Height correction of atmospheric motion vectors (AMVs) using lidar observations

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Supported by:
Alexander Cress and Harald Anlauf (both DWD)

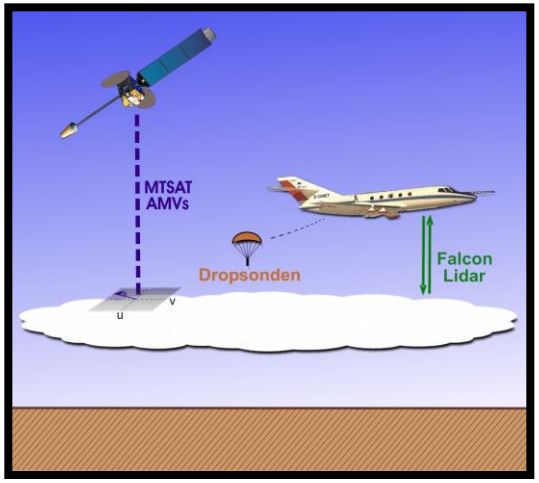
AMV height assignment issues and error correlations

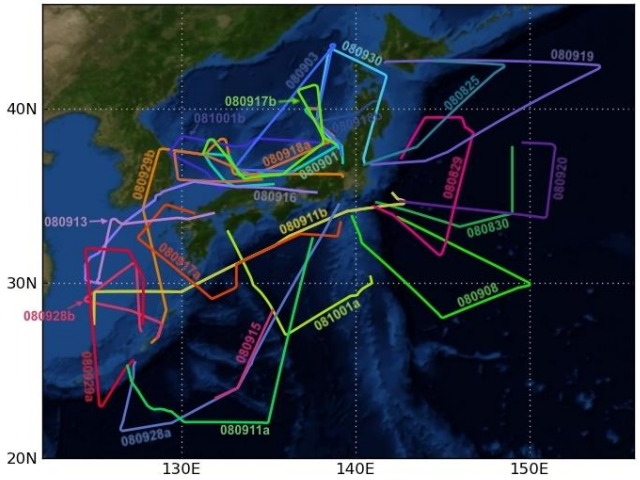
can lidar observations help?

→ independent data source
→ very accurate cloud-top height

First test: AMV height correction using airborne lidar observations during THORPEX Pacific Asian Regional Campaign (T-PARC) 2008

Relative error reduction: ~14%

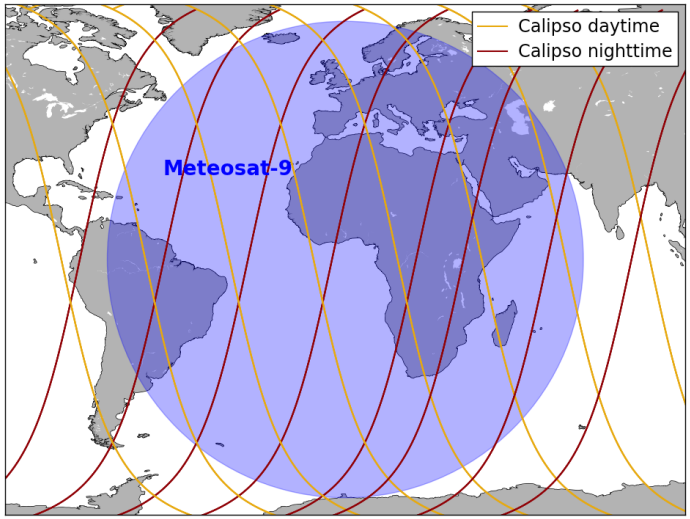




*Weissmann, M., K. Folger and H. Lange, 2013: Height correction of atmospheric motion vectors using airborne lidar observations. J. Appl. Meteor. Climatol., **52**, 1868–1877.*

AMV height correction with spaceborne lidar observations from the polar orbiting satellite CALIPSO

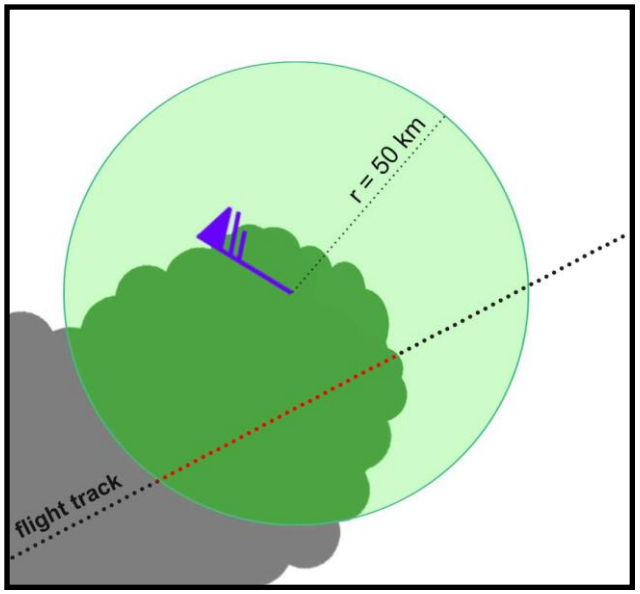
Verification with operational radiosondes



Folger, K., and M. Weissmann, 2014: Height correction of atmospheric motion vectors using satellite lidar observations from CALIPSO. J. Appl. Meteor. Climatol., accepted.

Approach

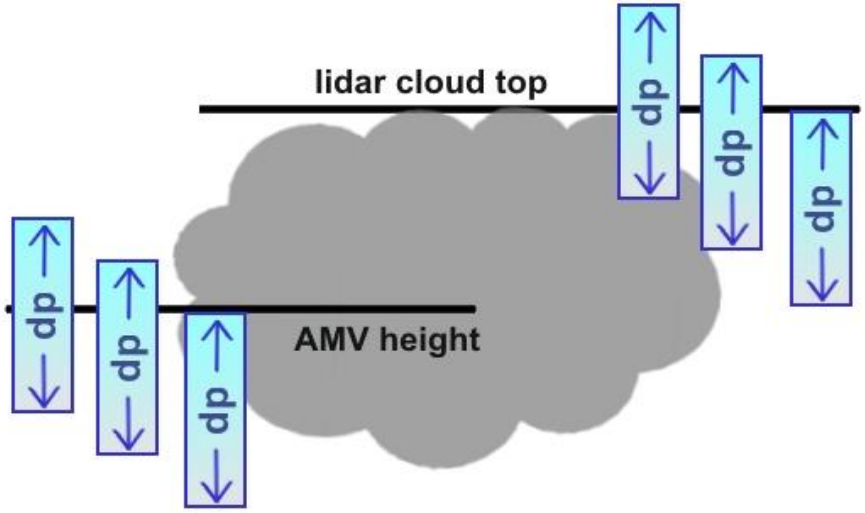
Collocation of AMV, lidar observation and radiosonde



