



# ATMOSPHERE TO ELECTRONS

U.S. DEPARTMENT OF ENERGY

## Case Identification – Site Measurements

Brandon Ennis

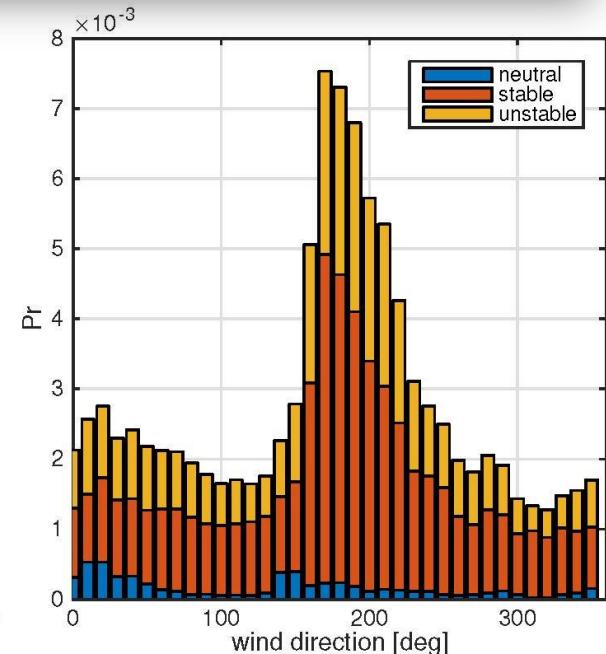
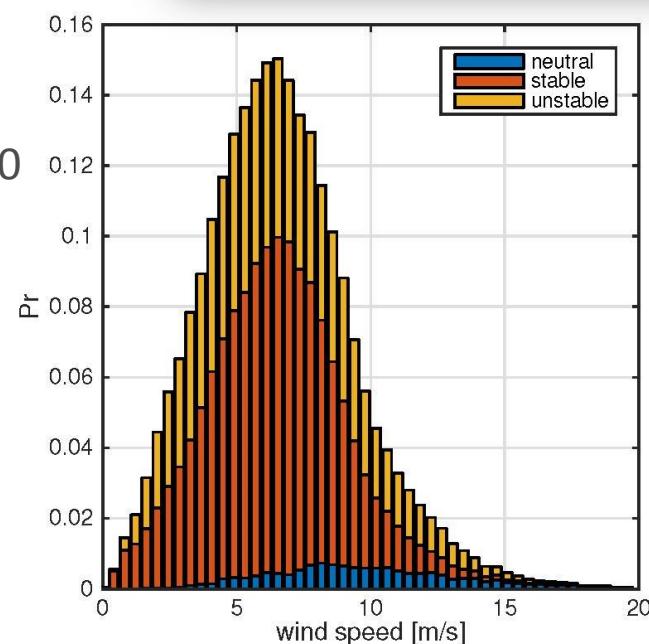
Sandia National Laboratories

# Site Location

- SNL SWiFT / TTU Reese site will be used for FY'16 simulations
  - diurnal cycle covering an evening transition
  - Possibly including simulation of case(s) with mesoscale features



- Contains Texas Tech University's National Wind Institute facilities
  - 200m tall-tower with 10 vertical stations
  - Radar Profiler measurements up to 6km



# Experimental Dataset

## TTU 200m meteorological tower

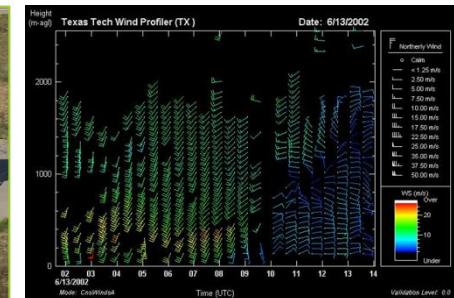
- ~2 years of historical 50-hz data beginning July 2012



200m Met Tower;  
50hz historical data

## Vaisala LAP-3000 radar profiler

- configured to log wind speed, direction, and temperature (RASS virtual temperature) profiles every 20-min.
- Resolution is 60m between 150-2000m AGL, 200m between 600-6000 m AGL

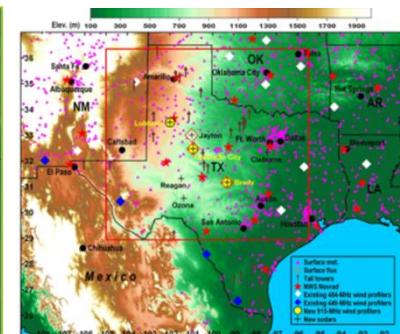


Radar Profiler; 20 min data logs

## Mesonet and Sodar Networks

Historical data from weather stations in surrounding area

- West Texas Mesonet



West Texas Mesonet and WFIP1 dataset

## Alstom meteorological tower

- 80m certification meteorological tower – unsure about instrumentation package
- Located near the SWIFT site

# Experimental Dataset

## Alstom 80m meteorological tower

- Alstom has agreed to let us use the data
- 1.8 km south of the TTU 200m tower
- Provides an additional measurement location for simulation comparison
- Turbulence coherence calculation may be possible, mostly N/S directions due to the large separation distance
- Includes date ranges:
  - **12/7/2010–2/28/2011**
  - **9/27/2012–12/11/2013**
- Data *may be available* for the time between 2/28/2011–9/27/2012



# National Wind Institute Facilities

## Tower Location Coordinates:

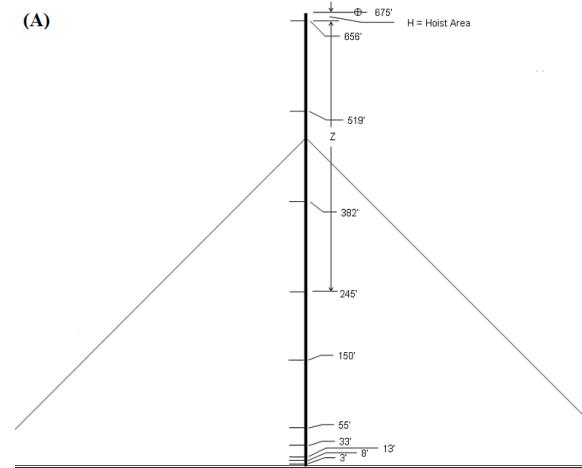
(33.61054 N, 102.05054 W)

at an elevation of 1021m

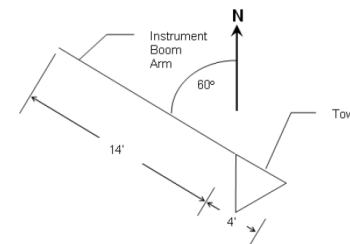
### 200m Tower Sensor Heights

[ft]	[m]
3	0.9
8	2.4
13	4.0
33	10.1
55	16.8
155	47.3
245	74.7
382	116.5
519	158.2
656	200.0

(A)



(B)



### Sensor Package

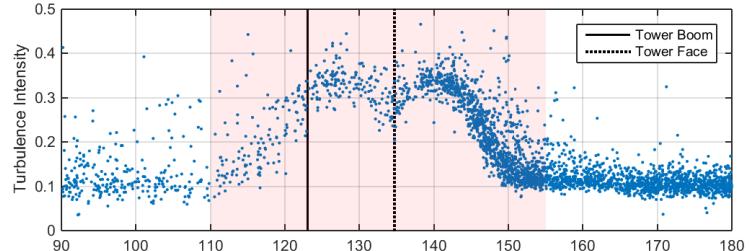
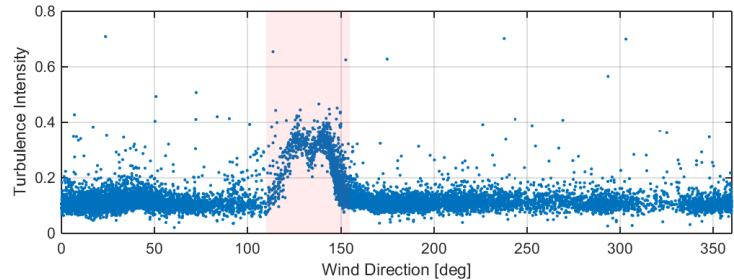
- Sonic U-arm
- Sonic V-arm
- Sonic W-arm
- Sonic Temperature
- Temperature
- Relative Humidity
- Barometric Pressure
- Propeller U-arm
- Propeller V-arm
- Propeller W-arm



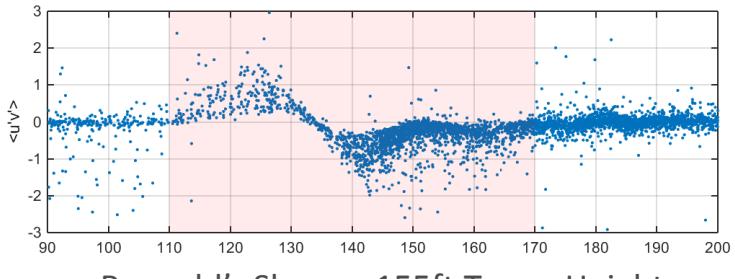
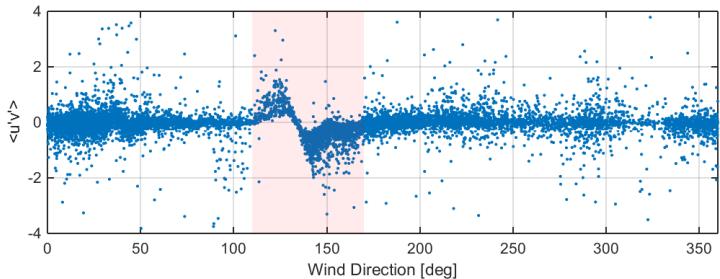
# TTU 200m Tower Wake

## Upper Stations (10-200 m)

- In a wake, velocity is decreased and turbulence is increased
- Turbulence Intensity (TI) therefore is a highly affected variable by the tower wake
- Only neutral stability cases are compared, which removes variation in TI from other sources



Turbulence Intensity – 155ft Tower Height

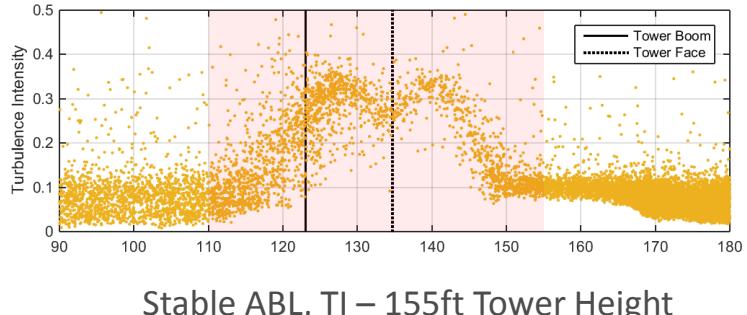
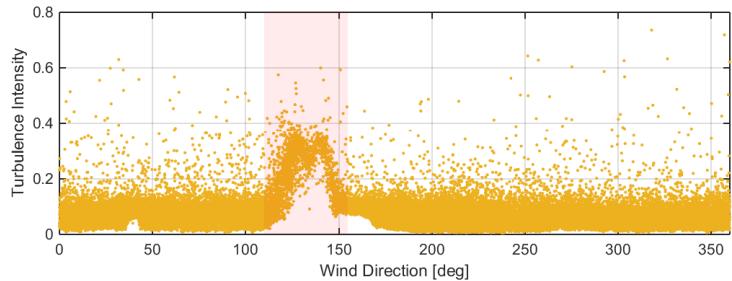


Reynold's Shear – 155ft Tower Height

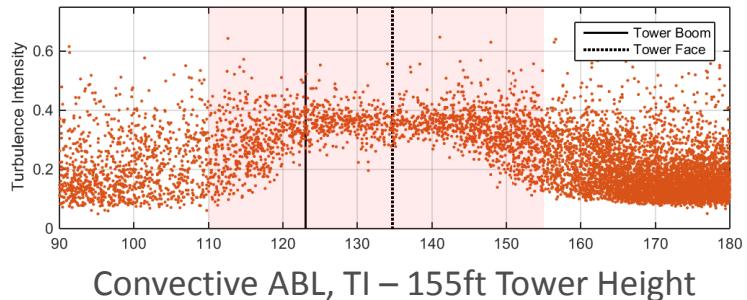
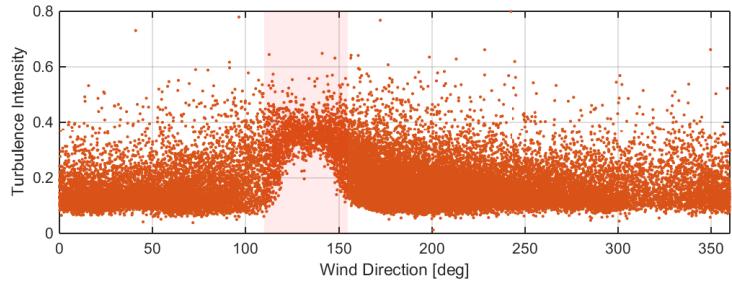
# TTU 200m Tower Wake

## Upper Stations (10-200 m)

- Stable and Convective ABL cases are also compared
- Wake effect would cover the largest directional sector for highest turbulence cases (convective)
- Tower wake sector for TTU 200m upper boom stations defined as [110, 155] deg.



Stable ABL, TI – 155ft Tower Height

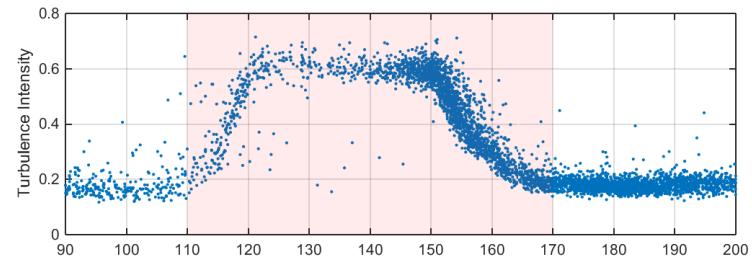
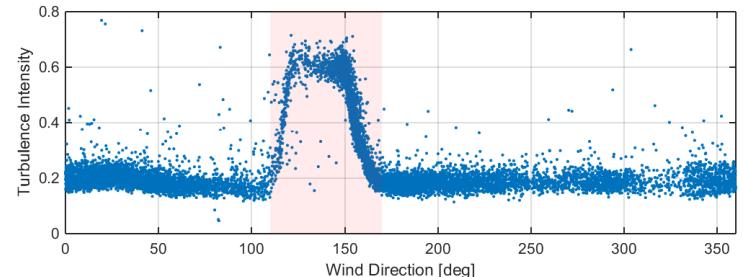


Convective ABL, TI – 155ft Tower Height

# TTU 200m Tower Wake

## Lower Stations (1-4 m)

- Sensors at 3, 8 and 13 ft stations have additional obstructions
- Analysis reveals a tower wake directional sector of [110, 170] deg for these station heights
- Affects stability calculations—2m station



Neutral ABL, TI – 8 ft Sensors



(a) Sensor Mounting at 3, 8, and 13 ft.



