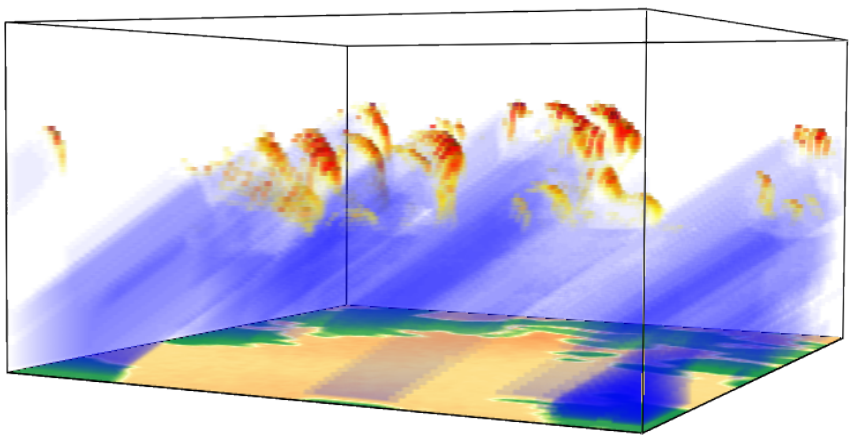
On the status of 3D Radiative Transfer in ICON and experiences with PETSc along the way

