Large-eddy simulations of cloud and convective processes

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The project

Motivation

- Convective clouds and resulting precipitation important for the weather and climate of many regions
- Need to be adequately represented in weather and climate models
- Represented through parameterizations because their size (from O(10-100 m)) smaller than typical grid spacings (O(10-100) km)
- Such parameterizations are a source of large biases (e.g. Fig. 1)
- These model biases reflect our missing understanding of the basic processes controlling the convective development

Strategy

- Use of large-eddy simulations (LES, grid spacing O(100 m)), where convective processes can be explicitly resolved
- Investigation of the detailed life cycle of convective clouds

Goals

- Improve our conceptual understanding of the processes controlling the convective development
- Improve our ability to represent and predict convective clouds

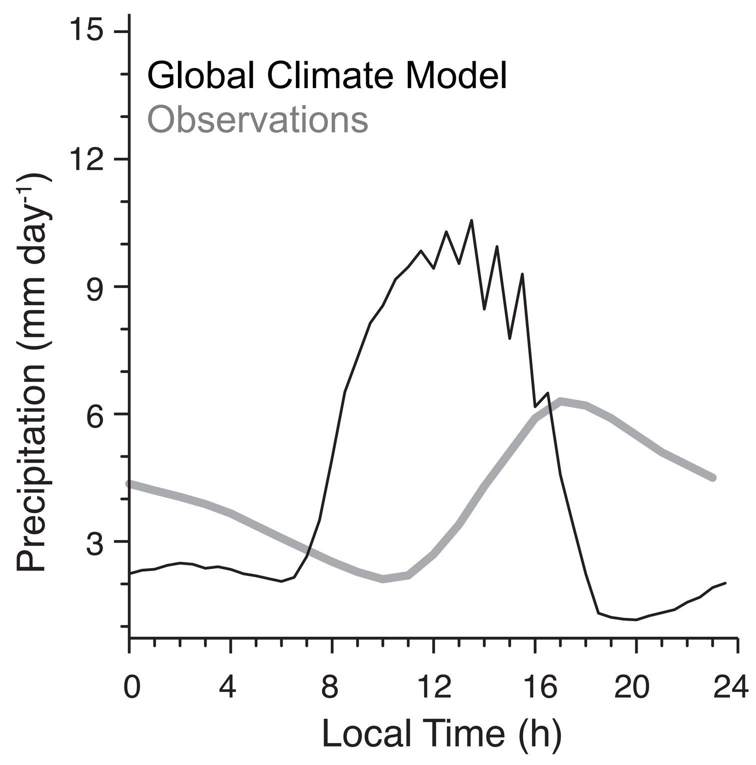
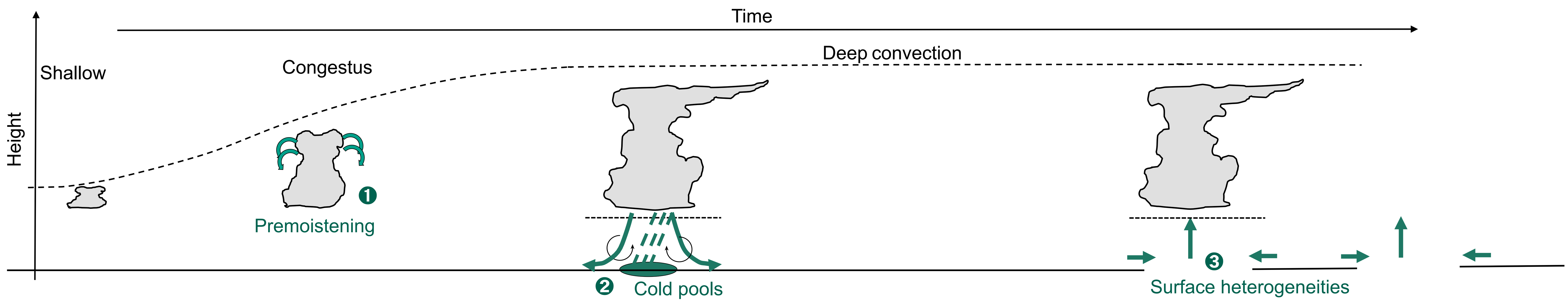


Fig. 1: Observed and simulated precipitation diurnal cycle.



1. Congestus clouds?

Question

Does the premoistening by congestus clouds promote the transition to deep convection?

