Height correction of AMVs using satellite lidar observations from CALIPSO

Kathrin Folger and Martin Weissmann

Hans-Ertel-Centre for Weather Research, Data Assimilation Branch, Ludwig-Maximilians-Universität München, Germany

Background

- Atmospheric Motion Vectors (AMVs) are derived by tracking clouds or water vapour structures in consecutive satellite images
- AMVs are the only wind information in many regions of the globe and are thus an essential ingredient for NWP
- Vertical height assignment issues are responsible for up to 70% of the total AMV error (Velden and Bedka, 2009)
- Lidars can provide accurate information on cloud top heights

Approach

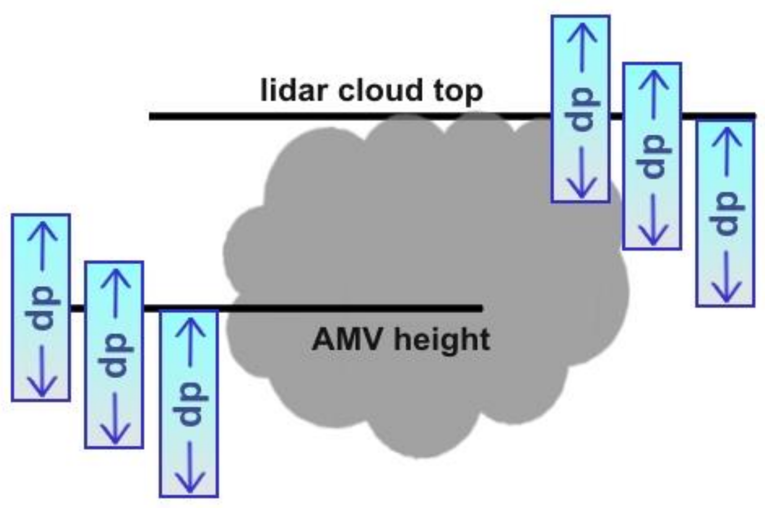
- Correct the pressure heights of AMVs
  - firstly with airborne lidar observations during the field campaign T-PARC (where independent dropsondes are available for verification)
  - secondly with spaceborne CALIPSO lidar observations
- Develop a height correction method for operational AMVs and improve the assimilation of AMVs by treating them as layer-averaged winds and/or including a height correction with lidar

References

- Weissmann, M., K. Folger and H. Lange, 2013: Height correction of atmospheric motion vectors using airborne lidar observations. J. Appl. Meteor. Climatol., **52**, 1868–1877.
- Folger, K., and M. Weissmann, 2014: Height correction of atmospheric motion vectors using satellite lidar observations from CALIPSO. J. Appl. Meteor. Climatol., submitted.

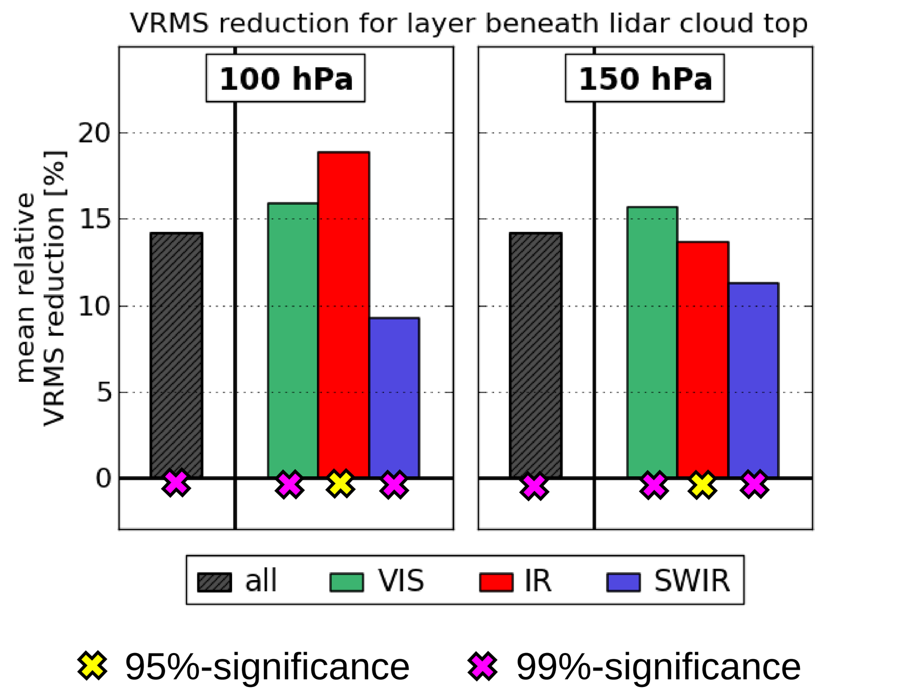
1. Method for AMV height correction with lidar cloud top information

