# More on Wind Shear Statistics: Intercomparison of Measurements from Airborne DWL and Ground-based Sensors

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# Motivation

- Shear is a major component of atmospheric instability
- From space and airborne platforms, a Doppler wind lidar offers the capability to measure high resolution vertical profiles of the wind, thus providing a direct, vertically contiguous measure of shear
- Shear can be persistent as well as transient (representativeness issue)

# Overview

- What is Wind Shear?
- Wind Shear Climatologies
- Sounding comparisons of winds and wind shear
  - RAOBs
  - Microwave sounders
  - Airborne Doppler Wind Lidar (TODWL)

# Wind Shear

- Wind Shear is defined in NOAA Technical Memorandum NWS FCST-23 as “a change in horizontal wind speed and/or direction, and/or vertical speed with distance, measured in a horizontal and/or vertical direction”

- *As defined by the National Weather Service, Low-Level Wind Shear is wind shear of 5 m/s or more per 30m (.169s-1) in a layer more than 60m thick within the lowest 600m of the atmosphere*

# Wind Shear

- Vertical wind shear is not a scalar quantity, but a vector. Using just “speed shear” will often underestimate the amount of shear present. Direction of the horizontal winds must be considered as well

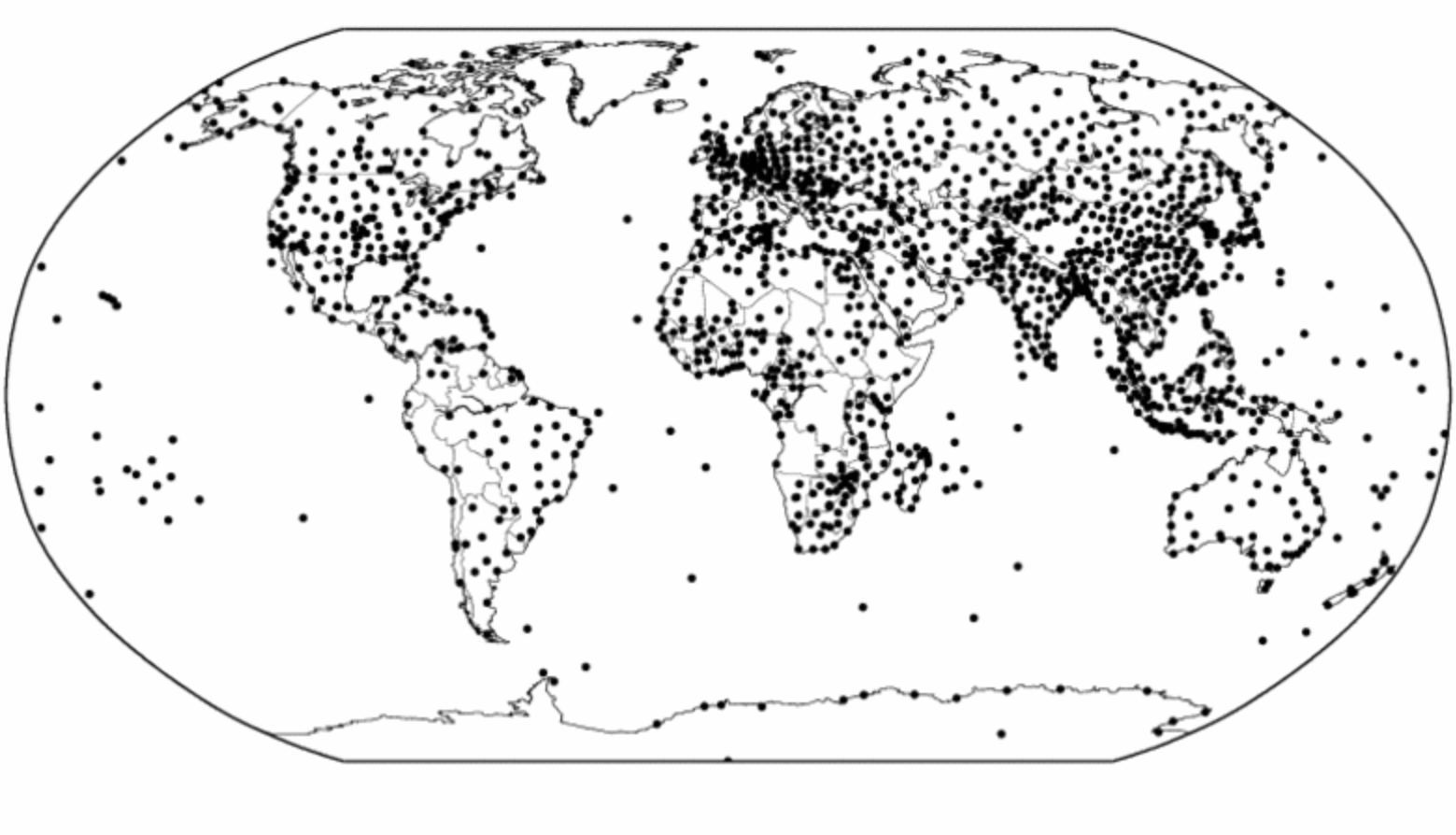
- On benign days, wind shear values are typically < 0.08 s-1. Wind shear meeting official criteria is 0.169 s-1

