Ship-based measurements of cloud microphysics and PBL properties in precipitating trade cumulus clouds during RICO

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- Ship-based, multi-sensor study of dynamics of trade-wind cumuli and the onset of precipitation.

- UNOLS ship Seward Johnson (202 ft)

- Cloud – precipitation microphysics

- PBL structure

- Surface fluxes (turbulent, radiative)

- Cloud – precipitation spatial structure

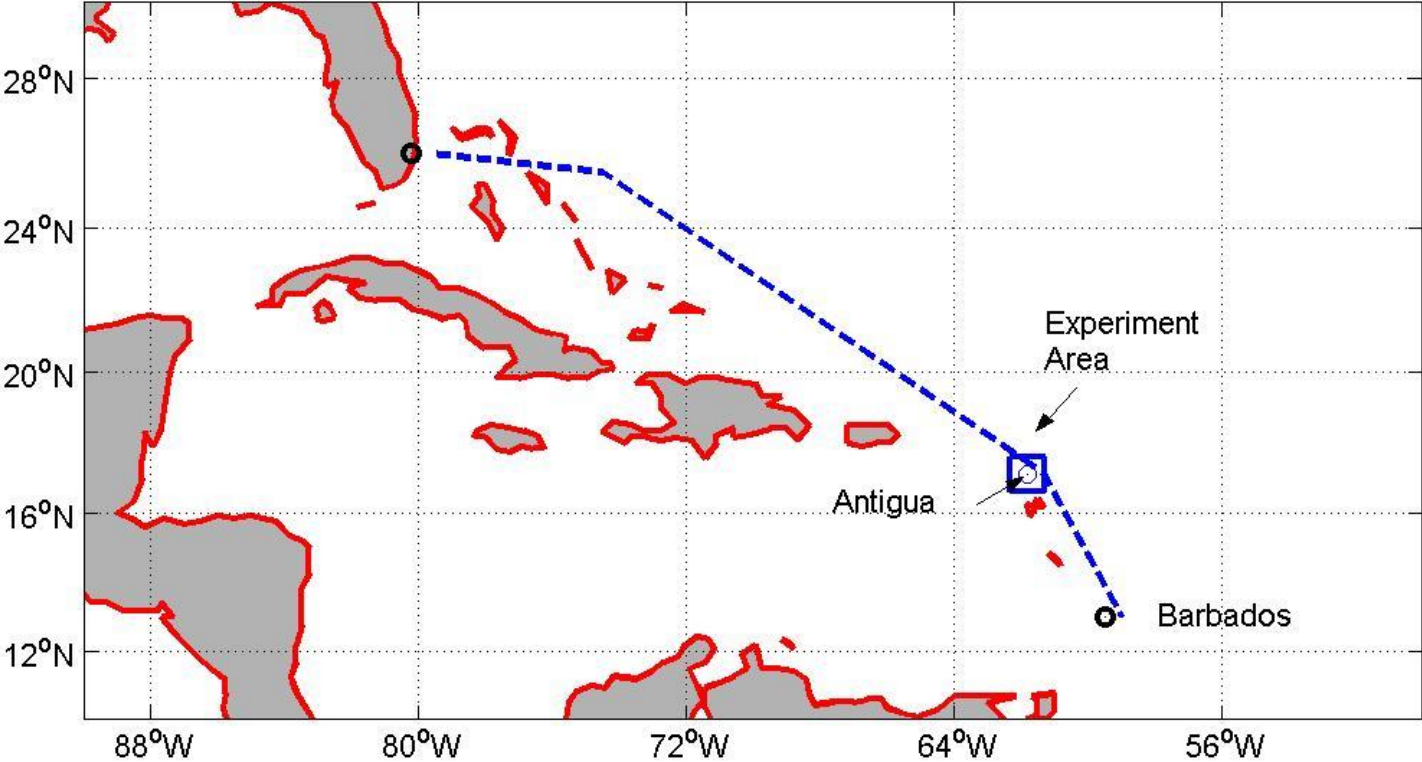- Aerosol, clear-air motions

Background

- More than 20 cruises since 1990
- 1991 Direct fluxes
- 1992 Ceilometer and wind profiler
- 1995 Lidar (4 cruises)
- 1998 CO2 fluxes (4 cruises)
- 1999 Cloud radar (6 cruises)

