



# AIRS observations of Dome Concordia in Antarctica and comparison with Automated Weather Stations during 2005

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**We used AIRS to look at Dome Concordia for two reasons:**

- 1. The research instrumentation at DomeC may be useful to support the validation of the calibration accuracy and stability of Polar orbiting infrared sounders.**
- 2. Due to the low temperatures, temperature trends in the Antarctic are expected to respond more rapidly to global warming effects than the rest of the globe.**



**Reports in the literature (Turner et al. "Significant Warming of the Antarctic Winter Troposphere" Science 31 March 2006 v. 311) show atmospheric temperature in Antarctica warming much faster (0.6 K/decade over the past 30 years) than the global temperatures (+0.1 K/decade).**

**As a first step in looking at temperature trends in the Antarctic we compare surface temperature measurements from AIRS with those reported by Automatic Weather Stations at Dome C.**



# Outline

**Quick Overview of AIRS**

**Stability and Accuracy of the AIRS radiances**

**Comparison with AIRS data centered on DomeC with and two Automatic Weather Stations between January – November 2005.**

**Conclusion**



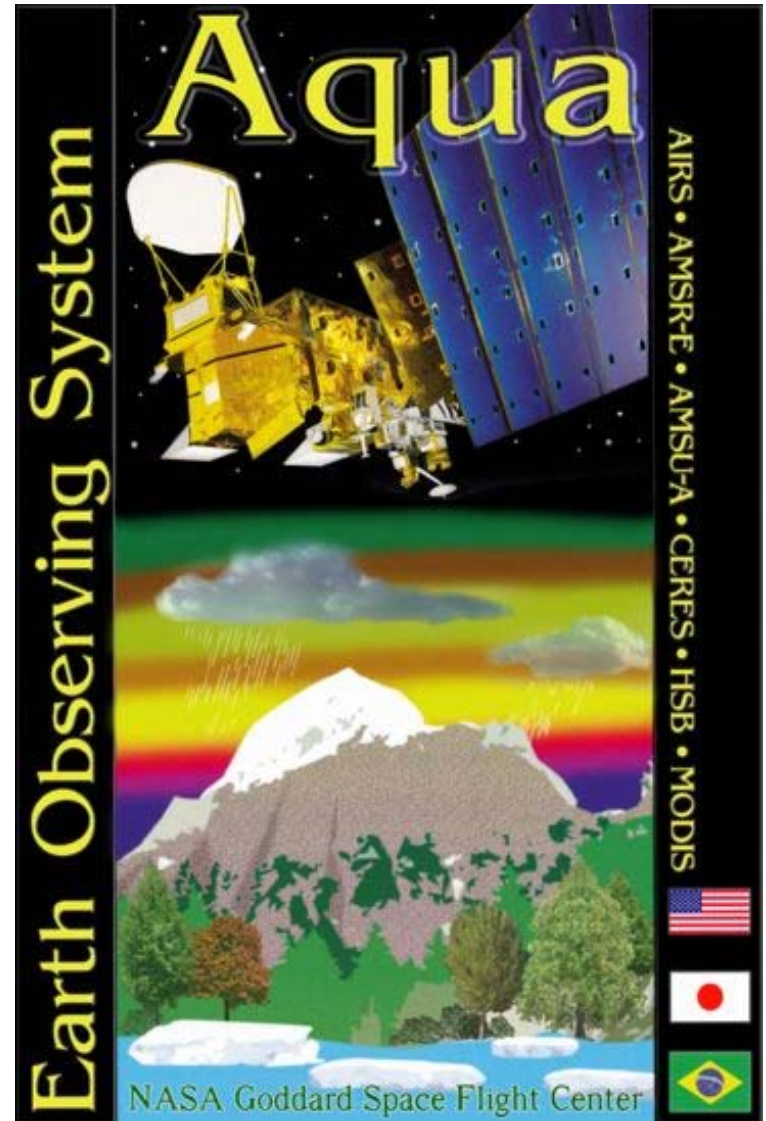
# AIRS/AMSU/HSB

**Spacecraft:** EOS Aqua  
**Instruments:** AIRS, AMSU, HSB, MODIS, CERES, AMSR-E  
**Launch Date:** May 4, 2002  
**Launch Vehicle:** Boeing Delta II Intermediate ELV  
**Mission Life:** 5 years  
**AIRS Team Leader:** Moustafa Chahine

## AIRS Project Objectives

1. Support Weather Forecasting
2. Climate Research
3. Atmospheric Composition and Processes

**Latest Prediction: 12 year life**

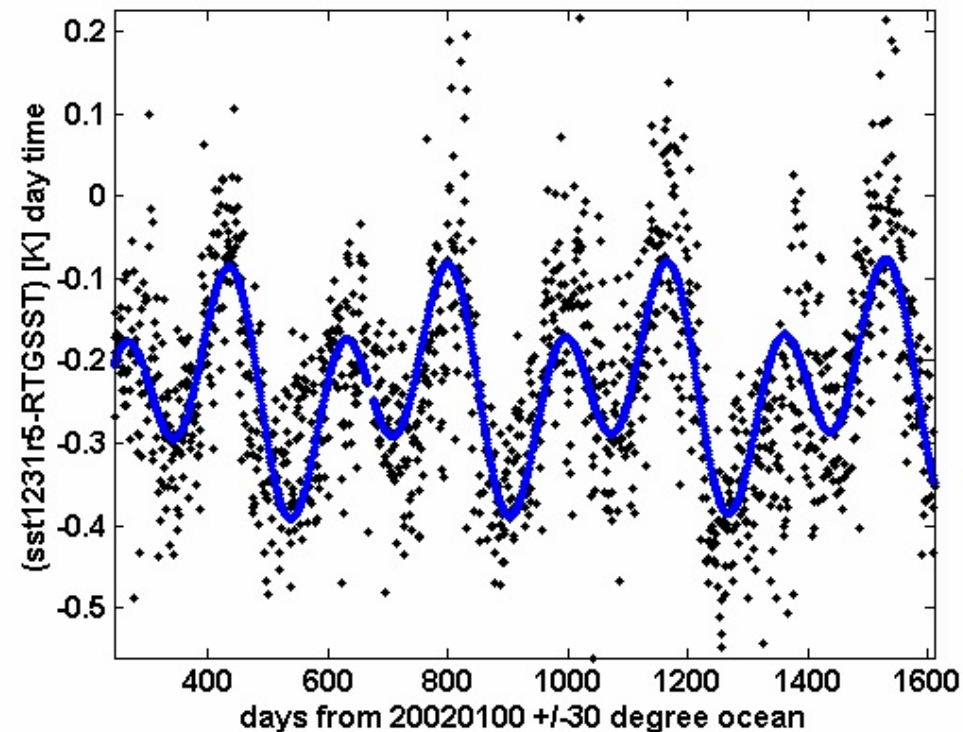




The NIST traceable absolute calibration of AIRS has been validated to within 200 mK (Tobin et al. 2006)

