OSTIA

This paper describes a new Sea surface temperature (SST) analysis that is produced with global coverage on a daily basis at the Met Office called the Operational SST and Sea Ice Analysis (OSTIA) system. OSTIA uses satellite SST data provided by international agencies via the Group for High Resolution SST (GHRSST) Regional/Global Task Sharing (R/GTS) framework. GHRSST products include data from microwave and infrared satellite instruments with accompanying uncertainty estimates. The system also uses in situ SST data available over the Global Telecommunications System (GTS) and a sea-ice concentration product from the EUMETSAT Ocean and Sea Ice Satellite Applications Facility (OSI-SAF). The SST analysis is a multi-scale optimal interpolation that is designed for applications in numerical weather prediction and ocean forecasting systems. The background error covariance matrix is specified using ocean model data and the analysis uses correlation length scales of 10 km and 100 km. The OSTIA system produces a foundation SST estimate (SSTfnd, which is the SST free of diurnal variability) at an output grid resolution of 1/20° (~ 6 km) although the smallest analysis feature resolution is based on the correlation length scale of 10 km. All satellite SST data are adjusted for bias errors based on a combination of ENVISAT Advanced Along Track Scanning Radiometer (AATSR) SST data and in situ SST measurements from drifting buoys. Data are filtered (based on surface wind speed data) to remove diurnal variability and AATSR data are adjusted to represent the SST at the same depth as drifting buoy measurements (0.2–1 m) before bias adjustments are made. Global coverage outputs are provided each day in GHRSST L4 netCDF format. A variety of secondary products are also provided including weekly and monthly mean data sets. OSTIA products are continuously monitored and validation/verification activities demonstrate that SST products have zero mean bias and an accuracy of ~ 0.57 K compared to in situ measurements. OSTIA is now used operationally as a boundary condition for all weather forecast models at the Met Office and at European Centre for Medium-range Weather Forecasting (ECMWF). OSTIA is produced by the Met Office as part of the European Union Global Monitoring for Environment and Security (GMES) MyOcean project.

FOAM

The Forecast Ocean Assimilation Model (FOAM) system is an operational ocean analysis and forecast system run daily at the Met Office. The system consists of various global, regional and shelf seas configurations. The underlying models/systems used in FOAM are the NEMO physical ocean model, the Los Alamos CICE sea ice model and the NEMOVAR data assimilation system. The NEMOVAR data assimilation system is a variational scheme which has been developed specifically for use in the NEMO ocean model. The system is being developed jointly by the Met Office, ECMWF and , with significant contributions from other research institutes, such as INRIA and LJK. The system is able to assimilate in-situ temperature and salinity profiles, sea surface temperature and sea level anomaly data and has capacity to produce both 3DVar and 4DVar analyses. Additional features include a diffusion operator for spreading observational information according to spatial correlations, and a multivariate balancing operator that accounts for covariances between ocean variables.

Operational ocean forecasting systems are run daily providing our customers with ocean analysis and forecast products. The ocean forecasting development team is responsible for developing, supporting and maintaining the operational ocean systems. The Forecast Ocean Assimilation Model FOAM is run for a number of global, regional and shelf seas configurations. It generates daily ocean analysis and forecast products. The ocean forecasting development team trial developments to the system and scientifically evaluate the impact on the model simulation. Following a successful trial, the team implements the changes in the operational systems.

The team is also responsible for the maintenance and development of both the Operational Sea surface temperature and sea Ice Analysis OSTIA system and the GHRSST Multi Product Ensemble GMPE. OSTIA is a SST analysis product that is used for a wide range of applications, including numerical weather prediction and climate monitoring. GMPE is a SST product derived from many international SST analyses, including OSTIA.

Key aims

To continually improve the accuracy of the Met Office's ocean forecast systems

To provide an accurate analysis of daily SST and sea ice using the OSTIA system

To support and maintain the operational ocean systems

FY-3

Generate imagery from MERSI instrument, direct broadcast data received at Met Office – CMA software for decoding files to Level 1B.

Microwave sounding instruments were launched on China's FY-3C platform in Sept 2013 and data have been operationally received since October 2014. The early operational data have been assessed using comparisons to Numerical Weather Prediction (NWP) fields and to the performance of similar instruments. The MicroWave Temperature Sounder - 2 (MWTS-2) exhibits features such as large scale negative biases, striping and an unexplained surface sensitivity in channels whose peak sensitivity should be high in the atmosphere. The MicroWave Humidity Sounder - 2 (MWHS-2) shows some promising results in a new suite of 118GHz channels, while data from the 183GHz channels are comparable in quality to equivalent channels on instruments already used successfully in NWP, reanalysis and climate applications. Results of assimilation experiments including data from MWHS-2 183GHz channels are discussed. While overall impacts on forecast accuracies are mostly neutral, improved fits to the model are seen in other humidity sensitive channels on independent instruments, indicating the MWHS-2 data improves the analysis.

China's Feng-Yun 3 (FY-3) platforms are a series of polar orbiting satellites which will become a major source of data for numerical weather prediction (NWP) and climate monitoring over the next two decades. The Microwave Humidity Sounder 1 (MWHS-1) and the Microwave Temperature Sounder 1 (MWTS-1) were launched as experimental instruments on board FY-3B in 2010. Observations from both instruments have been assessed for their assimilation in the Met Office NWP model. The comparison of one year of observations with NWP background fields revealed biases affected by seasonal modulation, surface type, scan position, and scene temperature. Except for window sensitive channels, the Met Office static bias correction scheme, and to a greater extent the new variational bias correction scheme, result to be effective in reducing most of the observed biases to operational quality standards. An assimilation experiment in NWP results in a mostly neutral impact, both on NWP indexes and in the fit of observations to model short range forecasts for independent humidity sensors.

GPSRO (GPS Radio Occultation)

At the Met Office, radio occultation (RO) data is currently assimilated in the form of bending angle profiles. These profiles are assimilated at a single horizontal location, provided with the observation as the 'occultation point'. In reality, during an occultation event, the tangent point of the ray drifts a considerable distance (usually 100 to 200km). This memo describes the motivation, technical implementation and forecast impact of assimilating individual bending angles at their drifted positions. The changes in the headline forecast impact scores are quite small, though possible reasons for this are discussed. It should be noted that as model resolution increases, it is anticipated that the tangent point drift (TPD) will play a more significant role.

GPS ZTD

Zenith total delay (ZTD) observations derived from ground-based GPS receivers have been assimilated operationally into the Met Office North Atlantic and European (NAE) numerical weather prediction (NWP) model since 2007. Assimilation trials were performed using the Met Office NAE NWP model at both 12- and 24-km resolution to assess the impact of ZTDs on forecasts. ZTDs were found generally to increase relative humidity in the analysis, increasing the humidity bias compared to radiosonde observations, which persisted through the forecasts at some vertical levels. Improvements to cloud forecasts were also identified. Assimilation of ZTDs using both three-dimensional and four-dimensional variational data assimilation (3D-Var/4D-Var) was investigated, and it is found that assimilation at 4D-Var does not deliver any clear benefit over 3D-Var in the periods studied with the NAE model.

