CGMS-42 EUM-WP-02
v1, 23 April 2014

Prepared by EUMETSAT
Agenda Item: C.4
Discussed in Plenary

# BENEFITS OF INFRARED SOUNDING MISSIONS FOR NOWCASTING PURPOSES

This paper reports on the outcome of the Workshop on Nowcasting Applications using MTG-IRS, which was held at EUMETSAT, Darmstadt on 25-26 July 2013.

The objectives of the workshop were twofold: to provide the user community information about what was planned by the Meteosat Third Generation (MTG) Programme, as the MTG Infrared Sounder (IRS) is a new instrument with relatively little heritage, and to explore with the user the potential use and benefits of the IRS data and products. Although the development has progressed very well, several key elements are still open. The discussion during the workshop provided insight on a way forward to close selected open issues. It was noted that the launch of a hyperspectral infrared sounder in geostationary orbit by EUMETSAT fulfils a longstanding dream by many users and scientists for a long time and presents a significant step forward in geostationary satellite observation techniques.

Action/Recommendation proposed: CGMS is invited to capitalise on the experiences from this workshop and to consider exploring and providing feedback to EUMETSAT on the available case studies.

# Benefits of Infrared Sounding Missions for Nowcasting Purposes

## Summary Outcome of the Workshop on NWC Applications using MTG-IRS (EUM/MTG/MIN/13/716610)

# Summary outcome of the Workshop on NWC Applications using MTG-IRS

**EUMETSAT HQ**
**Darmstadt**
***25 – 26 July 2013***

Doc.No. : EUM/MTG/MIN/13/716610
Issue : v1B
Date : 2 September 2013
WBS :

EUMETSAT
Eumetsat-Allee 1, D-64295 Darmstadt, Germany
Tel: +49 6151 807-7
Fax: +49 6151 807 555
http://www.eumetsat.int

# *Table of Contents*



## 1 SUMMARY OF THE MEETING

### 1.1 Opening of the meeting

On behalf of A. Ratier (EUMETSAT Director General) and S. Rota (Associate Director of GEO programme) who both were not able to participate because of other commitments, the workshop was opened by L. de la Taille (Deputy MTG Programme manager). In his welcome words he thanked the participants for their willingness to spend two days in Darmstadt during the summer holiday period to discuss the potential of using MTG-IRS data and products for nowcasting applications. He reminded the participants that the timing of this workshop is very appropriate as the MTG programme is in a new phase. Several MTG programme components successfully passed their preliminary design reviews, the procurement of the ground segment has started, with the signature of the mission operation facility contract in due time, the conclusion of the contract negotiations for the instrument data processing facility in September – October time frame, and the procurement started for the launching services. He closed by emphasising that this workshop is only the beginning. Further iterations with this group as representatives of the NWC community are required to get the best and earliest return of investment to the EUMETSAT Member States.

The participants were further welcomed by the workshop co-chairs H. Roquet and P. Menzel. According to H. Roquet the workshop illustrates the needed close link between the scientific and user communities during the development of a new satellite programme. The objectives of the workshop are twofold: to provide the user community information about what is planned at Programme level, as MTG-IRS is a new instrument with relatively little heritage, and to exchange information from the user community to EUMETSAT on the potential use of the satellite data and products. Although the development has progressed very well, several key elements are still open. The discussion during the workshop will provide insight on a way forward to close selected open issues. P. Menzel thanked EUMETSAT for the efforts to realise the launch of a hyperspectral infrared sounder in geostationary orbit. This has been a dream by many users and scientists for a long time. He hoped that the workshop will stimulate excitement regarding the possibilities such an instrument will offer and he was looking forward to the discussions on how data from MTG-IRS will affect nowcasting in 2020 and beyond.

After these welcome words the participants introduced themselves, and the first session on the MTG-IRS mission, instrument and ground segment started.

## 1.2 MTG IRS

Two presentations on the MTG-IRS mission, addressing the instrument and the associated ground segment were provided during the first session. S. Gigli provided the overview on the MTG-IRS instrument, and the level 1b data. In particular he indicated that the MTG-IRS instrument is an imaging Fourier transformation spectrometer, capable of observing the GEO disc in 60 minutes. As the instrument observes the upwelling radiances in a step-and-stare mode, the full GEO disc is covered by about 320 dwells encompassing areas of approximately 600 x 600 km². Each dwell consists of 25600 spectral soundings containing the upwelling radiance at top of the atmosphere in two broad spectral bands (700 – 1210 $cm^{-1}$ and 1600 – 2175 $cm^{-1}$), at a spectral resolution of 0.625 $cm^{-1}$. Because of the large data volume, part of the processing of the raw observations is done on ground, in the MTG Ground segment.

An overview of the MTG Ground Segment was provided by F. Roveda. After a functional summary, the main design drivers were presented. These are the large amount of data to be processed in a robust way to meet the availability requirements and in a relatively short time to meet the timeliness requirement. A breakout of the availability budget for the data processing chain was presented as well as timeliness of the different datasets. To illustrate that the MTG GS is not an evolution from the MSG GS, the expected data rates for MTG were compared to the data rates for the MTP and MSG system.

