The Second-generation Optimized Fabry-Perot Doppler Imager [SOFDI]: Daytime Measurements of Thermospheric Winds

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Special Thanks
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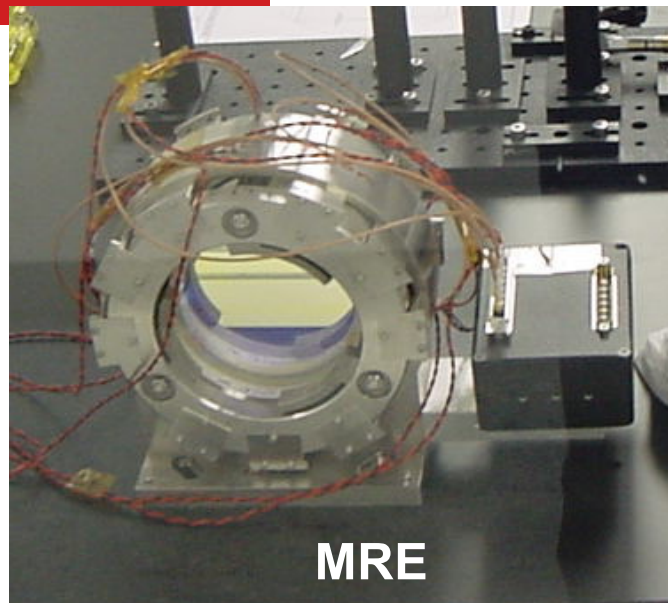
Many IGP Personnel

SOFDI

What is SOFDI?



- Essentially: A triple-etalon Fabry-Perot interferometer

  HRE: 88 mm diam., fixed 1.0007 cm gap => 12 fringes
  MRE: 88 mm diam., 0.1861 cm pzt tunable gap
  LRE: 88 mm diam., 0.0241 cm pzt tunable gap

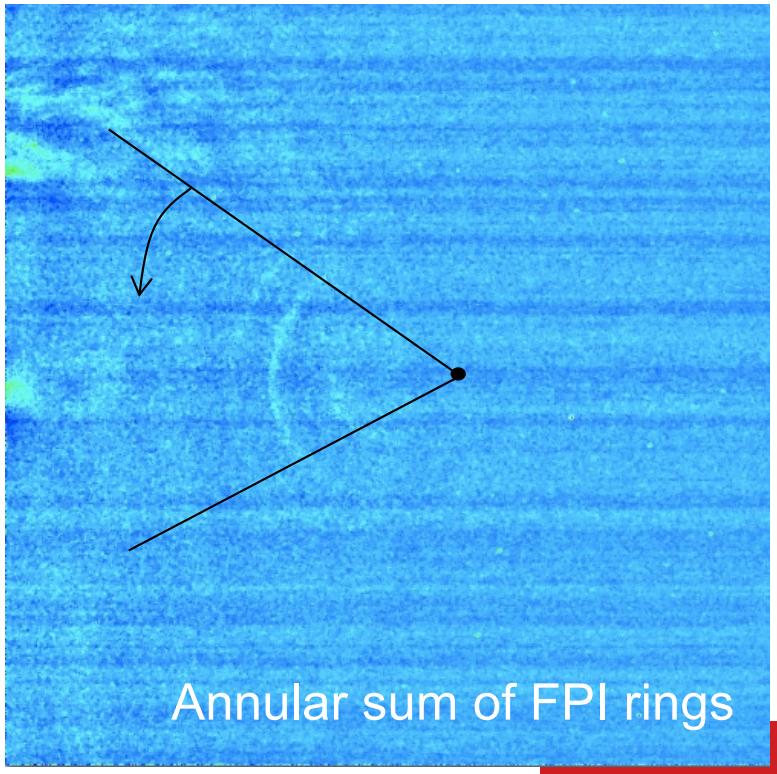
- For nighttime data: Use only the HRE
- For daytime data: Use all three etalons to substantially reduce transmission bandpass of system

- Similar in design to HRDI of UARS (e.g., same etalon gap spacings) but back-thinned CCD with 90% QE

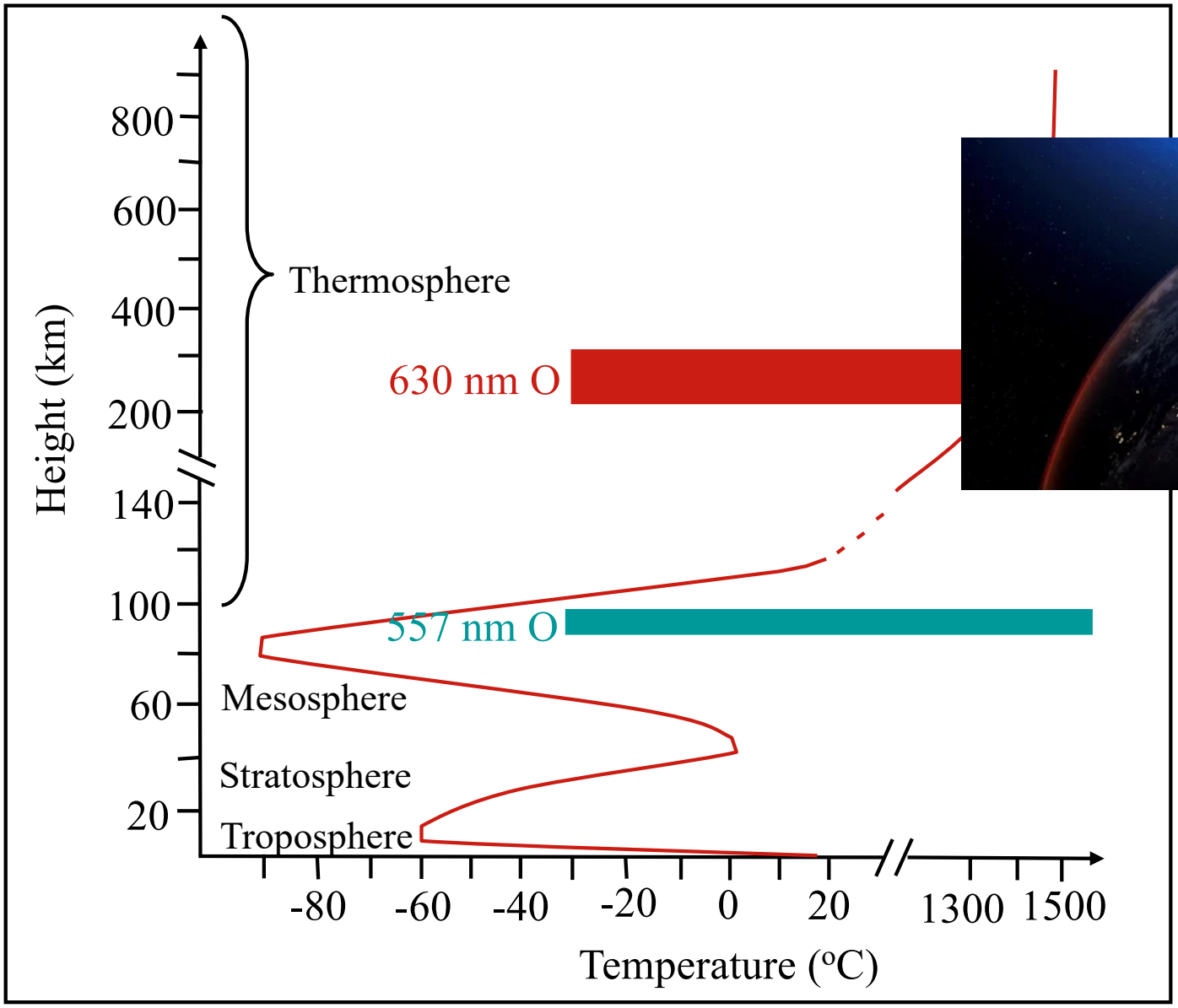
Thermospheric 630-nm OI and mesopause 557.7-nm filters for wind observations

