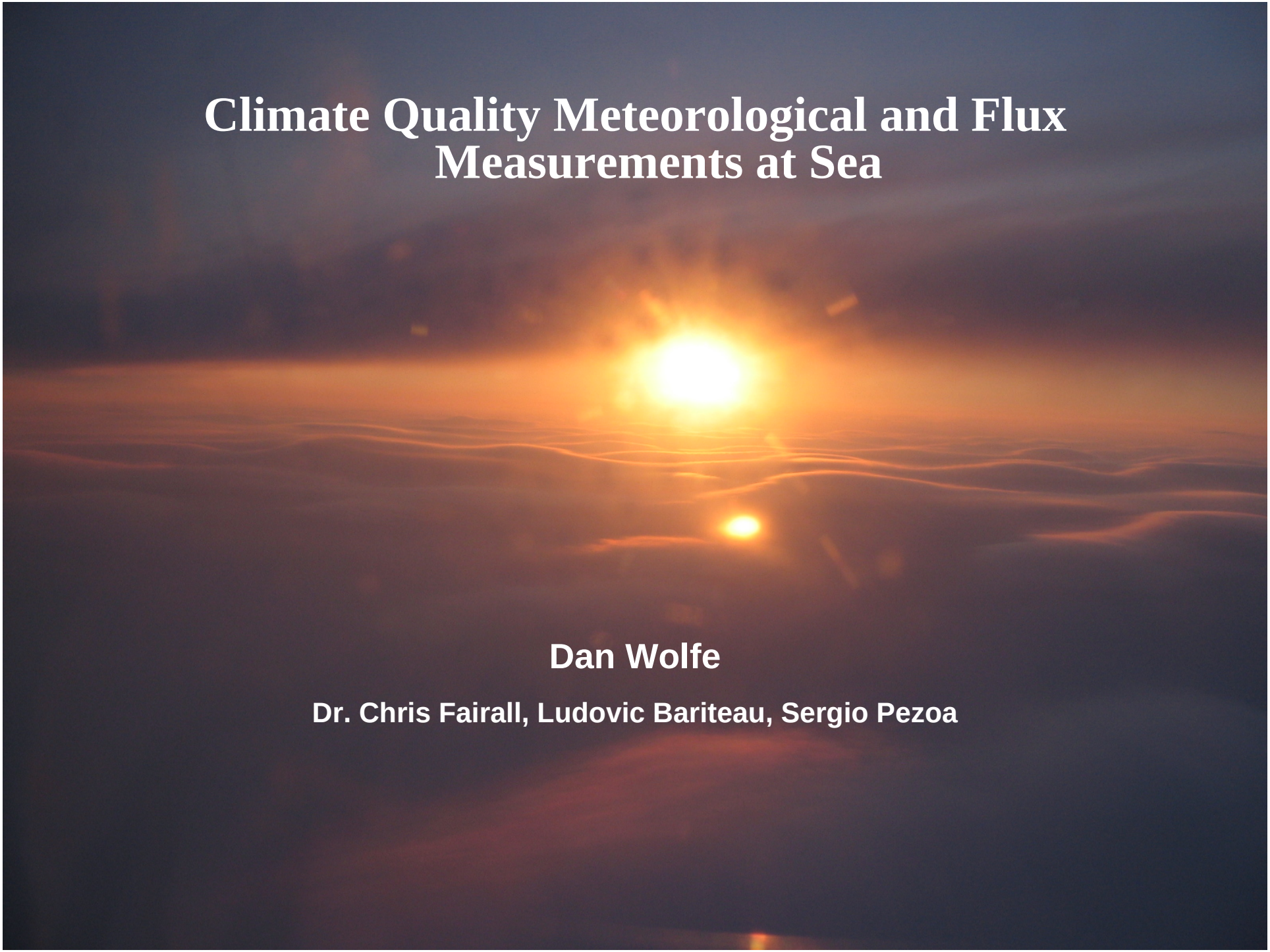


Climate Quality Meteorological and Flux Measurements at Sea

Dan Wolfe

Dr. Chris Fairall, Ludovic Bariteau, Sergio Pezoa

NOAA

Earth Systems Research Laboratory
Physical Sciences Division

Boulder, Colorado

Weather and Climate Physics
Boundary Layer Processes
Polar Observations and Processes/Boulder Atmospheric Observatory

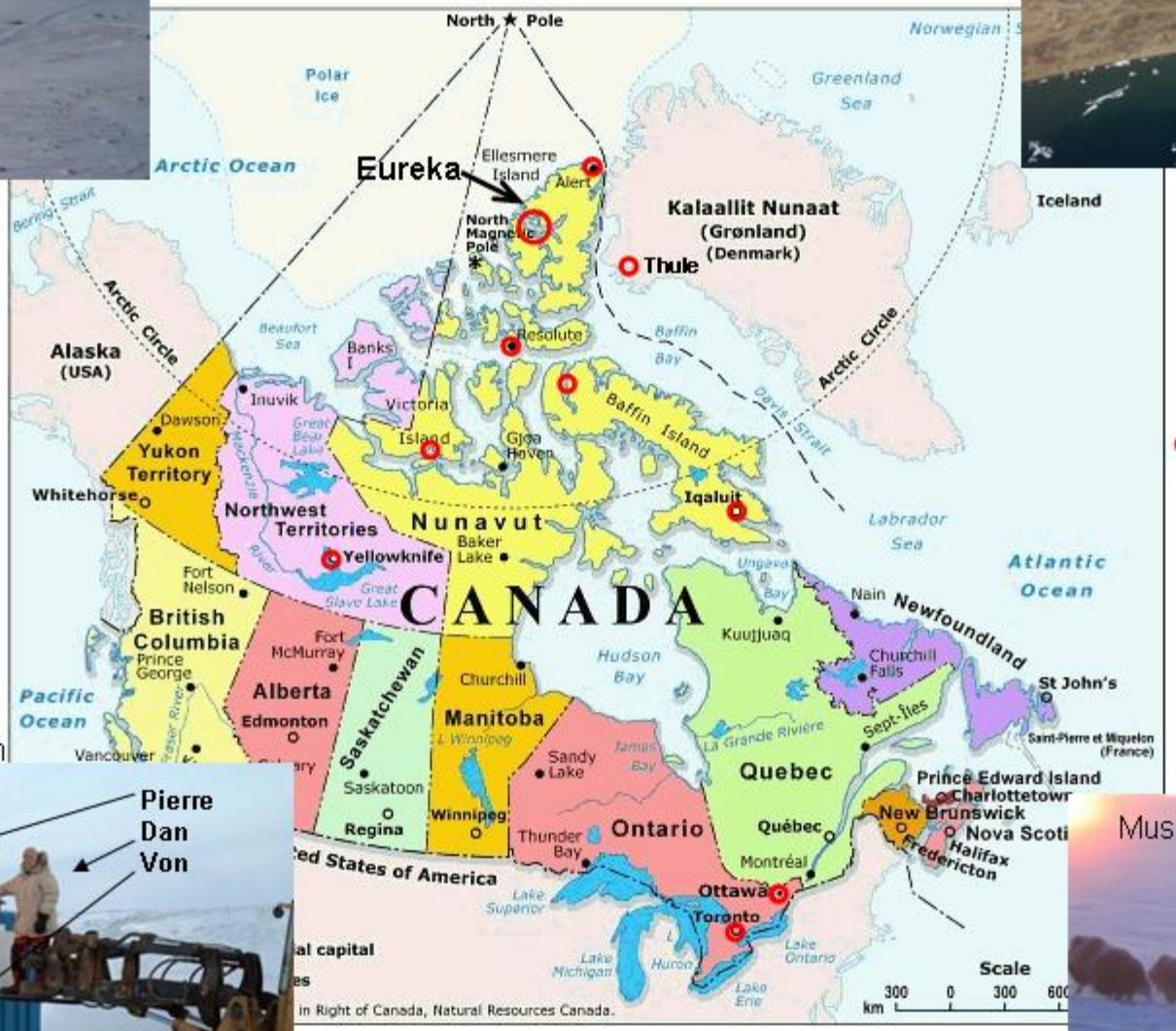
BAO 300m tower

LEADEX 1991 Arctic Ocean

Mt Washington 2001

South Pole 1993

Eureka, Canada 2006



Plane hops!!

Equipment Installation

Coupled Air-Sea models were sensitive to small changes in air-sea fluxes.

Accuracy goal of +/- 10 Wm^{-1} in short to medium time scales

TOGA-COARE measurements fell short

Problems traced to poor ship measurements

Instrument: location, knowledge, calibration

High-Resolution Marine Meteorology Workshop FSU 2003

Produce manual: online with standards

Dr. Chris Fairall NOAA/Earth Systems Research Laboratory
Dr Frank Bradley CSIRO Division of Land and Water (retired)
A Guide to Making Climate Quality Meteorological and Flux Measurements at Sea

"Climate Quality" Weller 2005

ftp://ftp.etl.noaa.gov/user/cfairall/wcrp_wgsf/flux_handbook/fluxhandbook_NOAA-TECH%20PSD-311v3.pdf