The increase in data volume might be a challenge for the MTG GS, but it provides an opportunity for the users to explore the information collected in an unprecedented way. In his presentation P. Menzel first presented a historical overview of the interest of the nowcasting community in high temporal resolution satellite observations of meteorological situations. Back in 1981, the VAS sounder was able to scan the continental US in a small number of spectral channels. These observations did not have an optimum aspect ratio between temporal and spatial (especially vertical) resolution. To improve upon this mismatch, hyperspectral observations are needed as foreseen by MTG-IRS. Currently an opportunity exists to explore the temporal domain for hyperspectral soundings at high latitudes by combining the observations from IASI, CrIS, and AIRS. He further demonstrated some of the novel capabilities of hyperspectral observations as envisaged for MTG-IRS; in particular the low level moisture signal, apparent in some weak water vapour lines in the atmospheric window region, is lost if the spectral resolution of the observations is degraded to that of current and future imagers. In the subsequent discussion, S. Bojinski touched upon the required flexibility of the processing system. P. Menzel indicated that users should not only focus on level 2 products, but also on information available at level 1 in the new system, as it will provide a wealth of opportunities to be explored for NWC applications. F. Roveda indicated that the system currently envisaged for procurement is flexible. However, as it will be a complex system, users should not propose novel algorithms without some considerations for operational implementation.

## 1.3 Nowcasting Now

The session entitled "Nowcasting now" was intended to be a review of how the various forecasters employ satellite data, in particular from modern hyperspectral sounders like IASI, CrIS and/or AIRS, in their nowcasting analysis. The session consisted of 7 oral presentations by A. Vocino (CNMCA), C. Herold (DWD), N. Mahovic (General forecast office Croatia), P. Francis (Met Office), M. Buzzi (Meteo Swiss), A.C. Fontan (Meteo France) and H. Sellman (SMHI).

The use of satellite observations is widely spread in the various nowcasting offices. Observations by geostationary satellites are used to characterise air masses (through RGB's among other methods), to monitor atmospheric motion vectors, to describe cloud macro physical properties like distribution and occurrence, and to monitor instability. Beyond these in-house generated applications, applications from the NWC-SAF are heavily used. Unfortunately the presentations also indicated that the use of IASI and/or CrIS observations for operational NWC applications is relatively limited. Though the forecasters are using very advanced methods to generate their nowcasting analysis (for instance the NinJo workstation by DWD, or MESAN by SMHI, or the COALITION approach by MeteoSwiss), none of the presenters indicated that they have been or will be looking at IASI and/or CrIS observations for their operational forecasting and warning tasks. Although there are multiple reasons for this omission, limited number of overpasses and challenges with timeliness are the most important factors, especially when considering moisture changes on small scales in space and time.

## 1.4 Current Demonstrations Projects

Preparing for the workshop, several participants were invited to perform, for selected meteorologically interesting weather situations, an initial analysis of level 2 products derived from MTG-IRS proxy data, generated by using a prototype retrieval algorithm configured in line with up-to-date baseline requirements for the MTG operational processor. Initial results of five demonstration projects were presented: Convection monitoring from space (P. Antonelli and A. Manzato), Nowcasting convection over Sweden (H. Sellman, T. Landelius and A. Dybbroe), Potential of hyperspectral sounders to nowcasting heavy convection (S. Bach, C. Herold and C. Köpken-Watts), LAPS 3D atmospheric analysis (E. Gregow), and 3D visualisation of IASI products (F. Debie and S. de Haan).

The hyperspectral MTG-IRS related presentations were complemented by M. König, summarizing the experience with and lessons learned from using the GII product generated from MSG observations within nowcasting applications. She specifically reminded the audience of a number of misconceptions about the use of forecast data and satellite products. A common misconception is that a good, useful satellite product should be different from a similar product derived from the NWP forecast. However, NWP forecasts are relatively good, so one should worry if the difference to the forecast is too large. For satellite derived stability indices, for instance, it is also important to realise that a general correlation to independent observations is not necessarily a 'good quality indicator' as only the correlation in case of meteorological important weather situations are significant. She gave a very positive outlook into the MTG future, pointing to the great potential combining FCI and IRS information to

generate GII like instability indices taking advantage of both, the higher IRS spectral information and the higher FCI space and time information.

Additionally, two recent ongoing study activities to improve very short range forecasts by use of satellite data, undertaken by R. Petersen and the group of W. Smith, E. Weisz and N. Smith at the University of Wisconsin, were presented.

R. Petersen reported on his research to better explore the humidity observation derived from SEVIRI on MSG complementing the information forecasters have from their NWP systems. Although he expects that more MSG data will be used in combination with regional NWP system using so-called rapid update cycles, he still sees several opportunities to exploit imager derived level 2 products for NWC applications. However, as especially the derived moisture observations can suffer from biases, it is important to ensure their quality through a long term monitoring system, e.g. through the use of surface based GPS data. It further stresses the importance of an early start working on verification and validation activities. He emphasised the advantage of hyperspectral soundings, increasing the information on independent moisture layers to 6-8 from the 2-3 for imagers. He showed that improving very short range forecasts by hyperspectral soundings is based on having moisture information of thinner layers closer to the surface. He pointed to that fact that specifically for aviation it is it is as important to forecast the non-event as the event itself. Looking ahead there is a clear expectation that MTG-IRS will further improve the short term forecast by providing better vertical moisture and temperature information and its capabilities to monitor clear air AMV's, the latter for monitoring the vertical sheer, important contribution for the development of severe convection. However, the information needs to be timely as humidity observations are perishable.

