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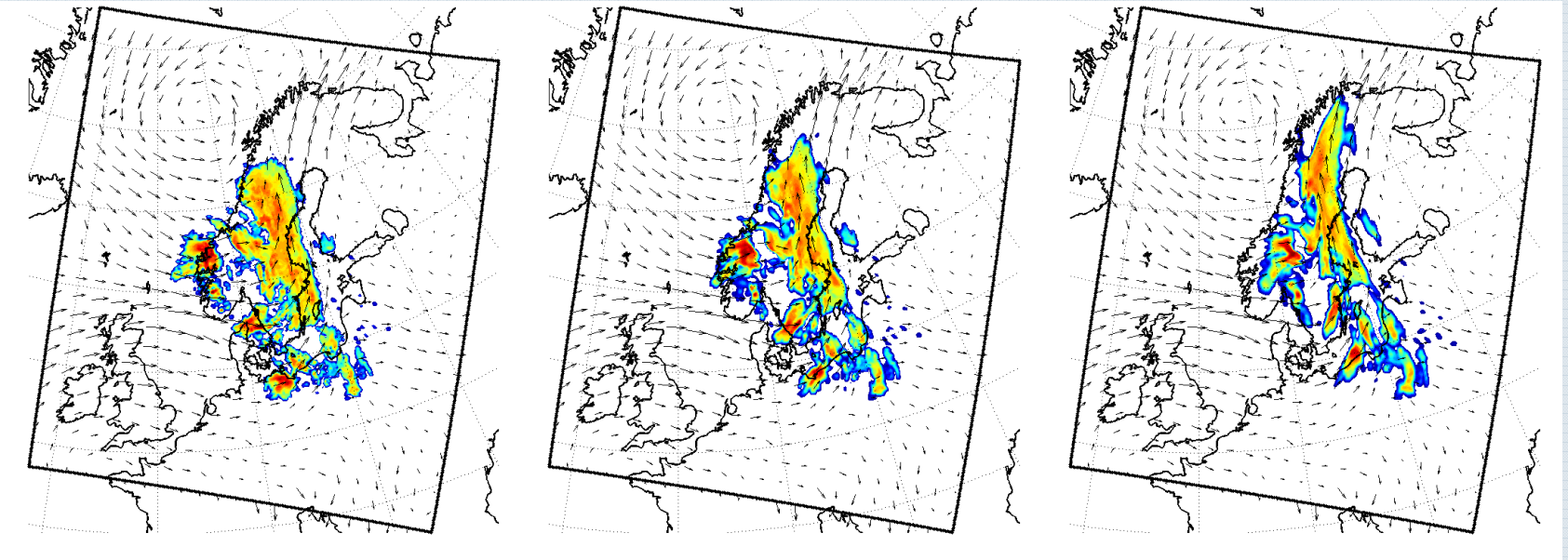
Radar based short-range precipitation forecasts



Workshop on Moist Processes in Future High Resolution NWP/Climate Models

Norrköping, Sweden, 15-17 June, 2009

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Swedish Meteorological and Hydrological Institute (SMHI)

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Structure

- Introduction
- Radar data
- Variational methodology
- The forecast
- Results
- Conclusions

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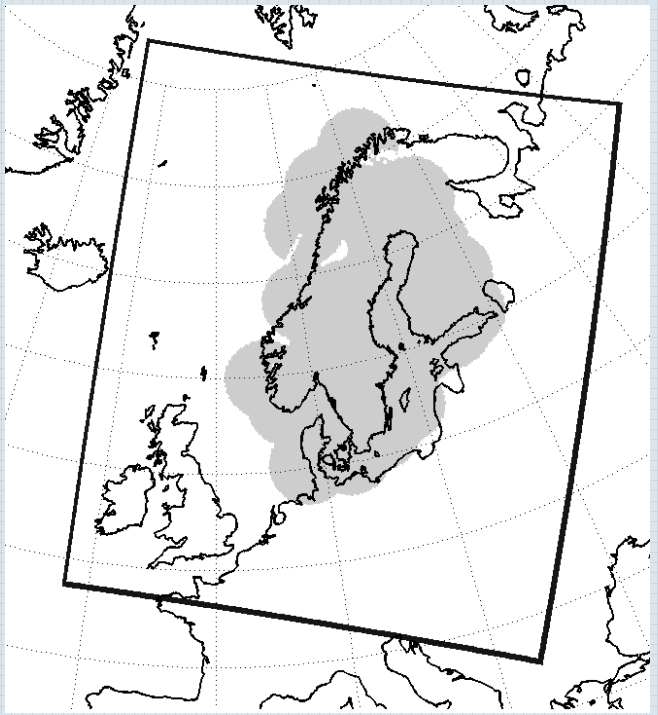
Introduction

General idea

1. Utilize a time-sequence of the latest available radar composites to derive an advection field for radar precipitation structures.
2. Advect precipitation structures from the latest available radar composite forward in time.
3. Weighting towards a HIRLAM NWP precipitation forecast.



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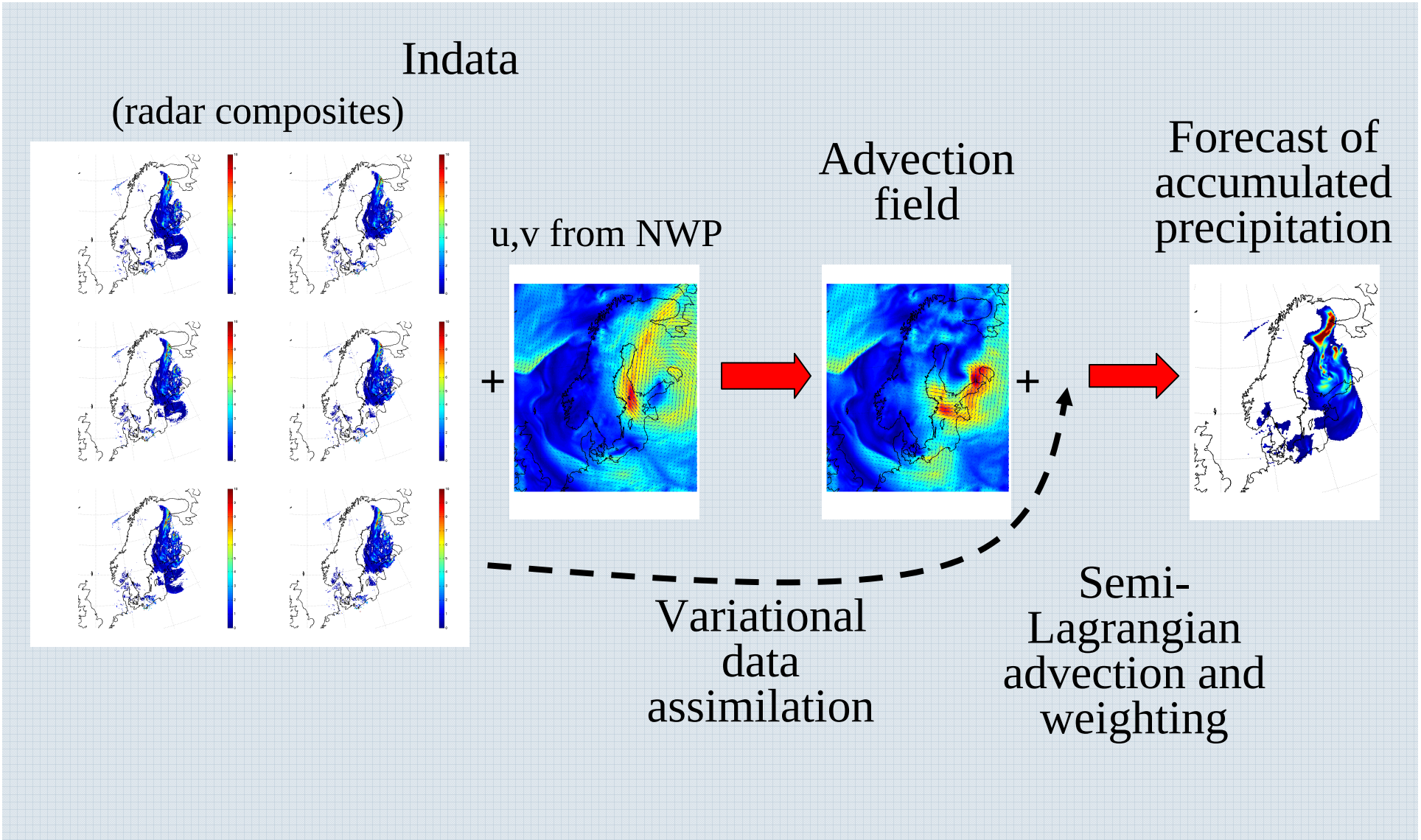
Schematic overview of methodology



