**Supplementary material**

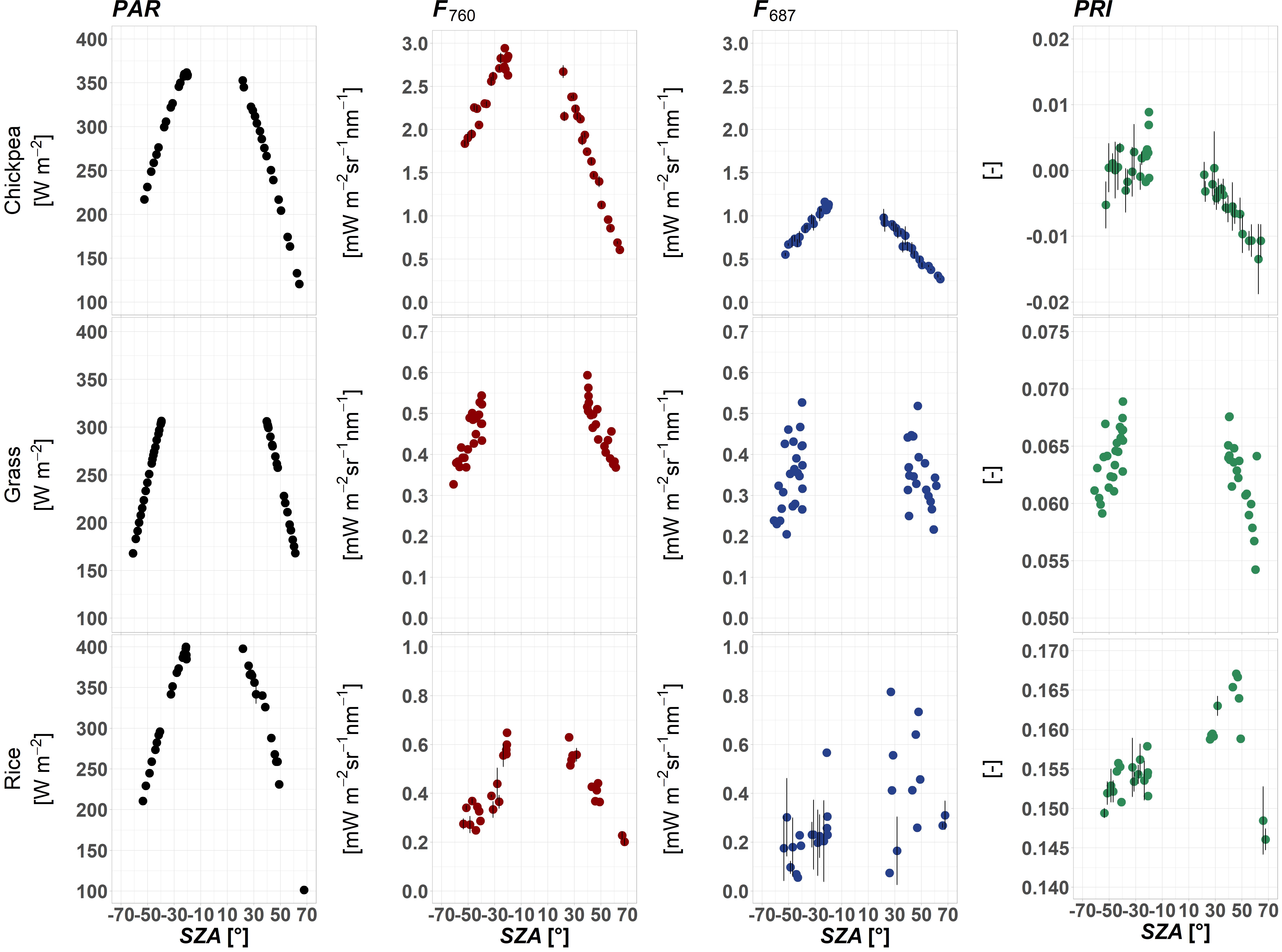


Figure S1. Diurnal cycles of *PAR*, *F*760, *F*687 and *PRI* acquired from a nadir-viewing direction for chickpea (row 1), grass (row 2) and rice (row 3). Error bars for chickpea and rice indicate standard deviation (n = 3). Measurements over the grass were collected as a single acquisition (n = 1). Negative values of *SZA* correspond to the cycles acquired before midday, positive - after midday.

