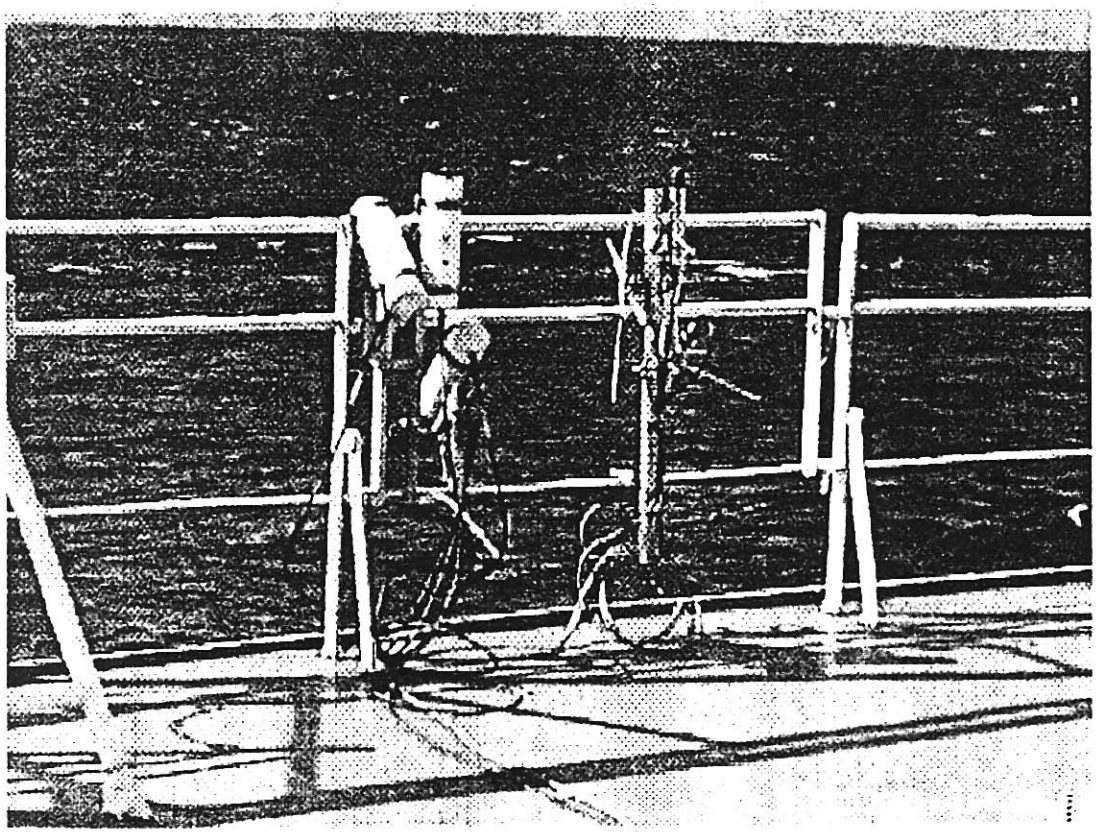
The spectrometer comparison experiment (Preliminary results from KY01-09)



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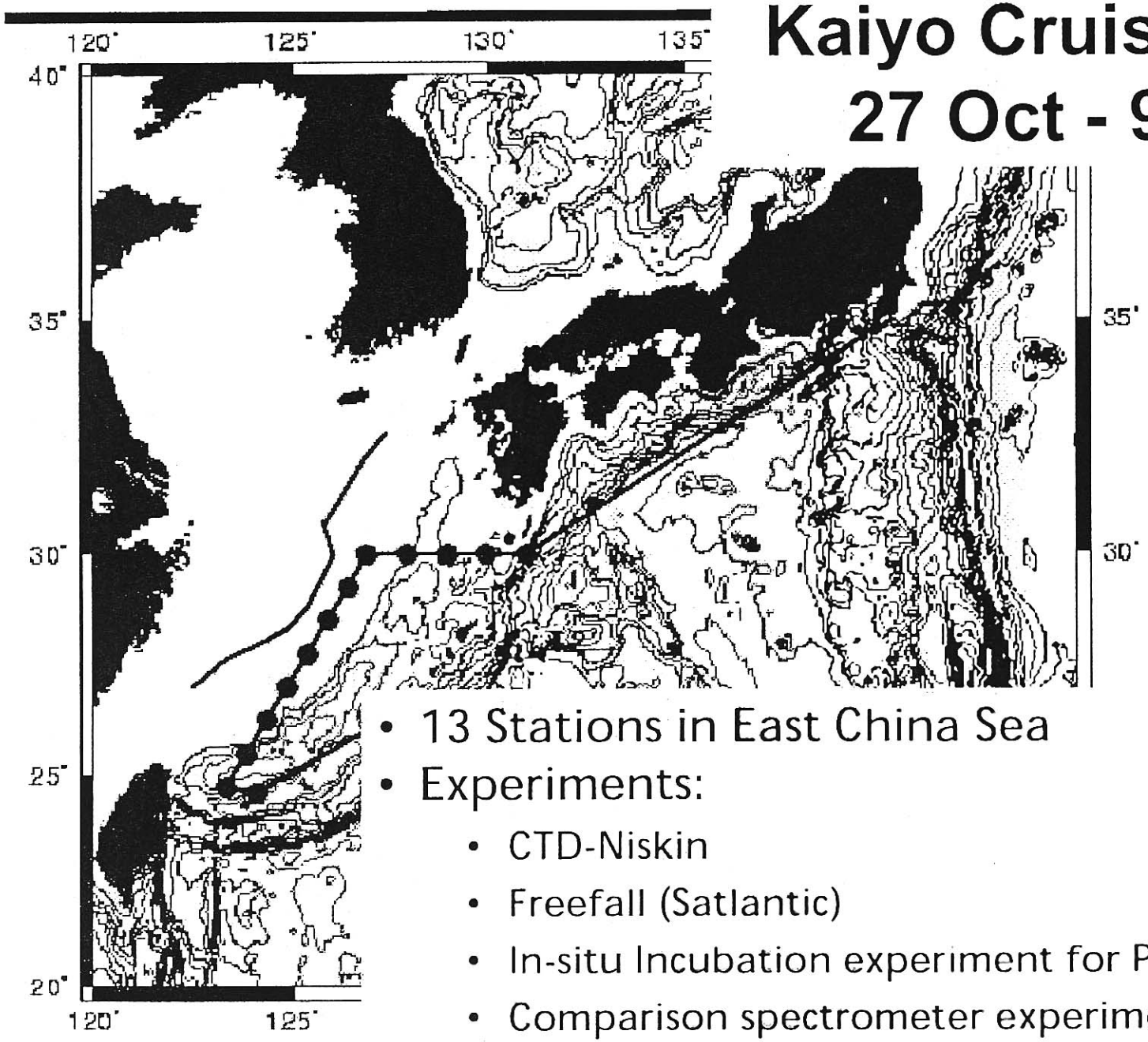
Kaiyo Cruise KY01-09
27 Oct - 9 Nov 2001



