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Eidgenössisches Departement des Innern EDI  
Bundesamt für Meteorologie und Klimatologie MeteoSchweiz

# Idealised Ensemble Simulations of a Convective Storm

**Daniel Leuenberger, MeteoSwiss**

**Manuel Bischof, MeteoSwiss**

**Heini Wernli, ETH Zürich**

daniel.leuenberger@meteoswiss.ch

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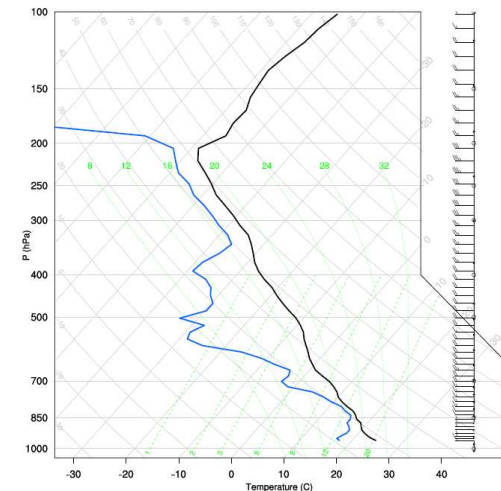
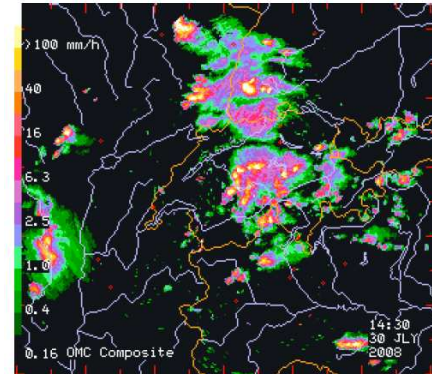
# Motivation

- Idealized simulations in simple atmospheric environments suitable to
  - test installation of new model components
  - foster new model/data assimilation developments
- Here, we set up an ensemble of idealized convection simulations to
  - help in getting to know and understand the KENDA system
  - test new algorithms/ideas to work towards ensemble data assimilation of convective storms
- Master thesis work of Manuel Bischof (ETH)



# Model Setup

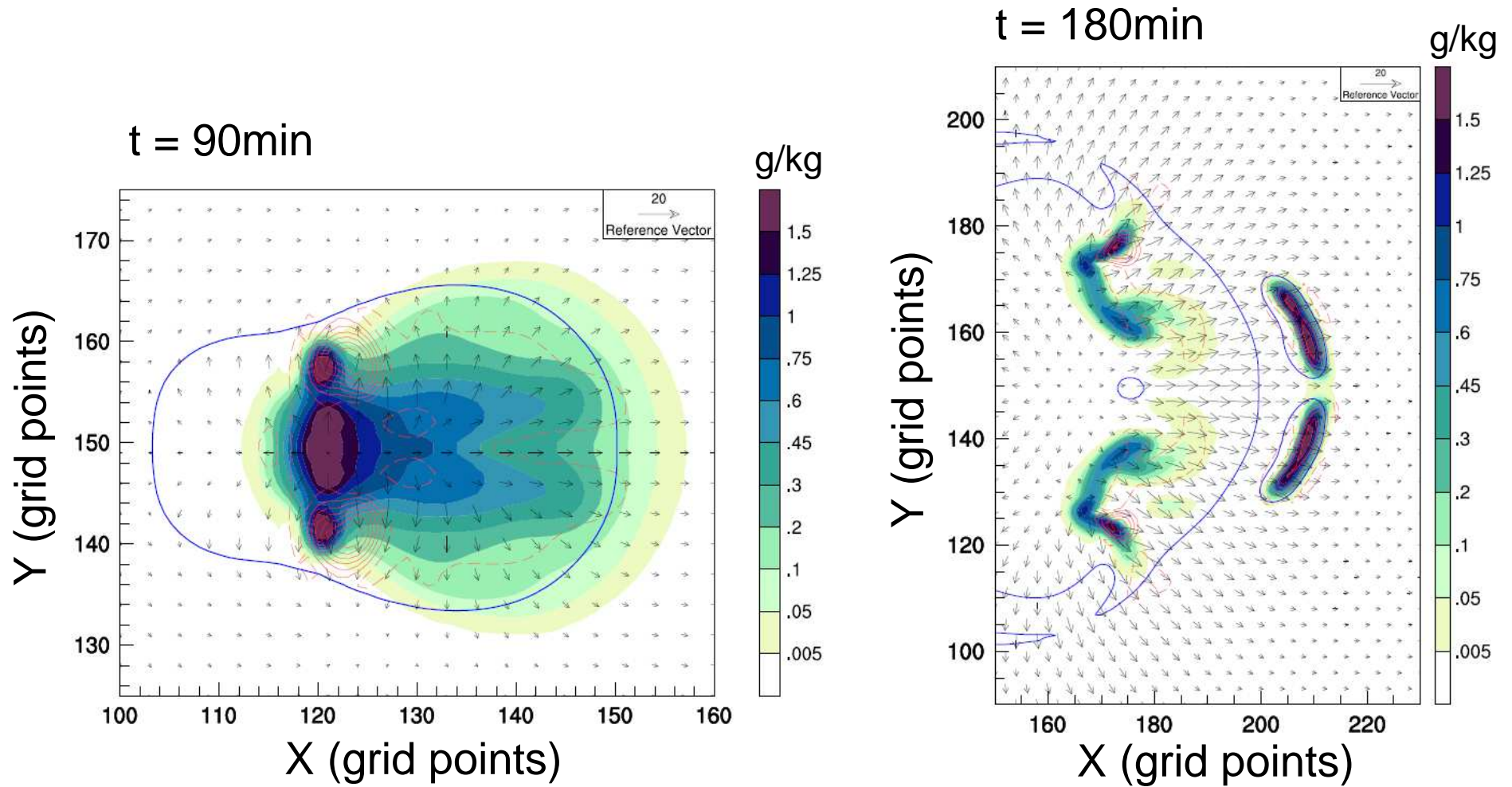
- Horizontal homogenous convective environment taken from the Payerne radio sounding of a convective day in Switzerland, specifies IC and LBC (const in time)
- Warm-bubble convection initiation
- Integration out to  $t = 300\text{min}$
- No topography, free-slip lower BC
- Only microphysics and turbulence parametrization switched on
- Otherwise as close as possible to the COSMO-2 model setup
- Specification of the sounding via ascii file





