Assessment of the Seasonal and Inter-annual Radiosonde Temperature Biases in the Lower Stratosphere using COSMIC, CHAMP, and GRACE from 2006 to 2013

Shu-peng Ho¹, Liang Peng¹, Ying-Hwa Kuo¹,²
1. University Corporation for Atmospheric Research/COSMIC, USA
2. National Center of Atmospheric Research, USA
Motivation:
Can we use RO data to identify structural uncertainty of stratospheric temperature trends from satellite data and radiosondes?

Challenges
- Radiosonde sensor characteristics can be affected by the changing environment, its measurement accuracy varies considerably in times and locations for different sensor types
- Changes with instrument types
- Limited spatial coverage especially over the oceans.
- Not traceable to SI units
- Temperature trends are subjective to the choices of radiosonde subset

It is important to assess systematic biases of radiosonde temperature measurements.

Objectives:

1) Using RO temperature profiles to identify temperature biases from radiosonde, where sensor characteristics vary considerably in times and locations for different sensor types

2) Using RO data to correct radiosonde systematic temperature biases

Outlines:

- Approaches
- Results, global, time series, trends
- Conclusions and Future Work
RO data for climate research

- Measure of time delay: no calibration is needed
- Requires no first guess sounding
- Not affect by clouds
- Uniform spatial/temporal coverage
- High precision (<0.05K) (Ho et al., TAO, 2009)
- Insensitive to clouds and precipitation
- No mission dependent bias (Ho et al., TAO, 2009)
- Reasonable structural uncertainty among data processed from different centers (Ho et al., JGR, 2009, 2012)
- Short term RAOB vs. RO comparison (He et al., 2009; Sun et al., 2011, 2013)
Approach: Using COSMIC, CHAMP, and GRACE data from 2006 to 2013 to assess the quality of radiosonde data.

Radiosonde data DS353.4 from NCAR:
- originally acquired from NCEP.
- contains the original data values transmitted by stations.
- no radiative or other corrections from NCEP are included in this dataset.

He et al., (2009 GRL)

<table>
<thead>
<tr>
<th>Region</th>
<th>Sonde Type</th>
<th>Matched Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russia</td>
<td>AVK-MRZ</td>
<td>2000 (20%)</td>
</tr>
<tr>
<td>China</td>
<td>Shang</td>
<td>650 (6.1%)</td>
</tr>
<tr>
<td>USA</td>
<td>VIZ-B2</td>
<td>600 (5.9%)</td>
</tr>
<tr>
<td>Others</td>
<td>Vaisala</td>
<td>3140 (30%)</td>
</tr>
</tbody>
</table>

Collocate COSMIC/CHAMP/GRACE and radiosonde profiles:
< 200 km
< 3 hrs
Check the accuracy of the RO temperature
RS 92 vs. COSMIC derived temperature profiles in 2007

Global Comparison

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ID = 80, Vaisala RS92/Digicora III (Finland)

Sample Number

Pressure [hPa]

Mean Bias = 0.164
Mean Abs(Bias) = 0.164
Mean SD = 1.835
90S to 90N

Sample Number

Pressure [hPa]

Mean Bias = 0.001
Mean Abs(Bias) = 0.012
Mean SD = 1.673
50N to 90N

Sample Number

Pressure [hPa]

Mean Bias = 0.184
Mean Abs(Bias) = 0.184
Mean SD = 1.857
20N to 60N

Sample Number

Pressure [hPa]

Mean Bias = 0.337
Mean Abs(Bias) = 0.337
Mean SD = 1.648
20S to 20N

Sample Number

Pressure [hPa]

Mean Bias = 0.246
Mean Abs(Bias) = 0.246
Mean SD = 1.548
60S to 20S

Sample Number

Pressure [hPa]

Mean Bias = 0.149
Mean Abs(Bias) = 0.149
Mean SD = 1.884
90S to 60S

Sample Number

Pressure [hPa]
Detection the Changing of Instrument Type

Solar absorptivity = 0.2
IR emissivity = 0.04

Solar absorptivity = 0.15
IR emissivity = 0.85
Using RO data to Identify Diurnal variation of Radiosonde Temperature Anomalies

Solar absorptivity = 0.2
IR emissivity = 0.04

150 hPa

Solar absorptivity = 0.15
IR emissivity = 0.85

MRZ 150 hPa

China Shang 150 hPa

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Using RO data to Identify Diurnal variation of Radiosonde Temperature Anomalies

Solar absorptivity = 0.15
IR emissivity = 0.85
USA VIZ-B2 150 hPa

150 hPa

Solar absorptivity = 0.15
IR emissivity = 0.02
Vaisala 150 hPa

VIZ-B2

Mean Bias = 0.217
Abs(Mean) Bias = 0.511
MeanSD = 1.441

Vaisala

Mean Bias = -0.053
Abs(Mean) Bias = 0.097
MeanSD = 1.563
Using RO data to identify/Correct Inter-seasonal Temperature Biases
Vaisala RS92
ECMWF-RO Time Series
Over locations of Vaisala RS92

Images showing time series plots for different latitude bands (90S~90N, 60N~90N, 20N~60N, 20S~20N, 60S~20S, 90S~60S) with mean bias and standard deviation values for day and night conditions.
Using RO data to Identify Inter-seasonal Temperature Biases

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Removing the seasonal cycle
Detection of the drifting of ROAB – RO temperature bias
Removing the seasonal cycle
Detection of the drifting of ROAB – RO temperature bias
Conclusions and Future Work

• Geo-location independent COSMIC RO data are useful to assess the quality of radiosonde temperature in the higher troposphere and lower stratosphere.
• These results suggest that COSMIC temperature observations are extremely useful as benchmark observations for differentiating radiosonde temperature errors resulting from instrument characteristics and identifying the variation of inter-seasonal biases.
• MRZ (RUSSIA) contains warm temperature bias during the day but seems consistent with RO temperature during the night.
• VIZ-B2 (USA) contains warm temperature bias during the day and cold bias comparing to RO temperature during the night due to radiative effect.