Assimilation of radar data in AROME and in Europe

Review and prospects

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1. Main features of radar assimilation within AROME
   • Short history
   • Radar network over France
   • Impact on forecast performance

1. Illustrations
   • Importance of quality of raw data
   • Importance of « no-rain » assimilation

1. Planned activities
   • Towards the use of European radars (OPERA)
Assimilation of radar data in AROME : a short history

- Since 2005: Development of the AROME data assimilation system:
  - ALADIN heritage: 3D-Var + observations but with 3-h cycling
  - Choice of radar data and method:
    - French territory fully covered with 24 Doppler radars
    - High frequency observations of radial wind and reflectivity
    - Assimilation of volume data from individual radars
    - Computation of model reflectivities using modelled hydrometeors, to compare with observations
  - Strong interactions with the Météo-France radar expert team (DSO/CMR) to define scientific and technical needs
French ARAMIS network
- 24 Doppler radars, 10 Polarimetric, between 3 and 11 PPIs in 15’

Within AROME:
- Radial wind from 22 radars
- Reflectivity from 24 radars

Radar observations considered as profiles in the model
Data usage in the AROME 3D-Var system

Monthly averaged number of data used in AROME

- November 2008: AROME becomes operational including radar radial winds
- Summer 2009: Assimilation of improved radar radial winds
- Spring 2010: Operational assimilation of radar reflectivities
- Autumn 2010: Improved assimilation of « no rain » information from reflectivities
Precipitation Brier Skill Score

Large improvement in short range forecast since assimilation of radar reflectivities in April 2010

Lead time 6h
Screening: pre-processing and quality control

- Useful information provided by the radar producers (CMR): ground clutter, clear air echoes, sea clutter, anomalous propagation, rain attenuation, pixels below noise level, ...

- Importance of pre-processing and post-processing: very restrictive data selection

Example of pre-processing of radial wind
Experience has demonstrated the importance of accounting for the "no-rain" information in the assimilation.

**Requirement:** knowledge of the sensitivity of each individual radar to be able to correct the model.
Precipitation scores

Scores over 36 days in winter: average of time series

Significant impact on scores of:

- Better quality of radial wind
- Reflectivity

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### Probability of detection

- Reference (with assimilation of radial wind)
- Assimilation of radial wind of better quality
- Assimilation with the added reflectivity
Conclusions

• Operational assimilation of radar data in AROME with a positive impact

• Strong involvement of various teams at Météo-France (CNRM/GMME, CNRM/GMAP, DSO/CMR) and collaborations have started with HIRLAM and ALADIN consortia

• Application to other models:
  • Assimilation of radial winds was tested in ALADIN 3D-Var
  • Assimilation of reflectivities can be introduced in ALARO 3D-Var (despite different microphysics)
  • Assimilation of radial winds and reflectivities started in HARMONIE 3D-Var (Norway, Netherlands)
Outlook

- The availability of radar reflectivities is growing within the EUMETNET OPERA project (112 Radars from 16 Countries) but are not exchanged.

- Radial winds are not available (could be easily exploitable).

- The **exchange of radar data** could benefit to data assimilation systems in Europe, at the cost of necessary telecommunication infrastructure.

- Radar networks can be upgraded without changing all the radars (eg Doppler, polarimetry).

- **Required information in OPERA files** to identify non-meteorological echoes and non-rainy areas: need to work with data producers in different countries to improve data usefulness.

- **Strong positive feedback to OPERA needed to specify demands.**
Questions?
An example of radar data assimilation in 3D-Var AROME

Available radar data (33550)

Assimilated RH profiles (1242)

Heterogeneous radar network over France – Lack of European radars

Data thinning (16x16 km²) + QC + rainy areas
1D+3D-Var methodology

Use of model hydrometeors to modify humidity (1D), wind, temperature .. (3D-Var) without changing hydrometeors!
Illustration – Analysis differences with and without radar reflectivity assimilation

Relative humidity vertical cross section (white line)
Effect on 3D-Var analysis

Positive relative humidity increments in rainy areas

Negative relative humidity increments in « no-rainy » areas of the radar

RH increments at 500 hpa
On the use of « no rain » information

Experience has demonstrated the importance of accounting for the « no-rain » information in the assimilation => better balance between creation and destruction of rainy areas in the model.

**Rain in radar (SNR>0)**

**Good radar can dry the model**

**No information from poor radar**

Requirement: knowledge of the sensitivity of each individual radar to be able to correct the model.

Minimum detectable Z as a function of distance from the radar.
1. 2 problems:

- If too much noisy pixels, smoothing by filters but weak quality of wind field after filtering
  => **Need for a good quality of radial wind** (identification of clear sky echoes, low SNR) and **need for a quality flag**

- Nyquist velocity is often reduced for a better quality of data, but then areas of strong winds are removed and high convective gusts are lost or smoothed
  => **Need for a minimum Nyquist velocity around 30 m/s**