Ship-board Flux Measurements made during CalNex 2010

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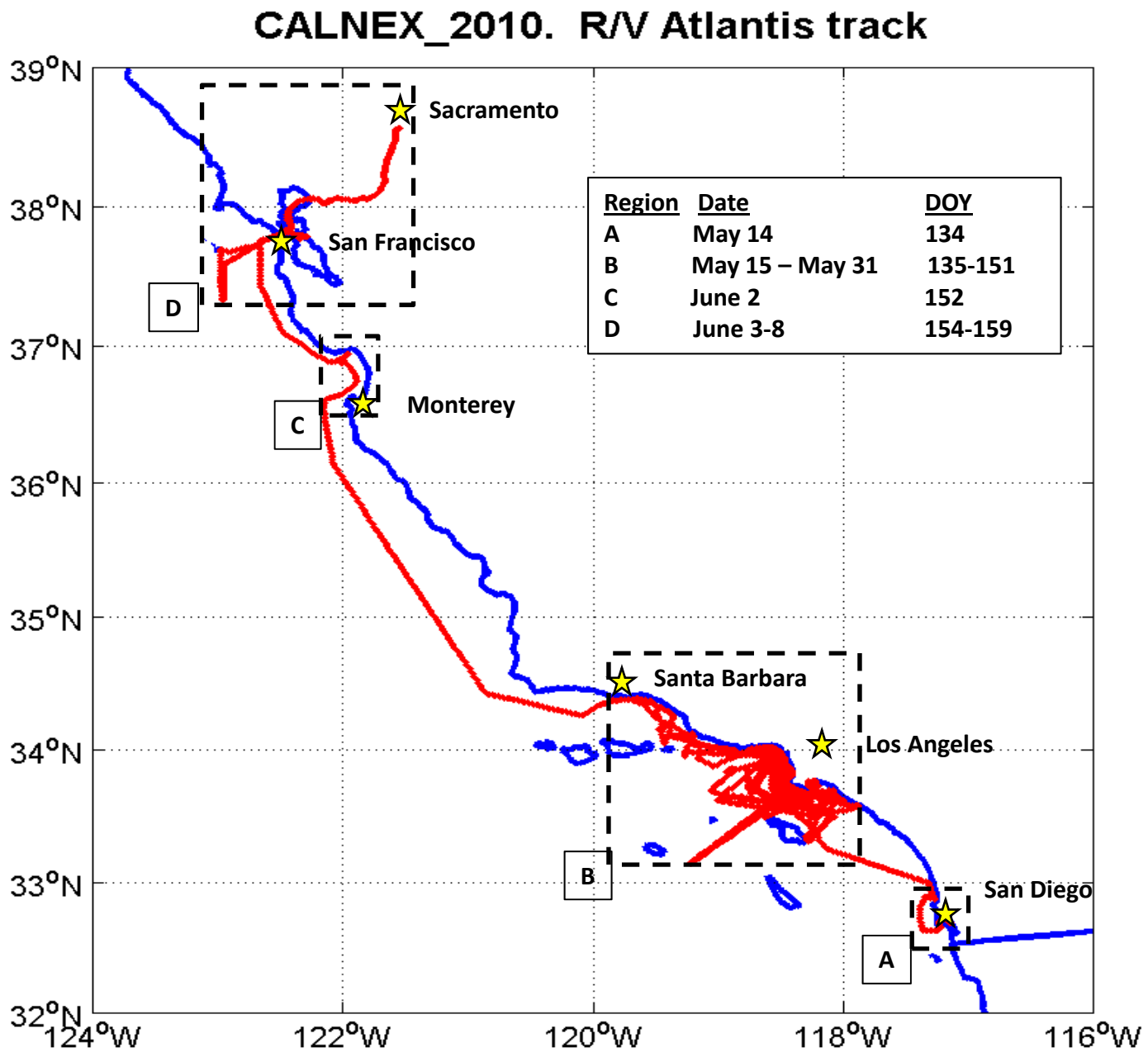
Air-Sea flux measurements were made from the research vessel Atlantis during the California Air Quality Study (CalNex 2010) off the California coast from San Diego to San Francisco Measurements included sensible and latent heat fluxes in conjunction with long and short-wave incoming solar radiation, total precipitable and liquid water, remote sensing of the clouds, and thermodynamic and wind profiles from radiosonde launches to capture the boundary layer structure. As can be seen in Fig. 1 a diverse and complicated set of data were collected in such regions as the harbors of San Diego, Los Angeles, and San Francisco, the Sacramento ship channel, coastal transects, and the open ocean. The two major study areas were just off the coast of Los Angeles where the ship spent 16 days and in the San Francisco bay/ Sacramento ship-channel for 5 days. Figure 2 shows hourly averaged data of the meteorological conditions encountered. Boundary layer conditions are summarized in Figure 2 which is a composite of the theta profiles calculated from the 79 radiosonde launches made during CalNex.

