Scale dependency of extreme precipitation.

COSMO-CLM evaluation in anticipation to hindcast ensemble analysis

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©dpa. Dresde, Elbe Flooding, 2013

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BMBF - ClimXtreme

FONA
Forschung für Nachhaltige Entwicklung
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Bundesministerium für Bildung und Forschung

KIT
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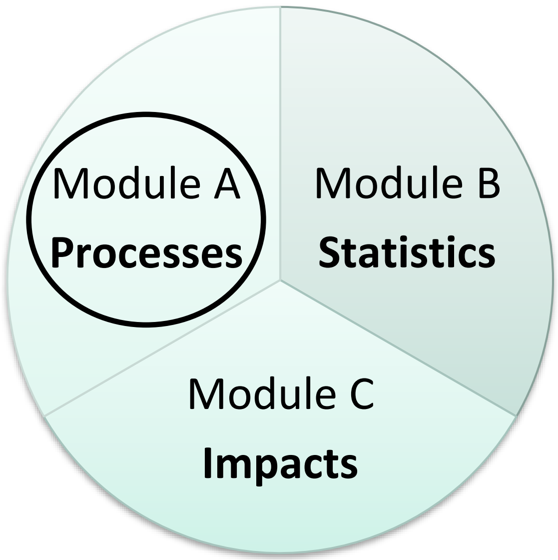
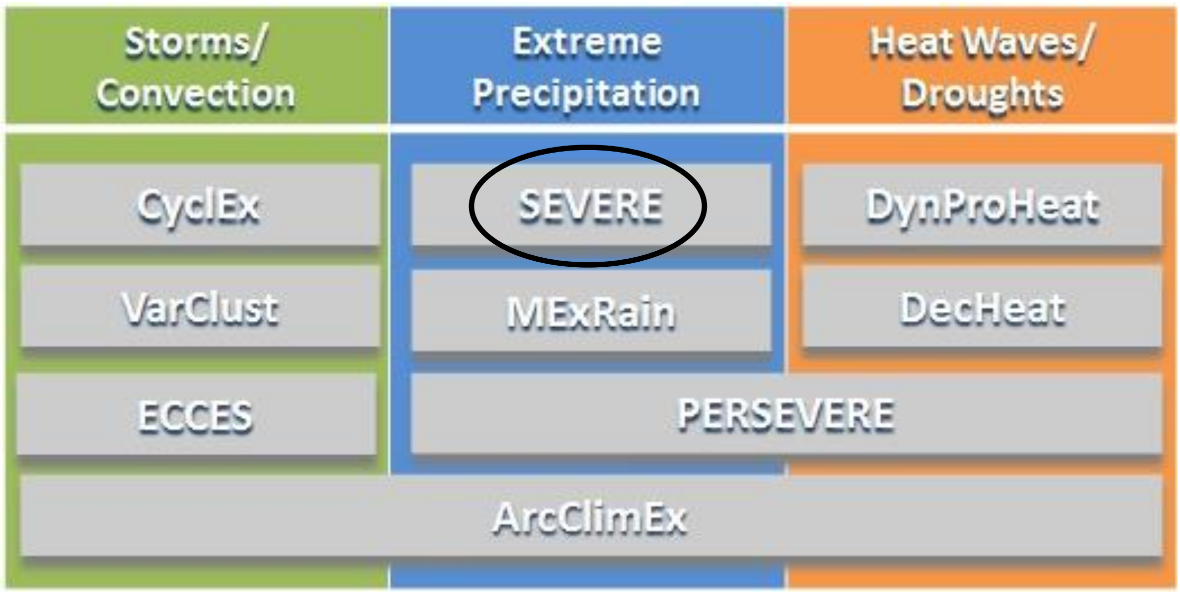
ClimXtreme is a joint effort to improve the assessment of extreme weather events and their changes in Central Europe in the past and in coming decades, with two central questions

Q.1 Has past climate change caused more extreme weather events?



Q.2 Will future climate change modify the occurrence of extremes?

