Height correction of atmospheric motion vectors with lidar observations

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Motivation

- Atmospheric Motion Vectors (AMVs) are the only wind information in many regions
- Height assignment issues are responsible for up to 70% of their error
- Significant error correlation causes rigid thinning of data in NWP
- Lidars provide accurate information on cloud top heights

Approach

- Develop a height correction method for AMVs using airborne lidar observations from the field campaign T-PARC, where independent dropsondes are available for verification
- Correct the height of AMVs with CALIPSO observations based on the method developed for airborne lidar observations
- Compare AMV winds to sounding winds averaged over vertical layers
- Improve the assimilation of AMVs by treating them as layer-averaged winds and/or including a height correction with lidar

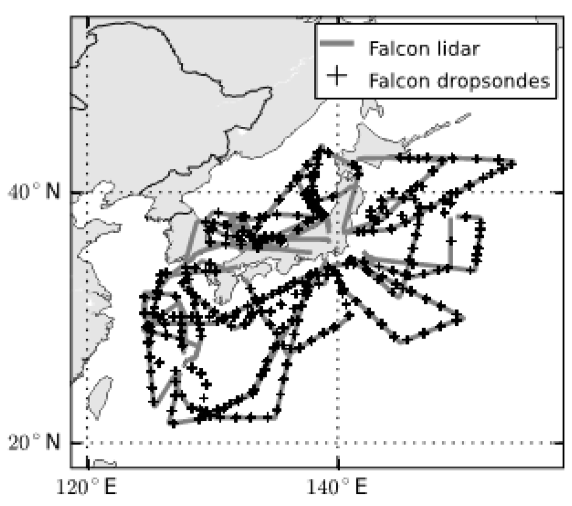
Results

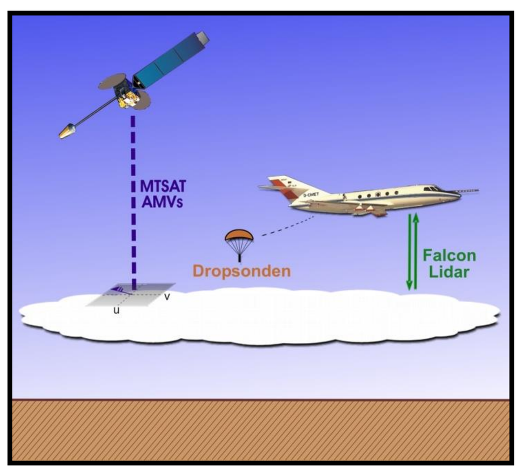
- Lidar observations can significantly reduce the errors of AMVs
- Using CALIPSO leads to 12% error reduction compared to reference layer and 17% error reduction compared to discrete AMV level
- Improvement even larger (20-25%) with closer verification radiosonde

References

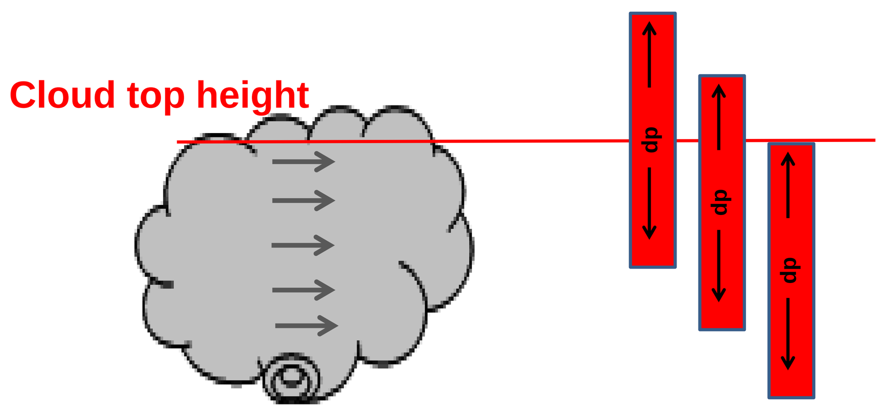
- Weissmann, M., K. Folger and H. Lange, 2013: Height correction of atmospheric motion vectors using airborne lidar observations. J. Appl. Meteor. Climatol., **52**, 1868–1877.
- Folger, K., M. Weissmann: Height correction of atmospheric motion vectors using satellite lidar observations from CALIPSO.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

Method for AMV height correction with airborne lidar





- 25 Falcon flights
- lidar backscatter ratio to determine cloud top height
- >300 dropsondes
- CIMSS hourly AMVs from MTSAT

