The MC3E Variational Analysis Forcing Dataset - Version 3

(*Please read the notes in section 5 for changes made in Version 3 compared to Version 2)

(This file is also available as a docx file).

1. Overview

The constrained variational objective analysis approach described in Zhang and Lin [1997] and Zhang et al. [2001] was used to derive the large-scale single-column/cloud resolving model forcing and evaluation data set from the observational data collected during Midlatitude Continental Convective Clouds Experiment (**MC3E**), which was conducted during April to June 2011 near the ARM Southern Great Plains (SGP) site. The analysis data cover the period from **00Z 22 April - 21Z 6 June 2011**. The forcing data represent an average over the 3 different analysis domains centered at central facility with a diameter of 300 km (standard SGP forcing domain size), 150 km and 75 km, as shown in Figure 1. This is to support modeling studies on various-scale convective systems.

2. Standard forcing data for 3 size domains

The data here are in both ASCII and netCDF formats for three domains.

Standard vertical resolution (25mb) data

There are two standard resolution (25mb) ASCII data files for layered variables and surface variables, respectively for each of the domain. They are:

*sgp180varanaiopsndgsurfacev*C1.c1.20110422.000000.dat*
*sgp180varanaiopsndglayerv*C1.c1.20110422.000000.dat*

*sgp180varanaiopsndg75kmsurfacev*C1.c1.20110422.000000.dat*
*sgp180varanaiopsndg75kmlayerv*C1.c1.20110422.000000.dat*

*sgp180varanaiopsndg150kmsurfacev*C1.c1.20110422.000000.dat*
*sgp180varanaiopsndg150kmlayerv*C1.c1.20110422.000000.dat*

where v* denotes the version number, current (2014-04-14) version number is **v3**.

These ASCII data files can be read using the following FORTRAN files:

read_layer.for
read_surface.for

The netCDF files that include all the variables contained in the two ASCII data files are also provided:

*sgp180varanaiopsndgv*C1.c1.20110422.000000.cdf* (for standard 300 km domain)
*sgp180varanaiopsndg75kmv*C1.c1.20110422.000000.cdf* (for 75 km domain)
*sgp180varanaiopsndg150kmv*C1.c1.20110422.000000.cdf* (for 150 km domain)

where v* is the version number. To see the quick look plots of the data please go to:

http://www-pcmdi.llnl.gov/ARM/scm-forcing/sgp-mc3e/html/preview_mc3e.html

3. Ensemble forcing based on precipitation rate for 300 km domain

The ensemble forcing data represent an ensemble of the average over the analysis domains centered at central facility with a diameter of 300 km.

Based on the feedback from cloud modelers, we developed ensemble forcing based on uncertainties in precipitation observation. The uncertainty range is derived based on differences in two independently developed precipitation datasets: one is the most commonly used value added product of precipitation from Arkansas-Red Basin River Forecast Center (ABRFC); the other is another widely used bias-corrected NOAA NMQ NEXRAD precipitation data (courtesy of S. Giangrande, BNL). The uncertain range also takes into account that the fractional root-mean-square error of areal estimates of rain for different radar-rainfall algorithms is about 40% (relative to mean rain rate) (Ryzhkov et al. 2005). We assume maximum spatial and temporal correlation of precipitation rate uncertainties across the analysis domain. The upper and lower bounds of the precipitation uncertainty range are then calculated as:

cases	**Upper bound (UB)**	**Lower bound (LB)**
Pa * Pn ≠ 0	Max (Pa, Pn) * (1+0.4)	Min (Pa, Pn) * (1-0.4)
Pa * Pn = 0	Max (Pa, Pn) * (1+0.4)	0

Where Pa is the domain mean precipitation rate based on ABRFC, while Pn from NEXRAD NMQ data. The first 11 ensemble members of precipitation rate are P_i = LB+(UB-LB)*i*0.1, where i= 0 to 10. Two additional ensemble members are P_11 = Pa and P_12 = Pn.

