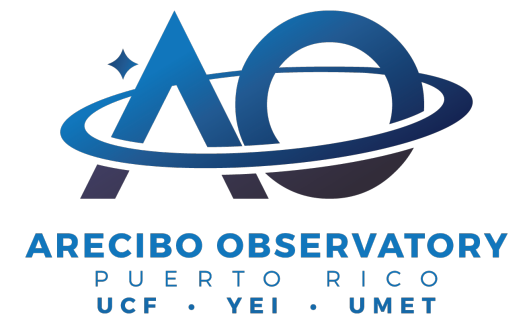
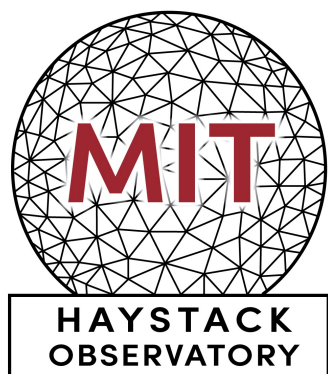


Real time neutral winds from CPI FPIs

John Noto, S. Kapali, R.B. Kerr, N. Riccobono, M. Migliozzi



Approach: High Precision Monitoring of Neutral Dynamics

Started 16 years ago!

Robust design

- ✓ Thermal and mechanical stability over long time period
- ✓ Pressure stabilized
- ✓ Minimal moving parts
- ✓ Air-cooling

Autonomous operation

- ✓ *ImageTool* software operates all airglow instruments
- ✓ Either interactive or robotic operation

Centralized data collection, analysis, and presentation

- ✓ Data as a Service (DaaS)
 - ✓ Centralized operation
 - ✓ different instrument data handled equally



Automated, Internet-aware Dual-Beam Imaging FPIs at MH and AO

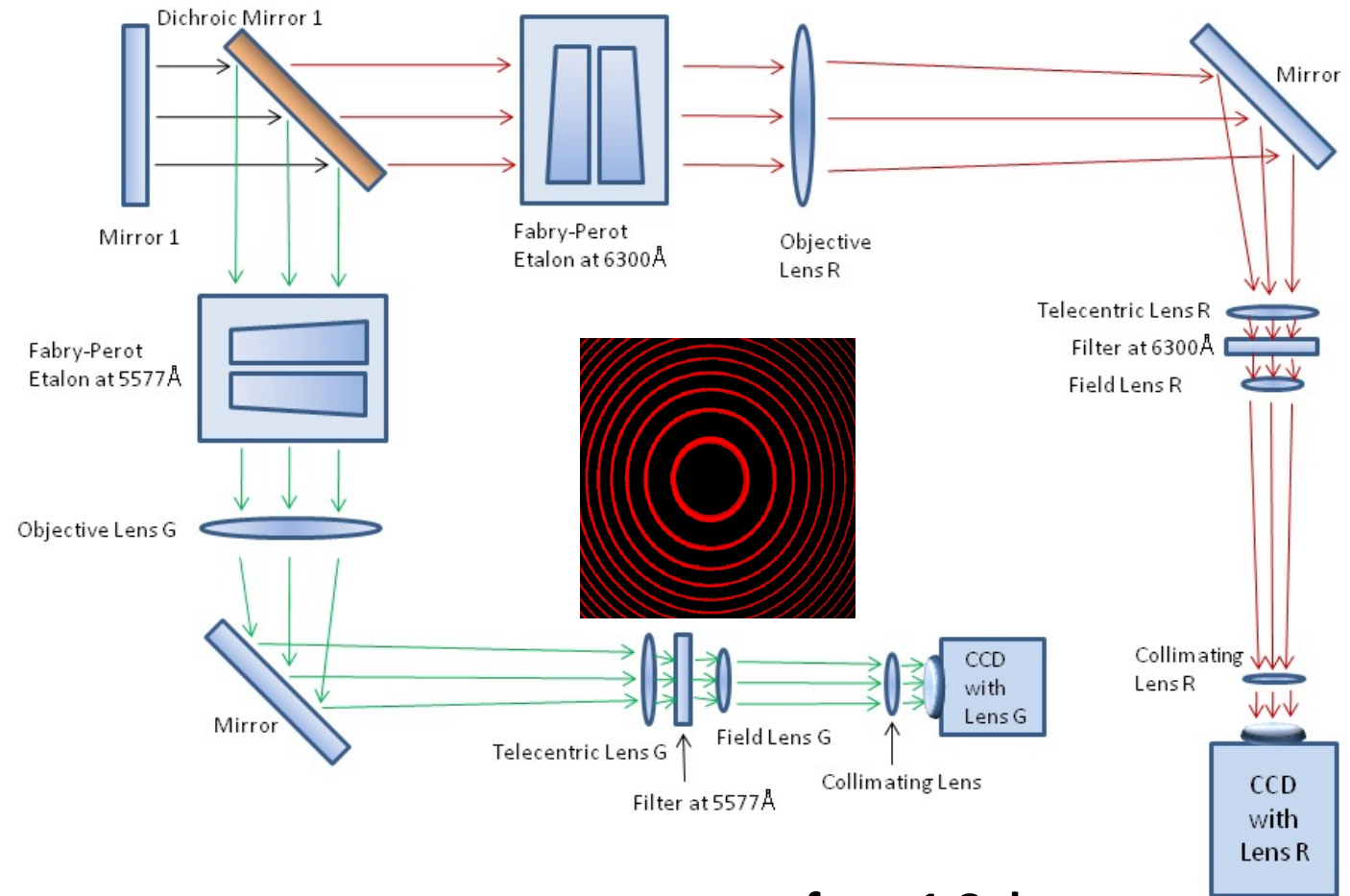
Data are collected during
About 300 nights each
year.

