Update frequency and resolution of lateral boundary conditions (LBC) as a source of internal variability

Klaus Pankatz[1,2] and Astrid Kerkweg[2]

1 Deutscher Wetterdienst
Wetter und Klima aus einer Hand

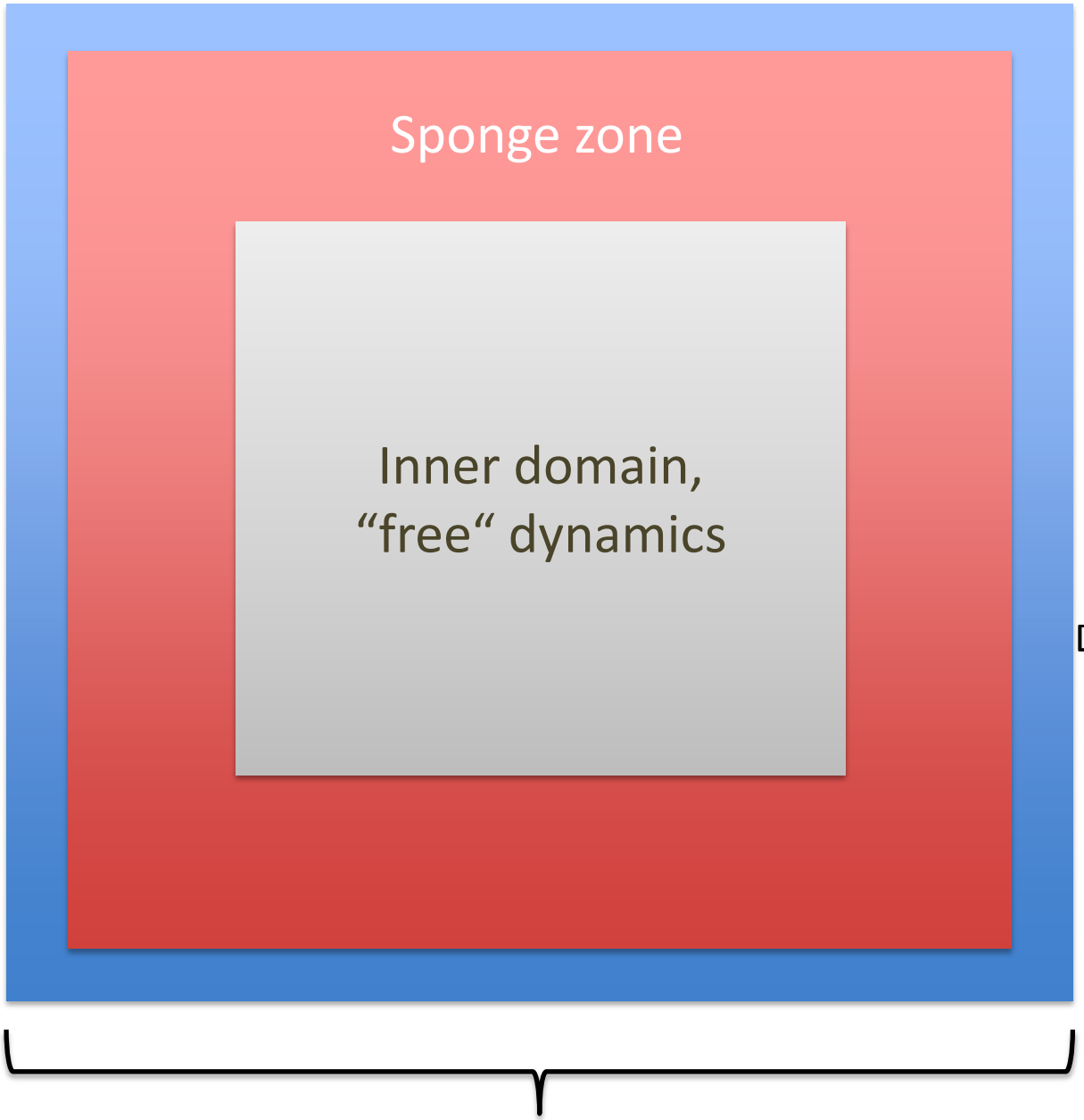
2 JOHANNES GUTENBERG UNIVERSITÄT MAINZ

FONA
Decadal
Climate Prediction
BMBF

MiKlip

Outline

- **Internal Variability** of Regional Climate Models (RCM) compared to the driving fields vs. **Forcing**; long-range
- **Perturbation/Error** evolution leading to Internal Variability; short-range
- Are these connected and if so, how are they connected?
- Interpret climatological results obtained by long-range simulations
- Results indicate that only in winter LBC update frequency has a statistically significant impact on climatological values (t_2m, slp, totprec)

