USEPA/OAQPS Meteorological Modeling Analyses

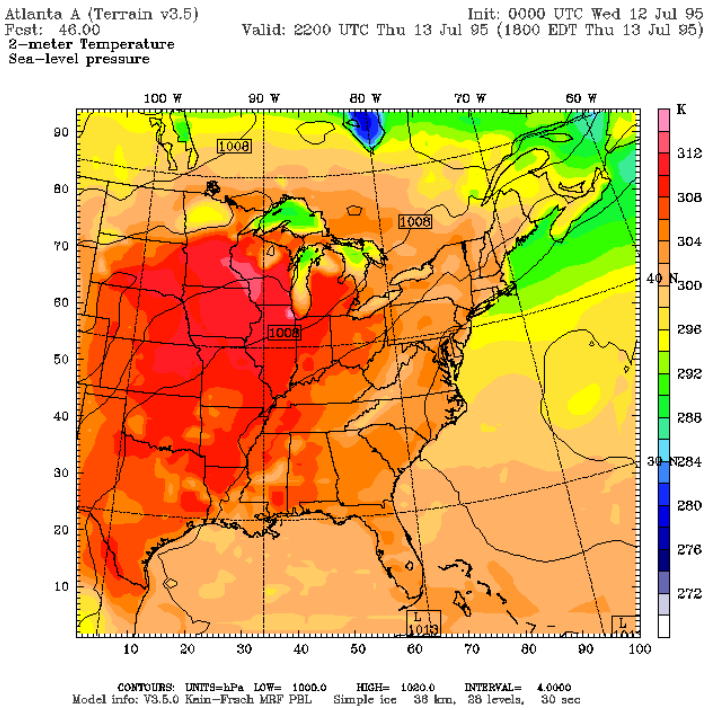
Ad Hoc Met Modeling Meeting

July 30, 2002

Pat Dolwick

USEPA: OAQPS/EMAD/AQMG

NOAA: ARL/ASMD/APSB



Overview

- Importance of Meteorological Modeling
  - often-overlooked, relative to emissions/AQ
  - increasingly important in PM/visibility
- Recent Meteorological Analyses @ EPA
  - 1996 continental U.S. MM5 data set (MCNC)
  - U.S./Canada modeling (July 1995 MM5)
- Present Meteorological Analyses @ EPA
  - support upcoming regulatory actions
  - improve overall quality of Federal/State/Local/RPO meteorological activities

Three-legged stool analogy

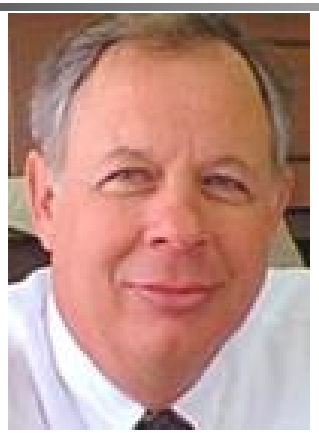
Air Quality Model

AQM: physics/chemistry

Emissions estimates

Meteorological Inputs

Three-legged stool analogy (the hidden truth)



Decision Maker

AQ Model

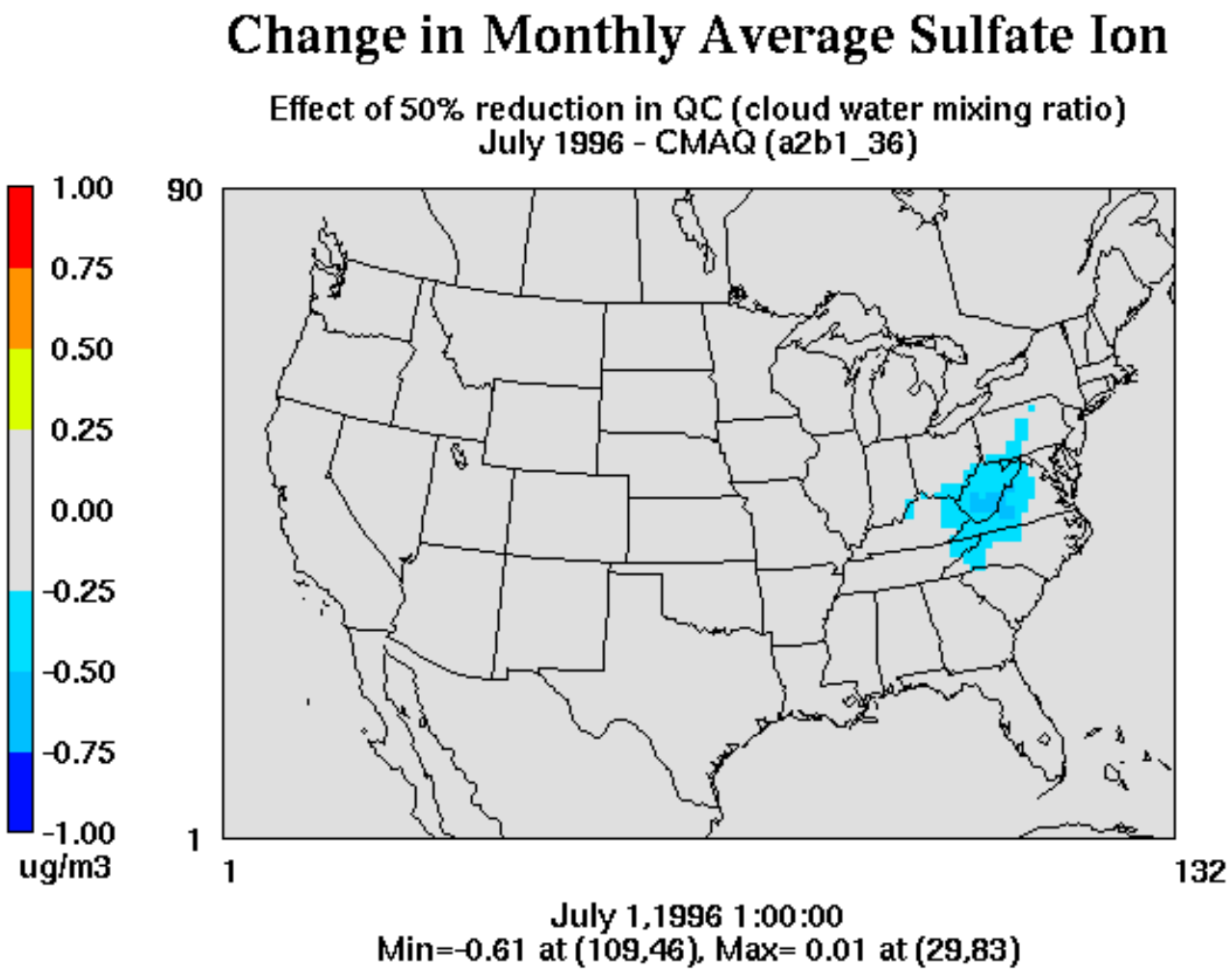
Importance of Meteorological Modeling (often overlooked)

- Case Study: EPA Technical Analyses
  - Emissions: develop/evaluate modeling tools; significant contractor resources; dedicated group w/in EMAD (EFIG)
  - Air Quality Modeling: develop/evaluate modeling tools; significant contractor resources; dedicated group w/in EMAD (AQMG)
  - Meteorology: limited & sporadic contractor resources; extremely limited staff resources
- Tends to be rule rather than exception