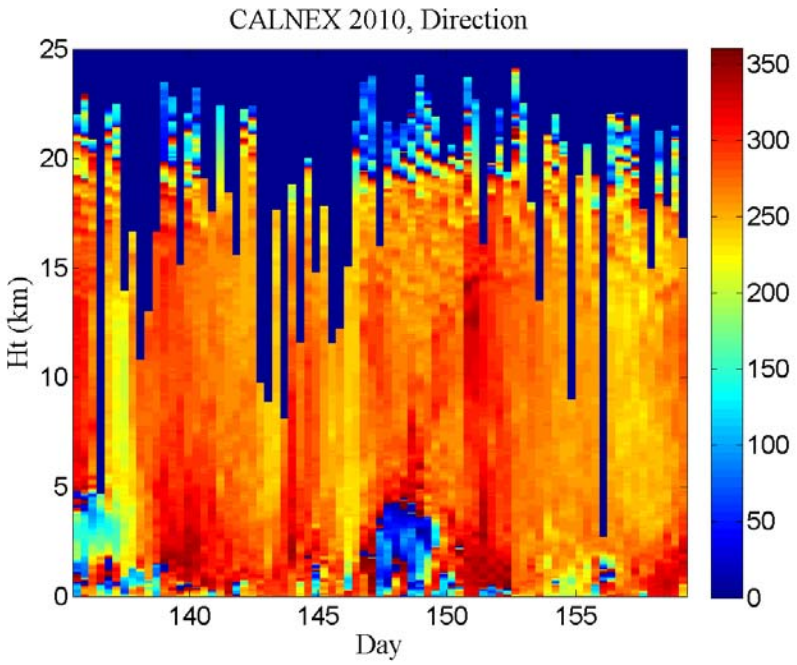
Basic Observation Summary

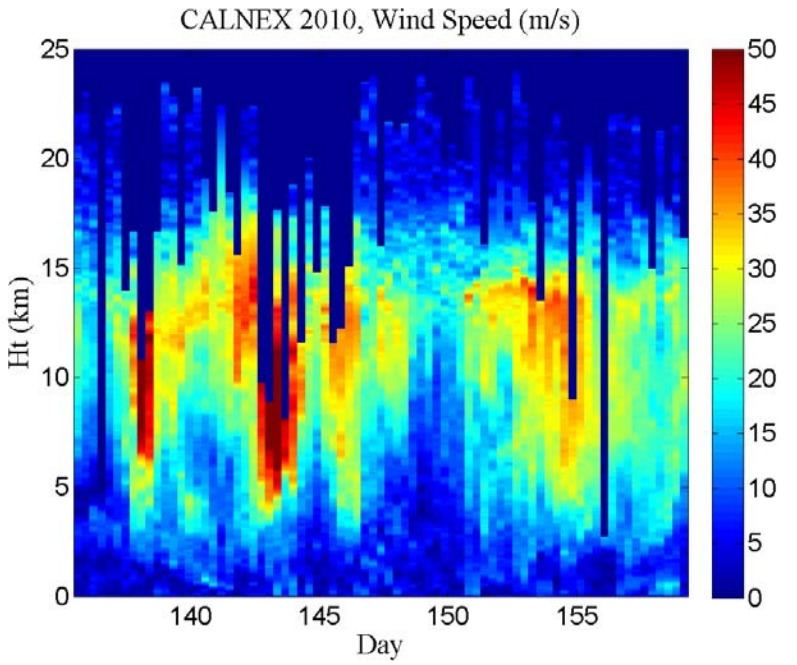
ESRL/PSD group CALNEX Observations		
PARAMETER	**METHOD**	**PI**
Gas Phase Composition		
Carbon dioxide (CO2)	Nondispersive IR	Fairall; ESRL
Carbon dioxide (CO2)	CRD	Blomquist; U
Carbon dioxide (CO2) & Methane	CRD	Sweeney; ESRL
Aerosol and Cloud - Physical, Optical, and Radiative Properties		
Radiative fluxes	Pyranmometer/Pyrgeometer	Fairall, PSD
Cloud liquid water path	Microwave radiometer	Fairall, PSD
Cloud structure, precip	W band cloud radar	Fairall, PSD
Seawater Parameters		
Near surface SST	SeaSnake	Fairall, PSD
Met and Boundary Layer Dynamics		
Wind vertical profiles	915 MHz wind Radar	Fairall; ESRL
Temperature/relative humidity/Wind profiles	Radiosondes	Fairall; ESRL
Surface energy/momentum balance (fluxes)	Eddy covariance (bow mounted)	Fairall; ESRL
Cloud base height. Cloud fraction	Ceilometer	Fairall; ESRL

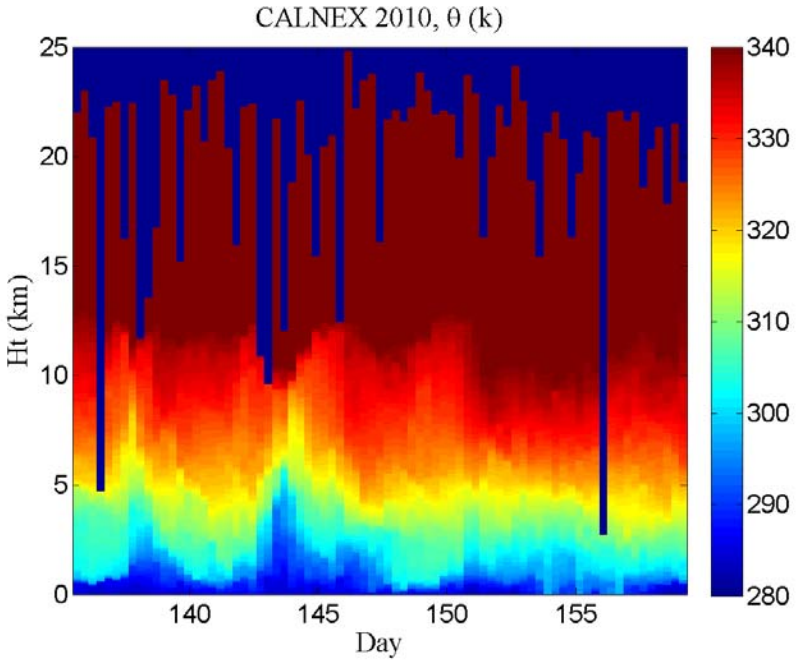
Flux and Near-surface Meteorological Sensors

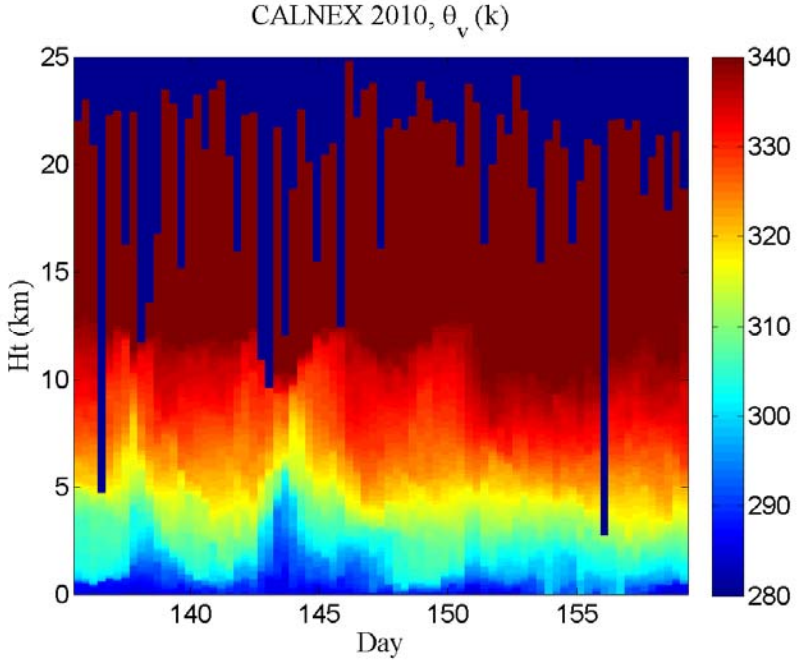
Doppler Cloud Radar and Wind Profiler


CALNEX_2010. R/V Atlantis track
39°N
38°N
37°N
36°N
35°N
34°N
33°N
32°N
124°W
122°W
120°W
118°W
116°W
Sacramento
San Francisco
Monterey
Santa Barbara
Los Angeles
San Diego
D
C
B
A
Region Date DOY
A May 14 134
B May 15 – May 31 135-151
C June 2 152
D June 3-8 154-159

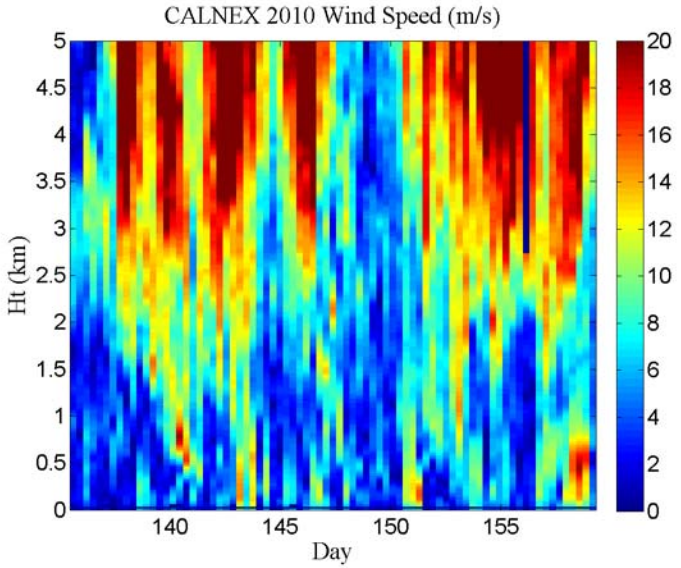

CALNEX 2010, Direction
Ht (km)
Day
0
5
10
15
20
25
140
145
150
155
0
50
100
150
200
250
300
350

