U.S. DEPARTMENT OF ENERGY | Office of Science

DOE/SC-ARM/TR-152

2D Gridded Surface Data Value-Added Product

Q Tang
S Xie

July 2015

ARM
CLIMATE RESEARCH FACILITY

DISCLAIMER

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Version 1.0

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Acronyms and Abbreviations

2D	2-dimensional
ARM	Atmospheric Radiation Measurement
ARMBE	Atmospheric Radiation Measurement Best Estimate
ARMBE2DGRID	ARMBE 2D gridded surface data
ARMBE2DSTNS	ARMBE station-based surface data set
BAEBBR	Best-Estimate Fluxes from EBBR Measurements and Bulk Aerodynamics Calculations
EBBR	Energy Balance Bowen Ratio Station
ECOR	Eddy Correlation Flux Measurement System
GOES	Geostationary Operational Environmental Satellites
QC	quality control
QCRAD	Data Quality Assessment for ARM Radiation Data
SGP	Southern Great Plains
SWATS	Soil Water and Temperature System

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1.0 Introduction

This report describes the Atmospheric Radiation Measurement (ARM) Best Estimate (ARMBE) 2-dimensional (2D) gridded surface data (ARMBE2DGRID) value-added product. Spatial variability is critically important to many scientific studies, especially those that involve processes of great spatial variations at high temporal frequency (e.g., precipitation, clouds, radiation, etc.). High-density ARM sites deployed at the Southern Great Plains (SGP) allow us to observe the spatial patterns of variables of scientific interests. The upcoming megasite at SGP with its enhanced spatial density will facilitate the studies at even finer scales. Currently, however, data are reported only at individual site locations at different time resolutions for different datastreams. It is difficult for users to locate all the data they need and requires extra effort to synchronize the data. To address these problems, the ARMBE2DGRID value-added product merges key surface measurements at the ARM SGP sites and interpolates the data to a regular 2D grid to facilitate the data application.

2.0 Input Data

Input data (see Table 1) are from various datastreams, and include surface atmospheric state variables (p, u, v, T, and q), surface fluxes (radiation and eddy fluxes, and precipitation), top-of-the-atmosphere net radiation fluxes, liquid water path, precipitable water vapor, cloud measurements (cloud fraction, thickness, and top height), and soil measurements (soil temperature and moisture).

Table 1. Input Datastreams and Variables included in ARMBE2DGRID

Variable Name	Input Datastream	Notes
Surf. u, v, T, q, precipitation	• ARM-standard meteorological instrumentation at surface • Oklahoma mesonet • Kansas State University mesonet	Merged.
Surf. pressure	• ARM-standard meteorological instrumentation at surface • Oklahoma mesonet	Merged.
Surf. radiative fluxes	• Data Quality Assessment for ARM Radiation Data	ARM value-added surface radiation fluxes.
Top-of-the-atmosphere net radiative fluxes	• Geostationary Operational Environmental Satellites	Satellite measurements at the top of the atmosphere.
Liquid water path, precipitable water vapor	• Microwave micrometer	Missing value used for periods (i.e., after 2011) when only one microwave micrometer station is available.
Surf. heat fluxes	• Best-Estimate Fluxes from Energy Balance Bowen Ratio Station (EBBR) measurements and bulk aerodynamics (BAEBBR) • Eddy Correlation Flux Measurement System (ECOR)	Merged, west domain mainly from BAEBBR, while east domain the mix of the two.
Cloud fraction for low, middle, high level clouds Cloud thickness, top height	• Geostationary Operational Environmental Satellites	Satellite data.
Soil moisture and temperature	• Soil Water and Temperature System (SWATS) • EBBR	Not merged. Both data are provided. SWATS data only use the top four layers (5, 15, 25, 35 cm) and EBBR only has one layer.

3.0 Algorithm and Methodology

The grid for the output data is at $0.25^o \times 0.25^o \times 1$ hour and covers the domain at 35°N—38.5°N and 95.5°W—99.5°W. The horizontal resolution as well as the domain size is identical to those of the Surface Cloud Grid (abbreviated as SFCCLDGRID) data set. If there are actual measurements within the $0.25^o \times 0.25^o$ grid box, simple arithmetic averaging is used to obtain the value for that grid box. Under circumstances during which multiple instruments observe the same quantities, their measurements are merged in the arithmetic averaging process with a weighting function depending on their quality. If there is no actual measurement in the grid box, the Barnes scheme (Barnes 1964) is used with the length scale of L_x = 50 km, L_y = 50km, and L_t = 6hr to fill the missing boxes. Domain means also are provided, because the coverage of some variables may be too sparse for some periods.

3.1 Flowchart

Figure 1 shows the flowchart of creating the ARMBE2DGRID data. The steps are straightforward, except quality control (QC). Details about the QC are given in the next section.