F. Jakub, C. Klinger, B. Mayer

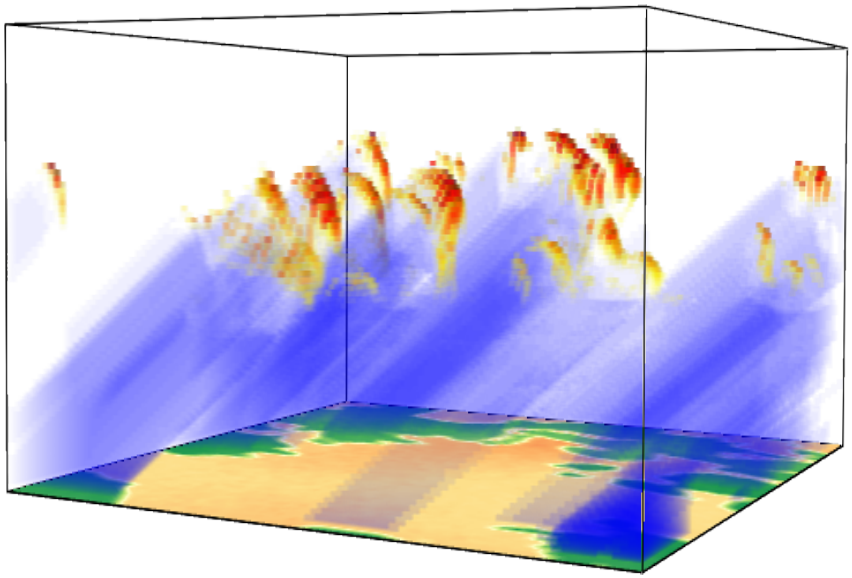
LMU — Meteorological Institute Munich



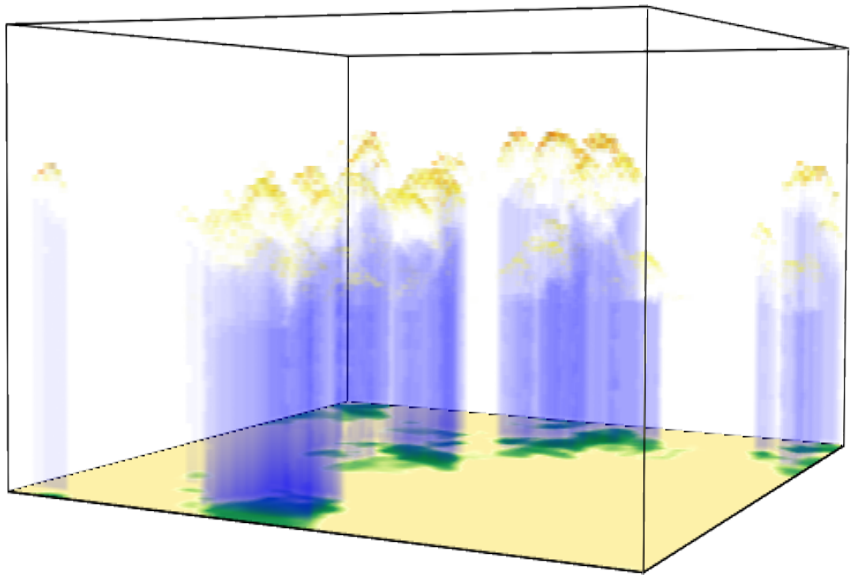
Sept 19, 2018

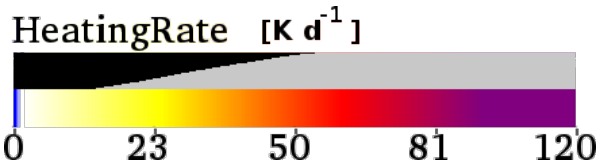
Errors of the ICA

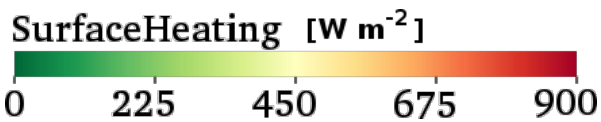
3D MYSTIC



1D independent-column Twostream

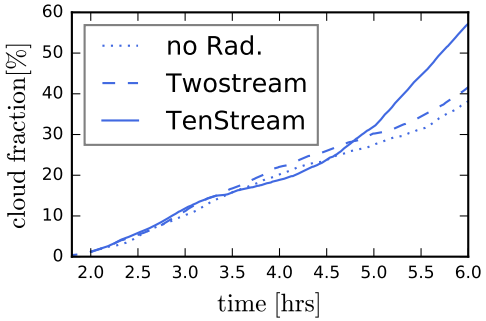


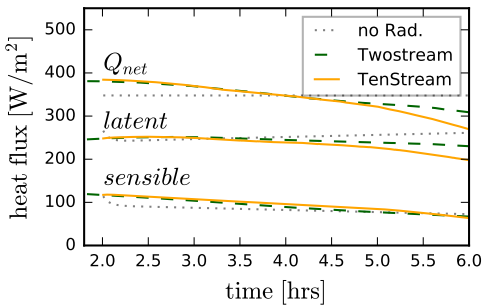


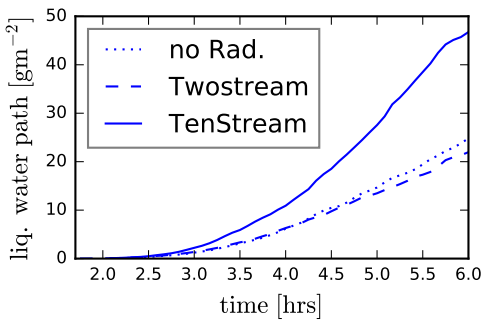


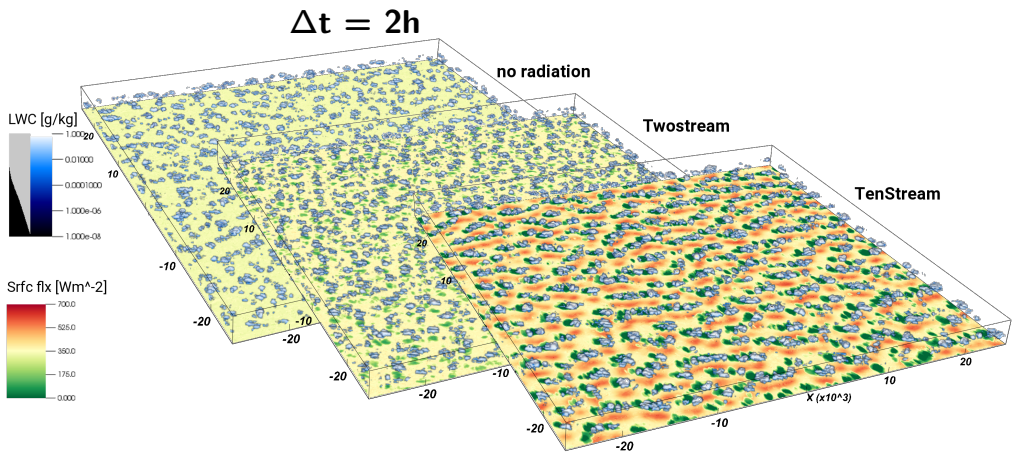
Computations done with libRadtran (Library for Radiative Transfer, libradtran.org)

