Evapotranspiration from Tropical Peatland of Sarawak, Malaysia




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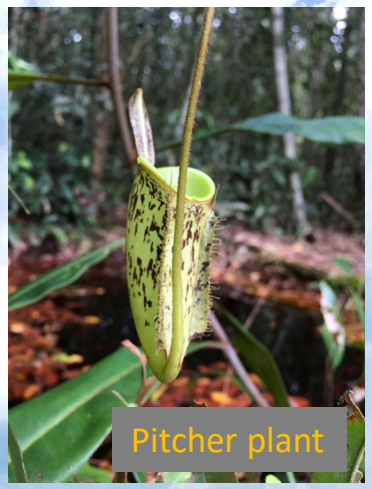
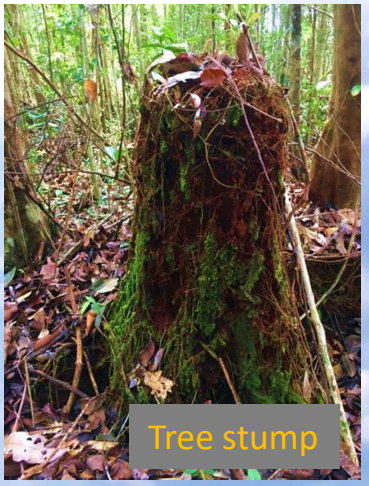
National Institute for Environmental Studies

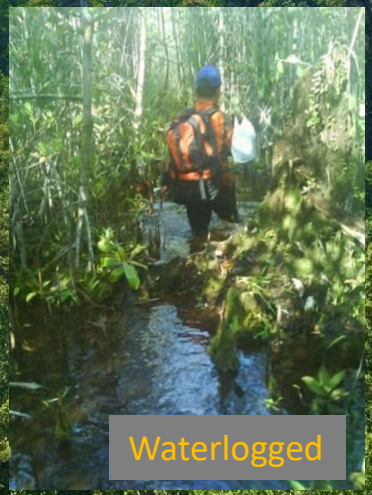
Tropical Peatland:

- Carbon rich ecosystem
- It an ecosystem with evapotranspiration dynamic less understood


Pitcher plant


Tree stump

Soil profile


Waterlogged

Characteristics:

- Acidic
- Thick organic soil
- Micro-topography
- Waterlogged

Background of Study

- Evapotranspiration (ET) is important process in water cycle particularly in peatlands ecosystem.

- **Vegetation and hydrological** changes caused by human activity and extreme climate may significantly alter the ET from the ecosystem.
- von Randow *et al.* (2004) reported that the conversion of tropical peat land to pasture decreased ET in Amazonia

Study Objectives

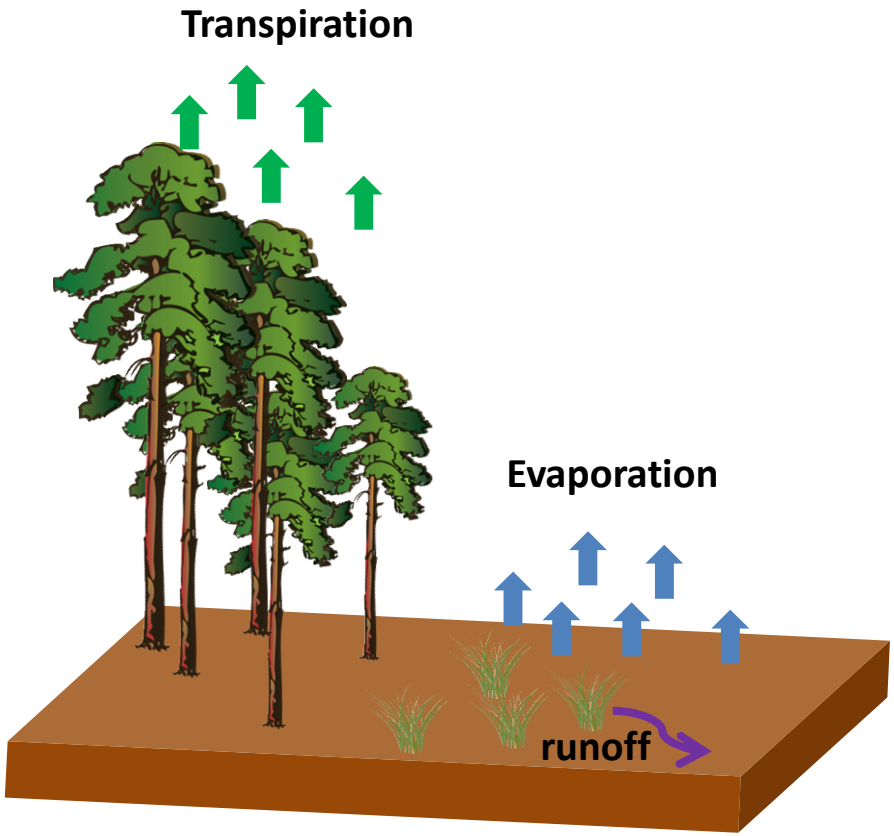
1. To quantify the evapotranspiration from three different ecosystems (PSF, SF, OP).
2. To determine the environmental response of evapotranspiration.
3. To scrutinize the effect of evapotranspiration toward the changes in groundwater level.