- Mounted in a ruggedized, relocatable platform (trailer) with satellite broadband web access

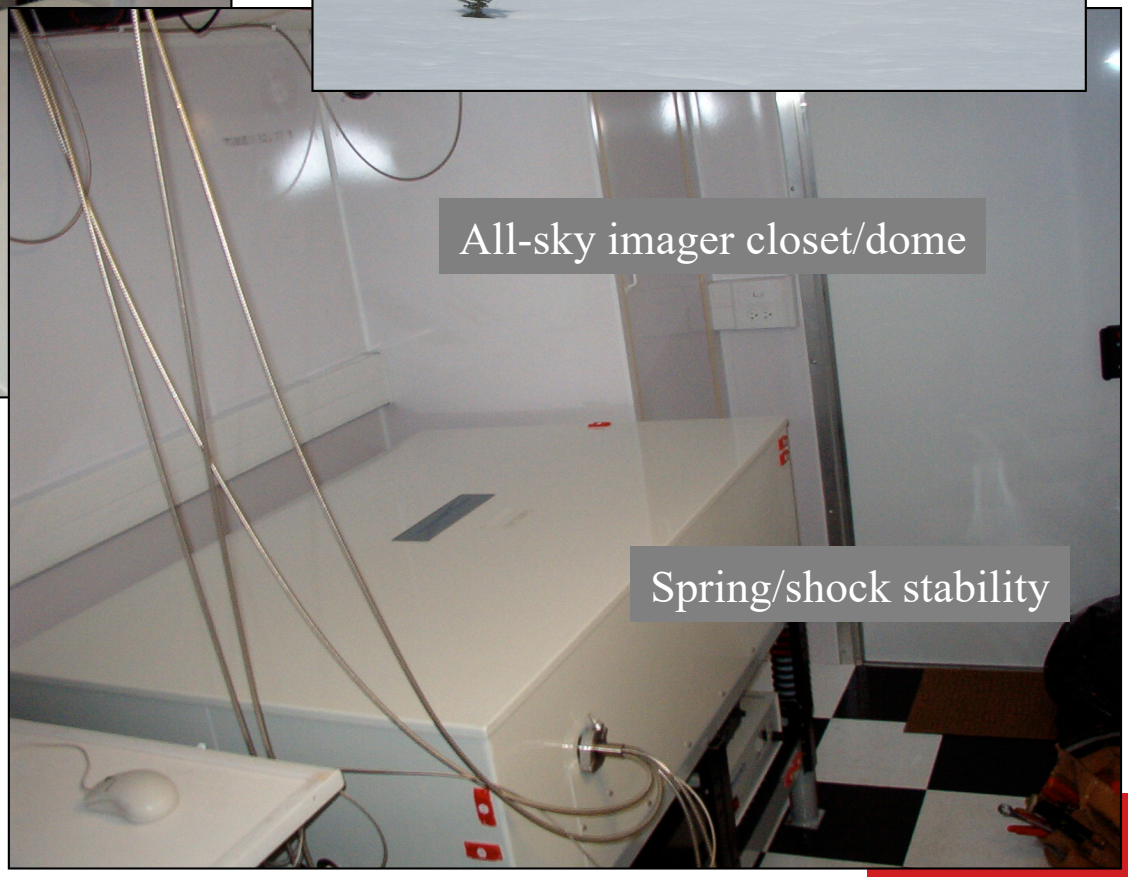
(Discussed in Gerrard and Meriwether [2011, JGR], and Gerrard et al. [2011, SPIE J. of A. R. S.])



Earth's Atmosphere



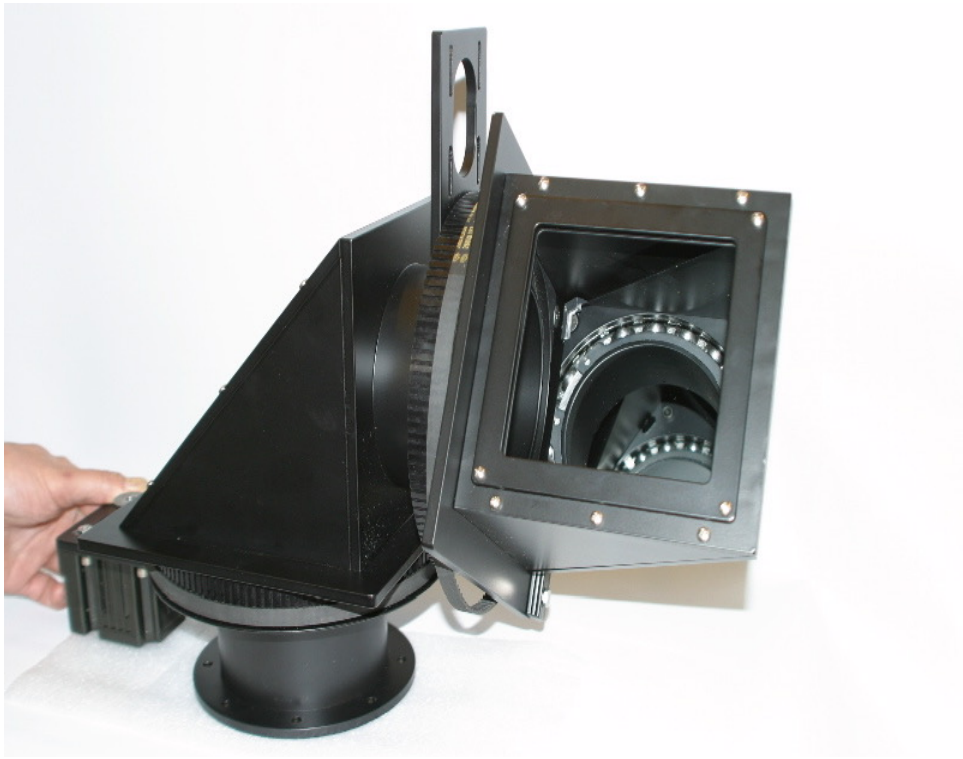
Environmental controls
keep ambient temperature
at 26 °C



