Preliminary assessment of AQ forecast model skill at predicting O_3 and PM2.5 during TexAQS 2006

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NOAA/Earth Systems Research Laboratory

- Question J: How well do air quality forecast models predict the observed ozone and aerosol formation?
- What are the implications for improvement of ozone forecasts

Do models have skill at forecasting ozone and PM2.5 during TexAQS II?

TexAQS-2006 model verification project

http://www.etl.noaa.gov/programs/2006/texaqs/verification/

Eight O_3 and PM2.5 Forecasts Available in Real-Time

NOAA NWS/NCEP, 12km, WRF/CMAQ - surface O_3, PM2.5, Modal

NOAA ESRL/GSD, 12km and 36km, WRF-CHEM, Modal

Canadian CMC, 21km, CHRONOS, Mass only

Canadian CMC, 28km, AURAMS, Sectional-8

University of Iowa, 12km, WRF/STEM, Sectional-6

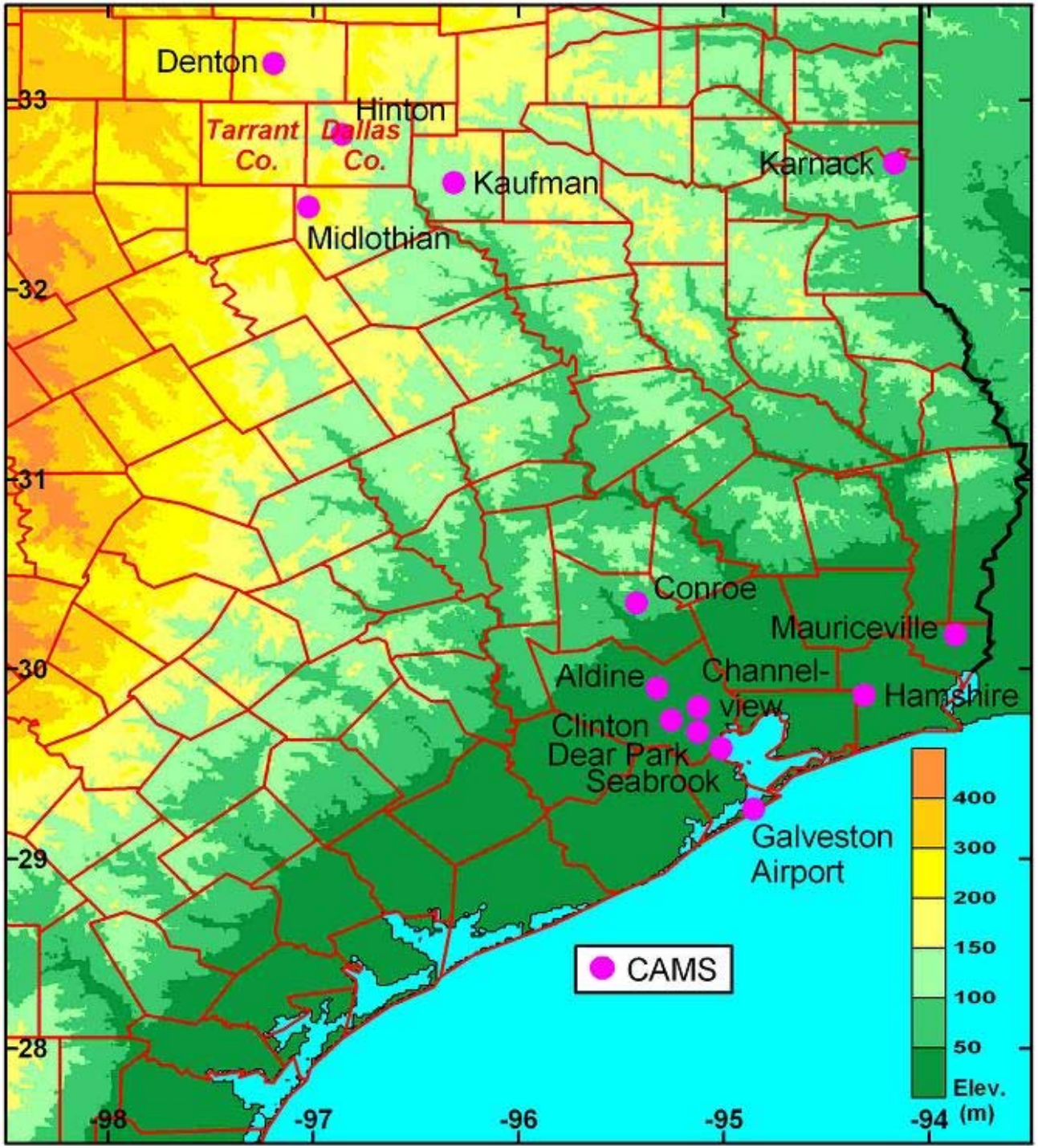
Baron AMS, 4km and 12km, MM5/MAQSIP-RT, Modal