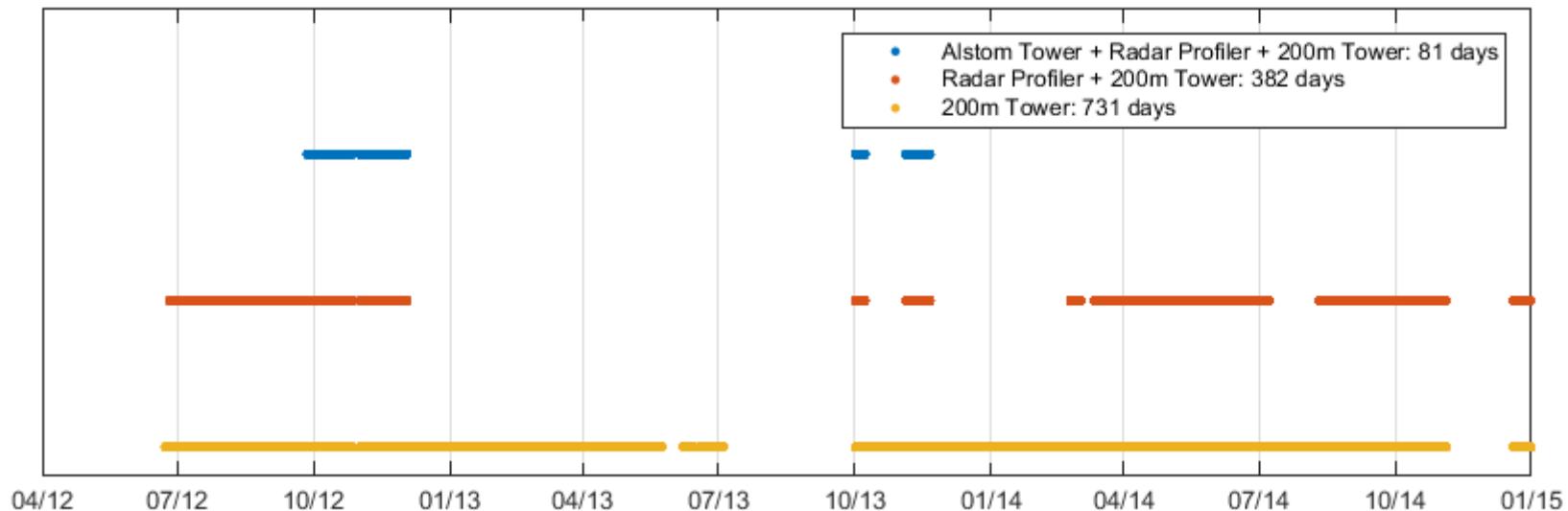
(b) Tower Structure Near the Ground.



(c) Adjacent Structures to the 200 m Tower.

# Asset Data Availability

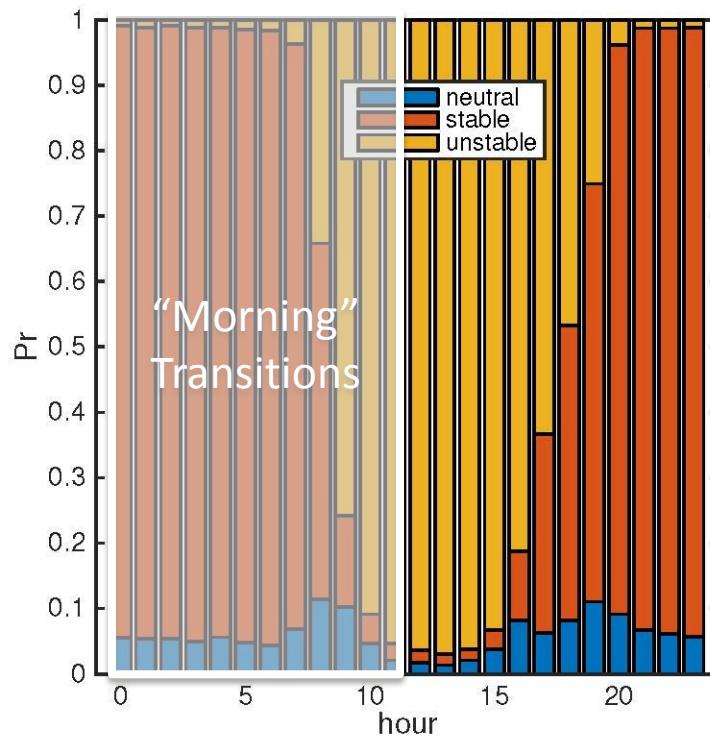
## Time Series Filters



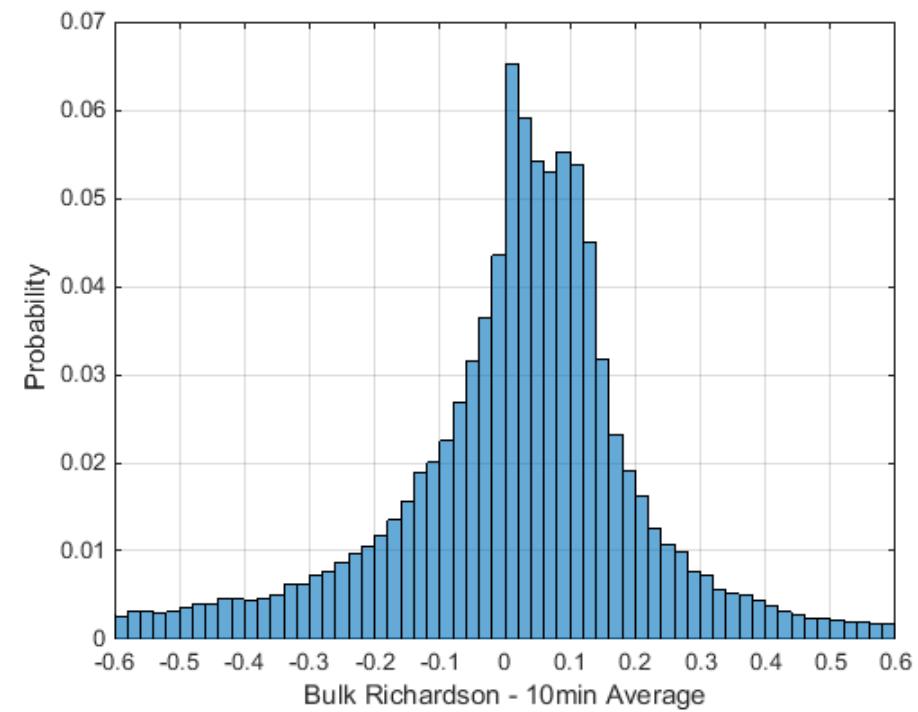
						dates: 6/23/2012 7/4/2013
						dates: 10/1/2013 11/4/2014
						dates: 12/19/2014 12/31/2014
Radar Profiler		Alstom	data may be available		TTU 200m Tower	
1/1/2012	4/2/2012	1/1/2012	2/28/2012	2/28/2012	4/2/2012	NO
6/26/2012	12/3/2012	9/27/2012	12/3/2013	6/26/2012	9/26/2012	6/26/2012 12/3/2012
8/20/2013	10/8/2013	8/20/2013	10/8/2013	--	--	10/1/2013 10/8/2013
11/5/2013	11/21/2013	11/5/2013	11/21/2013	--	--	11/5/2013 11/21/2013
2/24/2014	3/3/2014	--	--	--	--	2/24/2014 3/3/2014
3/12/2014	7/8/2014	--	--	--	--	3/12/2014 7/8/2014
8/11/2014	12/31/2014	--	--	--	--	8/11/2014 12/31/2014

# Site Specific Atmospheric Trends

- Stability trends with hour of the day
- Only considering overnight transitions: 1200-2400 local time (1700-0500 UTC)



- Bulk Richardson number average stability class magnitudes
- Stable ABL has a peak around  $Ri_{\text{Bulk}} = 0.8-1$  on the year
- In summer, overnight  $Ri_{\text{Bulk}} \sim 0.05$



# Case Identification Process

## Initial Benchmark – near-neutral stability

- Bulk Richardson magnitude average  $< 0.01$ ;  $\text{delta}(\text{RiBulk}) < 0.01$
- Wind Speed<sub>47m</sub>  $> 5$  m/s; Wind Speed<sub>116m</sub>  $< 15$  m/s; relevance for wind energy
- Wind Speed variance minimized;  $\text{delta}(\text{WindSpeed}_{\text{AllHeights}}) < 2$  m/s
- Wind Direction not from [110, 170] deg; avoid tower blockage effects
- Includes time frame where the Alstom tower data are available

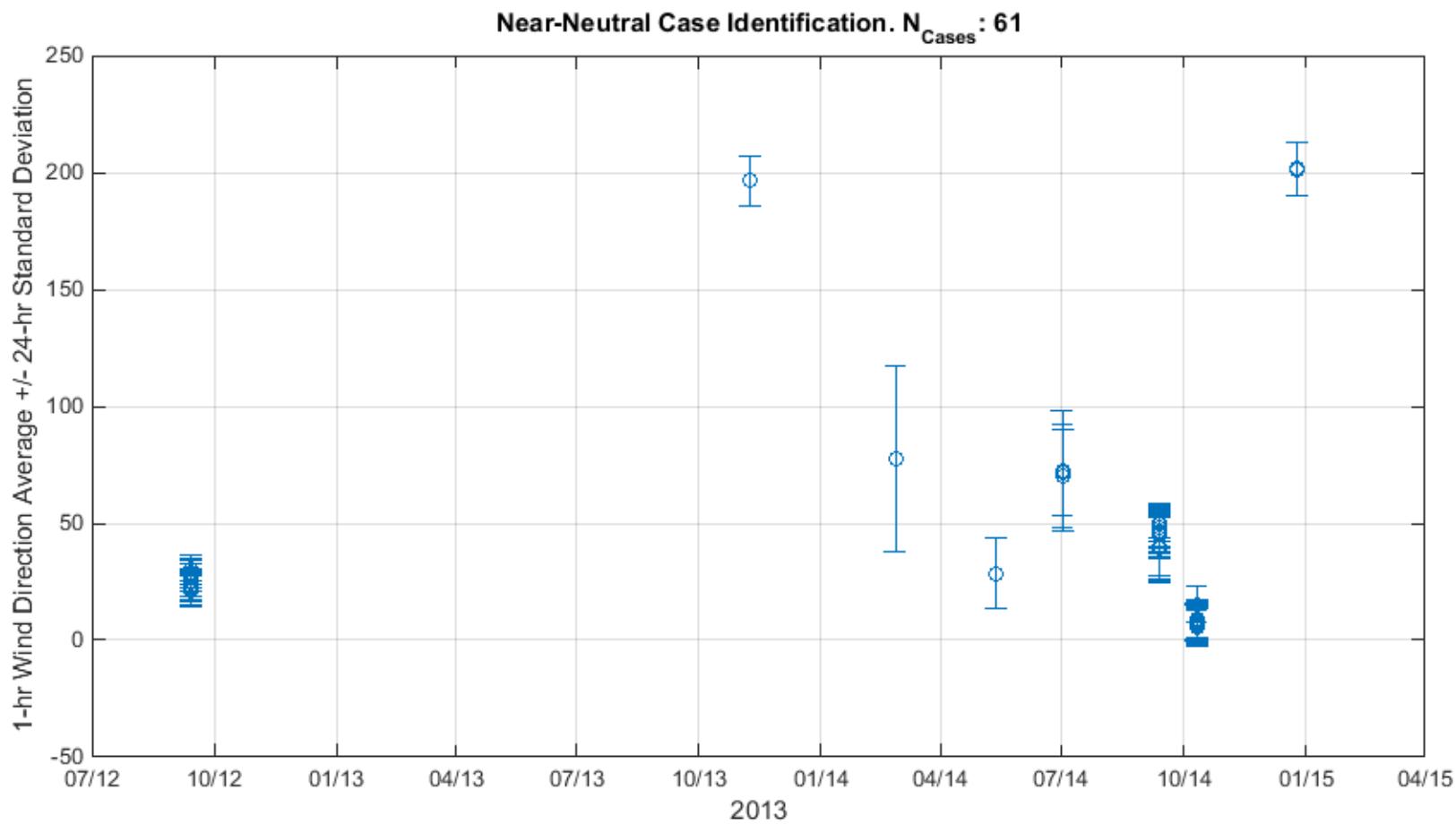
## Initial Benchmark – surrounding day

- Evening Transition neutral case; between [1700:0500] UTC
- Consistent Wind Direction;  $\text{delta}(\text{Wind Direction}) < 90$  deg
- Consistent Wind Speed;  $\text{stdev}(\text{Wind Speed}) < 4$  m/s

