Intercomparison of Surface Temperatures from AIRS, MERRA, and MERRA-2 with Greenland Weather Stations

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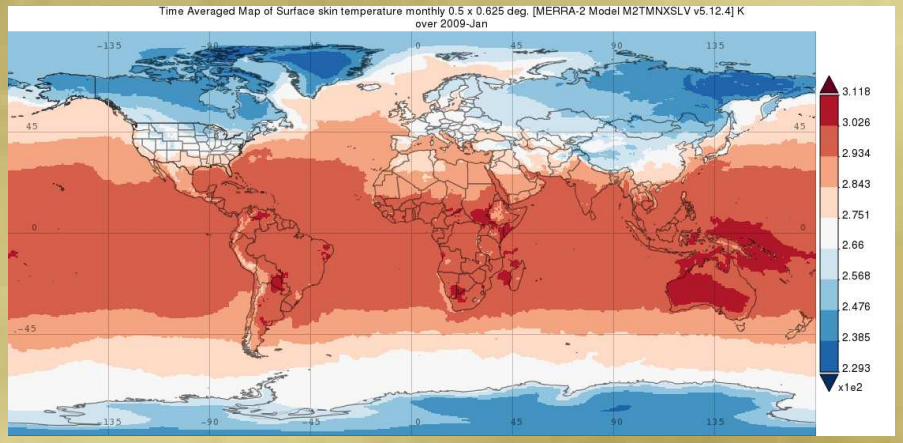
Introduction

We examined the AIRS surface skin and air temperatures at Summit, Greenland.

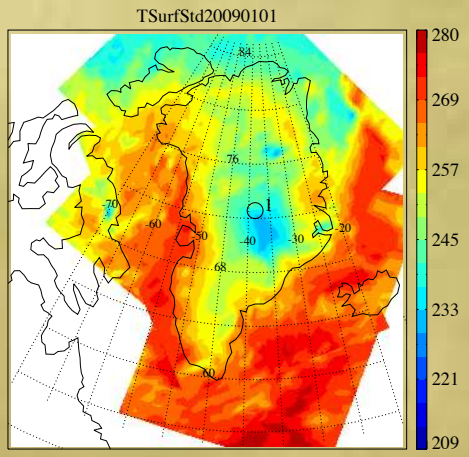
1. The AIRS surface temperature may be useful to fill the gaps in in-situ measurements with consistency and stability.
2. At high latitutes AIRS can obtain 4 to 5 measurements of the surface temperature per day which can compliment in-situ measurements and re-analysis to monitor the whole Greenland surface environment.
3. Greenland ice sheet melt is expected to respond rapidly to surface temperature.
4. The GES DISC is developing the capability to match swath data with station and possibly air-borne measurements.

Grid, Swath, and Point Data

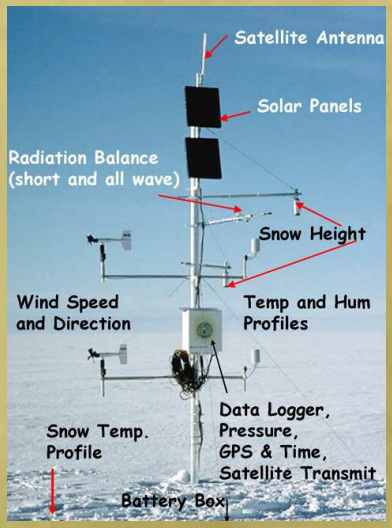
MERRA/MERRA–2 Grid Data



AIRS L2 Swath Data



Ground Station Point Data



- We compare NASA **grid** (MERRA/MERRA-2) and **swath** (AIRS) data to NOAA and GC-Net **point** measurements at Summit, Greenland.
- The MERRA/MERRA-2 and station data are reported hourly.
- There are typically 4-5 AIRS overpasses per day at Summit.

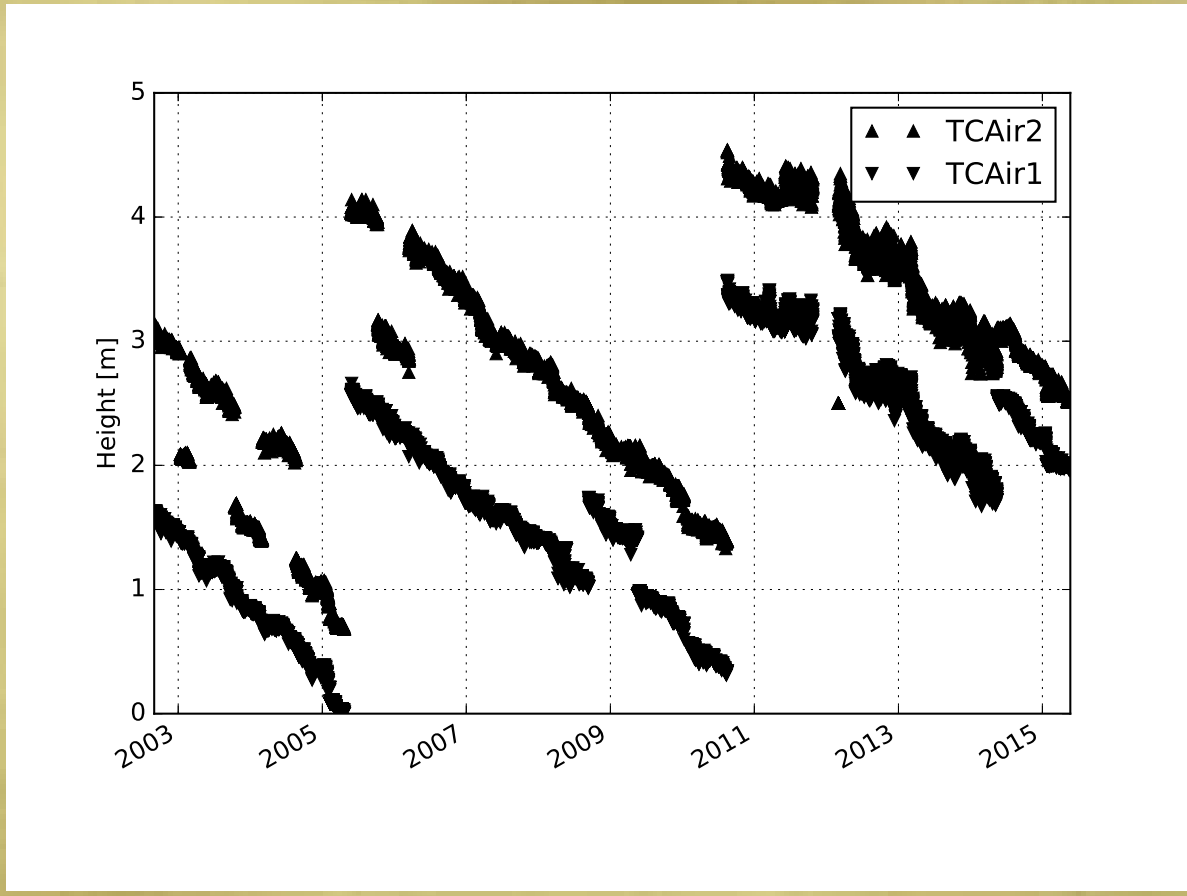
MERRA, MERRA-2 and AIRS

We created a subset of the following AIRS, MERRA, and MERRA-2 variables that are matched in space and time with the station observations. All AIRS observation within a radius of 30 km and 30 minutes are included.