Automated calibration and
sky airglow data collection.

- Automated bias cals
- Automated flat-field cals
- Automated dark cals.
- Automated frequency stabilized laser cals.
- Automated 5 position sky scans (N,S,E,W and zenith)

Reduced data are made available
each morning after data taking on
Madrigal and @

www.neutralwinds.com



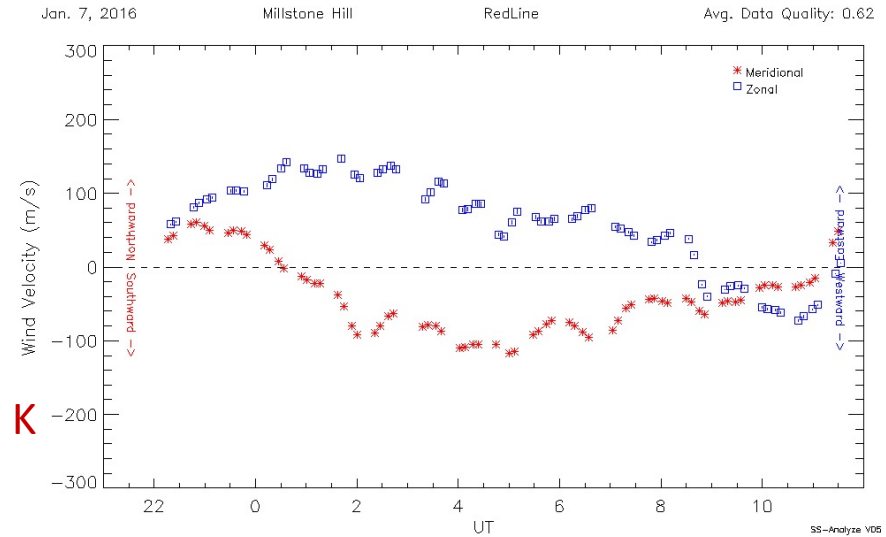
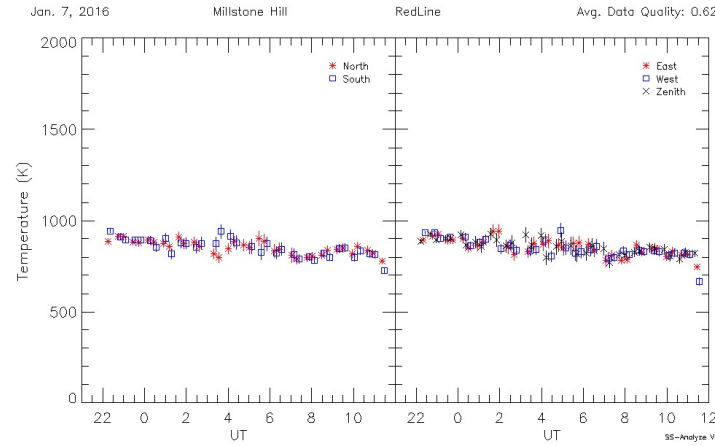
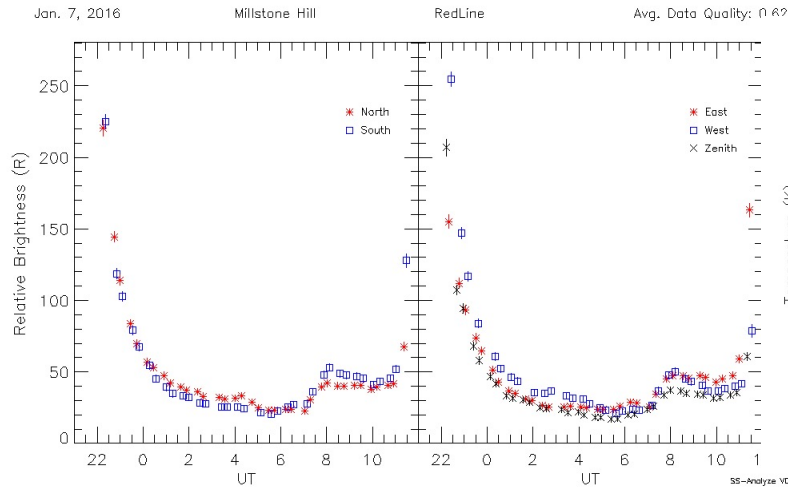
f.o.v. 1.8 deg
7.8 km zenith
11.1 km N,S,E,W