The radiometric stability in the 285-300 K range has been validated relative to the sea surface temperature to better than 10 mK/year (Aumann et al. 2006)

c8.b6a.acds.day.nite.200209-200605.18zone.stats.mat



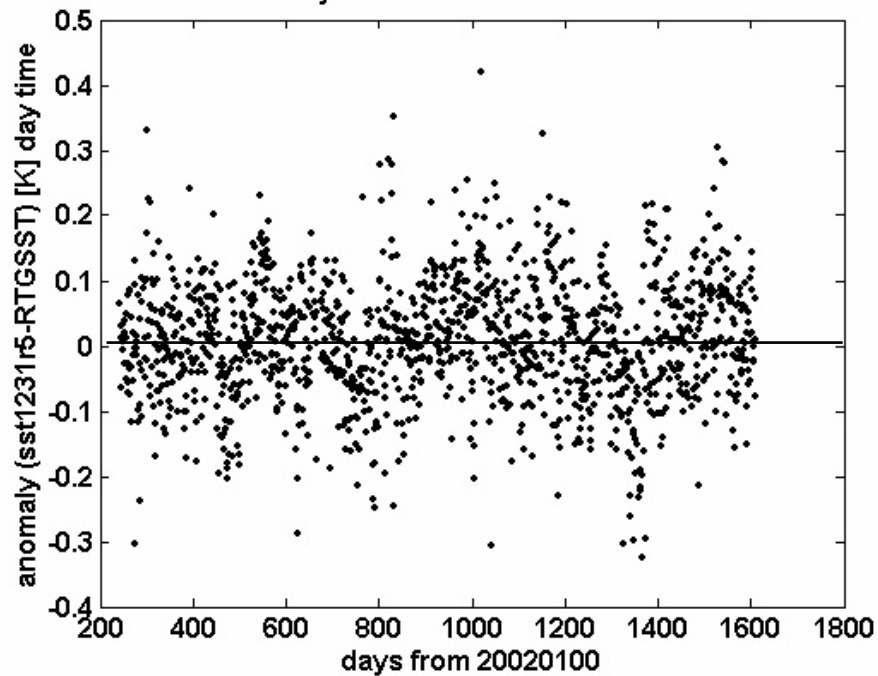
The black dots are the median from each day  
The blue trace is the four year seasonal mean, i.e.  
the annual variation derived from four years of data.

The instrumental trend  
is less than 10 mK/year

The anomaly trend for  
 $sst1231-rtgsst$   
 $= 3 \pm 3$  mK/year  
for 4 years of daytime data  
(uncertainty 1 sigma)

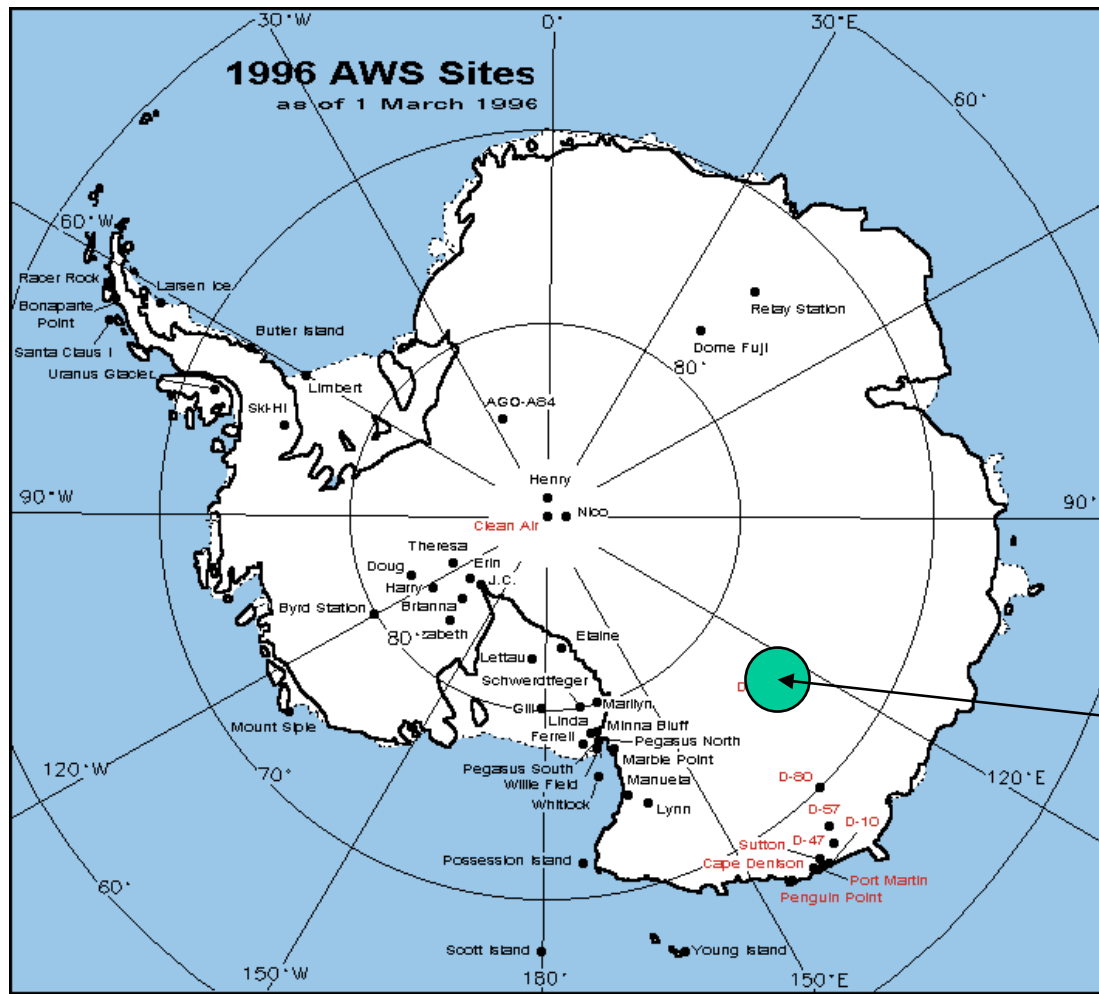


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Concordia Station is a research station located at DomeC on the Antarctic Plateau at latitude -75.1 and longitude E123.4, at 3260 m altitude.



