

Supporting information for: HL-TWiM empirical model of high-latitude upper thermospheric winds

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Additional Supporting Information:

1. Software S1 (hltwim.zip)

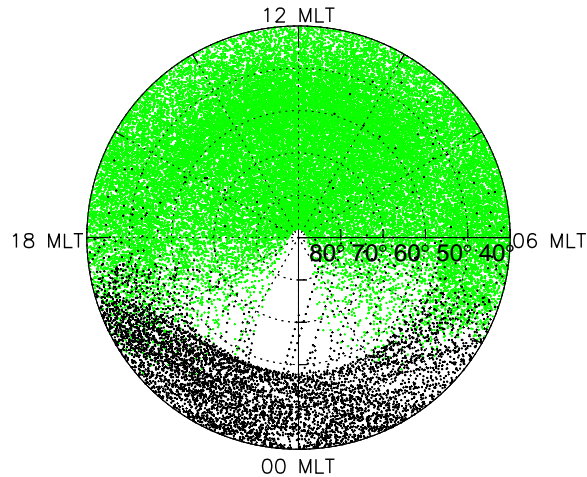


Figure S1. Polar plot of WINDII quiet-time ($Kp < 3$) wind data distribution as a function of MLAT and MLT at southern high latitudes above 40S MLAT. Green and black data points represent WINDII winds calculated from green line emissions (daytime winds) and red line emission (nighttime winds), respectively. Data accumulated in all the seasons is combined together.

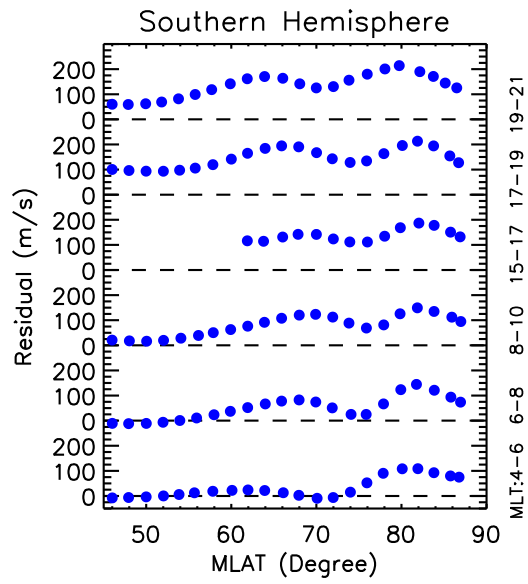


Figure S2. Residual cross-track winds (quiet-time GOCE cross-track wind – quiet-time WINDII climatological winds) as a function of southern magnetic latitudes (MLAT) for various magnetic local time bins.

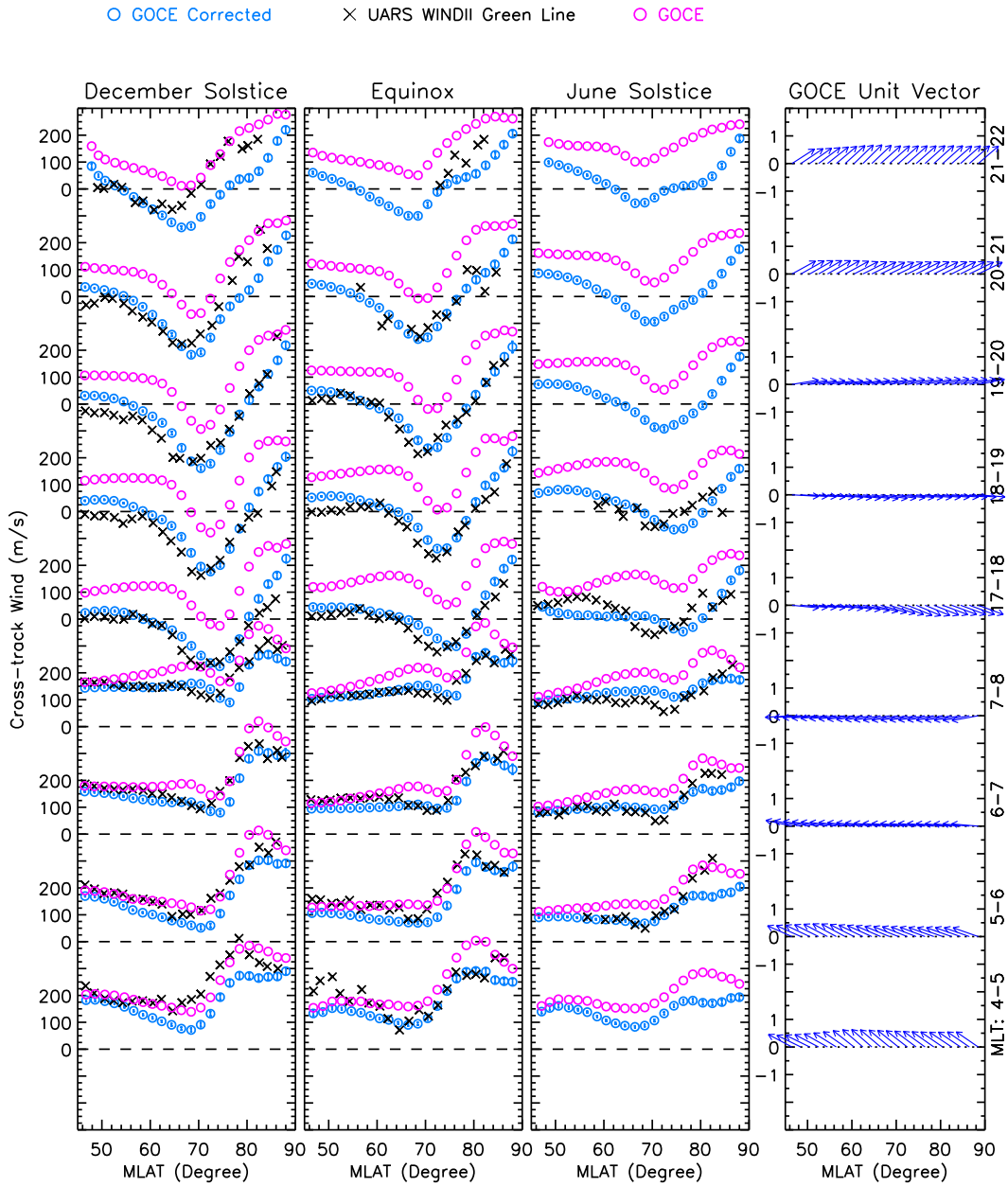


Figure S3. Comparison of GOCE corrected (blue), uncorrected (magenta), and WINDII (black) cross-track winds as a function of MLAT for various 1-hour MLT bins at southern high latitudes. The data are divided into three broad seasonal bins: December solstice (November, December, January, and February), equinox (March, April, September, and October), and June solstice (May, June, July, and August). The vectors in the rightmost column represent the average GOCE cross-track unit vector. For these unit vectors, magnetic north (east) is at the top (right) of the page.

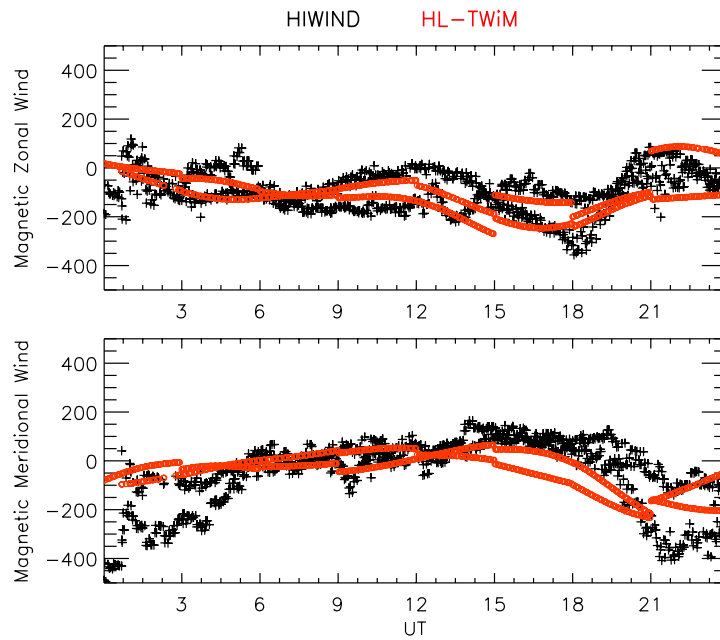


Figure S4. Comparison of HL-TWiM with two days of HIWIND neutral wind measurements (DOY 177 and 176 of 2018). It demonstrates that HL-TWiM captured the morphology of data. The climatological HL-TWiM winds are much smoother than the data from these specific days, as expected. The discontinuities in HL-TWiM winds every 3-hour are due to the 3-hour cadence of the Kp index.

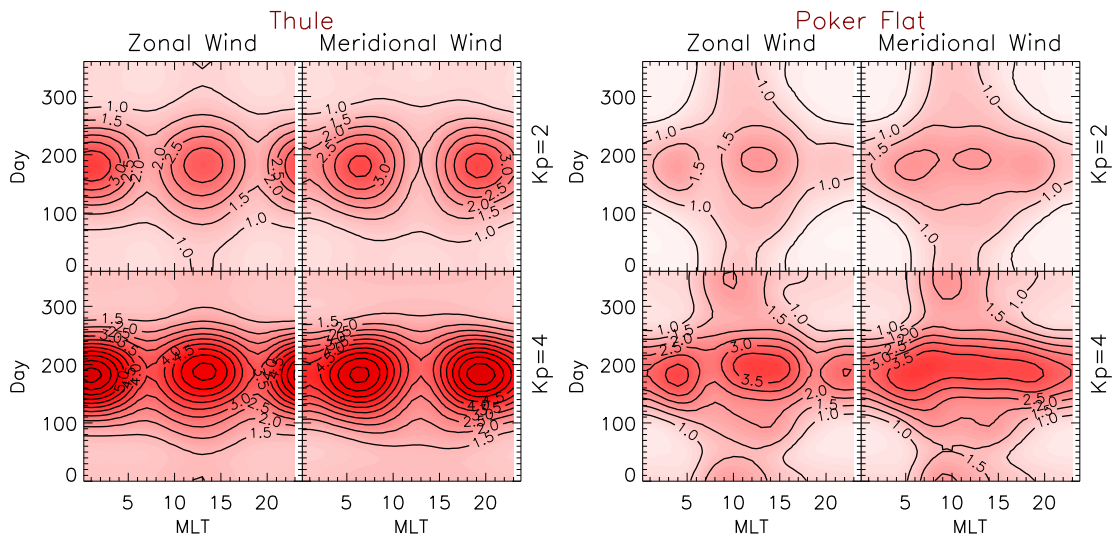


Figure S5. Estimated 1σ uncertainty in the modeled average zonal and meridional winds for Thule and Poker Flat as a function of magnetic local time and day-of-year for Kp quiet ($=2$) and active ($=4$).

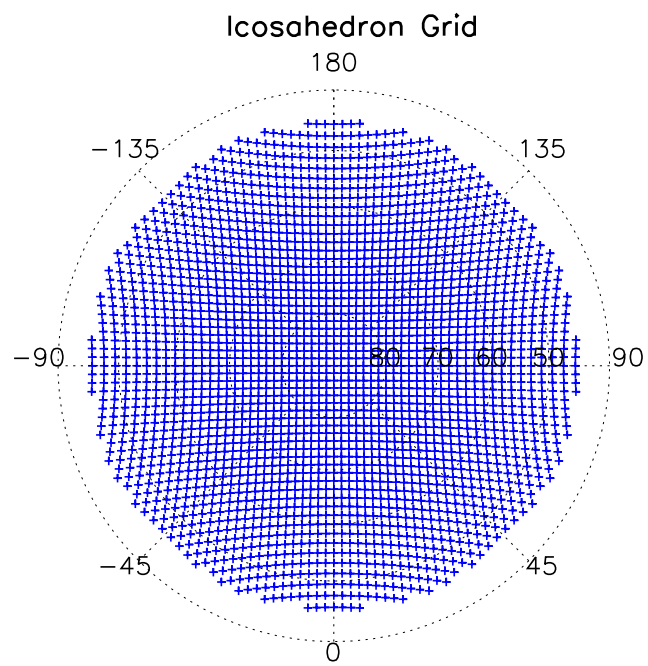


Figure S6. The equal area grid (icosahedron grid) as a function of MLAT and MLON used as a regular grid for calculating HL-TWiM winds.

