Meteorologisches Institut Universität Bonn

Uni Bonn
RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT

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

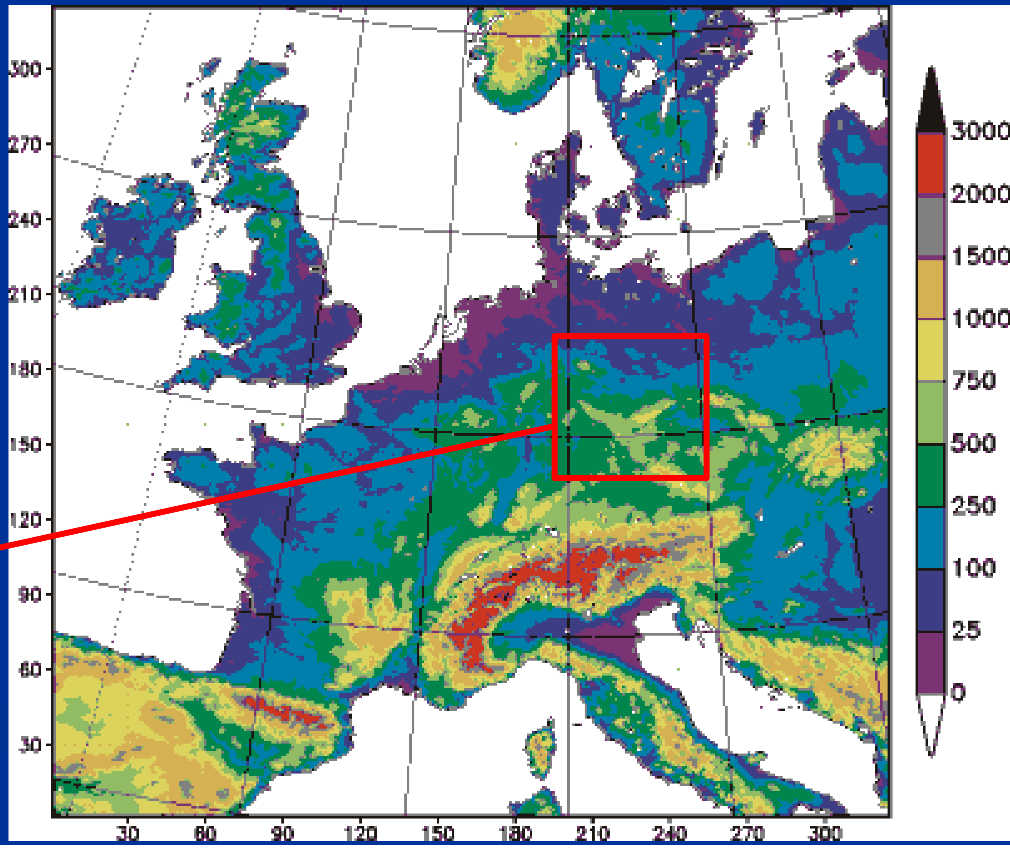
- 3 LM runs with different convection schemes
  - Tiedtke (operational)
  - Kain-Fritsch (option)
  - Bechtold (new option)

