LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN | MIM

M7 Radiation

HD(CP)² High definition clouds and precipitation for advancing climate prediction

Heating Rates in 3D Cloud Fields

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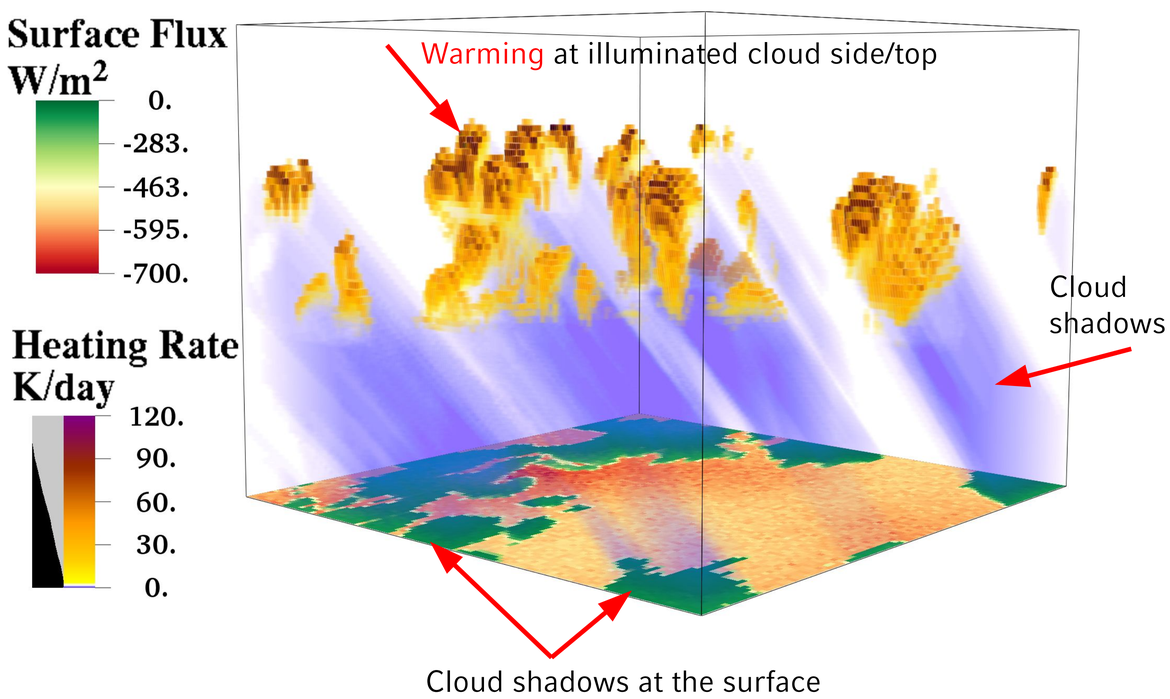
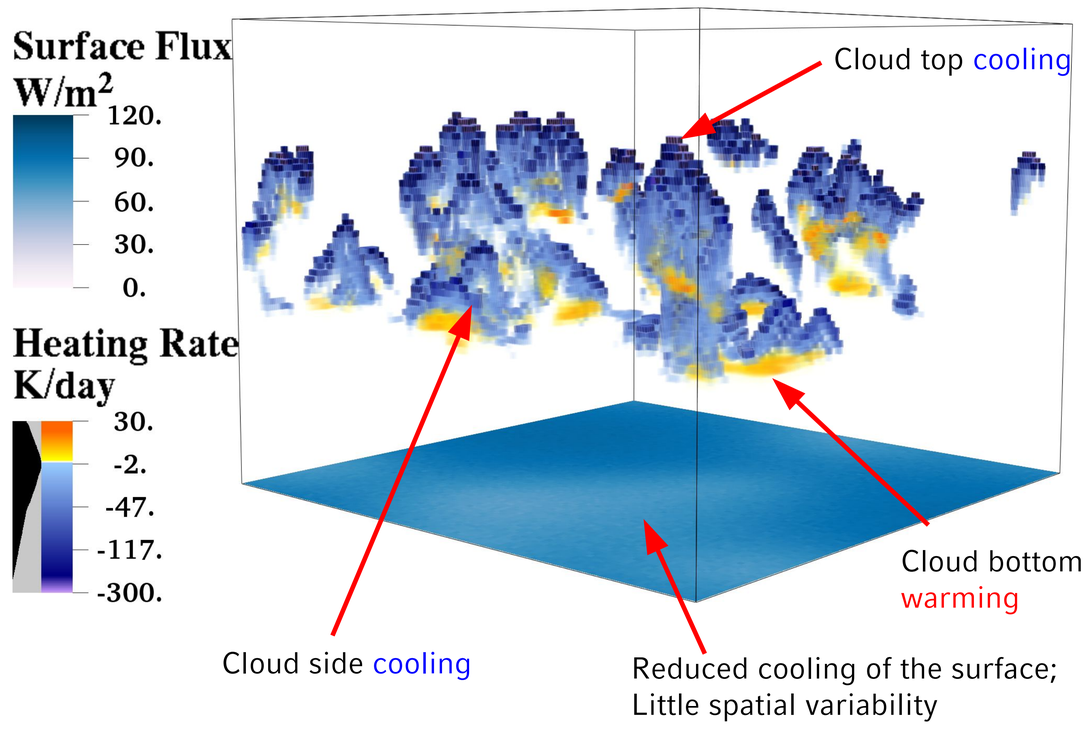
3D Solar Heating Rates



