



**ATMOSPHERE
TO ELECTRONS**
U.S. DEPARTMENT OF ENERGY

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Energy Efficiency &
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ATMOSPHERE TO ELECTRONS

U.S. DEPARTMENT OF ENERGY

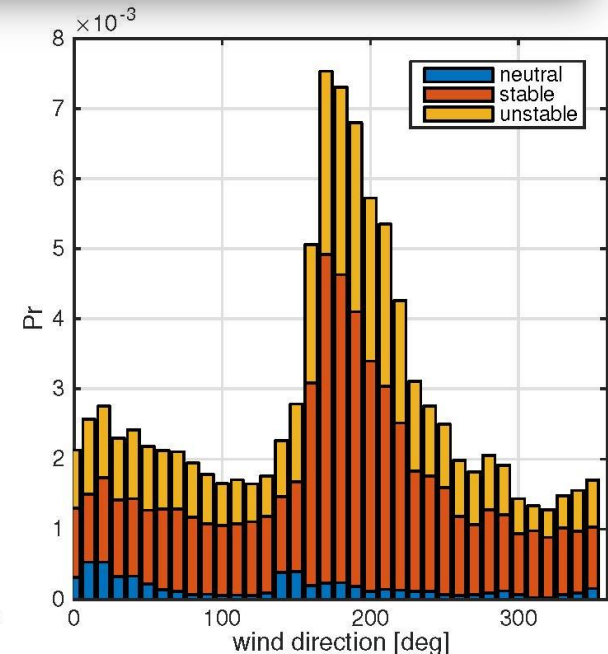
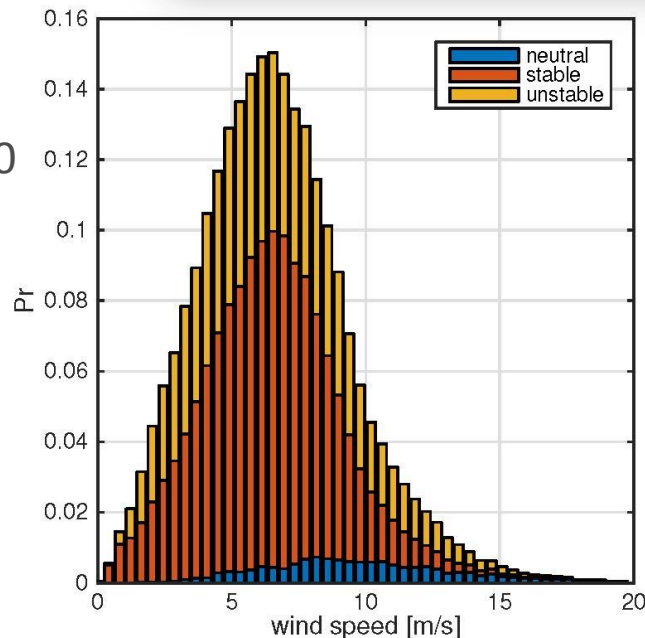
Case Identification – Site Measurements

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

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

Mesonet and Sodar Networks

Historical data from weather stations in surrounding area

- West Texas Mesonet

Alstom meteorological tower

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

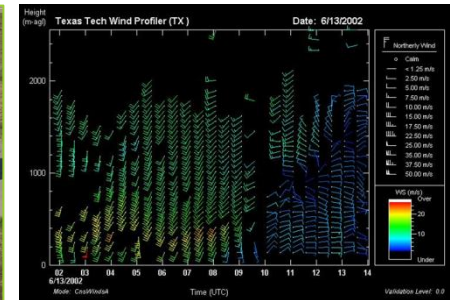


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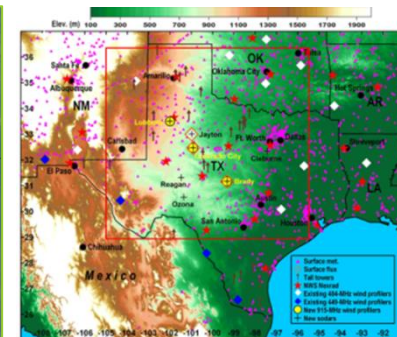


200m Met Tower;
50hz historical data

Radar Profiler; 20 min data logs



West Texas Mesonet and WFIP1 dataset



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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

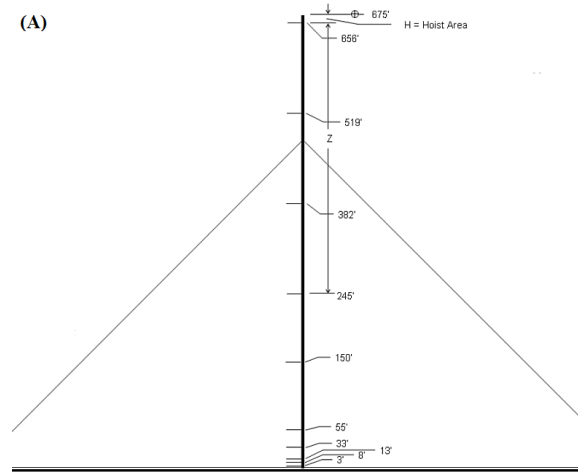
Tower Location Coordinates:

(33.61054 N, 102.05054 W)
at an elevation of 1021m

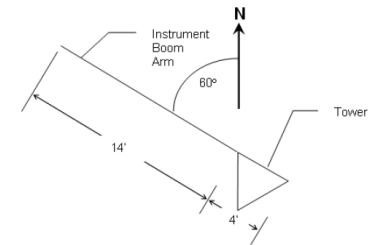
200m Tower Sensor Heights

[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

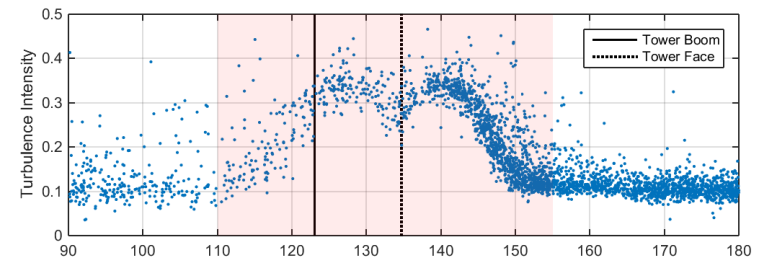
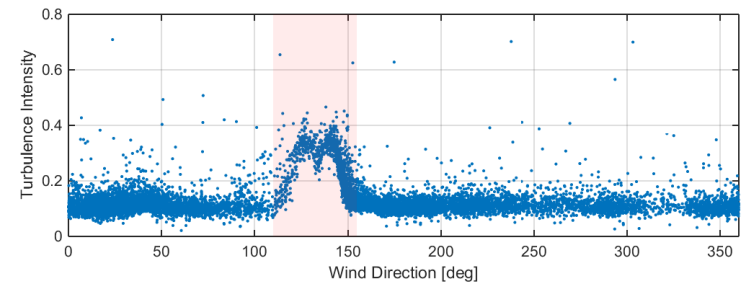


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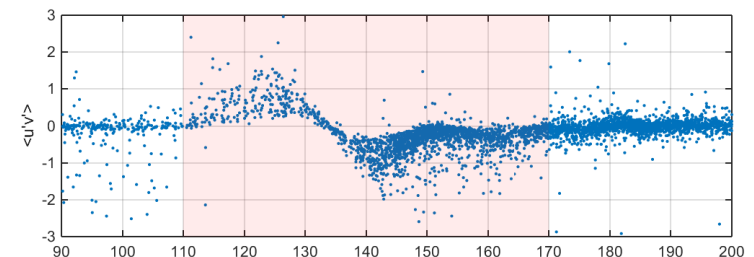
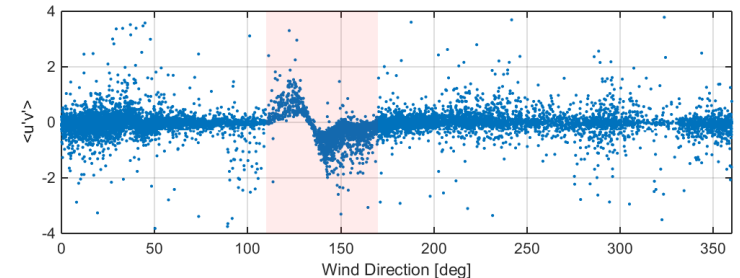
TTU 200m Tower Wake

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

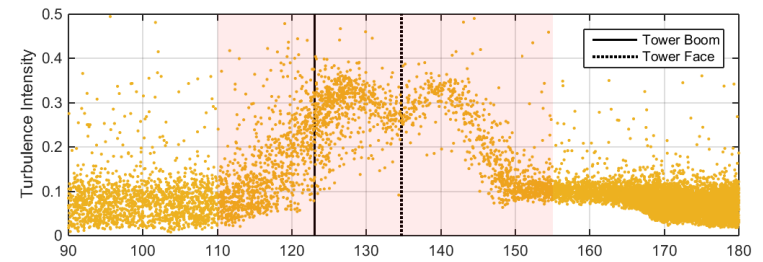
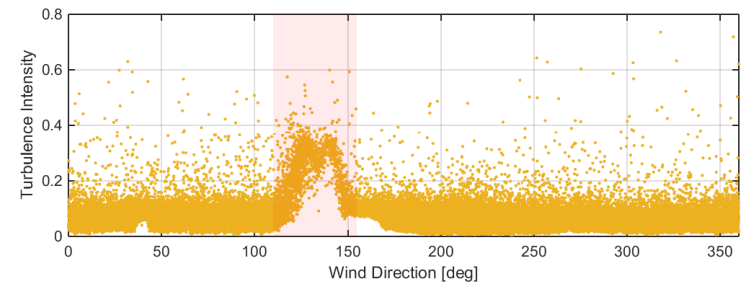


Reynold's Shear – 155ft Tower Height

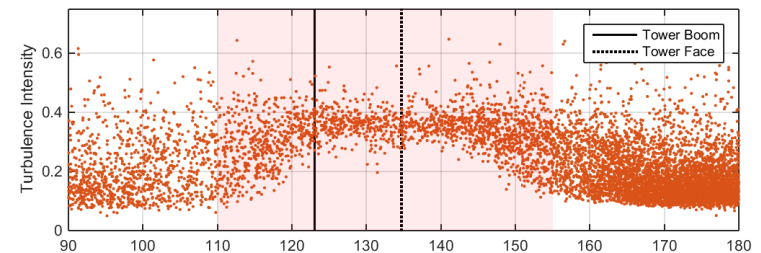
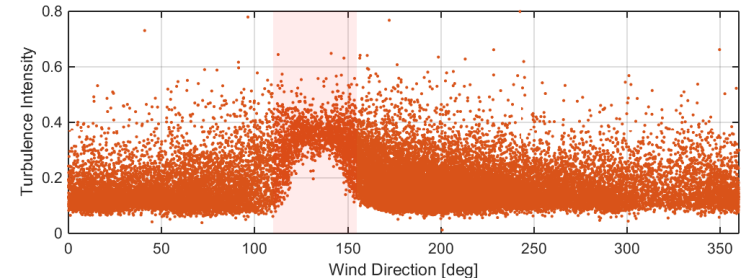
TTU 200m Tower Wake

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

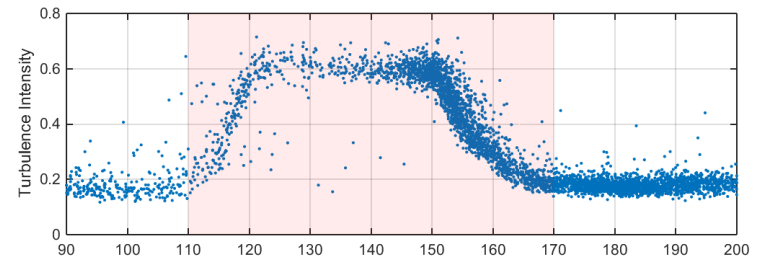
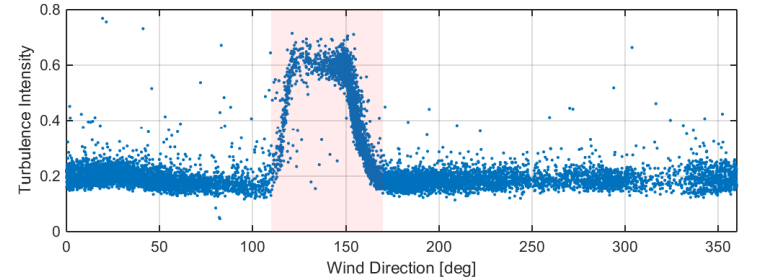


Convective ABL, TI – 155ft Tower Height

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.