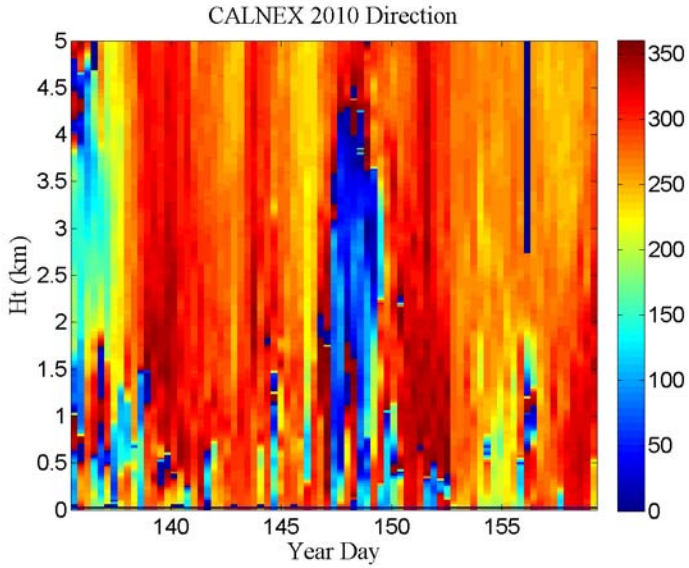

CALNEX 2010, Wind Speed (m/s)
Ht (km)
Day
0
5
10
15
20
25
140
145
150
155
0
5
10
15
20
25
30
35
40
45
50

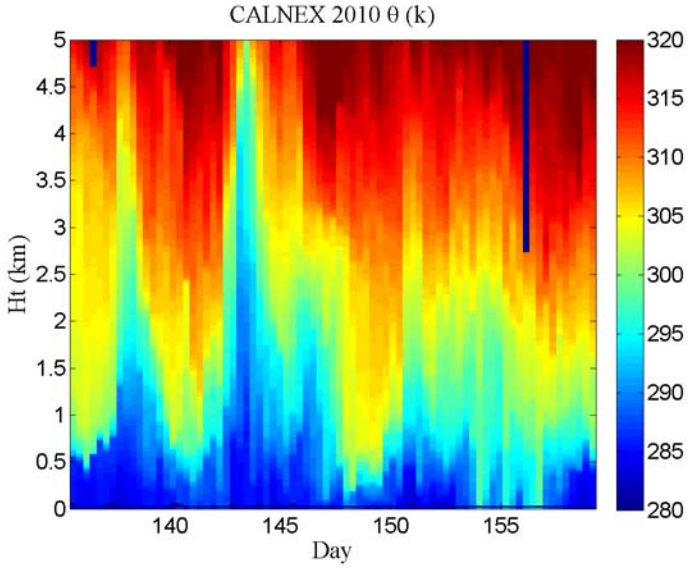

CALNEX 2010, θ (k)
Ht (km)
Day
0
5
10
15
20
25
140
145
150
155
280
290
300
310
320
330
340

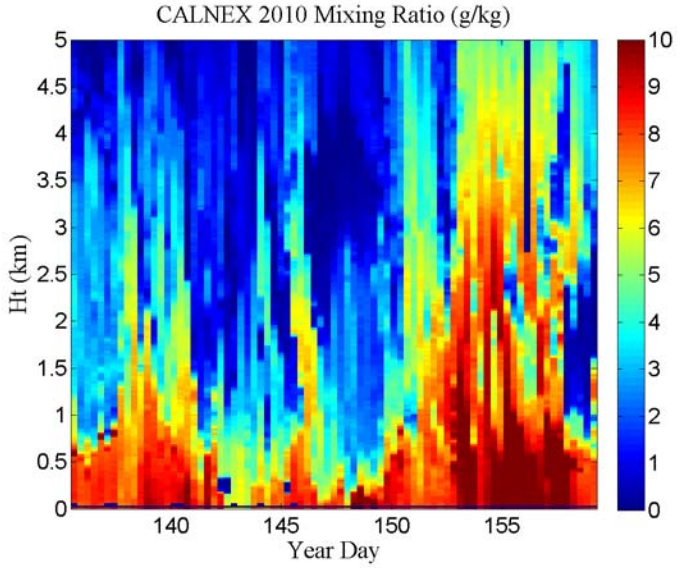

CALNEX 2010, θv (k)
Ht (km)
Day
0
5
10
15
20
25
140
145
150
155
280
290
300
310
320
330
340