Terminologies

Evapotranspiration (ET)
ET = Evaporation + Transpiration

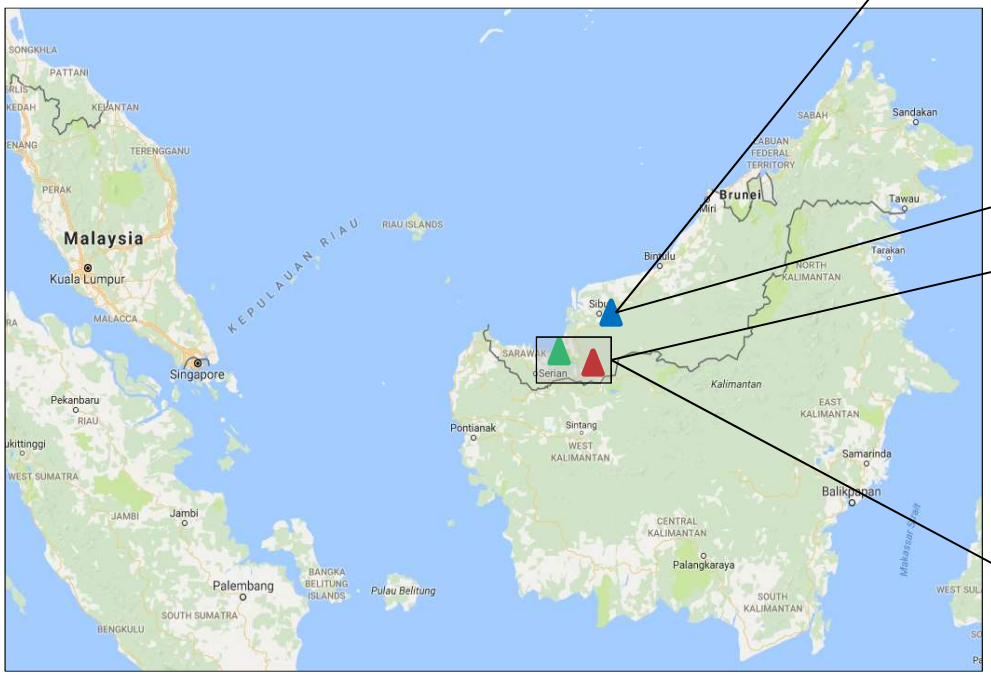
Evaporation
Water movement from wet soil & leaf surface

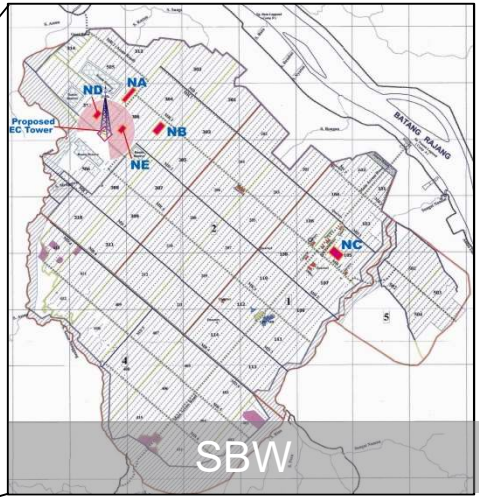
Transpiration
Water movement through plant

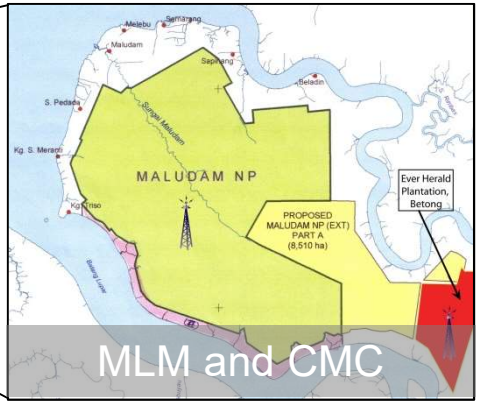


Study Site

- 3 Different Ecosystems
  - Oil palm plantation, SBW
  - Secondary peat swamp forest, CMC
  - Primary peat swamp forests, MLM







Sarawak, Malaysia

Site Description

Site	**SBW**	**CMC**	**MLM**
Forest type	Oil palm (Original vegetation: Mixed Peat Swamp Forest)	Padang Paya Swamp Forest (logged-over PSF)	Alan Batu Swamp Forest
Canopy height (in 2011)	~ 8 m	~ 25 m	~ 30 m
Peat depth	~ 13 m	~ 10 m	~ 10 m

- Tropic rainforest climate (moderately hot-very humid-receive substantial rainfall)
- Peat surface is relatively flat

Evapotranspiration Measurements

Eddy covariance system

Wind Sentry

Rain gauge

Solar Panel

T & RH probe

- Measurement of vertical transfer of water vapor by convective motion.
- Directly measure flux by sensing properties of eddies as they pass through a measurement level on an instantaneous basis.

Bulk Parameters

- To interpret the **seasonal variation & environmental response of ET**

1. **Stomata Conductance** (G_s)

$$\frac{1}{G_s} = \frac{1}{G_a}\left[\frac{\varepsilon(H+lE)+\rho C_p G_a \frac{VPD}{\gamma}}{lE} - \varepsilon - 1\right]$$

.....Montheith et.al (1965)