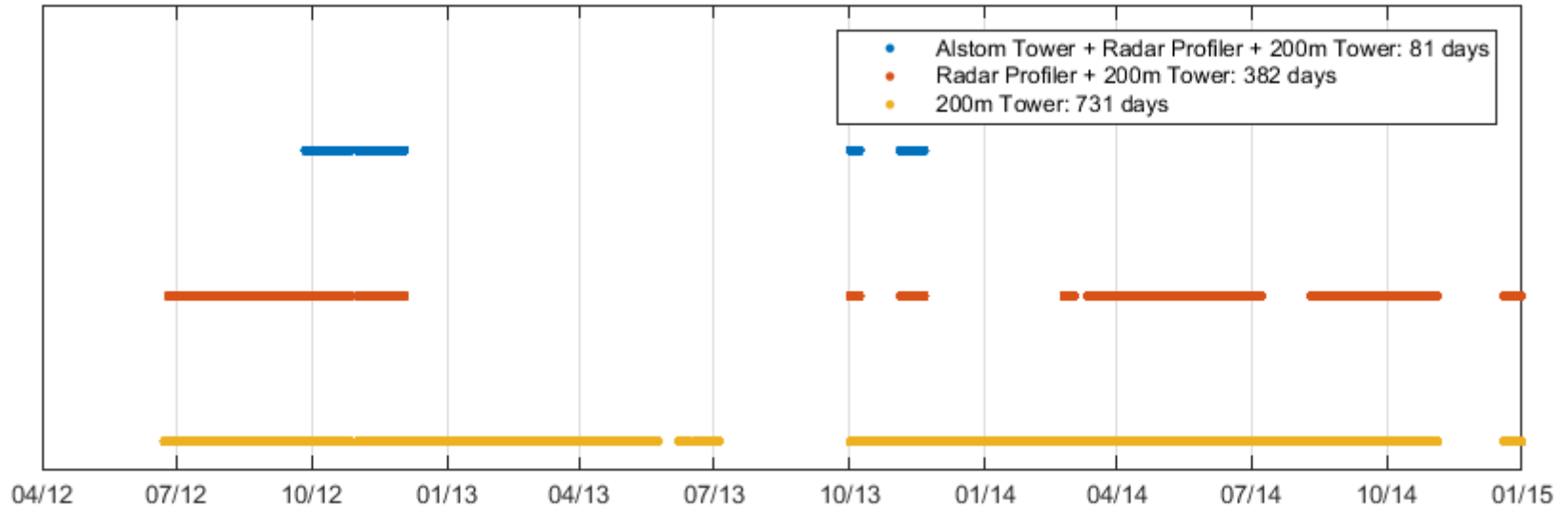
(b) Tower Structure Near the Ground.



(c) Adjacent Structures to the 200 m Tower.

Asset Data Availability

Time Series Filters

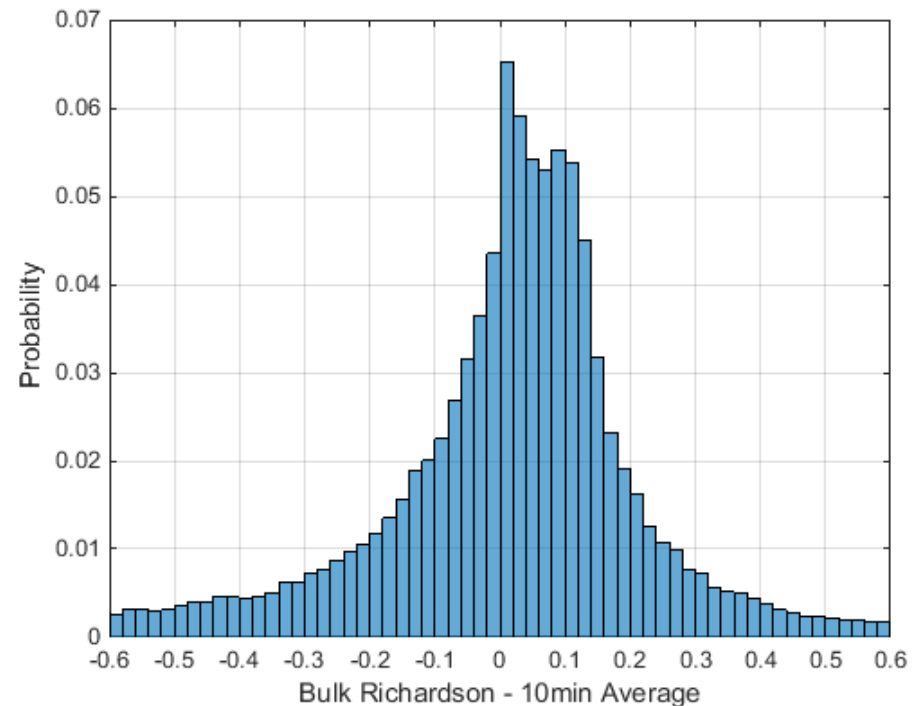
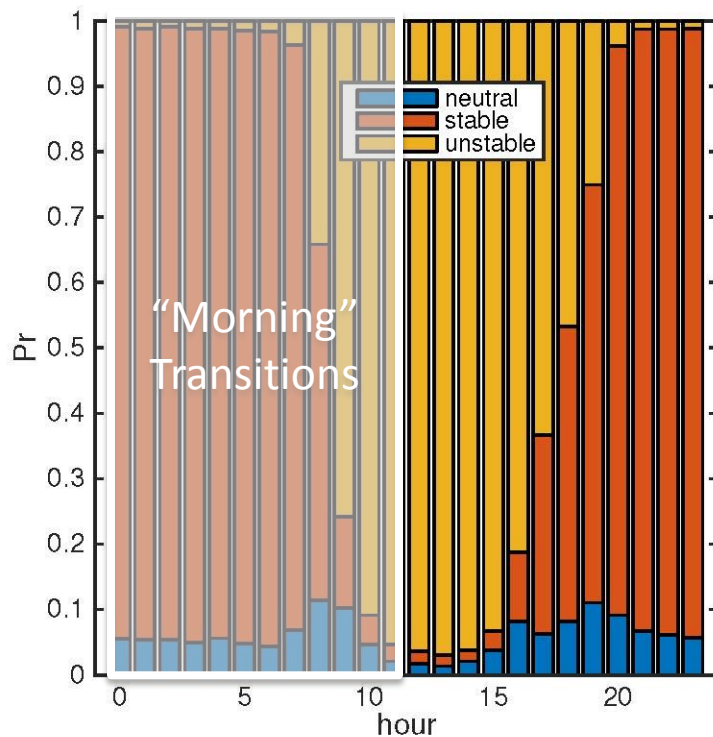


		dates: 12/7/2012 2/28/2012				dates: 6/23/2012 7/4/2013	
		dates: 9/27/2012 12/11/2013				dates: 10/1/2013 11/4/2014	
						dates: 12/19/2014 12/31/2014	
Radar Profiler		Alstom		data may be available		TTU 200m Tower	
1/1/2012	4/2/2012	1/1/2012	2/28/2012	2/28/2012	4/2/2012	NO	NO
6/26/2012	12/3/2012	9/27/2012	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 $Ri_{Bulk} = 0.8-1$ on the year
- In summer, overnight $Ri_{Bulk} \sim 0.05$



Case Identification Process

Initial Benchmark – near-neutral stability

- Bulk Richardson magnitude average < 0.01 ; $\text{delta}(\text{RiBulk}) < 0.01$
- Wind Speed_{47m} > 5 m/s; Wind Speed_{116m} < 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
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
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

Neutral Case - Wind Speed

WS,min47m [m/s]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
WS,max116m [m/s]	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

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
Time,max [UTC]	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		40
WD,delta** [deg]													90	90	

Surrounding Day - Wind Speed

WS,stdev [m/s]			999	999	999	999	999	999	999	999	999	999	999	999	999
WS,delta [m/s]	15	999													

