NCAR/EOL Technical Note Dropsonde Dry Bias

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1 Executive Summary

A dry bias in the RD94 and mini dropsonde (NRD94) humidity measurements has been discovered, which has existed since 2010. This document describes the background of the dry bias, how to identify impacted files, how to correct existing data, and how to implement a correction in AVAPS. ASPEN version 3.3-236 is used to correct this dry bias both in reprocessing of existing data as well as in real time data acquisition within AVAPS.

2 Background

2.1 Origin of the dry bias

The NCAR GPS dropsonde has been using a modified Vaisala RS92 sensor module since its inception in the mid 1990's. In 2009 a major upgrade of the dropsonde took place including replacing the original Vaisala PTU module with a next generation RS92 PTU module. As part of this development PTU calculations were moved from the AVAPS software package in the aircraft data system to a Vaisala provided microprocessor in the dropsonde. A bug in this change of processing software led to a systematic temperature dependent dry bias in the RH sensor. The new dropsonde design product code was changed from RD93 to RD94. The Driftsonde MIST sonde and the smaller Mini-Dropsonde (current product code NRD94) use the same technology as the RD94 and have this same dry bias issue. The NRD94 is being used with the automated launch systems onboard the NCAR G-V and the NASA Global Hawk.

2.2 Magnitude of the dry bias

This dry bias is strongly temperature dependent. It is considered small at warm temperatures and becomes strong at cold temperatures. The approximate magnitude of the dry bias as function of temperature is shown in Figure 1.