|  |  |  |  |
| --- | --- | --- | --- |
| *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* | *sPRI*\_*ANIX* |
| -52 | 1.968 | 3.862 | 1.0279 |
| -47 | 1.770 | 3.224 | 1.0258 |
| -43 | 1.734 | 2.730 | 1.0166 |
| -37 | 1.776 | 2.347 | 1.0253 |
| -32 | 1.635 | 2.450 | 1.0215 |
| -26 | 1.649 | 2.152 | 1.0175 |
| -23 | 1.660 | 2.266 | 1.0298 |
| -20 | 1.671 | 2.345 | 1.0279 |
| 22 | 1.942 | 2.216 | 1.0204 |
| 28 | 2.999 | 3.135 | 1.021 |
| 31 | 2.468 | 3.555 | 1.0226 |
| 35 | 3.255 | 4.198 | 1.0198 |
| 39 | 3.626 | 4.320 | 1.0205 |
| 44 | 3.048 | 4.354 | 1.0179 |
| 49 | 2.835 | 4.205 | 1.013 |
| 56 | 2.536 | 4.702 | 1.0197 |
| 63 | 1.930 | 4.397 | 1.0227 |

Table S1. *ANIX* calculated for *F*760, *F*687 and *sPRI* measured in the SPP over chickpea.

|  |  |  |  |
| --- | --- | --- | --- |
| *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* | *sPRI*\_*ANIX* |
| -50 | 1.135 | 1.299 | 1.0198 |
| -45 | 1.186 | 1.275 | 1.016 |
| -41 | 1.170 | 1.299 | 1.0161 |
| -36 | 1.209 | 1.299 | 1.0124 |
| -31 | 1.187 | 1.396 | 1.0147 |
| -25 | 1.288 | 1.398 | 1.0139 |
| -21 | 1.579 | 1.96 | 1.0337 |
| -20 | 1.819 | 1.919 | 1.0195 |
| 23 | 1.38 | 1.464 | 1.0116 |
| 30 | 1.289 | 1.49 | 1.0087 |
| 33 | 1.300 | 1.337 | 1.0114 |
| 37 | 1.257 | 1.178 | 1.0046 |
| 40 | 1.268 | 1.619 | 1.017 |
| 45 | 1.270 | 1.286 | 1.0102 |
| 51 | 1.438 | 1.296 | 1.0152 |
| 58 | 1.360 | 1.316 | 1.0124 |
| 65 | 1.326 | 1.176 | 1.0223 |

Table S2. *ANIX* calculated for *F*760, *F*687 and *sPRI* measured in the CPP over chickpea.

|  |  |  |  |
| --- | --- | --- | --- |
| *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* | *sPRI*\_*ANIX* |
| -60 | 1.547 | 2.812 | 1.0106 |
| -57 | 1.638 | 2.104 | 1.0137 |
| -55 | 1.711 | 3.432 | 1.0141 |
| -52 | 1.907 | 3.34 | 1.0146 |
| -50 | 1.775 | 2.408 | 1.0139 |
| -47 | 1.671 | 1.807 | 1.0167 |
| -44 | 1.892 | 3.526 | 1.0108 |
| -42 | 1.762 | 2.068 | 1.0141 |
| -40 | 1.876 | 2.178 | 1.0105 |
| -39 | 1.984 | 3.352 | 1.0102 |
| 41 | 1.880 | 2.565 | 1.0085 |
| 43 | 1.932 | 2.696 | 1.01 |
| 47 | 2.096 | 2.609 | 1.0101 |
| 53 | 1.867 | 1.895 | 1.0142 |
| 56 | 2.446 | 2.077 | 1.0163 |
| 60 | 1.652 | 2.907 | 1.013 |

Table S3. *ANIX* calculated for *F*760, *F*687 and *sPRI* measured in the SPP over grass.