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 clound ice

Operational Model Domain

Region of major rainfall

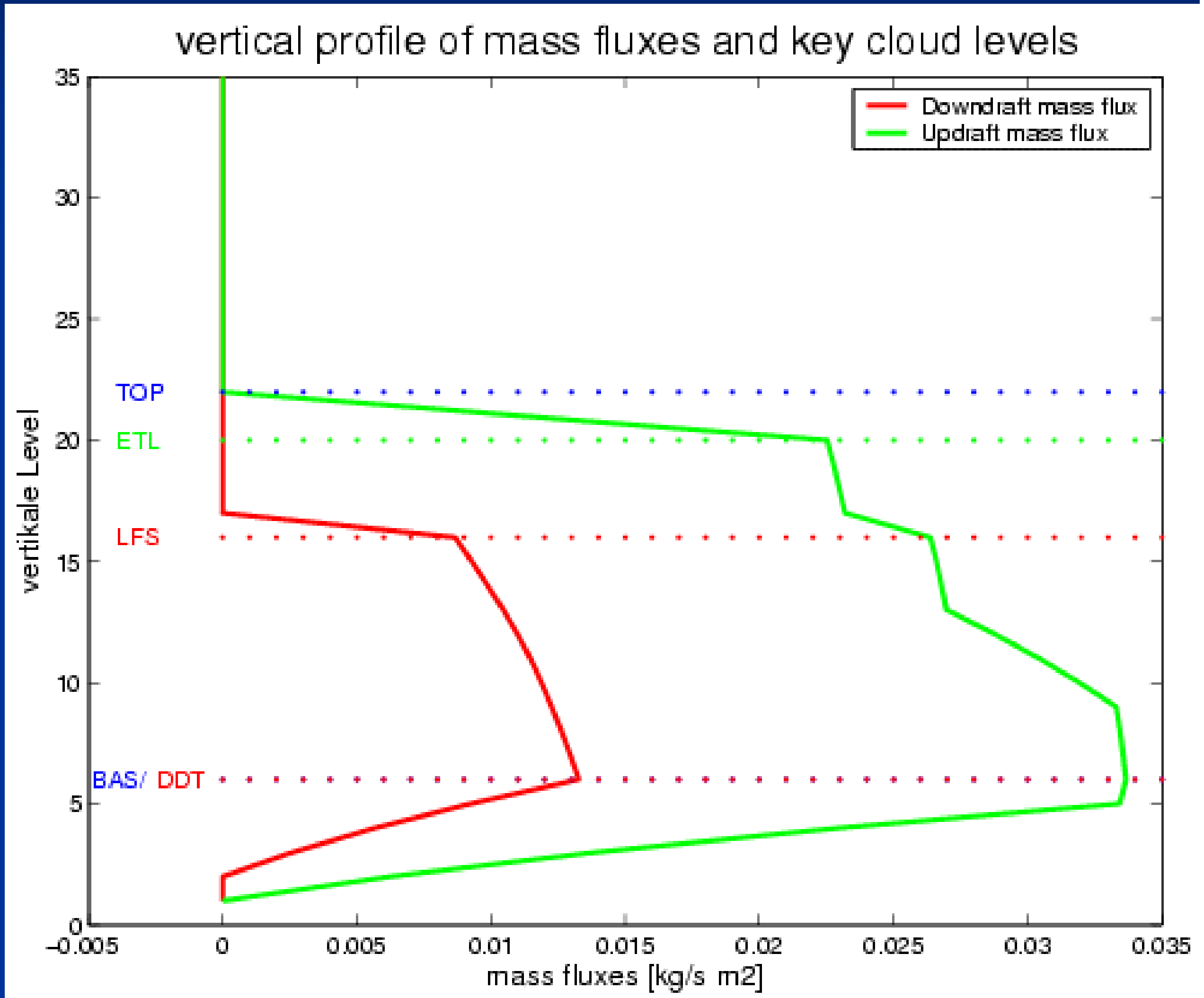


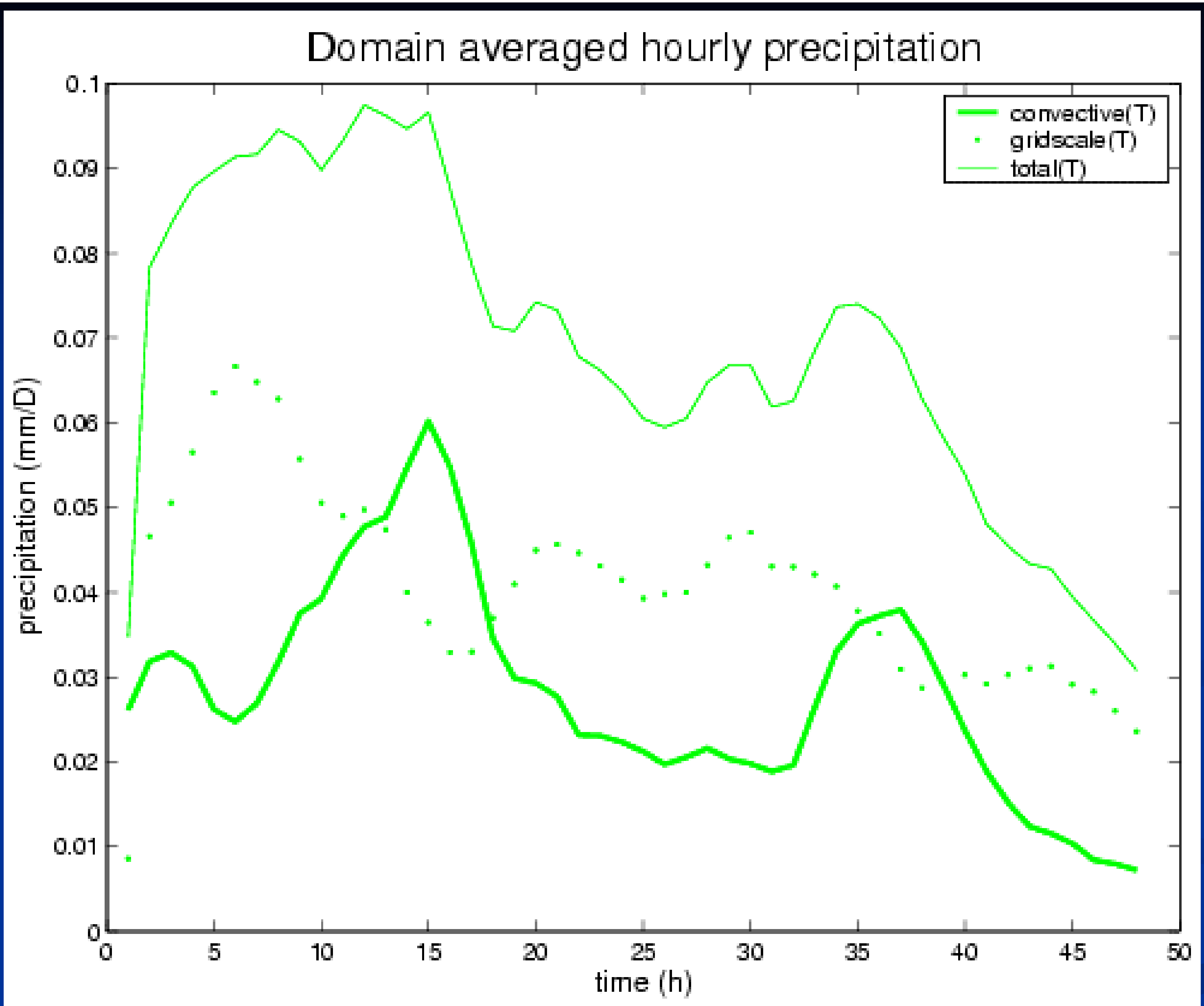
Main characteristics of the different convection schemes

Tiedtke	Kain-Fritsch	Bechtold
Moisture-convergence-closure (moisture balance at cloud base)	CAPE-Closure (enhance mass-flux until 90% of initial CAPE is removed during an adjustment periode)	CAPE-Closure
Entrainment/Detrainment by turbulent mixing and organized inflow	Entrainment/Detrainment by turbulent mixing, Minimum entrainment rate	Entrainment/Detrainment by turbulent mixing
Trigger criterium: Updraft source layer ~ model layer thickness Temperature increment $dT = 0.5$	Trigger criterium: Updraft source layer ~ 60hPa Temperature increment $dT = MAX(0, 4.64(\overline{w} - \frac{0.02 z_{LCL}}{2000})^{1/3})$	Trigger criterium: Updraft source layer ~ 60hPa Temperature increment $dT = \pm 6 \overline{w}^{1/3}$

