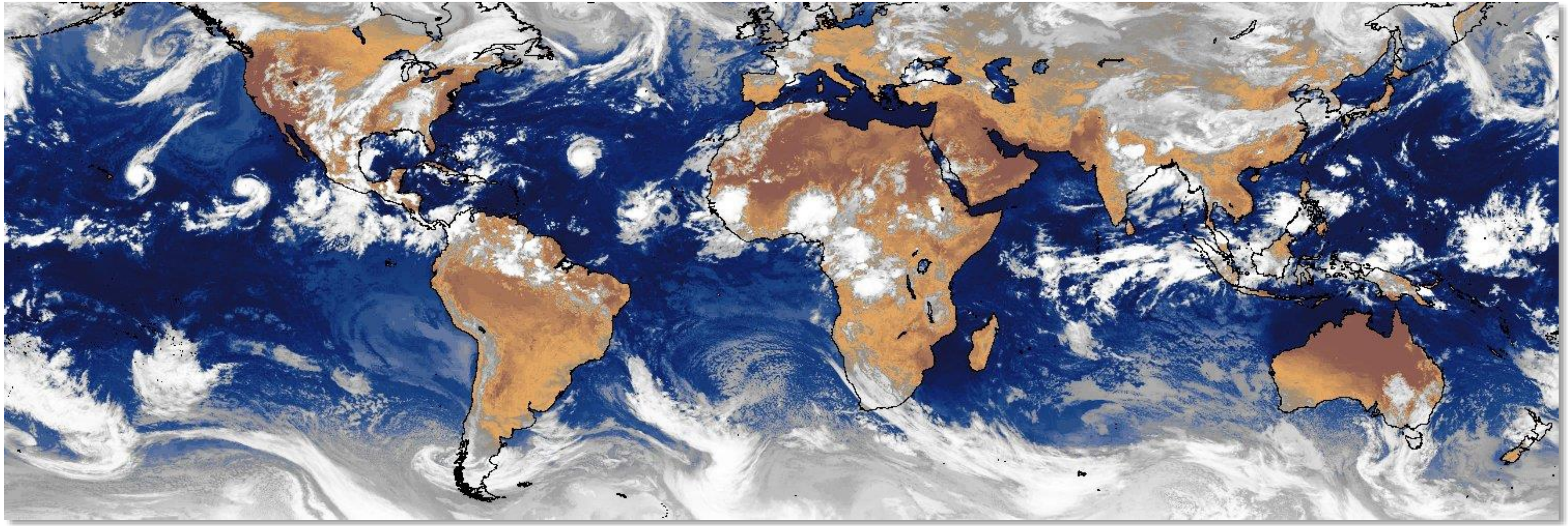
A Mesoscale Convective Systems Database Over the Tropical belt for the 2012-2016 Period derived from the Meteorological Geostationary fleet



Courtesy http://satmos.aeris-data.fr

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GEWEX Upper Tropospheric Clouds & Convection PROcess Evaluation Study meeting, 22 – 23 *October 2018, UPMC Sorbonne University, Paris, France*

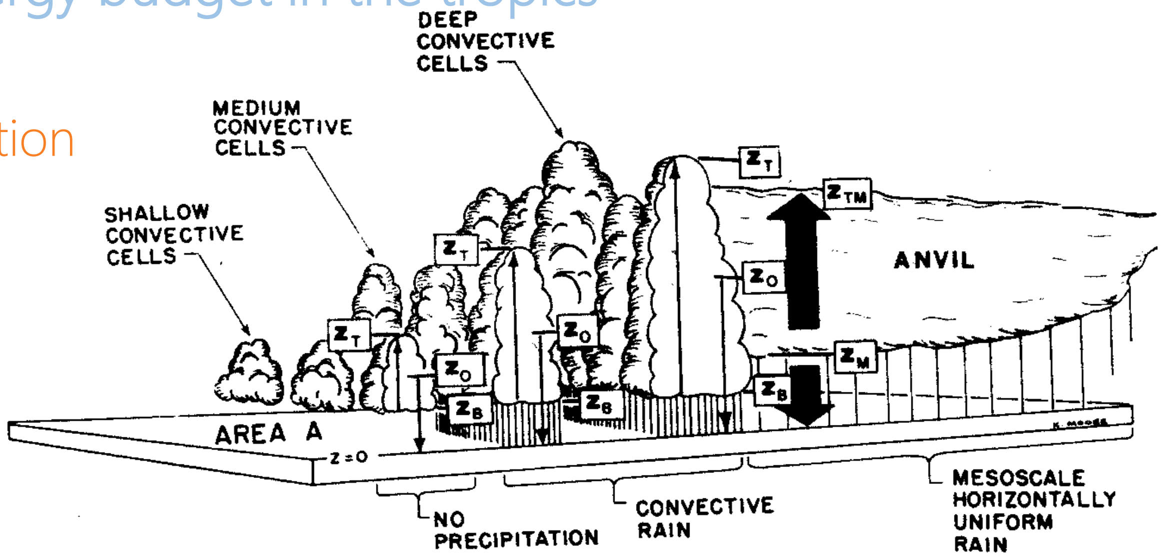
Outline

- Context and objectives
- The TOOCAN methodology
- A 5-year database of IR geostationary observation over the entire tropics.
- Homogenization of the IR geostationary ring database.
- A Convective Systems Database Over the Tropical belt for the 2012-2016 Period
- Conclusion and perspectives

Context and objectives

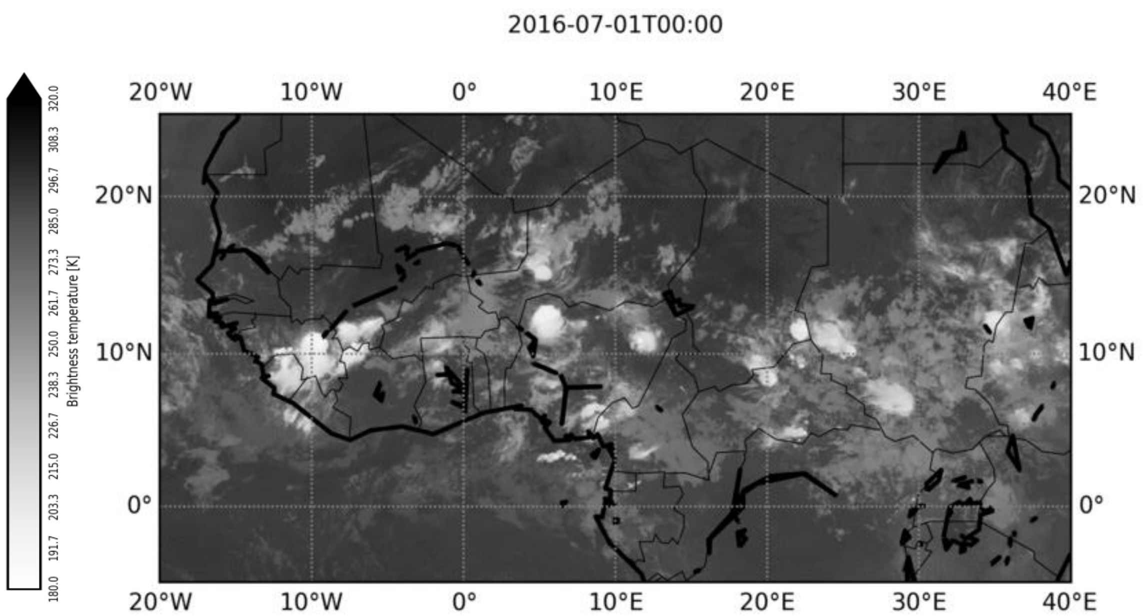
Mesoscale Convective Systems central to water and energy budget in the tropics

- Organization of Deep convection in Convective systems
- Span a wide range of spatial scale and degree of organization
- MCS Life cycle (duration, propagation distance ...)



(Houze et al., 1980
from Houze & Betts1981)

Observation of the high cloud clusters from geostationary infrared data

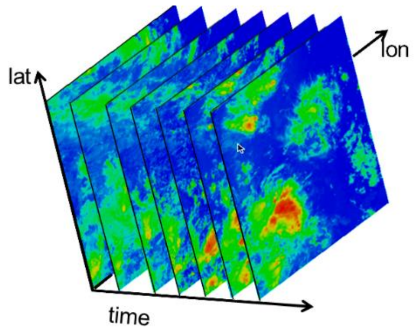


- pattern recognition and tracking algorithm
- Detection of high cold cloud cover by Applying a 235K threshold

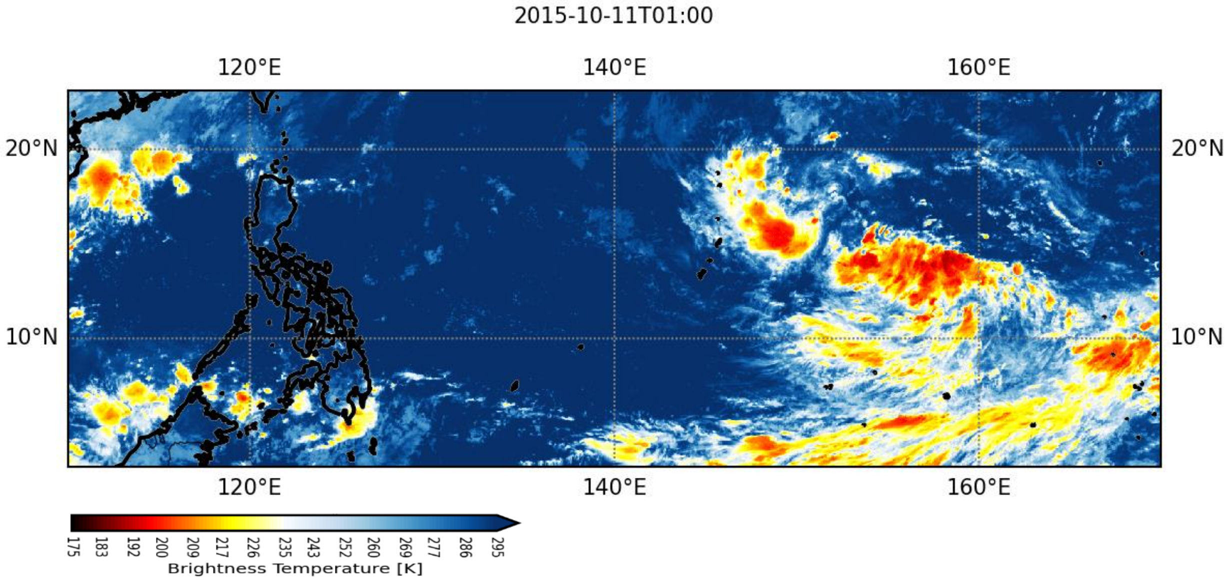
The TOOCAN methodology

Tracking Of Organized Convection Algorithm using a 3-dimensional segmentatioN

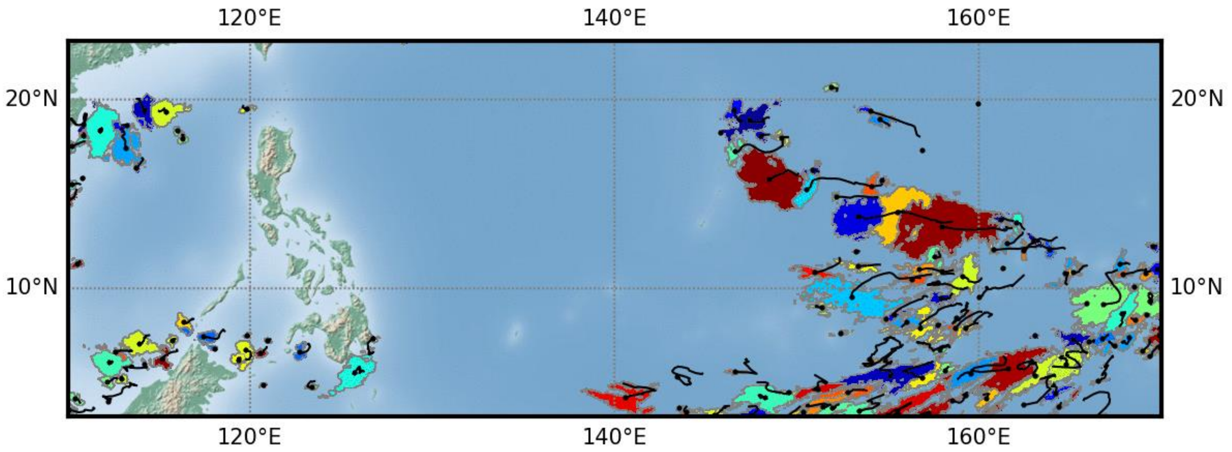
- Associate a convective core to its stratiform anvil in the 3-dimensional domain.
- An iterative process of detection and spread of convective seeds to identify individual convective systems



IR Imagery from HIMAWARI-08



MCS segmented by TOOCAN



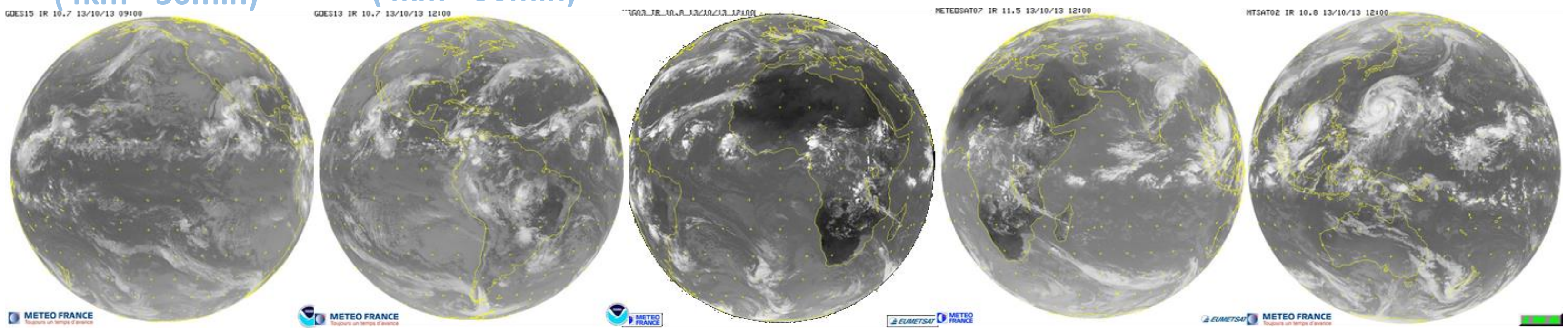
Fiolleau T. and R. Roca, (2013), An Algorithm For The Detection And Tracking Of Tropical Mesoscale Convective Systems Using Infrared Images From Geostationary Satellite, Transactions on Geoscience and Remote Sensing, doi: 10.1109/TGRS.2012.2227762.

