Examination of the effect of increasing greenhouse gas concentrations on HIRS intercalibrated and diurnally-corrected observations

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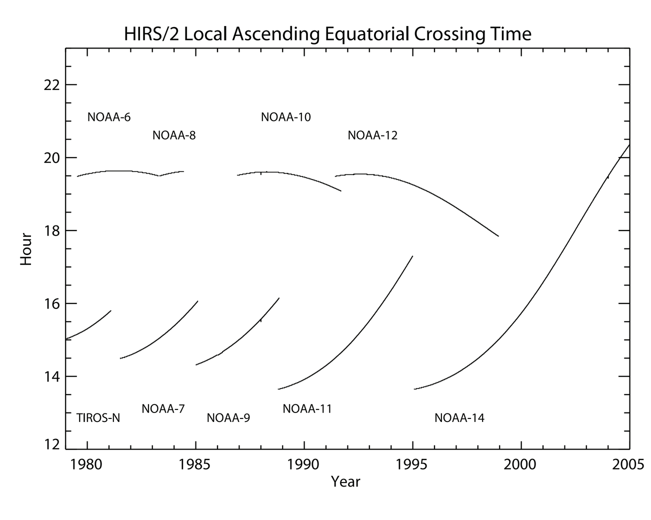
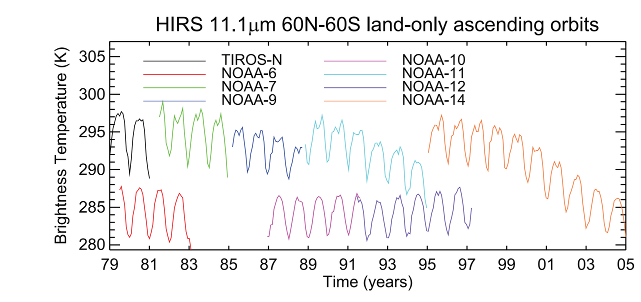
INTRODUCTION

Intercalibrated and diurnally corrected HIRS observations from eight NOAA satellites allows for investigation of the effects of increasing atmospheric carbon dioxide on HIRS brightness temperatures. This poster first describes the correction method to the HIRS observations and then gives preliminary discussion on the expected and observed effects of carbon dioxide on the HIRS brightness temperature data for temperature sounding channels 2 through 7.

Drifting Satellites

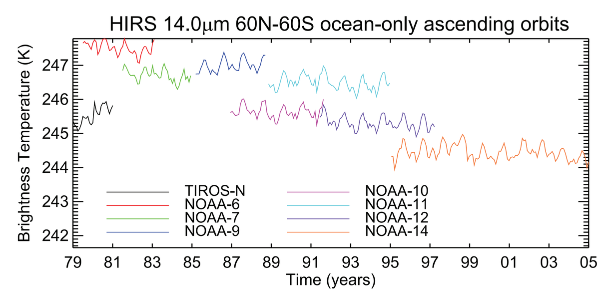


Orbital Drift Bias



- Drifting satellites contribute to trends in window channel for afternoon satellites.
- Intercalibration errors relatively small for 11.1 µm window channel.

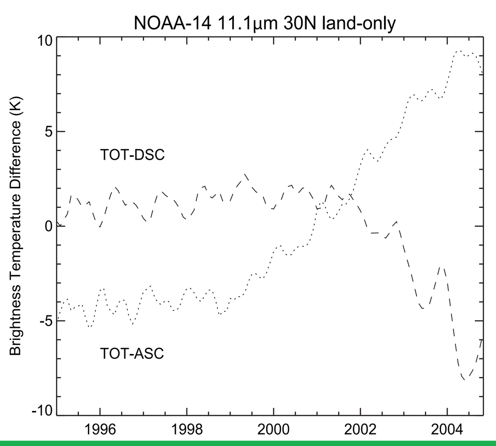
Intersatellite Bias



- Drifting satellites contribute small trends for middle and tropospheric channels.
- Calibration differences contribute most Tb difference between satellites.