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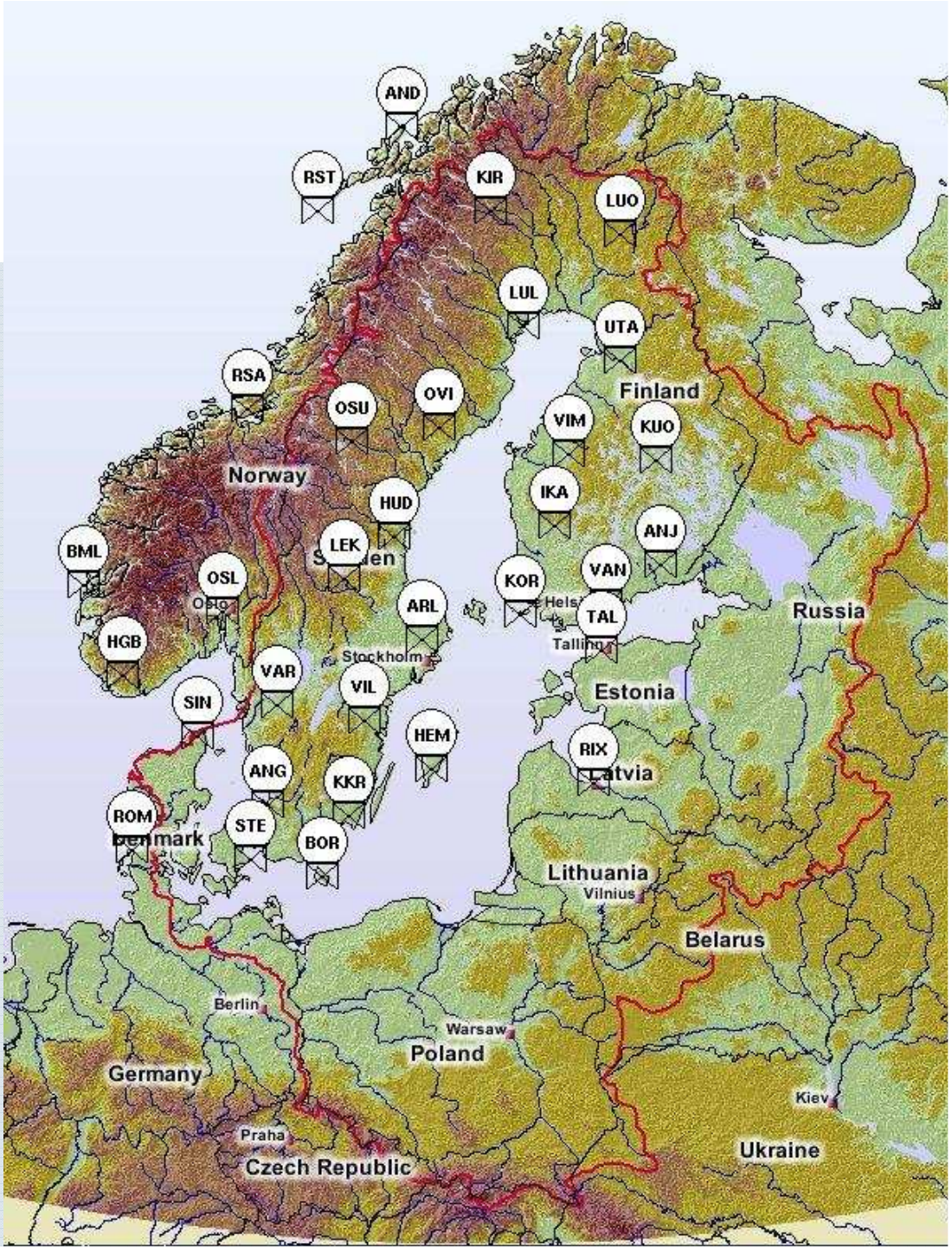
Radar data

- The NORDRAD network
- Precipitation fields at ground level from reflectivity composites (Z-R relation, down to Earth and Gauge adjustment applied on reflectivity composites)
- Horizontal resolution: 2 km (4 km)
- Temporal resolution:15 minutes