Objective:
- Elaboration of a 30min/full resolution global tropical and homogeneous Database of convective systems over the 2012-2016 period

A 5-year database of IR geostationary observation over the tropical belt

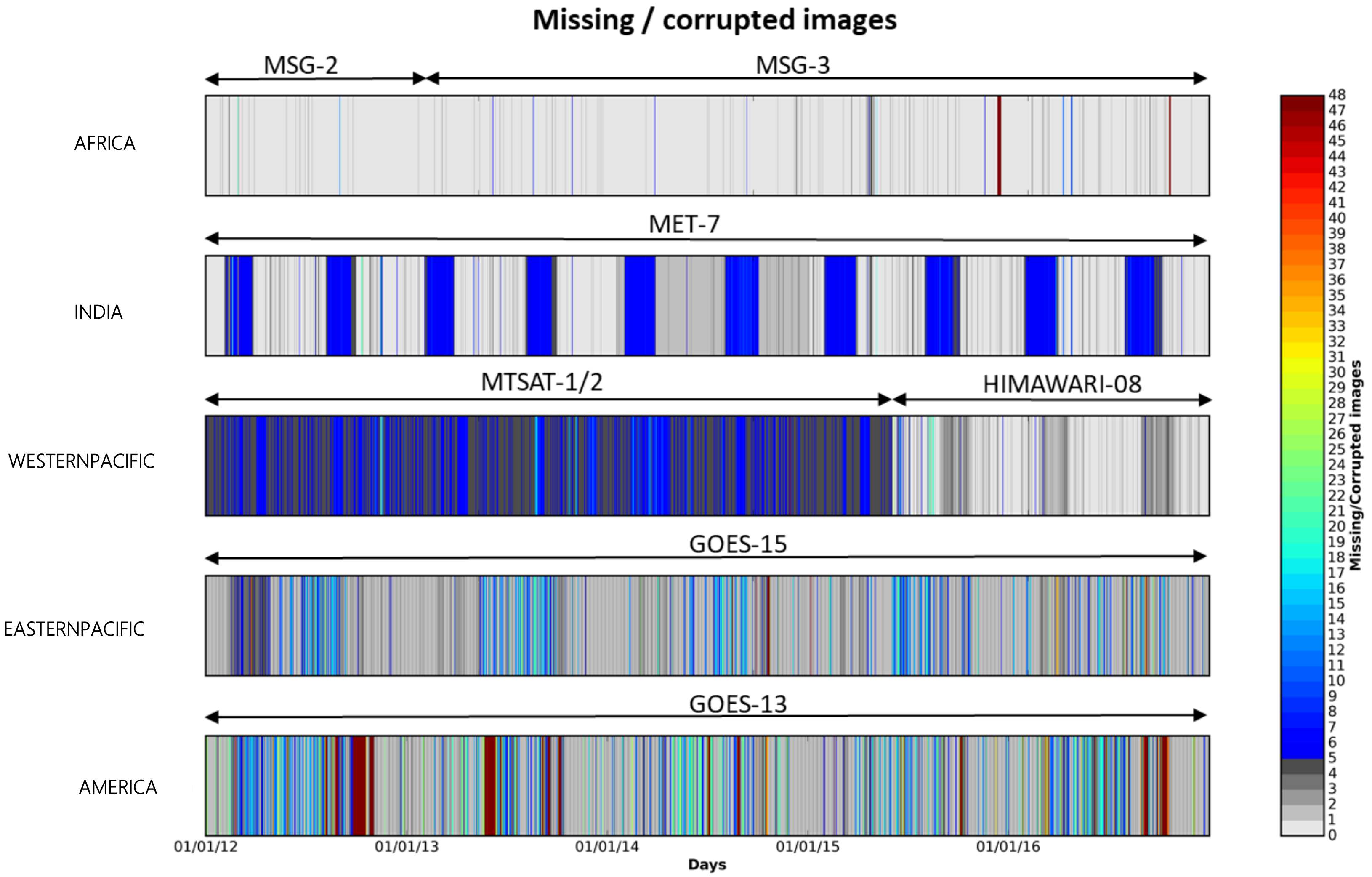
Observation of MCSs over the entire tropical belt performed by a full space/time resolution thermal infrared measurements obtained from the operational fleet of geostationary satellites

GOES-15 (4km - 30min) | GOES-13 (4km - 30min) | MSG-1/2/3 (3km - 30min) | MET-7 (5km - 30min) | MTSAT-1/2/HIMAWARI (4km/2km - 30min)



Platform	Nadir location	Instrument	Central wavelength	Spectral interval	Spatial resolution at nadir	Temporal resolution	Tracking region	Source
GOES-15	135°W	IMAGER	10,7 µm	10,2 µm - 11,2 µm	4km	30 min	180°W-105°W ; 40°S-40°N	NOAA
GOES-13	75°W	IMAGER	10,7 µm	10,2 µm - 11,2 µm	4km	30min	111°W-30°W ; 40°S-40°N	NOAA
METEOSAT-8/9/10	0°	SEVIRI	10,8 µm	9,8 µm - 11,8 µm	3km	15min	45°W-45°E ; 40°S-40°N	EUMETSAT/ CMS/ICARE
METEOSAT-7	57,5°E	MVIRI	11,5µm	10,5 µm - 12,5 µm	5km	30min	12°E-107°E ; 40°S-40°N	EUMETSAT/ Climserv
MTSAT-2	145°E	IMAGER	10,8 µm	10,3 µm - 11,3 µm	4km	30min	95°E-170°W ; 40°S:0°N	CMS/ICARE CIMSS
HIMAWARI-8	140,7°E	AHI	10,45 µm	10,15 µm - 10,75 µm	2km	10min	94°E-170°W ; 40°S:40°N	CMS/ICARE JMA

A 5-year database of IR geostationary observation over the tropical belt



- Average of 6% of missing images over the 5-years observation over the entire tropics.
- Minimum of missing images for MSG-2/3: 0,33%.
- Maximum for GOES13: 18%.

Ensure a temporally continuous record dedicated to the observation of convective systems from 2012 to 2016.
➔ Homogenization of the IR georing database

Homogenization of the IR geostationary ring database.

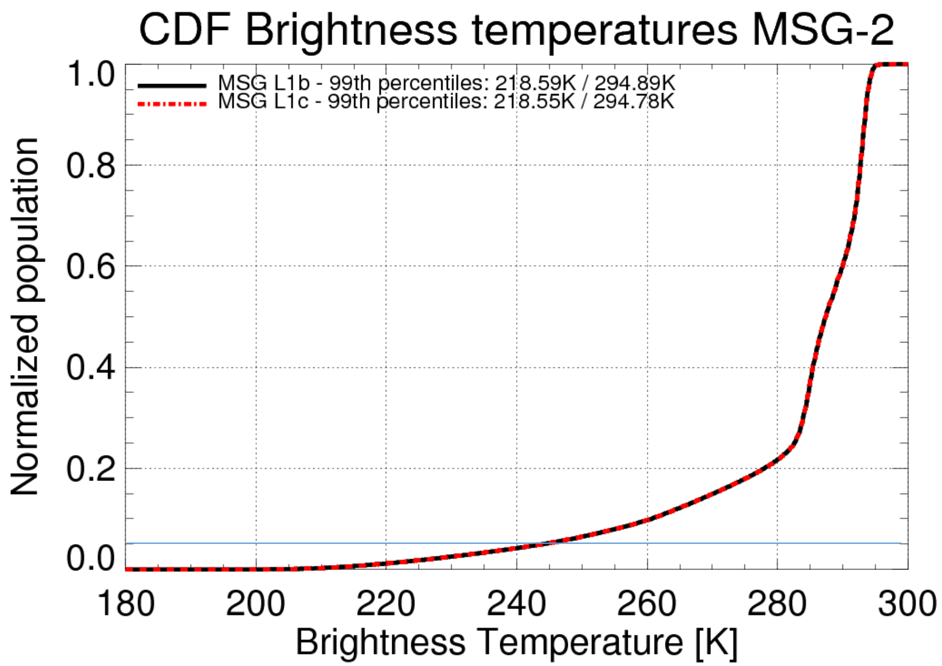
Temporal resolution homogenization

- inhomogeneity of the MSG/HIMAWARI temporal resolution :
- Use of the 30 minutes temporal resolution for MSG and HIMAWARI08 to avoid MCS over segmentation

Spatial resolution homogenization

- Remapping of the geostationary data from their native projections to a common map projection
- A 0.04° equal-angle latitude/longitude grid
- Use of the Inverse Distance Weighting method

- Weak impact on the brightness temperature distribution



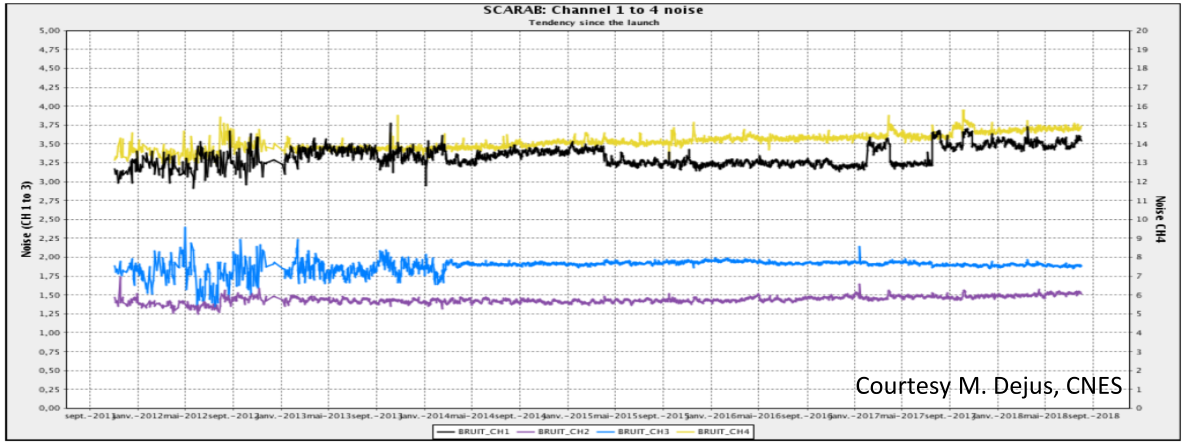
➔ Calibration and spectral corrections of the IR georing database with SCARAB observations for scenes corresponding to high cold clouds

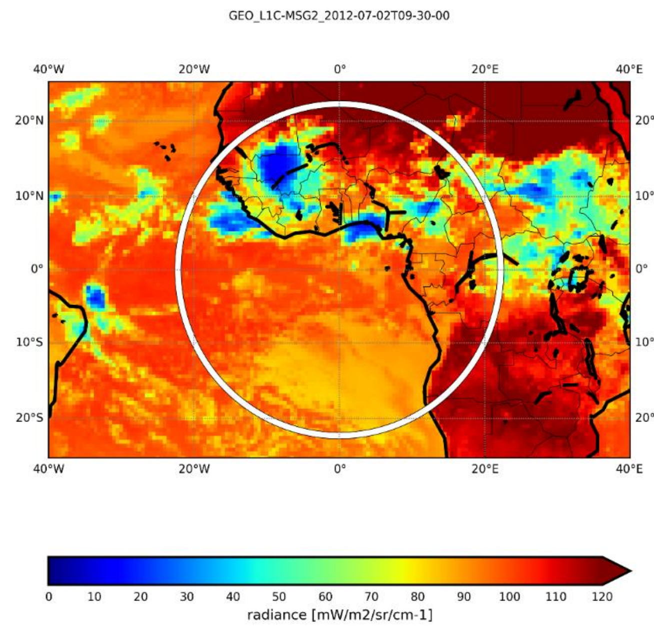
Homogenization of the IR geostationary ring database.