N. Smith reported on the work at the University of Wisconsin using data from the existing hyperspectral sounders on low earth orbit platforms. The retrievals are performed using a Dual-Regression Retrieval Algorithm based on Principal Components, which is very efficient in terms of computing time. A well known limitation for use of observations from instruments flown on low earth orbit platforms in support of very short range forecasts is their limited time sampling. For instance, a single IASI instrument provides only two observations per day. She presented a way to overcome this limitation by going to a multi-instrument retrieval approach. Especially at high latitudes using the combination of IASI on METOP A and B, CrIS and AIRS has the potential to dramatically improve the time sampling. As an example she presented a case of cloud top temperature development derived from four observations between 16:00 and 19:35 on 20 May 2013 over Oklahoma. During this period a tornado over the Moore Oklahoma was formed. Experiences collected from collaboration with nowcasters in Alaska indicate that the multi-satellite retrieval products complement the high spatial resolution imagery observations, usually used by forecasters, by adding quantitative information about the thermodynamic structure of the atmosphere. As an European case study she presented the multi-instrument time–series of convective development over northern Europe for 5-9 June 2013.

The setups for the various MTG-IRS like demonstration projects were similar. An interesting meteorological situation was identified for use in a case study by each participating nowcasting service. For these case studies EUMETSAT provided MTG-IRS like level 2 products on the basis of IASI-A/B observations, while the participating nowcasting services

were requested to integrate these level 2 products into their individual nowcasting tools and provide a qualitative or quantitative analysis of the impact of including these additional level 2 products in the analyses. All case studies showed a potential positive impact using the additional level 2 products in the nowcasting analyses, encouraging the teams to continue with further test studies.

For the nowcasting analysis of a meteorological situation, FMI makes use of the Local Analysis and Prediction System (LAPS). In their setup the satellite data is integrated with results from the nearest forecast by ECMWF. The LAPS system is used by the forecasters as input for their operational models to provide warnings (e.g. road-weather, fire-weather, air-quality). The impact of the level 2 products on the analysis for Finland was discussed by E. Gregow. Two periods of convective activities were selected (1 June 2012 and 29 July 2012). For each period three orbits over Finland were integrated into the LAPS system. Impact on the temperature profiles and the instability indices were analysed. The initial results indicated that the inclusion of the MTG-IRS like retrievals in the LAPS system had a neutral to positive impact on the analysis of the instability indices over Finland. The position of the analysed instability as indicated by the TotalsTotal index matched better with the actual occurrence of lightning after the ingestion of level 2 retrievals than without. Comparison of the temperature profile for a LAPS run with and without integrated MTG-IRS like level 2 products, showed that for a number of geographical positions where radiosonde observations were available, the analysed temperature profile was not significantly changed when including additionally the MTG-IRS like level 2 products, indicating that they are similar to the radiosonde observations. However, near the surface the retrieved temperature profiles frequently had a peculiar shape, deviating from radiosonde measurements. Overall he concluded that the MTG-IRS like level 2 products as provided by EUMETSAT have the potential to improve the analysis, however, he noted that MTG-IRS will observe the Scandinavian countries like Finland at high zenith angles, and there is the need to confirm the quality of MTG-IRS level 2 products derived at these high zenith angles.

The demonstration study performed by the DWD team and reported by C. Köpken-Watts followed a similar setup. Two different cases of convective activities over Germany were identified (20 June 2013 and 30 June 2012) for which the MTG-IRS like level 2 products generated by EUMETSAT were ingested into their NinJo meteorological analysis workstation. Attention was given by the forecasters to the satellite retrieved temperature and humidity profiles comparing them with radiosonde observations and with model results. At this stage no horizontal structures in the water vapour fields, or any time tendencies were assessed, which is planned for the future. After a general introduction of the meteorological situation, the initial results of the analysis were presented. The DWD team reported that overall the comparison was satisfactory. However, as for the FMI results, near the surface some of the retrieved temperature profiles deviated from the radiosonde observations. For these cases a typical S-shape pattern was observed in the retrieved temperature profiles not apparent in the radiosonde observations. The reason for this peculiar pattern in some of retrievals is not clear, and for a more detailed analysis it would be beneficial to have also the first guess available. The retrieved humidity profiles seem a bit too moist. As expected the fine scale structures of the humidity profiles provided by the radiosonde observations are not present in the satellite retrieved profiles. For the 20 June 2013 case, the DWD team reported that the equivalent potential temperature, derived from the delivered satellite retrievals, is more consistent to the actual meteorological situation than the forecast by their regional scale

NWP model. This would be a typical example of using satellite retrievals, namely for consistency checks with NWP forecast to gain a higher confidence in the information available to provide warnings. From this initial analysis the DWD team concluded that there is potential for MTG-IRS like level 2 products to be used by the operational nowcaster. However, further detailed evaluation is needed.

