The HIRS Pathfinder Radiance Data Set (1979-2001)

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INTRODUCTION

The objective of the HIRS Pathfinder radiance project is to provide the climate community a set of radiance data suitable for use in climate studies of temperature, water vapor and clouds. The version 2 data set utilizes 23 years of global observations collected from the HIRS infrared sounder riding aboard 11 different NOAA polar-orbiting satellites. The observed radiances provide vertical sounding information on temperature and water vapor and provide information on the height and location of clouds.

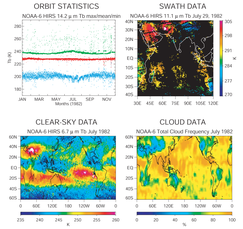
SUMMARY OF DATA PROCESSING

1. Calibrate HIRS 1b data using ITPP and AAPP software packages.
2. Compute all-sky orbit-by-orbit statistics.
3. Calculate the clear-sky observations using ISCCP-type approach (Jackson and Bates, 2000).
4. Perform cloud height retrievals using the CO_2 slicing method (Wylie and Menzel, 1999).
5. Archive all-sky data, clear-sky data, and cloud products at HIRS FOV.
6. Generate grid products from the archived swath data.

TABLE OF DATA PRODUCTS

Data type	File Type	Size	Description
Orbit Statistics	ASCII	0.3 Gb	All-sky statistics for each orbit (max, min, mean, std. dev, skew, kurt., # good and missing obs.
All-sky swath	Binary, Mixed	360 Gb	time, lon., lat., solar zen., line #, scan pos., alt., refl., clear-sky flag, T_b (4-8,10,12), cloud-top temp. and pres., eff. emis.
Clear-sky swath	Binary, Mixed	90 Gb	time, lon, lat, solar zen., line #, scan pos., alt., clear-sky flag, refl., T_b
Clear-sky grid	Binary, INT*2	40 Gb	Monthly T_b mean, std. dev., # obs. for each satellite and channel

IMAGE OF DATA PRODUCTS



Orbit statistics provide quality control measure for the data.

Clear-sky swath data have resolution of HIRS footprint.

Monthly grid data compiled from the swath data. Any grid time and resolution can be constructed from swath data.

Cloud top parameters and cloud frequency derived from the CO_2 slicing method are a new for version 2.

Version 1 and 2 Comparison

What's new in Version 2?

1. Improved the regression coefficients to the limb correction of the surface viewing channel (channel 8, 11.1 µm) prior to cloud detection.

2. Improved the long-term clear-sky statistics from channel 8 so to better eliminate persistent cloudy regions.

3. Eliminated leap year bug that caused greater amounts of cloud contamination during December of leap years.

3. New threshold test removes more persistent clouds over tropical regions.

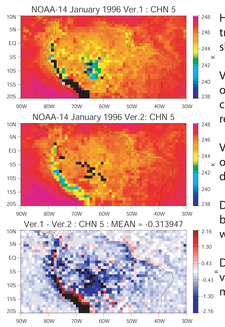
4. Observations now included over polar regions and high terrain.

5. 25% more clear-sky observations for version 2.

6. Retrieval of cloud parameters and archival of all-sky observations included in version 2.

7. Time series extended 2 years to end of December 2001.

Cloud Detection Difference



HIRS Channel 4 (14.2 µm) is an upper tropospheric temperature channel that should be sensitive only to high clouds.

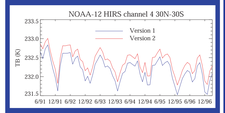
Version 1 shows cloud contamination over the lower Amazon region corresponding to persistent convective region

Version 2 has relatively few cold values over the same region and gives missing data values for a few of the grid boxes.

Difference map indicates Version 2 brightness temperatures are generally warmer for version 2.

Differences over the Andes show that version 2 includes observations over most high terrain.

Time Series Differences



1. Version 2 has warmer values due to removal of cold cloud contaminated observations.

2. Bias between versions remains constant through period.

1. Standard deviation of channel 8 shows spikes in December of leap years for version 1 caused by error in cloud detection.

2. Upward trend relates to the drift of the satellite toward the afternoon orbit.

CLOUD RETRIEVALS

Processing Steps

1. Used temperature and water vapor soundings from 4 x daily NCEP 2.5° Re-analysis data from NOAA/CDC.

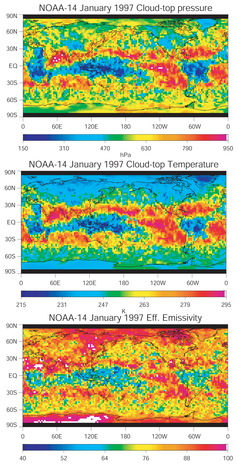
2. Added zonally averaged ozone climatology of Fortuin and Kelder (1998) to stratospheric soundings.

