Remote Sensing of Stratospheric Trace Gases by TELIS

Jian Xu, Franz Schreier, Adrian Doicu, Manfred Birk, Georg Wagner, and Thomas Trautmann

DLR — German Aerospace Center, Remote Sensing Technology Institute, Oberpfaffenhofen, GERMANY

TELIS Overview

TELIS (**TE**rahertz and submillimeter **LI**mb **S**ounder)

- On stratospheric balloon gondola with MIPAS-B and mini-DOAS
- 4 campaigns launched from Kiruna/Sweden and Timmins/Canada
- Observed upper troposphere and stratosphere over 10–40 km

List of Target Species:

1835 ± 45 GHz *DLR*

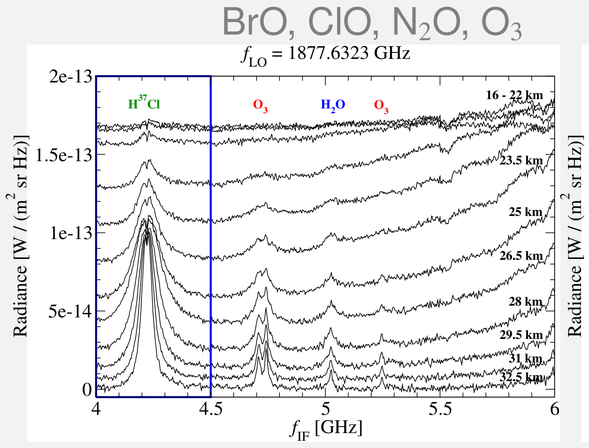
OH, HO_2, HCl, O_2, $H_2{}^{18}O$, $H_2{}^{17}O$, HDO, O_3, CO, ...

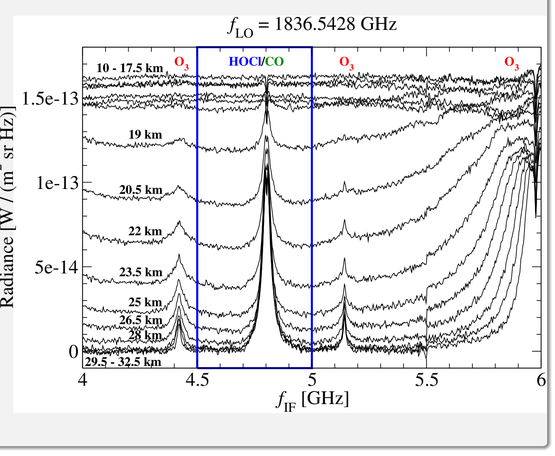
$480-650$ GHz *SRON*

BrO, HO_2, HCl, O_2, ClO, $H_2{}^{18}O$, $H_2{}^{17}O$, HDO, O_3, ...

$499-503$ GHz *RAL*

BrO, ClO, N_2O, O_3





Retrieval Code PILS

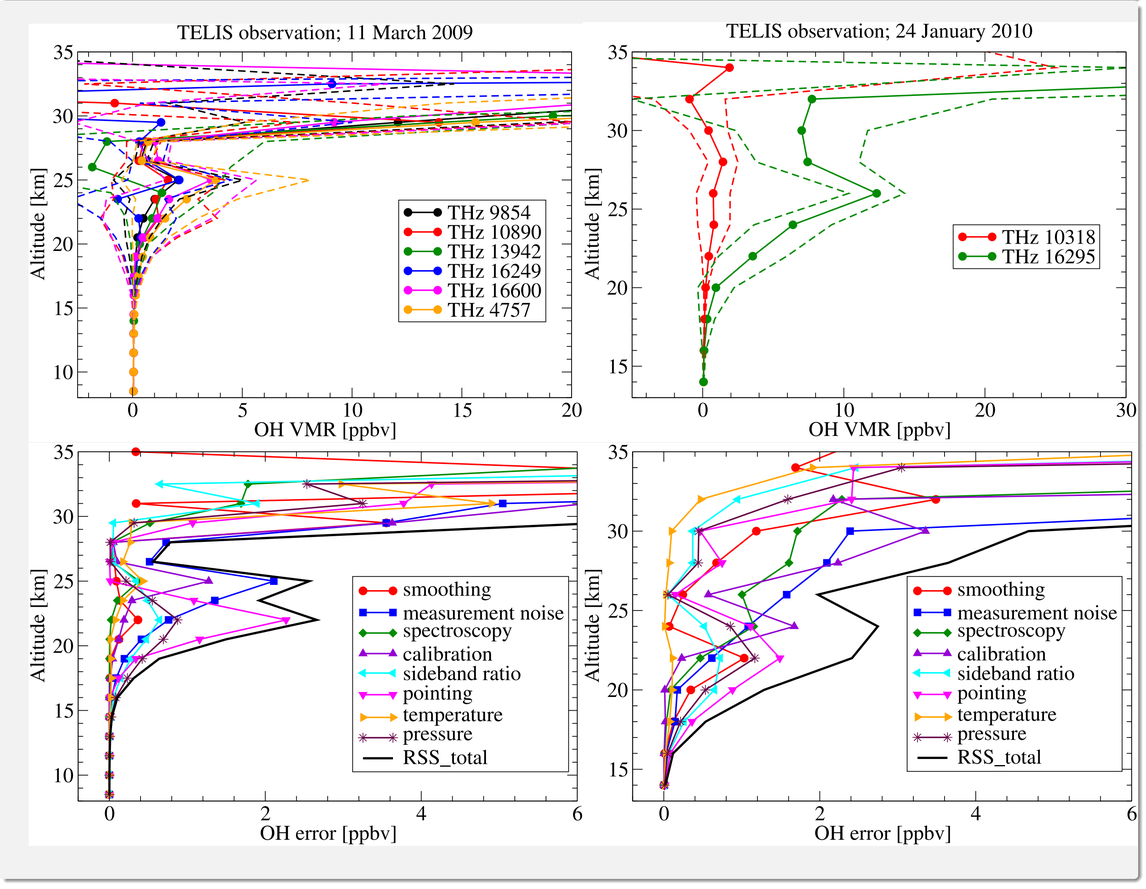
PILS (**P**rofile **I**nversion for **L**imb **S**ounding)

