Evaluation of a 10-year cloud-resolving climate simulation driven by ERA-Interim

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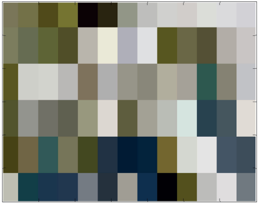
COSMO/CLM User seminar
March 2013

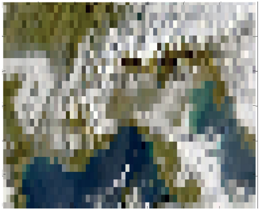
Outline

Clouds in climate model

GCM (100 km)



RCM (25 km)



- GCM & RCM: Parametrization of convective clouds
  - Underestimation of diurnal temperature range, overestimation of clouds, summer convective precipitation poorly represented (e.g. Dai and Trenberth, 2004; Brockhaus et al., 2008)

(Figures: E. Zubler)

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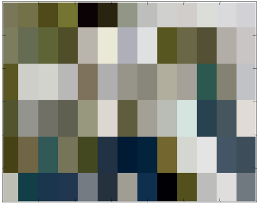

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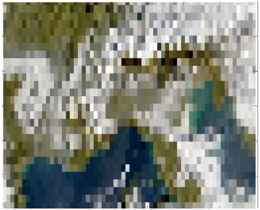
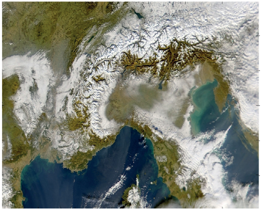


CRM (1 km)



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- CRM: Convection explicitly resolved

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Cloud-resolving modelling

Experience with NWP $\rightarrow$ CRM leads to better forecast (e.g. Mass et al., 2002; Richard et al., 2007)

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Climate time scale

- Process studies
  - CRM reproduces a better timing of convective diurnal cycle (e.g. Hohenegger et al., 2008)
  - Physical and numerical convergence of CRM (Langhans et al., 2012)
  - CRM yields negative soil-moisture precipitation feedback (Hohenegger et al., 2009)
- Application to long-term scenario simulations has been very limited

Today

- CRM simulation for the greater Alpine region
  - 10 year long period: 1998-2007
  - driven by ERA-Interim reanalysis

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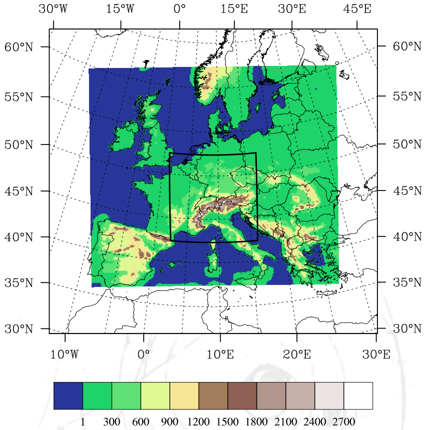
Objectives

- To evaluate the CRM climate simulation against observational datasets and to compare it against coarser climate simulation
- Does the CRM model improve the representation of geographical distribution of precipitation climatology and precipitation statistics (daily/hourly statistics)?
- To investigate whether and how the scaling of precipitation extremes with temperature in CRM model follows the expectations from the Clausius-Clapeyron relation

Setup

Two step one way nesting: ERA-Interim ⇒ CPM ⇒ CRM

- CPM
  - 12 km (0.11°)
- CRM
  - 2.2 km (0.02°)



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  - Parametrization of convection: Tiedtke
  - Spin-up: 5 years
- CRM
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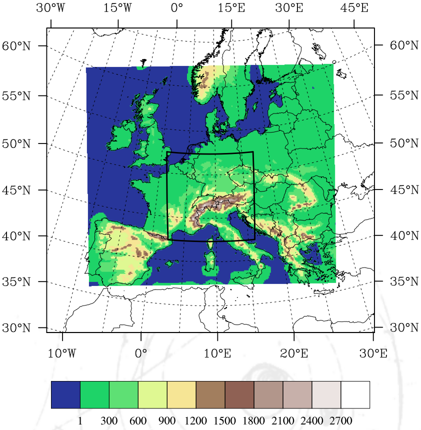
  - Convection explicitly resolved
  - Shallow convection: Tiedtke
  - Spin-up: 2 months