ETL cruises
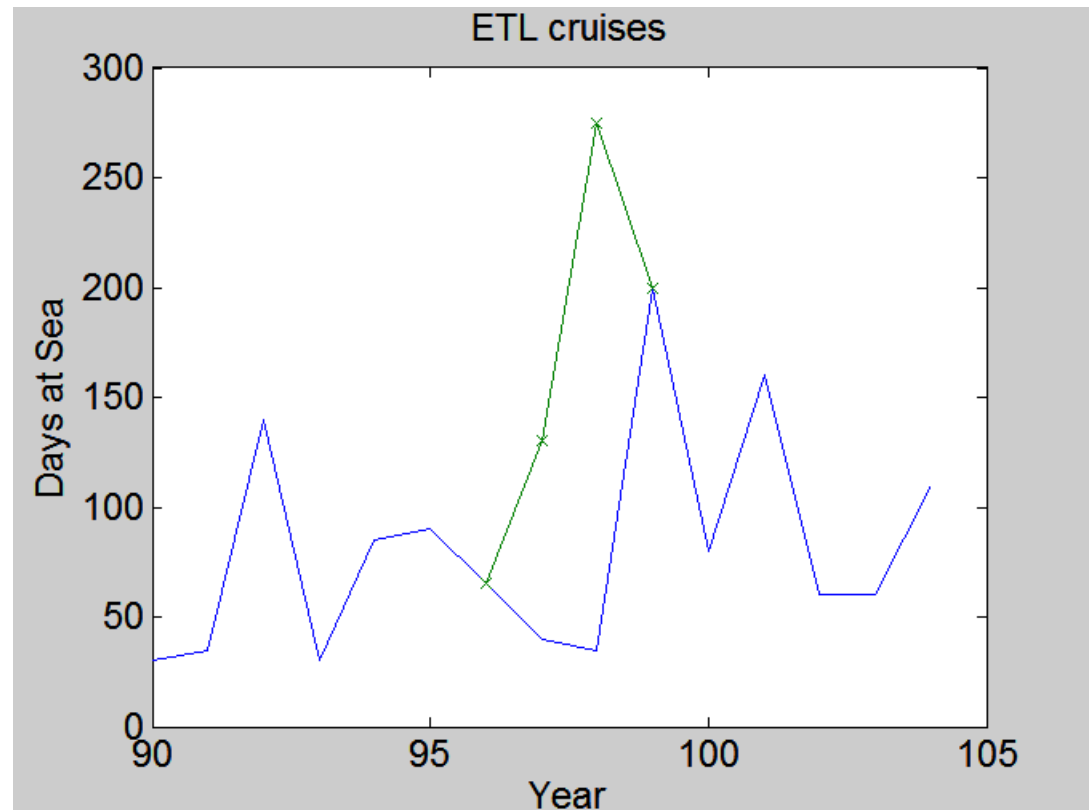
R/V Seward Johnson
Hobart Marine
Ft Pierce, FL

RICO 2004 R/V Ron Brown Proposed Track

Table 1. **Instruments and measurements for the ship-based cloud microphysics and PBL properties in precipitating trade cumulus clouds during RICO proposed study**.

Item	System	Measurement
1	Motion/navigation package	Motion correction for turbulence
2	Sonic anemometer/thermometer	Direct covariance turbulent fluxes
3	IR fast H_2O/CO_2 sensor	Direct covariance moisture/CO2 fluxes
4	Mean SST, air temperature/RH	Bulk turbulent fluxes
5	Pyranometer/Pyrgeometer	Downward solar and IR radiative flux
6	Ceilometer	Cloud-base height
7	915-MHz wind profiler	PBL 3-D winds, inversion height, clouds
8	94-GHz Doppler radar (UMDCR)	High resolution Doppler spectra, cloud and precipitation microphysics and dynamics
9	23, 31and 90 GHz microwave radiometer	Integrated cloud liquid water Integrated total water vapor
10	Riegl Laser wave sensor	Ocean surface wave height/period
11	Precipitation spectrometer	Drizzle droplet size spectra
12	BNL rotating shadowband radiometer	Direct/diffuse solar
13	35 GHz Doppler cloud radar (NOAA/K)	Cloud microphysical properties
14	Doppler lidar (NOAA ETL)	High resolution Doppler spectra around and below clouds

# Principal Remote Sensors

(a)

NOAA/K Cloud Radar
at Kennedy Space
Center, Feb. 2001

(b)

