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STATUS OF GSICS IMPLEMENTATION AT EUMETSAT

The working paper describes activities performed in EUMETSAT's GSICS Processing and Research Centre (GPRC) towards an efficient implementation and operation of the GSICS project.

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1 INTRODUCTION

In accordance with the implementation plan of the Global Space-Based Intercalibration System (GSICS) resulting from the proposal to CGMS 33 EUMETSAT has participated in a number of meetings to discuss the needs and activities to operate the GSICS Processing and Research Centre in the EUMETSAT headquarters in Darmstadt. First activities in the framework of the implementation plan have started and are described in this paper.

2 INTERCALIBRATION OF GEOSTATIONARY AND POLAR SYSTEMS

The operational EUMETSAT intercalibration activities have concentrated so far on the calibration of the current and past geostationary satellites (Meteosat First and Second Generation, MVIRI and SEVIRI instruments, resp.). This is based on intercalibration with the HIRS instruments, but first results from an intercalibration test with the newly available IASI data on Metop are available as well.

2.1 Operational Satellite Intercalibration

Routine operational satellite intercalibration between the Meteosat MVIRI instruments and the NOAA HIRS Instruments has been done for the infrared channels. This satellite intercalibration was performed following a manual procedure twice a week. The results have been published on the EUMESTAT web pages in graphical form as a time series of infrared calibration coefficients and of temperature differences (see Figure 1). Over time the structure of the relevant web pages has been improved.

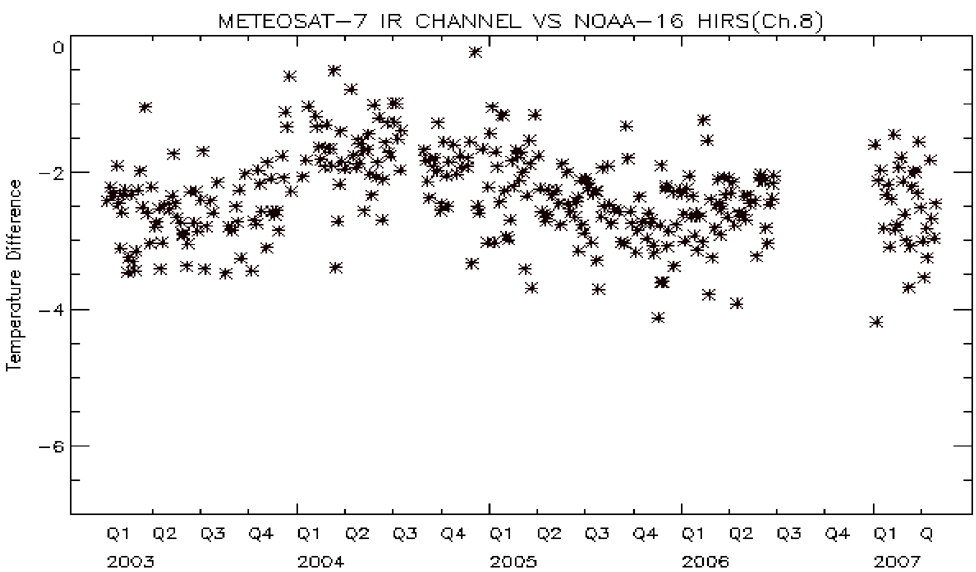

Figure 1: Temperature differences between the IR channel from Meteosat-7 and the NOAA-16 HIRS Channel 8for the period between 2003 and 2007.

The operational satellite intercalibration between the Meteosat SEVIRI instruments and the HIRS instruments onboard the NOAA and Metop satellites has been introduced operationally at the end of August 2007. The publication of the results on the EUMETSAT web pages will follow in early 2008. For the satellite intercalibration the following rules are applied to determine relevant collocations:

- Time delay between foreign satellite data and relevant Meteosat line is maximally 10 minutes
- Difference in viewing angle max. 5°
- Maximum viewing zenith angle 40°
- Minimally 98% cloud free pixels in search area (defined by the Meteosat cloud mask)
- Standard deviation of Meteosat pixel radiance in search area < 5%
- Number of valid calibration points per orbit/repeat cycle > 40
- Standard deviation of local calibration coefficients per orbit/repeat cycle < 10%

2.2 Planned Improvements

The satellite intercalibration between the various MVIRI and HIRS instruments will become part of the operational EUMETSAT meteorological product reprocessing environment. An improved prototype algorithm has already been designed and the initial testing has been completed. The following set of rules has been applied to this prototype version:

- The viewing angle difference between the instruments < 5 Degrees
- The time difference < 10 minutes
- The maximum viewing zenith angle is 50 Degrees
- The HIRS 3.78 µm brightness temperature > 290 K
- The maximum difference in counts between the Meteosat pixels in each HIRS pixel has to be less than 50 counts

The satellite intercalibration results for the test period show only a small difference between the operational and the prototype algorithm (see Figure 2).