3. Computed HIRS radiance from soundings using NCEP RT model (Van Delst et al., 2002)

4. Bias adjusted the model radiance using observed clear-sky radiance from this study.

5. Used bias adjusted clear-sky radiance and observed clear+cloud radiance from 5 HIRS temperature channels (4-8) to produce CO_2 slicing solution.

6. Cloudy solutions give cloud-top pressure and temperature and effective emissivity of the cloud.



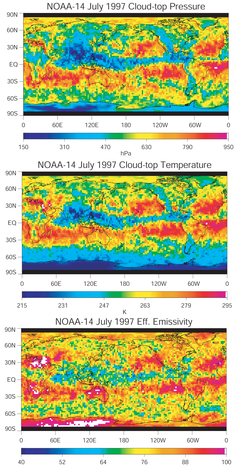
Cloud Parameter Products

Cloud-top pressure and temperature were averaged for January and July on 2.5° grid for cloudy observations only.

Effective emissivity is the product of the cloud fraction and cloud emissivity.

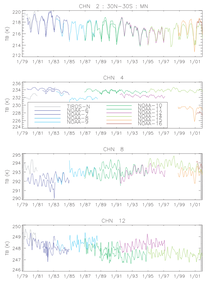
Coldest, highest clouds located over tropical convective regions. Seasonal progression of ITCZ and monsoon regions are evident

Other parameters such as total and high cloud frequency can be derived from these data.



INTERSATELLITE BIAS

Observed Clear-sky bias



Channel 2 (14.7 micron) indicates a gradual cooling of the lower stratosphere.

Channel 4 (14.2 micron) reveals a significant change in brightness temperature between the HIRS/2 and HIRS/3 instruments. HIRS/3 started with NOAA-15 satellite.

Intersatellite bias for channel 4, 8 and 12 can be as large as 5 K. Differences in overpass time, instrument response, and orbital drift contribute to some of this bias.

Modeled vs Observed Bias

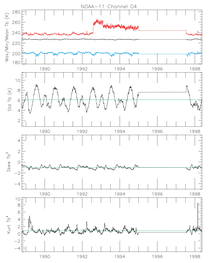
An experiment to isolate the source of bias between NOAA-11 and NOAA-12 channel 4 observations indicate instrument response, model error and sampling do not explain bias. Observations indicate NOAA-11 is warmer than NOAA-12 while model comparison indicates the same magnitude bias but opposite sign. Two possible reasons for this difference: (1) erroneous calibration values provided in 1b data (2) inaccurate representation of response function for these satellites.

Model / Observation comparison of HIRS channel 4 T_b for 30N-30S Jan. 1994

Model/Obs.	NOAA-11	NOAA-12	N11 - N12
Observations	232.45 K	231.33 K	1.12 K
NCEP RT	231.06 K	232.37 K	-1.31 K
MODTRAN	231.45 K	232.57 K	-1.12 K

ORBIT STATISTICS

Orbit statistics are derived by computing the moments of the all-sky HIRS data for each orbit, channel and satellite. For these two figures, a running 5 day mean is applied to all the fields. Red indicates the maximum brightness temperature and blue is the minimum brightness temperature for each orbit. Green indicates the climatological mean. Statistics like these are beneficial in locating potentially bad data in the 1b field.



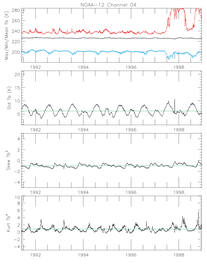
Maximum values show an abrupt increase at the beginning of 1993.

Flat line from 1995-97 indicates period of missing data when satellite was in standby mode.

Kurtosis spikes at beginning and end of time series may indicate short term problems in field.

Maximum and minimum values indicate abrupt change in May 1997. This change corresponds with known problem with HIRS filter wheel during this period.

Annual cycle is evident in all fields. Deviations from this annual cycle may provide good test for data quality.



CONCLUSIONS & BIBLIOGRAPHY

The HIRS Radiance Pathfinder data are an excellent source of infrared radiance data that can be utilized for temperature, water vapor, and cloud studies. The following conclusions were drawn from this study.

1. Version 2 radiance data has an improved cloud detection method that better removes persistent tropical cloudiness.

2. The CO_2 slicing technique provides long time series of cloud parameters. Discussion of trends in cloudiness can be seen at the Wylie et al. poster in this session.

3. Observed intersatellite bias can not always be modeled - empirical adjustments are required to remove bias at this time.

4. Orbit statistics provide an excellent source of quality control for these data.

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