Meteorological Satellites (MetSat)

Overview of the global network of Meteorological Satellites

Speaker: **Markus Dreis** (EUMETSAT)

Second ITU/WMO Seminar "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction", Geneva, 23 to 24 October 2017

Role of MetSat in the WMO Global Observing System (GOS)

- The space-based component of GOS for the measurement of environmental and meteorological data includes two constellations: geostationary (GSO) and non-geostationary (NGSO) low Earth-orbiting, mostly polar-orbiting observation satellites.
- NGSO and GSO MetSat satellites are normally equipped with visible and infrared imagers and sounders, from which one can derive many meteorological parameters. The polar-orbiting satellites are also equipped with active and passive microwave sensing instruments that provide for example vertical profiles of temperature and humidity on a worldwide basis.
- The huge amount of parameters and data from sensors on MetSat satellites resulted in significant improvements in Numerical Weather Prediction (NWP).
- In addition to the instruments on board, MetSat satellites also carry data collection systems (DCS) which gather basic meteorological and environmental data for the GOS from data collection platforms (DCPs) located anywhere in the world (mostly at remote locations or buoys at sea (e.g. for Tsunami warning)).

Overview of Instrument Types and Missions on MetSat systems

GSO MetSat:

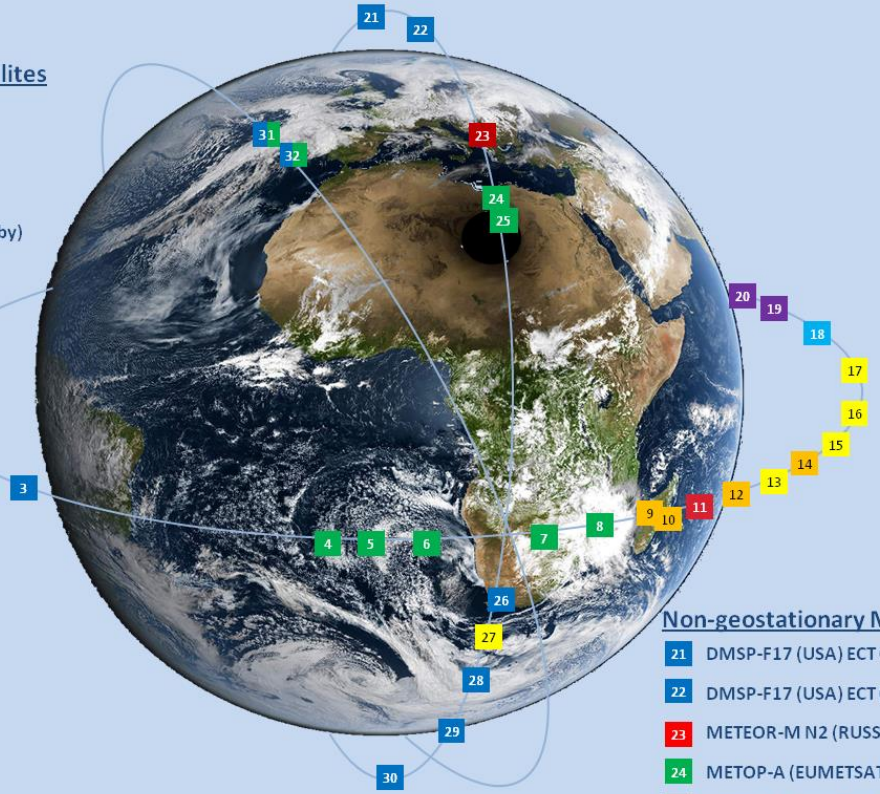
- Visible imagers
- Infrared imagers
- Infrared sounders (future)
- Data Collection System
- Search and Rescue
- Further instruments (individual to different MetSat systems)

NGSO MetSat:

- Visible imagers
- Infrared imagers
- Infrared sounders
- Data Collection System
- Search and Rescue
- Active microwave sensors
- Passive microwave sensors
- Further instruments (individual to different MetSat systems)

Current global network of MetSat in the WMO GOS

Currently operational Meteorological Satellites (Status: June 2016, Information Source: CGMS)



