CGMS

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Prepared by EUMETSAT
Agenda Item: 2.3
WGIII/2.3 and Plenary
G.4.2
Discussed in WGIII and Plenary

INDIAN OCEAN DATA COVERAGE (IODC) - CGMS ROADMAP

In response to CGMS actions/recommendations:

EUM WGIII/2.2 41.38:
EUMETSAT to initiate the dialogue with ISRO, ROSHYDROMET, CMA, and other interested partners to investigate a medium-term strategy for ensuring coverage of the Indian Ocean coverage with advanced geostationary imagery.

WMO, CMA, EUM, ROSH, ISRO WGIII/2.2 A42.01
WMO to initiate a dialogue with Indian Ocean satellite operators and clarify which data are essential in the sense of Resolution 40, in view of the meteorological requirements in the region.

EUM, ISRO WGIII/2.2 A42.02
EUMETSAT and ISRO will address the technical issues to accommodate high-resolution half-hourly data from INSAT-3D on dissemination means.

In this paper, EUMETSAT proposes a way forward for the provision of Indian Ocean Data Coverage (Services) after reorbiting of Meteosat-7 in 2017, based on the analysis of the current status of CGMS partner satellite systems (CMA, EUM, ISRO and ROSHYDROMET) in the region.

The combination of satellites and services should lead to an overall resilient multi-partner IODC service, for which a requirements baseline has been agreed at CGMS-42.

The paper proposes a scenario and roadmap for approval by the CGMS partners contributing to future IODC services.

Action proposed: CGMS is invited to endorse the proposed CGMS IODC roadmap and timeline with associated actions (as described in CGMS-43 EUM-WP-14).

Indian Ocean Data Coverage (IODC) - CGMS Roadmap

1 INTRODUCTION

This paper proposes a scenario with timeline for approval by CGMS for the future provision of Indian Ocean Data Coverage (Services) once Meteosat-7 reaches its End-of-Life in March 2017 with the re-orbiting of the satellite to follow in April/May 2017.

The paper gives updated information of CGMS partner satellites and services that was presented in the paper EUM-WP-26 'Roadmap for the future provision of Indian Ocean Data Coverage (IODC) services' presented at CGMS-42.

The aim of the proposal described in this document is to provide a resilient multi-partners IODC service in the region, which fulfils the baseline requirements agreed at CGMS-42.

The paper also presents the EUMETSAT best effort contribution to the overall IODC services, which includes the proposal to relocate Meteosat-8 at 40° E after successful MSG-4 launch and commissioning.

This document is also the response to the following actions:

EUM WGIII/2.2 41.38:
EUMETSAT to initiate the dialogue with ISRO, ROSHYDROMET, CMA, and other interested partners to investigate a medium-term strategy for ensuring coverage of the Indian Ocean coverage with advanced geostationary imagery.

WMO, CMA, EUM, ROSH, ISRO WGIII/2.2 A42.01
WMO to initiate a dialogue with Indian Ocean satellite operators and clarify which data are essential in the sense of Resolution 40, in view of the meteorological requirements in the region.

EUM, ISRO WGIII/2.2 A42.02
EUMETSAT and ISRO will address the technical issues to accommodate high-resolution half-hourly data from INSAT-3D on dissemination means.

In addition the following action is also relevant:

WMO WGIII/2.2 A42.03
WMO to consider sending a request to CMA for moving an FY-2 spacecraft over the Indian Ocean after successful launch and commissioning of FY-2G. (CGMSSEC Dec '14: Action slightly amended from "WMO to consider sending a request to CMA for moving FY-2D over the Indian Ocean after successful launch and commissioning of FY-2G."). This will be considered after launch of FY-2G. FY-2G was successfully launched on 31/12/2014.

1.1 Background

Indian Ocean Data Coverage (IODC) by EUMETSAT is a best effort undertaking which reflects a decision of the EUMETSAT Council to use a residual Meteosat First Generation capacity for this purpose, in the context of a temporary data gap over the Indian Ocean.

