

Observations of soil moisture and related land characteristics in Taiwan before Typhoon Morakot, 2009

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Ming-Hsu Li (NCU), Ping-Ho Lee (CWB), Ming-
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Typhoon Morakot (8 August 2009)



Maintain the Sites after rain events (Mt. PeiTungyen Flux Tower)

**Road
Condi
tions**

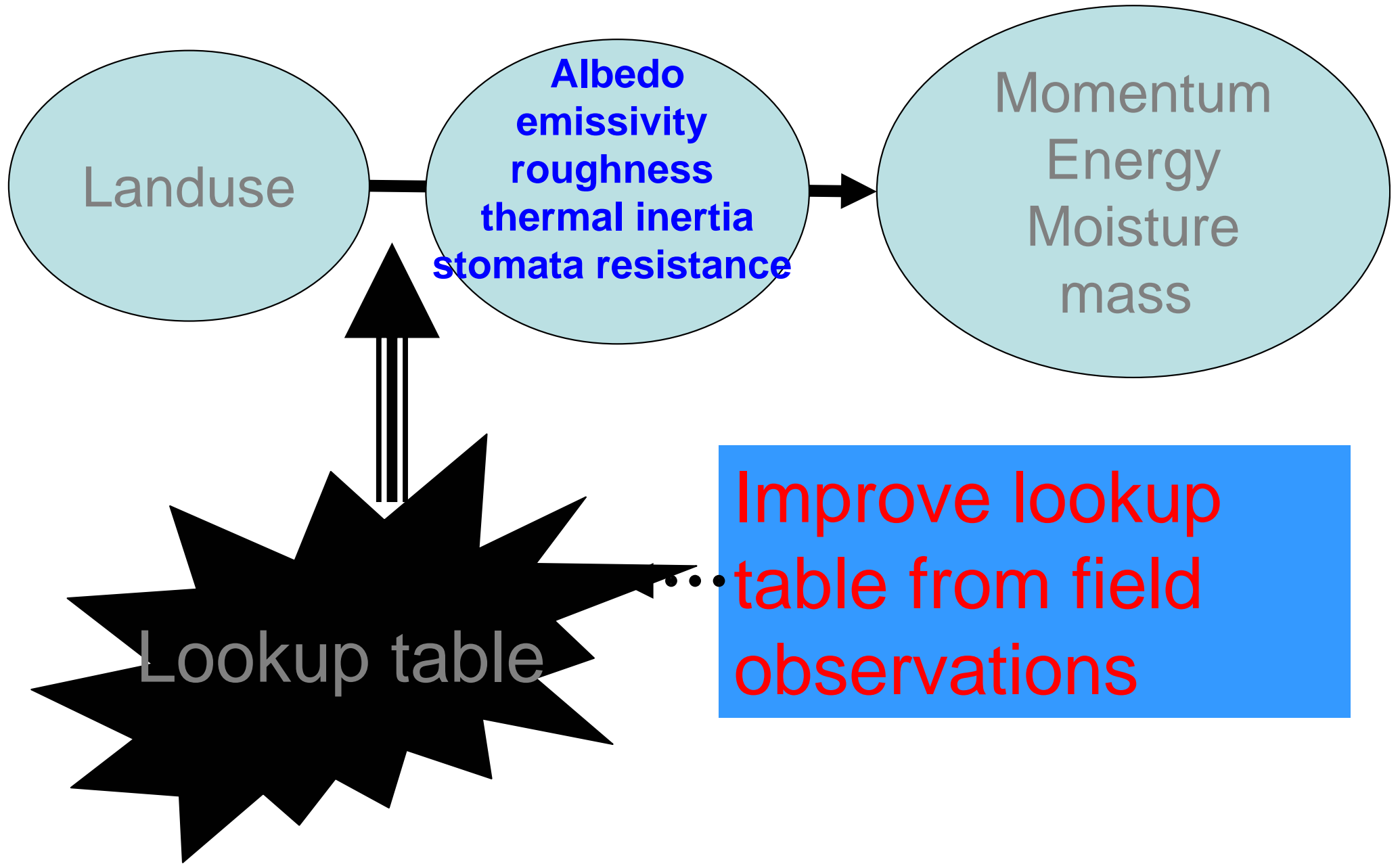


**Install/
Maintain**



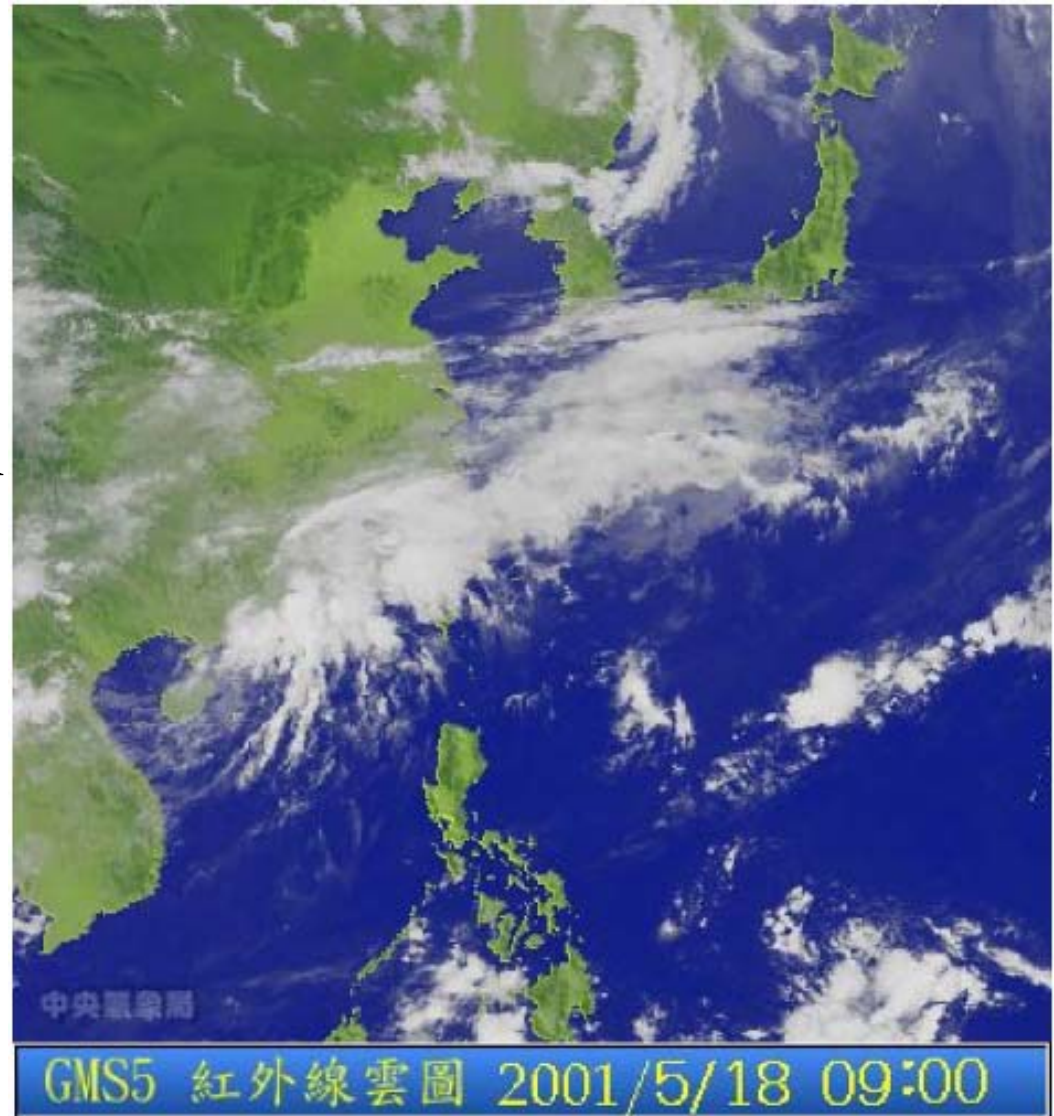
Instrument





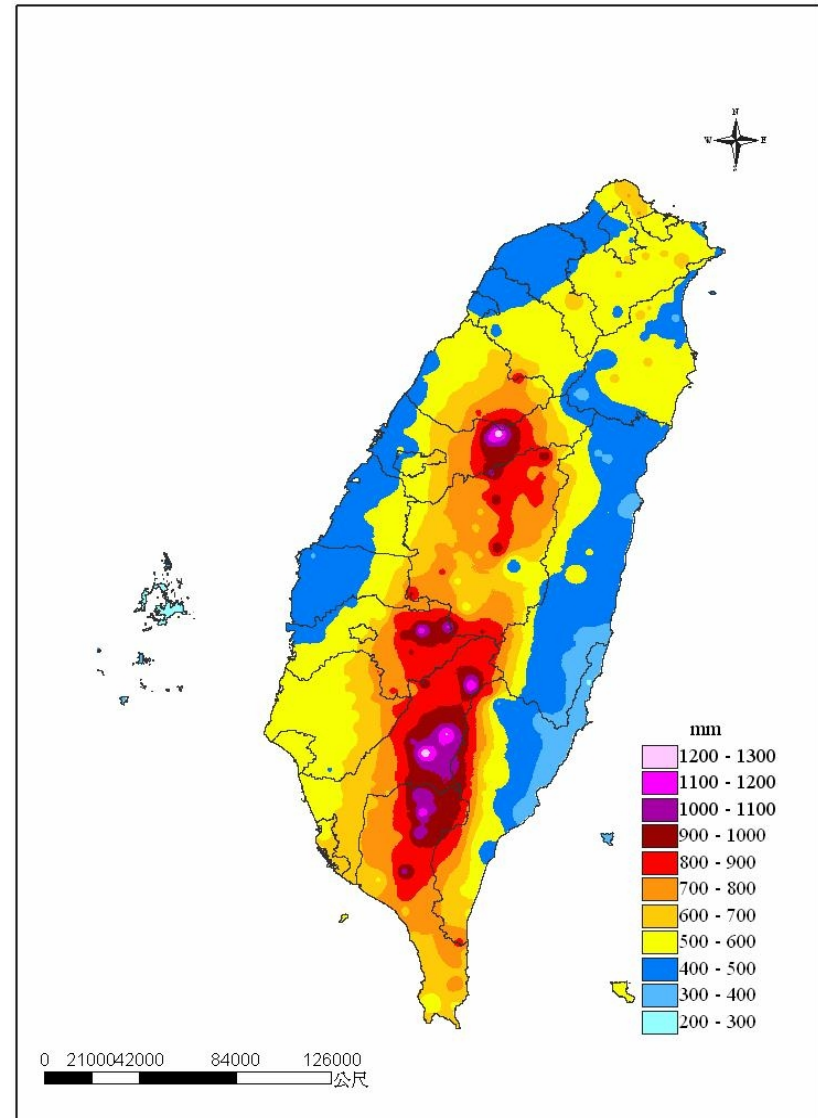
Mei-yu

- During May and June
- Intersection of the northeast monsoon and southwest monsoon
- Major sources of daily living and crops irrigation before typhoon season
- **numerous rainy events**



Satellite image of Mei-yu in the Eastern Asia

Rainfall during Mei-yu



The cumulative rainfall (mm) in May and June from 1992 to 2006 from CWB

Lists of Landuse/Vegetation in MM5 (PSU/NCAR)

Landuse Integer Identification	Landuse Description	Albedo(%)		Moisture Avail. (%)		Emissivity (% at 9 μ m)		Roughness Length (cm)		Thermal Inertia (cal cm ⁻² k ⁻¹ s ^{-1/2})	
		Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
1	Urban land	18	18	5	10	88	88	50	50	0.03	0.03
2	Agriculture	17	23	30	60	92	92	15	5	0.04	0.04
3	Range-grassland	19	23	15	30	92	92	12	10	0.03	0.04
4	Deciduous forest	16	17	30	60	93	93	50	50	0.04	0.05
5	Coniferous forest	12	12	30	60	95	95	50	50	0.04	0.05
6	Mixed forest and wet land	14	14	35	70	95	95	40	40	0.05	0.06
7	Water	8	8	100	100	98	98	.01	.01	0.06	0.06
8	Marsh or wet land	14	14	50	75	95	95	20	20	0.06	0.06
9	Desert	25	25	2	5	85	85	10	10	0.02	0.02
10	Tundra	15	70	50	90	92	92	10	10	0.05	0.05
11	Permanent ice	80	82	95	95	95	95	0.01	0.01	0.05	0.05
12	Tropical or sub tropical forest	12	12	50	50	95	95	50	50	0.05	0.05
13	Savannah	20	20	15	15	92	92	15	15	0.03	0.03

Description of 13-category (PSU/NCAR) vegetation categories and physical parameters for N.H. summer (15 April - 15 October) and winter (15 October - 15 April)

List of albedo in AERMET

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.12	0.10	0.14	0.20
Deciduous Forest	0.12	0.12	0.12	0.50
Coniferous Forest	0.12	0.12	0.12	0.35
Swamp	0.12	0.14	0.16	0.30
Cultivated Land	0.14	0.20	0.18	0.60
Grassland	0.18	0.18	0.20	0.60
Urban	0.14	0.16	0.18	0.35
Desert Shrubland	0.30	0.28	0.28	0.45

Albedo of ground covers by land-use and season

Flux sites

Mt./Forest

1) TWHS – Mt. Peitungyen (2080 m asl)

Valley/Forest

2) TWLHL – Lienhuachih (773 m asl)

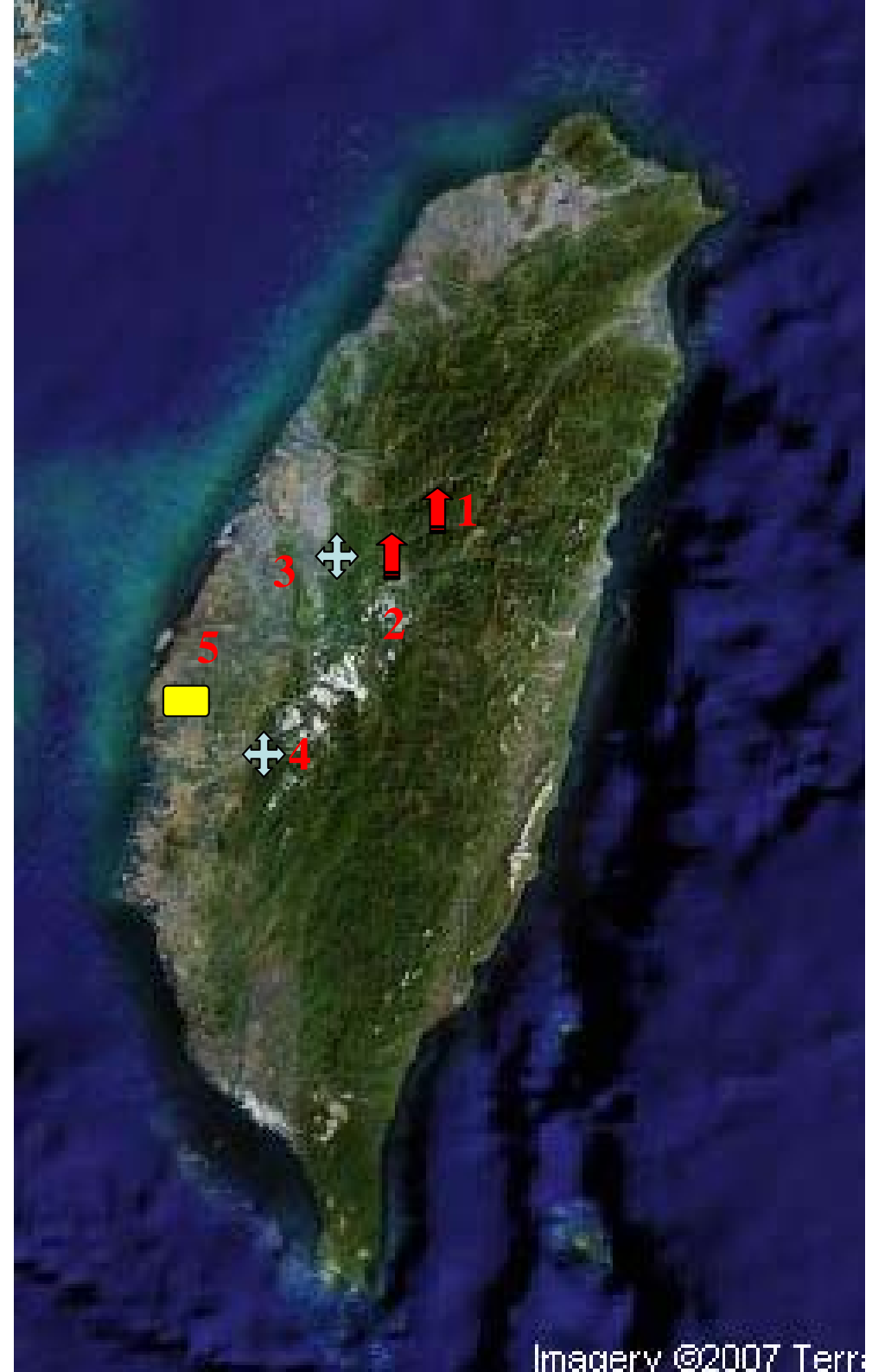
Agricultural/Urban/Country Sites

3) TARI – Wufong (55 m asl)

