Large-Scale Forcing Fields for MC3E

Richard H. Johnson and Paul E. Ciesielski

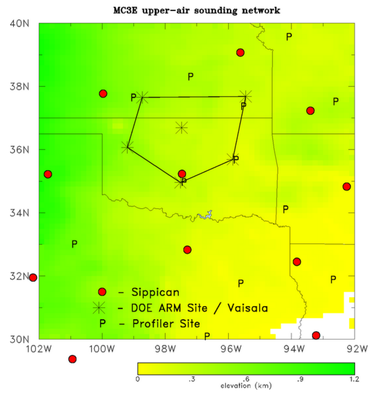
Department of Atmospheric Science, Colorado State University, Fort Collins, CO

johnson@atmos.colostate.edu

INTRODUCTION

- Objective: To create high-quality forcing fields for April-June 2011 Midlatitude Continental Convective Cloud Experiment (MC3E), and make them available to PMM and DOE science communities
- Strategy: To utilize both quality-controlled radiosonde data and wind profiler observations to produce large-scale tendencies over MC3E domain

MC3E SOUNDING/PROFILER NETWORK

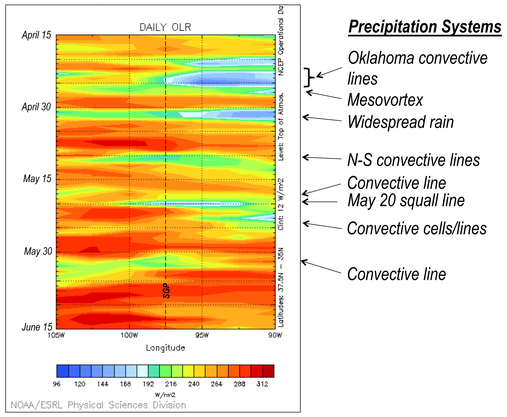


MC3E sounding array

- *Sounding array with six enhanced sites (4-8 sondes per day) embedded in NWS operational sounding and NOAA wind profiling sites*
- *These data will be used to create forcing fields and gridded analyses over large domain*

OVERVIEW OF CONVECTIVE EVENTS

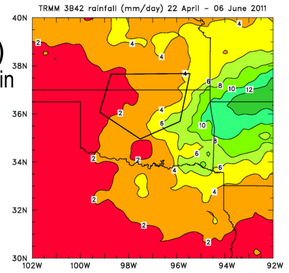
Field campaign: 22 April – 6 June 2011



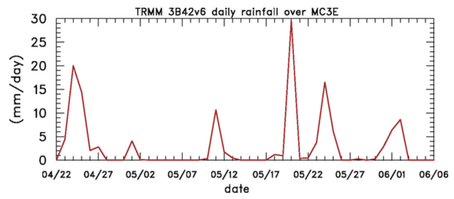
Time-longitude plot of Outgoing Longwave Radiation, 15 April – 15 June 2011

PRECIPITATION

- **Mean Rainfall (mm day^{-1})**
- Heaviest rainfall amounts in eastern OK, KS; rainfall gradient across sounding array



MC3E mean rainfall rates (mm day^{-1})



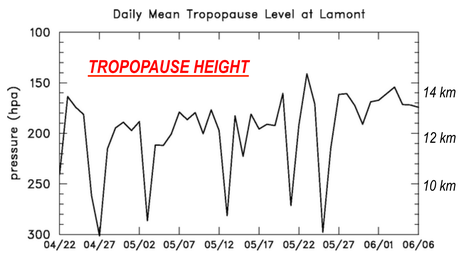
- *5-6 precipitation major episodes during 46-day period*

SOUNDING DATA

Quality Control Issues/Procedures:

- *MC3E sites operated Vaisala RS92 sondes*
- *Daytime dry bias: corrections made by DOE*
- *Colocated GPS retrievals of TPW used to scale sonde humidity*
- *Surrounding NWS sounding sites: Sippican systems – have sporadic humidity errors, missing winds; data will be quality controlled and corrected, if possible*
- *Profiler winds: employed to improve upon analyses based on MC3E sites alone*