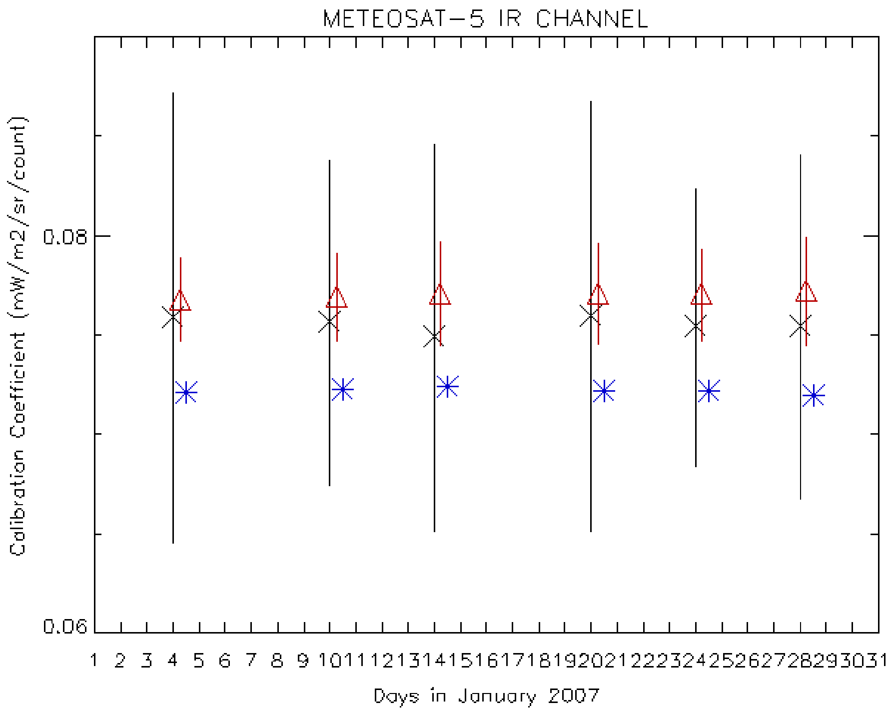

Figure 2: Comparison of the calibration coefficients for the IR channel from Meteosat-5 from the Operational Calibration (blue asterisks), the operational manual intercalibration (black crosses) and the prototype intercalibration (red triangles).

Within the automated satellite intercalibration it shall be possible to increase the number of intercalibration points drastically. In so far these initial results are very promising, as it is now possible to make the filter conditions more stringent, and thereby to decrease the variability between the individual intercalibration points. This can be noted already as a small increase in stability between the cross-calibration points can be seen in Figure 2.

It is intended to include the satellite intercalibration algorithm in EUMETSAT's reprocessing environment to be able to intercalibrate the MVIRI instruments of all Meteosat First Generation satellites with any available NOAA HIRS instrument. This will allow that the intercalibration can be repeated after every major algorithm update. Within the reprocessing environment another intercalibration algorithm is already being prototyped: the intercalibration between the various MVIRI instruments themselves. This intercalibration is a prerequisite for the generation of a homogenous calibrated long term image data set for all Meteosat First Generation satellites.

2.3 Intercalibration of MSG with the IASI Instrument – First Results

The Infrared Atmospheric Sounding Interferometer (IASI) onboard the Metop-A satellite provides a unique opportunity for satellite intercalibration of thermal infrared channels. IASI data fully cover the infrared spectrum between 645 cm^{-1} to 2745 cm^{-1} (corresponding to ~ 3.6 μm – 15.5 μm wavelengths) in a spectral resolution of 0.25 cm^{-1}.

The eight thermal infrared channels of the Meteosat Second Generation (MSG) SEVIRI instrument (Table 1) can be easily compared to the respective IASI data using a simple integration of the IASI hyper-spectral radiances over the MSG filter response function.

