Aerosol Observing System Cloud Condensation Nuclei Average (AOSCCNAVG) Value-Added Product

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July 2013

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1.0   Introduction

The Aerosol Observing System Cloud Condensation Nuclei Average (AOSCCNAVG) value-added product (VAP) was developed to consolidate the relevant CCN parameters into a single file and average the data over the 5-minute integration time of each percent super saturation (%ss) value. The surface sites measure the CCN concentration at several super saturations using a Droplet Measurement Technologies (DMT) single-column CCN counter (Roberts and Nenes 2005). The percent super saturation of the instrument is stepped through 7 intervals every 30 minutes with 5 minutes at each setting in a pyramid profile. For the first minute after a change in %ss, the CCN temperatures are unstable and the %ss value usually overshoots the set point value. For this reason the first minute of every %ss setting is disregarded and only the last four minutes are averaged together.

The %ss in the CCN datastream is calculated using a heat transfer and fluid dynamics model flow model (Lance et al. 2006). The model uses the calibrated temperature, pressure, and flows in the instrument to calculate the %ss. Small variations in the %ss will arise from changes in the column thermal properties in the instrument. Rose et al. (2008) discusses the model and salt calibration calculations of the instrument %ss and uncertainty associated with thermal properties. The calculated %ss value was chosen to be more reliable than the static calibration obtained via salt aerosol because the %ss value changes dynamically with the instrument flow, pressure, and room temperature, and because salt calibrations are inconvenient at remote locations and so happen infrequently.

2.0   Input Data

The AOSCCNAVG VAP produces two output datastreams; aosccnavg.c1 and aosccnavg.c2. a1 level input datastreams are required to produce the c1 level output, and b1 level input datastreams are required to produce the c2 level output.

Table 1. AOSCCNAVG input datastreams.

Instrument or VAP Source	Datastream Name
AOS	[site]aosccn[facility].a1 – input for producing aosccnavg.c1 [site]aosccn100[facility].a1 – use this if above datastream is not available [site]aos[facility].a1 – input for producing aosccnavg.c1 [site]aoscpc[facility].a1 – use this if above datastream is not available [site]noaaaosccn100[facility].b1 – input for producing aosccnavg.c2 [site]noaaaos[facility].b1 – input for producing aosccnavg.c2

3.0   Algorithm and Methodology

The raw CCN and CPC data are extracted and merged. Edit directives are applied to the data to remove times with instrument problems or short spikes in the CCN data. The program selects data over the 2:00–5:00 minute time interval every 5 minutes and then averages the data. Times with missing data are filled with missing value codes and flagged accordingly in the QC variables.

4.0   Output Data

The AOSCCNAVG VAP produces two datastreams: aosccnavg.c1 and aosccnavg.c2. The first datastream is produced daily in near-real-time with the a1 level datastreams as input. The second datastream takes mentor-edited b1 level datastreams as input. The mentor-edited data are usually available after six months. The VAP will be run after the edited data are available.

One file is created each day named with the following convention:

SSSaosccnavgFF.cN.YYYYMMDD.hhmmss
where:

> SSS = the location of the instrument (nsa, sgp, twp, pye, etc.)
> aosccnavg = The name of this VAP
> FF = facility (e.g., C1)
> N = 1 or 2
> YYYYMMDD = year, month, and day
> hhmmss = hour, minute, second

A sample netCDF header of the output datastream is given in Appendix A (both output datastreams have the same netCDF header).

5.0   Summary

AOSCCNAVG will be run at the Southern Great Plains (SGP) Central Facility (C1), North Slope of Alaska (NSA) Barrow site (C1), and the first ARM Mobile Facility (AMF1) sites where AOSCCN data are available. Evaluation data have been processed for c2 level output for SGP C1 from 20120101 through 20120628. More data will be processed when the input becomes available. Quicklook images for the evaluation data periods are available here:

http://www.dmf.arm.gov/ql.php?path=%2Fdata%2Fhome%2Fshi%2Feval_plots%2F
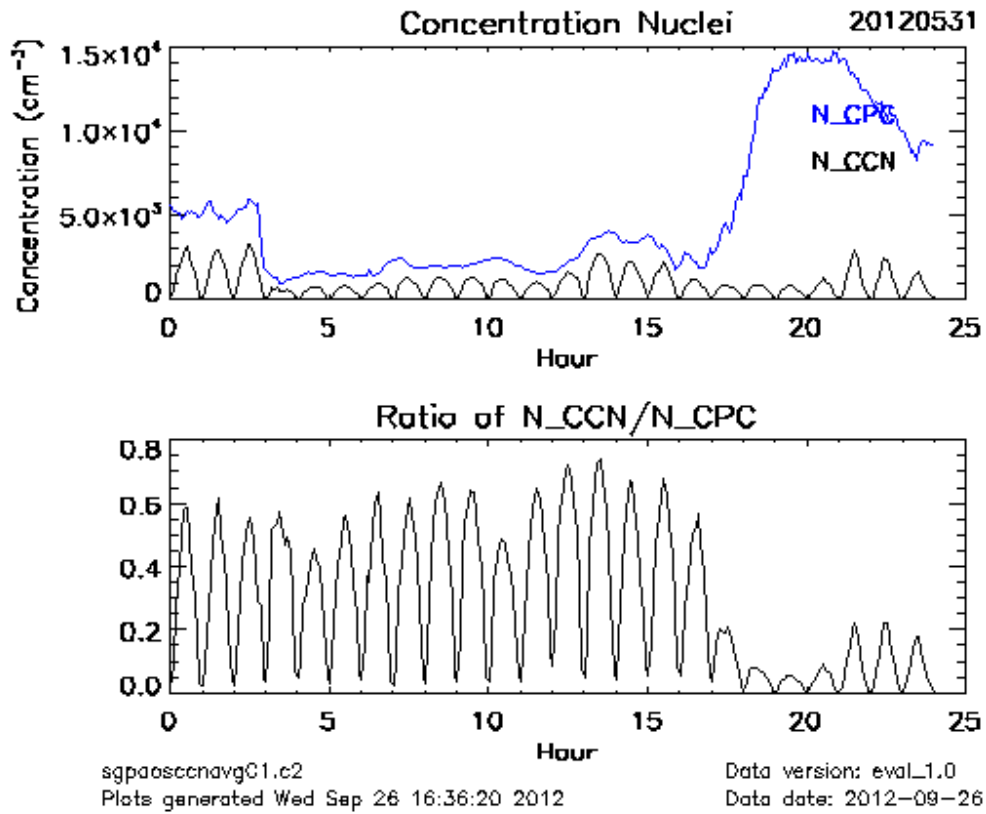
6.0   Example Plots

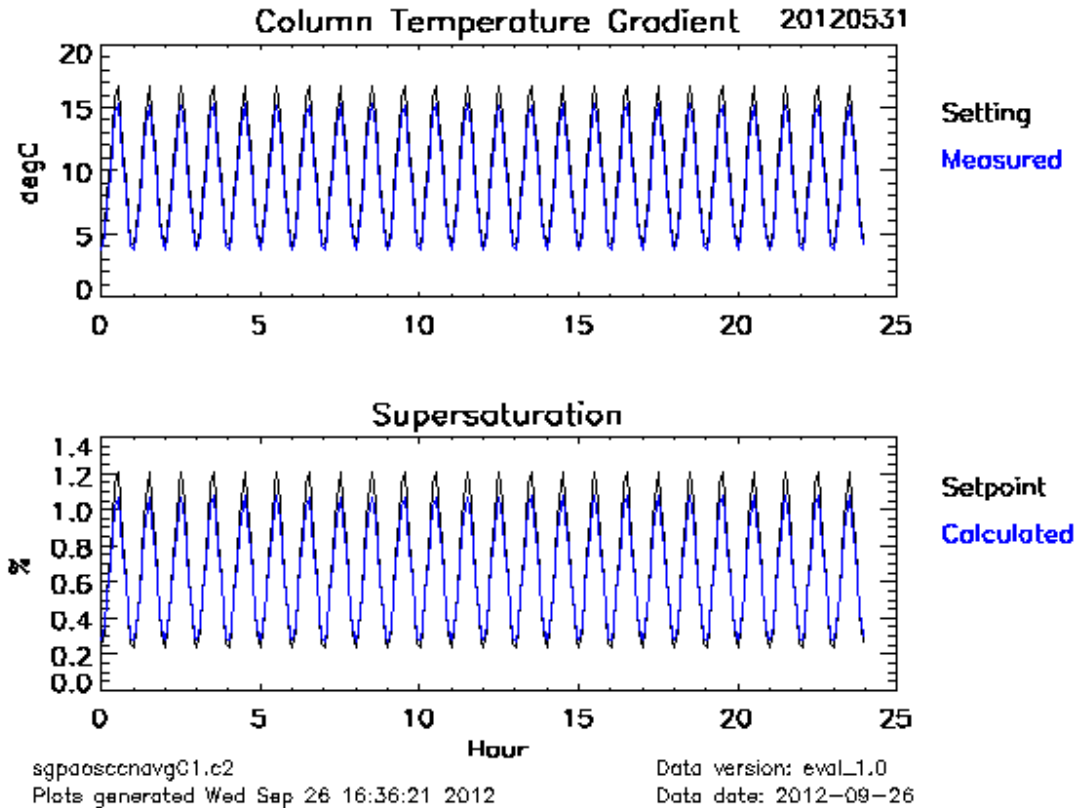**Figure 1**.   Concentration nuclei of N_CCN and N_CPC.