DomeC





**Every day the EOS Aqua spacecraft makes 14 passes over DomeC**

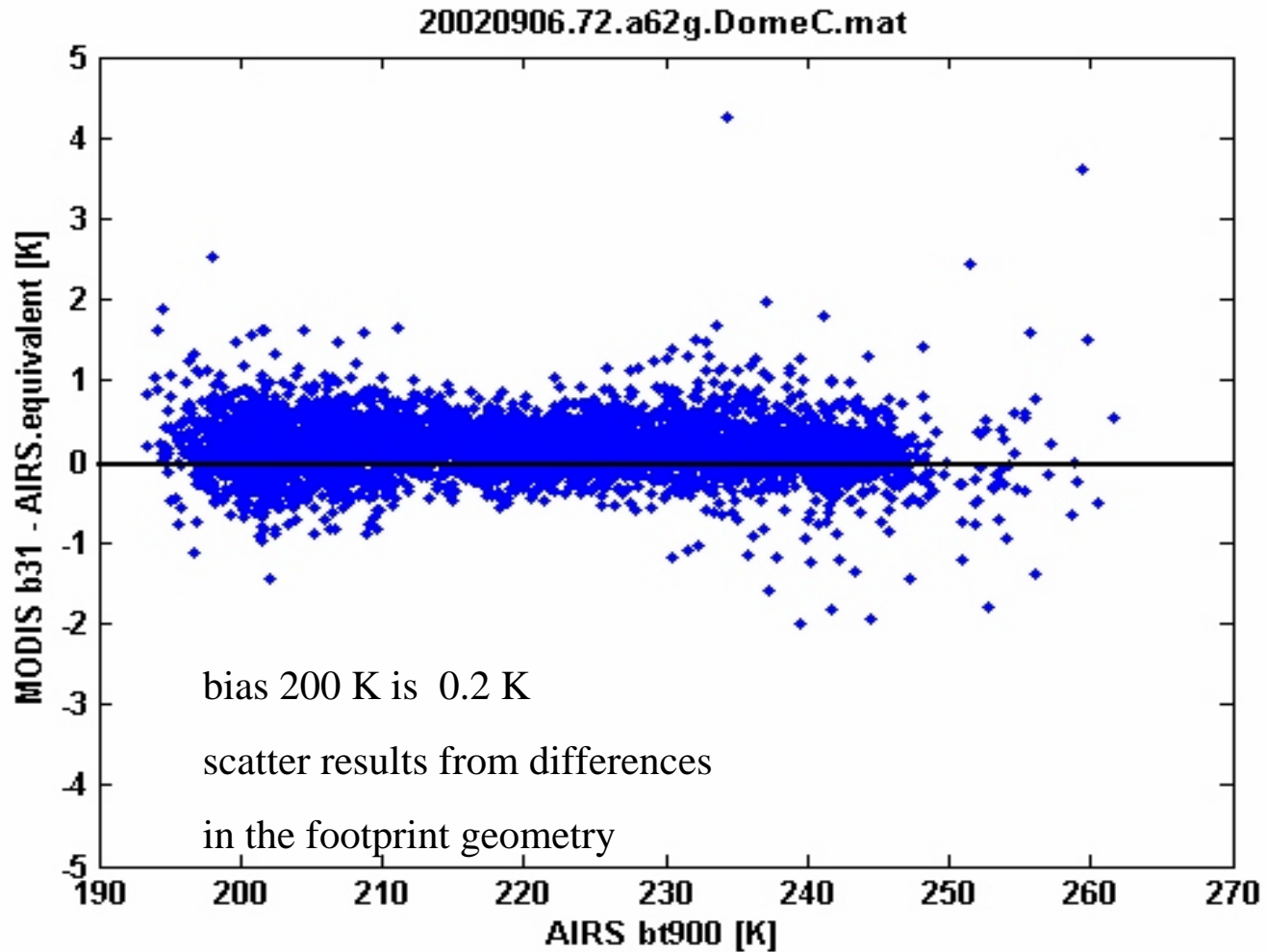
**For each pass we have collected all AIRS footprints which are centered within 50 km of the nominal position of Concordia Station. Typically this corresponds to about 230 footprints each day.**

**The absolute calibration of AIRS for 240 K temperatures has been validated at the 0.2 K level using spot checks from DomeC in January 2003 and 2004 (Walden 2006)**

**AIRS data comparisons with MODIS and HIRS/3 (Broberg 2006) over the Antarctic continent show agreement with a bias of less than 0.2 K for temperatures between 200 K and 260 K**



# The 20020906 granule 72 DomeC overpass comparison of MODIS and AIRS shows excellent agreement





**Now that we have established confidence in the stability and absolute accuracy of the AIRS data, we can evaluate the accuracy of the AWS data from Concordia Station**



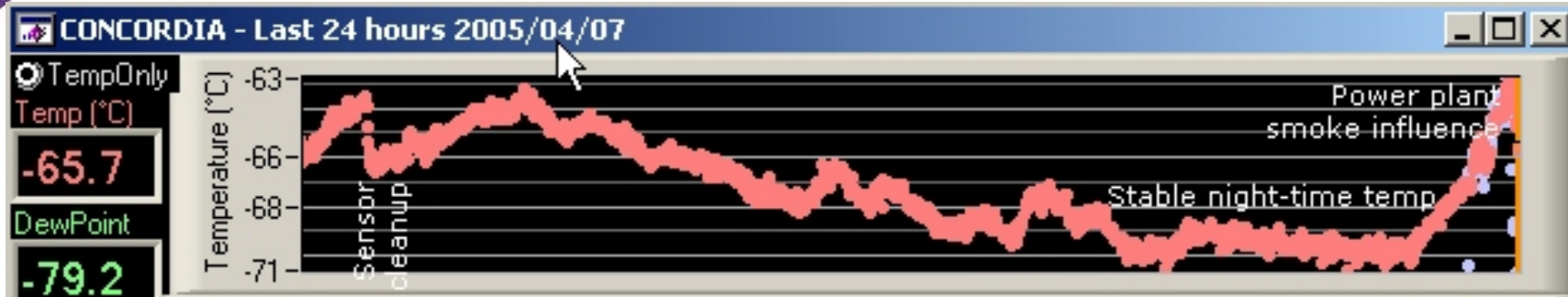
**There are two Automated Weather Stations (AWS) at DomeC**