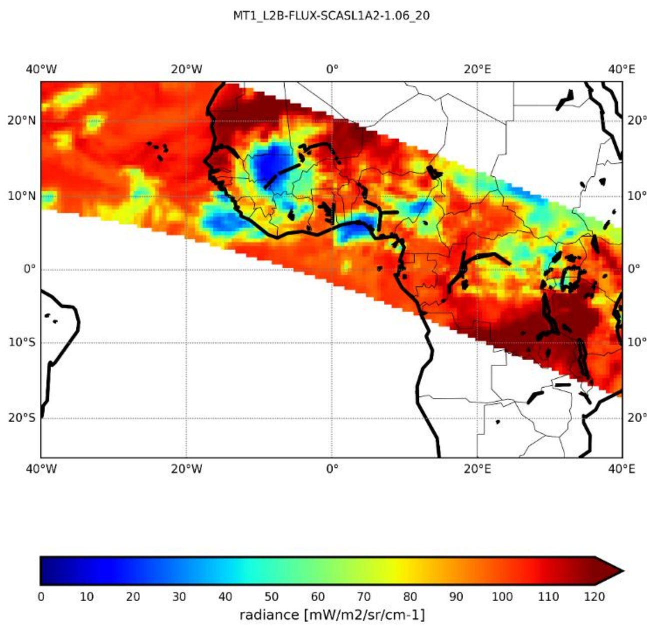
Spectral and calibration corrections by using the SCARAB L2B-0.5° observations

- IR Channel 4 : **[10.5µm – 12.5 µm]**
- **SCARAB L2B-0.5°**

- **Temporal stability** of the SCARAB observations
- Repetitivity of the measurements over the tropics







Inter-calibration based on the comparison of collocated GEO-SCARAB observation

- Collocation specification:

$VZA_{Geo} < 26°$

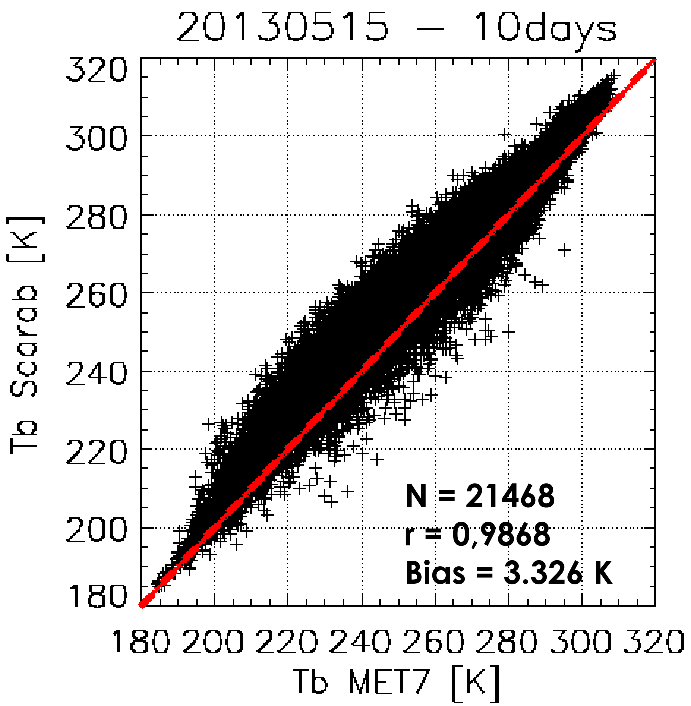
$VZA_{Scarab} < 20°$

timedelay < 15 minutes

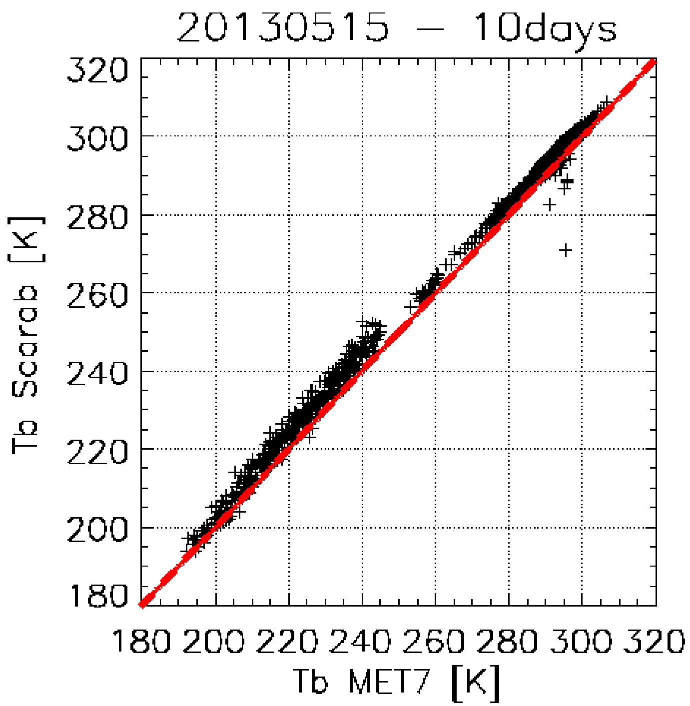
Homogenization of the IR geostationary ring database.

Spectral and calibration corrections by using the SCARAB L2B-0.5° observations

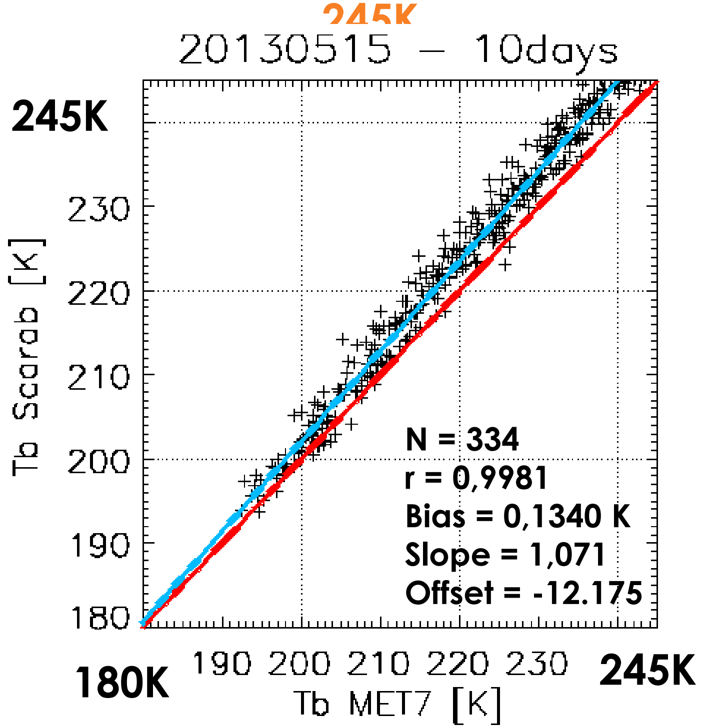
All matchups



BT_{Scarab} vs BT_{MET7} from the proportionate filter



Linear regression between BT_{Scarab} and BT_{MET7} ranging from **180K to 245K**



$BT_{Scarab} = 1{,}07 \times BT_{MET7} - 12{,}17K$

A proportionate filter select matchups with low noises:

- Keep more matchups for colder temperatures

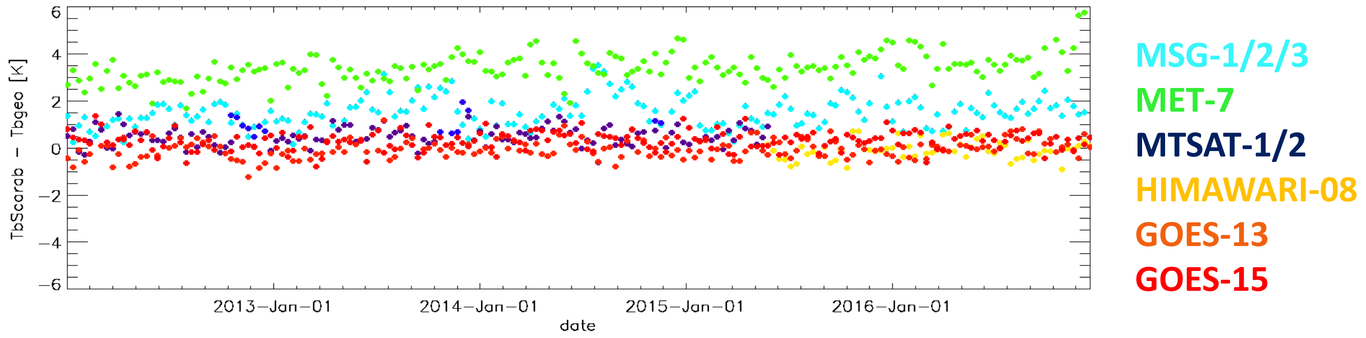
- Linear Regression computed for BT in the range **[180K-245K]**
- Time period for the regression: **10**

Homogenization of the IR geostationary ring database.

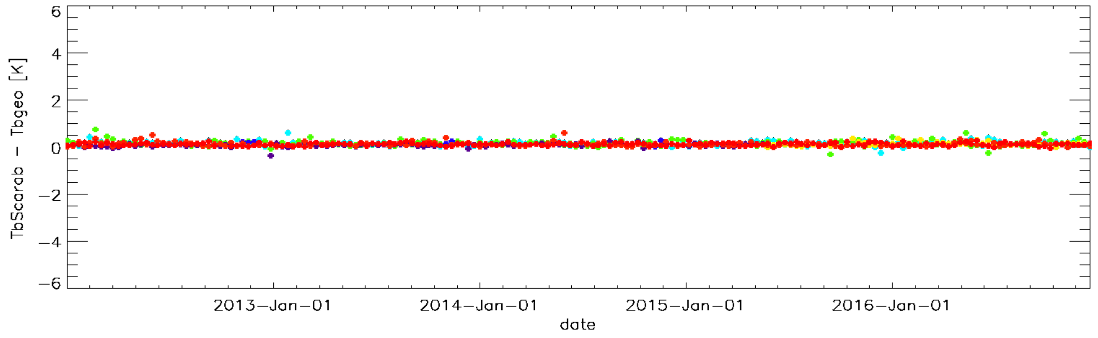
Spectral and calibration corrections by using the SCARAB L2B-0.5° observations

Time series of decadal mean BT differences between SCARAB and all the geostationary platforms in the range [180K-245K]

Before calibration correction

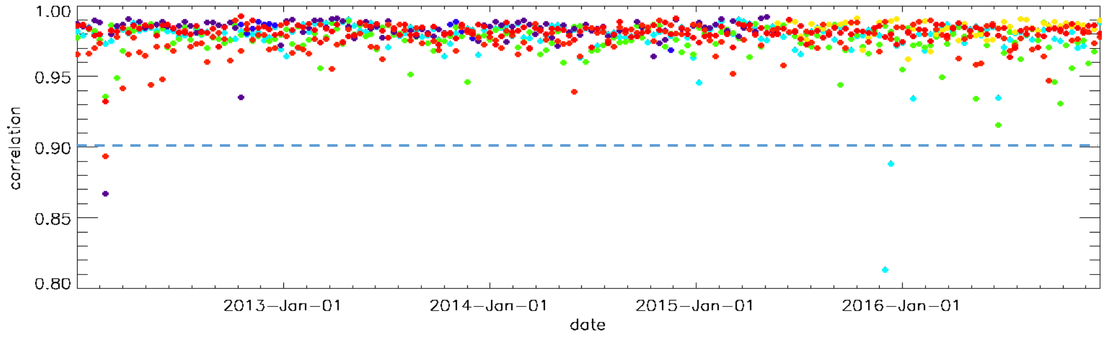


After calibration correction



➔ Residual bias close to 0 for all the platforms
➔ Lower disparity.

linear regression correlation

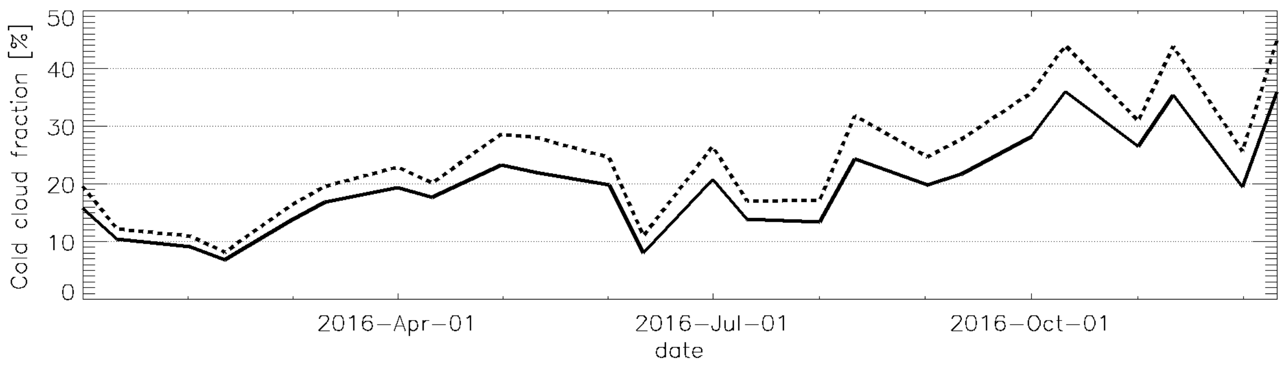


Homogenization of the IR geostationary ring database.

Spectral and calibration corrections by using the SCARAB L2B-0.5° observations

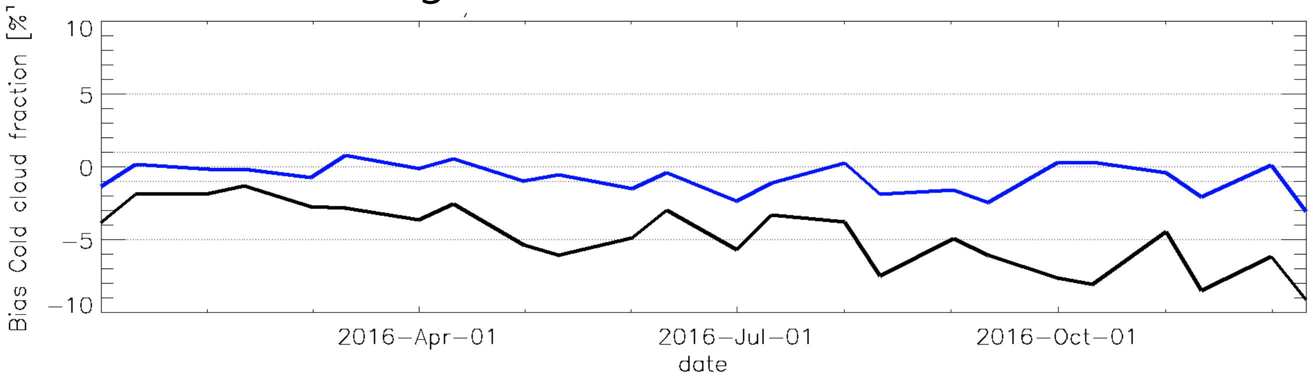
Impact of the Scarab spectral and calibration corrections on the high cold cloud fraction.

Time series of the high cold cloud surface Before correction



Evolution of the cold cloud fraction in 2016 on a common area observed by HIMAWARI-08 (solid line) and MET-7 (dashed line) with similar VZA.

