

1. About the data set

Site name (AsiaFlux three letter code)	Appi forest meteorology research site (API)	
Period of registered data	From January 1, 2006 to December 31, 2006	
This document file name	API_2006_003a.pdf	
Corresponding data file name	API_2006_003.csv	
Revision information		
Date	Details of revision	Renewed file name
31 July 2012	First registration	API_2006_001a.pdf API_2006_001.csv
20 April 2017	Second registration: IE is added.	API_2006_002a.pdf API_2006_002.csv
21 August 2017	Third registration: G data in version 002 is corrected.	API_2006_003a.pdf API_2006_003.csv
Contact person#1	[Flux & Meteorology] Yukio YASUDA (yassan@ffpri.affrc.go.jp)	
Contact person#2		
Contact person#3		

2. Site description

Hour line (Time difference from UTC)	Japan Standard Time(JST) (9 hours ahead of UTC)
Location (address)	Hachimantai, Iwate, Japan
Position	40.0001N, 140.9375E (World Geodetic System 1984)
Elevation	825m above sea level (World Geodetic System 1984)
Terrain type	Gentle slope
Slope	5-6 degrees
Area	43.5ha
Fetch	200-600m
Climate	Cool temperate (Köppen climate classification: (Snow-fully humid-warm summer [Dfb])
Mean annual air temperature	5.9 degree (2000-2006; Yasuda <i>et al.</i> , 2012)
Mean annual precipitation	2029 mm (2007-2009; Yasuda <i>et al.</i> , 2012)
Vegetation Type	Boreal deciduous broadleaf forest
Dominant Species (Overstory)	<i>Fagus crenata</i> (Japanese beech)
Dominant Species (Understory)	-
Canopy height	Approx. 20m (in 2009)
Aboveground forest biomass	130-140tCha ⁻¹ (Hoshino <i>et al.</i> , in preparation; Yasuda <i>et al.</i> , 2012)
Age	70-80years
Mean max. LAI	4.8 (2000-2006; Hoshino <i>et al.</i> , in preparation; Yasuda <i>et al.</i> , 2012)
Soil Type	Andosol (Ishizuka <i>et al.</i> , 2006; Hashimoto <i>et al.</i> , 2009) Brown forest soil B _{D(d)} (Yasuda <i>et al.</i> , 2012)
Other information	

References

ONO Kenji, YASUDA Yukio, MATSUO Tooru, HOSHINO Daisuke, CHIBA Yukihiro, MORI Shigeta (2013) Estimating forest biomass using allometric model in a cool-temperate *Fagus crenata* forest in the Appi Highlands, Iwate, Japan. Bulletin of Forestry and Forest Products Research Institute, 12(3), 125-141

YASUDA Yukio, SAITO Takeshi, HOSHINO Daisuke, ONO Kenji, OHTANI Yoshikazu, MIZOGUCHI Yasuko, MORISAWA Takeshi (2012) Carbon balance in a cool-temperate deciduous forest in northern Japan: seasonal and interannual variations, and environmental controls of its annual balance, Journal of Forest Research, 17(3): 253-267.

ISHIZUKA Shigehiro, SAKATA Tadashi, SAWATA Satoshi, IKEDA Shigeto, TAKENAKA Chisato, TAMAI Nobuaki, SAKAI Hisao, SHIMIZU Takanori, KAN-NA Kensaku, ONODERA Shinichi, TANAKA Nagaharu, TAKAHASHI Masamichi (2006): High potential for increase in CO₂ flux from forest soil surface due to global warming in cooler areas of Japan. Annals of Forest Science, 63(5):537-546.