ORBITAL DRIFT CORRECTION

- Described in Jackson and Soden (2007), JAOT
- Correction uses the difference between the HIRS-sampled anomaly fields for ascending and descending orbits and the total model anomaly field.
- The fit is a function of satellite, channel, latitude, surface type, local crossing time, and month.
- Significant corrections mainly for afternoon satellites and lower tropospheric channels.

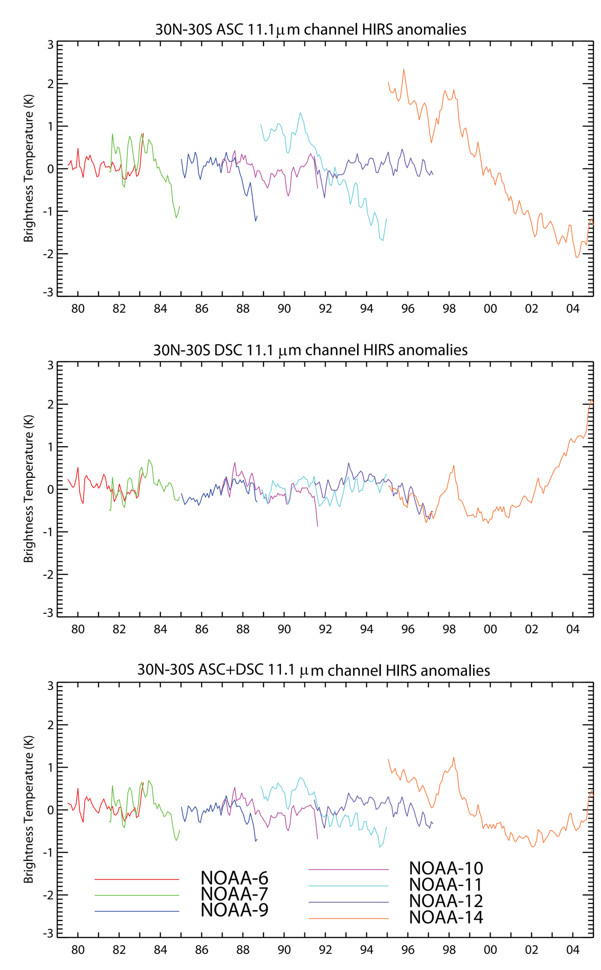


TOT = Anomaly field derived from total GFDL climate model output at 3-hour intervals.

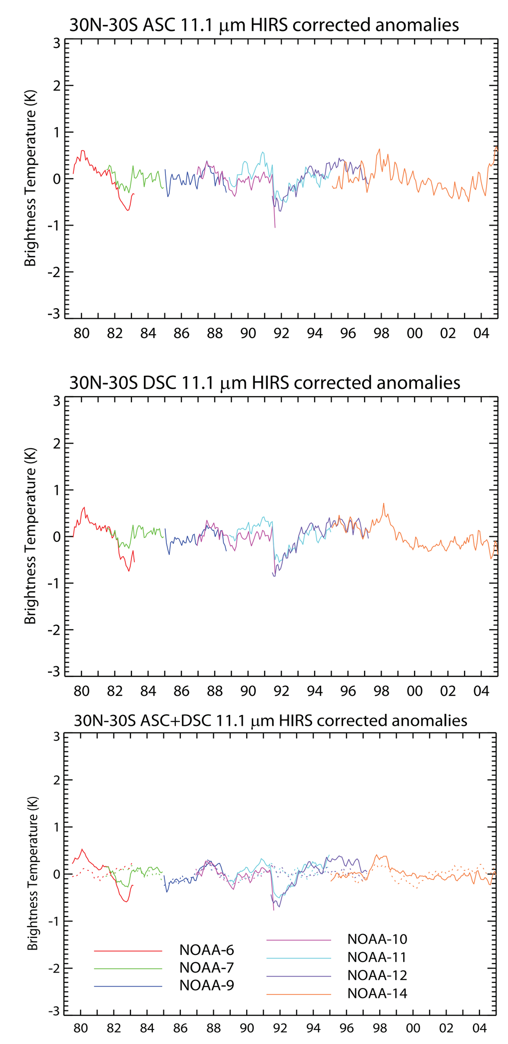
ASC = Anomaly field derived from subsampling model field with HIRS ascending data.