ClimXtreme – Module A Physics and Processes



SEVERE aims

In SEVERE we study the climate variability of extreme precipitation and the scale dependency of its representation in state-of-the art ensemble simulations from MiKlip

In this talk I…

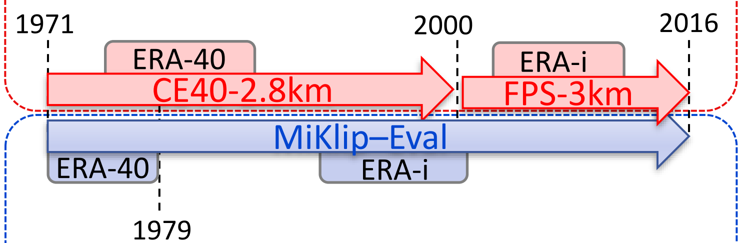
- **Evaluate downscaled reanalyses** (ERA40, ERA-i) over Germany in anticipation to their use as reference simulations for the MiKlip ensemble
- Study the **scale dependency of extreme precipitation representation** focusing on **intensity**, **frequency** and **location**
- **Present the extreme event set** to be used for high-resolution downscaling and process-based scale dependency studies

Methods

Evaluation of CCLM downscaled reanalyses at different resolutions in anticipation of the MiKlip ensemble assessment and event selection

