Surface Energy Fluxes over the Eastern North Pacific Measured during MAGIC

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Atmospheric System Research (ASR) Program

Atmospheric Radiation Measurement (ARM) Program

Importance of Surface Fluxes

Surface fluxes provide important (and often dominant) contributions to energy and moisture in the MBL.

Surface fluxes are controlling factors for the dynamics of the MBL and for cloud formation.

Surface fluxes are boundary conditions for models.

Surface Fluxes during MAGIC

1-minute time series of surface energy fluxes during MAGIC are available on the ARM archive

Two data files are available: "flux.mat" and "magic_flux.txt"
To access these data,

1) go to www.arm.gov/campaigns/amf2012magic
2) go to "Bulk Aerodynamic Fluxes" under "Campaign Data Sets"
3) click "Order Data"

Be sure to read the file "magic_flux_readme_arm.txt" which is also in the archive, and the document "OnDataProcessing" at www.rmrco.com/cruise/magic/data/OnDataProcessing/

Sea-Air Fluxes (watch sign conventions!)

$$H_{net}(\uparrow=+) = (H_{sens}+H_{lat}) - (R_{sw\downarrow}-R_{sw\uparrow}) - (R_{lw\downarrow}-R_{lw\uparrow}) + H_{rain}$$

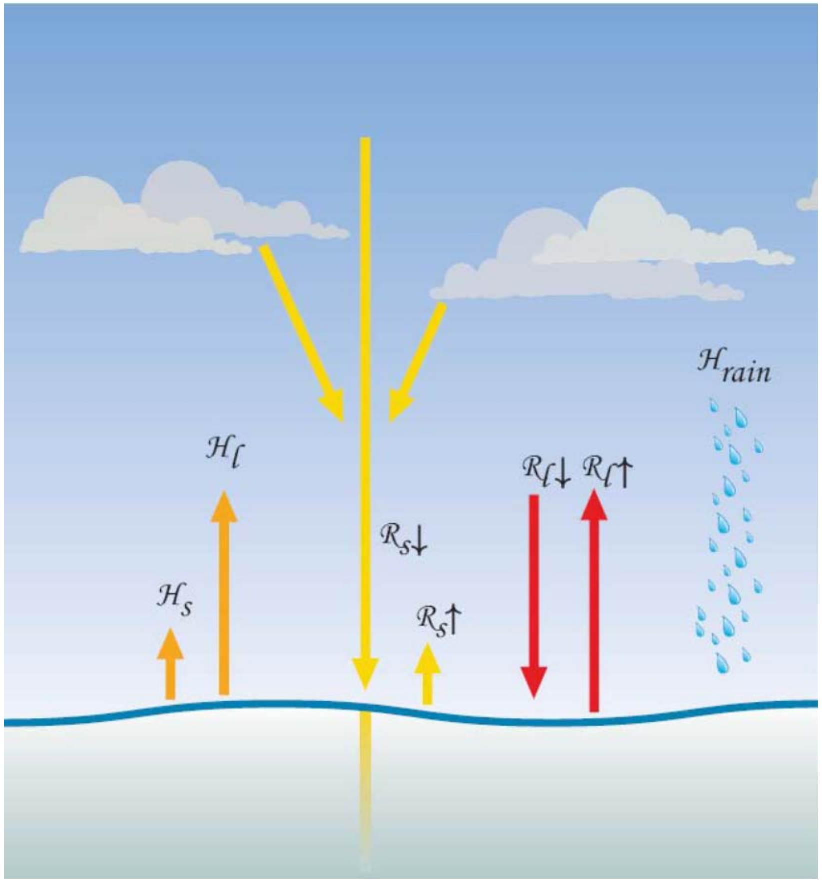
H_{net}: net heat flux

H_{sens}: sensible heat flux
H_{lat}: latent heat flux

$R_{sw\downarrow}$: SW downwelling irradiance
$R_{sw\uparrow}$: SW upwelling irradiance

$R_{lw\downarrow}$: LW downwelling irradiance
$R_{lw\uparrow}$: LW upwelling irradiance

H_{rain}: heat from rain at $T \neq T_{surf}$



Adapted from Fairall and Bradley, 2006

Bulk Aerodynamic Method

H_{sens} and H_{lat} are calculated using the TOGA-COARE algorithm, with the following measured quantities as inputs:

- U_{10} (wind speed)
- T_{air} (air temperature)
- SSST (sea surface skin temperature)
- RH (relative humidity)

$$H_{sens} = \rho_{air}\, C_{p,air}\, C_H\, (U_{10} - U_{sea}) * (\Theta_{surf} - \Theta)$$

