3DCATS – WP 200: Impact assessment

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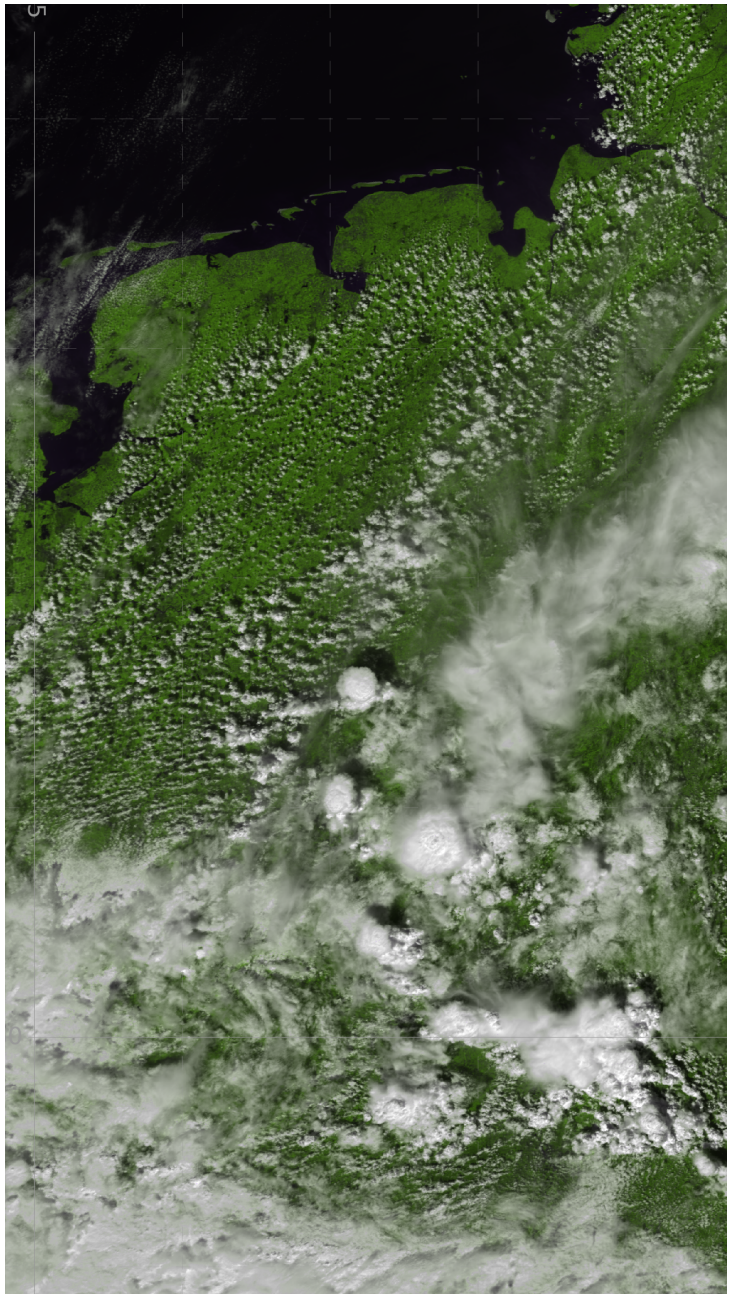
Introduction

- Operational retrievals of tropospheric trace gases from space-borne instruments based on 1D radiative transfer neglect
  1. cloud scattering into clear regions
  2. cloud shadows

- Monte Carlo radiative transfer (MYSTIC-ALIS)
  $\Rightarrow$ simulation of spectra for realistic 3D model atmospheres

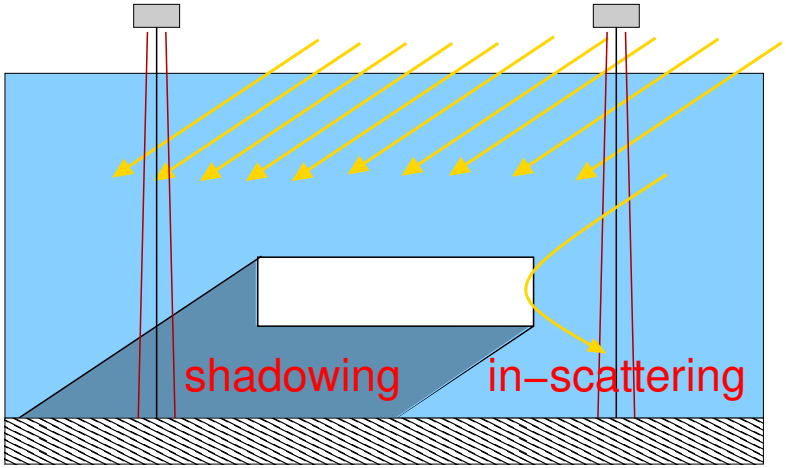
- Application of NO_2 retrieval algorithm on simulated data:
  $\Rightarrow$ estimation of retrieval error due to 3D cloud scattering



WP200 - Outline

- Aim: Generate synthetic data to test and improve NO_2 retrieval algorithm
- Retrieval test for one-dimensional geometry (clearsky and cloudy)
  - New simulations for 1D cloud to investigate accuracy of REPTRAN and to better understand cloud correction algorithms
- 2D cloud scenario
  - Simulated spectra (1x1km^2 footprint) for 2D cloud case to investigate retrieval error dependence on various parameters
  - Additional simulations, see below
- LES cloud scenario
  - Cloud scene from ICON-LES model over Europe ($698 \times 763\,km^2$)
  - All types of realistic clouds included
  - Various sun-satellite geometries and surface albedos
  - Generate synthetic dataset for geostationary orbit and Low Earth Orbit for VIS and O_2A-band
- Quantification of NO_2-retrieval error
  - Investigate impact of clouds on NO_2-retrieval using synthetic dataset
  - $\Rightarrow$ presentations for WP300

Clearsky pixels in vicinity of clouds



Sketch of step cloud setup.

Geometry settings

- nadir observation geometry
- 1x1km^2 square field-of-view
- solar zenith angle: 50°

Base case cloud settings

- cloud base at 2 km altitude
- cloud top at 3 km altitude
- cloud optical thickness: 10
- cloud droplet effective radius 10 μm
- optical properties from Mie calculations