Figure 2.   Column temperature gradient and percent supersaturation.

7.0 References

Lance, S, J Medina, JN Smith, and A Nenes. 2006. "Mapping the operation of the DMT continuous flow CCN counter." *Aerosol Science and Technology* 40: 242–254.

Roberts, G, and A Nenes. 2005. "A continuous-flow streamwise thermal-gradient CCN chamber for atmospheric measurements." *Aerosol Science and Technology* 39(3): 206–221.

Rose, D, SS Gunthe, E Mikhailov, GP Frank, U Dusek, MO Andreae, and U Poschl. 2008. "Calibration and measurement uncertainties of a continuous-flow cloud condensation nuclei counter (DMT-CCNC): CCN activation of ammonium sulfate and sodium chloride aerosol particles in theory and experiment." *Atmospheric Chemistry and Physics* 8: 1153–1179.

Appendix A: Sample Output

A.1 Sample Output Datastream netCDF Header

netcdf sgpaosccnavgC1.c2.20120620.000100 {
dimensions:
    time = UNLIMITED ; // (288 currently)
    droplet_size = 21 ;
variables:
    int base_time ;
        base_time:string = "2012-06-20 00:00:00 0:00" ;
        base_time:long_name = "Base time in Epoch" ;
        base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
    double time_offset(time) ;
        time_offset:long_name = "Time offset from base_time" ;
        time_offset:units = "seconds since 2012-06-20 00:00:00 0:00" ;
    double time(time) ;
        time:long_name = "Time offset from midnight" ;
        time:units = "seconds since 2012-06-20 00:00:00 0:00" ;
    int qc_time(time) ;
        qc_time:long_name = "Quality check results on field: Time offset from midnight" ;
        qc_time:units = "unitless" ;
        qc_time:description = "This field contains bit packed values which should be interpreted as listed. No bits set (zero) represents good data." ;
        qc_time:bit_1_description = "Delta time between current and previous samples is zero." ;
        qc_time:bit_1_assessment = "Indeterminate" ;
        qc_time:bit_2_description = "Delta time between current and previous samples is less than the delta_t_lower_limit field attribute." ;
        qc_time:bit_2_assessment = "Indeterminate" ;
        qc_time:bit_3_description = "Delta time between current and previous samples is greater than the delta_t_upper_limit field attribute." ;
        qc_time:bit_3_assessment = "Indeterminate" ;
        qc_time:delta_t_lower_limit = 240. ;
        qc_time:delta_t_upper_limit = 360. ;
        qc_time:prior_sample_flag = 1 ;
        qc_time:comment = "If the \'prior_sample_flag\' is set the first sample time from a new raw file will be compared against the time just previous to it in the stored data. If it is not set the qc_time value for the first sample will be set to 0." ;
    float droplet_size(droplet_size) ;
        droplet_size:long_name = "Upper limit of each CCN bin" ;
        droplet_size:units = "um" ;
        droplet_size:comment = "The last bin has no explicit upper limit. All particles larger than 10 micron are included in this last bin." ;
        droplet_size:missing_value = -9999.f ;
        droplet_size:attribution = "Named \"num_bins\" in aosccn.a1 and aosccn100.a1" ;
    float supersaturation_setpoint(time) ;
        supersaturation_setpoint:long_name = "Sample saturation setpoint" ;
        supersaturation_setpoint:units = "%" ;
        supersaturation_setpoint:missing_value = -9999.f ;
        supersaturation_setpoint:attribution = "Named \"num_bins\" in aosccn.a1 and aosccn100.a1" ;
    int qc_supersaturation_setpoint(time) ;
        qc_supersaturation_setpoint:long_name = "Quality check results on field: Sample saturation setpoint" ;
        qc_supersaturation_setpoint:units = "unitless" ;
        qc_supersaturation_setpoint:description = "This field contains bit packed values which should be interpreted as listed. No bits set (zero) represents good data." ;