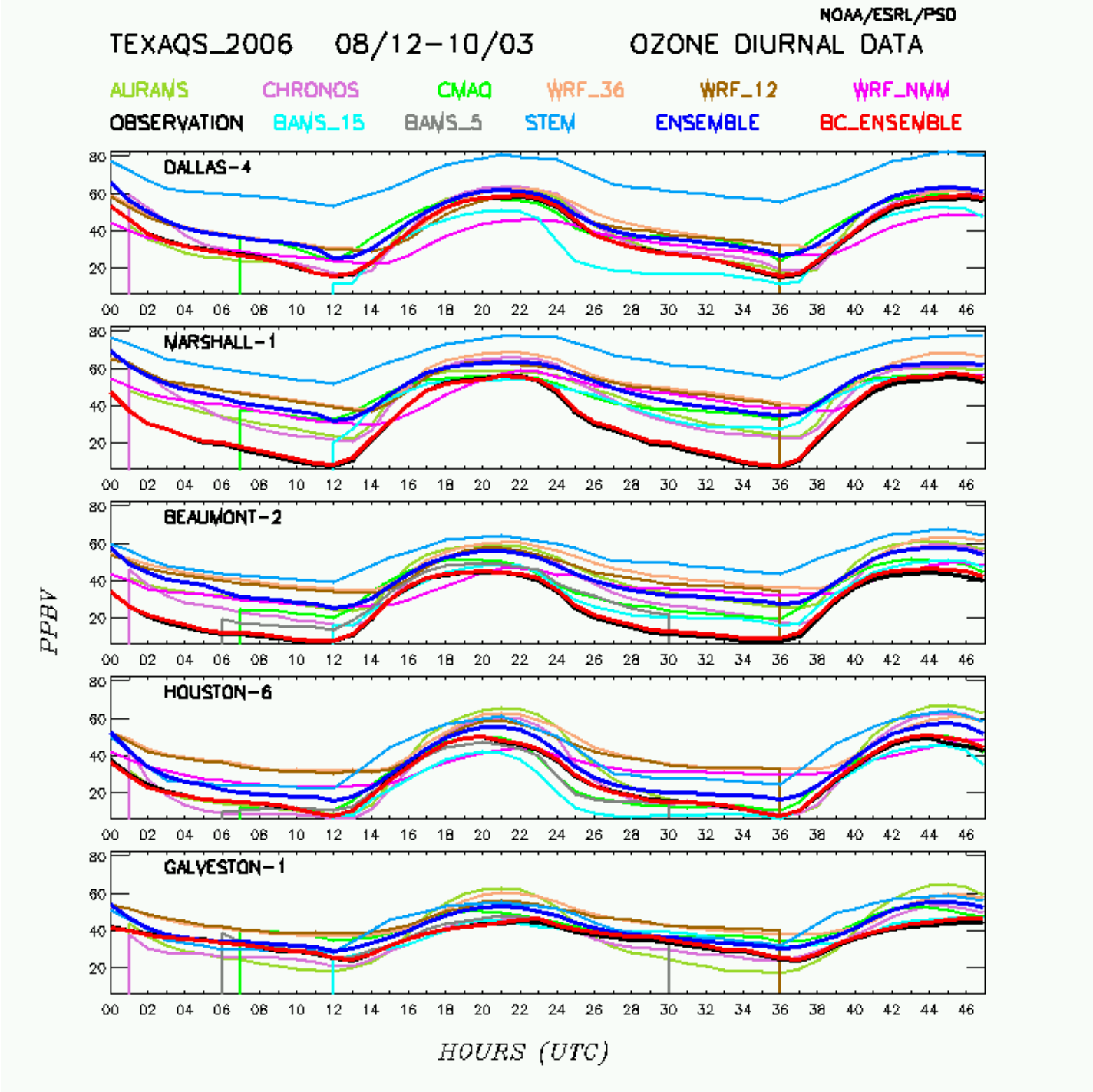
Available after the Experiment

NOAA NWS/NCEP, Upper-Air Composition, Modal

University of Houston, 4km and 12km, MM5/CB-IV, Modal

CAMS sites

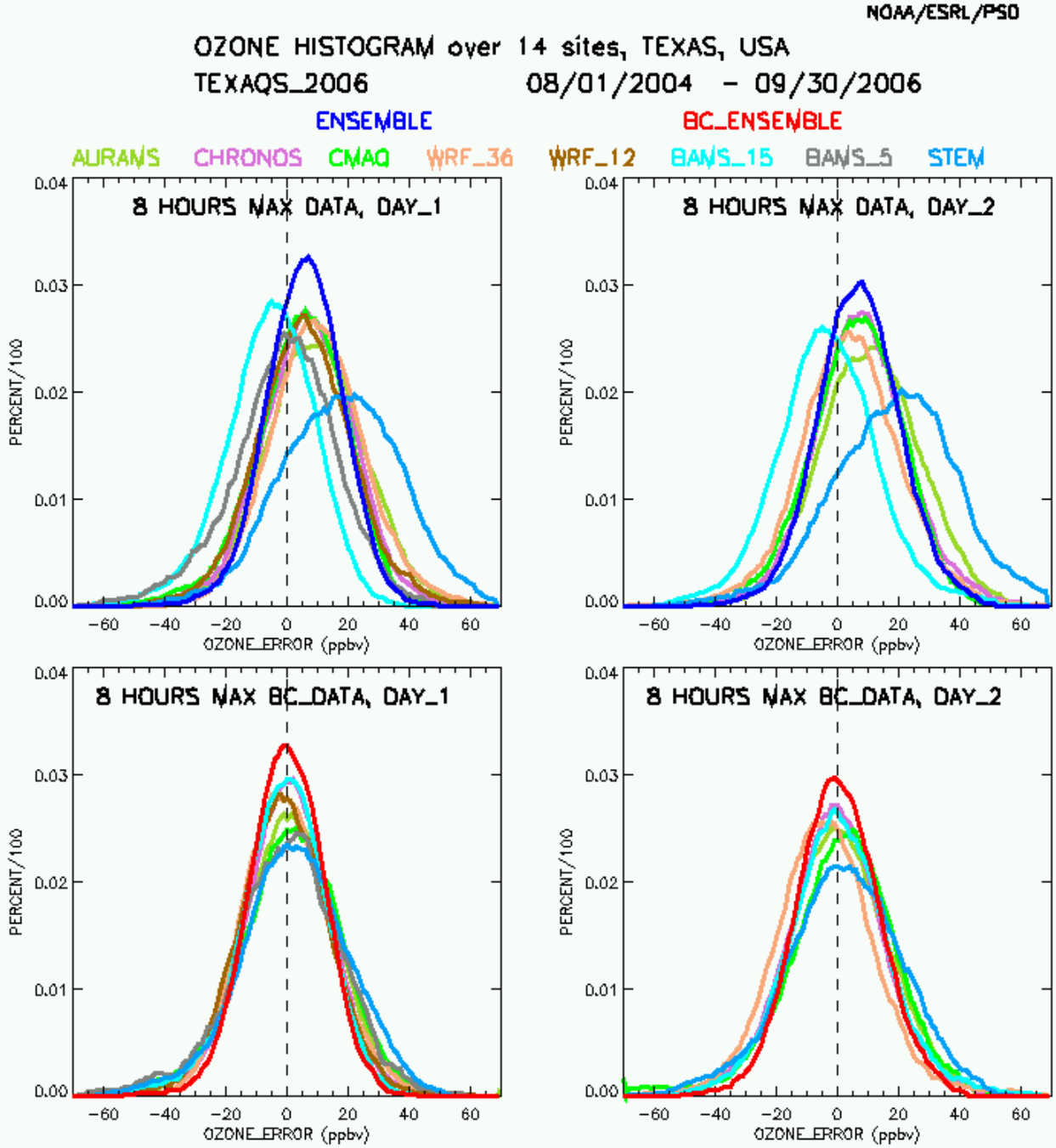

Denton
Hinton
Tarrant Co.
Dallas Co.
Kaufman
Karnack
Midlothian
Conroe
Mauriceville
Aldine
Channel-view
Hamshire
Clinton
Dear Park
Seabrook
Galveston Airport
CAMS
400
300
200
150
100
50
Elev. (m)
-33
-32
-31
-30
-29
-28
-98
-97
-96
-95
-94

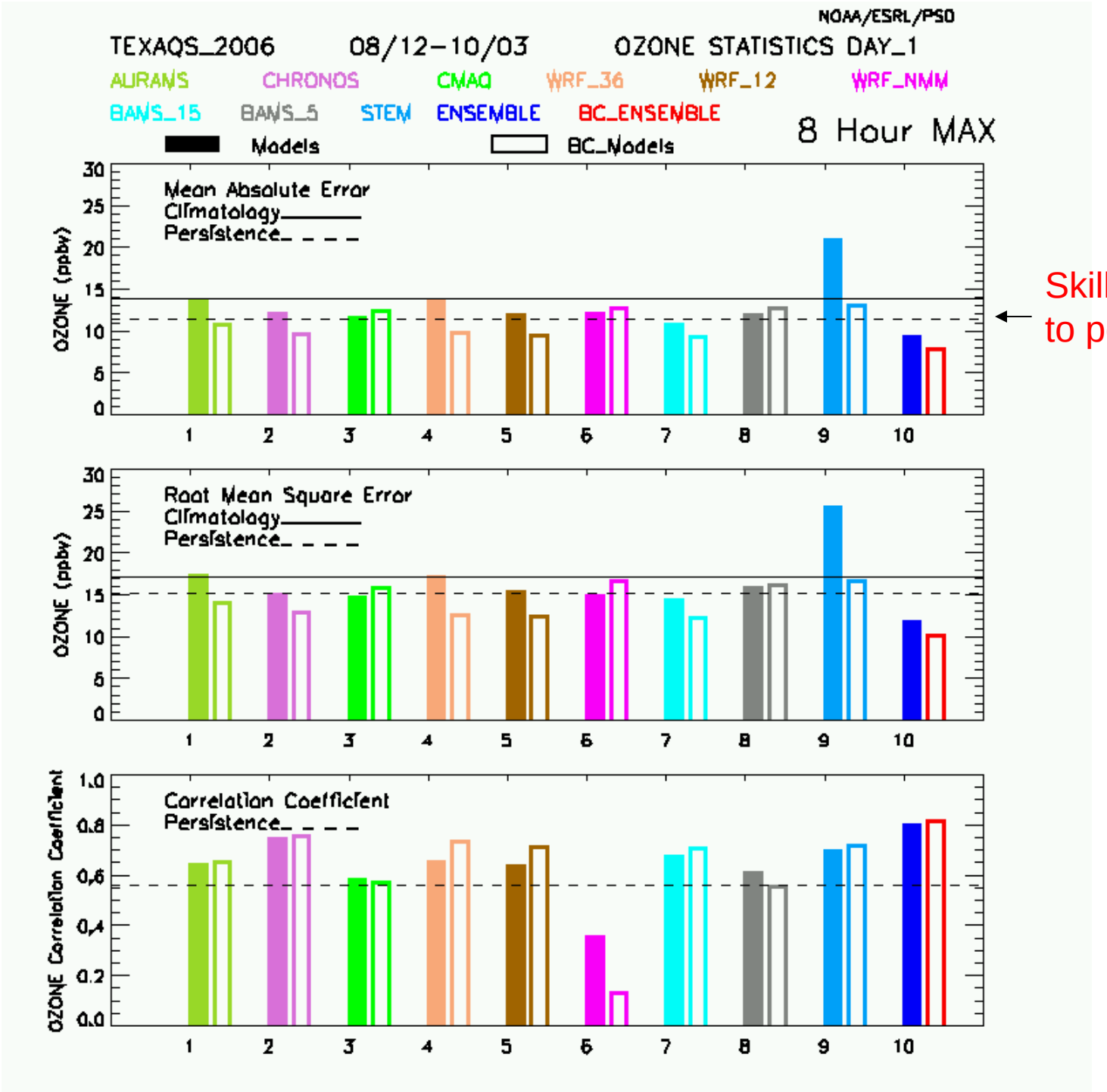

NOAA/ESRL/PSD
TEXAQS_2006 08/12-10/03 OZONE DIURNAL DATA
AURAMS
CHRONOS
CMAQ
WRF_36
WRF_12
WRF_NMM
OBSERVATION
BAMS_15
BAMS_5
STEM
ENSEMBLE
BC_ENSEMBLE
DALLAS-4
MARSHALL-1
BEAUMONT-2
HOUSTON-6
GALVESTON-1
PPBV
HOURS (UTC)

