PERFORMANCE ASSESSMENT OF THE SPACE-BORNE RAMAN LIDAR ATLAS ATMOSPHERIC THERMODYNAMICS LIDAR IN SPACE

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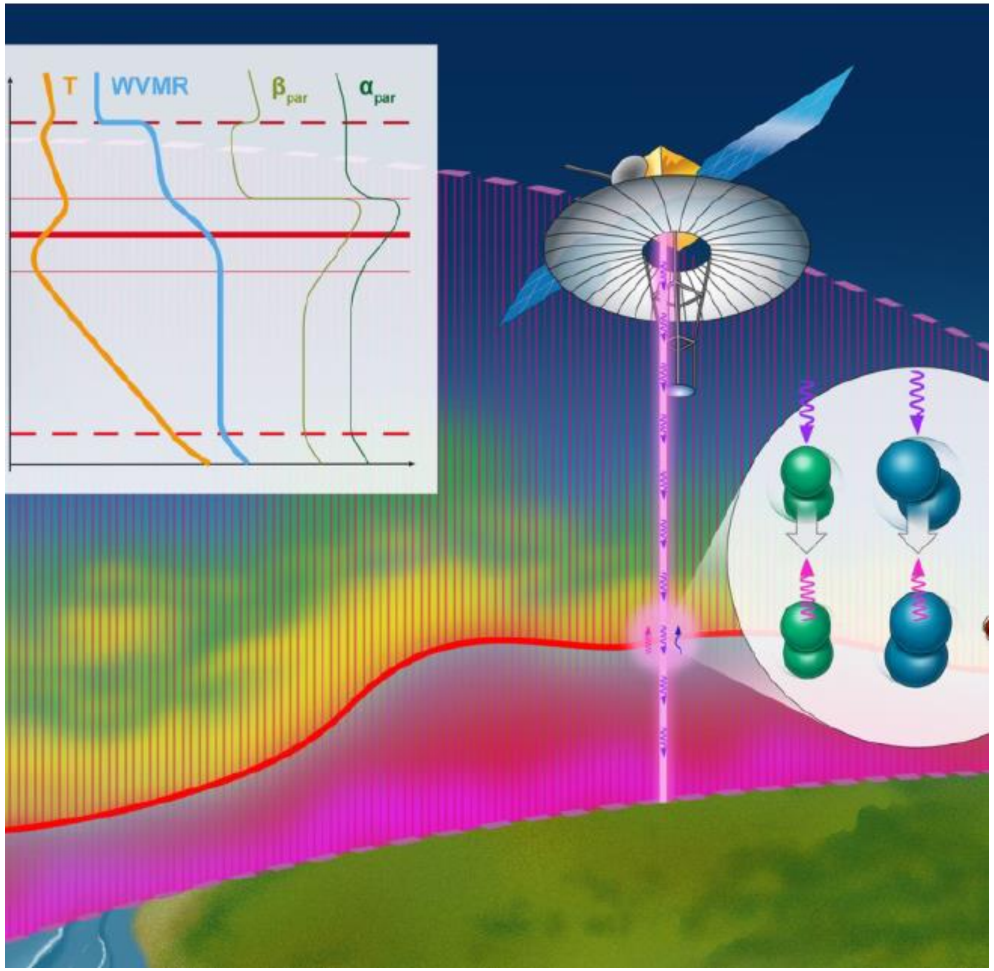
THE MISSION CONCEPT

<u>ATLAS</u>

Atmospheric **T**hermodynamics **L**id**A**r in **S**pace

The mission concept aims to develop the first Raman Lidar in space, capable to measure simultaneously atmospheric temperature (T) and water vapour mixing ratio (WVMR) with high temporal and spatial resolutions.

Further data products comprise relative humidity profiles, the particle extinction and backscatter coefficient profiles at 354.7 nm and the PBL depth over land and the oceans.



IMPACT OF THE MISSION

Accurate, high temporal and spatial resolution observations of thermodynamic profiles in the lower troposphere from the surface to the interfacial layer at the top of the planetary boundary layer (PBL) are critically essential for improving weather forecasting and re-analyses, and for understanding the Earth system.

Global scale measurements of 3D thermodynamic profiles would have a great impact in several research areas [Wulfmeyer et al., 2015]:

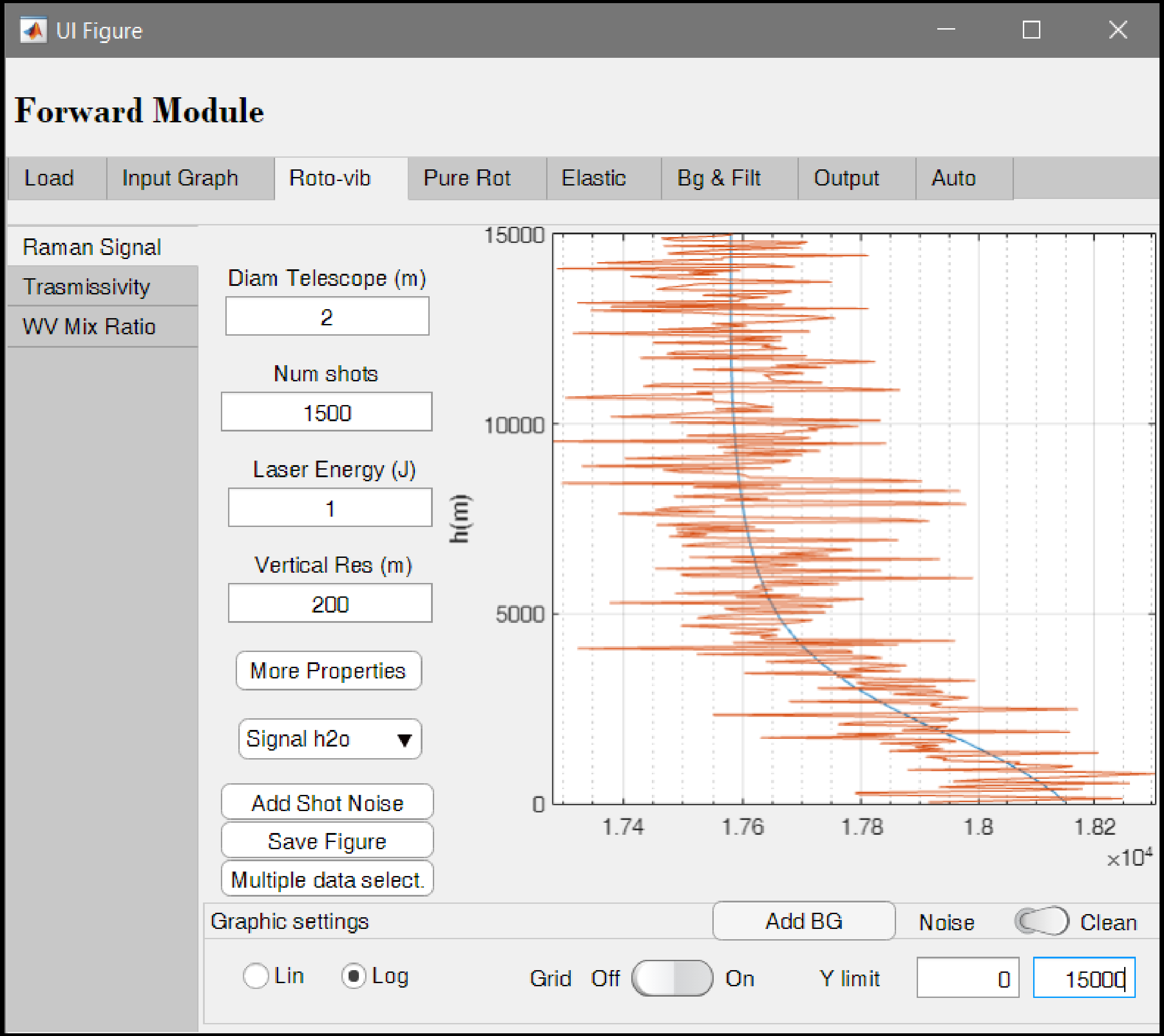
- Radiative transfer, as well as regional and global water and energy budgets,
- Land-atmosphere feedback including the surface energy balance and its dependence on soil properties and land cover,
- Mesoscale circulations and convection initiation
- Data assimilation

