

January 1st: Comparison of Met Tower Data and Simulation Data

NAU 3TIER Data, NAU MET TOWER Data,
and NREL 3TIER Data

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Wind Speed Data Sources

- Data was used from three sources:
 - **30m met tower data**. 30-m wind speed data from met towers that NAU owns. For more info or data, see http://wind.nau.edu/anemometer/index_ddmenu.shtml
 - **30m and 100m 3TIER NAU simulated wind speed data**. For the wind integration study that NAU conducted for Arizona Public Service in 2007, 3TIER performed a meso-scale simulation for two large regions of Arizona. The simulation was nominally for a 5-km grid, 10-minute resolution, 1996 through 2006 (though Aubrey Cliffs and Gray Mountain were at 1-km resolution). Study report: <http://wind.nau.edu/APSWindIntegrationsStudy.shtml>
 - **100m 3TEIR NREL simulated wind speed data (WWSIS)**.

Wind Power Data Sources

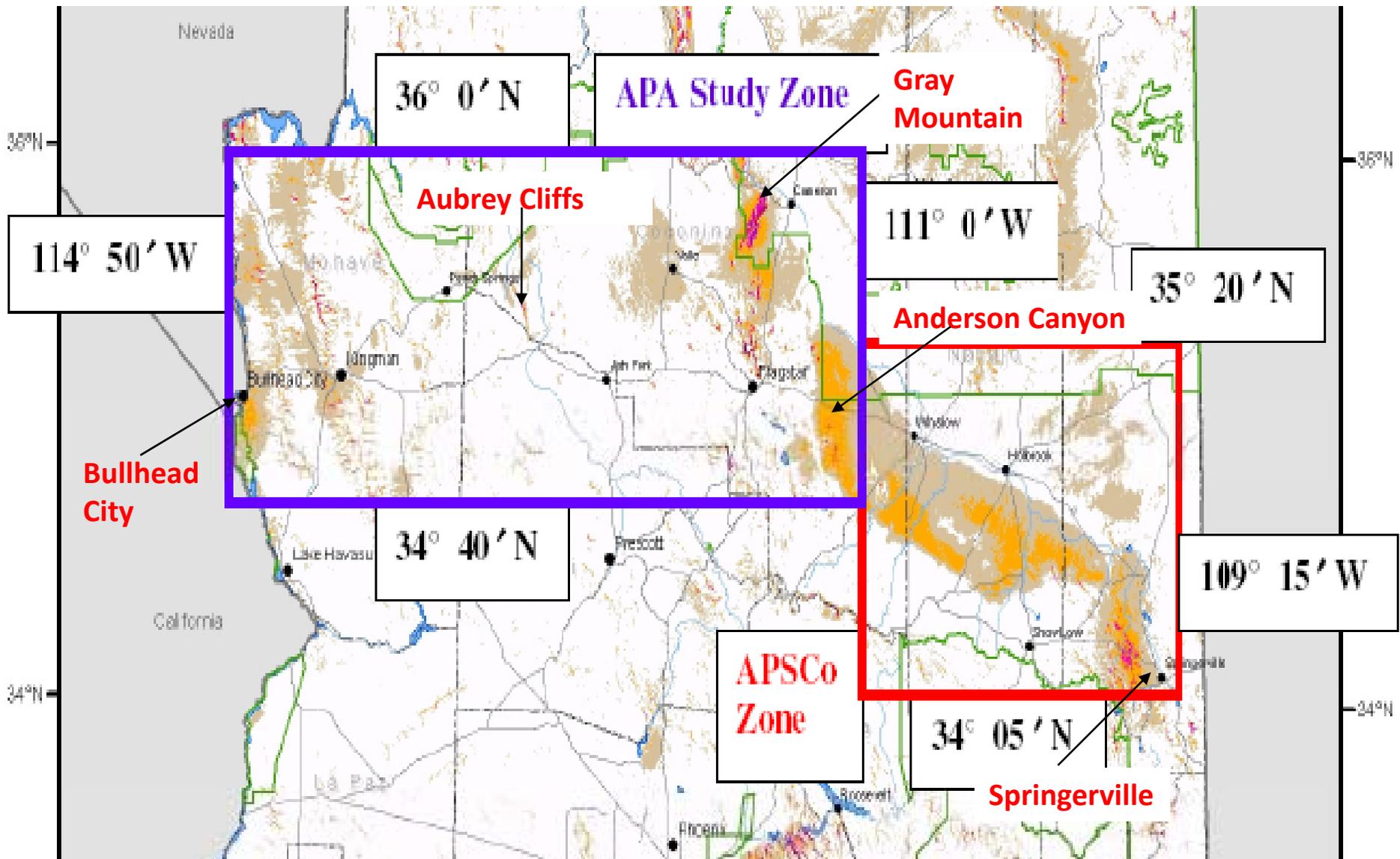
- Data was used from two sources:
 - **3TIER NAU simulated wind power data.**
 - 80-m hub height
 - GE 1.5sl turbines, 77-m rotor
 - 10 power plants simulated across AZ
 - Each power plant typically composed of Nine, 36-MW strings of wind turbines (24 1.5-MW turbines per string)
 - Power simulation conducted using 3TIER's SCORE method.
 - **100m 3TEIR NREL simulated wind speed data (WWSIS).**
 - 100-m hub height
 - Vestas V-90 3-MW turbines
 - 30,000 30-MW strings of turbines (10 3-MW turbines per string) modeled across the western US
 - Power simulation via 3TIER's SCORE-Lite method.

Comparison Locations

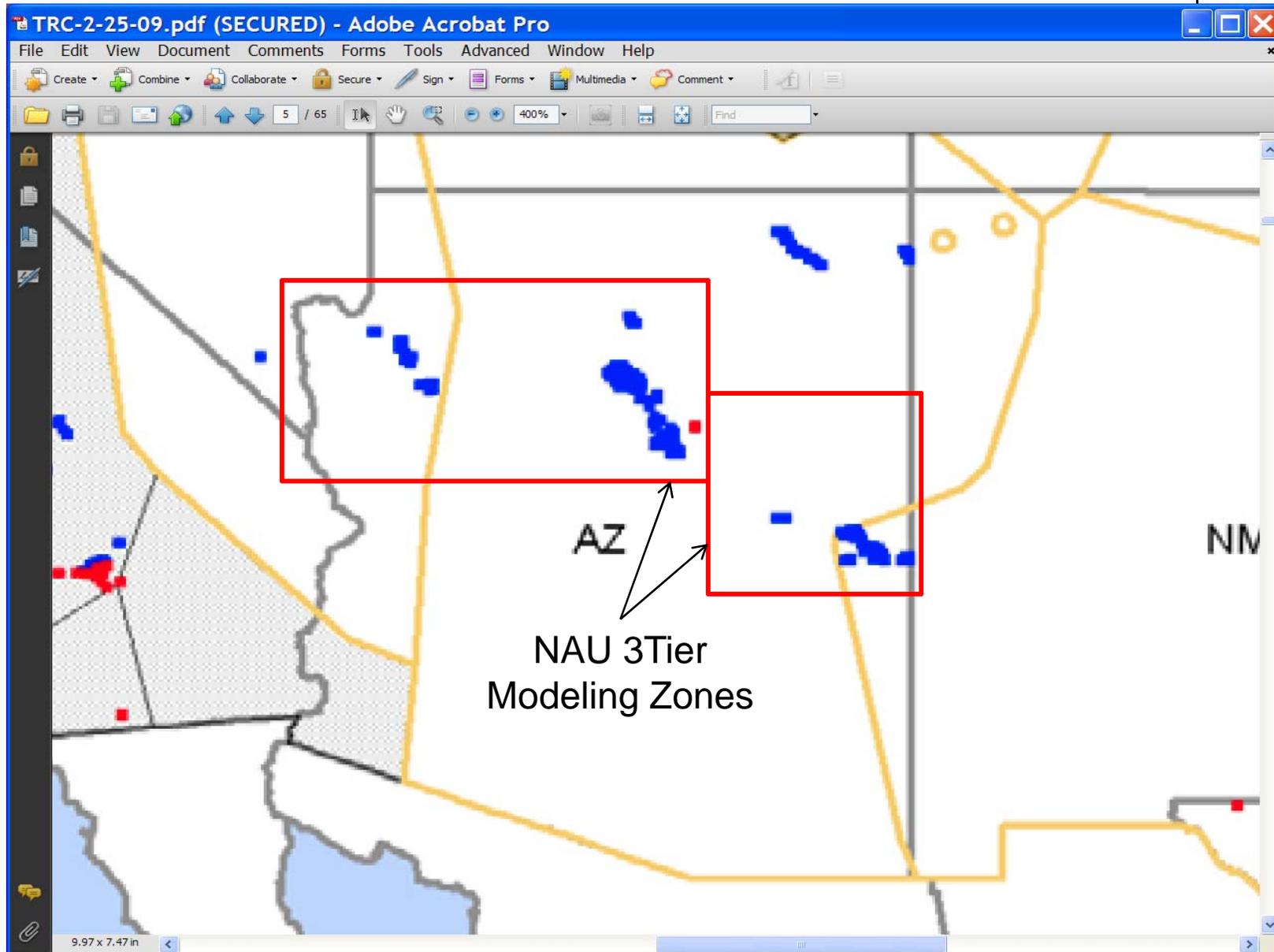
- Locations in Arizona (see following map):
 - Bullhead City, Aubrey Cliffs, Gray Mountain, Anderson Canyon, and Springerville
 - Met tower and simulation data available from all data sets at these locations (within a couple miles).
- Data compared:
 - Wind Speed: NAU Met Tower and wind speed data from the NAU 3TIER and NREL 3TIER simulations
 - Wind Power: Compared the two 3TIER simulations (note, there are no wind power plants in Arizona, therefore actual power data cannot be compared)