The dataset of 13 ensembles are in both ASCII and netCDF formats for 300 km domain.

There are two standard resolution (25mb) ASCII data files for layered variables and surface variables, respectively for each of ensemble member, and the netCDF files that include all the variables contained in the two ASCII data files. They are:

*sgp180varanaiopsndgsurfacev*e**C1.c1.20110422.000000.dat*
*sgp180varanaiopsndglayer v*e**C1.c1.20110422.000000.dat>*

*sgp180varanaiopsndg v*e**C1.c1.20110422.000000.cdf*

where v*e** is the version number (current - v3) and the e** describes the ensemble member e00 to e12 respectively. The ensemble forcing is only based on surface precipitation ensembles. Figure 2 shows different precipitation rate from the ensemble and Figure 3 shows the resulted difference in the large-scale vertical motion "omega" for the two major precipitation events on May 20th and 25th during 2011 MC3E period.

4. Some details of the analysis

The objective analysis domains used for analyzing the MC3E data are shown in Figure 1. The analysis grid points overlap the five boundary sounding stations and central facility that were available during MC3E. Sounding balloons were launched to measure the vertical profiles of temperature, relative humidity, and winds 8 times per day for certain interested periods at the six sounding stations. These measured upper-air data were first analyzed using the analysis scheme of *Cressman* [1957] with the background field from the RUC analyses. For the period when no sounding was available, the RUC analysis data was used. The original Vaisala Radiosonde (RS92) data showed a significant radiation dry bias during the daytime in the middle and upper troposphere. This dry bias is corrected by the BNL ARM infrastructure group using a similar algorithm described in *Voemel et al.* (2007) and *Miloshevich et al.*(2009) and also scaled with the "nearest" GPS integrated water vapor path observations. Such corrected sounding is adopted in the objective analysis.

The domain-averaged surface and TOA constraints required by the variational analysis were obtained from the ARM surface and satellite measurements. These include the rain gauge adjusted WSR-88D radar precipitation (ABFRC), surface radiative fluxes from the 22 ARM Extended Facilities, surface heat fluxes are the merged products from both ECOR and BAEBBR measurements, surface meteorological fields from both local surface ARM and mesonet stations and sounding measurements, cloud liquid water path measured by MWR, and TOA satellite data.

Observed hourly mean cloud fraction, "cld", is derived based on 4-second KAZR-ARSCL evaluation VAP (developed by BNL) and following ARMBE ARSCL cloud fraction algorithm (developed by LLNL). Two data quality flags, qc_cld and qc_cld_source, are also included to give users additional information on the conditions when cloud fraction is derived.

5. Notes on current release - version 3

In this newly released version 3, we made some major changes based on users' feedback:

- Used RH_adjust values instead of RH_scaled in the most updated corrected sounding data sets (from BNL). Such changes impact on precipitating periods most. In some cases, the domain average atmospheric RH increases by 10 to 20%. This is related to the situation when there is a wet flag of microwave radiometer measurement, RH_scaled values are all missing; if RH_adjust are used instead, RH values become valid and get accounted in the variational analysis. The actual value difference between RH_adjust and RH_scaled affects the forcing (when both values are valid), however the forcing data are mostly influenced when RH_scaled is missing but RH_adjust is not missing.

- Fixed a small bug in calculating sounding measurement time and locations.

These changes have resulted in some considerable changes in the derived large-scale forcing data. We *strongly encourage* users to re-run their experiments with the updated version and provide feedback to Shaocheng Xie. Feedback collected will be used to further improve the MC3E forcing data and guide our future forcing data development.

6. References

Cressman, G. P., (1959), *An operational objective analysis scheme*, *Mon. Wea. Rev., 87,* 367-374.

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Voemel et al. (2007),*Radiation Dry Bias of the Vaisala RS92 Humidity Sensor*, *J. Atmos. Ocean. Tech.*, 24, 953-963.