- 13 Stations in East China Sea
- Experiments:
  - CTD-Niskin
  - Freefall (Satlantic)
  - In-situ Incubation experiment for PP (24h)
  - Comparison spectrometer experiment TRIOS/WLR-2800
  - Mounting WLR-2800 on buoy (Off-Ishigaki Island)

Objective

To compare the performance of ground-truth spectrometer which will be used for GLI calval: WLR-2800 and TRIOS

WLR-2800 and TRIOS consist of 3 separated spectrometers

- global solar irradiance (Ed(λ) or downwelling irradiance),
- sky radiance (Li(λ,φ,θ) or indirect radiance),
- sky radiance (Li(λ,φ,θ).

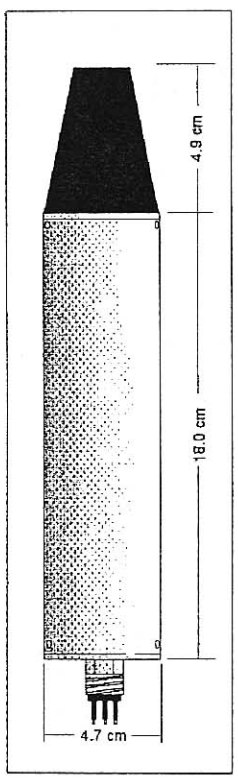
Experiment requirements:

similar conditions, such as

- radiance budget (case-1/case-2 waters)
- temperature,
- pointing angles, FOV etc.

TRIOS-Ramses ACC/ARC1

TriOS Optical Sensors, Oldenburg, Germany

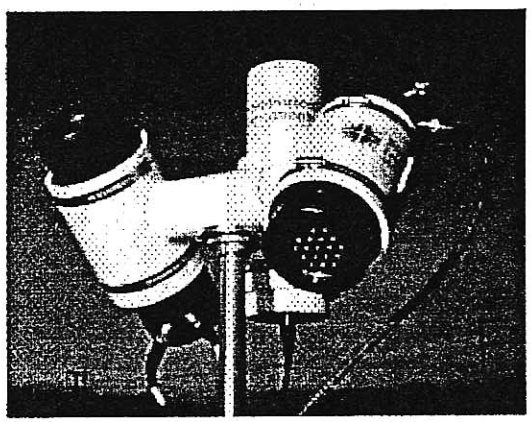


Technical specifications		
	UV/VIS	VIS
optical		
wavelenght range*	280 – 720 nm	320 – 950 nm
detector type*	channel silicon photodiode array	
spectral sampling*	2.2 nm/pixel	3.3 nm/pixel
spectral accuracy*	0.2 nm	0.3 nm
usable channels	200	190
typical saturation (at 500nm)	20 W m^{-2} nm^{-1} (4ms int time)	20 W m^{-2} nm^{-1} (4ms int time)
typical NE1 (at 500nm)	15µW m^{-2} nm^{-1} (8sec int time)	2µW m^{-2} nm^{-1} (8sec int time)
detection		
collector type	cosine response	
accuracy	better then 6 – 10% (depending on spectral range)	
electrical		
integration time	4 ms – 8 sec.	
telemetry data interface	RS-232	
data rate (RS-232)	1,200 – 19,200 baud	
power requirements	1.5 – 11 VDC 0.85 W (data acquisition active) 20 mW (interface active) 0.5 mW (stand-by modus)	
connector	SUBCONN-Micro 5 pins, male connector	
physical		
size	Ø 4.7 cm x 26 cm (without connector)	
weight in air	< 1.0 kg (stainless steel/POM housing)	
depth rating	300 m	
operating temperature	-10 to +50°C	

* specifications from Carl ZEISS, Germany

WLR-2800

Biospherical Instruments Inc. San Diego, USA



WLR-2800 Technical Specifications

Optical

Spectral Range: 313-900 nm

Standard Wavelengths: 340, 380, 412, 443, 465, 490, 510, 532, 555, 565, 589, 625, 665, 683, and 694 nm

Optional Wavelengths: 313, 320, 395, 455, 475, 520, 670, 710, 765, 780, 875 nm, and PAR (Photosynthetically Active Radiation—400-700 nm). Consult factory for availability.

