Satellite based rainfall estimation :

- Recent evaluation work in West-Africa
- Perspectives in the Megha-Tropiques and GPM framework

Marielle Gosset (GET-IRD)

Prepared with inputs from :

Remy Roca, Nicolas Viltard, MT Mission
Frédéric Cazenave, Matias Alcoba MTGV
Théo Vischel, Guillaume Quantin AMMA-CATCH

IR-based algorithms

Algorithm name	Institution	Developer/contact person
CMA	China Meteorological Agency (CMA), People Rep. of China	L. Naimeng
EURAINSAT/A 1.0	EURAINSAT project, EU	F. J. Tapiador
High resolution Precipitation Index (HPI)	EUMETSAT, EU	T. Heinemann
Hydro-Estimator for short term (1-6 hr) Extreme Precipitation	NOAA/NESDIS, USA	Bob Kuligowski
JMAMSC	Japan Meteorological Agency, Japan	N. Ohkawara

Multiple precipitation estimations blend

Algorithm name	Institution	Developer/contact person
GOES Multispectral Rainfall Algorithm (GMSRA)	NOAA/NESDIS, USA	M.Ba and A. Gruber
GPCP 1 Degree Daily	NASA/GSFC, USA	G. J. Huffman
GPCP Satellite-Gauge Combination	NASA/GSFC, USA	G. J. Huffman
TRMM var (3B41RT)	NASA/GSFC, USA	G. J. Huffman

How to choose from the variety of avaiable products ??

-

MW-based algorithms

Algorithm name	Institution	Developer/contact person
AMSR-E L2 NOAA-NESDIS global rain rates	NOAA/NESDIS, USA	R. R. Ferraro
AMSU NOAA-NESDIS orbital, pentad and monthly global rain rates	NOAA/NESDIS, USA	R. R. Ferraro
Microwave Integrated Retrieval System (MIRS)	NOAA/NESDIS, USA	S. A. Boukabara
SSM/I NOAA-NESDIS orbital, pentad and monthly global rain rates	NOAA/NESDIS, USA	R. R. Ferraro
TRMM HQ (3B40RT)	NASA/GSFC, USA	G. J. Huffman

Blended MW-IR algorithms

Algorithm name	Institution	Developer/contact person
CPC Morphing technique (CMORPH)	NOAA, USA	R. Joyce
EURAINSAT/B 1.0	EURAINSAT project, EU	C. Kidd
GSMaP	Osaka University, Japan	Tomoo Ushio and Ken'ichi Okamoto
Multi-sensor Precipitation Estimate (MPE)	EUMETSAT, Germany	T. Heinemann
NRL Blended Satellite Technique	Naval Research Laboratory, USA	F. J. Turk
Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN)	Univ. of California Irvine, USA	K.-L. Hsu
Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks - Cloud Classification System (PERSIANN-CCS)	Univ. of California Irvine, USA	Yang Hong
Self-Calibrating Multivariate Precipitation Retrieval (SCaMPR)	NOAA-NESDIS-STAR, USA	Bob Kuligowski
TRMM HQ/VAR (3B42RT)	NASA/GSFC, USA	G. J. Huffman

CGMS IPWG International Precipitation Working Group

The product developper perspective

What shall I use to estimate rainfall (ingredients):

- IR on Geos : cloud top only but good sampling
- Microwave on LEO : penetrating / closerly related to the rainfall physics but few overpasses.
- Gages : the ground 'truth ' (?)

How should I combine them (receipe):

- According to what I know of cloud/rain physics and scattering properties
- Using empirical/statistical relationships from obs
- According to the confidence I have in the ingredients

What resolution /time step is sound

- Spatial interpolation ?
- Instant versus accumulations ?

The user perspective

What is the offer ?

- I want it now !

RT versus post-processed/post-calibrated

- I want a homogeneous long time series

Stability/stationarity of the algo

- Small is beautiful !

High resolution / small time step to fit the user model

Is it satisfactory ?
What are the biases and uncertainties ?

Does it work globally ?
[and better then the other's]

GV !

Does it agree with my rain gage ?

Recent work on products evaluation over West Africa in link with AMMA :

Jobard et al, 2011
An intercomparison of 10-day satellite precipitation products during West African monsoon.
International Journal of Remote Sensing **32**:9, 2353-2376

Pierre et al, 2011
Pluriannual comparisons of satellite-based rainfall products over the Sahelian belt for seasonal vegetation modeling,
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, D18201, 25 PP., 2011

Regional

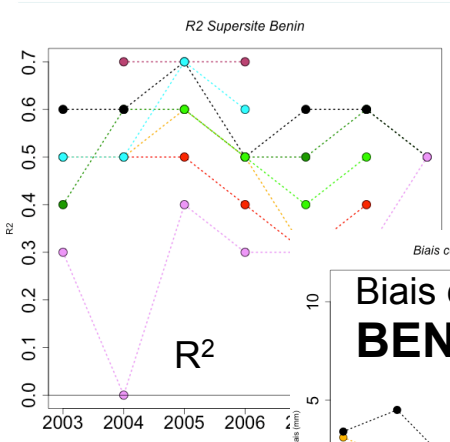
Roca et al, 2010
Comparing Satellite and Surface Rainfall Products over West Africa at Meteorologically Relevant Scales during the AMMA Campaign Using Error Estimates.
J. Appl. Meteor. Climatol., 49, 715–731.

Kirstetter et al., 2012
Building an error model for instantaneous satellite rainfall estimates, : evaluation of BRAIN-TMI over West Africa
Q. J. R. Meteorol. Soc, in press.

Gosset et al, 2012 (revis.)
Evaluation of several rainfall products used for hydrological applications over West Africa using two high resolution gages network,
Q. J. R. Meteorol. Soc, in revis..

Meso

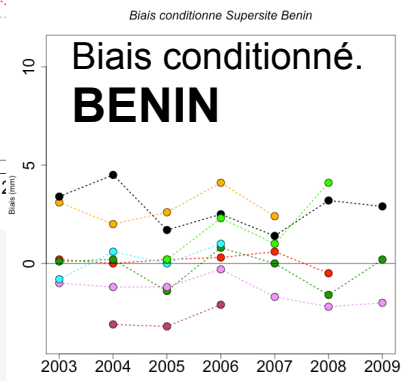
Recent work on products evaluation over West Africa in link with AMMA :

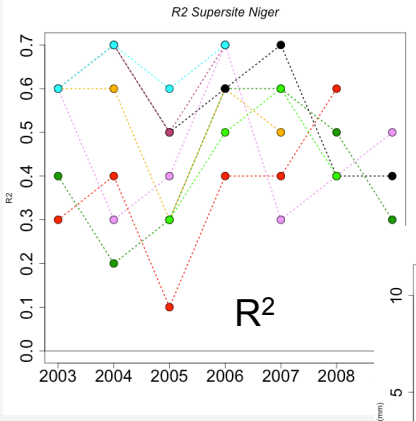


RT glob: PERSIANN, CMORH

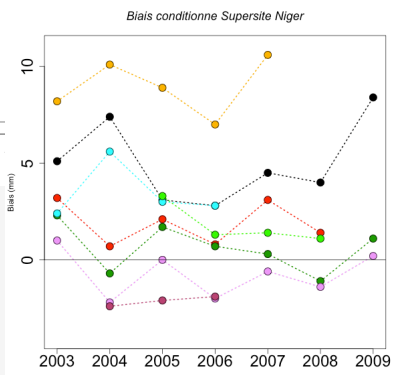
Post-calibr global: GSMAP, GPCP1dd, TRMM3B42v6