# Nature Simulation (1km)

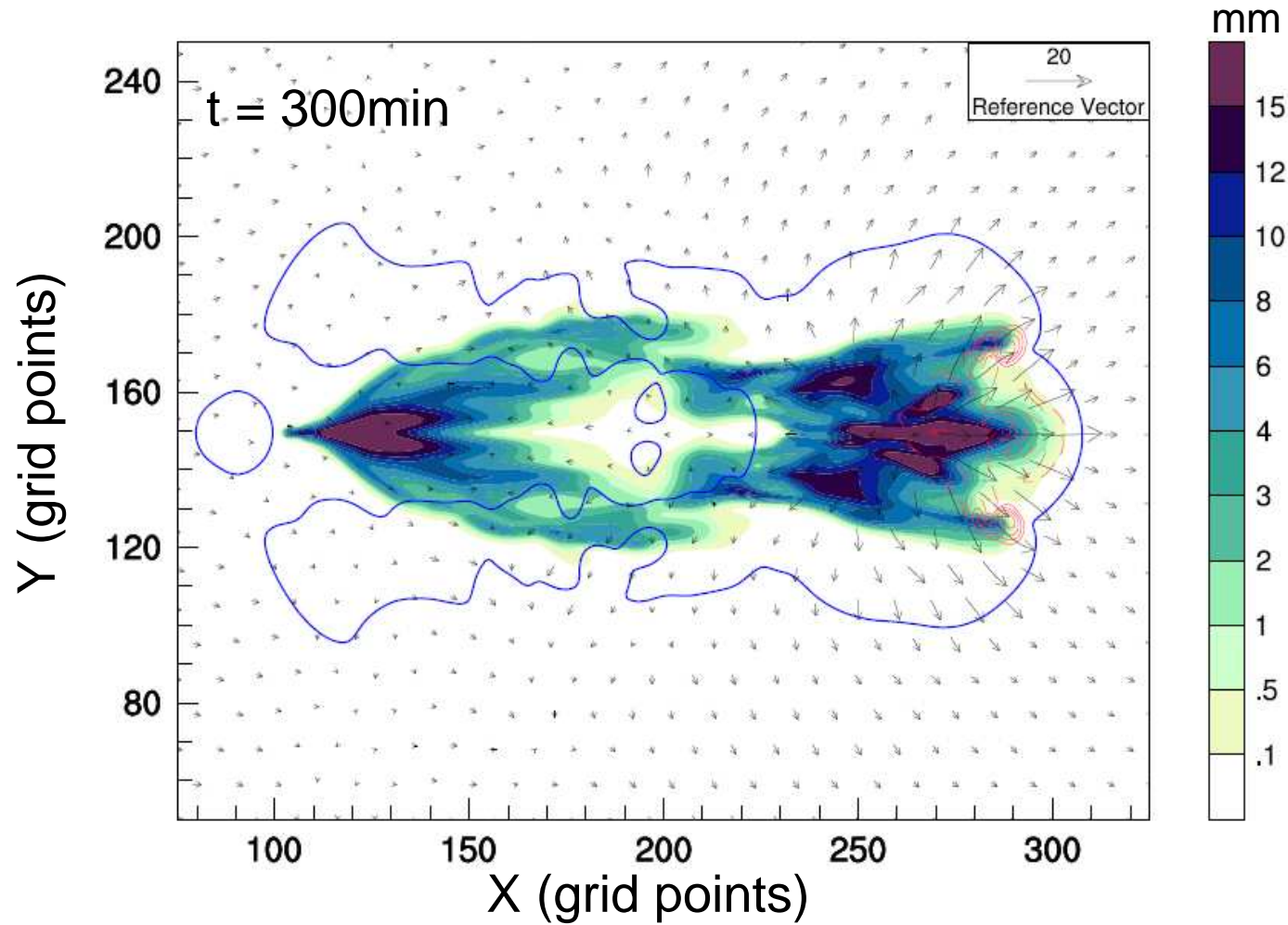
$q_r$ @sfc, mid-level W, 10m wind and cold pool (-5K T anomaly)





# Nature Simulation

TOT\_PREC@sfc, mid-level W, 10m wind and cold pool





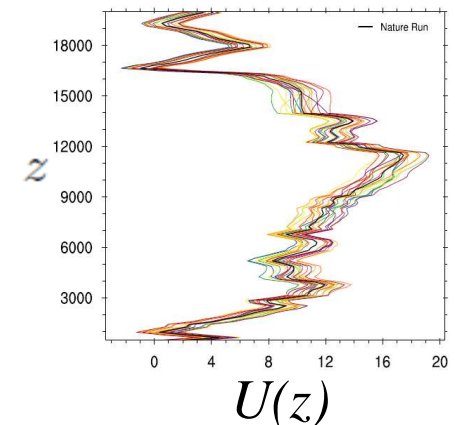
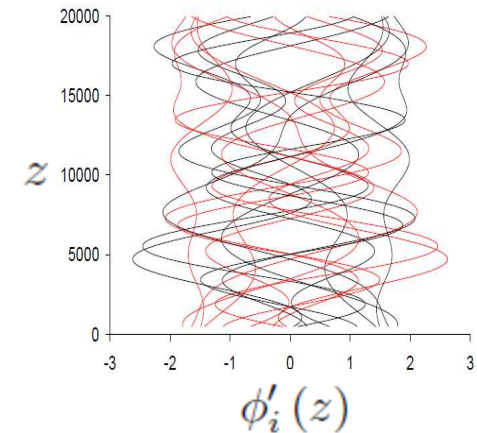
# Ensemble Generation

- Vertical variations in environmental sounding (IC and LBC)

$$\phi_i(z) = \phi^0(z) + \phi'_i(z)$$

$$\phi'_i(z) = \sum_{j=0}^3 A_{i,j} \cos\left(\varphi_{i,j} + 2\pi j \frac{z}{H}\right)$$

- $\varphi_{ij}$  random draws from  $[0, 2\pi]$ ,  $A_{ij}$  random draws from  $N(0, \sigma)$
- 18 symmetric (9 positive and 9 negative) perturbations of wind, temperature and humidity

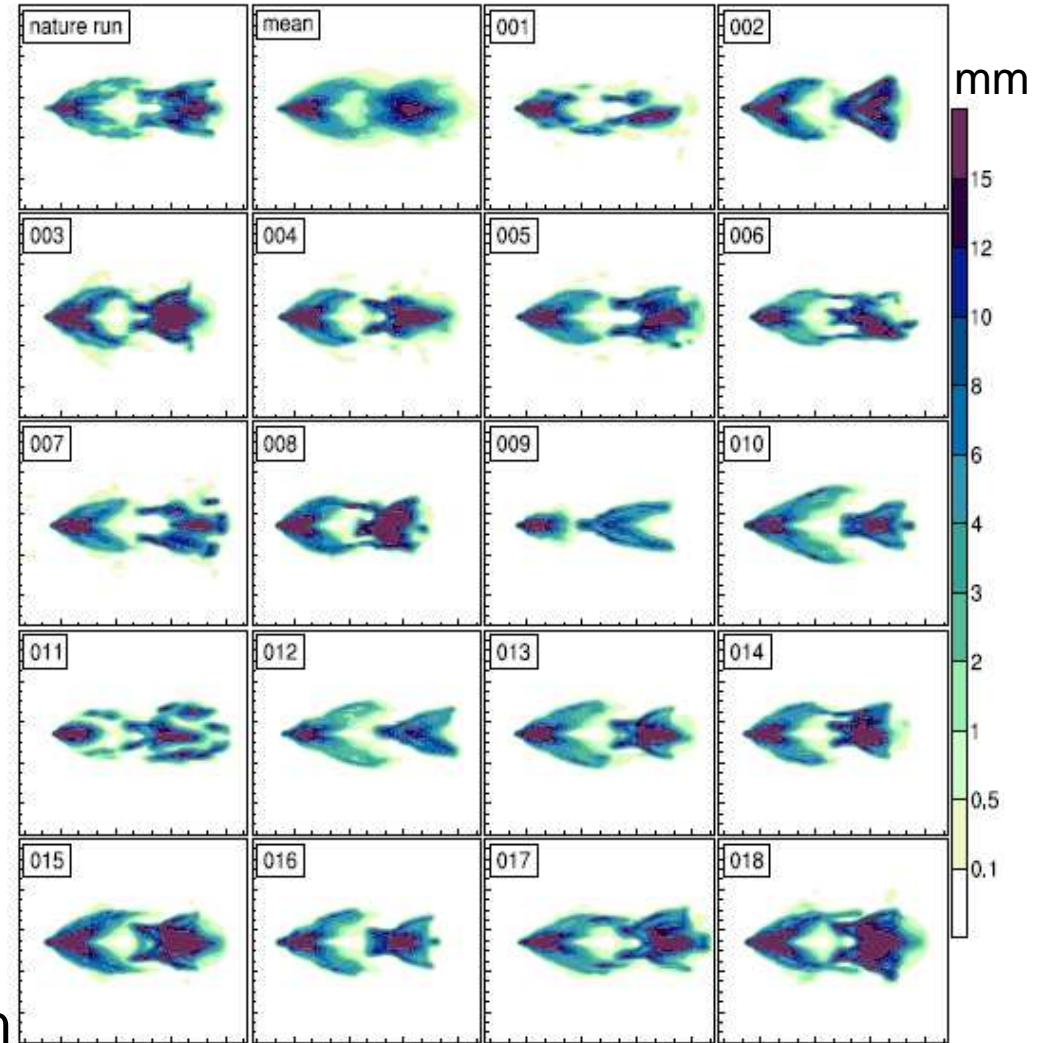






# Ensemble Simulations (2km)

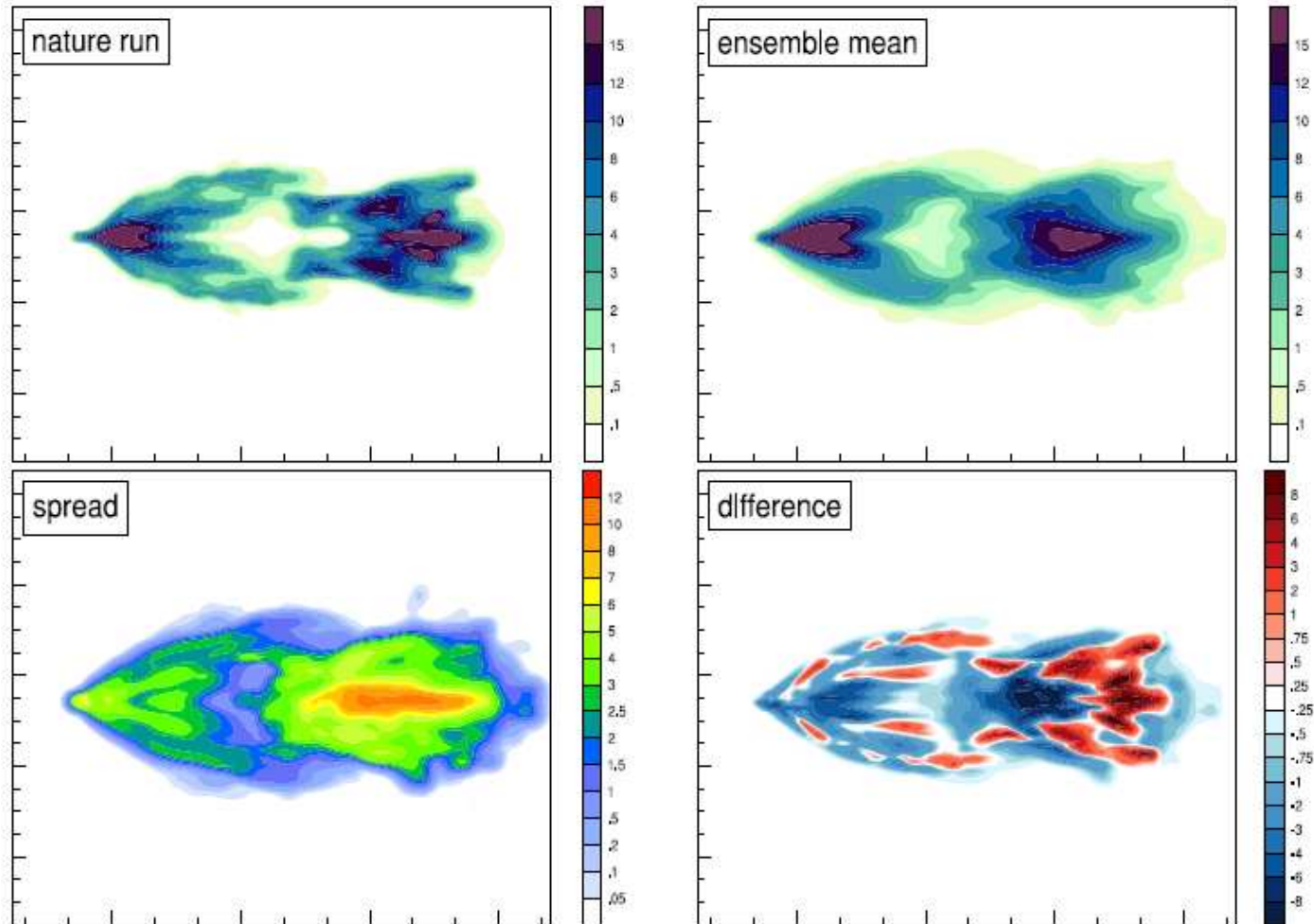
- U (s=1m/s) and T (s=0.25K) perturbations
- Variations in primary and secondary cell development





# Ensemble Simulations (2km)

t = 300min

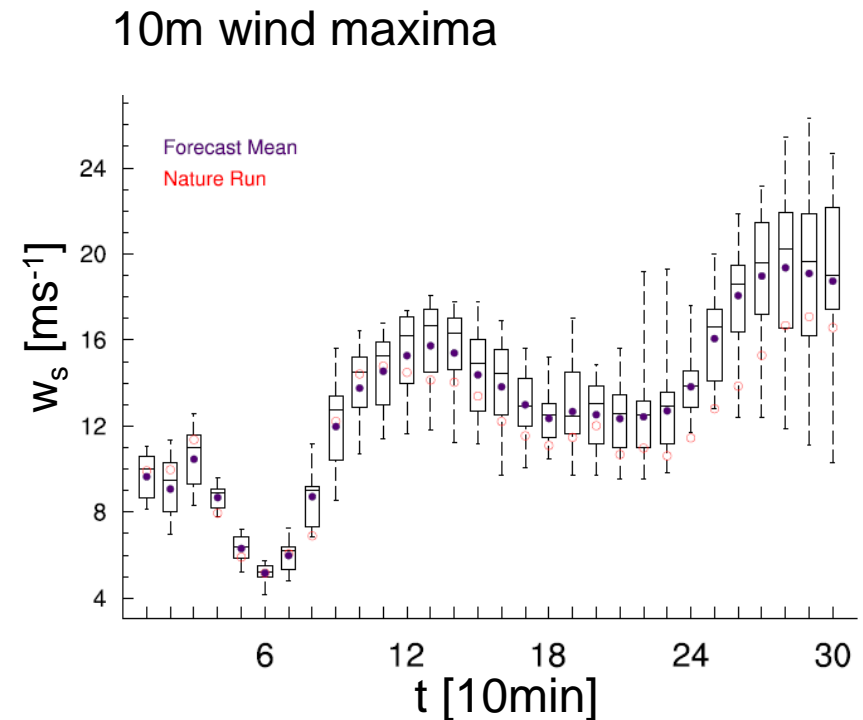
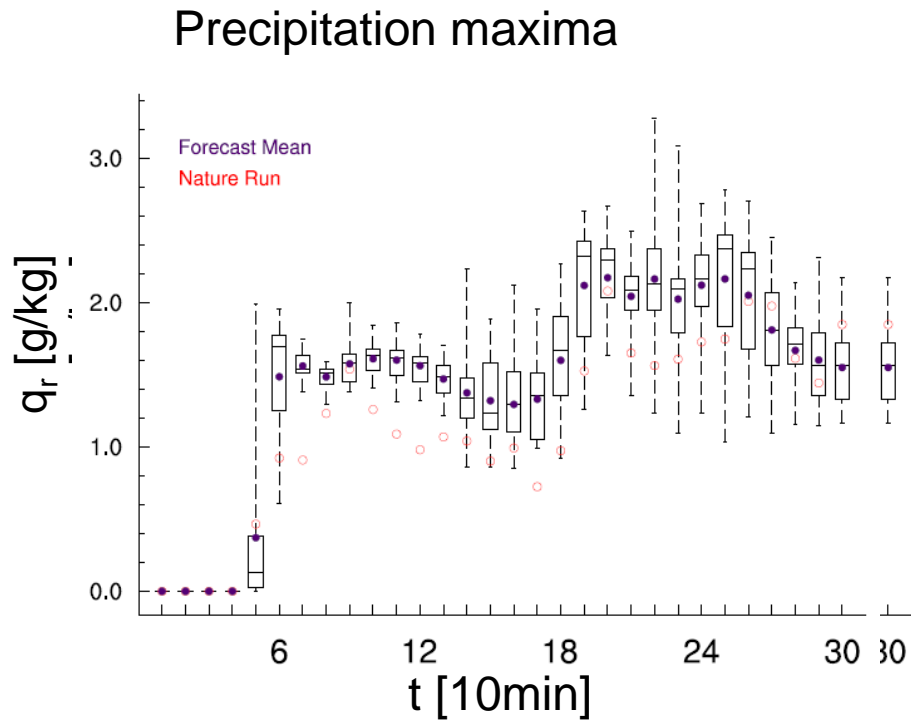






# Ensemble Simulations (2km)

Temporal development of areal precipitation and wind maxima





# Conclusions

- Wind speed, temperature and humidity profiles are all suited for perturbation of convective ensemble
- Spread is directly proportional to perturbation amplitude
- Appropriate perturbation standard deviations are  $2\text{ms}^{-1}$  for horizontal wind,  $0.25\text{K}$  for temperature, and  $2\%$  for relative humidity in our case.
- Variations in wind speed affect vorticity of rotating updrafts
- Variations in temperature and humidity affect CAPE and stability
- New idealized COSMO model namelist is well suited for generation of idealized ensemble simulations



# Outlook

- Further types of perturbations could include
  - Position of convection initiation
  - Horizontal variations of environment
  - Physical parametrization perturbations
  - Stochastic physics
- Conduct OSSE with KENDA LETKF