Balloon Soundings – Low Altitude

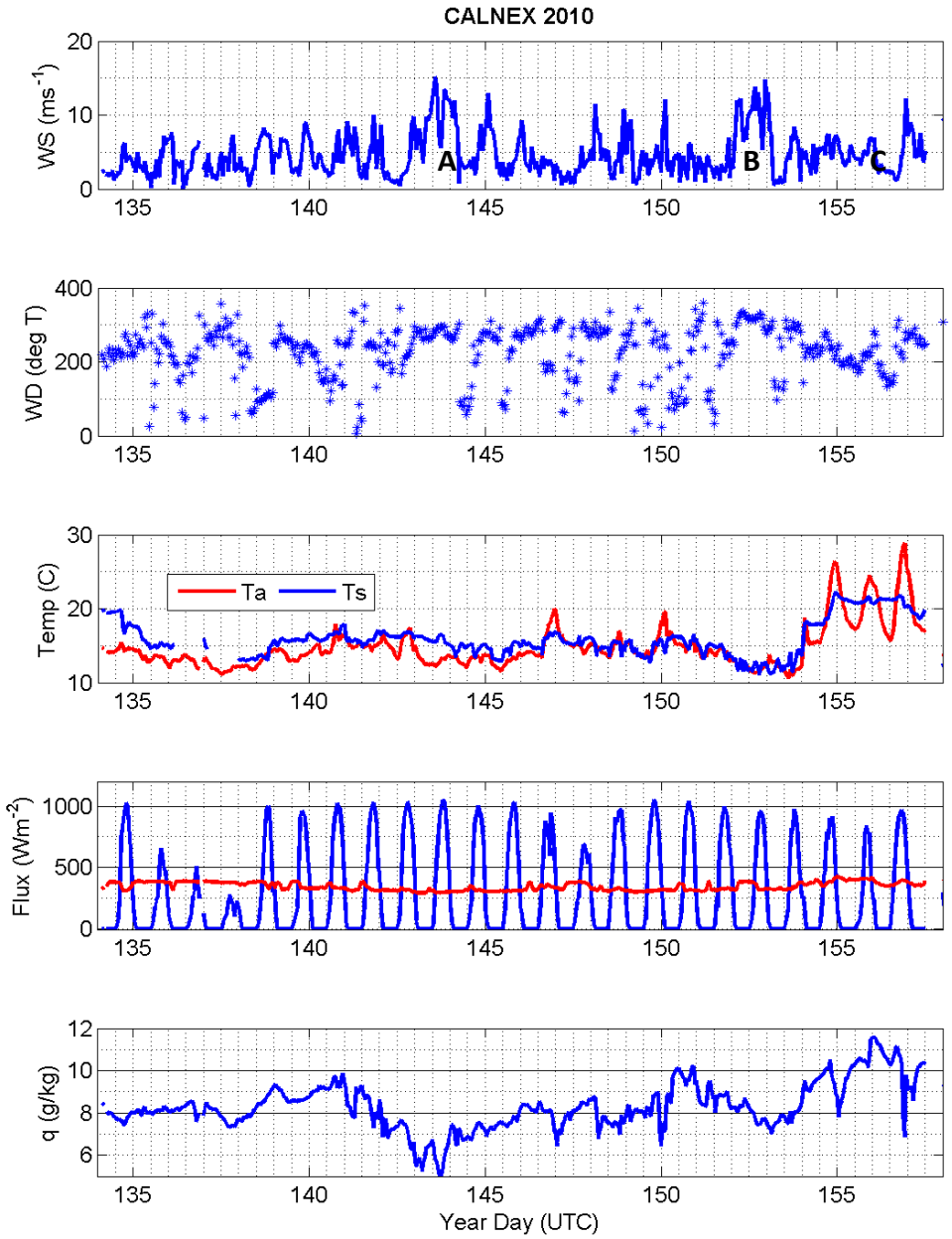




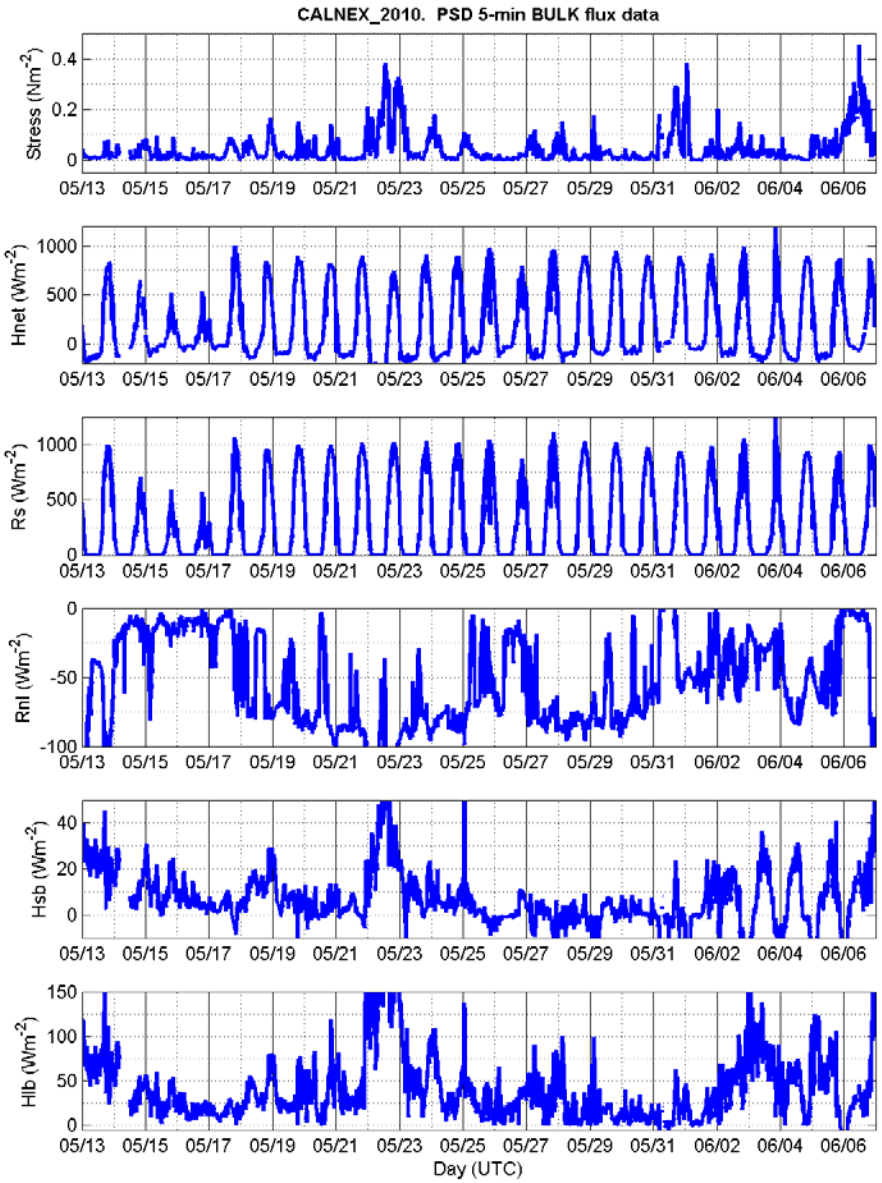




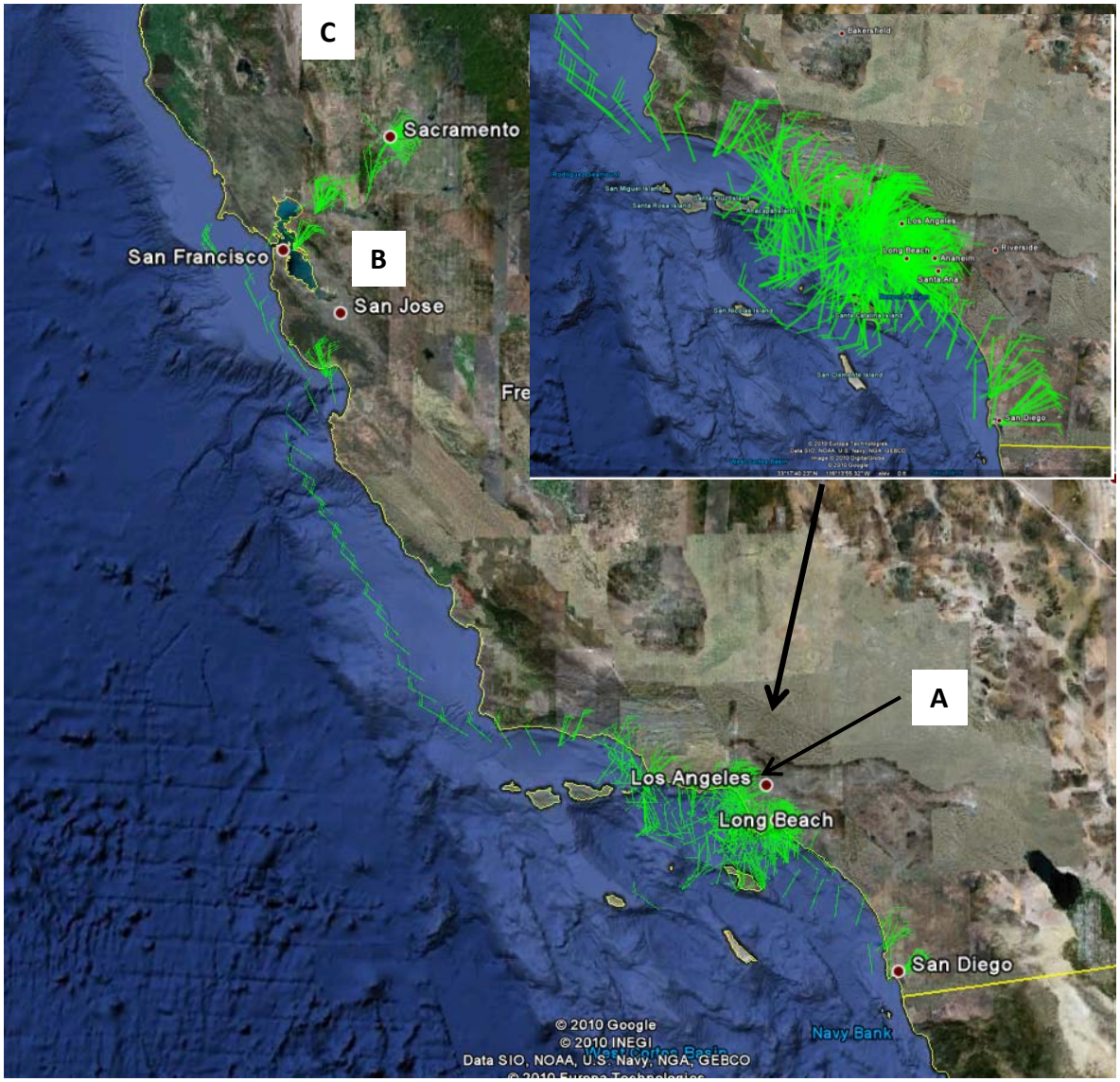
Basic Near-Surface Meteorology



Surface Fluxes

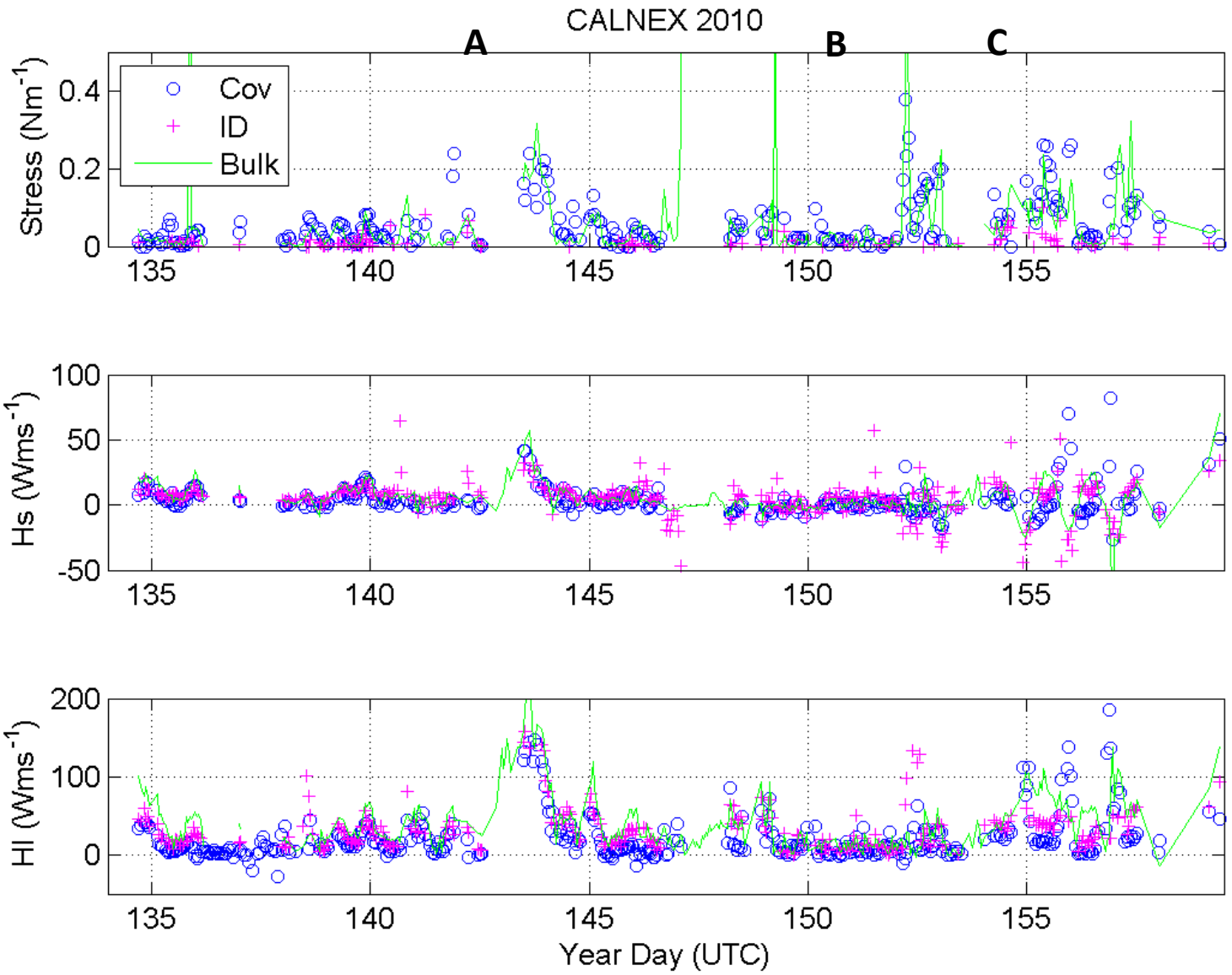