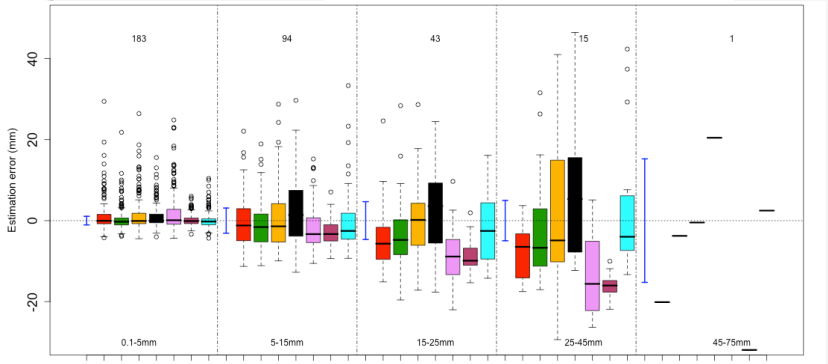
Regional: RFE2, EPSAT-SG

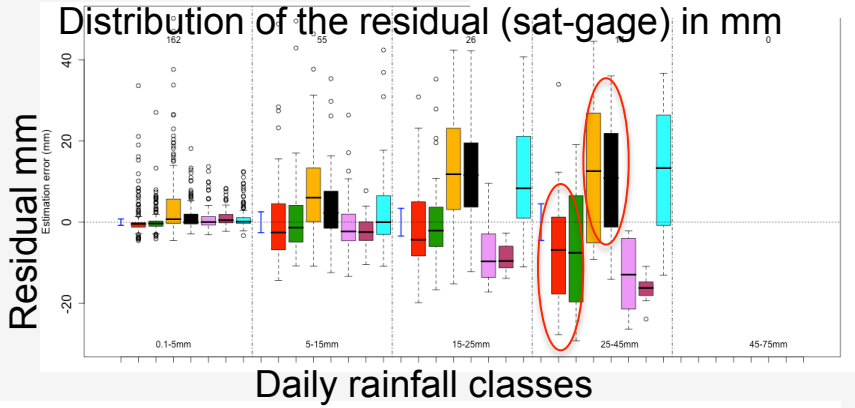




Biais conditionné.
NIGER

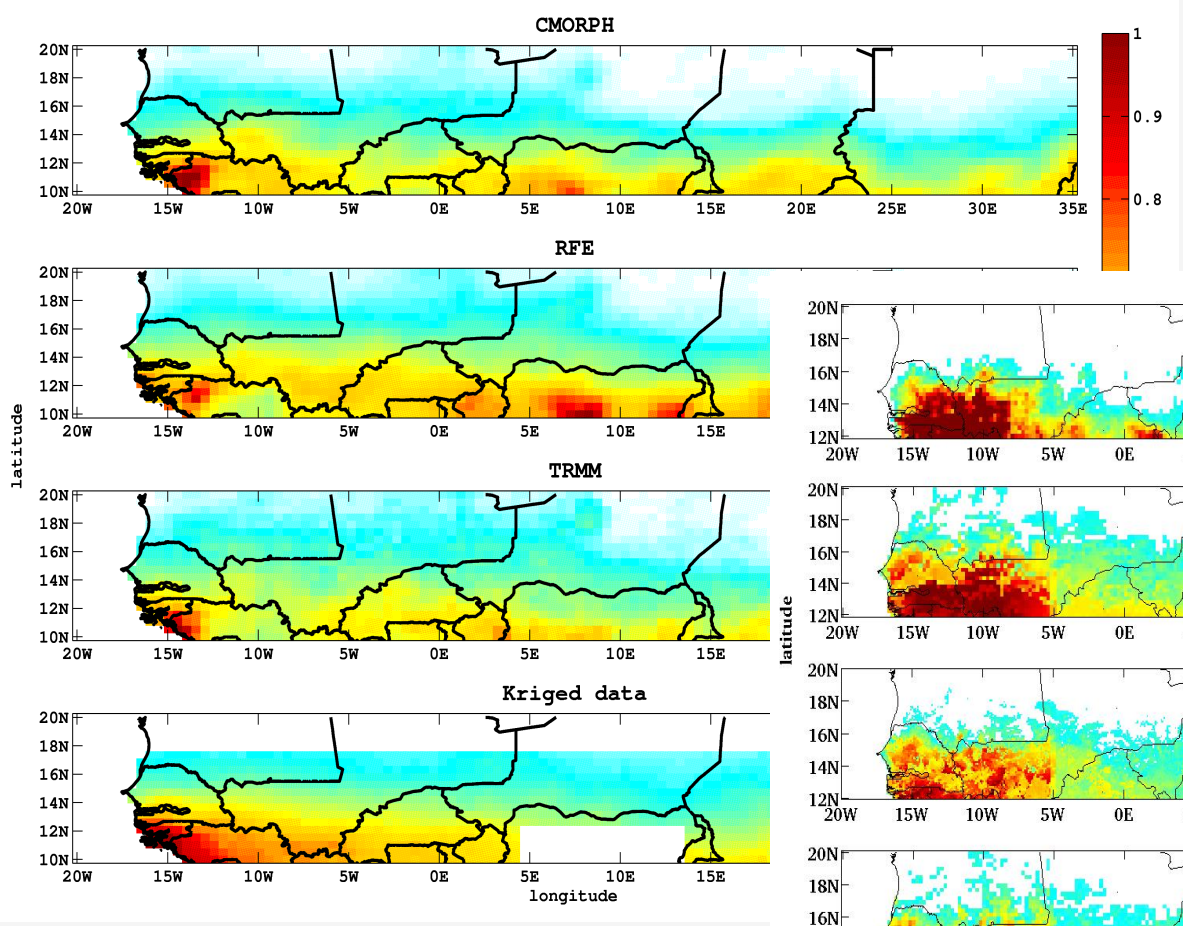




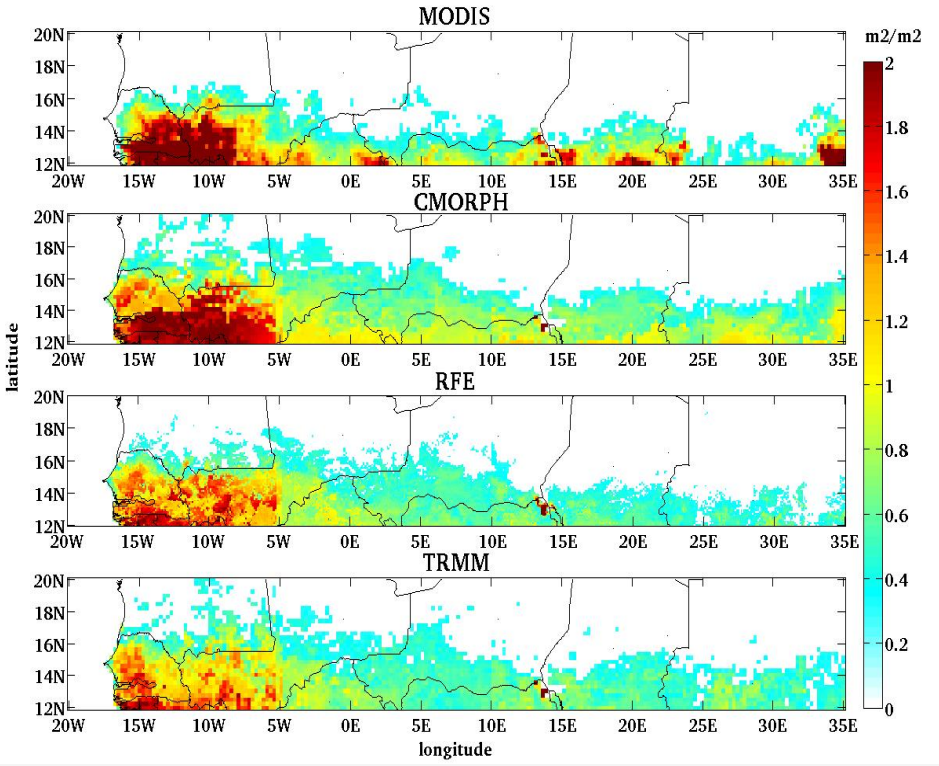


- Multi-criteria shows that no product is best overall
- The best at 10 days are not necessarily the best at 1 day
- Interannual variability of performances
- Differences between the Benin/sudanese regime site and the Niamey/sahel site

Recent work on products evaluation over West Africa in link with AMMA :



Good consistency at regional scale / Monsoon dynamic

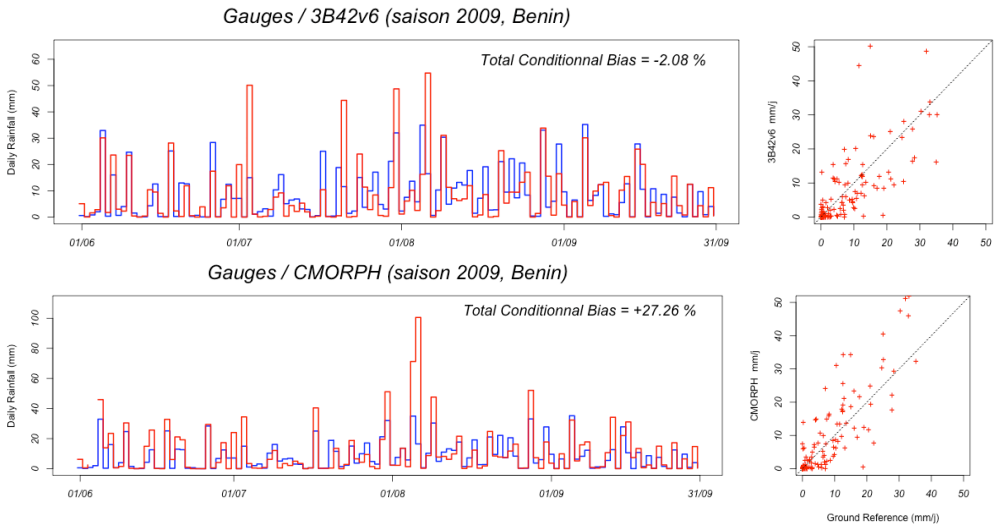


Courtesy
Pierre et al, 2011

Maximum of vegetation amount (LAI) over Sahel for the 3 satellite-based rainfall products + STEP Model and MODIS observations for 2004.

Some of what we have we have learned :

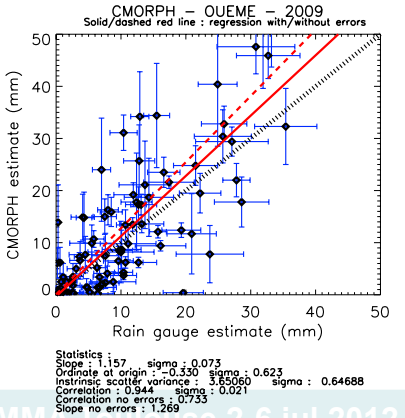
- 'good' depends of what you want to use the product for
  - Sensitivity of your application to (biases ? Far/ND ? Etc ..) to be checked



BENIN	CMORPH	TRMM3B42v6
Biais cond (mm/j)	2.7	-0.1
Biais total (mm/j)	2.3	-0.2
RMSD (mm)	11.6	8.8
WRMSD	10.9	8.3
Nash	-0.5	0.1
R2 cond	0.5	0.4
R2 total	0.6	0.5
FAR (%)	16.7	33.3
NDR (%)	9.5	13.8
Nobs conditionné	104	100

- Account for uncertainty / representatitivity error in the 'truth'

Roca et al, 2010



Some of what we have we learned :

- 'good' depends of what you want to use the product for
- Sensitivity of your application to (biases ? Far/ND ? Etc ..) to be checked
  - Account for uncertainty / representatitivity error in the 'truth'

- Beware of resolution !
  - Which trade off between uncertainty and resolution are you really ready to accept ?
  - Instant vs accumulations …. Think of it !