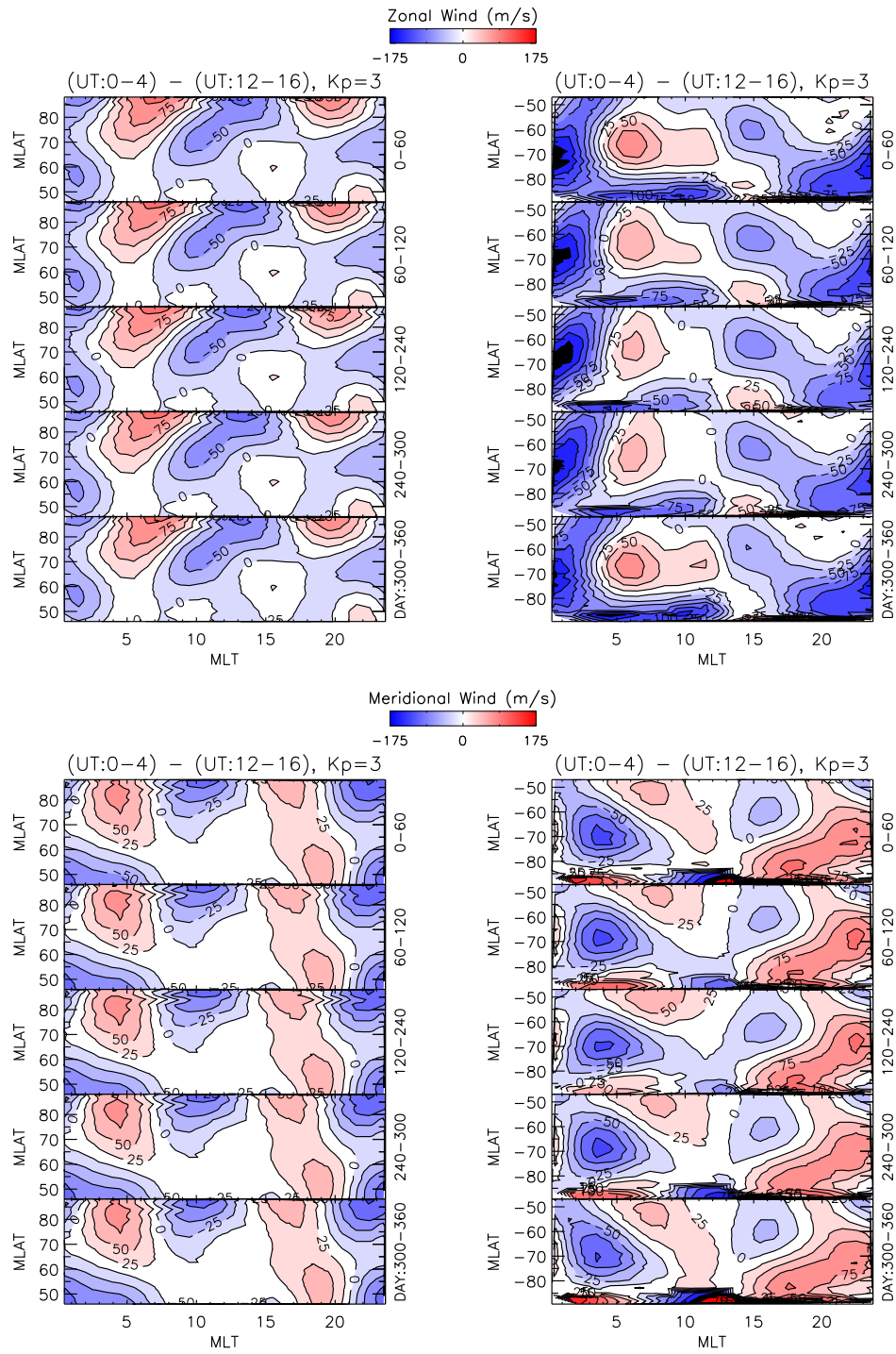


Figure S7. The difference between winds calculated for 0-4UT and 12-16 UT at $Kp=3$ as a function of MLAT and MLT for northern (left column) and southern (right column) high latitudes.

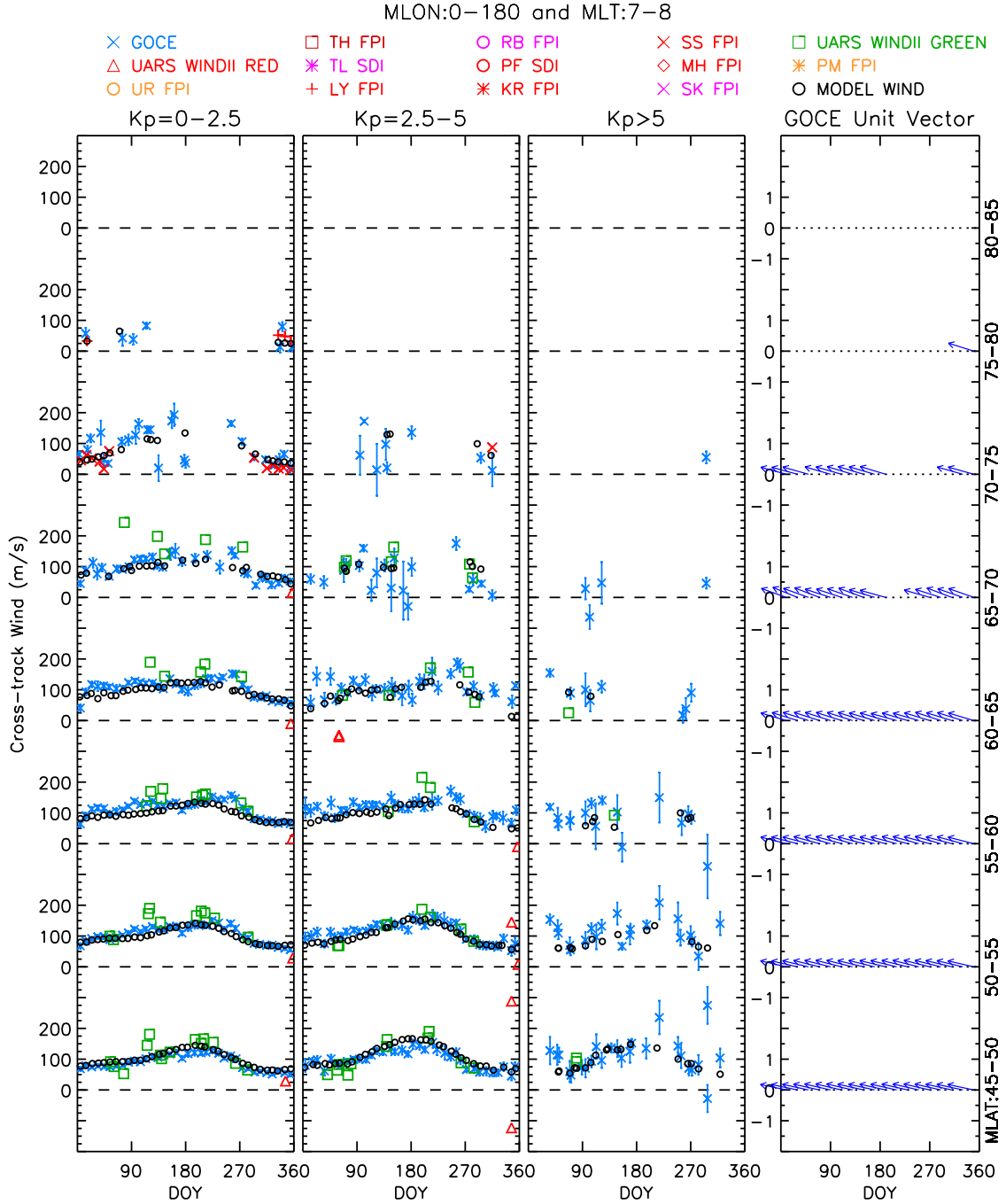


Figure S8. Average cross-track wind observed by GOCE and computed from FPIs, SDIs, and WINDII data as a function of DOY (5-day bin), for successive 5-degree NORTHERN MLAT around the dusk and dawn time sectors and three Kp bins (0-2.5, 2.5-5, and >5). Black symbols show HL-TWiM computed cross-track wind along the GOCE orbit. All other colors present cross-track winds calculated from different datasets. The rightmost column shows the direction of the average GOCE cross-track unit vector. Magnetic north (east) is at the top (right) of the page.

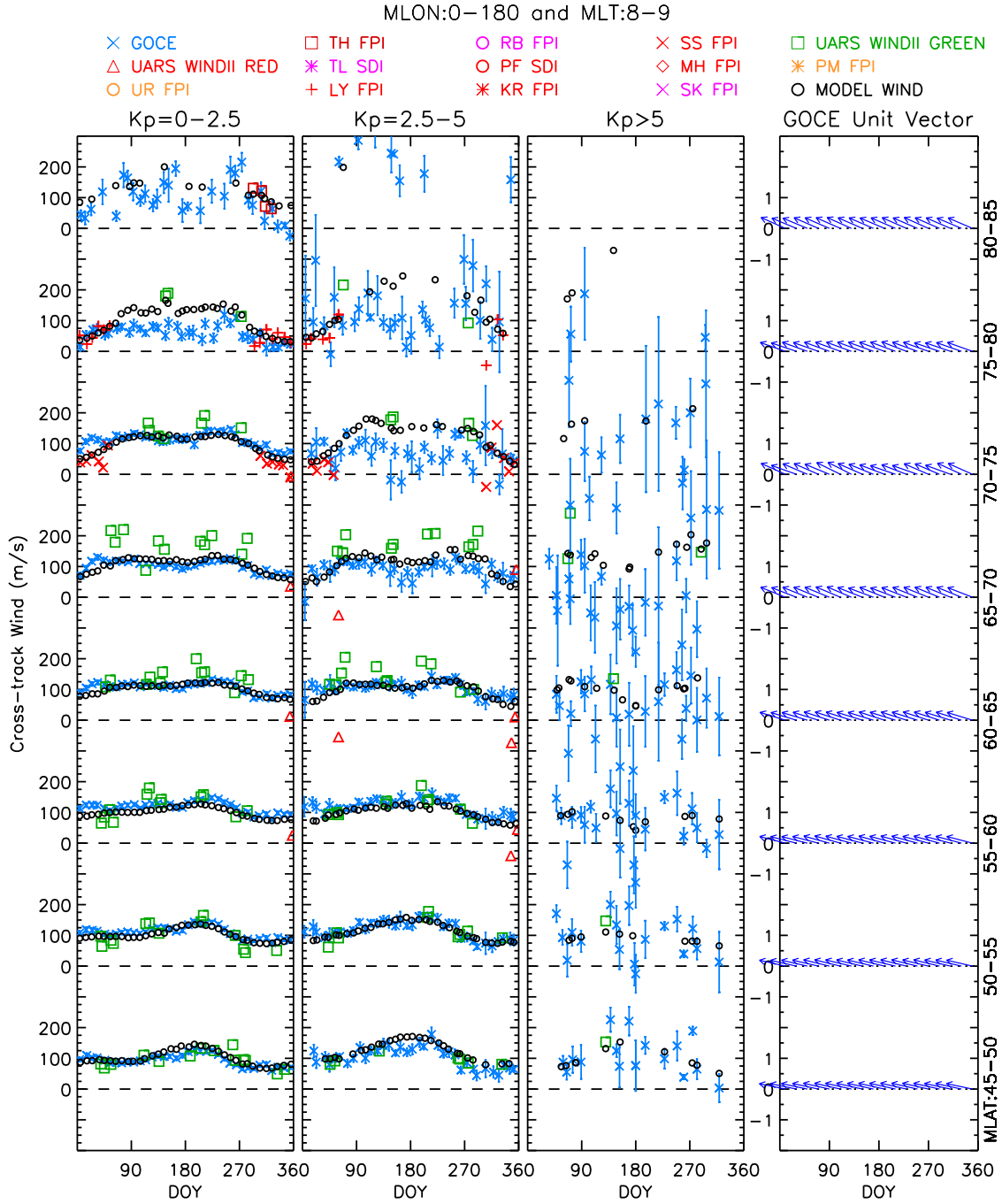
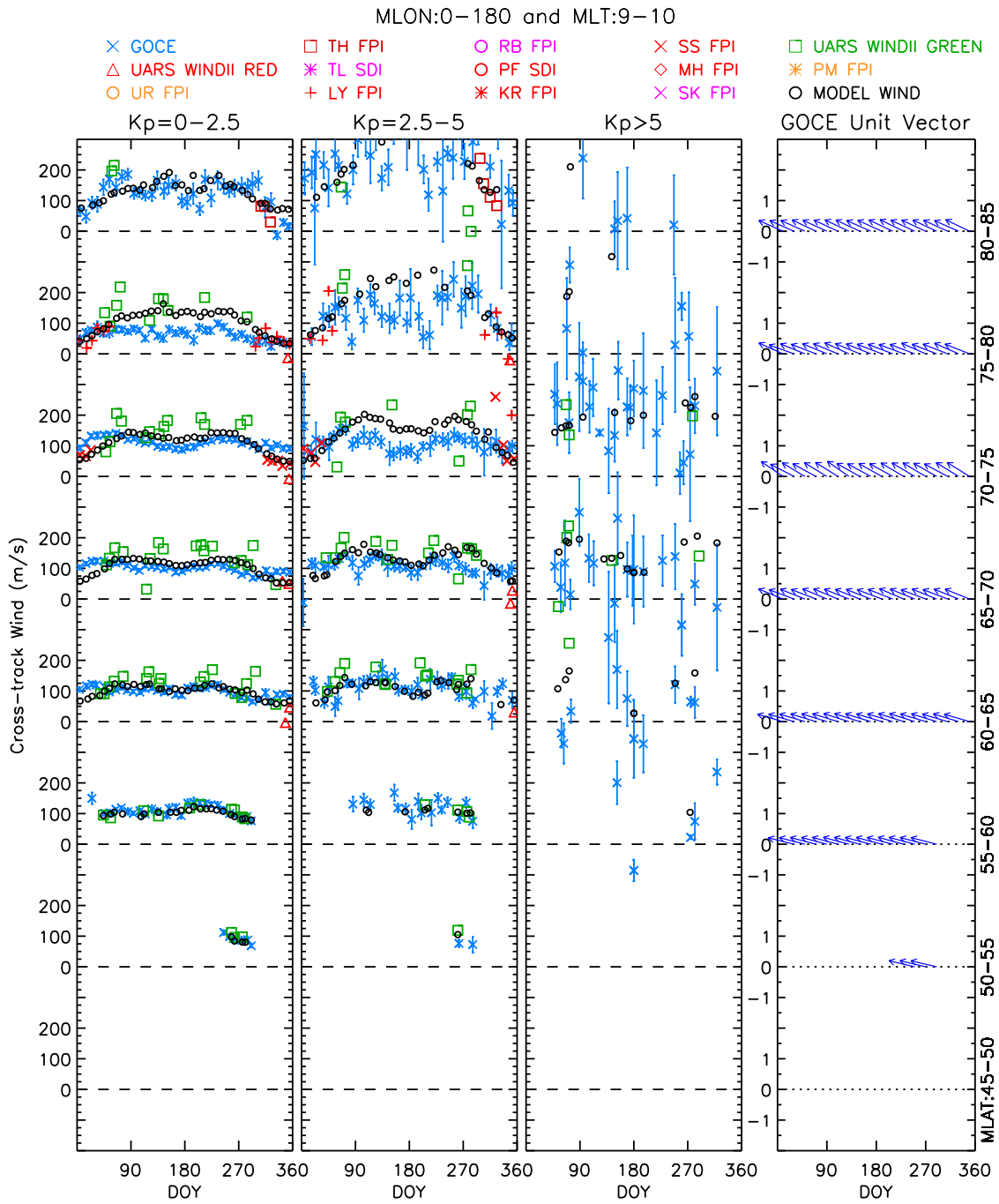