# Wind Shear Climatologies

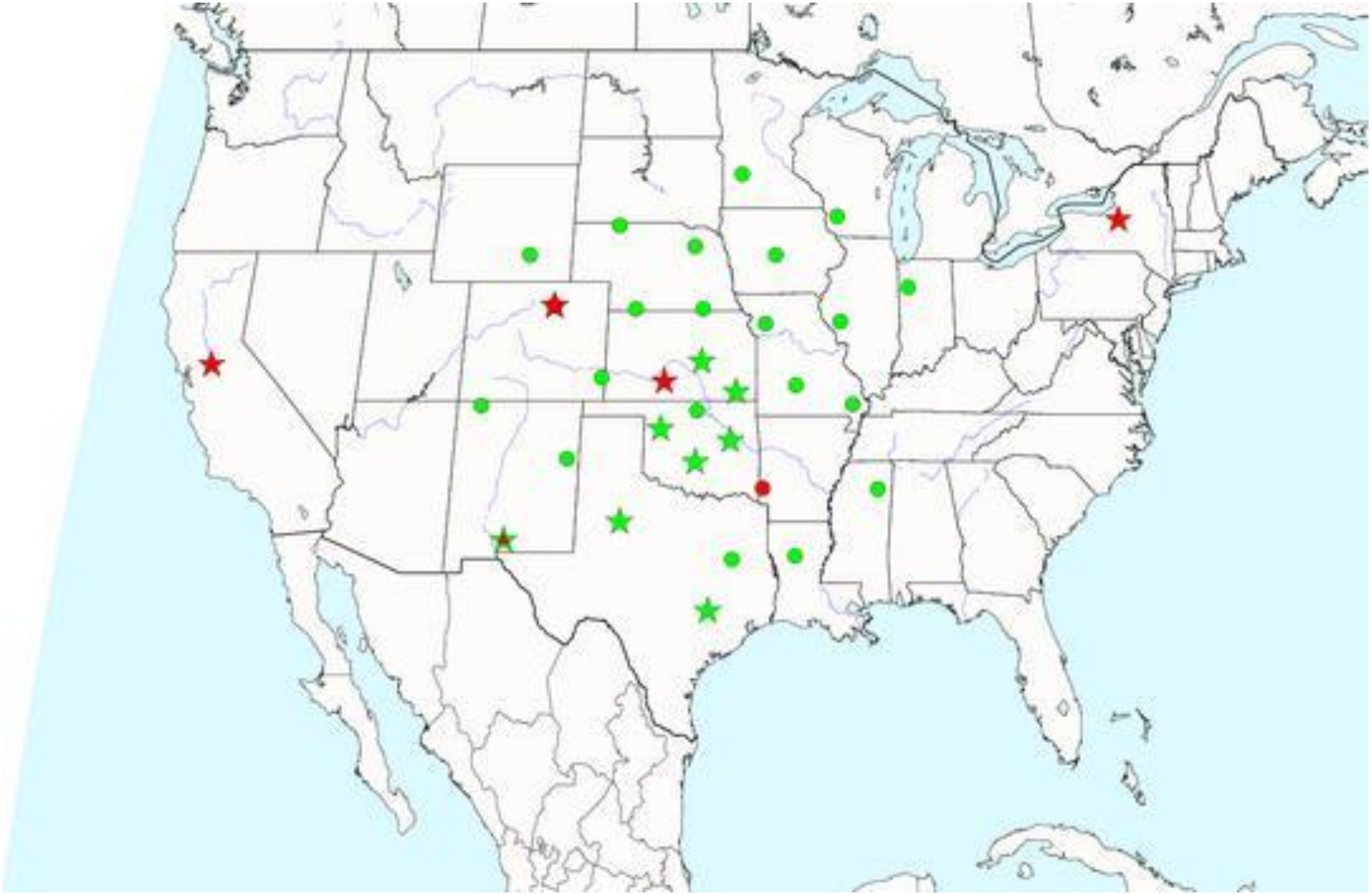
- Very limited and usually averaged (hourly, monthly, seasonally, annually)
- Deep layer (850 -200mb) shear for tropics but no full column shear values
- Mostly based on tower level data (0 -150m)
  - Central Plains network

