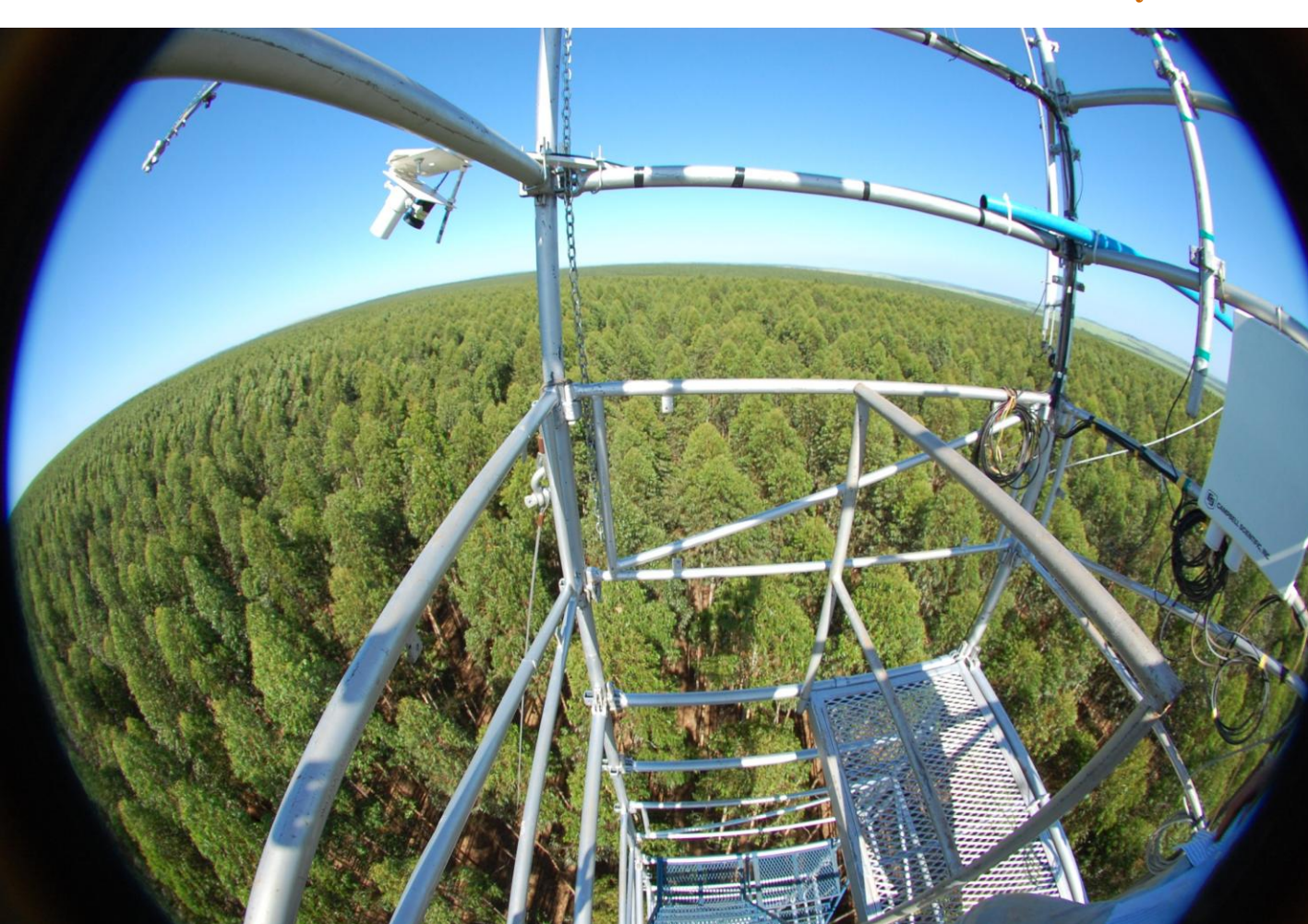
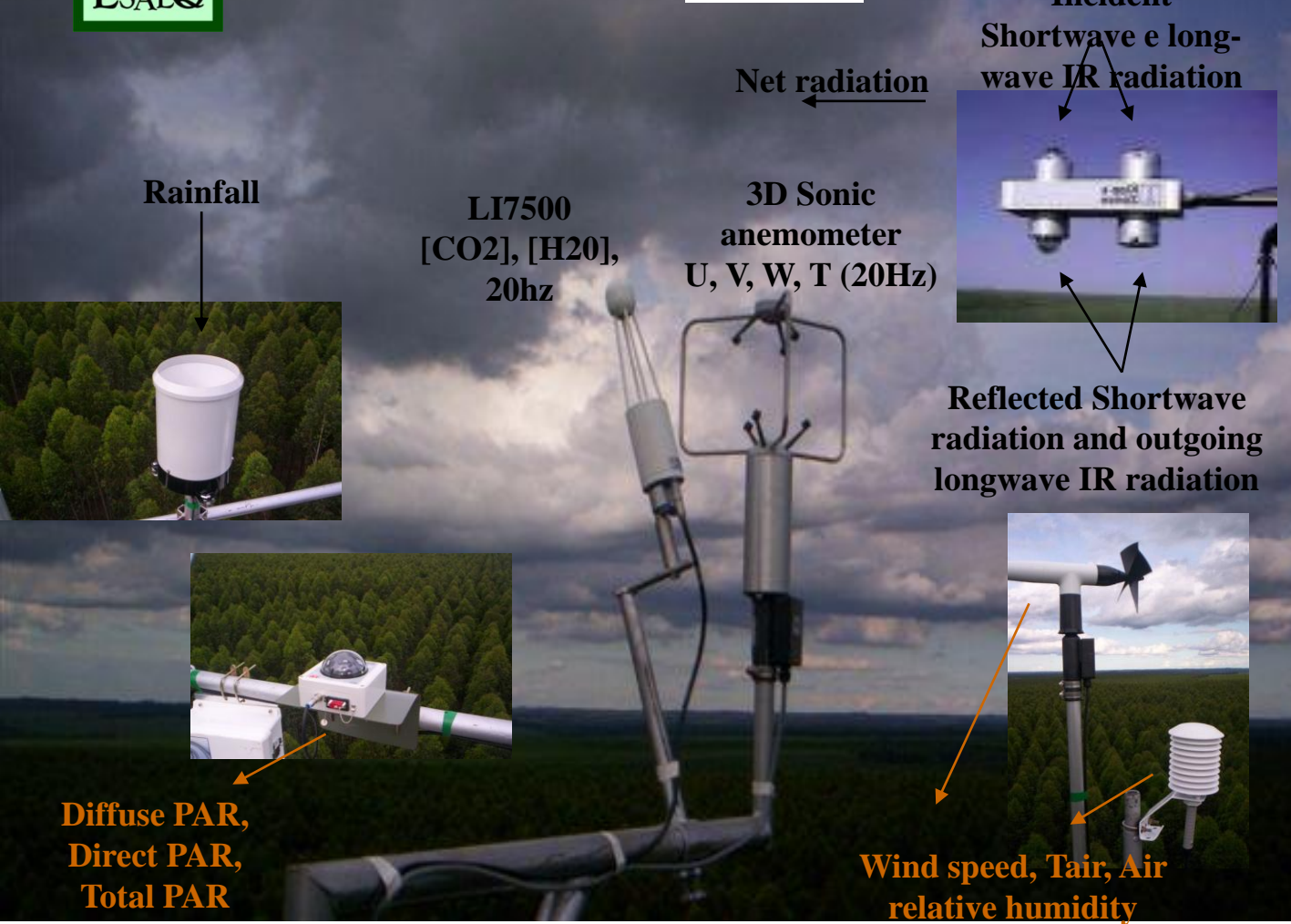