**One AWS is managed jointly by the USA (Univ. of Wisconsin) and France (IPEV), called "Dome C II" with Argos ID 8989. Data are available from <http://uwamrc.ssec.wisc.edu/> since December 1995 at 10 minute intervals. We refer to this station as AWS8989.**





# The AWS8989 location is sensitive to thermal contamination



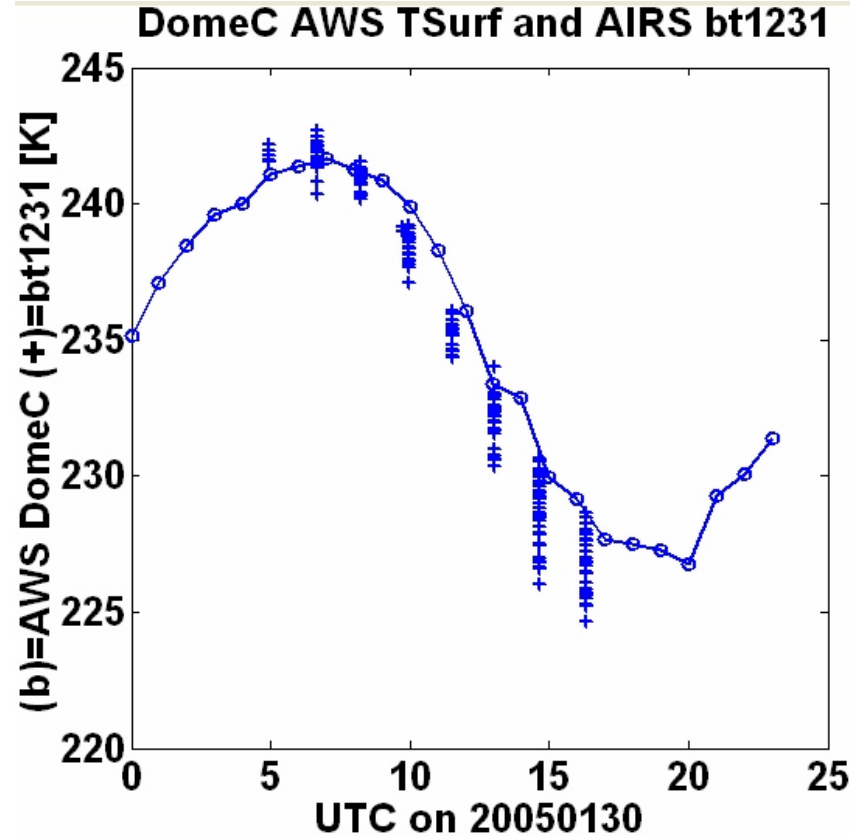
In 2005 researchers funded by the Italian Space Agency installed a new AWS at a location considered to be less sensitive than AWS8989 to thermal contamination from the power plant at Concordia Station . We refer to the data from the new site as AWS.it.

Measurements at AWS.it, taken every hour, are available from <http://www.climantartide.it/accesso-ai-dati/dati-stazioni-utenti.php?lang=en> from 27 January 2005 through 17 November 2005.

First we compare the AWS.it measurements with the AIRS 1231 cm-1 measurements, then we compare AWS8989 with AWS.it.



**AWS.it and the AIRS 1231 cm-1 channel agree very well.**

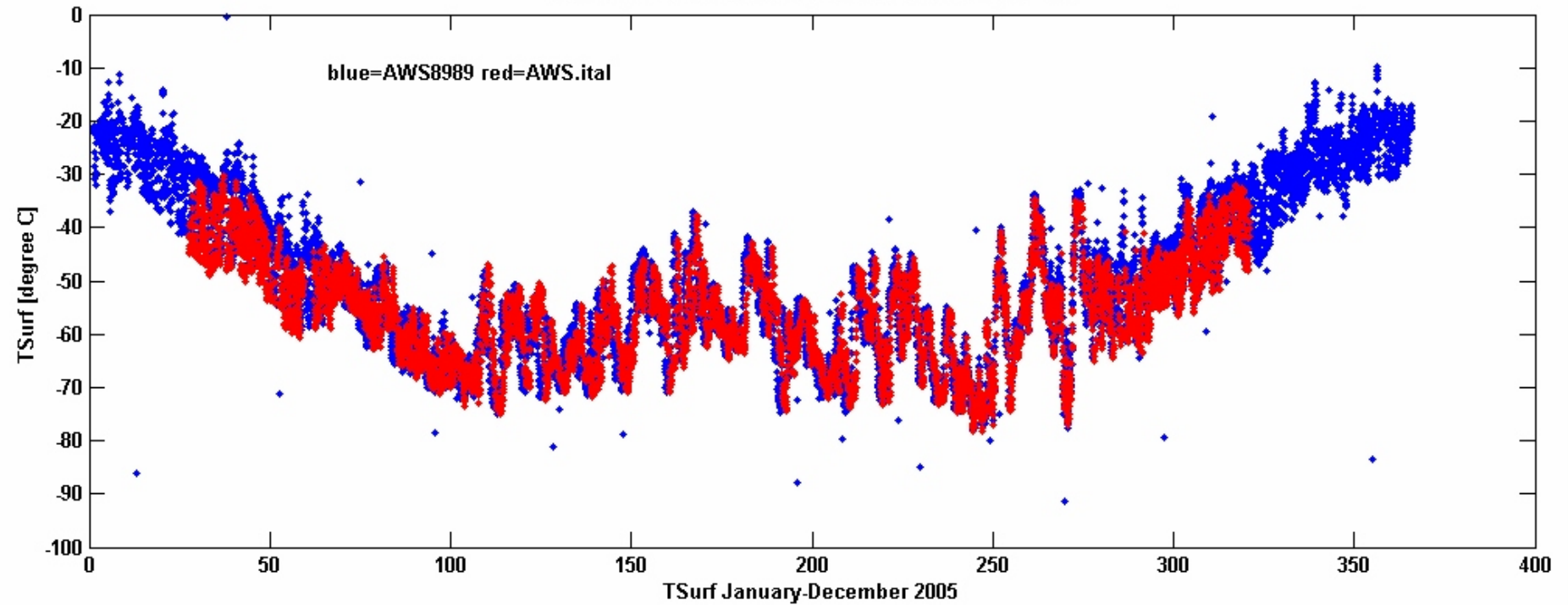


**The first complete day of AWS.it data, 20050130, had 8 overpasses of DomeC. All data within 50 km radius of the DomeC are shown**



