SPPT: status

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Done:

- bugs fixed (e.g. erroneous perturbation of Coriolis term, latent heat tendencies, etc., implementation details discussed with M. Baldauf), updated to COSMO V5_0
- 2 new namelist options: also perturb q_i, q_c, resp. q_r, q_s, q_g
- (short scientific documentation section written)
- Revised SPPT has been tested over 1 month, positive impact (next slides)

Being done / to be done:

- **implement** reproducibility of all random fields in subsequent runs to allow for sufficiently long time correlation function in a rapid **DA cycle**
- **implementation**: replace use of vertical coordinate parameters (for Grib-2)
- update of **User's Guide** (namelist parameters), inline modification comments

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Swiss Confederation

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

Excerpt from:

COSMO-E experiments with SPPT on the convection-permitting scale

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MeteoSwiss

COSMO User Seminar, 19 March 2014

compiled by C. Schraff for SMC teleconference, 16 April 2014

SPPT: Stochastic Perturbation of Physical Tendencies

$$\frac{\partial X}{\partial t} = D^X + K^X + (1 + rand) \sum_{i=1}^{N} {P_i}^X$$

dynamics — random pattern

local tendency — horizontal diffusion — physics

X	prognostic variable (u, v, T, q_v, q_c, q_i, q_r, q_s, q_g)
${P_i}^X$	physical parameterisation scheme *i* (turbulence, radiation, microphysics, shallow convection, …)

copied and adapted from Shutts

Validation:

- SPPT **must not** degrade (deterministic) quality of ensemble members
- **deterministic runs (1 month each in summer / winter 2012)**
  for (testing sensitivity to) different SPPT parameter settings
- COSMO version 5.0 with single precision
  (reduction of elapsed time to 60% with same forecast quality!)

- **generally (very) small differences between different tested SPPT parameter settings**
- larger differences found for summer
- no differences seen for humidity; no drying observed!
- no significant quality degradation observed with strong SPPT
- choose (aggressive) SPPT parameter settings for tests

Verification: COSMO-E test suite

- 1 month period **(26.07.-25.08.2012),** one run at 00 UTC every second day **(results in 16 runs per setup)**
- experiments:

name	***ICs***	***LBCs***	***Δt***	***Δi=Δj***	***σ***	***range***
19e111	**LETKF**	**ENS**	**6h**	**5.0°**	**1.0**	**0.9**
19e110	**LETKF**	**ENS**	**---**	**---**	**---**	**---**
19e011	**COSMO-2**	**ENS**	**6h**	**5.0°**	**1.0**	**0.9**
	COSMO-LEPS (ICs & LBCs: IFS-ENS)					

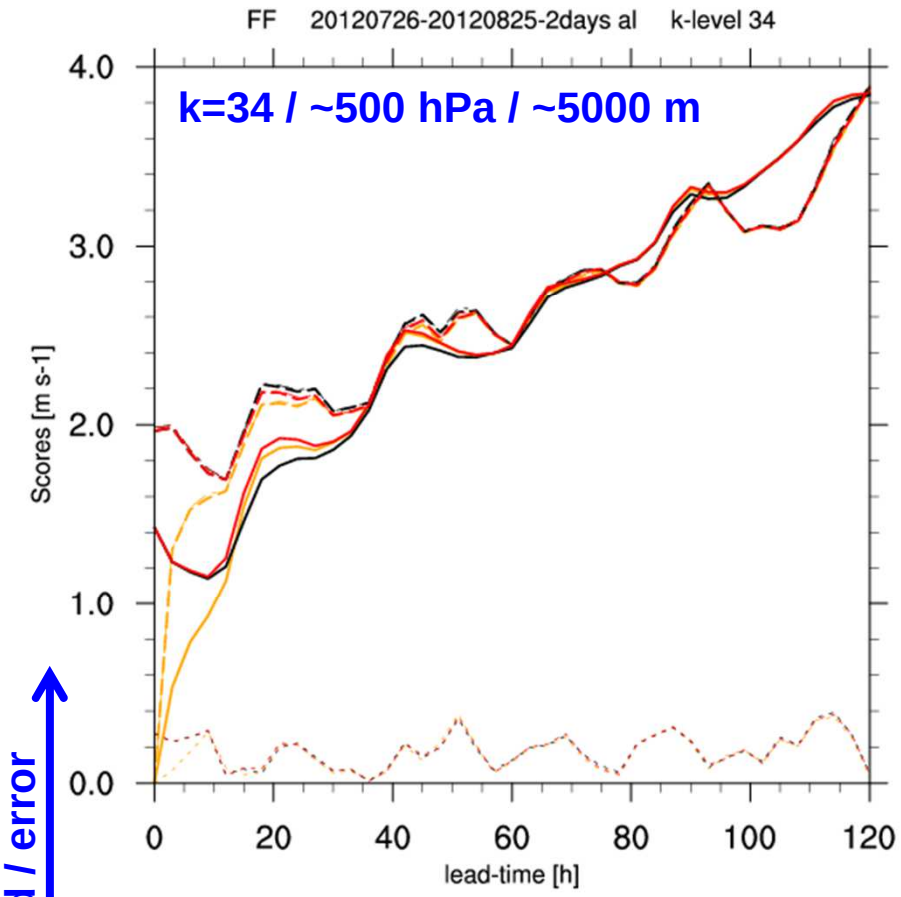
for SPPT: no tapering near the surface, no humidity limiter

