

Reducing **Systematic Forecast Errors** in Diurnal Temperature through **Data Analytics**

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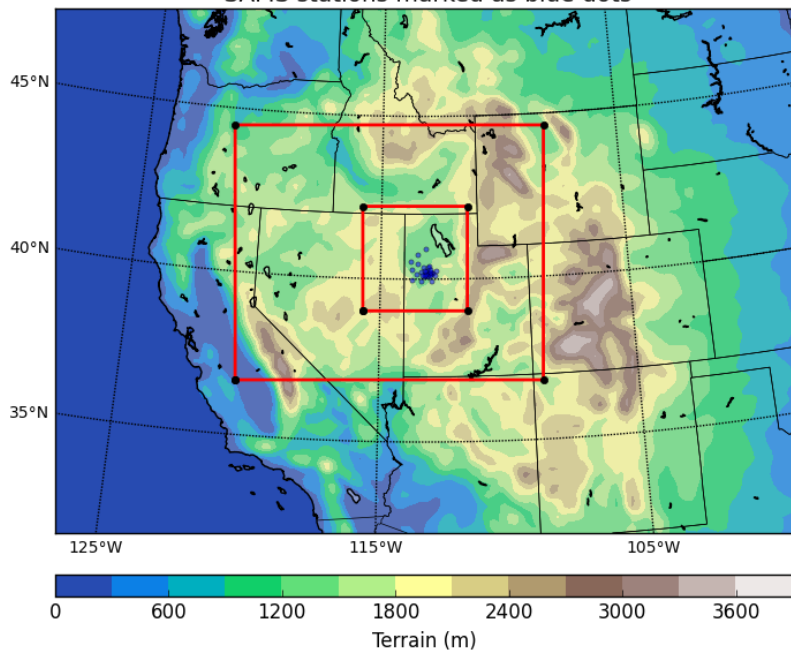
Research Applications Laboratory

National Center for Atmospheric Research

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Nested WRF Domains at 18, 6 and 2 KM)
SAMS stations marked as blue dots



3 nested domains:

