Evaluation of Prognostic and Diagnostic Meteorological Data

Why Is An Evaluation Necessary?

- The BART process taught us some valuable lessons:
  - The consultant has no familiarity with the data set, but typically obtains whatever is available. When asked for performance evaluation information, they were unfamiliar with where to obtain such information.
  - The consultant provided no justification regarding the suitability of the prognostic data set for the particular location and time period for the modeling.
  - No guidance or tools available to direct states and consultants.
  - The consultant did not perform any level of quality assurance of the CALMET datasets generated. MM5 fields from the RPO's were obtained, processed, and observations were incorporated into CALMET, but no inspection of the CALMET fields were made.
- The permit modeling community is not familiar with numerical meteorological products and how they are used.
- It is not well understood how CALMET uses prognostic data in conjunction with surface observations to create a final diagnostic windfield. Is CALMET doing what it should?

Review of Regulatory Requirements Governing Use of Prognostic Data

- GAQM 8.3.1.2(d) – A minimum of three years of prognostic model data is required.
- GAQM 8.3.1.2(d) - Mesoscale meteorological fields should be used in conjunction with NWS or comparable observations within and near the modeling domain.
- Acceptability of prognostic data can be established through demonstrations of statistical comparisons with observations of winds aloft and surface locations (GAQM – 8.3(d))
- Acceptability of prognostic data is contingent upon approval from appropriate reviewing authority

Meteorological Model Performance Evaluation

- GAQM Section 8.3(d) requires statistical comparison of prognostic meteorological fields with surface and upper air fields observations.
  - Question: Who determines what is appropriate?
  - Question: What statistical benchmarks are used to determine what is appropriate?
- Formal guidance should be developed which helps answer these and other questions.

Evaluation Paradigm

- Visual and statistical performance evaluation of MM-FDDA and CALMET datasets are essential.
- Performance evaluation of input data set is necessary ***before*** it is processed for and input into CALMET. Only then will you be able to isolate and identify any performance issues of the input data set. Once blended with data in CALMET and adjusted for terrain and radiation effects, it is not possible to separate all errors due to these adjustments.

Performance Evaluation Tools – Conceptual Framework

- CMET2NETCDF – software tool developed by US Forest Service for BlueSky system, updated and maintained for Versions 5.53 and above. Converts CALMET fields to IOAPI format for direct visualization in PAVE (Linux).
- CALVIS5D – software tool originally developed by Mike Barna (University of Washington/NPS), updated and maintained for Versions 5.53 and above. Converts CALMET fields to VIS5D format for direct 3D visualization in Vis5D (Linux).
- CALDESK – Windows software tool developed by Dr. Luis Matamala (Enviromodeling, LTD) which allows for easy 2D visualization of CALMET binaries without another format (Windows).
- CALMETSTAT – statistical evaluation tool based upon Environ's METSTAT tool for MM5. Compares CALMET binaries to observations and generates statistical results of performance (Windows/Linux).

Statistical Benchmarks

- Benchmarks for use of prognostic meteorological data were developed for the TCEQ in 2001 by ENVIRON and have been adopted by meteorological modelers in the air quality community as one set of “de facto” standards.
  - Standards were based upon review of performance evaluations of numerous MM5 and RAMS over the last decade or so.
  - Not necessarily designed to provide a passing or failing grade, but is designed to put modeling results into context within other air quality studies and also identify any systemic issues which may exist with respect to the prognostic model application currently under review.
- Reference document: ***Enhanced Meteorological Modeling and Performance Evaluation for Two Texas Ozone Episodes (ENVIRON 2001)***

Benchmark Statistics Used for MM5 Analyses

- Wind Speed Total RMSE: 2.0 m/s
- Wind Speed IOA: 0.6
- Wind Direction Gross Error: 30 degrees
- Temperature Bias: Temperature Bias: ±0.5 K
- Temperature Gross Error: 2.0 K
- Temperature IOA: 0.8
- Humidity Bias: ± 1.0 g/kg
- Humidity Gross Error: 2 g/kg
- Humidity IOA: 0.6

Evaluation Approach & Philosophy

- Evaluate MM-FDDA Dataset prior to extraction and processing in CALMET.
  - This will require the submittal of the raw MM-FDDA dataset for evaluation if evaluation is not performed in advance.
  - If your MM-FDDA dataset is not acceptable, do not use in CALMET.
- Evaluate CALMET using statistical package such as CALMETSTAT.
- CALMET should perform, at a minimum, as well as input MM-FDDA dataset. The theory is that using CALMET in a hybrid mode at a higher resolution, we should be enhancing the results from the coarser prognostic meteorological dataset.
- CALMET specific performance measures can be developed once a sufficient database is established.
- Visualization of CALMET windfields…do the wind fields pass the laugh test?

