Physics perturbations in HIRLAM-EPS

Henrik Feddersen, hf@dmi.dk

Attempts to account for forecast uncertainty due to model error...

How to perturb model physics

- Random perturbation of total physics tendencies ("ECMWF-type" stochastic physics; Buizza et al., 1999).
- Perturbation of selected parameters in physics parameterizations.
- Stochastic backscatter of kinetic energy.
- …

DMI

Stochastic physics

Model equations:

$$\dot{x}_j = A_j(x,t) + P_j(x,t) + r_j(x,t)\,P_j(x,t)$$

x_j = {T, u, v, q, cw}

A_j = dynamics tendencies, P_j = physics tendencies

r_j = stochastic parameter

$$r_j(t+T) = \alpha \langle r_j(t) \rangle_D + \langle s_j \rangle_D$$

T = update interval

$\langle . \rangle_D$ = spatial average over domain D

s_j = uniformly distributed random number

DMI

Stochastic physics

Typical values:

T = 1hr

$\alpha = 0.96$

D = 62×45 grid pts (=nlon×nlat on one PE)

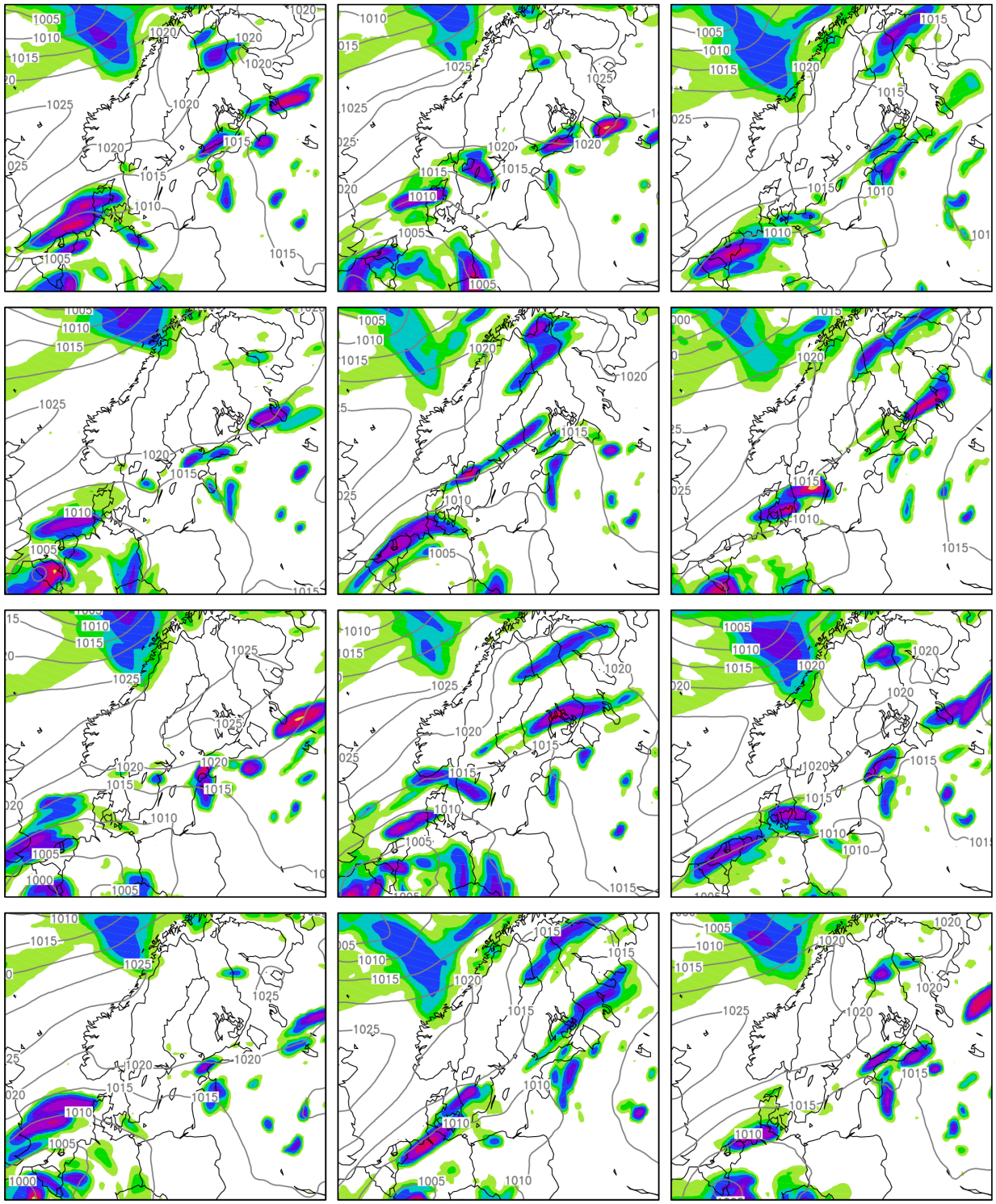
$s_j \in U(-0.25; 0.25)$

r_j bounded, e.g. by ± 0.5, i.e.