3Tier NAU Modeling Zones

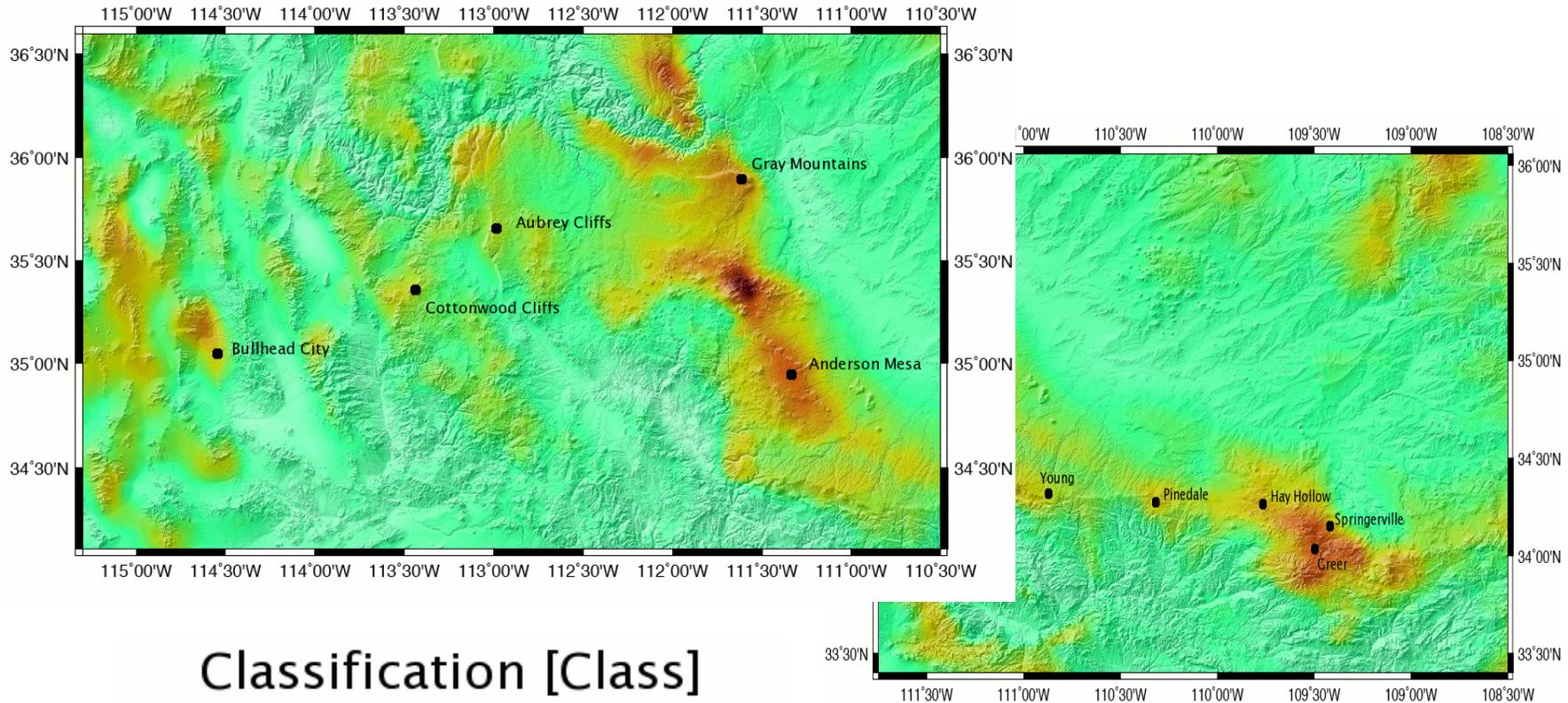
(Met tower/comparison locations in red)



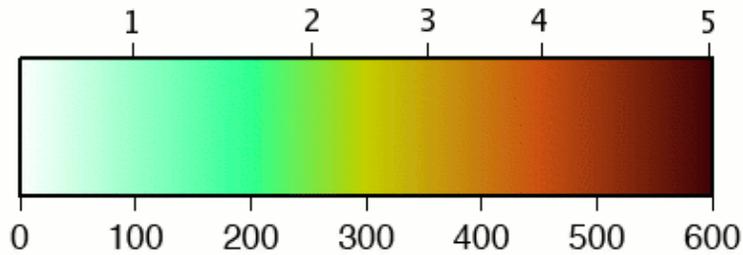
NREL 3TIER Power Plants



NAU 3TIER Wind Power Plant Locations



Classification [Class]



Wind Power Density [W/m^2]

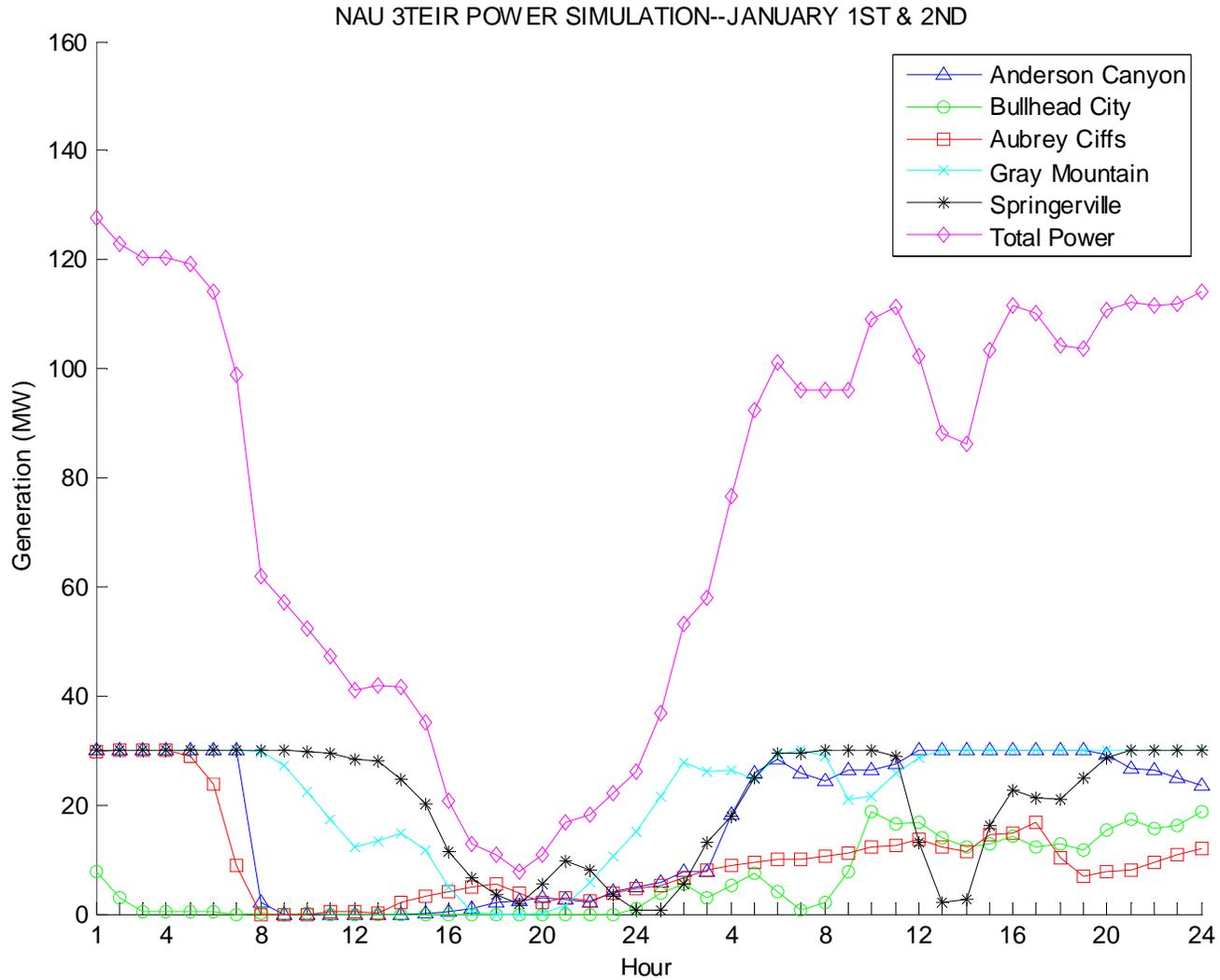
Power Simulation Plots for January 1, 2006

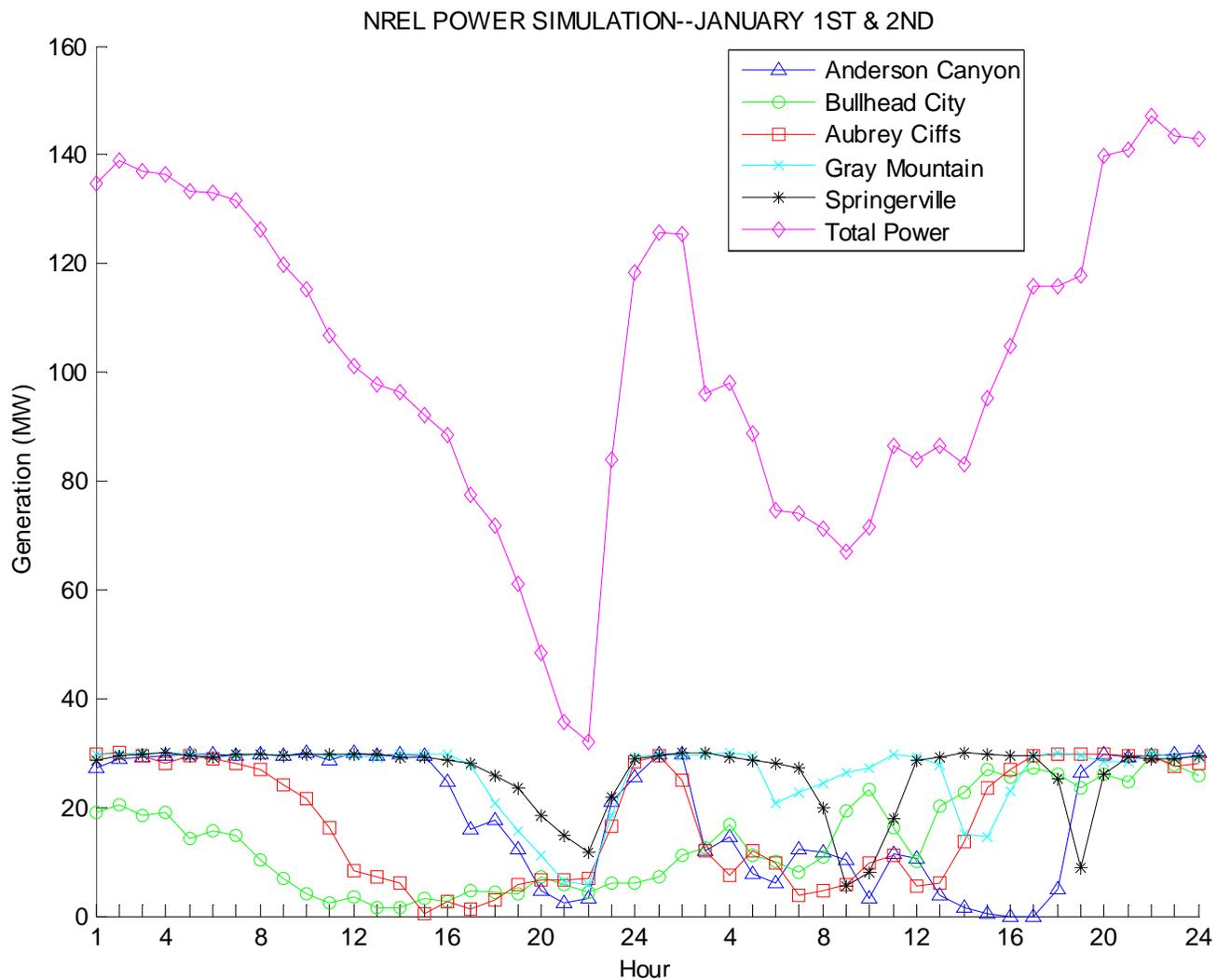
- Power data in Greenwich Mean Time (GMT) for both simulations (time is synchronized between the two simulations)
- 10-minute data was averaged every hour
- Plots:
 - NAU 3TIER power: MW vs. time, Jan 1-2, for each site
 - NREL 3TIER power: MW vs. time, Jan 1-2, for each site
 - Both NAU and NREL simulations: MW vs. time, Jan 1-2, (total power only... output of all sites combined)
 - NAU 3TIER power: MW vs. time, Dec 30 – Jan 3, for each site
 - NREL 3TIER power: MW vs. time, Dec 30 – Jan 3, for each site
 - Both NAU and NREL simulations: MW vs. time, Dec 30 – Jan 3, (total power only... output of all sites combined)