2. **Decoupling factor** (Ω)

$$\Omega = \frac{\varepsilon+1}{\varepsilon+1+\frac{G_a}{G_s}}$$

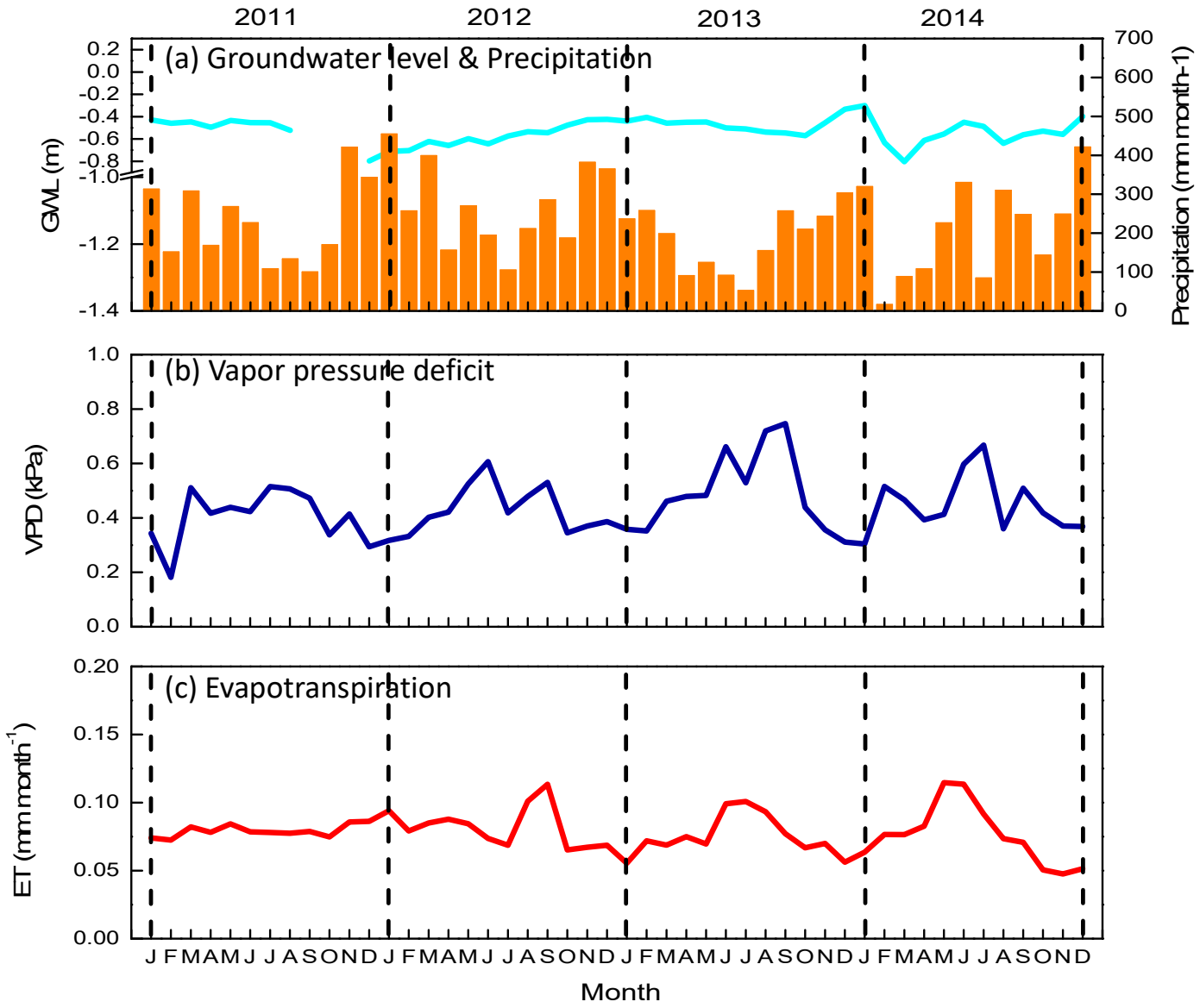
.....Jarvis & Mcnaugnthon (1986)

3. **Preistley-Taylor coefficient** (α)

$$\alpha = \frac{lE}{lE_{eq}} = \frac{lE}{\frac{(R_n-G_s)s}{s+\gamma}} \cong \frac{lE}{\frac{(H+lE)s}{s+\gamma}} = \frac{s+\gamma}{(1+\beta)s}$$