|  |  |  |  |
| --- | --- | --- | --- |
| *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* | *sPRI*\_*ANIX* |
| -58 | 1.368 | 2.035 | 1.0112 |
| -56 | 1.554 | 2.343 | 1.0141 |
| -54 | 1.387 | 1.525 | 1.0075 |
| -51 | 1.443 | 2.149 | 1.0099 |
| -48 | 1.515 | 1.435 | 1.0101 |
| -46 | 1.344 | 1.325 | 1.0094 |
| -43 | 1.329 | 2.845 | 1.0118 |
| -41 | 1.370 | 2.247 | 1.0116 |
| -40 | 1.371 | 2.83 | 1.0103 |
| -39 | 1.383 | 1.57 | 1.0055 |
| 41 | 1.337 | 2.227 | 1.0071 |
| 54 | 1.528 | 1.982 | 1.0078 |

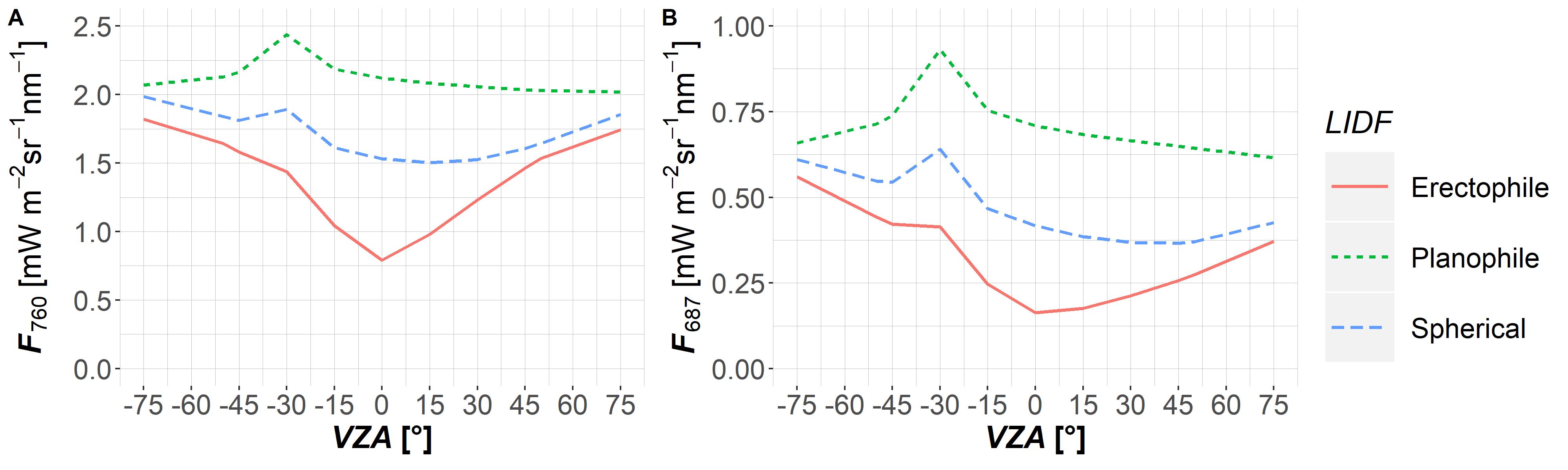
Table S4. *ANIX* calculated for *F*760, *F*687 and *sPRI* measured in the CPP over grass.