Notes on Power Comparisons

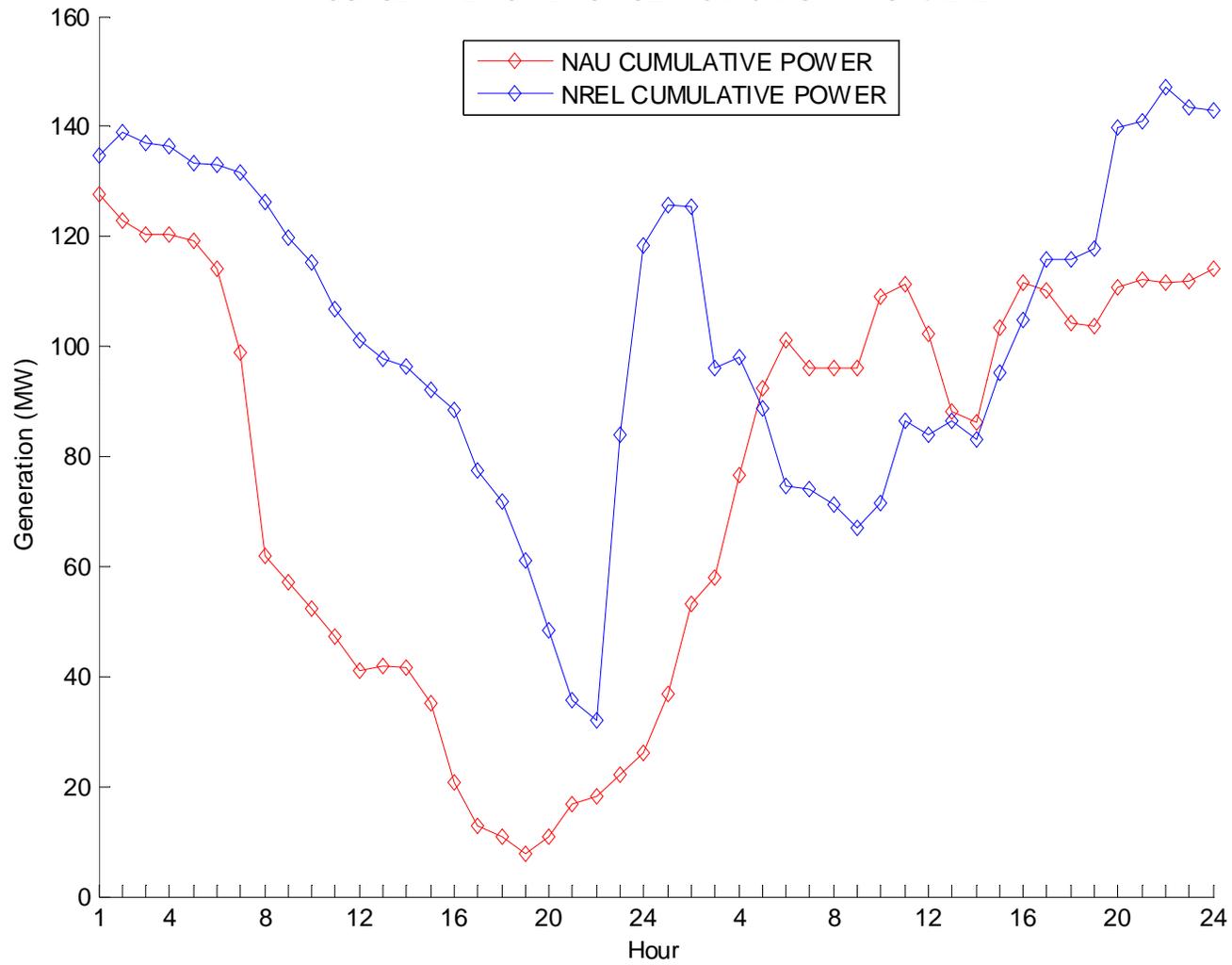
- The power output for one string of turbines from each simulation at each of the five sites were compared.
- The power output of one string of turbines was 30 MW for the NREL WWSIS simulation.
- The power output of one string of turbines at each site from the NAU power simulation was normalized to 30 MW, so that the plots will be directly comparable:
 - At Anderson Canyon, Aubrey Cliffs, Gray Mountain, and Springerville, one string of turbines output a max of 36 MW, therefore to match the NREL power simulation the power data was multiplied by a constant of $30/36=5/6$.
 - At Bullhead City, one string of turbines output a max of 39 MW, so the NAU power data was multiplied by $30/39=10/13$.
- NAU Power simulation data was shifted (+7) hours to GMT time. Looks better but might still be off one hour (will confirm later).