Extracting geophysical parameters

The 5-order summed profile is fit for:

- A linear background
- Amplitude (brightness)
- Linewidth (temperature)
- Doppler shift relative to the zenith (LOS winds in the emission layer)
- N/S and E/W LOS vectors are summed to extract meridional & zonal winds, respectively
- Meridional & Zonal wind gradients are also calculated
- **Vertical wind is assumed to be 0**
- Each cardinal position produces a meridional/zonal vector by interpolation into the partnered LOS wind

Temperature statistical errors: ~ 5 K
Wind statistical errors: < 1 m/s



Real-time Computation of Thermospheric Winds and Temperatures From an imaging FPI

- Data processing pipeline for the Redline FPI instrument is adapted to process image data in real time.
- Initial comparison of real-time and final data products was performed using the Millstone Hill redline FPI instrument.
- Scheduled to go live in the fall of 2021.

Real-time Analysis – Methodology

- Data is downloaded to the data analysis server at the CPI-NE location via rsync protocol.
- The data analysis program is converted to a service that is hosted on the CPI-NE data analysis server.
- There is *no correction for instrument drift* in the zenith and line-of-sight wind calculations.
- Real-time wind and temperature data products are generated as JSON strings that can be consumed via a web-interface.
- The real-time data products are archived on a local repository for comparing with the final data products. This facilitates tuning of the real-time analysis algorithm in terms of performance and accuracy.
- Initial comparison of real-time and final data products was performed using the Millstone Hill FPI instrument.