- Built on modular line-by-line program GARLIC
- Implementation of exact "Jacobians" by automatic differentiation
- Direct and iterative numerical regularization methods
- Inversion diagnostics based on semi-stochastic framework

$$\mathbf{S}_\lambda \approx \mathbf{S}_\mathrm{s} + \mathbf{S}_\mathrm{y} + \mathbf{S}_\mathrm{b} + \mathbf{S}_\mathrm{c}$$

- $\boldsymbol{x}_\mathrm{a}$: a priori state vector, $\mathbf{A}$: averaging kernel, $\mathbf{K}$: Jacobian matrix, $\mathbf{K}_\lambda^\dagger$: regularized generalized inverse, $\mathbf{C}$: covariance matrix
- smoothing error $\mathbf{S}_\mathrm{s} = (\mathbf{A} - \mathbf{I}_n)(\boldsymbol{x}_\lambda - \boldsymbol{x}_\mathrm{a})(\boldsymbol{x}_\lambda - \boldsymbol{x}_\mathrm{a})^T(\mathbf{A} - \mathbf{I}_n)^T$
- noise error $\mathbf{S}_\mathrm{y} = \sigma^2 \mathbf{K}_\lambda^\dagger \mathbf{K}_\lambda^{\dagger T}$
- forward model error $\mathbf{S}_\mathrm{b} = \mathbf{K}_\lambda^\dagger \mathbf{K}_\mathrm{b} \mathbf{C}_\mathrm{b} \mathbf{K}_\mathrm{b}^T \mathbf{K}_\lambda^{\dagger T}$
- instrument model error $\mathbf{S}_\mathrm{c} = \mathbf{K}_\lambda^\dagger \mathbf{K}_\mathrm{c} \mathbf{C}_\mathrm{c} \mathbf{K}_\mathrm{c}^T \mathbf{K}_\lambda^{\dagger T}$