Evaluation Philosophy Cont'd

- Acceptance criteria for meteorological products to be used in near-field models may have significant difference in comparison to CALPUFF in a LRT analysis.
  - Near-field models are "reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area."
  - LRT analyses calculate concentrations at specified locations in space, thus is more susceptible to errors in input meteorological fields.
- LRT analyses require more accurate windfields by the nature of the application.

CALPUFF LRT (BART/PSD Class I) Normal Options Selected

```
INPUT GROUP: 4 -- Map Projection and Grid control parameters
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SAMPLING Grid (GRIDDED RECEPTORS):

    The lower left (LL) corner of the sampling grid is at grid point
    (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
    sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
    The sampling grid must be identical to or a subset of the computational
    grid.  It may be a nested grid inside the computational grid.
    The grid spacing of the sampling grid is DGRIDKM/MESHDN.

      Logical flag indicating if gridded
      receptors are used (LSAMP)        Default: T     ! LSAMP = F !
      (T=yes, F=no)

      X index of LL corner (IBSAMP)      No default     ! IBSAMP =  1   !
       (IBCOMP <= IBSAMP <= IECOMP)

      Y index of LL corner (JBSAMP)      No default     ! JBSAMP =  1   !
       (JBCOMP <= JBSAMP <= JECOMP)


      X index of UR corner (IESAMP)      No default     ! IESAMP =  197   !
       (IBCOMP <= IESAMP <= IECOMP)

      Y index of UR corner (JESAMP)      No default     ! JESAMP =  225   !
       (JBCOMP <= JESAMP <= JECOMP)


     Nesting factor of the sampling
      grid (MESHDN)                  Default: 1     ! MESHDN =  1  !
      (MESHDN is an integer >= 1)

!END!
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Subgroup (17a)
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    Number of non-gridded receptors (NREC)  No default  !  NREC =  59 !

!END!

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Subgroup (17b)
---------------
                                    a
          NON-GRIDDED (DISCRETE) RECEPTOR DATA
          ----------------------------------

                X          Y        Ground       Height   b
Receptor      Coordinate  Coordinate   Elevation   Above Ground