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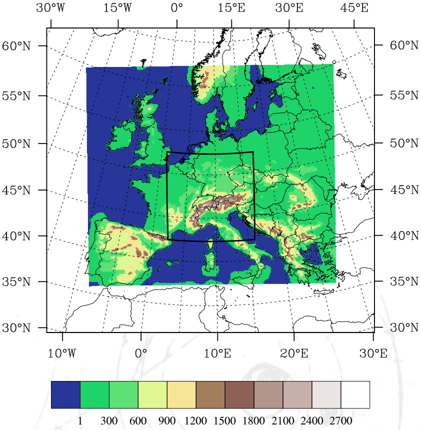


Model

COSMO-CLM 4.14

Observations

EOBS

- Gridded dataset, horizontal resolution 0.25°
- Temperature (version 7.0), Precipitation (version 5.0)

CH (Meteoswiss)

- High resolution (0.01°) gridded precipitation dataset, available over Switzerland
- Based on radar and raingauge data, not corrected for gauge undercatch
- Daily precipitation (1998-2006), Hourly precipitation (2004-2007)

ANETZ

- 24 Swiss station, 1998-2007
- T2M, SW↓, Precipitation

★ T2M → Simple height correction applied (0.65 K/100m)

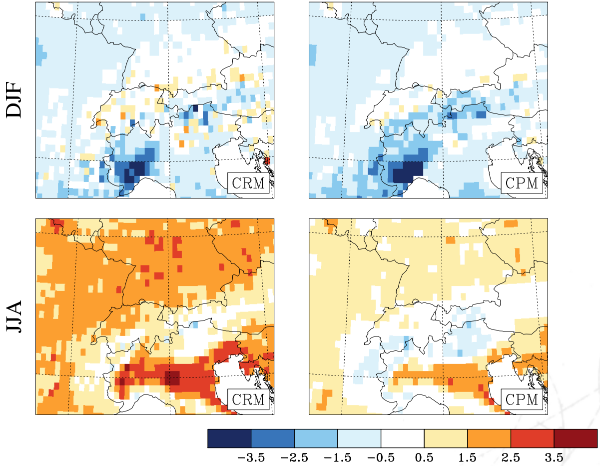
Evaluation

Evaluation

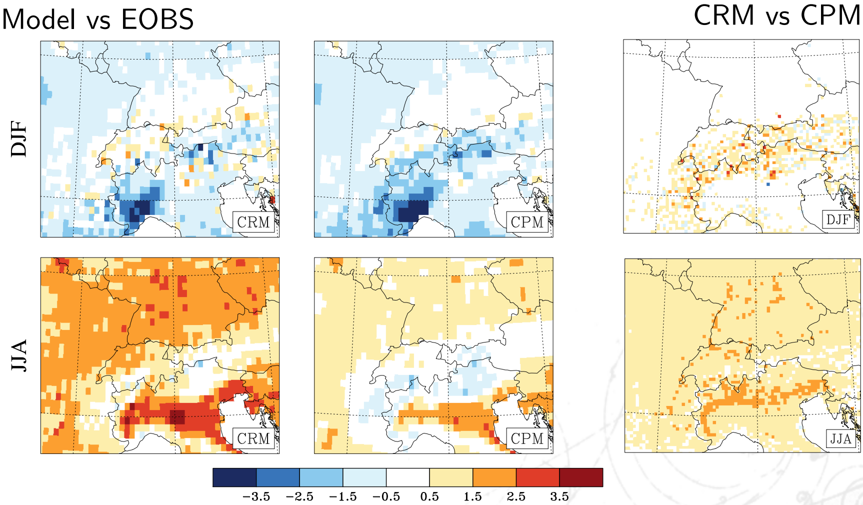
T2M, SEB

Temperature

Model vs EOBS



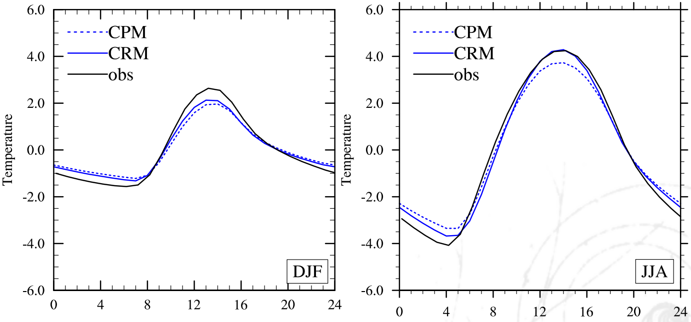
Temperature



Diurnal cycle of temperature

Perturbation of a daily temperature:

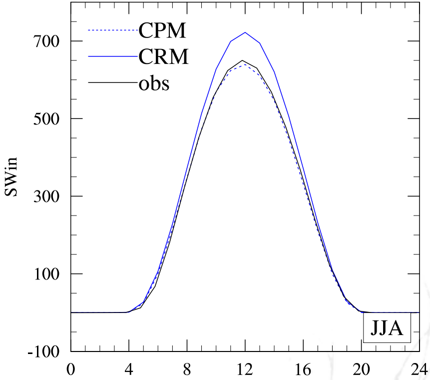
$$T' = T(\tau) - \overline{T}$$



[Analysis for 24 Swiss station]

- T' better presented by CRM

Diurnal cycle of SW↓



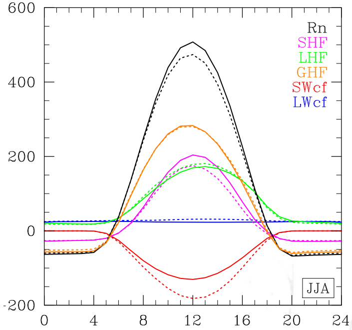
[Analysis for 24 Swiss stations]

- JJA → CRM overestimates SW↓ by up to 100 Wm^{-2}

Surface energy budget

Surface energy budget: Q = Rn + SHF + LHF + GHF

Net radiation: Rn = SHF + LHF + GHF



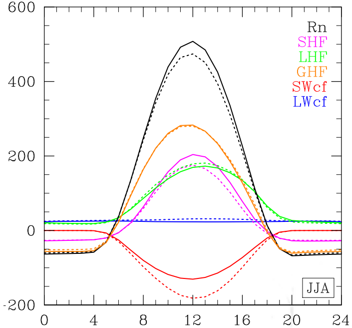
[CRM-solid lines, CPM-dashed lines]

- JJA → CRM: SHF>LHF → dry soil

Surface energy budget

Shortwave cloud forcing: SWcf = SWn - SWn(clear sky)

Longwave cloud forcing: LWcf = LWn - LWn(clear sky)



[CRM-solid lines, CPM-dashed lines]

- SWcf(CPM) < SWcf(CRM) → less clouds in CRM → more SW↓ → higher temperature

Reduced cloud cover (CRM vs. CPM)

★ Modified PBL scheme in CRM, graupel scheme

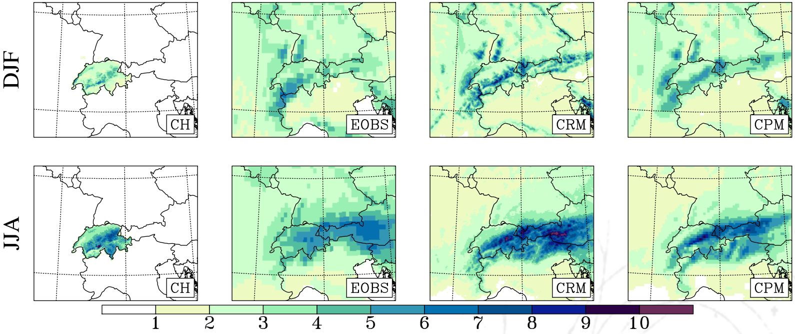
★ Validation of clouds against observations is underway (Michael Keller)

★ Langhans et al., 2012 → Both models, CPM and CRM overestimate cloud cover (over the Alps)

Evaluation

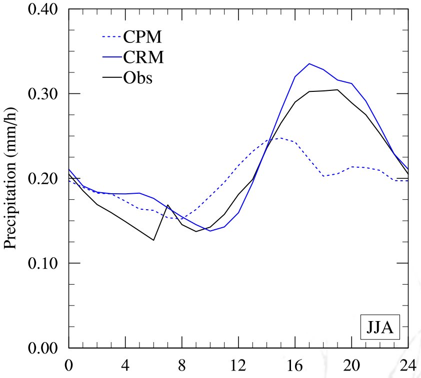
Precipitation

Mean precipitation



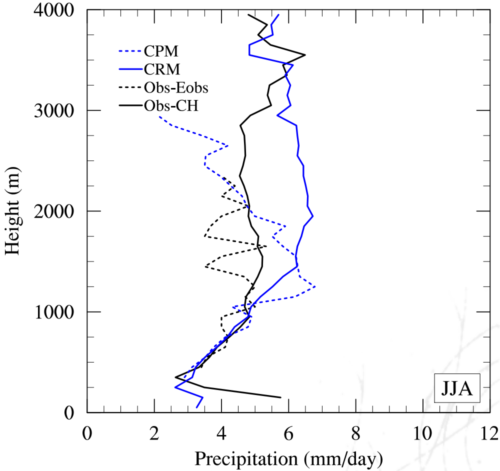
- DJF → Similar large-scale patterns for both models
- JJA → Too dry over NW part of domain and too wet over Alps for both models