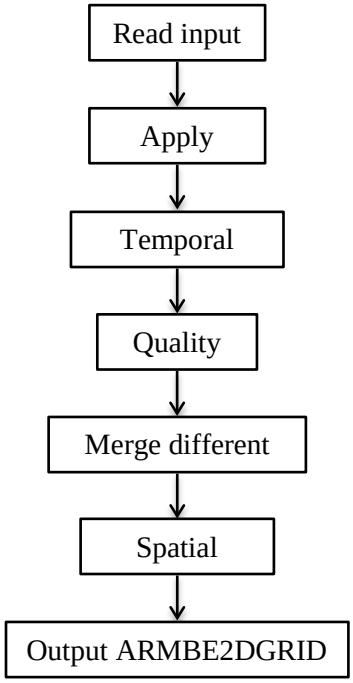

Figure 1. Procedures for Creating ARMBE2DGRID Data Procedures

3.2 Quality Control Methods

The following necessary stringent QC procedures (Zhang et al. 2001a, b) are applied to improve the data quality over the raw sources.

- Data range check on maximum and minimum values.
- Outlier check using standard deviation. If data values depart from the mean by more than four times the standard deviation, data are rejected.

- Temporal variability check using the moving window method. This method is applied with a sliding block of seven deviation scores. After each test, six deviation scores remain, and a new deviation score is added to the block. The Grubbs method is used to determine if the new score contributes an inordinate amount to the variance of the block, so that it ought to be considered to be an outlier.

4.0 Output Data

The full list of the output variables is given by the NetCDF header file (see Appendix A).

5.0 Example Plots

Example plots are shown in Figure 2 through Figure 6 to give a "quicklook" of the data.

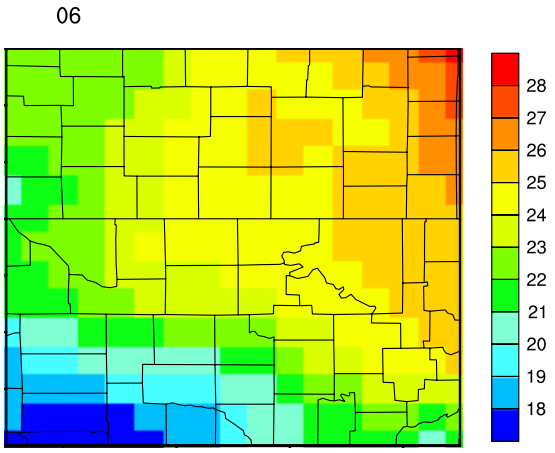

Figure 2. Monthly Mean High Cloud Fraction (expressed as %) for June 2011

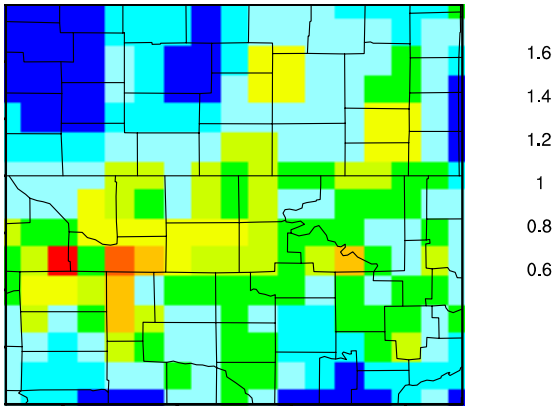

Figure 3. Same as Figure 2, but for Surface Precipitation Rate (expressed as mm/hour)

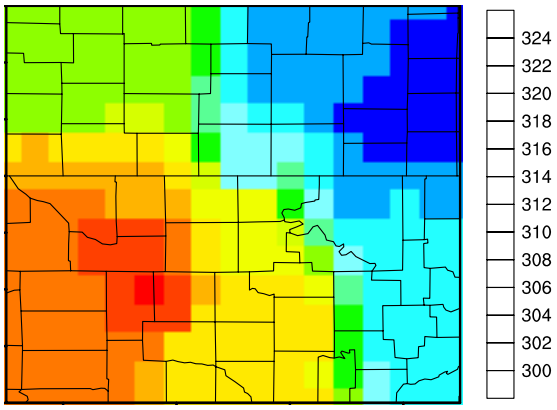

Figure 4. Same as Figure 2, but for Surface Downward Shortwave Radiation (expressed as W/m^2)

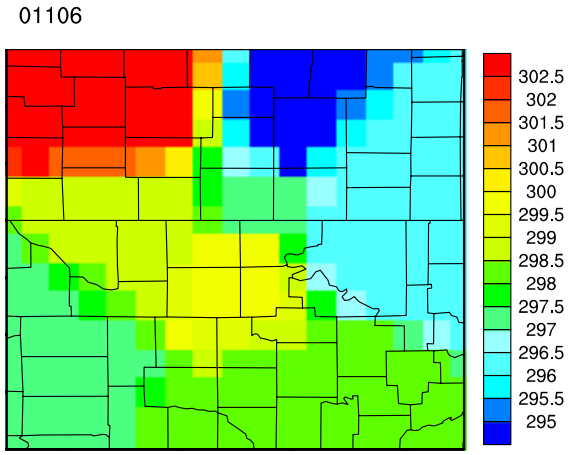

Figure 5. Same as Figure 2, but for SWATS Soil Temperature (expressed as K) at 5 cm

