Long-term HIRS-based temperature and humidity profiles

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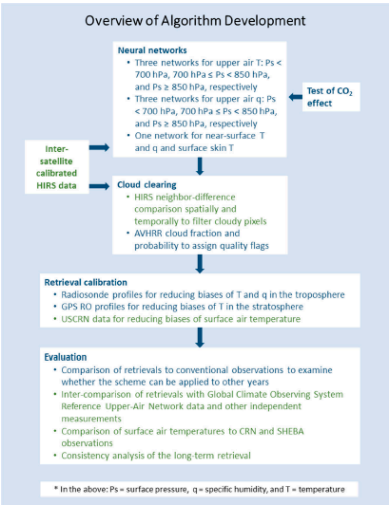
Introduction

The High-Resolution Infrared Radiation Sounder (HIRS) is an operational sounding system mounted on the NOAA polar orbiting spacecrafts. The longwave channels of HIRS provide temperature and humidity measurements at different levels of the atmosphere. Global clear-sky HIRS observations from more than a dozen satellites during the 1979-2013 time period are inter-calibrated (Shi et al. 2008) to a base satellite to form a temporally homogeneous time series.

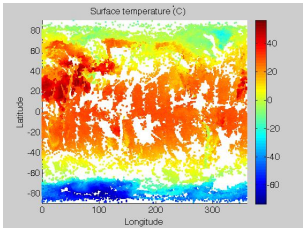
Retrieval

- A retrieval scheme is designed using a neural network technique to derive profiles at standard pressure levels from the surface to lower stratosphere for temperature and from the surface to upper troposphere for humidity.
- The profiles used to build a training dataset are obtained from a diverse sample of profiles in the European Center for Medium-Range Weather Forecasts (ECMWF) system (Chevallier, 2001).
- The corresponding HIRS channel brightness temperatures for the training dataset are simulated by a radiative transfer model, RTTOV.
- As atmospheric profiles over high surface elevations can differ significantly from those over low elevations, different neural networks are developed for 3 classifications of surface elevations.
- The significant impact from the increase of CO_2 in the last several decades on HIRS temperature sounding channel measurements is included.

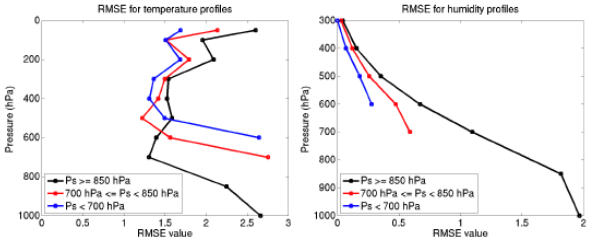


Cloud-clearing and bias reduction

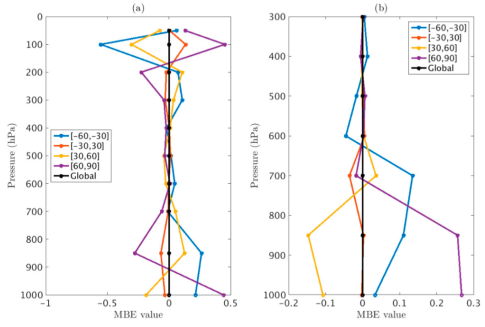
- Two-tiered cloud screening method:
  - Cloudy pixels identified by comparisons of brightness temperature differences both spatially and temporally, among neighboring pixels in days before and after.
  - An optimization scheme is used to find optimal thresholds for AVHRR Pathfinder Atmospheres-Extended (PATMOS-x) CDR cloud fraction and cloud probability to identify HIRS pixels that have high likelihood of being cloudy and, therefore, should not be used to derive clear-sky profiles. The HIRS temperature retrievals are compared to co-located RS92 observations in the lower atmosphere at 850 hPa.
- Calibration using radiosonde and Global Positioning System Radio Occultation (GPS-RO) measurements: For the upper air temperature and humidity retrievals in the troposphere, the calibration database is comprised of RS92 radiosonde observations. For the temperature outputs in the stratosphere, the retrievals are calibrated to GPS-RO profiles.
- Quality flags: (0) clear, (1) possibility of partially cloudiness, (2) likely cloudy, and (3) no cloud fraction/probability information available.



HIRS profile retrievals and comparisons



Results after neural network training: Using a set of data that consist of simulated HIRS channel brightness temperatures by RTTOV with ECMWF profile input that are not used in the retrieval scheme development, retrieval performances for upper air profiles over different surface elevations (represented by surface pressures) are examined. The RMSEs are shown for temperature (in °C, left panel) and specific humidity (in g/kg, right panel).



Results after cloud-clearing and bias correction: The MBE of HIRS retrievals compared to 2011–2012 radiosonde observations for global latitude bands (HIRS values minus radiosonde values) for (a) temperature (°C) and (b) specific humidity (g/kg).

Summary

- Global HIRS observations from satellites during the 1979-2013 time period are inter-calibrated to a base satellite to form a temporally homogeneous time series.
- A retrieval scheme is designed using a neural network technique to derive temperature and humidity profiles.
- Cloudy pixels are removed using a two-tiered approach.
- Profile retrieval biases are reduced based on one full year of global RS92 and COSMIC2013 profiles.

Future work

- Remove dependencies on HIRS channel 10, because of frequency anomalies in the channel found in the early part of the time series.
- Incorporate uncertainty measures into produced dataset.
- Evaluate inter-satellite differences.
- Examine long-term consistency.

References

Chevallier, F., 2001: Sampled databases of 60-level atmospheric profiles from the ECMWF analyses. E. E. S. P. R. Rep., Ed., 27.

Shi, L., Bates, J.J., Cao, C., 2008: Scene Radiance–Dependent Intersatellite Biases of HIRS Longwave Channels. *J Atmos Ocean Tech*, **25,** 2219-2229.

Shi, L., Matthews, J.L., Ho, S-P., Yang, Q., Bates, J.J., 2016: Algorithm development of temperature and humidity profile retrievals for long-term HIRS observations. *Remote Sensing*, 8:280.