$r_j := \max(r_j, -0.5)$

$r_j := \min(r_j, 0.5)$

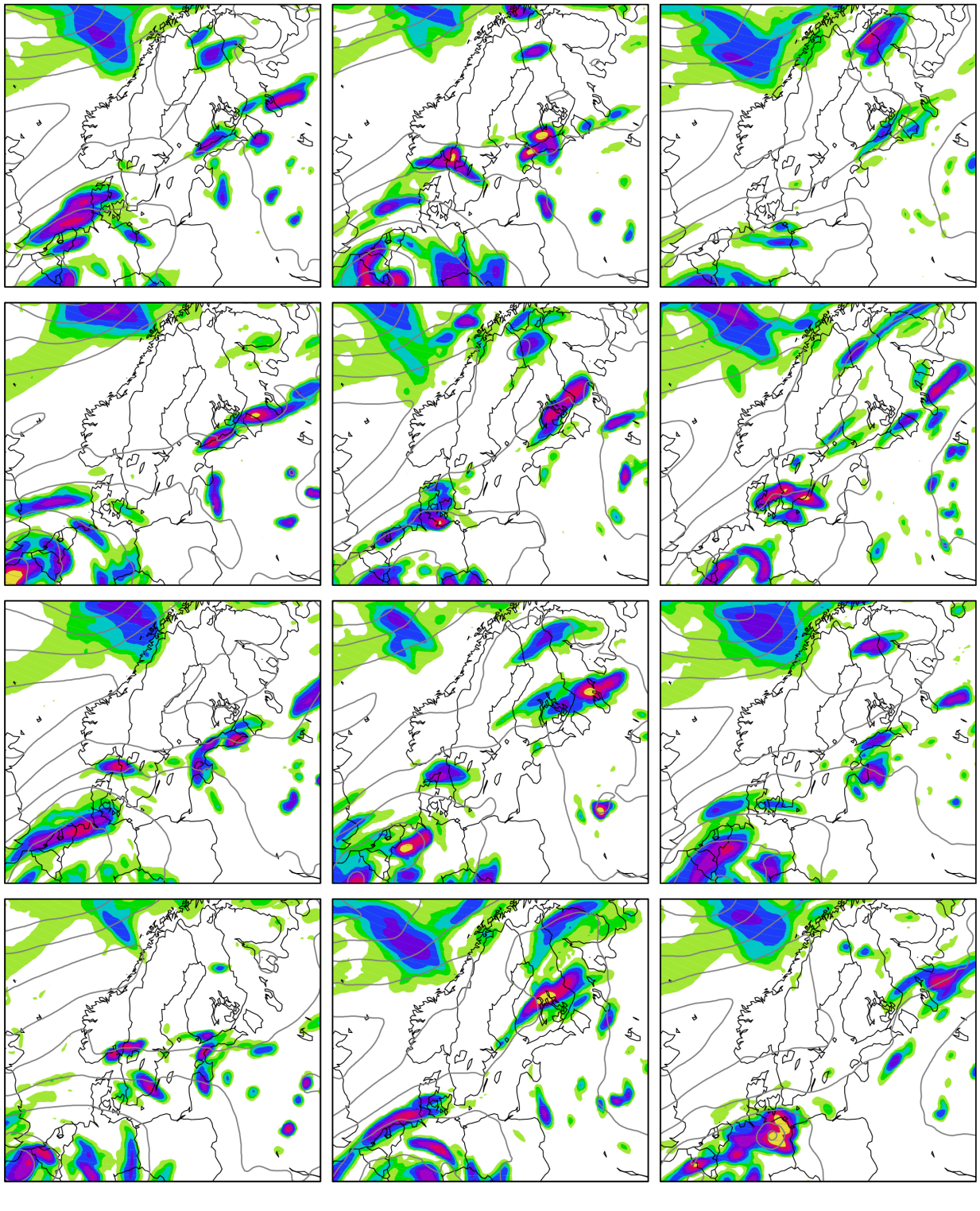
DMI



Example:
"The Finnish case:"

2007082012+48h.
6h accum. precip.
STRACO scheme.
Domain = EPS71.
IC and LBC from
ECMWF EPS.