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MC3E Homepage: http://campaign.arm.gov/mc3e/

MC3E forcing data page on ARM CMWG page: http://www-pcmdi.llnl.gov/ARM/scm-forcing/sgp-mc3e/html/preview_mc3e.html

7. Acknowledgement

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8. Contacts

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9. Figures

See below, or viewable in your browser:

Figure 1.
Figure 2.
Figure 3.

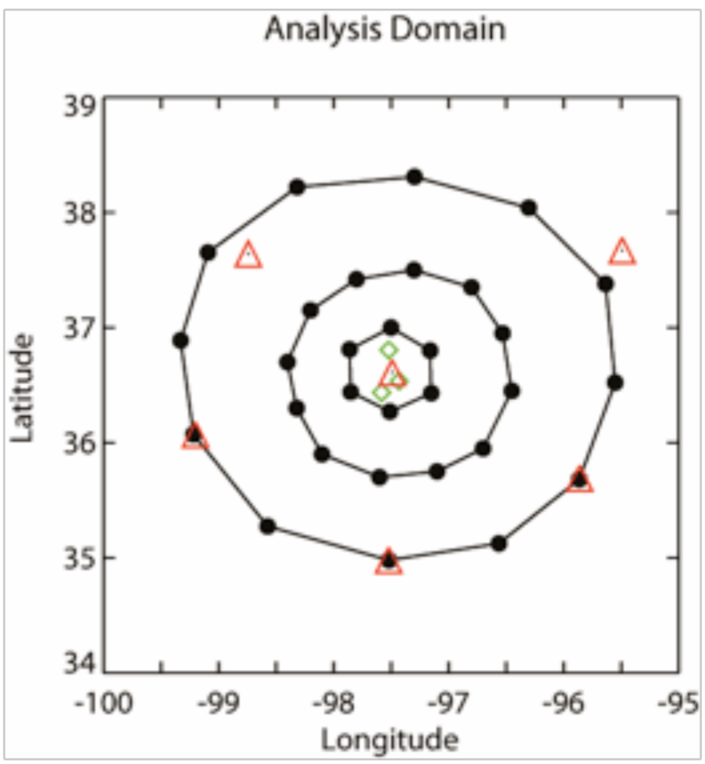

Figure 1: Multi-scale domains for MC3E, with diameters of 300 km, 150 km and 75 km. The red triangles denote sounding locations. The green diamonds denote the locations of scanning cloud radars.

