Toward the J-OFURO Ver.3

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Background 1

Global surface heat flux data sets are used in many studies related to air-sea interaction, global climate change...etc. Accurate surface flux data set is critical for climate studies. Recently various kinds of surface heat flux data sets are provided, e.g., satellite-derived data, reanalysis data and in situ data.

However, the accuracy of those flux data is not so high still now. We need more improvements !

Comparison Results

KEO and JKEO buoys

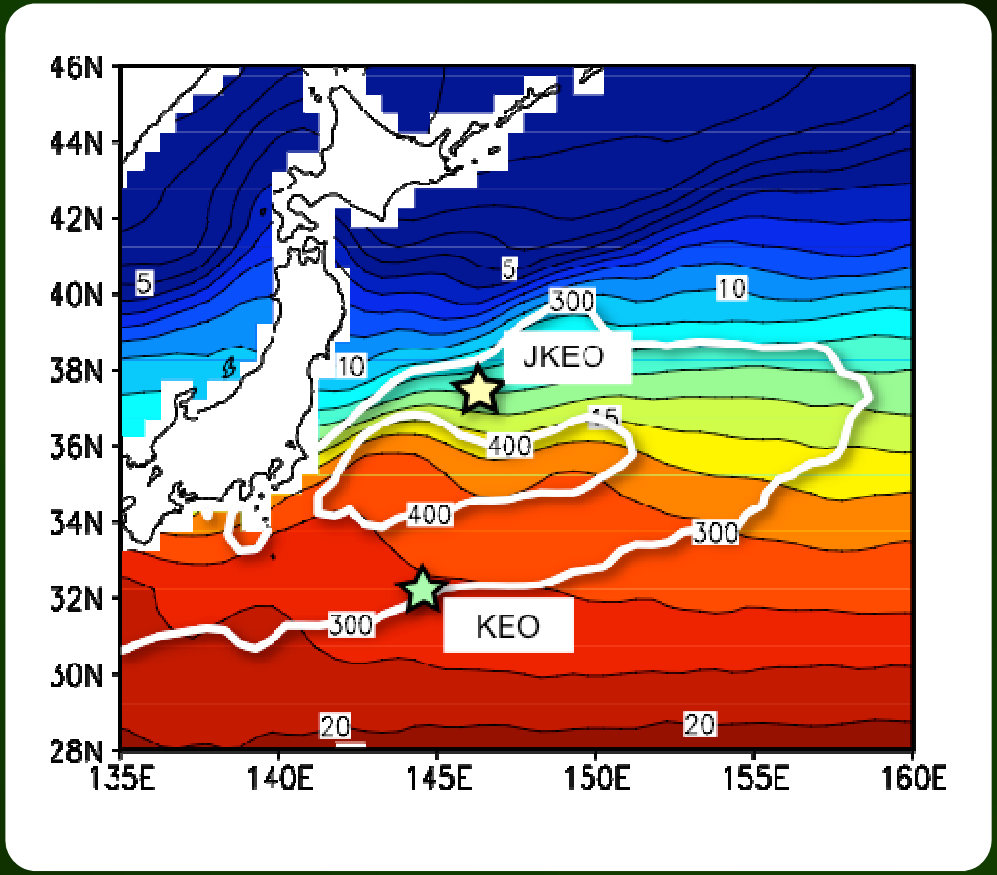
Surface Fluxes, Upper Ocean Temperature and Salinity

KEO buoy

NOAA/PMEL
32N, 145E
16-Jun-2004- Present

JKEO buoy

JAMSTEC/IORGC
NOAA/PMEL
38N, 146E
deployed on 18-Feb-2007



http://www.jamstec.go.jp/iorgc/ocorp/ktsfg/data/jkeo/

Table 1. Statistices for each surface flux component. (a) NRA1 and (b) NRA2

(a)

NRA1	SWR	LWR	LHF	SHF	THF
Corr.	0.80	0.79	0.92	0.93	0.93
RMS. Error	48	15	48	20	77
Bias	-1	1	38	9	49

(b)

NRA2	SWR	LWR	LHF	SHF	THF
Corr.	0.88	0.78	0.91	0.94	0.94
RMS. Error	38	15	62	23	85
Bias	5	-6	60	7	56

Kubota et al.(2008)

Background 2

Japanese Ocean Flux Data Sets with Use of Remote Sensing Observations (J-OFURO) was constructed in 2000. J-OFURO has provided global momentum and heat flux products.

