Environment and Climate Change Canada
Environnement et Changement climatique Canada

Estimation of AMV Height Assignment Errors using Model Best-Fit Pressure and Aeolus Height Data

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Motivation

- Estimation of AMV assigned height errors are used in the calculation of total AMV observation errors proposed by Forsythe and Saunder. This method has been implemented in the ECCC data assimilation systems

- Traditionally, these estimations are obtained from differences between AMV`s assigned height and model wind-vector best-fit height for each satellite and AMV type

- This approach works reasonably well. However, it would be preferable to use an independent source of observations that provide both wind and cloud information

- The main goal of this study is to examine the feasibility of using collocated Aeolus Mie-cloudy observations and AMVs to estimate AMV height errors. For this purpose, we examined the height difference between Aeolus and IR AMVs over the oceans for the Himawari-8, GOES-16/17 and Meteosat-8/11

Model Best-Fit Pressure for Estimating σ_p

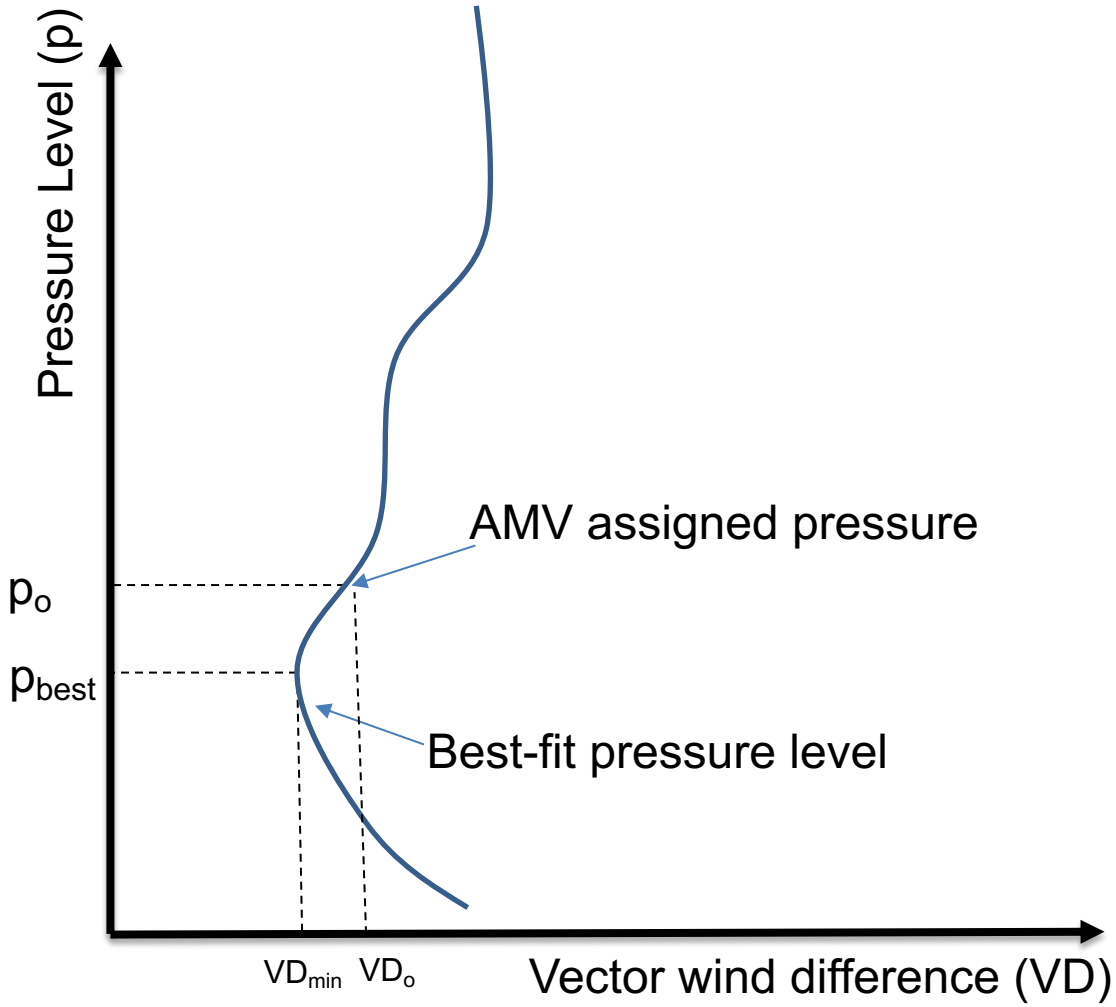
- The model best-fit pressure is where the vector wind difference (VD) between the AMV and model wind is minimum (VD_{min})

The model best-fit pressure is valid if :

1. $VD_{min} < 4$ m/s
2. $VD_{min} < (VD - 2$ m/s) for $|p - p_{best}| > 100$ hPa

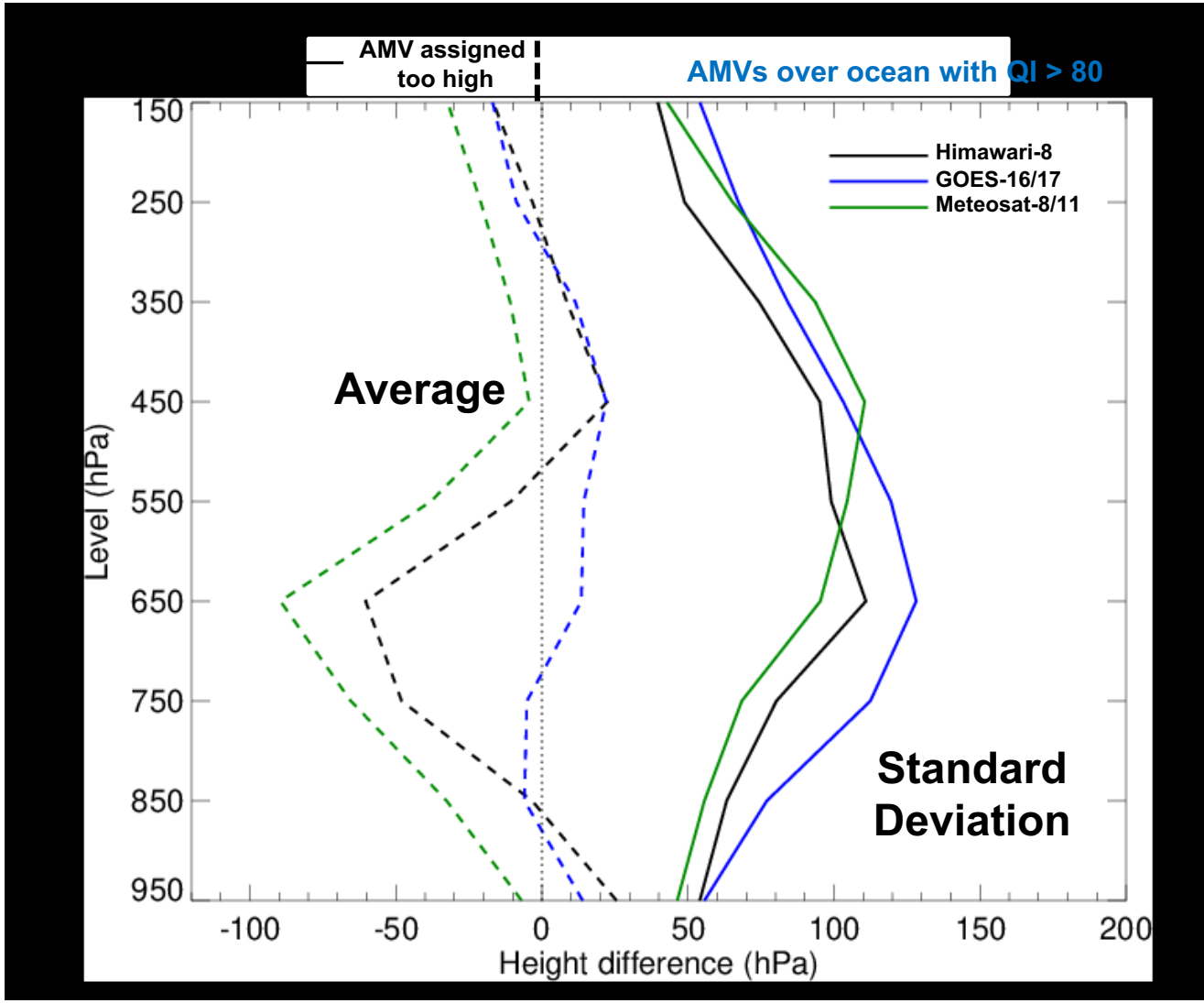
In case of multiple minima, the minimum closest to the originally assigned pressure (p_o) is chosen.