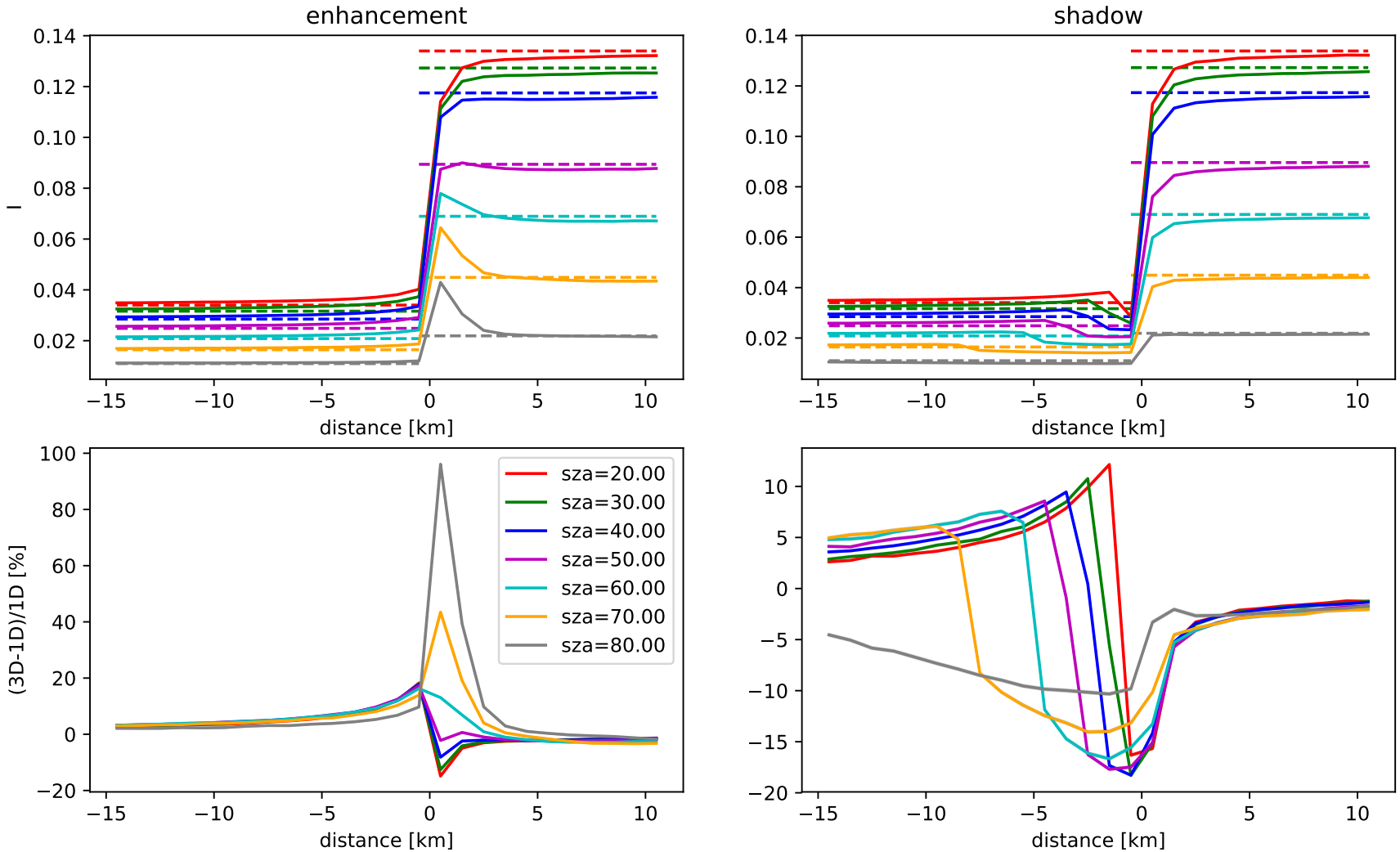
Other settings

- NO_2 profile: European polluted
- surface albedo: 0.05
- no aerosol

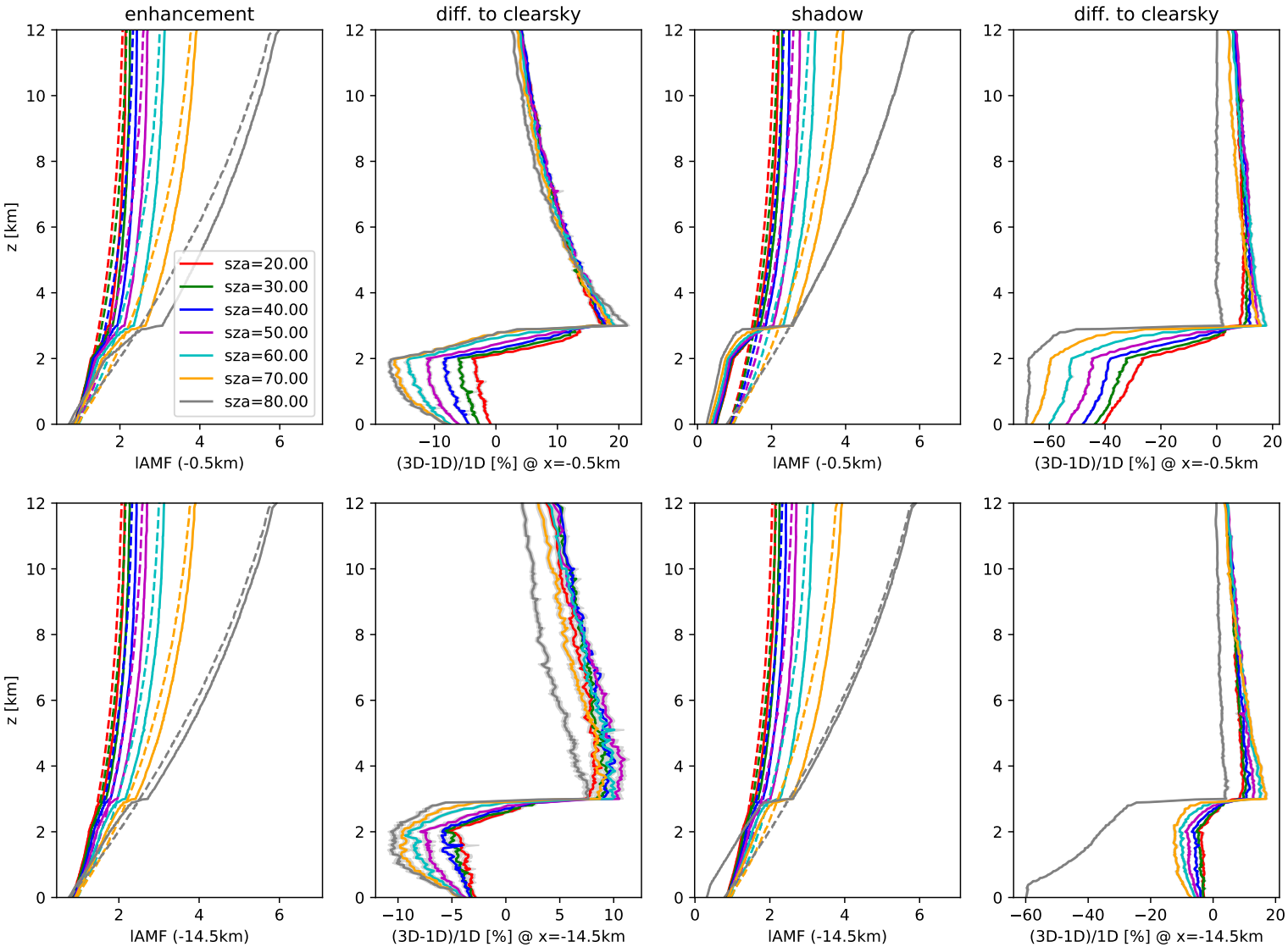
2D cloud simulations

- Simulated quantities:
  - Nadir radiance spectra in VIS and O2A band region
  - layer-AMF at 460 nm
- Simulations for all pixels from -15 km (clear part) to 10 km (cloudy part), before the sensitivity study was only done for one pixel 2-3km away from cloud edge.
- Investigated sensitivity on parameters: solar zenith angle, surface albedo, cloud optical thickness, cloud geometrical thickness, cloud bottom height
- Simulated all corresponding 1D clear and 1D cloudy cases to calculate 3D effect

Dependence of radiance on SZA



Dependence of layer-AMF on SZA



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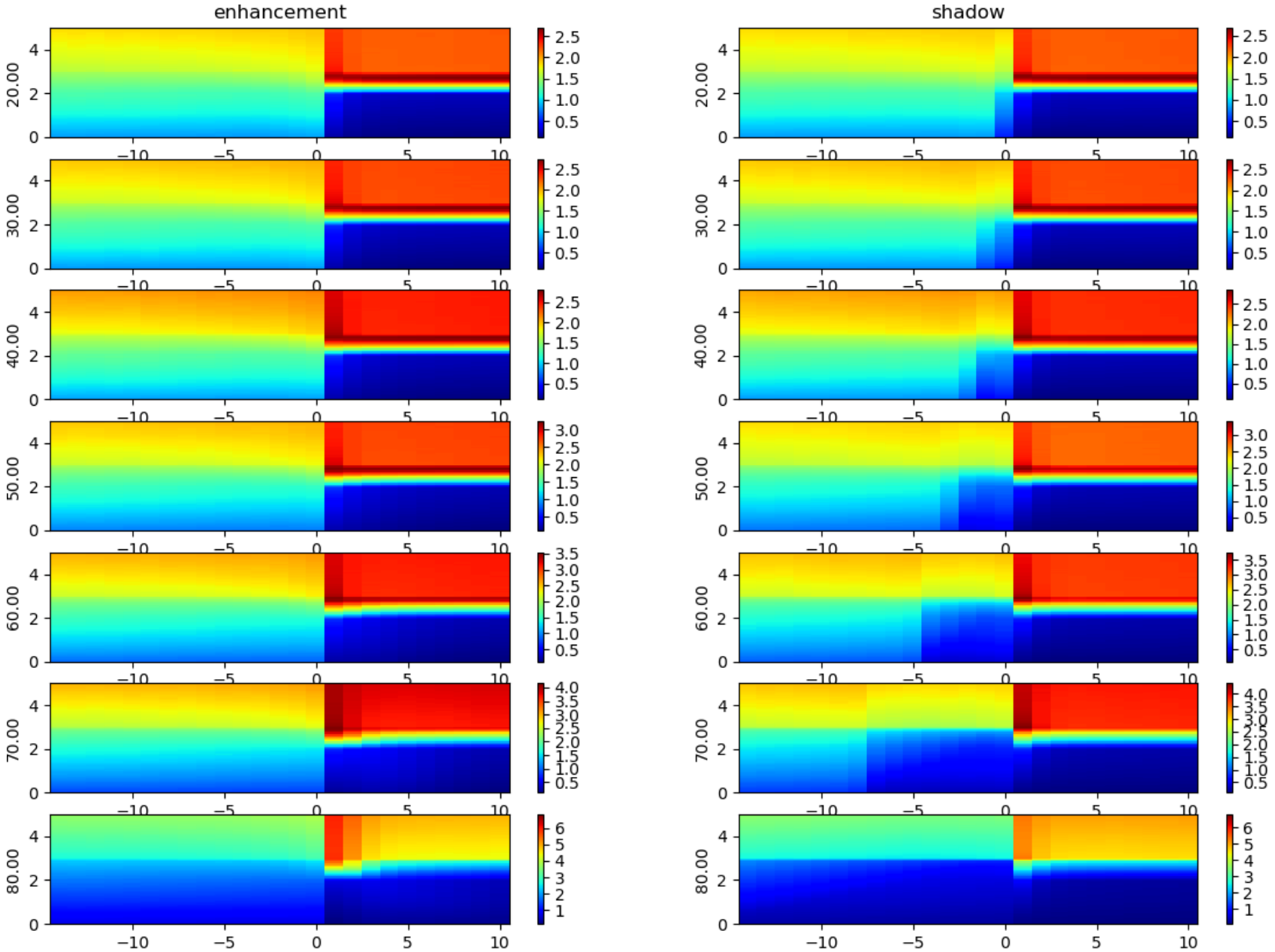
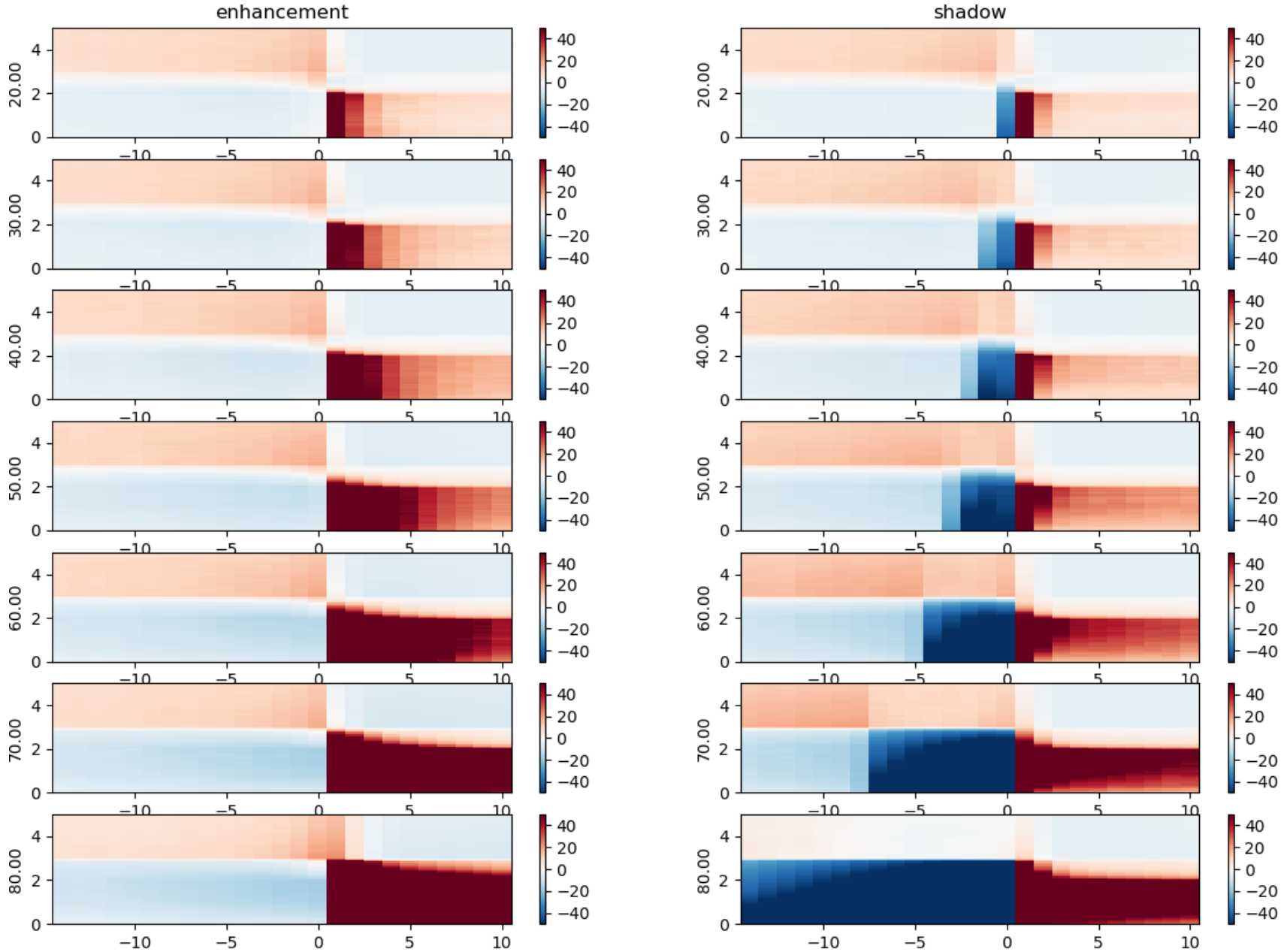
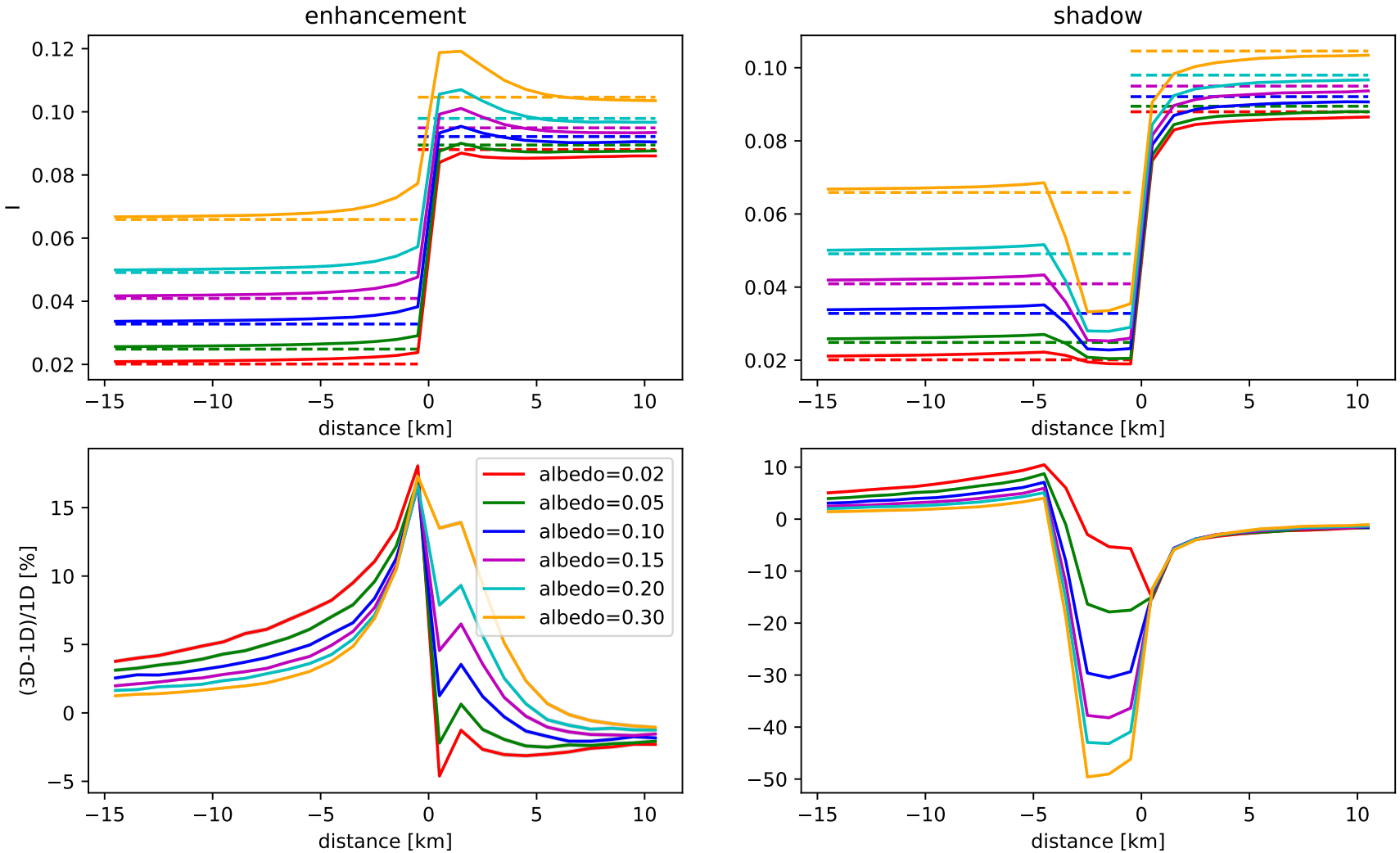