$$\Theta \approx T + 0.01z \text{ (for z in meters)}$$

$$H_{lat} = \rho_{air}\, L_w\, C_E\, (U_{10} - U_{sea}) * (q_{surf} - q)$$

$$q_{surf} = 0.98\, q_{sat}(T_{surf})$$

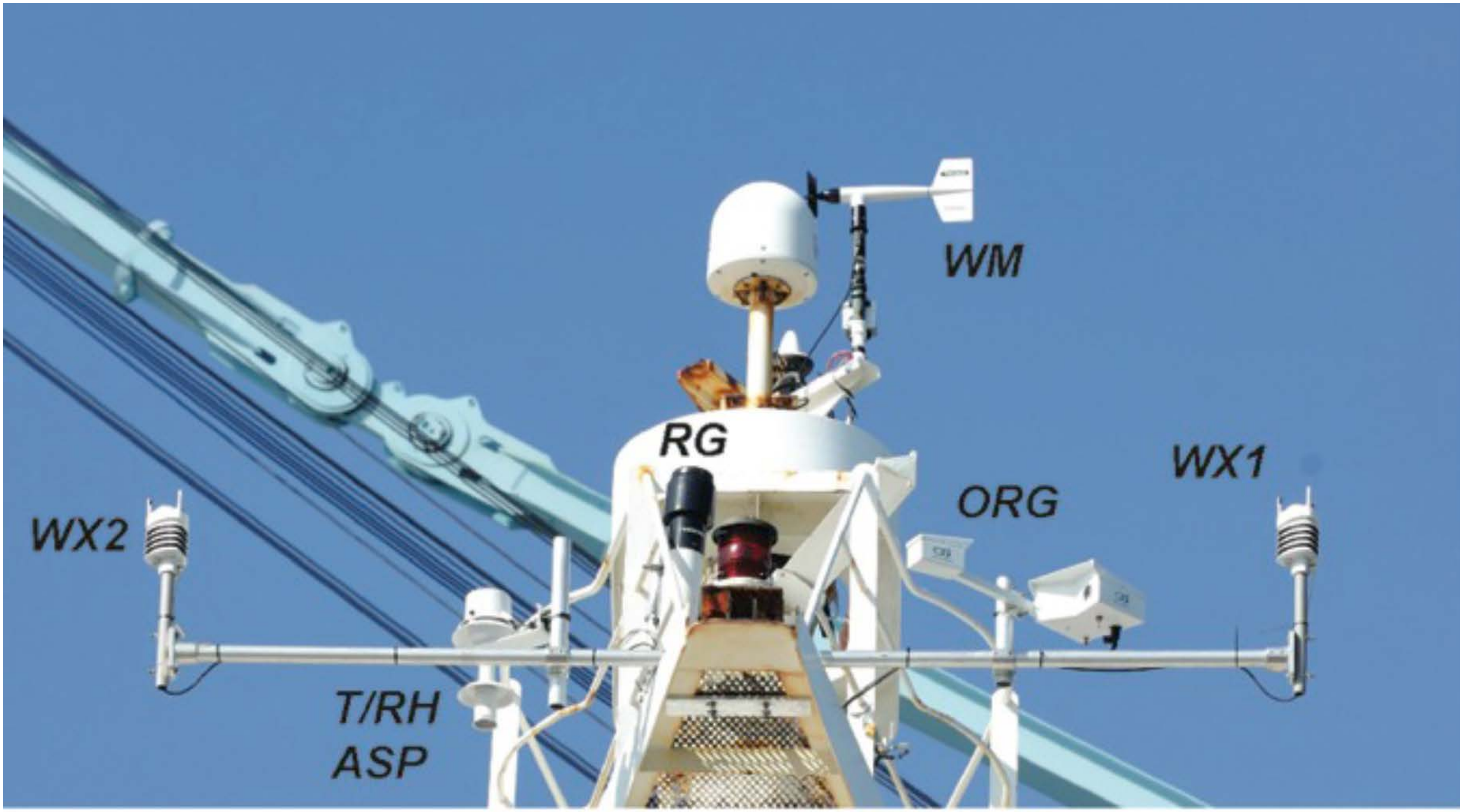
$$q = (RH/100)\, q_{sat}(T)$$

$C_H \approx C_E \approx 0.001$, with little U_{10} dependence (for neutral stability)

Meteorological Measurements

The meteorological mast is ~27 m above sea level.