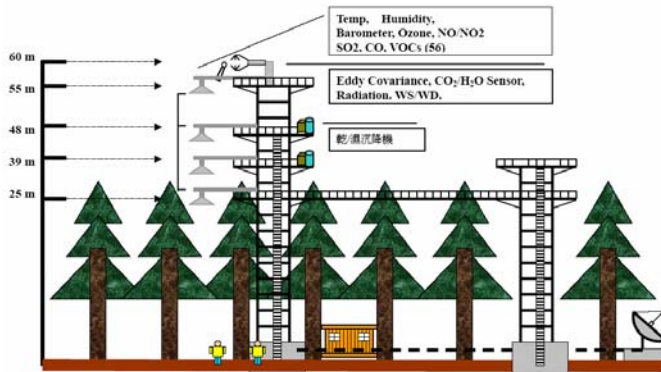
4) CWB – Chiayi (28 m asl)

Grass land/Coastal

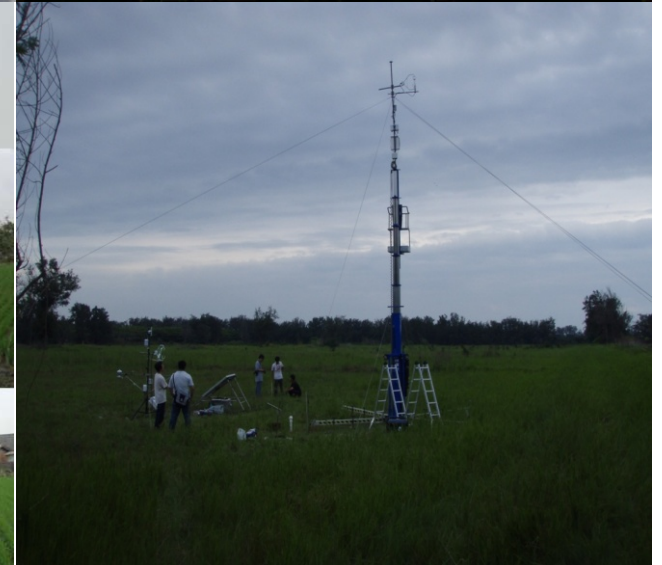
5) TTFRI- Chiayi, Dongshih (~0 m asl)



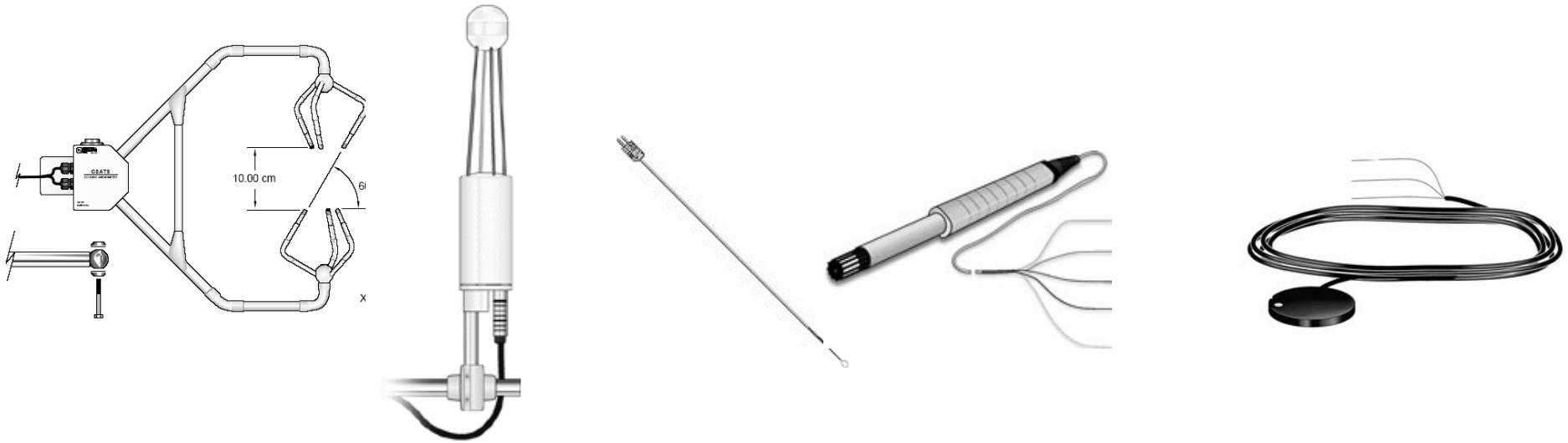
Landuse types



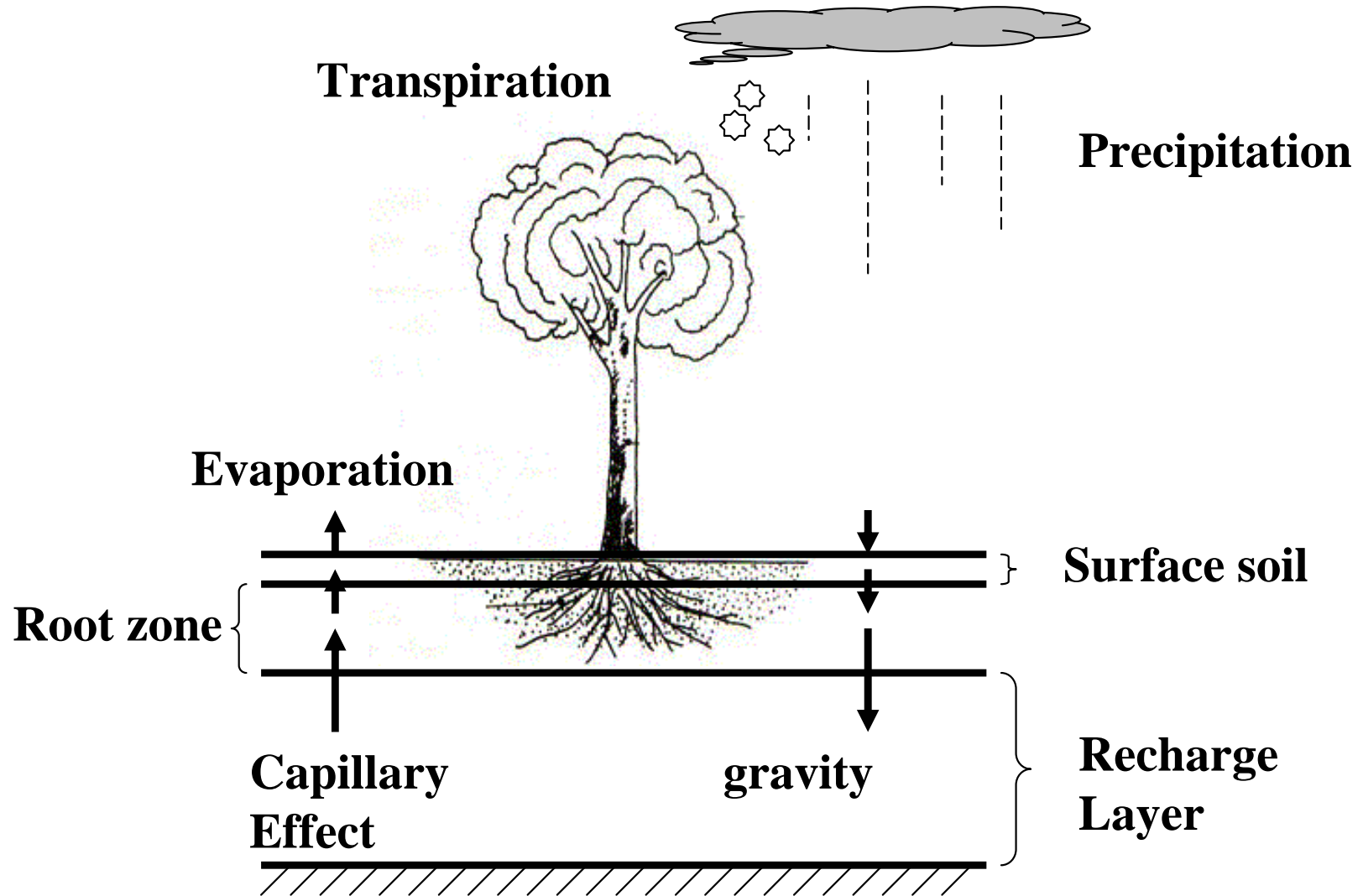
嘉義市市郊農田(鳥岫)