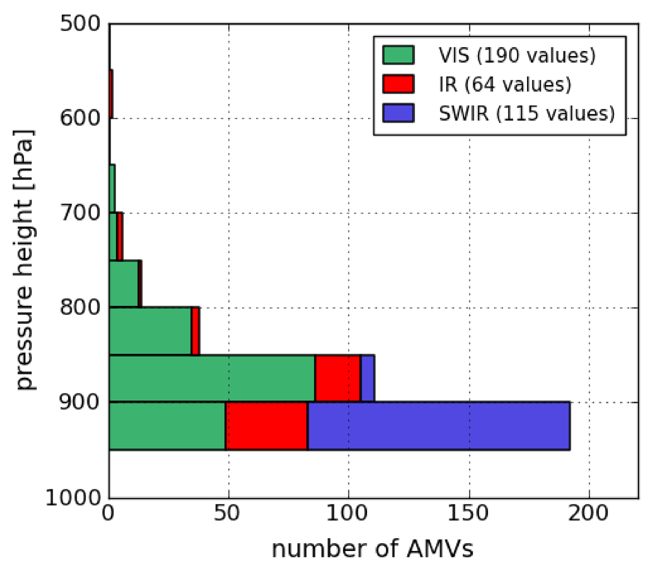


- Testing layers of different depth
- Testing three positions:
  - centered
  - 25% above, 75% below
  - below