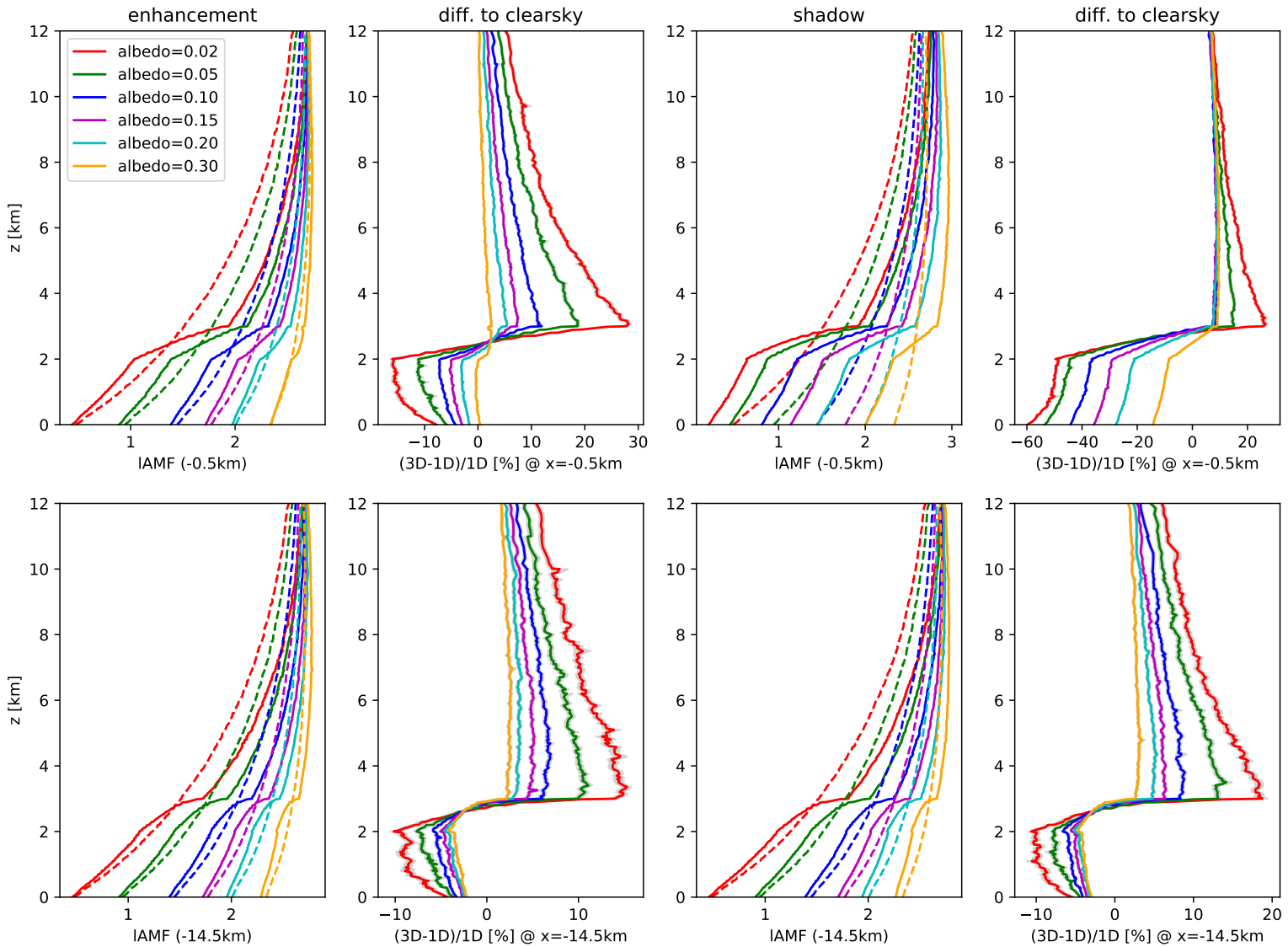
3D scattering impact, SZA



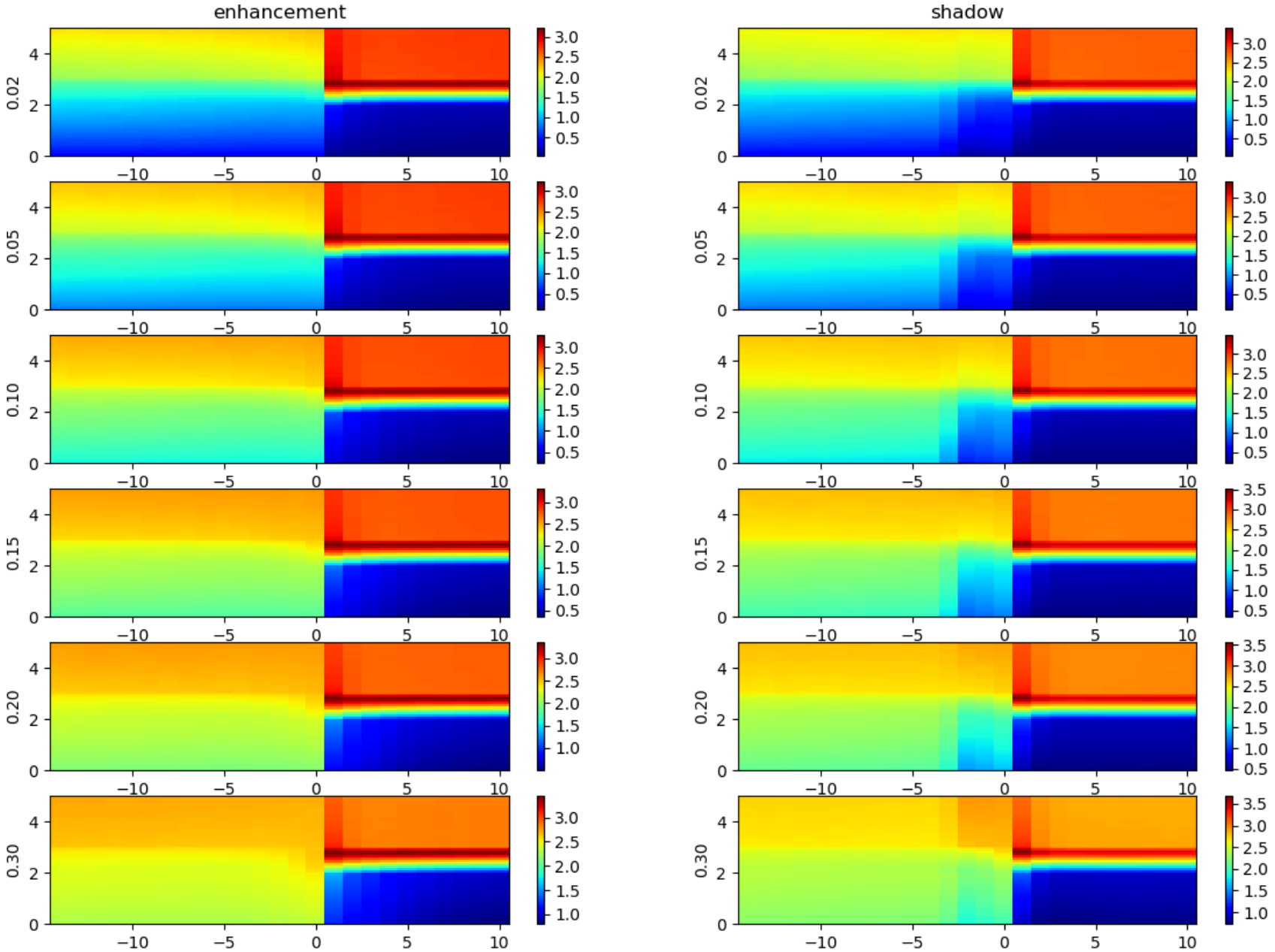
Dependence of radiance on surface albedo



