Turbulence Measurements on CIRPAS Twin Otter for POST

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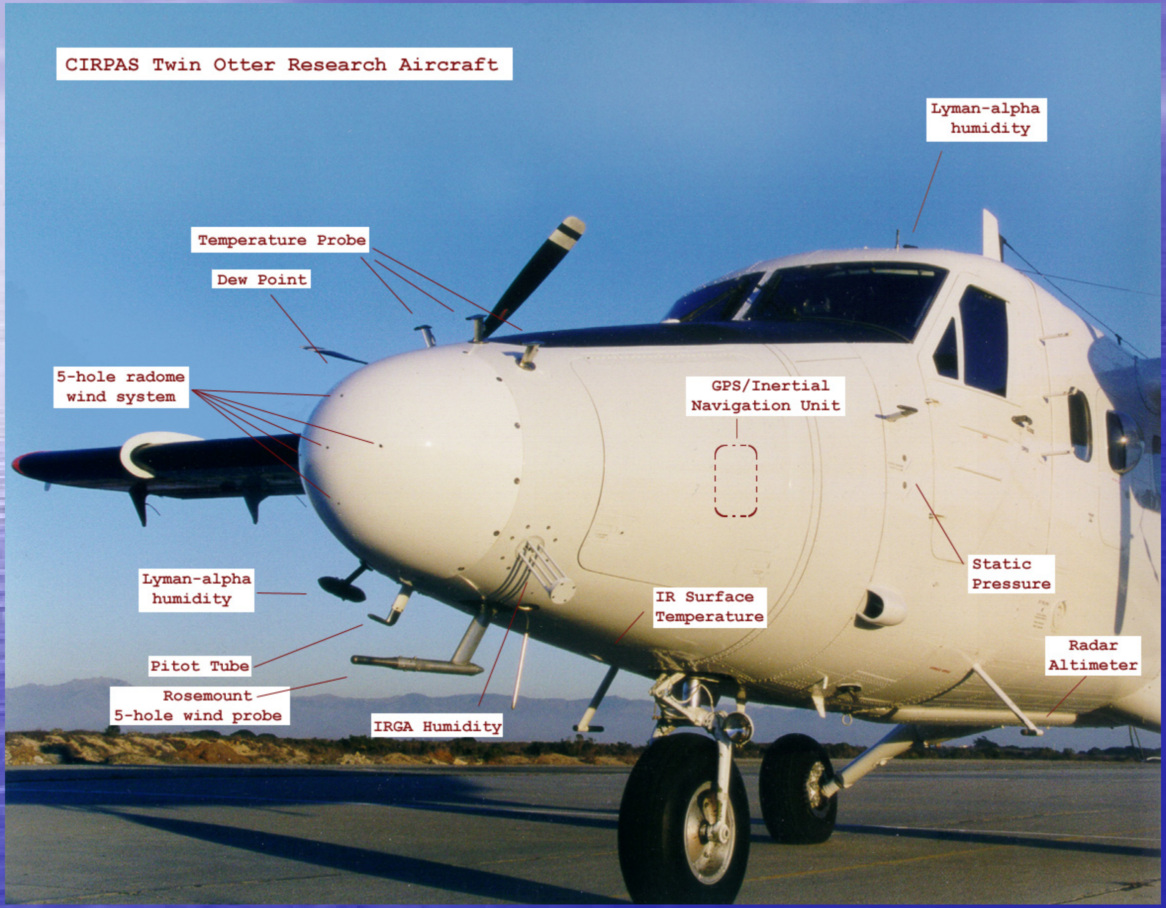
Contribution

POST turbulence measurements will help address/verify POST hypotheses ***H1*** (kinetic energy), ***H2*** (w_e estimates), ***H3*** (water vapor flux), and ***H4*** (input to models or validation of models results).

Nose Instrumentation

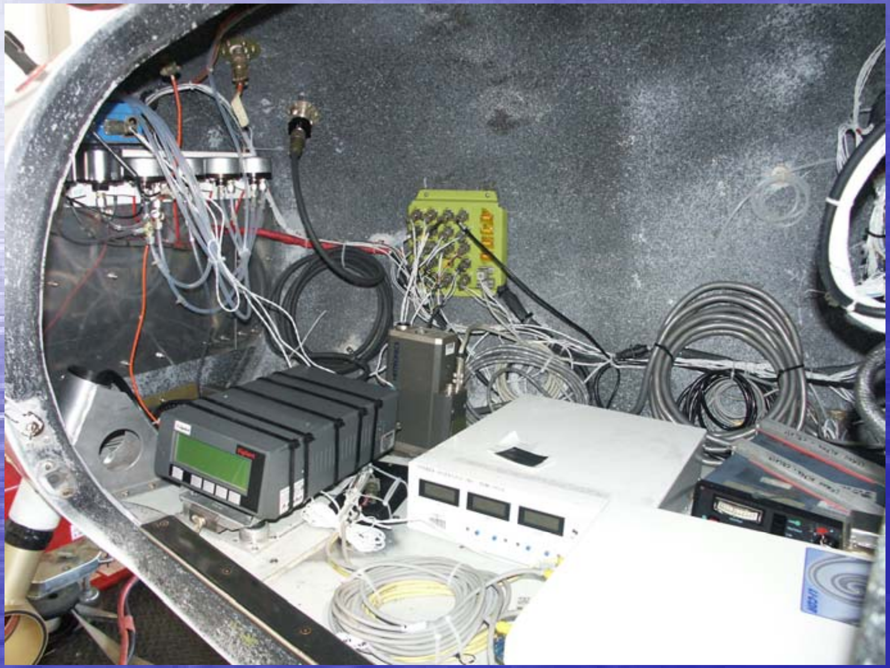


- Fast-response Humidity: Lyman-alpha
- 4 Fast-response Temperature (2 Rosemount and 2 UCI-modified Rosemount)
- Static pressure
- Slow Dewpoint (EdgeTech)
- IR SST (Heiman)
- Radar Altimeter
- Radome Wind system
- 2 INS/GPS motion units (C-MIGITS III)