Channel	Centre (µm)	Range (µm)
IR3.9	3.92	3.48 – 4.36
WV6.2	6.25	5.35 – 7.15
WV7.3	7.35	6.85 – 7.85
IR8.7	8.70	8.30 – 9.10
IR9.7	9.66	9.38 – 9.94
IR10.8	10.8	9.80 – 11.80
IR12.0	12.0	11.00 – 13.00
IR13.4	13.4	12.40 – 14.40

Table 1: MSG SEVIRI spectral channels in the thermal infrared (SEVIRI = Spinning Enhanced Visible and Infrared imager)

The only channel which is not quite fully covered by IASI is the IR3.9 channel, where the shortwave end is outside the IASI spectral coverage (Fig. 3)

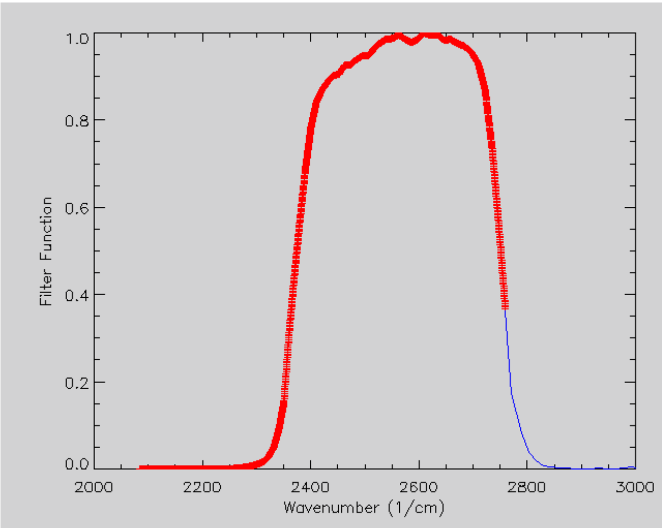

Figure 3: Spectral response function of MSG (blue) with overlaid IASI spectral observations (red) for IR3.9 – noticeable is the small lack of coverage beyond wave number 2745 cm^{-1} (or 3.65 µm wavelength), corresponding to 2% of the entire filter response

For the first comparisons here presented, 5 consecutive days between 27 April and 01 May 2007 were chosen: During this time, both MSG satellites Meteosat-8 and Meteosat-0 were in full earth disk scan mode, so that a comparison to both satellites could be performed.

For each day, one Metop evening orbit (equator crossing time in the ascending node is 21:30 LT) was chosen, as the south-north direction of Metop coincided with the south-north scan pattern of the MSG satellites. In addition, the following collocation criteria were applied:

1. Time collocation within 15 minutes
2. Viewing angle collocation within 2 degrees
3. Maximum viewing angle for either observation 15 degrees
4. The important spatial collocation was done by choosing 5 by 5 MSG pixels around the centre of a IASI field-of view, where the chosen 5 by 5 MSG field-of-view is always a little larger than an individual IASI pixel. The MSG brightness temperature standard deviation over the 5 by 5 pixels also had to be small (< 0.5 K) to ensure a homogenous area.

Figure 4 shows the 27 April constellation as an example, where the magenta lines show the limits due to the time and/or viewing angle constraints.

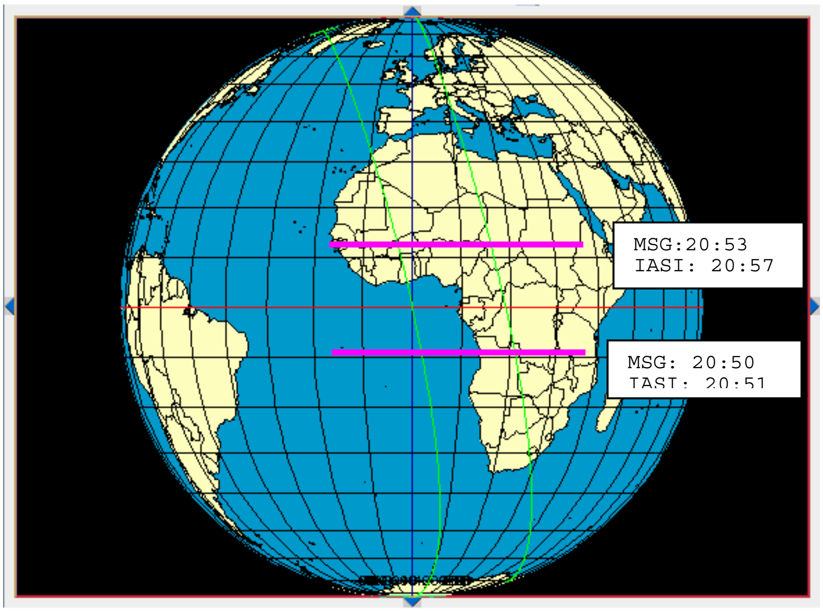

Figure 4: IASI coverage (green) on top of the MSG full earth view: IASI crossing times and respective MSG scan line times are given for two locations in the tropics (27 April 2007)

