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# COORDINATION BETWEEN WMO OSCAR/SPACE AND CEOS MIM

In response to CGMS Action WGIII/A47.06b

Efforts to improve coordination between the WMO OSCAR/Space (see https://www.wmo-sat.info/oscar/spacecapabilities) and CEOS/MIM (see http://database.eohandbook.com) databases have been pursued for the past few years, and these attempts so far have been generally inconclusive.

In response to CGMS action WG III/A47.06b, a study has been performed recently to analyse various related aspects: covered areas, timeliness requirements, information sources, validation procedures, measurements and maintenance.

The study concludes that *convergence* of the two systems is impossible, and *coordination* remains difficult. *Cooperation* may be attempted, at least in the areas of updating the status of satellites and instruments and implementing convergence of the names of observed variables.

The study results contained in this working paper have already been delivered to CEOS, and as a result, further efforts to improve coordination are being made.

**Action proposed:** CGMS to take note of the efforts to improve coordination between WMO OSCAR/Space and CEOS MIM and to close Action WG III/A47.06b.

# COORDINATION BETWEEN WMO OSCAR/SPACE AND CEOS MIM

20 November 2019

## 1. Preamble

Both OSCAR (Observing Systems Capability Analysis and Review Tool) and MIM (Missions, Instruments, Measurements and Datasets) draw origin from a CEOS initiative carried out in 1996-1997 for a "*Database on User requirements and Space capabilities*". The implementation was taken over by the WMO Space Programme Office. The collected information started to be issued in electronic form as a *Dossier on the Space-based Global Observing System*, published from 2004 to 2012, updated initially yearly, thereafter quarterly. Since Autumn 2012 the Dossier was replaced by the online OSCAR database. The MIM initiative took form in CEOS in 2009-2010 and gave rise to an online database around 2012. The idea of pursuing some convergence between OSCAR and MIM was naturally proposed at instances, and several times analysed.

This note collects background elements to take into account for searching possible convergences. Consideration is given to:

- the covered areas
- the timeliness requirements
- the information sources
- the validation procedures
- the measurements
- the maintenance aspects.

It is acknowledged that this note, produced in WMO, is biased by the full knowledge of the OSCAR features v/s the limited visibility of MIM details.

## 2. Covered areas

Probably all EO satellites since the first one (TIROS-1, 1st April 1960) and their instruments are recorded in both OSCAR and MIM. Planned satellites are slightly more numerous in MIM because of more stringent criteria for being accepted for entrance in OSCAR.

In addition to EO satellites, OSCAR describes satellites for Space weather launched in the past 30 years, and a selection of most important launched before; as well as earlier instruments when hosted on operational meteorological satellites.

OSCAR includes information on the architecture of data circulation, ground segment, and access to raw and processed data. MIM provides references to existing datasets.

OSCAR is used as repository of the frequency plans of operational meteorological satellites and some R&D satellites used in operations, and the frequencies of MW active or passive sensors, for the purpose of frequency protection.

## 3. Timeliness

Being OSCAR designed to meet requirements of operational meteorology, updating of the information is performed on a nearly continuous basis. This is a big difference from MIM, that uses to be updated on an yearly basis.

The announcement of a new launch is recorded as soon as the success of the launch is official. The description of the satellite and its instruments, in general, is already in place in OSCAR, following the information on future plans; otherwise it is searched around as quickly as possible.

## 4. Information sources

The main information source for space programmes, satellites and instruments in OSCAR is the yearly plenary meeting of CGMS. The members and observers in CGMS are:

| Members | | | |
|---|---|---|---|
| CMA | China | JAXA | Japan |
| CNES | France | JMA | Japan |
| CNSA | China | KMA | Korea |
| ESA | International | NASA (also reporting for USGS) | USA |
| EUMETSAT | International | NOAA (also reporting for DoD) | USA |
| IMD | India | ROSCOSMOS | Russia |
| IOC-UNESCO | International | ROSHYDROMET | Russia |
| ISRO | India | WMO | International |

| Observers | |
|---|---|
| CSA | Canada |
| ENV CAN | Canada |
| GCOS | International |
| KARI | Korea |
| KIOST | Korea |
| SOA | China |

In addition, in the course of the year there are several committees and expert groups that meet in WMO or elsewhere (more often: EUMETSAT and NOAA) and provide fresh information on programmes, satellites and instruments.

