Radar based short-range precipitation forecasts

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

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Structure

- Introduction
- Radar data
- Variational methodology
- The forecast
- Results
- Conclusions
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.
Schematic overview of methodology

Indata (radar composites)

u,v from NWP

Advection field

Variational data assimilation

Semi-Lagrangian advection and weighting

Forecast of accumulated precipitation
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
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
- \[ \psi_{obs} \] - refl. obs.
- \[ M \] - TL model

- \[ x_b = (u_b, v_b, \psi_b) \] - background field
- \[ H \] - obs. oper.
- \[ B, R \] - error cov. matrices
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-processing)

- to catch non-developed convection in the area.

<table>
<thead>
<tr>
<th>Forecast range (h)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radar advection field</td>
<td>90%</td>
<td>80%</td>
<td>60%</td>
<td>40%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>NWP forecast</td>
<td>10%</td>
<td>20%</td>
<td>40%</td>
<td>60%</td>
<td>80%</td>
<td>90%</td>
</tr>
</tbody>
</table>
An illustration with simulated observations

2 observations moving approx. 25 m/s

Background: $u=1$, $v=1$
Variationally derived advection field

Speed of advection

Direction of advection
Full scale example
Weather situation over Europe
20090327 00 UTC
Radar derived advection field

Unit: m/s

Variationally derived advection field

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

20090327 16 UTC
+1 hour forecast of 1h accumulated precipitation
20090327 17UTC

<table>
<thead>
<tr>
<th>Radar advection forecast field</th>
<th>HIRLAM NWP forecast</th>
<th>Observation derived from radar composites</th>
</tr>
</thead>
</table>

(90% adv, 10% HIRLAM)  Unit: mm
+3 hour forecast of 1h accumulated precipitation

20090327 19UTC

Radar advection forecast field

HIRLAM NWP forecast

Observation derived from radar composites

(60% adv, 40% HIRLAM)

Unit: mm
+5 hour forecast of 1h accumulated precipitation

20090327 21 UTC

Radar advection forecast field

HIRLAM NWP forecast

Observation derived from radar composites

(20% adv, 80% HIRLAM)

Unit: mm
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)
Unit: mm

+5 h
(20% adv, 80% HIRLAM)
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
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).