HASHIMOTO Toru, MIURA Satoru, ISHIZUKA Shigehiro (2009) Temperature controls temporal variation in soil CO₂ efflux in a secondary beech forest in Appi Highlands, Japan. Journal of Forest Research, 14:44-50

HOSHINO Daisuke *et al.* (in preparation)

3. Registered data

Observation items	Symbol	Unit	Height(s) Depth(s)	Instruments	Note
Date	DATE	-	-	-	yyyymmdd
Time	TIME	-	-	-	hhmm
Precipitation	PPT	NA	NA	NA	(Yasuda <i>et al.</i> , 2012)
Air temperature	Ta	degrees C	31.0m	HMP45D (VAISALA)	(Yasuda <i>et al.</i> , 2012)
Relative humidity	Rh	%	31.0m	HMP45D (VAISALA)	See Note [1] (Yasuda <i>et al.</i> , 2012)
Wind speed	U	$\text{m}\cdot\text{s}^{-1}$	31.0m	WM30P (IKEDA)	
Wind direction	WD	NA	NA	NA	
Global solar radiation (incoming / downward)	Sd	$\text{W}\cdot\text{m}^{-2}$	31.0m	CM6F (Kipp & Zonen)	See Note [2] (Yasuda <i>et al.</i> , 2012)
Reflected solar radiation (upward)	Su	$\text{W}\cdot\text{m}^{-2}$	31.0m	CM6B (Kipp & Zonen)	See Note [2]
Photosynthetic active photon flux density (downward)	Pd	$\text{micromol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	31.0m	LI190 (LI-COR)	See Note [2] (Yasuda <i>et al.</i> , 2012)
Reflected PAR (upward)	Pu	$\text{micromol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	31.0m	LI190 (LI-COR)	See Note [2]
Net radiation	Rn	$\text{W}\cdot\text{m}^{-2}$	31.0m	CM6F and CM6B (Kipp & Zonen), PIR (Eppley)	See Note [3]
Soil heat flux	G	$\text{W}\cdot\text{m}^{-2}$	-0.02m	MF-81 (EKO)	Average of 2 points
Sensible heat flux	H	$\text{W}\cdot\text{m}^{-2}$	31.0m	DA-600-3T (KAIJO)	
Latent heat flux	IE	$\text{W}\cdot\text{m}^{-2}$	31.0m	DA-600-3T (KAIJO) HMP45A (VAISALA)	
Friction velocity	Ust	$\text{m}\cdot\text{s}^{-1}$	31.0m	DA-600-3T (KAIJO)	
CO ₂ flux	Fc	$\text{micromol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	31.0m	DA-600-3T (KAIJO) LI-6262 (LI-COR)	Closed-path system, See 4-4 for QC (Yasuda <i>et al.</i> , 2012)
Storage change in canopy air layer	Sc	$\text{micromol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	31, 24, 20, 18, 15, 12, 9, 3 m	LI-6262 (LI-COR)	See 4-5, (Yasuda <i>et al.</i> , 2012)
Net ecosystem exchange	NEE	$\text{micromol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	-	-	NEE=Fc+Sc Gap filled (Yasuda <i>et al.</i> ,

					2012)
Ecosystem respiration	Re	$\text{micromol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	-	-	Gap filled (Yasuda <i>et al.</i> , 2012)
Gross primary production	GPP	$\text{micromol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	-	-	$\text{GPP} = -\text{NEE} + \text{Re}$

Note

[1] data of >100% is replaced by 100%

[2] night time data is replaced by 0.0.

[3] 4 elements (Sd, Su, Longwave radiation_downward and Longwave radiation_upward)

Gap filling

NEE	$F_{\text{NEE,day}} = \frac{-\phi Q - P_{\max} + \sqrt{(\phi Q + P_{\max})^2 - 4\phi Q \theta P_{\max}}}{2\theta} + R_d$ Parameters were derived daily, using the 7-day moving window for the 4 weeks after bud burst and before a completely yellow-tinged canopy, and, the 15-day window for the rest of period.
Re	$F_{\text{NEE,night}} = F_{\text{RE},T_{\text{ref}}} \exp \left[E_0 \left(\frac{1}{T_{\text{ref}} - T_0} - \frac{1}{T_a - T_0} \right) \right]$ Parameter $F_{\text{RE},T}$ was derived daily using the 21-day moving window, E_0 were determined for each period: growing, snow and defoliation (non-snow) seasons.

