MMP

Monitoring MSI/EarthCARE L1 Performances

using concomitant intercalibration and stand-alone approaches

ARA/ABC(t)/LMD/IPSL
Ecole Polytechnique
Palaiseau, France

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MMP co-Workers / co-Authors, Supporting Teams/Agencies

* Colleagues from LMD: A, Chédin, R, Armante, V. Capelle, L. Crépeau, O, Chomette, M, Capderou

* Colleagues from the IIR/Calipso Team and PI: Anne Garnier, Jacques Pelon

Thanks +++ to :

* ECMWF to provide access to their radiosonde, analysis and reanalysis data and archive

* CNES for opening GSICS doors to a "non operational meteo center": D. Renaut, P. Henry, D. Jouglet

* CNES TEC for fruitful discussions: D. Jouglet, T. Tremas

* CNRS and CNES for its more than "n*10 year" supporting of this Work through CNES/TOSCA/IASI and CNES/TOSCA/EECLAT (V. Noël, J. Delanoë et coll.)

* AERIS/Icare for the REMAP IIR/Modis/Seviri mapping algorithm : J. Descloitres, J.M. Nicolas, F. Ducos

* IDRIS/jean-Zay and AERIS / (ClimServ, Ciclad) computing facilities

* AERIS / Ether and AERIS/Icare for Observations Acquisition: IASI, SEVIRI, IIR, etc

* AERIS for the distribution of GEISA, 4A/OP, ARSA, TIGR

MMP : Heritage from a long LEO/GEO processing of vertical sounders @ LMD

Early 80's

A technique for the calibration of METEOSAT based on LEO/GEO space and time collocations with instruments on-board the NOAA series

(Bériot N., Scott N.A, Chédin A., Sitbon P.J. Appl. Meteor., vol 21, 1982).

From the early 90's onwards

Similar methods were applied to the processing of AIRS/AQUA, IASI/MetOpA and B, C and IIR/CALIPSO, including LEO/LEO and GEO/LEO collocations.

- our in-house L2 retrievals NOAA-series, AIRS, IASI, etc
- our involvement in the TOVS-NOAA/NASA Pathfinder Programme, then in GSICS activities
- Scientific Teams

A 3-way approach for a Qualitative and Quantitative characterization of variations/trends