Method

Wind layer *dp* of varying depth in three different positions

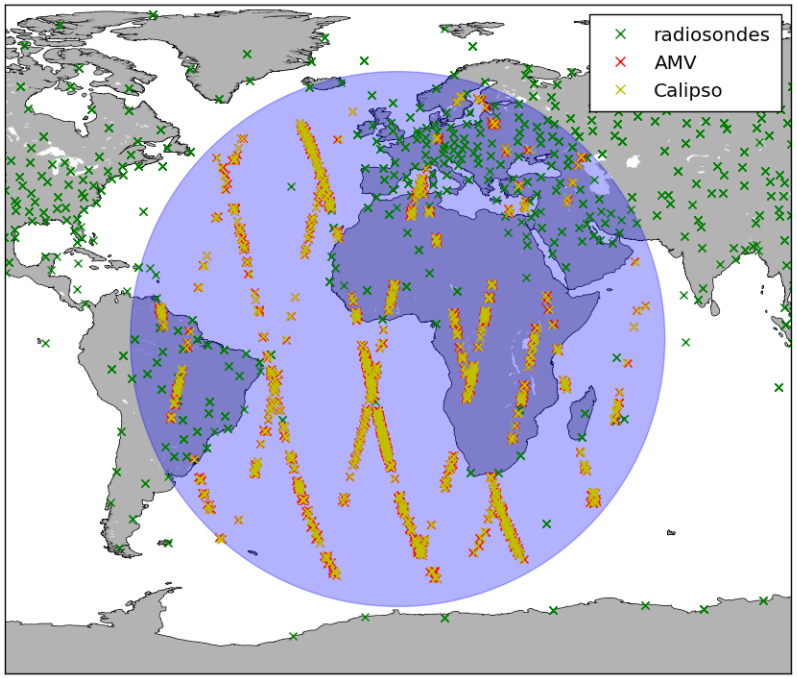
- relative to the original AMV height
- relative to lidar cloud top



AMV height correction using satellite lidar observations

AMVs from Meteosat-9 and Meteosat-10 (geostationary)
lidar cloud-top observations from CALIPSO (polar orbiting)

AMVs and Calipso lidar observations for 1 April 2012



~ 1200 matches

AMV height correction using satellite lidar observations

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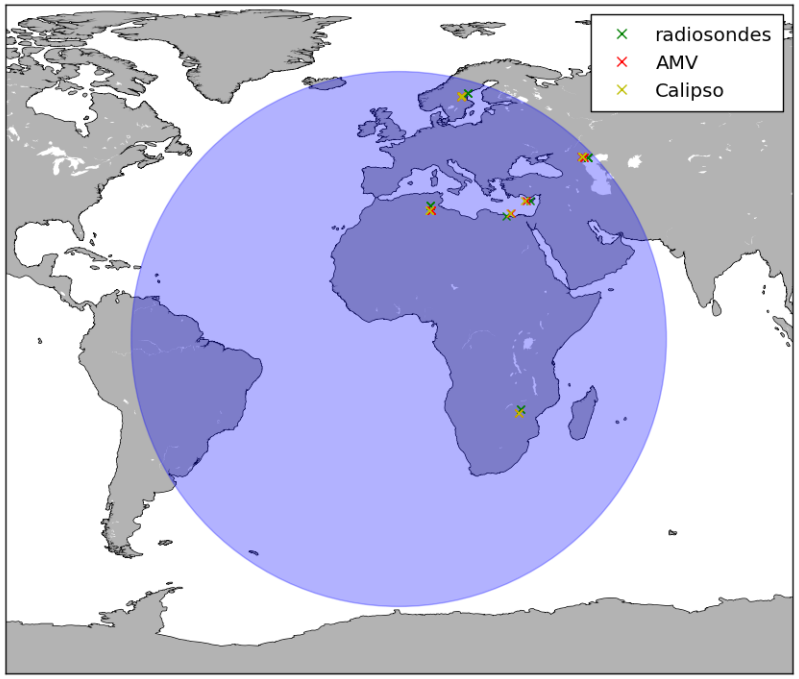
AMVs and Calipso lidar observations and radiosondes for 1 April 2012

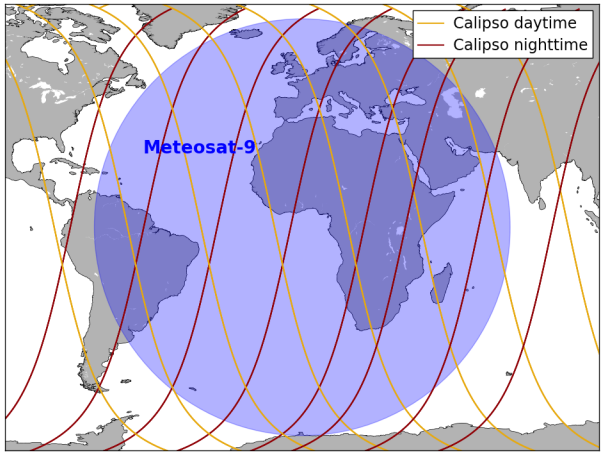


~ 15 matches

AMV height correction using satellite lidar observations

Dataset:

Hourly Meteosat AMVs (0° longitude) with collocated Calipso lidar observations and radiosondes



Time frame:

8 month period, 1 Apr. - 6 Oct. 2012
and 6 Apr. - 13 June 2013
→ 220 days

Collocation requirements:

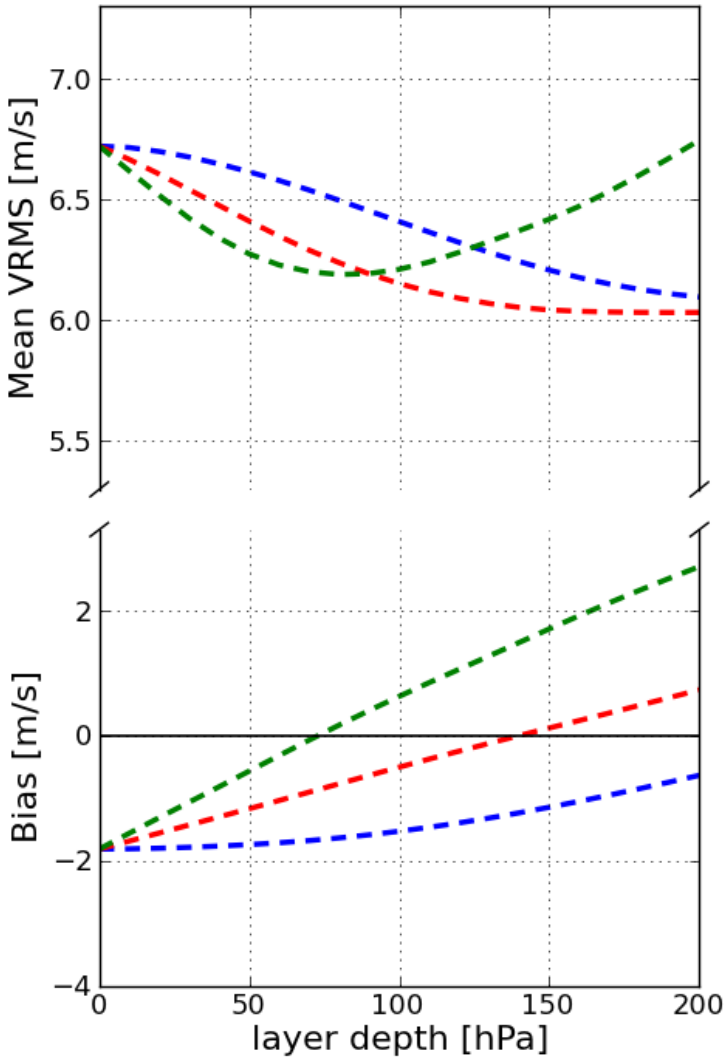
- for AMV – Calipso lidar observation: 50 km and 30 min
- for AMV – radiosonde: 150 km and 90 min

4478 matches
(1424 VIS, 1167 IR, 1887 WV cloudy)

Upper level AMVs **above 700 hPa** (WV and IR, 2835 matches)

dashed = layers assigned relative to the original AMV height

solid lines = layers assigned relative to the lidar cloud top height



- layer around corresponding height
- layer beneath corresponding height
- layer 25% above and 75% beneath corresponding height

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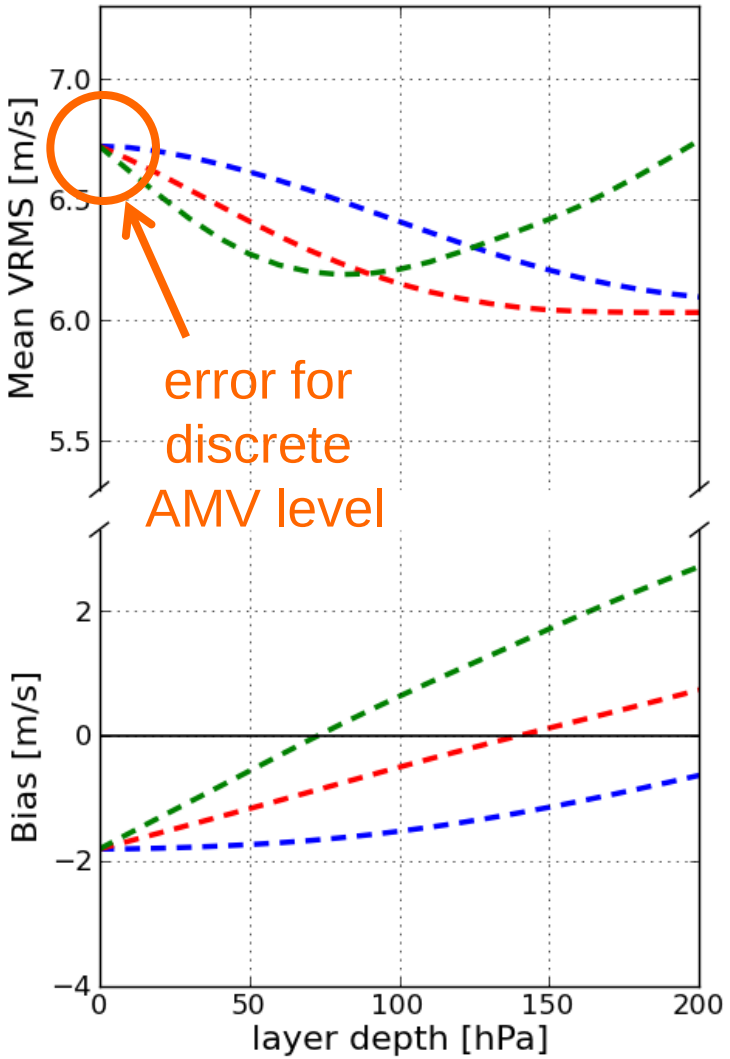

