Microwave Temperature and Humidity Probe (MTHP)

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1 Data Set Description

1.1 Introduction

This dataset is part of the TI3GER (Technological Innovation into Iodine and GV aircraft Environmental Research) campaign supported by the National Science Foundation (NSF) and the National Center for Atmospheric Research (NCAR).

Dataset created by Jet Propulsion Laboratory (JPL).

8 files are included, corresponding to 8 different flights:

- RF2: Second TI3GER research flight in Boulder, CO
- FF1: Ferry flight from Broomfield, CO to Kona, HI
- RF3: Research flight in Kona, HI
- RF4: Research flight in Kona, HI
- RF5: Research flight from Kona, HI, to Anchorage, Alaska
- RF6: Research flight from Anchorage, Alaska to Kona, HI
- RF7: Research flight in Kona, HI
- RF8: Research flight in Kona, HI

1.2 Data version

Dataset generated 09/16/2022. Version 0.1.

1.3 Data status

Final

1.4 Time period covered

April 7 to April 28, 2022. Total of 8 flights.

1.5 Physical location

Physical location is provided inside the data files at the sampling time specified in 1.6.

1.6 Data frequency

1 integrated spectrum sample (256 channels at the 60 GHz band and 4 channels at the 183 GHz band) every 6 seconds.

2 Instrument Description

The airborne Microwave Temperature Humidity Profiler [1] (MTHP) is the second version of the Microwave Temperature Profiler [2] (MTP), conceived in late 2013 to add water vapor information to MTP (183 GHz channels), and using state-of-the-art millimeter wave technology to be able to operate at very low integration times thanks to the receiver's low noise figure. In 2021, aligned with the need of a higher-resolution vertical profiling, the 60 GHz backend was upgraded using the Pacific Microchip Corporation (PMCC) P19800B digital spectrometer [3] in a time-division duplexing configuration, covering from 51 GHz to 59 GHz using 2048 contiguous channels with a bandwidth of 3.906 MHz each. MTHP scans the antenna along-track using a continuous scanning rotor, rotating a full 360° in 1.62 s. This approach scans the full atmosphere both above and below the plane. In addition, MTHP also measures the 183.31 GHz water vapor band using a filter bank with the frequencies centered at 169, 179, 181 and 182 GHz with a bandwidth of 250 MHz each

3 Data Collection and Processing

3.1 Data description

MTHP 60 GHz digital spectrometer collects data incoherently integrated during 10 ms while the antenna spins at 1.62 seconds per revolution (37 rpm), covering 2.2° in 10 ms. The spectrometer samples continuously 1024 channels of its 4 GHz bandwidth. By means of a single pole dual throw (SPDT) radio frequency (RF) switch connected to a band selector, the lower part (51 to 55 GHz) or the upper part (55 to 59 GHz) of the spectrum are selected. Every two full rotations the switch changes its position to sample a different band. Hence, every 6.5 seconds a new full rotation and full spectrum acquisition is recorded. After that, two consecutive angular measurements are aggregated into 5° bins to reduce measurement noise. The average system noise temperature for the system across the entire bandwidth was measured before flight using a Y-factor test, with an average Tsys of ~600 K. Additionally, given the high spectral resolution, nearby channels have been averaged from 2048 to 256, obtaining 31 MHz bandwidth channels. Therefore, given the aforementioned configuration, the noise equivalent differential temperature (NEΔT) of the system is, of 0.54 K.

3.2 Parameters and processing techniques used

MTHP has two internal targets, one at ambient temperature, monitored using a thermistor, and another one at a constant temperature of 333 K. While rotates, the antenna is pointed points 15° at the ambient load, and then to the warm load. The radiometric calibration is performed for each single channel using both targets, as described by Heckl. et. al. [4], but using the ambient target as cold temperature source. Note that, this calibration procedure works better for low internal ambient temperatures, where the difference between the hot and the ambient loads is larger than 100 K.

A second calibration process is provided by using collocated Airplane Static Air Temperature (SAT) for all flights, as described in [4]. Channels 150 to 256 have been averaged alltogether when MTHP angular position is 90° (+/- 5°), and linearly fitted to the SAT profile during ascents and descents.