The **relative (aka inter-calibration) approach**

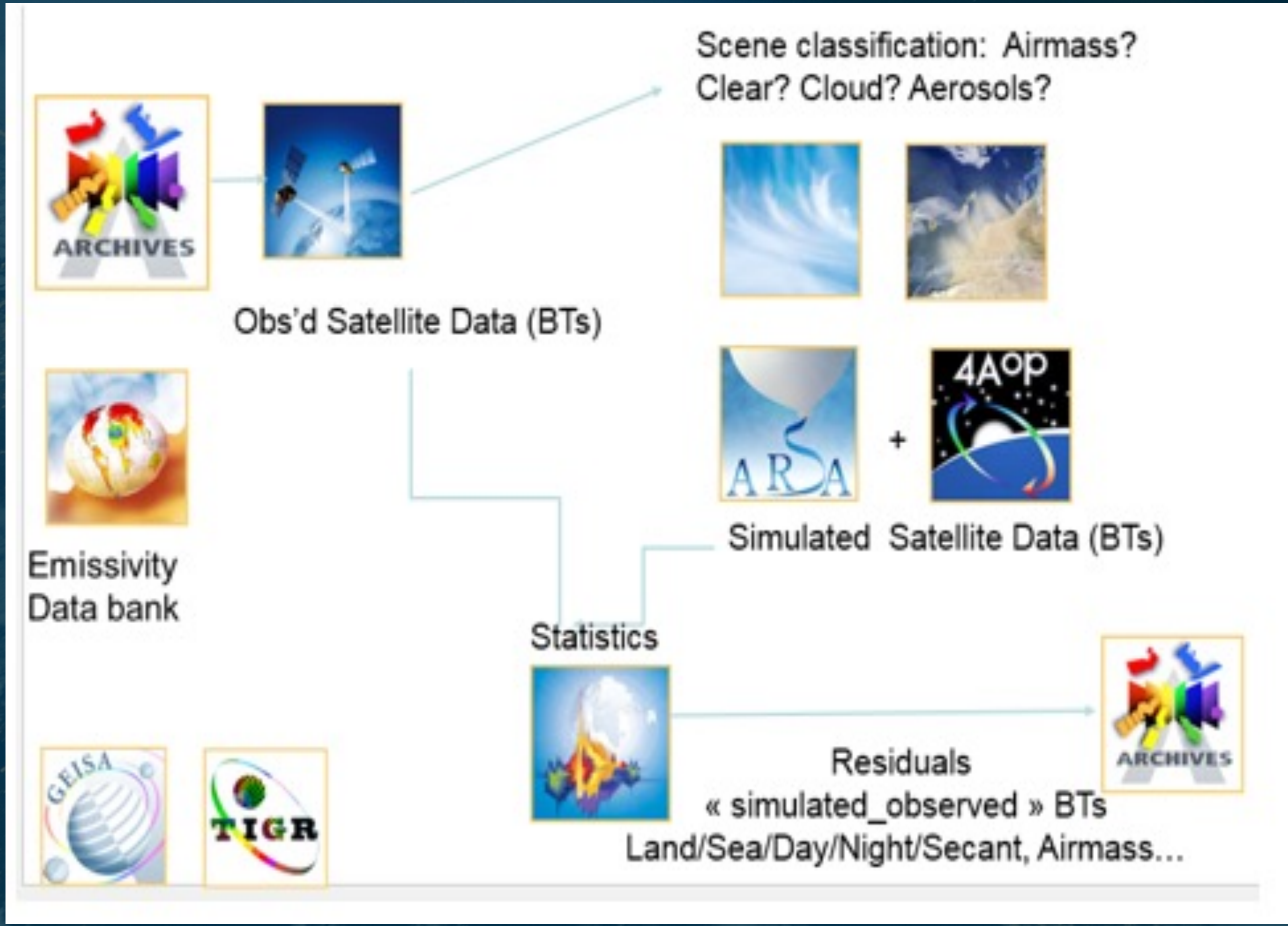
The **stand alone approach**

The **double-difference approach : whenever possible** to take advantage of the well assessed radiometric stability of satellites/instruments – e.g. MetOp/IASI

Time series of BTs, BT differences and residuals

LEO/LEO : IASI, AMSU, HIRS, MHS METOP-A and METOPB, from July 2007 onwards, Global
LEO/LEO/GEO : IIR/Calipso +Modis/Aqua + Seviri/MSG, from July 2006 onwards, Global

Related Research :
From January 1979 onwards : Constitution and validation of ARSA (Analyzed RadioSounding Archive)
"Clear/cloudy/aerosols" screening



Why several approaches?

The relative and stand-alone approaches are complementary:

- our "inter-calibration" approach compares observed BTs ➔ "OBS - OBS"
  - not restricted to clear scenes ➔ Thousands of instruments collocations
  - allows wide ranges of brightness temperatures being compared
  - assesses the behaviour of one channel *relative to its* companion channel.

- our "stand alone" approach simulates BTs of clear scenes (RT model and surface+atmospheric inputs) and screens every channel of each instrument, individually. ➔ "SIMUL – OBS"

This complementarity helps:

i) identifying which instrument/channel deviates from the other(s) and
ii) quantifying such trends/variations.

Lessons learned : Q/C, Q/A activities

Hereafter : Few examples from IASI/MetOp, IIR/Calipso Q/C, Q/A activities

At LMD : This activity is in near-real time on a T-1month basis for IASI, HIRS, AMSU, MHS on MetOp A, B, C