- IR / MW combination has allowed to improve drastically the products at the daily/3h – 0°25 to 1° scale

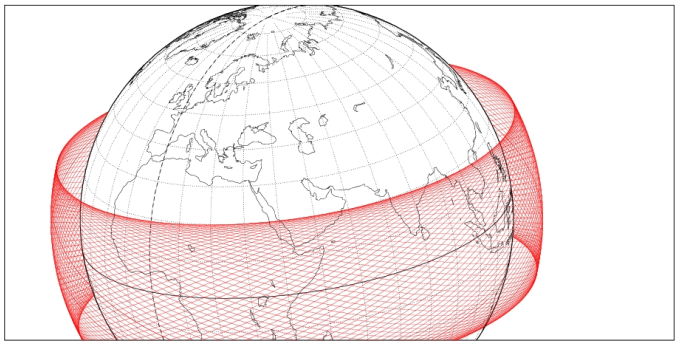
- RT still biased (tend to FA and overestimation – specially at the upper end of pdf)

- variability in skills inside the W Afr region (Benin / Niger …)
  - Perspective = why ?

A new era :

Megha-Tropiques

- French-Indian satellite launched on oct 11th 2011
- Dedicated to water+ energy budget in Tropical Atmosph
- 3 instrument on board / specific orbit



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

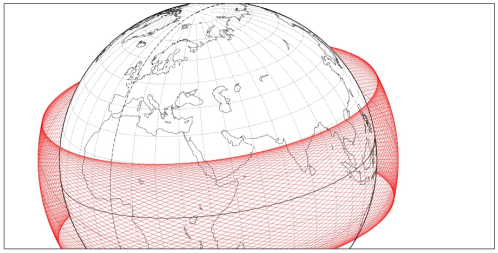
Member of the
Global Precipitation Measurement (GPM)
Constellation

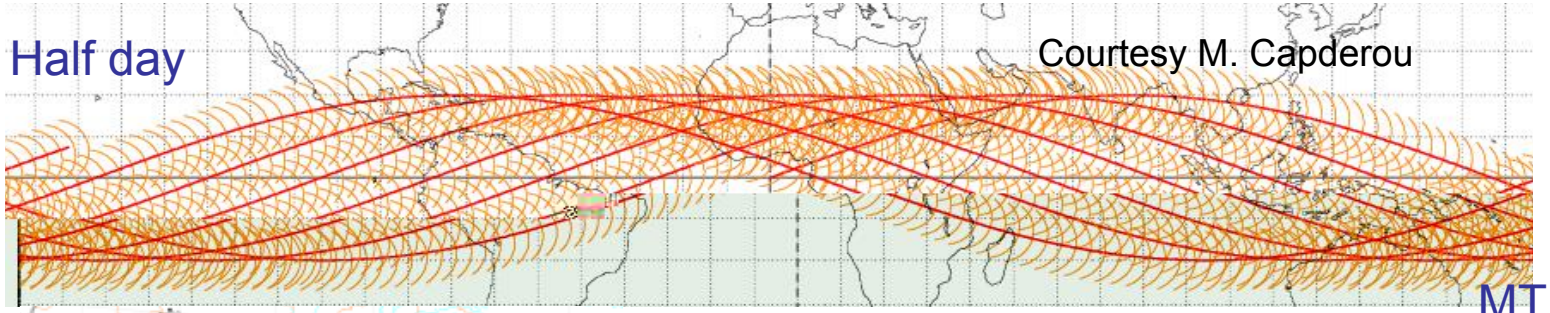
Program aimed at improving the Global precip c
the world with a coordinated / Int constellation

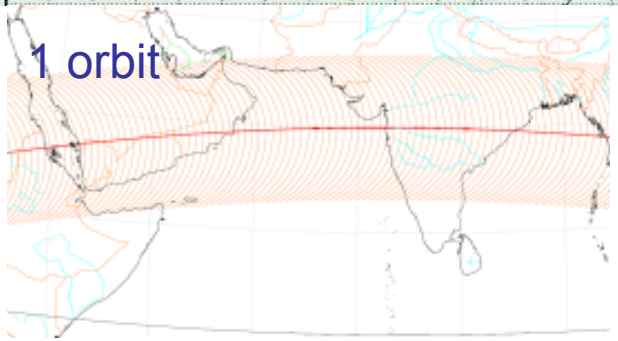
DPR Dual Freq Precip Radar – GPM core in 201

A new era ……. What is new ?

The sampling !

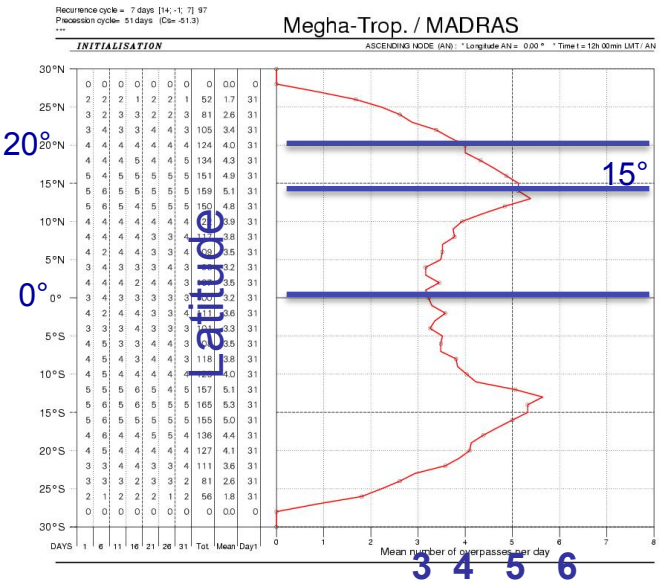






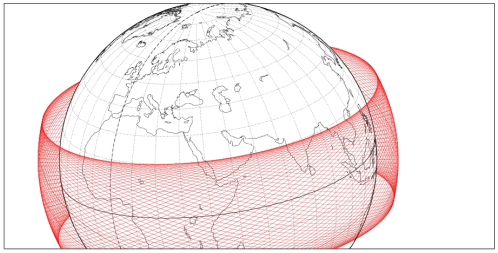
MT MADRAS sampling
over 20°S-20°n
Min 3 per day
Max 5 per day

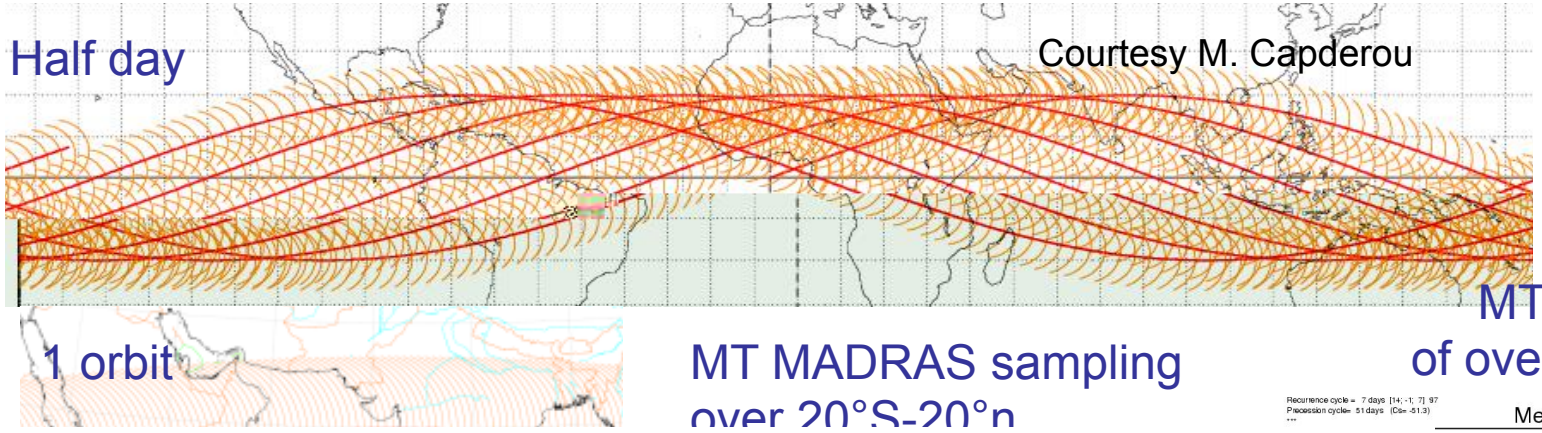
MT : Mean number of overpasses per day



A new era ……. What is new ?

