

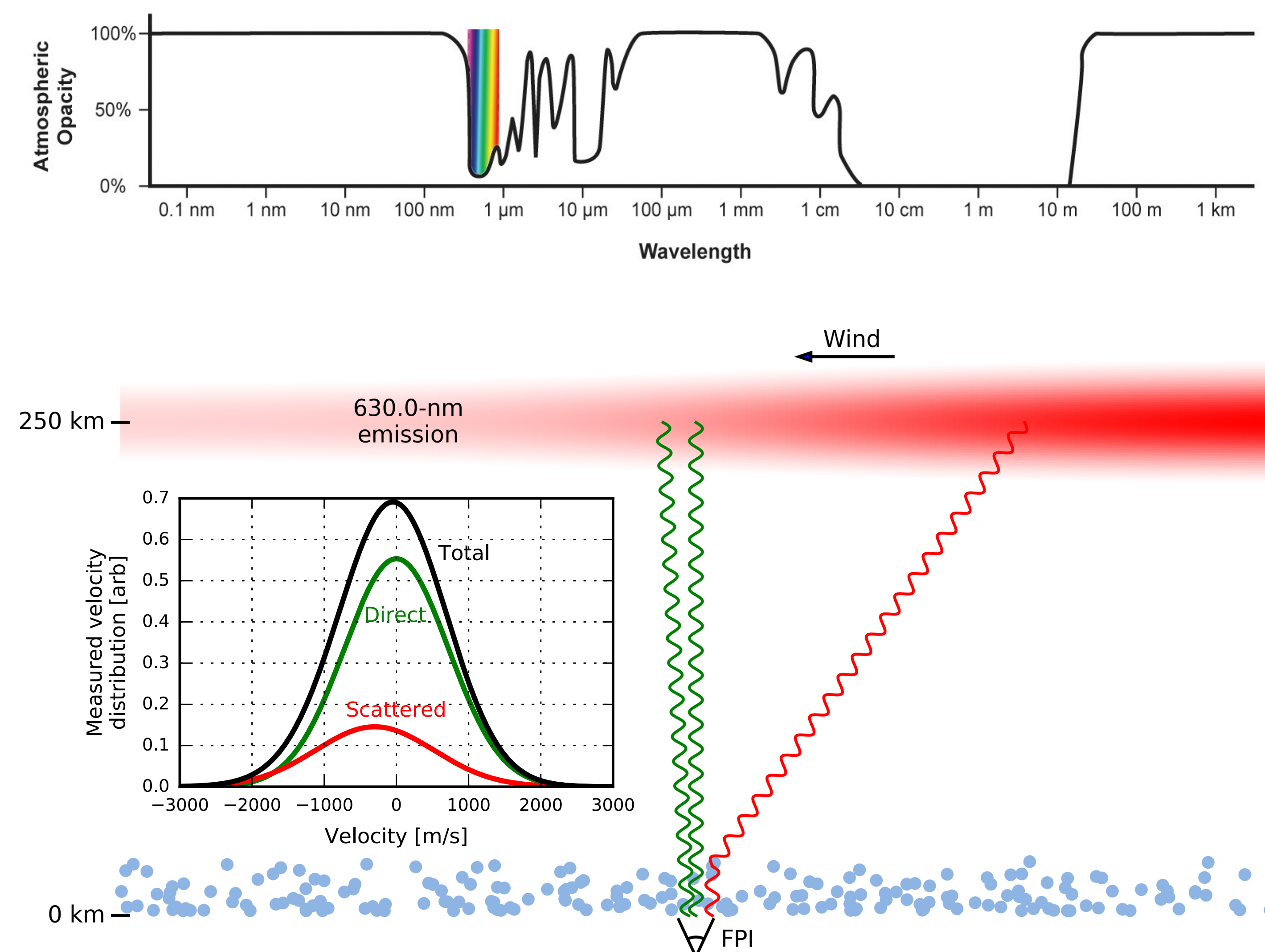
# Ground-based Thermospheric Wind Measurements: Sensitivity to Atmospheric Scattering