AERIS/Icare : Operational for IIR/Calipso

LMD Model and Databases accessibility

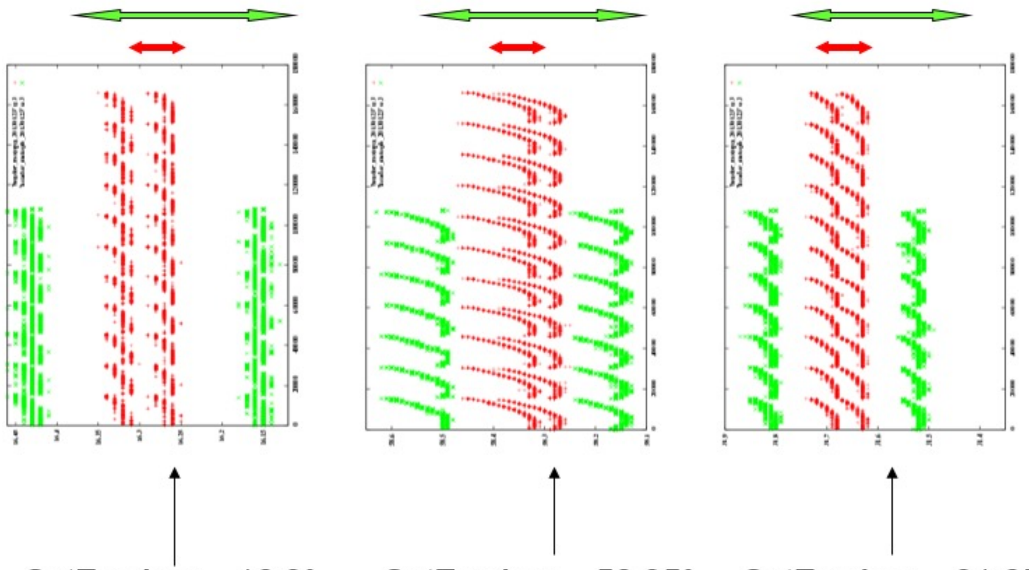
- TIGR data set : https://ara.lmd.polytechnique.fr/index.php?page=tigr
- ARSA data set : https://ara.lmd.polytechnique.fr/index.php?page=arsa
- GEISA spectroscopic database : https://geisa.aeris-data.fr
- 4A/OP radiative transfer model : https://4aop.aeris-data.fr

Publications : https://ara.lmd.polytechnique.fr/index.php?page=publications

Qualitative and Quantitative characterization of variations/trends/spurious behaviors … and anything good or wrong which can happen in remote sensing!

Sequence of Satellite Zenith Angle
Day : January 2013, 23rd

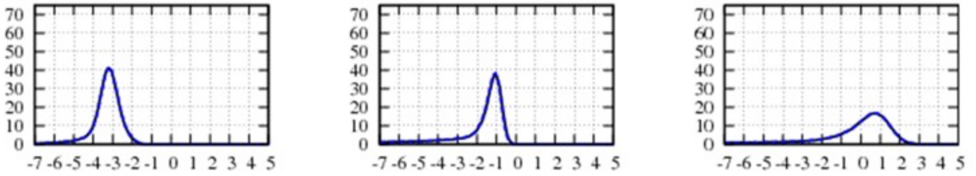
Tropics: -30,+30°
Red : MetopA Green: MetopB



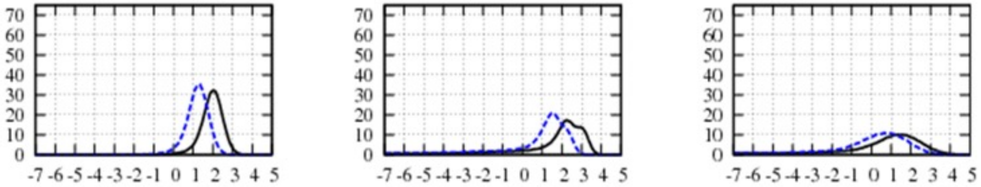
SatZenAng ~ 16.3° SatZenAng ~ 58.35° SatZenAng ~ 31.65°

IASI observations to highlight an AMSUA scan asymmetry

Histograms of the differences between collocated oberved values of IASI and AMSU companion channels highlight an asymmetric behavior of AMSU along the scan track



Near Nadir Observations



Secant 15 observations (blue dotted line → left part of the scan)

From left to right →

TEST	IASI CHANNEL # - AMSUA CHANNEL #	WAVENUMBER (CM^{-1})
1	0193 - AMSUA 8	693.00 - AMSUA 8
2	2634 - AMSUA 6	1303.25 - AMSUA 6
3	6343 - AMSUA 5	2230.50 - AMSUA 5

Present : IASI Conf' 2016

Qualitative and Quantitative characterization of variations/trends/spurious behaviors … and anything good or wrong which can happen in remote sensing!