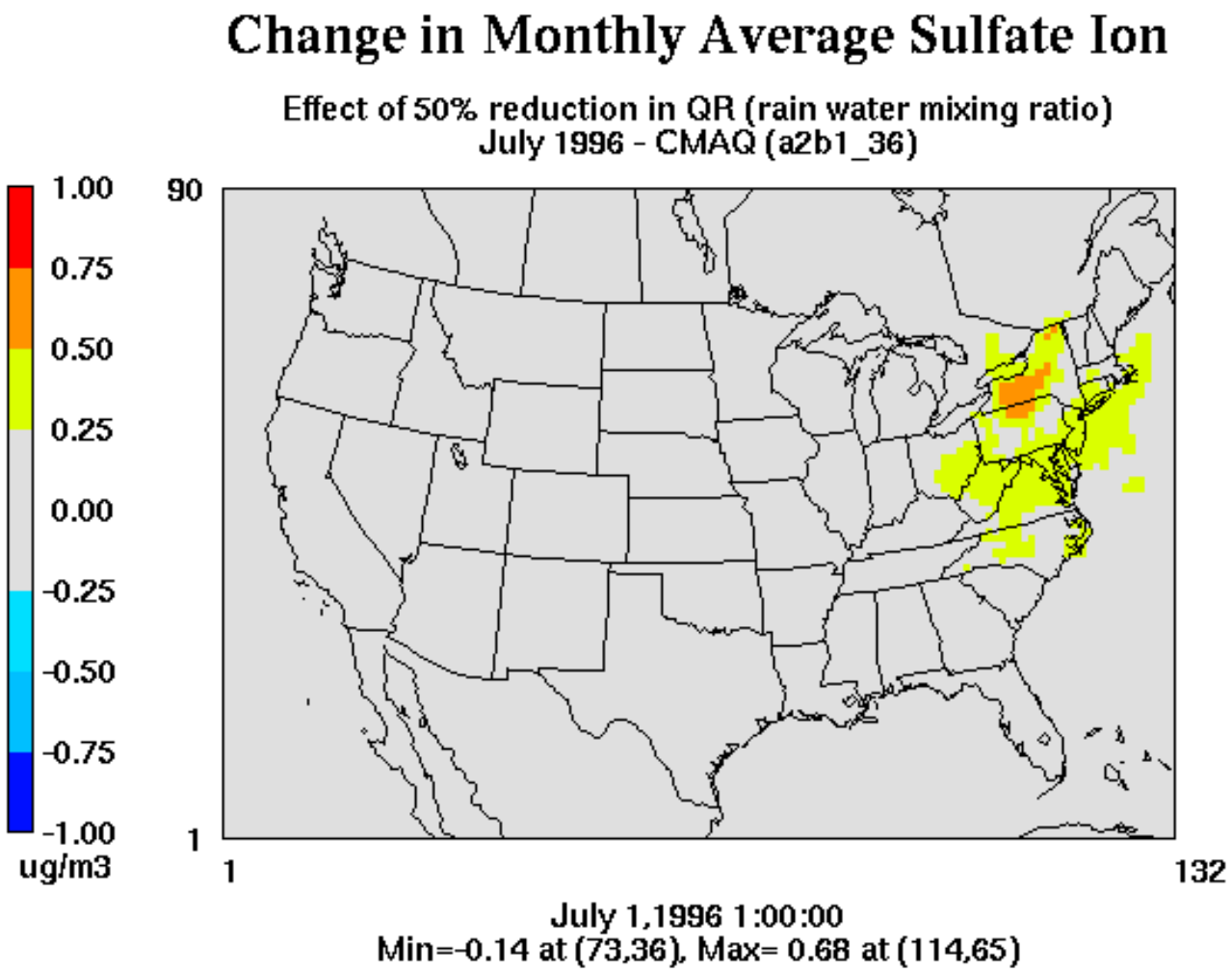
Importance of Meteorological Modeling (increasing for PM/Vis)

- Migrating from ozone to 1-atmosphere
  - Key parameters were generally well understood for local/regional ozone simulations. (PBL, wind, UV, T)
  - For PM/visibility, accurate representations of humidity, clouds, and precipitation will be critical for successful AQ model applications.

Importance of Meteorological Modeling (increasing for PM/Vis)

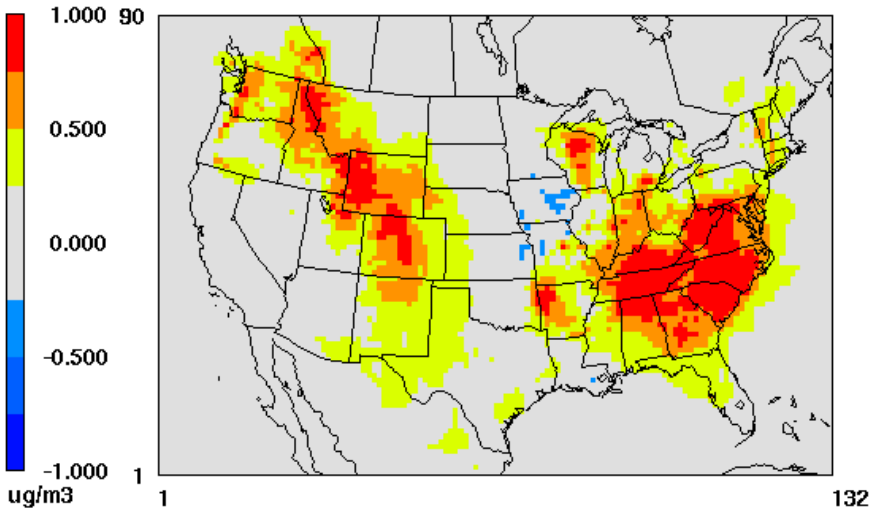


Importance of Meteorological Modeling (increasing for PM/Vis)



Change in Monthly Average PM 2.5

Effect of 50% less cloud water mixing ratio (QC)
a=CCTM_a2b1_36.combine.01.avg, c=CCTM_a2b12_36.combine.01.avg



January 1,1996 1:00:00
Min= -0.460 at (81,48), Max= 1.563 at (96,36)

Change in Monthly Average Sulfate

Effect of 50% less cloud water mixing ratio
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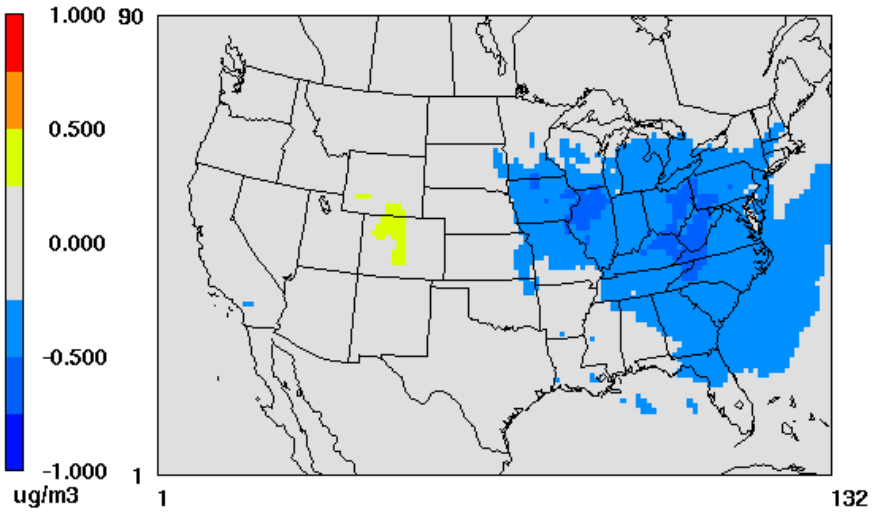

January 1,1996 1:00:00
Min= -0.726 at (81,48), Max= 0.384 at (48,49)

