Development of a Fast 3D Radiative Transfer Solver for NWP Models

Richard Maier, Bernhard Mayer, Claudia Emde and Fabian Jakub
Ludwig-Maximilians-Universität München, E-Mail: richard.maier@physik.uni-muenchen.de

Motivation:

- increasing resolution of NWP models
  → 3D radiative effects more and more important
- most current models: 1D independent column approximations
  → horizontal transport of energy neglected
- current 3D radiative transfer models computationally very demanding

→ **need for a fast 3D radiative transfer solver**

Idea:

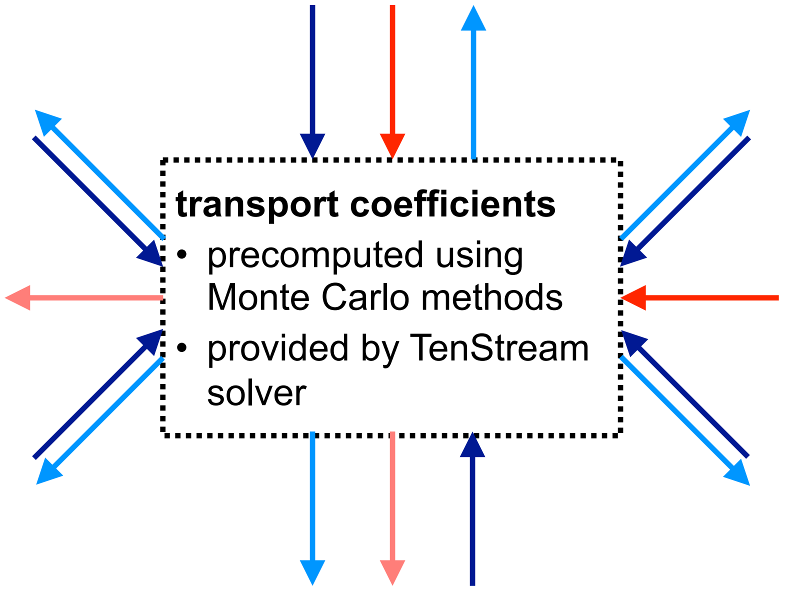
Dynamical/Explicit Radiative Transfer Solver based upon the TenStream solver
in every radiation time step, photons are only transported to adjacent grid boxes

ingoing direct and diffuse irradiances

from adjacent grid boxes

calculated at the previous time step

are used …



… to calculate

outgoing direct and diffuse irradiances

of the grid box

→ outgoing irradiances only depend on the ingoing irradiances from the adjacent grid boxes