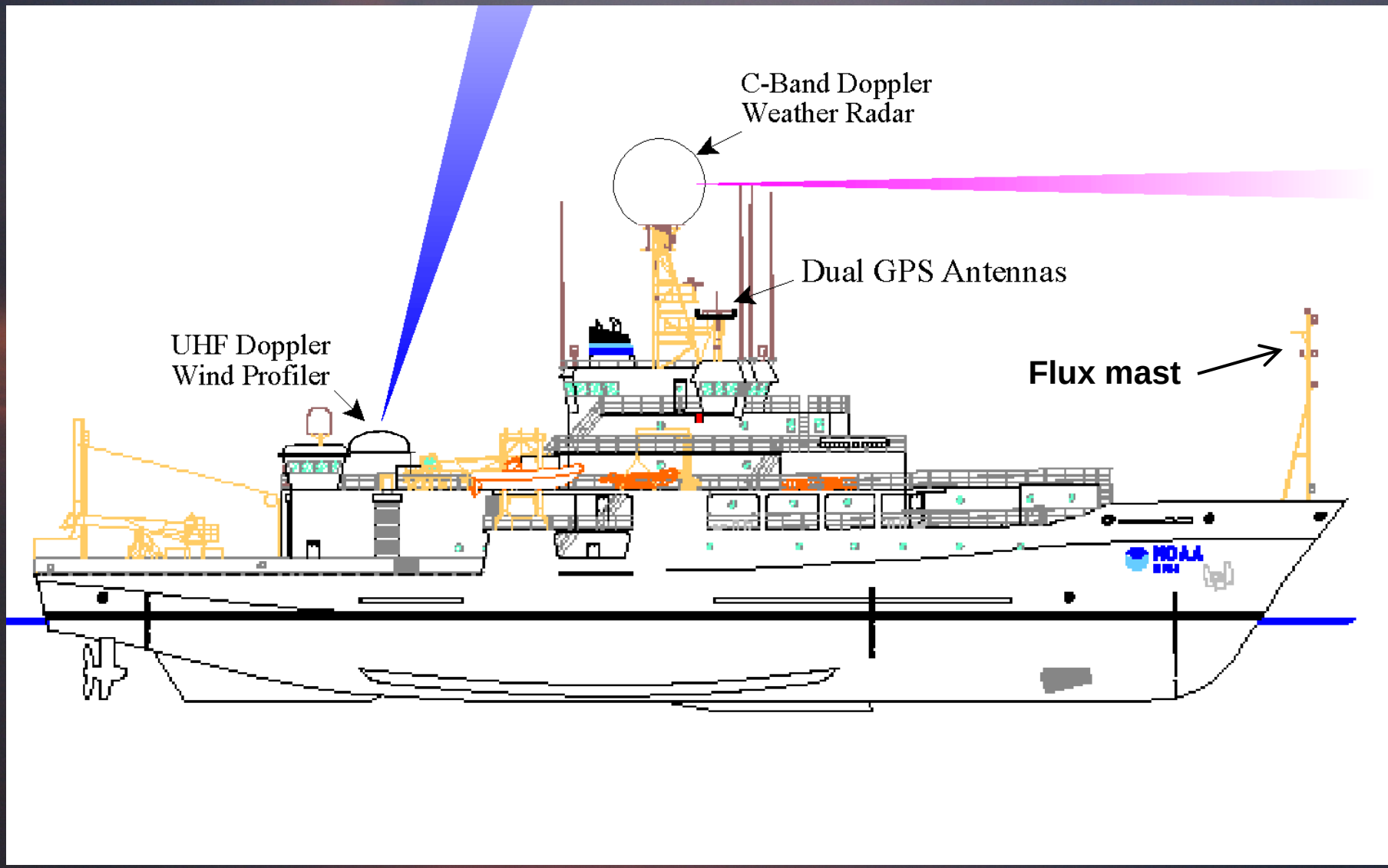
Key Measurements

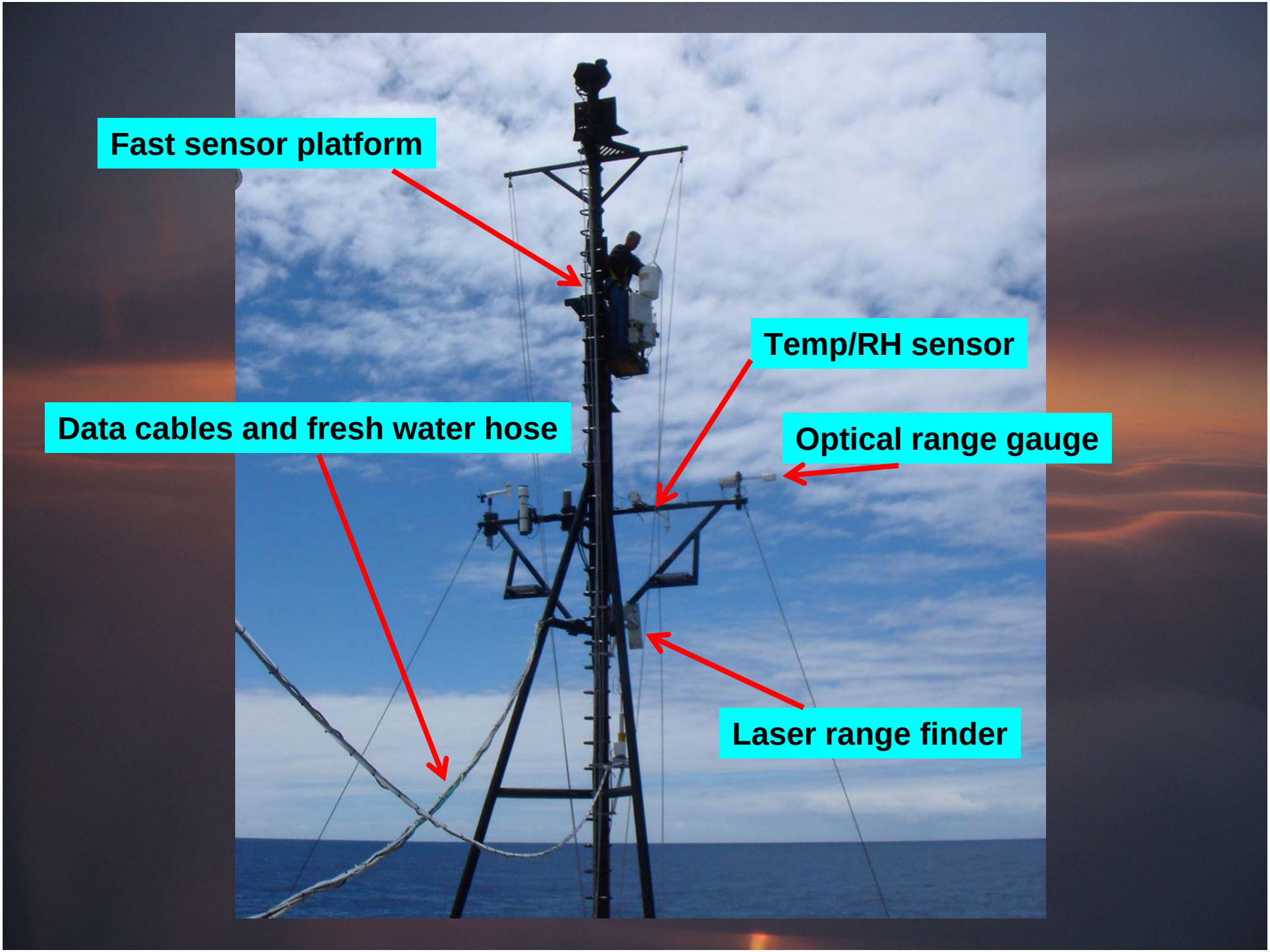
Wind speed and direction
Air temperature and RH
Sfc pressure
Downward SW/LW radiation
Rain rate
SST
Motion sensors

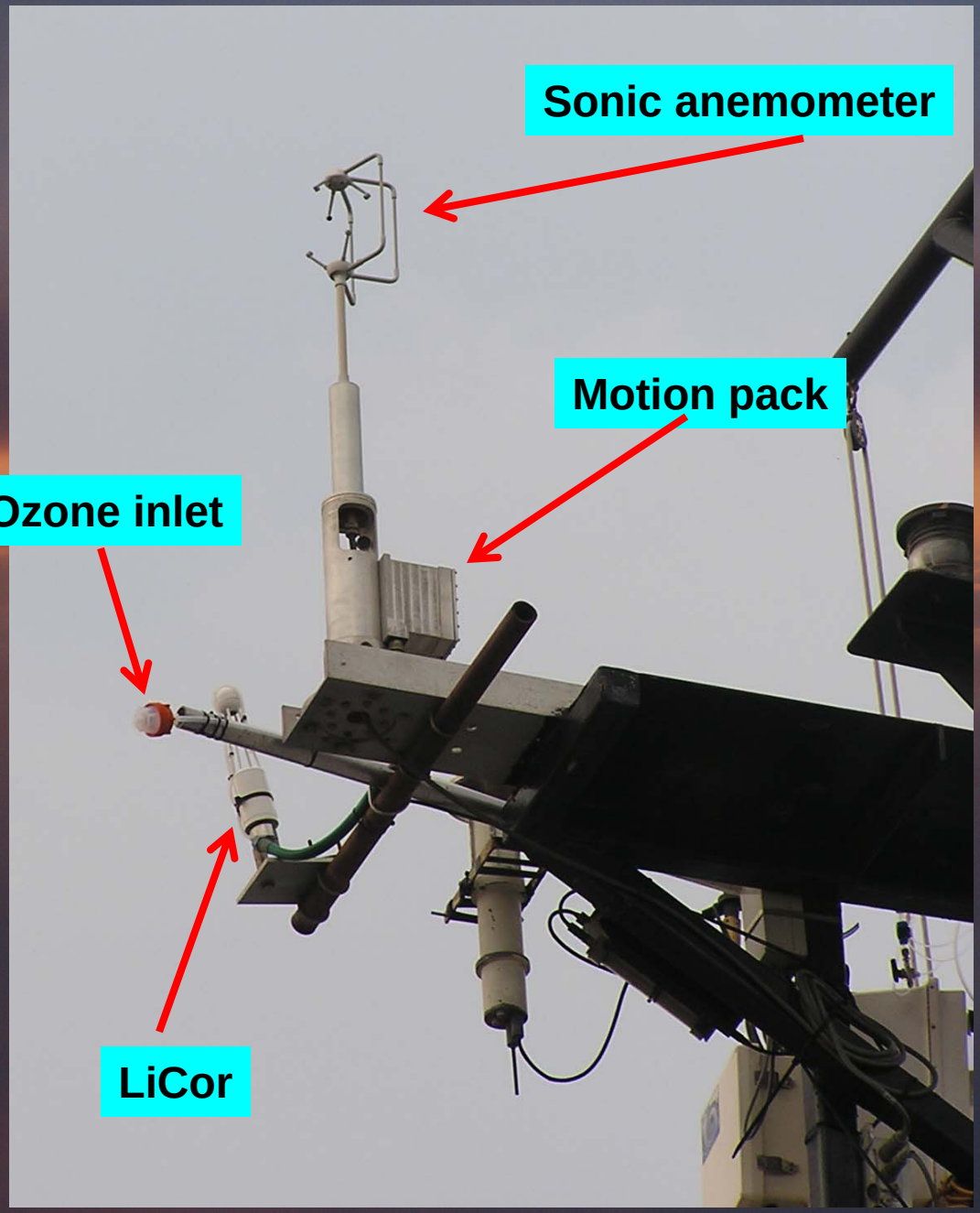
Direct flux measurements applying covariance or eddy correlation technique compared to bulk flux parameterization.

Remote Sensors

C-Band Doppler Radar
Laser Ceilometer
Microwave Radiometer (2 channel)
915 MHz Wind Profiler (electronically stabilized)
TeraScan Satellite System
Millimeter-Cloud Radar
Laser Range finder (wave measurement)


C-Band Doppler
Weather Radar
Dual GPS Antennas
UHF Doppler
Wind Profiler
Flux mast


Fast sensor platform
Temp/RH sensor
Data cables and fresh water hose
Optical range gauge
Laser range finder