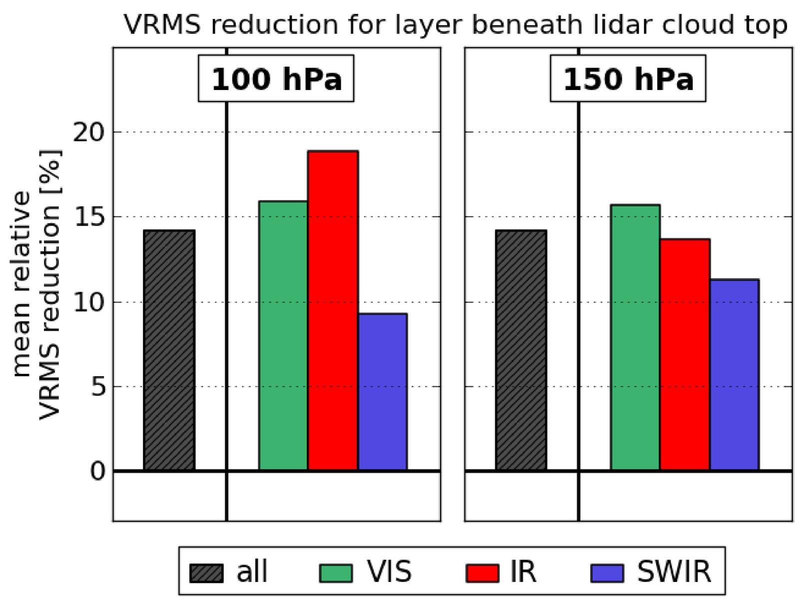
New layers

Results for AMV height correction with airborne lidar

Height distribution of AMVs

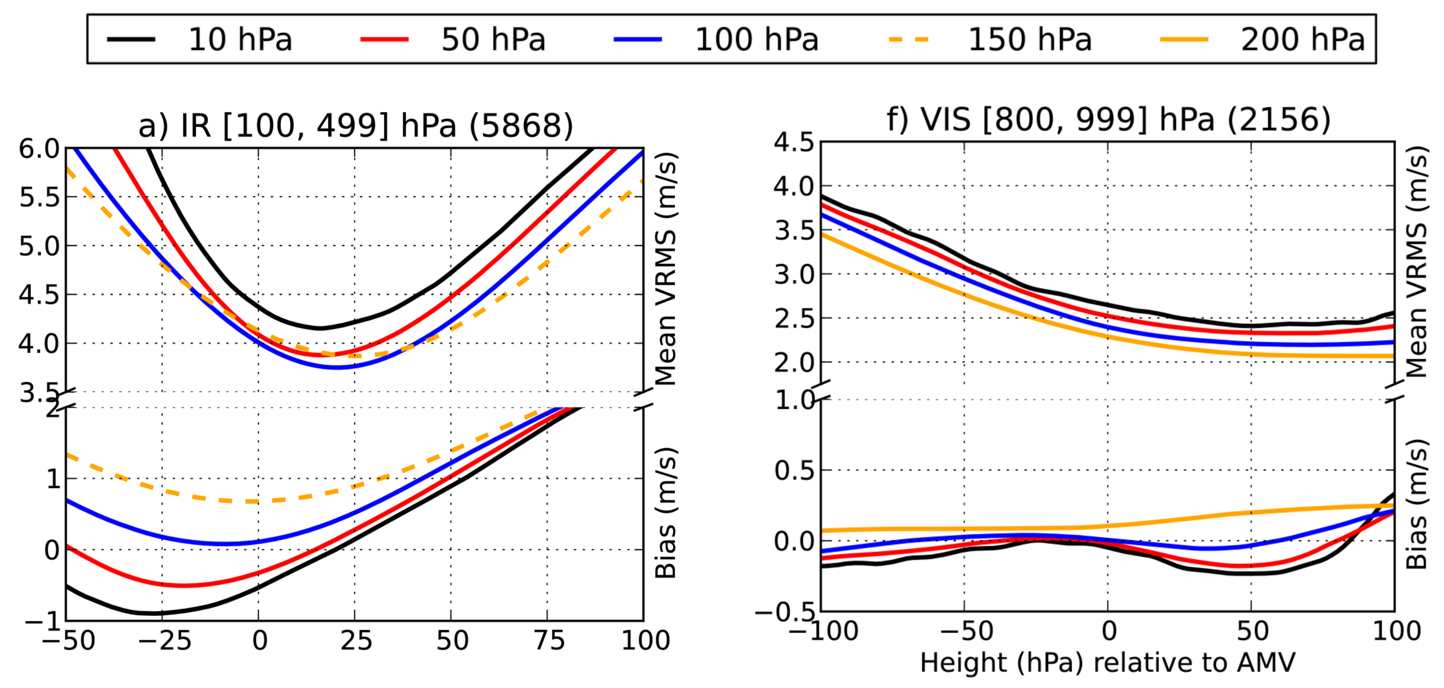


Relative error reduction through height correction with lidar



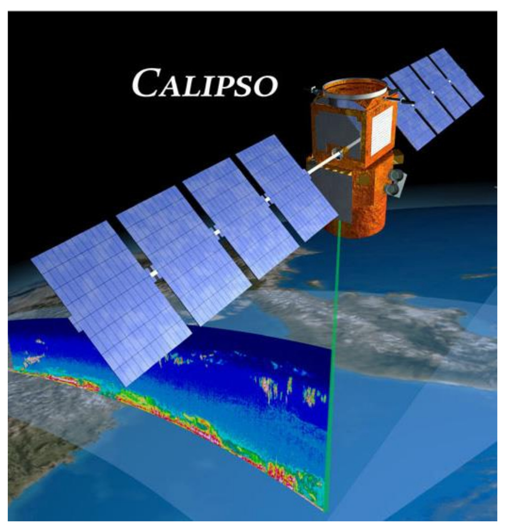
- Best results are achieved when 100-150 hPa layers beneath lidar cloud top observations are assigned to AMVs
- The height correction of AMVs with lidar observations on average decrease the AMV wind error by 14%, results are statistically significant

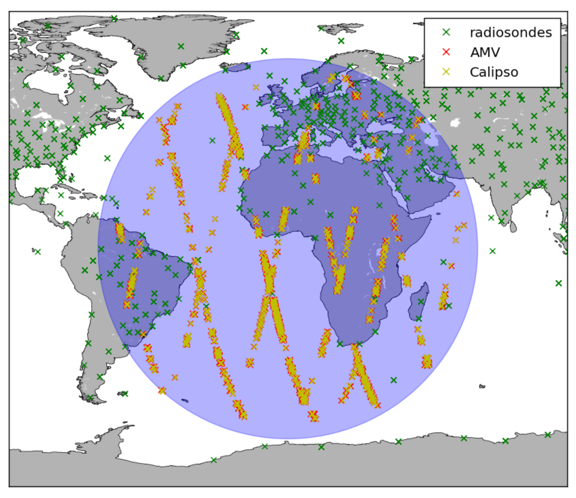
Comparing AMV winds to layer-averaged sounding winds



- Average VRMS reduction for 100 hPa layers centered at original AMV height is 5-10%
- Deeper layers further reduce the VRMS, but tend to increase the bias
- For low-level AMVs beneath 800 hPa, a layer beneath the AMV height may be appropriate