January 1-2 Plots

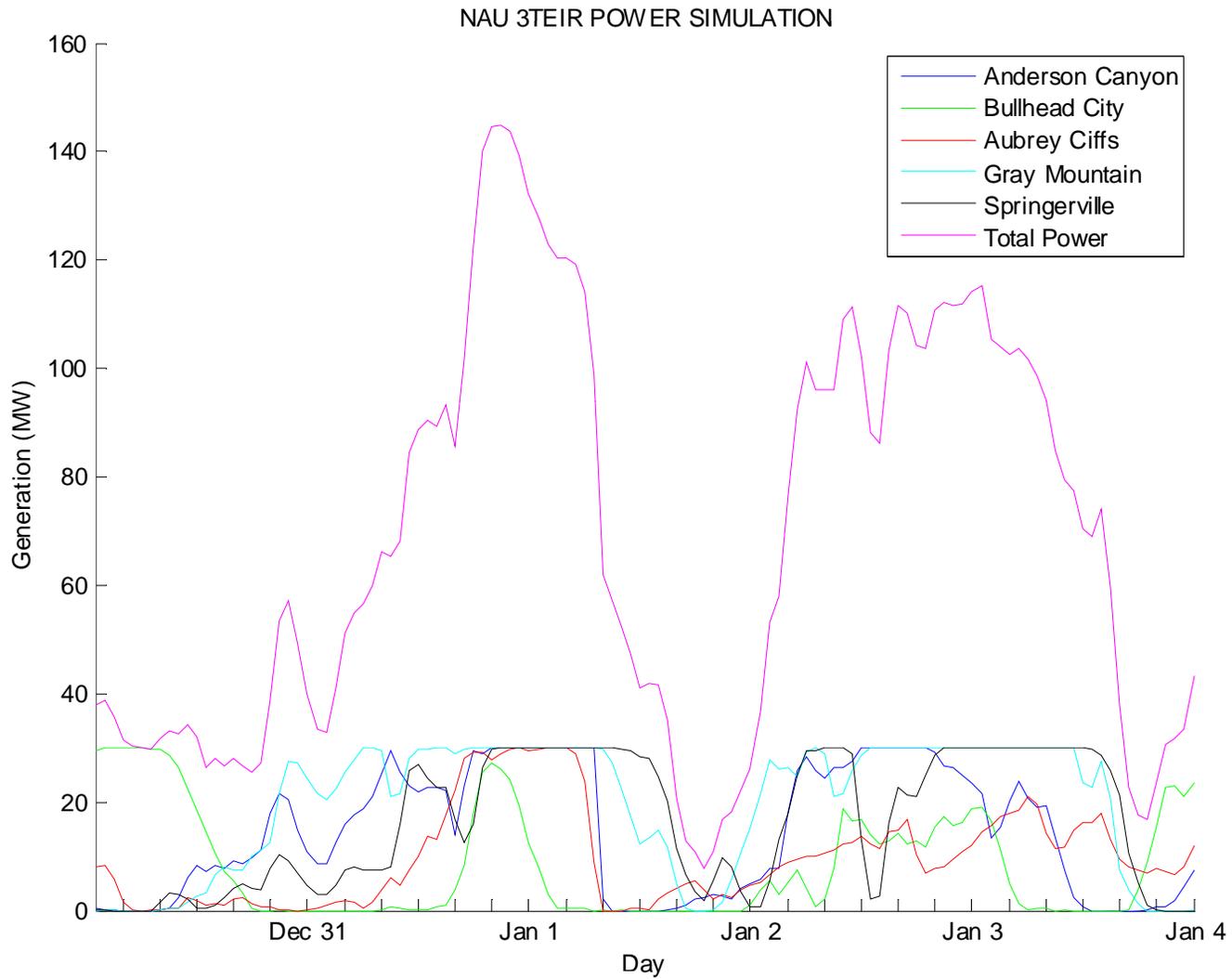


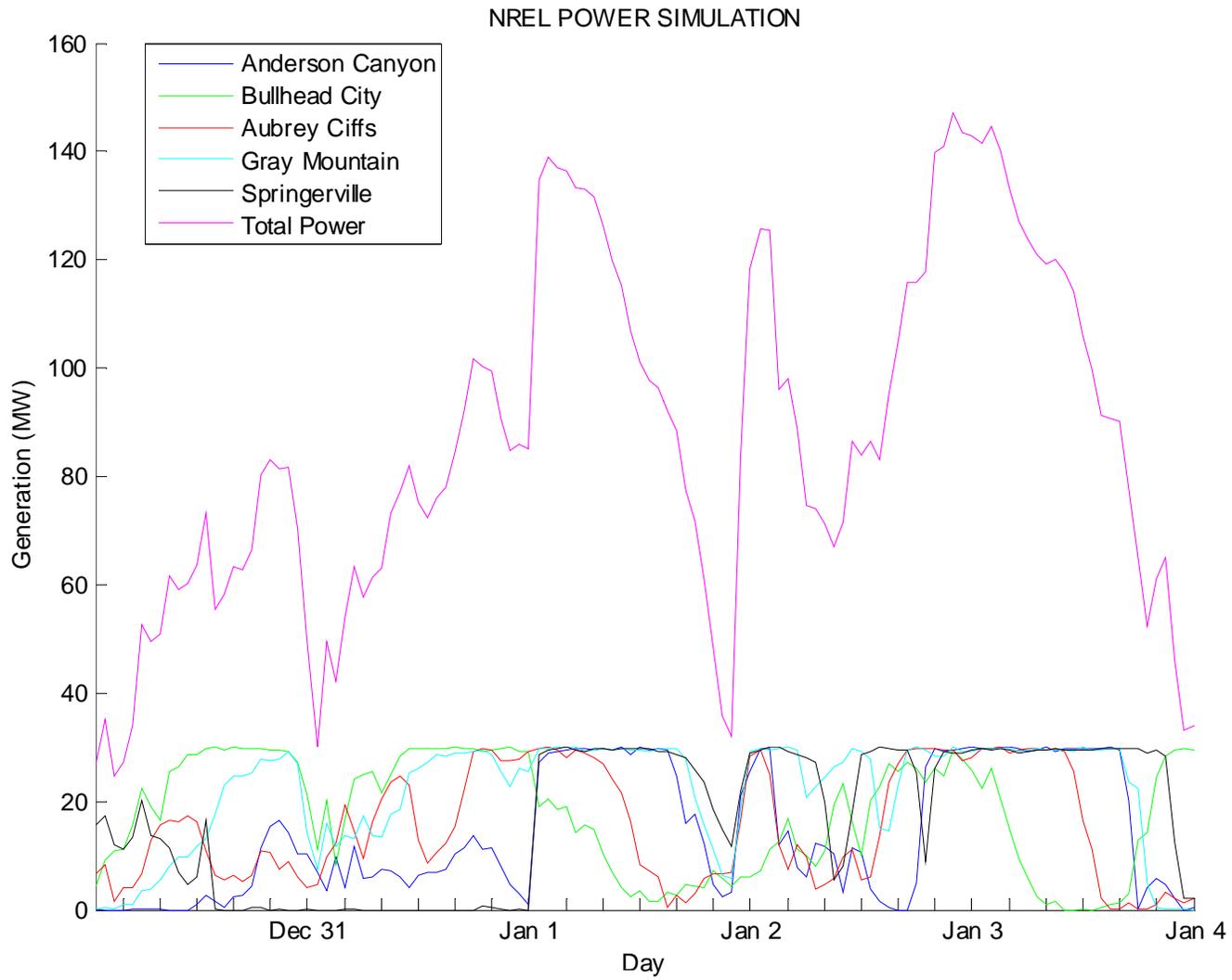


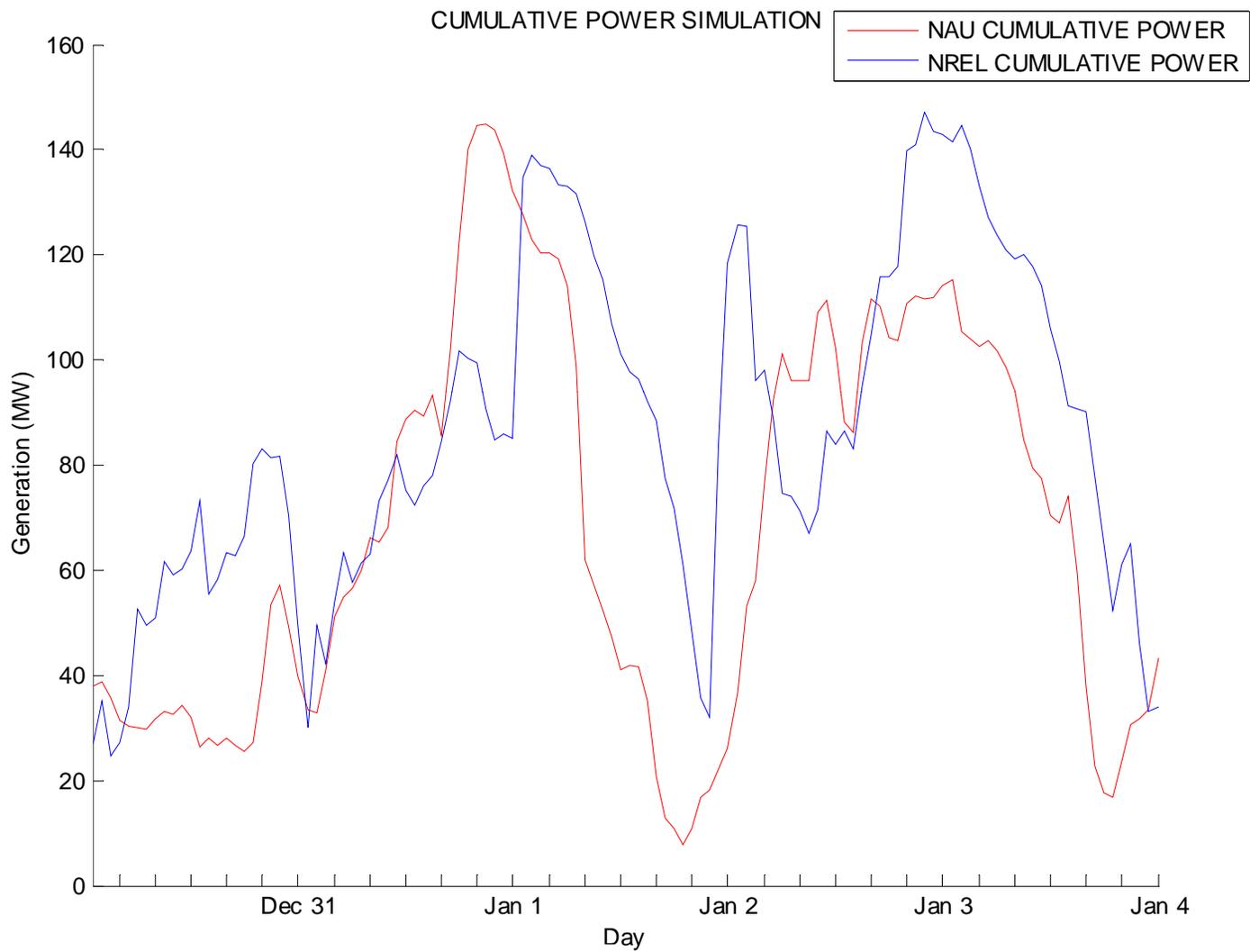
CUMULATIVE POWER SIMULATION--JANUARY 1ST & 2ND