qc_supersaturation_setpoint:bit_1_description = "Transformation could not finish (all values bad or outside range, etc.)." ;
qc_supersaturation_setpoint:bit_1_assessment = "Bad" ;
qc_supersaturation_setpoint:bit_2_description = "Transformation resulted in an indeterminate outcome." ;
qc_supersaturation_setpoint:bit_2_assessment = "Indeterminate" ;
qc_supersaturation_setpoint:bit_3_description = "A non-standard interpolation, used only in trans_interpolate.c." ;
qc_supersaturation_setpoint:bit_3_assessment = "Bad" ;
qc_supersaturation_setpoint:bit_3_comment = "interpolation performed using points other than the two that bracket the target index. Possibly because one or both of the nearest points was flagged as bad." ;
qc_supersaturation_setpoint:bit_4_description = "Extrapolation is performed out from two points on the same side of the target index, used only in trans_interpolate.c." ;
qc_supersaturation_setpoint:bit_4_assessment = "Bad" ;
qc_supersaturation_setpoint:bit_4_comment = "This occurs because the input grid doesn\'t span the output grid, or because all the points within range and on one side of the target were flagged as bad." ;
qc_supersaturation_setpoint:bit_5_description = "Nearest good point is not the nearest actual point, used in trans_subsample.c." ;
qc_supersaturation_setpoint:bit_5_assessment = "Bad" ;
qc_supersaturation_setpoint:bit_6_description = "Some, but not all, of the inputs used in the averaging were flagged as bad, used only in trans_bin_average.c." ;
qc_supersaturation_setpoint:bit_6_assessment = "Indeterminate" ;
qc_supersaturation_setpoint:bit_7_description = "The weights for all the input points to be averaged for this output bin were set to zero, used only in trans_bin_average.c." ;
qc_supersaturation_setpoint:bit_7_assessment = "Bad" ;
qc_supersaturation_setpoint:bit_7_comment = "The output \"average\" value is set to zero, by definition, no matter what the value of the input." ;
qc_supersaturation_setpoint:bit_8_description = "Nearest good bracketting points are farther away than the \"range\" transform parameter, used in trans_interpolate.c and trans_subsample.c." ;
qc_supersaturation_setpoint:bit_8_assessment = "Bad" ;
qc_supersaturation_setpoint:bit_8_comment = "Test can also fail if more than half an input bin is extrapolated beyond the first or last point of the input grid." ;
qc_supersaturation_setpoint:bit_9_description = "All the input values used in the transformation were flagged as bad" ;
qc_supersaturation_setpoint:bit_9_assessment = "Bad" ;
qc_supersaturation_setpoint:bit_9_comment = "This means slightly different things for the different transforms. For trans_bin_average.c, it means all the points that were attempted to be average dwere bad, while for trans_interpolate.c it usually means *every* point in our 1D slice of data that is to be transformed were bad." ;
    float supersaturation_calculated(time) ;
        supersaturation_calculated:long_name = "Sample supersaturation calculated by model" ;
        supersaturation_calculated:units = "%" ;
        supersaturation_calculated:missing_value = -9999.f ;
        supersaturation_calculated:model_documentation1 = "Roberts, G. C. and Nenes, A. (2005)" ;
        supersaturation_calculated:model_documentation2 = "A continuous-flow streamwise thermal-gradient CCN chamber for atmospheric measurements." ;
        supersaturation_calculated:model_documentation3 = "Aerosol Sci. Tech., 39, 206-221" ;
        supersaturation_calculated:model_documentation4 = "Lance, S., Medina, J., Smith, J. N. and Nenes, A. (2006)" ;
        supersaturation_calculated:model_documentation5 = "Mapping the operation of the DMT continuous flow CCN counter" ;
        supersaturation_calculated:model_documentation6 = "Aerosol Sci. Tech., submitted, not yet published" ;
        supersaturation_calculated:attribution = "Named \"num_bins\" in aosccn.a1 and aosccn100.a1" ;
    int qc_supersaturation_calculated(time) ;
        qc_supersaturation_calculated:long_name = "Quality check results on field: Sample supersaturation calculated by model" ;
        qc_supersaturation_calculated:units = "unitless" ;