DSC = Anomaly field derived from subsampling model results with HIRS descending data.

Observations without Correction

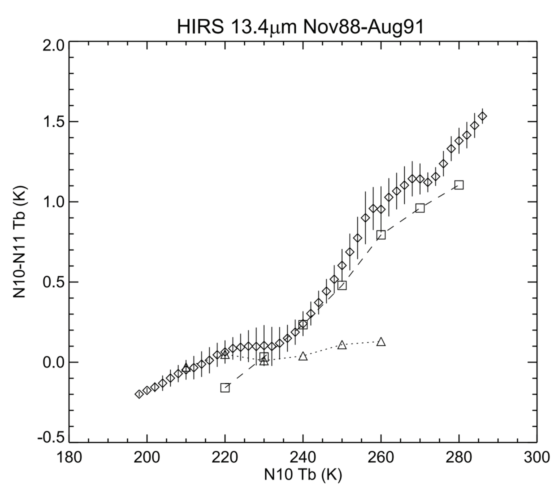


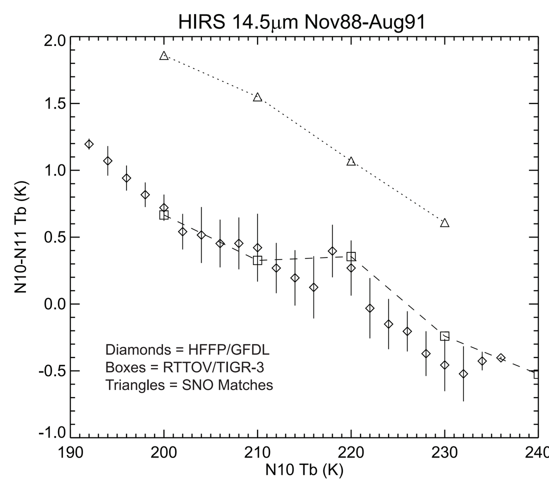
Orbital Drift Correction



SRFs and INTERCALIBRATION

- Two different RT models and input profile data sets give similar intersatellite bias but differ from simultaneous nadir overpass (SNO) data indicating spectral response functions (SRF) do not fully explain observed intersatellite bias.
- Using SRF differences between satellites for intercalibration should not be used for correcting intersatellite bias.
- Matching observed data more accurate method for correcting intersatellite biases.
- SNO correction does not account for Tb differences due to local time of observation.