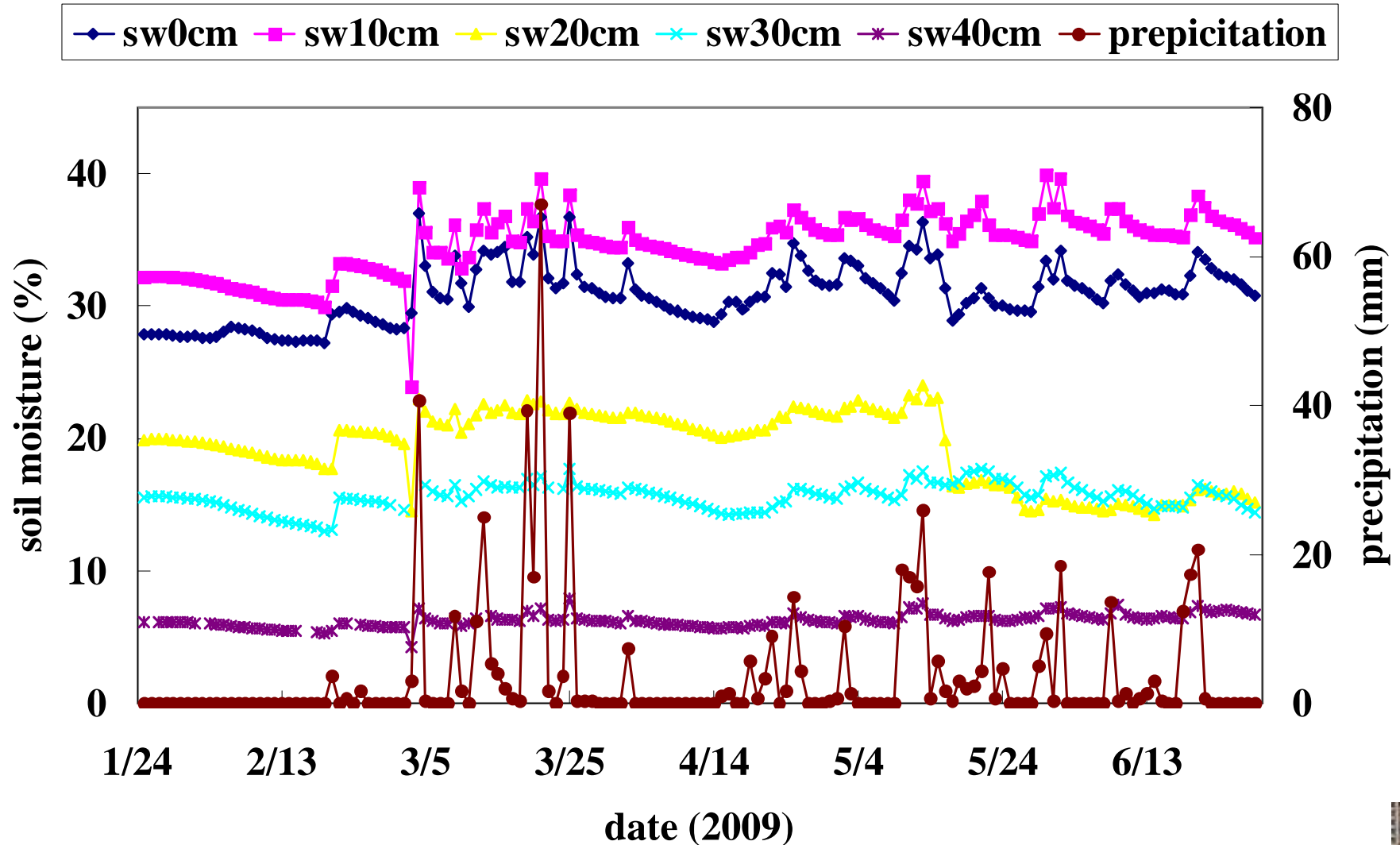
Instruments



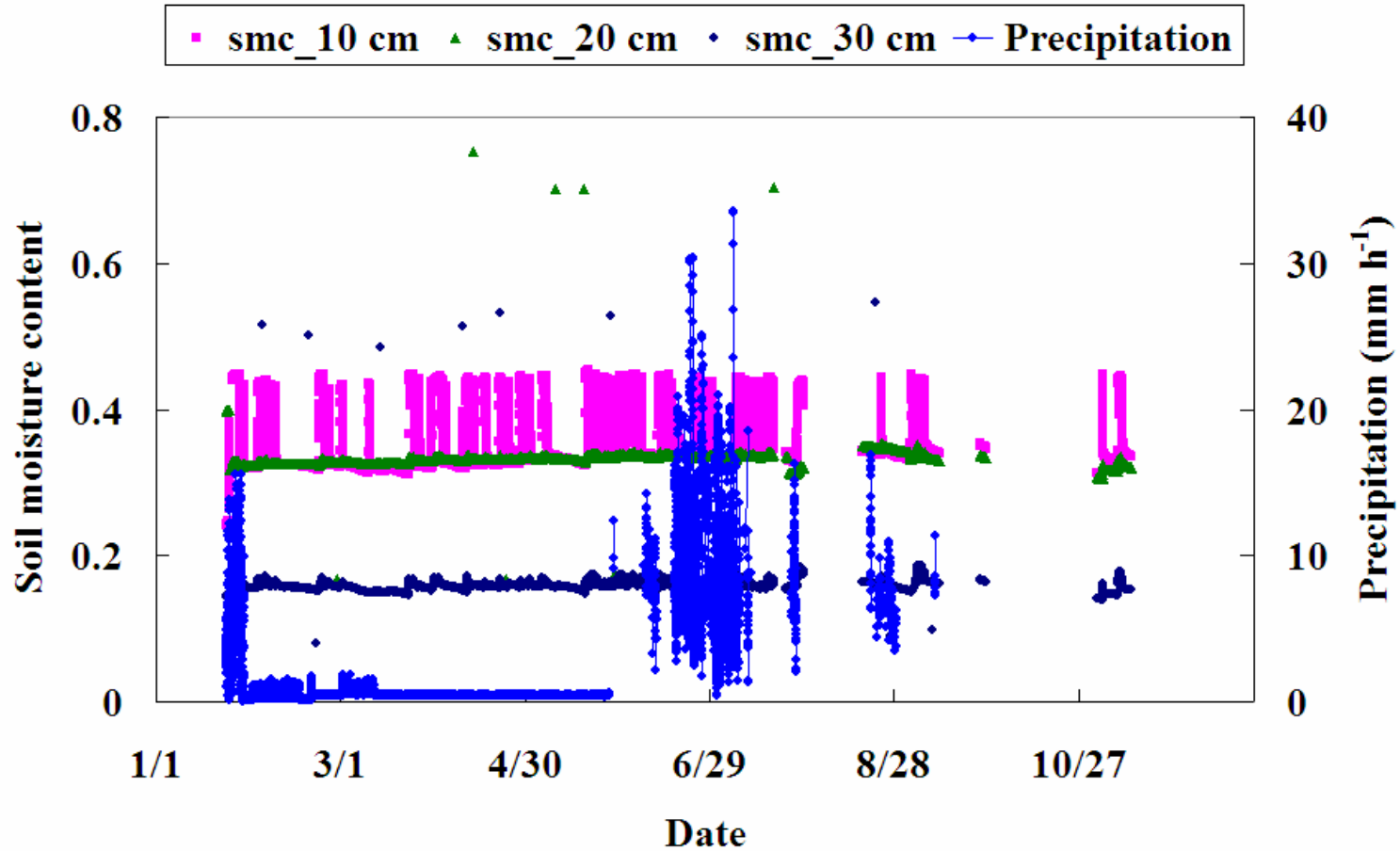
Precipitation and soil moisture



TWHS – Mt. Peitungyen

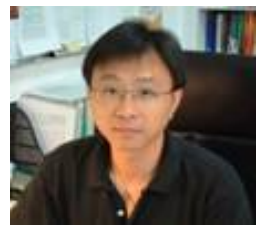
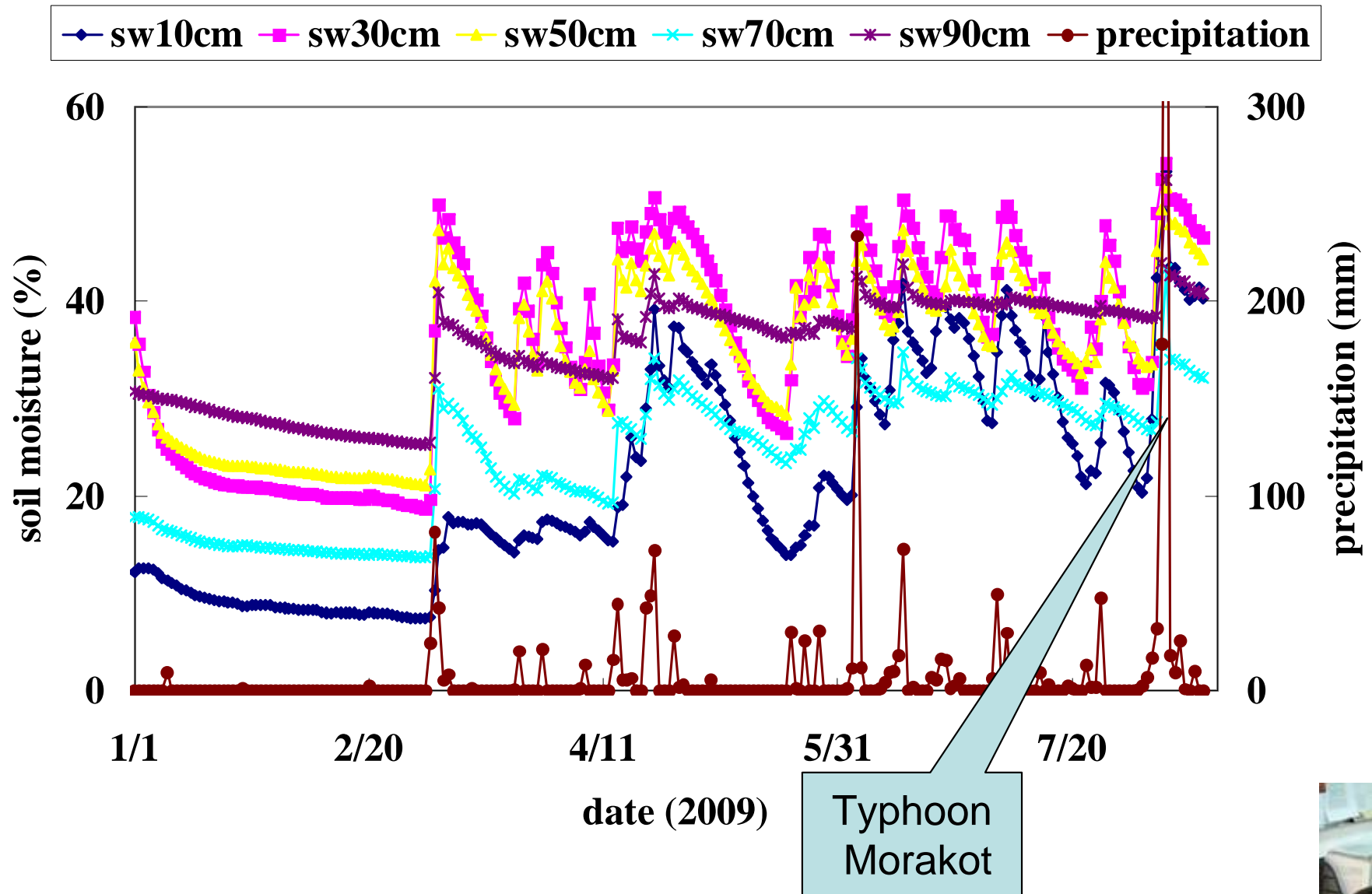


北東眼山

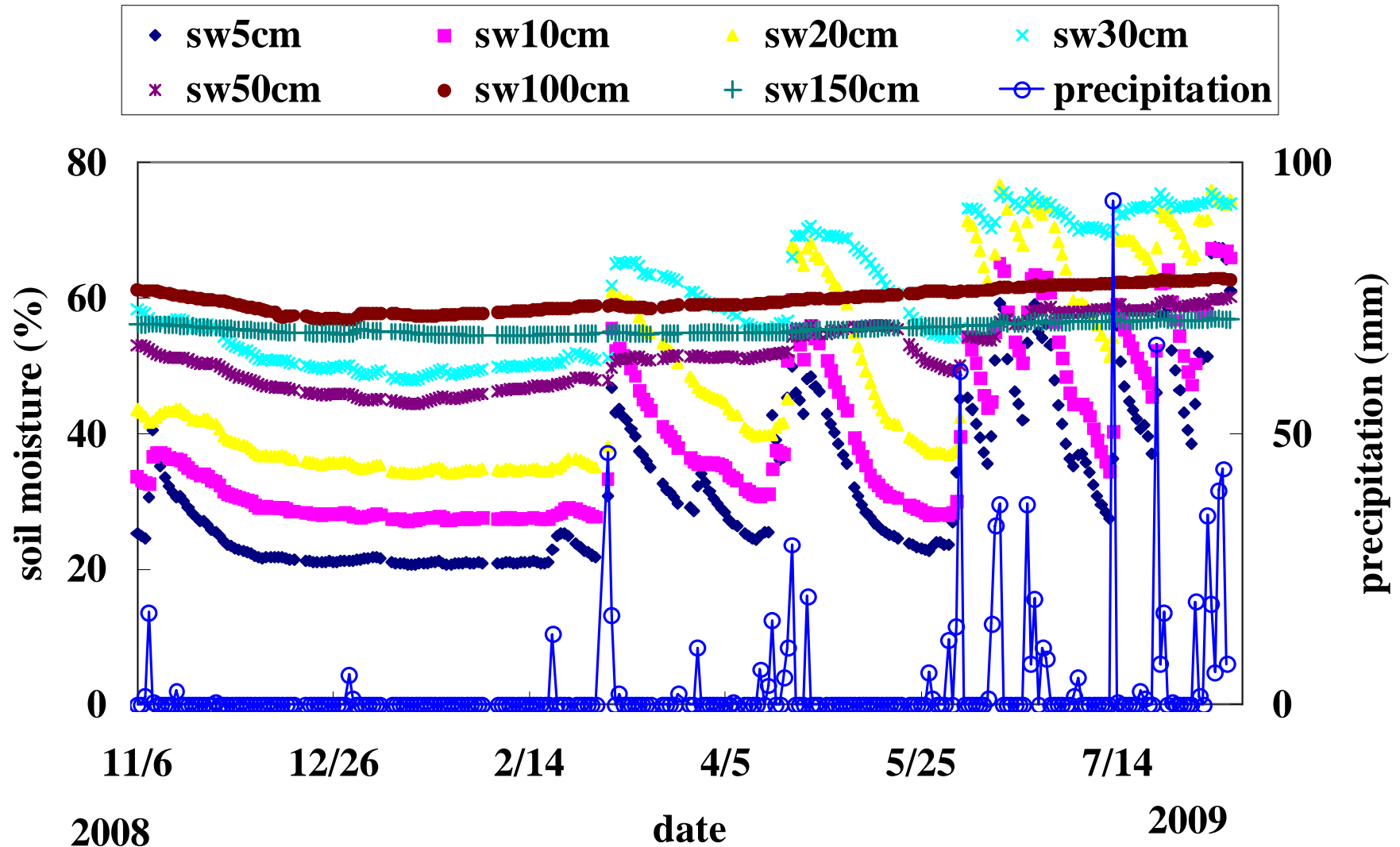


土壤含水率與雨量關係圖 (2008)

TWLHL - Lienhuachih

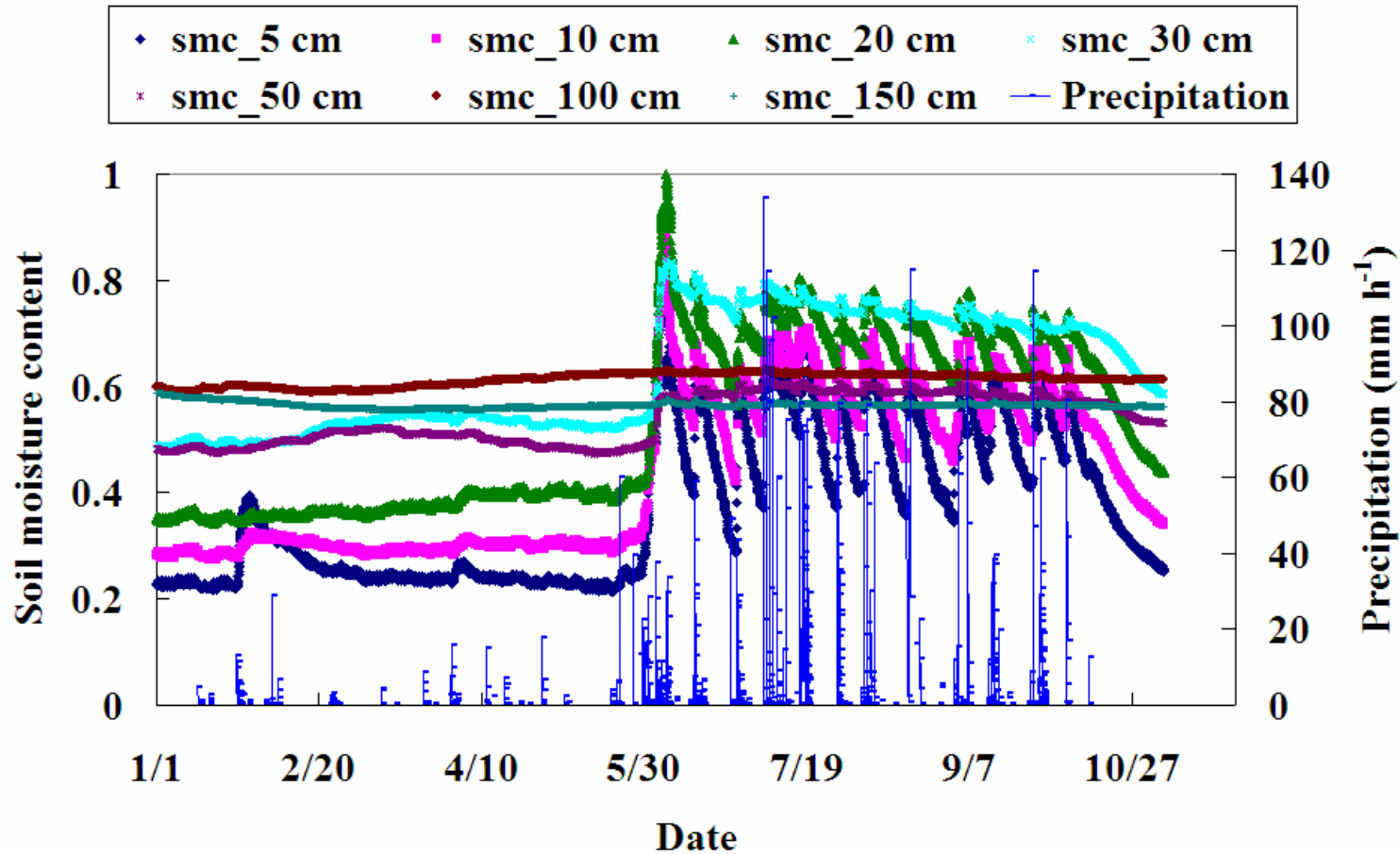


TWCIM (CWB) – Chiayi (2009)