Geostationary Meteorological Satellites

1 GOES-15 (USA) 135°W
2 GOES-14 (USA) 105°W (stand-by)
3 GOES-13 (USA) 75°W
4 METEOSAT-11 (EUMETSAT) 3.4°W (stand-by)
5 METEOSAT-10 (EUMETSAT) 0°
6 METEOSAT-9 (EUMETSAT) 9.5°E
7 METEOSAT-8 (EUMETSAT) 41.5°E
8 METEOSAT-7 (EUMETSAT) 57.5°E
9 INSAT-3C (INDIA) 74°E
10 KALPANA-1 (INDIA) 74°E
11 ELECTRO-L N2 (RUSSIA) 77.8°E
12 INSAT-3C (INDIA) 82°E
13 FY-2E (CHINA) 86.5°E
14 INSAT-3A (INDIA) 93.5°E
15 FY-2G (CHINA) 105°E
16 FY-2F (CHINA) 112.5°E (stand-by)
17 FY-2D (CHINA) 123.5°E
18 COMS-1 (SOUTH KOREA) 128.2°E
19 HIMAWARI-8 (JAPAN) 140.7°E
20 HIMAWARI-7 (JAPAN) 145°E (stand-by)

Non-geostationary Meteorological Satellites

21 DMSP-F17 (USA) ECT 06:20 descending
22 DMSP-F17 (USA) ECT 07:08 descending
23 METEOR-M N2 (RUSSIA) ECT 09:10 descending
24 METOP-A (EUMETSAT) ECT 09:30 descending
25 METOP-B (EUMETSAT) ECT 09:30 descending
26 SNPP (USA) ECT 13:29 ascending
27 FY-3B (CHINA) ECT 13:38 ascending
28 NOAA-19 (USA) ECT 14:36 ascending
29 DMSP-F16 (USA) ECT 16:12 ascending
30 NOAA-18 (USA) ECT 17:53 ascending
31 JASON-2 (USA, EUROPE) 66° inclination
32 JASON-3 (USA, EUROPE) 66° inclination

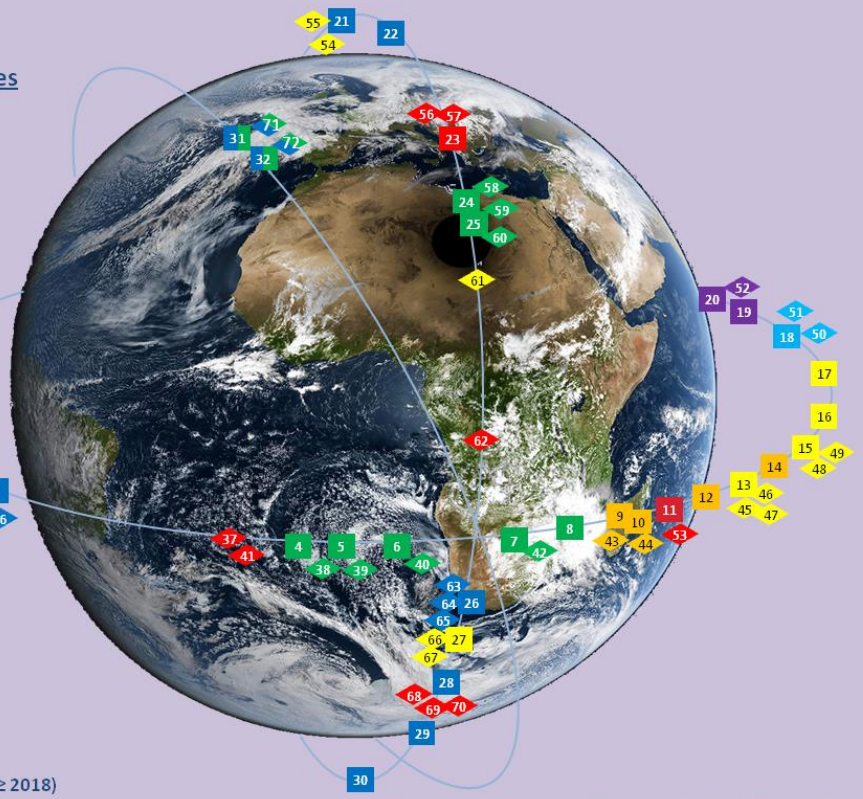
The actual list of currently operational MetSat and their parameters is available at: http://www.wmo.int/pages/prog/sat/GOSleo.html.