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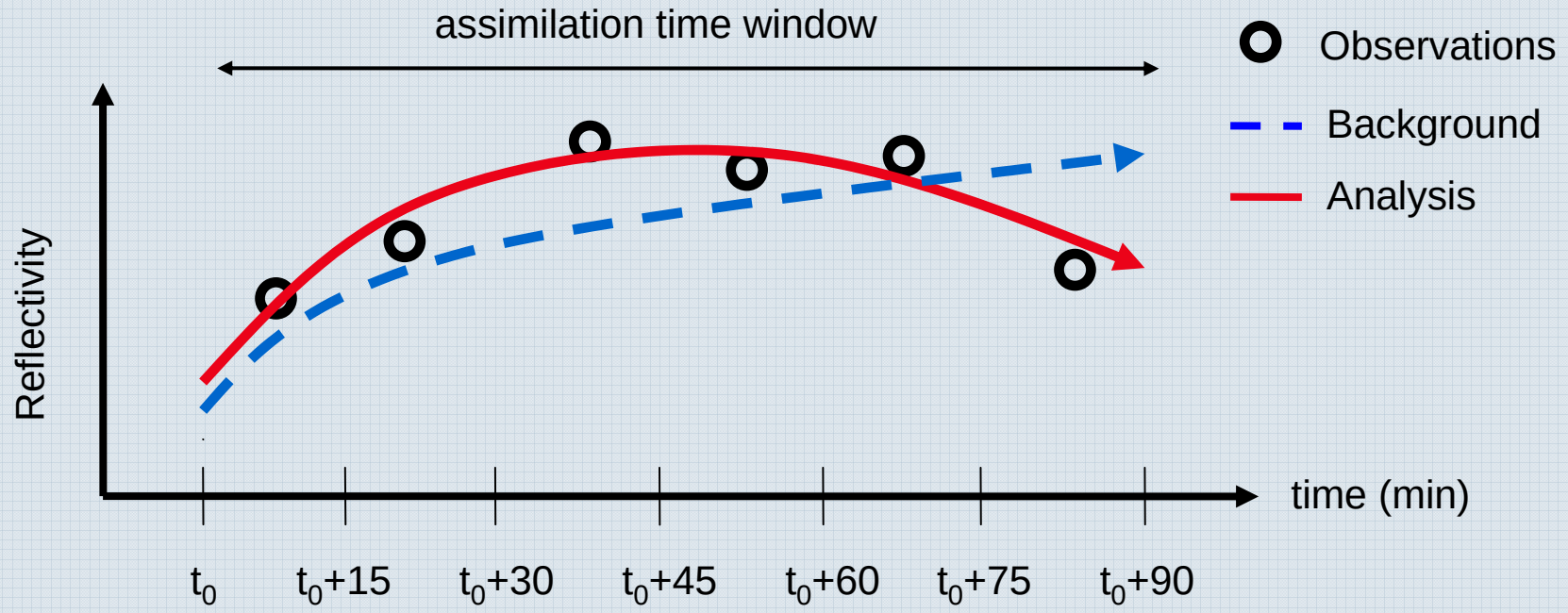
Variational methodology



Cost function

$$J = J_b(x_0) + J_o(x_0) = \frac{1}{2}(x_0 - x_b)^T B^{-1}(x_0 - x_b) + \frac{1}{2}(HMx_0 - \psi_{obs})^T R^{-1}(HMx_0 - \psi_{obs})$$

where

$x_0 = (u_0, v_0, \psi_0)$ - *model field*

$x_b = (u_b, v_b, \psi_b)$ - *backround field*

ψ_{obs} - *refl. obs.*

H - *obs. oper.*

M - *TL model*

B, R - *error cov. matrices*

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The forecast

A simplified version of HIRLAMs advection scheme

- Semi-Lagrangian advection in two dimensions of radar based precipitation patterns.
- u and v (the components of the advection field) are kept constant during the advection
- No physics

Weighting toward a HIRLAM NWP-forecast (post-processering)

- to catch non-developed convection in the area.

Forecast range (h)	1	2	3	4	5	6
Radar advection field	90%	80%	60%	40%	20%	10%
NWP forecast	10%	20%	40%	60%	80%	90%

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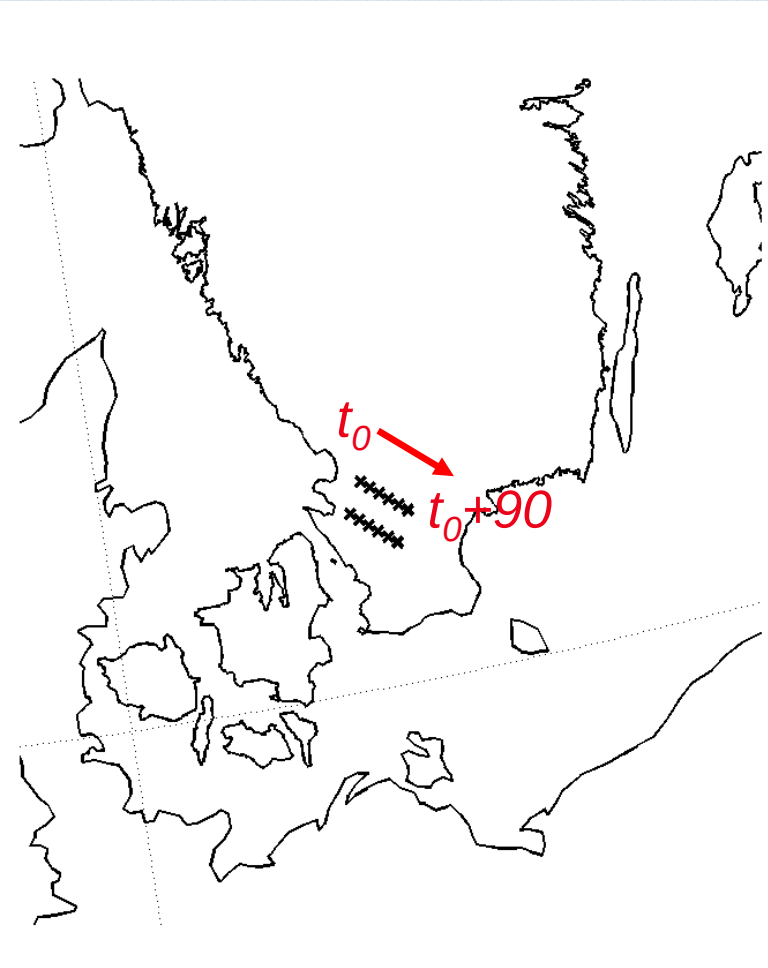
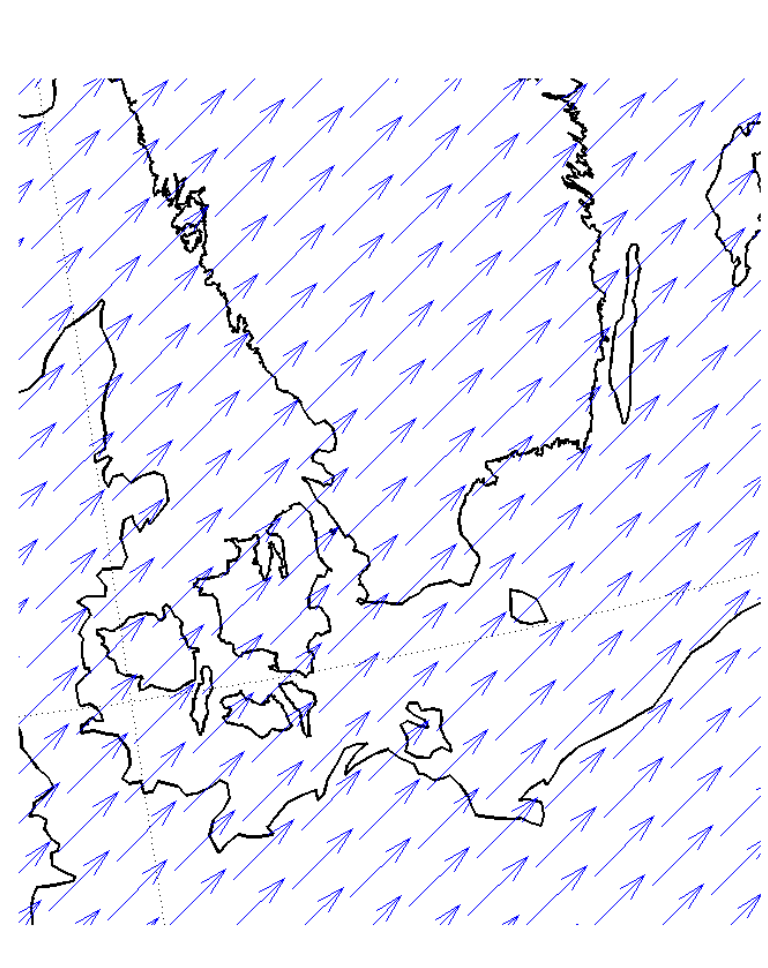
An illustration with simulated observations