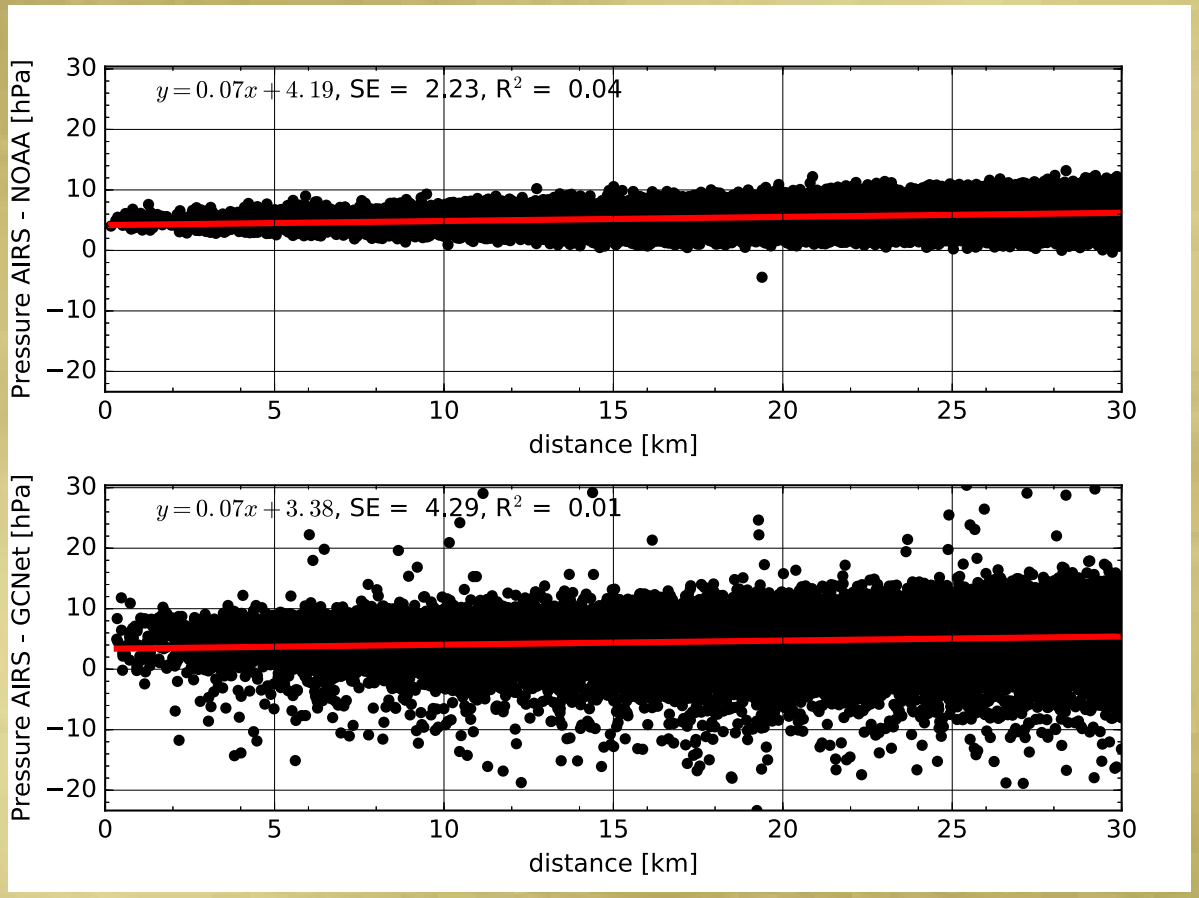
- AIRX2RET (TSurfStd, TSurfAir, CldFrcTot, SurfClass, PSurfStd, solzen)
- AIRI2CCF (scanang)
- AIRABRAD (brightness_temp)
- MAT1NXSLV (TS, T2M, T10M)
- M2T1NXSLV (TS, T2M, T10M)

Station Data

- The NOAA Station measures the 2-meter and 10-meter temperatures
- The GC-Net Station measures $\sim$1-meter and $\sim$2-meter temperatures

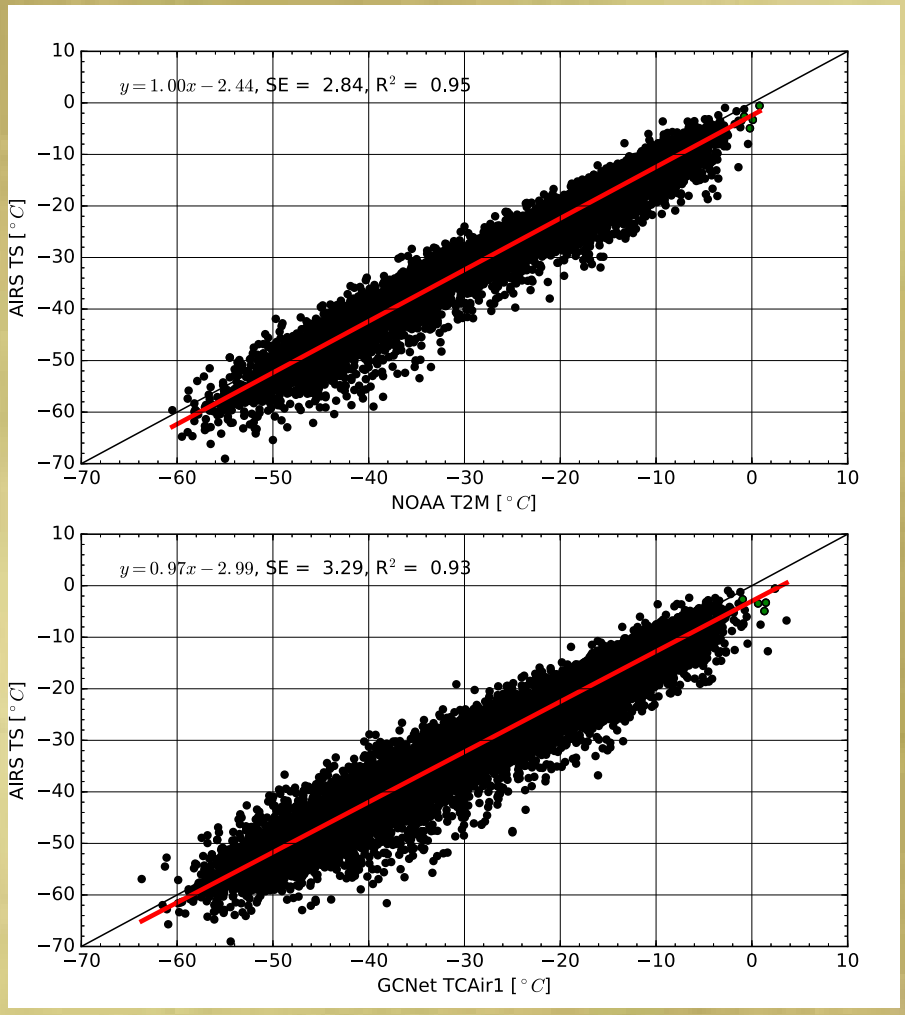


Surface Pressure



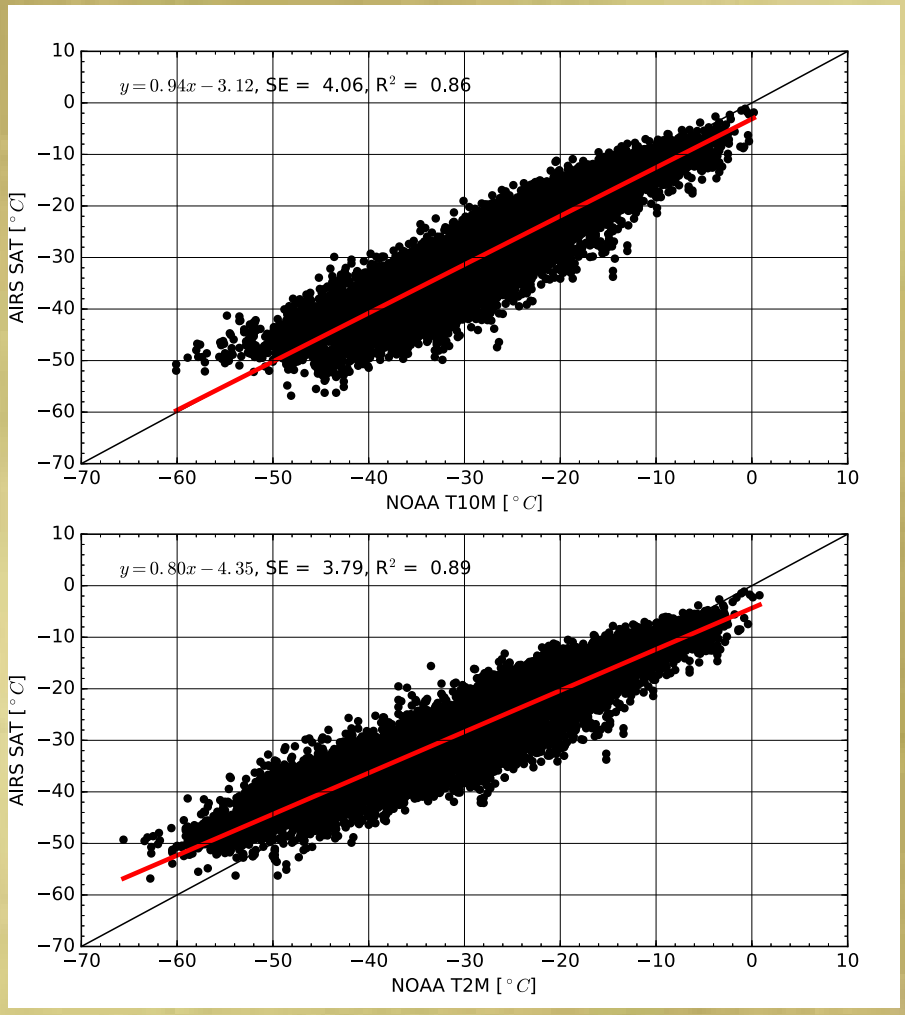
- Both stations have a slight offset with respect to PSurfStd probably because they are located at the Summit.
- GC-Net pressure has a larger standard error.