Simulations

- CCLM-3km

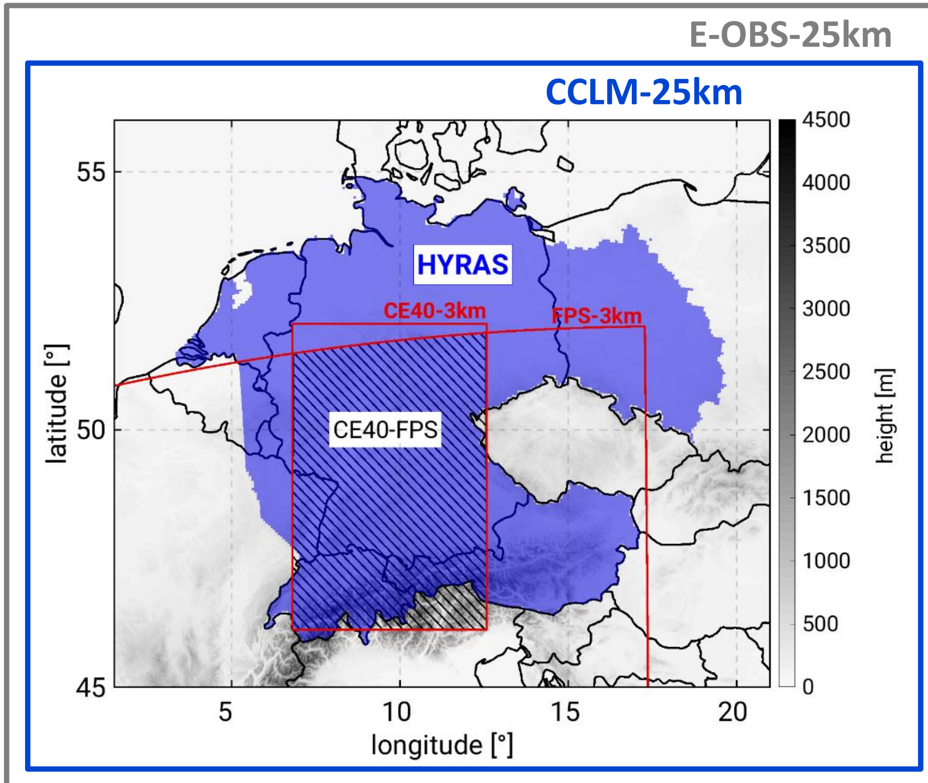


- CCLM-25km

Observations

- E-OBS-25km
- HYRAS-5km

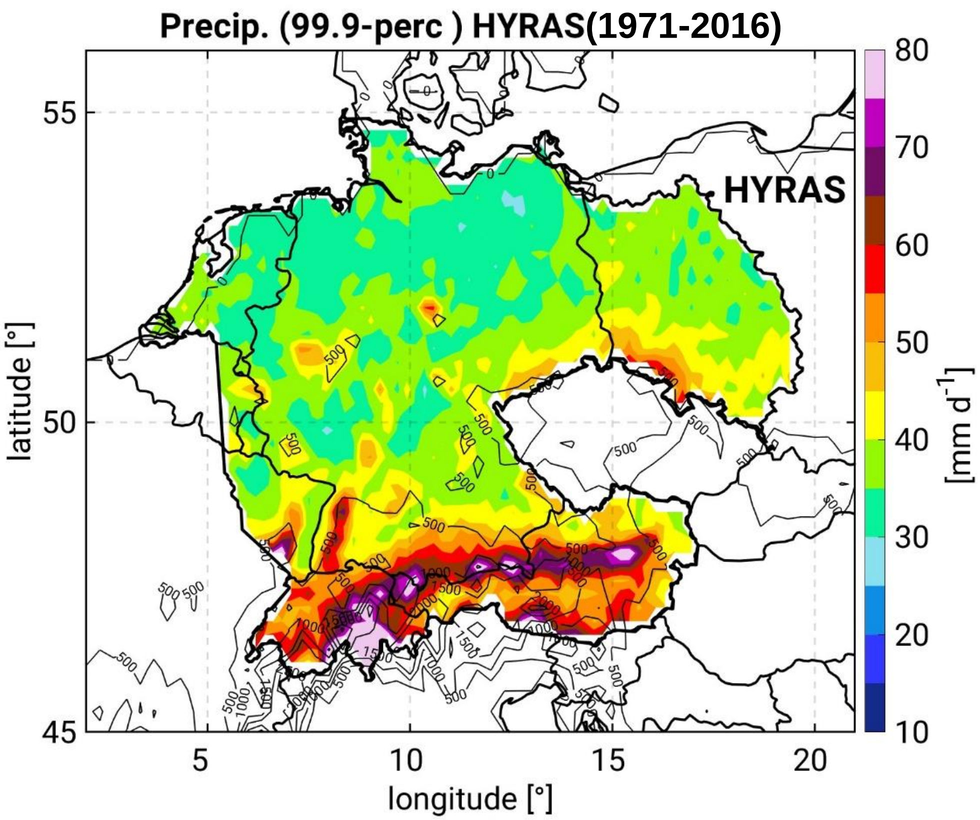
1971-2015



Model evaluation, process-studies, **event selection**

Spatial distribution of extreme precipitation

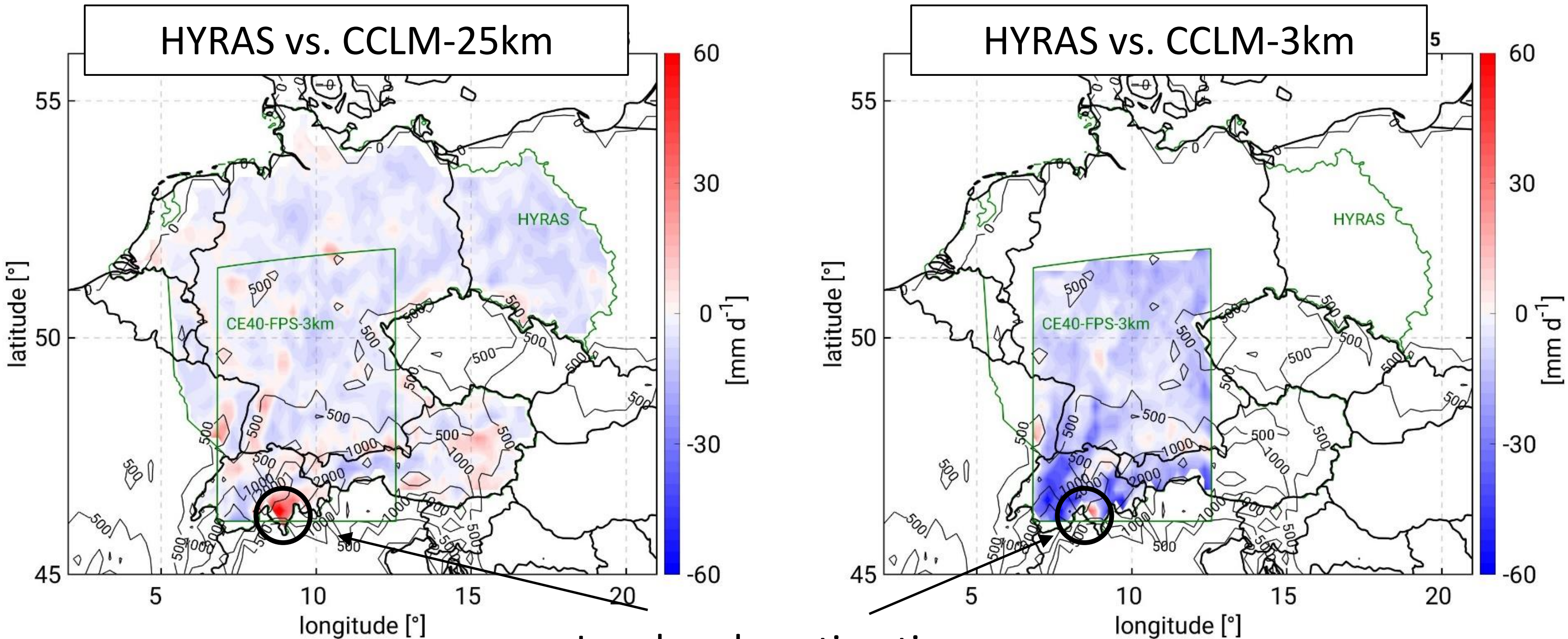
The downscaled simulations need to represent accurately the differences between flat and elevated terrain