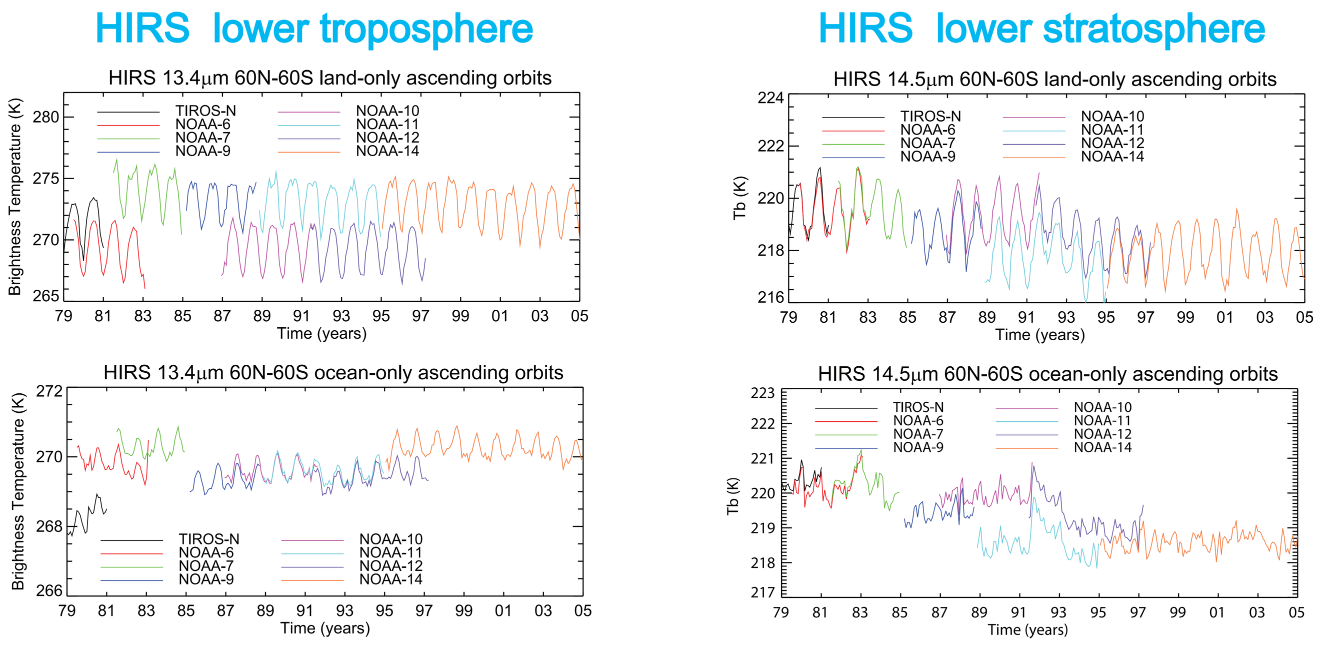




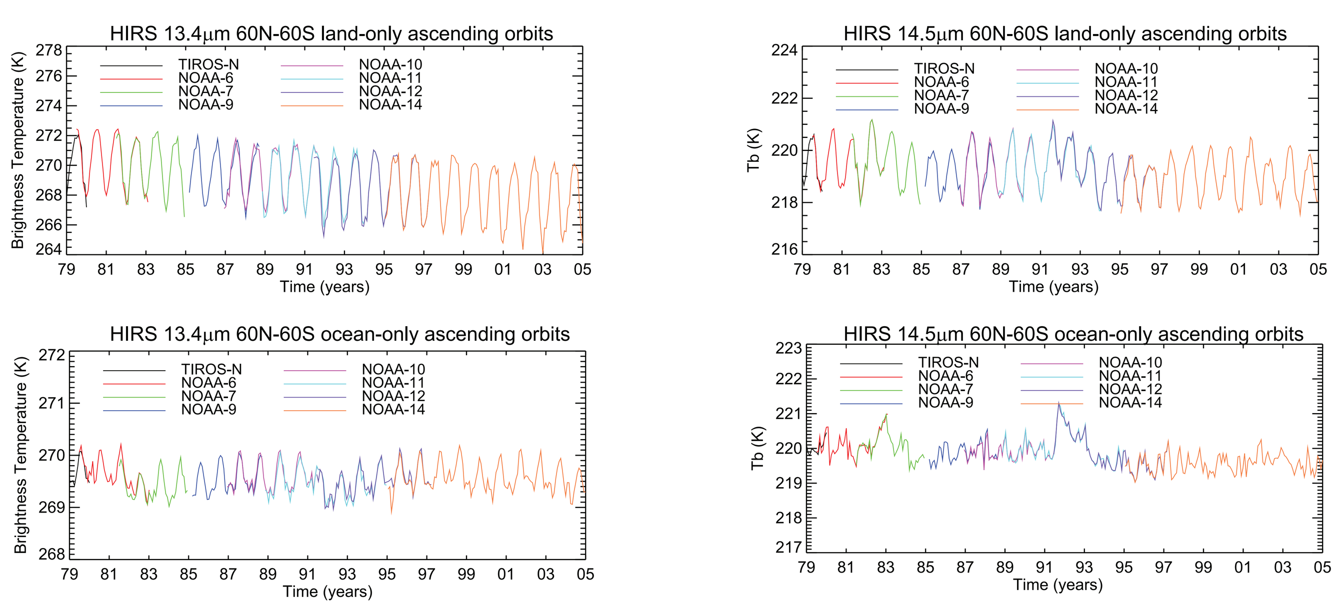
DIURNAL & INTERSATELLITE BIAS CORRECTION

