Wegener Center for Climate and Global Change

University of Graz

The ACCURATE Mission:

Measuring Profiles of Greenhouse Gases, Isotopes, Thermodynamic Variables, and Wind from Space

ways emerge in that we go them
Motto of the Wegener Center

Work supported by: asap, FFG, esa

Atmospheric Remote Sensing and Climate System Research Group

A R S C l i S y s

S. Schweitzer, G. Kirchengast, and F. Ladstädter

Wegener Center for Climate and Global Change (WegCenter) and Institute for Geophysics, Astrophysics, and Meteorology (IGAM), University of Graz, Graz, Austria • e-mail: susanne.schweitzer@uni-graz.at & gottfried.kirchengast@uni-graz.at • fax: +43-316-380-9830

Abstract. ACCURATE is a concept for a satellite mission enabling simultaneous profiling of trace gases, wind and thermodynamic parameters of the Earth's atmosphere. Measurement principle and first performance simulation results are presented here.

1. The ACCURATE mission concept

ACCURATE [*ACCURATE,* 2005] applies a combination of two forms of the occultation technique (Fig. 1): LEO-LEO Microwave Occultation (LMO) and LEO-LEO Infrared Laser Occultation (LIO). From measurements of phase delay/Doppler shift and signal amplitudes/transmissions, profiles of trace gases and line-of-sight wind (from LIO) as well as pressure/geopotential height, temperature and humidity (from LMO) can be retrieved within the UTLS (upper troposphere/lower stratosphere). In addition, cloud layering, aerosol extinction and turbulence strength may be derived. As characteristic for the occultation technique, measurements have high vertical resolution, accuracy and are long-term stable.

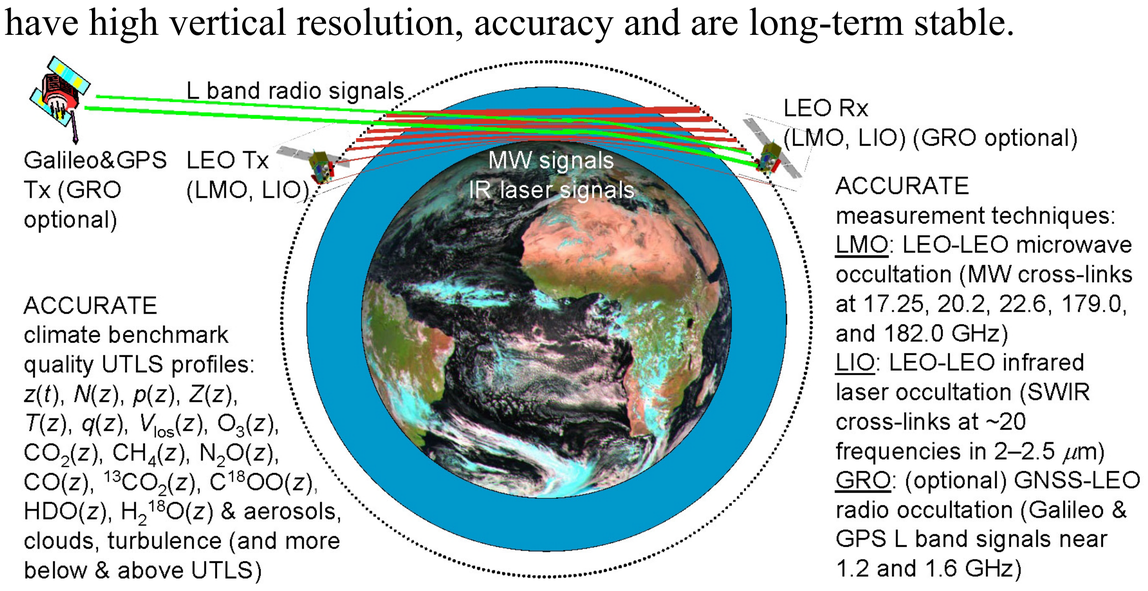

Fig. 1: *Schematic view of the ACCURATE technique with sidebar information.*

2. The novel LIO technique

ACCURATE is the first mission applying LIO, whereas LMO was already studied in fair detail previously [*ACEPASS*, 2005]. LIO uses carefully selected SWIR laser channels matching absorption lines of target species (λ_{abs}) complemented by nearby reference channels (λ_{ref}) where the atmosphere is close to transparent (Fig. 2). From differences of log-transmissions of λ_{abs} and λ_{ref} profiles of trace species can be accurately retrieved (best if transmissions within -0.5 to -12 dB). The ACCURATE design schedules 15 λ_{abs} and 6 λ_{ref} channels which were selected using RFM/HITRAN line-by-line transmission simulations [*RFM*, 2008; *HITRAN*, 2008] on the basis of the 6 FASCODE/U.S. standard atmospheres.

Fig. 2: *Tx-to-Rx transmission spectrum over the ACCURATE spectral range for a tangent height of 15 km (above). Transmission profiles for ACCURATE channels (below).*

3. Initial Retrieval Performance Estimation

An initial LIO retrieval performance estimation has been done building and expanding on experience with LMO [*ACEPASS*, 2005; *ACCURAID*, 2007; and references therein]. The focus interest was in greenhouse gases (GHGs), isotopes and wind. The results (e.g. Fig. 3) indicate that GHG and isotope profiles can generally be retrieved within the UTLS outside clouds accurate to < 1 to 5 % with a vertical resolution of 1 to 2 km. Wind can be retrieved accurate to < 2m/s within the targeted vertical range. Monthly-mean GHG profiles are found unbiased (no time-varying biases) and accurate to < 0.2 to 0.5 %.