All-sky imager closet/dome

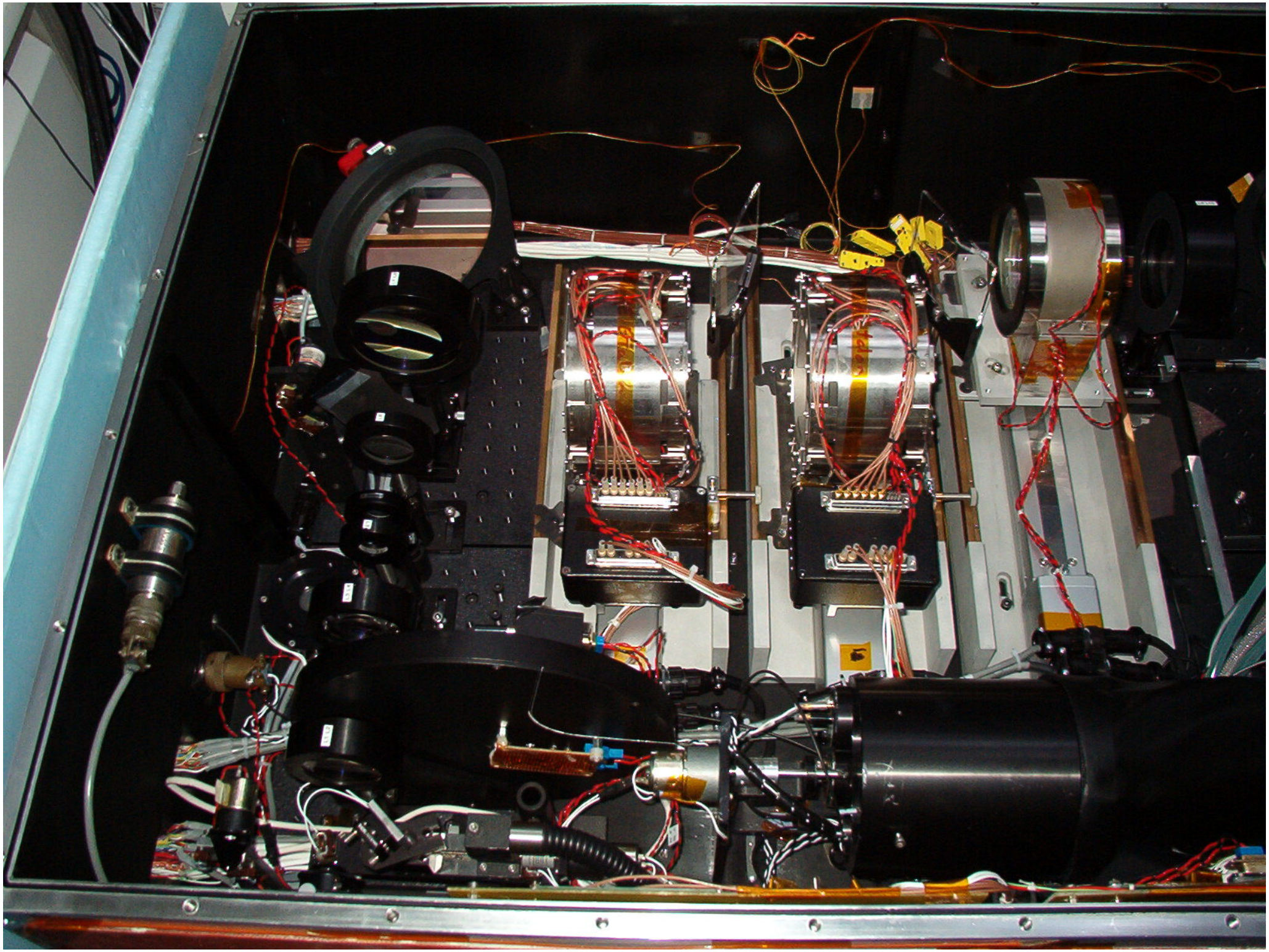
Spring/shock stability

SOFDI chamber
3/4” Al casing
(cover weighs ~135 lbs)
temperature stability ~0.01 °C
purged with N2



Four SkyScanners

Quad-fiber Optic Cable



sofdi-1

RSView32 Runtime 150

Main - Display

Full Screen

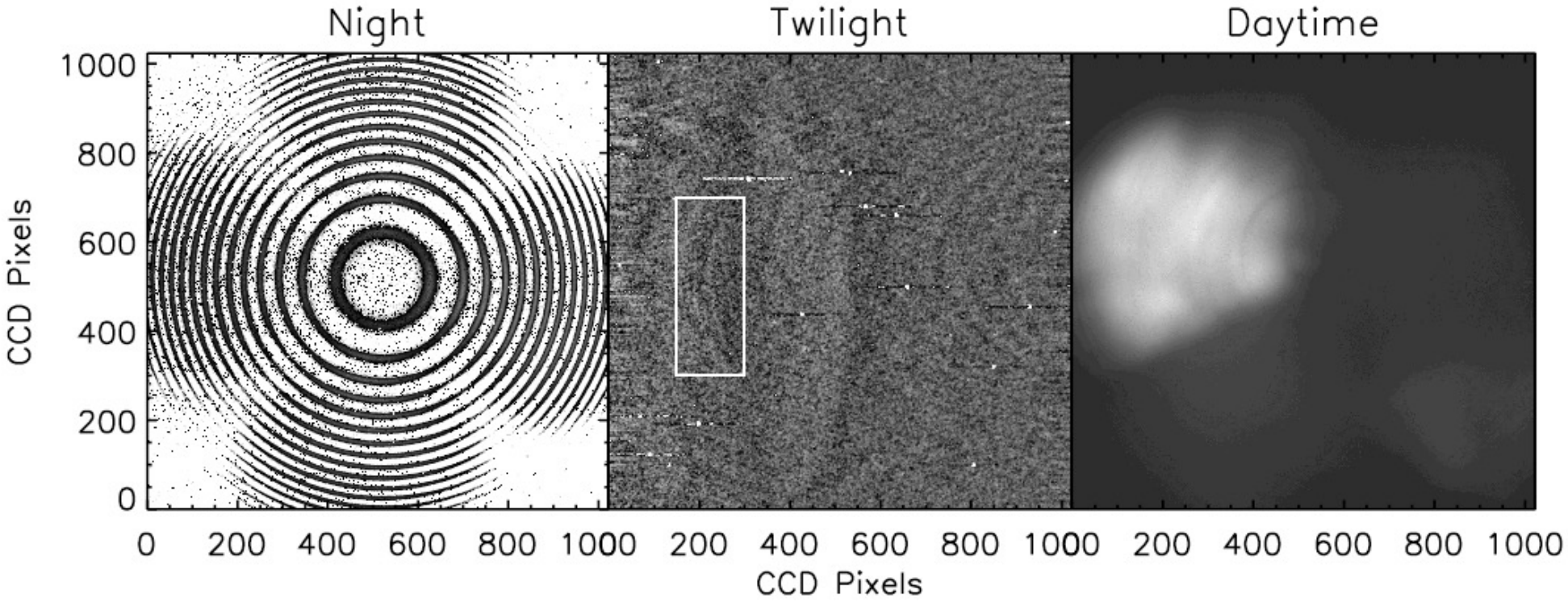
Outside	Inside	ASI	Coolant	Electronics	Equip. Rm.
50 °C	50 °C	50 °C	50 °C	50 °C	50 °C
-20	-20	-20	-20	-20	-20
0.0	24.2	21.4	19.6	25.4	13.0