AIRS Surface Skin Temperature



- The AIRS **surface** Temperature TS is well correlated with the station **air** Temperatures T2M and TCAir1.
- The TCAir1 has a larger standard error probably because the GC-Net sensors are not held at a fixed height for the entire time period. The GC-Net sensors are also not shielded.
- The weather station temperatures may be warmer because they are higher in the inversion layer.
- The SurfClass reported that the green symbols were land (more on this later).

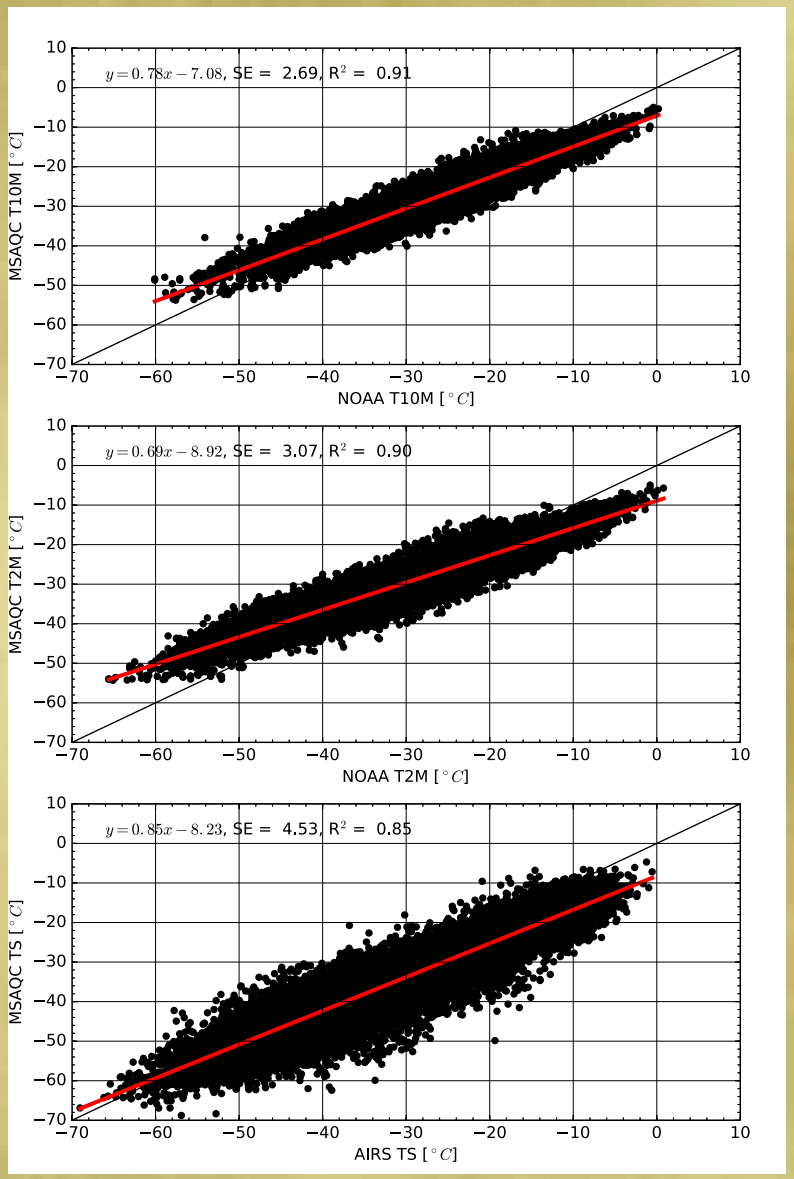
AIRS Surface Air Temperature



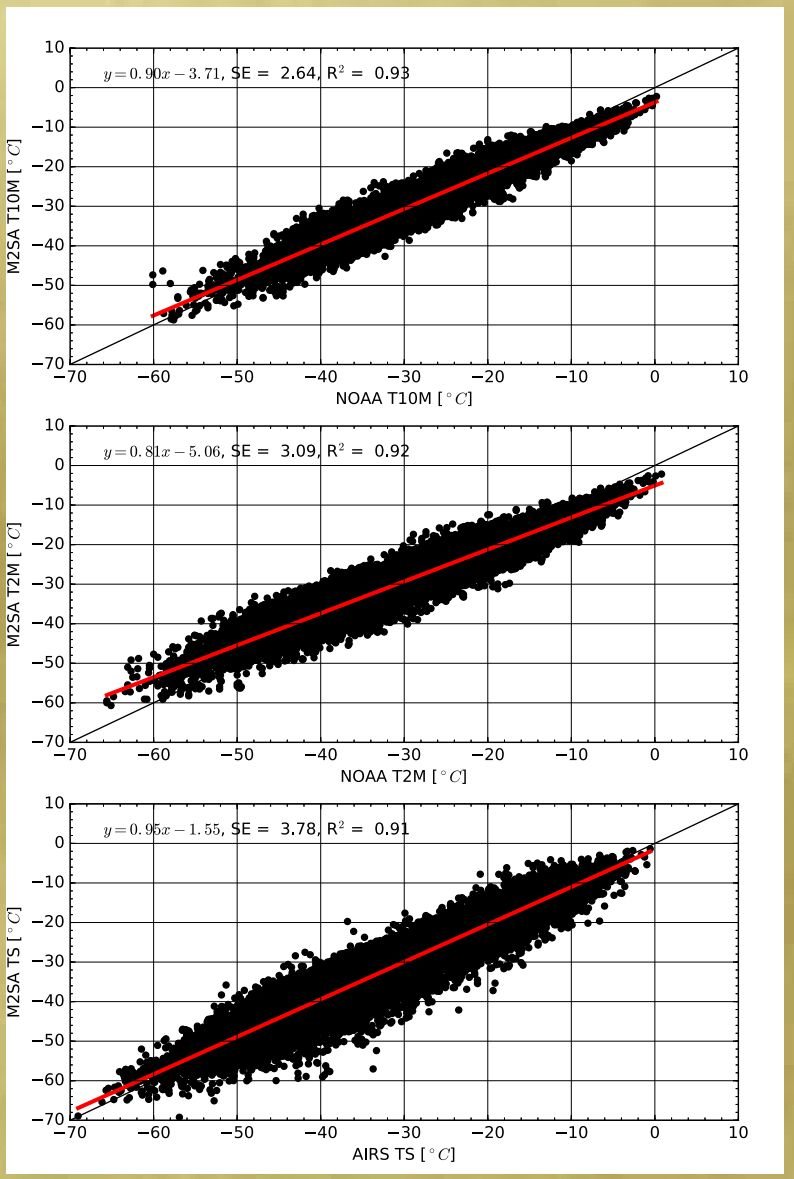
- The AIRS surface **air** temperature has a better correlation with the 2-meter temperature (bottom panel) than the 10-meter temperature (top panel) but many of the measurements have a warm bias at cold temperatures.
- The extrapolation of the temperature profile to the surface pressure probably does not fully account for the strong inversions and thus may be more representative of temperatures higher in the atmosphere.