References

YASUDA Yukio, SAITO Takeshi, HOSHINO Daisuke, ONO Kenji, OHTANI Yoshikazu, MIZOGUCHI Yasuko, MORISAWA Takeshi (2012) Carbon balance in a cool-temperate deciduous forest in northern Japan: seasonal and interannual variations, and environmental controls of its annual balance, *Journal of Forest Research*, 17(3): 253-267.

Data format

Data consists of fixed length (8 digits) comma separated format. Missing data is labeled as "-9999.00" or "-9999.0".

Line 1: Symbol (Date, Time, PPT, Ta,)

Line 2: Unit (yyyymmdd, hhmm, mm, degC,)

"hhmm" shows intermediate time of averaging period.

i.e. "1215" labels half-hourly average (or sum) of data from 12:00 to 12:30

Line 3: Comment

Line 4: Data

:

Data example

Date, Time,	PPT,	Ta,	Rh,	U,	WD,	Sd,	Su,	Pd,	Pu,	.....
yyyymmdd, hhmm,	mm,	degC,	%,	ms-1,	deg,	Wm-2,	Wm-2,	(#1),	(#1),	.....
File= KWG_2000_001.CSV; Created: 20100326; Gap= -9999.0; (*1): micro-mol m-2 s-1										
20000101, 0015,	0.0,	3.34,	87.19,	1.58,	-9999.0,	0.1,	-9999.0,	0.1,	0.0,	.....
20000101, 0045,	0.0,	3.12,	88.14,	1.44,	-9999.0,	0.0,	-9999.0,	0.1,	0.0,	.....
20000101, 0115,	0.0,	2.36,	90.51,	1.15,	-9999.0,	-0.3,	-9999.0,	0.1,	0.0,	.....
20000101, 0145,	0.0,	2.14,	91.32,	0.83,	-9999.0,	0.0,	-9999.0,	0.1,	0.0,	.....
20000101, 0215,	0.0,	2.28,	88.96,	0.49,	-9999.0,	-0.3,	-9999.0,	0.1,	0.0,	.....
20000101, 0245,	0.0,	2.24,	89.82,	0.35,	-9999.0,	-0.2,	-9999.0,	0.2,	0.0,	.....
20000101, 0315,	0.0,	2.05,	89.49,	1.50,	-9999.0,	0.1,	-9999.0,	0.2,	-0.1,	.....
20000101, 0345,	0.0,	2.41,	87.25,	1.27,	-9999.0,	0.0,	-9999.0,	0.2,	0.0,	.....
20000101, 0415,	0.0,	2.31,	86.83,	1.12,	-9999.0,	-0.2,	-9999.0,	0.1,	0.0,	.....
20000101, 0445,	0.0,	2.84,	83.36,	0.54,	-9999.0,	-0.6,	-9999.0,	0.0,	0.0,	.....
20000101, 0515,	0.0,	2.53,	83.32,	1.23,	-9999.0,	0.2,	-9999.0,	0.2,	0.0,	.....
20000101, 0545,	0.0,	1.59,	87.54,	1.29,	-9999.0,	-0.6,	-9999.0,	0.0,	0.0,	.....
20000101, 0615,	0.0,	1.89,	85.13,	0.94,	-9999.0,	0.4,	-9999.0,	0.3,	0.0,	.....
20000101, 0645,	0.0,	1.77,	82.40,	0.83,	-9999.0,	3.5,	-9999.0,	8.5,	0.4,	.....
20000101, 0715,	0.0,	2.67,	76.83,	1.38,	-9999.0,	45.8,	-9999.0,	71.9,	11.6,	.....
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	.	