Bandwidth: 10 nm FWHM standard; 20 nm FWHM optional

Filter Photodetectors: 15 wavelengths standard; up to 19 wavelengths (optional)

Detectors: Custom 13 mm^2 silicon photodiodes

Filter Type: Custom low-fluorescence interference

Field of View: 13.6° half angle in air; 10° half angle in water (SeaWiFS-compatible)

Out-of-band Rejection: $1x10^{-10}$

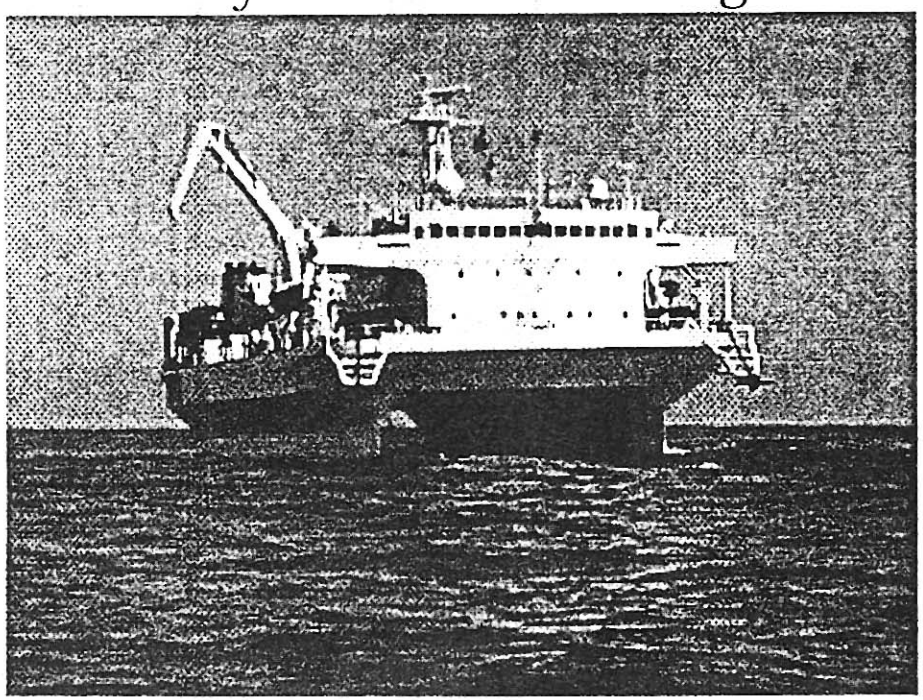
Typical Saturation: 10^3 $\mu Wcm^{-2}nm^{-1}sr^{-1}$

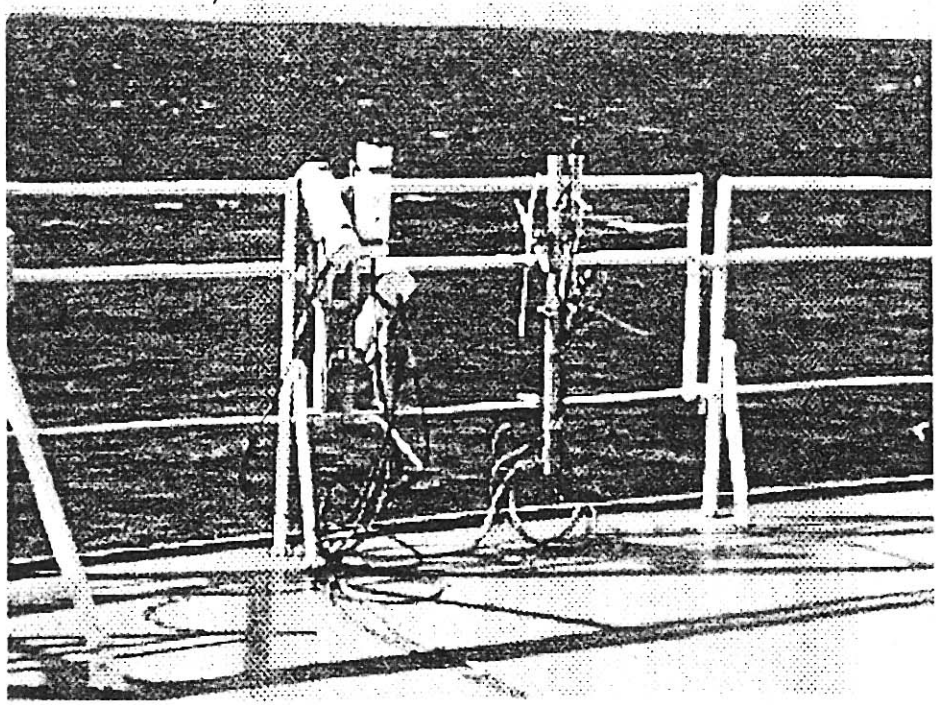
Noise Equivalent Radiance: 10^{-6} $\mu Wcm^{-2}nm^{-1}sr^{-1}$

Running the experiment

* Kaiyo is a very good platform for spectrometer inter-calibration since all spectrometer can be installed in a similar way

* Kaiyo is a semi-submerged catamaran => very stable conditions.





