The North Slope of Alaska: The Atmospheric Radiation Measurement Program's Window on High Latitude Phenomena

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A major thrust of the Atmospheric Radiation Measurement (ARM) Program is the establishment of five primary and four supplementary Cloud and Radiation Testbed (CART) sites. The CART sites will provide the means to acquire the necessary data to test and further develop the components of general circulation models (GCMs), which describe the relationships between the characteristics of the atmosphere and the solar and thermal radiation which passes through it.

The CART Locale Recommendation Team has presented a priority-ordered set of recommended locales for the primary and supplementary sites, along with alternatives for each (Schwartz et al. 1991). The selection was based primarily on the following criteria:

- geographical and climatological homogeneity
- occurrence of climatologically important cloud types
- seasonal change of surface properties
- variability of radiatively active atmospheric components
- synergism with other programs
- manageable logistics.

An additional criterion was that, taken together, the set of recommended locales must span a broad range of climate regimes. The recommended primary locales include two land and three ocean locales. The first CART site will be established in the Southern Great Plains (SGP) of the United States. The next CART site to be established on land is to be in the polar regions, on the North Slope of Alaska (NSA).

Scientific Motivation for Locale Selection

There are three basic scientific reasons why a high latitude locale was selected as a primary CART locale: 1) high latitude regions are climatologically important and represent one extreme of the climate regimes that need to be spanned, 2) solar insolation and surface property seasonal variation at high latitudes strongly stress the models, and 3) the operative feedback mechanisms are believed to produce extreme climate sensitivity at high latitudes.

With regard to climatological importance, the polar heat sink is known to be a major driver of global atmospheric circulation. Furthermore, small changes in insolation at high latitudes in the Northern Hemisphere are believed to trigger the transitions between ice ages and interglacials. With regard to model stress, high latitudes present the greatest seasonal variation in insolation and surface properties found anywhere. Finally, the seasonal variation engages feedback mechanisms—albedo change in response to warming, water vapor and cloud radiative forcing—which almost all models predict amplify climate change in the arctic. This combination of factors makes a high latitude CART locale an obvious choice.

Alternatives Considered

The CART Locale Recommendation Team presented two alternatives to the NSA: the Greenland, and the Antarctic Ice Plateaus. To these, the authors of the ARM Locale Analysis Report (Zak et al. 1991) added the North Slope of

Canada. For the ice plateaus, the surface warming-surface albedo feedback is weak; hence, they are less favorable for investigating feedback coupling phenomena. Of the remaining two locales, the NSA is preferred because it has many more synergistic programs in place which will be of benefit to ARM. The NSA also has the advantage of being within the United States, which confers substantial logistical benefits.

Focus of the NSA CART Site

It is proposed that the focus of the NSA site be the operative feedback mechanisms and how they relate to major CART issues at high latitudes, specifically:

- radiative transfer modeling under polar night and low sun angle conditions—surface property, cloud and atmospheric composition effects
- arctic stratus and altostratus formation, maintenance, and dissipation modeling—radiative, advective, and convective influences
- surface property dynamics modeling—radiative, advective, and convective influences
- identification of limits on prediction accuracy at high latitudes.

Strawman NSA Site Implementation Strategy

A potentially attractive strategy would be to locate the NSA CART Central Facility (CF) with its concentration of radiometric and atmospheric characterization instrumentation near the village of Atkasuk, about 90 km south of Barrow.[a] Offices and other facilities, which do not need to be near the instrumentation itself, would be located in Barrow. At the NSA CART site, the Auxiliary Facilities (AFs) for determination of the cloud spatial distribution over the central facility should be much closer to the CF than at other CART sites, because ceilings are typically low there. Boundary Facilities (BFs) to measure inflows and outflows at the periphery of the site can make use of existing National Weather Service stations on or near the coast and existing exploratory well sites with airstrips inland. Extended Measurement Facilities to determine uniformity and gradients between the CF and the BFs would extend outward beyond the AFs and inward from the BFs. This general implementation strategy responds to existing conditions on the NSA (no roads, few population centers, few landing strips). As at other CART sites, ground facilities would be augmented with periodic aircraft-based measurements aloft and satellite overflights.

Potential NSA Site Extension

The CART Locale Recommendation Team proposed that a polar regions ocean locale (the Marginal Ice Zone supplementary CART site) be geographically joined to the NSA locale by selecting the Beaufort (or Chukchi) Sea for that role. This has great appeal. Because the summer "ice edge" is typically a few tens of kilometers from the NSA, this extension would allow a natural progression, from understanding high latitude cloud and radiative phenomena on land to understanding the same phenomena over open water, intermittent and unbroken ice. It would also allow close collaboration with the National Science Foundation Arctic System Science Program on Ocean-Atmosphere-Ice Interactions and would offer logistical and cost advantages as well.

Recap

Several factors contribute to the importance of the NSA CART site, but the most important are that the NSA site is one of only two recommended primary CART sites on land; it is the only high latitude primary CART site; and it is an attractive gateway to the Arctic Ocean and the polar ice pack.

(a) During an ARM Workshop held at the University of Alaska, 7-9 July, 1992, R. Ellingson remarked that, as far as he could see, there is no compelling reason to locate the North Slope Central Facility near the geographical center of the CART site. In his view, the principal function of the CF relates to instantaneous radiative transfer experiments, which could equally well be conducted at any location within the area. As such, it may be feasible to locate the Central Facility in the vicinity of Barrow. This would result in large cost savings and greatly ease logistical and personnel problems. In addition, it would fit well with the Barrow Environmental Observatory, a several square mile area of land being permanently protected from development for the express purpose of environmental research by the Barrow Village Corporation (UIC) and the North Slope Borough with support from the National Science Foundation.

References

Schwartz, S. E. et al. 1991. *Identification, Recommendation and Justification of Potential Locales for ARM Sites.* DOE/ER-0495T, U.S. Department of Energy, Washington, D.C.

Zak, B. D. et al. 1991. *ARM Locale Analysis: North Slope of Alaska and Alternatives.* SAND91-0354/1, Sandia National Laboratories, Albuquerque, New Mexico.