Time series of the high cold cloud surface Bias between HIMAWARI-8 and MET-7 Before/After correction



Before correction (black line)
After correction (blue line)

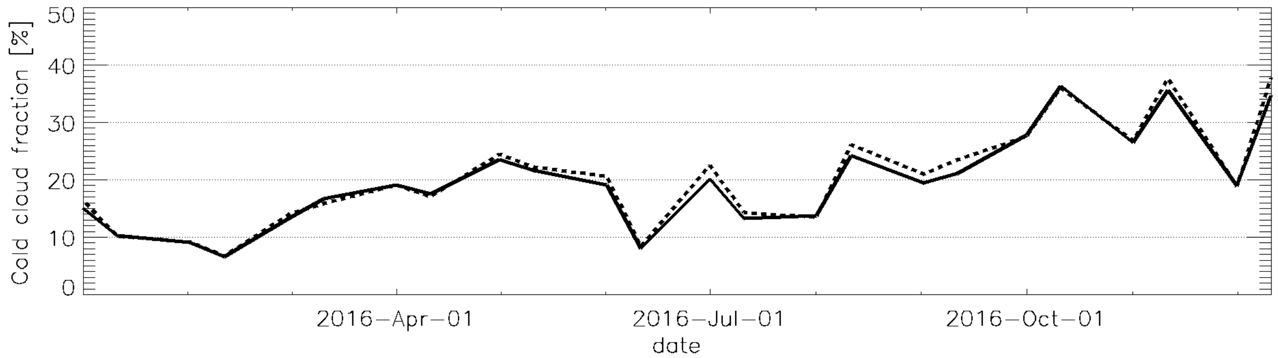
➔ Improvement brought by the SCARAB corrections on the cold cloud surface detection

Homogenization of the IR geostationary ring database.

Spectral and calibration corrections by using the SCARAB L2B-0.5° observations

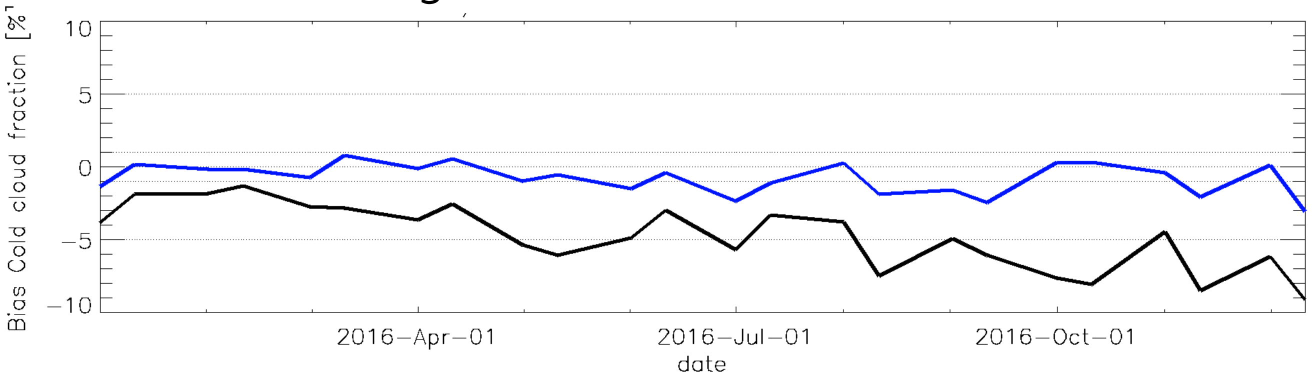
Impact of the Scarab spectral and calibration corrections on the high cold cloud fraction.

Time series of the high cold cloud surface After correction



Evolution of the cold cloud fraction in 2016 on a common area observed by HIMAWARI-08 (solid line) and MET-7 (dashed line) with similar VZA.

Time series of the high cold cloud surface Bias between HIMAWARI-8 and MET-7 Before/After correction



Before correction (black line)
After correction (blue line)

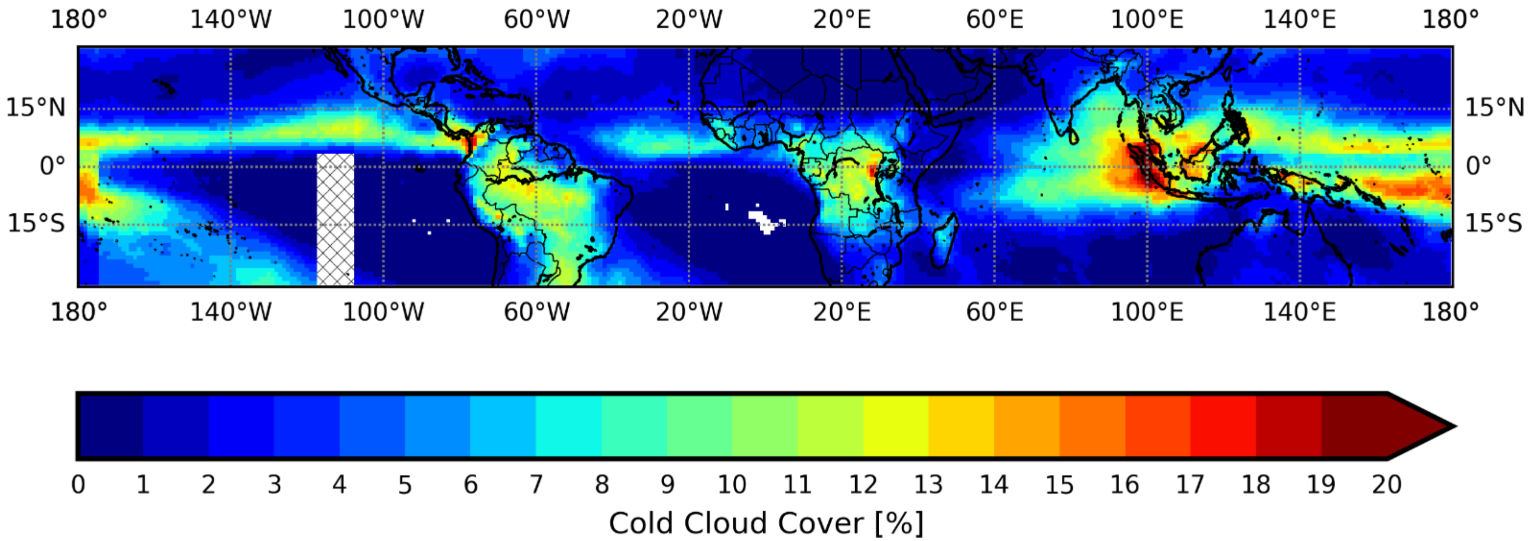
➔ Improvement brought by the SCARAB corrections on the cold cloud surface detection

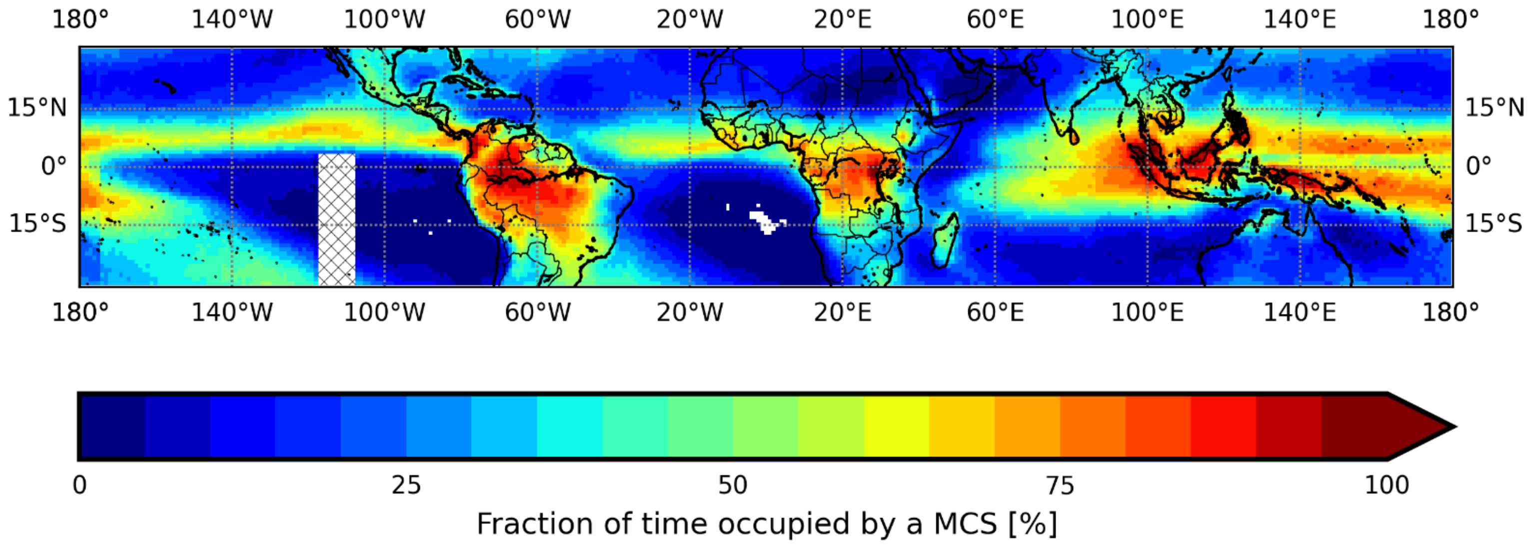
Application of the TOOCAN algorithm on the 5-year homogenized IR geostationary ring database

A Convective Systems Database Over the Tropics for the 2012-2016 Period

Application of the TOOCAN algorithm on the 5-year homogenized IR geostationary ring database

- ~ 5.1×10^6 convective systems
- ~ 1.4×10^6 over the Continents
- ~ 3.7×10^6 over the Oceans

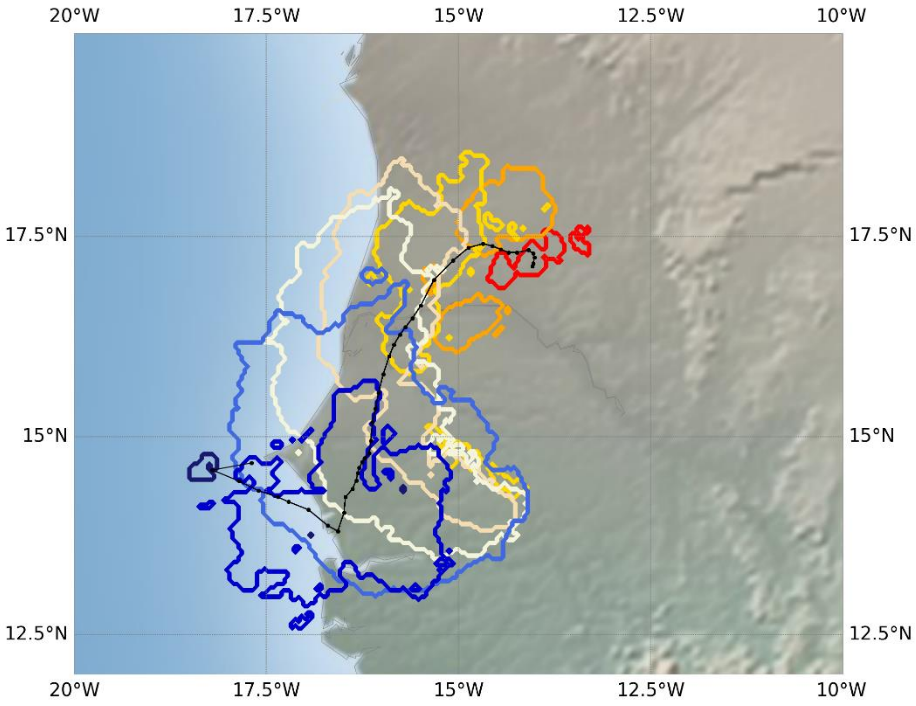




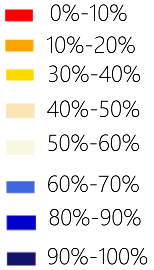
A Convective Systems Database Over the Tropics for the 2012-2016 Period

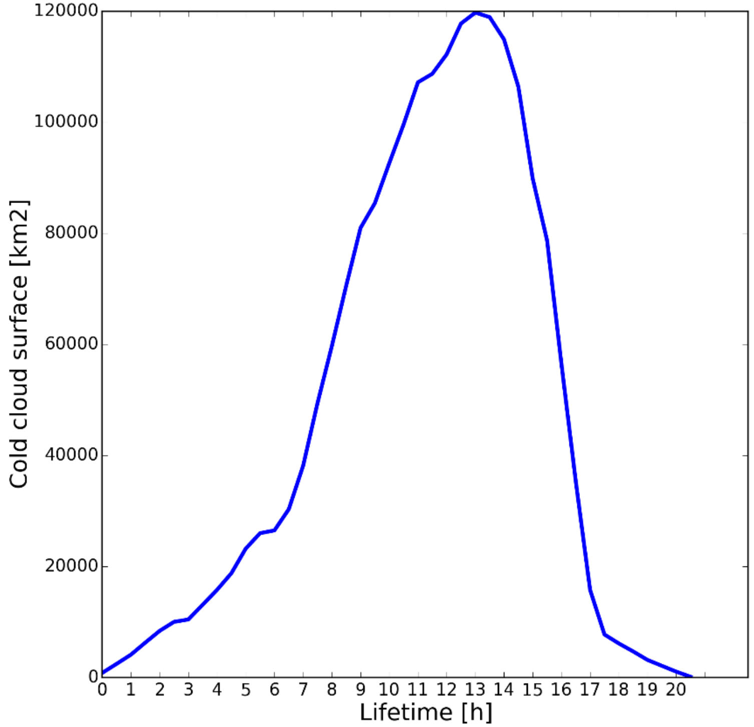
1) Access to the evolution of the MCS morphological parameters along their life cycles

- cold cloud surfaces at various Tb [km^2]
- Tbmin [k]
- Propagation speed [m/s]
- …