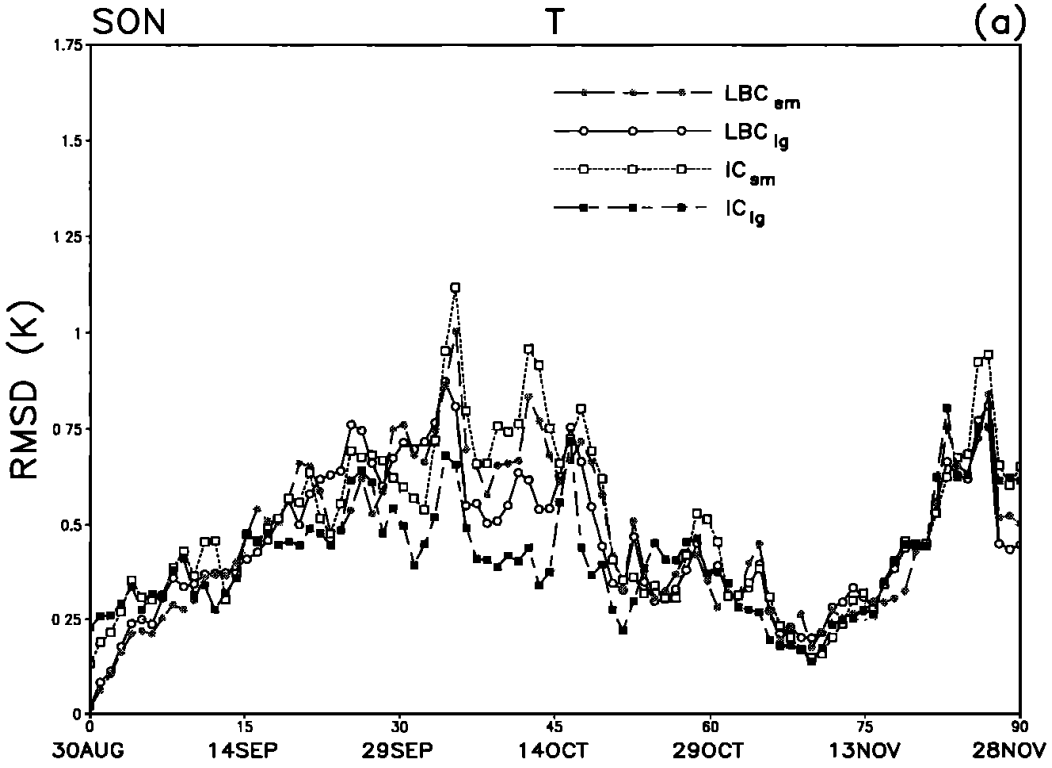

Sponge zone
Inner domain,
“free“ dynamics
Fixed to the driving field
Sponge zone, relaxed towards the global field
Davies relaxation
Regional domain