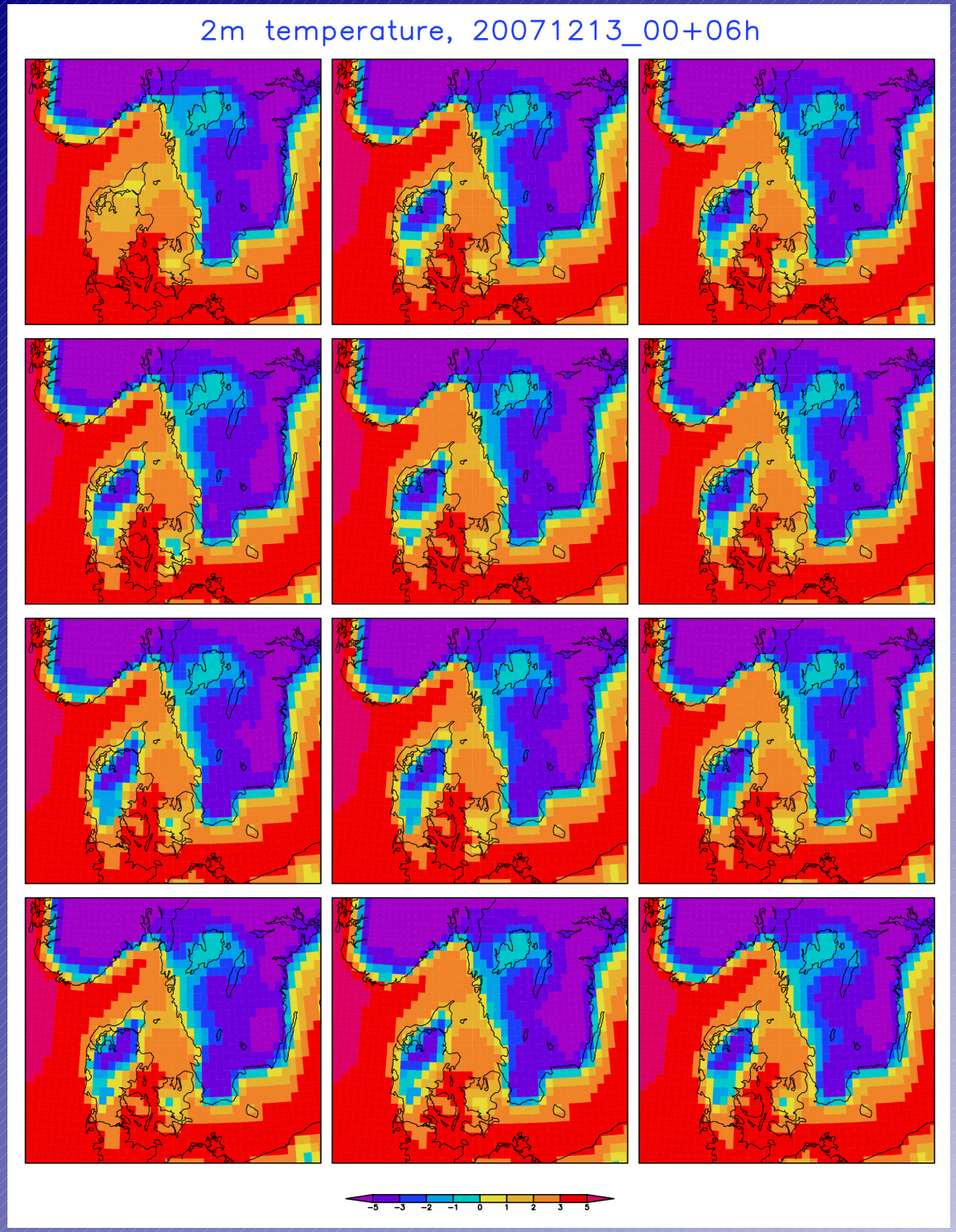
DMI



"The Finnish case:"

2007082012+48h.
6h accum. precip.
STRACO scheme+ stochastic physics, tendencies due to convection and condensation

DMI



Another example:

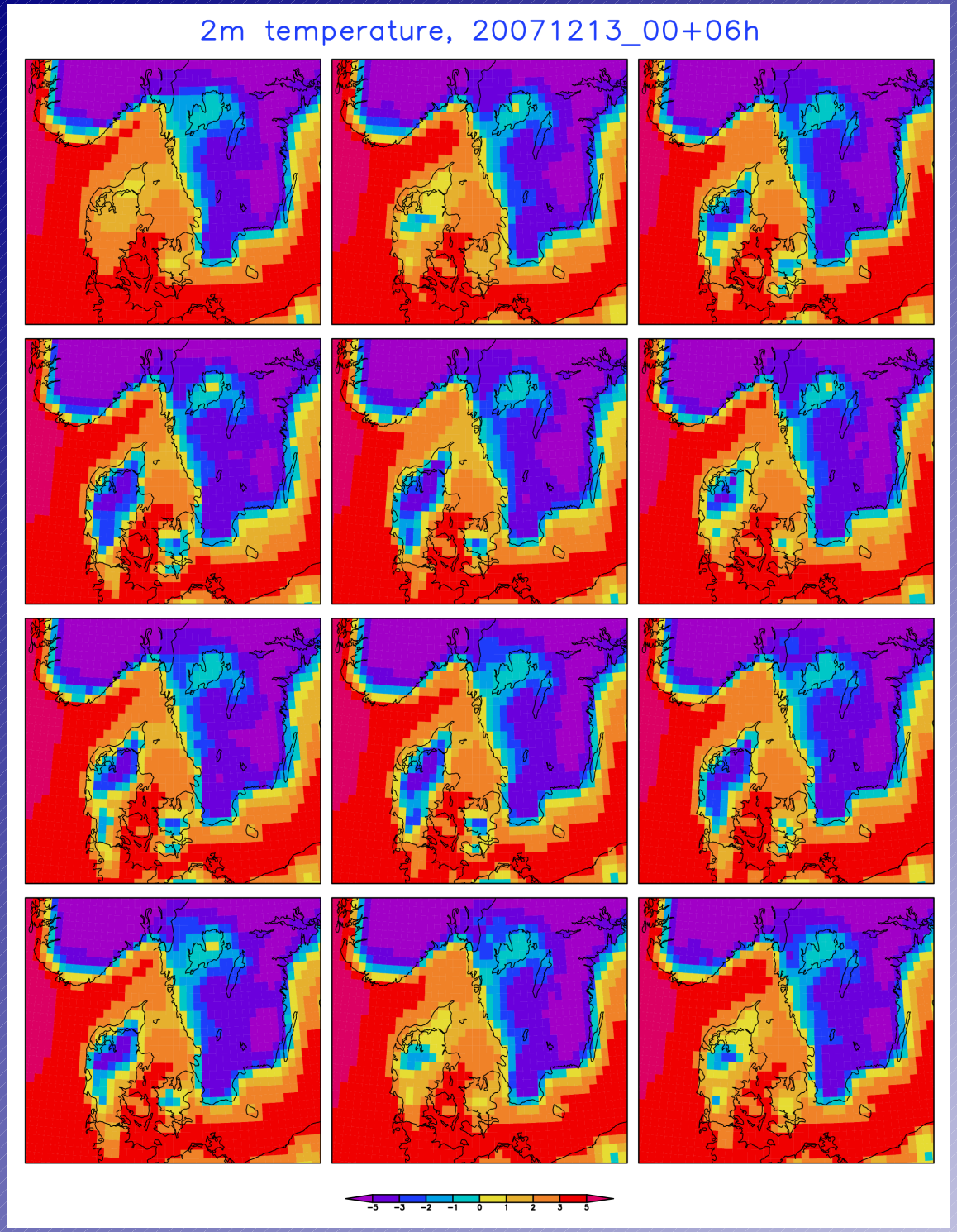
Domain = EPS71.

IC and LBC: ECMWF EPS

STRACO scheme.

No stochastic physics.

DMI



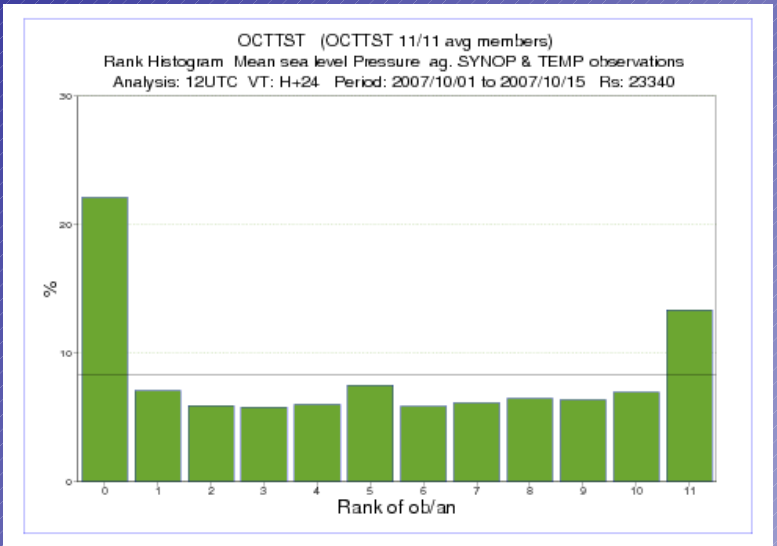
Stochastic physics included
- total physics tendencies, all variables

DMI

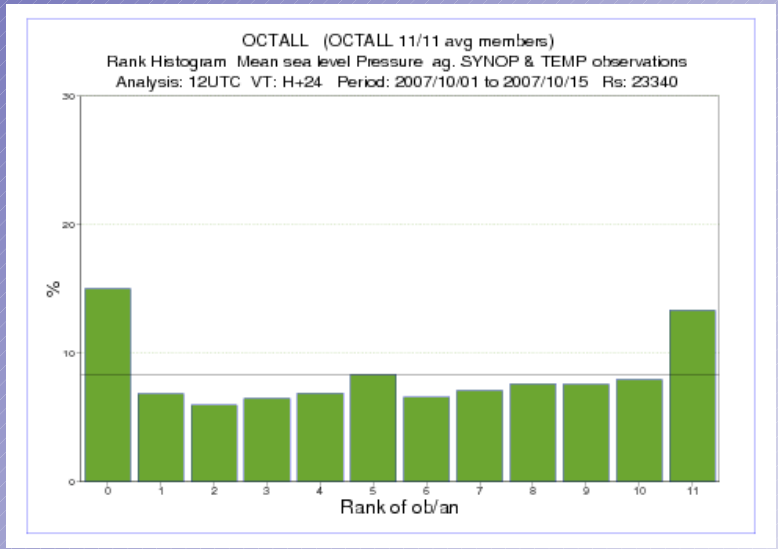
Validation (using hppv package)

