Deriving long-term global dataset of temperature and humidity profiles from HIRS

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Retrieval

- Global clear-sky HIRS observations from NOAA-6 to METOP-A during the 1979–2014 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 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 Centre for Medium-Range Weather Forecasts (ECMWF) system

- The corresponding HIRS channel brightness temperatures for the training dataset are simulated by a radiative transfer model
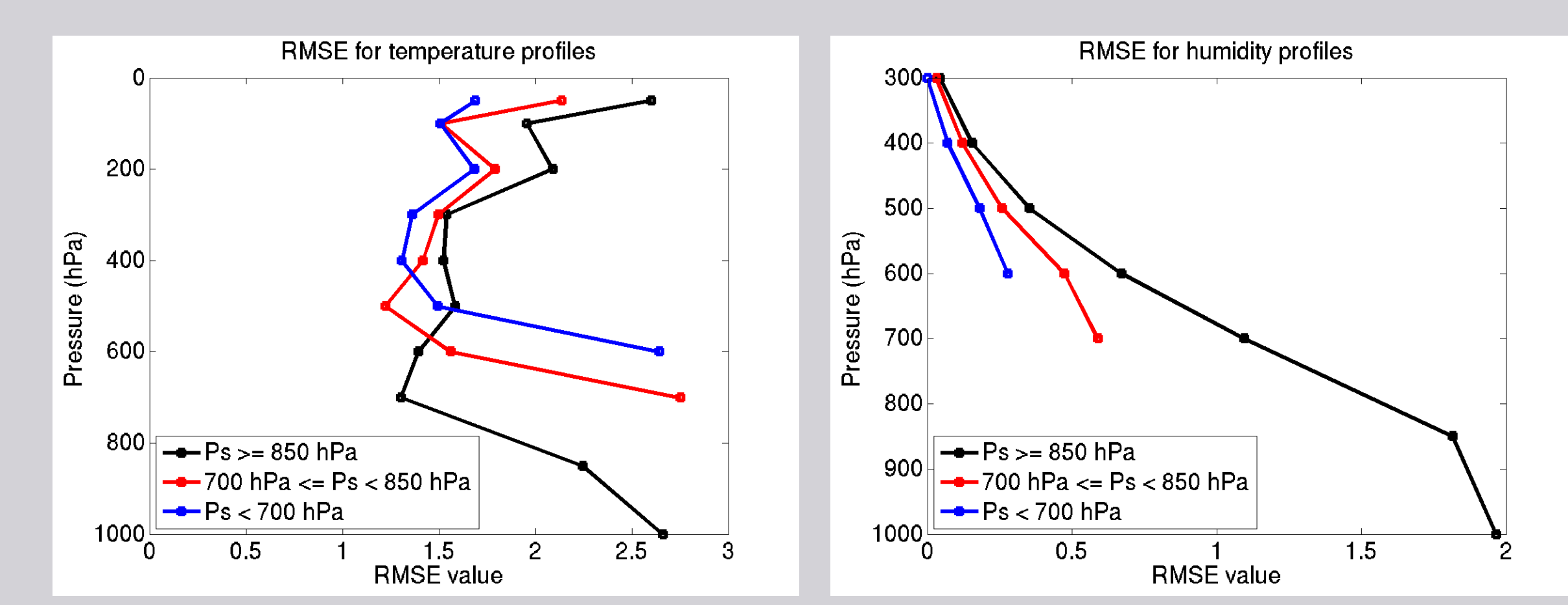
Cloud-Clearing and Bias Reduction

- First round of cloud-clearing uses a method similar to the International Satellite Cloud Climatology Project cloud detection approach

- Remaining pixels are further screened for probability of containing clouds by using AVHRR cloud products to further ensure a cloud-clear dataset

- Global GPS RO derived profiles (COSMIC), radiosonde observations, and U.S. Climate Reference Network (USCRN) and Regional Climate Reference Network (RCRN) observations are incorporated to reduce HIRS retrieval biases

Validation

- Upper air retrievals are compared to GRUAN radiosonde observations

- Surface temperature retrievals are compared to USCRN and RCRN observations

- Surface temperature retrievals in the polar region are compared to Surface Heat Budget of the Arctic Ocean (SHEBA) observations

