FPI Vertical Winds and ICON/MIGHTI

Brian J. Harding, Yen-Jung J. Wu

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ECE ILLINOIS

ILLINOIS

Equatorial Vertical Winds [*Fisher et al.*, 2015]

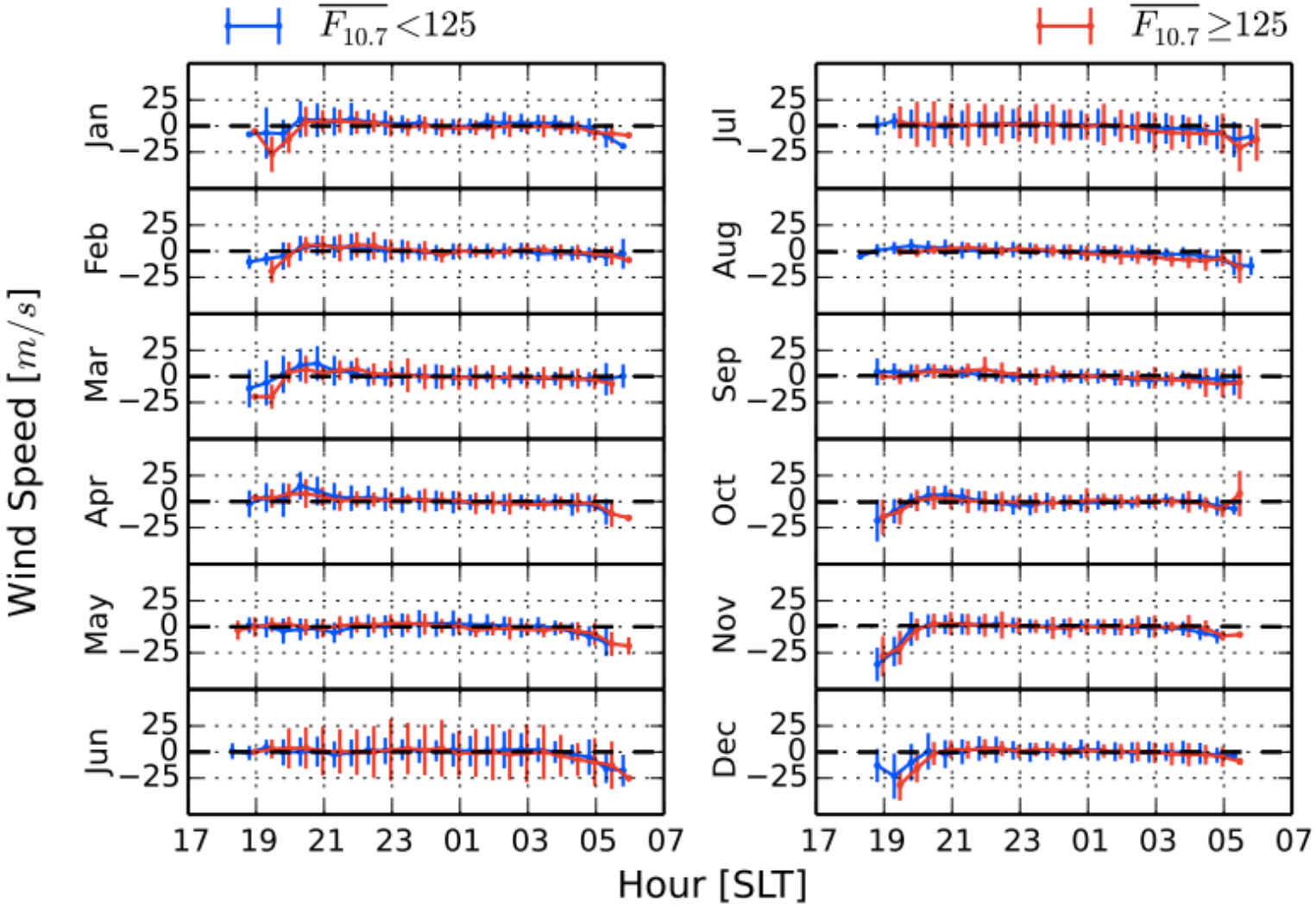
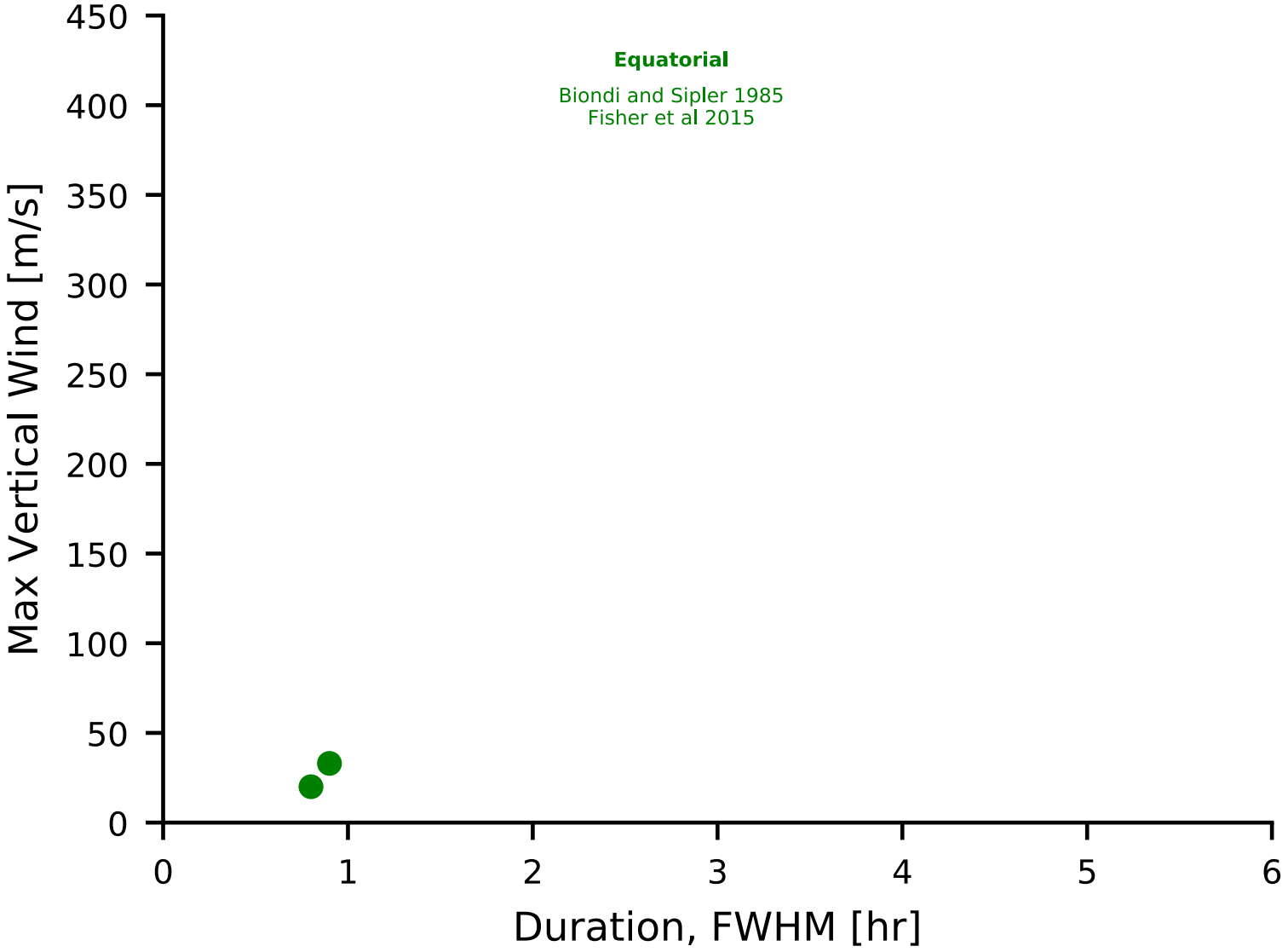
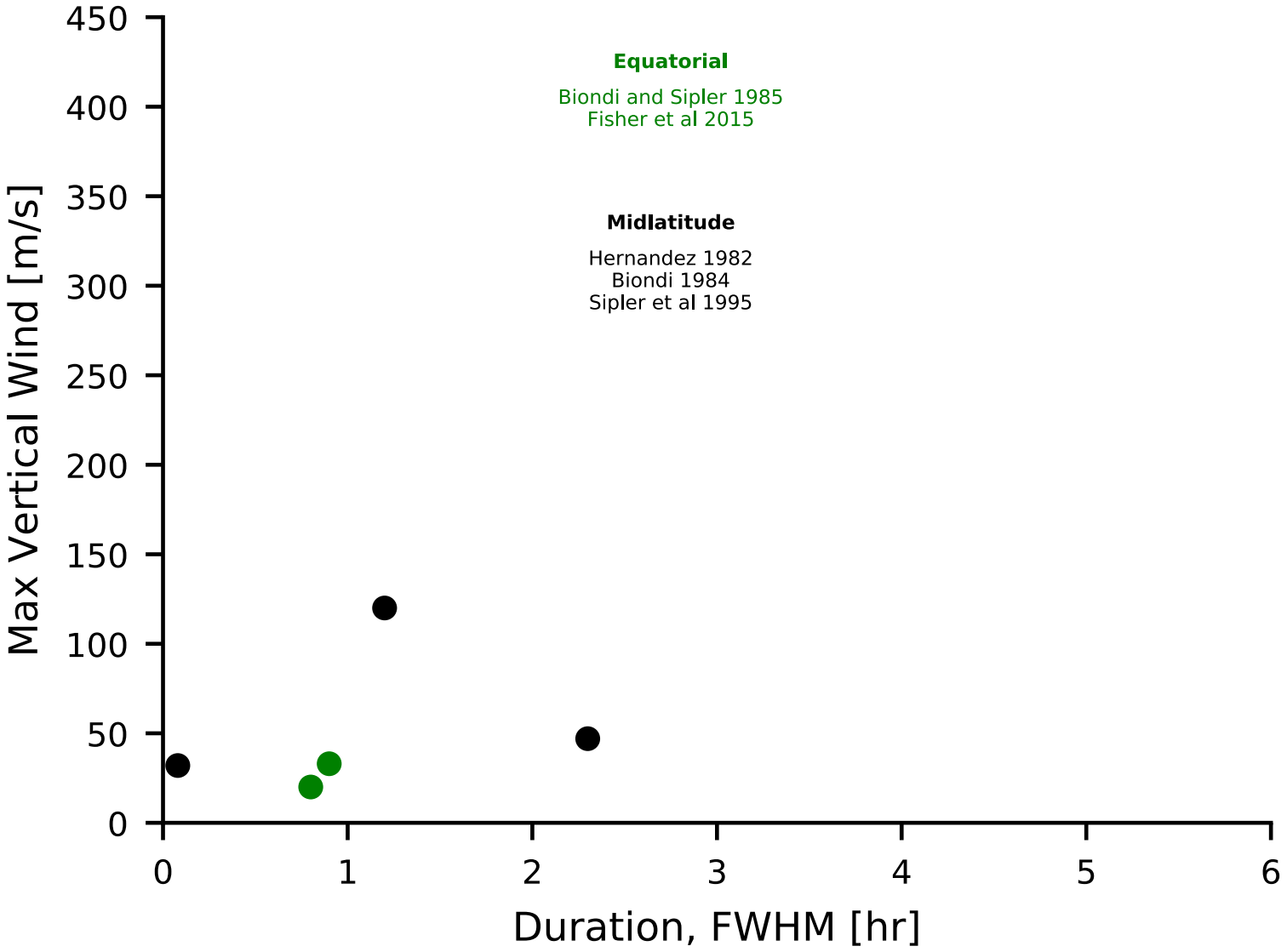