Recently new surface flux data set was constructed in J-OFURO as the version 2. In the version 2 many points are improved compared with the version 1.

http://dtsv.scc.u-tokai.ac.jp/j-ofuro/oracledatabase/web/index.html

Comparison of our J-OFURO products

	Ver.1	*Ver.2*
Parameters	Wind(-stress) Vectors U, V τ_x, τ_y	Wind(-stress) Vectors & Magn. U, V & $\lvert\vec{V}\rvert$ τ_x, τ_y & $\lvert\vec{\tau}\rvert$
Time Coverage	1999/8/1- 2000/6/30	1999/8/1-2008/12/31 ***Updating***
Time Resolution	Daily	Daily
Spatial Coverage	Almost Global (80°S-60°N, 0°E-0°E)	
Spatial Resolution	Only 1° x 1°	1° x 1° & **0.5° x 0.5° (preparation)**
Raw Data	**Level 2B swath data** (old version/ 25 km)	**Level 2B swath data** (new version/ 12.5 km)

Other Improvements in Wind-retrieval algoritum

- Flagging for **rain contamination**
- Performance at **high wind speeds**

OVERVIEW of the J-OFURO version 2

Key Features

- Daily and monthly mean, 1988-2005
- Global (60s-60n), 1 deg. x 1 deg. grid
- Modern bulk method (COARE 3.0)
- Use of Multi-satellite data
- Optimum Interpolation
- Variables

Latent and Sensible Heat Fluxes,
Net Heat Flux,
Wind Speed,
Surface Saturated Specific Humidity,
Surface Air Specific Humidity

OVERVIEW of the J-OFURO version 2

Major differences between J-OFURO1 and 2

	J-OFURO1	J-OFURO2
Availability	1992-2000 3 days mean	1988-2005 daily mean
Bulk Method	Kondo (1975)	COARE 3.0
Satellite	Single	Multi

USE of MULTI-SATELLITE DATA

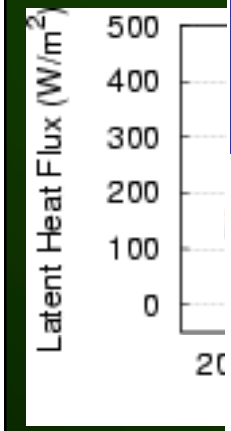
Data Sources

	J-OFURO1	J-OFURO2
Wind Speed	SSMI F10 or F13	All SSMIs (F08-F15) ERS1/2, QuikSCAT, AMSR-E, TMI
Surface Air Specific Humidity		All SSMIs (F08-F15)
SST	Reynolds SST	MGDSST (By JMA)
	AVHRR	AVHRR, AMSR-E

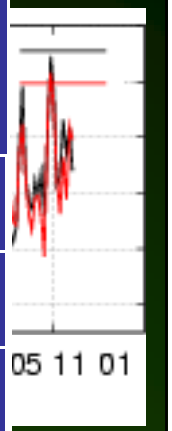
Comparison Results

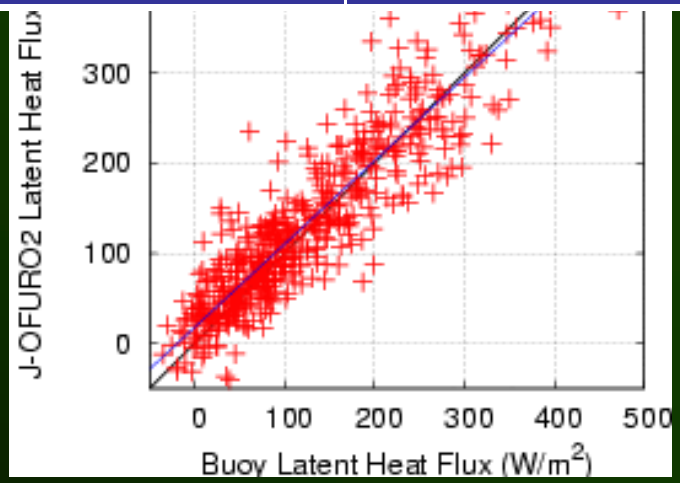
KEO buoy

Latent Heat Flux Jun 2004 - Nov 2005 daily mean



Statistics(Bias * : J-OFURO - KEO Buoy) * * Kubota et al.(2007)			
	J-OFURO2	NRA1 * *	NRA2 * *
Bias*	7W/m^2	38W/m^2	62W/m^2
RMS	42W/m^2	48W/m^2	60W/m^2
Corr.	0.92	0.93	0.91





Future Issues

1. Accurate Specific humidity
2. Spatial resolution of radiation products
3. Satellite-derived sensible heat fluxes
4. Continuity of data characteristics
5. Impact of high-speed winds on fluxes
6. Heat fluxes in the high-latitudes
7. Use of wind direction

etc.