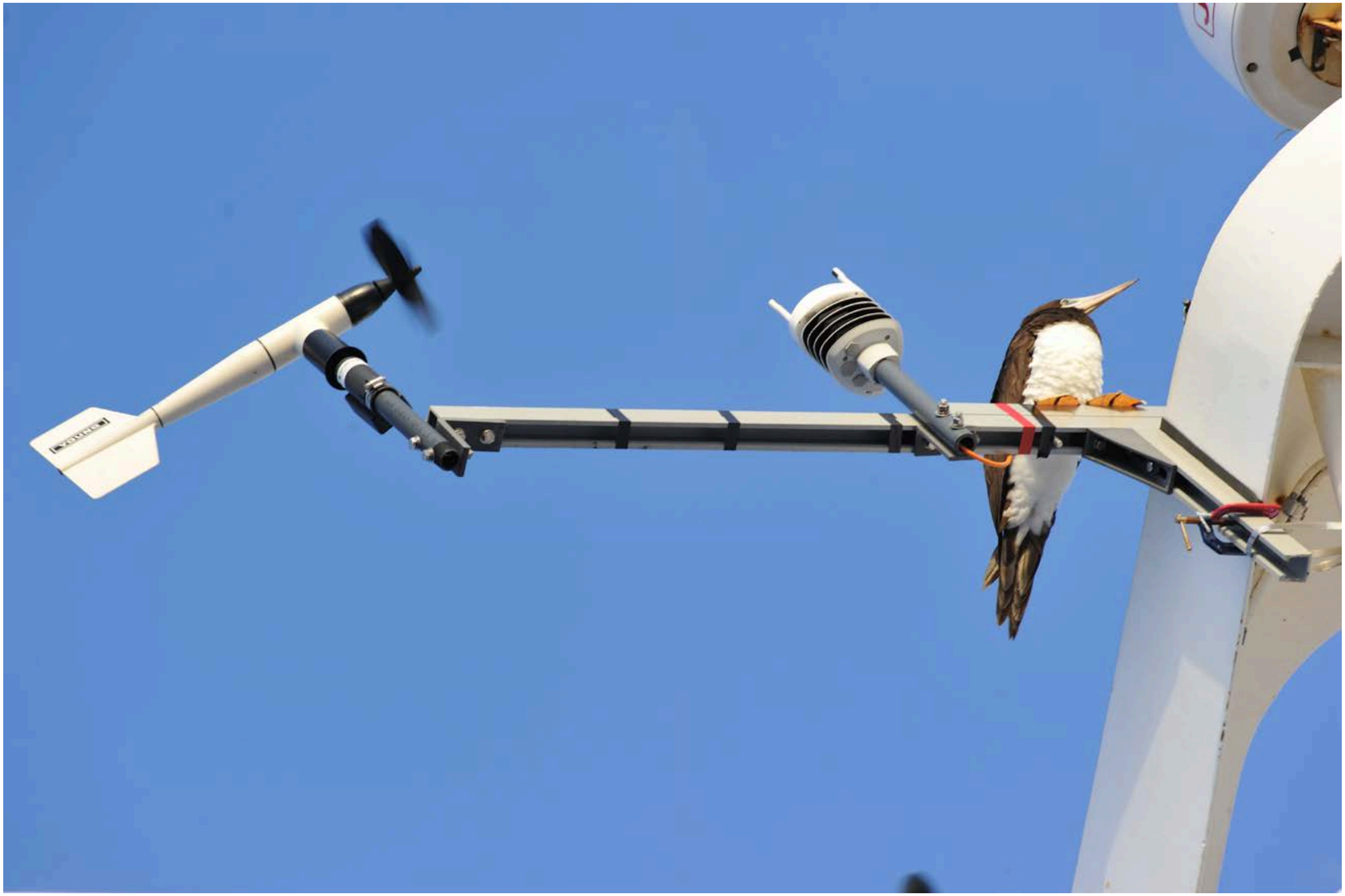
Meteorological Measurements



WX1, WX2 = Vaisala WXT520 (ws,wd,ta,rh,bp,ri)
RG = Young 50203 Siphon Rain Gauge
WM = Young 05106 Wind Monitor
T/RH = Vaisala HMP155, ASP = Aspirator
ORG = OSI Optical Rain Gauge