- Compare AMV winds to soundling winds averaged over vertical layers
  - relative to the original operational AMV heights
  - relative to (airborne or spaceborne) lidar cloud top height observations
- Testing layers of 0-200 hPa
- Testing three positions:
  - centered
  - 25% above, 75%below
  - below

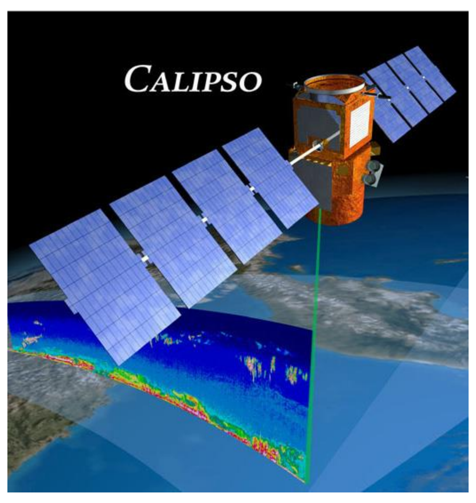


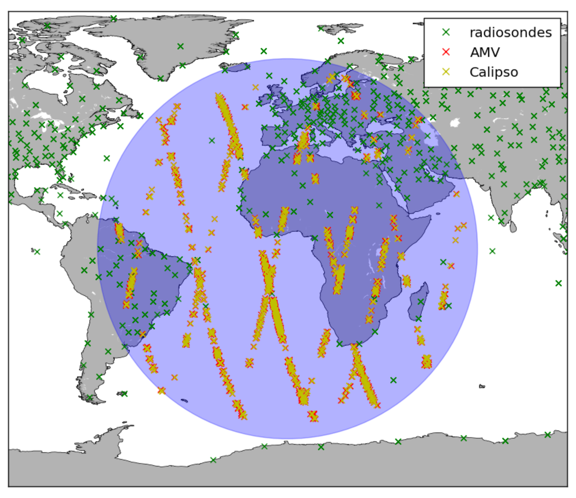
2. Results for AMV height correction with **airborne** lidar observations

- Based on data from the field campaign T-PARC in 2008:
  - 25 DLR Falcon flights with lidar backscatter measurements
  - over 300 dropsondes for the wind validation
  - AMVs from MTSAT processed hourly by CIMSS
- Best results are achieved when 100-150 hPa layers below lidar cloud top observations are assigned to AMVs
- The height correction of AMVs with lidar observations decrease the AMV wind error on average by 14 %, results are statistically significant