- The estimation of the AMV height error is made by using the difference between the AMV assigned and model best-fit pressures



Height Error Estimations from Model Best-Fit Approach for IR AMVs

- Average and Standard Deviation of differences between assigned and model best-fit pressures for **July-August 2019**
- AMV heights are generally assigned too high in the low to mid levels for Himawari and Meteosat AMVs
- Slightly larger standard deviations in the low and mid levels for GOES AMV products



Height Error Estimations from Collocated IR AMVs and Aeolus Mie-Cloudy winds

- The Aeolus mission provides Mie-Cloudy winds near the cloud tops and underneath
- These observations are suitable for comparisons with AMVs. The height differences between collocated Aeolus winds and AMVs can be used to evaluate the height errors
- To do this, we matched each Aeolus wind over the oceans with the closest AMV among those that respect the following criteria:
  - **QI > 80**
  - time difference is less than **1 hour**;
  - distance between the observations is within **100 km**;
  - height difference is less than **300 hPa**;
  - model best-fit pressure is well defined;
- About 60% of the Mie-cloudy winds are matched with AMVs using these criteria

Sampling Difference and Representation Issues

The nature of Aeolus winds and AMVs is quite different:

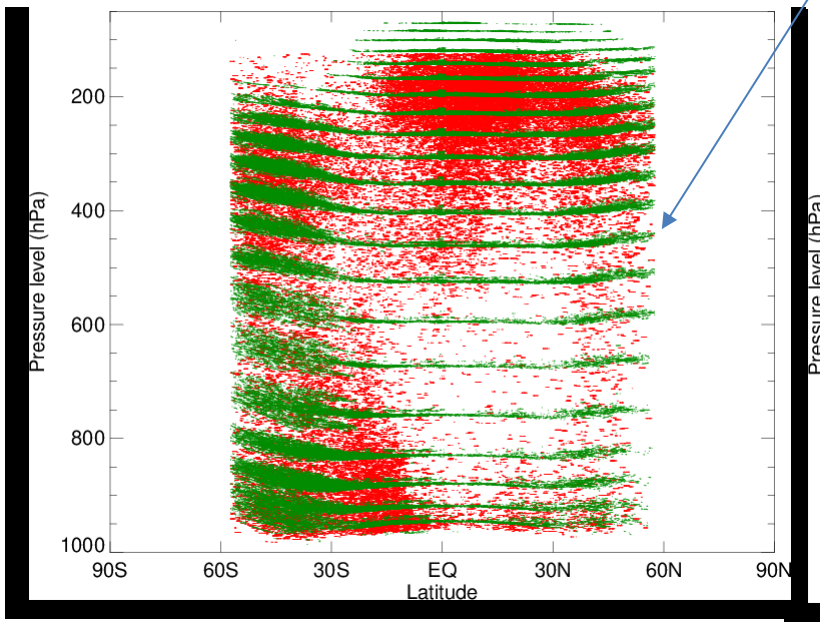
- For the Mie-Cloudy winds: the horizontal integration length along the satellite track is of the order of 10 km, the vertical integration length varies from 0.25 to 1.0 km and the measurements are quasi instantaneous
- IR AMVs are more representative of a cloud layer with horizontal and time resolutions of the order of 50 km and 20 minutes
- Cloud detection are very different: Mie-cloudy winds can be measured above AMVs. Also, Mie-cloudy winds can be observed in clouds, depending on the optical depth
- AMVs and Aeolus height errors as well as collocation errors will contribute to the height difference statistics. As a result, the standard deviation of collocated height differences is expected to be larger than the standard deviation of the AMV height error

