Supplementary Material

S1. Model uncertainty in transpiration and transpiration fraction

The transpiration anomaly estimates in this study are derived from MODIS, J2010, and GLEAM using the ET partitioning from an ensemble of CLM4 and CABLE simulations. The estimates are therefore data based and assumed more accurate than the transpiration as simulated by CLM4 or CABLE. Aside from this fundamental reason for disaggregating the ET, analysis of the simulations reveals the uncertainty in the simulated transpiration is generally greater than the uncertainty in the transpiration fraction (Figure S1). S1 shows the (S1a) standard deviation of the mean annual transpiration among the eight CLM4 simulations normalized the the ensemble mean annual transpiration, the (S1b) standard deviation among the simulations in the transpiration fraction normalized by the ensemble mean transpiration fraction, and (S1c) the difference (S1a minus S1b).

Comparing S1a to S1b it is clear that the ensemble variability in the raw transpiration is much larger than for the transpiration fraction in the Southeastern, Eastern, and Southwestern regions of Australia. Over these areas the ensemble standard deviation in the raw transpiration varies between 10-45% of the ensemble mean, the transpiration fraction is only 5-30% of the ensemble mean. The only region where the transpiration fraction has a higher spread is North-central Australia where the vegetation fraction and transpiration are small. Despite the range in transpiration fractions shown by Decker et al. [2013], figure S1c highlights that the spread in transpiration fraction is smaller than the spread in raw transpiration. The likely cause of the reduced uncertainty between Figure S1a and Figure S1b is the known bounds of transpiration fraction (zero and one), while the available radiation that bounds the raw transpiration varies in space and time. Combining the more certain transpiration fraction with the ET data therefore provides transpiration estimates with greater certainty and accuracy than the
transpiration as simulated by CLM4.
S2. Impact of the Annual Cycle

The analysis and discussion in Sections 4 and 5 are performed after subtracting the mean annual cycle from the vegetation and transpiration data. As discussed in Section 5, numerous physical processes govern transpiration and leaf growth. Several of these physical mechanisms, such as net radiation or water availability, can exhibit large annual cycles. The dependence of the agreement between greenness and transpiration (from Table 2 and Figures 3 and 4) on removing the annual cycle is presented here. We apply Equation (3) without removing the mean annual cycle to discern whether the vegetation greenness observations correspond to the transpiration estimates when the data are simply scaled.

Figure S2 replicates Figure 3, except Equation (3) is applied to the data without removing the annual cycle. The magnitude of LAI, EVI, and NDVI differs significantly from GLEAM.TR, GLEAM_CP, J2010_CP, and MODIS_CP in Figure S2 as a result of including the annual cycle. For example, in Figure S2a, EVI, NDVI, and LAI oscillate from approximately 0.8 to 1.2, in contrast to 0.3-1.7 and 0.4-2.5 for GLEAM.TR and GLEAM_CP, respectively. PVF shows similar magnitudes to the transpiration time series over Northern (Figure S2a) and Southwestern (Figure S2d) Australia, however the result is not consistent over the other regions. Figure S2 indicates that the physical processes controlling leaf growth (and hence greenness) and transpiration result in a lack of correspondence between greenness and transpiration. Although some agreement remains between the time series of vegetation greenness and transpiration in Figure S2, no clear one-to-one relationship is shown.

The differences between the transpiration estimates are highlighted in Figure S2. Over Northern Australia (Figure S2a), GLEAM.TR has a smaller annual cycle than GLEAM_CP, J2010_CP, and MODIS_CP.
and MODIS_CP, with the latter three all showing similar peaks in transpiration during the wet season.

In all four panels from Figure S2, MODIS_CP and J2010_CP are closely related, with slight differences in the magnitudes of the variations evident primarily over Southeastern Australia (Figure S2b). The differences between GLEAM.TR and GLEAM_CP are largest over Northern Australia during the wet season, with GLEAM.TR peaking around 1.7 while GLEAM_CP peaks near 2.5. The partitioning in GLEAM.TR and GLEAM_CP are similar in the dry season, where transpiration is dominant due to infrequent precipitation events. The partitioning is more complicated in the wet season due to ample available water, so that larger differences between GLEAM.TR and GLEAM_CP emerge. However, contrasting Figure S2 with Figure 3, the impact of partitioning is larger when the annual cycle is included in the analysis.

Contrasting Figure 3 with Figure S2, the impact of using anomalies when comparing greenness to transpiration is evident. The implication of this that the mean of transpiration is not uniquely defined by the greenness. This result isn't surprising given the numerous physical processes involved in transpiration, and the large annual cycle typically present in many of these factors. However, in products that assimilate vegetation greenness into ET models, the anomalies may be governed by greenness while the annual cycle is controlled by some combination of observations and the model itself.
Figure S1. (a) The scaled (by the ensemble mean) standard deviation in annual transpiration from the eight ensemble members, (b) the scaled (by the ensemble mean) standard deviation in annual transpiration fraction, and (c) the difference (a)-(b).
Figure S2. The scaled (by the mean) vegetation and transpiration data (including the mean annual cycle) spatially averaged over a) Northern, b) Southeastern, c) Eastern, and d) Southwestern Australia. The regions are shown in Figure 1.