Systron Donner C-MIGITS III INTEGRATED GPS-INS MOTION SENSING UNIT

- Latitude, Longitude, Elevation, GPS & UTC times
- Heading, Roll, Pitch,
- Aircraft Velocity components (East, North, Up)
- Analog pulse for serial-analog synchronization

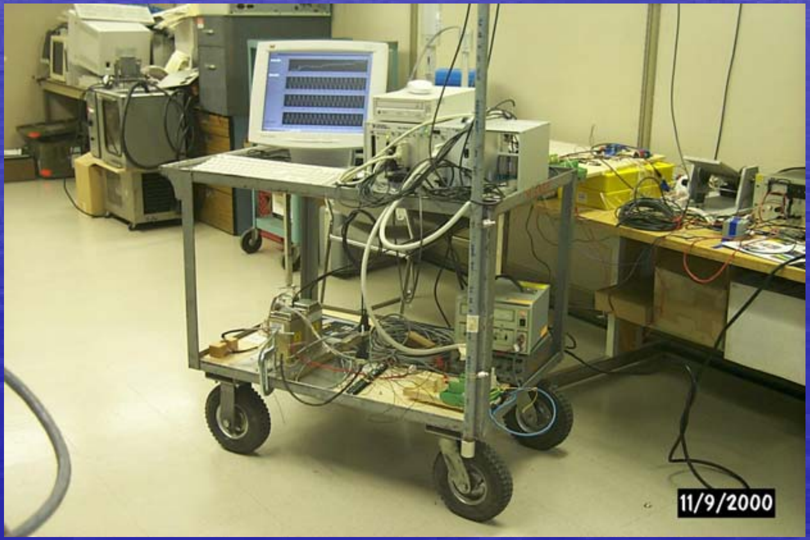
Inside Nose

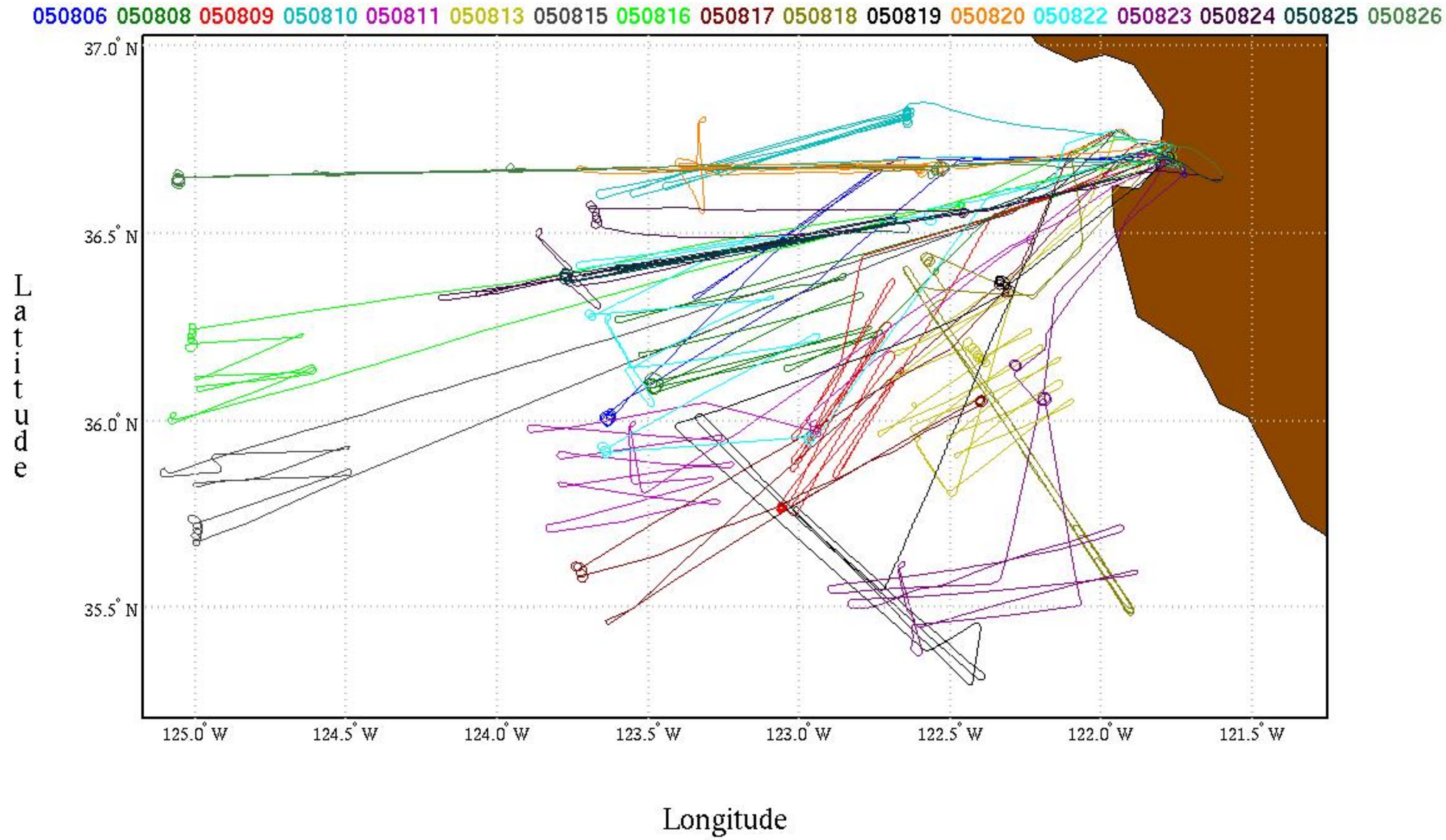


Radome Plumbing