CALNEX Wind Barb Plot

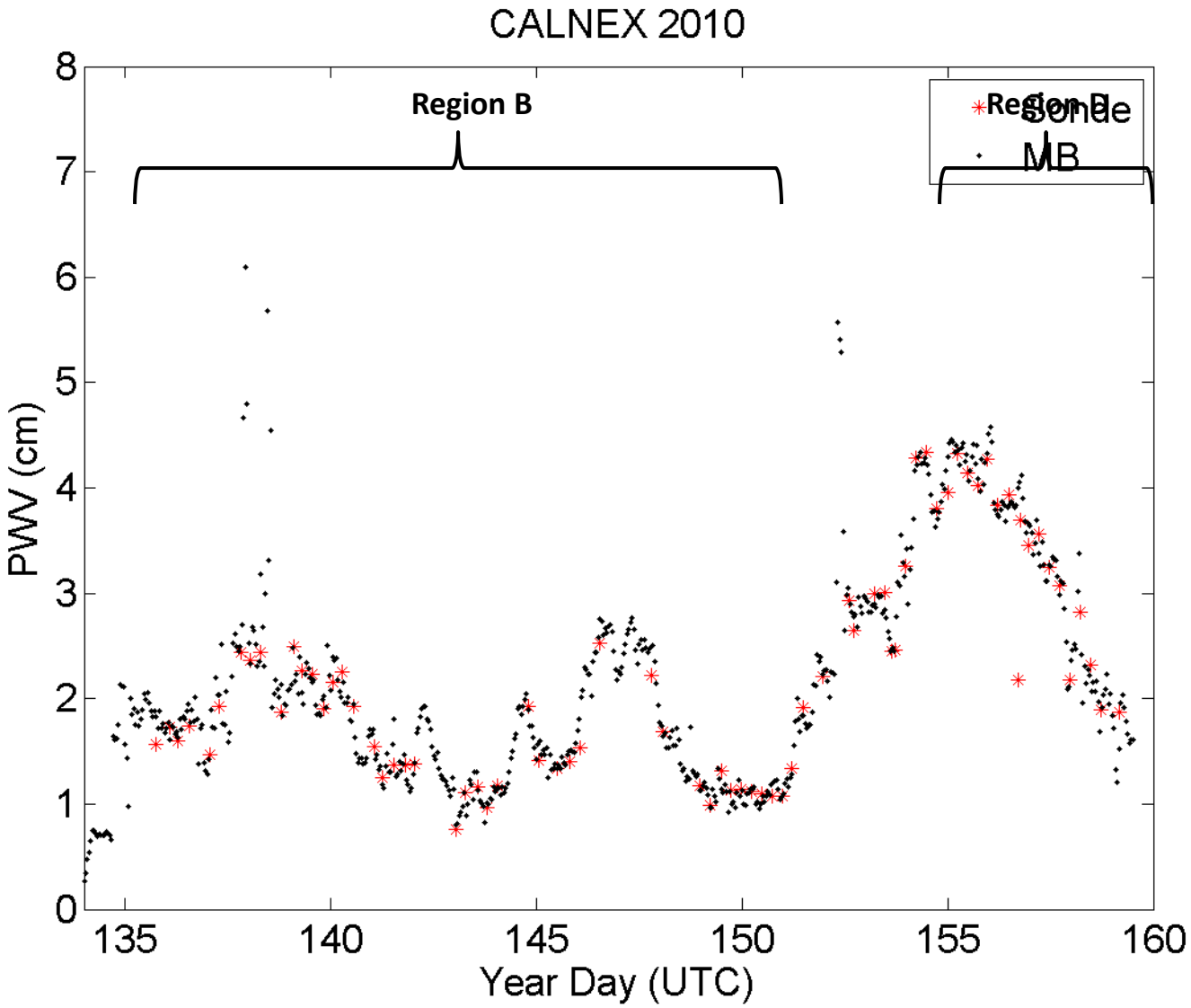


Each half pennant represents 5 knots (1 knot = 0.51 m/s) each whole pennant represents 10 knots; each flag represents 50 knots (which we should not see on that cruise). Max was ~30 knots.