* working room (incl. printer, etc.) is located underneath the experiment

=> great possibility to carry out: experiment and first analysis

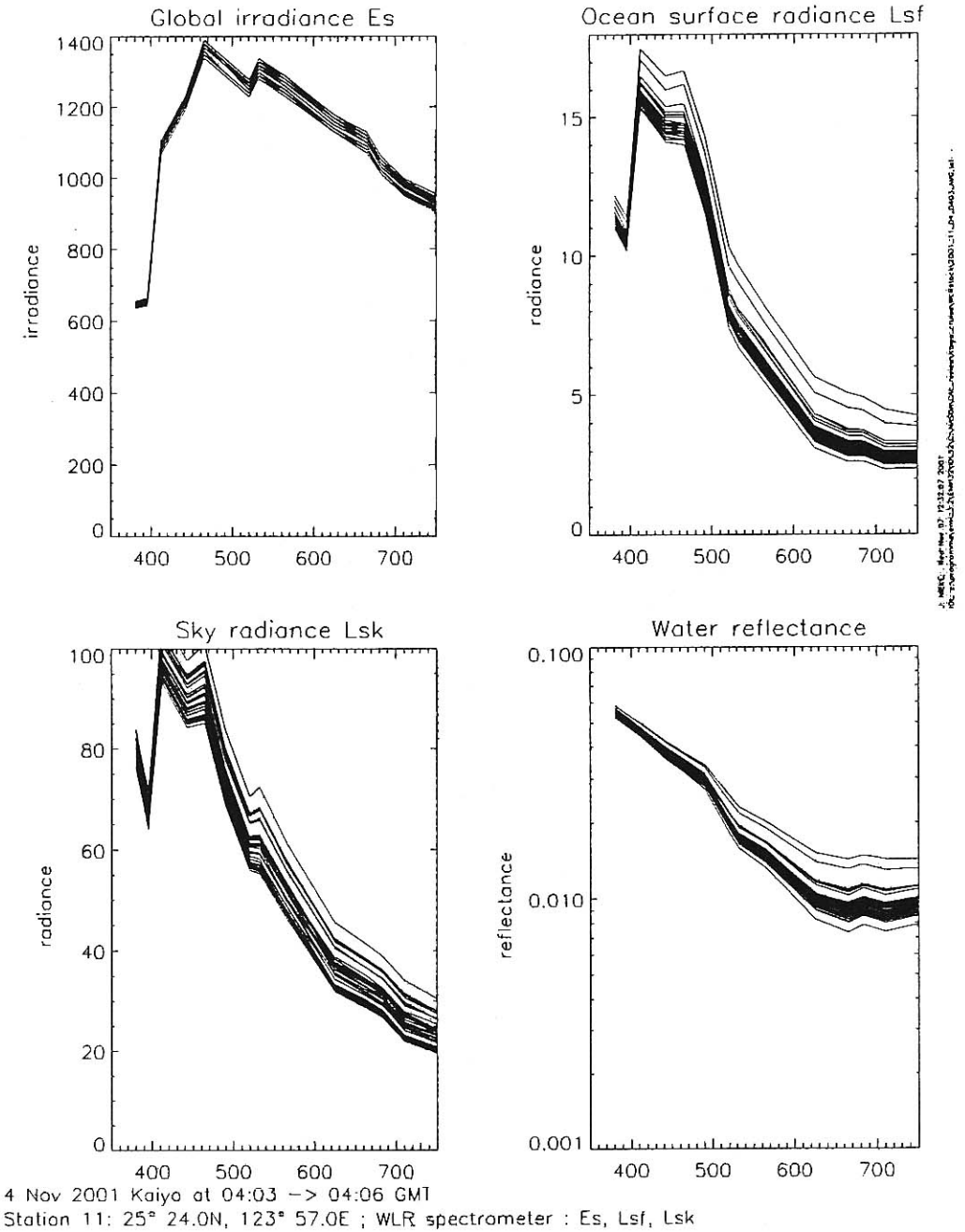
Preliminary results (1)

1. WLR spectrometer (laboratory calibration at K-engineering, Tokyo, JP)

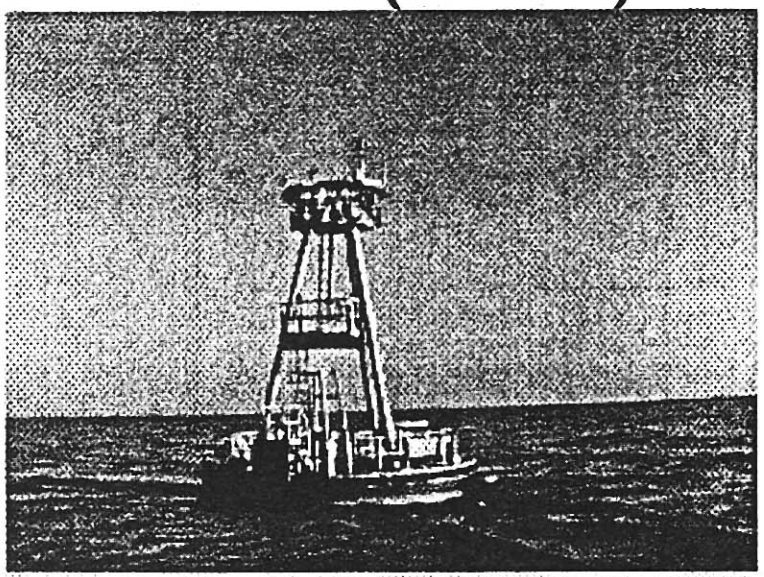
- 2 x measurement cycles (each 3 min) round 13:00 (local time) synchronized with TRIOS and (before/after) Freefall experiments.
- Sun from 90° to avoid shading and sun glitter; (except station 1)