Meteosat-7, the last satellite of the Meteosat First Generation, will reach its End-of-Life in March 2017 with the re-orbiting of the satellite to follow in April/May 2017, thereby ending the agreed best-effort support to IODC by EUMETSAT.

The paper starts by presenting the current IODC services and the agreed requirements for future IODC services.

Then, the capabilities of the CGMS partner's satellites and services in the region that may be available in 2017 and beyond are presented, followed by a detailed assessment of each system. This detailed assessment considers:

- Image acquisition schedule and scan pattern;
- Instrument performance;
- Image and product data access and redistribution;
- Product formats;
- Data Collection Systems.

The information is based on inputs received during the Intercessional period.

Annex I contains a table with detailed information concerning CGMS Satellites IODC Image and Products.

2 CURRENT IODC SERVICE AND REQUIREMENTS

2.1 Meteosat-7 IODC Services

Meteosat-7 was launched on 2 September 1997 and has been providing Indian Ocean Data Coverage (IODC) service at 57.5°E since 5 December 2006. The end-of-life of the spacecraft is in April 2017 with the re-orbiting in May 2017.

Meteosat-7 provides several services in the region:

Imaging

- Meteosat-7 takes a full Earth disc image in three spectral channels (Visible (VIS), Infra-Red (IR) and Water Vapour (WV)) every 30 minutes;
- The pixel resolution at the sub-satellite point is: 2.5 km VIS (using both VIS detectors); 5.0 km IR and WV.

Products

- The main meteorological products generated in Near-Real-Time (NRT) are Atmospheric Motion Vectors (AMV), Upper-Tropospheric humidity (UTH), Clear-Sky Radiances (CSR), All-Sky Radiances (ASR), Multisensor Precipitation Estimate (MPE), Cloud Analysis (CLA) and Cloud Mask (CLM);

- Of these, the AMV and CSR are currently assimilated by several numerical prediction centres operationally and the quality is monitored on an operational basis by the NWP SAF and early studies, performed by ECMWF, demonstrated the benefits of this data for their model;

- In addition, EUMETSAT IODC service supports other international activities like SCOPE-CM and is also the prime source of geostationary data in this region supporting also ISCCP (International Satellite Cloud Climatology Project).

Data Collection Systems

- 5 Indian Ocean Tsunami Warning Systems (IOTWS) networks are supported (Indonesia 12, Maldives 3, Burma 2, Sri Lanka 1 and Philippines 3) – 21 DCPs in total;

- Hydrology/Met stations - 129 stations: Sri Lanka 122 and Bhutan 5 – 127 DCPs in total;

- Capability for HRDCPs (1200bps) has been added to the Meteosat-7 system, but no DCPs allocated yet.

Dissemination

- Images, Products and DCP messages are variously disseminated on EUMETCast to Europe and Africa and Americas;

- Distribution of data also directly to NOAA;

- DCP bulletins disseminated on the GTS.

2.2 IODC User Requirements

The following user requirements for the IODC services were agreed at CGMS-42:

Imaging

- Coverage: Full Earth
- Bands: (Visible (VIS), Infra-Red (IR) and Water Vapour (WV)
- Resolution : 2.5 km VIS (using both VIS detectors); 5.0 km IR and WV
- Repetition rate: every 30 minutes

Products

- Atmospheric Motion Vectors (AMV)
- Clear-Sky Radiances (CSR)

Image and Product Data Distribution

- NRT Data Distribution of L1.5 images and L2 Products

Image and Product Data Policy

- Complies with WMO Resolution 40 (Cg-XII)

DCS

- Access (Data Policy): Free for environmental use
- Data Rates (Capacity): 100 bps
- Data distribution: NRT via GTS and Internet

3 SATELLITE OPERATORS IN THE INDIAN OCEAN REGION

The following tables list the satellites which are and may be in operations in the Indian Ocean region (defined by CGMS as 36°E – 108°E) in the timeframe 2014 – 2017 and beyond.

