Update on Atmospheric Satellite Missions

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Long-term ozone monitoring by nadir satellites

Pioneered by the US SBUV(-2)/TOMS series and the European GOME/SCIAMACHY/OMI instruments, global monitoring of the ozone column and profile continues now with three series of nadir-viewing polar orbiting missions: three EUMETSAT Polar System (EPS) MetOp satellites (MetOp-A launched 19 October 2006, MetOp-B launched 17 September 2012, MetOp-C planned for 2017, see below) equipped with the GOME-2 and IASI instruments, three Chinese CMA/NSMC FengYun-3 satellites (FY-3A launched on 27 May 2008, FY-3B on 5 November 2010, FY-3C planned for 2013) with aboard the SBUS/TOU ozone instruments, and OMPS aboard NOAA/NASA JPSS (NPP-Suomi launched on 28 October 2011, JPSS-1 planned for 2016, JPSS-2 for 2022). While multi-spectral UV instruments like OMPS and SBUS focus on ozone, hyper-spectral UV-visible and IR instruments like GOME-2 and IASI measure a list of trace gases and aerosols as well. Similar nadir-viewing facilities are envisaged in the post-EPS era with the ESA/EUMETSAT Copernicus Sentinel-5 (launch around 2020) and NASA's GACM (project for 2025), and with Sentinel-5 Precursor TROPOMI to be launched by ESA in 2015 as a gap-filler between Envisat SCIAMACHY and Copernicus Sentinel-5.

MetOp-B reaches operational status

MetOp-B, the second of three EUMETSAT polar orbiting satellites, was successfully launched on 17 September 2012 from Baikonur in Kazakhstan. MetOp platforms carry a host of instruments to provide key information on many weather forecasting and climate variables such as temperature and humidity, wind speed and direction over oceans, ozone and other atmospheric gases. They are part of the Initial Joint Polar-Orbiting Operational Satellite System (IJPS) constellation, along with the NOAA-N and -N' satellites. From the hyper-spectral measurements of GOME-2 and IASI, the EUMETSAT Satellite Application Facility on Ozone and Atmospheric Composition Monitoring (O3M-SAF) generates near-real-time data on O_3, NO_2, SO_2 and UV index, and in off-line mode data on BrO, HCHO, OClO, water vapour and aerosols. Data on additional trace gases are in development. All MetOp-B GOME-2 data generated by the O3M-SAF have been granted operational status following a recent review. Their near-real time dissemination via EUMETCast started on 15 July 2013, together with tandem operations with MetOp-A: while GOME-2/MetOp-B operates on the nominal wide swath at 1920 km (resolution of 80x40 km²), the swath width of GOME-2/MetOp-A has been reduced to 960 km to increase spatial resolution (40x40 km²).

