# AERI Observations at the ARM SGP, NSA, and TWP CART Sites

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## Introduction

A total of eight Atmospheric Emitted Radiance Interferometer (AERI) systems, developed at the University of Wisconsin-Madison Space Science and Engineering Center (UW-SSEC) for the measurement of the downwelling infrared radiance spectrum, have now been deployed at the Atmospheric Radiation Measurement (ARM) Program's Southern Great Plains (SGP), Tropical Western Pacific (TWP), and North Slope of Alaska (NSA) Cloud And Radiation Testbed (CART) sites (Revercomb 1993). In this paper we will review the status and recent results obtained from these AERI systems.

## A Grid Cell of AERIs (SGP CART)

By the end of 1998, there were five AERI systems in continuous operation at the SGP CART site near Lamont, Oklahoma. An AERI has been operating at the SGP central facility since March 1993. The four new AERIs were installed at the SGP boundary facilities of Hillsboro, Morris, Purcell, and Vici before the Winter Single-Column Model (SCM) Intensive Operational Period (IOP) (see Figure 1). Whereas the AERI at the central facility has been used primarily for validation of radiative transfer models in clear and cloudy atmospheres, the AERIs at the boundary facilities will be used primarily for the continuous profiling of the temperature and water vapor vertical structure of the atmospheric boundary layer. Additional information on atmospheric profiling using the ARM SGP AERIs in support of the SCM IOPs can be found in the paper of Wayne Feltz, UW (Feltz et al. 1999).

## Mexican Smoke

In May 1998, the SGP site experienced extensive smoke aerosol carried by winds from Mexican forest fires. Using information provided by Rich Ferrare (Langley Research Center [LaRC]) and David Turner (Pacific Northwest National Laboratory [PNNL]) from the CART Raman Lidar, a preliminary investigation of the infrared effects of these aerosols was undertaken. The initial conclusion of this study is that unlike earlier aerosol examples (e.g., a dry line passage), the Mexican smoke had little impact in the infrared (Whitney et al. 1996). Figure 2 illustrates the infrared effect of the smoke aerosol by comparing a scatter plot of the observed minus clear-sky calculated radiance versus the aerosol

