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Federal Department of Home Affairs FDHA  
Federal Office of Meteorology and Climatology **MeteoSwiss**

# KENDA at MeteoSwiss

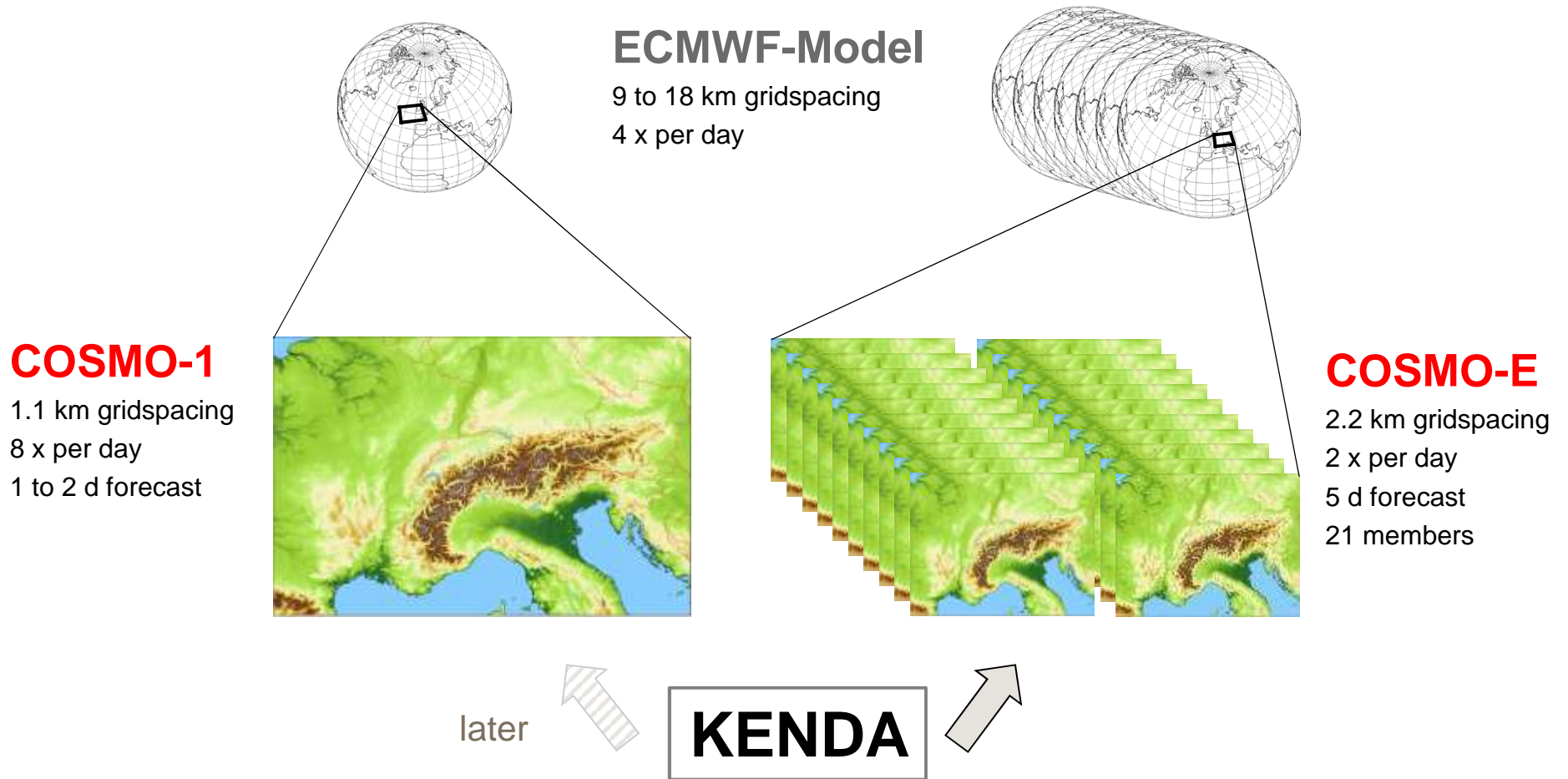
## Operational implementation and results