GAIA-CLIM

The GAIA-CLIM (Gap Analysis for Integrated Atmospheric ECV CLImate Monitoring) project has been recently funded in the frame of the call EO-3-2014 'Observation capacity mapping in the context of Atmospheric and Climate change monitoring' of EU framework program for Research and innovation Horizon2020. The project will start on March 1^st , 2015, and the Kick-off meeting will be hosted by the CNR-IMAA in Matera. The project sees 21 partners involved, including European insitutions, met service and US partners, such as ECMWF, MetOffice, NOAA, under the coordination of NERSC (Nansen Environmental and Remote Sensing Center).

The project will develop appropriate methods to map reference quality comparators onto EO measurements. It will document gaps in the current observing system and all aspects of measurement uncertainty mapping, and propose strategies to address these including recommendations regarding future funding of surface and sub-orbital observing capabilities to meet long term EO comparator needs. Finally, it will develop tools to aid end users through a 'virtual observatory'. The project will significantly increase the quality and use of ground based data for validation of satellite sensors and climatological models, with relapses of considerable interest for several sectors (climate, ocean monitoring and extreme events, land conservation, ...) and end users (meteorological services, civil protection, space agencies, environmental agencies, ...).

Objectives

Scientific objectives

S1. Define and document a tiered system of systems approach to EO measurements characterisation, based upon measurement properties, in order to categorize ground-based and sub-orbital measurement capabilities.

S2. Map in geographical space, and in terms of temporal congruence with EO measurements current and known future ground-based and sub-orbital capabilities into the system of systems framework for several of those atmospheric, oceanic and terrestrial GCOS ECVs that are measured from space.

S3. Provide quantified uncertainty estimates on atmospheric measurements for temperature, water vapour, carbon dioxide, methane, ozone and precursors (nitrogen dioxide, carbon monoxide, formaldehyde), and aerosols with a focus on provision of reference quality measurement uncertainties that are traceable to recognised measurement standards.

S4. Understand and quantify the metrology of data comparisons, including additional uncertainties that result from measurement mismatches in both space-time and in terms of the measurement volume and interval, using a suite of multi-dimensional descriptions with explicit physics, statistical methods and data assimilation systems. Some metrology errors are irreducible; others can be reduced by optimisation of the measurement settings.

S5. Integrate into data assimilation systems (global atmospheric models and reanalysis systems) the ability to utilize reference measurements so as to enable traceable characterisation of EO data.

S6. Perform a Cal/Val gap analysis based upon geographical coverage, measurement capabilities / characterisation, user needs, technological impediments and opportunities, and national and international measurement strategies and governance. Produce a set of prioritised recommendations arising.

Technological objectives

These technological objectives, taken together, form the basis for a ‘virtual observatory’ that will allow users to undertake data analysis and visualization with the aim of making the use of ground based and sub-orbital reference measurements a routine and integral part of EO instrument characterisation.

T1. Development of mapping tools to enable visualization of observing capabilities.

T2. Development of software tools that are extendable to quantify comparison uncertainties associated with space-time differences in sampling and smoothing of atmospheric structures and variability.

T3. Development of the ability to use reference quality measurements in a data assimilation framework to provide a robust data assimilation tie-points assuring traceability.

T4. Development and population of match-up database of satellite measurements with reference measurements including measurement uncertainties and comparison uncertainties, and diagnostics from data assimilation systems.

User outreach objectives

O1. To demonstrate to a wide audience (including satellite agencies, industry, and applied scientists) how reference measurements can be used to underpin the calibration and validation of EO data.

O2. Systematic consulting of the satellite and modelling end-user communities.

O3. Stakeholder meetings and canvassing throughout the project lifetime.

O4. Provision of software tools under a creative common licensing system.

O5. Provision of a graphical interface mapping tool of observing capabilities.

O6. Provision of collocation match up database and associated graphical user interface tools for reference quality observations for a number of atmospheric ECVs.

O7. Presentations by consortium partners at international meetings and papers in the peer reviewed literature to promote partnership with the consortium.

Project Summary

The advent of the European Commission's Copernicus Programme marks the start of a new era in Earth Observation for Societal Benefit. The operational capability being implemented for Copernicus will deliver a step-change in the end-to-end chain that begins with observing our environment by satellite-based and in-situ-based instruments, and ends with providing end-user services to decision-makers and the general public. By bringing the full chain within one programme, Copernicus provides the co-ordinated framework to exploit scientific and technological innovation and to translate these into usable high-quality information tailored to diverse sectors of society.

Hence a critical component of the Copernicus framework is the provision of high-quality observational datasets from satellites. It follows that these need to be calibrated and validated to standards that enable them to be used with confidence for applications across a broad range of sectors. In turn, this requires ancillary datasets from in-situ and other sources that need to be of high-quality and sufficient quantity to robustly characterise sensor performance and radiative transfer modelling to provide confidence in the satellite data. For the purpose of validation, established practice from space agencies and other satellite dataset providers is to make substantial use of satellite-to-satellite intercomparisons combined with in-situ datasets and supplemented by datasets from operational numerical weather prediction and/or reanalyses (which blend observations with model forecasts taking into account the uncertainties in both). Few, if any, of these comparator measures constitute fully traceable estimates. The challenges to rigorous satellite data characterisation are therefore formidable because without traceability in the comparator measures there is ambiguity in any comparison.

The objective of the Consortium is to play a full role in supporting Copernicus by establishing prioritized needs for further observational capacity targeted at providing the required step-change in satellite calibration and validation capability. The principal aim is to lead to a step change of availability of, and ability to utilize, truly reference quality traceable measurements in support of satellite data characterisation. It is only if robust uncertainty estimates are placed on the ground-based and sub-orbital data and used in the analysis that unambiguous interpretation of EO sensor performance can occur. The magnitude of the challenge requires a co-ordinated approach to both establish the strategic approach and define specific campaigns. The Consortium has drawn together leading stakeholders from the relevant communities, who provide the necessary experience to fulfil the objectives. Specifically, the consortium has been chosen to bring together scientific, technical and leadership expertise in high-quality in-situ and sub-orbital observations, gap analyses, modelling, satellite operations and data assimilation, and in setting the priorities for the EO community at the European and global levels.

