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# Impact of soil moisture variability on seasonal convective precipitation simulations

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## Why study land-climate interactions?

Relevant for climate variability, extreme events, and seasonal forecasting

**a) High complexity** due to the range of involved feedbacks and interactions

**b) Inconclusive results** evidence for positive, negative, and no feedbacks depending on region and period investigated, model characteristics and resolution.

**c) Possibly important factor affecting climate**

## Research focus

The **regional climate model COSMO-CLM** with a horizontal resolution of 7 km is used to investigate the **interactions** between the land surface and the atmosphere. The investigation time covers the Convective and Orographically-induced Precipitation Study (COPS) period in summer 2007 which provides suitable observations for **model validation and initialization**. Additionally, the impact of the prescribed **soil type** and the **land surface schemes** used as well as the **local soil moisture-precipitation feedback** were investigated .

## How reliable are our regional climate simulations?

To asses with what uncertainties the components of the regional water cycle can be modelled, simulations were validated using COPS observations.

The simulated **precipitation field** showed an underestimation in the complex orographic areas and an overestimation in the valley.

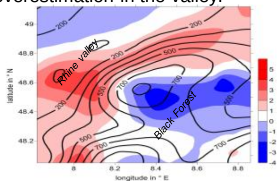


Fig. 1: Precipitation field [mm/day] (colour scale) as a difference between simulations and COPS observations. Orography is indicated by the isolines and the precipitation field is obtained as an average for the summer (JJA) of 2007.

The **soil moisture** distribution showed a strong underestimation in the valley and windward Black Forest areas, (a) too much rain was converted into runoff, and (b) the forcing data was too dry.

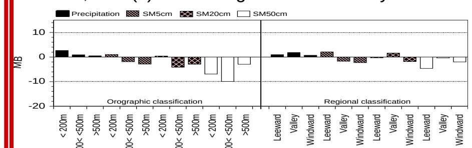


Fig. 2: Calculated Mean Bias (MB) in Vol. % using areal means of soil water content observations and simulations at depths of 5, 20 and 50 cm, and precipitation for the summer period of 2007.

## Soil moisture-precipitation feedback

A **local positive feedback** was found **between the simulated precipitation and soil moisture**, i.e., the precipitation increases when/where soil moisture increases in the complex terrain.

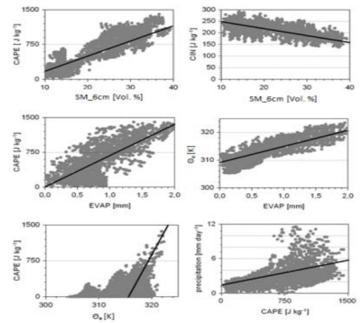

Fig. 3: Higuer CAPE and lower CIN with higher soil moisture and evapotranspiration (EVAP) indicate that wet soil and boundary layer conditions favoured the occurrence of convective precipitation. Higher EVAP was related to higher equivalent potential temperature ($\Theta_e$). CAPE significantly increased when $\Theta_e \geq 315$ K and the daily sum of precipitation revealed an increase with increasing CAPE.

## Impact of realistic initialization

After using COPS soil moisture observations for a new initialization, an **improvement was observed** until the first strong precipitation event occurred. A positive coupling between the soil moisture and the precipitation was found. A decrease of the model bias suggested that continuous correction of soil moisture shows the potential for improving the precipitation pattern. Other variables such as the surface fluxes or CAPE showed higher day to day variability.

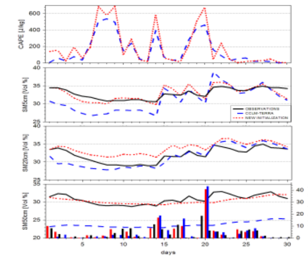

Fig. 4: Time series of the COPS-domain averaged of the temporal evolution daily mean CAPE as well as soil water content at 5, 20 and 50 cm depth and precipitation for the month of June comparing the observations when available and the simulations with the former and new initialization.

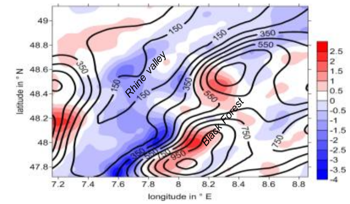


Fig. 5: Precipitation in mm day$^{-1}$ as a difference between the field obtained from the CCLM-VEG3D simulation and the one obtained from the CCLM-TERRA simulation averaged for the summer months of 2007 (JJA).

## Impact of prescribed soil type definition and SVAT models

Important differences were found between the precipitation simulations using the SVATs TERRA_ML and VEG3D.

The use of the more complex land-surface scheme, VEG3D, partially reduced the precipitation biases. An improved simulation of the soil water content, soil temperature, and surface fluxes resulted in a better representation of atmospheric conditions, thus precipitation.

A **strong dependency** was found **between the prescribed soil type and** variables such as the **soil moisture, surface fluxes and precipitation**. An **improved representation of the model soil type** at the near surface **and the use of different soil types within one soil column** showed an improvement on the simulation of precipitation.

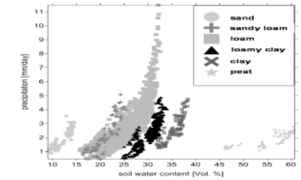


Fig. 6: Simulated summer months (JJA) averaged soil moisture and precipitation for the summer periods of 2005 to 2009 and its relation with respect to the orography, and soil type for the grid points within the investigation area.

## Conclusions

From this investigation important conclusions were obtained which help us to improve our models and to gain knowledge about the soil-atmosphere interactions,

a)important model deficiencies such as errors in the soil type inventory and the initialization of the deeper soil layers were pointed out,

b)a local positive feedback was found between the soil moisture and precipitation through the impact of soil conditions on boundary layer and thus precipitation,

c)realistic initialization of the model with soil moisture resulted in an improvement of the simulations until a extreme precipitation event removes the soil memory,

d)better results were obtained when simulations were conducted with the more complex VEG3D land surface scheme.

## References

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