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## Abstract

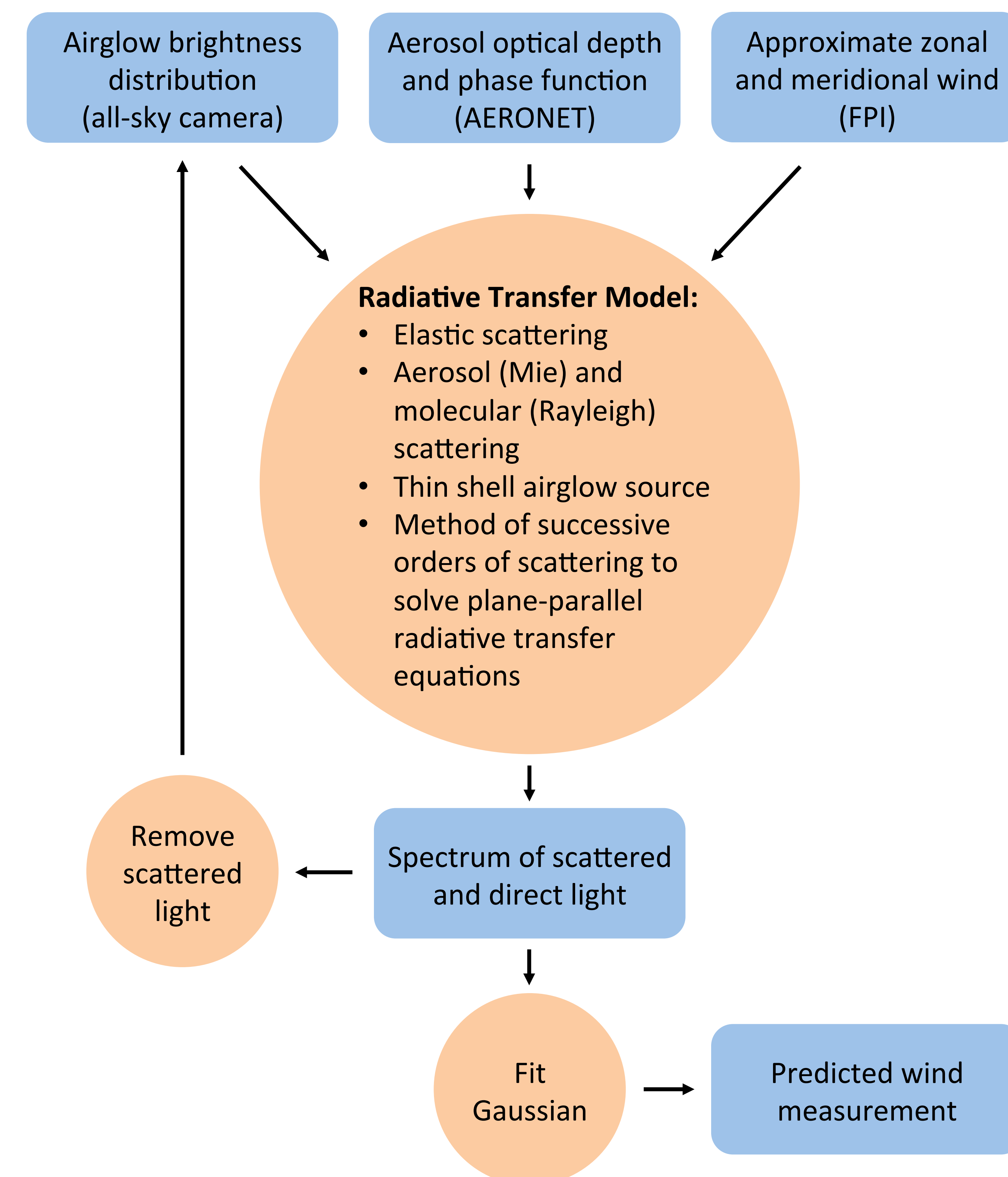
Recent measurements of surprising thermospheric wind features, such as apparent downward winds at midlatitudes during geomagnetic storms [Makela et al., 2014] and at low latitudes after sunset [Fisher et al., 2015], have raised questions regarding the reliability of ground-based thermospheric wind measurements. These measurements are made by observing the Doppler shift of optical airglow emissions. In this work, we develop a radiative transfer code to quantify the effect of scattering in the troposphere. We find that the storm-time apparent downward winds at midlatitudes are likely caused by atmospheric scattering. This is also a plausible explanation for low-latitude winds, but calibration uncertainties render this explanation inconclusive.