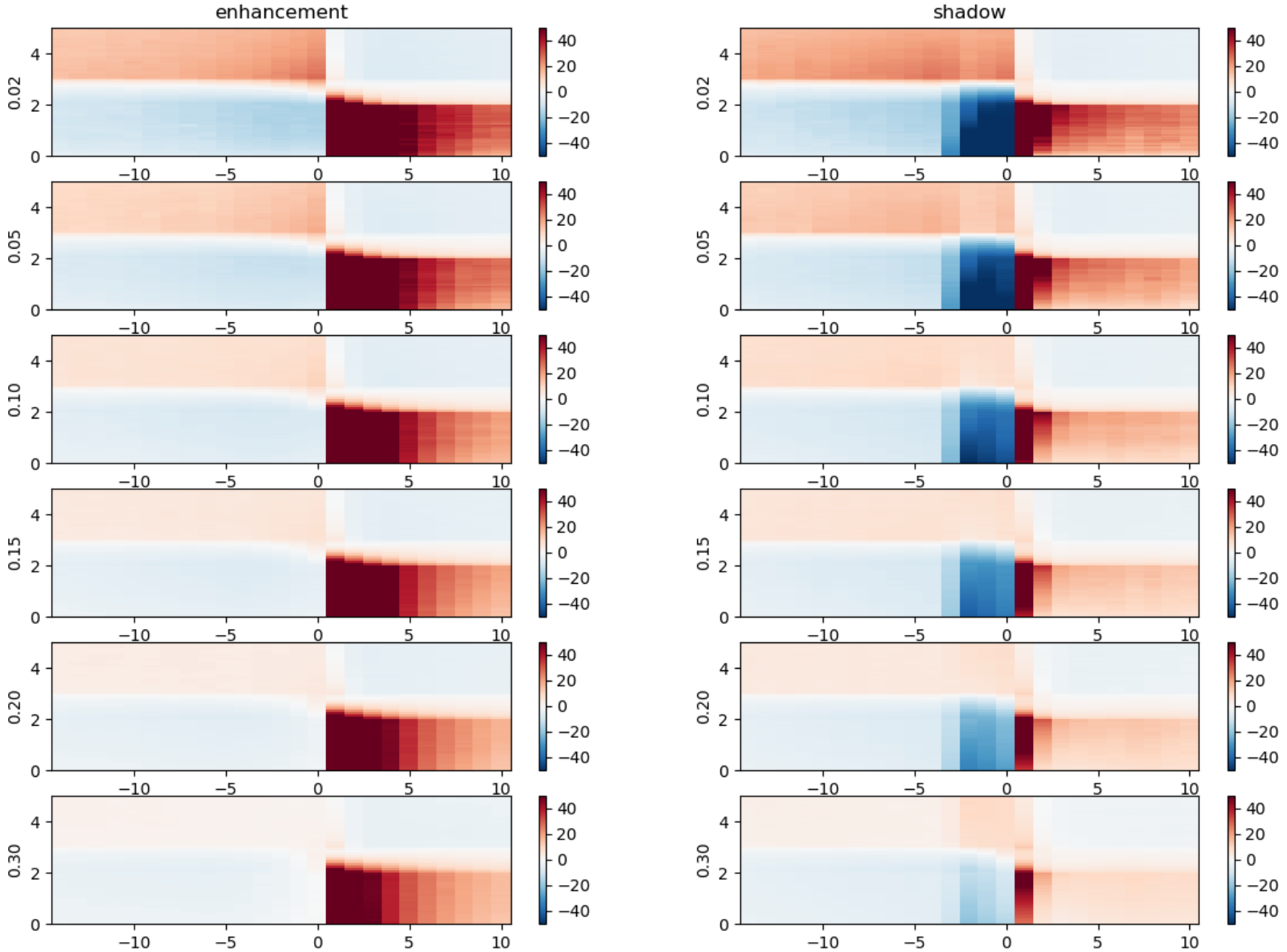
Dependence of layer-AMF on surface albedo



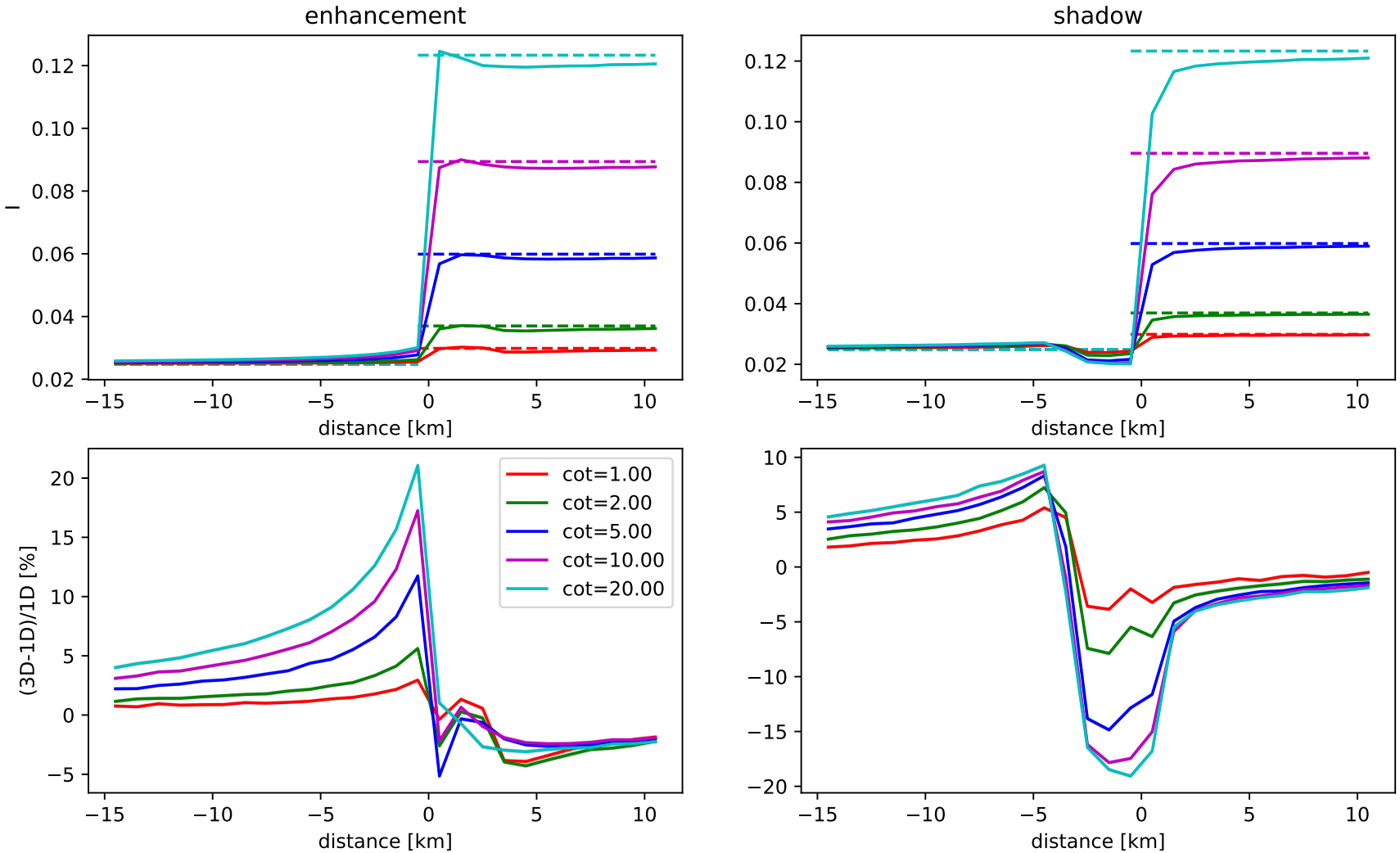
Dependence of layer-AMF on surface albedo