3.3 Quality assurance and control

Comparison between SAT profile and the front-view 150-256 channels average for all flights is provided in Fig. 2. R^2 for all flights is higher than 0.98 except for first flight (RF1, Boulder), with a R^2 = 0.94.

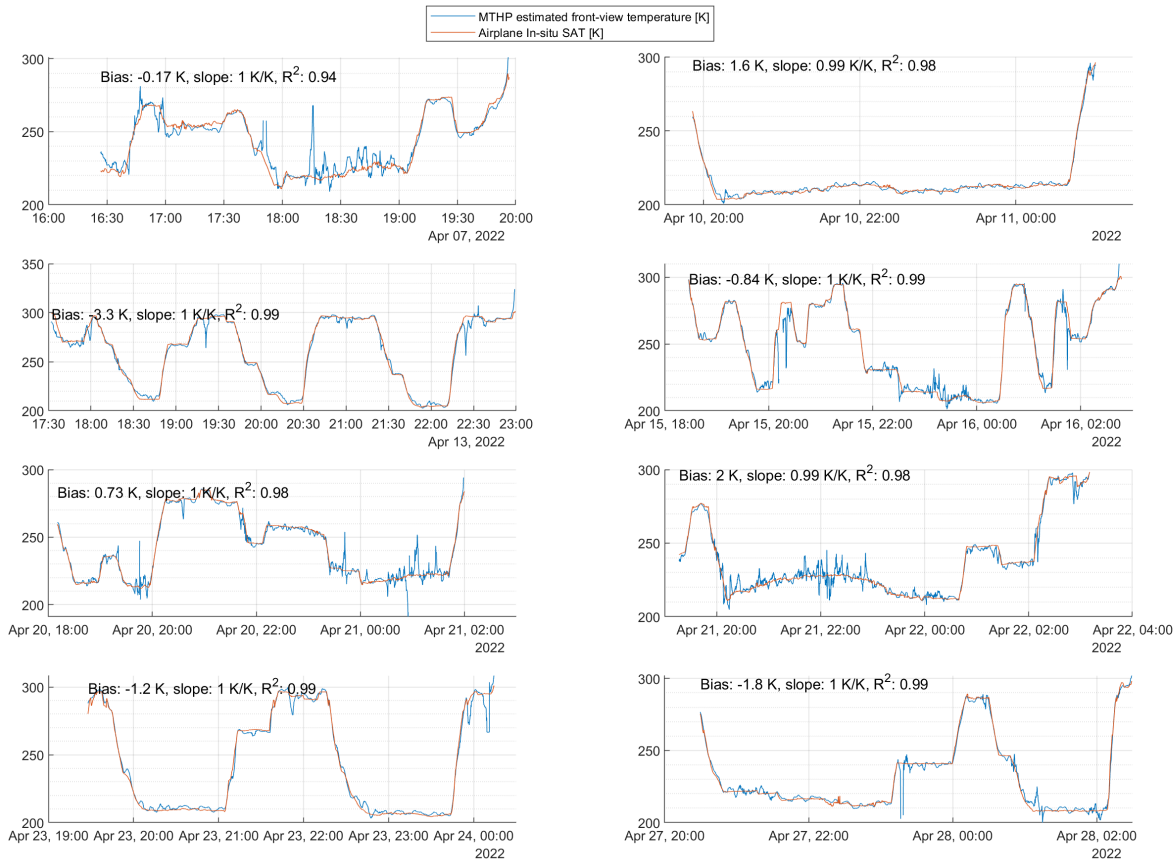

Figure 2. SAT and MTHP front-view temperature.