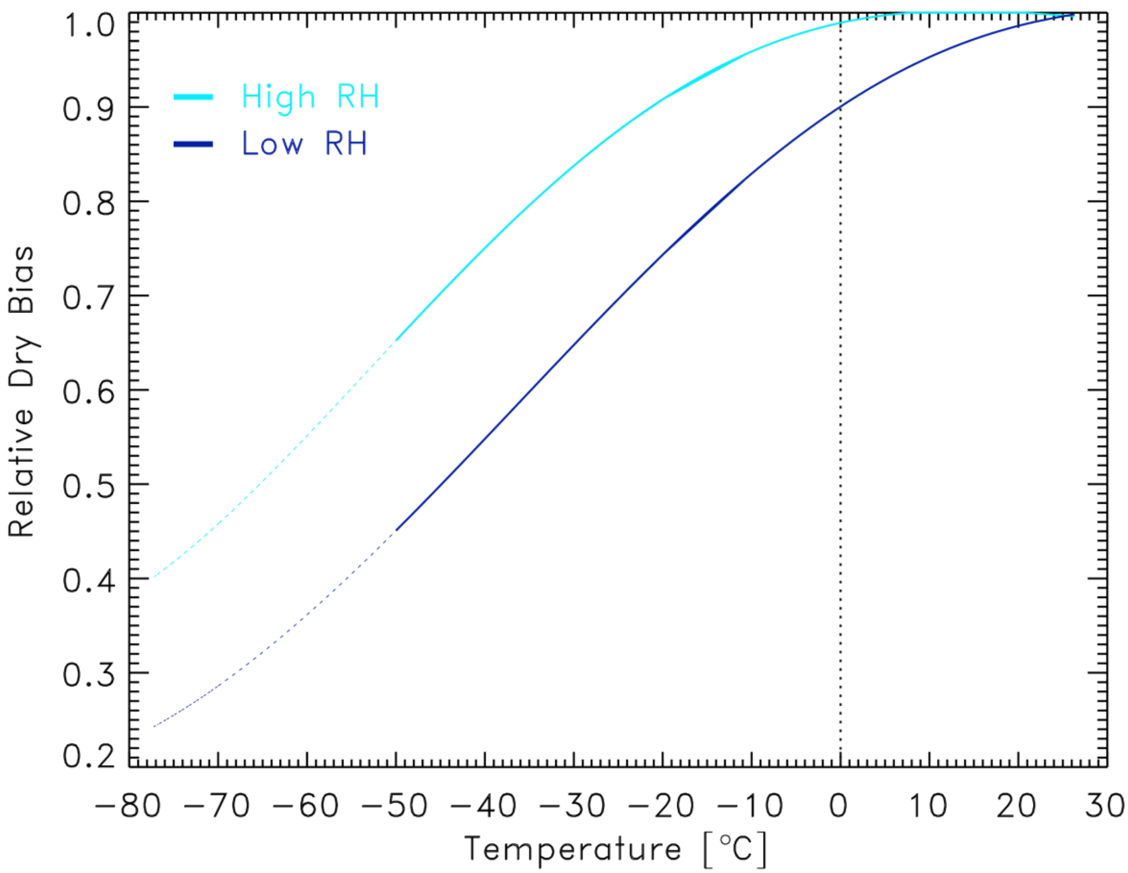

Figure 1: Approximate relative dry bias for high and low humidity conditions

Due to the fast falling speed of dropsondes and relatively slow equilibration time of the humidity sensor, relative humidity measurements from dropsondes currently are difficult to achieve below temperatures of approximately -50°C. For dry conditions the relative dry bias at that temperature may be as large as 50%. For wet conditions the relative dry bias may be as large as 30% and negligible at temperatures warmer than 0°C.

Most of the atmospheric water vapor is contained in the lower (and warmer) troposphere. Thus, the impact of the dry bias on total precipitable water vapor is significantly less. The overwhelming number of dropsondes is launched in mid and low latitudes, where the dry bias in total precipitable water vapor is 1% or less.

2.3 Impacted sonde models and data files

The dry bias impacts all observations of the RD94, which was introduced in 2009, all NRD94 (mini dropsonde) observations since its inception in 2010 and the Driftsonde MIST sonde used during Concordiasi and T-PARC.

2.3.1 Impacted raw data files

Impacted AVAPS raw data D-files can be identified by scanning the metadata in the footer of the data files for the sensor module code. Impacted sounding data will have a sensor identifier of either:

- RSS904
- RS904
- RSS921

2.3.2 Impacted product data files

Product data files may be of the *.EOL, *.FRD, *.CLS, *.CSV format type or may be in the form of TEMPDRPOP (FM 37) messages. These product data files cannot be uniquely identified due to the limitations in the data formats. Some guidelines are provided here to identify impacted soundings:

- All product data files for campaigns using the NRD94 (Minidropsonde) are impacted.
- No observations prior to 2010 are impacted, except for a small number of NOAA test drops and the November/December PLOWS observations.
- Starting in 2010 product data files may be of either type and cannot be identified using metadata of the product file. The user will need to refer to the metadata entry of the AVAPS raw data D-files or A-files and identify the impacted sensor from section 2.3.1.

3 Correction of the dropsonde dry bias

An algorithm to correct this dry bias has been provided by Vaisala and was implemented as additional correction step, which the Atmospheric Sounding Processing Environment (ASPEN) applies to raw data AVAPS D-Files. Users are reminded to never use AVAPS raw data files (D-files) for scientific studies of operational use in forecasting. Only ASPEN output files should be used for any quantitative analysis of dropsonde observations.

Aspen implemented this dry bias correction starting with version 3.3-236. All subsequent versions maintain the capability to correct this dry bias.

The application of the dry bias correction is indicated by:

- The string 'TDDryBiasCorrApplied' is added to the Comment data line *.EOL, *.FRD, and *.CLS data files
- A new key 'TDdrybiascorrection' has been added to the *.csv and *.ncdf data files with a value of 'applied'.
- TEMPDROP messages do not provide any possibility to indicate the dry bias correction. This data format will need to be used with caution.

- BUFR data files have not been used prior to the discovery of this issue. Therefore, all BUFR data files, which will be generated in the future, have the dry bias correction applied.

3.1 Real time data recording

To correct the dry bias in real time data, Aspen versions running on the AVAPS computer must be updated to at least version 3.3-236 . This version will assure that raw data AVAPS D-files will be properly processed to generate real time quality controlled ASCII EOL files, TEMPDROP message, as well as Skew-T plots.
If Aspen is used on other computers to generate product files and skew-T plots, then Aspen must be updated on these computers.
The correction was built into the default processing mode, so no modification needs to be done to ASPEN in order for it to apply the correction to raw files in real-time. Aspen identifies impacted data files and will correct only data files, which are impacted by the dry bias.

4 Document Version Control

Version	Date	Authors	Change Description
1.0	14 May 2016	Vömel	Initial Document
1.1	18 May 2016	Vömel	Added magnitude discussion
1.2	18 May 2016	Hock, Vömel	Additional information and edits
1.3	26 May 2016	Young, Vömel	Small edits