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INTERPOLATED SOUNDING AND GRIDDED SOUNDING VALUE-ADDED PRODUCTS

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Acronyms/Abbreviations

ARM	Atmospheric Radiation Measurement Climate Research Facility
GRIDDEDSONE	Gridded Sounding
INTERPOLATEDSONDE	Interpolated Sounding
MWR	microwave radiometer
PWV	precipitable water vapor
QC	quality control
SGP	Southern Great Plains (site)
VAP	value-added product

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1.0 Introduction

Standard Atmospheric Radiation Measurement (ARM) Climate Research Facility sounding files provide atmospheric state data in one dimension of increasing time and height per sonde launch. Many applications require a quick estimate of the atmospheric state at higher time resolution. The INTERPOLATEDSONDE (i.e., Interpolated Sounding) Value-Added Product (VAP) transforms sounding data into continuous daily files on a fixed time-height grid, at 1-minute time resolution, on 332 levels, from the surface up to a limit of approximately 40 km. The grid extends that high so the full height of soundings can be captured; however, most soundings terminate at an altitude between 25 and 30 km, above which no data is provided. Between soundings, the VAP linearly interpolates atmospheric state variables in time for each height level. In addition, INTERPOLATEDSONDE provides relative humidity scaled to microwave radiometer (MWR) observations.

Figure 1 through Figure 3 present sample data from INTERPOLATEDSONE collected at the Southern Great Plains (SGP) C1 site over 5 days from July 1-5, 2015. In Figure 1, the blue vertical lines represent times for which sounding data exists. The red contour represents gaps between soundings, where data is interpolated. Figure 2 and Figure 3 show resultant fields of temperature and relative humidity, respectively.

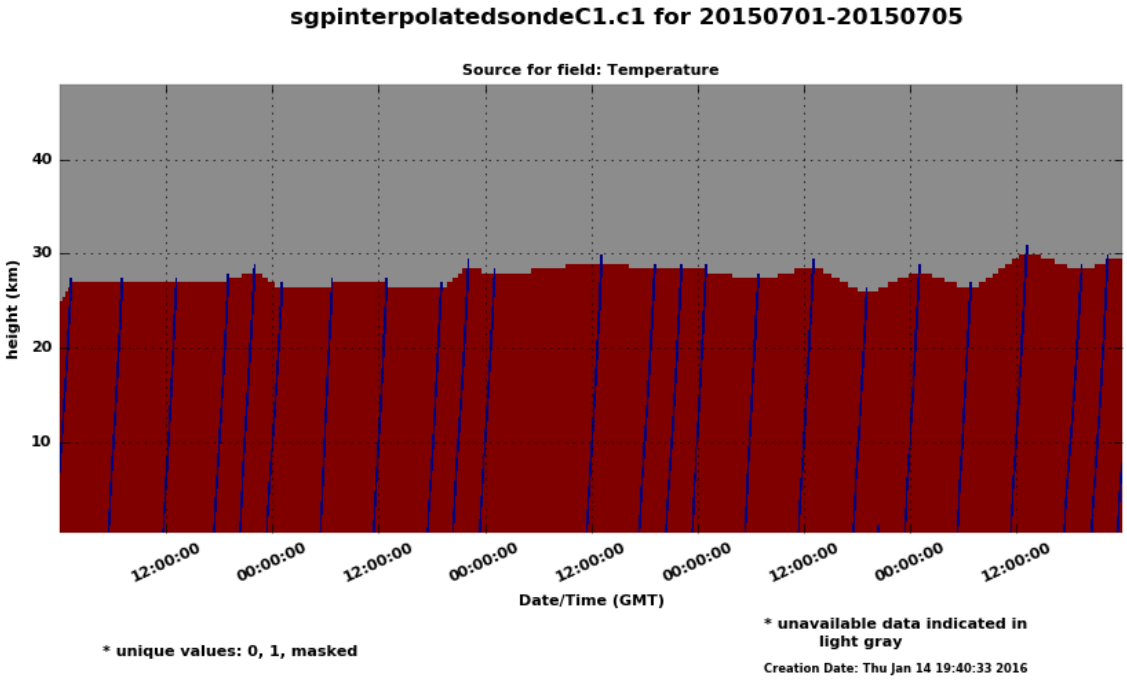

Figure 1. INTERPOLATEDSONDE output profiles at the SGP C1 site (July 1-5, 2015). Source of temperature data: blue is actually collected sounding data and red is linearly interpolated data.

