Influence of initial condition perturbations in COSMO-DE-EPS under different weather regimes

Christian Kühnlein[1], Christian Keil[1], George Craig[1], Christoph Gebhardt[2]

[1]Hans Ertel Zentrum für Datenassimilation, LMU München

[2]Deutscher Wetterdienst, Offenbach

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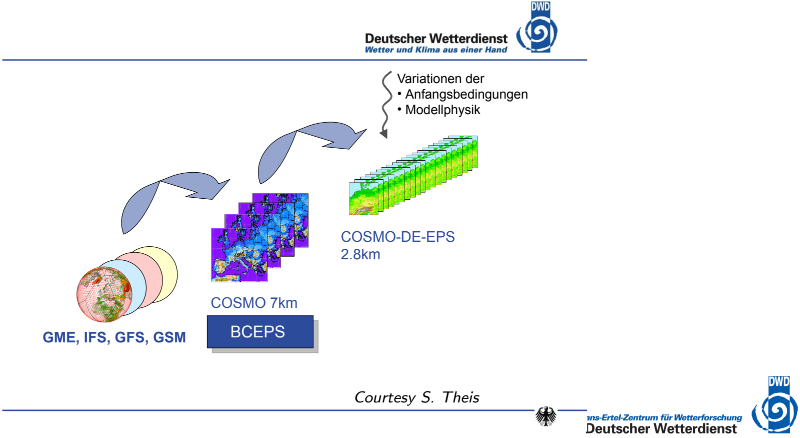
4-year project within Hans-Ertel centre (HErZ) for data assimilation at LMU München:

⇒ Study and improve the uncertainty representation in the convection-permitting ensemble prediction system COSMO-DE-EPS

- Analysis of current pre-operational COSMO-DE-EPS
  - → Study influence of recently introduced initial condition (IC) perturbations
  - → How does the EPS behave under distinct weather regimes

⇒ Experimental version of COSMO-DE-EPS with perturbations of lateral boundary conditions and perturbed parameters in selected physics schemes since 2007 (Gebhardt et al., 2011)

⇒ 20-member COSMO-DE-EPS with additional initial condition perturbations pre-operational at DWD since Dezember 2010 (Peralta et al., 2011)



Courtesy S. Theis

Study the influence of initial condition perturbations in COSMO-DE-EPS

Comparison of two EPS:

(i) "IBP": pre-operational COSMO-DE-EPS with (IC+BC+PH) perturbations

(ii) "BP": special "Experiment 8247" in COSMO-DE-EPS with only (BC+PH) perturbations

- ◇ Both IBP and BP use 20 ensemble members
- ◇ 3.5 month period from May 1st to August 15th 2011
- ◇ 21 h-forecasts with initialisation times 00,<u>06</u>,12,18 UTC
- ◇ Verification of total precipitation using DWD's high-resolution radar composite

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Convective adjustment time scale

- ◇ We are interested in the EPS performance of convective precipitation forecasts under different meteorological conditions – strong vs. weak synoptic-scale forcing
- ◇ Consider convective adjustment time scale τ_c (Done et al. 2006; Zimmer et al. 2011; Keil and Craig 2011):

$$\tau_c = \frac{CAPE}{d(CAPE)/dt} = 0.5 \left(\frac{\rho_0 c_p T_0}{L_v g} \right) \frac{CAPE}{P}$$

→ τ_c represents the rate at which convection releases conditional instability.

→ τ_c small (e.g. <6 h) indicates equilibrium convection (strong forcing)

→ τ_c large (e.g. >6 h) indicates non-equilibrium convection (weak forcing)

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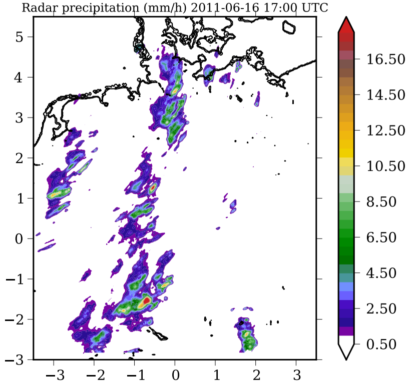
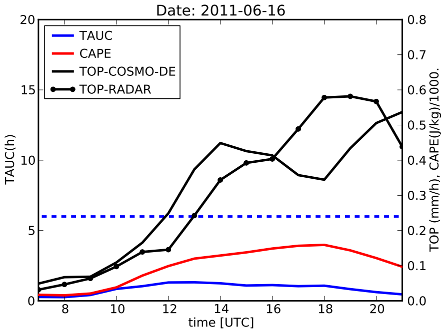
Convective time scale: typical example for STRONG forcing conditions