Shallow cumulus experiments







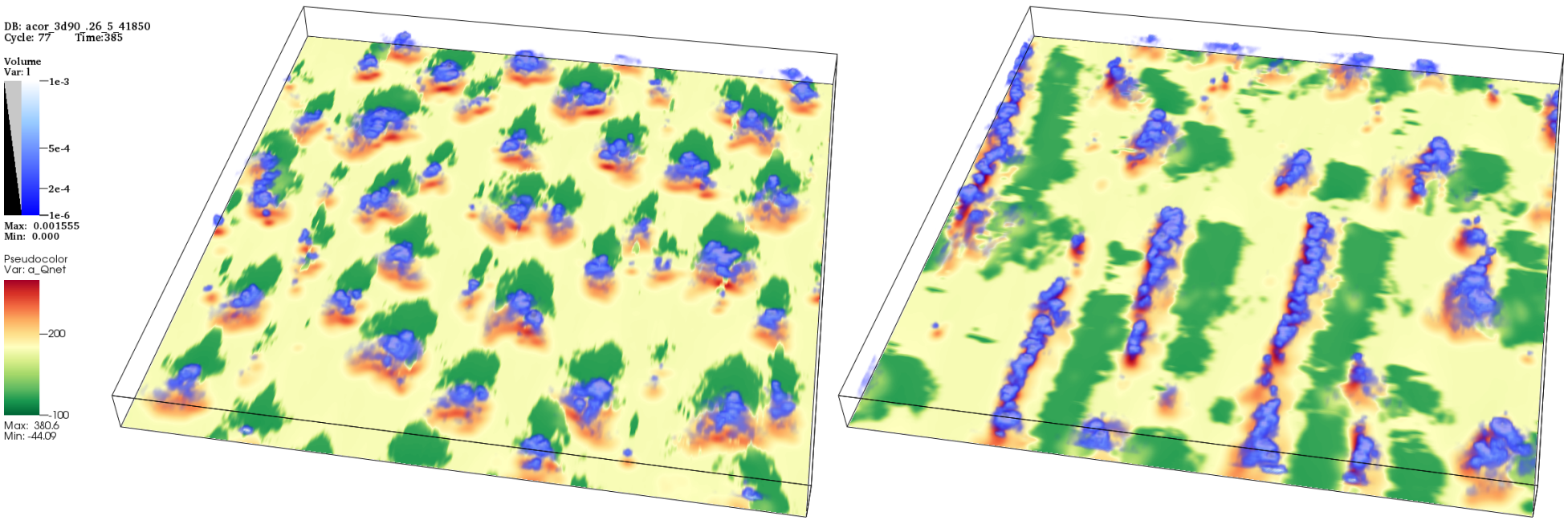


- bulk properties of simulations stay similar for about 2h
- increase in moisture flux
- increase in cloud lifetime (2x) and size