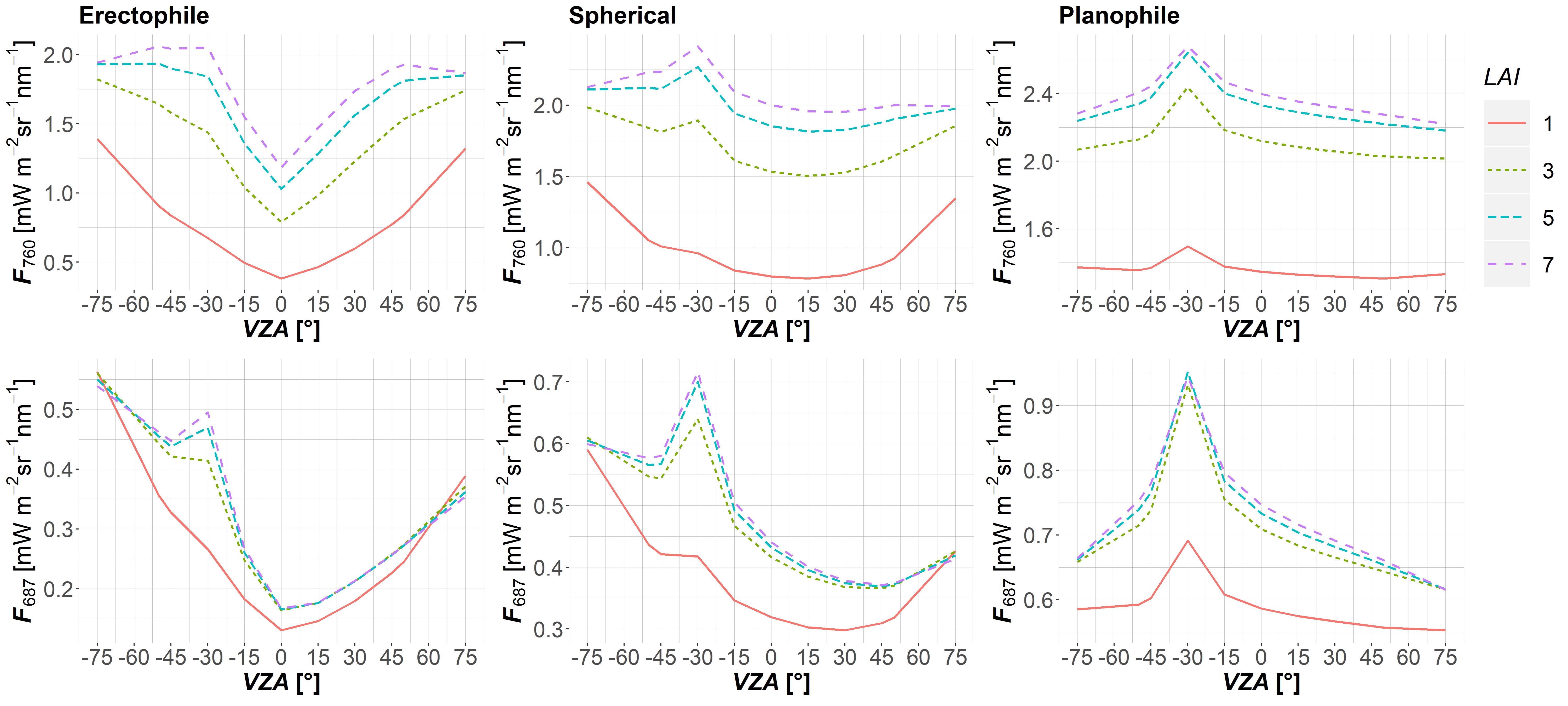
|  |  |  |  |
| --- | --- | --- | --- |
| *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* | *sPRI*\_*ANIX* |
| -53 | 2.615 | 3.165 | 1.0177 |
| -48 | 3.197 | 4.532 | 1.0225 |
| -43 | 3.547 | 8.86 | 1.0246 |
| -32 | 3.144 | 4.205 | 1.0172 |
| -26 | 2.690 | 4.189 | 1.015 |
| -23 | 2.356 | 3.479 | 1.0174 |
| -21 | 3.031 | 34.639 | 1.0246 |
| 26 | 3.335 | 8.767 | 1.0232 |
| 31 | 3.207 | 2.86 | 1.0198 |
| 37 | 5.068 | 3.829 | 1.0136 |
| 44 | 2.656 | 13.745 | 1.0172 |
| 46 | 2.725 | 4.334 | 1.0188 |
| 67 | 2.429 | 2.179 | 1.0181 |

Table S5. *ANIX* calculated for *F*760, *F*687 and *sPRI* measured in the SPP over rice.

|  |  |  |  |
| --- | --- | --- | --- |
| *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* | *sPRI*\_*ANIX* |
| -51 | 2.692 | 2.915 | 1.0168 |
| -46 | 2.508 | 4.124 | 1.0147 |
| -31 | 2.684 | 3.446 | 1.0098 |
| -28 | 1.721 | 6.423 | 1.0107 |
| -22 | 1.345 | 4.299 | 1.0106 |
| 27 | 3.682 | 65.169 | 1.0182 |
| 32 | 2.397 | 5.435 | 1.0147 |
| 39 | 3.528 | 2.265 | 1.0123 |
| 68 | 1.814 | 1.984 | 1.0152 |