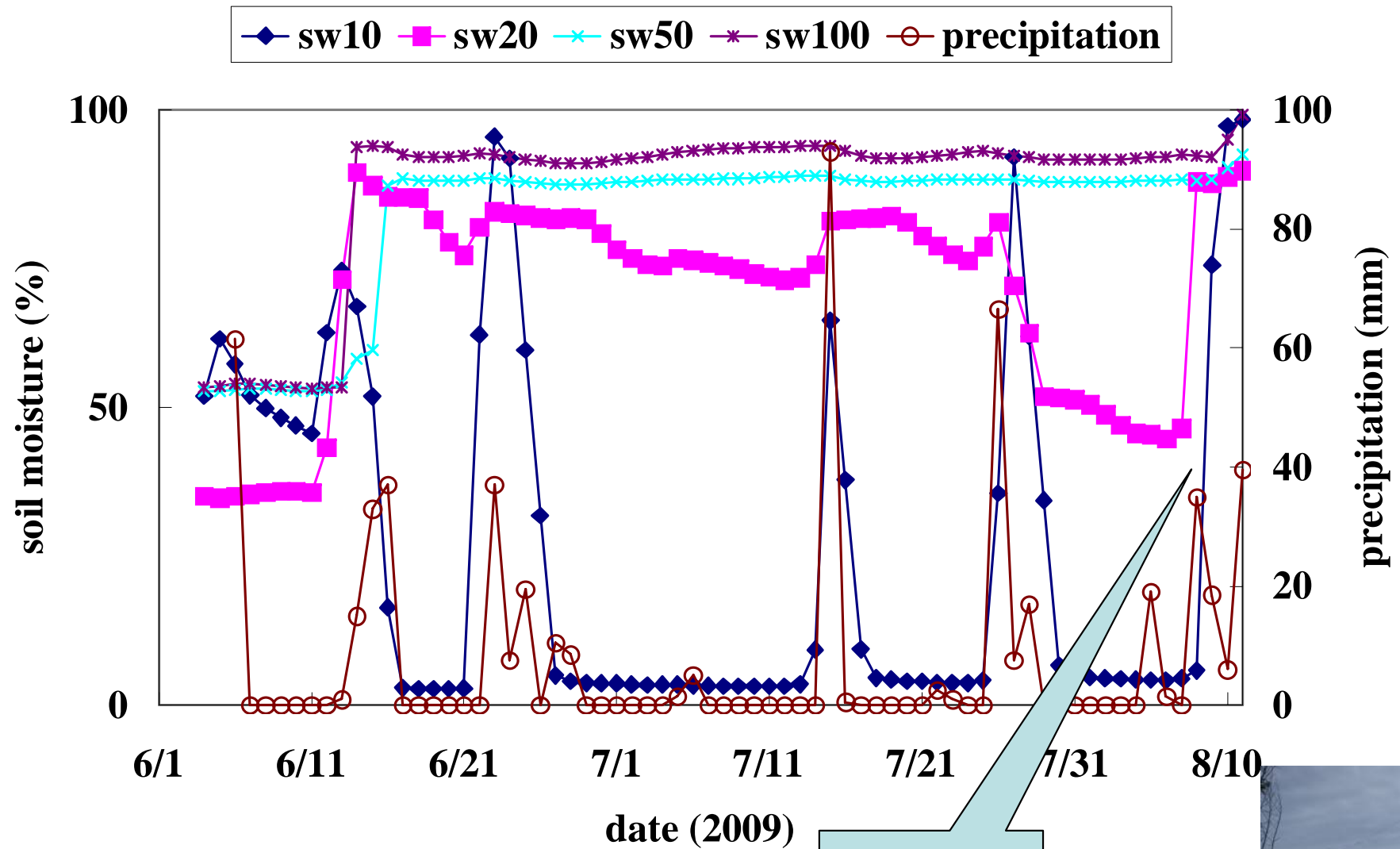
$sw = V_w / V_T$, where V_w is the volume of water; V_T is the total volume, including the soil, water and void solid.

TWCIM (CWB) – Chiayi (2008)



Soil Moisture and Rainfall(2008)

TTFRI – Dongshih, Chiayi



Typhoon Morakot



Land characteristics related to soil moisture

- Bowen ratio (β)

$$\beta = \frac{H}{LE}$$

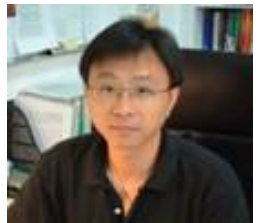
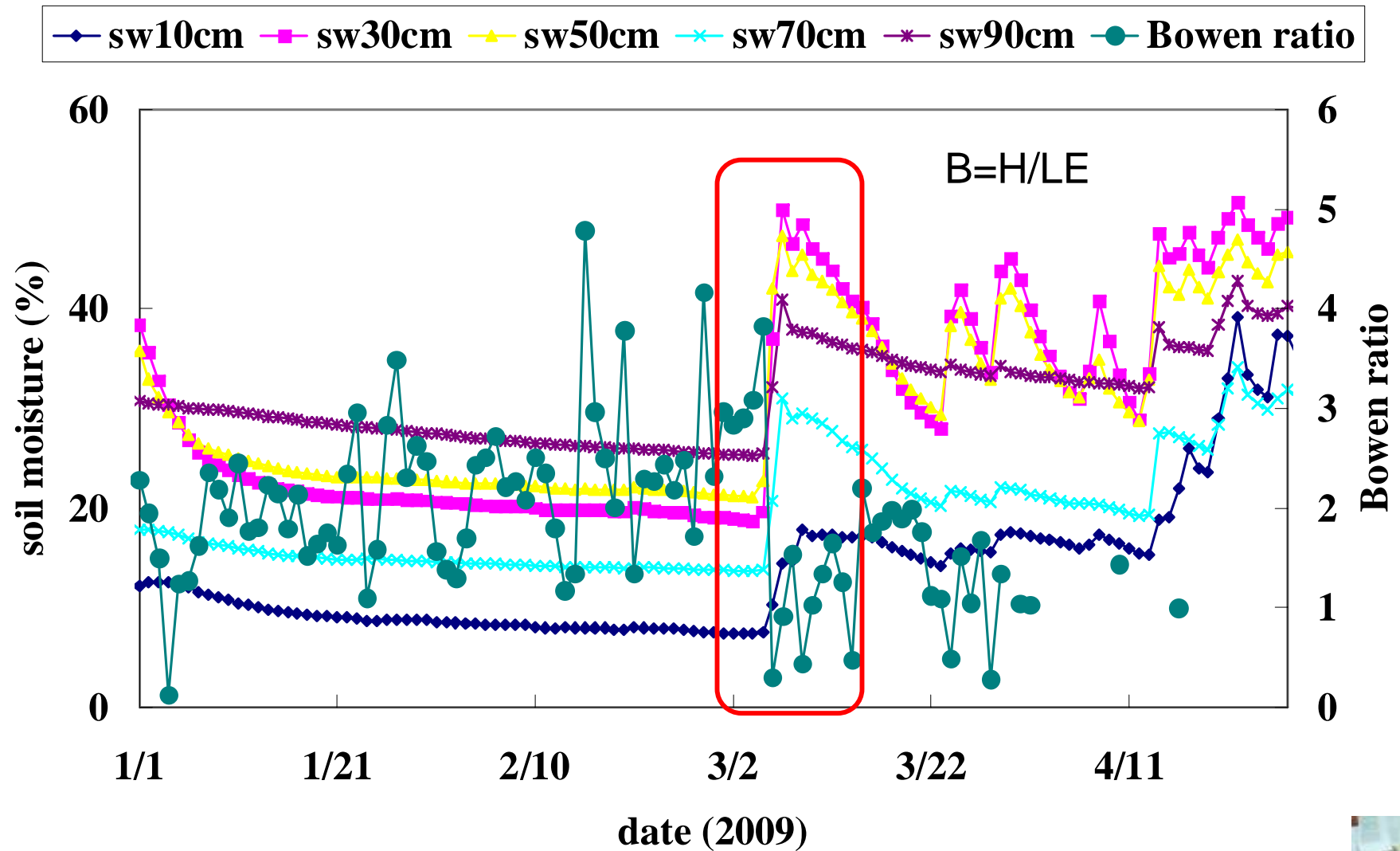
where H and LE are sensible and latent heat fluxes

- Albedo (α)

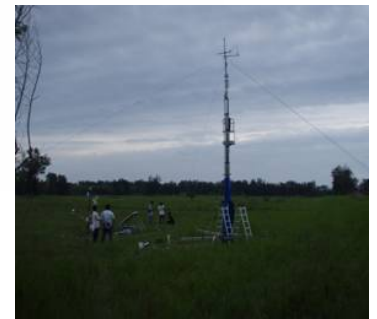
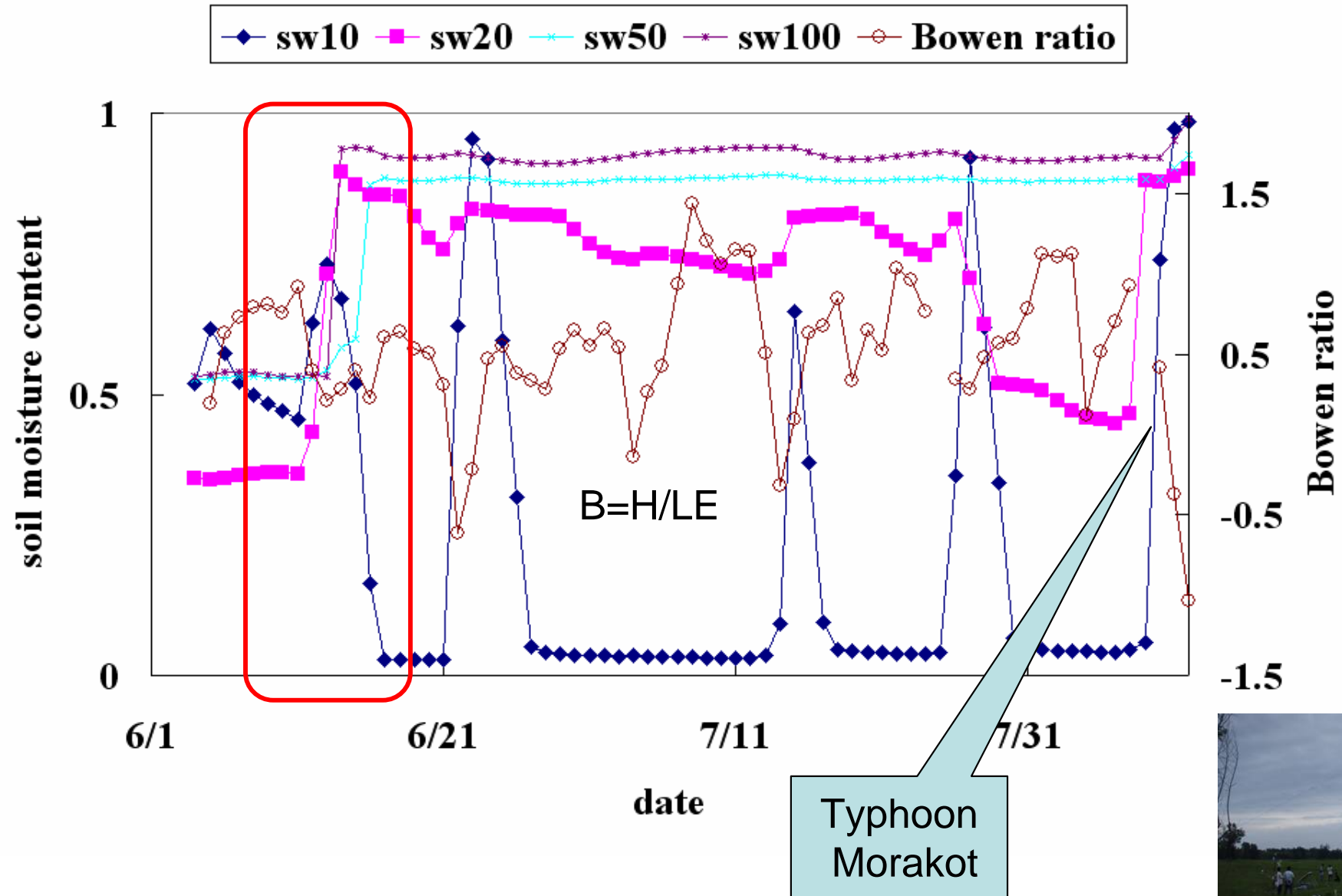
$$\alpha = \frac{R_{sr}}{R_s}$$

where R_s and R_{sr} are incoming and reflected solar radiations

Soil moisture and Bowen ratio



TTFRI – Dongshih, Chiayi



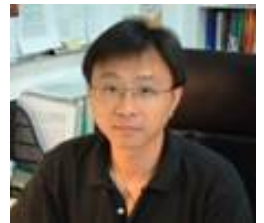
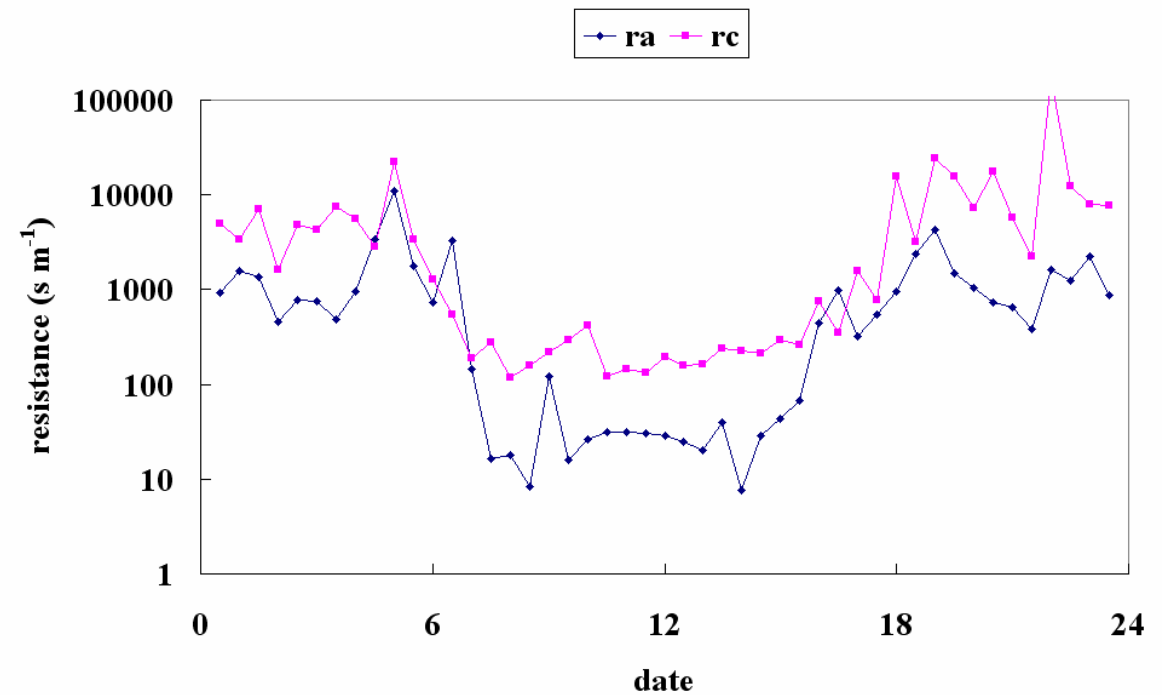
TWLHL - Lienhuachih

