Aerosol monitoring and modeling

Olivier Boucher

Met Office
Fitzoy Road, Exeter EX1 3PB, United Kingdom

Aerosols are particles in suspension in the atmosphere which interact closely with the meteorology. Aerosols have a range of natural and anthropogenic sources. Sources of natural aerosol precursors and primary aerosols (e.g., DMS, sea-salt, dust) depend strongly on meteorological conditions, in particular surface wind speed. Aerosols are short-lived species and their distribution in the atmosphere depends on wind, convection and precipitation among other meteorological parameters. In return aerosols do interact with radiation and clouds. Atmospheric aerosols should therefore be seen as an integral part of the climate system and it makes a lot of sense to merge aerosol models with numerical weather prediction models.

One may want to monitor aerosols for a number of reasons. Aerosols are important climate agents through the so-called direct effect (in clear-sky), semi-direct effect and indirect effects (in cloudy-sky). Aerosols play a key role for visibility (with impacts on tourism, aviation and military operations) and air quality (with impacts on health and ecosystems). Deposition of aerosols is important as it relates to acid rain; it may also bring nutrients to continental and oceanic ecosystems. Aerosols offer a surface area where heterogeneous chemistry can occur, with impacts on the ozone budget both in the troposphere (because of dust) and the stratosphere (because of sulphuric acid particles). Finally proper treatment of aerosols in NWP models may lead to improved weather forecasts and meteorological (re-)analysis.

An aerosol monitoring system should rely on existing networks: EMEP and IMPROVE air quality networks over Europe and United-States, respectively, the AERONET/PHOTONS network of sunphotometers, other existing networks measuring aerosol optical depths, the GAW WMO networks of sites with strong links to the World Data Centre for Aerosols. Coordination of these networks, involving inter-calibration of the instruments when necessary, is needed. An aerosol monitoring system also needs to integrate existing and future satellite data (see figures 1 and 2). More on this can be found in the IGACO (2004) report and an implementation plan is now being designed.

The GEMS aerosol project will usefully complement observational networks. GEMS will combine a global aerosol model (representing key aerosol species) and global satellite observations through data assimilation. The aerosol model needs to be of affordable complexity and make the best use of the meteorological information and physical parametrisations of the underpinning NWP model. Satellite data will be assimilated through a 3D-VAR procedure, with a preliminary focus on aerosol products (typically the columnar aerosol optical depth and aerosol extinction profile in the stratosphere) and a future focus on aerosol radiances if a benefit can be demonstrated. Special emphasis will be put on defining the background and observational error covariance matrices. A reanalysis of the 2000-2005 period will be eventually produced.

References

GEMS description of work.

IGACO report, 2004.

