Status of GOAL (Geostationary Obsertvation of Atmospheric Chemistry and Lightning) program

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GOAL (Geostationary Observation of Atmospheric chemistry and Lightning) is a proposal of small science satellite to observe (1) Large scale air pollution, and (2) Lightning.

Large scale air pollution causes damage on human health and expected crop yield damage (~30% in whole Northern hemisphere) in near future. It is a most threatening environmental issue with severe social-economical impact. Large scale air pollution is variable in places and time (diurnal cycle, meteorological conditions, seasonal change, long-term trends), and they are very complex and hard to describe quantitatively. Satellite observations well organized with other existing network are necessary to improve scientific understandings of large scale air pollution. The requirements on spatial and temporal resolution are 10km and 1 hour, which is almost impossible by polar orbit but is easily achieved from geostationary orbit. It is feasible to acquire 10 km and 1 hour sampling, by using UV-Visible imaging spectrograph, UV-Visible Imager and CO Imager, equivalent with GOME,TOMS, and MOPITT target species which are available only 100km and every 1-3 days. Optical observation of lightning was demonstrated by TRMM/LIS, but geostationary observation of lightning will improve science related with lightning. This paper describes recent progresses on GOAL proposal study.

UV-Visible Imaging Spectrograph will measure back-scattered light in the 270-450 nm region with 0.5 nm spectral resolution, which can observe total column O3, stratospheric O3 profile, NO2, SO2, HCHO, and land aerosols. Simple imaging spectrograph (f=180mm) with 2D detector is capable to measure 1000 pixels (North-South) in 3 seconds, and by scanning a mirror the whole earth disk can be measured within 1 hour. There are several equivalent programs, EUMETSAT is investigating possible geostationary air pollution measurement for the next generation meteorological satellite (after 2015).

UV-Visible Imager will measure 10 bands identical to TRIANA L1 point observatory (waiting for the launch), which will measure every 10 minutes. Feasibility of UV-Visible imager is quite acceptable (in power, mass, size, and performance) and it is ready for development.

Measurement principle of CO Imager is under investigation among (1) Gas correlation spectrometry, (2) grating imaging spectrograph, and (3) Stationary Michelson FTS. It was found that the gas correlation technique lacks sensitivity when using imager configuration. High spectral resolution Echelle grating imaging spectrograph is feasible (as already proposed to EUMETSAT), but it requires large size and mass. CO measurements is essential component in the large scale air pollution observation, where CO and HCHO (to be measure by UV-Visible imaging spectrograph) are the best indices of NMHC to be oxidized by NOx photochemical chain reactions.

Feasibility studies of optical lightning observation have been carried out, and there are no major issue in flight model development. Two engineering issues remain for future studies: (1) radiation hardness of high read-out speed CMOS detector, and (2) design of compact lightning event detection electronics. The optics, Telecentric lens system, can be identical with UV-Visible imager to save development cost.

It is obvious that there was significant progress in the public understandings on the necessity and importance of satellite observation of large scale air pollution. IGOS-P/IGACO and Earth Observation Summit mentioned necessity of large scale air pollution observation. EU is strongly supporting geostationary large scale observation program for the EUMETSAT third generation series. NASA is developing geostationary FTS (GIFTS) which can measure CO and CH4, and NOAA GOES-R will continues GIFTS-like observation. JAXA have started research of future geostationary observation of large scale air pollution. Geostationary lightning observation is under development by NOAA and EUMETSAT since late 1990s.