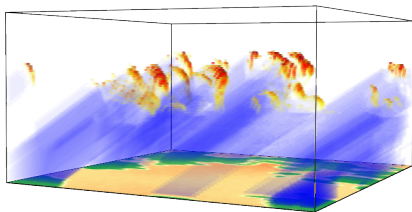


# 3D Radiative Heating Rates in Cloud Resolving Models – Methods and Impact on Cloud Evolution and Organization of Convection

F. Jakub, M. Veerman, J. Schaefer, P. Gregor, F. Negwer,  
C. Klinger, B. Mayer

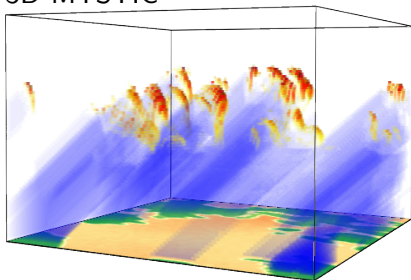
LMU — Meteorological Institute Munich



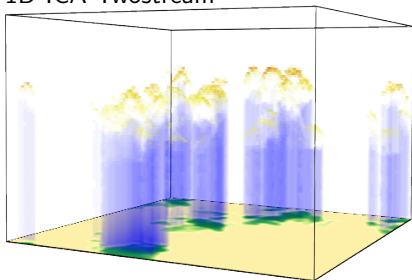
Jan 21, 2019

# Comparison to MYSTIC

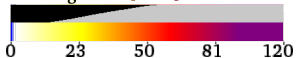
## 3D MYSTIC



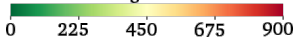
## 1D ICA Twostream



HeatingRate [ $\text{K d}^{-1}$ ]



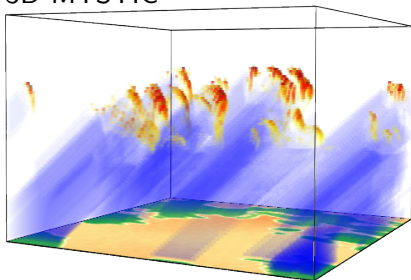
SurfaceHeating [ $\text{W m}^{-2}$ ]



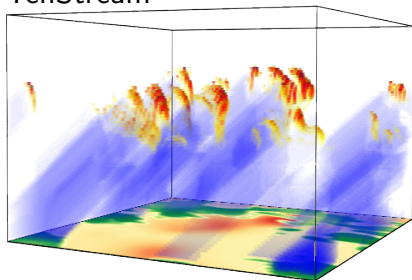
Computations done with libRadtran (Library for Radiative Transfer, [libradtran.org](http://libradtran.org))

# Comparison to MYSTIC

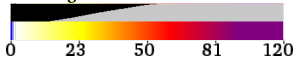
3D MYSTIC



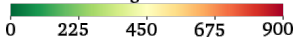
TenStream



HeatingRate [ $\text{K d}^{-1}$ ]



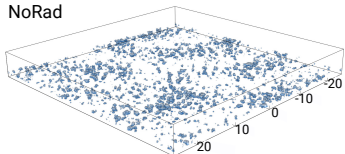
SurfaceHeating [ $\text{W m}^{-2}$ ]



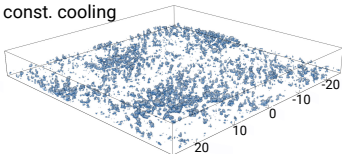
Computations done with libRadtran (Library for Radiative Transfer, [libradtran.org](http://libradtran.org))