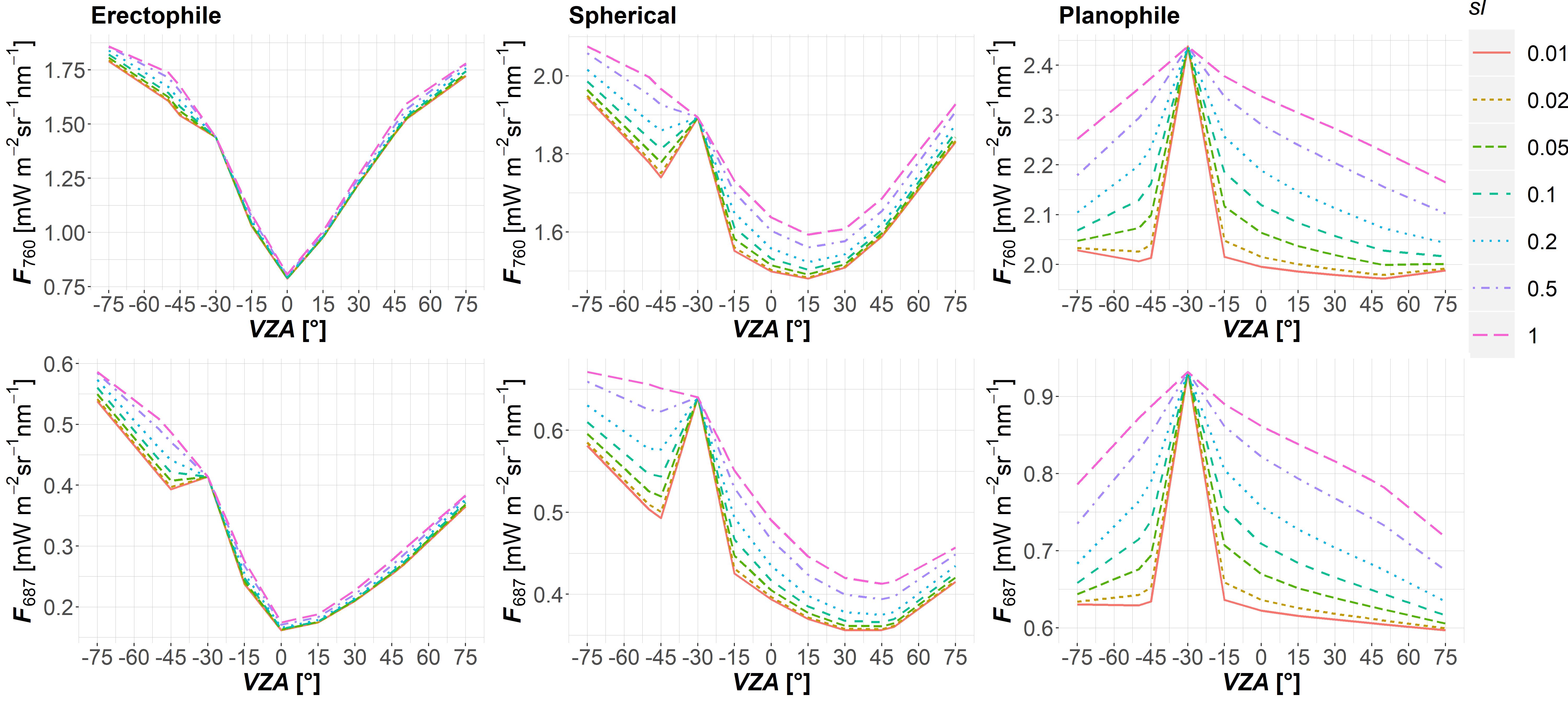
Table S6. *ANIX* calculated for *F*760, *F*687 and *sPRI* measured in the AR over rice.

Figure S2. Distribution of multi-angular *F*760 (A) and *F*687 (B) in the solar principal plane (SPP) as a function of view zenith angle (*VZA*) and *LIDF* (erectophile, planophile and spherical) simulated with the SCOPE model. *LAI* = 3 m2 m-2, *SZA* = 0°, *C*ab = 40 ug cm-2, *hc* = 0.5 m, *lw* = 0.05 m. Negative values of *VZA*s represent the backscatter direction, positive – the forward scatter direction within a plane.