## Atmospheric Scattering



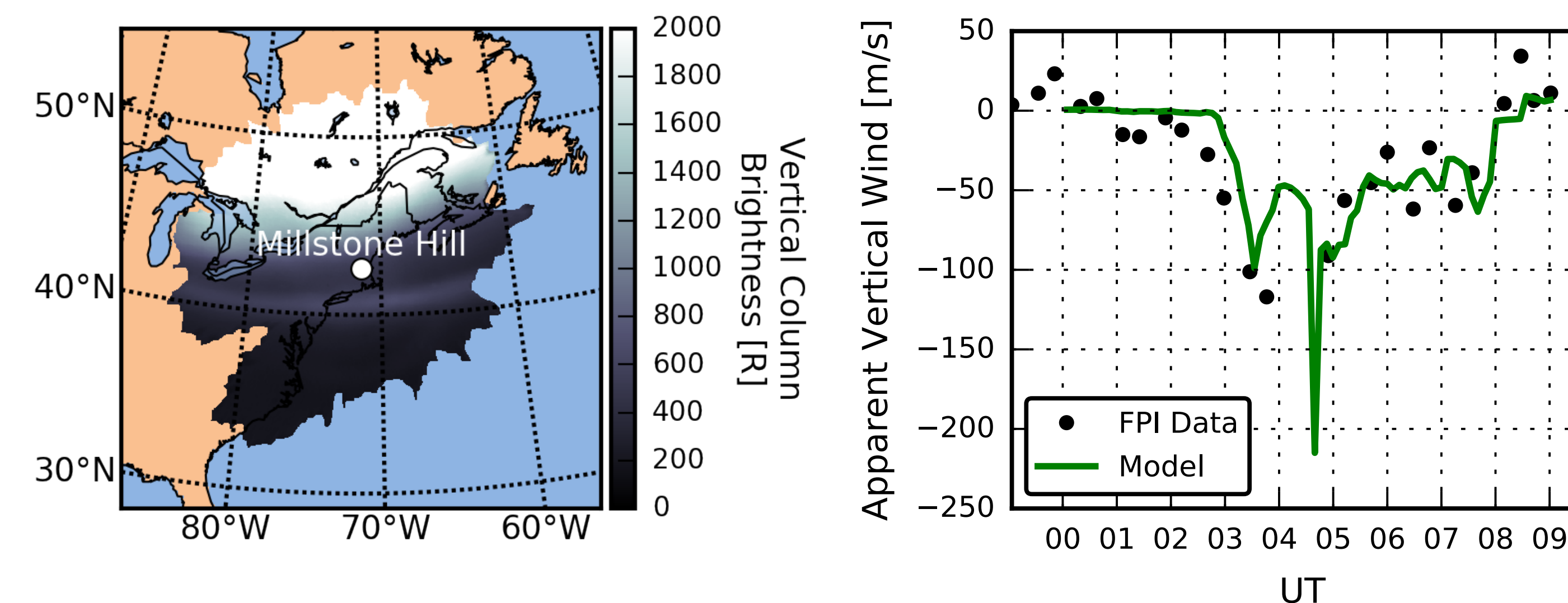
- Instruments such as Fabry-Perot interferometers (FPIs) use the Doppler shift of airglow emissions to remotely sense upper atmospheric wind
- Scattering causes contamination from outside the field of view
- This contamination manifests as an apparent vertical wind in zenith-looking observations, especially during geomagnetic storms when large horizontal winds and airglow gradients are present
- Estimates of horizontal wind and temperature are also affected
- Abreu et al. [1983] predicted this phenomenon, but the idea was largely dismissed in subsequent literature due to their erroneous claim that temperature measurements are not affected