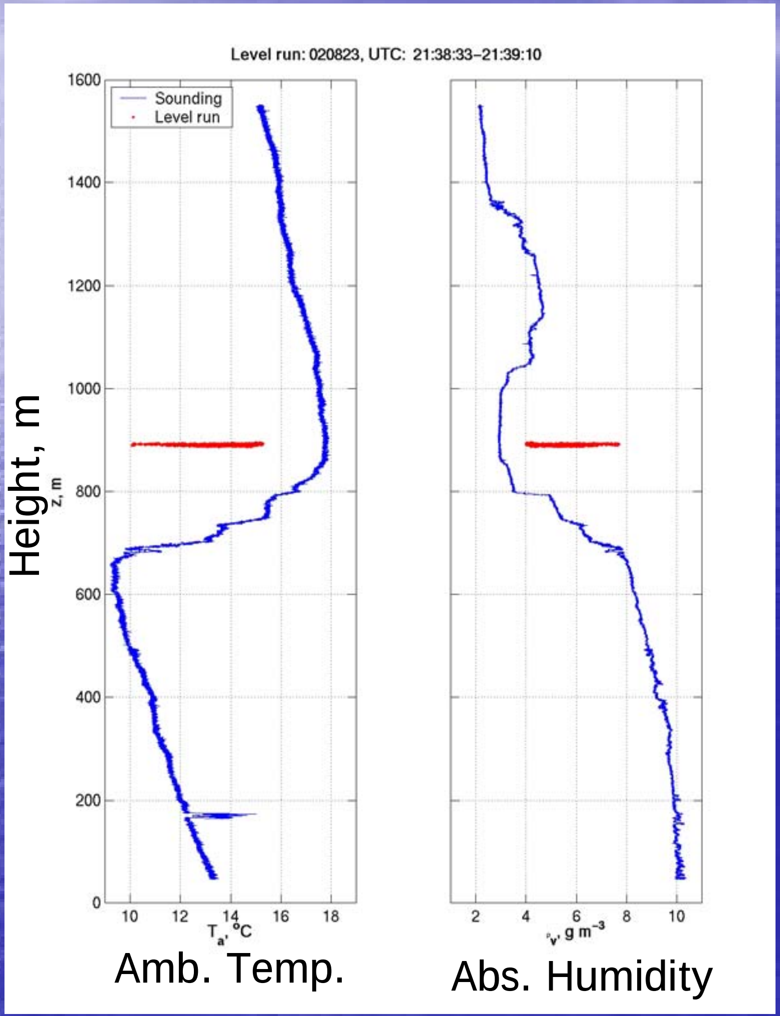
UCI Data System

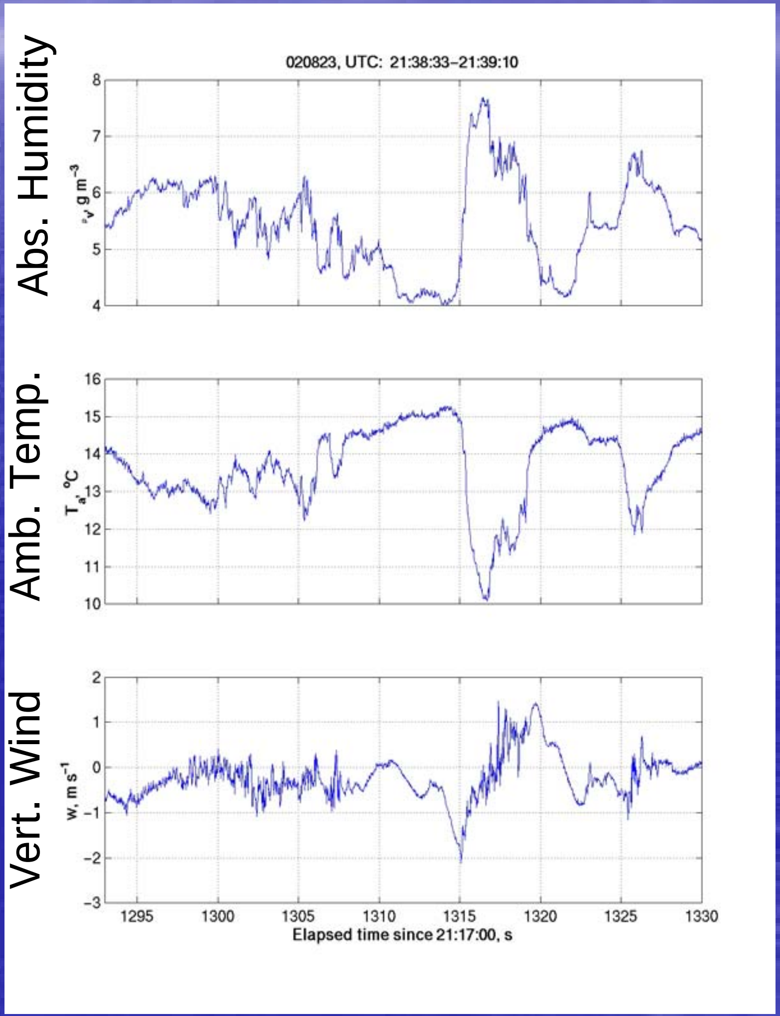
- 31 analog channels at 40 Hz + C-MIGITS III serial data
- Real-time monitoring of winds temperatures, humidity, profiles, flight track, attitude, etc ...
- First-look data and plots typically available within 2 hours after landing
- Redundancy with CIRPAS data system