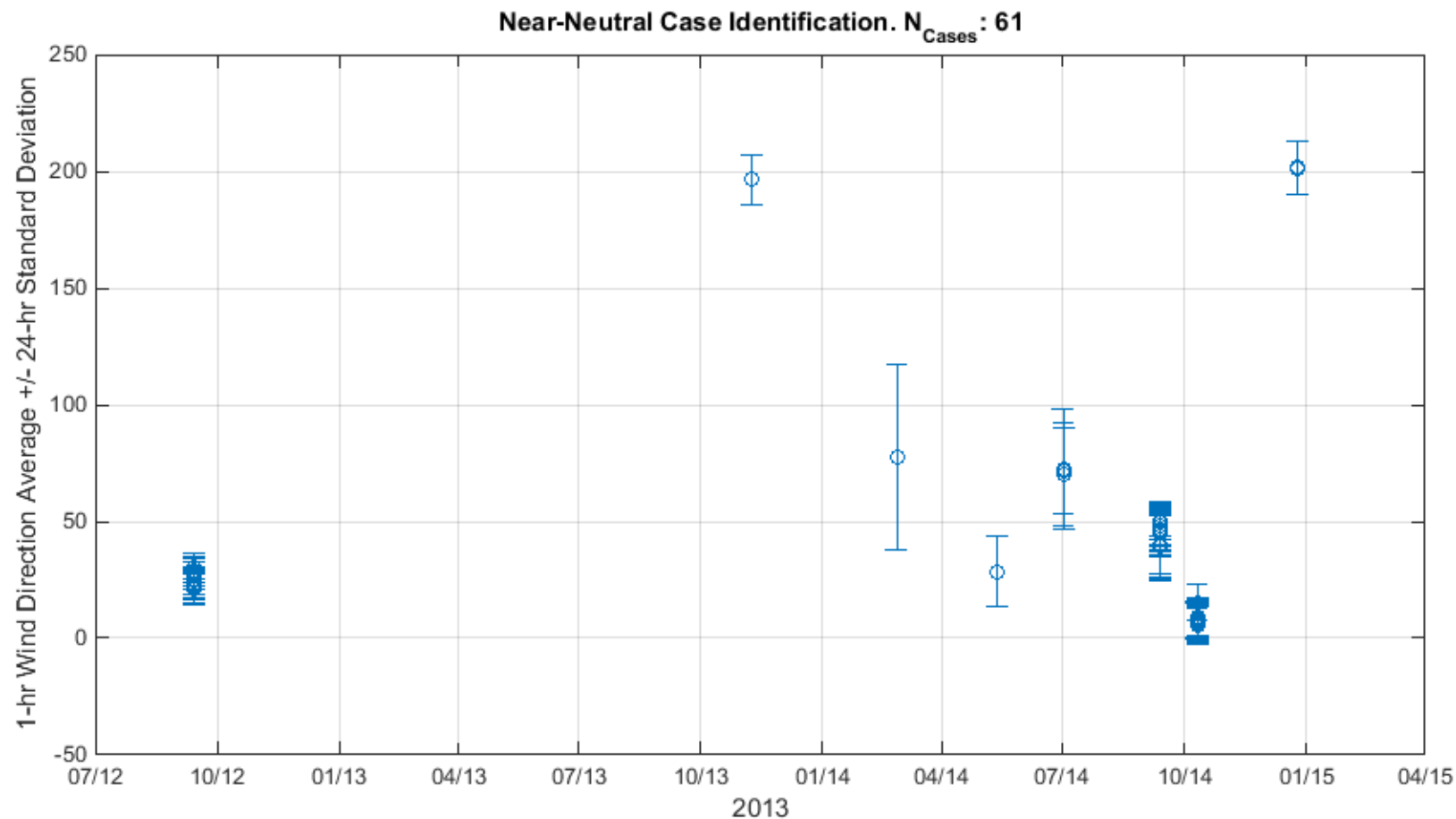
Total Number of Cases

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

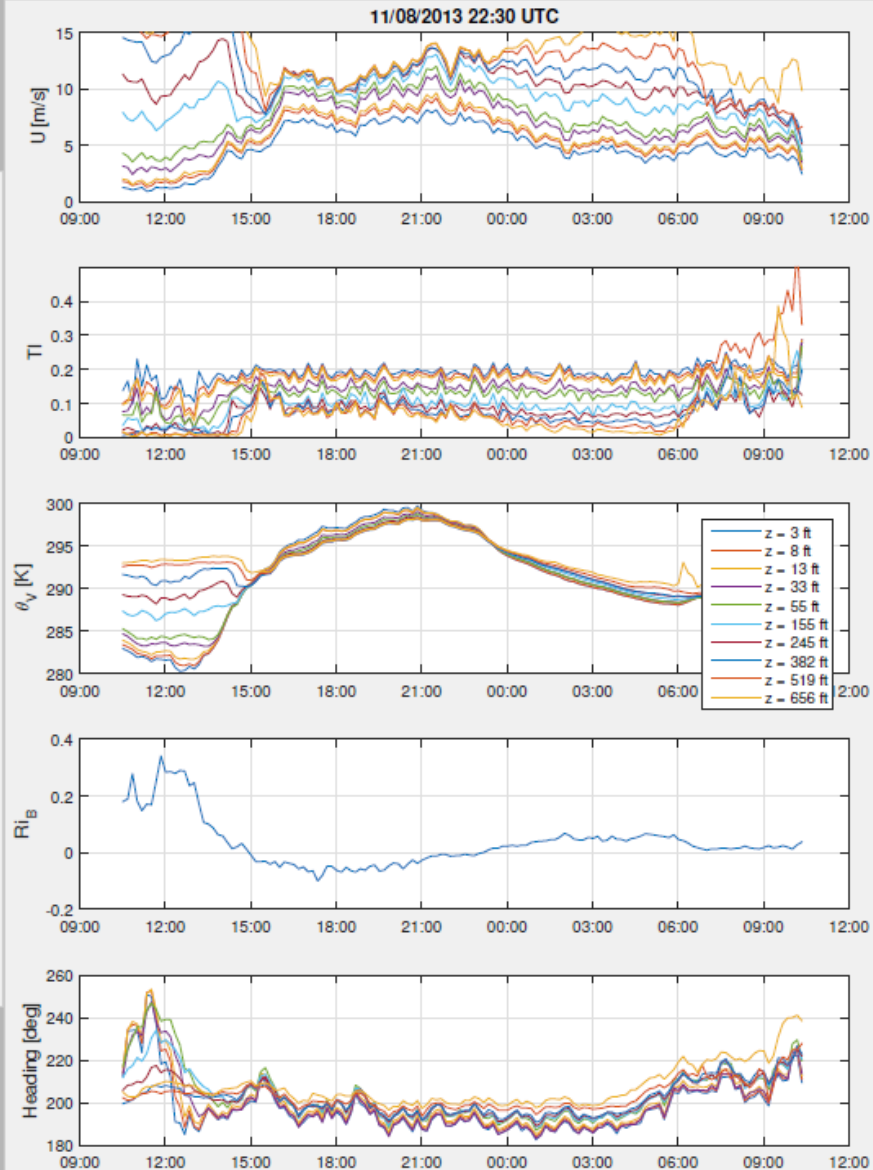
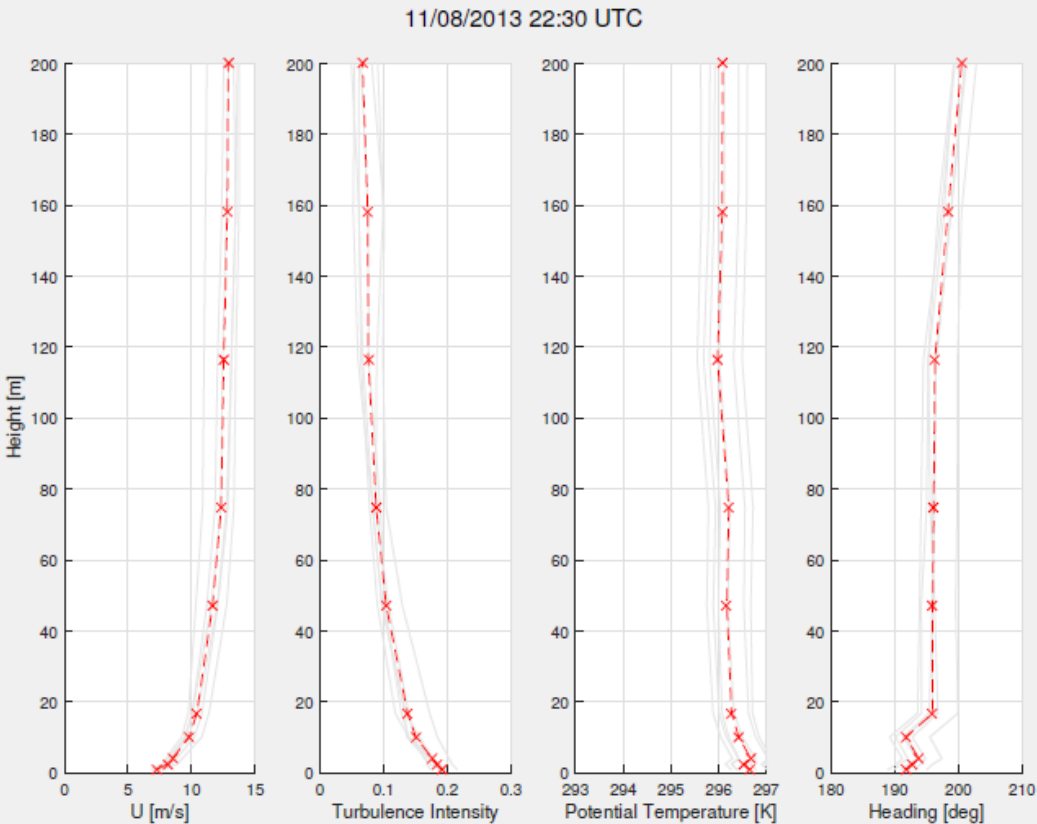
“strict” filter constraints

“relaxed” filter constraints

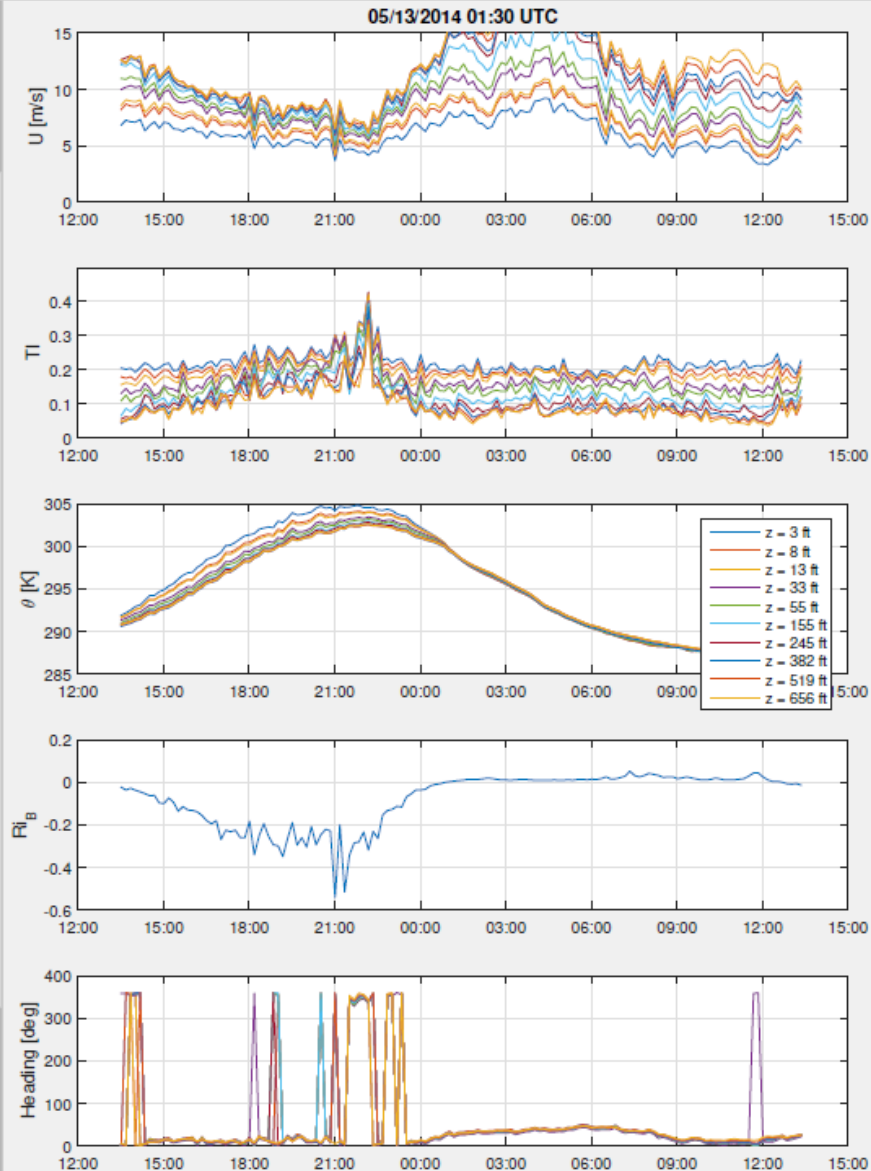
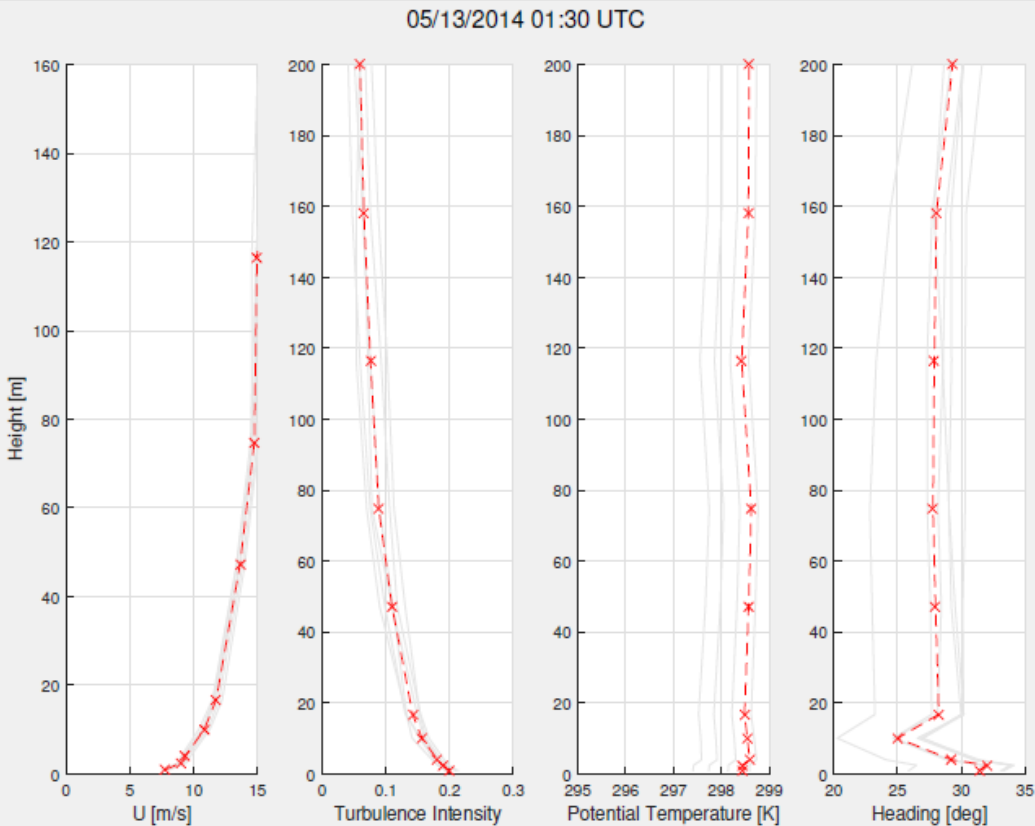
Case Identification – Strict Filter



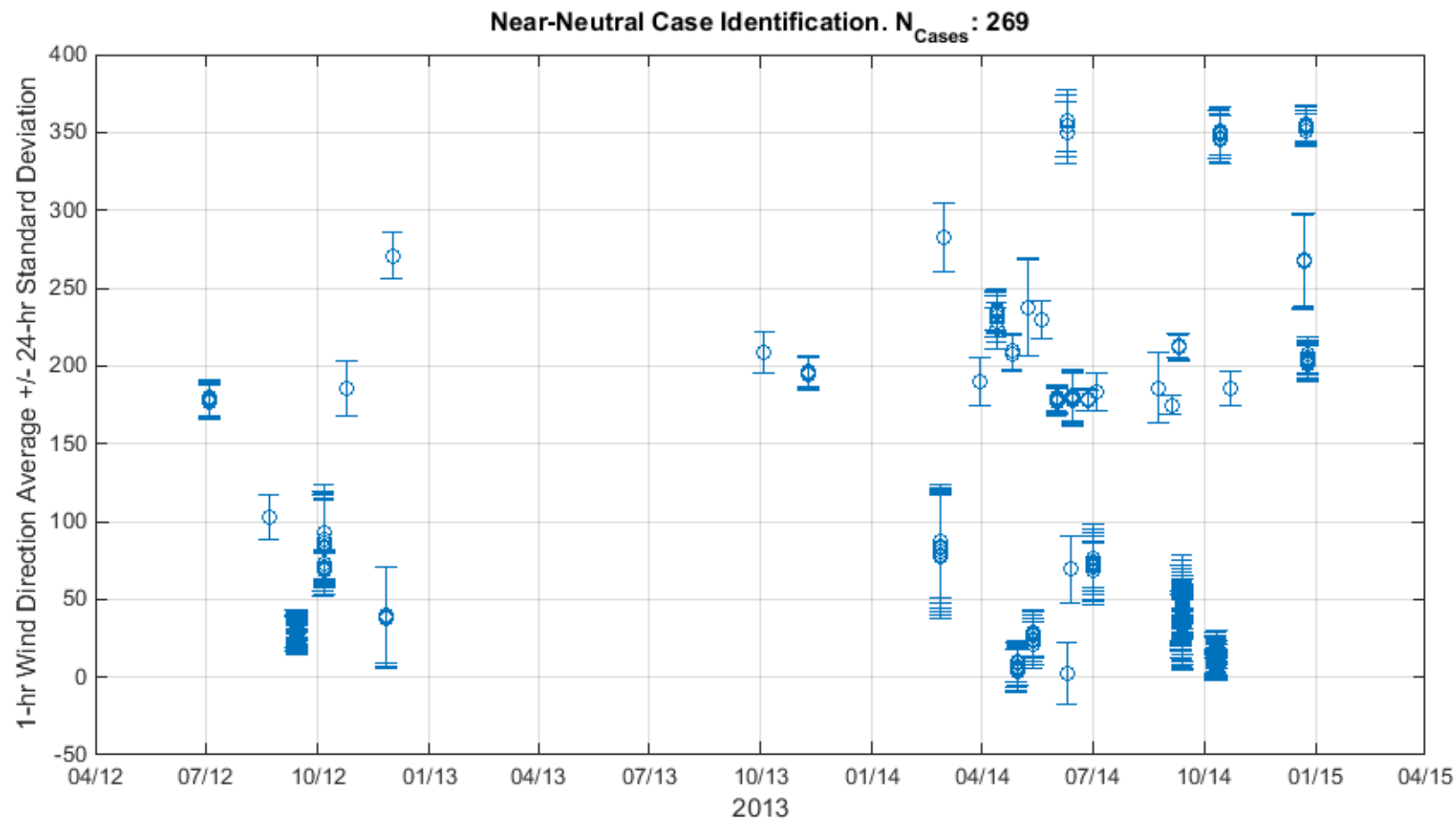
Case Identification – Strict Filter, **Alstom Data****