Alarm Screen

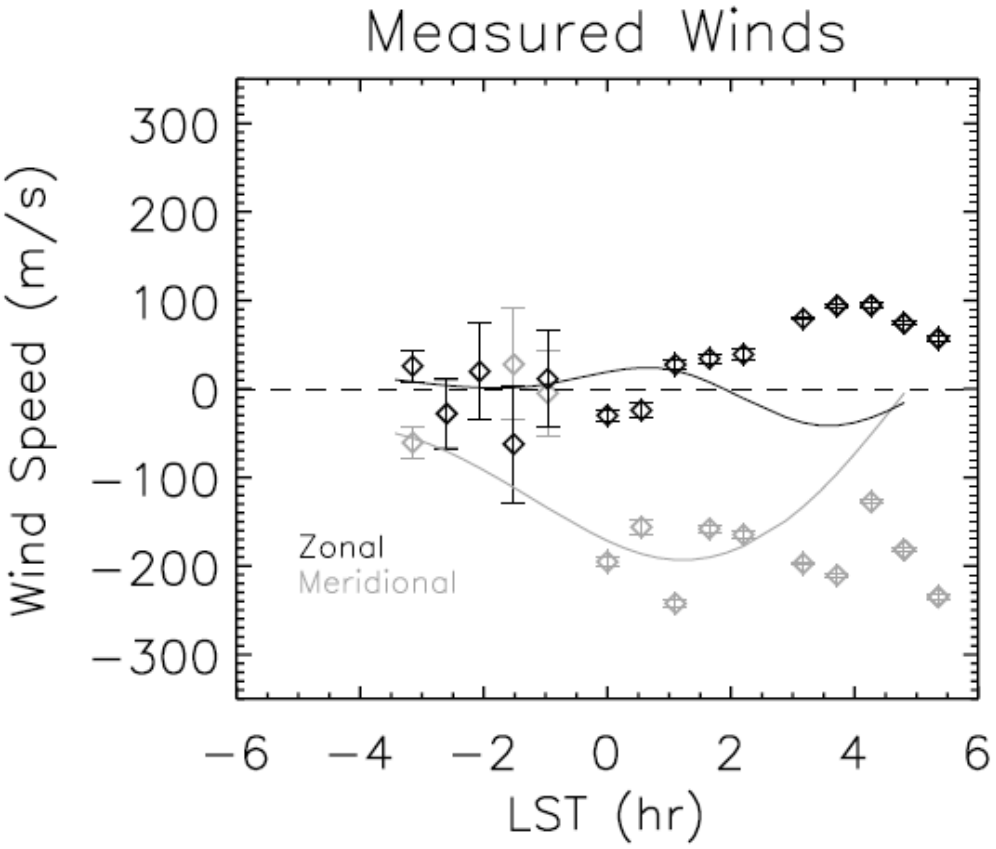
Clear | Clear All

Start | RSView32 Runtime 150 | TagServer | 1:48 PM

Typical SOFDI Data

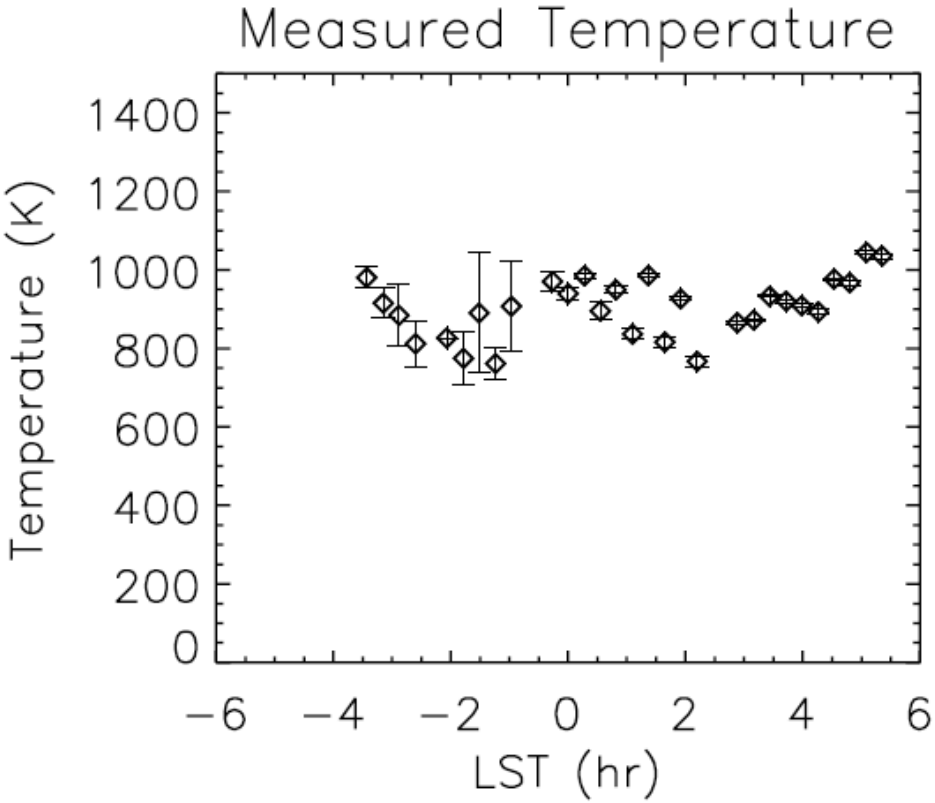


Nighttime OI 630-nm Winds and Temperatures are EASY!



Data from 2005 from upstate NY

Lots of system tweaks since 2005…
- New pointing heads [2006]
- New filters [2007]
- New methodologies [continual]
- [Cirrus clouds…]



Daytime…
A “Bit” Tougher

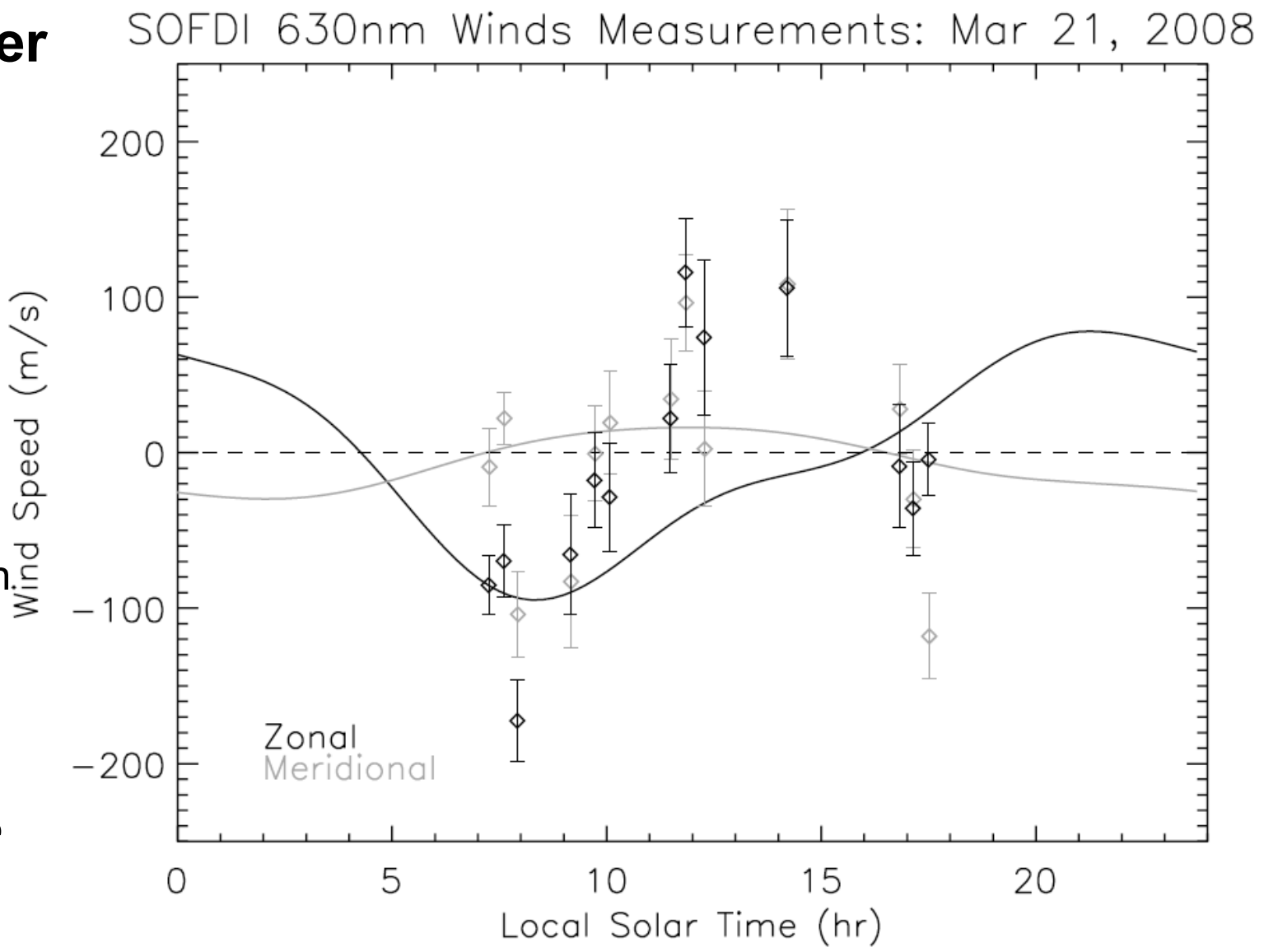
But done!