3.1 Satellites in orbit

Satellite	Longitude	Operator	Launch date	Projected EOL
Meteosat-7	57.5°E	EUMETSAT	02/09/1997	Q1 2017
Meteosat-8	3.5°E #	EUMETSAT	28/08/2002	2020
Elektro-L N1	76°E	Roshydromet	20/01/2011	≥ 2021
INSAT-3A	93.5°E	ISRO	04/10/2003	≥ 2015
INSAT-3D	82°E	ISRO	25/07/2013	≥ 2021
FY-2D	86.5°E	CMA	15/11/2006	≥ 2015
FY-2E	105°E*	CMA	19/10/2004	≥ 2017
FY-2G	99.5°E**	CMA	30/12/2014	≥ 2018

Potential relocation from 3.5°E to 40°E, subject to decision of the EUMETSAT Council

After the successful commissioning of FY2-G:

* FY-2E will be relocated from 105°E to 86.5°E
** FY-2G will be relocated from 99.5°E to 105.5°E

Note: for completeness FY-2F is located at 112.5°E.

3.2 Future Satellites

Satellite	Longitude	Operator	Launch date	Projected EOL
Elektro-L N2	77.8°E	Roshydromet	≥ 2015	≥ 2022
INSAT-3DR (Repeat)	74°E	ISRO	≥ 2015	≥ 2023
INSAT-3DS (Spare)	74°E	ISRO	≥ 2022	≥ 2029
FY-2H	86.5°E (TBC)	CMA	≥ 2016	≥ 2020
FY-4A	86.5°E (TBC)	CMA	≥ 2016	≥ 2022
FY-4B	105°E (TBC)	CMA	≥ 2018	≥ 2022
FY-4C	86.5°E (TBC)	CMA	≥ 2020	≥ 2022

All data taken from: http://www.wmo.int/pages/prog/sat/satellitestatus.php

4 ASSESSMENT BY EUMETSAT OF POTENTIAL CONTRIBUTIONS TO IODC SERVICES FROM PARTNERS

4.1 Roshydromet

4.1.1 Images and Products

The ROSHYDROMET's Elektro-L N1 system is located around 20 degrees further east than Meteosat-7, at 76°E with both the space and ground segments are in place. Elektro-L N1 provides full disk imagery at 30 minute intervals in 10 infrared and visible channels at a resolution of 4 km (IR channels) and 1 km (VIS channel), however, the overall performance of the satellite images and products in terms of quality, availability and timeliness is that of an experimental satellite, and not comparable to Meteosat-7.

Sample level 1.5 HRIT image files have been made available to EUMETSAT by ROSHYDROMET – these have also been made available to Member States' NMSs. An initial analysis of the image channels shows that some channels are badly affected by noise, also confirmed by ROSHYDROMET. No higher level products are available operationally and they are also not monitored by global NWP centers or the EUMETSAT NWP SAF (Satellite Application Facility).

A trial Elektro-L HRIT service on EUMETCast was started in August 2011 to allow an evaluation of the usefulness of the data to be made by EUMETSAT Member States, however at the time of writing, Elektro L-N1 data is only intermittently available due to an ongoing satellite anomaly.

4.1.2 Data Collection Services

Information concerning the Data Collection Service operated by Roshydromet is presented in Annex II.

The DCS is fully functional using Elektro-L N1.

Roshydromet is ready to provide WMO members with the international channels for data transmission from DCPs via Electro-L N1 if required.

Information concerning how to allocate DCPs and how to access DCP data outside Russia is not yet available. It should be noted that DCP messages are not currently distributed on the GTS. ROSHYDROMET has indicated its willingness in adding the data on the GTS should it be required.

4.2 ISRO

4.2.1 Images and Products

INSAT 3D at 82°E was launched in July 2013. Sample images and also sample L1b data (counts, radiances, temperatures, albedos, SST) have been made available to EUMETSAT for assessment. The preliminary results are very favourable. The L1B data are well laid out in HDF and easy to read with good metadata, with full explicit geo-location, the data size is about 420MB per image cycle. Additionally L1C data are available ~90 MB in HDF5, with projection details (50N to 50S, 20E to 150E). The SST is also in HDF and covers the Indian Ocean, the Arabian Gulf, the South China Sea, etc. INSAT-3D AMVs are available on the GTS.