Robust EO instrument characterisation is about significantly more than simply where and when a given set of EO and ground-based / sub-orbital measurements is taken. It requires, in addition, quantified uncertainty estimation for the reference measurements and an understanding of additional uncertainties that accrue and increase the apparent discrepancy between measured data sets through mismatches in spatio-temporal sampling, given the complex spatial and temporal variability of the atmosphere, spanning spatial scales from sub-kilometer to synoptic scale and timescales from seconds to decades. It also needs user tools, which include statistical tools and the integrating capabilities afforded by data assimilation systems to enable users to access and work with the data in a ‘virtual observatory’ setting. Mapping of capabilities in a spatio-temporal sense will be undertaken by GAIA-CLIM for several of those atmospheric, land and oceanic ECVs, which are measured by EO instruments. Subsequent measurement mapping and the development of a range of tools will be undertaken with a focus on the atmosphere as a test case, in particular fundamental geophysical (temperature, humidity) and composition (long lived greenhouse gases, ozone and its precursors, aerosols) parameters of importance to environmental monitoring across a broad range of time and space scales. Comparisons and mapping to EO data will be undertaken at both level1b (radiance) and level2/3 (parameter) data levels. There is a particular focus upon the value of high quality reference / benchmark measurement capabilities to long-term sustained high-quality characterisation of space based EO sensor performance to maximise their value for climate applications. Tools and capabilities developed in this project with direct application to atmospheric ECVs defined by GCOS (among which a few are linked as well to e.g. air pollution and air traffic management) will be built in such a way as to be extendable in future to further atmospheric parameters and the terrestrial and oceanic domains.

IASI in UKV

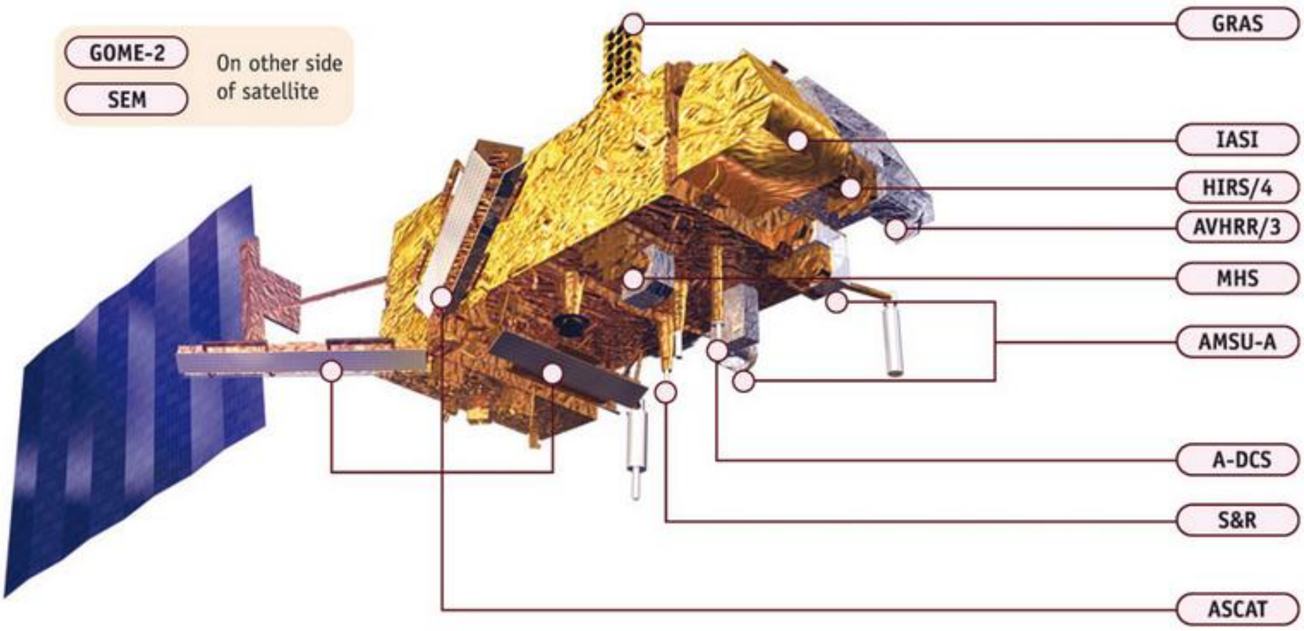
The potential for assimilating IASI into the UKV model has been assessed. Several tuneable aspects of the assimilation configuration have been investigated. These include how the data are thinned with potential options of using the most homogeneous field of view (FOV) of the 4 FOVs in one field of regard (as used in the global) or using all 4 FOVs. In the global model IASI data are thinned to one observation per ~100kmx100km box but in the UKV the data can be used more aggressively. Several thinning box sizes were tested, including no thinning at all. A static bias correction procedure is still used in the global model and so the performance of this same scheme has been assessed in the UKV. The observation errors include contributions from scale mismatch which will be different in the UKV from the global model so the errors used in the experiments have been diagnosed using a posteriori diagnostic methods and tuned as required. It is thought that the lateral boundary conditions (LBCs) from the global model will provide all of the information on the large scale synoptic features and that any data being assimilated will mainly provide useful information on small scale features, principally in the humidity and cloud fields. For this reason the channel selection for IASI has been xperimented with and in particular comparing the use of the full 138 channel selection used in the global model against just the use of surface and water vapour sensitive channels which are more sensitive to smaller scale features. The effect of assimilating IASI data on analysis increments has been investigated and results from OSEs using a variety of potential configurations are shown. The results show that IASI data is significantly modifying analysis increments and is having a small positive effect on forecasts as shown by reduced surface temperature forecast errors and improved fits to other satellite observations currently assimilated into the UKV.

Metop AVHRR AMVs

Are derived at EUMETSAT using image pairs and at CIMSS using image triplets. The Met Office uses the CIMSS Metop AMVs operationally. The EUMETSAT Metop AMVs have better timeliness and spatial coverage, but larger errors against model background, than the CIMSS Metop AMVs. Impact trials with these AMV products compared against a no polar AMV reference experiment showed slightly better results for the EUMETSAT AMVs.

ASCAT in UKV

The report examines the impact of migrating to use the coastal ASCAT wind products in the UKV instead of the current 12.5-km product. The coastal winds provide improved coverage near the islands and enclosed sea areas of the UKV domain. Spatial coverage is also improved through the addition of Metop-B data which are not available in the 12.5-km product. However, temporal coverage remains poor with data only available in the 12z and 21z cycles. The ASCAT coastal winds are validated against short range forecasts from the UKV model background and biases are found to be equivalent for both Metop-A and Metop-B. Validation also confirms that the 12.5-km and coastal winds products are consistent in quality. Assimilation experiments have been conducted and the impact on the UKV Index is found to be very neutral. The EARS data are found to be important, allowing 80% of data to make the model cut-off compared with just 30-50% for the conventional data. The impact of switching on the VarQC earlier in the assimilation has also been assessed. Overall, it is recommended that the coastal winds are implemented at PS35 in combination with the data received via EARS.



The positions of the instruments on the Metop satellite.