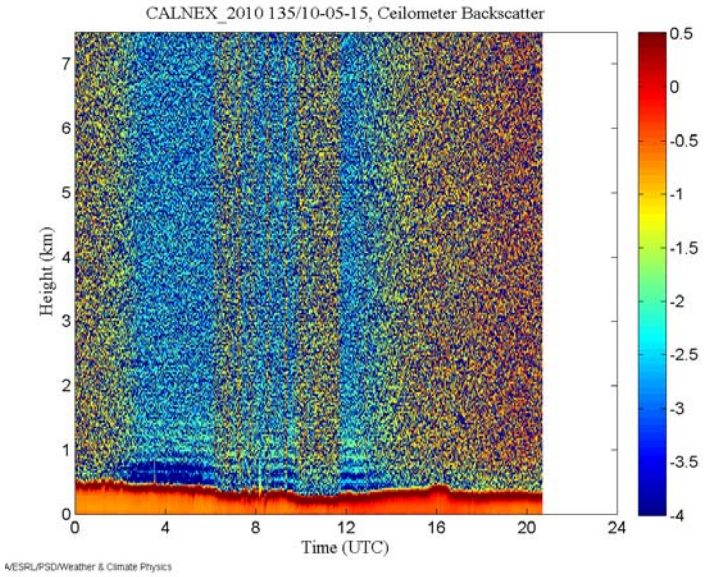
Direct Turbulent Fluxes

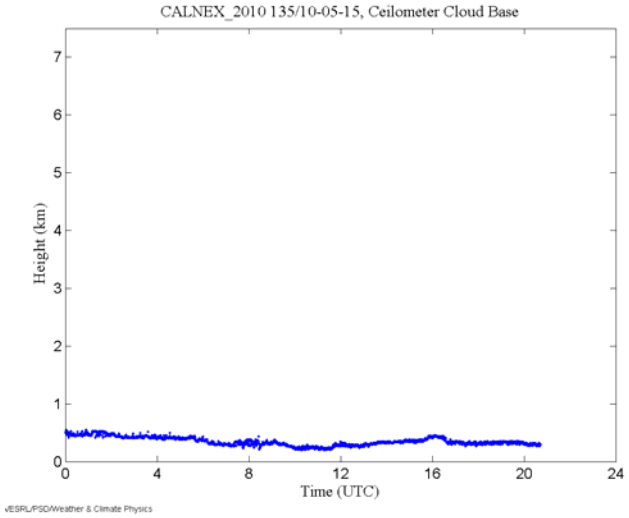


Column-Integrated Water Vapor (Precipitable Water)