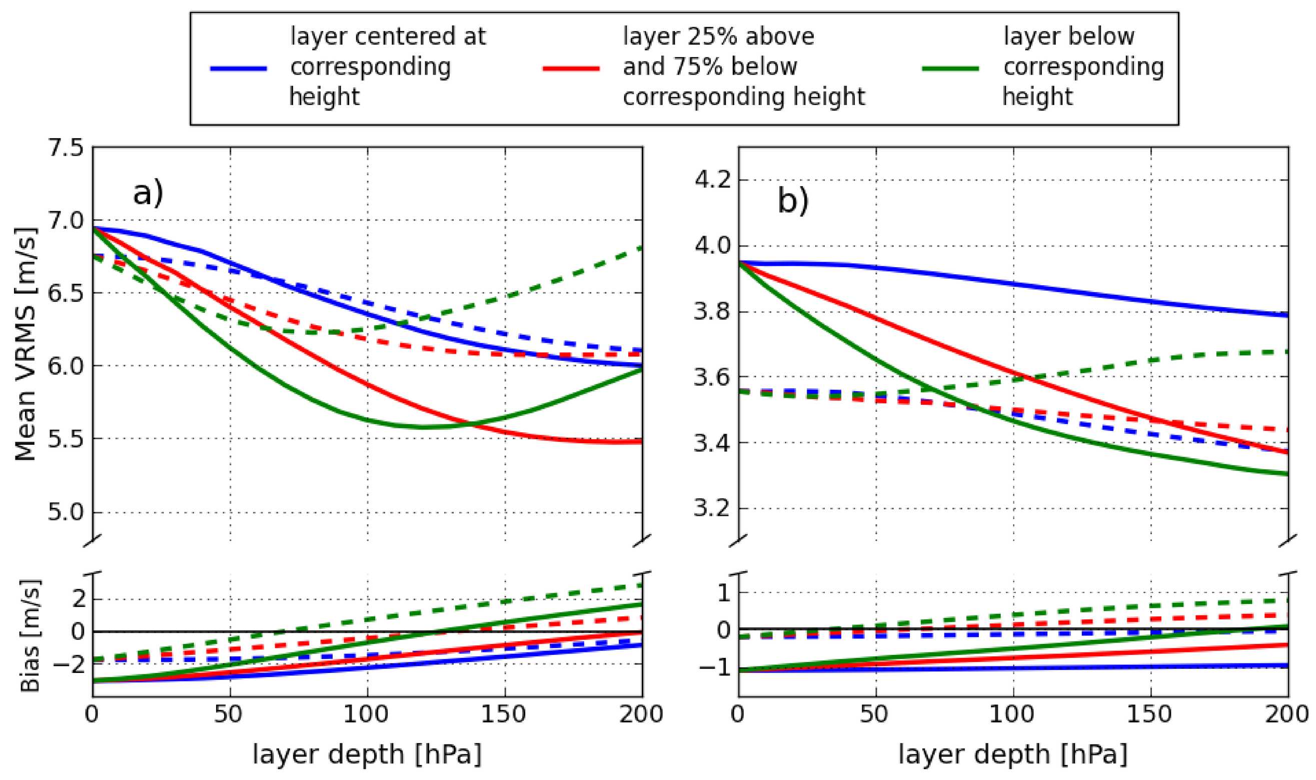
CALIPSO lidar observations



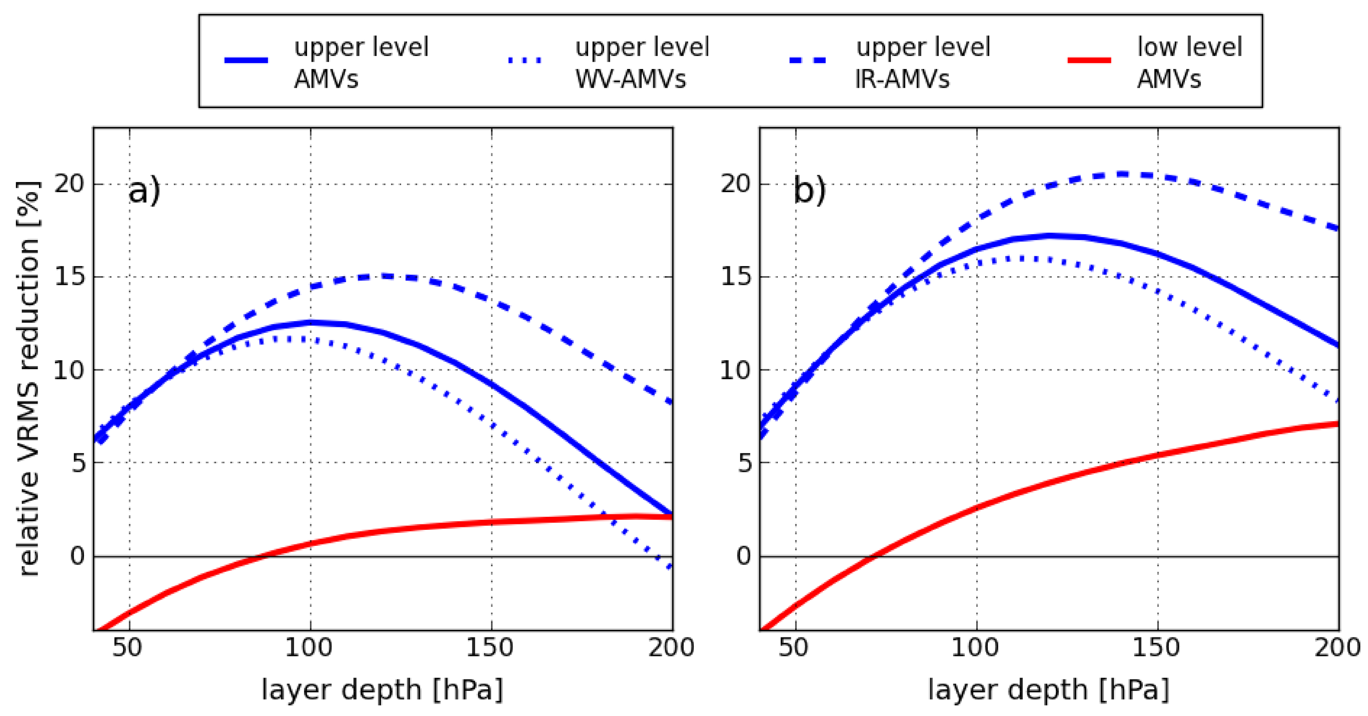


- About 1200 collocated MSG AMVs and CALIPSO observations per day (within 50 km and 60 min)
- About 4700 collocated MSG AMV, CALIPSO and radiosonde observations in 8-month period

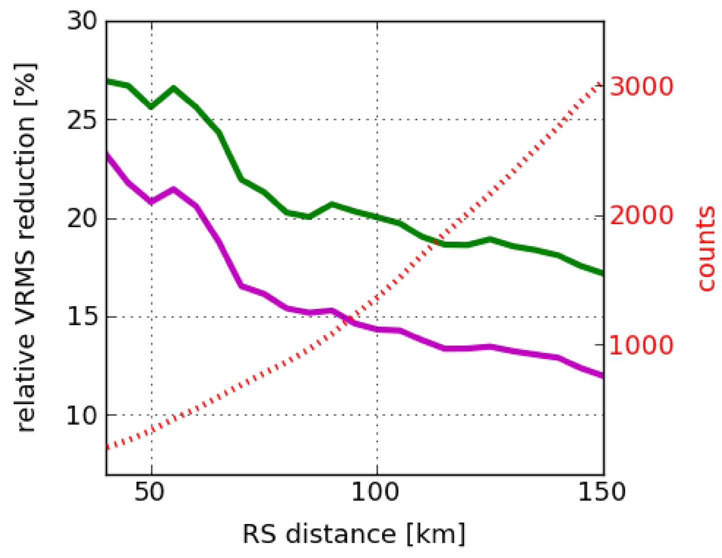
Results of AMV height correction with CALIPSO



- (a) AMVs above 700 hPa and (b) AMVs below 700 hPa
- Difference of AMVs and radiosonde winds for assigning (dashed) layers relative to AMV heights and (solid) layers relative to the lidar cloud top observations
- Best results are achieved with 120 hPa layers beneath CALIPSO cloud top observations for AMVs above 700 hPa



- Relative reduction of wind difference between AMVs and dropsondes through height correction with CALIPSO observations
- Results relative to (a) assigning a reference layer of the same depth centred at original AMV height and (b) assigning the AMV wind to the original discrete AMV level



- Error reduction as a function of the distance to the verification radiosonde: (green) relative to AMV layer and (purple) relative to discrete AMV level
- 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