The third presentation of initial results derived from the demonstration project at SMHI was given by H. Sellman. The results obtained by the SMHI team were ambiguous. They compared instability indices derived from the level 2 products to cloud evolution over Sweden. It was concluded that both the LI and KI indices from the MTG-IRS like observations were in general consistent with the development of convection, but none of the indices correlated with the main region of strong convection. Although there is an initial potential for the integration of these indices into the meteorological workstation used by SMHI (MESAN), the use of satellite derived instability indices did not provide additional benefit over the use of data derived from NWP. However, these results were generated from only limited number of cases, and more cases needs to be analysed. Despite this, SMHI recognised that there is a potential advantage using the level 2 products and recommended the following:

**EUMETSAT to consider the generation of level 2 products from MTG-IRS observations over the Scandinavian area.**

A totally different approach was presented by F. Debie (KNMI). KNMI is currently exploring the use of 3D visualisation of the results from their regional scale NWP model for operational nowcasting applications. They took the MTG-IRS like level 2 products and ingested them into their 3D visualisation system for a qualitative analysis. For the workshop they prepared as case study 20 June 2013, the same meteorological situation analysed by DWD, during which a squall line was developing over Europe. Over the ocean they found a good consistency between their model results and the level 2 products, while over land, especially near the surface some biases were found.

The final demonstration project presenting the use of MTG-IRS like data and products for nowcasting applications was given by M. Martinez. He focussed on the high potential of novel RGB images directly generated from hyperspectral level 1 spectra. RGBs derived from MSG observations, as for instance the ‘dust’ or ‘airmass’ RGBs, are heavily used by the forecasters to support their nowcasting analysis. Following a brief discussion on the heritage of SEVIRI RGBs, he argued that RGBs from IASI could be useful, not only because they provide the full globe view, but also because hyperspectral sounder observations contain information complementary to that from imager type instruments. He demonstrated that the information on low level inversions over North East Europe on 17 January 2013 can be visualised using dedicated spectral lines of the level 1 spectra measured by MTG-IRS like instruments directly in a RGB composition. As the MTG-IRS level 1b data will be disseminated in compressed form to save bandwidth using principal components, he also started to look at RGB's from principal components. His analysis suggested that as RGB might explore weak signals in the spectrum (as for instance in the case of low level moisture), it is not guaranteed that the principal components generated based on the complete spectrum, will preserve this information. He indicated that EUMETSAT should investigate the possibilities to disseminate not only the regular principal components describing the

information content of the spectrum as a whole, but also dedicated principal components optimised to describe the information within a limited spectral domain to satisfy the needs of applications like specialised RGBs. Eventually it was concluded that further joint work of nowcasters and remote sensing scientists is needed for optimising the direct use of MTG-IRS like spectra in support of nowcasting applications.

### 1.5 Nowcasting in 2020 and beyond

The nowcasting 2020 and beyond session was started with three presentations, one by M. Martinez on the plans of the NWC-SAF regarding MTG-IRS, one by A.C. Fontan on ideas and suggestion for new products derived from MTGIRS observations, and one by P. Pagano on the priority for MTG-IRS derived essential variables related to NWC services.

After a short introduction of the NWC-SAF, M. Martinez presented the study plans of the SAF consortium in relation to MTG. In particular he introduced the plans to derive clear sky AMVs and clear air products. In these studies they plan to explore the synergies with FCI. He introduces some of the studies in more detail, but no concrete results are available as this is work in progress.

A.C. Fontan introduced some of the ideas collected from discussions with forecasters at Météo-France on the use of satellite data for NWC applications. She stratified the presentations into 5 categories: heavy precipitation events, model validation, forest fire, aviation forecasting and volcanic ash. For each of these themes some suggestions for satellite products were discussed. A general expectation is that MTG-IRS will provide better information on cloud levels and cloud microphysics in support of aviation, on temperature inversions, on low level humidity, needed for e.g. forest fire forecasts, on characterisation of ash plumes, needed for VAAC. A further expectation is the MTG-IRS will deliver information on atmospheric instability and transport of total precipitable water, supporting the forecast of heavy precipitating events (HPE). But also an ozone product would be useful as currently the forecasters validate the NWP potential vorticity (PV) fields by comparison to the water vapour and ozone information from MSG. In addition to the water vapour the ozone channel is used as it has more potential (in specific cases) to depict the upper level dynamics. It is expected that the ozone derived from MTG-IRS will have more vertical information increasing the potential use. In general she concluded that the retrieval fields should be as continuous as possible and retrievals above clouds should be considered. She also noted that the IRS being a novel instrument, its capabilities are scarcely known by operational users. In order to overcome this deficiency EUMETSAT should consider an early start of training activities.

P. Pagano presented an initial analysis of user requirements for satellite observations. This analysis was initially performed for the EUMETSAT EPS/post-EPS application expert group, and modified for the workshop, as a methodology exercise, to depict preliminary results for an MTG-IRS instrument. The method tries to be as objective as possible, and starts with a stratification of the techniques currently used to prepare a NWC analysis, identifying specifically the role of satellite data in these techniques. His analysis identified 8 application areas and a total of 101 operational services. The high number of services is a reflection that the same service might be used for different application areas, each having different requirements (e.g. for spatial resolution) on the same service. Eventually, the analysis extracts

the essential geophysical variable needed for the identified services and links them to the capabilities of MTG-IRS. The exercise as presented has to be considered as a methodology example and should be subject to a thoroughly revision. Nevertheless, the preliminary analysis resulted in a priority table for MTG-IRS derived variables for each of the eight application areas, which could be considered as a first start to address the role of MTG-IRS for NWC applications..

After these presentations, the group was split into small break out groups to discuss questions prepared by the co-chairs. Three themes were identified namely: Identifying improved information from MTG-IRS, Anticipating nowcasting in 2020, and Training. The specific questions for each break out group are attached to this document for reference. After the discussion within the three groups the workshop continued with a plenary session discussing the summary outcomes presented by each of the groups. For completeness these summaries are also enclosed in the current document.