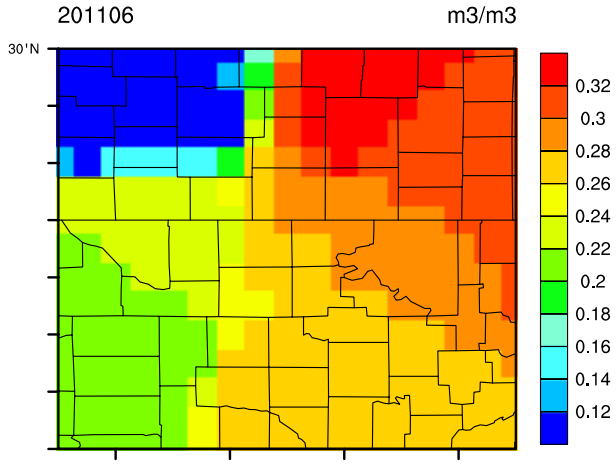

Figure 6. Same as Figure 2, but for SWATS Soil Moisture (expressed as m^3/m^3, volumetric) at 5 cm

6.0 Data Caveat/Uncertainty

Like any other gridded data products, ARMBE2DGRID data suffer from the uncertainties introduced by interpolating/extrapolating data points to common grids. It is recommended that for scientific applications caution should be taken when interpolating data from limited points and/or unevenly distributed sites (e.g., EBBR and ECOR). The station data (ARMBE2DSTNS) are provided to compensate the limitations imposed by interpolations and are encouraged to use with the 2D gridded data when original information is needed. When the site number is extremely low (e.g., microwave radiometer for year 2011), we opt to fill in missing values as placeholders instead of reporting unphysical, interpolated values. For turbulence fluxes, we merge data from two different instruments (EBBR and ECOR) to achieve a better spatial coverage and representativeness, despite of the known differences in these two measurements.

7.0 References

Barnes, S. 1964. "A technique for maximizing details in numerical map analysis." *Journal of Applied Meteorology* 3:396-409. doi: http://dx.doi.org/10.1175/1520-0450(1964)003<0396:ATFMDI>2.0.CO;2.

Zhang, MH, JL Lin, RT Cederwall, JJ Yio, and SC Xie. 2001(a). "Objective analysis of ARM IOP data: Method and sensitivity." *Monthly Weather Review* 129:295-311.
doi: http://dx.doi.org/10.1175/1520-0493(2001)129<0295:OAOAID>2.0.CO;2

Zhang, M, S Xie, RT Cederwall, and JJ Yio. 2001(b). Description of the ARM Operational Objective Analysis System, DOE/SC-ARM/TR-005, U.S. Department of Energy, Office of Biological and Environmental Research, Washington, D.C.
Available at http://www.arm.gov/publications/tech_reports/arm-tr-005.pdf.