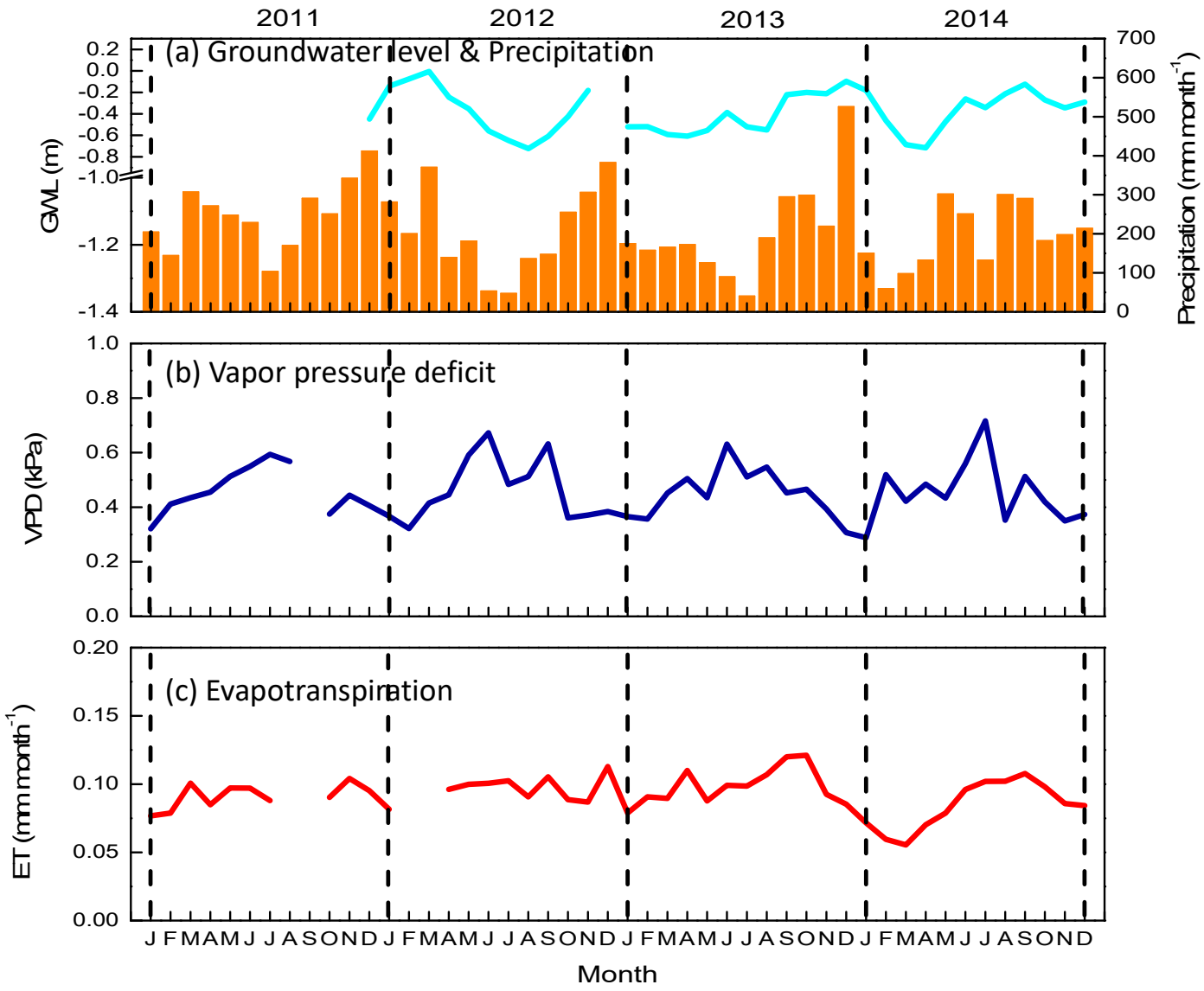
.....Priestley & Taylor (1972)

Seasonal Variation - **SBW**



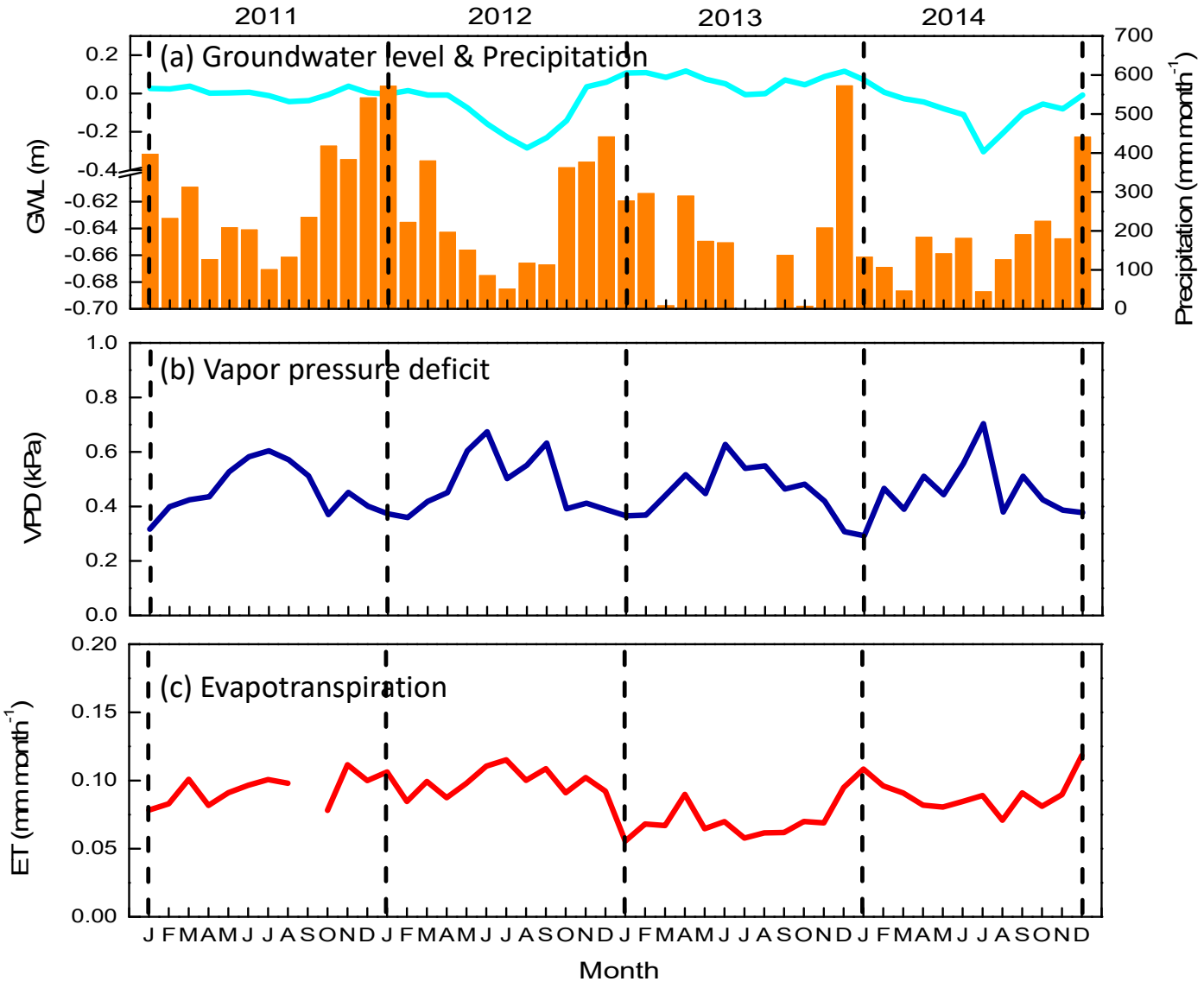
- The GWL was stable at -0.4 to -0.7 m
- GWL decreases due to low PT for year 2014
- VPD increased significantly during dry season for all years due to low PT
- ET increase increased during dry season for all year except 2011 due to low VPD