D1: 18KM 140X100

D2: 6KM 175X145

D3: 2Km 178X178

WRF3.6.1

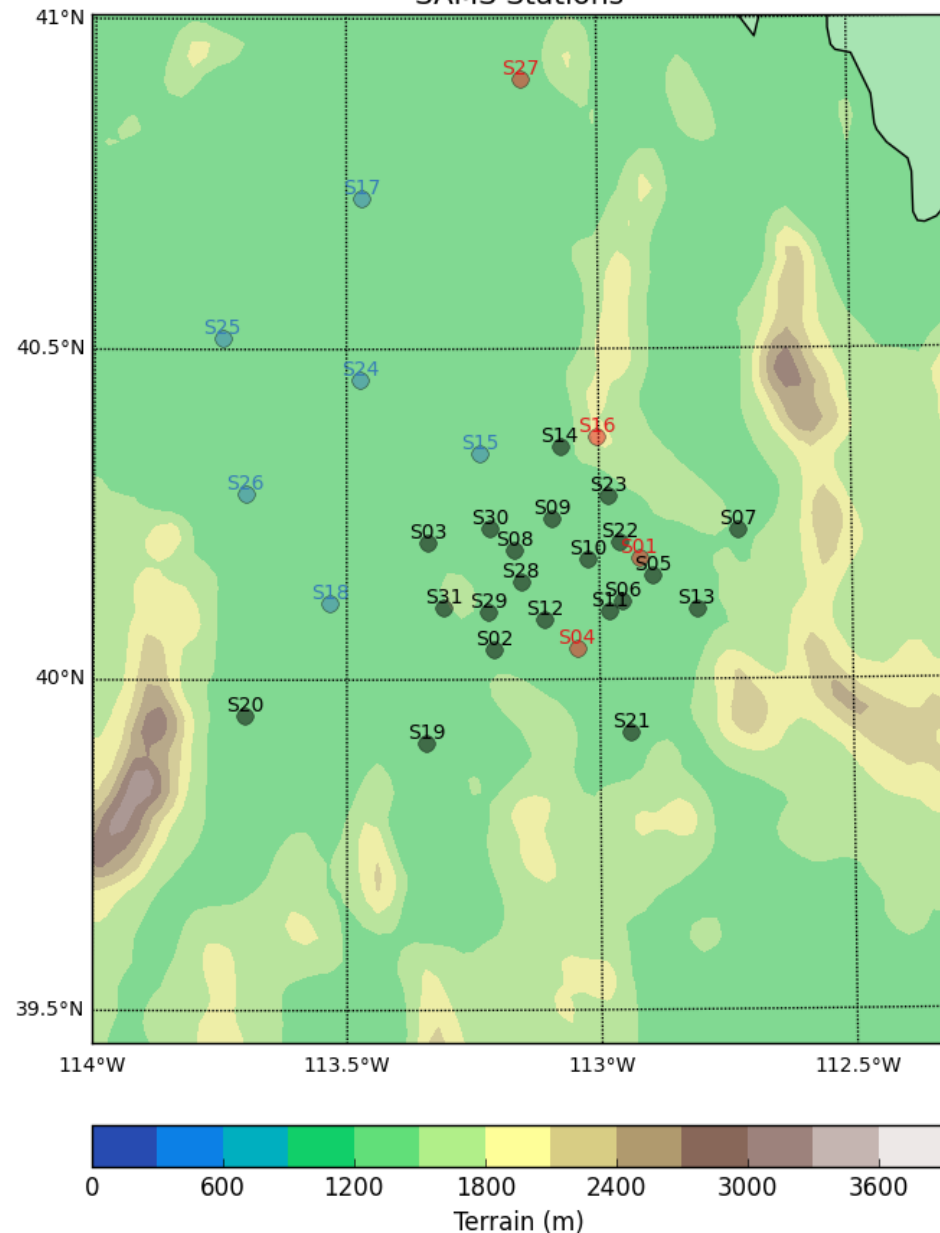
YSU, KF,

WSM6, RRTM/Dudhia, LSM

**36 hours forecast initiated by CFSR at 12Z
from Oct. 12 to Nov. 5 2015 (24 days)**

**The last 24 hours forecast @ 5MIN
output in D3 for Data Analytics**

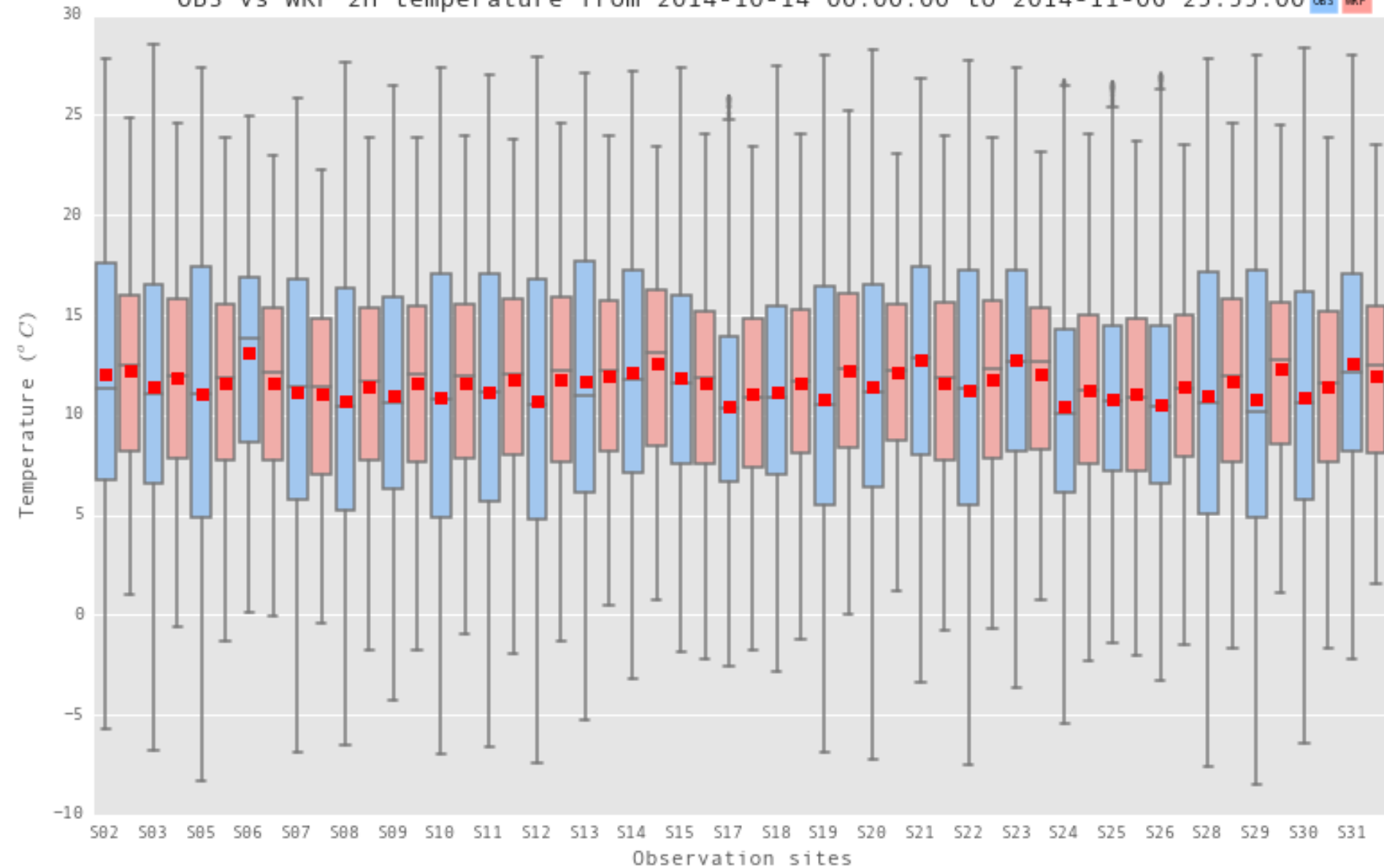
SAMS Stations



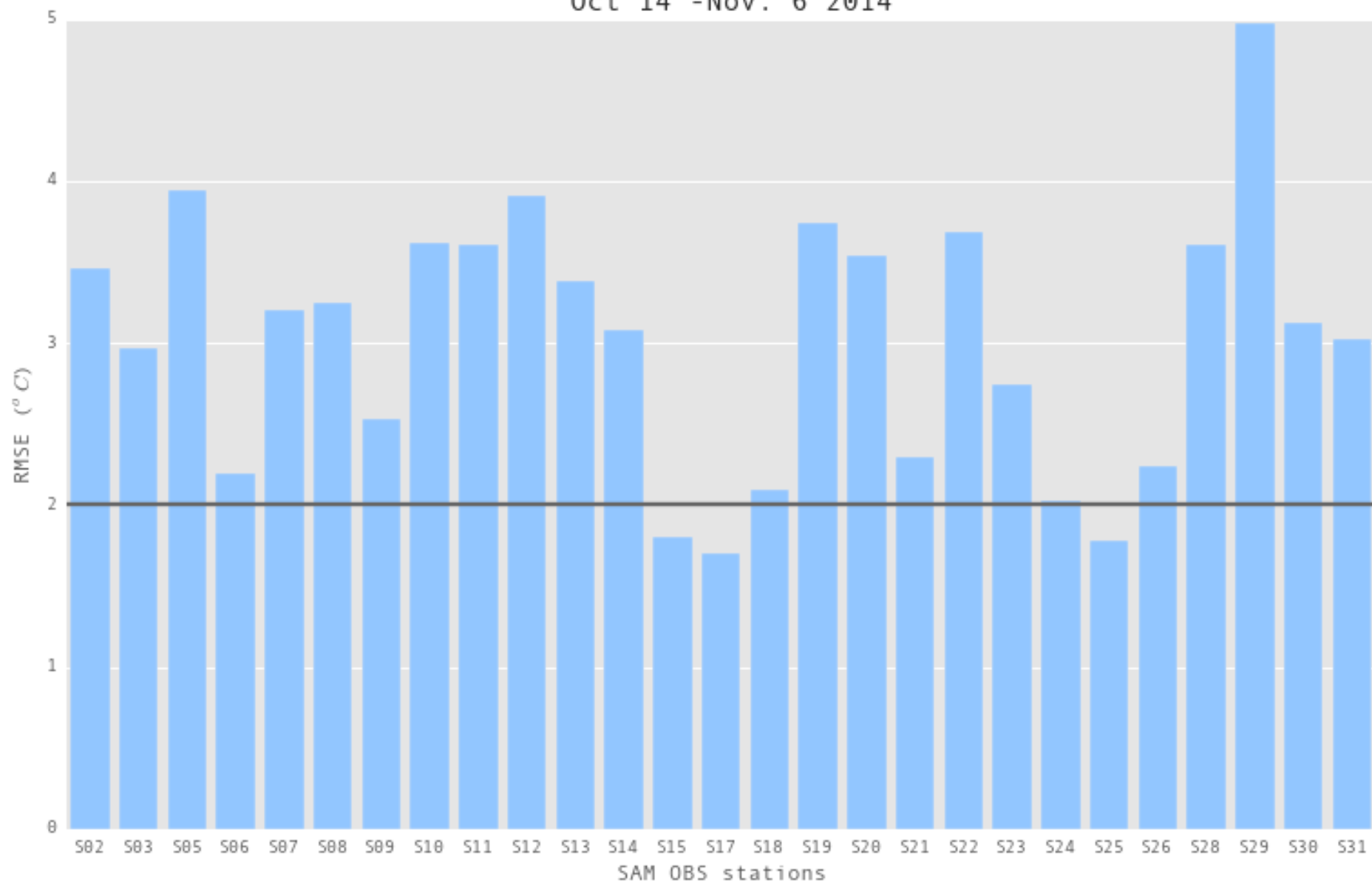
**Observations every 5MIN @ 31 Stations
within 100X100km²**