# Effects of Thermal Cooling (C. Klinger)

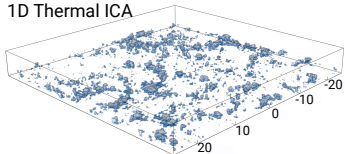
NoRad



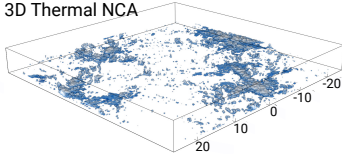
const. cooling



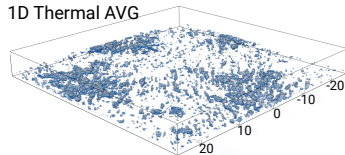
1D Thermal ICA



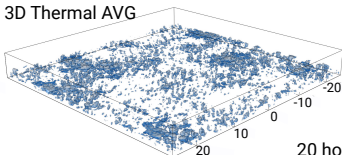
3D Thermal NCA



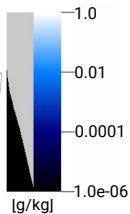
1D Thermal AVG



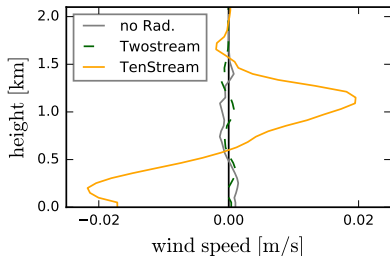
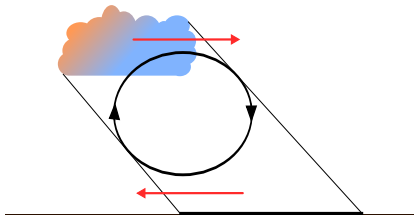
3D Thermal AVG



20 hours



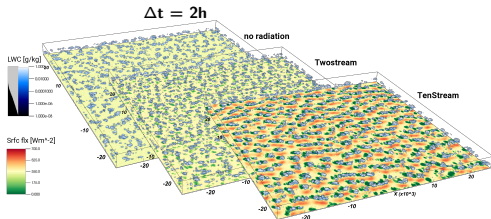
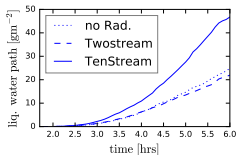
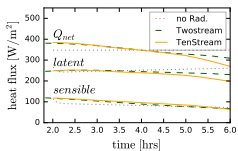
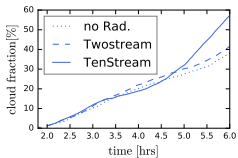
# Radiatively induced windshear



## Asymmetric heating of clouds

- ▶ sunlit side rises stronger
- ▶ increased effective cloud cover
- ▶ induces secondary circulation
- ▶ more pronounced with an interactive surface

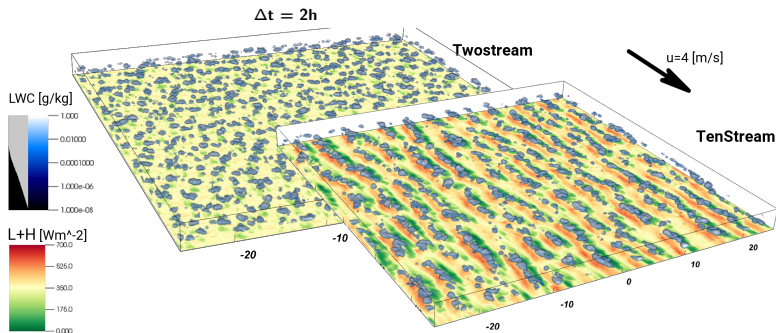
# Shallow cumulus experiments



wind  $u = 0\text{ m/s}$ ,  $\text{sza}\theta = 60^\circ$

- ▶ 3D radiation produces larger, higher and thicker clouds
- ▶ constant influx of moist air increases cloud lifetime (2x)
- ▶ more efficient moisture flux into the cloud layer

# Convective Organization through Radiation



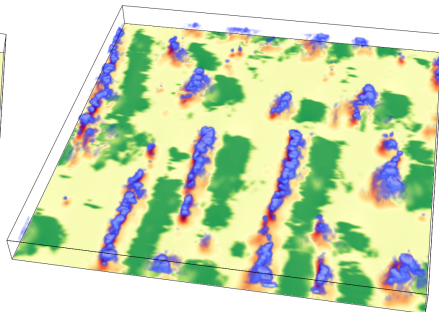
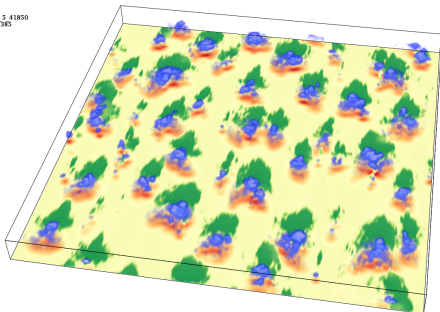
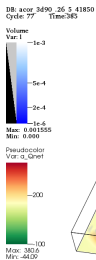
Organization of convection with 3D RT depends on