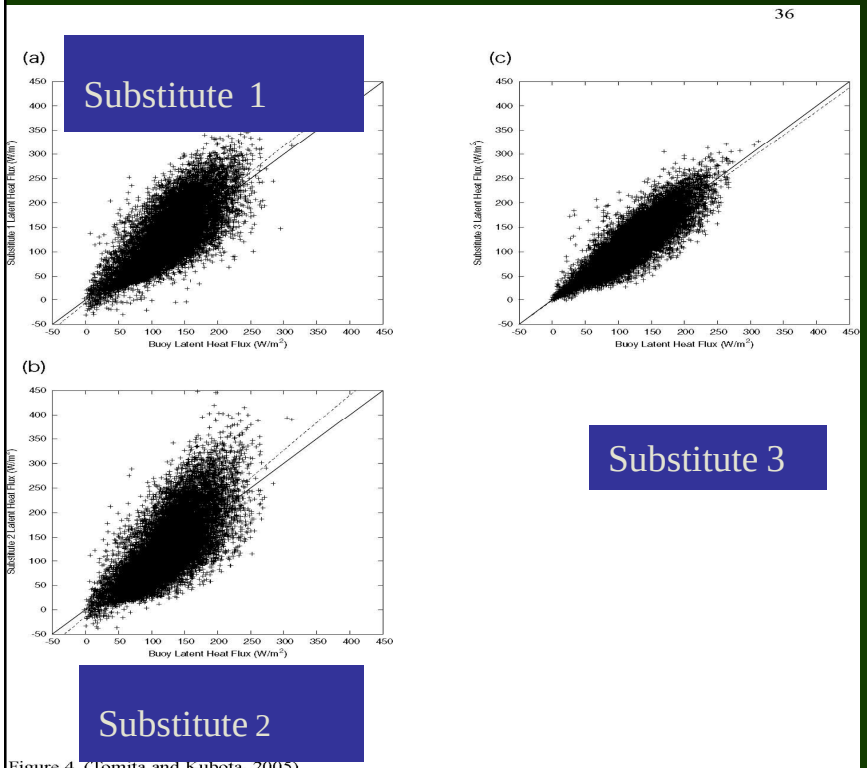


Figure 4 (Tomita and Kubota, 2005)

Tomita and Kubota, 2006

Table 4
The Substituted data sets of J-OFURO latent heat flux and the statistics between TAO/TRITON buoy and each Substituted data set. Units in W m^-2, except correlation.

Data set	W	SST	Qa	Bias (buoy - Substitute)	RMSR	Corr.
Substitute 1	buoy	J-OFURO	J-OFURO	-8.74	40.93	0.74
Substitute 2	J-OFURO	buoy	J-OFURO	-9.07	47.44	0.71
Substitute 3	J-OFURO	J-OFURO	buoy	4.06	23.30	0.87
Substitute 4	buoy	J-OFURO	buoy	0.57	10.10	0.97
Substitute 5	J-OFURO	buoy	buoy	3.53	20.91	0.90

Accurate (temporal and spatial mean) specific humidity data

1. Improvement of the algorithm for DMSP/SSMI
2. Development of algorithms for new sensors
3. Usage of multi-sensors for specific humidity

USE of MULTI-SATELLITE DATA

Data Sources

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Wind Speed	SSMI F10 or F13	All SSMIs (F08-F15) ERS1/2, QuikSCAT, AMSR-E, TMI
Surface Air Specific Humidity		All SSMIs (F08-F15)
SST	Reynolds SST	MGDSST (By JMA)
	AVHRR	AVHRR, AMSR-E

Microwave Radiometers

- DMSP/SSMI
- Aqua/AMSR-E
  (Zong et al., 2007, Kubota and Hihara, 2008)
- TRMM/MI