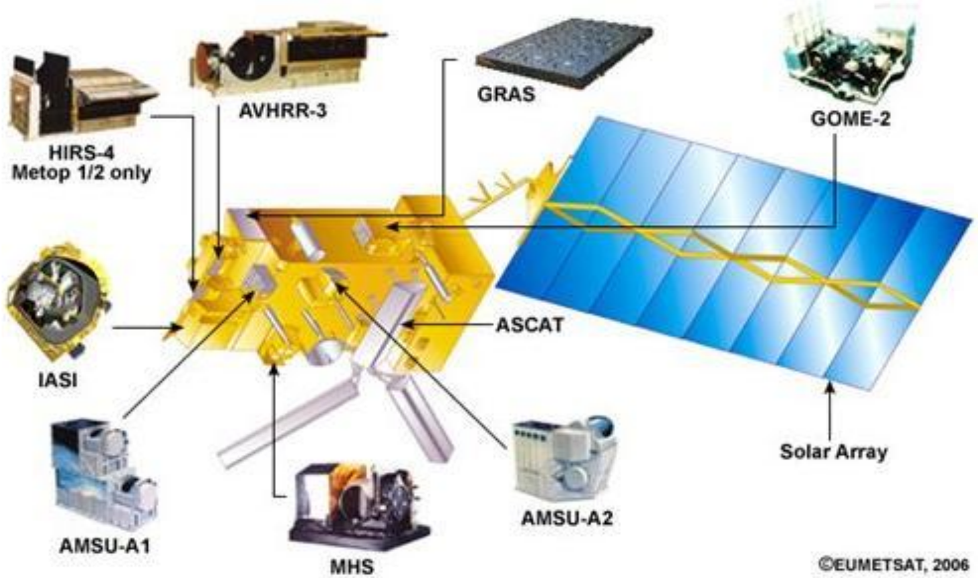

Fig. 1 – The MetOp satellite and its payload (image courtesy EUMETSAT).

End of Envisat operation

Contact to ESA's European environmental satellite Envisat was lost on 8 April 2012, shortly after celebrating its tenth year in operation. Envisat payload includes three complementary instruments measuring atmospheric composition under different geometries in the ultraviolet, visible, near infrared and thermal infrared: GOMOS, MIPAS, and SCIAMACHY. In ten years those instruments acquired unprecedented data records on tropospheric, stratospheric and mesospheric components relevant to thematic domains such as air quality and tropospheric chemistry, stratospheric ozone and the monitoring of Montreal Protocol effects, links between atmospheric composition and climate changes, atmospheric impacts of volcanism, solar proton events and other natural hazards… In March 2013 ESA hosted the Atmospheric Composition Validation and Evolution workshop (ACVE), during which the status of the recently reprocessed atmospheric data sets from Envisat, ERS-2, MetOp and ESA Third Party Missions (GOSAT, Odin, OMI, SciSat, Terra, Aqua) was reported and discussed. The quality of Envisat data products improves continuously and ESA anticipates further improvements and reprocessings of the full data archive in the coming years.

Monitoring of greenhouse gases

Global nadir monitoring of the vertical column of greenhouse gases (including CO_2 and CH_4) by Envisat SCIAMACHY and the Japanese JAXA/NIES/MOE GOSAT (in operation since 2009, see Fig. 2) is planned to continue in the 2014-2020 era with the NASA OCO-2 and OCO-3, the Chinese CAS/NSMC/MOST TanSat, and GOSAT-2. Regarding profiling facilities, CNES/DLR Merlin will start in 2016 lidar profile measurements of CH_4. Implementation of ACE-FTS solar occultation measurements on future platforms is envisaged. Unfortunately there are no firm plans for the replacement of terminated limb missions (see below).

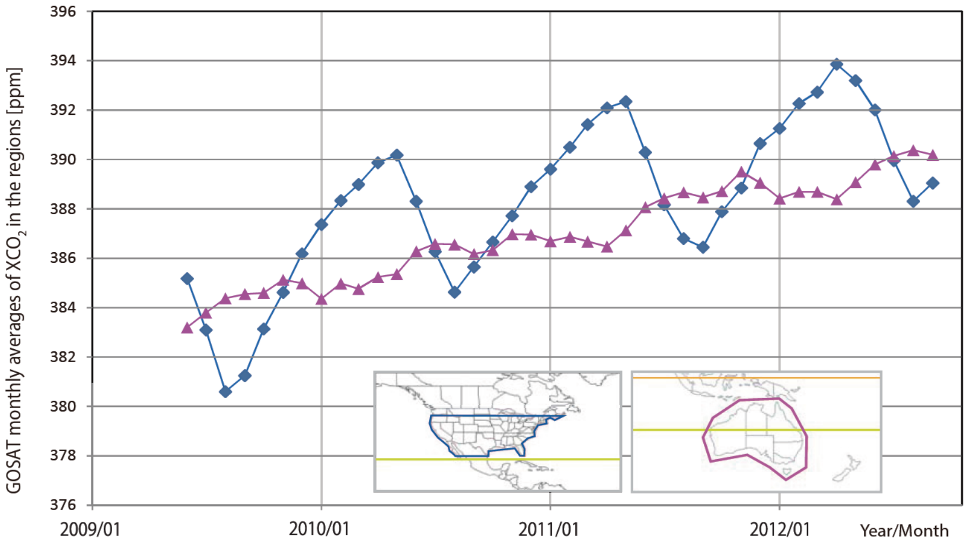

Fig. 2 - Monthly mean column-averaged volume mixing ratio of carbon dioxide (XCO_2) V2 over North America and Australia, measured by GOSAT (courtesy MOE/JAXA/NIES).