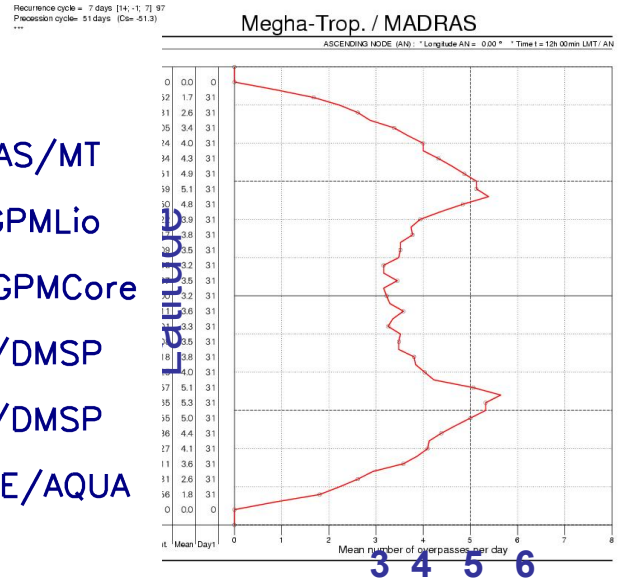
The sampling !

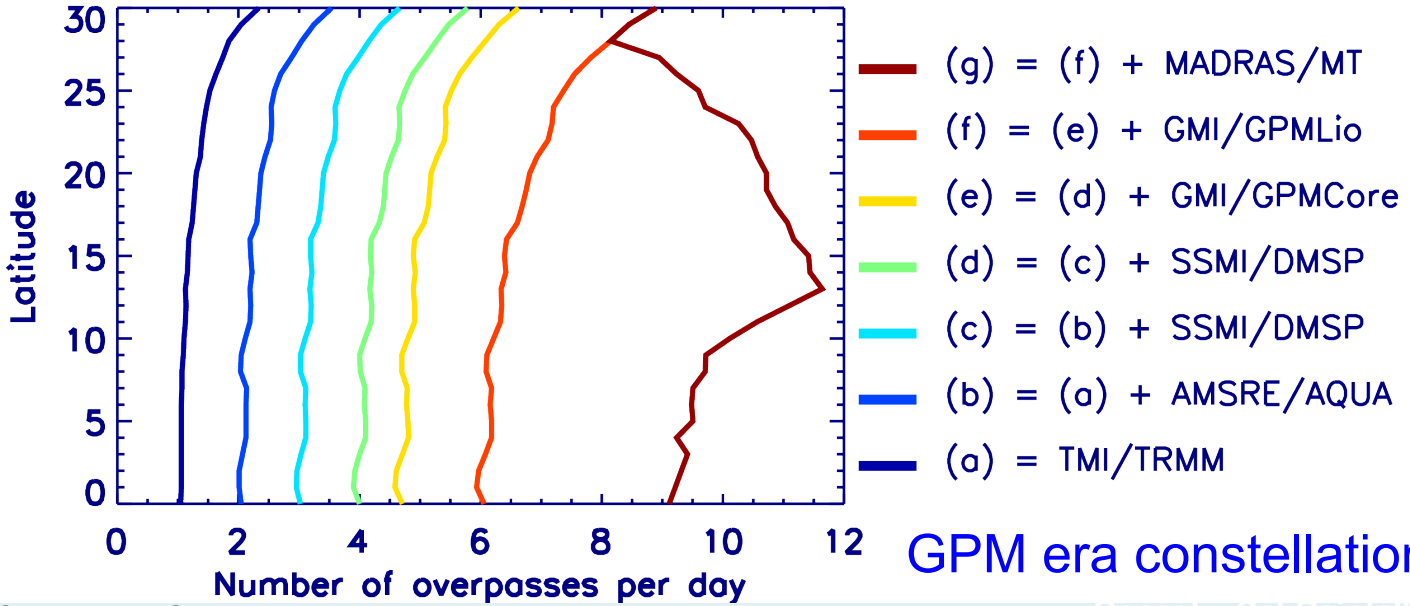




MT MADRAS sampling over 20°S-20°n

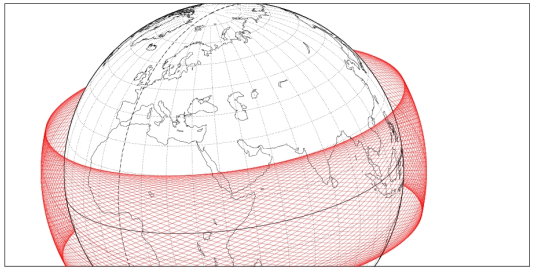
MT : Mean number of overpasses per day





GPM era constellation

A new era ……. What is new ?



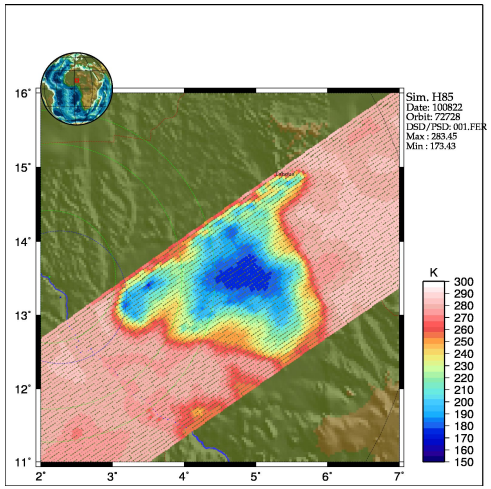
The sampling

More Physics !

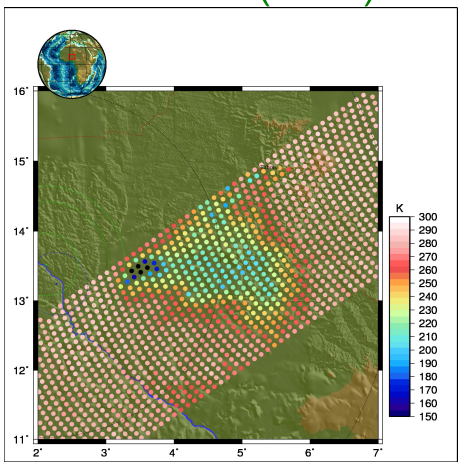
Improvement of the microphysics representation in the BRAIN (Viltard et al.) algo for instant rainfall estimation on MT

TB 85H Snow 0.1/Graupel 0.4

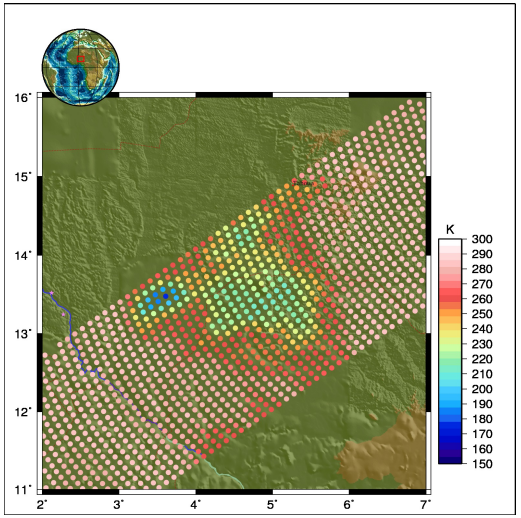
Old simul



TB 85H observed (TMI)



New mass law fro the icy hydrometeors – new simul



Courtesy Viltard

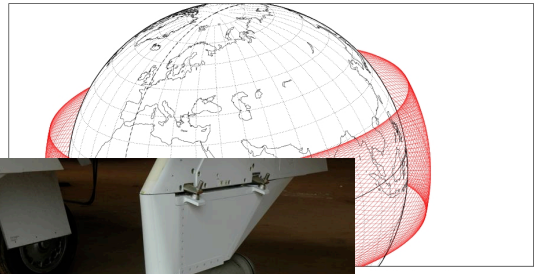
Improvement of the radiative Transfert Model used in BRAIN instant rain estimator

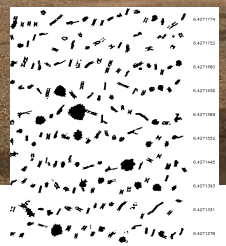
Thanks to in situ observations.

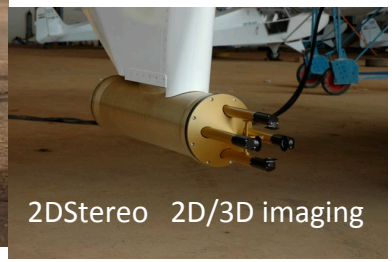
A new … ?

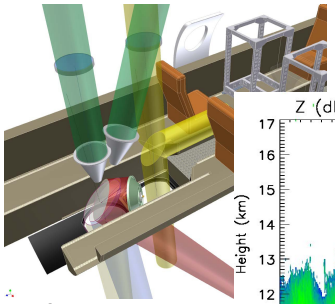
Thanks to the MTGV Niamey 2010 campaign !

Instrumented aircraft

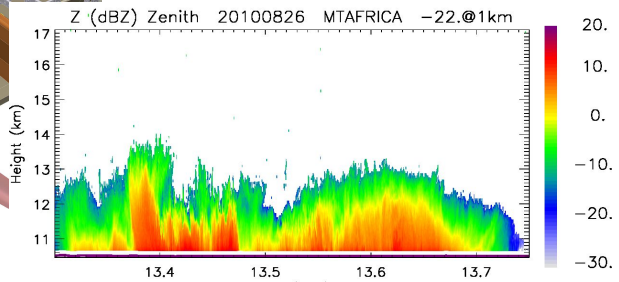


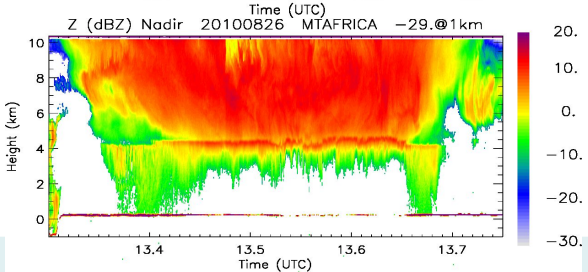






Airborne 94 GHz Doppler RASTA Radar (PI A Protat)



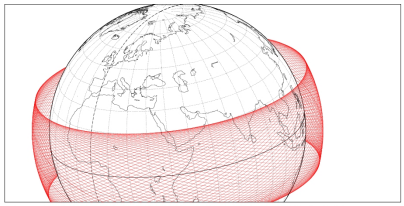


Niamey August 2010 Airborne microphysics in MCS

Aircraft + 2 ground radars in Niamey

- Mass/diameter law for Icy Hydrometeors
- 10 flights in the precipitating part of MCS
- See poster Po 2C.11

A new era ……. What is new ?



