Final Report for:
"Radiation Studies in Support of the CRYSTAL-FACE Project"
NASA Project CRYSTAL-0000-0091 (# NAG5-11637)
Project Report Period 2/1/2002- 1/31/2005
PI: Francisco P. J. Valero
Co-I: Shelly K. Pope, Brett C. Bush

As proposed, we successfully completed radiometric observations aboard the ER-2 and WB-57 platforms during the field phase of the CRYSTAL-FACE campaign. Quick look plots of the data were immediately archived after the missions and quality-controlled and completely processed final data products were archived in a timely manner to the CRYSTAL-FACE data archive. The successful operation of the observational platforms on the two aircraft consisted of the following steps that were all completed according to the timeline of the CRYSTAL-FACE project:

- Integration aboard the ER-2 and WB-57 platforms. Significant integration was required on the WB-57 since it was the first time on this aircraft. The ER-2 integration was only a slight modification to that flown in prior NASA funding missions.
- Pre- and post-mission calibrations of all radiometric instrumentation. This included all absolute, angular, and thermal responses necessary to adequately characterize the instrument responses.
- Field operation of the radiometric packages. ARL scientists operated all instrument packages in coordination with the research flights and participated in pre-mission planning meeting and post-mission scientific discussions and presentations. Quick look plots of the radiometric data were immediately uploaded to the CRYSTAL-FACE archive.
- Post-flight data processing. We obtained a very high quality data set by applying all of the instrument calibrations and a navigational correction analysis to the measurements. This data was uploaded to the CRYSTAL-FACE data archive within the six month period from the end of the deployment (as required by the CRYSTAL-FACE mission statement).

The specific radiometric instrumentation operated aboard the two NASA airborne platforms is summarized below:

ER-2

- Infrared broadband radiometer (IRBR) to measure upwelling and downwelling irradiances in the spectral range from 4.0 to about 50 μm.
- Total solar broadband radiometer (TSBR) to measure upwelling and downwelling irradiances in the spectral range from 0.224 to 3.91 μm.
- Cryogenic black body reference infrared narrow field-of-view radiometer (NFOV) to measure upwelling infrared radiances in one channel at 10 μm and at 4-40 μm.

WB-57

- Infrared broadband radiometers (IRBR) to measure upwelling and downwelling irradiances in the spectral range from 4.0 to about 50 μm.
- Total solar broadband radiometers (TSBR) to measure upwelling and downwelling irradiances in the spectral range from 0.224 to 3.91 μm.
- Total-Direct-Diffuse radiometers (TDDR) to measure upwelling and downwelling radiative fluxes in six 50-nm wide channels spanning 400 to 700 nm and one 10-nm wide channel centered at 500 nm. The zenith instrument had a scanning shadowband, permitting determination of the direct and diffuse radiation components and thus optical depths at the given wavelengths.

Using data obtained during a few of the CRYSTAL-FACE missions, we were able to measure the clear-sky water vapor greenhouse effect (super greenhouse effect) that takes place over the very warm oceans. It has previously been shown that such effects influence climate on a global scale. As a result of this finding, we have published the paper entitled "Observation of Water Vapor Greenhouse Absorption over the Gulf of Mexico using Aircraft and Satellite Data" (*J. Atmos. Sci.*, 61(6), 745-753, 15 March 2004) by Marsden and Valero.

Using the broadband, spectral, and infrared radiometric data acquired during the CRYSTAL-FACE campaign, we have also begun to develop a new set of algorithms to retrieve cloud parameters (optical depth and effective ice particle diameter) using remote irradiance measurements aboard an airborne platform. The data available from this campaign allows us to test these algorithms and verify the proof-of-concept of these theories. The motivation for developing the cloud parameter retrieval algorithms on airborne platforms is to increase the sensing capabilities of the instruments being operated and consequently improve modeling studies in comparison with satellite retrievals and direct observations. A manuscript, currently in preparation, will soon be submitted to a leading journal in atmospheric sciences.

During the super greenhouse and cloud parameter retrievals mentioned above, a coordinated effort was made with other scientists in order to validate a variety of satellite data products. Specifically, the GOES-8 and CERES broadband outgoing longwave radiation (OLR) and broadband albedo were compared to our measurements of these parameters. These unpublished studies have lead to some modifications of the CERES narrowband-to-broadband algorithms as well as the GOES-8 absolute longwave flux computation.

Oral and poster presentations utilizing the radiometric measurements that we made during CRYSTAL-FACE were made at the joint EGS-AGU meeting in Nice, France in April 6-11, 2003 ("Water Vapor Greenhouse Absorption Over the Gulf of Mexico Using Observations from Aircraft, Satellite Data, and Model Calculations," by Marsden and Valero; "Modeled, Several RTM Models, and Observed IR Irradiances during CRYSTAL-FACE" by Valero and Hart). Also, a collaboration with the University of Utah, Meteorology Department resulted in a further co-author publication, "Evolution of a Florida Cirrus Anvil," *J. Atmos. Sci.*, (in press) by Garrett, *et al.*