METOP - AMSU

The Advanced Microwave Sounding Unit-A (AMSU-A) is designed to measure global atmospheric temperature profiles. It provides information on atmospheric water in all of its forms (with the exception of small ice particles, which are transparent at microwave frequencies). AMSU-A provides information even in cloudy conditions. AMSU-A is a multi-channel microwave radiometer which measure scene radiances in 15 discreet frequency channels (23-90 GHz). At each channel frequency, the antenna beamwidth is a constant 3.3 degrees (at the half power point). Thirty consecutive scene resolution cells are sampled in a stepped-scan fashion every eight seconds, each scan covering about 50 degrees on either side of the subsatellite path. These scan patterns and geometric resolution translate to a 48 km diameter cell at nadir and a 2,074 km swath width from the 837 km nominal orbital altitude. AMSU-A uses oxygen absorption bands/lines for atmospheric temperature sounding. Window channels at 23.8, 31.4 and 89 GHz provide information on surface temperature and emissivity. Hardware for the two lowest frequencies is located in one module (Fig 2), with the remaining 13 frequencies being accommodated in the second module (AMSU-A1). This arrangement puts the two lower atmospheric moisture viewing channels into one module and the oxygen absorption channels into a second common module, in order to ensure commonality of viewing angle (independent of any module and/or spacecraft misalignment due to structural or thermal distortions). The AMSU-A2 module has a single antenna assembly, providing data for channels 1 and 2. AMSU-A1 has two separate antenna assemblies: AMSU-A1.1 provides data for channels 6,7 and 9-15 and AMSU-A1.2 provides data for channels 3, 4, 5 and 8.AMSU-A is part of the ATOVS package, together with MHS and HIRS. AMSU-A scanning is synchronized with MHS and IASI scanning. The instrument is manufactured by Northrop Grumman (previously Aerojet), Azusa, California under contract to NASA. For more in-depth information, see the ATOVS Level 1b Product Guide.

METOP MHS

The Microwave Humidity Sounder (MHS) is designed to collect information on various aspects of the Earth's atmosphere and surface, in particular, atmospheric ice, cloud cover and precipitation. Temperature information at the Earth's surface can also be determined by MHS. The Microwave Humidity Sounder (MHS) is a self-calibrating, cross-track scanning, five-channel microwave, full-power radiometer, operating in the 89 to 190 GHz region. MHS channels H1 at 89.0 GHz and H2 (157 GHz) are window channels that detect water vapour in the very lowest layers of the atmosphere and also observe the Earth's surface. H1 provides information on surface temperature and emissivity (in conjunction with AMSU-A data) and detects low altitude cloud and precipitation. Channels H5 (190.3 GHz), H4 (183.3 +/- 3.0 GHz) and H3 (183.3 +/- 1.0 GHz) measure water vapour at increasing heights in the atmosphere. The MHS instrument scans the surface of the Earth three times every eight seconds, taking 90 pixels across the Earth view each scan. The five channels are co-registered, with each pixel being separated by 1.111 degrees in angle. At nadir, the instrument footprint corresponds to a circle of diameter approximately 16 km. The full swath of the instrument is approximately 1920 km. The instrument views a hot on-board calibration target and cold space each scan to provide a two-point calibration. Using data from these calibration views, the Earth view pixels can be converted into calibrated radiances or brightness temperatures. The MHS data is used in Numerical Weather Prediction models to improve the accuracy of future weather forecasts. MHS data is also used to generate specific products, such as cloud liquid water content and total precipitable water in the atmosphere, as well as rain rates. MHS is part of the ATOVS (Advanced TIROS Operational Sounder) package, and is a follow-on to the Advanced Microwave Sounding Unit-B (AMSU-B) provided by the Met Office, and flown on the Metop and NOAA-K, L, M satellites. The MHS has been designed and developed by Airbus Defence and Space (formerly EADS Astrium), under contract to EUMETSAT.

HIRS

The High-resolution Infrared Radiation Sounder (HIRS/4) provides calibrated vertical profiles of temperature and humidity; information on cloud cover, cloud top height, cloud top temperature and cloud phase, as well as surface albedo. HIRS is a 20-channel infrared scanning radiometer that performs operational atmospheric sounding. HIRS has 19 infrared channels (3.8-15 µm) and one visible channel. The swath width is 2160 km, with a 10 km resolution at nadir. IR calibration of the HIRS/4 is provided by programmed views of two radiometric targets mdash; the warm target, mounted on the instrument baseplate, and a view of deep space. Data from these views provides sensitivity calibrations for each channel at 256 second intervals, if commanded. Internally generated electronic signals provide calibration and stability monitoring of the detector amplifier and signal processing electronics. HIRS uses CO_2 absorption bands for temperature sounding (CO_2 is uniformly mixed in the atmosphere). HIRS also measures water vapour, ozone, N_2O and cloud and surface temperatures. HIRS/4 is manufactured by ITT Exelis in Fort Wayne, Indiana under contract to NASA.

IASI

The main goal of the IASI mission is to provide temperature and humidity profiles for use in the understanding and making atmospheric forecasts. IASI is the main payload instrument for the purpose of supporting Numerical Weather prediction. It provides information on the vertical structure of the atmospheric temperature and humidity in an unprecedented accuracy of 1 K and a vertical resolution of 1 km, which is needed to decisively improve NWP. The use of Metop data in NWP accounts for 40% of the impact of all space based observations in NWP forecasts. Dieter Klaes, EPS Programme Scientist at EUMETSAT, explains: "When first launched on Metop-A, in 2006, IASI was a world-leading instrument. It was the first polar-orbiting interferometer providing huge amounts of operational data. The impact on NWP was enormous, much higher than anticipated." IASI measures in the infrared part of the electromagnetic spectrum at a horizontal resolution of 12 km over a swath width of about 2,200 km. With 14 orbits in a sun-synchronous mid-morning orbit (9:30 Local Solar Time equator crossing, descending node) global observations can be provided twice a day. The temperature of the troposphere and lower stratosphere is measured under cloud-free conditions with a vertical resolution of 1 km in the lower troposphere; a horizontal resolution of 25 km, and an accuracy of 1 kelvin. The humidity of the troposphere is measured under cloud-free conditions, with a vertical resolution of 1–2 km in the lower troposphere; a horizontal resolution of 25 km, with an accuracy of 10%.IASI also measures the fractional cloud cover and cloud top temperature and pressure. The total amount of ozone under cloud-free conditions is measured with a horizontal resolution of 25 km and an accuracy of 5%, and total column-integrated content of CO, CH_4 and N_2O with an accuracy of 10% and a horizontal resolution of 100 km. The IASI instrument has led to an increase in knowledge of atmospheric composition monitoring, as well as volcanic ash detection. It was observed that during volcanic eruptions SO_2, values exceeded initial expectations. Cathy Clerbaux, from the SAF on Ozone and Atmospheric Chemistry Monitoring, said: "IASI has provided unprecedented atmospheric chemistry data, allowing near-real-time mapping of chemical species and aerosols, contributing to air traffic safety and to our understanding of atmospheric transport processes. "Observations from IASI have unexpectedly allowed the detection from space of volatile chemical species, providing an ability to map sources and sinks of gases, such as ammonia. It has already been shown that IASI exhibits sensitivity to the change in quantities of greenhouse gases, can be used to study cloud and aerosol properties, and will provide information on a range of other climate variables." Dieter Klaes explains: "Additional products derived from IASI include Sea Surface Temperature (SST) at a high accuracy, and Surface Emissivity, the latter still a matter of further research and improvement. The continuity provided by Metop-B, for the coming years (its nominal life time is five years), means we can continue the valuable service to our users and continue to develop more products for and with our users. For weather forecasters worldwide the data IASI on Metop-B will provide, along with similar data from the new CrIS (Cross-track Infrared Sounder) instrument on Suomi-NPP — in cooperation with our partner NOAA — will be invaluable." The IASI programme is led by CNES in association with EUMETSAT.