2015/08/08 - 2015/08/09
Lifetime duration: 21h
Smax: 119754 km^2

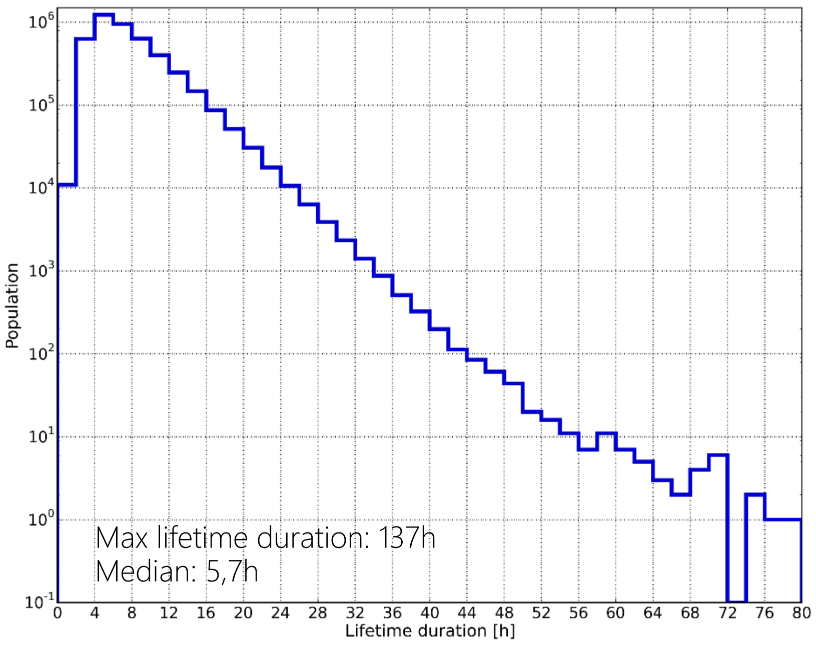


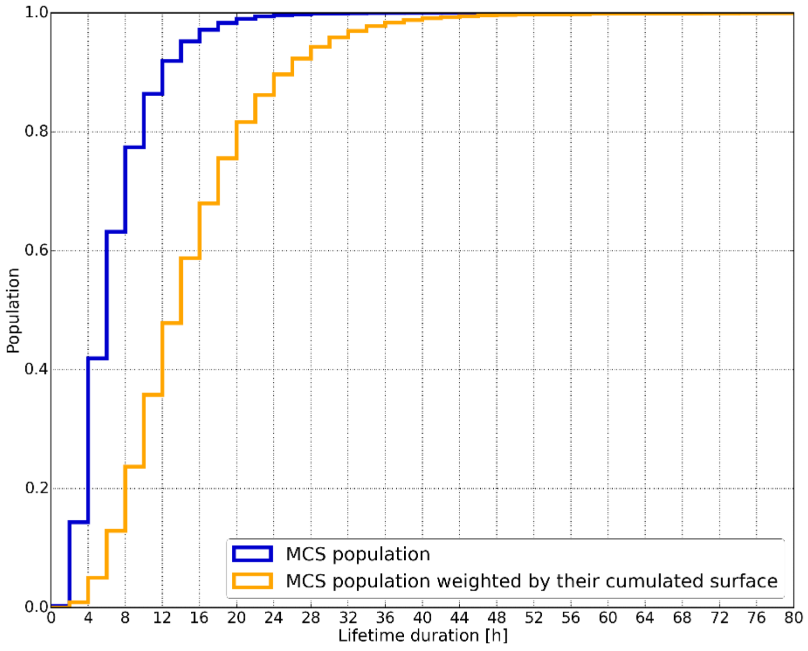


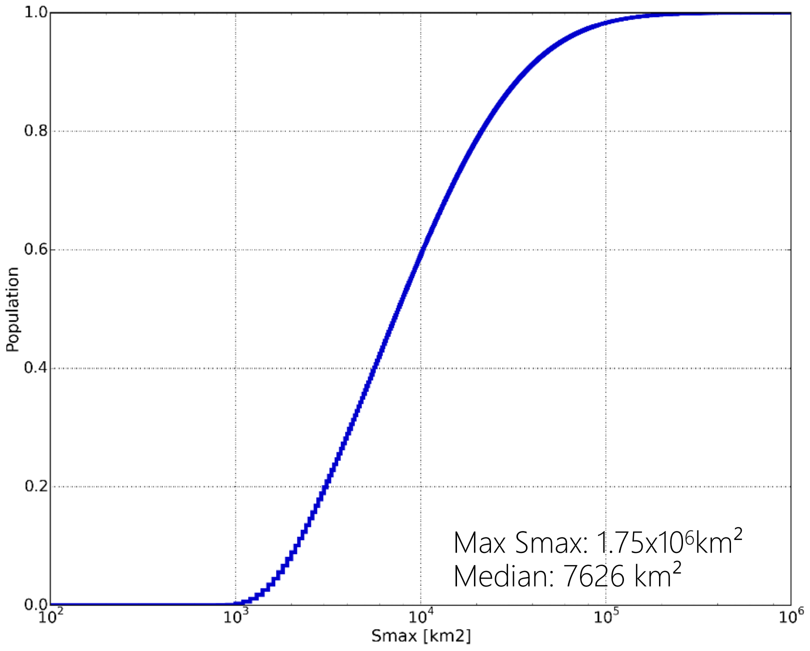
A Convective Systems Database Over the Tropics for the 2012-2016 Period

2) Access to the integrated morphological parameters of each MCS

- Lifetime duration [h]
- Smax [km²]
- Tbmin [K]
- Time/localization of initiation/dissipation
- Propagated distance [km]
- …

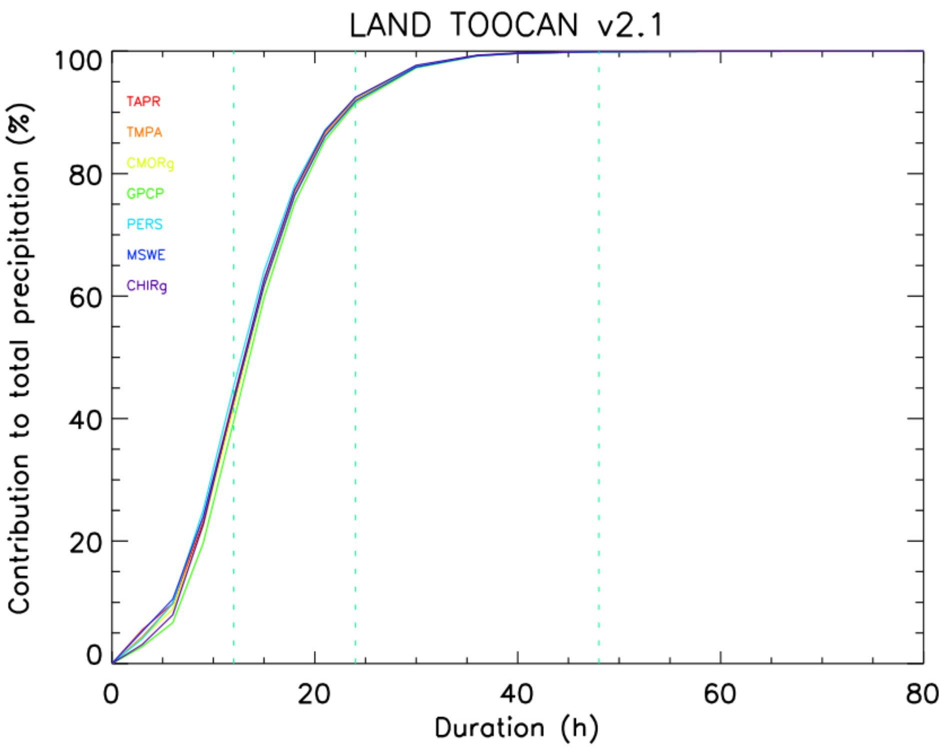


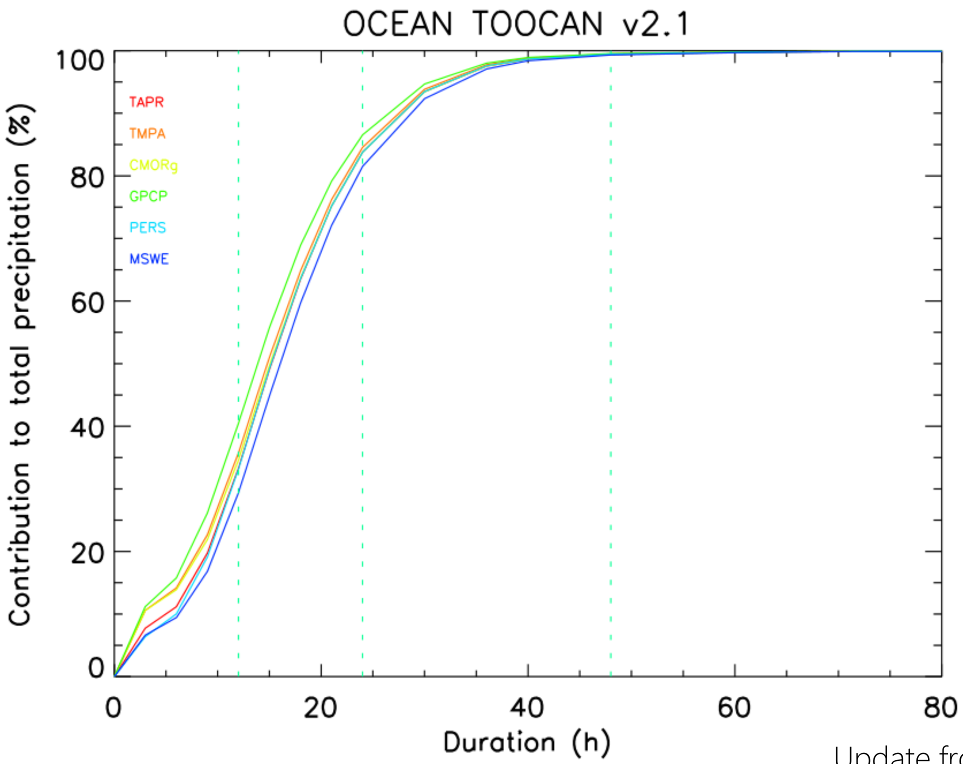




A Convective Systems Database Over the Tropics for the 2012-2016 Period

Exploring the role of MCS to the precipitation distribution





2012-2016

30°S-30°N

Update from Roca et al., 2014 J Climate

The systems lasting up to 12h only explains
- 30 % of the rainfall over ocean
- 40% over land

Robust to the selection of the satellite products

Conclusion & Perspectives

Conclusion

- Objective to build a **Mesoscale Convective Systems Database Over the Tropics for the 2012-2016** Period and derived from the Meteorological Geostationary fleet
- **Homogenization** of the IR geostationary ring database.
- Importance of the geostationary ring data homogenization **to investigate MCS morphological characteristics**
- **Run of the TOOCAN algorithm on the homogenized IR geostationary database.**

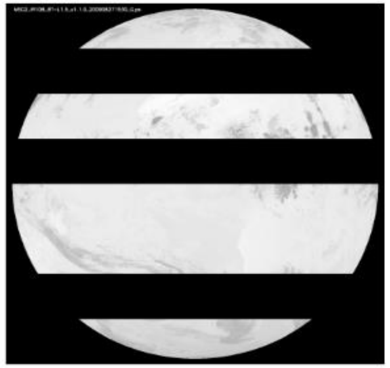
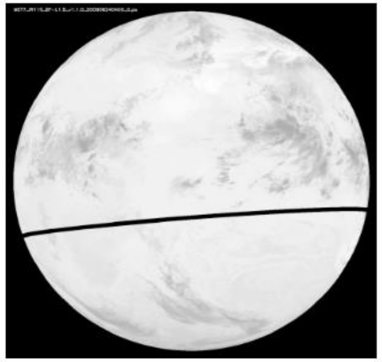
Perspectives

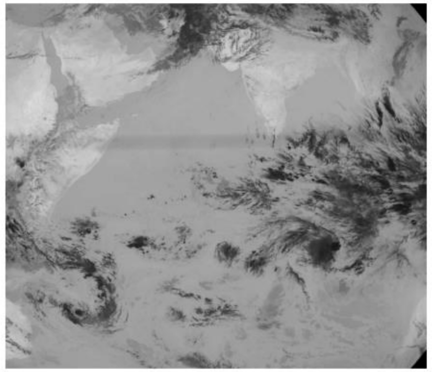
- Publication of the Georing spectral/calibration correction by using SCARAB/Megha-Tropiques
- Publication of the MCS database in ESSD (Earth System Science Data) Soon.
- **Availability** of the database soon
- Extend the period to **2017-2018**. (GOES-13 replaced by GOES-16 and INSAT-3DR over the Indian Ocean)
- Use the **IBTrACS** database to flag the **cyclones/tropical storms**.

A 5-year database of IR geostationary observation over the entire tropics.

Quality Controls / Database validity

A radiometric quality control procedure on geostationary data



- Missing lines/pixels/pixel blocks
- Smeared line
- Radiometric alteration due to Eclipse periods....

