Current and Future Microwave Remote Sensing Instruments at ESA

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Abstract
This paper will give an overview of the current operational microwave remote sensing instruments developed at the European Space Agency (ESA) for earth observation. In addition to already operational instruments, ESA has a large number of microwave instruments under design, development and verification phases. This paper will also give an overview of the future instruments under development and to be launched within the next 10 years.

1 Introduction
The Earth Observation Directorate of ESA is building instruments under different programmatic frameworks. ESA’s Living Planet Programme comprises of a science and research element, which includes the Earth Explorer missions, and an Earth Watch element, which is designed to facilitate the delivery of Earth observation data for use in operational services (e.g. meteorological satellites for EUMETSAT). In addition, the GMES (Global Monitoring for Environment and Security) Sentinel missions, which form part of the GMES Space Component, will collect robust, long-term climate-relevant datasets.

2 Operational Microwave Instruments

CRYOSAT-2
Cryosat-2 primary payload is the SAR/Interferometric Radar Altimeter (SIRAL) [1]. It operates at 13.575 GHz. Cryosat-2 has a highly stable antenna subsystem with two reflector antennas (1.15 x 1.4 m) for interferometry. Cryosat-2 provides data about the polar ice caps and tracks changes in the thickness of the ice with a resolution. Cryosat-1 was launched 2005 but was lost due to a launcher failure. Sapcecrsaft and instruments were re-built and Cryosat-2 was launched 2010.

SMOS
The instrument of the Soil Moisture and Ocean Salinity (SMOS) mission is synthetic aperture microwave radiometer, consisting of 69 antennas and 72 receivers operating at 1400 MHz – 1427 MHz) in a Y-shaped form [2]. With the three arms extended SMOS has 8 m in diameter, leading to spatial resolution of 30 km – 50 km. SMOS was launched 2009.

MetOp
MetOp is the operational polar orbit meteorological satellite that ESA developed for EUMETSAT. First satellite was launched 2006 and 2nd satellite 2012 and both satellites are still operational. Third satellite is due for launch 2017. ESA was in charge of developing two microwave instruments for MetOp, namely the ASCAT and GRAS.

ASCAT scatterometer is a real-aperture, pulsed imaging radar working at 5.3 GHz [3]. It has 50km² footprint. ASCAT provides wind vector surface observations over ocean
GRAS is a passive instrument measuring the time variation of the excess path length of GPS signals [4]. The GRAS Instrument is composed of three antennas, one zenith antenna to obtain coarse real-time measurements of the satellite position and two side looking antennas to track rising and setting GPS satellites crossing the Earth limb. GRAS provides measurements of atmospheric temperature and humidity profiles as well information on surface pressure.

3 Future Microwave Instruments

SENTINEL-1

Sentinel-1 is an imaging Synthetic Aperture Radar mission at 5.405 GHz with a bandwidth of 0 MHz – 100 MHz (selectable) [5]. SAR antenna size is 12.3 m x 0.821 m and the highest spatial resolution is 5 m x 5m at 80 km swath. SAR instrument supports operation in dual polarisation (HH-HV, VV-VH), which requires the implementation of one transmit chain (selectable to H or V) and two parallel receive chains for H and V polarisation. The Sentinel-1 mission will provide continuity of all weather, day-and-night radar imagery supply for user services associated with three priorities of the European Union: Marine Core Services, Land Monitoring and Emergency Services.

SENTINEL-3

Sentinel-3 topography payload includes Synthetic Aperture Radar Altimeter (SRAL).[6] The SRAL main frequency used for range measurements is 13.575 GHz with 350 MHz bandwidth, whereas the 5.41 GHz, 320 MHz frequency is used for ionosphere correction. SRAL provides accurate (2 – 3 cm), closely spaced altimetry measurements from a high-inclination orbit with a long repeat cycle.

Microwave radiometer (MWR) is required for removing the errors added as the signals are delayed by water vapor in the atmosphere. MWR is a two channel (23.8 GHz and 36.5 GHz) microwave radiometer. Conceptually it is a balanced Dicke radiometer for brightness temperatures below the Dicke load temperature. The balancing is achieved by means of a noise injection circuit. For brightness temperatures higher that the Dicke load temperature a conventional Dicke mode is used. Sentinel-3 provides data on sea, ice and land surface altimetry products, land and ocean colour/reflectance products, sea and land surface temperature products, and vegetation products.

METOP SECOND GENERATION

MetOp Second Generation (MetOp-SG) includes in total five RF/Microwave instruments developed by ESA, making it the most complex microwave instrument mission ESA has developed so far [7]. The Met-op-SG will replace the current MetOp satellites in around 2020.

Microwave Sounder (MWS) is a cross-track scanning microwave radiometer consisting of 24 channels between 23 GHz and 230 GHz. It also provides a footprint sizes from 40 km down to 17 km, leading to an antenna size of ~35 cm. The antenna scan speed is not constant, but is accelerated/decelerated in order to maximize the earth scene viewing time.

Microwave Imager (MWI) is a conically scanning microwave radiometer, providing a total number of 26 channels (including dual polarisation channels). MWI frequency coverage is from 18 GHz up to 183 GHz and footprints vary from 50 km down to 10 km, depending on a frequency. All MWI channels up to 89 GHz are measured with both V- and H polarisations. Channels above 89 GHz are measured at V polarisation only. The main objective of the MWI is to measure precipitation. In addition, MWI provides measurements of cloud products, water vapour and temperature profiles and surface imagery.

Ice Cloud Imager (ICI) is a conically scanning millimetre/sub-millimetre wave radiometer, providing a total number of 13 channels (including dual polarisation channels). The ICI
frequency coverage is from 183 GHz up to 664 GHz, with two window channels (243 GHz and 664 GHz) measured at both V and H polarization. ICI provides 15 km footprints for all channels. Complementarily to MWI instrument, ICI will measure primarily ice clouds, especially cirrus clouds, cloud ice water path, cloud ice effective radius and cloud altitude. In addition, ICI will provide vertical humidity profile and vertical profiles of hydrometeors (cloud ice, graupel, snow, rain and cloud liquid), as well as total column precipitation rate and water vapour.

Scatterometer (SCA) is a real-aperture, pulsed imaging radar working at 5.3 GHz with six fixed fan beam-antennas. The SCA instrument has 6 antennas, 3 on both sides of the satellite ground-track. All antennas transmit in vertical polarization. The 4 side antennas receive only vertically polarized signals, whereas the 2 mid antennas receive both V and H-polarized signals. The SCA instrument will provide wind vector surface observations over ocean at 25 km2 footprint.

Radio Occultation (RO) payload is a passive instrument measuring the time variation of the excess path length of GNSS signals as they are occulted by the atmosphere. RO will track the GALILEO and GPS signals and optionally also GLONASS and Compass Beidou signals in total covering the Frequency range at 1.1 GHz – 1.6 GHz. RO provides measurements of atmospheric temperature and humidity profiles as well information on surface pressure.

Earth Explorer #7

At the time of writing, three missions are under consideration for the next Earth Explorer mission [8]. The final selection for implementation will be done March 2013. BIOMASS is a SAR (435 MHz) in side-looking geometry with full polarimetric and interferometric capabilities. CoReH2O is a dual frequency SAR, operating at 17 GHz and 9.6 GHz, VV and VH polarizations. PREMIER payload consists of a millimetre-wave (320 GHz – 360 GHz) limb-sounder using a heterodyne multi-beam receiver, and an imaging limb-sounding infrared Fourier-transform spectrometer.

4 References

References


