Future opportunities from MTG and Post-EPS

Johannes Schmetz, Rolf Stuhlmann, Peter Schlüssel and many colleagues

EUMETSAT

Darmstadt, Germany
Content:

- EUMETSAT programmes: current and future
- Current utilisation => best first guess for future
- Meteosat Second Generation
- Evolution to MTG
- EUMETSAT Polar Programme/Metop
- Evolution to Post-EPS
- A look at (or gleaning from) our partner NOAA/NESDIS
- Examples for future opportunities
- Importance of calibration
FROM THE EUMETSAT CONVENTION

• “The primary objective ... is to establish, maintain and exploit European systems of operational meteorological satellites.....“

• “A further objective ... is to contribute to the operational monitoring of the climate and the detection of global climatic changes.“

EUMETSAT's mission is:
• To deliver cost efficient operational satellite data and products ..... satisfy ..... requirements of its Member States,
• taking into account the recommendations of the World Meteorological Organization.
Current Space Based Components of the Global Observing System

ECMWF Seminar 2007, Recent Developments in the use of Satellite Observations in NWP
EUMETSAT Programme Planning

Meteosat First Generation
- Meteosat-5
- Meteosat-6
- Meteosat-7

MSG
- Meteosat-8
- Meteosat-9
- Meteosat-10
- Meteosat-11

MTG

EPS
- MetOp-A
- MetOp-B
- MetOp-C

Post-EPS
- OSTM
- Jason-2
- Jason-3 (GMES Sentinel 3)

96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18

IODC (63° E)
Rapid Scanning (10° E)
Primary Service (0° E)

3.4° W
0°

Potentially available for use at 57° E

Possible extension

ECMWF Seminar 2007, Recent Developments in the use of Satellite Observations in NWP
Meteosat Second Generation:
A breakthrough for meteorology

- Imager with 12 spectral channels
- Full-disk repeat cycle of 15 minutes
- Spatial sampling 3 km (1km for high resolution visible channel)
- On-board calibration for infrared channels
- GERB instrument => radiation budget
- Meteosat-9 (2005)
- Two more to follow
Twelve spectral channels of Meteosat Second Generation

• so far in space
Meteosat-8 and -9
Winds for Numerical Weather Predictions
(see also presentation by M. Forsythe on 3 September)

Winds from tracking atmospheric motions here: 10.8 µm channel

R. Borde, 2006
Observing the cradle of hurricanes: Combination of VIS images from Meteosat-8 tracks Hurricane Isabel (September 2003)
Fire detection from MSG (=> perspective with MTG)
Forest fires in Greece

Meteosat-9, 25 August 2007, 1200 UTC

Modis on Aura

H.J. Lutz, 2007
Meteosat monitors onset of convection

M. König, 2006

Lifted index at 1200 UTC

10.8µm image at 1200 UTC

10.8µm image at 1800 UTC
Example of Convective Cloud Mask Product from MSG

1 km MSG Convective Cloud Classification: 20060727 at 1300 UTC

W. Feltz et al., pers. communication
Example of a climate product: Outgoing Longwave Radiation (OLR) (courtesy M. König)

Bias
GERB – SEVIRI:
-1.3 to -1.9 Wm$^{-2}$
Future geostationary programme
Meteosat Third Generation (MTG)

Focus is on Numerical Weather Prediction and Nowcasting.

Candidate missions:

• High Resolution Fast Imagery (HRFI) mission.
• Full Disk High Spectral Imagery (FDHSI) mission.
• Infrared Sounding (IRS) mission.
• Lightning Imagery (LI) mission.
• UV-VIS Sounding (UVS) mission.

The need date is 2015.
Technical analysis with ESA.
MTG Imagery Missions

- MTG imagery missions served by a Flexible Combined (FC) imager
- Use of in-orbit spare satellite for rapid scan

FDHSI mission (continuation of MSG-SEVIRI):
FC imager on the operational satellite in Full Disk mode with 10 min repeat cycle

HRFI mission (continuation of Rapid Scan):
FC imager on fully commissioned in-orbit hot standby in Rapid Scan mode over ¼ of Full Disk with 2.5 min repeat cycle

<table>
<thead>
<tr>
<th>Mission</th>
<th>Coverage</th>
<th>Repeat cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDHSI</td>
<td>Full Disk</td>
<td>10 min</td>
</tr>
<tr>
<td>HRFI</td>
<td>1/4 FD</td>
<td>2.5 min</td>
</tr>
</tbody>
</table>
### MTG Imager Requirements