qc_supersaturation_calculated:description = "This field contains bit packed values which should be interpreted as listed. No bits set (zero) represents good data." ;

qc_supersaturation_calculated:bit_1_description = "Transformation could not finish (all values bad or outside range, etc.)." ;

qc_supersaturation_calculated:bit_1_assessment = "Bad" ;

qc_supersaturation_calculated:bit_2_description = "Transformation resulted in an indeterminate outcome." ;

qc_supersaturation_calculated:bit_2_assessment = "Indeterminate" ;

qc_supersaturation_calculated:bit_3_description = "A non-standard interpolation, used only in trans_interpolate.c." ;

qc_supersaturation_calculated:bit_3_assessment = "Bad" ;

qc_supersaturation_calculated:bit_3_comment = "interpolation performed using points other than the two that bracket the target index. Possibly because one or both of the nearest points was flagged as bad." ;

qc_supersaturation_calculated:bit_4_description = "Extrapolation is performed out from two points on the same side of the target index, used only in trans_interpolate.c." ;

qc_supersaturation_calculated:bit_4_assessment = "Bad" ;

qc_supersaturation_calculated:bit_4_comment = "This occurs because the input grid doesn\'t span the output grid, or because all the points within range and on one side of the target were flagged as bad." ;

qc_supersaturation_calculated:bit_5_description = "Nearest good point is not the nearest actual point, used in trans_subsample.c." ;

qc_supersaturation_calculated:bit_5_assessment = "Bad" ;

qc_supersaturation_calculated:bit_6_description = "Some, but not all, of the inputs used in the averaging were flagged as bad, used only in trans_bin_average.c." ;

qc_supersaturation_calculated:bit_6_assessment = "Indeterminate" ;

qc_supersaturation_calculated:bit_7_description = "The weights for all the input points to be averaged for this output bin were set to zero, used only in trans_bin_average.c." ;

qc_supersaturation_calculated:bit_7_assessment = "Bad" ;

qc_supersaturation_calculated:bit_7_comment = "The output \"average\" value is set to zero, by definition, no matter what the value of the input." ;

qc_supersaturation_calculated:bit_8_description = "Nearest good bracketting points are farther away than the \"range\" transform parameter, used in trans_interpolate.c and trans_subsample.c." ;

qc_supersaturation_calculated:bit_8_assessment = "Bad" ;

qc_supersaturation_calculated:bit_8_comment = "Test can also fail if more than half an input bin is extrapolated beyond the first or last point of the input grid." ;

qc_supersaturation_calculated:bit_9_description = "All the input values used in the transformation were flagged as bad" ;

qc_supersaturation_calculated:bit_9_assessment = "Bad" ;

qc_supersaturation_calculated:bit_9_comment = "This means slightly different things for the different transforms. For trans_bin_average.c, it means all the points that were attempted to be average dwere bad, while for trans_interpolate.c it usually means *every* point in our 1D slice of data that is to be transformed were bad." ;

float column_temperature_gradient_setting(time) ;

column_temperature_gradient_setting:long_name = "Gradient between column top and bottom temperature settings" ;

column_temperature_gradient_setting:units = "degC" ;