HIRS Retrievals and Comparisons

Fig. 1. Using a set of data that consists of simulated HIRS channel brightness temperatures by a radiative transfer model (RTTOV) with ECMWF profile input, retrieval performances for profiles with difference surface pressures are examined. The root-mean-square errors are shown in the figure.
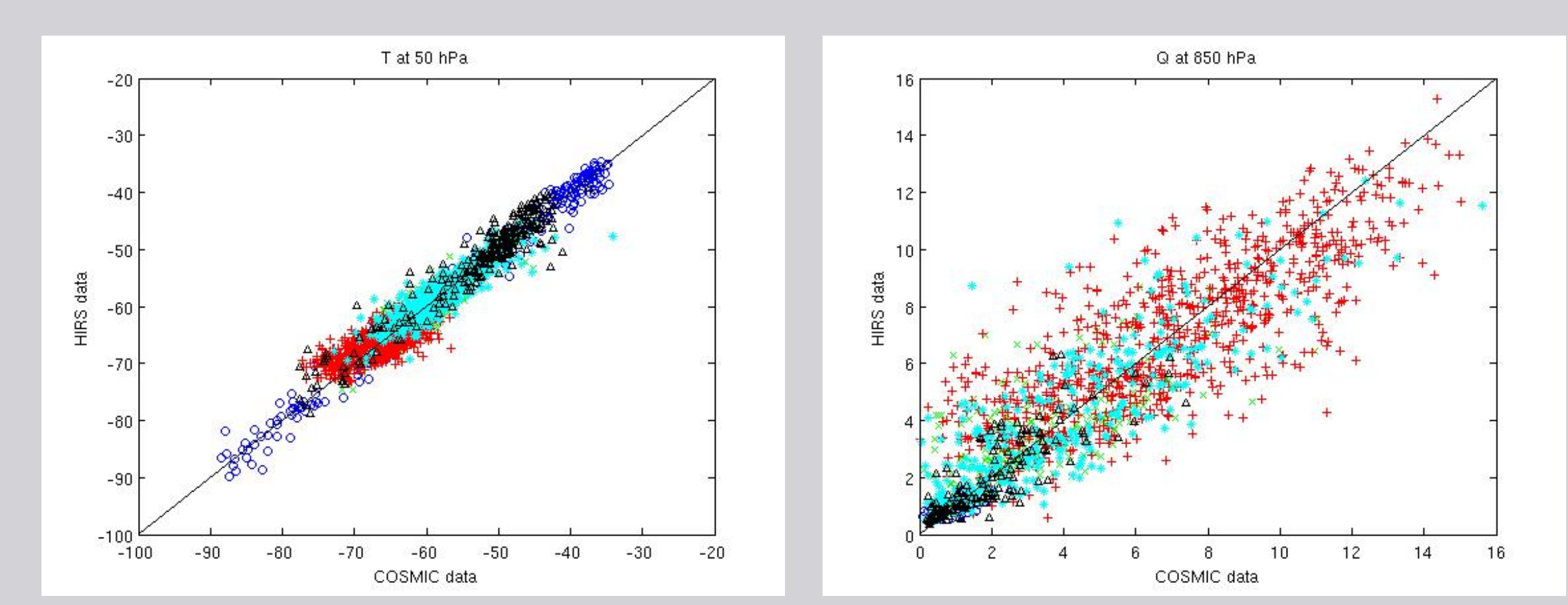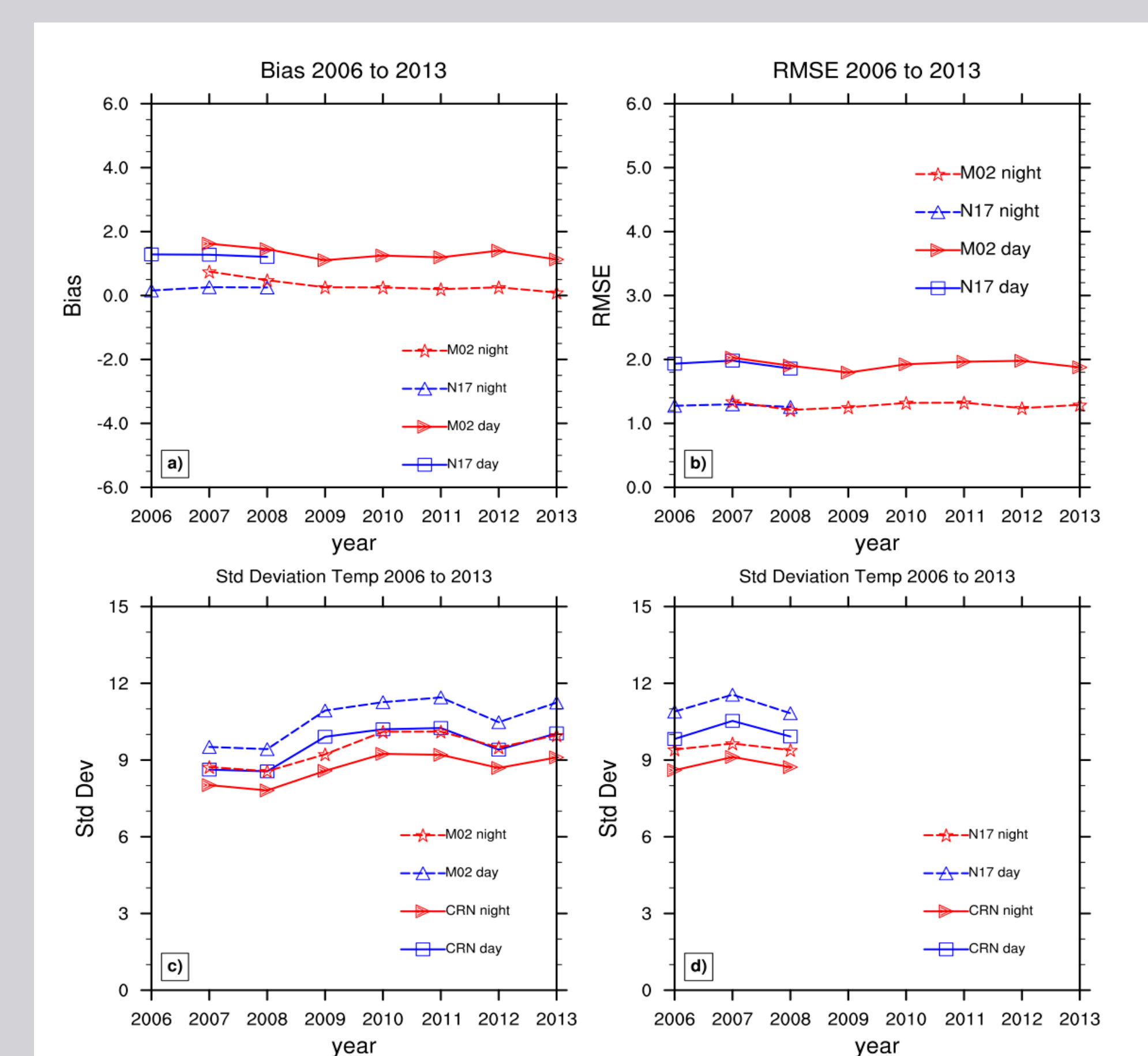