Seasonal Variation - **CMC**



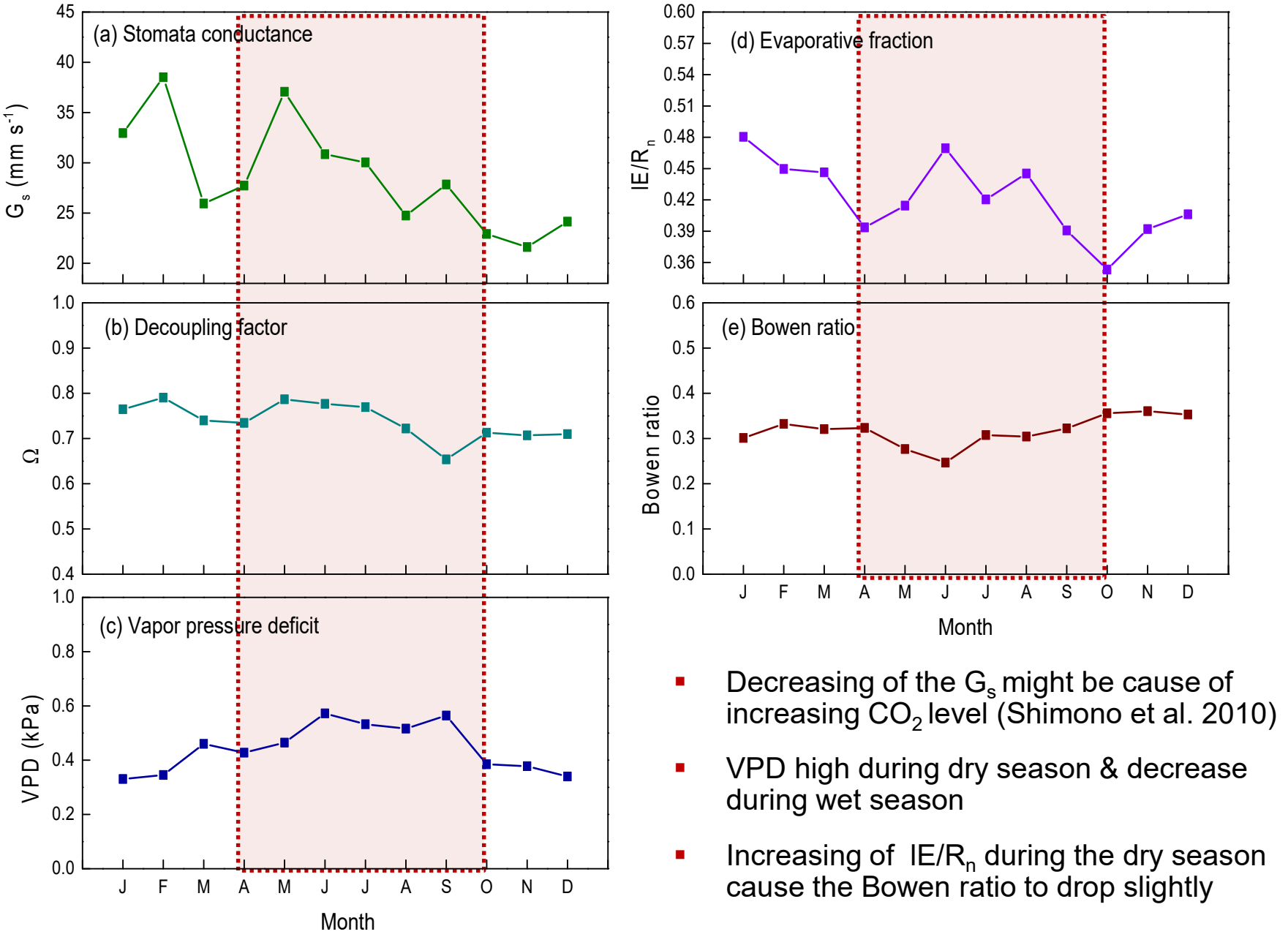
- The GWL were low during dry season (Apr - Oct)
- Significant low VPD in Dec 2013 due to high PT
- ET was low in Jan to Mar for 2014