Carbon, water and energy balances of an *Eucalyptus grandis* plantation in Brazil: effects of clearcut and stand age

1. UMR Eco&Sols, CIRAD, Montpellier, France.
2. ESALQ, USP, Piracicaba, Brazil.
3. IAG, USP, São Paulo, Brazil.
4. NCSU, Raleigh, NC, United States.
5. EPHYSE, INRA, Villeave d'Ormon, France.
6. IPEF, Piracicaba, Brazil.
7. UNESP, Botucatu, Brazil.

Yann Nouvellon^{1, 2}, José Luiz Stape^{4, 2}, Gueric Le Maire¹, Jean-Marc Bonnefond⁵, Humberto Rocha³, Otavio Campoe⁶, Jean-Pierre Bouillet^{1, 2}, Jean-Paul Laclau^{1, 7}



Rotation 1

Rotation 2

2008

Clearcut and replantation

February 2010

June 2010

August 2012

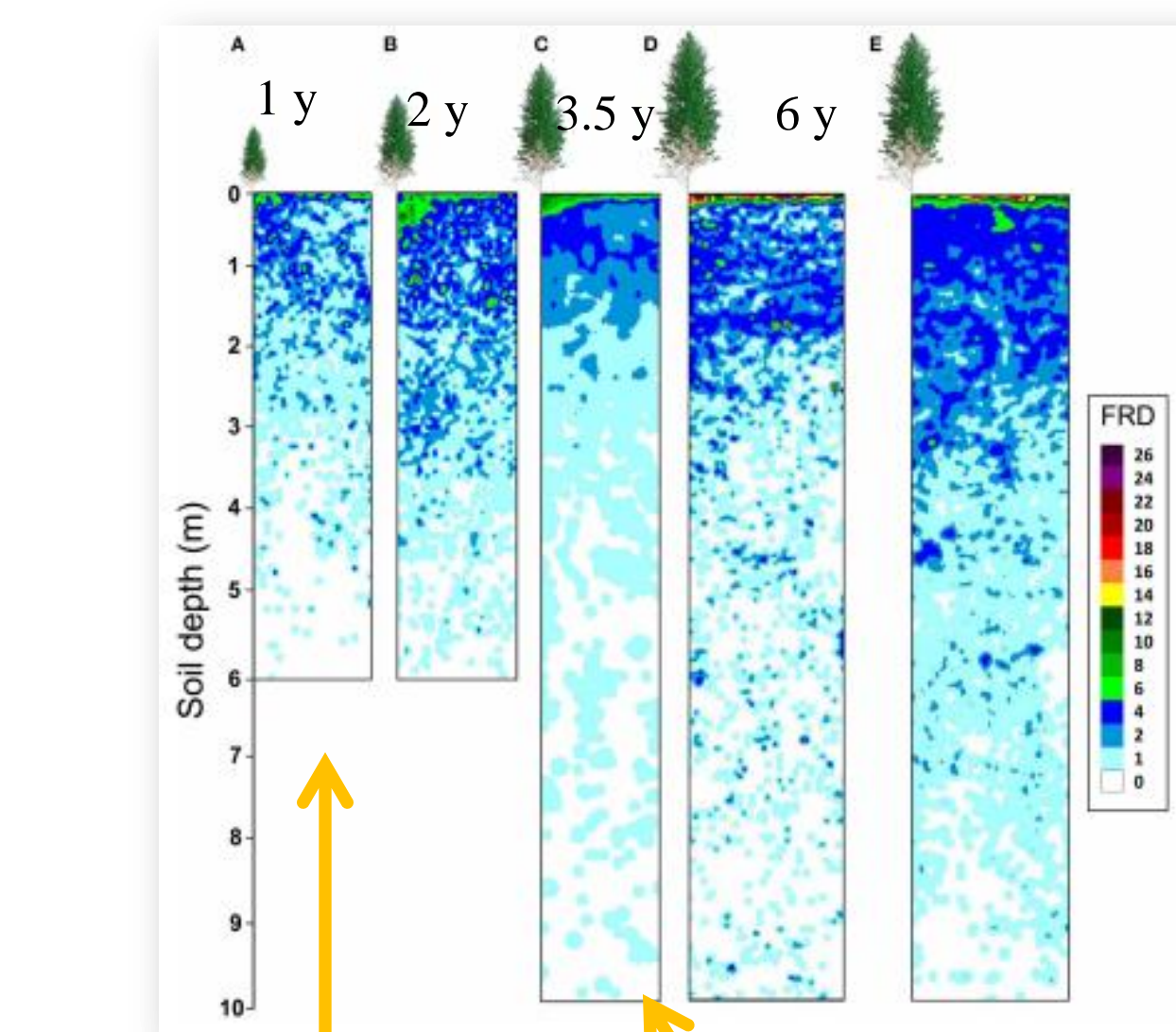


Figure 1: Fine root distribution for different stand ages (from Laclau et al., 2013, Frontiers in Plant Sciences)

Introduction: *Eucalypt grandis* plantations in Brazil are among the most productive forests of the world, reaching mean annual increments of about 50 m³/ha/yr over short (6 yr) rotations. These high productions are generally associated with high water-use, but little is known on the effects of management practices on their carbon (C), water and energy budgets. We investigated the effects of stand age and clear cutting on the C and water balances through continuous eddy-covariance measurements of latent (LE), sensible heat (H), and CO₂ fluxes over a 5 yrs period encompassing two successive rotations: 2 yrs before and 3 yrs after clear cutting and replanting.

Results:

For the last 2 yrs before clearcutting, LAI was ~3.5 and fine roots were found down to a depth of 16 m. No percolation was observed below 5 m, and the 5-10 m soil layer was water-depleted. Actual evapotranspiration (AET) was approximately equal to annual precipitation (1350 mm). H was very low, except during some dry events characterized by sharp increases in the bowen ratio (H/LE) (Figure 2). Clearcut resulted in an increase in soil temperature and H, and a strong decrease in AET (Figure 3), allowing gravitational water to reach 6, 8 and 10 m depths about 1.5, 2.5, and 3.5 months after clearcutting, respectively, in this sandy soil (Figure 4). From the clearcut (Oct 2009) to the end of the first rainy season (May 2010), the water table had raised from -18.5 to -15 m (Figure 5).

