

F-region Winds for Space Weather Operational Forecasts

FPI Strengths, Weaknesses, Opportunities and Threats(?)

CEDAR - 2020



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F2-region wind data sources

technique	height	accuracy	Day/Night	comment
<i>in situ</i>				
NATE mass spec	220-400 km	+/- 50 m/s	both	cross-track, poor accuracy, 799 days
WATS mass spec	200-600	+/- 50	both	zonal, poor accuracy 536 days
TMA release	59-277	+/- a few m/s	both	episodic, excellent accuracy; limited altitude
GOCE accelerometer	~475 km	+/- 50-100 m/s	both	crosstrack, indirect, model dependant
CHAMP accelerometer	~300 - 454 km	+/- 50-100 m/s	both	crosstrack, indirect, model dependant
<i>on orbit remote sensing</i>				
FPI DE-2	250	~ +/- 15 m/s	both	meridional only, 308 days, 1981-1983
WINDII UARS Michelson	200-300	~ +/- 15 m/s	night	243 nights, 1991-1996
MIGHTI				aboard ICON
<i>ground-based remote</i>				
ISR (6 sites)	90-400	~ +/- 5 m/s	day/some both	MH & Sonde only >170 km. Model dependant.
Doppler FPIs (>15 sites)	95, 250, 700(?)	~ +/- 1 m/s	night	altitude limited, night only, durable, accurate & cheap
allsky FPIs	95, 250	~ +/- 5 m/s ?	polar night	auroral zone instrument of choice

Weakness: Very limited temporal and spatial coverage

Weakness: No real-time data stream

Weakness: Except FPIs, uncertainties are poor for “weather” applications

Millstone Hill

Arecibo

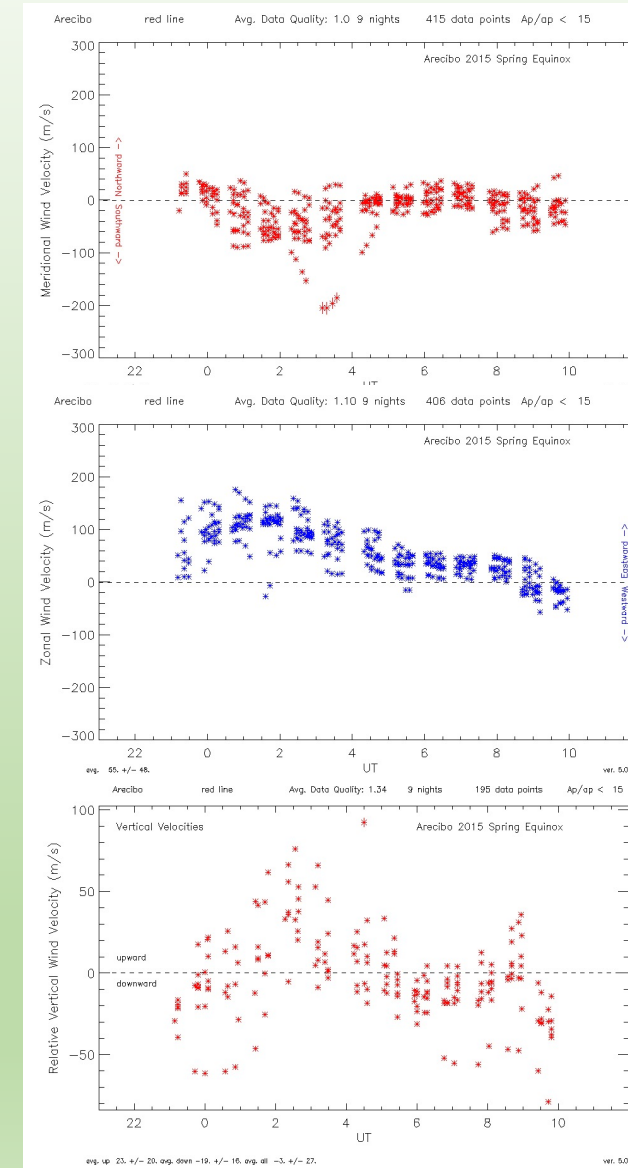
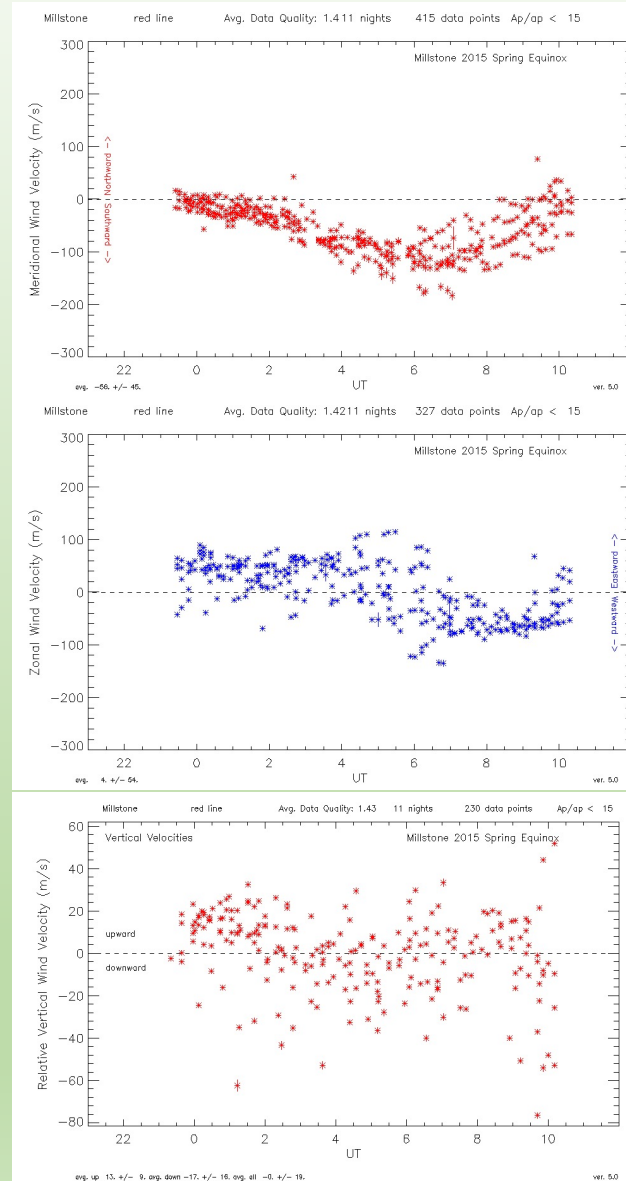
Data are collected during more than 300 nights each year.

