IntegratedPath Differential Absorption Lidar Optimizations Based on Pre-analyzed Atmospheric Data for ASCENDS Mission Applications

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Satellite trace gas sensing modeling for missions such as ASCENDS

- Simulation framework to predict performance of trace gas sensing in the atmosphere from space
- Non-stationary simulation with spatially-dependent lidar signal
- Applicable to other sensing mission such as ASCENDS and a variety of molecules including CO₂, CH₄, N₂O etc.
- Precise aerosol-driven distributions

ASCENDS mission overview

Requirements and approach

- ASCENDS is identified as a new mission in the NASA decadal survey and is currently slated for 2024 launch
- ASCENDS will deliver laser-based remote sensing measurements of global CO₂ mixing ratios
- 10.6 µm in advance of 2.0 µm as a heritage of 300 km over land and 200 km over ocean, and passive CO₂ measurements for the future
- ASCENDS is a follow-on mission to OCO-2 and OSUM

Benefits for climate science

- Quantify global spatial distribution of atmospheric CO₂, on scales of smaller models
- Quantify global spatial distribution of terrestrial and oceanic sources and sinks of CO₂, during day and night over all latitudes
- Provide sensitive bands for future projections of CO₂, sources and sinks through data-driven enhancements of Earth system process modeling

NASA LARC-ASCENDS approach

- > 0.5% accuracy (7 ppb at 2 µm), mixing ratio resolution is required NASA Langley Research Center (LARC) is developing an intensity and correlated continuous (INTC) laser absorption path-based remote sensing scheme for the detection of CO₂, of 0.5 µmol/mol, and of 2 µmol/mol from space-based platforms
- Moderate wavelength with high differential absorption (HDA) at 5 µm and 1.56 µm bands for H₂O sensing in relation to surface pressure
- 1.5 µm on-board pre-detection and on-board noise advantages
- For our representation, two candidate wavelengths in this band will be selected: IR-band wavelength (around 1.262 and 2.035 µm) have been identified in the initial trials. Here, these two wavelength bands are being further analyzed for sensitivity to environmental parameters

Modeling framework for integrated path space lidar performance estimates

- Annual MERRA data for all locations is analyzed to establish the density of points within each temperature-pressure level grid bin
- Combining individual layer error estimates

Global annual temperature sensitivity analysis for CO₂ and O₂ bands

- Global annual temperature sensitivity analysis for the 137 micron CO₂ band
- Total absorption fraction of CO₂ and estimated error due to line-by-line band
- Hairline variation in temperature sensitivity for the 2050 period

Global annual temperature sensitivity analysis for alternative O₂ bands

- Temperature sensitivity is comparable for the A-band and 1.26-2.03 micron O₂ bands

Wavelength instability effects

- Laser wavelength jitter analysis for selected O₂ spectral lines

Pre-analyzed atmospheric data for error analysis

Analysis and processing of the MERRA dataset

- Use of MERRA data at different atmospheric conditions
- Analysis of errors in temperature and pressure sensitivity for the 2050 period
- Impact of error due to the observed variations in temperature and pressure

Conclusions and further work

- Framework applicable to any mission
- Framework operated in the E2E version, further debugging and improvements are ongoing
- Simulation program is ready for the analysis of temperature sensitivity, wavelength stability effects and the impact of error in atmospheric parameters
- Further analysis and evaluation of water vapor interferometers is under investigation
- Verification of the modeling framework: component is planned
- Use of the implemented methodology in the validation is required: number of simulations (ordinary PC may be used)

References