**Studies in Support of an Advanced ESA Mission to Sound Atmospheric Composition after Envisat**

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**Introduction**

During the last three years, two studies have been undertaken in parallel for ESA to consolidate the scientific basis for an advanced future mission to sound atmospheric composition in the period beyond Envisat: An overview is given of the scope and principal findings from these two ESA studies.

Tomographic limb-sounding: The principle of tomographic limb-sounding is to exploit information on horizontal as well as vertical structure in the atmosphere available by viewing a given airmass from different directions. This is accomplished by over-sampling in the horizontal and vertical dimensions and inverting measurements from multiple limb-scans simultaneously to a 2-D atmospheric field model.

**UTLS Study**

Through the "Consideration of a Mission Surveying Chemistry of the Upper Troposphere and Lower Stratosphere" the state-of-the-art for limb-sounding of the UTLS region has been advanced in the following ways:

1. Development of tomographic (ie fully 2-D) retrieval schemes for the advanced mm-wave and IR limb-sounders MASTER and AMIPAS and performing iterative, non-linear retrieval simulations for multiple trace gases in the presence of realistic, horizontal (and vertical) structure in temperature, trace gas and cloud fields;

2. Development of a radiative transfer model (ARTS-1.1) to calculate limb radiation spectra rigorously for a multiply-scattering 3-D cloud field

3. Incorporation of cloud scattering into IR and mm-wave radiative transfer models (KOPRA and FM2D) that are fast enough for use in retrievals, through use of approximations

4. Determination of penetration depth into the troposphere for limb-sounding at different wavelengths as a function of latitude, time of year and time of day, on the basis of ECMWF temperature, humidity and cloud fields.

**UTLS Study Principal Findings**

The study has confirmed that the MASTER and AMIPAS limb-sounders offer:

1. Retrieval of UTLS structure with higher fidelity than preceding missions, through use of tomographic limb-sounding and advanced instrument design (~100 km horizontal resolution along-track achievable)

2. Complementary information from mm-wave and IR emission in respect to:
   - Depth and frequency of penetration into troposphere for H2O, O3, CO
   - Sensitivity to aerosol, PSC and cirrus
   - The additional trace gases measured

**ACOR-2 Study**

The "Atmospheric Chemistry Observational Requirements Study - 2nd Extension" focused on refining the specifications of new instruments in polar orbit for limb-sounding of the UTLS and nadir-sounding of the troposphere at near-IR wavelengths. These instruments were selected in the original ACOR study to extend and complement the observational capabilities of the future operational missions MetOp and NPOESS.

Key elements were:

- 2-D radiative transfer and retrieval models to determine error sensitivities and to define instrument specifications of limb sounders (MASTER, AMIPAS)
- quantitative investigation of the potential value of a limb cloud imager (LCI) to support UTLS trace gas retrievals from the limb FTIR emission sensor.
- refining the specifications of near-IR nadir-sounding spectrometers (Fourier transform and grating) by means of detailed retrieval simulations and comparison against (externally specified) requirements for worthwhile satellite observations of CO2, CO, CH4 and other hydrocarbons.

**Some Findings from ACOR-2 Study**

This study has led to a number of recommendations for changes to instrument specifications which do not detract from the ACECHEM scientific objectives. Examples of instrument simplifications are:

- AMIPAS: spectral resolution is less critical than previously anticipated - relaxation of requirement
- LCI: Two near-IR channels are needed to distinguish aerosol/cloud. One could replace the 12µm channel - reduction in size and complexity
- MASTER: High spectral resolution spectrometers found not to be needed and some reduction in bandwidth achievable

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