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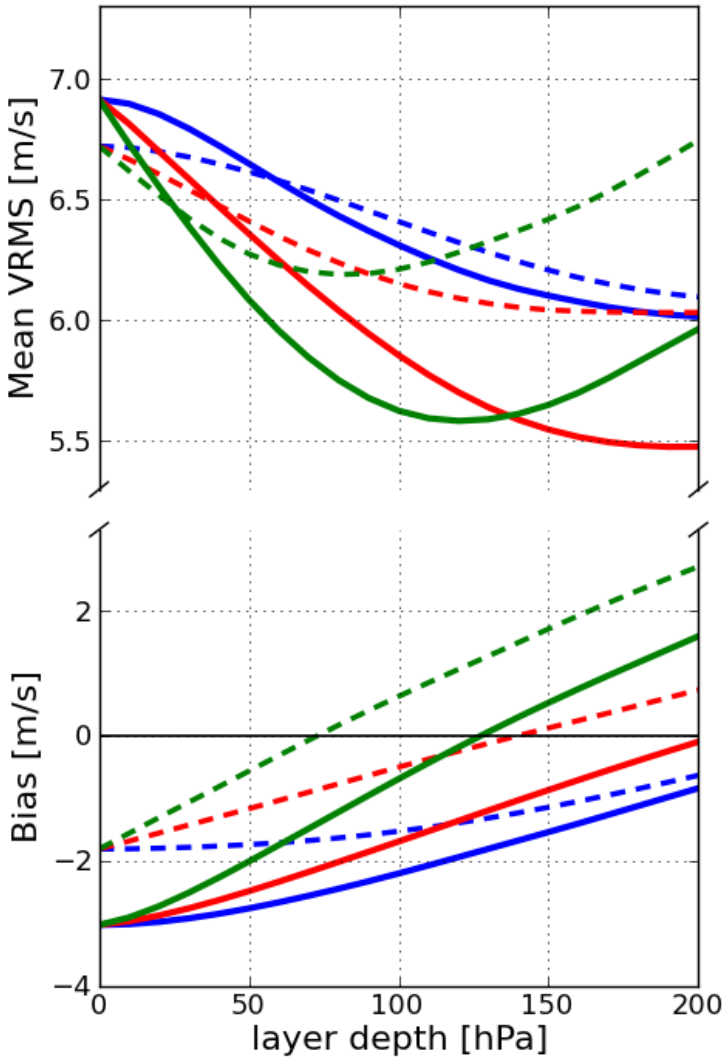
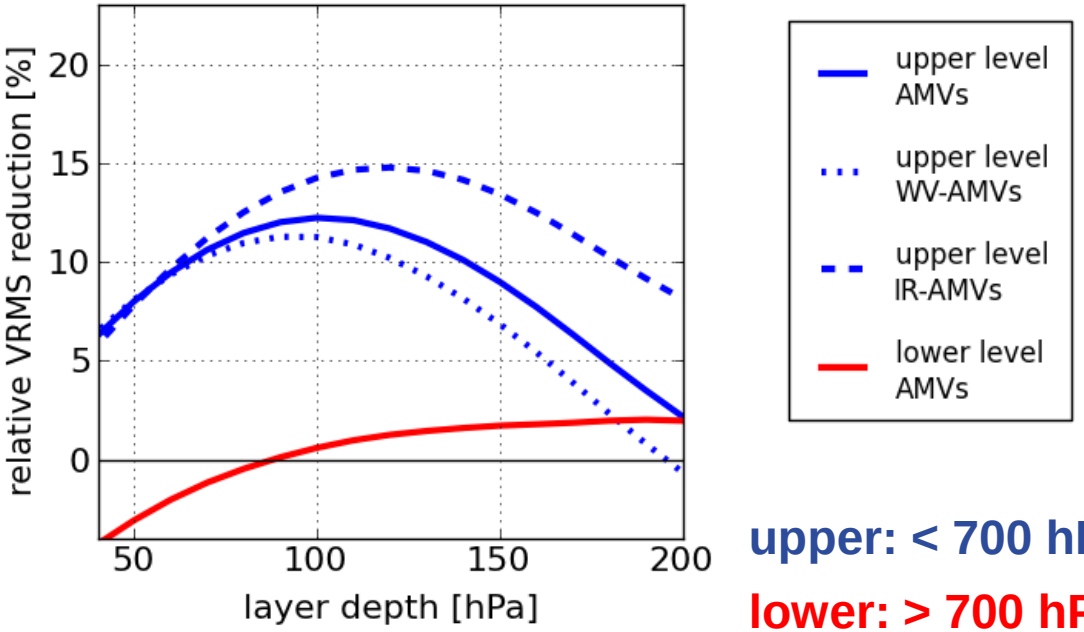


Wind error reduction for layers below the lidar cloud top relative to…

… **layers** of the same depth centered at the AMV height



upper: < 700 hPa

lower: > 700 hPa

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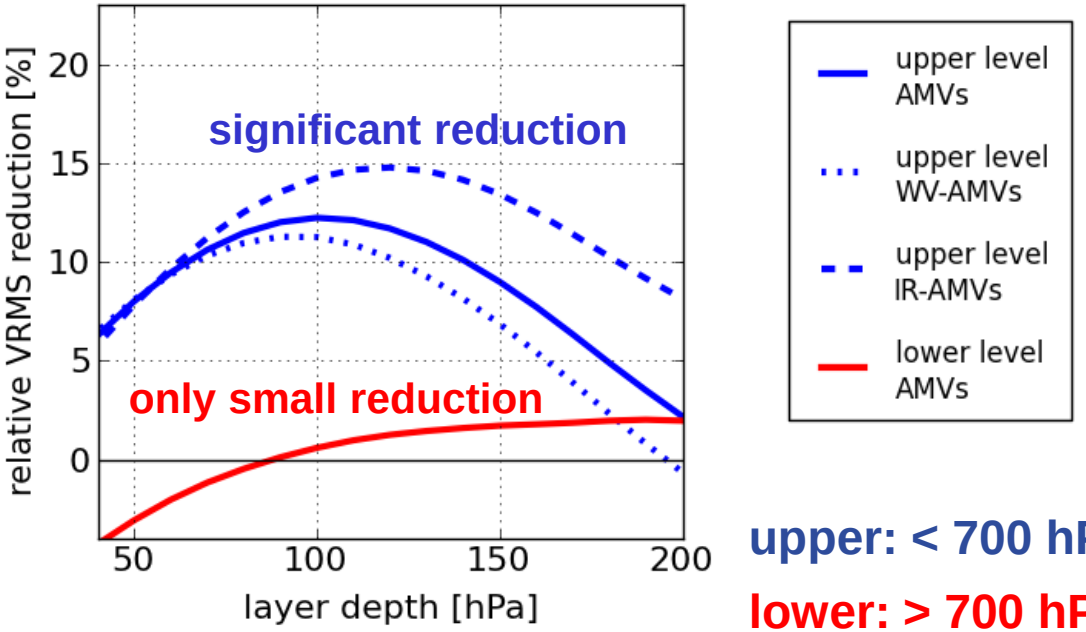