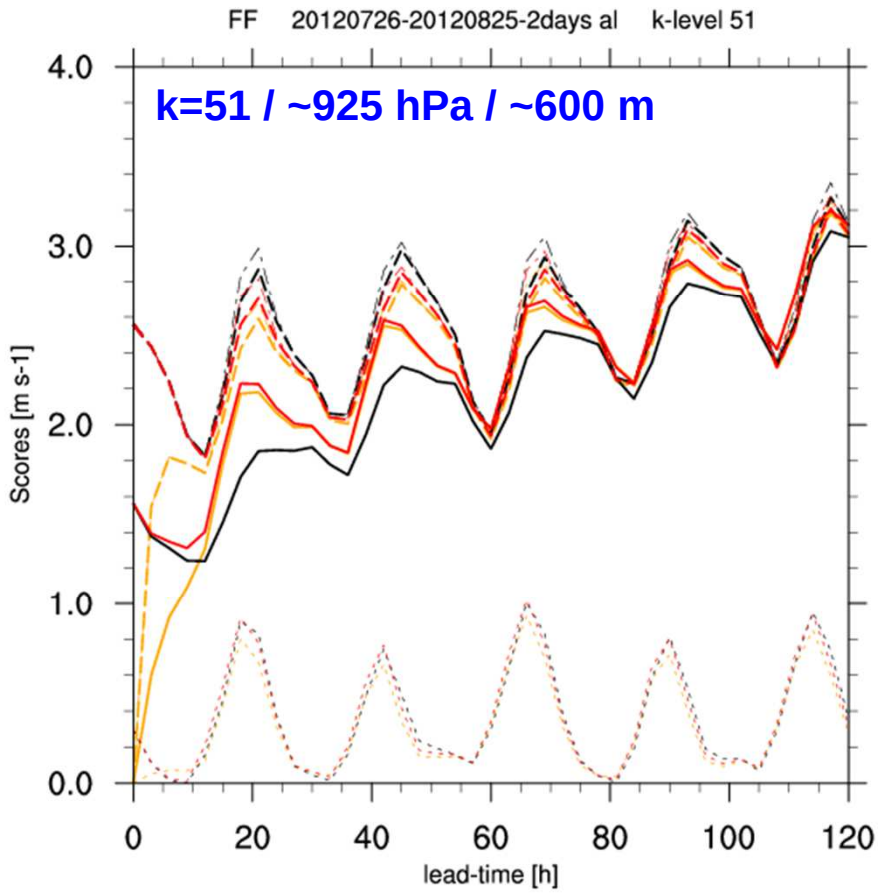
→ spread / error relation against COSMO-2 analysis

→ BS and BSS against surface observations

(COSMO-E: 2.2 km L60, N_{ens}=21, IC: KENDA, LBC: IFS-EPS, single precision)

spread / error: wind speed





spread / error

lead-time [h]

ICs plus LBCs plus SPPT

ICs plus LBCs

LBCs plus SPPT

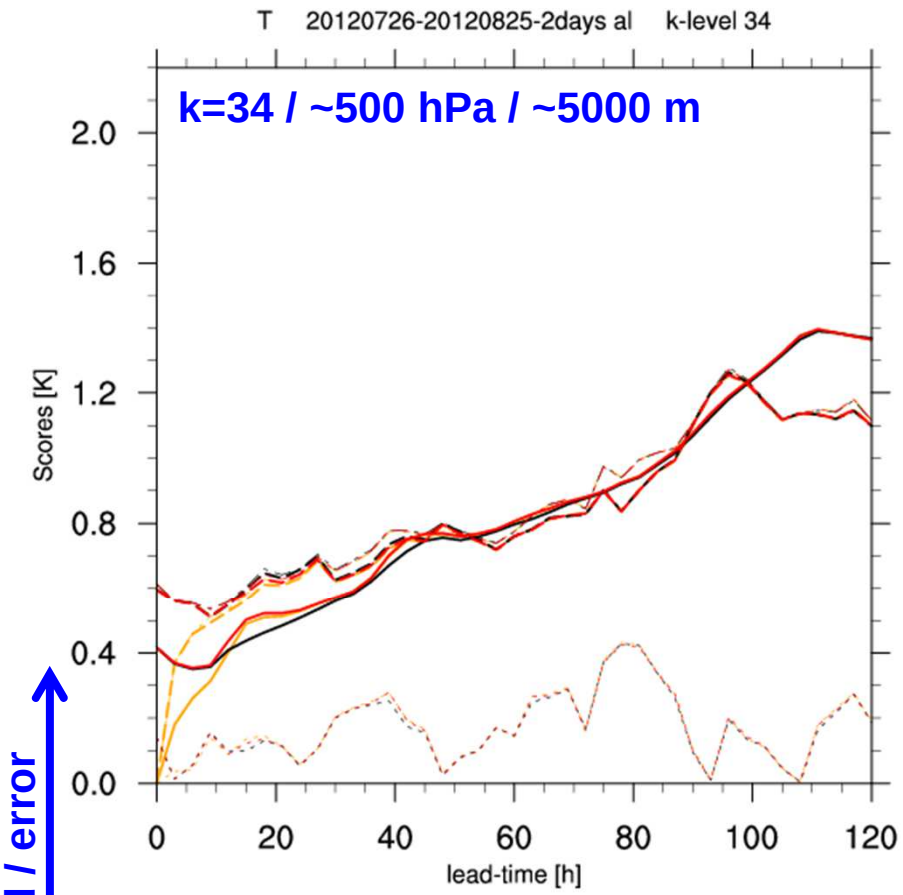
RMEV

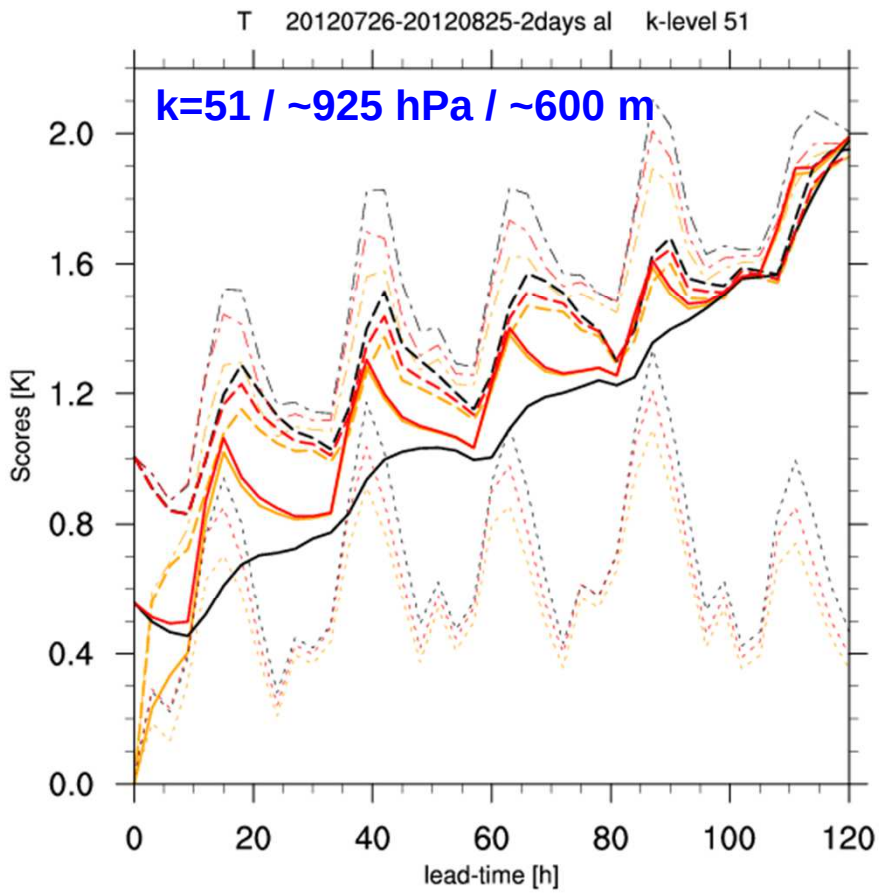
STDE

RMSE

abs(BIAS)