Off-line AMV passive monitoring at ECMWF was introduced from October 2014, and there are plans to include this in the operational monitoring. ECMWF state that AMV quality looks promising. The monitoring statistics are generally in line with what is seen for other GEO satellites. Some open issues remain, which have been passed to IMD.

There are some issues with the provision of the data that should be solved before actual use of the data can be considered:

- provide more meaningful quality control information;
- separate cloudy and clear-sky water vapour AMVs;
- use correct computational method in the BUFR file;
- understand why and when a limit of 1000 observations/channel/time is applied.

4.2.2 Data Collection Services

Information concerning the Data Collection Service operated by ISRO is presented in Annex II.

INSAT 3A currently supports the DCS.

ISRO have agreed to the possible use of the INSAT DCS by WMO members if required, however it should be noted that the ISRO System does not support 100 bps DCPs, which transmit via Meteosat-7.

4.3 CMA

4.3.1 Images and Products

The FY-2D and 2E satellites currently provide full disk images every half an hour in five channels (Vis at 1.24 km all infrared (IR) shortwave IR, water vapour and two split window at 5 km). These images are received at EUMETSAT and disseminated via EUMETCast.

For FY-2E located at 105°E, coverage of the Indian Ocean region is not comparable to that provided by Meteosat-7 and not focused on the same area of interest. FY-2D at 86.5°E provides better coverage of the Indian Ocean region but is 30 degrees to the east of Meteosat-7. The flow of FY2-D and FY2-E image data and products to EUMETSAT is reliable and is simple in terms of configuration leading to a service of high availability.

The FY-2D imagery has been reported to have significant straylight problems affecting the FY-2D image and product quality. This was confirmed at bilateral meetings with CMA, where CMA also stated that the water-vapour channel spectral response function was not well characterized pre-launch. Therefore, it is not possible to generate clear-sky radiance products from this satellite. The water-vapour channel issues, combined with the straylight effects have rendered the FY-2D AMVs unusable for global NWP data assimilation.

These observations are in line with the results of the EUMETSAT NWP SAF and global NWP centres satellite-derived wind-speed and radiance product monitoring. This site shows the results of product comparisons routinely generated for any satellite operator that makes the products available to the global community.

The following URL provides a link to the NWP SAF AMV monitoring as well as to the monitoring provided by some other NWP centres:

http://research.metoffice.gov.uk/research/interproj/nwpsaf/monitoring.html

CMA is planning to replace FY-2D with FY-2E, following the successful launch and commissioning of FY2-G in 2015.

4.3.2 Data Collection Services

Information concerning the Data Collection Service operated by CMA is presented in Annex II.

CMA operates the DCS on FY-2E at 105°. CMA also confirmed that the international channels can be used by international users if required. The DCS would need to be operated via the satellite at 86.5°E if it were to be a replacement for the current Meteosat-7 service. Additionally further information is required concerning the allocation process and the DCP data distribution mechanisms.

4.4 Satellite product usage at ECMWF

The following table shows the usage of the data (AMV, CSR) from satellites in the region by the European Centre for Medium-range Weather Forecasts (ECMWF).

Provider	Satellite	Radiances monitored	Radiances assimilated	AMVs monitored	AMVs assimilated
CMA	FY-2D/2E	No	No	Yes	no
Roshydromet	Elektro-L N1	No	No	No	No
ISRO	INSAT-3D	No	No	Yes	No
EUMETSAT	Meteosat-7	Yes	Yes	Yes	Yes

There is no experience on the ROSHYDROMET products as Elektro-L N1 is currently not imaging.

The CMA FY-2E Atmospheric Motion Vectors have been assimilated experimentally. Regarding the ISRO INSAT-3D AMVs, initial indications are that the winds are of good quality.