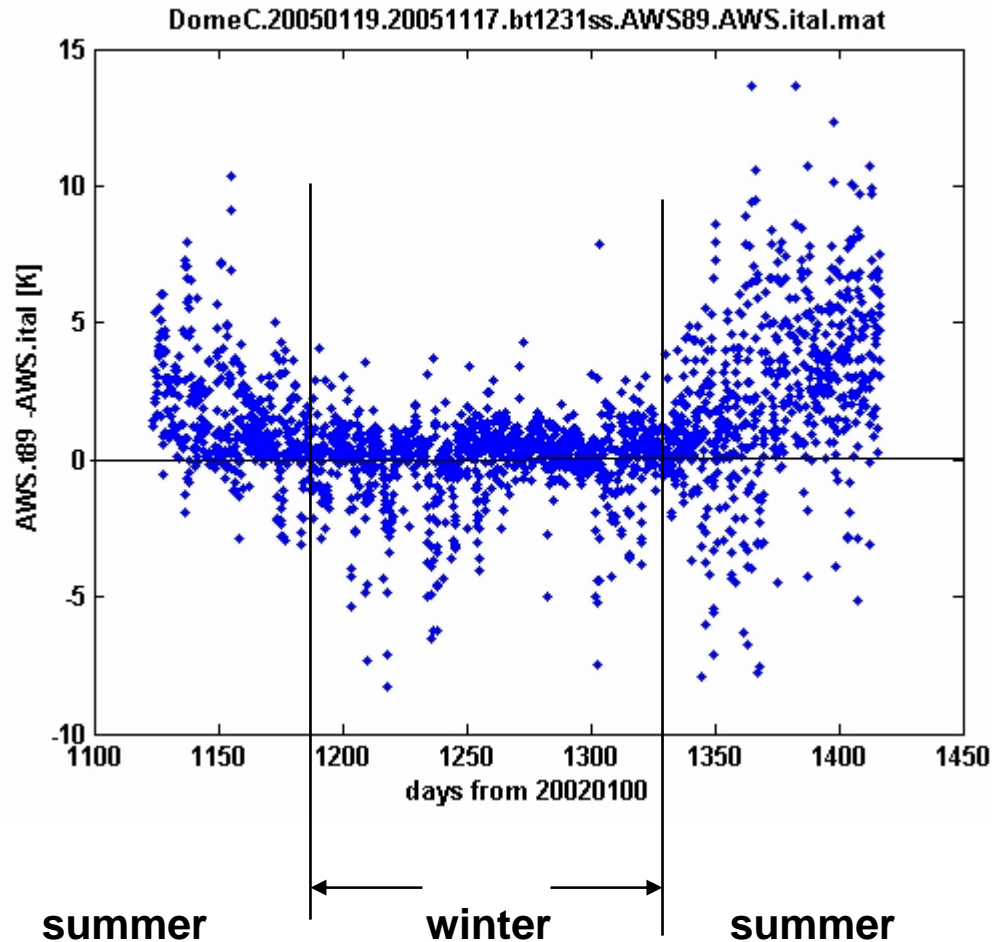
## The AWS899 reading agree qualitatively with AWS.it

AWS8989 and AWS ital. from two locations at DomeC





There is a season dependent bias between AWS8989 and AWS.it



During the summer the AWS89 reads 3 – 7 K warmer than AWS.it.







**The two AWS readings agree within 0.7 K during the Antarctic winter.  
Agreement during the summer is poor. AWS8989 is 3.7 K warmer than AWS.it.**

**AWS8989 temperature is systematically biased warm relative to AWS.it and AIRS.**

**AWS.it reads about 1.3 K warmer than AIRS bt1231.**



**AWS.it reads on average 1.3 K warmer than AIRS bt1231**

**Possible Reasons:**

- 1. AIRS bt1231 measures the temperature at the surface, AWS.it measures the air temperature 3 meter above the surface.**
- 2. The AIRS data could be cloud contaminated.**