Bias Correction Schemes

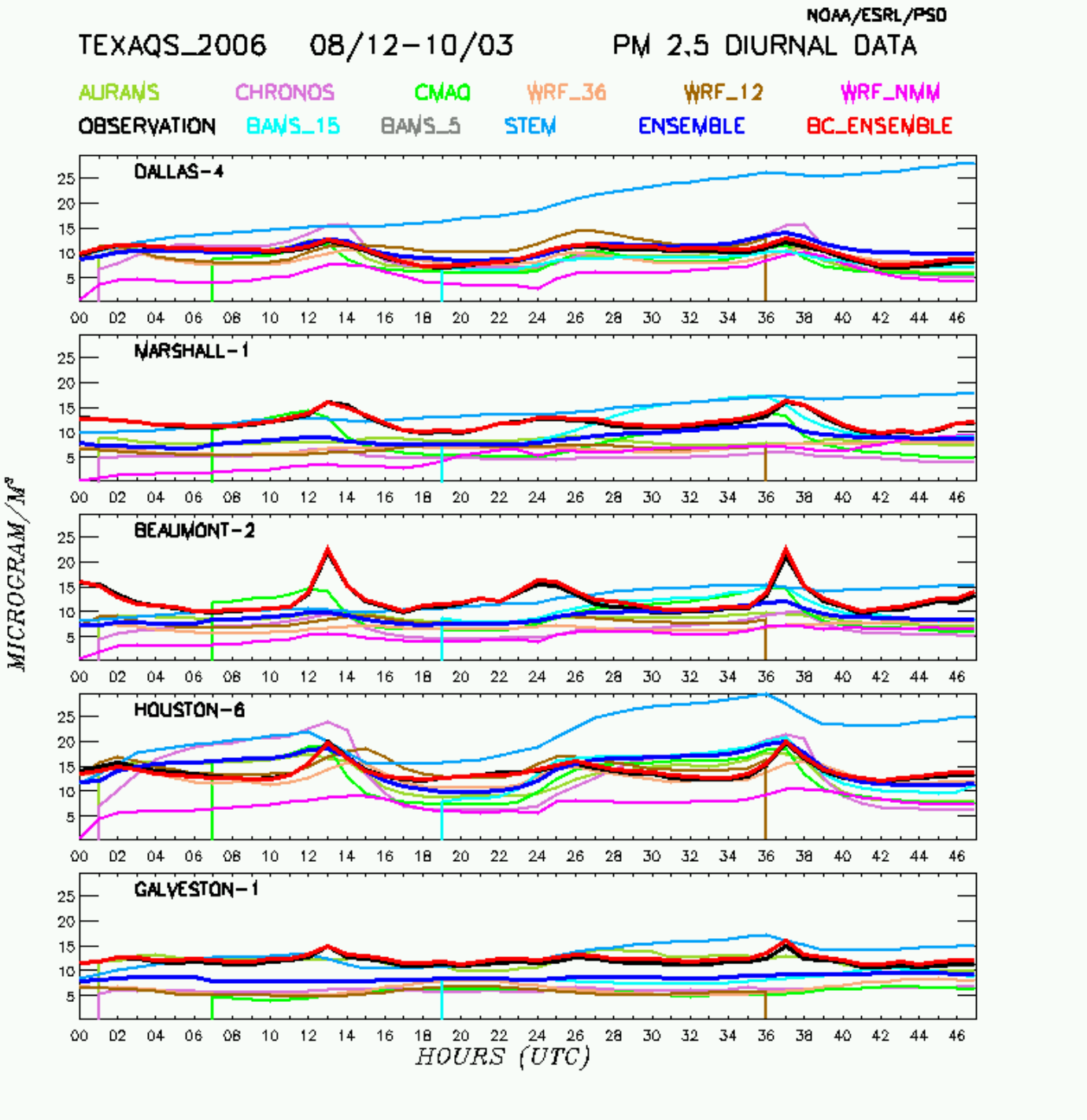
- 7-Day running mean
- Kalman Filter

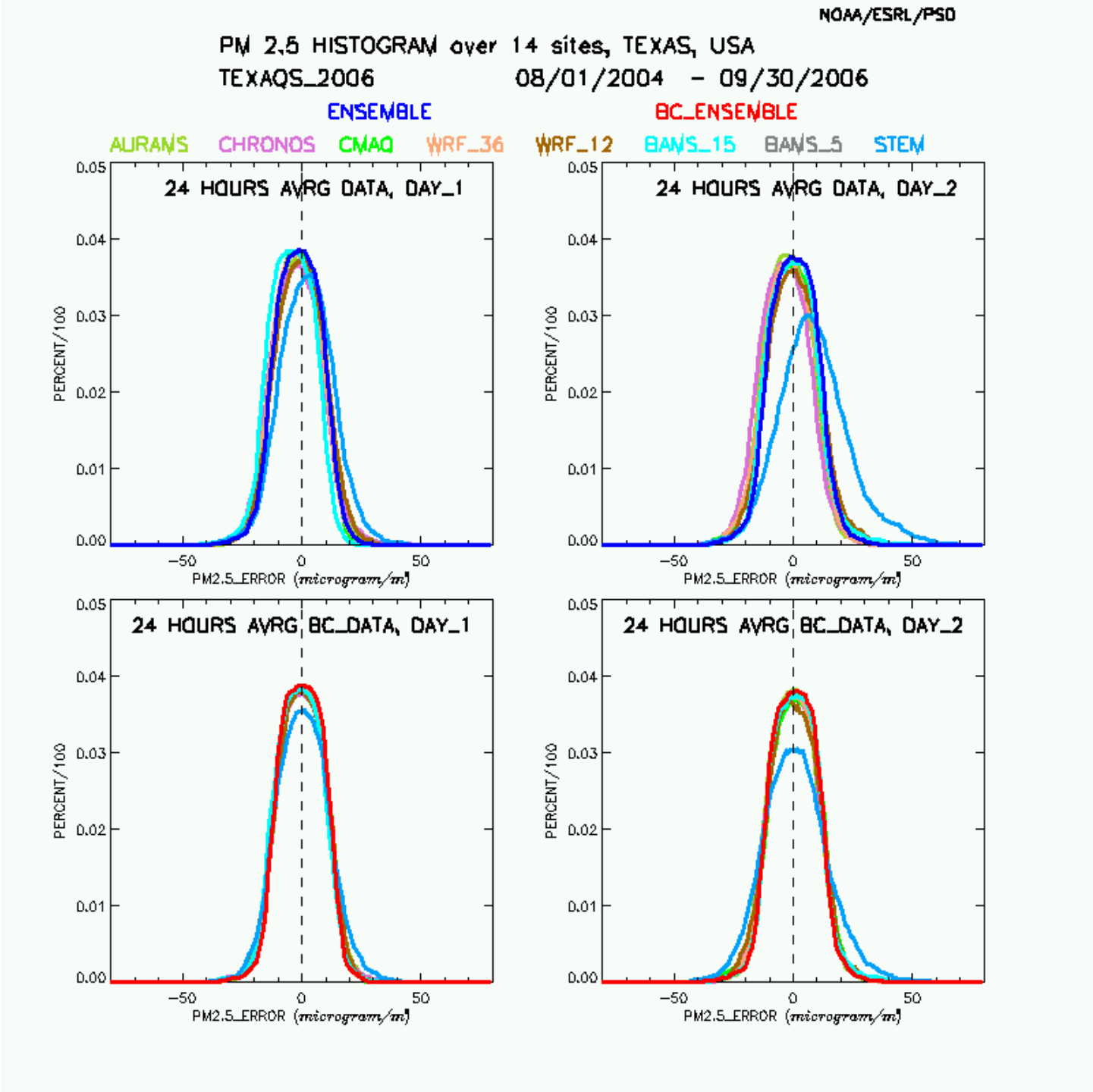
Both are location and time of day specific

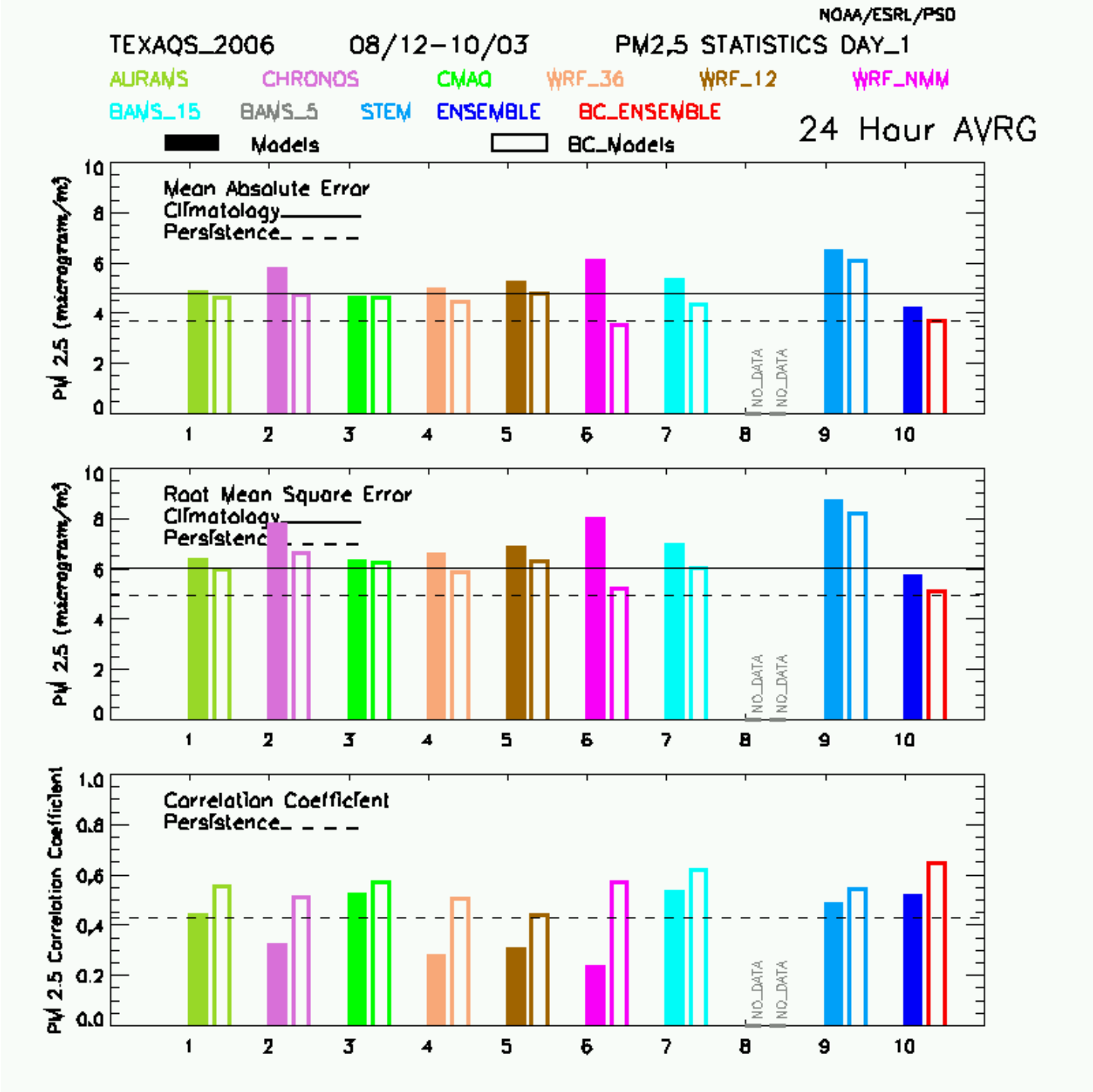

NOAA/ESRL/PSD
OZONE HISTOGRAM over 14 sites, TEXAS, USA
TEXAQS_2006
08/01/2004 - 09/30/2006
ENSEMBLE
BC_ENSEMBLE
AURAMS
CHRONOS
CMAQ
WRF_36
WRF_12
BAMS_15
BAMS_5
STEM
8 HOURS MAX DATA, DAY_1
8 HOURS MAX DATA, DAY_2
8 HOURS MAX BC_DATA, DAY_1
8 HOURS MAX BC_DATA, DAY_2
PERCENT/100
OZONE_ERROR (ppbv)
0.00
0.01
0.02
0.03
0.04
-60
-40
-20
0
20
40
60