3. Satellite lidar observations from CALIPSO

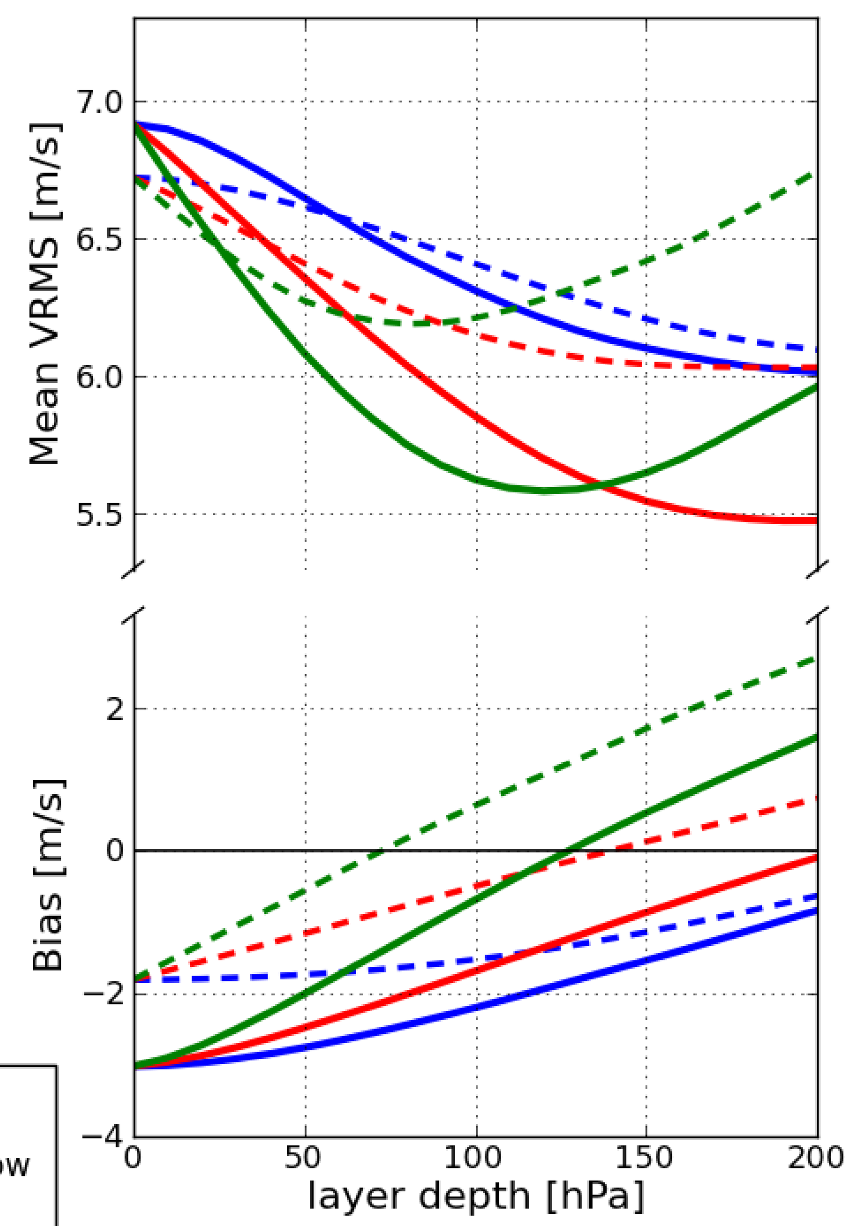


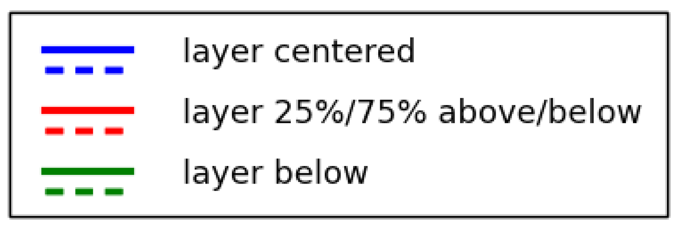


- About 1000-1300 collocated MSG AMVs and CALIPSO lidar observations per day (within 50 km and 30 min)
- About 4500 collocated MSG AMVs, CALIPSO **and** radiosonde observations in 8-month period in 2012/2013