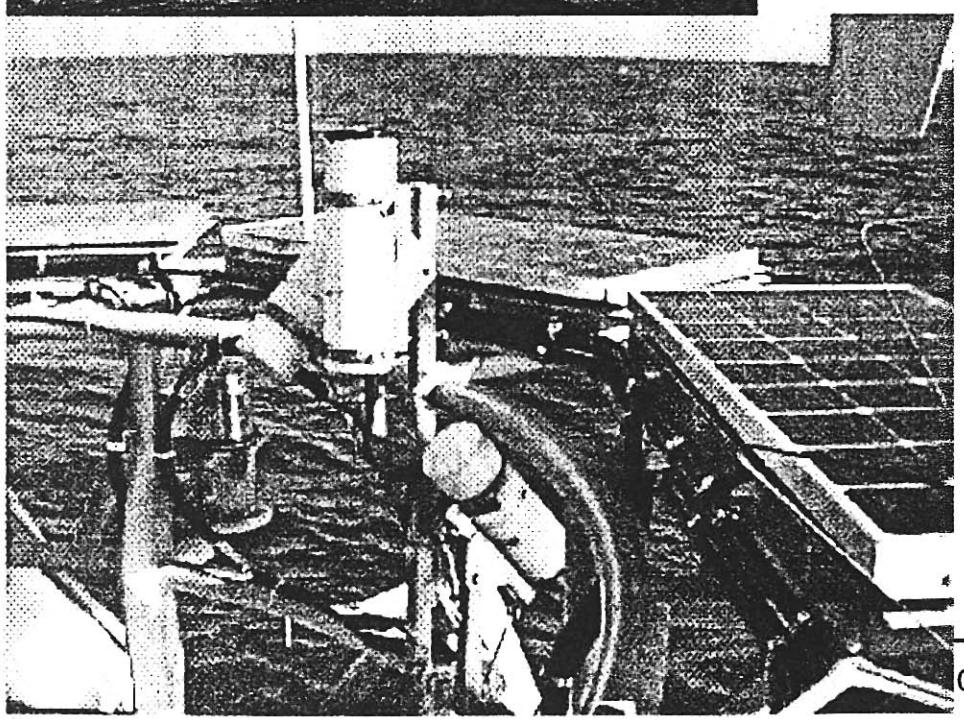
Date	Station	File in directory CD~ results /*.*	remarks
29 Oct. 2001	1	WLR_1.pdf	1st and 2nd cycle
30 Oct. 2001	3	WLR_2.pdf	1st and 2nd cycle
31 Oct. 2001	5	WLR_3.pdf	1st and 2nd cycle
1 Nov. 2001	6	WLR_4.pdf	1st and 2nd cycle
2 Nov. 2001	7	WLR_5.pdf	1st and 2nd cycle
4 Nov. 2001	11	WLR_6.pdf WLR_6_1.pdf	1st cycle 2nd cycle
6 Nov. 2001	Buoy	WLR_buoy pdf	1st and 2nd cycle

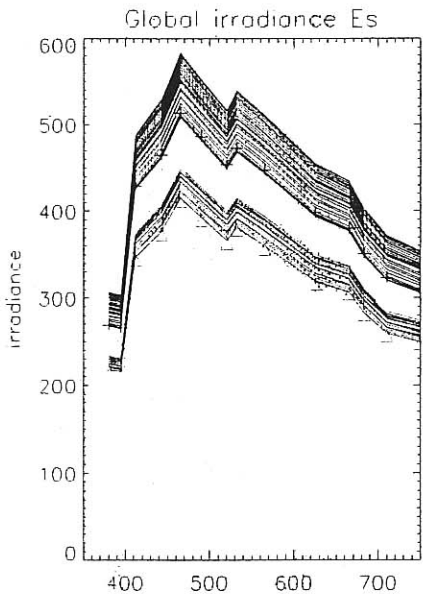
example: WLR 2800 (Nov. 4, Station 11, 1st cycle)