Real-time Analysis – Millstone Hill Redline Results

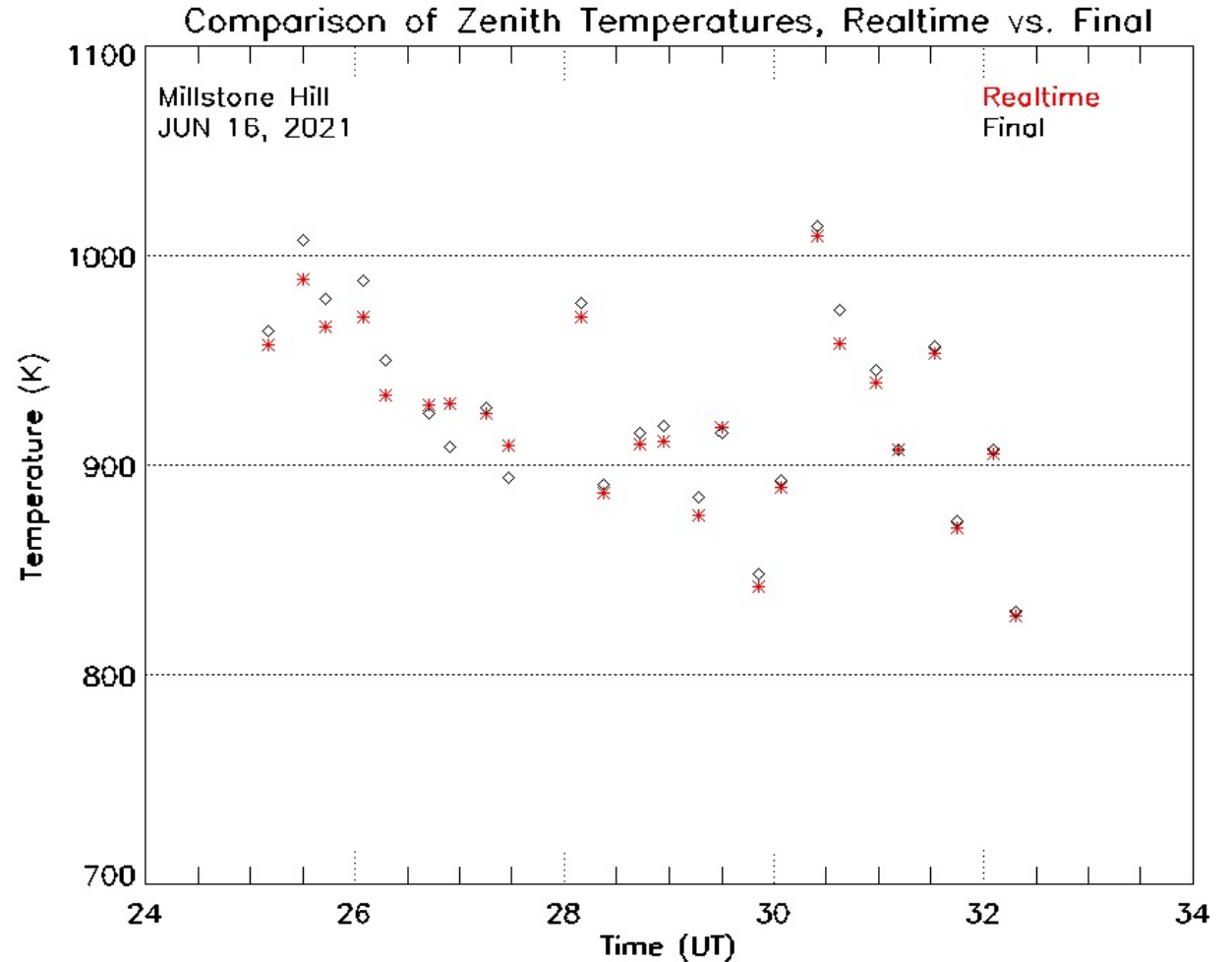
Average difference in temperature: 8.3 K