 No.            (km)        (km)         (m)          (m)
--------      ----------  ----------   ---------   ------------
1   ! X = 53.583, 57.336,   454,        0 ! !END!
2   ! X = 54.344, 57.341,   486,        0 ! !END!
3   ! X = 55.105, 57.346,   487,        0 ! !END!
4   ! X = 55.866, 57.351,   478,        0 ! !END!
5   ! X = 56.627, 57.356,   518,        0 ! !END!
6   ! X = 57.388, 57.361,   518,        0 ! !END!
7   ! X = 52.055, 58.253,   510,        0 ! !END!
8   ! X = 52.816, 58.258,   493,        0 ! !END!
9   ! X = 53.577, 58.262,   488,        0 ! !END!
10   ! X = 54.338, 58.267,   615,        0 ! !END!
11   ! X = 55.099, 58.272,   522,        0 ! !END!
12   ! X = 55.860, 58.277,   494,        0 ! !END!
13   ! X = 56.621, 58.282,   609,        0 ! !END!
14   ! X = 57.382, 58.287,   518,        0 ! !END!
15   ! X = 51.288, 59.174,   487,        0 ! !END!
16   ! X = 52.049, 59.179,   518,        0 ! !END!
17   ! X = 52.810, 59.184,   609,        0 ! !END!
-------------------------------------------------------------------
```
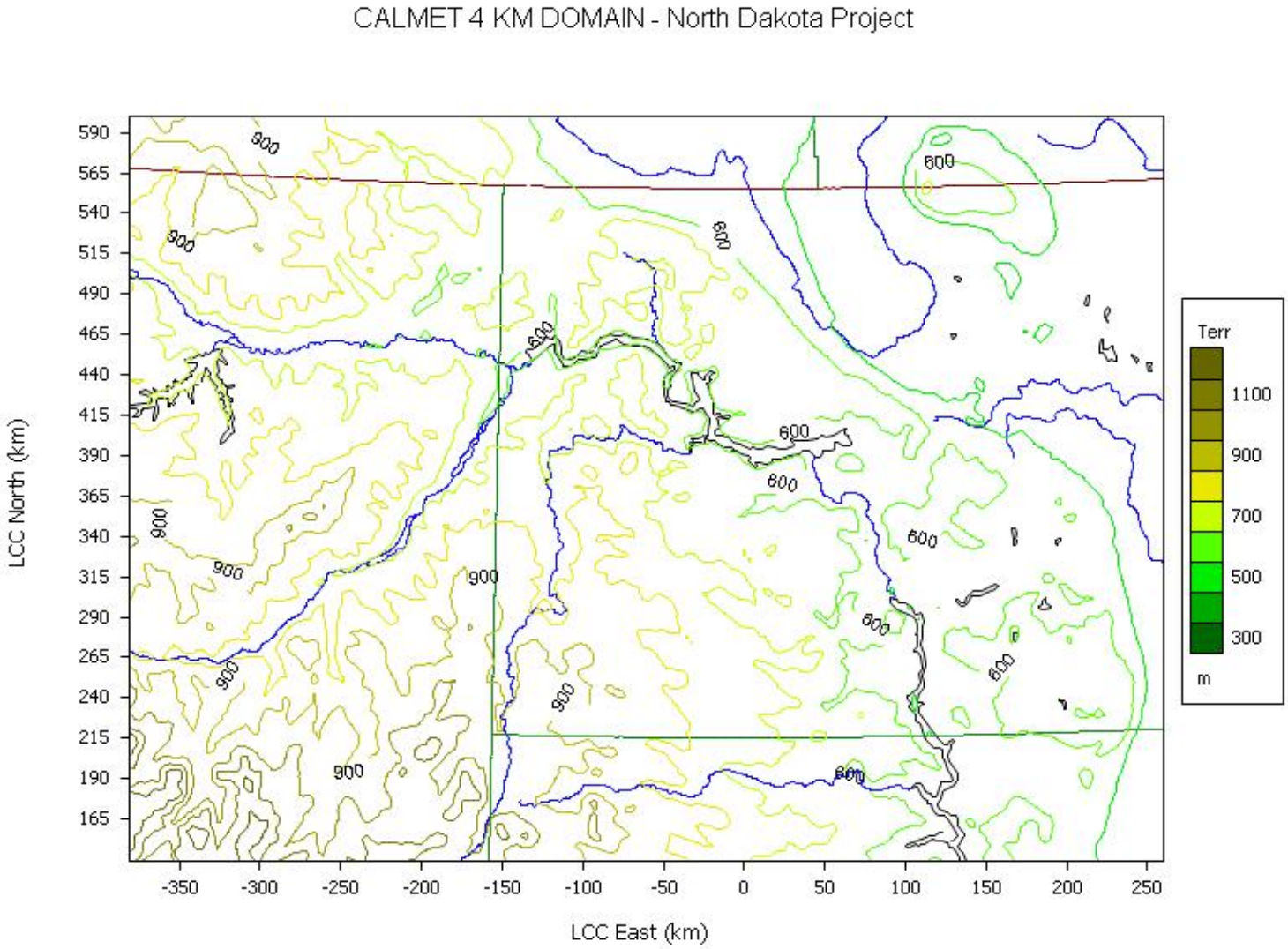
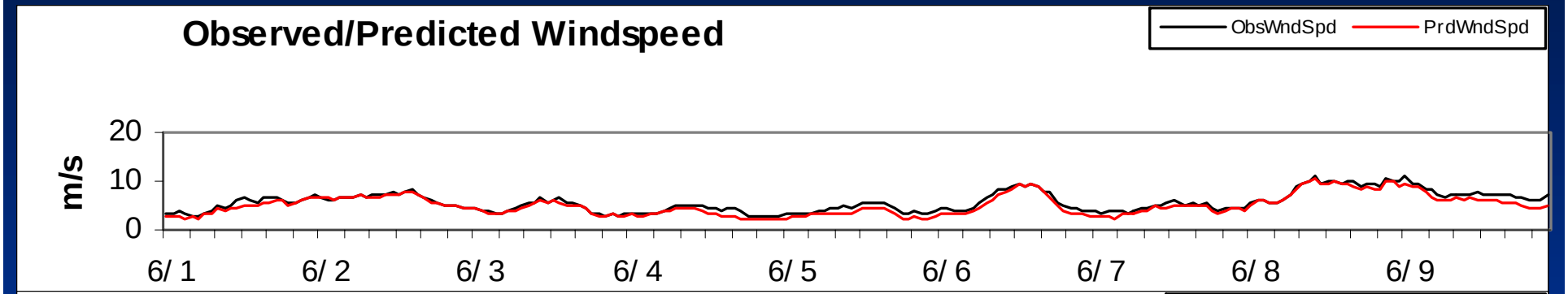
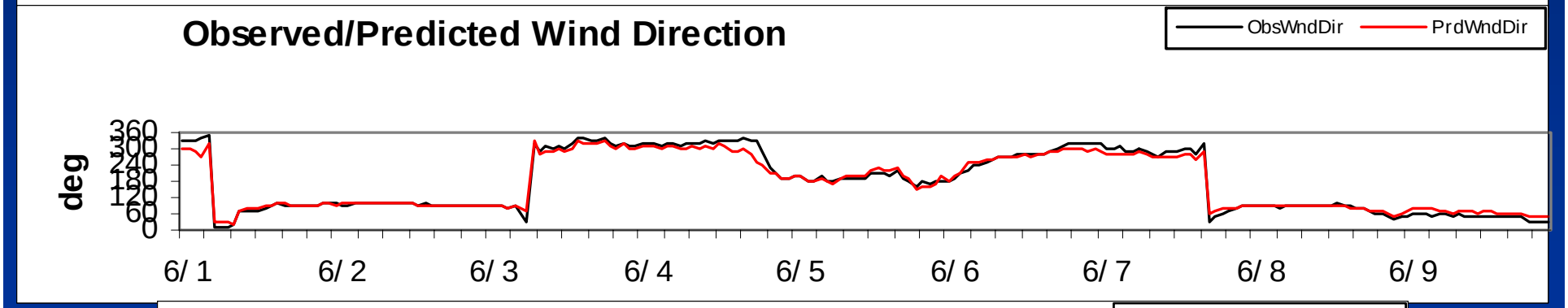
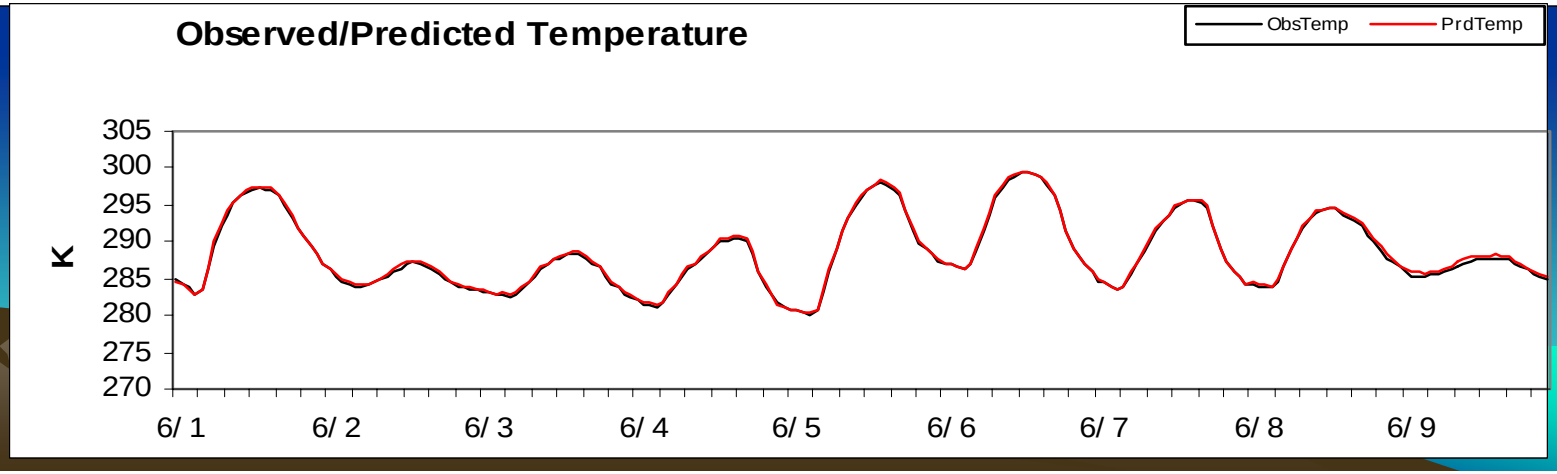