Case Identification – Strict Filter, NO Alstom Data**

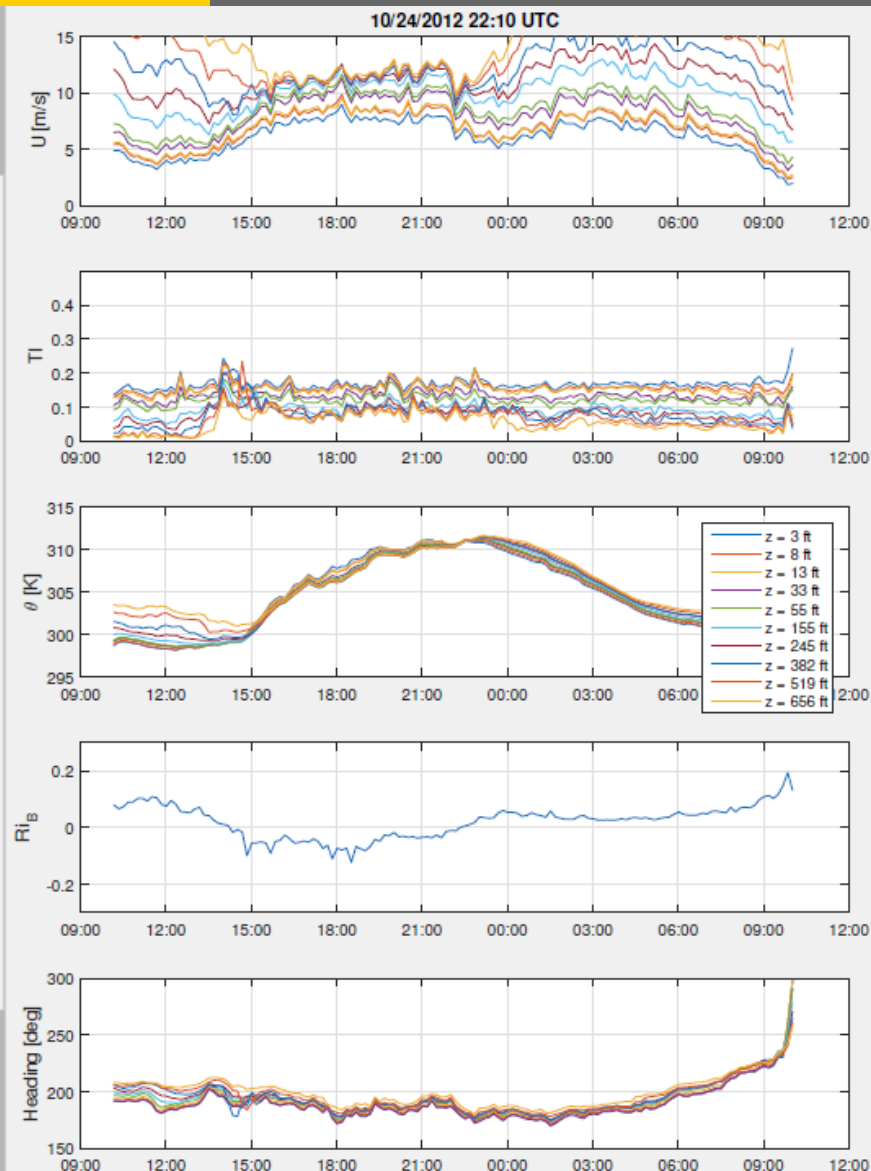
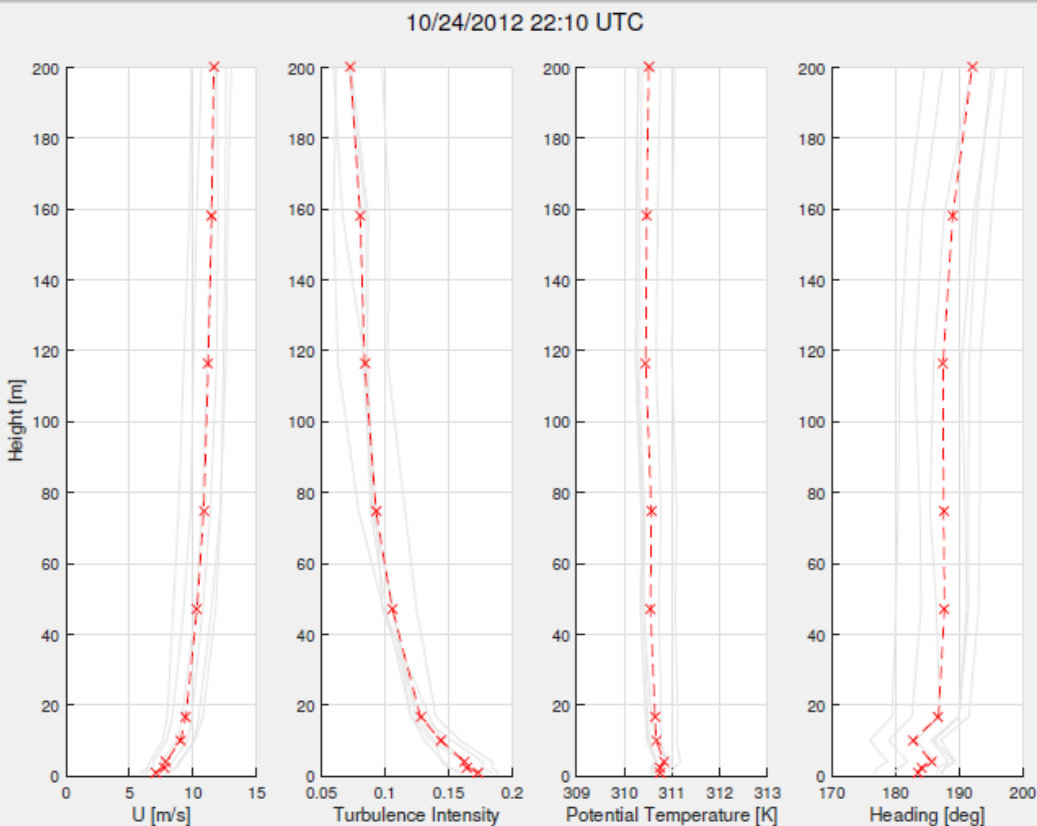


Case Identification – Relaxed Filter

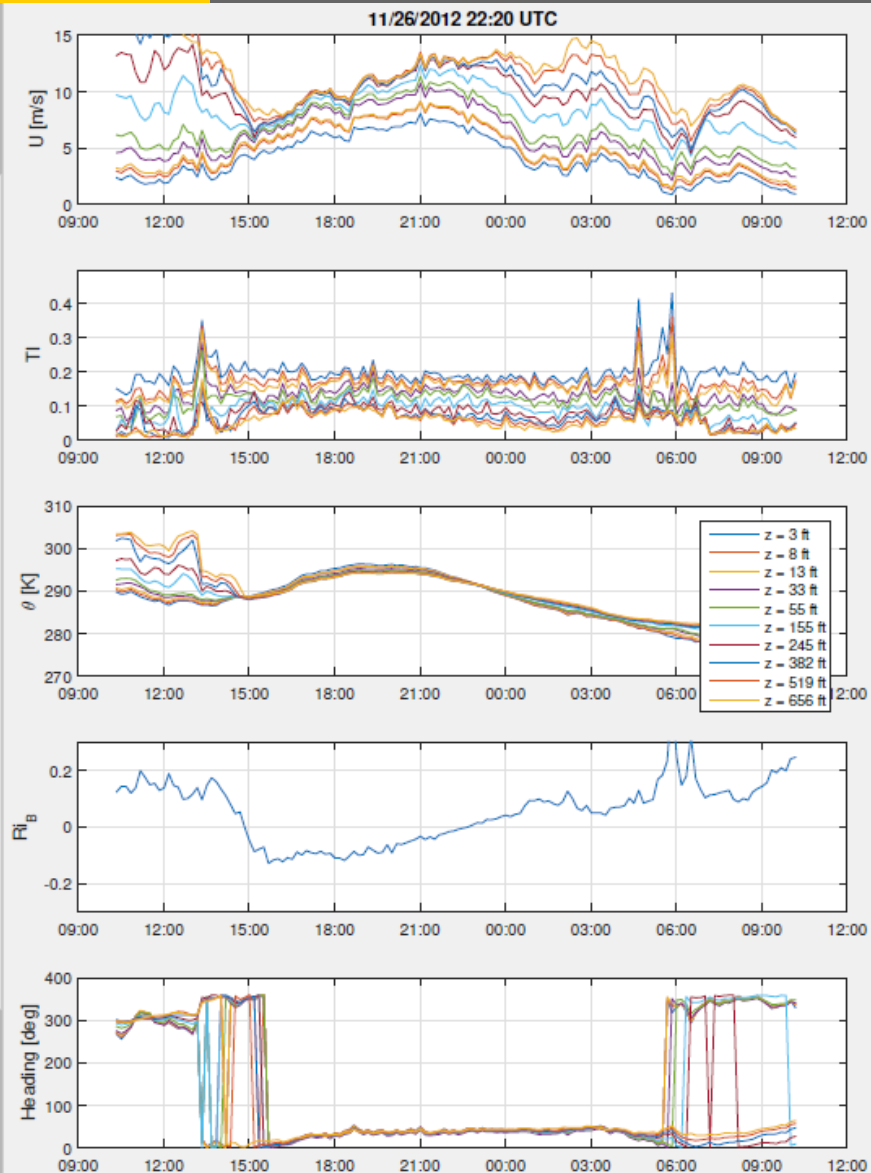
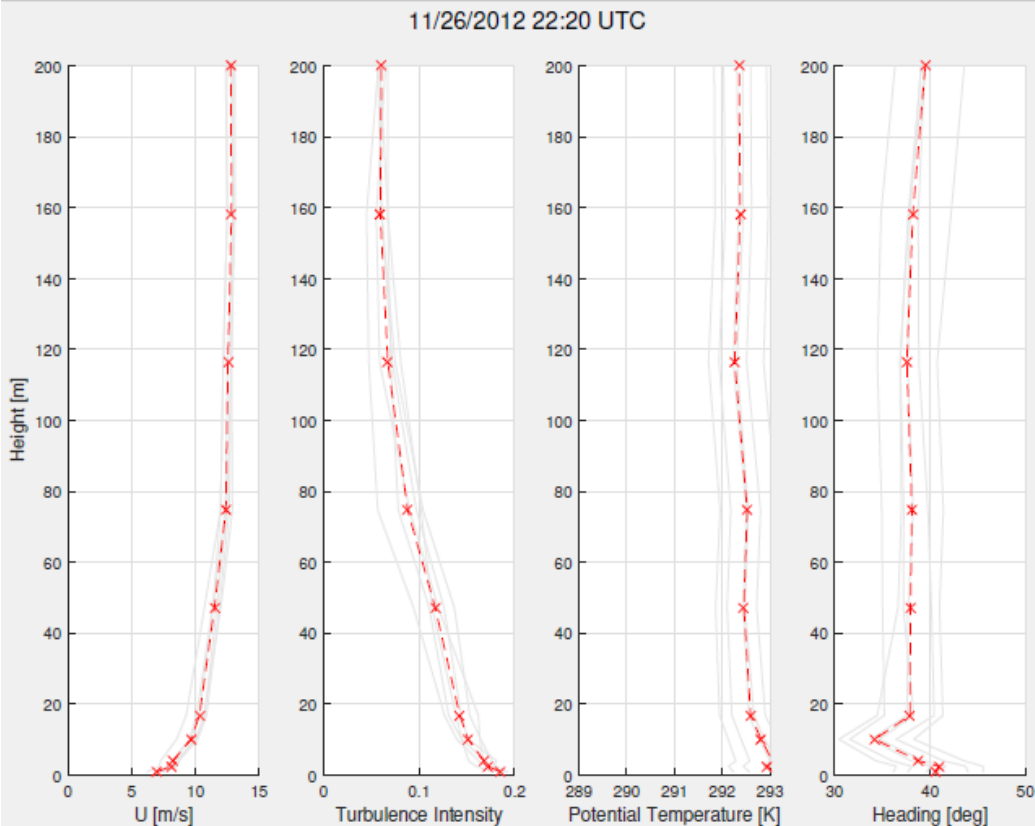