Figure 4. Monthly averages of the vertical thermospheric wind over northeast Brazil plotted against solar local time (SLT). Positive values are upward.

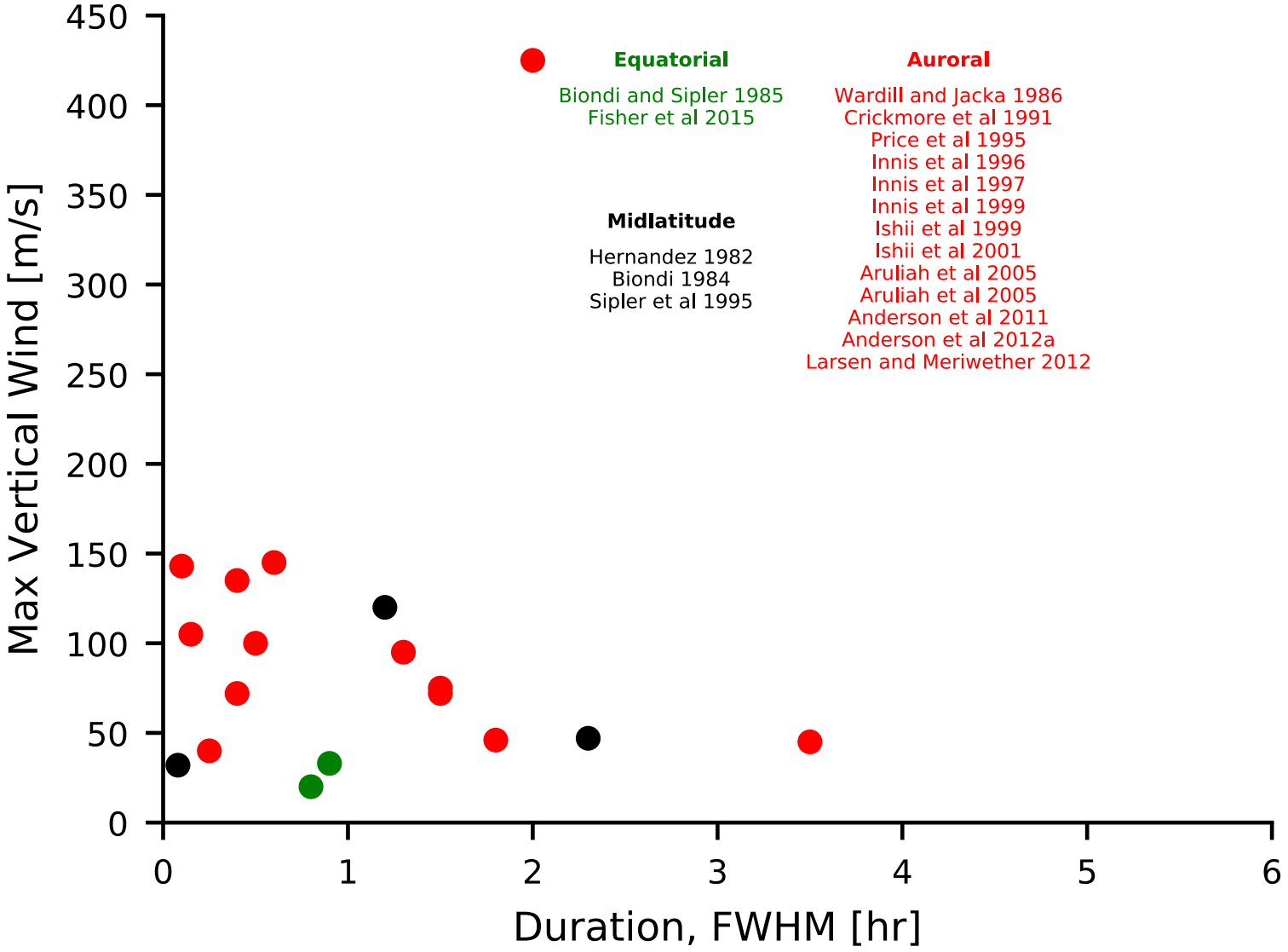
Previous vertical wind observations



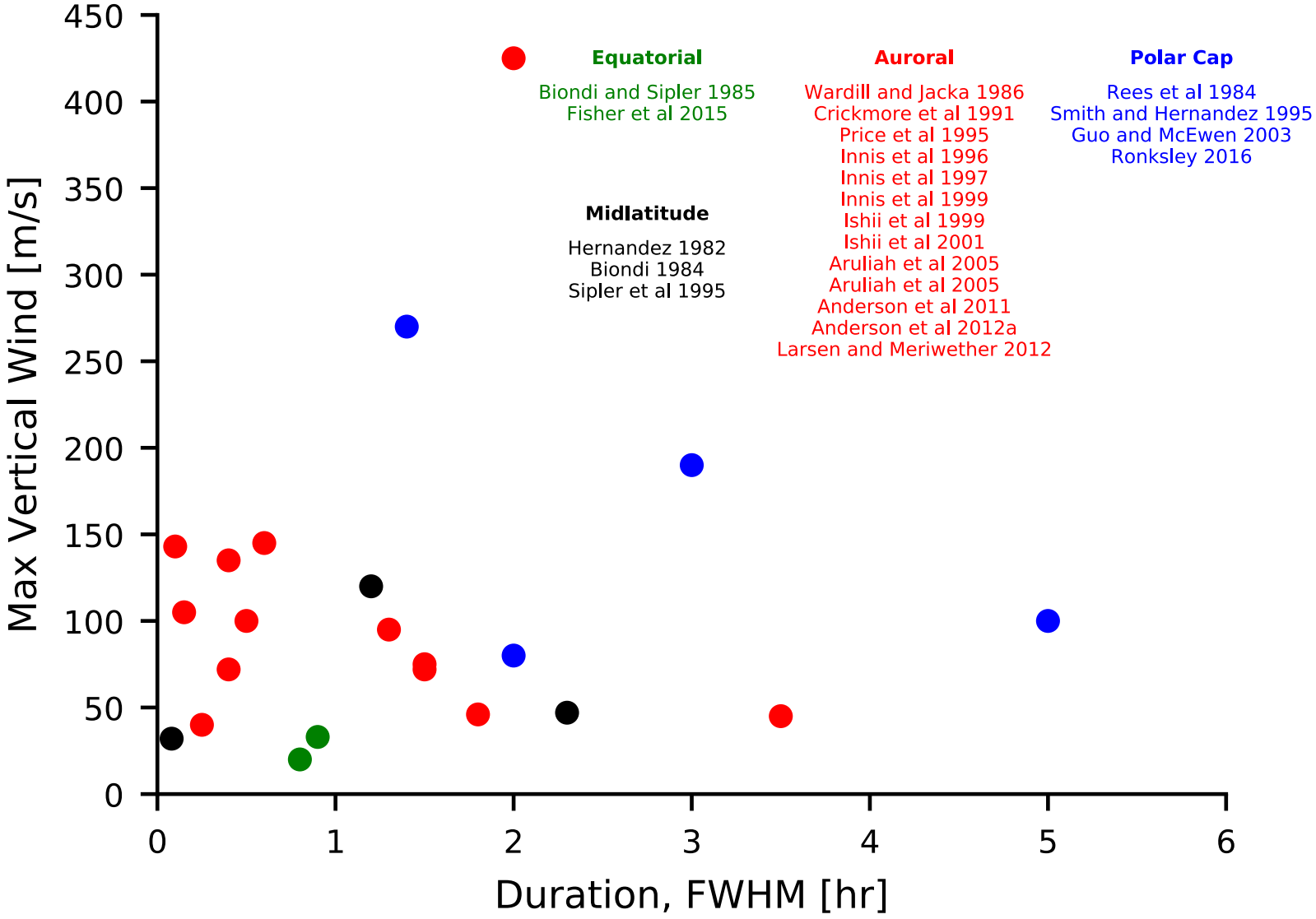
Previous vertical wind observations



Previous vertical wind observations



Previous vertical wind observations



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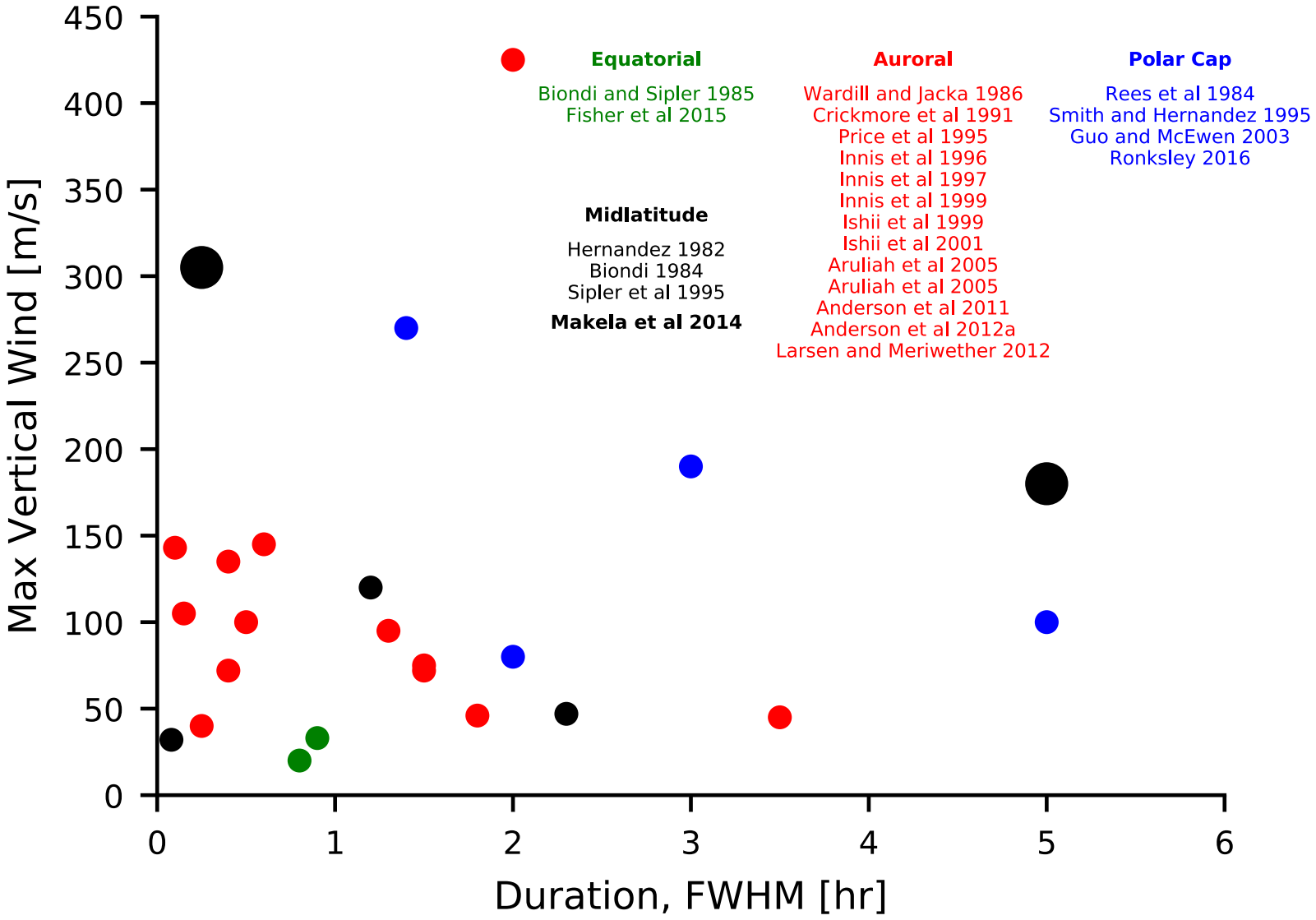