- Clouds reduce the amount of radiation that reaches the surface
- Heat flux from surface to the atmosphere is reduced
- Absorption of solar radiation at illuminated cloud tops/cloud sides → warming effect

→ Influence on:
- Cloud microphysics
- Dynamics
- Cloud development

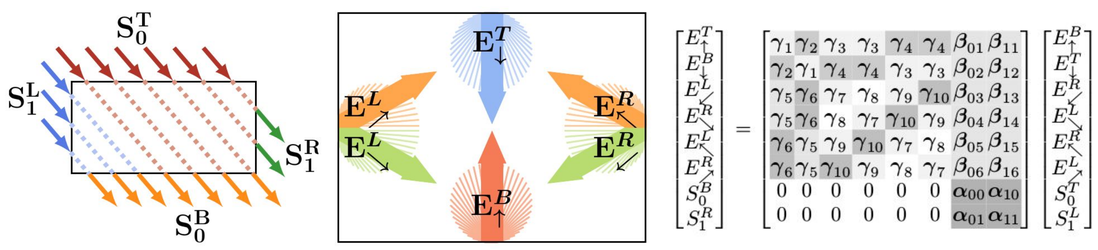
3D Thermal Heating Rates



←
- Main interactions: thermal absorption and emission of the clouds and the atmosphere
  → Cloud side and cloud top cooling
  → Cloud bottom warming

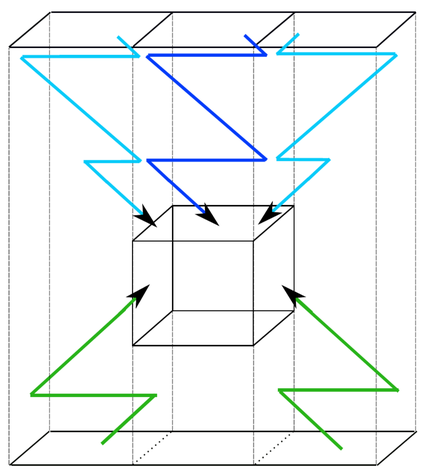
Solar Parameterization

Tenstream



- Generalization of the twostream method to 3 dimensions
- Obtain arbitrarily complex bulk scattering functions with exact Monte Carlo methods
- Solution of equation system with parallel iterative solver

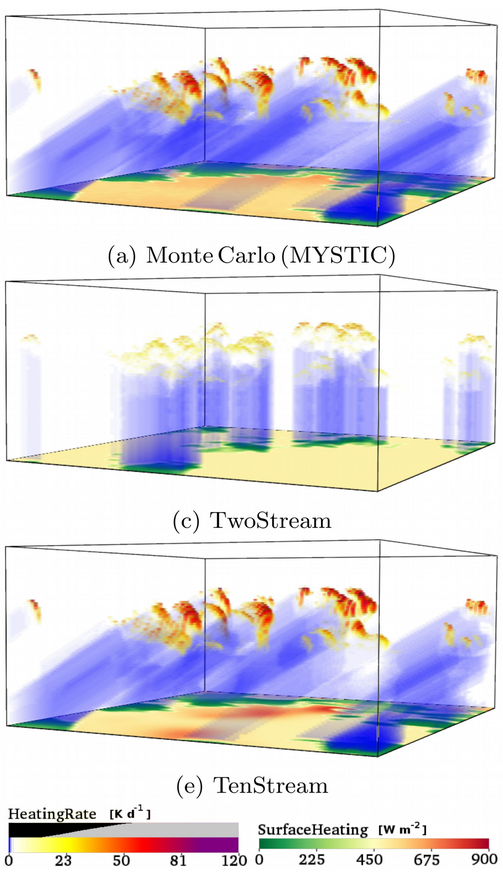
Thermal Parameterization

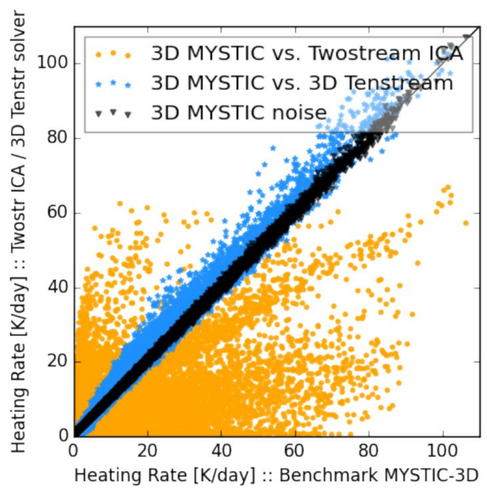


Neighbouring Column Approximation (NCA)