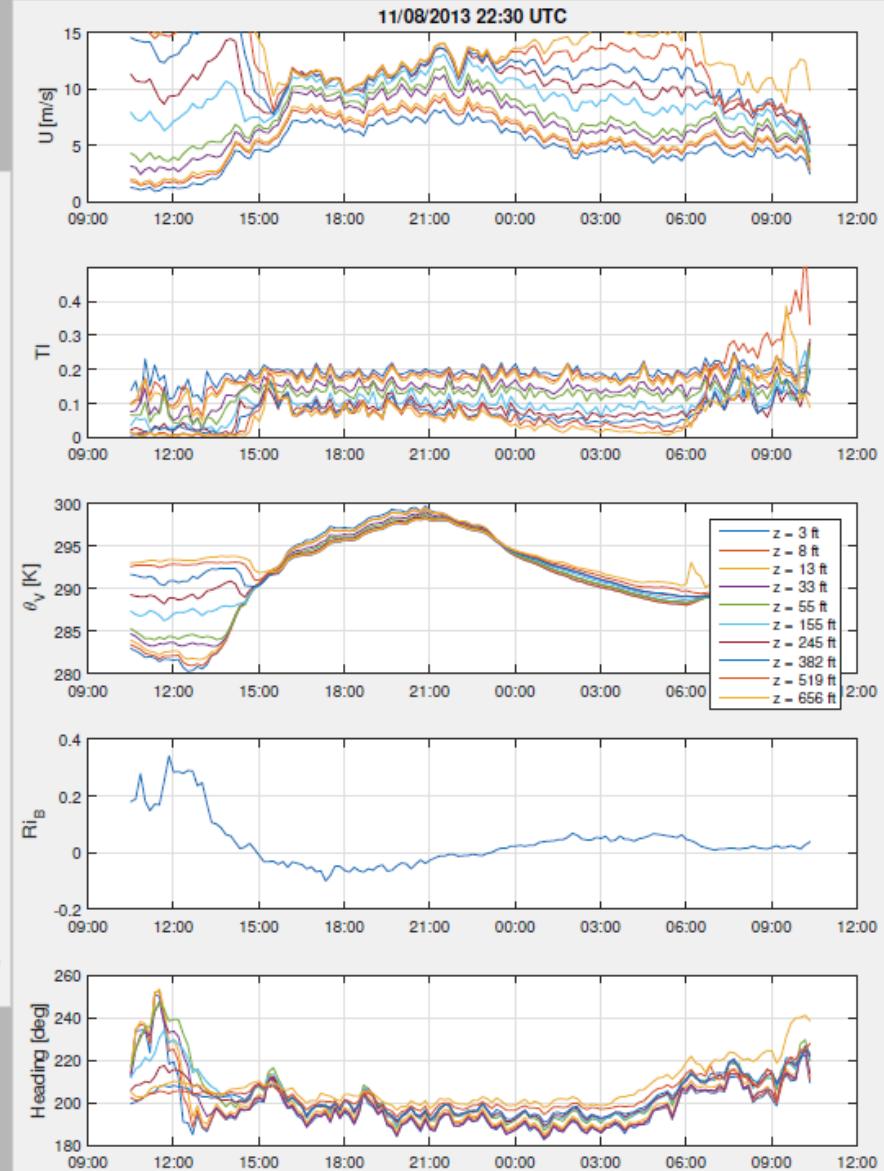
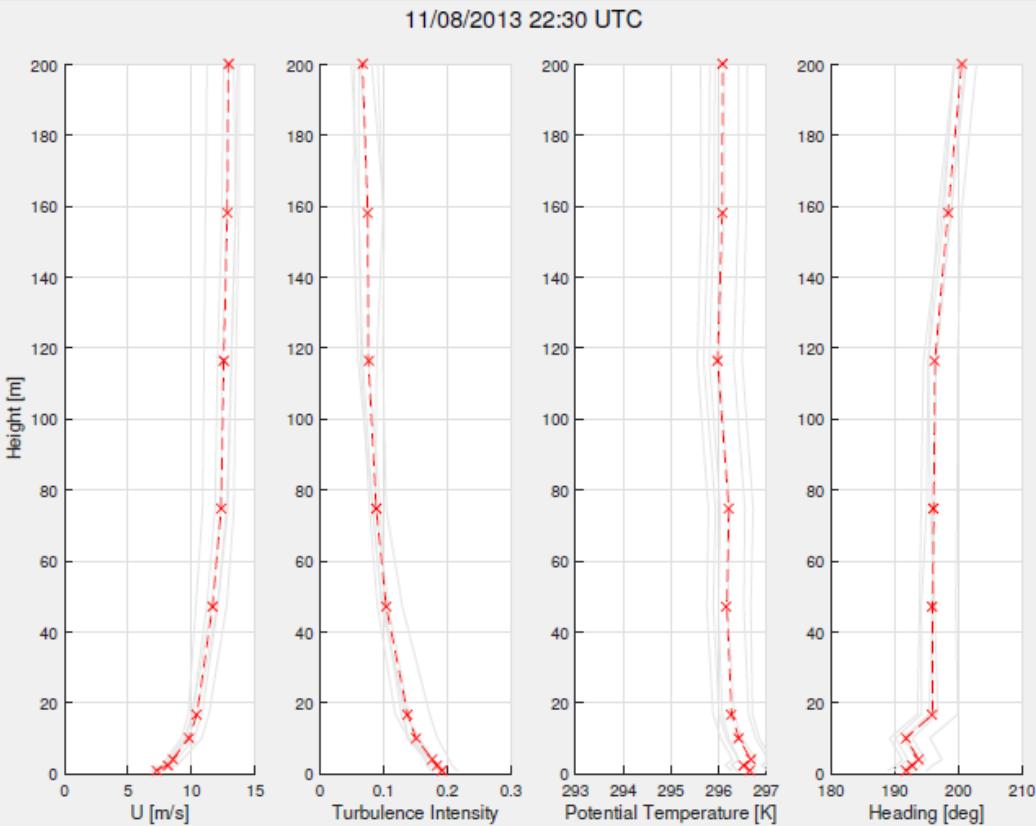
# Case Identification

Neutral Case - Stability																	
Ri_Bulk, min [ND]	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	
Ri_Bulk, max [ND]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ri_Bulk, stdev [ND]																	
Ri_Bulk, delta [ND]	0.01	0.01	0.02	0.03	999	0.03	0.01	0.01	0.02	0.03	0.03	999	999	0.03	0.03	0.03	0.03
Neutral Case - Wind Speed																	
WS,min47m [m/s]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
WS,max116																	
m	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
WS,stdev [m/s]																	
WS,delta [m/s]	2	2	2	2	2	2	3	999	3	3	999	999	999	999	999	999	999
Neutral Case - Wind Direction																	
WD,exclude [deg]	[110,170]																
Neutral Case - Time Filter																	
Profiler																	
Surrounding Day - Evening Transition																	
Time,min	[UTC]	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
Time,max	[UTC]	0500	0500	0500	0500	0500	0500	0500	0500	0500	0500	0500	0500	0500	0500	0500	0500
Surrounding Day - Wind Direction																	
WD,stdev	[deg]	40	999	999	999	999	50	999	999	999	999	999	999	999	999	999	40
WD,delta**	[deg]															90	90
Surrounding Day - Wind Speed																	
WS,stdev	[m/s]																
WS,delta	[m/s]	15	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
Total Number of Cases																	
Identified Cases		61	75	109	146	236	125	169	196	233	292	367	556	384	288	269	
Distinct Days		8	11	18	28	84	24	19	21	32	47	57	142	83	40	36	
"strict" filter constraints																	
"relaxed" filter constraints																	

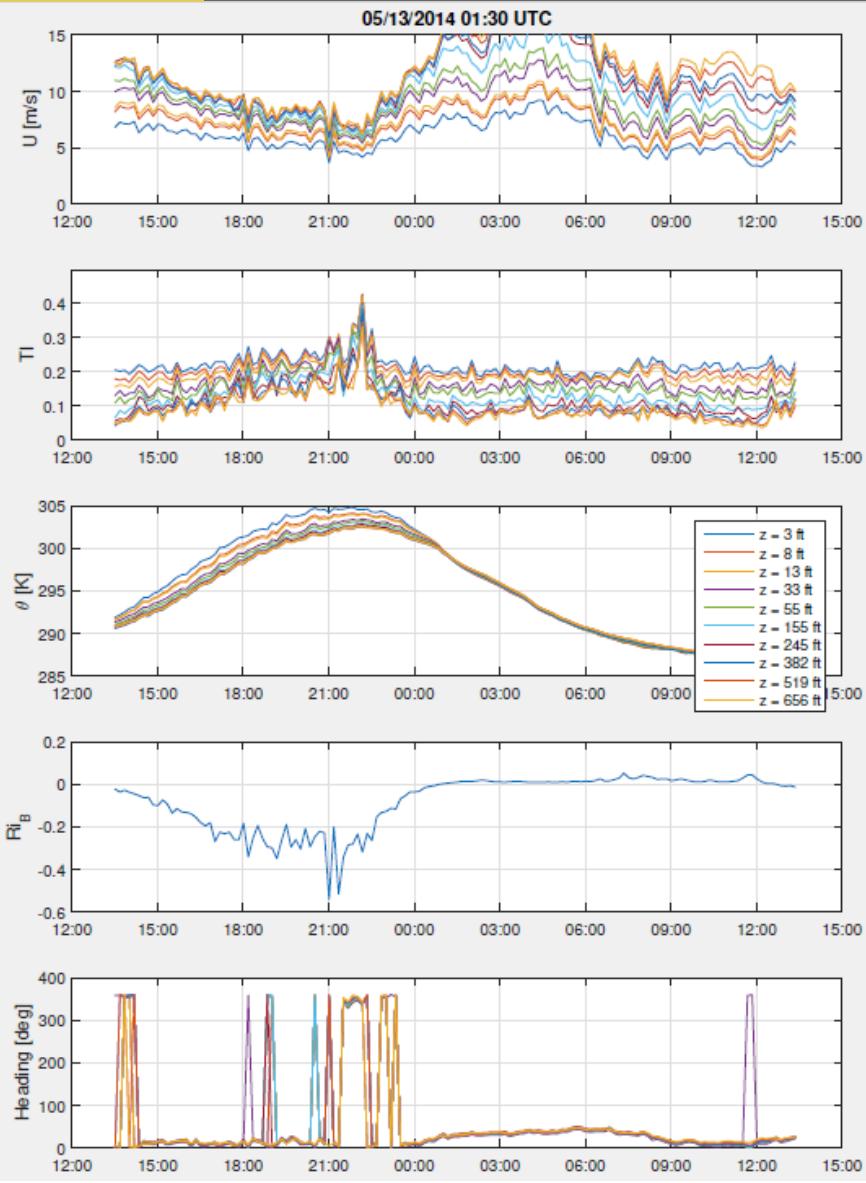
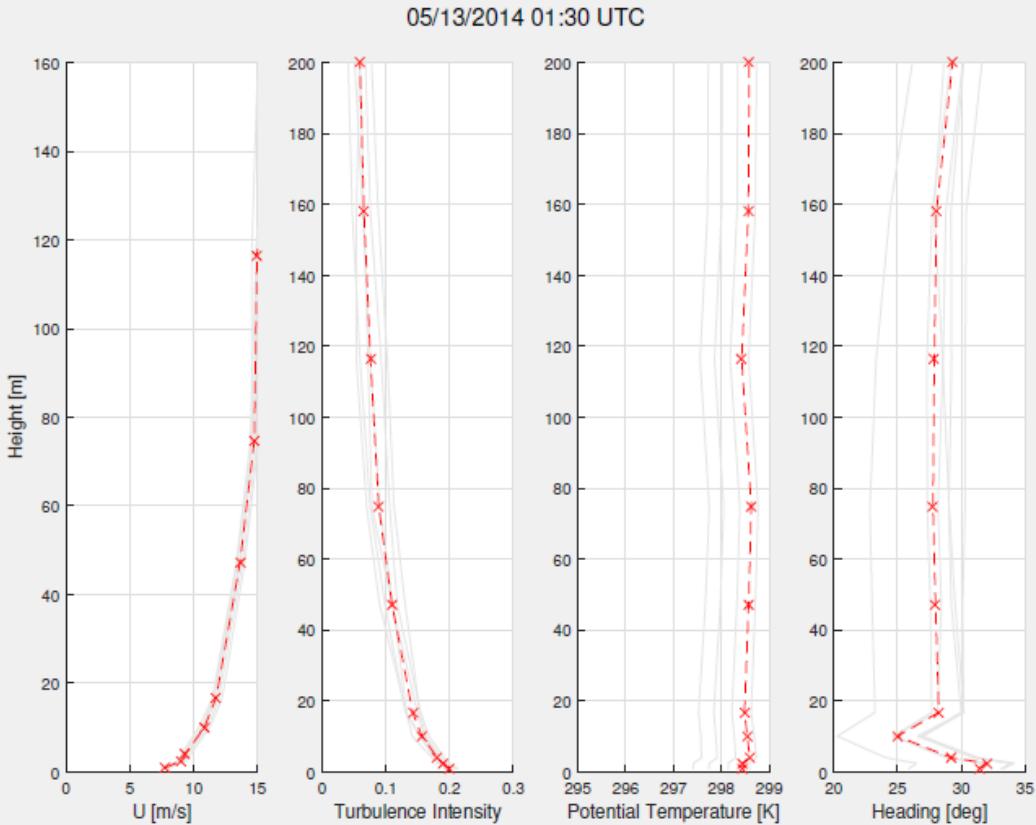
# Case Identification – Strict Filter