- The Alps, the Vosges and the Black Forest are highlighted as regions prone to extreme precipitation

Spatial distribution of extreme precipitation

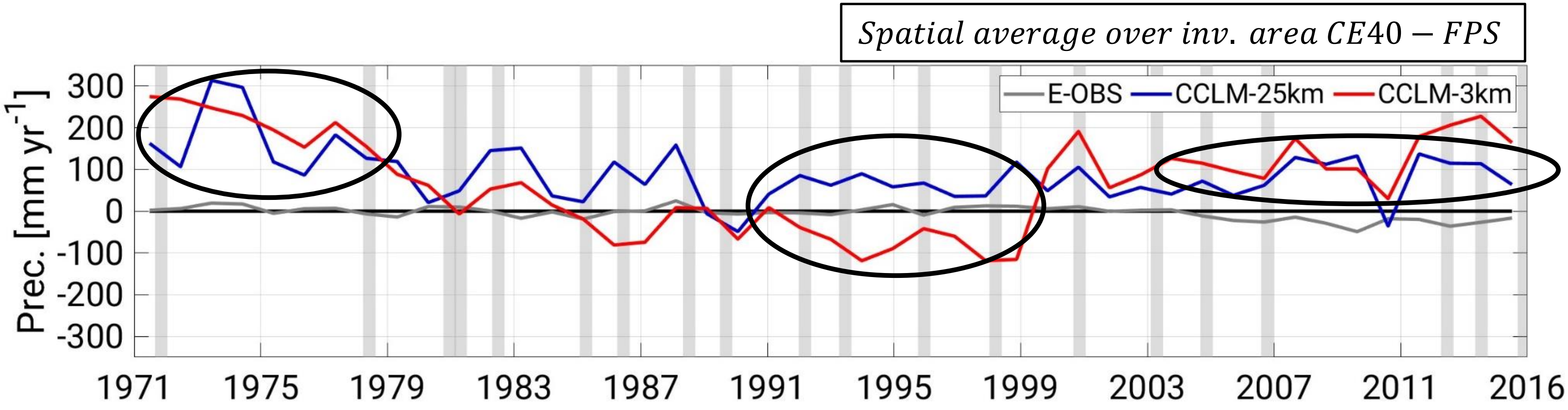
General overestimation of 99.9-percentile precipitation by CCLM-25km and CCLM-3km. Especially the Alpine region is enhanced (orography).