Total Collocated IR AMVs and Aeolus data for July-August 2019

Aeolus data available on prescribed altitudes

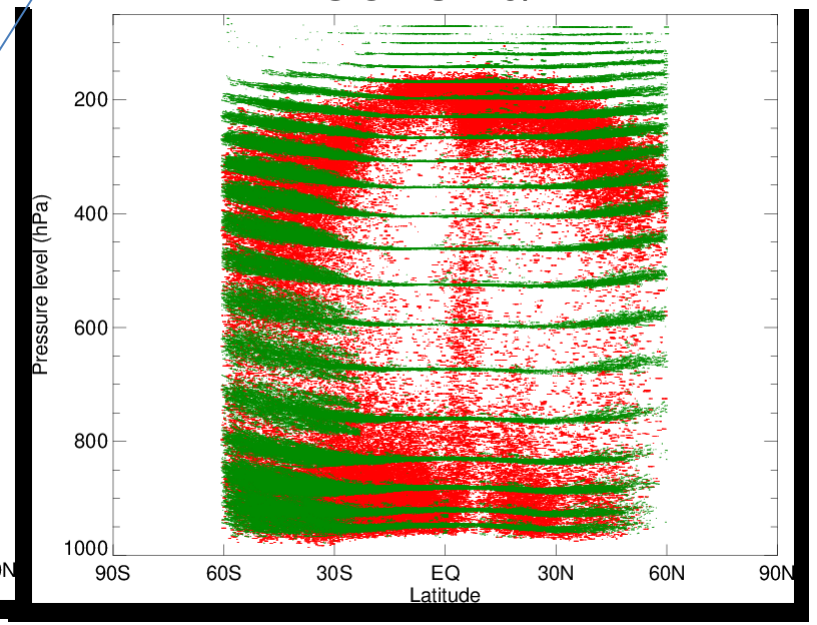
Aeolus
AMV

Himawari-8



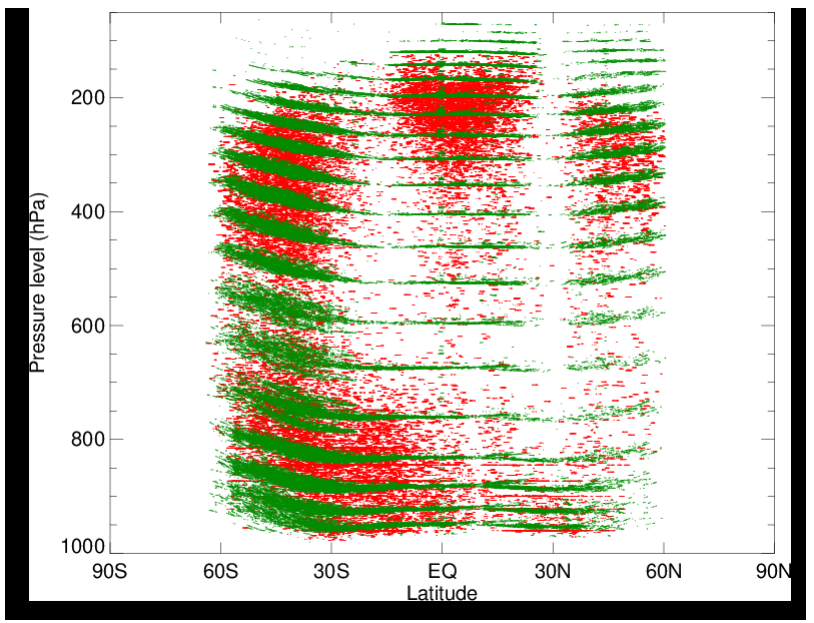
Number of observation pairs : 431 088

GOES-16/17



Number of observation pairs : 741 286

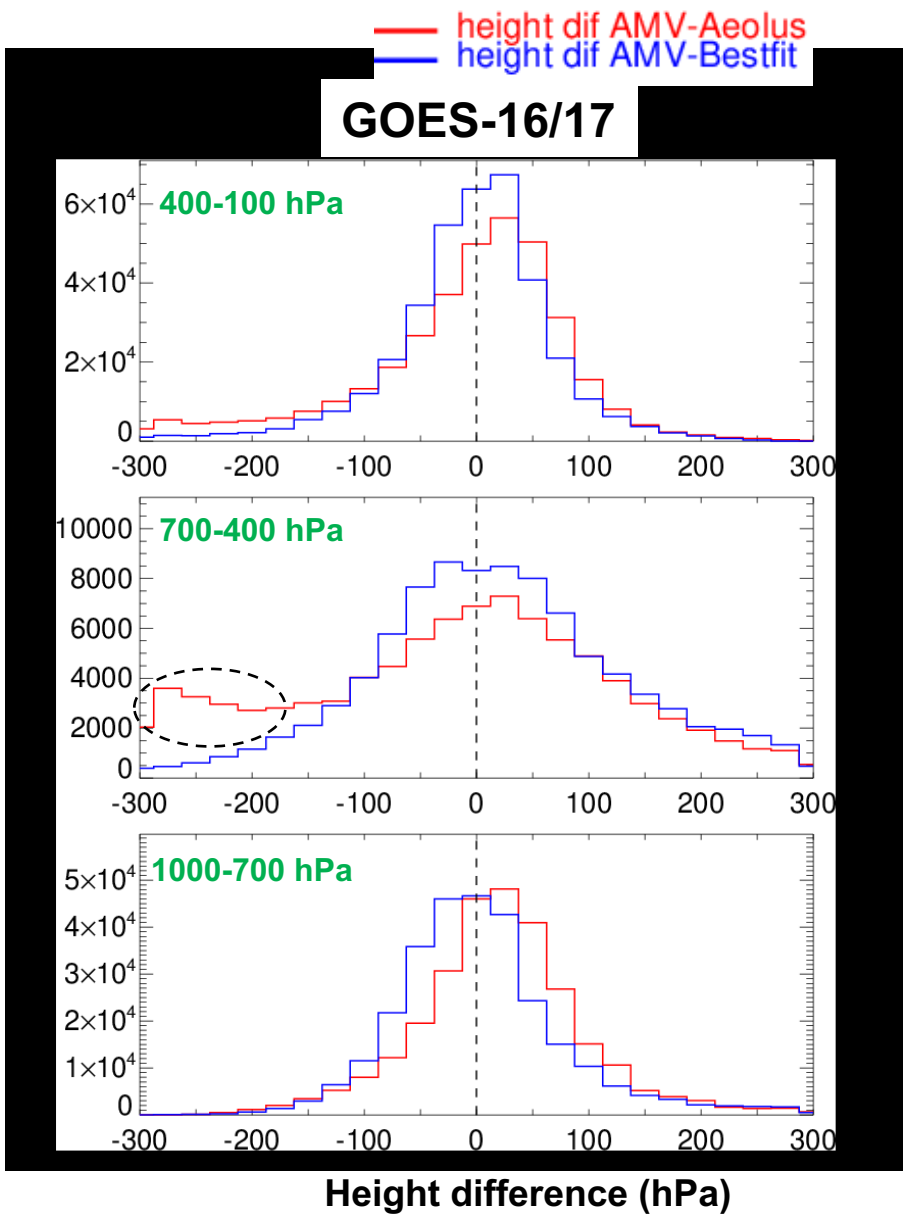
Meteosat-8/11



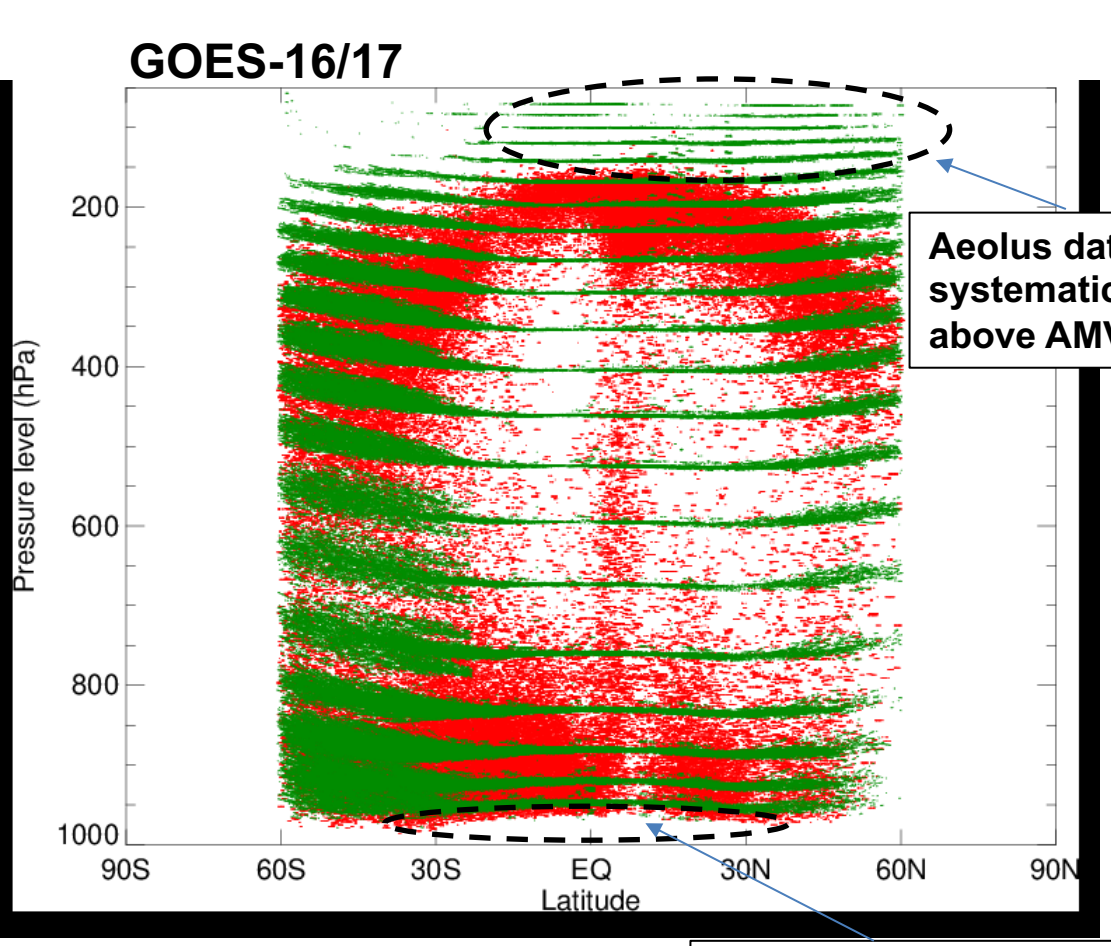
Number of observations pairs : 306 160

Height Difference Histograms for GOES

- Height difference histograms for GOES in the low, mid and high levels. AMV - Aeolus pressures are in red and AMV - model best-fit pressures are in blue
- The height difference distributions from AMV - Aeolus data are in good agreement with those from AMV - model best-fit pressures
- The histograms of AMV - Aeolus are shifted towards positive values in the low and high levels
- The number of counts for AMV - Aeolus between -300 and -200 hPa remains large in the mid levels