Convective Organization in Streets

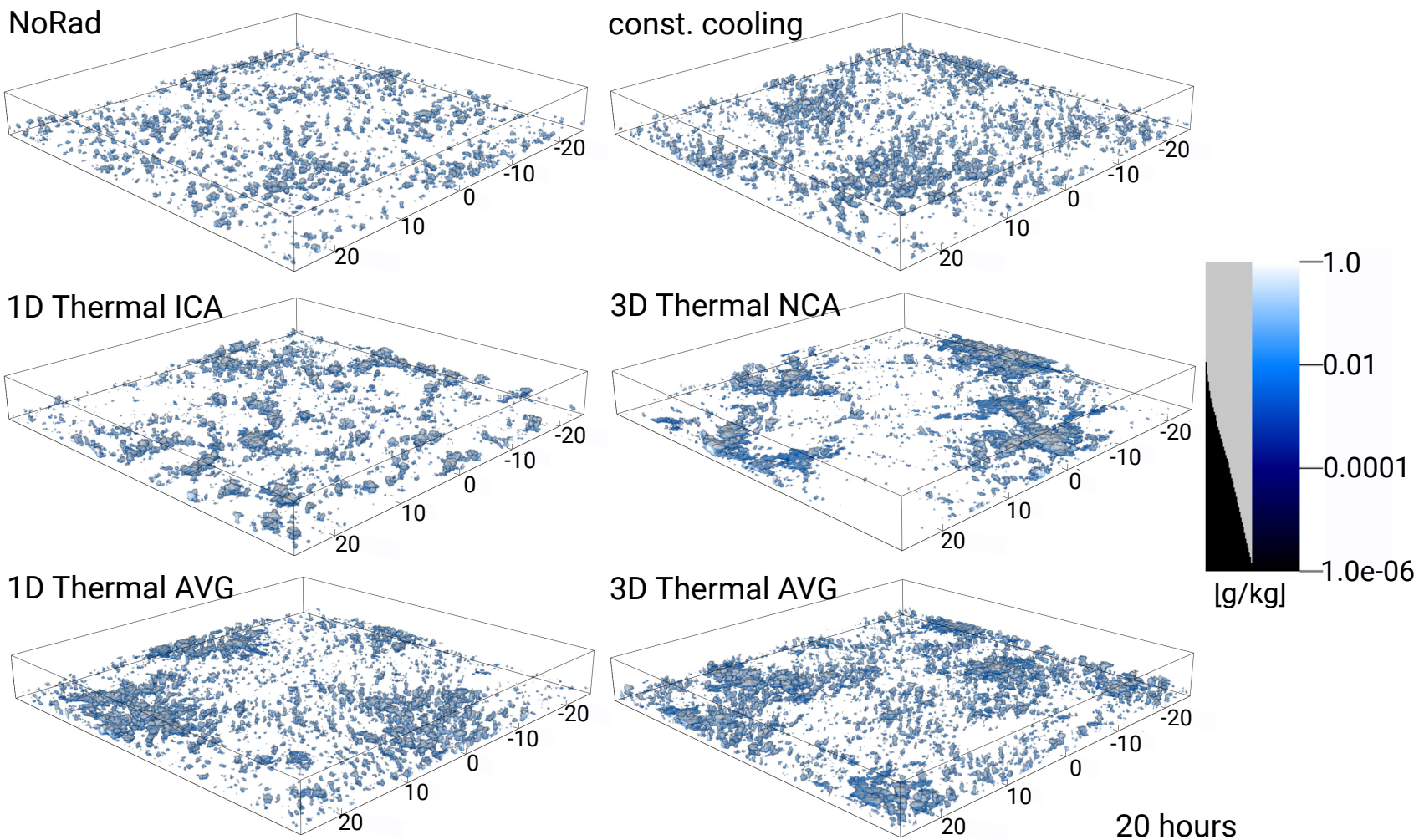
Sun in the South

Sun in the West



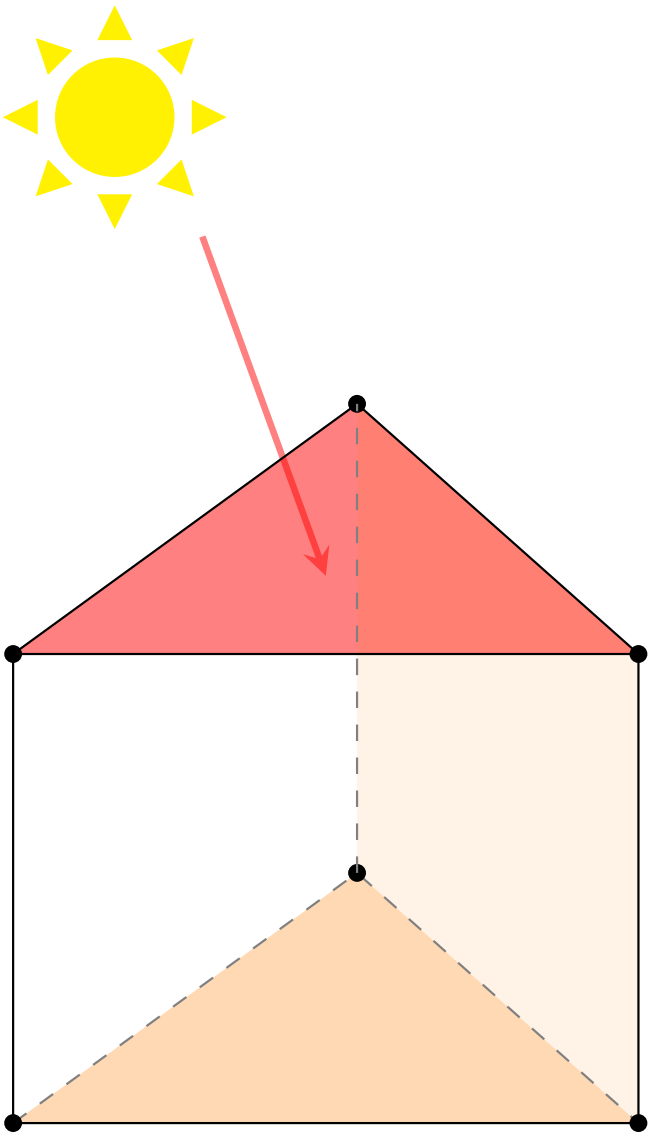
F. Jakub, 2017. The Role of 1D and 3D Radiative Heating on the Organization of Shallow Cumulus Convection and the Formation of Cloud Streets

Effects of Thermal Cooling (C. Klinger)



Klinger, C., Mayer, B., Jakub, F., Zinner, T., Park, S.