Daniel Leuenberger and the COSMO-NExT team  
MeteoSwiss, Zürich, Switzerland

COSMO General Meeting, 5.– 8. September 2016



# COSMO-NExT





# Operational KENDA Implementation

- General
  - 40 ensemble members, additional deterministic analysis
  - Hourly cycle
  - LBC perturbations from 30-42h old ECMWF ENS perturbations centered around the latest HRES forecast
- LETKF
  - Adaptive localization
  - Adaptive multiplicative covariance inflation
  - Relaxation to prior perturbations (RTTP)



# Operational KENDA Implementation

- Additionally
  - LHN in every ensemble member
  - Snow analysis for each ensemble member once per day
- Runtime for one cycle

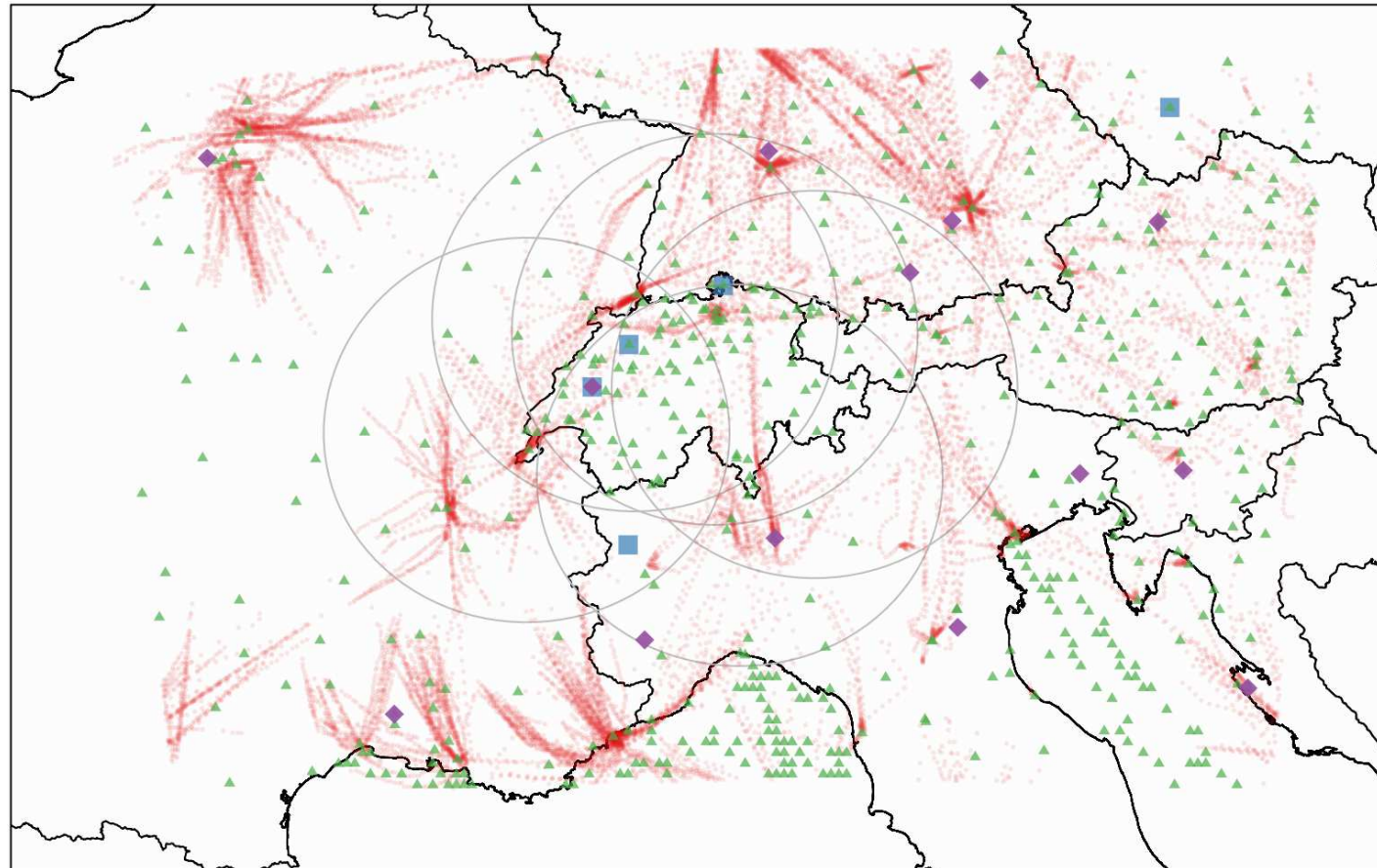
<b>Component</b>	<b>Run Time</b>	<b># of GPU</b>	<b># of CPU cores</b>
COSMO (fc step)	6.0 min	176	176
LETKF (update step)	2.5 min	--	264