4 Data Format

NETCDF4/HDF5 compatible.

```
dimensions:
sample = Time_Samples;
look_angle = 72;
f_60 = 256;
f_183 = 4;
variables:
float sample(sample=Time_Samples);
    :description = "Sample number (see time, lat, and lon for reference)";
    :coordinates = "time lat lon";
    :unit = "counts";

float look_angle(look_angle=72);
    :description = "MTHP look angle. 0 is Zenith, 90 is front view, 180 is nadir,
others are internal view (calibration).";
    :unit = "degree";

float f_60(f_60=256);
    :description = "IF central frequency for the 60 GHz channels";
    :unit = "GHz";

float f_183(f_183=4);
```

```
    :description = "IF central frequency for the 183 GHz channels";
    :unit = "GHz";

double lat(Time_Samples);
    :description = "Latitude of the airplane at the time of measurement"

double lon(Time_Samples);
    :description = "Longitude of the airplane at the time of measurement"

double time(Time_Samples);
    :description = "UTC time of measurement";
    :calendar = "gregorian";
    :axis = "T";
    :unit = "seconds since 1970-01-01 00:00:00";

double alt(Time_Samples);
    :coordinates = "time lat lon";
    :unit = "meters";
    :description = "Plane altitude";

double roll(Time_Samples);
    :coordinates = "time lat lon";
    :unit = "degree";
    :description = "Plane roll angle";

double pitch(Time_Samples);
    :coordinates = "time lat lon";
    :unit = "degree";
    :description = "Plane pitch angle";

group: channel_60_ghz {
variables:
    double ta(256, 72, Time_Samples);
    :description = "Antenna Temperatures at look angle and central frequency";
    :units = "Kelvin";
    :dimensions = "sample look_angle f_60";
    :coordinates = "time lat lon";

    double tr(256, Time_Samples);
    :description = "Receiver Temperature (Tsys) t central frequency";
    :dimensions = "sample f_60";
    :coordinates = "time lat lon";
    :units = "Kelvin";

    double counts(256, 72, Time_Samples);
    :description = "Raw counts at look angle and central frequency";
    :units = "unitless";
    :dimensions = "sample look_angle f_60";
    :coordinates = "time lat lon";

}

group: channel_183_ghz {
variables:
```

```
    double ta(4, 72, Time_Samples);
    :description = "Antenna Temperatures at look angle and central frequency";
    :units = "Kelvin";
    :dimensions = "sample look_angle f_183";
    :coordinates = "time lat lon";

    double tr(4, Time_Samples);
    :description = "Receiver Temperature (Tsys) t central frequency";
    :dimensions = "sample f_183";
    :coordinates = "time lat lon";
    :units = "Kelvin";

    double counts(4, 72, Time_Samples);
    :description = "Raw counts at look angle and central frequency";
    :units = "unitless";
    :dimensions = "sample look_angle f_183";
    :coordinates = "time lat lon";

}
```

5 Data Remarks

No additional remarks

6 References

[1] Lim, B. et al. The microwave temperature and humidity profiler instrument airborne shakeout performance. International Geoscience and Remote Sensing Symposium (IGARSS) 2017-July, 4530–4533 (2017).

[2] Lim, B., Mahoney, M., Haggerty, J. & Denning, R. The Microwave Temperature Profiler performance in recent airborne campaigns. International Geoscience and Remote Sensing Symposium (IGARSS) 3363–3366 (2013) doi:10.1109/IGARSS.2013.6723549.

[3] www.pacificmicrochip.com. P19800B - 4GHz Spectrometer ASIC. (2022).

[4] Heckl, M. et al. Measurement characteristics of an airborne microwave temperature profiler (MTP). Atmos Meas Tech 14, 1689–1713 (2021).

7 Appendix

Keywords

- EARTH SCIENCE ATMOSPHERE ATMOSPHERIC TEMPERATURE ATMOSPHERIC TEMPERATURE INDICES 25d73bcf-c8d4-4c0e-ac98-8f3e98677e73
- EARTH SCIENCE ATMOSPHERE ATMOSPHERIC TEMPERATURE UPPER AIR TEMPERATURE VERTICAL PROFILES 72304037-ce59-451a-beeb-4258f3db296a
- EARTH SCIENCE ATMOSPHERE ATMOSPHERIC WATER VAPOR WATER VAPOR PROFILES acc824e7-8eea-4e7d-aa3d-757cda7e6ec9