Figure S9. Same as Figure S8, but for a different MLON and MLT combination as shown on the top.



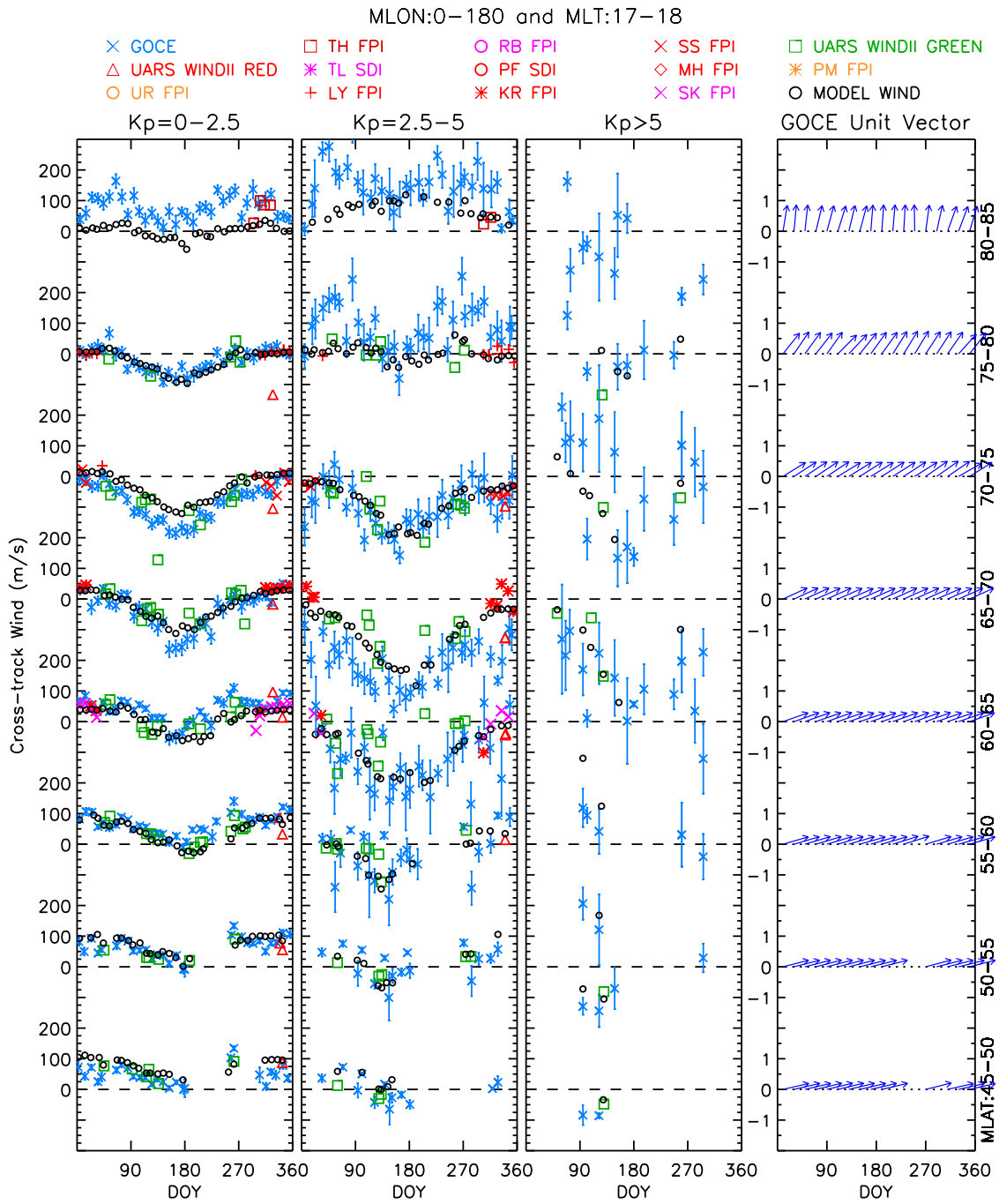


Figure S11. Same as Figure S8, but for a different MLON and MLT combination as shown on the top.

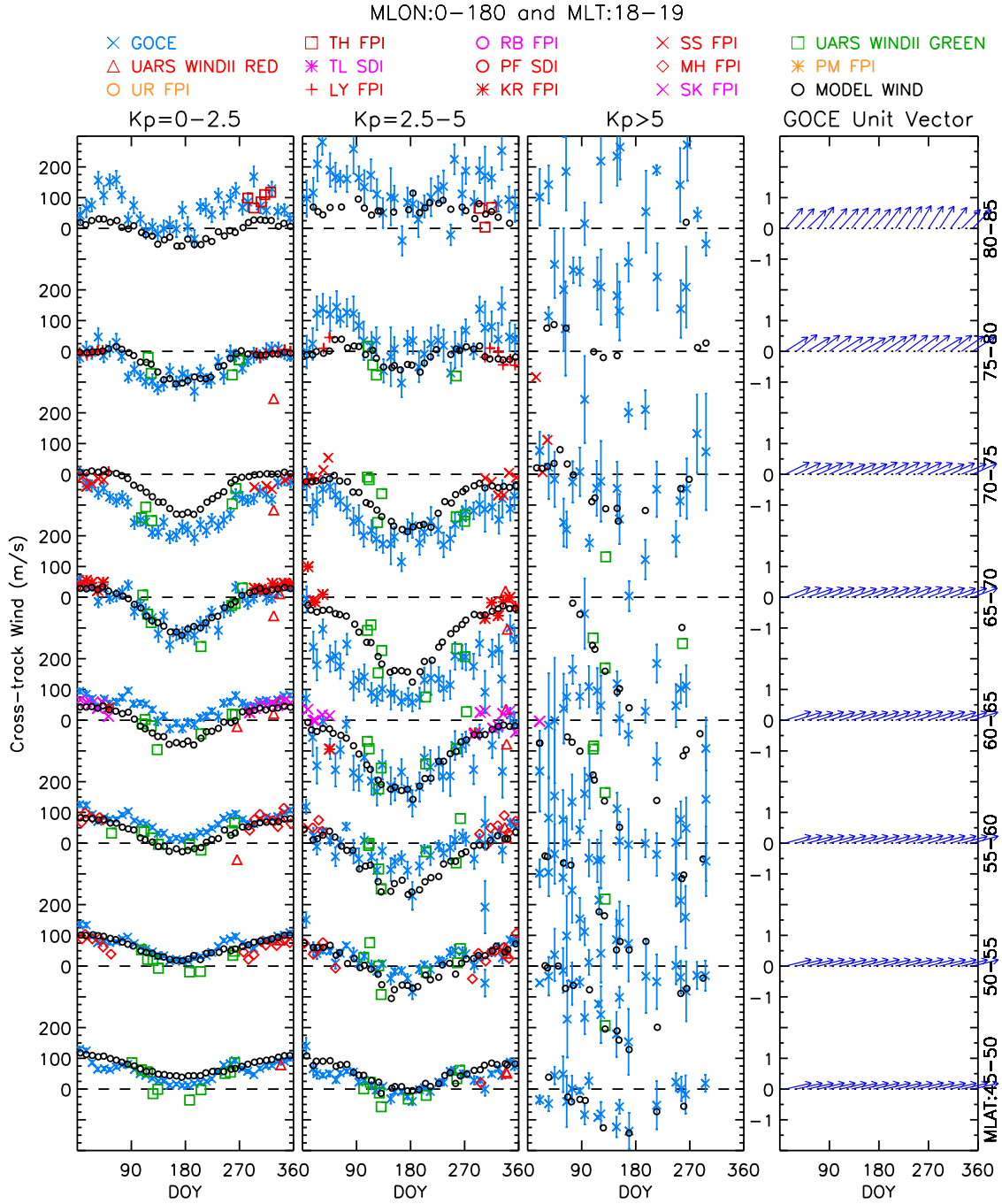


Figure S12. Same as Figure S8, but for a different MLON and MLT combination as shown on the top.