**** NOTE: following cases are likely not centered on the best near-neutral dataset**

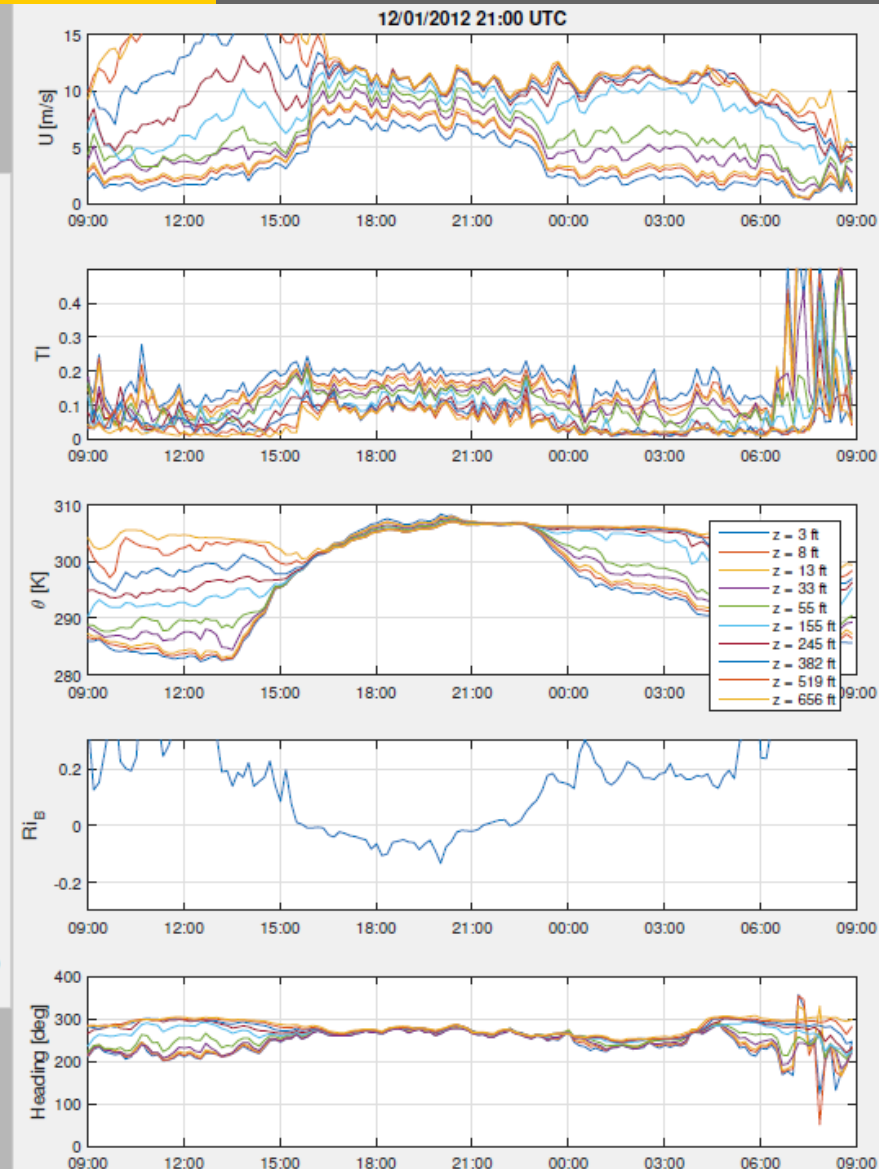
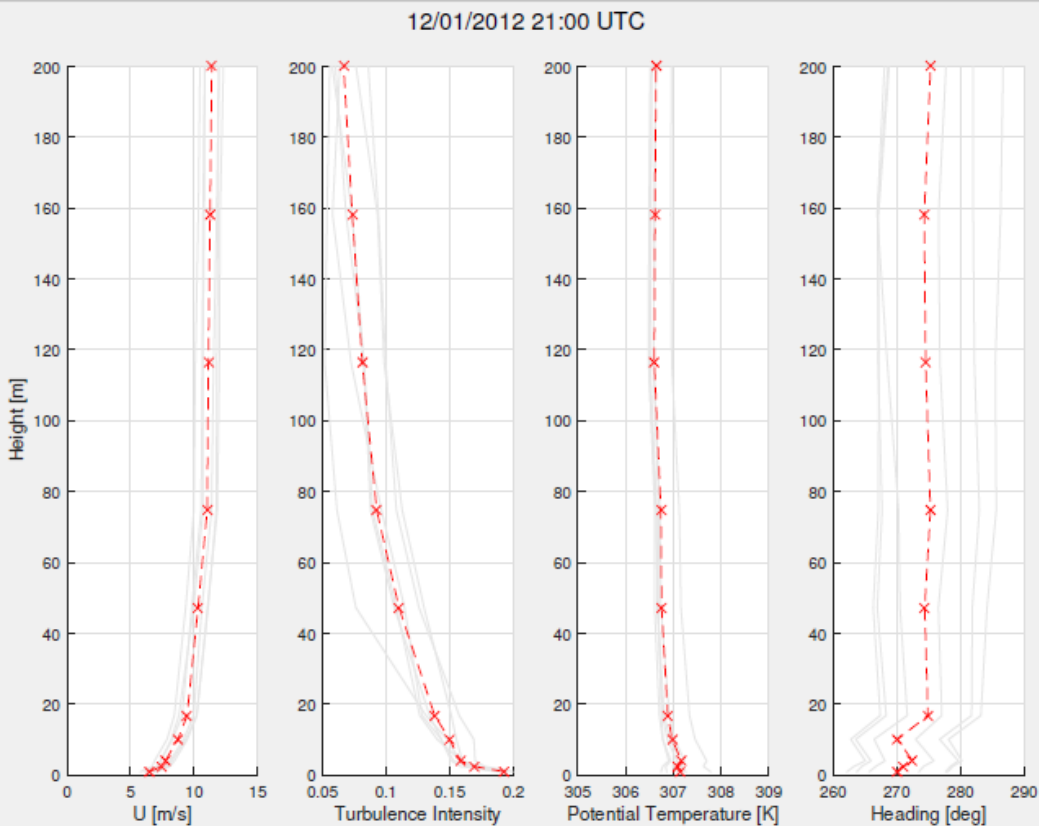
Case Identification – Relaxed Filter, **Alstom Data**



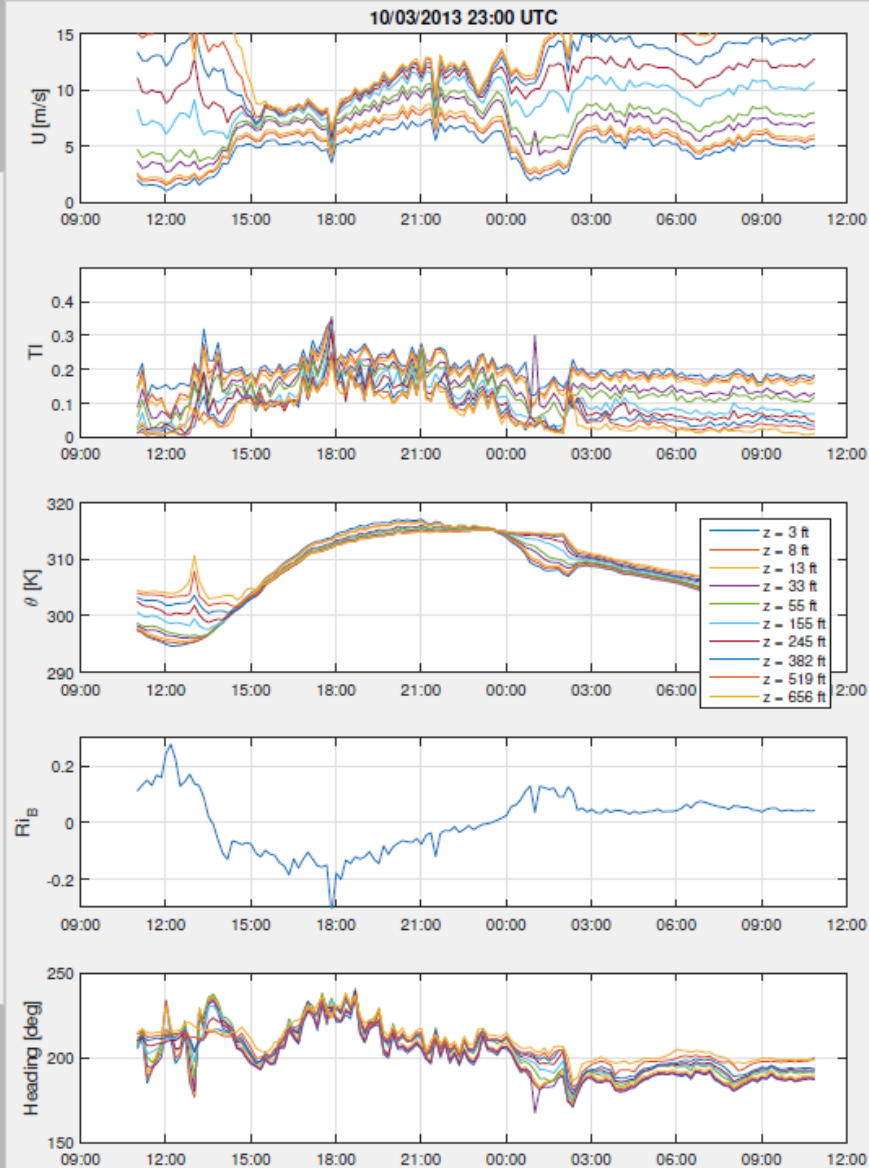
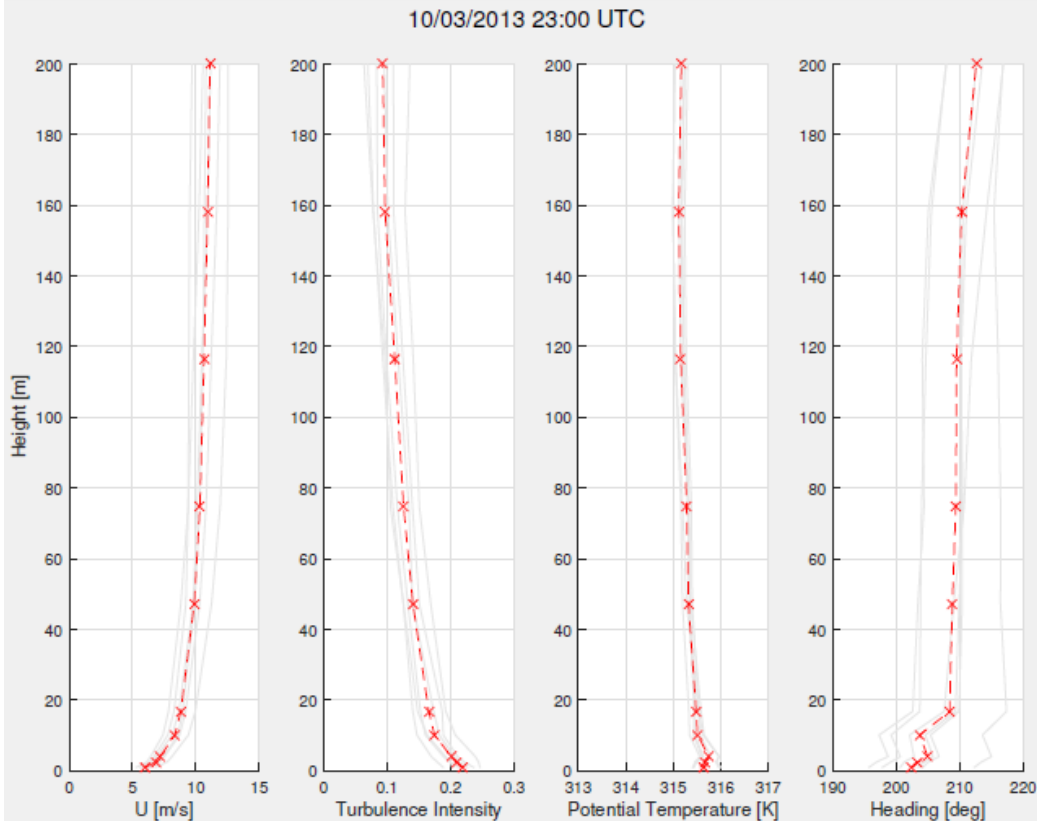
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Case Identification – Relaxed Filter, **Alstom Data**