Seasonal Variation - **MLM**



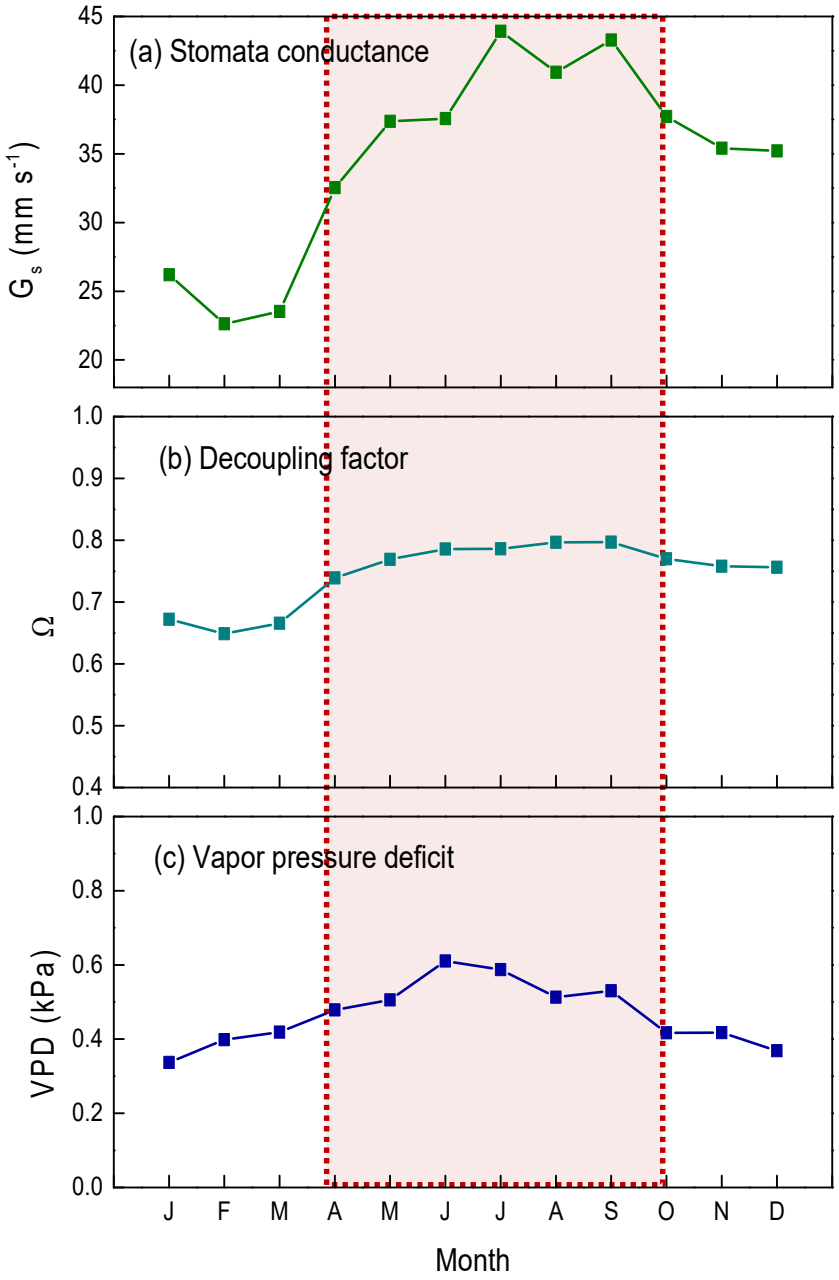
- The GWL drop during dry season for 2012, 2012 & 2013
- Significant low VPD in Dec 2013 & Jan 2014 following large PT in Dec 2013
- Substantial low ET in 2013 due to low PT during dry season

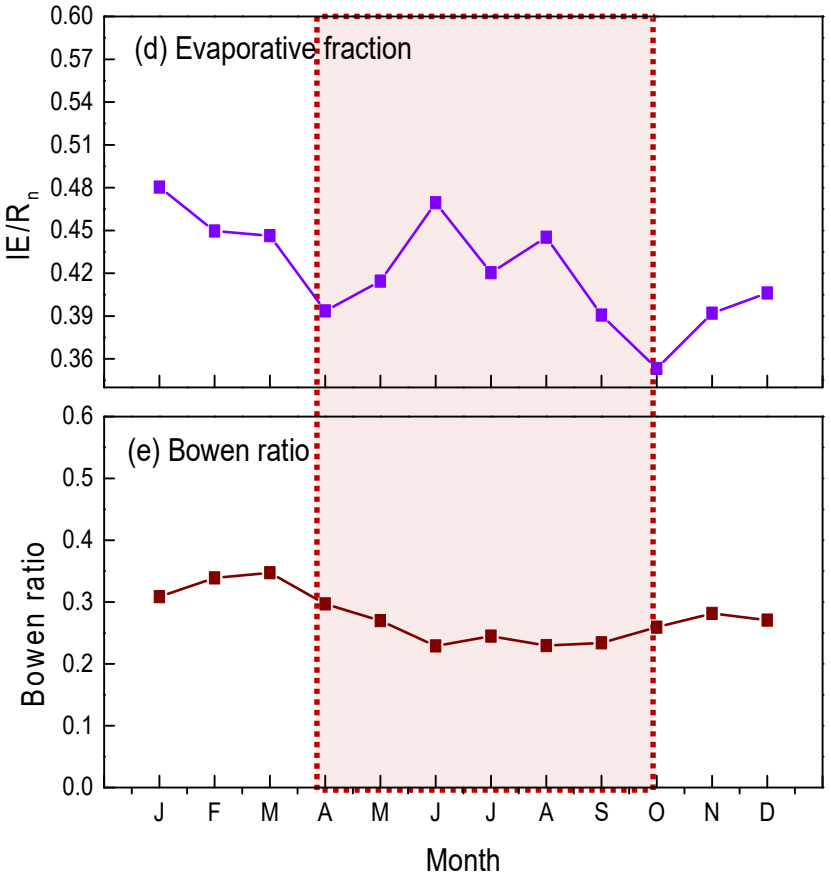
Environmental response of ET - **SBW**



- Decreasing of the G_s might be cause of increasing CO_2 level (Shimono et al. 2010)
- VPD high during dry season & decrease during wet season
- Increasing of IE/R_n during the dry season cause the Bowen ratio to drop slightly

