

Airborne Doppler Wind Lidar data impacts on tropical cyclone track and intensity forecasting: the data processing, interpretation and assimilation

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Outline

- TPARC/TCS08 objectives
- Instrument and data description
 - The Doppler Wind Lidar
 - The data products and comparisons with dropsondes
- Typhoon targets
 - Nuri
 - Hagupit
 - Sinlaku
 - Jangmi
- Early impact study on storm track and intensity forecasts

Acknowledgements

- Funding
 - Ron Ferek(ONR)
- Operators
 - CDR Dan Eleuterio (NAVY)
 - Dan Carre' (Simpson Weather Associates)
 - Michael Riemer (NPS)
 - Brian Tang (MIT)
- Key support (software and hardware)
 - Chris O'Handley (SWA)
 - Kevin Godwin (SWA/UVA)
 - LMCT

Mission Plan

- Study of tropical cyclogenesis, intensification, transition and weakening
- Based out of Guam (P3)
- Other aircraft include USAF C130 and DLR Falcon
 - P3: dropsondes, ELDORA and P3DWL
 - C130: dropsondes
 - Falcon: dropsondes, DWL, DIAL
- Use ferry flights to collect long curtains of wind soundings to test data impact on NWP.
 - Pax River to West Coast
 - West Coast to Hawaii
 - Hawaii to Guam

P3DWL for TPARC/TCS-08



1.6 μm coherent WTX (ARL/LMCT)
10 cm bi-axis scanner (NASA)
P3 and other parts (NRL)
Analyses software (SWA/CIRPAS)



Activity Summary

- P3DWL in the field from August 4 to October 8, 2008
- Total data (ground and airborne) = 171 hours
- Flew 18 missions with Tropical Cyclones as target
 - 118 hours of data
- Additional flights:
 - Calibration of other instruments
 - Ferry flights between bases
 - Ferry flights USA – Guam – USA (> 20000 km)

Basic LOS Signal

- 50 meter range resolution (Gaussian pulse ~ 70 meters FWHM)
- 10 cm beam diameter
- Spectral domain (Heterodyne detection)
 - Frequency (LOS speed)
 - Spectral feature width (turbulence within the illuminated volume)
 - Frequency discrimination of multiple LOS motions (ground, air, precipitation signals all in same spectrum)

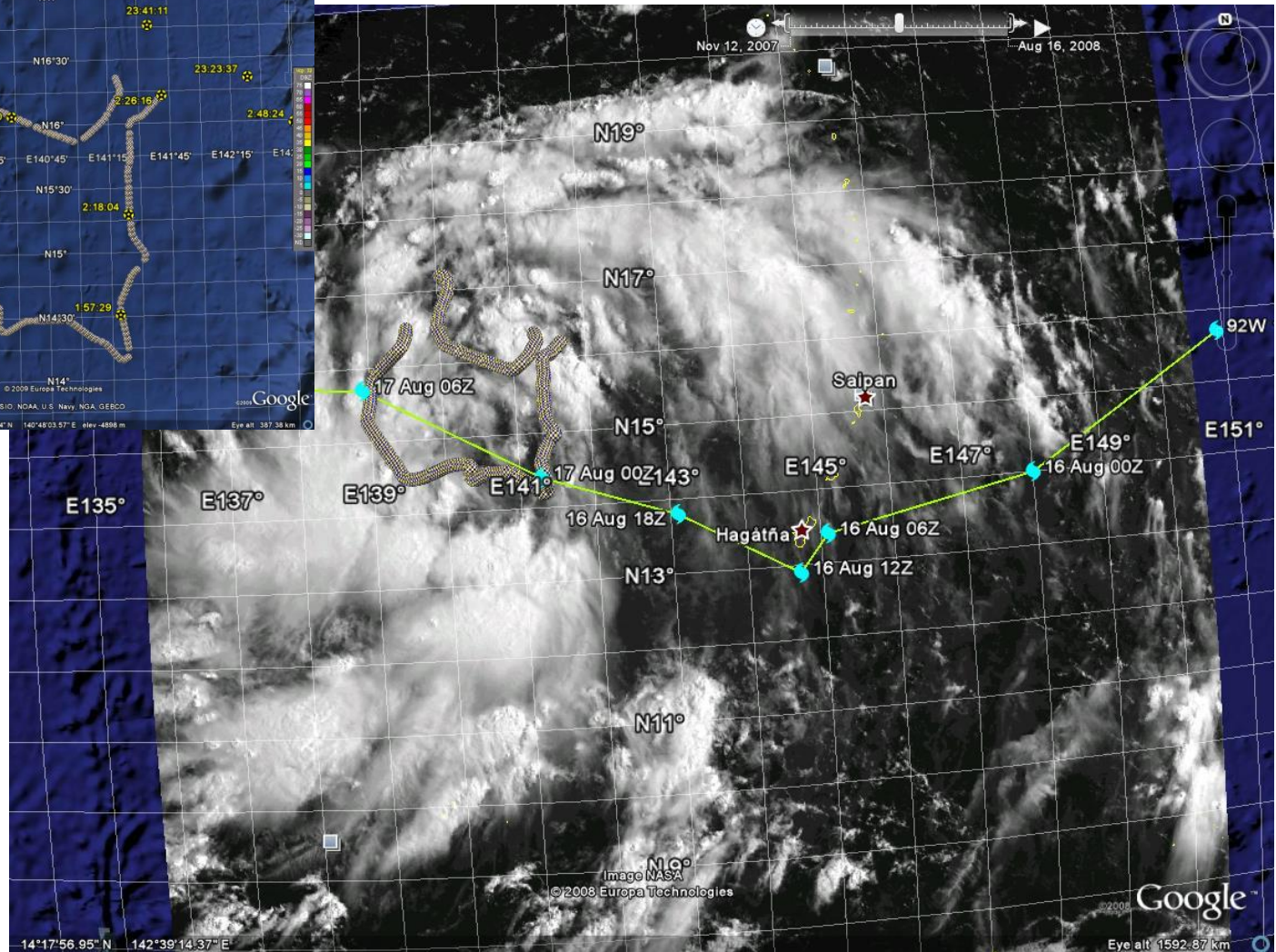
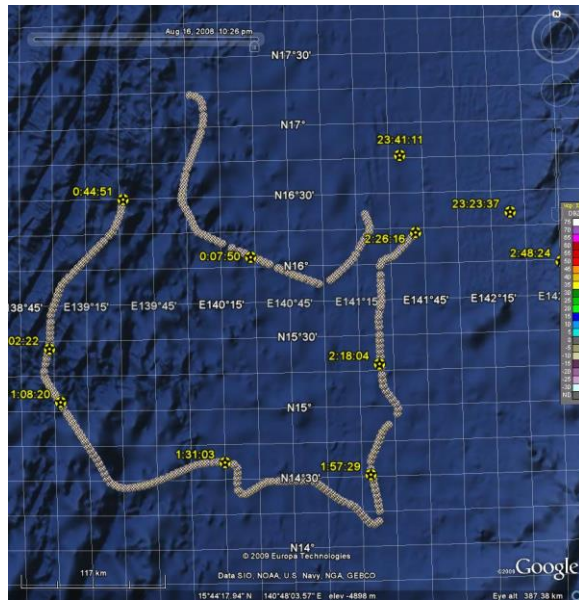
The Data

- Profiles of u, v , and w above and below flight level following $\sim 3\text{km}$ of scanning.
- Information on aerosol structures, precipitation, and sea state
- Challenges to signal processing and interpretation
 - Aircraft extreme motions (mainly rolling)
 - Chaotic marine boundary layer
 - Sprays, waves and foam
 - Clouds (partial obscuration)
 - Precipitation
- Comparisons with dropsondes provides basis for developing “smarter” algorithms

Data Impact Studies

- Initial impact study on typhoon Nuri conducted at University of Utah and published
Zhaoxia Pu, Lei Zhang, and G. David Emmitt
“Impact of airborne Doppler wind lidar profiles on numerical simulations of a tropical cyclone”, GRL, VOL. 37, 2010
- Working on additional impact evaluation for other typhoons in various segments of their life cycles.

Typhoon Nuri



Courtesy G. D. Emmitt



N17°30'

Nov 12, 2007

Aug 16, 2008

N16°30'

N15°30'

E138°30'

E139°30'

E140°30'

E141°30'

E142°30'

E143°30'

E144°30'

17 Aug 06Z

N14°30'

17 Aug 00Z

16 Aug 18Z

N13°30'

Image NASA
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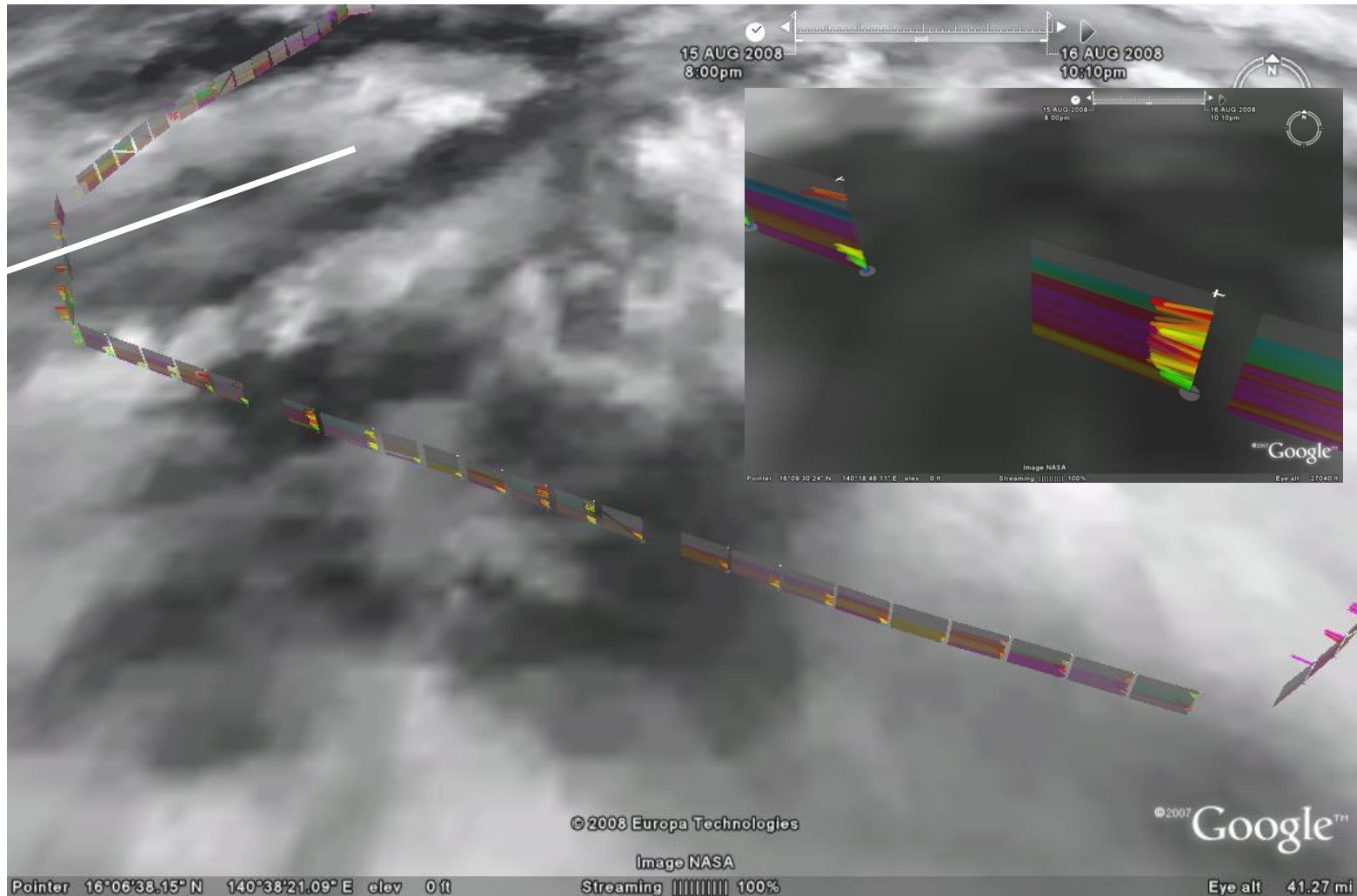
Google

15°11'31.88" N 141°22'18.56" E

elev 0m

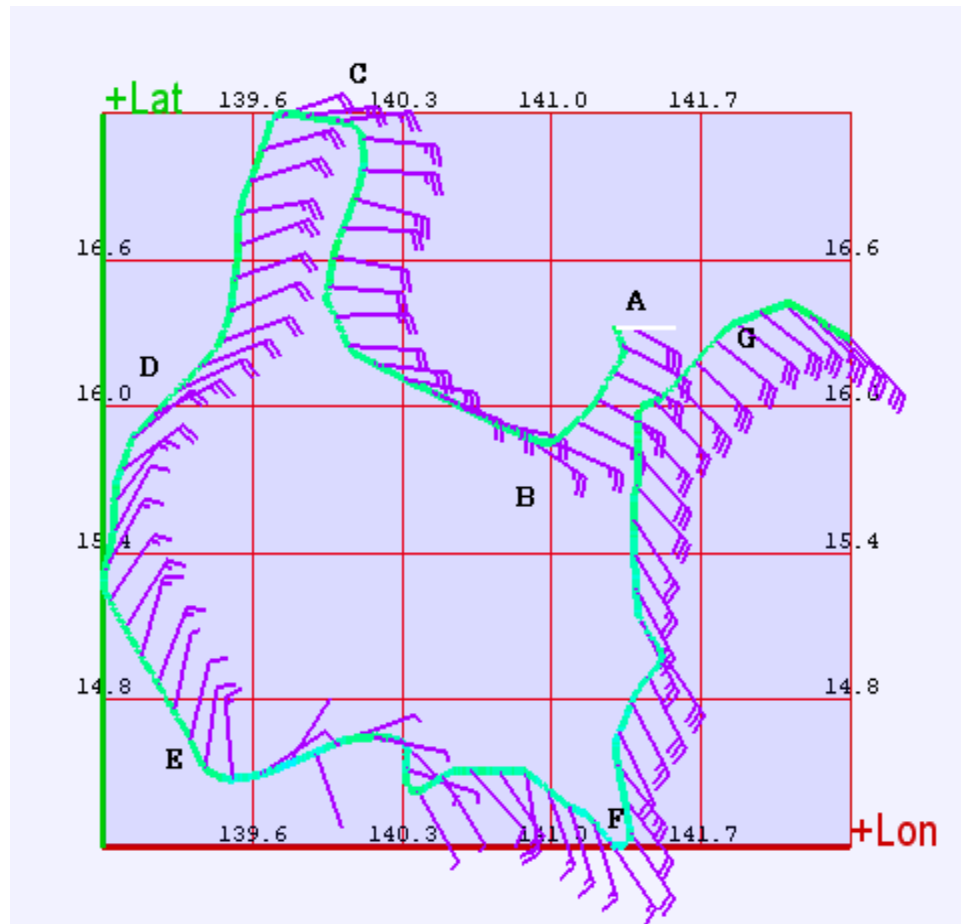
Eye alt 612.94 km

Example of P3DWL data display in Google Earth



Winds are displayed in 50 meter vertical resolution wind flags;
Panel between wind profiles contains aerosol loading as function of height

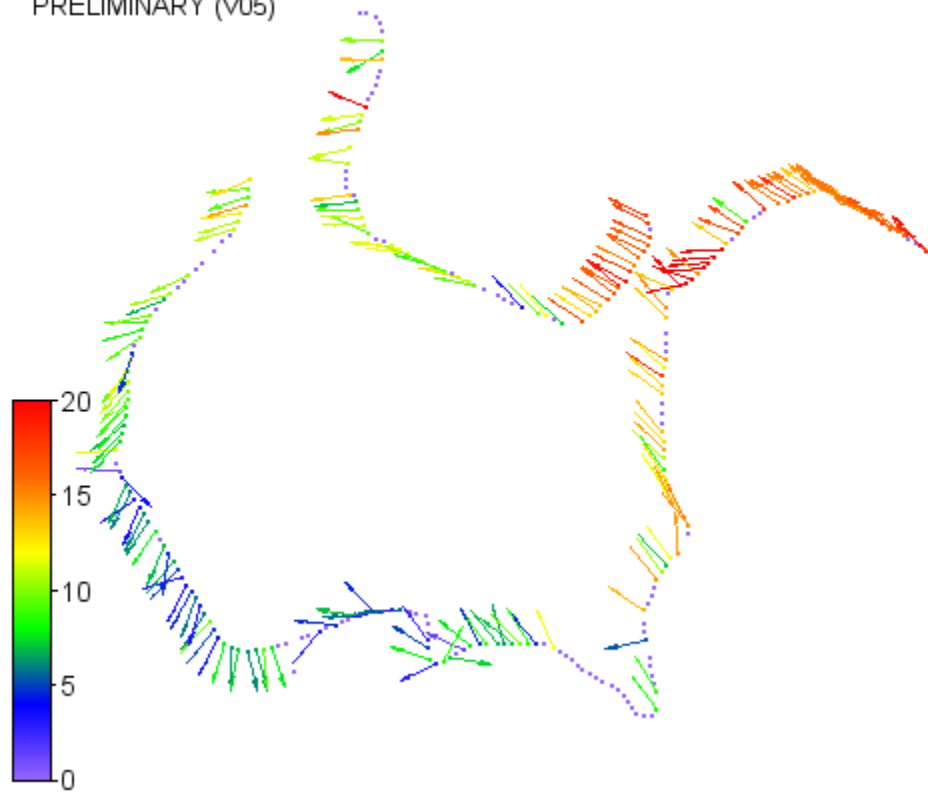
Flight level winds from P3



A –G denote location of dropsondes

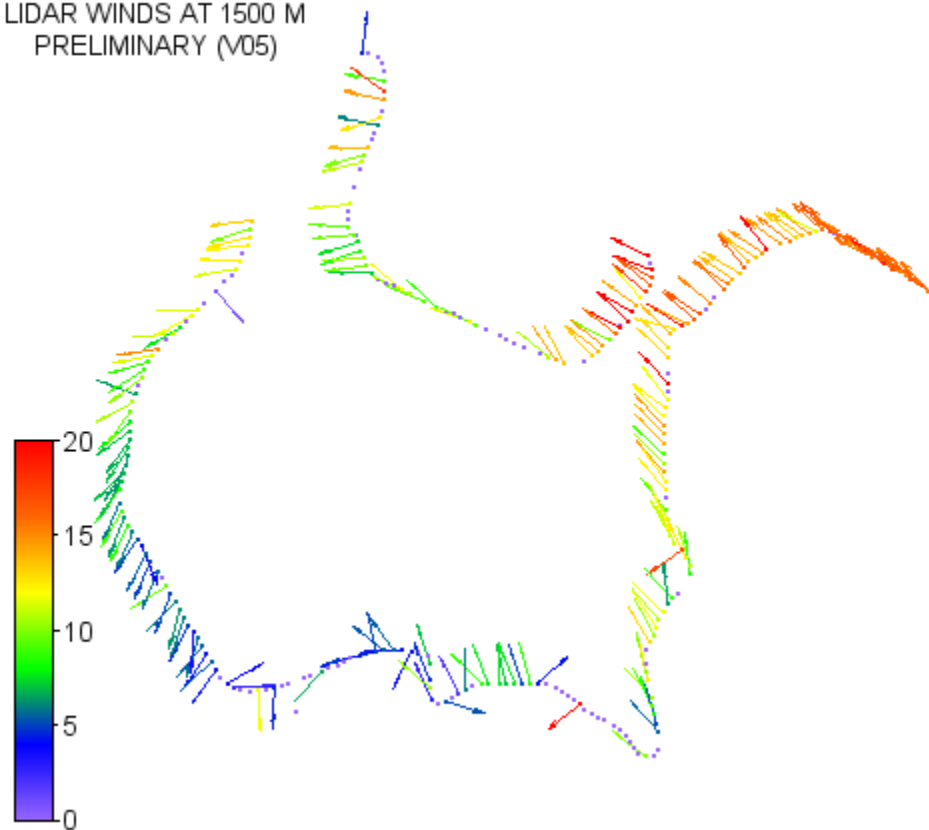
P3DWL winds at 2100 M

AUG 16 - 17 2008
LIDAR WINDS AT 2100 M
PRELIMINARY (V05)



