The Megha-Tropiques Mission

Rémy Roca (LMD)
and the French MT science team
The Megha-Tropiques mission

Outline of the talk

- Mission & Objectives
  - Payload
  - Orbit
- Activities on ERB in the MT team
  - Organisation
  - L2 and up
  - Side activities on GEO
- Cal/val plan
- International science team
- Follow on to MT!
The Megha-Tropiques mission
Overview

Indo-french mission realized by
The Indian Space Research Organisation and the
Centre National d’Etudes Spatiales

Dedicated to the

Water and energy cycle in the Tropics

Low inclination on the equator (20°);
865 km height

High repetetivity of the measurements

Launch foreseen in spring 2010 ... 2011
Expected duration: instruments 3 yr Plateform 5 yr fuel/operation
The Megha-Tropiques mission
Scientific objectives

Atmospheric energy budget in the intertropical zone and at system scale (radiation, latent heat, …)

Life cycle of Mesoscale Convective Complexes in the Tropics (over Oceans and Continents)

Monitoring and assimilation for Cyclones, Monsoons, Mesoscale Convective Systems forecasting. NRT capability.

Contribution to climate monitoring:

- Radiative budget (complementary to CERES)
- Precipitation (enhanced sampling in the tropics)
- Water vapour (enhanced sampling in the tropics)
The Megha-Tropiques mission
Payloads (1/2)

- **ScaRaB**: broad band instrument for inferring longwave and shortwave outgoing fluxes at the top of the atmosphere

- **ScaRaB-3 on MT**

- Cross track scanning
- 40 km resolution at nadir

<table>
<thead>
<tr>
<th>Channel</th>
<th>Description</th>
<th>Spectral Interval</th>
<th>Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VIS (visible)</td>
<td>0.55 – 0.65 µm</td>
<td>Interferential</td>
</tr>
<tr>
<td>2</td>
<td>SW (or solar)</td>
<td>0.2 – 4 µm</td>
<td>Silice filter</td>
</tr>
<tr>
<td>3</td>
<td>T (total)</td>
<td>0.2 – 100 µm</td>
<td>No filter</td>
</tr>
<tr>
<td>4</td>
<td>IR (Infrared)</td>
<td>10.5 – 12.5 µm</td>
<td>Interferential</td>
</tr>
</tbody>
</table>
The Megha-Tropiques mission

Payloads (2/2)

**SAPHIR** : microwave sounder for water vapour sounding : 6 channels in the WV absorption band at 183.31 GHz. (cross track, 10 km)

**MADRAS** : microwave imager for precipitation : channels at 18, 23, 37, 89 and 157 GHz, H and V polarisations. (conical swath, <10 km to 40 km)

**GPS RO** : water vapor profile …

**GEOSTATIONARY DATA**
- Cloud mask for the MW algo
- Quicklook for interpreting MT data
- Basic inputs for MCS tracking algorithm
- Basic inputs for Level 4 rainfall (radiation) products
The Megha-Tropiques mission
Orbit (1/3)

Megha-Tropiques
Orbite par rapport à la Terre

Altitude = 865.5 km
Inclinaison = 20.00 °

Période = 101.93 min * Révol./j.=14.13
Décalage à l’équateur = 2892.0 km ( 26.0 °)

Projection: Orthographique
CP: 20.0° N; 45.0° E/CZ: 30.0° N; 60.0° E
Nœud asc. : -180.00 ° [00:00 TSM]

Rémy Roca et al, MT Overview, Paris, France, September 2010
The Megha-Tropiques mission
Orbit (2/3)
The Megha-Tropiques mission

Orbit (3/3)

Half day

1 orbit

SCARAB sampling over 20°S-20°n
Min 4 per day
Max 6 per day
Life cycle of Mesoscale Convective Systems
Compositing with MT

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO
© 2010 Cnes/Spot Image
The Megha-Tropiques mission
Who’s doing what in France

MT is a research space mission carried by both the CNES and the CNRS
Two teams are sharing the responsibilities:

A PROJECT TEAM led by
Dr Nadia Karouche,
Project Manager from CNES
In the team:
Engineers from CNES,
Engineers from Astrium (Madras),
and from the research labs (CNRS)

A MISSION TEAM led by
- Dr Rémy Roca, PI from CNRS
(formerly Dr Michel Desbois)
In the team:
Scientists from research Lab
(mainly CNRS), and programmatic
from CNES

Interactions between the teams in a”mission group” + dedicated meetings
Project team to change after calibration to Operation Team
Scientific Ground segment (~DTM+ASCD) called ICARE in Lille, France
The Megha-Tropiques mission
Who’s doing what  Data flow (as of June ’08)