column_temperature_gradient_setting:comment = "The temperature settings (and thus the column temperature gradient) are determined according to the supersaturation setting." ;

column_temperature_gradient_setting:missing_value = -9999.f ;

float column_temperature_gradient_measured(time) ;

column_temperature_gradient_measured:long_name = "Measured temperature difference between top and bottom of column" ;

column_temperature_gradient_measured:units = "degC" ;

column_temperature_gradient_measured:comment = "mean(CCN_T_TEC3 - CCN_T_TEC1)" ;

column_temperature_gradient_measured:missing_value = -9999.f ;

float column_temperature_gradient_measured_std(time) ;

column_temperature_gradient_measured_std:long_name = "Standard deviation of measured difference in temperature readings at top and bottom of column" ;

column_temperature_gradient_measured_std:units = "degC" ;
column_temperature_gradient_measured_std:comment = "stddev(CCN_T_TEC1 - CCN_T_TEC3)" ;
column_temperature_gradient_measured_std:missing_value = -9999.f ;
float N_CCN(time) ;
N_CCN:long_name = "Number concentration of CCN" ;
N_CCN:units = "1/cm^3" ;
N_CCN:missing_value = -9999.f ;
int qc_N_CCN(time) ;
qc_N_CCN:long_name = "Quality check results on field: Number concentration of CCN" ;
qc_N_CCN:units = "unitless" ;
qc_N_CCN:description = "This field contains bit packed values which should be interpreted as listed. No bits set (zero) represents good data." ;
qc_N_CCN:bit_1_description = "Transformation could not finish (all values bad or outside range, etc.)." ;
qc_N_CCN:bit_1_assessment = "Bad" ;
qc_N_CCN:bit_2_description = "Transformation resulted in an indeterminate outcome." ;
qc_N_CCN:bit_2_assessment = "Indeterminate" ;
qc_N_CCN:bit_3_description = "A non-standard interpolation, used only in trans_interpolate.c." ;
qc_N_CCN:bit_3_assessment = "Bad" ;
qc_N_CCN:bit_3_comment = "interpolation performed using points other than the two that bracket the target index. Possibly because one or both of the nearest points was flagged as bad." ;
qc_N_CCN:bit_4_description = "Extrapolation is performed out from two points on the same side of the target index, used only in trans_interpolate.c." ;
qc_N_CCN:bit_4_assessment = "Bad" ;
qc_N_CCN:bit_4_comment = "This occurs because the input grid doesn\'t span the output grid, or because all the points within range and on one side of the target were flagged as bad." ;
qc_N_CCN:bit_5_description = "Nearest good point is not the nearest actual point, used in trans_subsample.c." ;
qc_N_CCN:bit_5_assessment = "Bad" ;
qc_N_CCN:bit_6_description = "Some, but not all, of the inputs used in the averaging were flagged as bad, used only in trans_bin_average.c." ;
qc_N_CCN:bit_6_assessment = "Indeterminate" ;
qc_N_CCN:bit_7_description = "The weights for all the input points to be averaged for this output bin were set to zero, used only in trans_bin_average.c." ;
qc_N_CCN:bit_7_assessment = "Bad" ;
qc_N_CCN:bit_7_comment = "The output \"average\" value is set to zero, by definition, no matter what the value of the input." ;
qc_N_CCN:bit_8_description = "Nearest good bracketing points are farther away than the \"range\" transform parameter, used in trans_interpolate.c and trans_subsample.c." ;
qc_N_CCN:bit_8_assessment = "Bad" ;
qc_N_CCN:bit_8_comment = "Test can also fail if more than half an input bin is extrapolated beyond the first or last point of the input grid." ;
qc_N_CCN:bit_9_description = "All the input values used in the transformation were flagged as bad" ;
qc_N_CCN:bit_9_assessment = "Bad" ;
qc_N_CCN:bit_9_comment = "This means slightly different things for the different transforms. For trans_bin_average.c, it means all the points that were attempted to be average dwere bad, while for trans_interpolate.c it usually means *every* point in our 1D slice of data that is to be transformed were bad." ;
