1. About the data set

Site name (three letter code)	Tomakomai Flux research site (TMK)
Period of registered data	From January 1, 2001 to December 31, 2003
This document file name	FxMt_TMK_2001_30m_03-1.pdf
Corresponding data file name	FxMt_TMK_2001_30m_03-1.csv

Revision information

Date	Details of revision	Renewed file name
February 8, 2007	First registration	SiIn_TMK_2001_01.pdf FxMt_TMK_2001_30m_01.pdf FxMt_TMK_2001_30m_01.csv
January 28, 2008	Second registration	SiIn_TMK_2001_04.pdf FxMt_TMK_2001_30m_02.pdf FxMt_TMK_2001_30m_02.csv
June 11, 2021	Contact persons were updated. Notation of date was revised. DOI (Digital Object Identifier) was assigned.	SiIn_TMK_2001-2003_05.pdf FxMt_TMK_2001_30m_03-1.pdf FxMt_TMK_2001_30m_03-1.csv

Contact person#1	[Flux] Ryuichi Hirata (hirata.ryuichi@nies.go.jp)
Contact person#2	[General] Yoshiyuki Takahashi (yoshiyu@nies.go.jp)
Contact person#3	[General] Takashi Hirano (hirano@env.agr.hokudai.ac.jp)
Other information	When this data set is referred to in publications, it should be cited in the following format. Hirata, R. (2021), Micrometeorological CO2 Flux Data at Tomakomai Flux Research Site (TMK), Ver.x.x *1, NIES, DOI:10.17595/20210611.001, (Reference date*2: YYYY/MM/DD) *1 The version number is indicated in the name of each data file. *2 As the reference date, please indicate the date you downloaded the files.

2. Site description

☺to Data provider ………Please explain <u>the site condition during the period of this dataset.</u>
☻to DB user ……………See also the general information file.

Hour line (Time difference from UTC)	9 hours ahead of UTC (Japan Standard Time (JST))
Vegetation Type	Japanese larch forest
Dominant Species (Overstory)	Japanese larch (*Larix Kaempferi Sarg.*), Birch (*Betula ermanii* and *Betula platyphylla*), Japanese elm (*Ulmus japonica*), Spruce (*Picea jezoensis*)
Dominant Species (Understory)	Fern (*Dryopteris crassirhizoma*, *Dryopteris austriaca*) and *Pachysandra terminalis*
Canopy height	About 15 m
LAI	9.2 m^2 m^{-2} (max) (Overstory: 5.6 m^2 m^{-2}, Understory: 3.6 m^2 m^{-2})
Other information	Details are described by Hirata et al. (2007). Hirata, R., Hirano, T., Saigusa, N., Fujinuma, Y., Inukai, K., Kitamori, Y., Yamamoto, S. 2007. Seasonal and interannual variations in carbon dioxide exchange of a temperate larch forest, Agricultural and Forest Meteorology, 147: 110–124.

3. Observation and calculation

☺to Data provider ················ A list of references is shown in the last page. **Please fill-in the blanks as much as possible, or select the suitable option. If you are not sure what to write, leave it as a blank.**

3-1. Flux observation system and data acquisition

Type of sonic anemometer	DA600-3TV (Probe TR-61C) (KAIJO)
Type of IRGA	Open-path CO_2/H_2O gas analyzer, LI-7500 (LI-COR) (H, LE) Closed-path CO_2/H_2O gas analyzer, LI-6262 (LI-COR) (F_C)
Sampling rate	10 Hz
Averaging time	30 min
Flux measurement height #1	22 m above the ground (from January 1, 2001 to May 28, 2001)
Flux measurement height #2	27 m above the ground (from May 28, 2001 to December 2003)
Flux measurement height #3	
Zero-plane displacement	11.2 m
Roughness length	
Calibration information	Open-path analyzer was calibrated approximately every two months with standard CO_2 gases and a dew point generator (LI610, LI-COR). The gain of CO_2 of the closed-path analyzer was checked once a day by flowing two standard CO_2 gases of 320 ppmv and 420 ppmv that were automatically controlled using a CR23X (LI-COR).
Other information	

3-2. Flux calculation

		Note/References
Flow attenuation [*4-6]	✓ Yes	Shimizu, T. et al., 1999. Boundary-Layer Meteorol., 64: 227–236.
Coordinate rotation [*1-3]	✓ Planar fit	
Lag removal [*2, 7, 8]	✓ Constant	Digital delay for LI7500 and DA-600 Time lag between *w*' and *c*' for closed-path system