Housekeeping Telemetry HKTM

Satellite Telecommands

Payload Science Telemetry (PLTM)

Ground station Scheduling

Science data packets

State Vector Payload HKTM packets

Level-0 & 1 data

Level-0 & 1 data

Level-2 data

Payload Telecommands

INDIAN USERS

MOSDAC

SAC

INDIA EXPERTISE CENTRE

(ftp)

Level 0 data (MADRAS)

ICARE

FRENCH EXPERTISE CENTRE

EXTERNAL USERS

Level 1 data

Level 1 data

(ftp)

S- band mission ground station (ISTRAC)

S- band mission ground stations (CNES)

CNES NCC

Indian Space Science Data Centre (ISSDC)

Level 0 & 1 data

SATELLITE SEGMENT

S band command and Control ground stations

INDIAN SPACE SCIENCE DATA CENTRE

SPACECRAFT CONTROL CENTER

Satellite Telecommands

Indian Space Science Data Centre (ISSDC)

Housekeeping Telemetry HKTM

S- band mission ground station (ISTRAC)

S- band mission ground stations (CNES)

CNES NCC
The Megha-Tropiques mission
Who’s doing what  Science Side in France

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Role/Responsibility</th>
</tr>
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<tbody>
<tr>
<td>Rémy Roca</td>
<td>LMD</td>
<td>Science</td>
</tr>
<tr>
<td>Olivier Chomette</td>
<td>LMD</td>
<td>Level 2 &amp; 3</td>
</tr>
<tr>
<td>Patrick Raberanto</td>
<td>LMD</td>
<td>Instrument, calibration, Level 3</td>
</tr>
<tr>
<td>Michel Capderou</td>
<td>LMD</td>
<td>Celestial mechanics</td>
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<tr>
<td>Nicolas Gif</td>
<td>LMD</td>
<td>Programming</td>
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<tr>
<td>Sophie Cloché</td>
<td>IPSL</td>
<td>Data management &amp; QC</td>
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<tr>
<td>Rodrigo Guzman</td>
<td>LMD</td>
<td>PhD Clear sky OLR</td>
</tr>
<tr>
<td>Bijoy Thampi</td>
<td>LMD</td>
<td>Post doc (soon) Cloud radiative forcing</td>
</tr>
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</table>
ERB activities in the MT Team

Products developpements
Chomette, Raberanto, et al

ERB products Day 1
L2 Instantaneous TOA fluxes (SW+LW)
Accuracy of 10 Wm\(^{-2}\) for instantaneous fluxes
CERES ADMs are considered as reference

Scarab Artificial Neural Network algorithm (SANN)

<table>
<thead>
<tr>
<th>Table 2, Loeb, JAM, 2003</th>
<th>Estimated regional (1°) instantaneous SW TOA flux error (W.m(^{-2})) – All sky</th>
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<tbody>
<tr>
<td>ANN</td>
<td>10.8</td>
</tr>
<tr>
<td>ERBE-like</td>
<td>24.4</td>
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</table>

L3 Clear sky fluxes (SW+LW)
In the process of defining the most suited space-time averaging
Finalizing the error model to help in assessing the above

See Olivier Chomette presentation
ERB activities in the MT Team

GEO cloud activities

SAF NWC cloud classification is streaming

Geneviève Sèze et al.

GOES-E 1500GMT 3 channels  GOES-W 2100GMT 3 channels

SEVIRI 1200GMT 5 channels

MTSAT 0300GMT 4 channels

Broken
Th. above
Thin Cir.
Cirrus
Thk. Cirrus
High
Very High
Medium
Low
Very Low
Sea
Land
The Megha-Tropiques mission
Earth radiation budget measurement summary
Across scales:
from the tropical belt down to the MCS scale (See Talk R Roca)

Combination of the payloads:
• WV sounding (SAPHIR) and OLR (Scarab) to study the greenhouse effect (See Talk from R. Guzman)
• Latent heat (MADRAS) and Cloud Radiative Forcing (Scarab) to study the relative role of these two components of the atmospheric heating
• Cloud information (GEO) and WV in the low levels (MADRAS) and TOA RB (ScaRaB) to constrain surface radiation budget estimates
• Use of high frequencies in the microwave (85, 157, 183 Ghz) for ice characterisation (MADRAS, SAPHIR and SCARAB)
• …
The CAL/VAL Plan

- Radiometric quality check before & after launch
  - Spectral characterization
  - Gain determination
  - Independence of TOA fluxes on the viewing geometry
    \[ \sim 2\% \text{ SW} ; \sim 1\% \text{ LW} \]

- Vicarious calibration (indirect methods)
  - With terrestrial targets with known SW reflectance such as desert (precision \( \sim 2\% \))
  - or thick cloud with the DCC method to calibrate LW & SW radiances (precision \( \sim 1\% \))