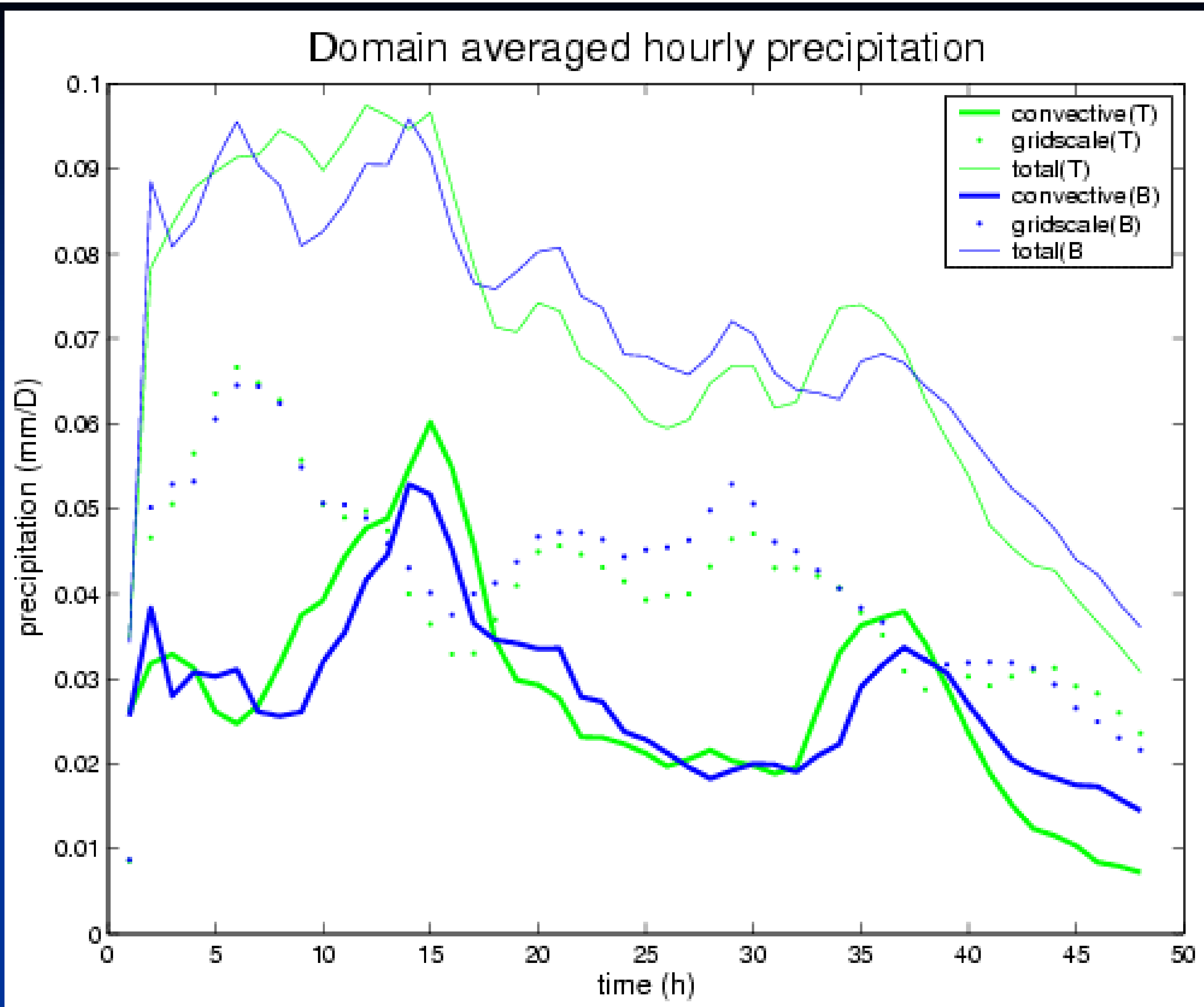
Basics about working-mechanism of the Bechtold-scheme

- **DDT:** Top of Downdraft Detrainment Layer
- **LFS:** Level of free sinking
- **ETL:** Equilibrium Temperature Level
- **BAS:** Cloud Base Level
- **TOP:** Cloud Top Level

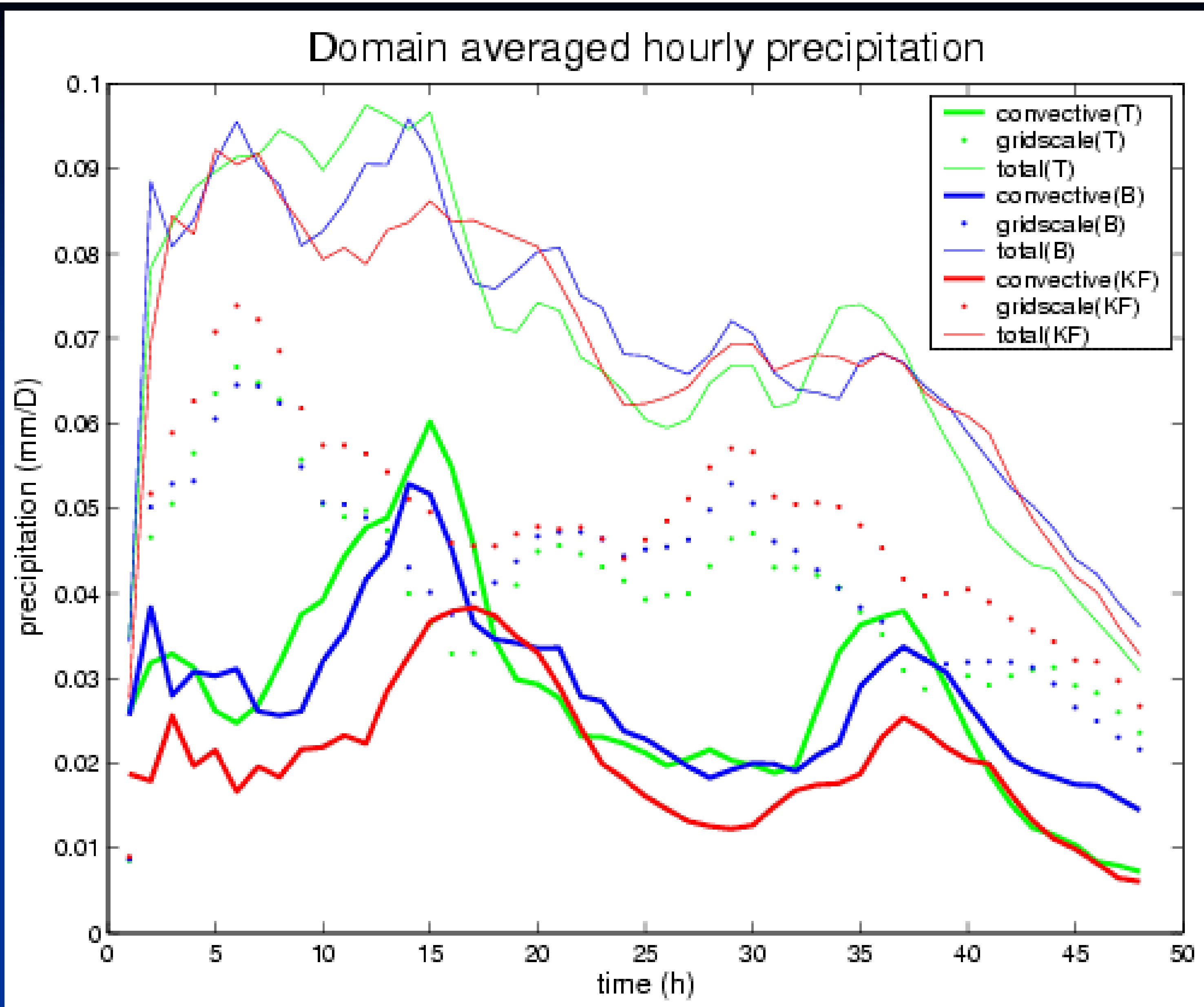




Daily course of hourly convective precipitation with maximum in the early afternoon