qc_N_CCN:bit_10_description = "N_CCN > N_CPC" ;
qc_N_CCN:bit_10_assessment = "Indeterminate" ;
qc_N_CCN:bit_10_comment = "Physically, it is not possible for N_CCN to exceed N_CPC so one or the other of these fields must be in error. Use either value with caution." ;
float N_CCN_std(time) ;
N_CCN_std:long_name = "standard deviation of number concentration of CCN" ;
N_CCN_std:units = "1/cm^3" ;
N_CCN_std:missing_value = -9999.f ;
float N_CPC(time) ;
N_CPC:long_name = "Condensation Particle Concentration Number" ;

```
        N_CPC:units = "1/cm^3" ;
        N_CPC:missing_value = -9999.f ;
        N_CPC:instrument = "TSI model 3010 Condensation Particle Counter" ;
    int qc_N_CPC(time) ;
        qc_N_CPC:long_name = "Quality check results on field: Condensation Particle Concentration Number" ;
        qc_N_CPC:units = "unitless" ;
        qc_N_CPC:description = "This field contains bit packed values which should be interpreted as listed. No
bits set (zero) represents good data." ;
        qc_N_CPC:bit_2_description = "N_CCN > N_CPC" ;
        qc_N_CPC:bit_2_assessment = "Indeterminate" ;
        qc_N_CPC:bit_2_comment = "Physically, it is not possible for N_CCN to exceed N_CPC so one or the
other of these fields must be in error.  Use either value with caution." ;
        qc_N_CPC:bit_1_assessment = "Bad" ;
        qc_N_CPC:bit_1_description = "Transformation could not finish (all values bad or outside range, etc.)." ;
    float N_CPC_std(time) ;
        N_CPC_std:long_name = "standard deviation of Condensation Particle Concentration Number" ;
        N_CPC_std:units = "1/cm^3" ;
        N_CPC_std:missing_value = -9999.f ;
        N_CPC_std:instrument = "TSI model 3010 Condensation Particle Counter" ;
    float N_CCN_dN(time, droplet_size) ;
        N_CCN_dN:long_name = "Size distribution of activated nuclei" ;
        N_CCN_dN:units = "unitless" ;
        N_CCN_dN:missing_value = -9999.f ;
        N_CCN_dN:comment1 = "Each bin contains a droplet count, based on droplet size" ;
        N_CCN_dN:comment2 = "Bin droplet size (top of each bin) are 0.75um, 1.0um, 1.5um, 2.0um, 2.5um ...
to 10um in 0.5um incrementsincrements; Bin 21 is the count for droplets with sizes greater than 10 um" ;
    int qc_N_CCN_dN(time, droplet_size) ;
        qc_N_CCN_dN:long_name = "Quality check results on field: Size distribution of activated nuclei" ;
        qc_N_CCN_dN:units = "unitless" ;
        qc_N_CCN_dN:description = "This field contains bit packed values which should be interpreted as listed.
No bits set (zero) represents good data." ;
    float lat ;
        lat:long_name = "North latitude" ;
        lat:units = "degree_N" ;
        lat:valid_min = -90.f ;
        lat:valid_max = 90.f ;
    float lon ;
        lon:long_name = "East longitude" ;
        lon:units = "degree_E" ;
        lon:valid_min = -180.f ;
        lon:valid_max = 180.f ;
    float alt ;
        alt:long_name = "Altitude above mean sea level" ;
        alt:units = "m" ;

// global attributes:
        :command_line = "aosccnavg_vap -n aosccnavg1jefferson -s sgp -f C1 -b 20120330 -e 20120629 -D 2 -R"
;
        :process_version = "$" ;
        :dod_version = "aosccnavg-c2-0.1" ;
        :site_id = "sgp" ;
        :facility_id = "C1: Lamont, Oklahoma" ;
        :input_datastreams_description = "A string consisting of the datastream(s), datastream version(s), and
datastream date (range)." ;
        :input_datastreams_num = 2 ;
```

```
        :input_datastreams = "sgpnoaaaosccn100C1.b1 : 1.000000 : 20120620.000000sgpnoaaaosC1.b1 :
Unknown : 20120620.000000" ;
        :qc_standards_version = "1.0" ;
        :datastream =  ;
        :history = "created by user shi on machine borax at 2012-09-07 17:59:15, using $" ;
}
```