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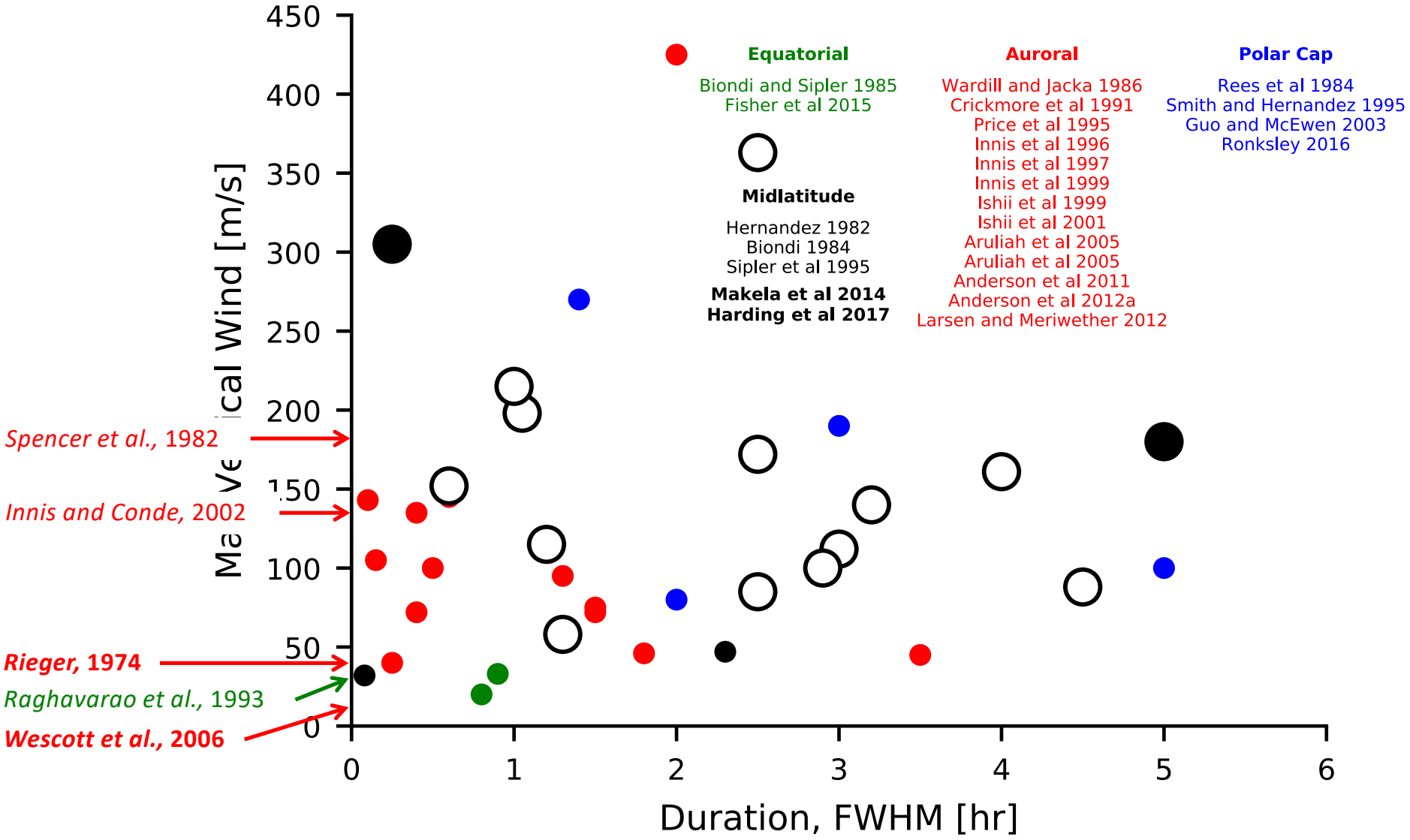

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