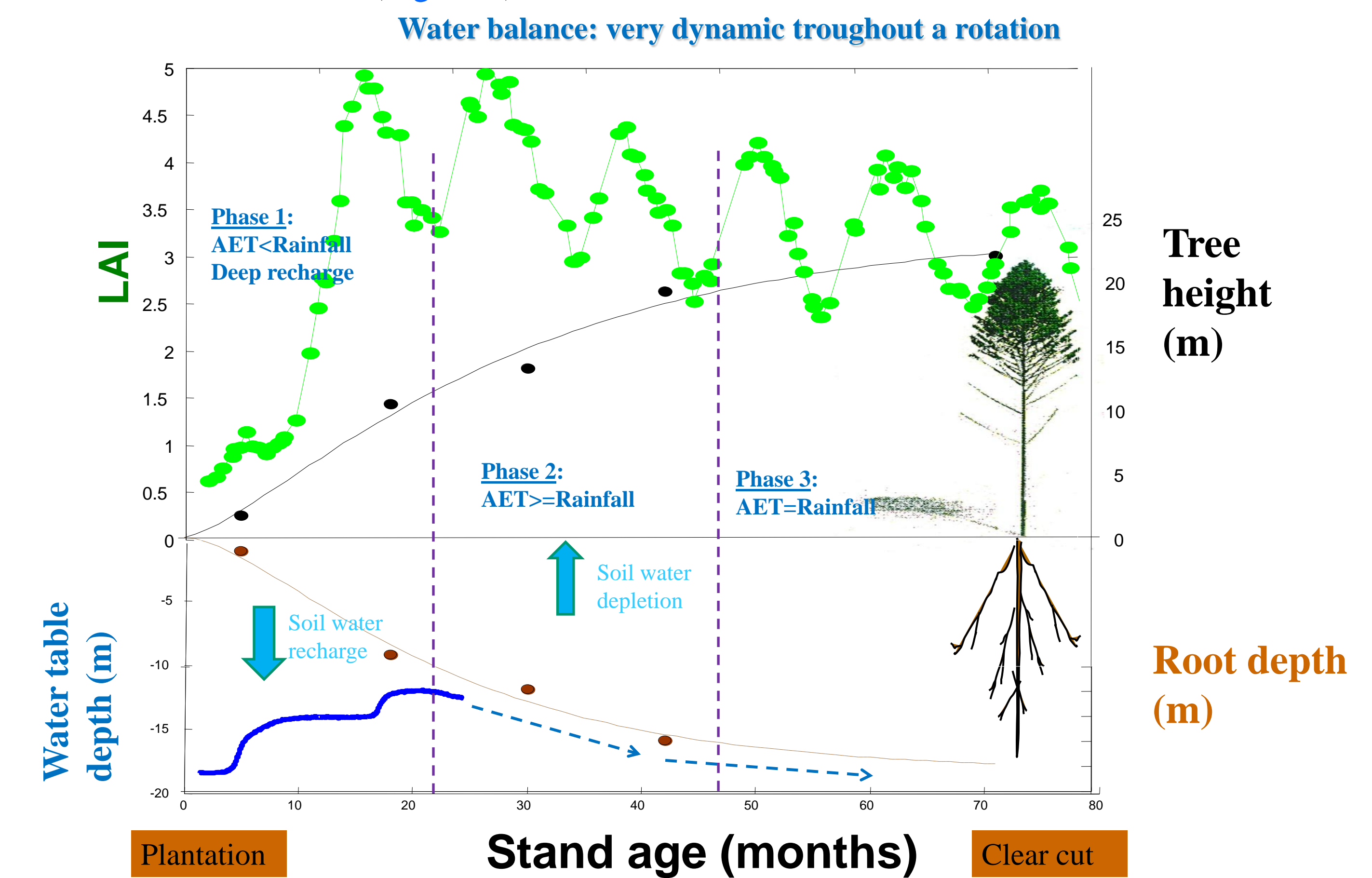
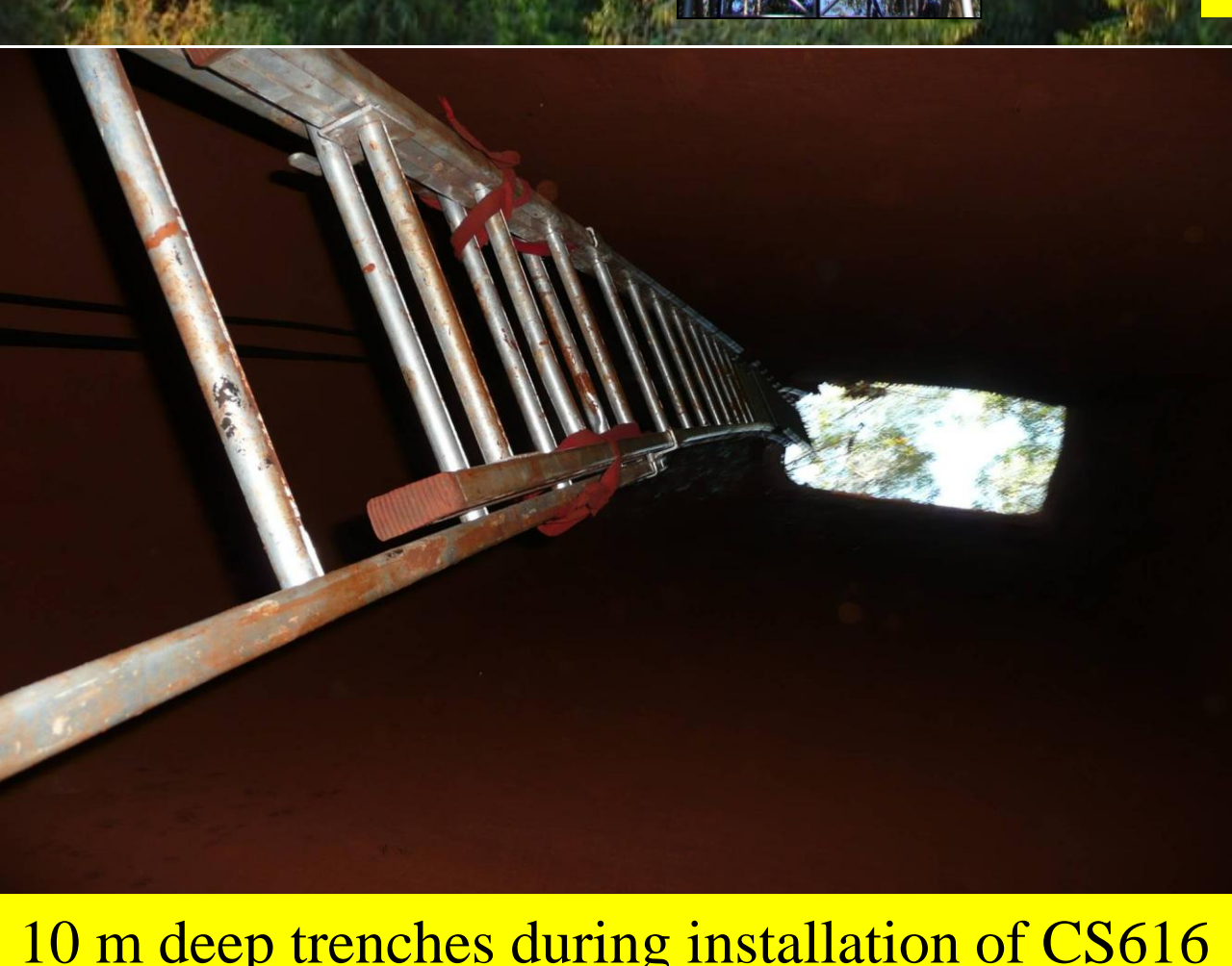


