Improving 3-D reflectivity radar mosaics using an inverse method

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Introduction

Dense radar networks could benefit from factors such as better coverage or less attenuation to produce better QPE than those obtained with individual radars.

Usual mosaicking techniques [e.g. selection of the maximum observed value, distance-weighted average (see Zhang et al. 2005)] are based on simplified assumptions, but may not get the full benefit of the network information.

Here, we propose and test an alternative methodology to obtain high-resolution radar reflectivity mosaics based on an inverse method.

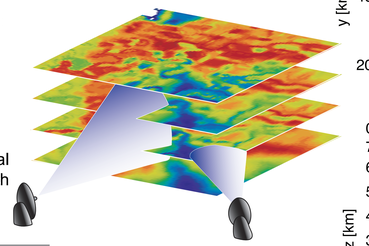
The methodology [similar as in Llort et al. (2006)]

It is based on the iterative minimization of a cost function:

$$\mathbf{z_{ret}} = \arg\min J(\mathbf{z})$$

$$J(\mathbf{z}) = \sum_{i=1}^{N_{rad}} \| Z_{obs,i} - Z_{sim,i} \|^2$$

The cost function penalizes discrepancies between actual and simulated radar observations (Z_{sim} and Z_{obs}) for each of the radar of the network.

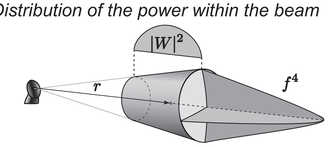


The simulation model

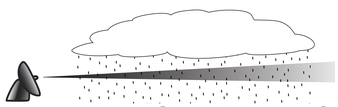
Z_{sim} is obtained simulating the radar sampling of the atmosphere:

$$Z_{sim}(r,\theta) = C \int_{V(r,\theta)} |W|^2 f^4 z(\mathbf{x}) \, dV \cdot A(r,\theta)$$

- *Distribution of the power within the beam*



- *Signal attenuation by rain*

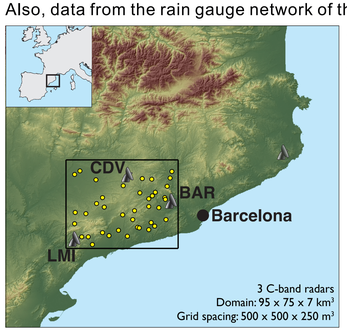


$$A(r,\theta) = \exp\left[-0.46 \int_0^r \alpha Z(s,\theta)^\beta \, ds\right]$$

Study area

The algorithm has been implemented to composite the observations of the CDV and LMI C-band radars of the Catalan Meteorological Service (SMC). Data from the BAR C-band radar of the Spanish Agency of Meteorology (AEMET) have been used in the evaluation of the results.

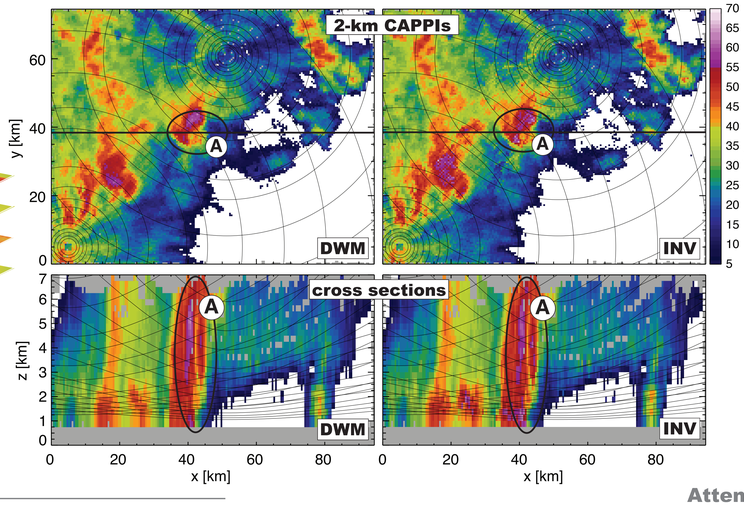
Also, data from the rain gauge network of the Catalan Water Agency (ACA) have been used to evaluate the produced radar rainfall estimates.