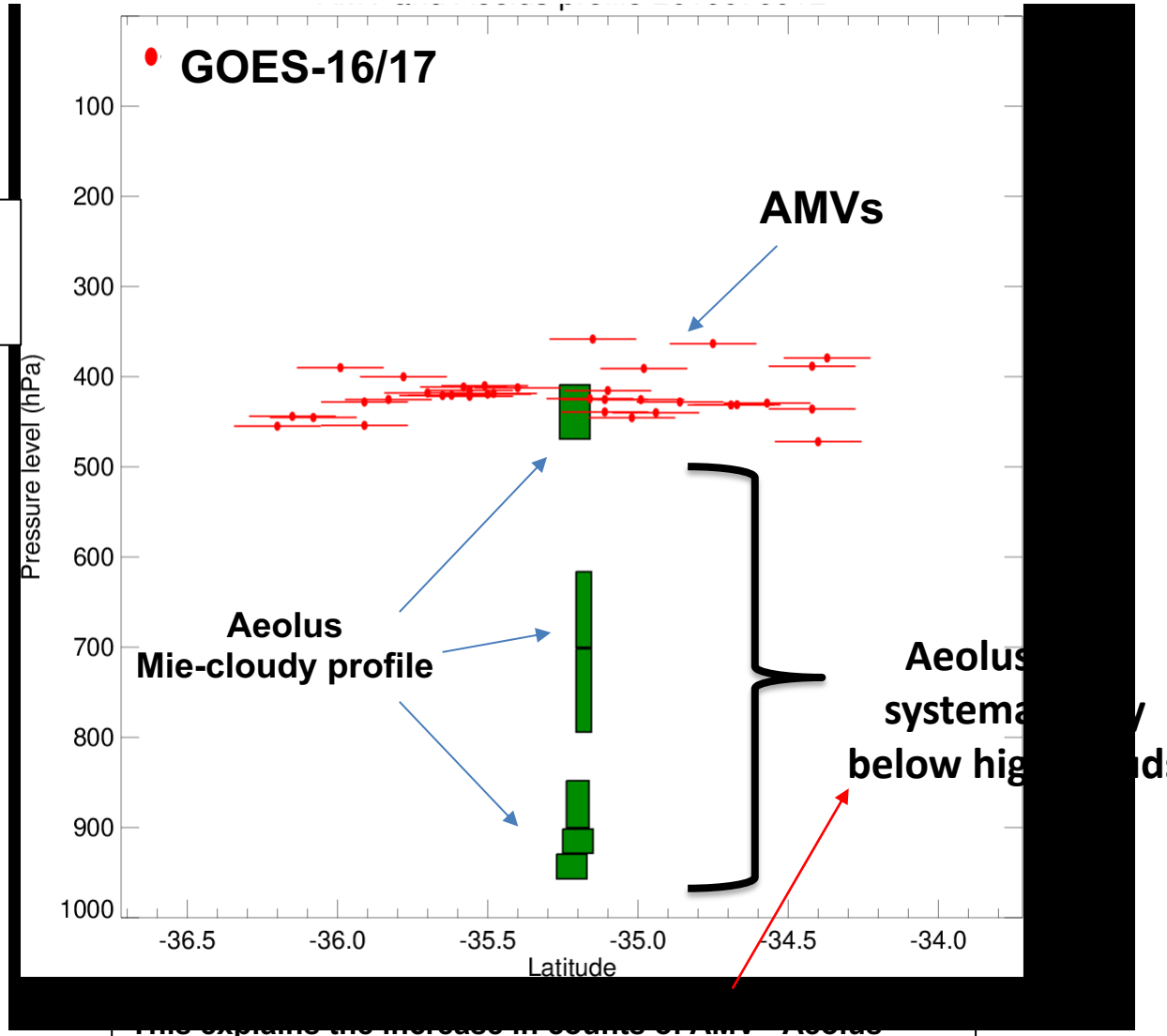


Systematic Sources of Error in Collocating AMV – Aeolus data



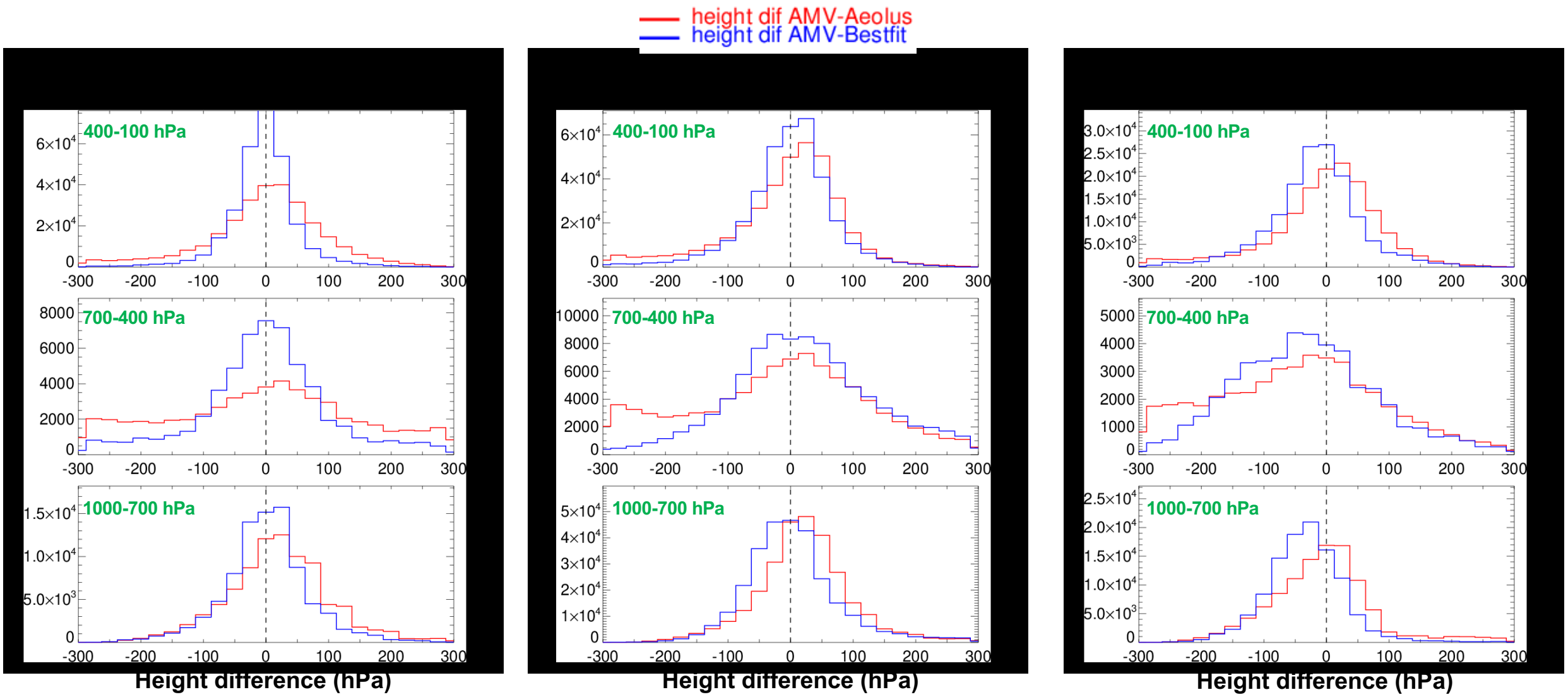
Aeolus data systematically above AMVs

AMVs systematically below the Aeolus lowest vertical bin



between -300 and -200 hPa in the mid level

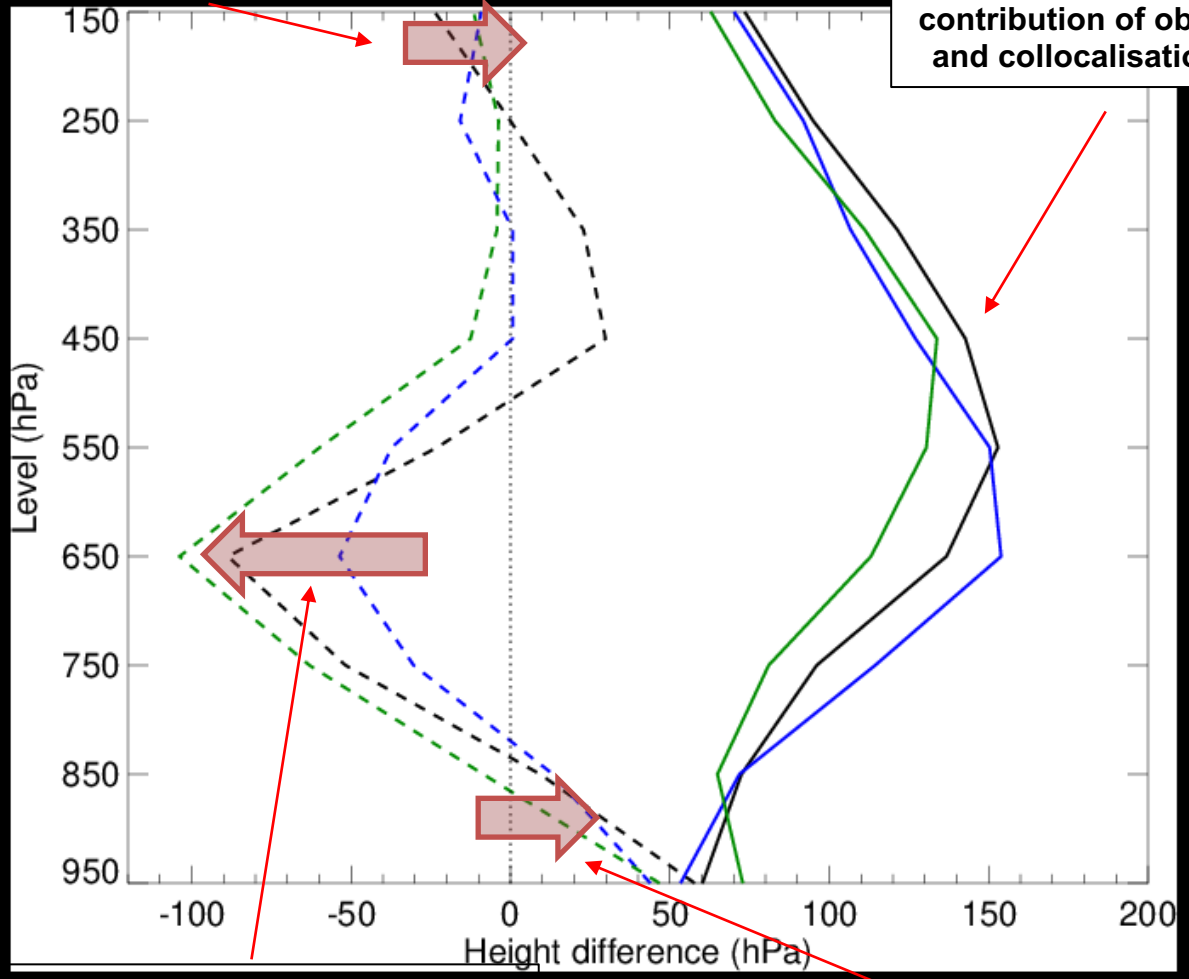
Height Difference Histograms for Himawari, GOES and Meteosat

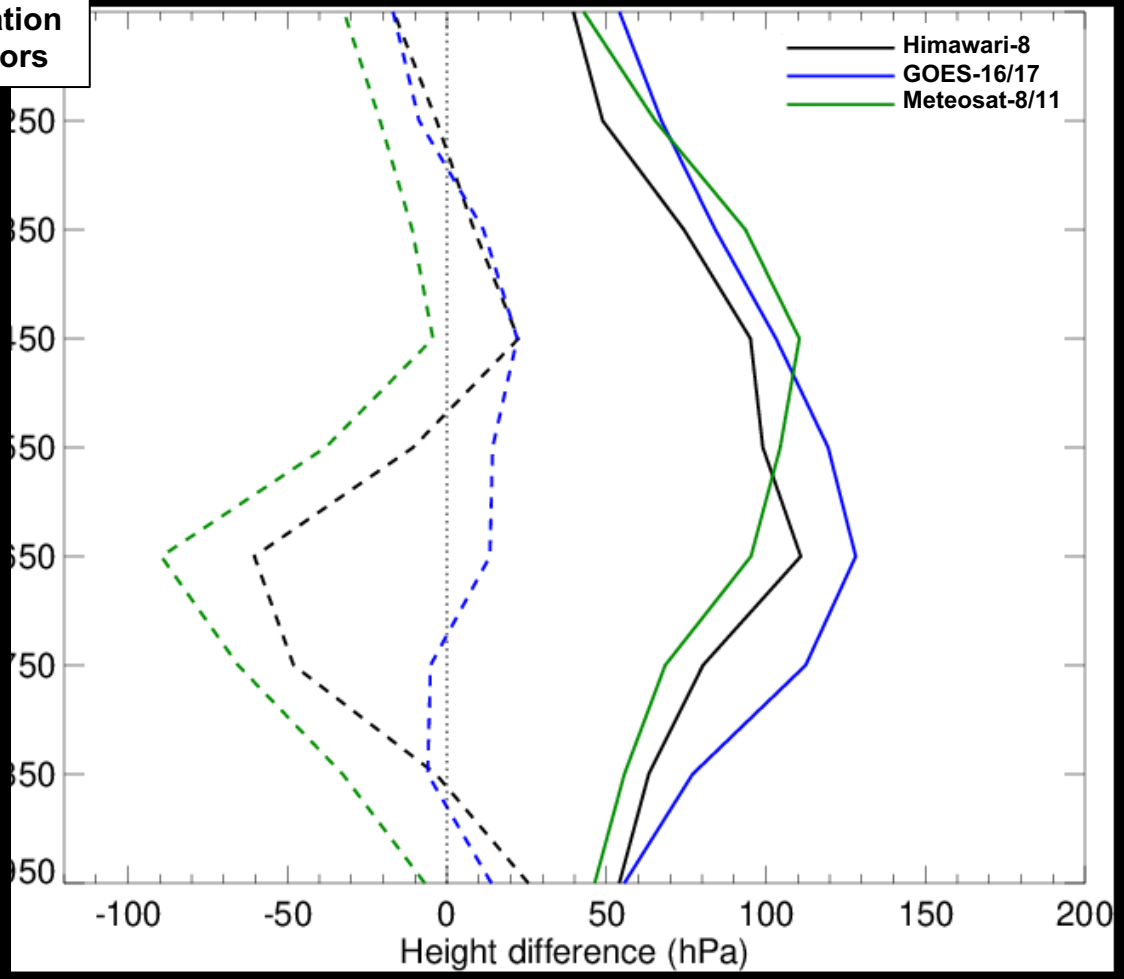


Height Error Estimations from AMV-Aeolus Collocations and Model Best-Fit Pressure