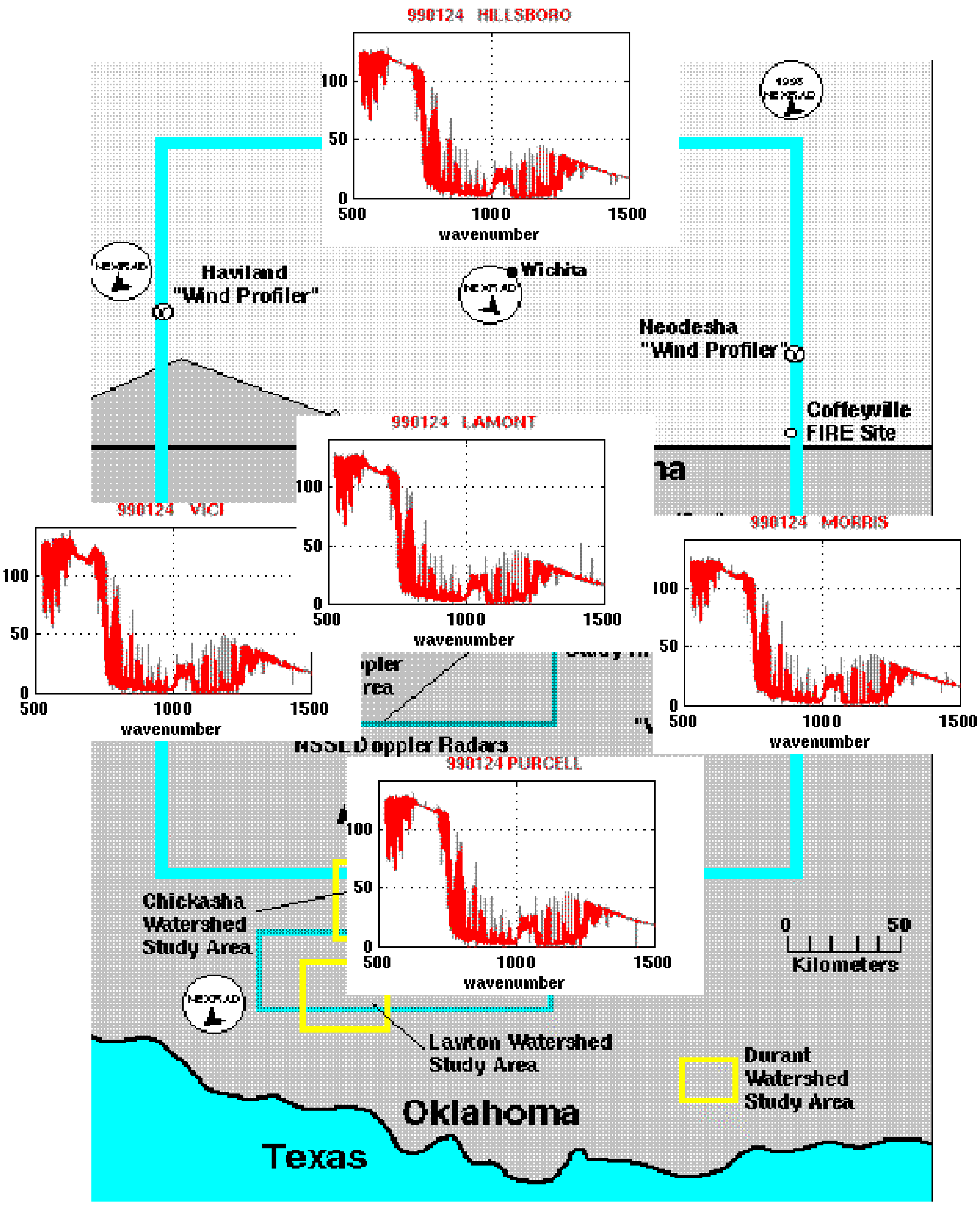


**Figure 1**. AERI systems are now operating at the SGP boundary facilities (Hillsboro, Morris, Purcell, and Vici) in addition to the AERI at the central facility near Lamont. The boundary facility AERIs are providing continuous profiling of the atmospheric boundary layer temperature and water vapor structure to augment the radiosonde launches from these sites used for input to ARM SCMs.

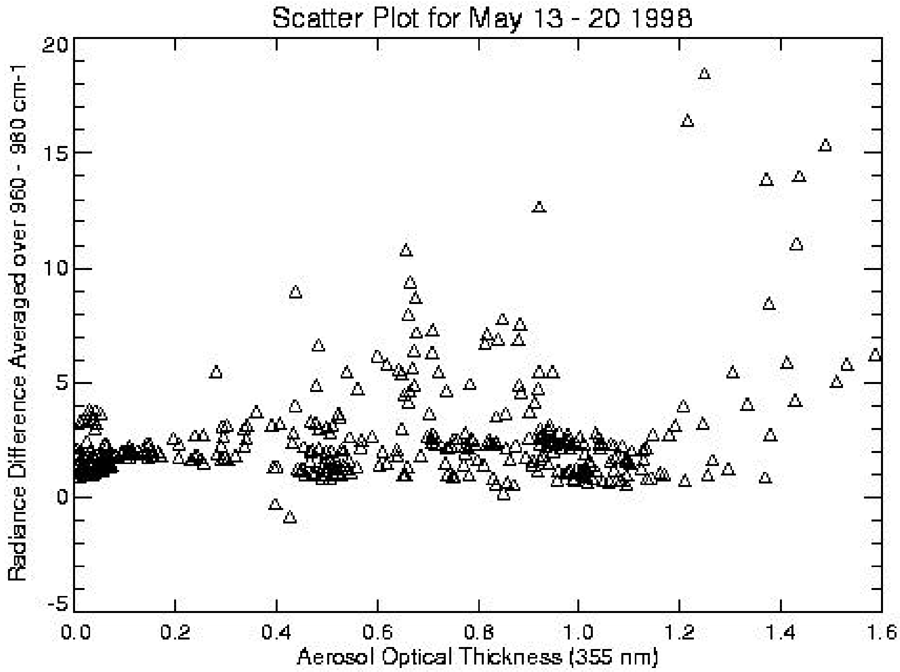


**Figure 2**. Aerosol radiative signal (AERI minus clear-sky calculation) versus aerosol optical thickness (AOT) from the CART Raman Lidar. Scatter of points above 5 radiance units are likely due to cloud contamination. The independence of the radiance difference from the AOT suggests that the Mexican smoke aerosol has little impact in the downwelling infrared. This is considerably different than the result for hydroscopic aerosols seen previously.

optical thickness (AOT) derived from coincident measurements of the CART Raman Lidar. This high time frequency comparison was obtained by using a fast forward model developed by the UW with input from the temperature and water vapor retrievals from the AERI derived using wavelengths outside the window region used for the aerosol study. Further work in this area will extend the analyses to include long time series (beginning in January 1998) with a goal of characterizing the frequency and magnitude of aerosol episodes with significant infrared radiation effects.