Change in Monthly Average Nitrate

Effect of 50% less cloud water mixing ratio
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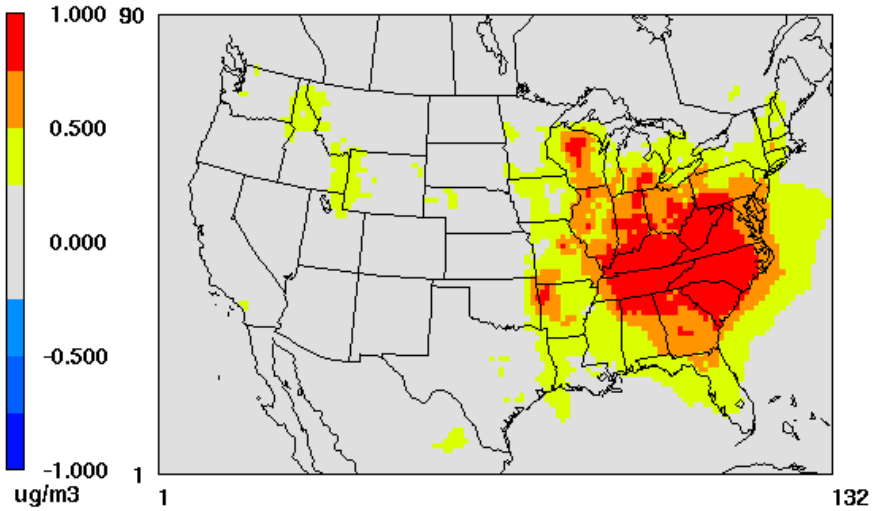
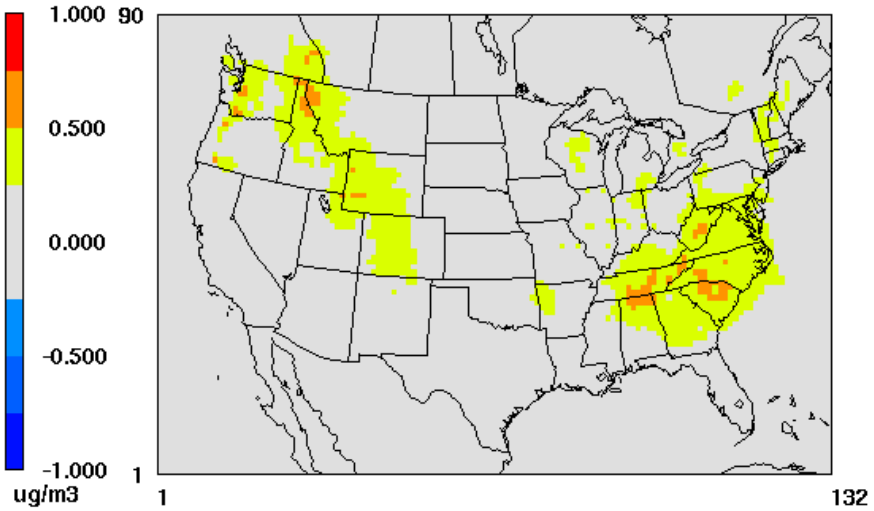


January 1,1996 1:00:00
Min= -0.033 at (62,72), Max= 1.336 at (104,43)

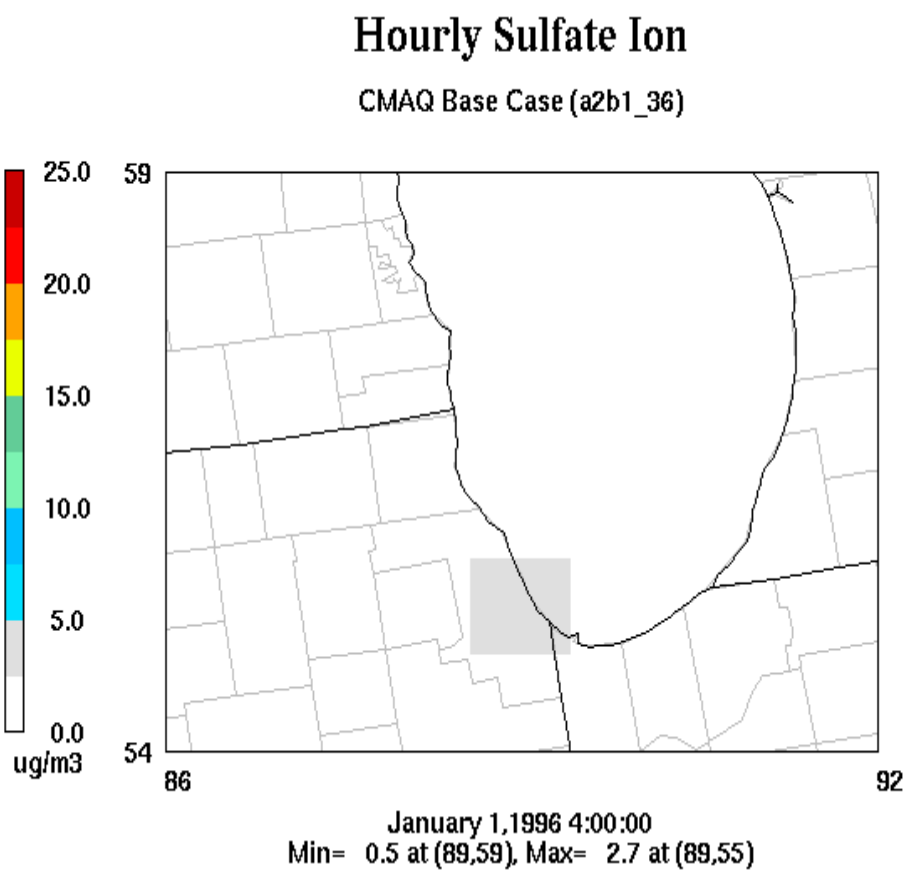
Change in Monthly Average (AMM + OC +EC + Other PM 2.5)

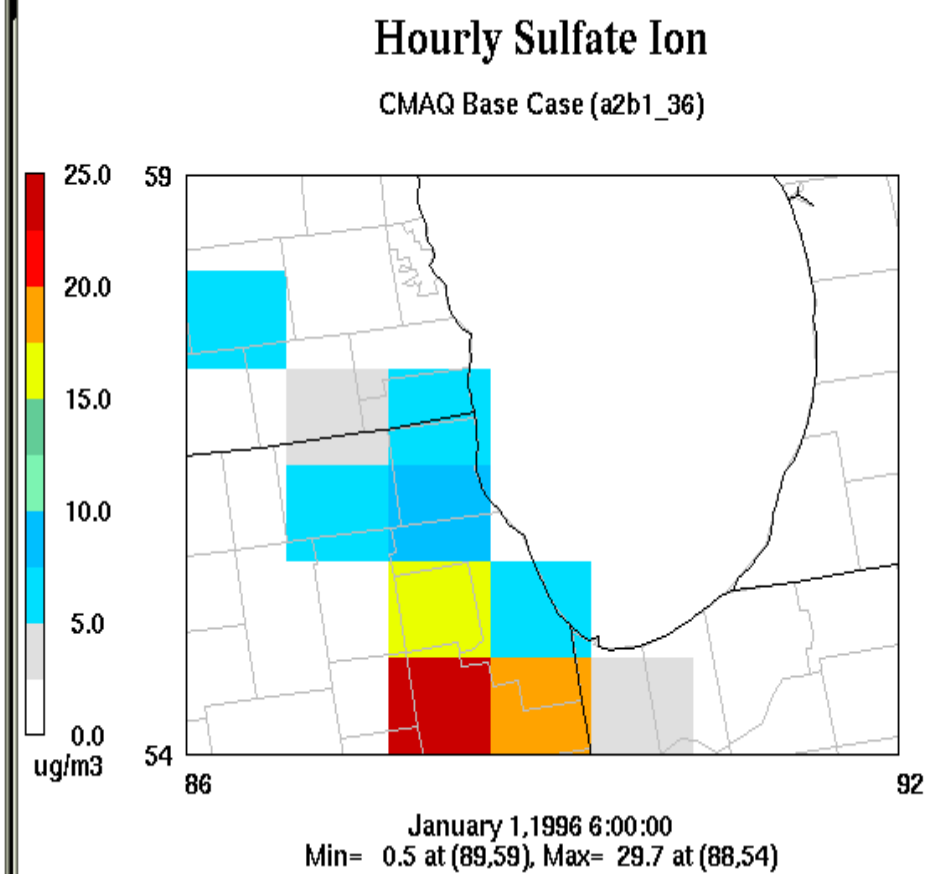
Effect of 50% less cloud water mixing ratio
a=CCTM_a2b1_36.combine.01.avg, c=CCTM_a2b12_36.combine.01.avg