# Observations

# Global Radiosonde Network

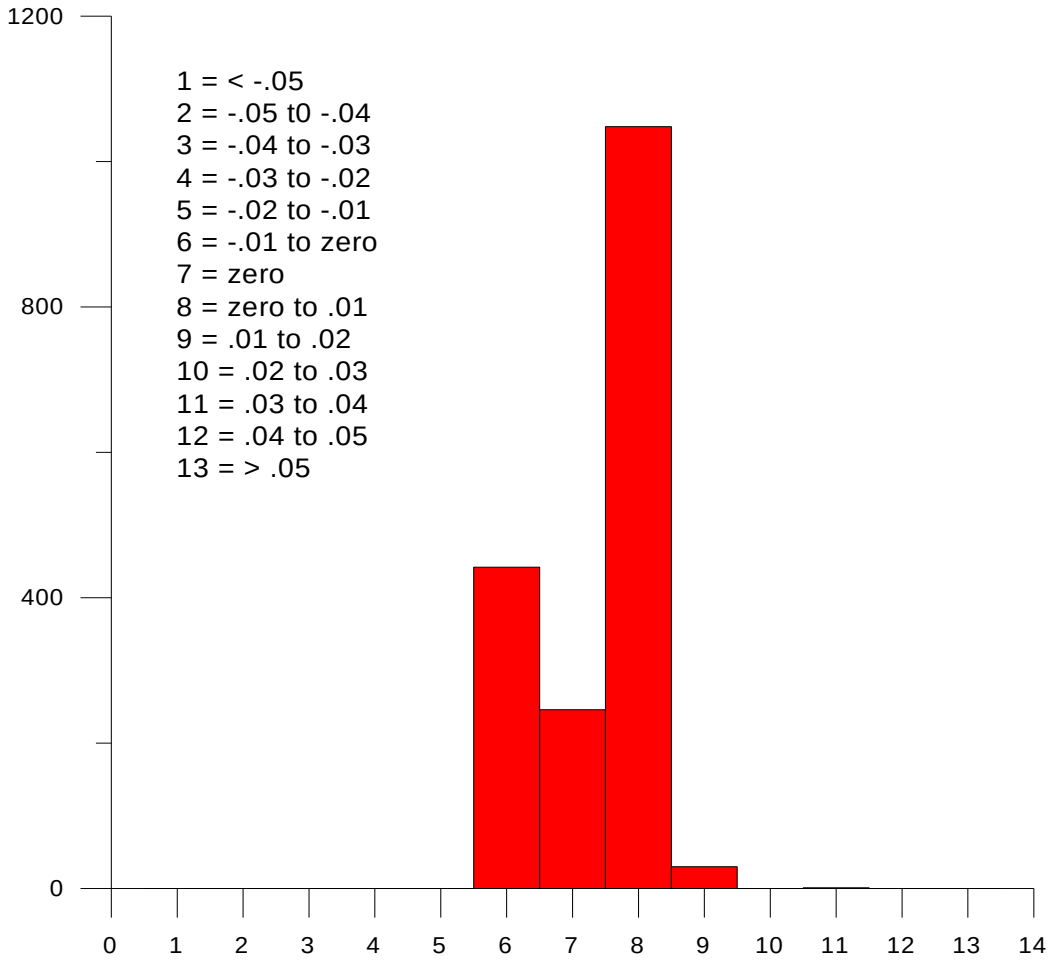


# NOAA Profiler Network (Central US)

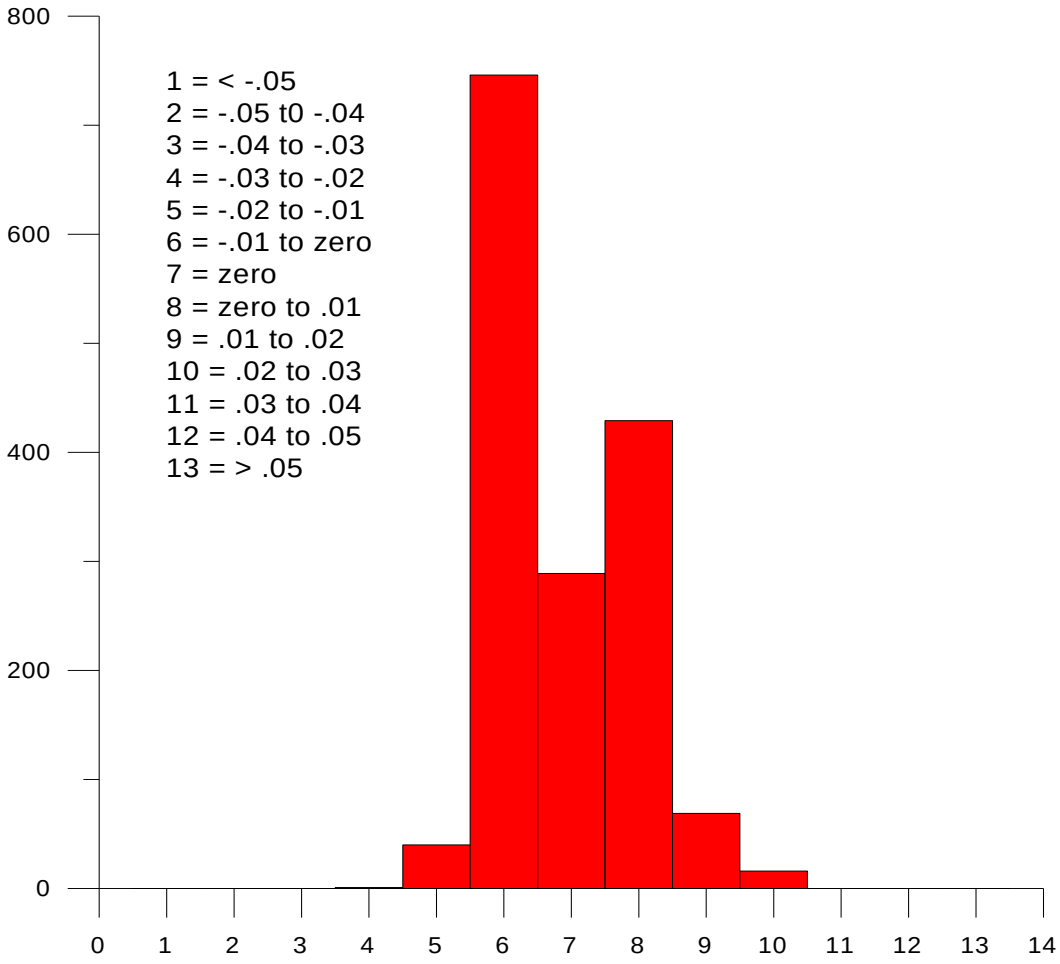