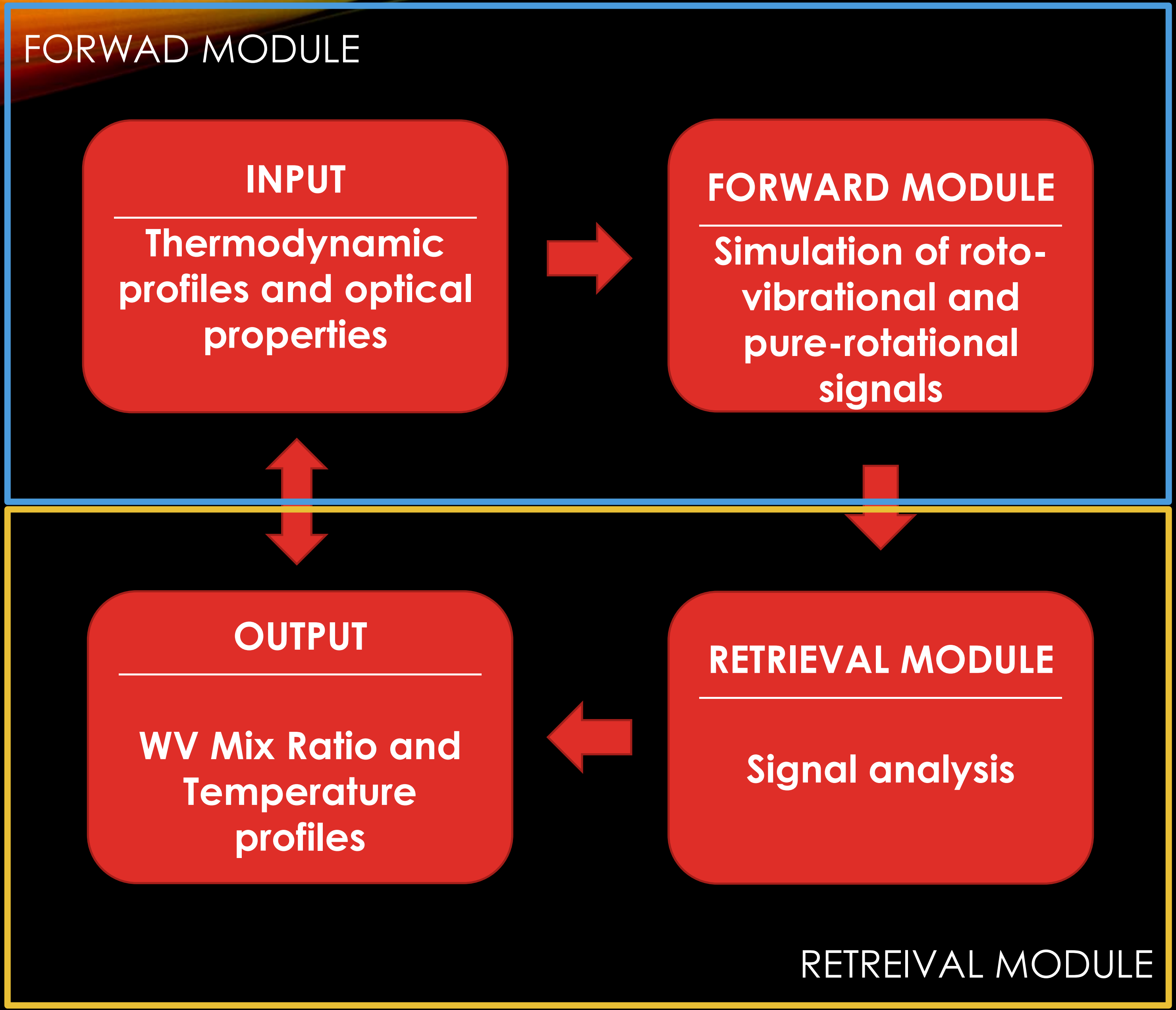
EXPERIMENTAL SETUP

LIDAR TRANSMITTER	
Source	Injection-seeded frequency tripled, diode-laser pumped Nd:YAG
Laser Wavelength	354.7 nm
Single-shot pulse energy	1 J
Repetition rate	200 Hz
LIDAR RECEIVER	
Telescope	f/5 a-focal Cassegrain
Telescope diameter	2 m
Field-of-View (FWHM)	25 µrad
SPECTRAL SELECTION AND DETECTION	
Spectral selection devices	Interference Filters (IFs)
Detection Devices	Photodiodes or Photomultipliers
Quantum efficiences	85 %

THE END TO END SIMULATOR

The end-to-end simulator is a numerical model for the simulations and analysis of signals collected by a space-borne Raman Lidar.





FORWAD MODULE
INPUT
Thermodynamic profiles and optical properties
FORWARD MODULE
Simulation of roto-vibrational and pure-rotational signals
OUTPUT
WV Mix Ratio and Temperature profiles
RETRIEVAL MODULE
Signal analysis
RETREIVAL MODULE