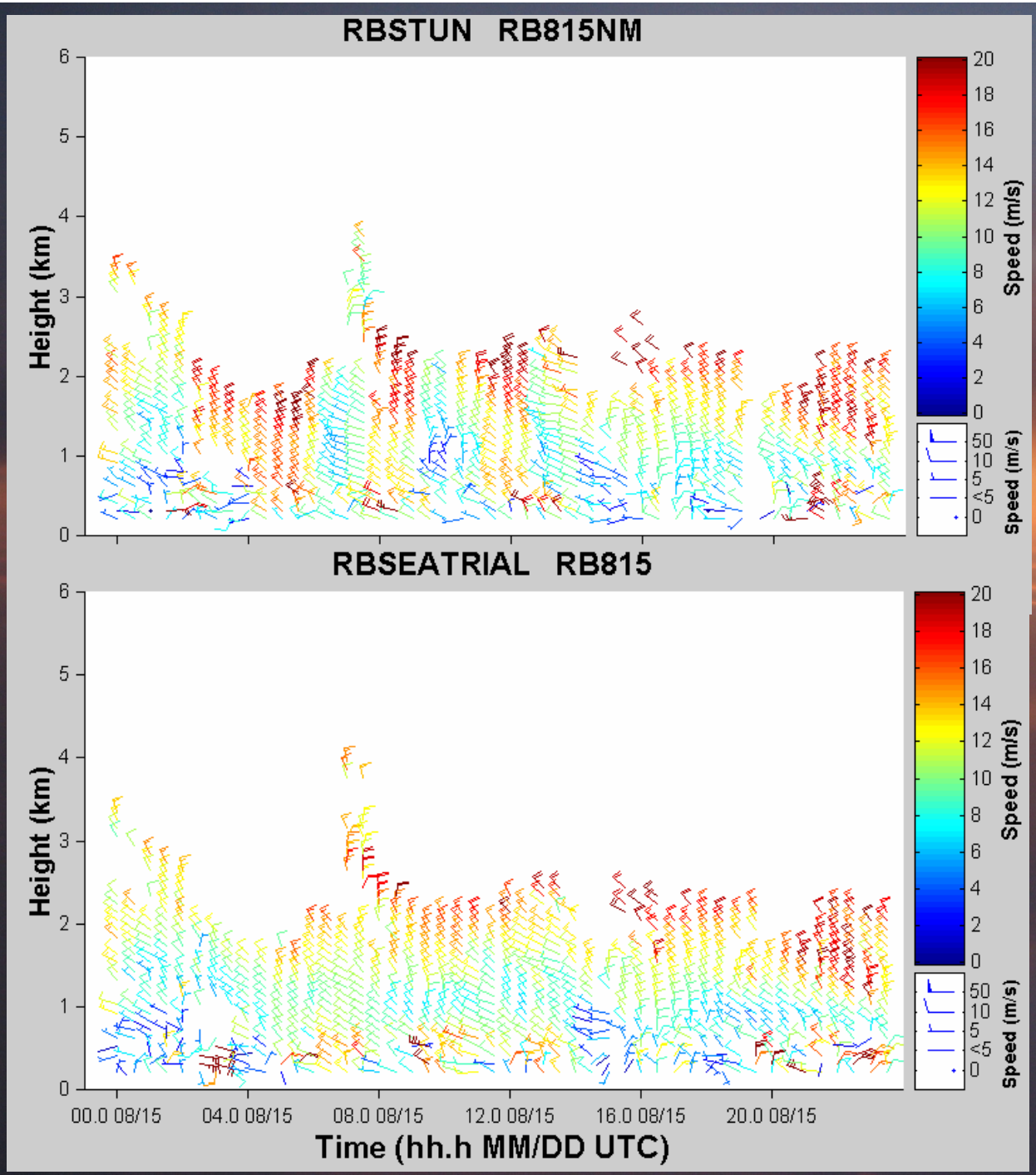

Sonic anemometer
Motion pack
Ozone inlet
LiCor


Sea Snake
SST

PC/Electronics Rack

Phased-array antenna

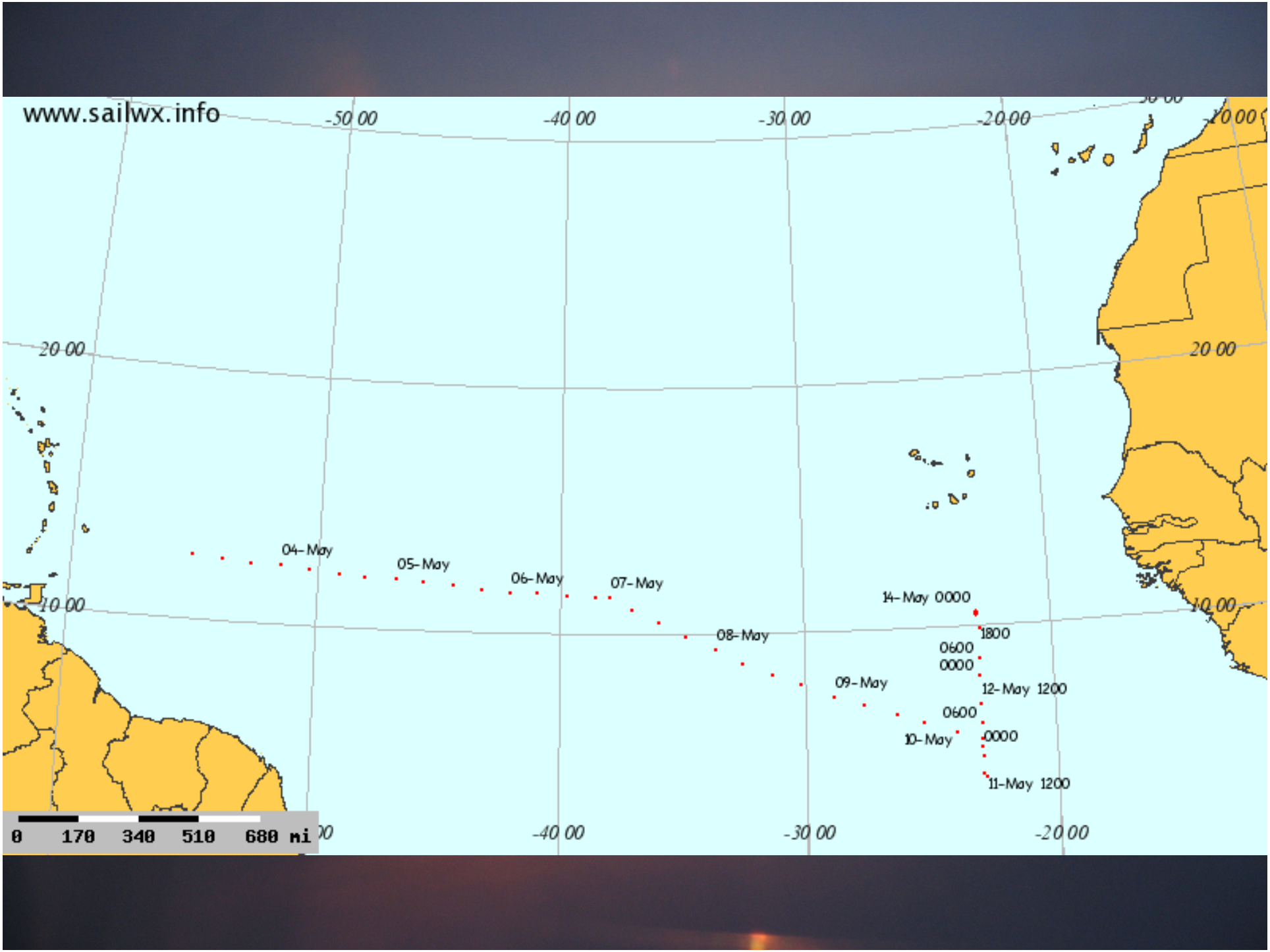
Pictures by Dan Wolfe
NOAA/ETL

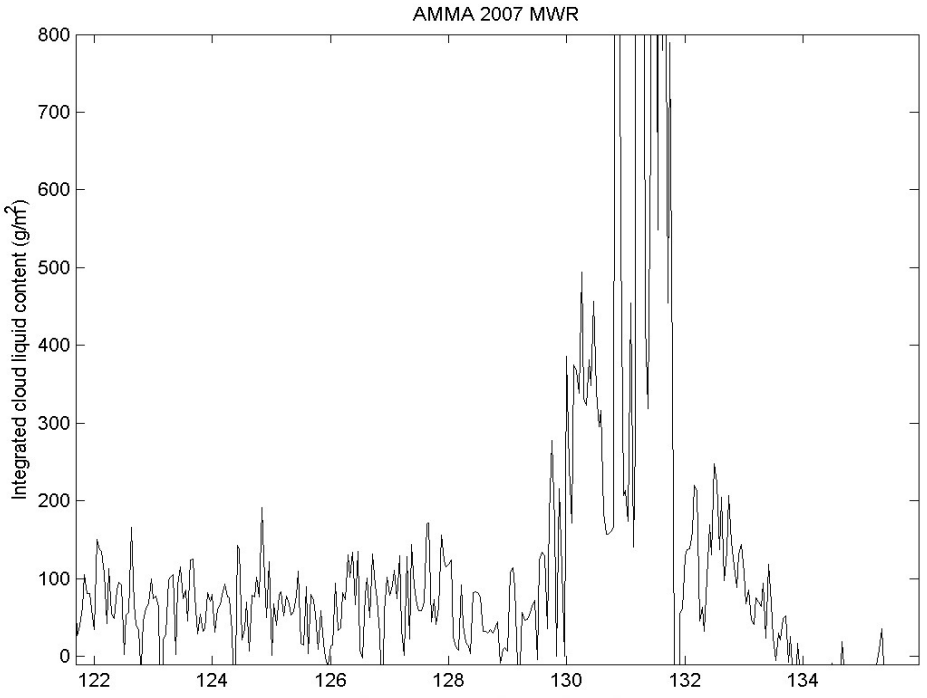


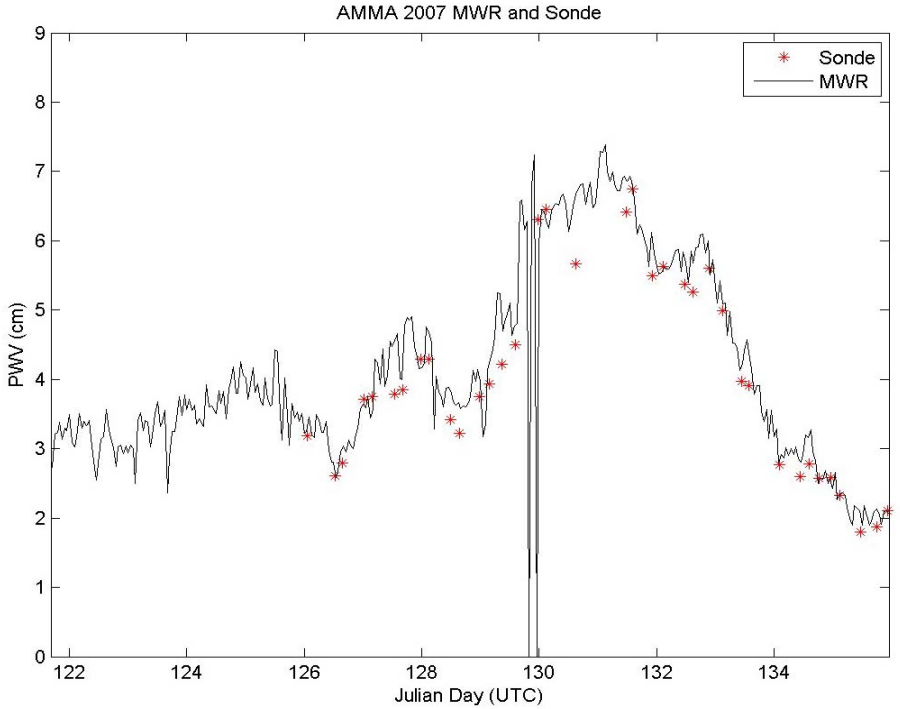
No Motion Correction

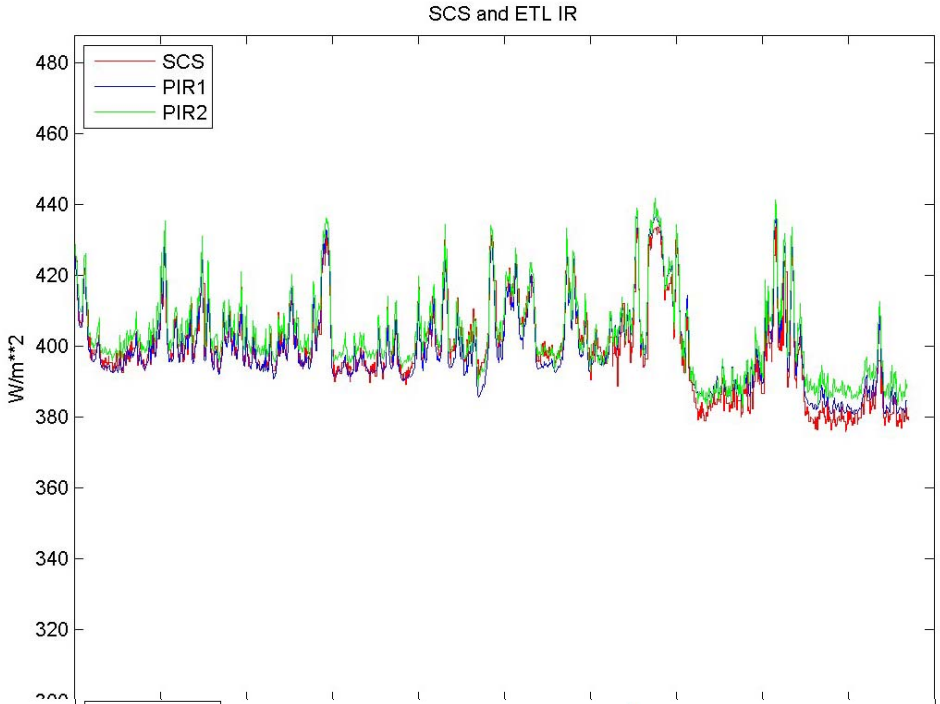
Motion Corrected

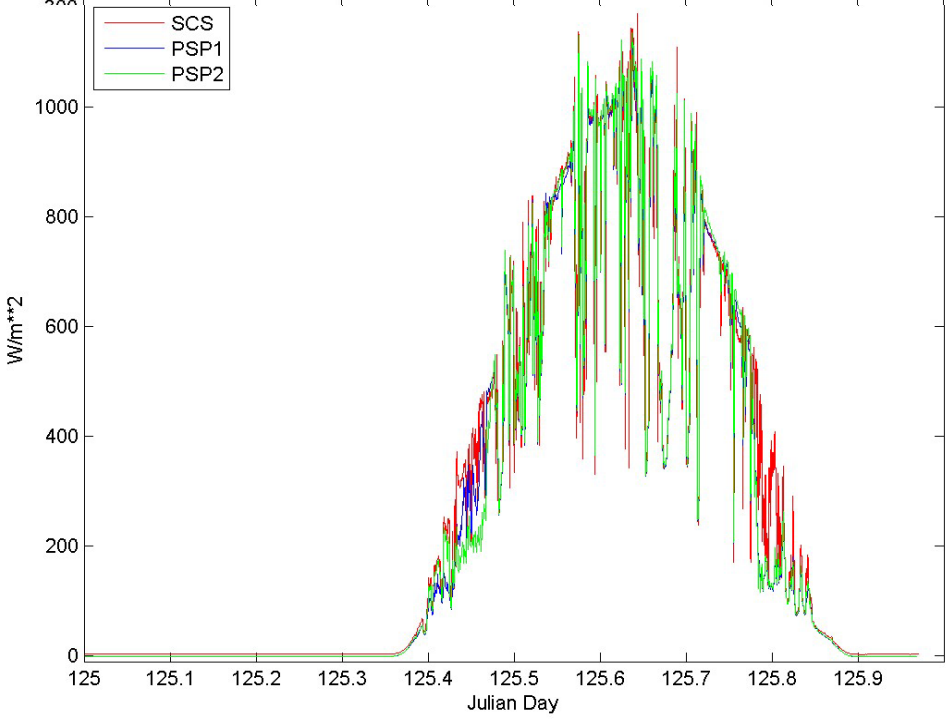

PNE/AMMA
2007

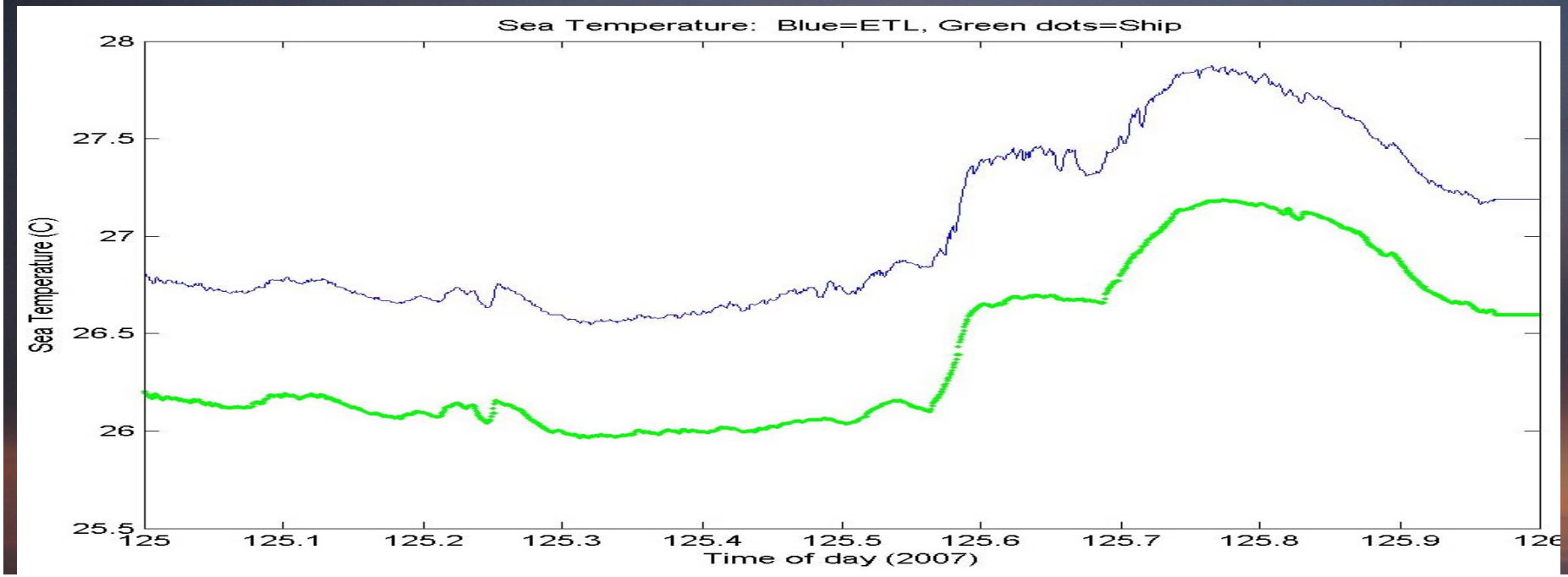

www.sailwx.info
-50 00
-40 00
-30 00
-20 00
20 00
10 00
04-May
05-May
06-May
07-May
08-May
09-May
10-May
11-May 1200
12-May 1200
14-May 0000
1800
0600
0000
0600
0000
0 170 340 510 680 mi