3-3. Flux corrections

		Note/References
For sensible heat flux	✓ Cross wind correction [*9, 10] ✓ Water vapor correction [*11]	
High frequency loss	・ **[u*, H, LE]** ✓ Moor (1986) *15 (Correction for path length and sensor separation)	

	• **[Fc]** ✓ Experimental approach *2	
Low frequency loss *16 (Detrending)	✓ Block average	
WPL Correction*17-21	✓ For latent heat (LE) flux ✓ For CO_2 flux	
Others *22-24	✓ Temperature dependency for latent heat: L ✓ Temperature dependency for air density ✓ Pressure dependency for air density	

3-4. Quality control *25-26

		Note/References
Raw data test	✓ Spike test *27 ✓ Absolute limits	
Non steady state test	✓ YES	
Integral turbulence characteristics	✓ YES (u*)	
Correlation coefficient	✓ Not applied	
Wind direction	✓ YES	Data with wind blowing from the tower were excluded to remove the tower's influence on measurements.
Footprint test *28, 29	✓ Not applied	
Absolute thresholds	✓ YES	
Others	✓	

3-5. Storage term

		Note/References
Storage term	• **[CO_2]**	From CO_2 profile data (26, 22, 16, 12, 6, 3, 1 m) When CO_2 profile data were missing, CO_2 data at the flux measuring height was used.

3-6. Other information

☺ to Data provider ······················ If your flux data were evaluated by gradient method, please explain the observation method here.

		Note/References

4. Registered Data

Observation items	Symbol	Unit	Height(s) Depth(s)	Instruments	Level of data processing
Year	Year	#### (YYYY)	****	****	
Date	DOY	1～365	****	****	
Time	TIME	#### (HHMM)	****	****	
CO_2 flux	Fc	micoromol・m^{-2}・s^{-1}	27 m	Three-dimensional sonic anemometer-thermometer (DA-600-3TV (Probe TR-61C), KAIJO) and closed-path CO_2/H_2O analyzer (LI6262, LI-COR)	Quality-controlled
Net ecosystem carbon exchange	NEE	micoromol・m^{-2}・s^{-1}	-	CO_2 flux + CO_2 storage in canopy air layer	Quality-controlled
Sensible heat flux	H	W・m^{-2}	27 m	Three-dimensional sonic anemometer-thermometer (DA-600-3TV (Probe TR-61C), KAIJO, Japan) and open-path CO_2/H_2O analyzer (LI7500, LI-COR)	Quality-controlled
Latent heat flux	LE	W・m^{-2}	27 m	Three-dimensional sonic anemometer-thermometer (DA-600-3TV (Probe TR-61C), KAIJO, Japan) and open-path CO_2/H_2O analyzer (LI7500, LI-COR)	Quality-controlled
Friction velocity	USt	m・s^{-1}	27 m	Three-dimensional sonic anemometer-thermometer (DA-600-3TV (Probe TR-61C), KAIJO)	Quality-controlled
Atmospheric stability parameter	ZL	-			
Global solar radiation (incoming)	Rg	W・m^{-2}	40 m	Pyranometer (MS-601, Eko, Japan)	Quality-controlled
Global solar radiation (incoming)	Rg_gf	W・m^{-2}	40 m	Pyranometer (MS-601, Eko, Japan)	Gap filled
Global solar radiation (outgoing)	Rg_out	W・m^{-2}	40 m	Radiometer (MR40, Eko, Japan)	Quality-controlled
Long-wave radiation (incoming)	Rgl	W・m^{-2}	40 m	Radiometer (MR40, Eko, Japan)	Quality-controlled
Long-wave radiation	Rgl_out	W・m^{-2}	40 m	Radiometer (MR40, Eko,	Quality-controlled