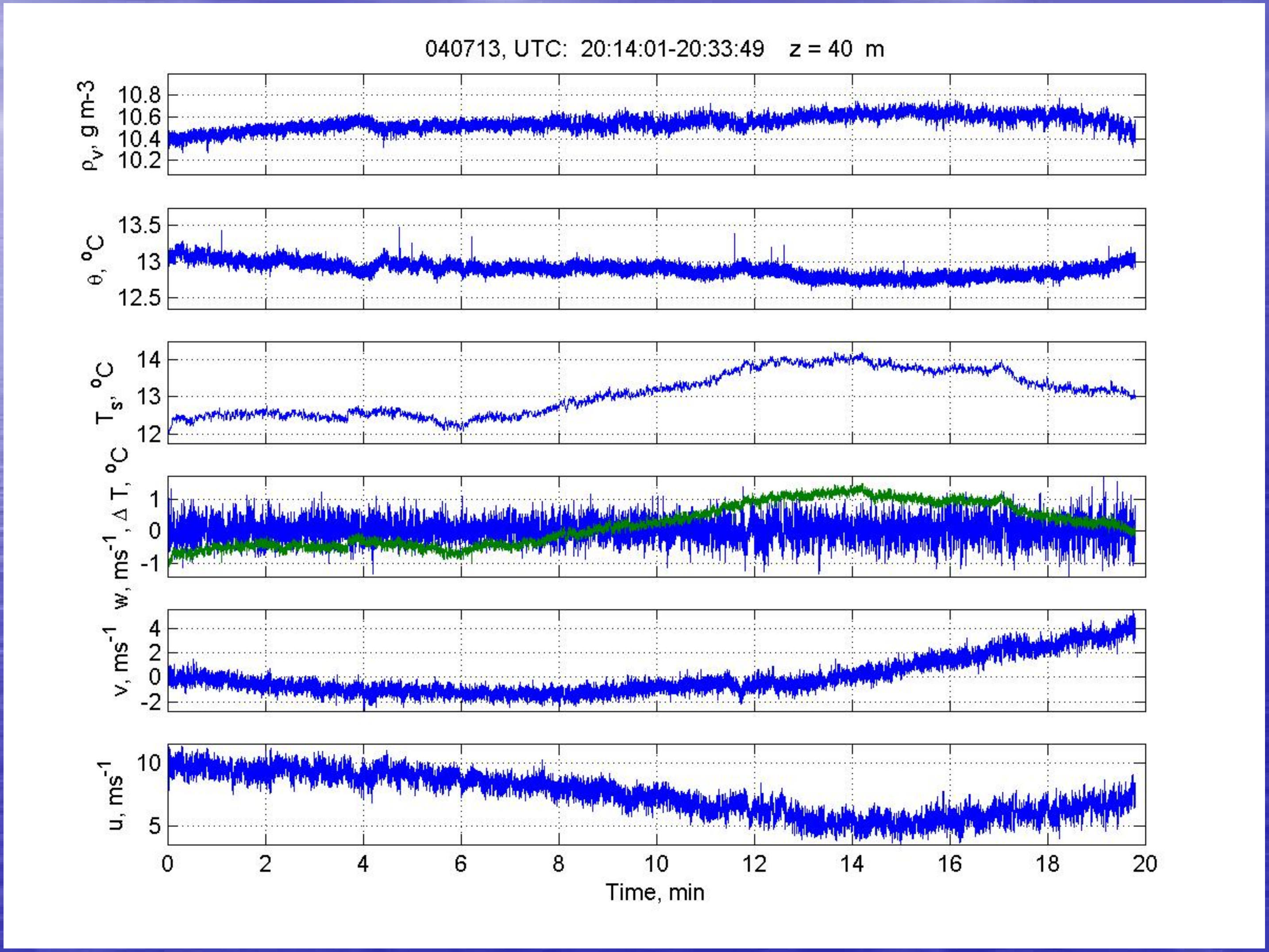

050806 050808 050809 050810 050811 050813 050815 050816 050817 050818 050819 050820 050822 050823 050824 050825 050826
37.0° N
36.5° N
36.0° N
35.5° N
Latitude
125.0° W
124.5° W
124.0° W
123.5° W
123.0° W
122.5° W
122.0° W
121.5° W
Longitude

Detrainment





Time Series



040713, UTC: 20:14:01-20:33:49 z = 40 m
ρv, g m-3
10.8
10.6
10.4
10.2
θ, oC
13.5
13
12.5
Ts, oC
14
13
12
w, ms-1, Δ T, oC
1
0
-1
v, ms-1
4
2
0
-2
u, ms-1
10
5
0
2
4
6
8
10
12
14
16
18
20
Time, min