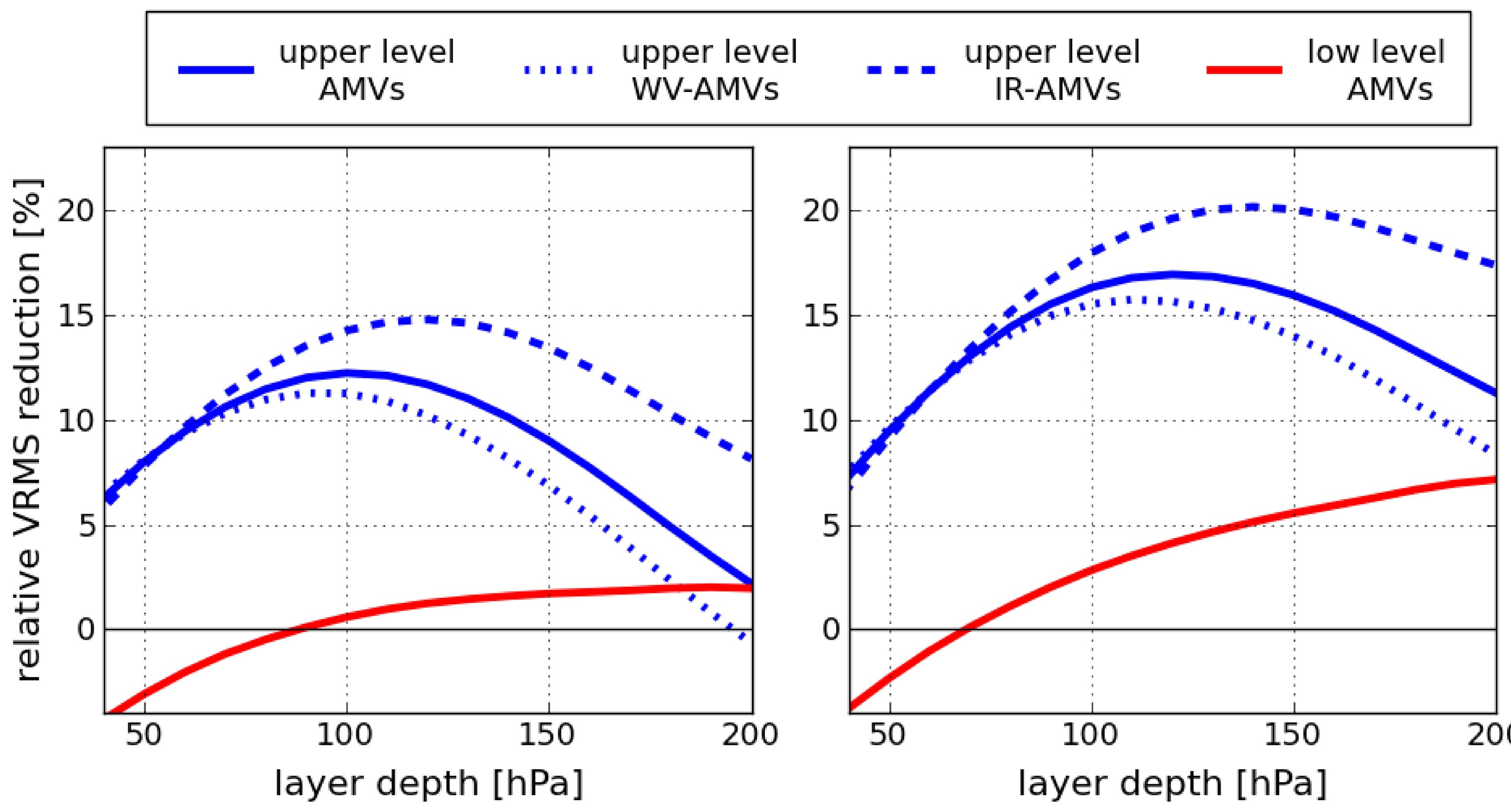
4. Results for AMV height correction with **satellite** lidar observations from CALIPSO

- Mean VRMS (**V**ector **R**oot **M**ean **S**quare) and wind speed bias for upper level AMVs above 700 hPa (2835 AMVs)
- Differences of AMVs and radiosonde winds for assigning layers relative to AMV heights (dashed) and layers relative to lidar cloud top observations (solid)
- Best results are achieved for 120 hPa layers below the lidar cloud top (—) or 200 hPa layers with 25% above and 75% below the lidar cloud top (—) with lowest VRMS differences and bias values close to zero