- Aerodynamic resistance

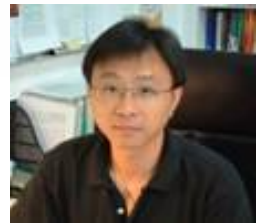
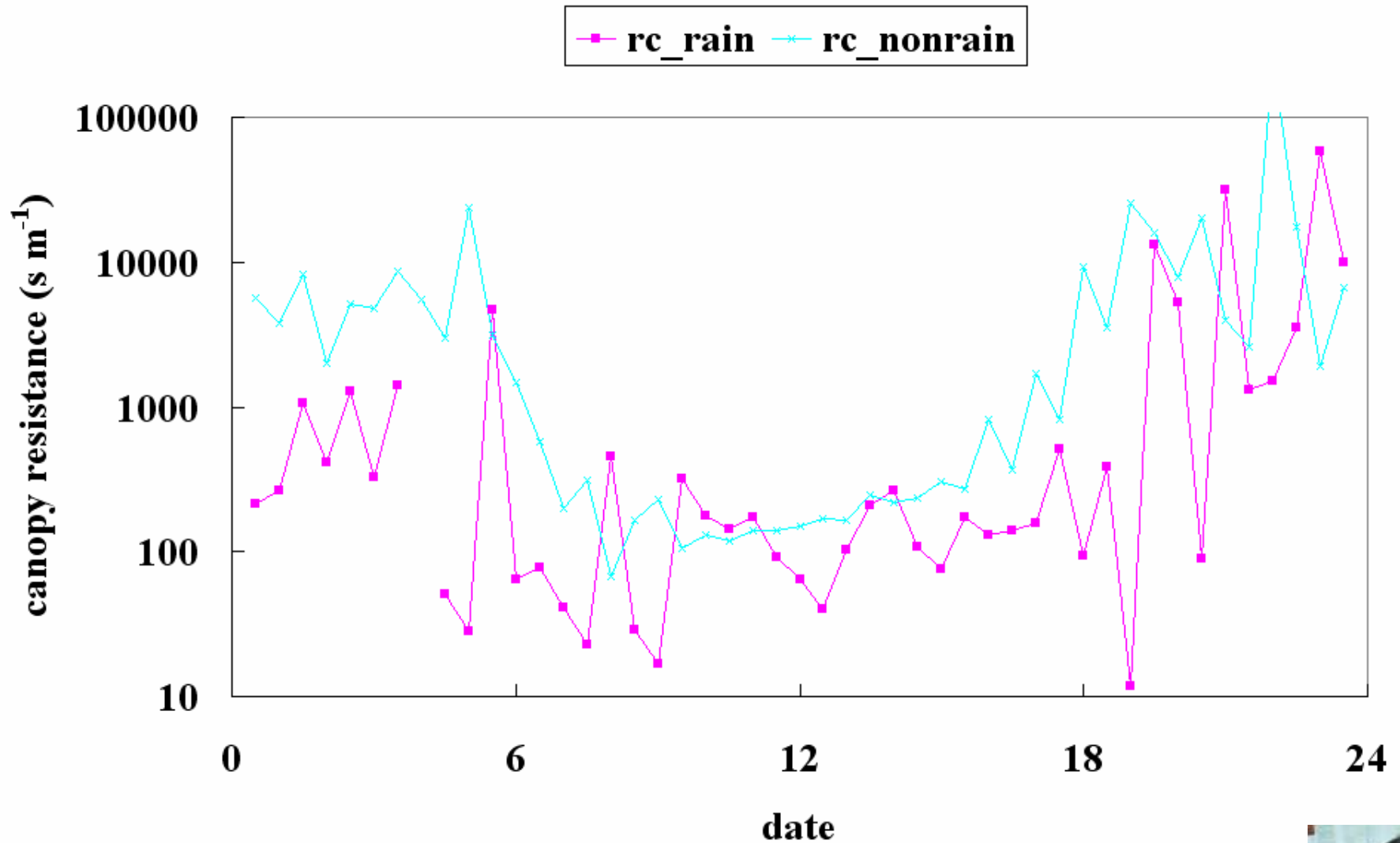
$$r_a = \rho c_p \frac{(T_s - T_a)}{H}$$

- Canopy resistance

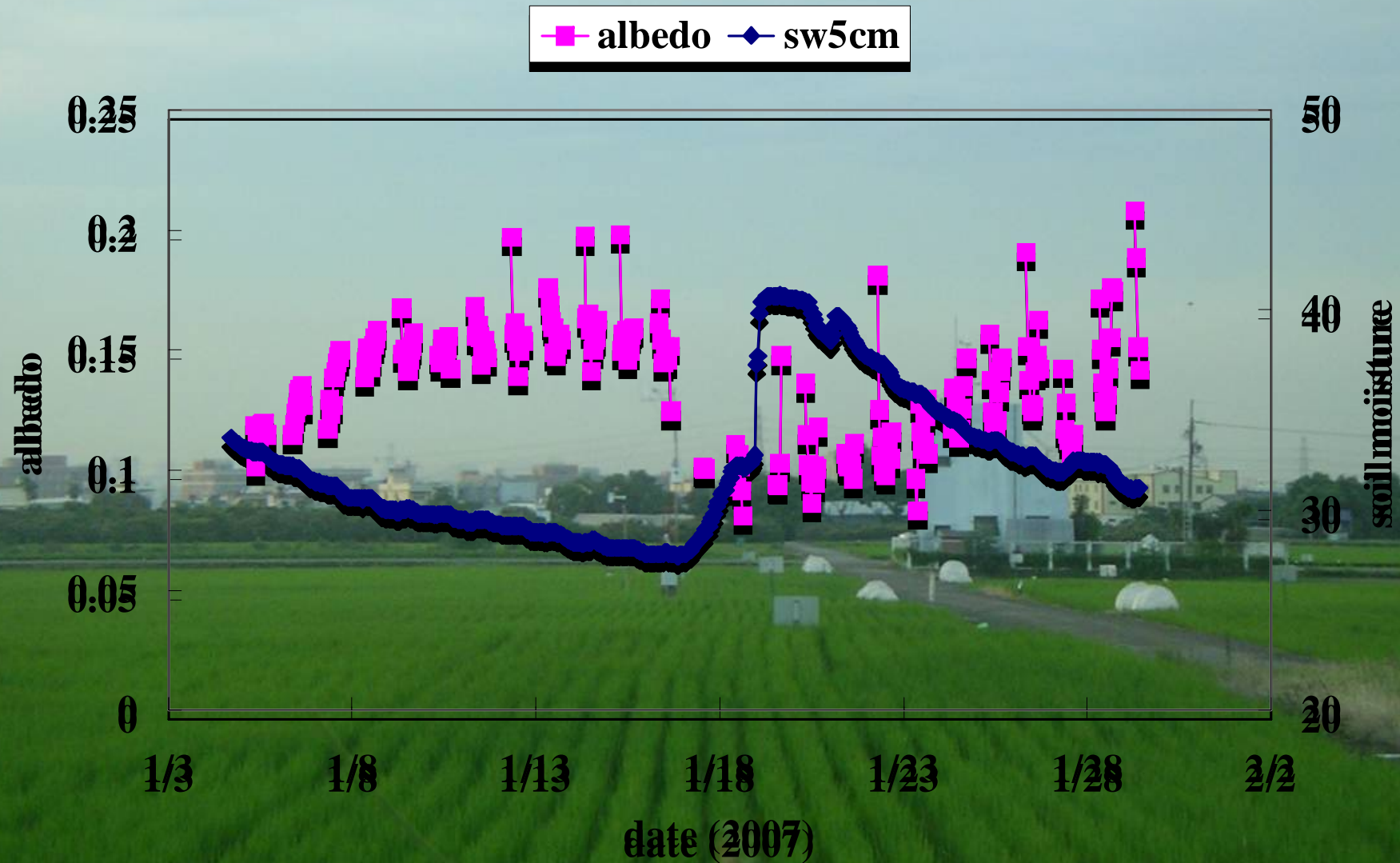
$$r_c = \rho L v \frac{(q^* - q_a)}{LE} - r_a$$



TWLHL - Lienhuachih



Soil moisture and albedo



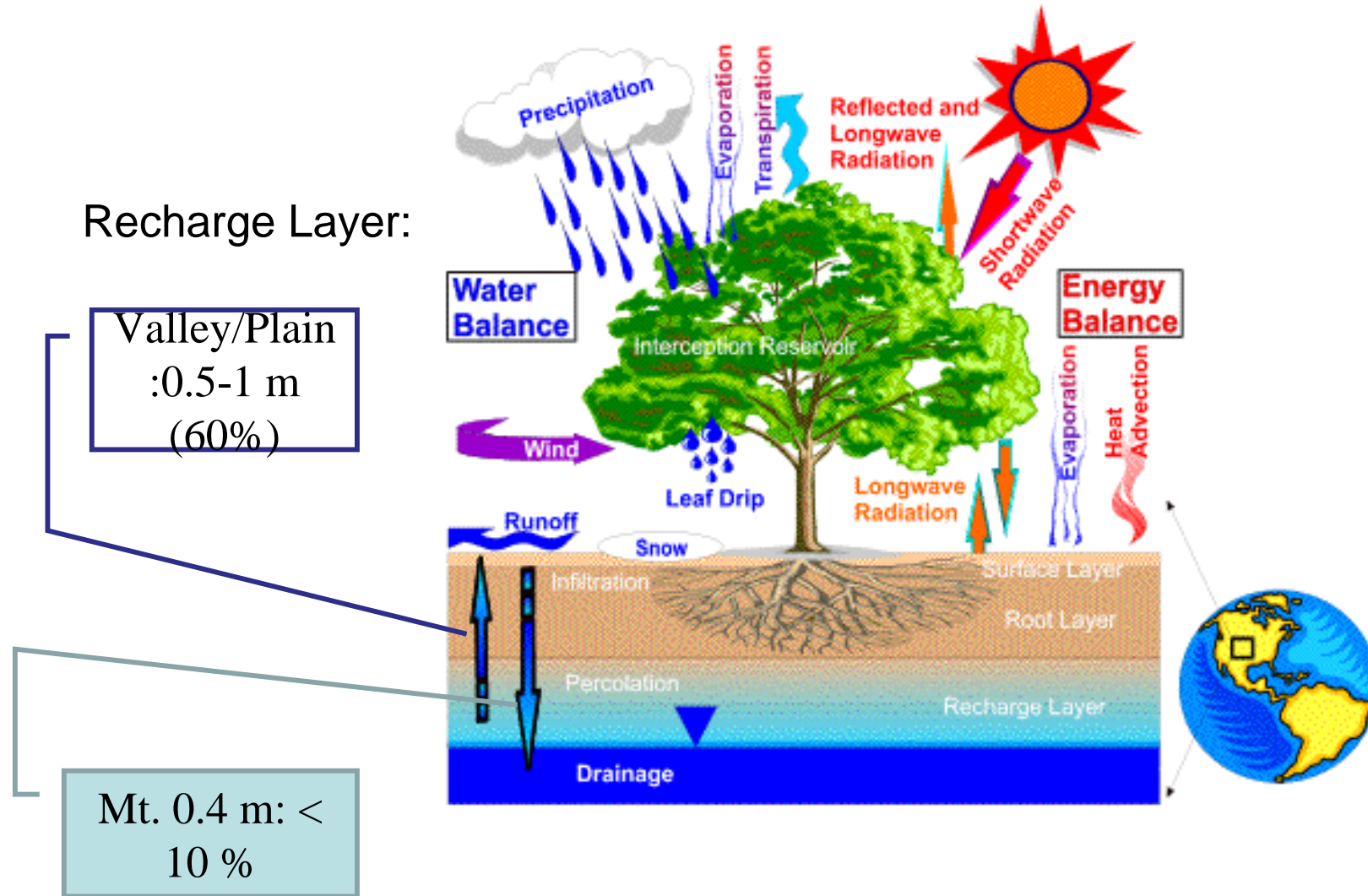
Conclusions

1. After rainy events, soil moisture increases.
2. The lowest background soil moisture is in before Spring rainfall (~Feb.).
3. Bowen ratio and canopy resistance decrease with soil moisture. Or, moisture availability increases with soil moisture content. That is, more available energy is allocated for latent heat flux in energy partitioning.
4. Moreover, albedo decreases with larger soil moisture content.
5. Taiwan has a unique characteristics of very shallow water table (SM: 55 - 65%)
 - Coastal area (Dongshih): 0.5 m
 - Plain Terrain (Chiayi)/Valley (Lienhuachih): 1m
 - During monsoon, numerous rainy events would result in the values of land characteristics different from those assigned in the model.

Conclusions

4. Taiwan has a unique characteristics of very shallow water table (SM: 55 - 65%)
 - Coastal area (Dongshih): 0.5 m
 - Plain Terrain (Chiayi)/Valley (Lienhuachih): 1m
5. After rain events, the values of land characteristics different from those assigned in the models and this should be considered in the models

