A model setup for simulations of ground-based scattered sunlight measurements

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Motivation

- radiative transfer models are necessary to retrieve the information contained in spectrometer measurements
- many wavelengths have to be modeled to sufficiently represent the absorption lines
- often 1D models are used for a fast analysis, however they assume horizontal homogeneity

→ increase efficiency of a computational costly 3D Monte Carlo model for a more realistic simulation

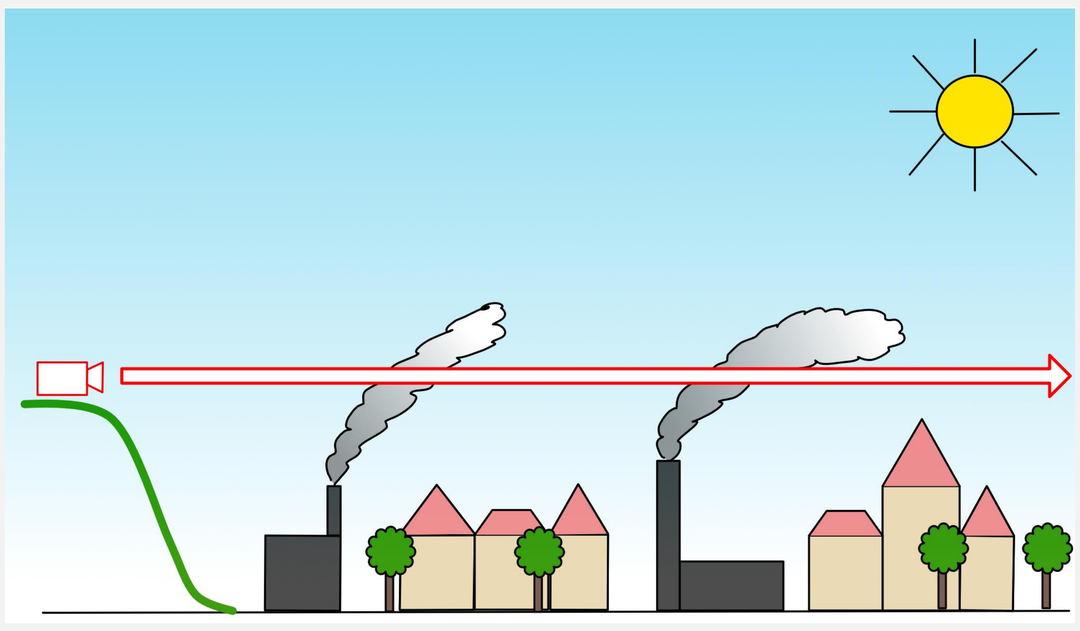
McArtim

- **M**onte **C**arlo **a**tmospheric **r**adiative **t**ransfer **i**nversion **m**odel
- introduced by Deutschmann et al. (2011) [1]
- solving of the adjoint RTE using Neumann series
- core module: *ray tracing*
- calculation of Jacobians with respect to optical parameters via importance sampling

Objective

ultimate goal: detection of sources along the line of sight of ground-based measurements of scattered sunlight (e.g. over cities)

steps:
- reduction of computational cost of 3D RT model McArtim
  → e.g. the linear-*k* method [2] or Absorption Lines Importance Sampling [3]
- coupling of 1D and 3D models to further reduce computation time
  → separation between use of models by scatter order or vertical layer