Appendix A

Output Data

Appendix A

Output Data

```
netcdf sgparmbe2dgridX1.c1.20110601.000000 {
dimensions:
    time = UNLIMITED ; // (720 currently)
    lat = 15 ;
    lon = 17 ;
    depth = 4 ;
    bound = 2 ;
variables:
    int base_time ;
        base_time:string = "2011-6-1 0:00:00 0:00, UTC" ;
        base_time:long_name = "Base time in Epoch" ;
        base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
        base_time:ancillary_variables = "time_offset" ;
    double time_offset(time) ;
        time_offset:long_name = "Time offset from base_time" ;
        time_offset:units = "seconds since 2011-6-1 0:00:00 0:00" ;
        time_offset:ancillary_variables = "base_time" ;
        time_offset:bounds = "time_bounds" ;
    double time(time) ;
        time:long_name = "Time offset from midnight" ;
        time:units = "seconds since 2011-6-1 0:00:00 0:00" ;
        time:bounds = "time_bounds" ;
        time:calendar = "gregorian" ;
        time:standard_name = "time" ;
    double time_bounds(time, bound) ;
        time_bounds:long_name = "Time cell bounds" ;
        time_bounds:units = "seconds since 2011-6-1 0:00:00 0:00" ;
        time_bounds:bound_offsets = -1800.f, 1800.f ;
    double time_frac(time) ;
        time_frac:long_name = "Calendar day fraction of the year" ;
        time_frac:units = "days since 2010-12-31" ;
        time_frac:calendar = "gregorian" ;
    short depth(depth) ;
        depth:long_name = "Sensor depth below surface" ;
        depth:units = "cm" ;
        depth:positive = "down" ;
    float z_a ;
        z_a:long_name = "Height above ground level, a coordinate" ;
        z_a:units = "m" ;
        z_a:positive = "up" ;
    float z_b ;
        z_b:long_name = "Height above ground level, b coordinate" ;
        z_b:units = "m" ;
        z_b:positive = "up" ;
    float z_c ;
```

```
        z_c:long_name = "Depth below ground level, c coordinate" ;
        z_c:units = "cm" ;
        z_c:positive = "down" ;
    float z_d ;
        z_d:long_name = "Integration of top layer below ground level, d coordinate" ;
        z_d:units = "cm" ;
        z_d:positive = "down" ;
    float pressure(time, lat, lon) ;
        pressure:long_name = "Surface pressure" ;
        pressure:units = "hPa" ;
        pressure:standard_name = "surface_air_pressure" ;
        pressure:missing_value = -9999.f ;
        pressure:_FillValue = -9999.f ;
    float u_wind(time, lat, lon) ;
        u_wind:long_name = "U wind component" ;
        u_wind:units = "m s-1" ;
        u_wind:standard_name = "eastward_wind" ;
        u_wind:coordinates = "z_a" ;
        u_wind:missing_value = -9999.f ;
        u_wind:_FillValue = -9999.f ;
    float v_wind(time, lat, lon) ;
        v_wind:long_name = "V wind component" ;
        v_wind:units = "m s-1" ;
        v_wind:standard_name = "northward_wind" ;
        v_wind:coordinates = "z_a" ;
        v_wind:missing_value = -9999.f ;
        v_wind:_FillValue = -9999.f ;
    float precip_rate(time, lat, lon) ;
        precip_rate:long_name = "Precipitation rate" ;
        precip_rate:units = "mm hour-1" ;
        precip_rate:standard_name = "lwe_precipitation_rate" ;
        precip_rate:missing_value = -9999.f ;
        precip_rate:_FillValue = -9999.f ;
    float temp(time, lat, lon) ;
        temp:long_name = "Air temperature" ;
        temp:units = "K" ;
        temp:standard_name = "air_temperature" ;
        temp:coordinates = "z_b" ;
        temp:missing_value = -9999.f ;
        temp:_FillValue = -9999.f ;
    float rh(time, lat, lon) ;
        rh:long_name = "Relative humidity" ;
        rh:units = "%" ;
        rh:standard_name = "relative_humidity" ;
        rh:coordinates = "z_b" ;
        rh:missing_value = -9999.f ;
        rh:_FillValue = -9999.f ;
    float longwave_net_toa(time, lat, lon) ;
        longwave_net_toa:long_name = "Net longwave flux at the top of the atmosphere" ;
        longwave_net_toa:units = "W m-2" ;
        longwave_net_toa:standard_name = "toa_net_upward_longwave_flux" ;
```

```
        longwave_net_toa:missing_value = -9999.f ;
        longwave_net_toa:_FillValue = -9999.f ;
    float shortwave_net_toa(time, lat, lon) ;
        shortwave_net_toa:long_name = "Net shortwave flux at the top of the atmosphere" ;
        shortwave_net_toa:units = "W m-2" ;
        shortwave_net_toa:standard_name = "toa_net_upward_shortwave_flux" ;
        shortwave_net_toa:missing_value = -9999.f ;
        shortwave_net_toa:_FillValue = -9999.f ;
    float shortwave_down_toa(time, lat, lon) ;
        shortwave_down_toa:long_name = "Solar insolation at the top of the atmosphere" ;