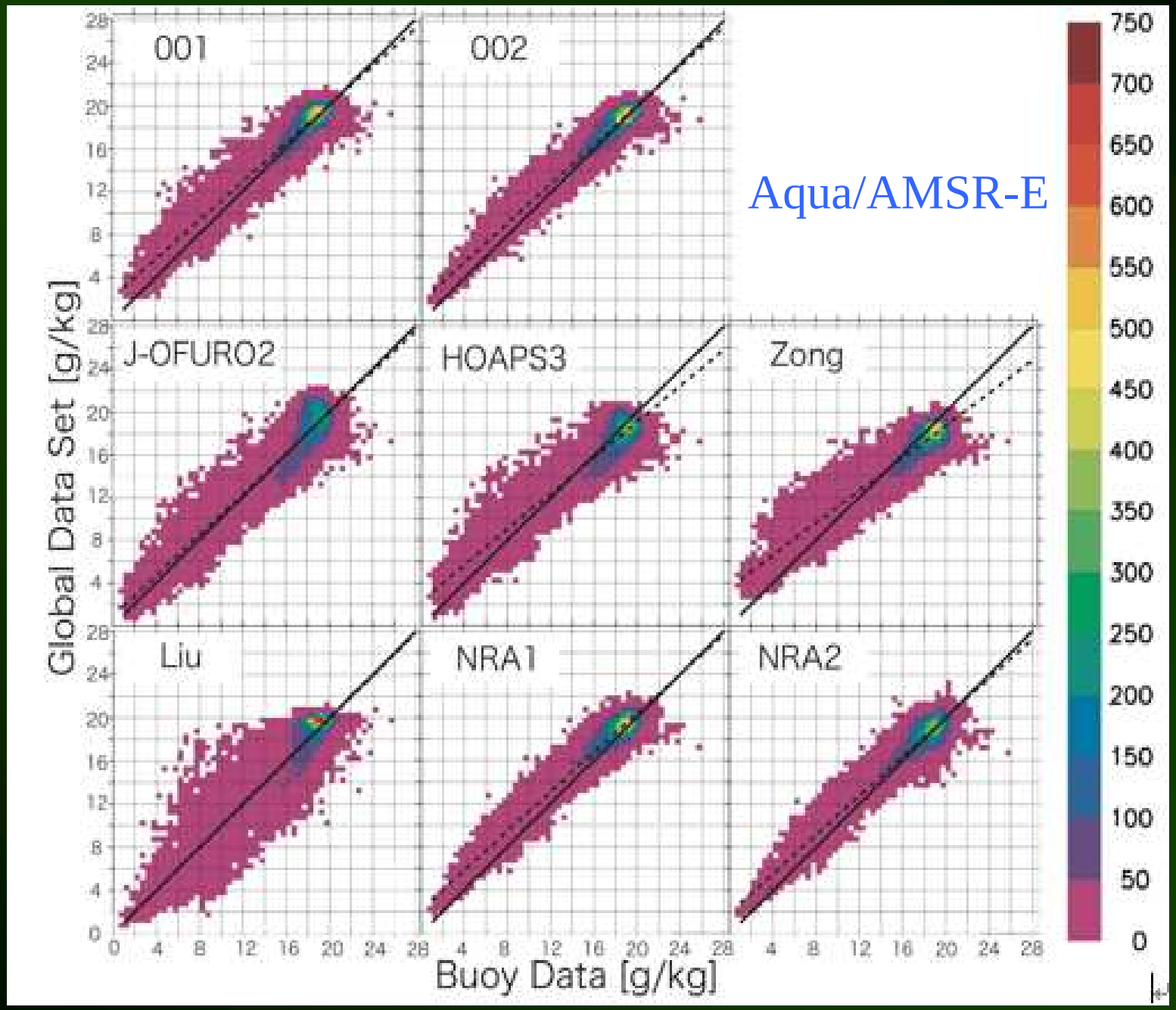
- GCOM-W 1 and 2
- GPM/MI

→ Good algorithm for various microwave sensors

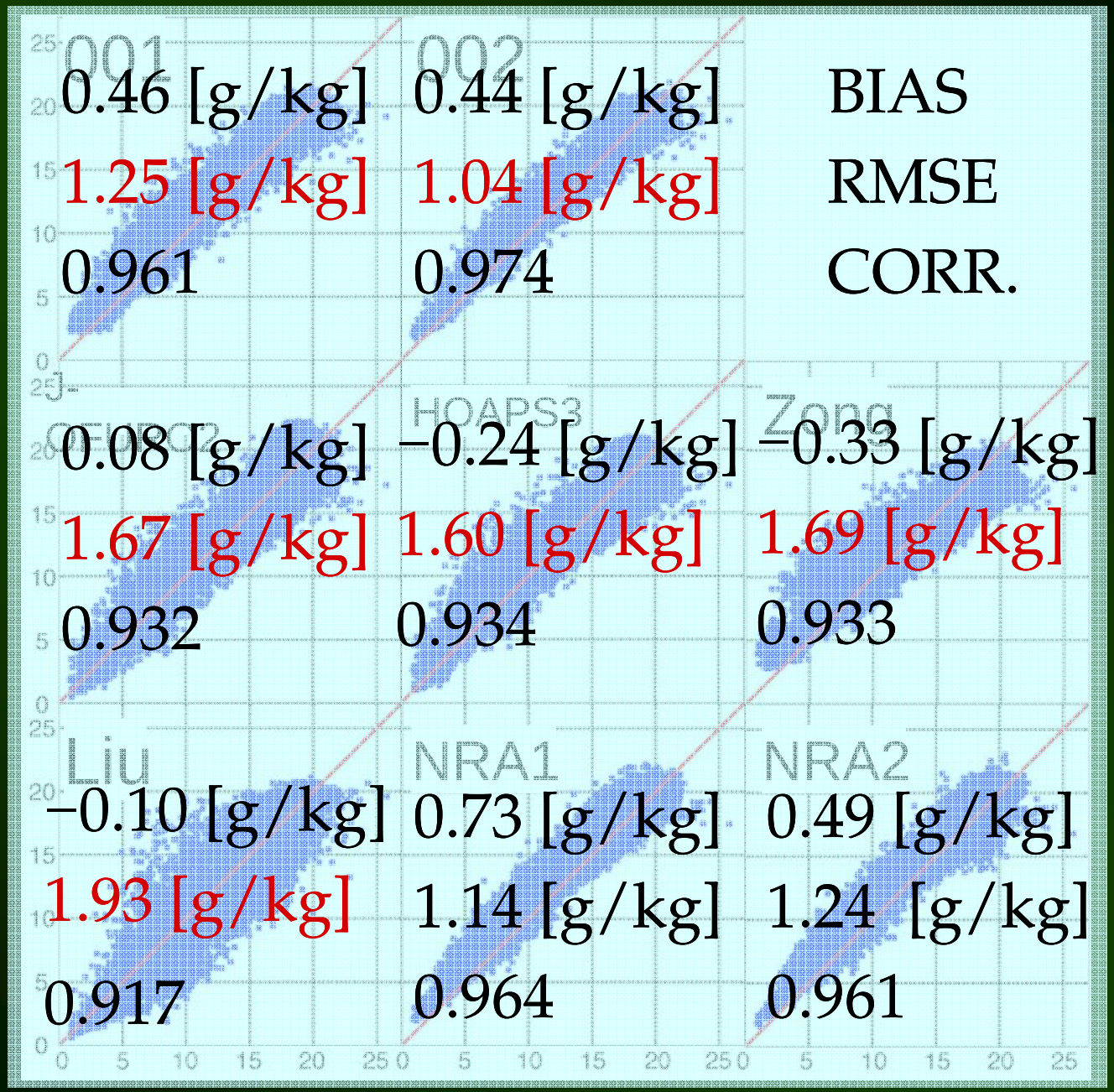
Products used in this study for comparison(Kubota and Hihara,2008)

Products	Algorithm	Sensor
J-OFURO 2	Schlussel et al. (1995)	SSM/I
HOAPS 3	Bentamy et al. (2003)	SSM/I
Zong	Zong et al. (2007)	AMSR-E
Liu	Liu (1986)	AMSR-E
NCEP/NCAR	Reanalysis data	
NCEP/DOE	Reanalysis data	

"Zong" and "Liu"s products are estimated by ourselves using AMSR-E Geophysical data provided by Remote Sensing Systems


Aqua/AMSR-E
001
002
J-OFURO2
HOAPS3
Zong
Liu
NRA1
NRA2
Global Data Set [g/kg]
Buoy Data [g/kg]
0
4
8
12
16
20
24
28
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0