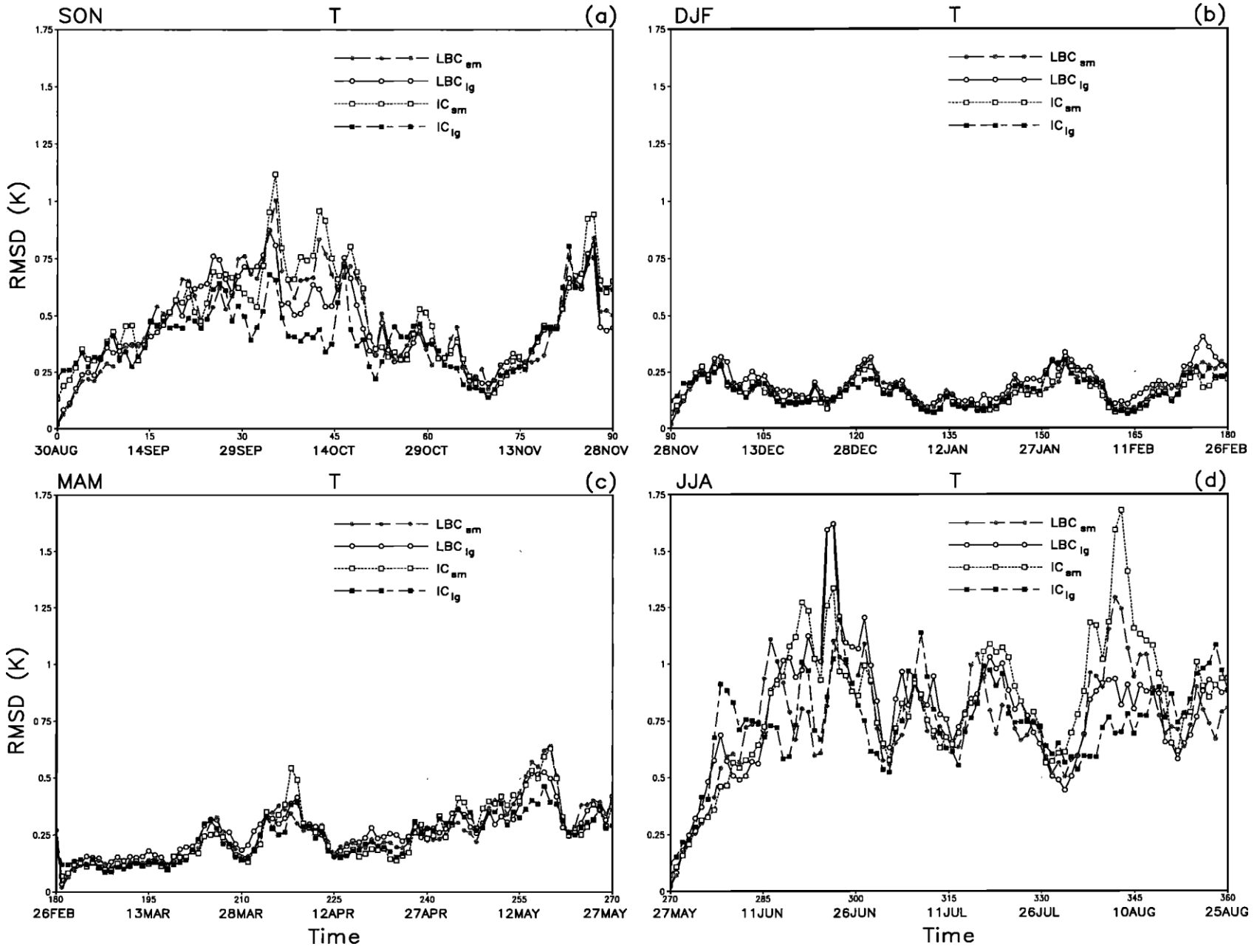
Sources of LBC-Errors

- Differences between GCM and RCM dynamics, parameterizations and grids
  - Inevitable; minimal when using same model for global and regional simulations
  - Increase GCM resolution – decrease resolution jump
- Temporal resolution of LBC; could be as high as the GCM time step
  - Demand for large storage capacity
  - Or: Use on-line coupling
    (e.g. MECO(n) Paper by Kerkweg et al. 2012)
  - Surface pressure time series: Errors up to 8 hPa in 6 hourly updated LBC compared to updates with the global model time step
  - Non-linearity leads to chaotic evolution of deviations

Internal Variability

- Evolution of Internal Variability due to perturbations of the LBC and ICs
  (Giorgi and Bi, 2000)
- Comparison (RMSD) with control run