        shortwave_down_toa:units = "W m-2" ;
        shortwave_down_toa:standard_name = "toa_incoming_shortwave_flux" ;
        shortwave_down_toa:missing_value = -9999.f ;
        shortwave_down_toa:_FillValue = -9999.f ;
    float latent_heat_flux(time, lat, lon) ;
        latent_heat_flux:long_name = "Surface latent heat flux" ;
        latent_heat_flux:units = "W m-2" ;
        latent_heat_flux:standard_name = "surface_upward_latent_heat_flux" ;
        latent_heat_flux:positive = "up" ;
        latent_heat_flux:missing_value = -9999.f ;
        latent_heat_flux:_FillValue = -9999.f ;
    float sensible_heat_flux(time, lat, lon) ;
        sensible_heat_flux:long_name = "Surface sensible heat flux" ;
        sensible_heat_flux:units = "W m-2" ;
        sensible_heat_flux:standard_name = "surface_upward_sensible_heat_flux" ;
        sensible_heat_flux:positive = "up" ;
        sensible_heat_flux:missing_value = -9999.f ;
        sensible_heat_flux:_FillValue = -9999.f ;
    float pwv(time, lat, lon) ;
        pwv:long_name = "Column precip water vapor" ;
        pwv:units = "cm" ;
        pwv:missing_value = -9999.f ;
        pwv:_FillValue = -9999.f ;
    float lwp(time, lat, lon) ;
        lwp:long_name = "Cloud liquid water path" ;
        lwp:units = "cm" ;
        lwp:missing_value = -9999.f ;
        lwp:_FillValue = -9999.f ;
    float longwave_net_toa_clear(time, lat, lon) ;
        longwave_net_toa_clear:long_name = "Clear sky net longwave flux at the top of the atmosphere"
;
        longwave_net_toa_clear:units = "W m-2" ;
        longwave_net_toa_clear:missing_value = -9999.f ;
        longwave_net_toa_clear:_FillValue = -9999.f ;
    float shortwave_net_toa_clear(time, lat, lon) ;
        shortwave_net_toa_clear:long_name = "Clear sky net shortwave flux at the top of the
atmosphere" ;
        shortwave_net_toa_clear:units = "W m-2" ;
        shortwave_net_toa_clear:missing_value = -9999.f ;
        shortwave_net_toa_clear:_FillValue = -9999.f ;
    float cloud_low(time, lat, lon) ;
```

```
        cloud_low:long_name = "Satellite-measured low-level cloud" ;
        cloud_low:units = "%" ;
        cloud_low:missing_value = -9999.f ;
        cloud_low:_FillValue = -9999.f ;
    float cloud_mid(time, lat, lon) ;
        cloud_mid:long_name = "Satellite-measured middle-level cloud" ;
        cloud_mid:units = "%" ;
        cloud_mid:missing_value = -9999.f ;
        cloud_mid:_FillValue = -9999.f ;
    float cloud_high(time, lat, lon) ;
        cloud_high:long_name = "Satellite-measured high-level cloud" ;
        cloud_high:units = "%" ;
        cloud_high:missing_value = -9999.f ;
        cloud_high:_FillValue = -9999.f ;
    float cloud_total(time, lat, lon) ;
        cloud_total:long_name = "Satellite-measured total cloud" ;
        cloud_total:units = "%" ;
        cloud_total:standard_name = "cloud_area_fraction" ;
        cloud_total:missing_value = -9999.f ;
        cloud_total:_FillValue = -9999.f ;
    float cloud_thickness(time, lat, lon) ;
        cloud_thickness:long_name = "Satellite-measured cloud thickness" ;
        cloud_thickness:units = "km" ;
        cloud_thickness:missing_value = -9999.f ;
        cloud_thickness:_FillValue = -9999.f ;
    float cloud_top(time, lat, lon) ;
        cloud_top:long_name = "Satellite-measured cloud top" ;
        cloud_top:units = "km" ;
        cloud_top:standard_name = "cloud_top_altitude" ;
        cloud_top:missing_value = -9999.f ;
        cloud_top:_FillValue = -9999.f ;
    float longwave_up_sfc(time, lat, lon) ;
        longwave_up_sfc:long_name = "Surface upwelling longwave" ;
        longwave_up_sfc:units = "W m-2" ;
        longwave_up_sfc:standard_name = "surface_upwelling_longwave_flux_in_air" ;
        longwave_up_sfc:missing_value = -9999.f ;
        longwave_up_sfc:_FillValue = -9999.f ;
    float longwave_down_sfc(time, lat, lon) ;
        longwave_down_sfc:long_name = "Surface downwelling longwave" ;
        longwave_down_sfc:units = "W m-2" ;
        longwave_down_sfc:standard_name = "surface_downwelling_longwave_flux_in_air" ;
        longwave_down_sfc:missing_value = -9999.f ;
        longwave_down_sfc:_FillValue = -9999.f ;
    float shortwave_up_sfc(time, lat, lon) ;
        shortwave_up_sfc:long_name = "Surface upwelling shortwave" ;
        shortwave_up_sfc:units = "W m-2" ;
        shortwave_up_sfc:standard_name = "surface_upwelling_shortwave_flux_in_air" ;
        shortwave_up_sfc:missing_value = -9999.f ;
        shortwave_up_sfc:_FillValue = -9999.f ;
    float shortwave_down_sfc(time, lat, lon) ;
        shortwave_down_sfc:long_name = "Surface downwelling shortwave" ;
```