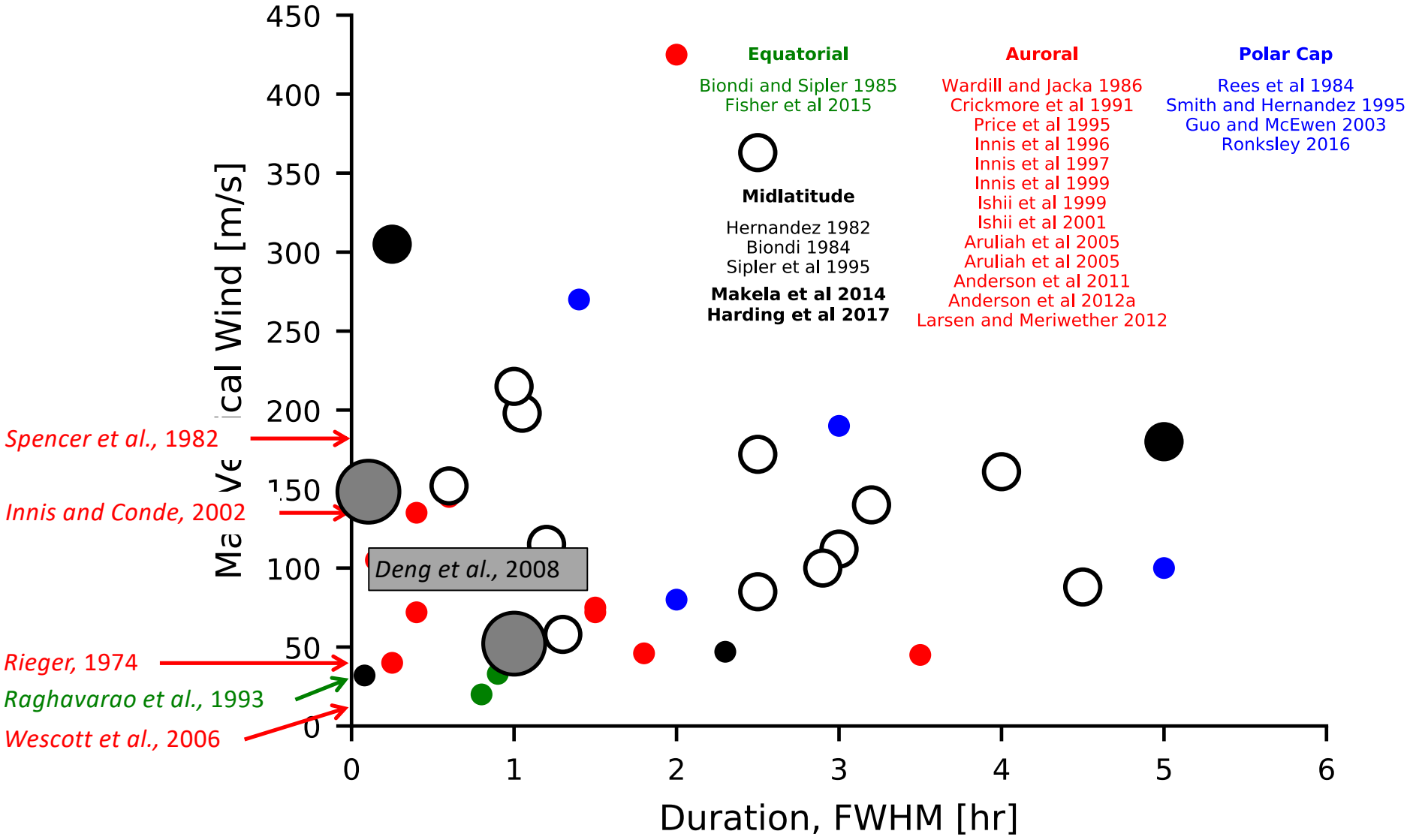
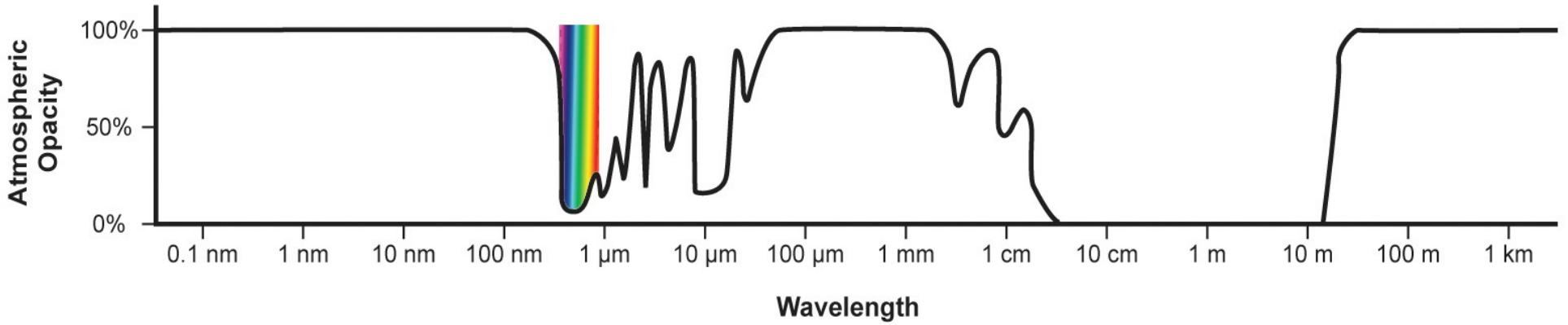
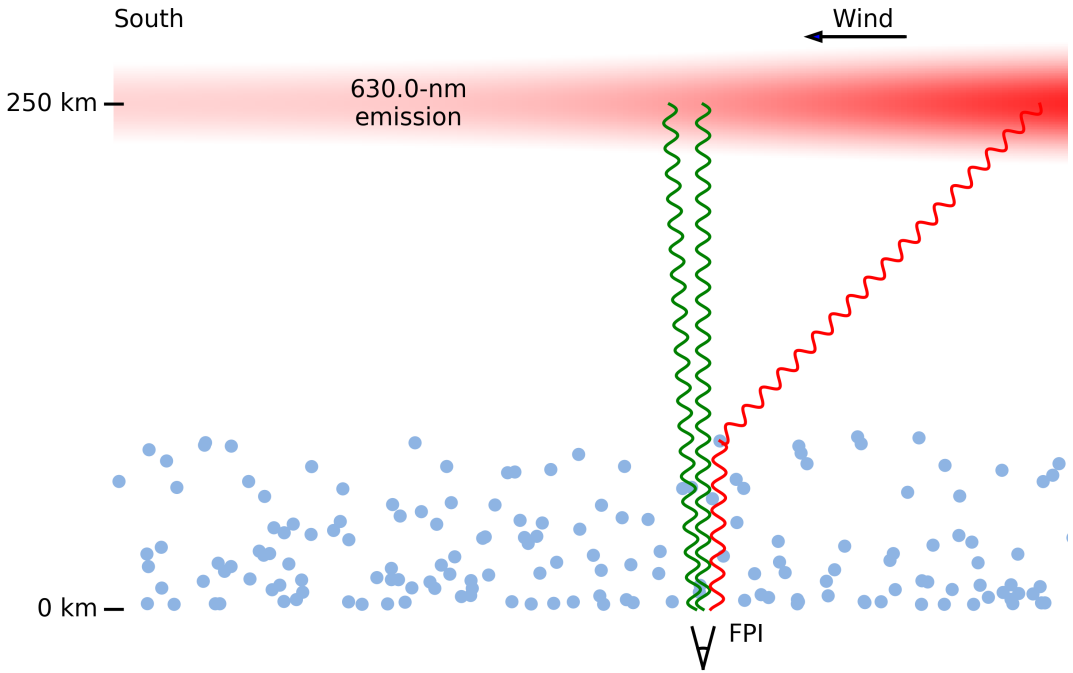
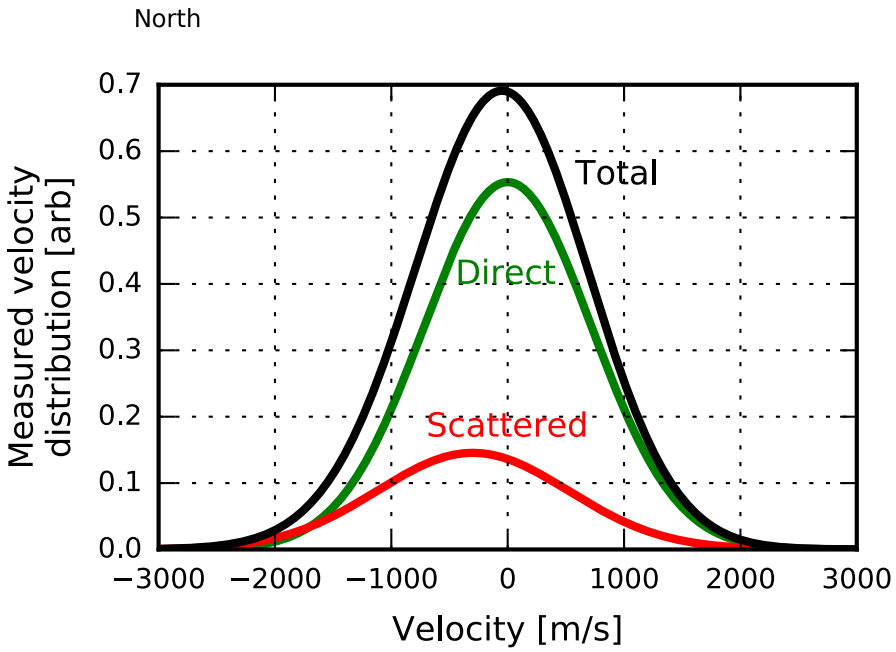