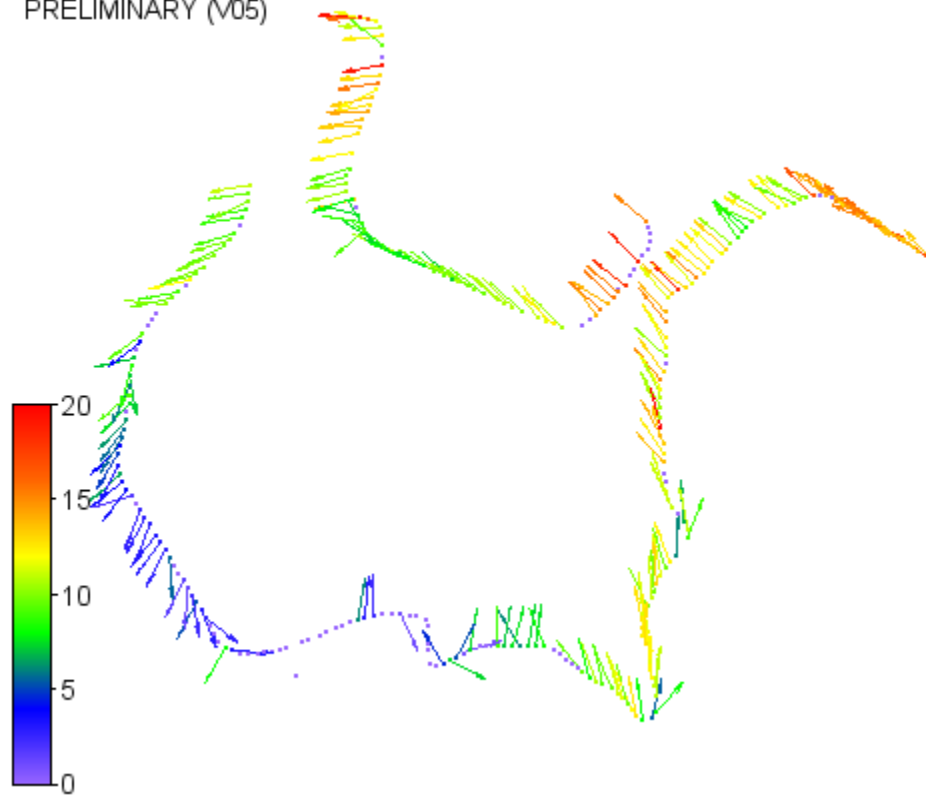
P3DWL winds at 1500 M

AUG 16 - 17 2008
LIDAR WINDS AT 1500 M
PRELIMINARY (V05)



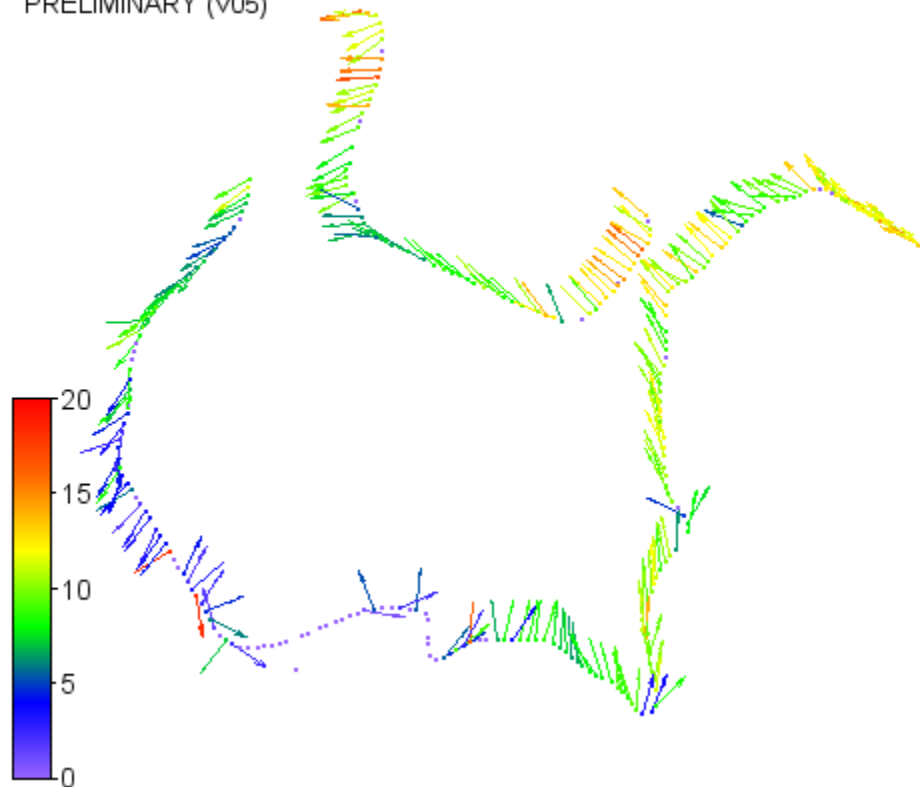
P3DWL winds at 500 M

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LIDAR WINDS AT 500 M
PRELIMINARY (V05)



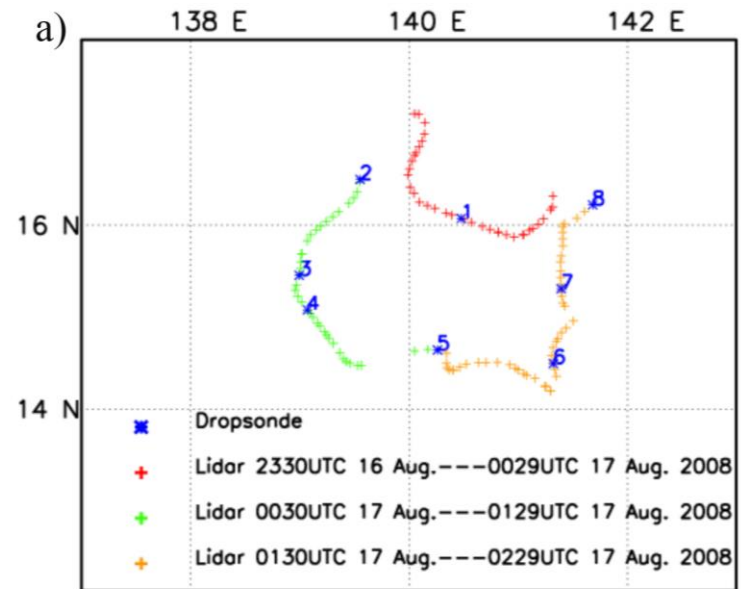
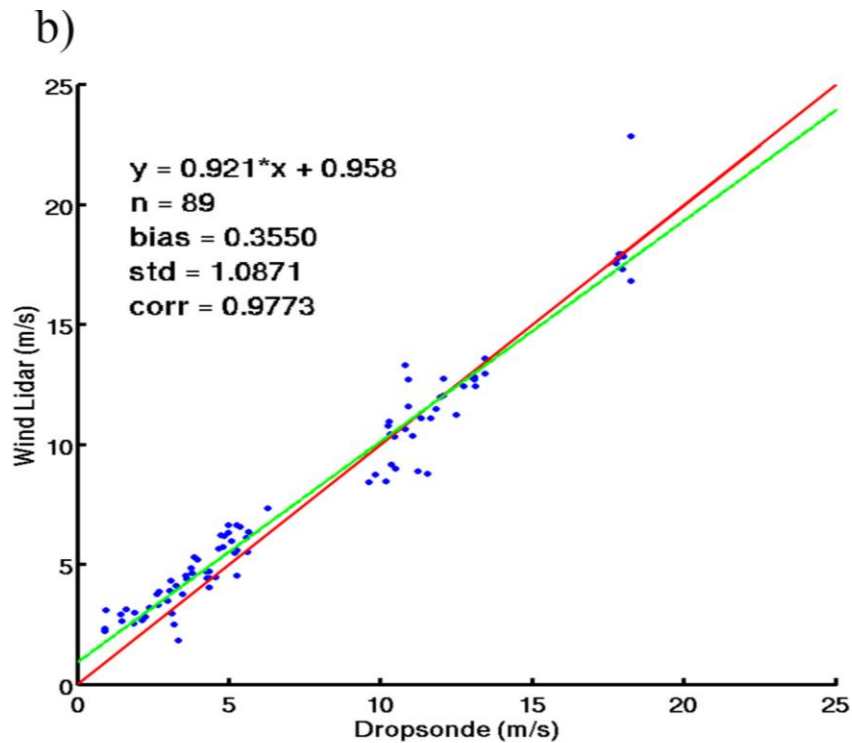
P3DWL winds at 200 M

AUG 16 - 17 2008
LIDAR WINDS AT 200 M
PRELIMINARY (V05)



DWL vs. Dropsonde

Quality of the data



**Correlation of wind speed
is nearly 98%**

Impact of Airborne Doppler Wind Lidar obtained near Typhoon Nuri (2008)

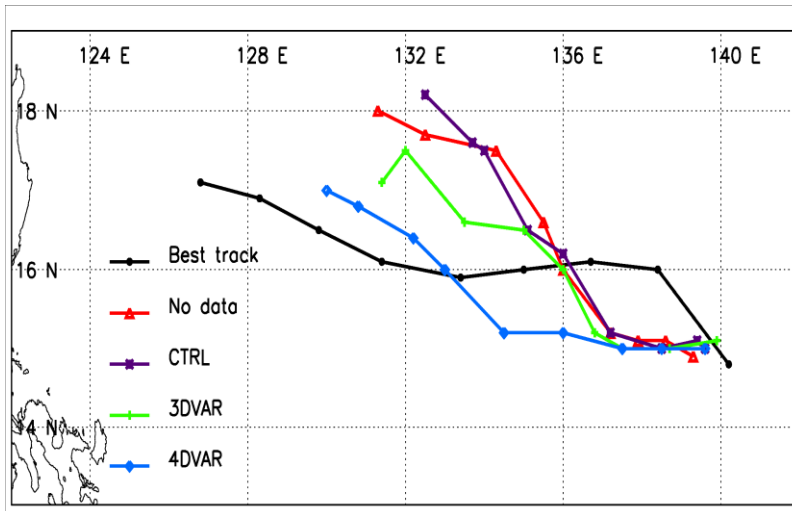
Model: Mesoscale community Weather Research and Forecasting (WRF) model

Data: Doppler wind Lidar (DWL) profiles during T-PARC for the period of 0000UTC –0200 UTC 17 August 2008

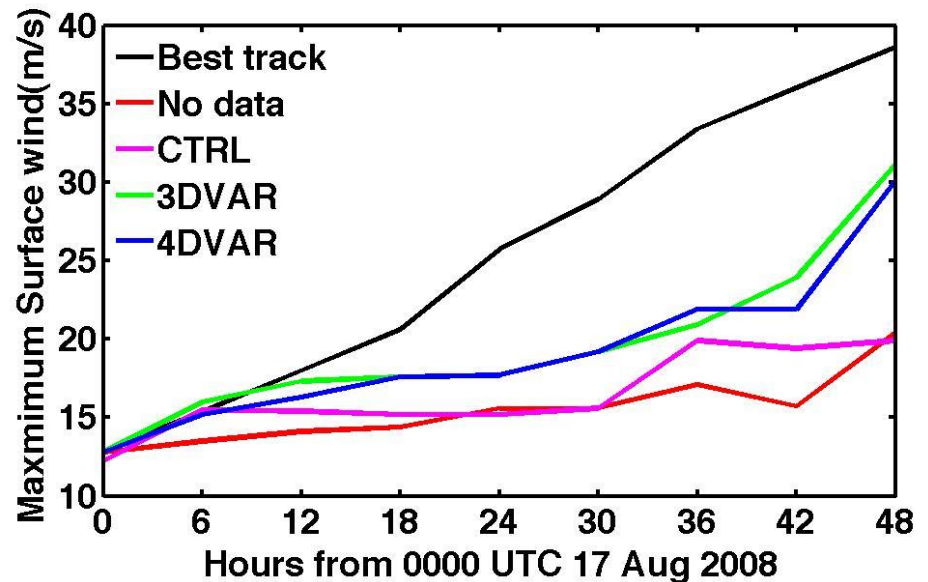
Forecast Period: 48-h forecast from 0000UTC 17 August 2008 to 0000UTC 19 August 2008

Control: without DWL data assimilated into the WRF model.

Data Assimilation: With DWL data assimilated into the WRF model

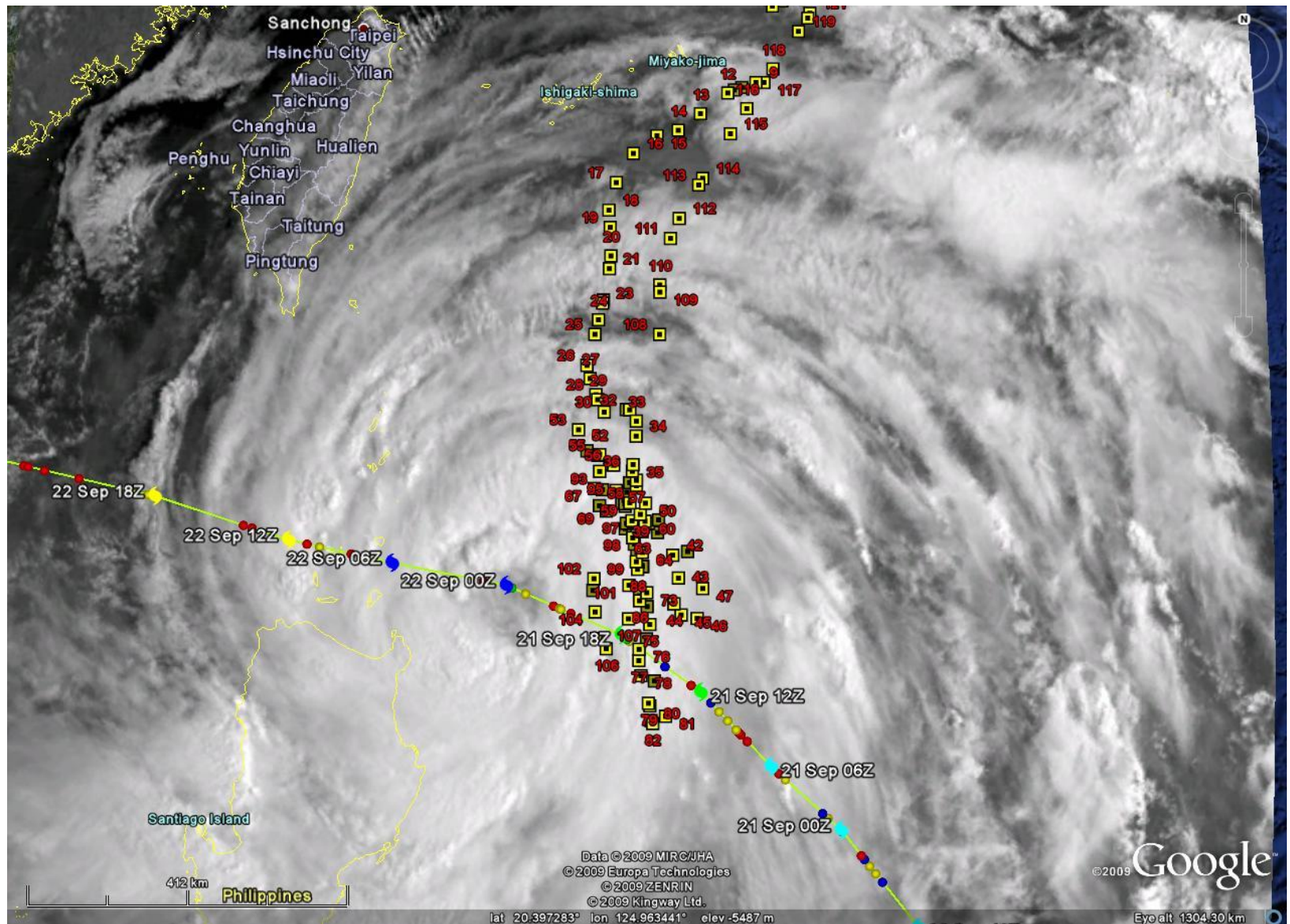


- Assimilation of DWL profiles eliminated the northern bias of the simulated storm track .



- Assimilation of DWL profiles resulted in a stronger storm that is more close to the observed intensity of the storm.