Land Surface Modeling Concept



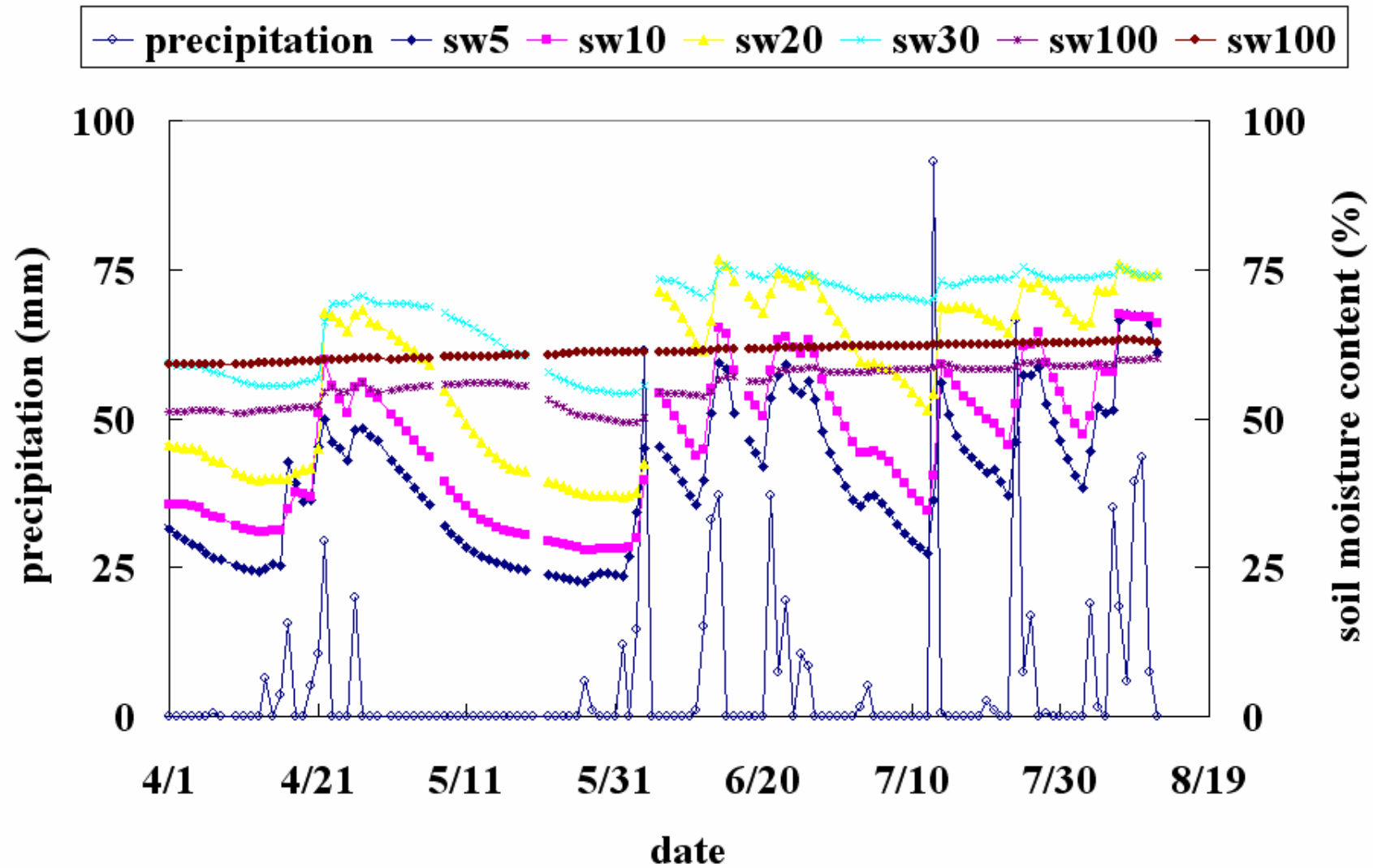
Further Readings

1. Tsai, J.-L.; Tsuang, B.-J.*; Lu, P.-S.; Chang, K.-H.; Yao, M.-H.; Shen, Y. 2009: Measurements of aerodynamic roughness, Bowen Ratio and atmospheric surface layer height by eddy-covariance and tethered sonde systems simultaneously over heterogeneous rice paddy. *Journal of Hydrometeorology*. (in press)
2. Tsuang, B.-J.*, C.-Y. Tu, J.-L. Tsai, J.A. Dracup, K. Arpe and T. Meyers, 2009: A more accurate scheme for calculating Earth's skin temperature. *Climate Dynamics* 32, 251-272, DOI 10.1007/s00382-008-0479-2.
3. Tsuang, B.-J.*; Tsai, J.-L.; Lu, P.-S.; Yao, M.-H.; Shen, Y., 2008/6: Surface energy components and land characteristics of a rice paddy. *Bulletin of the American Meteorological Society*, 791. (Papers of Note)
4. Tsuang, B.-J.*, M.D. Chou, Y. Zhang, A. Roesch, and K. Yang, 2008: Evaluations of Land–Ocean Skin Temperatures of the ISCCP Satellite Retrievals and the NCEP and ERA Reanalyses. *J. Climate*, 21, 308–330.
5. Tsai, J.-L.; Tsuang, B.-J.*; Lu, P.-S.; Yao, M.-H.; Shen, Y., 2007: Surface energy components and land characteristics of a rice paddy. *Journal of Applied Meteorology and Climatology* Vol. 46, No. 11, 1879–1900. (data source: TARI, Taiwan)
6. Tai, Li-Hui; Jing-Shan Hong, Ben-Jei Tsuang, J.-L. Tsai, and P. J. Ni, 2008: Update of Taiwan land use data in WRF model. *Atmospheric Sciences* (in Chinese), 36(1), 43-61.
7. Tsai, J.-L.; Tsuang, B.-J.*, 2005/9: Aerodynamic roughness over an urban area and over two farmlands in a populated area as determined by wind profiles and surface energy flux measurements. *Agricultural and Forest Meteorology* 132 (1-2), 154-170.
8. Tsuang, B.-J.*, 2005/8: Ground heat flux determination according to land skin temperature observations from in-situ stations and satellites. *J. of Hydrometeorology*, Vol. 6, No. 4, 371-390.
9. Tsuang, B.-J.*, 2003: Analytical asymptotic solutions to determine interactions between the planetary boundary layer and the Earth's surface. *J. Geophys. Res. – Atmospheres*, 108 (D16), 8608, doi: 10.1029/2002JD002557.
10. Tsuang, B.-J.*; Tsai, J.-L.; Lin, M.-D.; Chen, C.-L., 2003/5: Determining aerodynamic roughness by tethered sonde and heat flux measurements in an urban area over a complex terrain. *Atmos. Environ.* 37 (14), 1993-2003, DOI: 10.1016/S1352-2310(03)00032-3.
11. Tsuang, B.-J.*; Tu, C.-Y., 2002/5: Model structure and land parameter identification: an inverse problem approach. *J. Geophys. Res. – Atmospheres*, 107 (D10), 4096, DOI: 10.1029/2001JD000711.

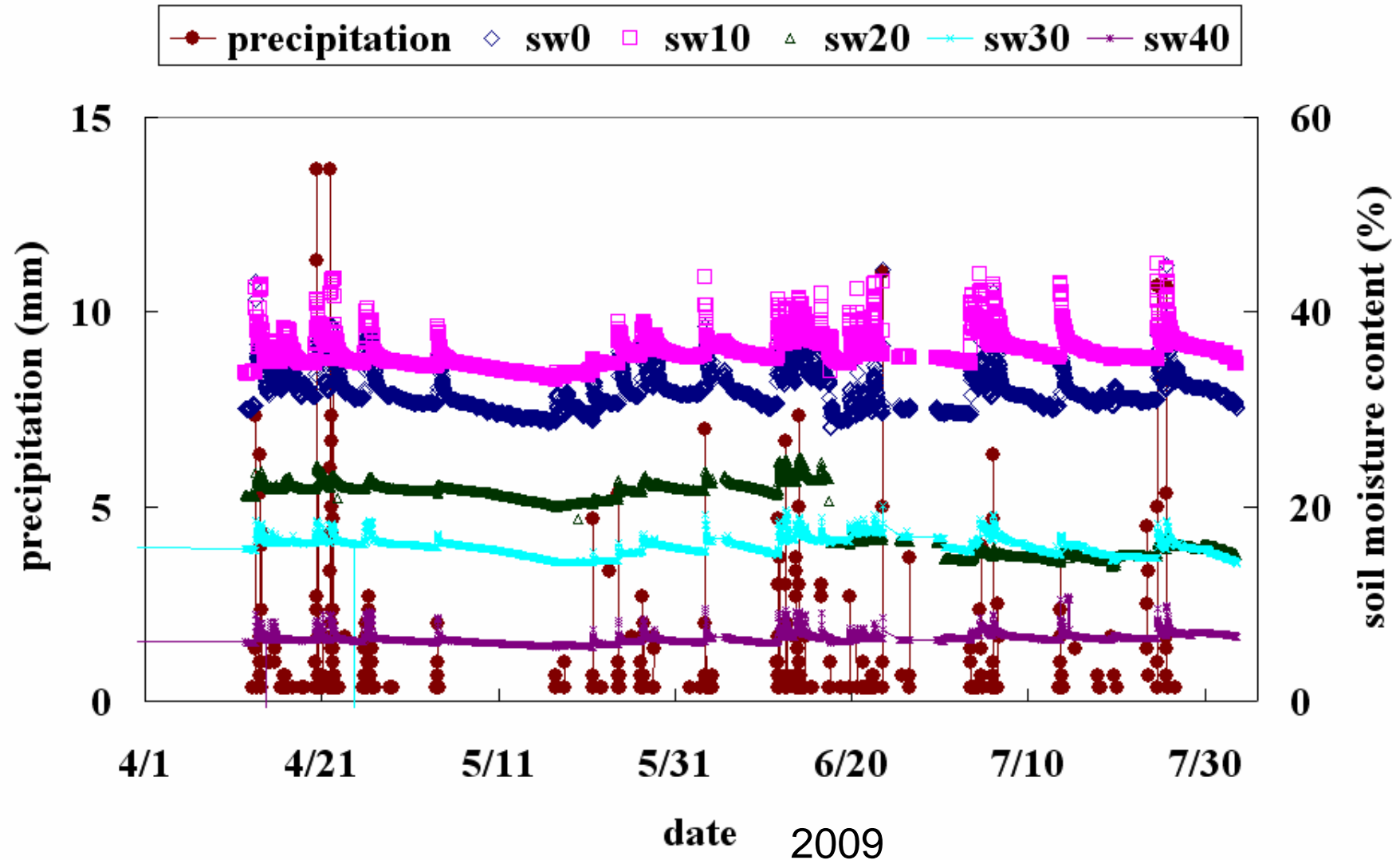
Cheer up!! Taiwan.....