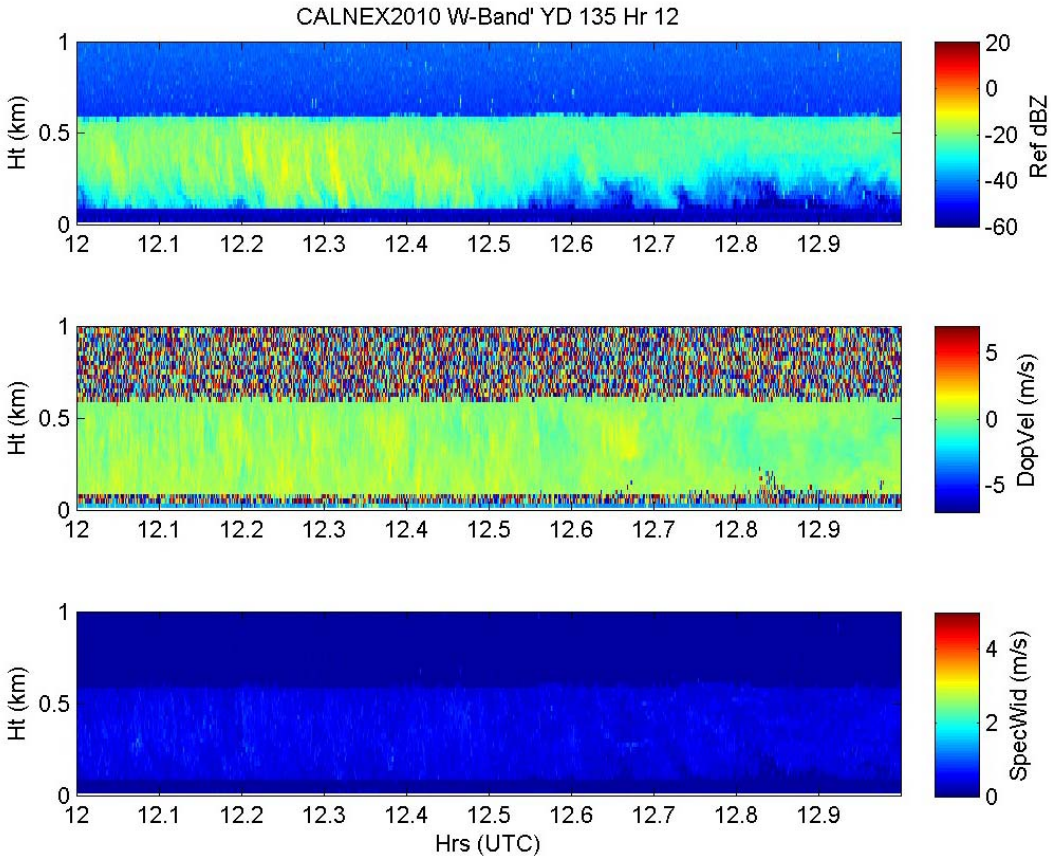


Cloud Views



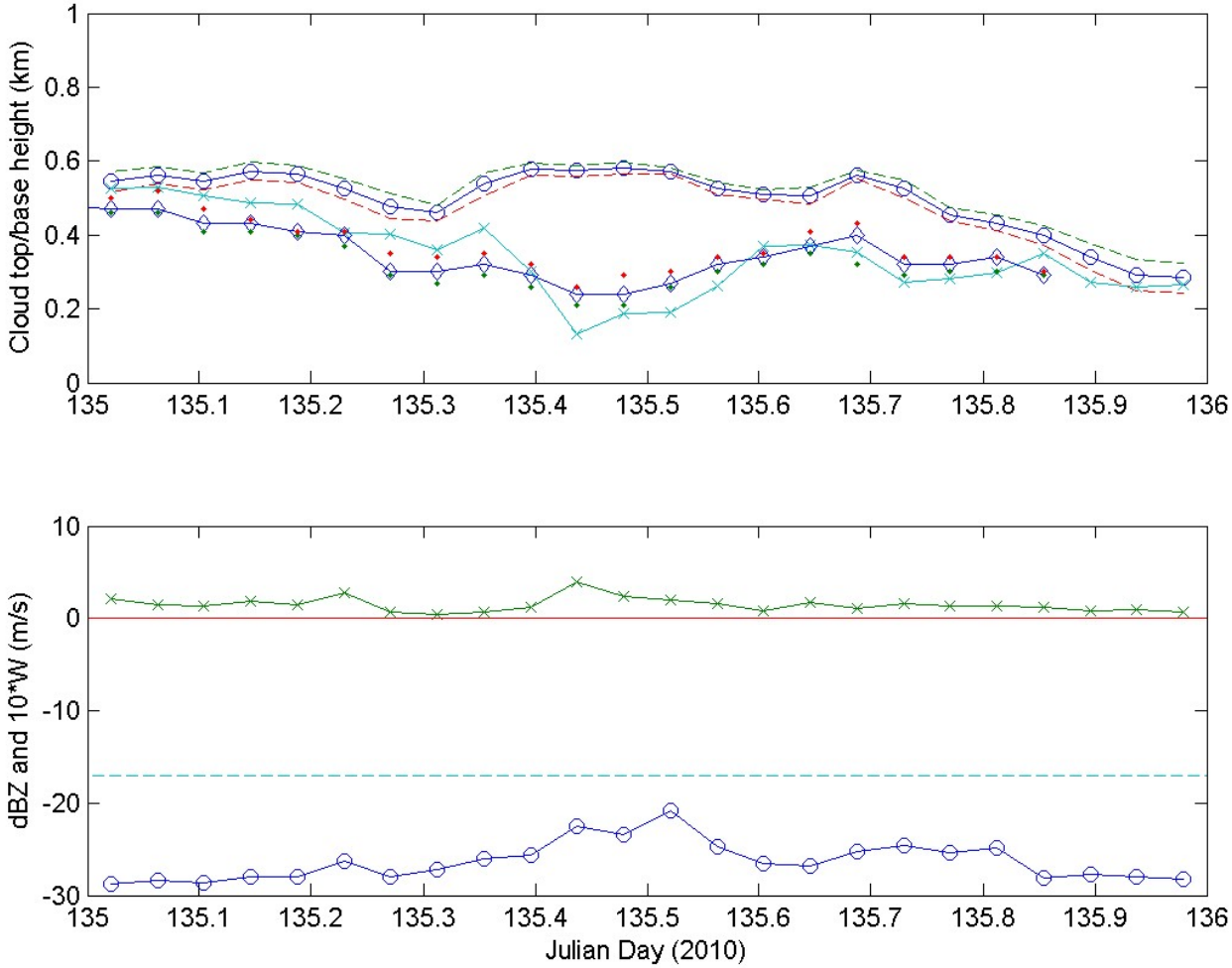


Time series of **ceilometer** cloudbase height for May 15.



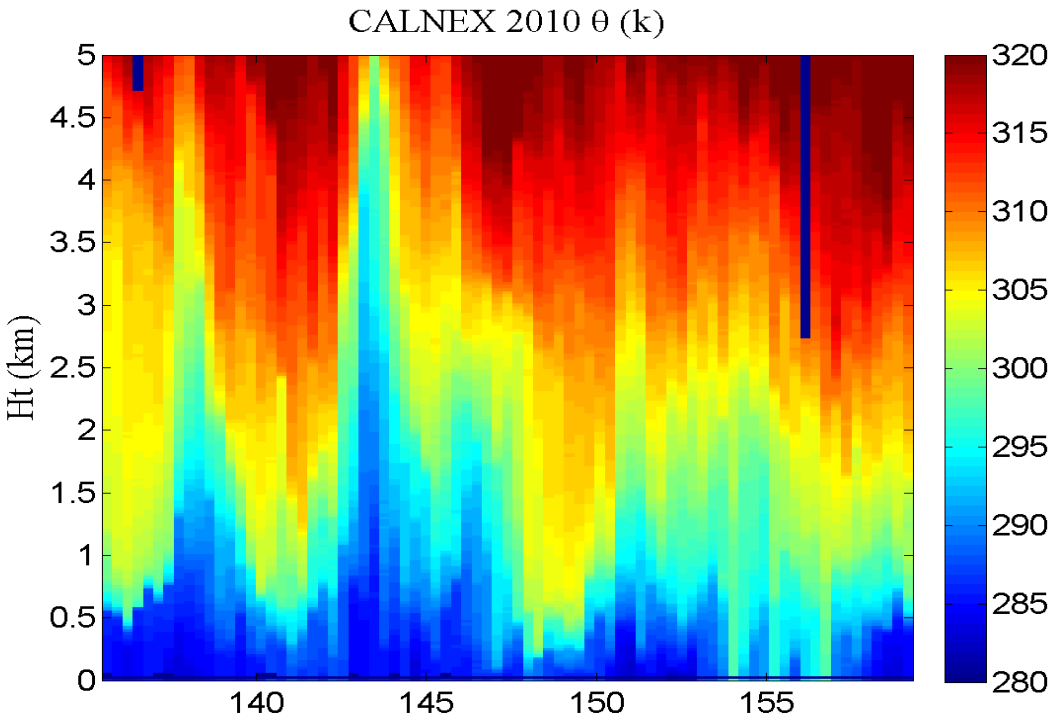
Time-height cross section from **1 hour** of data beginning at 1200 on May 5 from ESRL/PSD **W-band cloud radar**. The top panel is the radar reflectivity (dBZ); the middle panel is the mean Doppler velocity (m/s, positive down); the bottom panel is the Doppler width (m/s) of the return.

Combined Ceilometer – Cloud Radar

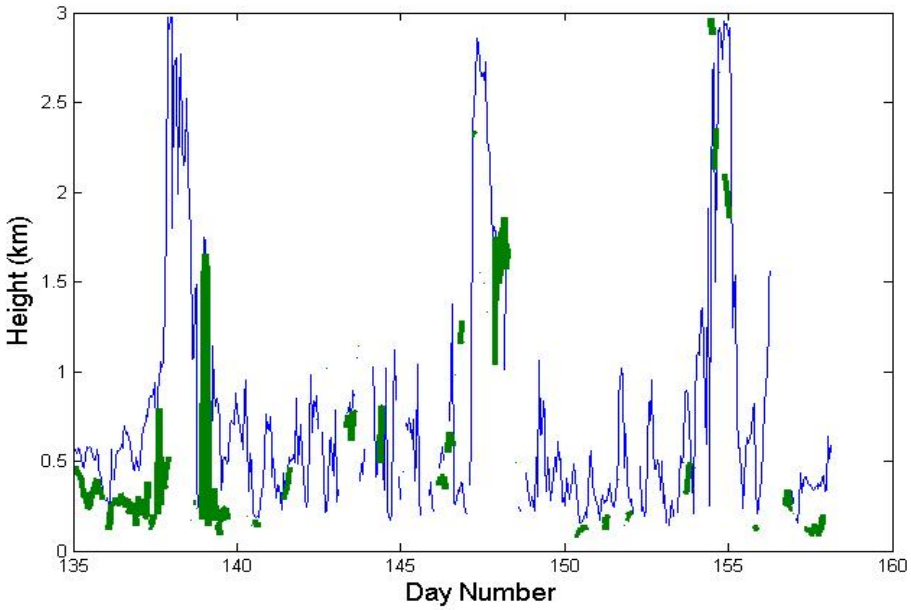


Time series of cloud properties for May 5, 2010. Upper panel: cloud top height (circle with solid line; ±1 standard deviation, dashed line) and cloud base height (diamonds with solid line; 1 standard deviation, dots). Lower panel: mean radar backscatter for the cloud/drizzle layer (circle with solid line) and mean droplet fall speed (x's with solid line) multiplied by 10 (in m/s).

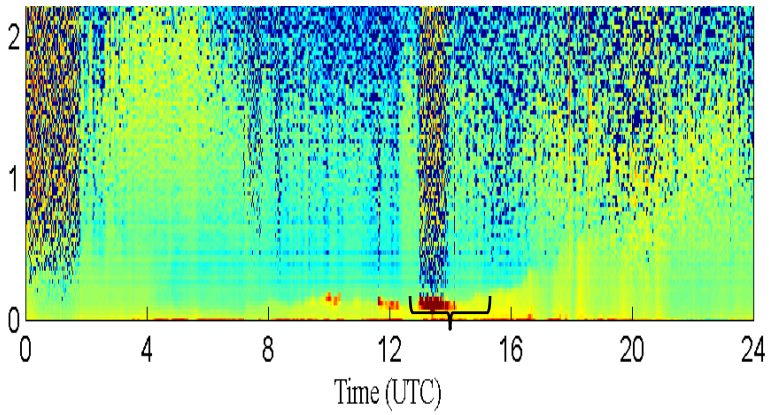
Time/height cross section of potential temperature