MTTM n°3 - Quality of geostationary satellite images (**André Szantai** LMD, Bruno Six GCTD/ICARE, Sophie Cloché IPSL, Geneviève Sèze LMD)

Management of missing / low quality images

Quality control procedure

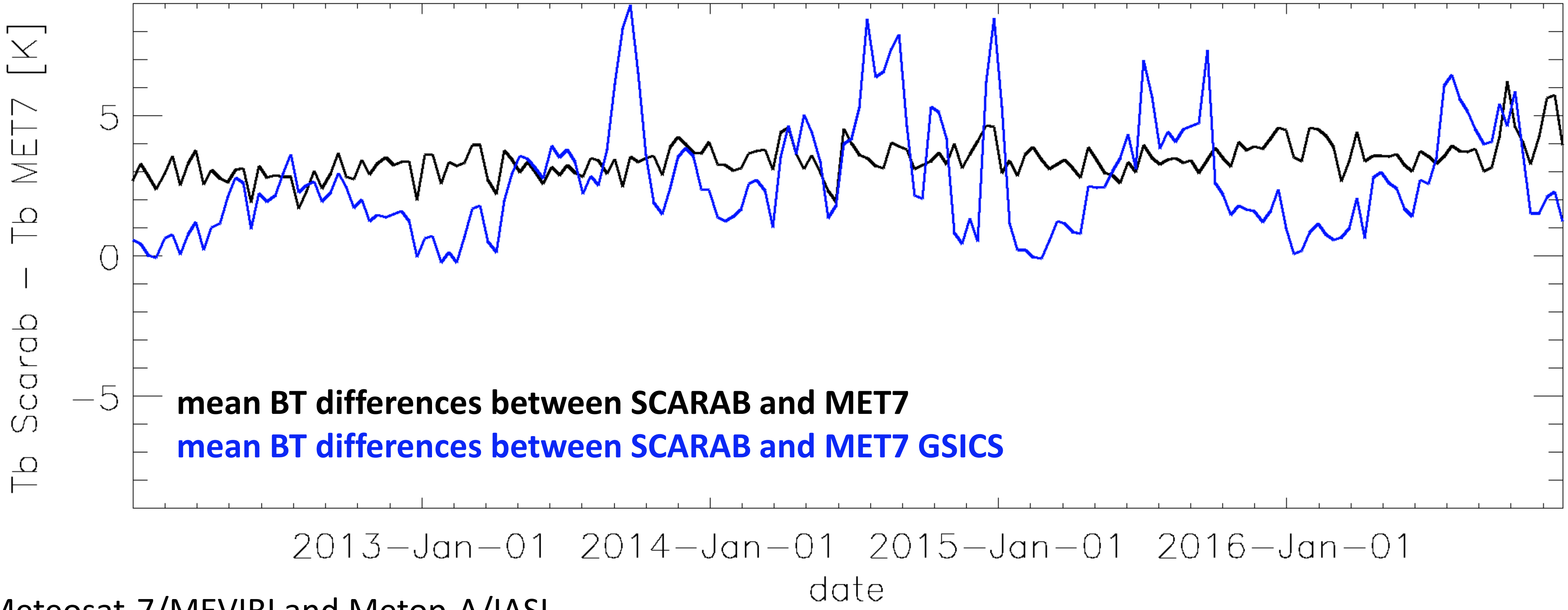
→ Application of the radiometric quality control procedure

→ Management of missing / low quality images

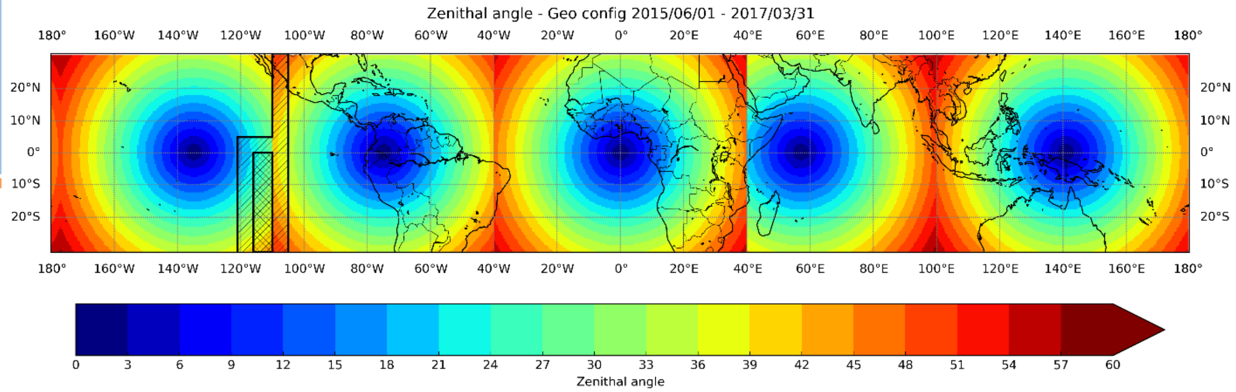
Homogenization of the IR database.

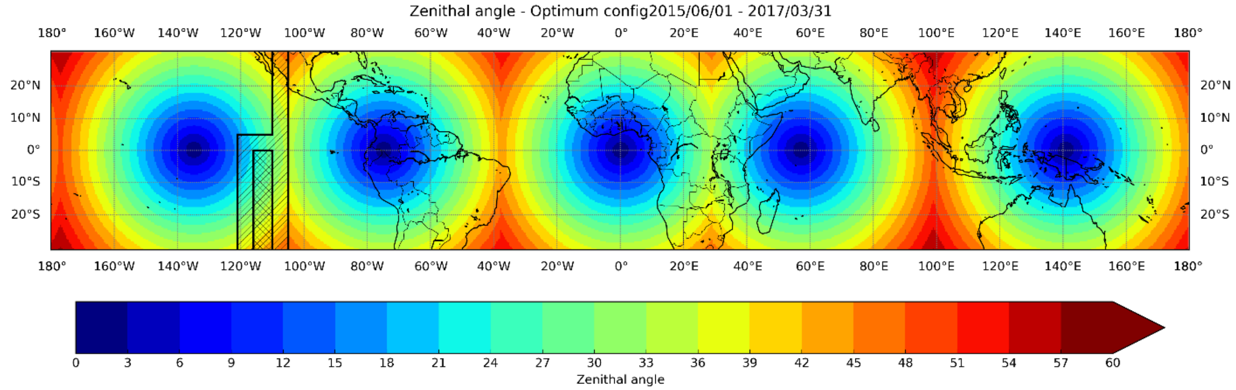
spectral and calibration corrections by using the SCARAB L2B observations

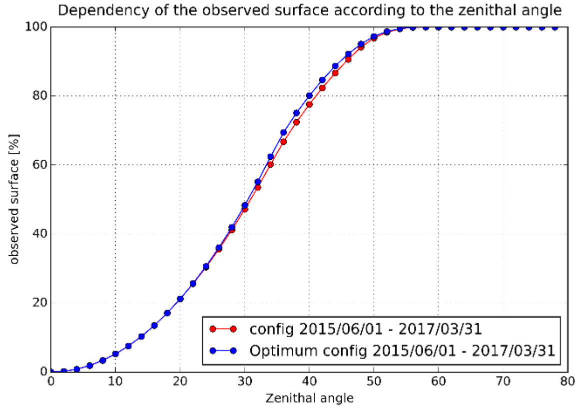
Time series of decadal mean BT differences between SCARAB and MET7 in the range [180K-245K]

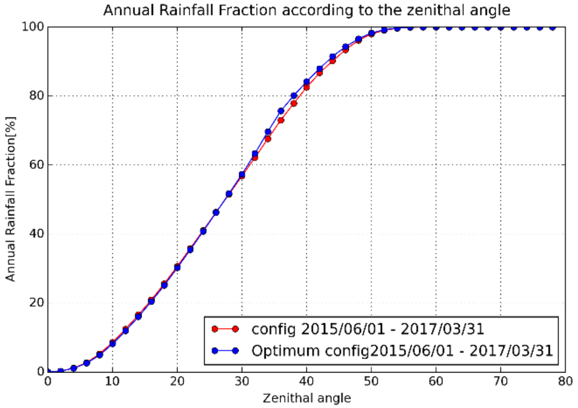


Bias between Meteosat-7/MEVIRI and Metop-A/IASI









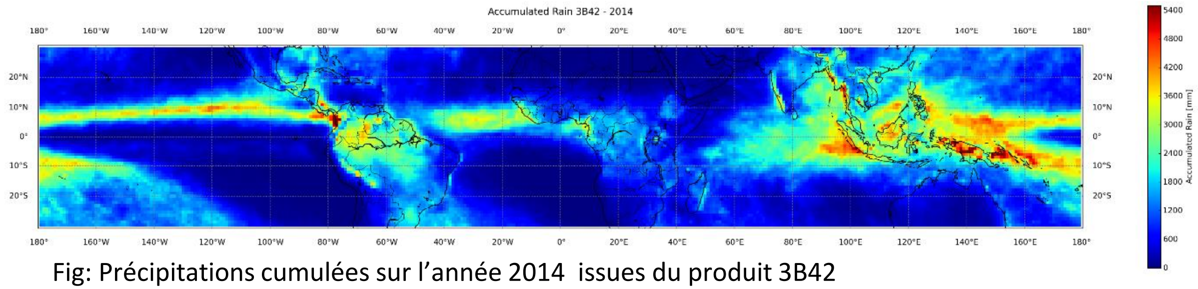


Fig: Précipitations cumulées sur l'année 2014 issues du produit 3B42

98% des précipitations annuelles observées avec la config2
Avec une bande d'exclusion de 5°

a) Angles zénithaux de chacune des plateformes géostationnaires pour une configuration maximisant la qualité des données (nombre d'images manquantes, tests qualités, Données impactées par les période d'éclipses) sur l'ensemble de la bande tropicale.
b) Angles zénithaux de chacune des plateformes géostationnaires pour une configuration idéale minimisant la distance entre nadir de chaque plateforme sur l'ensemble de la bande tropicale.
c) Dépendance de la surface observée par rapport à l'angle zénithal sur l'ensemble de la bande tropicale
d) Dépendance du taux de précipitation observé annuellement en fonction de l'angle zénithal.

Homogenization of the IR geostationary ring database.

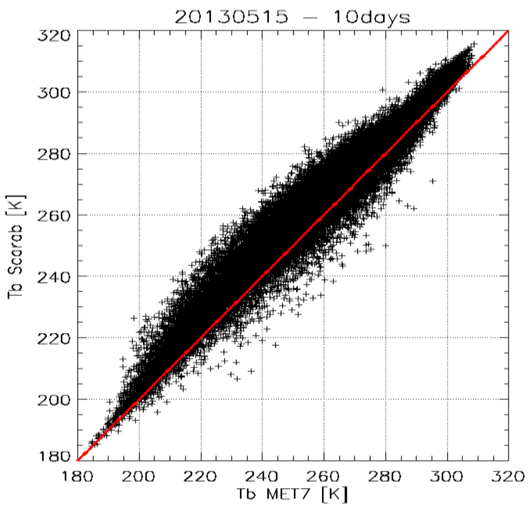
spectral and calibration corrections by using the SCARAB L2B observations

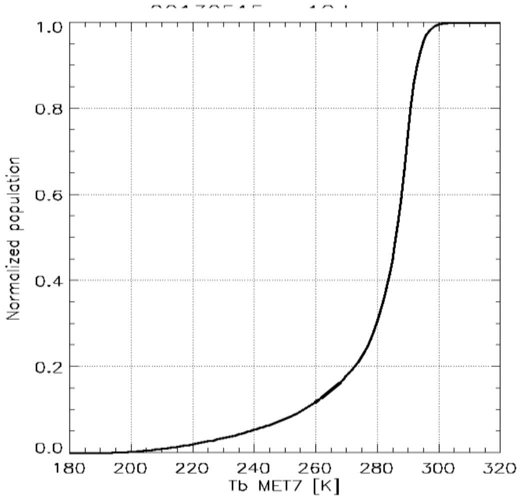
All matchups

A proportionate filter for matchups

- $\sigma(BT_{geo}) < 2K$ for $BT < 245K$
- $\sigma(BT_{geo}) < 1K$ for $BT > 245K$
- $\sigma(BT_{geo}) < 0.5K$ for $BT > 280K$

- **Keep more matchups for colder temperatures**
- Linear Regression computed for the range **[180K-245K]**
- Time period for the regression: **10 days**



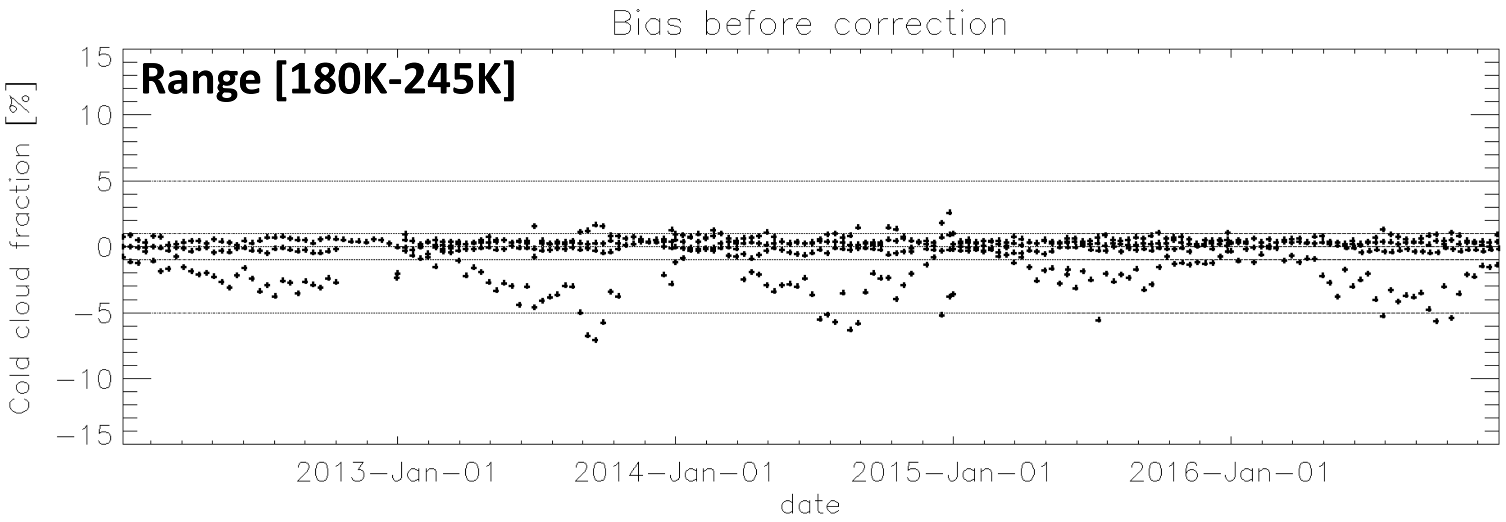


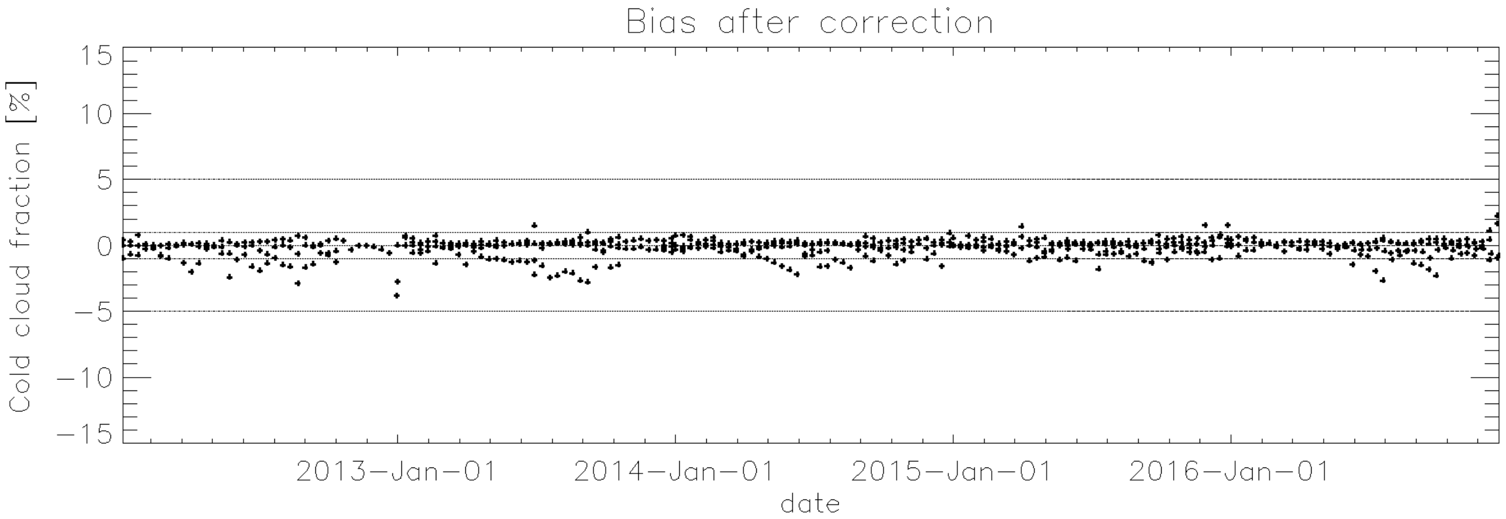
N = 21468
r = 0,9868
Bias = 3.326 K

Homogenization of the IR geostationary ring database.

spectral and calibration corrections by using the SCARAB L2B observations

Independant validation of the Scarab spectral and calibration corrections.





