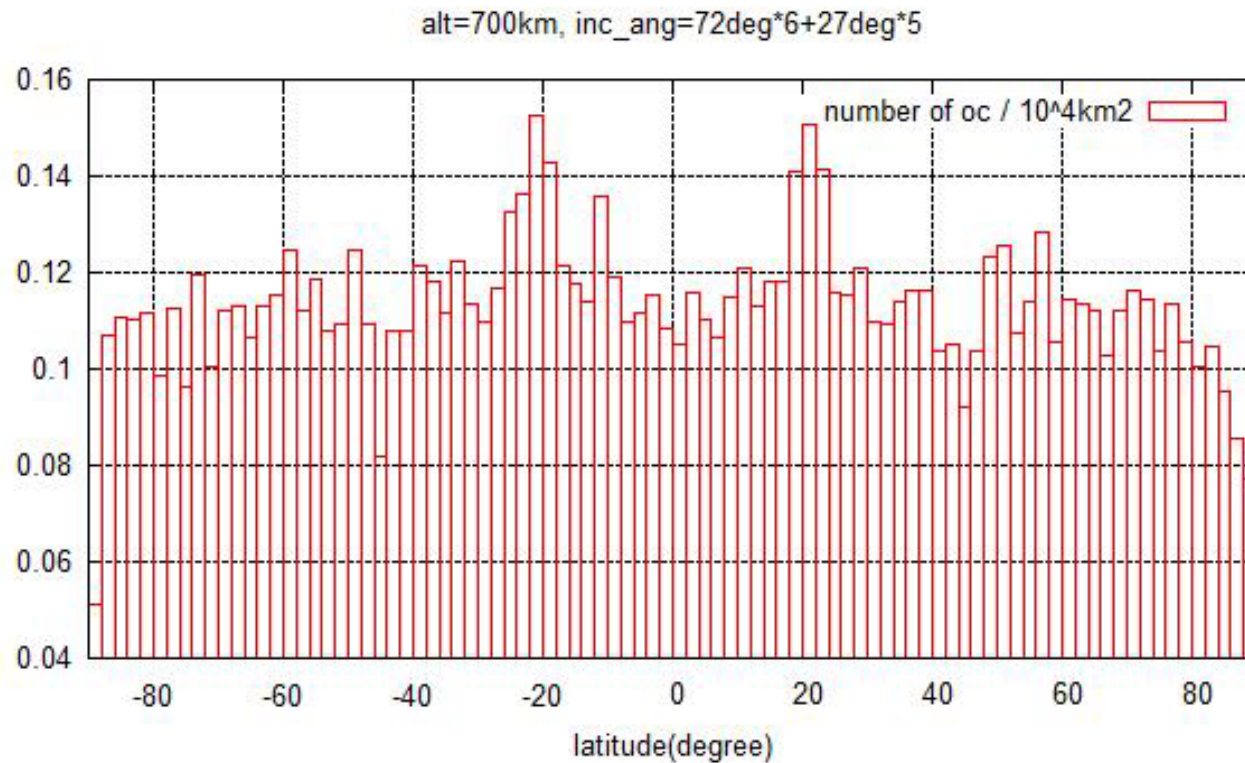


| | | | |
|------------------|-----------------|------------------------------|---|
| Data rate | 5,000/yr | 150-200/day/Satellite | 2,500/day >10,000/day |
|------------------|-----------------|------------------------------|---|

GEMSS: constellation of low inclination LEO satellites

Homogeneous data distribution per unit area

Number of
GPS RO
events
/100x100
km² /day



6 LEO satellites: inclination angle at 72 degrees

5 LEO satellites: inclination angle at 27 degrees