- Comparison with other ERB instruments
  - CERES & GERB real time (monitoring)
  - Comparison with historical data
Validation using CERES one example

Example with CERES (2 days), ±5 mn, no viewing angular conditions

Megha-Tropiques

0 km <-> 2292 km - Superposition (pt interm.) avec Aqua
Phasage = [14; -1; 7] 97

Altitude = 865.5 km  a = 7243.678 km
Inclinaison = 20.00°
Période = 101.93 min  Révol./jour = 14.13

>>> Durée représentée : 2880.0 min = 2.00 jours

*** [±/ 1108 km] Megha-Tropiques [±/ 1801 km] Aqua

Kemy Roca et al, MI Overview, Paris, France, September 2010
**Megha-Tropiques International Science Team**

No cost call spring 2010  
20 teams from 11 countries were selected

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Country</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brett Candy</td>
<td>Met Office</td>
<td>UK</td>
<td>Water vapor</td>
</tr>
<tr>
<td>Steven Sherwood</td>
<td>Univ of New South Wales</td>
<td>Australie</td>
<td>rain</td>
</tr>
<tr>
<td>Mathias Milz</td>
<td>Lulea Univ of Technology</td>
<td>Suède</td>
<td>Water vapor</td>
</tr>
<tr>
<td>Ziad Haddad</td>
<td>NASA-JPL</td>
<td>USA</td>
<td>Water vapor</td>
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<tr>
<td>Arthur Hou</td>
<td>NASA Goddard</td>
<td>USA</td>
<td>rain</td>
</tr>
<tr>
<td>Kenji Nakamura</td>
<td>Nagoya Univ</td>
<td>Japon</td>
<td>rain</td>
</tr>
<tr>
<td>Byung-Ju Sohn</td>
<td>Seoul National Univ</td>
<td>Corée du Sud</td>
<td>Water vapor and radiation</td>
</tr>
<tr>
<td>David Doelling</td>
<td>NASA Langley</td>
<td>USA</td>
<td>Radiation</td>
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<tr>
<td>Abdou Ali</td>
<td>Aghrymet</td>
<td>Niger</td>
<td>Rain</td>
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<tr>
<td>Edward Kim</td>
<td>NASA Goddard</td>
<td>USA</td>
<td>Microwave</td>
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<tr>
<td>Lakshmi Kumar</td>
<td>SRM University City Campus</td>
<td>Inde</td>
<td>Rain</td>
</tr>
<tr>
<td>Hareef Baba Shaeb</td>
<td>ISRO-DOS, Nagpur</td>
<td>Inde</td>
<td>Radiation</td>
</tr>
<tr>
<td>Flávio Ponzoni</td>
<td>NISR – INPE</td>
<td>Brésil</td>
<td>Radiation</td>
</tr>
<tr>
<td>Mark Ringer</td>
<td>Met Office, Hadley Center</td>
<td>UK</td>
<td>Rain, radiation, etc..</td>
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<tr>
<td>Sante Laviola</td>
<td>ISAC-CNR</td>
<td>Italie</td>
<td>Rain</td>
</tr>
<tr>
<td>V. Chandrasekar</td>
<td>Colorado State University</td>
<td>USA</td>
<td>Rain</td>
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<tr>
<td>Carlos Angelis</td>
<td>INPE</td>
<td>Brésil</td>
<td>Rain</td>
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<tr>
<td>Eric A. Smith</td>
<td>CRCES</td>
<td>USA</td>
<td>Rain</td>
</tr>
<tr>
<td>Arona Diedhiou</td>
<td>IRD-LTHE</td>
<td>France</td>
<td>Rain</td>
</tr>
</tbody>
</table>

Soon start the animation (newsletter etc..) of the International Science Team  
A second call is anticipated after the launch
The Megha-Tropiques mission
Follow –on!

Elaboration of a new concept instrument

SCARAB+ IR Imager « inside the pixel »

Courtesy of EADS Astrium
The Megha-Tropiques mission
On going

Science and cal/val
• Special Issue with Day 1 algorithm QJRMS
  – Around 15 papers
  – October 2010
• New post doc student (B. Thampi) to start this fall on ScaRab and MCS with us
• Update the cal/val plan document for CNES accounting for possible delay
• Consolidate participation to DYNAMO (Oct 2011)
• ScaraB-4 RDM (end of phase 0 in 27 Sep)

Ground segment
• L3 daily multiplatform decision
• L1 still not finalized from the project
• Finalize implementation QC on geo and other
Thank you for your attention

http://megha-tropiques.ipsl.polytechnique.fr