All Areas



	Q01	Q02
BIAS	0.46 [g/kg]	0.44 [g/kg]
RMSE	1.25 [g/kg]	1.04 [g/kg]
CORR.	0.961	0.974

	HOAPS3	Zong
BIAS	0.08 [g/kg]	−0.24 [g/kg]
RMSE	1.67 [g/kg]	1.60 [g/kg]
CORR.	0.932	0.934

	Liu	NRA1	NRA2
BIAS	−0.10 [g/kg]	0.73 [g/kg]	0.49 [g/kg]
RMSE	1.93 [g/kg]	1.14 [g/kg]	1.24 [g/kg]
CORR.	0.917	0.964	0.961

Global data sets [g/kg]

Buoy data [g/kg]

- We should continue to develop a good algorithm for various microwave sensors including a new sensor

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2. Spatial resolution of radiation products
3. Satellite-derived sensible heat fluxes
4. Continuity of data characteristics
5. Impact of high-speed winds on fluxes
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7. Use of wind direction

etc.

3. Spatial resolution of radiation products

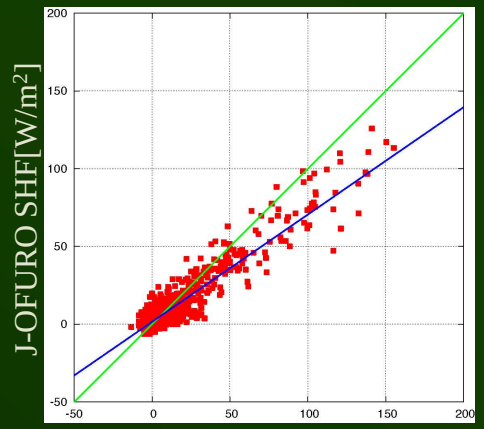
ISCCP data: Results (called the FD datasets) are obtained every three hours over the whole globe on a 280 km equal-area (EQ) global grid covering the time period July 1983 through December 2007.

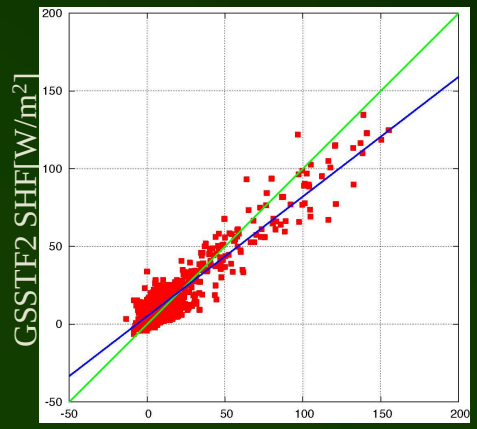
3. Satellite-derived sensible heat fluxes

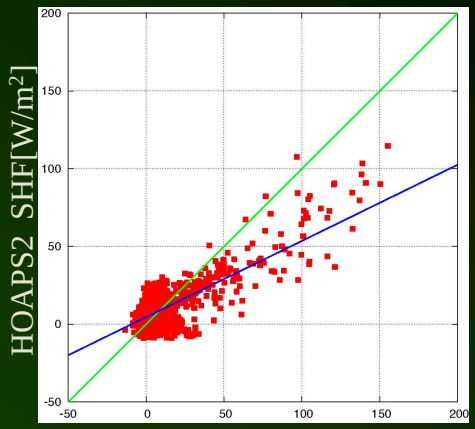
	Wind speed	SST	Air temperature	Algorithm
J-OFURO				Kubota and Mitsumori (1997) (Bowen Ratio)
J-OFURO1.5	SSMI/Wentz (1994, 1997) single Satellite	Reynolds and Smith (1994)	ERA40	COARE 3.0 (Fairall et al., 2003)
J-OFURO2	Multi Satellite (SSMI,QSCAT,ERS,TMI)	MGDSST	NRA1	COARE 3.0 (Fairall et al., 2003)
GSSTF2	SSMI/Wentz (1994, 1997)	Reynolds and Smith (1994)	NRA1	Chou (1993)
HOAPS3	new developed neuronal network algorithm (not published yet). Satellite is SSMI/Wentz (1994)	NODC/RSMAS AVHRR Oceans Pathfinder SST product	the mean of 2 methods: 1) assume 80% constant RH and 2) assume the DT (1 K).	COARE 3.0 (Fairall et al., 2003)