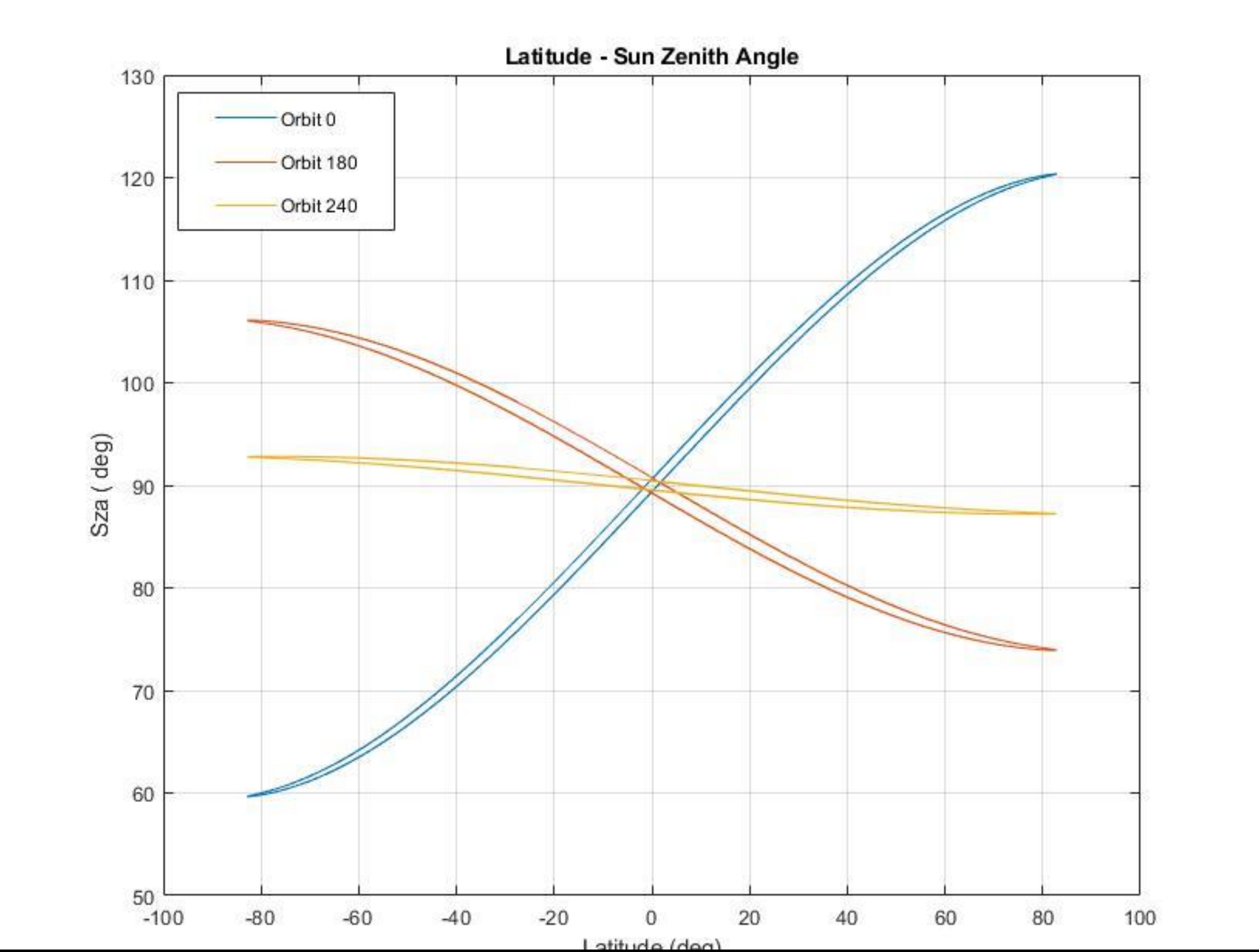
SIMULATIONS

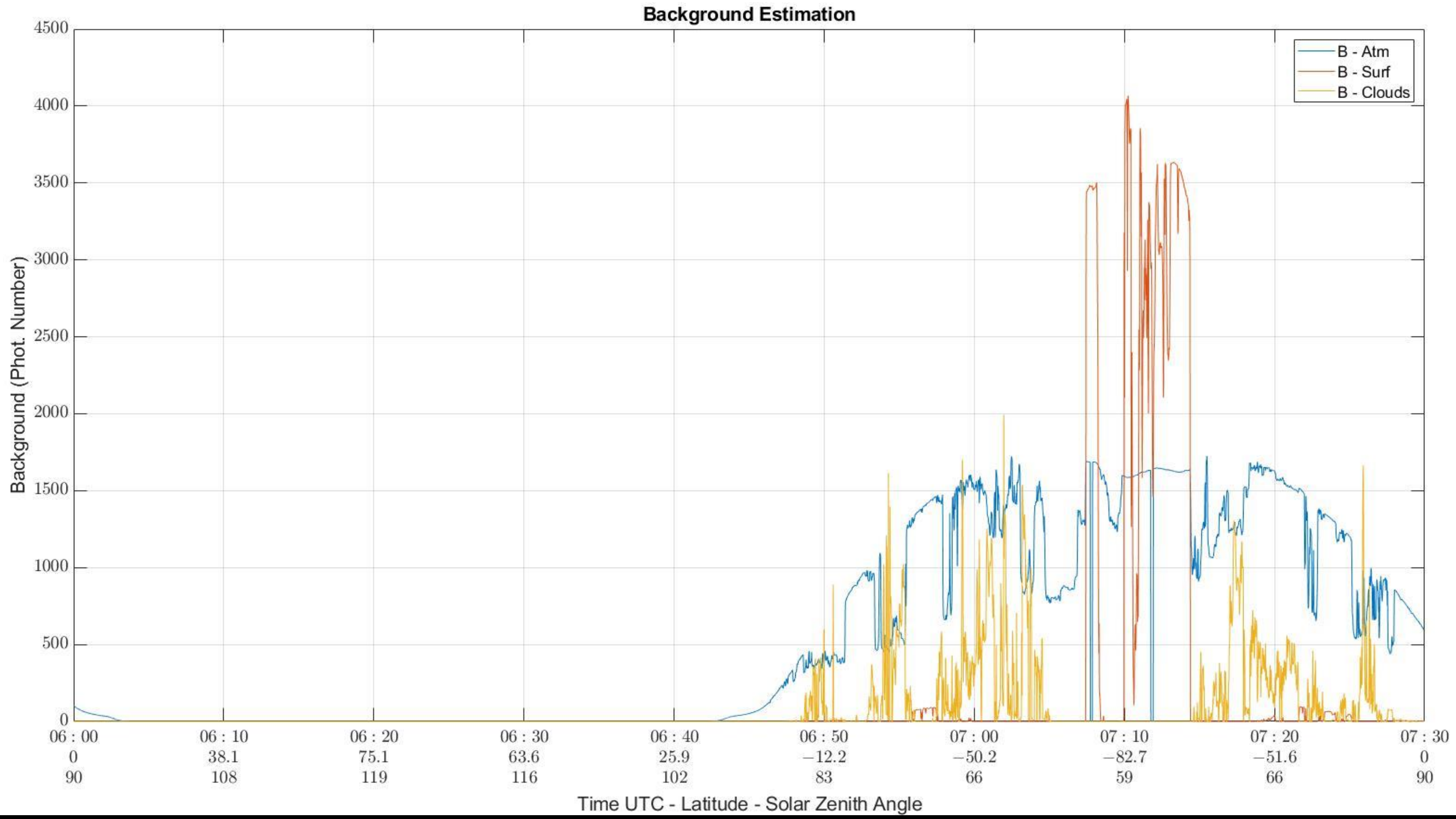
To verify the capabilities of ATLAS, simulations along several orbits around the Earth were performed.

The orbit were selected to consider the different variability of the sza during the year:

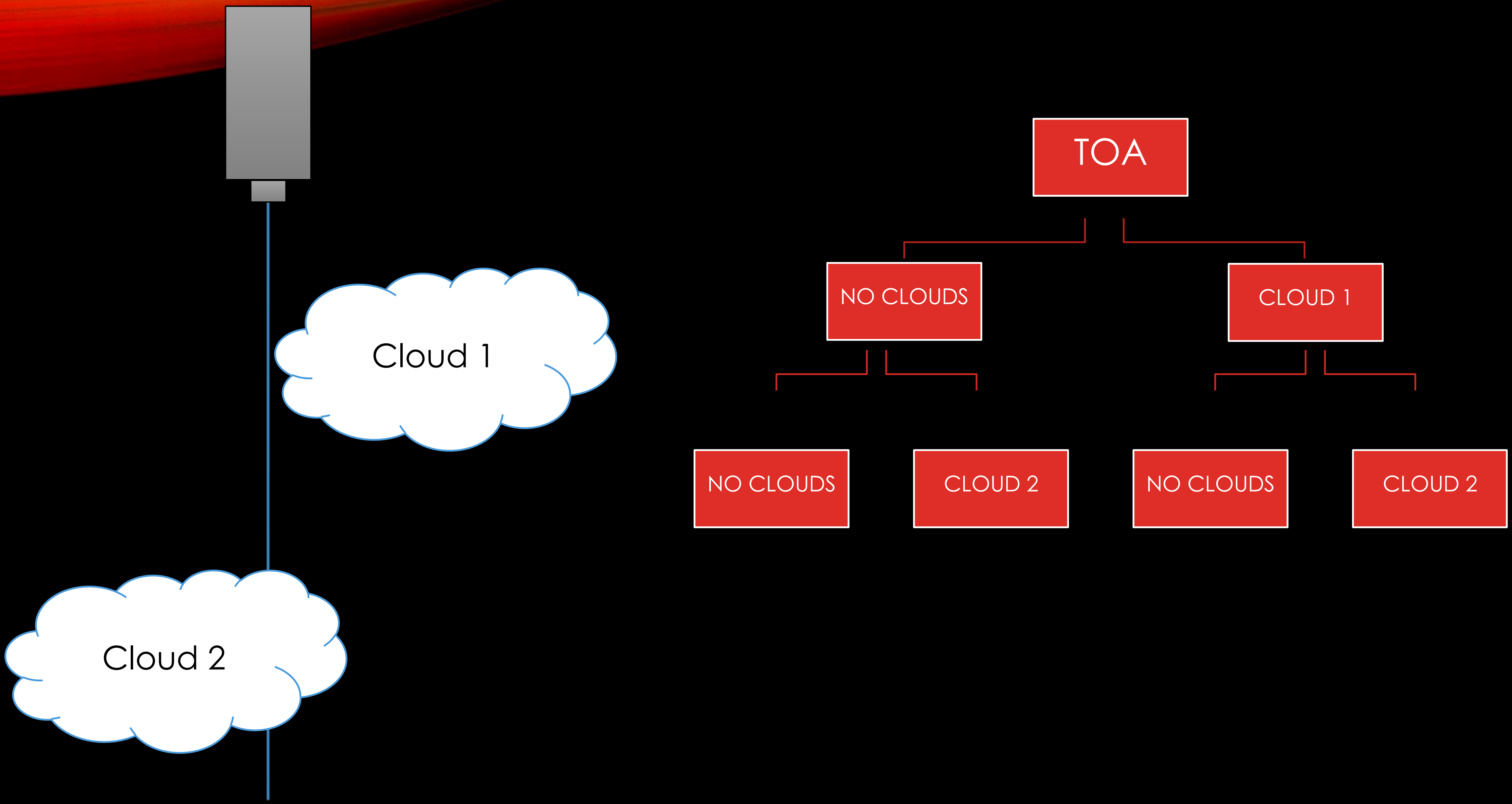
- Day 0: 90° ± 30° (High background)
- Day 180: 90° ± 15° (Mean background)
- Day 240: 90° ± 3 ° (Low background)

The data are extracted from NASA's Goddard Earth Observing System Model (GEOS-5) analysis