The sampling

More Physics

Error bars !

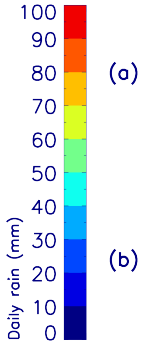
TAPEER the 1° x 1 day rainfall product

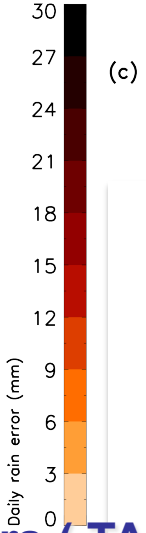
Integrates MT and other platform MW BRAIN based rainfall
+ IR information

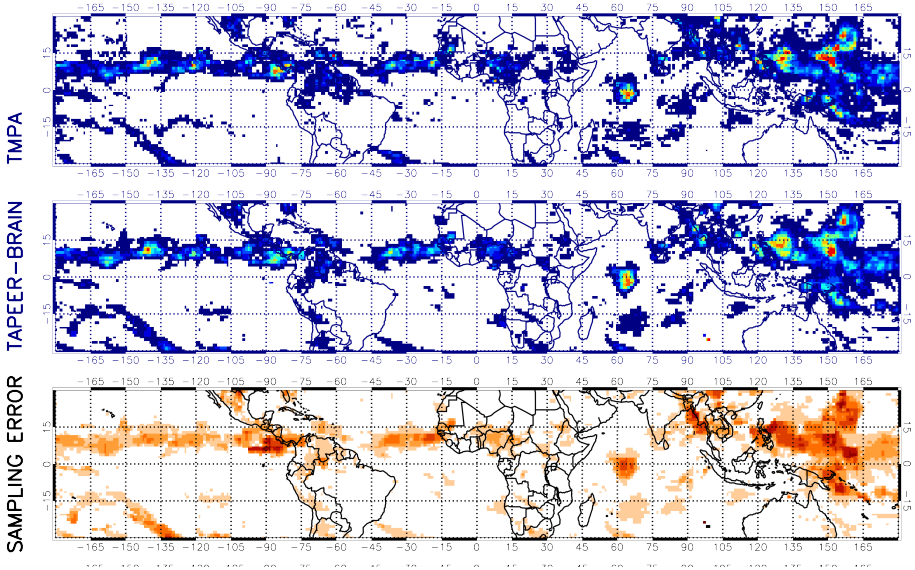
Tropical Amount of Precipitation with an Estimation of ERror

Provided with an estimation of uncertainty :

-sampling
-algorithmic (from BRAIN L2 to TAPEER L4)





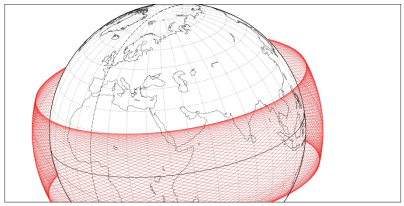


Example from 2009 test run
Courtesy Roca/Chambon

- **Error bars now available to users (TAPEER – 3B42 v7) to account for uncertainty**
  - **Perspective = refine error model - time-space correlation of the errors**

A new era ……. What is new ?

The sampling
More Physics
Error bars



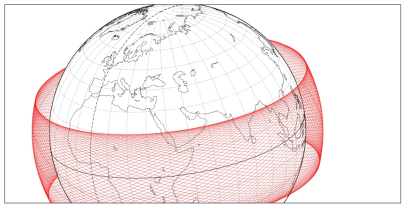
Hydrological applications

a perspective :

- MT based flood prediction / extreme hydrometeorological events ?
- Basin integrated / regional monitoring of the continental water budget (in link with SWOT/SMOS etc…)
- Hydrological Validation of Rainfall products

  - CNES funded - PhD to start in october

West African perspective on MT / GPM ?



- A lot of AMMA <-> MT scientific interactions
  - MT Products (rain, MCS composites, water vapor profiles, radiative balance) for AMMA questions

- 2 West-African teams member of the MT Int Scientific Team (since IAO 2009)

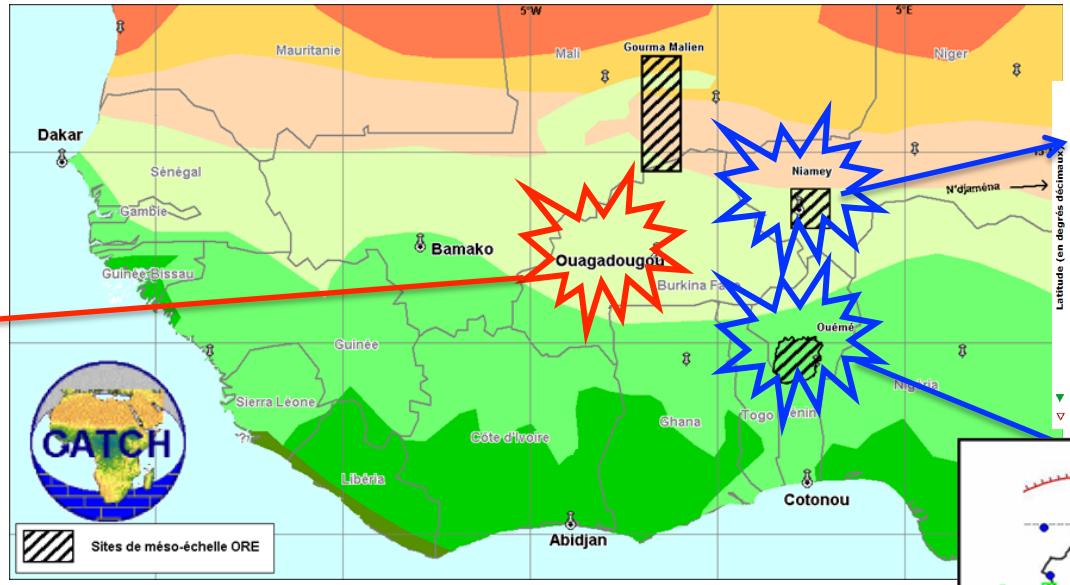
  - ACMAD / AMMA-NET proposal VESPA (Prec System Efficiency and Variab.)

  - AGRHYMET / IRD
    - MT GV on CILSS network
    - **Hydrological Applications / early warning / flood**

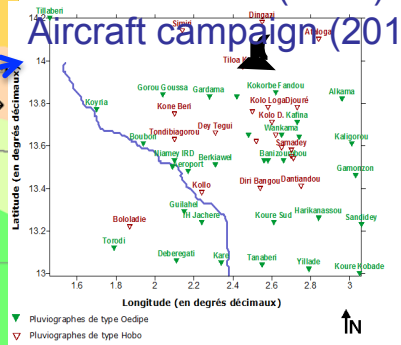
- A lot of partners involved in the MTGV campaigns (Niamey 2010 / Ouaga 2012->)
  - LAPA Abidjan CI, UAC Benin, Univ et 2IE Ouagadougou
  - ASECNA - DMN : Niger, Burkina

The MTGV West African 'meso' sites

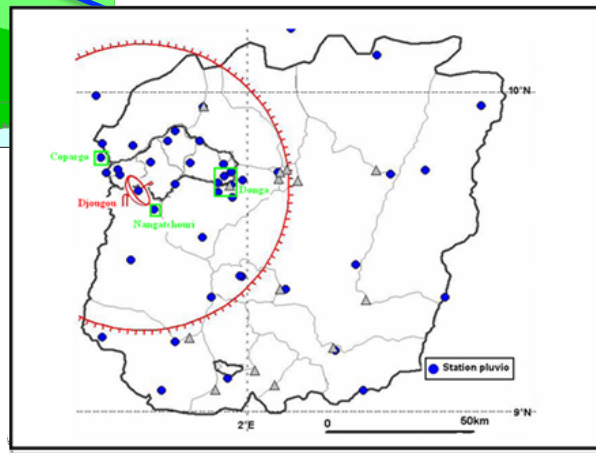
Ouagadougou
2012
15 gages
MW links



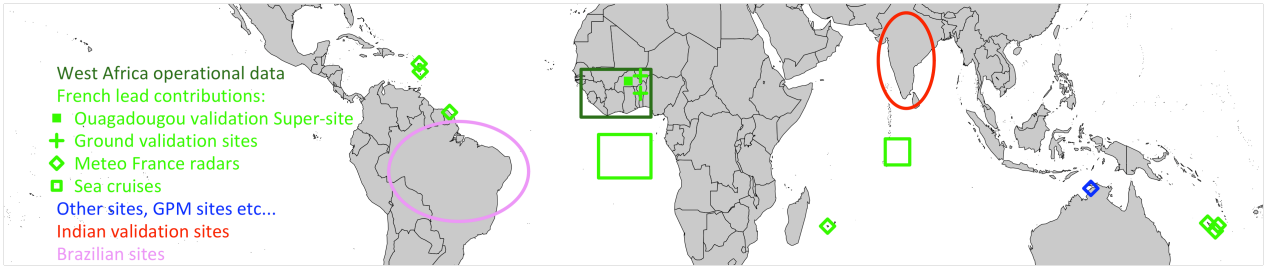
Niamey
40 gages
1 Cband radar (2010)
Aircraft campaign (2010)