<table>
<thead>
<tr>
<th>'Core' Channels</th>
<th>Meteosat 1st Generation</th>
<th>Meteosat 2nd Generation</th>
<th>Meteosat 3rd Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Central Wavelength (μm)</td>
<td>Width (FWHM) (μm)</td>
<td>Spatial Sampling (km)</td>
</tr>
<tr>
<td>FC-VIS 0.4</td>
<td>0.444</td>
<td>0.06</td>
<td>1.0</td>
</tr>
<tr>
<td>FC-VIS 0.5</td>
<td>0.510</td>
<td>0.05</td>
<td>1.0</td>
</tr>
<tr>
<td>FC-VIS 0.6</td>
<td>0.645</td>
<td>0.08</td>
<td>0.5</td>
</tr>
<tr>
<td>FC-VIS 0.8</td>
<td>0.86</td>
<td>0.07</td>
<td>1.0</td>
</tr>
<tr>
<td>FC-NIR 0.9</td>
<td>0.96</td>
<td>0.06</td>
<td>1.0</td>
</tr>
<tr>
<td>FC-NIR 1.3</td>
<td>1.375</td>
<td>0.03</td>
<td>1.0</td>
</tr>
<tr>
<td>FC-NIR 1.6</td>
<td>1.61</td>
<td>0.06</td>
<td>1.0</td>
</tr>
<tr>
<td>FC-NIR 2.1</td>
<td>2.26</td>
<td>0.05</td>
<td>0.5</td>
</tr>
<tr>
<td>FC-IR 3.8</td>
<td>3.8</td>
<td>0.40</td>
<td>1.0</td>
</tr>
<tr>
<td>FC-IR 6.7</td>
<td>6.3</td>
<td>1.00</td>
<td>2.0</td>
</tr>
<tr>
<td>FC-IR 7.3</td>
<td>7.35</td>
<td>0.50</td>
<td>2.0</td>
</tr>
<tr>
<td>FC-IR 8.5</td>
<td>8.7</td>
<td>0.40</td>
<td>2.0</td>
</tr>
<tr>
<td>FC-IR 9.7</td>
<td>9.66</td>
<td>0.30</td>
<td>2.0</td>
</tr>
<tr>
<td>FC-IR 10.8</td>
<td>10.5</td>
<td>0.70</td>
<td>1.0</td>
</tr>
<tr>
<td>FC-IR 12.0</td>
<td>12.3</td>
<td>0.50</td>
<td>2.0</td>
</tr>
<tr>
<td>FC-IR 13.3</td>
<td>13.3</td>
<td>0.60</td>
<td>2.0</td>
</tr>
</tbody>
</table>

| Repeat Cycle | 30 min | 15 min | 10 min |

ECMWF Seminar 2007, Recent Developments in the use of Satellite Observations in NWP
MTG Infrared Sounder (IRS)

<table>
<thead>
<tr>
<th>Mission Band</th>
<th>Frequency range cm(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRS-1</td>
<td>700 770</td>
</tr>
<tr>
<td>IRS-2</td>
<td>770 980</td>
</tr>
<tr>
<td>IRS-3</td>
<td>980 1070</td>
</tr>
<tr>
<td>IRS-4</td>
<td>1070 1210</td>
</tr>
<tr>
<td>IRS-6</td>
<td>1600 2000</td>
</tr>
<tr>
<td>IRS-7</td>
<td>2000 2175</td>
</tr>
</tbody>
</table>

**Main Contribution**

- CO\(_2\)  
  Surface, Clouds  
- O\(_3\)  
  Surface, Clouds  
- H\(_2\)O, CO

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Repeat cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Disk Coverage</td>
<td>18°x18°</td>
</tr>
<tr>
<td>Local Area Cov.</td>
<td>18°x6°</td>
</tr>
</tbody>
</table>

1800 channels  
Spec.res. 0.62 1/cm
MTG InfraRed Sounder (IRS)

First IASI Level 1C Spectra

MTG spectral coverage

ECMWF Seminar 2007, Recent Developments in the use of Satellite Observations in NWP
MTG Infrared Sounder (IRS)

Hyperspectral IR sounding with focus on time evolution of vertically resolved water vapour structures

Priorities IRS Mission
- Atmospheric dynamic variables with high vertical resolution (e.g. water vapour flux, wind profile, transport of pollutant gases)
- More frequent information on Temperature and Humidity profiles for NWP (regional and global)
- Monitoring of instability / early warning of convective intensity
- Cloud microphysical structure
- Support chemical weather and air quality applications

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Repeat cycle</th>
</tr>
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<tbody>
<tr>
<td>Full Disk Coverage</td>
<td>18°x18°</td>
</tr>
<tr>
<td>Local Area Cov.</td>
<td>18°x6°</td>
</tr>
<tr>
<td></td>
<td>30 min</td>
</tr>
<tr>
<td></td>
<td>10 min</td>
</tr>
</tbody>
</table>
Benefits of high-spectral over broad-band measurements!