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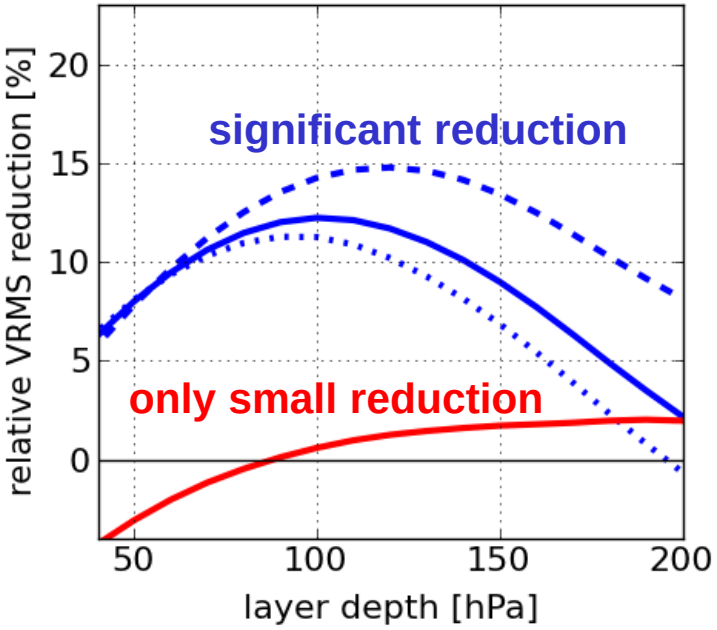
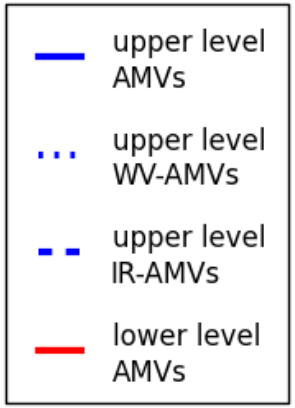
Wind error reduction for layers below the lidar cloud top relative to…

… **layers** of the same depth centered at the AMV height

… the discrete **level** of the AMV height





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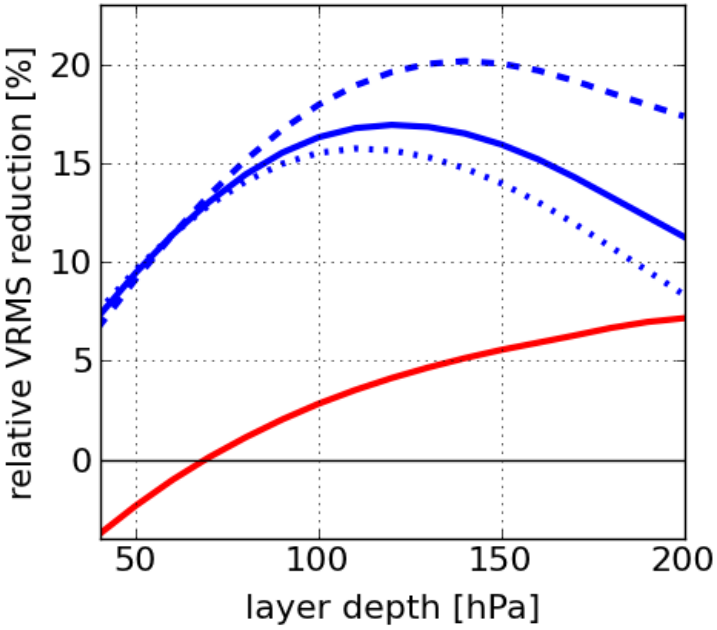
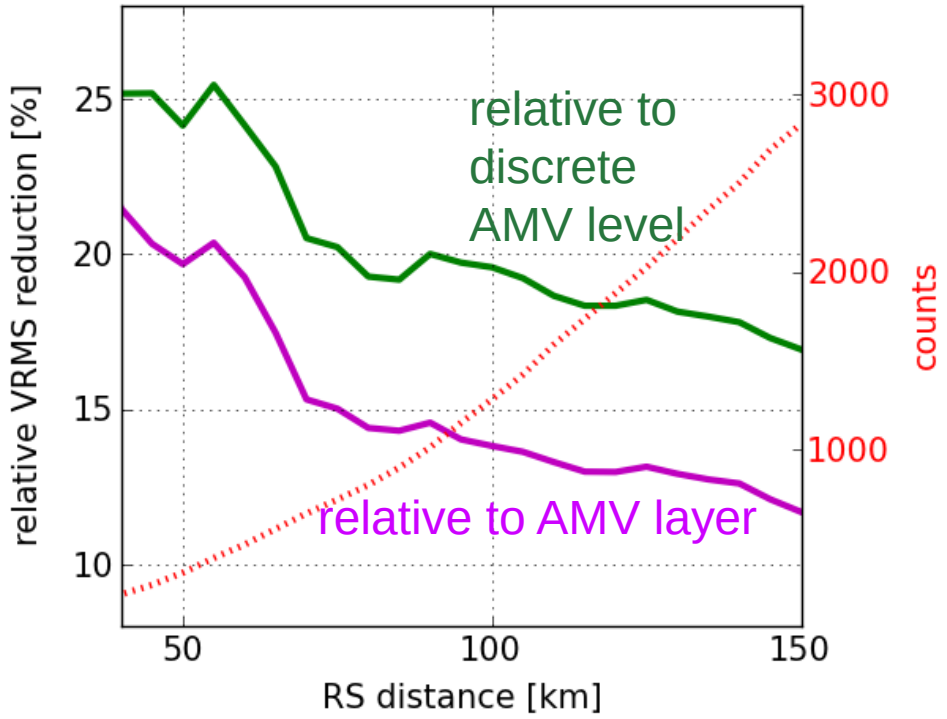