OBS vs WRF 2M temperature from 2014-10-14 00:00:00 to 2014-11-06 23:55:00

OBS WRF

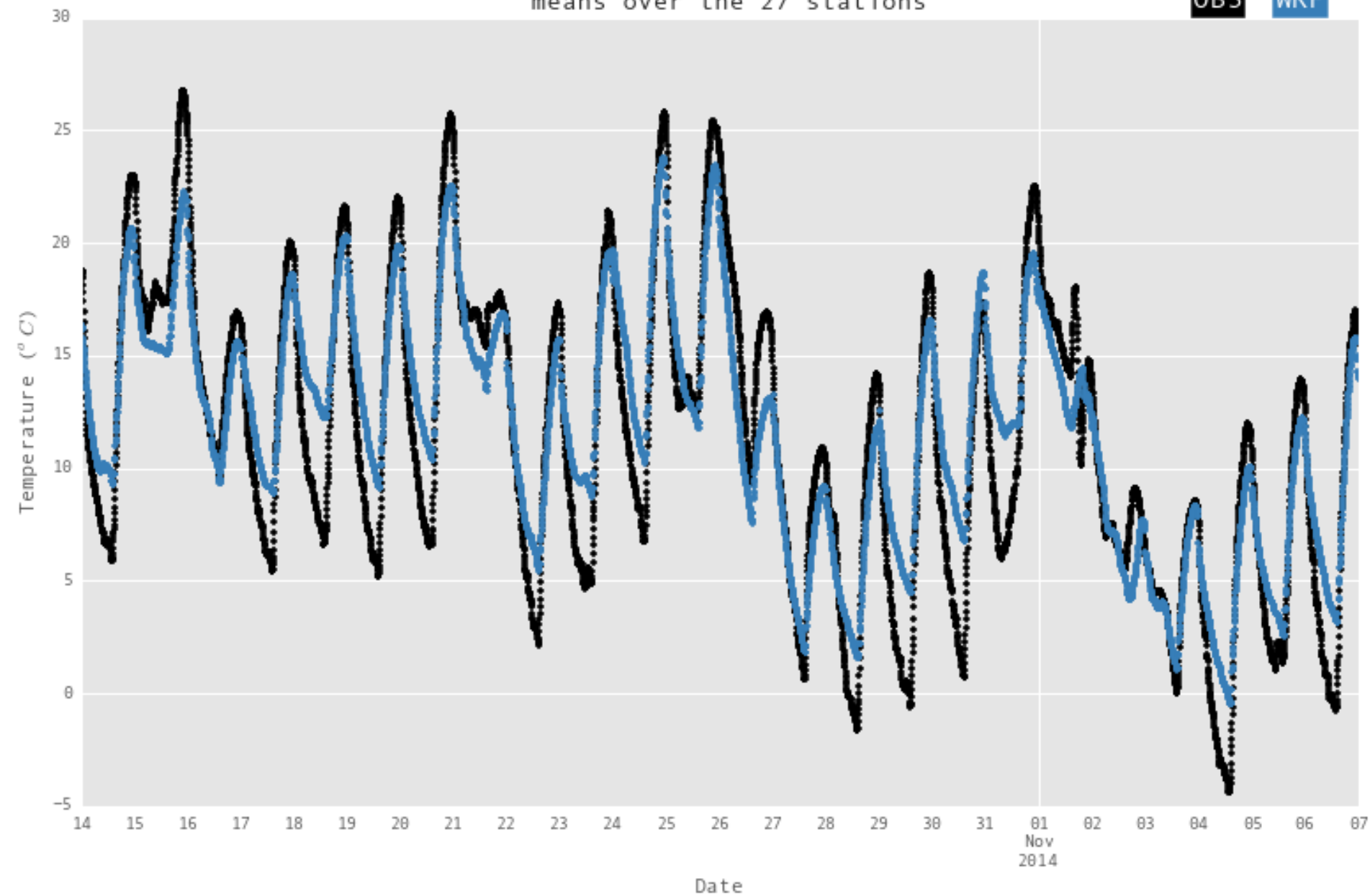


RMSE in Temperature between OBS and WRF at 27 stations
Oct 14 -Nov. 6 2014



OBS vs WRF 2M temperature from 2014-10-14 00:00:00 to 2014-11-06 23:55:00
means over the 27 stations

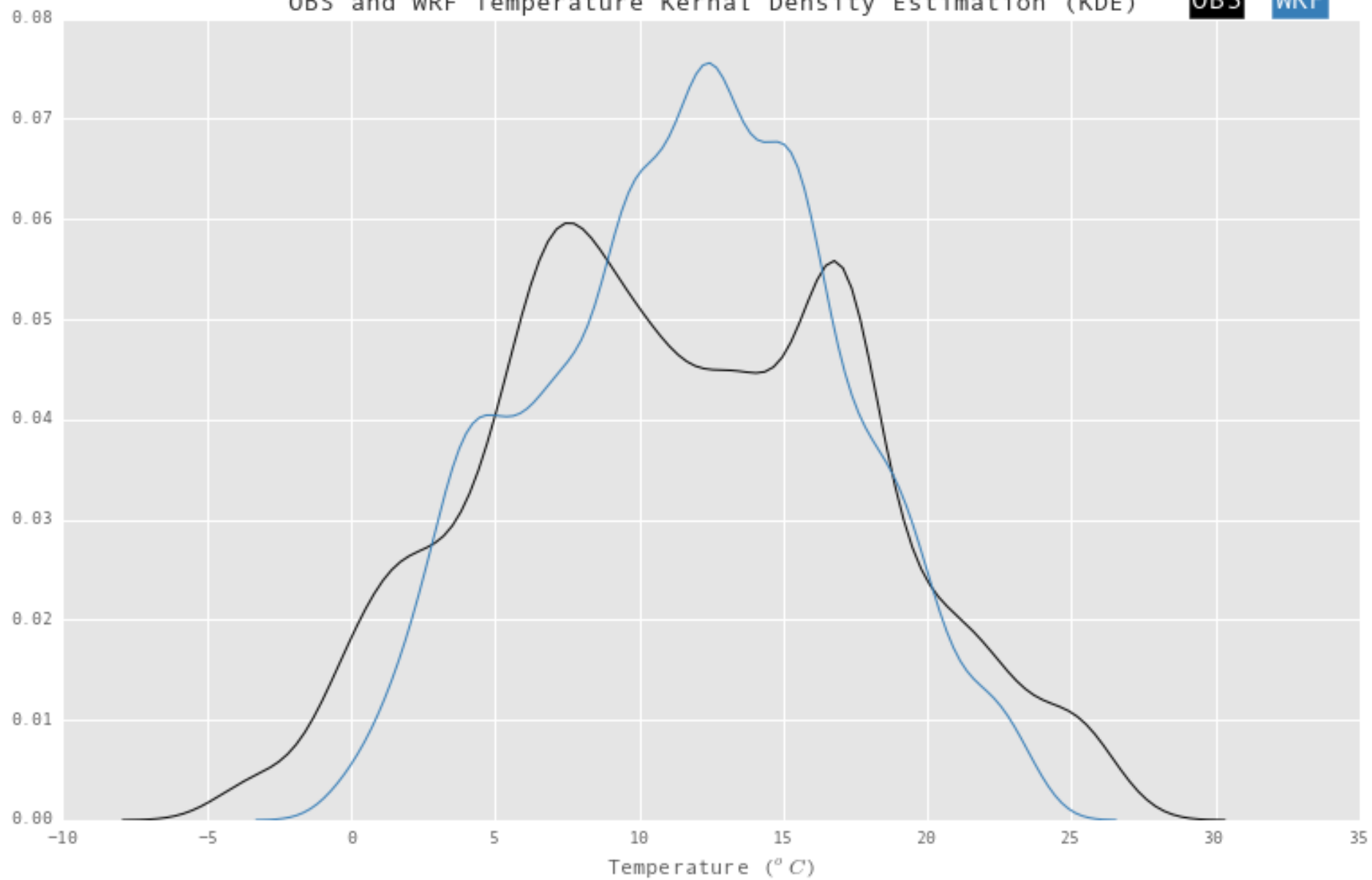
OBS WRF



OBS and WRF Temperature Kernel Density Estimation (KDE)

OBS

WRF

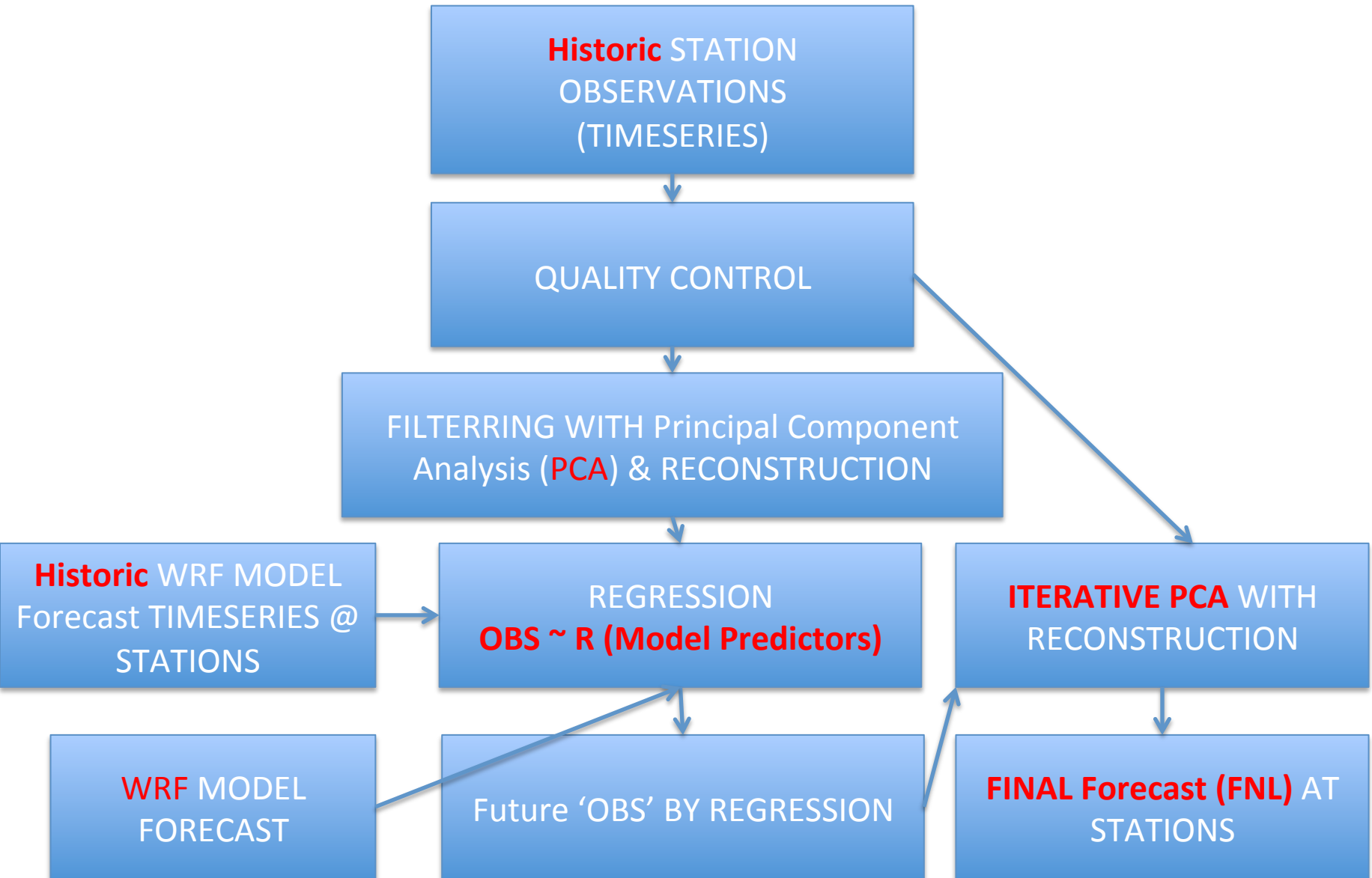


WRF forecasts weak diurnal cycle...

