

Brief explication of modifications integrated in revision 2628 in trunk ORCHIDEE for enhancement about DGVM by Dan Zhu, 30 april 2015

Lpj_cover:

1. In the recalculation of carbon variables (*biomass*, *litter*, etc.) to conserve total C when *veget_max* changed, the original method for *turnover_daily* and *bm_to_litter* cannot guarantee C closure, since it doesn't account for the case when *veget_max* decrease to 0.

So the recalculation method for *turnover_daily* and *bm_to_litter* is revised as the same as *litter* and *carbon*. Now the C is conserved in DGVM.

2. The C flux variables (*gpp_daily*, *resp_hetero*, *resp_maint*, *resp_growth*, *co2_fire*, *co2_to_bm*) are all recalculated using the same method as *litter* and *carbon*. The total value (sum over 13 PFTs) of all C variables are written (*histwrite_p*) at the end of the module, with the variable names preceded by "t". We output them because, if *veget_max* changes every day but we output history files at monthly or yearly step, the *tGPP*, for example, will be slightly different from the sum of $GPP * veget_max$.

Lpj_constraints:

1. We introduce a growing-season temperature limit to tree extension: mean air temperature during the growing season (*Tseason*) must exceed 7°C for trees to survive; and the growing season is calculated (in *stomate_season*) as the period when weekly air temperature is greater than 0°C.

(Reference: Körner, C. and Paulsen, J.: A world-wide study of high altitude treeline temperatures, *J. Biogeogr.*, 31, 713-732, 2004)

2. Originally there was a *tmin_crit* constraint: if *t2m_min_daily* (minimum temperature in each day) is below *tmin_crit* (a PFT-dependent threshold), the corresponding PFT will all be eliminated. This makes the vegetation distribution highly sensitive to the minimum temperature during a few extremely cold days. Thus, we replace it by a linearly increasing mortality rate as a function of *t2m_min_daily* (calculated in *lpj_gap*).

Lpj_gap:

1. Originally the flag *lpj_gap_const_mort* was default to be TRUE, in which the calculation of mortality for tree PFTs was the inverse of *residence_time* (PFT-specific longevity parameter). It defined a constant mortality for each PFT in all grid cells, without considering the variations in mortality of that PFT caused by adaptation to different climate conditions.

In DGVM, we chose the dynamic mortality formulation (set *lpj_gap_const_mort*=n), but modified the parameter *availability_fact* which

was previously identical for all PFTs. Now *availability_fact* is set to different values for tropical, temperate and boreal tree PFTs (in *constantes_mtc*), proportional to the inverse of their *residence_time*.

2. We add a spring frost-damage limitation to the distribution of the two broadleaf deciduous tree PFTs (PFT6 and PFT8). After leaf-out in the model, if daily minimum temperature drops below a threshold of -3°C , tree mortality will increase with decreasing temperature. This frost-induced mortality is multiplied by the period elapsed since leaf-out, because the more time that has elapsed, the larger the mass of vulnerable foliage.

(Reference: Kollas, C., Körner, C. and Randin, C. F.: Spring frost and growing season length co-control the cold range limits of broad-leaved trees, *J. Biogeogr.*, 41, 773–783, 2014.)

Lpj_establish:

Previously, when DGVM is activated, NBP cannot reach 0 however long it runs in spinup, due to a constantly large sink term *co2_to_bm*, which represents the amount of carbon taken from the atmosphere by saplings during establishment or PFT introduction. This overestimation of *CO2_to_bm* is more prominent in boreal regions, where total tree PFTs only take up a small fraction, leading to large available space for establishment, thus large *d_ind* (establish rate).

Now, we solve this problem by distinguishing “effective” establishment, which equals to *d_ind* minus *mortality*ind*. The non-effective establishment is subtracted from *CO2_to_bm* and *bm_to_litter*. It means that, when equilibrium is reached, the established individuals will quickly die, so the corresponding carbon intake by the “virtual” saplings should not be counted, neither should the corresponding dead biomass be added into litter.

Stomata_litter:

All loops of PFTs (DO j = 2, nvm) are revised as (DO j = 1, nvm), because the bare soil PFT1 may have above-zero values for litter, when other PFTs die and turn into PFT1.