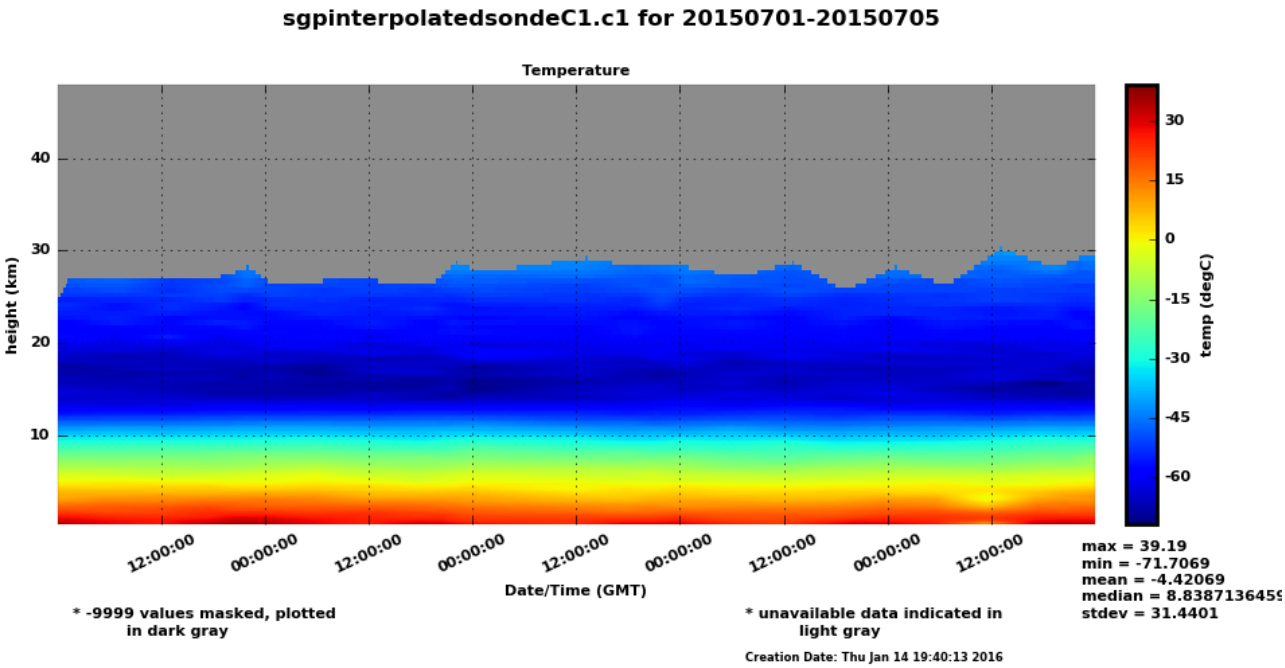

Figure 2. INTERPOLATEDSONDE temperature output profiles at the SGP C1 site (July 1-5, 2015).