Are these large uncertainty bars?

NO!

1) Only using 1/4 system etandue
2) Mid-latitude trough
3) Low solar activity

More Importantly:
Better than infinite uncertainty bars!



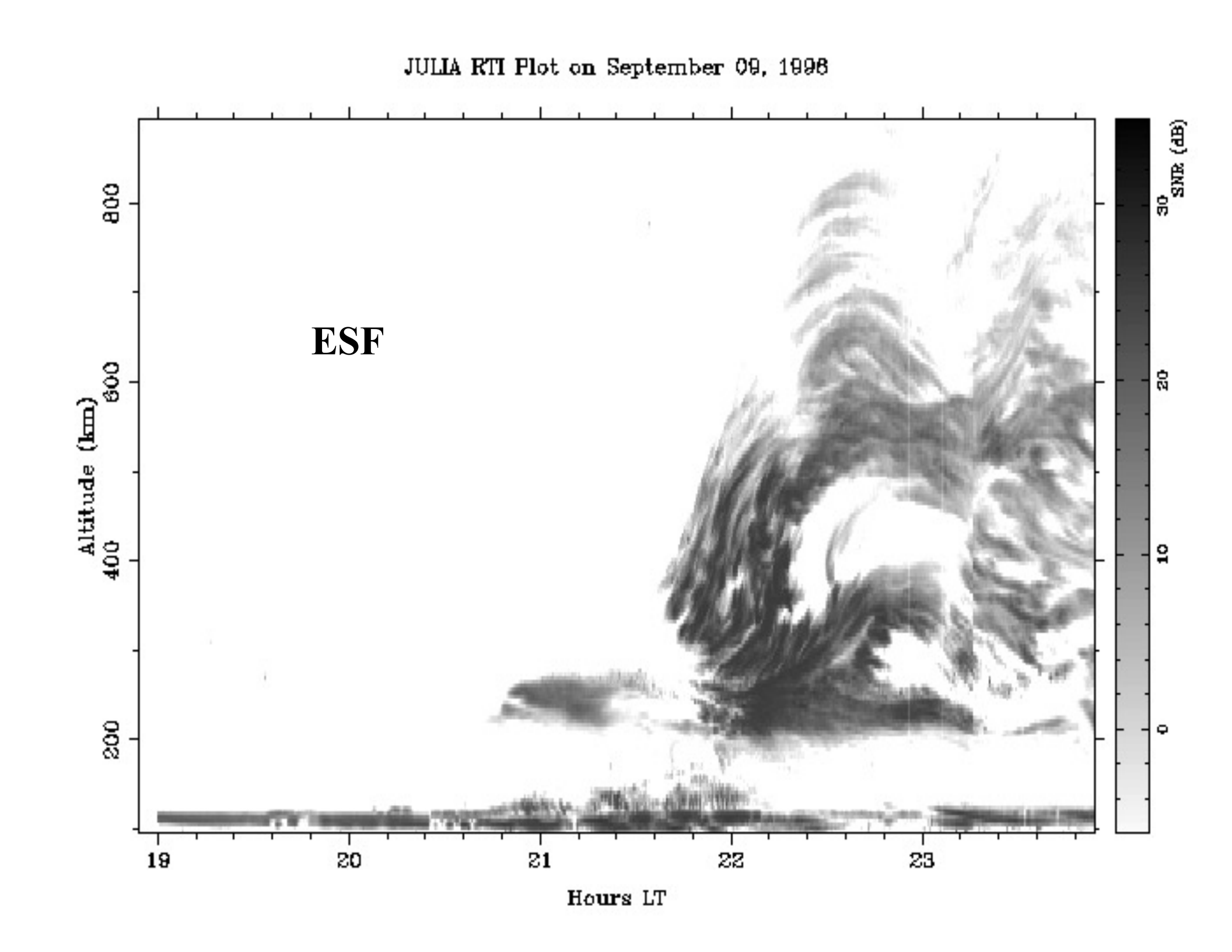
One Particular Measurement Phenomena: Equatorial Spread-F (ESF)

1) An effect that occurs in the nighttime equatorial region, now known as ESF, disrupts radio communications, particularly the L-band (~1 GHz, ~VHF and microwave) and surrounding communication/navigation frequencies.

2) This 'disruption' is in the form of radio scintillation, an effect caused by the loss of coherency of the radio wave phase fronts due to the scattering off of irregularities of the same size as the radio wavelength (similar to the scintillation of starlight leading to 'twinkling'). Power loss is ~10 dB.

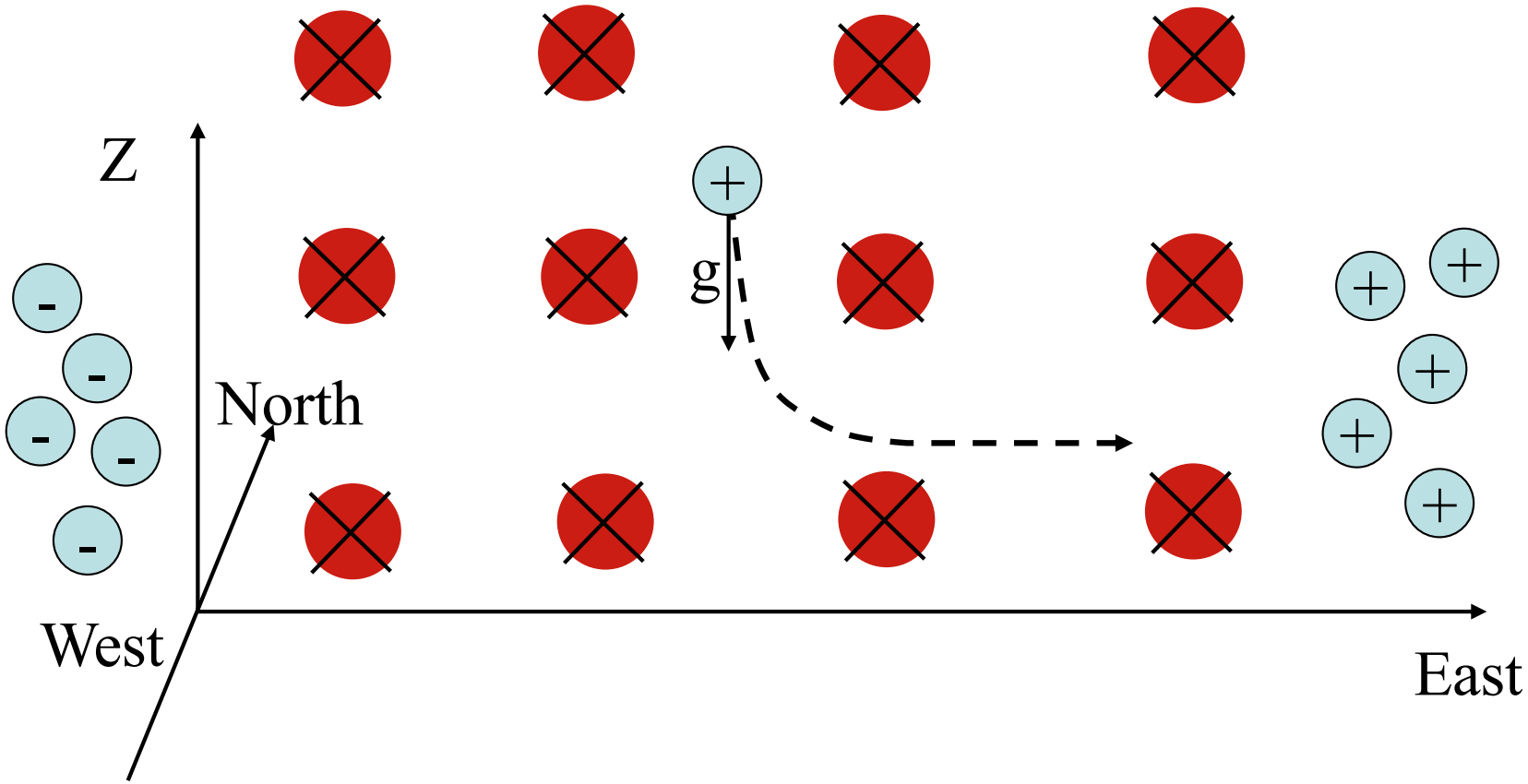
3) The basic physical mechanisms that cause ESF are generally well-known, and DSP measures can be taken to account for the signal degradation.