(c)
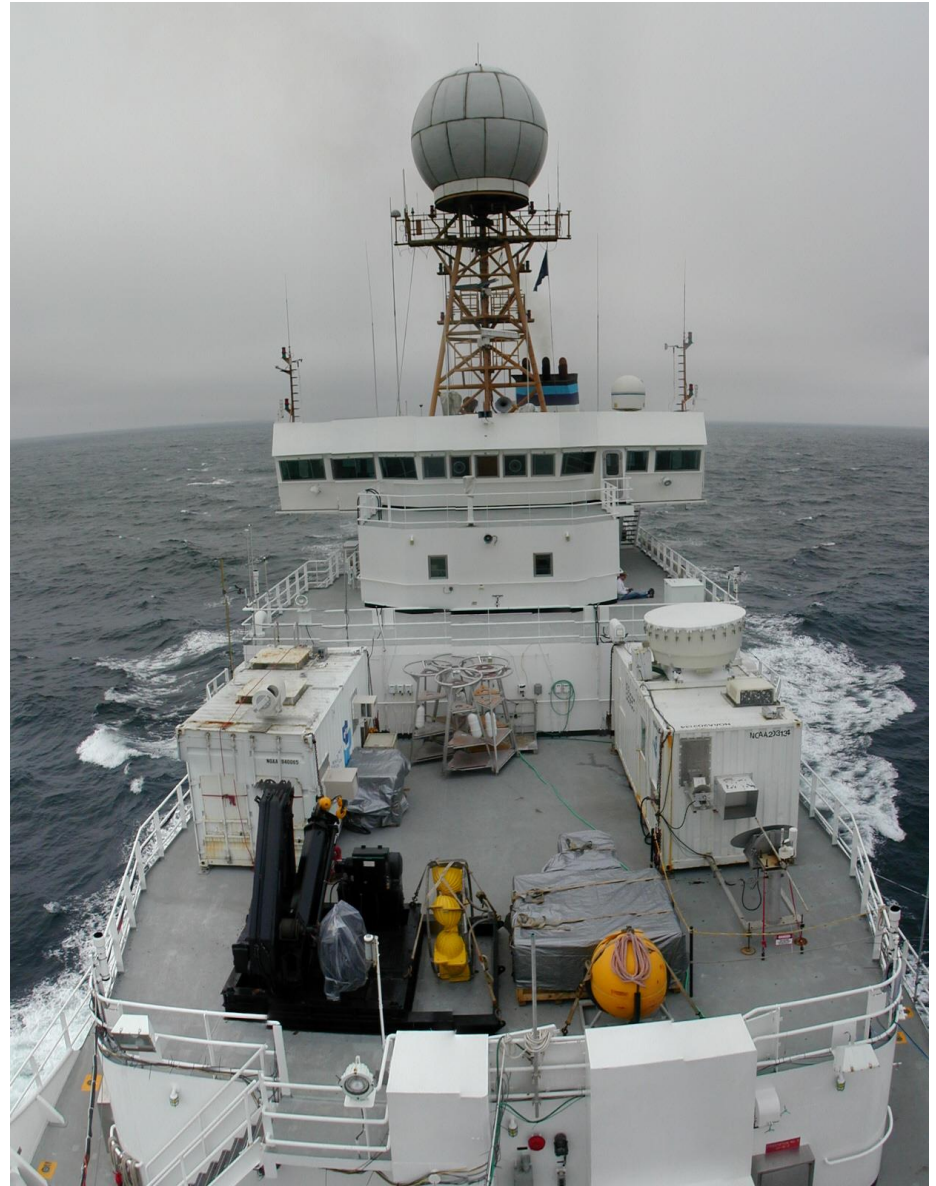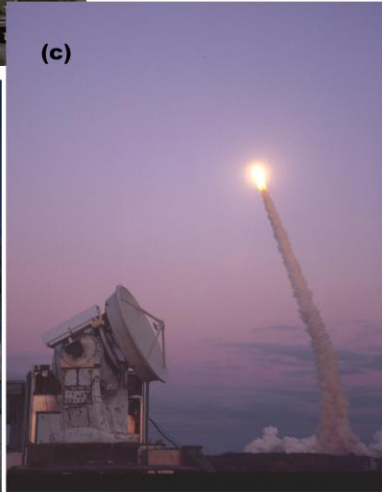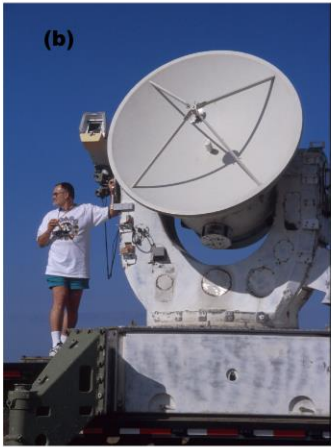
Air-Sea Fluxes and Mean PBL Structure