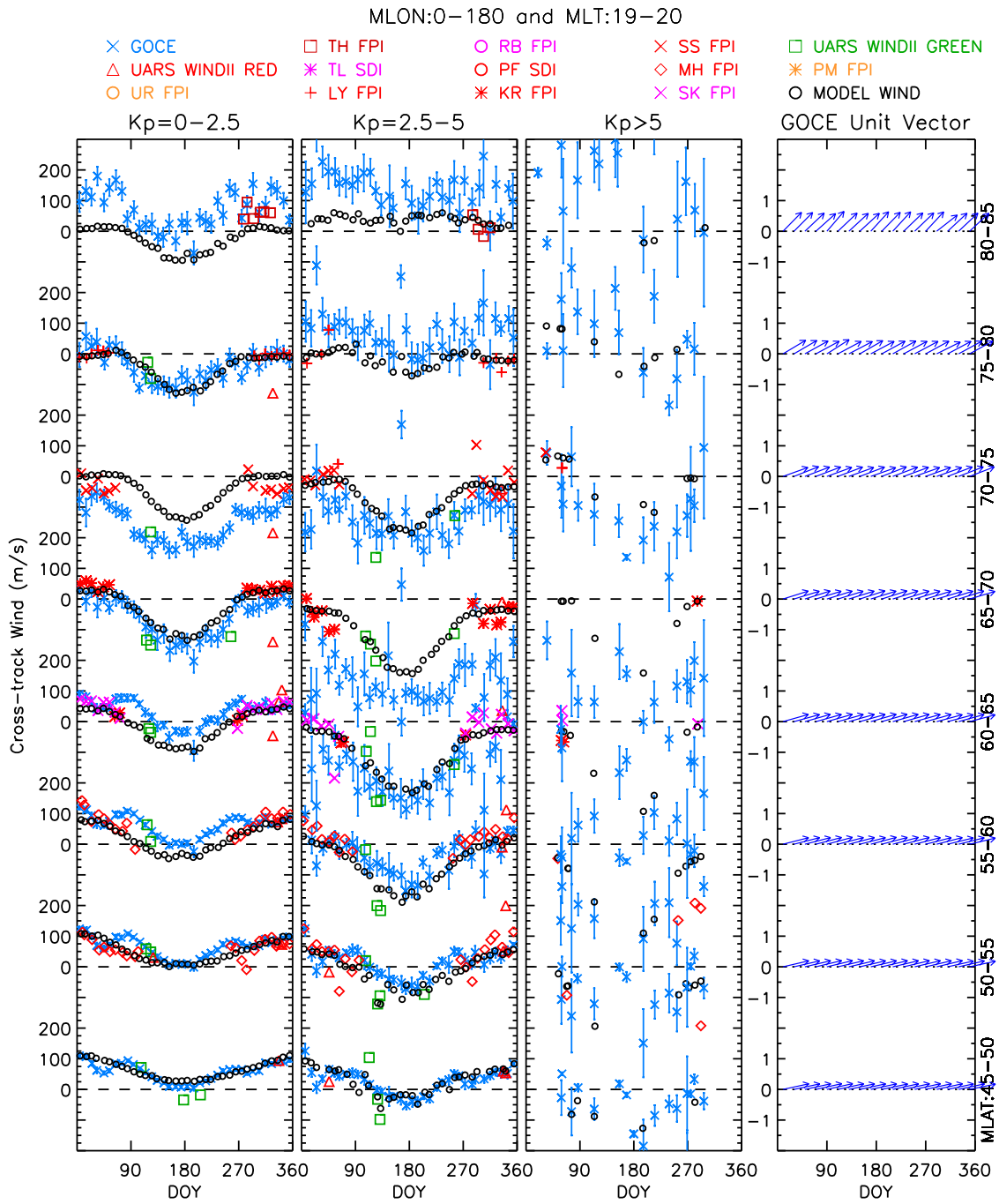


Figure S13. Same as Figure S8, but for a different MLON and MLT combination as shown on the top.

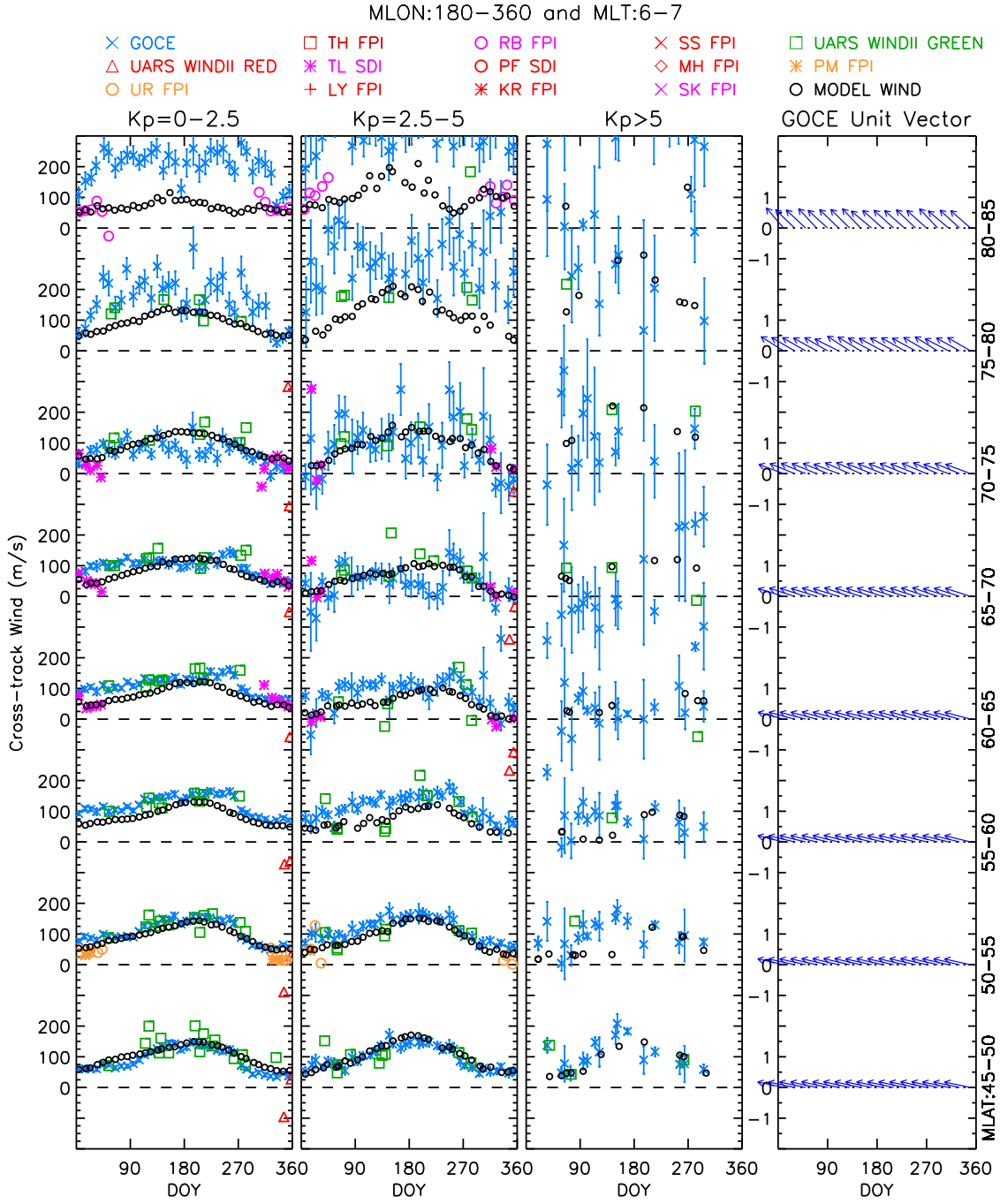


Figure S14. Same as Figure S8, but for a different MLON and MLT combination as shown on the top.

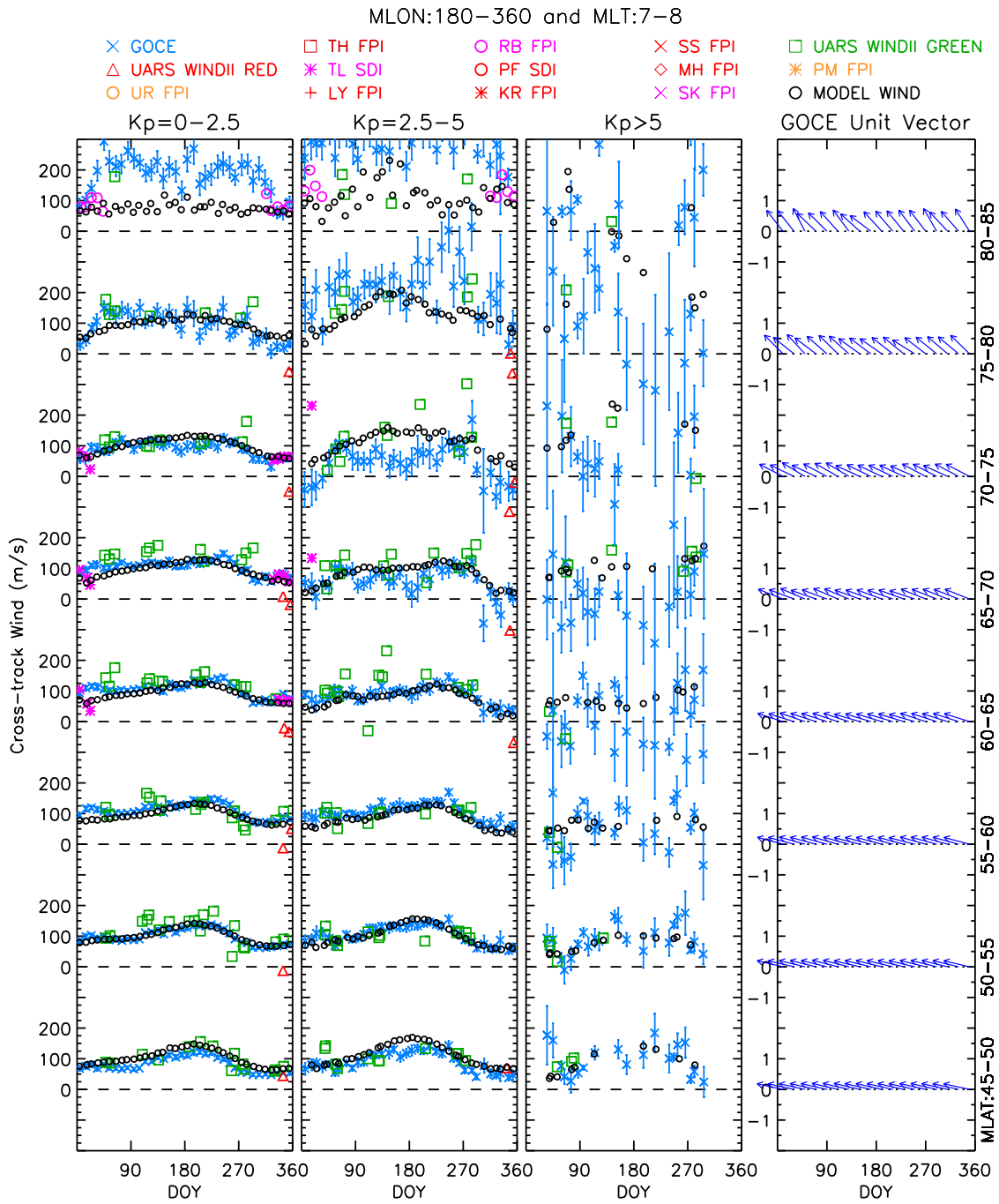


Figure S15. Same as Figure S8, but for a different MLON and MLT combination as shown on the top.

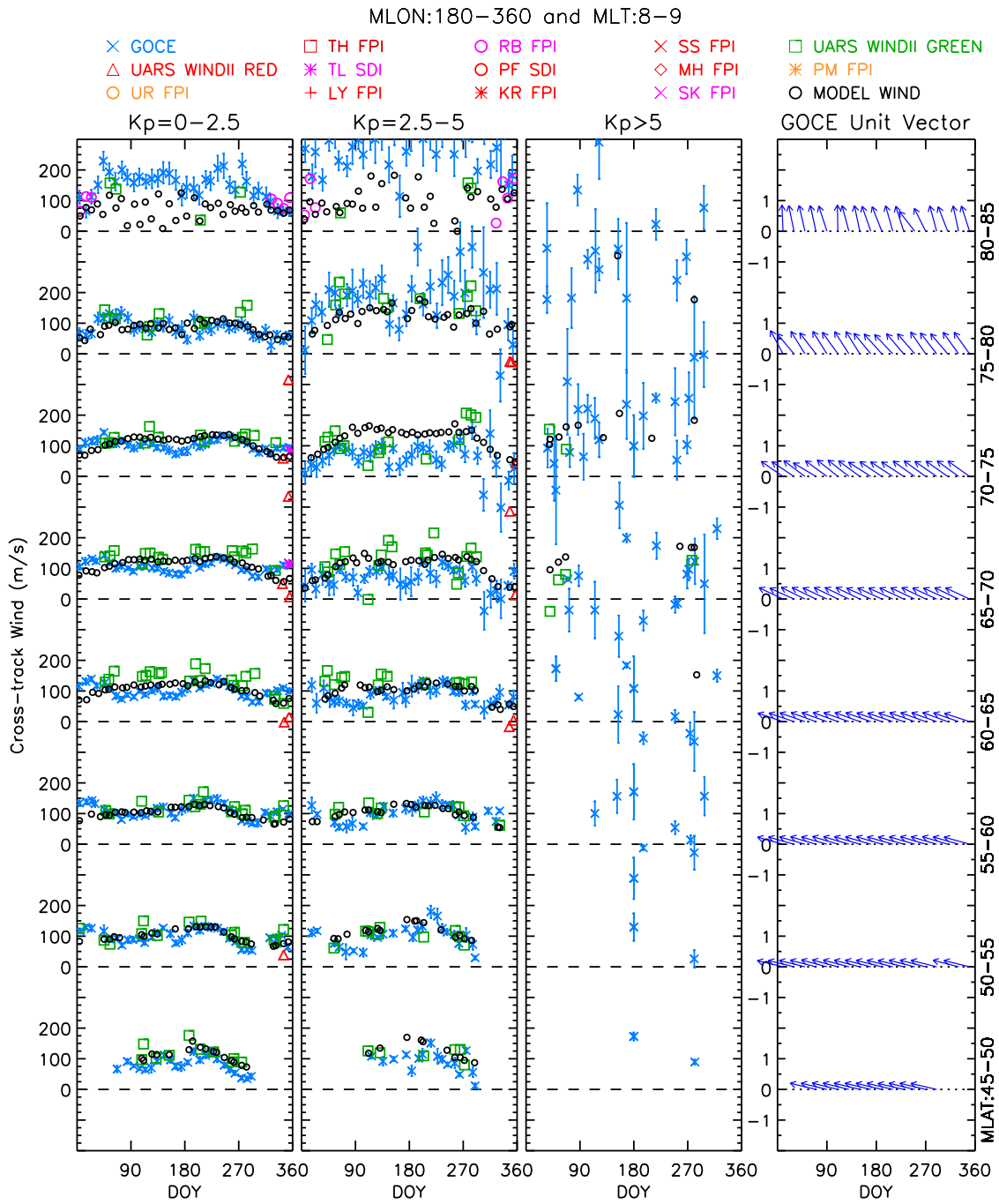


Figure S16. Same as Figure S8, but for a different MLON and MLT combination as shown on the top.