IASI/MetOpA : Stand Alone approach

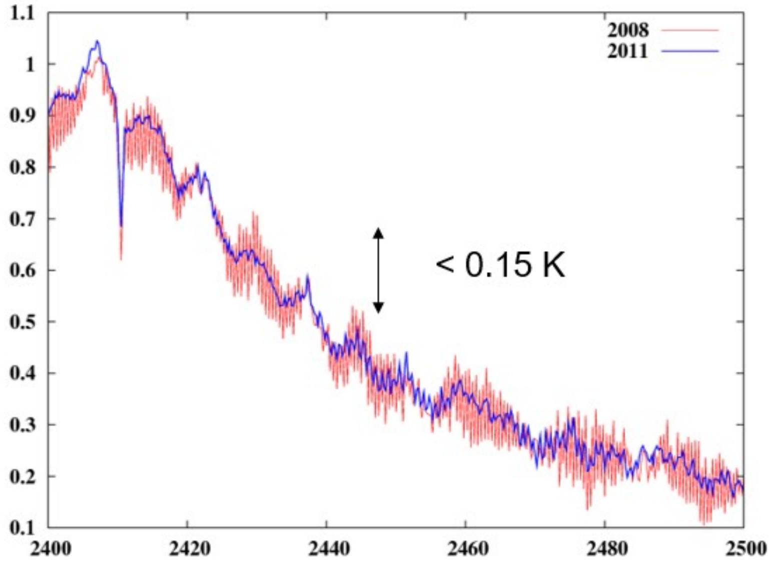
Revealing a bias due to the observed data processing in the 2400-2500cm-1

History: In 2008, Unexpected behavior of BTs residuals (red curve) ➔ no plausible explanation @ LMD

Meanwhile at CNES:

Numerical error identified during the data processing from level1a ➔ level1b (Gibbs effects)

Corrected by the TEC (Toulouse) in 2010



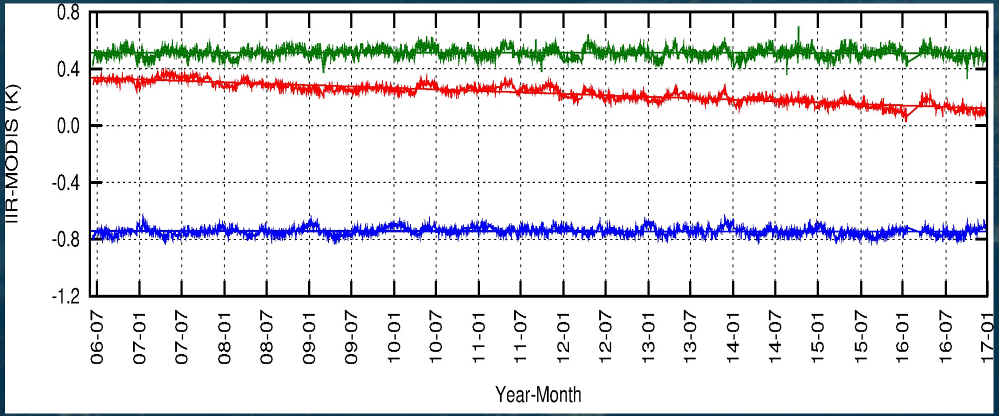
Happy end:
When reprocessed @ LMD after CNES/TEC correction ➔ blue curve : as expected

ITSC 18, March, 23th

A decade (2006-2017) of IIR/CALIPSO L1 assessment against MODIS/Aqua

Complementarity of the Inter Calibration and the Stand-Alone approaches (1/2)

Time series (2006-2017) of IIR-MODIS daily average BTDs
IIR1-MODIS29 (red),
IIR2-MODIS31 (green) and
IIR3-MODIS32 (blue).
Latitude range: 30°S-30°N.
Temperature range: 290-300 K. Sea only.