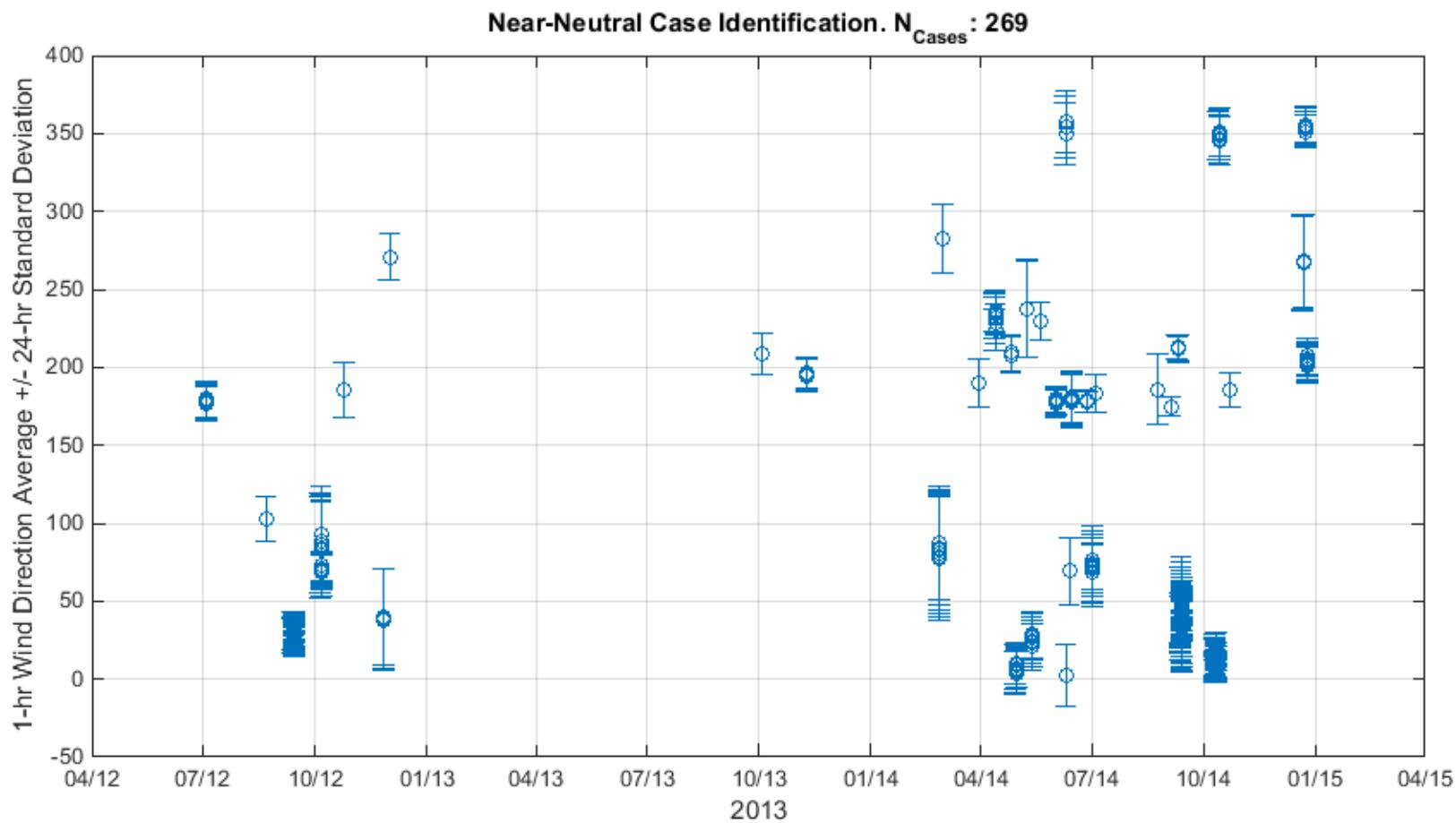
# Case Identification – Strict Filter, Alstom Data\*\*



# Case Identification – Strict Filter, NO Alstom Data\*\*

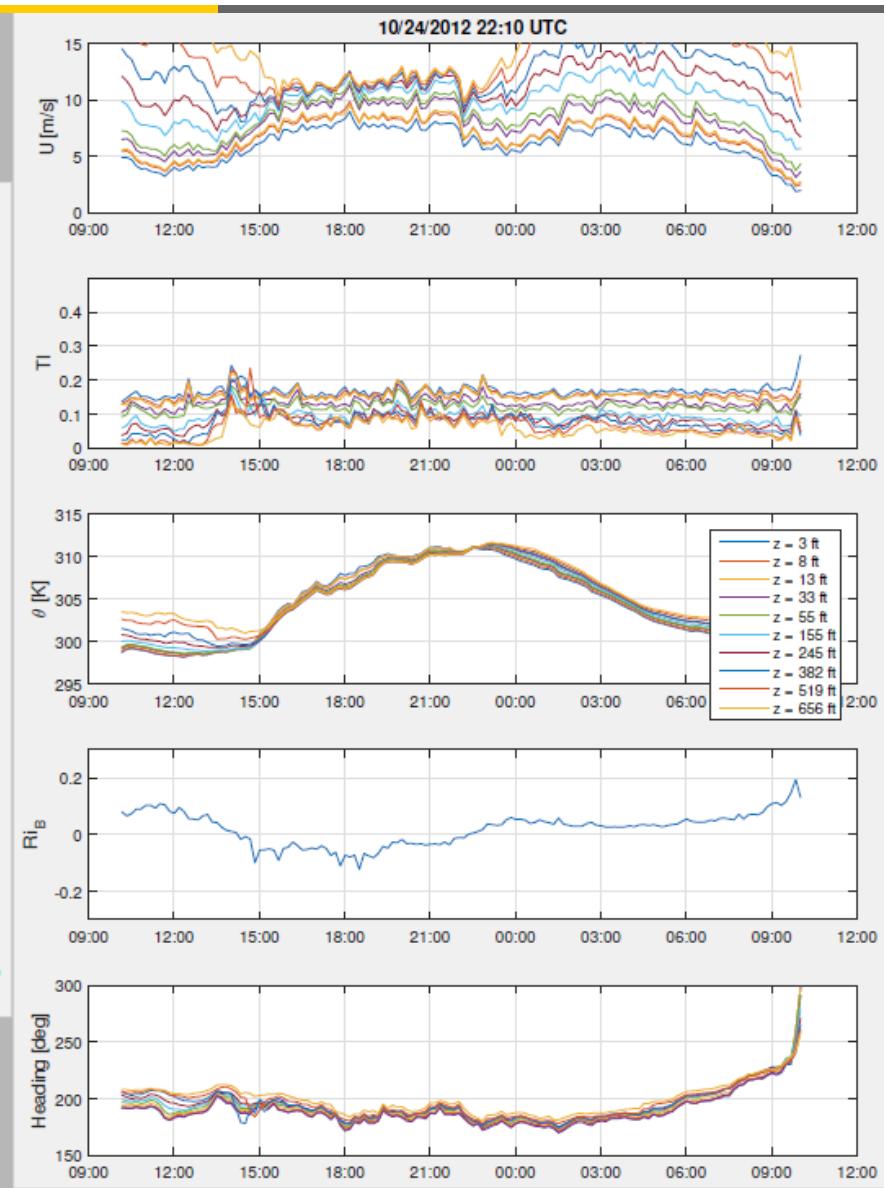
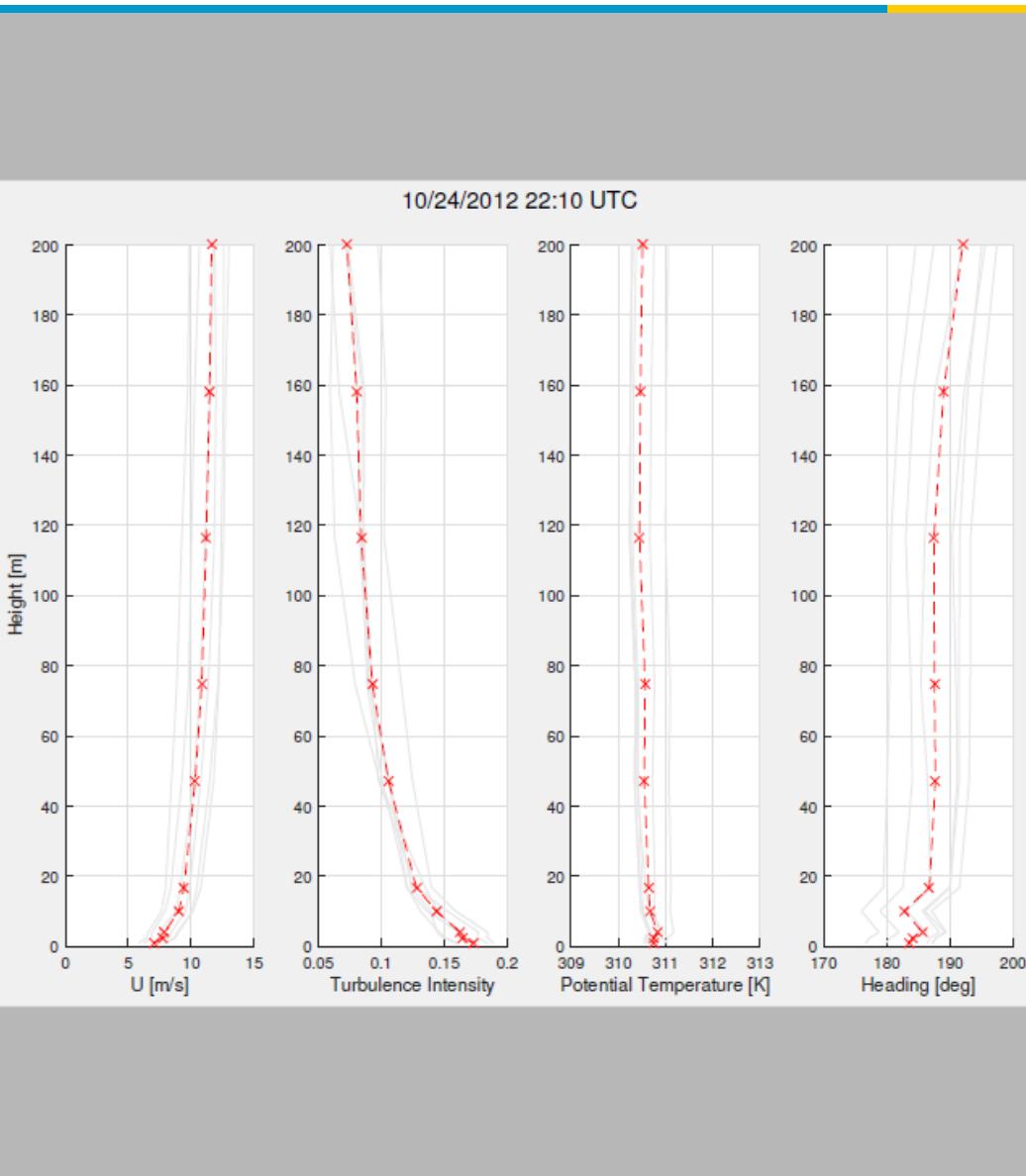


# Case Identification – Relaxed Filter

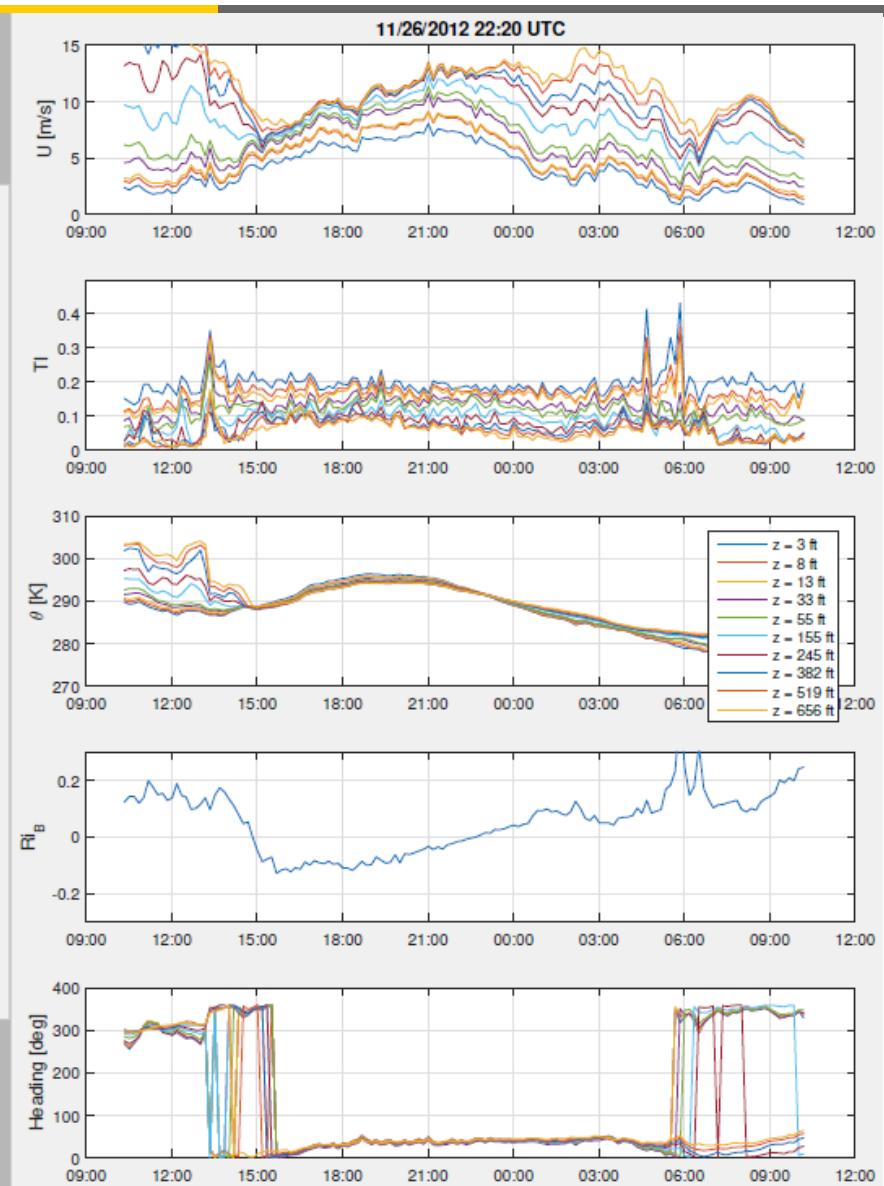
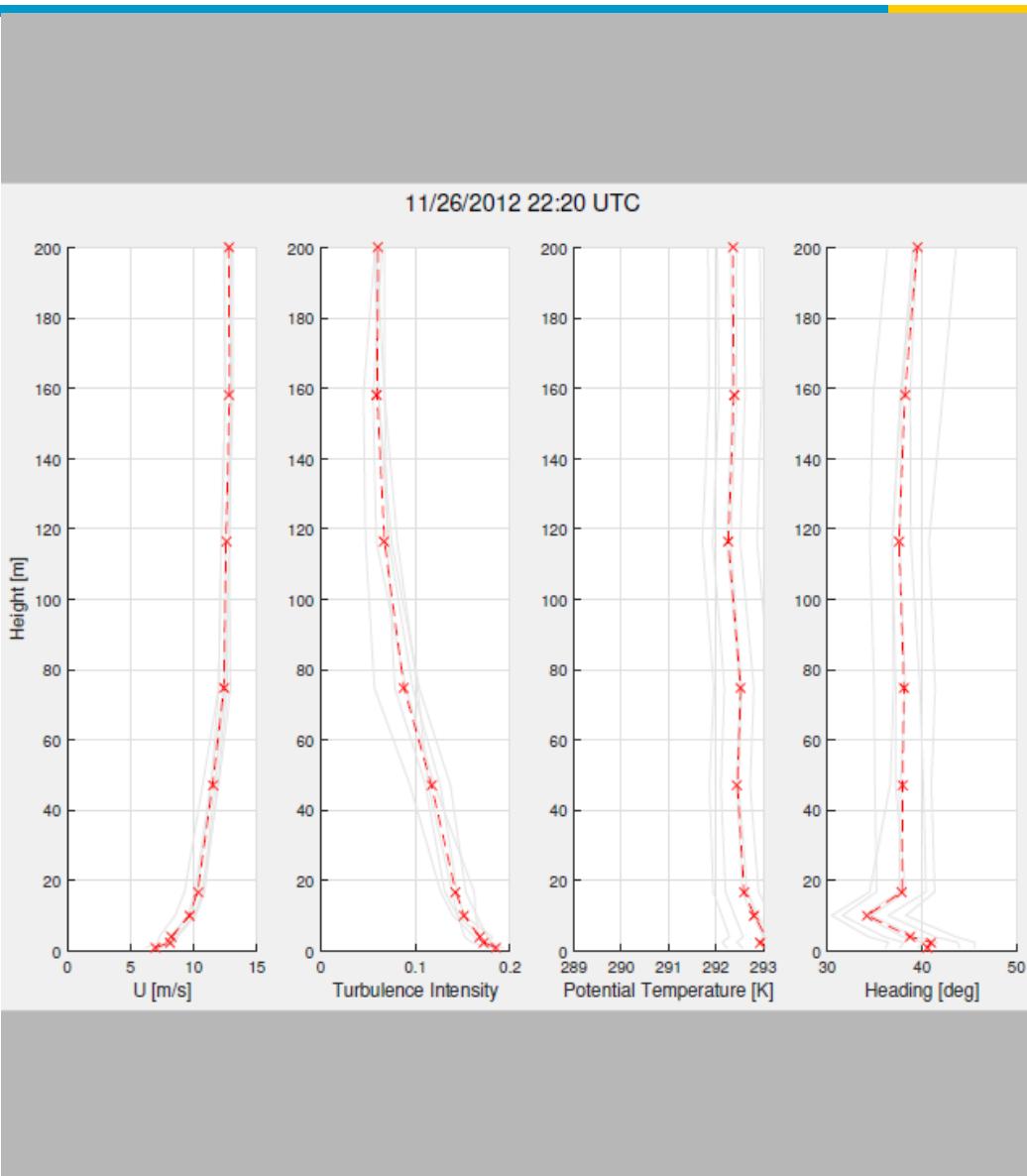