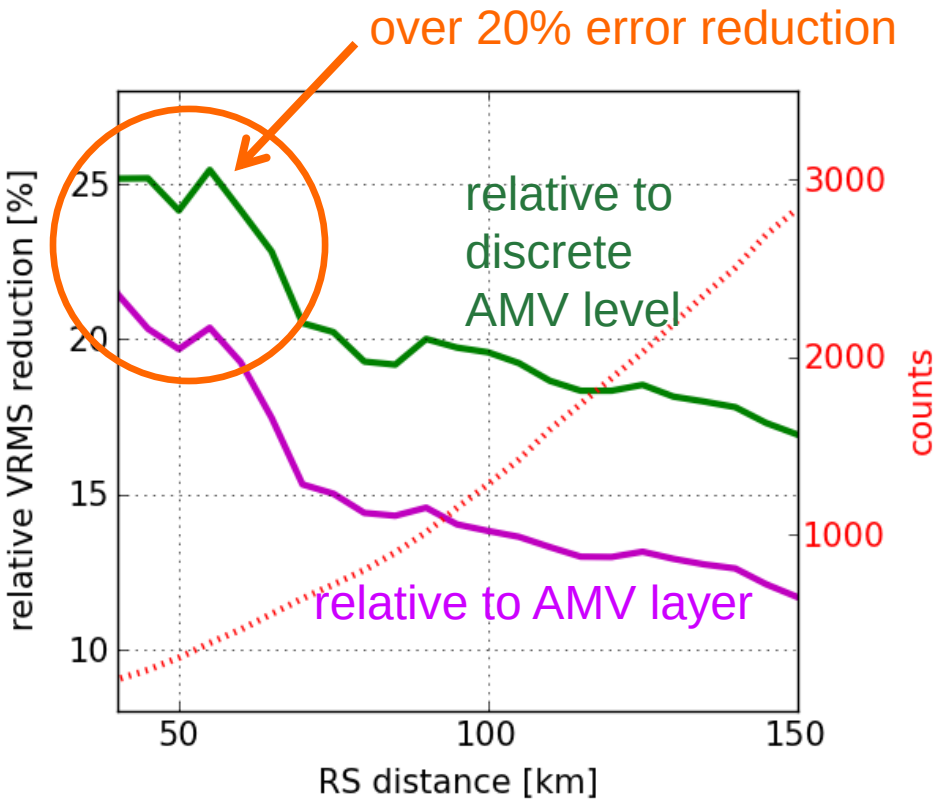
Wind error reduction for upper level AMVs as a function of horizontal distance to the verification radiosonde



temporal and spatial displacement of AMVs and radiosondes introduces additional error component

→ **underestimation of the relative error reduction** as radiosondes are not required for lidar height correction itself

Wind error reduction for upper level AMVs as a function of horizontal distance to the verification radiosonde



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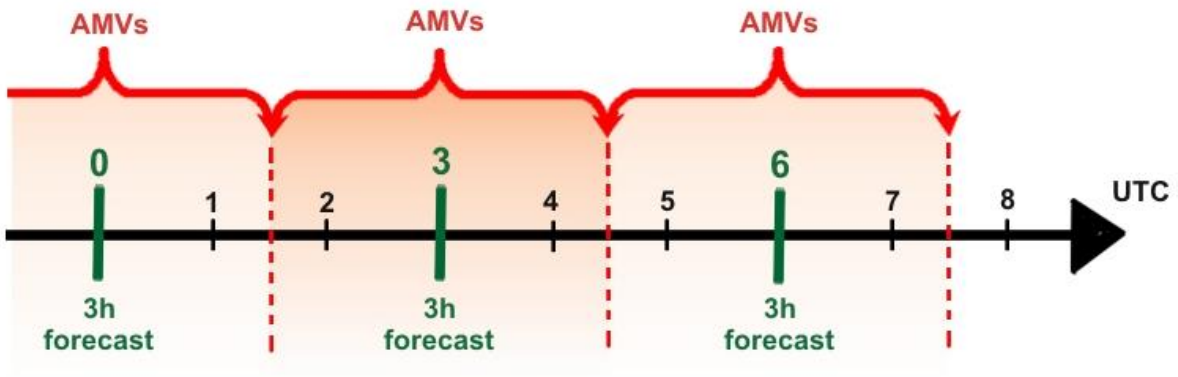
AMV height correction with spaceborne lidar observations from the polar orbiting satellite CALIPSO

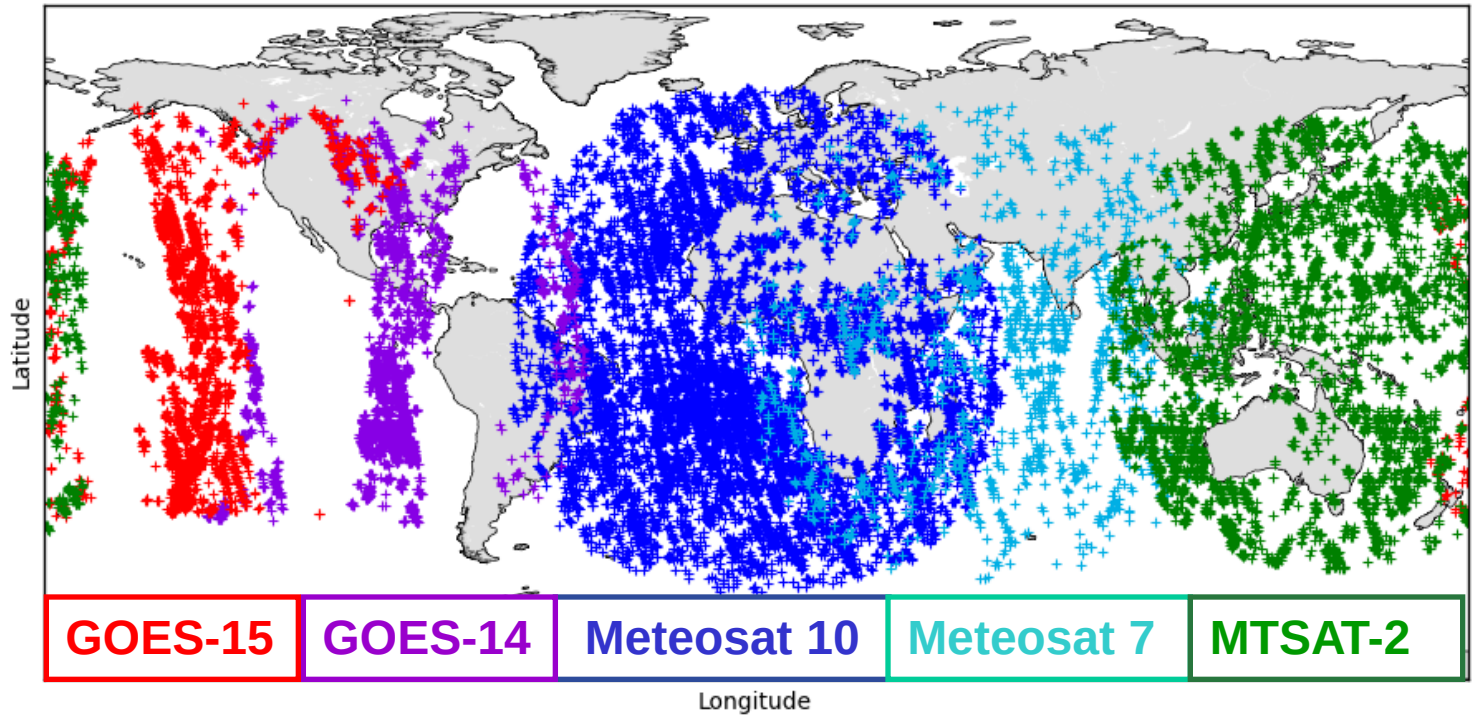
Wind verification with model equivalents from GME