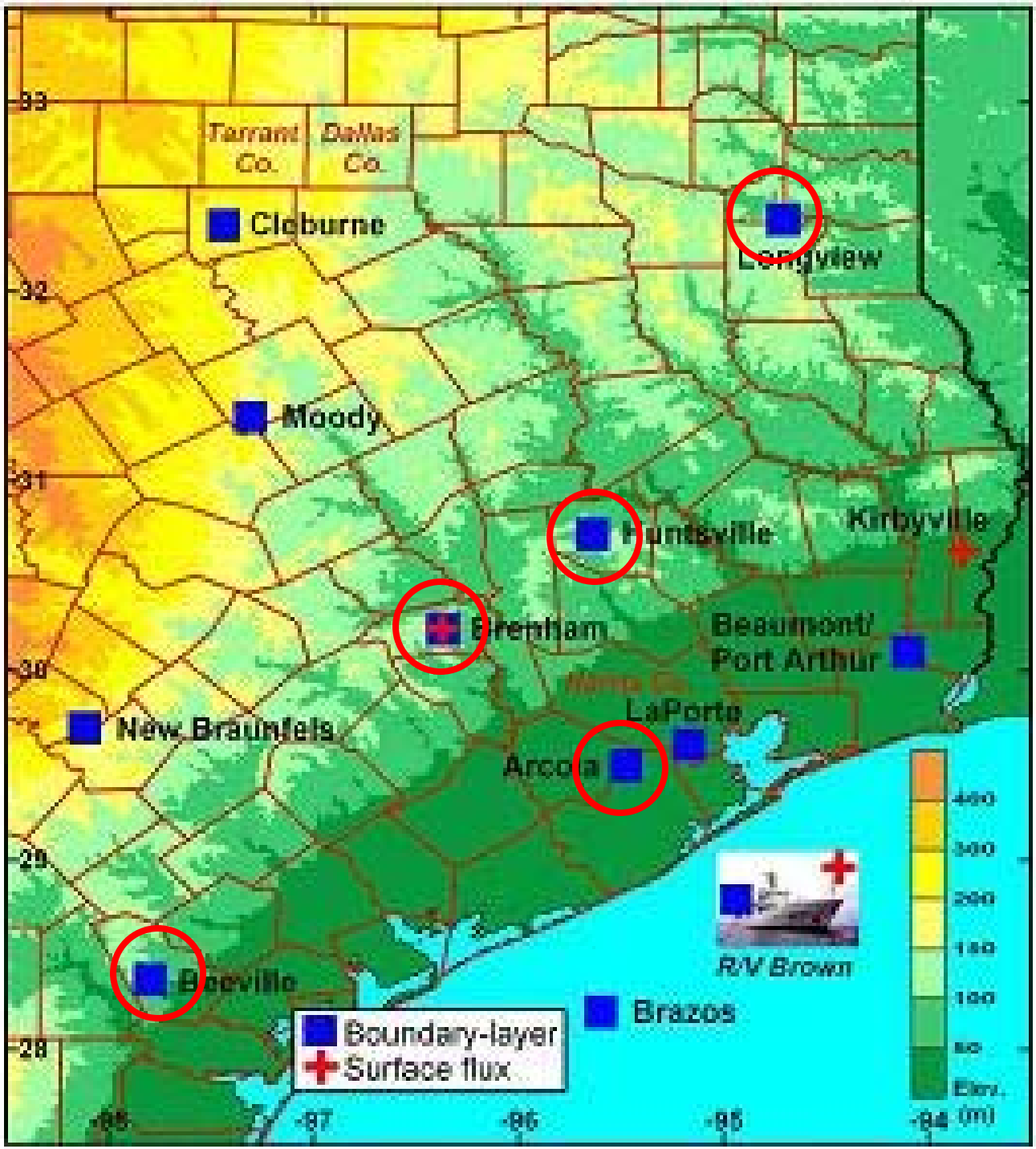


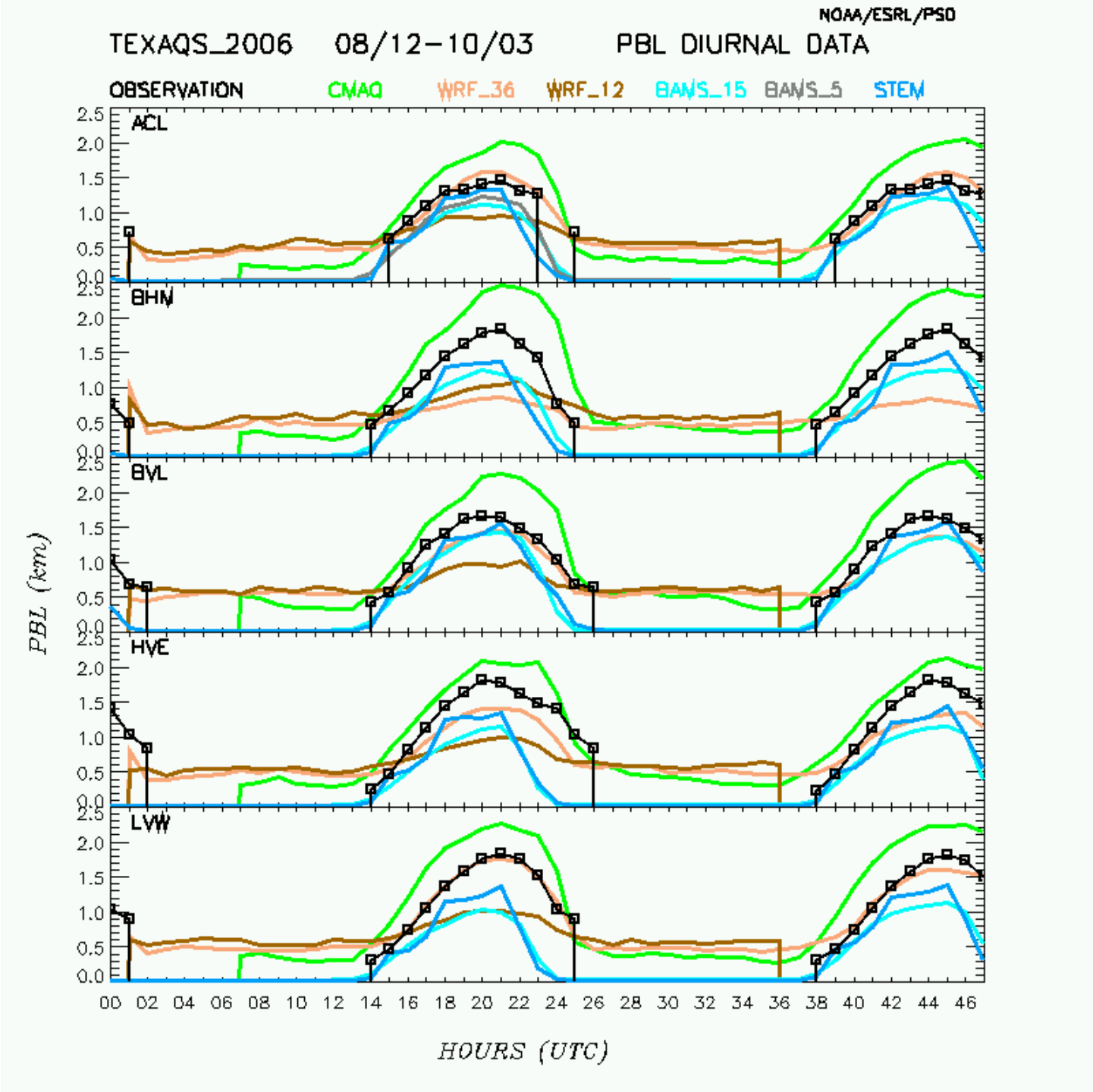
Skill relative to persistence


NOAA/ESRL/PSD
TEXAQS_2006 08/12-10/03 PM 2.5 DIURNAL DATA
AURAMS
CHRONOS
CMAQ
WRF_36
WRF_12
WRF_NMM
OBSERVATION
BAMS_15
BAMS_5
STEM
ENSEMBLE
BC_ENSEMBLE
DALLAS-4
MARSHALL-1
BEAUMONT-2
HOUSTON-6
GALVESTON-1
MICROGRAM/M³
HOURS (UTC)


NOAA/ESRL/PSD
PM 2.5 HISTOGRAM over 14 sites, TEXAS, USA
TEXAQS_2006
08/01/2004 - 09/30/2006
ENSEMBLE
BC_ENSEMBLE
AURAMS
CHRONOS
CMAQ
WRF_36
WRF_12
BAMS_15
BAMS_5
STEM
24 HOURS AVRG DATA, DAY_1
24 HOURS AVRG DATA, DAY_2
24 HOURS AVRG BC_DATA, DAY_1
24 HOURS AVRG BC_DATA, DAY_2
PERCENT/100
PM2.5_ERROR (microgram/m³)
0.05
0.04
0.03
0.02
0.01
0.00
-50
0
50