Local underestimation in the Lugano area

Biases in the temporal evolution

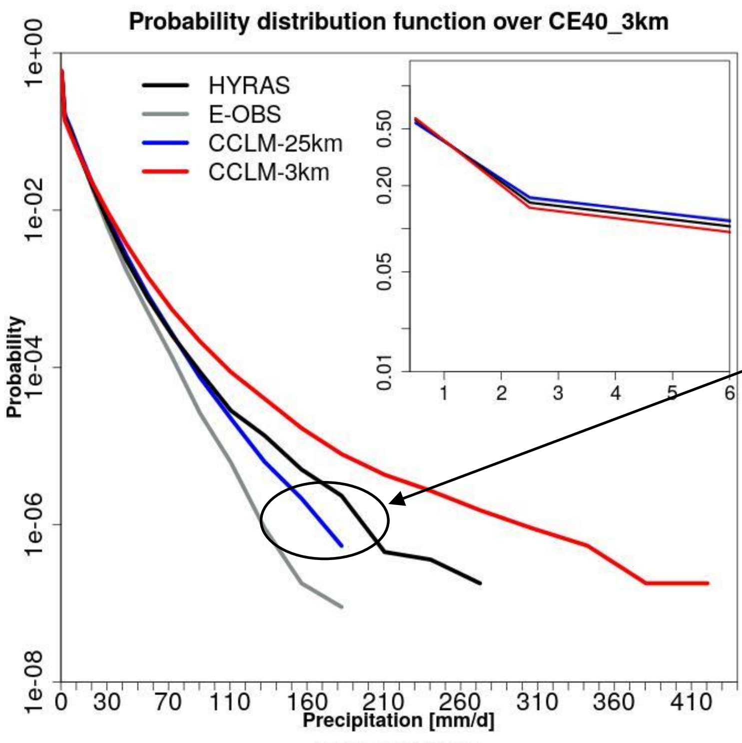
CCLM-25km overestimates yearly precipitation during the whole period, CCLM-3km especially at the beginning and the end

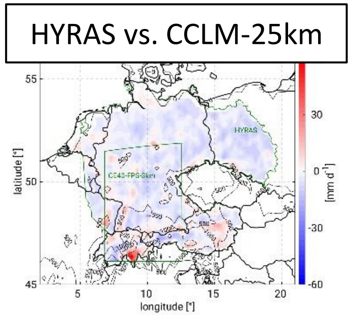


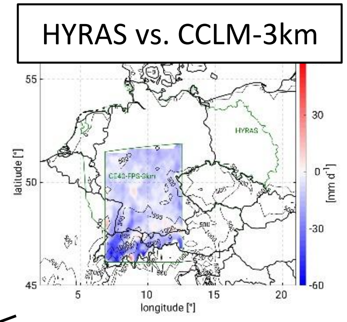
- Reduction of the mean bias at the expense of a larger error spread