Eddy Correlation Fluxes

$$Q_h = \rho c_p \overline{w'\theta'}$$

$$Q_e = L_v \overline{w'\rho_v'}$$

$$\tau_x = -\rho \overline{w'u'}$$

$$\tau_y = -\rho \overline{w'v'}$$

$$\tau = (\tau_x^2 + \tau_y^2)^{1/2}$$

where

u, v and w are along-, cross- and vertical wind components

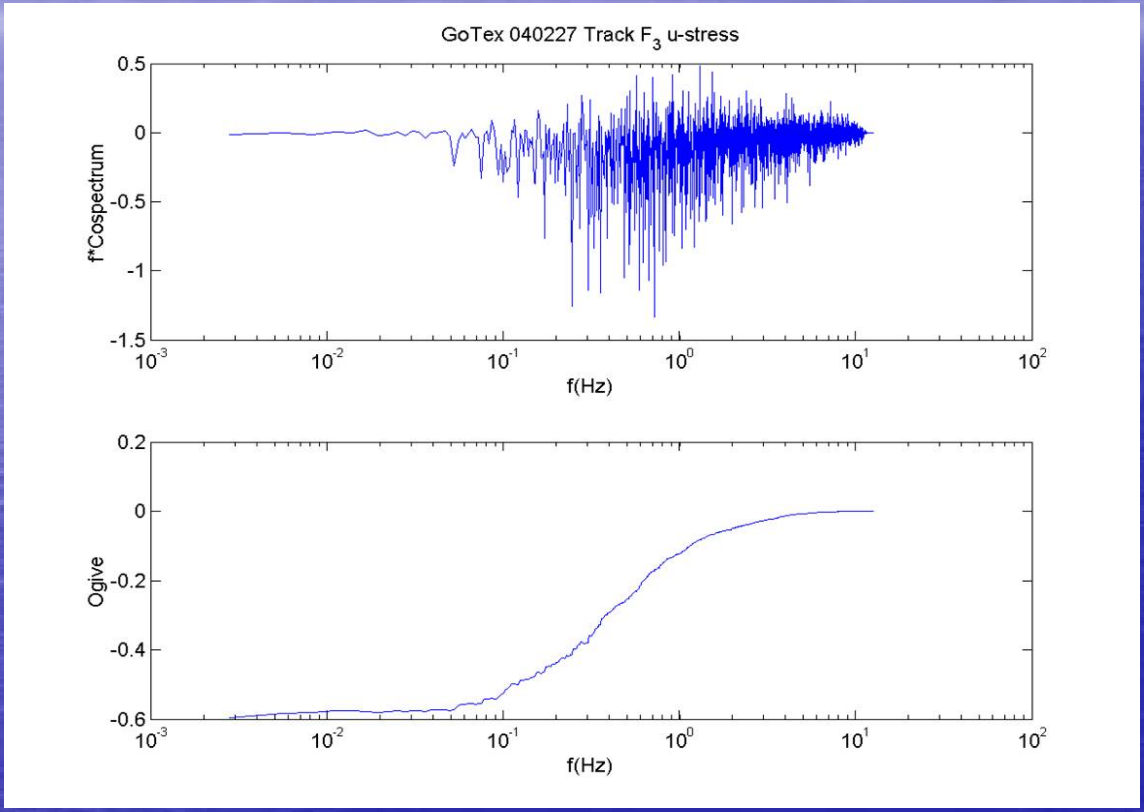
ρ is the air density

c_p is the air specific heat at constant pressure

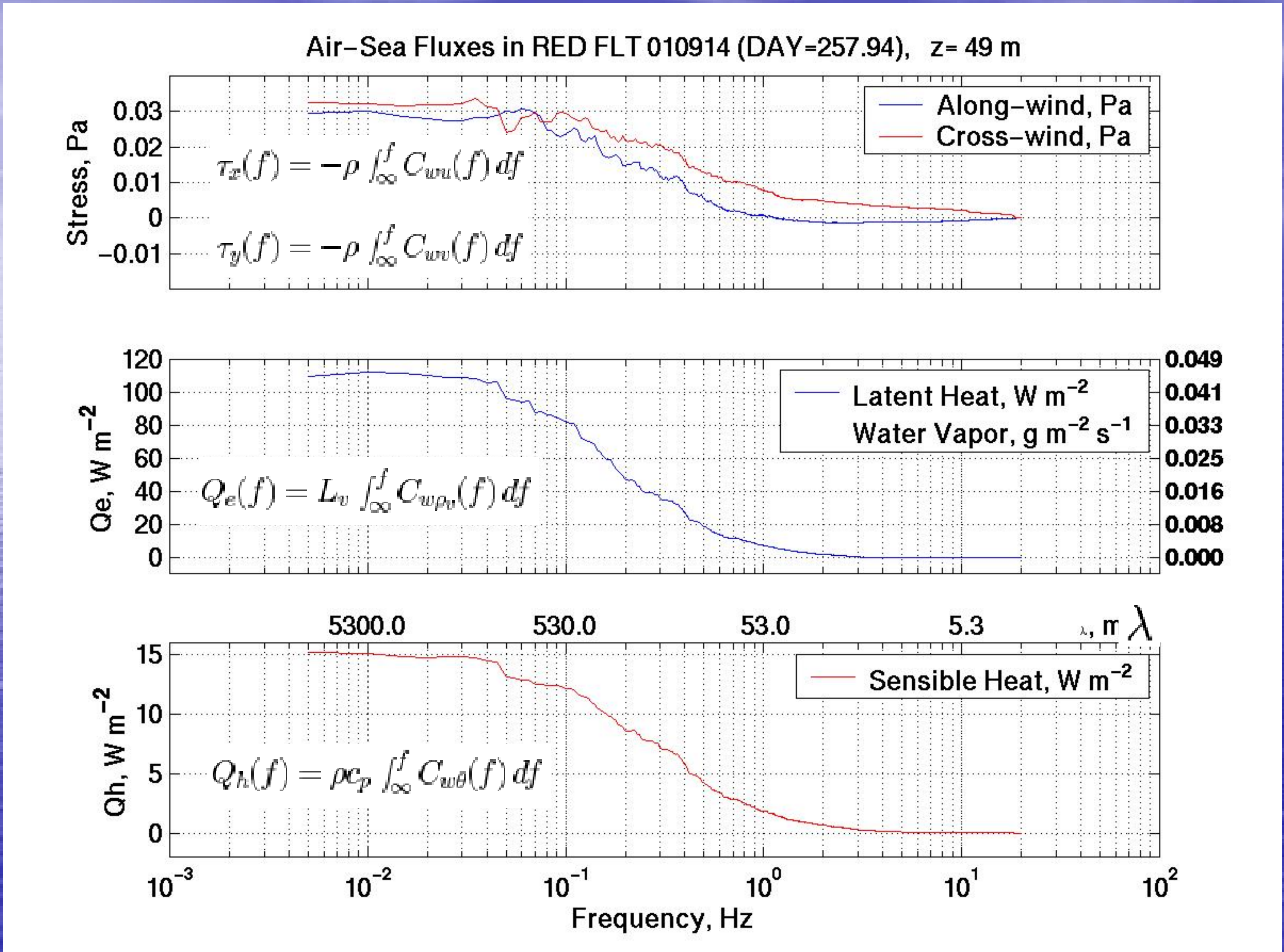
ρ_v is the water vapor density (absolute humidity)