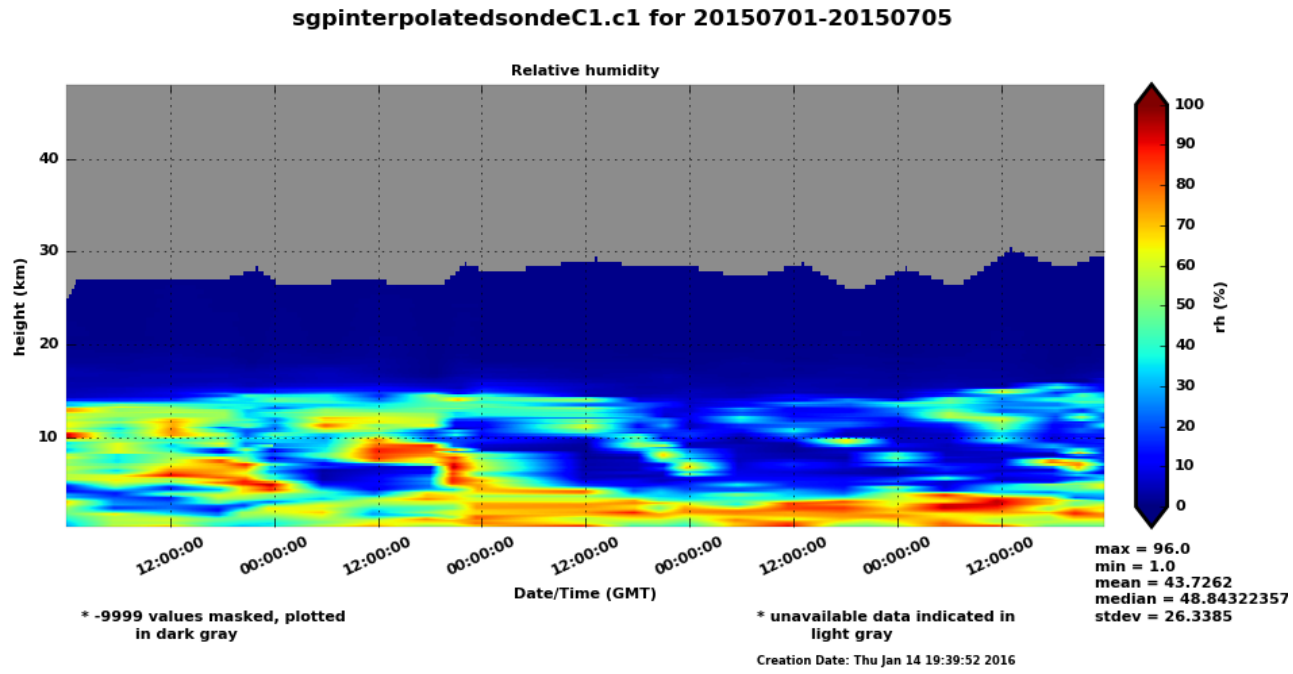

Figure 3. INTERPOLATEDSONDE relative humidity output profiles at the SGP C1 site (July 1-5, 2015)

2.0 Input Data

The current version of INTERPOLATEDSONDE only accepts sounding data and precipitable water vapor (PWV) estimates from MWR measurements as input, making it a true "interpolated sounding" product. Previous versions of INTERPOLATEDSONDE incorporated surface and tower meteorology.

2.1 GRIDDEDSONDE

INTERPOLATEDSONDE is ultimately generated from sounding files, but indirectly, through an intermediate product, known as the Gridded Sounding VAP (GRIDDEDSONE), which is described in this section. GRIDDEDSONDE simply transforms standard ARM-format soundings files from one-dimensional, increasing in time and height, to a two-dimensional time-height grid, identical to the INTERPOLATEDSONDE grid. To illustrate, the data provided by GRIDDEDSONDE is represented by the blue vertical lines in Figure 1. Note that each sounding value interpolated onto the fixed grid extends ±7.5 minutes, such that each blue vertical bar in Figure 1 is 15 minutes wide.

GRIDDEDSONDE accepts the ARM SONDEADJUST VAP (sondeadjust.c1) (Troyan, 2011) for older soundings and original ARM sounding data files for newer and improved soundings (sondewnpn.b1). The SONDEADJUST VAP corrects Viasala radiosonde observations for known humidity biases (e.g., Milosevich et al. 2009). New Viasala software that accounts for these humidity biases was adopted by ARM beginning in 2001, thus negating the need for the SONDEADJUST VAP. Dates on which GRIDDEDSONDE switches from using SONDEADJUST to using sondewnpn will vary from site to site as shown in Table 1.

Table 1. Date of last SONDEADJUST

Site.Facility	Dates of Last SONDEADJUST	Site.Facility	Dates of Last SONDEADJUST
GAN.M1	February 9, 2012	TWP.C1	September 8, 2011
NSA.C1	July 16, 2012	TWP.C2	April 5, 2012
SGP.C1	August 32, 2012	TWP.C3	December 18, 2012

GAN is the ARM site on Gan Island in the Indian Ocean.
NSA is the ARM site on the North Slope of Alaska.
TWP is the ARM site in the Tropical Western Pacific.

Table 2 lists the input data streams and variables to GRIDDEDSONDE, and the GRIDDEDSONDE output variable names. The GRIDDEDSONDE output is direct input to INTERPOLATEDSONDE.

Table 2. Input data stream and variable names, and GRIDDEDSONDE output variables

Data Stream	Input Variables	GRIDDEDSONDE Output Variables
sondeadjust.c1 or sondewnpn.b1	alt	none
sondeadjust.c1 or sondewnpn.b1	pres	bar_pres
sondeadjust.c1 or sondewnpn.b1	dp	dp
sondeadjust.c1	rh_adjust	rh
sondewnpn.b1	rh	rh
sondeadjust.c1 or sondewnpn.b1	temp	temp
sondeadjust.c1 or sondewnpn.b1	u_wind	u_wind
sondeadjust.c1 or sondewnpn.b1	v_wind	v_wind

Note that GRIDDEDSONE is not provided by ARM as an available data stream; however, the data contained in GRIDDEDSONDE can be gleaned from INTERPOLATEDSONDE by using the source variables.