# COOPERATIVE AGENCY PROFILERS

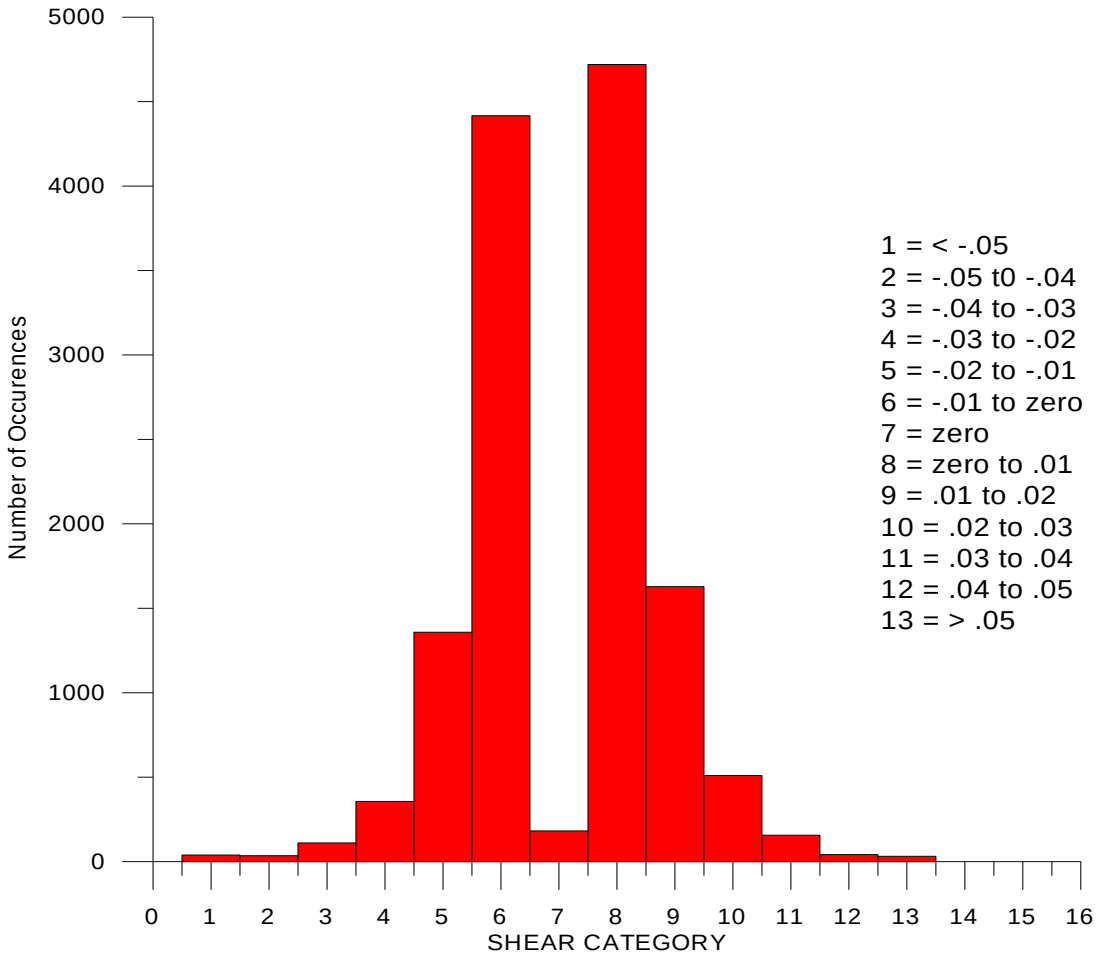
Wind Speed Shear (All Levels)
Miramar CA 12Z RAOB
August 2007