## TWP Nauru

An example AERI observation from the tropical island of Nauru is shown in Figure 3 compared to a similar clear-sky observation from the ARM NSA site under much colder and drier conditions. One of the important uses of the TWP AERI is the validation of radiative transfer models under conditions of high absolute water amount. Of particular interest is the validation of the emission due to the self-broadened water vapor continuum in the 8-12 micron window region (850-1250 $cm^{-1}$), a significant contributor to the greenhouse warming in the TWP. The first results of comparison of AERI observations with Line-by-Line Radiative Transfer Model (LBLRTM) calculations using a small sample of coincident radiosondes have been performed. There is a significant variability in the observed minus calculated radiance differences among these cases, which is attributed to the uncertainty of the

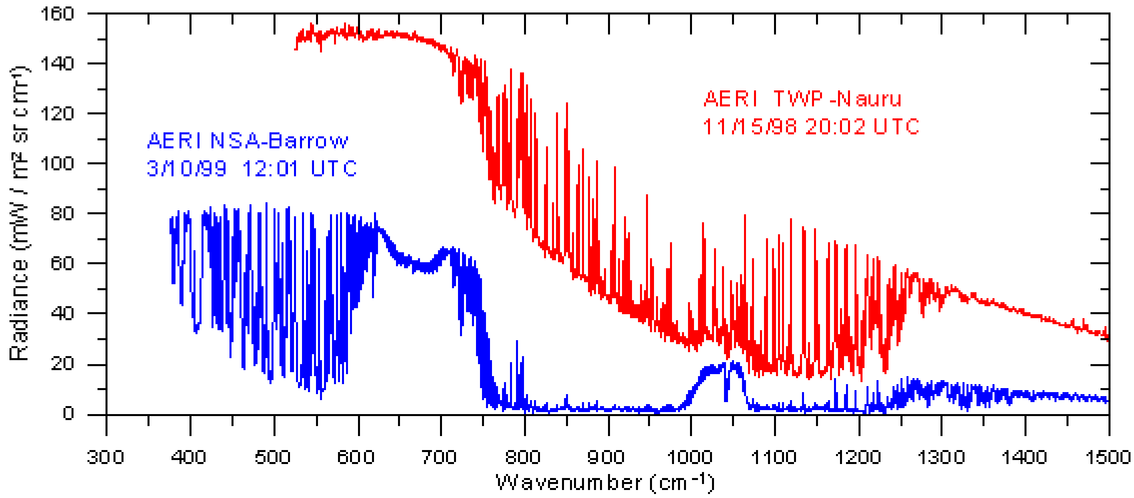


**Figure 3**. AERI clear-sky observations of arctic and tropical atmospheres from the U.S. Department of Energy ARM sites. The downwelling radiance in the tropics is dominated by the warmer temperatures and the greatly increased water vapor content of the lower atmosphere. The dip in the arctic radiance at 650 $cm^{-1}$ is due to the near surface temperature inversion caused by radiative cooling of the surface to space. The peak at 1050 $cm^{-1}$ is the radiance signal of the atmospheric column of ozone.

temperature and water vapor profile as measured by the radiosonde. Some preliminary conclusions from these first analyses are 1) the need to modify the handling of sondes before launch to reduce the effects of overheating of the sonde on the ground, 2) the need to perform some type of sonde water vapor scaling (such as to the Microwave Radiometer [MWR]) as is being done at the SGP site, and 3) the need to incorporate effective cloud screening (using coincident ceilometer data) to automate the selection of clear-sky radiances. Further work will be performed when more Nauru data become available.

## NSA/SHEBA

An important accomplishment of the AERI instrument development conducted under this grant has been the successful implementation of an Extended Range AERI (ER-AERI) system, which extends the longwave spectral coverage of the standard AERI system from about 520 $cm^{-1}$ (19 µm) to about 400 $cm^{-1}$ (25 µm). This covers most of the important rotational water vapor window, which is important in the dry arctic conditions in modulating the radiative cooling of the surface to space (see Figure 3). An ER-AERI was incorporated in a special shelter provided by PNNL and put aboard the Canadian ice-breaker Des Groiselliers at the beginning of the Surface Heat Budget of the Arctic (SHEBA) experiment in October 1997. A second ER-AERI system was installed at the new ARM NSA site in Barrow, Alaska. Data from each system was collected coincident with the National Aeronautics and Space Administration (NASA) FIRE-ACE (First ISCCP [International Satellite Cloud Climatology Program] Regional Experiment-Arctic Cloud Experiment) during May-June 1998, which involved the NASA C-130 aircraft and the high altitude ER-2. On board the ER-2, the UW High-resolution Infrared Sounder (HIS) instrument was able to obtain the first coincident Arctic upwelling infrared spectra to complement the downwelling spectra obtained by the ARM AERI systems. The water vapor continuum in the 19 μ to 25 μm spectral region has recently been modified to be consistent with the ER-AERI observations in the arctic (Tobin et al. 1999). A climatology of spectral infrared observations in the arctic is also in progress (Walden et al. 1999).

## References

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