Figure 5 shows an example of the final intercalibration targets that passed the viewing angle difference and spatial coherence tests.

Figure 6 shows, again for the example of 27 April 2007, the intercalibration results as scatter plots of MSG – in this case Meteosat-8 – radiances, using the operational calibration, versus the "MSG-like" IASI radiances, i.e. the integral of the IASI spectral data over the respective MSG filter response curve. While the collocation data that have passed only the spatial and temporal tests (1 – 3 of above list of tests) still show some scatter (black points), the spatial coherence test (4) shows a high correlation between the MSG and the IASI observation in every channel (red points).

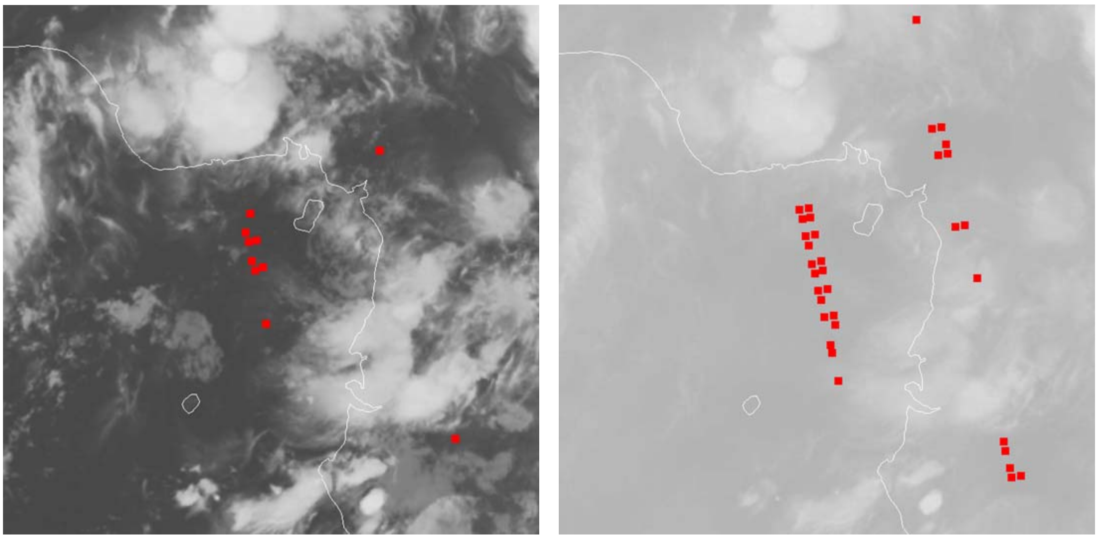

Figure 5: Final collocation targets which passed all the collocation criteria, for the IR108 channel (left) and the WV6.2 channel (right) – the higher number of collocations for WV6.2 is explained by the smoother radiance fields in this channel. Collocations were done separately for Meteosat-8 and Meteosat-9, but showed, as expected, practically no difference.

These "MSG-like" IASI radiance define an intercalibration coefficient, which for MSG is defined as

$$Radiance = offset + cal\_coefficient \bullet Count$$

with

Radiance:	radiance in physical unit mW/ster/m^2/cm^{-1}
offset:	radiometric offset of the instrument (constant value, taken from the MSG operational image processing)
cal_coefficient:	intercalibration coefficient
Count:	MSG raw value, a 10-bit number