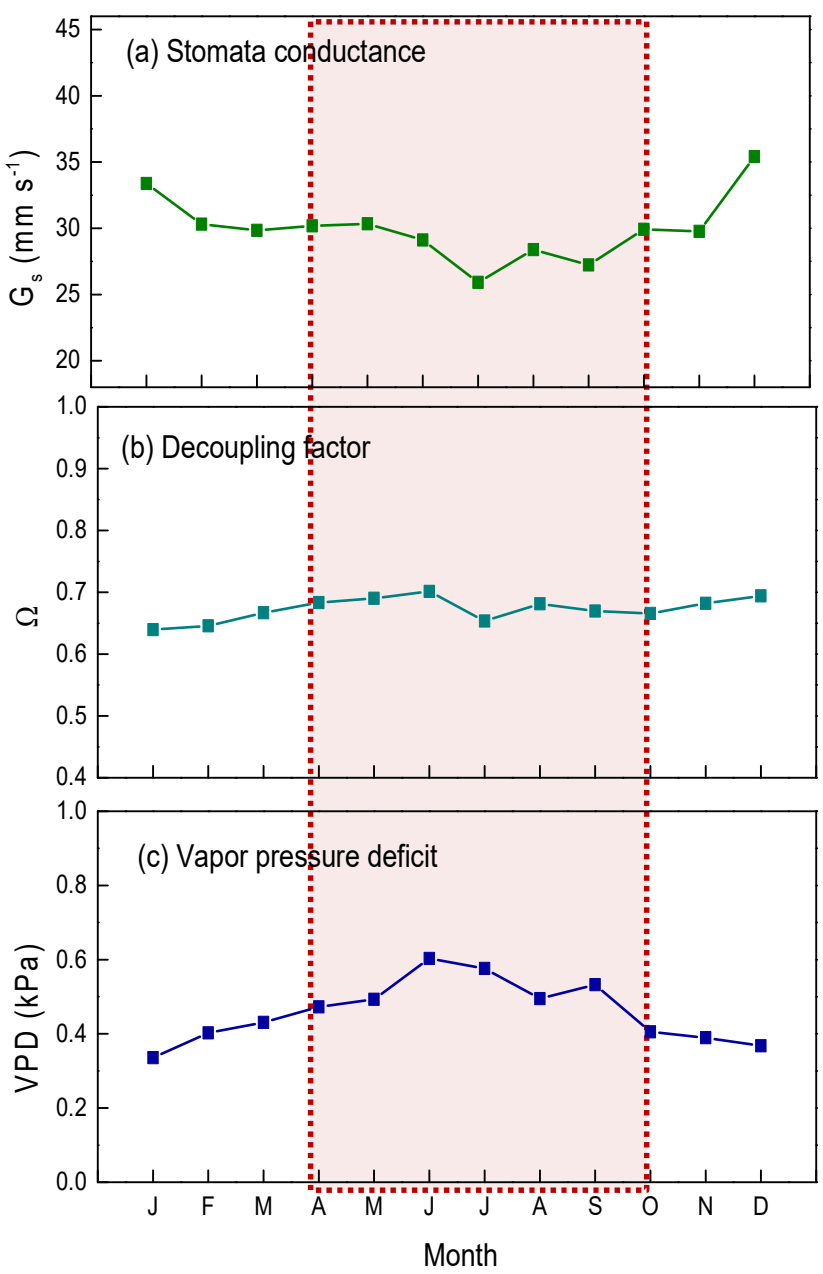
Environmental response of ET - **CMC**

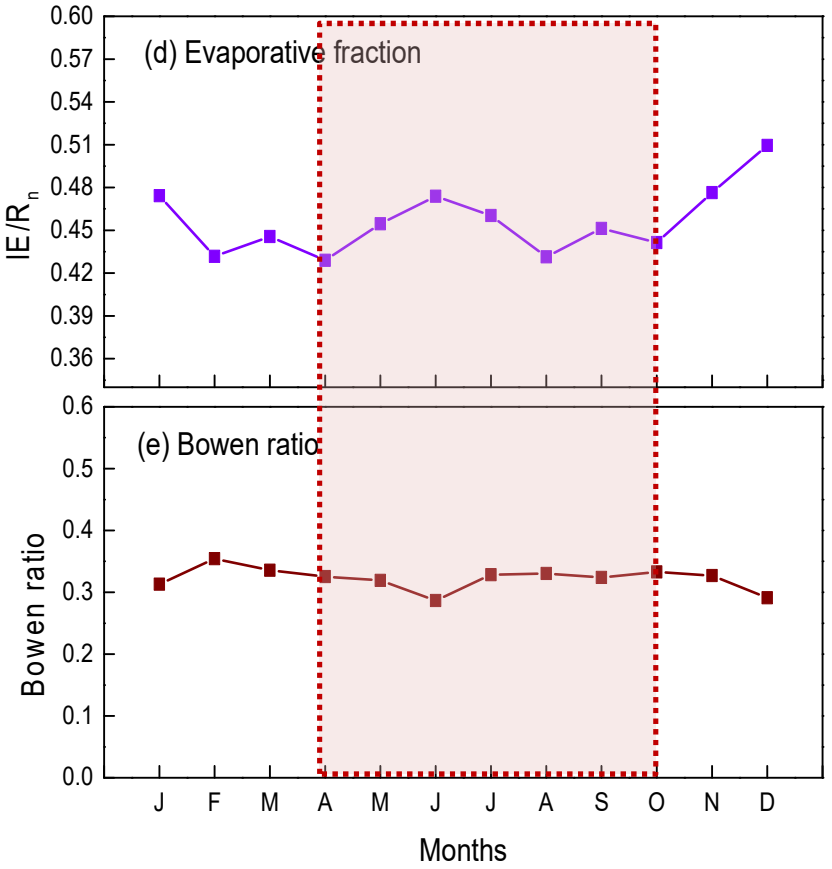




- G_s ,Ω & VPD increasing during dry season & decrease during wet season
- VPD increase during dry season due to low precipitation has resulted of decreasing in the relative humidity.

Environmental response of ET - **MLM**



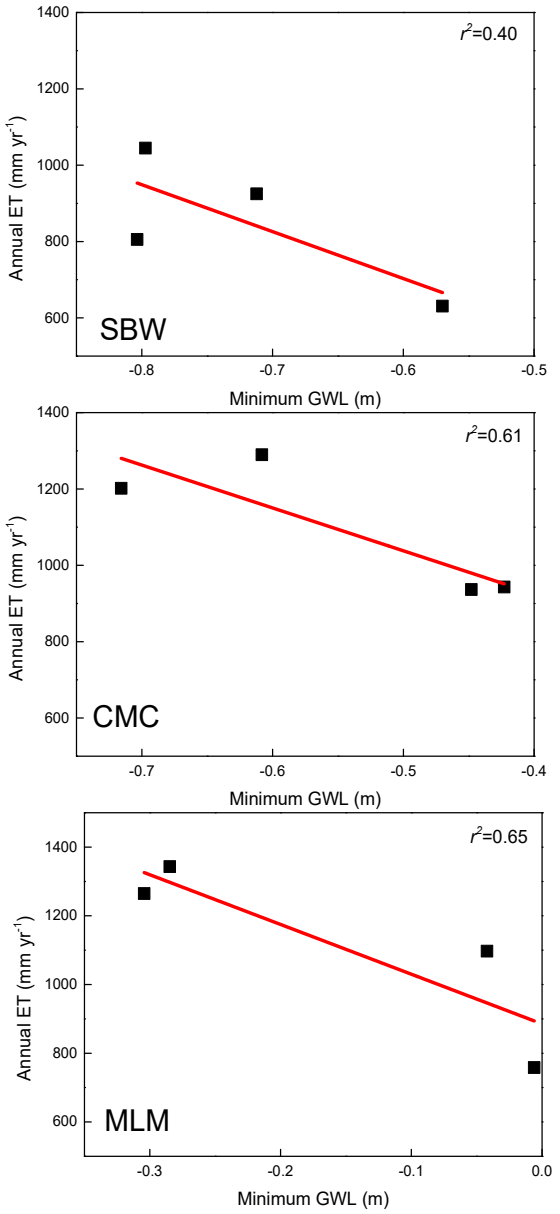


- Decreasing G_s due to water stress of the stomata closure due to decreasing of GWL and increasing of VPD during dry season (Hirano *et al.* 2015, da Rocha *et al.* 2004, Hasler & Avissar, 2007 &Tanaka *et al.* 2008)
- Increase of IE/R_n during the dry season cause the Bowen ratio to drop slightly.

Annual Evapotranspiration

Year	Evapotranspiration (ET) mm yr^{-1}		
	SBW	CMC	MLM
2011	1044	936	1097
2012	925	943	1343
2013	630	1289	758
2014	805	1201	1264
Mean ± SD	851 ± 177	1093 ± 180	1116 ± 259

- A negative linear relationship for all sites.
- SBW has low r^2 compare to CMC and MLM
- Highest r^2 observed for MLM site (r^2=0.65).



Comparison with other studies

Ecosystem type	ET mm yr^{-1}	P mm yr^{-1}	ET/P	References