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

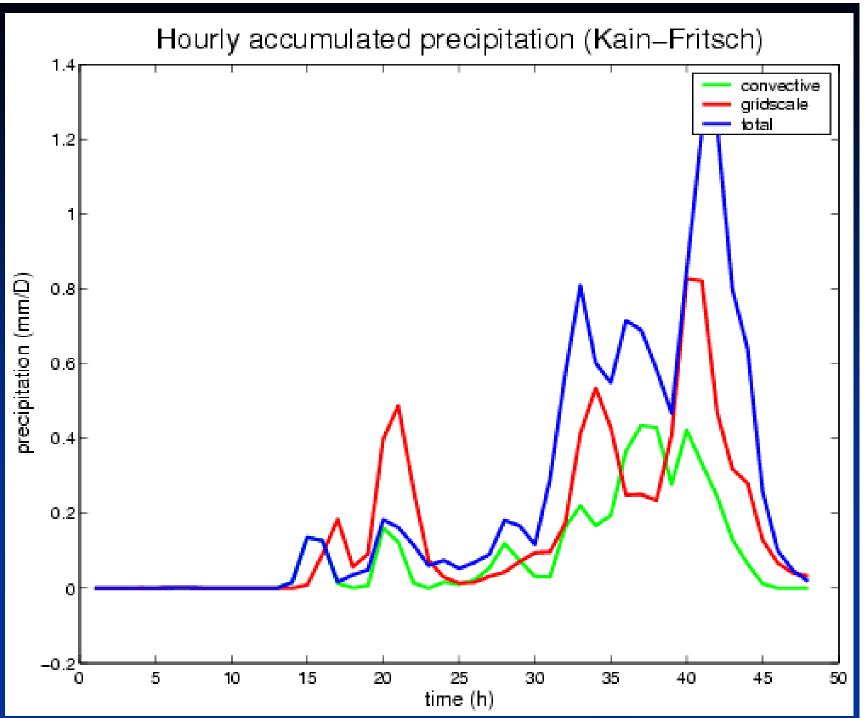
Convective
crecipiatin at
backside of front

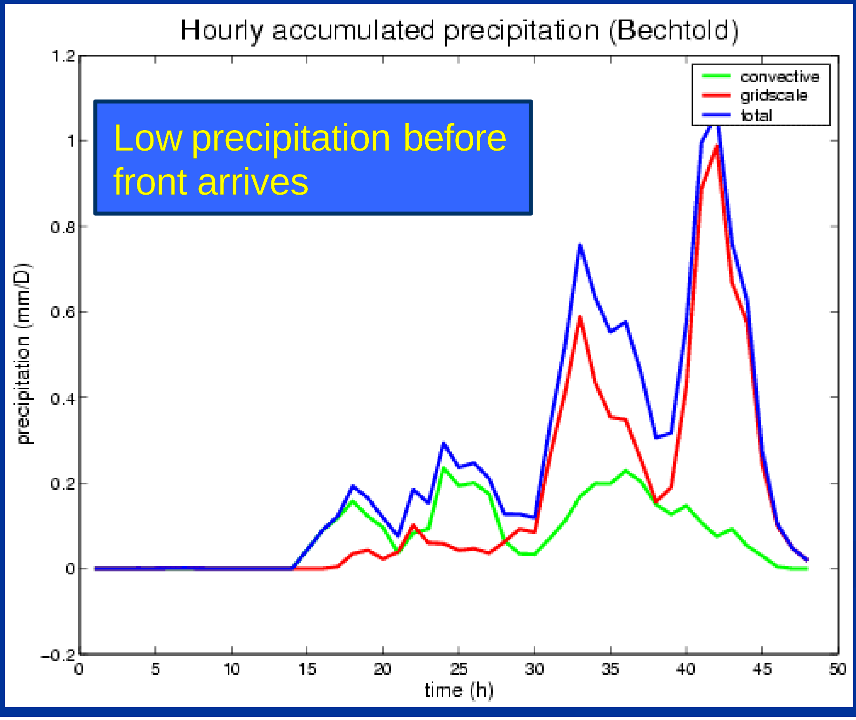
Low precipitation
rates but spread
over a large region

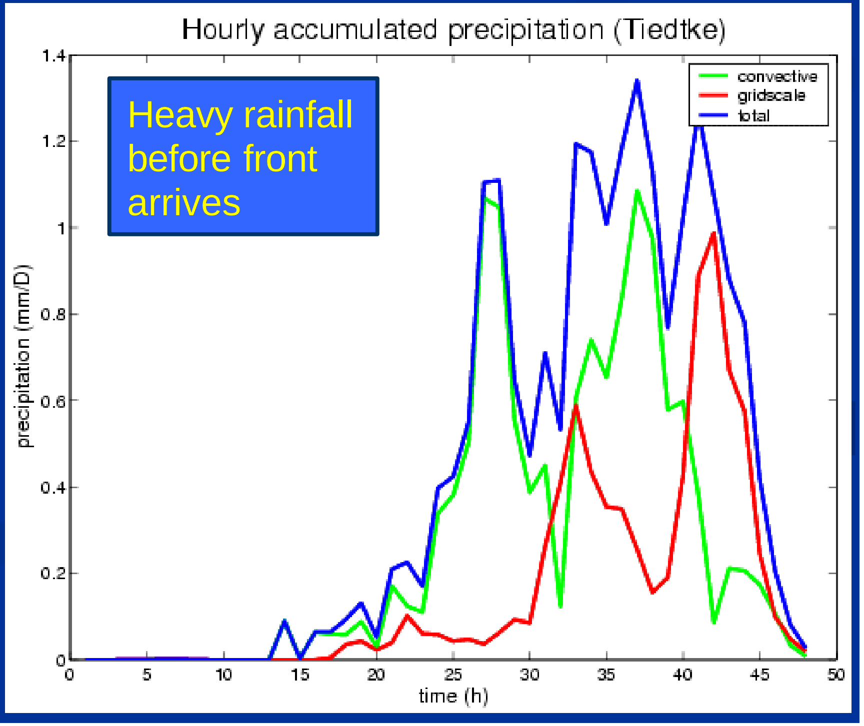
Precipitation in mountainous region of Erzgebirge