Figure S3. Distribution of multi-angular *F*760 (top) and *F*687 (bottom) in the solar principal plane (SPP) as a function of view zenith angle (*VZA*) and *LAI* simulated with the SCOPE model for erectophile (left), spherical (middle) and planophile (right) canopy types. *SZA* = 30°, *C*ab = 40 ug cm-2, *hc* = 0.5 m, *lw* = 0.05 m. Negative values of *VZA*s represent the backscatter direction, positive – the forward scatter direction within a plane.

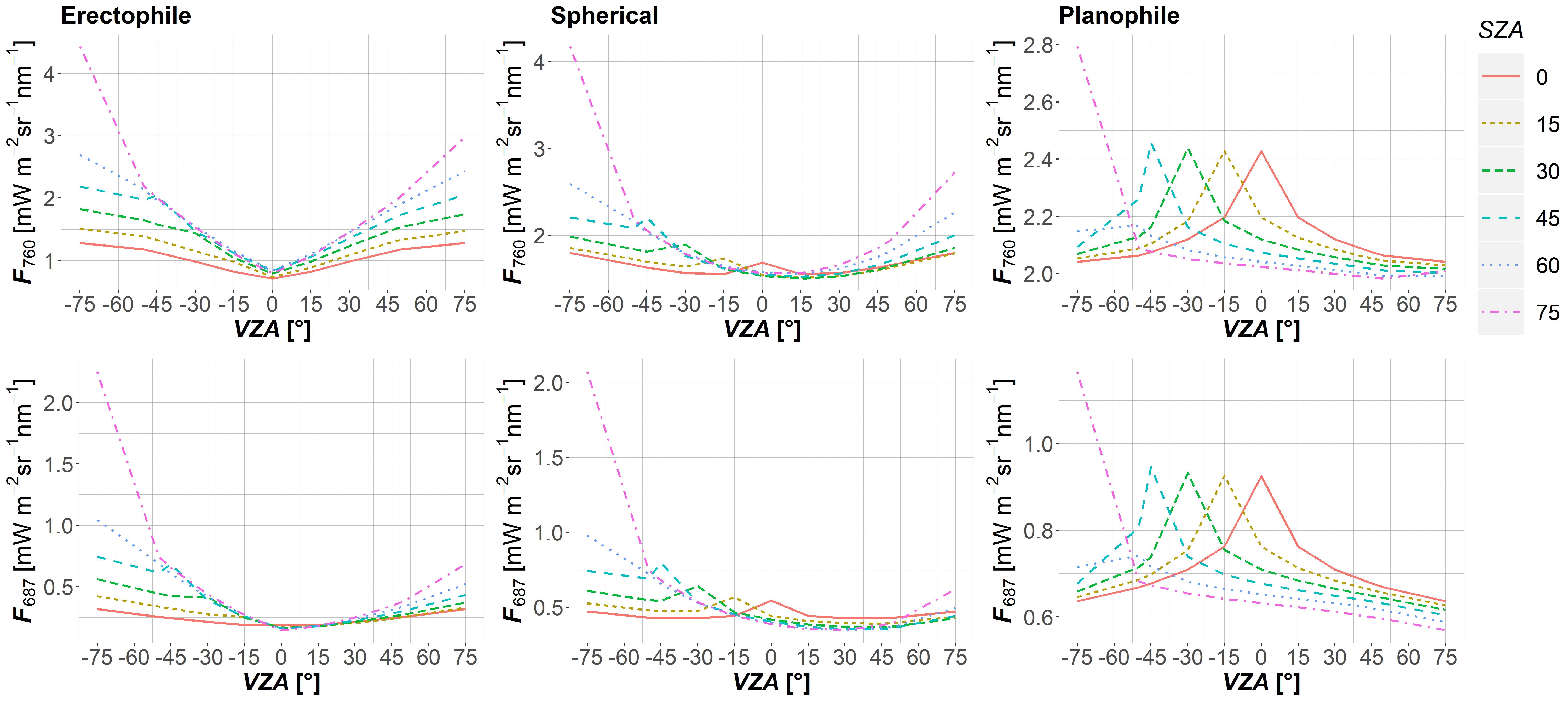
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *LIDF* | *C*ab  (ug cm-2) | *LAI*  (m2 m-2) | *hc*  (m) | *lw*  (m) | *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* |
| erectophile | 40 | 1 | 0.5 | 0.05 | 30 | 3.677 | 4.3761 |
| erectophile | 40 | 3 | 0.5 | 0.05 | 30 | 2.336 | 3.5383 |
| erectophile | 40 | 5 | 0.5 | 0.05 | 30 | 1.926 | 3.4654 |
| erectophile | 40 | 7 | 0.5 | 0.05 | 30 | 1.783 | 3.3834 |
| spherical | 40 | 1 | 0.5 | 0.05 | 30 | 1.893 | 2.0301 |
| spherical | 40 | 3 | 0.5 | 0.05 | 30 | 1.359 | 1.7913 |
| spherical | 40 | 5 | 0.5 | 0.05 | 30 | 1.271 | 1.9671 |
| spherical | 40 | 7 | 0.5 | 0.05 | 30 | 1.26 | 2.0237 |
| planophile | 40 | 1 | 0.5 | 0.05 | 30 | 1.16 | 1.2665 |
| planophile | 40 | 3 | 0.5 | 0.05 | 30 | 1.232 | 1.5551 |
| planophile | 40 | 5 | 0.5 | 0.05 | 30 | 1.233 | 1.6129 |
| planophile | 40 | 7 | 0.5 | 0.05 | 30 | 1.235 | 1.6241 |