L_v is the latent heat of vaporization

Ogive* Method

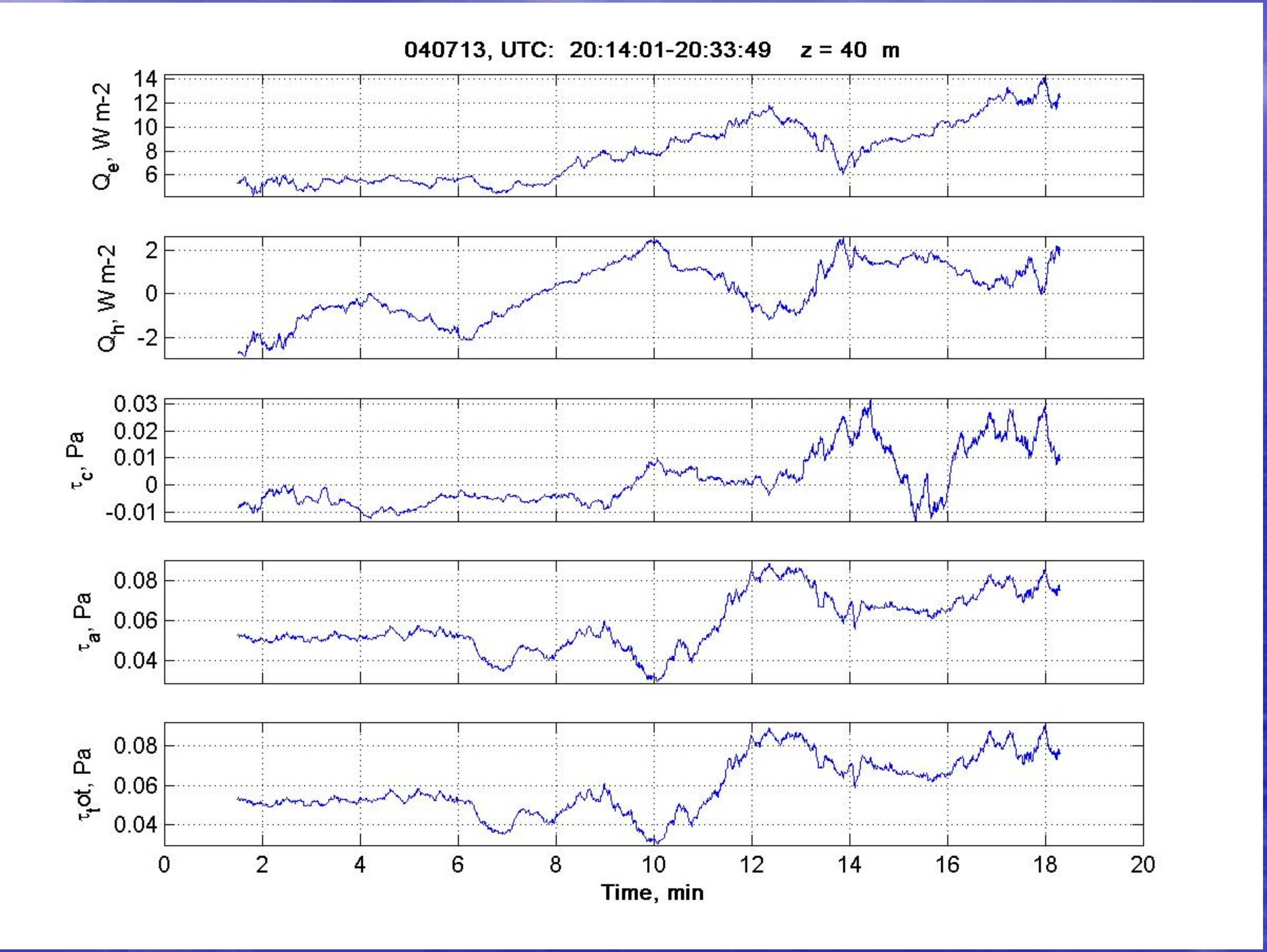


(*) An ogive is the cumulative integral of the co-spectrum of two variables (here fluctuations u and w). The ogive's "asymptotic" value on the low-frequency end is the value of the stress estimate.



