Hawaii '98: A Tropical Cloud Mission

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Overview

Hawaii ’98 is a joint U.S. Department of Energy (DOE)-National Aeronautics and Space Administration (NASA) mission to use unmanned aerospace vehicles (UAVs) to improve our understanding of the effect of clouds on the energy balance of the atmosphere. It has three major goals: one operational and two scientific:

- Extend UAV measurements to ~60 Kft, thereby providing “top-of-the-troposphere” measurements in the tropics.
- Explore the relationship between remotely sensed cloud properties (structure, microphysics) and their radiative behavior.
- Compare the UAV-measured quantities with satellite-based measurements from the newly launched Tropical Rainfall Measurement Mission (TRMM).

Hawaii ’98 will be conducted out of the Pacific Missile Range Facility on the island of Kauai in September/October 1998. A General Atomics Altus UAV will provide the top-of-the-troposphere measurements. A “Twin Otter” will provide the bottom-of-the-column measurements. As described below, both aircraft will be extensively instrumented with both up- and down-looking instruments. GPS systems on-board the two aircraft will allow precise stacking of the aircraft—one above the other—though separated by 50,000 ft and intervening clouds.

Scientific Objectives

As noted above, Hawaii ’98 will focus on two key scientific issues: the role of tropical cirrus on the energy balance of the atmosphere, and the combined use of aircraft and satellite-based measurements to characterize atmospheric heating.

Tropical Cirrus

By reflecting sunlight and trapping the earth’s thermal energy, tropical cirrus have a significant effect on the overall radiative balance of the atmosphere. Yet the radiative properties of cirrus clouds (albedo, transmissivity) and their relation to cloud microphysics (droplet number, size) and cloud structure is not well understood. Hawaii ’98 will contribute to this understanding by providing a highly accurate, collocated, simultaneous data base of

- up- and down-welling solar and infrared (IR) broadband fluxes, as well as solar spectral flux
- cloud microphysics as inferred from spectral, lidar, and radar measurements
- cloud structure as measured by a down-looking lidar on the Altus and an up-looking 95-GHz radar on the Twin Otter.

Satellite Calibration/Validation

The launch of TRMM in November 1997 marks the start of a new era in radiative balance measurements from space. The goal is to infer the atmospheric heating profile from space-based measurements of broadband fluxes [Cloud and Earth Radiant Energy System (CERES)] combined with cloud properties retrieved from a five-channel radiometer [Visible and Infrared Scanner (VIRS)] and water abundances from a microwave imager (TMI). Hawaii ’98 will contribute to the early stage of the goal by 1) comparing aircraft and satellite-derived quantities, and 2) exploring how best to use TRMM data in campaigns like Hawaii ’98.

Measurement Capabilities

Hawaii ’98 builds on the radiative payloads and coordinated (stacked) flight techniques demonstrated in previous

Atmospheric Radiation Measurement (ARM)-UAV campaigns. In addition, it has added significant new capabilities in shortwave spectral measurements [i.e., the "Pilewskie" Solar Spectral Flux Radiometers (SSFR), spectrally scanning polarimeter (SSP)-2, new total direct diffuse radiometer (TDDR) bands described below], and an up-looking 95-GHz cloud radar on the Twin Otter. A description of the complete Altus and Otter payloads is given in the table below, where ↑ indicates upward looking and ↓ indicates down looking.

Altus (~60 Kft)	**Twin Otter (~ 5 Kft)**
↑↓ RAMS (Scripps/Valero) • solar flux (0.2-3.9 μm) • IR flux (4.0-30 μm) • spectral flux (0.4-0.7 μm, in six 0.05 μm channels)	↑↓ RAMS (Scripps/Valero) • solar flux (0.2-3.9 mm) • IR flux (4.0-30 mm) • spectral flux (0.4-0.7 mm, in six 0.05 μm channels)
↑↓ SSFR (NASA/Pilewskie) • spectral flux (0.3-2.5 μm, ~ 300 channels)	↑↓ SSFR (NASA/Pilewskie) • spectral flux (0.3-2.5 mm, ~ 300 channels)
↓ SSP2 (CSU/Stephens) • spectral flux (0.4-2.5 μm) spectral radiance (0.4-4.0 μm)	↑ SSPI (CSU/Stephens) • spectral flux & radiance (0.4-1.1 μm, 55 channels)
↓ MPIR (SNL/Phipps)[(a)] • imaging radiometer (0.65, 0.88, 1.38, 1.62, 2.19 μm)	↑ 95 GHz Radar (NASA-JPL-UMass/Li Silewskie)
↓ CDL (LLNL/Ledebuhr)[(a)] • micropulse cloud lidar • WFOV CCD camera	
Frost point hygrometer[(a)] (BNL/Tsenum)	Chilled mirror hygrometer (BNL/Tsenum)

Note:
BNL Brookhaven National Laboratory
CCD charge-coupled device
CDL cloud detection lidar
CSU Colorado State University
JPL Jet Propulsion Laboratory
LLNL Lawrence Livermore National Laboratory
MPIR multispectral pushbroom imaging radiometer
RAMS Regional Atmospheric Modeling System
WFOV wide field of view

(a) Because of payload weight consideration on any given flight the Altus can only accommodate any 2 of the following 3 instruments: MPIR, CDL, frost point. The decision as to which instrument to leave out on a given day will be dictated by the science objective for that day.