Djougou / Oueme
30 gages
Hydro / basin



BENIN: OUEME's Hydrological Observatory (OHHVO)



cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

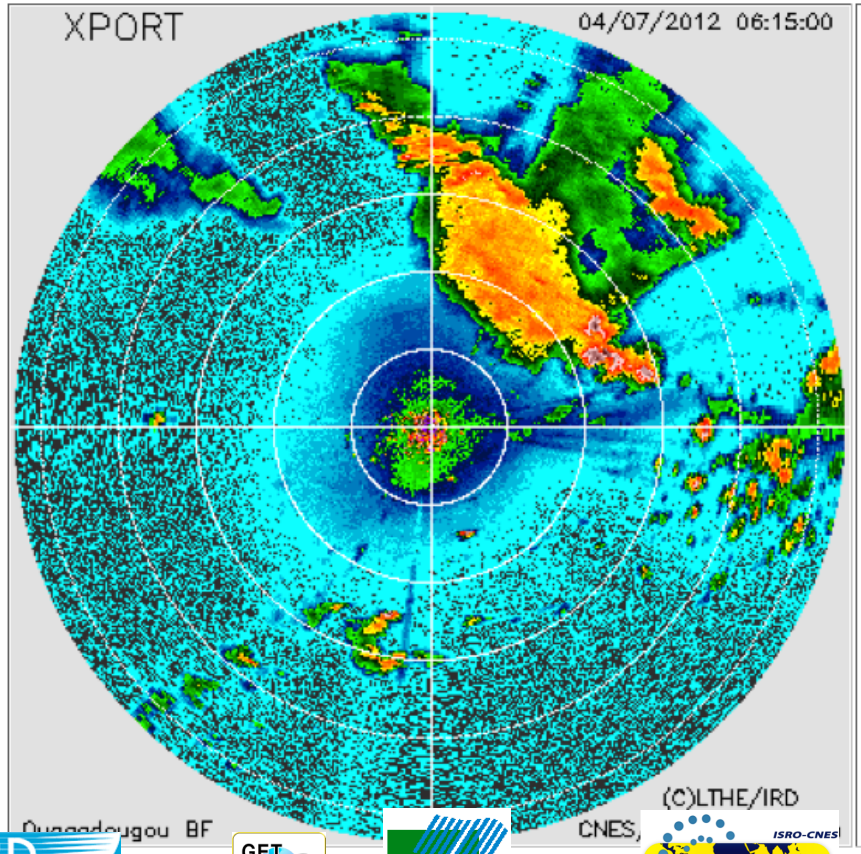
ISRO-CNES
megha-tropiques

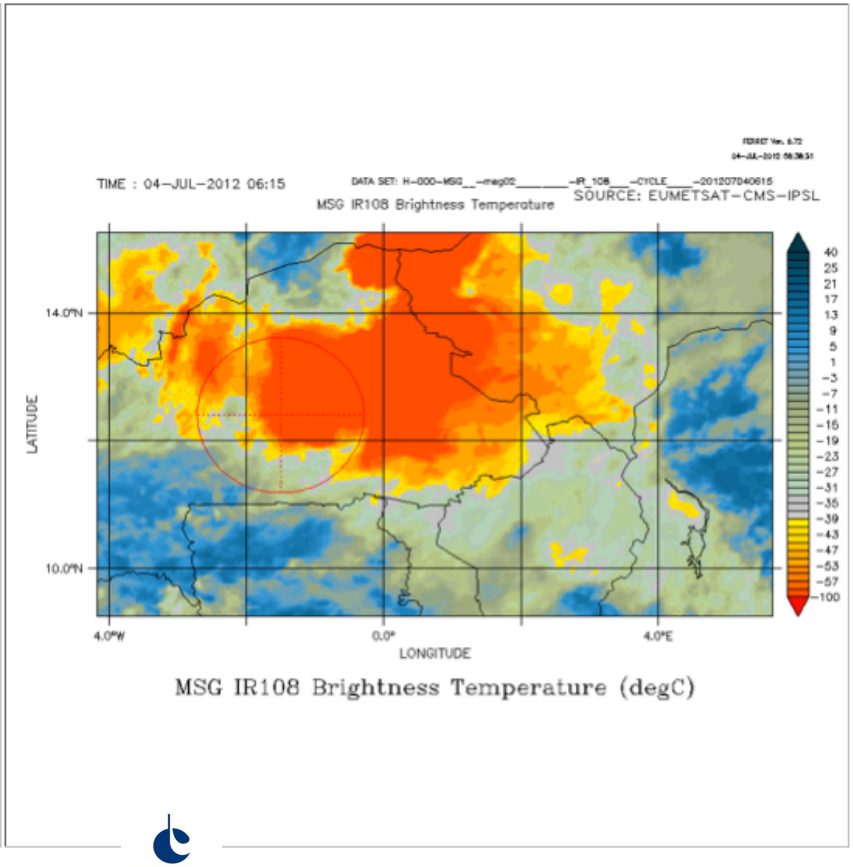
The Ouagadougou Validation Super Site !
Xport radar on the DMN premices

xport | Xport Reflectivity | Jul | 04 | 2012 | 06 h 15 | UTC | Field Comparison On | MSG | 10.8 IR Brightness Temperature | Jul | 04 | 2012 | 06 h 15 | UTC

Zoom: Burkina Faso | Video

Zoom: Burkina Faso | Video

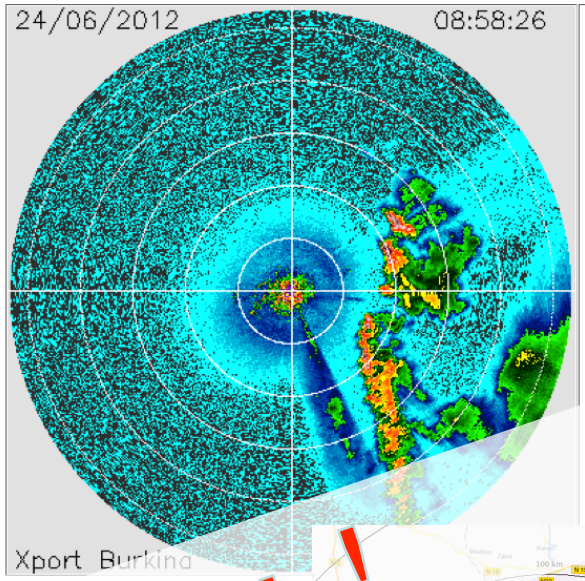


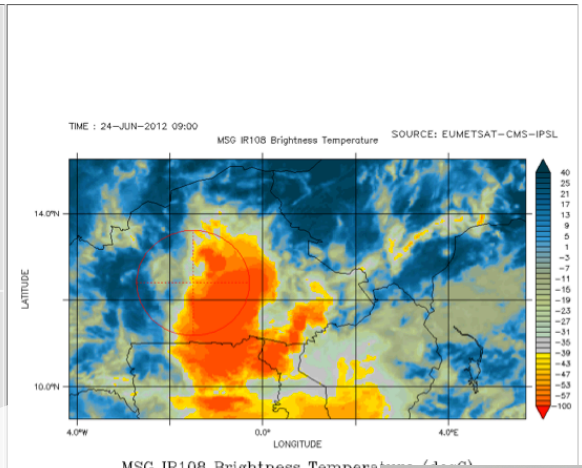


WEB site http://megha-tropiques.ipsl.polytechnique.fr

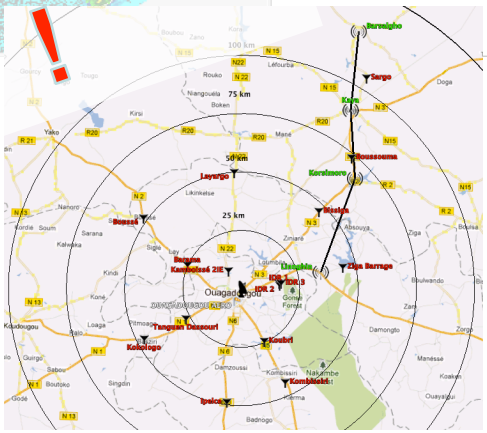
WEB site http://megha-tropiques.ipsl.polytechnique.fr

F Cazenave – Coordiinating the Super site in OUaga





Thank you !

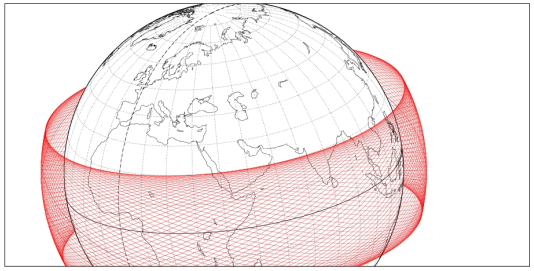


A new era ……. What is new ?