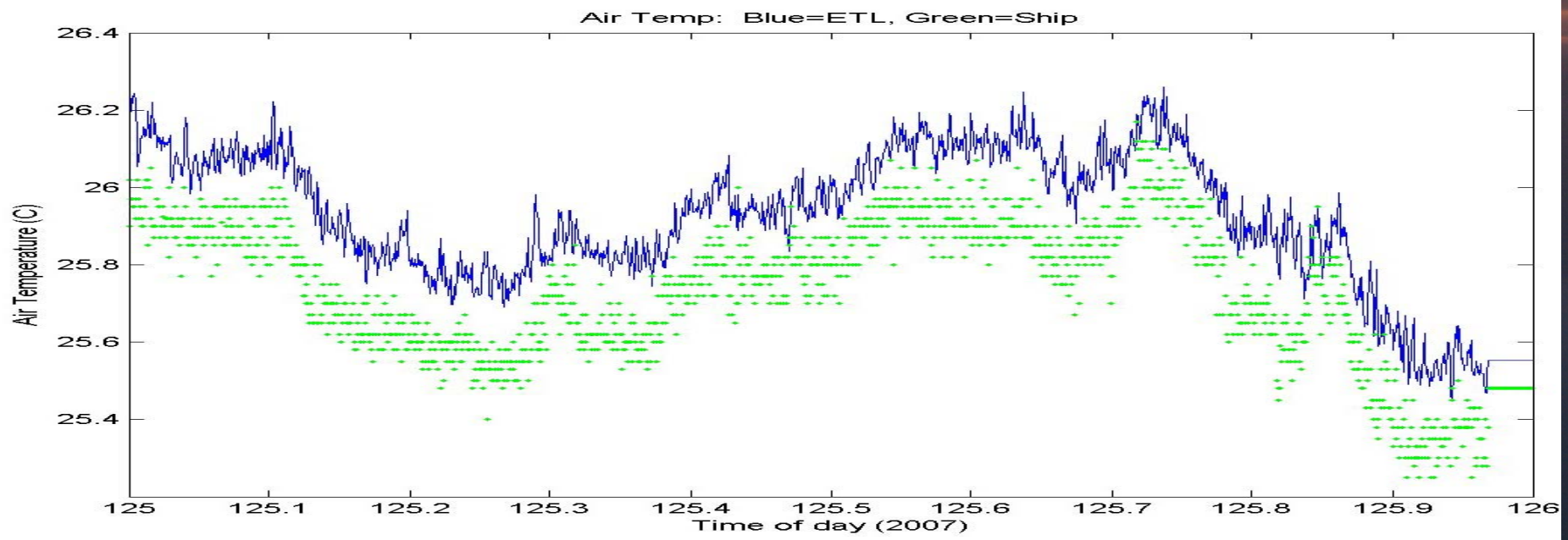

AMMA 2007 MWR
Integrated cloud liquid content (g/m^2)
800
700
600
500
400
300
200
100
0
122
124
126
128
130
132
134

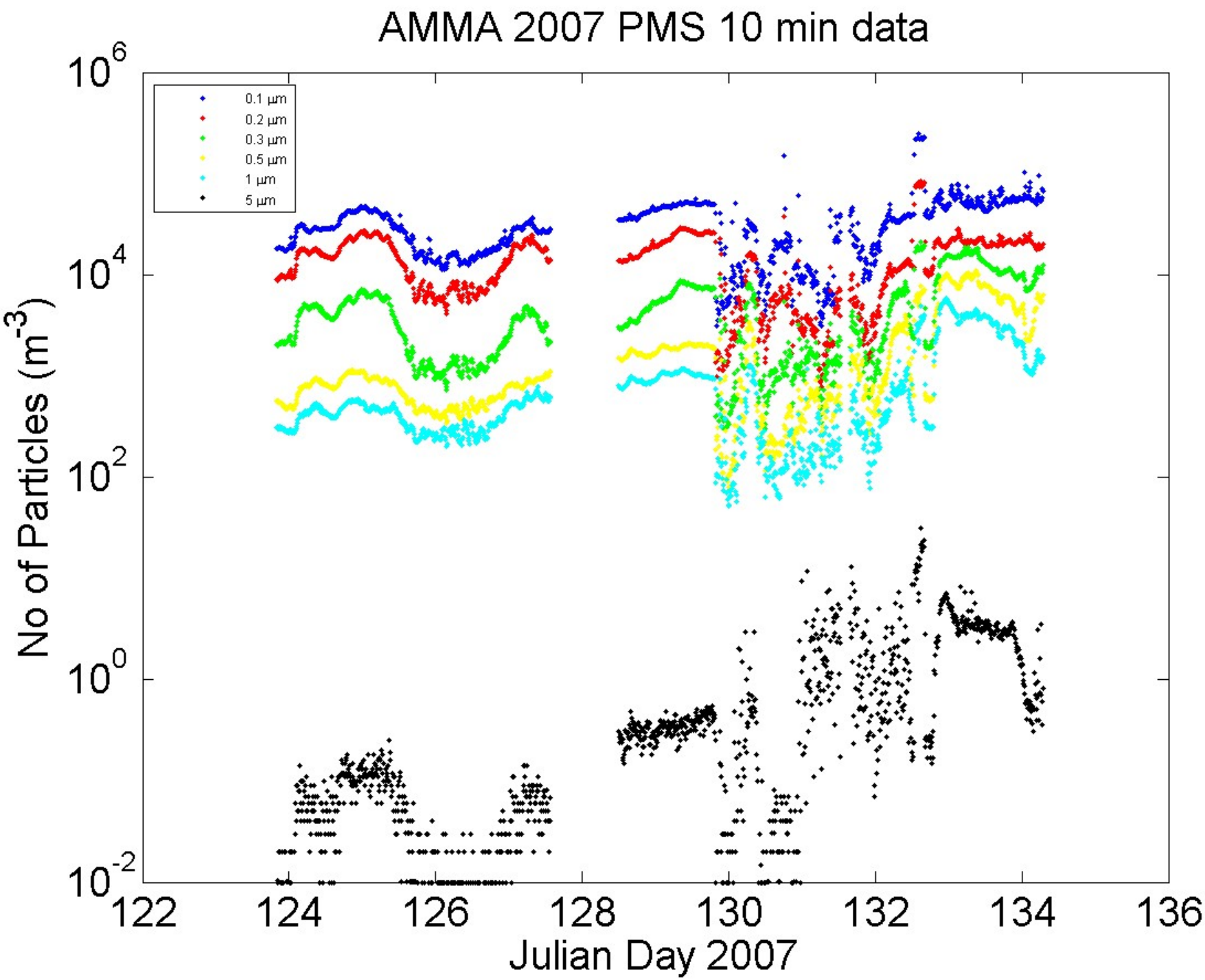

AMMA 2007 MWR and Sonde
Sonde
MWR
PWV (cm)
9
8
7
6
5
4
3
2
1
0
122
124
126
128
130
132
134
Julian Day (UTC)

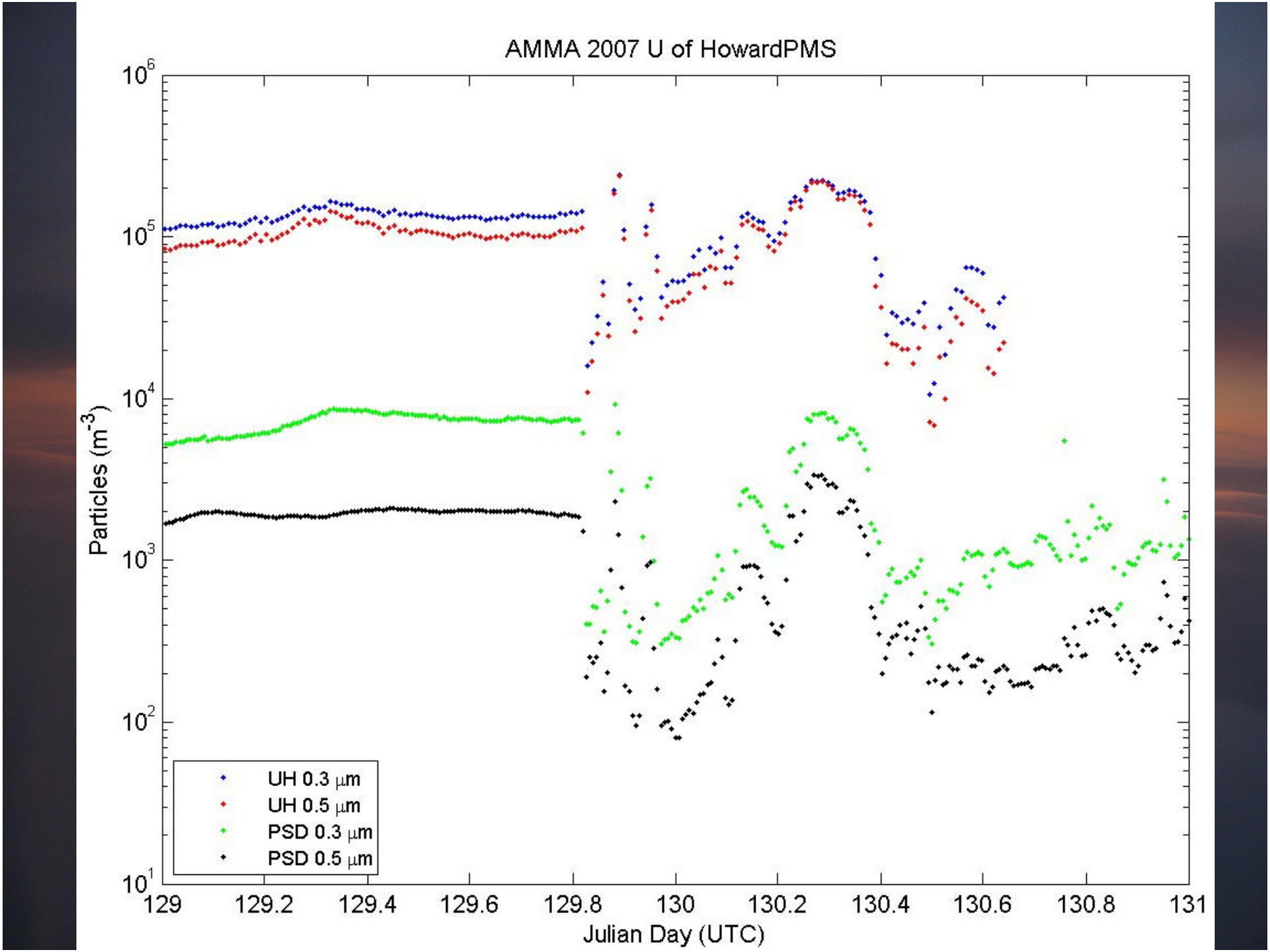

SCS and ETL IR
SCS
PIR1
PIR2
W/m**2
480
460
440
420
400
380
360
340
320


SCS
PSP1
PSP2
W/m**2
1000
800
600
400
200
0
125
125.1
125.2
125.3
125.4
125.5
125.6
125.7
125.8
125.9
Julian Day