Orbital Drift Correction Only

HIRS lower troposphere — HIRS lower stratosphere

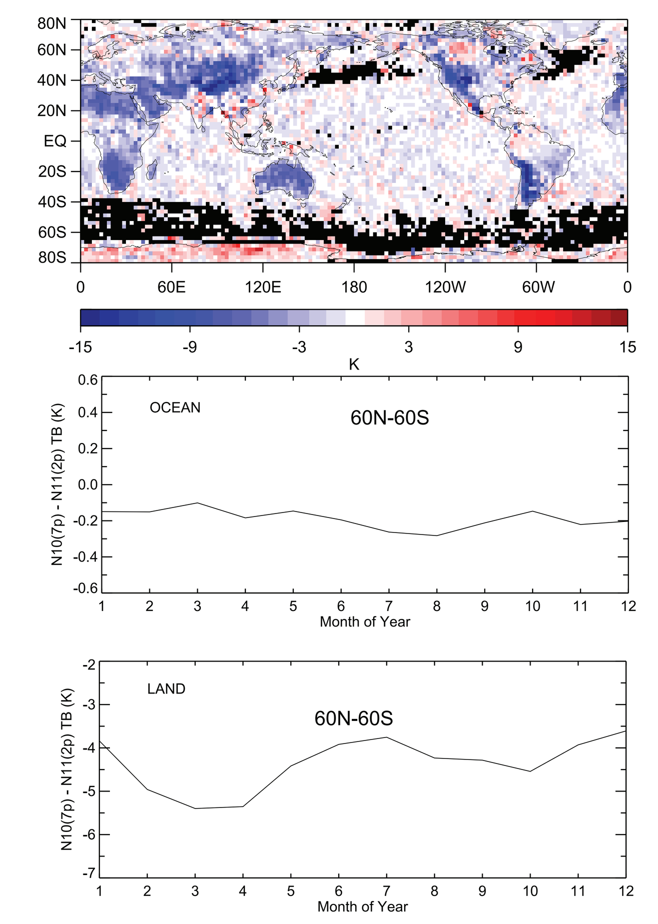


Orbital drift + Diurnal + Intersatellite Bias Correction



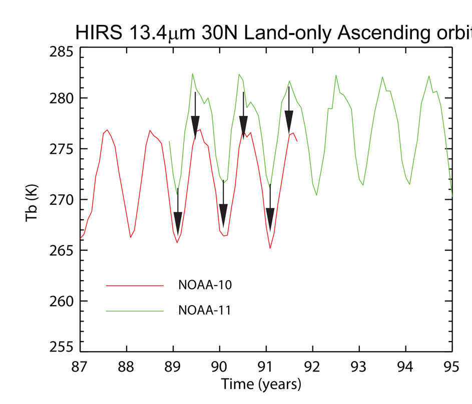
- Land regions have larger brightness temperature differences. Differences mainly due to different local time sampling between satellites and much larger than SNO differences between satellites.
- Brightness temperature difference over the ocean more likely intercalibration difference since diurnal temperature changes have smaller amplitude
- Diurnal temperature differences less evident in stratospheric channel

NOAA-11 13.4µm Correction



- Since SNO matches do not account for differences in local time of observation, correction uses coincident monthly-mean 2.5 degree averaged clear-sky near-nadir brightness temperature data.
- First applied orbit drift correction defined in Jackson and Soden (2007). This is important since each grid cell needs observation to have fixed local time of observation.
- Ascending satellite observations corrected to NOAA-10 7:30pm LST overpass times, Descending observations corrected to NOAA-10 7:30am LST.
- Overlapping satellite periods used to adjust brightness temperatures to NOAA-10
- Seasonal cycle preserved in correction due to differences in seasonal cycle of diurnal temperature cycle.