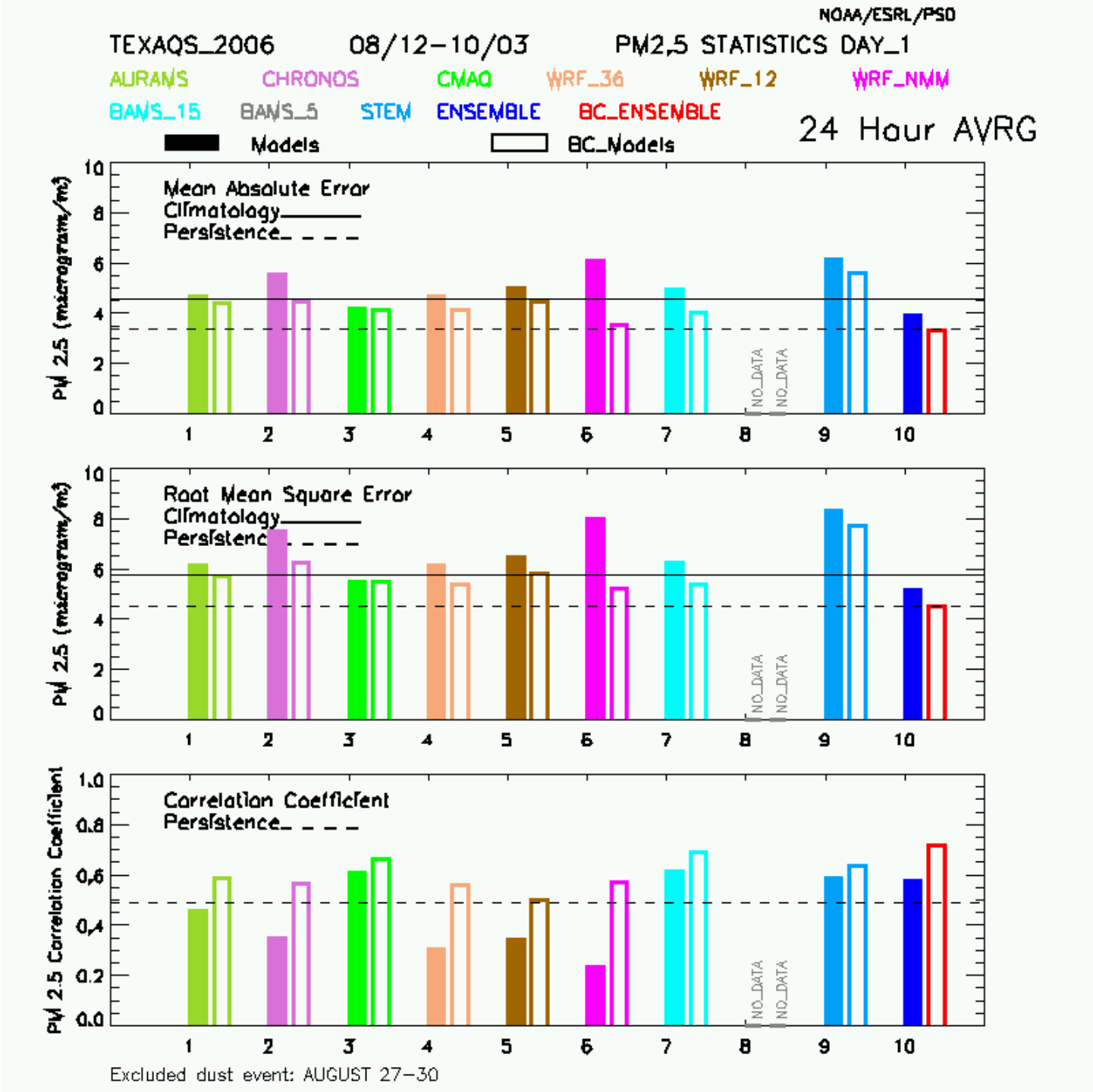

NOAA/ESRL/PSD
TEXAQS_2006
08/12-10/03
PM2.5 STATISTICS DAY_1
AURAMS
CHRONOS
CMAQ
WRF_36
WRF_12
WRF_NMM
BAMS_15
BAMS_5
STEM
ENSEMBLE
BC_ENSEMBLE
Models
BC_Models
24 Hour AVRG
Mean Absolute Error
Climatology
Persistence
PM 2.5 (microgram/m3)
NO_DATA
Root Mean Square Error
Correlation Coefficient
PM 2.5 Correlation Coefficient

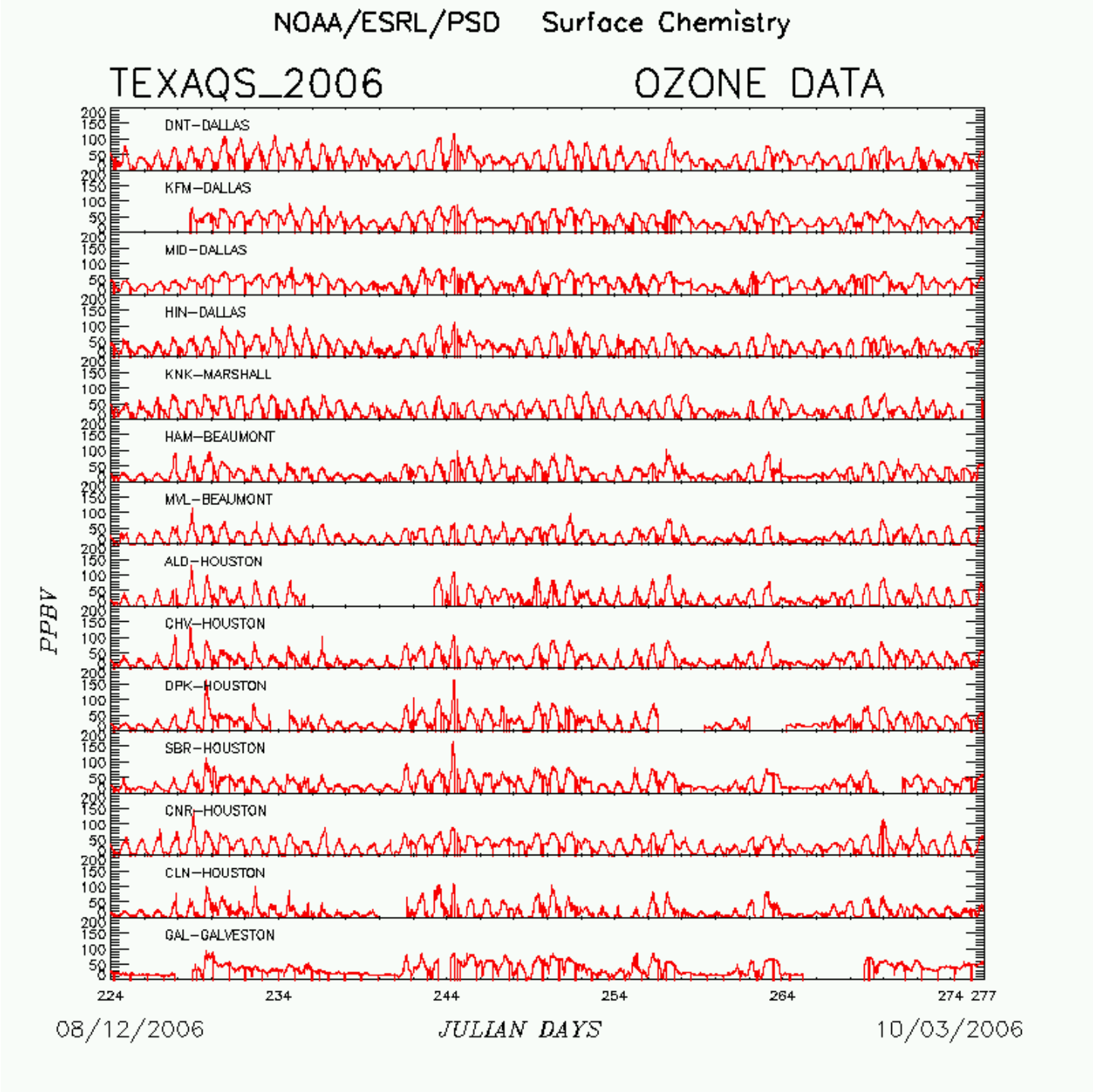

Tarrant Co.
Dallas Co.
Cleburne
Longview
Moody
Huntsville
Kirbyville
Brenham
Beaumont/
Port Arthur
Harris Co.
LaPorte
New Braunfels
Arcola
R/V Brown
Bacville
Brazos
Boundary-layer
Surface flux
Elev. (m)
33
32
31
30
29
28
-98
-97
-96
-95
-94

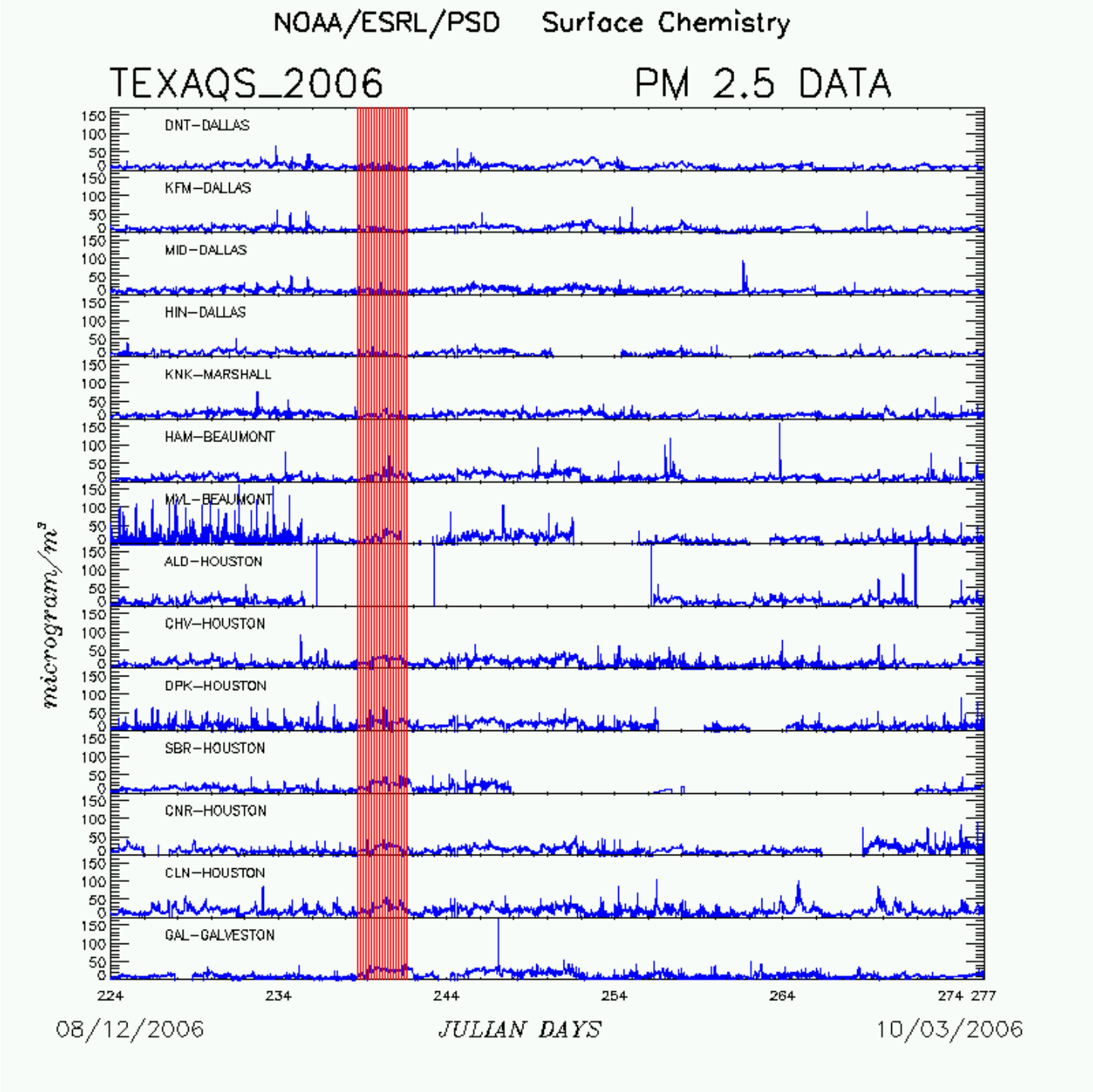

NOAA/ESRL/PSD
TEXAQS_2006 08/12-10/03 PBL DIURNAL DATA
OBSERVATION
CMAQ
WRF_36
WRF_12
BANS_15
BANS_5
STEM
ACL
BHN
BVL
HVE
LVW
PBL (km)
HOURS (UTC)