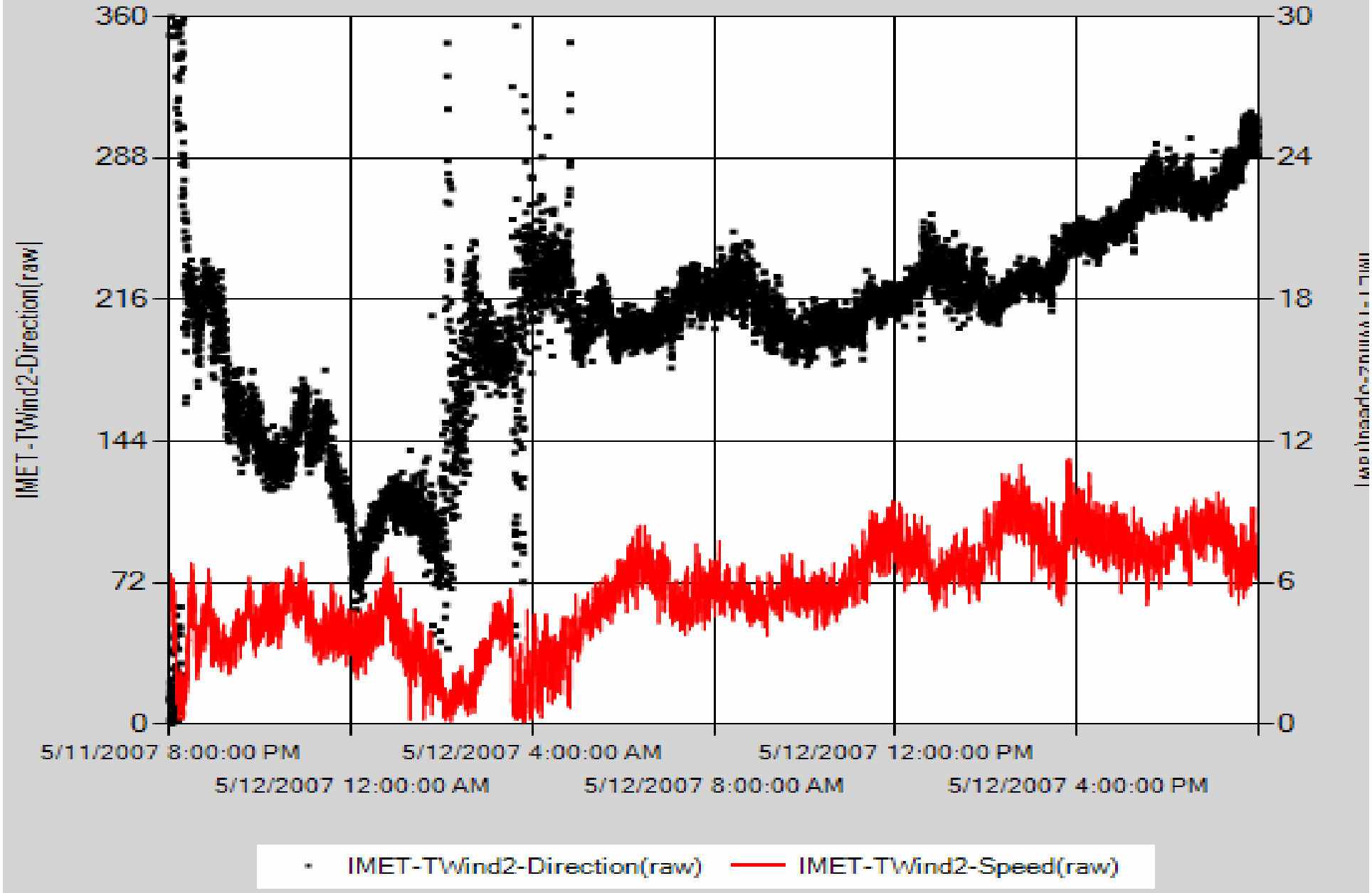

Sea Temperature: Blue=ETL, Green dots=Ship
Sea Temperature (C)
28
27.5
27
26.5
26
25.5
125
125.1
125.2
125.3
125.4
125.5
125.6
125.7
125.8
125.9
126
Time of day (2007)

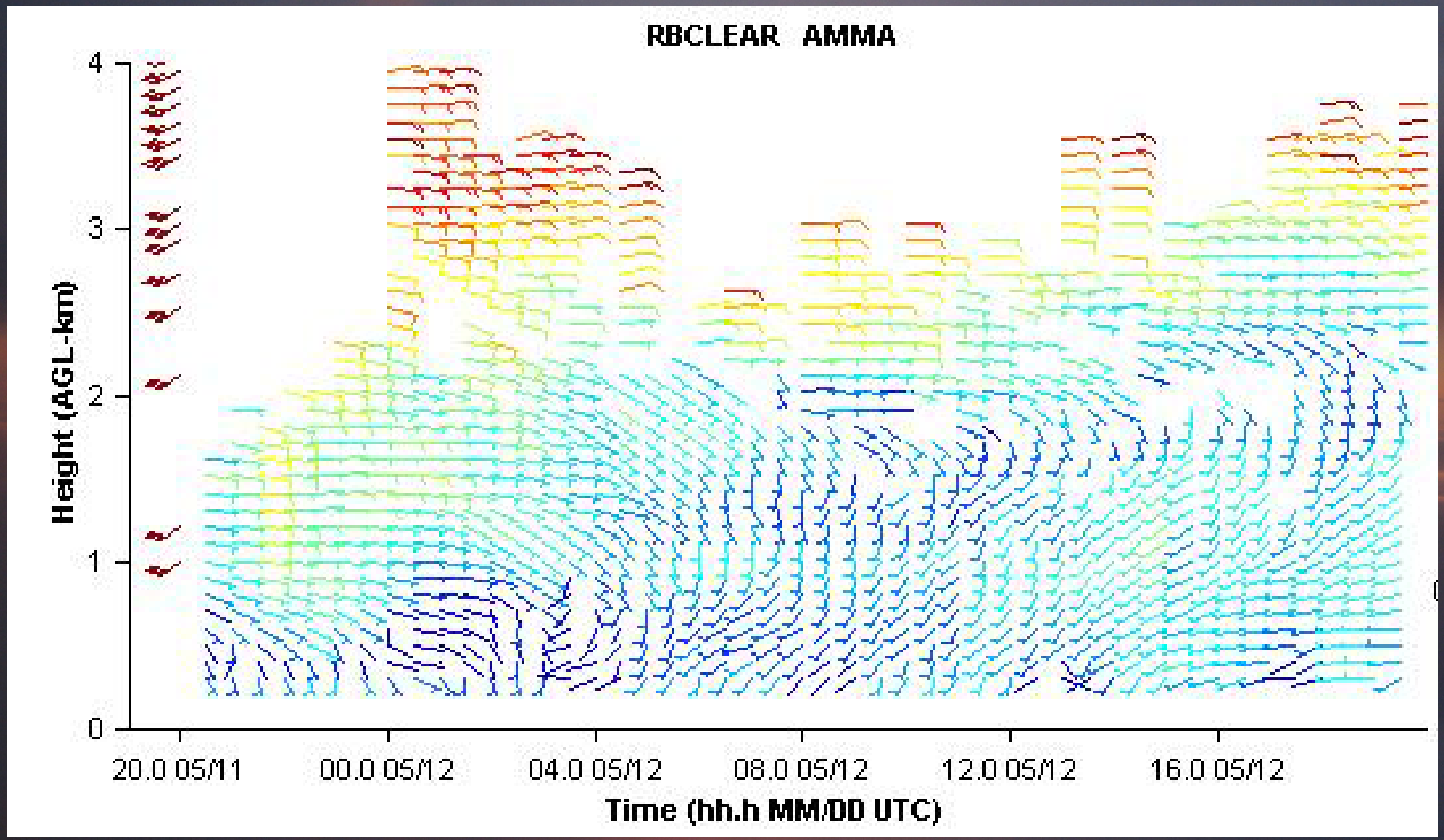

Air Temp: Blue=ETL, Green=Ship
Air Temperature (C)
26.4
26.2
26
25.8
25.6
25.4
125
125.1
125.2
125.3
125.4
125.5
125.6
125.7
125.8
125.9
126
Time of day (2007)

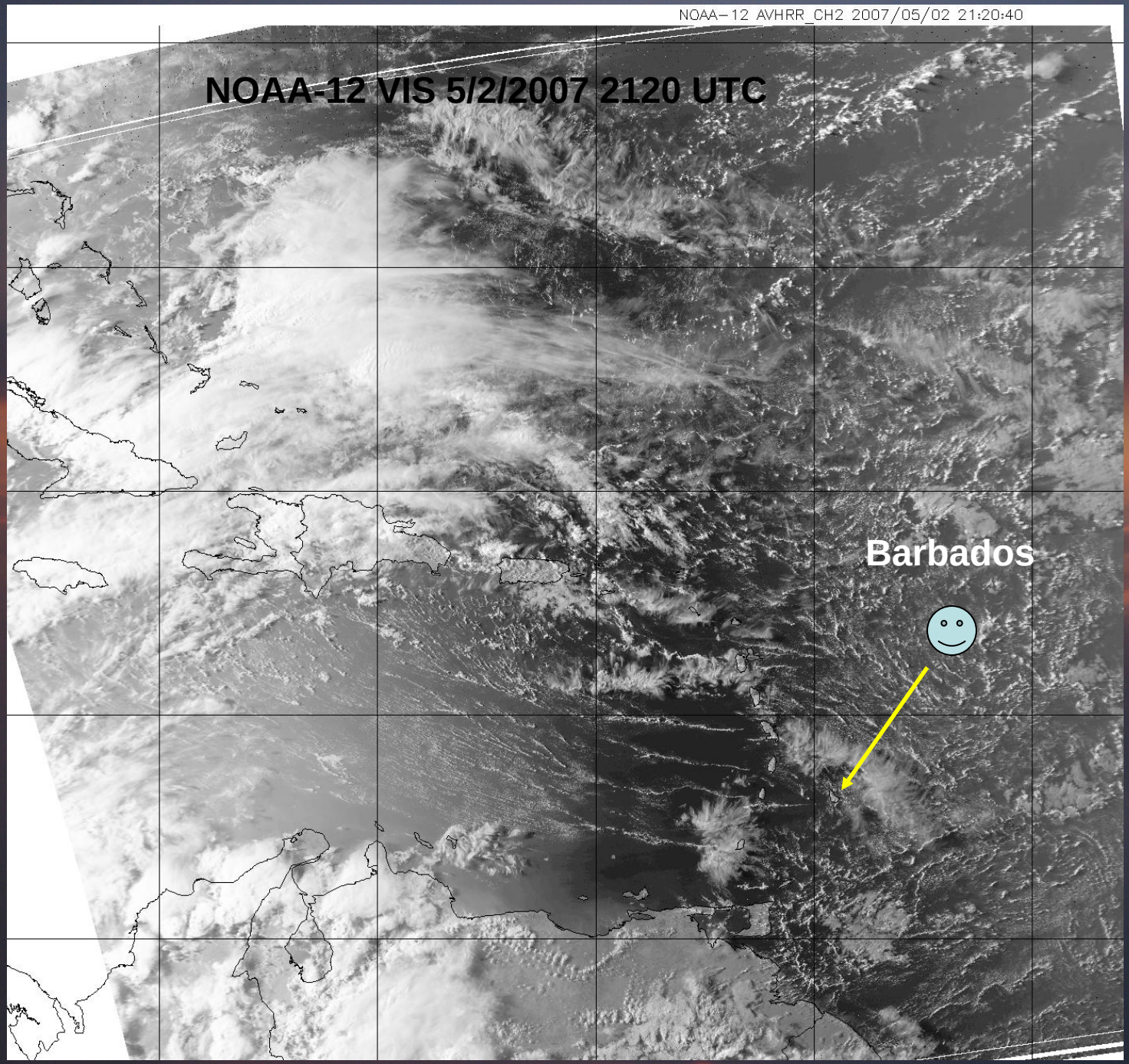

AMMA 2007 PMS 10 min data
0.1 µm
0.2 µm
0.3 µm
0.5 µm
1 µm
5 µm
No of Particles (m-3)
10^6
10^4
10^2
10^0
10^-2
122
124
126
128
130
132
134
136
Julian Day 2007

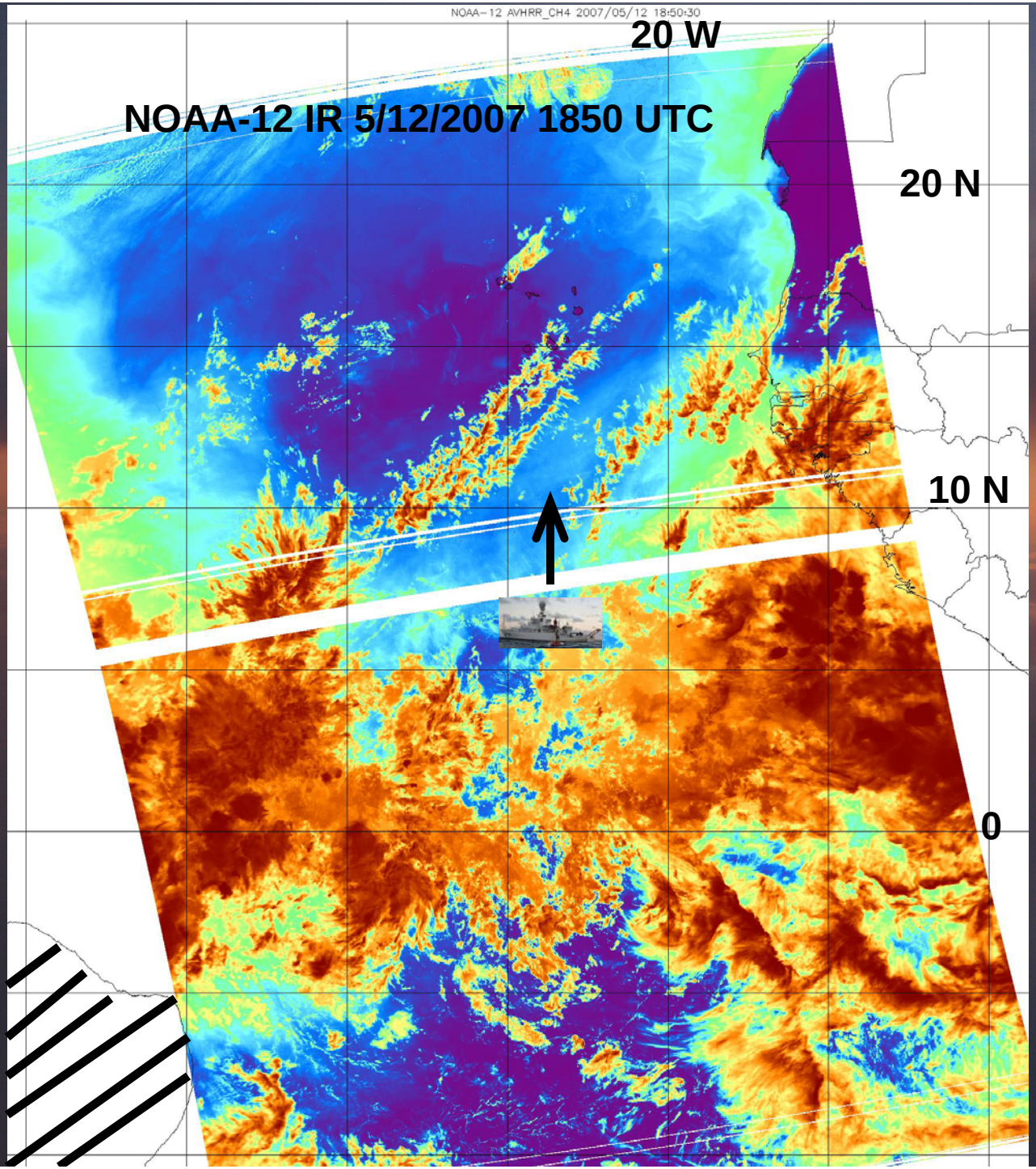

AMMA 2007 U of HowardPMS
Particles (m-3)
Julian Day (UTC)
UH 0.3 μm
UH 0.5 μm
PSD 0.3 μm
PSD 0.5 μm

