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# MethaneSAT OSSE Simulation to Assess Errors in $XCH_4$ Derived From the $CO_2$ and $O_2$ Proxy Methods


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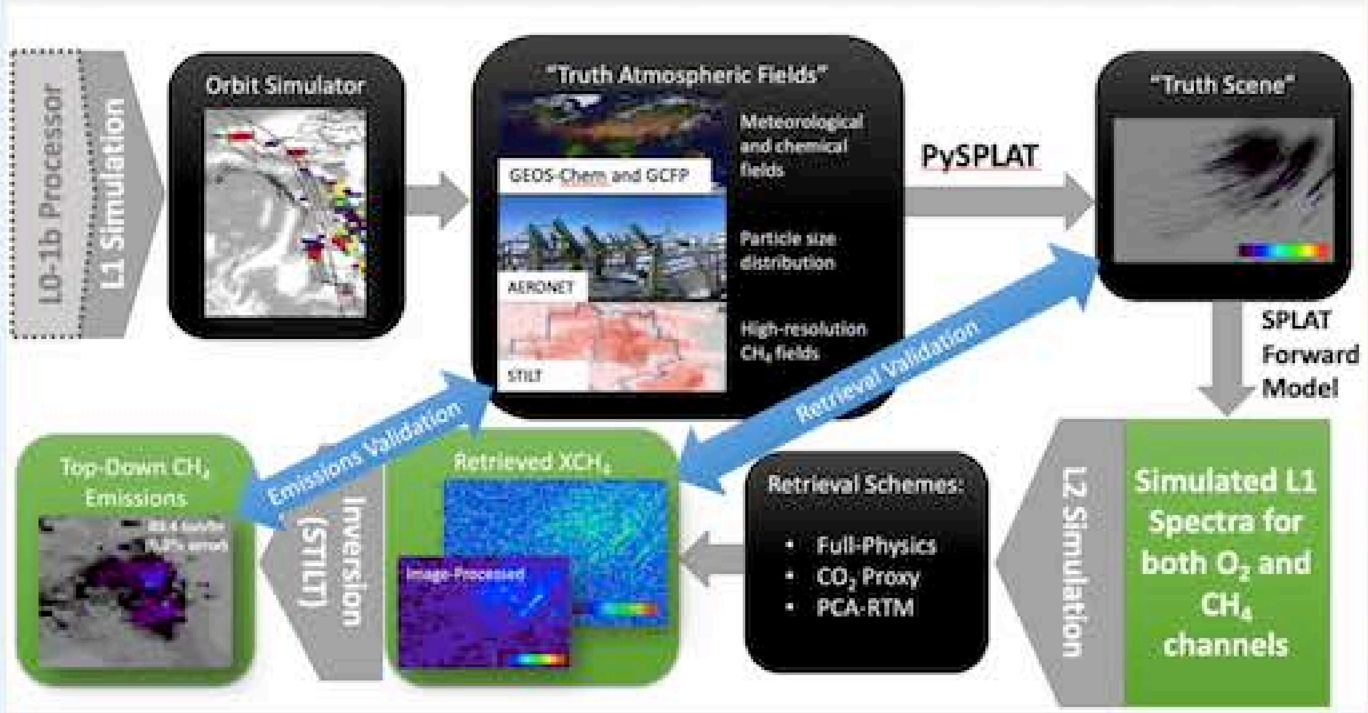
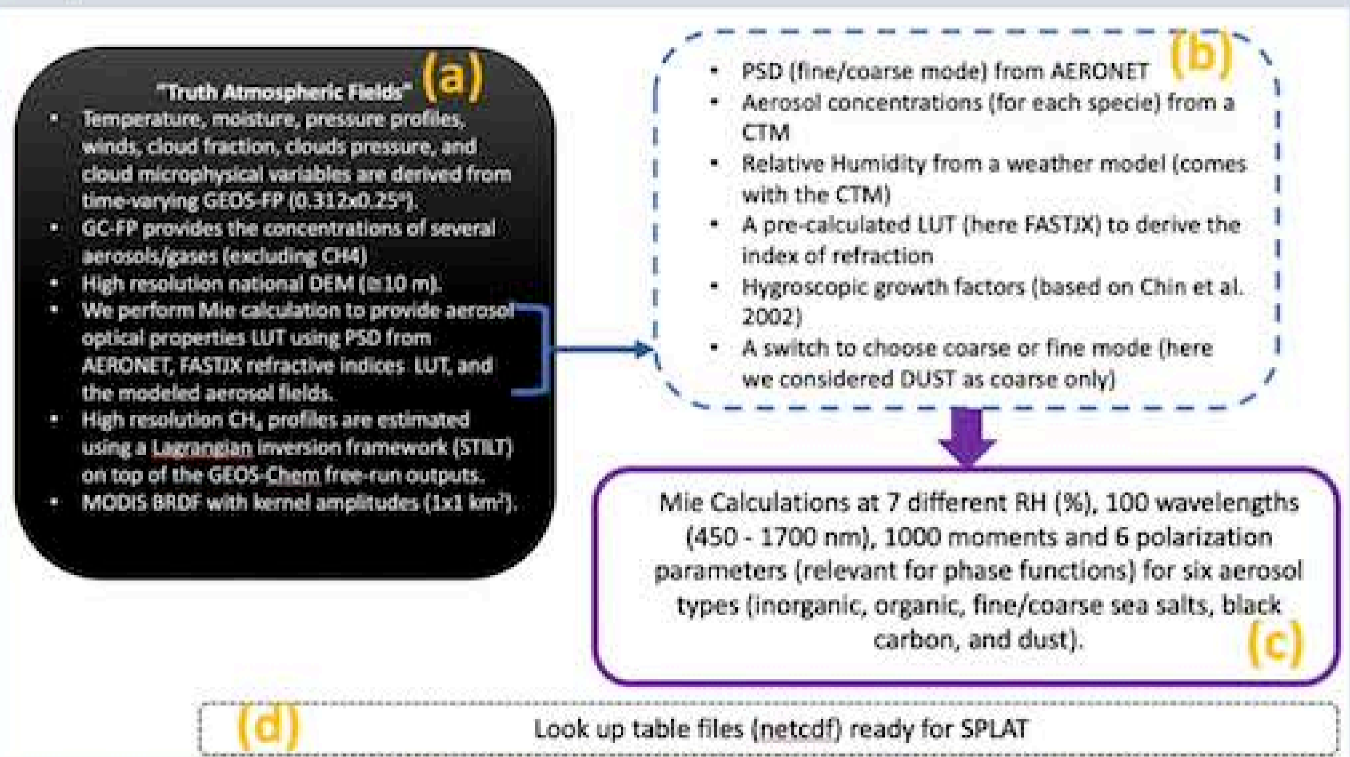
## Framework