- horizontal wind
- sun angle
- surface properties

# Convective Organization in Streets

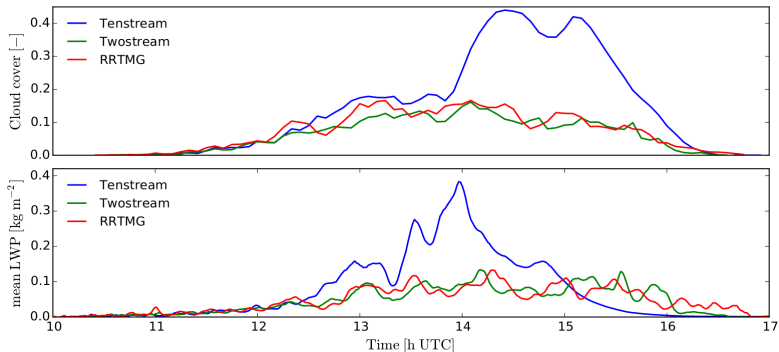
Sun in the South

Sun in the West



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

# Influence of 3D Radiation in a setup with a diurnal cycle



## Internship of Menno Veerman

- ▶ DALES shallow convection simulations with a diurnal cycle
- ▶ Shows same effects as in idealized studies with stationary sun
- ▶ Focused on the partitioning between direct and diffuse light

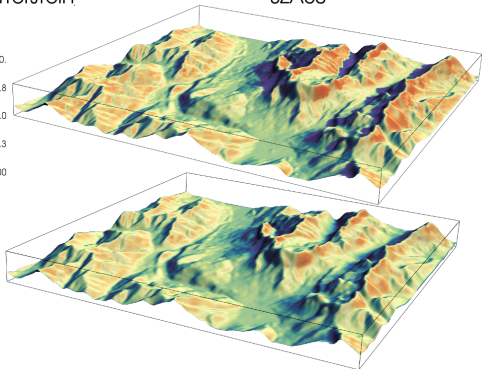
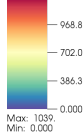
# Propagation of Radiation in Terrain Following Coordinates

wetterstein

SZA60

Pseudocolor

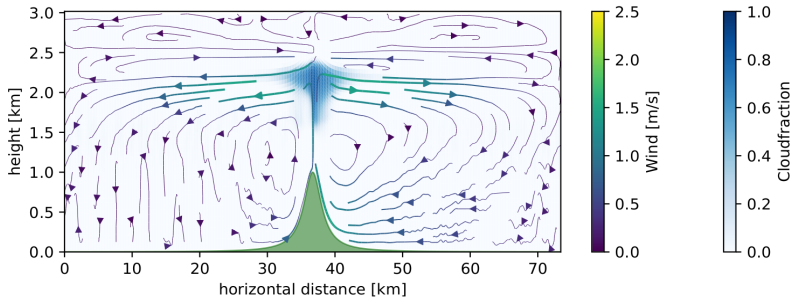
Var: Qdir



3D propagation of radiation above complex terrain:

- ▶ top: 3D MonteCarlo
- ▶ bot: 10str with "raybending"
- ▶ account for surface inclination
- ▶ also account for dynamic surface heterogeneity of (stationary) clouds

# WRF LES Simulations

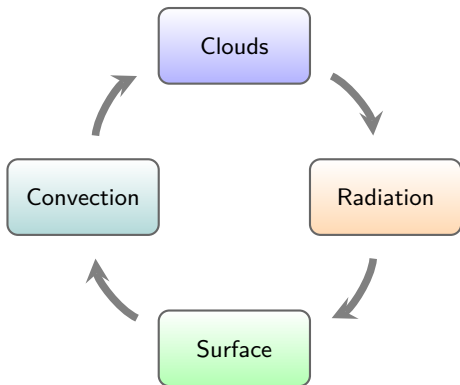


## Bachelorthesis of Janik Schaefer

- ▶ WRF-LES simulations comparing 1D and 3D radiation effects in the vicinity of clouds
- ▶ Stronger, stationary cloud development instead of "pumping" popcorn convection
- ▶ Finds changes in circulation pattern, 2xLWP, etc..

# Non-linear interactions keep it interesting

Several studies show the intricate relationship between processes. . .



- ▶ ... non-linear
- ▶ ... on short timescales
- ▶ expert communities may need to join efforts!

