There files were generated by Greg McFarquhar and Gong Zhang at the University of Illinois. Please contact mcfarq@atmos.uiuc.edu or gzhang2@atmos.uiuc.edu for more information or for assistance in interpreting the content of these files. We highly recommend that anyone wishing to use these files do so in a collaborative endeavor and we welcome queries and opportunities for collaboration.

The files give our best estimates of the size distributions of supercooled water droplets and ice crystals for mixed-phase clouds measured during M-PACE for spiral ascents/descents over Barrow and Oliktok Point, and for ramped ascents/descents between Barrow and Oliktok Point. Our best estimates of the bulk microphysical properties such as ice water content (IWC), liquid water content (LWC), effective radius of ice crystals defined following Fu (1996) (rei), effective radius of supercooled water droplets (rew), total ice crystal number concentration (Ni), total water droplet number concentration (Nw) and total condensed water content (CWC), are also provided. The quantities were derived from the FSSP, 1DC, 2DC, HVPS and the CVI. Note HVPS data are only available after 10 Oct 2004 and some procedures have been developed to account for the missing data.

**Data format**

Time interval: 10 seconds (see note below on averaging procedures)
Starting time: in seconds from the midnight 12:00 am
Phase id: 0 no clouds, 1 ice clouds, 2 mixed-phase clouds, 3 water clouds
Temperature in Celsius
Normalized height (For single layer cases on Oct 09, 10 and 12 this height is included. This indicates the normalized height in cloud layer. When height is close to 1, it is near the cloud top. When height is near 0, it is near the cloud bottom. Values can be negative if precipitating ice is sampled beneath the liquid cloud base.)
CWC: out best estimate of the total water content g/m^3
LWC: liquid water content from king probe when available; otherwise estimated from FSSP size distributions g/m^3
IWC: ice water content g/m3
Re_ice and Re_water in microns
Number concentration of water droplets #/liter
Number concentration of ice crystals #/liter

Concentrations for each buffer #/liter (not normalized by the width of the bins)

FSSP bin limits (microns)
2.911 5.513 8.906 11.222 13.407 15.808 18.697 21.996 25.221 29.480 33.398 36.985 40.638 44.604 48.858 53.258
1DC bin limits (microns)
20.00 40.00 60.00 80.00 100.00 120.00 140.00 160.00
180.00 200.00 220.00 240.00 260.00 280.00 300.00 320.00
340.00 360.00 380.00 400.00 420.00 440.00 460.00 480.00
500.00 520.00 540.00 560.00 580.00 600.00 620.00
2DC bin limits (microns)

54.56 96.00 128.00 160.00 192.00 224.00 256.00 288.00
320.00 352.00 384.00 416.00 448.00 480.00 512.00 544.00
576.00 640.00 704.00 832.00 960.00 1250.00 1472.00 1984.00
2496.00 2976.00 3488.00 4000.00
Number of AR Bins for 2DC: 10 evenly spaced bins
HVPS bin limits (microns)
400.00 700.00 1000.00 1300.00 1600.00 1900.00 2200.00
2600.00 3000.00 3500.00 4000.00 5000.00 6000.00 7000.00
8000.00 9000.00 10000.00 11000.00 12000.00 13000.00 14000.00
15000.00 16000.00 17000.00 18000.00 19000.00 20000.00 21000.00
22000.00 23000.00 24000.00 25000.00 26000.00 27000.00 28000.00
29000.00 30000.00 31000.00 32000.00 33000.00 34000.00 35000.00
36000.00 37000.00 38000.00 39000.00 40000.00
Number of AR Bins for HVPS: 10

**Averaging Procedures (3/5/07):**

Note that all of the data that are written in the data files are written out at 10-s intervals. However, some of the values (especially those pertaining to ice clouds) are based on 30-s averages as required in order to provide a statistically significant sample. When 30-s data are supplied, they are derived from a 30-s running average of 10 second data. The original 10-s data are still supplied for those quantities from which statistically significant samples can be derived from a 10-s averaging procedure. The averaging time periods for the quantities in the data file are as follows:
Phase id: 30-second average
Temperature: 10-second average
Normalized height: 10-second average
CWC: 30-second average
LWC: 10-second average
IWC: 30-second average
Re_ice: 30-second average
Re_water: 10-second average
Number concentration of water droplets: 10-second average
Number concentration of ice crystals: 30-second average
FSSP size distribution: 10-second average
1DC size distribution: 10-second average
2DC size distribution: 30-second average
HVPS size distribution: 30-second average

**Changes to the M-PACE microphysics data files for the version released on February 22, 2007:**

1) The normalized height has been changed for some of the spiral ascents/descents over Oliktok Point and Barrow. Cloud base is now identified from the ground-based lidar as the height where the lidar depolarization ratio was equal to 0.15 in order to capture the base of the liquid cloud more accurately. Previously, cloud

base was identified as that location where the lidar depolarization was equal to 0.1. The net effect is that the cloud base height is shifted higher than in the previous version.

2) For 2DC and HVPS data, the 10 second averaged size distributions have been replaced by 30 second average size distributions (centered on each 10 second time period). This is done by applying a running average of 30 seconds over each 10 second distribution. Thus, the net effect is that the size distributions and calculated bulk parameters are still listed at 10 second resolution. This change was necessitated by the fact that the 2DC sometimes wrote out data at time intervals greater than 10 s because it took that long for the data buffer to be filled. The net result of this change is that the number of time periods with liquid is significantly reduced, while the number of time periods identified as mixed-phase is substantially increased. In addition, the average number concentration of ice crystals is reduced because fewer time periods involve no ice crystal concentrations.