-B., and Gentine, P.: Effects of 3-D thermal radiation on the development of a shallow cumulus cloud field. (ACP 2017)

Propagation of Radiation in Wedges



3D propagation of radiation through wedges needs to account for:

- transport between each face
- including **absorption**
- and **multiple scattering**

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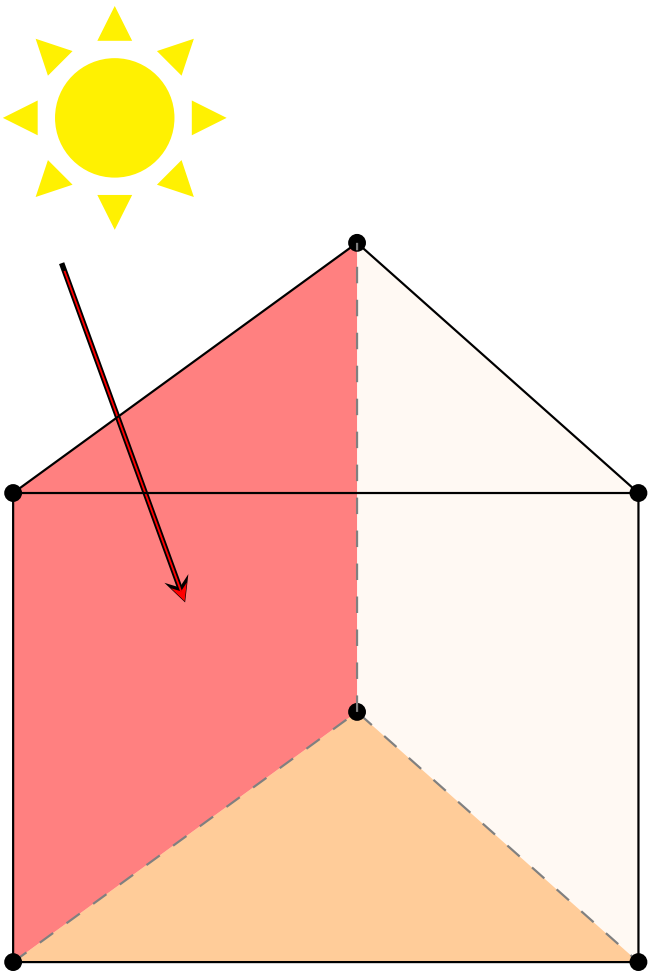