Spatial interpolation of the 3h-forecast
Time difference at most +/-90 minutes



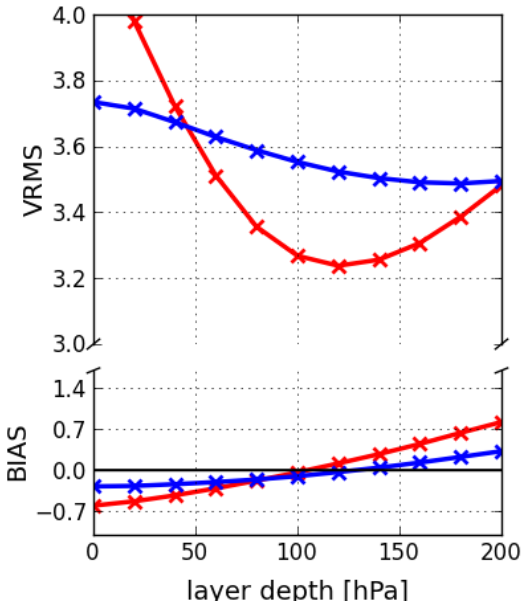
Wind verification with model equivalents from GME

Matches of collocated Calipso lidar observations and AMVs:
for a 10-day-period (1 June – 10 June 2013) for the main geostationary satellites



AMV wind error (VRMS) and wind speed bias
of a 10-day-period (1 June – 10 June 2013) for different satellites

Meteosat-10
(13190 matches)



GOES-15
(3916 matches)

MTSAT-2
(5039 matches)

layer below lidar cloud top

layer centered at operational AMV height

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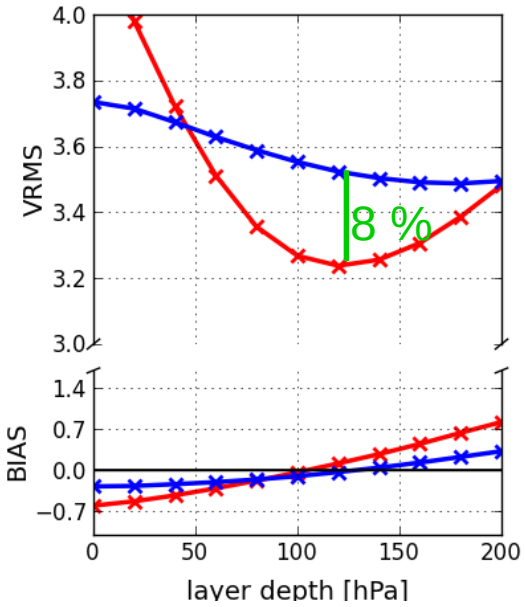

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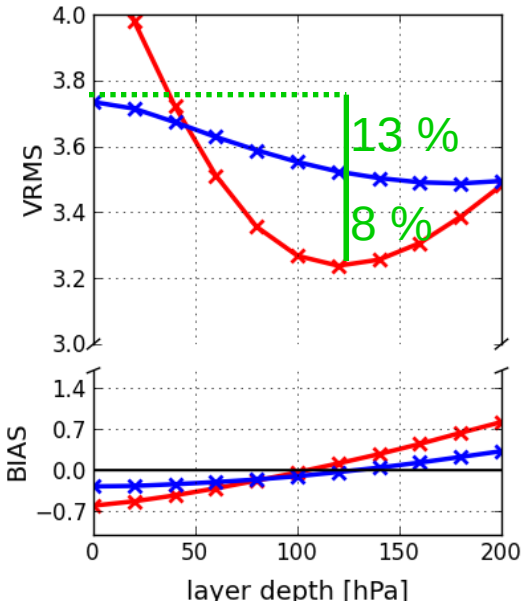

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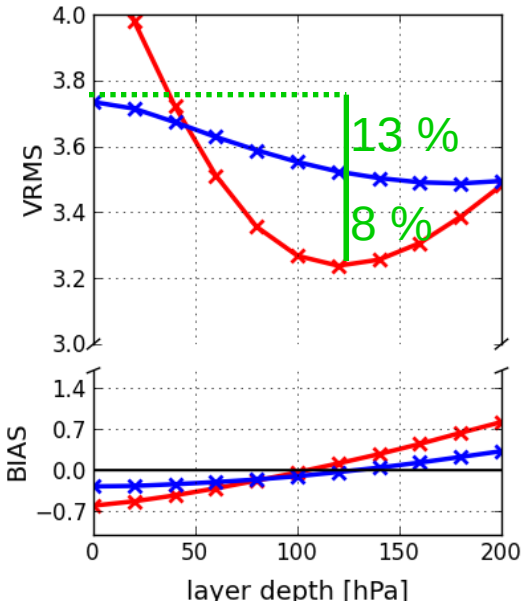

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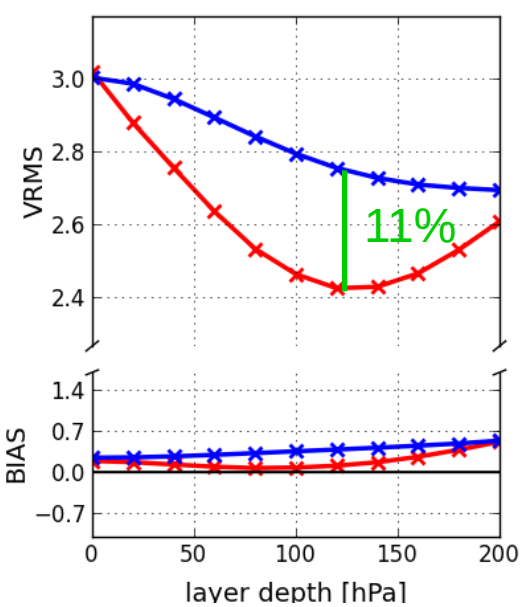