**The effect surface emissivity, from ice/snow is only 0.3 K and is ignored in the following.**



## **1. Gradient between the surface and the AWS at 3 meters**

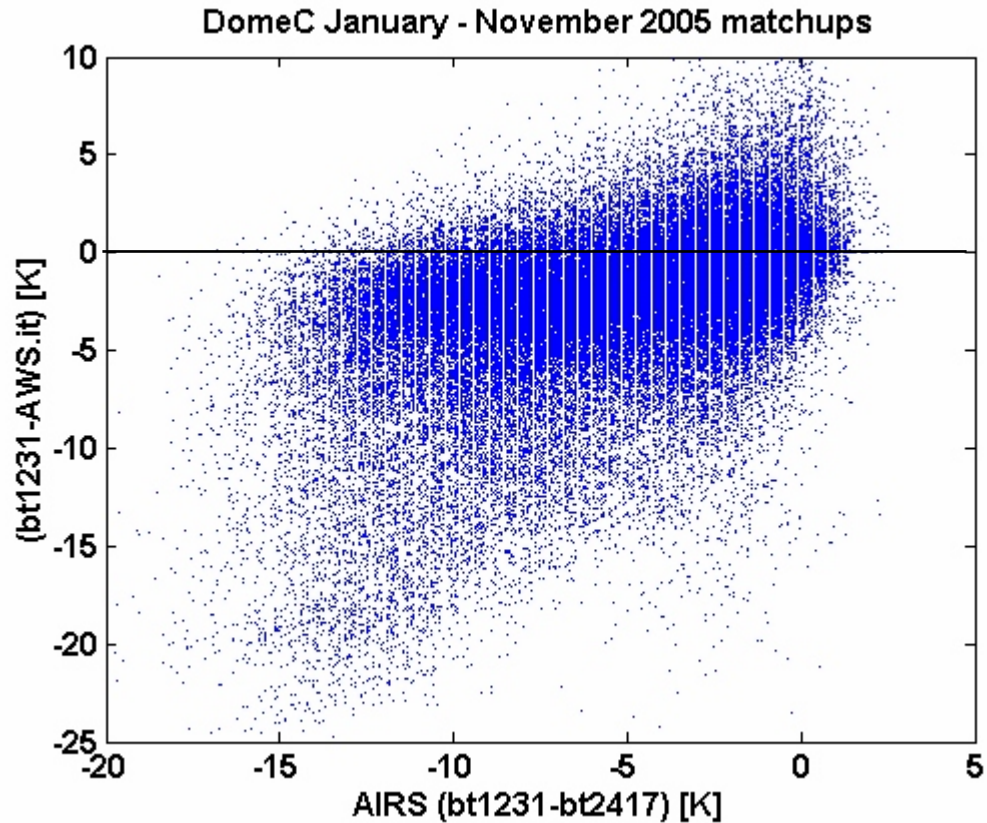
**AIRS bt1231 measures the temperature at the surface, AWS.it measures the air temperature 3 meters above the surface.**

**A typical temperature profile at DomeC has the temperature rising for the first 250 meter above the surface by as much as 25 K or more. The temperature then drops, but never again reaches the low temperature measured at the surface.**

**The gradient between the surface temperature and the air temperature in a 1 km thick layer above the surface at DomeC can be measured directly by AIRS as the difference between the 1231 cm<sup>-1</sup> surface channel and the 2417 cm<sup>-1</sup> CO<sub>2</sub> sensitive channel.**



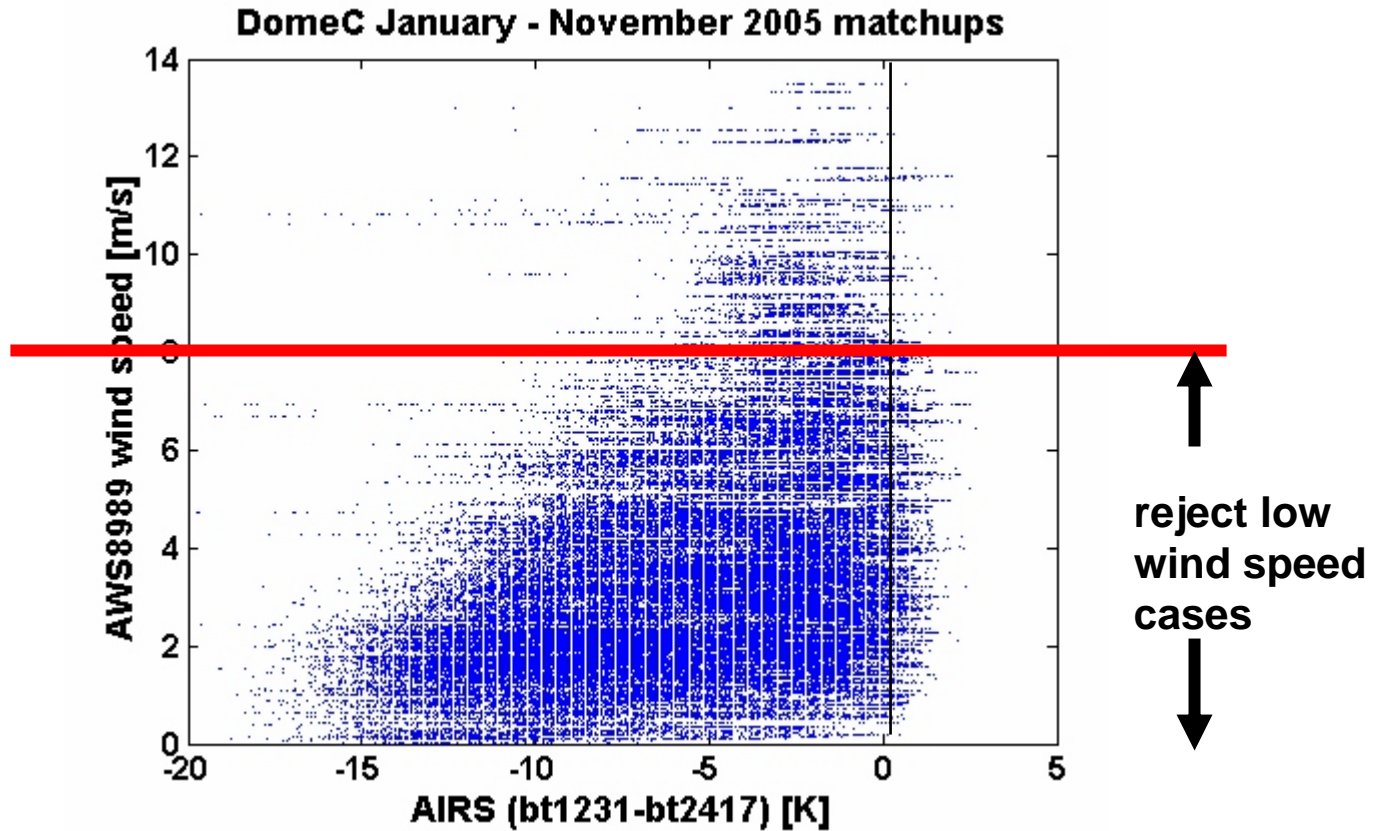
As the gradient between the surface and the mean air temperature in the 1 km layer above the surface increases, bt1231 becomes increasingly colder than ATW.it.