Limb/occultation profiling facilities endangered

The loss of Envisat follows the termination of UARS HALOE and MLS, SAGE-II/III and POAM-III in 2005, Aura HIRDLS in 2009, and ISS JEM SMILES in 2010. This drastic reduction of atmospheric limb and solar occultation profiling capabilities of atmospheric constituents will even turn into a real gap in coming years (see Fig. 3) with the anticipated end of aging missions, namely, Odin (in operation since 2001), SCISAT ACE-FTS/MAESTRO (since 2003) and Aura MLS (since 2004). Mission concept studies are in development, e.g., ACE-FTS and OSIRIS on CASS (proposed for 2015?), the ALTIUS concept for the PROBA micro-satellite, and MLS like instrument on GACM (in 2025?). But no comprehensive replacement of the disappearing facilities has been planned so far, and there is simply no replacement envisaged for several species. Continuation of limb and solar occultation ozone profiling after OMPS on NPP (launched in 2011) and SAGE-III on ISS (launch in early 2015) is uncertain.

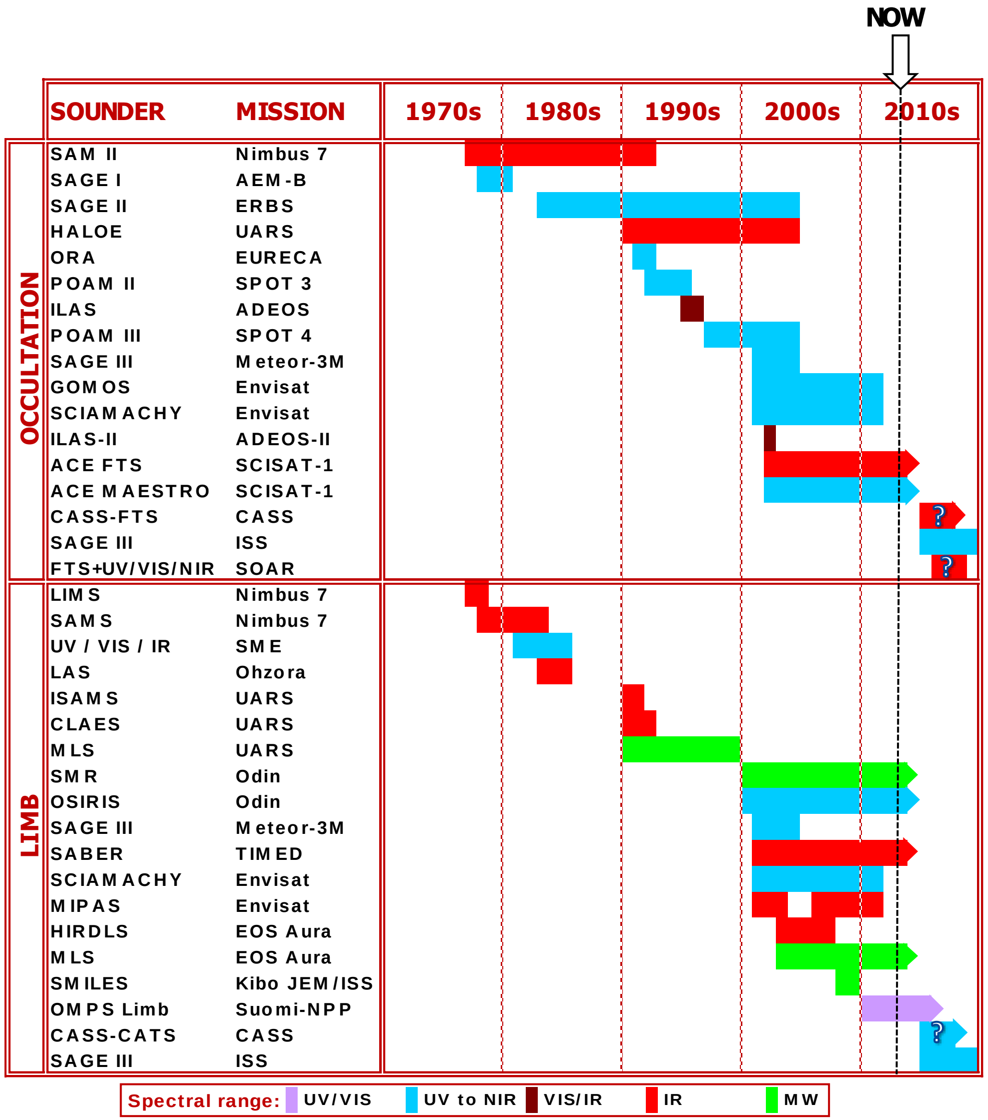

Fig. 3 – Overview of atmospheric composition satellites using the solar/lunar/stellar occultation and atmospheric limb emission/scattering profiling techniques.