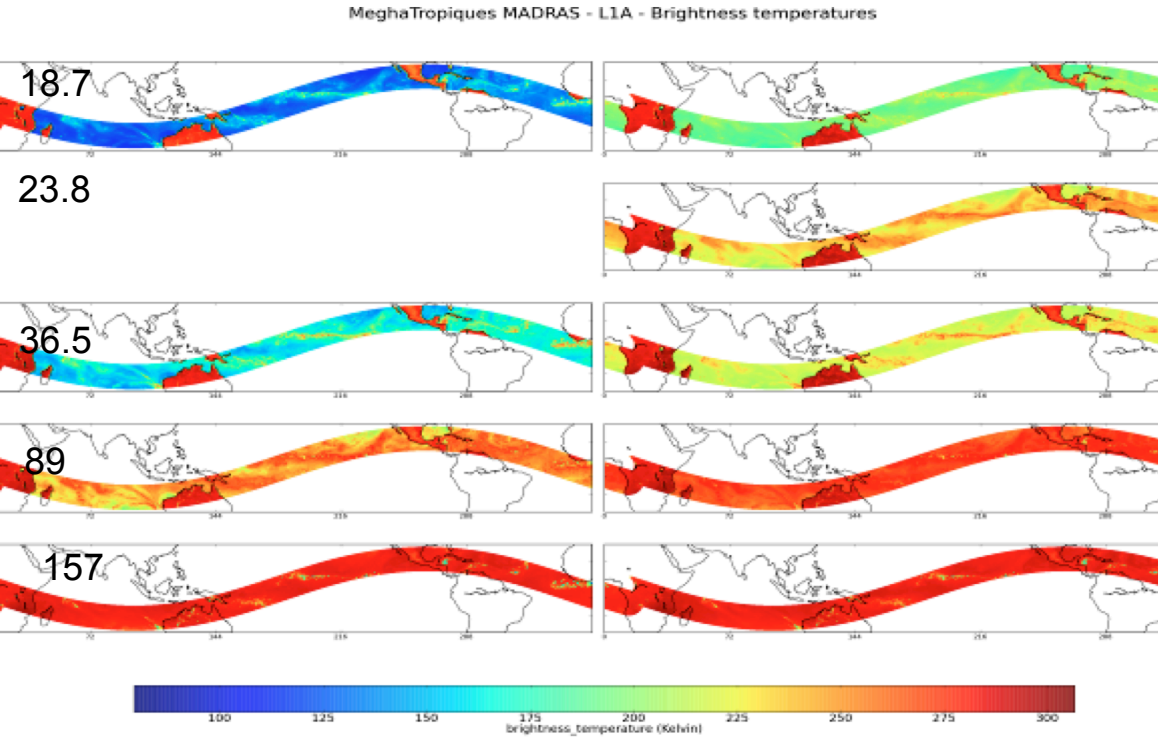
The sampling

More Physics

More microwave channels !

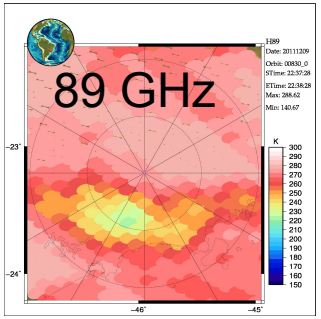


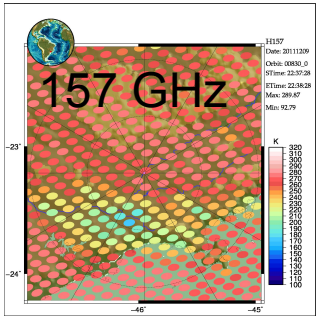
Les mêmes informations ont été reportées sur le globe :

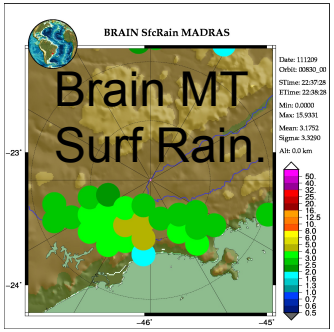


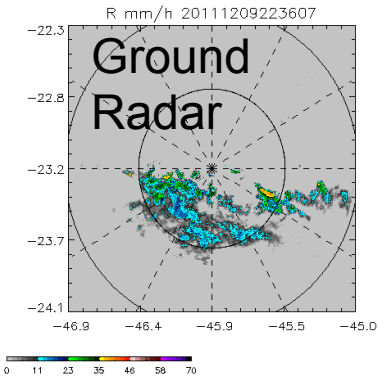
Température de brillance des 9 canaux de MADRAS : Orbite 187

MT Rio example dec 2011









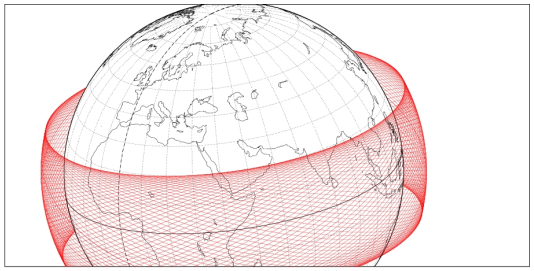
and in 2014 the GPM Dual Freq Radar !!!! ……

I - Frame work and Motivations

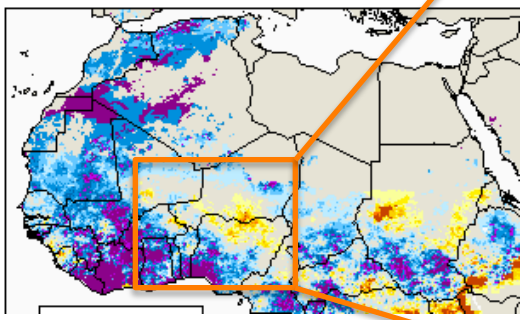
- Xport a 'lab made' radar (2000)
  - For hydro-meteorological applications in IRD instrumented basin (i.e. Tropical)

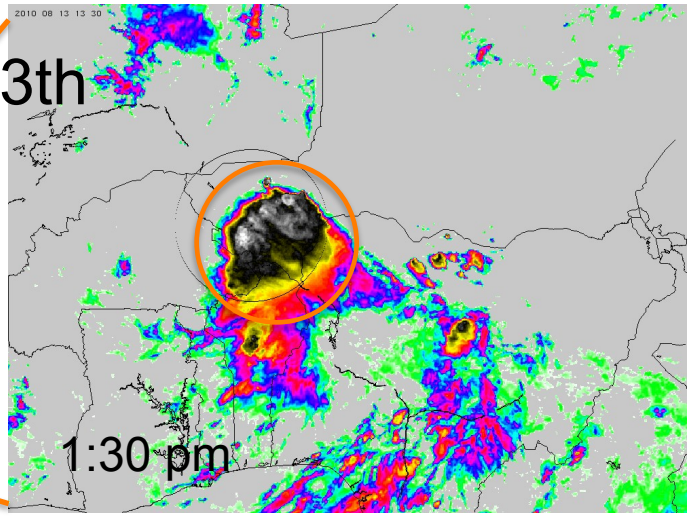
- AMMA – Interdisciplinary studies of the African Monsoon,
  - rainfall variability and impact on water ressources

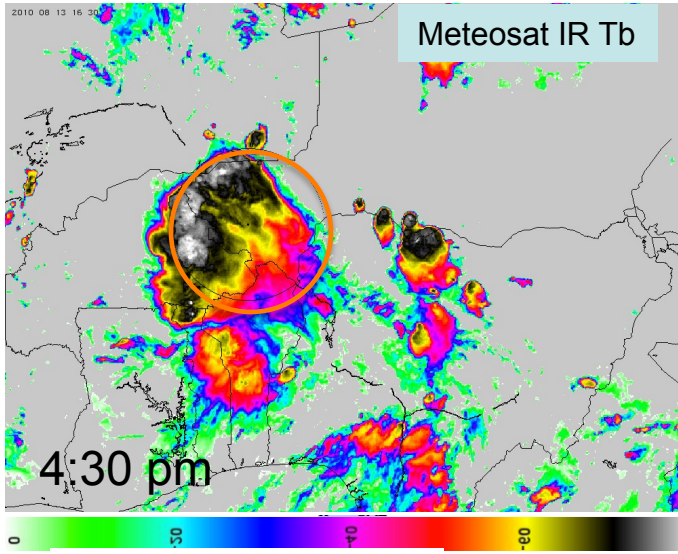
- MEGHA-TROPIQUES - a new satellite mission dedicated to Water budget in Tropical Atmosph.
  - Rainfall fields for Ground validation