spread / error: temperature

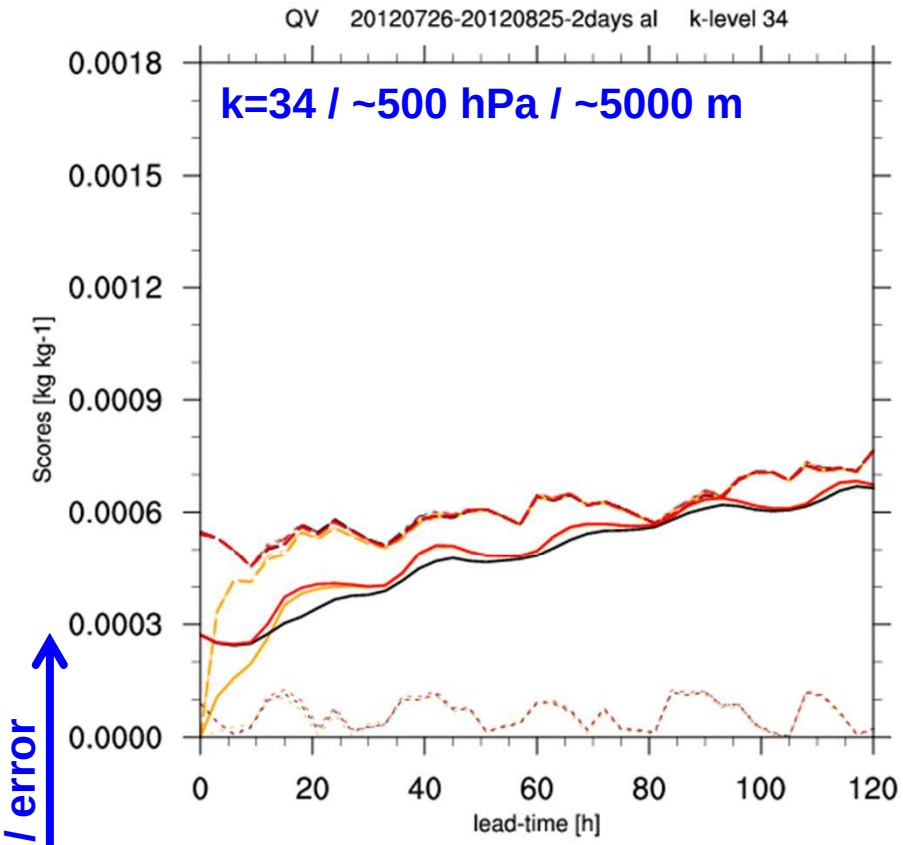


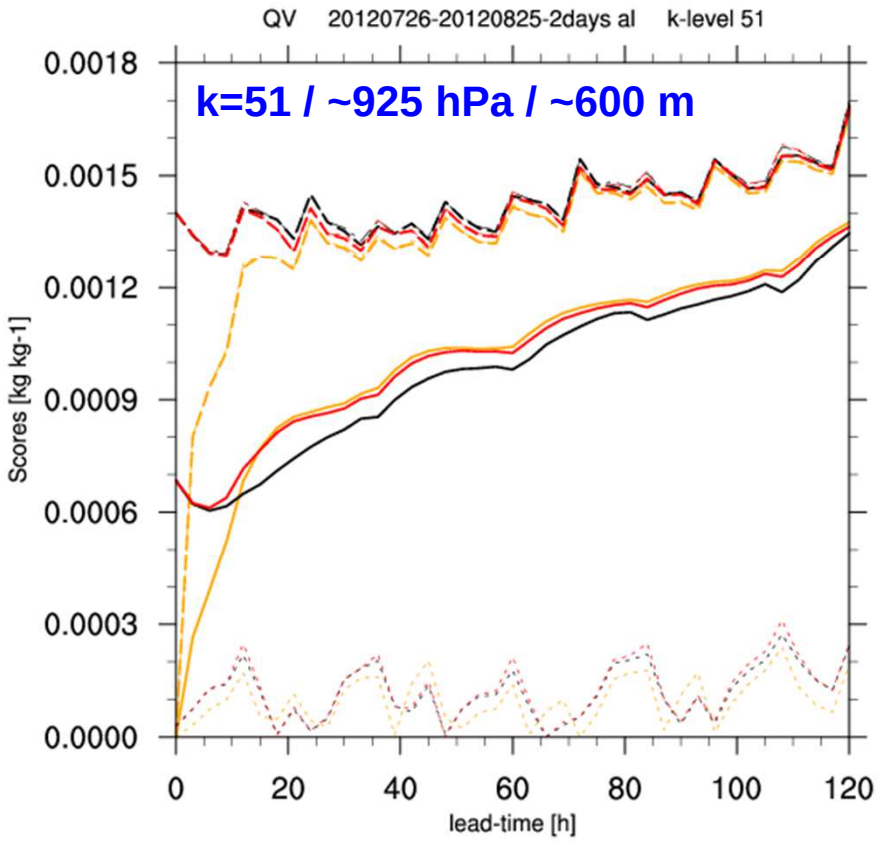


ICs plus LBCs plus SPPT
ICs plus LBCs
LBCs plus SPPT

RMEV
STDE
RMSE
abs(BIAS)

spread / error: humidity





spread / error

lead-time [h]