MERRA and MERRA-2 Data

MERRA



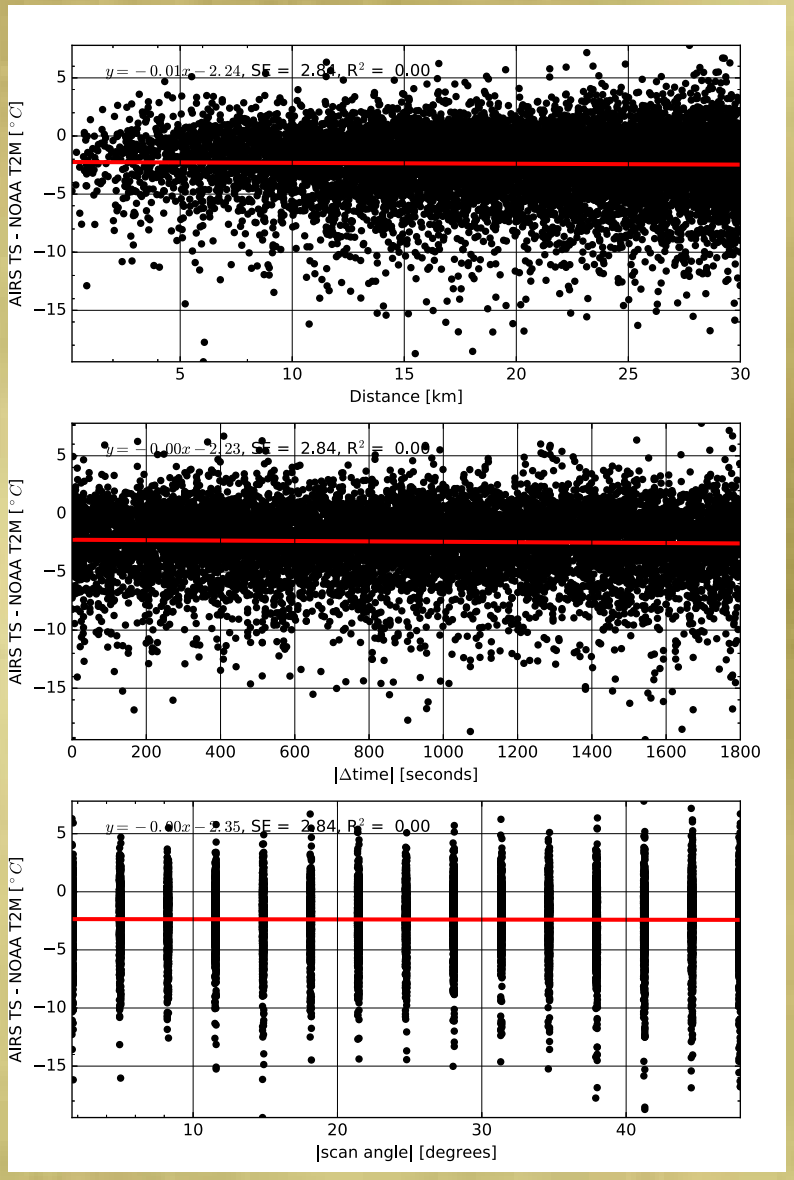
MERRA-2



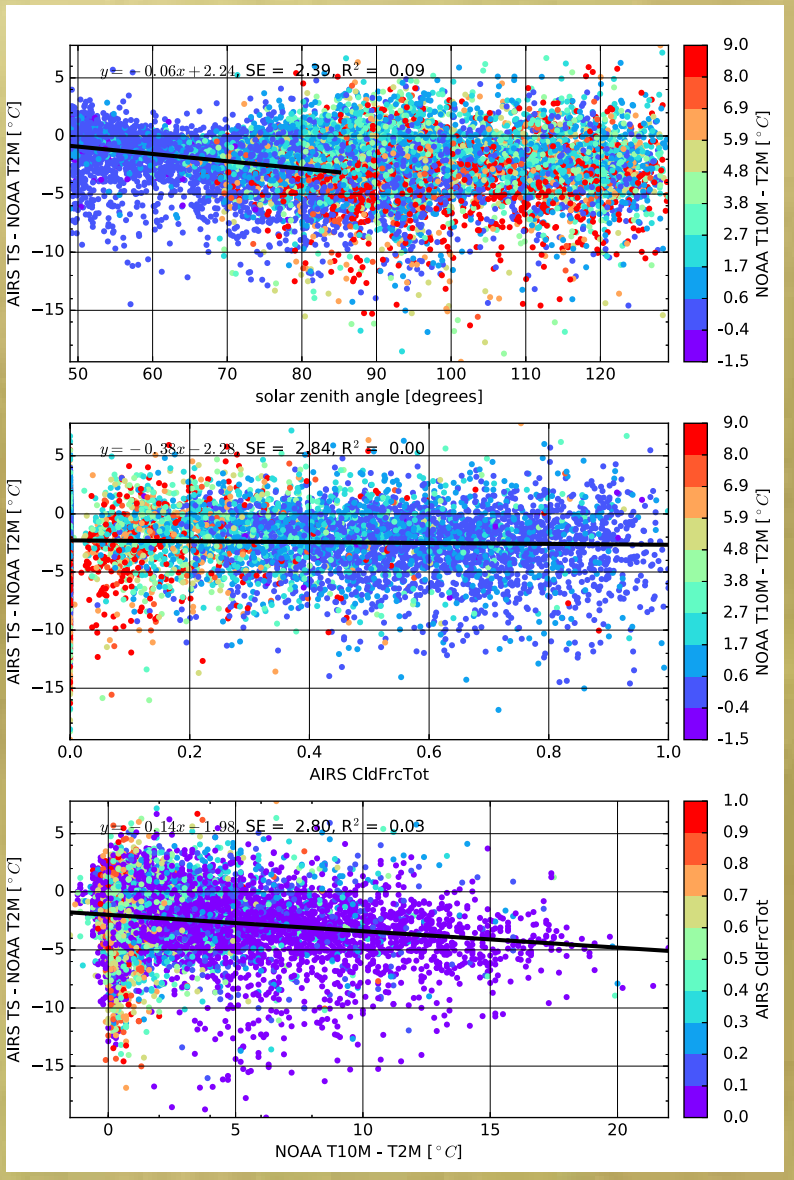
MERRA-2 shows improvements (less rotation and smaller errors) over MERRA due to improved surface modeling.

Observing Conditions

Geometrical



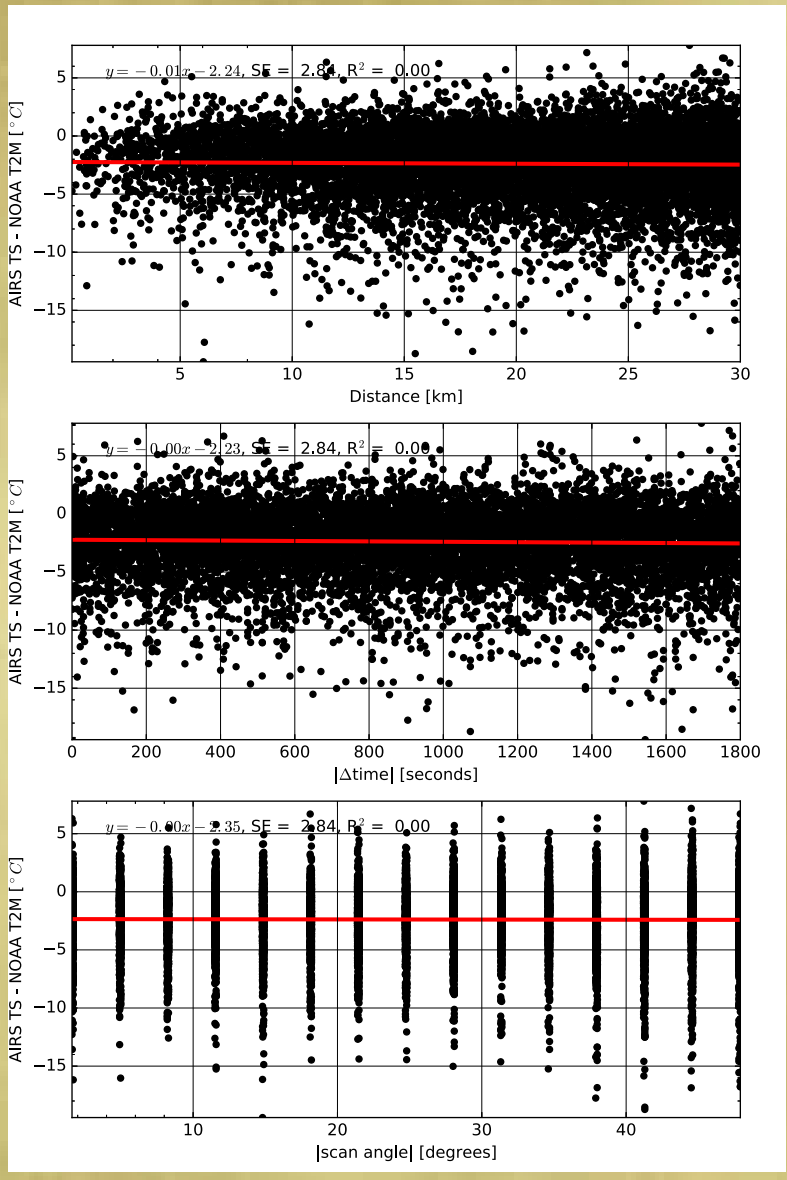
Environmental



We examined geometrical and environmental effects on the AIRS Surface Temperature.