EPS-SG

The EPS follow-on system (EPS-SG) will provide continuity of observations and respond to the needs of the users in the 2020–2040 time frame. EPS-SG represents Europe's contribution to the future Joint Polar System (JPS), which is planned to be established together with the National Oceanic and Atmospheric Administration (NOAA) of the United States, following on from the Initial Joint Polar System (IJPS). Polar orbiting satellites, due to their global coverage and of the variety of passive and active sensors that can be deployed from Low Earth Orbits, have the most significant positive impact on Numerical Weather Prediction (NWP). The Initial Joint Polar System (IJPS), shared by EUMETSAT and NOAA, currently accounts for around 45% of the total error reduction on Day 1 forecasts achieved by all types of observation ingested in real-time by NWP models. Polar orbiting satellites also deliver unique infrared and microwave imagery inputs to critical nowcasting of high impact weather at high latitudes. These are vital for the National Meteorological Services of all EUMETSAT Member and Cooperating States. The EPS-SG Programme is expected to be one of the most important sources of satellite observations for all forecasts based on NWP in the 2020–2040 time frame. It is expected to increase direct socio-economic benefits to Member States and leverage additional benefits through its integration into the JPS and cooperation in the context of CGMS and WMO. The European Space Agency will develop the Metop-SG satellites and a number of instruments, with CNES and DLR developing some of the key instruments. EUMETSAT will provide the launch and LEOP services and operate the satellites for a nominal duration of 21 years.

EPS-SG consists of two, parallel series of satellites (Metop-SG A and Metop-SG B).

1. The Metop-SG A series has the optical imaging, infrared and microwave sounding; aerosol imaging, and radio occultation missions. It also hosts the Copernicus Sentinel-5 mission.
2. Metop-SG B series is dedicated to microwave and sub-millimetre-wave imaging, scatterometry and radio occultation. It also hosts the ARGOS data collection system.

The plan is for a series of three satellites of each type (six in total) and a constellation deployment scenario allowing parallel operations of multiple satellites.

Technical details

	METOP-SG A	METOP-SG B
First Launch	Currently mid-2021	Currently end of 2022
Orbit and Altitude	LEO, 817 km	LEO, 817 km
Mass	4200 kg	4000 kg
Design Lifetime	7.5 years	7.5 years

INSTRUMENTS

INSTRUMENT	SATELLITE	PROVIDER
Infrared Atmospheric Sounding Interferometer (IASI-NG)	Metop-SG A	CNES
Visible/Infrared Imager (METimage)	Metop-SG A	DLR
Microwave Sounder (MWS)	Metop-SG A	ESA
Radio Occultation (RO)	Metop-SG A and Metop-SG B	ESA
Multi-viewing, multi-channel, multi-polarisation Imager (3MI)	Metop-SG A	ESA
Sentinel-5	Metop-SG A	Copernicus/ESA
Scatterometer (SCA)	Metop-SG B	ESA
Microwave Imager (MWI)	Metop-SG B	ESA
Ice Cloud Imager (ICI)	Metop-SG B	ESA
Advanced Data Collection (ADCS-4)	Metop-SG B	CNES

The AIRS Instrument Suite

The Atmospheric Infrared Sounder (AIRS) instrument suite is designed to measure the Earth's atmospheric water vapor and temperature profiles on a global scale. It is comprised of a space-based hyperspectral infrared instrument (AIRS) and two multichannel microwave instruments, the Advanced Microwave Sounding Unit (AMSU-A) and the Humidity Sounder for Brazil (HSB). The AIRS instrument suite along with several other instruments was launch aboard NASA's Earth Observing System Aqua satellite on May 4, 2002. The Atmospheric Infrared Sounder (AIRS) instrument built by BAE SYSTEMS for NASA/JPL, is a cross-track scanning instrument. Its scan mirror rotates around an axis along the line of flight and directs infrared energy from the Earth into the instrument. As the spacecraft moves along, this mirror sweeps the ground creating a scan 'swath' that extends roughly 800 km on either side of the ground track. Within the AIRS instrument the infrared energy is separated into wavelengths. This information is sent from AIRS to the Aqua spacecraft, which relays it to the ground. The term "sounder" in the instrument's name refers to the fact that temperature and water vapor are measured as functions of height. AIRS also measures clouds, abundances of trace components in the atmosphere including ozone, carbon monoxide, carbon dioxide, methane, and sulfur dioxide, and detects suspended dust particles. AIRS measures the infrared brightness coming up from Earth's surface and from the atmosphere. constituent wavelengths, or "colors". The effect (but not the technique) is similar to rain drops splitting sunlight into a rainbow. Each infrared wavelength is sensitive to temperature and water vapor over a range of heights in the atmosphere, from the surface up into the stratosphere. By having multiple infrared detectors, each sensing a particular wavelength, a temperature profile, or sounding of the atmosphere, can be made. While prior space instruments had only 15 detectors, AIRS has 2378. This greatly improves the accuracy, making it comparable to measurements made by weather balloons. High spectral resolution infrared of the AIRS improves vertical resolution, however the resolution degrades in the presence of clouds. Microwave energy sensed by the AMSU and HSB instruments is insensitive to clouds and provides valuable soundings in all weather conditions. Using a special computer algorithm, data from AIRS and the microwave instruments are combined to provide highly accurate measurements in all cloud conditions resulting in a daily global snapshot of the state of the atmosphere.

GPM-GMI

The Global Precipitation Measurement (GPM) Microwave Imager (GMI) instrument is a multi-channel, conical-scanning, microwave radiometer serving an essential role in the near-global-coverage and frequent-revisit-time requirements of GPM. The instrumentation enables the Core spacecraft to serve as both a precipitation standard and as a radiometric standard for the other GPM constellation members. The GMI is characterized by thirteen microwave channels ranging in frequency from 10 GHz to 183 GHz. In addition to carrying channels similar to those on the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI), the GMI carries four high frequency, millimeter-wave, channels about 166 GHz and 183 GHz. With a 1.2 m diameter antenna, the GMI will provide significantly improved spatial resolution over TMI.

