Upper-Air Observations from Dropsondes over Pacific Ocean from THORPEX Pacific Asian Regional Campaign (T-PARC)

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ABSTRACT

High quality, high vertical resolution upper air observations over open oceans have historically been scarce because of the limited availability of in-situ data and because available satellite data is typically low resolution, and of questionable quality. During the THORPEX Pacific Asian Regional Campaign (T-PARC), from August 1 to September 30, 2008, approximately 1900 soundings were collected over the Pacific Ocean. These included dropsondes deployed from four aircrafts and zero-pressure balloons in the stratosphere (NCAR's driftsonde system). The sounding data include profiles of pressure, temperature, humidity, wind speed and wind direction from the ocean surface to the troposphere for dropsondes, and from the surface to approximately 50 hPa for driftsondes. The data are 0.5-s vertical resolution, corresponding to ~10 m near surface and ~30 m at 50 hPa. All soundings are undergoing a series of vigorous quality control at NCAR. Such an unprecedented sounding dataset is valuable for studying characteristics of thermodynamic and kinematic profiles over the Pacific Ocean. Statistical analyses are applied to the data to characterize vertical, spatial and diurnal variability of different parameters, and compare them with previous studies such as bimodality in tropical water vapor. In addition, the dataset will be used to evaluate the performance of upper-air data from four global reanalysis (RA) products, including NCEP I/II, Japanese reanalysis (JRA-25) and ERA-Interim.

1. INTRODUCTION

Upper air observations over Ocean are primarily obtained from satellites. It is known that satellite measurements rely on in-situ observations to derive atmospheric parameters from radiance and for validation and calibration. In addition, satellite data have coarse vertical resolution and are not available under all weather conditions. As a result, characteristics of upper air profiles over open Ocean are not well understood, and the performance of the model and reanalysis products over Ocean is not thoroughly assessed. This study analyzes Upper-Air Observations from Dropsondes over Pacific Ocean from THORPEX Pacific Asian Regional Campaign (T-PARC) between August 1 and September 30, 2008. The objective is to show the importance of this unique, high quality and high vertical resolution dataset in understanding characteristics of thermodynamic and kinematic profiles and validating the performance of global reanalysis products over the Pacific Ocean. The uniqueness of the latter is twofold. First, the T-PARC sounding data are not assimilated by any of the RAs, and thus serve as an independent data source for validating RAs. Second, the performance of upper air profiles in RAs over oceans has not been thoroughly assessed due to a lack of independent, high quality observations.

2. DATA

T-PARC was an International project, conducted in the Western Pacific from August 1 and September 30, 2008, aimed at collecting measurements to increase understanding of the mechanisms that lead to improved predictive skill of high impact weather events and to provide data for research to examine typhoon genesis. During T-PARC, approximately 1900 dropsondes were launched from four aircrafts (NRL-P3, AF-C130, DLR-Falcon and DOTSTAR) and NCAR driftsonde system. This study only uses the soundings from the driftsonde, NRL-P3 and AF-C130 (see Fig. 1 for sounding locations), including total 1351 soundings. Average drop altitudes are 22.5 km, 3.8 km and 6.5 km for driftsonde, NRL-P3 and AF-C130, respectively.

The NCAR GPS dropsonde includes a pressure, temperature, humidity sensor module, a codeless GPS receiver module for wind measurements and a 400 MHz telemetry transmitter to transmit data from the sonde to the onboard receiving system (see Fig. 1 in [1]). The dropsonde is deployed from research aircrafts or other platforms over remote areas such as the oceans, Polar regions and sparsely inhabited land masses. It descends through the atmosphere on a parachute measuring pressure, temperature, humidity and wind profiles at a 0.5 second vertical resolution (equivalent to ~5-10 m). T-PARC was the second deployment of the NCAR/EOL driftsonde system which was developed in an effort to produce a low-cost measurement system capable of capturing vertical profiles of in-situ measurements in forecast sensitive regions, and filling critical gaps in data coverage over remote locations. The driftsonde system consists of a zero-pressure polyethylene balloon attached to a gondola that houses up to 50 Miniature In-situ Sounding Technology (MIST) dropsondes. The balloon floats along with the wind currents in the lower stratosphere or upper troposphere between 16-30 kilometers, and can remain airborne for between 5-7 days. The MIST sondes are released upon command via the ground operations center.