How could the systematic errors be reduced?

- Model dynamics and physics improvement
- Data assimilation
- Post-processing
 - e.g. MOS, Analog, ...
 - Data Analytics (data mining)**

Integrated Data Analytics for Systematic Forecast Error Reduction



Powered by PYTHON in few hundreds of lines of code

Test the Data Analytics Framework

HISTORIC PERIOD (14 days)

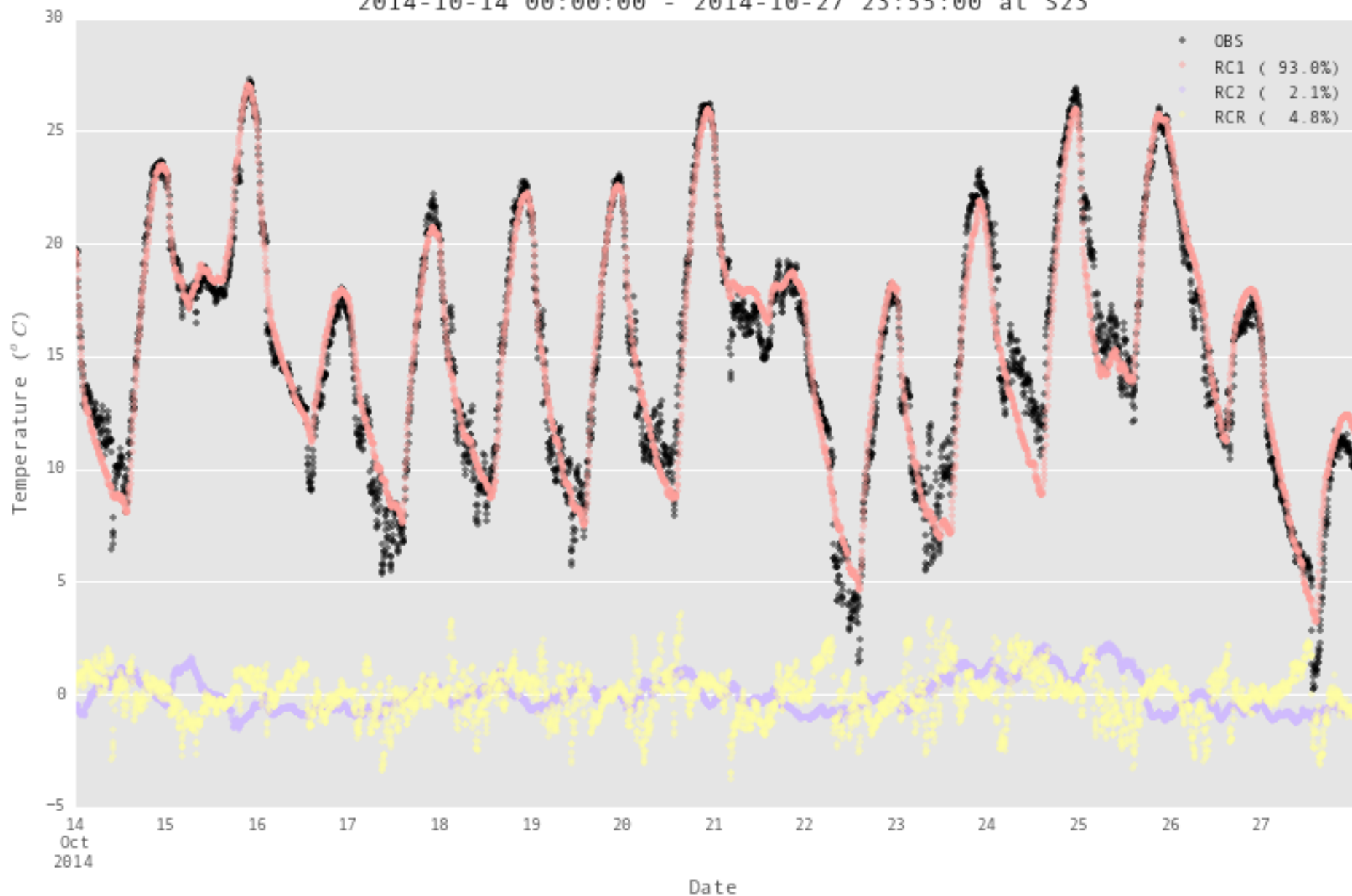
FORECAST PERIOD (10 days)



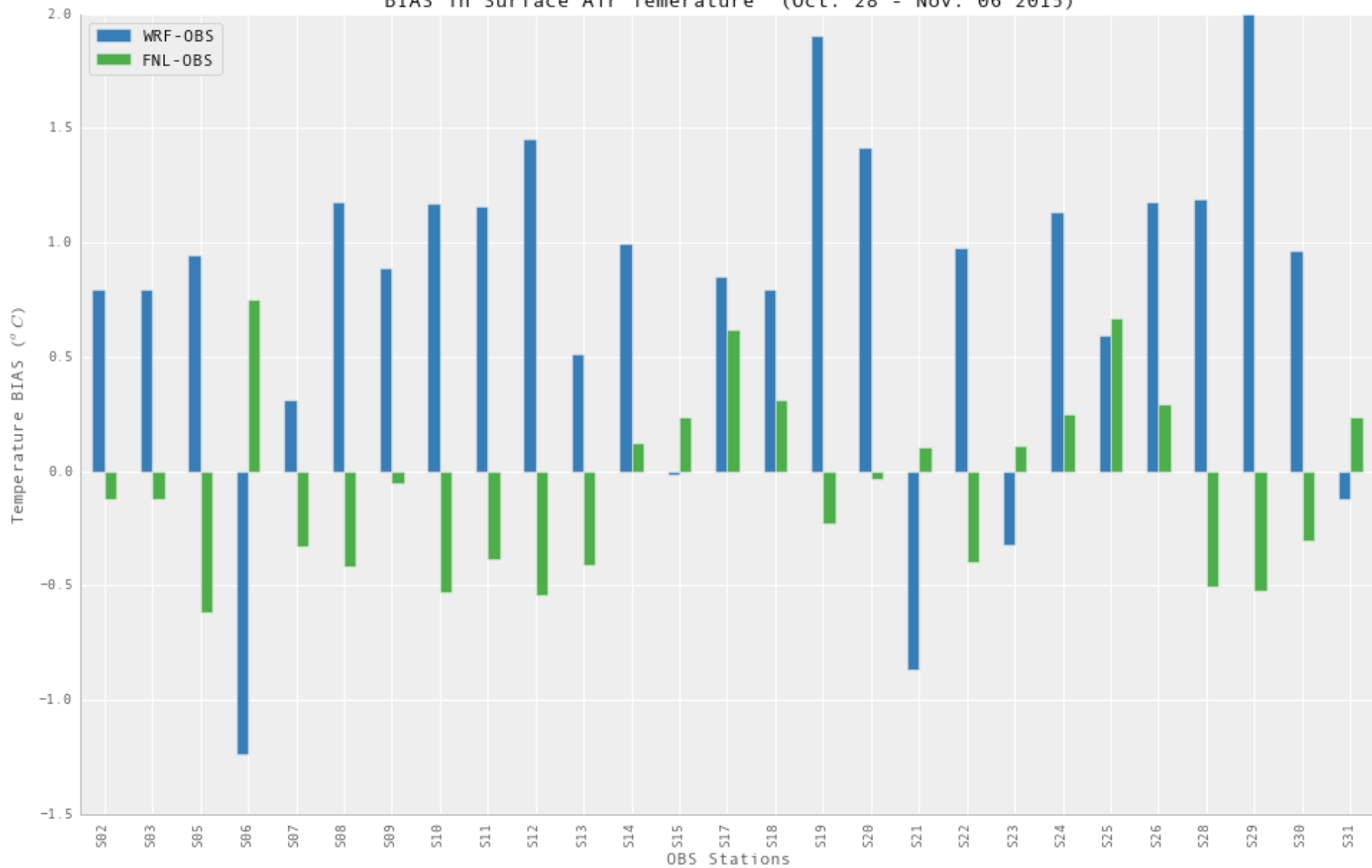
PCA: retains 90% or above variance (first one component with 93% variance)