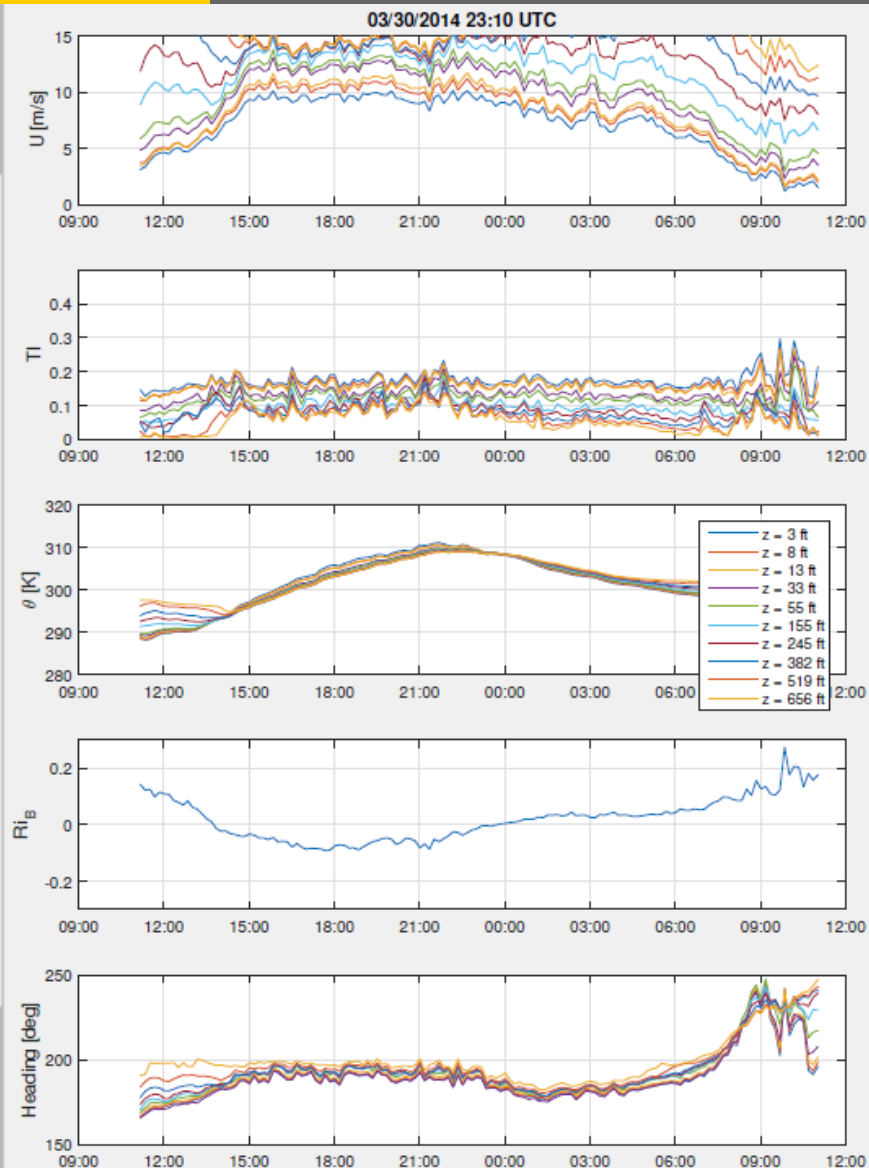
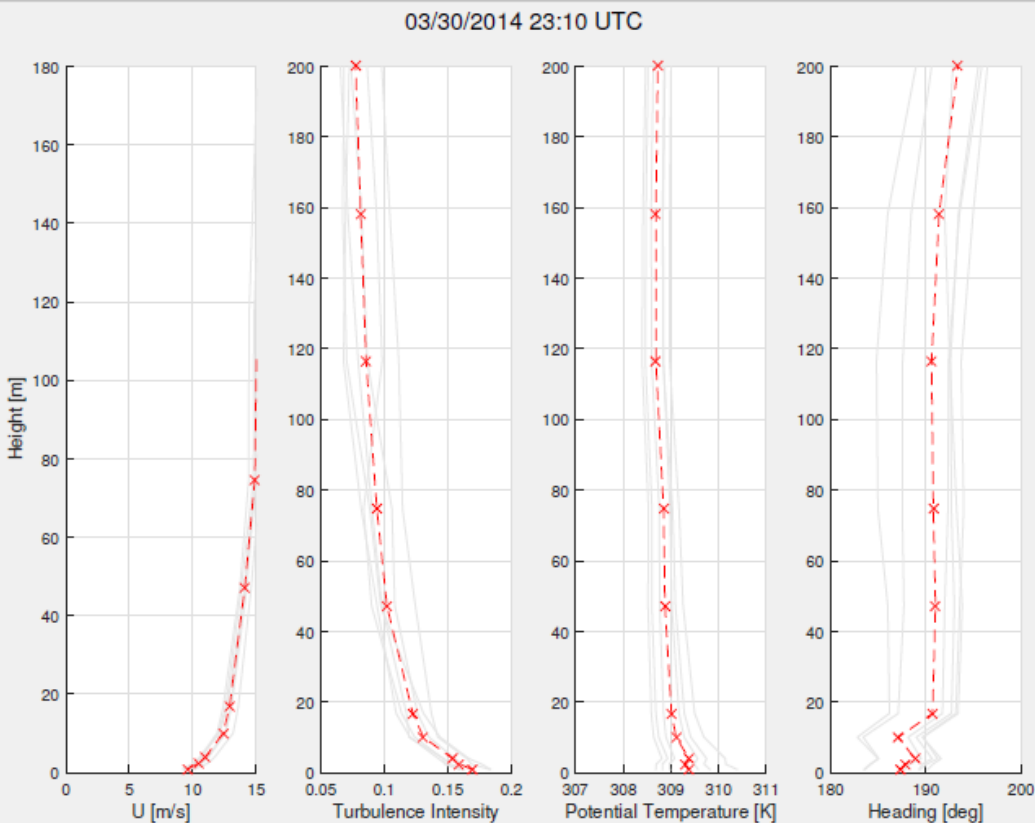
Case Identification – Relaxed Filter, **Alstom Data****



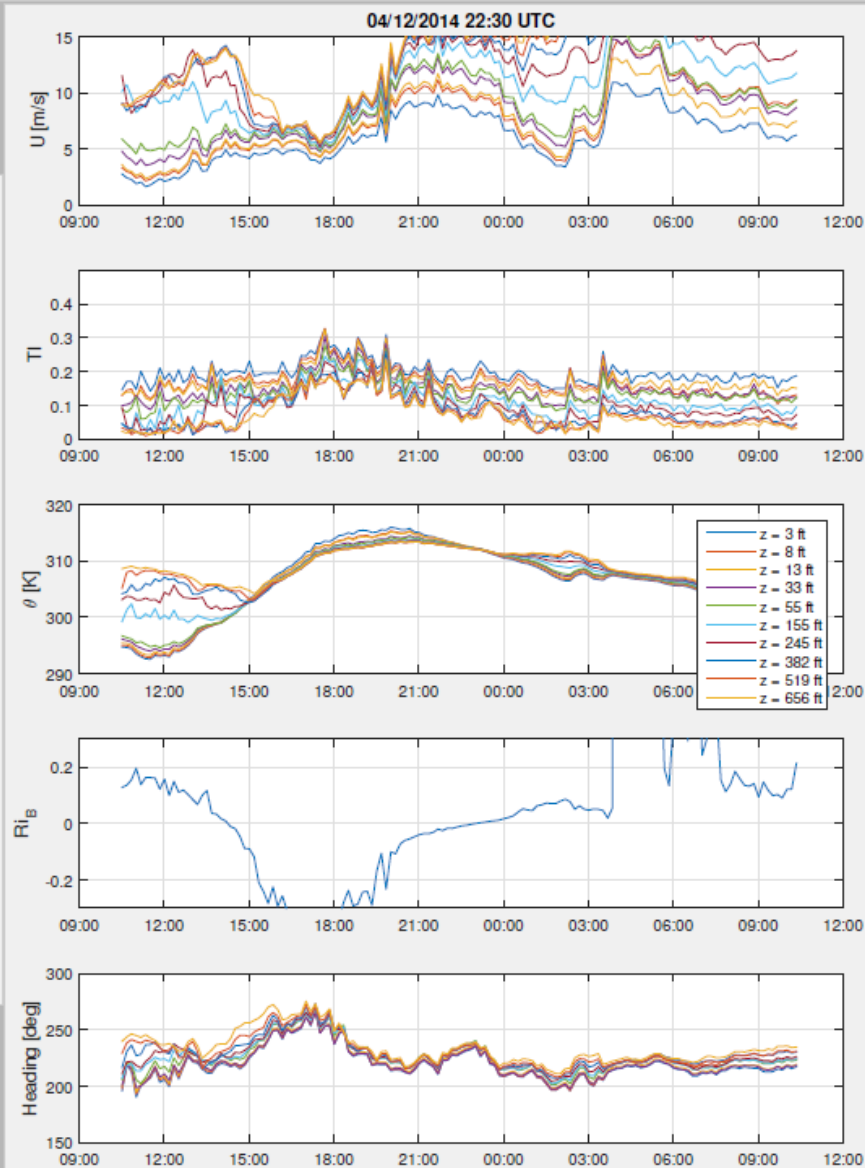
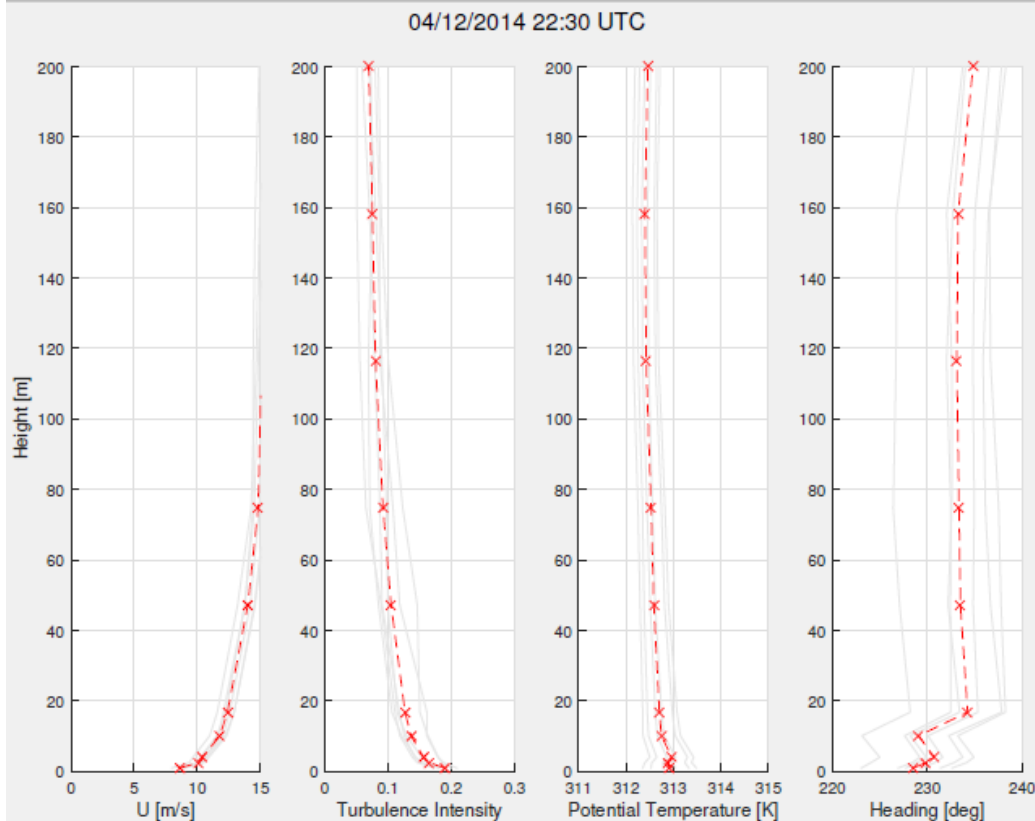
Case Identification – Relaxed Filter, NO Alstom Data

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

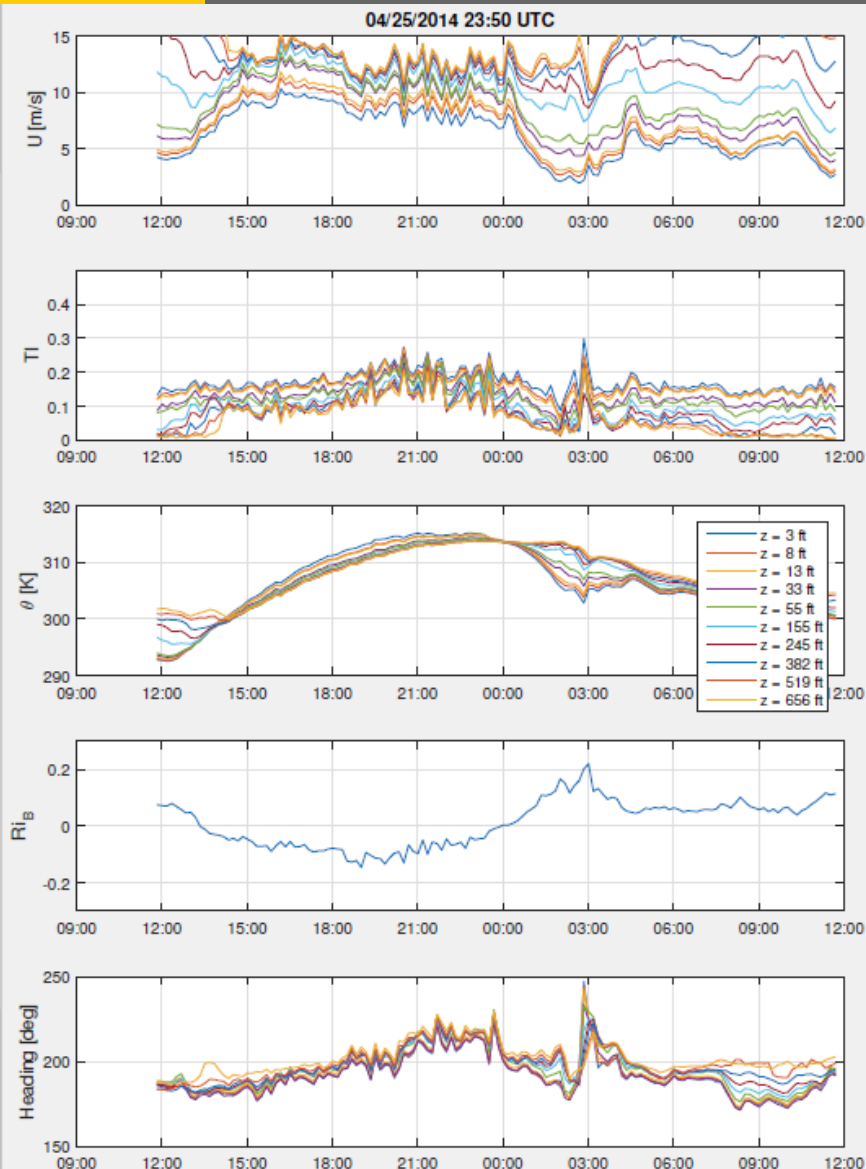
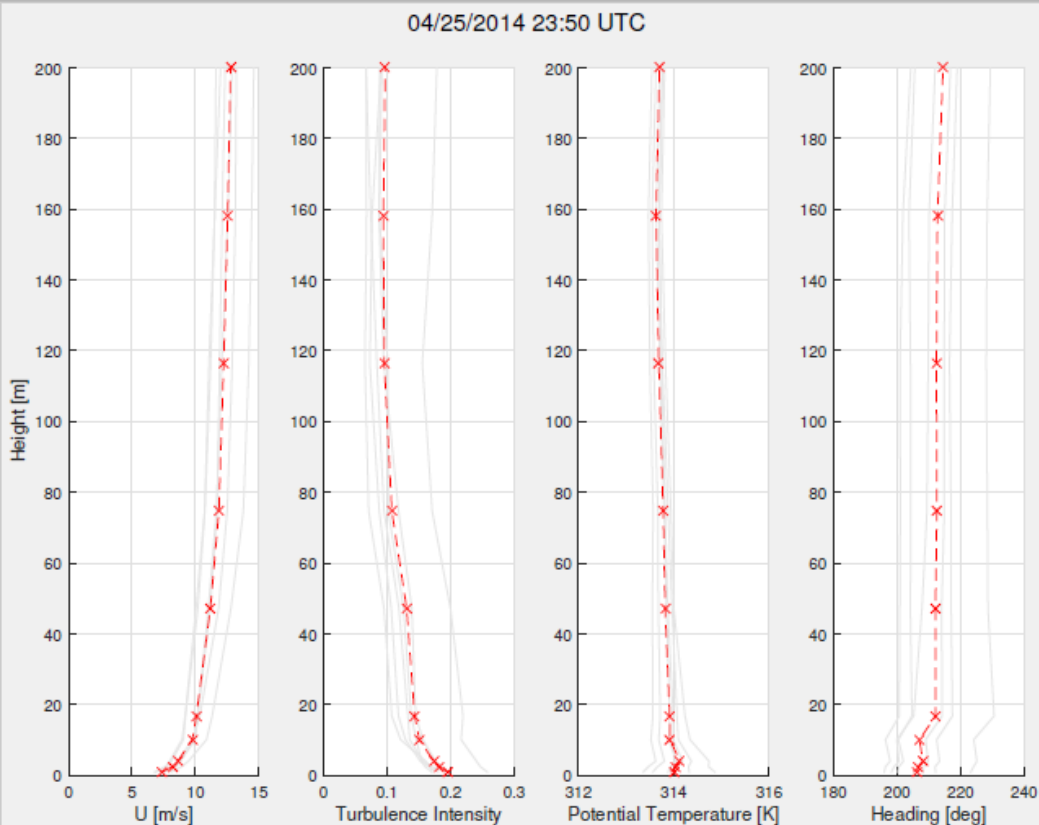
Case Identification – Relaxed Filter, NO Alstom Data