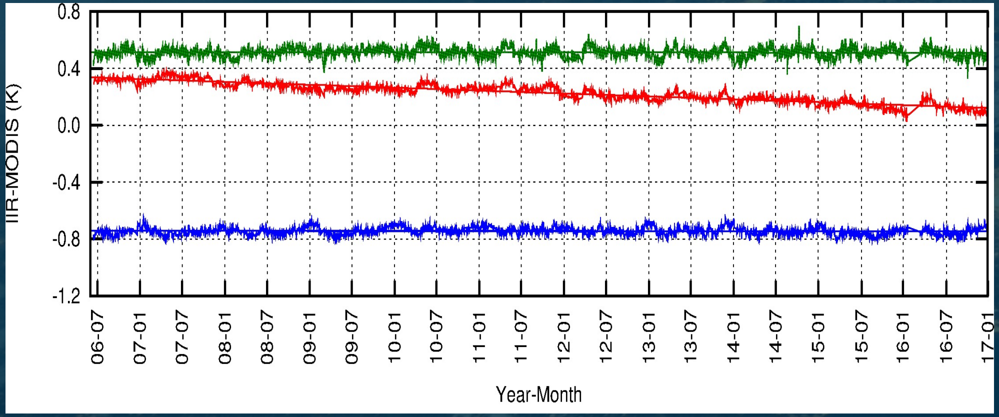


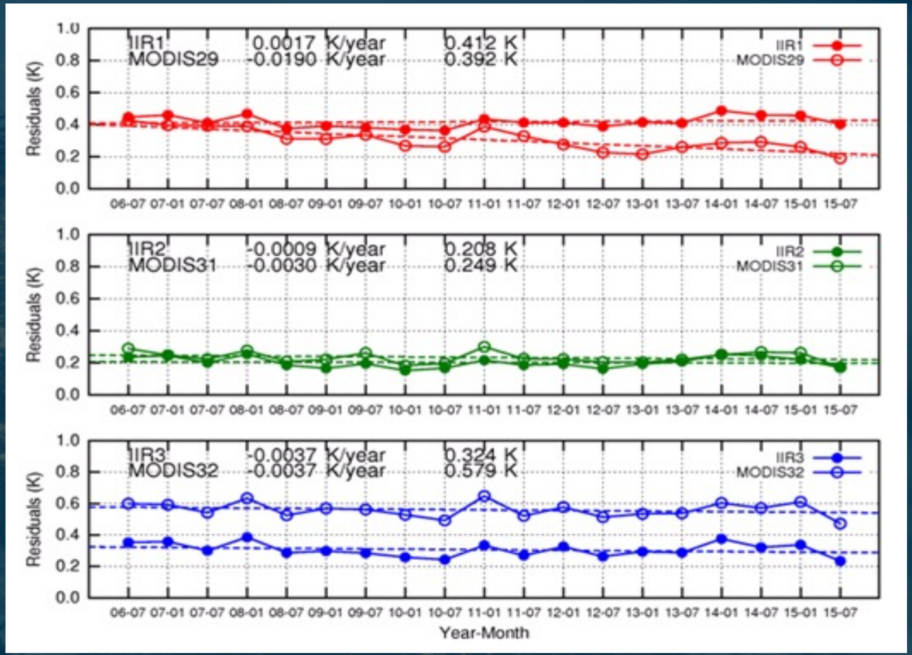
The relative (aka Intercalibration) approach shows a slight trend of the IIR1-MODIS29 BTDs, equal to -0.02 K/year on average, is visible at all latitudes and temperatures ranges, whereas no trend is seen in the IIR2-MODIS31 and IIR3-MODIS32 BTDs

The Inter Calibration results raise a question : which channel deviates from the other? IIR1 or MODIS 29?