Due to Aeolus data available above AMVs

Larger STD due to contribution of observation and collocalisation errors



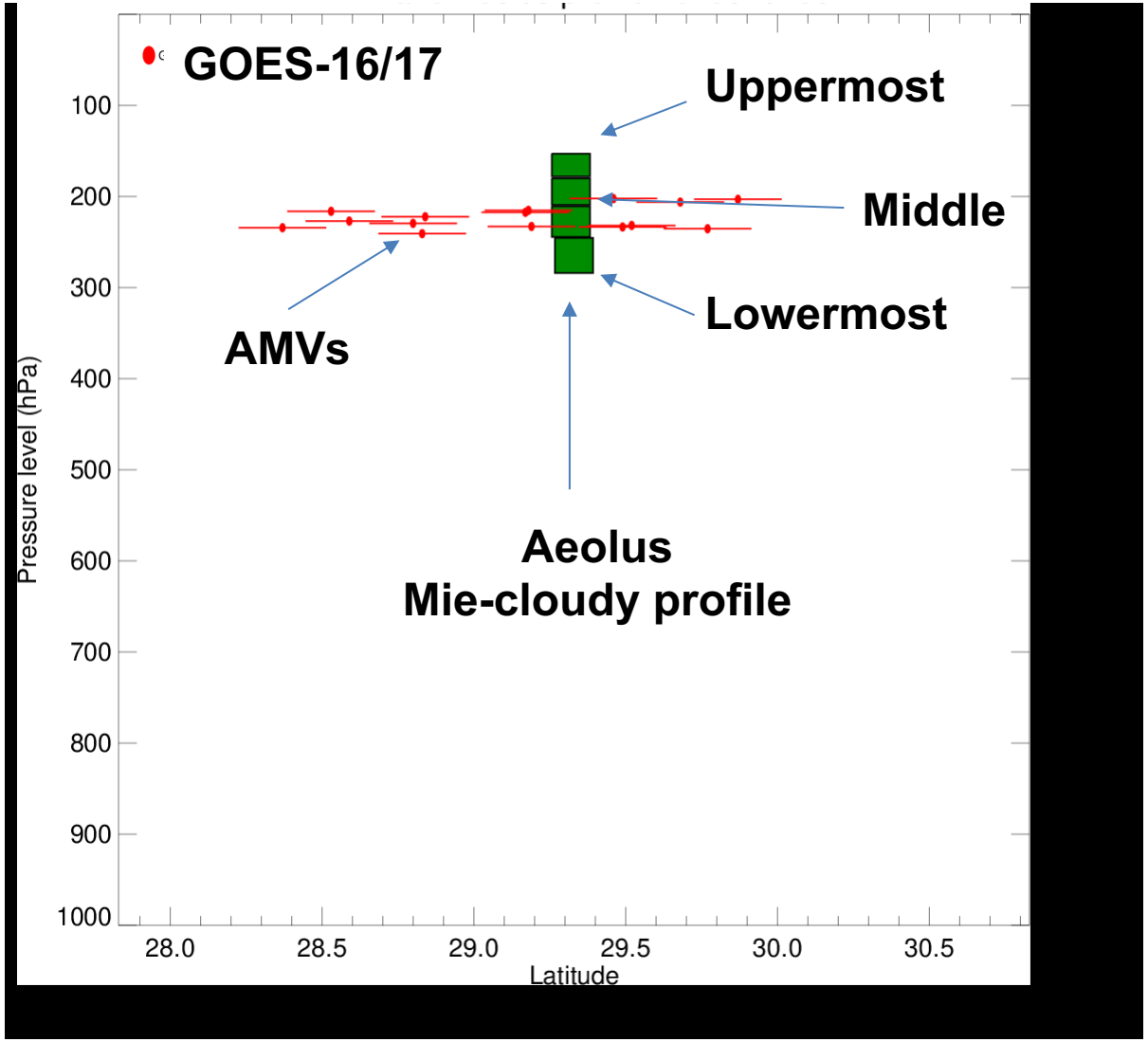


Due to Aeolus data located below high level clouds

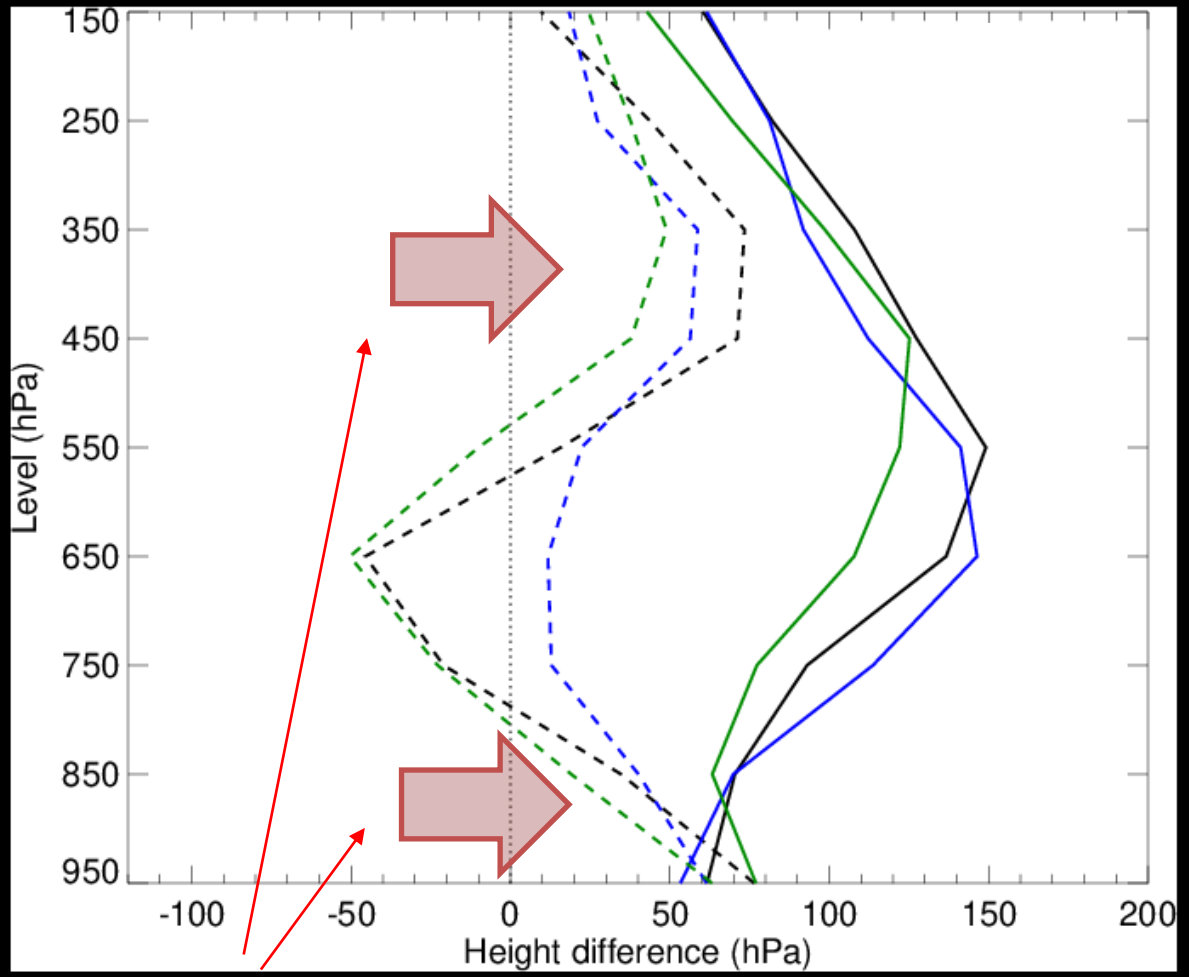
Due to AMVs located below the Aeolus lowest vertical bin

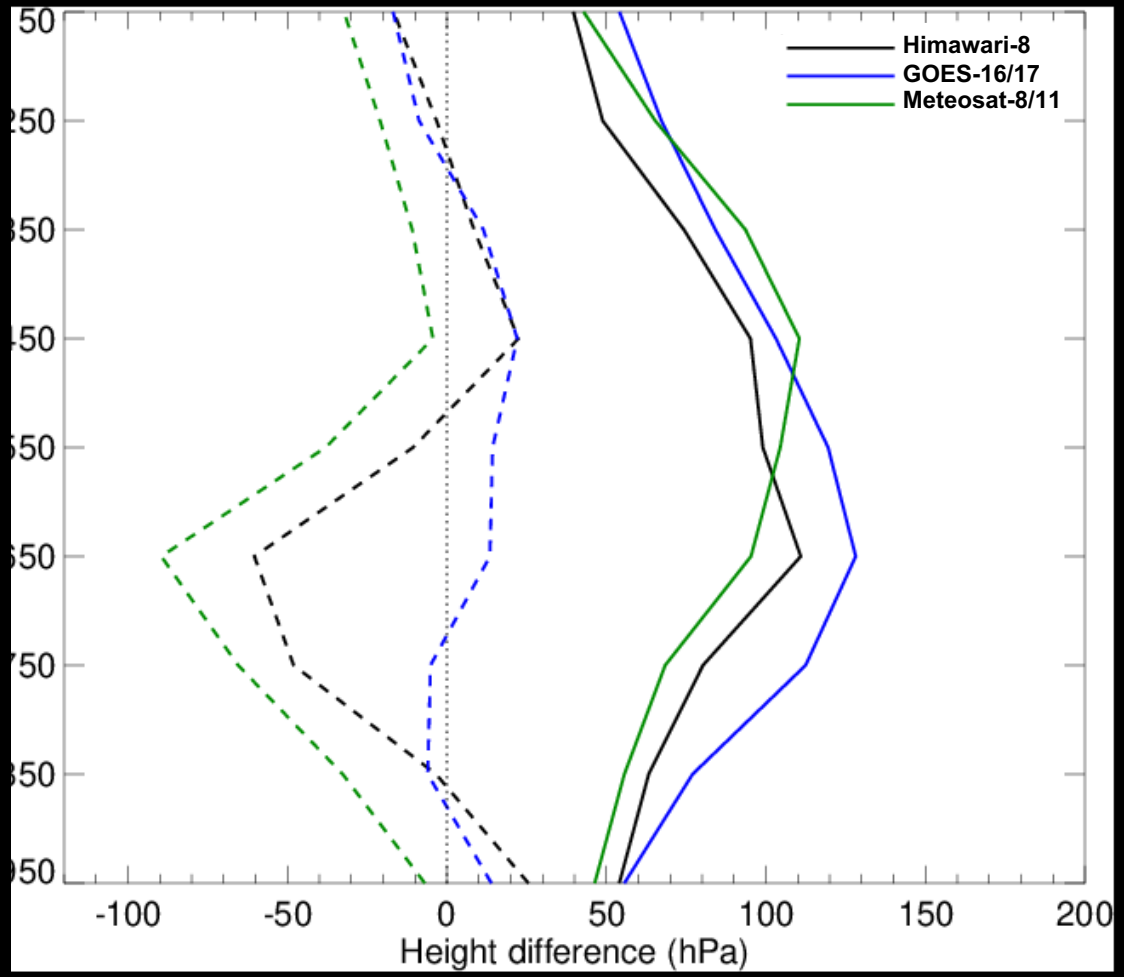
Impact of Selecting Subset of Observations in the Mie-cloudy Profile