All dropsonde data have been carefully quality-controlled using several methods including applying automatic sounding quality-control software called

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Atmospheric Sounding Processing Environment (ASPEN), visually examining each sounding and plotting the histogram and time series of each parameter. Special problems in data quality are identified and corrected if possible.

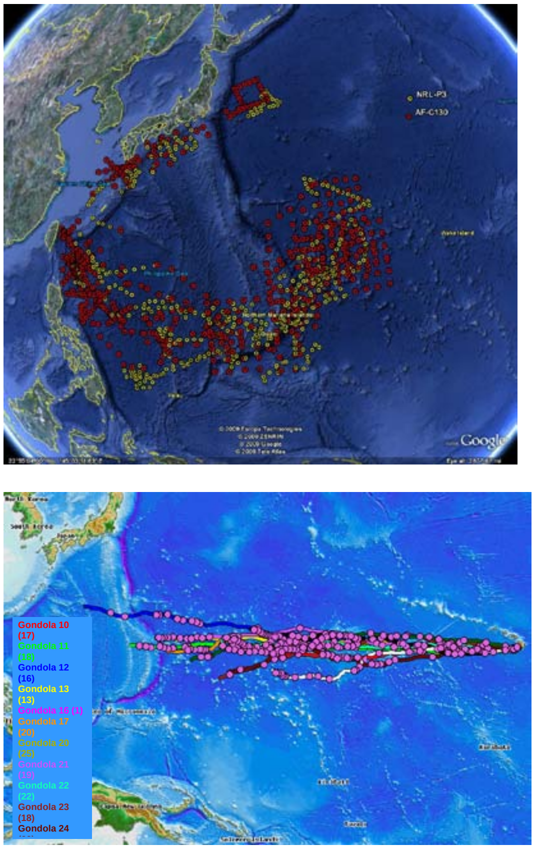

Figure 1. Maps of dropsonde launch locations from NRL-P3/AF-C130 (upper panel, yellow for NRL-P3 and red for AF-C130) and the driftsonde (lower panel). Different flights for driftsonde are distinguished by different colors.

3. RESULTS

T-PARC upper air observations are highlighted by the driftsonde data in Fig. 2. Temperature profiles show detailed temperature structures over open Ocean from the surface to the stratosphere. Profiles above 200 hPa for 25 soundings from Flight #9 shown in Fig. 3 denote detailed structures in tropical tropopause layer (TTL) and stratosphere, including single and double tropopauses, tropopause layer, and waves in the stratosphere. RH profiles show moist marine boundary layer (>62% RH) in all soundings (Fig. 2). The free troposphere is very dry (< 10% RH) near Kona, HI, and then becomes moister westward except in Fight #6 where there was drier air encountered in the middle of the flight (Fig. 2).