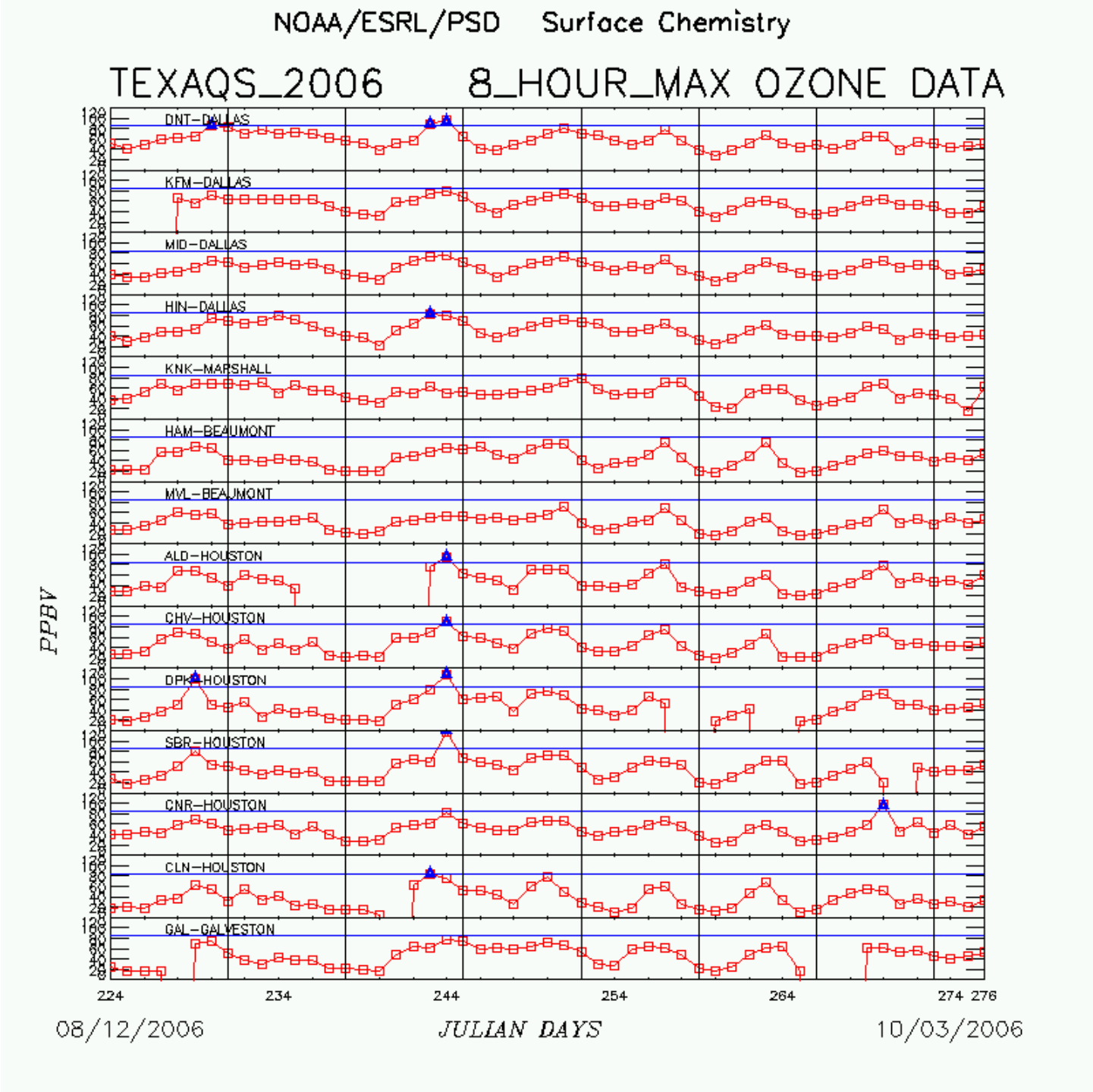
Do models have skill at predicting ozone and PM2.5?

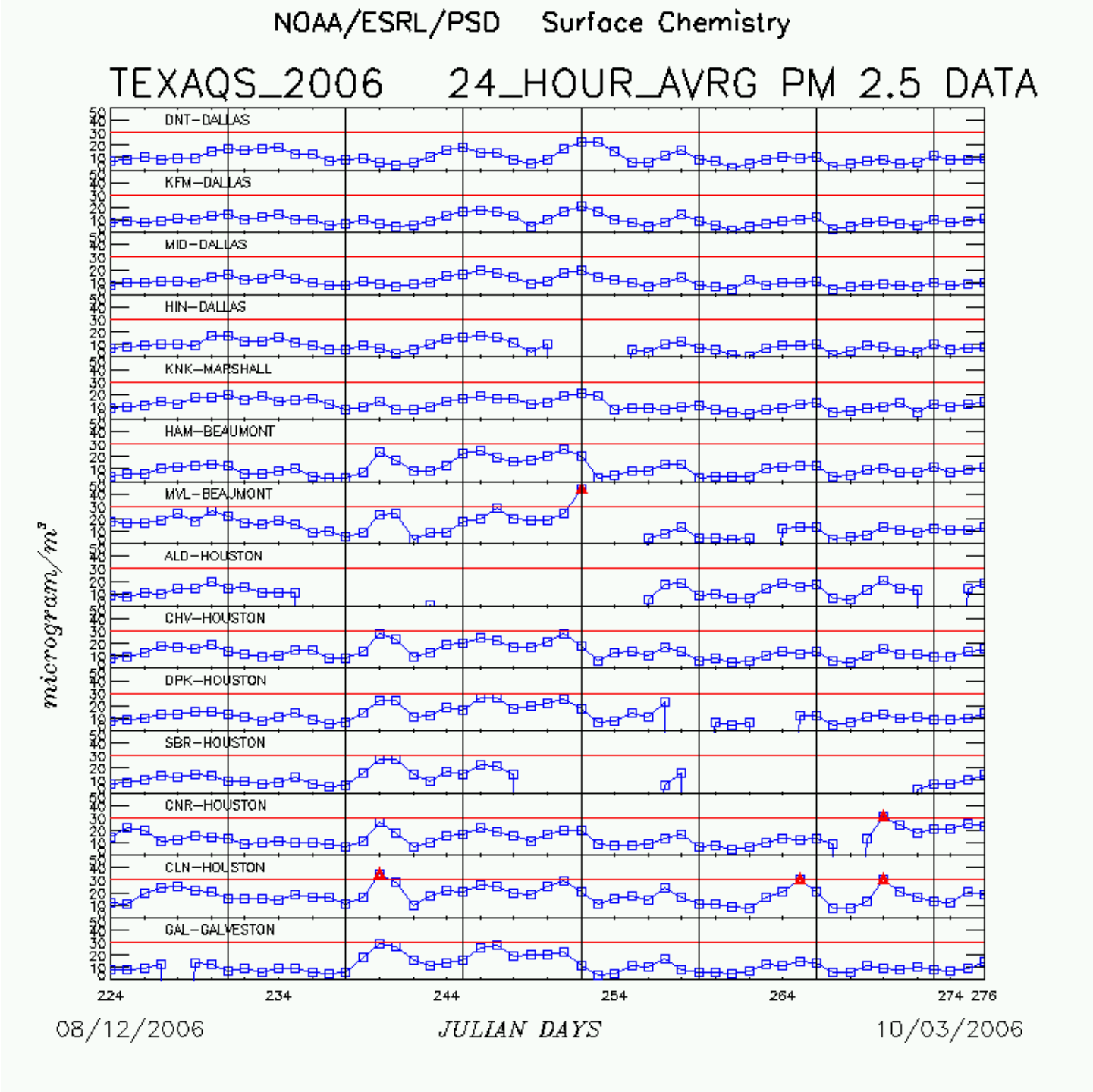
- No model beats persistence MAE and RMSE by a significant amount.
- Bias correction usually improves forecasts.
- Ensemble is better than all individual models.
- Ensemble beats persistence for ozone correlation, but not for PM2.5.
- Bias-corrected ensemble provides best forecast.
- Models forecast ozone better than PM2.5.