From the plenary discussion a number of statements have been extracted

- Moisture flux as well as moisture is important, hence motion vectors (horizontal and maybe vertical retrievals from MTG-IRS must be studied).
- The most appropriate test-bed for the use of MTG-IRS in NWP will likely be in regional Rapid Refresh systems using 4-dimensional assimilation approaches (like e.g. 4DVar or EnKF), as opposed to longer range global NWP systems.
- Frequently updated Level-2 products (especially moisture) and short-range projections thereof are potentially important tools for forecasters both to detect details not present in NWP guidance as well as to monitor model performance
- Timeliness of data/products is critical for nowcasting (within 15 min is good and greater than one hour is useless)
- Persistence of MTG-IRS data information will help screen noise from signal
- It is extremely important that end users are made aware of the intrinsic limitations of atmospheric profiles retrieved from hyperspectral infra-red sounders, both in terms of accuracy and information content (number of independent pieces of information).
- Both Derived Product Images and RGBs will be important and remain complementary. RGBs allow more nowcaster interaction / adjustment.
- Machine learning will become more important via expert systems in 2020.
- Deficiencies of NWP systems can be explored via nowcasting investigations – MTG IRS offers new opportunities.
- Training will assure an excellent return on the investment in IRS.

In addition to the above mentioned statements a set of recommendations were formulated as a result of the discussion:

**EUMETSAT to consider the following for the operational derivation of level 2 products derived from MTG-IRS observations at Day-1:**

1. **to confirm the quality of the level 2 products under large viewing angle over the Scandinavian countries,**
2. **to generate the level 2 products for cloudy fields of view,**
3. **to generate the Atmospheric Motion Vectors from clear sky field of views, and**
4. **to include an ozone product in support of PV analysis.**

**To promote the user awareness of opportunities provided by MTG-IRS mission, EUMETSAT should**

1. **continue the LEO demonstration studies started in preparation of this workshop,**
2. **collaborate with potential users to explore the time-sequence of LEO sounder data,**
3. **investigate how ESSL could be engaged to become a test bed for demonstration studies,**
4. **develop and validate specialised RGB products (e.g. focused on low-level inversion and moisture, strong wind events, precursors of PV anomalies),**
5. **explore synergies with other MTG missions (FCI, LI) in the framework of expert systems, and**
6. **support the development of rapid update cycle assimilation methods currently developed within NWP groups to ingest in an efficient way MTG-IRS data and products.**

**To prepare the operational users of MTG-IRS data and products EUMETSAT should**

1. **support the development of easy accessible data objects and data access and post-processing software for the handling of MTG data by the end users,**
2. **identify partners as part of a network of user preparedness for MTG-IRS,**
3. **prepare Effective training material,**
4. **explore as soon as possible the opportunities provided by EUMETrain and VLab to support training of operational users, and**
5. **align its training activities for MTG-IRS with the WMO 5-year training strategy.**

**EUMETSAT to organise another workshop to discuss progress made and plans updated.**

### 1.6 Meeting closure

During the meeting closure the co-chairs thanked the participants for the constructive and pleasant collaboration over the last two days. J. Schmetz indicated that he was very impressed about the outcome of the workshop and that he observed that the NWC community is well aligned with respect to the concepts and future aspiration of MTG-IRS data and products. He congratulated the participants for arriving at achievable recommendations which EUMETSAT will evaluate to understand how these recommendations can be achieved. He also supported the idea of continuing the demonstration projects using hyperspectral observations from instruments in polar orbits as IASI, CrIS and AIRS. In the next years, the combination of these observations will provide some understanding of the true potential of MTG-IRS.

## ANNEX 1 : WORKSHOP RECOMMENDATIONS

| | |
|---|---|
| **NWCWS.1** | **EUMETSAT to consider the following for the operational derivation of level 2 products derived from MTG-IRS observations at Day-1:**<br>**1. to confirm the quality of the level 2 products under large viewing angle over the Scandinavian countries,**<br>**2. to generate the level 2 products for cloudy fields of view,**<br>**3. to generate the Atmospheric Motion Vectors from clear sky field of views, and**<br>**4. to include an ozone product in support of PV analysis.** |
| **NWCWS.2** | **To promote the user awareness of opportunities provided by MTG-IRS mission, EUMETSAT should**<br>**1. continue the LEO demonstration studies started in preparation of this workshop,**<br>**2. collaborate with potential users to explore the time-sequence of LEO sounder data,**<br>**3. Investigate how ESSL could be engaged to become a test bed for demonstration studies**<br>**4. develop and validate specialised RGB products (e.g. focused on low-level inversion and moisture, strong wind events, precursors of PV anomalies),**<br>**5. explore synergies with other MTG missions (FCI, LI) in the framework of expert systems, and**<br>**6. support the development of rapid update cycle assimilation methods currently developed within NWP groups to ingest in an efficient way MTG-IRS data and products.** |
| **NWCWS.3** | **To prepare the operational users of MTG-IRS data and products EUMETSAT should**<br>**6. support the development of easy accessible data objects and data access and post-processing software for the handling of MTG data by the end users,**<br>**7. identify partners as part of a network of user preparedness for MTG-IRS,**<br>**8. prepare Effective training material,**<br>**9. explore as soon as possible the opportunities provided by EUMETrain and VLab to support training of operational users, and**<br>**10. align its training activities for MTG-IRS with the WMO 5-year training strategy.** |
| **NWCWS.4** | **EUMETSAT to organise another workshop to discuss progress made and plans updated.** |

