Comparison of the different turbulent measuring sensors (Session 4: Problems for Flux Measurements studies)

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1. Introduction

A lot of micrometeorological observations using fast response sensors have been carried out to understand the energy and water balances and CO_2 flux on different places. Though different sensors were used, comparisons of these sensors have been rarely seen. During May 14 to 25, 2000, turbulent measurement with 14 different models of sensors, most of which were used in the observations of GAME (GAWEX Asian Monsoon Experiment) projects, was carried out at Terrestrial Environment Research Center (TERC), University of Tsukuba by the Flux Enthusiast Party (authors). Our interests are the energy imbalance problem, flux footprint (or source area), methods to evaluate turbulent flux and comparison of the different turbulent measuring sensors (Toda *et al.*, 2000). The object of this report is focused on comparison of the sensors.

2. Measurement

Site The measurement was made at TERC field. The surface was covered by grass (mainly *Solidago altissima*, *Andropogon virginicus* and *Equisetum arvence*). And the fetch toward the prevailing wind direction (east) was about 100m.

Sensors Table 1 lists the installed sensors to compare. Because of bad weather conditions (lightning and heavy rain), only the data obtained by 6 sensors is available. Every open path sensor measures spatial mean properties of the air between probes. The sonic anemothermometers calculates wind speed and air temperature by measuring the speed of sound, and gas analyzers calculate the gas densities by measuring the absorption of infrared radiation. The spans of all the sensors' probes are 0.12m to 0.2m except closed path sensor. Shorter span sensors enable to measure smaller eddies, but errors are larger. Closed path system pumps the object air into the sampling cells of the sensor through tube, and calculates the gas concentrations by measuring the difference

Table 1 Available installed sensors. *Italics* are the abbreviations used in figures.

Set No. (Logger)	Model	Sensor	[Object]	Installation height	Span
1(a)	Flux-*PAM* type*	3D Sonic anemothermometer	[Temperature]	3.33m	0.15m
2(b)	DA-600-*1T***	1D Sonic anemothermometer	[Temperature]	2.55m	0.20m
3(b)	DA-600-*3T***	3D Sonic anemothermometer	[Temperature]	2.52m	0.20m
1(a)	OP2***	Open path CO_2/H_2O gas analyzer	[H_2O, CO_2]	3.30m	0.20m
2(a)	LI-7500****	Open path CO_2/H_2O gas analyzer	[H_2O, CO_2]	2.80m	0.12m
1(a)	LI-6262****	Closed path CO_2/H_2O gas analyzer	[H_2O, CO_2]	2.85m	(tube)

[Makes] *: GILL, **: KAIJO, ***: Data Design Group, ****: LI-COR in absorption of infrared radiation passing trough the sample and reference cells. The sensors were installed at heights of 2.5 to 3.3m, and the horizontally distance of each set was around 0.3m. A sampling frequency set at 10Hz.

3. Comparison

It is difficult to compare raw data of the sensors, because each set of sensors is apart horizontally. Thus standard deviations (σ) in every 10 minutes were used to make comparisons. The concentrations are converted into the densities.

Fig. 1 shows time series on σ of the available data. They agree with each other. The weather of the former two days is finer than the latter, so every σ varied more regularly in the former days.

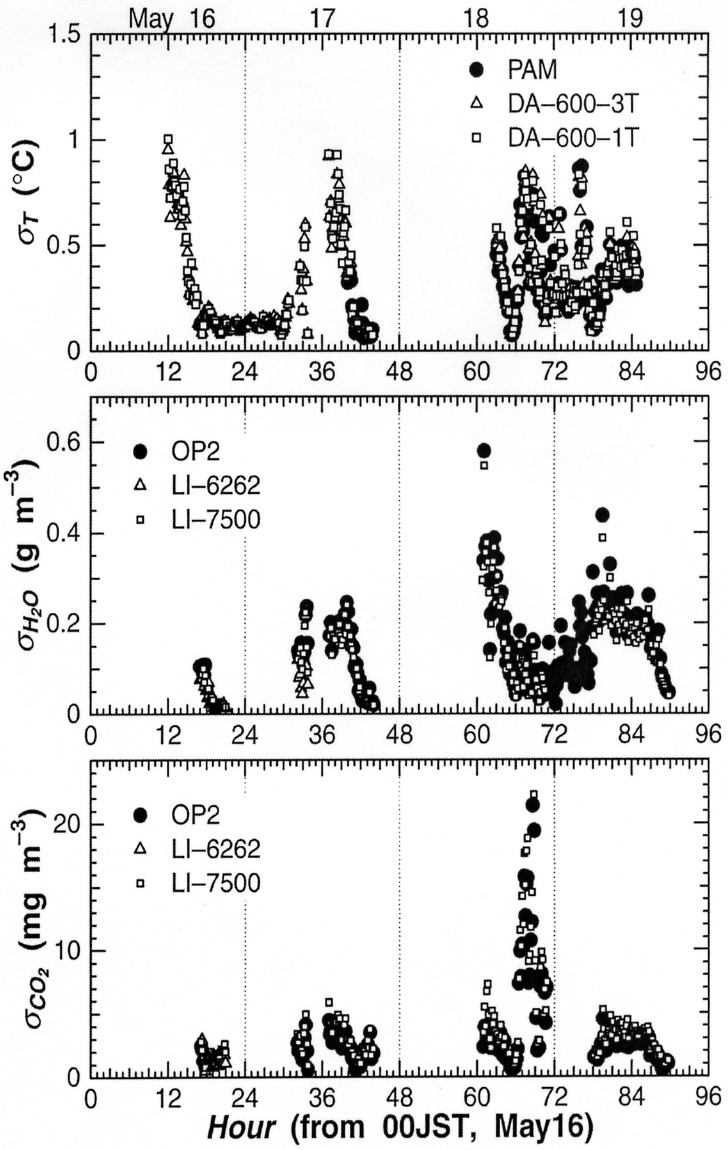

Fig. 1 Time series on standard deviations (σ) of the raw data.