- **Stress, Sensible & Latent heat, CO2**
  - Direct motion-corrected covariances
  - Intertial-Dissipation
  - Bulk
- **Radiative Fluxes**
- **Stabilized Doppler 915 MHz wind profiler**
- **Rawinsondes (UW)**
- **Near-surface Bulk Meteorology**
  - SST, Tair, Humidity, wind speed
  - State-of-art accuracies
- **Ocean Surface Waves**
  - Significant height, period
- **Near-Surface Aerosols**
  - ETL PMS Lasair-II
  - Other?
- **Precipitation**
 - STI optical raingauge
 - DMT CIP drizzle spectrometer
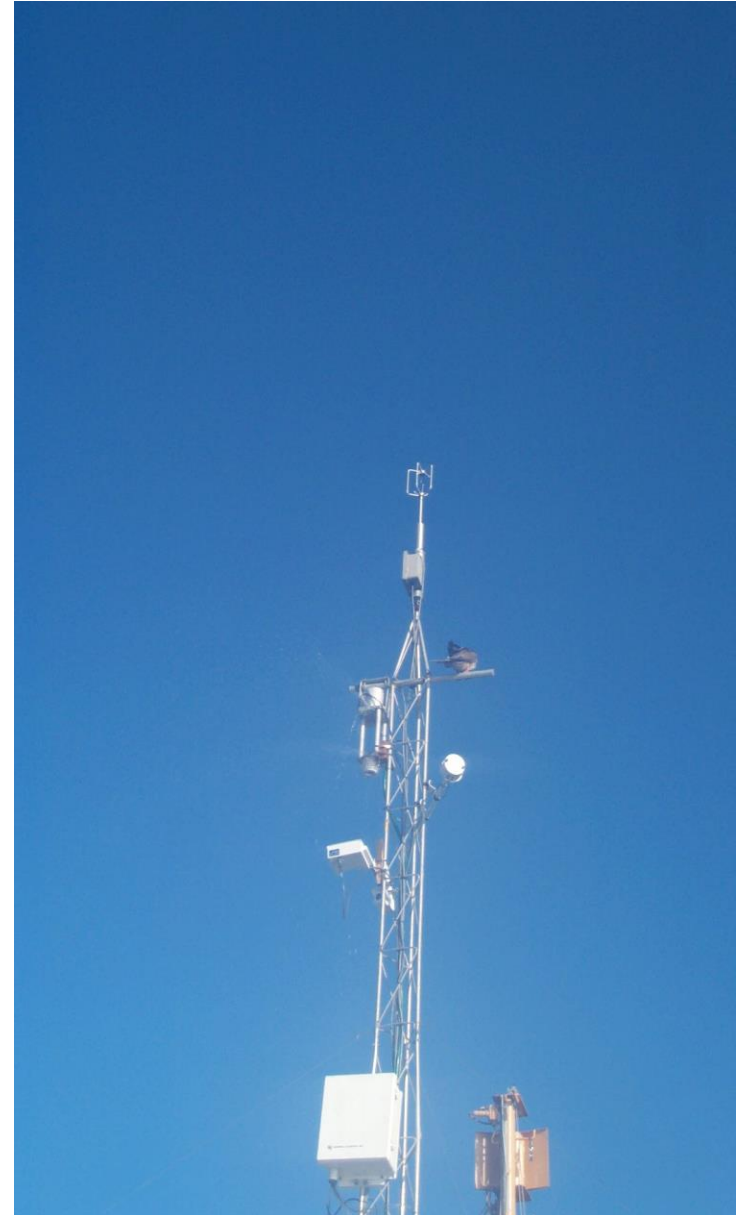
Mean Doppler velocity (Left) mapping of a fair weather cumulus cloud and Doppler spectrum width (Right) mapping of a fair weather cumuli. The black contour corresponds to the +1 ms-1 vertical velocity contour. The large values of spectrum width near the top