HOWEVER: The community still cannot forecast the occurrence of ESF…


JULIA RTI Plot on September 09, 1996
ESF
Altitude (km)
200
400
600
800
19
20
21
22
23
Hours LT
SNR (dB)
0
10
20
30

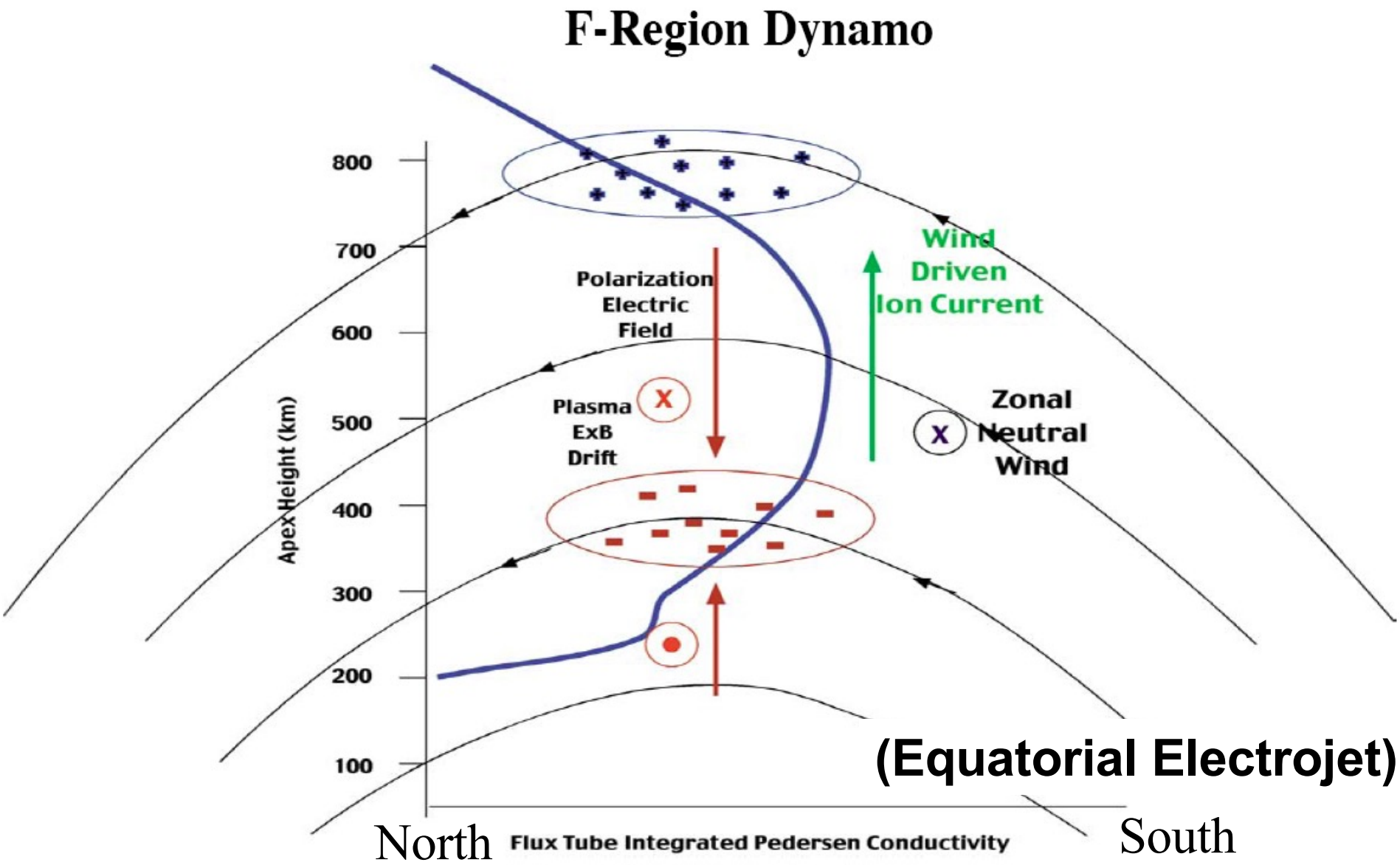
What Are Physics of ESF?

First, Consider the Following… (post-sunset at the equator)