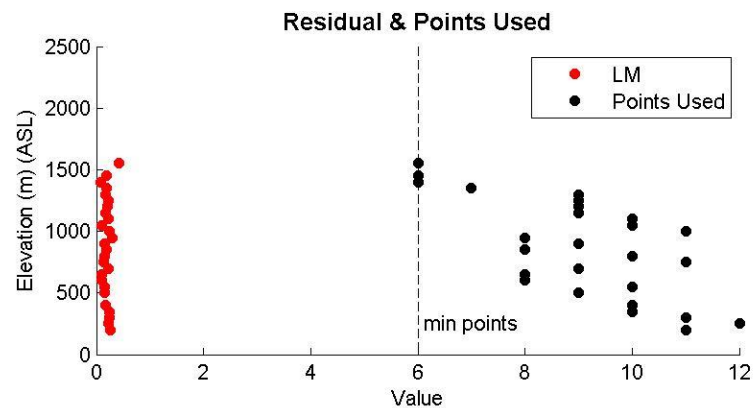
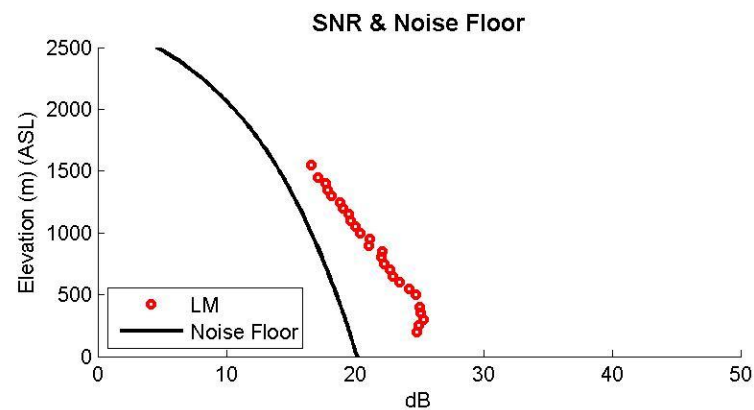
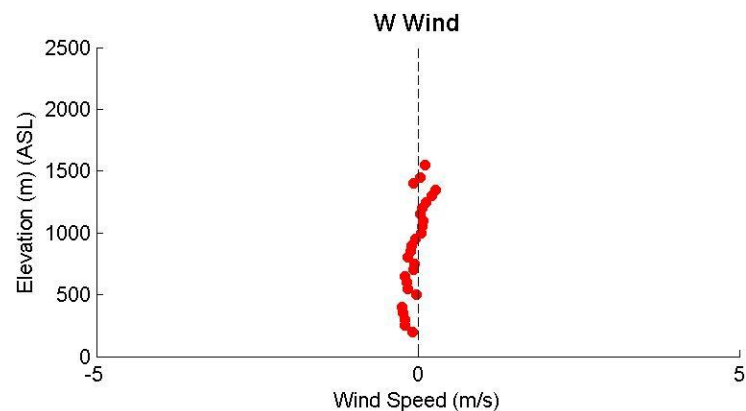
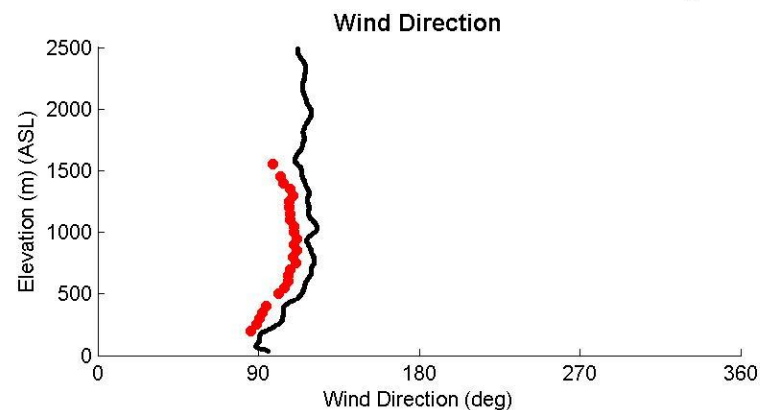
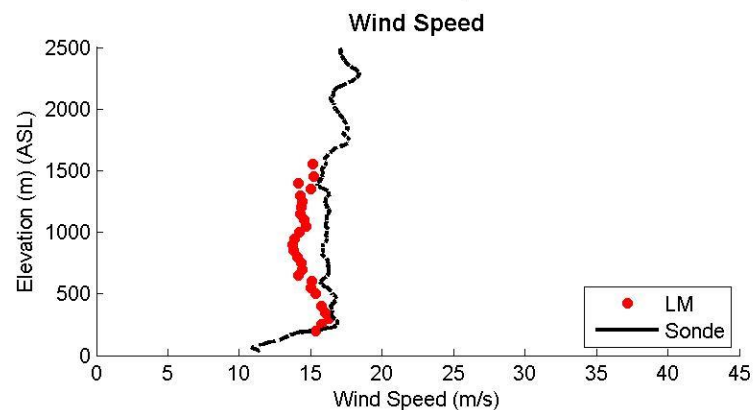
P3DWL flight near Typhoon Hagupit (September 21, 2008)

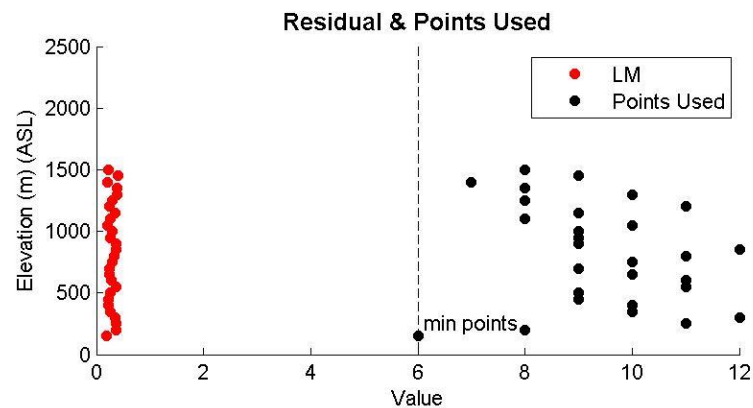
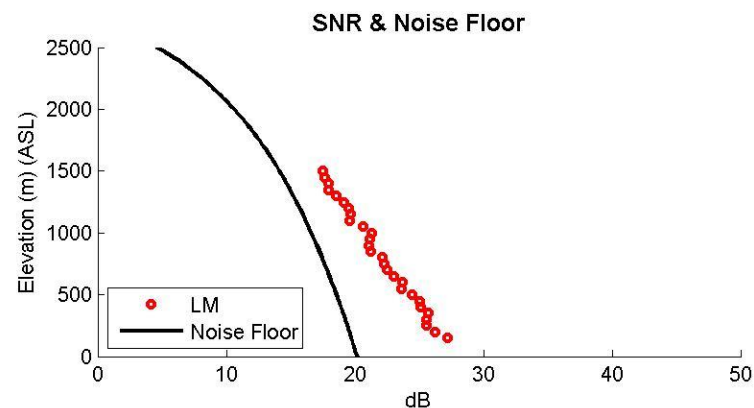
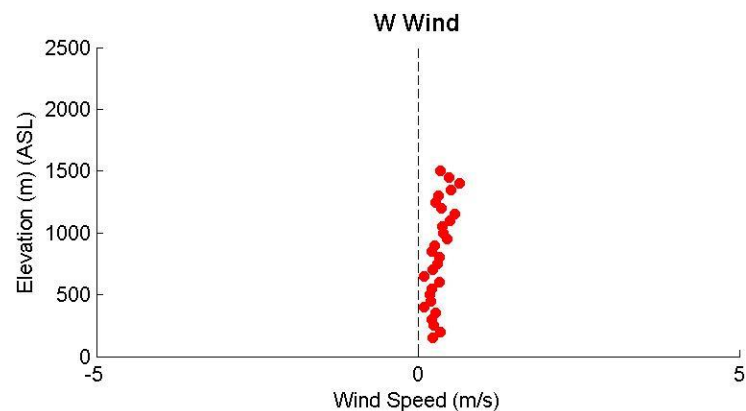
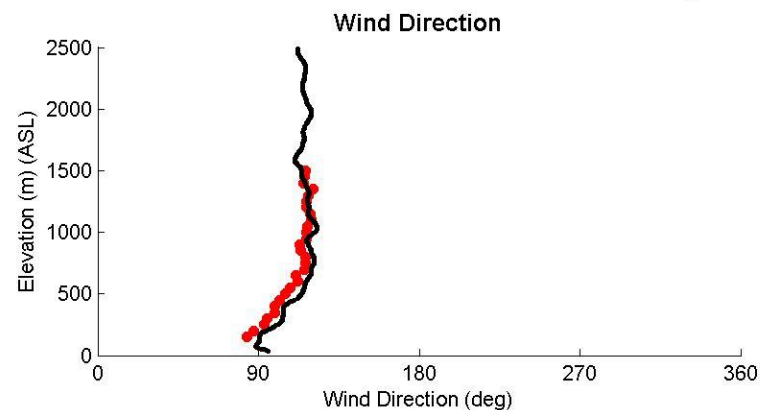
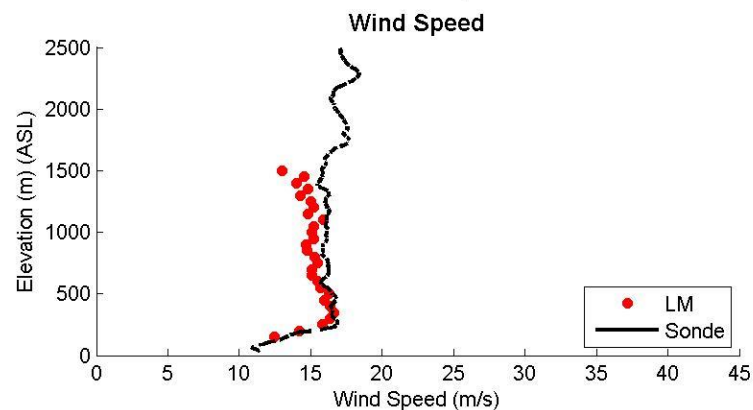


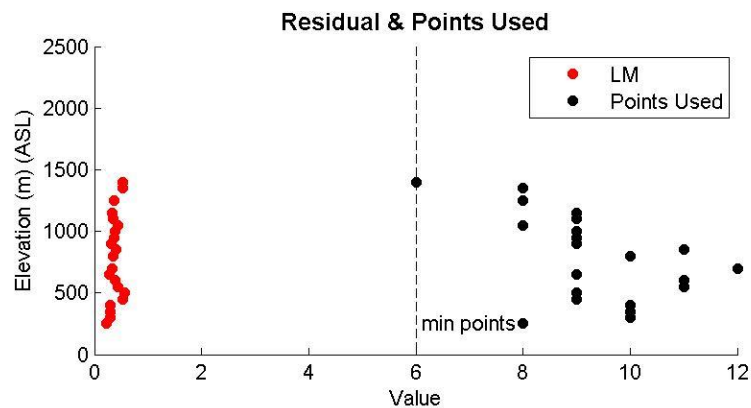
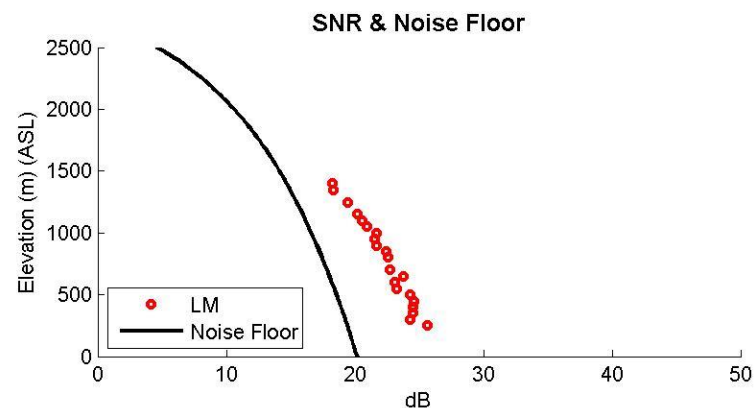
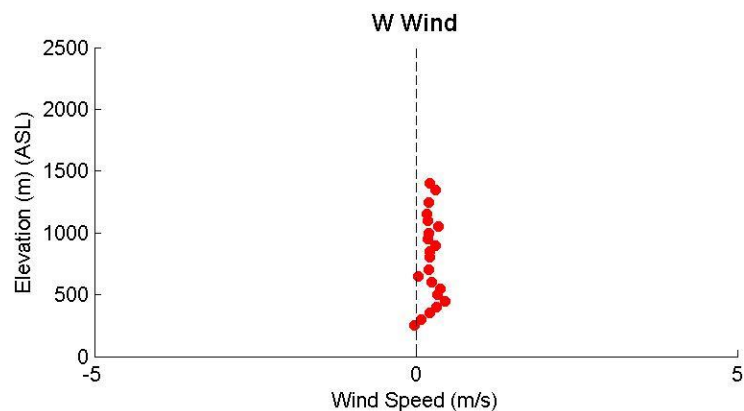
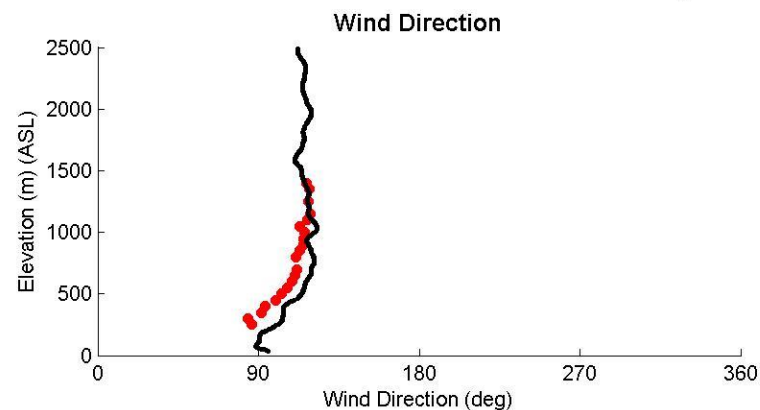
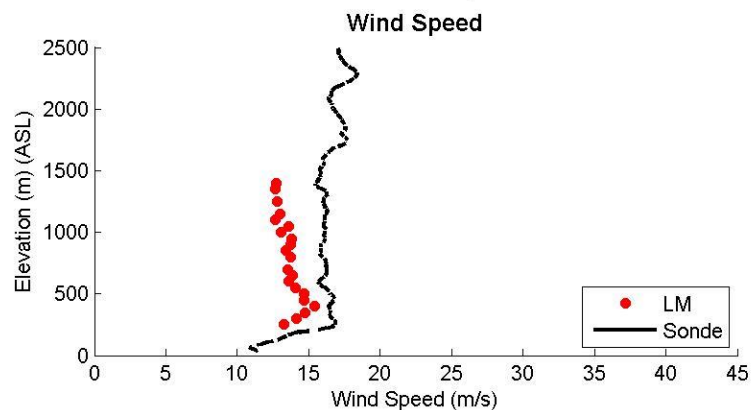
Dropsonde Comparisons

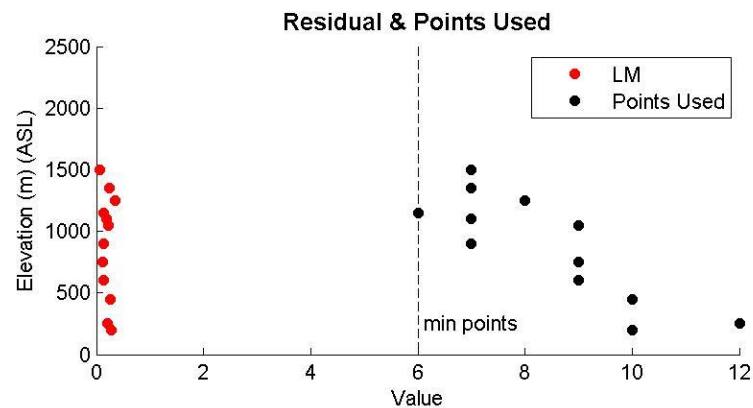
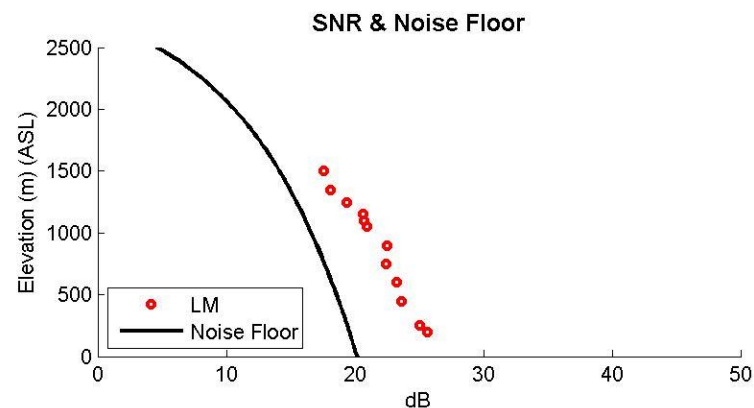
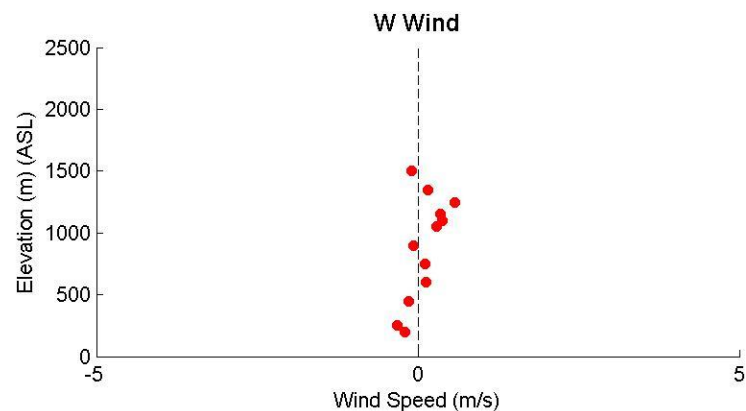
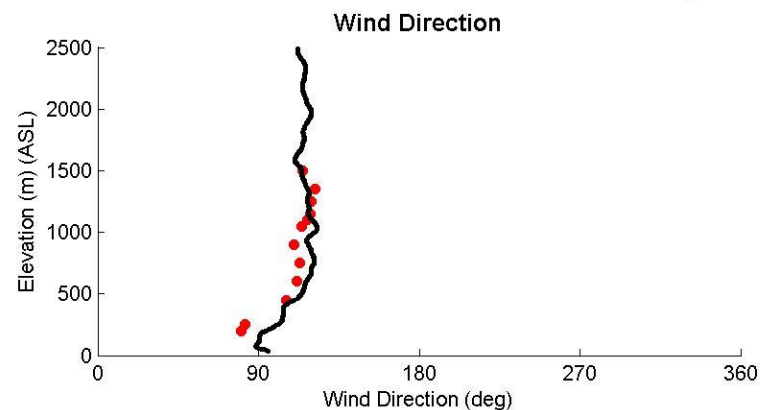
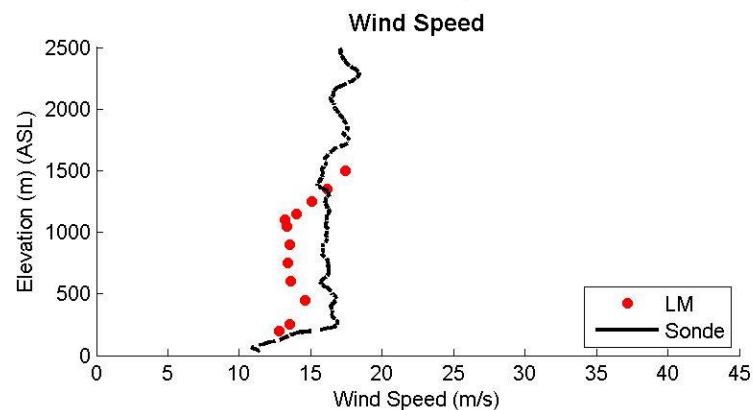
- The following series of comparisons are selected from a much larger set of DWL profiles obtained near Typhoon Haugapit.
- It is expected that the curtain of DWL profiles will be used for independent diagnostics on typhoon dynamics and to assign situational observation errors to the dropsondes (mass field information) for assimilation into forecasting models.