Scan Geometry

The off-nadir-angle defining the cone swept out by the GMI is set at 48.5 degrees which represents an earth-incidence-angle of 52.8 degrees. To maintain similar geometry with the predecessor TMI instrument, the-earth-incidence angle of GMI was chosen identical to that of the TMI. Rotating at 32 rotations per minute, the GMI will gather microwave radiometric brightness measurements over a 140 degree sector centered about the spacecraft ground track vector. The remaining angular sector is used for performing calibration; i.e. observation of cold space as well as observation of a hot calibration target. The 140 degree GMI swath represents a swath of 904 km (562 miles) on the Earth's surface. For comparison, the DPR instrument is characterized by cross-track swath widths of 245 km (152 miles) and 120 km (75 miles), for the Ku and Ka-band radars respectively. Only the central portions of the GMI swath will overlap the radar swaths (and with approximately 67 second duration between measurements due to the geometry and spacecraft motion). These measurements within the overlapped swaths are important for improving precipitation retrievals, and in particular, the radiometer-based retrievals.

Sentinel 3

The Sentinel-3 mission's main objective is to measure sea-surface topography, sea- and land-surface temperature and ocean- and land-surface colour with high-end accuracy and reliability in support of ocean forecasting systems, and for environmental and climate monitoring. Sentinel-3 builds directly on a proven heritage pioneered by ERS-2 and Envisat. Its innovative instrument package includes:

A Sea and Land Surface Temperature Radiometer (SLSTR), which is based on Envisat's Advanced Along Track Scanning Radiometer (AATSR), to determine global sea-surface temperatures to an accuracy of better than 0.3 K.

The SLSTR improves the along-track-scanning dual-view technique of AATSR and provides advanced atmospheric correction. SLSTR measures in nine spectral channels and two additional bands optimised for fire monitoring. The SLSTR has a spatial resolution in the visible and shortwave infrared channels of 500 m and 1 km in the thermal infrared channels.

An Ocean and Land Colour Instrument (OLCI) is based on heritage from Envisat's Medium Resolution Imaging Spectrometer (MERIS). With 21 bands, compared to the 15 on MERIS, a design optimised to minimise sun-glint and, a resolution of 300 m over all surfaces, OLCI marks a new generation of measurements over the ocean and land. The swath of OCLI and nadir SLSTR fully overlap.

A dual-frequency (Ku and C band) advanced Synthetic Aperture Radar Altimeter (SRAL) is based CryoSat heritage and provides measurements at a resolution of ~300m in SAR mode along track. SRAL is supported by a microwave radiometer for atmospheric correction and a DORIS receiver for orbit positioning.

The combined topography package will provide exact measurements of sea -surface height, which are essential for ocean forecasting systems and climate monitoring. SRAL will also provide accurate topography measurements over sea ice, ice sheets, rivers and lakes.

The pair of Sentinel-3 satellites will enable a short revisit time of less than two days for OLCI and less than one day for SLSTR at the equator. The satellite orbit provides a 27-day repeat for the topography package, with a 4-day sub-cycle.

Sentinel-3 will benefit services for the marine environment. Near-realtime data will be provided for ocean forecasting, sea-ice charting, and maritime safety services needing accurate and timely measurements of the state of the ocean surface, including surface temperature, ocean ecosystems, water quality and pollution monitoring. Land services to monitor land-use change, forest cover, photosynthetic activity, soil quality and fire detection will also benefit significantly from Sentinel-3.

JPSS 1

The Joint Polar Satellite System (JPSS) is the Nation's next generation polar-orbiting operational environmental satellite system. JPSS is a collaborative program between the National Oceanic and Atmospheric Administration (NOAA) and its acquisition agent, National Aeronautics and Space Administration (NASA). This interagency effort (JPSS) is the latest generation of U.S. polar-orbiting, non-geosynchronous environmental satellites. JPSS was established in the President's Fiscal Year 2011 budget request (February 2010) as the civilian successor to the restructured National Polar-orbiting Operational Environmental Satellite System (NPOESS). As the backbone of the global observing system, JPSS polar satellites circle the Earth from pole-to-pole and cross the equator about 14 times daily in the afternoon orbit—providing full global coverage twice a day. Satellites in the JPSS constellation gather global measurements of atmospheric, terrestrial and oceanic conditions, including sea and land surface temperatures, vegetation, clouds, rainfall, snow and ice cover, fire locations and smoke plumes, atmospheric temperature, water vapor and ozone. JPSS delivers key observations for the Nation's essential products and services, including forecasting severe weather like hurricanes, tornadoes and blizzards days in advance, and assessing environmental hazards such as droughts, forest fires, poor air quality and harmful coastal waters. Further, JPSS will provide continuity of critical, global Earth observations— including our atmosphere, oceans and land through 2025.

Advanced Technology Microwave Sounder (ATMS)

The Advanced Technology Microwave Sounder (ATMS) instrument is the next generation cross-track microwave sounder providing atmospheric temperature and moisture for operational weather and climate applications. ATMS is a key instrument that collects microwave radiation from the Earth's atmosphere and surface all day and all night, even through clouds. ATMS currently flies on the Suomi NPP satellite mission and will fly on the JPSS-1 and JPSS-2 satellite missions.

Cross-track Infrared Sounder (CrIS)

The Cross-track Infrared Sounder (CrIS) instrument is the first in a series of advanced operational sounders that provides more accurate, detailed atmospheric temperature and moisture observations for weather and climate applications. CrIS is a key instrument currently flying on the Suomi NPP satellite and represents a significant enhancement over NOAA's legacy infrared sounder—High Resolution Infrared Radiation Sounders (HIRS). The sounding accuracy of CrIS is well beyond the capabilities of current NOAA operational sounders. CrIS will also fly on the JPSS-1 and JPSS-2 satellite missions.

Visible Infrared Imaging Radiometer Suite (VIIRS)

The Visible Infrared Imaging Radiometer Suite (VIIRS) instrument collects visible and infrared imagery and global observations of land, atmosphere, cryosphere and oceans. Currently flying on the Suomi NPP satellite mission, VIIRS generates many critical environmental products about snow and ice cover, clouds, fog, aerosols, fire, smoke plumes, dust, vegetation health, phytoplankton abundance and chlorophyll. VIIRS will also be on the JPSS-1 and JPSS-2 satellite missions.