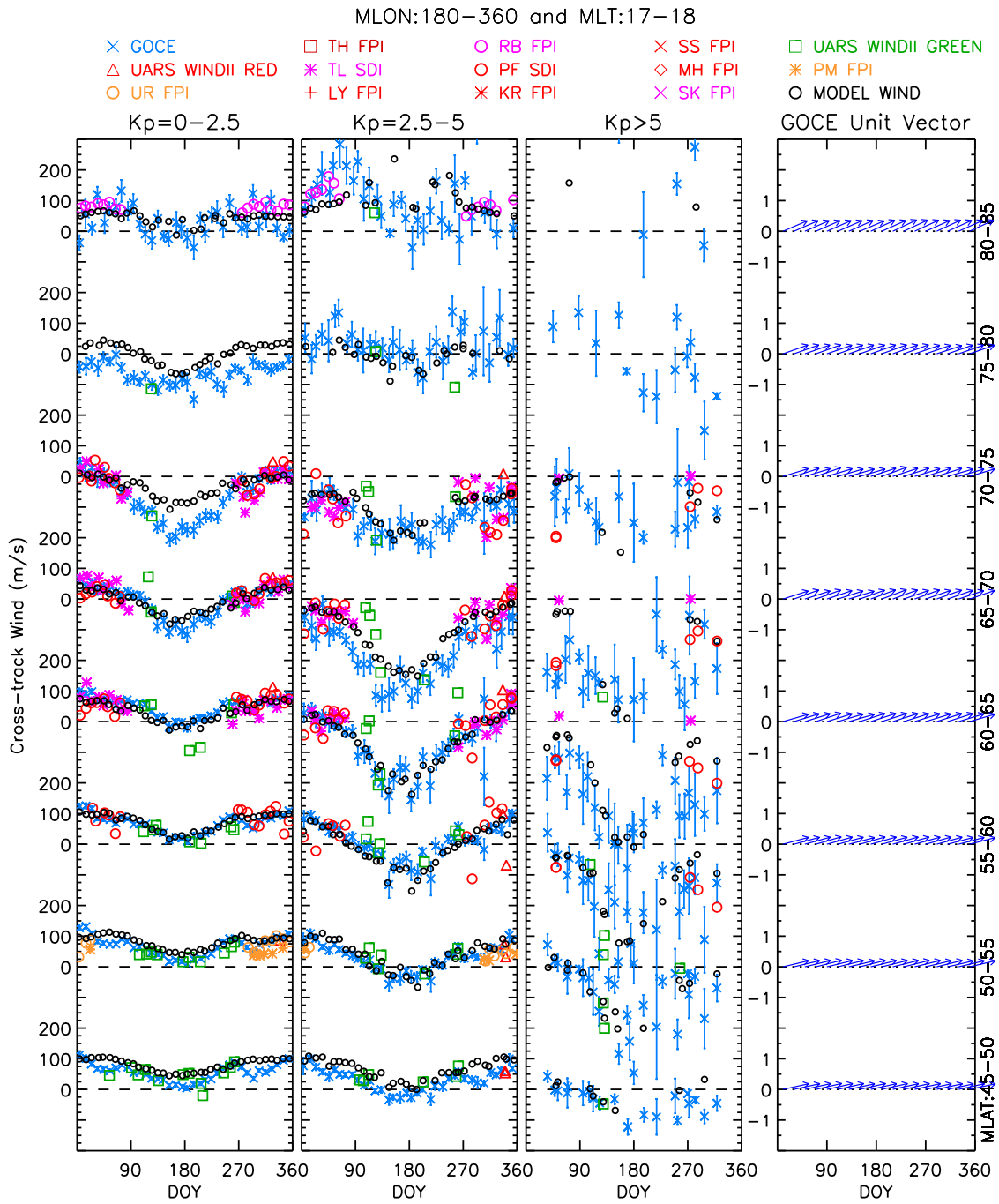


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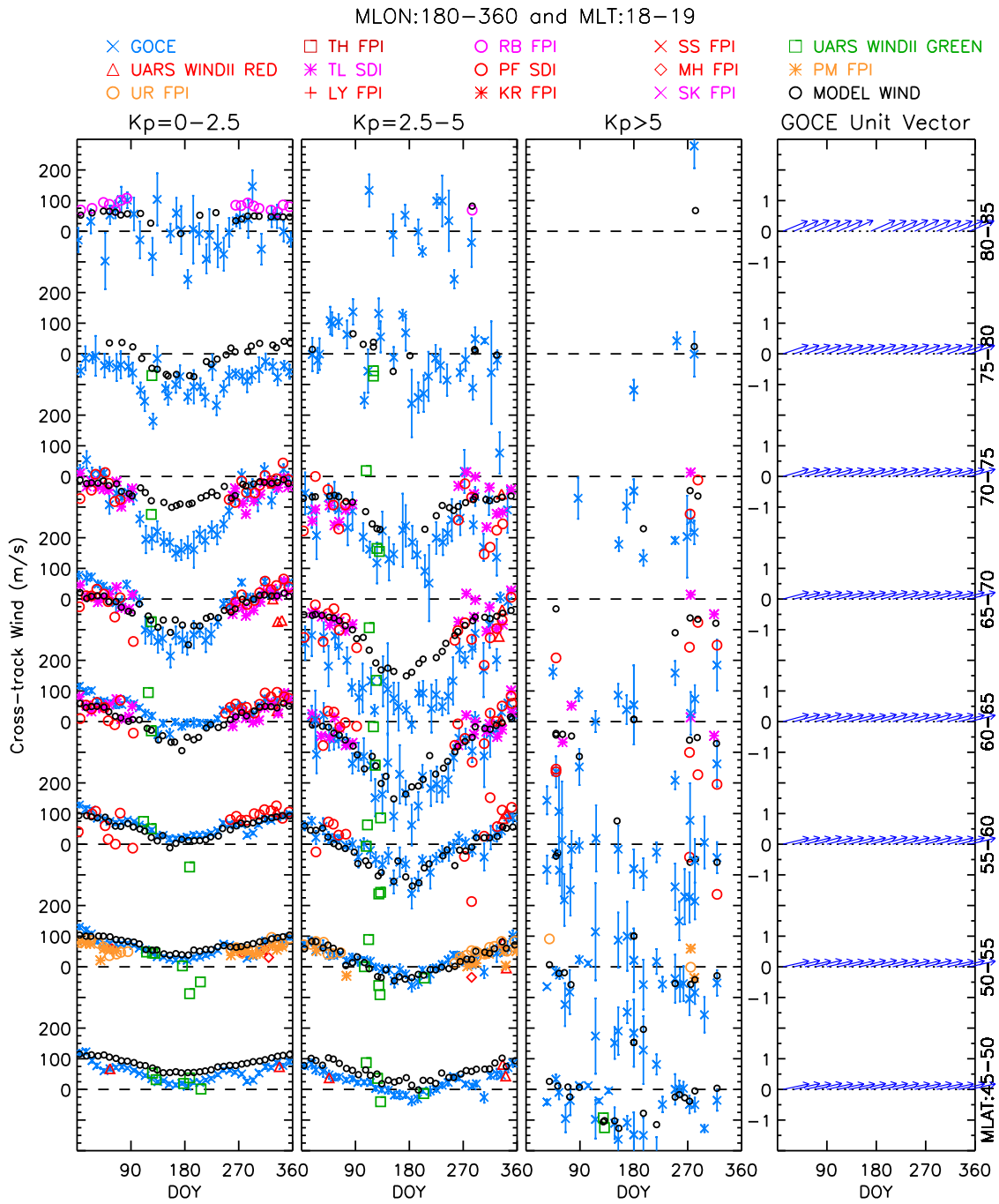


Figure S18. Same as Figure S8, but for a different MLON and MLT combination as shown on the top.

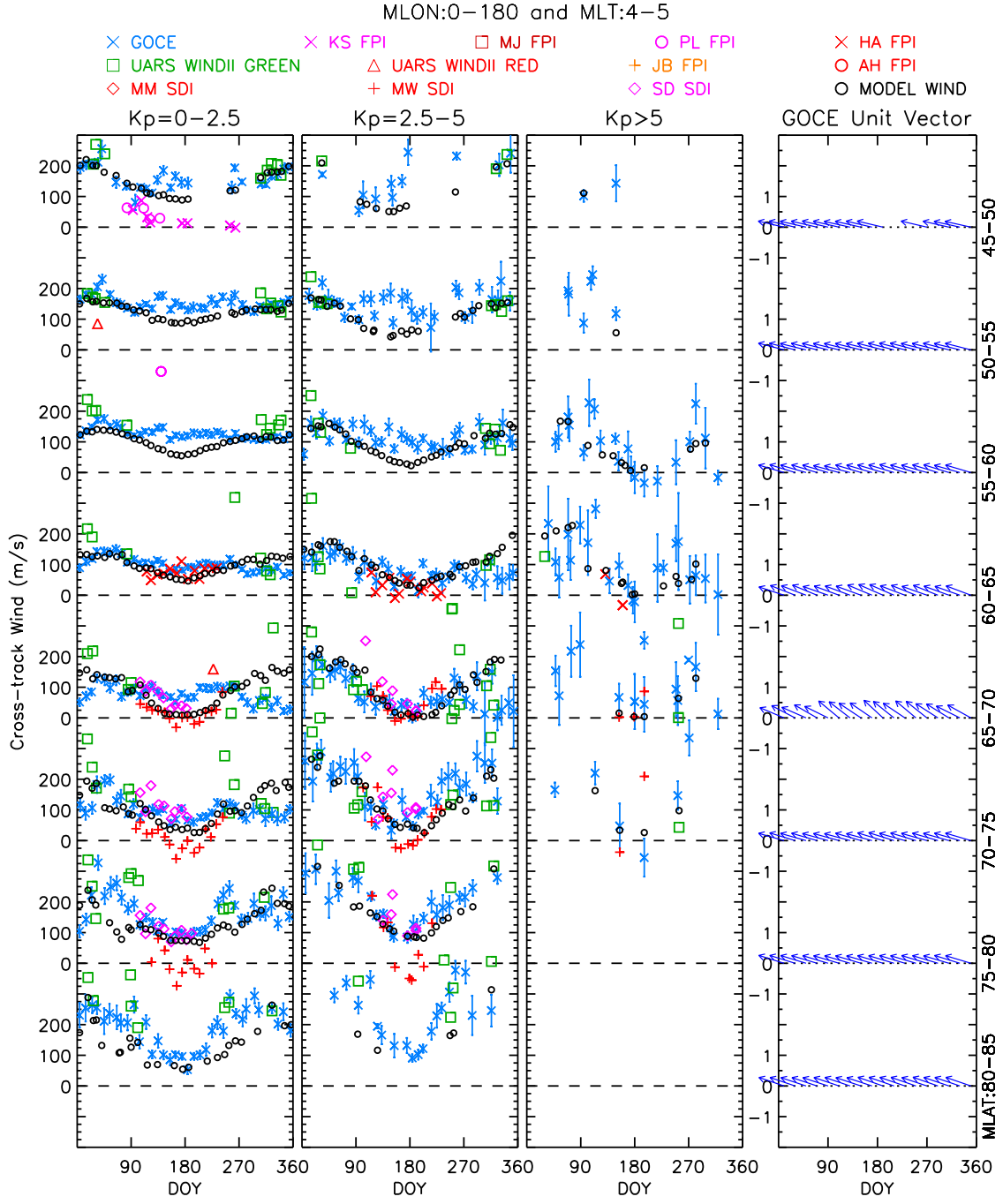


Figure S19. Same as for Figure S8, but for SOUTHERN high latitudes. MLON and MLT combination is shown on the top.