[mm yr-1]	CCLM-25km	CCLM-3km
$\mu_{OBS-MOD}$	89	70
$\sigma_{OBS-MOD}$	69	113

Probability distribution function





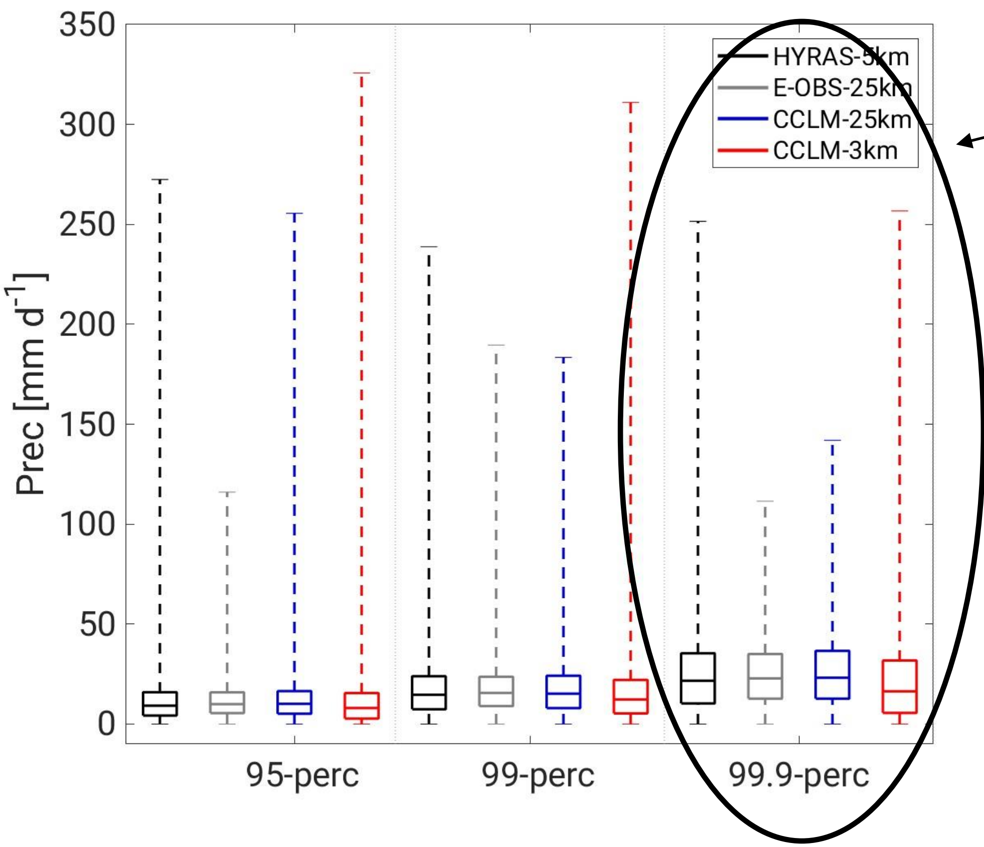


- Better representation by CCLM-25km for moderate precipitation
- Enhanced extreme precipitation needed in CCLM-25 km
- CCLM-3km overestimates extreme precipitation intensities

All datasets upscaled o a common grid of 25 km

Evaluation of ranked precipitation intensities

CCLM-3km shows an over dispersive distribution with underestimation of the median and quartiles. For most extreme cases (99.9-perc), CCLM-3km shows the best extent of the tail.



How are the charactereistics of the most severe events in the period?

Precipitation Severity Index

The Precipitation Severity Index (PSI)

(Leckebusch et al., 2008; Pinto et al., 2012; Piper et al., 2016)

Considers **intensity**, **coverage** and **persistence** of heavy precipitation. Only intensities over the 80-perc are included.

$$PSI_T = \sum_{i=1}^{N} \sum_{j=1}^{M} \sum_{t=T-t_\alpha}^{T} \frac{RR_{ijt}}{RR_{perc_{ij}}} \cdot I\left(RR_{ijt}, RR_{perc_{ij}}\right) \cdot I\left(RR_{ijT}, RR_{perc_{ij}}\right)$$

$$I\left(RR_{ij\tau}, RR_{perc_{ij}}\right) \quad \begin{cases} 0 \; if \; RR_{ij\tau} < RR_{perc_{ij}} \\ 1 \; if \; RR_{ij\tau} \geq RR_{perc_{ij}} \end{cases}$$

T=Time step	t_α=Accumulation (days), max 2
M y-dim	RR_{ijt} =24-h prec. at grid point (i,j) at time (t)
N x-dim	$RR_{perc_{ij}}$ = Percentile of precip (period)

The 21 event SEVERE extreme data set

Karlsruhe Institute of Technology

Making use of the PSI over the CE40-FPS and HYRAS areas we subjectively select 21 events.

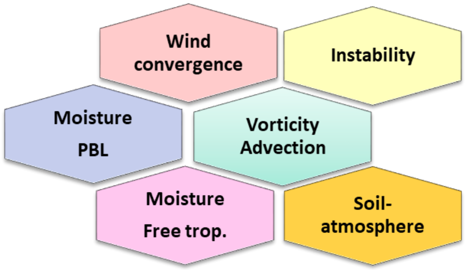
Categorization based on

- Synoptic situation
  From FI500, PMSL and RETOP in GFS analyses
- Circulation Weather Types (CWT) Adapted from Lamb (1972) by Thomas Schartner (FUB) based on ERA-interim for 1980-2010