Fig. 2 shows the relationships between σ of the sensors. This figure also shows good agreement of the sensors. The closed path LI-6262 sensor is a little smaller in both H_2O and CO_2 because of the measuring method. Slightly curving relationship between the σ of H_2O_{OP2} and $H_2O_{LI\text{-}7500}$ is seen in this figure, maybe because only the OP2's H_2O sensor has 2nd order calibration coefficient (others have only linear). LI-7500's calibration coefficients are questionable, therefore σ of CO_2 $_{LI\text{-}7500}$ seems quite larger. However the root mean square error (RMSE) of two open path sensors seems small enough. These results mean that the sensors in this report are good to use together, although not only absolute quantities but also σ calibration should be made before flux observations using different turbulent measuring sensors.

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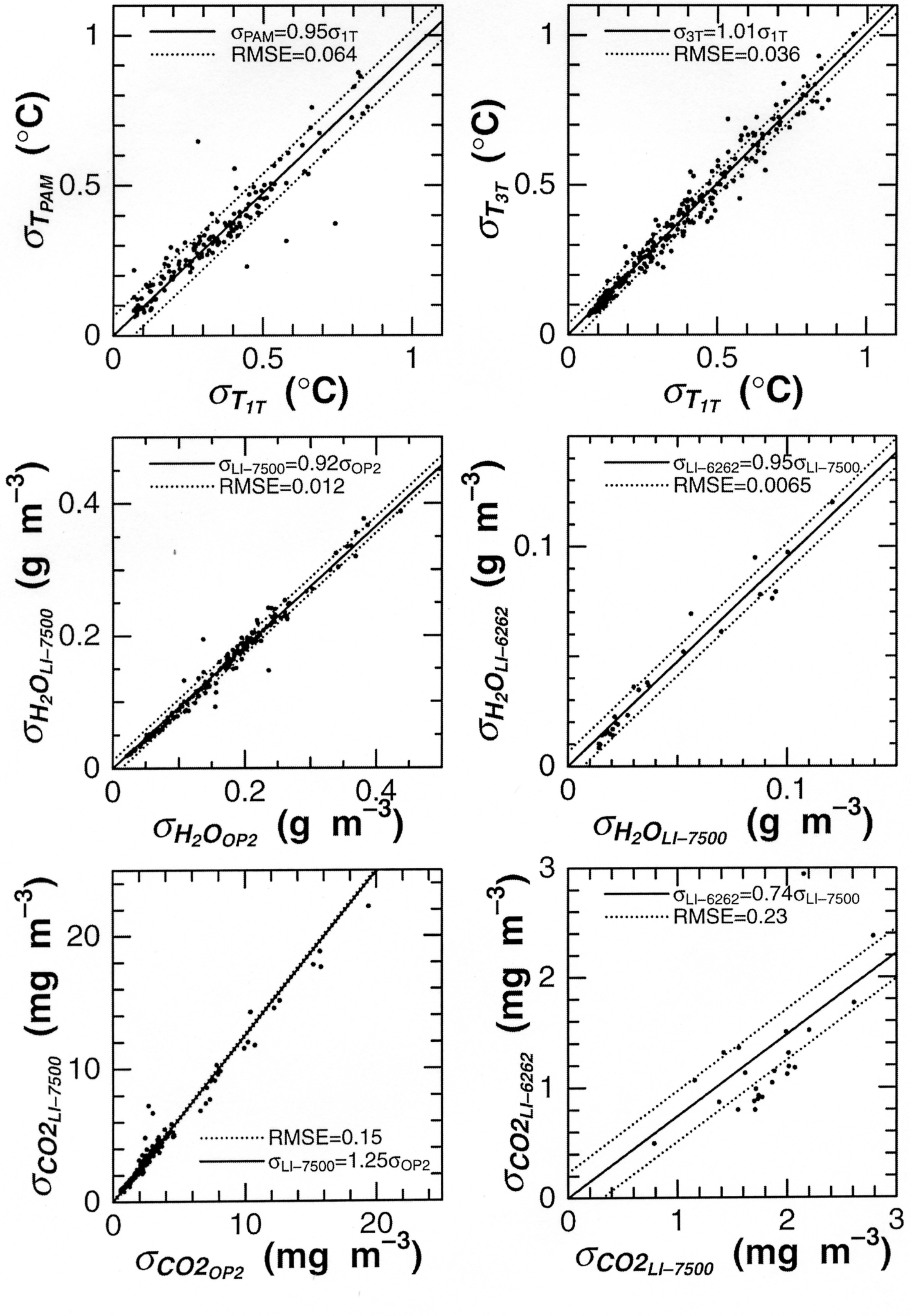

Fig. 2 Comparison of different sensors by standard deviations (σ).
Solid and dotted lines indicate linear regression line and RMSE width, respectively.