Regarding inter-calibration with other satellites, the Global Space based Inter-Calibration System (GSICS) is the forum where these activities are developed.

A summary of the capabilities of the main CGMS partner satellite systems is contained in Annex I and II, these tables were updated during CGMS-42. These tables and the table in Section 3 have also been distributed to partners prior to CGMS-43. It is expected that the information contained in the tables will also be consolidated during the Working Group III meeting.

5 POSSIBLE EUMETSAT CONTRIBUTION TO CONTINUATION OF IODC SERVICES

Based on the EUMETSAT analysis of the CGMS partners' capacities presented in section 4 and on bilateral discussions held with international partners, EUMETSAT presented a possible scenario for the continuation of the IODC services beyond 2016 to its Council in November 2014.

This scenario would be to rely in the future on the operational capability provided by ISRO (INSAT-3D at 82°E and INSAT-3DR / DS at 74°E) and by CMA (FY-2E and follow-on at 86.5°E). Such a constellation would become available by the end of 2015,

once FY-2E has been repositioned at 86.5°E. Once Elektro-L N2 is launched and successfully commissioned, this could also be added to the overall constellation.

In addition, in the 2016 timeframe, Meteosat-8 might be repositioned around 40°E, to support the acquisition of images in the Western part of the Indian Ocean. This intermediate position would overlap with other satellites, maximising opportunities of cross-calibration, and increasing the robustness/resilience of the IODC mission thanks to international cooperation.

Should Meteosat-8 be relocated to 40°E, then the DCS, currently using Meteosat-7 could easily be moved to Meteosat-8.

The EUMETSAT Council agreed that EUMETSAT further study the relocation of Meteosat-8 to 40°E, with the understanding that this would only be decided if and when MSG-4 has been successfully launched and commissioned and if, at that time, the remaining Meteosat satellites are capable of supporting the EUMETSAT Baseline operational services. In the nominal MSG-4 schedule, such a decision by the EUMETSAT Council can be expected in June 2016.

6 PROPOSED CGMS IODC SCENARIO AND TIMELINE

Based on the above, EUMETSAT is proposing to CGMS a scenario and a timeline for IODC services after 2016 with associated actions. This scenario is proposed for endorsement under the following assumptions.

Assumptions:

- FY2-G is successfully commissioned in 2015
- MSG-4 is successfully launched and commissioned in 2015
- EUMETSAT Council approves the relocation of Meteosat-8 to 40°E in 2016
- Elektro-L N2 is successfully launched and commissioned in 2015

Proposed scenario

Satellite	Location	Image	Products	DCS
Meteosat-8	40°E	Yes	Yes	Yes (International)
INSAT 3D	74°E	Yes	Yes	Yes (regional)
Elektro-L N2	77.8°E	Yes	Yes	Yes (regional)
FY2-E	86.5°E	Yes	Yes	Yes (regional)

Dissemination of CGMS Satellite data and products via EUMETCast and the GTS. Further Meteosat-8 data access mechanisms for CGMS partners will be discussed during the WG III meeting.

Proposed timeline

2015

- EUMETSAT to disseminate INSAT-3D images and products via EUMETCast
- CMA to relocate FY2-E to 86.5°E and commence an operational service
- EUMETSAT to disseminate FY2-E images and products from 86.5°E via EUMETCast

2016

- EUMETSAT relocate Meteosat-8 to 40°E
- EUMETSAT commence a Meteosat-8 operational service including images and products via EUMETCast
- Roshydromet commence an Elektro-L N2 operational service
- EUMETSAT to disseminate Elektro-L N2 images and products via EUMETCast

The timeline and actions will be reviewed between CGMS-43 and CGMS-44, with an update presented to the CGMS-44 Plenary in June 2016.

7 CONCLUSION

CGMS is invited to endorse the proposed CGMS IODC roadmap and timeline with associated actions (as described in CGMS-43 EUM-WP-14).