Geostationary Air Quality Constellation

A geostationary constellation of air quality and regional climate monitoring satellites (GEO-AQ) will be launched between 2017 and 2022: the Korean KARI GMES, the Japanese JAXA GMAP-Asia, the European ESA/EUMETSAT Copernicus Sentinel-4, and the US NASA TEMPO and GEO-CAPE. This geostationary constellation will be complemented by two coordinated Canadian CSA PCW/PHEMOS missions operating from highly elliptical Molniya orbits with pseudo-geostationary focus on the Arctic. Equipped with nadir UV-visible and infrared instruments, the GEO-AQ constellation will offer, at typical spatial resolution of 8x8 km^2 and temporal sampling of 1h, access to short-term variations of the atmospheric composition, including lower tropospheric ozone, its precursors and aerosols. Geographical areas targeted by this constellation are highlighted in Fig. 4.

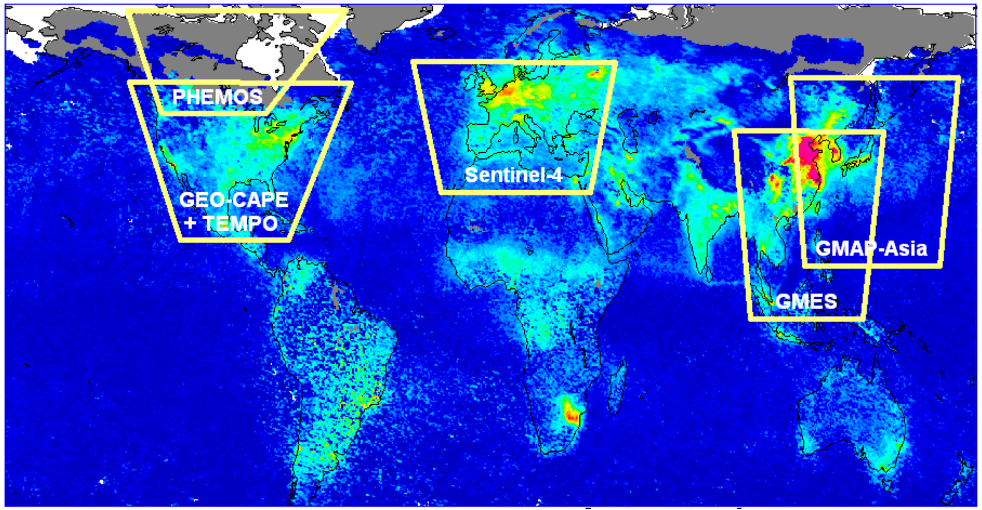

Fig. 4 – Areas targeted by the future geostationary constellation of air quality satellites (approximate areas on top of MetOp-A GOME-2 tropospheric NO_2 April 2013 monthly mean, courtesy KNMI/BIRA-IASB/EUMETSAT)