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

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Atmospheric Motion Vectors (AMVs) in data assimilation systems

- Excellent wind field coverage (almost global)
- Only available wind information in many regions (oceans, SH)
- Height assignment issues and error correlations require strong thinning of available AMVs in data assimilation

AMV coverage in 24h
AMV height assignment issues → can lidar observations help?

Lidar provides accurate cloud top height information

Collocation of AMV, lidar observation and dropsonde/radiosonde

Method

Wind layer $dp$ of varying depth in three different positions
- relative to lidar cloud top
- relative to the original AMV height

Studies indicate that AMVs represent wind in layer within cloud rather than at cloud top
AMV height correction using airborne lidar observations during THORPEX Pacific Asian Regional Campaign (T-PARC) 2008

- airborne lidar observations on 24 DLR Falcon flights
- over 300 dropsondes for verification
- MTSAT-AMVs provided by CIMSS

Collocation requirements:
AMV – Falcon lidar: 100 km, 60 min
AMV – dropsonde: 100 km, 60 min
AMV height correction using airborne lidar observations during T-PARC/TC08

Rel. AMV error reduction when 100 hPa layer beneath lidar cloud is assigned instead of layer centered at original AMV height

significance:
- 95%-level
- 99%-level

Weissmann, M., K. Folger and H. Lange: Height correction of atmospheric motion vectors using airborne lidar observations. JAMC 2013
AMV height correction using satellite lidar observations

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

Collocated AMVs and CALIPSO observations for 1 April 2012

~ 1200 matches
AMV height correction using satellite lidar observations

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

Collocated AMVs and CALIPSO 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)

Wind difference of AMVs and radiosondes for:
- assigning layers relative to AMV height (dashed)
- assigning layers relative to lidar cloud top (solid)

- error for lidar layers
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

Significant reduction

Only small reduction

Upper: < 700 hPa
Lower: > 700 hPa
Wind error reduction for upper level AMVs as a function of horizontal distance to the verification radiosonde

- Over 20% error reduction
- Relative to discrete level
- Relative to AMV layer
- RS distance [km]
- Temporal and spatial displacement of AMV and verification radiosonde introduces additional error component that is independent of AMV error itself
- Underestimation of the actual relative error reduction as radiosondes are not required for lidar height correction

(all AMVs above 700 hPa)
AMV height correction developed using airborne lidar observations

Wind error reduction with CALIPSO height correction for AMVs
- compared to single level value at AMV height: ~17%
- compared to layer centered at original AMV height: ~12%
- indication of larger reduction (>20%) with stricter verification criterion

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

CALIPSO observations may be useful to derive bias correction functions
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