shortwave_down_sfc:units = "W m-2" ;
shortwave_down_sfc:standard_name = "surface_downwelling_shortwave_flux_in_air" ;
shortwave_down_sfc:missing_value = -9999.f ;
shortwave_down_sfc:_FillValue = -9999.f ;
float soil_temp_ebbr(time, lat, lon) ;
soil_temp_ebbr:long_name = "Mean soil temperature over the 5 sensors from EBBR" ;
soil_temp_ebbr:units = "K" ;
soil_temp_ebbr:standard_name = "soil_temperature" ;
soil_temp_ebbr:coordinates = "z_d" ;
soil_temp_ebbr:missing_value = -9999.f ;
soil_temp_ebbr:_FillValue = -9999.f ;
float soil_moisture_ebbr(time, lat, lon) ;
soil_moisture_ebbr:long_name = "Mean soil moisture over the 5 sensors from EBBR, volumetric" ;
soil_moisture_ebbr:units = "m3/m3" ;
soil_moisture_ebbr:coordinates = "z_c" ;
soil_moisture_ebbr:missing_value = -9999.f ;
soil_moisture_ebbr:_FillValue = -9999.f ;
float soil_temp_swats(time, depth, lat, lon) ;
soil_temp_swats:long_name = "Soil temperature from SWATS" ;
soil_temp_swats:units = "K" ;
soil_temp_swats:standard_name = "soil_temperature" ;
soil_temp_swats:missing_value = -9999.f ;
soil_temp_swats:_FillValue = -9999.f ;
float soil_moisture_swats(time, depth, lat, lon) ;
soil_moisture_swats:long_name = "Soil moisture from SWATS, volumetric" ;
soil_moisture_swats:units = "m3/m3" ;
soil_moisture_swats:missing_value = -9999.f ;
soil_moisture_swats:_FillValue = -9999.f ;
float pressure_mean(time) ;
pressure_mean:long_name = "Surface pressure, domain mean" ;
pressure_mean:units = "hPa" ;
pressure_mean:standard_name = "surface_air_pressure" ;
pressure_mean:missing_value = -9999.f ;
pressure_mean:_FillValue = -9999.f ;
pressure_mean:cell_methods = "area: mean" ;
float u_wind_mean(time) ;
u_wind_mean:long_name = "U wind component, domain mean" ;
u_wind_mean:units = "m s-1" ;
u_wind_mean:standard_name = "eastward_wind" ;
u_wind_mean:coordinates = "z_a" ;
u_wind_mean:missing_value = -9999.f ;
u_wind_mean:_FillValue = -9999.f ;
u_wind_mean:cell_methods = "area: mean" ;
float v_wind_mean(time) ;
v_wind_mean:long_name = "V wind component, domain mean" ;
v_wind_mean:units = "m s-1" ;
v_wind_mean:standard_name = "northward_wind" ;
v_wind_mean:coordinates = "z_a" ;
v_wind_mean:missing_value = -9999.f ;
v_wind_mean:_FillValue = -9999.f ;