Pearson Correlation Coefficient
for temperature: 0.98

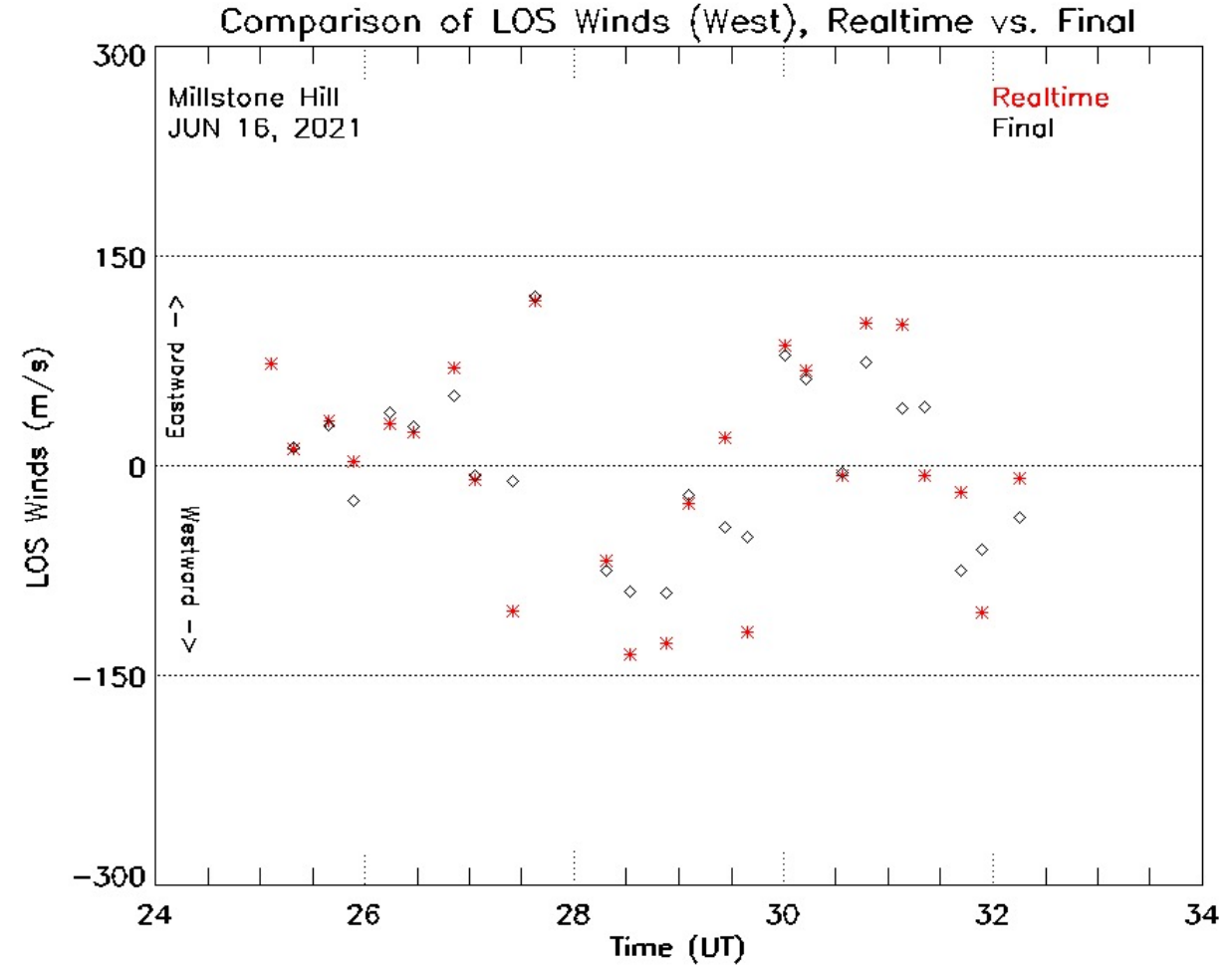