ANNEX I – CGMS SATELLITES IODC IMAGE AND PRODUCTS

Satellite	Imaging coverage	Channel central wavelength (μm)	Resolution (SSP)	Repeat Cycle	Products	Quality	NRT Data Access	Data Policy
Meteosat-7	Full disc	0.7 6.4 11	2.5 Km 5.0 Km 5.0 Km	Every 30 minutes	AMV CSR ASR UTH CLA CLM MPE		EUMETCast	Essential Data free Licence for other data
Meteosat-8	Full disc	0.6 0.8 1.6 3.9 6.2 7.3 8.7 9.7 10.8 12.0 13.4 Broadband (0.4 – 1.1)	3.0 Km 3.0 Km 3.0 Km 3.0 Km 3.0 Km 3.0 Km 3.0 Km 3.0 Km 3.0 Km 3.0 Km 3.0 Km 1.0 Km	Every 15 minutes	AMV CSR ASR TH CLA CLM CTH MPE SCE TOZ AFM VAD		EUMETCast	Essential Data free Licence for other data
Elektro N L1/2	Full disc	0.57 0.72 0.86	1.0 Km 1.0 Km 1.0 Km	Every 30 minutes	–		EUMETCast*	Essential Data free

Satellite	Imaging coverage	Channel central wavelength (μm)	Resolution (SSP)	Repeat Cycle	Products	Quality	NRT Data Access	Data Policy
		3.75 6.35 8.0 8.7 9.7 10.7 11.7	4.0 Km 4.0 Km 4.0 Km 4.0 Km 4.0 Km 4.0 Km 4.0 Km				* Currently unavailable, due to on board anomaly (till the further notice).	
INSAT 3D	Full disc (Imager) Sounder	0.65 1.63 3.9 6.8 10.8 12 1 Visible 18 IR Channel	1.0 Km 1.0 Km 4.0 KM 8.0 Km 4.0 Km 4.0 Km 10 Km	Every 30 minutes Every 60 Minutes - 5 Regions over INDIA and 1 Region in INDIAN OCEAN	AMV OLR UTH QPE SST FOG AEROSOL Temp, Humidity & Ozone Profiles		IMD MOSDAC IMD MOSDAC	Registered User Registered User
FY2-F	Full disc	0.77 3.75 6.95 10.8 12.0	1.25 KM 1.5 KM 5 KM 5 KM 5 KM	Every 30 minutes	AMV UTH OLR PRE TBB SST ….			Essential data free Bilateral agreement for other data

ANNEX II – DATA COLLECTION SYSTEMS

Satellite	Location	Transmission Rate	TX method	Band (MHz)	Data Distribution	Data Policy	Platforms allocated
Meteosat-7	57.5°E	• 100 bps • 1200 bps (Capability, no platforms allocated)	• Self-timed • Alert • Hybrid (Self-timed and Alert	Regional 402.0025 – 402.0325 International 402.0355 – 402.0655	• EUMETCast • GTS • Internet	Free for Environmental use for EUMETSAT Member States and WMO Members	150
Elektro N L1	76°E	• 100 bps • 1200 bps (260 platforms allocated)	• Self-timed • Alert • Hybrid (Self-timed and Alert)	Regional 401.5 – 402.5 International 402.0 – 402.1*	• E-mail transmission service (regional users) • GTS (TBD)	Free for WMO Members	531
INSAT 3D	82°E	• 2400 bps • 4800 bps?	• Self-timed • TBD	402.75 – 402.93	• GTS • Internet	Registered Users in India	About 1100 AWS Stations deployed by ISRO & IMD
FY2-D FY2-E	86.5°E 105°E	• 100 bps • 600 bps (FY2-E onwards)	• Self-timed • Alert • Hybrid (Self-timed and Alert)	Regional 401.1 – 401.4 International 402.0 – 402.1*	• Internet • GTS • CMACast	Free for Environmental use for WMO Members	No 100 bps 400 DCP on regional channels 600 bps

ANNEX III - ANALYSIS OF METEOSAT-8 CAPACITY TO BE OPERATED AT 40°E

1. Orbital Slot Availability

A preliminary investigation has been carried out to identify a potential slot in the in the orbital arc around 40 ºE. This investigation has indicated that the 40°E longitude is currently free, although it is noted that this longitude was occupied until August 2013 by the Russian “EXPRESS AM-1” satellite. The satellite had a serious anomaly during 2010, preventing it to perform inclination control from then on. From September 2013 it results to be re-orbited at around 300 km above GEO.