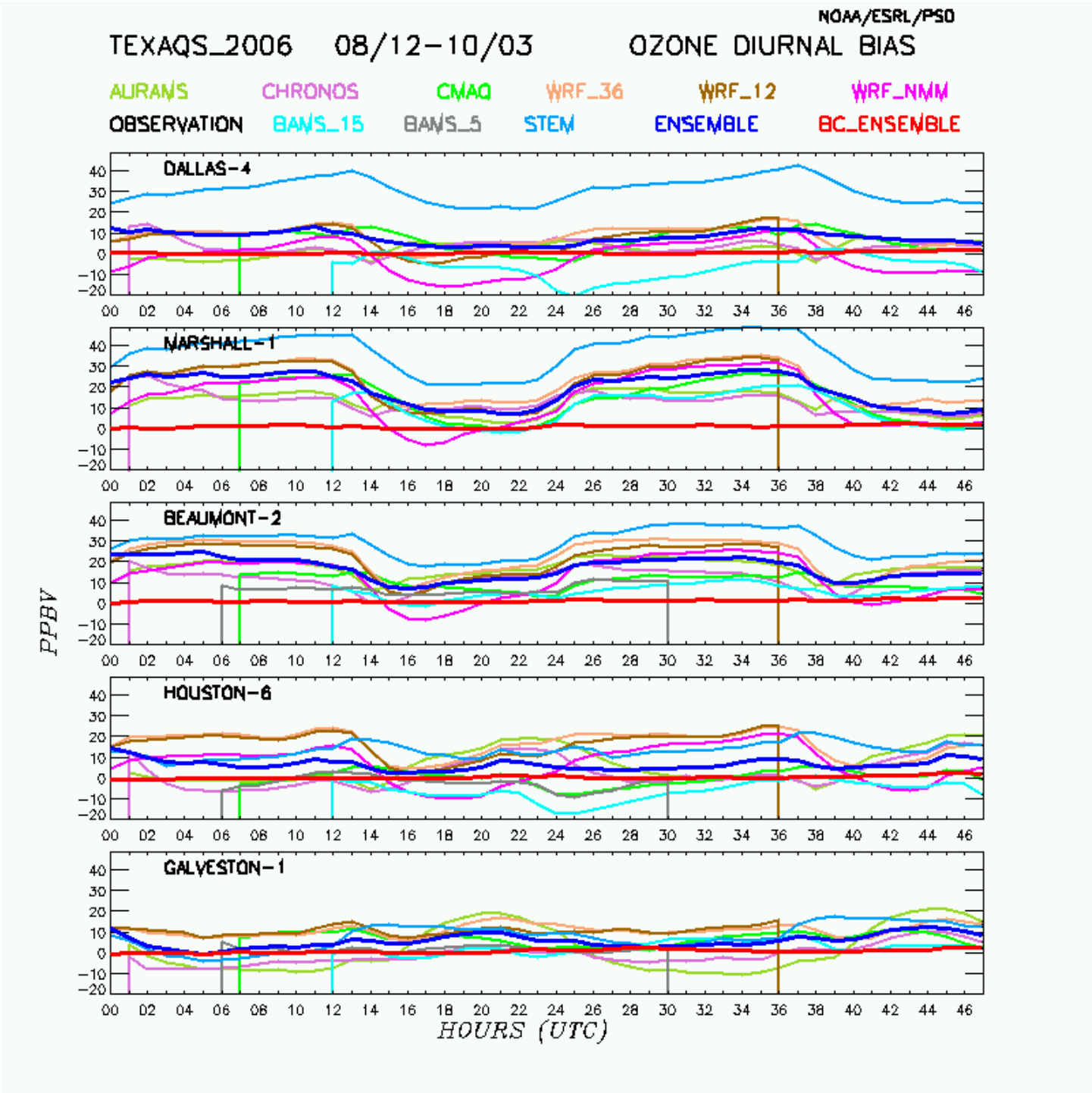

NOAA/ESRL/PSD
TEXAQS_2006
08/12-10/03
PM2.5 STATISTICS DAY_1
AURAMS
CHRONOS
CMAQ
WRF_36
WRF_12
WRF_NMM
BAMS_15
BAMS_5
STEM
ENSEMBLE
BC_ENSEMBLE
Models
BC_Models
24 Hour AVRG
Mean Absolute Error
Climatology
Persistence
PM 2.5 (microgram/m3)
NO_DATA
Root Mean Square Error
Correlation Coefficient
PM 2.5 Correlation Coefficient
Excluded dust event: AUGUST 27-30

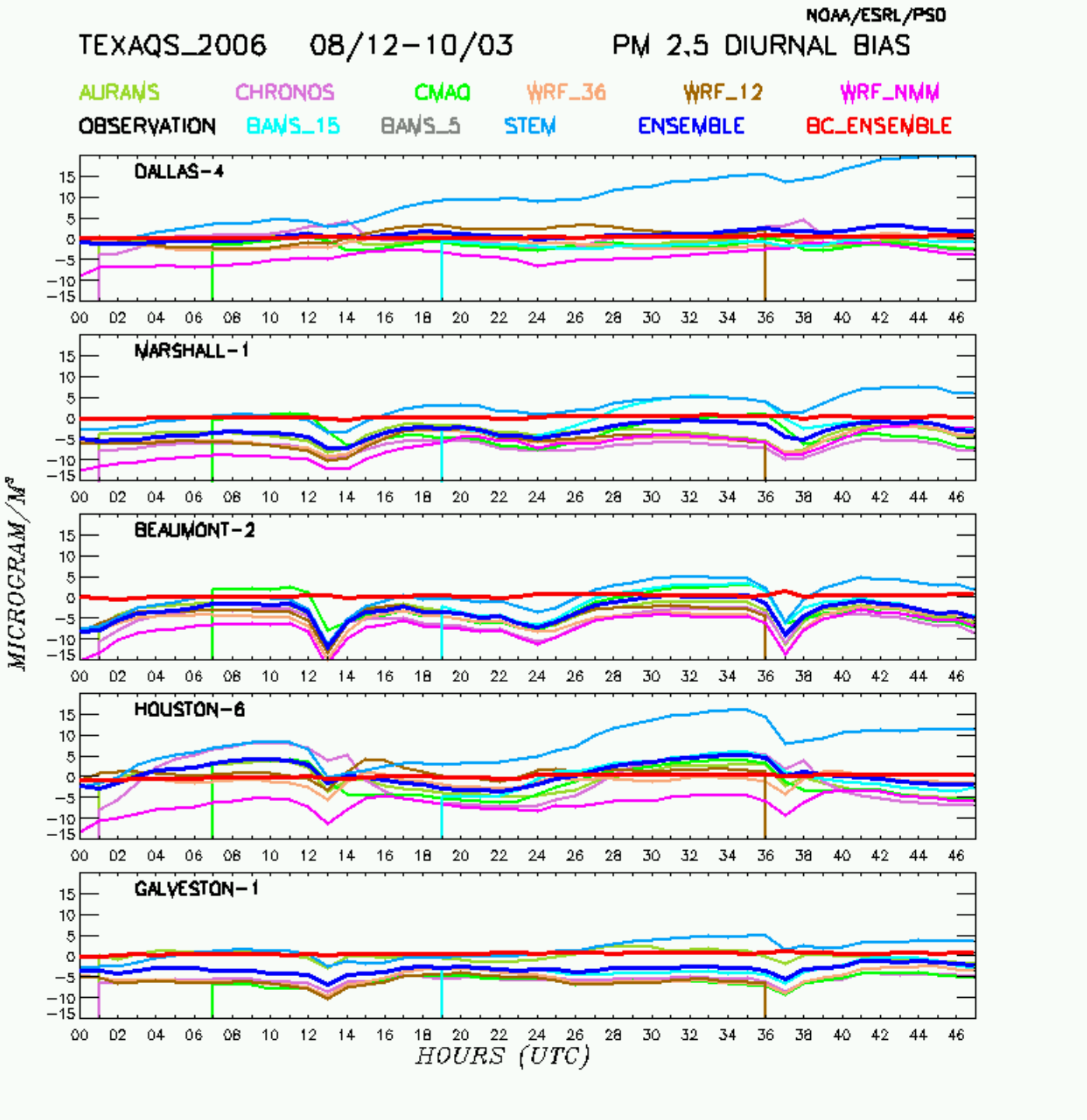

NOAA/ESRL/PSD Surface Chemistry
TEXAQS_2006
OZONE DATA
DNT-DALLAS
KFM-DALLAS
MID-DALLAS
HIN-DALLAS
KNK-MARSHALL
HAM-BEAUMONT
MVL-BEAUMONT
ALD-HOUSTON
CHV-HOUSTON
DPK-HOUSTON
SBR-HOUSTON
CNR-HOUSTON
CLN-HOUSTON
GAL-GALVESTON
PPBV
200
150
100
50
0
224
234
244
254
264
274
277
08/12/2006
JULIAN DAYS
10/03/2006


NOAA/ESRL/PSD Surface Chemistry
TEXAQS_2006
PM 2.5 DATA
DNT-DALLAS
KFM-DALLAS
MID-DALLAS
HIN-DALLAS
KNK-MARSHALL
HAM-BEAUMONT
MWL-BEAUMONT
ALD-HOUSTON
CHV-HOUSTON
DPK-HOUSTON
SBR-HOUSTON
CNR-HOUSTON
CLN-HOUSTON
GAL-GALVESTON
microgram/m³
150
100
50
0
224
234
244
254
264
274 277
08/12/2006
JULIAN DAYS
10/03/2006