3D scattering impact, surface albedo



Dependence of radiance on cloud optical thickness



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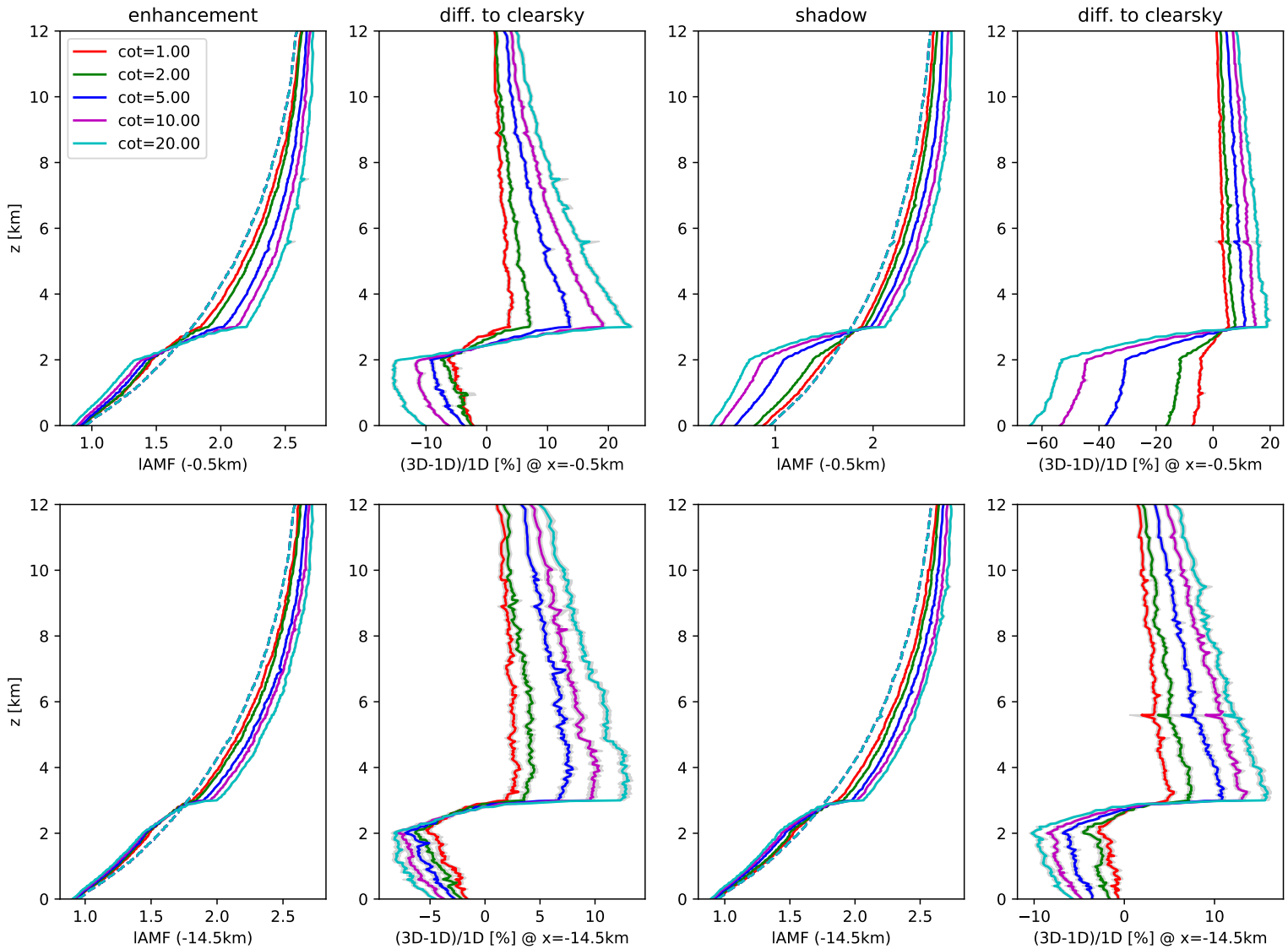

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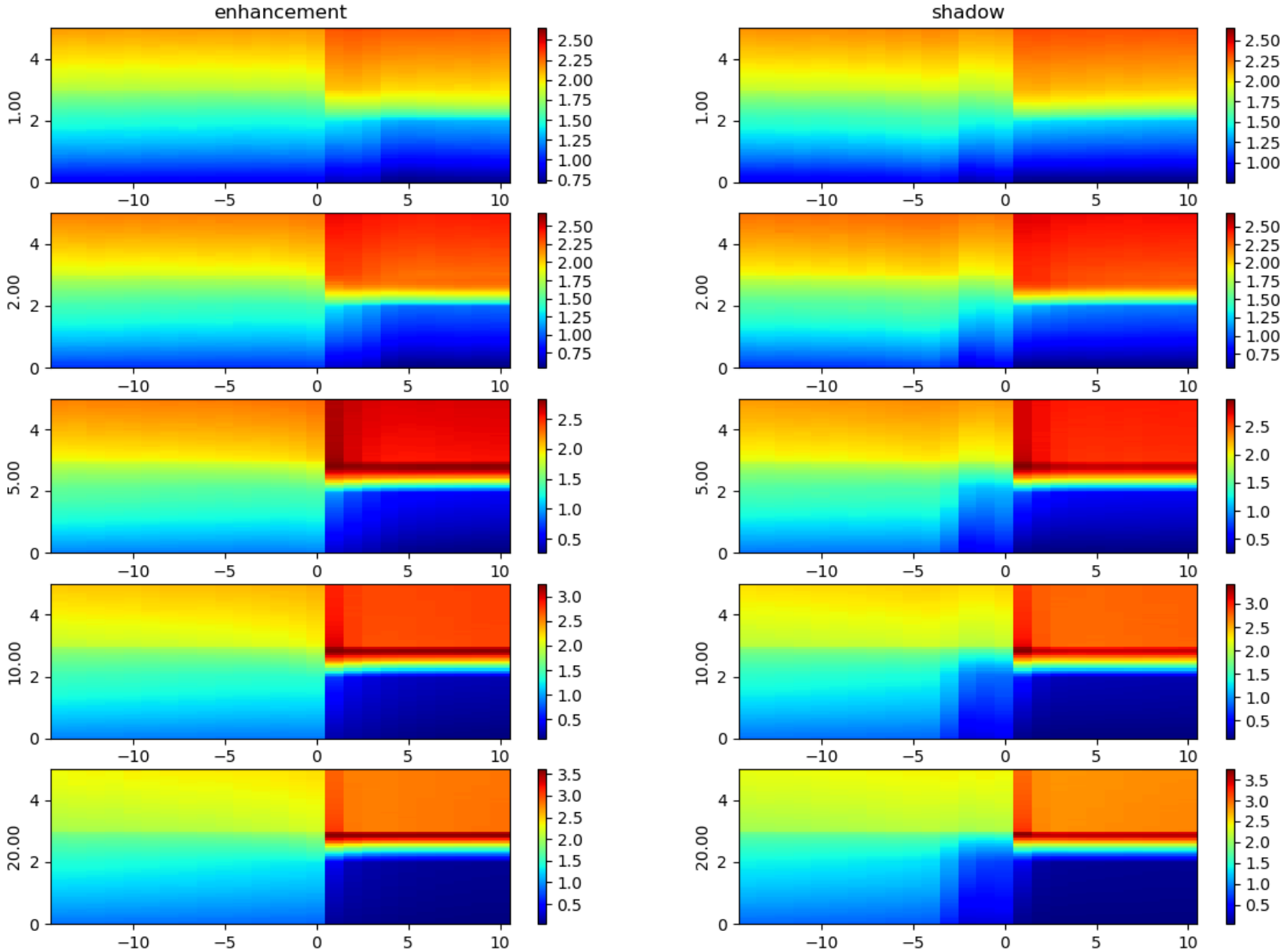
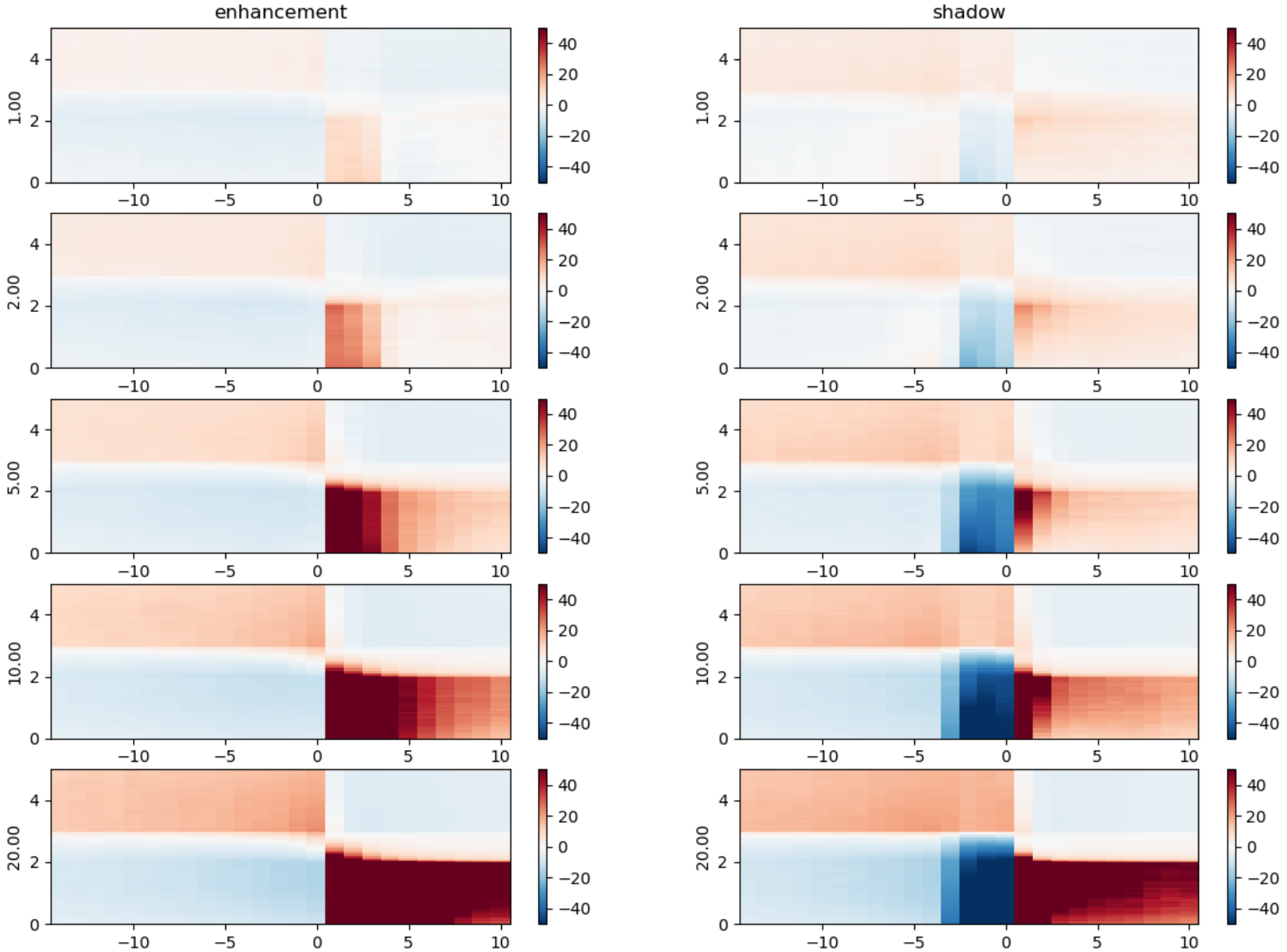
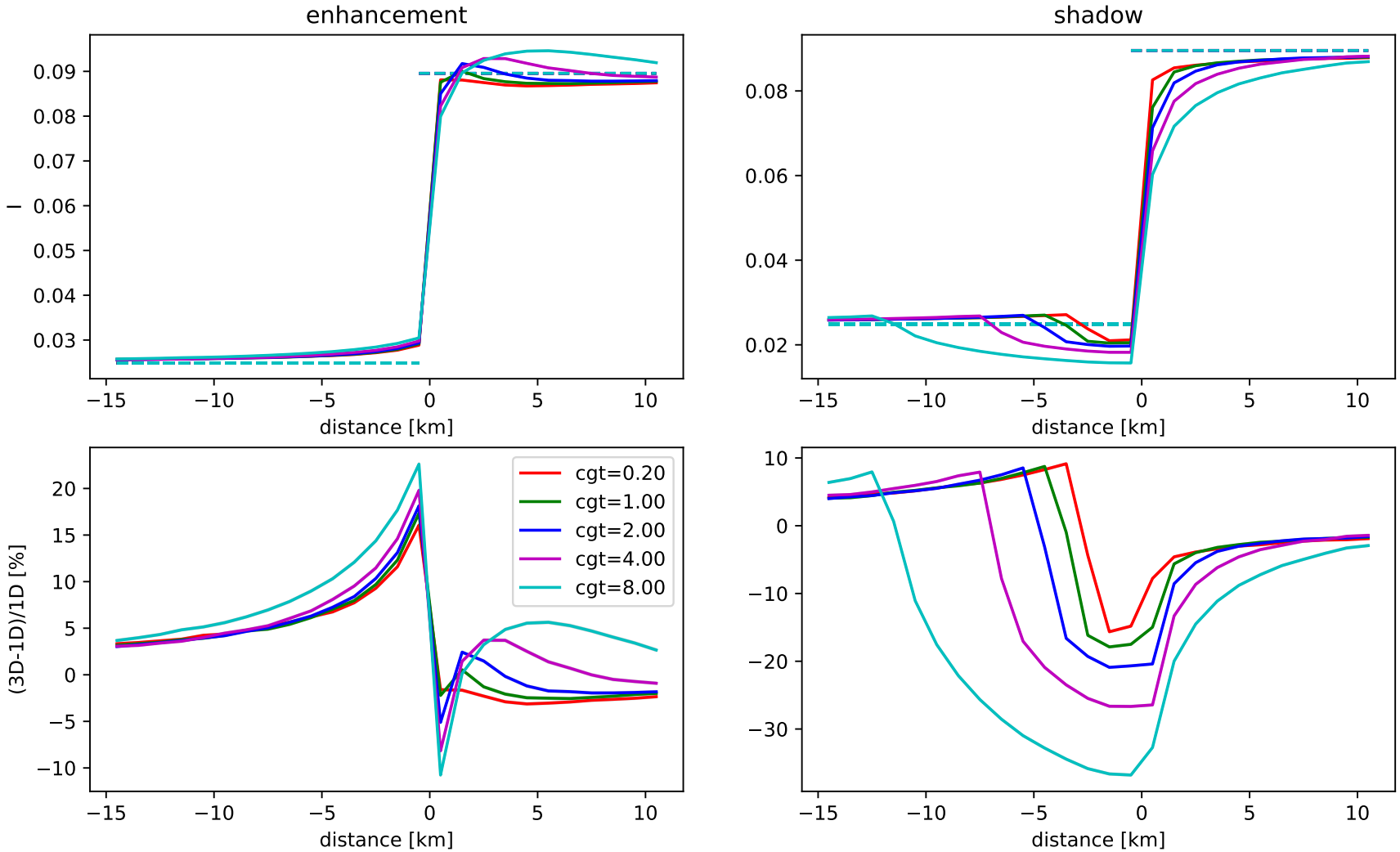