\*\* NOTE: following cases are likely not centered on the best near-neutral dataset

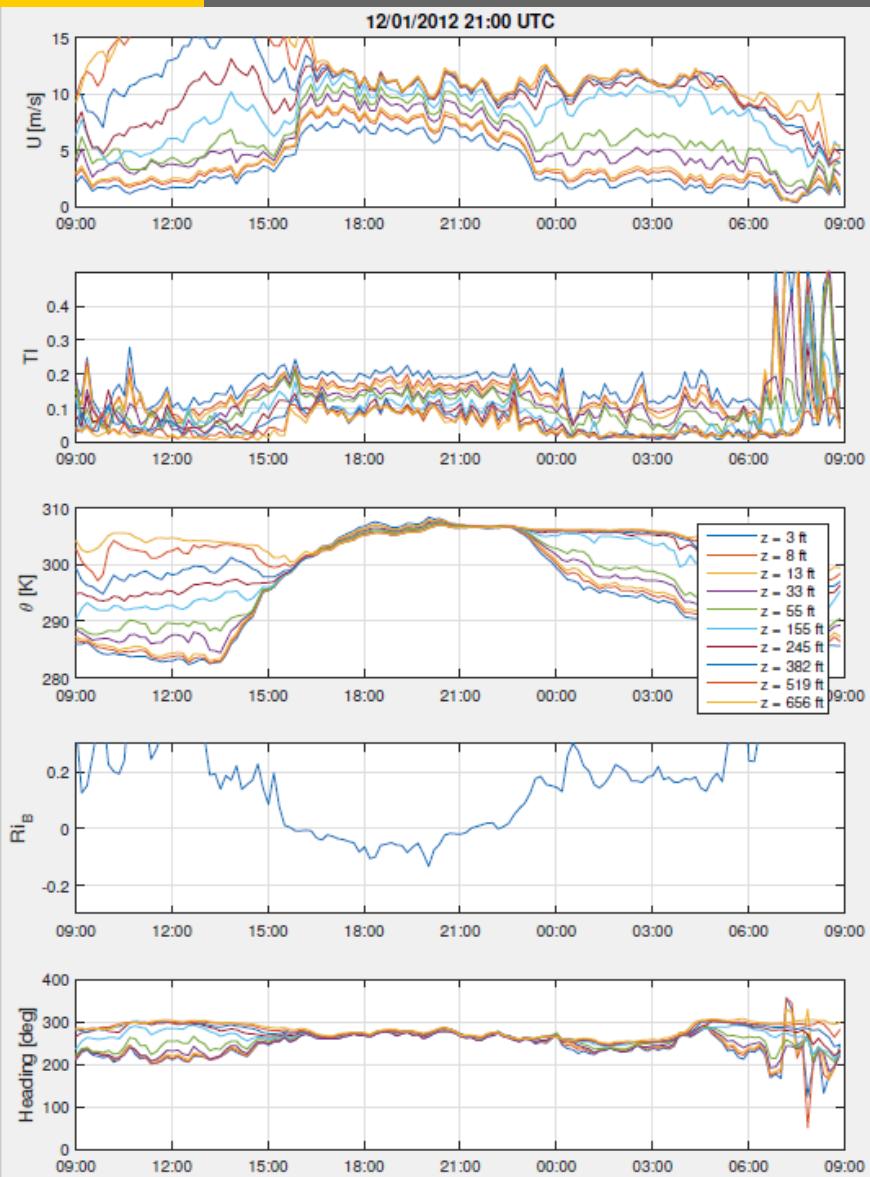
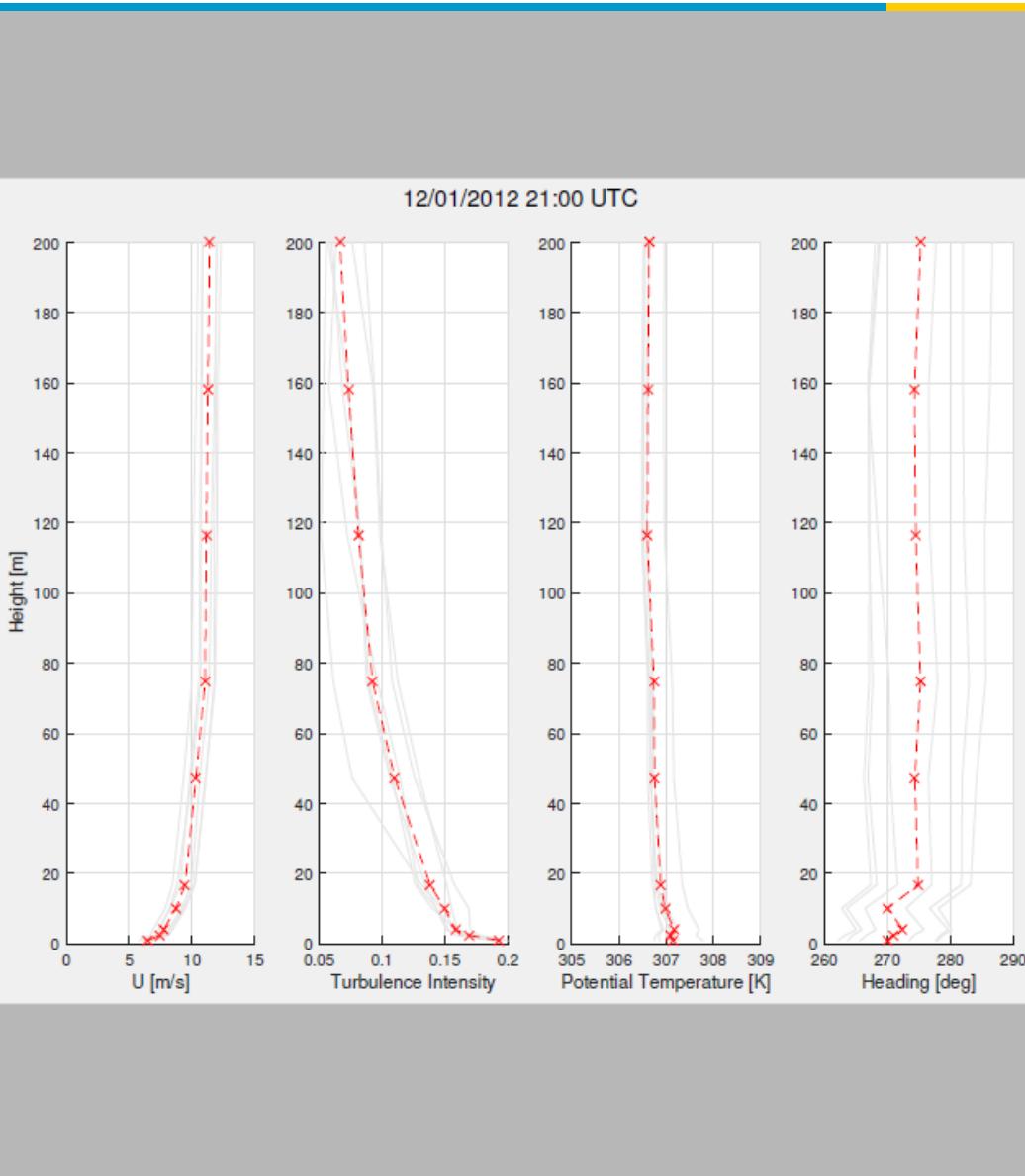
# Case Identification – Relaxed Filter, Alstom Data



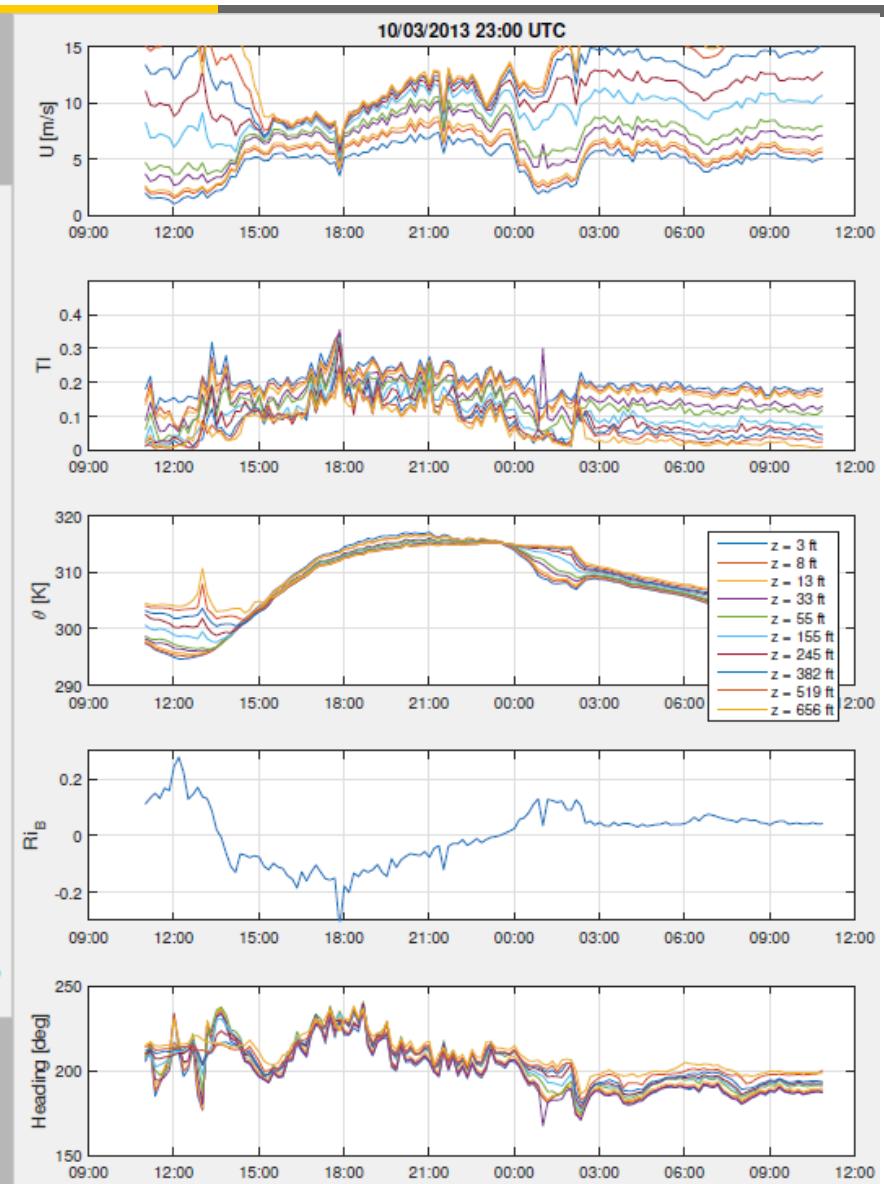
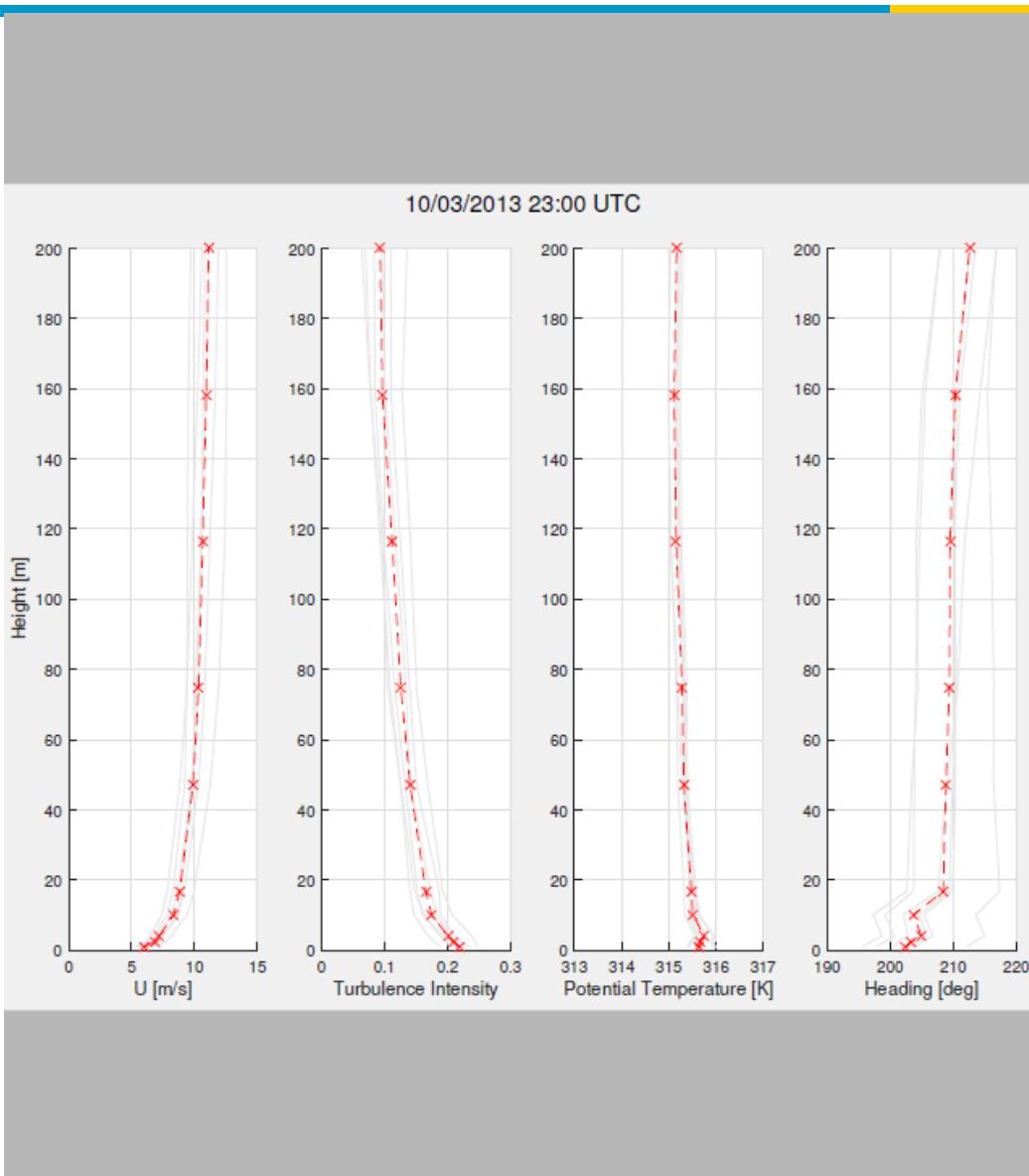
# Case Identification – Relaxed Filter, Alstom Data