v_wind_mean:cell_methods = "area: mean" ;
float precip_rate_mean(time) ;
precip_rate_mean:long_name = "Precipitation rate, domain mean" ;
precip_rate_mean:units = "mm hour-1" ;
precip_rate_mean:standard_name = "lwe_precipitation_rate" ;
precip_rate_mean:missing_value = -9999.f ;
precip_rate_mean:_FillValue = -9999.f ;
precip_rate_mean:cell_methods = "area: mean" ;
float temp_mean(time) ;
temp_mean:long_name = "Air temperature, domain mean" ;
temp_mean:units = "K" ;
temp_mean:standard_name = "air_temperature" ;
temp_mean:coordinates = "z_b" ;
temp_mean:missing_value = -9999.f ;
temp_mean:_FillValue = -9999.f ;
temp_mean:cell_methods = "area: mean" ;
float rh_mean(time) ;
rh_mean:long_name = "Relative humidity, domain mean" ;
rh_mean:units = "%" ;
rh_mean:standard_name = "relative_humidity" ;
rh_mean:coordinates = "z_b" ;
rh_mean:missing_value = -9999.f ;
rh_mean:_FillValue = -9999.f ;
rh_mean:cell_methods = "area: mean" ;
float longwave_net_toa_mean(time) ;
longwave_net_toa_mean:long_name = "Net longwave flux at the top of the atmosphere, domain mean" ;
longwave_net_toa_mean:units = "W m-2" ;
longwave_net_toa_mean:standard_name = "toa_net_upward_longwave_flux" ;
longwave_net_toa_mean:missing_value = -9999.f ;
longwave_net_toa_mean:_FillValue = -9999.f ;
longwave_net_toa_mean:cell_methods = "area: mean" ;
float shortwave_net_toa_mean(time) ;
shortwave_net_toa_mean:long_name = "Net shortwave flux at the top of the atmosphere, domain mean" ;
shortwave_net_toa_mean:units = "W m-2" ;
shortwave_net_toa_mean:standard_name = "toa_net_upward_shortwave_flux" ;
shortwave_net_toa_mean:missing_value = -9999.f ;
shortwave_net_toa_mean:_FillValue = -9999.f ;
shortwave_net_toa_mean:cell_methods = "area: mean" ;
float shortwave_down_toa_mean(time) ;
shortwave_down_toa_mean:long_name = "Solar insolation at the top of the atmosphere, domain mean" ;
shortwave_down_toa_mean:units = "W m-2" ;
shortwave_down_toa_mean:standard_name = "toa_incoming_shortwave_flux" ;
shortwave_down_toa_mean:missing_value = -9999.f ;
shortwave_down_toa_mean:_FillValue = -9999.f ;
shortwave_down_toa_mean:cell_methods = "area: mean" ;
float latent_heat_flux_mean(time) ;
latent_heat_flux_mean:long_name = "Surface latent heat flux, domain mean" ;
latent_heat_flux_mean:units = "W m-2" ;