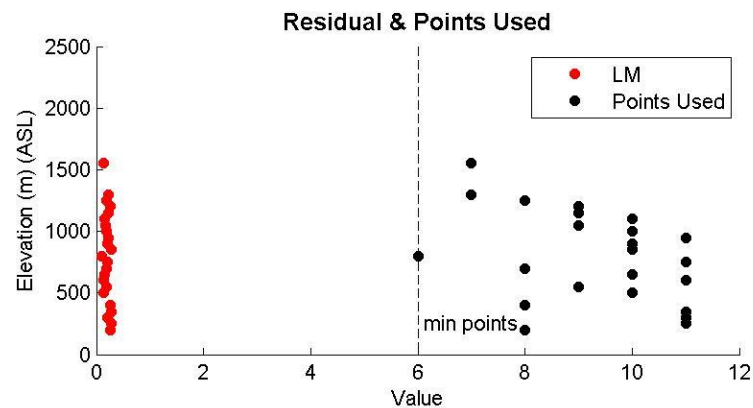
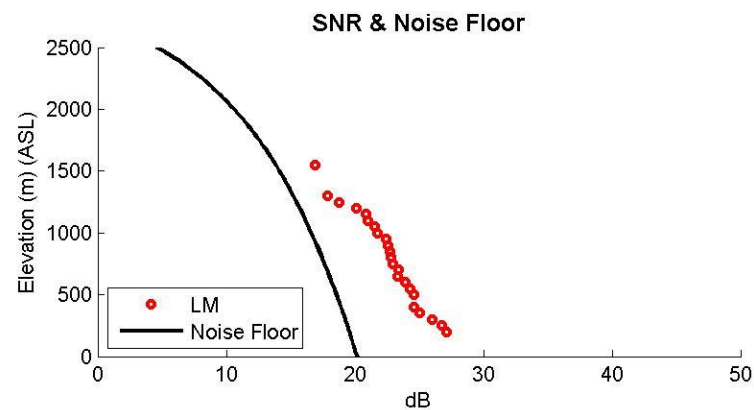
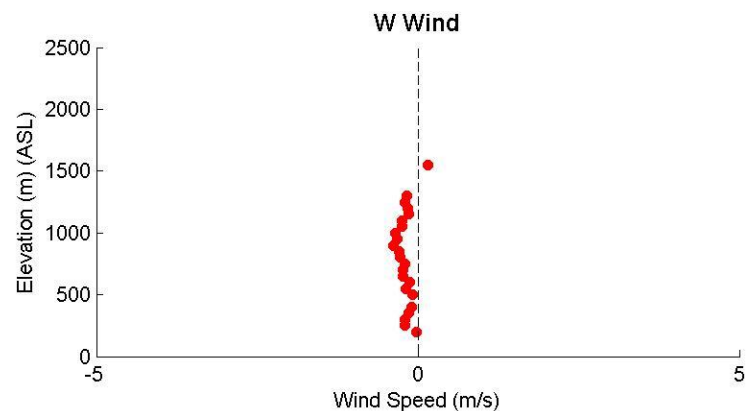
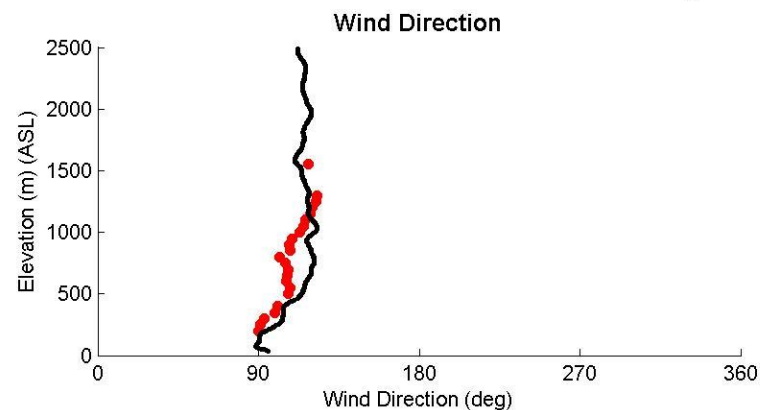
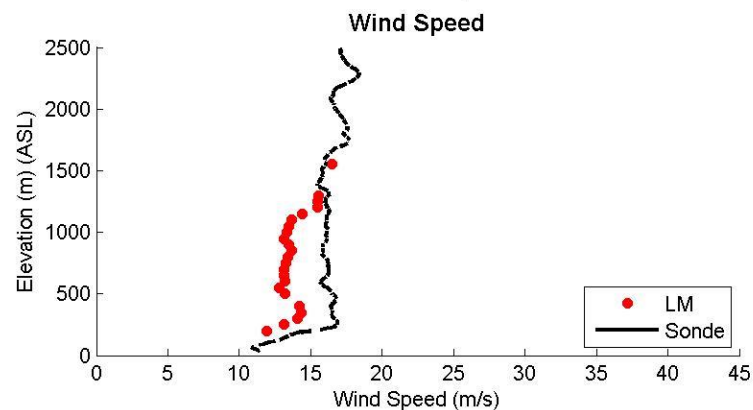
Profiling in a turn
267 CW 205 (62 degrees)

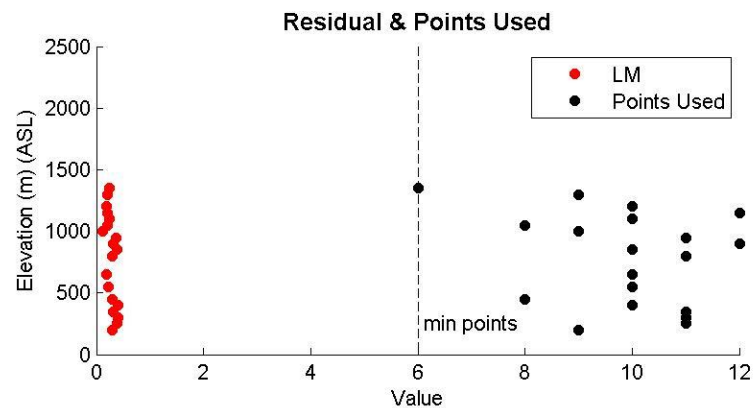
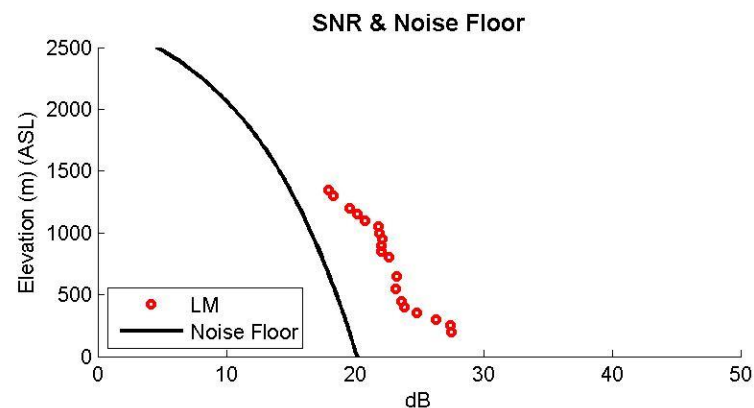
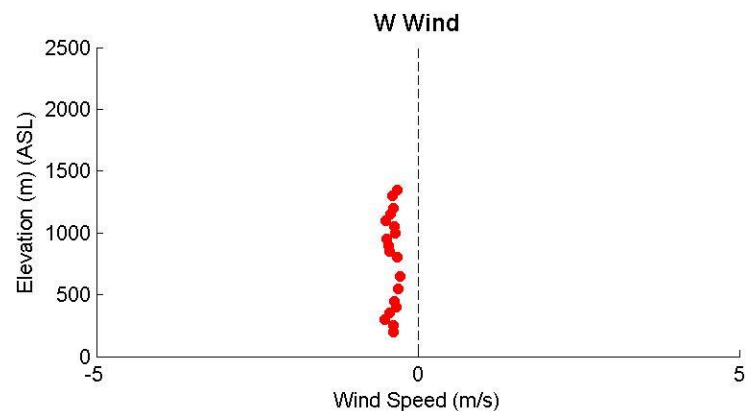
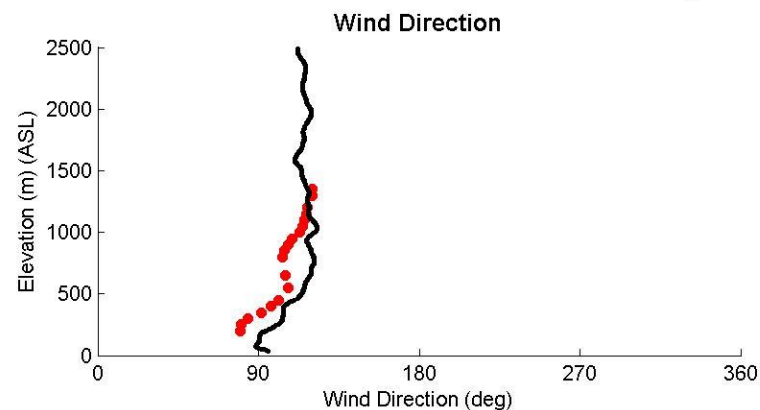
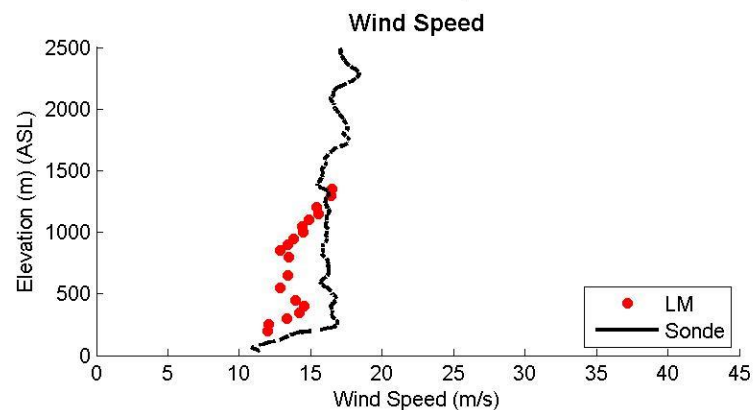




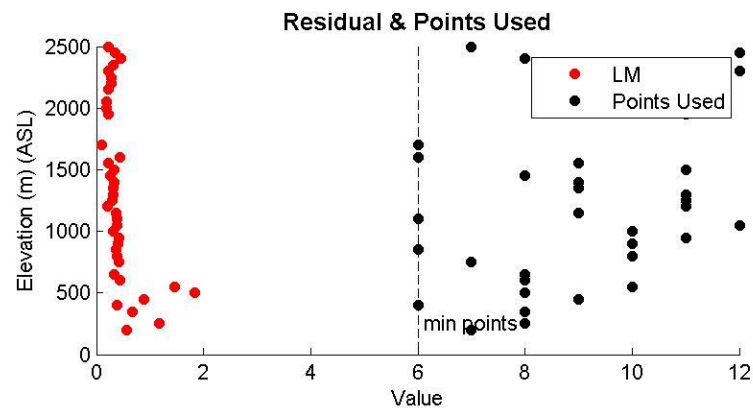
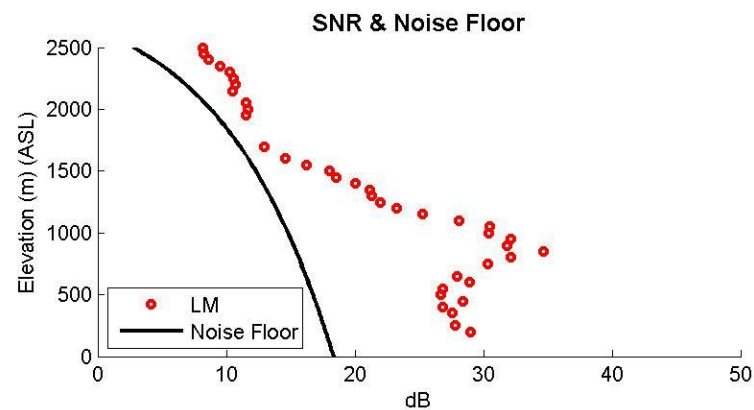
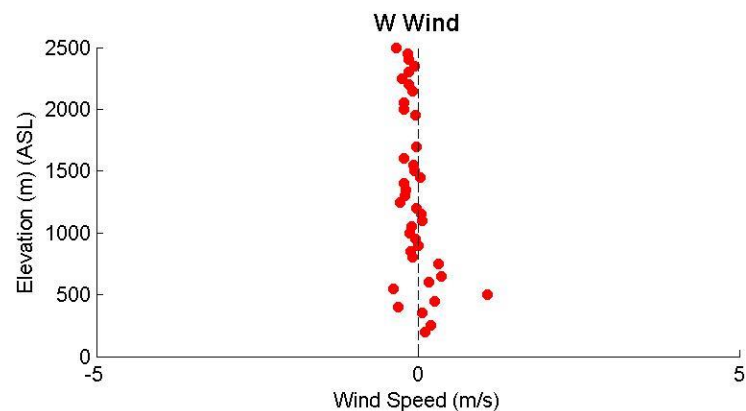
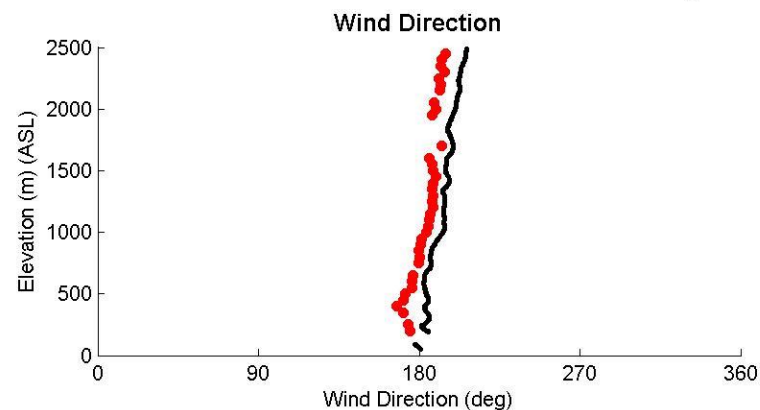
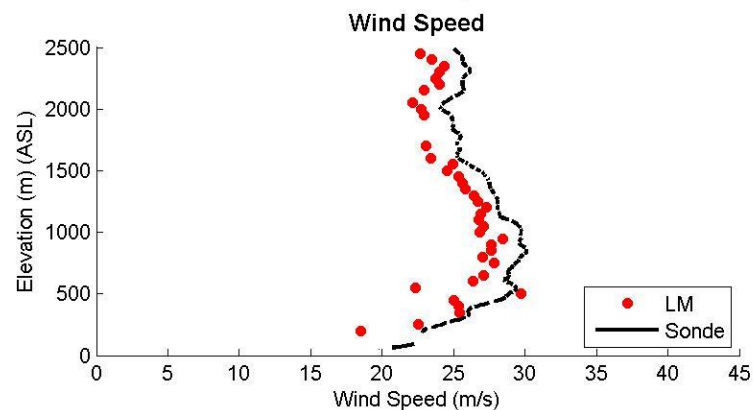