REGRESSION: WRF T2, U10, V10 as predictors

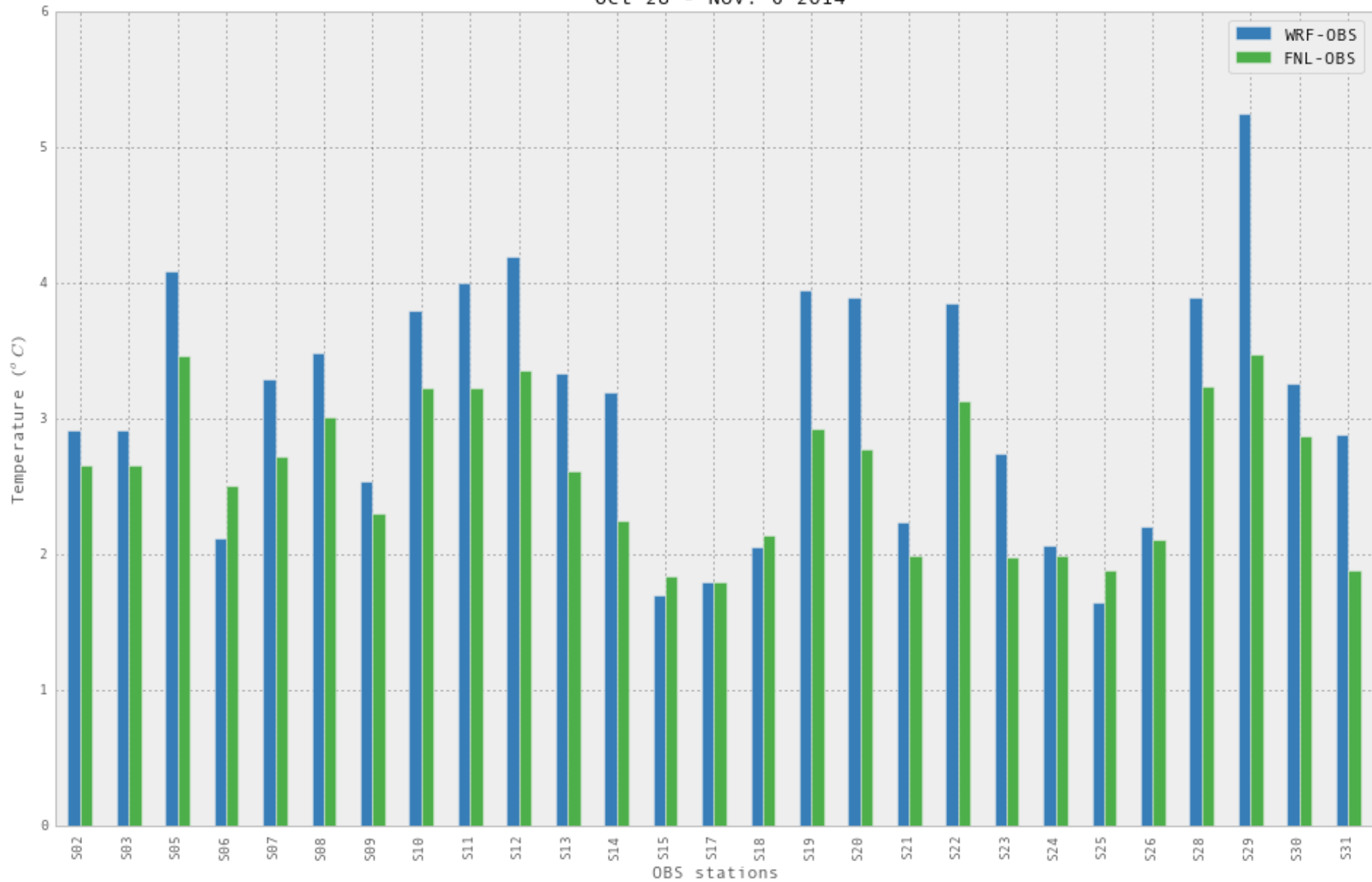
OBS and PCA Reconstructed timeseries
2014-10-14 00:00:00 - 2014-10-27 23:55:00 at S23



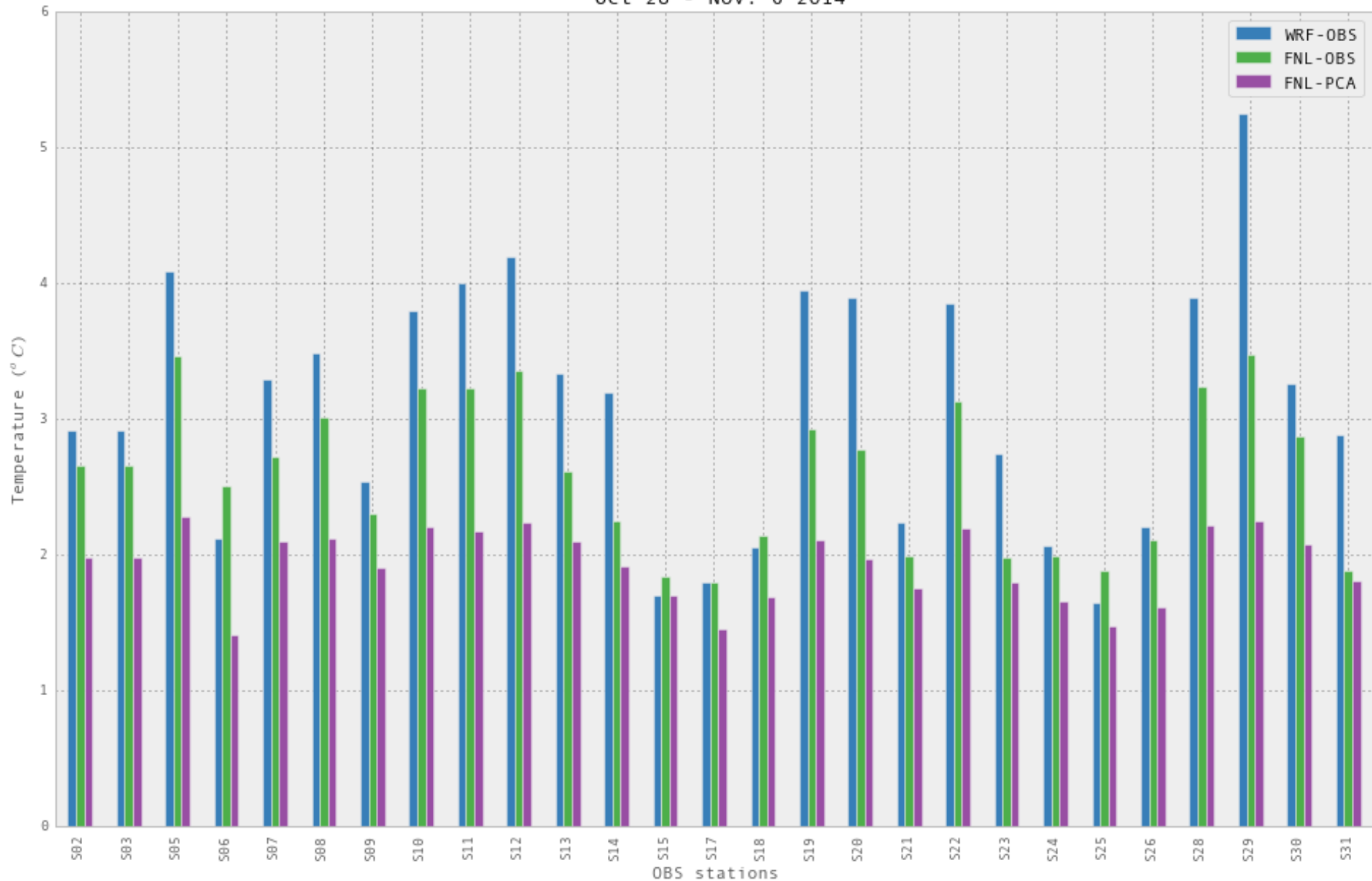
BIAS in Surface Air Temperature (Oct. 28 - Nov. 06 2015)