OH: First Results

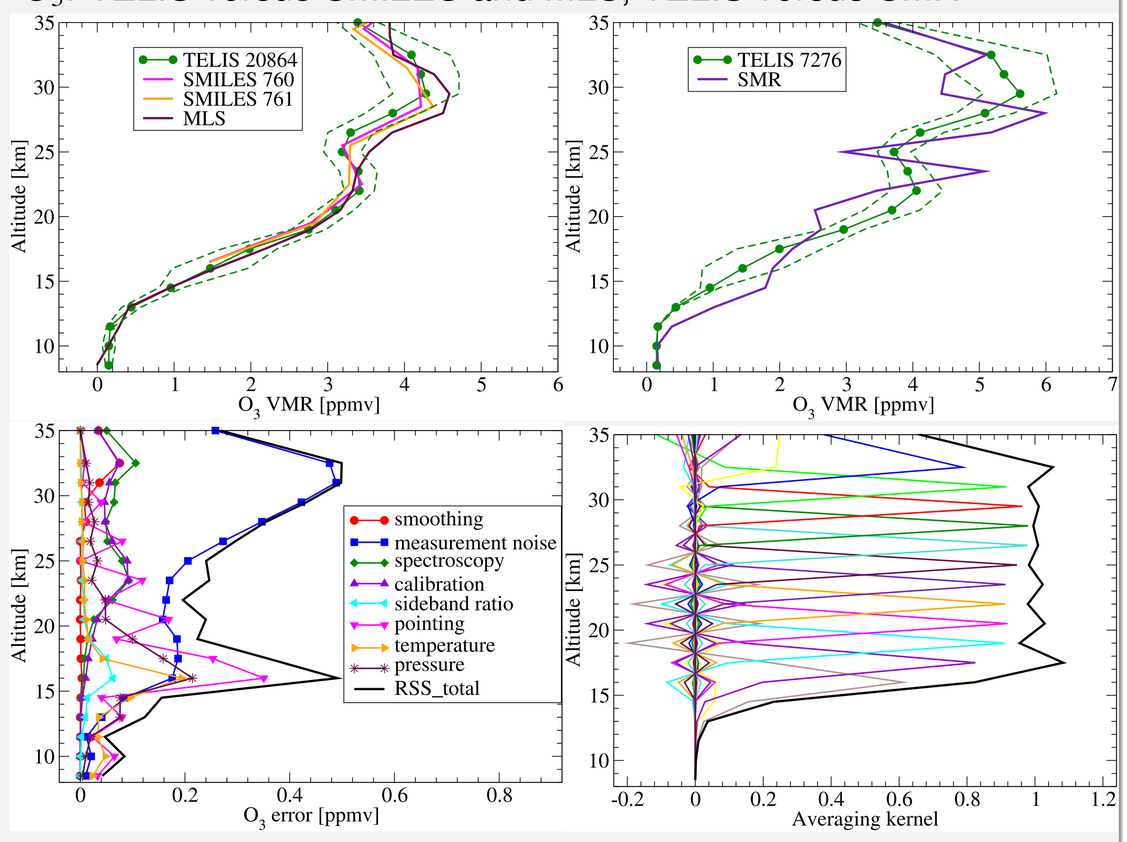


Summary

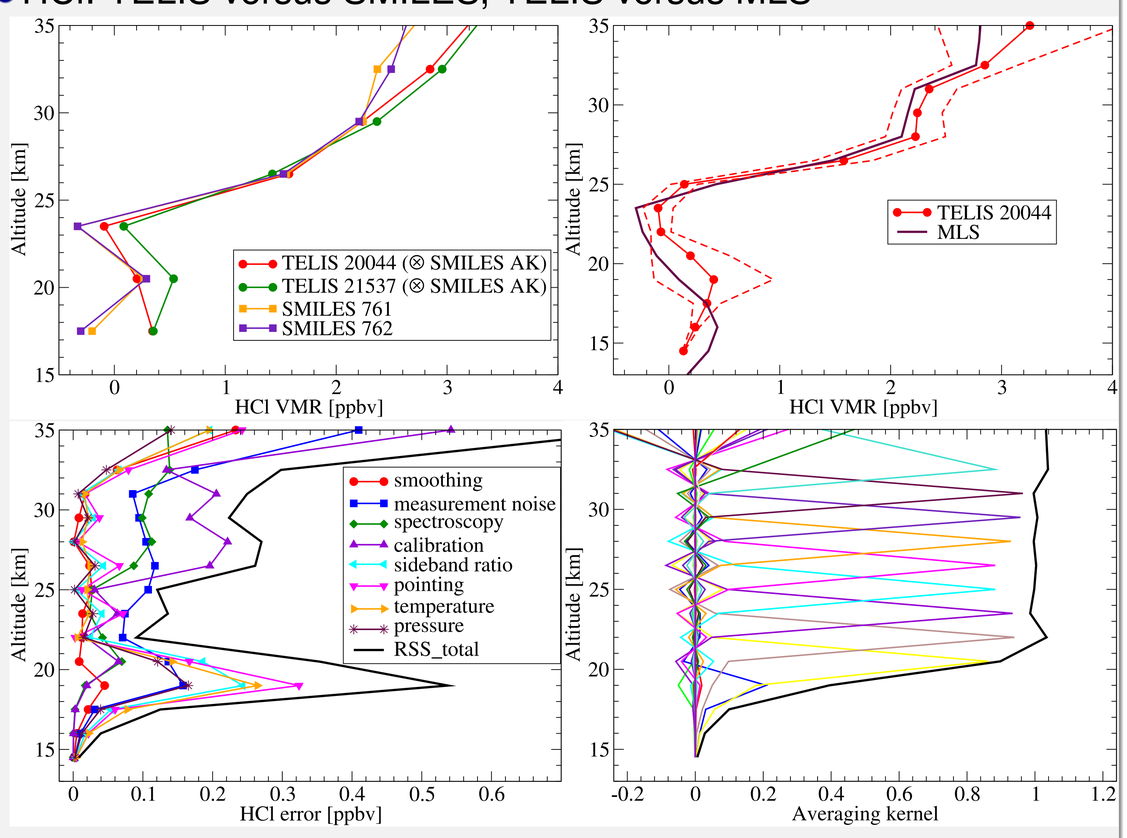
- Retrievals of winter flights during 2009–2011 over the polar region
- High vertical sensitivity above 20 km
- Good agreement with spaceborne limb sounding observations
- Instrument parameters crucial in the retrieval accuracy