AEROCOM website, http://nansen.ipsl.jussieu.fr/AEROCOM

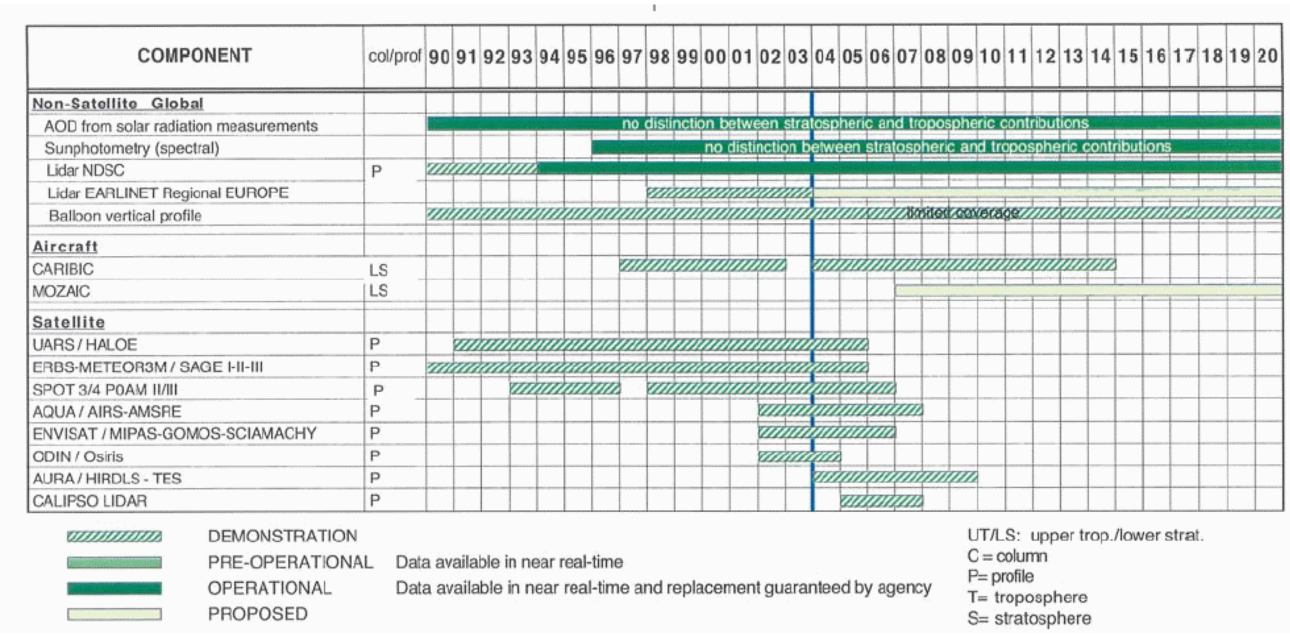

Figure 1 :Summary of observation systems for stratospheric aerosols. From IGACO (2004).

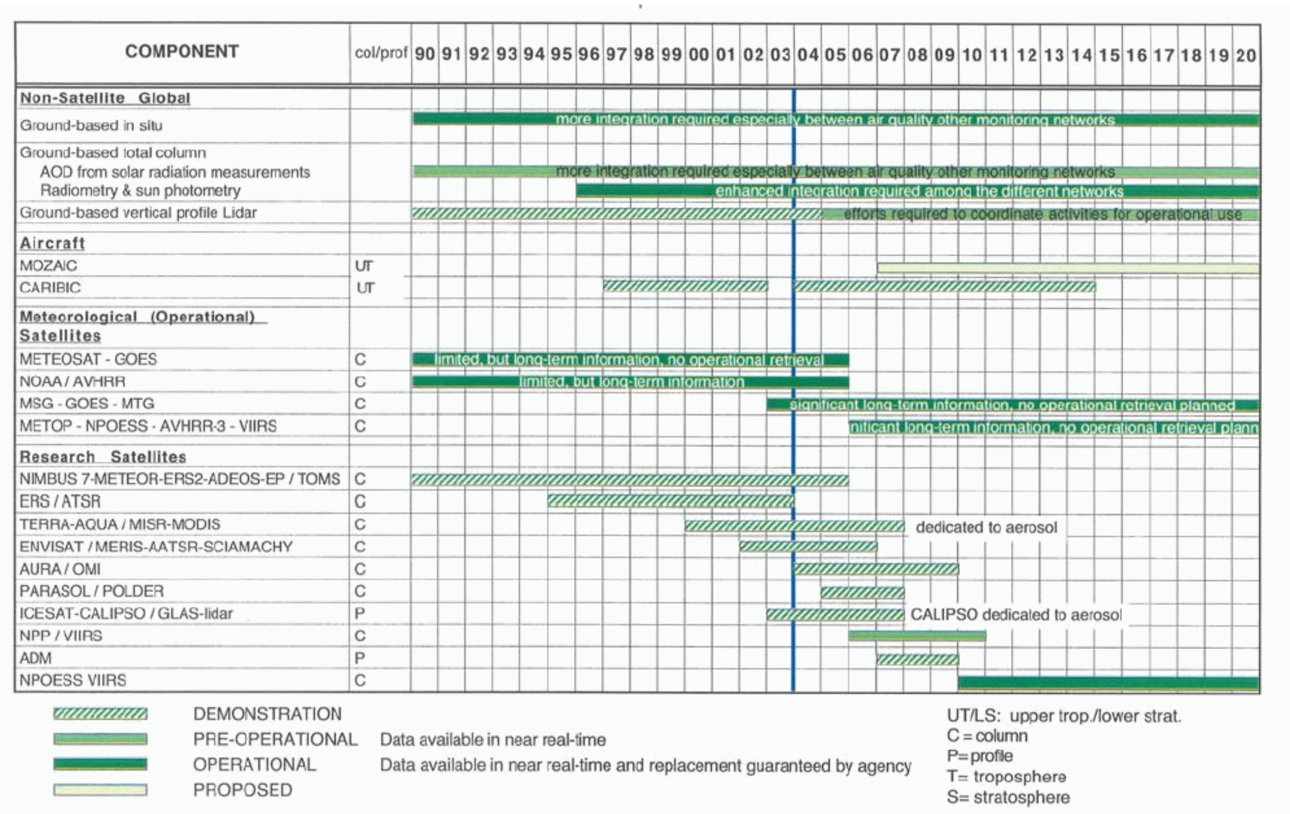

Figure 2: Summary of observation systems for tropospheric aerosols. From IGACO (2004).