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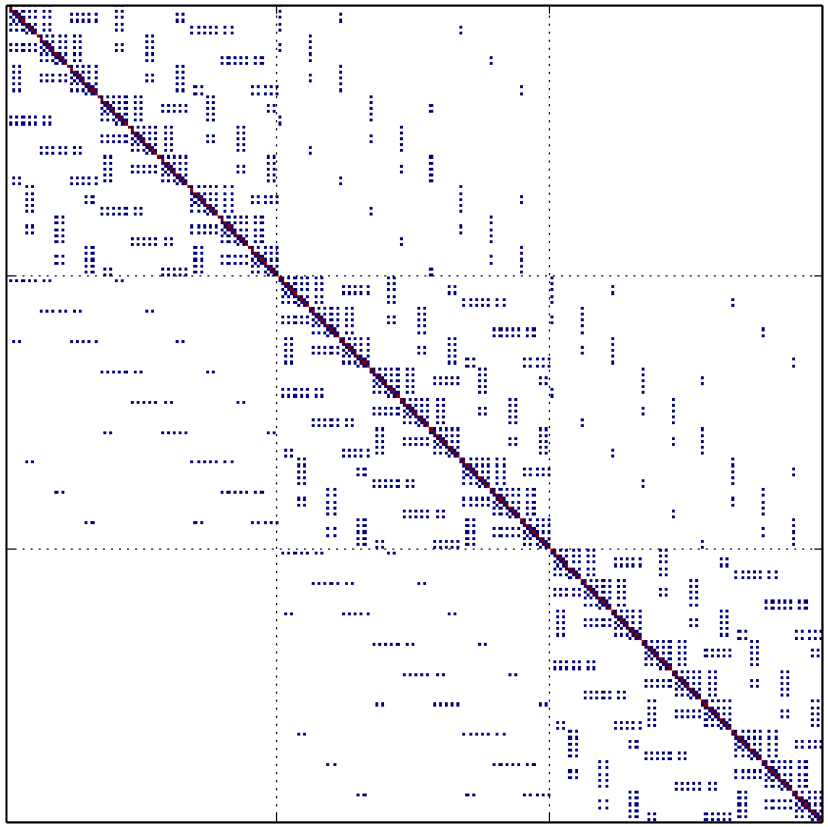
Propagating Radiation between voxels

Coupling voxels in 3 dimensions gives a huge but sparse matrix



$\Longrightarrow$ then globally solve into a steady state solution,
e.g. with iterative solvers from PETSc!

The PETSc Framework

The Portable, Extensible Toolkit for Scientific Computation.

What is ist?

- MPI parallelized
- Krylov solvers: GMRES, CG, BCGS, ...
- Preconditiones: ILU, SOR, GAMG, ML, Hypre
- and more...

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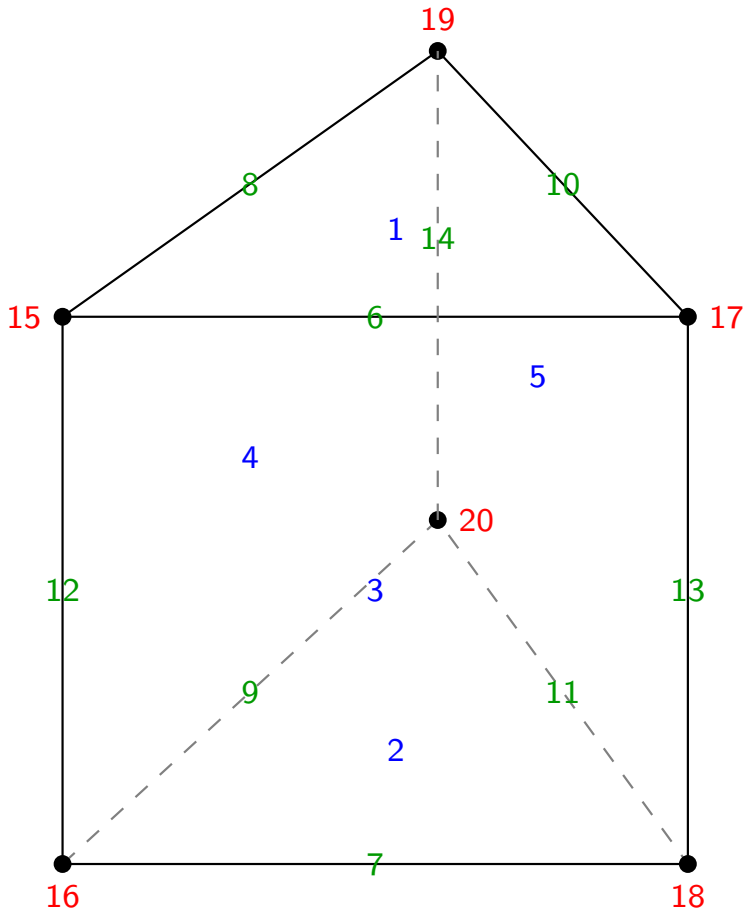
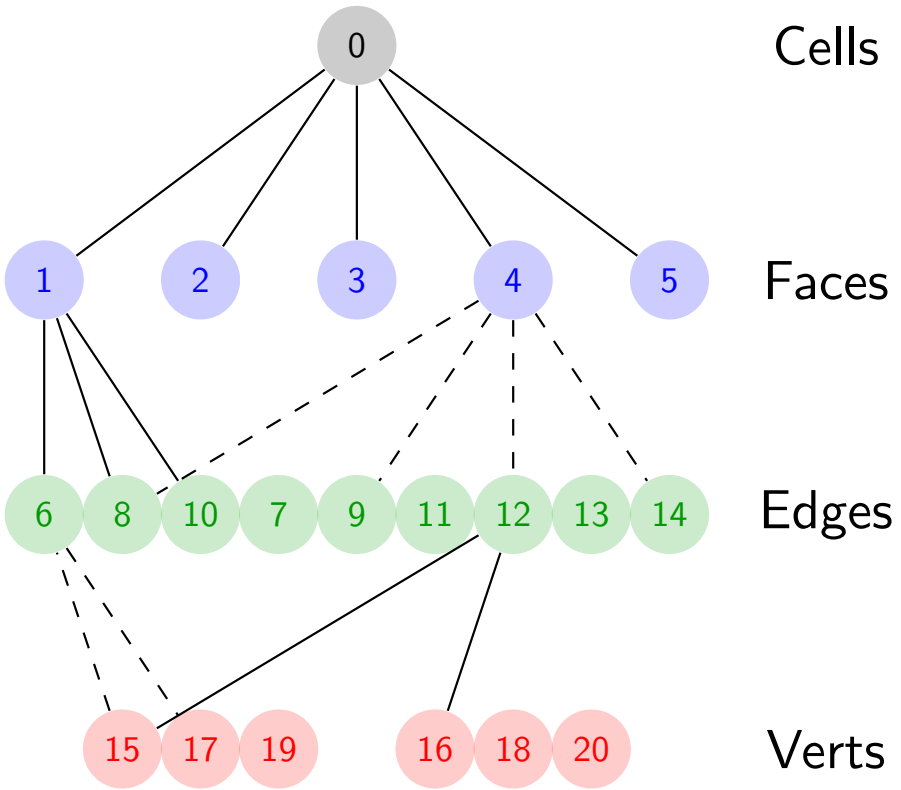
What is ist?