ICs plus LBCs plus SPPT

ICs plus LBCs

LBCs plus SPPT

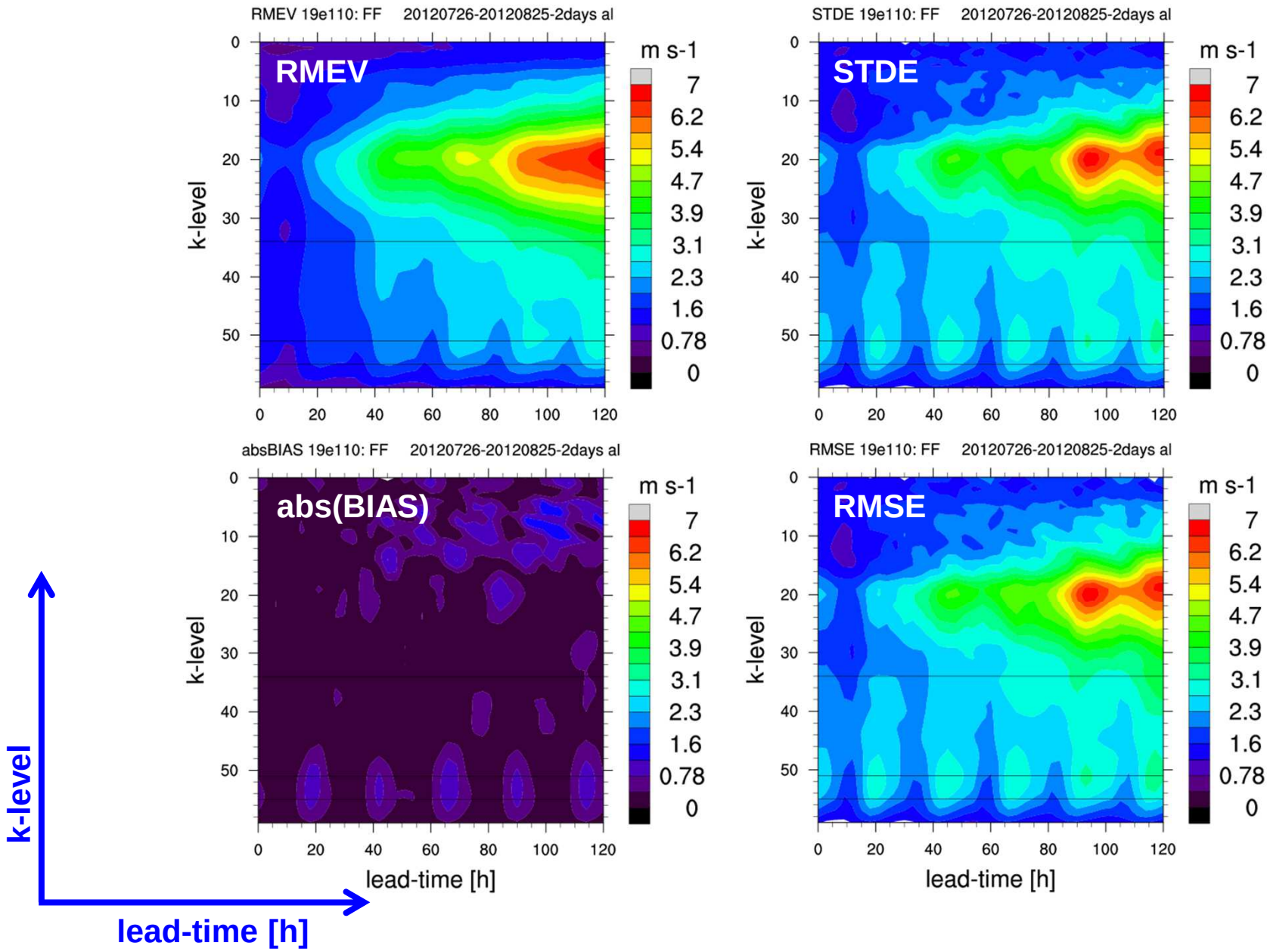
RMEV

STDE

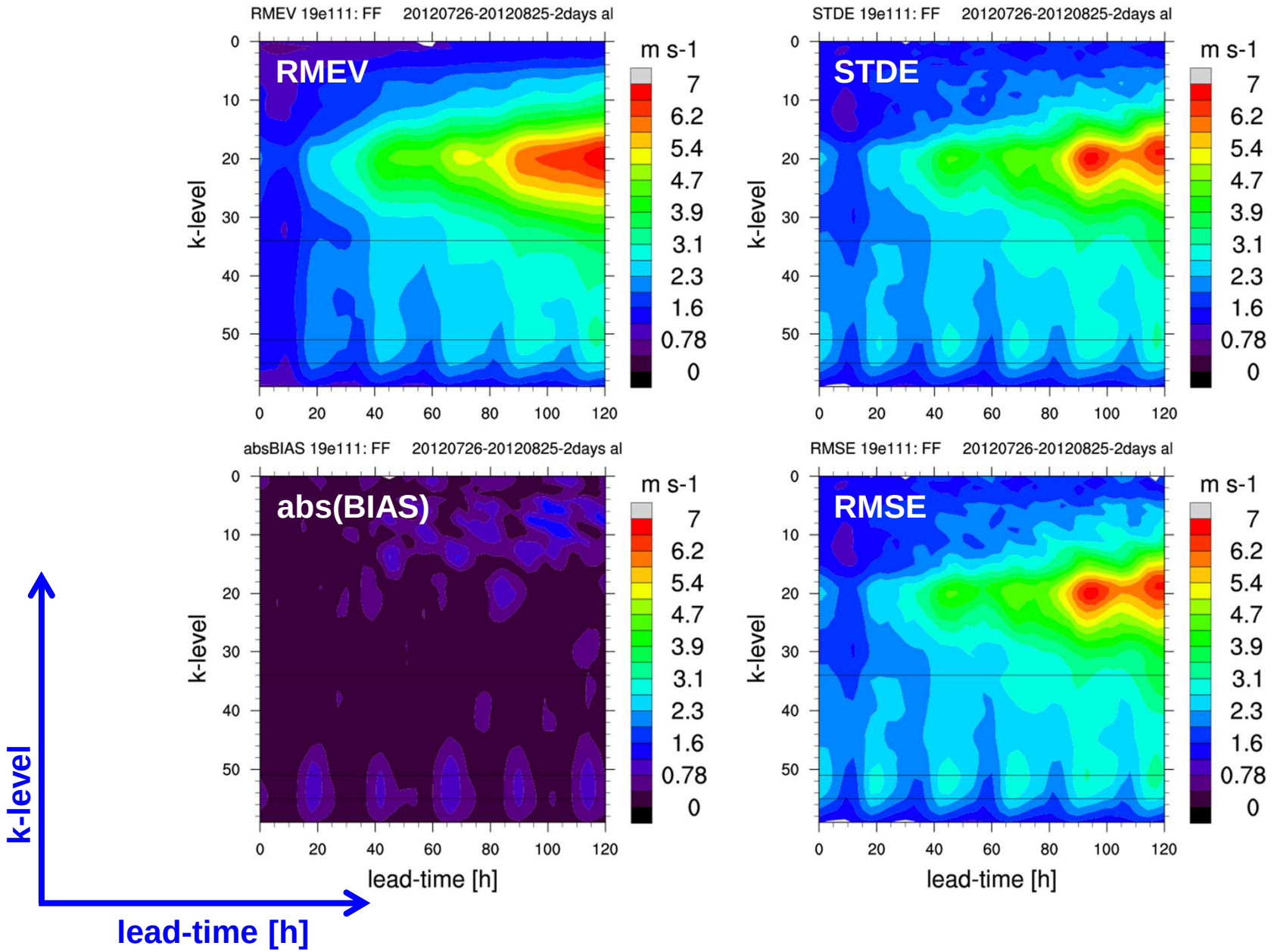
RMSE

abs(BIAS)