Ozone, HCl, and CO: External Comparisons

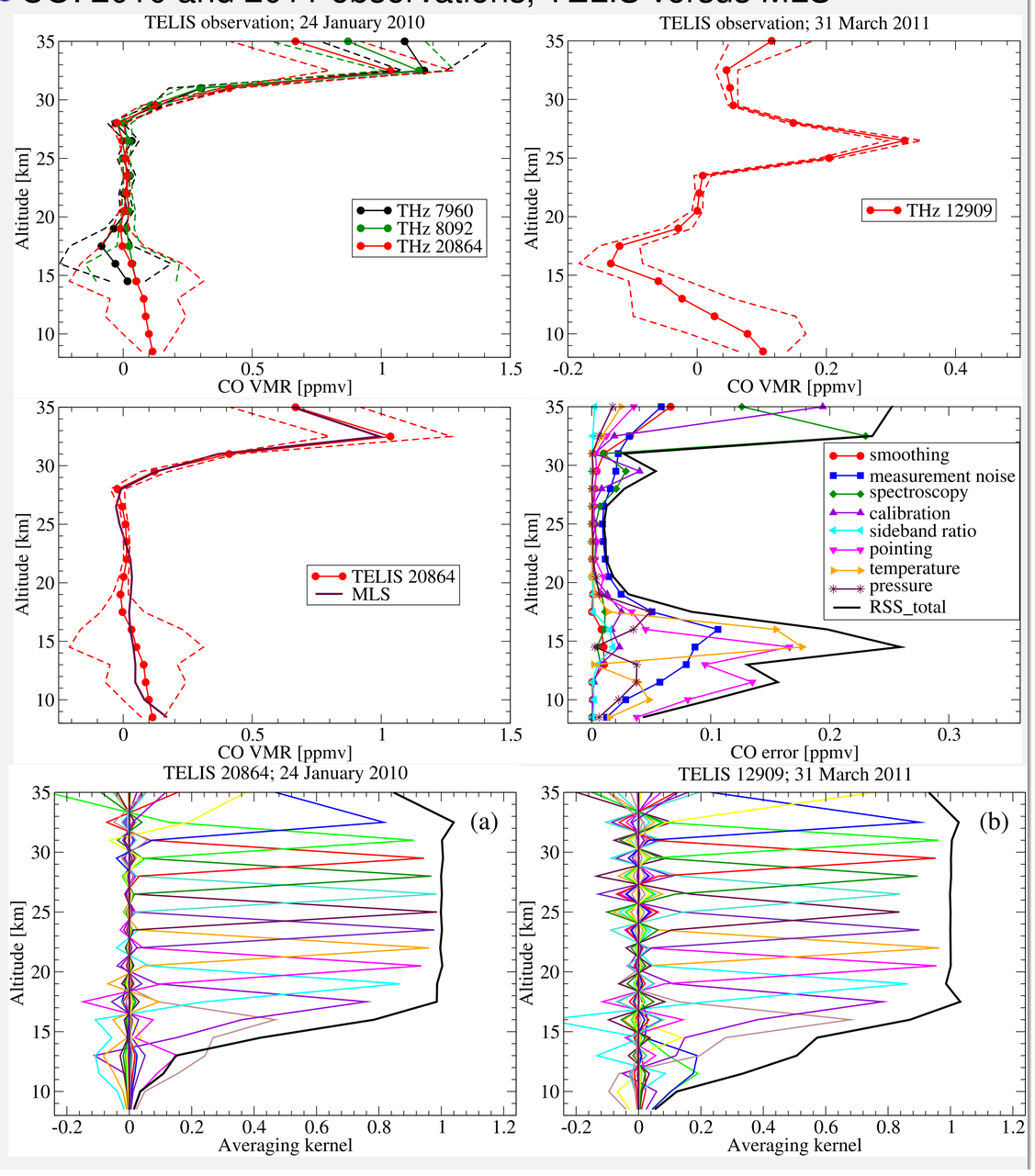
- O_3: TELIS versus SMILES and MLS, TELIS versus SMR



- HCl: TELIS versus SMILES, TELIS versus MLS



- CO: 2010 and 2011 observations, TELIS versus MLS



INSTITUT FÜR METHODIK DER FERNERKUNDUNG

Institut Methodik der Fernerkundung
DLR Oberpfaffenhofen
D-82234 Wessling
Internet: www.dlr.de/caf