Period: 1-15 Oct 2007
Ensemble: 1 control + 10 perturbed forecasts
IC pert. and LBC: ECMWF EPS
Area: 35-70°N, 15°W-30°E

Without stochastic physics

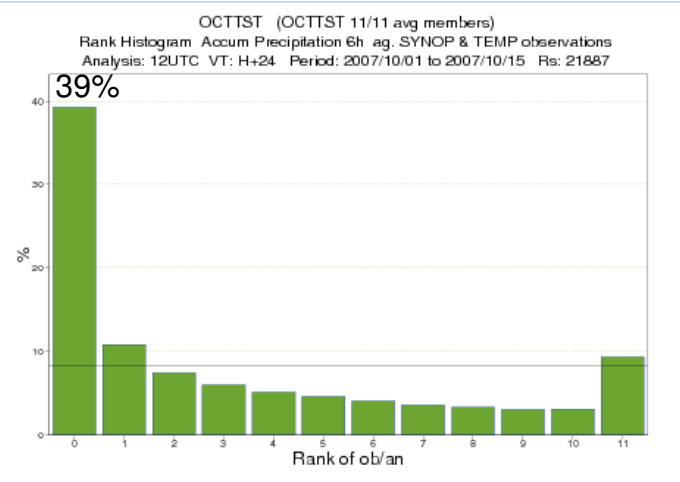


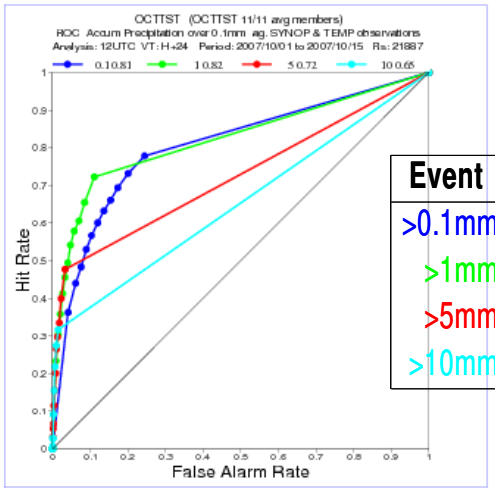
With stochastic physics



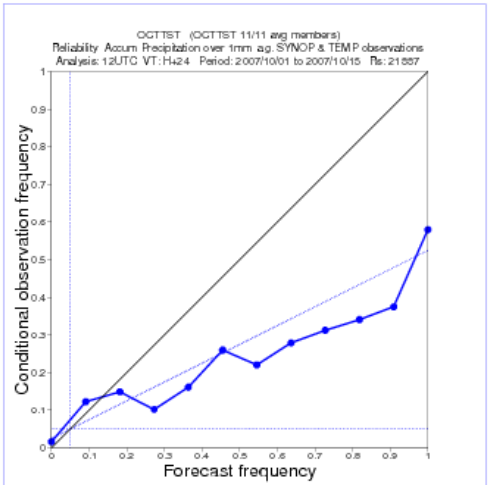
DMI

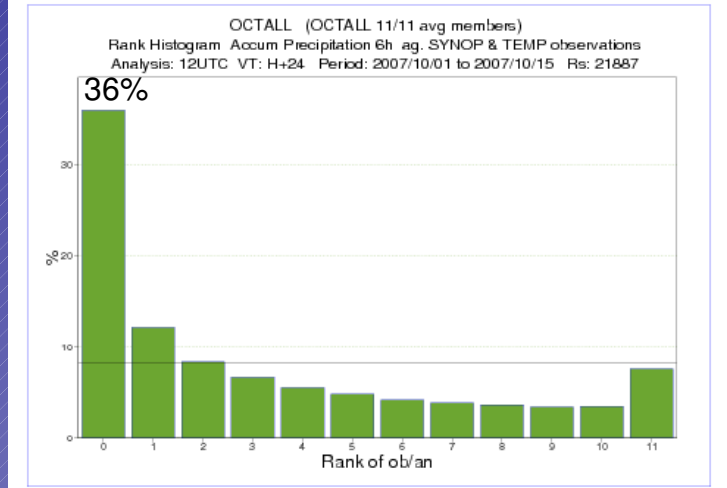
Without stochastic physics

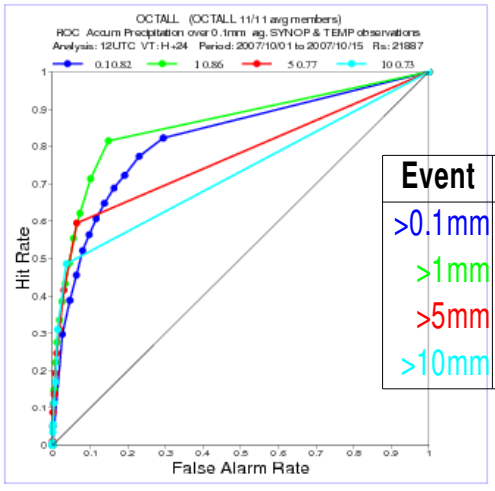




