TOOCAN technical documentation

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[Contact]

Thomas Fiolleau
OMP/LEGOS
14, av. Edouard Belin
31400 TOULOUSE
thomas.fiolleau@legos.obs-mip.fr
tel : +33 561333082

Rémy Roca
OMP/LEGOS
14, av. Edouard Belin
31400 TOULOUSE
FRANCE
Remy.roca@legos.obs-mip.fr

I. The homogenized IR GEOring dataset

To monitor the entire tropics, the homogenized IR data of various geostationary platforms have been used covering 5 specific regions: Africa, India, Western-Pacific, Eastern-Pacific, America

From 1 January 2012 to 31 May 2015, the tracking algorithm has been applied on the IR data of MSG1/2/3, METEOSAT-7, MTSAT-2, GOES-15 and GOES-13 to monitor respectively the African, Indian, Western Pacific, Eastern Pacific, and the American region. From the 1 June 2015, MTSAT-2 has been replaced by the HIMAWARI-08 platform to monitor the Western-Pacific region. The characteristics of each platform table 1…

It is to be noticed that there are periodical backups of MTSAT-2 during equinox season, which is then replaced by MTSAT-1 with a nadir located at 140°:

- 2012/10/18 – 2012/12/25
- 2013/10/22 – 2013/12/19
- 2014/11/10 – 2014/11/28

The scanning pattern of MTSAT-2 and MTSAT-1 does not provide half-hourly sampling of the southern hemisphere region and by consequence in order to avoid inhomogeneity with other satellites; this region is not considered.

The GOES-13 and GOES-15 sensors follow a complex scanning sectors schedule. In routine operation, the full disk images are produced every 3h, while the north hemisphere and the south hemisphere images are produced every 30 minutes with a time lag of few minutes between each scan. A processing has then been performed to concatenate the Northern images with the southern images in order to ensure a continuity of the MCS trajectories. If one of the northern or southern scan is missing, the concatenation process is not performed and the data is regarded as missing. Note that the GOES-15 imagery does not scan every 30 minutes a region defined by the following limits [116°W-105°W; 40°S-0°N]. The tracking algorithm cannot be applied on this region, which is then not considered.

The GOES-13 and 15 platforms can also perform in rapid scan operations in case of extreme weather events (cyclones …). In that case, the full disk is still scanned every 3 hours, and the Northern Hemisphere every 30 minutes. However, in this configuration, the whole southern hemisphere is not observed anymore. During the rapid scan mode periods, the tracking algorithm will be then applied on the Northern hemisphere available every 30 minutes.

A homogenization procedure has been performed on the IR database to ensure a homogeneous database of convective systems over the tropical belt (Fiolleau etal 2019):

- The temporal frequency used is 30min, even for MSG and HIMAWARI-8, to avoid over segmentation of the convective systems due to their original temporal resolution of respectively 15 and 10 minutes compared to other platforms.
- The inhomogeneity of the spatial resolution has been accounted for by regridding the IR data of each geostationary satellite from their native projections to a common map projection, a 0.04° equal-angle latitude/longitude grid.
- The IR data have also been spectrally normalized and inter-calibrated by using the ScaRaB/Megha-Tropiques observations.

-   A limb adjustment has also been applied to correct the brightness temperature dependency to the viewing zenithal angle.

A radiometric quality control procedure (Szantai etal, 2011) has been applied on the IR images of each geostationary platform. Figure 1 shows the different kind of radiometric issues that can affect the geostationary infrared data. The radiometric quality control procedure allows us to detect such issues and to remove the data affected.
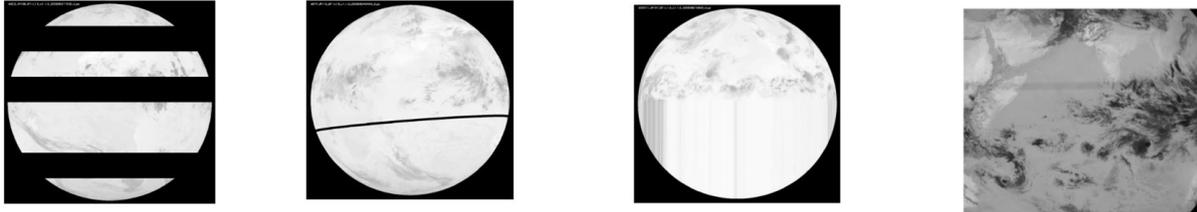

Figure 1: radiometric geostationary image problems that can be encountered. a) missing lines in the MSG-2 IR 10.8µm observation; b) oblique and curved line in the METEOSAT-7 IR 11.5 µm observation; c) smeared lines encountered in the GOES-11 (West) IR 10.7 µm image; d) horizontal band of darkened pixels in the METEOSAT-5 IR 11.5 µm data.