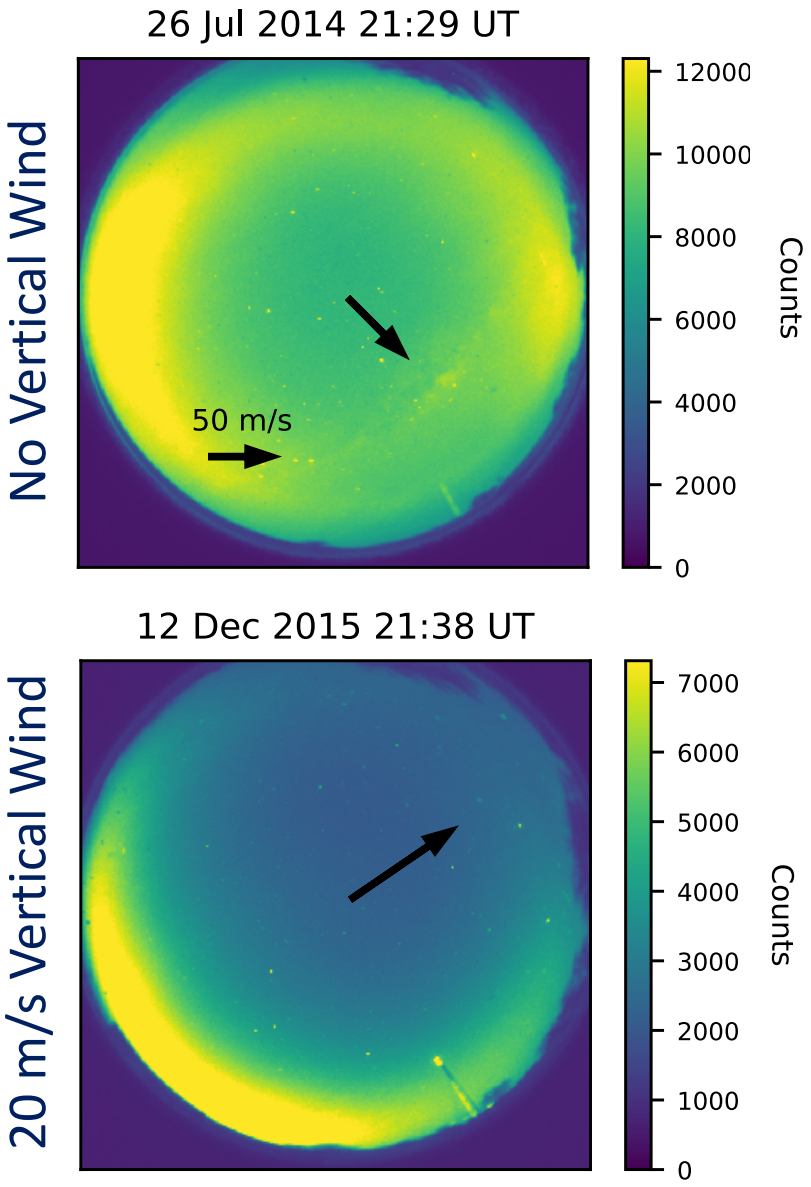
Atmospheric Scattering



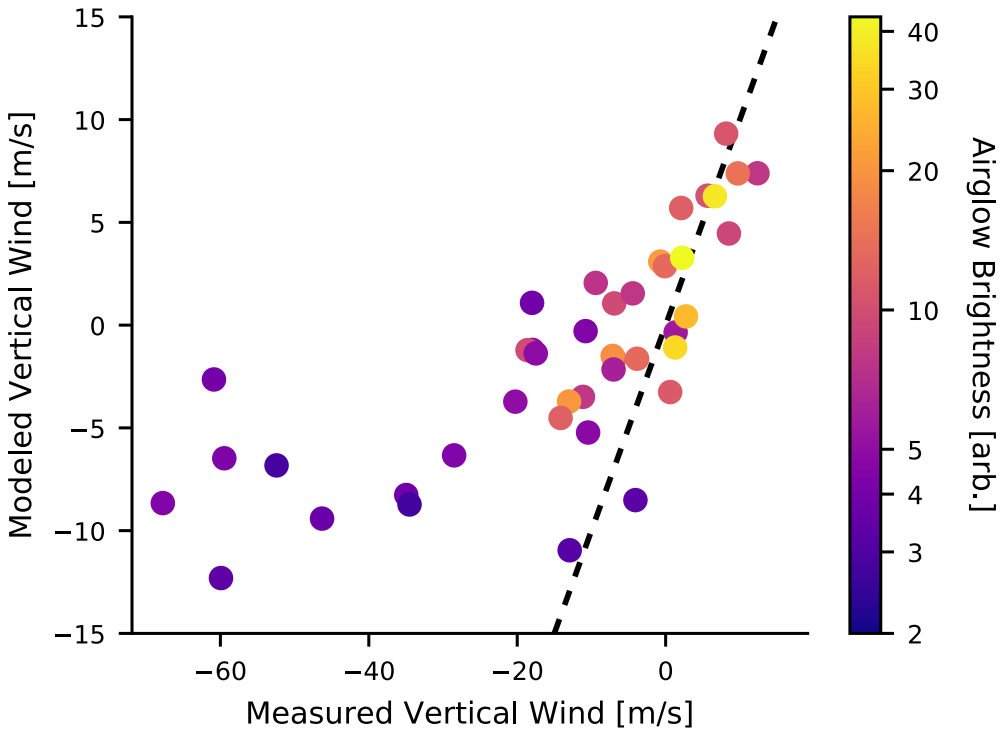




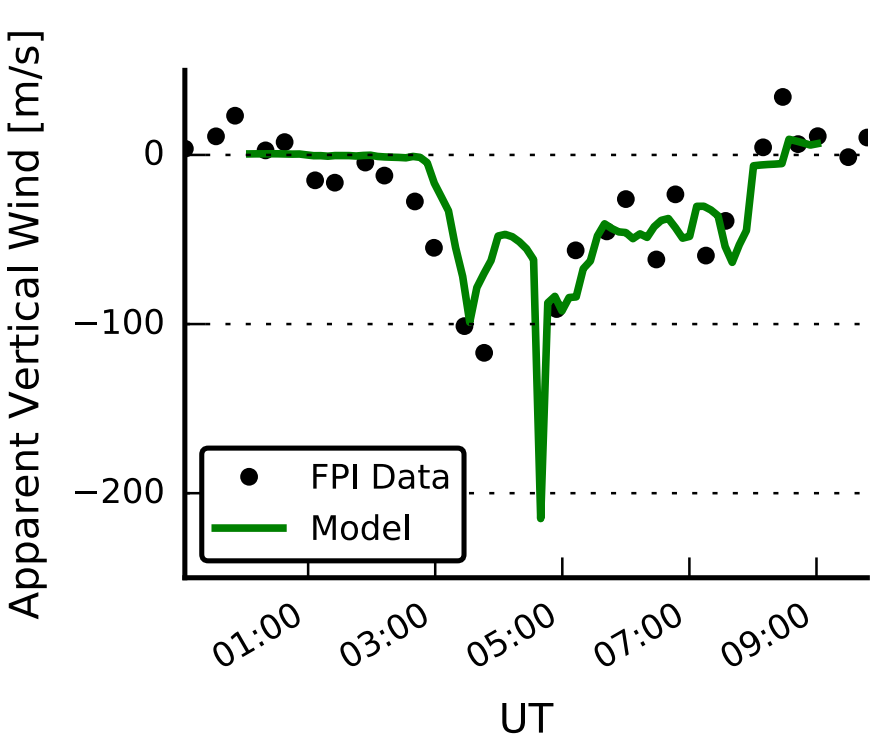
Equatorial Vertical Winds

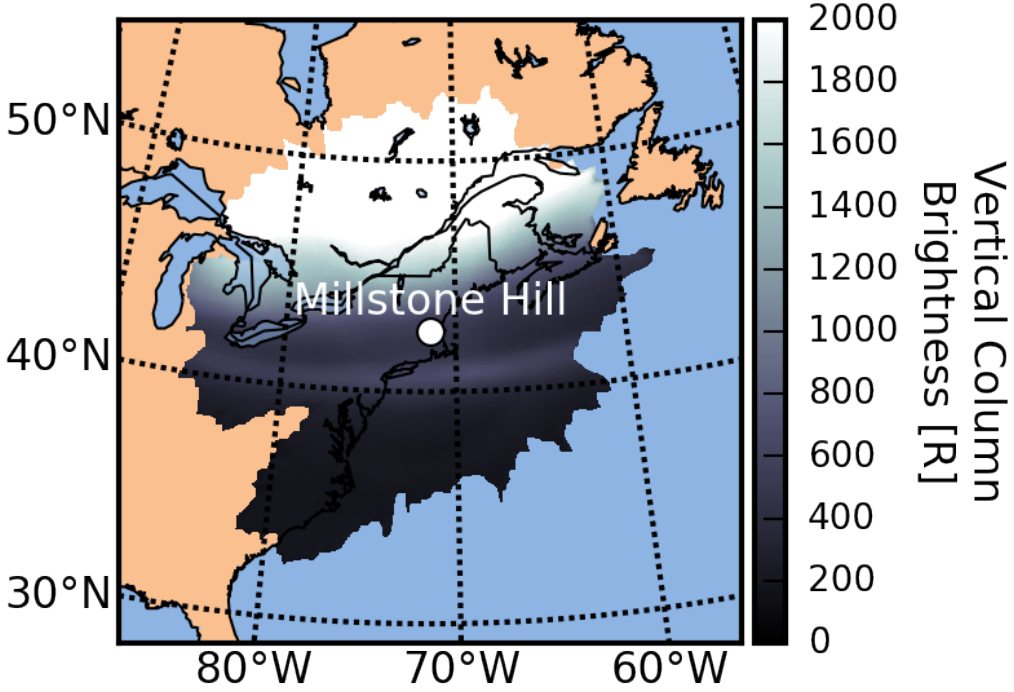


- 21 nights during 2013–2015 with coincident high-quality data
  - Average of 1st hour after sunset
  - Average of 2nd hour after sunset
- Wind from Horizontal Wind Model 2014 [*Drob et al.*, 2015]