## ANNEX 2: AGENDA

**Workshop on**
**NWC Applications using MTG-IRS**
**EUMETSAT Headquarter**
**Darmstadt, Germany**

***Draft Agenda***

***Day 1 – 25 July 2013***

| | | |
|---|---|---|
| **08:00** | | **Arrival of Participants** |
| | | **Opening of Meeting** |
| 08:30 - 08:45 | | Opening and Welcome: (L. de la Taille, EUMETSAT)<br>Objective of the meeting (co-chair: P. Menzel, SSEC and H. Roquet, Météo France)<br>Introduction of the participants |
| **Session 1** | | **MTG-IRS (session chair: R. Stuhlmann, EUMETSAT)** |
| 08:45 – 09:15 | S1.1 | Introduction to MTG-IRS Mission (S. Gigli, EUMETSAT) |
| 09:15 – 09:45 | S1.2 | Introduction to MTG-IRS Ground Segment (F. Roveda, EUMETSAT) |
| 09:45 – 10:15 | S1.3 | Introduction to information contained in hyperspectral observations (P. Menzel, SSEC) |
| **10:15 – 10:45** | | **Break** |
| **Session 2** | | **Nowcasting now (session chair: A-C. Fontan, Météo France)** |
| 10:45 – 11.05 | S2.1 | NWC at CNMCA (A. Vocino, CNMCA) |
| 11:05 – 11:25 | S2.2 | NWC at DWD (C. Herold, DWD) |
| 11:25 – 11:45 | S2.3 | NWC at Meteo Kroatia (N. Mahovic, General Forecast Office Croatia) |
| **11:45 - 13:00** | | **Lunch Break** |
| 13:00 – 13:20 | S2.4 | Mesan and the use of satellite data in nowcasting at SMHI (H. Sellman, SMHI) |
| 13:20 – 13:40 | S2.5 | The use of satellite data for NWC at the Met Office (P. Francis, N. Grahame and M. Young, Met Office) |
| 13:40 – 14:00 | S2.6 | NWC at Meteo Swiss (M. Buzzi, Meteo Swiss) |
| 14:00 – 14:20 | S2.7 | NWC at Météo France (A-C. Fontan, Météo France) |

| | | |
|---|---|---|
| **Session 3** | | **Current Demonstration Projects (session chair: C. Köpken-Watts, DWD)** |
| 14:20 – 15:00 | S3.1 | Nowcasting convection occurrence from space borne instability indices (P. Antonelli, SSEC and A. Manzato, OSMER) |
| **15:00- 15:30** | | **Break** |
| 15:30 - 16:00 | S3.2 | GII from MSG (M. König, EUMETSAT) |
| 16:00 – 16:30 | S3.3 | Nowcasting applications with Polar-Orbiting Hyperspectral Sounders: a multi-instrument approach (N. Smith, E Weisz, B. Smith, SSEC) |
| 16:30 - 17:00 | S3.4 | Nowcasting convection using hyperspectral sounding data in MESAN. A case study to evaluate the potential of IRS data over Sweden (H. Sellman, T. Landelius, A. Dybbroe, SHMI) |
| 17:00 - 17:30 | S3.5 | Improving very-short-range predictions of the pre-convective environment, from MSG-SEVIRI to MTG-IRS (R. Petersen, SSEC) |
| 17:30 - 18:00 | S3.6 | Potential of high-resolution sounder retrievals for predicting heavy convection: A case study using IASI retrievals (S. Bach, C. Herold, Ch. Köpken-Watts, DWD) |
| 18:00 - 18:30 | S3.7 | 3D Visualisation of MTG-IRS level 2 products (F. Debie, S. De Haan, KNMI). |
| **19:00** | | **End of Day-1** |

***Day 2 – 26 July 2013***

| | | |
|---|---|---|
| **Session 3** | | **Current Demonstration Projects (session chair: C. Köpken-Watts, DWD)** |
| 08:30 – 09:00 | S3.8 | LAPS 3D atmospheric analysis: Impact study using sounder profiles (IASI/MTG) (E. Gregow, FMI) |
| 09:00 – 09:30 | S3.9 | RGB images from hyperspectral instruments and brainstorming (M. Martinez, AEMET) |
| **Session 4** | | **Nowcasting in 2020 and beyond (session chair: P. Menzel, SSEC and H. Roquet, Météo France))** |
| 09:30 - 09:45 | S4.1 | Preparation of using MTG-IRS at nowcasting SAF (M. Martinez, NWC-SAF) |
| 09:45 - 10:15 | S4.2 | "Dreams" of Météo France Forecasters for nowcasting in 2020 and beyond (A-C. Fontan, Météo France ) |
| 10:15 – 10:45 | S4.3 | Priority for IRS-derived essential variables related to NWC services (P. Pagano, USAM) |
| 10:45 - 12:00 | | Splinter group discussion on potential of direct use of MTG-IRS products for NWC applications. |

| | |
|---|---|
| **12:00 - 13:00** | **Lunch** |
| **Session 5** | **Summary Session (session chair: P. Menzel, SSEC and H. Roquet, Météo France)** |
| **13:00 - 16:00** | Short report of the discussion in the splinter groups<br>Demonstration projects: way forward<br>Summary and workshop closure |
| **16:00** | **End of Workshop** |