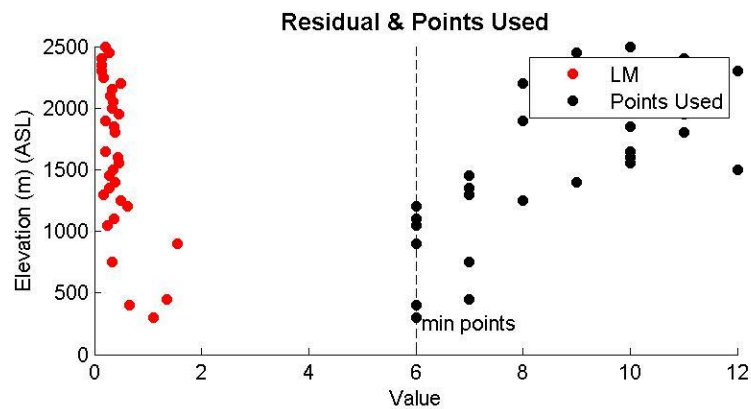
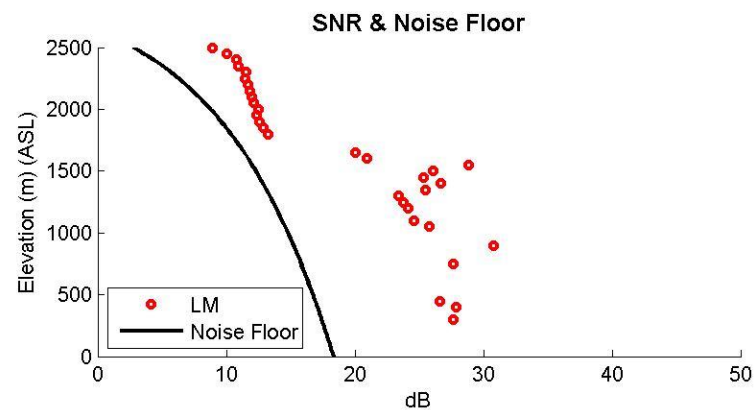
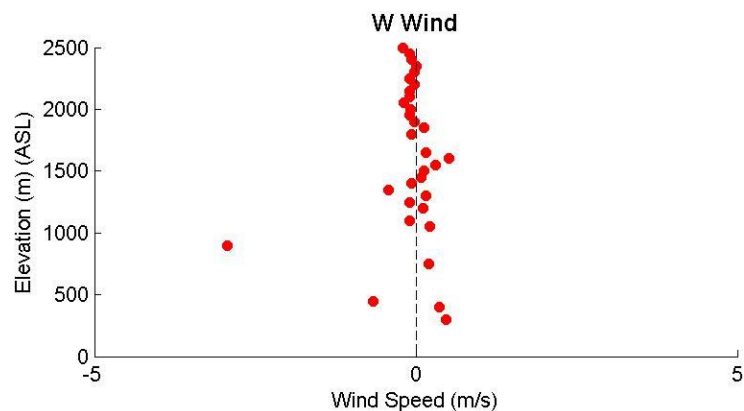
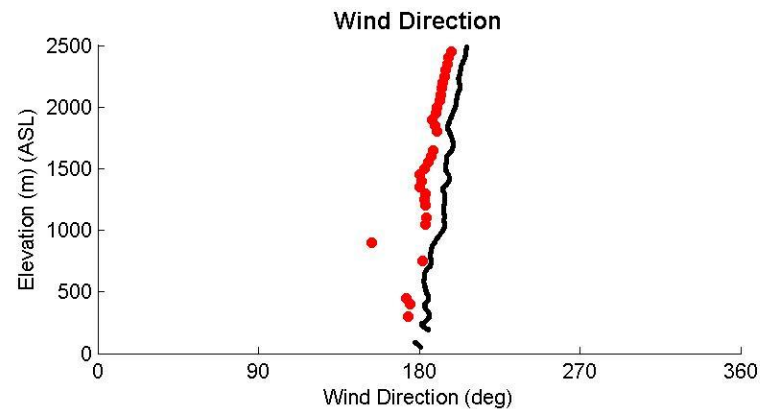
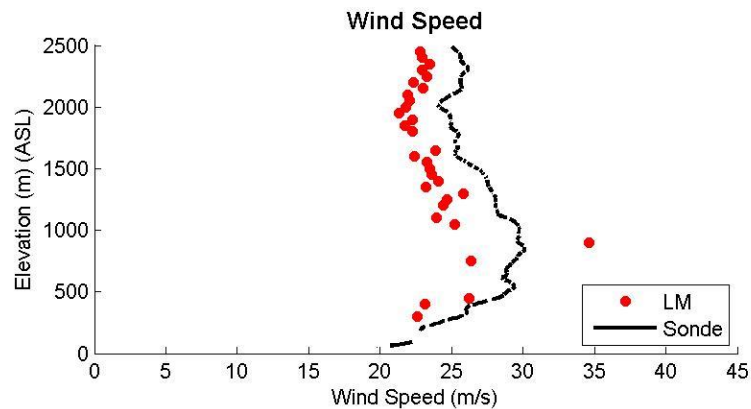


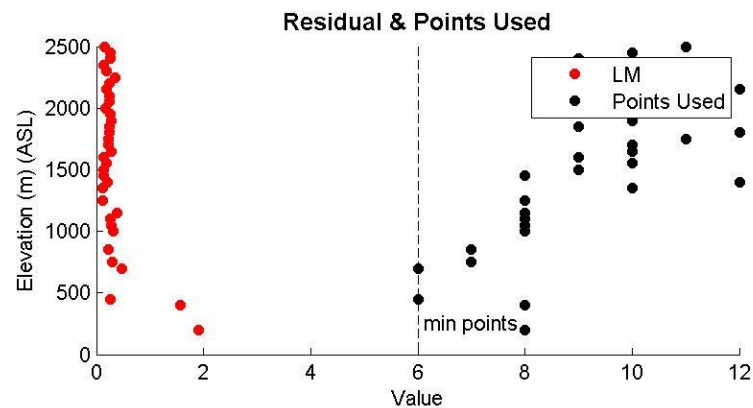
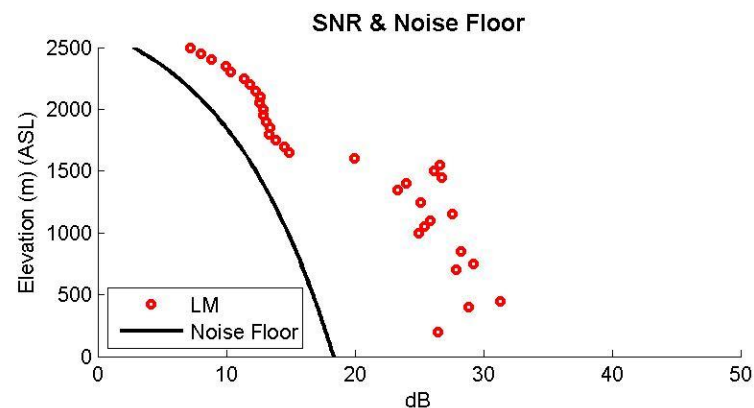
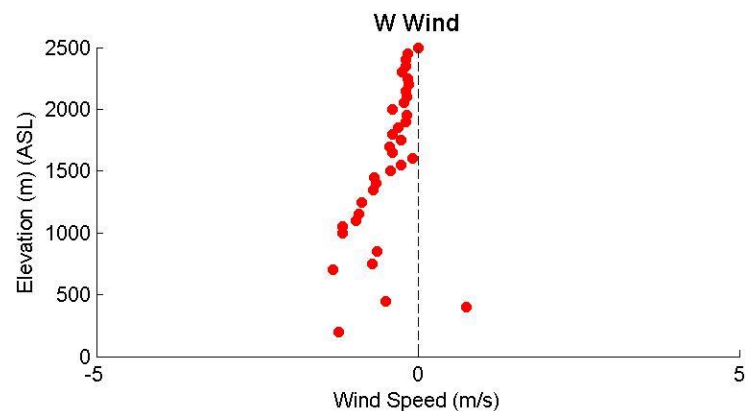
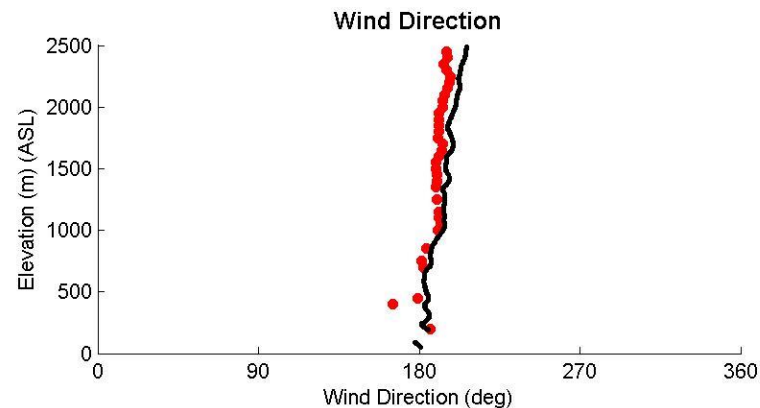
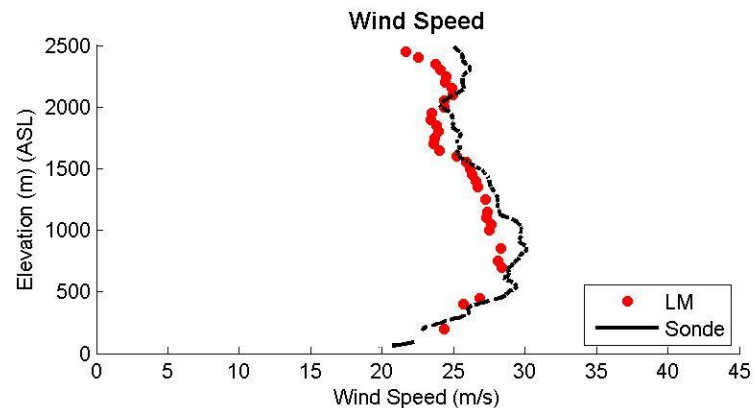


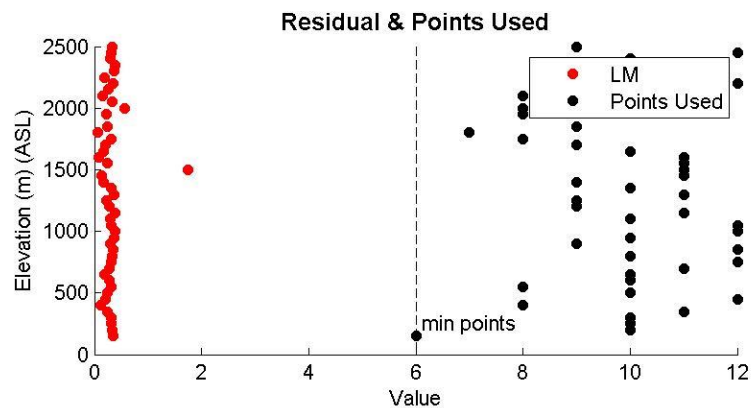
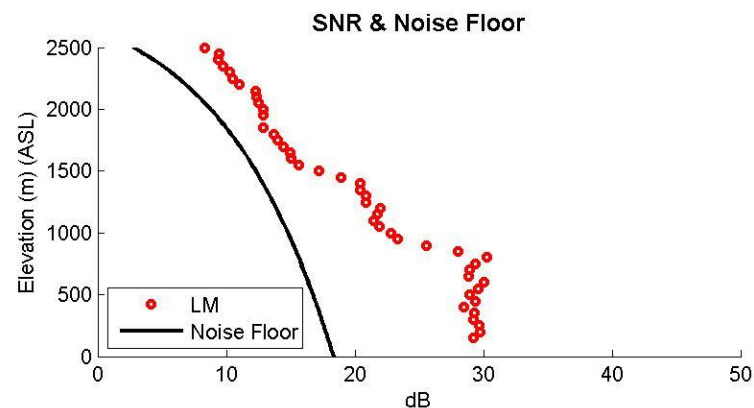
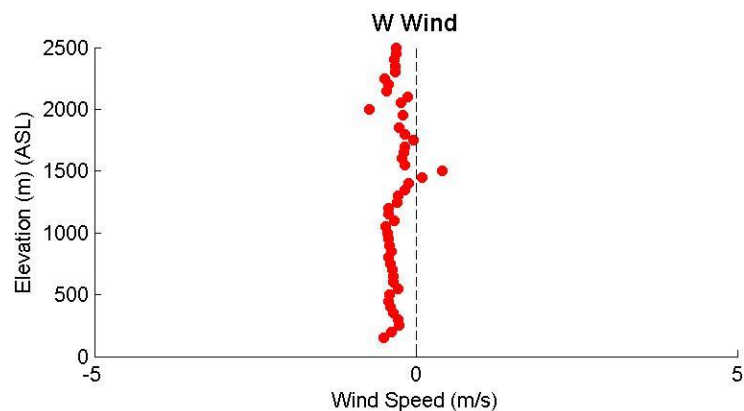
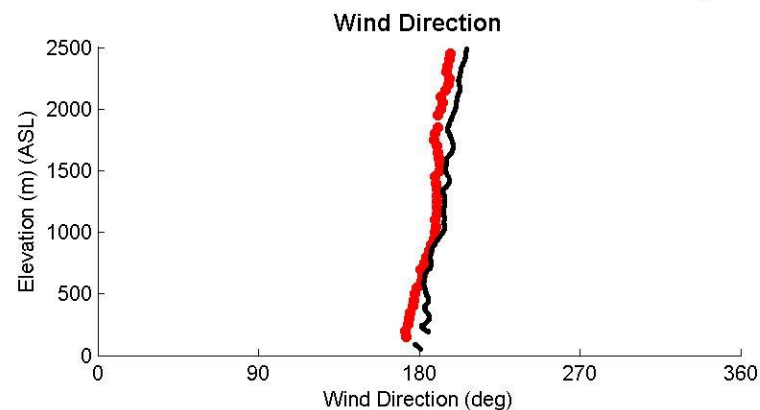
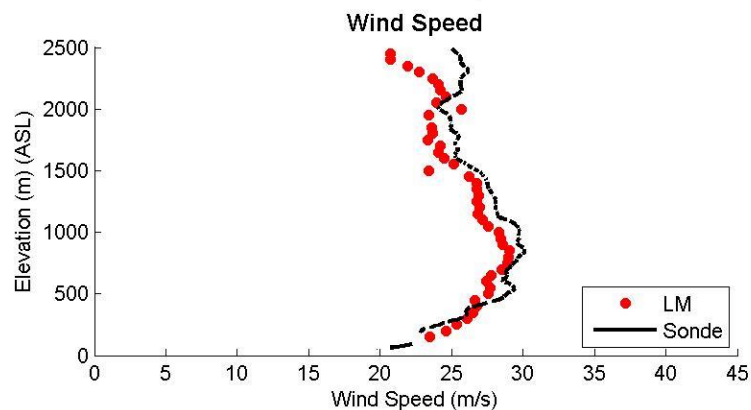


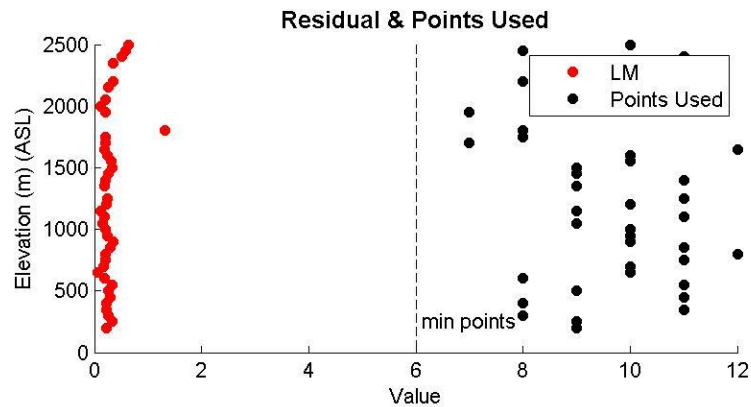
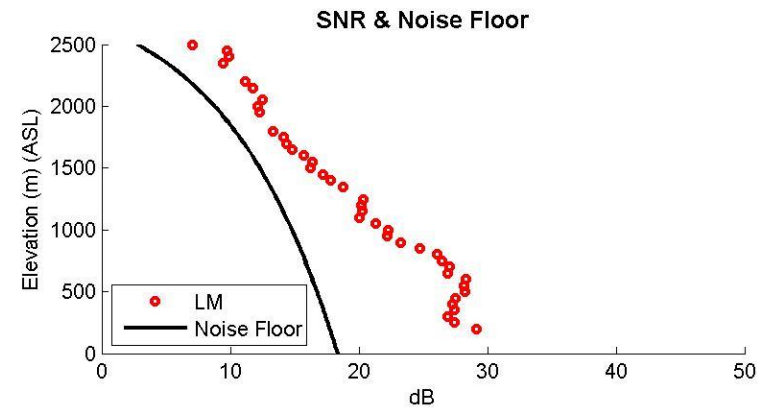
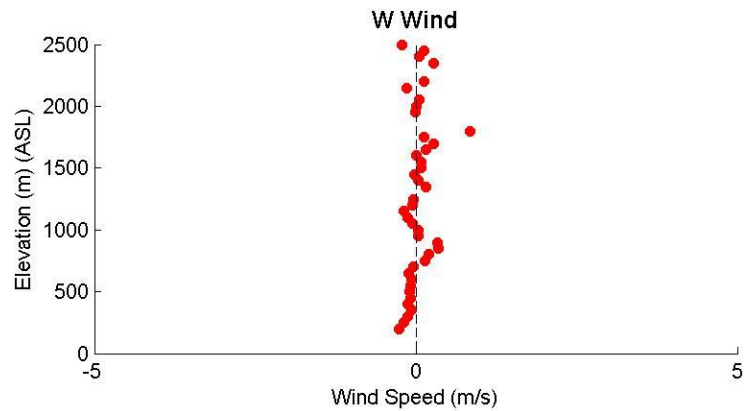
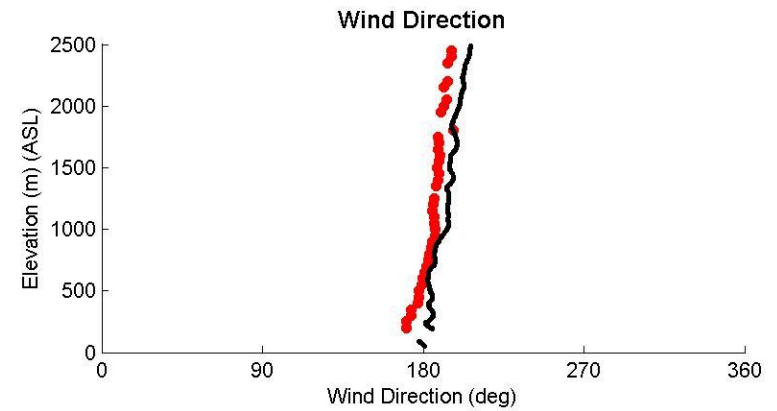
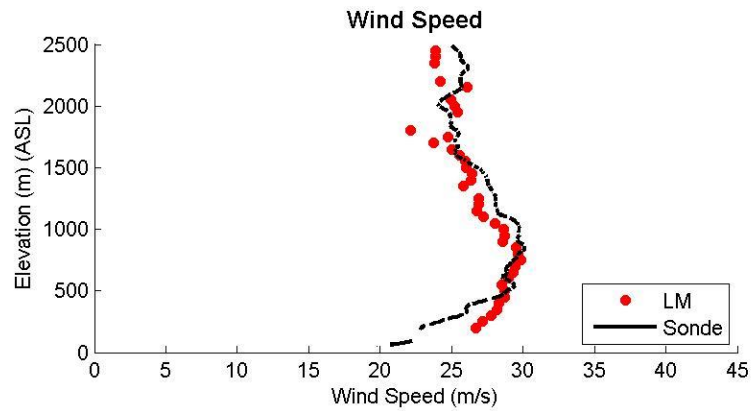
Profiling in a turn
327 CW 25 (57 degrees)