latent_heat_flux_mean:standard_name = "surface_upward_latent_heat_flux" ;
latent_heat_flux_mean:positive = "up" ;
latent_heat_flux_mean:missing_value = -9999.f ;
latent_heat_flux_mean:_FillValue = -9999.f ;
latent_heat_flux_mean:cell_methods = "area: mean" ;
float sensible_heat_flux_mean(time) ;
sensible_heat_flux_mean:long_name = "Surface sensible heat flux, domain mean" ;
sensible_heat_flux_mean:units = "W m-2" ;
sensible_heat_flux_mean:standard_name = "surface_upward_sensible_heat_flux" ;
sensible_heat_flux_mean:positive = "up" ;
sensible_heat_flux_mean:missing_value = -9999.f ;
sensible_heat_flux_mean:_FillValue = -9999.f ;
sensible_heat_flux_mean:cell_methods = "area: mean" ;
float pwv_mean(time) ;
pwv_mean:long_name = "Column precip water vapor, domain mean" ;
pwv_mean:units = "cm" ;
pwv_mean:missing_value = -9999.f ;
pwv_mean:_FillValue = -9999.f ;
pwv_mean:cell_methods = "area: mean" ;
float lwp_mean(time) ;
lwp_mean:long_name = "Cloud liquid water path, domain mean" ;
lwp_mean:units = "cm" ;
lwp_mean:missing_value = -9999.f ;
lwp_mean:_FillValue = -9999.f ;
lwp_mean:cell_methods = "area: mean" ;
float longwave_net_toa_clear_mean(time) ;
longwave_net_toa_clear_mean:long_name = "Clear sky net longwave flux at the top of the atmosphere, domain mean" ;
longwave_net_toa_clear_mean:units = "W m-2" ;
longwave_net_toa_clear_mean:missing_value = -9999.f ;
longwave_net_toa_clear_mean:_FillValue = -9999.f ;
longwave_net_toa_clear_mean:cell_methods = "area: mean" ;
float shortwave_net_toa_clear_mean(time) ;
shortwave_net_toa_clear_mean:long_name = "Clear sky net shortwave flux at the top of the atmosphere, domain mean" ;
shortwave_net_toa_clear_mean:units = "W m-2" ;
shortwave_net_toa_clear_mean:missing_value = -9999.f ;
shortwave_net_toa_clear_mean:_FillValue = -9999.f ;
shortwave_net_toa_clear_mean:cell_methods = "area: mean" ;
float cloud_low_mean(time) ;
cloud_low_mean:long_name = "Satellite-measured low level cloud, domain mean" ;
cloud_low_mean:units = "%" ;
cloud_low_mean:missing_value = -9999.f ;
cloud_low_mean:_FillValue = -9999.f ;
cloud_low_mean:cell_methods = "area: mean" ;
float cloud_mid_mean(time) ;
cloud_mid_mean:long_name = "Satellite-measured middle level cloud, domain mean" ;
cloud_mid_mean:units = "%" ;
cloud_mid_mean:missing_value = -9999.f ;
cloud_mid_mean:_FillValue = -9999.f ;
cloud_mid_mean:cell_methods = "area: mean" ;

```
float cloud_high_mean(time) ;
    cloud_high_mean:long_name = "Satellite-measured high level cloud, domain mean" ;
    cloud_high_mean:units = "%" ;
    cloud_high_mean:missing_value = -9999.f ;
    cloud_high_mean:_FillValue = -9999.f ;
    cloud_high_mean:cell_methods = "area: mean" ;
float cloud_total_mean(time) ;
    cloud_total_mean:long_name = "Satellite-measured total cloud, domain mean" ;
    cloud_total_mean:units = "%" ;
    cloud_total_mean:standard_name = "cloud_area_fraction" ;
    cloud_total_mean:missing_value = -9999.f ;
    cloud_total_mean:_FillValue = -9999.f ;
    cloud_total_mean:cell_methods = "area: mean" ;
float cloud_thickness_mean(time) ;
    cloud_thickness_mean:long_name = "Satellite-measured cloud thickness, domain mean" ;
    cloud_thickness_mean:units = "km" ;
    cloud_thickness_mean:missing_value = -9999.f ;
    cloud_thickness_mean:_FillValue = -9999.f ;
    cloud_thickness_mean:cell_methods = "area: mean" ;
float cloud_top_mean(time) ;
    cloud_top_mean:long_name = "Satellite-measured cloud top, domain mean" ;
    cloud_top_mean:units = "km" ;
    cloud_top_mean:standard_name = "cloud_top_altitude" ;
    cloud_top_mean:missing_value = -9999.f ;
    cloud_top_mean:_FillValue = -9999.f ;
    cloud_top_mean:cell_methods = "area: mean" ;
float longwave_up_sfc_mean(time) ;
    longwave_up_sfc_mean:long_name = "Surface upwelling longwave, domain mean" ;
    longwave_up_sfc_mean:units = "W m-2" ;
    longwave_up_sfc_mean:standard_name = "surface_upwelling_longwave_flux_in_air" ;
    longwave_up_sfc_mean:missing_value = -9999.f ;
    longwave_up_sfc_mean:_FillValue = -9999.f ;
    longwave_up_sfc_mean:cell_methods = "area: mean" ;
float longwave_down_sfc_mean(time) ;
    longwave_down_sfc_mean:long_name = "Surface downwelling longwave, domain mean" ;
    longwave_down_sfc_mean:units = "W m-2" ;
    longwave_down_sfc_mean:standard_name = "surface_downwelling_longwave_flux_in_air" ;
    longwave_down_sfc_mean:missing_value = -9999.f ;
    longwave_down_sfc_mean:_FillValue = -9999.f ;
    longwave_down_sfc_mean:cell_methods = "area: mean" ;
float shortwave_up_sfc_mean(time) ;
    shortwave_up_sfc_mean:long_name = "Surface upwelling shortwave, domain mean" ;
    shortwave_up_sfc_mean:units = "W m-2" ;
    shortwave_up_sfc_mean:standard_name = "surface_upwelling_shortwave_flux_in_air" ;
    shortwave_up_sfc_mean:missing_value = -9999.f ;
    shortwave_up_sfc_mean:_FillValue = -9999.f ;
    shortwave_up_sfc_mean:cell_methods = "area: mean" ;
float shortwave_down_sfc_mean(time) ;
    shortwave_down_sfc_mean:long_name = "Surface downwelling shortwave, domain mean" ;
    shortwave_down_sfc_mean:units = "W m-2" ;
    shortwave_down_sfc_mean:standard_name = "surface_downwelling_shortwave_flux_in_air" ;
```

```
        shortwave_down_sfc_mean:missing_value = -9999.f ;
        shortwave_down_sfc_mean:_FillValue = -9999.f ;
        shortwave_down_sfc_mean:cell_methods = "area: mean" ;
    float soil_temp_mean_ebbr(time) ;
        soil_temp_mean_ebbr:long_name = "Soil temperature from EBBR, domain mean" ;
        soil_temp_mean_ebbr:units = "K" ;
        soil_temp_mean_ebbr:standard_name = "soil_temperature" ;
        soil_temp_mean_ebbr:coordinates = "z_d" ;
        soil_temp_mean_ebbr:missing_value = -9999.f ;
        soil_temp_mean_ebbr:_FillValue = -9999.f ;
        soil_temp_mean_ebbr:cell_methods = "area: mean" ;
    float soil_moisture_mean_ebbr(time) ;
        soil_moisture_mean_ebbr:long_name = "Soil moisture from EBBR, domain mean, volumetric" ;
        soil_moisture_mean_ebbr:units = "m3/m3" ;
        soil_moisture_mean_ebbr:coordinates = "z_c" ;
        soil_moisture_mean_ebbr:missing_value = -9999.f ;
        soil_moisture_mean_ebbr:_FillValue = -9999.f ;
        soil_moisture_mean_ebbr:cell_methods = "area: mean" ;
    float soil_temp_mean_swats(time, depth) ;
        soil_temp_mean_swats:long_name = "Soil temperature from SWATS, domain mean" ;
        soil_temp_mean_swats:units = "K" ;
        soil_temp_mean_swats:standard_name = "soil_temperature" ;
        soil_temp_mean_swats:missing_value = -9999.f ;
        soil_temp_mean_swats:_FillValue = -9999.f ;
        soil_temp_mean_swats:cell_methods = "area: mean" ;
    float soil_moisture_mean_swats(time, depth) ;
        soil_moisture_mean_swats:long_name = "Soil moisture from SWATS, domain mean,
volumetric" ;
        soil_moisture_mean_swats:units = "m3/m3" ;
        soil_moisture_mean_swats:missing_value = -9999.f ;
        soil_moisture_mean_swats:_FillValue = -9999.f ;
        soil_moisture_mean_swats:cell_methods = "area: mean" ;
    float lat(lat) ;
        lat:long_name = "North latitude" ;
        lat:units = "degree_N" ;
        lat:standard_name = "latitude" ;
        lat:valid_min = -90.f ;
        lat:valid_max = 90.f ;
    float lon(lon) ;
        lon:long_name = "East longitude" ;
        lon:units = "degree_E" ;
        lon:standard_name = "longitude" ;
        lon:valid_min = -180.f ;
        lon:valid_max = 180.f ;
    float alt ;
        alt:long_name = "Altitude above mean sea level for the SGP CF" ;
        alt:units = "m" ;
        alt:standard_name = "altitude" ;

// global attributes:
        :Conventions = "CF-1.7" ;
```

:command_line = "nc_2d, iop=1106" ;
:site_id = "sgp" ;
:facility_id = "X1" ;
:process_version = "vap-armbe2dgrid-1.0" ;
:location_description = "Southern Great Plains (SGP)" ;
:title = "Atmospheric Research Measurement Best Estimate (ARMBE) 2D Gridded Product, ARMBE2DGRID" ;
:description = "ARMBE2dGrid 1-hourly averaged 0.25 deg x 0.25 deg area interpolated product";
:platform_id = "armbe2dgrid" ;
:data_level = "c1" ;
:datastream = "sgparmbe2dgridX1.c1" ;
:dod_version = "armbe2dgrid-c1-v1.0" ;
:averaging_interval = "1 hour" ;
:date_created = "Wed Apr 22 17:55:08 2015" ;
:doi = "DOI:10.5439/1178331" ;
:history = "created by user tang30 on machine arm.llnl.gov at Wed Apr 22 17:55:08 2015";
}

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