Observing Conditions

Geometrical



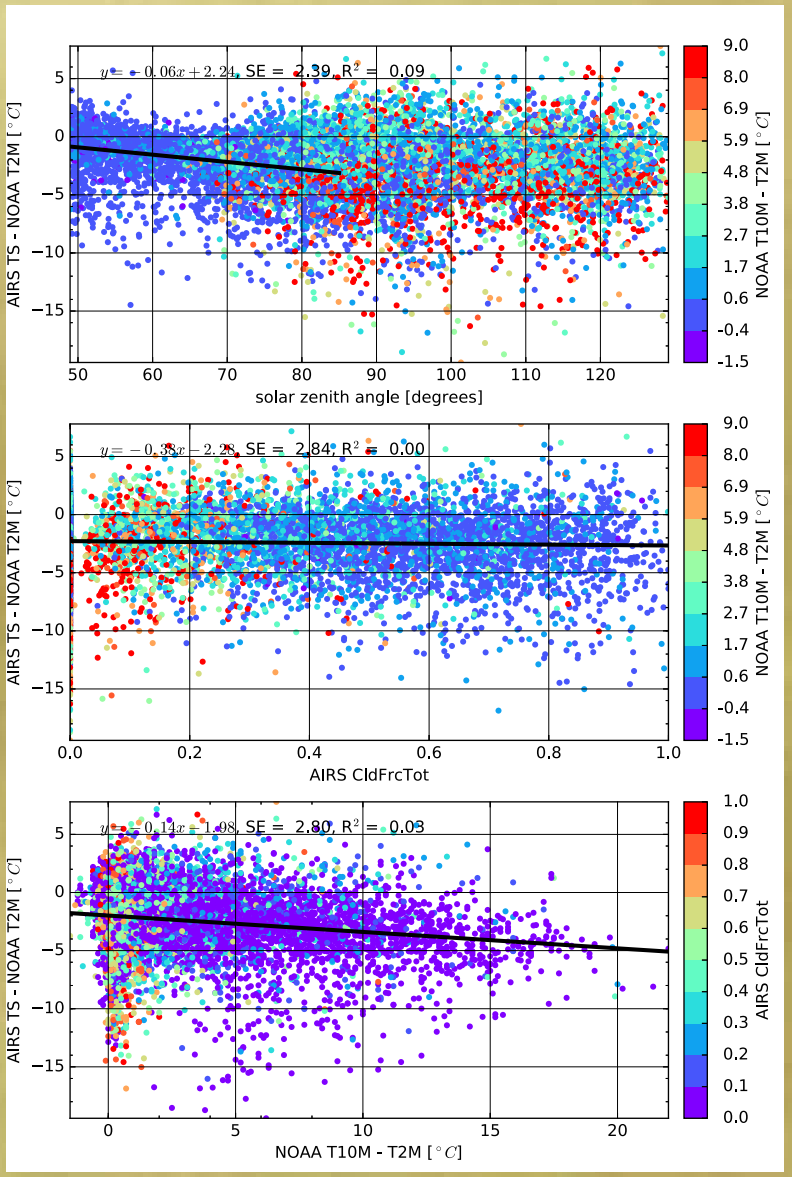
We found very little dependence on the **geometrical** factors considered which are

- **Distance** of the AIRS footprint from the station (top panel).
- **Δtime** offset (middle panel).
- **Scan Angle** (bottom panel).

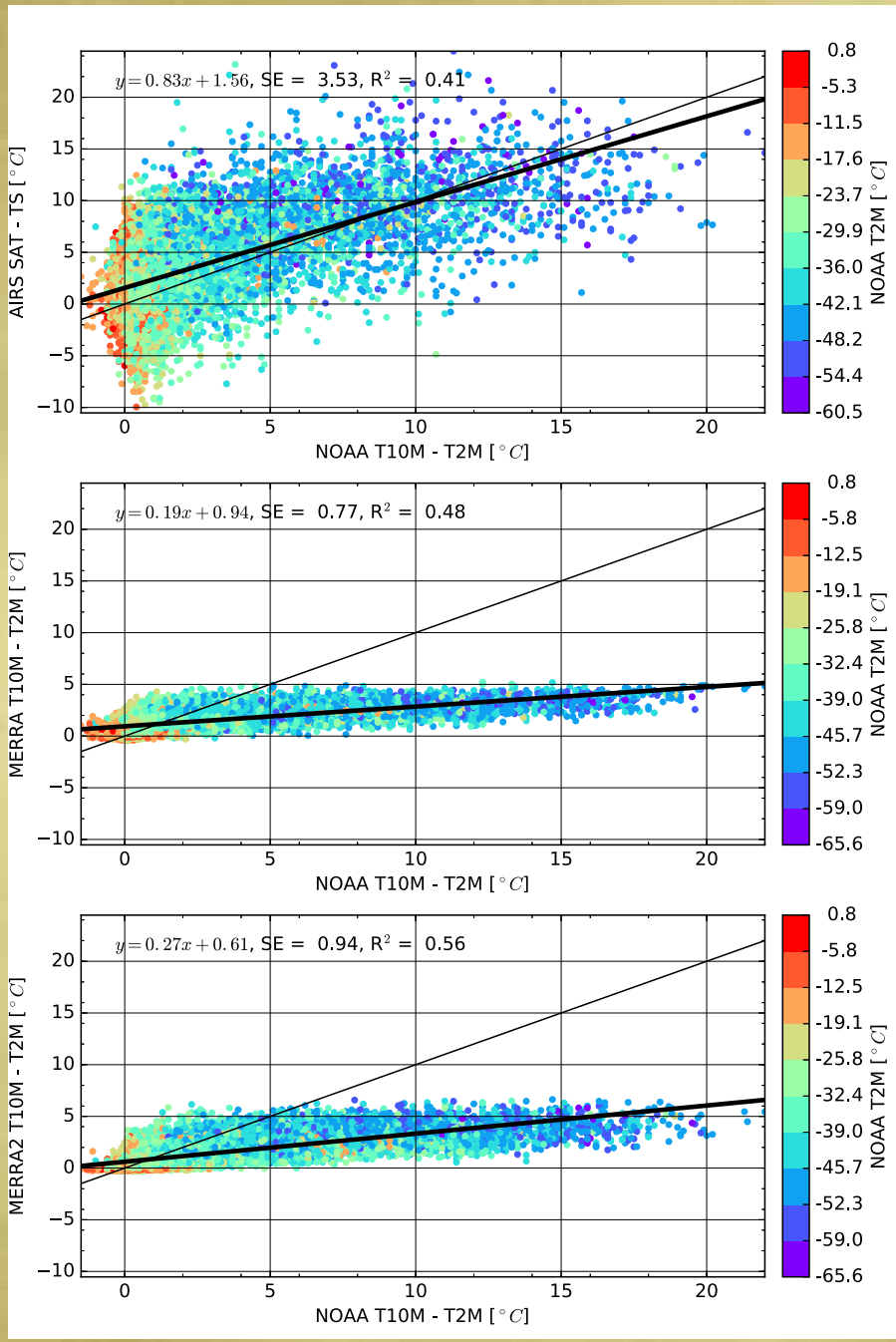
Observing Conditions

Environmental

- The top panel shows that there is a dependence on the **solar zenith angle**. The color of the symbols represents the near surface **inversion strength** which we estimate as the NOAA 10-meter - 2-meter temperatures. Note: The strongest inversions occur during the polar night and correspond with greater differences between the AIRS surface and NOAA 2-meter air temperatures.
- The middle panel shows that there is very little dependence on the **cloud fraction**.
- The bottom panel shows that there is a dependence on the inversion strength. This may explain the **solar zenith angle** dependence seen in the top panel.