of the updraft core appear to be associated with large horizontal shear of the vertical air velocity. The large values within the updraft core are indicative of large drops within the updraft core.
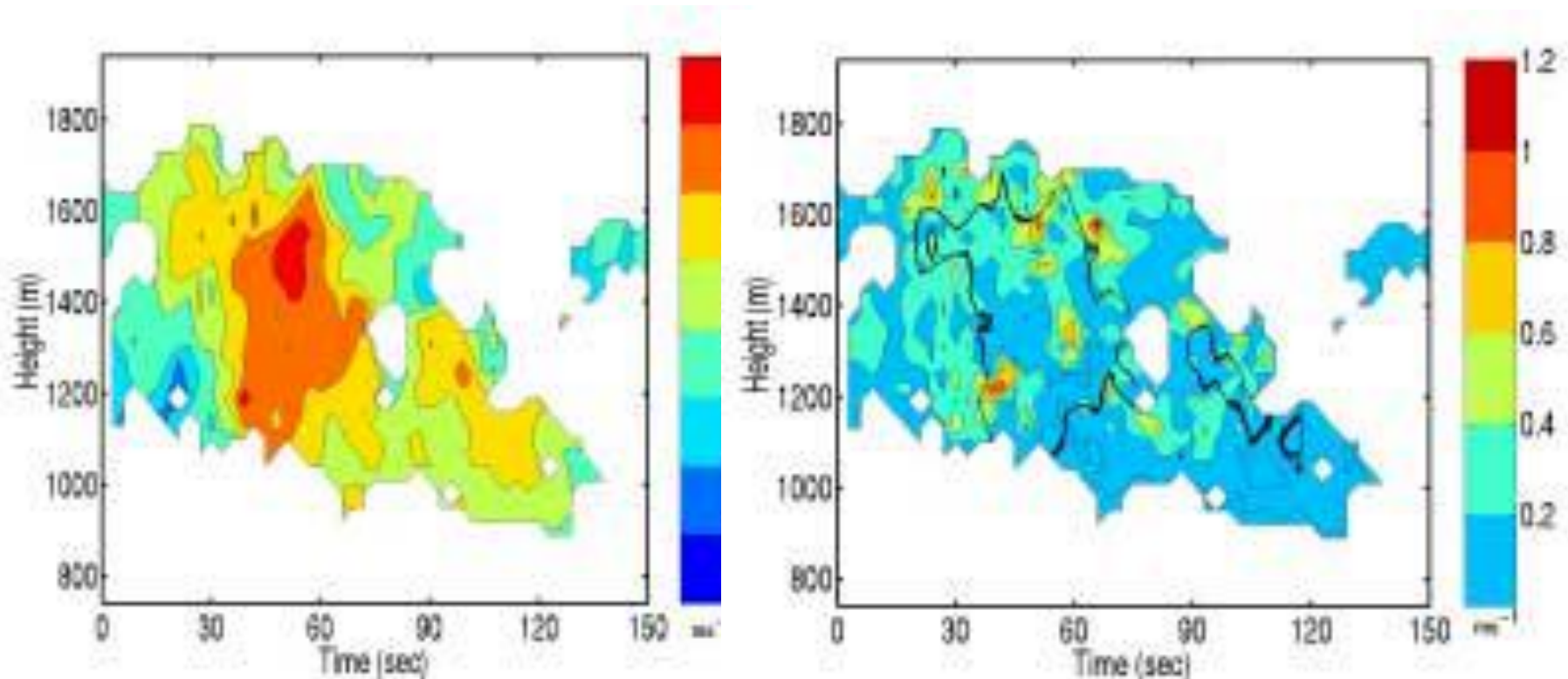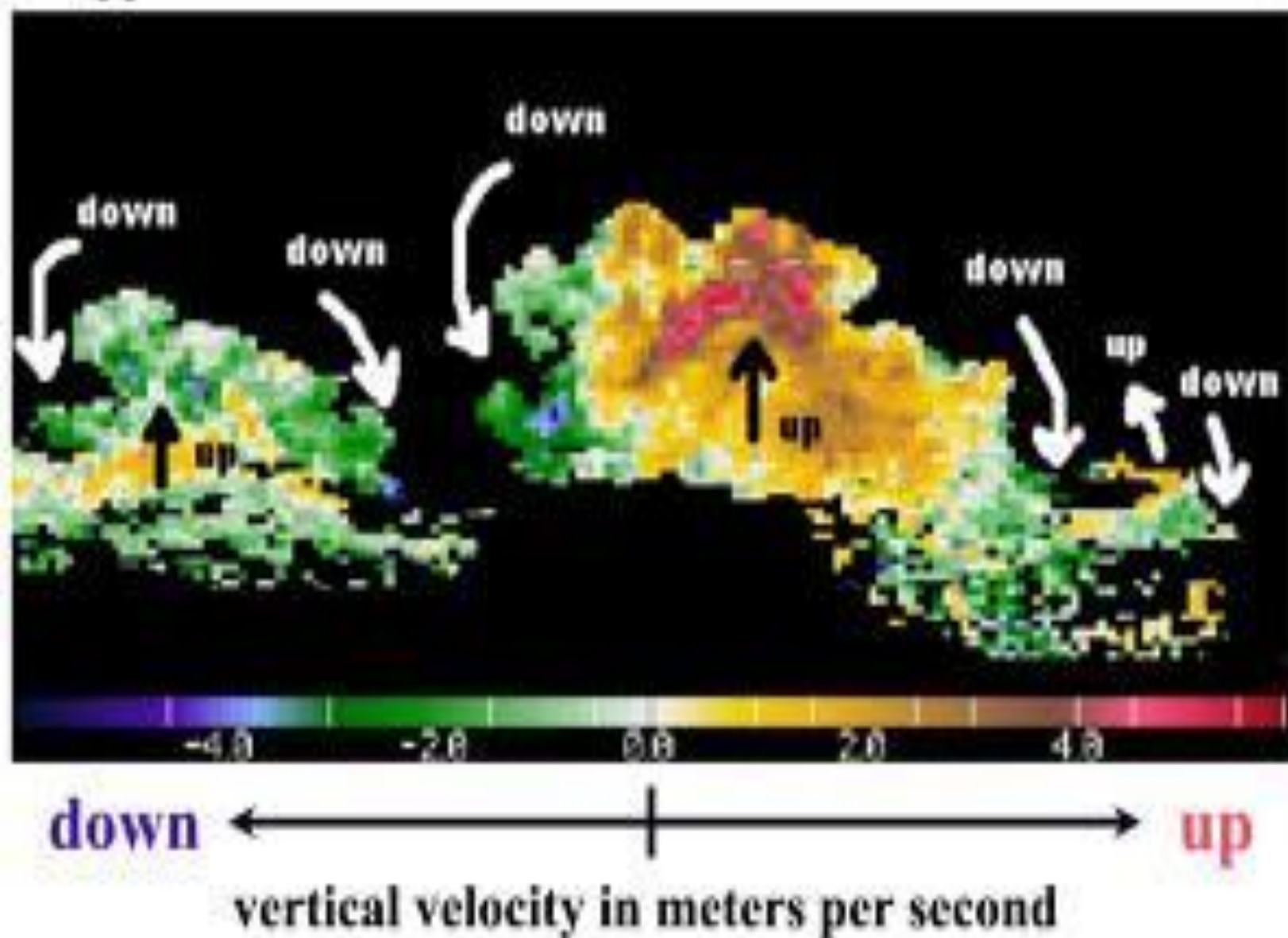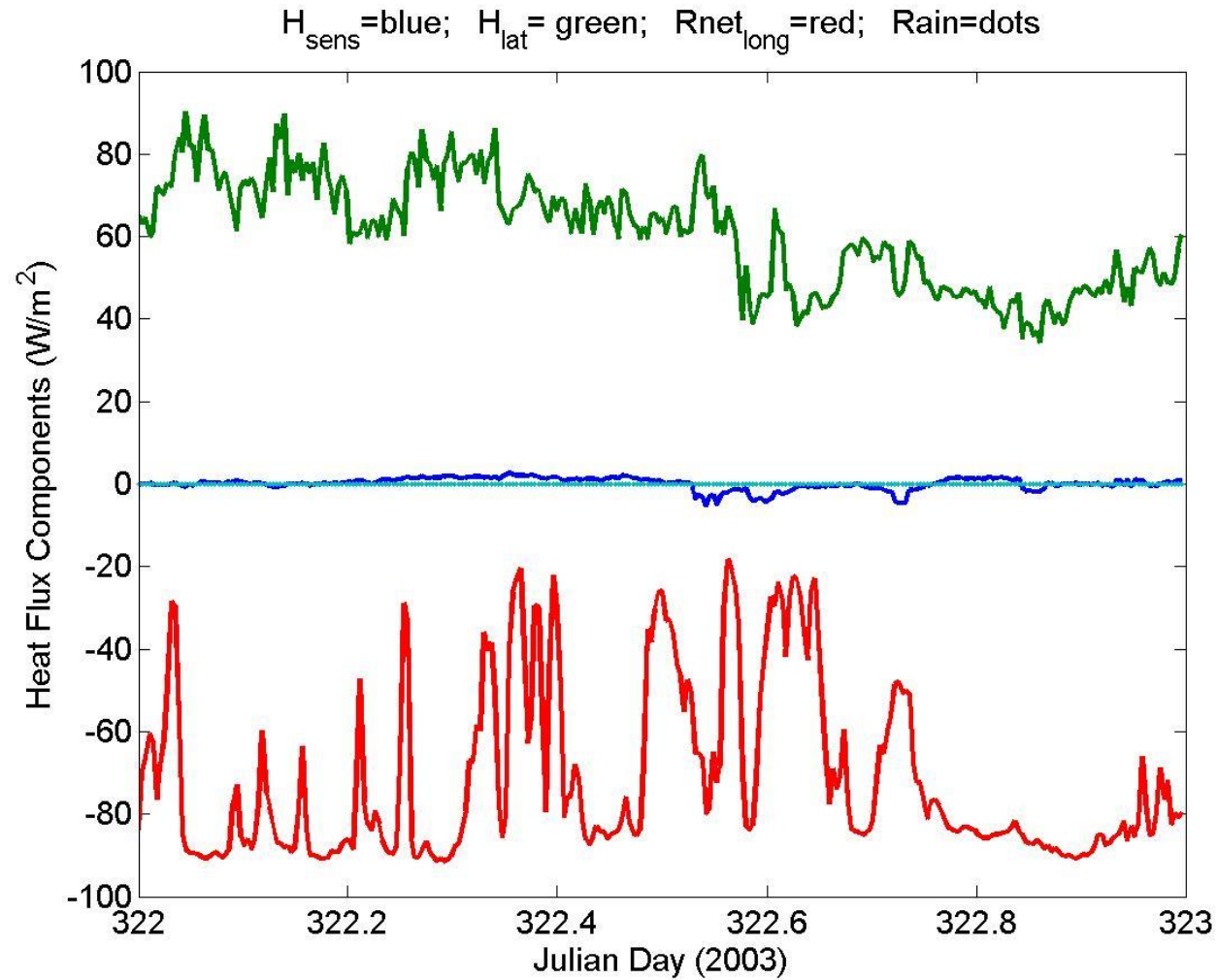
Lidar Cross-Sections
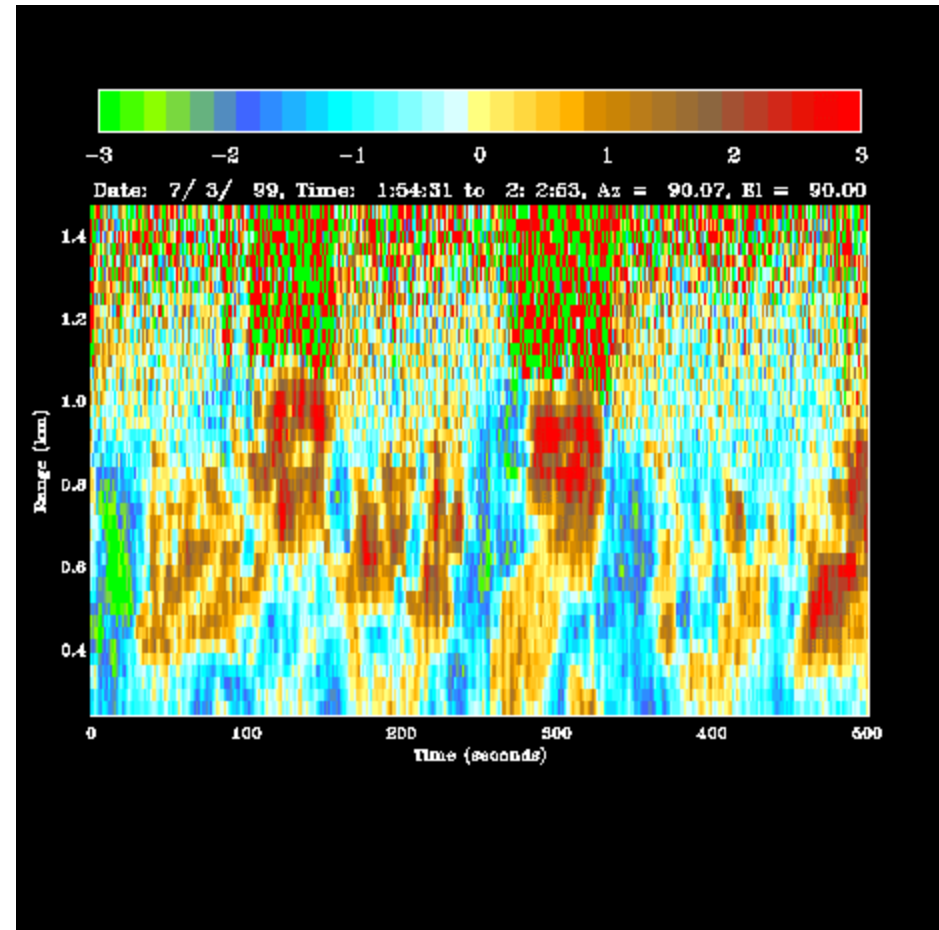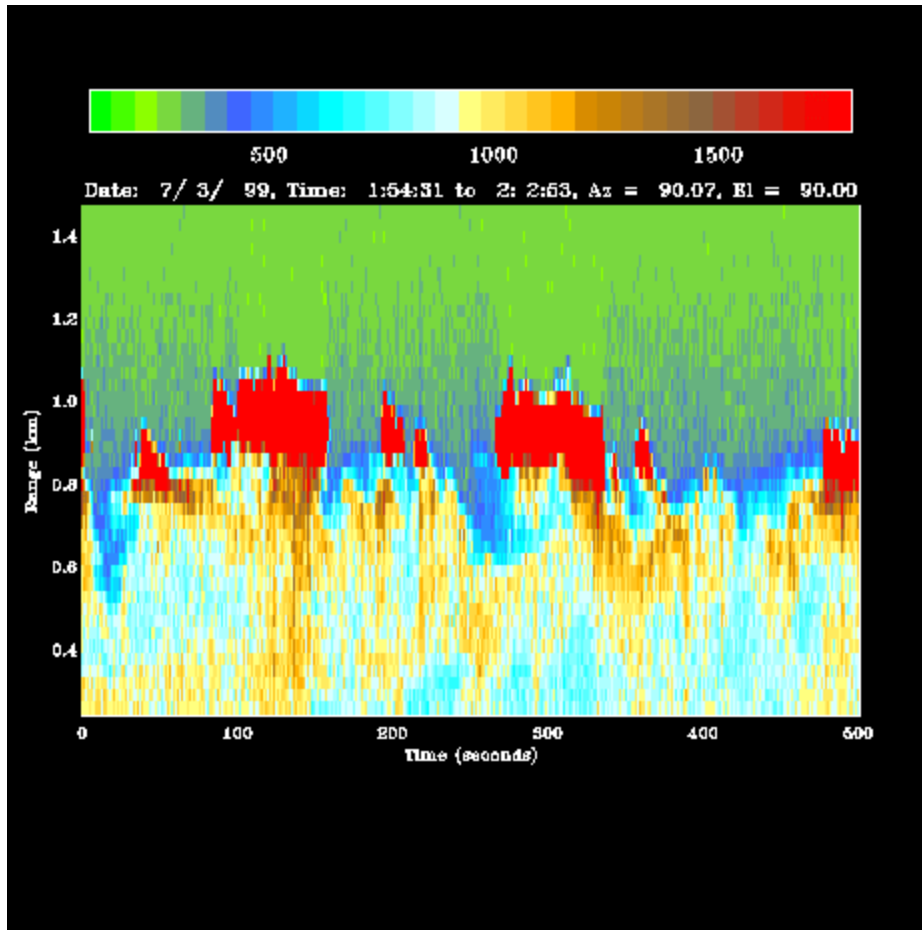