# Observations

Location of observations collected during one month



- ◆ Radiosondes
- ▲ SYNOP ( $p_s$  only)
- Windprofiler
- Aircrafts
- Radar (with LHN)



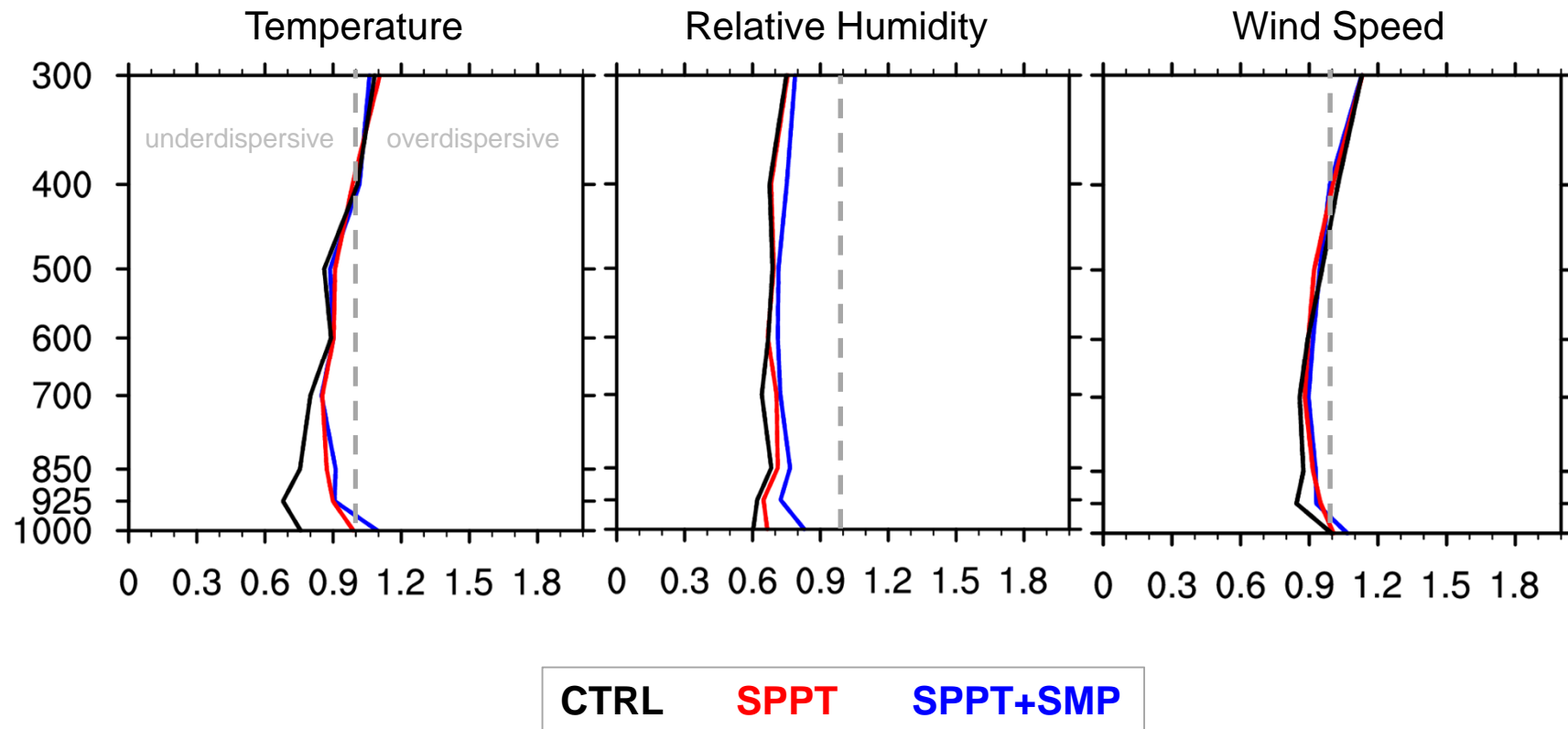
# Additional Perturbations

- LETKF assumes bias-free model
- As this is far from true, use ad-hoc ways to account for model error (covariance inflation, RTTP)