Figure 6: Canopy and root dynamic and soil water budget over a rotation

The third year after clearcutting and replanting, AET was higher than rainfall, leading to soil water depletion till 10 m deep (Figure 4). This rapid depletion of soil water was consistent with the fast exploration of the soil by fine roots (root front at 6-7 m deep at age 1 yr; Figures 1 and 6) and the fast increase in LAI (reaching 5 at age 2.5 yr).

Carbon budget: Clearcutting turned the forest from a strong C sink (NEP of ~ -1 tC/ha/month) to a C source (NEP increased up to ~ 1.6 tC/ha/month during replanting, about 1 month after the clearcut), but the plantation rapidly turned back to a C sink (C neutrality (NEP = 0) reached 7 months after clearcutting (Figure 7), and then monthly NEP was always negative) due the rapid increase in LAI.

The water balance of these eucalypt plantations is thus characterized by three successive phases: 1) the first 18 months of the rotation, AET<rainfall allowing water storage in deep soil layers and a recharge of the water table, 2) from age 1.5 to 3 yrs, AET>=rainfall, resulting in water depletion in soil layers down to a depth of 10 m, and 3) from age 3 yrs to the end of the rotation, AET=rainfall. Our results suggest that process based models should take into account soil water dynamics in very deep soil layers to make reliable predictions of the effects of forest disturbances on C and water fluxes in deep tropical soils.