Wind Speed Shear (All Levels)
Lamont OK 12Z RAOB
August 2007

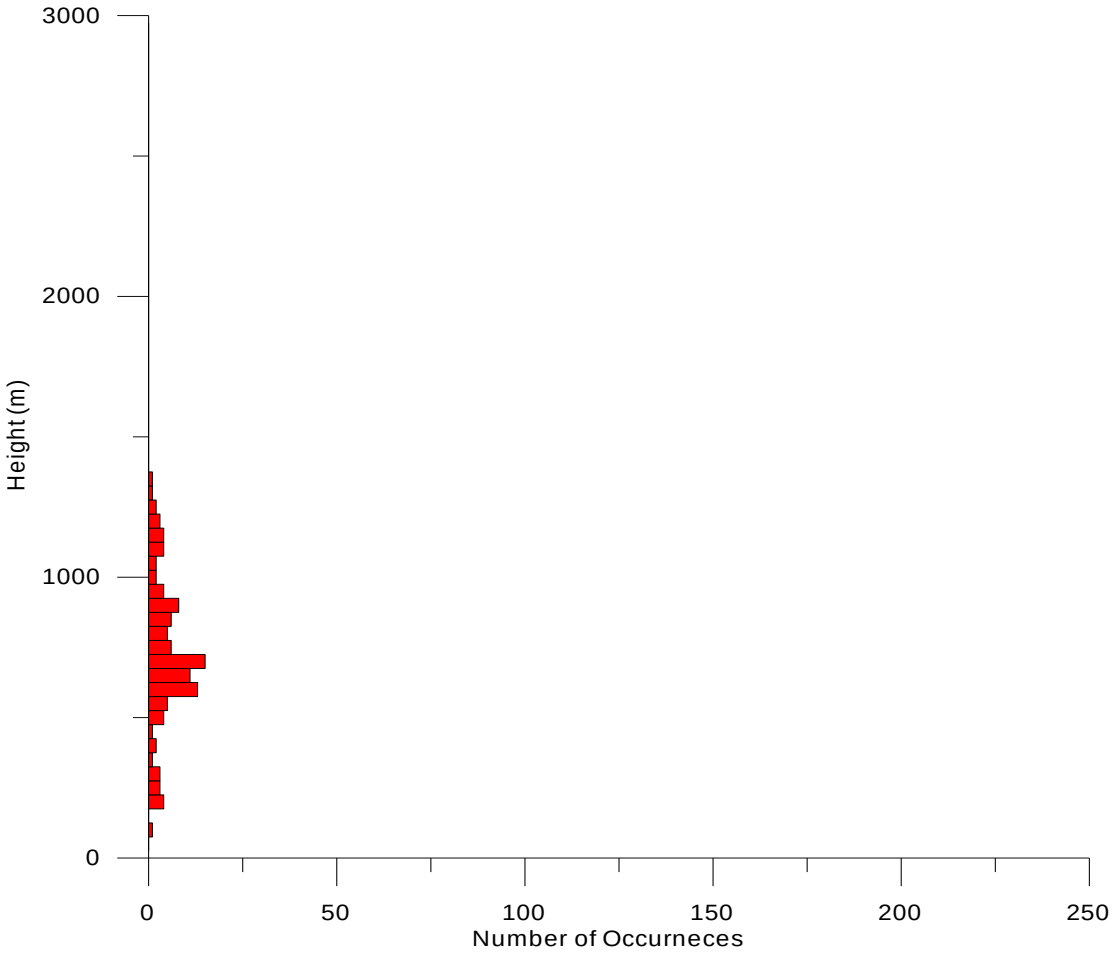


Wind Speed Shear (All Levels)