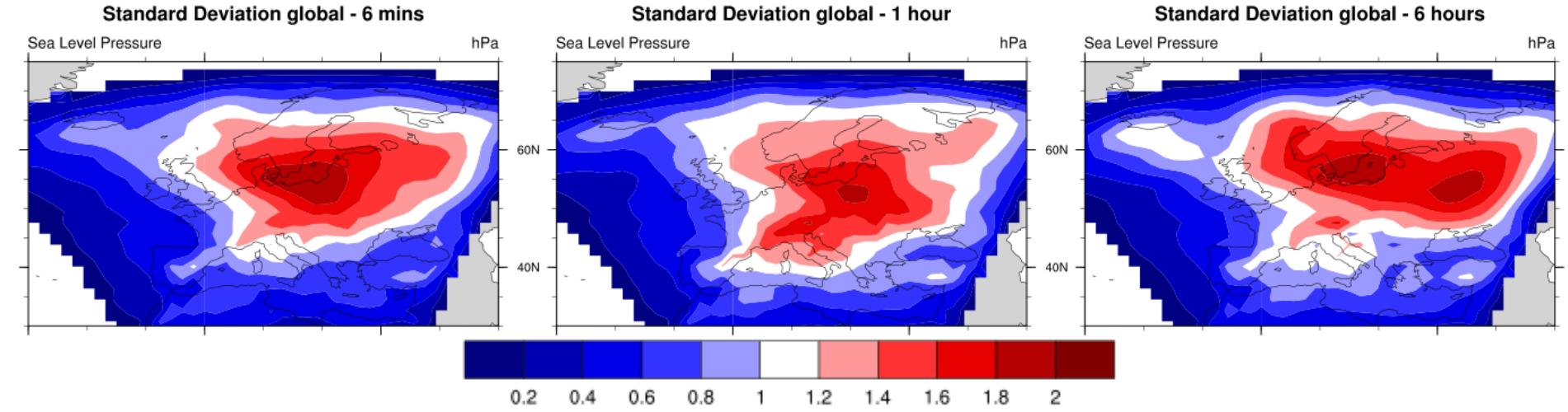
Adapted from Giorgi and Bi, 2000

Internal Variability

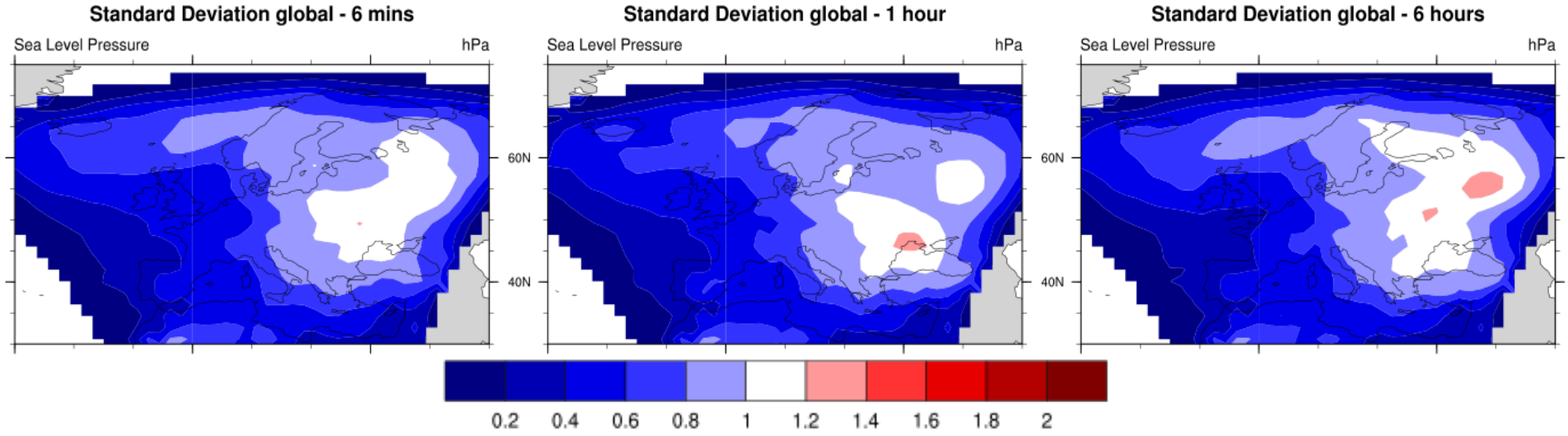
- Definition: Difference of the GCM solution and the RCM solution (e.g. RMSD)
- Factors:
  - Domain size and location
  - Resolution jump GCM -> RCM
  - LBC and IC perturbations lead to similar Internal Variability
- Generated by non-linear processes which lead to different solutions

Internal Variability on climatological timescales

December



July

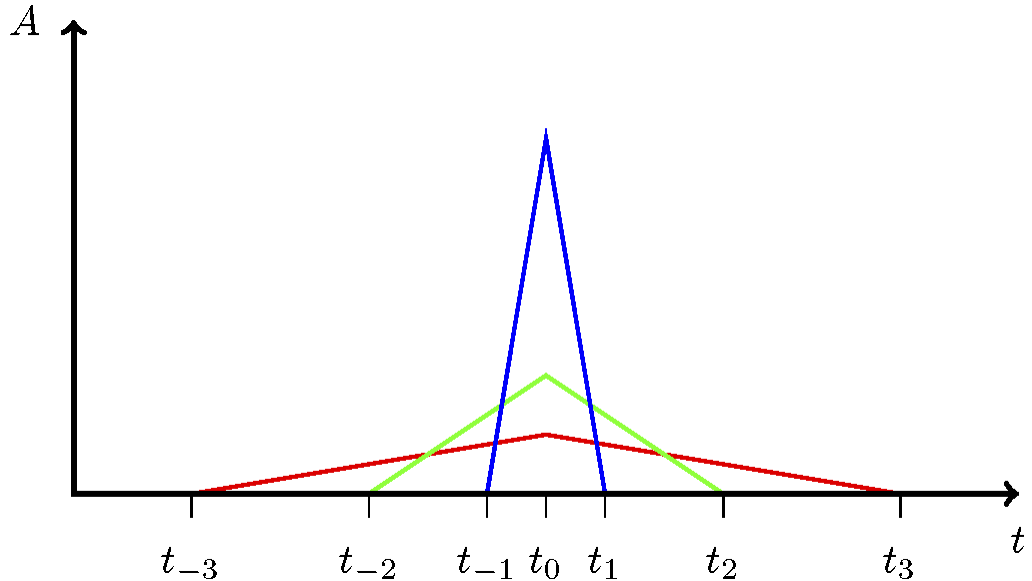


Perturbation sensitivity

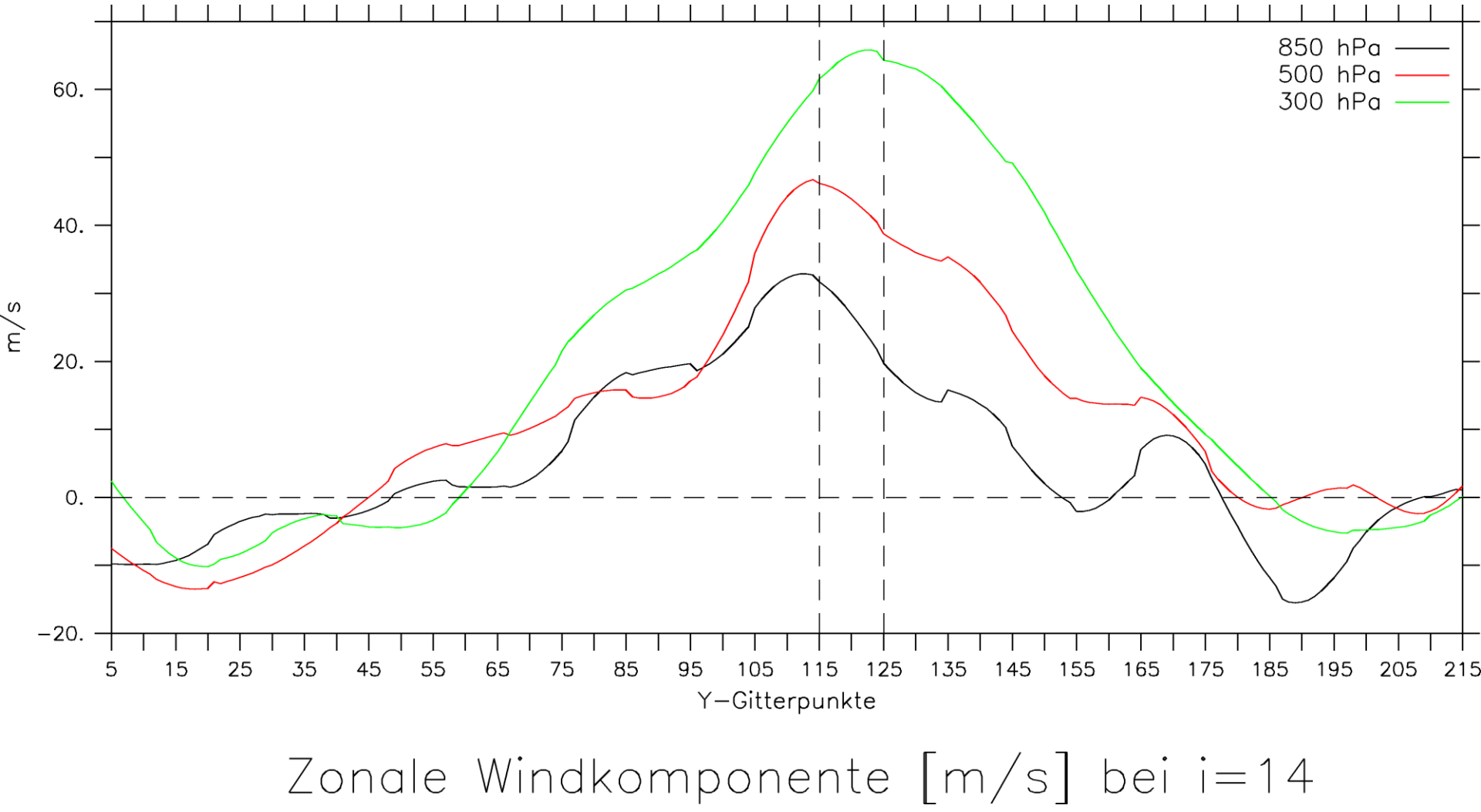
- Following the approach by Giorgi and Bi
  - define sensitivity experiment with a temperature perturbation at the LBC
  - Perturbation is local and scaled by the update frequency
  - Time-integral over perturbation amplitude is constant

Maximum Amplitude A:

- 6 hourly – 1K
- 1 hourly – 10K
- 6 minutely – 60K



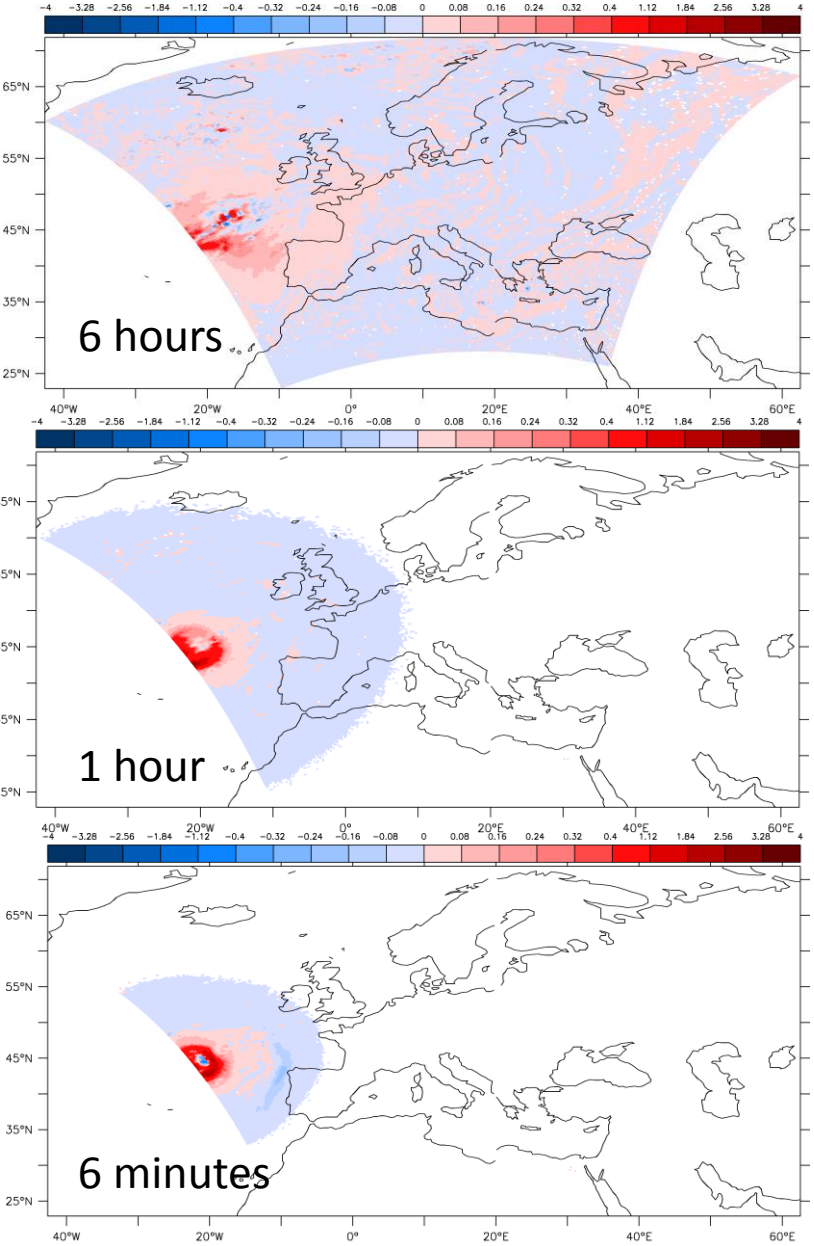
Perturbation location



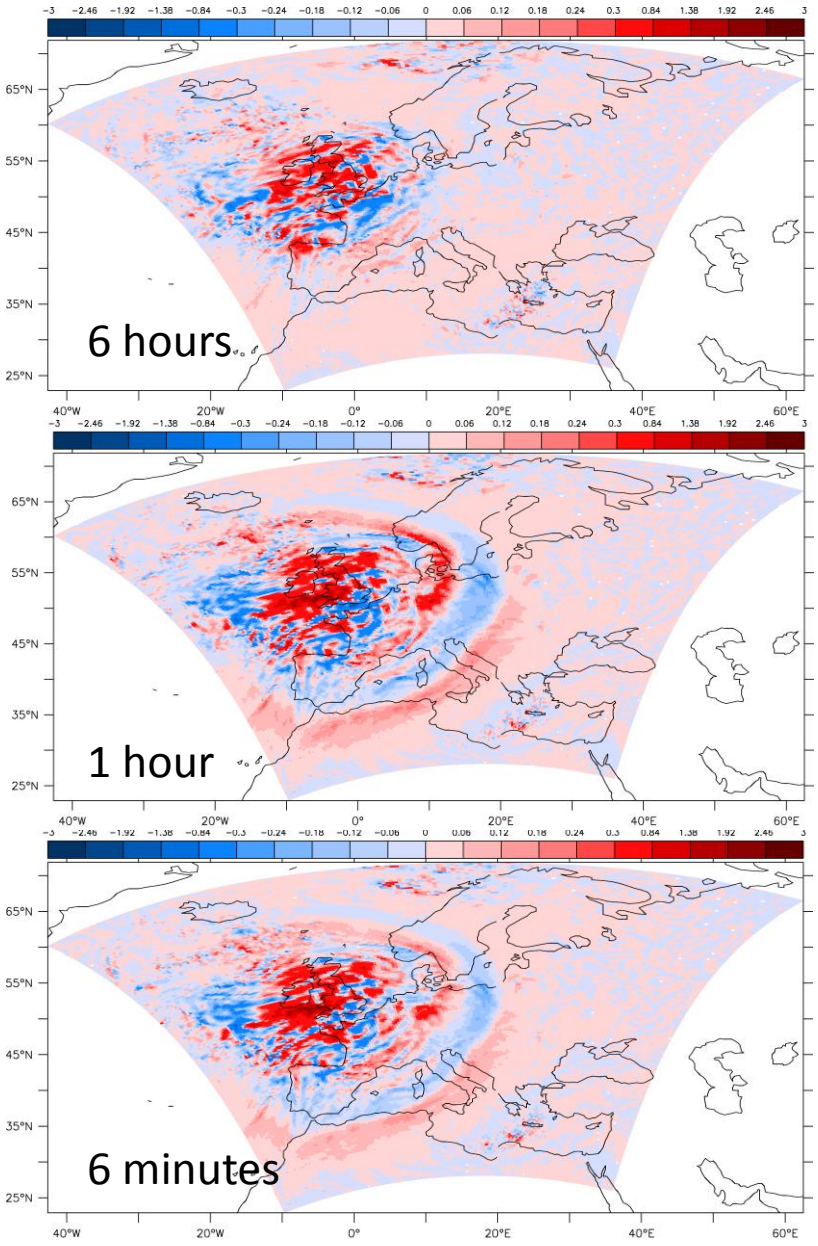
Zonale Windkomponente [m/s] bei i=14

Difference T 500 hPa

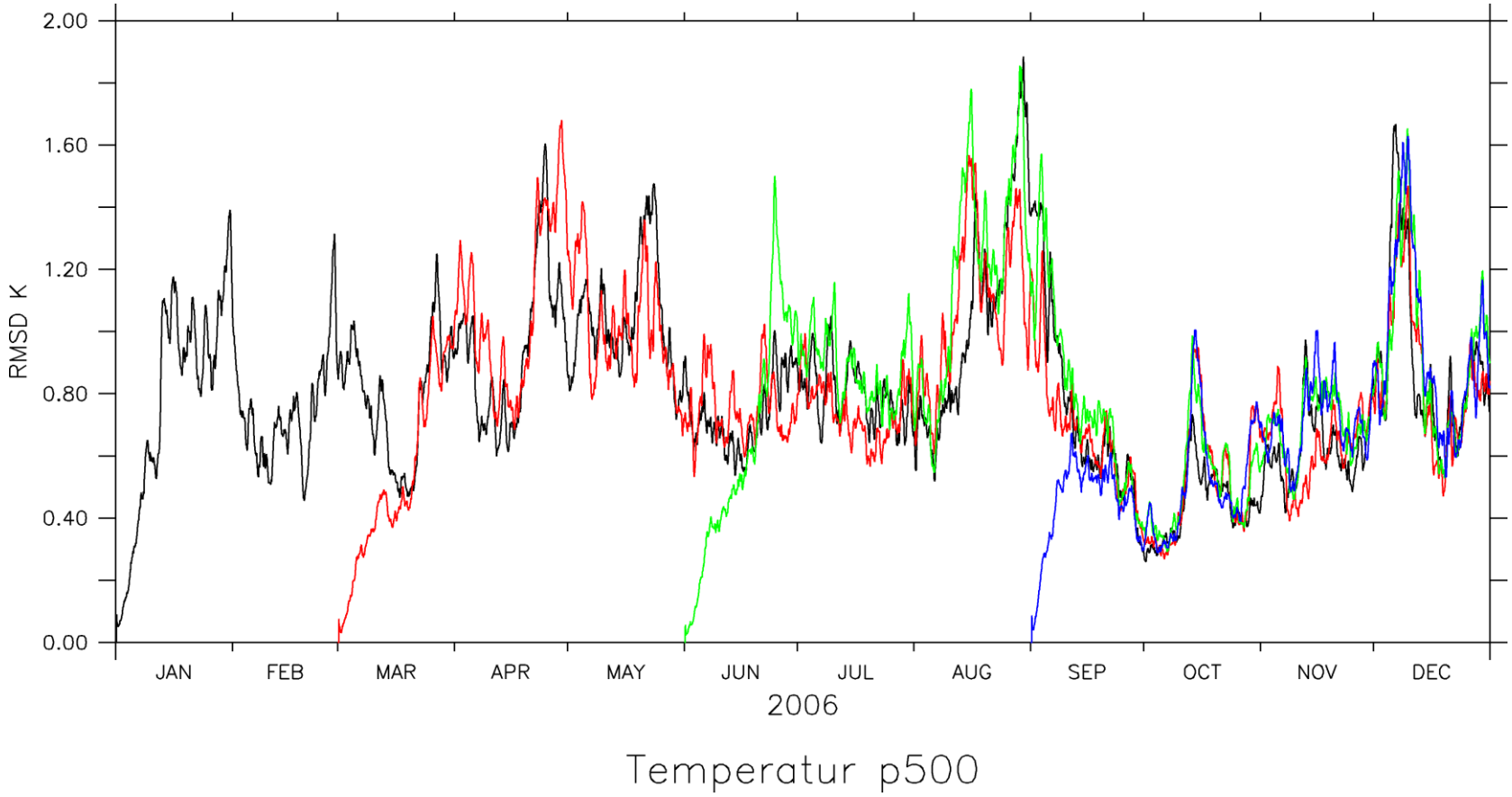
T_{pert} + 1h



T_{pert} + 12h



Dependence on season



- COSMO with CORDEX-EU domain shows different Internal Variability than the study by Giorgi and Bi.
- RMSD only slightly dependent on season
- No marked decrease in RMSD during winter

Conclusion (I)