4. Observation and calculation

4-1. Flux observation system and data acquisition

Type of sonic anemometer	DA600-3T (KAIJO)
Type of IRGA	LI-6262, LI-COR
Sampling rate	10Hz
Averaging time	30 min
Flux measurement height #1	31.0m
Zero-plane displacement	
Roughness length	
Calibration information	Once a day using zero and standard CO ₂ gases
Other information	

4-2. Flux calculation

Calculation methods		Note
Flow attenuation ^{*4-6}	applied	
Coordinate rotation ^{*1-3}	applied	double rotation
Lag removal ^{*2, 7, 8}	applied	manual

4-3. Flux corrections

Correction methods		Target flux	Note
Cross wind correction ^{*9, 10}		sensible heat flux (H)	
Vapor correction		sensible heat flux (H)	
High frequency loss	Band-pass covariance method ^{*12}	latent heat flux (IE)	
	Experimental approach ^{*2}		
High frequency loss	Band-pass covariance method ^{*25}	CO ₂ flux (Fc)	
	Experimental approach ^{*2}		
Low frequency loss (Detrending)	Linear detrend ^{*16}	sensible heat flux (H), friction velocity (Ust), CO ₂ flux (Fc),	
WPL Correction ^{*17-21}		(Not applied)	
Others ^{*22-24}			

4-4. Quality control ^{*26-27}

QC methods			Note
Raw data test ^{*26,27}	Spike test ^{*28}	Applied	
	Absolute limits	Applied	
	Absolute variance	Applied	
	Higher-moment statistics	skewness	Applied
		kurtosis	Applied
	Discontinuities	Harr mean test	Applied
		Harr variance test	Applied
	Visual inspection	Applied	
Non steady state test ^{*26}		Not applied	
Absolute thresholds		Applied	
Others			

4-5. Storage term

Target storage		Note
CO ₂	[from the initiation to 2008-06-13] CO ₂ profile data (31, 24, 20, 18, 15, 12, 9, 3 m) Sampling interval: 2 minute at each height ([from 2008-06-13 to 2009-11-24] CO ₂ profile data (31, 24, 20, 18, 15, 12, 9, 3 m) Sampling interval: 1 minute at each height [from 2009-11-24 to the present] CO ₂ profile data (31, 25, 23, 21, 15, 12, 9, 3 m) Sampling interval: 1 minute at each height	(Yasuda <i>et al.</i> , 2012)

References

YASUDA Yukio, SAITO Takeshi, HOSHINO Daisuke, ONO Kenji, OHTANI Yoshikazu, MIZOGUCHI Yasuko, MORISAWA Takeshi (2012) Carbon balance in a cool-temperate deciduous forest in northern Japan: seasonal and interannual variations, and environmental controls of its annual balance, Journal of Forest Research, 17(3): 253-267.
--

5. Important event

Date	Events
	Data of Pd and Pu are not available during winter season.

6. Publications relating to this site

YASUDA Yukio, SAITO Takeshi, HOSHINO Daisuke, ONO Kenji, OHTANI Yoshikazu, MIZOGUCHI Yasuko, MORISAWA Takeshi (2012) Carbon balance in a cool-temperate deciduous forest in northern Japan: seasonal and interannual variations, and environmental controls of its annual balance, *Journal of Forest Research*, 17(3): 253-267.