5-day Plots



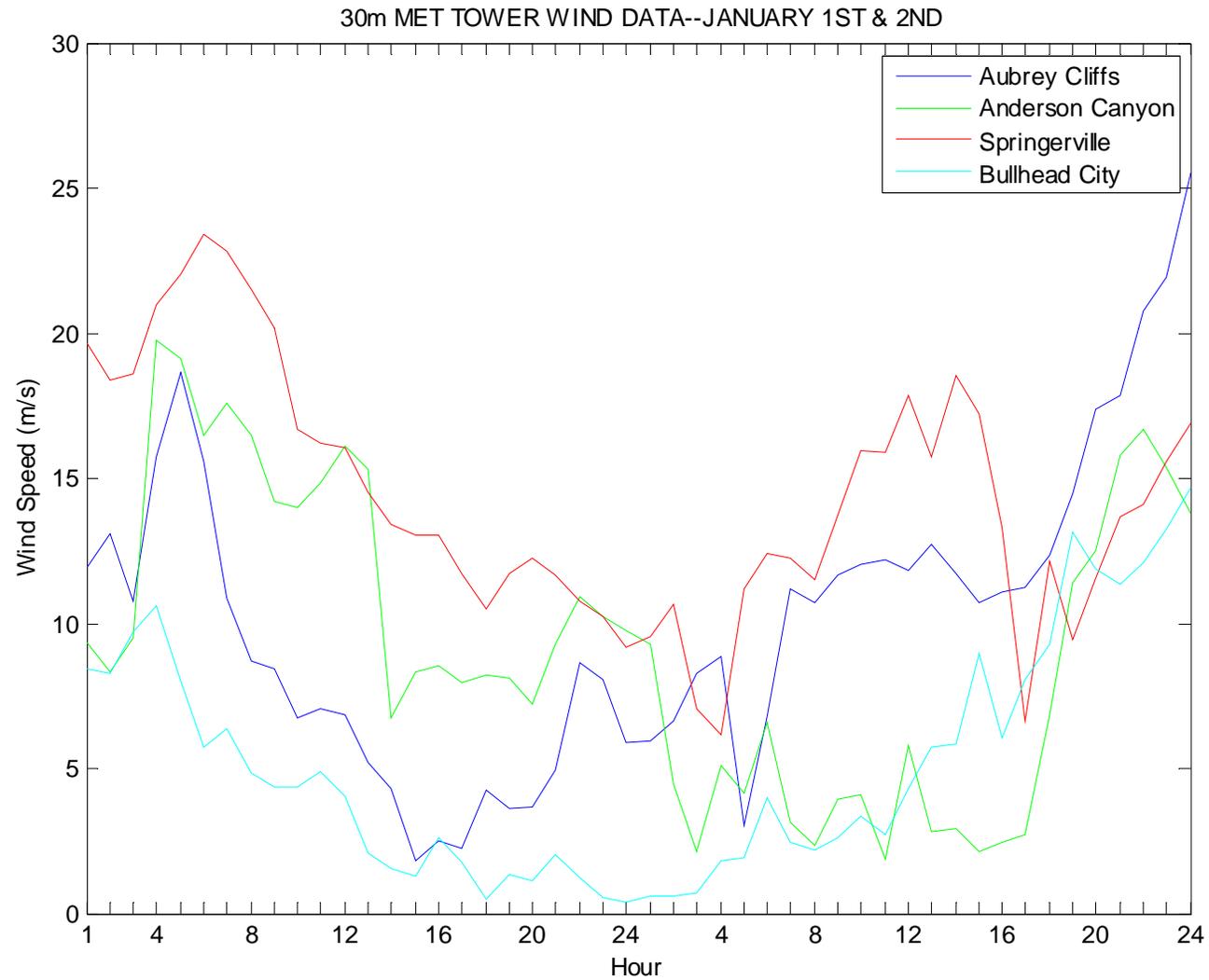


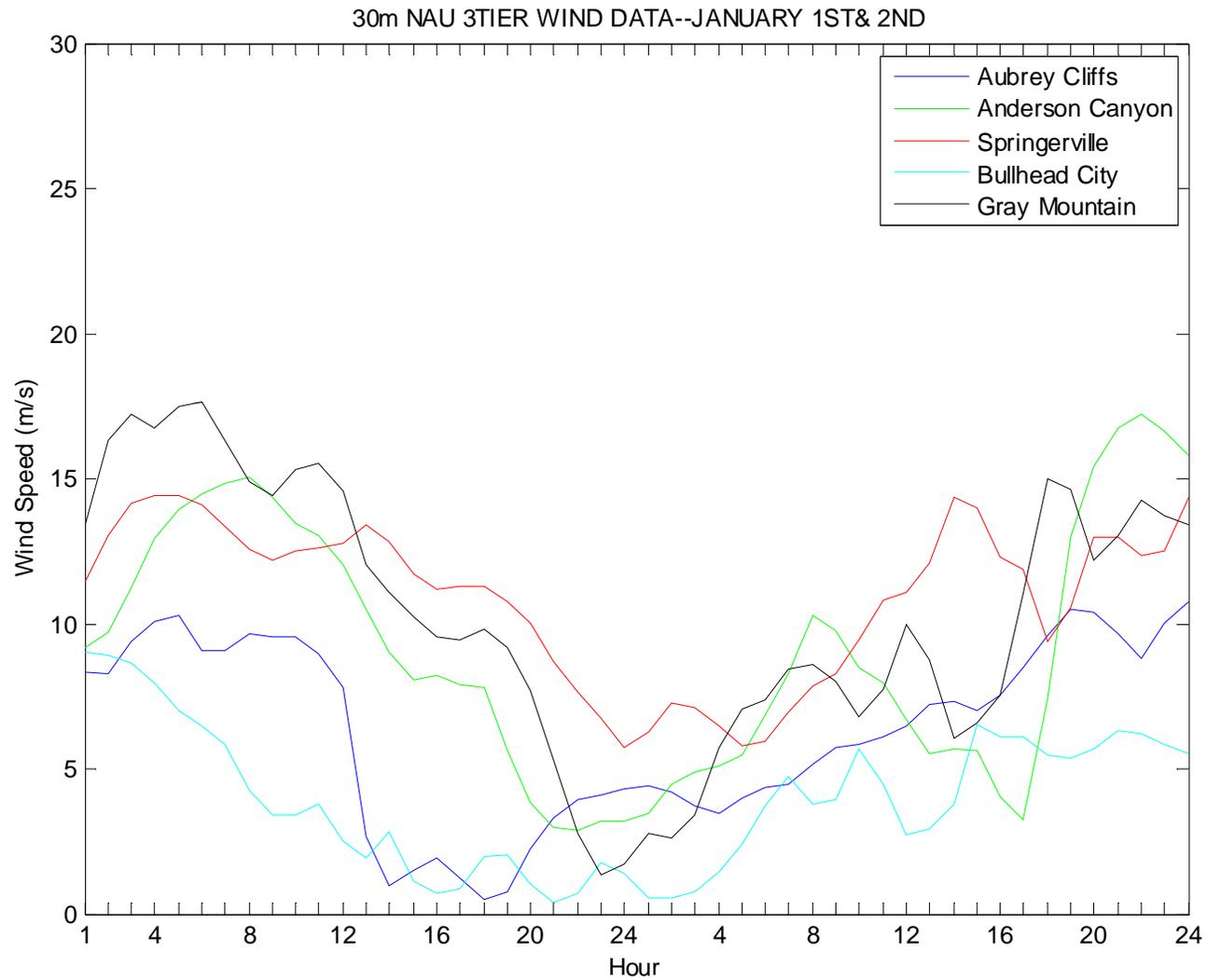


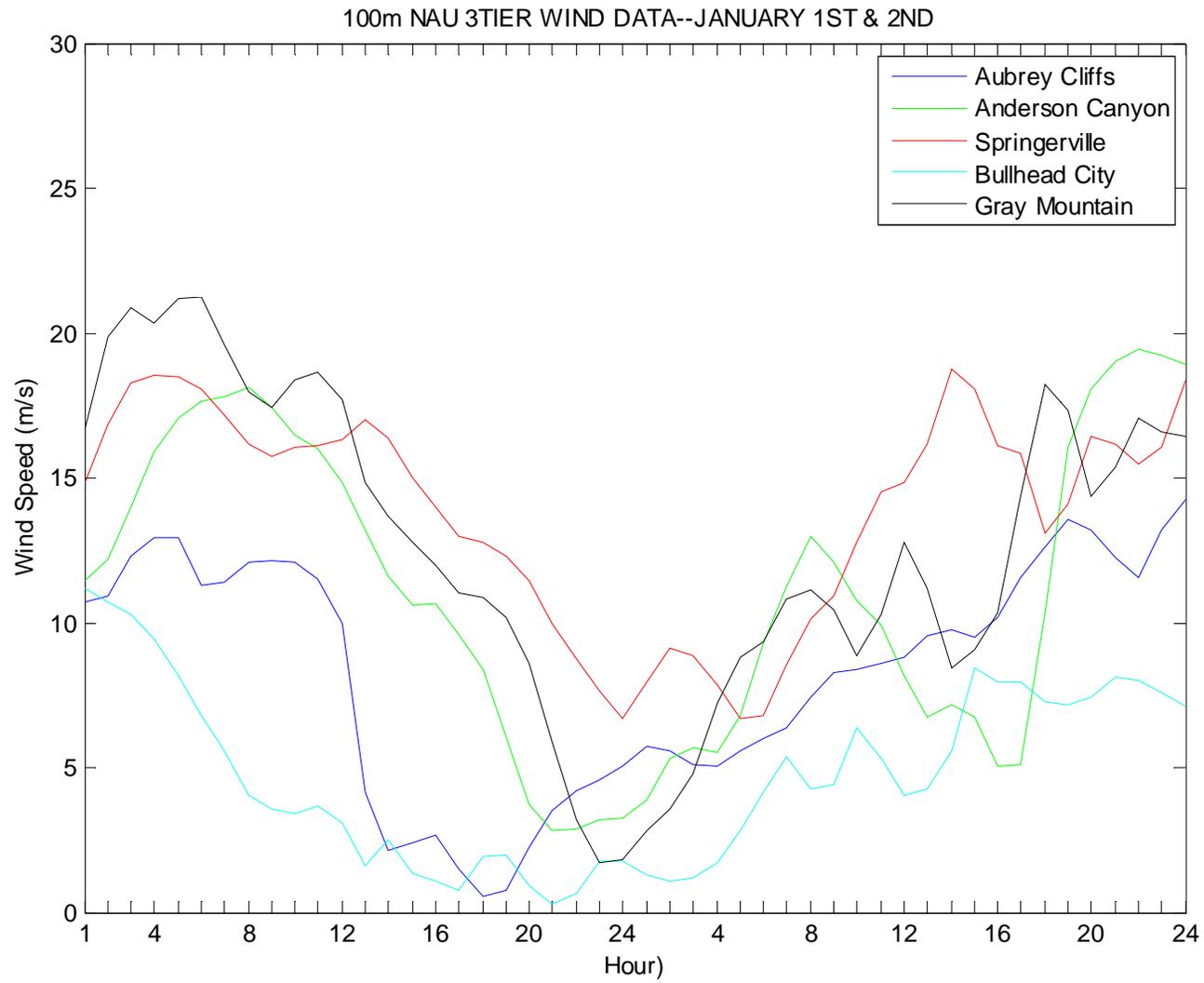
Wind Speed Plots

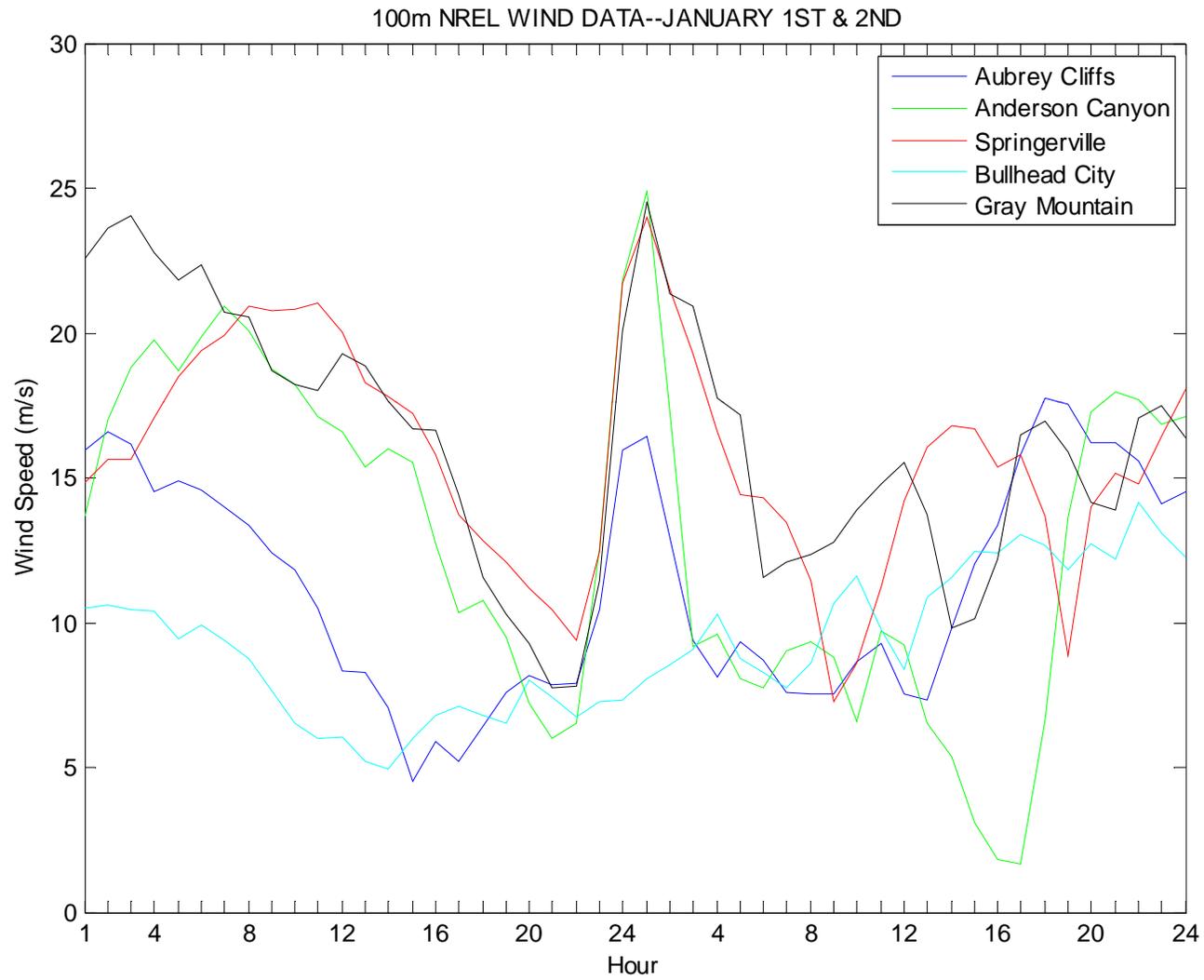
- Wind Data in Greenwich Mean Time (GMT) for 3TIER simulations.
- AZ Met tower data shifted to GMT.
- 10-minute wind speed data was averaged hourly
- Plots: Hourly average wind speed vs. time
 - NAU 30-m met tower (all sites)
 - NAU 3TIER 30-m wind speed
 - NAU 3TIER 100-m wind speed
 - NREL 3TIER 100-m wind speed
 - Plots for Jan 1 and Dec 30 to Jan 3

