Description of the M_PACE objective analysis

1. Overview

This README file gives a brief description about the objective analysis of the Mixed-Phase Arctic Cloud Experiment (M-PACE) data collected at the ARM NSA site during the period from 00Z 5 October – 12Z 22 October 2004. Detailed information of the analysis is described in *Xie at al.* (2006a, b). The data are analyzed by the LLNL ARM infrastructure team (S. Xie, J. Yio, S. Klein, and R. Cederwall), in collaboration with Prof. Minghua Zhang at SUNY Stony Brook.

The variational analysis approach described in *Zhang and Lin* [1997] and *Zhang et al*. [2001] is used for the objective analysis of the M-APCE data. The analysis products include both the large-scale forcing terms (i.e., vertical velocity and advective tendencies of temperature and water vapor mixing ratio) and the evaluation fields, which can be used for driving SCMs/CRMs and validating model simulations. The analysis data are at 3-hour and 25-mb intervals and are in the same format as that in other ARM IOP variational analysis datasets.

The data can be obtained from the ARM Archive:

http://iop.archive.arm.gov/arm-iop/0special-data/cpm-forcing/iop_at_nsa/200410/

There are two data files. One is for layered variables, the other for surface variables and TOA variables (*layer_*.dat, surface_*.dat*). The two Fortran programs:

read_layer.for
read_surface.for

are used to read these ASCII files. They contain all the required information describing the data fields. From the site, you also can get the ARSCL clouds over the Barrow site. The ARSCL cloud data (*arscl_clouds_*.dat*) have been averaged to 3- hour and 25-mb intervals, in consistent with the analysis data. The Fortran file to read ARSCL cloud data:

read_arscl_clouds.for

Note: (12/14/05) *The MPACE forcing and evaluation dataset has been revised and changed slightly according to the update to the TOA shortwave fluxes made at Langley. The change in the TOA SW fluxes has only minor impact on the derived forcing fields. In addition to this change, we have improved the 3-hourly averaged ARSCL cloud frequency by using the laser ceilometer and micropulse lidar detected cloud-base height. The earlier data contained ice precipitation and/or clutter, which caused an underestimation of the cloud-base height.*

For questions, or to report data problems, please contact:

Shaocheng Xie: xie2@llnl.gov
Renata McCoy: Renata@llnl.gov
Steve Klein: *klein21@llnl.gov*
Minghua Zhang: mzhang@notes.cc.sunysb.edu

2. Some details of the analysis

The objective analysis domain and analysis grids defined for analyzing the M-PACE data are shown in Figure 1. The analysis grids A1, A2, and A5 overlap with the sounding stations Barrow, Atqasuk, and Oliktok Point, respectively. Toollik Lake site is not used as one of the analysis grids because it has much higher surface elevation (760m) than the other three sounding stations (less than 30m), which can cause problem to obtain the analysis domain-averaged quantities. To use the sounding information collected from the Toolik Lake site, we define one extra analysis point (A4) with the surface elevation of 50m as shown in Figure 1. Following *Zhang et al.* [2001], we also add another two auxiliary grid points at the middle of the two long sides of the domain (i.e., A3 and A6 in Figure 1) to improve the linear assumption that is used in the variational analysis to derive the fluxes into or out of the analysis domain. The grids A1-A6 consist of the final objective analysis grids used in this study and the finial-analyzed fields represent an average over the domain encompassed by these analysis grids.

During M-PACE, two radiosonde Intensive Operational Periods (IOPs) were conducted to measure the vertical profiles of temperature, relative humidity, and winds four times per day at the four ARM sounding stations. The first radiosonde IOP was from 00Z 5 October to 00Z 10 October 2004 and the second one from 00Z 14 October to 12Z 22 October 2004. Between the two IOPs, sounding data were available one time per day at the Barrow and Atqasuk sites. In additional to the ARM soundings, these upper-air data were also available two times a day from a National Weather Service (NWS) sounding station at Barrow. Similar to *Zhang et al.* [2001], these measured upper-air data are first analyzed using the analysis scheme of *Cressman* [1957] but with the background field from the ECMWF analyses, whose grids are shown by the "plus" symbols in Figure 1.

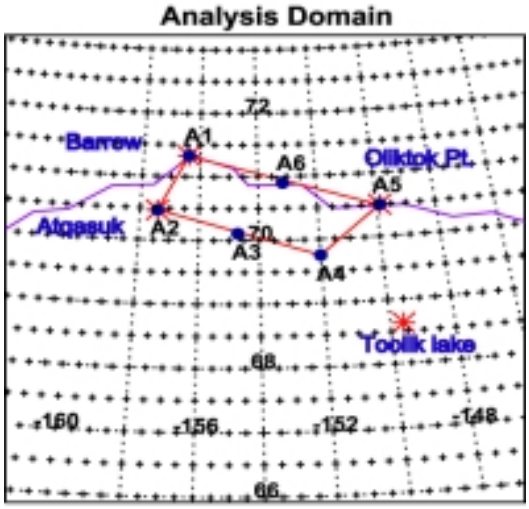

Figure 1. "●" symbols represent the analysis grids, "*" symbols are the locations of sounding stations, and "+" symbols denote the ECMWF model output grids

The required domain-averaged surface and TOA constraints are obtained from measurements at the two ARM ground-based sites (Barrow and Atqasuk) and the PARSL remote sensing facility (Oliktok Point). The ARM surface instruments and the PARSL ARM-like remote sensing facility provide measurements of surface precipitation, pressure, horizontal winds, temperature, relative humidity, surface broadband upwelling and downwelling radiative fluxes, and column precipitable water and cloud liquid water path. The radiative fluxes at TOA are from the 1 x 1 degree analysis of the NASA Terra satellite and the NOAA-15 and NOAA-16 satellites. In the analysis, we merged the ARM observed surface precipitation data with

those measured at the National Weather Service (NWS) Barrow station. Because the ARM precipitation data were contaminated by blowing snow, more weights (0.75) were given to the NWS data which were thought to be more reliable (Dr. James Pinto, University of Colorado, personal communication). Note that the surface sensible and latent heat fluxes required by the variational analysis are not available during M-PACE. These fields are calculated by:

HFLX = f * HFLX_bulk + (1-f) *HFLX_EC_ocean

where HFLX represents SH or LH. f = land grids/total grids within the analysis domain HFLX_bulk represents the bulk heat fluxes calculated using the algorithm described in *Fairall et al.* (1996) with some modifications so that it can be suitable for use over a surface covered by snow or ice, which is the case for M-PACE. HFLX_EC_ocean denotes the heat fluxes over the ocean grids within the analysis domain. The heat fluxes over ocean are from the ECMWF model.

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References

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