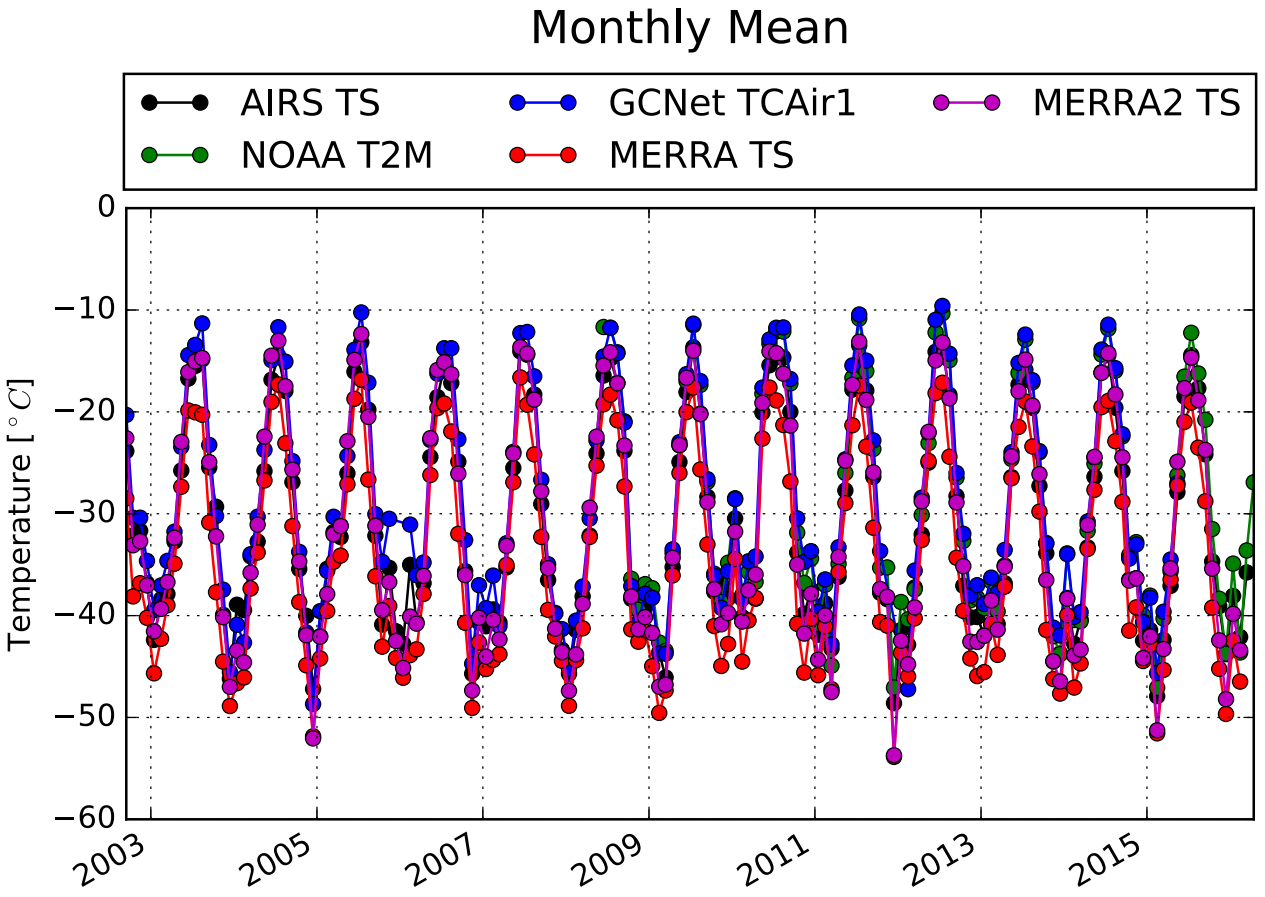


Inversion Strength



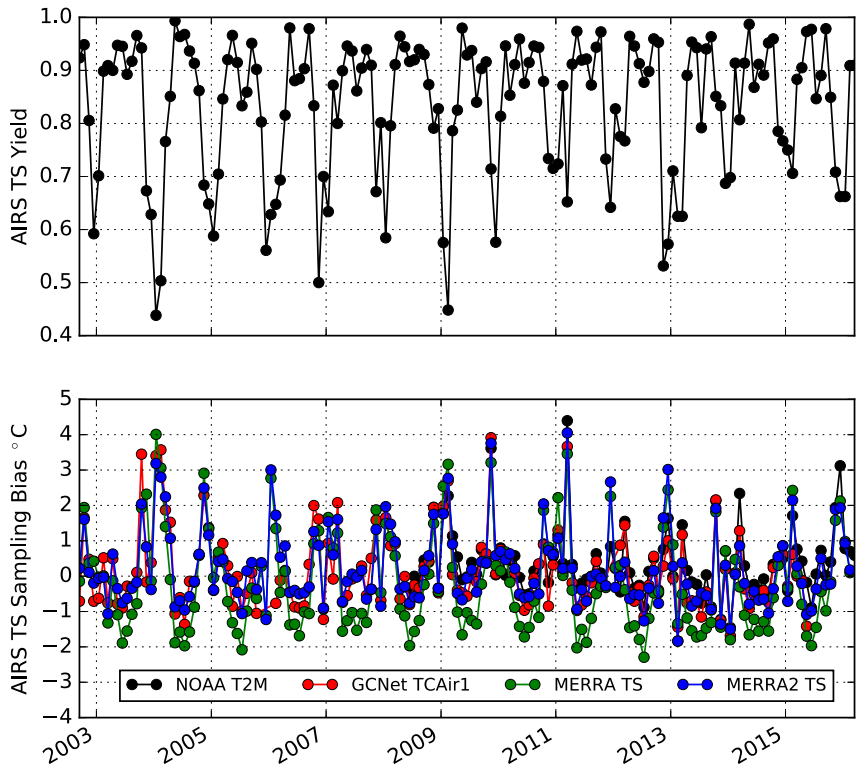
- Several different measures of the near surface inversion strength are compared to the 10-meter - 2-meter temperature difference measured at the NOAA station.
- The difference between the AIRS surface air and surface skin temperatures (**TSurfAir - TSurfStd**) shows more skill at detecting near surface temperature inversions than MERRA or MERRA-2.

Monthly Mean Time Series



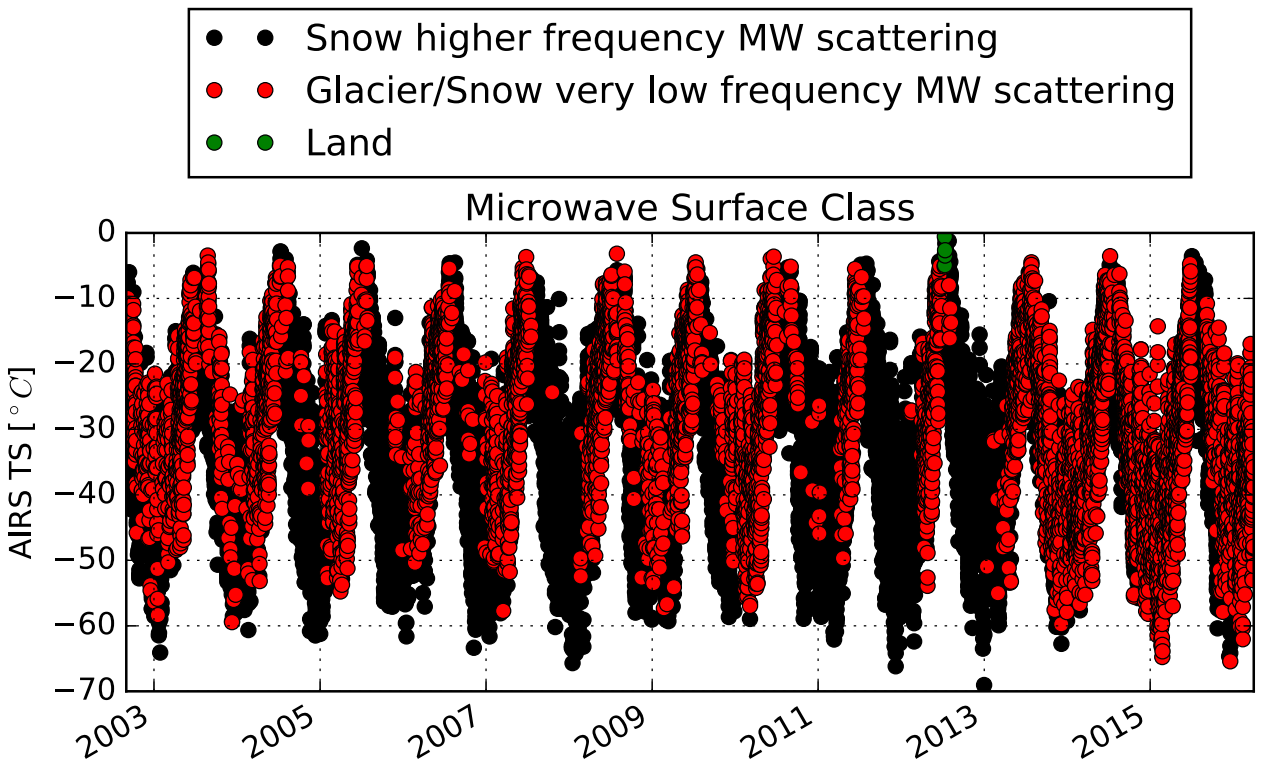
A time series of monthly mean values of AIRS TS, MERRA and MERRA-2 TS, GC-Net TCAir1, and NOAA T2M shows that they all agree fairly well.