Total Precipitable Water (TPW) from high-spectral (HES) data much improved over current broadband (GOES-12 + forecast).

Menzel et al. (2007)

Root Mean Square Error
Forecast: 0.40
ABI like + fcst: 0.35
GOES 12 + fcst: 0.34
HES + fcst: 0.16
The relative vertical information is shown for radiosondes, a high-spectral infrared sounder and the current broad-band GOES Sounder. The high-spectral sounder is much improved over the current sounder.

*Figure courtesy of A. Huang*
Greatly Improved Atmospheric Motion Vectors with hyperspectral sounder
(Figure courtesy of C. Velden)
## MTG Lightning Imaging Mission

**User Request:** detect 90% of lightest events in Cloud (IC), Cloud to Cloud (CC), and Cloud to Ground (CG)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOV</td>
<td>16° Earth Disk ~ 80% of the Full Disk</td>
</tr>
<tr>
<td>IFOV + Spatial Resolution</td>
<td>10 km (45 degree North)</td>
</tr>
<tr>
<td>Wavelength</td>
<td>Neutral oxygen line OI(1) at 777.4 nm</td>
</tr>
<tr>
<td>Integration time</td>
<td>2ms - 1ms optimised to meet DE and FAR</td>
</tr>
<tr>
<td>Discharge optical pulse</td>
<td>0.5ms</td>
</tr>
<tr>
<td>Energy range</td>
<td>4 - 400 µJm(^{-2})sr(^{-1})</td>
</tr>
<tr>
<td>Detection Efficiency (DE)</td>
<td>&gt; 90% - 40% for any individual event</td>
</tr>
<tr>
<td>False Alarm Rate (FAR)</td>
<td>&lt; 1 flash/sec (averaged over the full Earth, assuming 50% cloud cover)</td>
</tr>
<tr>
<td>Repeat cycle</td>
<td>continuous (as integration time)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>intensity better 50% (20% goal)</td>
</tr>
</tbody>
</table>

**Co-registration HRFI/FDHSI:** better than 1 IFOV

**Event:** single CCD-pixel above energy threshold integrated over time (1 - 2 ms)

**Group:** optical pulse associated with a single discharge of a CG return stroke or a recoil streamer of IC/CC

**Flash:** lightning flash, consisting of several discharges - strokes/recoil streamer - separated by 50-300 ms close in space (65% of all flashes consists of more than 5 groups)

(90% of all flashes have a discharge event with radiances above 10 µJm\(^{-2}\)sr\(^{-1}\))
Continuation and enhancement of Geostationary Services