Automated calibration and sky airglow data.

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

Reduced data are made available each morning after data taking on Madrigal and at www.neutralwinds.com

Real-time data soon.



Strengths:

- High accuracy
- High precision
- Robust
- Longevity

Weakness

- Night only
- Too sparse spatially
- Single altitude

Climatology

Weather

**October 2, 2013 Storm
(DST -80; Kp 7)**

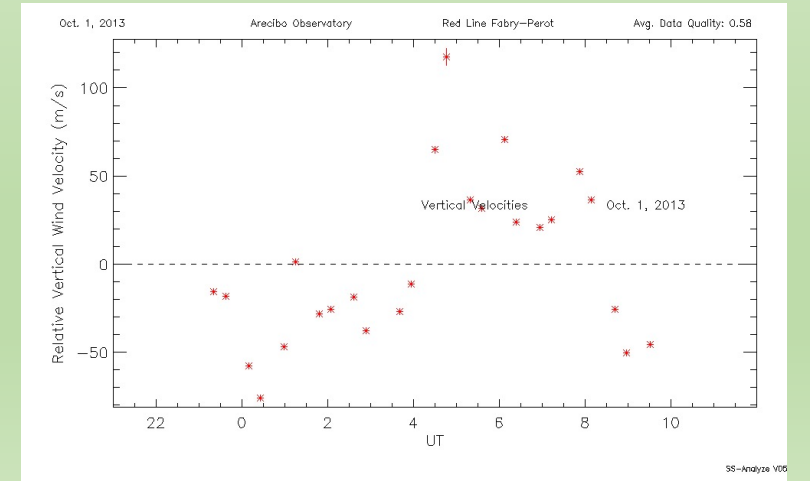
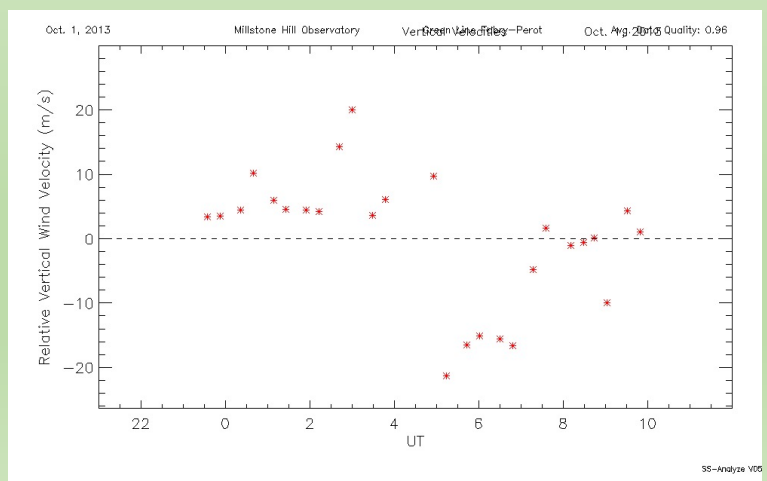
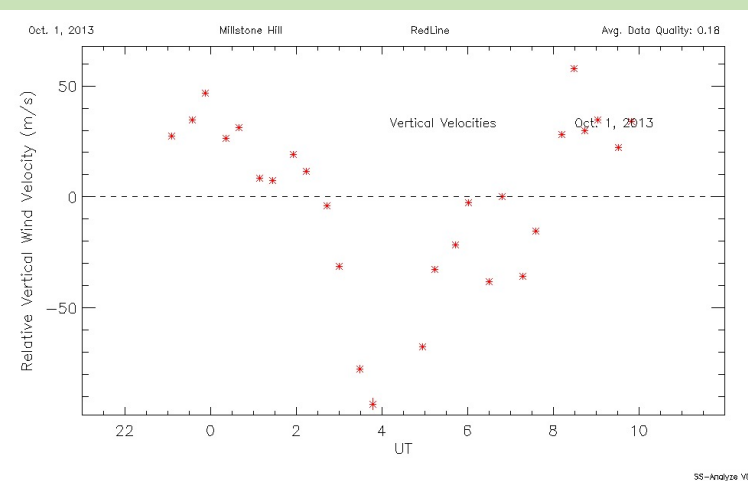
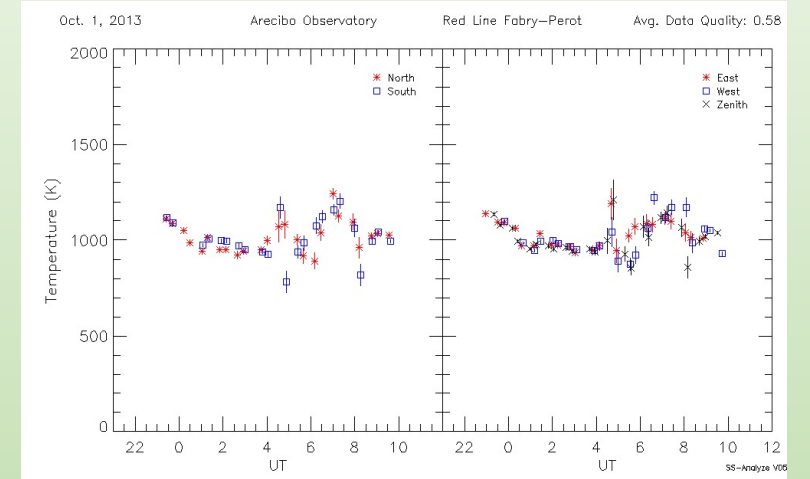
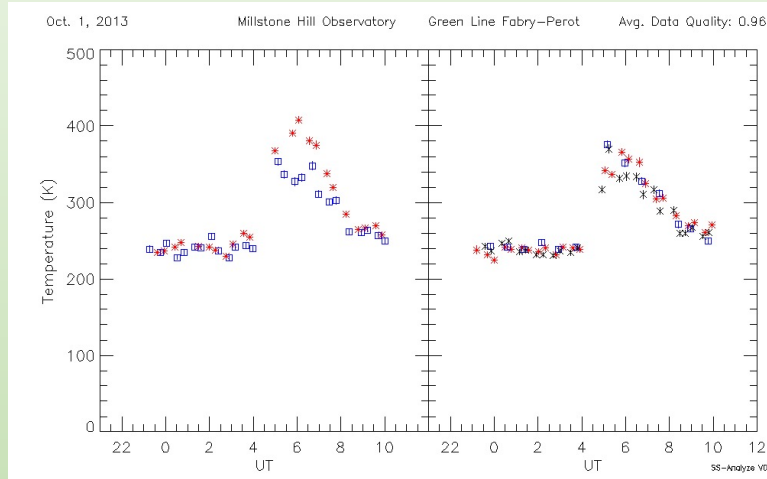
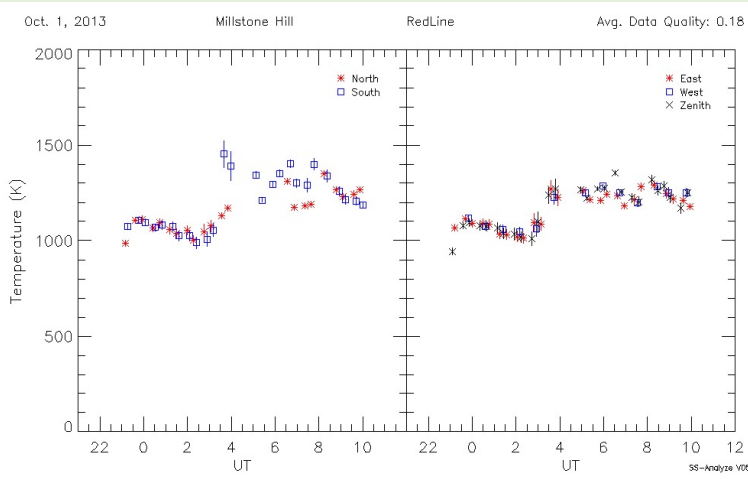
Millstone Hill