- Aeolus is able to detect thin clouds and penetrate through clouds depending on the optical depth. The Mie-cloudy wind most representative of AMVs is located within the Aeolus profile
- However, the selection of the most representative observation in the profile is not trivial
- In an attempt to select the most representative observation, we examined the height difference statistics when the uppermost, middle or lowermost observation in the profile is chosen



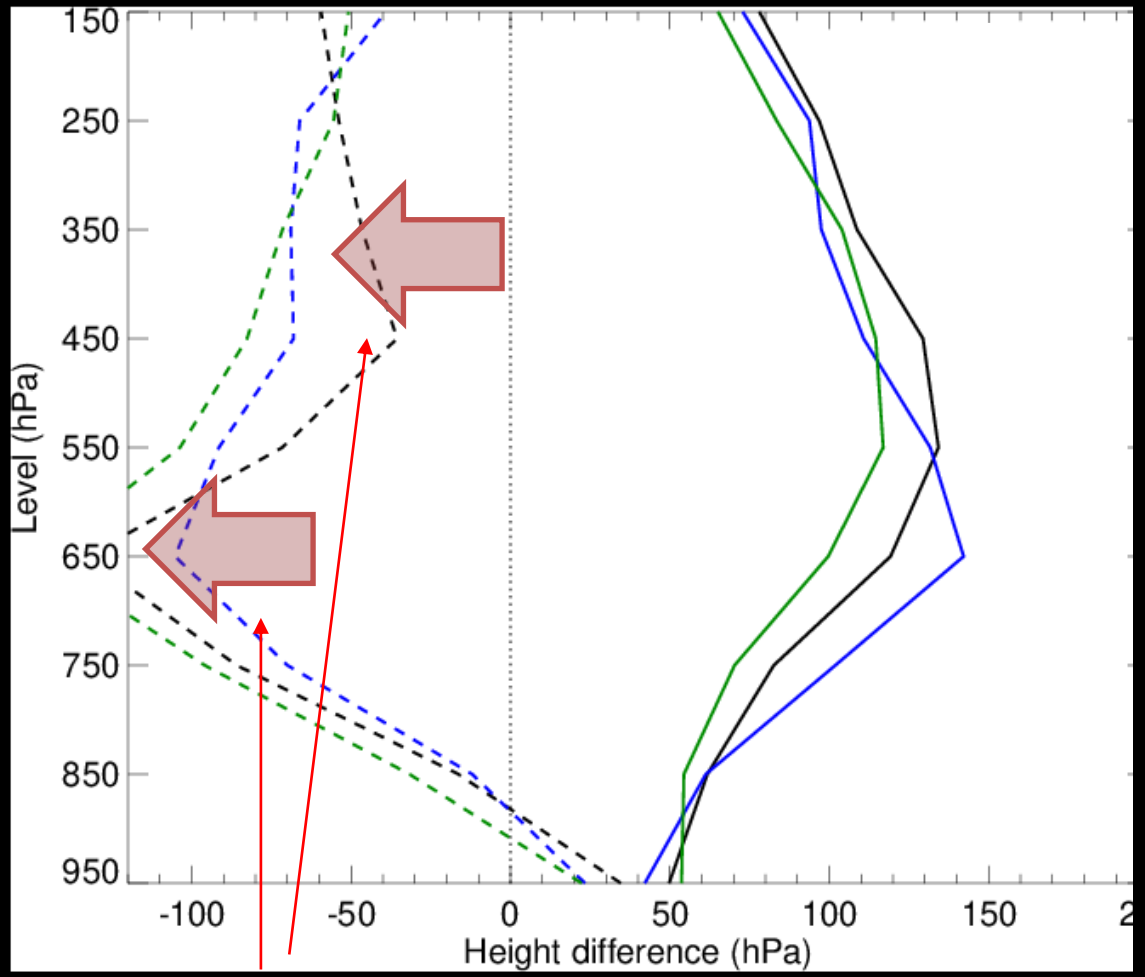
Impact of Selecting only the Uppermost Observation in the Mie-Cloudy Profile

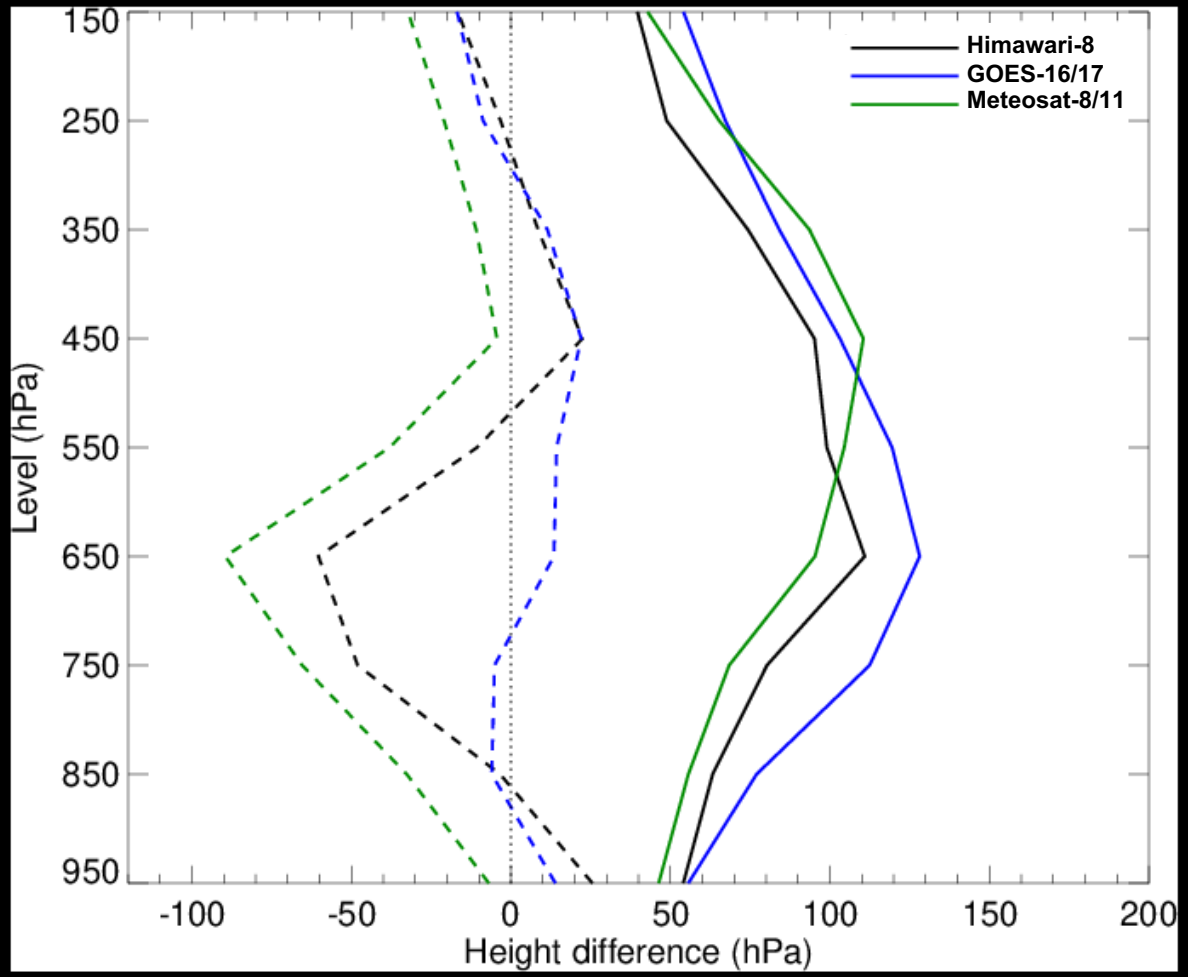




Systematic shift to positive height difference due to selection of the uppermost Aeolus

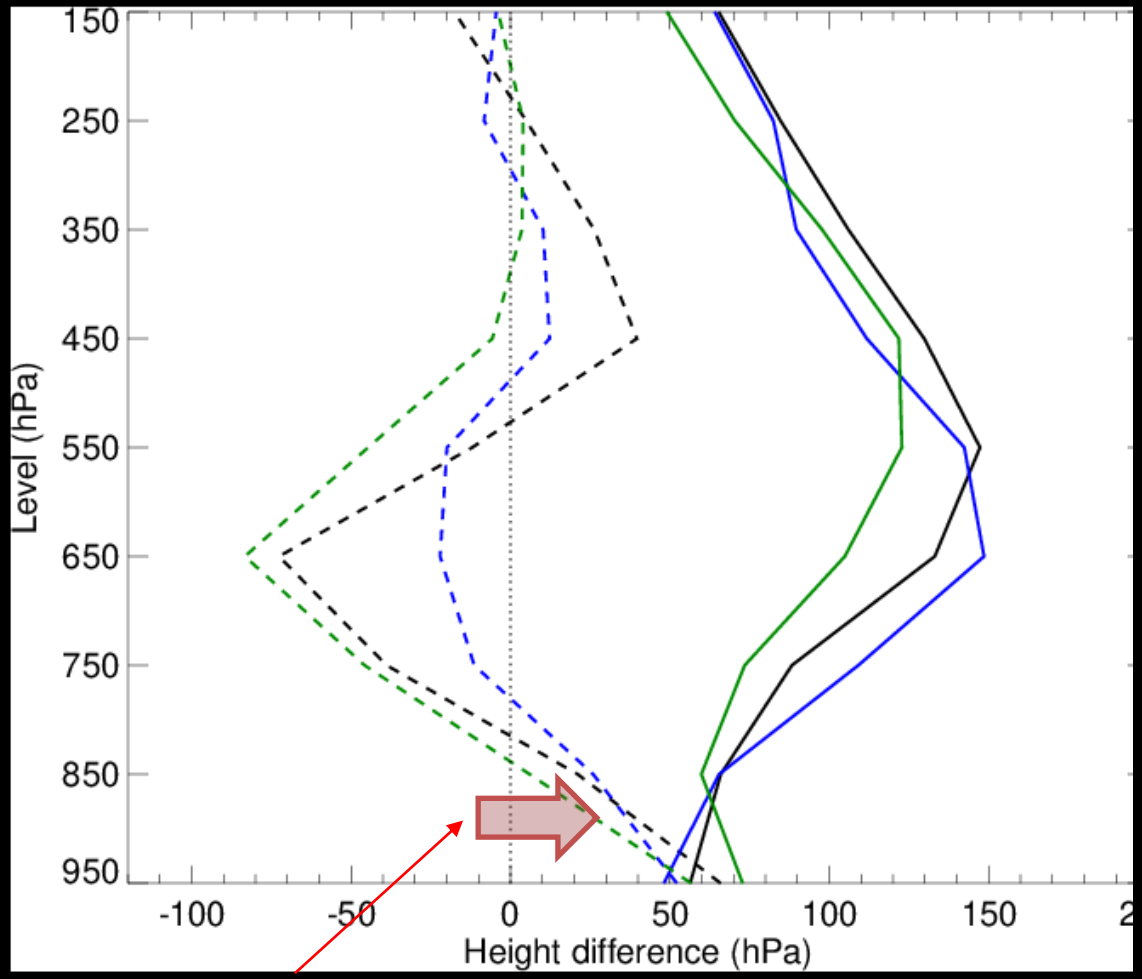
Impact of Selecting only the Lowermost Observation in the Mie-Cloudy Profile