- GCM and RCM deviations in dynamical balance
- Internal Variability is limited by LBCs at a given time
- Extended set of sensitivity studies: Strength of Internal Variability is not correlated to
  - (Strength of) inflow or outflow at the boundaries
  - Location of the perturbation
  - Amplitude of the perturbation
  - Perturbed Variable

Conclusions (II)

- Dynamical balance is depended also on size and location of the domain
- Constant stirring of Internal Variability by imprecise/unphysical boundary conditions
- Balance implies restrains on ensemble spread
- Perturbation of the model solution only leads to distinguishable signal of LBC forcing changes, if forcing is strong
  - Differences of climatology only significant in winter

Update frequency and resolution of lateral boundary conditions (LBC) as a source of internal variability

Klaus Pankatz and Astrid Kerkweg

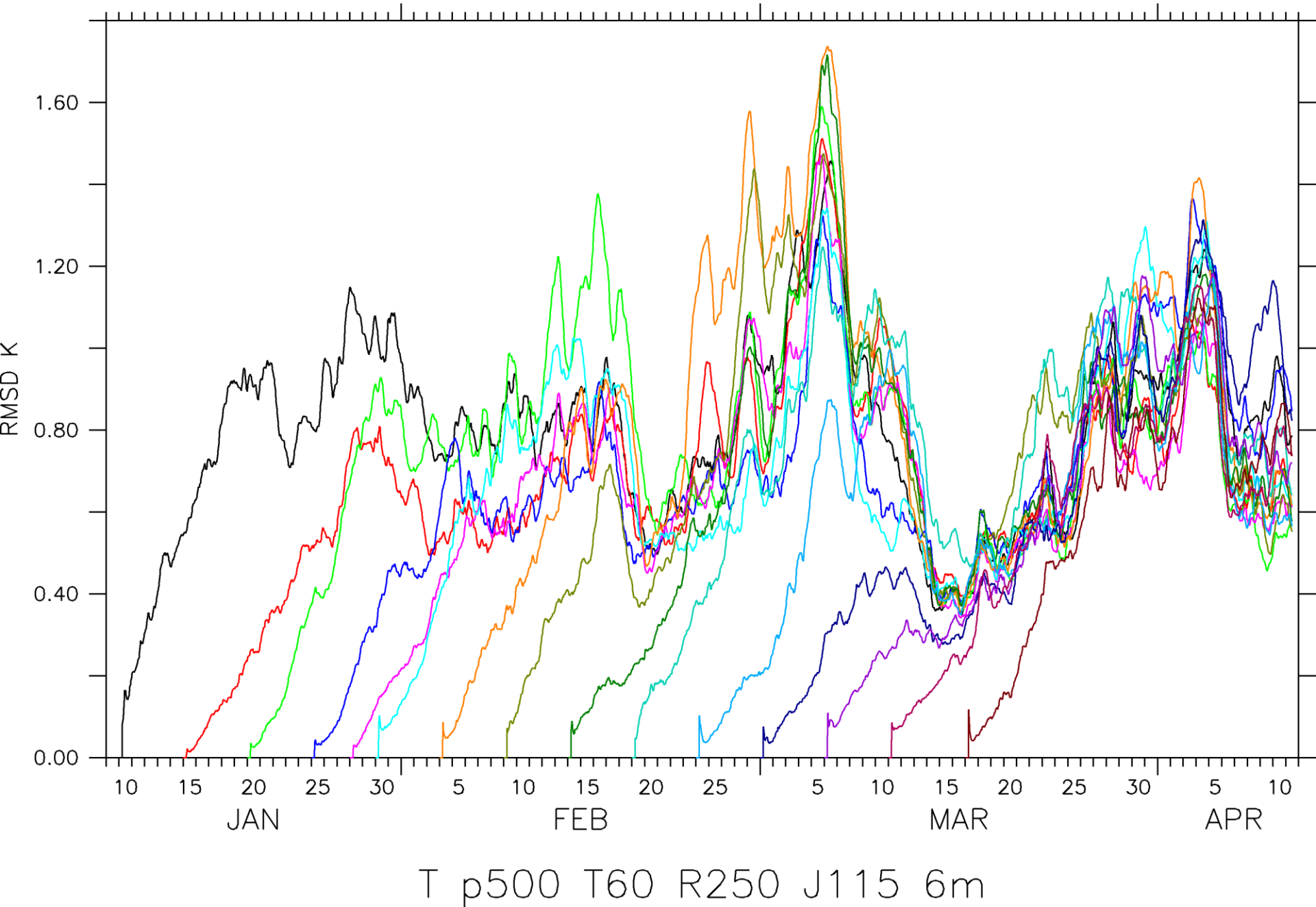
JOHANNES GUTENBERG UNIVERSITÄT MAINZ

FONA Decadal Climate Prediction BMBF

MiKlip

Thank you!

RMSD in dynamical balance, sensitivity on start date



RMSD in dynamical balance, sensitivity on perturbation location