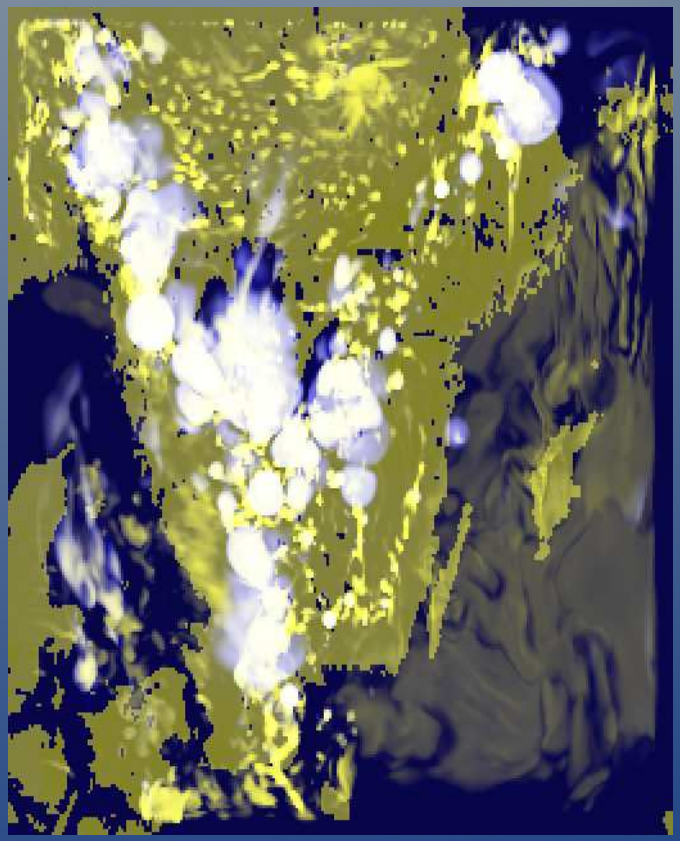
Impact of Semi-Lagrangian horizontal damping on resolved deep convection

(Or part 2 of Sander Tijm's presentation)

Lisa Bengtsson, SMHI
Sander Tijm, KNMI

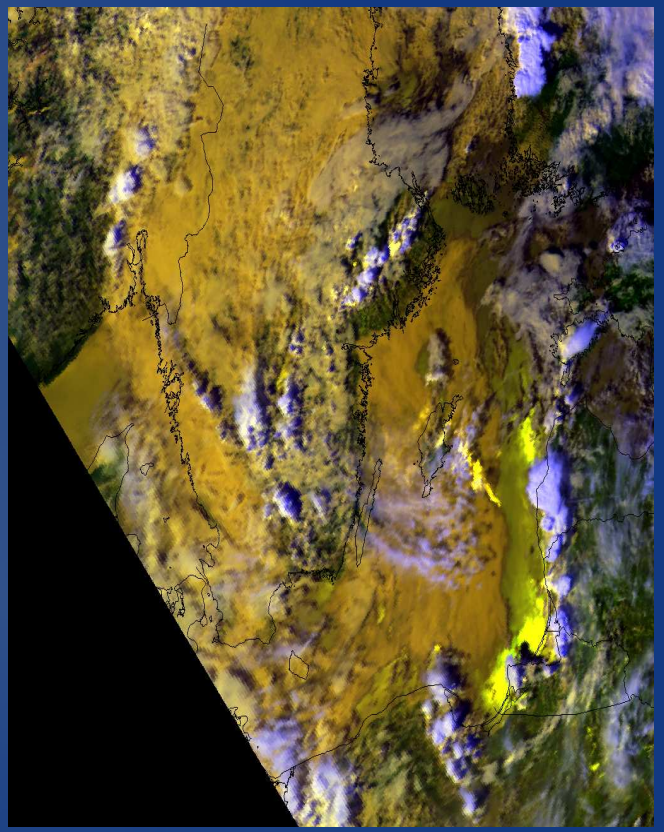
Acknowledgments to:
Filip Vána (CHMI) & Radmila Brožková (CHMI)

Background 1 – Intense “bubble” like convection cycle 32h3 “prototype AROME”



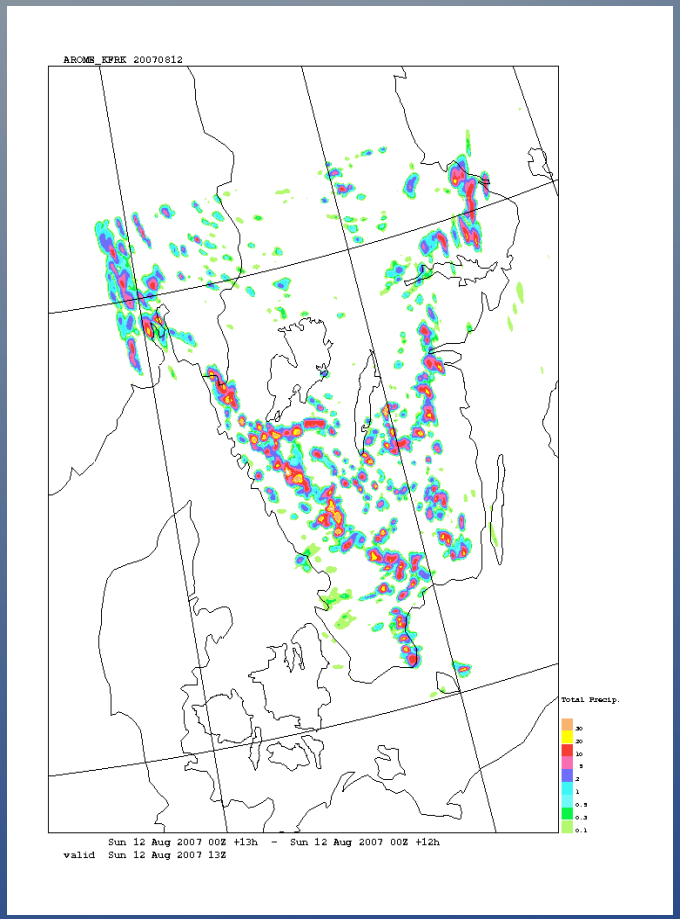
AROME 2.5 km

ALARO 2.5 km

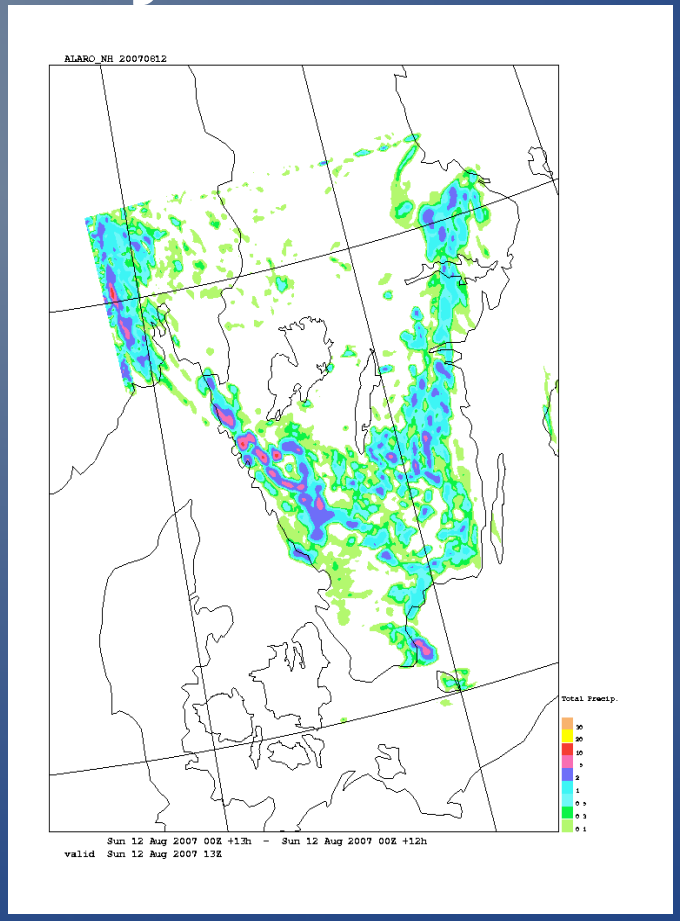


Satellite

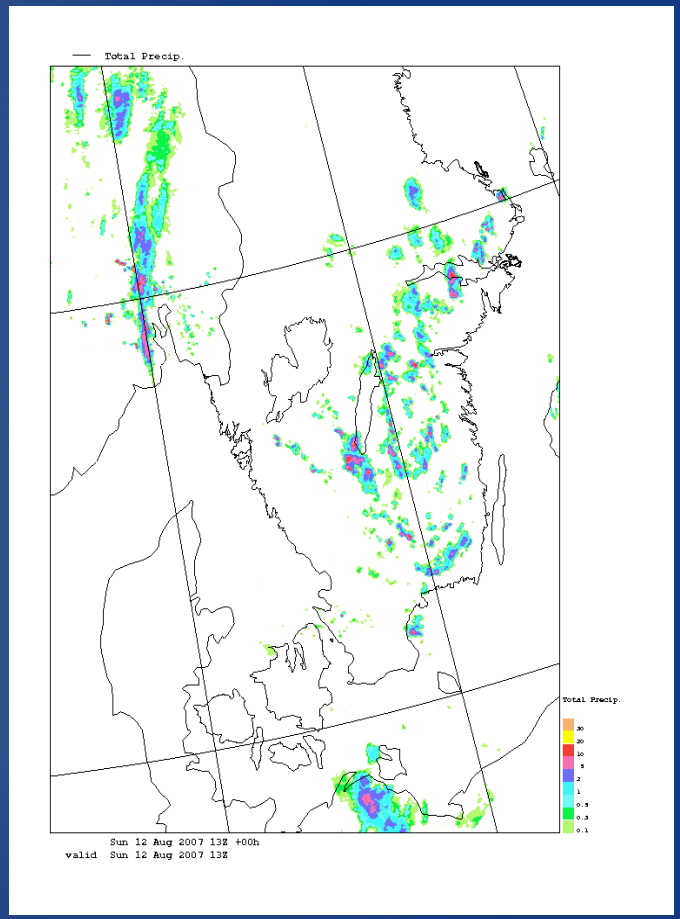
Background 2 – Intense precipitation amounts Cycle 32h3



AROME 2.5 km

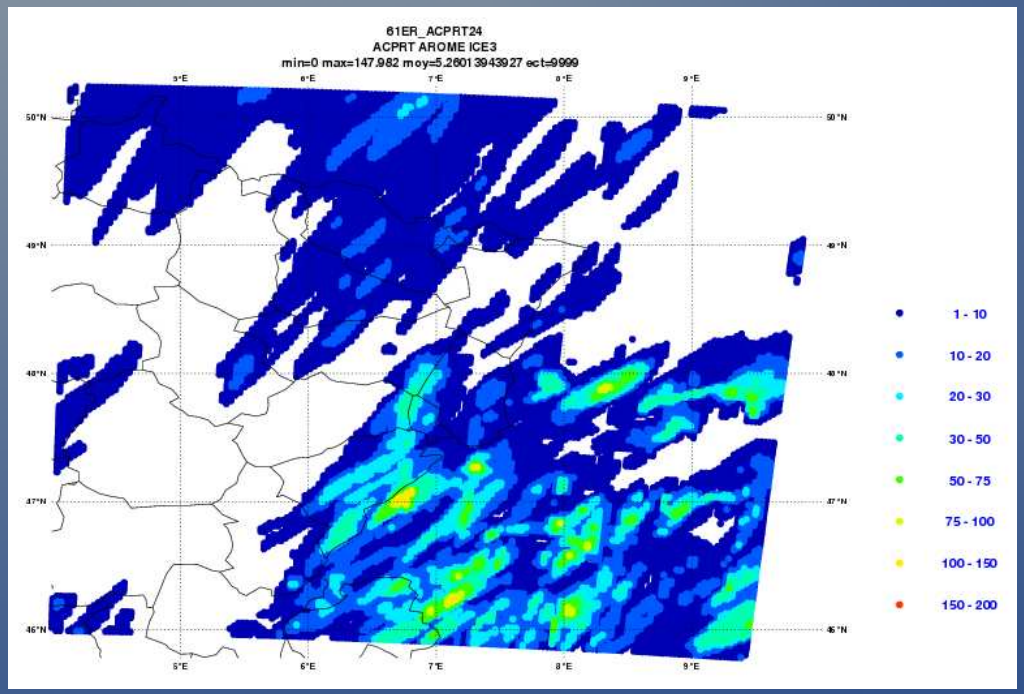


ALARO 2.5 km

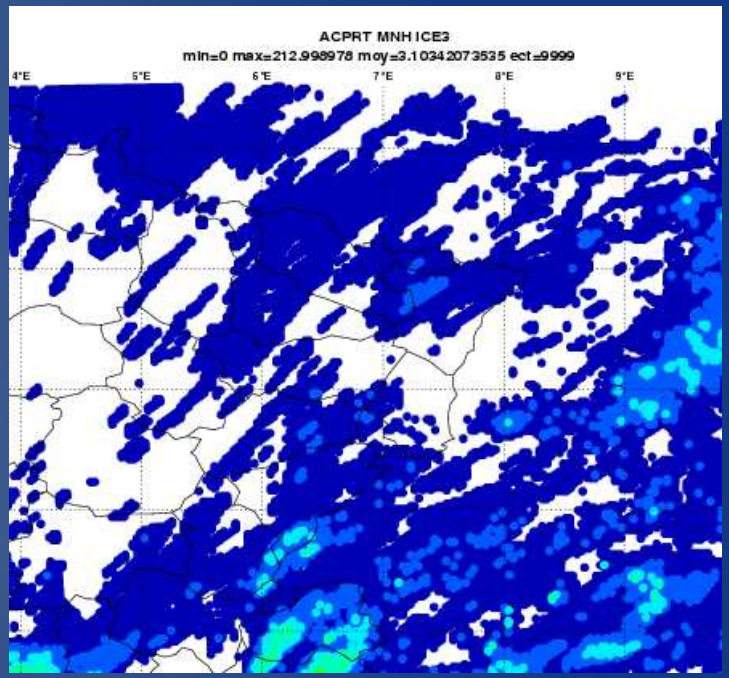


Radar (total precip)

Background 3 – Intense precipitation amounts Cycle 32h3



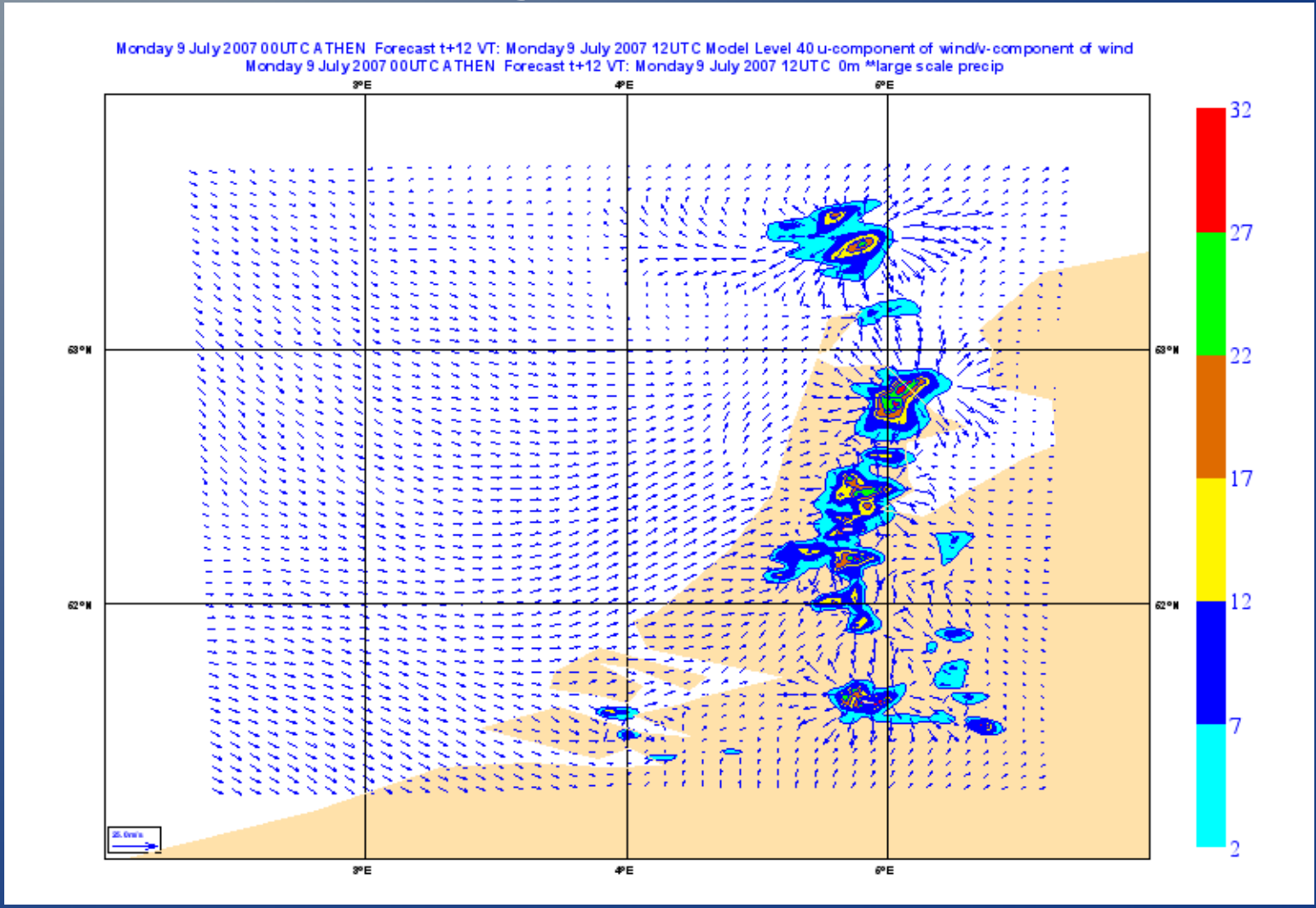
AROME 2.5 km



Meso-NH, 2.5 km

Courtesy Yann Seity

Background 4 – Strong outflow from convective events cycle 32h3



Courtesy: Jan Barkmeijer

Motivation

- Since cycle 32h3 changes have been applied to the spectral horizontal diffusion in AROME (in order to reduce “fireworks”), and SLHD on rain, snow and graupel (in order to reduce large amounts of precipitation).
- Continuing with the case study previously presented by Sander, can we learn something about the effect of linear spectral horizontal diffusion vs SLHD on characteristics of convection.

Horizontal diffusion – three parts
(Damping from semi-Lagrangian advection - SLHD)

- Grid-point diffusion acting through SL interpolators. This is the key part of SLHD
- Background (or residual) spectral diffusion
- Supporting spectral diffusion acting on divergence, vorticity and vertical divergence (in case of NH) only. (typically 6th order) and aims to suppress noise originating from the model orography.

"Physical" grid-point diffusion

Numerical spectral diffusion

Vana et. al 2008 QJRM "Semi-Lagrangian advection scheme with controlled damping: an alternative to nonlinear horizontal diffusion in a numerical weather prediction model"

Note 1:

- Contradictory to ALARO, AROME uses a linear spectral diffusion scheme rather than the full SLHD scheme, however, SLHD can be active for some subset of arrays only.
- Bazile et. al show that local (grid-point) SLHD applied on falling rain, snow and graupel has an important positive impact in AROME on large precipitation amounts (~ >7mm/h).

Note 2:

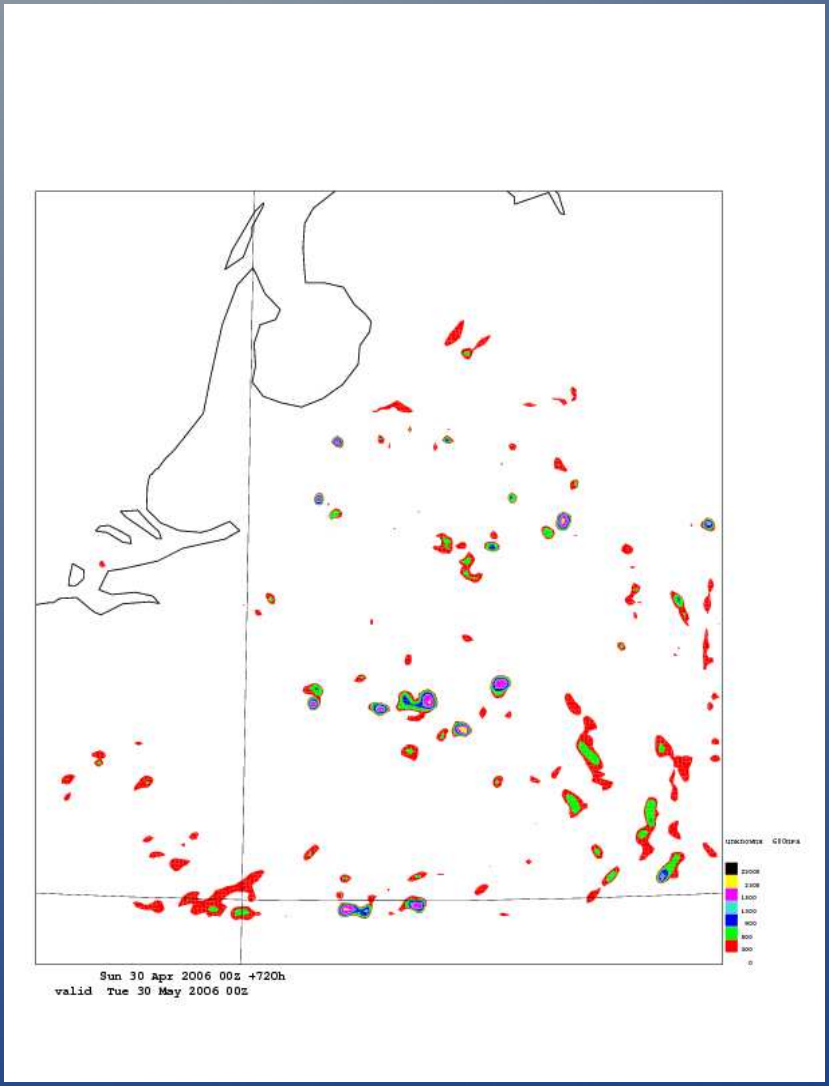
- The linear spectral diffusion used in AROME is reduced 4 times with respect to theoretical values (RDAMP[x] are set to 20 instead of default 5) -> very weak diffusion.

Motivation

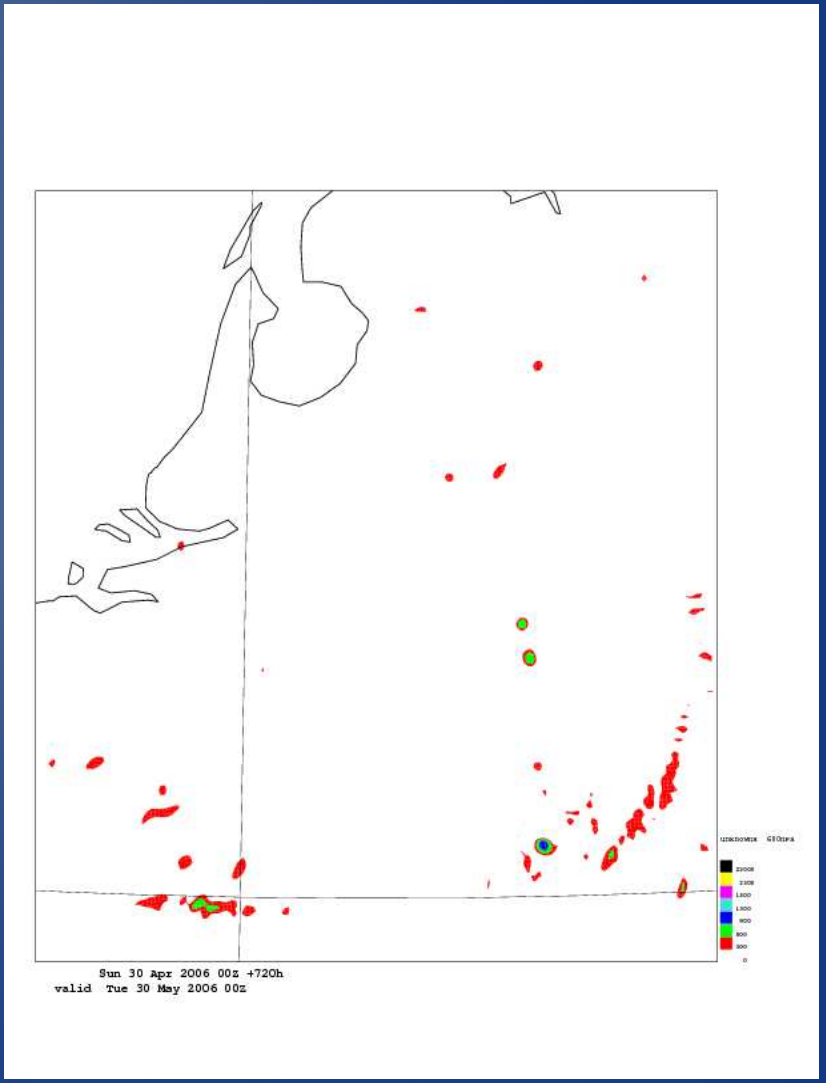
For a “moderate” deep convective case, what is the impact of:

- Applying SLHD on variables used with NH dynamics in ALARO without convective param.
- Applying SLHD also on falling hydrometeors in ALARO without convective param, at increasing resolution
- Turning SLHD off of falling hydrometeors in AROME, and imposing full SLHD rather than linear horizontal diffusion.

Vertical Velocities at 600 hPa

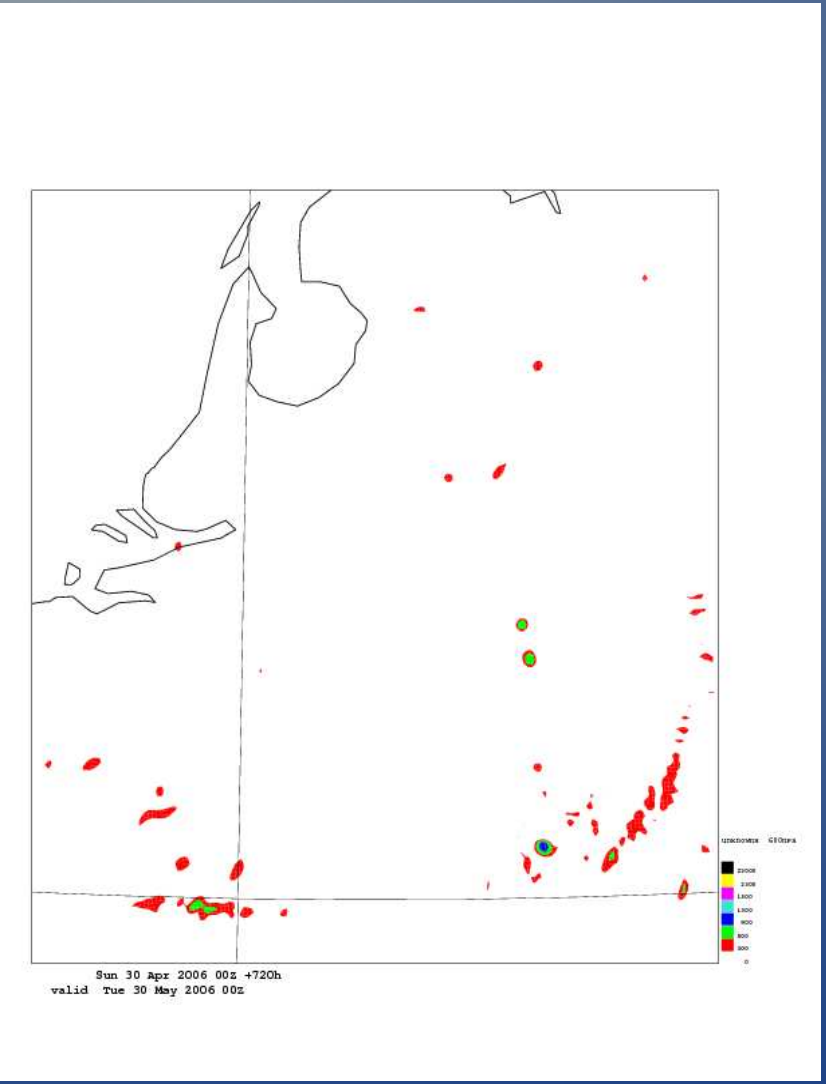


AROME 35h1
2km

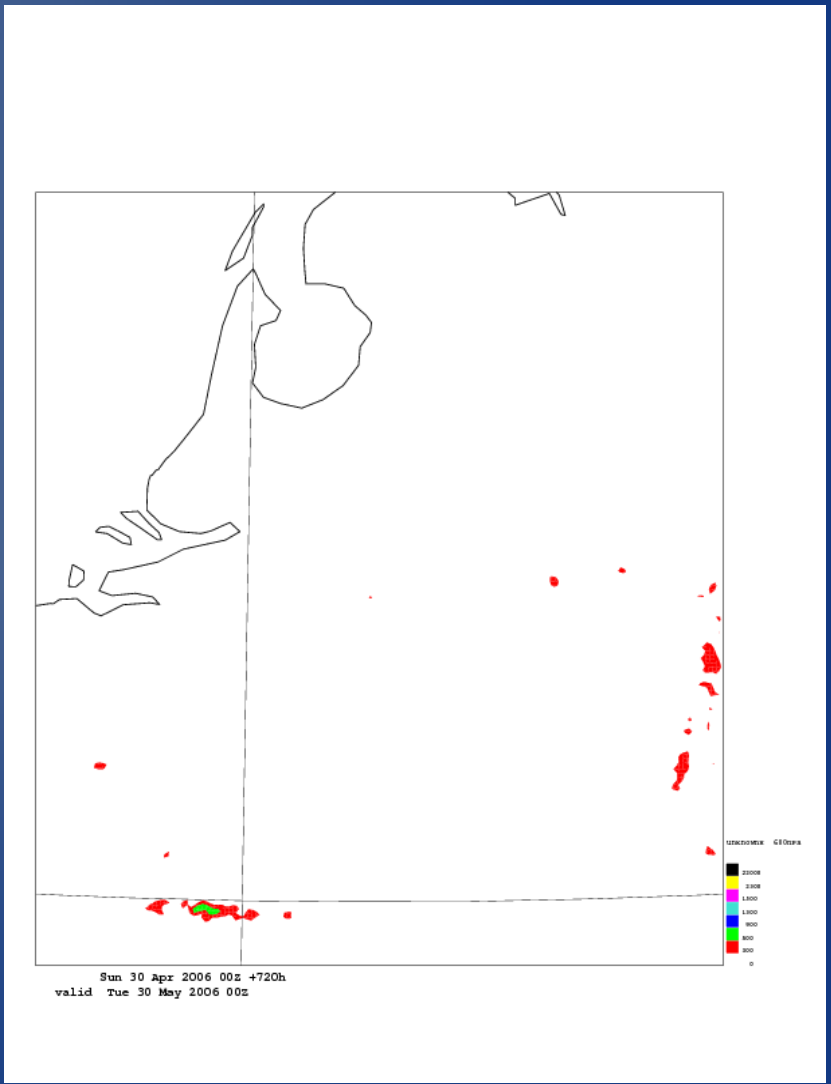


ALARO resolved conv. 35H1
2km

Vertical Velocities at 600 hPa

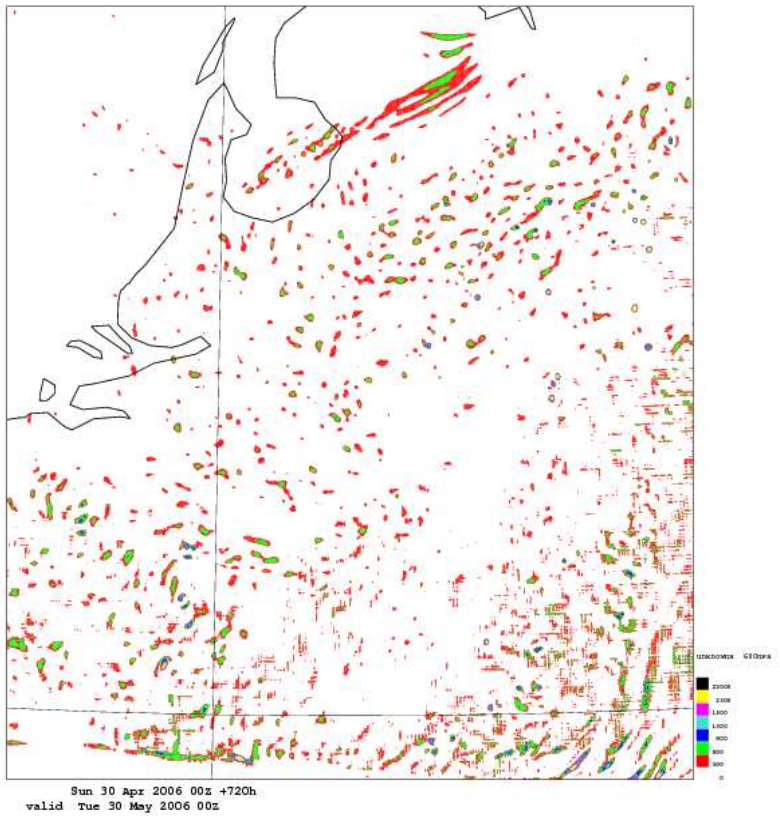


ALARO resolved conv. 35H1
2km

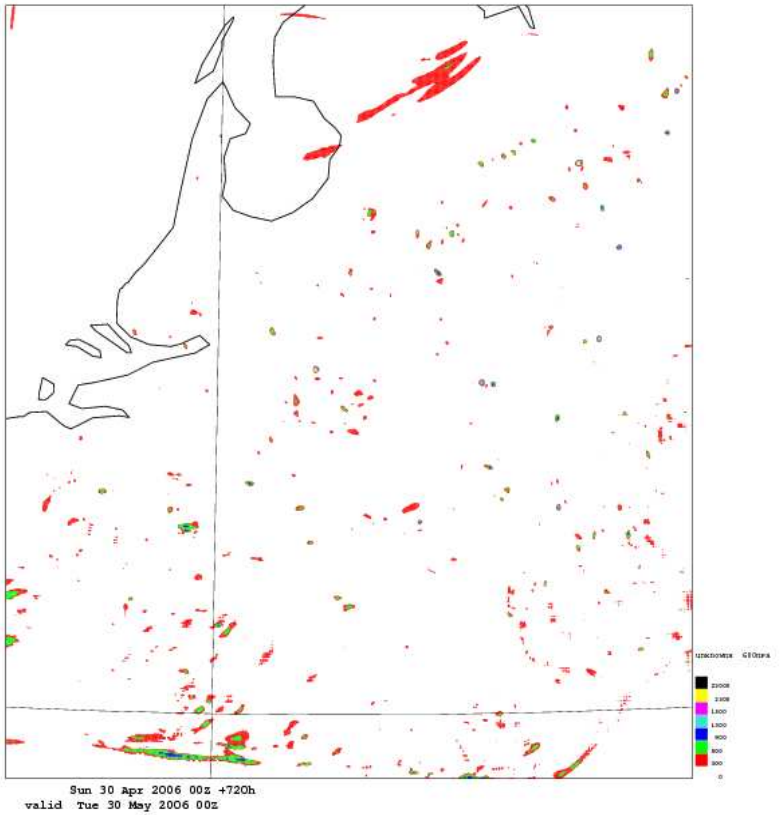


ALARO resolved conv.
Full SLHD

Vertical Velocity at 600 hPa



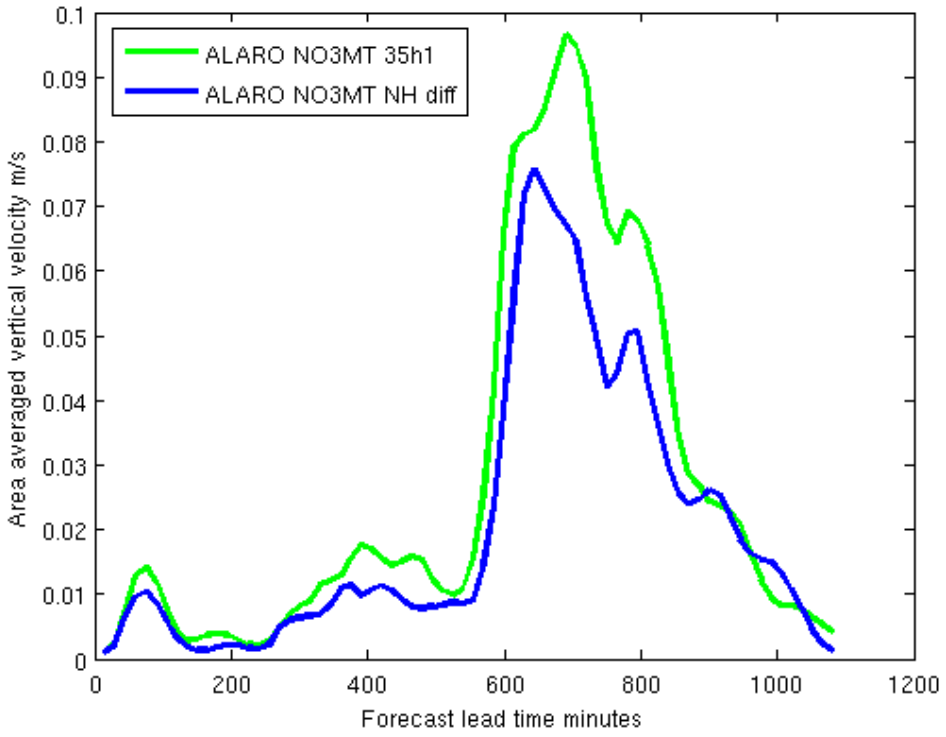
ALARO resolved conv. 35H1
500 m



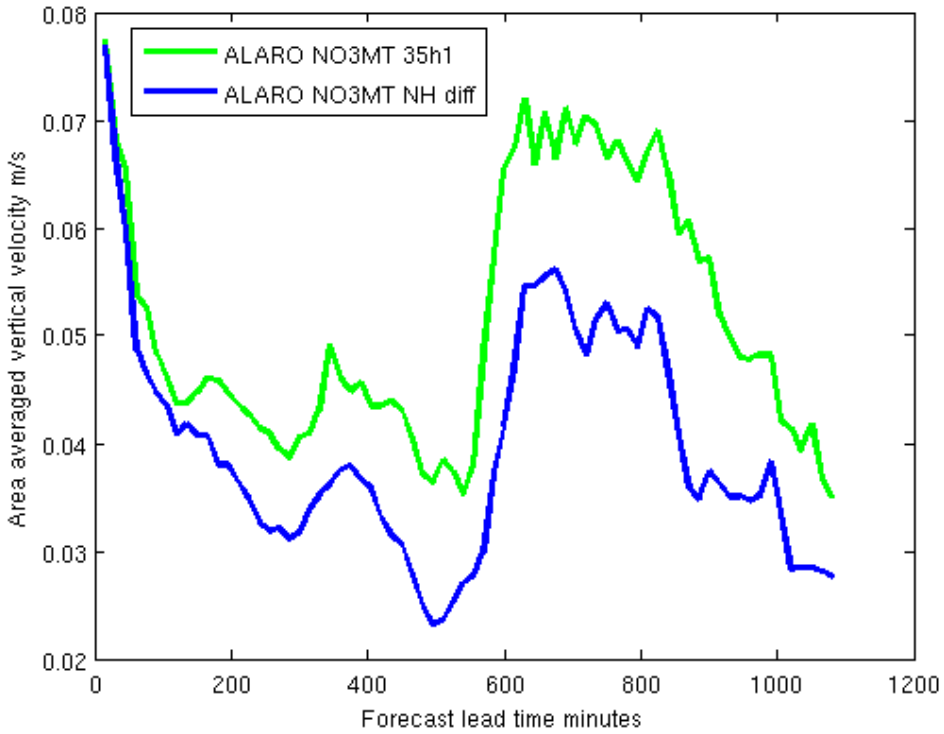
ALARO resolved conv.
Full SLHD

2 km precip. and vertical velocity

Precipitation mm/15m



Vertical velocity m/s



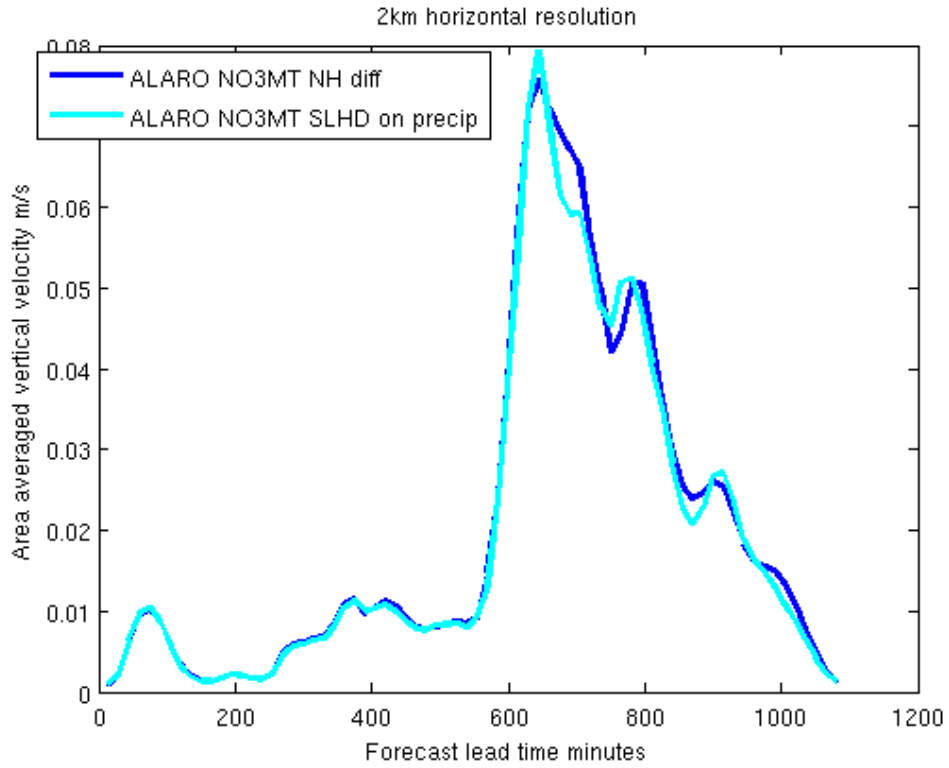
ALARO no conv. 35h1

ALARO no conv. NH diff

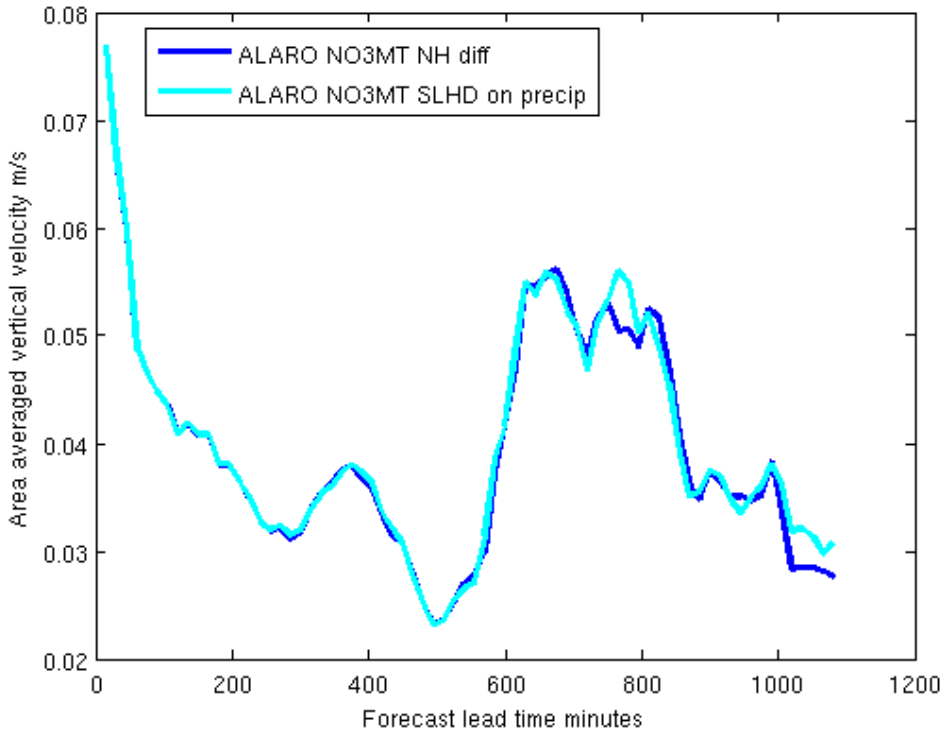
- Applying SLHD also on falling hydrometeors in ALARO without convective param, at increasing resolution

2km Precipitation and Vert. Vel

Precipitation mm/15m



Vertical velocity m/s

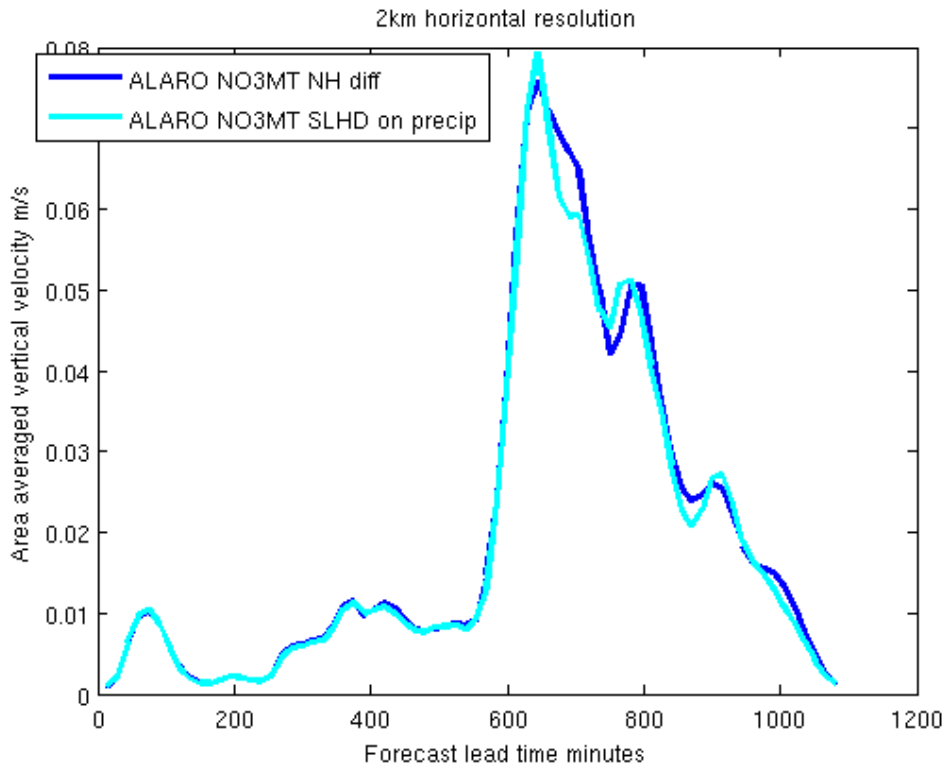


ALARO no conv.

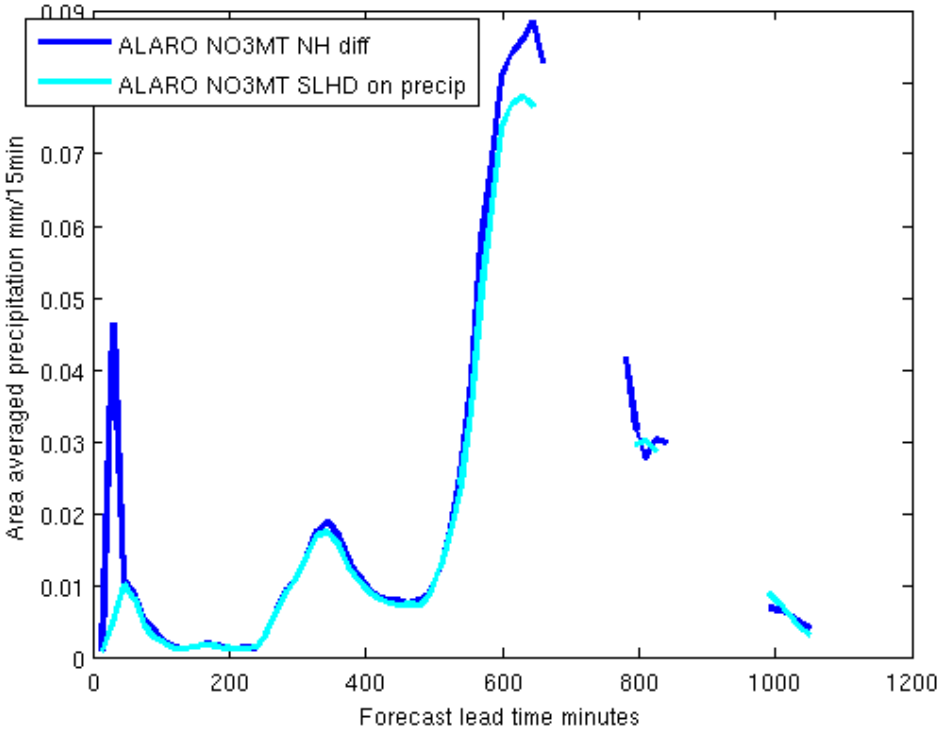
ALARO no conv. SLHD on falling precipitation

2km and 500m precipitation

Precipitation mm/15min 2 km res



Precipitation mm/15min 500 m res



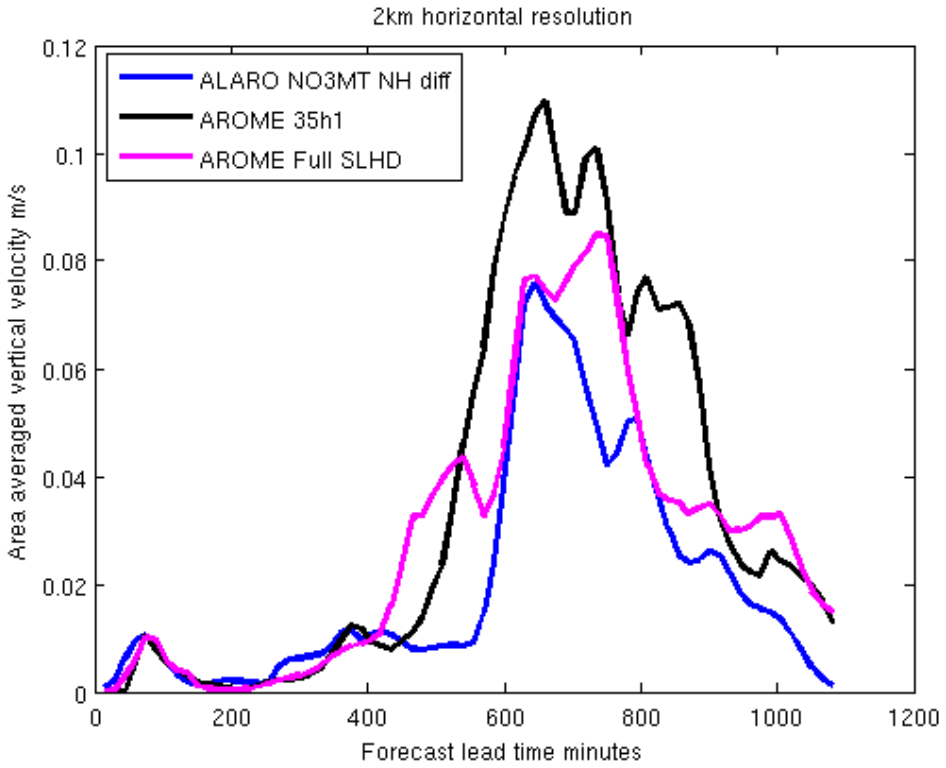
ALARO no conv.

ALARO no conv. SLHD
on falling precipitation

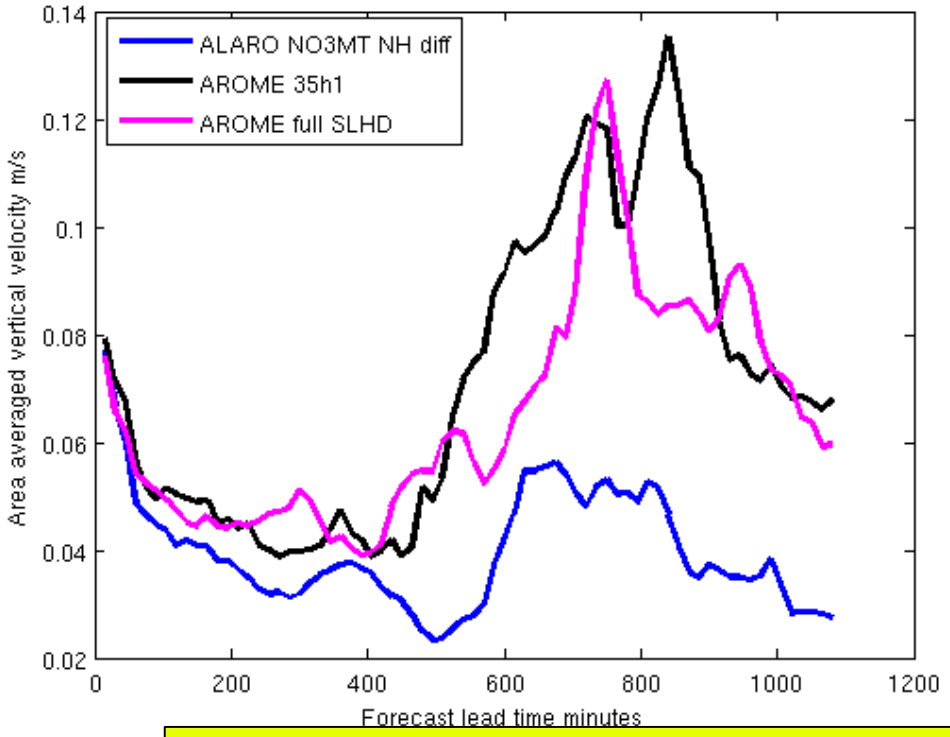
- Turning SLHD off of falling hydrometeors in AROME, and imposing full SLHD rather than linear horizontal diffusion. (except for q)

2km Precipitation and vert. velocity

Precipitation mm/15m



Vertical velocity m/s



AROME 35h1

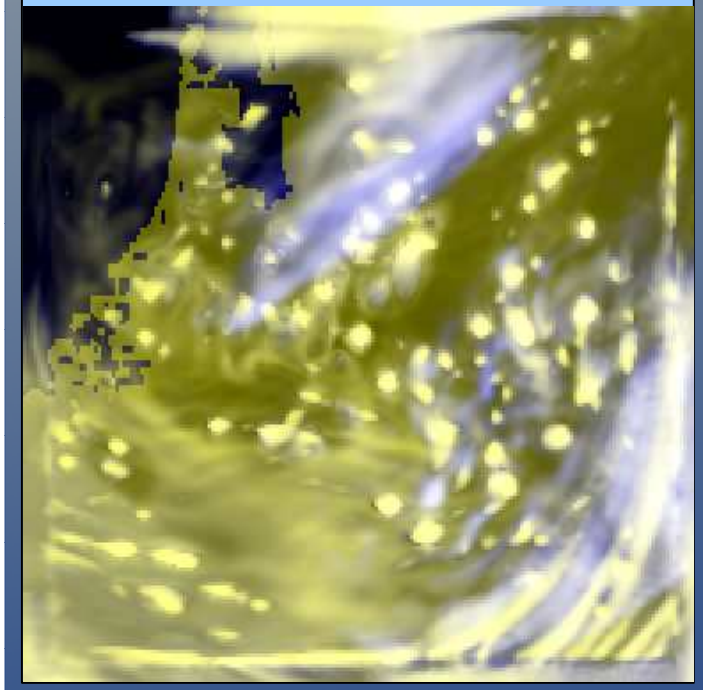
AROME with full SLHD (not on falling precipitation)

ALARO No conv. NH

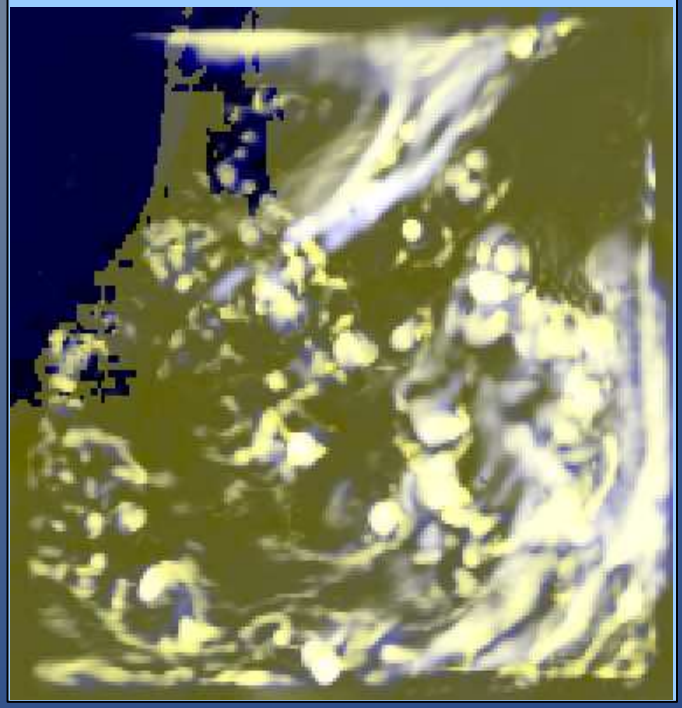
Impact of “full SLHD” on AROME
1. Earlier onset of precipitation
2. Less intense precipitation
3. Weaker vertical updrafts than ref, but still stronger than in ALARO.
4. Second peak delayed

Pseudo Satellite images, 2km 20060430_00 + 13h

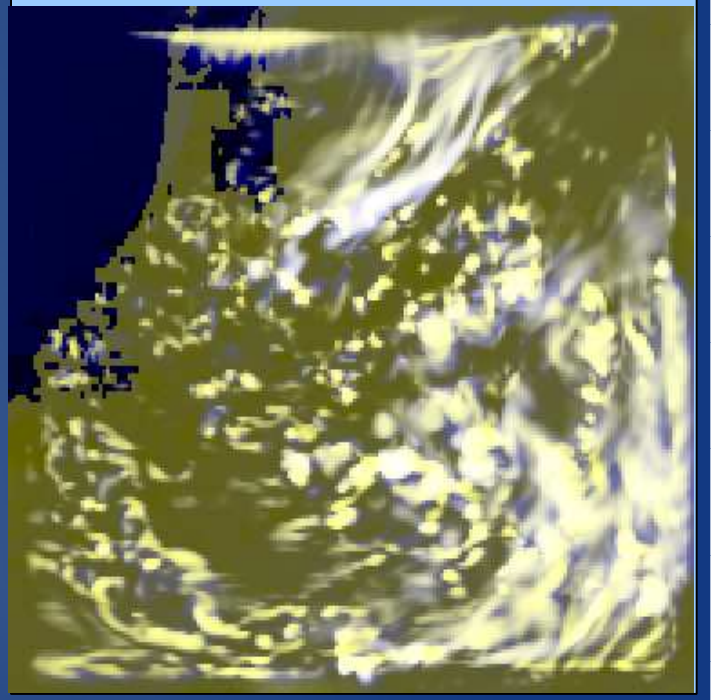
ALARO no conv 2km



AROME 2km, Full SLHD



AROME 2km 35h1



Impact of “full SLHD” in AROME: Larger (wider) structures than in reference and ALARO.

Conclusions

- At 2 km and 500 m horizontal resolution, the effect of applying SLHD on falling precipitation in ALARO without deep convection parameterization is small. One reason may be that that the dynamic damping is stronger in ALARO than in AROME (where the effect is large).
- Applying “Full SLHD (minus q)” in AROME reduces the precipitation for this case, and generates an earlier onset of precipitation. But the structure of the cells get more widespread.

Discussion

- Already discussed briefly yesterday; Currently SLHD in AROME is used as a crude parameterization of microphysics, which may or may not be satisfactory. Should we at 2.5 km resolution rather use a deep convection parameterization scheme with some diffusive properties?

Thank you :)