January 1 Plots

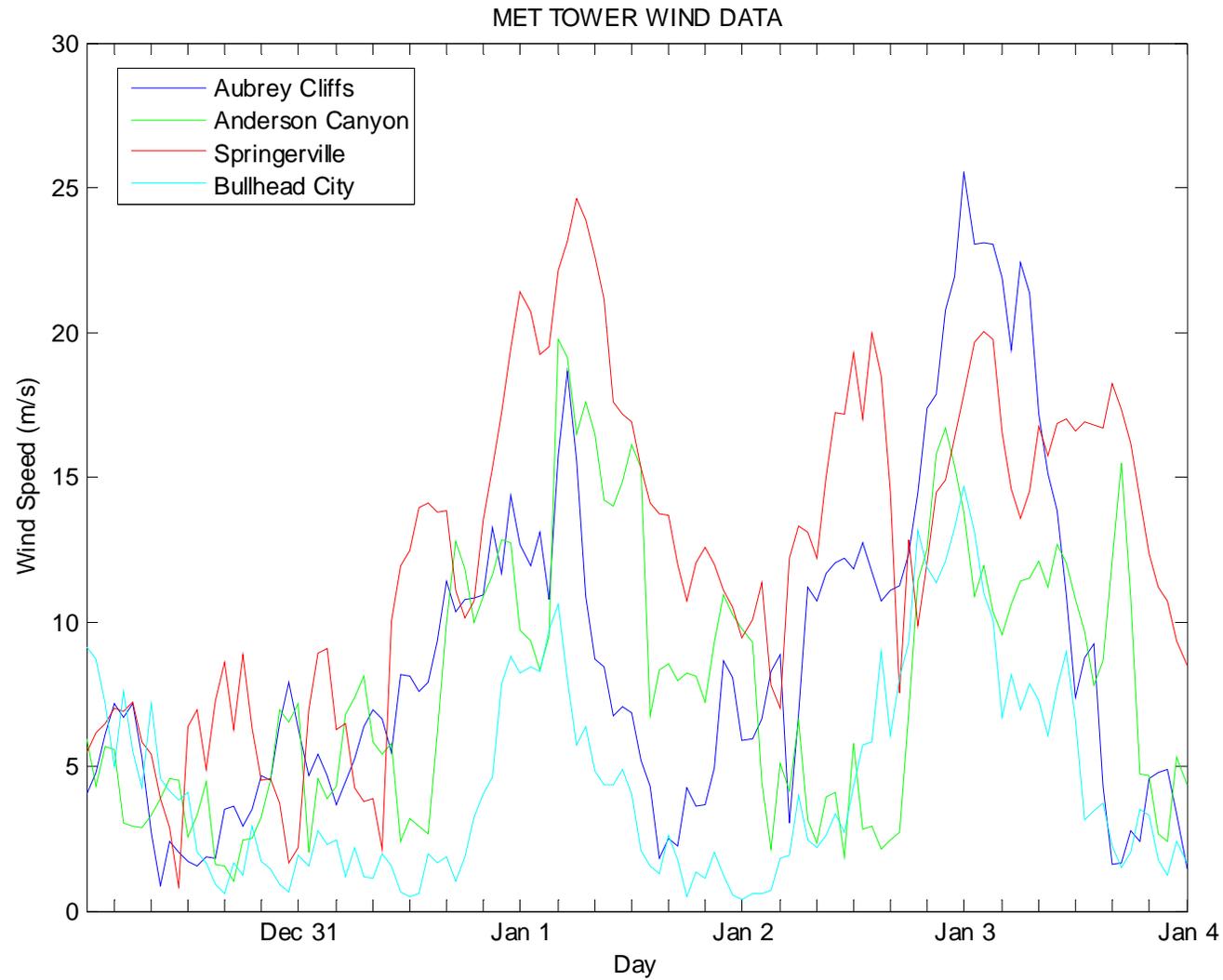


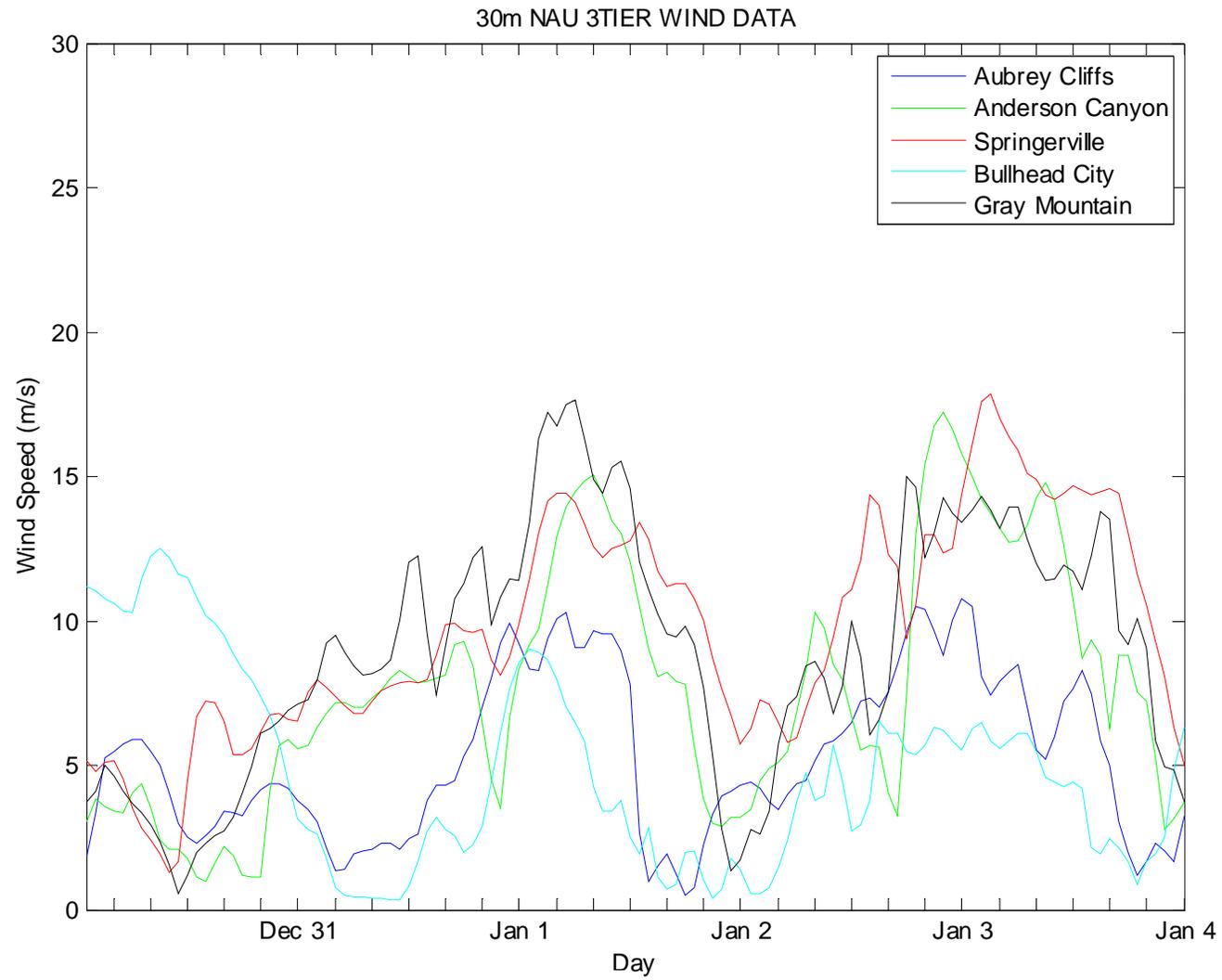


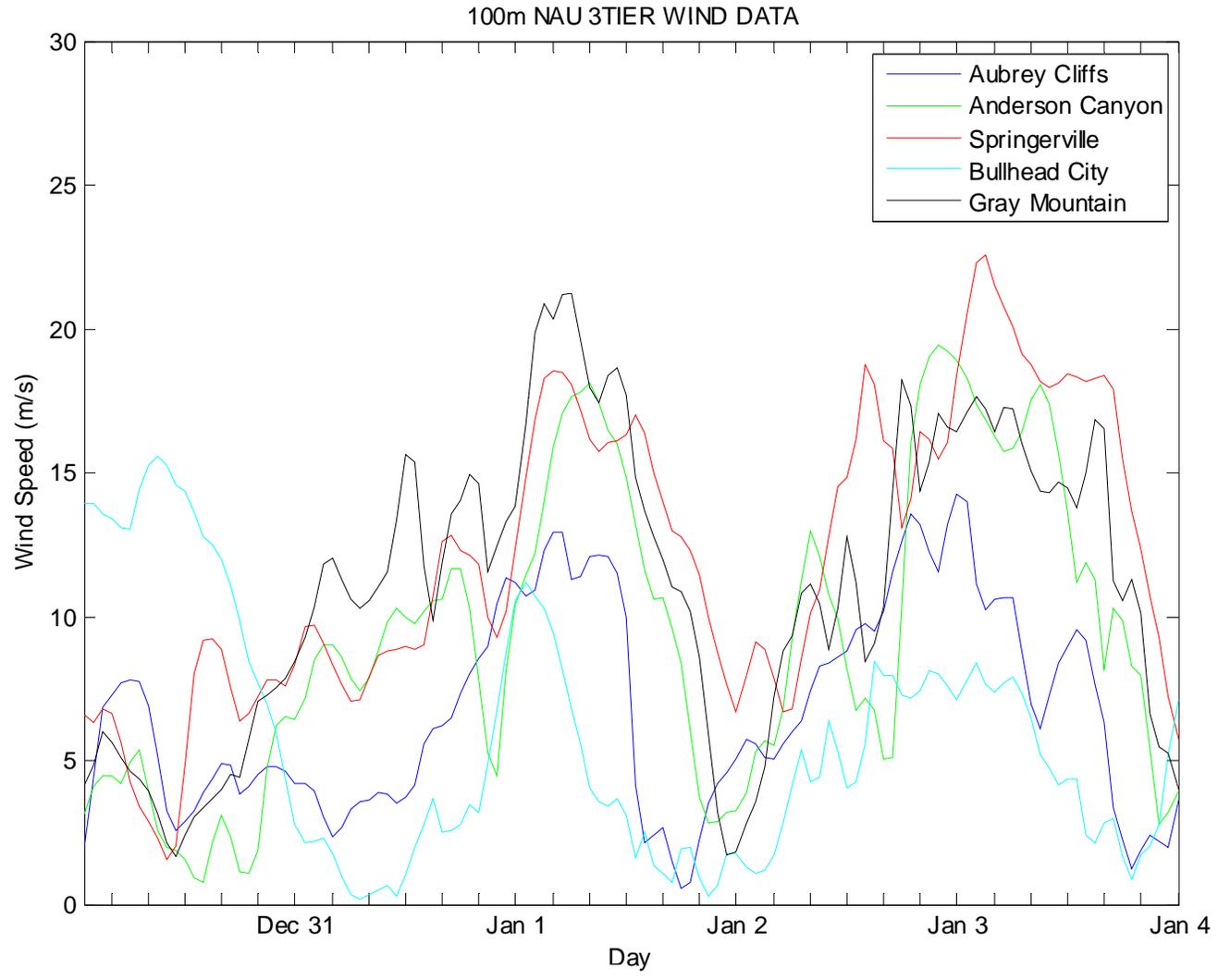


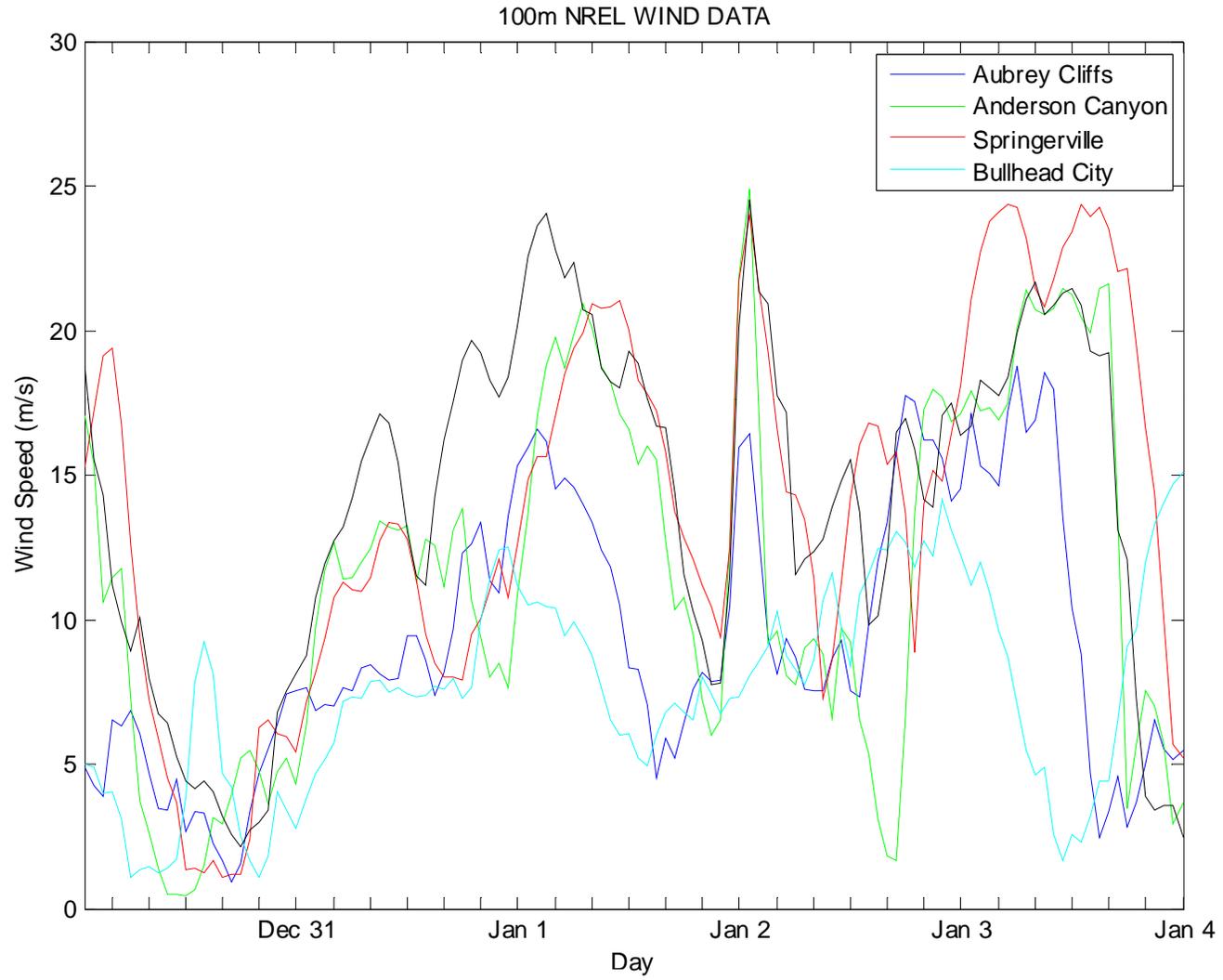


5-day Plots





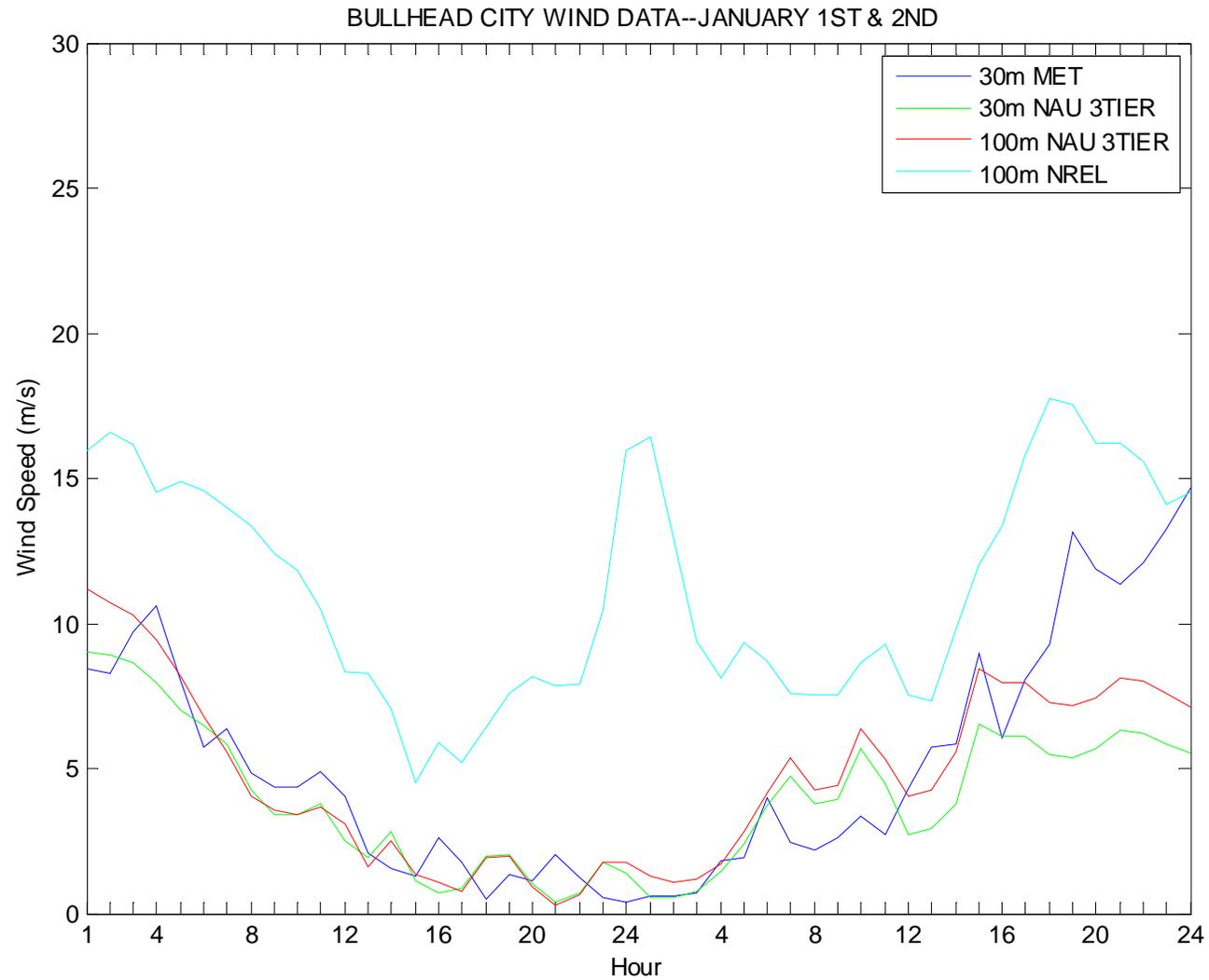