surface temperature – 1 km layer air temperature



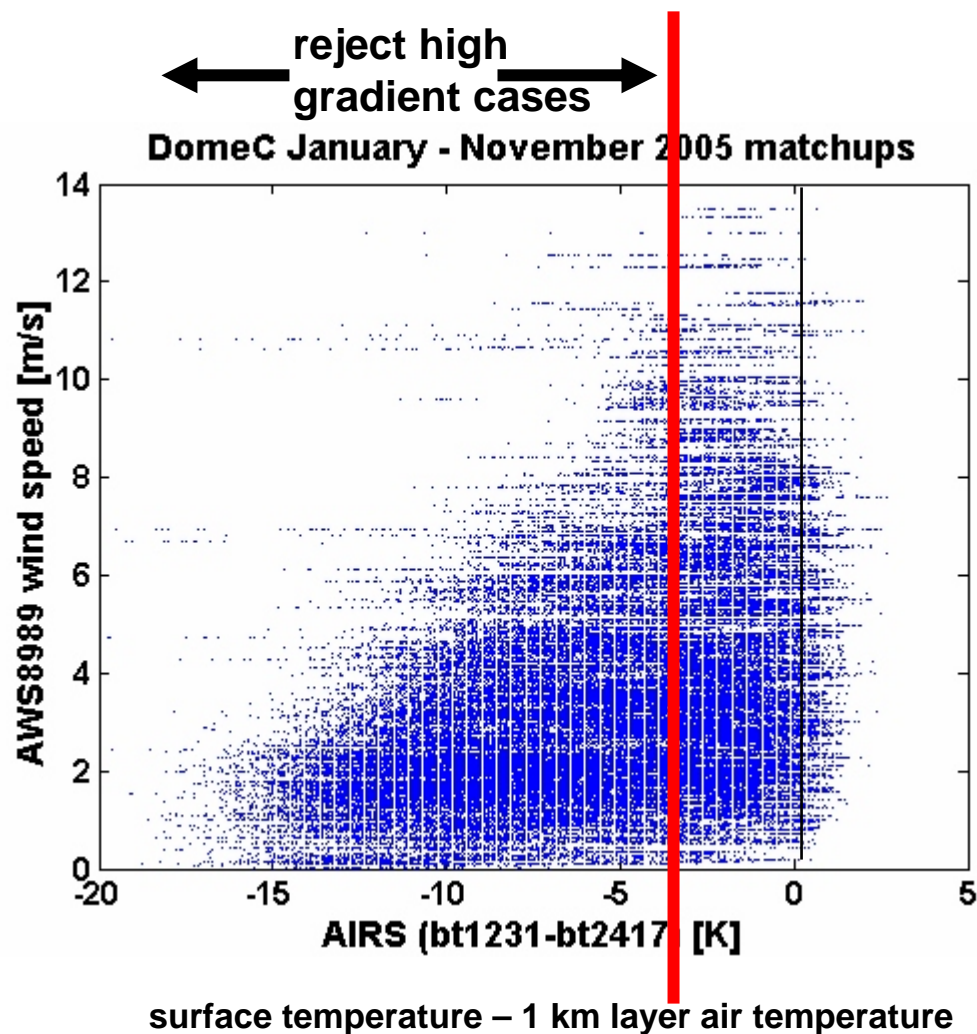
Strong surface inversions are not likely in the presence of surface wind.



surface temperature – 1 km layer air temperature



Filter out strong inversion using the AIRS 2417 cm<sup>-1</sup> sounding channel.





**If the data are filtered to eliminate large surface inversions, then AIRS bt1231 and AWS.it agree to within a fraction of a degree**

	bt1231-AWS.it	population stdev	yield
all matchups	-1.91 K		75661
v>6 m/s	-0.39 K	2.1 K	11264
v>8 m/s	-0.31 K	2.0 K	4221
bt1231- bt2417>-4 K	-0.30	2.5	31694
bt1231- bt2417>-3 K	-0.17	2.4 K	24689



**If the data are filtered to eliminate large surface inversions, AWS8989 has a warm bias of about 3 K**

	bt1231- AWS8989	population stdev	yield
all matchups	<b>-3.55 K</b>	3.27	75661
v>6 m/s	<b>-2.40 K</b>	2.4 K	11264
v>8 m/s	<b>-2.1 K</b>	2.1 K	4221
bt1231- bt2417>-4 K	<b>-3.27</b>	3.4 K	31694
bt1231- bt2417>-3 K	<b>-3.26</b>	3.5 K	24689





The warm bias of AWS8989 is larger in the summer than in the winter

	bt1231- AWS8989	bt1231- AWS.it	AWS8989- AWS.it
summer			+2.71 K
v>6 m/s	-2.85 K	-0.14 K	+2.26 K
bt1231-bt2417>-3 K	-4.16 K	-0.17 K	+3.72 K
winter			+0.36 K
v>6 m/s	-1.76 K	-0.99 K	+0.70 K
bt1231-bt2417>-3 K	-0.60 K	+0.06 K	+0.70 K

The difference between bt1231 and AWS.it is small and independent of season



**The warm bias of AWS8989 is not limited to the data from 2005.**

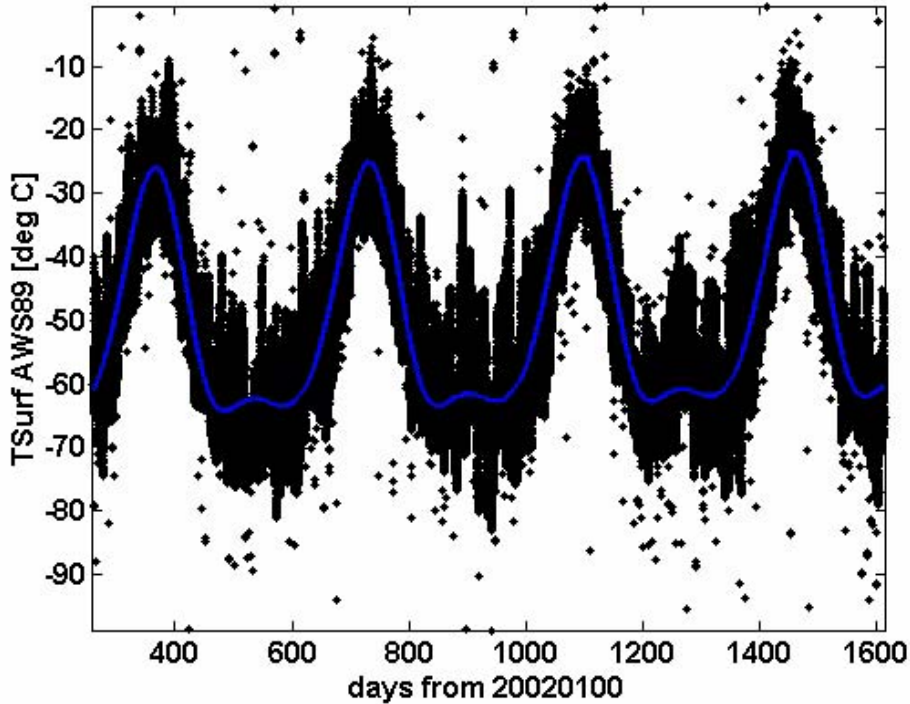
**For the 2002-2006 period the AWS8989 station the mean temperature reported by AWS8989 was 5 K warmer than the mean temperature measured by AIRS in a 50 km radius centered on AWS8989.**