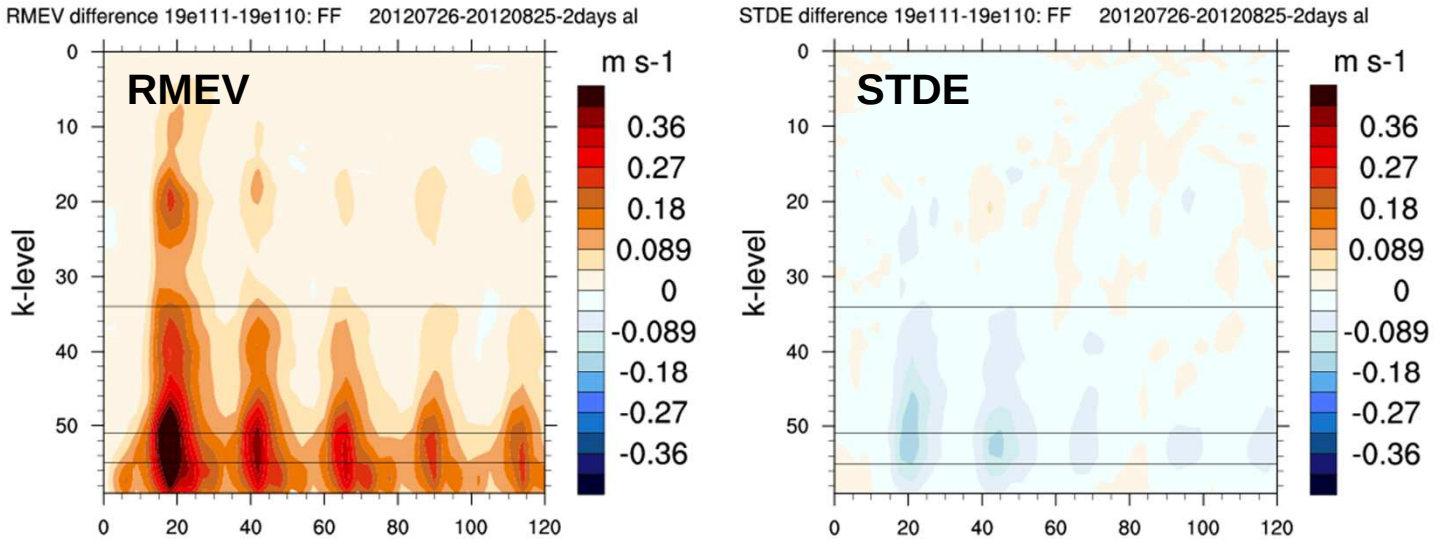
spread / error: wind speed, 19e110

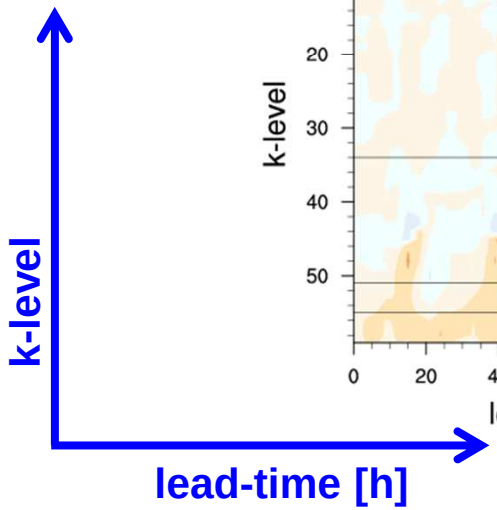


spread / error: wind speed, 19e111

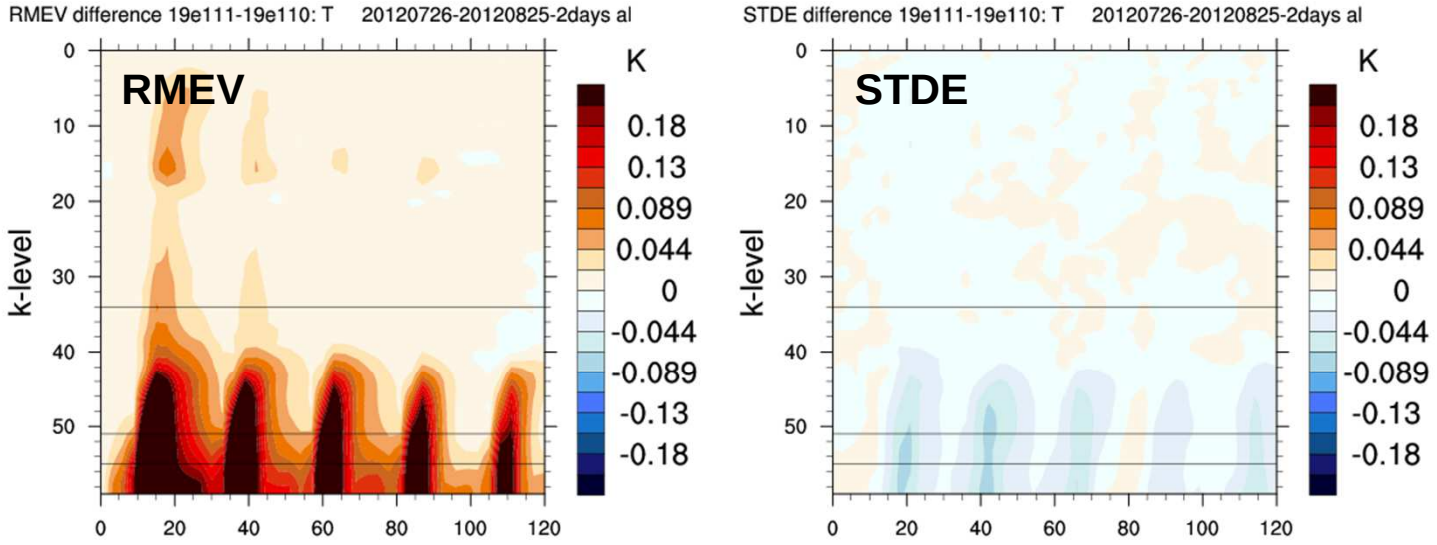


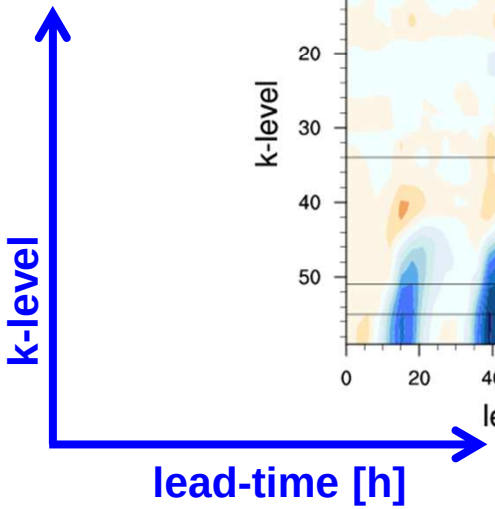
spread / error: FF, 19e111-19e110



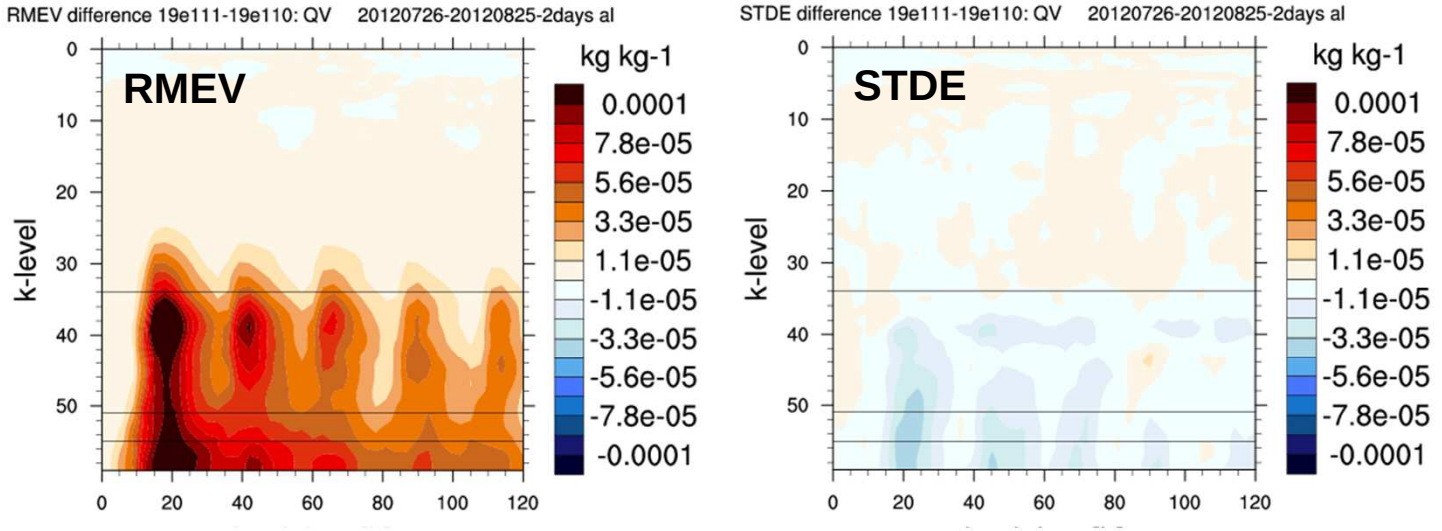


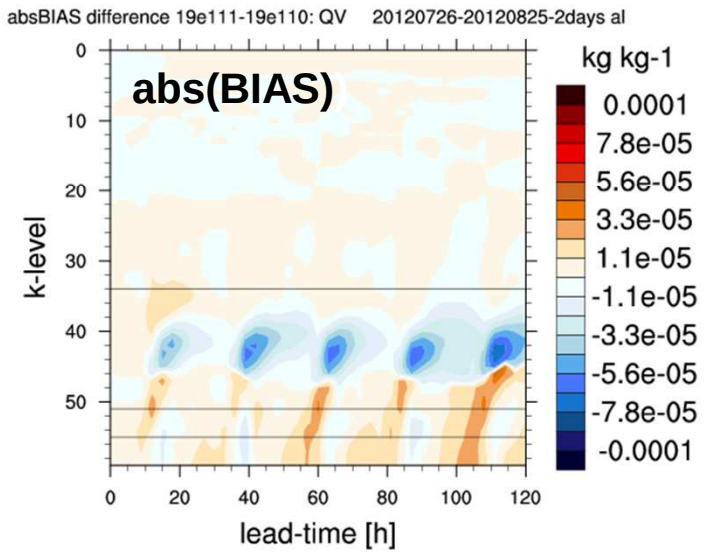
spread / error: T, 19e111-19e110

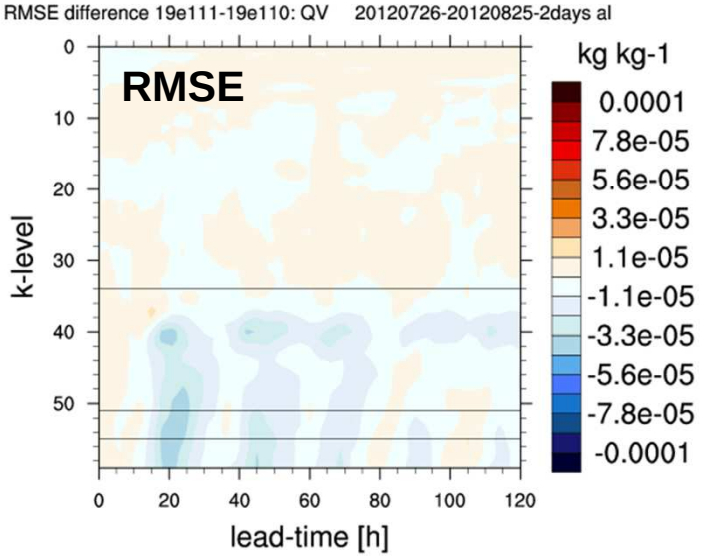


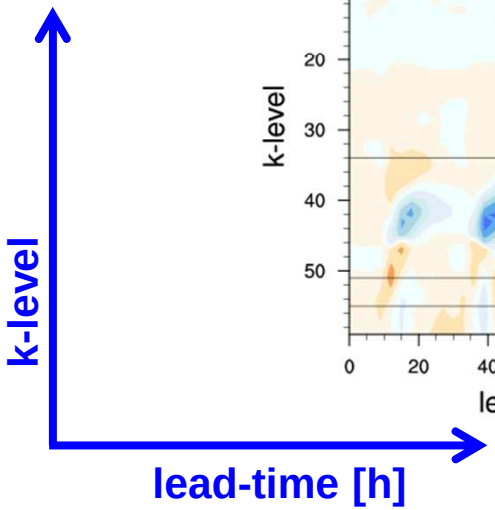


spread / error: QV, 19e111-19e110

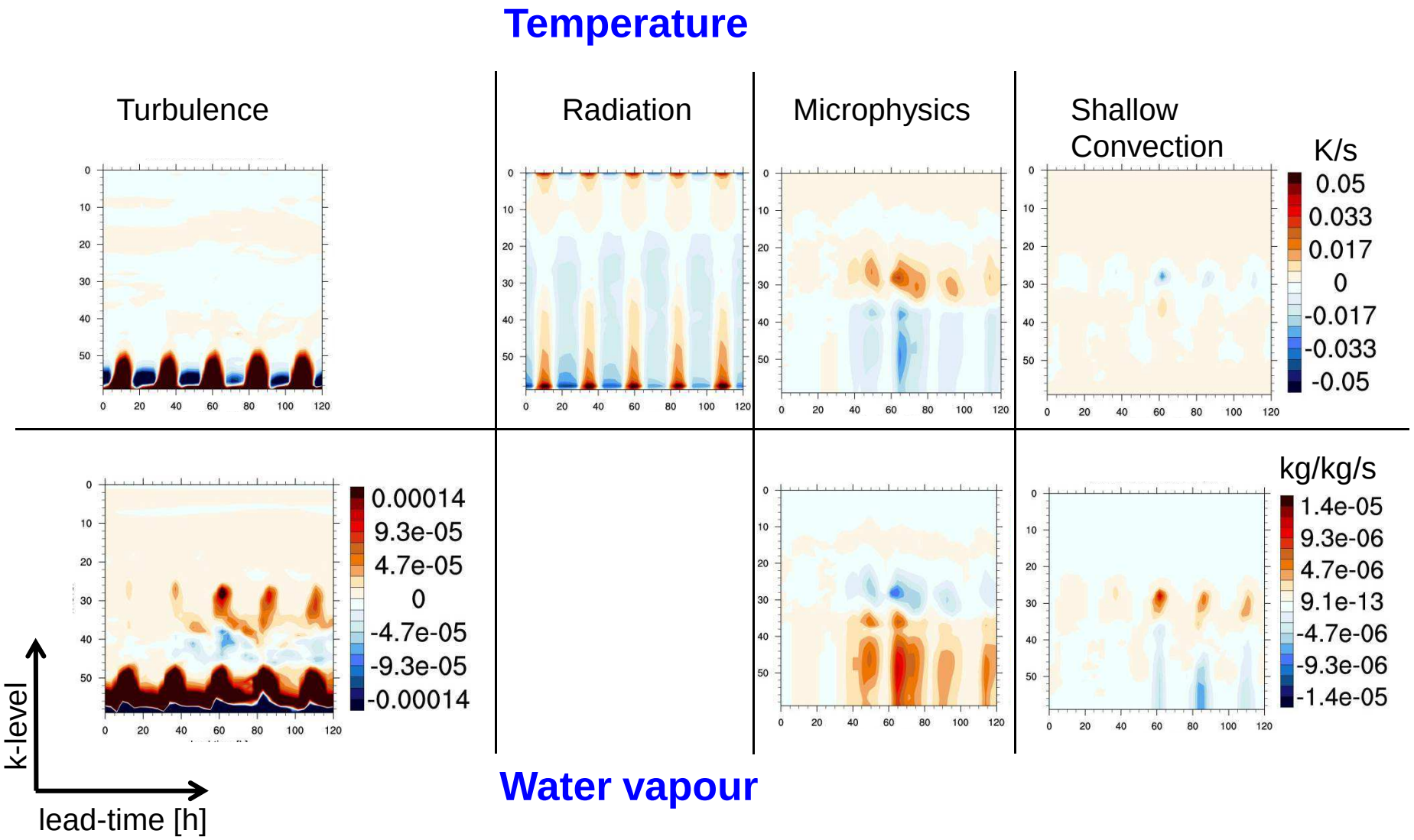




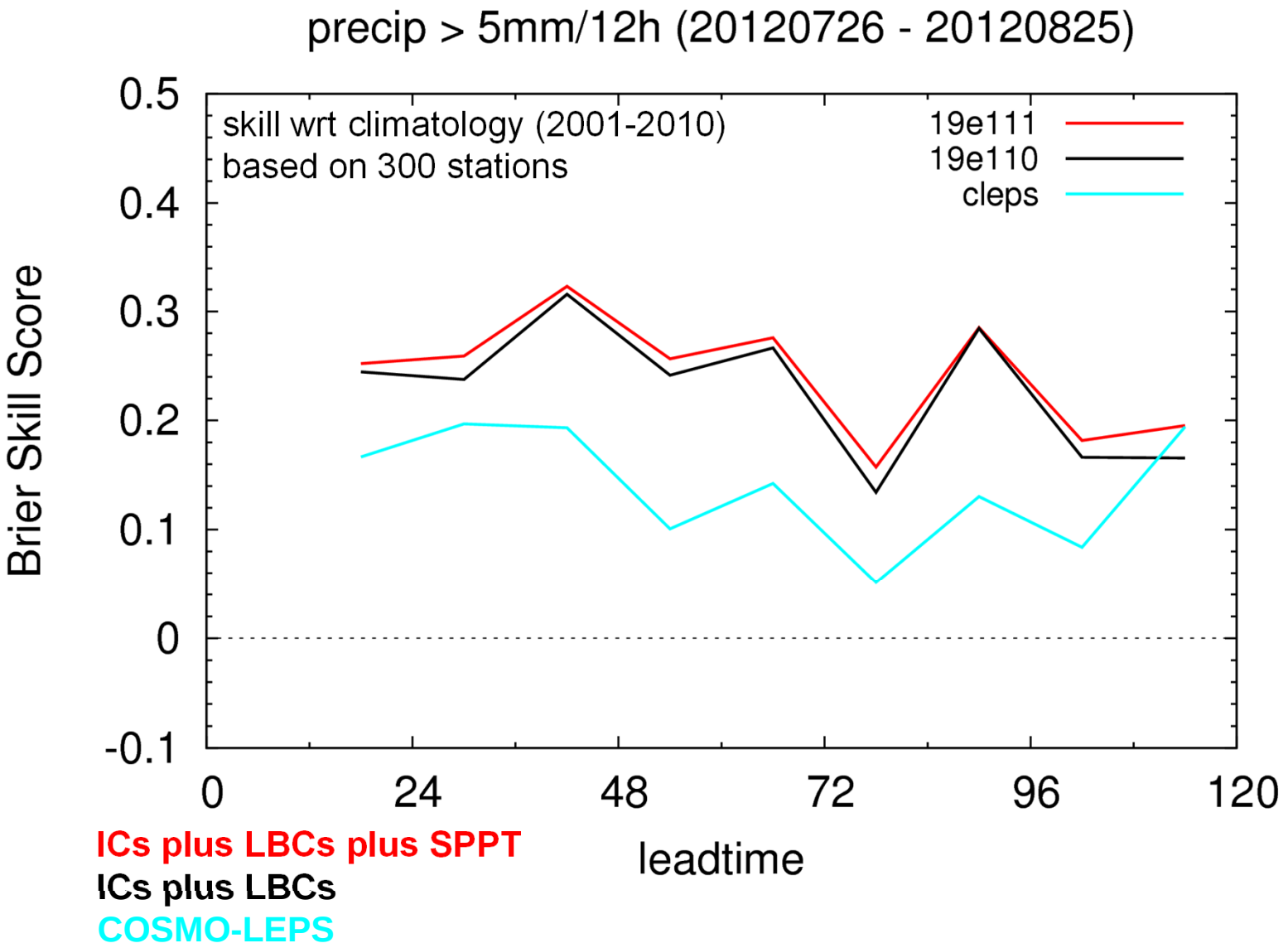