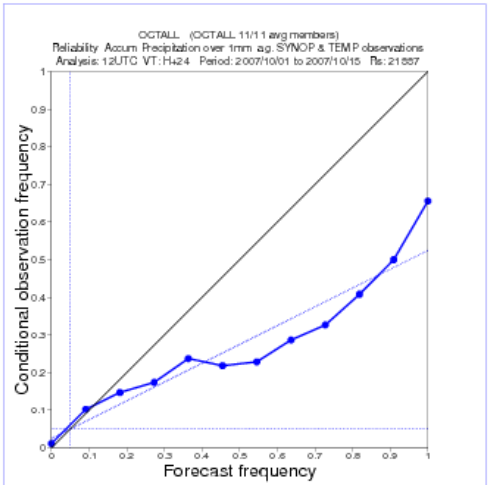
Event	Area
>0.1mm	0.81
>1mm	0.82
>5mm	0.72
>10mm	0.65







Event	Area
>0.1mm	0.82
>1mm	0.86
>5mm	0.77
>10mm	0.73



With stochastic physics

DMI

Perturbed parameters

STRACO

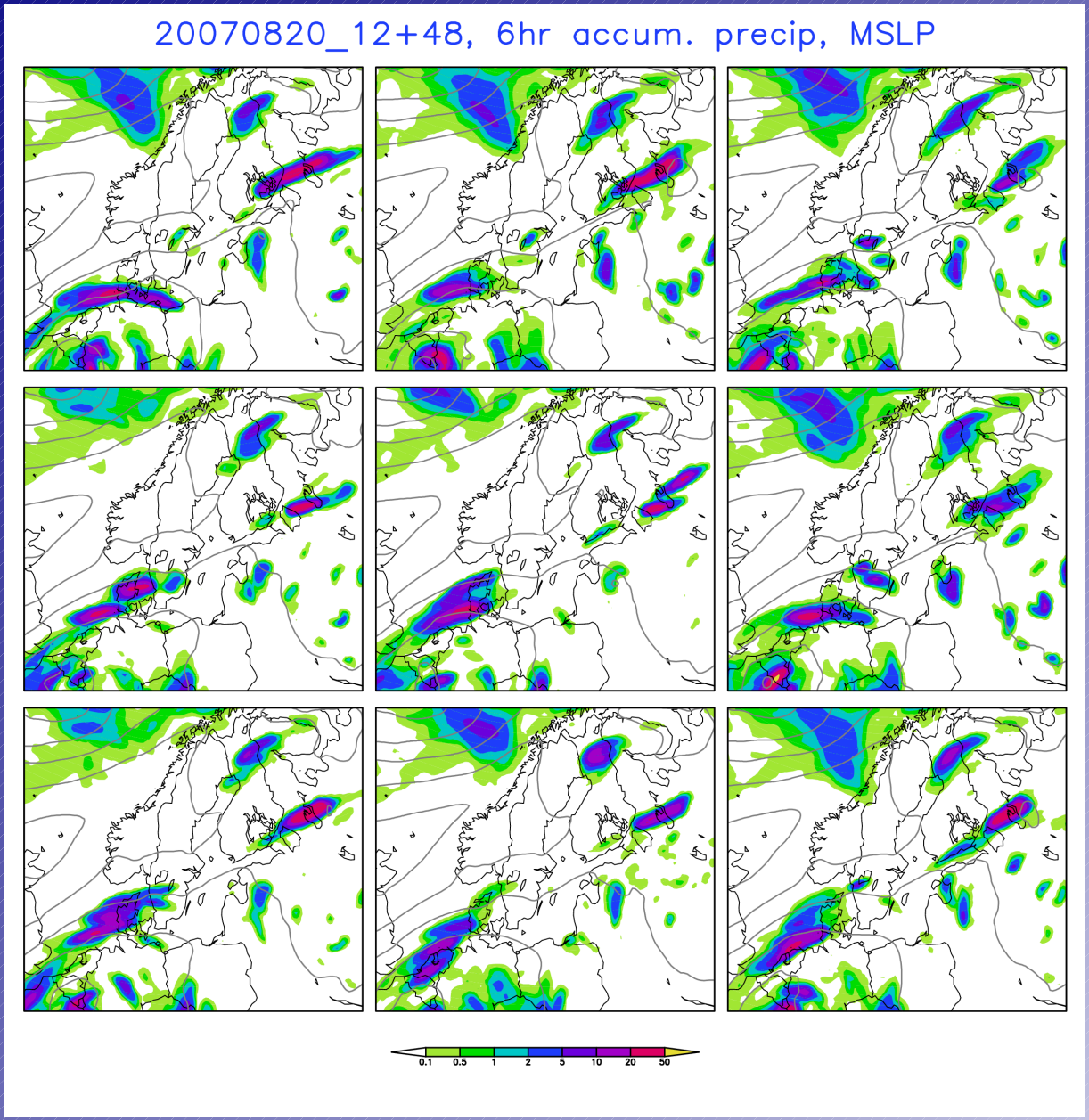
- Entrainment parameter for convective cloud model
- Evaporation of cloud water
- Evaporation/sublimation of precipitation