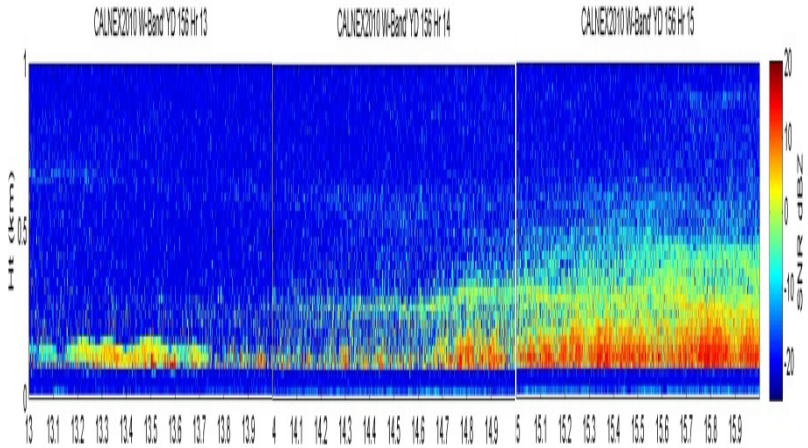


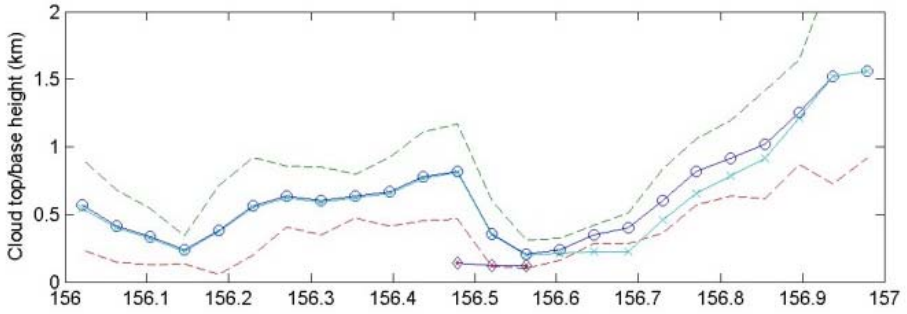
Time series of BL/Mixing height (blue) and cloud base height (green)

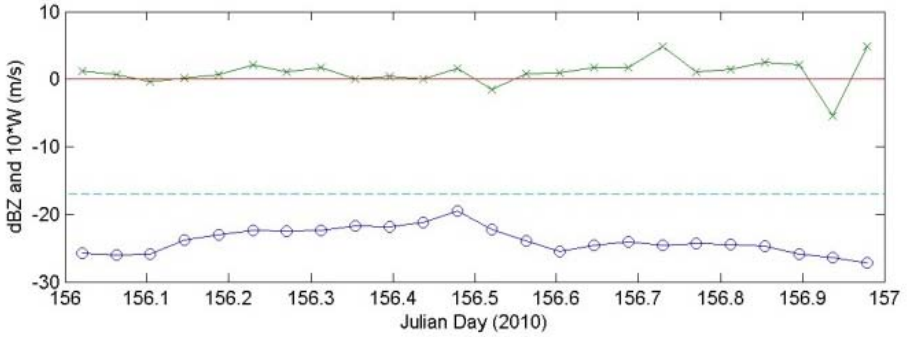


Year Day 156 May 23, 2010
Cloud Radar Returns from Non Cloud Targets (Bugs, pollen, bird???)







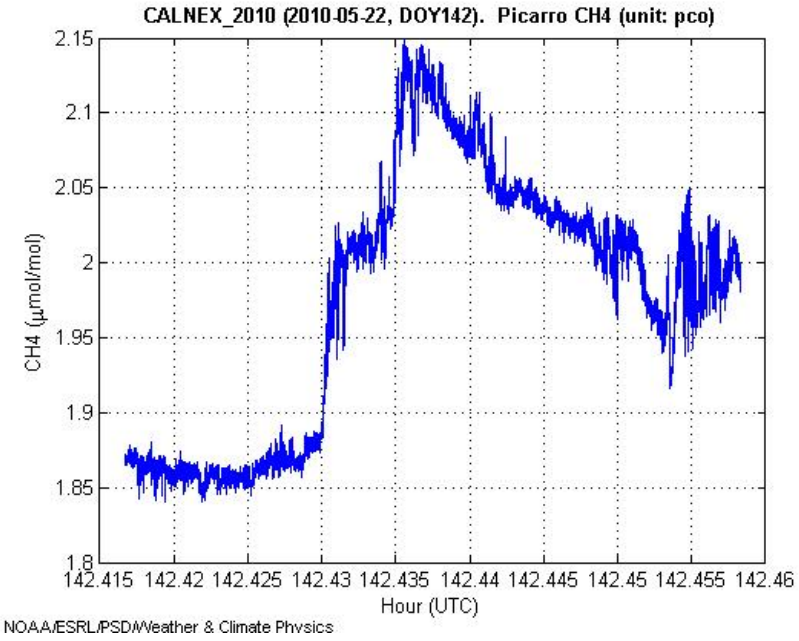


Upper panel: cloud top height from radar (circle with solid line; ±1 standard deviation, dashed line) and cloud base height from ceilometer (diamonds with solid line; 1 standard deviation, dots).

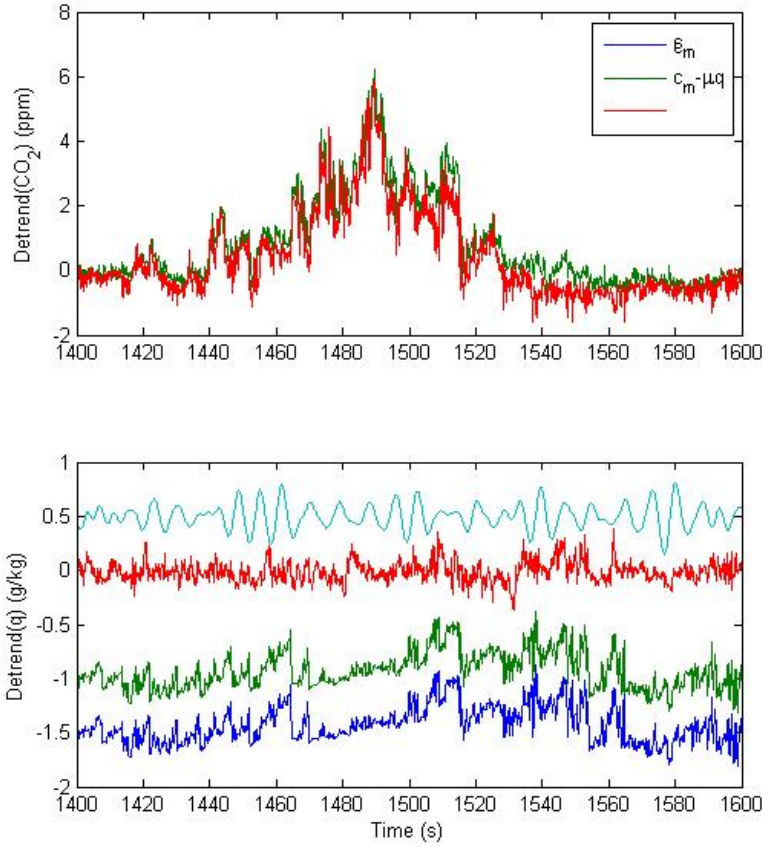
Lower panel: mean radar backscatter for the cloud/drizzle layer (circle with solid line) and mean droplet fall speed (x's with solid line) multiplied by 10 (in m/s).

Measurements of CO2 and CH4
Blomquist/Huebert and Sweeney/McGillis

Blomquist – Picarro CRD CO2
Sweeney – Picarro CRD CO2/CH4, H2O
PSD – Licor7500 open path



Sample Methane Signal



Upper Panel – Detrended CO2 Picarro and Licor
Lower Panel – Detrended Humidity – Blue; Temperature – Green;Vertical Velocity – Red;Ship Vertical Motion - Cyan