Tendencies: vertical, 19.08.2012



Brier Skill Score: precip, > 5mm/12h



Conclusions from verification

vs. COSMO-2 analysis

- **generally satisfactory** spread-error relation in **middle / upper troposphere**
  - beyond day 2 spread only determined by LBC perturbations
  - too little spread in first 36 hrs (IC !), almost too much spread for day 5
- **significant improvement** of RMEV (spread), STDE, and BIAS **due to SPPT** in (mainly **lower**) **troposphere**
  - positive effect of SPPT for entire forecast range
  - poorest effect / results for **humidity** (still too little spread); skilful perturbation of humidity most difficult
  - impact of SPPT much larger than of parameter perturbations (not shown)

vs. (surface) observations

- 12h precipitation : **small (!) improvement due to SPPT**
  - surprisingly good reliability for all lead-times
  - outperforms COSMO-LEPS
- 2m temperature : **moderate improvement due to SPPT**

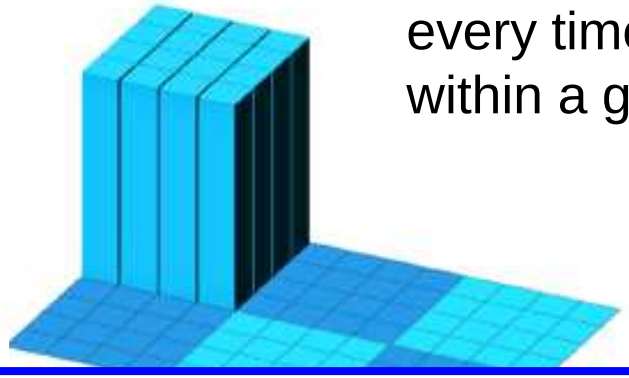
Outlook

- increase statistics (e.g., winter); **start regular runs**
- improve ICs and IC perturbations (KENDA/LETKF)
- add "additional" perturbations at/in the surface (e.g., soil moisture; LETKF already allows for a free evolving soil, but time-scales involved are large …)?