Miramar CA PROFILER - HIGH RES
August 2007



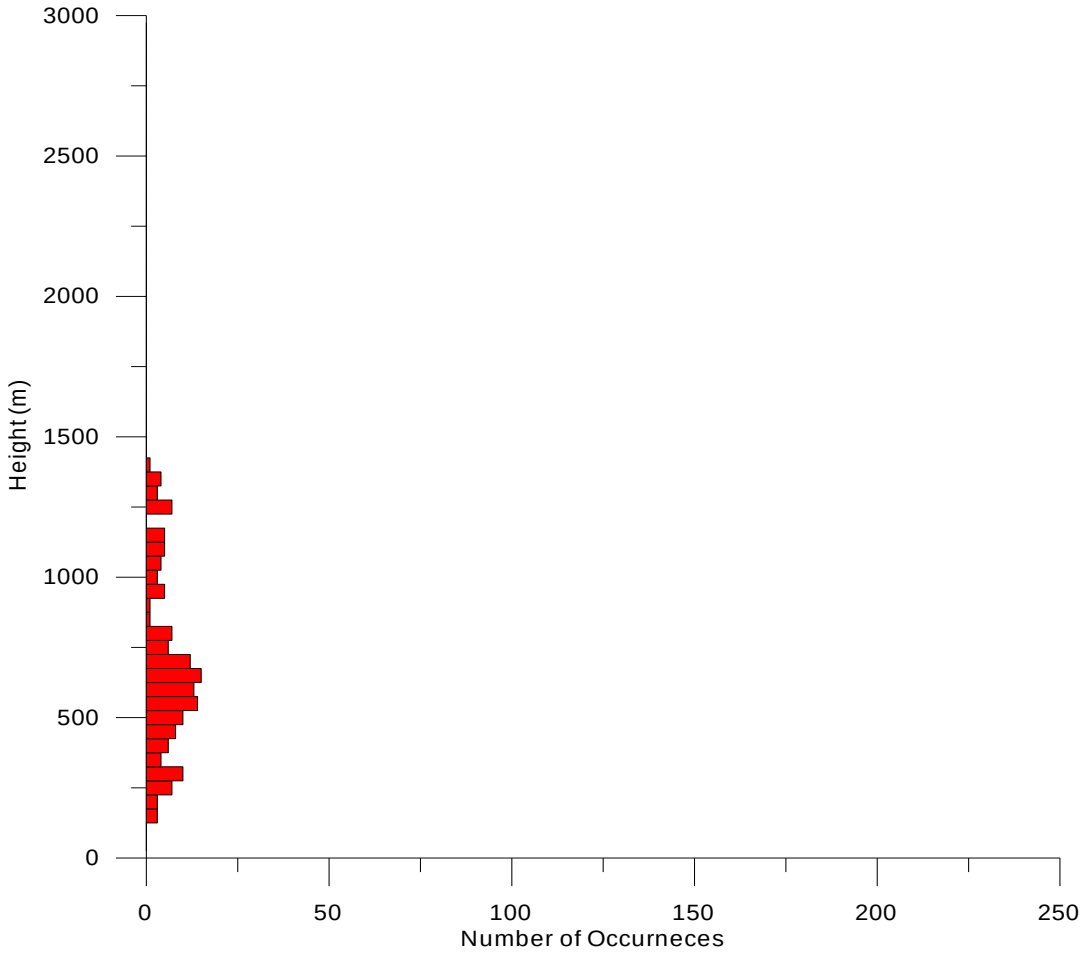
WIND Shear for AUG 2007
Miramar, CA Profiler (High Res)