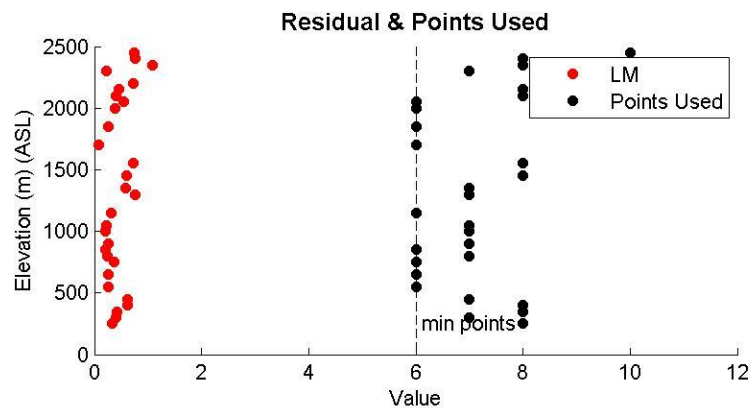
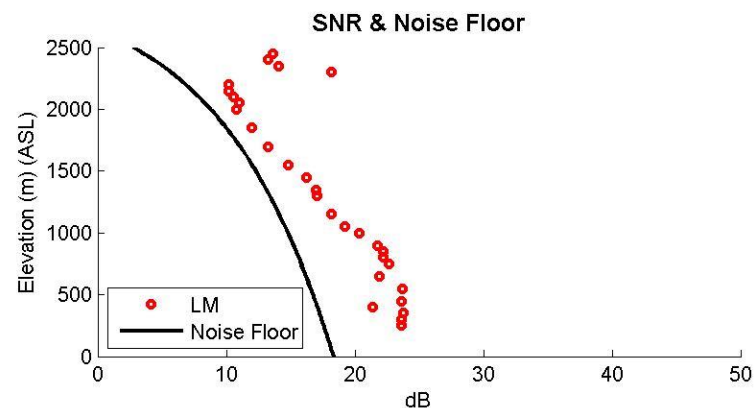
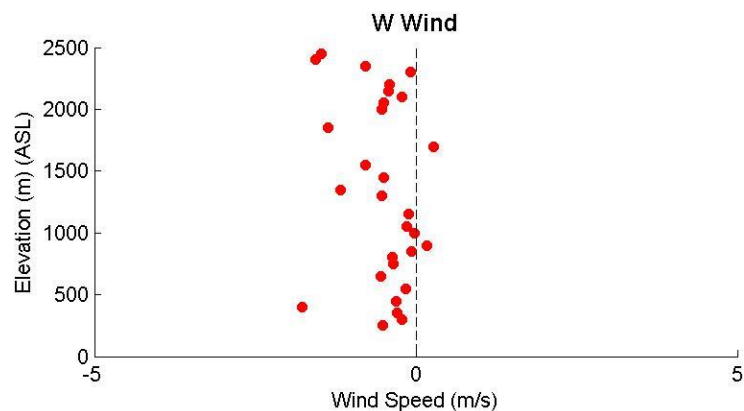
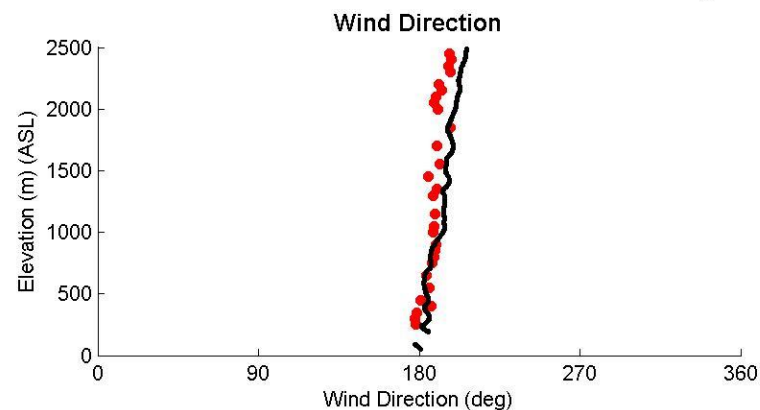
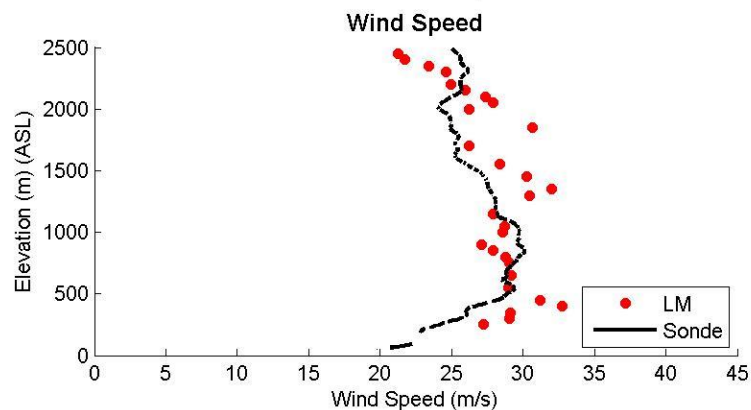




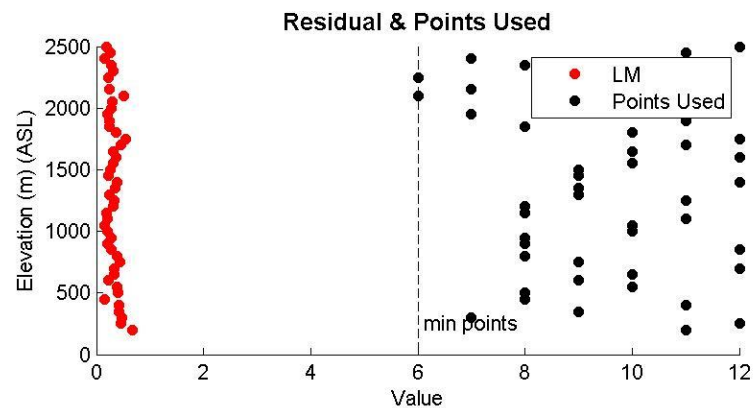
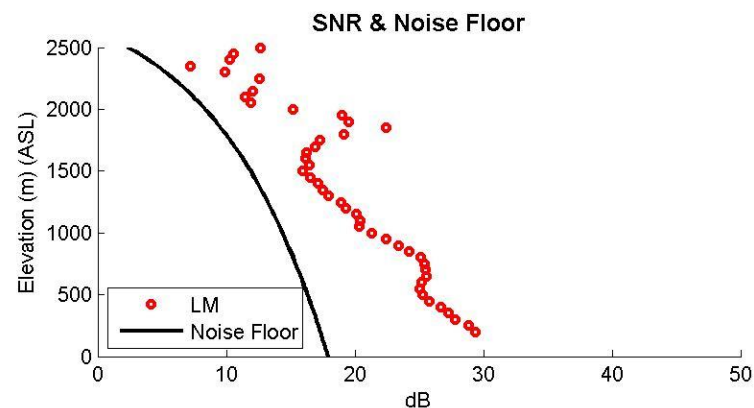
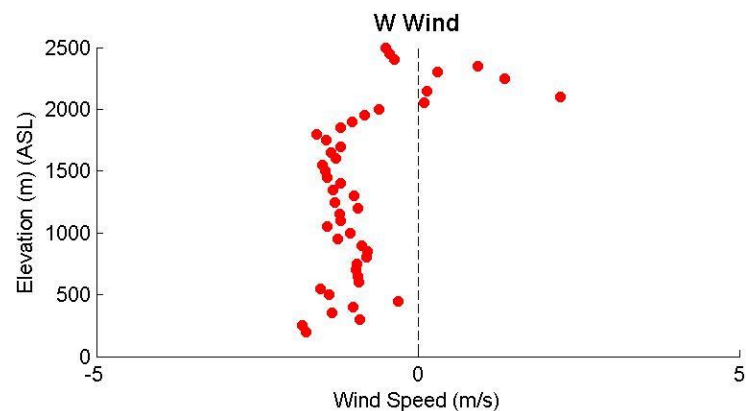
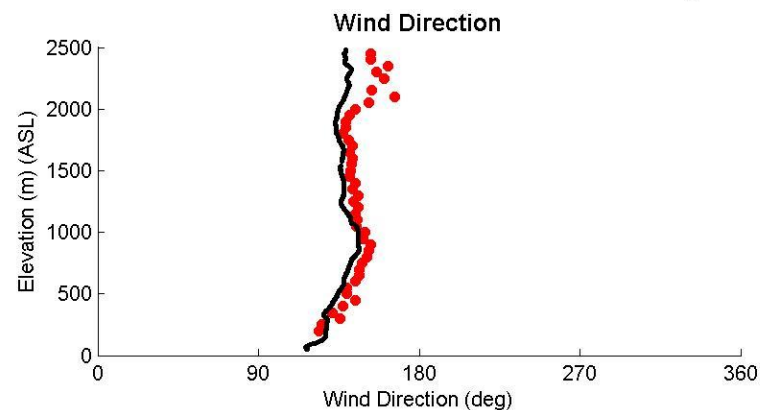
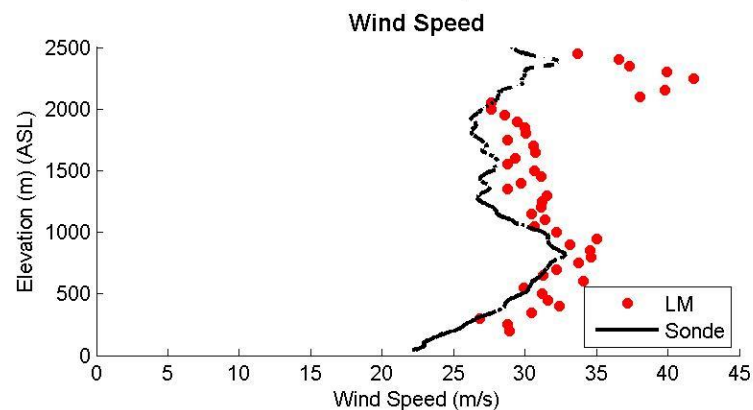


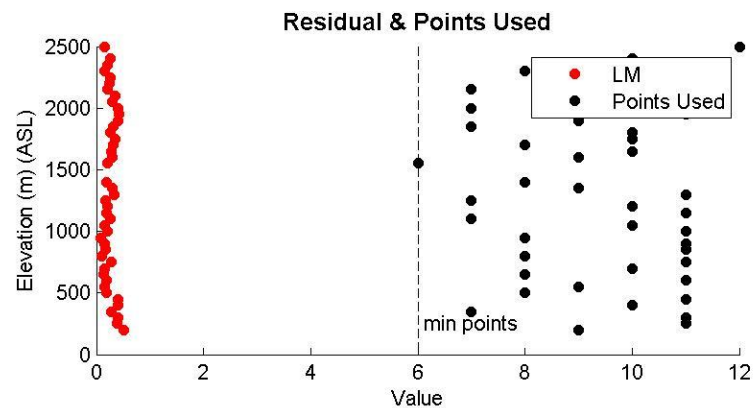
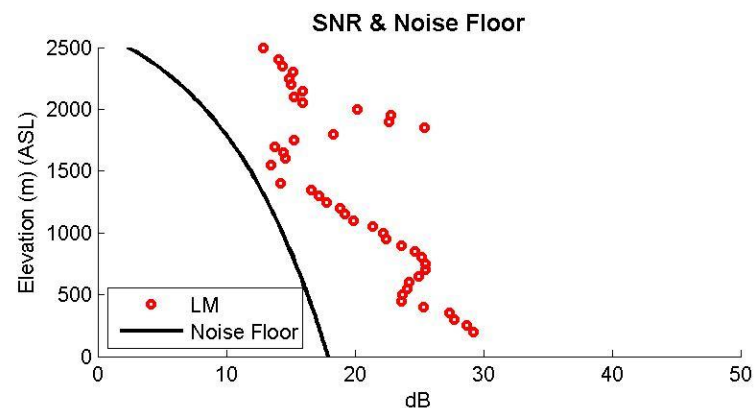
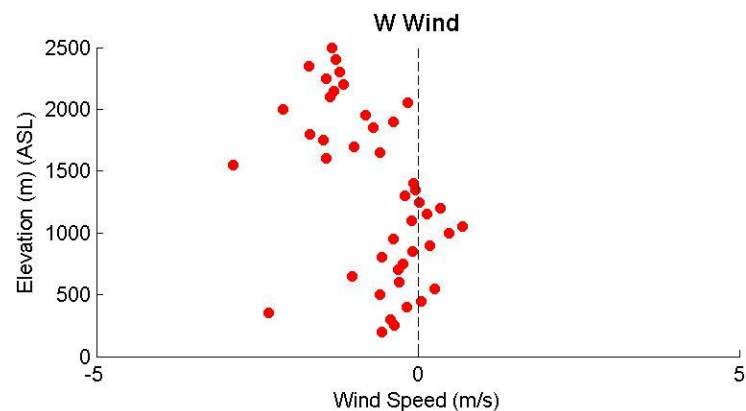
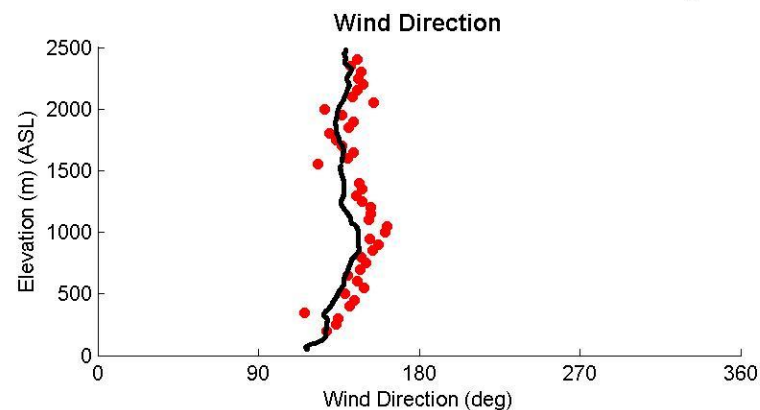
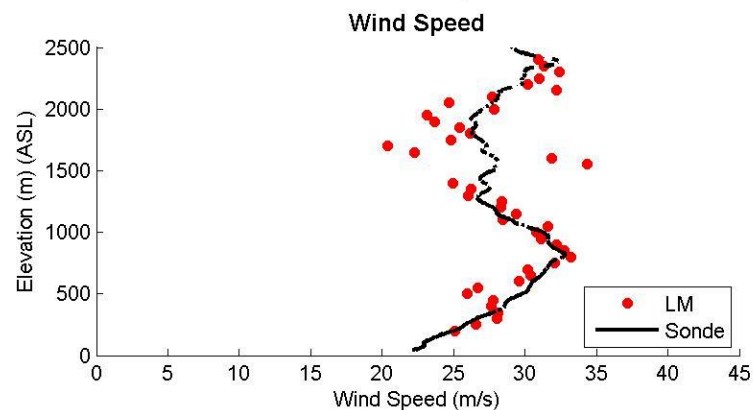


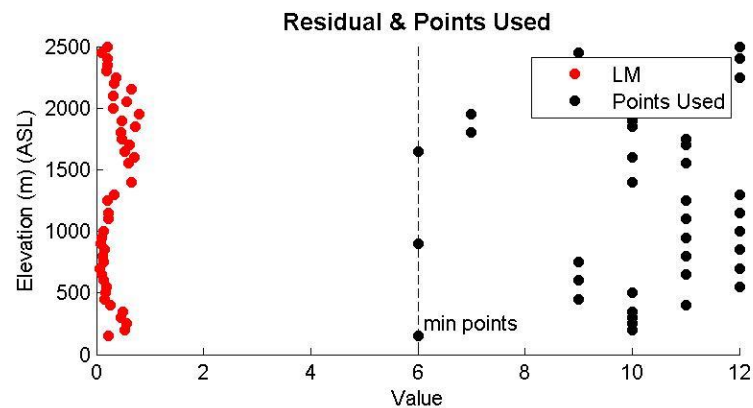
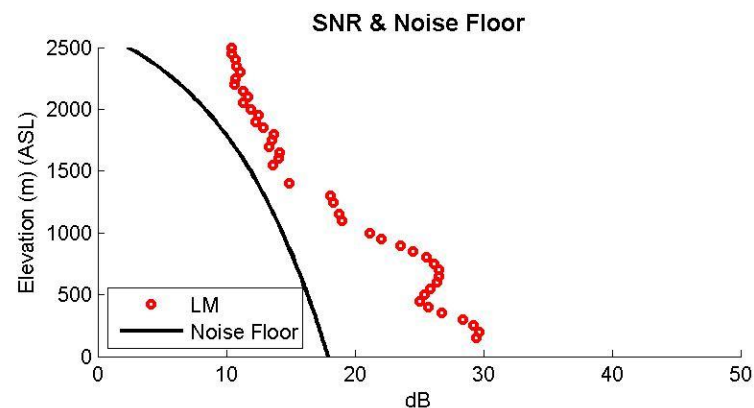
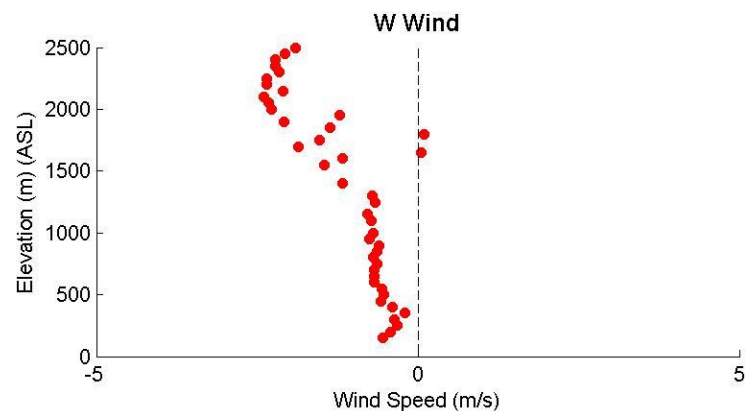
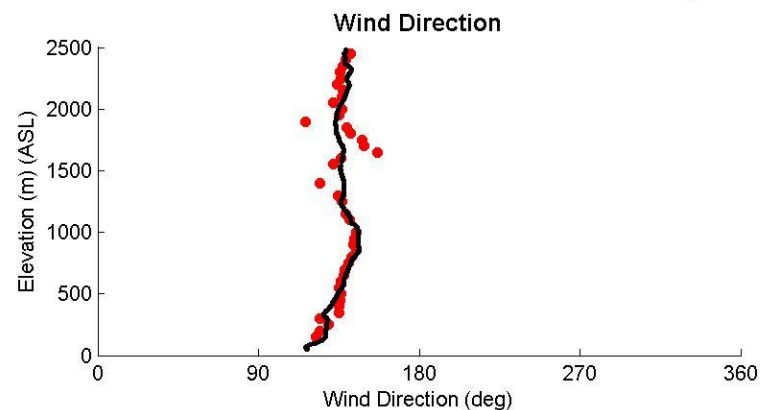
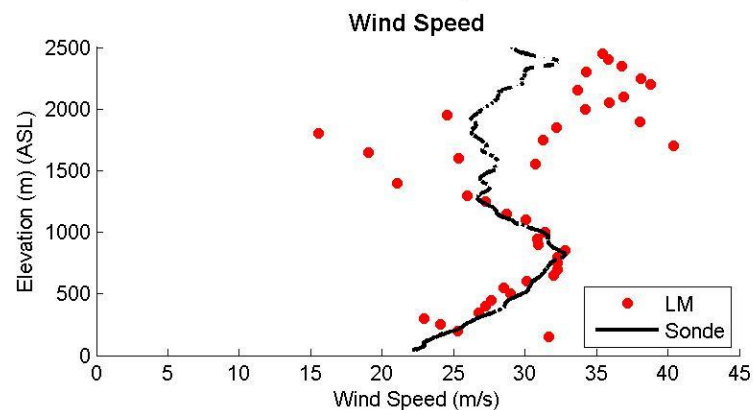