NOAA-11 Correction Example



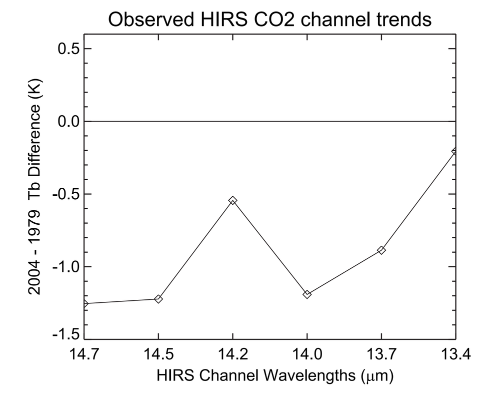
Correction function form: $\Delta Tb\ (\lambda,\phi,c,s,n,m)$
λ = longitude
ϕ = latitude
c = channel
s = satellite
n = orbital node (ascending/descending)
m = month of year

OBSERVED AND MODELED CARBON DIOXIDE EFFECTS

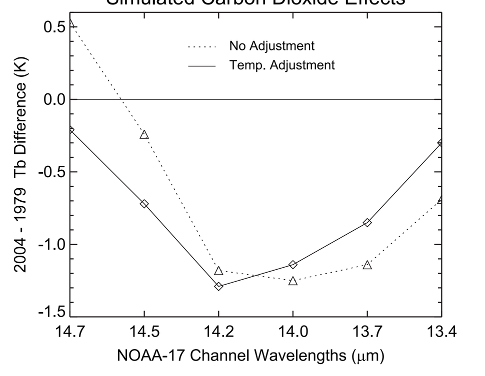
HIRS Model Simulation

- HIRS simulation uses standard atmospheric profile using RTTOV version 8.5.
- Carbon dioxide varied from 338 ppmv to 380 ppmv to simulate change from 1979 to 2004.
- Temperature adjustment indicates temperature profile modified to simulate temperature changes over 25-year period.
- Tropospheric temperature trend set at +0.2 K/decade and lower stratospheric temperature trend set at -0.4 K/decade.

Observed Trend



Modeled Trend



HIRS Observed Trend

- Negative Tb trend for all carbon dioxide channels.
- Modeled result indicates weaker negative trend in lower stratosphere.

Upcoming Research

- Compare trends in clear-sky HIRS channels between simulations derived from GFDL climate model profiles and intercalibrated HIRS data.
- Construct broadband clear-sky OLR from HIRS data and compare with GFDL climate model OLR.
- Examine HIRS observations for spatial trends in carbon dioxide.

CONCLUSIONS

- Orbital drift and differences in local time of observation along with intercalibration differences contribute to brightness temperature differences between satellites.
- Trends introduced by orbital drift can be removed using climate model simulations of diurnal cycle.
- SRF differences do not sufficiently characterize differences in brightness temperatures between satellites, and SNO intercalibration method does not account for differences due to the diurnal temperature cycle.
- The affect of the diurnal temperature cycle on the HIRS temperature channels causes larger brightness temperature differences between satellites than intercalibration differences identified by SNO matches.
- HIRS diurnal + intercalibrated correction method adjusts all brightness temperature data to NOAA-10 and was applied to HIRS observations from 1978-2004 for satellites TIROS-N to NOAA-14.
- Brightness temperature trends in HIRS carbon dioxide channels indicate negative 25-year trend.
- RTTOV simulations of HIRS carbon dioxide channels also indicate negative Tb trend even when including atmospheric temperature trends.