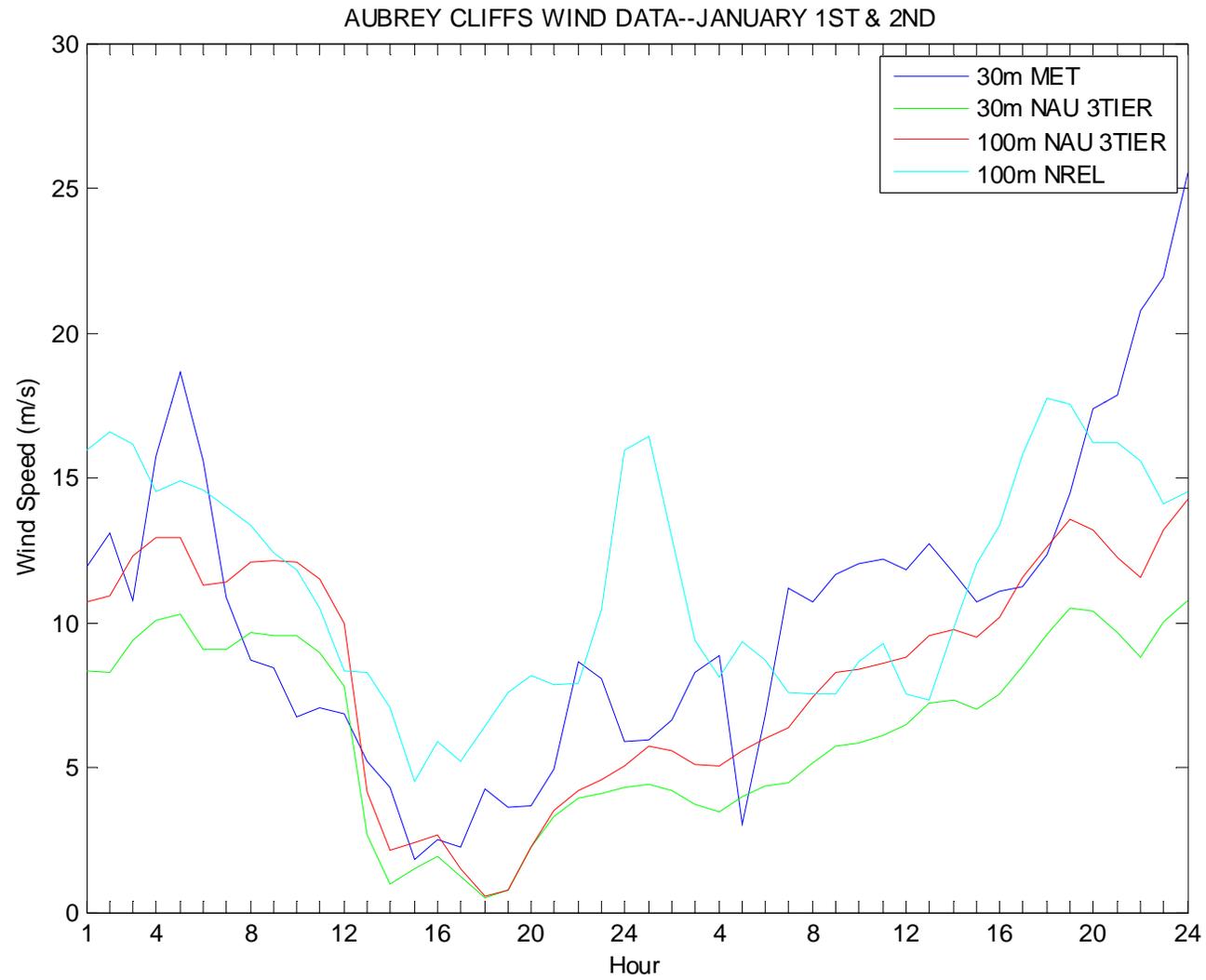


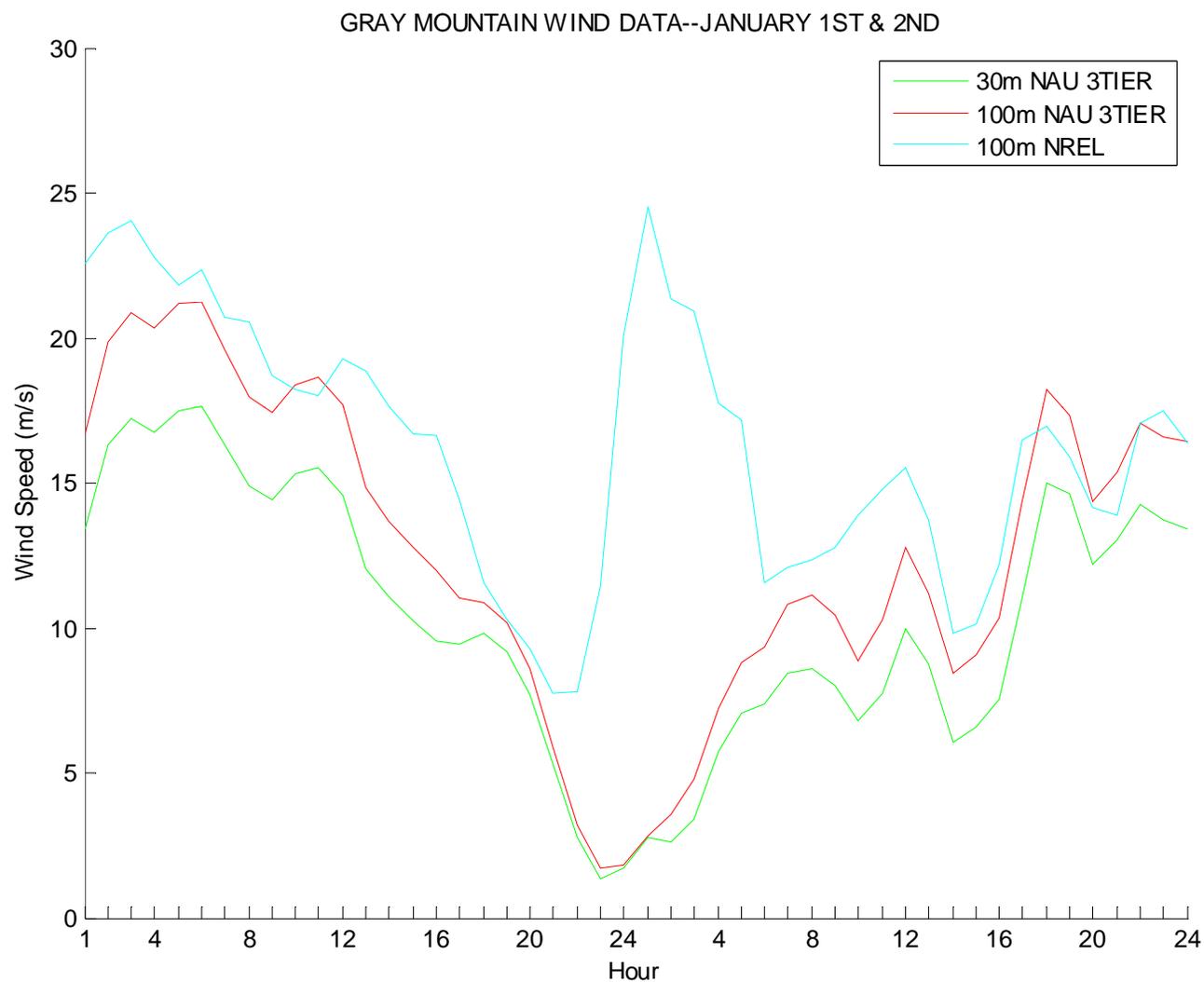
More Wind Speed Plots

- Comparing wind speed at each site from each source
- Hourly average wind speed vs. time:
 - Bullhead City
 - Aubrey Cliffs