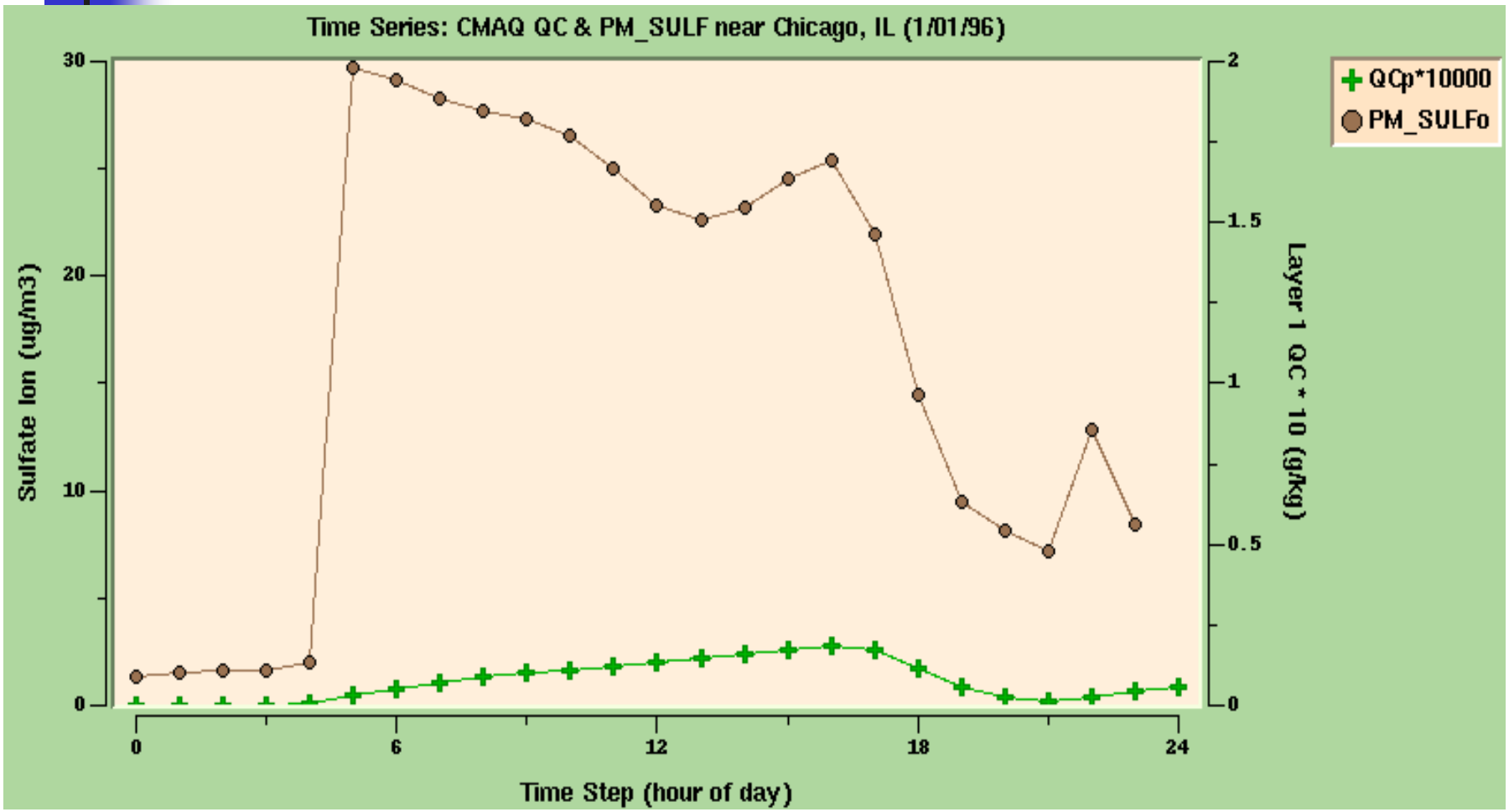
January 1,1996 1:00:00
Min= -0.138 at (19,34), Max= 0.681 at (17,75)

Importance of Meteorological Modeling (increasing for PM/Vis)





Importance of Meteorological Modeling (increasing for PM/Vis)