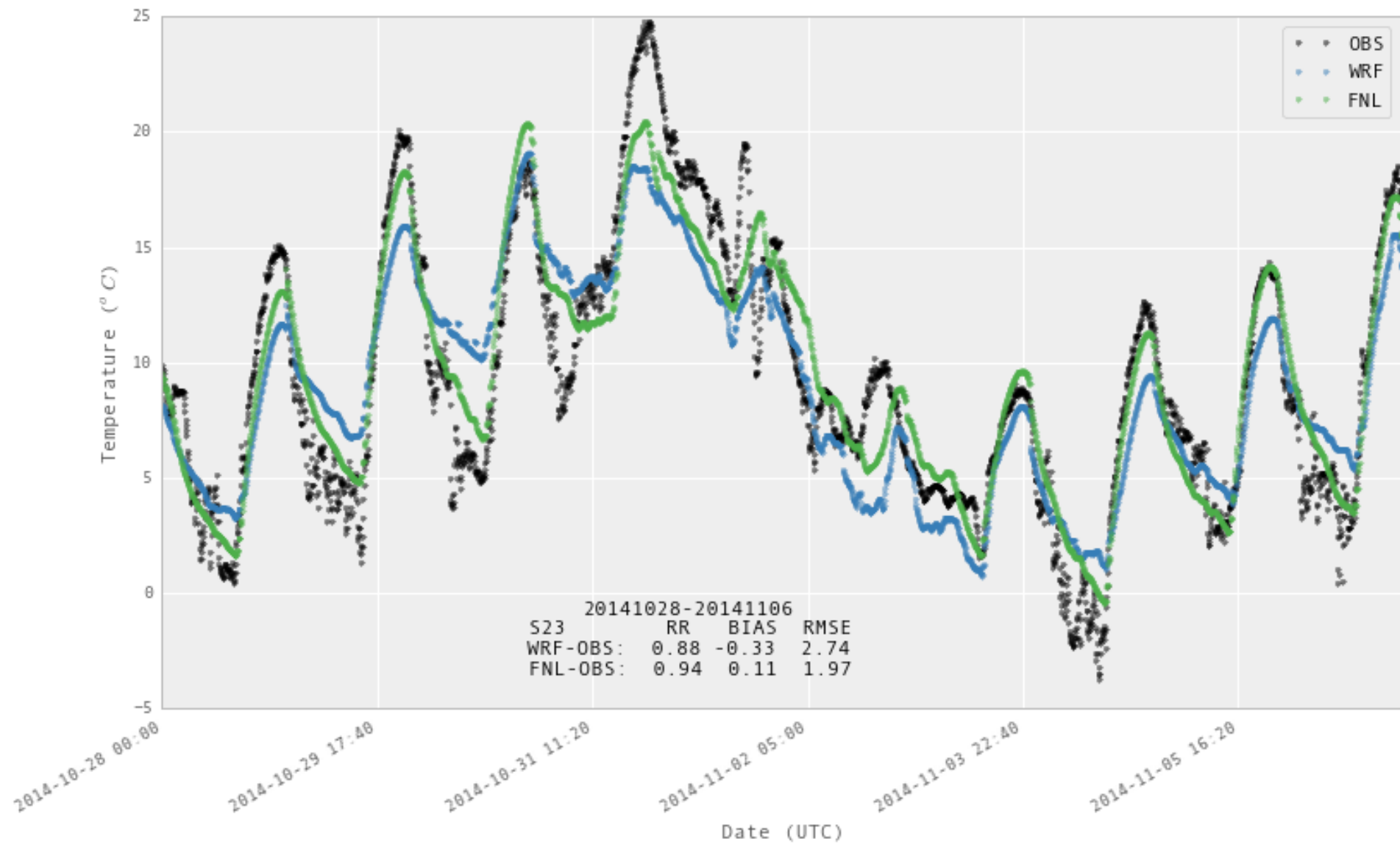
Station RMSE between WRF, FNL (data analytics) and OBS
Oct 28 - Nov. 6 2014



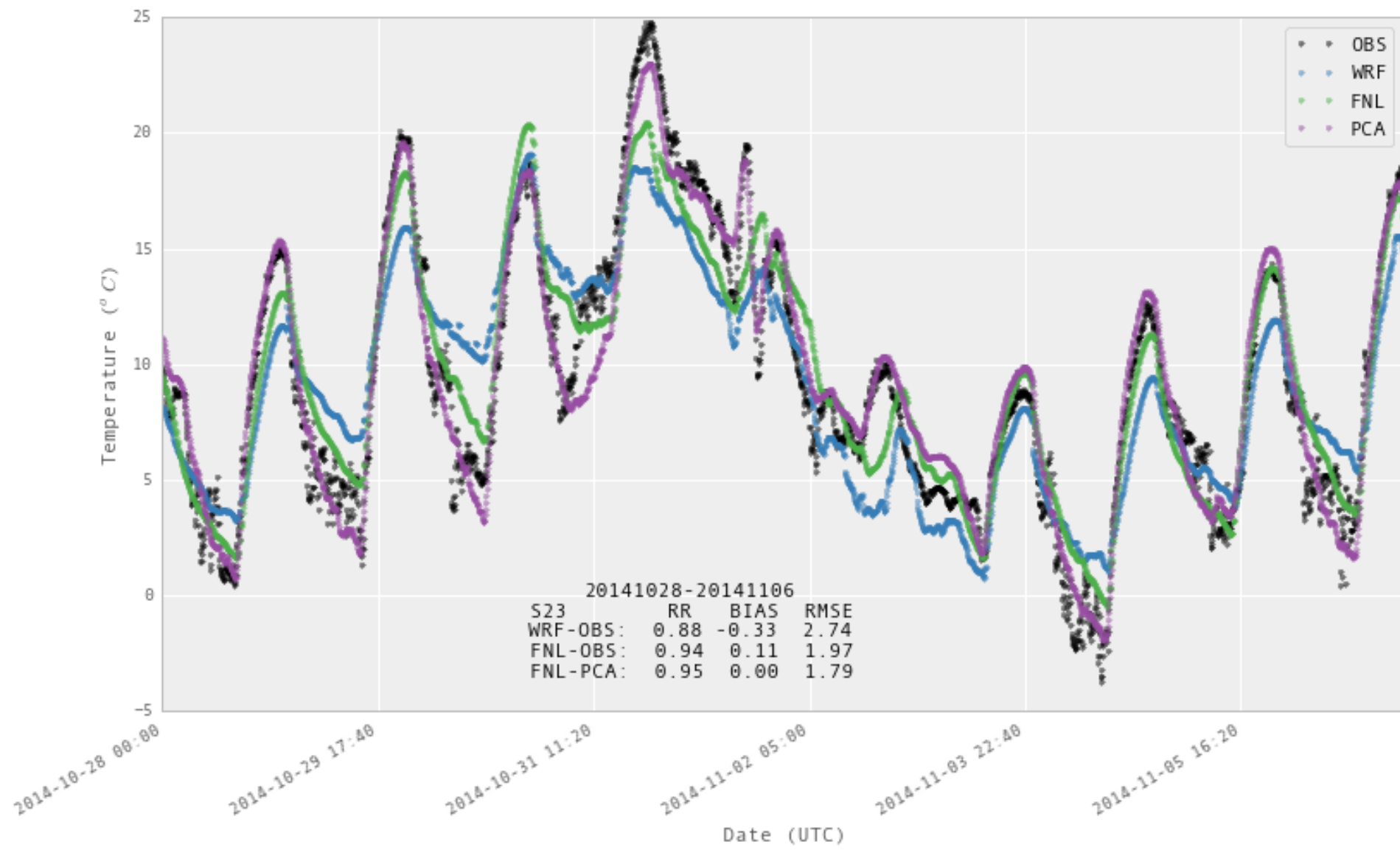
Station RMSE between WRF, FNL (data analytics) and OBS, and FNL againsts PCA-filtered OBS
Oct 28 - Nov. 6 2014



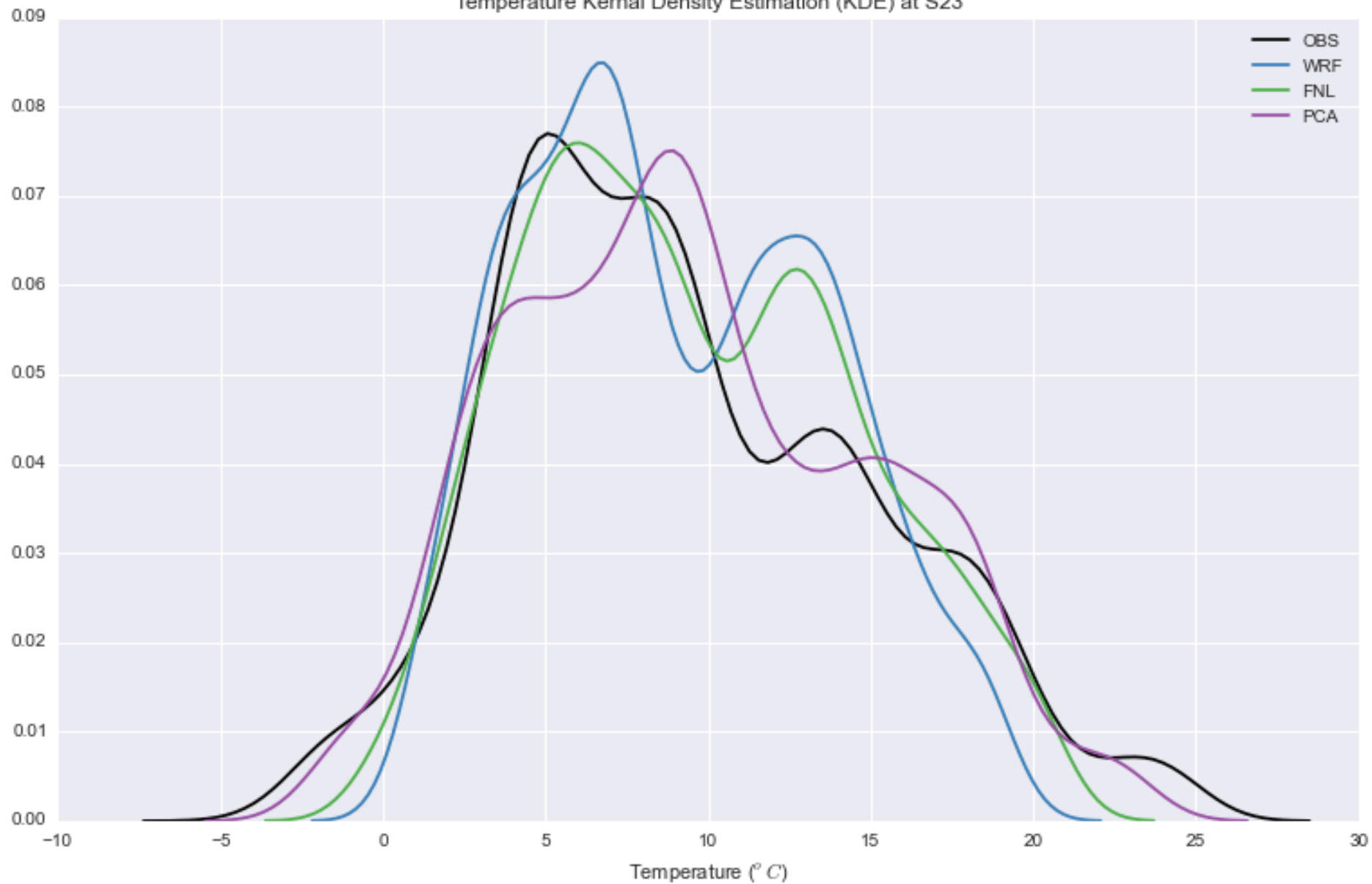
Data Analytics Final Product (FNL) VS WRF, and OBS @ S23



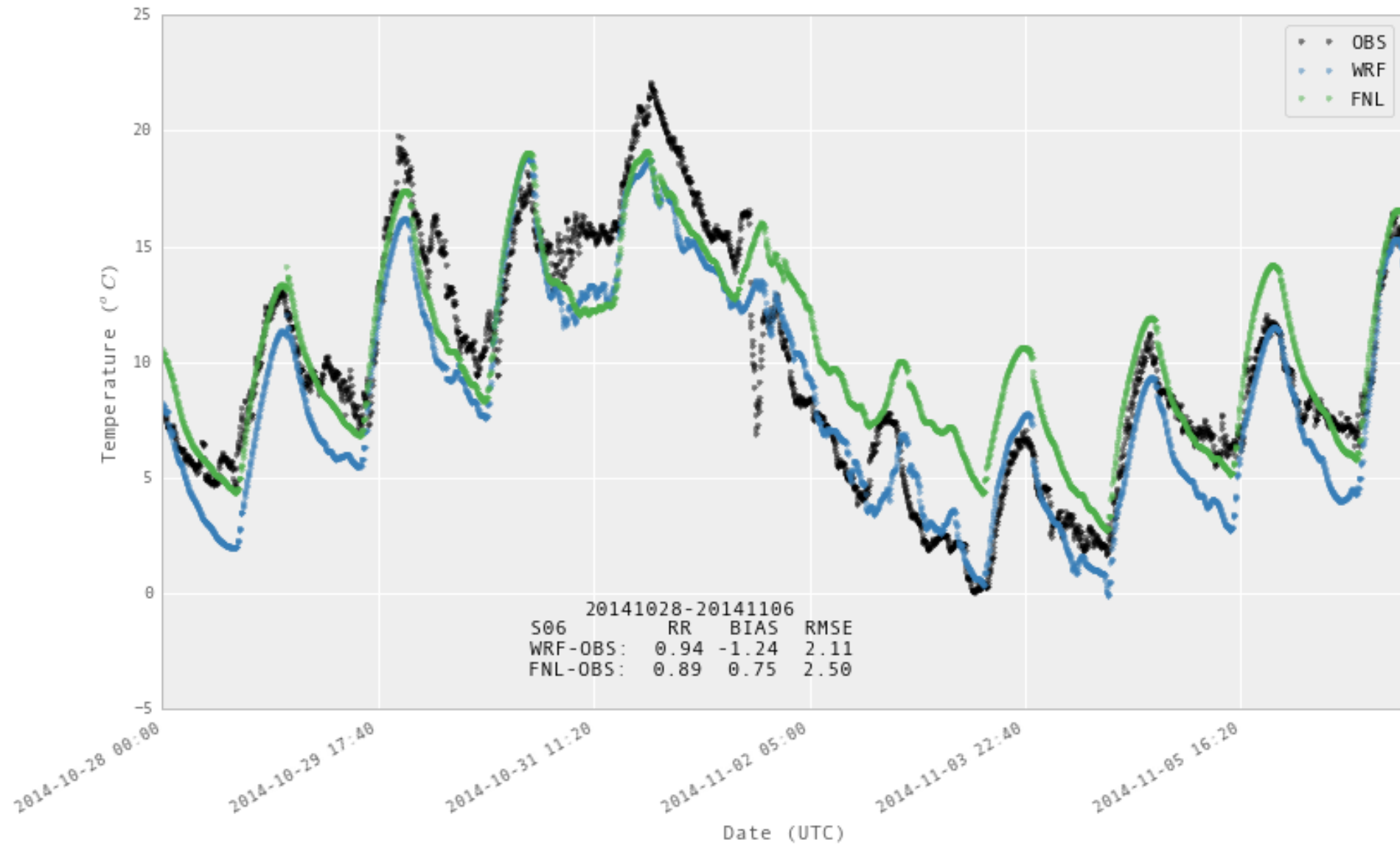
Data Analytics Final Product (FNL) VS WRF, OBS, and PCA-filtered OBS @ S23



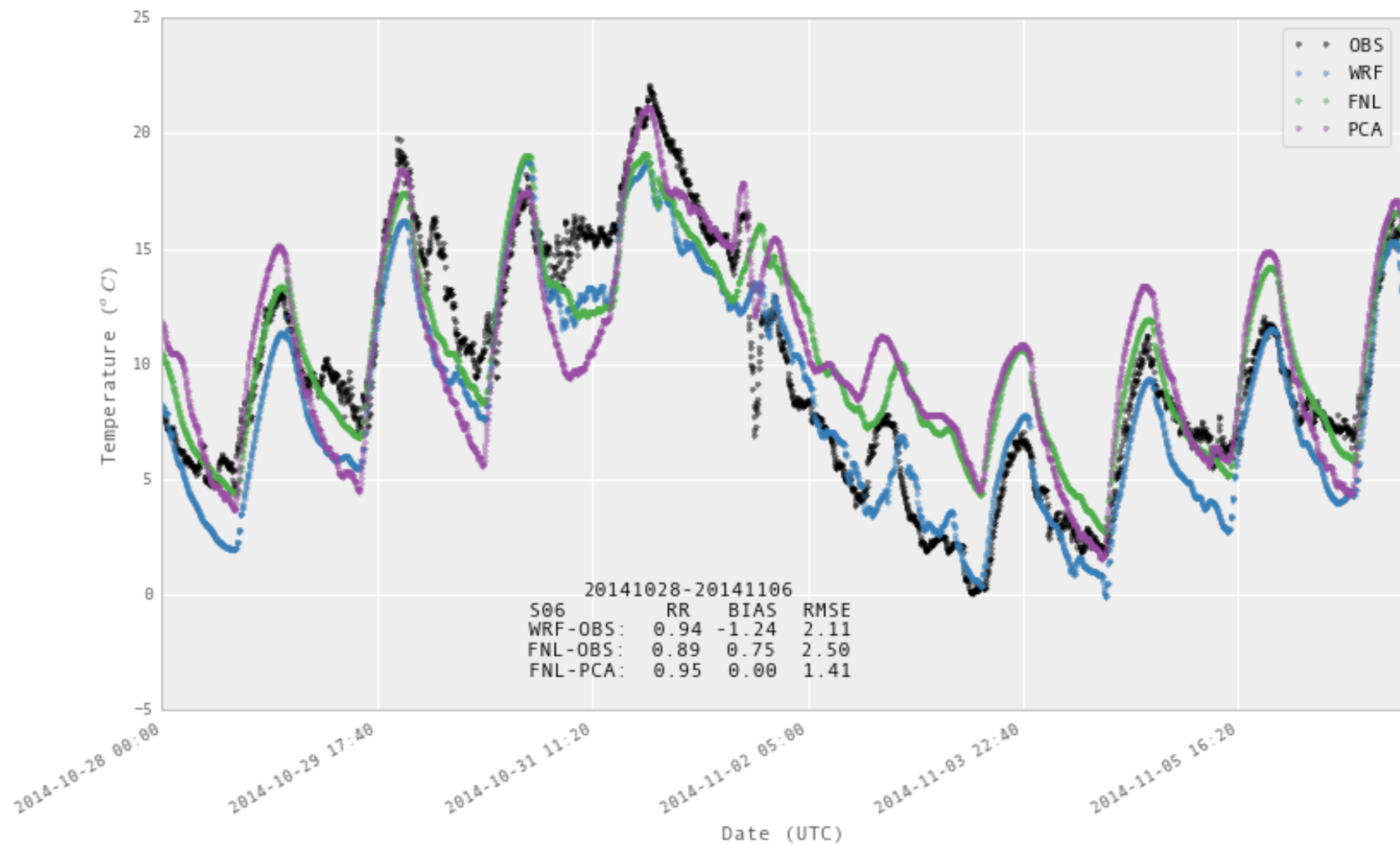
Temperature Kernel Density Estimation (KDE) at S23



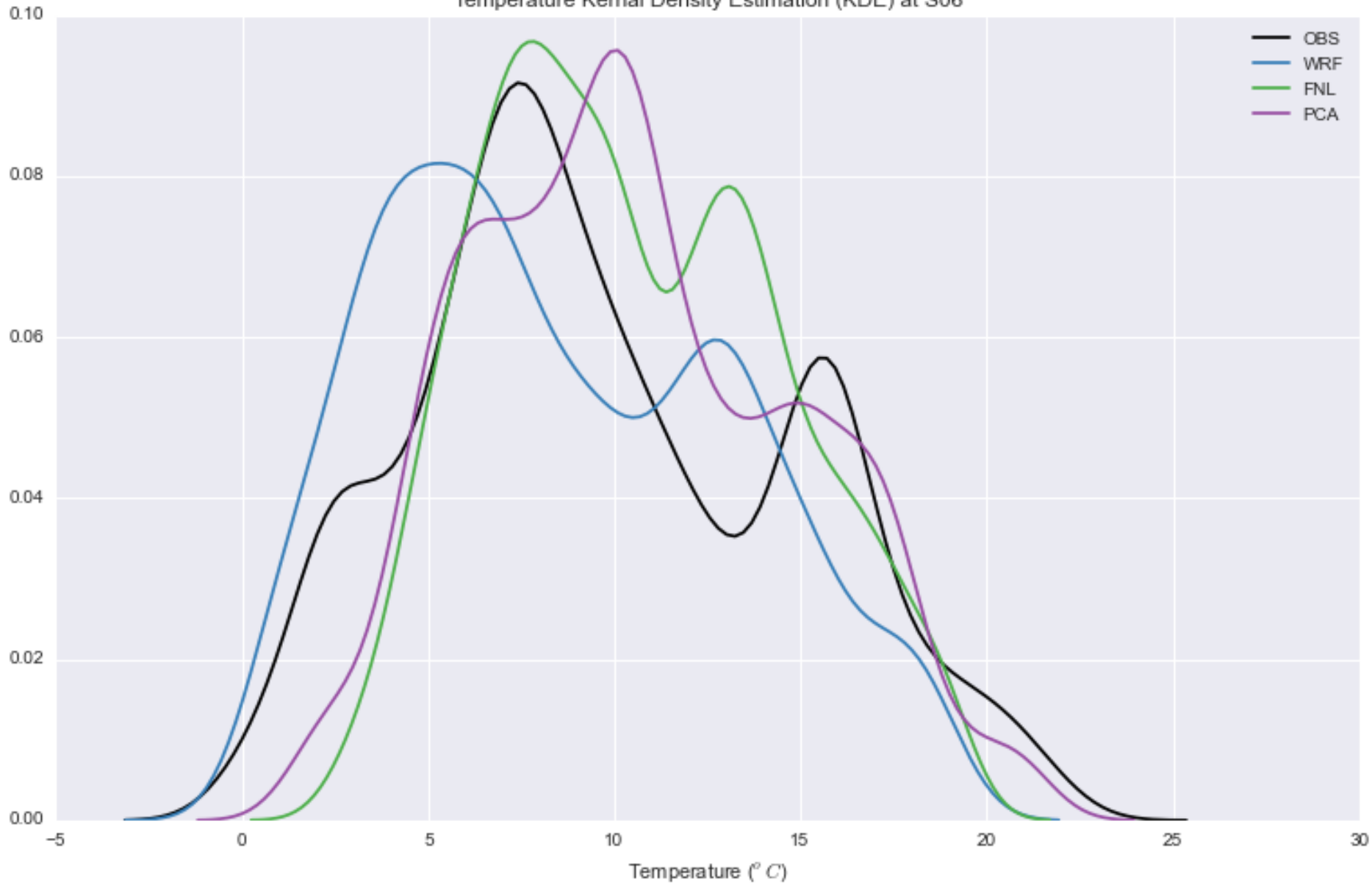
Data Analytics Final Product (FNL) VS WRF, and OBS @ S06



Data Analytics Final Product (FNL) VS WRF, OBS and PCA-Filtered OBS @ S06



Temperature Kernel Density Estimation (KDE) at S06



Summary

- A data analytics framework was introduced for model systematic forecast error reduction. The framework integrates massive observational and modeling data available, It uses WRF forecasts as predictors to establish regression relationship with spatial-temporal filtered OBS, then derives error-reduced 'final' forecasts through iterative PCA filtering.
- Experiment on 10 days forecasts of diurnal temperatures at 27 stations shows promising systematic bias and error reduction, especially for stations with large forecast errors. Temperature diurnal cycle was clearly enhanced.
- The framework can be applied to other meteorological elements.