Constellation of planned MetSat for the WMO GOS

World Meteorological Organization

International Telecommunication Union

Planned Meteorological Satellites in the Timeframe 2016 - 2026 (Status: June 2016, Information Source: CGMS)



Geostationary Meteorological Satellites

- 33 GOES-T (USA) 137°W (≥ 2019)
- 34 GOES-R (USA) 89.5W (≥ 2016-11)
- 35 GOES-S (USA) 75°W (≥ 2018)
- 36 GOES-U (USA) 75°W (≥ 2025)
- 37 ELECTRO-L N3 (RUSSIA) 14.5°W (≥ 2017)
- 38 MTG-I1 (EUMETSAT) 0°E/9.5°E (≥ 2020)
- 39 MTG-S1 (EUMETSAT) 0°E (≥ 2022)
- 40 MTG-I2 (EUMETSAT) 0°E (≥ 2023)
- 41 ELECTRO-L N5 (RUSSIA) TBD (≥ 2025)
- 42 METEOSAT-8 (EUMETSAT) 41.5°E (≥ 2016-09)
- 43 INSAT-3DR (INDIA) 74°E (≥ 2016-08)
- 44 INSAT-3DS (INDIA) 74°E (≥ 2022)
- 45 FY-4A (CHINA) 86.5°E (≥ 2016)
- 46 FY-2H (CHINA) 86.5°E (≥ 2017)
- 47 FY-4C (CHINA) 86.5°E (≥ 2020)
- 48 FY-4B (CHINA) 105°E (≥ 2018)
- 49 FY-4D (CHINA) 105°E (≥ 2020)
- 50 GEO-KOMPSAT-2A (SOUTH KOREA) 128.2°E (≥ 2018)
- 51 GEO-KOMPSAT-2B (SOUTH KOREA) 128.2°E (≥ 2019)
- 52 HIMAWARI-9 (JAPAN) 140°E (≥ 2016)
- 53 ELECTRO-L N5 (RUSSIA) TBD (≥ 2019)

Non-geostationary Meteorological Satellites

- 54 FY-3E (CHINA) ECT 06:00 desc. (≥ 2018)
- 55 FY-3H (CHINA) ECT 06:00 desc. (≥ 2021)
- 56 METEOR-M N2-2 (RUSSIA) ECT 09:00 desc. (≥ 2017)
- 57 METEOR-M N2-4 (RUSSIA) ECT 09:00 desc. (≥ 2021)
- 58 METOP-C (EUMETSAT) ECT 09:30 desc. (≥ 2018-10)
- 59 METOP-SG A (EUMETSAT) ECT 09:30 desc. (≥ 2021)
- 60 METOP-SG B (EUMETSAT) ECT 09:30 desc. (≥ 2023)
- 61 FY-3F (CHINA) ECT 10:00 desc. (≥ 2019)
- 62 METEOR-M N3 (RUSSIA) ECT 12:00 asc. (≥ 2021)
- 63 JPSS-1 (USA) ECT 13:30 asc. (≥ 2017-01)
- 64 JPSS-2 (USA) ECT 13:30 asc. (≥ 2021)
- 65 JPSS-3 (USA) ECT 13:30 asc. (≥ 2026)
- 66 FY-3D (CHINA) ECT 14:00 asc. (≥ 2016-12)
- 67 FY-3G (CHINA) ECT 14:00 asc. (≥ 2021)
- 68 METEOR-M N2-1 (RUSSIA) ECT 15:00 asc. (≥ 2017)
- 69 METEOR-M N2-3 (RUSSIA) ECT 15:00 asc. (≥ 2020)
- 70 METEOR-M N2-5 (RUSSIA) ECT 15:00 asc. (≥ 2022)
- 71 72 SENTINEL-6 A/B(USA, EUROPE) 66° incl. (≥ 2020/2025)

- Operational continuity in the space-based meteorological observations is ensured by replacing existing series of meteorological satellites with new or next generation meteorological satellites.
- Next generation MetSats have significantly increased observation capabilities and instrument resolution, resulting in corresponding higher data volume available to the meteorological user community.