Oil palm plantation	851 ± 177	1991 ± 177	0.43	
Secondary PSF	1093 ± 180	2152 ± 299	0.51	This study
Primary PSF	1116 ± 259	2090 ± 895	0.53	
Undisturbed PSF	1636 ± 176		0.67	
Disturbed PSF	1553 ± 53	3732 ± 281	0.63	Hirano et al. (2015)
Disturbed & Burn PSF	1374 ± 75		0.56	
Tropical rainforest in Peninsular Malaysia	1287 ± 52	1865 ± 288	0.69	Kosugi et al. (2012)
Bornean tropical rainforest	1323 ± 74	2600 ± 272	0.51	Kume et al. (2011)
Tropical forest in Asia and Oceania region	1255 ± 329	2557 ± 1057	0.49	Komatsu et al. (2012)

Conclusions

- The unadjusted ET for three different ecosystem SBW (oil palm plantation), CMC (secondary forest) and MLM (primary forest) was 851± 177, 1097± 180 and 1116±259 mm yr^{-1}
- The decreasing of stomatal conductance (G_s) during the dry season because of water stress effect the stomatal closure due the decreasing of GWL and increasing of VPD.
- SBW ET was primarily controlled by Rn since the relationship between ET and GWL was weak
- ET for CMC and SBW was mainly control by the GWL since the relationship between ET and GWL was strong



Thank You Very Much for Your Attention