10 m deep trenches during installation of CS616

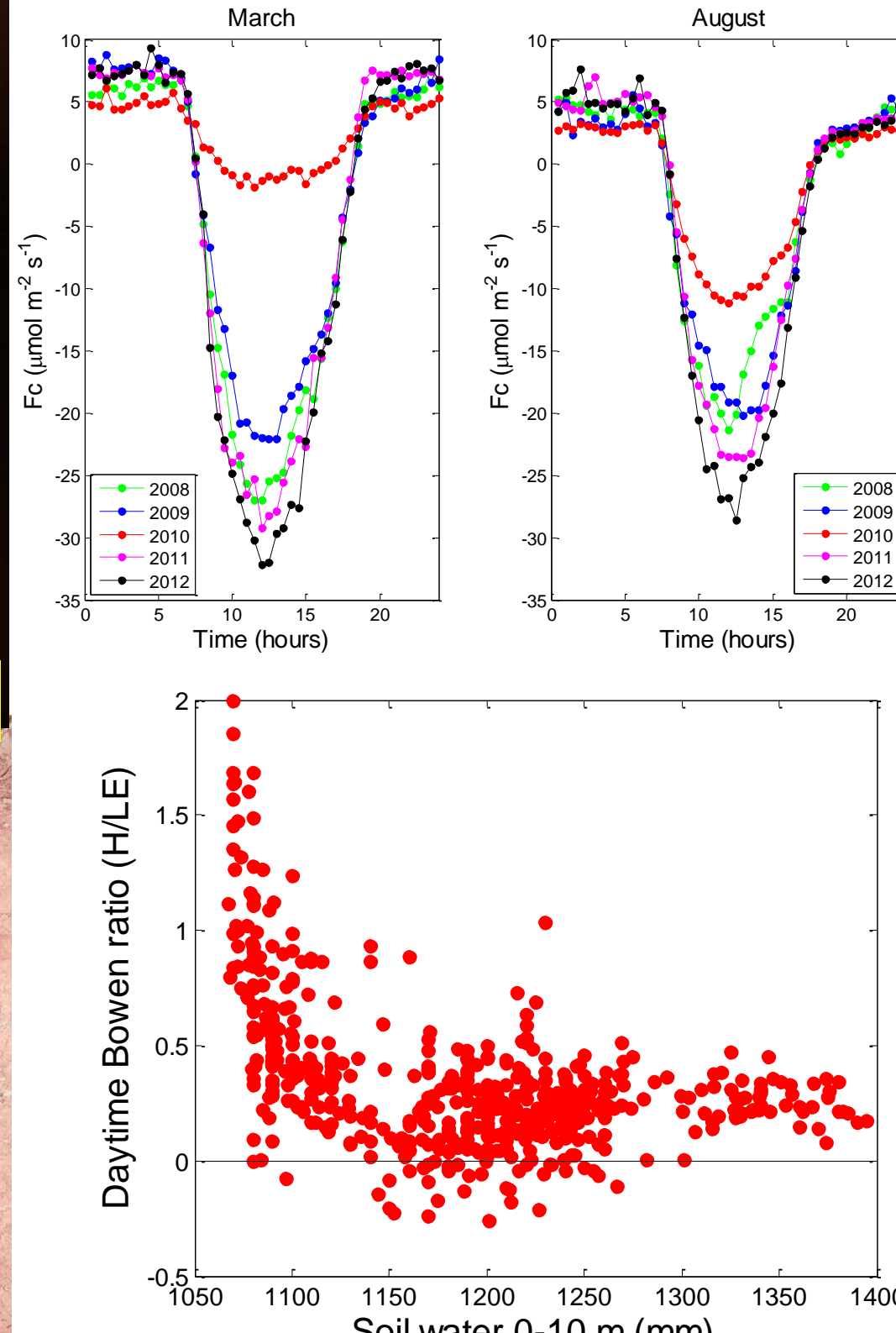


Figure 2: Bowen ration (H/LE) versus SWC (0-10 m) for the last 2 years of the rotation