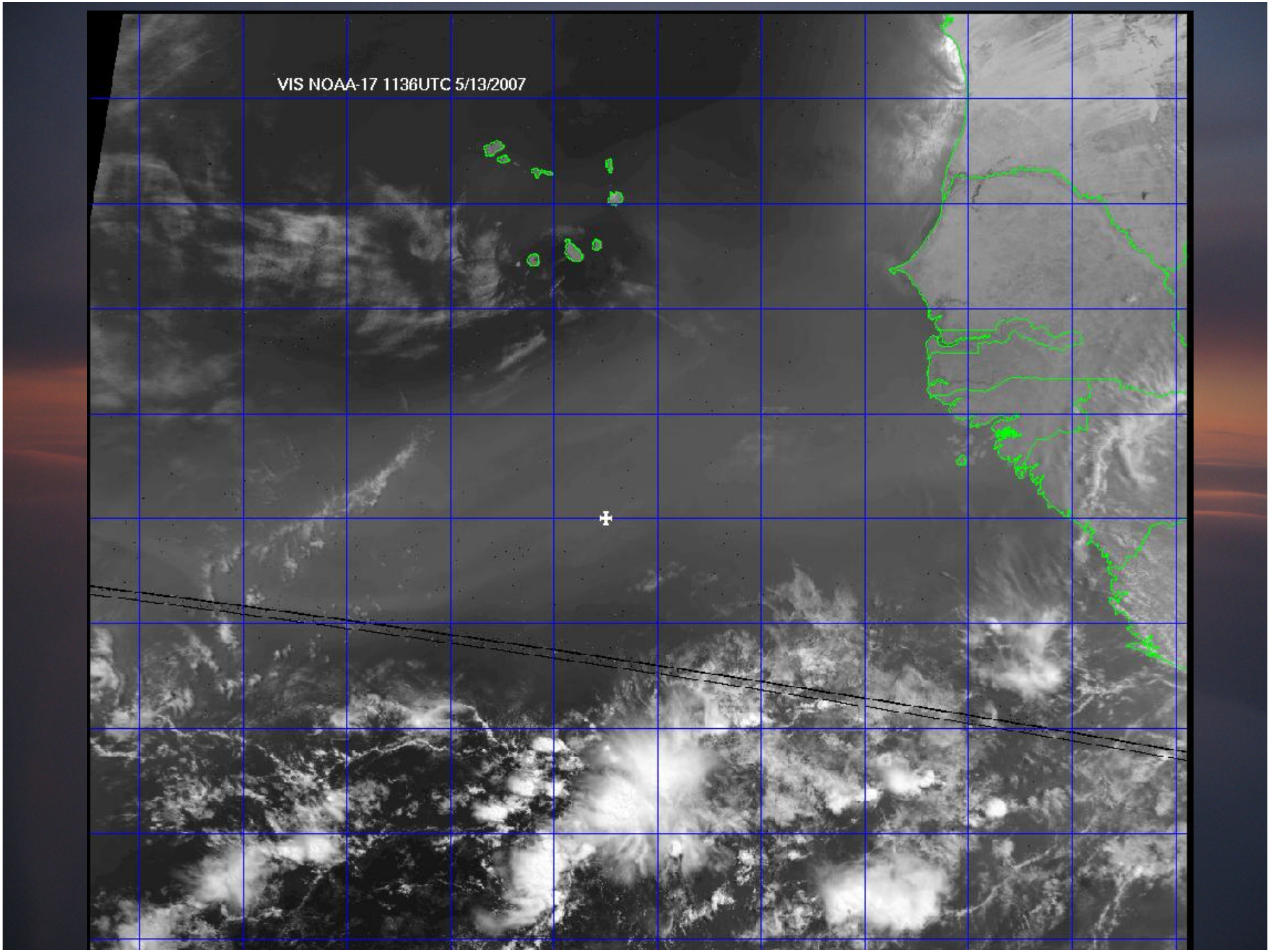
Ship Computer System (SCS)

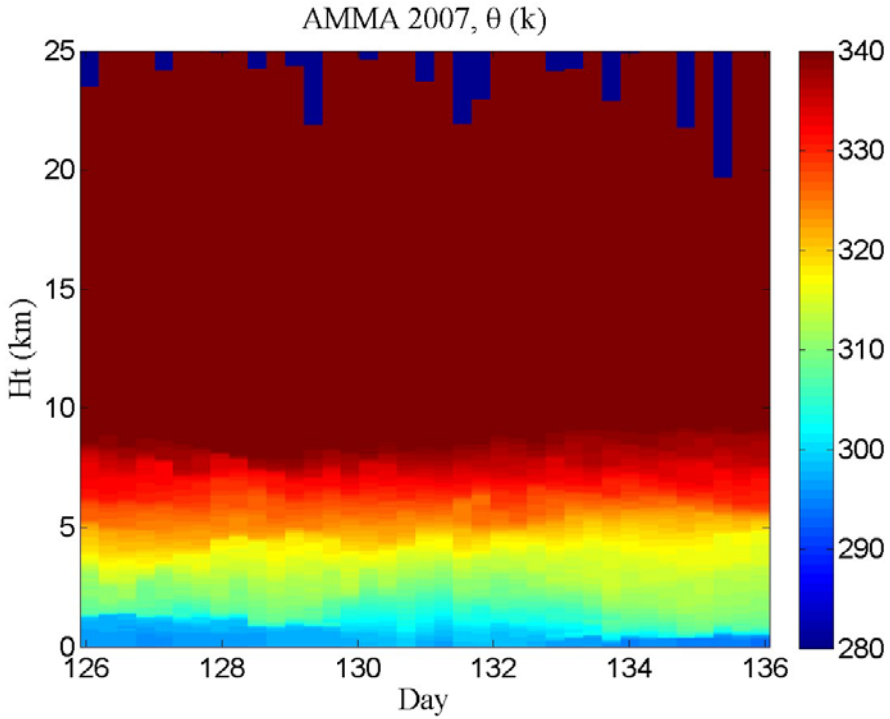


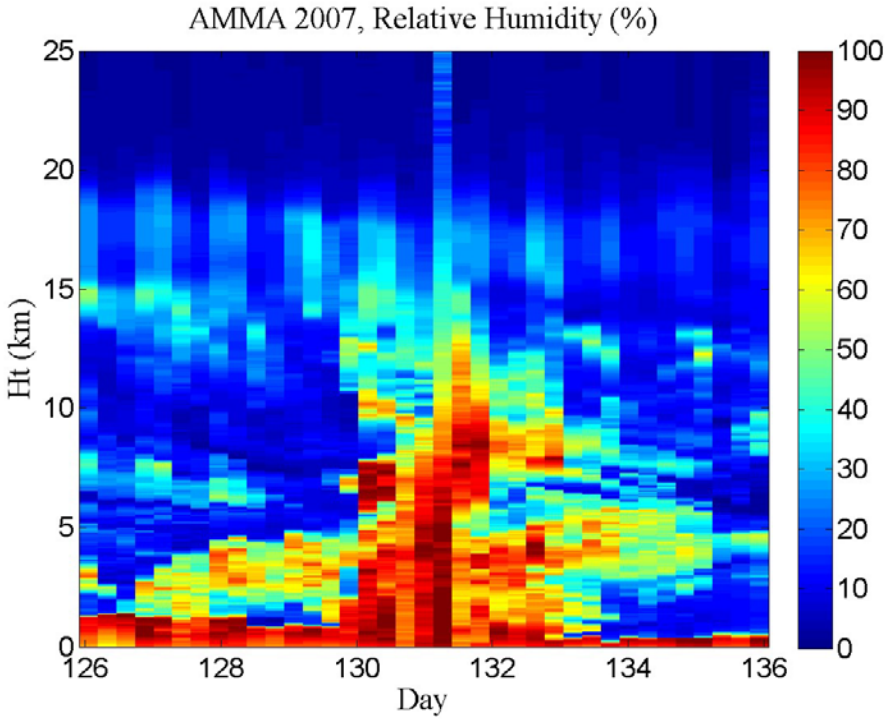

RBCLEAR AMMA
Height (AGL-km)
0
1
2
3
4
20.0 05/11
00.0 05/12
04.0 05/12
08.0 05/12
12.0 05/12
16.0 05/12
Time (hh.h MM/DD UTC)

