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Radiosonde Intercomparison and Validation (RIVAL) Field Campaign Report

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Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement
ENA	Eastern North Atlantic
GCOS	Global Climate Observing System
GRUAN	GCOS Reference Upper Air Network
JPSS	Joint Polar Satellite System
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NPROVS	NOAA Products Validation System
NSA	North Slope of Alaska
RIVAL	Radiosonde Intercomparison and Validation
SGP	Southern Great Plains
STAR	Center for Satellite Applications and Research

Contents

Figures

Tables

1.0 Summary

This section outlines the campaign, explains the roles of collaborating agencies, and discusses problems encountered.

1.1 Overview

Radiosondes provide the primary source of high-vertical-resolution temperature, humidity, and pressure data from the surface through to the lower stratosphere, and are a key component of the sustained measurement program at U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facility observatories. At the end of 2017 the radiosonde manufacturer Vaisala ceased sales and production of the RS92 radiosondes, which were in use at the ARM field sites since 2005, and transitioned to the RS41 model. The Radiosonde Intercomparison and Validation (RIVAL) field campaign was proposed in order to undertake a sustained intercomparison and validation campaign at the Eastern North Atlantic (ENA), North Slope of Alaska (NSA) at Barrow, and Southern Great Plains (SGP) observatories in order to fully quantify the RS92-RS41 sonde differences and their dependence on all relevant influencing variables, and to understand the effects of the sonde model transition.

1.2 Duration and Collaborating Agencies

RIVAL was initially approved for one year of weekly RIVAL launches (RS92 and RS41 on the same balloon) at each of the ARM field sites at ENA, NSA, and SGP. The field campaign was extended at the SGP site to make use of the remaining RS92 sondes and to better characterize any day-night and seasonal dependencies. This effort was in collaboration with Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) and partially funded by the Joint Polar Satellite System (JPSS) Radiosonde field campaign. All RIVAL launches targeted National Oceanic and Atmospheric Administration NOAA20 satellite overpasses at each of the field sites, and for this reason, the RIVAL launches not only benefit the scientific radiosonde user community, but also the satellite retrieval community.

Table 1. RIVAL sonde launch summary. NOAA20 overpasses were targeted with either a single RIVAL balloon (RS92 & RS41 radiosondes on the same balloon) or twin balloons consisting of the RIVAL balloon followed by a second balloon with a single RS41 radiosonde.

RIVAL sonde launches			
Site	**ENA**	**NSA**	**SGP**
Start date	26 Apr 2018	20 Jun 2018	13 Feb 2018
End date	18 Oct 2019	20 Oct 2019	12 Jan 2022
Launches completed total (single/twin)	54 (54/0)	19 (12/7)	110 (38/72)

1.3 Issues

Preparations were made at each of the three ARM field sites to accommodate RIVAL launches. These preparations included the design and building of launch carts, tarps, rigs, and stands to assist with the RIVAL launches that used large 1200-g balloons. An additional sonde ground system was installed at each site, including a loaner system from Vaisala installed at SGP. These systems worked very well. There were no unexpected instrument issues that impacted this field campaign. However, early in the campaign, staffing shortages and weather conditions, which included high winds and overcast conditions, prevented routine RIVAL launches at NSA. As a result, a lower-than-expected number of RIVAL launches were completed at NSA. Remaining supplies from NSA were sent to SGP and used with additional remaining stock through January 2022. The RS92 radiosonde sensors began to expire during the late spring and early summer of 2019. This was not an issue initially, but as the field campaign continued into late 2021 the rate of failure of the sondes increased and the field campaign was ended in January 2022. The ARM-Vaisala processed radiosonde data files were available from the ARM Data Center, but some of the ‘raw’ radiosonde data files were not made available. These files are necessary for additional analysis and GRUAN processing of the radiosondes.