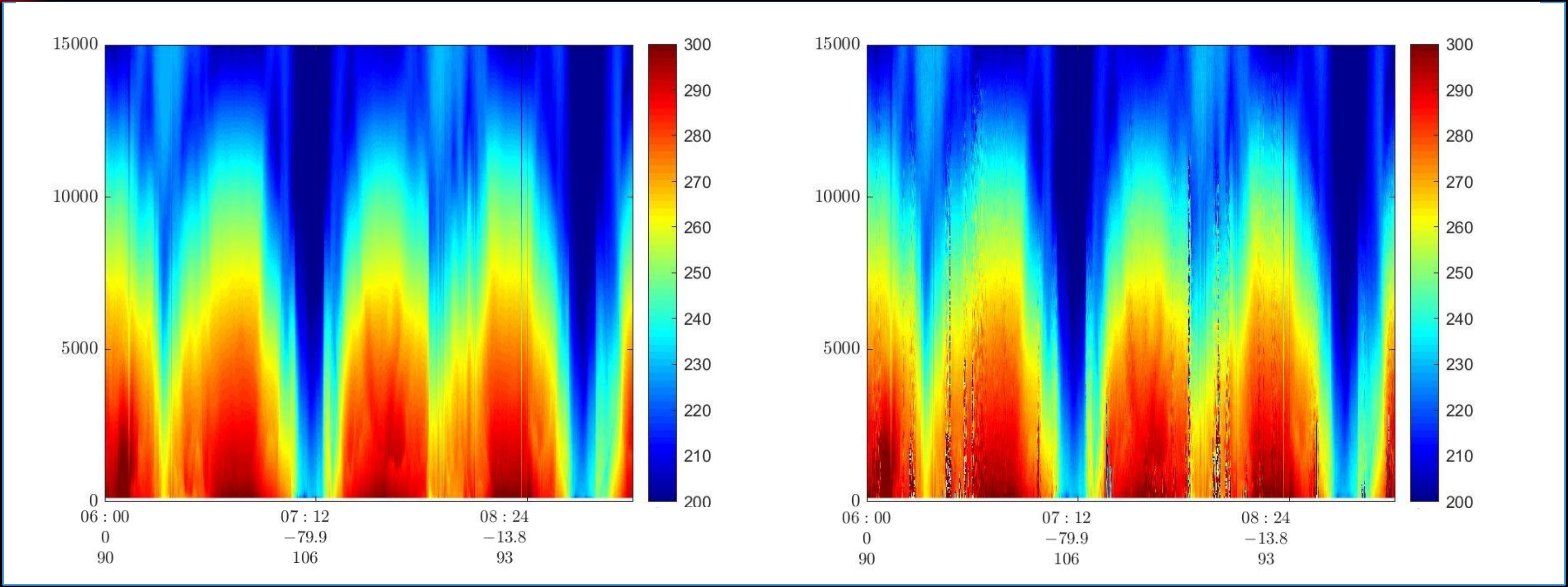




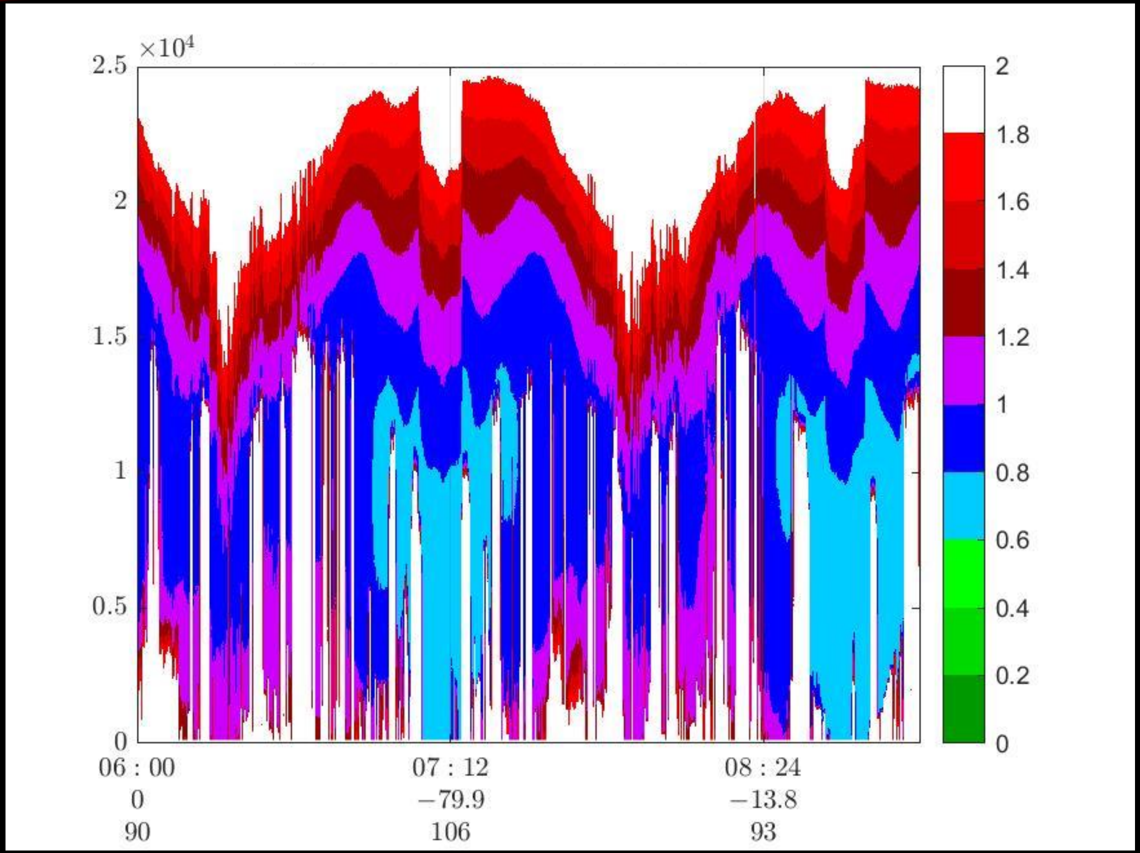
Background Estimation
B - Atm
B - Surf
B - Clouds
Background (Phot. Number)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
06 : 00 06 : 10 06 : 20 06 : 30 06 : 40 06 : 50 07 : 00 07 : 10 07 : 20 07 : 30
0 38.1 75.1 63.6 25.9 −12.2 −50.2 −82.7 −51.6 0
90 108 119 116 102 83 66 59 66 90
Time UTC - Latitude - Solar Zenith Angle