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

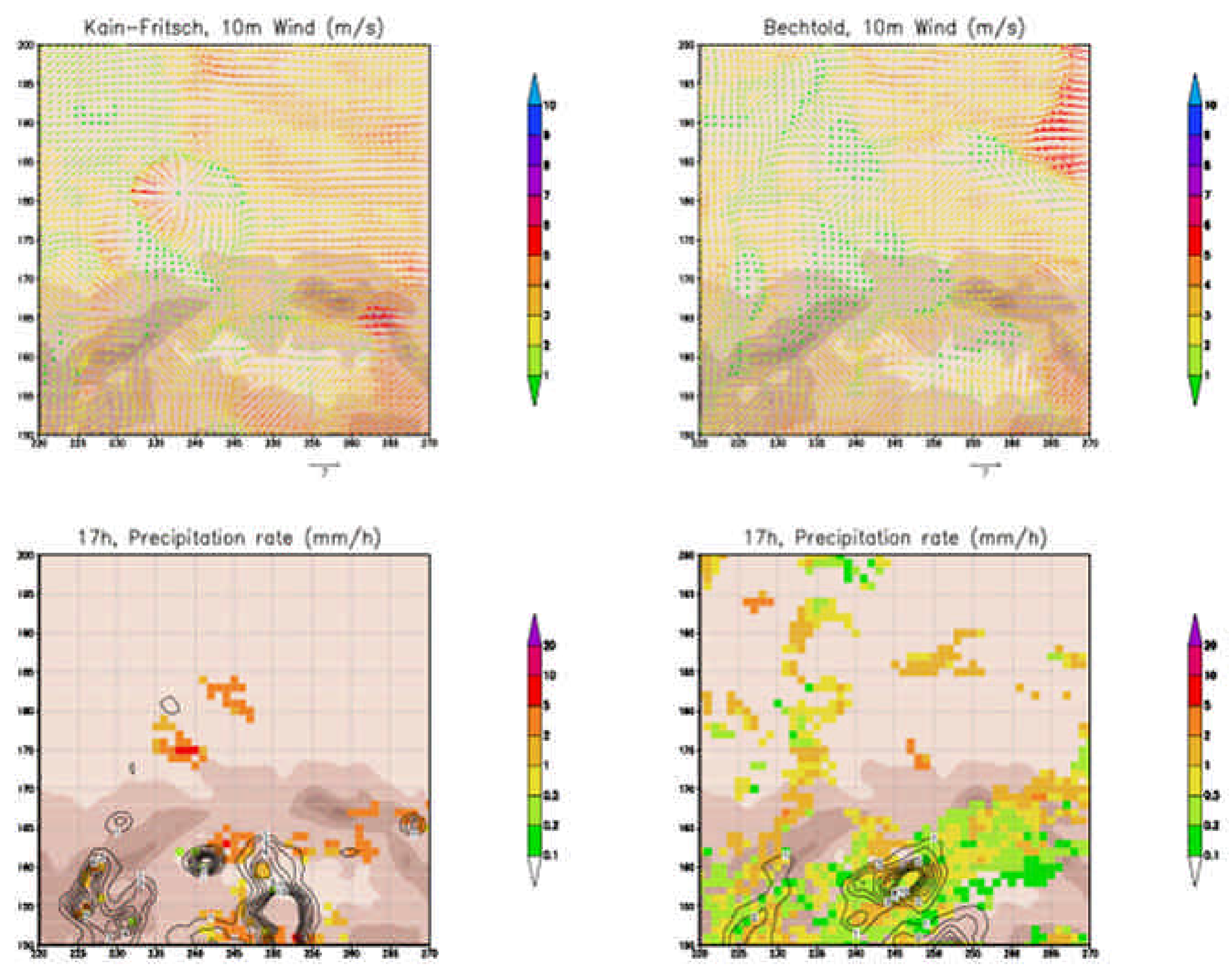
- **Bechtold** + **Kain-Fritsch** only act when front arrives







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.

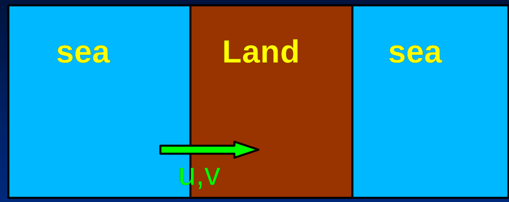
- Further work: Comparison with observations

  Closer look at single processes (triggering, subsidence, en/detrainment)