References cited

Flux calculation

- *1 McMillen, R.T., 1988. *Boundary-Layer Meteorology*, 43: 231-245.
- *2 Aubinet M. et al., 2000. *Advances in Ecological Research*, 30: 113-175.
- *3 Wilczak, J.M., Oncley, S.P. and Stage, S.A., 2001. *Boundary-Layer Meteorology*, 99: 127-150.
- *4 Wyngaard, J. C. and Zhang, S. F., 1985. *J. Atmos. Oceanic Tech.*, 2: 548-558.
- *5 Kaimal, J.C. et al., 1990. *Boundary-Layer Meteorol.*, 53: 103-115.
- *6 Shimizu, T. et al., 1999. *Boundary-Layer Meteorol.*, 64: 227-236.
- *7 Leuning, R. and Judd M.J., 1996. *Global Change Biology*, 2: 241-254.
- *8 Information from Li-Cor

Flux correction

- *9 Schotanus, P. et al., 1983. *Boundary-Layer Meteorology*, 26: 81-93.
- *10 Liu, H., Peters, G. and Foken, T., 2001. *Boundary-Layer Meteorology*, 100: 459-468.
- *11 Kaimal J.C. and Gaynor, J.E., 1991. *Boundary-Layer Meteorology*, 56: 401-410.
- *12 Watanabe et al., 2000. *Boundary-Layer Meteorol.* 96, 743-491.
- *13 Massman, W. J., 2000. *Agric. For. Meteorol.* 104, 185-198
- *14 Massman, W. J., 2001. *Agric. For. Meteorol.* 107, 247-251
- *15 Moore, C.J., 1986. *Boundary-Layer Meteorology*, 37: 17-35.
- *16 Moncrieff, J. et al., 2004. Averaging, detrending and filtering of eddy covariance time series. In: X. Lee (Editor), *Handbook of Micrometeorology: A guide for surface Flux Measurements*. Kluwer, Dordrecht, pp. 7-31.
- *17 Webb, E. K., Pearman, G.I. and Leuning, R., 1980. *Quarterly Journal of the Royal Meteorological Society*, 106: 85-100.
- *18 Fuehrer, P.L. and Friehe, C.A., 2002. *Boundary-Layer Meteorology*, 102: 415-457.
- *19 Liebethal, C. and Foken, T., 2003. *Boundary-Layer Meteorology*, 109: 99-106.
- *20 Leuning, R. 2004. Measurements of trace gas fluxes in the atmosphere using eddy covariance: WPL corrections revisited. In: X. Lee (Editor), *Handbook of Micrometeorology: A guide for surface Flux Measurements*. Kluwer, Dordrecht, pp. 119-132.
- *21 Massman, W. 2004. Concerning the measurement of atmospheric trace gas fluxes with open- and closed-path eddy covariance system: The WPL terms and spectral attenuation. In: X. Lee (Editor), *Handbook of Micrometeorology: A guide for surface Flux Measurements*. Kluwer, Dordrecht, pp. 133-160.
- *22 Fischer, G (Editor), 1988. *Landolt-Börnstein, Numerical data and functional relationships in science and technology, Group V: Geophysics and space research, Volume 4: Meteorology Subvolume b: Physical and chemical properties of the air*. Springer, Berlin, Heidelberg, 570pp.
- *23 Stull, R.B., 1988. *An Introduction to Boundary Layer meteorology*. Kluwer Acad. Publ., Dordrecht, Boston, London, 666pp.
- *24 Cohen, E. R. and Taylor, B. N., 1986. The 1986 adjustment of the fundamental physical constants. International Council of Scientific Unions (ICSU), Committee on Data for Science and Technology (CODATA). CODATA-Bulletin, No. 63: 36pp.
- *25 Yasuda et al., 2001. *Boundary-Layer Meteorol.* 100, 191-208.

Quality control

- *26 Vickers, D. and Mahrt, L., 1997. *Journal of Atmospheric and Oceanic Technology*, 14: 512-526.
- *27 Foken, T. and Wichura, B., 1996. *Agricultural and Forest Meteorology*, 78: 83-105.
- *28 Hojstrup, J., 1993. *Measuring Science Technology*, 4: 153-157.
- *29 Schmid, H. P., 1994. *Boundary-Layer Meteorology*, 67: 293-318.
- *30 Korman, R. and Meixner, F.X., 1990. . *Boundary-Layer Meteorology*, 99: 207-224.