Cloud 1
Cloud 2
TOA
NO CLOUDS
CLOUD 1
NO CLOUDS
CLOUD 2
NO CLOUDS
CLOUD 2

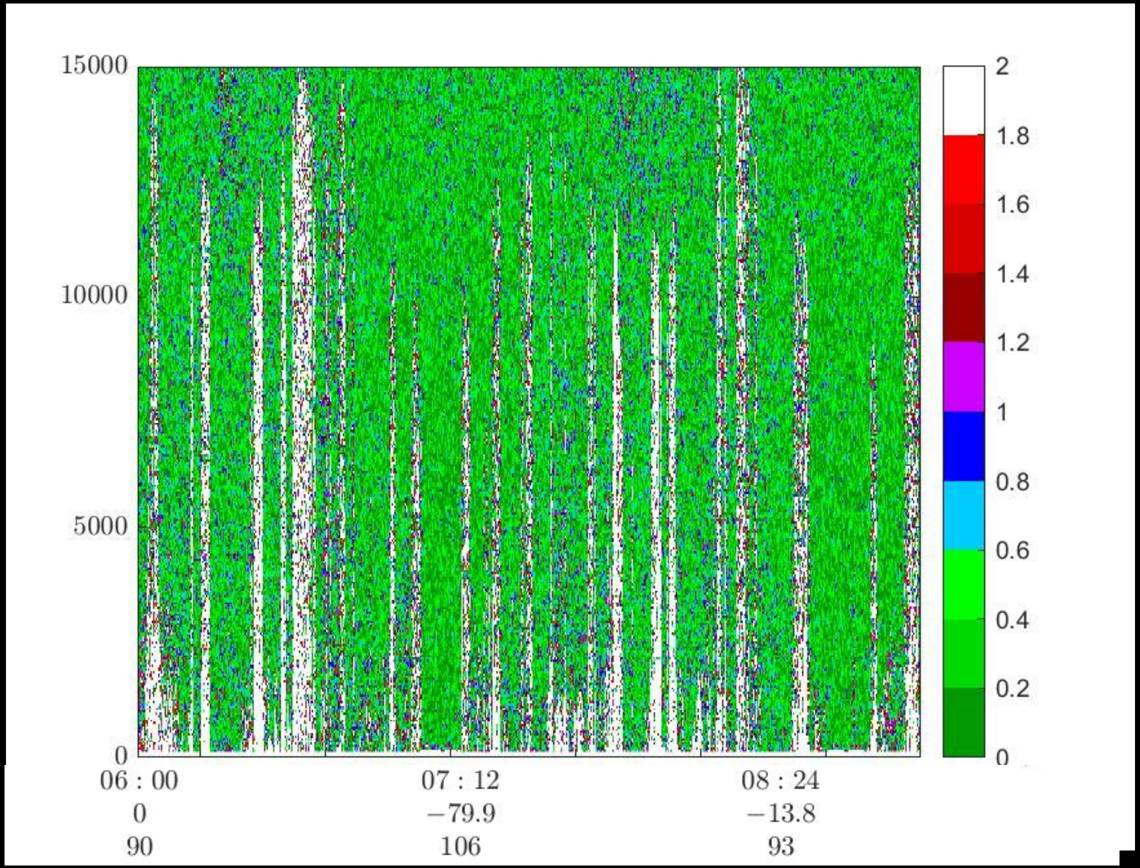
TEMPERATURE



STATISTICAL UNCERTAINTY (K) AND BIAS (K)

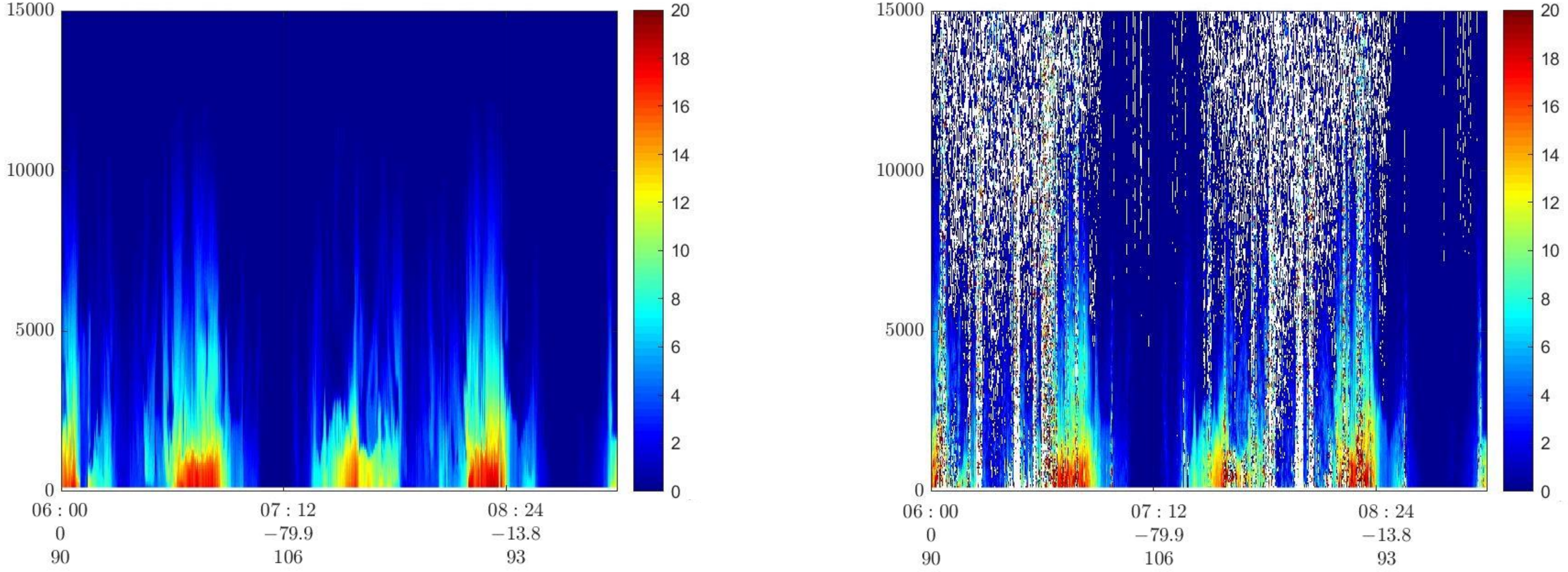


$$\Delta T(z) = \frac{\partial T(z)}{\partial R} R(z) \sqrt{\frac{N_{LoJ}(z) + bg_{LoJ}}{N_{LoJ}^2(z)} + \frac{N_{HiJ}(z) + bg_{HiJ}}{N_{HiJ}^2(z)}}$$