Arecibo

630.0 nm

557.7 nm

630.0 nm



FPI Strengths:

- Robust – essentially solid state
- Longevity
- Precision and accuracy
- Direct vector measurement
- Real time data provision

FPI Weaknesses:

- Nighttime only
- Very limited spatial coverage
- Complex operation (no longer true)
- Cost

Opportunity:

We are technologically ready
for ocean buoy deployment



Gyro-Stabilized Platform

SMS-P233



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Phone: +1 (715) 839-0628 Fax: +1 (715) 839-8248
e-mail: support@watson-gyro.com Website: www.watson-gyro.com

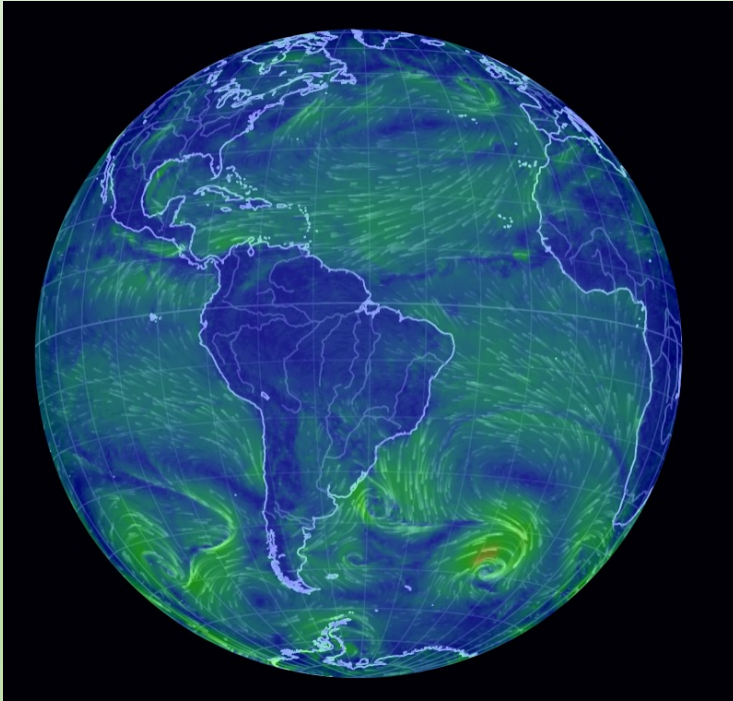


Plymouth Marine Laboratory pml.ac.uk



Weakness: Spatial coverage

- FPIs gridded 1000 km apart cover the entire Pacific Ocean with ~331 FPIs
- With a cost target of \$200k/buoy, the Pacific is populated for ~\$66.2M, and operating costs of ~\$6M/year (UARS: \$750M)



How do we lower FPI cost?