An Observing System Simulation Experiment (OSSE) has been designed to systematically analyze and estimate the retrieval errors in $XCH_4$ for an upcoming MethaneSAT which is a satellite under development by MethaneSAT, LLC, a subsidiary of the Environmental Defense Fund.



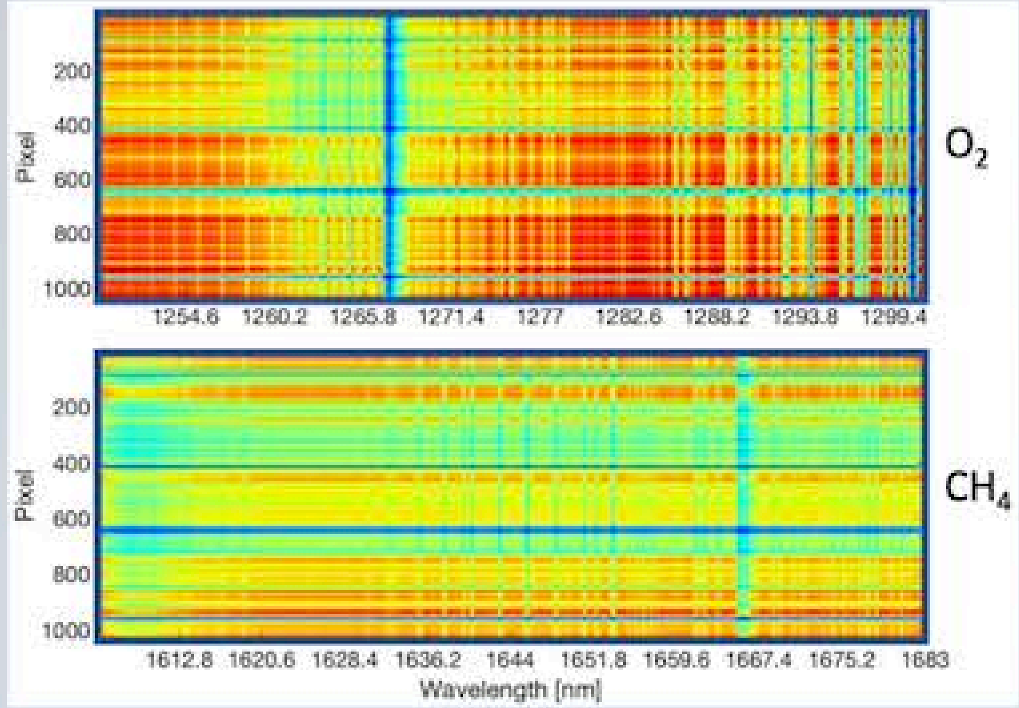

## Forward Simulations

To account for a wide range of atmospheric conditions and surface properties, we incorporated dynamical inputs into the Smithsonian PLanetary ATmosphere interface to VLIDORT (SPLAT-VLIDORT) radiative transfer model to simulate radiance at MethaneSAT $O_2$ and $CH_4$ channels.