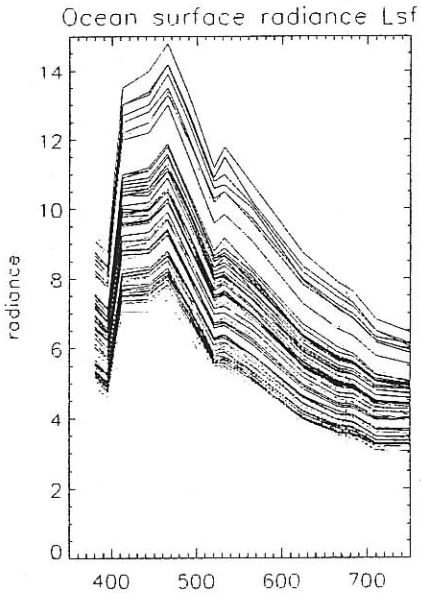


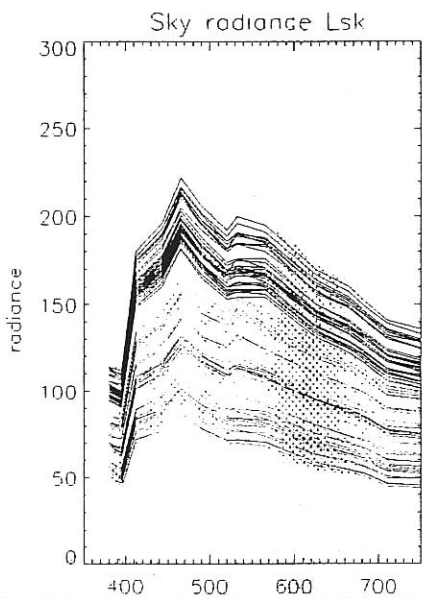
Example: WLR at buoy (Nov. 6)

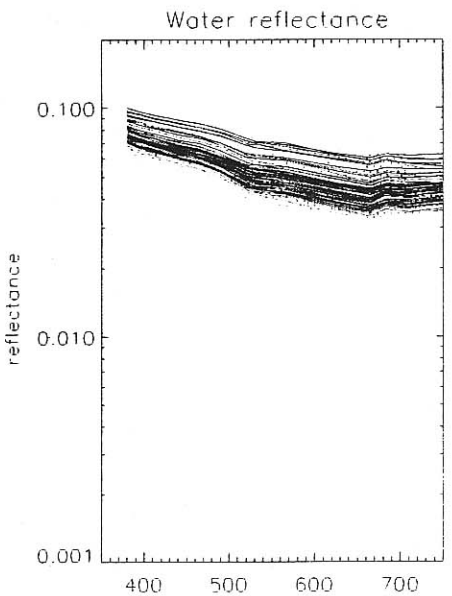












6 Nov 2001 Kaiyo at 03:00 -> 03:03 GMT (Plus sign) ; 01:30 -> 01:33 GMT (Triangle)
Buoy 24° 37.8N, 123° 27E ; WLR spectrometer : Es, Lsf, Lsk

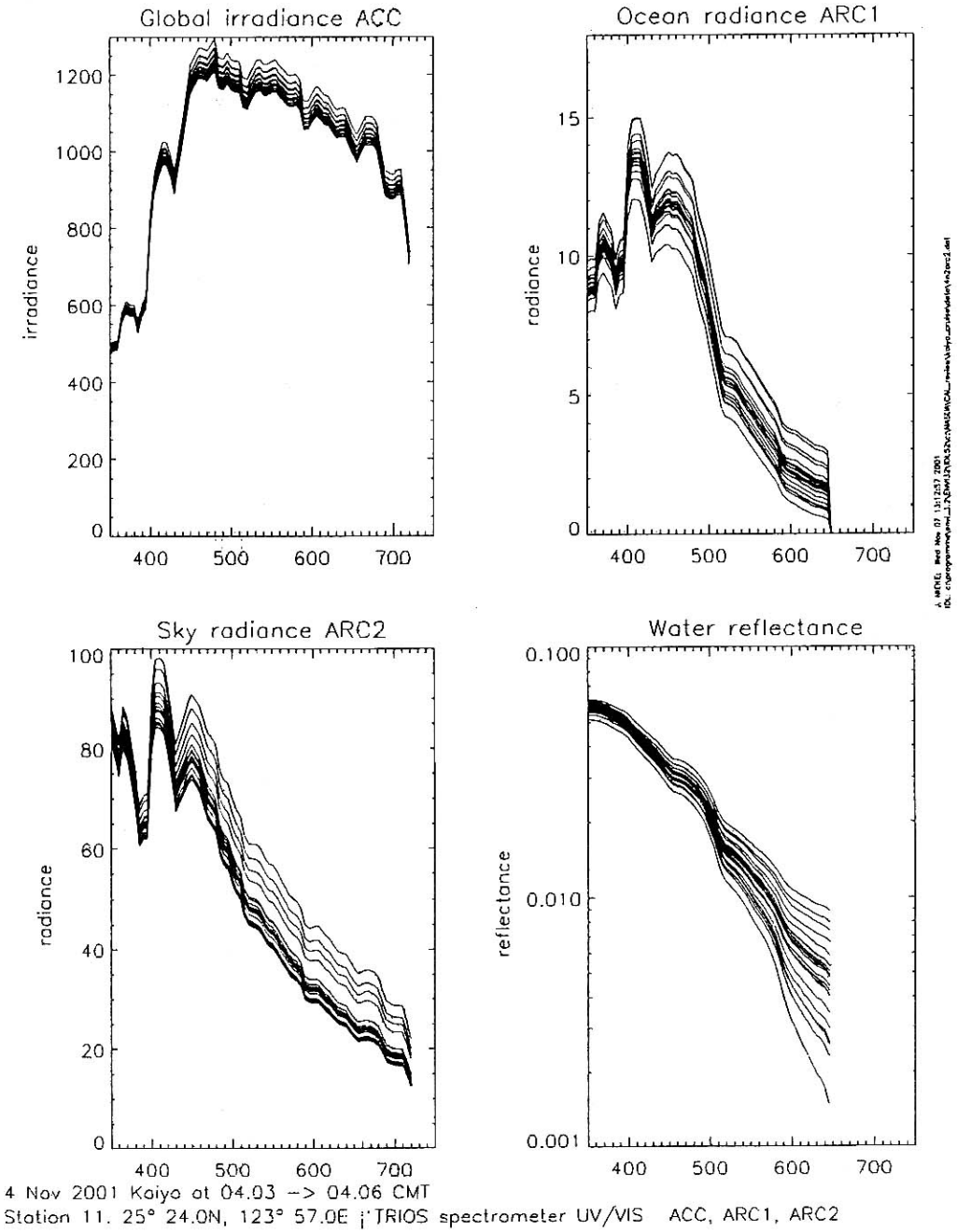
Preliminary results (2)