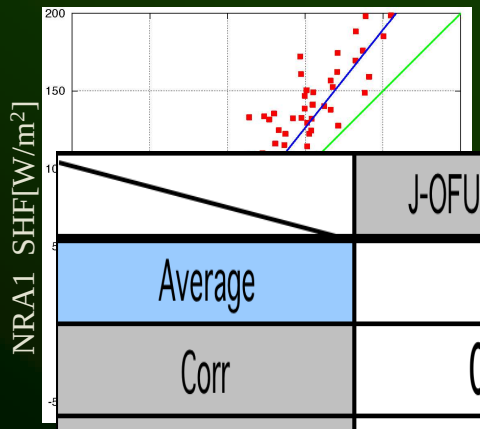
Results

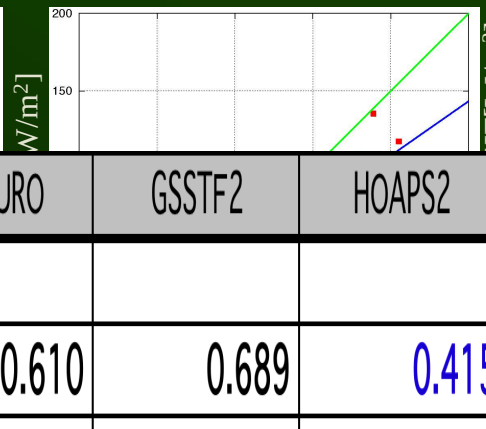
Scatter plots

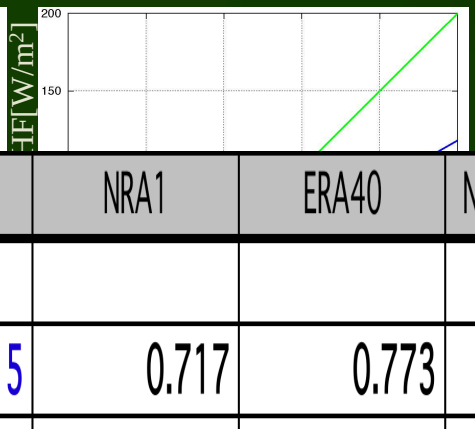


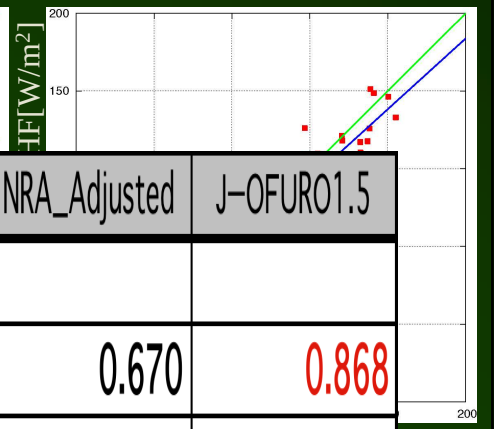












	J-OFURO	GSSTF2	HOAPS2	NRA1	ERA40	NRA_Adjusted	J-OFURO1.5
Average							
Corr	0.610	0.689	0.415	0.717	0.773	0.670	0.868
RMSD [W/m^2]	8.612	7.909	13.143	11.931	8.436	10.374	5.900
RMSR [W/m^2]	8.181	7.187	12.082	10.481	7.490	9.285	5.547
BIAS [W/m^2]	-2.565	1.124	-3.588	5.669	-2.201	-3.094	-0.667

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etc.

4. Continuity of data characteristics

Carol Anne suggested the trend is related to the number of usable sensors the day before yesterday. This means the characteristics of satellite-derived flux data is not continuous by changing sensors and increasing the number of the sensor. This is an important problem when we use satellite-derived flux products for climate studies. Although it is difficult to make reanalysis data for satellite- derived flux , we should be careful about this point.

Important things:

The products should be used by many users in many studies. The results provide us important information for improvement of the products. We need any feedback from users.