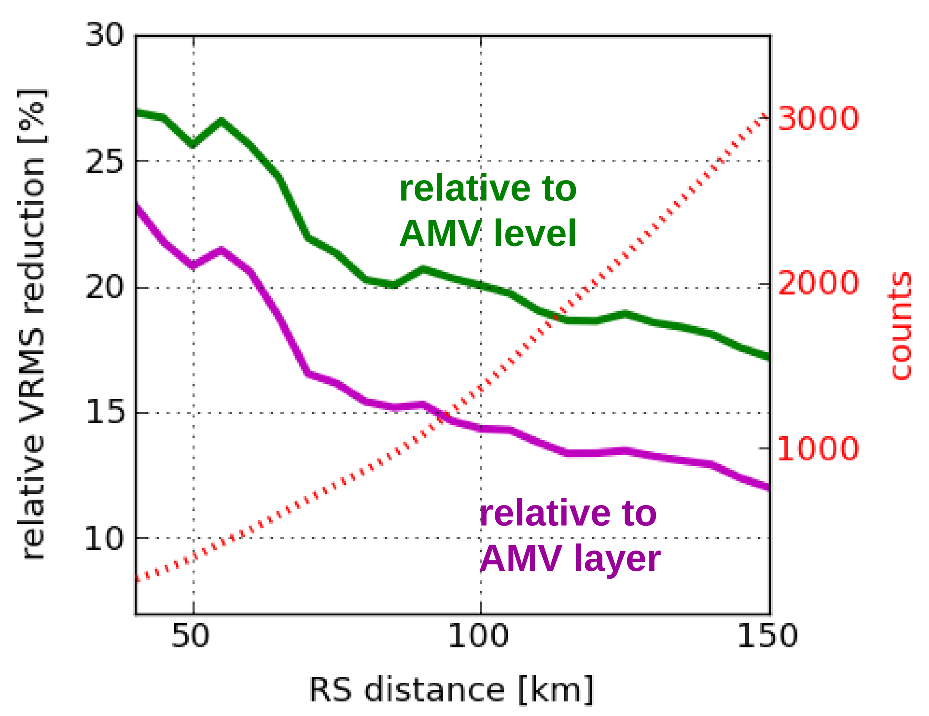


5. Relative VRMS reduction



- Relative reduction of VRMS differences between AMVs and radiosondes through height correction with CALIPSO lidar observations
- Results relative to (left) assigning a reference **layer** of the same depth centered at original AMV height and (right) assigning the AMV wind to the original discrete AMV **level**
- Upper level AMVs above 700 hPa (blue) show clear error reduction (12-17%) which is apparent in both high level channels IR and WV (blue dashed and dotted)
- Only small error reduction for low level AMVs below 700 hPa (red)

6. Tighter collocation criterion for AMV – radiosonde – distance



- Error reduction as a function of the distance to the verification radiosonde
- Results (green) relative to layers at original AMV heights and (purple) relative to discrete original AMV levels
- Results demonstrate that the distance between AMV and verification radiosonde leads to an underestimation of the actual improvement
- The improvement reaches over 20% (25%) with a tight collocation criterion

7. Conclusion

- Lidar observations can significantly reduce the errors of AMVs, as they provide high-resolution cloud top observations that are expected to be independent of the height assignment method used in the AMV processing
- Wind error reduction with CALIPSO height correction for AMVs
  - compared to layer centered at original AMV height: ~12%
  - compared to single level value at AMV height: ~17%
  - indication of larger reduction (>20%) with stricter verification criterion
- Lidar observations are also expected to reduce error correlations.

8. Outlook

- Evaluation of AMV height correction with model field: First results indicate a slight error reduction for MSG Meteosat-10-AMVs when lidar information is included
- Assimilation experiments with lidar-corrected and layer-averaged AMVs in NWP models
- Develop situation-depended correction functions for NWP