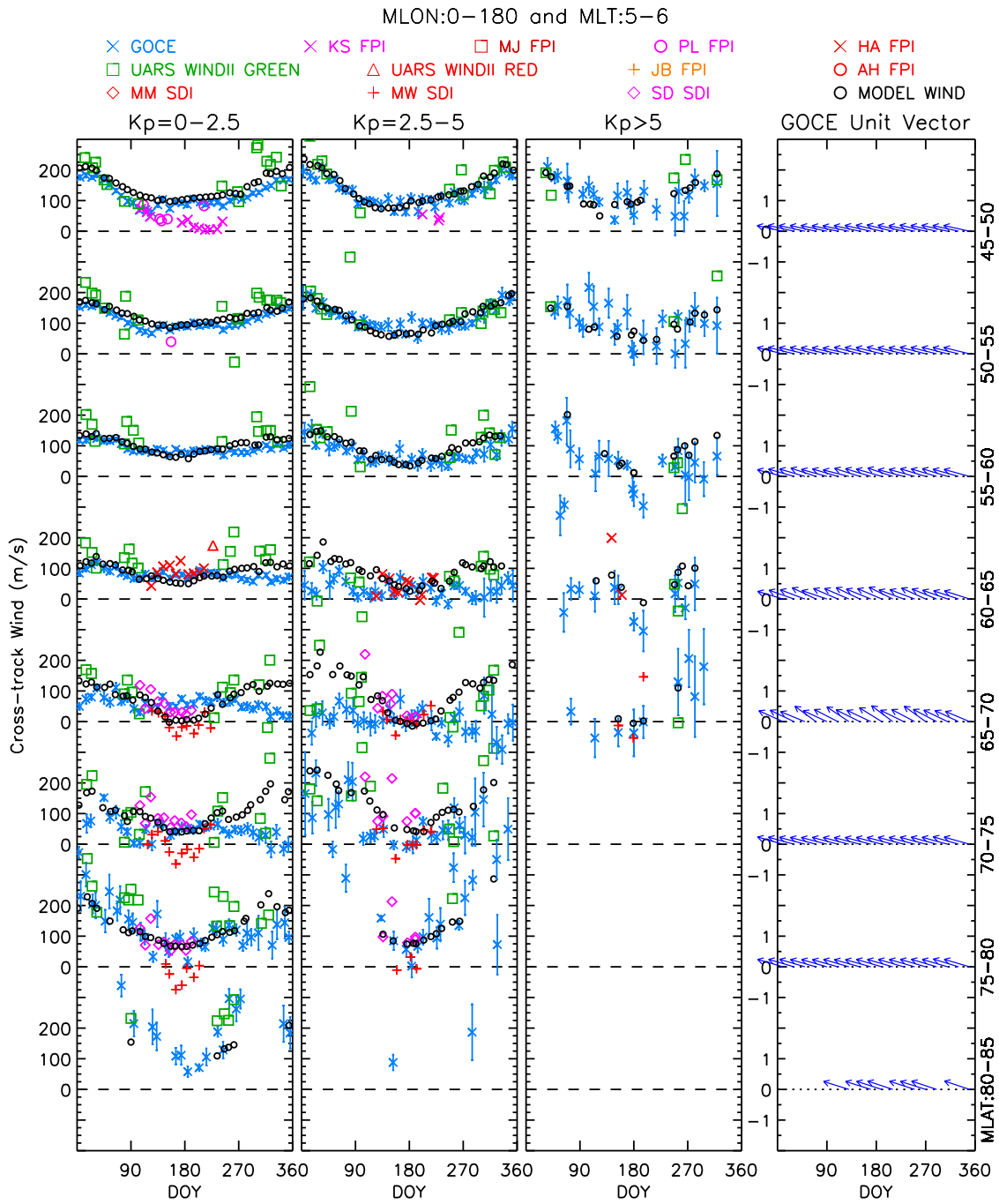
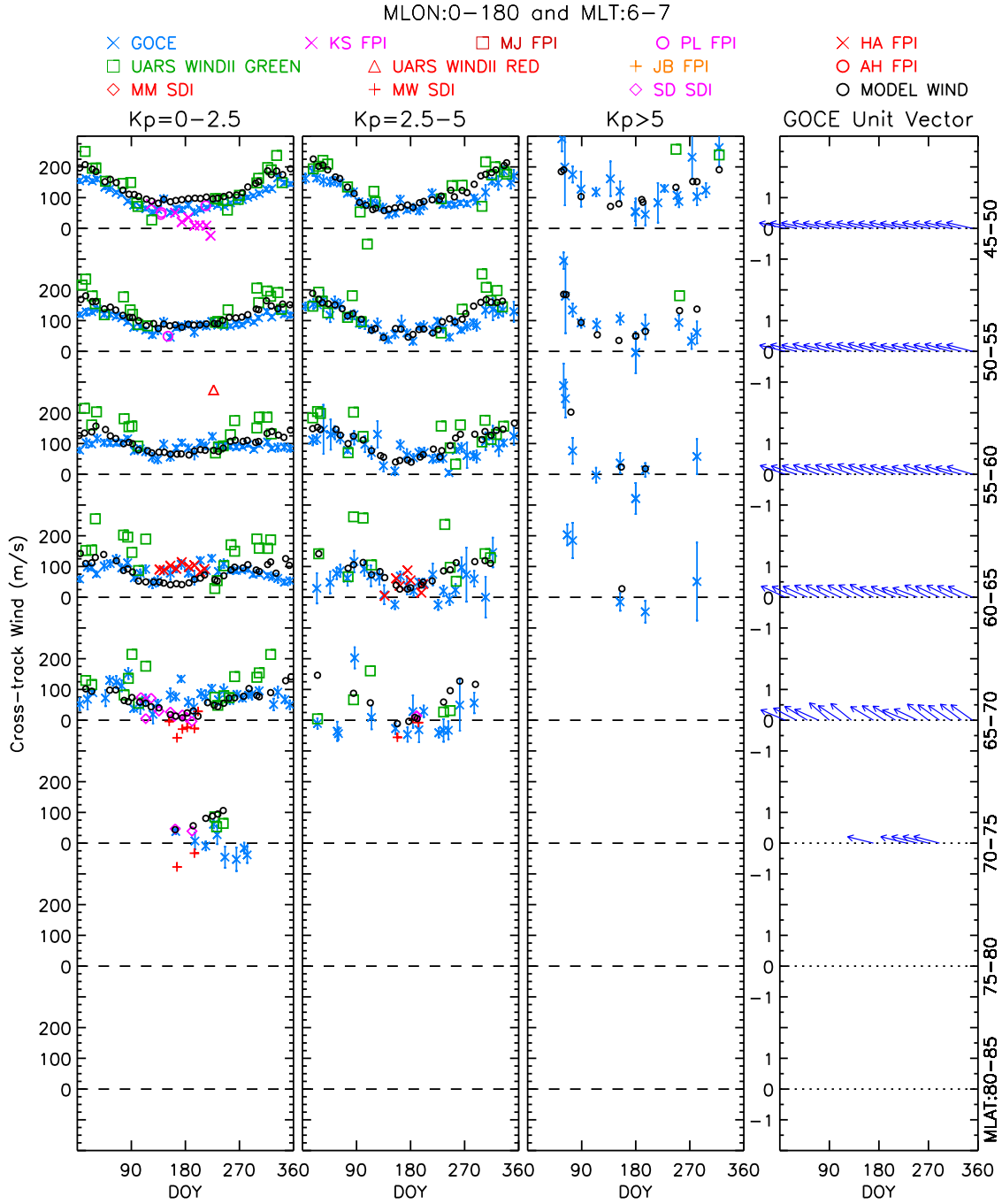


Figure S20. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.



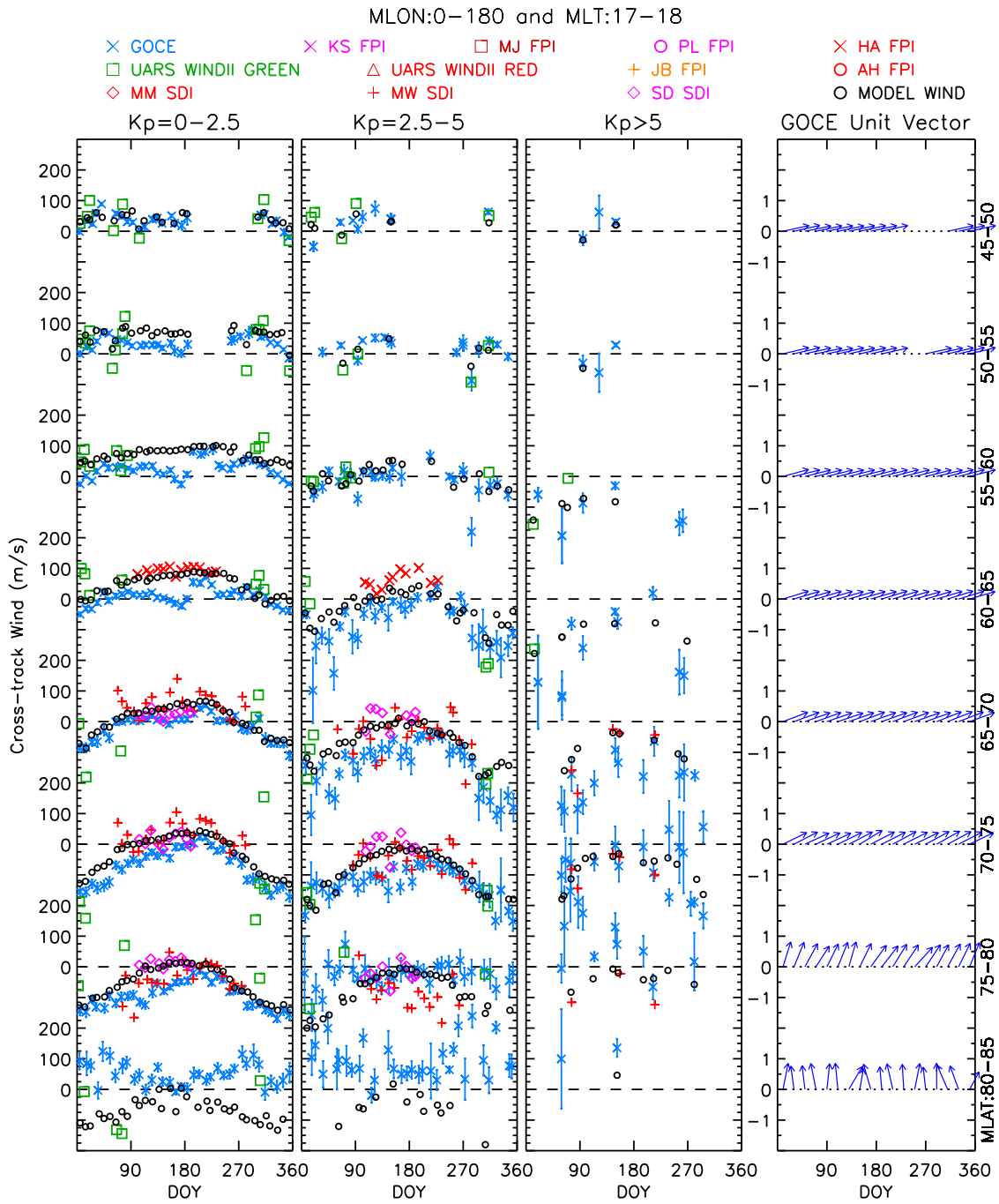


Figure S22. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.