Strategy

Estimate typical transition time scales (from observations) and compare them to moistening time scales (obtained from LES)

Results

- Moistening time scales : 10 h
- Transition time scales (Fig. 2): 2-4 h
- Premoistening by congestus clouds cannot explain the transition.

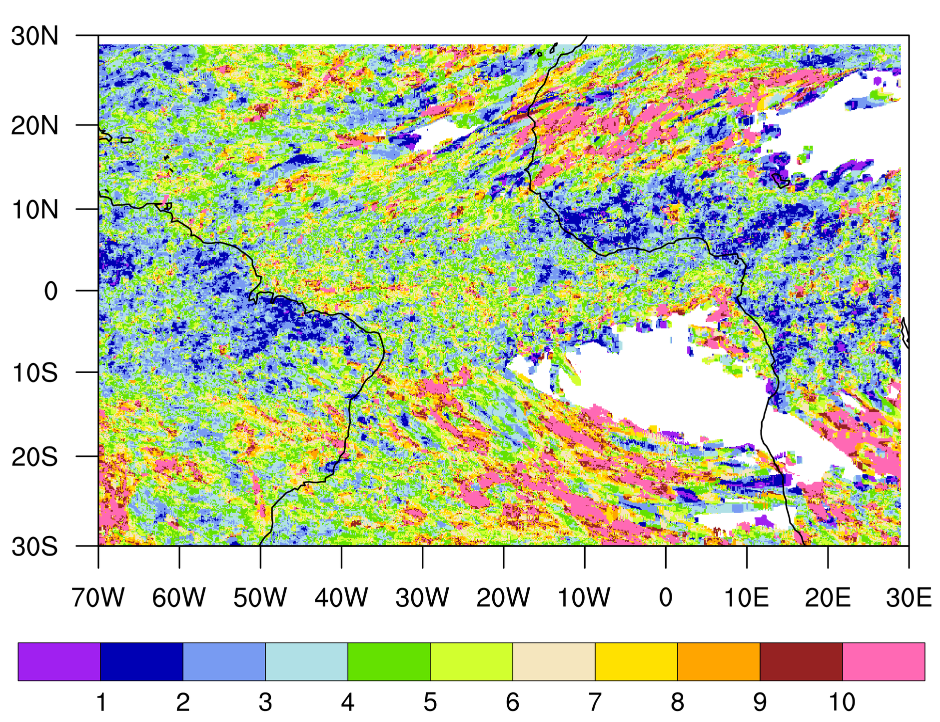


Fig. 2: Observed mean transition time (h).

Hohenegger, C. and B. Stevens, 2013: Preconditioning deep convection with cumulus congestus, *J. Atmos. Sci.*, **70**, 448-464.

2. Cold pools?

Question

How do cold pools promote the transition to deep convection in different environments?

Strategy

LES of developing convection under different environmental conditions. Tracking of cold pools and cloud statistics.

Results

- Cold pools generate wet patches that determine the cloud size (Fig. 3)
- Larger clouds entrain less and transition more rapidly
- Convergence induced by the cold pools further helps the transition
- Similar mechanisms act under different conditions.