Complementarity of the Inter Calibration and the Stand-Alone approaches (2/2)

The stand alone approach gives the answer: the MODIS29 residuals (top, red) exhibit a negative trend of -0.019K/year when the IIR1 residuals are stable





Approach and Results widely described and discussed in Science Groups, Revex, …, and open literature:

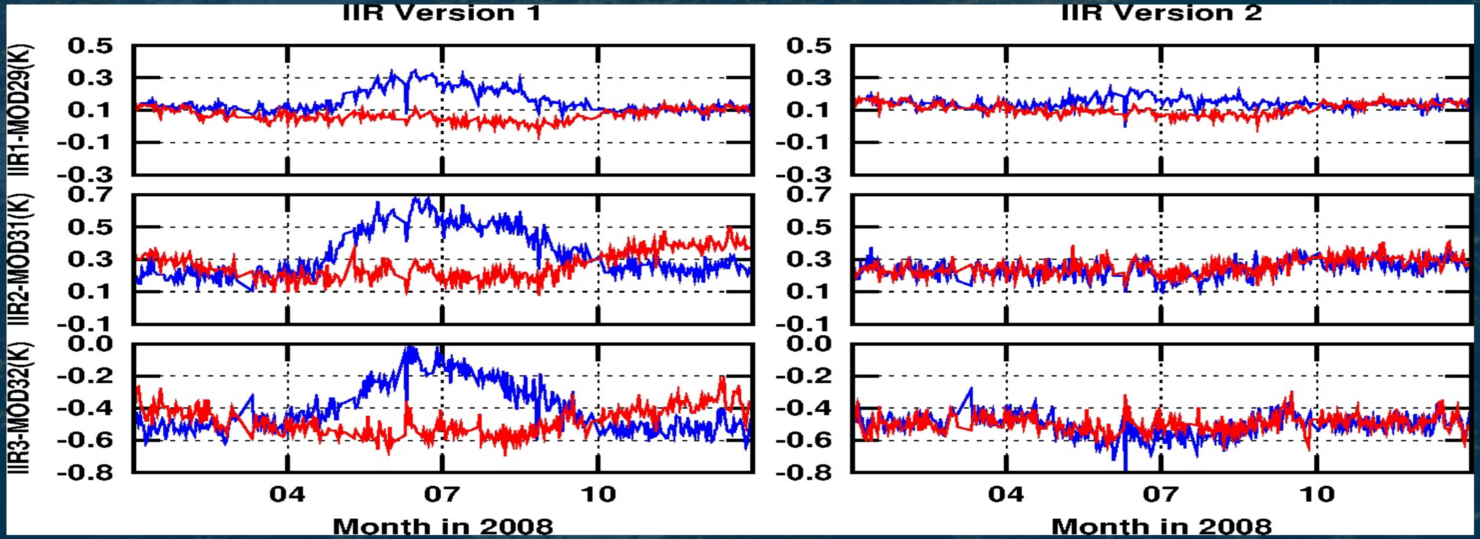
- Scott N.A. *et al GSICS Quarterly Newsletter* 2009,
- Garnier A., Scott N.A., Pelon J., Armante R., Crépeau L., Six B. and Pascal N. *Atmos. Meas. Tech.*, 10 , 2017.
- Scott N.A. , Garnier A., Pelon J., Armante R. *GSICS Quarterly Newsletter*, 11, 2017
- Garnier A. , Trémas T. , Pelon J., Lee K., Nobileau D., Gross L., Pascal N., Ferrage P. and Scott N.A. *Atmos. Meas. Tech.*, 11 , 2018.

Unexpected, moreover seasonal, IIR-MODIS BTDs day/night differences are seen since launch in the 30N-60N latitude band, but not south of 30N.

In July, the nighttime BTDs in the descending portion of each orbit are larger than the daytime BTDs by up to 0.2 K to 0.4 K on average (see example below for year 2008).

IIR Version 1

IIR Version 2 in 2017
after correction by CNES/TEC



. Nighttime (blue) and daytime (red) time series of IIR-MODIS daily average BTDs for IIR1-MODIS29 (top), IIR2-MODIS31 (middle) and IIR3-MODIS32 (bottom). Latitude range: 30°N-60°N. Temperature range: 280-290 K. Sea only.

Lessons learned... so far for Q/A and Q/C activities

Satellite data have to be followed all along the instrument/satellite life time, looking and correcting for: Unstabilities , Spurious Trends, Night/Day differences Asymetric behavior along scan line, ...while preserving natural variability, natural trends

Pay the highest attention to permanently control all the elements of the observations Q/A , Q/C : models, auxiliary data sets.