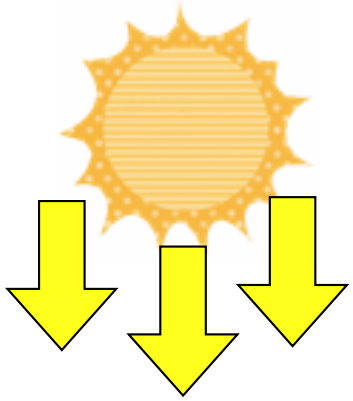
The **g**×**B** Dynamo

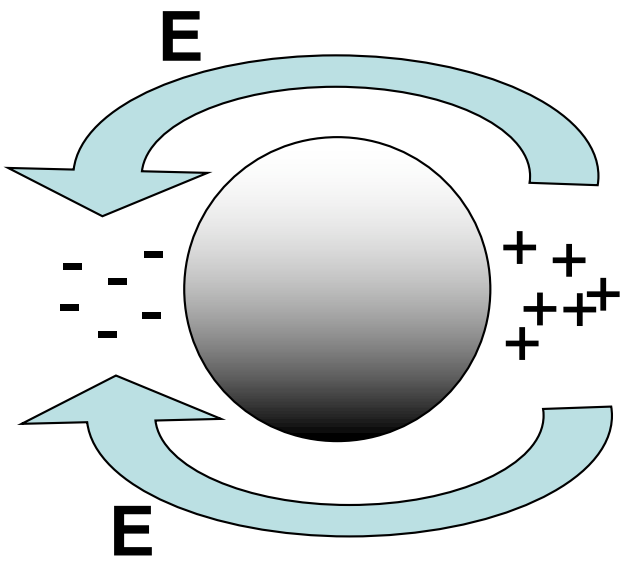
Also Consider…



Plus… E-Region Dynamo

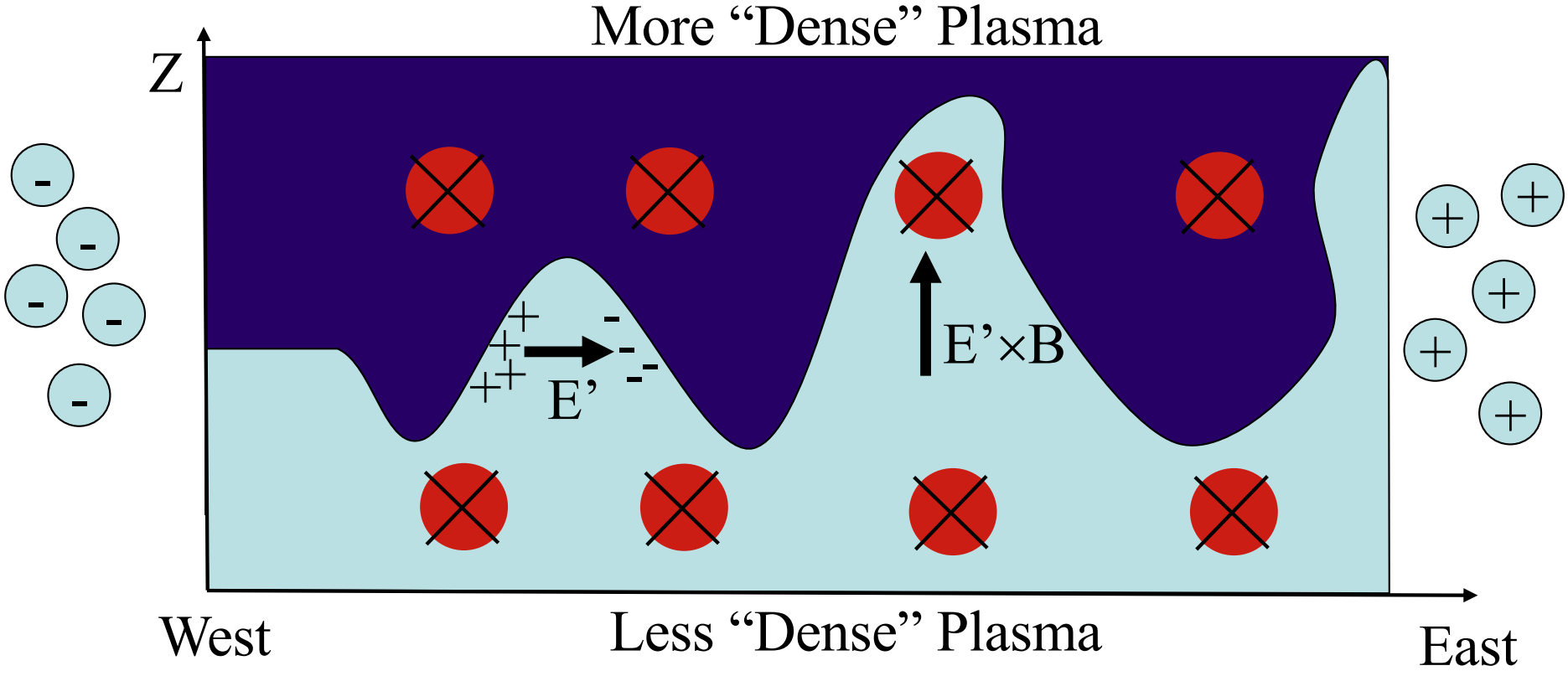
Leads to the Following E-field Pattern





This E-field plays a pivotal role in equatorial phenomena

Causes of ESF: Rayleigh-Taylor Instability

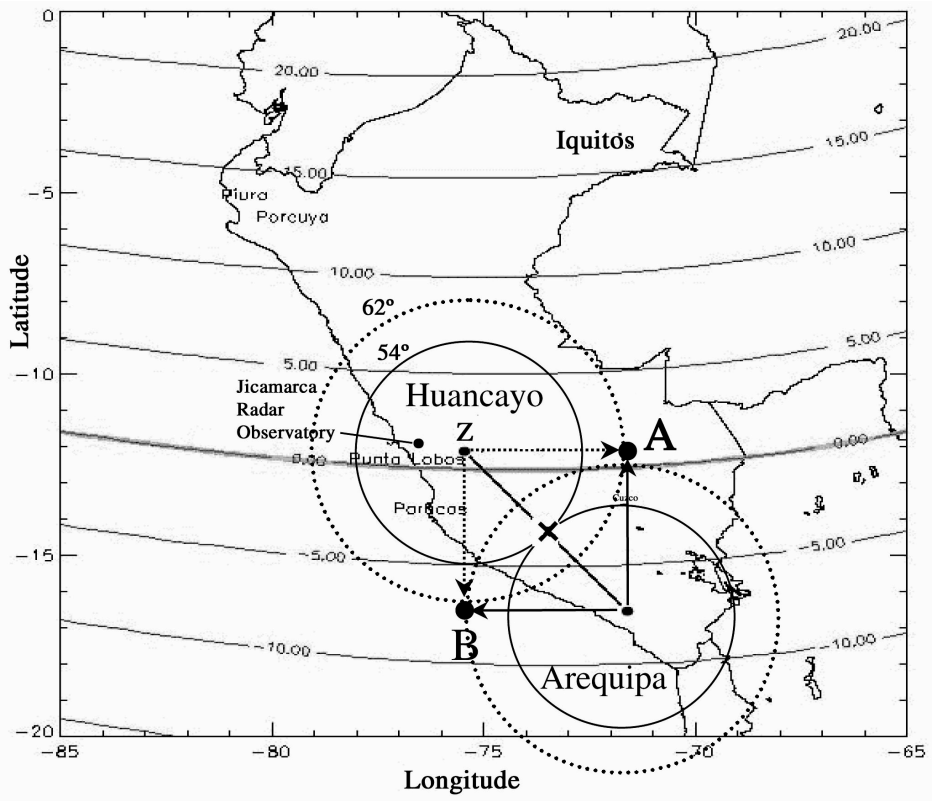


So… we "know" what causes ESF, but how do we use this knowledge to forecast it?