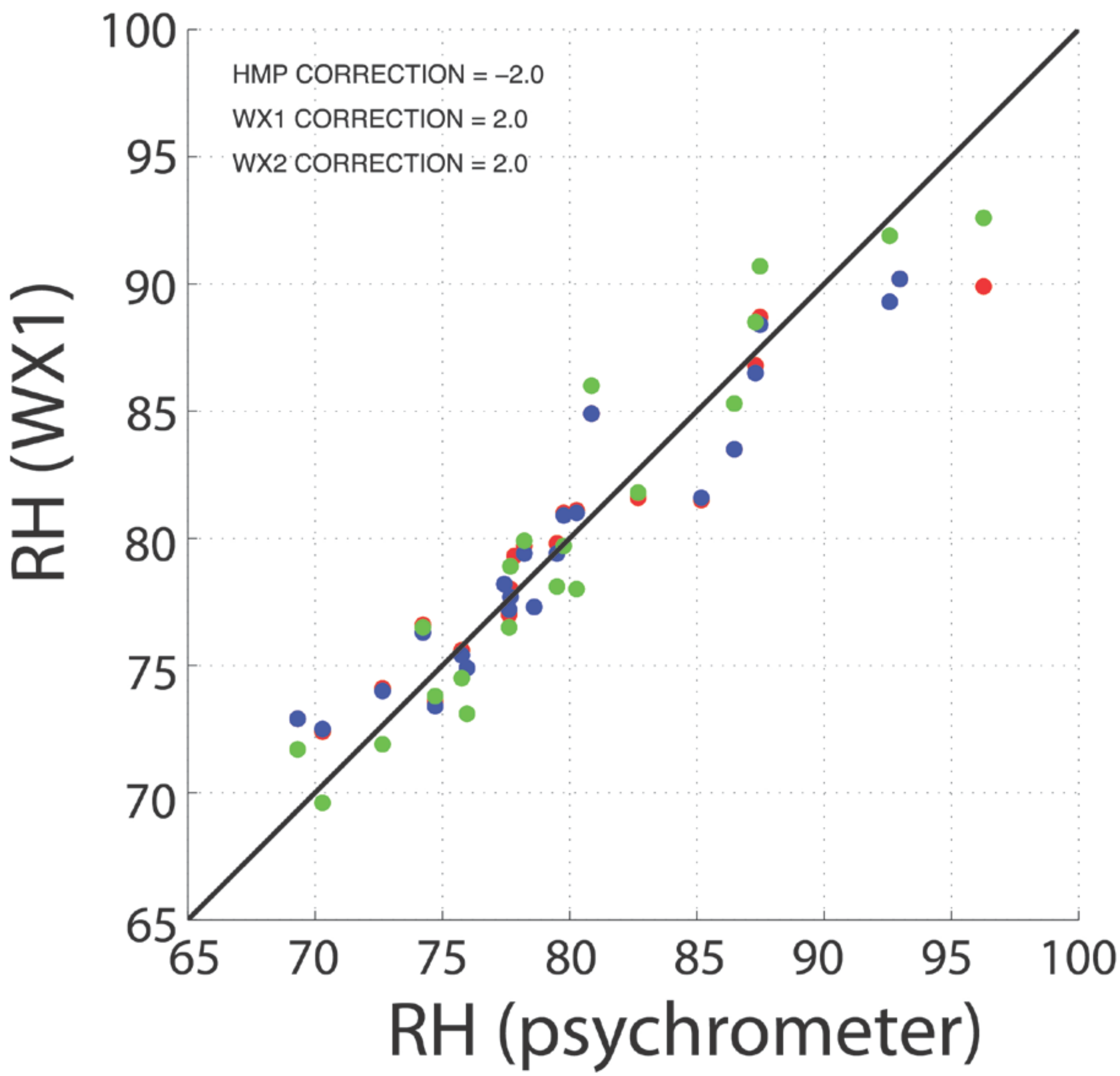
met-boom

Meteorological Measurements

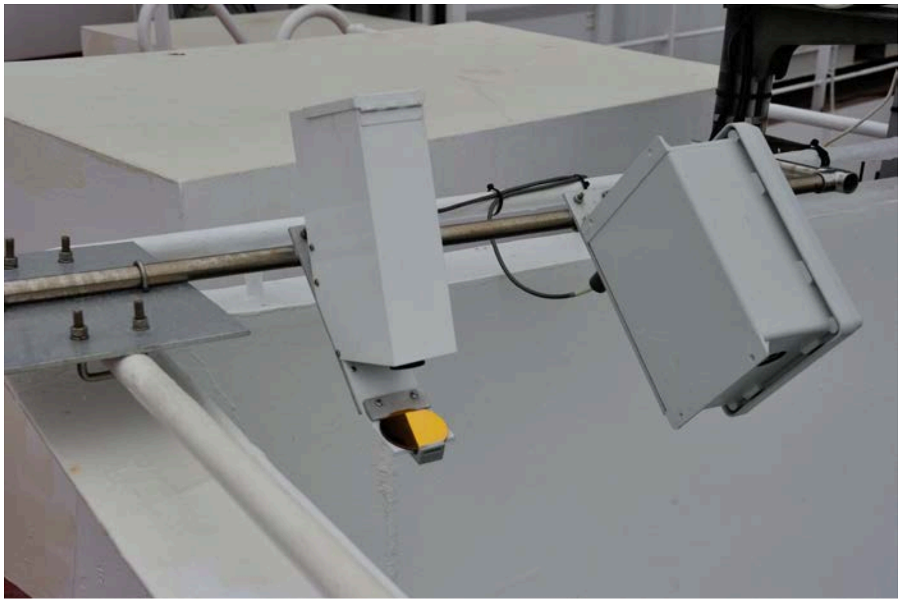


Meteorological Measurements

RH Calibration with Psychrometer



Sea Surface Temperature

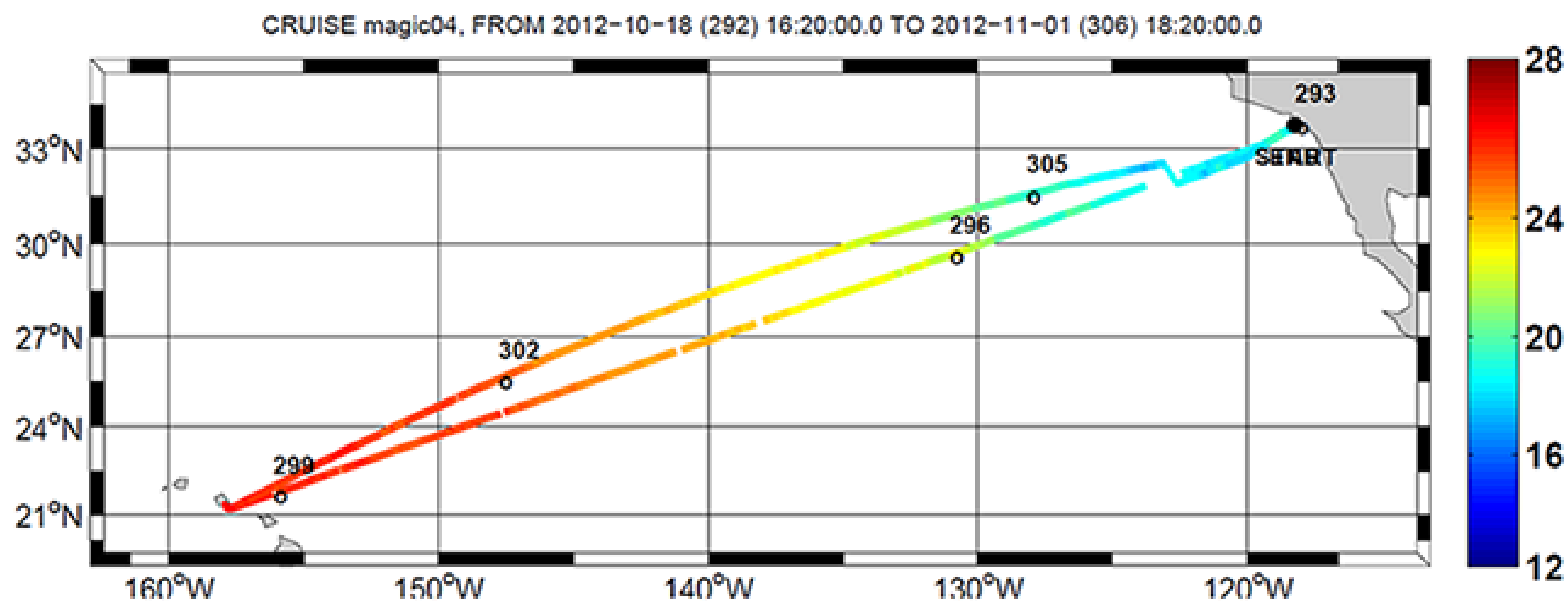

IRT


ISAR

IRT (Wintronics): Heitronics KT19.85 Infrared Radiation Pyrometer
ISAR – Infrared Sea Surface Temperature Autonomous Radiometer

Both detect in the 9.6-11.5 μm window.

Sea Surface Temperature



Leg04 (2012-10-18 to 2012-11-01)

Radiometric Fluxes

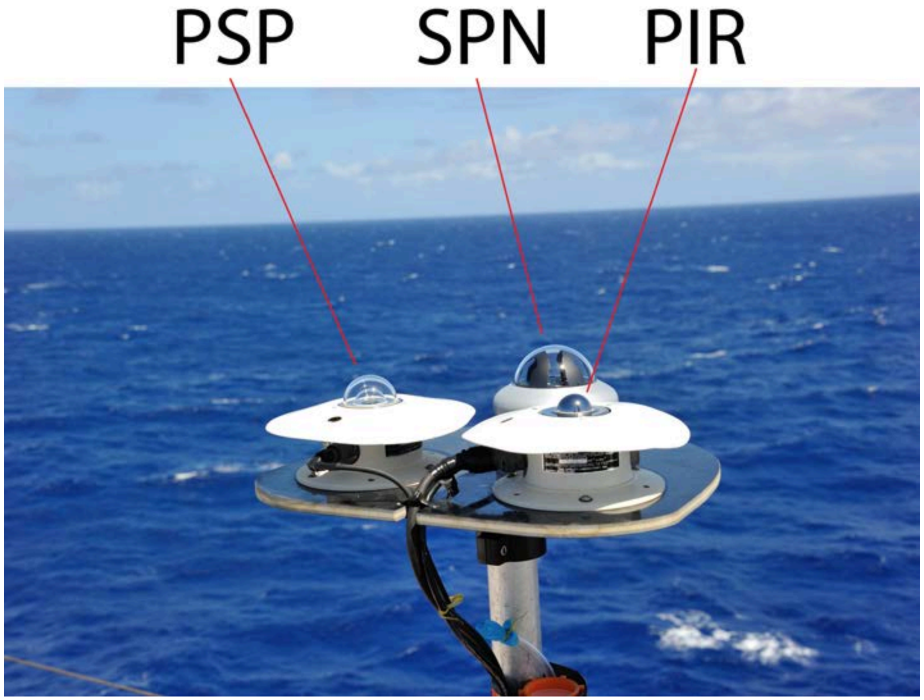
$R_{sw\downarrow}$: measured with Precision Spectral Pyranometer (PSP)

$R_{sw\uparrow}$: calculated from $R_{sw\downarrow}$, sea surface albedo, solar angle

$R_{lw\downarrow}$: measured with Precision Infrared Radiometer (PIR)

$R_{lw\uparrow}$: calculated from measured SSST, sea surface emissivity

Radiation Measurements



Portable Radiation Package (PRP)

PRP with FRSR

Precision Spectral Pyranometer (PSP) – downwelling broadband, 0.285-2.8 μm

Precision Infrared Radiometer (PIR) – downwelling broadband, 4-50 μm

Sunshine Pyranometer (SPN1) – total and diffuse irradiance

Fast Rotating Shadowband Radiometer (FRSR)

- 10 nm wide channels at 415, 500, 680, 870, and 940 nm
- direct normal irradiance, diffuse irradiance, total irradiance; also AOT