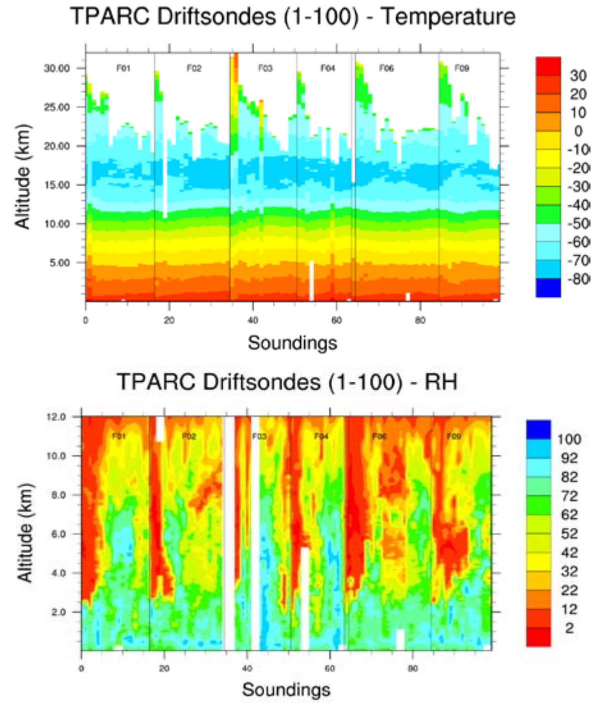

Figure 2. Profiles of temperature (in °C, upper panel) and RH (in %, lower panel) for 100 soundings from driftsonde. “F01” in the legend means Flight #1.

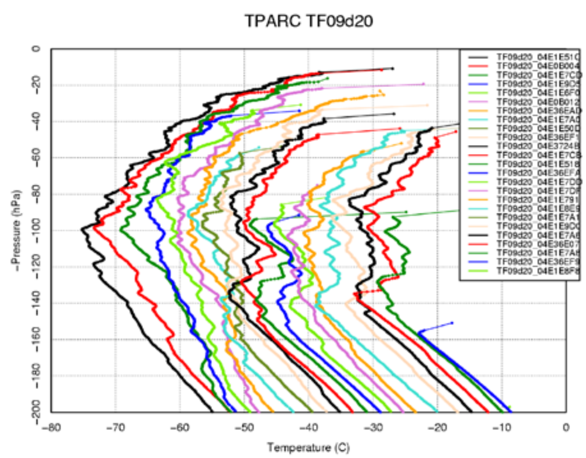

Figure 3. Temperature profiles above 200 hPa for 25 soundings from driftsonde Flight #9.

There have been a few studies on probability density functions (PDFs) of relative humidity (RH) in the tropical and subtropical troposphere (e.g., [2], [3], [4]). RH frequency distributions for all soundings from NRL-P3 and AF-C130 in Fig. 4 show that the peak frequency occurs at higher RHs (> 70%) throughout the troposphere. This is mainly due to the fact that aircraft dropsondes were targeted for tropical cyclones (TC) and dropped within TCs and in the surrounding environment. Therefore, the aircraft soundings are not representative of all conditions and unsuitable for studying PDFs of RHs investigated by previous studies. In contrast, driftsonde soundings cover the subtropical Pacific from

156°W to 140°E and sample all weather conditions (Fig. 1). The RH frequency distribution of driftsonde data shows two distinct features below and above approximately 700 hPa (Fig. 4). The frequency maximizes at 70-90% RHs below 700 hPa and has a narrow distribution. Around 700 hPa, there is a jump in locations of peak frequency from ~70% to less than 10% RHs. Such breakout of RH frequency distribution has shown in Fig. 2 of [5]. There is a bimodal distribution in ~700-600 hPa with one peak at ~70% and one at RHs less than 10%. This is consistent with [2] and [4]. RH profiles for individual soundings in Fig. 2 suggest that the bimodal distributions are a result of a combination of dry air near Kona and moist air westward and represent RH spatial variations in the region. Above 700 hPa, the distribution shows a primary peak at RH less than 10% and a secondary peak near ice saturation.

4. CONCLUSIONS AND FUTURE WORK

Nearly 1900 high-quality, high resolution upper air soundings were collected by dropsondes over the Pacific Ocean during T-PARC in August and September of 2008. Such a unique dataset plays an important role in fulfilling specific scientific objectives of T-PARC. In this study, additional applications of this dataset have been and will be explored, including investigating features of temperature, humidity and wind profiles and validating global RA products. Preliminary analyses show detailed vertical and horizontal variations of temperature and RH in the driftsonde soundings. RH frequency distributions from aircraft soundings are biased toward TC environments and thus are not representative of all conditions. The driftsonde RH profiles show some interesting features consistent with previous studies.