2.2 Microwave Radiometer Precipitable Water Vapor

Once data from GRIDDEDSONDE has been interpolated between soundings, INTERPOLATEDSONDE uses estimates of PWV from MWR measurements as a constraint (Turner et al. 2007). As shown in Table 3, the process first attempts to use PWV estimates from the MWRRET VAP (mwrret1liljclou; Gaustad et al. 2011), if available, and then from MWRLOS. [1]

Table 3. Input data stream and variable names

Data Stream	Input Variable
mwrret1liljclou.c1 or mwrretliljclou.c2	be_pwv
mwrlos.b1	vap

3.0 Algorithm and Methodology

3.1 General Flowchart

The flowchart in Figure 4 depicts the general steps involved in the production of the INTERPOLATEDSONDE VAP.

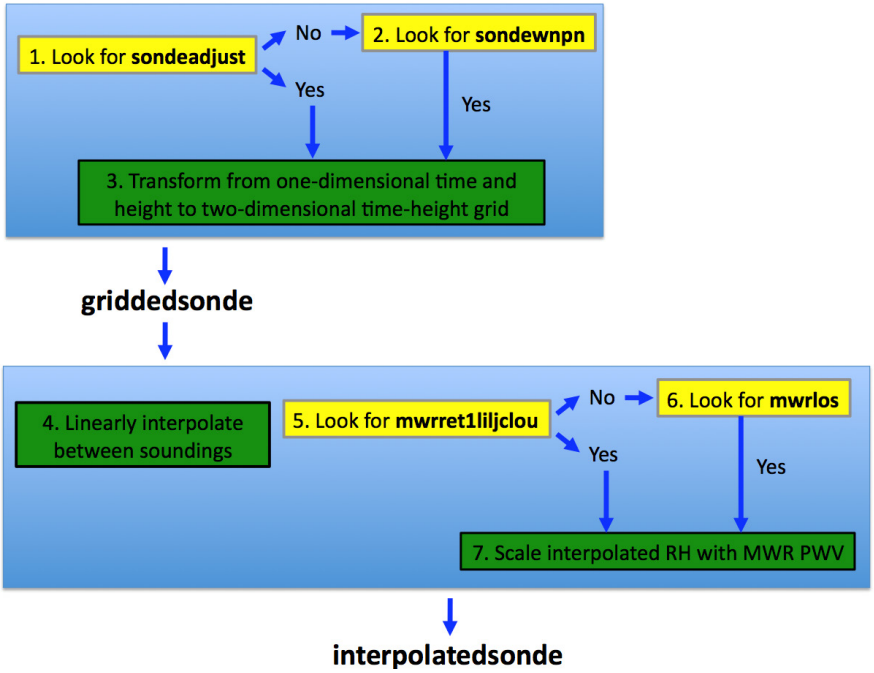

Figure 4. Steps to produce the INTERPOLATEDSONDE Value-Added Product.

[1] http://www.arm.gov/data/datastreams/mwrlos

Note that, when processing a day of INTERPOLATEDSONDE, ±2 days' worth of input data are retrieved, so values may be interpolated in gaps between soundings of up to 5 days.

3.2 Relative Humidity Scaling Flowchart

In Figure 5, we expand on step 7 from Figure 4, depicting the steps required to scale the relative humidity.