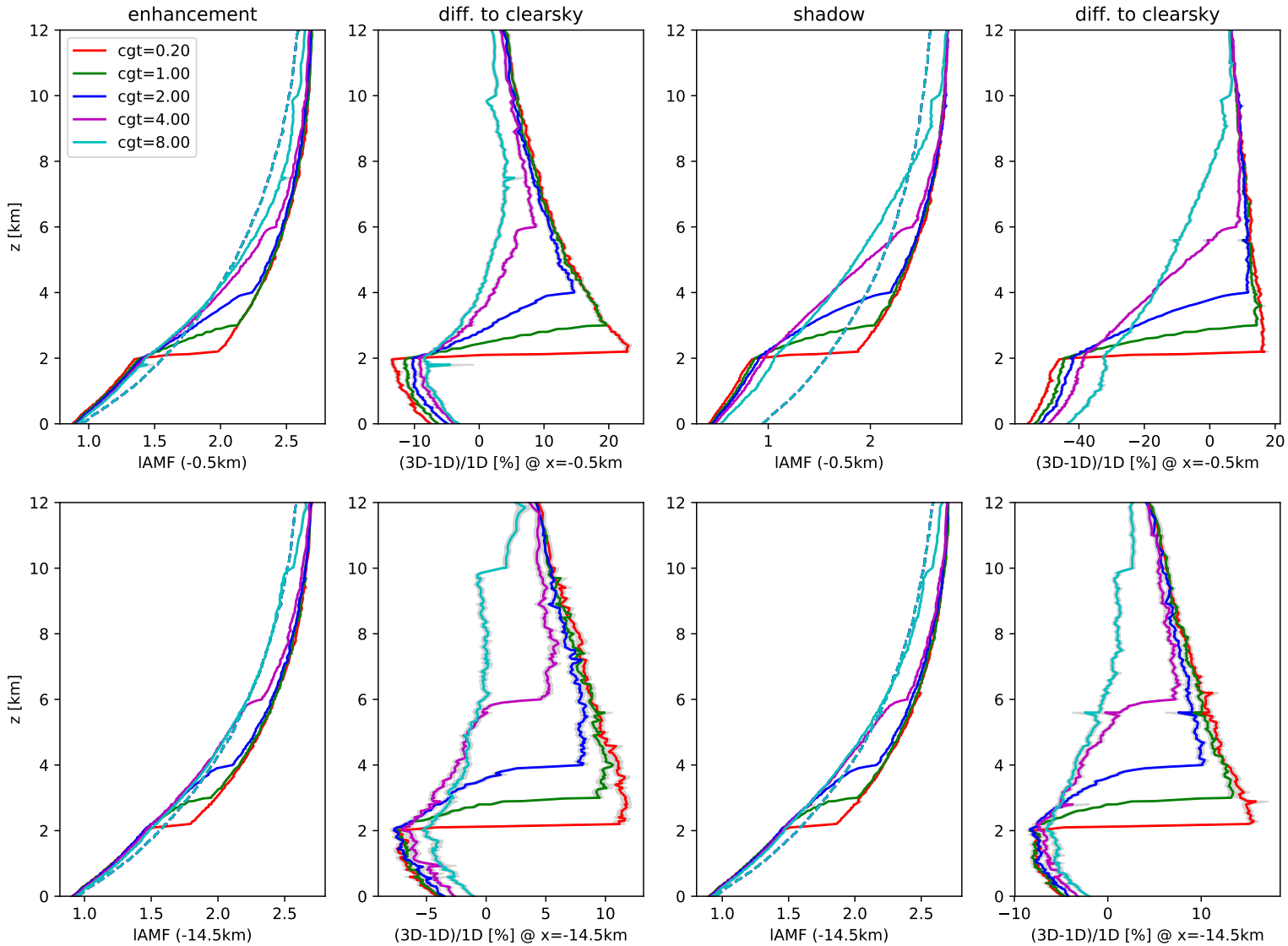
3D scattering impact, cloud optical thickness



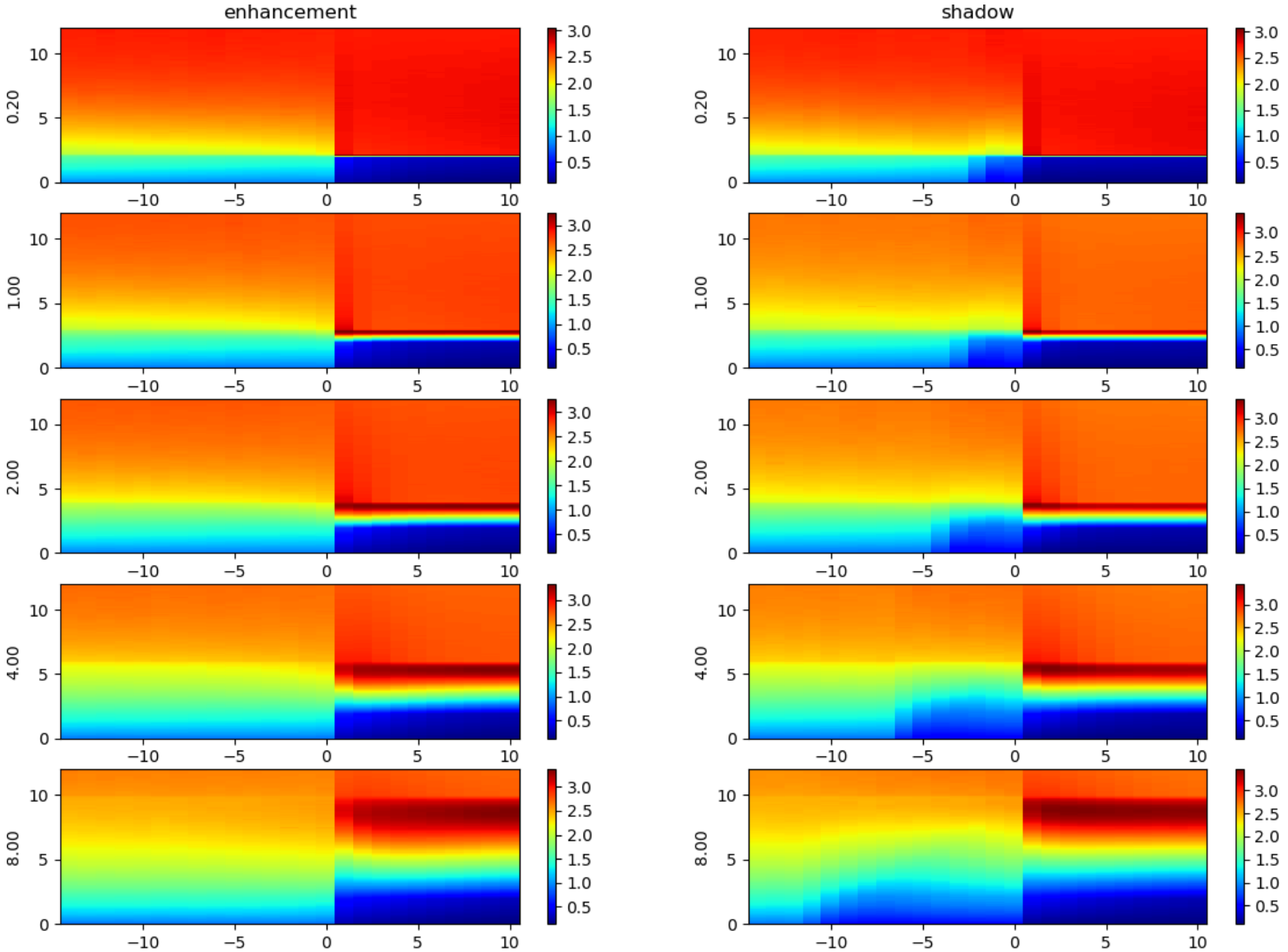
Dependence of radiance on cloud geometrical thickness