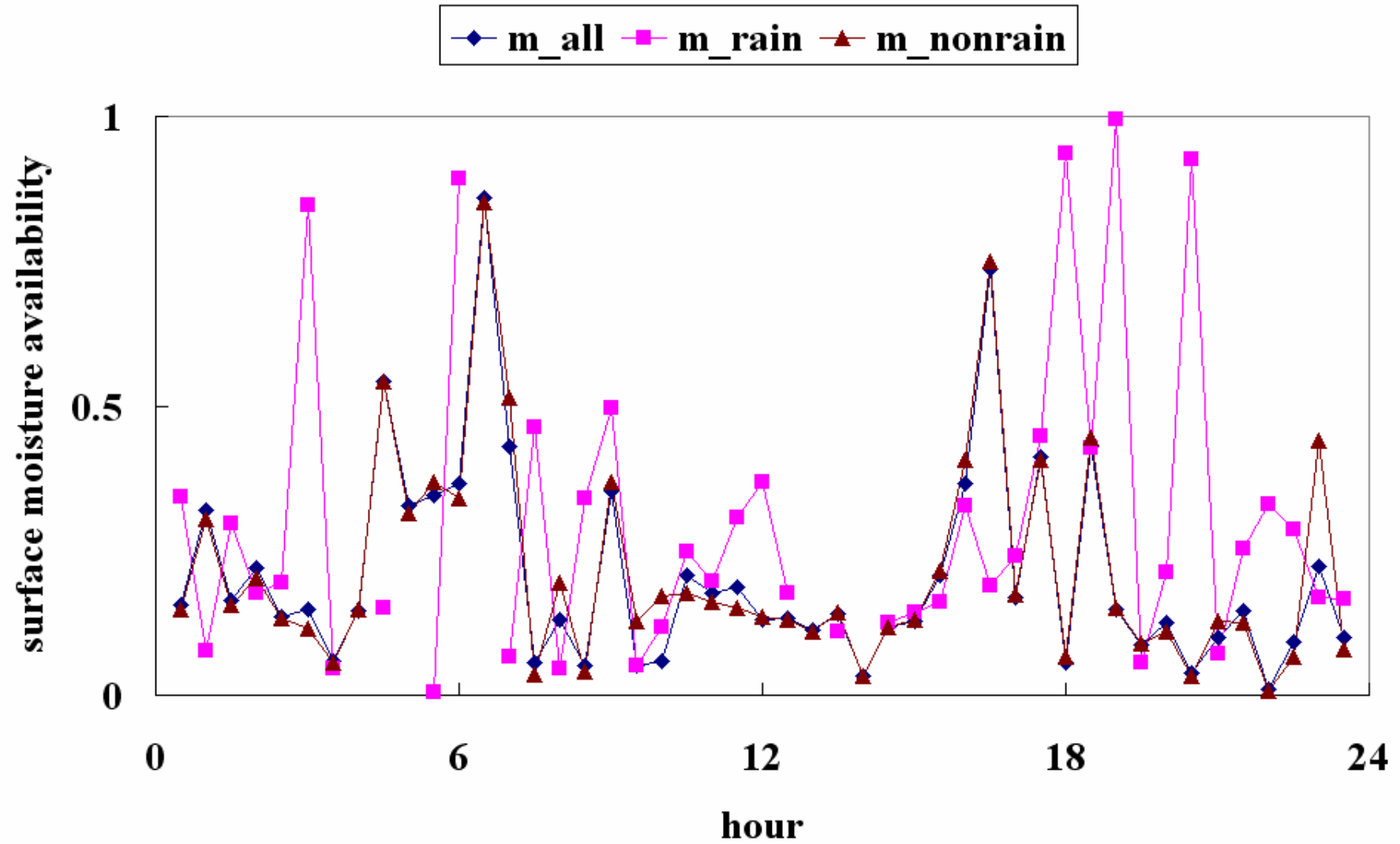
TWCIM(CWB) – Chiayi



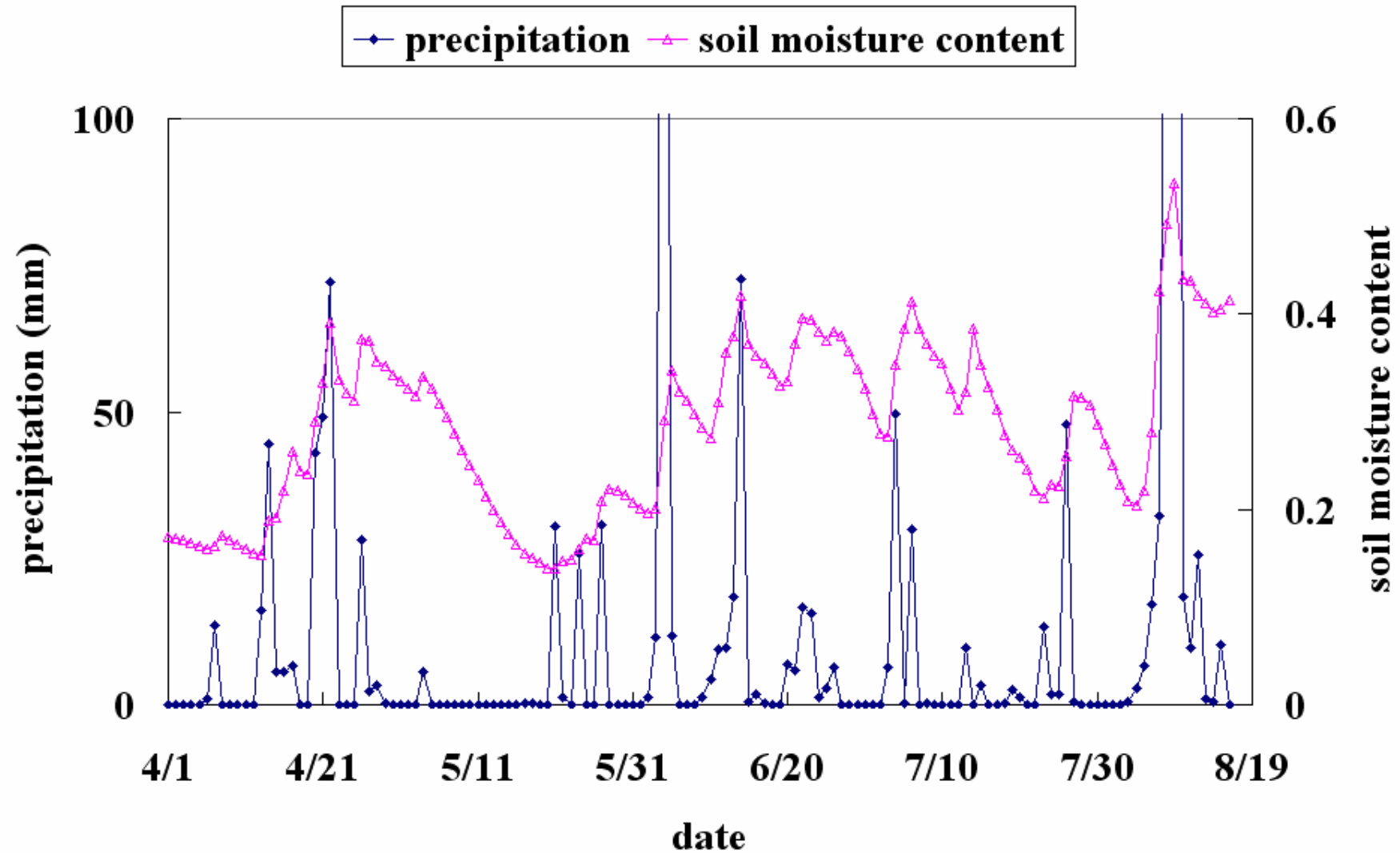
TWHS – Mt. Peitungyen



TWLHL - Lienhuachih

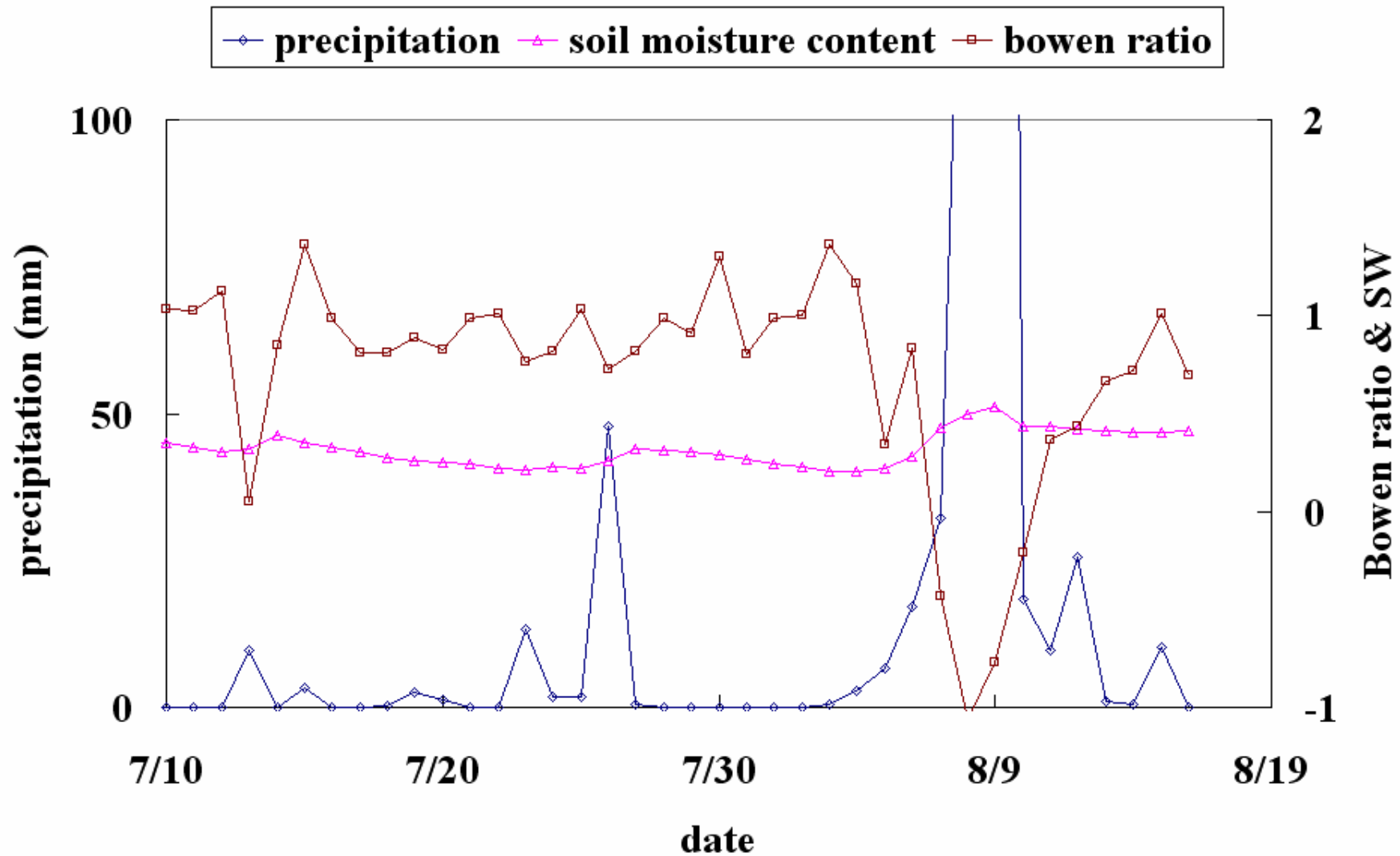


TWLHL - Lienhuachih

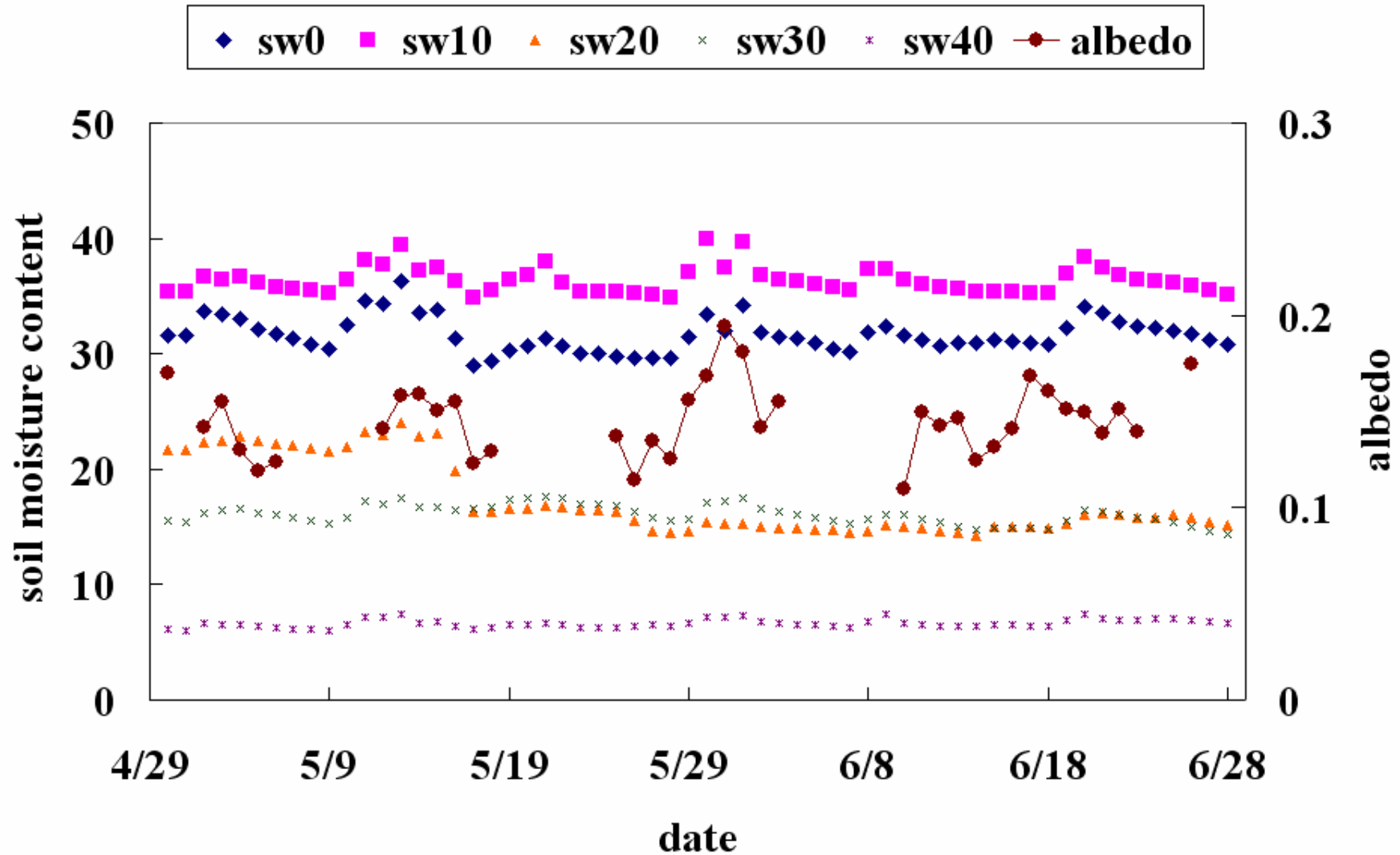


TWLHL - Lienhuachih

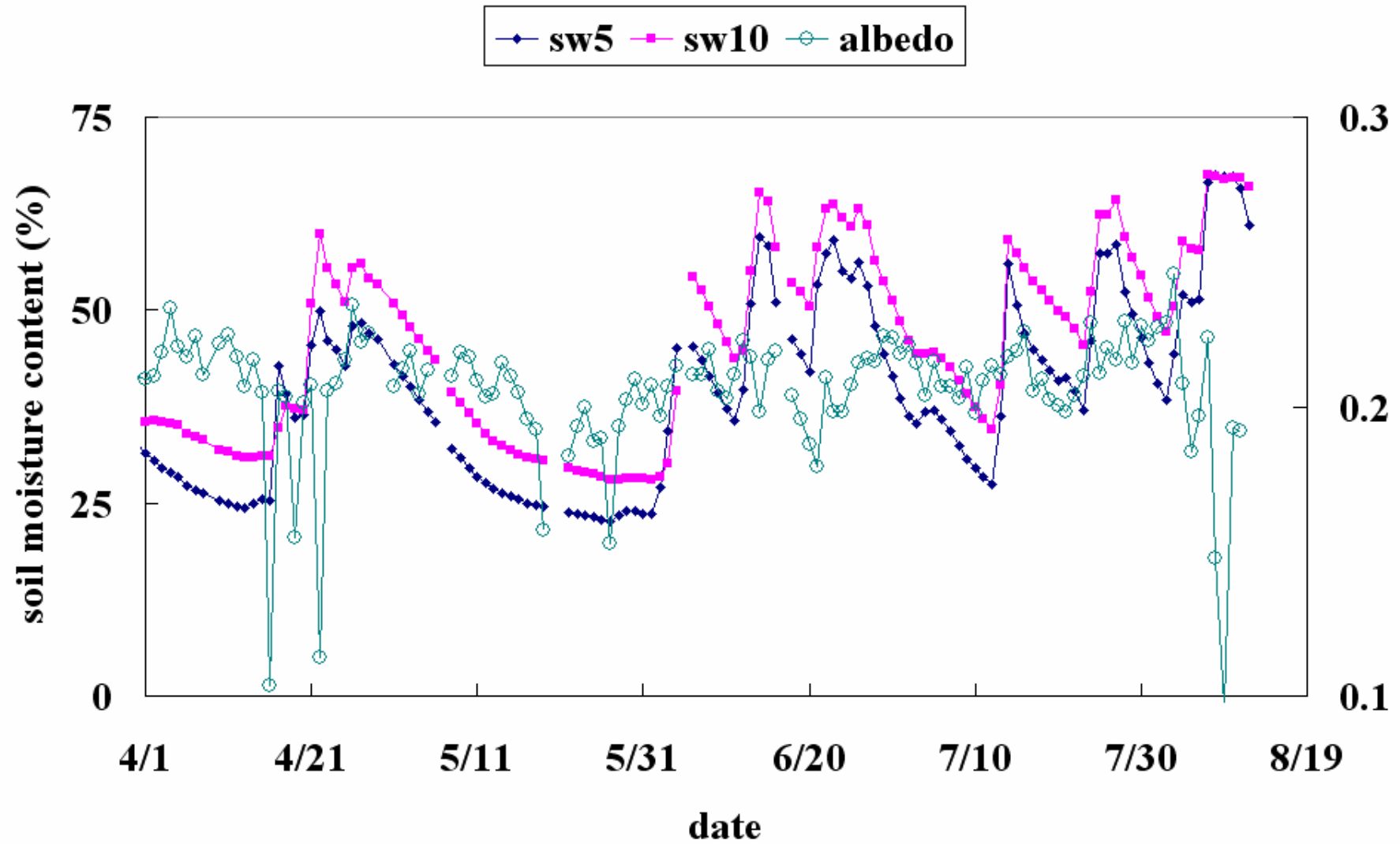
$$B=H/LE$$



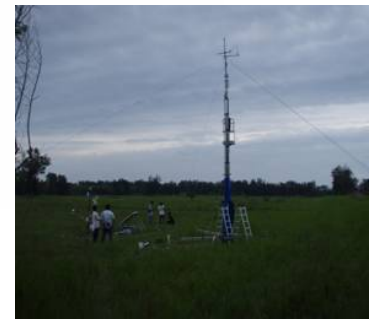
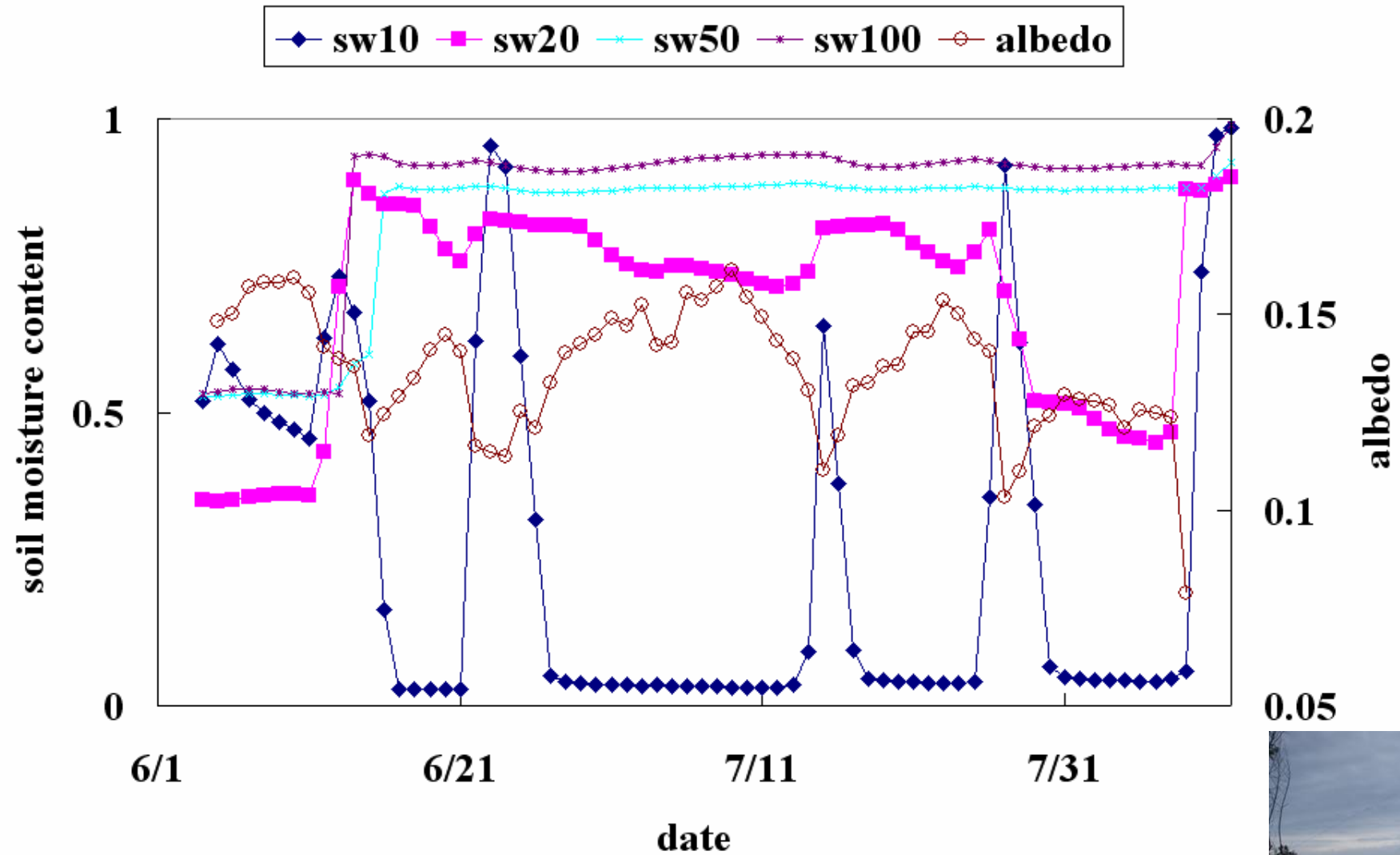
TWHS – Mt. Peitungyen



