# PYDOME: python library for radiative transfer computations

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## Introduction

Radiative transfer model simulations are an important component of atmospheric correction and trace gas retrieval algorithms. During the last few years at the German Aerospace Center (DLR) we developed a software package PYDOME for the simulation of satellite-based measurements of reflected and scattered solar radiation in the ultraviolet and visible spectral ranges. The tool is based on a one-dimensional scalar radiative transfer model, which incorporates the exact solver, namely, the *discrete ordinate method with matrix exponential* (DOME) (Doicu&Trautmann, 2009, Efremenko et al. 2017), as well as several approximate solvers (the single scattering solver, the two-stream solver and others). The model is implemented *for coupled atmosphere-ocean systems*. It takes into account the change in the refraction index across the interface between two media and the wind-induced roughness of the water surface described by the *Cox-Munk model*. In addition, PYDOME can also treat a *specular reflection* from the surface (a "mirror" case).

## Processing chain in PYDOME

**Physical parameters**

- Temperature profile
- Pressure profile
- Gas concentration profile
- Aerosols/cloud parameters
- etc

**Physical adapter**

**Optical parameters**

- Optical thickness
- Single scattering albedo
- Phase function
- Bidirectional reflectance distribution function

**PYDOME**

**Radiative transfer model**

**Values relevant for a certain application**

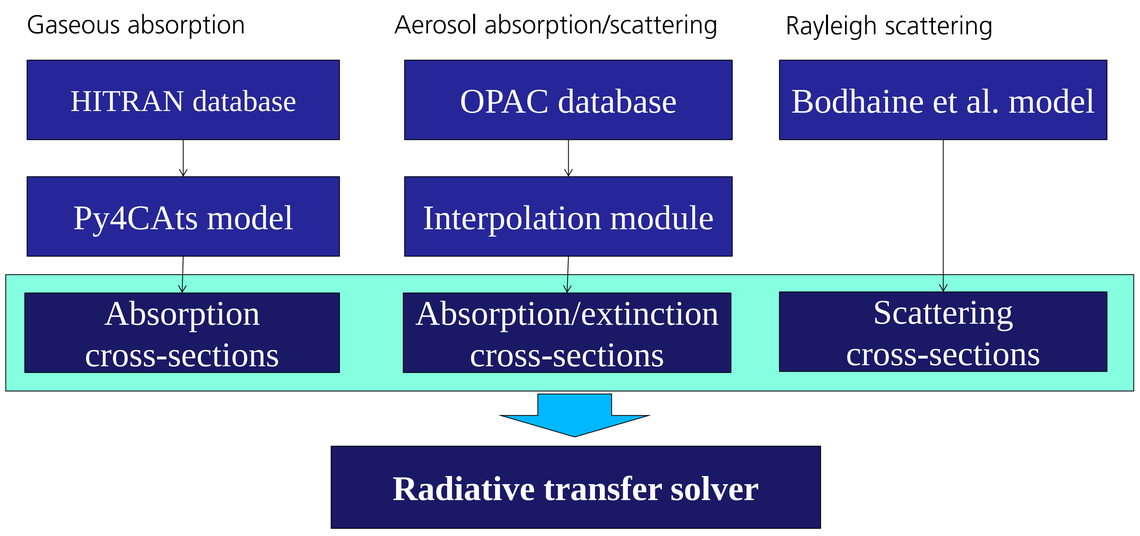
- Convolved radiance
- Path radiance
- Irradiance
- Actinic flux
- Radiant energy density
- etc

**Post-processing step**

**Radiance field**

Spectral radiance as a function of location and observation geometry

## Interfaces




- The physical adapter is based on the Py4CAts (Schreier&Gimeno Garcia 2013) model for computation of line-by-line optical depth due to molecular absorption based on the HITRAN database.
- The aerosols are modeled by using the OPAC database (Hess et al.), while for the Rayleigh scattering the model of Bodhaine et al. (1999) is implemented.
- The model covers the spectral interval 250 – 2500 nm;
- For computations in the UV region, pre-convolved cross-sections are used, while for the rest spectral range, line-by-line computations are employed.

## Validation and benchmarking

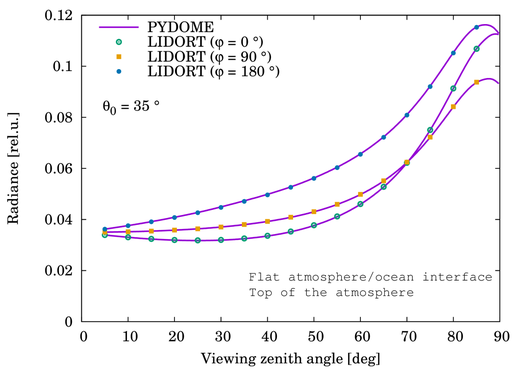



**Figure 1**. Comparison against LIDORT for a coupled atmosphere/ocean model with a flat interface (agreement up to the 5th digit).

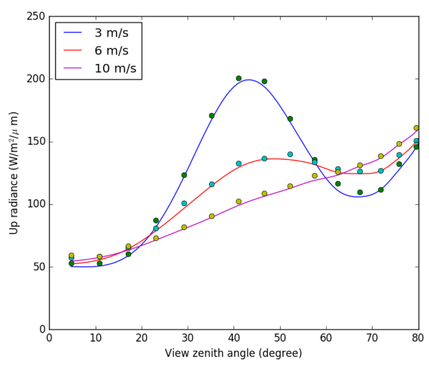



**Figure 2.** Comparison against coupled DISORT model (COART) with the Cox-Munk interface (COART dots are taken from Jin et al., 2006).

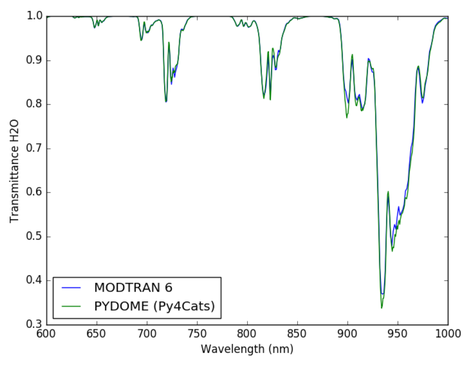



**Figure 3.** Computations of the transmittance in the $H_2O$ band: comparison against MODTRAN 6. The results are convolved with a triangular slit function with 15 $cm^{-1}$ FWHM (the root mean square deviation is 2 %).

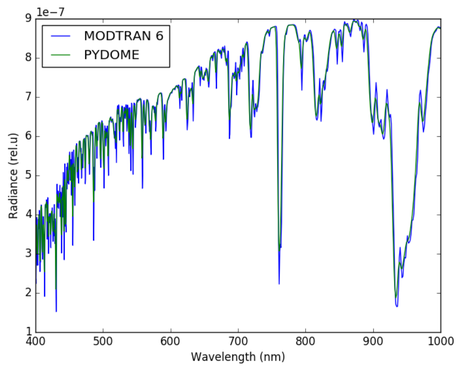



**Figure 4.** Radiance at the top of the atmosphere: comparison against MODTRAN 6 (the root mean square deviation is 3 %)

## Additional features

1. **The PYDOME model is implemented on the basis of Numpy and Scipy libraries.**
2. **The model is *linearized*, i.e. is able to compute the weighting functions with respect to atmospheric parameters.**
3. **The acceleration techniques based on the principal component analysis are implemented in PYDOME for improving the performance of hyperspectral computations.**
4. **It is planned to publish the model in the public domain.**

## References

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