Special Considerations:



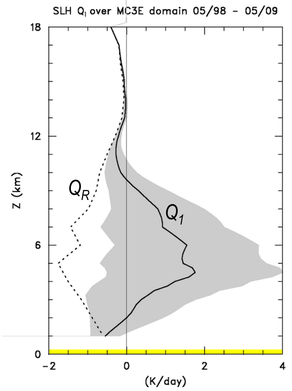
- *Large variability in tropopause height during field campaign*
- *Creates complication in mass balancing divergence profiles*

SOUNDING DATA (cont.)

Mass balancing condition at tropopause:

$$\frac{d\theta}{dt} = \frac{\partial\theta}{\partial t} + \mathbf{v}\cdot\nabla\theta + \omega\frac{\partial\theta}{\partial p} = Q_R$$

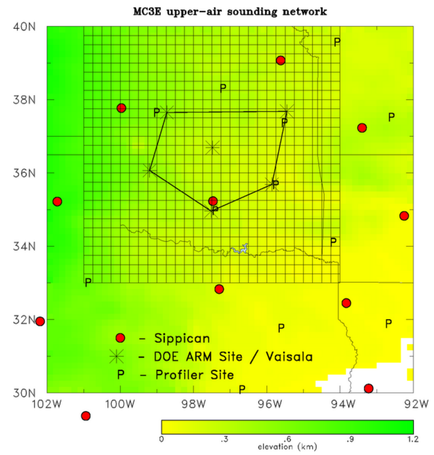
- Can solve for ω if Q_R is known



- *Mean Q_R varies between -1 and 0 K day^{-1} between 10 and 14 km*
- *However, much larger variations are expected over the diurnal cycle*
- *Use DOE ARM value-added radiative heating product to better determine Q_R over the diurnal cycle*

Average Q_1, Q_R profiles for May for 12 years of TRMM data from SLH (Shige et al.) product. Shading indicates standard deviation of Q_1. Q_R is from L'Ecuyer and McGarragh (2010).

FORCING FIELDS



Proposed MC3E analysis domain

- *Approach: use multiquadric interpolation with sonde and profiler data to produce a gridded dataset of basic fields with 0.25° horizontal resolution, 5 hPa in vertical and every 3 hours*
- *Balloon drift included*
- *May subdivide sounding pentagon for budgets over smaller regions*

INTEGRAL CONSTRAINTS ON BUDGETS

Heat Budget: $< Q_1 >=< Q_R > + LP + S$ (1)

Moisture Budget: $< Q_2 >= L(P - E)$ (2)

Moist Static Energy Budget:

$< Q_1 > - < Q_2 > - < Q_R >= S + LE$ (3)

- *Precipitation rate P and vertically integrated net radiative heating rate < Q_R > will be determined as residuals from (2) and (3) using < Q_1 >, < Q_2 >, and estimates of surface sensible and latent heat fluxes S and LE over sounding domain*
- *DOE variational constraint procedure (Xie, Zhang et al.) uses alternative procedure: surface precipitation and radiative heating rates are used to constrain basic fields and obtain Q_1 and Q_2 profiles*
- *Consideration will be given to hydrometeor storage within and advection into and out of domain*

SUMMARY

- *MC3E special sounding data will be merged with surrounding NWS operational sounding and NOAA wind profiler data to create large-scale forcing fields for PMM and DOE science teams*
- *Sounding data will be quality controlled; special consideration will be given to upper boundary condition for mass balancing divergence field*
- *Integral constraints to be evaluated*
- *Comparison will be made to variational constraint forcing fields through collaboration with DOE science team*

- *Four grad students, five civilians participated in sounding operations at Pratt, KS*

- *CSU sounding operations center at Pratt , KS*

ACKNOWLEDGMENTS

This research has been supported by the National Aeronautics and Space Administration under Grants NNX10AG81G and NNX13AF74G. We thank Dr. Ramesh Kakar for his encouragement and support of this research.