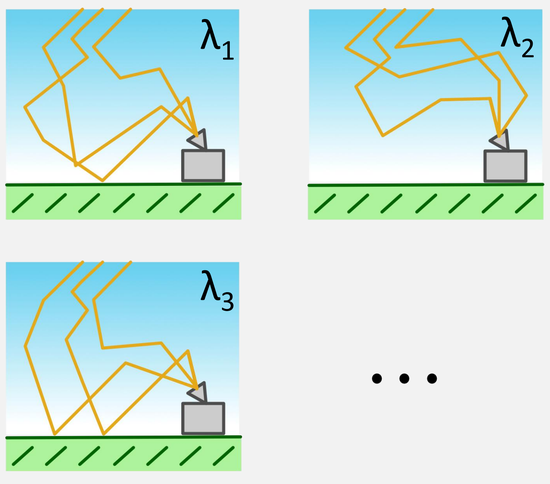


Method

standard procedure

- new photon paths for each wavelength

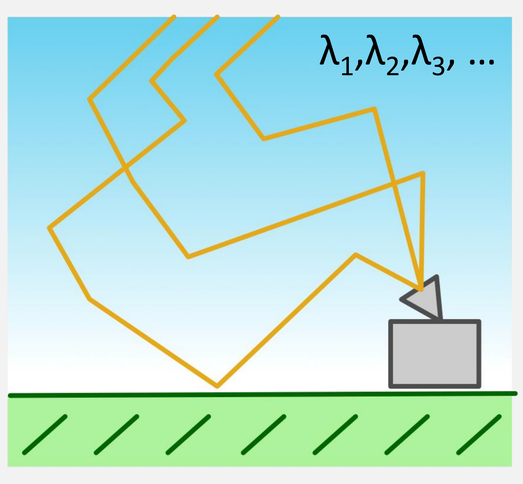
→ independent simulations



modification

- Absorption Lines Importance Sampling (ALIS) following Emde et al. (2011) [3]
- only one set of trajectories and adjust the optical properties depending on the wavelength

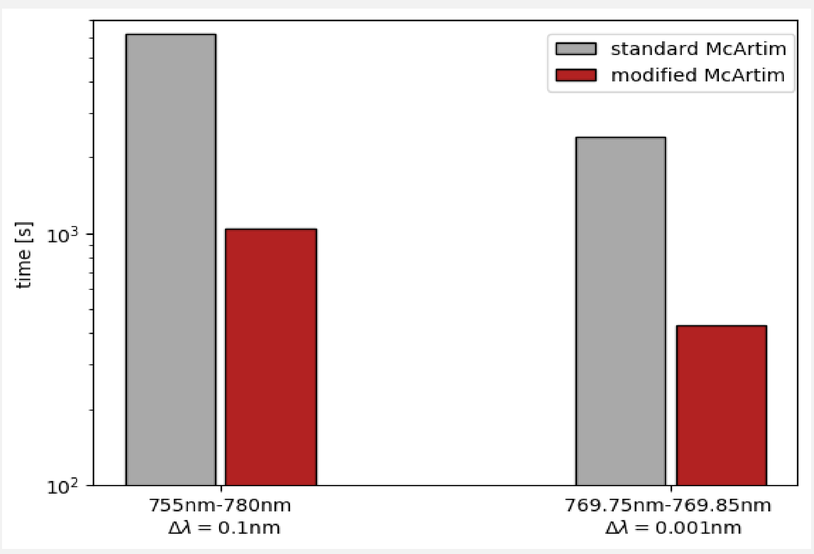
→ radiance is calculated simultaneously for all wavelengths



Results

- coarse simulation of the O2 A-band in 17 minutes
- detailed simulation of a single absorption line in 7 minutes

→computational cost decreased by about 80%



Outlook

- problem solving: quality of the modeled spectrum using the modified algorithm is not yet as good as if using the original ray tracing algorithm
- including the derivatives in the modified algorithm
- optional: implementing an additional technique to reduce the computation time of McArtim
- coupling to 1D model

References: **[1] Deutschmann, T. et al.**, 2011: The Monte Carlo atmospheric radiative transfer model McArtim: Introduction and validation of Jacobians and 3D features, *Journal of Quantitative Spectroscopy and Radiative Transfer*, **112**, 6, 1119-1137, https://doi.org/10.1016/j.jqsrt.2010.12.009. **[2] Hasekamp, O. P., and Butz, A.**, 2008: Efficient calculation of intensity and polarization spectra in vertically inhomogeneous scattering and absorbing atmospheres, *J. Geophys. Res.*, 113, D20309, doi:10.1029/2008JD010379. **[3] Emde, C., Buras, R., Mayer, B.**, 2011: ALIS: An efficient method to compute high spectral resolution polarized solar radiances using the Monte Carlo approach, *Journal of Quantitative Spectroscopy and Radiative Transfer*, **112**, 10, 1622-1631, https://doi.org/10.1016/j.jqsrt.2011.03.018.