  Effect of convection schemes on moisture field and wind field

  Other case studies

(2) Idealized Case

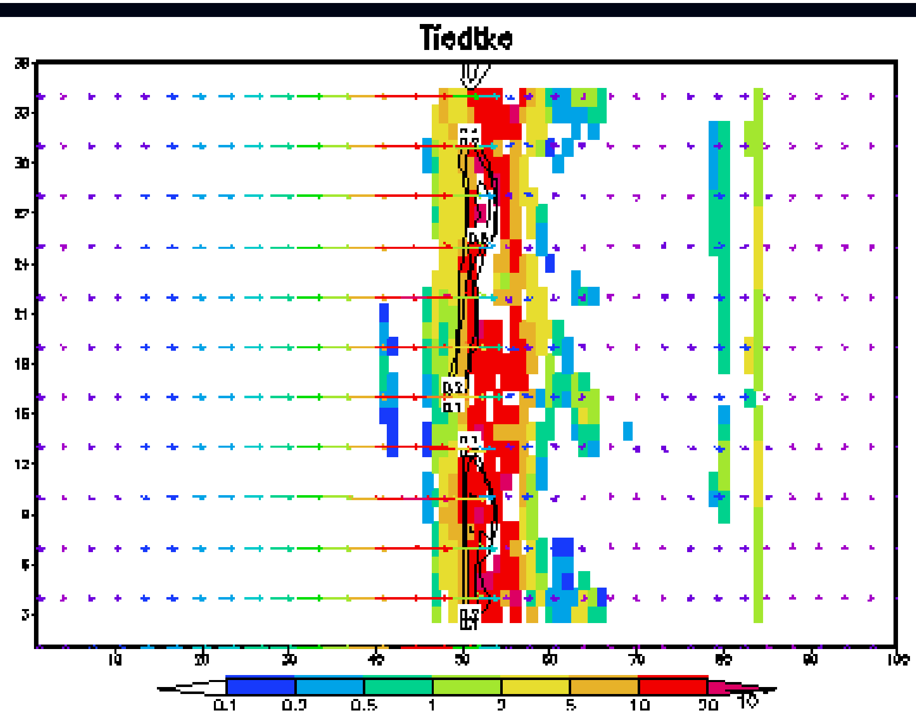


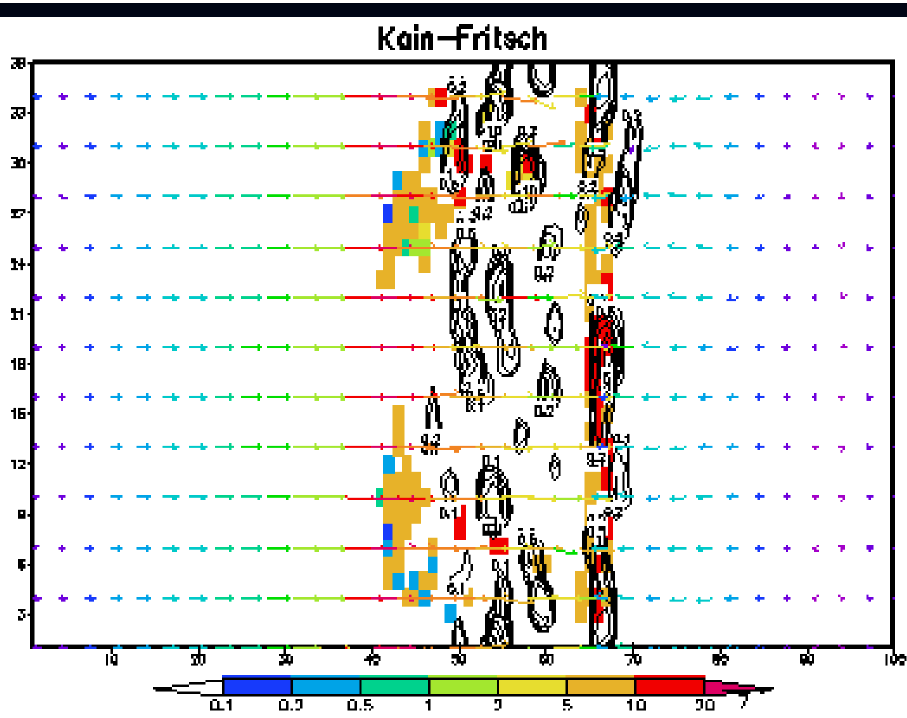
Model Setup

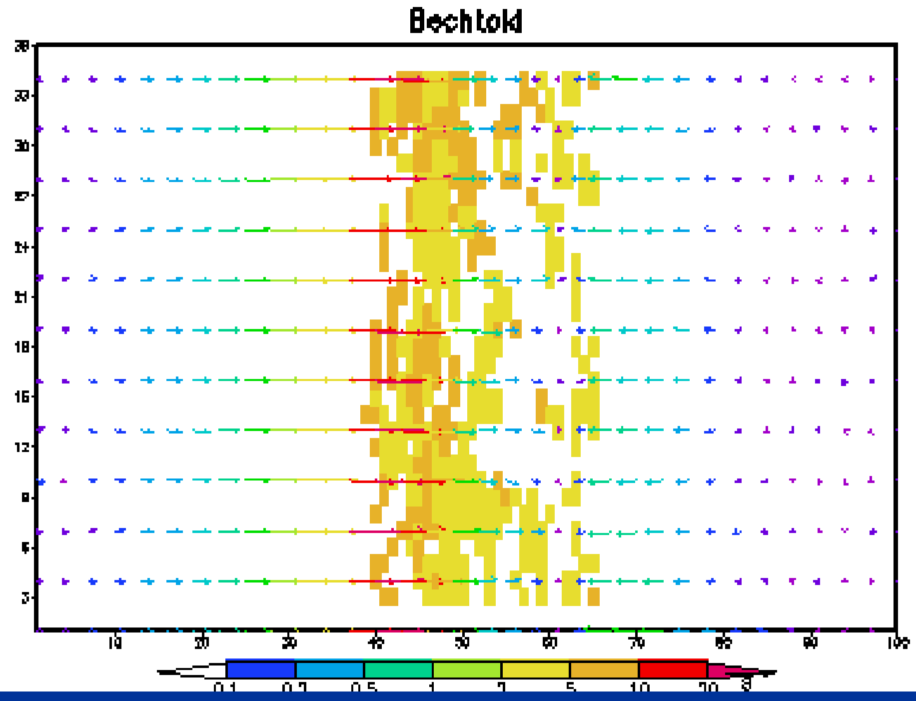
- Model domain consist of 2/3 sea and 1/3 land (100x36x35 gridpoints, dt =40)

  → sea breeze will develop

- No radiation and Coriolis force
- Periodic boundary conditions
- Ground temperature variies sinusoidally at each grid point
- Stable initial sounding for initialization of temerature- and humidity profile
- 18h forecast, 3 LM runs with **Tiedtke** scheme, **Kain-Fritsch** scheme and **Bechtold** scheme