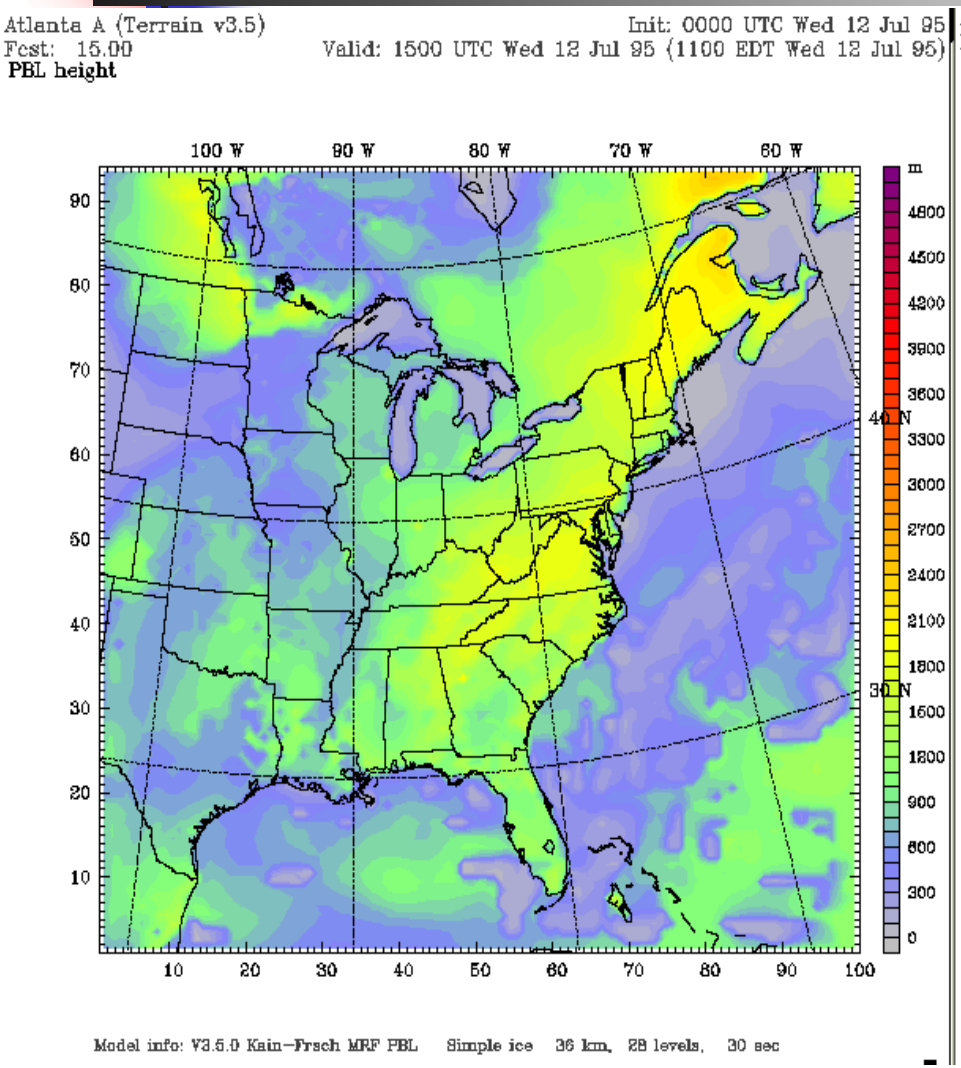
Recent Meteorological Analyses @ USEPA

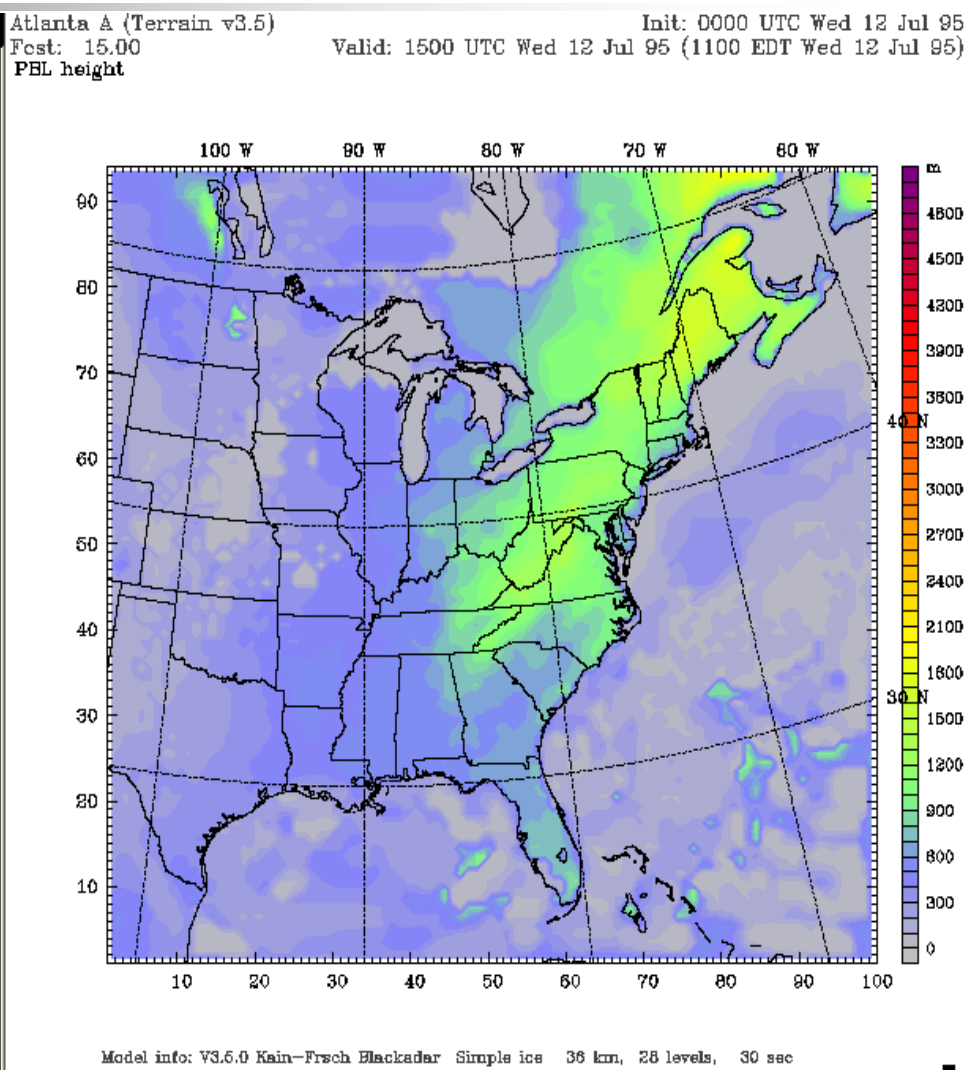
- Continental U.S. MM5 Application: 1996
  - MM5 v2.12, 108/36 km, 23 layers
  - applied by MCNC
  - MRF, K-F, simple ice, long & short-wave radiation
  - resources did not permit diagnostic testing
  - model evaluation (low T, low PBL, winds in West)
  - used in Tier-2, Heavy-Duty Diesel, Clear Skies
  - data also sent to multiple other groups
    - (WRAP, TVA, Trinity Consulting, Ontario, AER, etc.)

Recent Meteorological Analyses @ USEPA

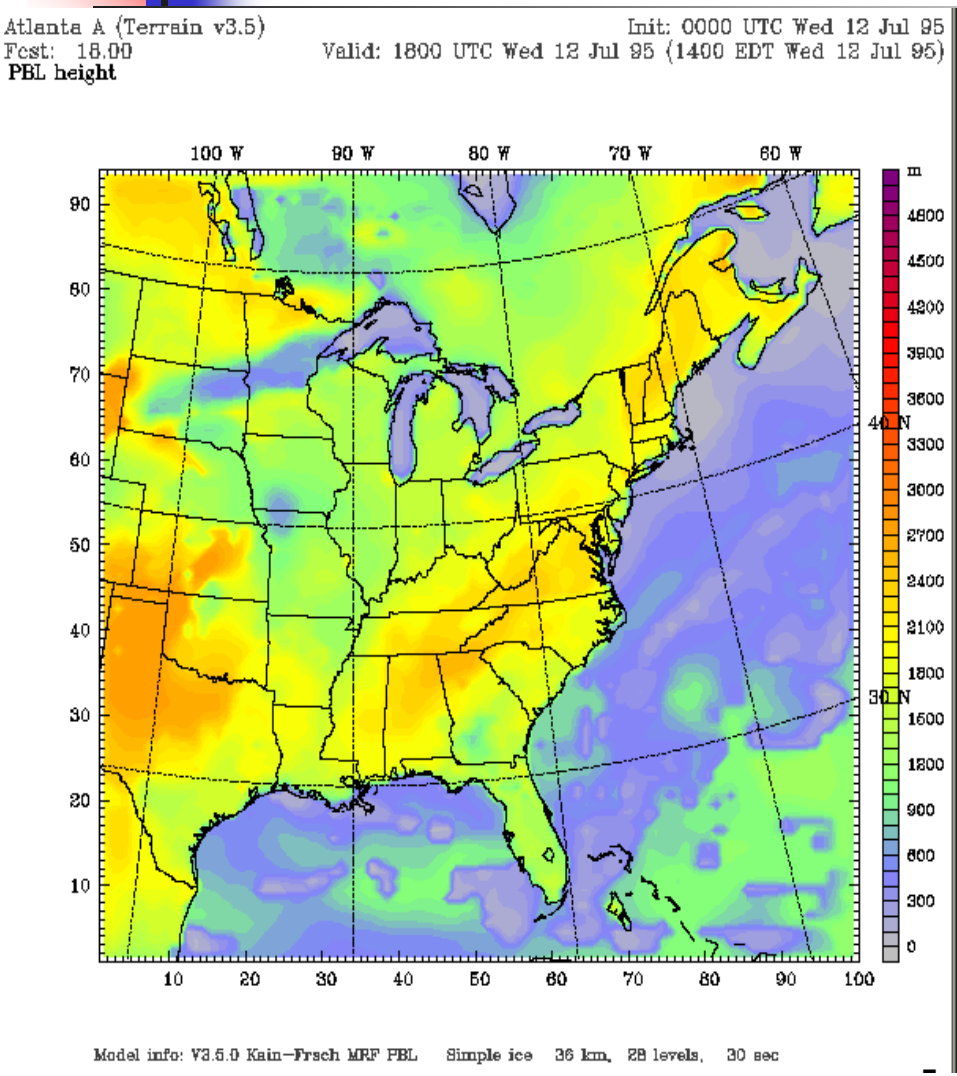
- Eastern U.S. MM5 application: July 1995
  - MM5 v3.5, 108/36/12/04 km, 28 layers
  - applied at EPA
  - Blackadar, K-F, simple ice, surface radiation
  - schedule permitted only limited diagnostic testing
  - only qualitative model evaluation
  - used in US/Canada annex modeling, proof-of-concept