2. TRIOS spectrometer (laboratory calibration at TRIOS, Germany)

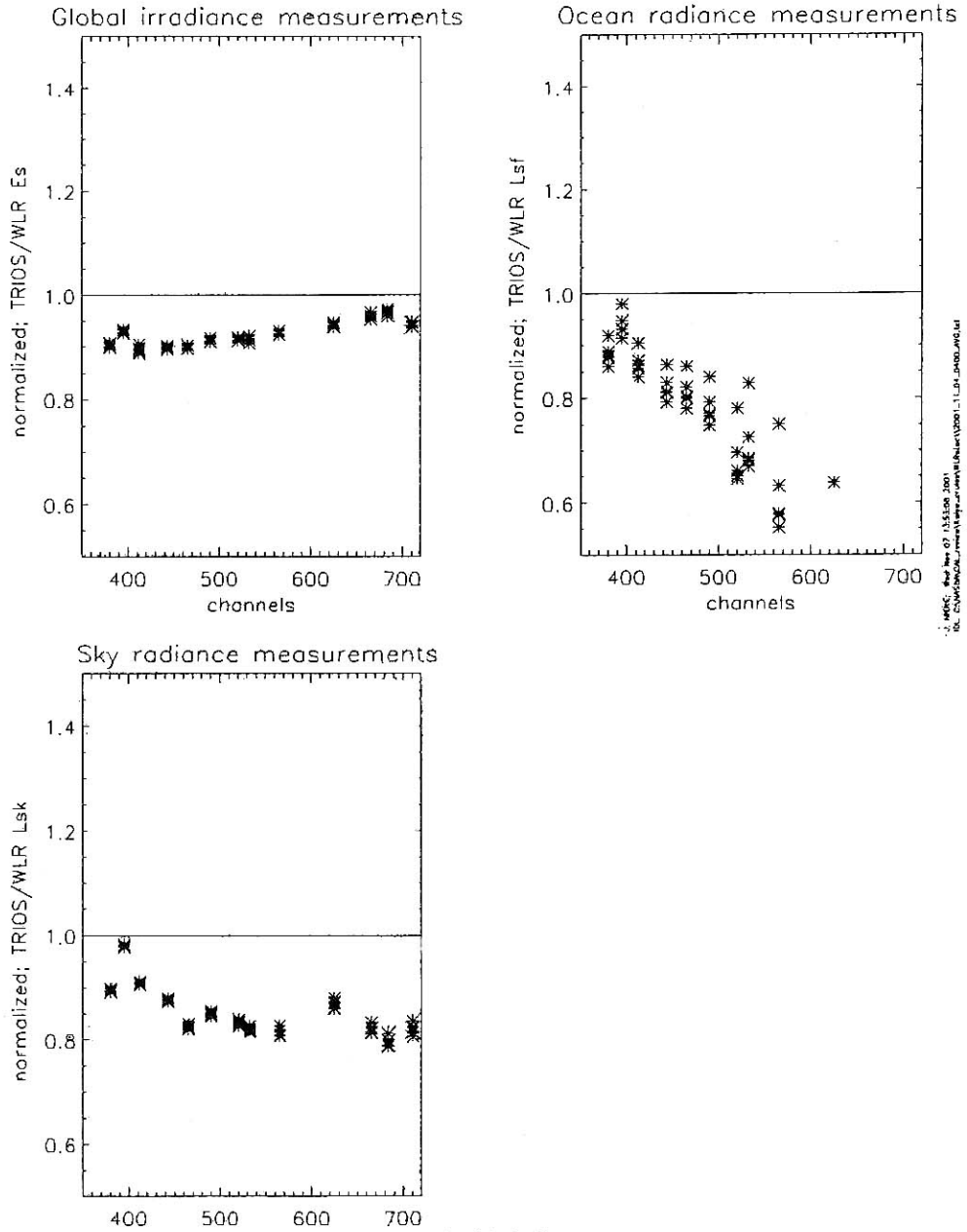
- 2 x measurement cycles (each 3 min) round 13:00 (local time) synchronized with WLR and (before/after) Freefall experiments.
- Sun from 90° to avoid shading and sun glitter; (except station 1)

Date	Station	File in directory CD~results/*.*	remarks
29 Oct. 2001	1	TRIOS _1.pdf	1st and 2nd cycle
30 Oct. 2001	3	TRIOS _2.pdf	1st and 2nd cycle
31 Oct. 2001	5	TRIOS _3.pdf	1st and 2nd cycle
1 Nov. 2001	6	TRIOS _4.pdf	1st and 2nd cycle
2 Nov. 2001	7	TRIOS _5.pdf	1st and 2nd cycle
4 Nov. 2001	11	TRIOS _6.pdf TRIOS _6_1.pdf TRIOS_6_d.pdf TRIOS_6_1d.pdf	1st cycle manually offset 2nd cycle man. Offset 1st cycle dynamic offset 2nd cycle dynamic offset
6 Nov. 2001	13	TRIOS _7.pdf	1st and 2nd cycle

example: TRIOS (Nov. 4, Station 11, 1st cycle)