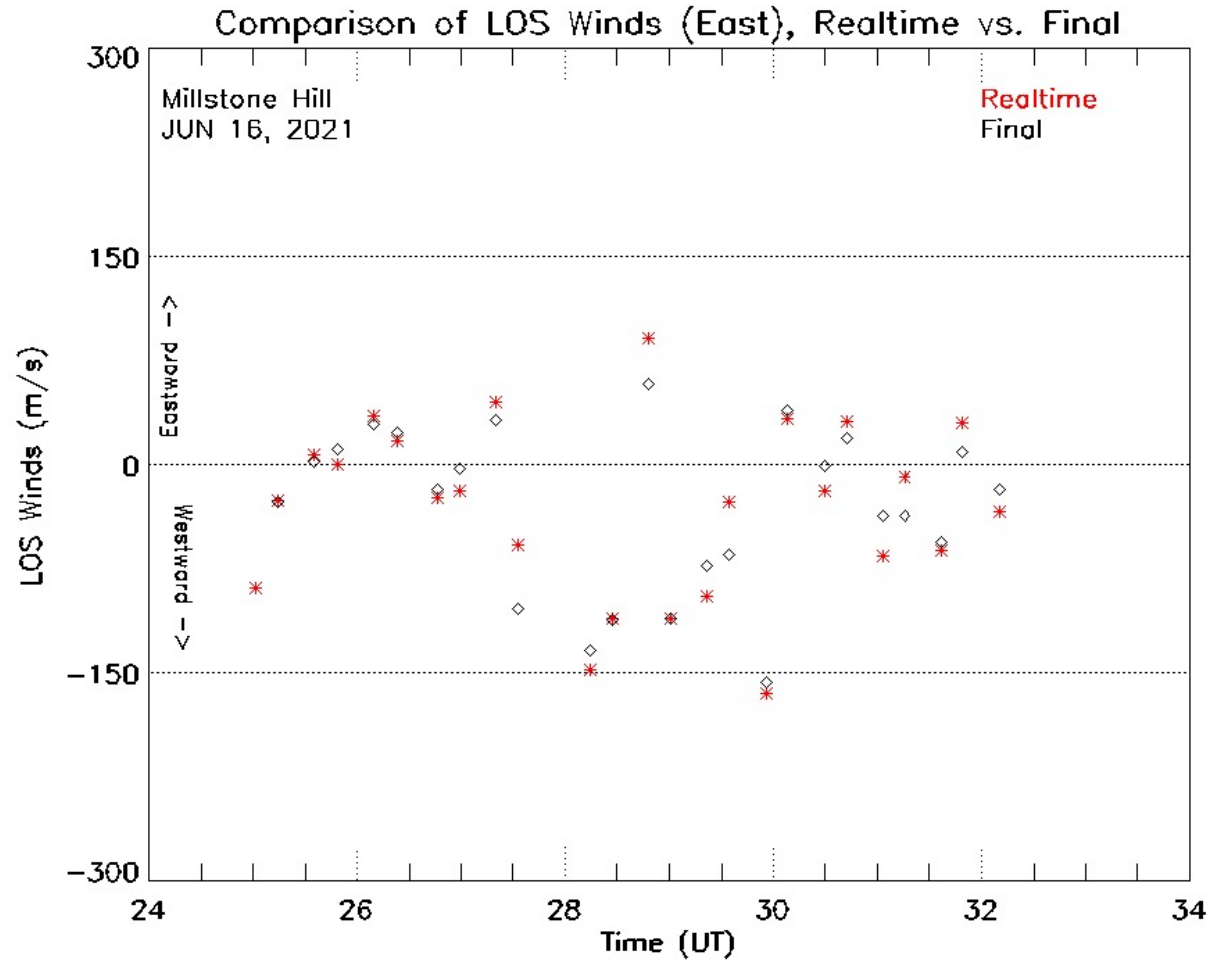
On average, the error in temperature was
larger than the final data products by 1.2 K