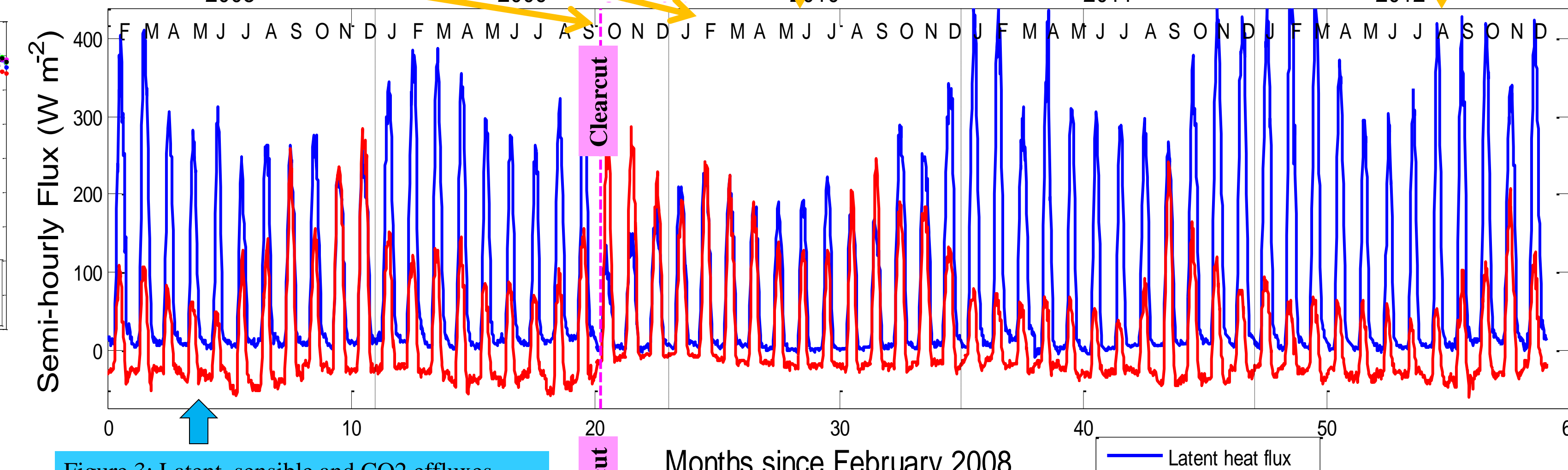


Figure 3: Latent, sensible and CO₂ effluxes before and after clearcutting

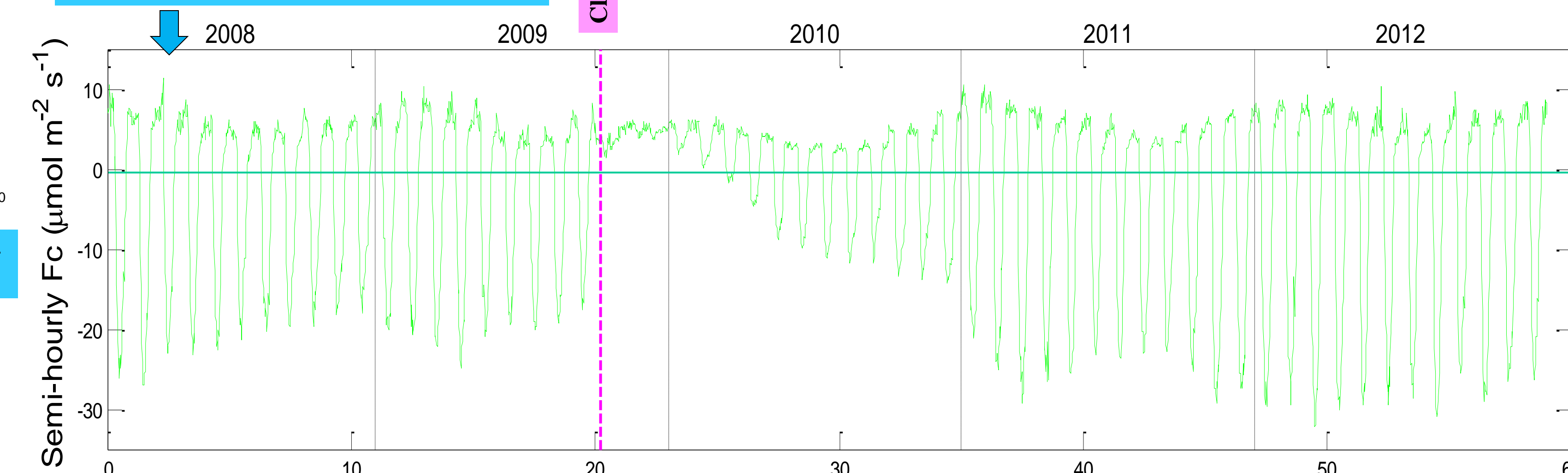


Figure 4: Soil water content for different soil layers (till 10 m deep)