2 observations moving approx. 25 m/s



Background: u=1, v=1



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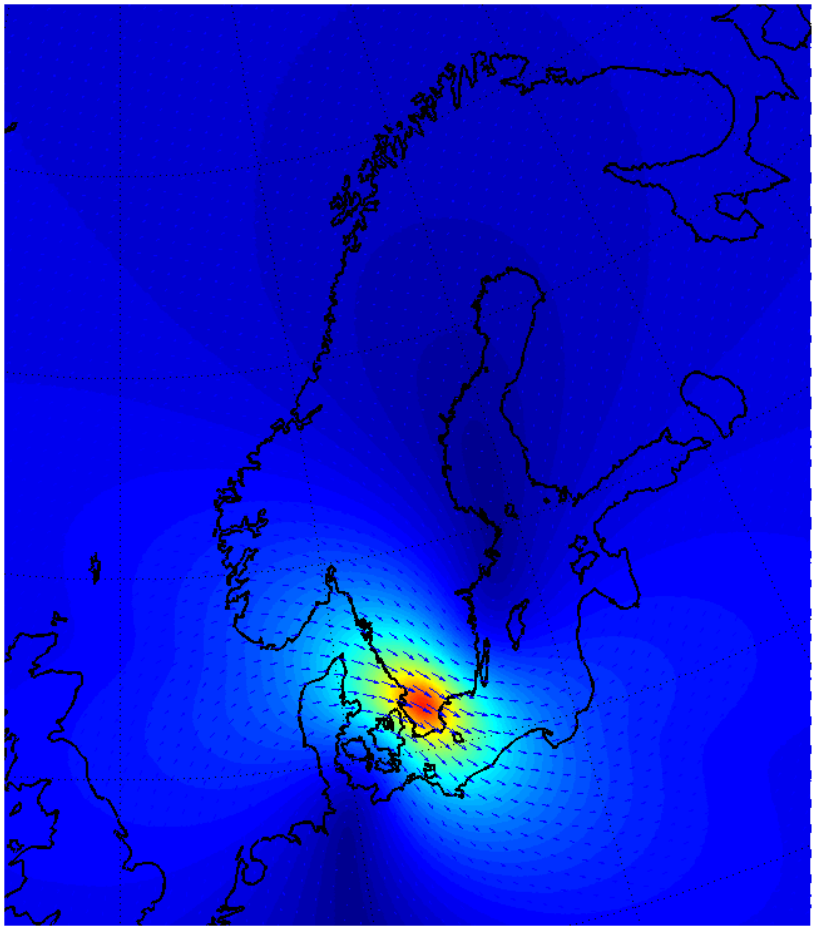
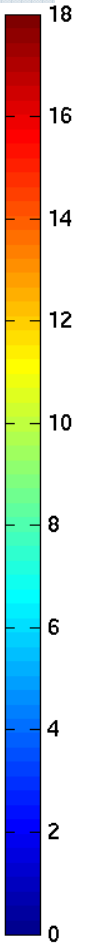
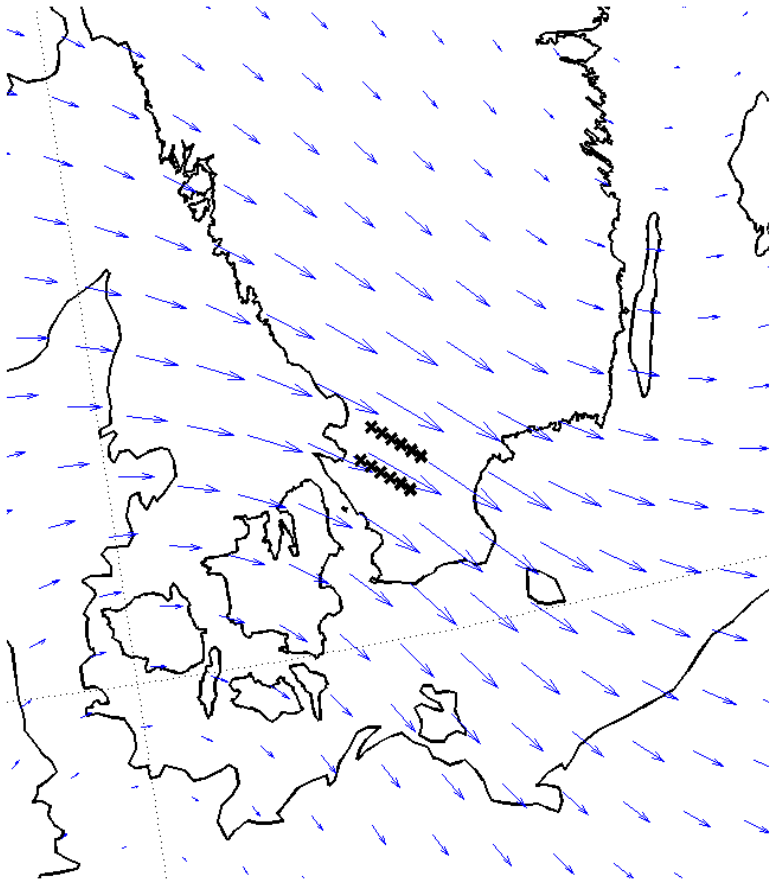
Variationally derived advection field