The occurrence of new launches is announced within a few hours after the event by the *Gunter's Space Page* at https://space.skyrocket.de/index.html. This site also provides some summary description of the satellite and its instruments, as well as an approximate calendar of scheduled launches. A more accurate calendar is provided by *Spaceflight Now* at the site https://spaceflightnow.com. Here also, after the event, there is some information on satellite and its instrument. The instrument descriptions at *Gunter's Space Page* and *Spaceflight Now* are not enough detailed for the purpose of OSCAR, but they are useful to check that the instruments effectively launched correspond to what was planned.

For MIM, the nominal information source is an yearly inquiry to the CGOS members and associates:

| Members | | | |
|---|---|---|---|
| ASI | Italy | KARI | Korea |
| CAST | China | KMA | Korea |
| CDTI | Spain | NASA | USA |
| CMA | China | NASRDA | Nigeria |
| CNES | France | NIER | Korea |
| CONAE | Argentina | NOAA | USA |
| CRESDA | China | NRSCC | China |
| CSA | Canada | NSAU | Ukraine |
| CSIRO | Australia | NSO | Netherlands |
| DLR | Germany | Roscosmos | Russia |
| EC | International | RosHydroMet | Russia |
| ESA | International | SANSA | South Africa |
| EUMETSAT | International | TÜBITAK | Turkey |
| GISTDA | Thailand | UAE SA | United Arabe Emirates |
| INPE | Brazil | UKSA | United Kingdom |
| ISRO | India | USGS | USA |
| JAXA | Japan | VAST | Viet Nam |

| Associates | |
|---|---|
| AEM | Mexico |
| AGEOS | GABON |
| ANGKASA | Malaysia |
| BELSPO | Belgium |
| BOM | Australia |
| CCMEO | Canada |
| CRI | New Zealand |
| CSIR | South Africa |
| ESCAP | International |
| ESSO | India |
| FAO | International |
| GA | Australia |
| GCOS | International |
| GGOS | International |
| GOOS | International |
| ICSU | International |
| IOC | International |
| IOCCG | International |
| ISPRS | International |
| NSC | Norway |
| SNSA | Sweden |
| UNEP | International |
| UNESCO | International |
| UNOOSA | International |
| WCRP | International |
| WMO | International |

It is noted that members or observers of both CEOS and CGMS (yellow-highlighted) support the large majority of satellite programmes for meteorology, oceanography and climate, whereas the non-CGMS institutes are mostly oriented to national programmes for land observation and disaster monitoring.

In OSCAR, satellites from non-CGMS-nor-CEOS countries also are recorded; as well as commercial satellites sustained by the following companies:

| Commercial Companies sustaining high-resolution land observation satellites |
|---|

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 21AT | China | DigitalGlobe | USA | GeoEye | USA | SpacEyes | China | SSTL | UK |
| BSG | USA | Elecnor-Deimos | Spain | RapidEye | Germany | Spot Image | France | Terra Bella | USA |

## 5. Validation

The MIM approach for information entering is to rely on the material provided by the space agencies in response to the yearly inquiry. This has the advantage of leaving the responsibility to authoritative sources, but the disadvantage of dependence from the amount of care placed by the responder.

In OSCAR, every input information is scrutinised before entering, because of the envisaged follow-on process (see next section). Each data is cross-checked with any other available information, to identify and correct possible mistakes and ensure completeness as needed. Templates have been developed, initially as guidance to information providers (failed plan, because of excess of complexity or lack of careful responses), thereafter for internal use as a check list.

The most difficult task is to validate the information on the status of satellites and instruments. Whilst is it relatively easy to collect the announcements of successful launches, the notification of satellite decommissioning and instrument degradation or failure is rarely reported. Consequently, the information on time availability for gap and risk analysis tends to be unreliable. In OSCAR the case is handled by recording the status of these satellites as "Unclear" and flagging the instruments as "presumably active"; but they continue to appear in the timeline of the gap analysis, undermining its credibility. Expected launch or EOL dates are recorded as ≥yyyy. In MIM, simply the nominal launch or EOL dates are recorded, that sometimes may be misunderstood as really occurred.