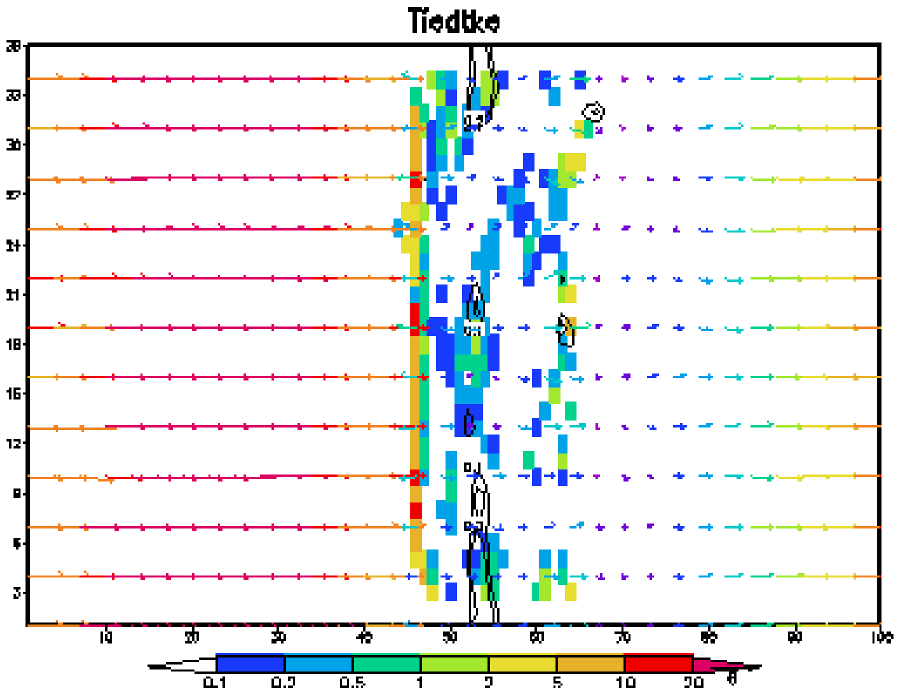


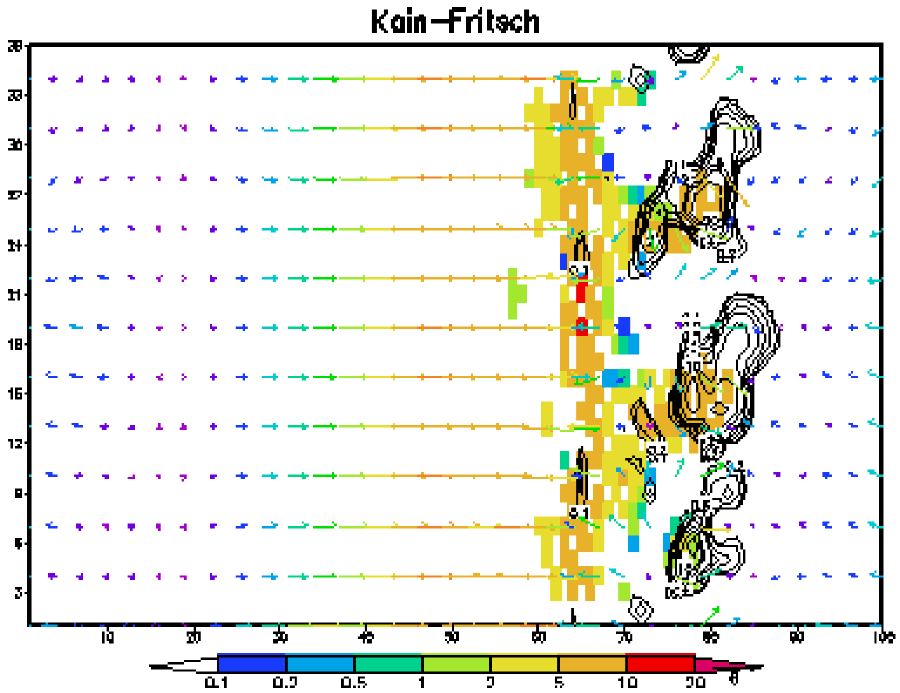


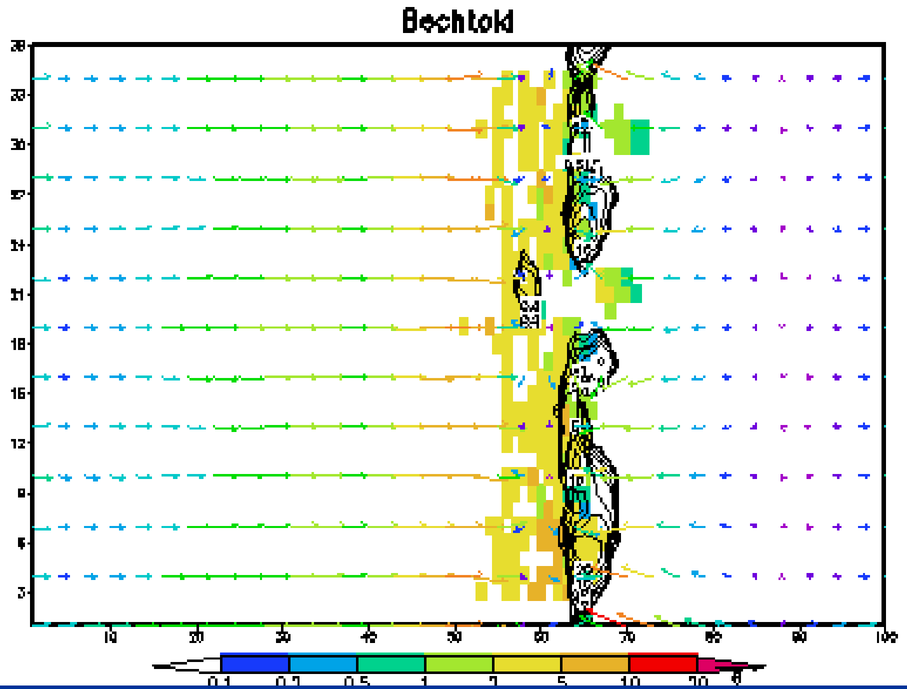


Precipitation rate (mm/h) after 9h of forecast
<u>Coloured</u>: convective precipitation
<u>Contoured</u>: gridscale precipitation
<u>Arrows</u>: 10m wind field