Category 3 - (-.04 to -.03)

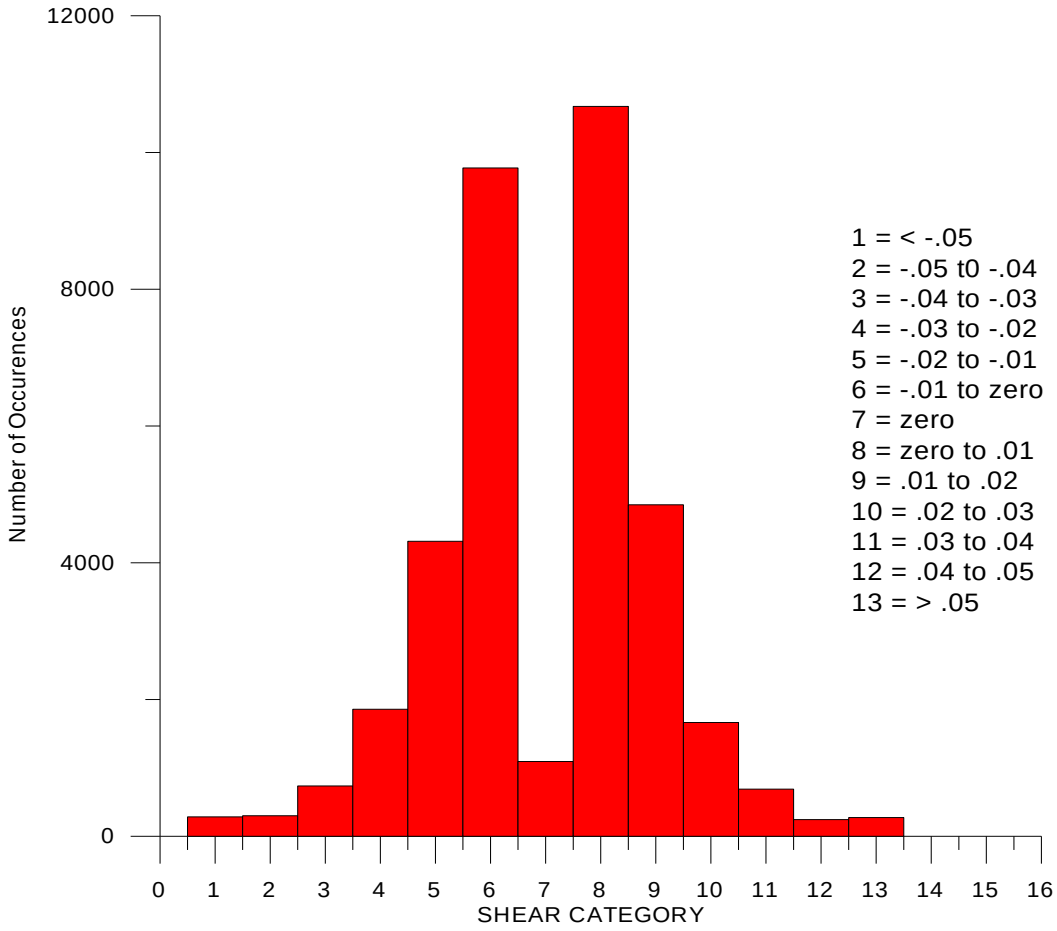


WIND Shear for AUG 2007
Miramar, CA Profiler (High Res)