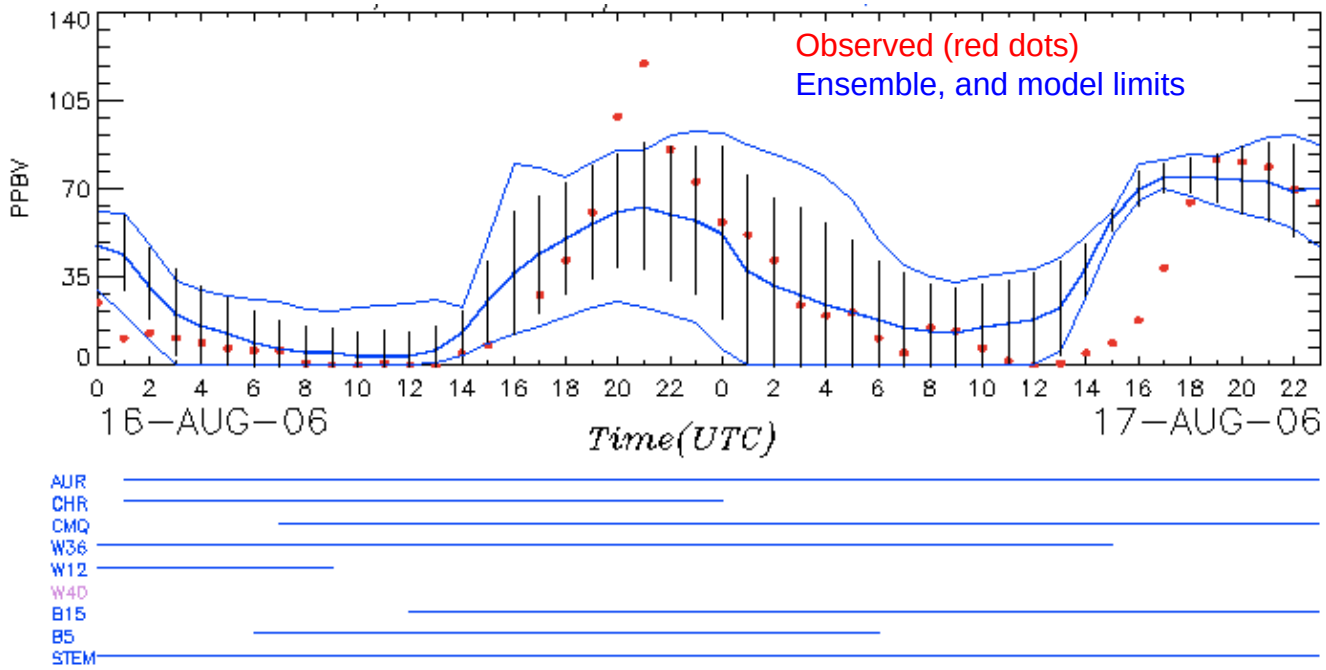

NOAA/ESRL/PSD Surface Chemistry
TEXAQS_2006 8_HOUR_MAX OZONE DATA
DNT-DALLAS
KFM-DALLAS
MID-DALLAS
HIN-DALLAS
KNK-MARSHALL
HAM-BEAUMONT
MVL-BEAUMONT
ALD-HOUSTON
CHV-HOUSTON
DPK-HOUSTON
SBR-HOUSTON
CNR-HOUSTON
CLN-HOUSTON
GAL-GALVESTON
PPBV
224
234
244
254
264
274 276
08/12/2006
JULIAN DAYS
10/03/2006


NOAA/ESRL/PSD Surface Chemistry
TEXAQS_2006 24_HOUR_AVRG PM 2.5 DATA
DNT-DALLAS
KFM-DALLAS
MID-DALLAS
HIN-DALLAS
KNK-MARSHALL
HAM-BEAUMONT
MVL-BEAUMONT
ALD-HOUSTON
CHV-HOUSTON
DPK-HOUSTON
SBR-HOUSTON
CNR-HOUSTON
CLN-HOUSTON
GAL-GALVESTON
microgram/m³
224
234
244
254
264
274 276
08/12/2006
JULIAN DAYS
10/03/2006


NOAA/ESRL/PSD
TEXAQS_2006 08/12-10/03 OZONE DIURNAL BIAS
AURAMS
CHRONOS
CMAQ
WRF_36
WRF_12
WRF_NMM
OBSERVATION
BAMS_15
BAMS_5
STEM
ENSEMBLE
BC_ENSEMBLE
DALLAS-4
MARSHALL-1
BEAUMONT-2
HOUSTON-6
GALVESTON-1
PPBV
HOURS (UTC)


NOAA/ESRL/PSD
TEXAQS_2006 08/12-10/03
PM 2.5 DIURNAL BIAS
AURAMS
CHRONOS
CMAQ
WRF_36
WRF_12
WRF_NMM
OBSERVATION
BAMS_15
BAMS_5
STEM
ENSEMBLE
BC_ENSEMBLE
DALLAS-4
MARSHALL-1
BEAUMONT-2
HOUSTON-6
GALVESTON-1
MICROGRAM/M³
HOURS (UTC)

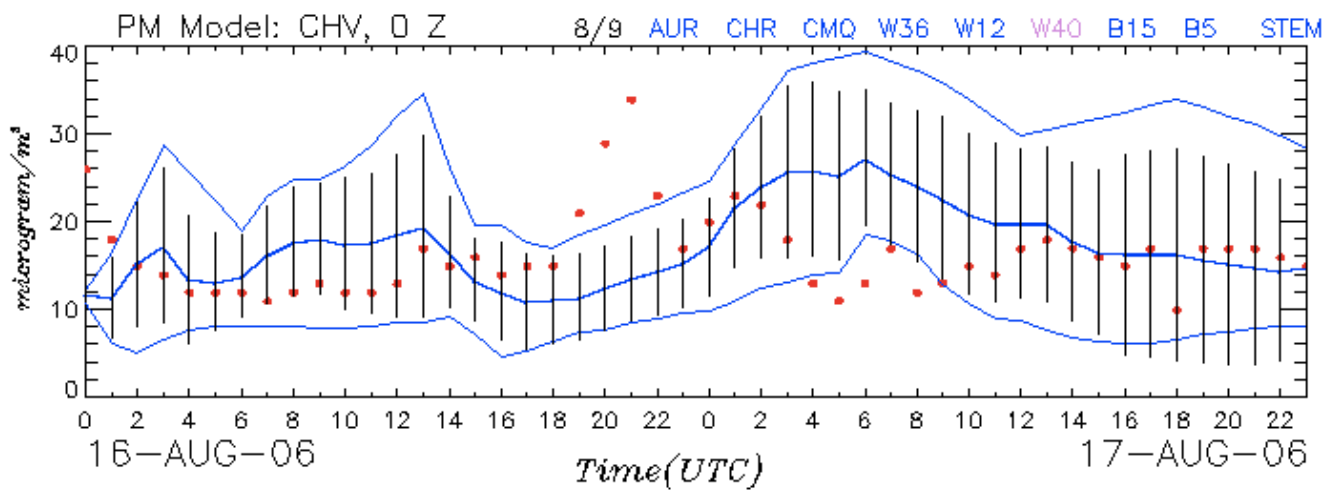
Ensemble Forecasts: Channelview, TX - O_3 and PM2.5 event of 8/16/06



O_3 Ensemble:

None of 7 models predict observed peak

< Models contributing
< to ensemble

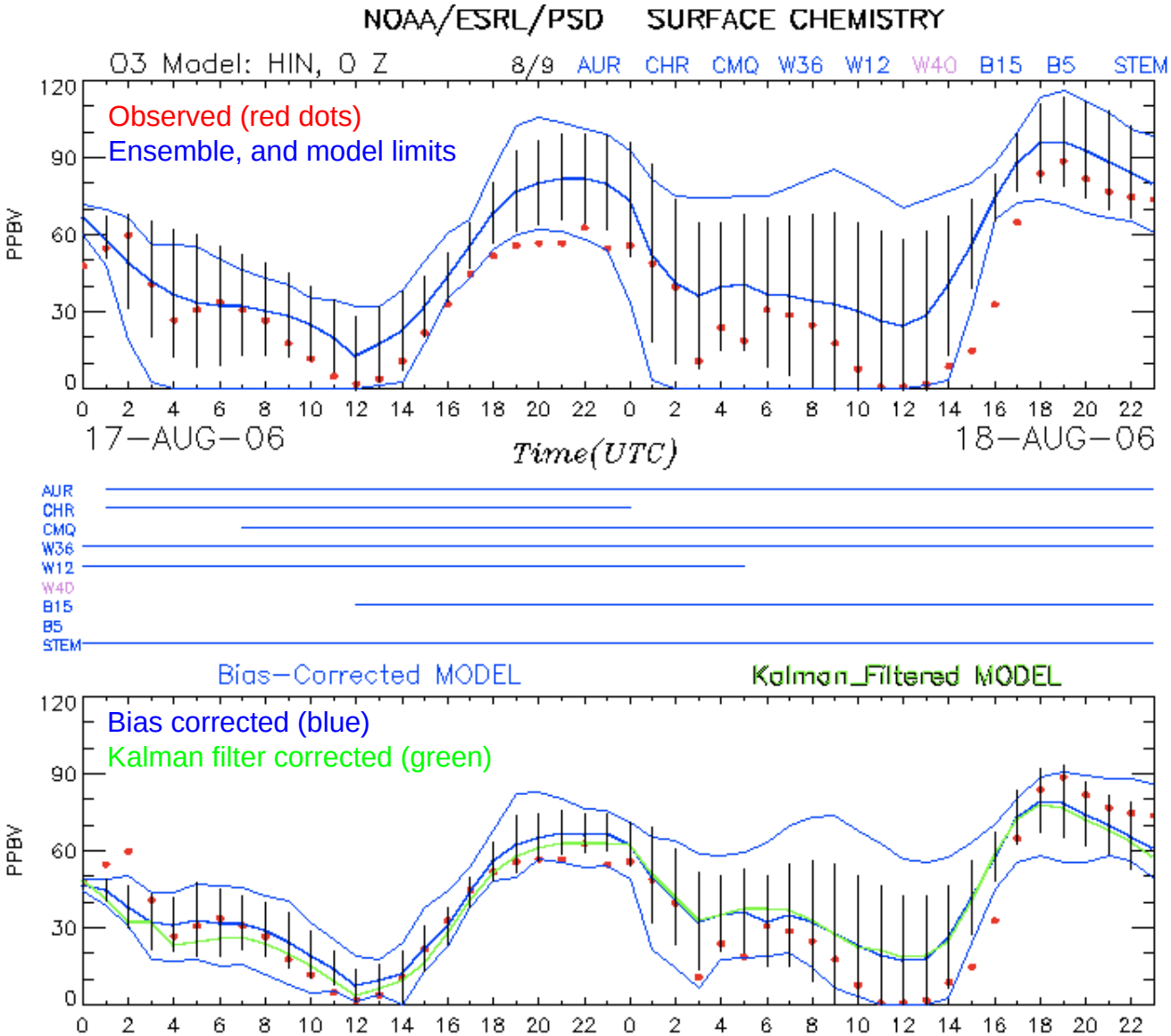


PM2.5 Ensemble:

First real-time PM2.5 ensemble forecast

No mid-day peak correlated with O_3

Dallas TX, Hinton Street site, 8/17/06



O_3 ensemble sometimes has bias

Bias corrected ensemble refines forecast further

No advantage of Kalman filter over simple bias correction technique