Frontally-forced precipitation



Spatially-averaged τ_c small



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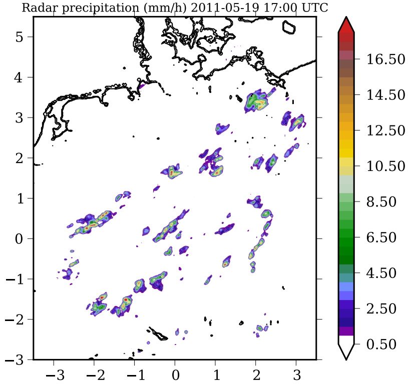
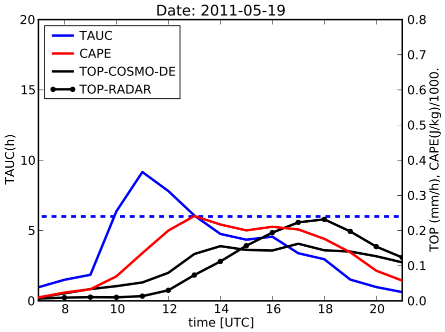
Convective time scale: typical example for WEAK forcing conditions

Locally-forced convective precipitation



Spatially-averaged τ_c large



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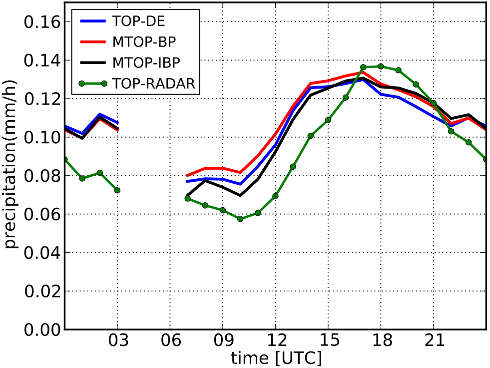
Spatio-temporal mean of hourly precipitation (regime-independent)



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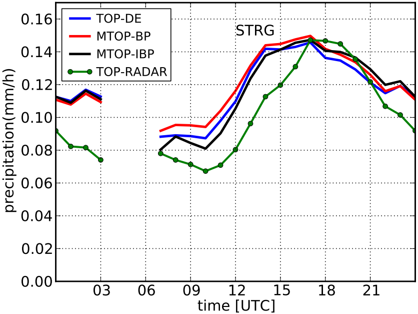
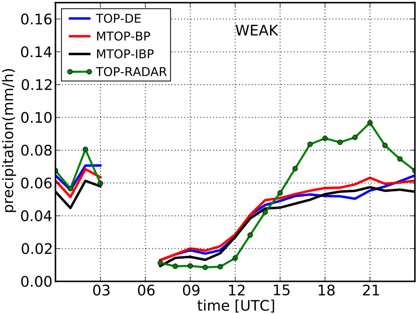
Spatio-temporal mean of hourly precipitation (strong vs. weak forcing)

	strong: $\langle\tau_c\rangle_{max} < 6\ h$	weak: $\langle\tau_c\rangle_{max} > 6\ h$	"dry"	missing	total
number of days	80	16	6	5	107