Vertical velocity and corresponding intensity measurements. Maximum range is 1.5 km and time range is 10 minutes. The strong lidar echoes correspond to trade-wind cumuli cloud bases. Coherent updraft structures coincident with strong aerosol backscatter are observed below the cloud bases
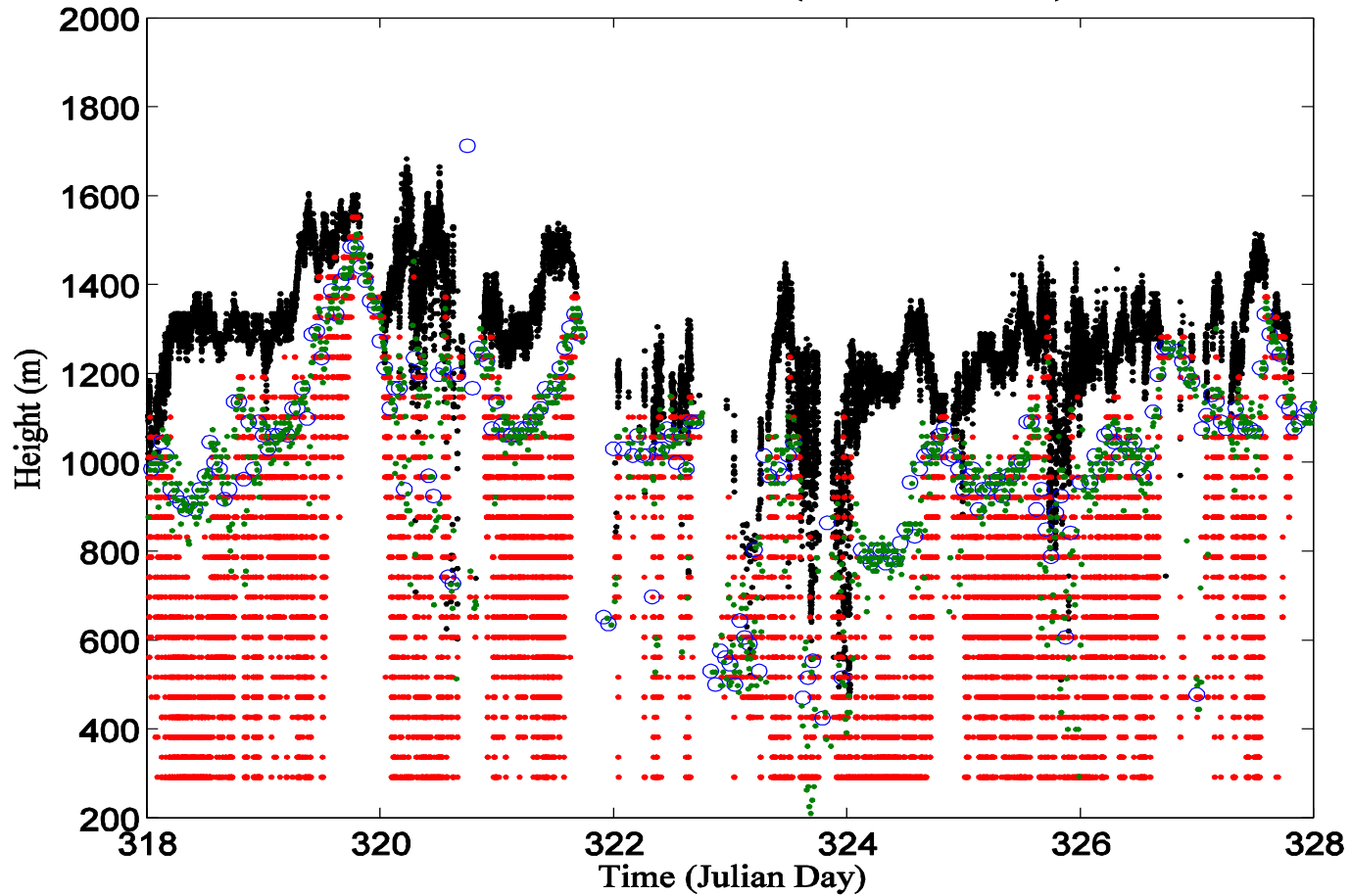
Doppler Radar Measurements of Shallow Cumulus Clouds