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stats before correction:
Bias (%): -0.432871
stddev(%): 1.42362
rmsd(%): 1.48693

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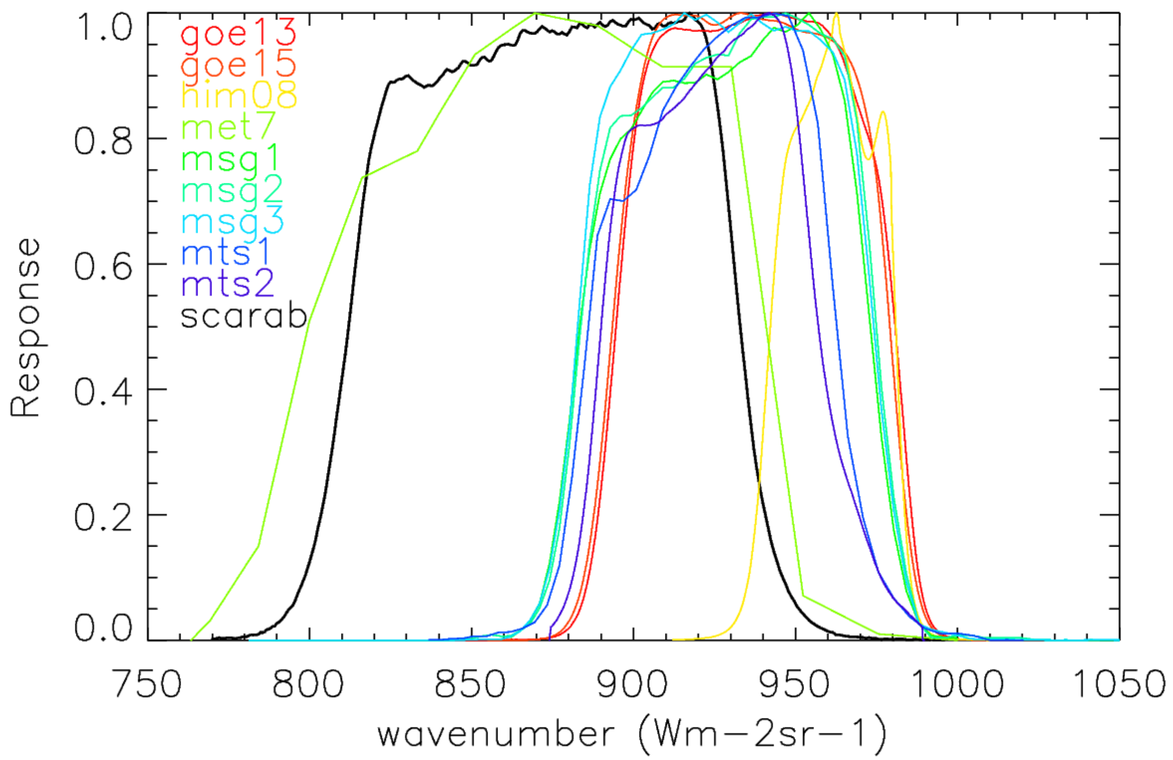
stats after correction:
Bias (%): -0.160829
stddev (%): 0.655962
rmsd (%): 0.674903

Homogenization of the IR geostationary ring database.

spectral and calibration corrections by using the SCARAB IR channel 4 observations



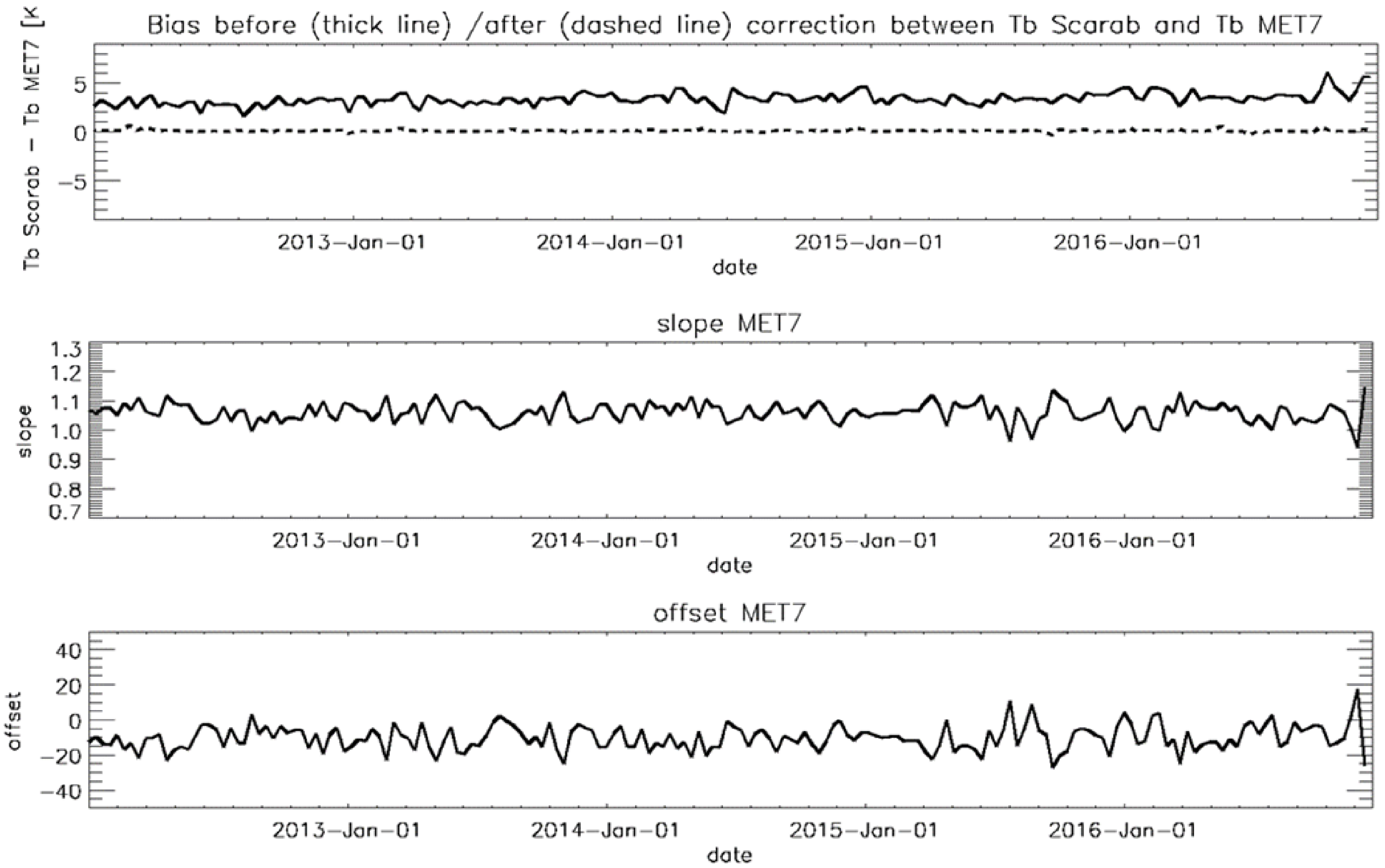
- **SCARAB IR channel 4 used as a reference**
- Temporal stability of the SCARAB observations
- Spectral interval: **[10.5µm – 12.5 µm]**

➔ Normalize the geostationary observation with SCARAB observations to remove intersatellite biases and more specifically for the cold brightness temperatures

Homogenization of the IR geostationary ring database.

spectral and calibration corrections by using the SCARAB L2B-0.5° observations

Time series of decadal mean BT differences between SCARAB and MET-7 in the range [180K-245K]



- ➔ **Residual bias close to 0**
- ➔ **Stability of the correction over the entire period**

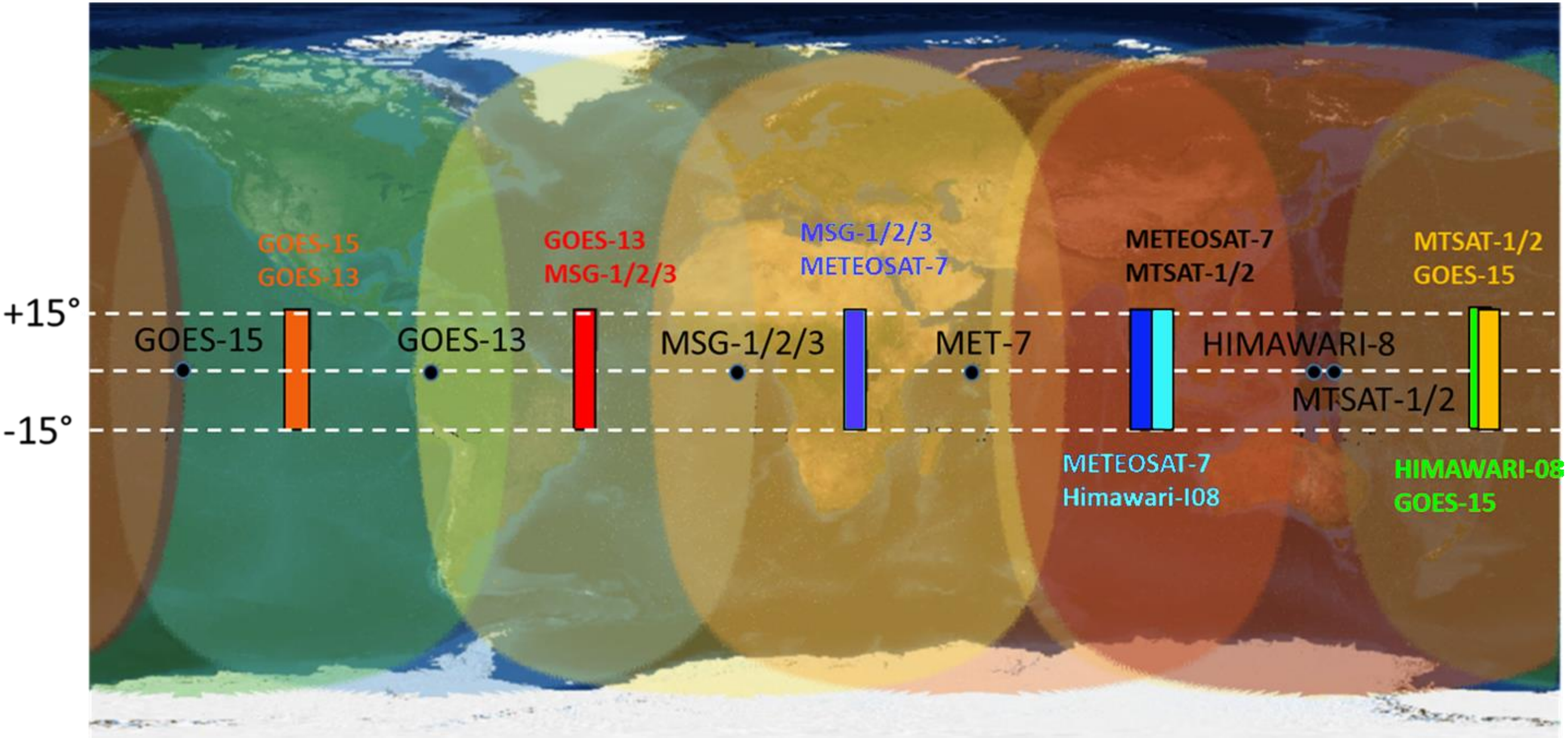
	Before correction	After correction
Bias	3,2639 K	0,16 K
Standard deviation	2,52 K	2.34 K
rmsd	4,12 K	2.35 K

Homogenization of the IR geostationary ring database.

spectral and calibration corrections by using the SCARAB L2B-0.5° observations

Independant validation of the Scarab spectral and calibration corrections.