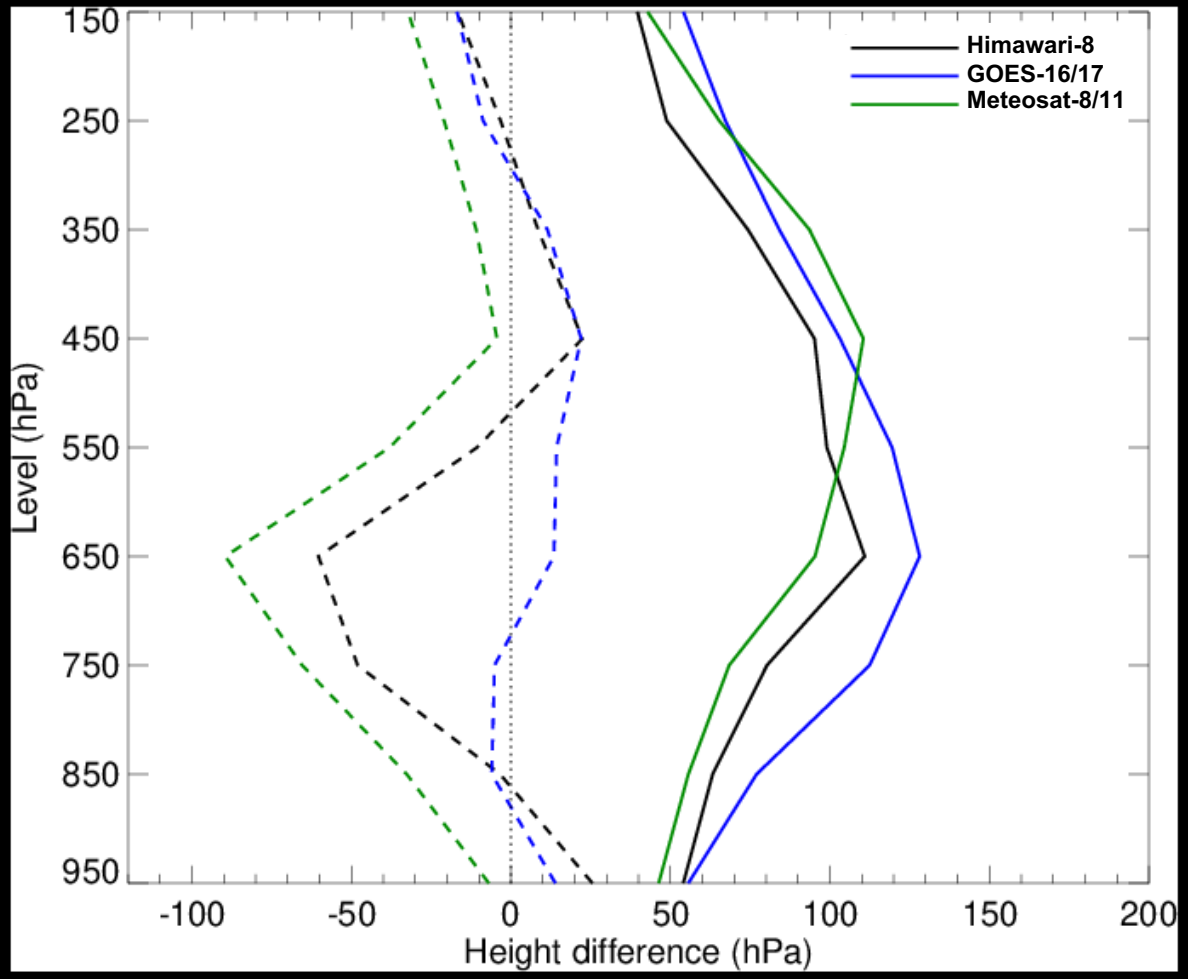




Systematic shift to negative height difference due to selection of the lowermost Aeolus