 - Gray Mountain
 - Anderson Canyon
 - Springerville

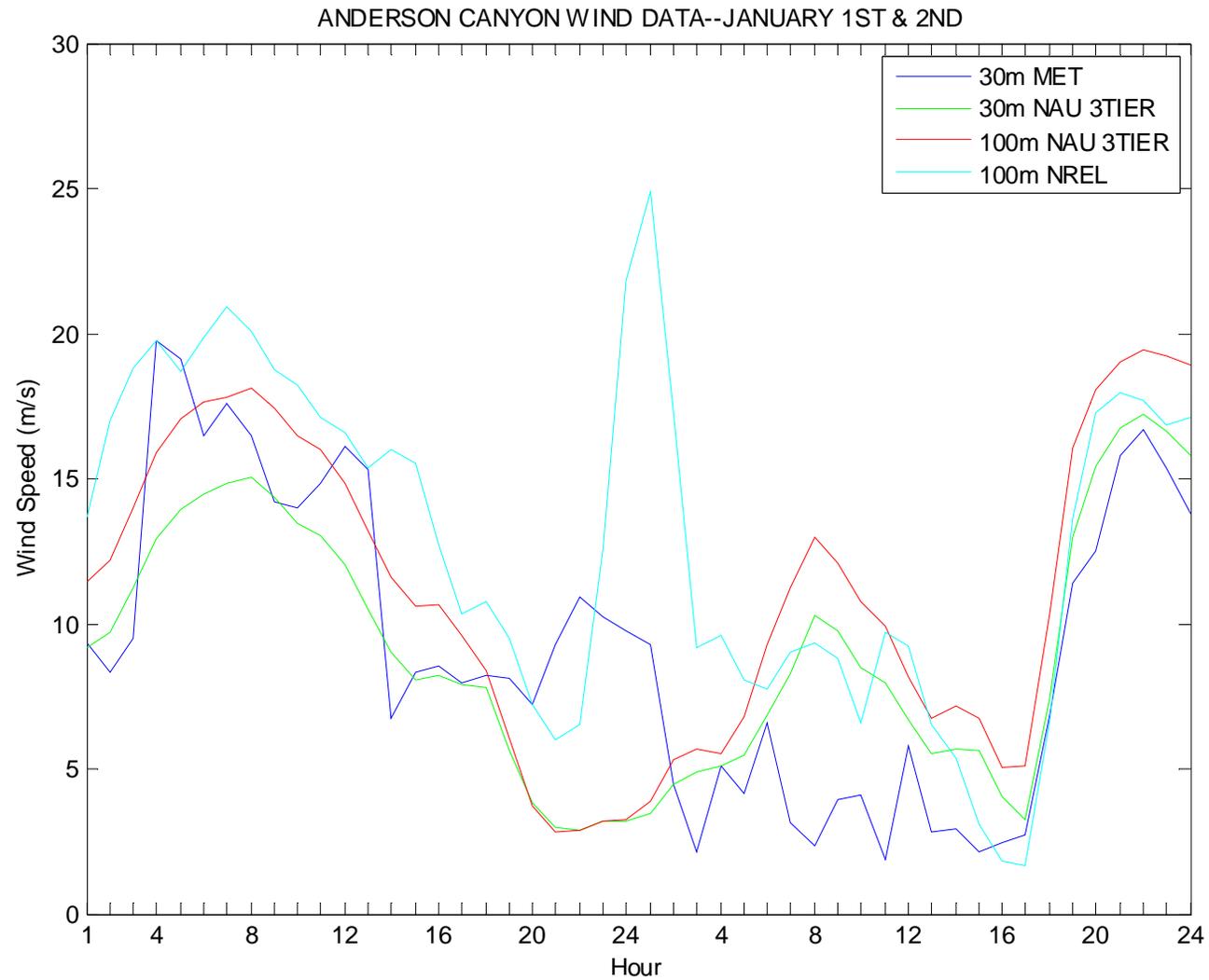
January 1 Plots

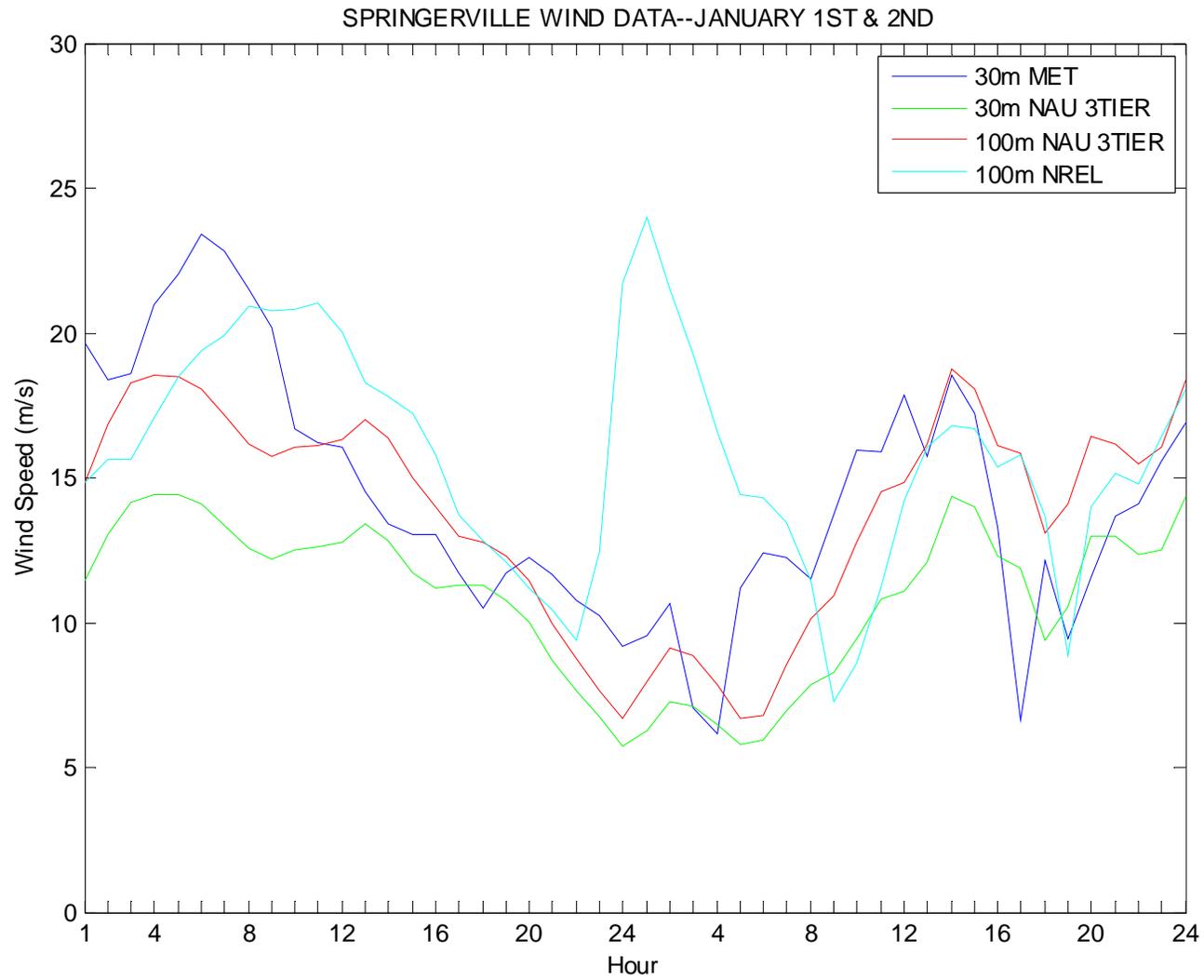






Note, no met tower data was available at Gray Mountain for these dates. ²⁸





5-day Plots