New temperature data every 3.35 Minutes

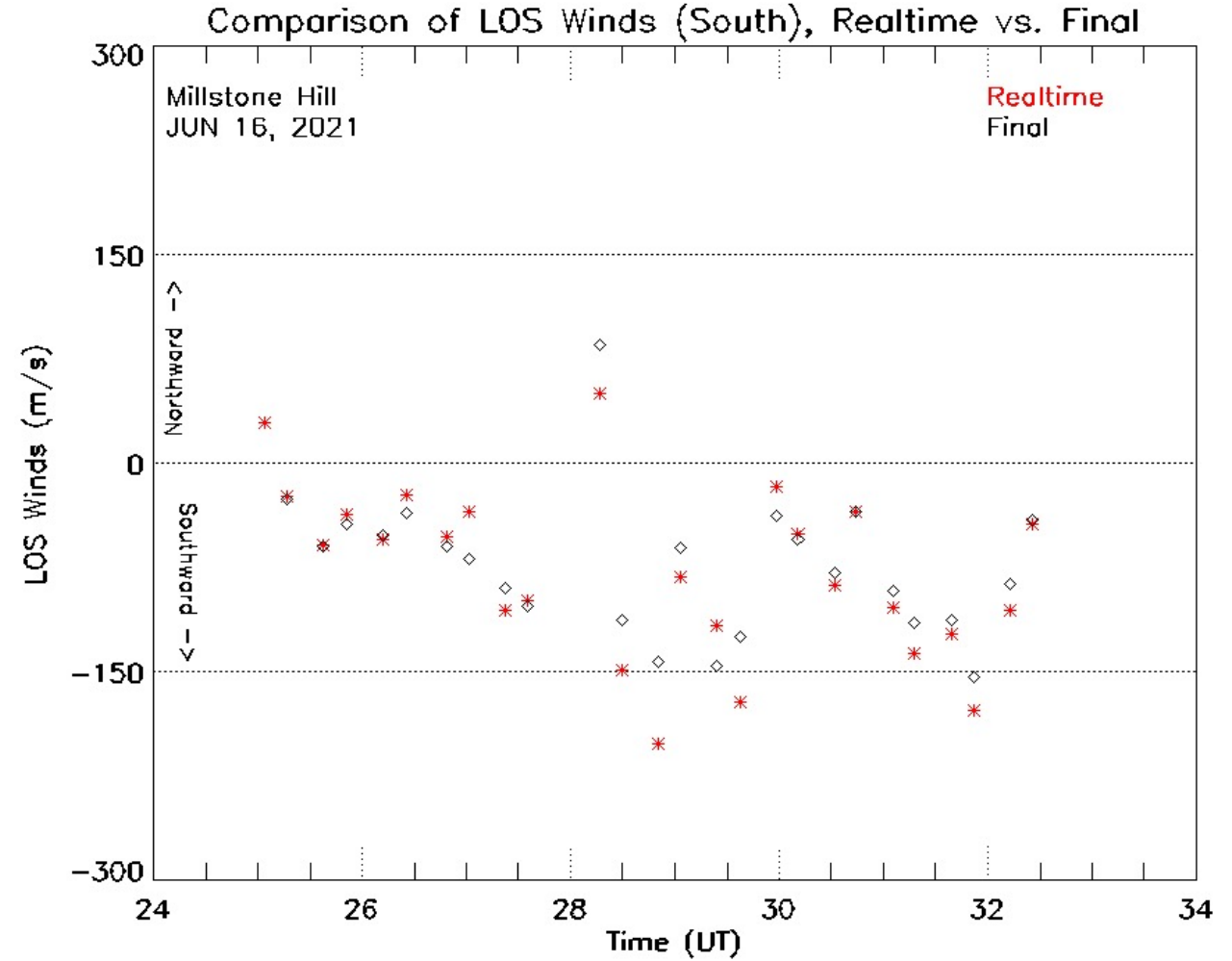
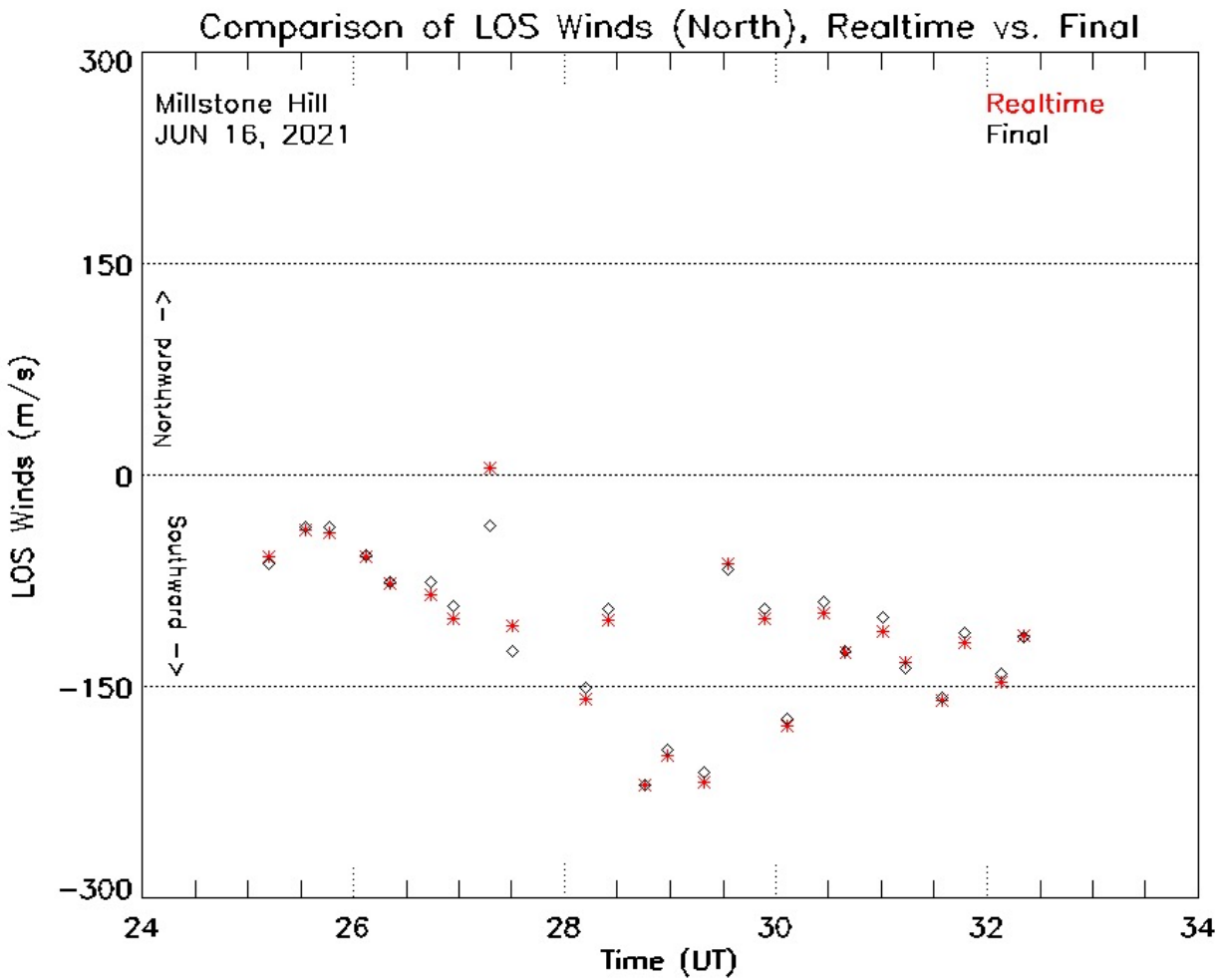
Median time of observation cadence:
2.4 Minutes



Real-time Analysis – Millstone Hill Redline Results



Real-time Analysis – Millstone Hill Results



Real-time Winds – Summary of Comparative Studies

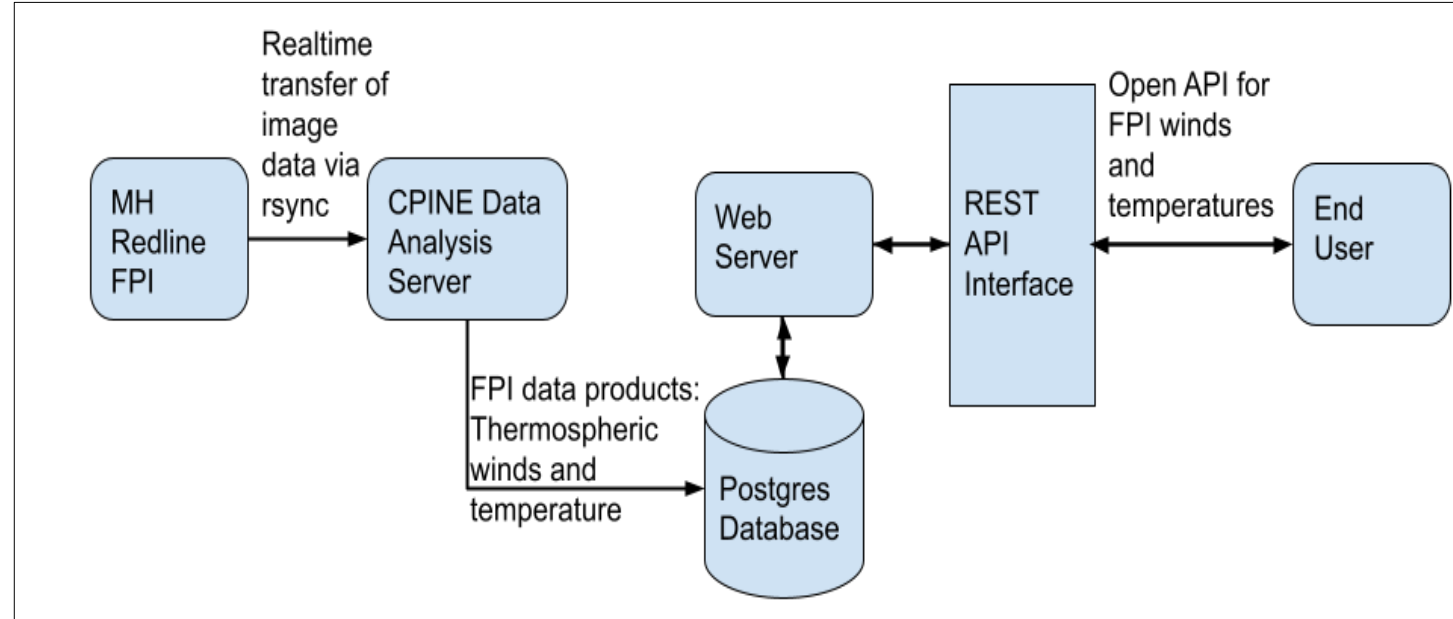
	Pearson Correlation Coefficient	Average difference in LOS winds values	Average increase in error estimates
LOS (North)	0.98	6.96 m/s	0.043 m/s
LOS (South)	0.93	17.62 m/s	0.1 m/s
LOS (East)	0.95	15.06 m/s	0.064 m/s
LOS (West)	0.86	27.98 m/s	0.21 m/s

Good Thermal & pressure control are essential to the quality of the real-time data products!



Future Work

- Open API for self-explanatory and simplified access.
- Add database support to facilitate downloads of past data.
- Improve run-time performance of data analysis.
- Add the Red Line and Green Line instruments hosted by CPI at Arecibo and Millstone Hill.



Architecture of the real-time FPI data analysis system

The End