3) For 2DC sizes less than 125 microns, the 2dc number concentration has been replaced by the number concentration measured by the one-dimensional cloud probe (1DC). This was necessitated by the fact that the 2DC has a poorly defined sample volume, and hence poorly known number concentrations, at sizes less than 125 micrometers. This causes some changes in ice crystal concentrations.

4) The total cloud droplet number concentration is directly calculated from the FSSP, rather than having the FSSP size distribution so that the bulk water matched that of the King probe. The LWC in the files, however, is still that from the King probe. This change does not make a substantial difference in the data file.

Changes to the M-PACE microphysics data files for the version released on October 17, 2006:

Note that a paper will be submitted shortly to J. Atmos. Sci. or J. Geophys. Res. where the trends in how rew, rei, Ni, Nw, LWC, IWC and fl=LWC/TWC vary with normalized height for the single-layer clouds will be presented. Anyone wishing to compare these data against their modeling simulations or retrieval schemes should reference the following paper (also reference this paper for the processing techniques):

McFarquhar, G.M., G. Zhang, M. Poellot, J. Verlinde, G. Kok, R. McCoy, T. Tooman and A.J. Heymsfield, 2006: Verical variability of the phases, shapes and sizes of hydrometeors in single layer mixed-phase Arctic stratus clouds. J. Geophys. Res., to be submitted November 2006.

A second paper describing the results for the multi-layer stratus cases is under preparation.

A few changes have been made to the M-PACE data files that give information on how the bulk properties of the mixed-phase clouds vary with height (or in the case of the single-layer mixed-phase clouds how the quantities vary with normalized height). These changes are documented below.

1. Calculation of normalized height, zn = (z-zb)/(zt-zb) for single layer clouds, where z is the height, zb cloud base and zt cloud top. For cases over Oliktok Point or Barrow where lidar data are available, the base height is defined as the lidar derived liquid cloud bottom. The top is defined as either the location where the Citation ascended above the top of the cloud or the radar derived cloud top. For ramped legs, the bottom and top are our best guess of top and bottom from determining where the Citation went above and below cloud. Note that negative normalized heights are included in the new data file. These occur because precipitating ice beneath cloud base was frequently measured. On occasion, trace amounts of liquid were also measured below what we identified as the lidar derived cloud base.

2. Calculation of the ice crystal size distributions for maximum dimensions greater than 1500 micrometers. For several of the flights the HVPS, which measures the size distributions of the larger ice crystals, did not record data. Because our preliminary analysis showed that these crystal sizes can make substantial contributions to the total ice mass, it was critical to get an estimate of the number of these crystals. Ultimately fits to the 2DC distributions were made and extended to larger crystal sizes to account for the numbers of these larger crystal sizes. We used data from the cases where we had the HVPS data to develop the fitting algorithms and to ensure that the fitting procedures gave a good estimate of the number and mass contained in the large crystal sizes compared to the HVPS observations (these techniques are further described in McFarquhar et al. 2006).

3. Calculation of IWC. For reasons previously explained, the IWC cannot be simply estimated as the difference of the CSI TWC and the King LWC. Thus, we have derived a and b coefficients that describe how the mass scales with the maximum dimension of the ice crystal through the relation $m=aD^b$. The coefficients a and b were determined by minimizing the chi-squared difference between the mass estimated from the size distributions and that estimated from the CSI for cases where we were only in ice. The McFarquhar et al. (2006) paper describes the basis for this technique. The resulting a and b coefficients were applied to calculated IWC for both ice-phase and mixed-phase clouds. McFarquhar et al. (2006) shows that there are not statistically significant differences in crystal morphology between the mixed-phase and ice-phase cases suggesting that the application of these data may be reasonable.

4. Calculation of rei. This follows Fu’s (1996) definition. The IWC is calculated as above. The bulk density of ice is assumed to be 0.91 g/cm3. The cross-sectional area of the distributions is derived from the 2DC/HVPS size distributions sorted by maximum dimension and area ratio. For cases without HVPS data, it is assumed that the mean cross-sectional area varies with maximum dimension following the relation derived from days with HVPS data.

5. For ice only cases the FSSP data is not included in calculation of total ice crystal number. We believe that shattering of larger ice crystals on the protruding arms of the FSSP will lead to an overestimate of ice crystal number. We can provide a separate estimate of the upper bound of ice crystal number that includes contributions from the FSSP upon request. We are also conducting a separate research project to try and better quantify the phase/shape of crystals between 50 and 100 micrometers.

6. Uncertainties and error estimates are better quantified in the McFarquhar et al. (2006) paper which we will make available when we have finished writing it. Estimates in IWC are probably a bit larger than a factor of 2, especially for those cases where we do not have HVPS data. Similarly, uncertainty estimates in rei must be at least a factor of two.

7. There is missing temperature data for several of the spiral ascents/descents and ramped legs because the temperature inlet froze up. We have provided our best estimate of the temperature for all legs by developing relations between pressure and temperature for those spiral legs where we have data. See McFarquhar et al. (2006) for more details on how these corrections are made. For one date, 10 October, altitude data are also missing. Therefore a relationship between pressure and altitude gave the altitudes used to determine the normalized altitudes.