H_{rain} calculated from measured rainfall rates

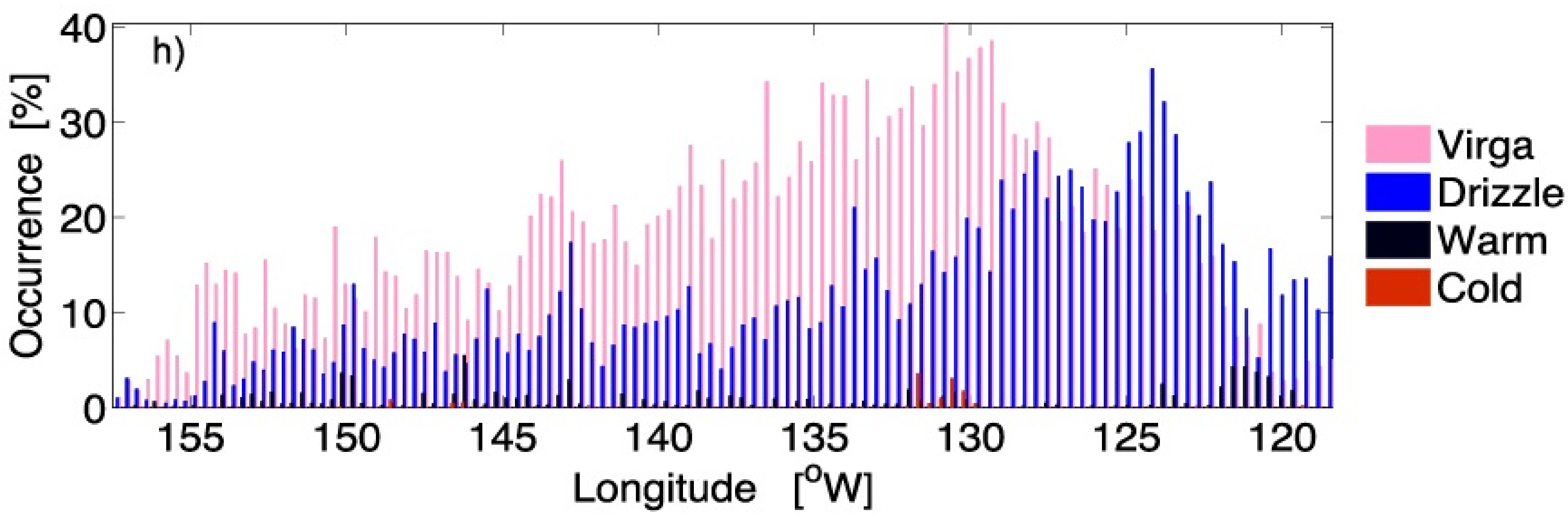
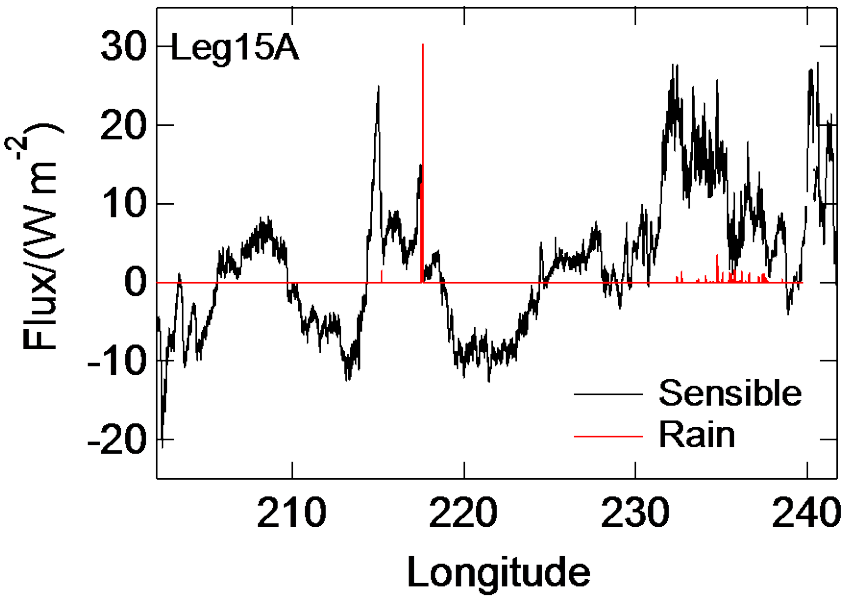
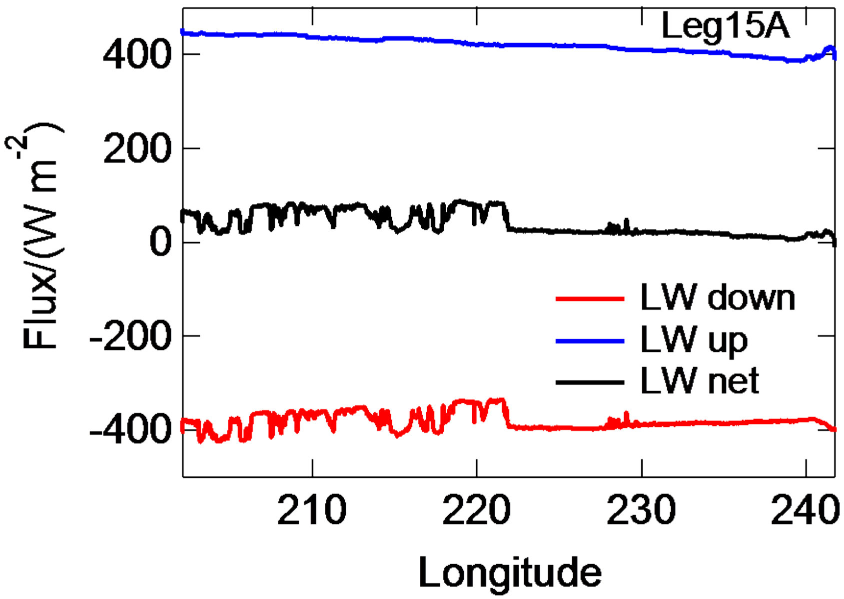
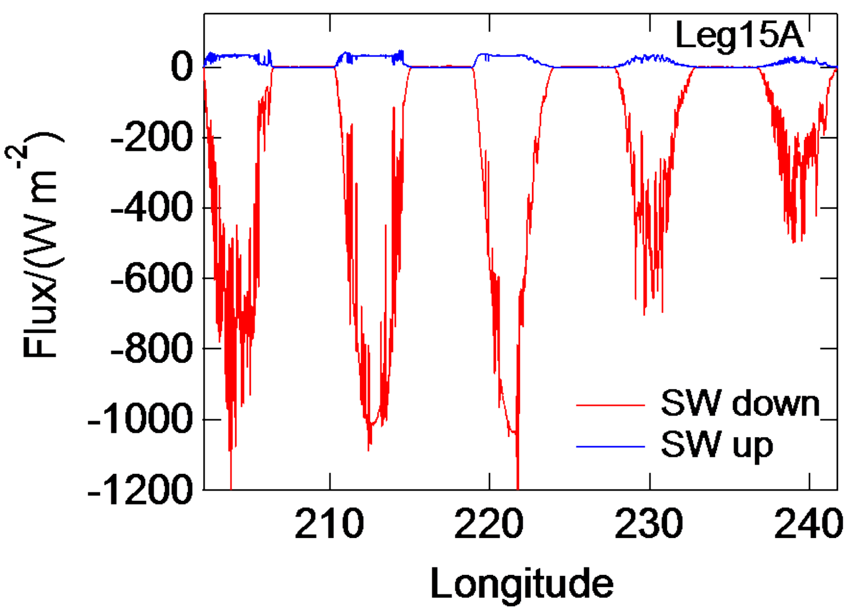