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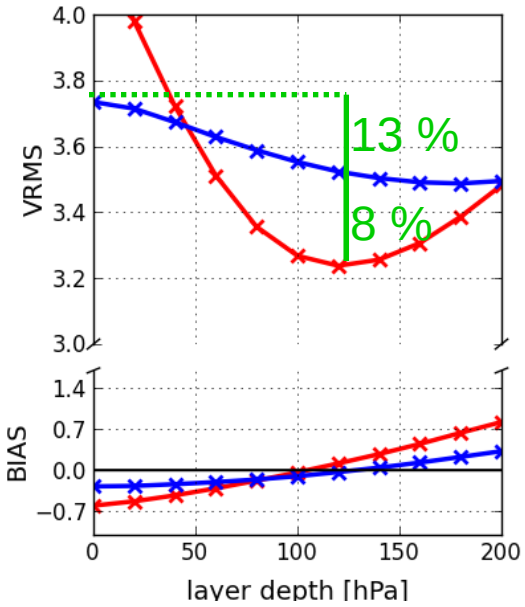

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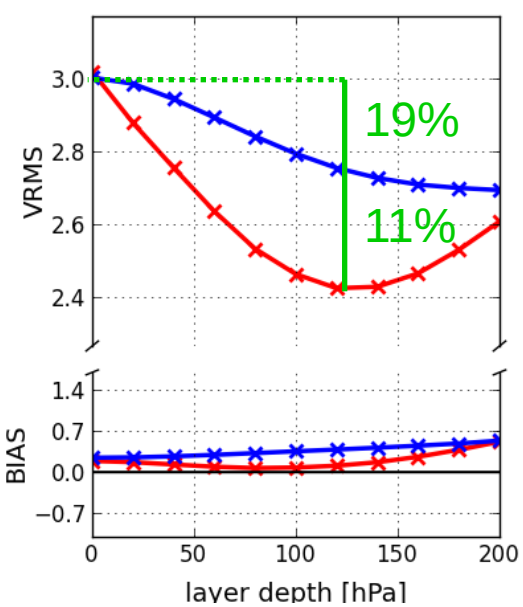

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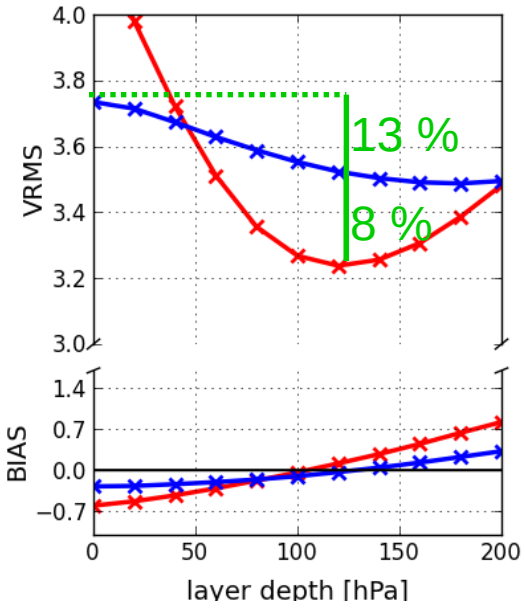

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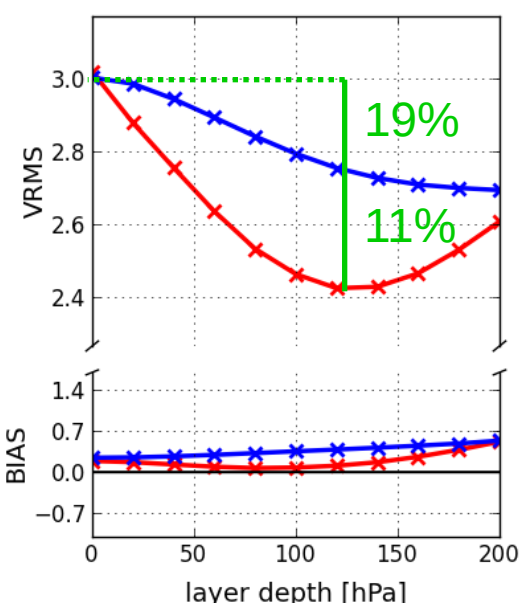

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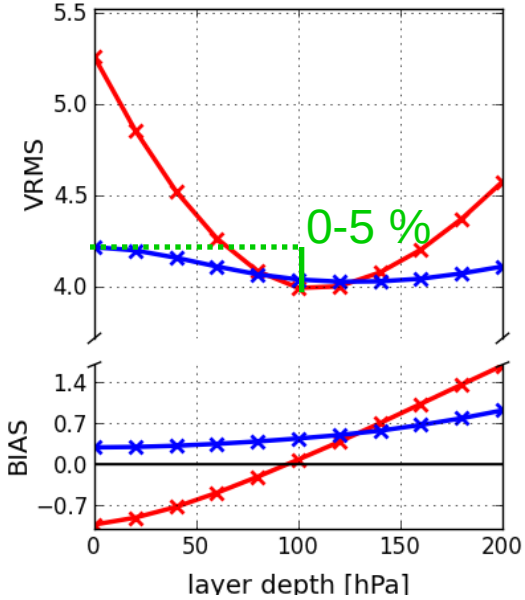

layer below lidar cloud top

layer centered at operational AMV height

Summary and conclusion

AMV height correction developed using airborne lidar observations

Wind error reduction with CALIPSO height correction for AMVs:

- **Radiosonde verification for Meteosat-10-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
- **Model verification for different geostationary satellites**
  - Meteosat : 8 - 13 %
  - GOES: 11 - 19 %
  - MTSAT-2: 0 - 5 %

Summary and conclusion

- Lidar observations (as an independent data source) are expected to **reduce error correlations**
- NWP may benefit from **assimilating** lidar-corrected AMVs and treating them as layer-averaged winds in the future
- CALIPSO observations may be useful to **validate AMV processing algorithms** and to derive **bias correction functions**