down ← → up

vertical velocity in meters per second

H$_{sens}$=blue;   H$_{lat}$= green;   Rnet$_{long}$=red;   Rain=dots

- Heat fluxes from one day on Stratus03.

Cloud boundaries and drizzle from Stratus03. Cloud top (black – MMCR); Cloud bottom (green dots – ceilo, blue circles – sonde LCL); range gates with drizzle (red dots – MMCR)

Statistical Properties of precipitating trade wind cumuli from cloud scale to mesoscale

UM (W/X)

NOAA/K "cloud entity" swath

10-15°

NOAA 915-MHz

NOAA/K meso-scale swath

500m

30 km
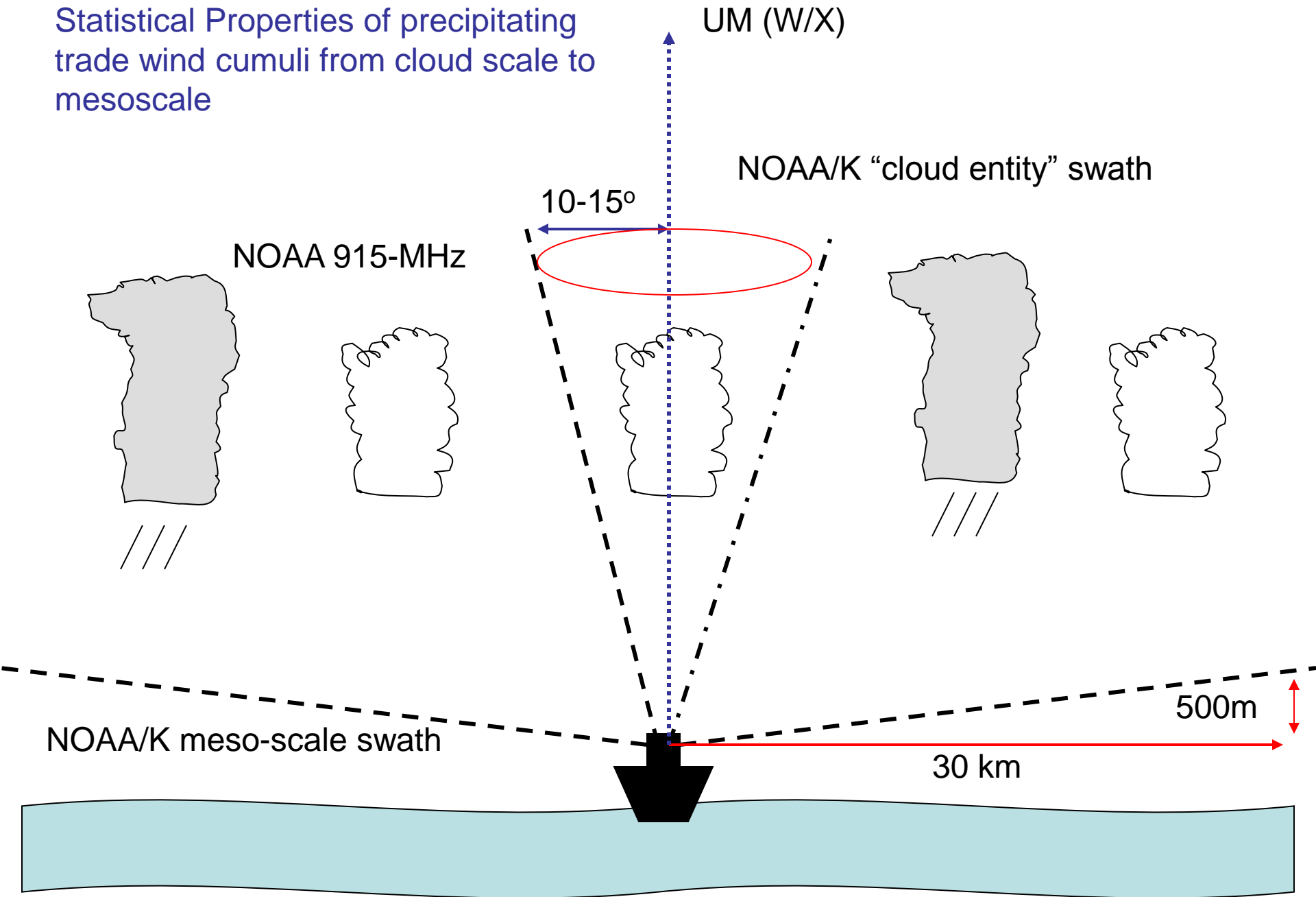
Preparation Tasks

NOAA – K   Harden for Marine work, stabilize

Miami – W/X   Install in ETL seatainer; stabilize

Visit the ship and design container layout, etc

Arrange installation issues with ship

Ship equipment and install

Field Program Time Table

- Dec   5 days to load
- Dec 30   Depart Ft. Pierce FL
- Jan 4   Arrive Barbuda
- Jan 25   Depart Barbuda
- Jan 29   Arrive Ft Pierce FL
- Jan 30-31   Destage