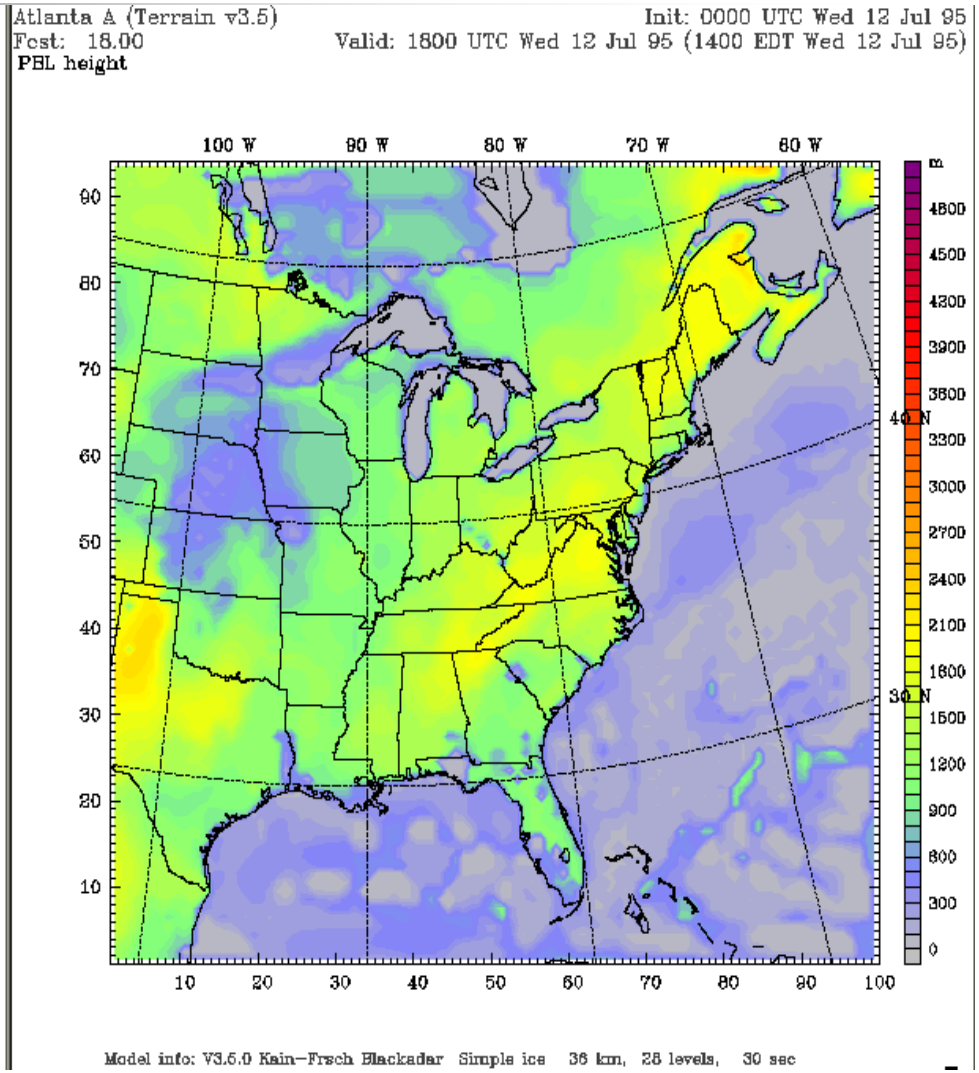
Recent Meteorological Analyses @ USEPA (July 1995, Eastern US)