# Case Identification – Relaxed Filter, Alstom Data



# Case Identification – Relaxed Filter, Alstom Data\*\*

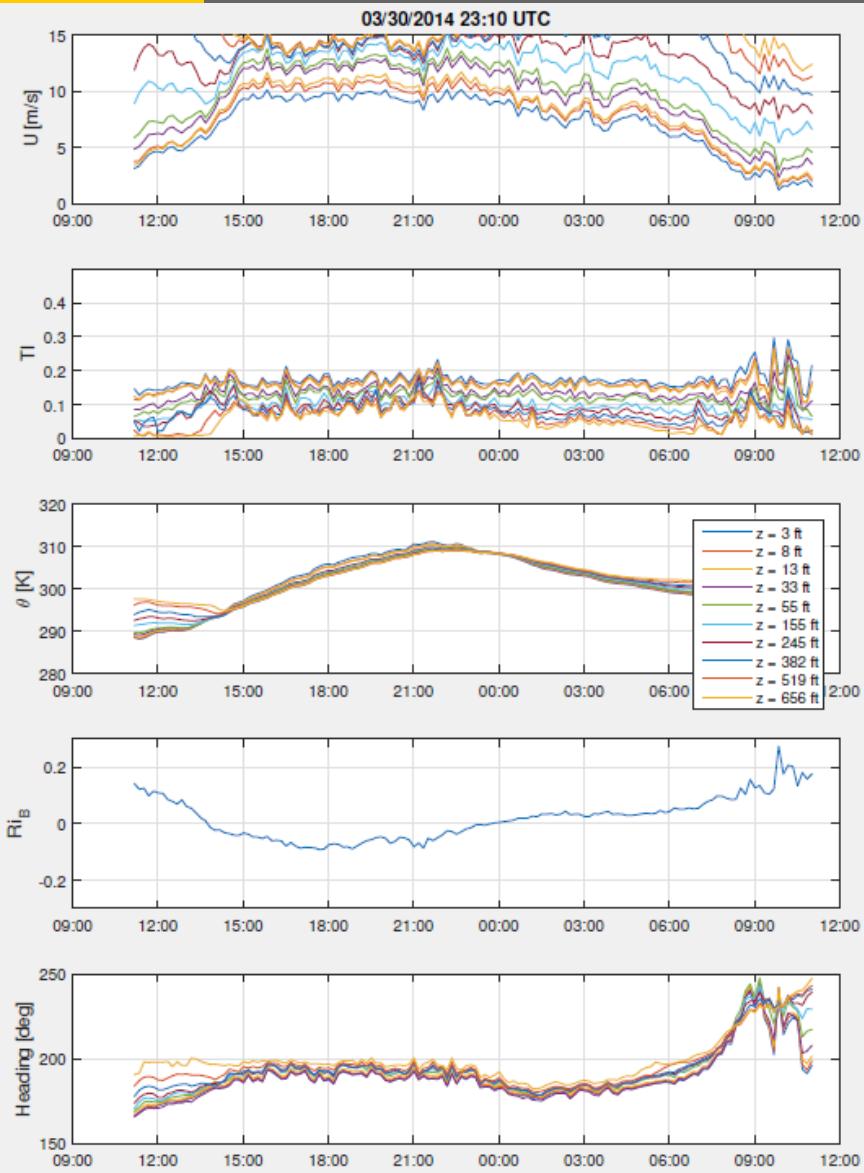
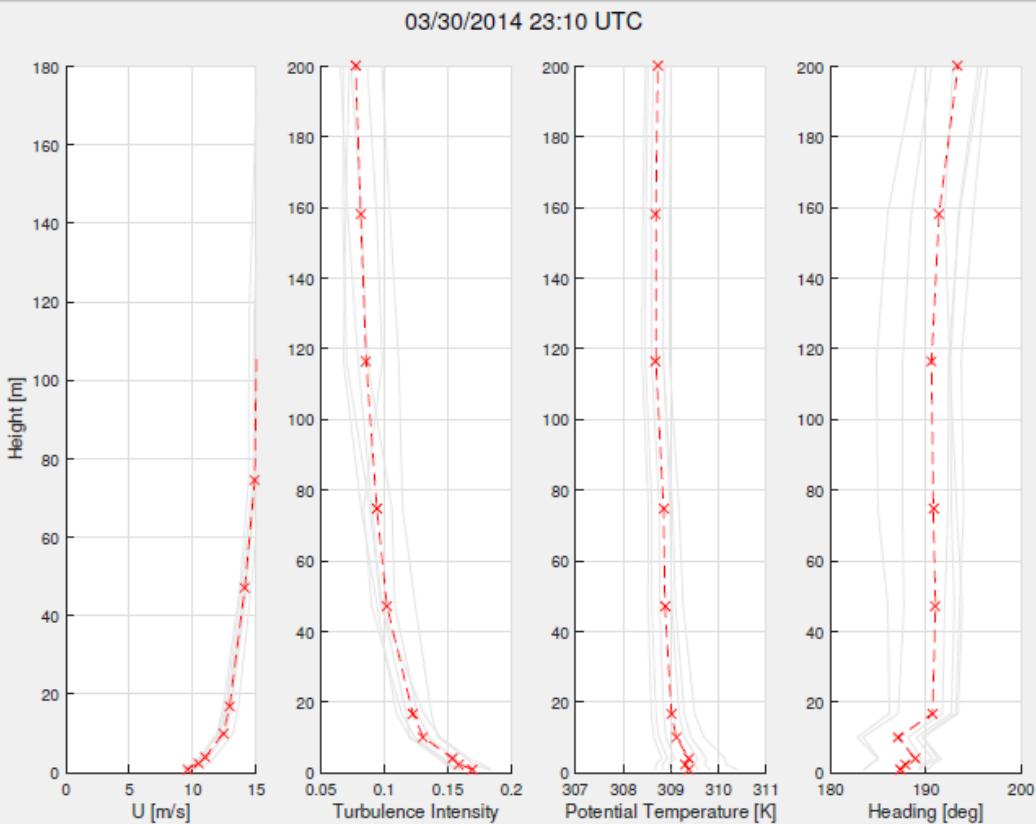


# Case Identification – Relaxed Filter, NO Alstom Data

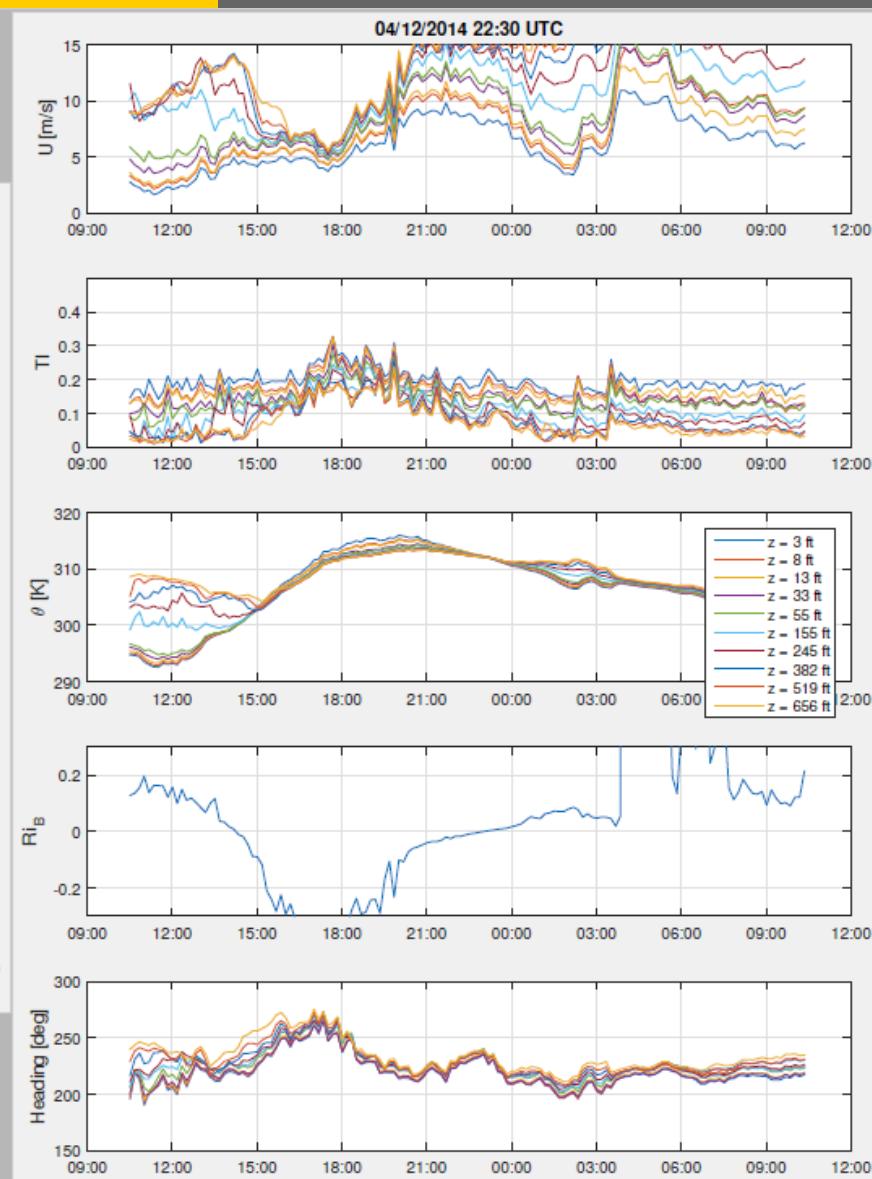
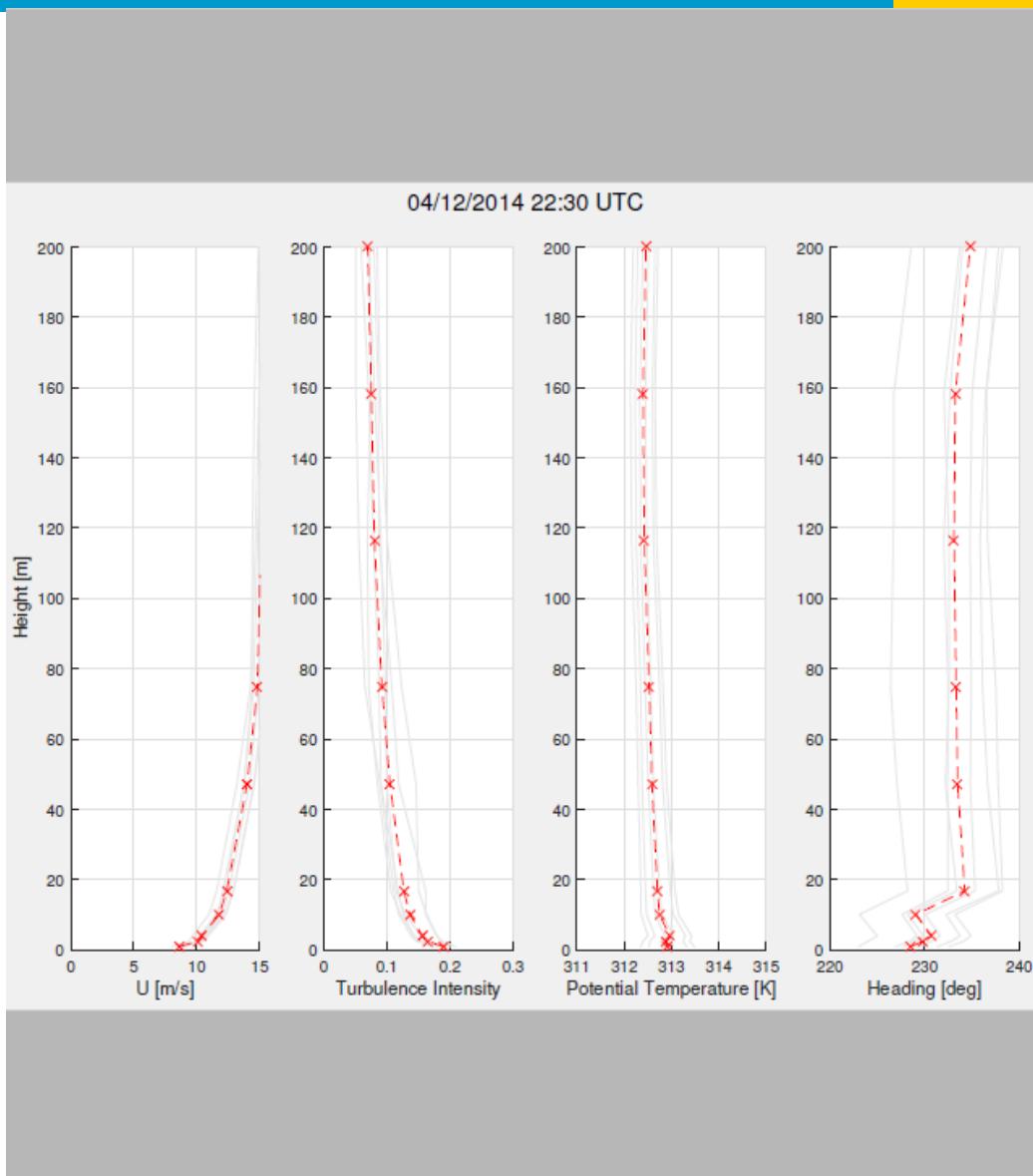
---