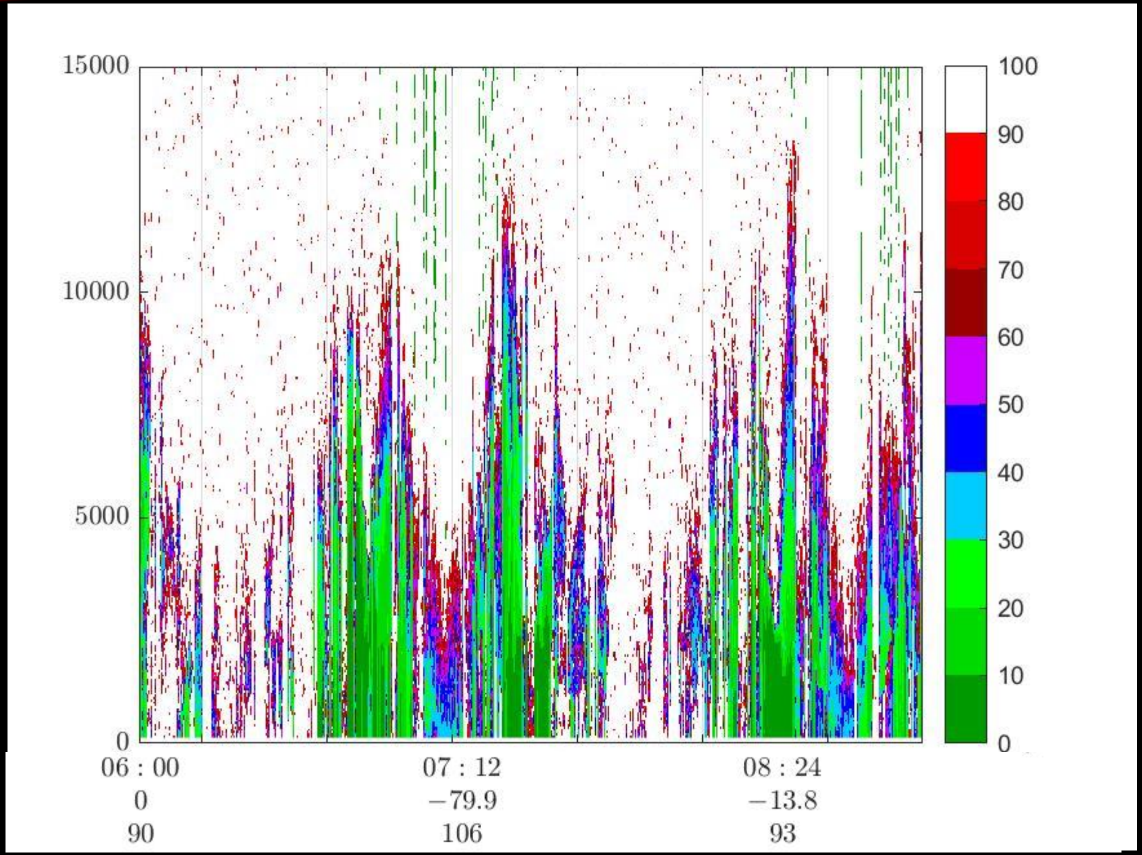


$$\Delta T = |T_{inp} - T_{ret}|$$

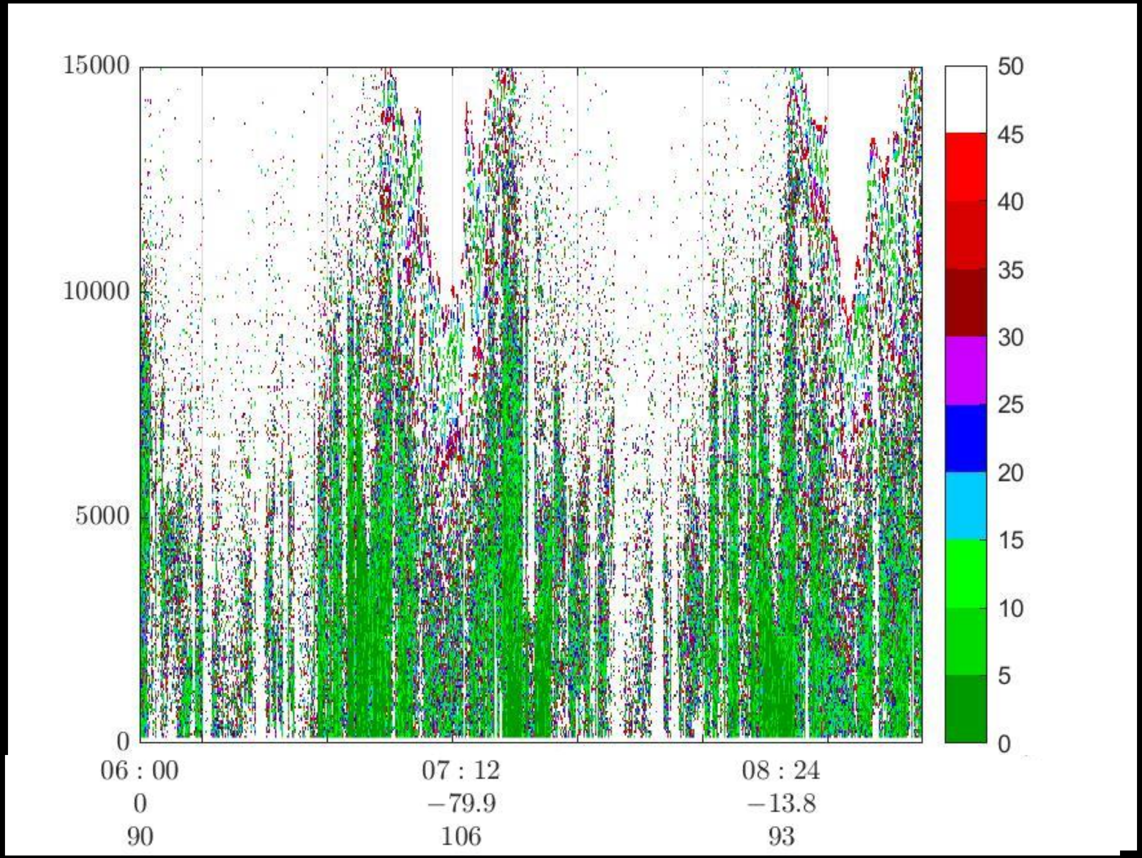
WATER VAPOUR MIXING RATIO



RELATIVE STATISTICAL UNCERTAINTY (%) AND RELATIVE BIAS (%)



$$\frac{\Delta\chi_{H_2O}(z)}{\chi_{H_2O}(z)} = 100 \times \sqrt{\frac{N_{H_2O}(z) + bg_{H_2O}}{N_{H_2O}^2(z)} + \frac{N_{ref}(z) + bg_{ref}}{N_{ref}^2(z)}}$$



$$\frac{\Delta\chi_{H_2O}}{\chi_{H_2O}} = 100 \times \frac{|\chi_{inp} - \chi_{ret}|}{\chi_{inp}}$$