Table S7**.** *ANIX* calculated for *F*760, *F*687 simulated by SCOPE with the input parameters: *SZA* = 30°, *C*ab = 40 ug cm-2, *hc* = 0.5 m, *lw* = 0.05 m, *LAI* = 1, 3, 5,7 m2 m-2 and *LIDF* corresponding to erectophile, spherical and planophile canopy types.

Figure S4. Distribution of multi-angular *F*760 (top) and *F*687 (bottom) in the solar principal plane (SPP) as a function of view zenith angle (*VZA*) and *sl* simulated with the SCOPE model for erectophile (left), spherical (middle) and planophile (right) canopy types. *LAI* = 3 m2 m-2, SZA = 30°, *C*ab = 40 ug cm-2. Negative values of *VZA*s represent the backscatter direction, positive - the forward scatter direction within a plane.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *LIDF* | *C*ab  (ug cm-2) | *LAI*  (m2 m-2) | *sl* | *hc*  (m) | *lw*  (m) | *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* |
| erectophile | 40 | 3 | 0.1 | 0.1 | 0.01 | 30 | 2.352 | 3.578 | |
| erectophile | 40 | 3 | 0.02 | 0.5 | 0.01 | 30 | 2.336 | 3.538 | |
| erectophile | 40 | 3 | 0.01 | 1 | 0.01 | 30 | 2.314 | 3.466 | |
| erectophile | 40 | 3 | 0.5 | 0.1 | 0.05 | 30 | 2.352 | 3.578 | |
| erectophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 30 | 2.336 | 3.538 | |
| erectophile | 40 | 3 | 0.05 | 1 | 0.05 | 30 | 2.314 | 3.466 | |
| erectophile | 40 | 3 | 1 | 0.1 | 0.1 | 30 | 2.352 | 3.578 | |
| erectophile | 40 | 3 | 0.2 | 0.5 | 0.1 | 30 | 2.336 | 3.538 | |
| erectophile | 40 | 3 | 0.1 | 1 | 0.1 | 30 | 2.314 | 3.466 | |
| planophile | 40 | 3 | 0.1 | 0.1 | 0.01 | 30 | 1.209 | 1.512 | |
| planophile | 40 | 3 | 0.02 | 0.5 | 0.01 | 30 | 1.232 | 1.555 | |
| planophile | 40 | 3 | 0.01 | 1 | 0.01 | 30 | 1.236 | 1.561 | |
| planophile | 40 | 3 | 0.5 | 0.1 | 0.05 | 30 | 1.209 | 1.512 | |
| planophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 30 | 1.232 | 1.555 | |
| planophile | 40 | 3 | 0.05 | 1 | 0.05 | 30 | 1.236 | 1.561 | |
| planophile | 40 | 3 | 1 | 0.1 | 0.1 | 30 | 1.209 | 1.512 | |
| planophile | 40 | 3 | 0.2 | 0.5 | 0.1 | 30 | 1.232 | 1.555 | |
| planophile | 40 | 3 | 0.1 | 1 | 0.1 | 30 | 1.236 | 1.561 | |
| spherical | 40 | 3 | 0.1 | 0.1 | 0.01 | 30 | 1.381 | 1.834 | |
| spherical | 40 | 3 | 0.02 | 0.5 | 0.01 | 30 | 1.359 | 1.791 | |
| spherical | 40 | 3 | 0.01 | 1 | 0.01 | 30 | 1.341 | 1.797 | |
| spherical | 40 | 3 | 0.5 | 0.1 | 0.05 | 30 | 1.381 | 1.834 | |
| spherical | 40 | 3 | 0.1 | 0.5 | 0.05 | 30 | 1.359 | 1.791 | |
| spherical | 40 | 3 | 0.05 | 1 | 0.05 | 30 | 1.341 | 1.797 | |
| spherical | 40 | 3 | 1 | 0.1 | 0.1 | 30 | 1.381 | 1.834 | |
| spherical | 40 | 3 | 0.2 | 0.5 | 0.1 | 30 | 1.359 | 1.791 | |
| spherical | 40 | 3 | 0.1 | 1 | 0.1 | 30 | 1.341 | 1.797 | |