Why PETSc?

- textbook decision to select optimal solvers is impossible
- PETSc provides a playground to test and create scalable solvers

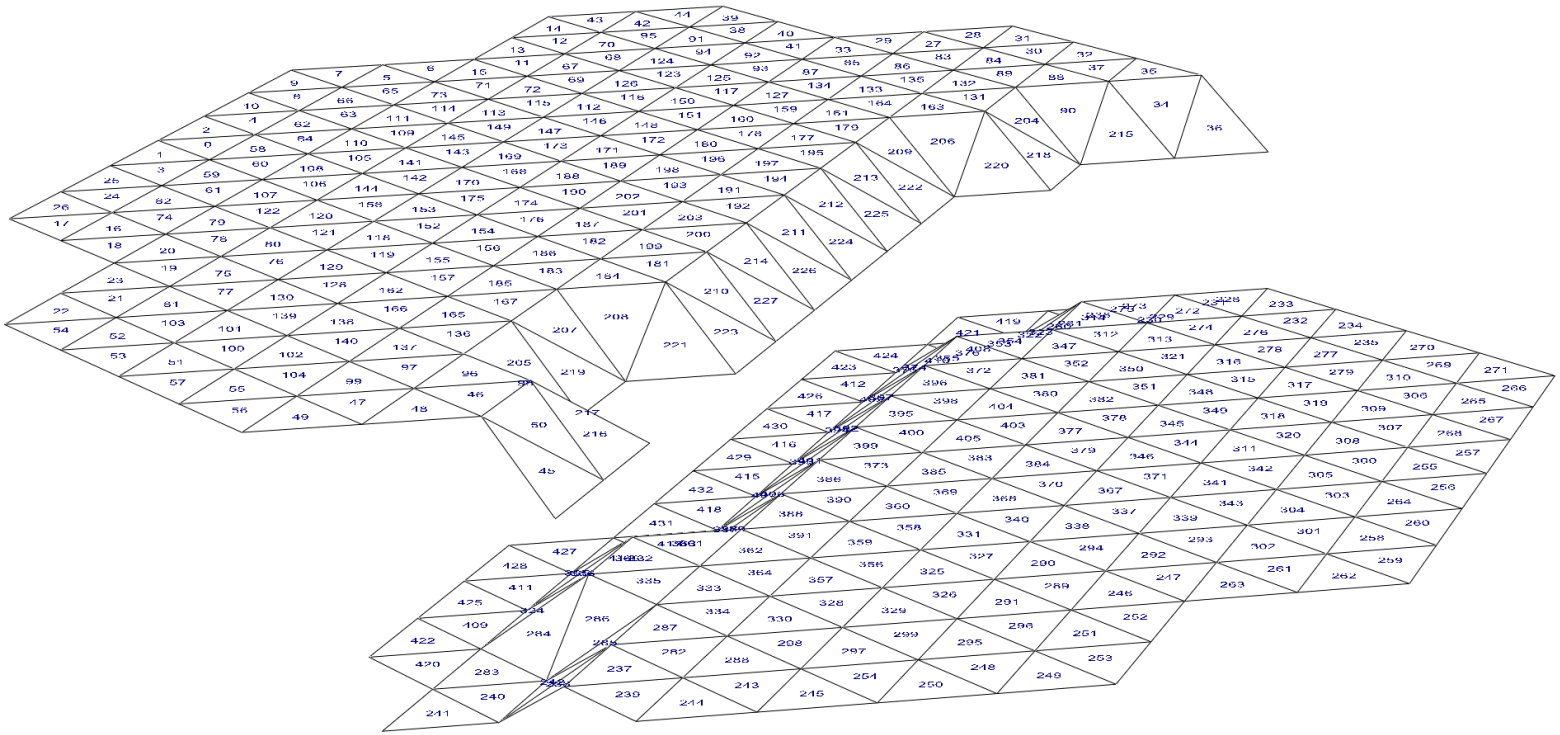
DMPlex Mesh for ICON Wedges





- Acyclic Graph for a single element of an ICON Mesh

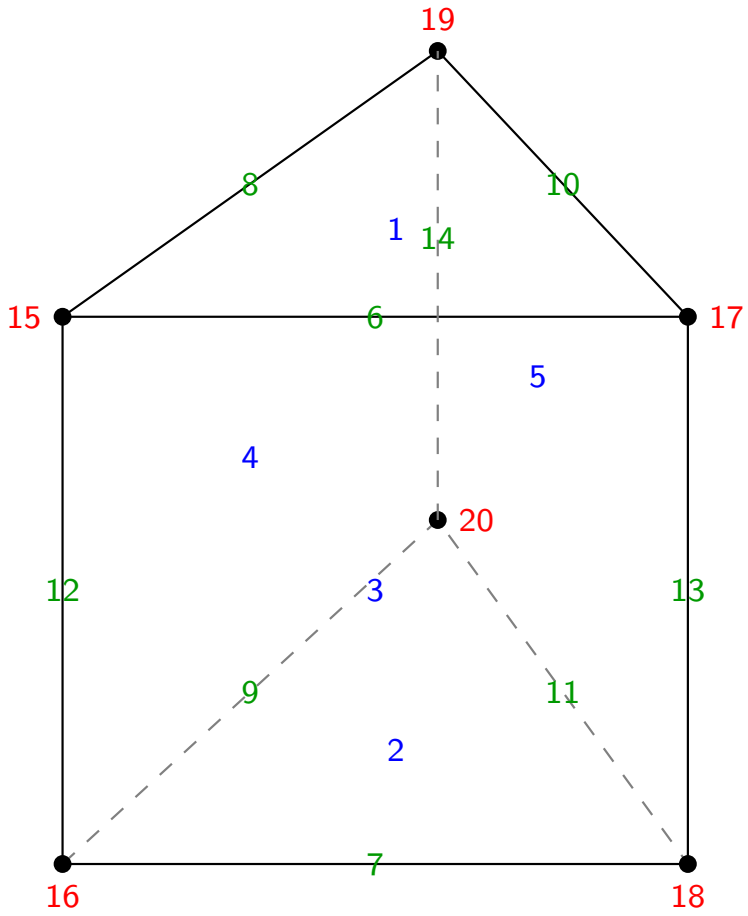
DMPlex Mesh for ICON Wedges

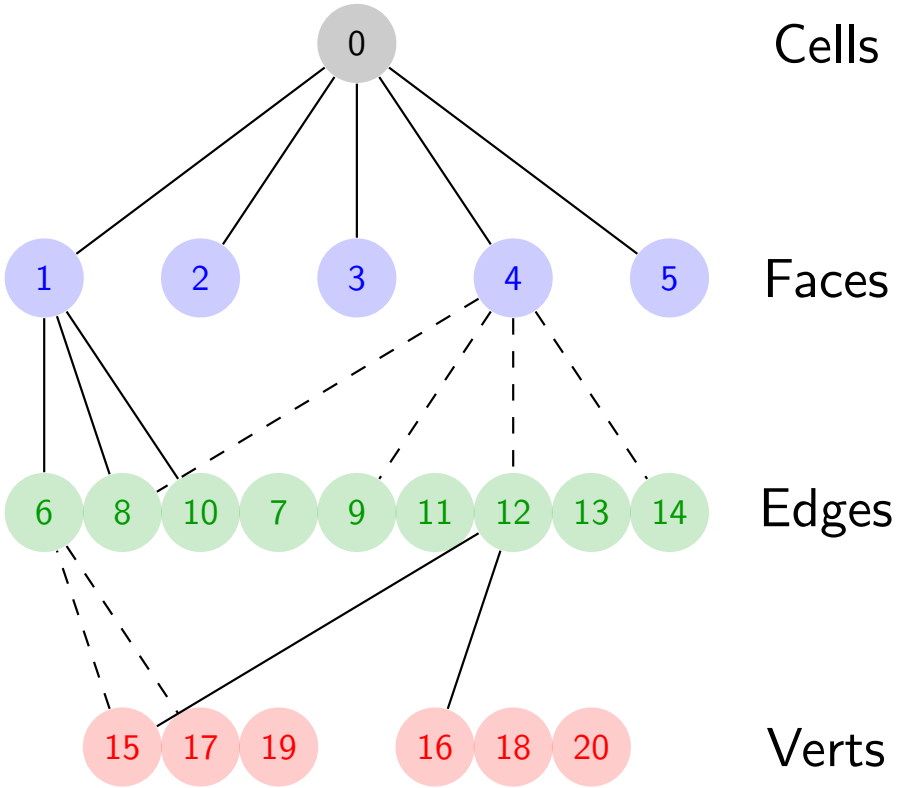


Use ICON struct *"decompinfo"* to build DMPlex in parallel, then exchange element indices with neighbors. I.e. need to haggle about elements and have to know the local index at the owning process

* Special thanks to Moritz Hanke, Jan and Panos (DKRZ) who helped a lot to get started.