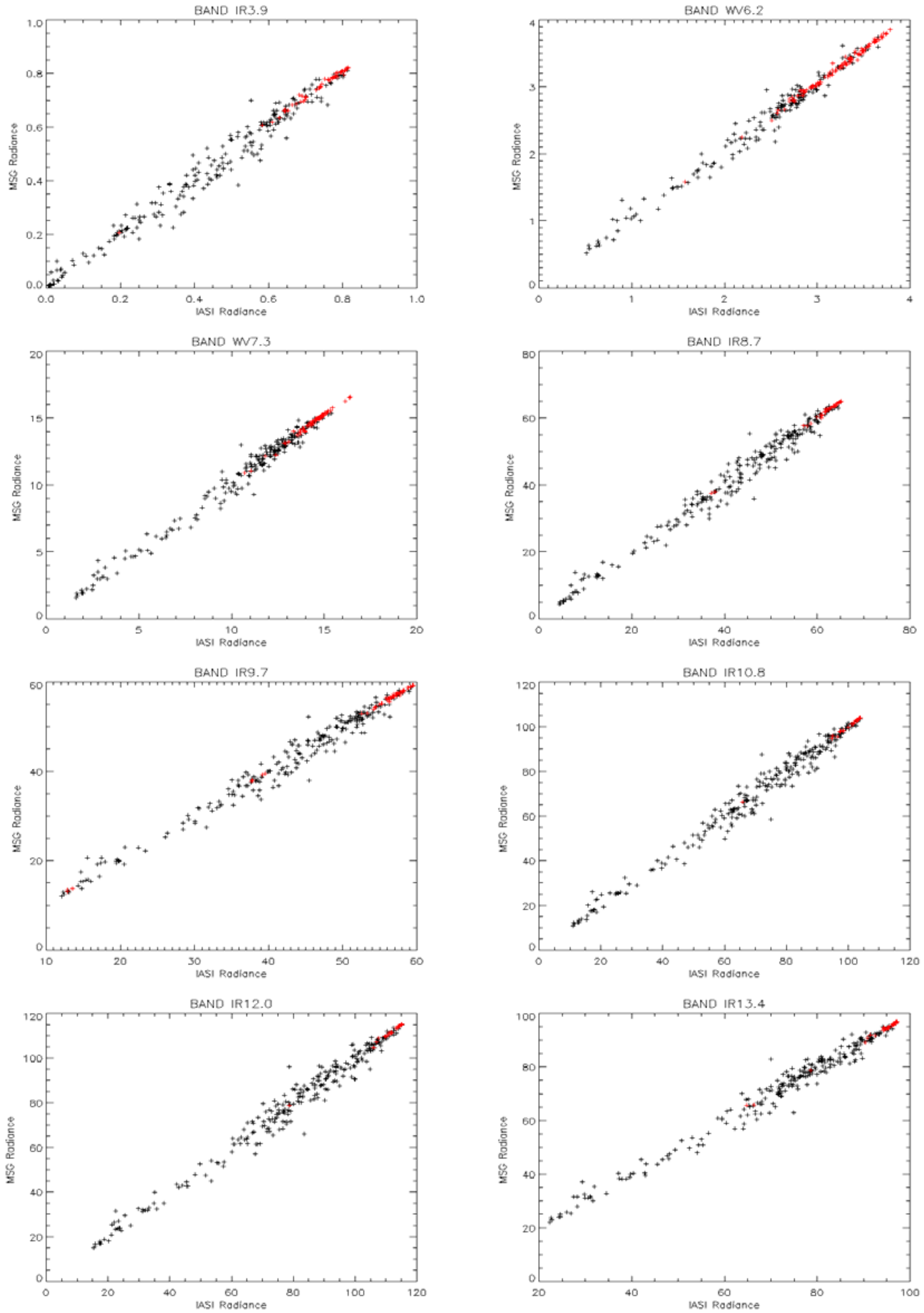

Figure 6: Example of the inte-comparison results: MSG radiances using the operational MSG calibration versus the IASI radiances, integrated over the respective MSG filter response function (27 April 20-07, Meteosat-8). Shown are the results for all geometrically possible collocations (black) and for the collocations of low temperature standard deviation (red). Only the red points are retained for the final intercalibration.

The first MSG-IASI intercalibration results are shown in Table 2 as a brightness temperature difference between these two instruments. These temperature differences refer to the given reference temperatures. The overall uncertainty of each of these values, due to radiometric resolution and linear fit of the calibration equation, is in the order of 0.1 – 0.2 K.