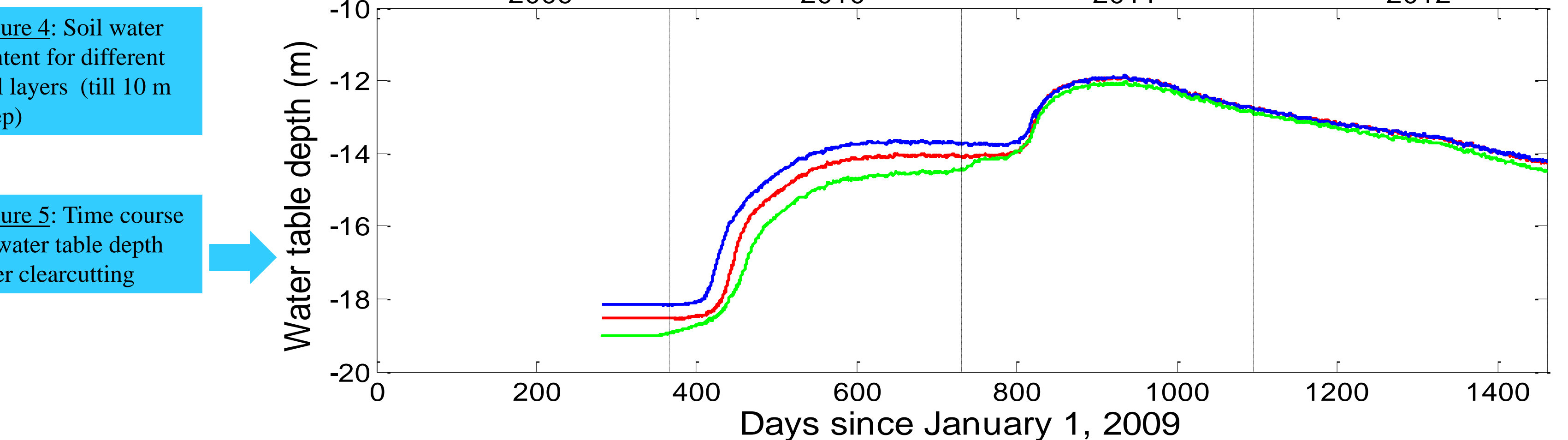


Figure 5: Time course of water table depth after clearcutting

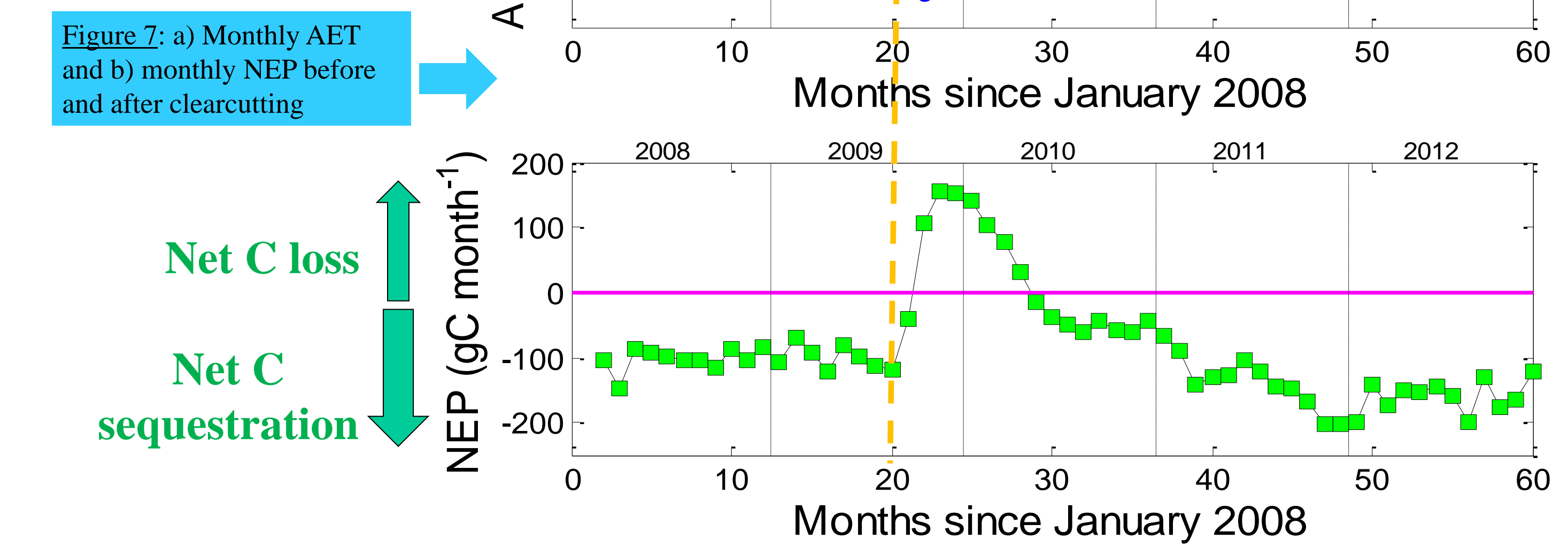