All days (80) with $\langle\tau_c\rangle_{max} < 6\ h$



All days (16) with $\langle\tau_c\rangle_{max} > 6\ h$



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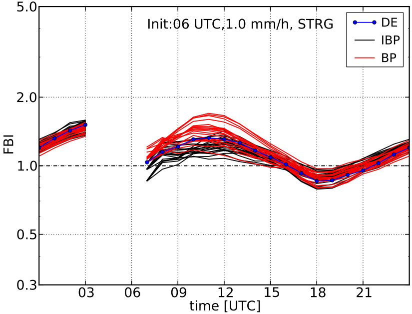
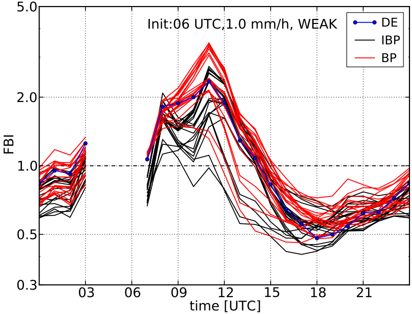
Forecast time series of frequency bias index (FBI); init 6 UTC

All days with $\langle \tau_c \rangle_{max} < 6\ h$



All days with $\langle \tau_c \rangle_{max} > 6\ h$



$$\text{FBI} = \frac{hits + false\ alarms}{hits + misses}$$

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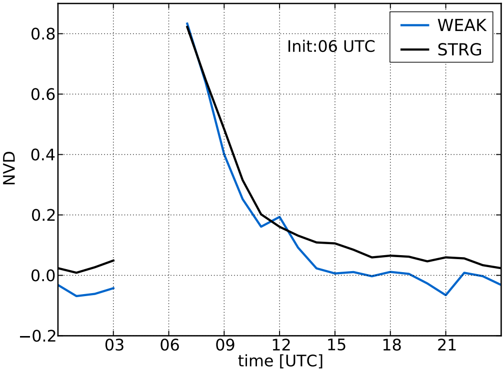
Influence of initial condition perturbations on ensemble variance



Normalised variance difference (Clark et al., 2009; Gebhardt et al., 2011):

$$NVD = \frac{var(P_{IBP}) - var(P_{BP})}{var(P_{IBP}) + var(P_{BP})}$$

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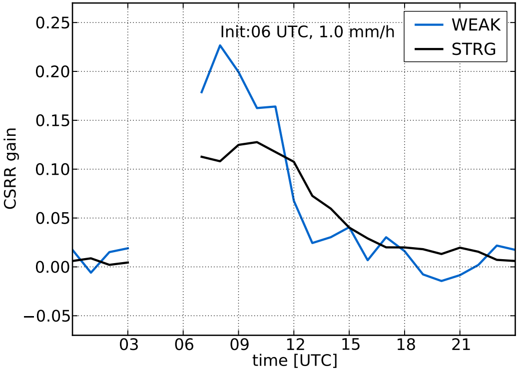

Single-threshold (1mm/h) conditional square-root of ranked probability score (Germann and Zawadzki, 2003; Kober et al., 2011):

$$\mathrm{CSRR}(t) = \left(\frac{1}{\tilde{\tilde{\Omega}}} \int_{\Omega} \left[p(t_0 + t, \mathbf{x}) - \hat{p}(t_0 + t, \mathbf{x}) \right]^2 d\mathbf{x} \right)^{0.5}$$

Consider CSRR gain:

$$\mathrm{CSRRG} = 1 - \frac{\mathrm{CSRR}_{\mathrm{IBP}}}{\mathrm{CSRR}_{\mathrm{BP}}}$$

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Summary and future work

Selected results:

- ⇒ Response of the EPSs different under different meteorological conditions
- ⇒ Both EPSs and COSMO-DE overestimate the precipitation under strong forcing, and underestimate precipitation under weak forcing conditions
- ⇒ FBI shows much larger error amplitude and spread for weak forcing days than for strong forcing days
- ⇒ Generally, positive impact of IC perturbations on ensemble variance (e.g. NVD) and probabilistic measures (e.g. CSRR), which applies to either strong or weak forcing conditions
- ⇒ Impact of IC perturbations on NVD and CSRRG is particularly large in the first 6-9 hours. Impact is longer lasting under strong forcing conditions, and decays faster under weak forcing conditions.

Future work in HErZ-DA project:

- ◇ Compare current IC perturbations to IC perturbations from COSMO-KENDA.
- ◇ Introduce and investigate stochastic physics perturbations – e.g. in atmospheric boundary layer scheme (K. Kober, LMU München).

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