- Community source of polished flats
- Community camera acquisition



Photo credit: Skywatch Newsletter, July 2011.

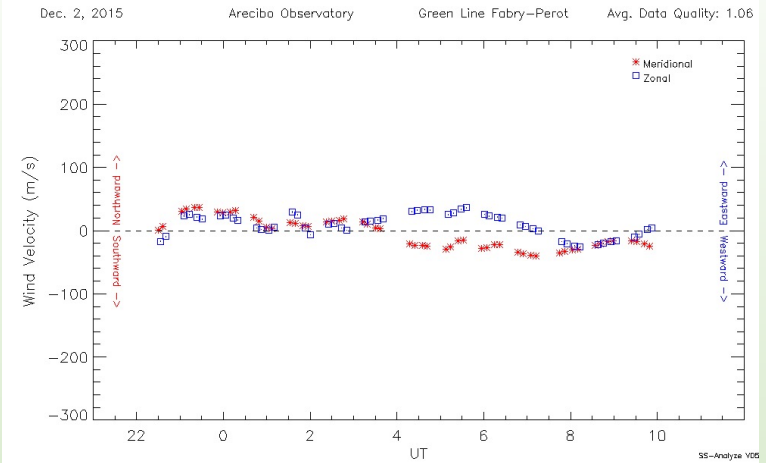
Horizontal wind as a function of altitude

- The increase of the wind speed with altitude is roughly consistent with a steady flow through a medium with density exponentially decreasing with altitude.

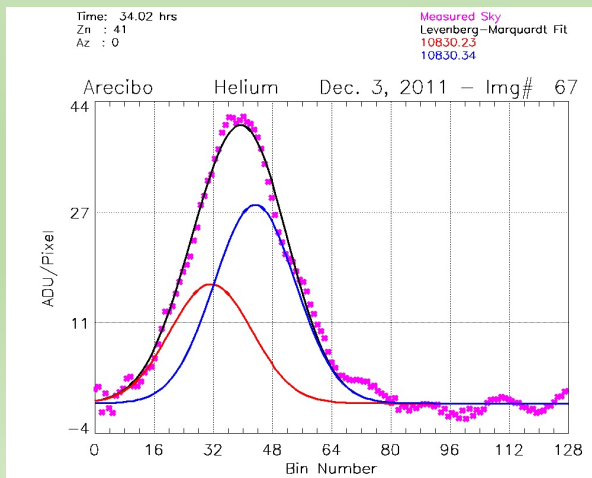
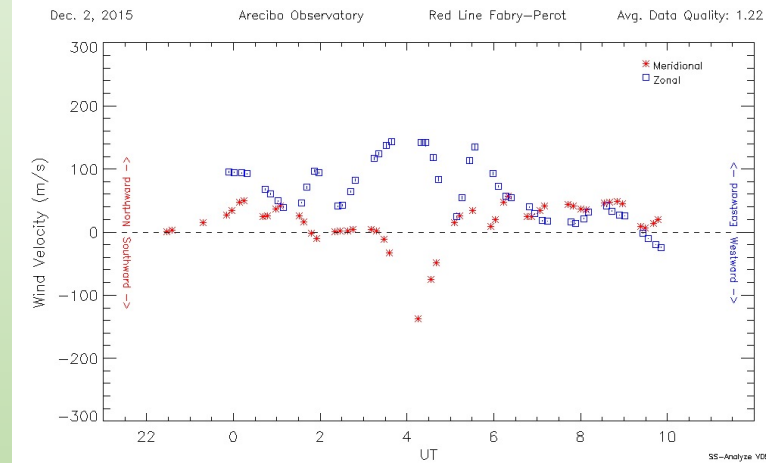
- We have one, tantalizing example of meridional winds in the exosphere, near 700 km, at Arecibo.

- Strong horizontal winds in the exosphere enhance the H escape flux, and efficiently redistribute light species in a region with vanishing viscosity. [Hartle and Mayr, 1976]

~98 km
OI 557.7 nm



~220 km
OI 630 nm



~700 km
He* at 1083 nm