If a follow on of “EXPRESS” is planned, then the longitude of to 41.5°E would be an appropriate backup longitude for Meteosat-8.

A recent Radio-Frequency survey has been performed by Leeheim Satellite Monitoring Station of the German Federal Network Agency (BNetzA) and no RF signals were detected on the relevant frequencies from geostationary satellites around the identified orbital location.

This can be repeated in due course to ensure the availability of the selected slot.

2. Fuel Budget

The fuel consumption for the Meteosat-8 relocation depends on the drift rate and not on the targeted longitude. The relocation “corridor” has to be sufficiently far from the geostationary ring to avoid collision risks with the satellites of the other operators, but a large distance from the geostationary ring also implies a fast drift rate which, in turn, is more demanding in terms of fuel. Following a trade off on fuel consumption and collision risk, a distance above 30 km from the geostationary altitude has been selected which corresponds to an average S/C drift rate of 0.47º/day, fully in line with previous relocations for which a drift rate of approximately 0.5º/day was used.

The following table gives a preliminary assessment of the fuel lifetime for the Meteosat-8 contribution to IODC from the longitude of 40ºE.

	IODC at 40ºE
Relocation Drift Rate	0.47 deg/day
Relocation Fuel consumption	1.2 kg
Relocation Duration	77 days
Start of relocation	Q3 2016
Expected end of life (*)	April 2020
Time at IODC (*)	3.6 years
EOL Orbit Inclination at End Of Life	6.5 deg

*It assumes a Fuel Reserve of 26.8 kg.

3. Earth View Angle

The following figure gives an overview of the Earth as observed from 40ºE.

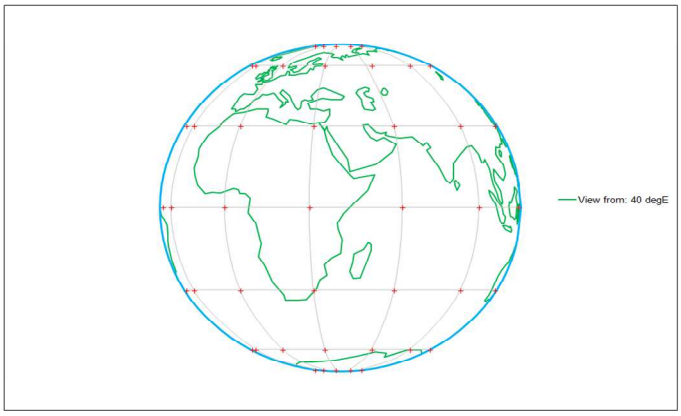

Figure 1: Earth View from 40ºE

4. Product extraction, product comparison and inter-calibration

The Meteorological Product Extraction Facility (MPEF) is able to cope with a new sub-satellite position, provided that the correct background maps are available. The new products would need some validation effort and some local tuning may be necessary. The following areas are expected to need product processing adaptation for Meteosat-8 operations at 40ºE:

- Surface type map;
- Surface emissivity map;
- Distance to coast map;
- Elevation map.

These background maps need to be created for any new rectification longitude, irrespective of the sub-satellite longitude.

The following figure gives an indication of the image area overlap between Meteosat-8 at 40ºE and Meteosat-10 at 0º. It should be noted that in the figure below and in the rest of the document the “orange” line shows the eastern edge of the overlap for the Meteosat-8 position at 40ºE and the “red” line represents the 60° great circle arc from where the meteorological product are generally extracted.