Sampling Bias



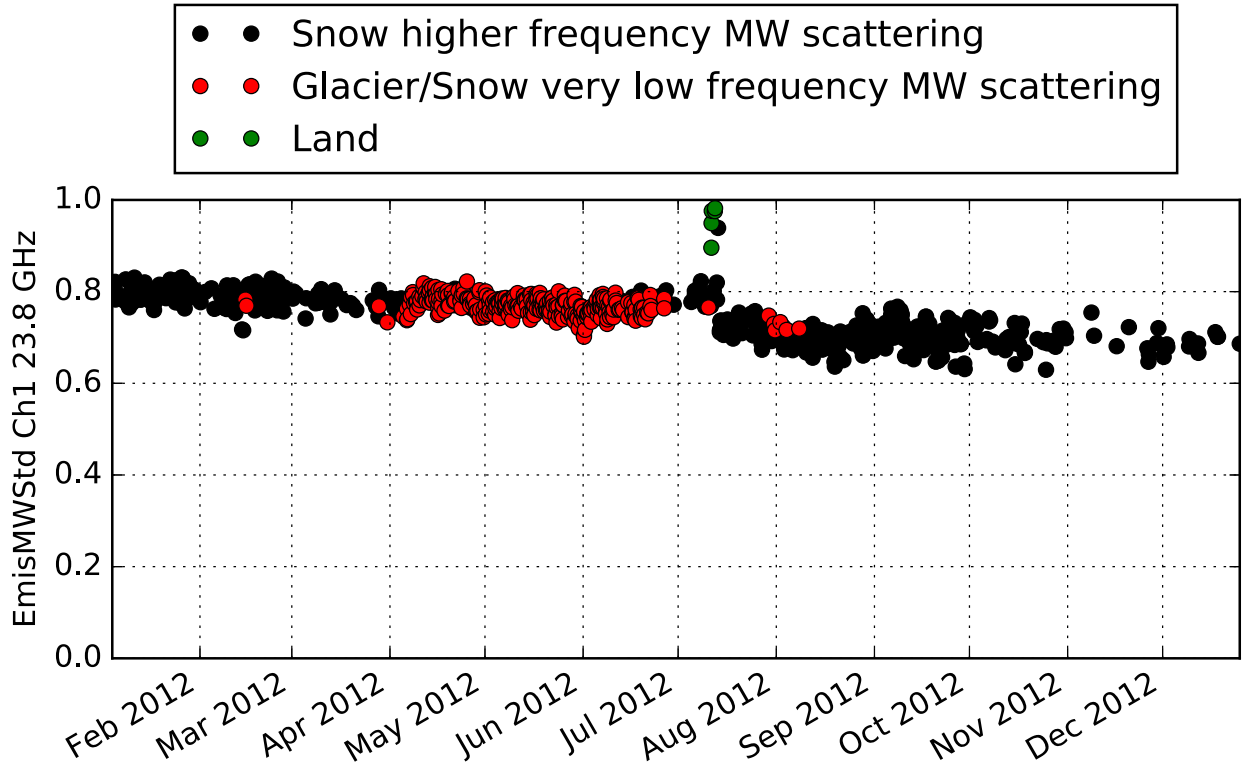
The difference between the correlative data sets averaged with and without AIRS quality control applied shows that the sampling bias of monthly mean estimates can be as large as 4 degrees during the winter months.

Summer of 2012



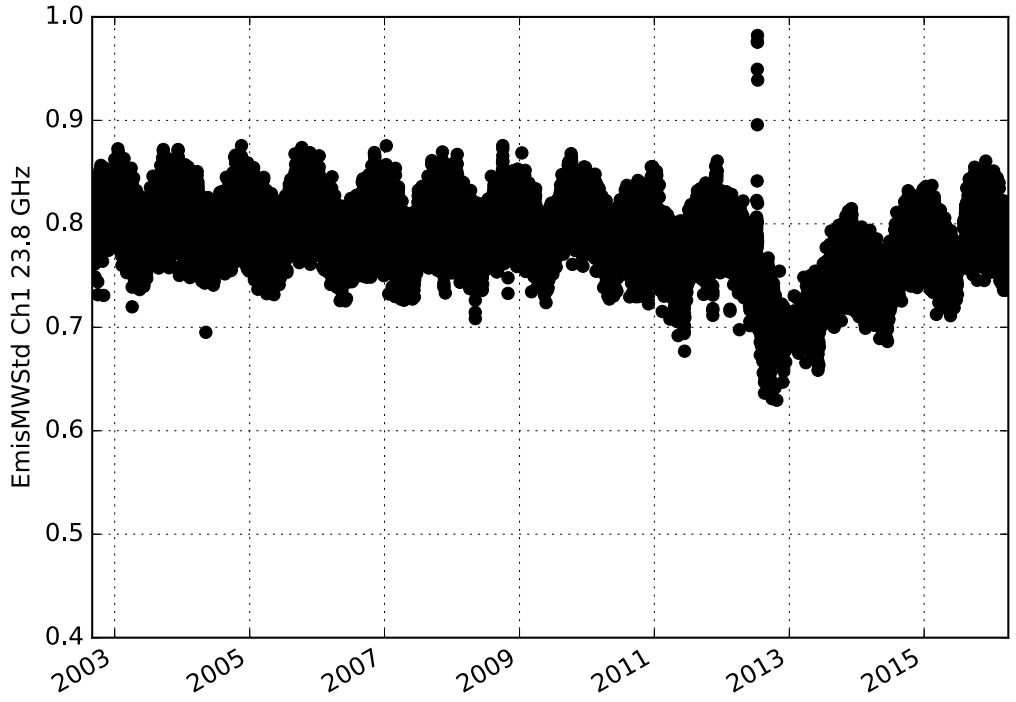
The surface was classified as “land” in July 2012 when melting was observed at the summit.

Microwave Emissivity



A time series of MW Channel 1 emissivity shows that there was a change in the MW Emissivity associated with the melt event.