Table S8**.** *ANIX* calculated for *F*760, *F*687 simulated by SCOPE with the input parameters: *SZA* = 30°, *C*ab = 40 ug cm-2, *LAI* = 3 m2 m-2, *hc* = 0.1, 0.5, 1 m, *lw* = 0.01, 0.05, 0.1 m, *sl* = 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1 and *LIDF* corresponding to erectophile, spherical and planophile canopy types.

Figure S5. Distribution of multi-angular *F*760 (top) and *F*687 (bottom) in the solar principal plane (SPP) as a function of view zenith angle (*VZA*) and *SZA* simulated with the SCOPE model for erectophile (left), spherical (middle) and planophile (right) canopy types. *LAI* = 3 m2 m-2, *C*ab = 40 ug cm-2, *hc* = 0.5 m, *lw* = 0.05 m. Negative values of *VZA*s represent the backscatter direction, positive – the forward scatter direction within a plane.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *LIDF* | *C*ab  (ug cm2) | *LAI*  (m2 m-2) | *sl* | *hc*  (m) | *lw*  (m) | *SZA* (°) | *F*760\_*ANIX* | *F*687\_*ANIX* |
| erectophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 75 | 5.621 | 15.664 |
| erectophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 60 | 3.335 | 7.268 |
| erectophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 45 | 2.692 | 4.884 |
| erectophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 30 | 2.336 | 3.538 |
| erectophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 15 | 2.075 | 2.564 |
| erectophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 0 | 1.807 | 1.709 |
| planophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 75 | 1.425 | 2.083 |
| planophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 60 | 1.143 | 1.379 |
| planophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 45 | 1.248 | 1.606 |
| planophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 30 | 1.232 | 1.555 |
| planophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 15 | 1.222 | 1.523 |
| planophile | 40 | 3 | 0.1 | 0.5 | 0.05 | 0 | 1.216 | 1.501 |
| spherical | 40 | 3 | 0.1 | 0.5 | 0.05 | 75 | 2.707 | 6.087 |
| spherical | 40 | 3 | 0.1 | 0.5 | 0.05 | 60 | 1.744 | 3.092 |
| spherical | 40 | 3 | 0.1 | 0.5 | 0.05 | 45 | 1.499 | 2.32 |
| spherical | 40 | 3 | 0.1 | 0.5 | 0.05 | 30 | 1.359 | 1.791 |
| spherical | 40 | 3 | 0.1 | 0.5 | 0.05 | 15 | 1.266 | 1.494 |
| spherical | 40 | 3 | 0.1 | 0.5 | 0.05 | 0 | 1.205 | 1.339 |

Table S9**.** *ANIX* calculated for *F*760, *F*687 simulated by SCOPE with the input parameters: *SZA* = 10°, 30°, 45°, 60°, 75°, *C*ab = 40 ug cm-2, *LAI* = 3 m2 m-2, *hc* = 0.5m, *lw* =0.05 m and *LIDF* corresponding to erectophile, spherical and planophile canopy types.