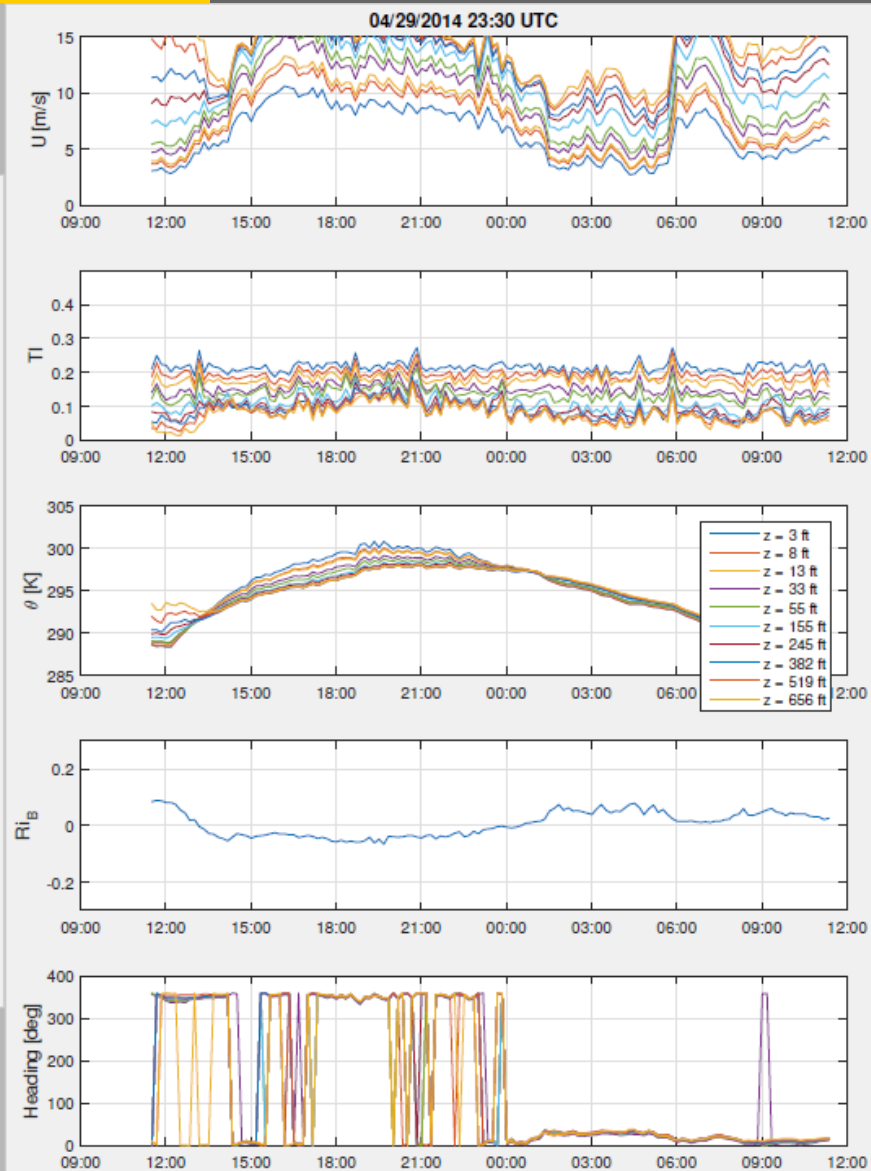
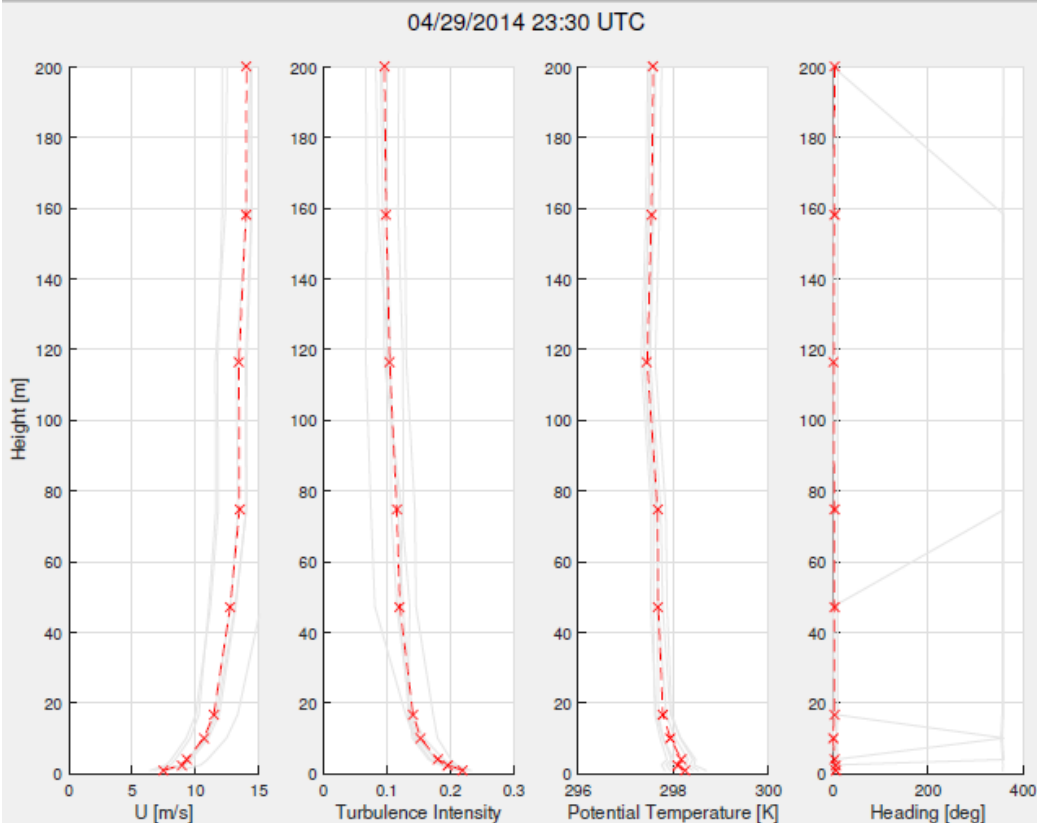
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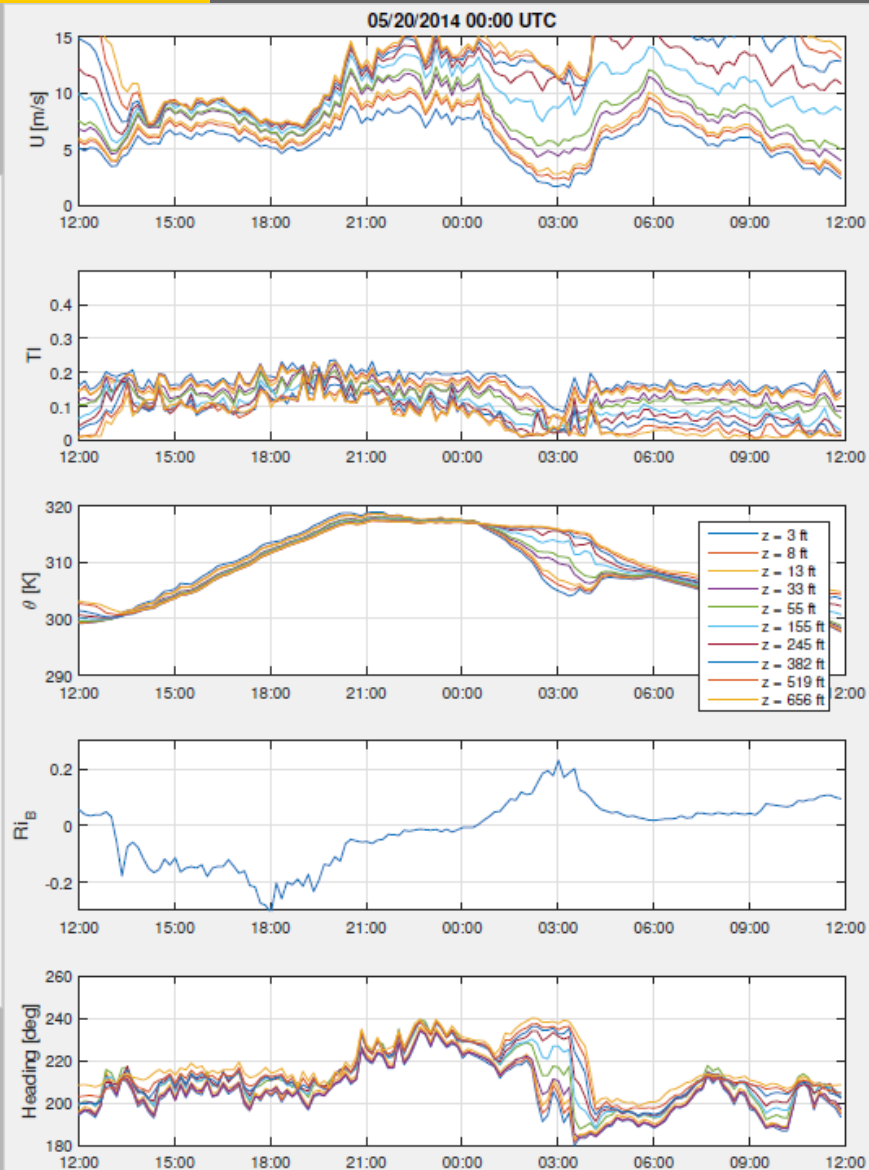
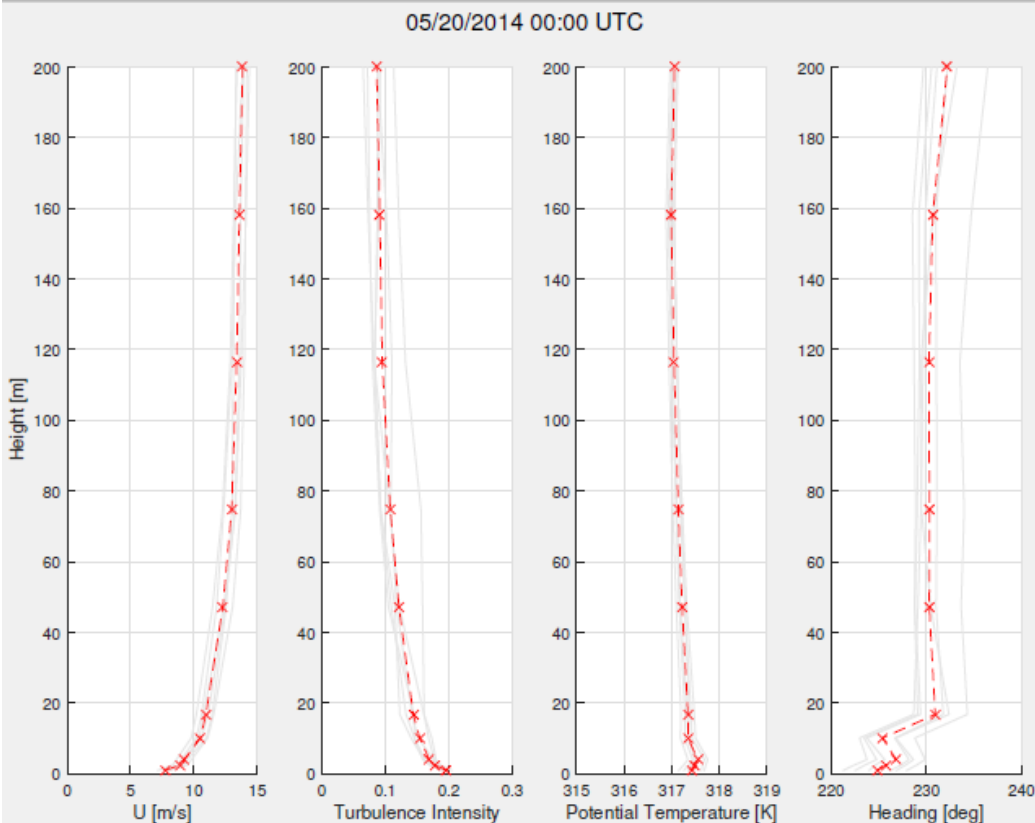
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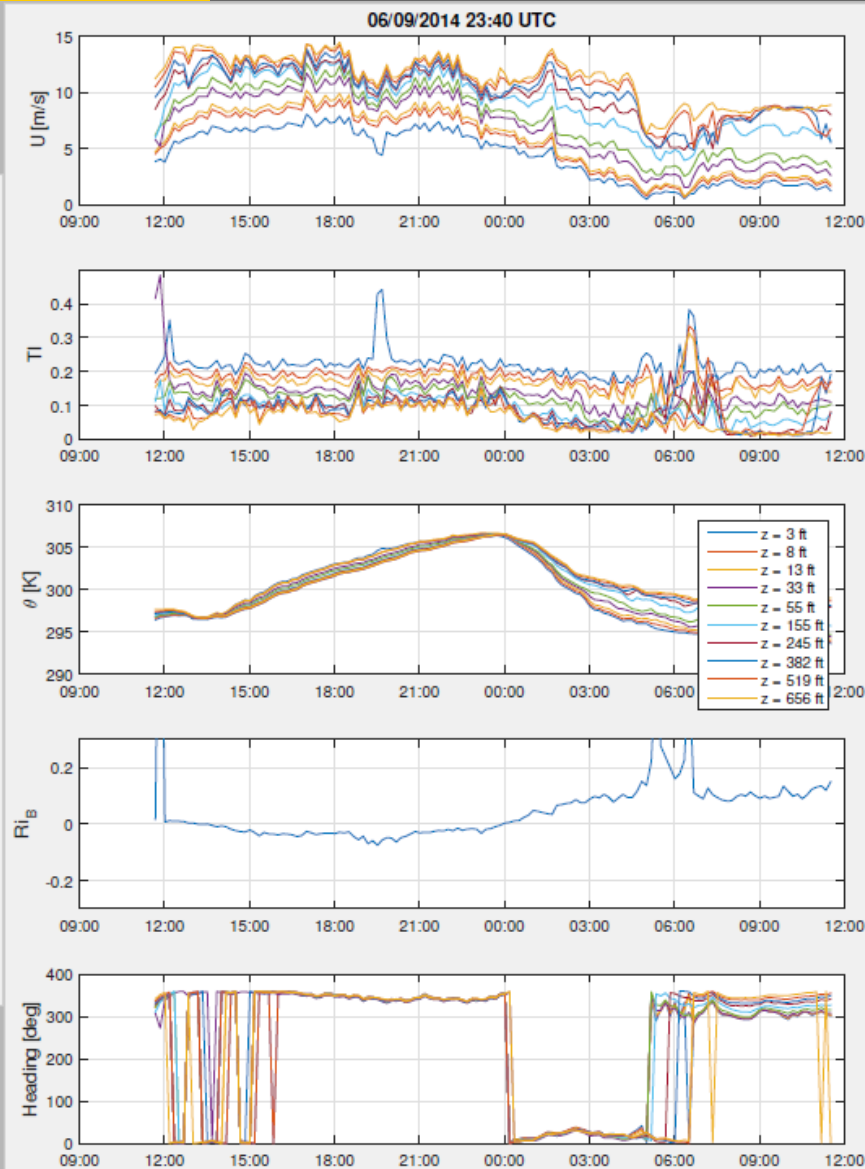
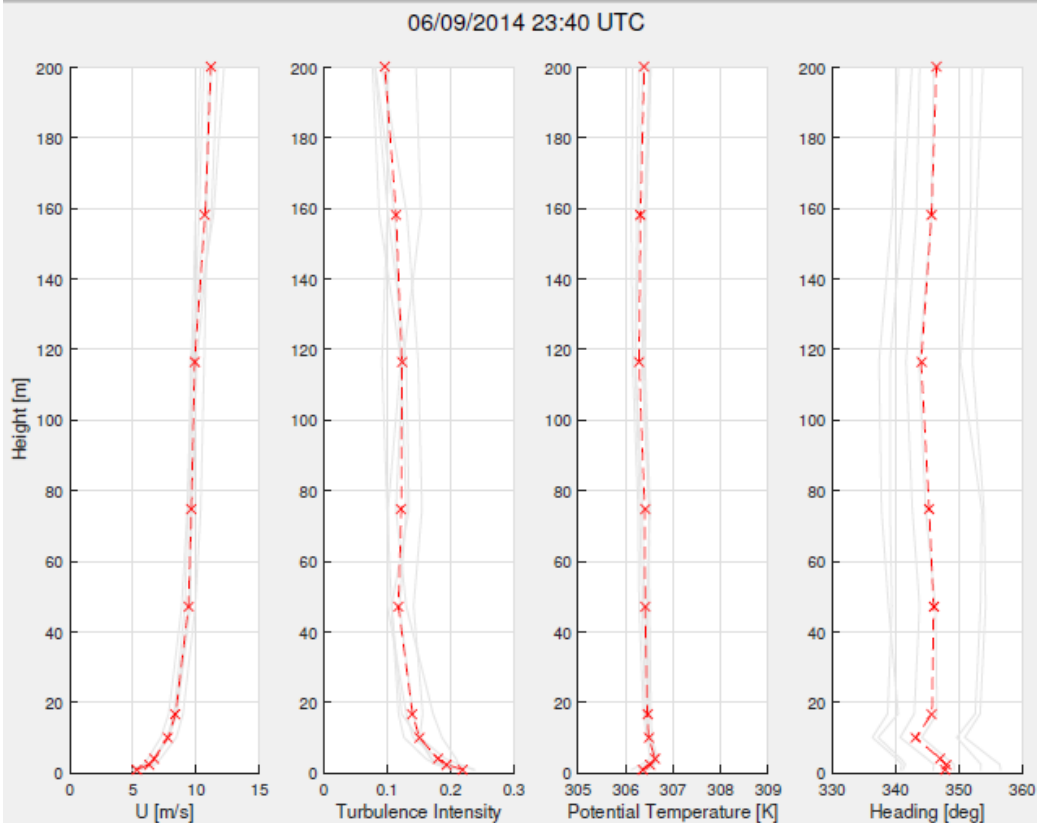