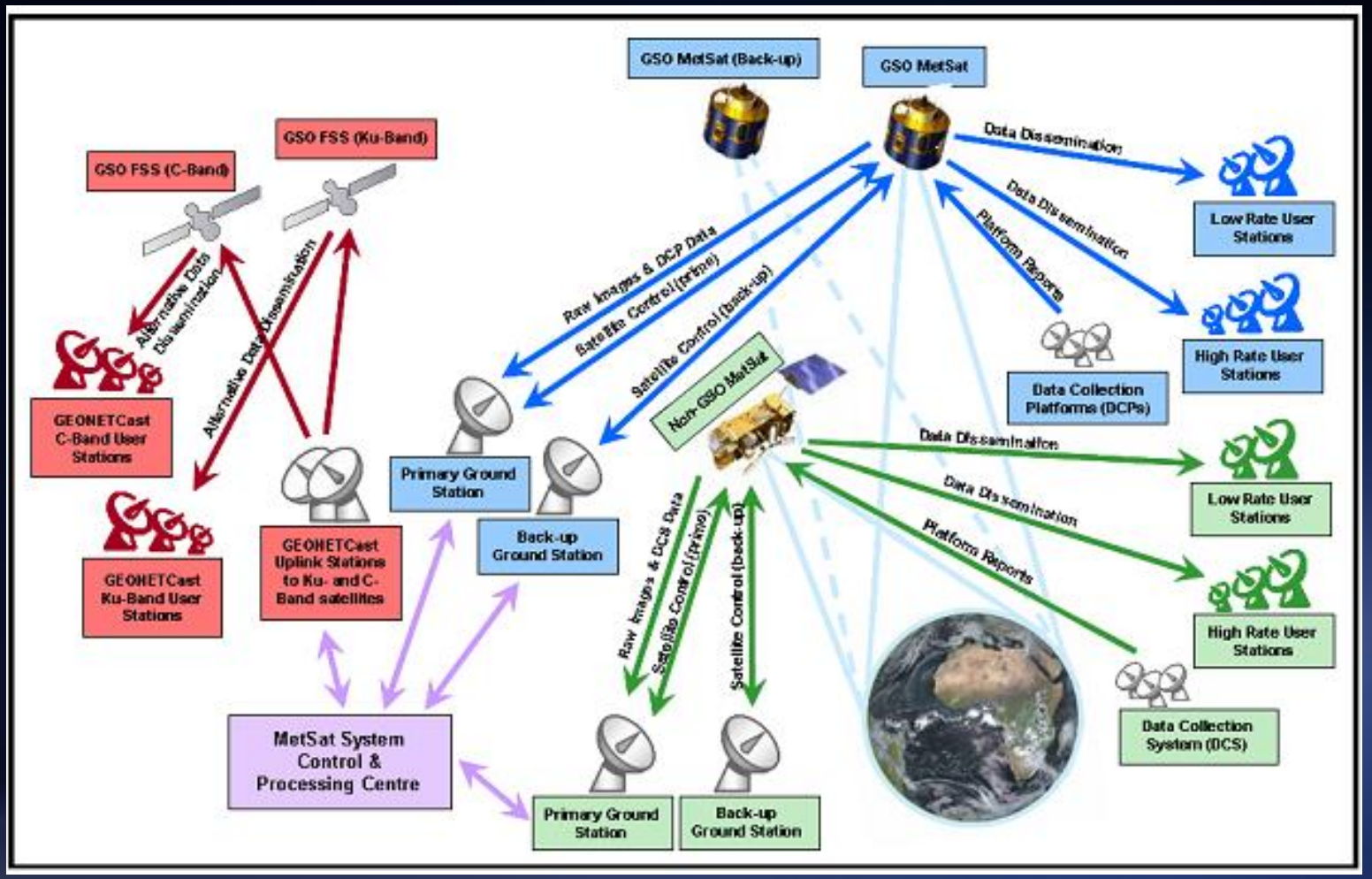
Definition of MetSat in the ITU Radio Regulations

- MetSat is defined in No. 1.52 of the Radio Regulations (RR) as "an Earth exploration-satellite service for meteorological purposes".
- It allows the radiocommunication operation between earth stations and one or more space stations, which may include links between space stations, with links to provide:
  - Information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment, obtained from active or passive sensors on Earth satellites;
  - Information collected from airborne or Earth-based platforms;
  - Information distributed to earth stations;
  - Feeder links necessary for the operation of MetSat satellites and its applications.

MetSat radio-frequency transmissions

- Radio-frequencies are used for the following MetSat applications (not including active and passive microwave sensing):
  - telemetry, telecommand and ranging of the spacecraft
  - transmissions of observation data from MetSat satellites to main reception stations;
  - re-transmissions of pre-processed data to meteorological user stations through MetSat satellites;
  - direct broadcast transmissions to meteorological user stations from MetSat satellites;
  - alternative data dissemination to users (GEONETCast) via other satellite systems than MetSat (not in MetSat/EESS allocated frequency bands);
  - transmissions from Data Collection Platforms through MetSat satellites;
  - relay of Search and Rescue messages (COSPAS-SARSAT).