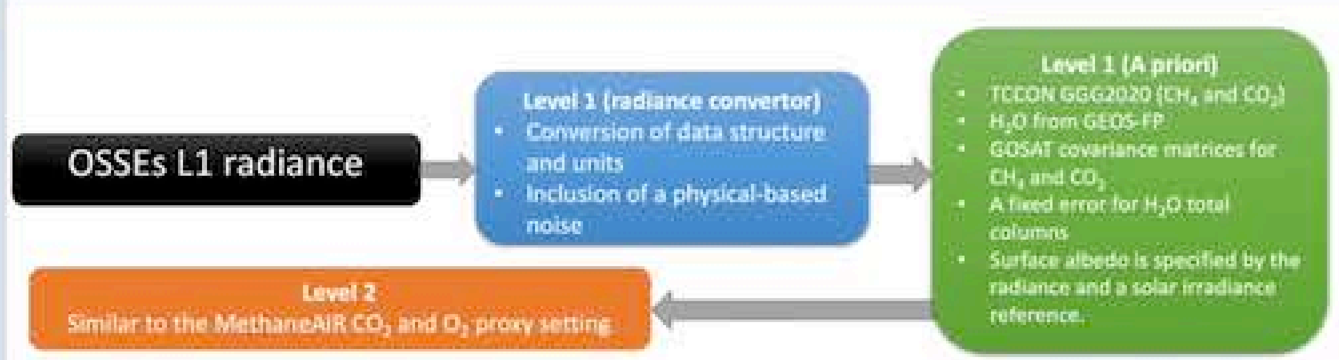

## Forward Simulations

The forward model with 0.001 nm spectral grid, GGG2020 cross sections, 8 full streams, 1000 moments, an inclusion of multiscattering induced by aerosols and clouds.




## Inverse Estimations

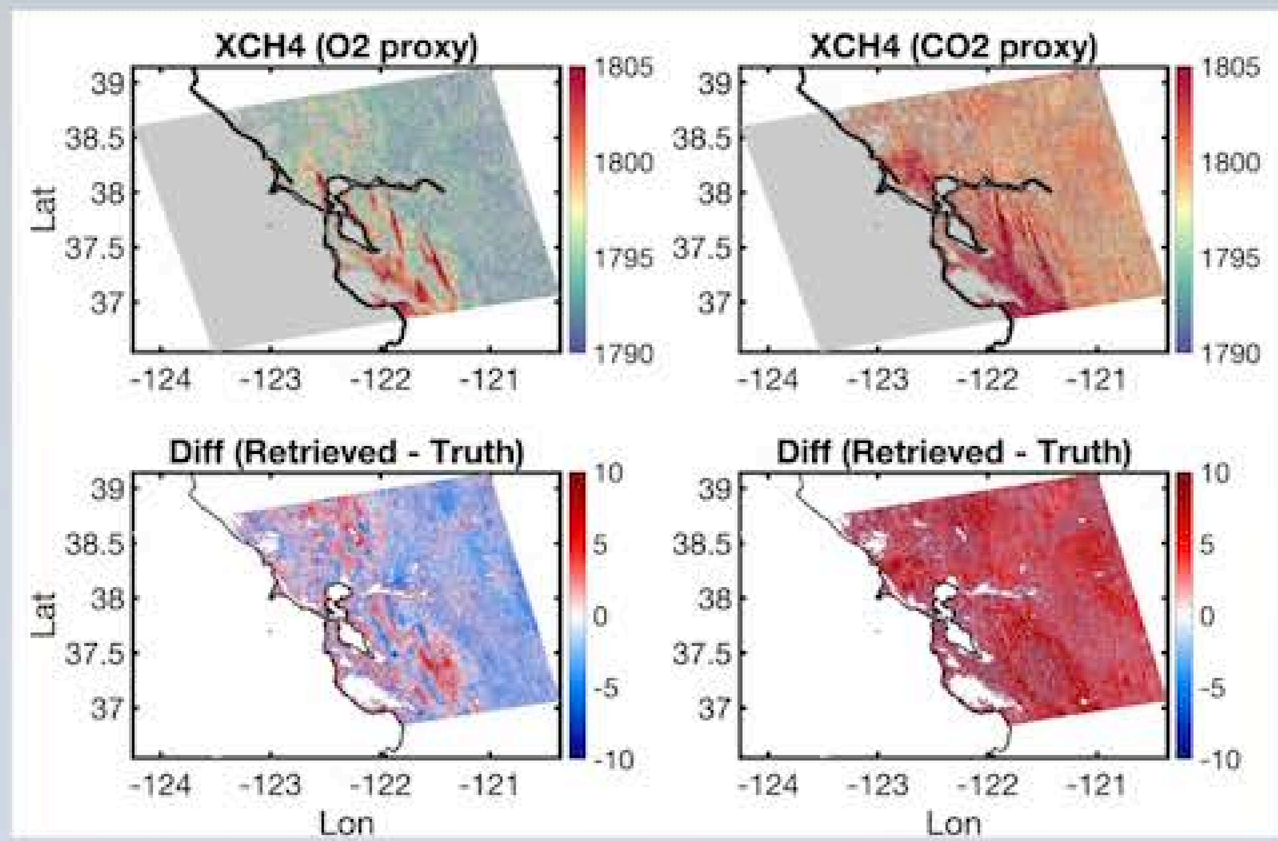
We retrieve the total concentrations of $CH_4$, $O_2$, $H_2O$, and $CO_2$ without the consideration of multi-scattering (i.e., transmission only) from the simulated radiance with expected SNR levels. We then leverage the retrieved $CO_2$ and $O_2$ as lightpath proxies to calculate $XCH_4$ and compare it to the true state of $XCH_4$ defined in the forward simulation.