Ratio: TRIOS/WLR (Nov. 4, Station 11, 1st cycle)

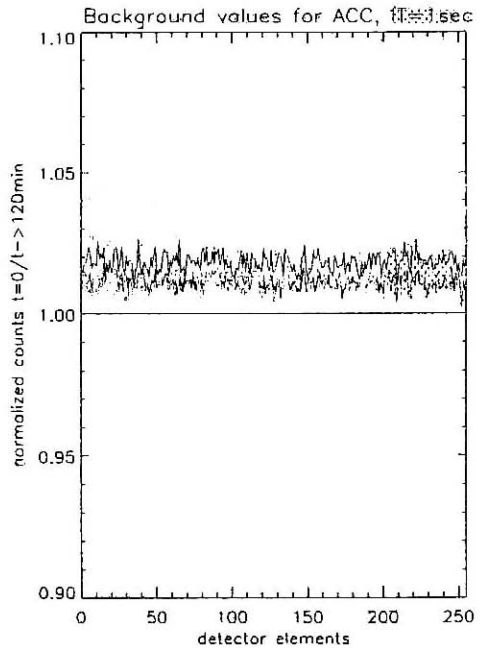


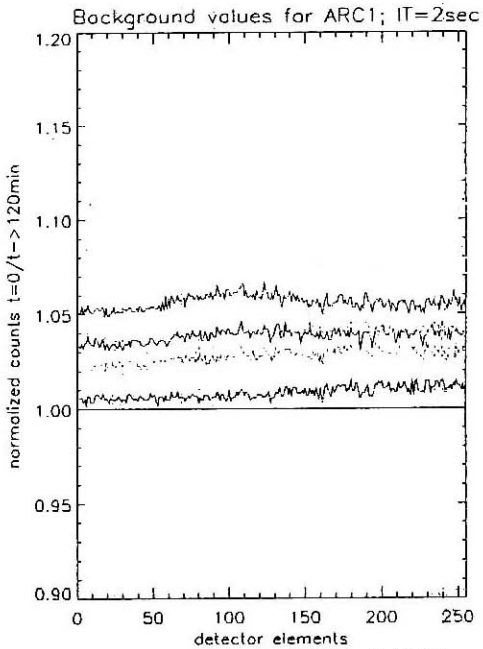
4 Nov 2001 Keiyo at not shown ; 04:00 --> 04:06 GMT
Station 11: 25° 24.0N, 123° 57.0E ; TRIOS spectr. UV/VIS: ACC, ARC1, ARC2 : WLR spectr Es, Lsf, Lsk

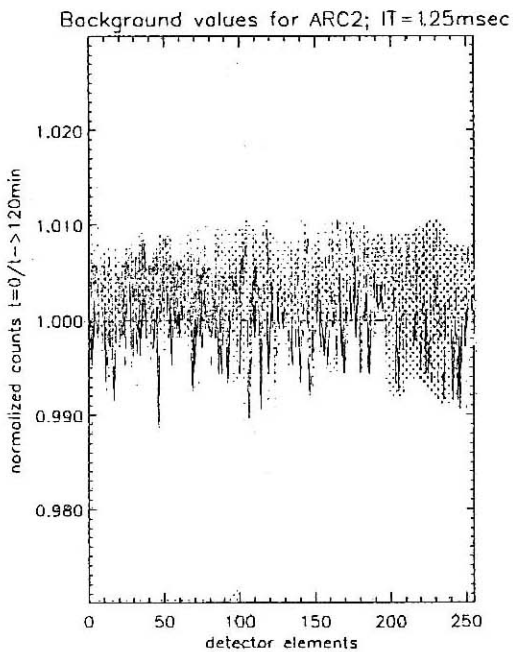
Preliminary results (3)

3. Hardware related tests

- Temperature dependency
- Integration time tests
- Spectral reflectance measurements various materials







t=0 min, T=23.5°
t=5
t=10
t=15
t=20
t=25
t=30 , T=23.1°
t=45 , T=23.0°
t=60 , T=22.9°
t=90 , T=22.6°
t=120, T=22.5°
t=300, T=22.0°

3 Nov 2001 Koiyo

dark measurements during cruise

TRIOS spectrometer UV/VIS

ACC, ARC1, ARC2

07:00 -> 12:00 GMT

Conclusion (1)

KY01-09 gave a good opportunity to perform a first round-robin experiment

- First measurements were performed
- Absolute: WLR is always [redacted] positive / TRIOS [redacted] negative $\Delta L \sim 10\%$ for $Ed(\lambda)$ measurements
- Relative: Reasonable good results in the VIS
- ... but significant differences in the NIR => re-think about calibration settings, FOV, etc.
- Hardware seems to be reliable (e.g. temperature dependencies checked)

Conclusion (2)

Suggestions for future campaigns:

- Global solar irradiance, Ed(λ) sensor at higher position on ship to avoid reflectance from antenna
- Re-calibration of the TRIOS spectrometer with WLR cal-source at K-Engineering
- Understanding of the under-/overestimation of the spectrometer
- Include other (well-calibrated) spectrometer in the round-robin campaign.....?