(outgoing)				Japan)	
Net Radiation	Rn	W・m^{-2}	40 m	Radiometer (MR40, Eko, Japan)	Quality-controlled
Net Radiation	Rn_gf	W・m^{-2}	40 m	Radiometer (MR40, Eko, Japan)	Gap filled
Transmitted global solar radiation	TRg	W・m^{-2}	2 m (five point-averag -e)	Radiometer (MR40, Eko, Japan)	Quality-controlled
Absorbed global solar radiation	ARg	W・m^{-2}		ARg=Rg-Rg_out-TRg	Quality-controlled
Albedo	Alb		40 m	Alb=Rg_out/Rg	Quality-controlled
Photosynthetic active photon flux density	PPFD	micoromol・m^{-2}・s^{-1}	40 m	Quantum sensor (LI-190S, LI-COR)	Quality-controlled
Photosynthetic active photon flux density	PPFD_gf	micoromol・m^{-2}・s^{-1}	40 m	Quantum sensor (LI-190S, LI-COR)	Gap filled
Reflected PAR	RPAR	micoromol・m^{-2}・s^{-1}	40 m	Quantum sensor (LI-190S, LI-COR)	Quality-controlled
Transmitted PAR	TPAR	micoromol・m^{-2}・s^{-1}	2 m (two point-averag e)	Quantum sensor (LI-190S, LI-COR)	Quality-controlled
Absorbed PAR	APAR	micoromol・m^{-2}・s^{-1}		APAR=PPFD-RPAR -TPAR	Quality-controlled
PAR Albedo	Alb_PAR	-	40 m	AlbPAR=RPAR/PPFD	Quality-controlled
Wind direction	WD	degrees	27 m	Sonic anemometer (MA-130A, Eko, Japan)	Quality-controlled
Wind speed	WS	m・s^{-1}	27 m	Sonic anemometer (MA-130A, Eko, Japan)	Quality-controlled
Barometric pressure	Pa	kPa	40 m	Barometer (PTB100, Vaisala)	Quality-controlled
Air temperature	Ta_27m	degrees C	27 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Quality-controlled
Air temperature	Ta_27m_gf	degrees C	27 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Gap filled
Air temperature	Ta_14m	degrees C	14 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Quality-controlled
Air temperature	Ta_14m_gf	degrees C	14 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Gap filled
Vapor pressure deficit	VPD_27m	kPa	27 m	Platinum resistance thermometers and	Quality-controlled

				capacitive hygrometer (HMP45D, Vaisala)	
Vapor pressure deficit	VPD_27m_gf	kPa	27 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Gap filled
Vapor pressure deficit	VPD_14m	kPa	14 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Quality-controlled
Vapor pressure deficit	VPD_14m_gf	kPa	14 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Gap filled
Relative humidity	Rh_27m	%	27 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Quality-controlled
Relative humidity	Rh_14m	%	14 m	Platinum resistance thermometers and capacitive hygrometer (HMP45D, Vaisala)	Quality-controlled
Precipitation	PPT	mm	40 m	Tipping-bucket rainguage with heater (52 202, R. M. Young)	If data were missing, we gap-filled using data from the nearest meteorological station
Ground heat flux	G	$W \cdot m^{-2}$	0.05 m (five point-average)	Heat flux plate (MF-81, Eko, Japan) and Platinum resistance thermometer	G was calculated by adding the heat storage change in the topsoil layer above the heat plates to conductive soil heat flux (MF-81). Quality-controlled
Soil temperature	Ts_5cm	degrees C	0.05 m (three point-average)	Platinum resistance thermometer	Quality-controlled
Soil temperature	Ts_5cm_gf	degrees C	0.05 m (three point-average)	Platinum resistance thermometer	Gap filled
Soil temperature	Ts_10cm	degrees C	0.1 m (three point-average)	Platinum resistance thermometer	Quality-controlled

Soil temperature	Ts_20cm	degrees C	0.2 m (three point-average)	Platinum resistance thermometer	Quality-controlled
Soil temperature	Ts_50cm	degrees C	0.5 m (three point-average)	Platinum resistance thermometer	Quality-controlled
Soil water content	SWC_5cm	m^3 m^{-3}	0.05 m (three point-average)	TDR sensor (CS615, Campbell)	Quality-controlled
Soil water content	SWC_10cm	m^3 m^{-3}	0.1 m (three point-average)	TDR sensor (CS615, Campbell)	Quality-controlled

5. Note for data users

☺to Data provider ················ If you use some tags (flags/identifiers) to identify the levels of data processing, please explain the meanings of the tags.

The figure of "-99999" denotes missing or rejected data.

6. Important events

☺to Data provider················· Please list noteworthy events during the observation period. For example, relocation of the instruments, reasons for missing observation, dates of sowing and harvesting at agricultural site should be listed in the table by date.

Date	Events
May 28, 2001	Flux measuring height was changed from 22 to 27 m.
October 10, 2001	Direction of flux measuring boom was changed from 153 to 273 degrees.

References

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.

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*15 Moore, C.J., 1986. Boundary-Layer Meteorology, 37: 17-35.

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Quality control

*25 Vickers, D. and Mahrt, L., 1997. Journal of Atmospheric and Oceanic Technology, 14: 512-526.

*26 Foken, T. and Wichura, B., 1996. Agricultural and Forest Meteorology, 78: 83-105.

*27 Hojstrup, J., 1993. Measuring Science Technology, 4: 153-157.

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*29 Korman, R. and Meixner, F.X., 1990. . Boundary-Layer Meteorology, 99: 207-224.