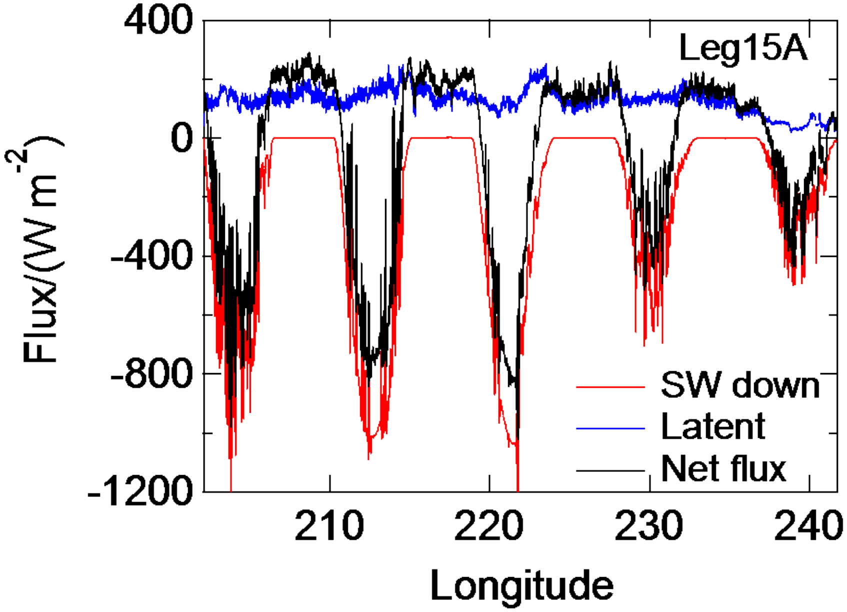
Figure from Xiaoli Zhou, McGill University