The following cases DO NOT overlap with the Alstom meteorological tower data set.

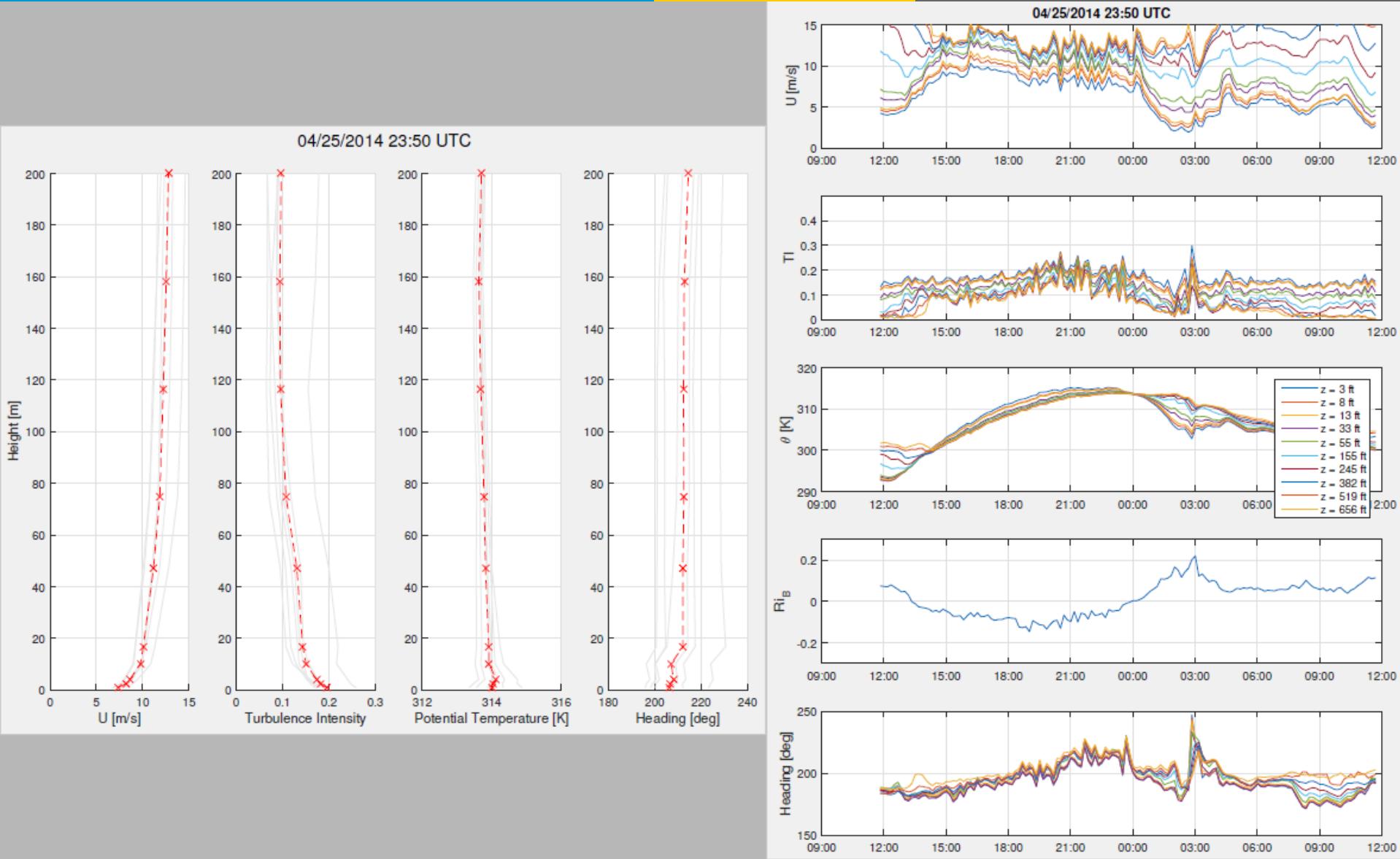
# Case Identification – Relaxed Filter, NO Alstom Data



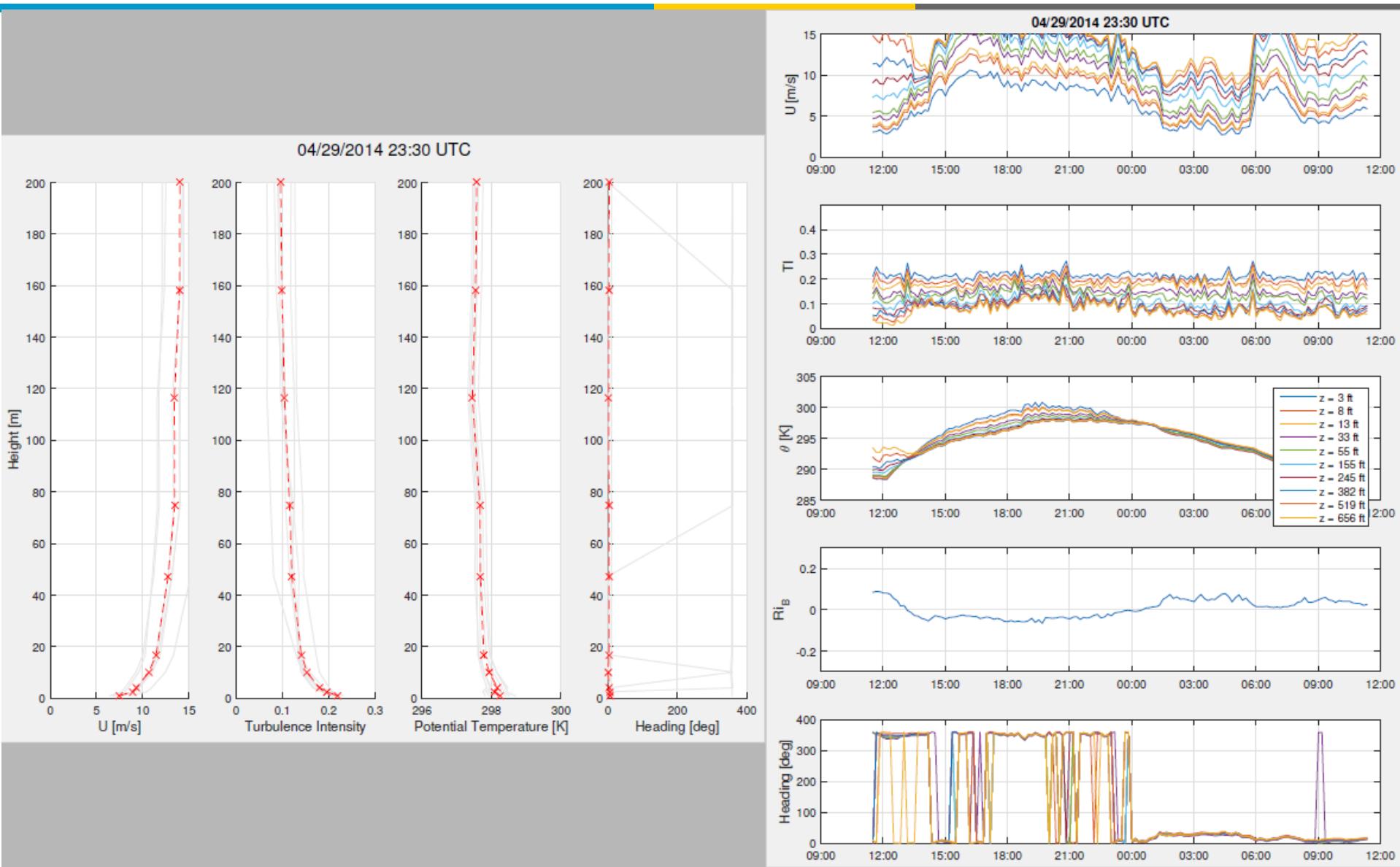
# Case Identification – Relaxed Filter, NO Alstom Data



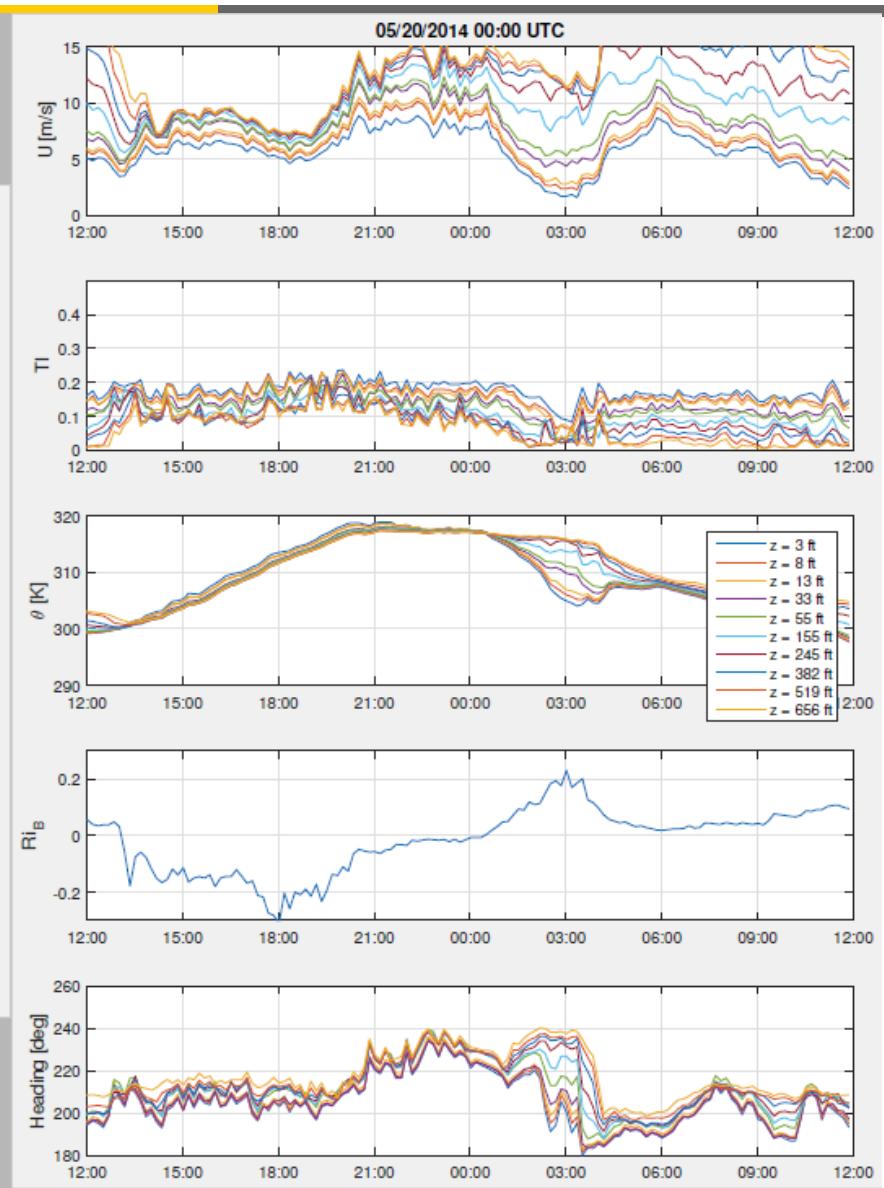
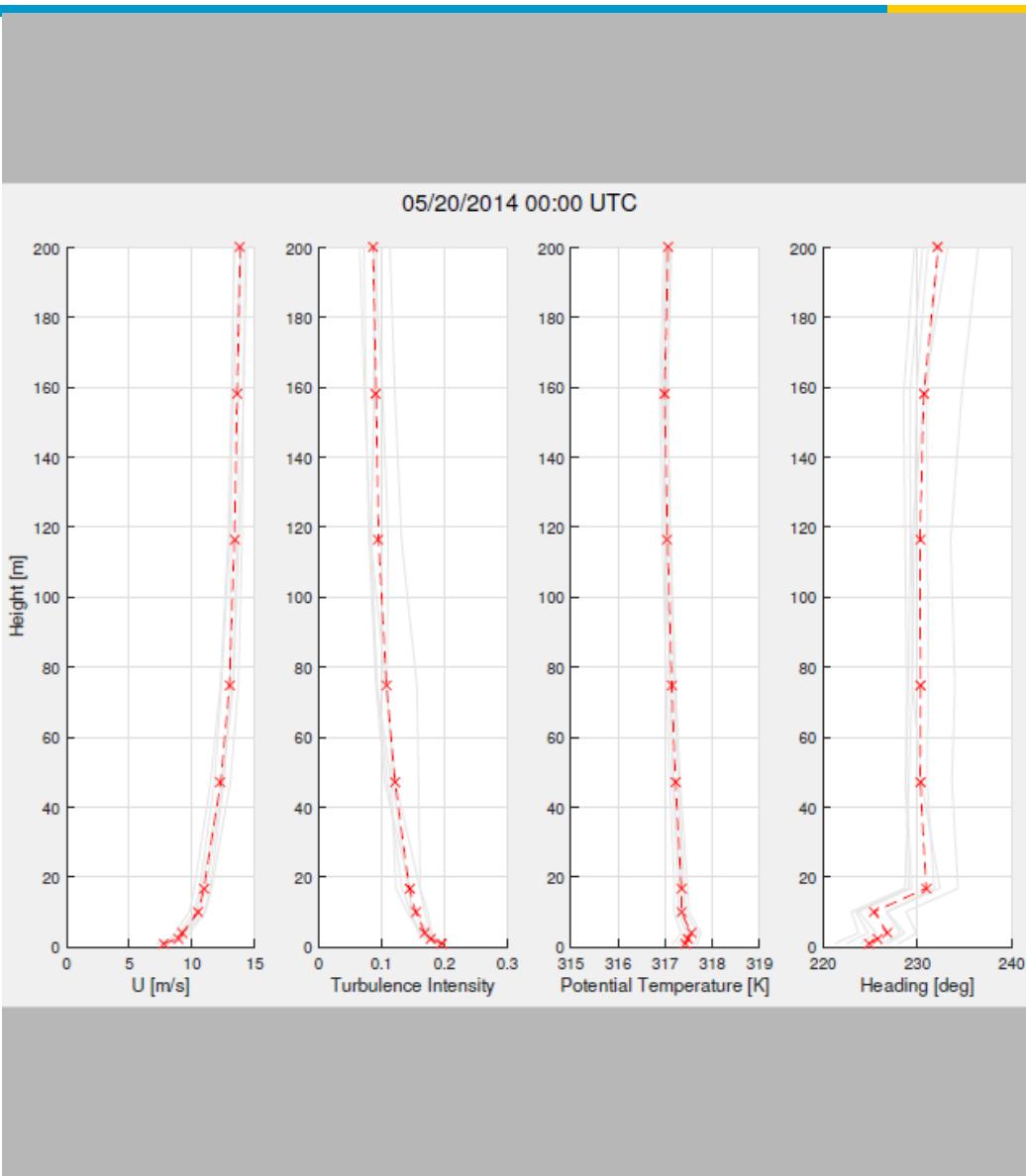
# Case Identification – Relaxed Filter, NO Alstom Data