Impact of Selecting only the Middle Observation in the Mie-Cloudy Profile

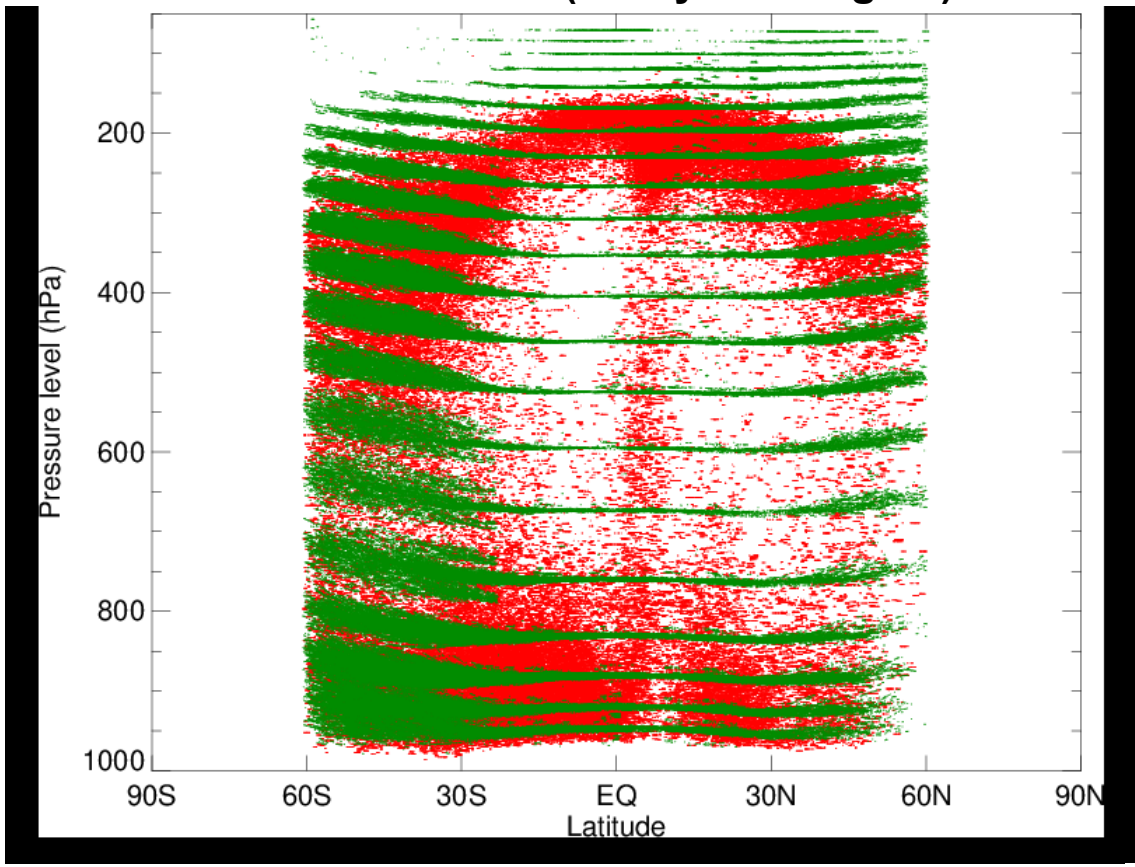




Due to AMVs located below the Aeolus lowest vertical bin

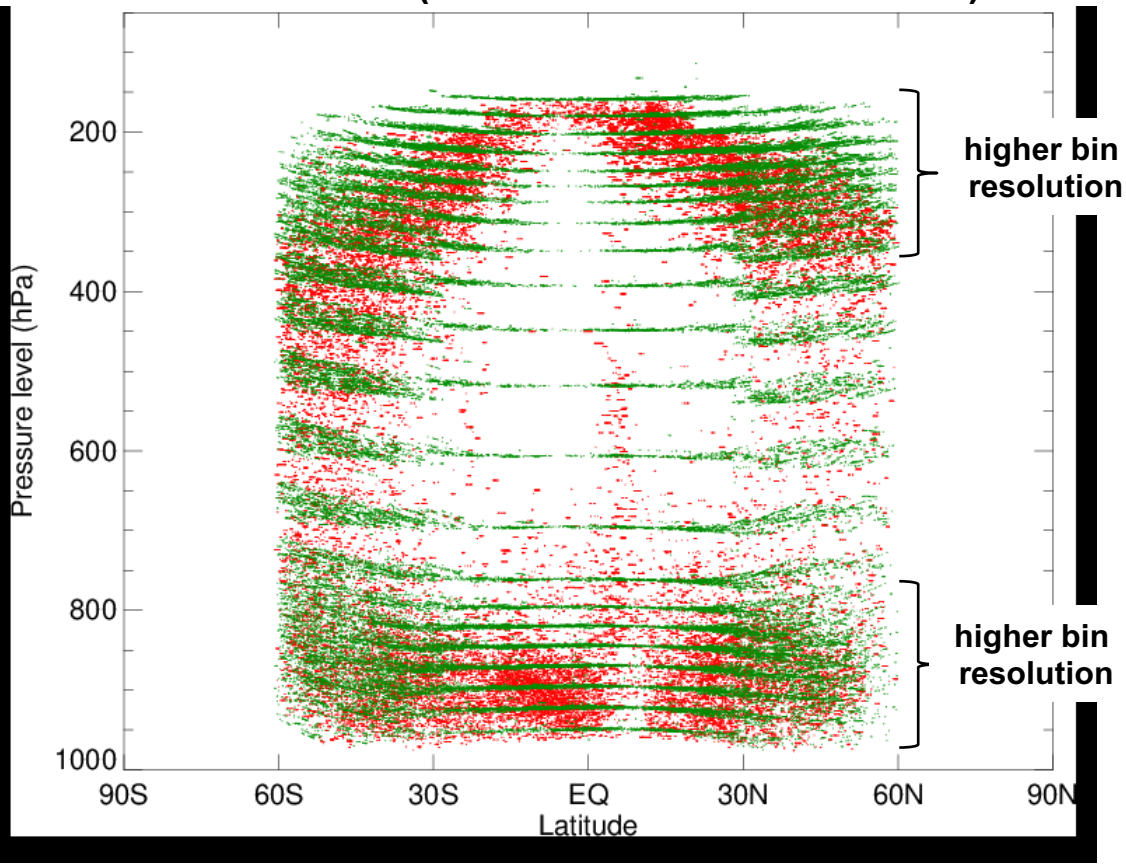
All collocated Mie-cloudy winds and AMVs for GOES

Summer 2019 (1 July - 31 August)



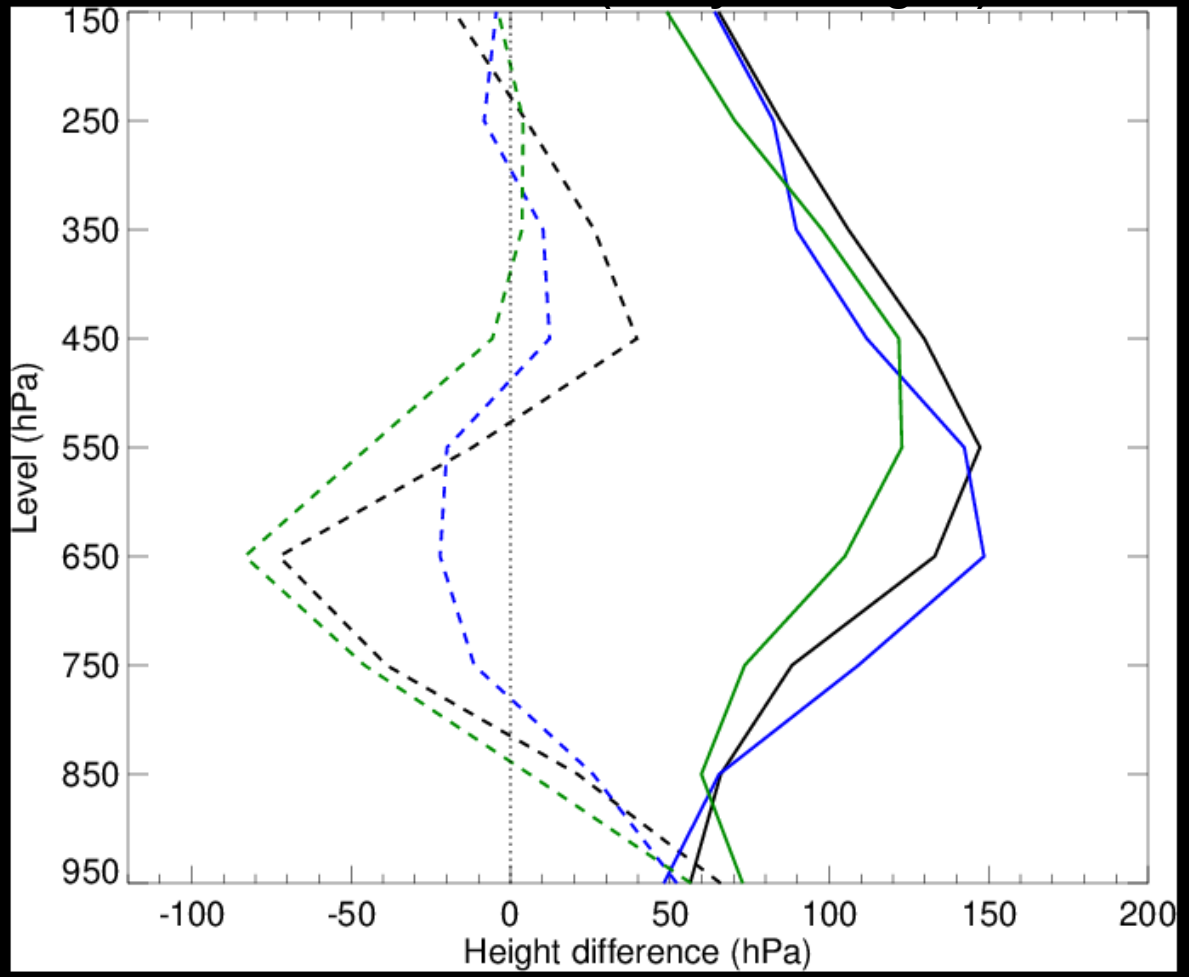
Number of observation pairs : 741 286

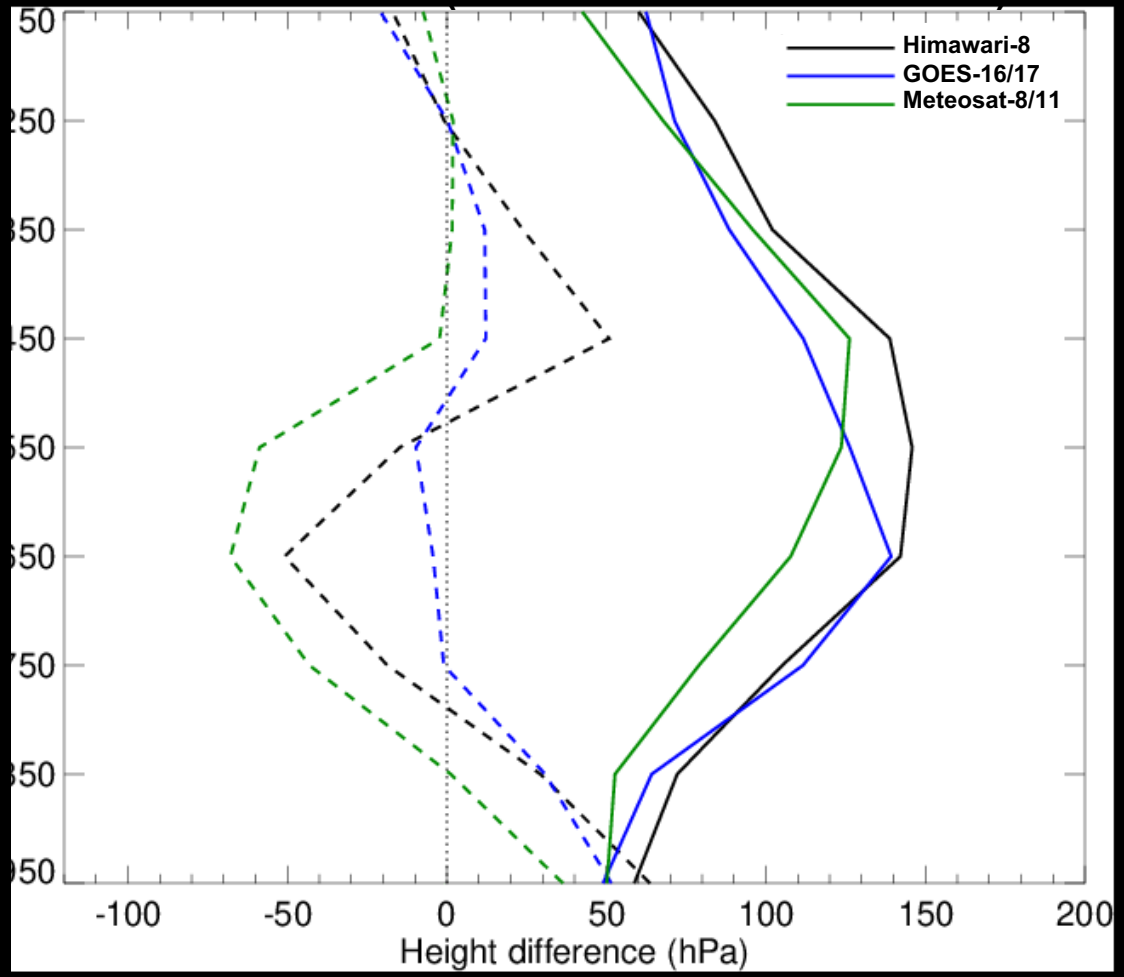
Special Range Bin Setting
Fall 2019 : (28 October – 10 November)



Number of observation pairs : 110 394

Impact of Selecting only the Middle Observation in the Mie-Cloudy Profile





Conclusions

- The collocation between Mie-cloudy winds and AMVs is challenging due to significant representation differences
- The average of height differences are sensitive to the selection criteria for the Mie-cloudy winds
- However, the standard deviations of height differences are not too sensitive to the selection criteria and varies between 50 hPa (low and high levels) to 150 hPa (mid level). The standard deviations are larger than those obtained from the best-fit approach due to the contribution of AMV and Aeolus height errors and colocalisation errors
- The average and standard deviation of height differences are not sensitive to the range bin settings for the Aeolus data
- Despite significant differences between Aeolus-AMV collocation and model best-fit approaches, the results agree reasonably well, particularly when only Mie-cloud winds in the mid-profile are selected