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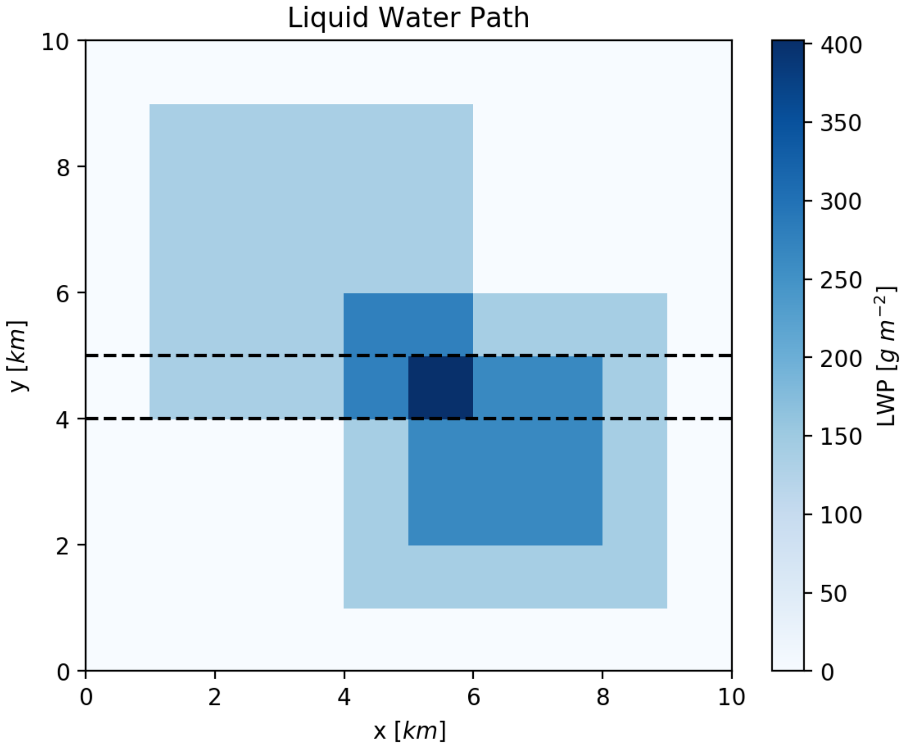
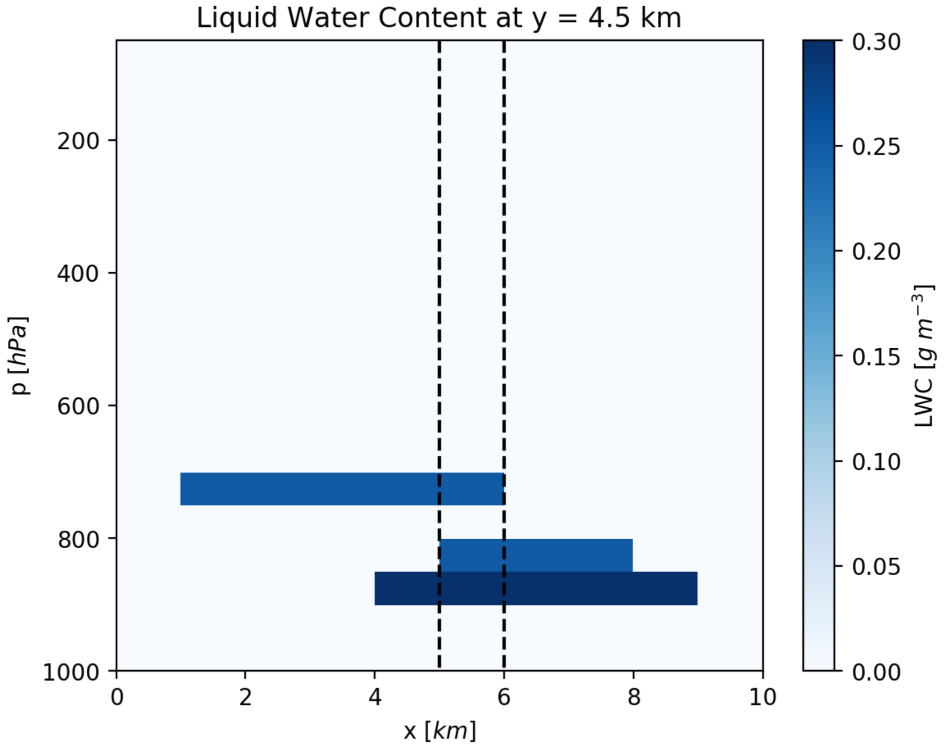
Cloud and Model Setup

- testing domain size: 19 vertical layers, 10 x 10 grid boxes in the horizontal
- dynamical/explicit tenstream solver is spinned up using 100 time steps in a Rayleigh atmosphere
- after 101 time steps, we suddenly introduce
  - a simple rectangular two-layer 3D cloud between 900 hPa and 800 hPa height and
  - another simple, horizontally shifted rectangular one-layer 3D cloud between 750 hPa and 700 hPa height