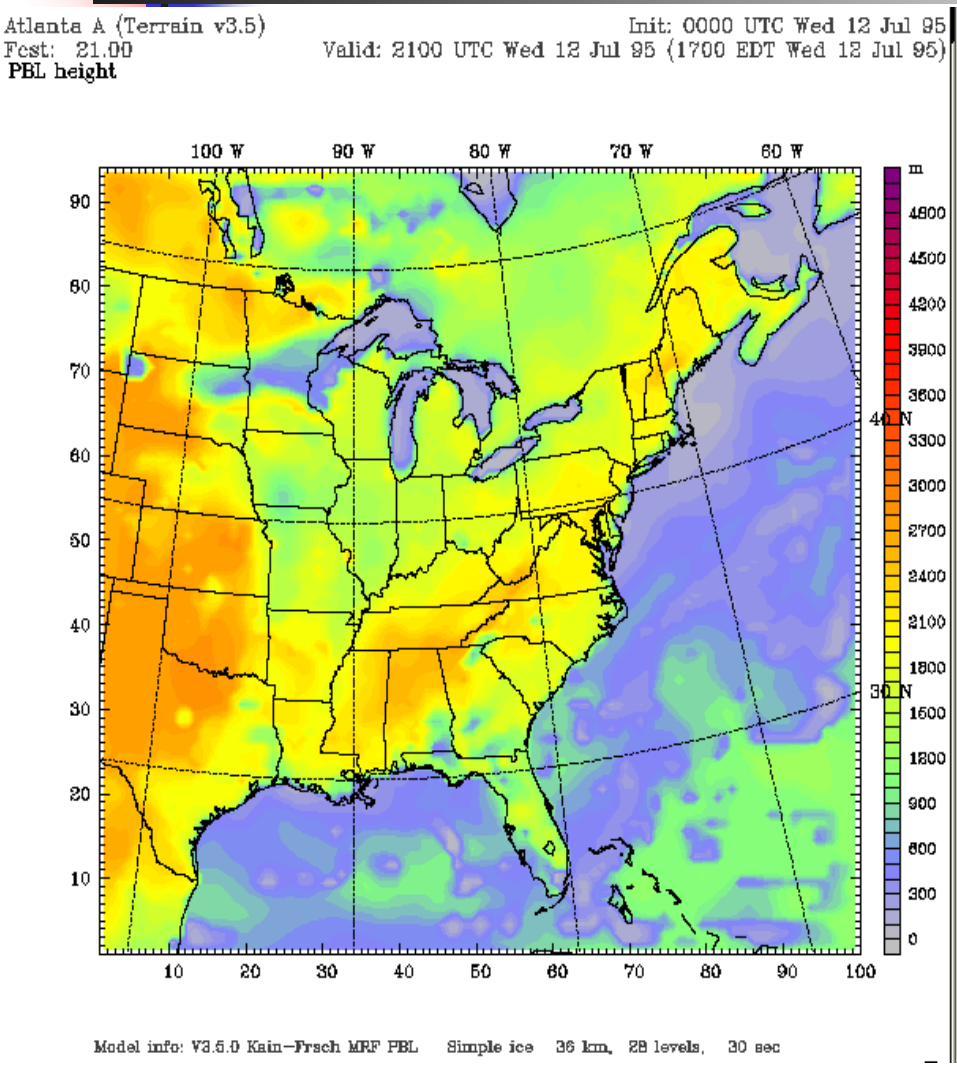


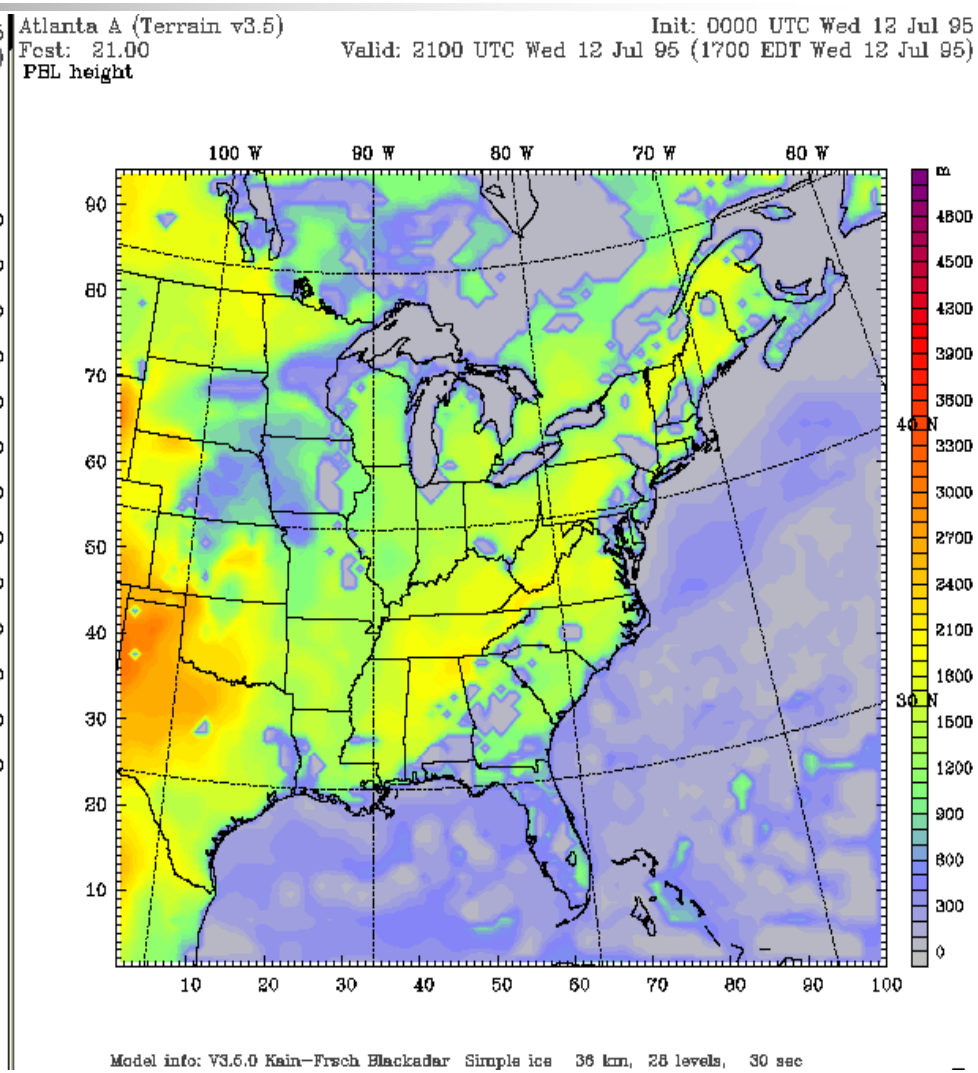
Recent Meteorological Analyses @ USEPA (July 1995, Eastern US)