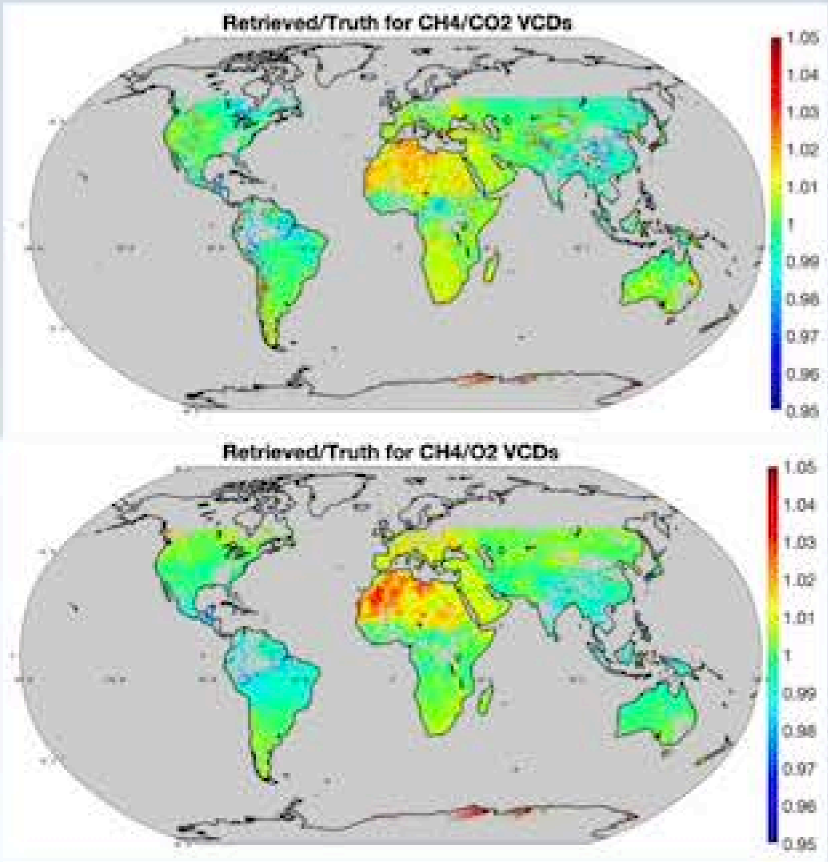

| State vectors | Errors |
|---|---|
| CH4 profile | GOSAT |
| CO2 profile | GOSAT |
| H2O columns | 0.01 total column |
| Temperature shift | 5 K |
| Surface Albedo | 50% (third order) |
| Wavelength grid | 5% (offset) |
| Surface Pressure | 5 hPa |

| Observations | Range |
|---|---|
| Radiance (CO2 Proxy) | 1605.0 - 1618.0 nm |
| Radiance (CO2 Proxy) | 1629.0 - 1654.0 nm |
| Radiance (O2 Proxy) | 1289.2 – 1287.8 nm |

## Some case studies




The $O_2$ proxy reveals a higher precision (18 ppbv at 100×400 m²) and a lower bias (<1%) under specific aerosol conditions relative to the $CO_2$ proxy (26 ppbv at 100×400 m², 3% bias).




The advantage of the $CO_2$ proxy is less sensitivity to dust particle interference compared to the $O_2$ proxy.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