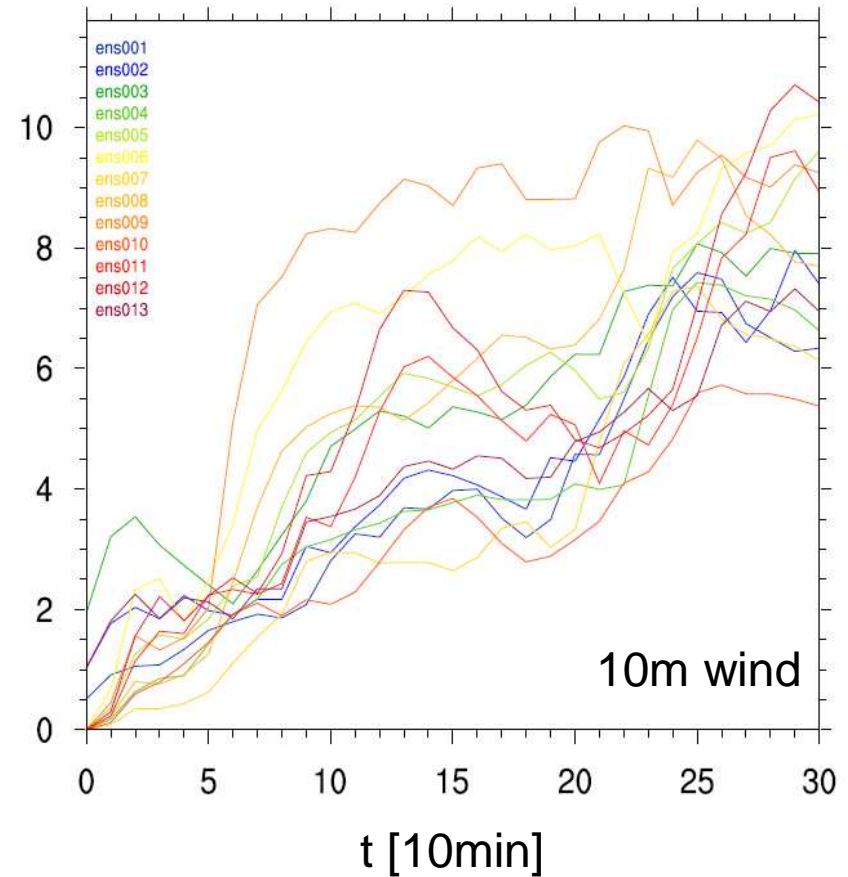
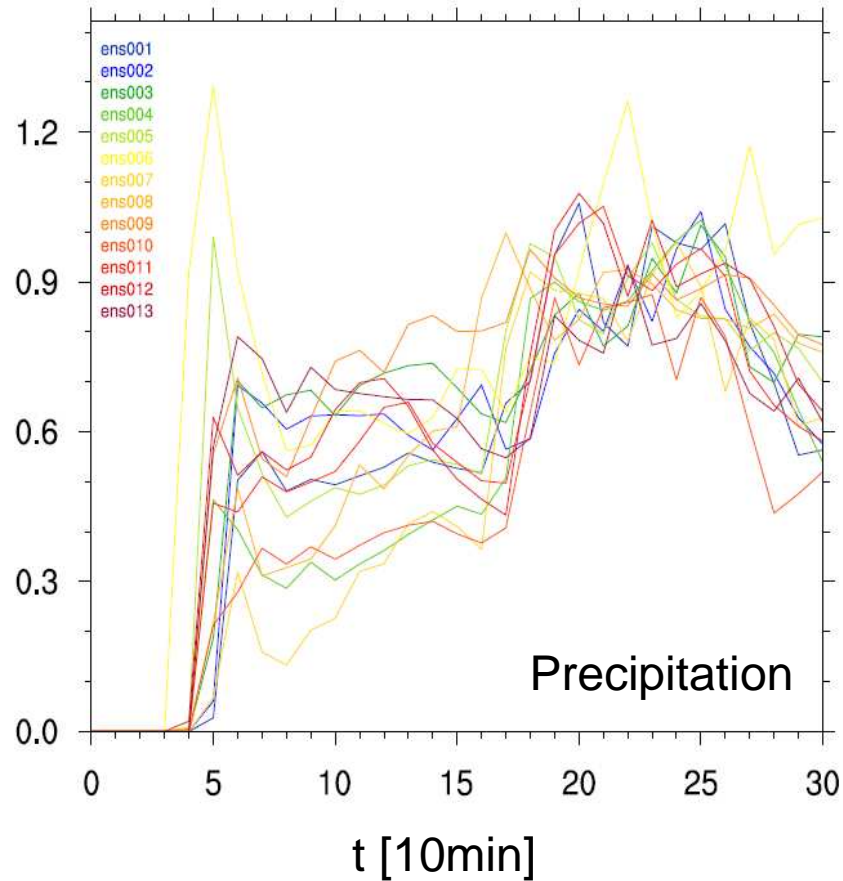


# Thank you for your attention



# Ensemble Simulations (2km)

- Development of maximum spread in computational domain







# Nature Run