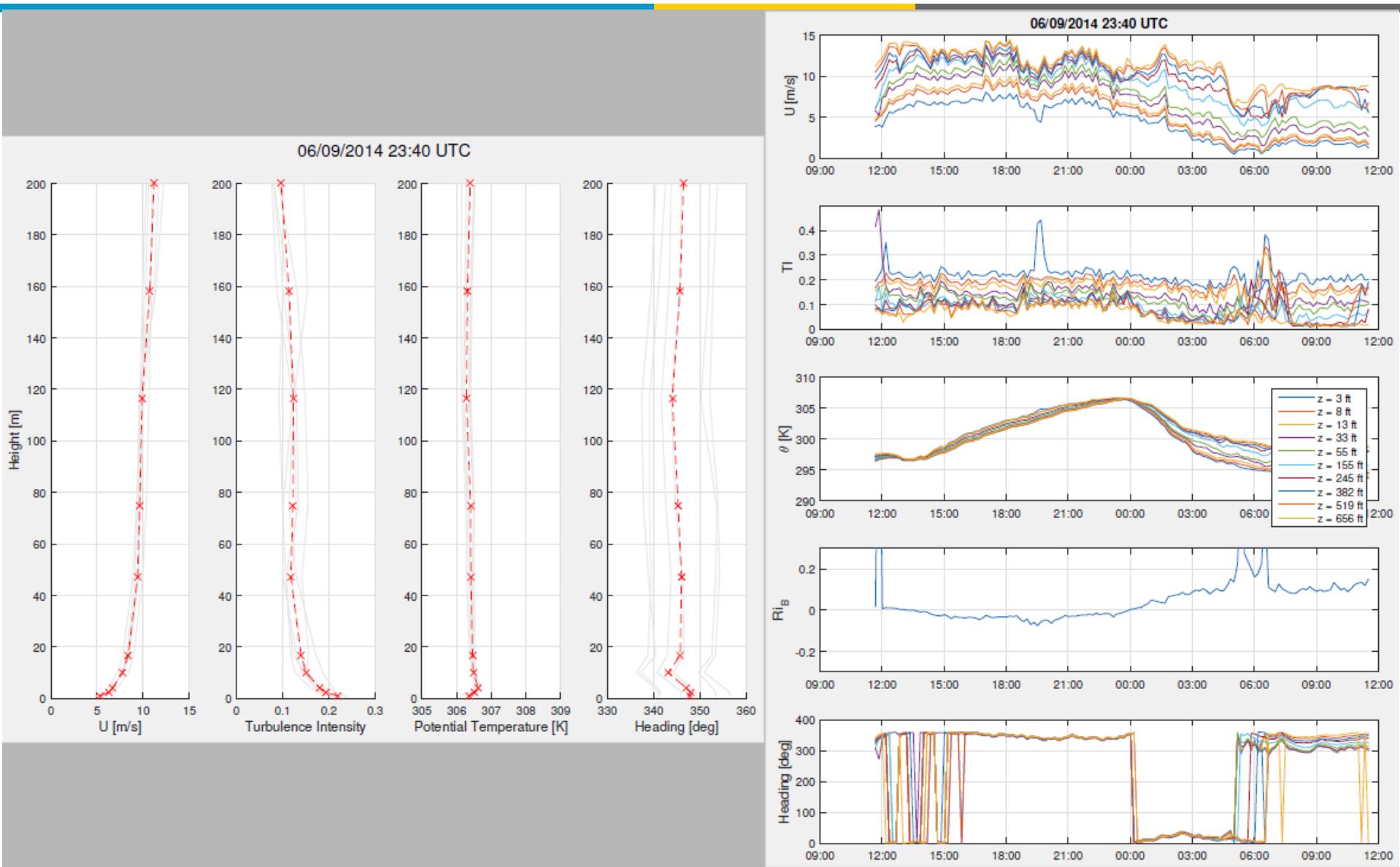
# Case Identification – Relaxed Filter, NO Alstom Data



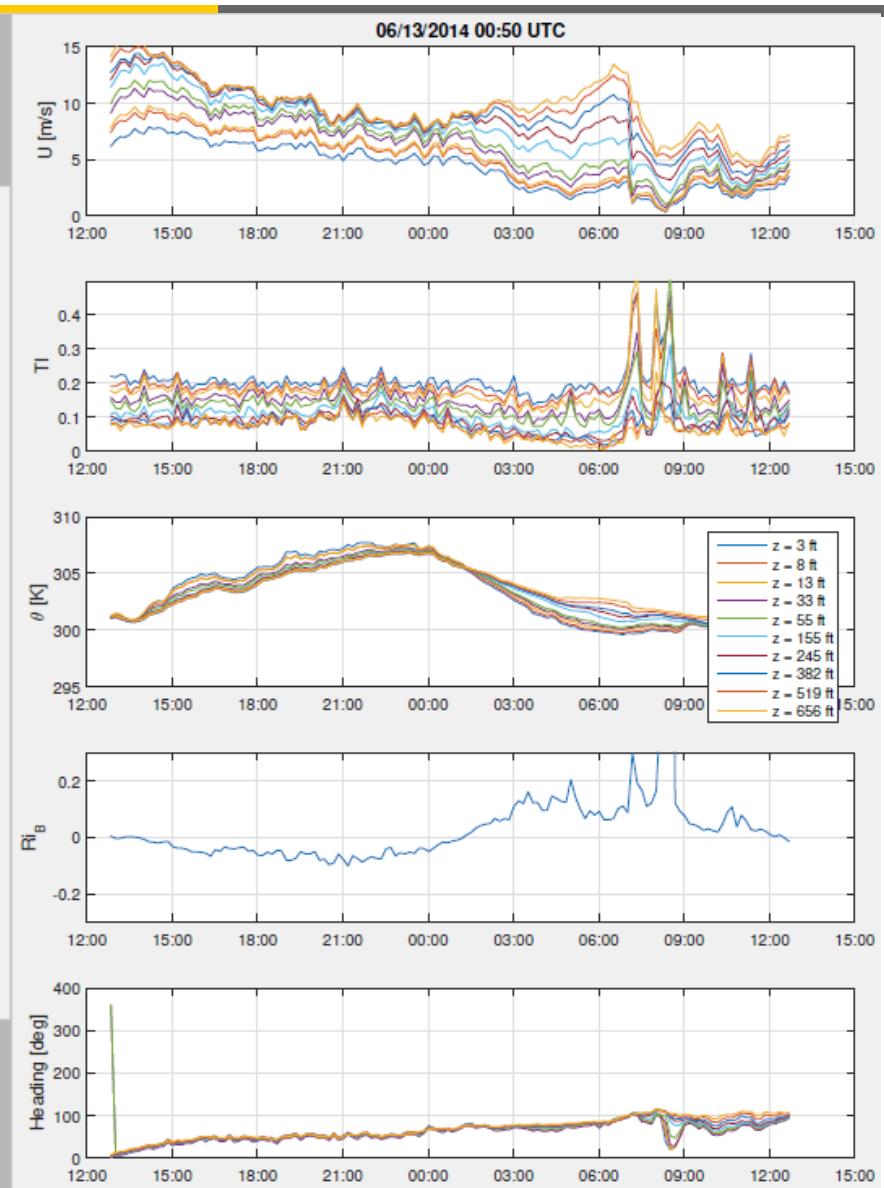
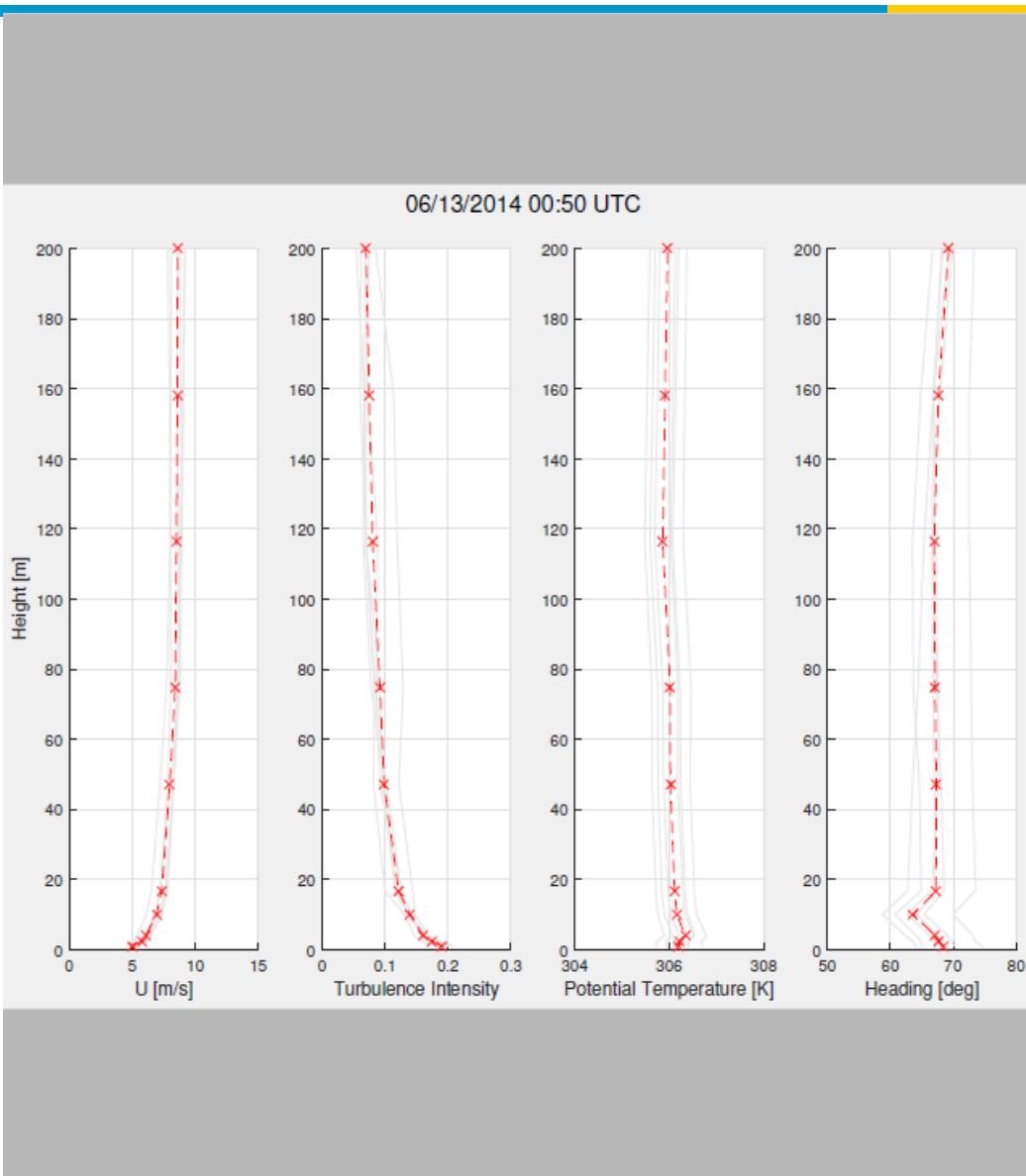
# Case Identification – Relaxed Filter, NO Alstom Data



# Case Identification – Relaxed Filter, NO Alstom Data\*\*



# Case Identification – Relaxed Filter, NO Alstom Data\*\*



## Case Identification – Relaxed Filter, NO Alstom Data\*\*