## ANNEX 3: PARTICIPANTS OF THE MTGIRS NWC WORKSHOP

Antonelli, Paolo (SSEC)
Asmus, Jorg (DWD)
Bojinksi, Stephan (WMO)
Buzzi, Matteo (MeteoSwiss)
Debie, Frans (KNMI)
De Haan, Siebren (KNMI)
Eklund, Joonas (FMI)
Fontan, Anne-Claire (Météo-France)
Francis, Peter N. (Met Office)
Gregow, Erik (FMI)
Herold, Christian (DWD)
Irsic-Zibert, Mateja (Slovenian Met Office)
Köpken-Watts, Christina (DWD)
Manzato, Agostino (OSMER-ARPA)
Martinez, Miguel (AEMET)
Mecikalski, John (UAH)
Menzel, Paul (SSEC)
Roquet, Hervé (Météo-France)
Pagano, Paolo
Petersen, Ralph (SSEC)
Sellman, Hampus (SMHI)
Smith, Nadia (SSEC)
Strelec Mahovic, Natasa (Kroatian Met. And Hydromet Service)
Vocino, Antonio (CNMCA)

**EUMETSAT:**

Lionel de la Taille
Johannes Schmetz
Volker Gärtner
Fausto Roveda
Sally Wannop
Dieter Klaes
Marianne König
Jochen Kerkmann
Rob Roebeling
Stefano Gigli
Rolf Stuhlmann
Stephen Tjemkes

## ANNEX 4: BREAKOUT SESSIONS SUMMARY SLIDES

### *General themes and questions*

1. Group 1: *Improved Information from MTG IRS*
    a. What help do you anticipate for nowcasting from MTG IRS L1B and/or L2 products? What have you heard in these two days that would interest you for further study
    b. Depiction of changes in low level moisture is expected to be significantly improved with MTG IRS; how can this best be displayed for nowcasting utilization?
    c. In what situations will MTG IRS most complement / supplement ground based data?
2. Group2*: Anticipating Nowcasting in 2020*
    a. What is your perspective on the role of RGB versus derived product images?
    b. What is the best balance of manual versus automated applications? In what situations will one serve the nowcaster better than the other?
3. Group3: *Training*
    a. What training programs will best help you prepare for MTG IRS utilization?
    b. What leo demonstrations / collaborations would best help you get ready for MTG IRS?

### ***Summary discussion Group 1: Improved information from MTG-IRS***

1. How will new IRS L1B and/or L2 products improve Nowcasting?
    a. Two distinct sets of 'users' – NWP and Forecasters
    b. Assimilate L1B radiances, but too complicated for forecasters –
    c. Forecasters will use L2 to Monitor/validate/correct model trends – but want L1B in models
    d. Simple/frequent projections of observations are also needed for forecasters to improve overall understanding and monitor models, as well as project data into areas where clouds will have formed later
    e. IRS will improve Moisture accuracy and profile resolution, but need to understand observing limits and data/product 'confidence'
    f. Current IASI retrievals give ~5 layers of improvement on guess in T, ~6+ in q
    g. Nowcasting data are perishable - Desire latency of <15 minutes
    h. Need to validate all Products and Retrievals to determine accuracy on a standard community data set, including at high latitudes
    i. Appropriate for Rapid-Update models – must be 4-dimensional data assimilation (like e.g. in 4D Var or EnKF implementations) – either with Retrievals or Radiances
    j. AMV (WV) needed to monitor WV winds and possible low-level lift and vertical wind shear
2. What that you've heard/seen deserved further study?
    a. See above list plus:
        i. Addition of information on cloud properties
        ii. What is the role of surface observations in improving IRS products
        iii. How best should low level moisture be displayed?
    b. Show both:
        i. The overall patterns and trends and
    c. How much more information is coming to forecasters beyond what is already in NWP guidance.

   d. 3-D displays could include lifting and compare with model evolution
   e. Relate dryness patterns to other weather processes
   f. View as modeled and observed Moisture Flux, also vertical shear
3. When will other ground-based systems (and what) complement/supplement MTG-IRS?
   a. Surface based GPS TPW – every 50km in Germany, ~40km in Netherlands, ~30km in Belgium
   b. Independent validation of cloudy conditions for retrieval Q/C flags – METARS
   c. Expanded sets of AMDAR WVSS-II Profiles
   d. Vertical profiles from LIDARs with Temperature and Moisture Profiles
4. What Risk-Reduction Tests (Demonstration Projects) should be considered?
   a. Inclusion of IASI Proxy data in ESSL Test Beds – Needs to include training and near-term data projections
   b. After that, expand tests to forecast offices
   c. Expand testing of Rapid Refresh systems after successful proof-of-concepts using IASI
5. Eumetsat should hold another Nowcasting Workshop is about 2 years time

***Summary discussion Group 2: Anticipating Nowcasting in 2020***

(Antonio Vocino, Christina Köpken-Watts, Joerg Asmus, John Mecikalski, Frans Debie,Miguel A. Martinez, Joonas Eklund, Paolo Pagano)

*Input key points:*

1. role of RGB vs derived product images
2. manual vs automated procedures

*2020 scenario:*

**WHO** ("stakeholders"):

- the nowcasting community, intended as meteorological service provider (to a large variety of intermediate-users and end-users),
- automated systems, able to synthetize different informations (satellite, ground-based,NWP,etc.) and to produce e.g. warnings.