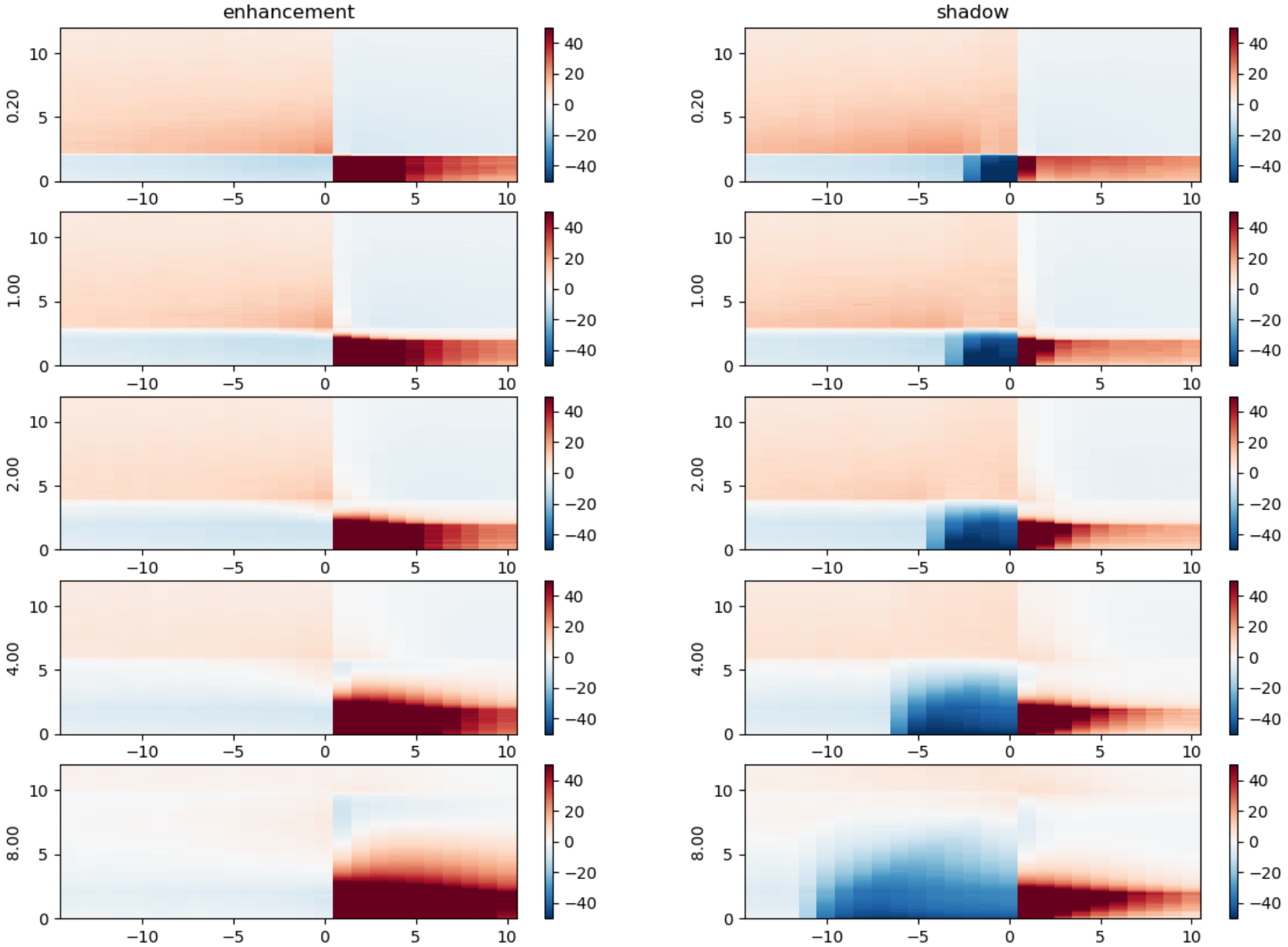
Dependence of layer-AMF on cloud geometrical thickness