Comparison with FPI data



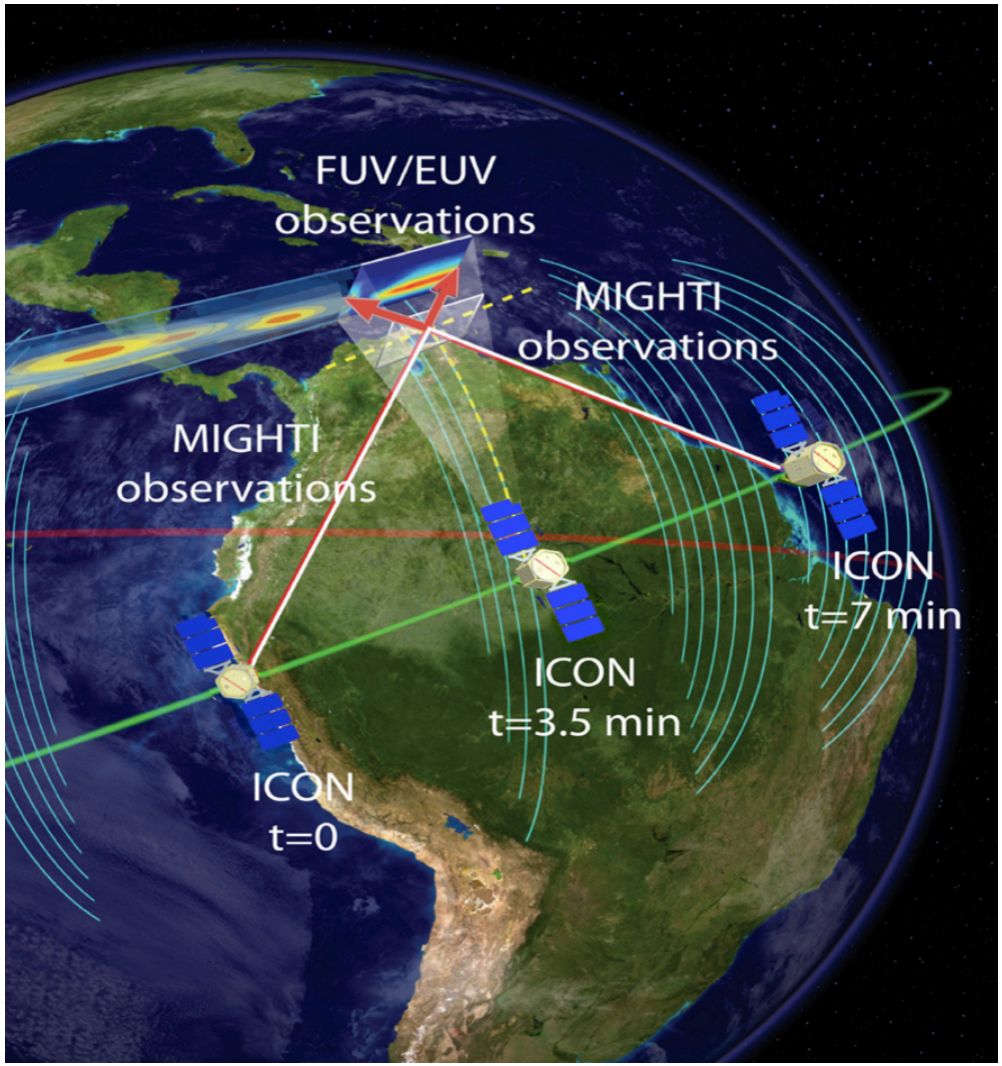


Atmospheric scatter can explain vertical winds measured at midlatitudes during storms

Solutions

- Deploy imagers with FPIs
- Exercise caution when airglow gradients are present
  - And when zenith emission is dim

ICON Instrumentation

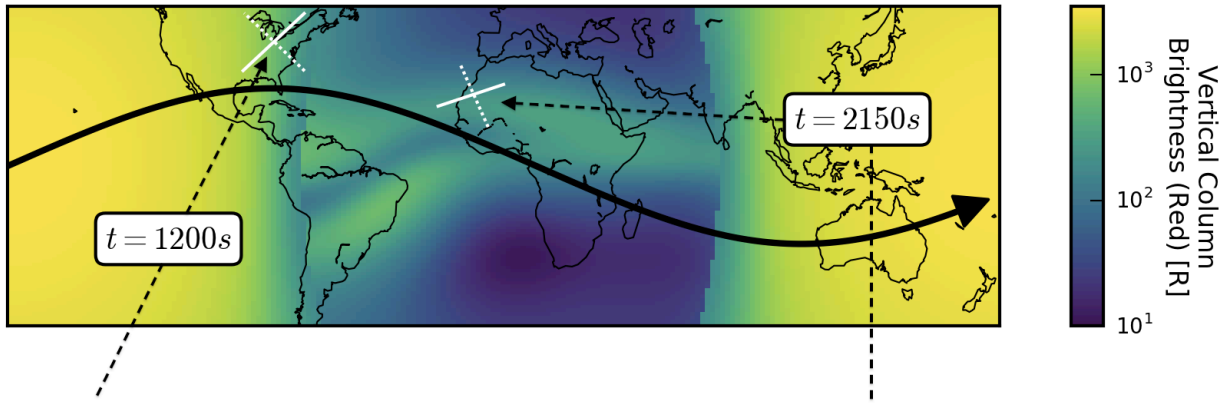


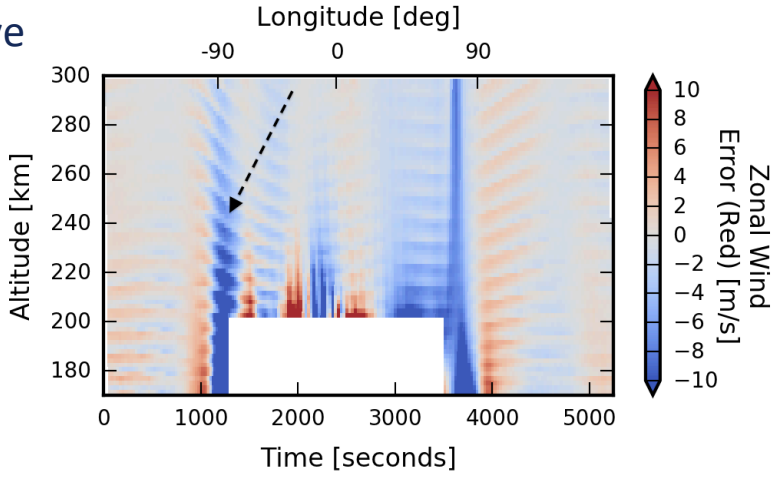
Four Instruments:

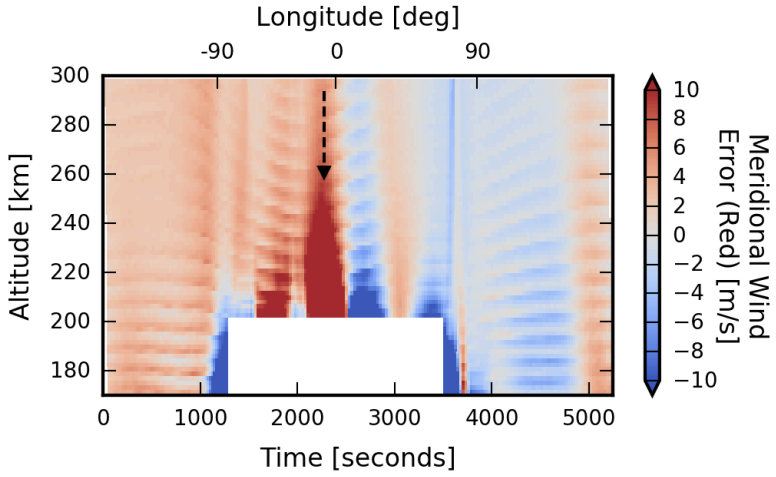
- MIGHTI
  - Neutral Wind
  - Neutral Temperature
- FUV
  - Ion density
  - O/N_2 (day only)
- EUV
  - Ion density (day only)
- IVM
  - Ion Drift (in situ)

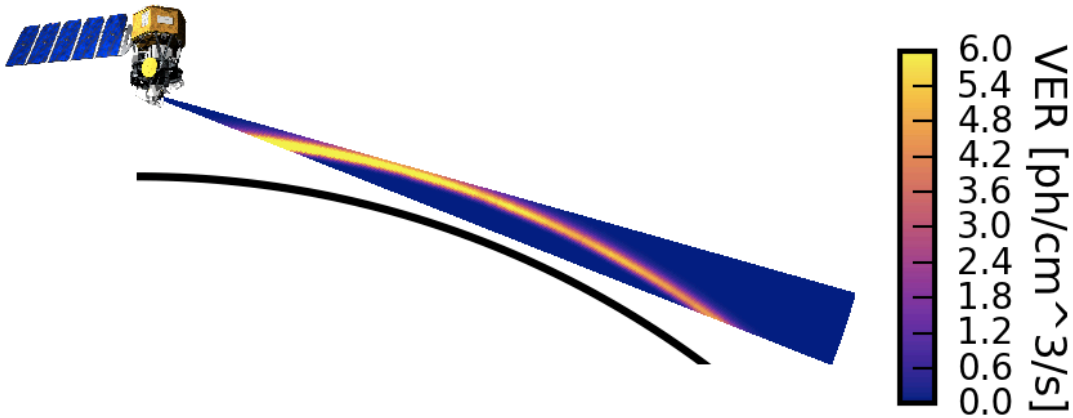
Errors

- Expected precision:
  - **1-4 m/s** at 30km or 5km vertical res
- 80% of retrievals have systematic error less than:
  - **3.5 m/s** (Red)
  - **5.8 m/s** (Green)