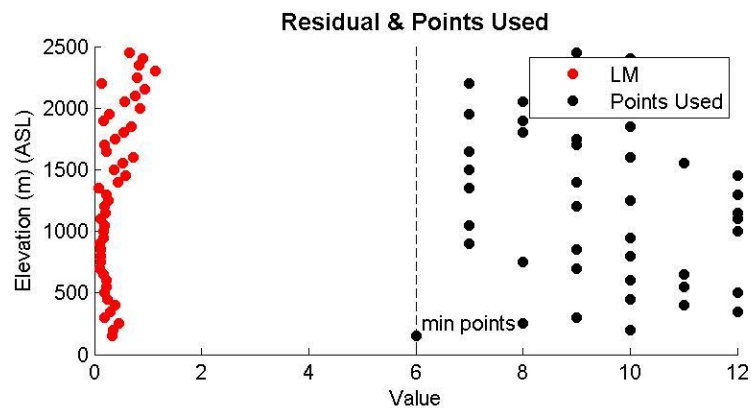
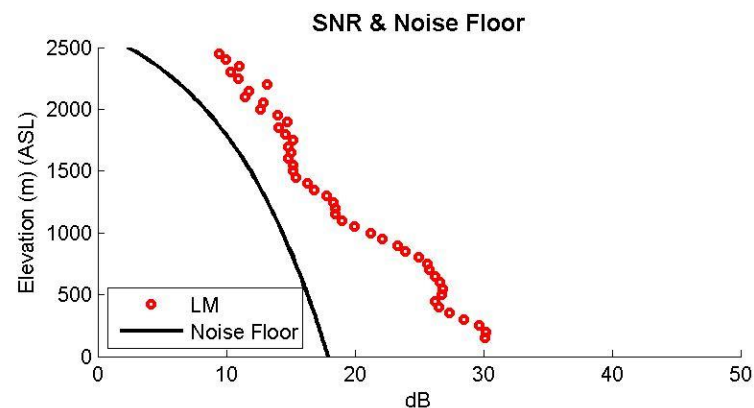
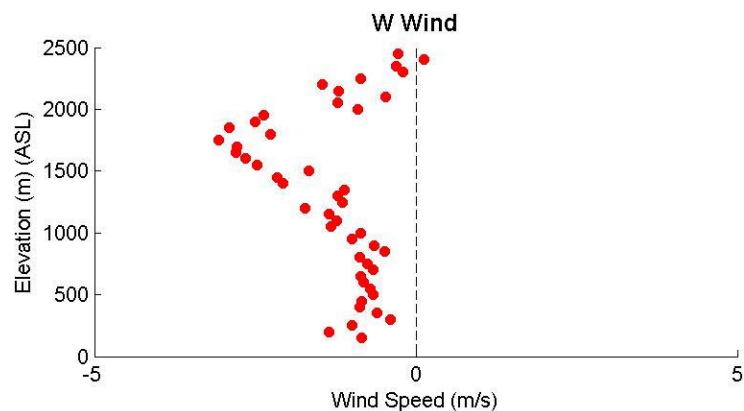
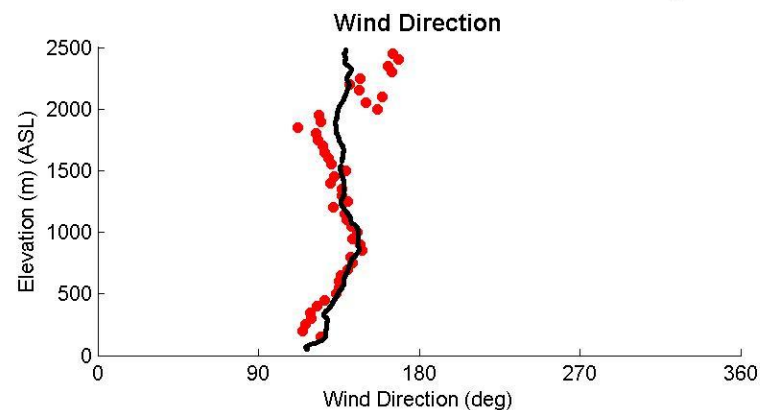
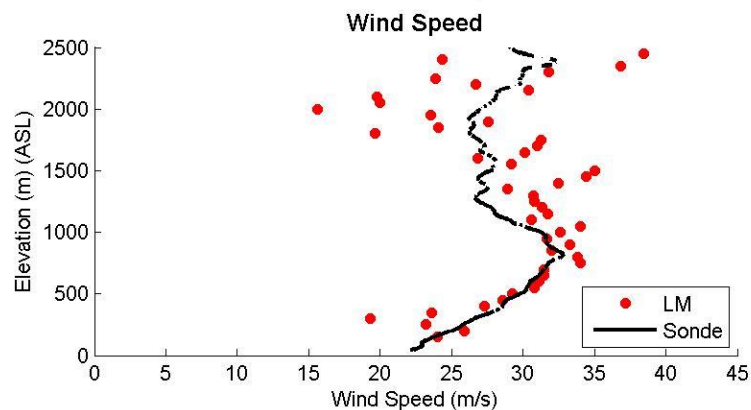


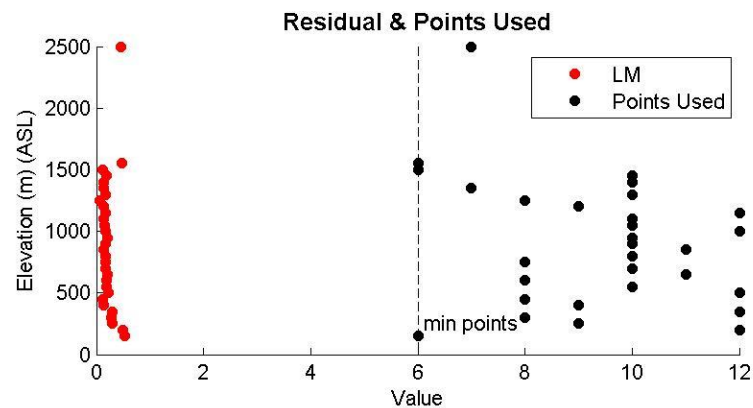
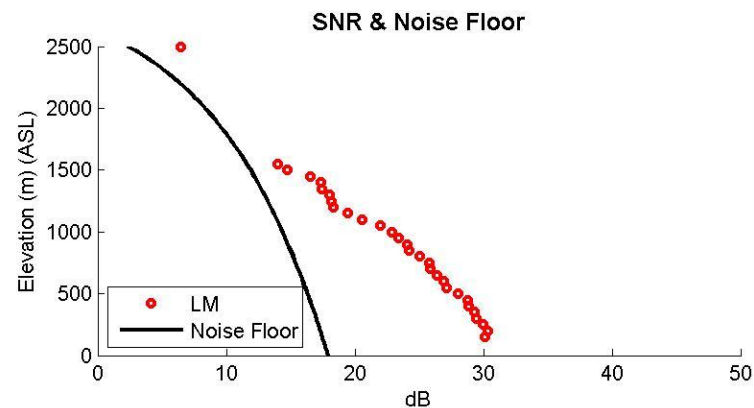
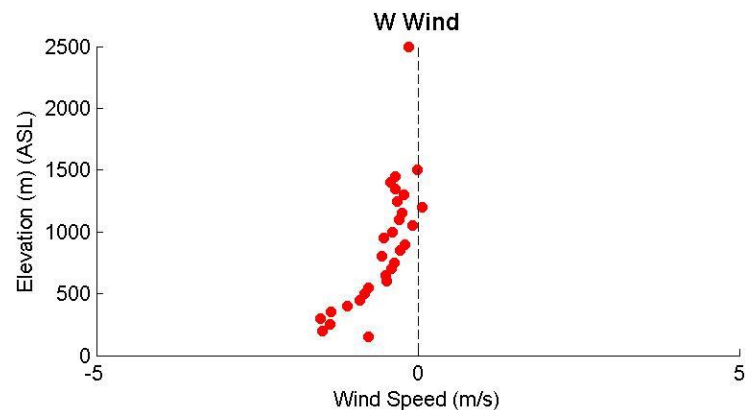
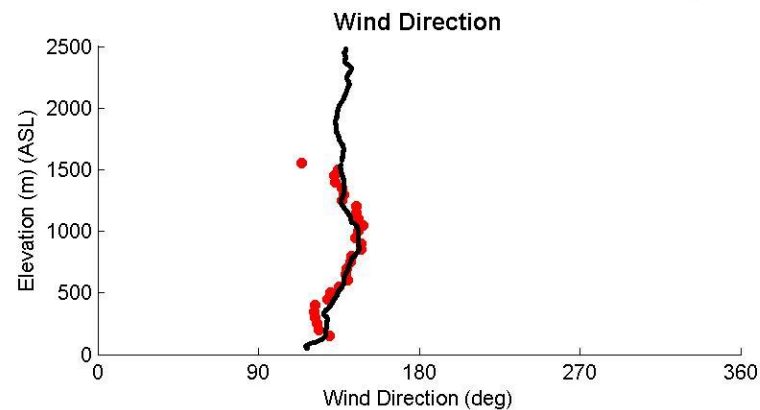
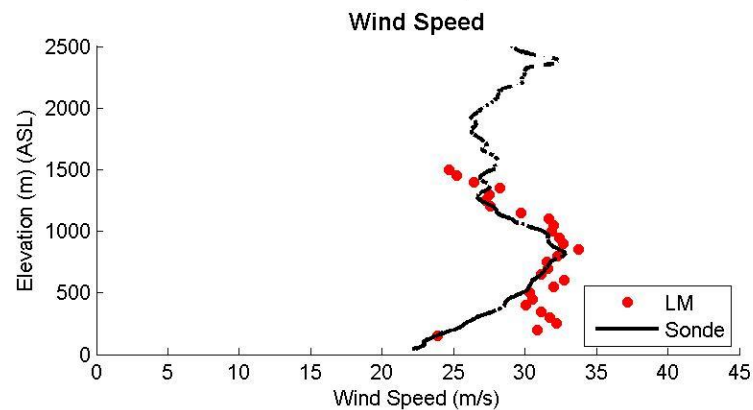
Profiling in rain and through clouds
while turning
114 CW 75 (39 degrees)

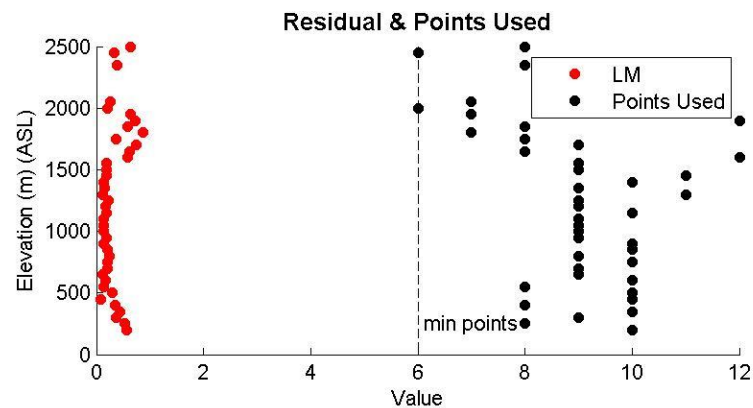
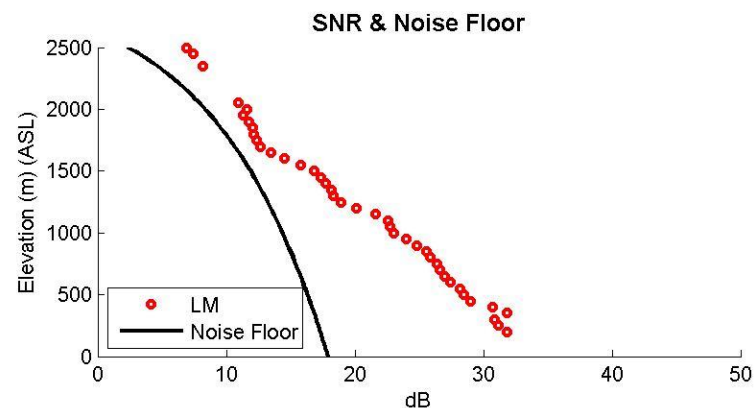
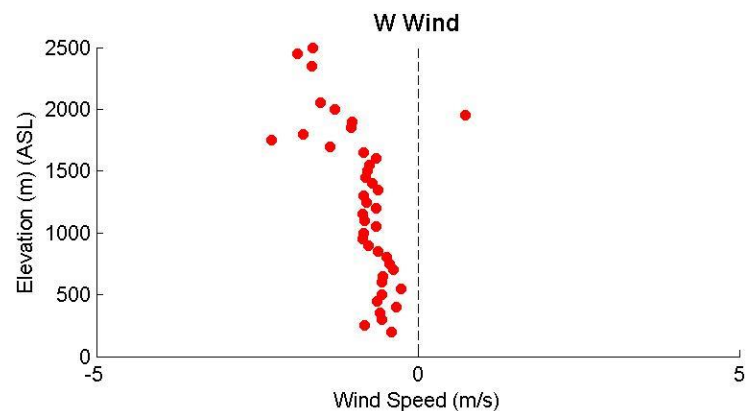
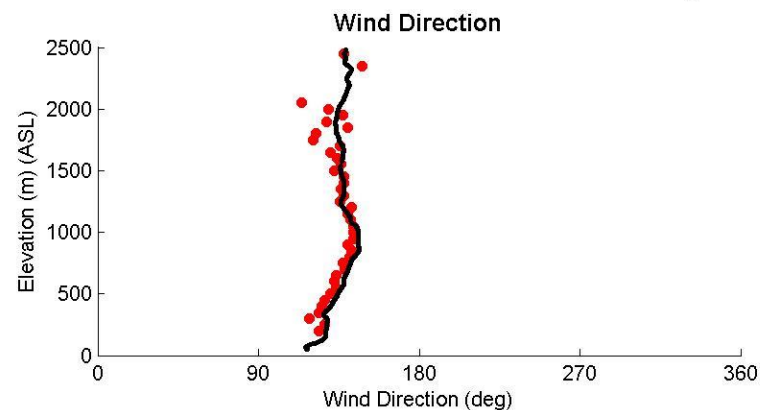
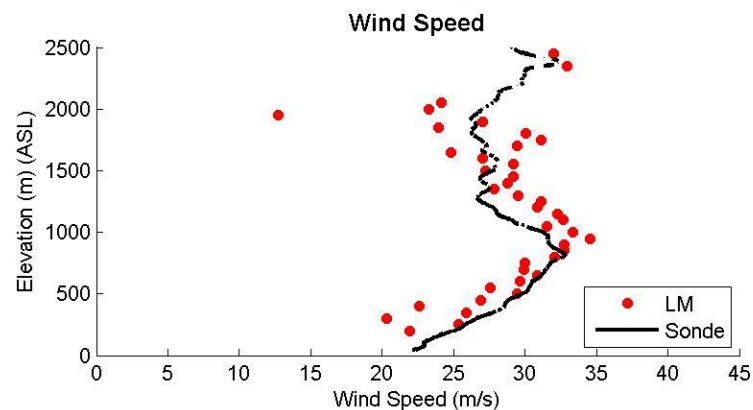