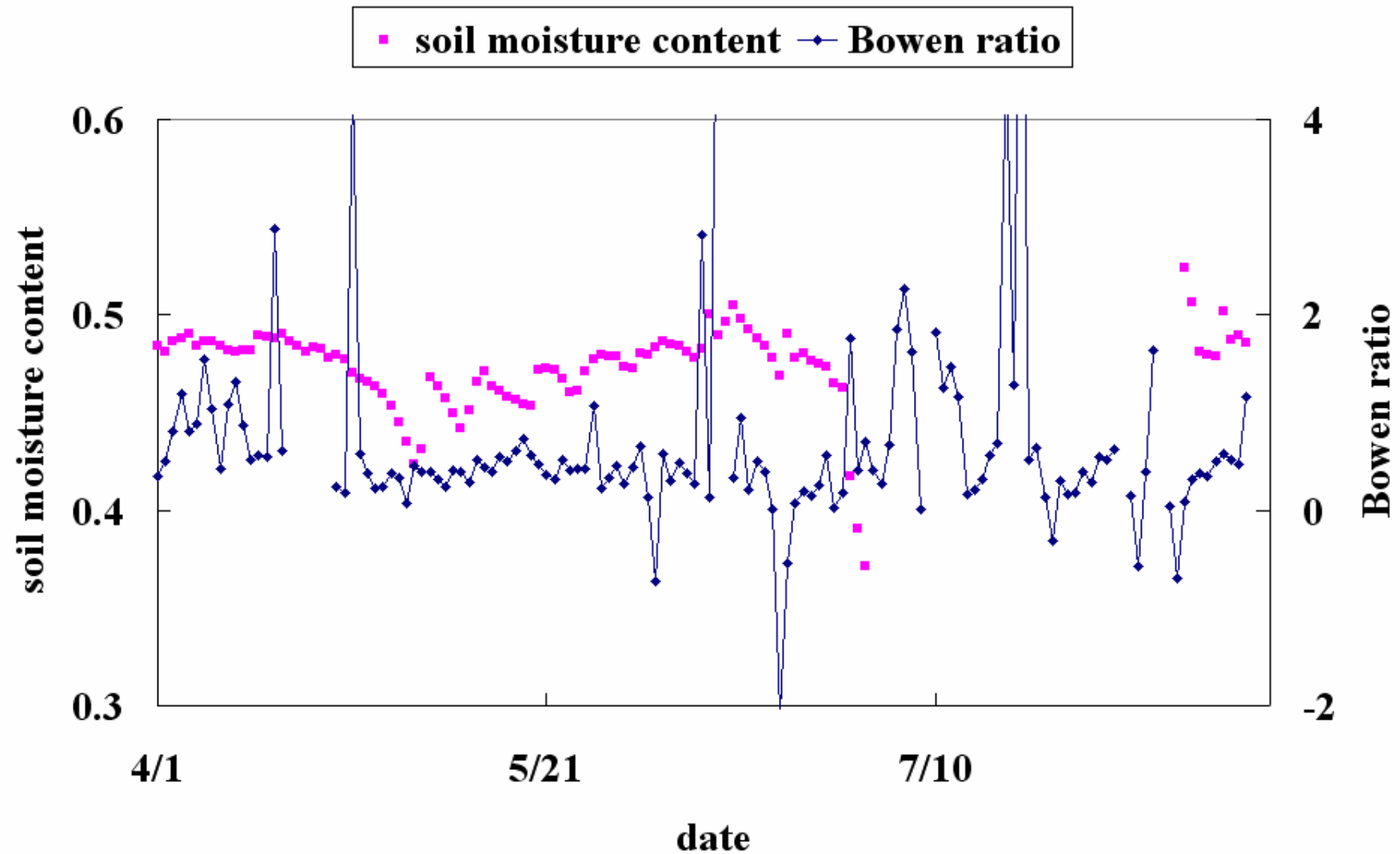
TWCIM(CWB) – Chiayi



TTFRI – Dongshih, Chiayi



TARI – Sikou, Chiayi

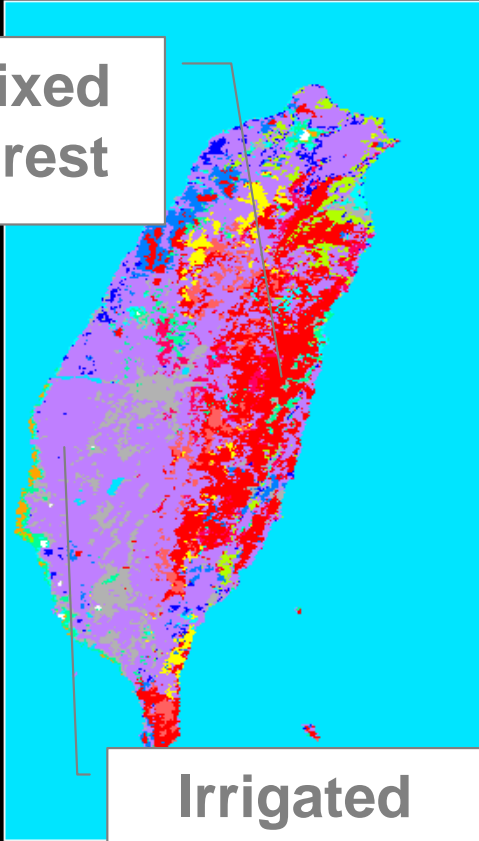


**Observations of the soil moisture and the
related land characteristics during Asia
summer monsoon in Taiwan**

Ben-Jei Tsuang, Chiai-Ying Tu, Jeng-Lin Tsai,
Yuei-An Liou, Ping-Ho Lee, Ming-Hwi Yao,
Ming-Tung Shueh

USGS 30s ORIGINAL LANDUSE

Mixed forest

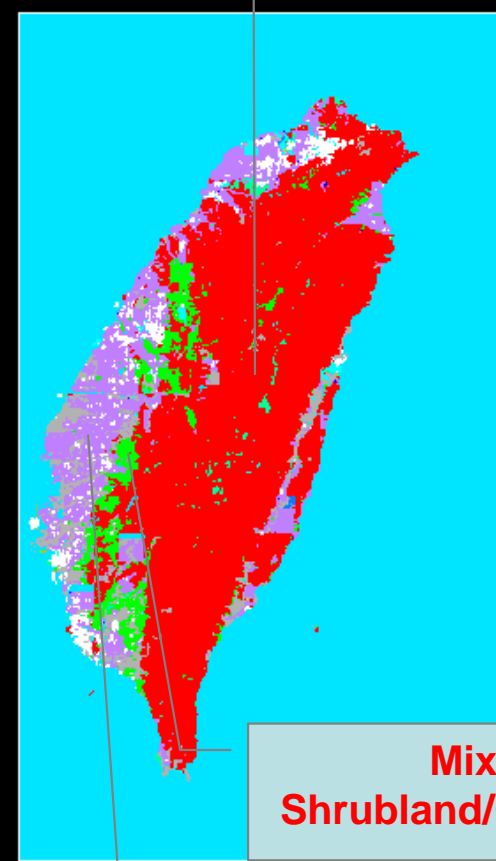


Irrigated Cropland



Mixed forest

CTCI



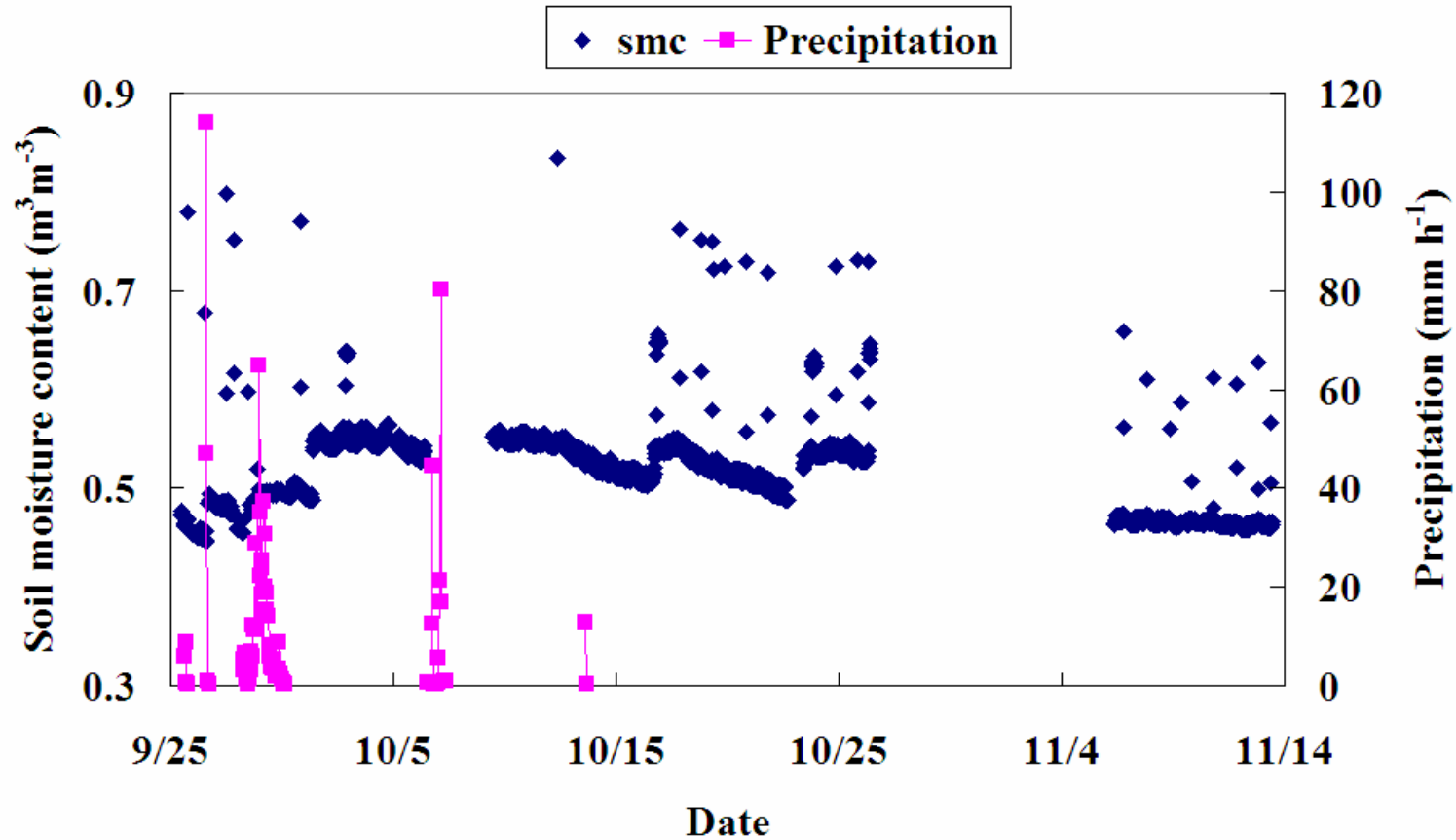
Mixed Shrubland/Grassland

MODIFIED POINTS: 31884
UNMODIFIED POINTS: 113556

Irrigated Cropland



農試所嘉義溪口站



土壤含水率與雨量關係圖 (2008)

Lists of Landuse/Vegetation in MM5 (SiB)

Vegetation Integer Identification	Vegetation Description	Albedo(%)		Moisture Avail. (%)		Emissivity (% at 9 μ m)		Roughness Length (cm)		Thermal Inertia (cal cm ⁻² k ⁻¹ s ^{-1/2})	
		Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
1	Evergrn. Broadlf.	12	12	50	50	95	95	50	50	0.05	0.05
2	Broadlf. Decids.	16	17	30	60	93	93	50	50	0.04	0.05
3	Decids. Evergrn.	14	14	35	70	95	95	40	40	0.05	0.06
4	Evergrn. Needlf.	12	12	30	60	95	95	50	50	0.04	0.05
5	Decids. Needlf.	16	17	30	60	93	93	50	50	0.04	0.05
6	Gmd. Tree Shrb.	20	20	15	15	92	92	15	15	0.03	0.03
7	Ground only	19	23	15	30	92	92	12	10	0.03	0.04
8	Broadlf. Shrb.P.G.	19	23	15	30	92	92	12	10	0.03	0.04
9	Broadlf. Shrb.B.S.	19	23	15	30	92	92	12	10	0.03	0.04
10	Gmdcvr. DT. Shrb	15	70	50	90	92	92	10	10	0.05	0.05
11	Bare Soil	25	25	2	5	85	85	10	10	0.02	0.02
12	Agricltr. or C3 Grs	17	23	30	60	92	92	15	5	0.04	0.04
13	Perst. Wetland	14	14	50	75	95	95	20	20	0.06	0.06
14	Dry Coast Cmplx	19	23	15	30	92	92	12	10	0.03	0.04
15	Water	8	8	100	100	98	98	.01	.01	0.06	0.06
16	Ice cap & Glacier	80	82	95	95	95	95	5	5	0.05	0.05

Description of 17-category (SiB) vegetation categories and physical parameters for N.H. summer (15 April - 15 October) and winter (15 October - 15 April)

Lists of Landuse/ Vegetation in MM5 (USGS)

Vegetation Integer Identification	Vegetation Description	Albedo(%)		Moisture Avail. (%)		Emissivity (% at 9 μ m)		Roughness Length (cm)		Thermal Inertia (cal cm ⁻² k ⁻¹ s ^{-1/2})	
		Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
1	Urban	15	15	10	10	88	88	80	80	0.03	0.03
2	Drylnd Crop. Past.	17	23	30	60	98.5	92	15	5	0.04	0.04
3	Irrg. Crop. Past.	18	23	50	50	98.5	92	15	5	0.04	0.04
4	Mix. Dry/Irrg.C.P.	18	23	25	50	98.5	92	15	5	0.04	0.04
5	Crop./Grs. Mosaic	18	23	25	40	99	92	14	5	0.04	0.04
6	Crop./Wood Mosc	16	20	35	60	98.5	93	20	20	0.04	0.04
7	Grassland	19	23	15	30	98.5	92	12	10	0.03	0.04
8	Shrubland	22	25	10	20	88	88	10	10	0.03	0.04
9	Mix Shrb./Grs.	20	24	15	25	90	90	11	10	0.03	0.04
10	Savanna	20	20	15	15	92	92	15	15	0.03	0.03
11	Decids. Broadlf.	16	17	30	60	93	93	50	50	0.04	0.05
12	Decids. Needlf.	14	15	30	60	94	93	50	50	0.04	0.05
13	Evergm. Braodlf.	12	12	50	50	95	95	50	50	0.05	0.05
14	Evergm. Needlf.	12	12	30	60	95	95	50	50	0.04	0.05
15	Mixed Forest	13	14	30	60	94	94	50	50	0.04	0.06
16	Water Bodies	8	8	100	100	98	98	.01	.01	0.06	0.06
17	Herb. Wetland	14	14	60	75	95	95	20	20	0.06	0.06
18	Wooded wetland	14	14	35	70	95	95	40	40	0.05	0.06
19	Bar. Sparse Veg.	25	25	2	5	85	85	10	10	0.02	0.02
20	Herb. Tundra	15	60	50	90	92	92	10	10	0.05	0.05
21	Wooden Tundra	15	50	50	90	93	93	30	30	0.05	0.05
22	Mixed Tundra	15	55	50	90	92	92	15	15	0.05	0.05
23	Bare Grnd. Tundra	25	70	2	95	85	95	10	5	0.02	0.05
24	Snow or Ice	55	70	95	95	95	95	5	5	0.05	0.05

Description of 25-category (USGS) vegetation categories and physical parameters for N.H. summer (15 April - 15 October) and winter (15 October - 15 April)