## 6. Measurements

The instrument descriptions in OSCAR are much more detailed than in MIM, because the evaluation of the retrievable measurements is performed by an *expert system* that moves from the instrument *properties* and simulates the retrieval process by a number of *rules*. Here is an example of results:

| Tentative Evaluation of Measurements from TMI on TRMM | | | |
|---|---|---|---|
| **Variable** | **Rating** | **Operational limitations** | **Explanation** |
| **Accumulated precipitation (over 24 h)** | 2 - very high | Poor time sampling. Time sampling to be interpolated by GEO. | MW channels around 10, 19, 23, 37 and 90 GHz, with high spatial resolution |
| **Cloud liquid water (CLW)** | 3 - high | No specific limitation. | MW channels around 37 and 90 GHz |
| **Cloud liquid water (CLW) total column** | 3 - high | No specific limitation. | MW channels around 37 and 90 GHz |
| **Integrated Water Vapour(IWV)** | 3 - high | Over sea only. | MW channel(s) in the water vapour band around 23 GHz |
| **Land surface temperature** | 5 - marginal | Coarse spatial resolution. | MW channels around 10 GHz |
| **Long-wave Earth surface emissivity** | 4 - fair | Long time series needed. | MW channels around 10, 19, 37 and 90 GHz. Emissivity across this MW range inferred by statistical analysis |
| **Precipitation intensity at surface (liquid or solid)** | 2 - very high | No specific limitation. | MW channels around 10, 19, 23, 37 and 90 GHz, to cover sea and land, heavy and light precipitation. High spatial resolution consistent with the scale of precipitation |
| **Sea surface temperature** | 5 - marginal | Warm temperature only. | MW channels around 10 GHz |
| **Snow cover** | 2 - very high | Coarse spatial resolution. | MW channels around 19, 37 and 90 GHz. Higher frequencies less sensitive to emissivity from ground under snow . High resolution closer to the scale of snow fields |
| **Snow status (wet/dry)** | 1 - primary | Coarse spatial resolution. | MW channels around 19, 37 and 90 GHz. Higher frequencies less sensitive to emissivity from ground under snow. High resolution closer to the scale of snow fields |
| **Snow water equivalent** | 1 - primary | Coarse spatial resolution. Ground stations network needed. | MW channels around 19, 37 and 90 GHz. Higher frequencies less sensitive to emissivity from ground under snow. High resolution closer to the scale of snow fields |
| **Soil moisture at surface** | 3 - high | Coarse spatial resolution. Strongly affected by vegetation. | MW channels around 10 GHz |
| **Wind speed (near surface)** | 3 - high | Over sea only. | MW channels around 10, 19 and 37 GHz |

This process is performed automatically by the *expert system* as soon as an instrument is entered in OSCAR with described properties (hence the need for careful validation of the input data). Currently, about 900 instruments are described in OSCAR, ~600 for EO, ~300 for Space weather.

It is noted that the *expert system*, in addition to identifying the geophysical variables potentially retrievable, also assigns a rating of the quality of the retrieval (in 5 steps). The table of potential measurements also indicates possible operational limitations and provides explanation of the main factors that drive the retrieval process.

The evaluation is performed addressing *geophysical variables* that have been requested and described by a large number of expert groups coordinated by the WMO *Inter-Programme Expert Team on Observing System Design and Evolution (IPET-OSDE)* of the *Commission for Basic Systems (CBS)*. Currently, the list includes 317 variables described in the OSCAR section for Observation Requirements (*OSCAR/Requirements*). Those considered in the OSCAR section for Space-based Capabilities (*OSCAR/Space*) are 188 (124 for EO, 64 for Space weather) split in 11 themes, as follows:

**Geophysical variables considered in OSCAR/Space as of 18 November 2019**

| | | | |
|---|---|---|---|
| **Basic atmospheric** | **Ocean** | **Atmospheric chemistry** | Heavy ion flux energy and mass spectrum |
| Atmospheric temperature | Ocean chlorophyll concentration | O3 | Heavy ion angular flux energy and mass spectrum |
| Specific humidity | Colour Dissolved Organic Matter (CDOM) | O3 (Total column) | Cosmic ray neutron flux spectrum |
| Integrated Water Vapour (IWV) | Ocean suspended sediments concentration | BrO | Energetic Neutral Atom (ENA) |
| Wind (horizontal) | Ocean Diffuse Attenuation Coefficient (DAC) | C2H2 | Solar wind density |
| Height of the top of the PBL | Oil spill cover | C2H6 | Solar wind temperature |
| Height of the tropopause | Sea surface temperature | CFC-11 | Solar wind velocity |
| Temperature of the tropopause | Sea surface salinity | CFC-12 | Interplanetary magnetic field |
| Wind speed over the surface (horizontal) | Ocean dynamic topography | CH4 | Electrostatic charge |
| Wind vector over the surface (horizontal) | Coastal sea level (tide) | ClO | Radiation Dose Rate |
| Atmospheric density | Significant wave height | ClONO2 | **Solar monitoring** |
| **Clouds and precipitations** | Dominant wave direction | CO | Solar gamma-ray flux spectrum |
| Cloud cover | Dominant wave period | $CO_2$ | Solar X-ray flux |
| Cloud top temperature | Wave directional energy frequency spectrum | COS | Solar X-ray flux spectrum |
| Cloud top height | **Sea ice** | H2O | Solar X-ray image |
| Cloud type | Sea-ice cover | HC3Br | Solar EUV flux |
| Cloud base height | Sea-ice elevation | HCFC-22 | Solar EUV flux spectrum |
| Cloud optical depth | Sea-ice thickness | HCHO | Solar EUV image |
| Cloud liquid water (CLW) | Sea-ice type | HCHO (Total column) | Solar Lyman-alpha flux |
| Cloud liquid water (CLW) total column | **Land surface** | HCl | Solar Lyman-alpha image |
| Cloud drop effective radius | Land surface temperature | HDO | Solar UV flux |
| Cloud ice | Soil moisture at surface | HNO3 | Solar UV flux spectrum |
| Cloud ice (total column) | Soil moisture (in the roots region) | N2O | Solar UV image |
| Cloud ice effective radius | Biomass | N2O5 | Solar Ca II-K image |
| Freezing level height in clouds | Fraction of vegetated land | NO | Solar VIS flux |
| Melting layer depth in clouds | Vegetation type | NO2 | Solar VIS flux spectrum |
| Precipitation (liquid or solid) | Leaf Area Index (LAI) | NO2 (Total column) | Solar VIS image |
| Precipitation intensity at surface (liquid or solid) | Normalised Difference Vegetation Index (NDVI) | OH | Solar white light image |
| Accumulated precipitation (over 24 h) | Fire fractional cover | PAN | Solar H-alpha image |
| Lightning detection | Fire temperature | PSC occurrence | Solar radio flux spectrum |
| **Aerosols and radiation** | Fire radiative power | SF6 | Solar coronagraphic image |
| Aerosol Optical Depth | Snow status (wet/dry) | SO2 | Solar electric field |
| Aerosol mass mixing ratio | Snow cover | SO2 (Total column) | Solar magnetic field |
| Aerosol column burden | Snow water equivalent | **Ionospheric disturbances** | Solar velocity fields |
| Aerosol effective radius | Soil type | Aurora | Gamma-ray flux |
| Aerosol type | Land cover | Electric field | Gamma-ray flux spectrum |
| Aerosol volcanic ash | Land surface topography | Electron density | X-ray flux |
| Aerosol volcanic ash (Total column) | Glacier cover | Ionospheric plasma density | X-ray flux spectrum |
| Downward short-wave irradiance at TOA | Glacier motion | Ionospheric plasma velocity | X-ray sky image |
| Upward spectral radiance at TOA | Glacier topography | Ionospheric radio absorption | EUV flux |
| Upward long-wave irradiance at TOA | Ice sheet topography | Ionospheric scintillation | EUV flux spectrum |
| Upward short-wave irradiance at TOA | **Solid Earth and magnetic field** | Ionospheric Vertical Total Electron Content (VTEC) | EUV sky image |
| Short-wave cloud reflectance | Geoid | **Energetic particles and solar wind** | UV flux |
| Downward long-wave irradiance at Earth surface | Crustal plates positioning | Electron integral directional flux | UV flux spectrum |
| Downward short-wave irradiance at Earth surface | Crustal motion (horizontal and vertical) | Electron differential directional flux | UV sky image |
| Earth surface albedo | Gravity field | Proton integral directional flux | VIS flux |
| Earth surface short-wave bidirectional reflectance | Gravity gradients | Proton differential directional flux | VIS sky image |
| Upward long-wave irradiance at Earth surface | Geomagnetic field | Alpha particles integral directional flux | Radio-waves |
| Long-wave Earth surface emissivity | | Alpha particles differential directional flux | Heliospheric image |
| Photosynthetically Active Radiation (PAR) | | | |
| Fraction of Absorbed PAR (FAPAR) | | | |

Measurements that can be provided from space also are considered in MIM. In the MIM edition for 2020 the following areas (5) and measurements (28) are listed:

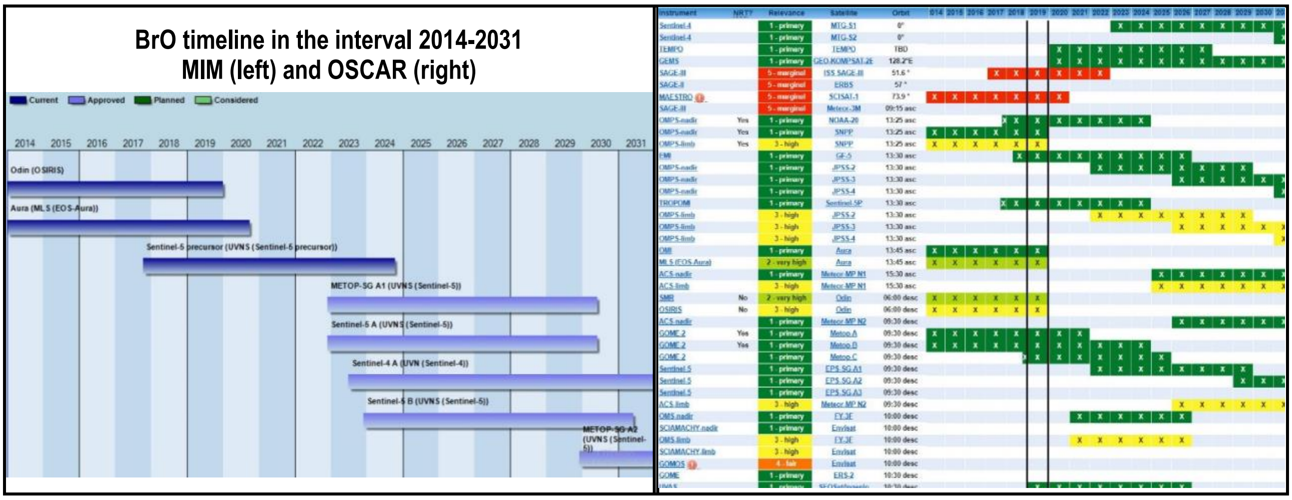
**Measurements considered in MIM in the edition for 2020**

| | | | |
|---|---|---|---|
| **Atmosphere** | Liquid water and precipitation rate | Soil moisture | Ocean topography/currents |
| Aerosols | Ozone | Surface temperature (land) | Ocean wave height and spectrum |
| Atmospheric Humidity Fields | Radiation budget | Vegetation | Surface temperature (ocean) |
| Atmospheric Temperature Fields | Trace gases (excluding ozone) | **Ocean** | **Snow and ice** |
| Atmospheric Winds | **Land** | Multi-purpose imagery (ocean) | Ice sheet topography |
| Cloud particle properties and profile | Albedo and reflectance | Ocean colour/biology | Sea ice cover, edge and thickness |
| Cloud type, amount and cloud top temperature | Landscape topography | Ocean Salinity | Snow cover, edge and depth |
| Lightning Detection | Multi-purpose imagery (land) | Ocean surface winds | **Gravity and Magnetic field** |
| | | | Gravity, Magnetic and Geodynamic measurements |

However, the “measurements” addressed by MIM often imply a number of “variables”. This section of MIM is still under development, and currently only analyses a limited number of variables, whose definition is often imported from OSCAR. It may be inferred that, finally, the variables handled in MIM will roughly correspond to those handled in OSCAR, except for Space weather variables. To be noted that the names of a few variables do not match each other.

It has been mentioned that the variables handled in OSCAR/Space are identified by an *expert system* automatically deriving the variable from the instrument properties. In MIM, the retrievable variables are declared by the agency responsible of the satellite and instrument.

Both OSCAR and MIM provide timelines of availability of measurements/variables. MIM is so far limited to current or planned missions, in practice since 1999. OSCAR includes past missions, since their start date (for some, since 1960). However, the main difference is the degree of detail, that for OSCAR is at instrument level whereas for MIM is at satellite level, with some indication of the instrument. One comparative example, BrO, is shown below.




It may be noted that the OSCAR plot records each instrument potentially capable of measuring BrO, with indication of the satellite and its geostationary position or Equatorial Crossing Time. Also, there is a rating indicating the relative relevance of the various instruments, that may exploit different technologies, to meet user requirements [for example, in this particular case the rating is: 1 High-resolution UV spectrometer, 2 Mm-submm spectrometer, 3 UV spectrometer scanning the limb mechanically or electronically, 4 UV spectrometer scanning the limb by star occultation, and 5 UV spectrometer scanning the limb by solar occultation.