AVHRR

The Advanced Very High Resolution Radiometer (AVHRR) sensor is carried on NOAA's Polar-orbiting Operational Environmental Satellites (POES) starting with TIROS-N in 1978. Onboard the TIROS-N, NOAA-6, 8 and 10 POES Satellites, the AVHRR Sensor measures in four spectral bands, while on the NOAA-7, 9, 11, 12 and 14 POES Satellites, the sensor measures in five bands. The AVHRR/3 sensor on NOAA-15, 16, 17, 18 and 19 measures in six bands though only five are transmitted to the ground at any time. The visible data values may be converted into albedos and the IR data into radiances or temperatures using the calibration information which is appended but not applied. Latitudes and longitudes of 51 benchmark data points along each scan are included. Other parameters appended are: time codes, quality indicators, solar zenith angles, and telemetry.

Applications

The objective of the AVHRR instrument is to provide radiance data for investigation of clouds, land-water boundaries, snow and ice extent, ice or snow melt inception, day and night cloud distribution, temperatures of radiating surfaces, and sea surface temperature, through passively measured visible, near infrared and thermal infrared spectral radiation bands. The Advanced Very High Resolution Radiometer for TIROS-N and the follow-on satellites is a scanning radiometer with either four or five channels, which is sensitive to visible/near IR and infrared radiation. The instrument channelization has been chosen to permit multispectral analyses which provide improved determination of hydrologic, oceanographic, and meteorological parameters. The visible (0.5 micron) and visible/near IR (0.9 micron) channels are used to discern clouds, land-water boundaries, snow and ice extent, and, when the data from the two channels are compared, an indication of ice/snow melt inception. The IR window channels are used to measure cloud distribution and to determine the temperature of the radiating surface (cloud or surface). Data from the two IR channels is incorporated into the computation of sea surface temperature. By using these two channels, it is possible to remove an ambiguity introduced when clouds fill a portion of the field-of-view. On later instruments in the series, a third IR channel was added for the capability of removing radiant contributions from water vapor when determining surface temperatures. Prior to inclusion of this third channel, corrections for water vapor contributions were based on statistical means using climatological estimates of water vapor content. AVHRR data have been used for many diverse applications. In general, AVHRR applications encompass meteorological, climatological and land use. Obvious meteorological and climatological applications include detection and analysis of: cold fronts; plumes; weather systems; cloud movement; squall lines; boundary clouds; jet stream; cloud climatology; floods and hurricanes. In addition, land use applications of the AVHRR include monitoring of: food crops; volcanic activity; forest fires; deforestation; vegetation; snow cover; sea ice location; desert encroachment; icebergs; oil prospecting and geology applications. Other miscellaneous AVHRR applications include the monitoring of: migratory patterns of various animals; animal habitats; environmental effects of the Gulf War; oil spills; locust infestations; and nuclear accidents such as Chernobyl.

Data Acquisition

NOAA Polar-orbiting Operational Environmental Satellites obtain global imagery daily. These data are transmitted to the Command and Data Acquisition (CDA) stations. The CDA stations relay the data to the National Environmental Satellite, Data and Information Service (NESDIS), located in Suitland, Maryland, for processing and distribution. As a result of the design of the AVHRR scanning system, the normal operating mode of the satellite calls for direct transmission to Earth (continuously in real-time) of AVHRR data. This direct transmission is called HRPT (High Resolution Picture Transmission). In addition to the HRPT mode, about 11 minutes of data may be selectively recorded on board the satellite for later playback. These recorded data are referred to as LAC (Local Area Coverage) data. LAC data may be recorded over any portion of the world, as selected by NOAA/NESDIS, and played back on the same orbit as recorded or during a subsequent orbit. LAC and HRPT have identical Level 1b formats. The full resolution data are also processed on board the satellite into GAC (Global Area Coverage) data which are recorded only for readout by NOAA's CDA stations. GAC data contain only one out of three original AVHRR lines. The data volume and resolution are further reduced by averaging every four adjacent samples and skipping the fifth sample along the scan line. POES satellites operate in relatively low orbits, ranging from 830 to 870 km above the earth. They circle the earth approximately 14 times per day (with orbital periods of about 102 minutes). The orbits are timed to allow complete global coverage twice per day, per satellite (normally a daytime and a nighttime view of the earth) in swaths of about 2,600 km in width. High resolution (1 kilometer) data are transmitted from the satellite continuously, and can be collected when the satellite is within range of a receiving station. Recorders on board the satellite are used to store data at a 4 kilometer resolution (processed by the on-board computers) continuously, and a limited amount of data at a 1 kilometer resolution on demand. The recorders are dumped when the satellite is within range of a NOAA receiving station.

Data Description

AVHRR Level 1b data are present as a collection of data sets. Each data set contains data of one type for a discrete time period. Thus, for AVHRR, there are separate HRPT, LAC, and GAC data sets. Time periods are arbitrary subsets of orbits, and may cross orbits (i.e., may contain data along a portion of an orbital track that includes the ascending node, the reference point for counting orbits). Generally, GAC data sets are available for corresponding time periods and usually have a three to five minute overlap between consecutive data sets. Level 1b (following FGGE terminology) is raw data in 10 bit precision that have been quality controlled, assembled into discrete data sets, and to which Earth location and calibration information has been appended, but not applied. Other parameters appended are: time codes, quality indicators, solar zenith angles, and telemetry.

Spatial Coverage

The AVHRR provides a global (pole-to-pole) on-board collection of data from all spectral channels. At an 833 km altitude, the 110.8 degree scan equates to a swath 27.2 degrees in width (at the Equator), or 2,600 km, centered on the subsatellite track. This swath width is greater than the 25.3 degree separation between successive orbital tracks, providing overlapping coverage (side-lap). For LAC and HRPT, the instantaneous field-of-view (IFOV) of each channel is approximately 1.4 milliradians (mr) leading to a resolution at the satellite subpoint of 1.1 km for a nominal altitude of 833 km. Since GAC data contain only one out of three original AVHRR lines and the data volume and resolution are further reduced by averaging every four adjacent samples and skipping the fifth sample along the scan line, the effective resolution is 1.1 x 4 km with a 3 km gap between pixels across the scan line. This is generally referred to as 4 km resolution.

Temporal Coverage

Each scan of the AVHRR views the Earth for a period of 51.282 milliseconds (msec). The analog data output from the sensors is digitized on-board the satellite at a rate of 39,936 samples per second per channel. Each sample step corresponds to an angle of scanner rotation of 0.95 milliradian (mr). At this sampling rate, there are 1.362 samples per IFOV. A total of 2,048 samples for the LAC/HRPT data are obtained per channel per Earth scan, which spans an angle of +/- 55.4 degrees from the nadir (subpoint view). Successive scans occur at the rate of 6 per second, or at intervals of 167 msec. For GAC data, successive sets of 4 out of every 5 samples in every third scan line are averaged to obtain an array of data spaced at intervals of 125 msec along the scan and at 500 msec along the satellite track. This leads to a data rate of 49,080 samples-per-minute and 2 scans-per-second. There are a total of 409 samples for the GAC data per channel per Earth scan. Because the satellite is sun-synchronous, visible data revisit time is daily. Infrared imaging is accomplished twice daily with the second visit occurring during the pass over the dark side of the Earth. Instrument operation is continuous. The overall coverage of the archived AVHRR data base is shown in the following tables. However, associated with equipment malfunctions, there may be short gaps in the time ranges.