- Spread is **still too small**, use **more perturbations**:
  - Stochastic Perturbations of Physical Tendencies (**SPPT**)
  - Soil moisture perturbations (**SMP**)



# Analysis Performance

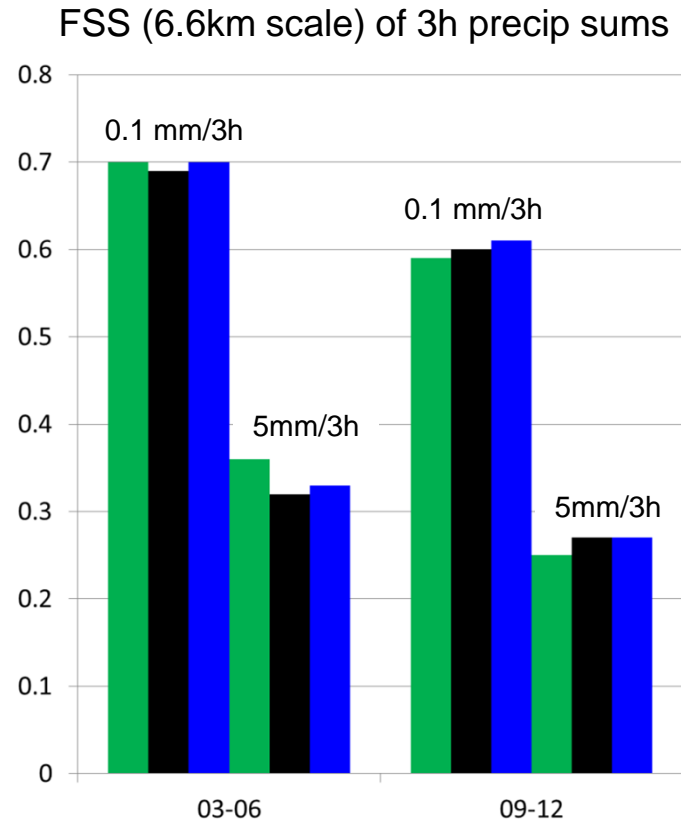
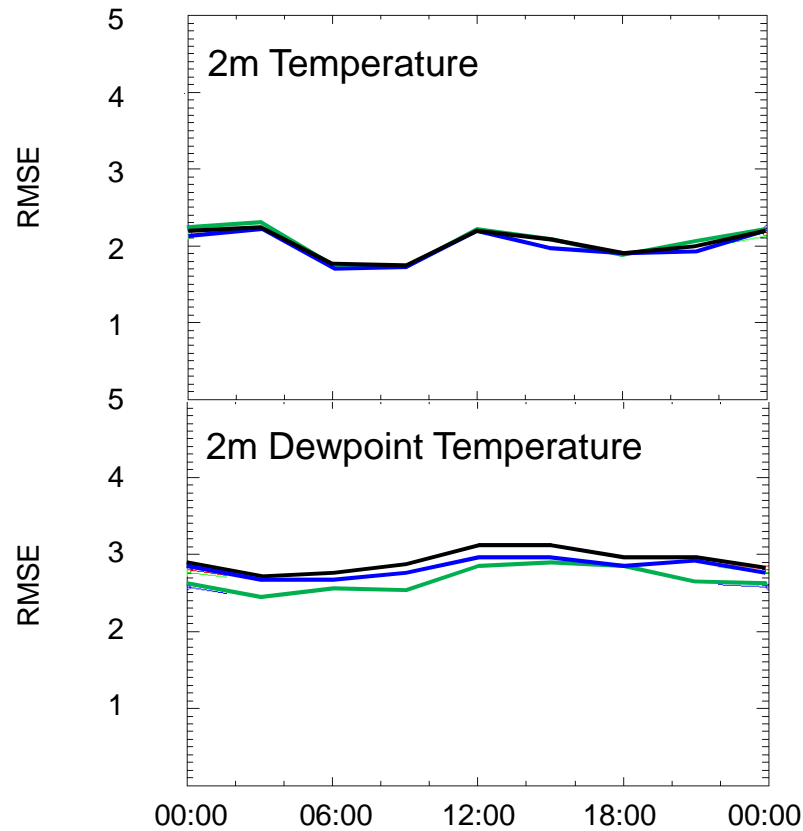
First guess spread-RMSE ratio, verification period: 17.7.-28.8.2015