2.0 Outcomes

2.1 Results

In general, a RIVAL launch was scheduled once per week at each site and coordinated with a NOAA20 overpass. At the ENA and SGP sites, the RIVAL launches alternated between targeting daytime and nighttime overpasses of the NOAA20 satellite. At NSA, RIVAL launches were limited to the ‘day’-time NOAA20 overpasses. This was due to limited staffing at NSA at night. Launch criteria were primarily driven by the cloud clearing capabilities of the retrieval algorithm for NOAA20 requiring conditions to be at least 50% clear, not precipitating, not overcast, and no threatening skies in the vicinity. At NSA, these launch criteria were difficult to meet with cloudiness preventing many launches. While the clear sky criterion was reduced at NSA to 25% clear, this had little impact increasing the launch rate.

At ENA, RIVAL launches occurred 15 minutes prior to overpass, as shown in the left panel of Figure 1. At NSA and SGP, both single-balloon and two-balloon, also known as twin launches, were possible. A twin launch, shown in the right panel of Figure 1, consists of the RIVAL balloon, with a payload of both

the RS92 and RS41 radiosondes, launched 45 minutes prior to overpass followed by a second balloon carrying a RS41 radiosonde launched 5 minutes prior to overpass. This configuration is highly valuable for satellite retrieval validation as the information from both of the balloons can be interpolated to the satellite overpass time and used to estimate the variation in temperature and water vapor that occurred during the flights.

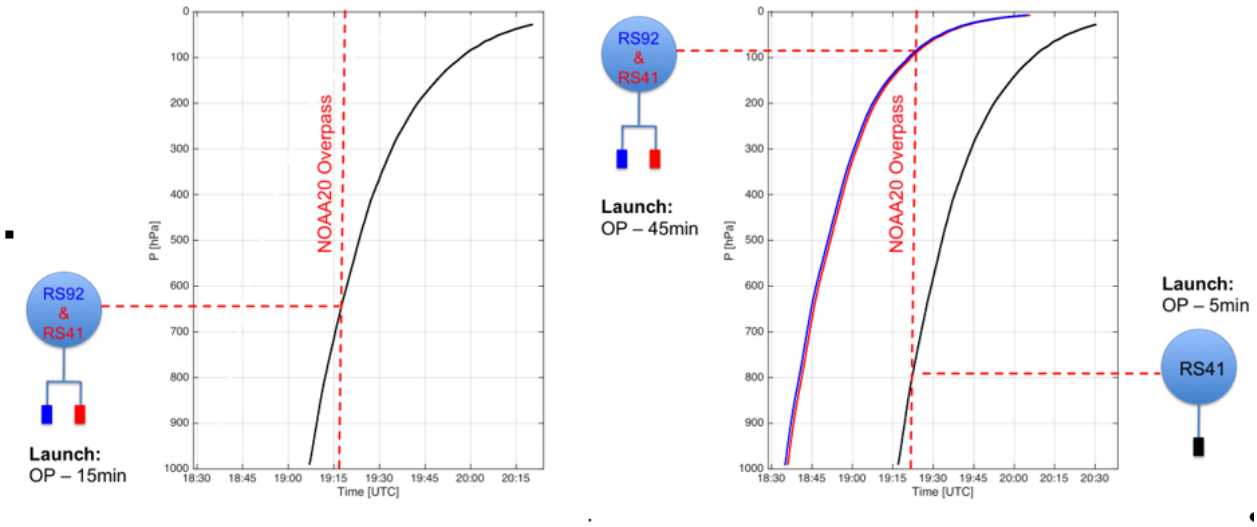

Figure 1. RIVAL launch configurations and timing. Single balloon launches occurred 15 minutes prior to overpass and 2-balloon twin launches occurred 45 minutes and 5 minutes prior to overpass.

Example temperature and relative humidity profiles from a twin RIVAL sonde are shown below in Figure2. The measured profiles from the first balloon are shown in red and blue for the RS41 and RS92 respectively. The profiles from the RS41 on the second balloon are shown in black. The differences between the red and blue profiles are due to the differences between the RS41 and RS92 radiosonde models and the Vaisala processing of these measurements. It is these differences that are of interest to this study. In addition, the RIVAL radiosonde profiles have been ingested by the NOAA Products Validation System (NPROVS) and compared to NOAA20 retrievals. The analysis of these data sets is still ongoing.