Leg15A (2013-07-20 to 2013-07-25) Fluxes

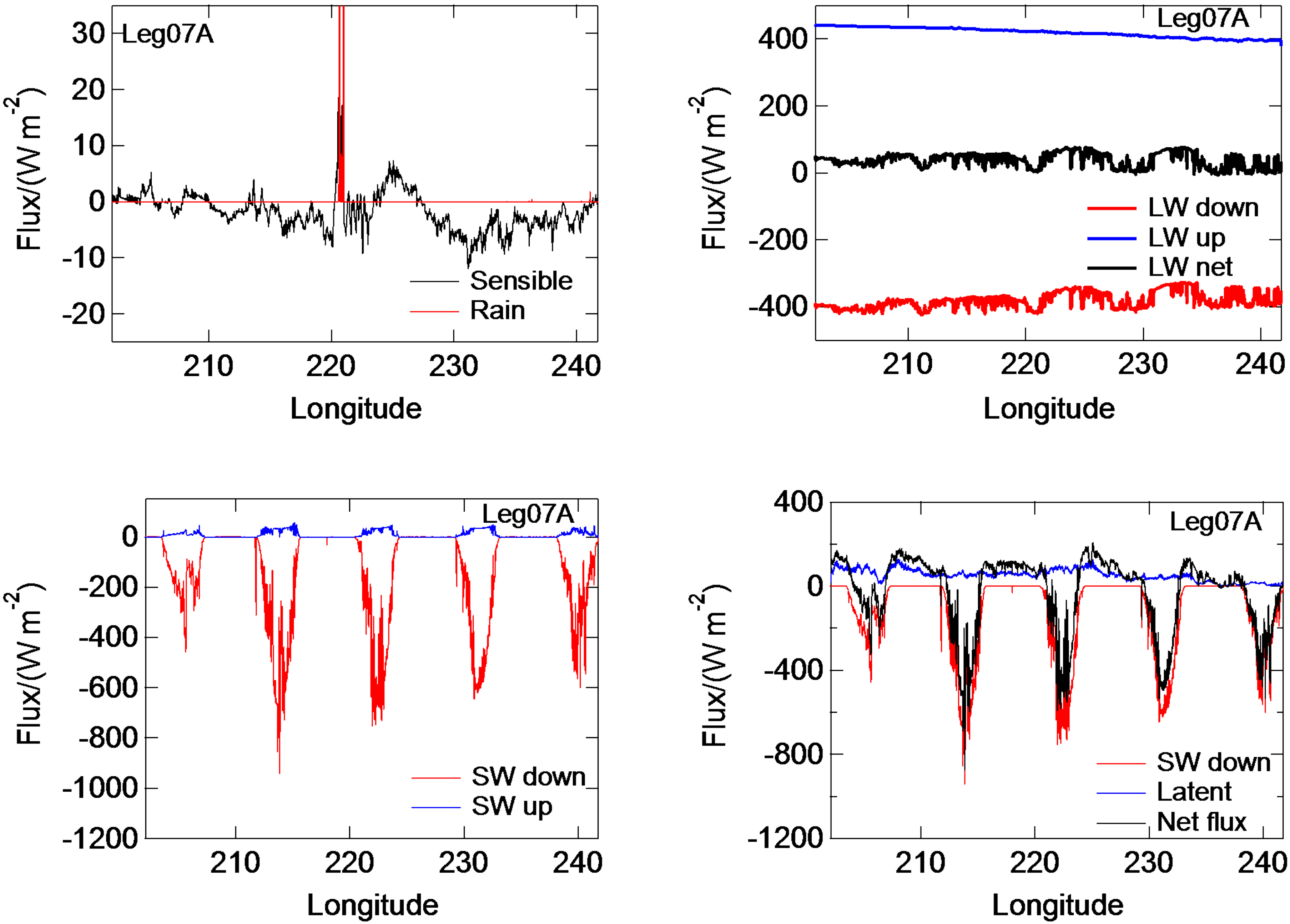








Leg07A (2012-12-01 to 2012-12-06) Fluxes



Sea-Air Fluxes (up = +)

	Overall (n ≈ 200,000)		Leg15A (n ≈ 6,800)		Leg07A (n ≈ 6,900)
Rain	1.5 ± 14		0.03 ± 0.5		0.04 ± 1
Sensible	7 ± 10		2 ± 8		-2 ± 3
Latent	114 ± 58		128 ± 42		52 ± 28
LW_{up}	420 ± 18		421 ± 17		419 ± 15
LW_{down}	-377 ± 26		-382 ± 18		-381 ± 23
LW_{net}	46 ± 25		40 ± 25		38 ± 22
SW_{up}	11 ± 14		12 ± 14		9 ± 13
SW_{down}	-210 ± 302		-241 ± 317		-123 ± 189
SW_{net}	-200 ± 291		-229 ± 305		-114 ± 177
Net	-31 ± 292		-61 ± 305		-25 ± 178

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Issues

Possible sampling bias (day/night sampling might not be equal)

Moving target – days start and stop at different locations and
length of day changes as ship moves

Conclusions

H_{net} is generally downward, but with large variability

H_{sens} provides only a very minor component

H_{lat} is a major (upward) component, summer larger than winter

$R_{sw\downarrow}$ is large and downward, but with large diurnal variability and distinct longitudinal patterns (due to clouds)

$R_{sw\uparrow}$ provides only a minor contribution

$R_{lw\downarrow}$ is largest downward component, but nearly cancelled by $R_{lw\uparrow}$ such that $R_{lw,net}$ is upward but small

H_{rain} is quite variable but very small

Thank you!