- sea-breeze has developed at east coast







Precipitation rate (mm/h) after 13h of forecast

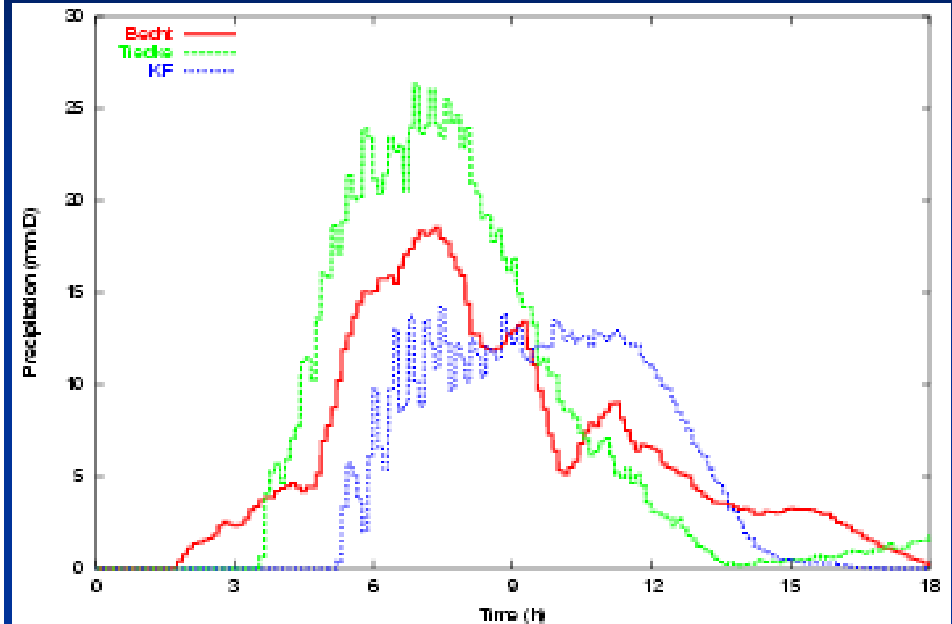
Coloured: convective precipitation

Contoured: gridscale prcipitation

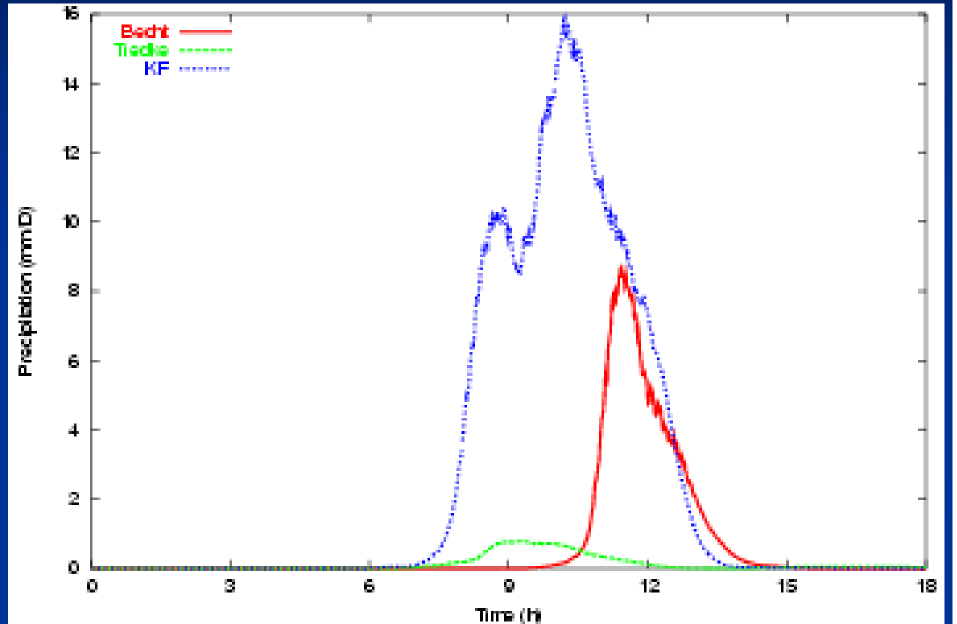
Arrows: 10m wind field

Domain averaged hourly precipitation rate

Convective precipitation



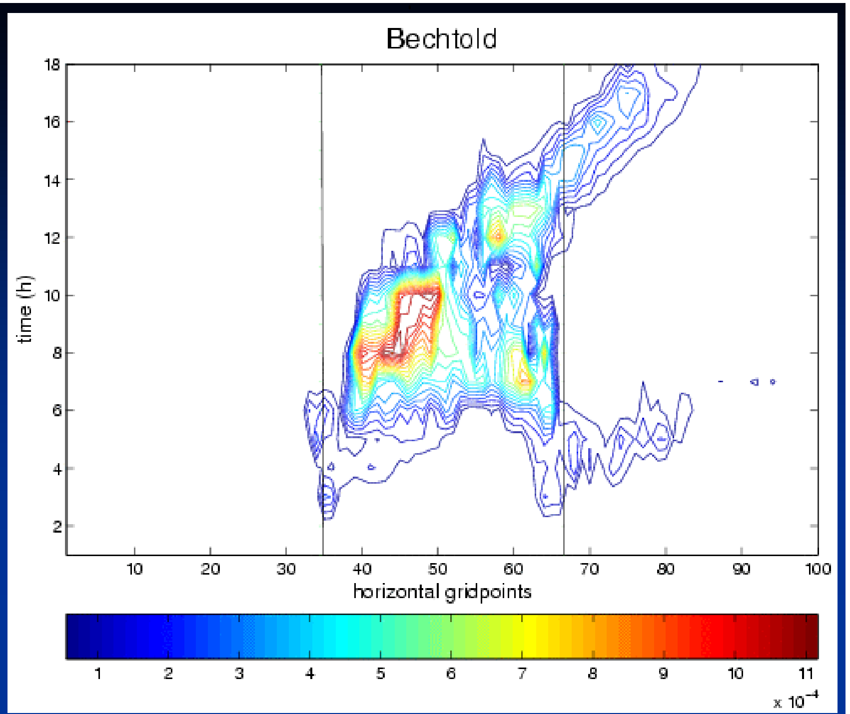
Gridscale precipitation

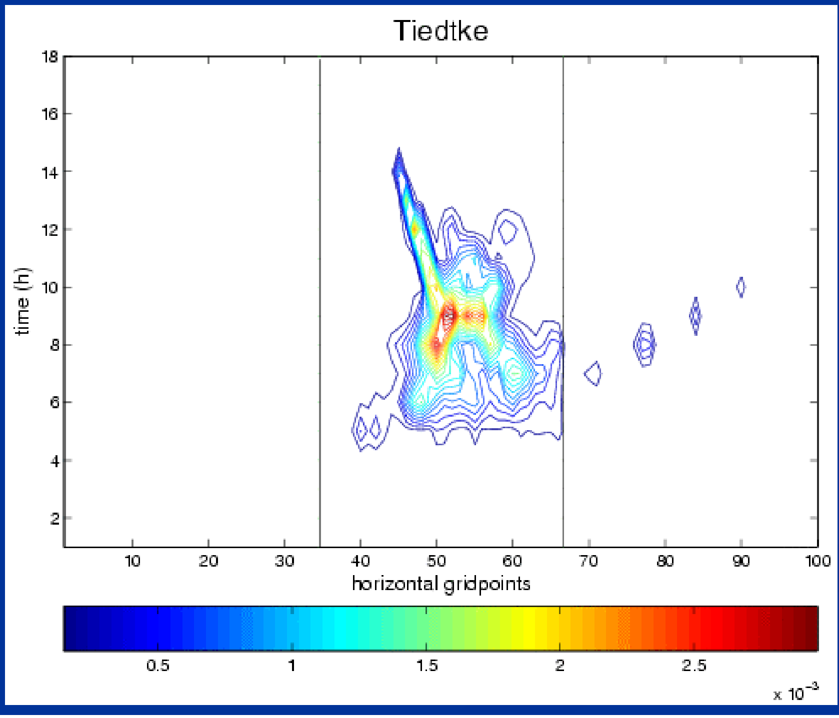


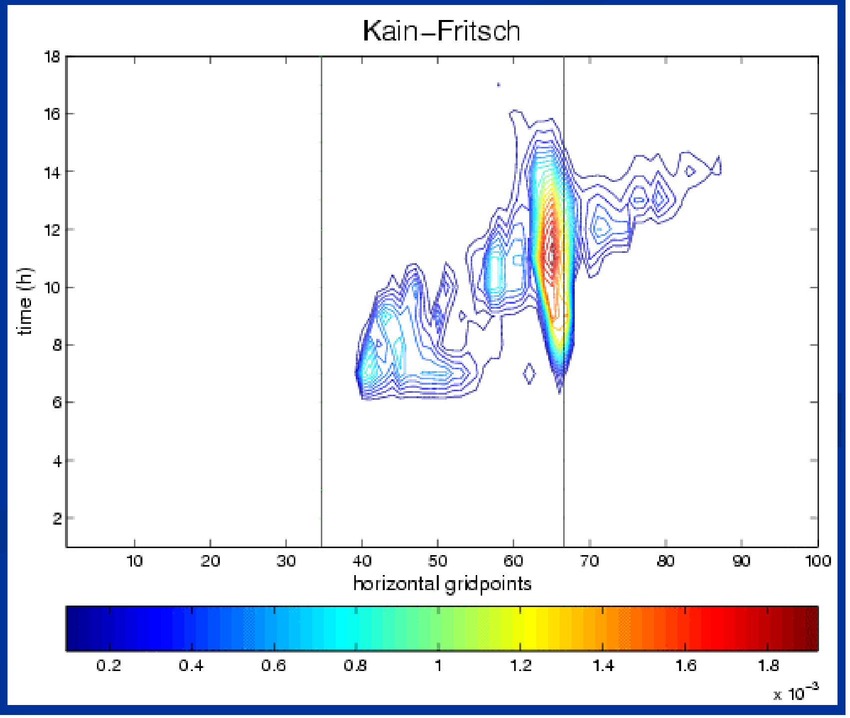
- **Bechtold**: activates first
  gridscale precipitation at end of forecast
- **Tiedtke**: produces largest amounts of convective precipitation after 5-8 hours of forecast
  nearly no gridscale precipitation
- **Kain-Fritsch**: least amount of convective precipation
  (relatively) large amount of gridscale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

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 <u>east</u> coast
- **Tiedtke**: light precipitation over whole land, but strong precip. at <u>west</u> coast







Conclusions

- Precipiation 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 procuce *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