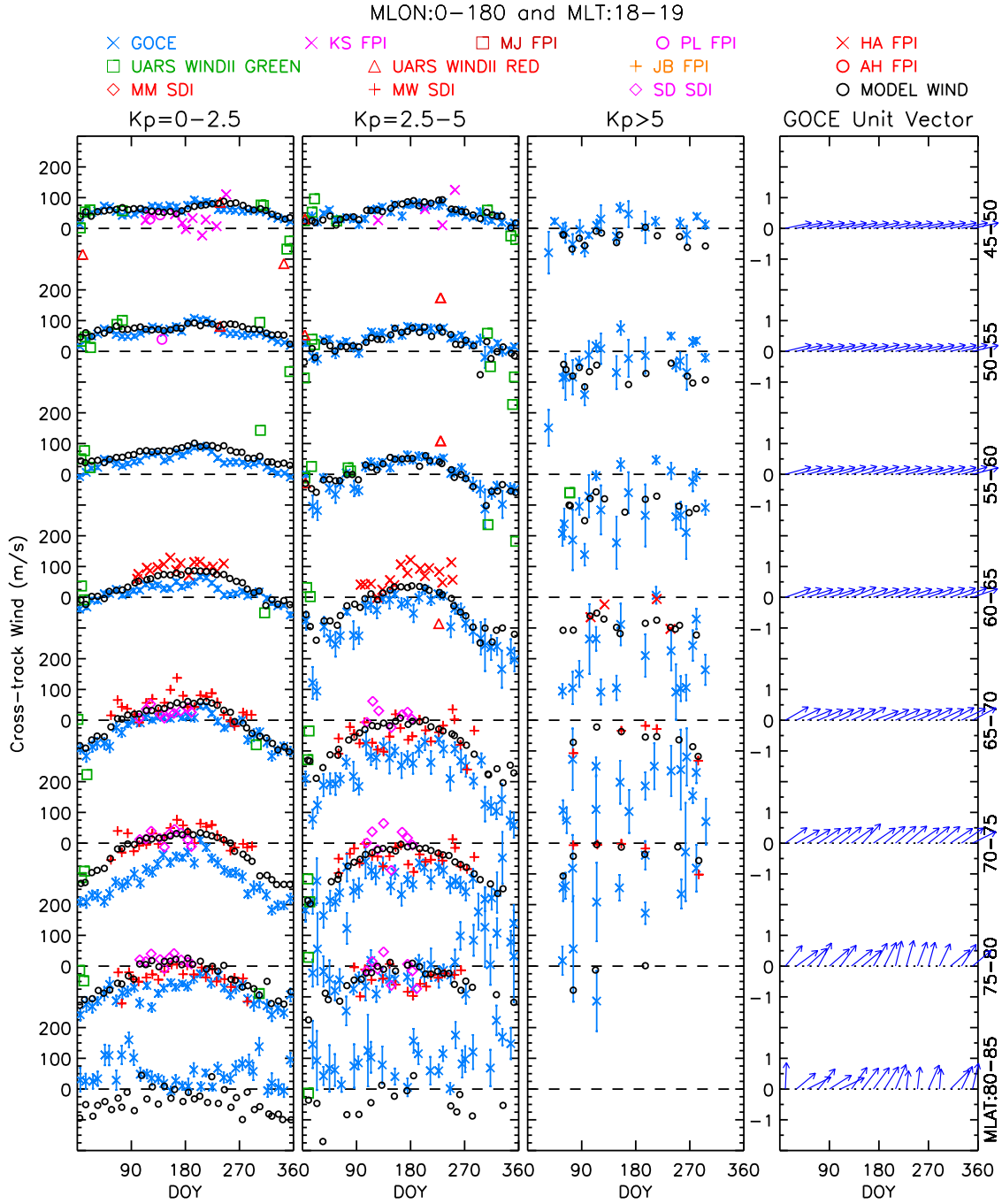


Figure S23. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.

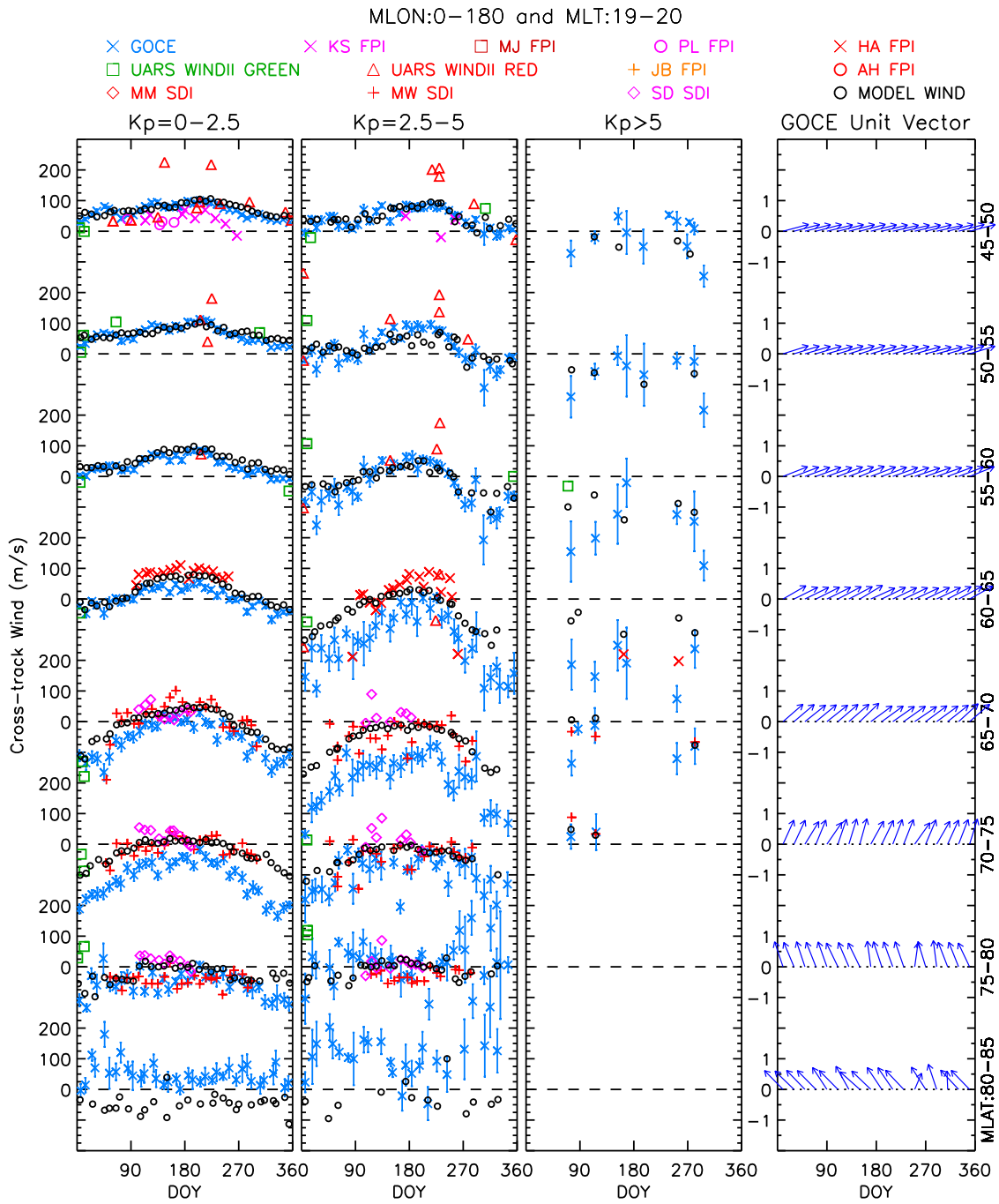


Figure S24. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.

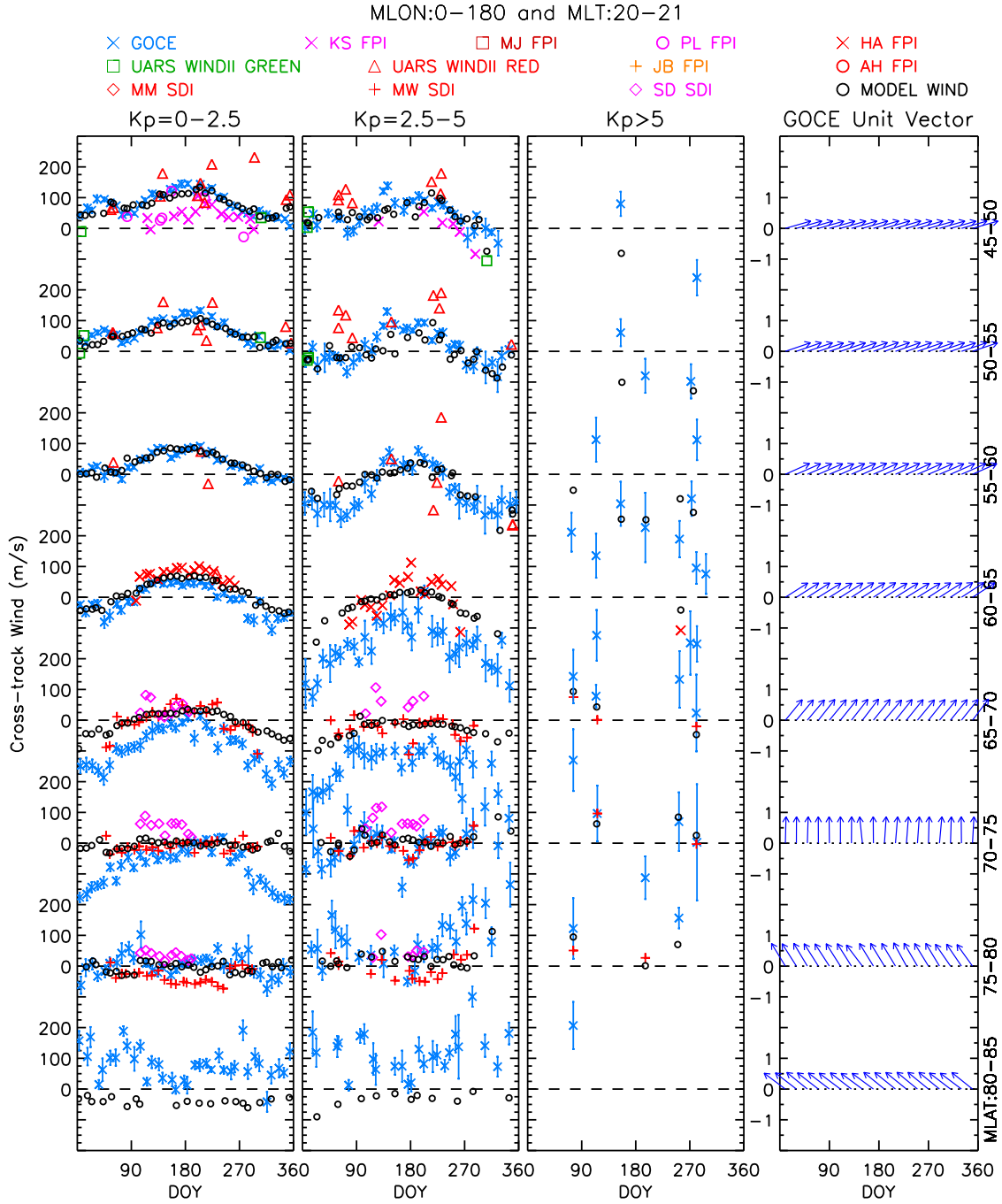


Figure S25. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.

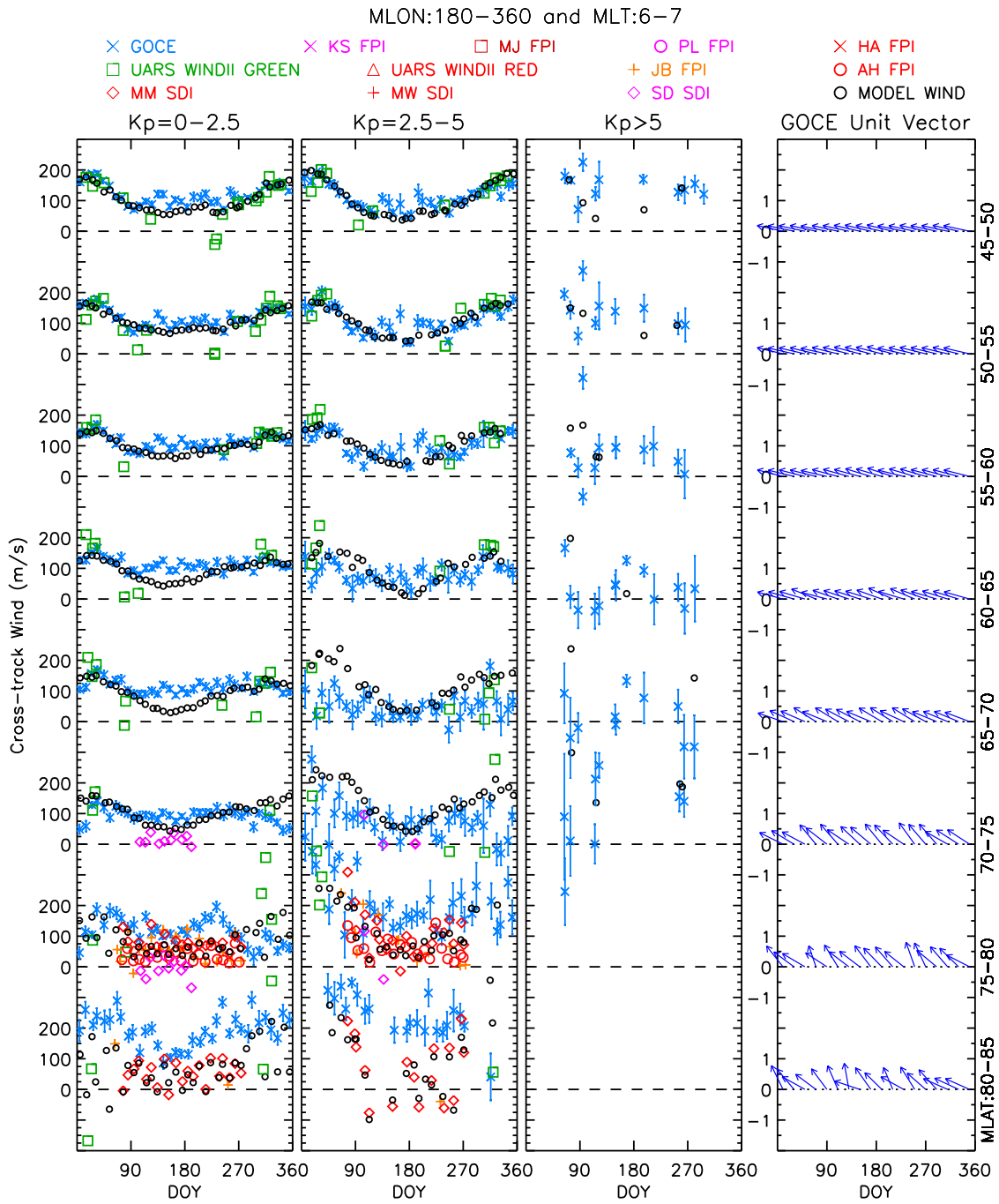


Figure S26. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.

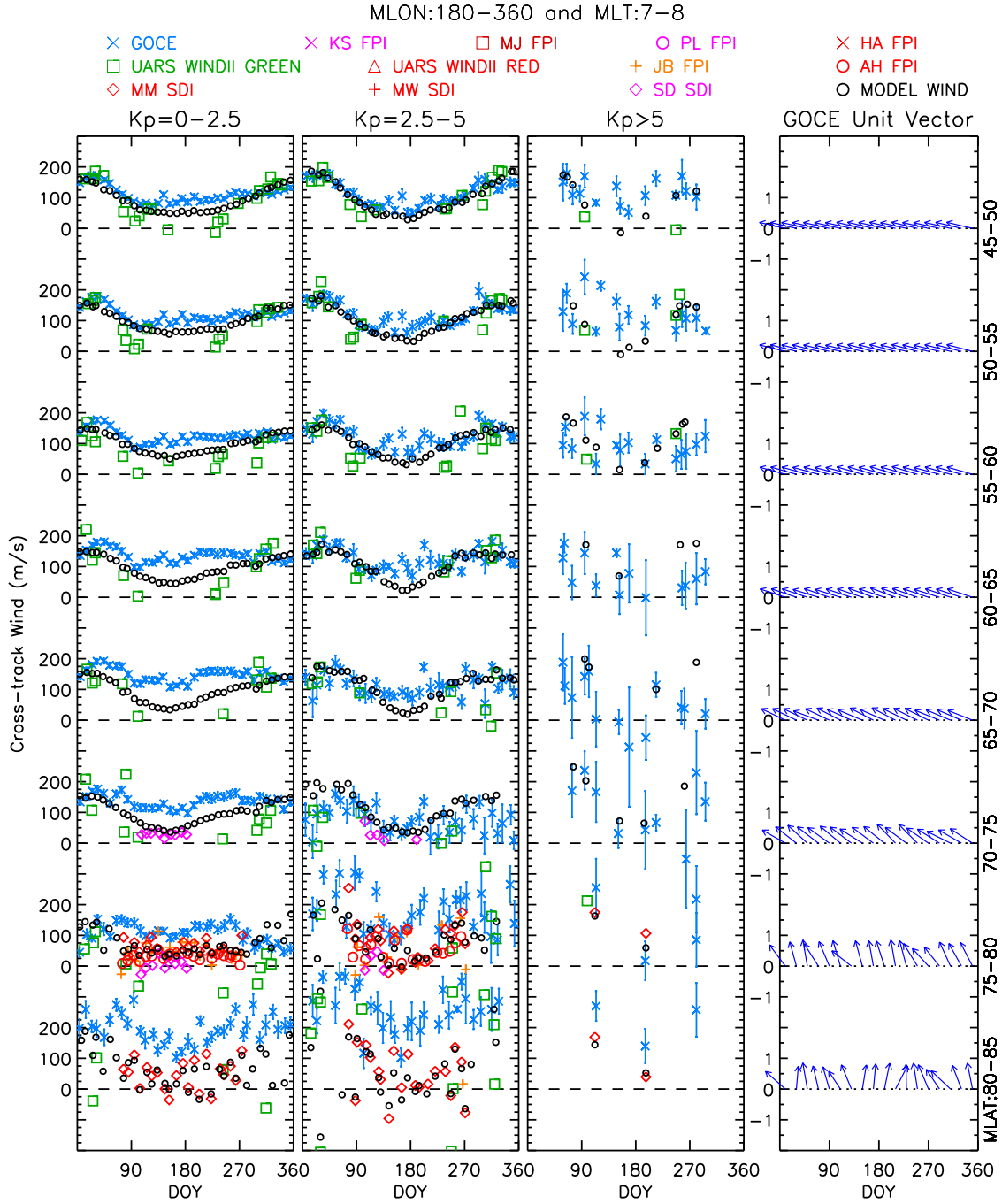


Figure S27. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.

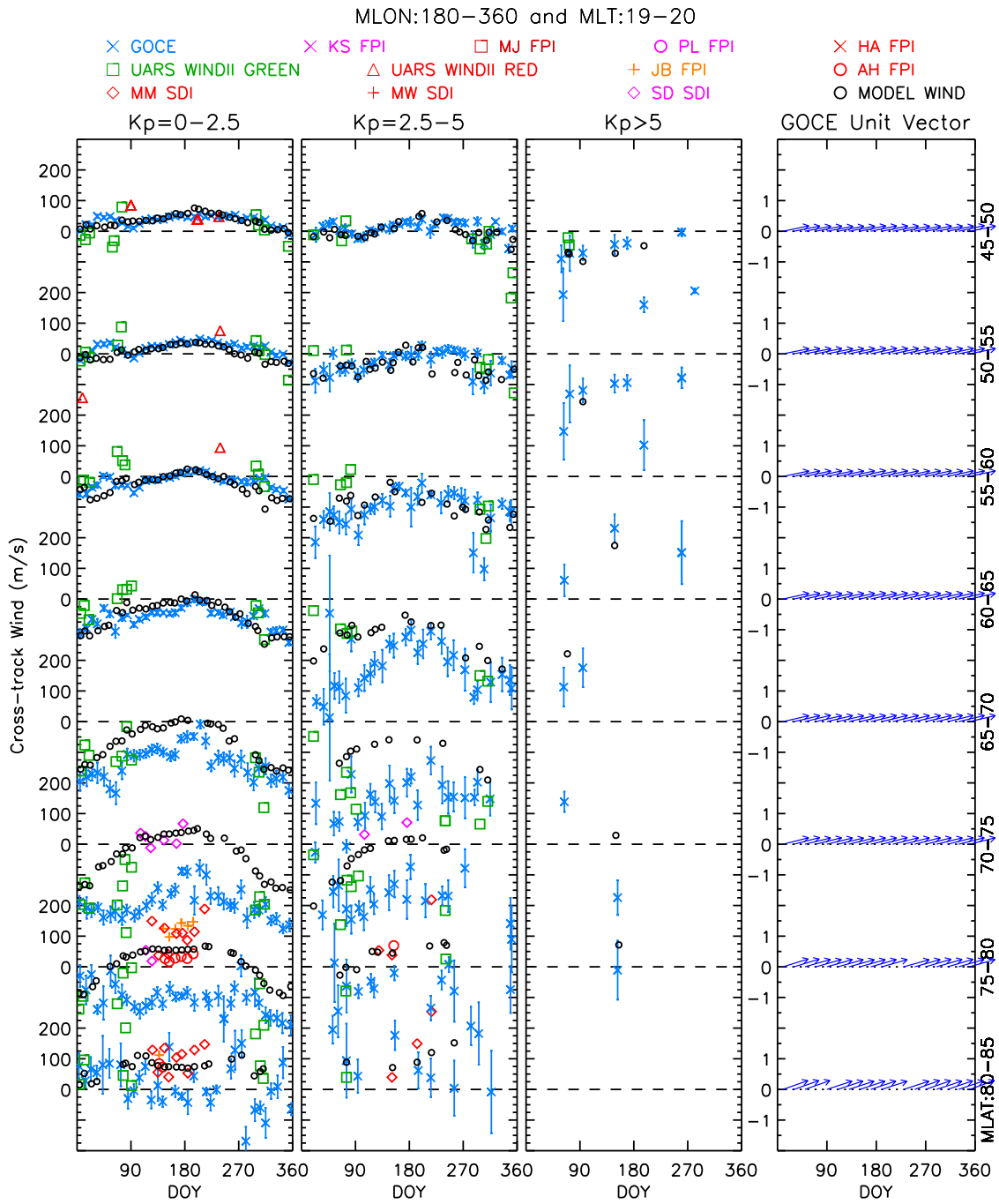


Figure S28. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.

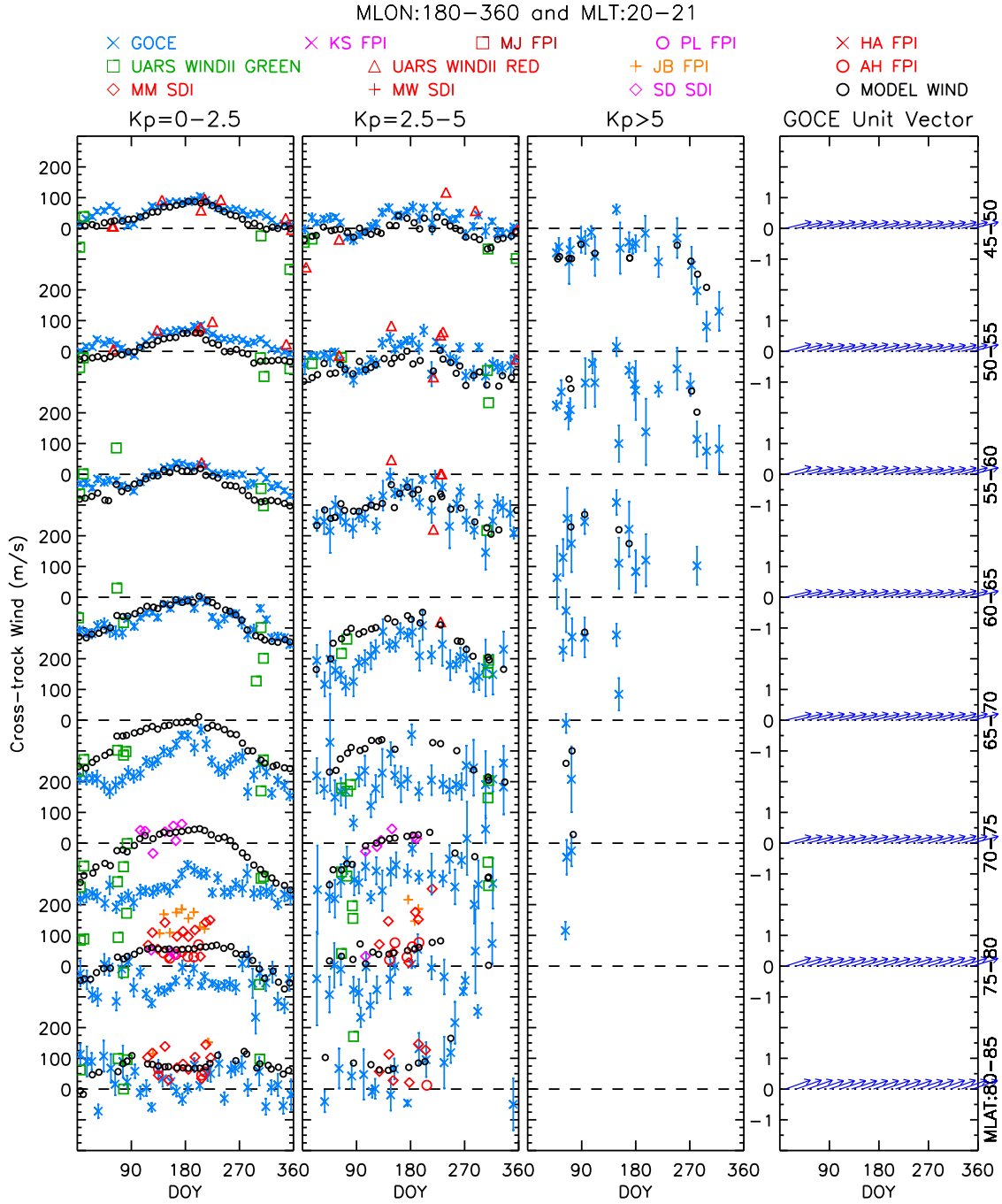


Figure S29. Same as Figure S19, but for a different MLON and MLT combination as shown on the top.