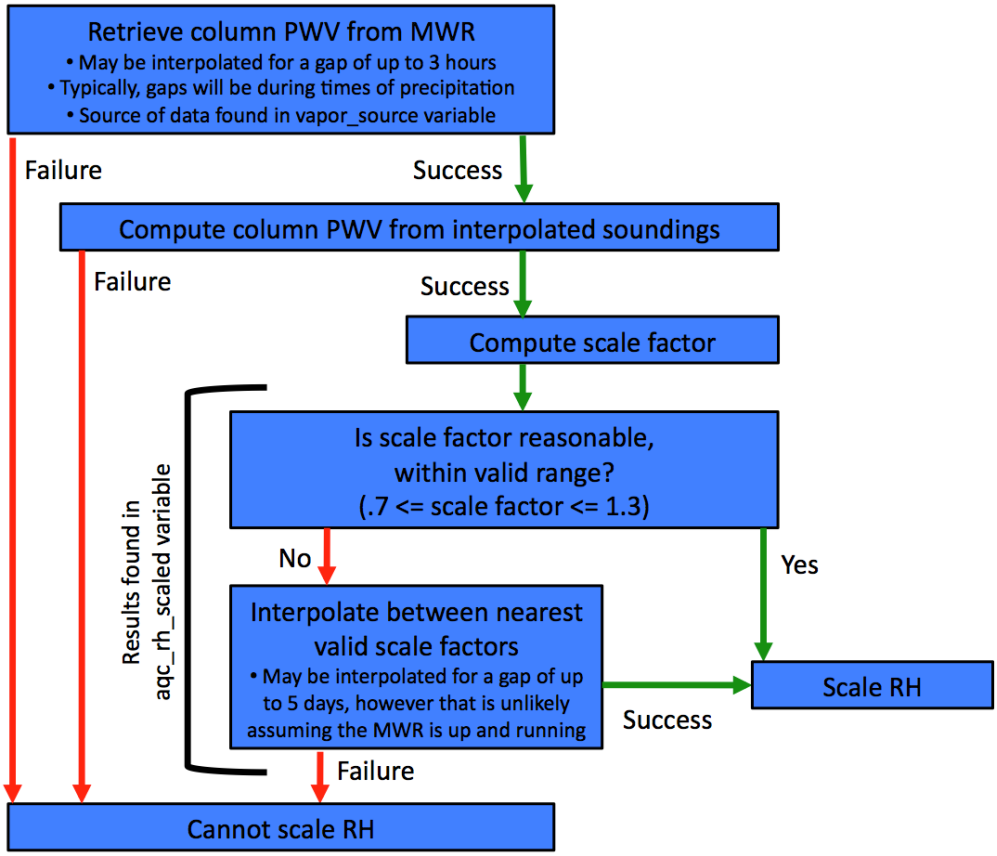

Figure 5. Steps taken to scale relative humidity.

4.0 Output Data

4.1 Output Variables

Table 4 lists the meteorological variables provided by INTERPOLATEDSONDE, along with long name, an indication of whether quality control (QC) data exists for the variable, and an indication of whether source data is available for the variable. Tests to ensure that values are within a valid range are provided for variables interpolated from GRIDDEDSONDE, as well as the scaled relative humidity. Computed values, such as specific humidity, wind speed, wind direction, and potential temperature, do not require QC tests. Source fields are provided for variables from GRIDDEDSONDE, indicating whether the source is GRIDDEDSONDE itself or interpolation.

Table 4. INTERPOLATEDSONDE meteorological variables

Variable Name	Long Name	Units	QC	Source?
precip	Precipitation	Mm	yes	No; static source
temp	Temperature	°C	Yes	Yes
rh	Relative humidity	%	Yes	Yes
vap_pres	Vapor pressure	kPa	Yes	No; computed
bar_pres	Barometric pressure	kPa	Yes	Yes
wspd	Wind speed	m/s	Yes	No; computed
wdir	Wind direction	degree	yes	No; computed
u_wind	Eastward wind component	m/s	Yes	Yes
v_wind	Northward wind component	m/s	Yes	Yes
dp	Dew-point temperature	°C	Yes	Yes
potential_temp	Potential temperature	K	Yes	No; computed
sh	Specific humidity	g/g	Yes	No; computed
rh_scaled	Relative humidity scaled using MWR	%	Yes[a]	No[b]

[a] In addition to the general valid range QC provided for rh_scaled, ancillary QC provides additional information, in aqc_rh_scaled, that describes the quality of computed scale factors (Figure 5).
[b] The vapor_source variable provides the source of the PWV used for scaling relative humidity (Figure 5).

4.2 Grid Resolution

Regarding the fixed grid of INTERPOLATEDSONDE, the temporal resolution of the VAP is 1 minute, and the vertical resolution varies with height as shown in Table 5.

Table 5. Vertical resolution (on 332 levels)

Height (km above ground level)	Resolution (m)
0–3.5	20
3.5–5	50
5–7	100
7–20	200
20–~40	500

5.0 Summary

The INTERPOLATEDSONDE VAP, a continuous time-height grid of relative humidity-corrected sounding data, is intended to provide input to higher-order products, such as the Merged Soundings (MERGESONDE; Troyan 2012) VAP, which extends INTERPOLATEDSONDE by incorporating model data. The INTERPOLATEDSONDE VAP also is used to correct gaseous attenuation of radar reflectivity in products such as the KAZRCOR VAP.

6.0 References

Gaustad, KL, DD Turner, and SA McFarlane. 2011. *MWRRET Value-Added Product: The Retrieval of Liquid Water Path and Precipitable Water Vapor from Microwave Radiometer (MWR) Data Sets*. DOE/SC-ARM-TR-081.2, Washington, D.C., available at http://www.arm.gov/publications/tech_reports/doe-sc-arm-tr-081.2.pdf?id=496.

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