# Comparison with Nudging

Lead time 1-12h, verification period: 17.7.-28.8.2015



CTRL

SPPT+SMP

Nudging

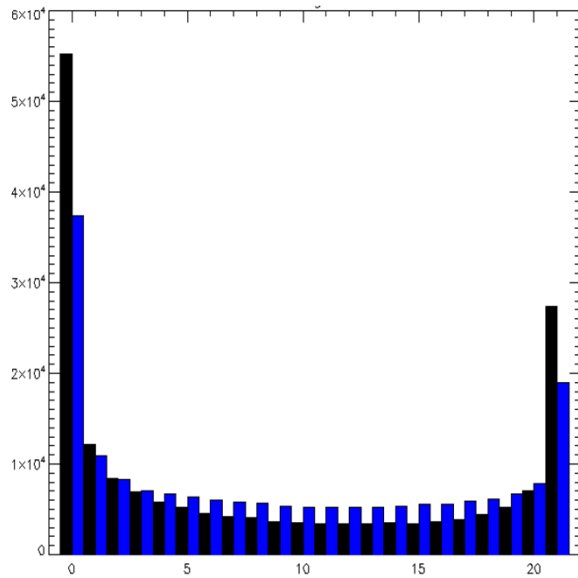




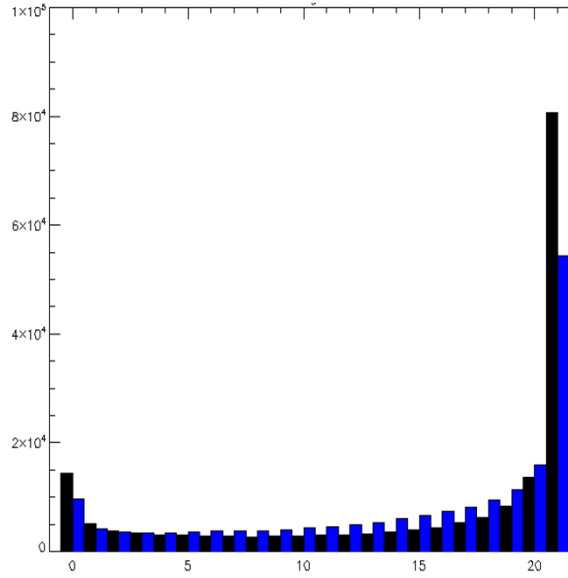
# Benefit of additional Perturbations

Lead time 1-12h, verification period: 17.7.-28.8.2015

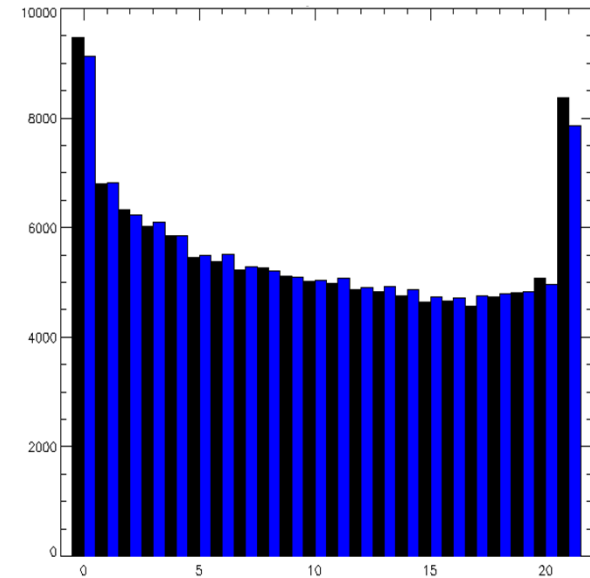
2m Temperature



2m Dewpoint Temperature



Precipitation



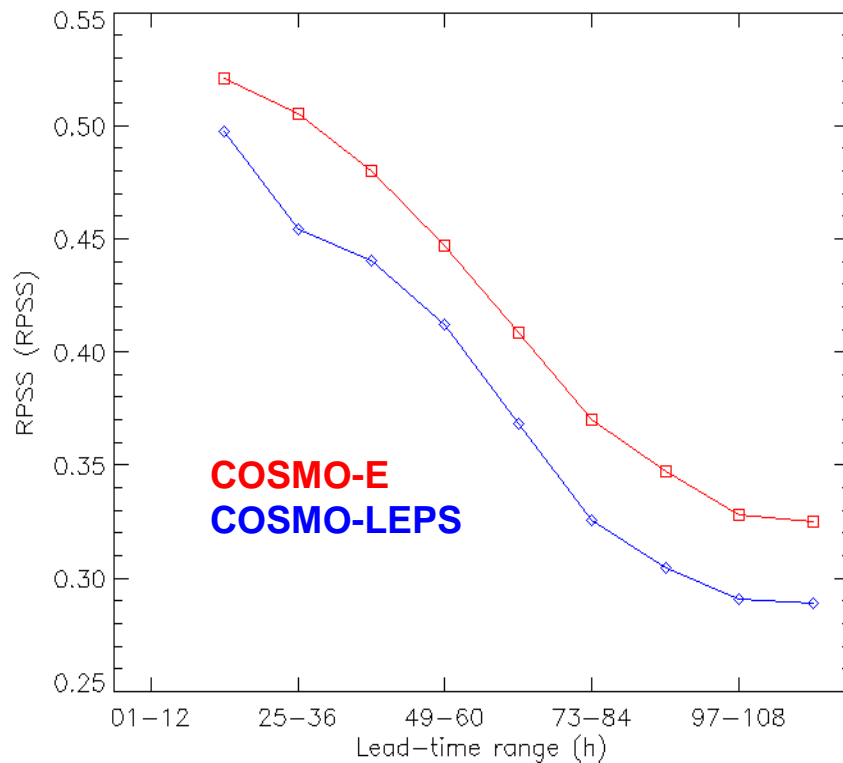
CTRL SPPT+SMP



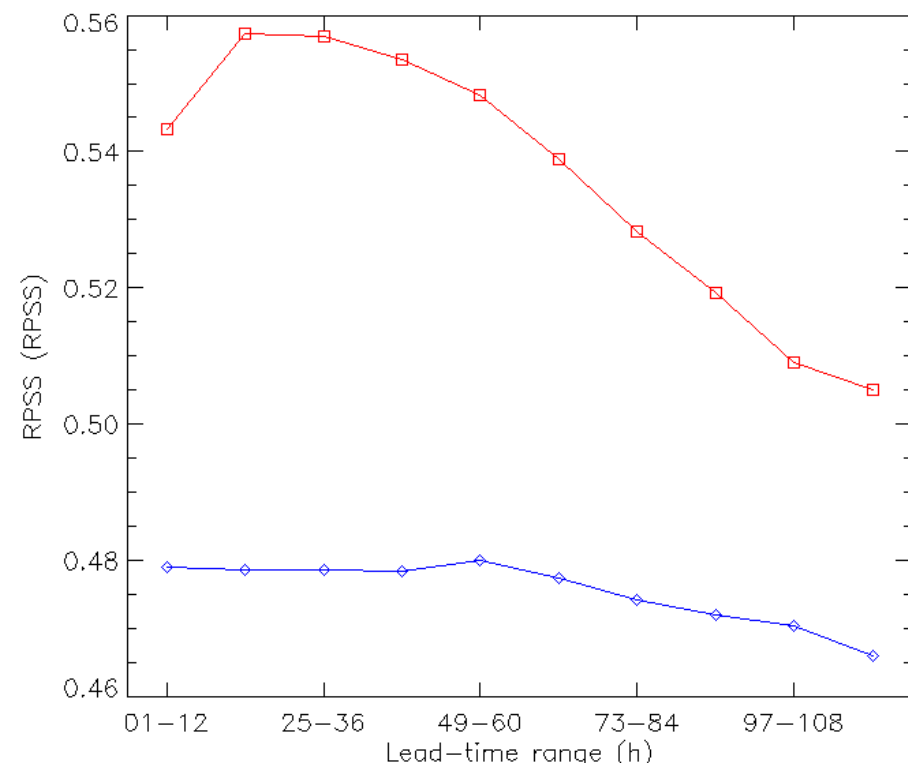
# COSMO-E outperforms COSMO-LEPS

RPSS of 12h precipitation sum and T<sub>2M</sub>, verification period: MAM 2016

Precipitation



2m Temperature





# Summary

- COSMO-E and KENDA operational since 19th March 2016
- COSMO-E outperforms COSMO-LEPS in most variables and seasons, out to +120h!
- KENDA deterministic analyses and forecasts similar to Nudging analyses and forecasts
- KENDA still slightly worse than nudging for summer TD\_2m and precipitation
- SPPT and Soil Moisture Perturbations consistently improve KENDA and forecasts started therefrom, benefit larger in Summer than in Winter period



# Outlook

- Assimilation of T\_2M and TD\_2M
- Deterministic analysis with  $\Delta x=1.1\text{km}$
- Assimilation of MODE-S observations
- Assimilation of more remote-sensing observations (Radar, Lidar, Radiometer, Satellites)



## Thanks...

- ... **to DWD**: Andreas Rhodin, Christoph Schraff, Harald Anlauf, Hendrik Reich, and Roland Potthast
- ... **to the COSMO-NExT team**: André Walser, Guy de Morsier, Jean-Marie Bettems, Marco Arpagaus, Oliver Fuhrer, Petra Baumann, Philippe Steiner, Pirmin Kaufmann, Simon Förster, Xavier Lapillonne, and Yann Lepoittevin
- ... **for your attention!**