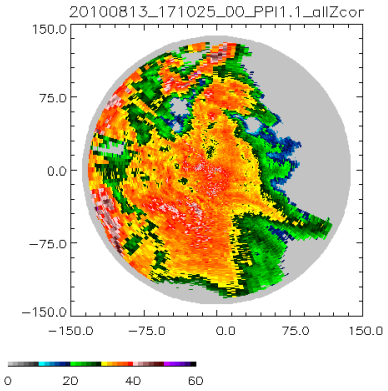


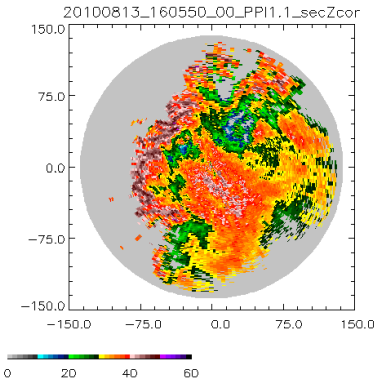
A scarry case :
(Friday) August 13th

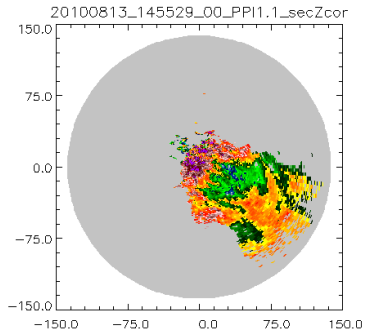


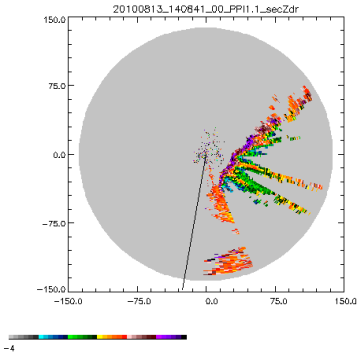


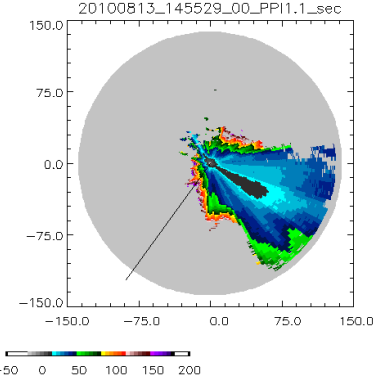


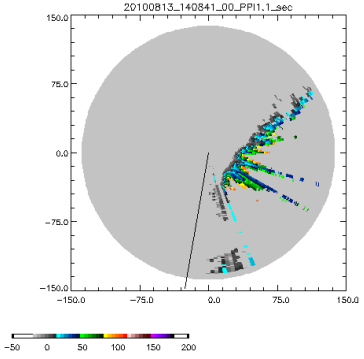


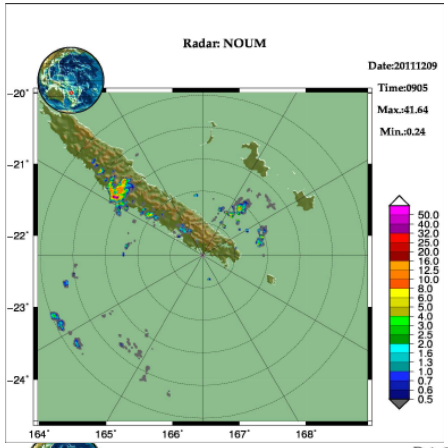


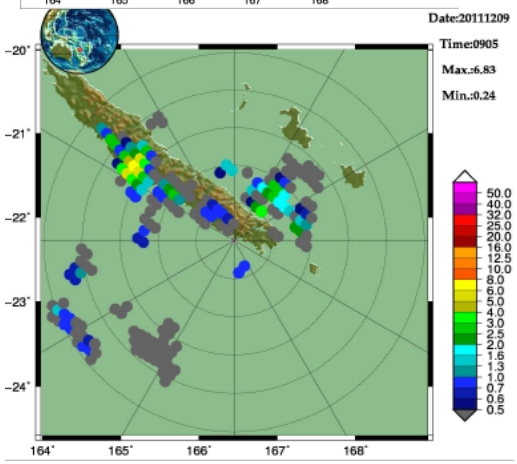




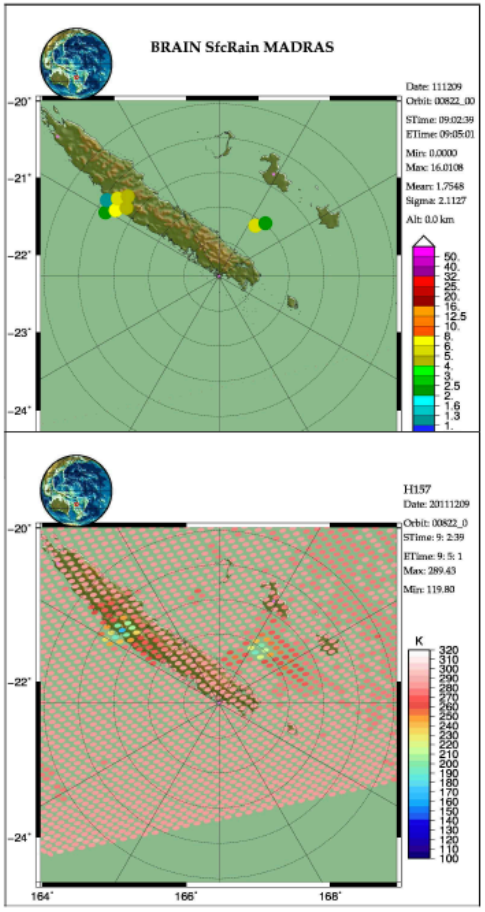


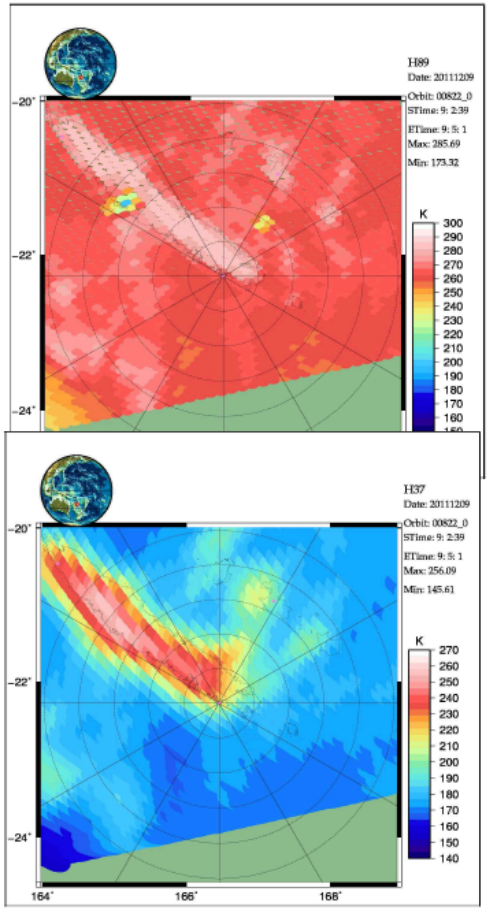




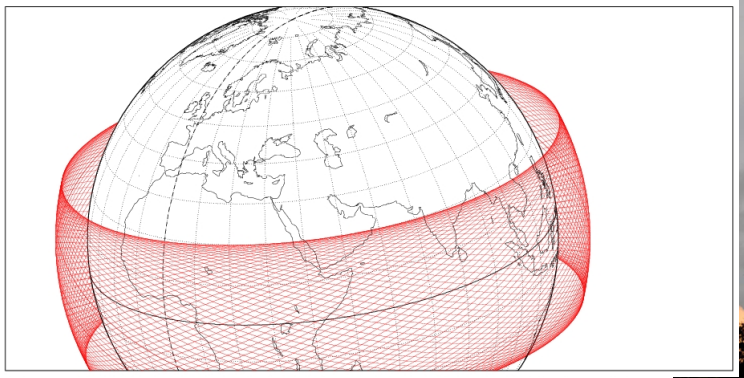


- NOUMEA - Example (N Viltard)
  MT sample du 9 dec 2012





The Megha-Tropiques mission

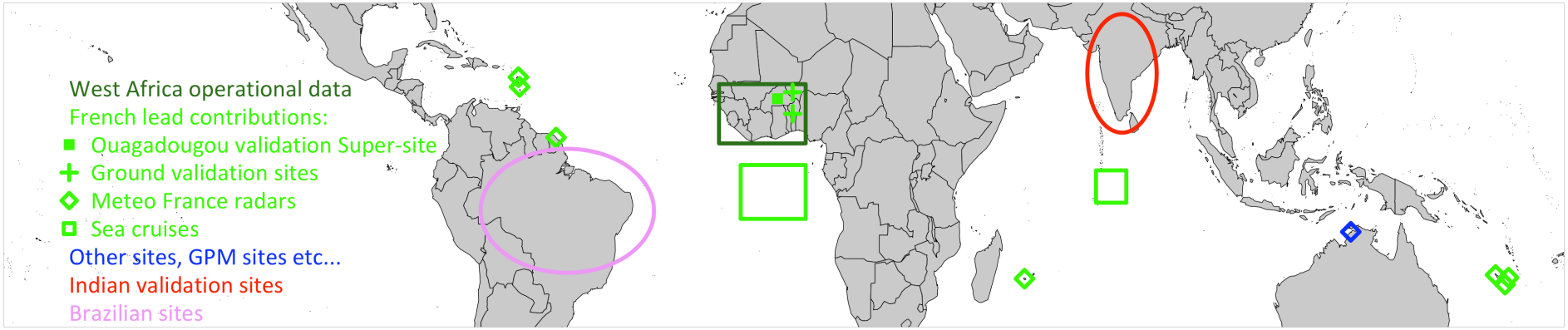


MT RT Track

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

MT - Validation sol

Partenariat et International



- Plan de validation décliné sur une gamme d'échelles et méthodes

- Validation directe / indirecte (ou intégrée) / microphysique

Partenariat à l'ech. Nationale

- Labos : LATMOS-LMD-GET-LTHE-LAMP- etc
- Systemes d'observations et autres programmes scientifiques Tropicaux

AMMA-CATCH ; HYBAM ; BVET (Inde)

- Météo-France : radars Outre Mer / RS

International

- Afrique : AGRHYMET CILSS – ASECNA – DMN (Super site Burkina)
- Brésil – Pérou : INPE campagne CHUVA ; CEMADEN ; Réseaux radar SIPAM amazonie (cadre swot) ; CENAMHI Pérou.
- Inde – Joint plan – Bassin de la Kabini exploité par la CEFIRSE (Iisc/IRD)
- US (Niamey ; Dynamo, etc…) - Australie (radar Darwin)
- GPM -GV

Another exemple :

Pond monitoring in the framework of desease risk prediction