Results

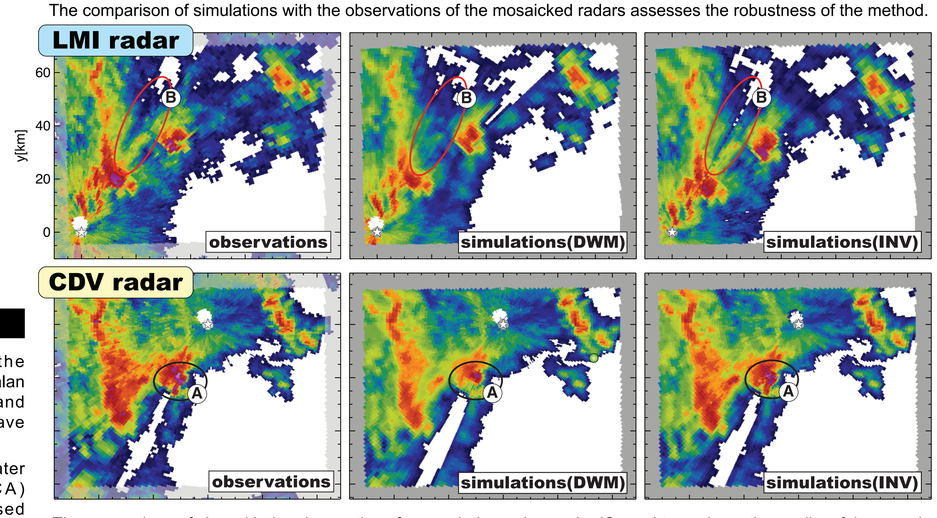
Comparison of mosaicking techniques

The mosaics obtained with the proposed method (INV) have been compared with those generated with the method of Zhang et al. (2005), DWM, based on a distance-weighted mean.



Observations vs simulations (1st PPI)

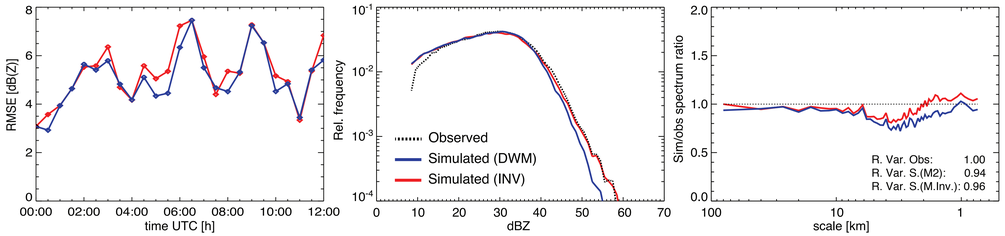
The comparison of simulations with the observations of the mosaicked radars assesses the robustness of the method.



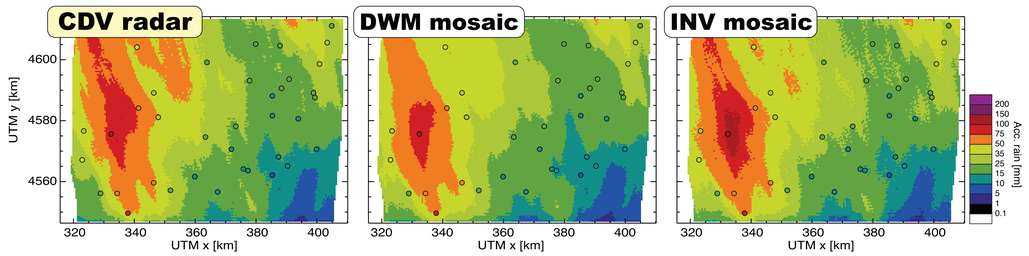
The comparison of sim. with the observations from an independent radar IS used to evaluate the quality of the mosaic.

Evaluation

Comparison between simulated and observed PPIs for the BAR radar over the event of 02 Nov 2008 from 00:00 to 12:00 UTC.

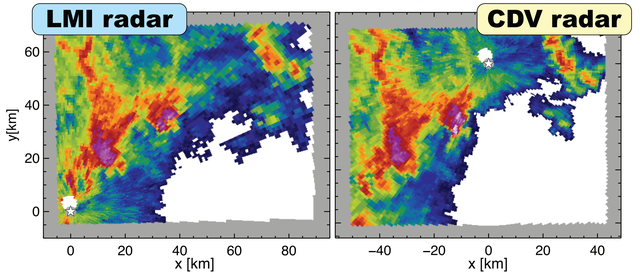


Rainfall accumulations



Attenuation correction

The use of redundant information allows estimating the effect of attenuation.



Conclusions

- The proposed approach allows compositing the observations of a radar network considering the radar sampling of the atmosphere.
- The method implicitly corrects for attenuation by constraining the correction with network observations.
- Quantitatively, the obtained mosaics are more consistent with the observations than fields obtained with other existing mosaicking techniques.
- Verification with the observations of an independent radar shows:
  1) No systematic improvement in terms of reduced errors.
  2) Better reproduction of the pdf of reflectivity.
  3) Better reproduction of the Fourier spectrum (except for an overestimation of small-scale noise).
- DWM and INV show similar results in R-G comparison. INV reproduces better large accumulations.

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References

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