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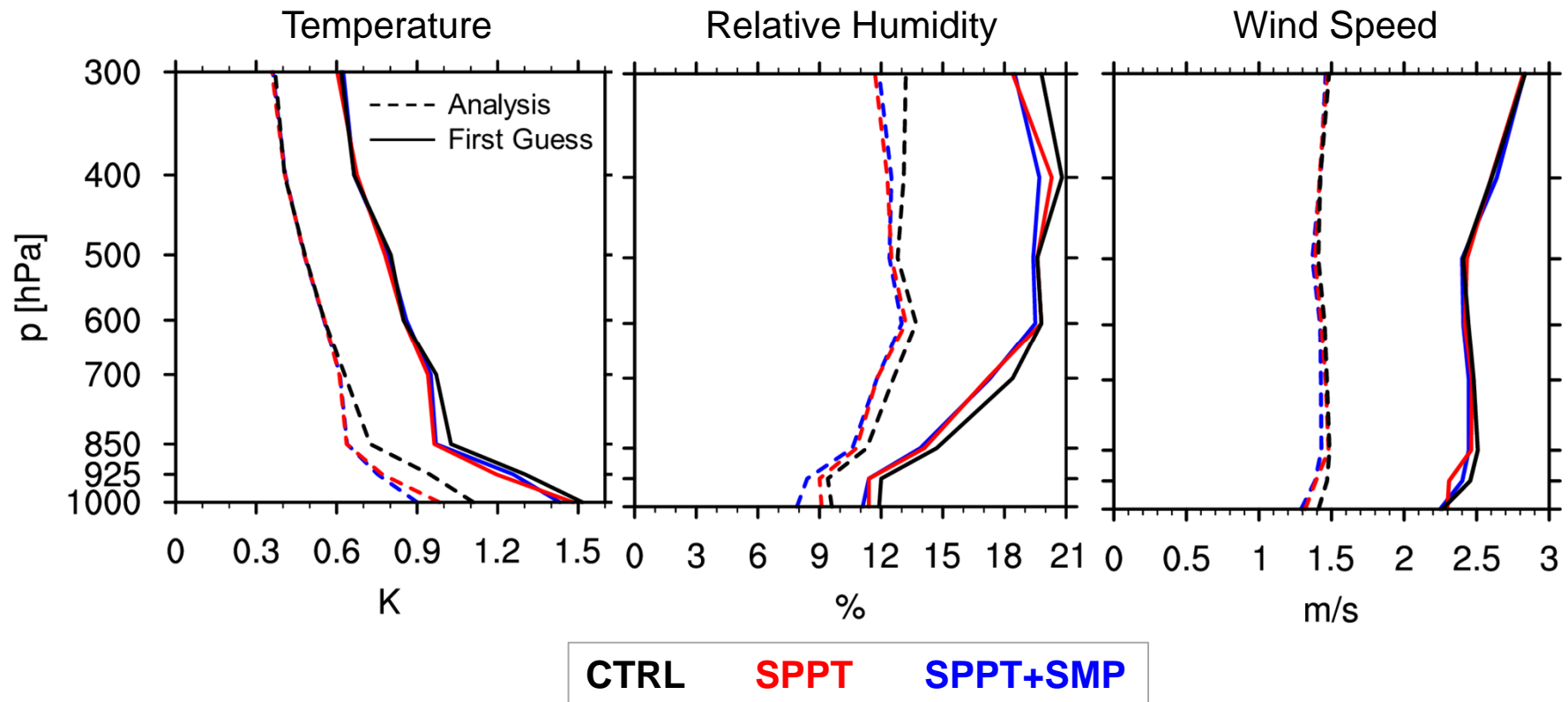
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# Analysis Performance

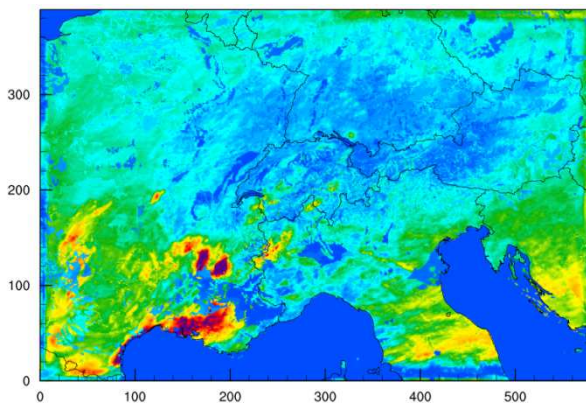
RMSE of Analysis and First Guess



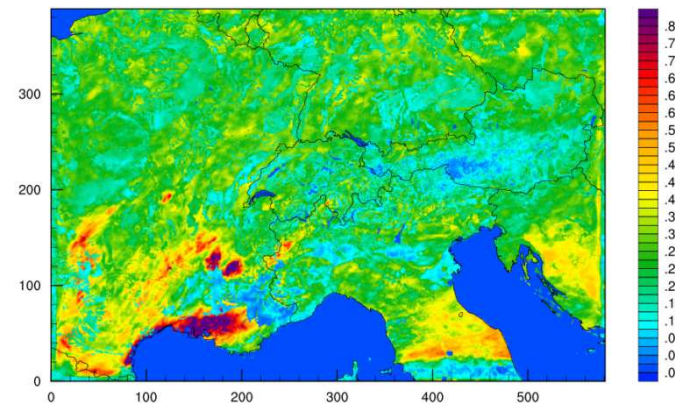


# Additional Perturbations

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- Spread is still too small, use more perturbations:
  - Stochastic Perturbations of physical tendencies (SPPT)
  - Soil moisture perturbations
  - Increase in soil moisture spread by ca 80%



**MeteoSwiss**



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Daniel Leuenberger

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