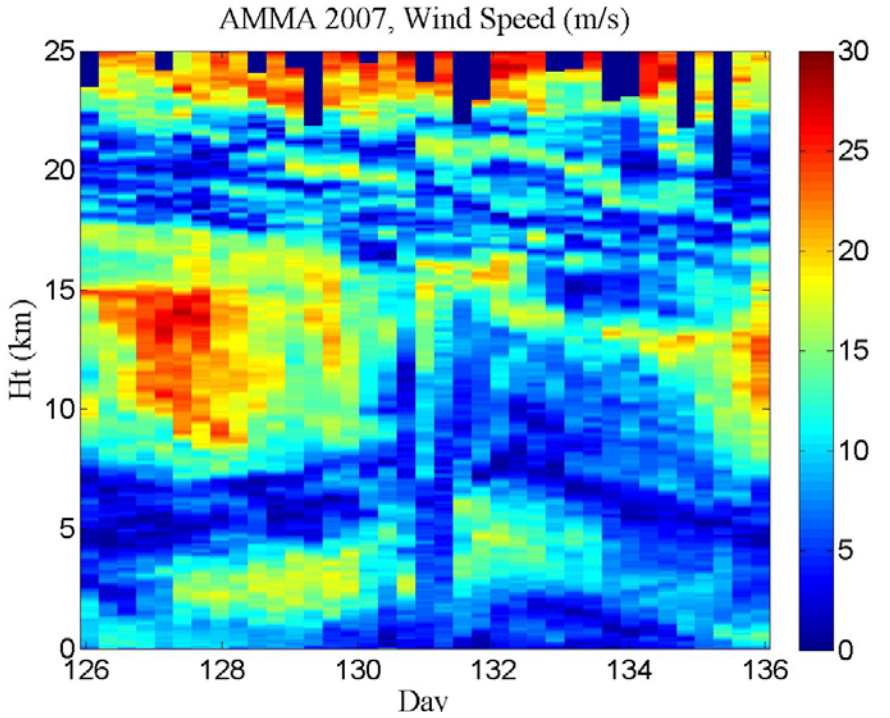

NOAA-12 VIS 5/2/2007 2120 UTC
NOAA-12 AVHRR_CH2 2007/05/02 21:20:40
Barbados

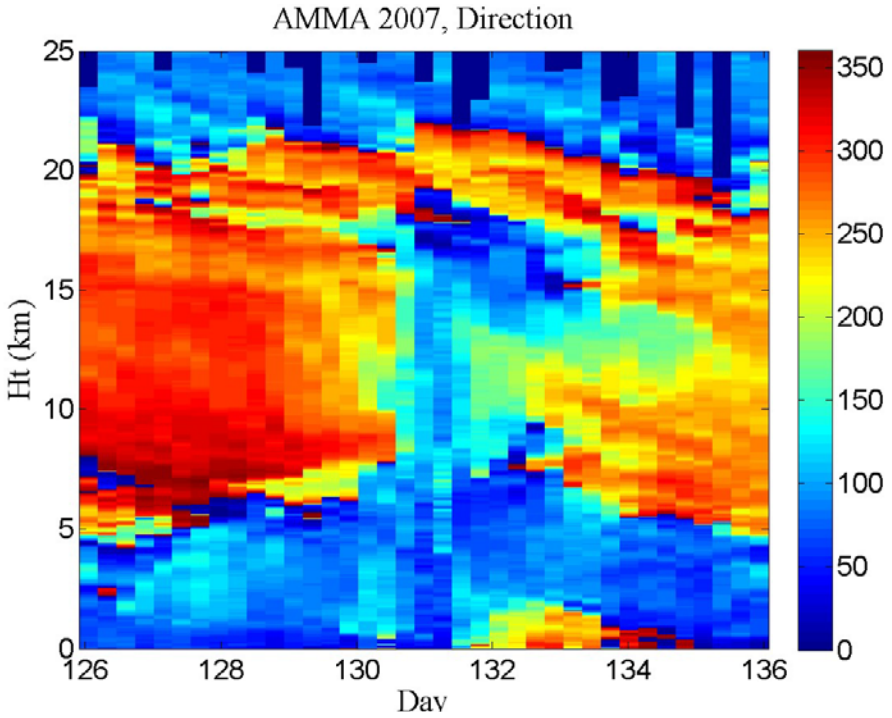

NOAA-12 AVHRR_CH4 2007/05/12 18:50:30
NOAA-12 IR 5/12/2007 1850 UTC
20 W
20 N
10 N
0

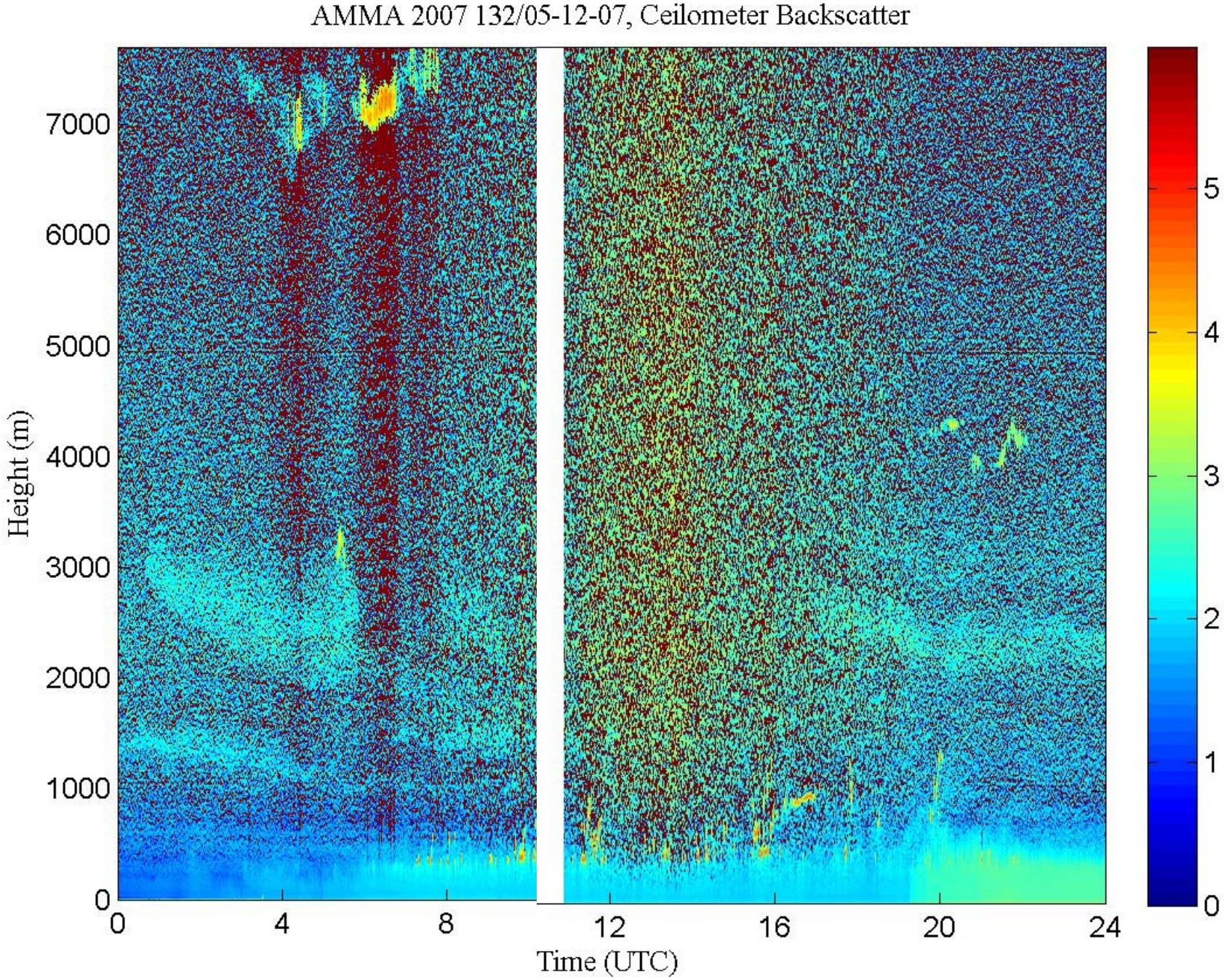

VIS NOAA-17 1136UTC 5/13/2007


AMMA 2007, θ (k)
Ht (km)
Day
25
20
15
10
5
0
126
128
130
132
134
136
340
330
320
310
300
290
280

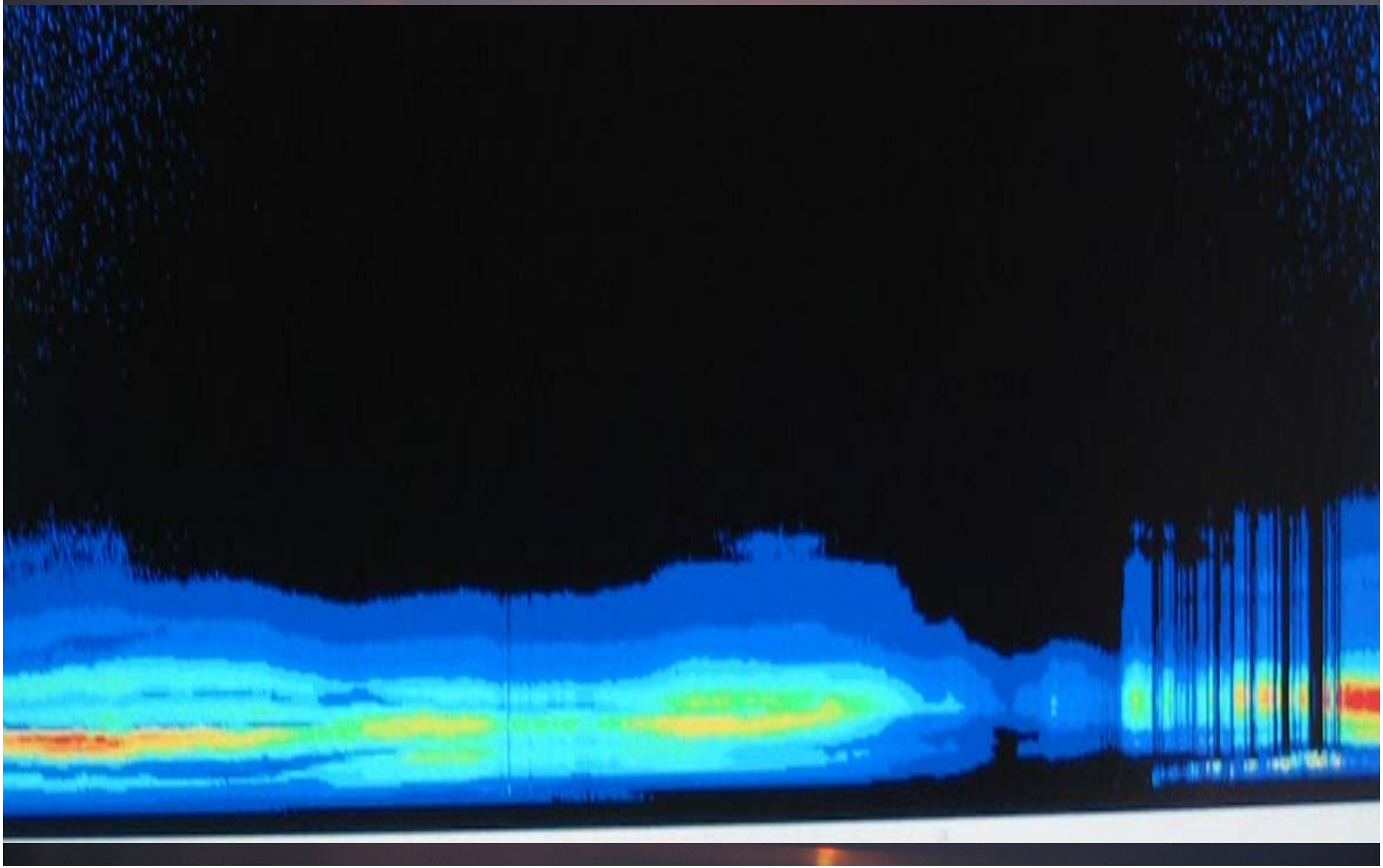

AMMA 2007, Relative Humidity (%)
Ht (km)
Day
25
20
15
10
5
0
126
128
130
132
134
136
100
90
80
70
60
50
40
30
20
10
0

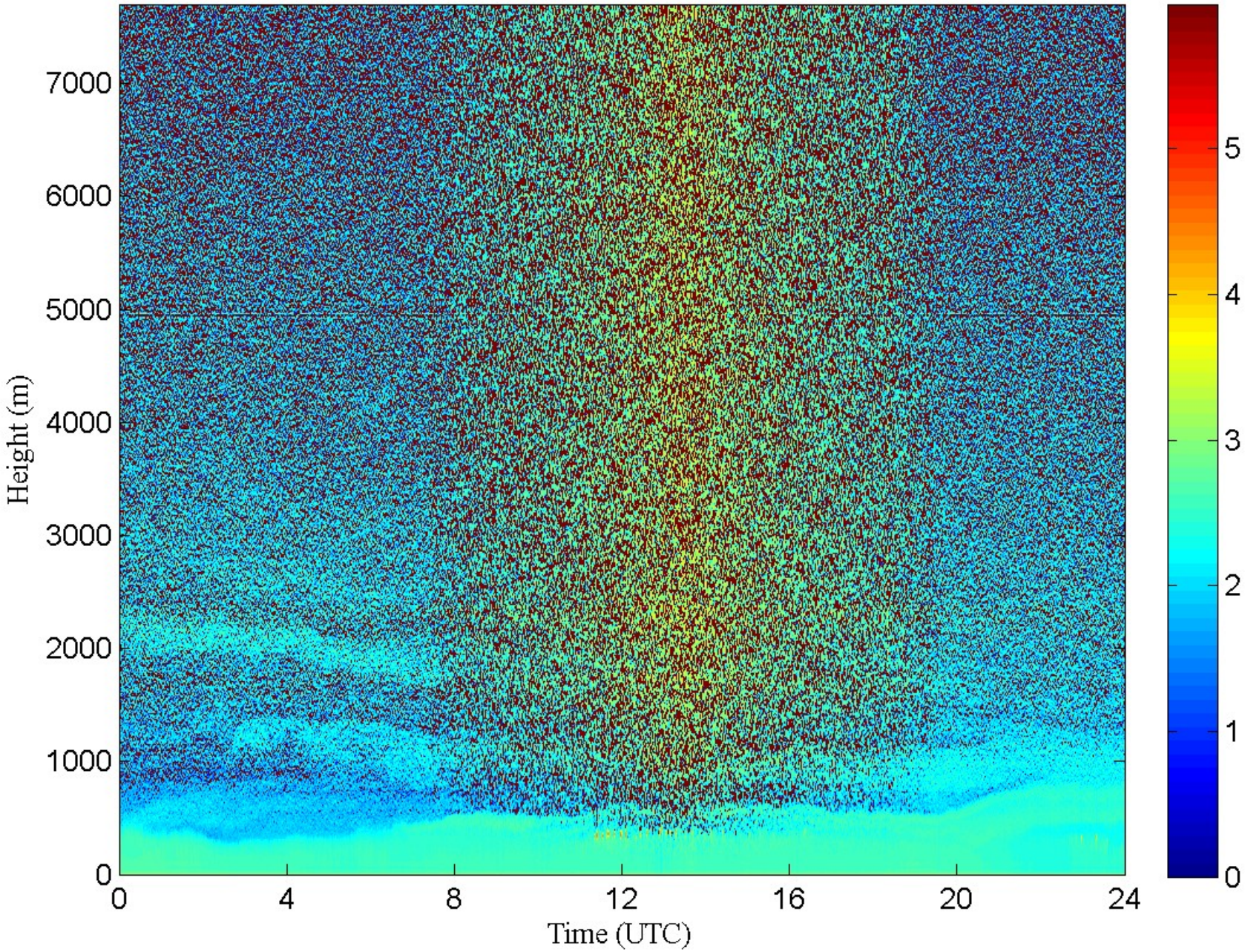

AMMA 2007, Wind Speed (m/s)
Ht (km)
Day
25
20
15
10
5
0
126
128
130
132
134
136
30
25
20
15
10
5
0