DMPlex Mesh for ICON Wedges





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Status

Current state and a glimpse at whats to come:

- can use solvers and preconditioners of PETSc in ICON
- can compute solar and thermal radiative fluxes in 3D

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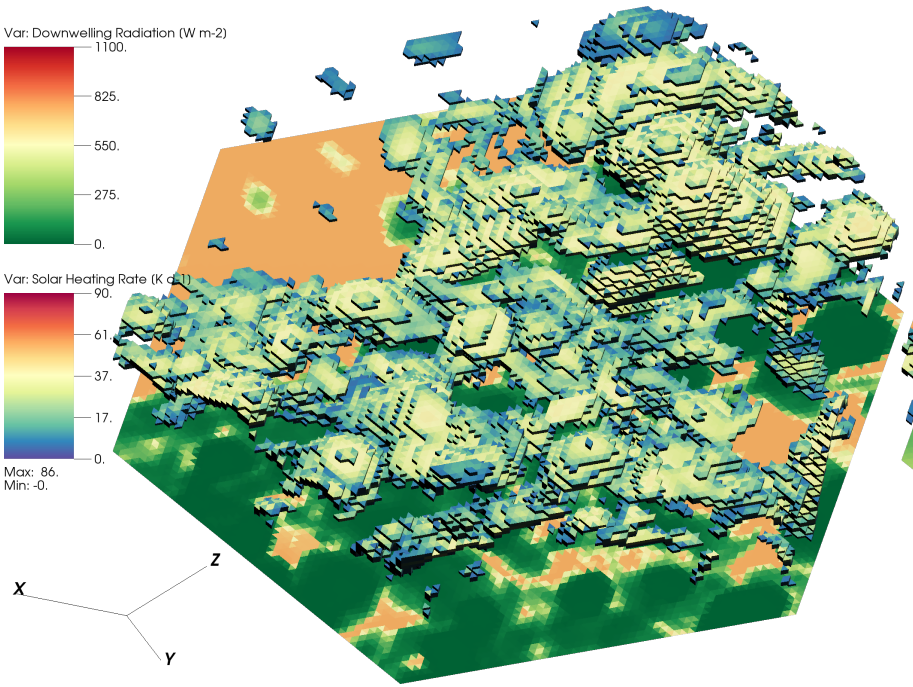
- can use solvers and preconditioners of PETSc in ICON
- can compute solar and thermal radiative fluxes in 3D

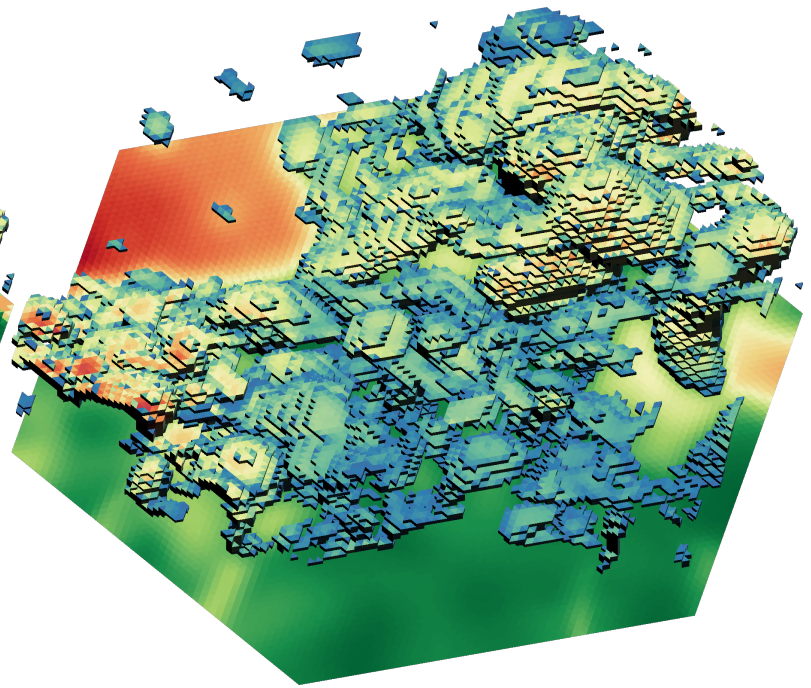
- currently working on the coupling and testing of heating rates
- have yet to check for performance and scalability of my PETSc solvers

Let me know if you would like to play with PETSc!

1D and 3D Radiation in ICON



1D Twostream



3D ?? – open for suggestions