Simulations with different convection parameterizations in the LM

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Aims

- What is the effect of different convection schemes on the forecast?
- Which systematic patterns are typical of each scheme?
- What can we learn for improving convection schemes?

(1) **Elbe - Flooding**

- 3 LM runs with different convection schemes
  - Tiedtke (operational)
  - Kain-Fritsch (option)
  - Bechtold (new option)
**LM - Model Setup**

- 48h forecast with the LM (11.08.02 00UTC – 12.08.02 24UTC)
- LM with:
  - Operational Setup (325x325x35 gridpoints)
  - 7km horizontal resolution
  - Analysis and boundary condition from DWD
  - gridscale prognostic precipitation scheme with cloud ice

**Operational Model Domain**

Region of major rainfall
### Main characteristics of the different convection schemes

<table>
<thead>
<tr>
<th>Tiedtke</th>
<th>Kain-Fritsch</th>
<th>Bechtold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moisture-convergence-closure</strong> (moisture balance at cloud base)</td>
<td>CAPE-Closure (enhance mass-flux until 90% of initial CAPE is removed during an adjustment period)</td>
<td>CAPE-Closure</td>
</tr>
<tr>
<td><strong>Entrainment/Detrainment by turbulent mixing and organized inflow</strong></td>
<td>Entrainment/Detrainment by turbulent mixing, Minimum entrainment rate</td>
<td>Entrainment/Detrainment by turbulent mixing</td>
</tr>
<tr>
<td><strong>Trigger criterium:</strong> Updraft source layer ~ model layer thickness</td>
<td><strong>Trigger criterium:</strong> Updraft source layer ~ 60hPa</td>
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</tr>
<tr>
<td>Temperature increment</td>
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</tr>
<tr>
<td>$dT = 0.5$</td>
<td>$dT = \text{MAX}(0, 4.64(\bar{w} - \frac{0.02z_{LCL}}{2000})^{1/3})$</td>
<td>$dT = \pm 6\bar{w}^{1/3}$</td>
</tr>
</tbody>
</table>
Basics about working-mechanism of the Bechtold-scheme

- **DDT**: Top of Downdraft Detrainment Layer
- **LFS**: Level of free sinking
- **ETL**: Equilibrium Temperature Level
- **BAS**: Cloud Base Level
- **TOP**: Cloud Top Level
Daily course of hourly convective precipitation with maximum in the early afternoon
Bechtold and Tiedtke produce similar amounts of convective gridscale and total precipitation
Kain-Fritsch produces least amount of convective precipitation
Animation of precipitation rates in the target region

Heavy rainfall at Mountain site

Low precipitation rates but spread over a large region

Convective precipitation at backside of front
Precipitation in mountainous region of Erzgebirge

- **Tiedtke** produces large amount of (convective) precipitation in mountains due to moisture convergence closure

- **Bechtold + Kain-Fritsch** only act when front arrives

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Low precipitation before front arrives

Heavy rainfall before front arrives
Effect on 10m wind field
Summary of Elbe-case

- Tiedtke: Predicts much precipitation in mountainous regions, precipitation pattern is scattered and has strong maxima.
- Bechtold: Predicts precipitation in connection with the backside of the front, but in other regions predicted precipitation rates are small and spread over too large areas.
- Kain-Fritsch: Total precipitation rates are small but once activated it produces large amount of precipitation, total convective precipitation is least of all schemes – triggering refuses convection too much?
- All convection schemes are most active in early afternoon.

Further work: Comparison with observations
- Closer look at single processes (triggering, subsidence, en/detrainment)
- Effect of convection schemes on moisture field and wind field
- Other case studies
Model Setup

- Model domain consist of 2/3 sea and 1/3 land (100x36x35 gridpoints, \( dt = 40 \))
  - sea breeze will develop
- No radiation and Coriolis force
- Periodic boundary conditions
- Ground temperature varies sinusoidally at each grid point
- Stable initial sounding for initialization of temperature- and humidity profile
- 18h forecast, 3 LM runs with Tiedtke scheme, Kain-Fritsch scheme and Bechtold scheme
Precipitation rate (mm/h) after 9h of forecast

Coloured: convective precipitation
Contoured: gridscale precipitation
Arrows: 10m wind field

- sea-breeze has developed at east coast
Precipitation rate (mm/h) after 13h of forecast
Coloured: convective precipitation
Contoured: gridscale precipitation
Arrows: 10m wind field
Domain averaged hourly precipitation rate

Convective precipitation

- **Bechtold**: activates first gridscale precipitation at end of forecast
- **Tiedtke**: produces largest amounts of convective precipitation after 5-8 hours of forecast nearly no gridscale precipitation
- **Kain-Fritsch**: least amount of convective precipitation (relatively) large amount of gridscale precipitation activates last nearly no precipitation after 15h of forecast

Gridscale precipitation
Time and west-east variation of convective precipitation (averaged over latitude)

- **Bechtold**: at the beginning only precipitation at cost lines, later precip. regions move to east coast
- **Kain-Fritsch**: main precipitation region along east coast
- **Tiedtke**: light precipitation over whole land, but strong precip. at west coast
Conclusions

- Precipitation patterns produced by schemes are very different
  - Variation in: spacial distribution
    - time distribution
    - amount of precipitation

- **Bechtold** tends to activate *first* and **Kain-Fritsch** *last*

- **Tiedtke** shows tendency to produce *single* points with *strong* precipitation
  - and **Bechotld** shows tendency to produce *larger* areas with *light* precipitation

- **LM** with **Kain-Fritsch** has *largest* amount of *gridscale* precipitation

- **Tiedtke** does NOT predict sea-breeze correctly

- **Bechtold**: qualitative good results
  - potential Weakness: Trigger-criterium