<table>
<thead>
<tr>
<th>Absorbed Shortwave Radiation</th>
<th>Cloud Top Phase</th>
<th>All Sky Radiances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Fire Detection / Monitoring</td>
<td>Cloud Top Pressure</td>
<td>Rainfall Potential and Probability</td>
</tr>
<tr>
<td>Aerosol/Dust Detection</td>
<td>Cloud Top Temperature</td>
<td>Rainfall Rate/ Multisensor QPE</td>
</tr>
<tr>
<td>Aerosol Optical Thickness</td>
<td>Cloud Type</td>
<td>Reflected Solar Radiative Flux TOA</td>
</tr>
<tr>
<td>Aerosol Particle Size</td>
<td>CO Concentration</td>
<td>Scene Analysis</td>
</tr>
<tr>
<td>All Sky Radiances</td>
<td>Convection Initiation</td>
<td>Sea &amp; Lake Ice/Age</td>
</tr>
<tr>
<td>Aircraft Icing Threat</td>
<td>Atmospheric Motion Vectors</td>
<td>Sea &amp; Lake Ice/Concentration</td>
</tr>
<tr>
<td>Air Mass Analysis</td>
<td>Downward Longwave Irradiance</td>
<td>Sea &amp; Lake Ice/ Displacement and Direction</td>
</tr>
<tr>
<td>Atmospheric Moisture Profile</td>
<td>Downward Shortwave Irradiance</td>
<td>Sea &amp; Lake Ice/Extent and Characterization</td>
</tr>
<tr>
<td>Atmospheric Temperature Profile</td>
<td>Emitted Longwave Radiative Flux TOA</td>
<td>Sea Surface Temperature</td>
</tr>
<tr>
<td>Capping Inversion Information</td>
<td>Enhanced Overshooting Top Detection</td>
<td>Snow Cover</td>
</tr>
<tr>
<td>Clear Sky Masks</td>
<td>Fire Radiative Power</td>
<td>SO₂ Concentration</td>
</tr>
<tr>
<td>Clear Sky Radiances</td>
<td>Fire Radiative Energy</td>
<td>Surface Albedo</td>
</tr>
<tr>
<td>Clear Sky Reflectance Map</td>
<td>Flood/Standing Water</td>
<td>Surface Emissivity</td>
</tr>
<tr>
<td>Climate Data Set</td>
<td>Global Instability Indices</td>
<td>Total Precipitable Water</td>
</tr>
<tr>
<td>Cloud Coverage</td>
<td>High Resolution Precipitation Index</td>
<td>Total Water Content</td>
</tr>
<tr>
<td>Cloud Ice Water Path</td>
<td>Humidity Products (upper/midlevel rel. Hu)</td>
<td>Turbulence</td>
</tr>
<tr>
<td>Cloud Imagery</td>
<td>Ice Covered Land</td>
<td>Upward Longwave Radiation at Surface</td>
</tr>
<tr>
<td>Cloud Layers / Heights and Thickness</td>
<td>Land Surface (Skin) Temperature</td>
<td>Vegetation Fraction LAI</td>
</tr>
<tr>
<td>Cloud Liquid Water</td>
<td>Lightning Detection</td>
<td>Vegetation Index</td>
</tr>
<tr>
<td>Cloud Mask</td>
<td>Low Cloud and Fog</td>
<td>Visibility</td>
</tr>
<tr>
<td>Cloud Optical Depth</td>
<td>Moisture Flux</td>
<td>Volcanic Ash</td>
</tr>
<tr>
<td>Cloud Particle Size Distribution</td>
<td>Ozone Layers</td>
<td>Wind Divergence</td>
</tr>
<tr>
<td>Cloud Top Height</td>
<td>Ozone Total</td>
<td></td>
</tr>
</tbody>
</table>

Service supported by:

- MTG Flexible Combined Imager
- MTG Infrared Sounder
- MTG Lightning Imager

ECMWF Seminar 2007, Recent Developments in the use of Satellite Observations in NWP
“Mesoscale” Atmospheric Motion Vector Algorithm (courtesy J. Mecikalski)

“Operational Settings”

New Mesoscale AMVs
(only 20% shown)

- Combination of mesoscale AMV’s with sequences of 10.7 μm T_B imagery to identify growing convective clouds, which represent a hazard to the aviation community
Convective initiation (courtesy J. Mecikalski)

Satellite data valid at: 2000 UTC 4 May 2003

- Satellite-based CI indicators provided 30-45 min advanced notice of CI in E. and N. Central Kansas.
- Methods provide ~65% POD scores for 1-hour convective initiation.

These are 1 hour forecasted CI locations!
MTG will provide continuity of EUMETSAT Services

1977

MOP/MTP

1 observation mission:
- MVIRI: 3 channels
- Spinning satellite 800 kg

2002

MSG

2 observation missions:
- SEVIRI: 12 channels
- GERB
- Spinning satellite Class 2-ton

2015

MTG

4 observation missions:
- Combined Imager: 16 channels
- Infra-Red Sounder
- Lightning Imager
- 3-axis stabilised satellites
- Twin Sat configuration 2.5 and 2.2 t

Implementation of the EUMETSAT Mandate for the Geostationary Programme

... 30 years of continuous operations achieved ...