  freva *Thanks to H. Feldmann*
- HYRAS Precipitation structure

In order to

- Carry out process-studies on the scale dependency



- Provide a very high-resolution downscaled event set

21 events classified in 6 categories

Synoptic classification of the 21 selected events

Cat. 1 (2 cases)
- Stratiform and conv. precip.
- Spring-summer
- Cut-off Lows

Cat. 2 (6 cases)
- Summer conv. Precip.
- large blocking
- Atlantic Low

May-June-2016

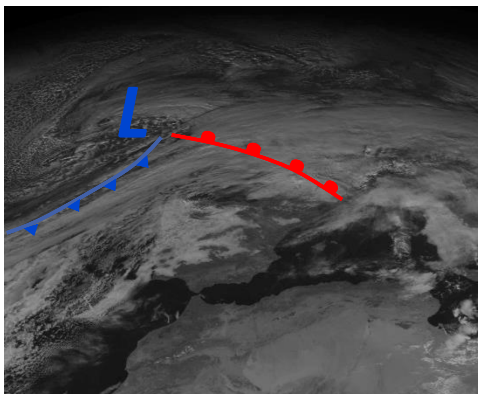
Cat. 3 (4 cases)
- Summer-Autumn
- Azores, Russian Highs
- Large-ampl. Cut-off Low

08-Juli-2014, Schönenberg

Cat. 4 (3 cases)
- Autumn
- Polar front over mid Europe
- Frontal precipitation

Cat. 5 (5 cases)
- Winter
- Polar front over mid-Europe
- Small Lows within polar front

Cat. 6 (1 case)
- Extratropical cyclone



20-Dec-1993

The May-June 2016 severe precipitation season

Moisture and instability over Germany with blocking over Scandinavia caused a static synoptic situation *(Piper et al., 2016)*

- Affecting Mid-Europe for +15 days
- Scandinavia blocking + weak winds
  - → Quasi-stationary convection
- Flash flooding, 5.4 billion losses
- Testbench for process scale-dependency studies

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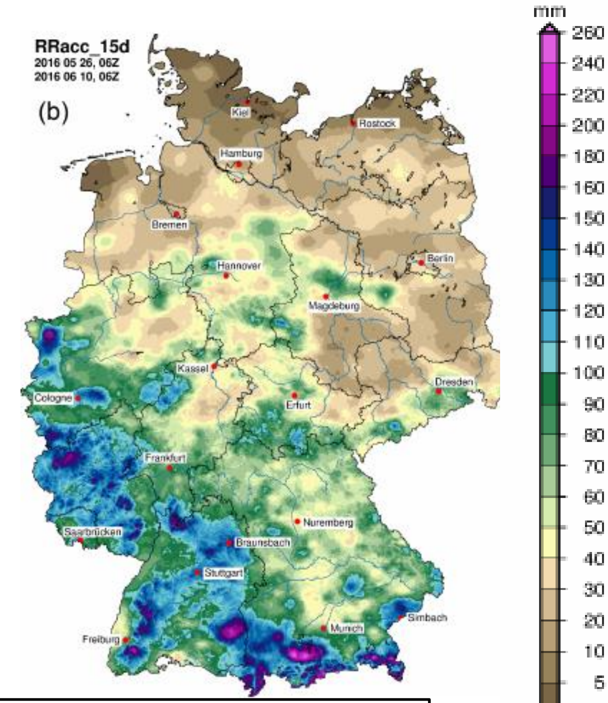
Eulerian & Lagrangian approach

Collaboration with FUBerlin



RR_{acc} 26-May to 09 June 2016

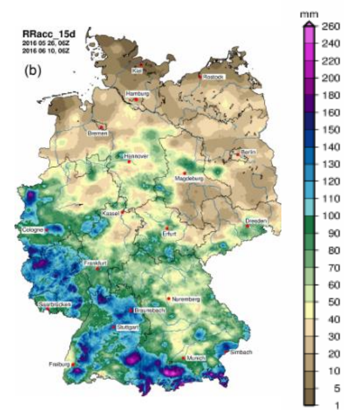
(Piper et al., 2016)

Conclusions

- Both resolutions of the ERA-I, ERA-40 downscaled simulations **overestimate precipitation**
  - Extreme precipitation (99p) is overestimated over flat and elevated terrain
  - The wet bias showed by CCLM-25km in the temporal evolution is reduced in CCLM-3km at the expense of inducing a larger error spread
  - For very extreme events, CCLM-3km overestimates the frequency of occurrence, whereas CCLM-25km underestimates it
- **21** events classified in 6 synoptic patterns supported by Circulation Weather Types analyses

Next steps

- Process-studies of the scale dependency for the 21 selected events
- Eulerian-lagrangian analysis of the May-June 2016 heavy precipitation season



Thanks for your attention