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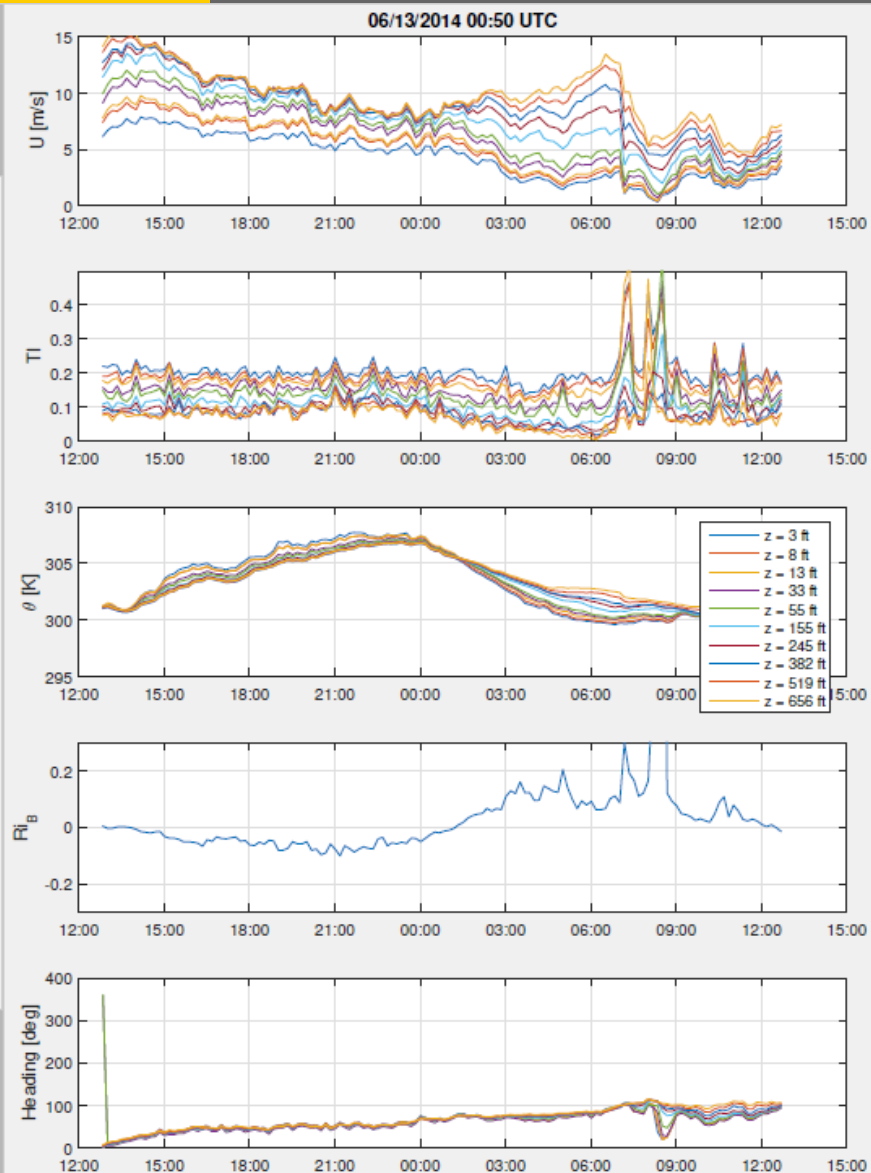
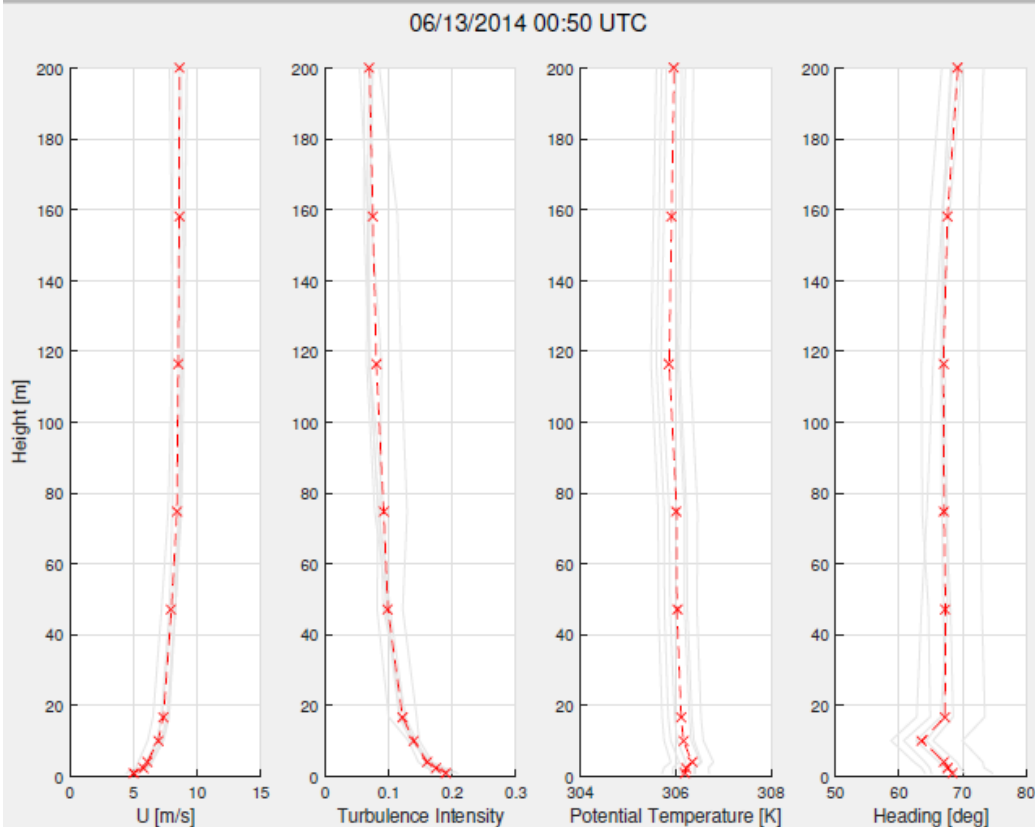
Case Identification – Relaxed Filter, NO Alstom Data



Case Identification – Relaxed Filter, NO Alstom Data**



Case Identification – Relaxed Filter, NO Alstom Data**



Case Identification – Relaxed Filter, NO Alstom Data**