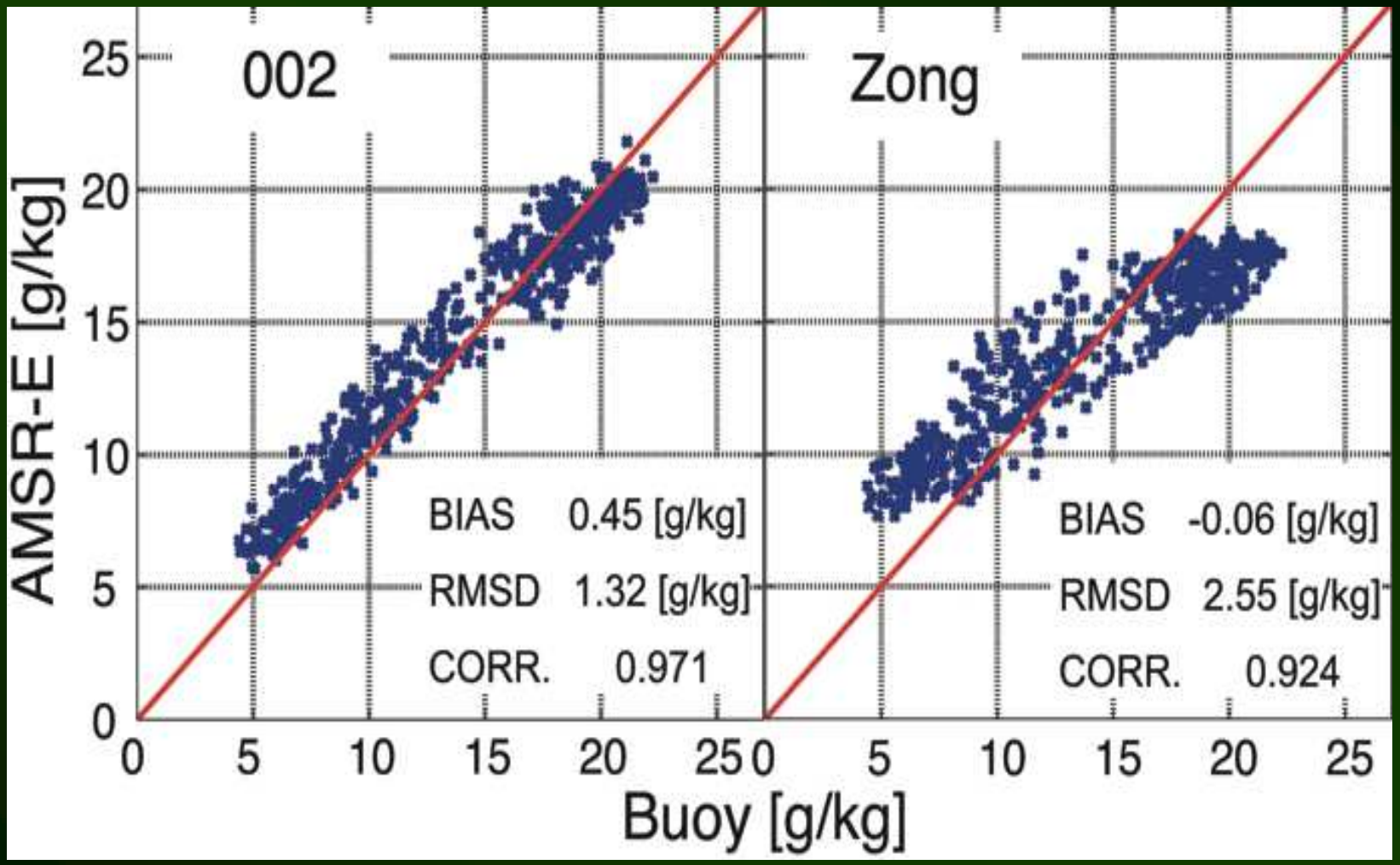
http://dtsv.scc.u-tokai.ac.jp/j-ofuro/oracledatabase/web/index.html

Thank you!

Table 5 (Tomita and Kubota, 2007)

Sensors		F11	F13	F14	F15	TMI	ERS	QuikSCAT
Sampling error		0.99	0.99	1.15	1.13	-	0.91	0.80
Combination	RMS error	2.30	1.93	1.88	1.67	2.38	3.01	1.70
Sim2 + TMI	1.40	*	*	*	*	*	*	*
Sim2	1.45	*	*	*	*	-	*	*
Sim4	1.71	*	*	*	-	-	-	-
Sim5	1.70	*	*	*	-	-	*	-

(Example)



Scatter plots of surface specific humidity observed by KEO buoy and derived from AMSR-E data.