2002 RUC Evaluation – Simple Terrain



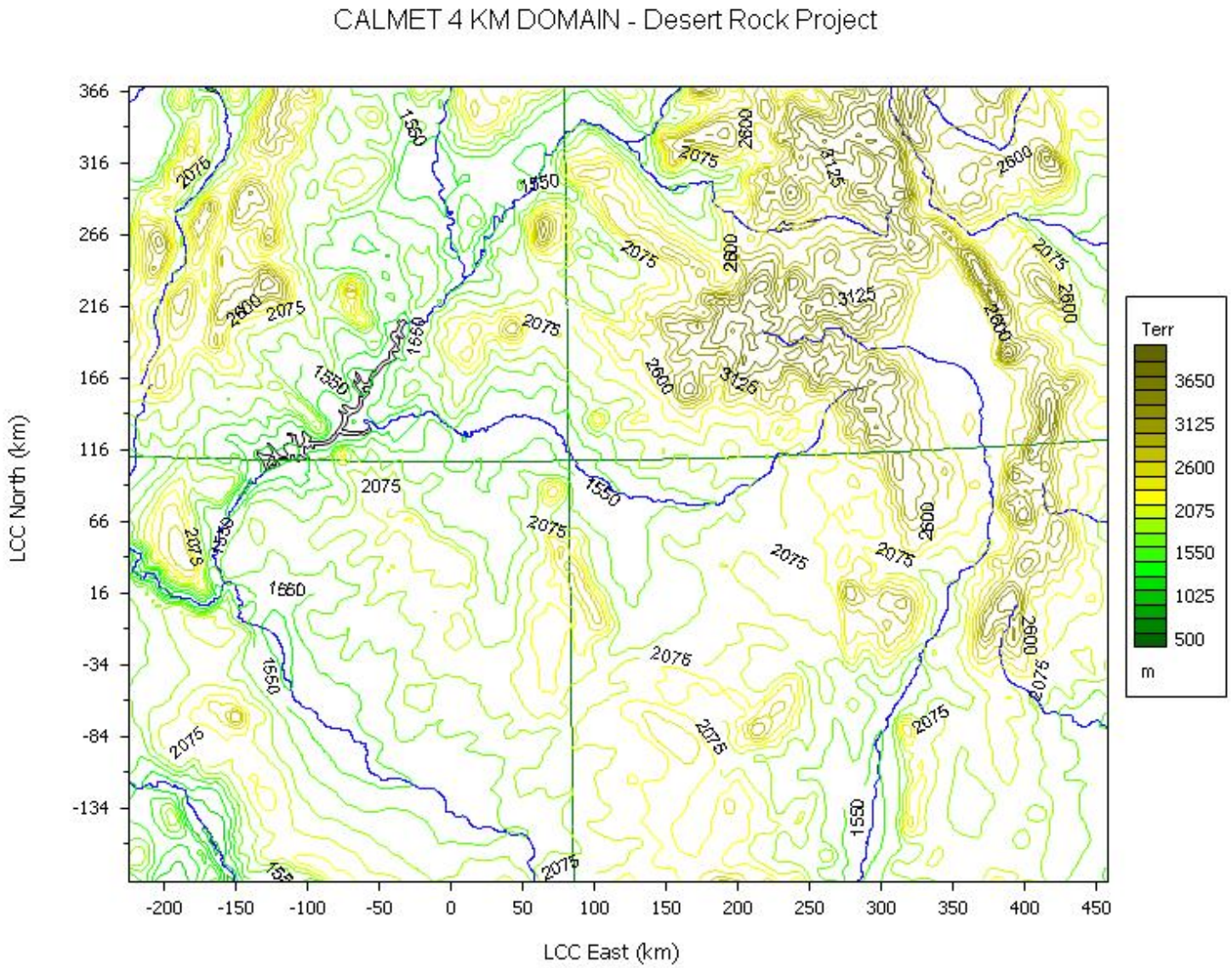
ND CALMET NOOBS W/RUC2



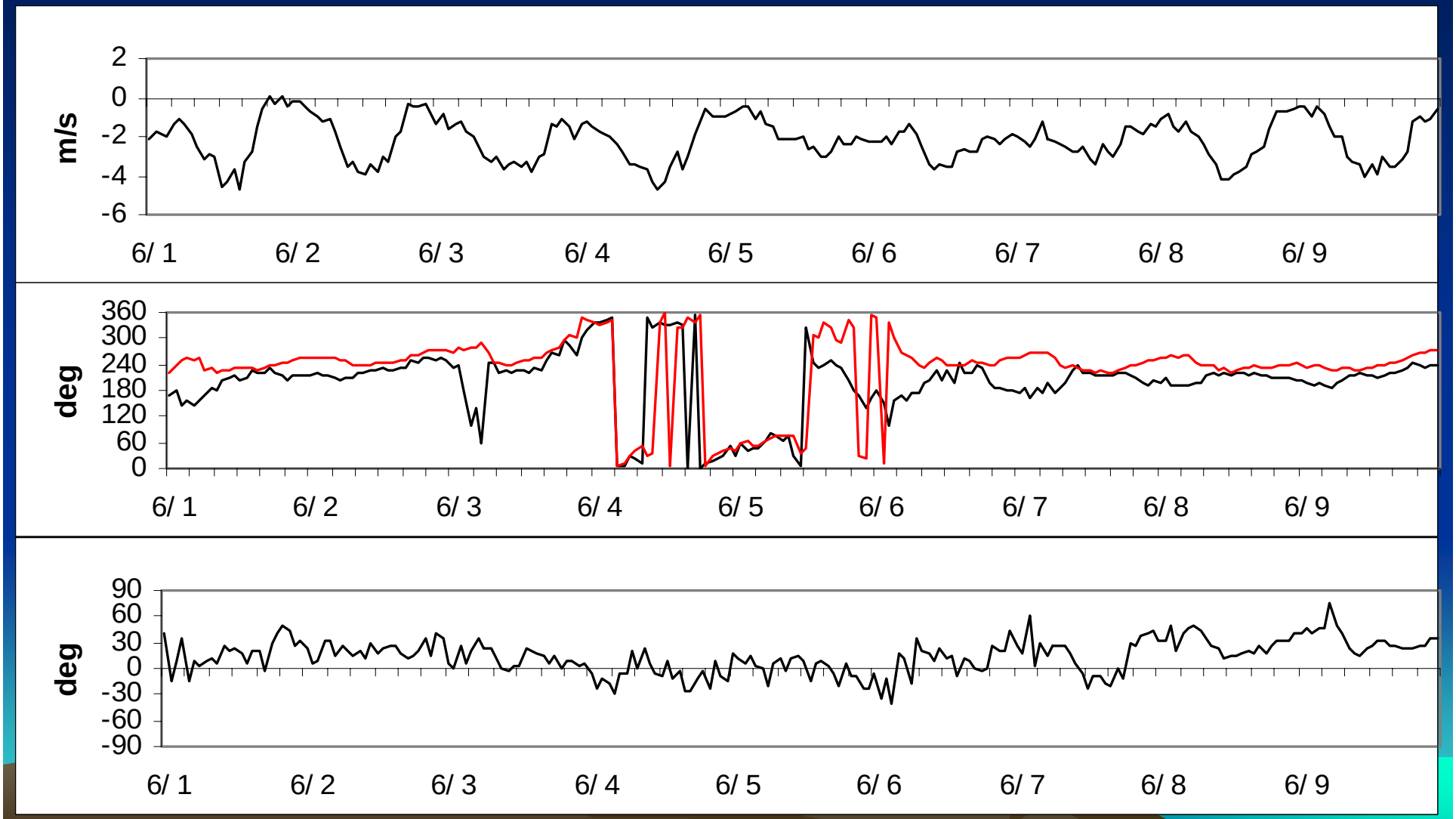