Channel	IASI – Meteosat-8	IASI – Meteosat-9	Reference Temperature
IR3.9*	-0.20	-0.13	300 K
WV6.2	-0.32	-0.48	250 K
WV7.3	-0.48	-0.11	250 K
IR8.7	+0.09	+0.15	300 K
IR9.7	+0.05	+0.16	255 K
IR10.8	+0.07	+0.08	300 K
IR12.0	+0.08	+0.07	300 K
IR13.4	+0.26	+1.67	270 K

Table 2: Average brightness temperature difference (in K) between IASI and the two Meteosat satellites for the eight MSG thermal channels. Results are the average over the processed consecutive 5 days in April/May 2007.
* the IR3.9 channel results were not corrected for the missing IASI overlap

Overall, the results show that the MSG calibration is always within 0.5 K, for the majority of channels even within 0.2 K. The only exception is the IR13.4 channel onboard Meteosat-9, which has a much larger temperature difference of almost 1.7 K. This result, however, was somewhat expected, as also the EUMETSAT internal radiance monitoring and the monitoring done by numerical weather prediction centres show a ~1.5 K discrepancy between the two Meteosats, which is confirmed by the IASI intercalibration results. This behaviour seems to be coupled with filter changes onboard Meteosat-9 following a sensor decontamination, and is currently under investigation by EUMETSAT. It should be noted that at least slight filter changes due to sensor ageing etc. are known effects on broad-band imaging instruments.

Based on the IR13.4 channel findings, the presented IASI – Meteosat inte-calibration technique could ultimately also serve to identify a “most appropriate” MSG filter for cases of such discrepancy.

Further progress of this intercalibration work in the near future will include:

- Application to the first generation Meteosats (Meteosat-6 and Meteosat-7)
- Application to the HIRS and AVHRR instruments onboard MetOp
- Check for consistent filter responses to explain larger discrepancies

3 IMPLEMENTATION OF THE DATA MANAGEMENT COMPONENT

In June 2007 the first meeting of the GSICS working group on Data Management was held in Darmstadt at the EUMETSAT headquarter. As a result a number of recommendations and actions to get an operational flow of intercalibration data and related information going were formulated.

3.1 Recommendations from GDWG-I

During the GDWG a number of recommendations which concern the GPRCs were formulated. Those which are of imminent importance for EUMETSAT were:

Once the GRWG has defined the co-location sub-area for each partner's data sets (for example, using spectral channel, time frequency, granules within a bounding box) EUMETSAT will store those datasets during the test and operational phases permanently, if affordable.

EUMETSAT will provide especially a permanent archive of collocated IASI and AVHRR data. This is relevant as the global AVHRR data stored in the EUMETSAT archive are of 1 km pixel resolution.

For the initial implementation of these collection centres, EUMETSAT will set up an FTP server to store and mirror all GSICS partner co-location data. This can be considered as a vital part of the GCC implementation.

In addition EUMETSAT has started to define the metadata and common catalogue schemes for the GSICS datasets.

An initial static set of GEO/LEO data sets covering a 1-month period will be provided by NOAA/NESDIS and EUMETSAT on the federated FTP servers for GSICS benchmark processing. The intercalibration results from these data sets shall be made available to GSICS partners and discussed in a subsequent meeting in 2008.

It was agreed that HDF5 shall be used initially as the format for these co-location data sets. This format is compatible with tools such as OPeNDAP, NetCDF and IDV. Once NetCDF 4 is validated, data will then be provided in this format.

3.2 Fist steps towards EUMETSAT FTP server setup

The GSICS Data and Products Server will receive datasets for the storage of intercalibration products from the GSICS partners. A source data organiser process will distribute these data sets into directories scanned by a THREDDS Data Server (TDS). The TDS provides an automated mechanism for extracting metadata information from known data sets. This information together with links to the actual datasets themselves is presented by the TDS via a tomcat web server in form of simple web pages for users to view and download.

Users of these data sets are envisaged to be GSICS partners (especially the Regional Satellite Specialised Centre (RSSC) for Climate monitoring), scientists and interested parties such as experts not directly associated with GSICS (e.g. Universities). These users are expected to create products based on the GSICS datasets. If relevant, some of the derived products can be uploaded back onto the GSICS Data and Products Server via a dedicated product and metadata client process.

Each product shall be accompanied by a metadata file providing a description of the product. Both files will be ingested into EUMETAT'S ARCHIVE. If the product format is known by the TDS, it can be viewed and downloaded in the same manner as the source datasets.

A housekeeping process periodically checks the resource status of the server and removes any obsolete data sets found.

4 CONCLUSIONS

CGMS is invited to take note of the GSCIS implementation status within the EUMETSAT GRPS and to comment accordingly.