**WHY** ("context"): as baseline the use of observations/products (satellite input data) within NWC is twofold:

- necessary to improve the analysis (understanding) of the "true state" of atmosphere,
- used to assess the possible deficiencies of the available NWP forecasts.

**TOOLS** ("applications"):

- the displaying techniques (2D, 3D or even 4D) are a key element for the exploitation (and for the presentation, of course) of the information content of future satellites. Consequently, the format and the structure of the disseminated products should be adequate to ensure their efficient ingestion.

- the availability of SW tools and libraries for the handling of the new data, made available by EUMETSAT (CAF, SAF) could be strongly beneficial to NWC community. Examples: PCs to radiances converter, dwell concatenation/merging/blending,

**TECHNIQUES** ("procedures"):

- conceptual models drive (in classical sense) the activity of the forecasters. In this sense the guidance (manuals) and standard procedures using RGBs or any pre-computed product are kept as reference for their work. It is worth to remark that both RGBs and derived products (e.g. L2), will be used as complementary information.
- the relative importance of automatic systems (machine learning), able to assist the activity of the forecasters especially for extreme or rare events, will be much larger in 2020, therefore the role of the forecaster will be more and more to evaluate and possibly improve the automatic guidance. This requires, also, an enhancement of the skill of the forecasters in the field of the expert systems.
-

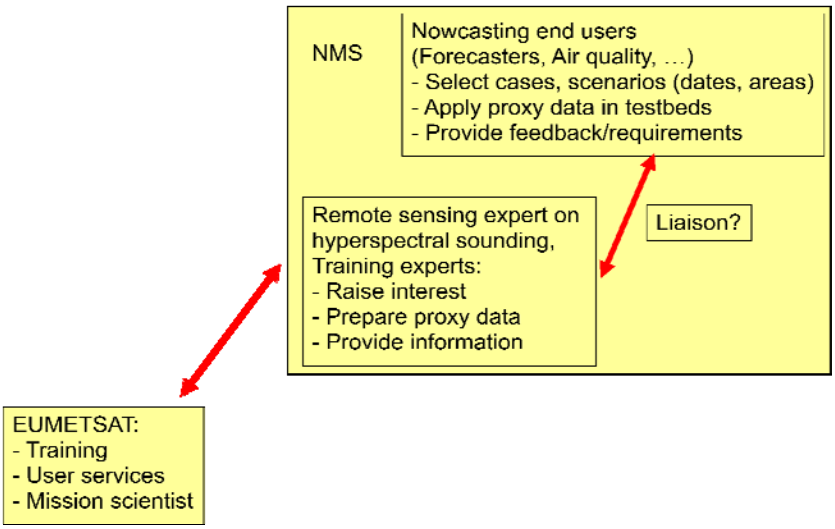
**KEY POINTS (recommendations)**

1. to improve the integration of IRS with other products (lightning, FCI, etc.), in the framework of expert-systems;
2. to develop within NWP groups RUC able to ingest in efficient way IRS data;
3. to setup studies aiming at the development of specialized RGB products (focused on low-level inversion and moisture, strong wind events, precursors of PV anomalies, etc.). The evaluation of these products by forecasters should be pursued.
4. to support the development of post-processing SW deliverable to NWC community for the handling of MTG data
5. to explore the possibility to make available to NWC community also IRS cloudy retrievals

***Summary discussion Group 3: Training***

- Training is an excellent return-on-investment for those having invested in IRS.

***User preparedness schematic:***




- Consider sub-European groupings of NMS operating in similar conditions (level of satellite use, capacity; geography and climate)

**Recommendation I: Develop a network of user preparedness for IRS**

- Training Methods:
  - Basic and visual resources, including explanatory comments
  - Attractive material (3D, Apps, interactive, social media)
  - Use currently available data (MSG, IASI) to start with
  - Subsequently introduce synthetic and proxy data for new sensors
  - Demonstration cases (impact with and without new datasets)
  - Ready 2 years before launch
- Test cases: (For example)
  - Morning lectures raising interest and presenting tools and data
  - Then let participants be creative! (NMS, research institutes)
  - Results in interesting case studies

**Recommendation II: Develop effective training material**

- Training programmes
  - Align EUMETrain 5-year Training Strategy (in revision)
    i. Event Weeks
    ii. Courses
  - Align EUMETSAT 5-year Training Plan
    i. Build on user preparation projects
  - WMO/CGMS Virtual Laboratory can assist users in Africa through its Centres of Excellence

**Recommendation III: Use EUMETSAT, EUMETrain and VLab training strategy in the interest of IRS.**

- References

- WMO Commission for Basic Systems (2012) "Guideline for Ensuring User Readiness for New Generation Satellites":
    i. "Establishment by NMSs of user readiness projects focused on introduction of new satellite data streams into operations, to be initiated ~5 years prior to launch"
    ii. Direct link: http://www.wmo.int/pages/prog/sat/documents/SAT-GEN_CBS-15-GuidelineUserReadiness.pdf
    iii. Official reference: ftp://ftp.wmo.int/Documents/PublicWeb/mainweb/meetings/cbodies/governance/tc_reports/english/pdf/1101_en.pdf (page 265)

- Acknowledgment:
Nataša Strelec-Mahović , Mateja Iršič Žibert, Anne-Claire Fontan, Sally Wannop, Paolo Antonelli, Stephan Bojinski