Fig. 2. Scatter plots of temperature (left panel) and specific humidity (right panel) between 2010 HIRS profiles and COSMIC profiles for selected levels. Symbols represent different latitude ranges: −90° to −60°, blue circle; −60° to −30°, green x; −30° to 30°, red +; 30° to 60°, cyan *; and 60° to 90°, black triangle.

Fig. 3. Annual bias and RMSE (°C, both day and night) of HIRS M02 and N17 satellites surface temperatures. Each year represents the average bias and RMSE of the stations. Bias is defined here as HIRS minus USCRN. The annual standard deviation of the temperatures (both day and night) for the M02 and N17 satellites and the associated collocated standard deviation of USCRN temperatures.
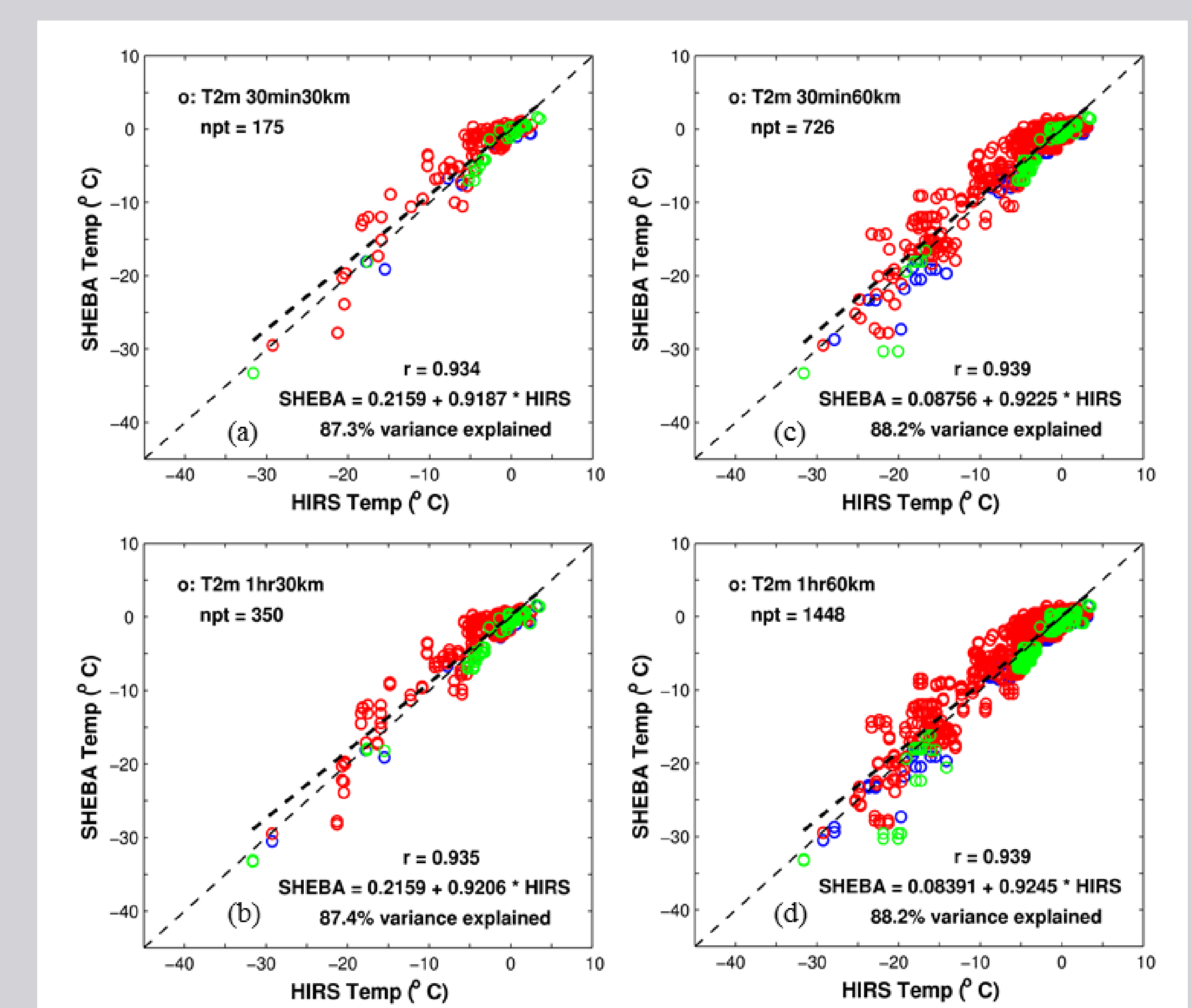

Fig. 4. Scatter diagram of co-located HIRS and SHEBA T2m using different co-location criteria. The color code is for overcast (red: SHEBA cloud fractions ≥ 80%), clear-sky (green: SHEBA cloud fractions ≤ 10%), and cloudy (blue: 10% < SHEBA cloud fractions < 80%). The cross-correlation coefficient between the two time series is denoted in the plot by "r".

Table 1. The root-mean-square errors for (a) HIRS derived temperature and (b) specific humidity compared to 2010 COSMIC profiles, global and latitude bands.

(a)

(C)	-90 to -60	-60 to -30	-30 to 30	30 to 60	60 to 90	Global
850 mb	5.4494	3.0858	2.9832	2.8356	3.0475	3.0592
700 mb	3.9336	1.8838	1.7205	2.0483	2.0690	2.0087
600 mb	3.2724	1.6538	1.5843	1.8671	1.8747	1.8418
500 mb	2.6417	1.6146	1.5305	1.6863	2.0348	1.7359
400 mb	3.1131	1.9649	1.4701	1.8612	2.3052	1.8686
300 mb	2.6653	2.1710	1.6928	2.1423	2.3895	2.0117
200 mb	2.5422	2.7576	1.7474	2.7501	2.6323	2.3038
100 mb	2.1708	2.4603	2.3512	2.1149	2.4116	2.3003
50 mb	2.1287	2.3456	2.4072	2.1632	2.7518	2.3608

(b)

(g/kg)	-90 to -60	-60 to -30	-30 to 30	30 to 60	60 to 90	Global
850 mb	0.4295	1.5903	1.9251	1.4275	0.7744	1.6601
700 mb	0.2600	0.9152	1.4433	1.0044	0.5544	1.1835
600 mb	0.1418	0.5072	0.8624	0.5762	0.2636	0.6935
500 mb	0.0858	0.2691	0.4497	0.3785	0.1992	0.3800
400 mb	0.0427	0.1069	0.2169	0.1541	0.1218	0.1776
300 mb	0.0180	0.0445	0.0592	0.0413	0.0214	0.0488

SUMMARY

- Global HIRS observations from satellites during the 1979–2014 time period are inter-calibrated to a base satellite

- A neural network retrieval scheme is used to derive HIRS temperature and humidity profiles including surface variables

- Cloudy pixels are screened using a two-tiered approach

- Profile retrieval biases are reduced based on global COSMIC profiles and in situ observations

- Retrievals are validated using high-quality in situ observations

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