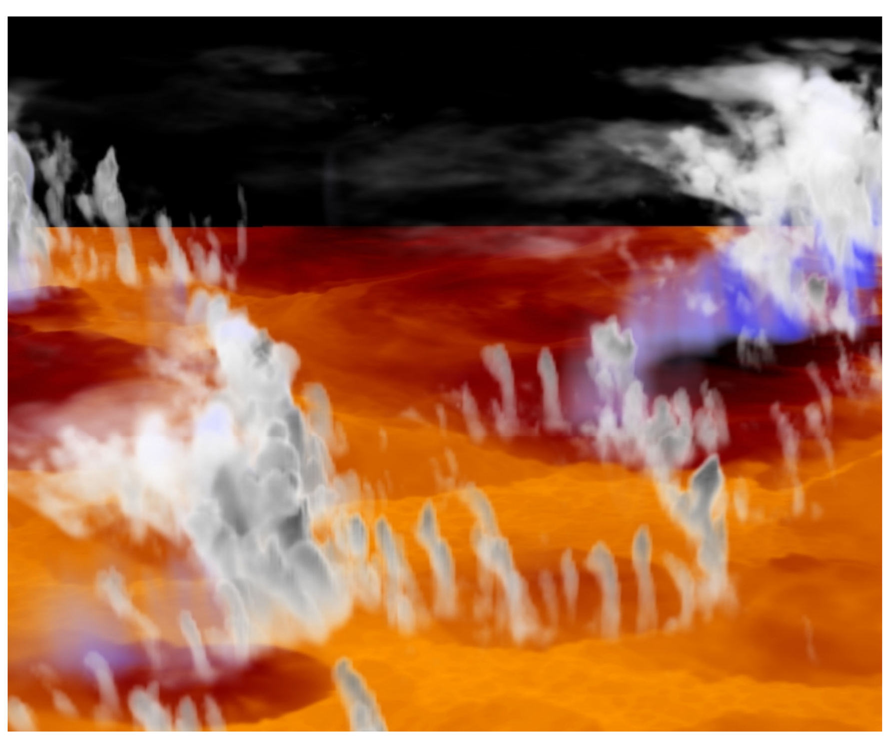


Fig. 3: Overview of the cloud field.

Schlemmer, L. and C. Hohenegger, 2013: The formation of wider and deeper clouds through cold-pool dynamics. In preparation.

3. Surface heterogeneities?

Question

Does the cloud size distribution depend upon surface heterogeneities?

Strategy

LES of developing convection with an interactive land surface and imposed surface heterogeneities of different length scales.

Results

- Surface heterogeneities determine the shape of the cloud size distribution in the shallow phase (Fig. 4)
- Only larger-scale surface heterogeneities impact deep convection
- Domain averaged cloud cover remains mostly unaffected by heterogeneous surface conditions.

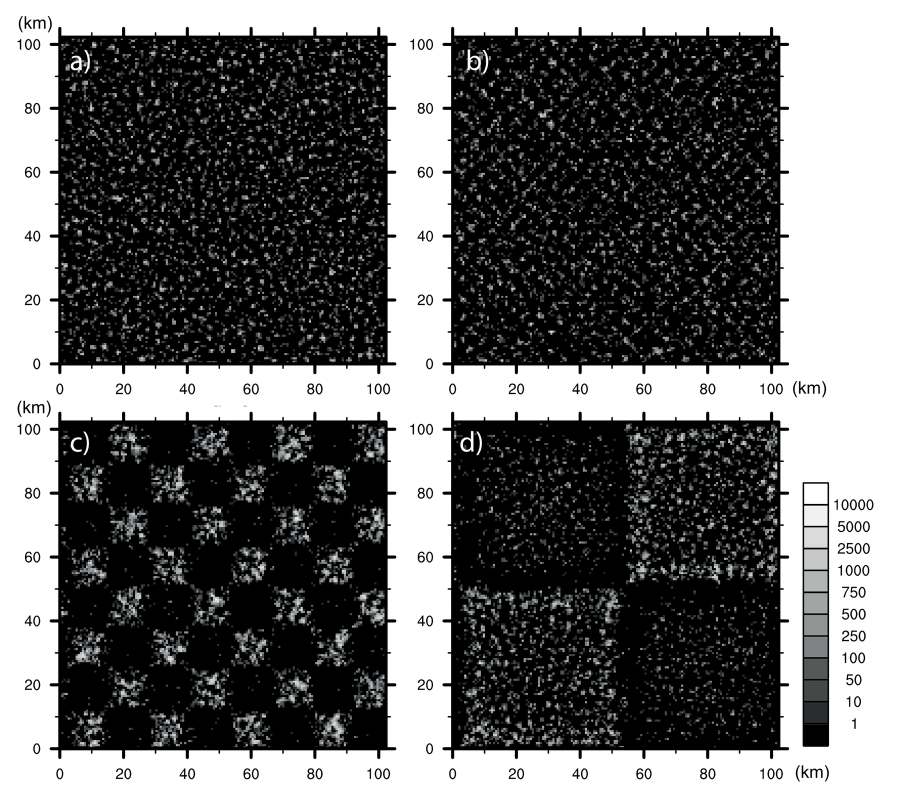


Fig. 4: Liquid water path (gm^{-3}) at 10 LT over surfaces with different heterogeneities length scales.

Rieck, M., C. v. Heerwaarden, and C. Hohenegger, 2013: The influence of land-surface heterogeneities on cloud size development. In preparation.