Speed of advection





Direction of advection



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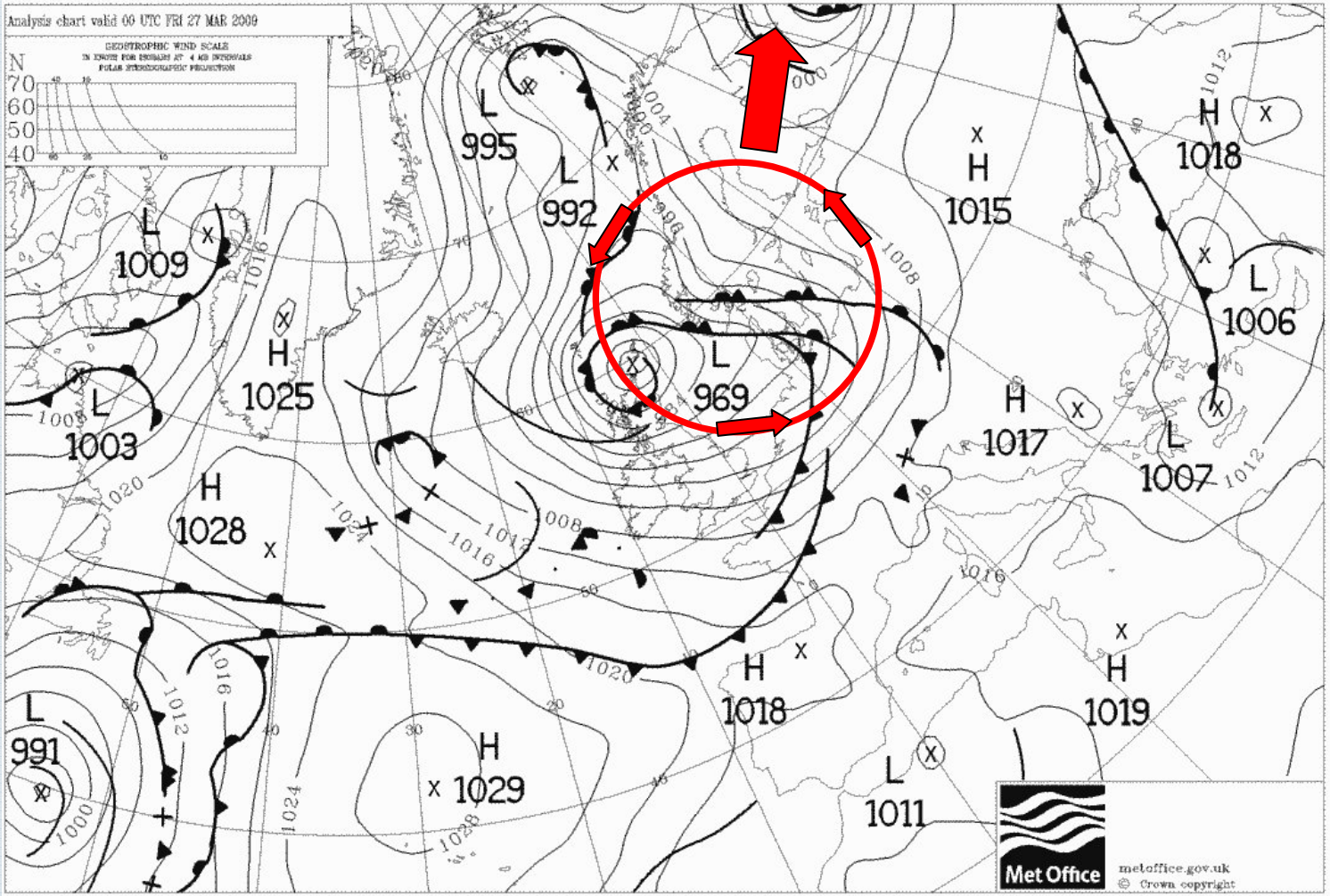
Full scale example

Weather situation over Europe
20090327 00 UTC



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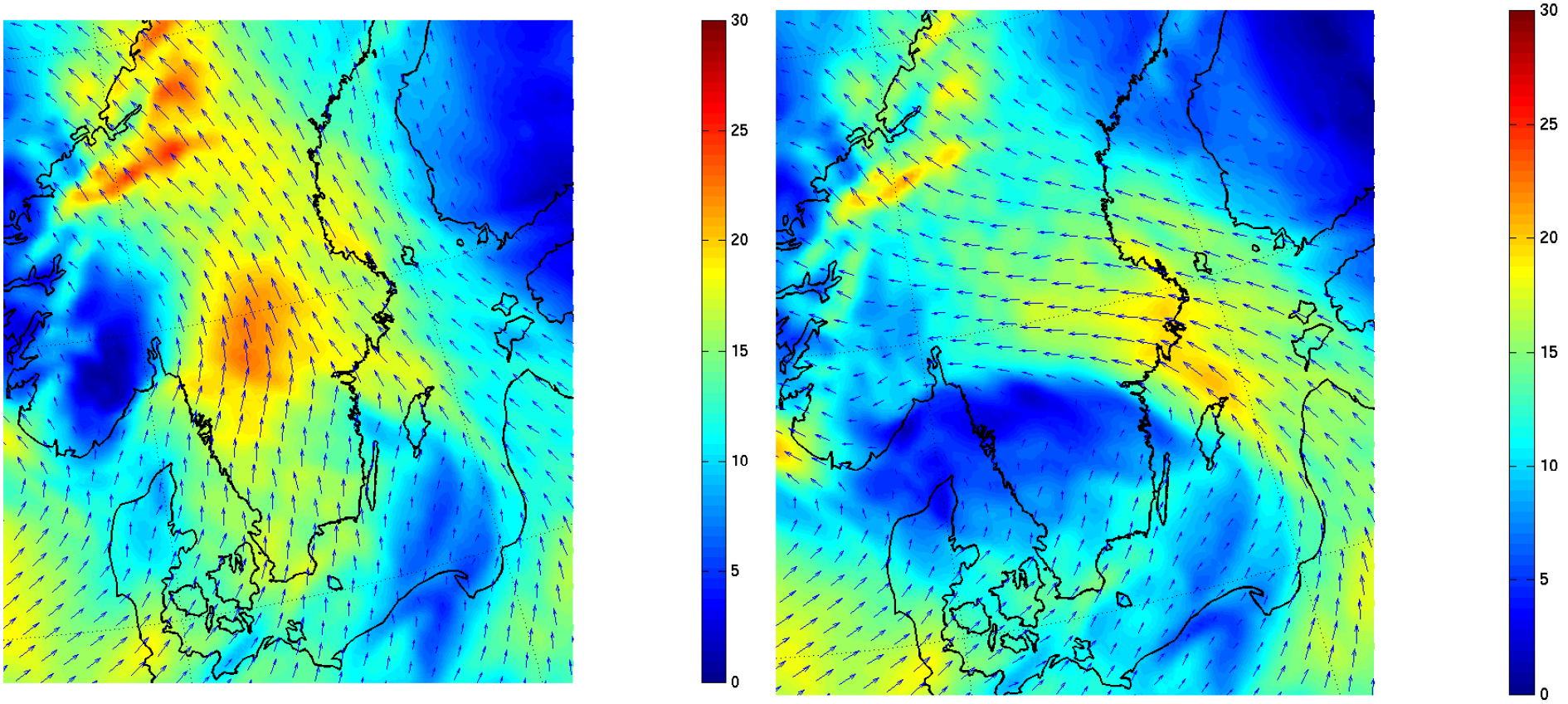
Radar derived advection field

20090327 16 UTC

Variationally derived advection field

NWP wind field at model level 50,
Close to 900 hPa (background)



Unit: m/s

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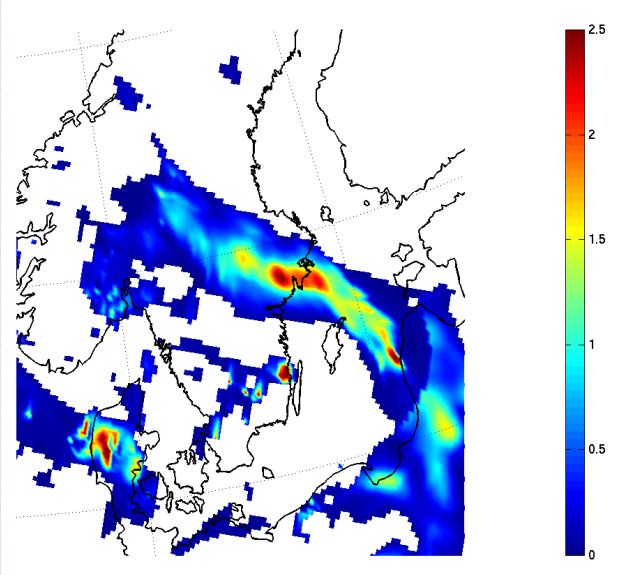
+1 hour forecast of 1h accumulated precipitation

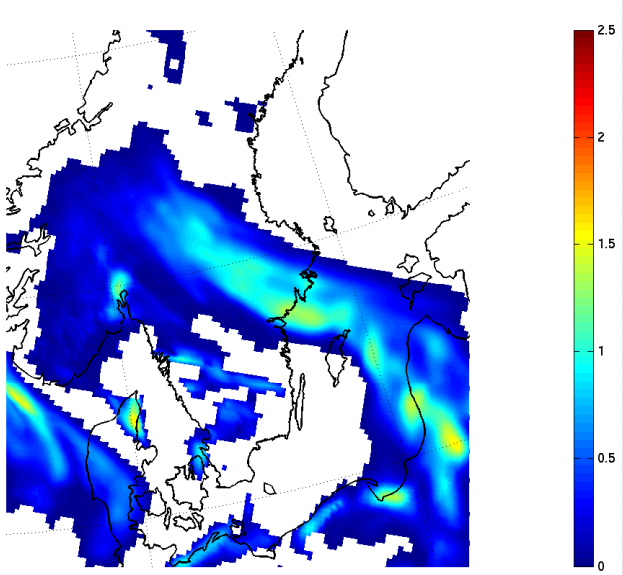
20090327 17UTC

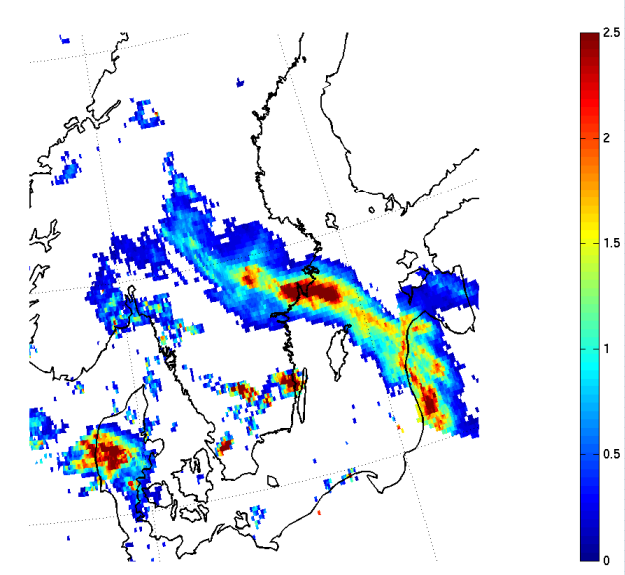
Radar advection forecast field

HIRLAM NWP forecast

Observation derived from radar composites







(90% adv, 10% HIRLAM)

Unit: mm

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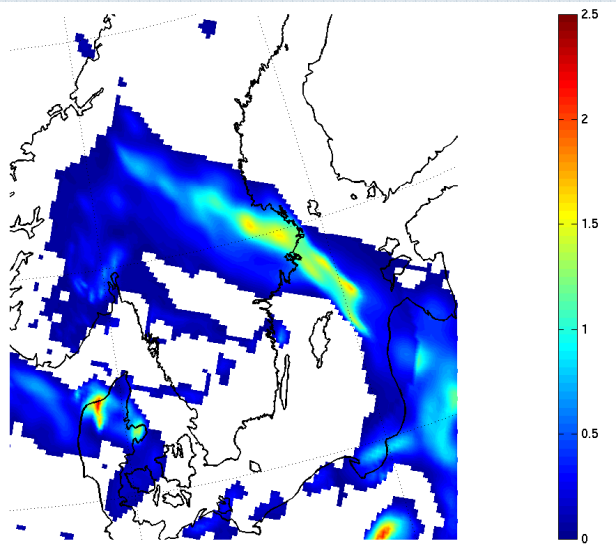
+3 hour forecast of 1h accumulated precipitation

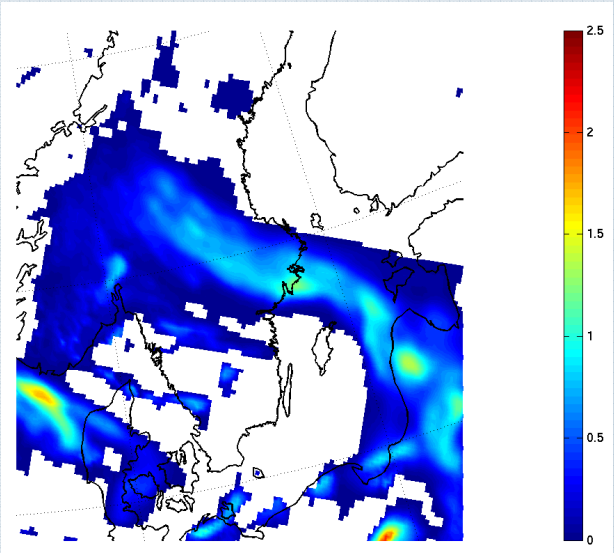
20090327 19UTC

Radar advection forecast field

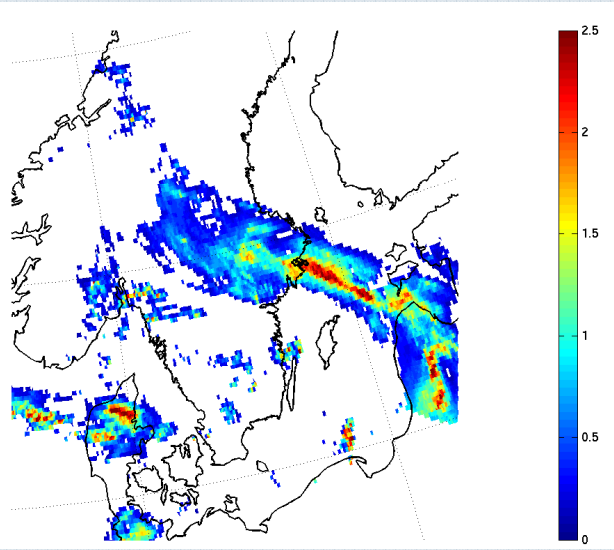


(60% adv, 40% HIRLAM)

HIRLAM NWP forecast



Observation derived from radar composites



Unit: mm

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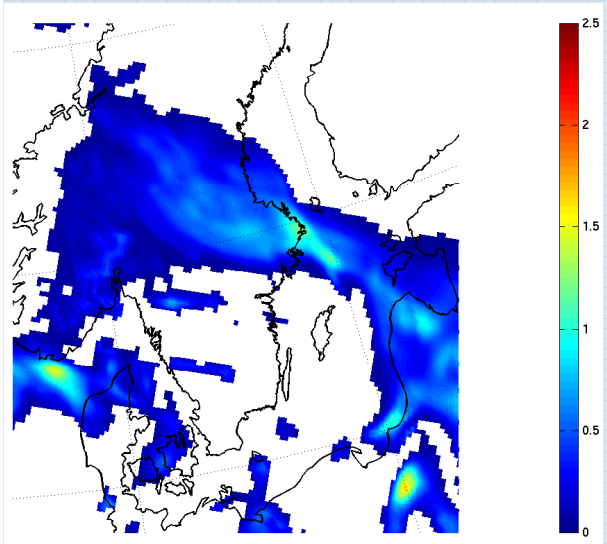
+5 hour forecast of 1h accumulated precipitation

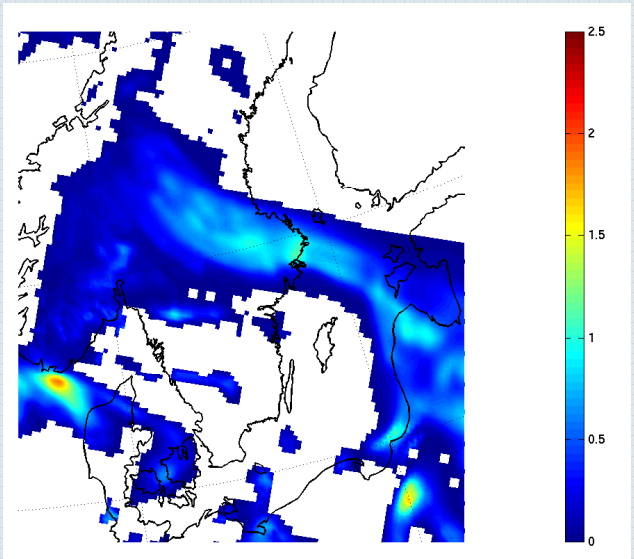
20090327 21 UTC

Radar advection forecast field

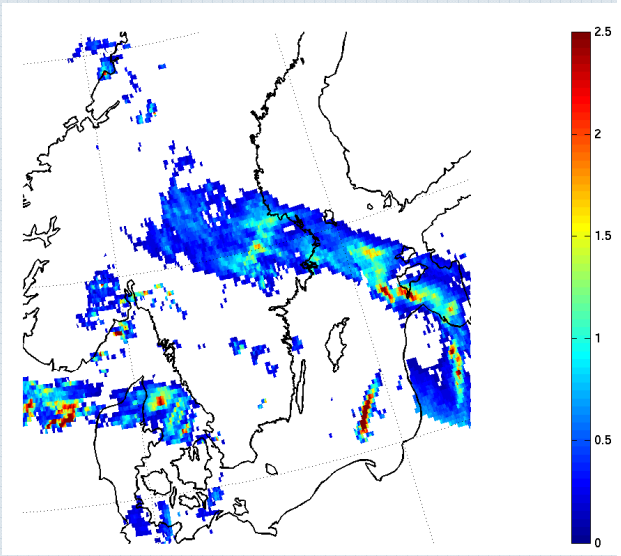


(20% adv, 80% HIRLAM)

HIRLAM NWP forecast



Observation derived from radar composites



Unit: mm

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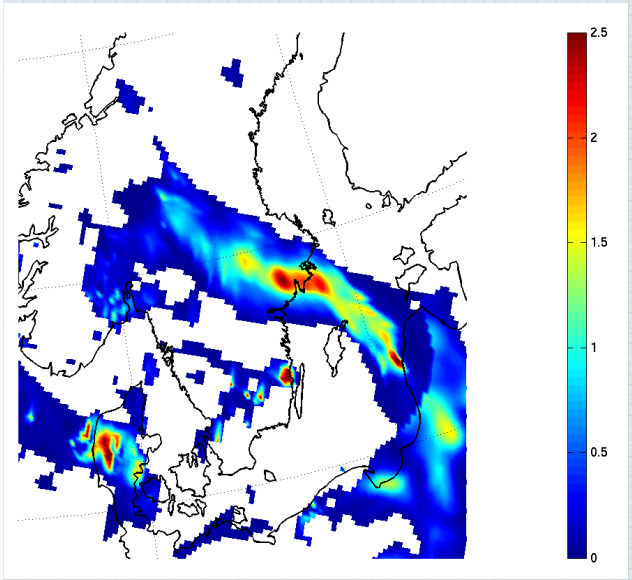
Time evolution of radar advection forecasts of 1h accumulated precipitation

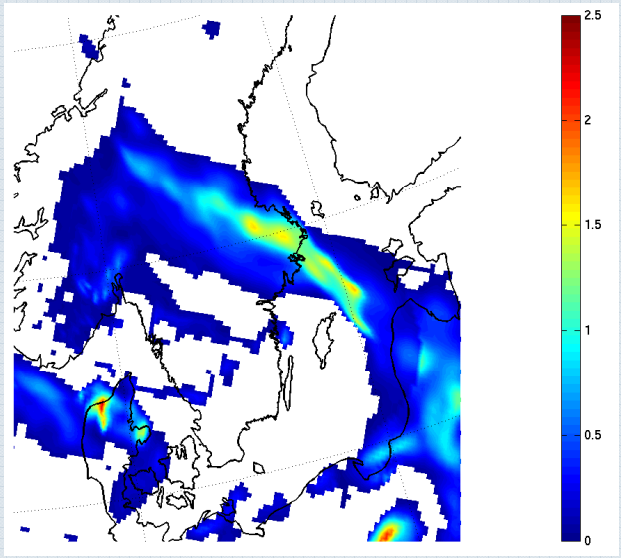
Forecast starting from 20090327 16 UTC

+1 h



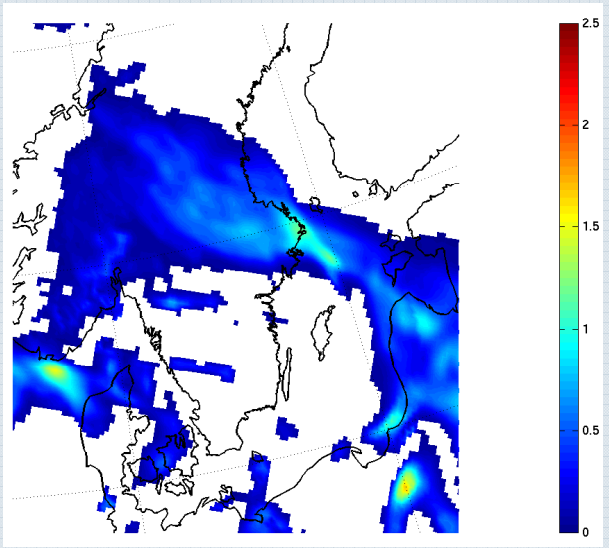
(90% adv, 10% HIRLAM)

+3 h



(60% adv, 40% HIRLAM)

+5 h



(20% adv, 80% HIRLAM)

Unit: mm

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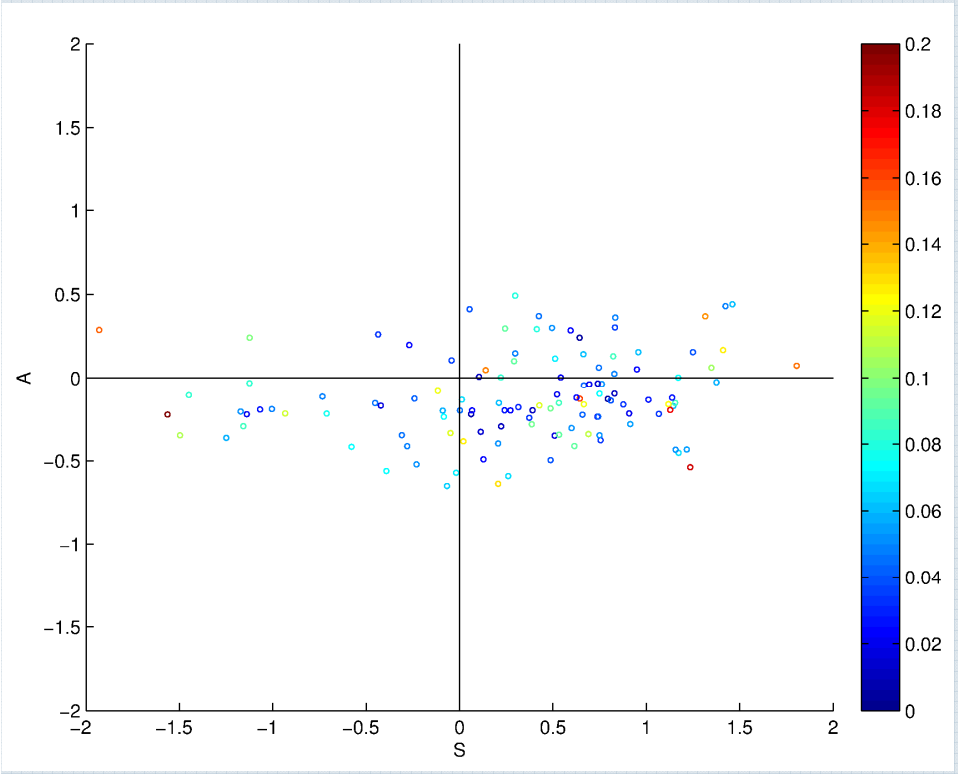
SAL verification of precipitation forecasts for a 44 day period

(00, 06, 12, 18 UTC gives 176 cases)

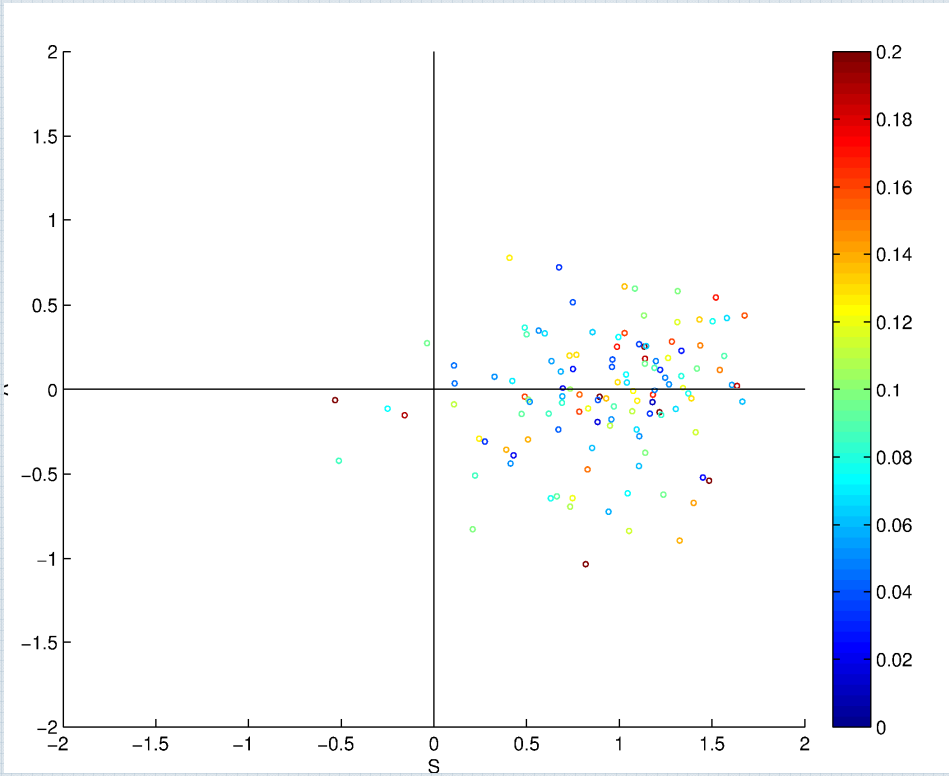
Verification against accumulated precipitation derived from radar composites

S - Structure (-2 to 2) A - Amplitude (-2 to 2) L - Location (0 to 2)

+3 h Radar advection forecasts



+3h HIRLAM NWP forecasts



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Conclusions

•A system using a variational method for deriving the advection field for radar precipitation structures has been developed.
•The functionality of the system has been demonstrated in an idealised experiment as well as in a full scale assimilation experiment.
•Verification shows that there are large benefits from using the radar advection model as compared to HIRLAM NWP forecasts, for short forecast ranges (1-4 h).