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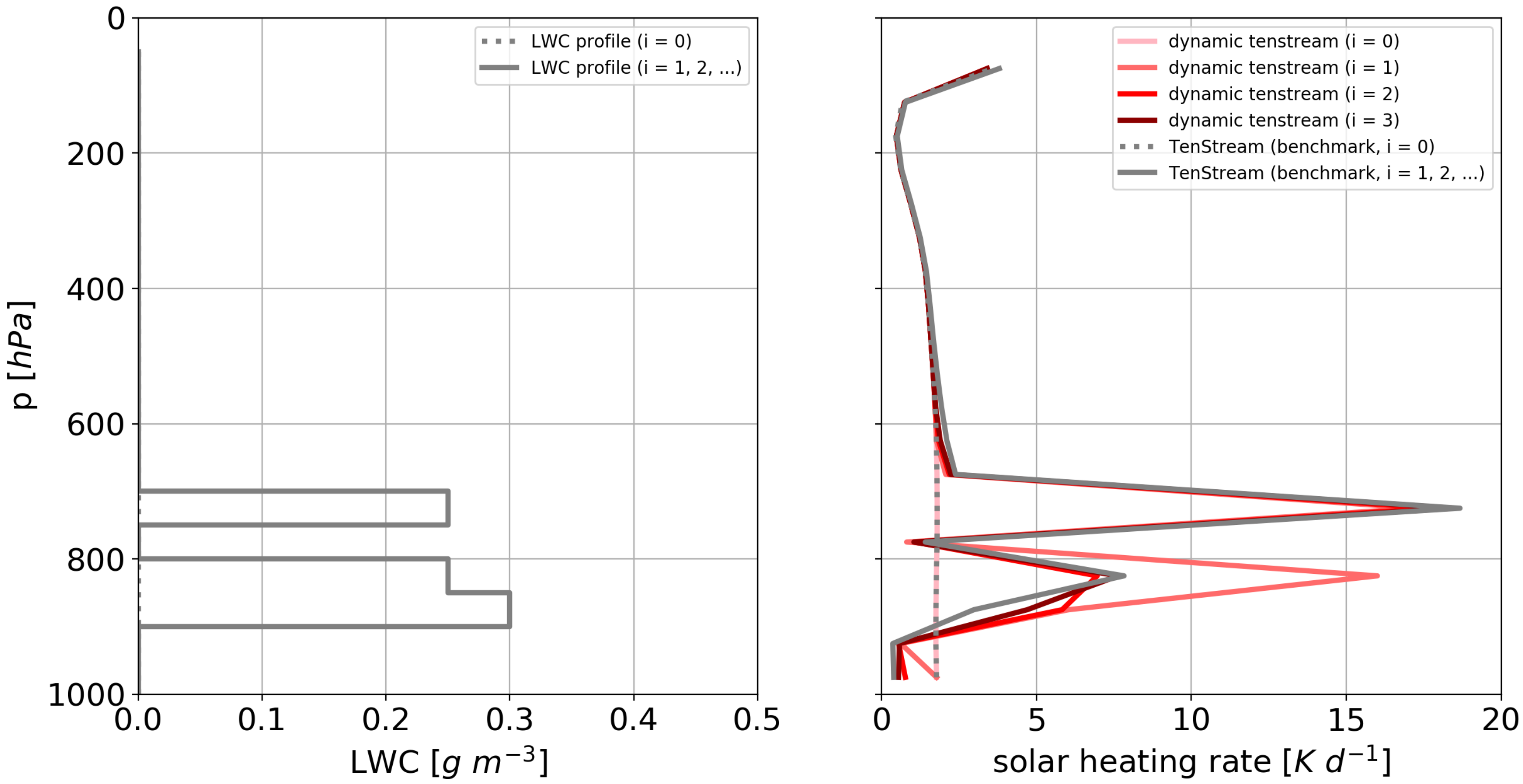
Implications of the Advective Treatment of Radiation and Convergence Behavior of the Solver



- **first order radiative effects**, i.e. changes in the heating rate pattern due to changing optical properties within the same layer, **are considered immediately**
- it takes some time for the individual model layers to communicate with each other
- new solver **converges towards TenStream fluxes and heating rates** in the limit of a large number of iterations
- **rate of convergence** primarily dependent on the distance between different clouds and the information that has to be exchanged over that distance