Title: Effects of spatio-temporal distribution of soil moisture on a lowland dipterocarp forest at Pasoh Forest Reserve in Peninsular Malaysia
（土壌水分の時空間分布が半島マレーシアパソ森林保護区低地フタバガキ林に与える諸影響）

Name: Marryanna Lion

In tropical rainforests, the amount of rainfall and changes in rainfall patterns are of great concern with respect to future climate change and global warming; shifts in rainfall patterns can subsequently influence soil moisture, evapotranspiration (ET), stand dynamics, and many other forest functions. Therefore, to evaluate important effects of future climate change, an evaluation of the influence of moisture on these forest functions is needed. This study examined the effects of spatio-temporal distribution of soil moisture and hydrological processes on ET, water sources and stand dynamics in a lowland dipterocarp forest at Pasoh Forest Reserve in Peninsular Malaysia.

The temporal variability of oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$) isotope signatures in precipitation are reported in Chapter 2. The daily and seasonal variability of stable isotope signatures in precipitation were analysed, particularly in relation to the effects of monsoon seasons, rainfall characteristics, and larger scale trends compared with those at nearby Global Network of Isotopes in Precipitation (GNIP) monitoring stations. The isotope signatures did not differ between monsoon seasons but were correlated with amount of rainfall, and its intensity and duration. An effect of rainfall amount on isotope composition was clearly detected and comparable to long-term mean monthly statistics from the nearby GNIP stations. Unfortunately the effect was obscured at the daily timescale and, for monthly rainfall, not averaged over the long-term. No large deuterium excess was detected at the daily timescale for small-scale rainfall events. The amount of $\delta^{18}O$ in precipitation was more closely correlated with the 60-day antecedent rainfall index than with the daily amount of rainfall. These findings suggest that the isotopic composition in the study area was the result of a rainout on a larger scale in addition to the local scale and specific rain events, and not the result of re-evaporated moisture added from the land surface.

Chapter 3 evaluated water use and the supporting water sources of the study site using a 4-year assessment of ET. The eddy covariance method and isotope signals of rain, plant, soil, and stream waters were used to determine forest water sources under different moisture conditions. Four sampling events were conducted to collect soil and plant twig samples in wet, moderate, dry and very dry conditions to identify isotopic signals. The annual ET from 2012 to 2015 was quite stable with an average of 1,182 ± 26 mm, and a substantial daily ET was observed even during drought periods, although some decline was observed, corresponding to volumetric soil water content. During the wet period, water for ET was supplied from the surface soil layer between 0 and 0.5 m, whereas in the dry period, approximately 50–90% was supplied from the deeper soil layer, below a depth of 0.5 m. This water originated from water precipitated in this forest several months previously. Isotope signatures demonstrated that the water sources of the plants, soil and stream were all different. Water in plants was often different from soil water, probably because plant water came from a different source than water that was strongly bound to soil particles. Plants showed no preference for soil depth with size, whereas there was evidence of storage water in the xylem. The ET at this forest was balanced and maintained using most of the available water sources except for a proportion of rapid response runoff.

In Chapter 4, the spatial distribution of volumetric soil water content (VSWC) measured over 1 year was analysed in the context of stand dynamics at the study site. Forest surface-layer VSWC was determined largely by relative elevation and soil physical properties. Patterns of spatial variation in surface-layer VSWC and residual VSWC during the dry period suggested that drier surface soil areas had developed forest soil texture with a larger pore size. Drier surface soil areas were associated with wetter deep soil. There were no relationships between VSWC and tree mortality or number of trees for any soil layer; however, a significant negative relationship was found between surface-layer VSWC and tree basal area, and therefore also biomass. This finding could be due to the preference of trees for drier surface areas with coarse soil texture, and to feedback processes increasing root distribution in such areas. The number of trees in the *Dipterocarpaceae* family, as well as of emergent tree species, was negatively correlated with VSWC in the deep soil layer. This finding may have been due to the preference of trees with deep rooting systems for drier aerobic conditions.

Tropical rainforests contain abundant moisture; however, after investigating water sources for ET in a Southeast Asian tropical rainforest in Peninsular Malaysia, it can be concluded that this tropical rainforest experiences water stress, particularly during dry periods. The temporal and spatial distribution of soil moisture affects ET, water sources and stand dynamics differently, suggesting that a simple model or simulation of the impact of future climate change on tropical rainforests, without data collected in the field, will result in poor estimates. This study is anticipated to contribute to our understanding of the hydrology of tropical rainforests and provide baseline data describing the stable isotope signatures of precipitation, soil, plants and stream water for further research at this study site. Baseline data obtained in this study are important for environmental modelling for diverse applications, including water-use policy and forest conservation.