In addition to providing *gap analysis by variable*, OSCAR also generates a *gap analysis by mission*. Currently, the following 41 missions are defined:

| Missions addressed in the Gap analysis of OSCAR/Space | | |
|---|---|---|
| Multi-purpose VIS/IR imagery from LEO | Imagery with special viewing geometry | Space Weather: Field and wave monitoring |
| Multi-purpose VIS/IR imagery from GEO | Lightning imagery from GEO or LEO | Gravity field measuring systems |
| IR temperature/humidity sounding from LEO | Cloud and precipitation profiling by radar | Precise positioning |
| IR temperature/humidity sounding from GEO | Lidar observation (for wind, for cloud/aerosol, for trace gases, for altimetry) | Data Collection Systems and Search-and-Rescue |
| MW temperature/humidity sounding from LEO | Cross-nadir SW spectrometry (for chemistry) from LEO | Instruments covering 200-400 nm |
| MW temperature/humidity sounding from GEO | Cross-nadir SW spectrometry (for chemistry) from GEO | Instruments covering 400-700 nm |
| MW imagery | Cross-nadir IR spectrometry (for chemistry) from LEO | Instruments covering 700-1300 nm |
| Radio occultation sounding | Cross-nadir IR spectrometry (for chemistry) from GEO | Instruments covering 1300-3000 nm |
| Earth radiation budget from LEO | Limb-sounding spectrometry | Instruments covering 3.0-5.0 micrometers |
| Earth radiation budget from GEO | High-resolution imagery for land observation | Instruments covering 5.0-8.5 micrometers |
| Sea-surface wind by active and passive MW | Synthetic Aperture Radar | Instruments covering 8.5-15 micrometers |
| Radar altimetry | Space Weather: Solar activity monitoring | Instrument covering 15 micrometers - 1 mm (300-20,000 GHz) |
| Ocean colour imagery from LEO | Space weather: Heliospheric radiation monitoring | Instruments covering 1-300 GHz |
| Ocean colour imagery from GEO | Space weather: Energetic particles monitoring | |

The gap analysis by mission identifies all the instruments that measure variables relevant to implement a mission, independently from their type (that, however, impact on the effectiveness of the instrument impact. The following example refers to the mission *Limb-sounding spectrometry*:

**Timeline of the mission "Limb sounding spectrometry" in the Gap analysis of OSCAR/Space (limited to period 2005-2031)**

| Instrument | NRT? | Sorting | Satellite | Orbit | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIGHTI | | 4 | ICON | 27 ° | | | | | | | | | | | | | | | X | X | X | X | X | X | | | | | | | |
| SHIMMER | | 4 | STPSat-1 | 37.4 ° | | | X | X | X | | | | | | | | | | | | | | | | | | | | | | |
| SAGE-III | | 2 | ISS SAGE-III | 51.6 ° | | | | | | | | | | | | | X | X | X | X | X | X | | | | | | | | | |
| SAGE-II | | 2 | ERBS | 57 ° | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MLS | | 3 | UARS | 57 ° | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| HRDI | | 4 | UARS | 57 ° | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WINDII | | 4 | UARS | 57 ° | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MAESTRO | | 2 | SCISAT-1 | 73.9 ° | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | |
| ACE-FTS | | 3 | SCISAT-1 | 73.9 ° | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | |
| TIDI | | 4 | TIMED | 74 ° | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | |
| SAGE-III | | 2 | Meteor-3M | 09:15 asc | X | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| OMPS-limb | Yes | 2 | SNPP | 13:25 asc | | | | | | | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | |
| OMPS-limb | | 2 | JPSS-2 | 13:30 asc | | | | | | | | | | | | | | | | | | X | X | X | X | X | X | X | X | | |
| OMPS-limb | | 2 | JPSS-3 | 13:30 asc | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | X |
| OMPS-limb | | 2 | JPSS-4 | 13:30 asc | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| AIUS | | 3 | GF-5 | 13:30 asc | | | | | | | | | | | | | | X | X | X | X | X | X | X | X | X | | | | | |
| TES-limb | | 3 | Aura | 13:45 asc | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | | |
| MLS (EOS-Aura) | | 3 | Aura | 13:45 asc | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | |
| ACS-limb | | 1 | Meteor-MP N1 | 15:30 asc | | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | X | X |
| OSIRIS | No | 2 | Odin | 06:00 desc | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | |
| SMR | No | 3 | Odin | 06:00 desc | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | | | |
| ACS-limb | | 1 | Meteor-MP N2 | 09:30 desc | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | X | X |
| SCIAMACHY-limb | | 1 | Envisat | 10:00 desc | X | X | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | |
| GOMOS | | 2 | Envisat | 10:00 desc | X | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | |
| OMS-limb | | 2 | FY-3F | 10:00 desc | | | | | | | | | | | | | | | | | X | X | X | X | X | X | | | | | |
| MIPAS | | 3 | Envisat | 10:00 desc | X | X | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | |
| ILAS-I | | 5 | ADEOS | 10:30 desc | | | | | | | | | | | | | | | | | | | | | | | | | | | |

