Scientific Issues in the Gulf Stream Locale[a]

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Locale Characteristics

Cloud and Radiation Testbed (CART) sites have been selected so that, taken collectively, they span the range of attributes needed to realize the goals of the Atmospheric Radiation Measurement (ARM) Program. Thus, the selection of a locale as a primary CART site was based on its ability to contribute uniquely and significantly to the ARM scientific mission. The Gulf Stream locale has four characteristics of significance to climate research and to the ARM program:

1. The Gulf Stream locale exhibits extreme ranges in magnitude of surface heat fluxes; no other locale exhibits such a range in air-water temperature differentials and latent heat fluxes. These large fluxes provide a rigorous test of surface exchange and convection schemes in general circulation models.
2. This locale provides the best opportunity among the candidate locales to observe mature synoptic storms. These systems, which are characterized by extensive stratiform clouds, are the only such cloud systems that might be resolved by a general circulation model. Hence, they offer the possibility of testing process models and parameterizations, including microphysics parameterizations, without the usual difficulties associated with sub-grid variability.
3. The inhomogeneity that exists in the Gulf Stream Locale provides a severe test for cloud generation modules of climate models. These modules usually assume uniformity of surface conditions over domains of several hundreds of kilometers.
4. The anthropogenic aerosol loading off the east coast of the United States is highly variable; thus, the locale provides a testbed for hypotheses on the effects of changes in cloud condensation nuclei (CCN) concentrations upon cloud optical properties, structure and life cycle.

Of the five primary CART sites, the Gulf Stream locale, a western boundary current location, uniquely experiences positive sensible and latent heat fluxes that span wide ranges and are likely the largest on the earth (item 1 above).

It should be noted that while the locale characteristics derive from the properties of the Gulf Stream, the locale itself is best defined as those places where the effects of concern manifest themselves; for example, the greatest air-sea temperature differences during cold air outbreaks occur not over the core of the Gulf Stream but over its landward edge, and the large-scale storms reach their maturity beyond the northern wall of the Gulf Stream. Therefore, implementation of ARM program measurements is not to be limited to locations within the Gulf Stream proper.

Science Issues

The science issues, posed as questions, are grouped below under the two classes of ARM objectives as initially outlined in the ARM program plan and restated in the ARM report on the recommendation of potential locales for ARM sites.

(a) A draft report with more detail on this extended abstract is available from Paul Michael, Building 318, Brookhaven National Laboratory, Upton NY 11973.Telephone: 516-282-2264, FAX: 516-282-3264. Internet: PMICHAEL@BNL.GOV

Class 1 ARM Objective

Relate observed instantaneous radiative properties of the atmosphere (spectrally resolved) to the then-present atmospheric temperature and composition (specifically including water vapor and clouds) and surface radiative properties, both as a function of position, and develop parameterizations for these relationships.

1. Cloud classification: What modifications are needed in the cloud classification schemes used in climate models in order to characterize radiation adequately?
2. Water vapor distribution: How does spatial and temperature distribution of water vapor affect radiation?
3. Aerosol effects: How do the number density and size distribution of aerosols and CCN affect radiative transfer?
4. Surface roughness: What is the effect of surface roughness upon radiation?

Class 2 ARM Objective

Develop parameterizations to describe atmospheric composition (again, specifically including water vapor and clouds) and surface properties governing atmospheric radiation in terms of relevant prognostic variables, with the objective of incorporating these parameterizations into general circulation and related models.

1. Surface flux parameterizations: What is the range of applicability of the parameterizations of sensible and latent heat fluxes?
2. Surface fluxes and cloud formation: What is the effect of variations of latent and sensible heat flux upon cloud formation?
3. Cloud life cycle: What improvements are required in the methods of predicting the formation, maintenance, and dissipation of large-scale cloud systems?
4. Surface heterogeneity: What is the effect of surface heterogeneity upon cloud formation?
5. Aerosol effects on clouds: How do the number density and size distribution of aerosols and CCN affect cloud size, structure, and lifetime?
6. Sub-grid processes: What is the effect of surface heterogeneity upon model parameterization?

Phased Implementation

The ultimate target is a series of measurements, aimed at investigating specific scientific issues, conducted over a period of time, and with sufficient continuity that a full range of conditions can be spanned. Before full occupation, which is some years in the future, it is anticipated that activities can be undertaken both to further ARM objectives and to assist in the design of the CART program. The expectation is that considerable emphasis will be put upon developing a preoccupation design for using and incorporating existing data into the ARM data stream. In addition, opportunities for limited augmentation will be investigated. Any preoccupation activities would, of course, be dependent upon the availability of resources.