Figure 2 shows the availability of the IR data for each satellite and over the 2012-2016 period. In average and over the period, we find 6% of missing/corrupted images, with a minimum of lack of data for MSG (0.66%). For the METEOSAT-7 platform, we can observe some periods with more than 5 missing images per day and which occurred twice per year. These periods correspond to the eclipse periods, which affect the MVIRI imager. It is also to notice the improvement, in terms of data availability, brought by HIMAWARI-08 in comparison to MTSAT-2 over the Western Pacific region from June 2015. The maximum of missing images is observed for GOES-13 with around 18% of lack of data. The availability of the geostationary IR data is important because it can affect the quality of the tracking.
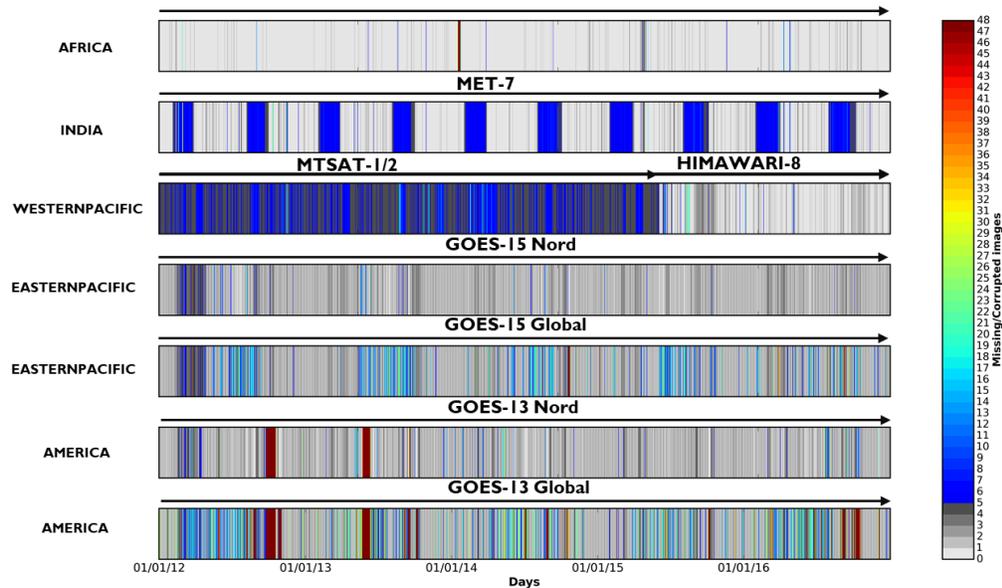

Figure 2: Availability of the geostationary IR database, sorted by regions of interest and over the 2012-2016 period. Each color corresponds to the number of missing images per day.

2. TOOCAN database

The TOOCAN algorithm has then been performed geostationary platform per geostationary platform on the homogenized IR database. The tracking is run over a wide longitudinal and latitudinal areas to minimize edges effects. Thus, it is suggested to analyze the MCSs which occurred within the boundaries of the exploitable regions (table 1) than the boundaries of the tracking regions. It will filter MCSs which occurred near the boundaries of the tracking regions and which can impact MCSs shapes and trajectories. Thus, for instance, the tracking latitude span is 40°S-40°N and the effective latitude span is 35°N-35°S.

The management of missing/low quality of geostationary images is taken into account by the TOOCAN algorithm. Thus, the tracking process is stopped when 5 successive missing or low quality images in the time series is encountered. Otherwise, the tracking is performed nominally up to 4 consecutive missing images.

The Outputs of the tracking algorithm consists of a monthly tracking file in ASCII as well as the corresponding segmented images each 30 minutes. The tracking file allows to describe the morphological parameters of each detected MCS at each step of their life cycles:

- cold cloud surfaces, time step, lifetime duration, longitude/latitude of the center of mass, label...

The tracking file gives also an access to the integrated morphological parameters of each MCS:

- lifetime duration, propagated distance, minimum brightness temperature, time/geolocation of initiation/dissipation…

Each MCS is also described by a unique label, which is useful to make the link between a given MCS described in the tracking file and the same MCS identified within the segmented images from the IR images. That's way, by using both the tracking file and the segmented images, you can have an access to every pixel (latitude/longitude) of a given identified MCS (use of the segmented images) as well as the morphological parameters of this MCS (use of the tracking file)

3. The TOOCAN programs

You can find some programs in IDL and Python in the: Programs/ repertory

IDL codes

Load_TOOCAN.pro :

- Read the tracking files produced by the TOOCAN algorithm and load the morphological parameters of each MCS into a data structure.

open_imsegTOOCAN_NETCDF.pro:

- open/read the NETCDF TOOCAN segmented images

example.pro

- a main program which plots a distribution of the MCS life duration, an evolution of the cold cloud shield of a given MCS along its life cycle.
- The program reads also the segmented images, plots the MCS trajectories and save the segmented images. You can select the region to be processed with the "iregion" variable.
- I also established smallest region boundaries than the boundaries of the processed regions into the "example.pro" code. It prevents MCS shapes and trajectories which can be affected if they occurred near the boundaries of the processed regions.

- To use the IDL codes you need to compile them with @setup.

Python codes

Load_TOOCAN.py:

- Read the tracking files produced by the TOOCAN algorithm and load the morphological parameters of each MCS into a data structure.

open_imsegTOOCAN_NETCDF.py:

- open/read the NETCDF TOOCAN segmented images

example.py

- a main program which plots a distribution and CDF of the MCS life duration, and the CDF of the maximum size reached by the MCSs.
- The program reads also the segmented images, plots the MCS trajectories and save the segmented images. You can select the region to be processed with the "iregion" variable.
- I also established smallest region boundaries than the boundaries of the processed regions into the "example.py" code. It prevents MCS shapes and trajectories which can be affected if they occurred near the boundaries of the processed regions.