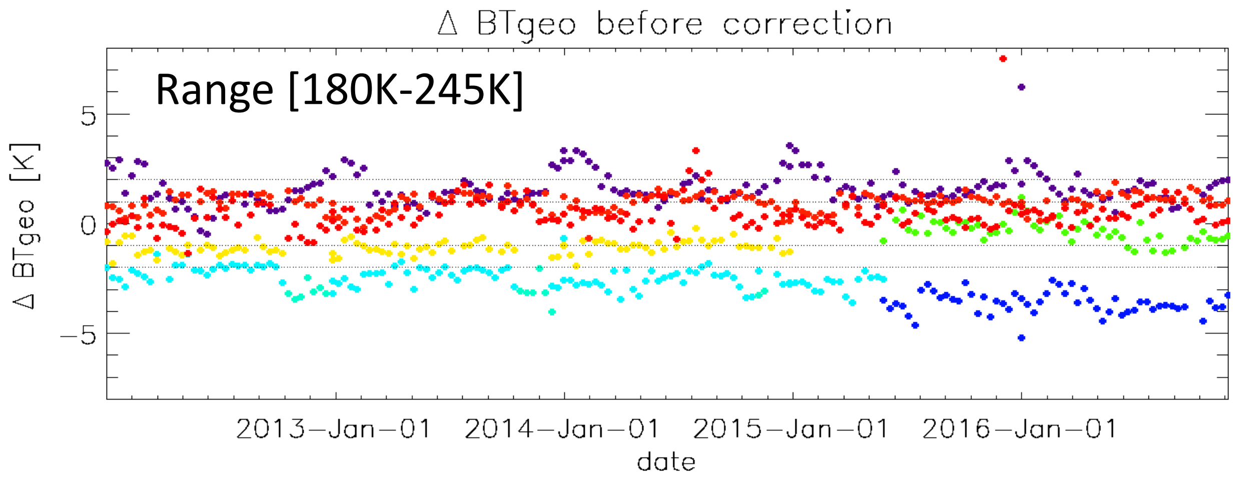
Comparison of the corrected BT between GEO platforms on common areas sharing equivalent VZA



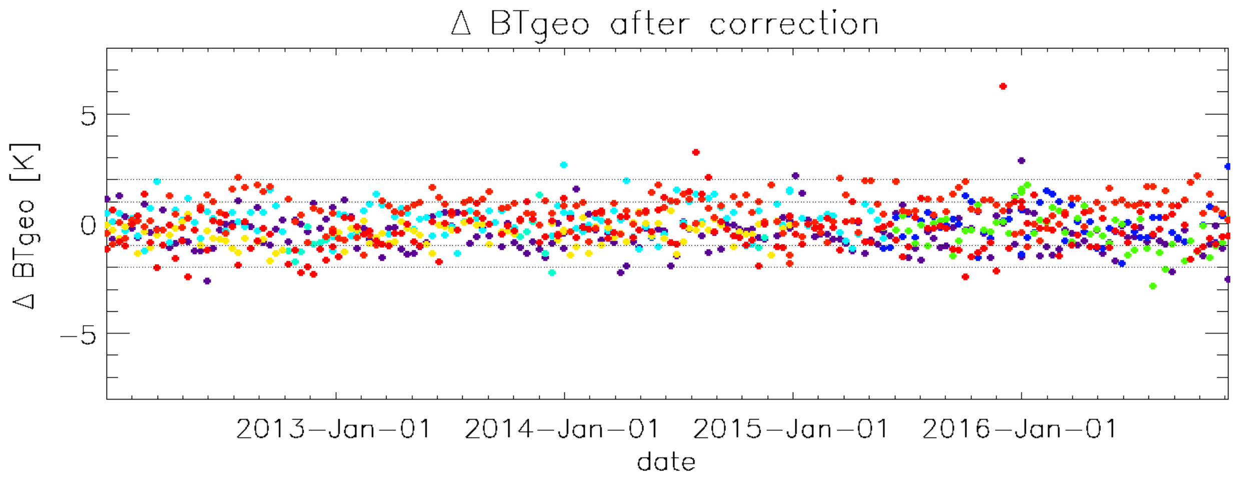
Homogenization of the IR geostationary ring database.

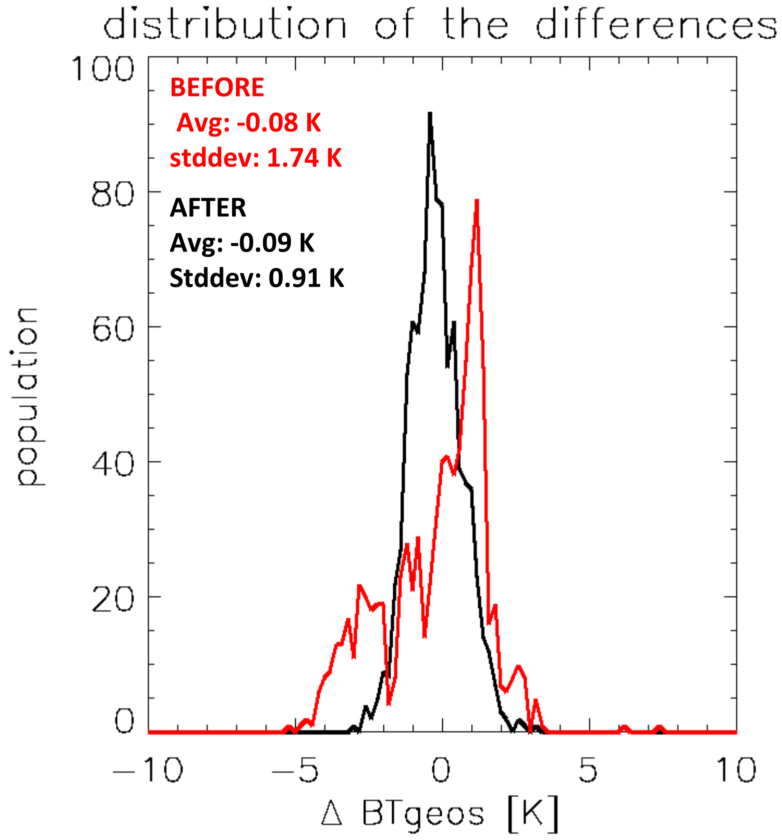
spectral and calibration corrections by using the SCARAB L2B-0.5° observations

Independant validation of the Scarab spectral and calibration corrections.



[MSG-1/2/3 – MET7]
[MET-7 - MTSAT-1/2]
[MET-7 - HIMAWARI-08]
[MTSAT-1/2 – GOES-15]
[HIMAWARI08 – GOES-15]
GOES-15 - GOES-13
GOES-13 - MSG





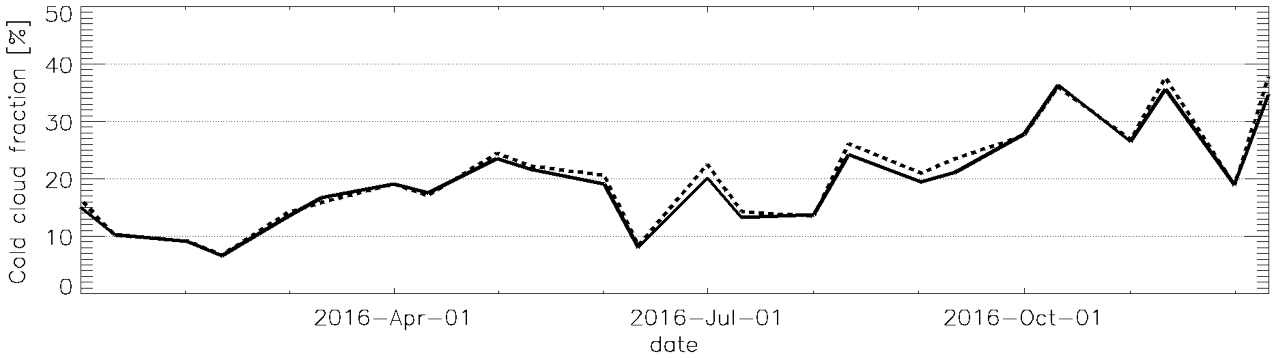
➔ Improvement of the bias stability and disparity of the distribution over the entire period.

Homogenization of the IR geostationary ring database.

spectral and calibration corrections by using the SCARAB L2B-0.5° observations

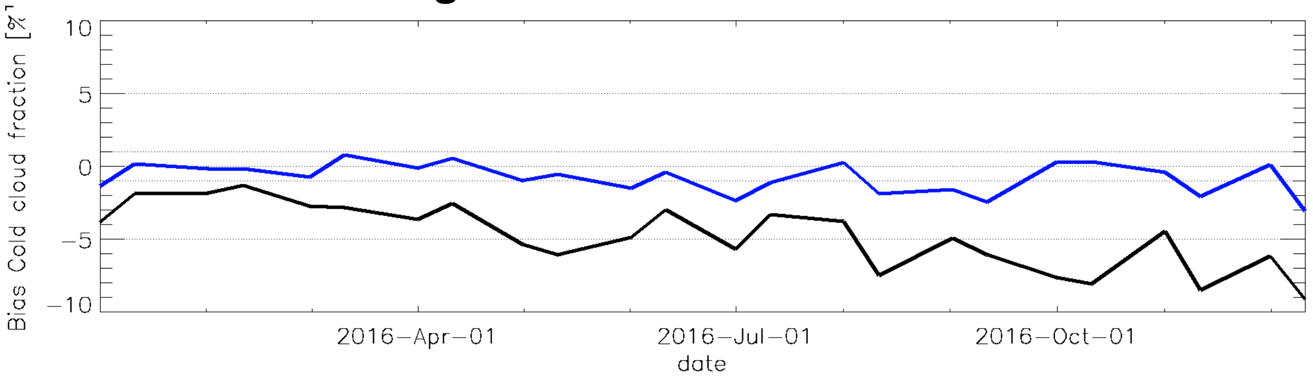
Impact of the Scarab spectral and calibration corrections on the high cold cloud fraction.

Time series of the high cold cloud surface AFTER correction



Evolution of the cold cloud fraction in 2016 on a common area observed by HIMAWARI-08 (solid line) and MET-7 (dashed line).

Time series of the high cold cloud surface Bias between HIMAWARI-8 and MET-7 Before/After correction



Before correction (black line)

After correction (blue line)

➔ High improvement of the SCARAB corrections on the cold cloud surface detection

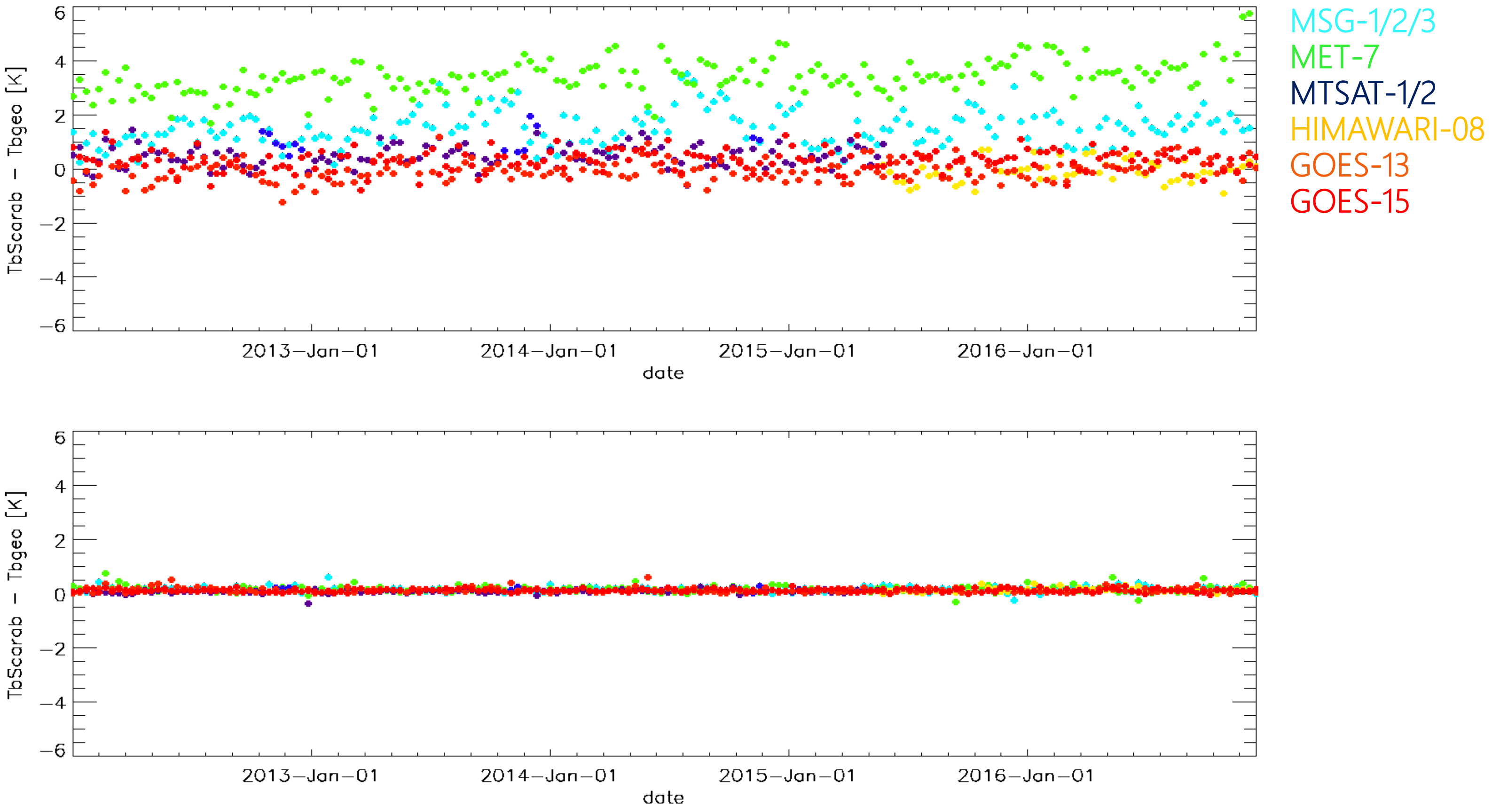
Homogenization of the IR geostationary ring database.

Spectral and calibration corrections by using the SCARAB L2B-0.5° observations

Time series of decadal mean BT differences between SCARAB and all the geostationary platforms in the range [180K-245K]

Before calibration correction

After calibration correction



➔ Residual bias close to 0 for all the platforms

➔ Lower disparity.