Air−Sea Fluxes in RED FLT 010914 (DAY=257.94), z= 49 m
Stress, Pa
Along−wind, Pa
Cross−wind, Pa
$\tau_x(f) = -\rho \int_\infty^f C_{wu}(f)\, df$
$\tau_y(f) = -\rho \int_\infty^f C_{wv}(f)\, df$
Qe, W m^{-2}
Latent Heat, W m^{-2}
Water Vapor, g m^{-2} s^{-1}
$Q_e(f) = L_v \int_\infty^f C_{w\rho_v}(f)\, df$
5300.0
530.0
53.0
5.3
λ, m
Qh, W m^{-2}
Sensible Heat, W m^{-2}
$Q_h(f) = \rho c_p \int_\infty^f C_{w\theta}(f)\, df$
Frequency, Hz

“Sliding-Window” Fluxes



UCI POST DATA

Name	Description	Units	Accuracy
t	UTC	YYYYMMDDHHMMSS.xx	0.5 ms
hr	Radar Height	m	1 m ?
lat	Latitude	deg N	< 0.00002 deg
lon	Longitude	deg E	< 0.00002 deg
trk	Aircraft Track Angle	deg	0.3 deg
wx	East Wind Component	m/s	0.4 m/s
wy	North Wind Component	m/s	0.4 ms
wz	Vertical Wind Component	m/s	0.4 m/s
ah	Absolute Humidity	g/m^3	
ta	Ambient Temperature	^oC	0.4 ^oC
td	Dewpoint Temperature	^oC	0.4 ^oC
ts	Downlooking IR Temperature	^oC	0.4 ^oC
ps	Static Pressure	hPa	5 Pa
tas	True Airspeed	m/s	0.2 m/s
rhoa	Air Density	kg/m^3	
mr	Mixing Ratio	g/kg	
theta	Potential Temperature	K	0.4 ^oC
tvir	Virt. Pot. Temperature	^oC	0.4 ^oC
thetae	Eqiv. Pot. Temperature	K	0.4 ^oC
thetal	LW Pot. Temperature	K	?

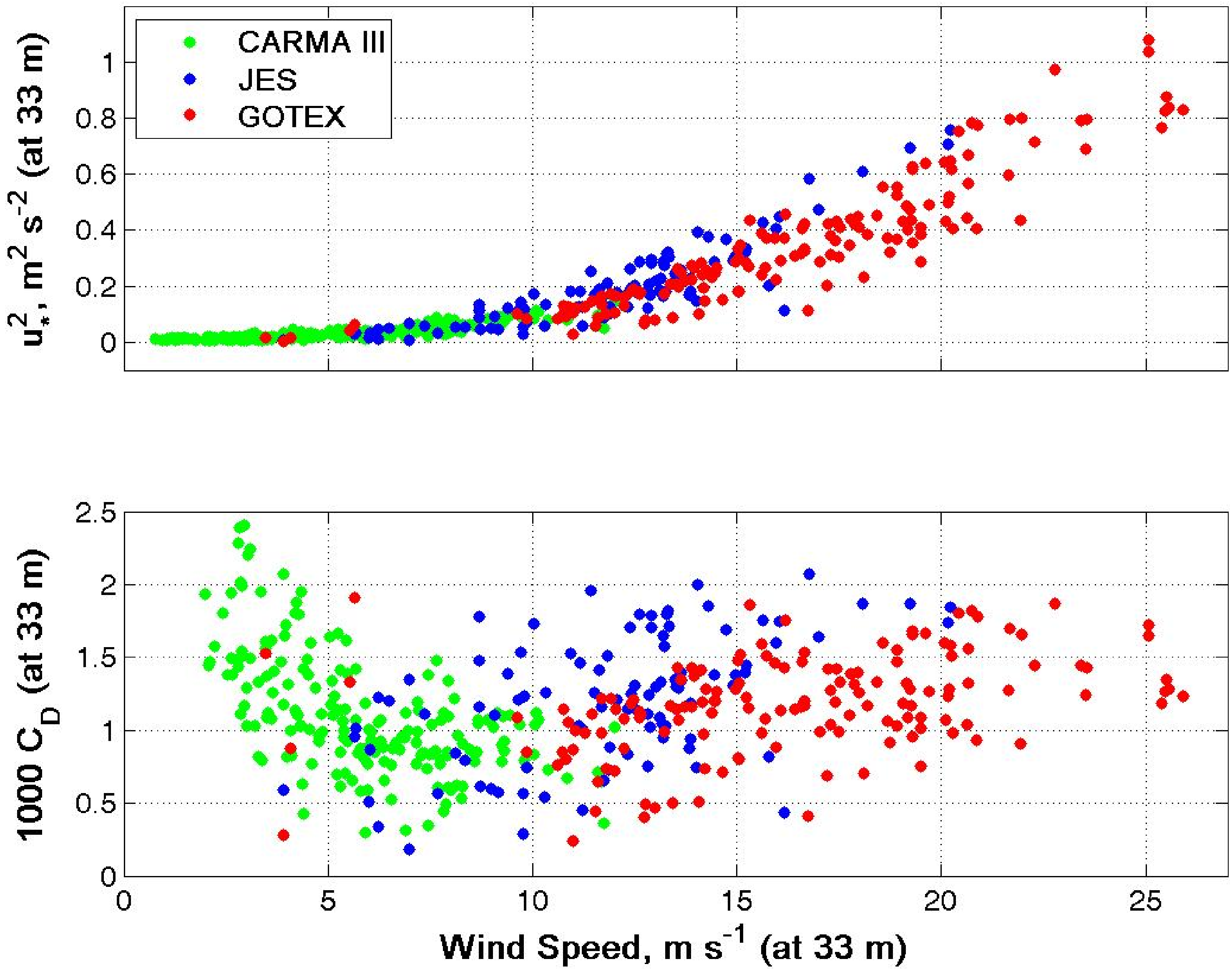
POST Hypotheses

- ***Hypothesis H1: The turbulent kinetic energy originating from buoyant thermals in Sc is consumed by the entrainment process resulting in the cloud-free, moist, and cool EIL that separates Sc cloud top from the free atmosphere and that forms the environment from which air is ultimately entrained into cloud top.***