Microwave Emissivity



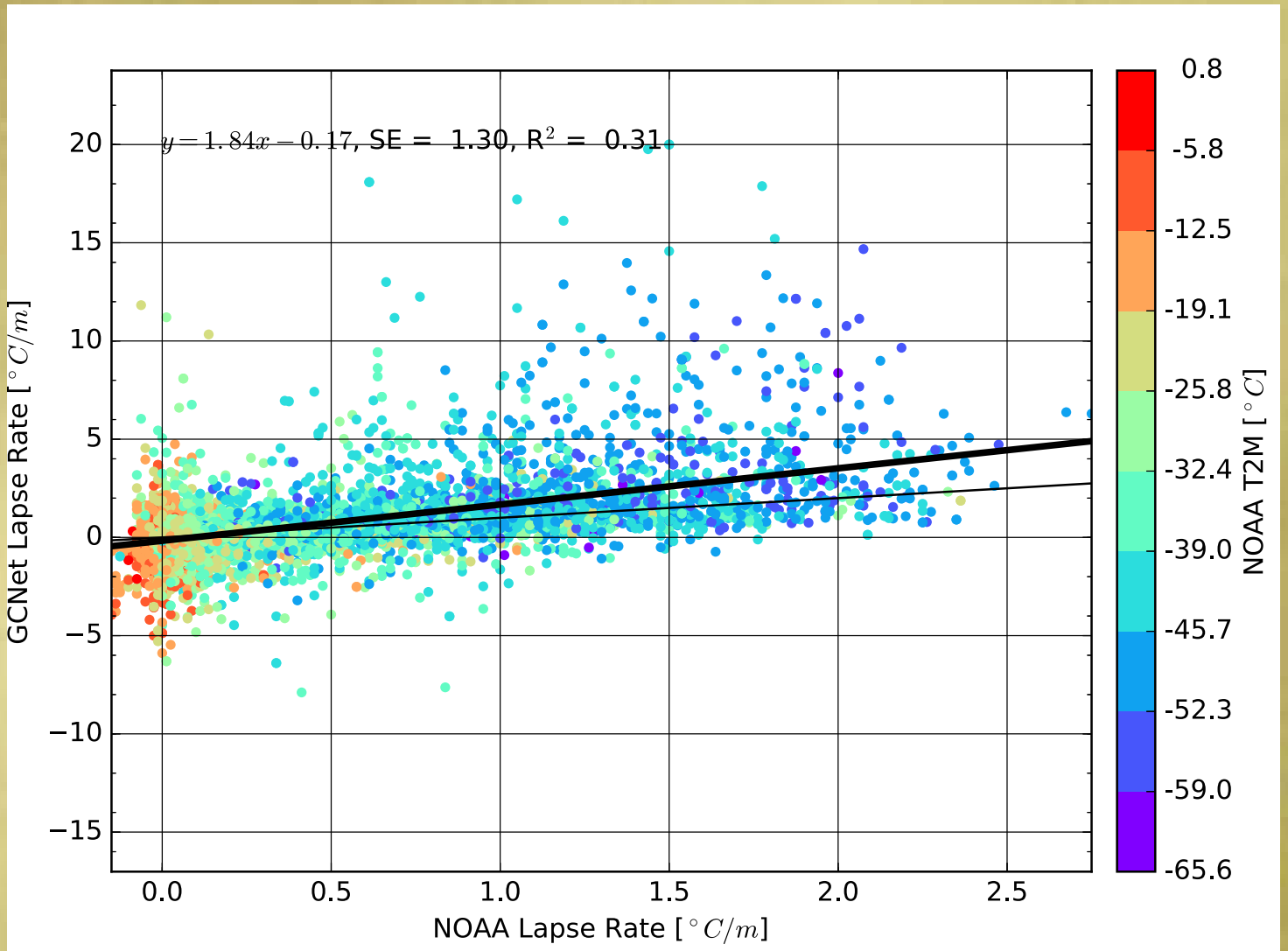
- An almost 15 year time series suggests that only 1 melting event occurred in the AIRS+AMSU data record.
- The change in emissivity of the refrozen ice can be seen for several years.

Summary and Future Work

- The GES DISC is working on services to facilitate this type of investigation.
- The AIRS Surface Temperature (TSurfStd) is a good predictor of the near surface air temperature at Summit but it has an offset that is probably due to the near surface temperature inversion.
- The extrapolation to the AIRS Surface Air Temperature (TSurfAir) probably does not capture the near surface temperature inversions.
- Monthly mean estimates of the surface temperature can have a sampling bias of up to 4 K over Greenland during the winter months.
- The Microwave channels provide insight into melting events.
- Find out if the IR-Only algorithm has similar properties.
- Perform similar analyses with other station observations over Greenland and elsewhere.

Extra Slides

Near Surface Lapse Rate

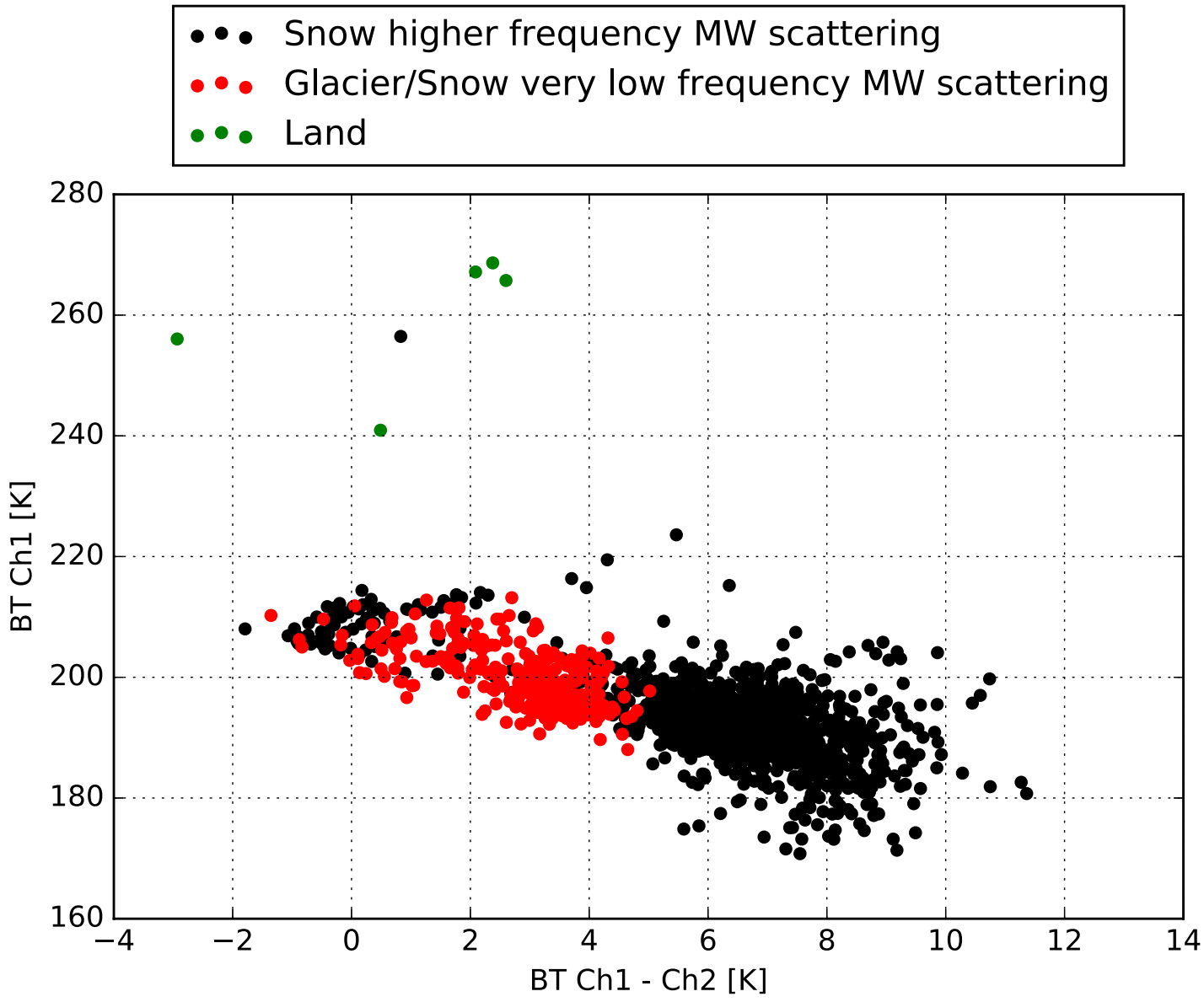


- The the GC-Net sensors are typically closer to the surface that the NOAA sensors.
- The differences between the lapse rate measured at the two stations suggest that the lapse rate increases closer to the surface.

AMSU Channels

Chan ID#	Mod-Rec	Frequency MHz	Notes
1	A2	23800	Surface
2	A2	31400	Surface
3	A1-2	50300	Surface
4	A1-2	52800	Atmosphere
5	A1-2	53596 ± 115	Atmosphere
6	A1-1	54400	Atmosphere
7	A1-1	54940	Atmosphere
8	A1-2	55500	Atmosphere
9	A1-1	57290.344 [f_0]	Atmosphere
10	A1-1	$f_0 \pm 217$	Atmosphere
11	A1-1	$f_0 \pm 322.4 \pm 48$	Atmosphere
12	A1-1	$f_0 \pm 322.4 \pm 22$	Atmosphere
13	A1-1	$f_0 \pm 322.4 \pm 10$	Atmosphere
14	A1-1	$f_0 \pm 322.4 \pm 4.5$	Atmosphere
15	A1-1	89000	Surface

AMSU Ch1



Microwave color magnitude diagram.