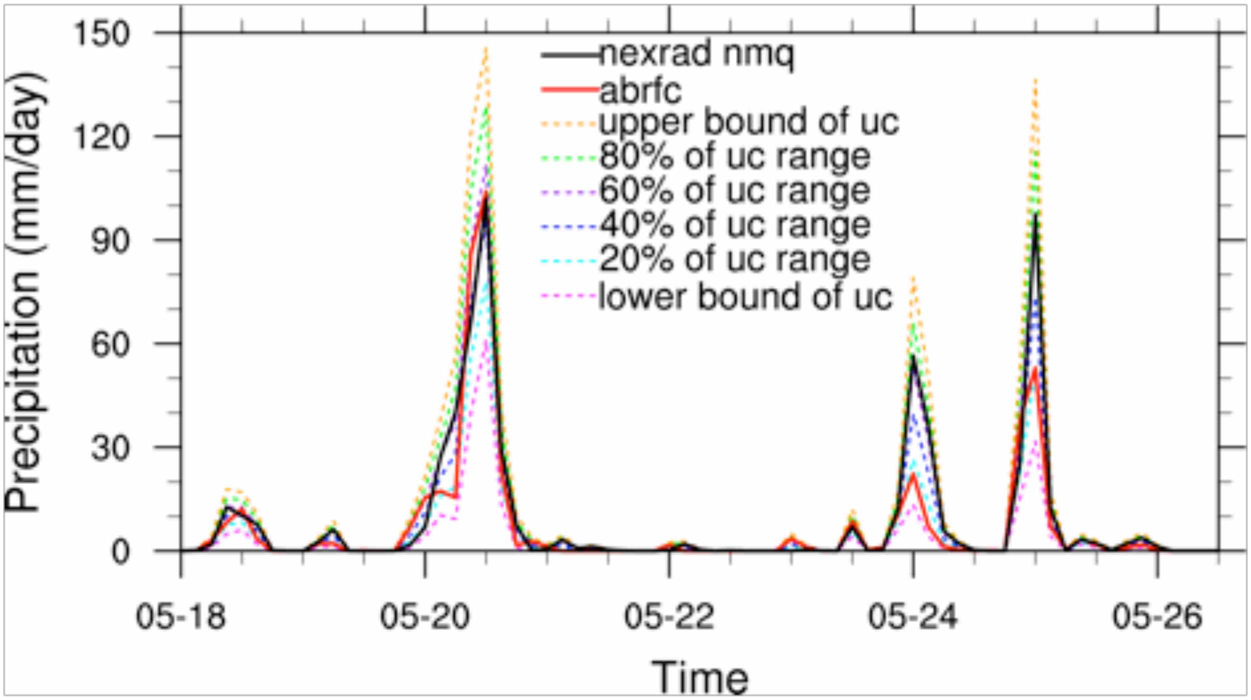

Figure 2: Ensemble precipitation rate.

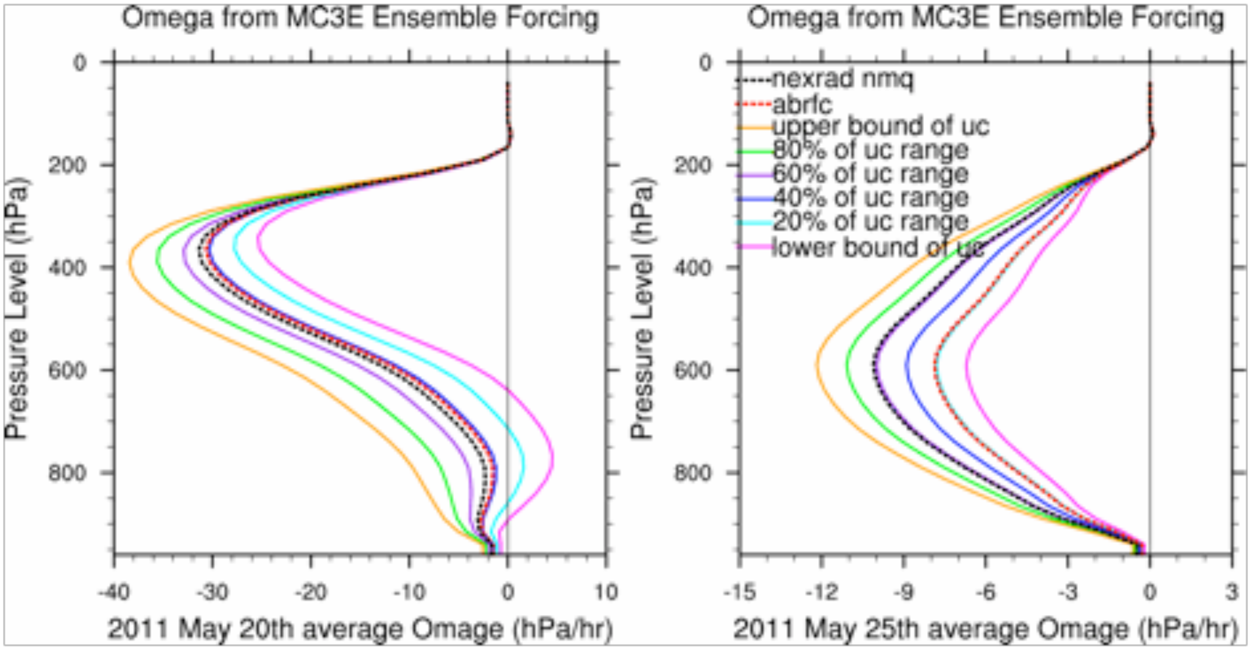

Figure 3: Omega, large-scale vertical motion difference resulted from difference in precipitation ensemble.