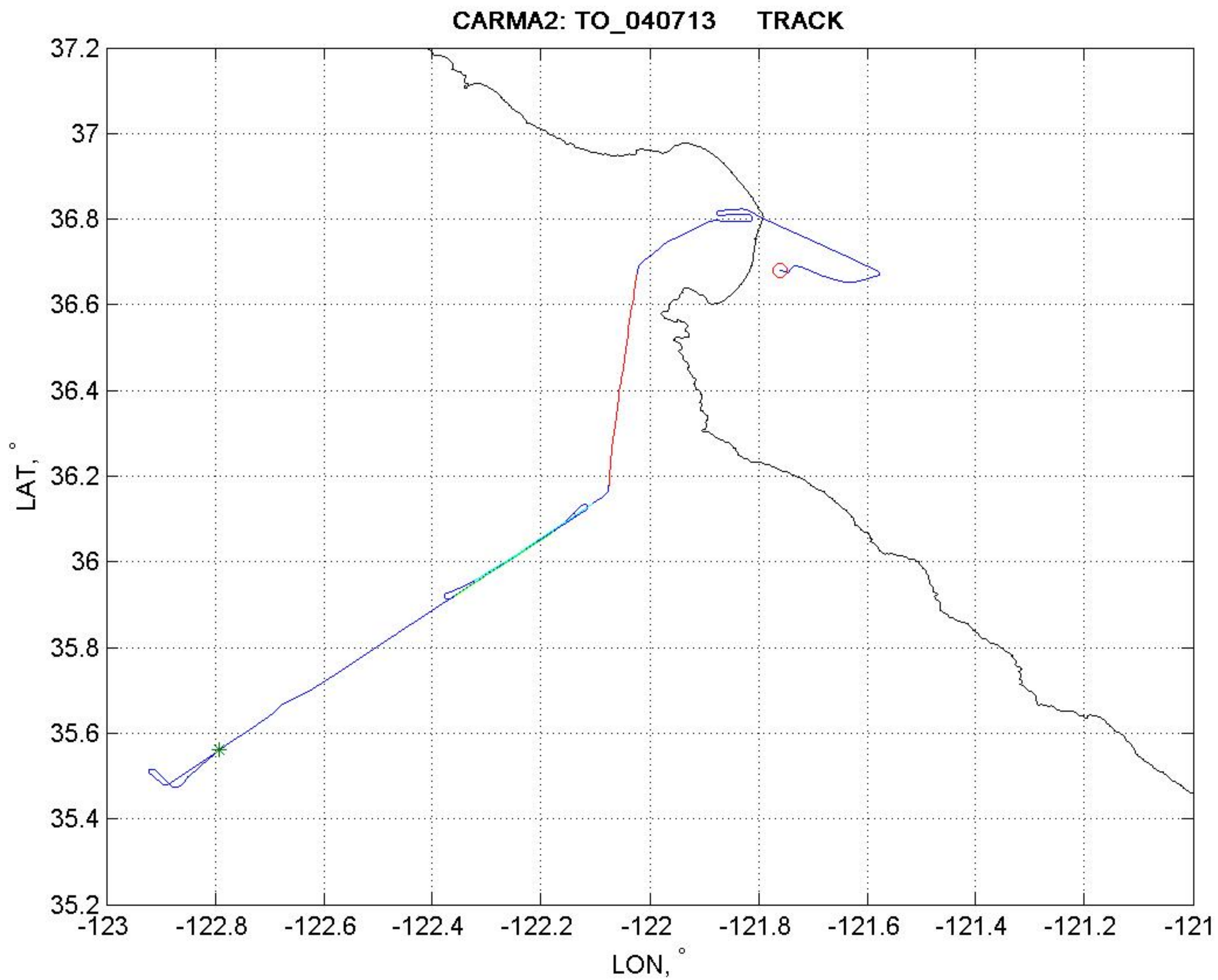
- ***Hypothesis H2: Knowledge of the details of cloud top interface behavior (local horizontal variability, EIL geometry and evolution, microphysics, drizzle, shear, entrainment-parcel thermodynamics and physical description, and vertical distribution of ir cooling) is necessary to yield acceptable estimates of*** w_e ***whereas, using basic STBL parameters including surface heat and moisture fluxes, cloud top jumps, and buoyancy fluxes to estimate*** w_e ***is insufficient.***

- ***Hypothesis H3: Evaporation of LWC by entrained air contributes to buoyancy production that helps drive the larger cellular convection and that enhances entrainment in Sc.***

- ***Hypothesis H4: Modeling results covering relevant spatial scales from microphysics to larger-scale dynamics compare favorably with POST observations of STBL behavior including shear, cloud layer structure, EIL behavior, and entrainment rates.***



CARMA III
JES
GOTEX
u_*^2, m^2 s^{-2} (at 33 m)
1000 C_D (at 33 m)
Wind Speed, m s^{-1} (at 33 m)



CARMA2: TO_040713 TRACK
37.2
37
36.8
36.6
36.4
36.2
36
35.8
35.6
35.4
35.2
LAT, °
-123
-122.8
-122.6
-122.4
-122.2
-122
-121.8
-121.6
-121.4
-121.2
-121
LON, °