Stay in close contact and interact with PIs and all human actors/teams in charge of the observations or of the processing of the observations (L1, L2, …) : feedbacks are of paramount importance

…. Reprocessing data (L1,L2, …) is part of the game

MMP

Monitoring **M**SI/EarthCARE L1 **P**erformances

A Close Heritage from the QA/QC of IIR/Calipso through a coupling with Modis/Aqua and Seviri/MSG

for the three 8 to 10 microns channels

Towards MSI : From Pre-Launch Activities to In-Flight real world

IIR vs Modis (K) Simulations	IIR1- Modis29 (K) Mean Std. Dev.	IIR2- Modis31 (K) Mean Std. Dev.	IIR3- Modis32 (K) Mean Std. Dev.
TIGR_tropical	-0.225 0.068	0.504 0.240	-1.015 0.340
TIGR_mid-lat1	-0.313 0.061	0.321 0.054	-0.485 0.294
TIGR_ mid-lat2	-0.305 0.051	0.297 0.032	-0.347 0.200
TIGR_polar1	-0.332 0.044	0.337 0.046	-0.050 0.143
TIGR_ polar	-0.319 0.063	0.355 0.040	-0.081 0.159

Pre-Launch Simulations
(IIR-Modis) BTDs
4A/OP + fed with TIGR2000

Latitude	Temperature	IIR1- Modis29 (K)	IIR2- Modis31 (K)	IIR3- Modis32 (K)
30S-30N	290-300 K	-0.0374±0.001	0.414±0.002	-0.925±0.001
60S-30S	280-290 K	-0.230±0.001	0.168±0.001	-0.632±0.001
30N-60N	280-290 K	-0.246±0.002	0.248±0.003	-0.611±0.003
90S-60S	270-280 K	-0.336±0.002	0.240±0.003	-0.251±0.003
60N-90N	270-280 K	-0.307±0.003	0.467±0.004	-0.083±0.003

Real world observed IIR-MODIS BTDs at warm temperature confirm, within 0.3 K, the pre-launch simulations

MMP STATUS : Pre-Launch Activities (1/2)

Instruments/Satellites candidates

MSI/EarthCare, VIIRS/NOAA-20 , FCI/MTG

Others?

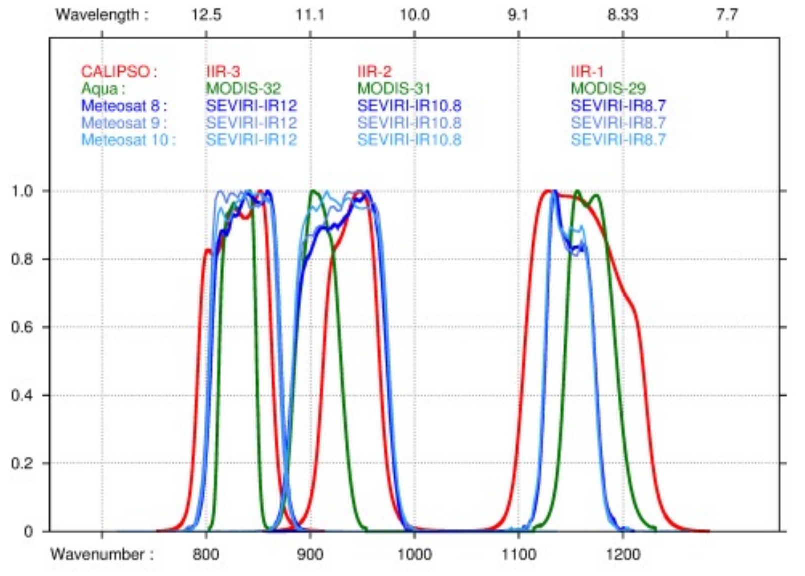


Figure 2. IIR/CALIPSO (red), MODIS/Aqua (green), and SEVIRI/Meteosat 8, 9, 10 (navy blue, medium blue, light blue) instrument spectral response functions against wavelength in microns (top x axis) and wavenumber in cm^{-1} (bottom x axis).