Diurnal cycle of summer precipitation



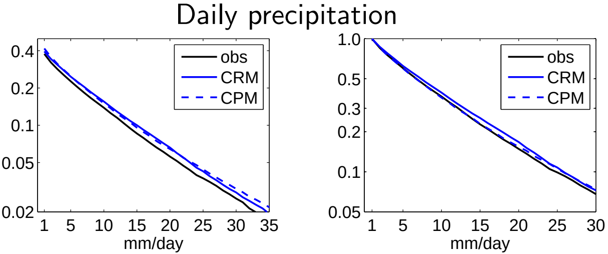
- Unlike CPM, CRM gives a much better representation of diurnal cycle

Mean precipitation as a function of height



[The analysis covers only Switzerland]

Frequency distribution of precipitation (JJA)



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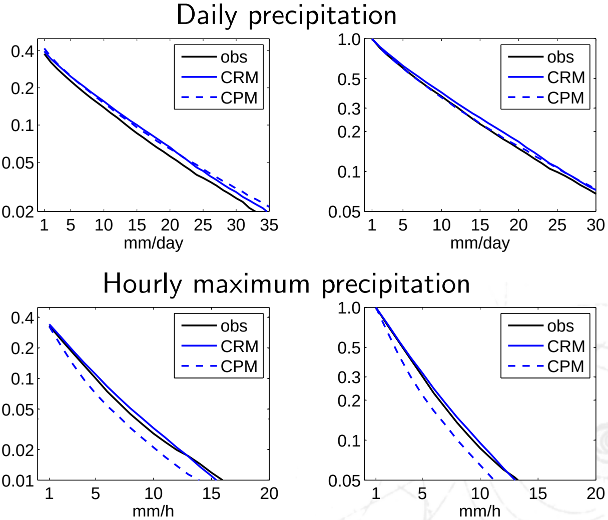

[Analysis for 24 Swiss stations; W&D days (hours)-left, W days (hours)-right column]

Evaluation

The scaling of precipitation extremes with temperature

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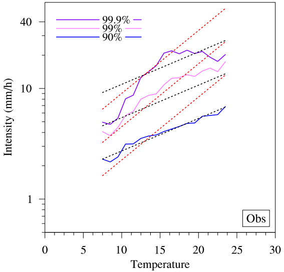
★ 7% increase per °C

★ 14% increase per °C

[Analysis for 24 Swiss stations, JJA]



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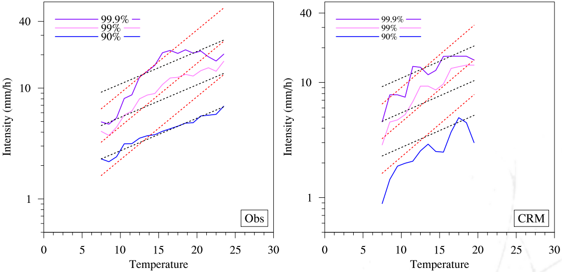

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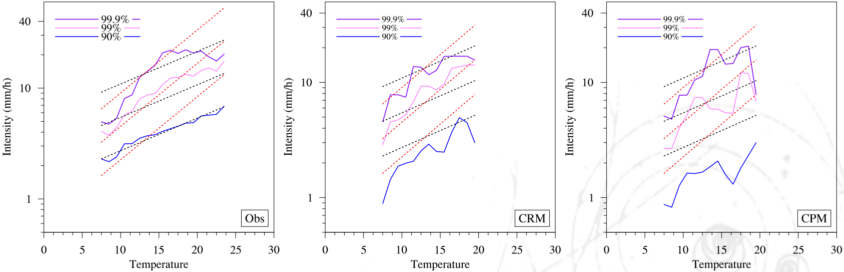

Conclusion and Outlook

- Differences in biases between CPM and CRM are comparatively small, and likely due to differences in cloud forcing
- CRM improves the simulation on sub-daily time-scale (Timing of summer convection)
- CPM has a poor diurnal cycle associated with the use of parametrized convection
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