The impact is rated as follows: 1. UV/VIS/NIR/SWIR spectrometer, 2. UV/VIS and possibly NIR spectrometer, 3. IR spectrometer in MWIR and TIR OR Mm-submm spectrometer in the range 60-250 GHz or possibly 60-650 or possibly 60-3000 GHz, 4. Very-high resolution spectrometer operating on lines in VIS and NIR, and 5. Occultation spectrometers.

## 7. Maintenance aspects

The maintenance of OSCAR is heavier that of MIM because of:

- higher complexity of the system, in spite of the automatism granted by the developed *expert system* for identification and handling of the retrievable geophysical variables;
- need for wide-range scientific support for validation and, at instances, development.

Uploading the information on current and planned satellites and instruments implies a massive analysis of documents made available at CGMS plenary sessions and, to a minor extent, expert groups reporting to WMO and cooperating agencies. In addition, there is the continuous monitoring of launch events. A major problem is the need for careful checking of all the incoming information in order to ensure the quality and completeness necessary to enter the *expert system*.

Since, in general, the information is anticipated by the planning, therefore may need actualisation, it is necessary to control at instances whether something (especially in the instrument characteristics) needs updating after consolidation. An OSCAR/Space Support Team (O/SST) representing all CGMS operators ensures correctness and completeness of the factual content of OSCAR/Space.

A major problem is to find information on the status of satellites and instruments, never enough emphasised by the responsible agencies. Periodic requests are addressed to designated or otherwise identified contact points, but the response rate is generally poor. Of course, this problem strongly affects the realism of the gap analyses.

The scientific contents of OSCAR/Space also need to be monitored and, at instances, updated. A critical point, fortunately infrequent, arises when the *expert system* needs additions to deal with an instrument of new conception. To deal with updating the OSCAR/Space functionalities, e.g. for mapping mission capabilities to WMO observational requirements, there is an OSCAR/Space Science and Technical Advisory Team (O/SSAT), made of representatives of international science working groups such as ITWG (sounding), IWWG (winds), IPWG (precipitation), IROWG (radio occultation), ICWG (clouds), and from the Global Space-based Inter-Calibration System (GSICS).

For detailed characteristics and information on the status of satellites and instruments managed by CGMS, OSCAR/Space, in cooperation with GSICS, records the links to *Landing pages* that, in principle, the space agencies should maintain updated.

One important maintenance task regards the User requirements. Side-to-side with OSCAR/Space, OSCAR/Requirements define the needed geophysical variables and quotes their uncertainty as:

- "goal": an ideal performance above which further improvements are not necessary
- "breakthrough": a performance that, if achieved, would result in a significant improvement
- "threshold": minimum requirement to be met to ensure that data are useful.

The requirements are subject to a *Rolling Requirements Review* process (RRR) overviewed by the previously mentioned IPET-OSDE. They cover the following application areas:

| **Applications areas currently considered in the Rolling Requirements Review** | | |
|---|---|---|
| Global Numerical Weather Prediction | Aeronautical Meteorology | Ocean Applications |
| High-Resolution Numerical Weather Prediction | Agricultural Meteorology | Monitoring Atmospheric Composition |
| Nowcasting / Very Short Range Forecasting | Climate Monitoring (GCOS) | Forecasting Atmospheric Composition |
| Sub-Seasonal to Longer Predictions (SSLP) | Climate Science | Atmospheric Composition for urban and populated areas |
| Hydrology | Climate applications | Space Weather |

The geophysical variables were defined by several User groups, representing a number of international programmes. They formulated the quantitative requirements, and continue to update them periodically, issuing *Statements of Guidance*. The current list of User groups is as follows:

| **User groups involved in development and updating of the Rolling Requirements Review** | |
|---|---|
| Expert Team on Observational Data Requirements and Redesign of the Global Observing System (ET ODRRGOS) | Global Climate Observing System (GCOS) |
| Atmospheric Observation Panel for Climate (AOPC) | World Climate Research Programme (WCRP) |
| Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) | Oceans Observation Panel for Climate (OOPC) |
| Terrestrial Observation Panel for Climate (TOPC) | Global Atmosphere Watch (GAW) |
| Interprogramme Coordination Team on Space Weather (ICTSW) | World Meteorological Organization (WMO) |