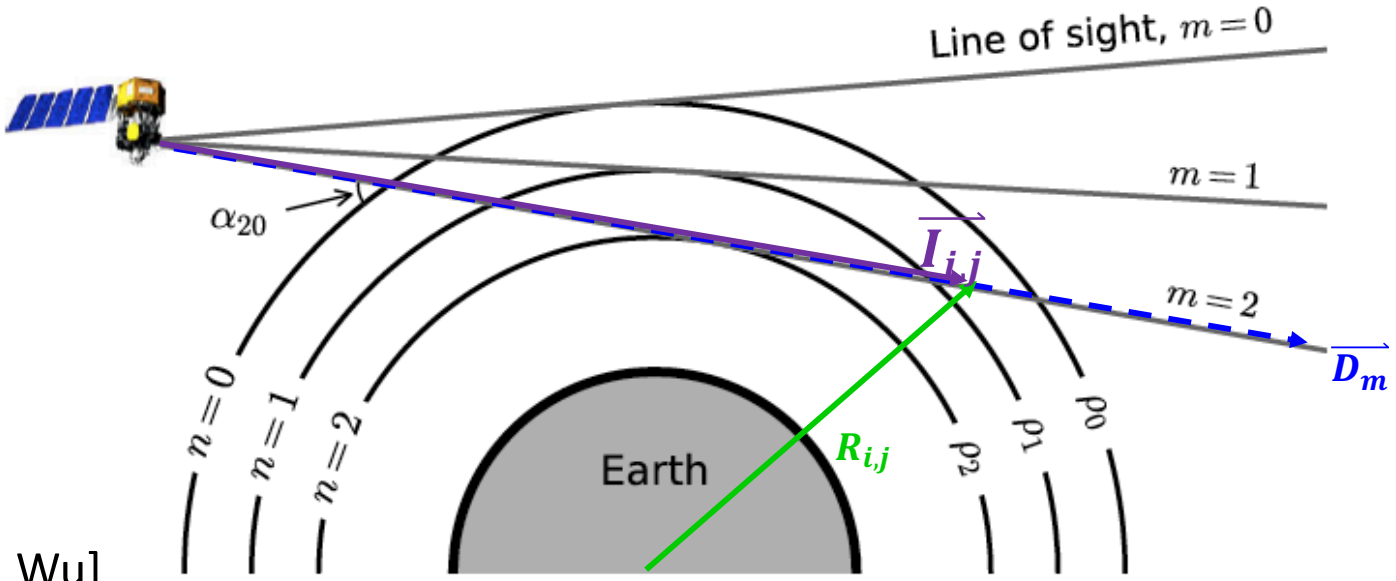








Alternative inverse matrix for non-uniform airglow



[Yen-Jung J. Wu]

$$I_m(x)\,e^{j\Delta\phi_m} = \frac{1}{w_{mm}}\left(H_m(x) - \sum_{n=0}^{m-1} I_n(x)\,e^{j\Delta\phi_n \cos\alpha_{mn}}\,w_{mn}\right) \quad \forall m \in [1, M-1]$$

$$= \frac{1}{w_{mm}}\left(H_m(x) - \sum_{n=0}^{m-1} I_n(x)e^{j\phi_n cos\alpha_{mn}}\boldsymbol{w'_{mn}}\right),$$

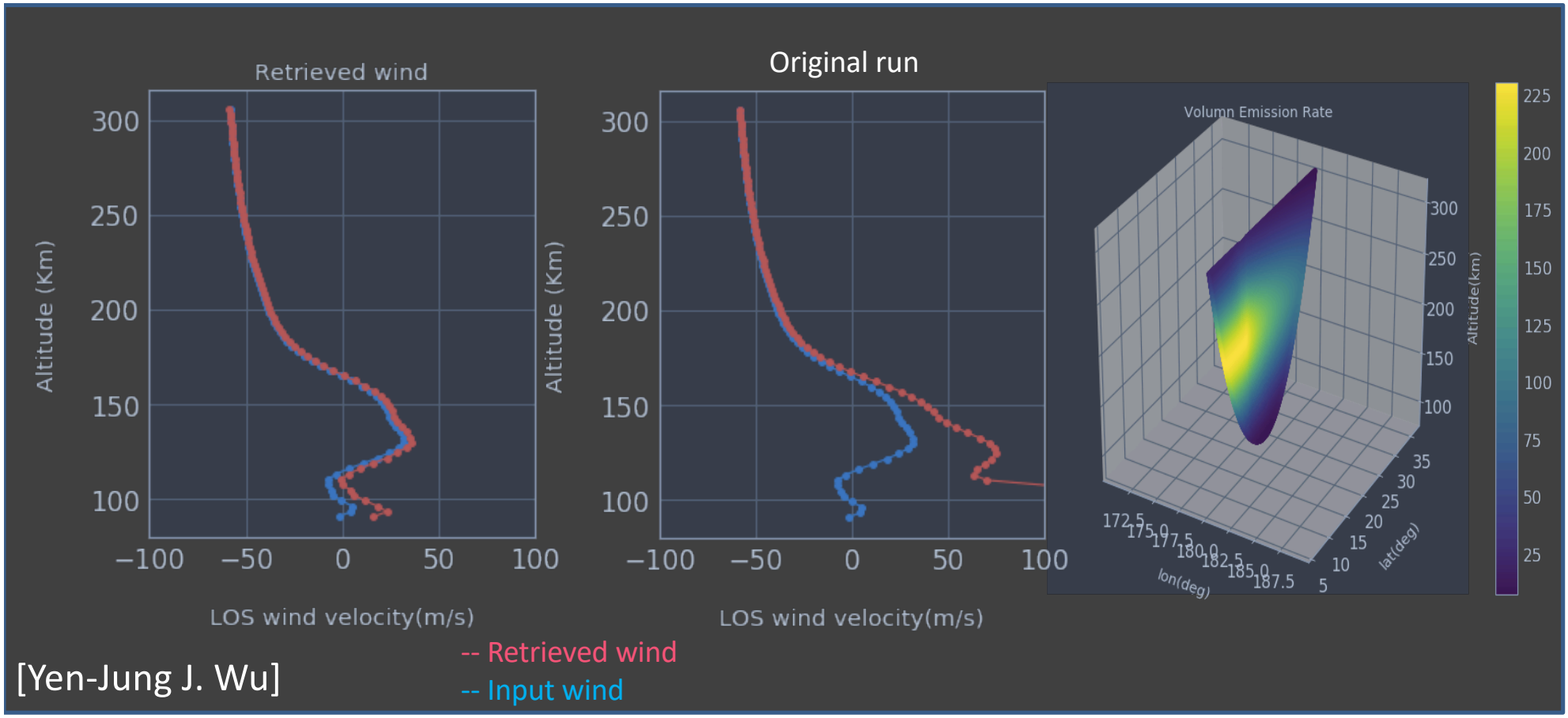
$$w'_{mn} = \sum_{q=H_{nb}}^{H_{nt}} c_q d_q$$

$$c_q = \frac{I_q}{I_n} \quad I_q: VER\ of\ the\ target\ area, I_n: VER\ of\ nth\ layer$$

$$d_q: unit\ length$$

Uniform V & Non-uniform VER
-- VER*exp(-x/2000km)

Theoretically, the accuracy of the retrieved wind is improved after implementing a proper weighting matrix w'_{mn}.



Challenge in the real world: How to sense the VER gradient in practice ?

Conclusions

- Atmospheric scatter is important to consider for measurements of airglow (e.g., all-sky and FPIs)
  - Up to 25% error in brightness
  - Up to **100 m/s error in wind**
  - Up to 200 K error in temperature
- Efforts ongoing to provide accurate ICON/MIGHTI winds near terminators and edges of equatorial arcs