⇒ Must understand the conditions that cause ESF

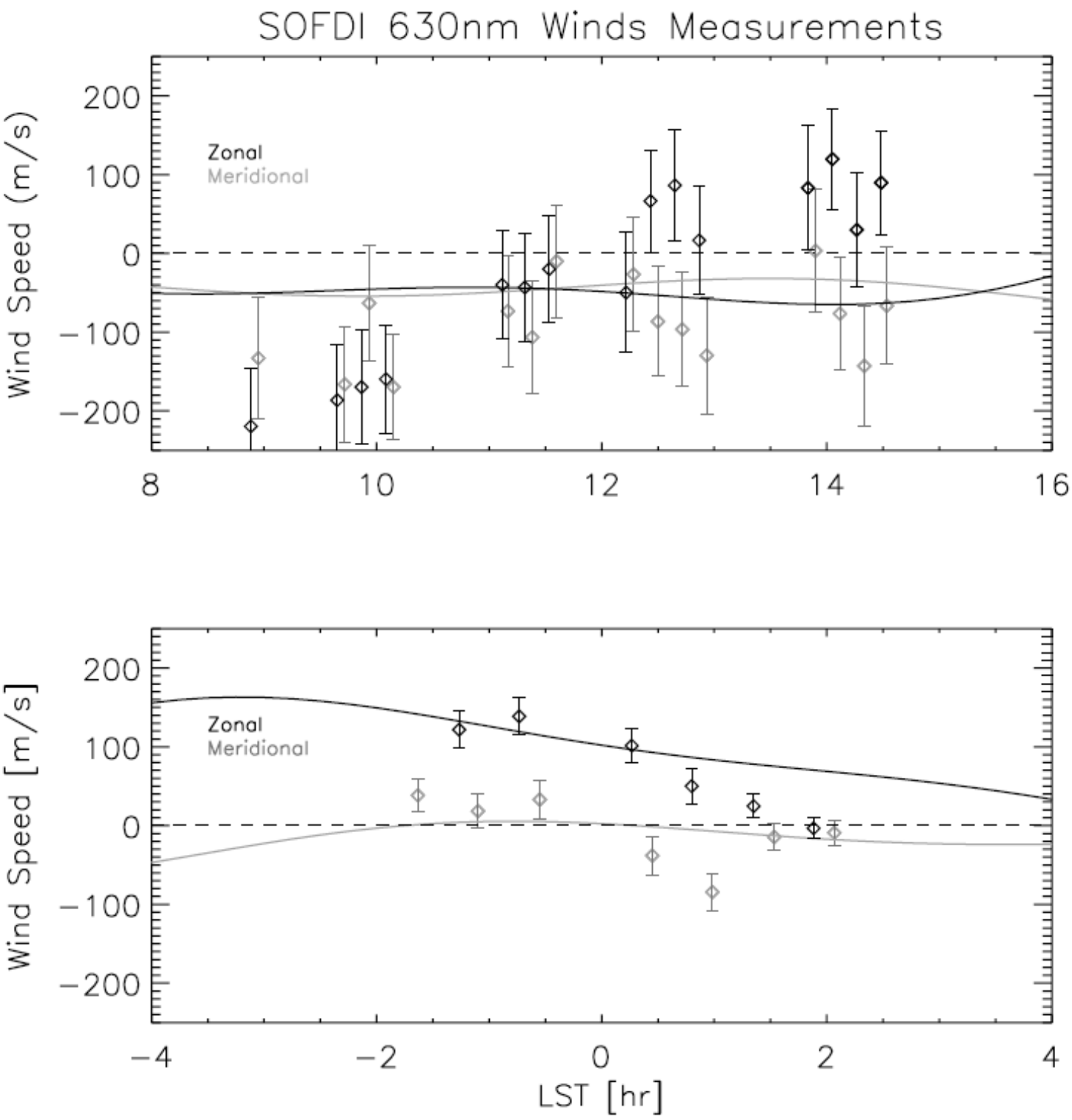
1) Measure horizontal wind amplitudes*
2) Measure zonal E-polarization field strength
3) Measure variation in B-field
4) Measure status of E-dynamo
5) Measure gradient in electron density concentration
6) Try to better understand the seeding mechanisms*

SOFDI's Current Status

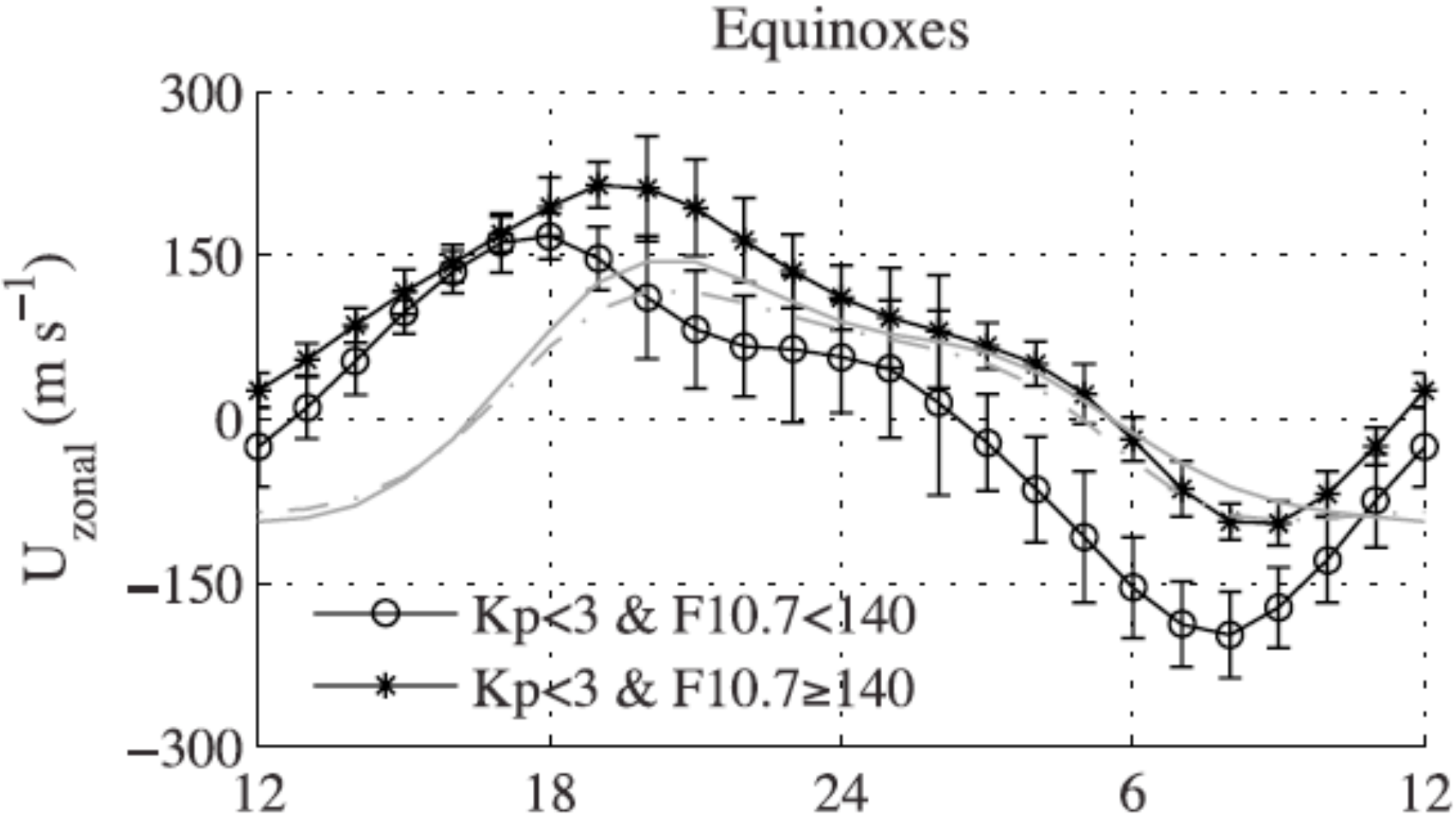


With the winds, we hope to shed light on ESF formation and prediction!

SOFDI is currently in Huancayo, Peru (Geo: 12.1° S, 75.3° W; Mag: 1.9° N) with the Cornell All-Sky Imager (CASI), housed within SOFDI.


SOFDI 630nm Winds Measurements
Wind Speed (m/s)
200
100
0
−100
−200
Zonal
Meridional
8
10
12
14
16
Wind Speed [m/s]
200
100
0
−100
−200
Zonal
Meridional
−4
−2
0
2
4
LST [hr]

CHAMP
(CHAllenging Minisatellite Payload)



Work In Progress and Conclusions

- What is up with the winds?!?!
  - Special 2011 CEDAR session
  - Proposed AGU session at Fall 2011 meeting

- How does the timing of the zonal wind reversal relate to ESF formation?
  - Collaborative measurements

- How can we increase SNR?
  - New observing schemes
  - Automated alignment

- What about “seeding” mechanisms?
  - Gravity wave studies