There is strong interaction between OSCAR/Space and OSCAR/Requirements. Currently, out of the 317 variables listed in OSCAR/Requirements, only 188 are processed in OSCAR/Space. Most of the missing ones are not processed because currently impossible to be observed from space, or impossible to be retrieved with acceptable accuracy and/or reliability [it is noted that the RRR is technology-free in respect of measuring either from space or on/from the ground]. Other variables are not processed because trivial derivative of a processed one. Another reason for not processing is when the retrieval algorithm is too much dependent from external information, or requires a combination of more instruments [ideally, OSCAR/Space tends to be limited to consider “Level 2” products, i.e. those where it is possible to recognise the originating instrument].

Adding further variables to be processed is part of the OSCAR/Space maintenance task. It may turn to be a difficult task because it implies additions to the *expert system*, that is something that requires substantial scientific capability.

A main problem with OSCAR/Space maintenance is the level of resources in WMO. The in-house scientific resources do not allow to face significant developments, and the technical assistance is so scarce that even developments already prepared cannot be put in operation. This backlog of prepared developments mostly focusses on improved User interfaces, especially for better exploitation of the Gap analyses. Other maintenance issues currently on stand regard the re-alignment of the *Gap analysis by mission* to the latest WIGOS deliberations.

As for MIM, maintenance is, in principle, simpler because of the limited timeless requirements and the lower degree of needed scientific validation, due to the trust given to the space agency statements and to the CEOS study groups assessments. Handling technical activities is facilitated by the support of an efficient company specialised in database development and maintenance (*Symbios*), that also is tasked of producing the CEOS EO Handbook, published at circumstances on variable thematic issues.

## 8. Opportunities for OSCAR-MIM cooperation

The idea of cooperation between the OSCAR and MIM databases is rather obvious, and was suggested in several occasions, sometimes tasking the responsible persons to study the matter.

Correspondence on the subject was exchanged is a few occasions. The results have always been inconclusive, because of reasons not obvious if one does not enter the details of the two databases.

The background difficulty is that, although both OSCAR and MIM address most of the areas of interest (except for Space weather for MIM), OSCAR has to pay particular care to applications requiring demanding timeliness (e.g., operational meteorology). The updating rate of MIM (yearly) does not fit this requirement.

The next problem is that OSCAR is user-oriented and pays regard to the *Rolling Requirements Review* (RRR), where requirements are formulated in a technology-free fashion. This implies that the instrument capability to measure a geophysical variable, and the quality of the retrieval, are assessed by the users, not simply declared by the instrument provider. Because of this, the instrument description in OSCAR must be sufficiently detailed, and the declared characteristics carefully validated before entering the evaluation process.

The evaluation process applied in OSCAR (the *expert system*) would be difficult to run on MIM, not only because of lack of validation of the input data, but also because any correction or adaptation or addition require scientific knowledge that might not be available. Actually, it is not sure that the result from the *expert system* is more accurate, but at least all instruments are compared on a fair basis, and the statements of the results are traceable to the instrument characteristics.

The gap analysis in OSCAR is performed at instrument level, covering the past by about 50 years; in MIM at satellite level (with some indication of the concerned instrument), over about 20 past years. As for the future, MIM includes more planned satellites than OSCAR, since OSCAR does not include yet satellites and instruments not described with sufficient detail.

In OSCAR, the geophysical variables are defined and quantitatively specified by the RRR. In MIM, most geophysical variables are imported from OSCAR (thus from the RRR), but several others do not match. Anyway, several quoted measurement capabilities do not match. The quality of the retrieved measurement is evaluated in OSCAR, not mentioned in MIM.

In conclusion, *convergence* of the two systems is impossible, and *coordination* is difficult. *Cooperation* may be attempted, at least in the following two areas:

- since CEOS/MIM interacts with more agencies than WMO/OSCAR, it could help for updating the status of satellites and instruments in order that the gap analyses stop carrying forward systems that perhaps are inactive since long;

- WMO/OSCAR could help CEOS/MIM for implementing convergence of the names of observed variables towards those established in the framework of the RRR. Perhaps MIM could adopt the quality rating of the retrieved measurements as computed by the OSCAR *expert system*.