In the future, more analyses will be done, including separating the data into different regions and different times (daytime vs. nighttime). Additional parameters, including temperature and wind, will also be analyzed. The soundings from DLR-Falcon and DOTSTAR will also be added into the analysis after they are quality-controlled. In addition, RA soundings will be matched with dropsonde soundings spatially and temporally and are compared.

REFERENCES

[1] Hock, T. F., and J. L. Franklin, 1999: The NCAR GPS dropwindsonde. *Bull. Amer. Meteor. Soc.*, **80**, 407-420.

[2] Zhang, C., B. E. Mapes, and B. J. Soden, 2003: Bimodality in tropical water vapor. *Quart. J. Roy. Meteor. Soc.*, **129**, 2847-1866.

[3] Sherwood S. C., E. R. Kursinski, and W. G. Read, 2006: A distribution law for free-tropospheric relative humidity. *J. Climate*, **19**, 6267-6277.

[4] Ryoo, J.-M., T. Igusa, and D. W. Waugh, 2009: PDFs of tropical tropospheric humidity: Measurement and Theory. *J. Climate*, **22**, 3357-3373.

[5] Sun, D.-Z., and R. S. Lindzen, 1993: Distribution of tropical tropospheric water vapor. *J. Atmos. Sci.*, **50**, 1643-1660.

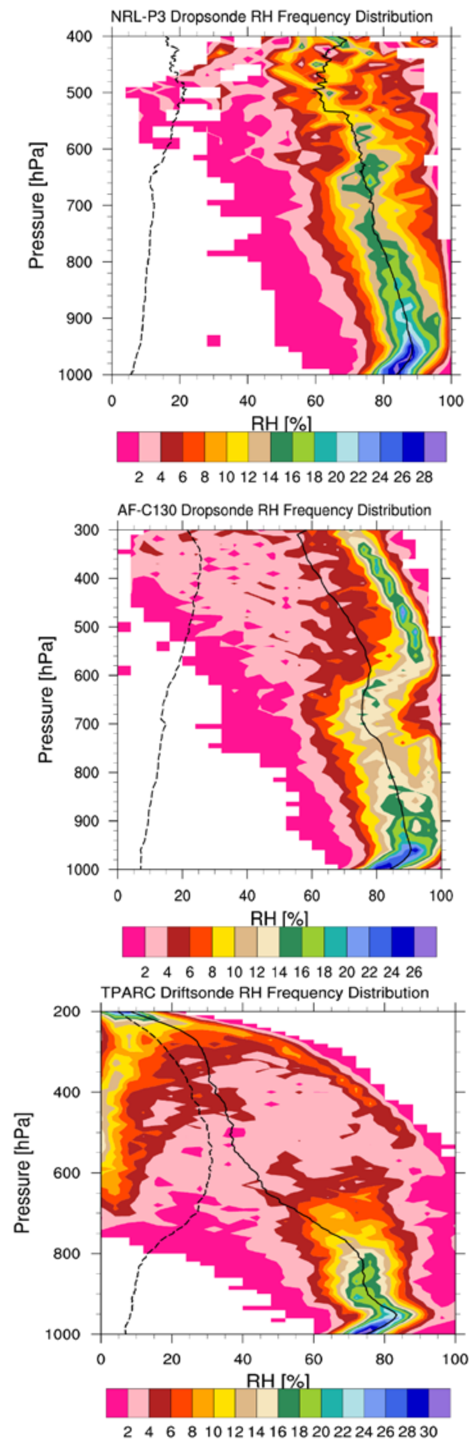

Figure 4. RH frequency distributions for all soundings from NRL-P3 (upper panel), AF-C130 (middle panel) and driftsonde (lower panel). Solid and dashed black lines are means and standard deviations, respectively.