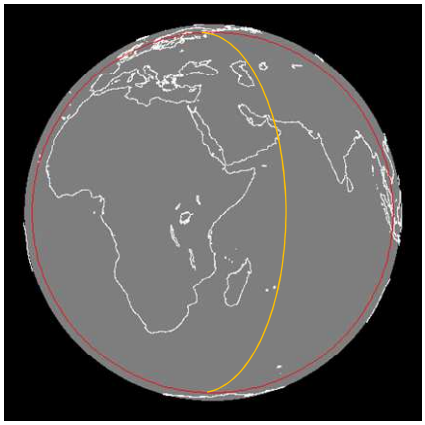

Figure 2: Image Overlap Area between Meteosat-8 at 40ºE and Meteosat-10 at 0º

The overlap area between Meteosat-10 and Meteosat-8 is large enough to allow extensive comparisons for all products.

In terms of other operators in the IODC region and the possible product comparison, the following figure gives the other potential candidates and the overlap area with Meteosat-8 at 40ºE:

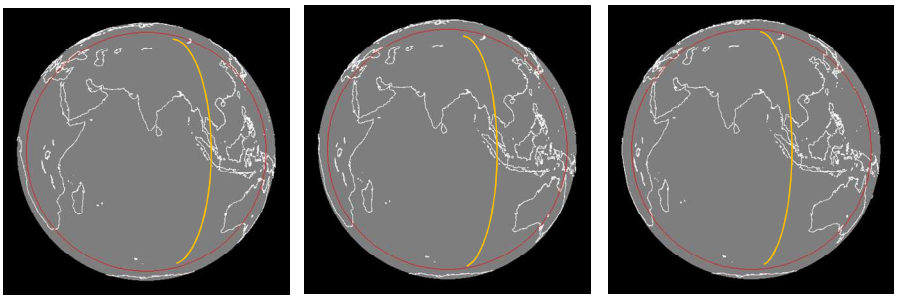

Figure 3: Image Overlap Area between Meteosat-8 at 40ºE and other satellites

From a preliminary analysis it also appears necessary to characterise the angular effects on the VIS/NIR calibration during the Meteosat-8 relocation.

5. Data Collection Platforms (DCP)

The following figure gives the DCP distribution over the Indian Ocean

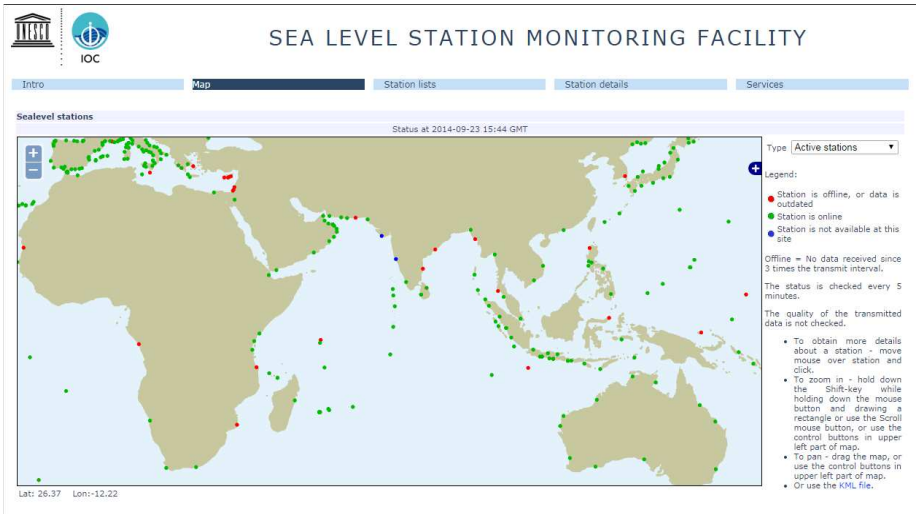

Figure 4: DCP distribution for IODC

Most of the DCPs allocated to Meteosat-7 at 57.5ºE could be re-allocated to Meteosat-8 at 40ºE. Some of the DCPs at the eastern edge of the Indian Ocean are already being received by MTSAT/Himawari-8 as it also supports the international DCP channels used by the Indian Ocean Tsunami Warning System (IOTWS).