RKKF

- Evaporation
- Autoconversion of cloud water
- Relative humidity threshold for clouds
- Relaxation time for removal of CAPE
- Entrainment rate
- Fraction of condensate available for precipitation

DMI

Perturbed parameters, STRACO



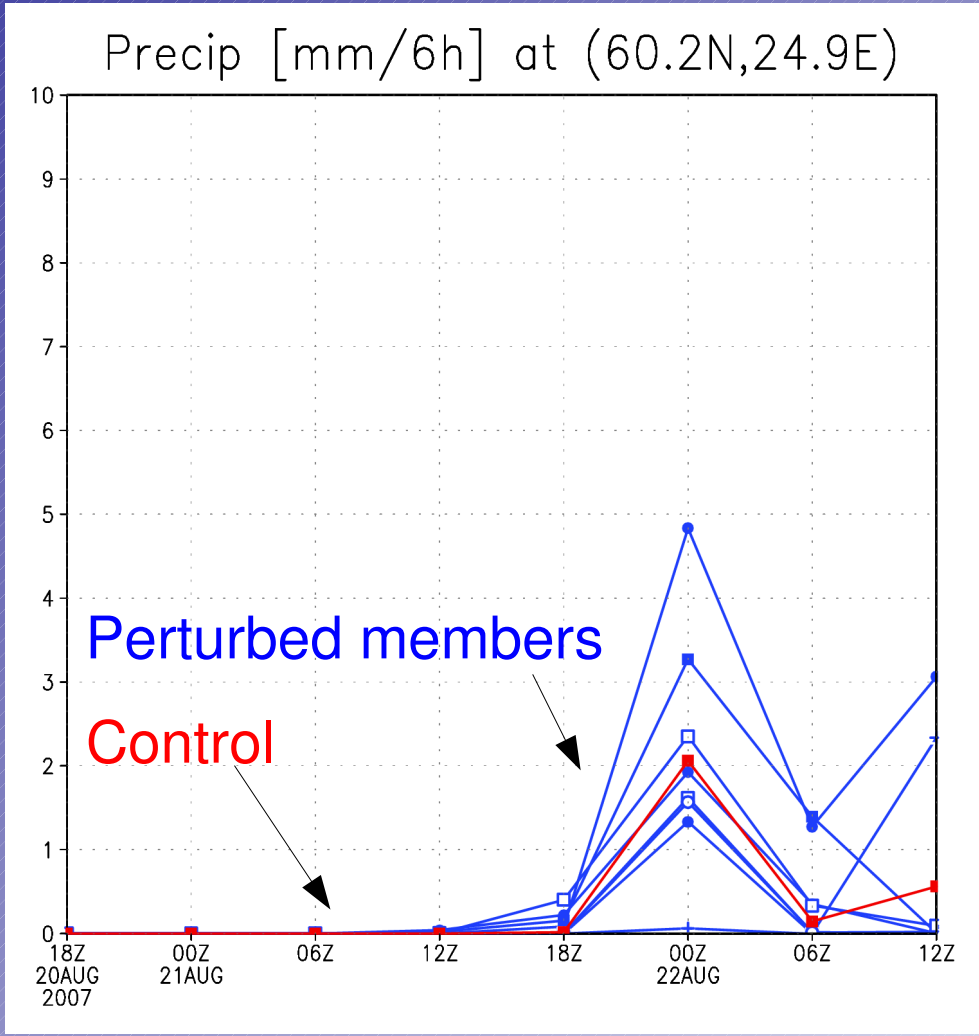
"The Finnish case:"
Domain = EPS71.
Identical IC and LBC.

Parameters are randomly perturbed initially; they are not changed during the integration.