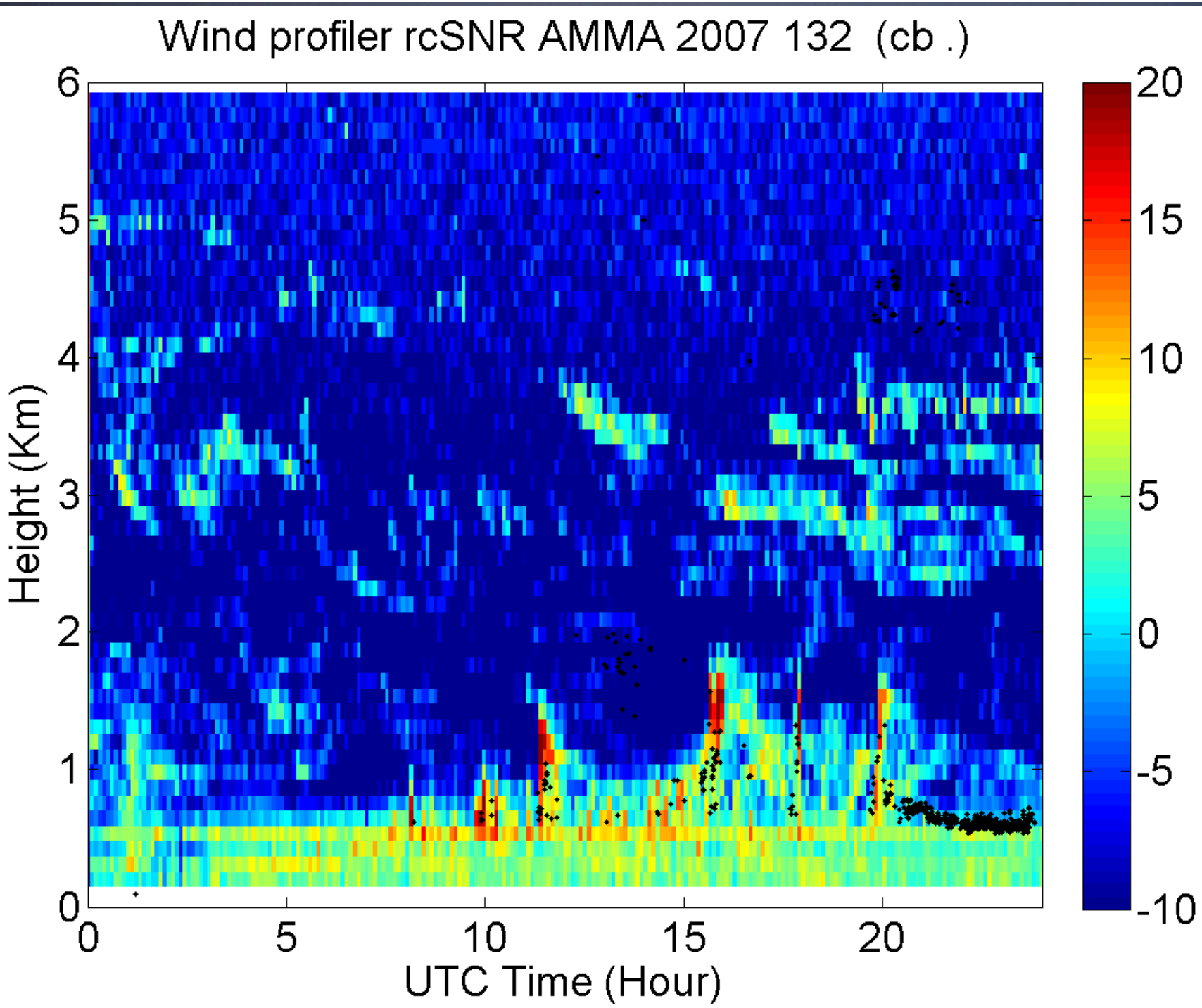

AMMA 2007, Direction
Ht (km)
Day
25
20
15
10
5
0
126
128
130
132
134
136
350
300
250
200
150
100
50
0


AMMA 2007 132/05-12-07, Ceilometer Backscatter
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
4
8
12
16
20
24
Time (UTC)
5
4
3
2
1
0

Micro Pulse Lidar JD 133 AMMA 2007 0-10km

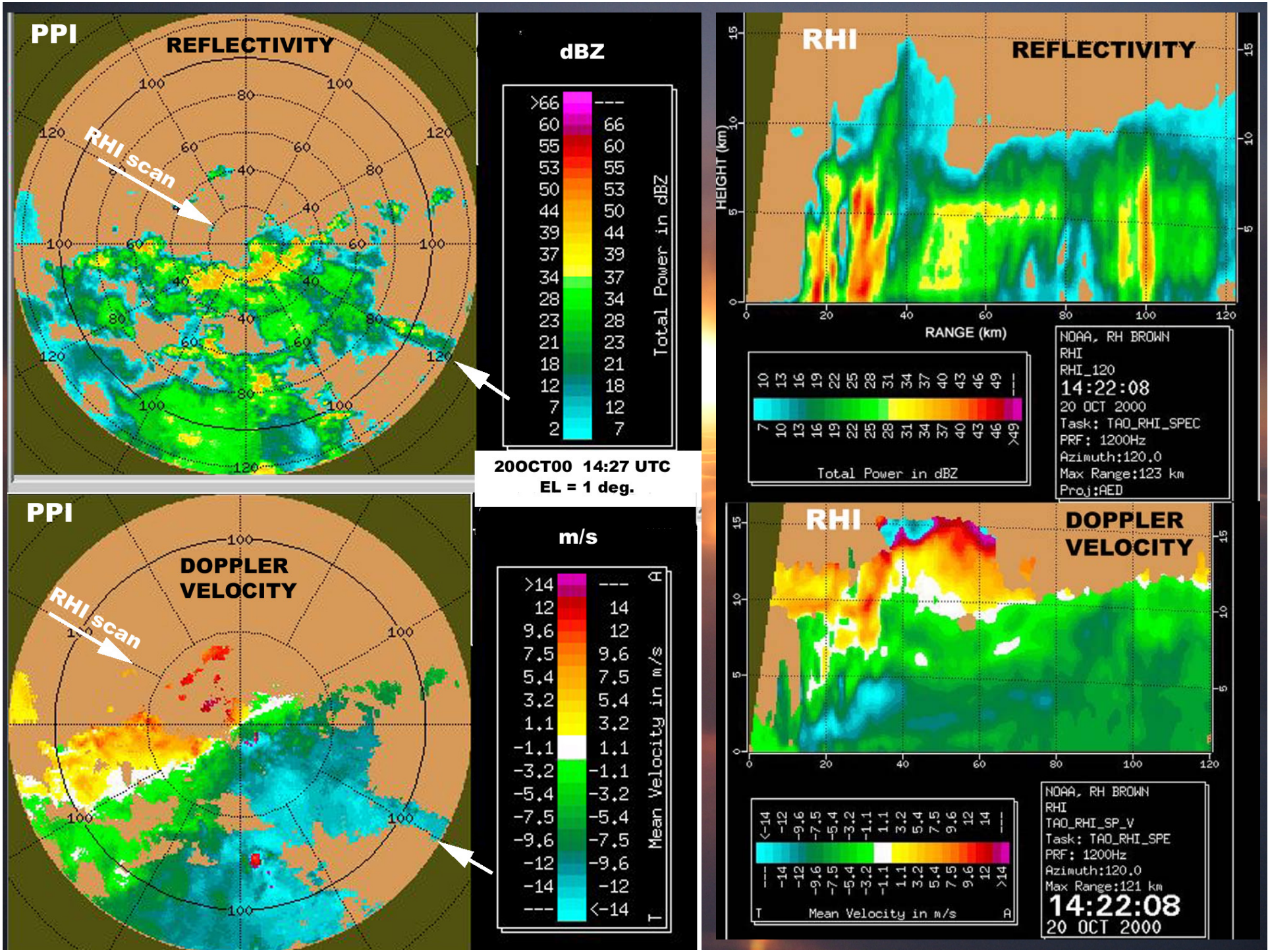


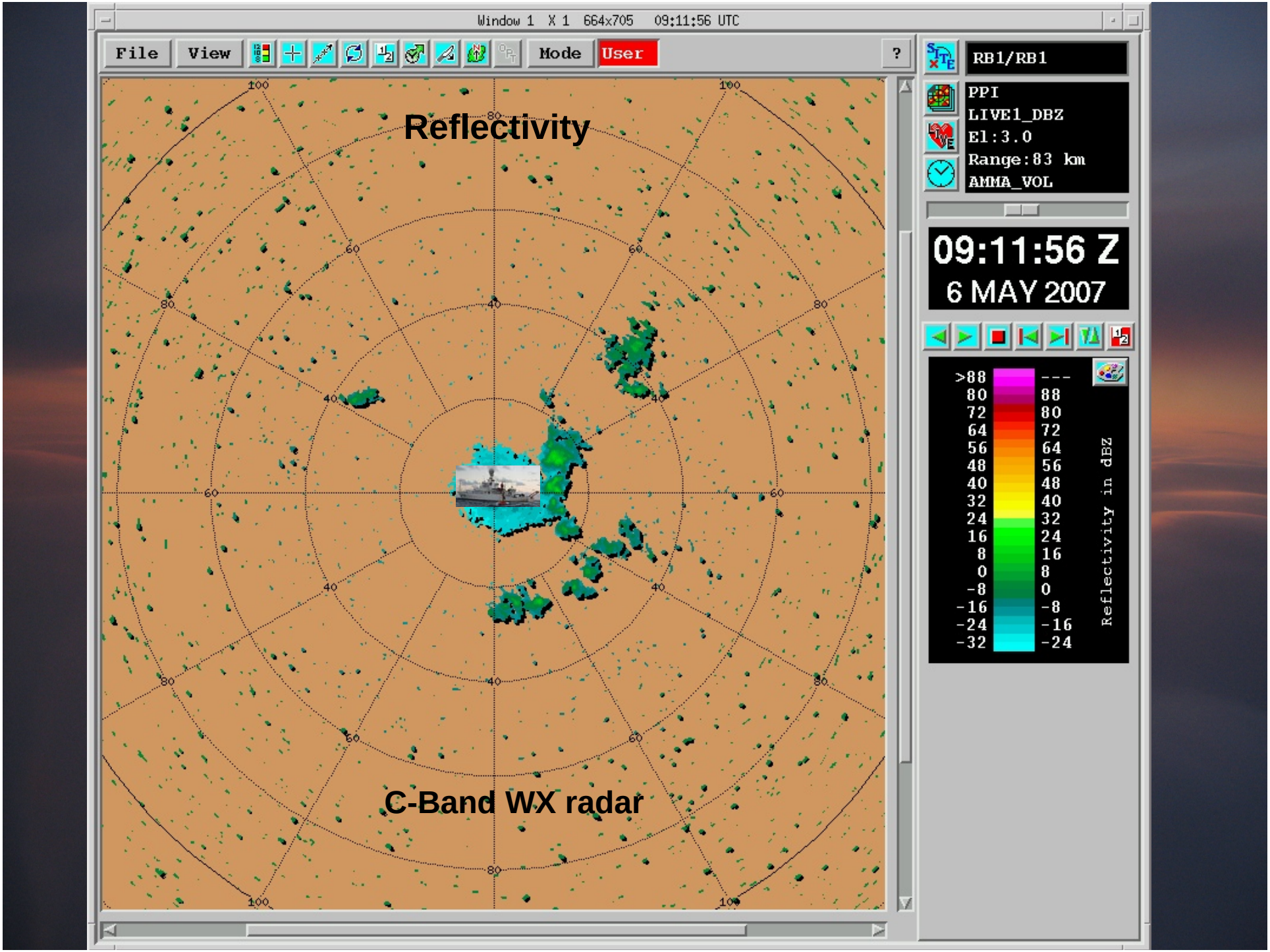

AMMA 2007 133/05-13-07, Ceilometer Backscatter
Height (m)
7000
6000
5000
4000
3000
2000
1000
0
0
4
8
12
16
20
24
Time (UTC)
5
4
3
2
1
0


Wind profiler rcSNR AMMA 2007 132 (cb .)
Height (Km)
0
1
2
3
4
5
6
0
5
10
15
20
UTC Time (Hour)
20
15
10
5
0
-5
-10

Characteristics of the RHB Radar

- ***Frequency:*** **5.595 GHz (C-band, wavelength = 5.4 cm)**
- ***Transmit Power:*** **250 kW peak**
- ***Antenna:*** **4.3-m parabolic, 5.5-m radome.**
- ***Scan Rates:*** **up to 36 deg/s**
- ***Polarization:*** **linear horizontal;**
- ***Number of range gates:*** **1024**
- ***Maximum Unambiguous Range:*** **300 km at PRF=500.**
- ***Sensitivity:*** **approx. –22 dBZ at 10 km range using 0.5 microsec pulse length.**


PPI
REFLECTIVITY
RHI scan
dBZ
>66 60 55 53 50 44 39 37 34 28 23 21 18 12 7 2
--- 66 60 55 53 50 44 39 37 34 28 23 21 18 12 7
Total Power in dBZ
20OCT00 14:27 UTC
EL = 1 deg.
PPI
DOPPLER VELOCITY
RHI scan
m/s
>14 12 9.6 7.5 5.4 3.2 1.1 -1.1 -3.2 -5.4 -7.5 -9.6 -12 -14 ---
--- 14 12 9.6 7.5 5.4 3.2 1.1 -1.1 -3.2 -5.4 -7.5 -9.6 -12 <-14
Mean Velocity in m/s
RHI
REFLECTIVITY
HEIGHT (km)
RANGE (km)
10 13 16 19 22 25 28 31 34 37 40 43 46 49 ---
7 10 13 16 19 22 25 28 31 34 37 40 43 46 >49
Total Power in dBZ
NOAA, RH BROWN
RHI
RHI_120
14:22:08
20 OCT 2000
Task: TAO_RHI_SPEC
PRF: 1200Hz
Azimuth:120.0
Max Range:123 km
Proj:AED
RHI
DOPPLER VELOCITY
<-14 -12 -9.6 -7.5 -5.4 -3.2 -1.1 1.1 3.2 5.4 7.5 9.6 12 14 ---
--- -14 -12 -9.6 -7.5 -5.4 -3.2 -1.1 1.1 3.2 5.4 7.5 9.6 12 >14
Mean Velocity in m/s
NOAA, RH BROWN
RHI
TAO_RHI_SP_V
Task: TAO_RHI_SPE
PRF: 1200Hz
Azimuth:120.0
Max Range:121 km
14:22:08
20 OCT 2000


Window 1 X 1 664x705 09:11:56 UTC
File
View
Mode
User
?
RB1/RB1
PPI
LIVE1_DBZ
El:3.0
Range:83 km
AMMA_VOL
09:11:56 Z
6 MAY 2007
>88
80
72
64
56
48
40
32
24
16
8
0
-8
-16
-24
-32
88
80
72
64
56
48
40
32
24
16
8
0
-8
-16
-24
Reflectivity in dBZ
Reflectivity
C-Band WX radar