General Concept of MetSat Systems



Data Transmission Concepts of MetSat Systems

- The raw data gathered by the instruments on-board geostationary MetSats are permanently transmitted to a primary ground station of the operating agency, processed, and distributed to various national meteorological centres, to official archives, and other users.
- Processed data from geostationary MetSats are either sent back to the meteorological satellite for re-transmission as part of a direct broadcast to user stations via low and/or high rate digital signals.
- Different to geostationary MetSat satellites, where the satellite is permanently in visibility of its ground stations, the raw data acquired by instruments on non-geostationary MetSats have to be gathered and stored on-board the satellite until they can be transmitted to a primary ground station of the operating agency when the satellite passes over such a ground station.
- The raw instrument data are then processed by the operating agency and provided to the users by different data dissemination mechanisms. To improve the latency of the data, a subset of the data acquired by the instruments are “broadcasted” directly from the satellite and can be received by user stations when the satellite is in the visibility of such a user station which can be located anywhere. Such a service is called “direct read-out”.
- In addition, the processed data are also distributed to users by using alternative means of data dissemination, e.g. GEONETCast.

Frequency band allocations to MetSat & EESS in the RR

Available allocations for MetSat data transmissions	
space-to-Earth direction	**Earth-to-space direction**
137-138 MHz (MetSat primary)	
400.15-401 MHz (MetSat primary)	401-403 MHz (EESS and MetSat primary)
460-470 MHz (EESS and MetSat secondary)	
1 670-1 710 MHz (MetSat primary)	
2 200-2 290 MHz (EESS primary) (Note 1) (and space-to-space direction)	2 025-2 110 MHz (EESS primary) (Note 1) (and space-to-space direction)
7 450-7 550 MHz (MetSat primary, limited to geostationary satellites only)	7 190-7 250 MHz (EESS primary) (Note 1) (and space-to-space direction)
7 750-7 900 MHz (MetSat primary, limited to non-geostationary satellites only)	
8 025-8 400 MHz (EESS primary) (Note 1)	8 175-8 215 MHz (MetSat primary)
18.0-18.3 GHz (MetSat primary for space-to-Earth direction in Region 2, limited to geostationary satellites only)	
18.1-18.4 GHz (MetSat primary for space-to-Earth direction in Regions 1 and 3, limited to geostationary satellites only)	
25.5-27.0 GHz (EESS primary) (Note 1) (and space-to-space direction in 25.25-27.5 GHz)	28.5-30.0 GHz (EESS secondary) (Note 1)
37.5-40.0 GHz (EESS secondary) (Note 1)	40.0-40.5 GHz (EESS primary) (Note 1)
65.0-66.0 GHz (EESS primary) (Note 1)	

(Note 1) – Since MetSat is a sub-class of EESS, those allocations (for example: 8 025-8 400 MHz and 25 500-27 000 MHz) can also be used for the operation of MetSat satellites and their applications.

Overview of bands and their applications most commonly used by current & future MetSat systems

Application	Orbit	Timeline	Frequency Band(s)
Telemetry/Telecommand & Ranging	GSO/NGSO GSO/NGSO GSO/NGSO	current/future current/future future	2025 – 2110 MHz 2200 – 2290 MHz 7190 – 7250 MHz
Instrument raw data downlink	GSO NGSO GSO NGSO GSO/NGSO GSO/NGSO	current/future current/future current/future current/future current/future current/future	1675 – 1710 MHz 2200 – 2290 MHz 7450 – 7550 MHz 7750 – 7900 MHz 8025 – 8400 MHz 25.5 – 27 GHz
Processed data re-transmission uplink	GSO	current	2025 – 2110 MHz
Low rate direct dissemination to user stations	NGSO GSO/NGSO	current current/future	137 – 138 MHz 1675 – 1710 MHz
High rate direct dissemination to user stations	GSO/NGSO NGSO NGSO	current/future current/future current/future	1675 – 1710 MHz 7750 – 7900 MHz 25.5 – 27 GHz
Data Collection Systems	GSO/NGSO NGSO	current/future current/future	401 – 403 MHz 400.15 – 401 MHz, 460 – 470 MHz
Search and Rescue	GSO/NGSO GSO/NGSO	current/future current/future	406 – 406.1 MHz 1544 – 1545 MHz