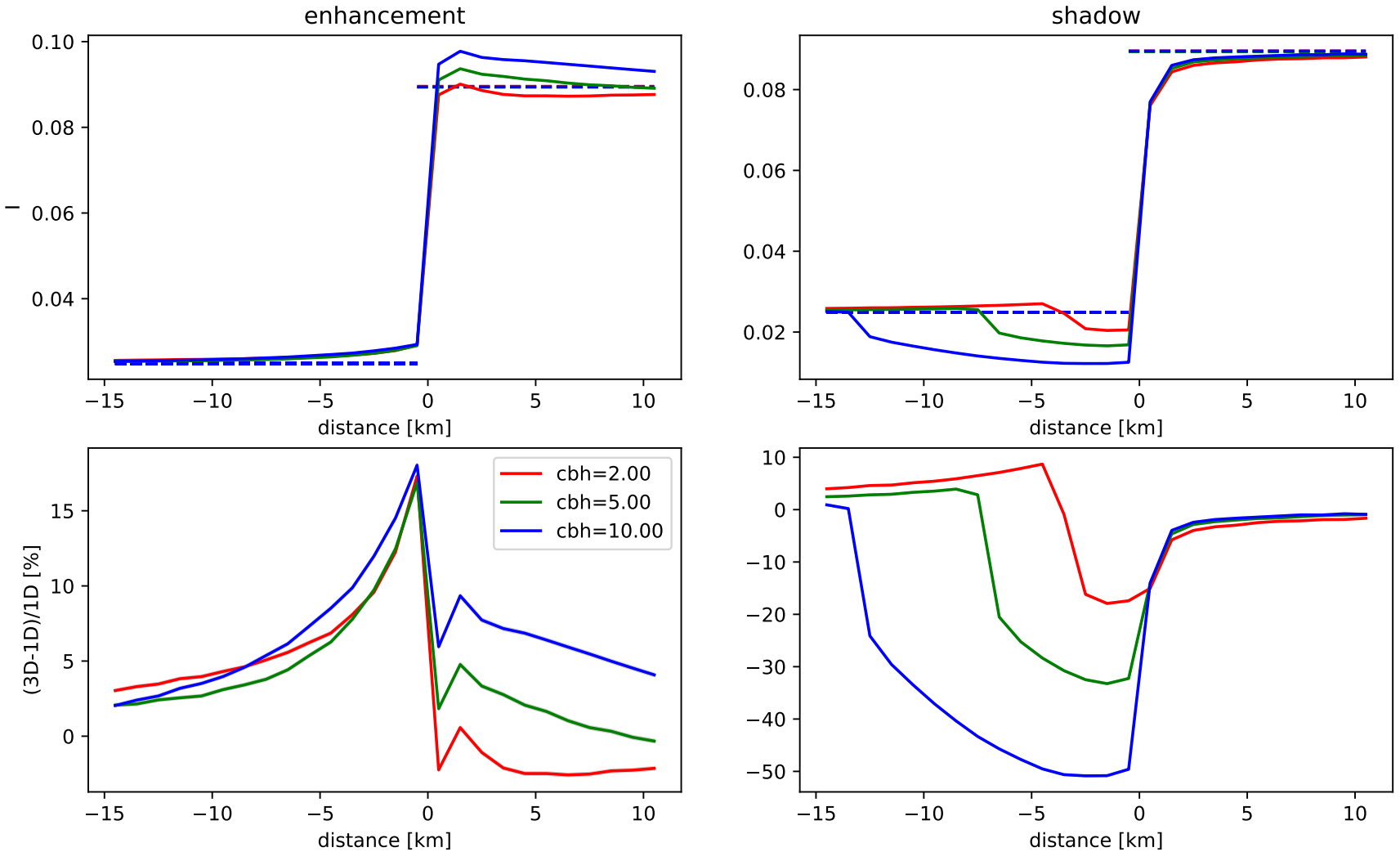
Layer-AMF, cloud geometrical thickness



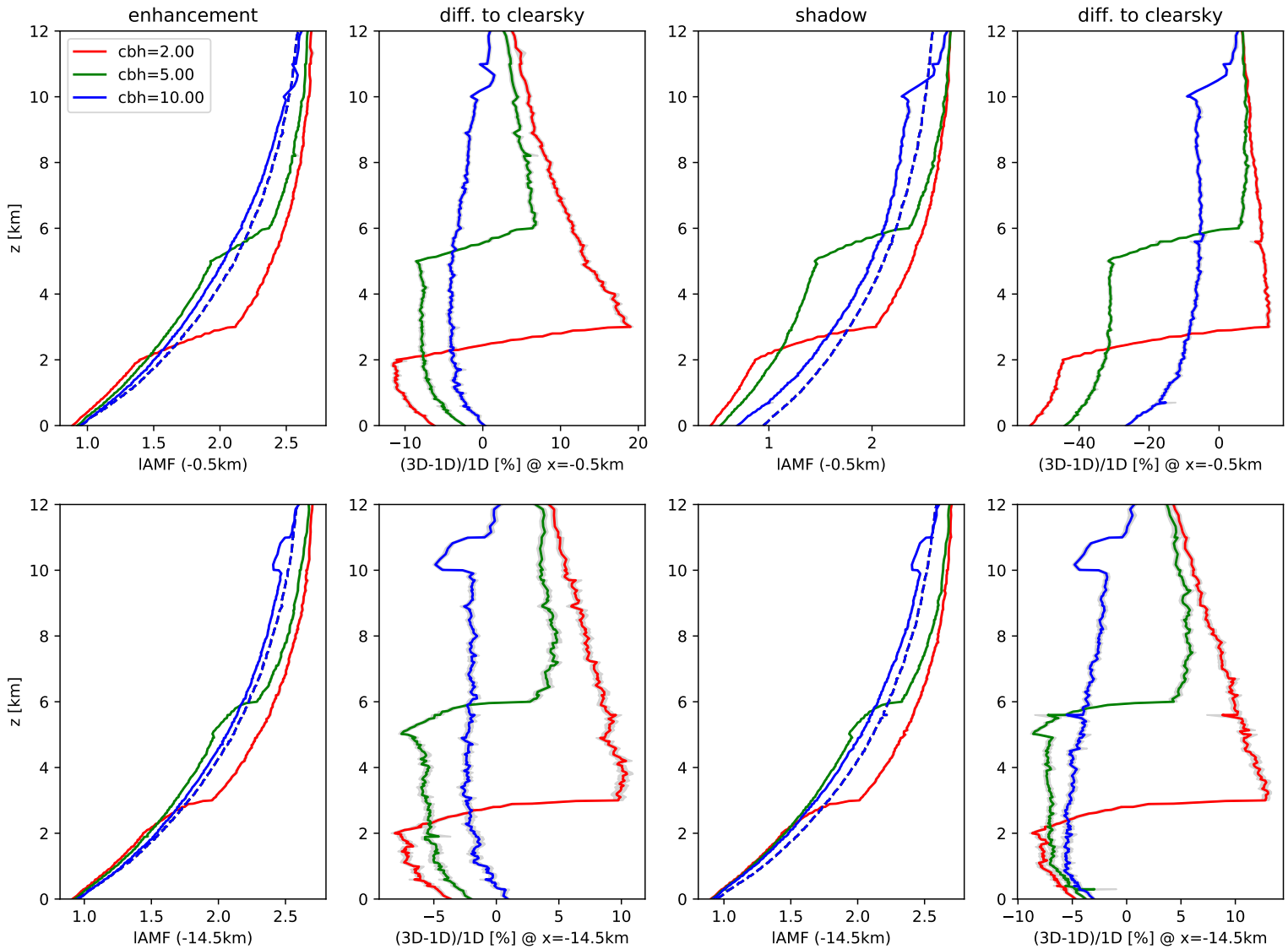
3D scattering impact, cloud geometrical thickness



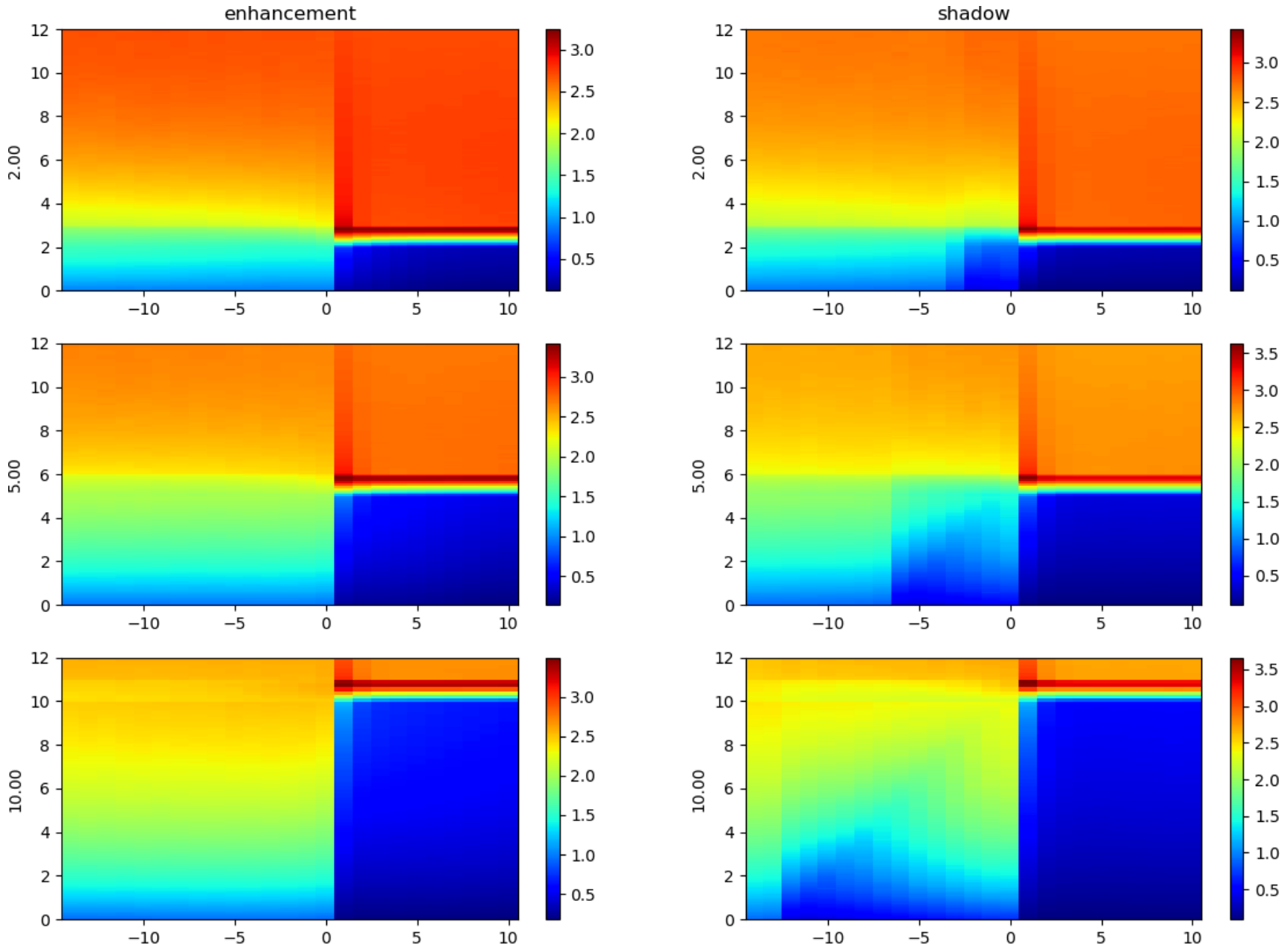
Dependence of radiance on cloud bottom height



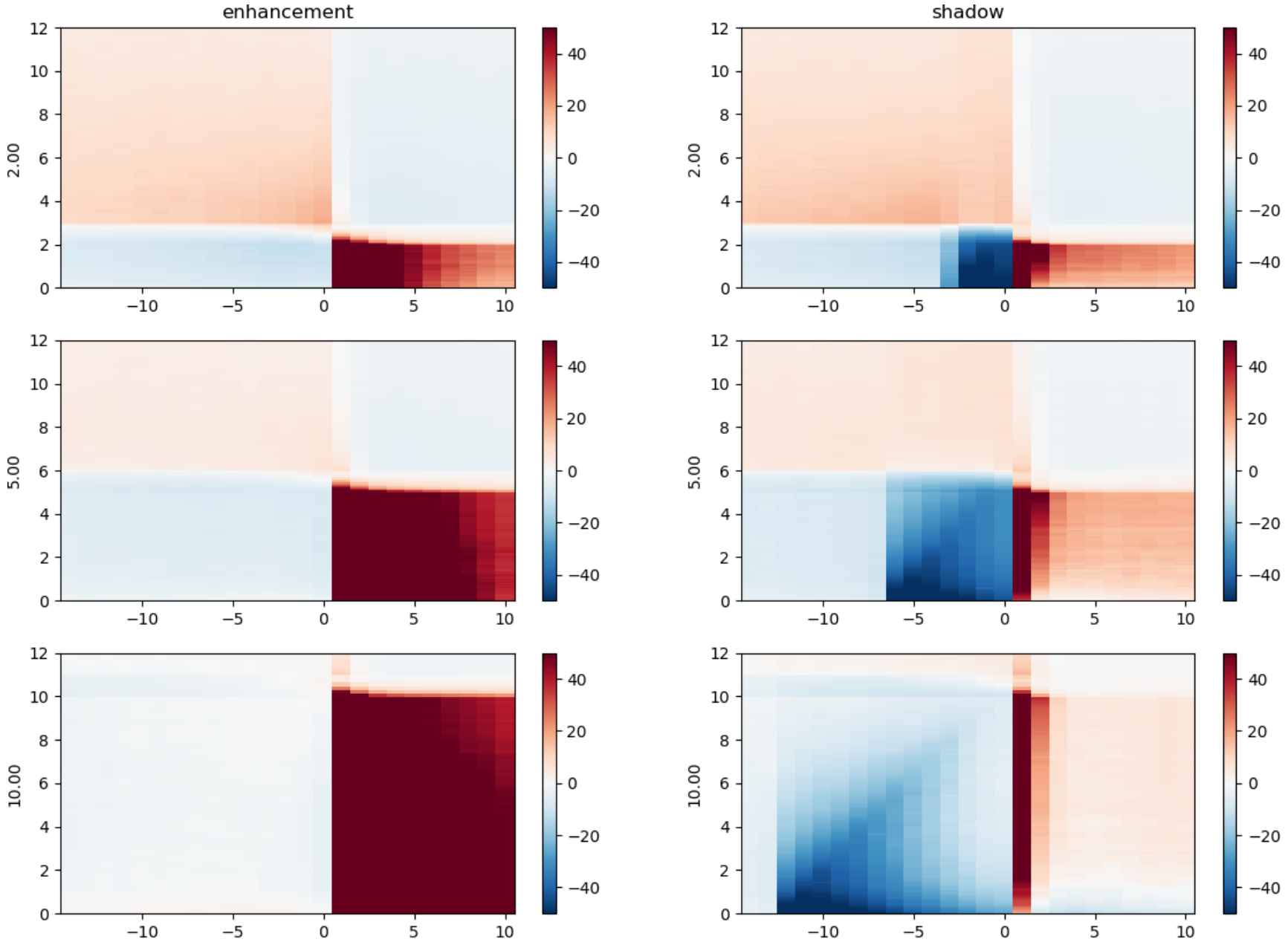
Dependence of layer-AMF on cloud bottom height



Dependence of layer-AMF on cloud bottom height



3D scattering impact, cloud bottom height



Summary of progress since MTR

- Provided more one-dimensional cloud simulations
  - Aim: Test cloud correction algorithm (O_4 and FRESCO) for 1D cloud cases
  - Compare line-by-line and REPTRAN simulations
- New 2D cloud simulations
  - Simulation of reflectance spectra and layer-AMFs for clear pixels near cloud and cloudy pixels
  - Impact of solar zenith angle, albedo, cloud optical thickness, cloud geometrical thickness and cloud bottom height on NO_2 retrieval error
  - Comparison to corresponding 1D clear and cloud cases allows to quantify 3D cloud scattering impact
- Detailed investigation of NO_2 retrieval error due to cloud scattering ongoing $\Rightarrow$ WP300
- Started writing publication for 2d cloud sensitivity study