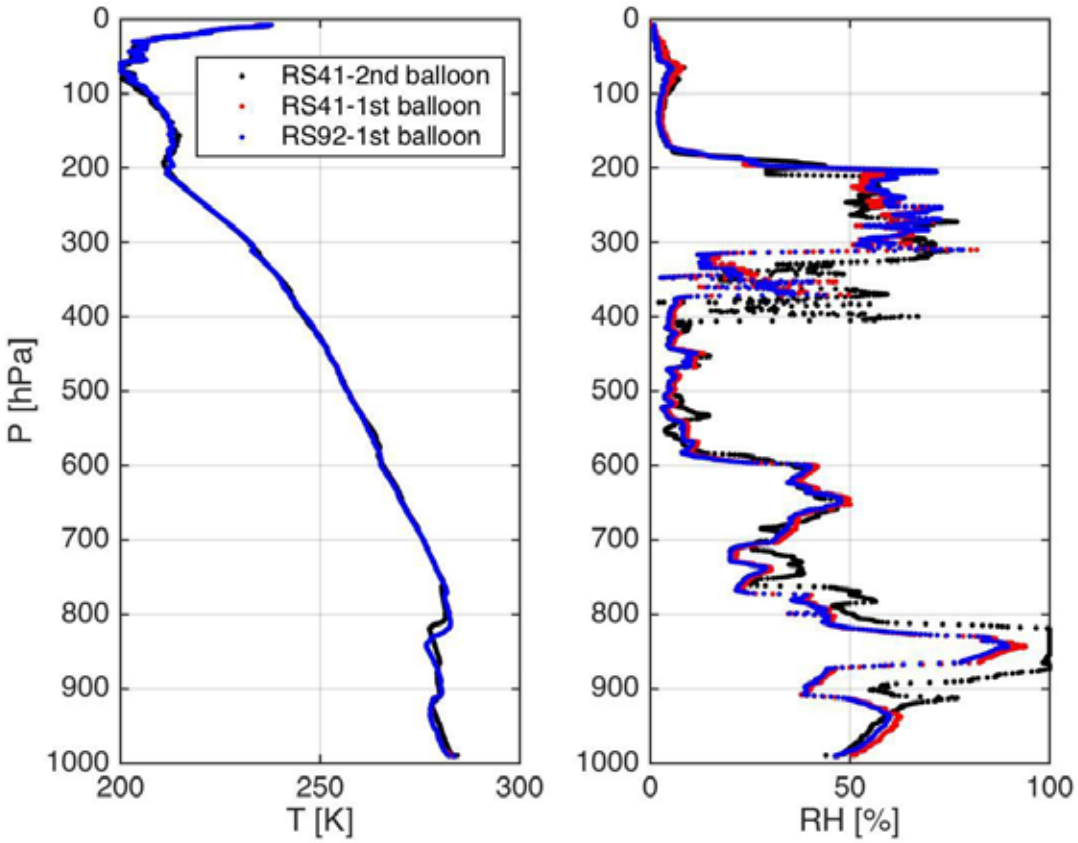

Figure 2. Example temperature and relative humidity measurements from a twin RIVAL launch on 13 February 2018.

2.2 Further Research Opportunities

Given that the analysis of this data set is still underway, so are opportunities for further research. These measurements will continue to be studied by the RIVAL collaborators. The measurements have been reprocessed using the GRUAN processing algorithm and will be compared to the Vaisala processed versions of these measurements and used together with data from similar RS92-RS41 radiosonde campaigns at other GRUAN sites. The RIVAL team intends that these measurements will be included in a final publication on the RS92-RS41 radiosonde transition.

3.0 Publications and References

Borg, L, R Dirksen, and R Knuteson. 2022. “Land-based cal/val campaigns.” In *Field Measurements for Passive Environmental Remote Sensing. Instrumentation, Intensive Campaigns, and Satellite Applications*. Edited by Nicholas Nalli, Elsevier, Amsterdam, pp 219-233. ISBN: 9780128239537.

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