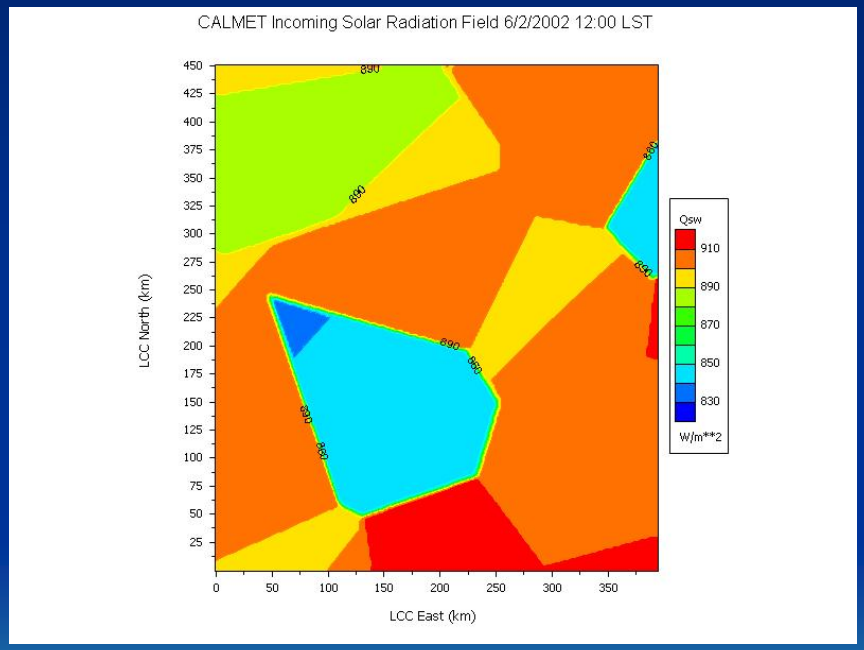
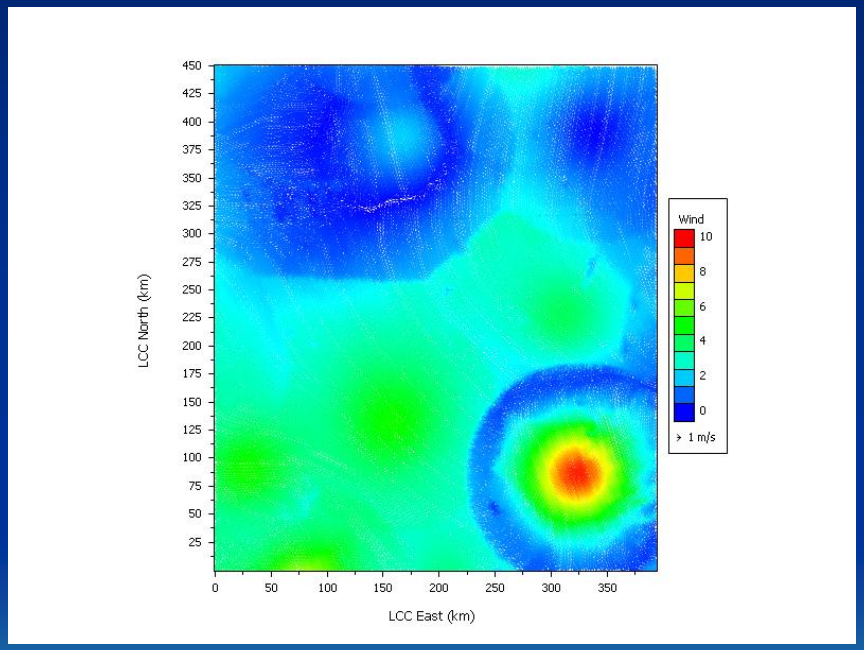




2002 RUC Evaluation – Complex Terrain



Wind Speed Bias/WD Trace/WD Bias – Complex Terrain



CALMET Visualization – Do I Really Want to Use This?!!?