SSMI/S

The Special Sensor Microwave Imager/Sounder (SSMIS) continues the legacy of passive microwave instruments carried aboard Defense Meteorological Satellite Program (DMSP) satellites. Beginning with the launch of the DMSP F-16 satellite on 18 October 2003, the SSMIS marks the commencement of a new series of passive microwave conically scanning imagers and sounders planned for launch over the next two decades (Sun and Weng 2008). SSMIS improves upon the surface and atmospheric retrievals of the Special Sensor Microwave Imager (SSM/I), and upon the atmospheric temperature and water vapor sounding capabilities of both the Special Sensor Microwave Temperature Sounder (SSM/T-1) and the Special Sensor Microwave Humidity Sounder (SSM/T-2). Furthermore, the SSMIS imaging and sounding sensors share the same viewing geometry, thereby allowing surface parameters to be retrieved simultaneously (Yan and Weng 2008). The SSMIS instrument is able to estimate atmospheric temperature, moisture, and surface parameters from data collected at frequencies ranging from 19 to 183 GHz over a swath width of 1707 km. SSMIS is currently carried aboard DMSP-F16, -F17, and -F18 satellites, and is slated for future missions aboard DMSP-F19 and -F20. This document discusses the mission objectives, principles of operation, sensor specifications, and calibration information of the SSMIS instrument.

AMSR-E

The Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) is a twelve-channel, six-frequency, passive-microwave radiometer system. It measures horizontally and vertically polarized brightness temperatures at 6.9 GHz, 10.7 GHz, 18.7 GHz, 23.8 GHz, 36.5 GHz, and 89.0 GHz. Spatial resolution of the individual measurements varies from 5.4 km at 89 GHz to 56 km at 6.9 GHz. AMSR-E is developed and provided by the Japan Aerospace Exploration Agency (JAXA, Contractor: Mitsubishi Electric Corporation) with close cooperation of U.S. and Japanese scientists. AMSR-E was modified for Aqua from the design used for AMSR, which is onboard the Japanese ADEOS-2 satellite. AMSR-E improves upon past microwave radiometers. The spatial resolution of AMSR-E data doubles that of Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager (SSM/I) data. Also, AMSR-E combines into one sensor all the channels that SMMR and SSM/I had individually. The AMSR-E instrument measures geophysical variables related to the earth's water cycle, including: precipitation rate, cloud water, water vapor, sea surface winds, sea surface temperature, sea ice concentration, snow water equivalent, and soil moisture. AMSR-E uses an offset parabolic reflector, 1.6 m in diameter, to focus Earth-emmitted microwave radiation into an array of six feedhorns, which then feed the radiation to the detectors. The reflector and feedhorn arrays are mounted on a drum that contains the radiometers, digital data subsystem, mechanical scanning subsystem, and power subsystem. The reflector/feed/drum assembly is rotated about the axis of the drum by a coaxically-mounted bearing and power transfer assembly. All data, commands, timing and electronic signals, and power pass through the assembly on slip ring connectors to the rotating assembly. A cold load (cold-sky mirror) reflector and warm load (high-temperature source) are mounted on a transfer assembly shaft that do not rotate with the drum assembly. The loads are positioned off-axis such that they pass between the feedhorn array and the parabolic reflector, hiding it once per scan. The cold load reflector reflects cold-sky radiation into the feedhorn array. Both loads also serve as calibration references for the instrument.

ADM-Aeolus

Atmospheric Dynamics Mission Aeolus, is an ESA satellite that is due for launch in 2017.[1][2][3] ADM-Aeolus will be the first equipment capable of performing global wind-component-profile observation and will provide much-needed information to improve weather forecasting. The Aeolus is the fifth planned satellite in the Living Planet Programme of the European Space Agency. The central aim of this mission is to further the knowledge of the Earth's atmosphere and weather systems. By recording and monitoring the weather in different parts of the world, Aeolus will allow scientists to build complex models of our environment, which can then be used to help predict how that environment will behave in the future. These predictions will be useful in the short-term, since they can be applied to Numerical Weather Prediction (NWP) in order to make forecasts more accurate. The mission will thus improve the knowledge of all sorts of weather phenomena, from global warming to the effects of pollution. ADM-Aeolus is seen as a mission that will pave the way for future operational meteorological satellites dedicated to measuring the Earth's wind fields. The spacecraft is being built by Airbus Defence and Space.[4] In 2014 integration of ALADIN was completed and vacuum along with vibration testing begun.

The wind-component profiles will be measured by the Aeolus payload, namely the Atmospheric LAser Doppler INstrument (ALADIN). ALADIN instrument, essentially a direct detection Lidar, consists of three major elements: a transmitter, a combined Mie and Rayleigh backscattering receiver assembly, and a Cassegrain telescope with a 1.5 metres (4.9 ft) diameter.[6] The transmitter architecture is based on a 150 mJ diode-pumped frequency-tripled Nd:YAG laser operating in the ultraviolet at 355 nm.[6] The Mie receiver consists of a Fizeau spectrometer with a resolution of 100 MHz (equivalent to 18 m/s). The received backscatter signal produces a linear fringe whose position is directly linked to the wind velocity; the wind speed is determined by the fringe centroid position to better than a tenth of the resolution (1.8 m/s).[6] The Raleigh receiver employs a dual-filter Fabry–Pérot interferometer with a 2 GHz resolution and 5 GHz spacing. It analyzes the wings of the Rayleigh spectrum with a CCD; the etalon is split into two zones, which are imaged separately on the detector.

The processing of the backscatter signals will produce line-of-sight wind-component profiles above thick clouds or down to the surface in clear air along the satellite track, every 200 kilometres (120 mi). Wind information in thin cloud or at the tops of thick clouds is also attainable; from the data processing, information on other elements like clouds and aerosols can also be extracted. The data will be disseminated to the main NWP-centres in near-real-time.

Development of the ALADIN instrument has been problematic. The ultraviolet laser was causing damage to the optical surfaces in a vacuum. ESA scientists asked NASA for support, however NASA has minimal experience with lidar of this design. Technology required for the satellite was pushing the technology envelope, therefore after problematic development ESA asked Airbus to perform additional full-model tests in a vacuum before continuing mission development. Overall complications involved in the instrument caused an estimated 50% final cost overrun; ESA has agreed to come with additional funding for the project.

MODIS

MODIS (or Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the Terra (originally known as EOS AM-1) and Aqua (originally known as EOS PM-1) satellites. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths (see MODIS Technical Specifications). These data will improve our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. MODIS is playing a vital role in the development of validated, global, interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment.