Towards the assimilation of radar reflectivities: improving the observation operator by applying beam blockage information

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Status report

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Currently, Météo-France is developing an NWP system for the convective scale. This system, called AROME (Application de la Recherche à l'Opérationel à Méso-Echelle), covers France with 2.5 km horizontal resolution. It uses a three-dimensional variational (3DVAR) data assimilation scheme and has an advanced representation of the water cycle with five hydrometeor classes (cloud water, rainwater, primary ice, snow and graupel) governed by a bulk microphysics parameterization.

The assimilation of radar reflectivities consists of three steps:

- simulate reflectivities from the model hydrometeors using an observation operator (Caumont et al. 2006),
- retrieve columns of pseudo-observations of humidity and other model prognostic variables from a reflectivity column, and
- assimilate the pseudo-observations through the 3DVAR assimilation scheme.

The French radar network consists of 24 radars. Polar volume data – averaged to a conical Cartesian grid of 1×1 km^2 – contains quality flags allowing to distinguish precipitation from spurious echoes (e.g. ground clutter). The distance to the radar is used as quality measure through the observation error covariances. Instead of correcting topographical beam blockage in the observed reflectivities which might be difficult for strong rates of shielding, so-called visibility maps are applied in the observation operator for each elevation angle.

Visibility is defined as the minimum height asl detectable by the radar main lobe. It depends on the beam width and the topography.

a) Beam Propagation Model (BPM)

The BPM is able to simulate visibility maps using information on the radar scan geometry, the vertical refractivity gradient and the topography (Bech et al. 2007). Currently, we are applying AROME's topography interpolated onto the radar grid. As real and model topography differ considerably in mountainous terrain we think of using the GTOPO30 topography instead.

b) Concept of visibility in the observation operator

The interpolation of variables from model space (model levels) to radar space (beam center) is part of the observation operator for reflectivities. Figure 1 illustrates the vertical interpolation with and without beam blockage assuming a Gaussian-shaped beam. Currently, topographical beam blockage is not considered in the radar observation operator. This might cause problems in mountainous regions where the interpolation considers model levels which are not visible by the radar (Fig 1 at 80 km). By using BPM's visibility maps for standard propagation the vertical interpolation becomes more realistic where the radar beam is partly blocked. In this case the simulated reflectivities below the minimum detectable height (i.e. visibility) are ignored while the Gaussian weighting remains untouched.

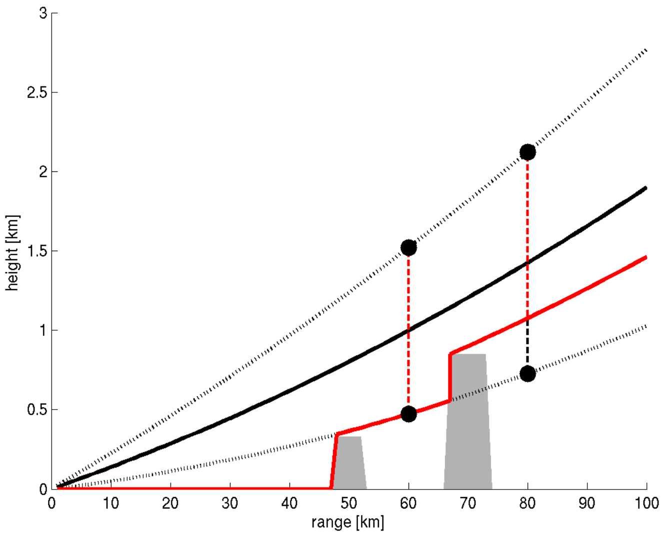

Fig 1: Vertical interpolation from model to radar space along the dashed lines (circles indicate the integration limits). The black solid line corresponds to the beam center while the dotted lines mark the beam width of the unblocked beam. The red solid line defines the visibility assuming atmospheric standard conditions. Simulated reflectivities below the minimum detectable height are ignored.

Visibility maps for all French radars have been simulated and integrated in the ODB. The AROME model was run over 24 hours for a case study on 11 September 2008 1800 UTC. Radar reflectivities were assimilated every third hour using the improved observation operator. Additionally, a control experiment has been performed. A thorough evaluation of the model runs is still pending and planned for 2009.

References:

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Caumont, O., V. Ducrocq, G. Delrieu, M. Gosset, J.- P. Pinty, J. P. du Châtelet, H. Andrieu, Y. Lemaître, and G. Scialom, 2006: A Radar Simulator for High- Resolution Nonhydrostatic Models. *J. Atmos. Oceanic Technol.*, **23**, 1049—1067.