**A warm bias of comparable magnitude has been seen in the comparison of MODIS Aqua data with AWS8989. (2006 priv. comm. J. Xiong, MODIS Calibration team)**

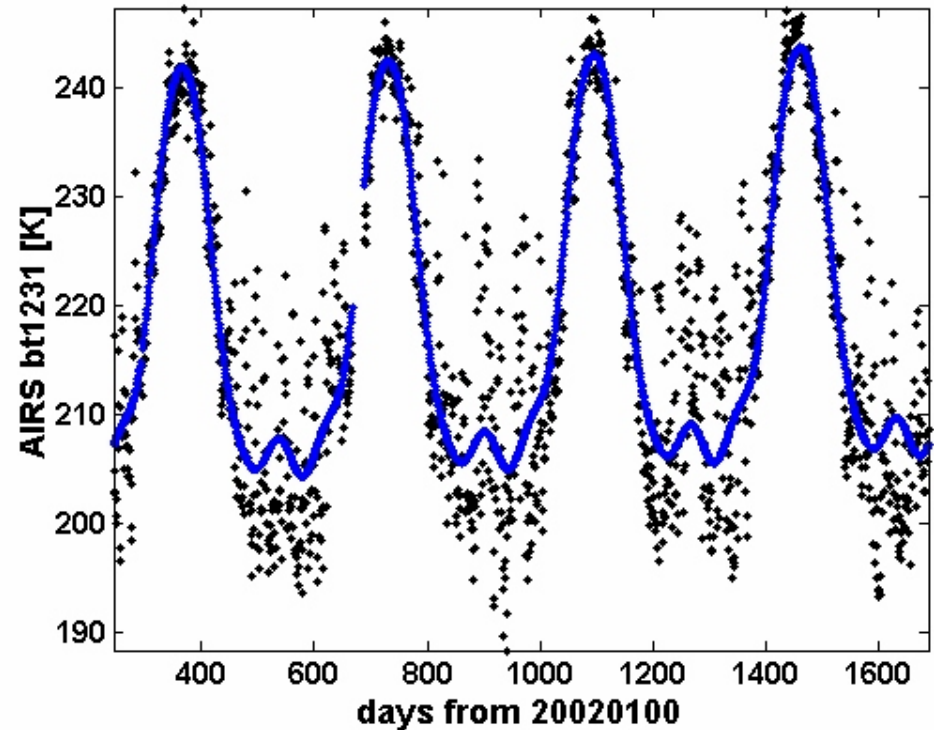


The AWS8989 between September 2002 and May 2006 reported a mean temperature of 220.5 K. For the same period the AIRS 1231 cm-1 window channel finds a mean of 215.5 K

AWS8989.DomeC.1996-2006.mat



DomeC.c8.1.ACDS.200209-200608





## **2. Cloud effects are not detected**

**Could the agreement between AIRS and AWS.it be accidental, i.e AIRS bt1231 has 1 K of undetected cold cloud contamination. and the calibration of AWS.it happens to be cold by 1 K ?**

**This is extremely unlikely, because the clouds have to be colder than the surface to create a cold bias. This is inconsistent with the typical vertical temperature profile at DomeC. The temperature above the surface is always warmer than the surface.**



## Conclusions

**AWS.it was installed because of concern about thermal contamination of the AWS8989 location by the increase in activity at DomeC.**

**We conclude that this concern was justified:**

**There is a 3 K season dependent warm bias in AWS8989, with more bias during the summer season (when there is more activity at DomeC).**

**AWS.it appears to be in a better location and agrees with AIRS temperatures within a fraction of a degree, if data with large surface inversions are filtered out.**

**An AWS.it quality station could be used for the validation of polar orbiting satellites. Unfortunately, AWS.it data has been available only for 11 months in 2005.**



## **Conclusions (continued)**

**Due to the warm bias and thermal contamination the AWS8989 station has limited potential for the validation of polar satellite calibration accuracy, even if data with the strong surface air gradients are eliminated.**

**An AWS.it quality instrument could be useful for the quick-look validation of polar satellites.**

**The report of the unexpected much faster warming in the Antarctic over the past decade than the global average has to be re-evaluated with respect to potential thermal contamination of the instrumentation.**



# Thank you for our attention.

The AIRS data are freely available from the DAAC at GSFC

To learn more about AIRS visit [www.jpl.nasa.gov/airs](http://www.jpl.nasa.gov/airs)

For the effect of smoke from the power plant at Concordia Station on AWS8989 temperatures and an insiders story about life at Concordia Station see [www.gdargoud.net/Antarctica/WinterDC3.html](http://www.gdargoud.net/Antarctica/WinterDC3.html)







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### Significant Warming of the ANTARCTIC Winter Troposphere

J. TURNER,\* T. A. Lachlan-Cope, S. Colwell, G. J. Marshall, W. M. Connolley

We report an undocumented major warming of the ANTARCTIC winter troposphere that is larger than any previously identified regional tropospheric warming on Earth. This result has come to light through an analysis of recently digitized and rigorously quality controlled ANTARCTIC radiosonde observations. The data show that regional midtropospheric temperatures have increased at a statistically significant rate of 0.5° to 0.7°Celsius per decade over the past 30 years. Analysis of the time series of radiosonde temperatures indicates that the data are temporally homogeneous. The available data do not allow us to unambiguously assign a cause to the tropospheric warming at this stage.

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International TOVS Study Conference, 15<sup>th</sup>, ITSC-15, Maratea, Italy, 4-10 October 2006  
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,  
Cooperative Institute for Meteorological Satellite Studies, 2006.