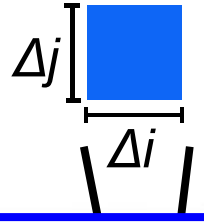
- look into Stochastic Kinetic Energy Backscattering Scheme (SKEBS) and/or Stochastic Pattern Generator (→ poster)?

- last but not least: get a versatile and powerful verification tool

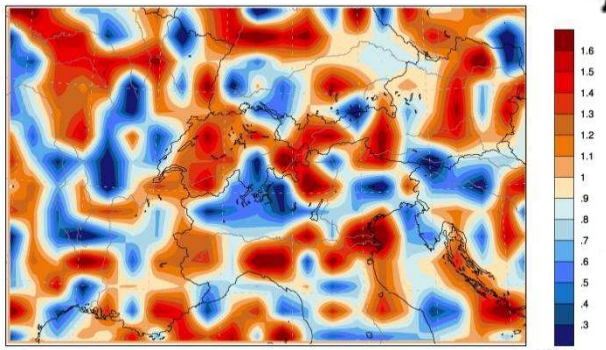
SPPT: Generation of random pattern



every timestep Δt draw N(0,σ) random numbers within a given *range* on coarse grid Δi, Δj

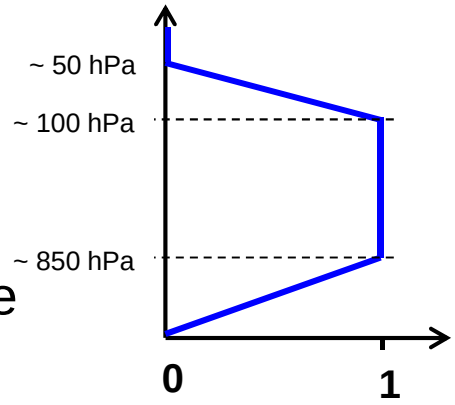


will (probably) be available with COSMO 5.1



random pattern (1+*rand*)

if required:
vertical tapering at model top and close to the surface



copied and adapted from Torrisi