DMI

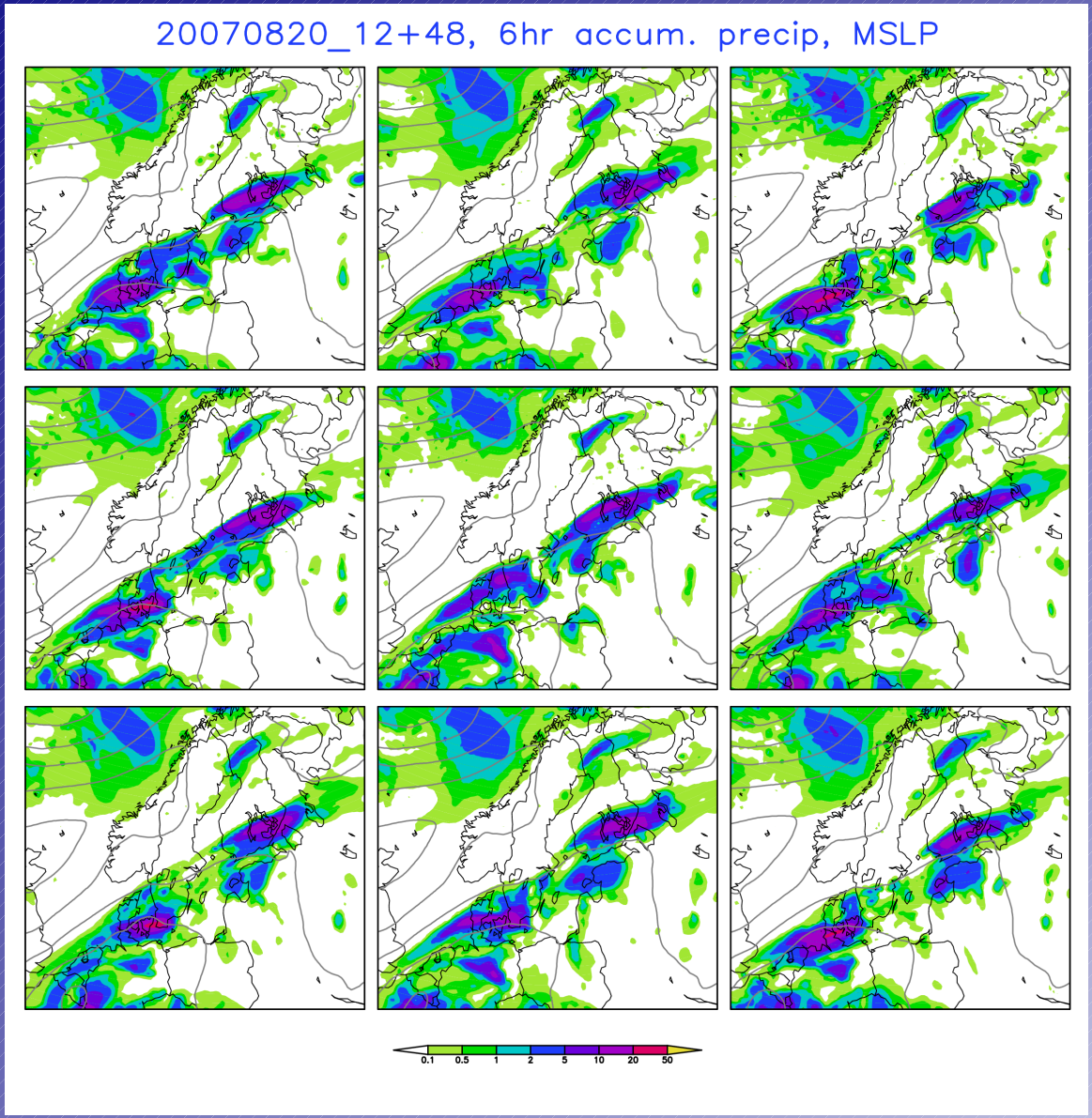
Perturbed parameters, STRACO

Finnish case, continued...



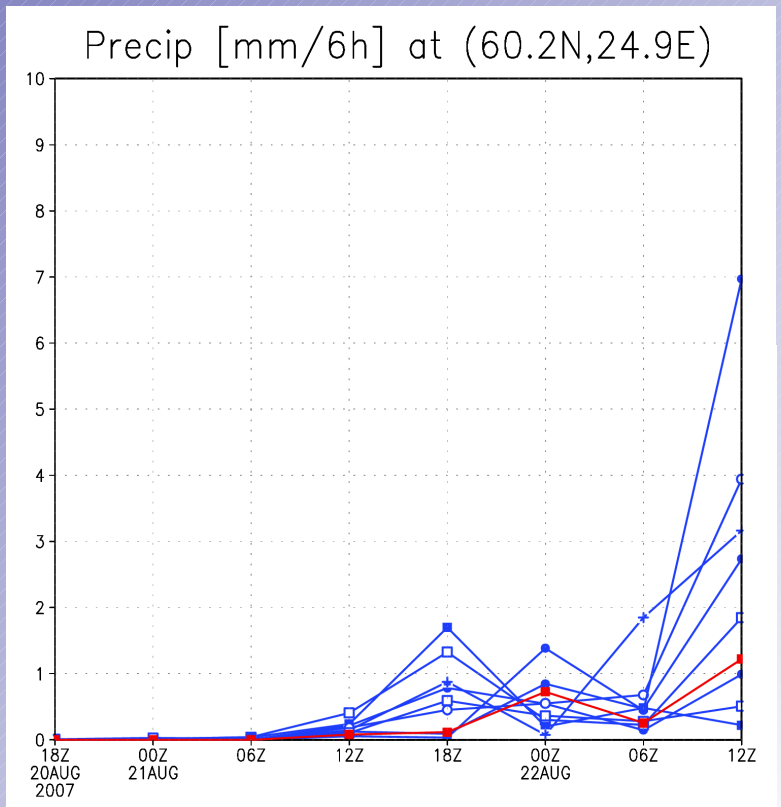
DMI

Perturbed parameters, RKKF



Perturbed parameters:

- Evaporation
- Rel. humidity threshold
- Entrainment rate



Conclusion

Physics pertubations appear to have the potential to add value to HIRLAM-EPS