These results underline the potential of LIO for providing data of unprecedented quality for monitoring climate and chemistry variability and change.

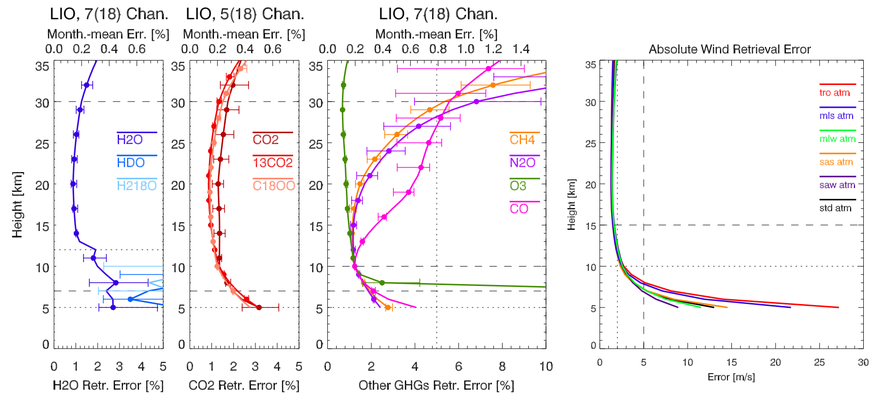

Fig. 3: *Retrieval performance estimates for water+isotopes (left), CO_2+isotopes (mid-left), other greenhouse gases (mid-right) and constant wind (right). Horizontal and vertical dotted/dashed lines mark target/threshold requirements. Horizontal bars indicate variation within the 6 FASCODE/U.S. standard atmospheres.*

4. Initial Wind Retrieval Results

A local line-of-sight wind (V_{los}) retrieval was developed [*EOPSCLIM*, 2008] which is based on observation of CO_2 or $C^{18}OO$ line wing-to-wing log-transmission differences ($\Delta\Delta Tr$), resulting from V_{los} induced Doppler shift, as well as transmissions and their derivatives obtained from model (Fig. 4):

$$V_{los} = -\frac{c}{\nu_0}\,\frac{\Delta\Delta Tr_{w1w2} - \Delta Tr_{w1w2,0,Mod}}{(dTr/d\nu)_{w1,Mod} - (dTr/d\nu)_{w2,Mod}}$$

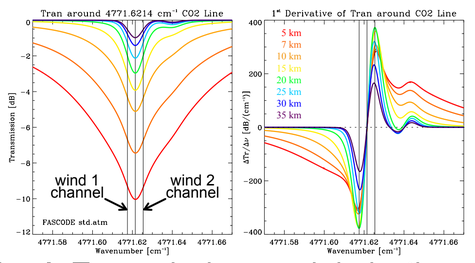

Fig. 4: *Transmissions and derivatives around the ACCURATE CO_2 channel.*

The initial retrieval is well suited for the investigation of smooth wind conditions (Fig. 5). An enhanced retrieval exploiting information from the whole occultation path via using an appropriate Abel transform will be developed as a next step. This is expected to provide an accuracy of the retrieval as shown in Fig. 3 also in non-smooth wind conditions.

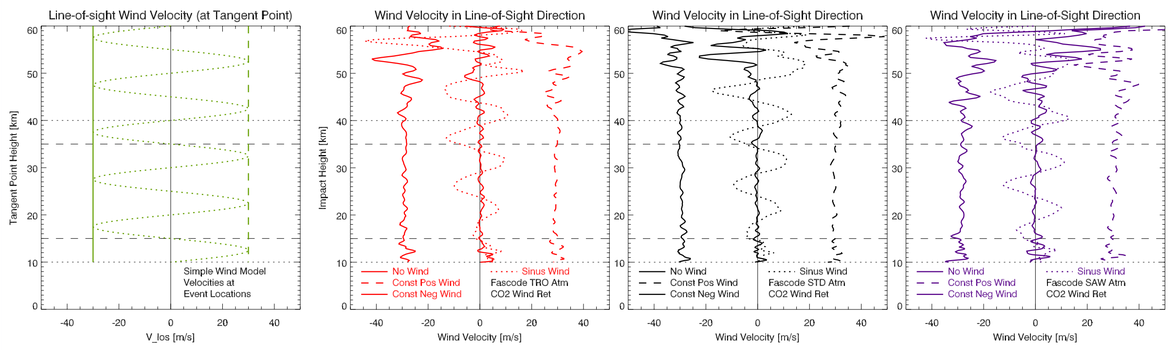

Fig. 5: *Initial wind retrieval results assuming simple wind conditions in three FASCODE atmospheres. The left panel shows the "true" wind.*

References. *ACCURAID* (2007), G. Kirchengast and S. Schweitzer, ACCURATE LIO Initial Assessment, Tech. Rep. for FFG-ALR No. 3/2007, WegCenter/UniGraz, Austria. *** *ACCURATE* (2005), ACCURATE - ESA Earth Explorer Core Mission Proposal, Ref.No. CCM2-13, WegCenter/UniGraz, Austria. *** *ACEPASS* (2005), G. Kirchengast et al., ACEPASS - Summary Report, Tech. Rep. for ESA/ESTEC No. 2/2005, IGAM/UniGraz, Austria. *** *EOPSCLIM* (2008), S. Schweitzer et al., EGOPS - Enhancement of GPS RO Data Processing and IR Laser Occultation Capabilities, Tech. Rep. for FFG-ALR No. 1/2008, WegCenter/UniGraz, Austria. *** *HITRAN* (2008), www.cfa.harvard.edu/HITRAN/. *** *RFM* (2008), www.atm.ox.ac.uk/RFM/.

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