Atmospheric Chemistry Mission (UVS) coordinated with ESA for implementation via GMES Sentinel 4/5
Polar-orbiting Satellites (Metop)

EUMETSAT Polar System (EPS)

• a series of three Metop satellites
• operate over at least 14 years.
• Metop A launched in October 2006
• Metop also contributes to oceanography, environmental observations and fosters research
EUMETSAT Polar System: Space Segment
Metop Satellite, Instruments and Missions

- Atmospheric Sounding (temperature, moisture, O_3/species):
  - IR/MW imaging sounders: HIRS-4/IASI, AMSU-A/MHS
  - UV/VIS imaging sounder: GOME-2
  - limb viewing radio-occultation sounder: GRAS
- Global VIS/IR Imagery: AVHRR/3

- 2-D wind field at the ocean surface: ASCAT
- Data Location and Collection: ARGOS terminal
- Global and Local Data Access: solid state recorder/HRPT/LRPT
- Search & Rescue Terminal

ECMWF Seminar 2007, Recent Developments in the use of Satellite Observations in NWP
**Metop instruments: Continuity + heritage + novel technology**

- **Continuity:**
  - Imaging => AVHRR (NOAA)
  - Sounding => HIRS (NOAA), MHS, AMSU-A (NOAA)

- **Science heritage:**
  - GOME-2 => ozone, aerosol, trace gases (ESA)
  - ASCAT => ocean surface winds (ESA)

- **Novel:**
  - Hyperspectral sounding => IASI (CNES)
  - Radio-occultation => GRAS

  => Initial Joint Polar System with NOAA
Global imaging

Nile river delta, March 2007

Metop-A, AVHRR
6 March 2007,
07:42 UTC
(3-channels combination for
vegetation monitoring)
IASI

• Covered by dedicated talk by P. Schlüssel
GOME-2 Ozone measurements
Provided courtesy of DLR (O3MSAF) [http://wdc.dlr.de/sensors/gome2/index.html]
Winds from ASCAT compared with ECMWF

Level-2 processing at OSI-SAF, KNMI

Courtesy, ESA, 2006
Winds over polar regions (composite from MODIS), Key et al. 2003
⇒ Large positive impact on forecasts
⇒ need to derive winds from AVHRR
EUMETSAT Strategic Guidelines for Post-EPS

EUMETSAT will remain committed, as a minimum and top priority, to the mid-morning sounding mission

There is a joint commitment between EUM Member States and NOAA for a future Polar System (JPS)

Possible EUMETSAT contribution to a JPS fully open:
- instruments across the various orbits;
- satellites on different orbits; etc.

EUMETSAT will keep responsibility for at least one end-to-end system

Need date for the core mission with instruments for Atmospheric Temperature and Humidity Sounding 2018 (1st priority), followed by the remaining missions in 2020
Future polar programme
Post-EPS

For Post - EPS the user needs in the following areas are considered as result of User Consultation through Expert Groups:

Atmospheric Chemistry;
Atmospheric Sounding and Wind Profiling;
Climate Monitoring;
Cloud, Precipitation and Large Scale Land Surface Imaging;
Ocean Surface Topography and Imaging;
Nowcasting and NWP.

The need date is 2019 and the mission will be balanced with GMES and GEO needs.
Joint technical analysis with ESA.
# Post-EPS Candidate Missions

<table>
<thead>
<tr>
<th>Name</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Resolution Infrared Sounding (IRS)</td>
<td>3</td>
</tr>
<tr>
<td>Microwave Sounding (MWS)</td>
<td>3</td>
</tr>
<tr>
<td>Scatterometry (SCA)</td>
<td>3</td>
</tr>
<tr>
<td>VIS/IR Imaging (VII)</td>
<td>3</td>
</tr>
<tr>
<td>Microwave Imaging (MWI) - Precipitation</td>
<td>2</td>
</tr>
<tr>
<td>Microwave Imaging (MWI) - Ocean and Land</td>
<td>2</td>
</tr>
<tr>
<td>Radio Occultation Sounding (RO)</td>
<td>2</td>
</tr>
<tr>
<td>Nadir viewing UV/VIS/NIR - SWIR Sounding (UVNS)</td>
<td>1</td>
</tr>
<tr>
<td>Doppler Wind Lidar (DWL)</td>
<td>1</td>
</tr>
<tr>
<td>Multi-viewing, Multi-channel, Multi-polarisation Imaging (3MI)</td>
<td>1</td>
</tr>
<tr>
<td>Dual View Radiometry (DVR)</td>
<td>1</td>
</tr>
<tr>
<td>Radar Altimetry (ALT)</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Rank value 3: highest priority
‘Near’ simultaneous observations from space for operational Earth observation – Example: The A-Train (courtesy NASA)
Thought on a deployment scenario: ‘Near’ simultaneous observations from polar orbit for operational Earth observation:

- 4-D Var assimilation makes need for distribution of observations over time less critical
- For process studies and research near simultaneous observations are essential => this will advance understand and utilisation of data
- Trains of satellites might be an option for operational observations ... serves operational (NWP) requirements and fosters research/utilisation
Meteosat-8 monitors deep convective clouds

Red pixels: T6.2 > T10.8

How can this be explained?
Cloudsat explains physics in areas with T6.2 > T10.8  
(from Cloudsat website and adapted by Chung et al., 2007)
Input data for IASI simulated spectra for a tropical atmosphere

Latitude: 1.66°

IASI simulation by X. Calbet, personal communication
A hyperspectral sounder in a geostationary orbit could vertically slice and track the moisture outflow in tropical convective regions

⇒ an important process in the global water cycle
⇒ e.g. moistening of the UTLS

IASI simulation by X. Calbet, personal communication
Reasons behind improvements in NWP due to satellite data
(from Uccellini, 2007)

- Improvement due to a balance among
  - Observations
  - Data Assimilation & Model technology
  - Computing resources
- Estimated 30 - 40% of improvement from observations (principally global LEO satellite data) and 60 - 70% from data assimilation and modeling techniques and computing resources
Need to foster utilisation and continuous development has been recognised:

=> De-centralised applications ground segment:
   - Satellite Application Facilities (SAF)

- Support to Nowcasting and Very Short Range Forecasting
- Ocean and Sea Ice
- Climate Monitoring
- Numerical Weather Prediction
- Land Surface Analysis
- Ozone & Atmospheric Chemistry Monitoring
- GRAS Meteorology
- Support to Operational Hydrology and Water Management

=> BENEFITS:
- Makes use of European expertise,
- Fosters cooperation and utilisation,
- Maximises return on investment
The importance of good satellite calibration => GSICS (Global Space-based Inter-Calibration System)

- To improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of satellite sensors.

- Improve global satellite data sets by ensuring observations are well calibrated through operational analysis of instrument performance, satellite intercalibration, and validation over reference sites.

- Provide ability to re-calibrate archived satellite data with consensus GSICS approach, leading to stable fundamental climate data records (FCDR).

- Ensure pre-launch testing is traceable to SI standards.

- => Under WMO Space Programme
  - GSICS Implementation Plan and Program formally endorsed
  - at CGMS 34 (11/06)
GSICS: Intercalibrating MSG with IASI
IASI – like instruments will be excellent reference for calibration => climate monitoring

<table>
<thead>
<tr>
<th>Channel</th>
<th>$\Delta T$ IASI – Meteosat-8*</th>
<th>$\Delta T$ IASI – Meteosat-9*</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR3.9</td>
<td>-0.17</td>
<td>-0.20</td>
</tr>
<tr>
<td>WV6.2</td>
<td>-0.24</td>
<td>-0.40</td>
</tr>
<tr>
<td>WV7.3</td>
<td>-0.51</td>
<td>-0.14</td>
</tr>
<tr>
<td>IR8.7</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>IR9.7</td>
<td>0.17</td>
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</tr>
<tr>
<td>IR10.8</td>
<td>0.16</td>
<td>0.07</td>
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<tr>
<td>IR12.0</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>IR13.4</td>
<td>0.44</td>
<td>1.7</td>
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</tbody>
</table>

*Uncertainty 0.1 – 0.2 K
Conclusion (1)

• Operational satellites do provide important contribution to meteorological services
• Need for continuous development of utilisation techniques (e.g. algorithms, timeliness, interpretation, ...)
• Future satellite missions hold promise for improved weather forecasting, better climate monitoring and better understanding of physical processes
• Realisation of future satellite systems is result of competing and complementary interests from: i) Existing operational requirements, ii) Science and anticipated future applications, iii) Technical constraints (feasibility), iv) Political considerations and v) Affordability
Conclusions (2)

- EUMETSAT satellite systems (Meteosat and Metop) are key elements of the operational space-based observing system
- Continuity and serving the evolving needs of our Member States has highest priority
- EUMETSAT’s International partnership (e.g. the Joint Polar System with NOAA) ensures a European contribution to a Global Earth Observation System of Systems (GEOSS) that are mutually consistent and also cost-effective
- EUMETSAT mandate evolves, therefore a further priority is to develop new activities in operational oceanography and atmosphere monitoring jointly with partners (ESA, NOAA, ….)
- More information (including SAF links): www.eumetsat.int