- 3 dimensional approximation based on the 1D radiation solution, scattering neglected
- Representative angle instead of hemispheric integration
- Only direct neighbouring columns are used for the calculation → **can be used in parallelized models**

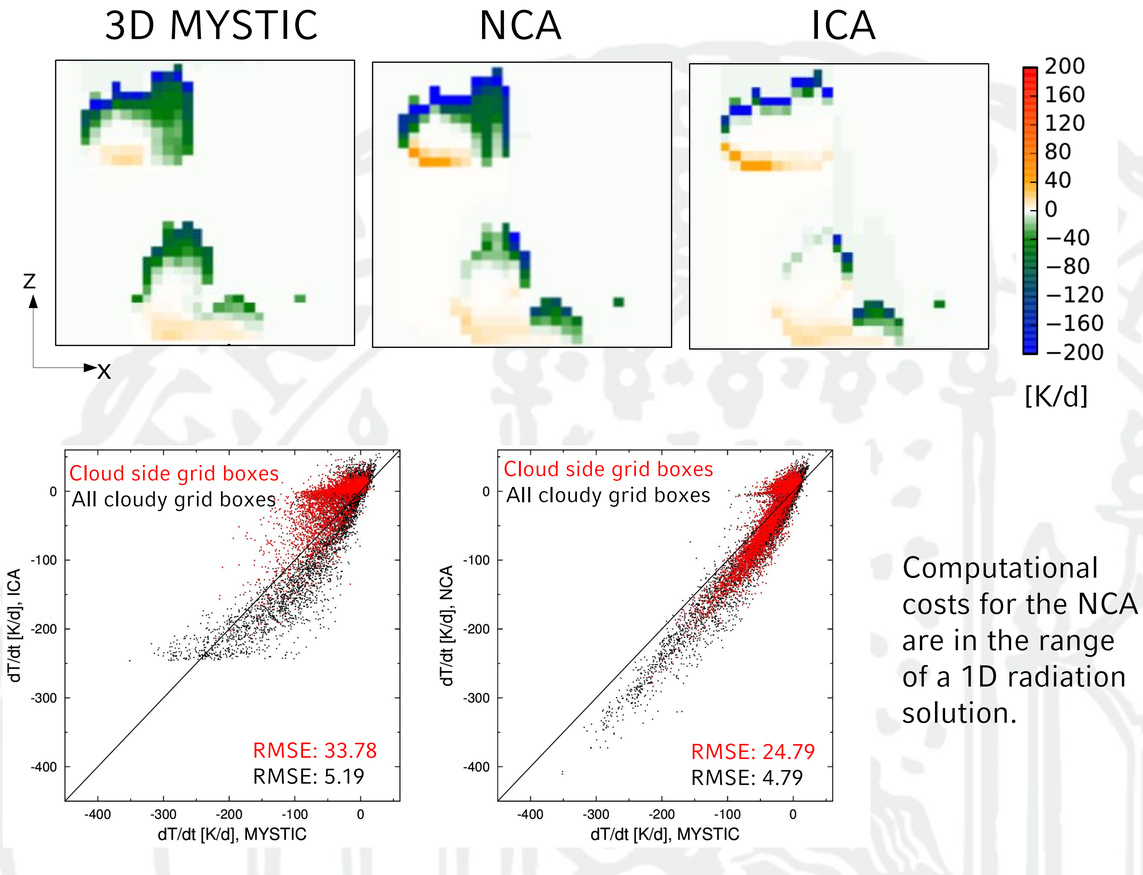
Performance





- Compared to ICA, reduce rel. RMSE for heating rates from **171%** to **31%** and bias from **-12.2%** to **-0.5%** for heating rates.
- For surface heating, reduce rel. RMSE from **62%** to **17%** and bias from **4.4%** to **-1.1%**.
- Total computational cost for radiation increased by a factor of **10-15.**

Performance



Computational costs for the NCA are in the range of a 1D radiation solution.

References

Klinger, C. and Mayer, B., 2014, Three-dimensional Monte Carlo calculation of atmospheric thermal heating rates, Journal of Quantitative Spectroscopy and Radiative Transfer, Volume 144, Pages 123-136, ISSN 0022-4073, http://dx.doi.org/10.1016/j.jqsrt.2014.04.009.

Jakub, F. and Mayer, B., 2015, A Three-Dimensional Parallel Radiative Transfer Model for Atmospheric Heating Rates - the TenStream Solver, Journal of Quantitative Spectroscopy and Radiative Transfer, submitted.

Klinger, C. and Mayer, B., 2015, The Neighbouring Column Approximation (NCA) - A fast Approach for the Calculation of 3D Thermal Heating Rates in Cloud Resolving Models, Journal of Quantitative Spectroscopy and Radiative Transfer, in preparation.

http://www.meteorologie.lmu.de