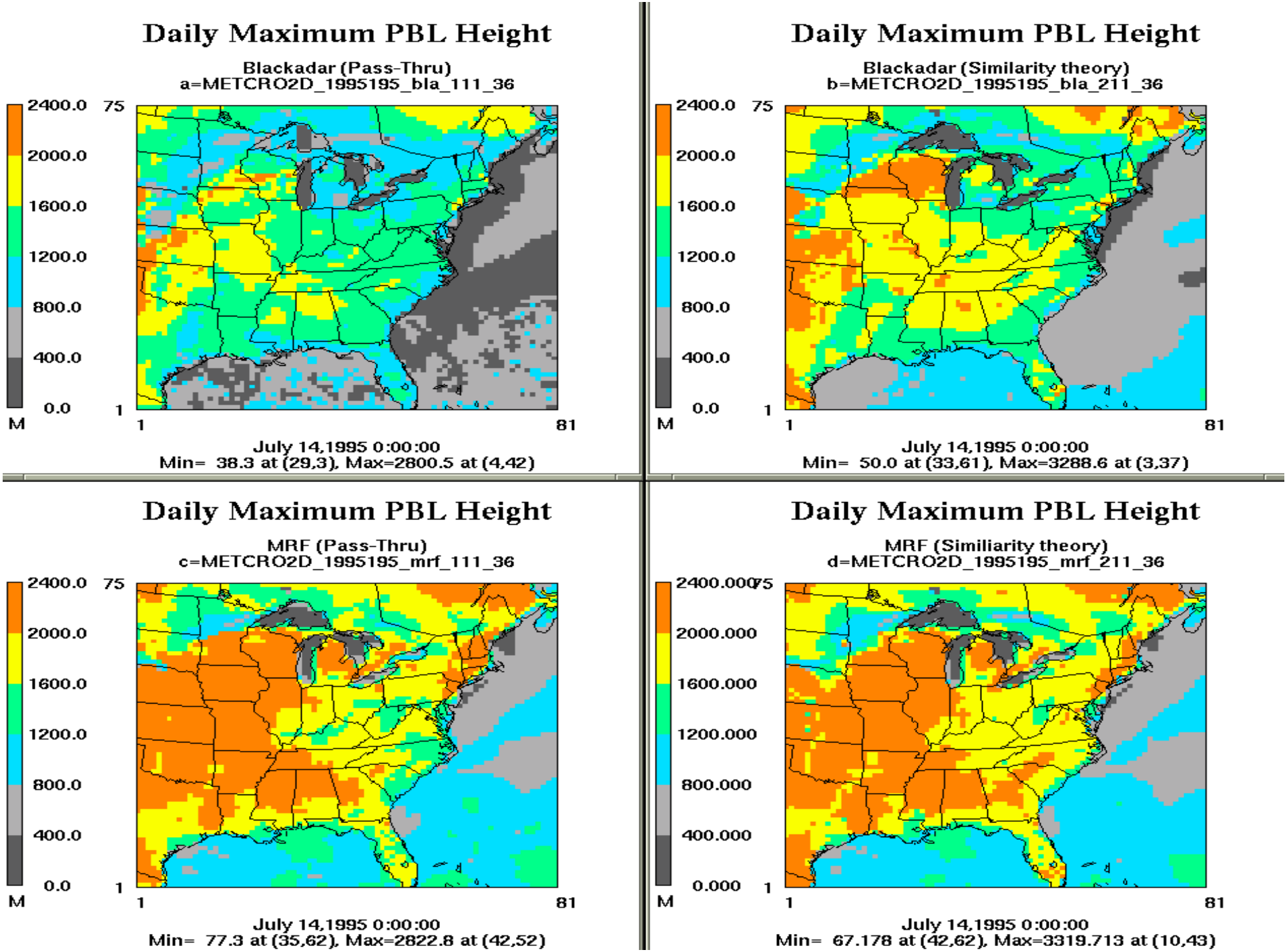


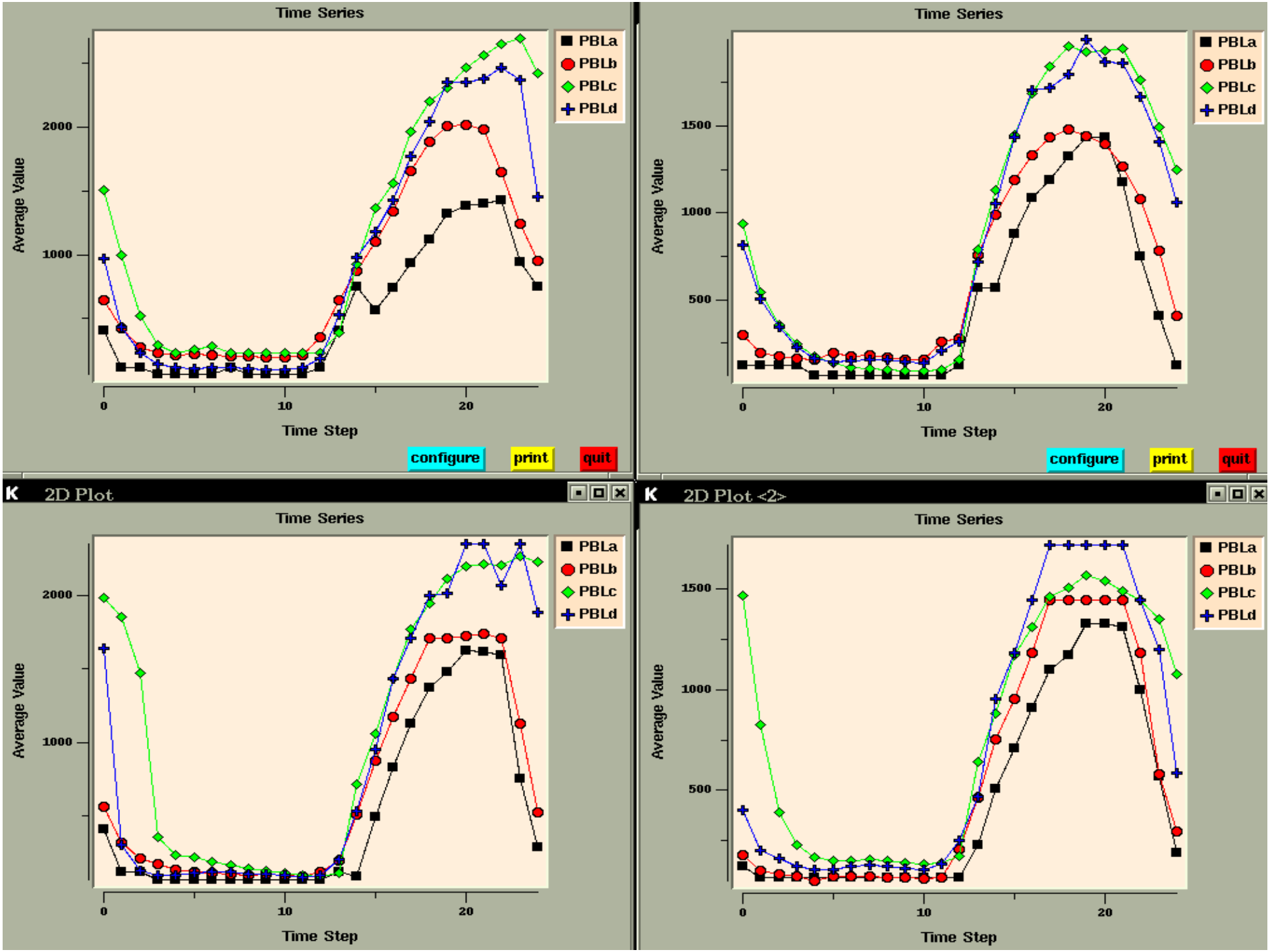


Recent Meteorological Analyses @ USEPA (July 1995, Eastern US)






Daily Maximum PBL Height
Blackadar (Pass-Thru)
a=METCRO2D_1995195_bla_111_36
2400.0
2000.0
1600.0
1200.0
800.0
400.0
0.0
M
75
1
1
81
July 14,1995 0:00:00
Min= 38.3 at (29,3), Max=2800.5 at (4,42)
Daily Maximum PBL Height
Blackadar (Similarity theory)
b=METCRO2D_1995195_bla_211_36
2400.0
2000.0
1600.0
1200.0
800.0
400.0
0.0
M
75
1
1
81
July 14,1995 0:00:00
Min= 50.0 at (33,61), Max=3288.6 at (3,37)
Daily Maximum PBL Height
MRF (Pass-Thru)
c=METCRO2D_1995195_mrf_111_36
2400.0
2000.0
1600.0
1200.0
800.0
400.0
0.0
M
75
1
1
81
July 14,1995 0:00:00
Min= 77.3 at (35,62), Max=2822.8 at (42,52)
Daily Maximum PBL Height
MRF (Similiarity theory)
d=METCRO2D_1995195_mrf_211_36
2400.000
2000.000
1600.000
1200.000
800.000
400.000
0.000
M
75
1
1
81
July 14,1995 0:00:00
Min= 67.178 at (42,62), Max=3319.713 at (10,43)


Time Series
Average Value
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PBLa
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configure
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2D Plot <2>

Developing Meteorological Input Data for Air Quality Modeling Analyses

- Goal: development of high-quality, gridded meteorological datasets that can be used to support urban, regional, and national air quality modeling exercises over the United States.

- Alpine Geophysics is the primary contractor for the work assignment with assistance from Atmospheric, Meteorological and Environmental Technologies, LLC (ATMET)

- The work assignment consists of four major activities:
  - Recommend meteorological model evaluation methodologies
  - Investigate the utility of alternative meteorological data sets
  - Perform episodic, 12km MM5 simulation over the eastern U.S. (July/Aug 2001)
  - Perform an annual, continental U.S. MM5 simulation (2001)

Annual Application of MM5 to the Continental U.S.

- Goal: development of gridded meteorological datasets that can be used to support national air quality modeling

- A modeling protocol has been developed and is available
  - Version 3.5 of MM5
  - Model to be run in 5-day intervals, with 12 hours of overlap for initialization
  - RPO grid projection (40°, -97° centroid; true latitudes of 33° and 45°)
  - 34 vertical layers; surface layer 38 m
  - Key model physics options (pending final determination):
    - Kain-Fritsch cumulus parameterization,
    - Blackadar PBL scheme,
    - Dudhia Simple Ice microphysics,
    - RRTM radiation scheme, and
    - the P-X land surface model (???).

Annual Application of MM5 to the Continental U.S.

- The performance of the model will be assessed via an operational evaluation and a scientific evaluation:
  - Operational: parameters will include winds, temperature, moisture, cloud, precipitation, etc.
  - Operational: statistics will include bias, error, RMSE, index of agreement, comparions of the mean values and standard deviations, skill scores, etc.
  - Operational: evaluation will be conducted on national, RPO, and State levels for several time scales.
  - Scientific: several diagnostic tests have been identified to provide additional insight into model performance (i.e., assess the sensitivity of the results to certain physics options).

- Several diagnostic/sensitivity tests have been completed (testing is done for two 20-day episodes in February and July)
  - use of larger domain with NNRP initialization data; use of “ZFAC” mods; no FDDA; double FDDA; alternative land surface models; alternative microphysics schemes (Reisner).