Pre-launch activities ready to start

Aim :
* Select the best companion pairs of channels
** Establish interchannel+Interinstrument radiometric stats

For Land/ea/SZA/Air mass types, BTs bins

How:
4A/OP + TIGR → BTs, Jacobians, Transmittances,
Sensitivity ← LMD in house models and databases

4A/OP parallel version v1.8 (rel, 2019)
TIGR- 2020 (released 2020)
GEISA-2020 (released 2020)
ARSA v2.8 (to be released 2021)

All available on AERIS and/or LMD Data clusters

MMP STATUS : Pre-Launch Activities (2/2)

Instruments/Satellites candidates

MSI/EarthCare, VIIRS/NOAA-20 , FCI/MTG

Others? Already in flight?

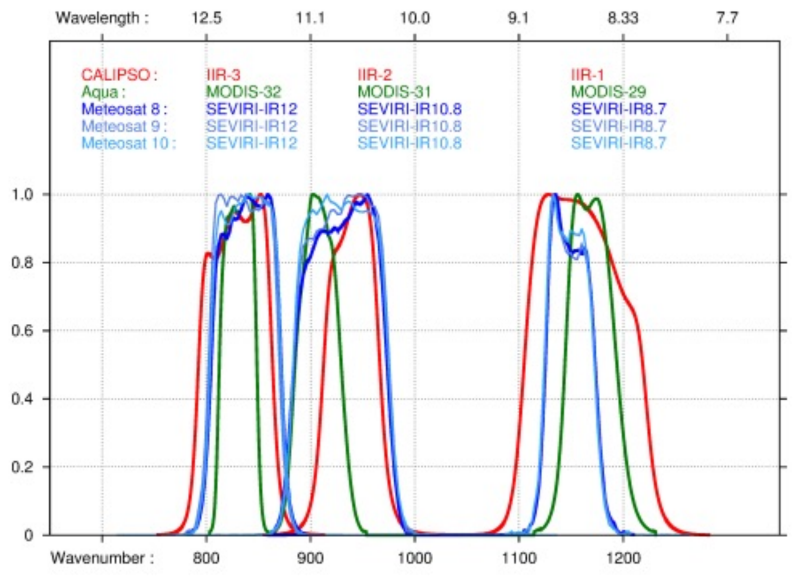


Figure 2. IIR/CALIPSO (red), MODIS/Aqua (green), and SEVIRI/Meteosat 8, 9, 10 (navy blue, medium blue, light blue) instrument spectral response functions against wavelength in microns (top x axis) and wavenumber in cm^{-1} (bottom x axis).

Pre-launch activities ready to start .....

HOWEVER !.... Some questions for the best possible spatial-spectral-temporal homogeneity

How to get the more reliable ISRF, orbitography, scanning characteristics for all companion satellites ans instruments?

Spatial homogeneity of the pixels? Spatial averaging required?

Time collocation? Any A-Train like temporal coincidence?

How to minimize the naturally occurring GEO–LEO "mismatch"
Limit the scanning angles to avoid heterogeneous optical pathes?

MMP : Technical Approach / Phase 2 = In-Flight activities

Global data will be processed in delayed-mode.

Results will be presented on a day-to-day basis or on a month-to-month basis with distinct day/night, land/sea outputs, within 10 brightness temperature bins from min-max defined values (e.g. 190 to 330K),

During the lifetime of the instrument, the versions of the radiative transfer model, spectroscopic database, …, used for the pre-launch time characterization will be frozen. If any change had to intervene, the error evaluation process as well as thresholds values would be revisited accordingly.

Moreover, reference satellites/instruments may undergo variations (spectral, geolocation, etc) during EarthCARE lifetime: the impact of such changes will be taken into account, evaluated and controlled owing to the stand alone approach.

esa

LMD Model and Databases accessibility

https://ara.lmd.polytechnique.fr/

TIGR data set : https://ara.lmd.polytechnique.fr/index.php?page=tigr

ARSA data set : https://ara.lmd.polytechnique.fr/index.php?page=arsa

GEISA spectroscopic database : https://geisa.aeris-data.fr/

4A/OP radiative transfer model : https://4aop.aeris-data.fr/

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