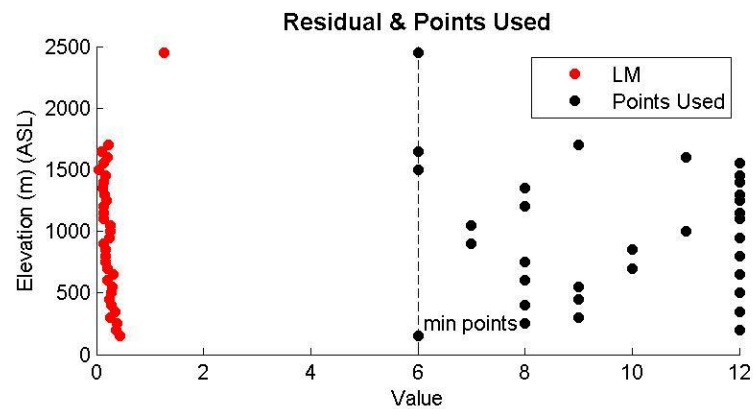
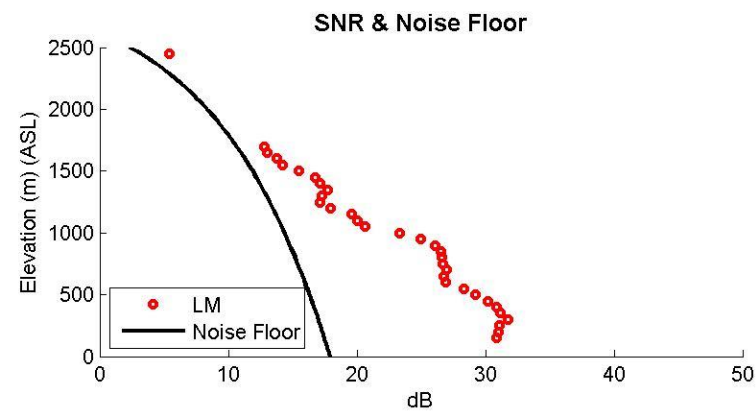
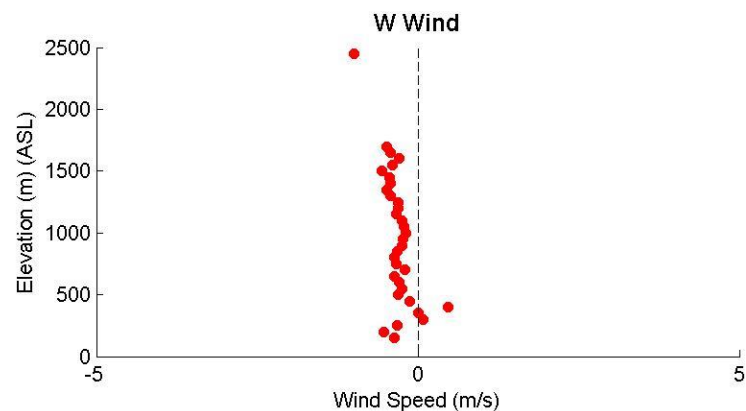
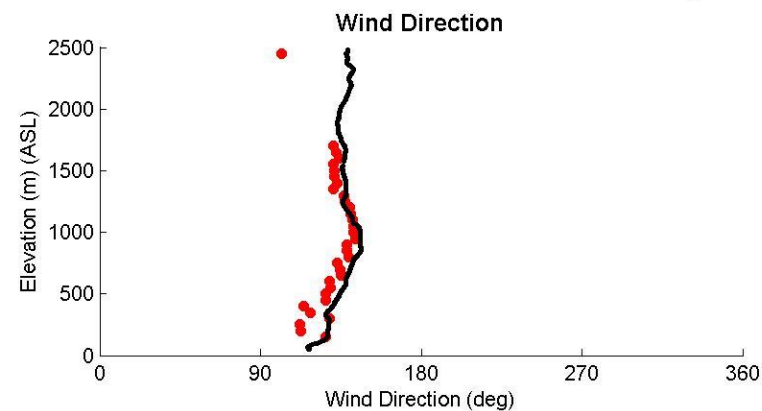
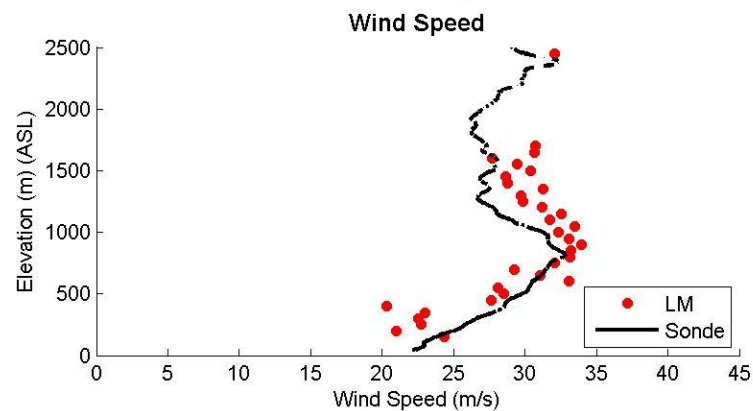


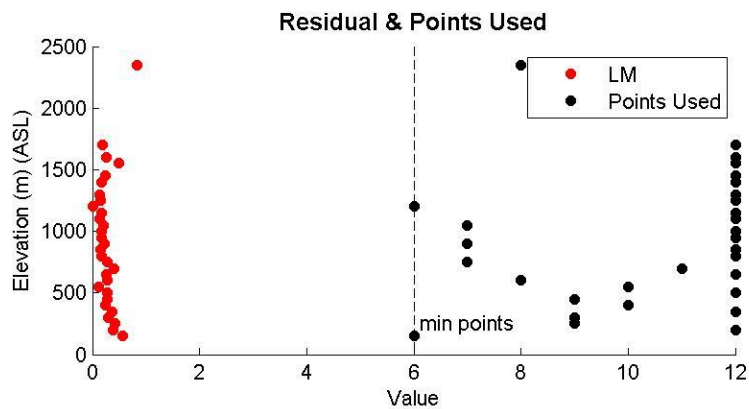
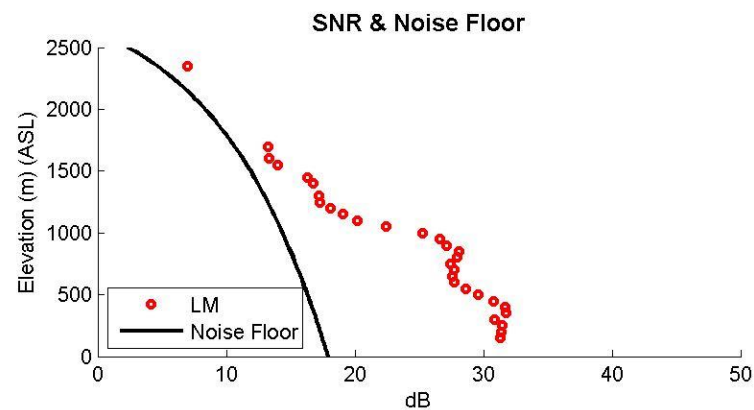
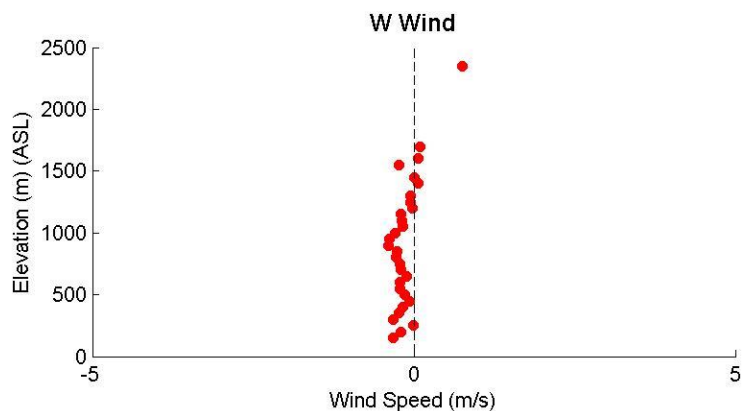
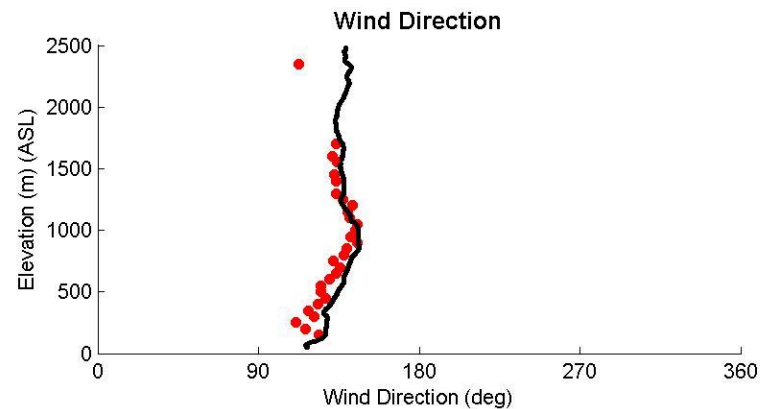
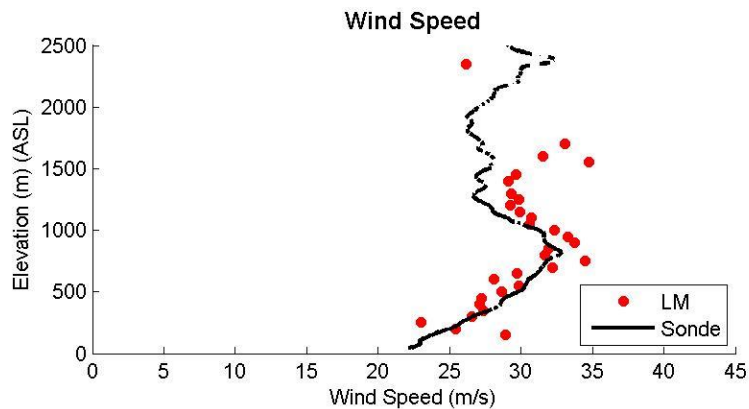


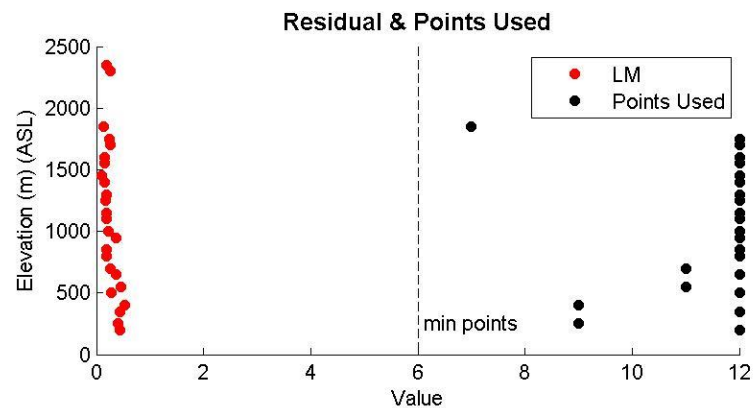
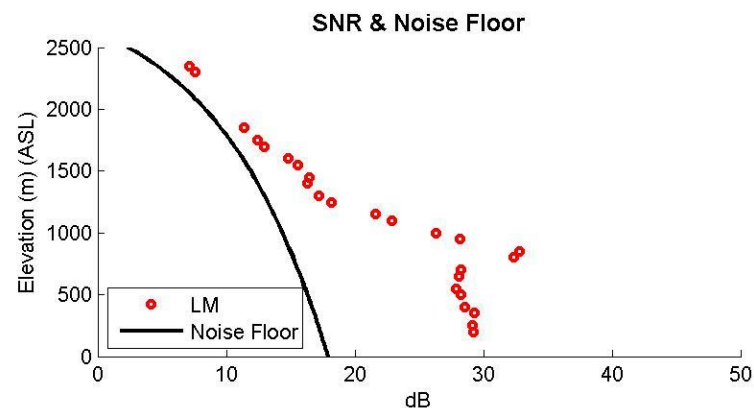
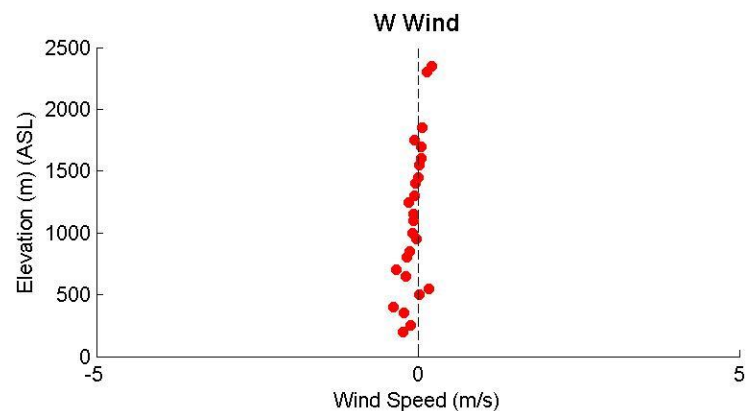
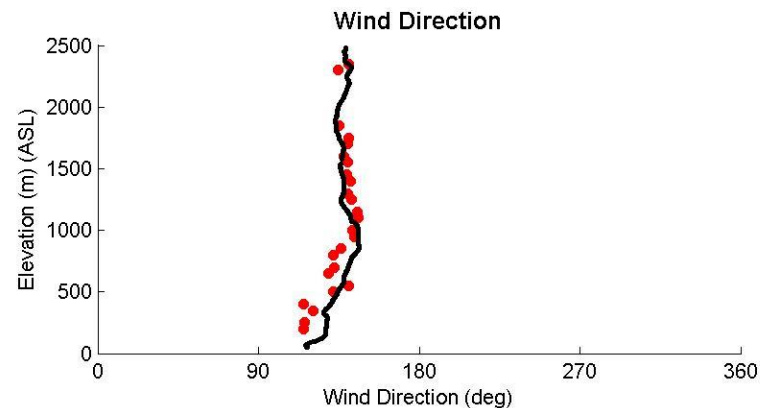
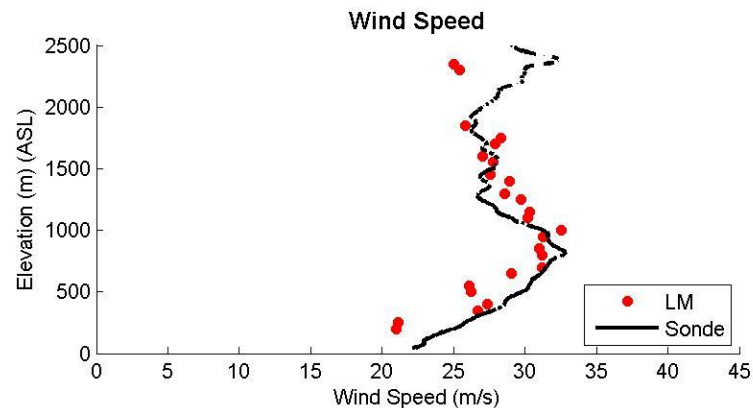










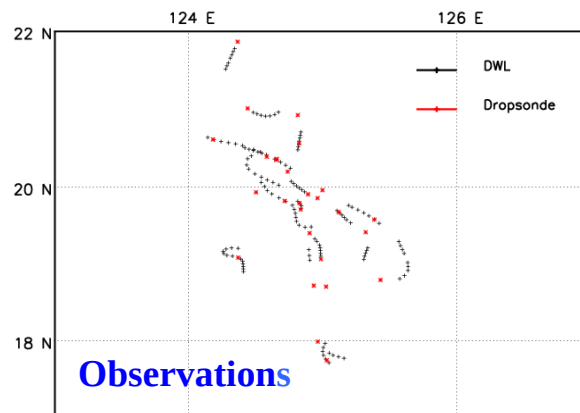


Impact of DWL wind profiles on numerical simulations of Typhoon Hagupit's rapid intensification

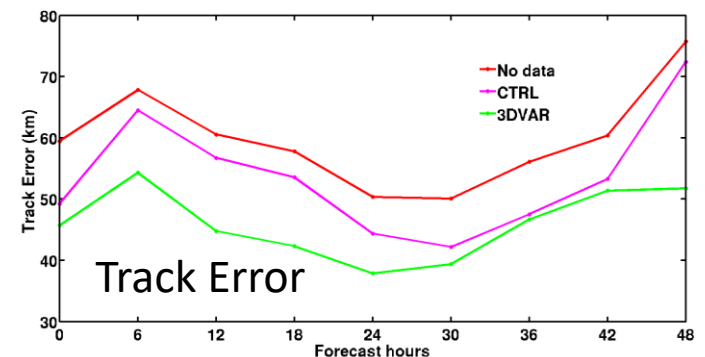
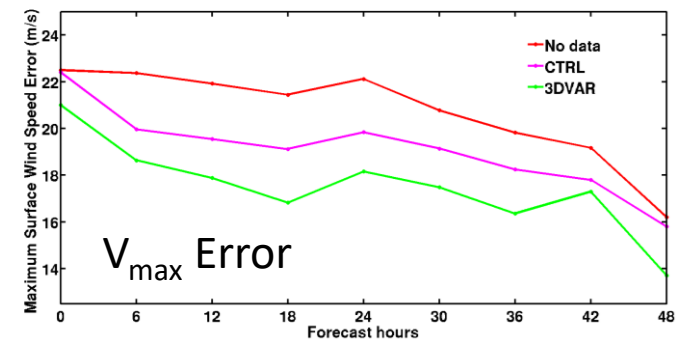
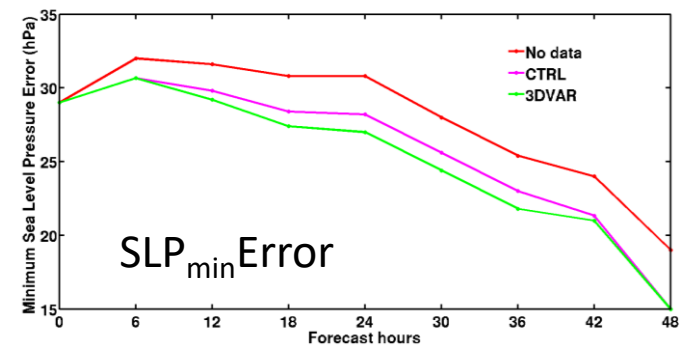
Zhaoxia Pu and Lei Zhang, Department of Atmospheric Sciences, University of Utah
G. David Emmitt, Simpson Weather Associates, Charlottesville, VA

Data: Doppler wind Lidar (DWL) profiles during 0000UTC –0430 UTC 22 September 2008

Forecast Period: 48-h forecast; 0000UTC 22 September 2008 --- 0000UTC 24 September 2008



- Assimilation of conventional and dropwindsonde data (CTRL) shows a positive impact on Hagupit's track and intensity forecasts.
- Including the DWL wind observations in the model initialization (3DVAR) resulted in significant improvements for both the track and intensity forecasts



Current research using P3DWL data

- Zhaoxia Pu (University of Utah)
 - Nuri
 - Sinlaku
 - Hagupit
 - Jangmi
- Foster (University of Washington)
 - Organized Large Eddies
- Emmitt (Simpson Weather Associates)
 - Dropsonde comparisons
 - Layer Adjacent to the Surface (LAS) investigations

Summary

- More than 10,000 profiles of the three dimensional Doppler lidar winds in the vicinity of tropical cyclones have been processed and are now available for use.
- FTP site set up for P3 processed data
- Questions regarding data access and utility:
gde@swa.com