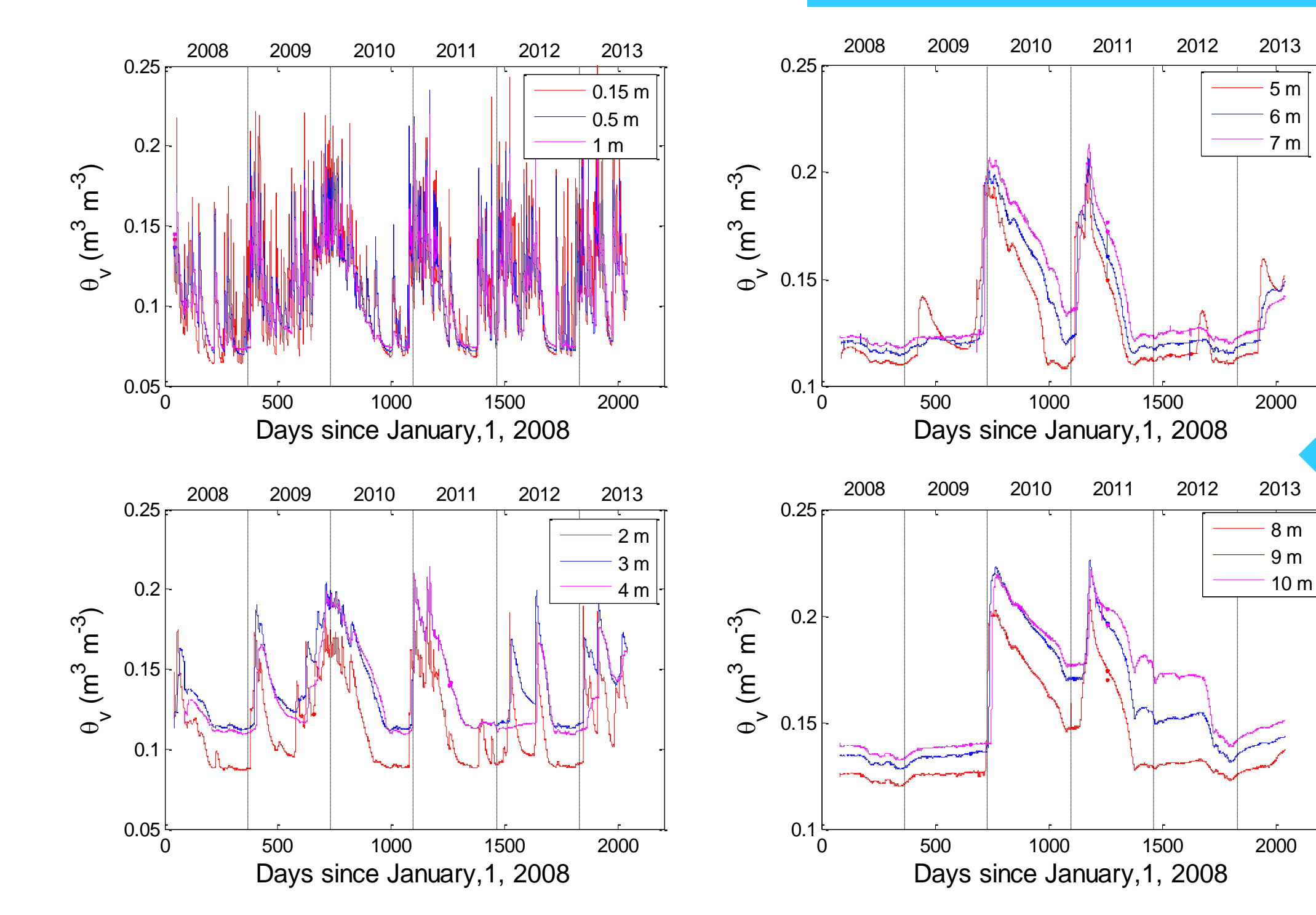


Figure 7: a) Monthly AET and b) monthly NEP before and after clearcutting