## Scattering Model



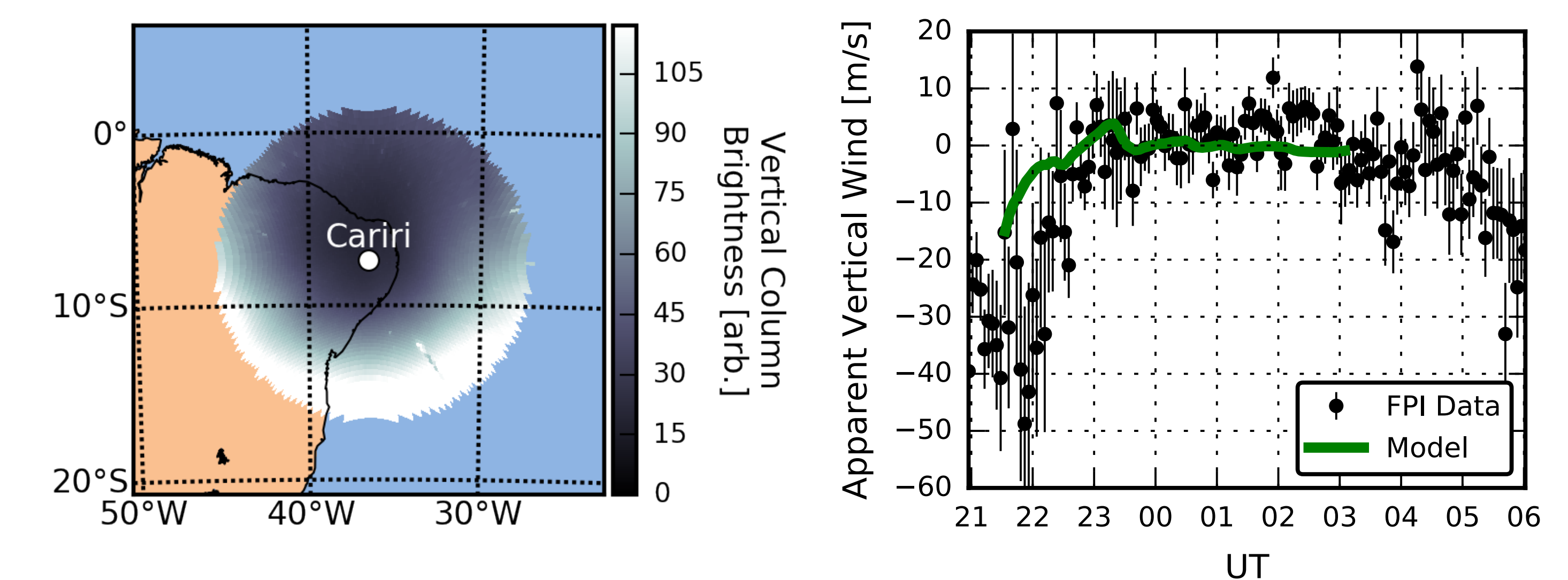
## Case Study 1: Midlatitudes during storms

- Large 100 m/s sustained apparent downward wind at midlatitudes observed during moderate storm (Dst = -60 nT), attributed initially to the effect of precipitating oxygen ions [Makela et al., 2014]
- Data-model comparison using collocated FPI and all-sky camera from Millstone Hill suggests that apparent downward winds are fully explained by atmospheric scattering (optical depth = 0.12)



## Case Study 2: Low latitudes after sunset

- Repeatable, unexplained ~20 m/s postsunset downward wind observed in the low latitude local summer [Fisher et al., 2015]
- Comparison of data and model using instruments in Cariri, Brazil suggests that atmospheric scattering may be the explanation (optical depth = 0.16)
- Uncertainties in all-sky camera calibration and aerosol properties prevent conclusive result



## Conclusions

- A model has been developed to quantify the impact of atmospheric scattering on ground-based airglow measurements (e.g., by FPIs or all-sky cameras)
- Atmospheric scattering can explain apparent vertical winds seen at midlatitudes during storms, eliminating the O<sup>+</sup> precipitation hypothesis
- Atmospheric scattering may explain post-sunset vertical winds seen at low latitudes, but there are large uncertainties in model inputs
- Other reported vertical wind measurements should be examined, such as those in the auroral region
- Future work includes developing an algorithm to correct for atmospheric scattering in vertical wind, horizontal wind, and temperature measurements, but preliminary work suggests this is not well-posed

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