Category 11 - (.03 to -.04)



Wind Speed Shear (All Levels)
NPS, CA PROFILER - HIGH RES
August 2007

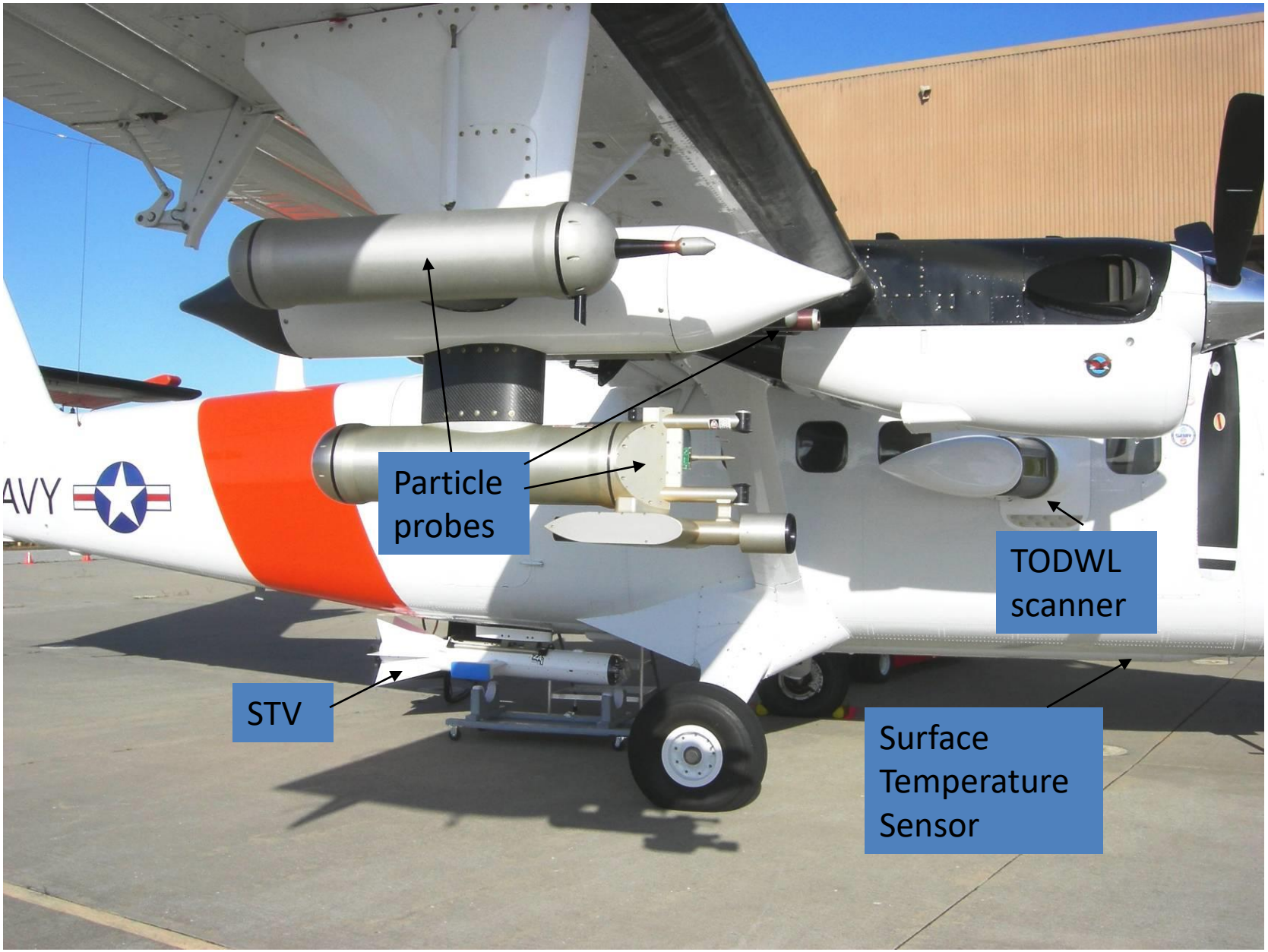


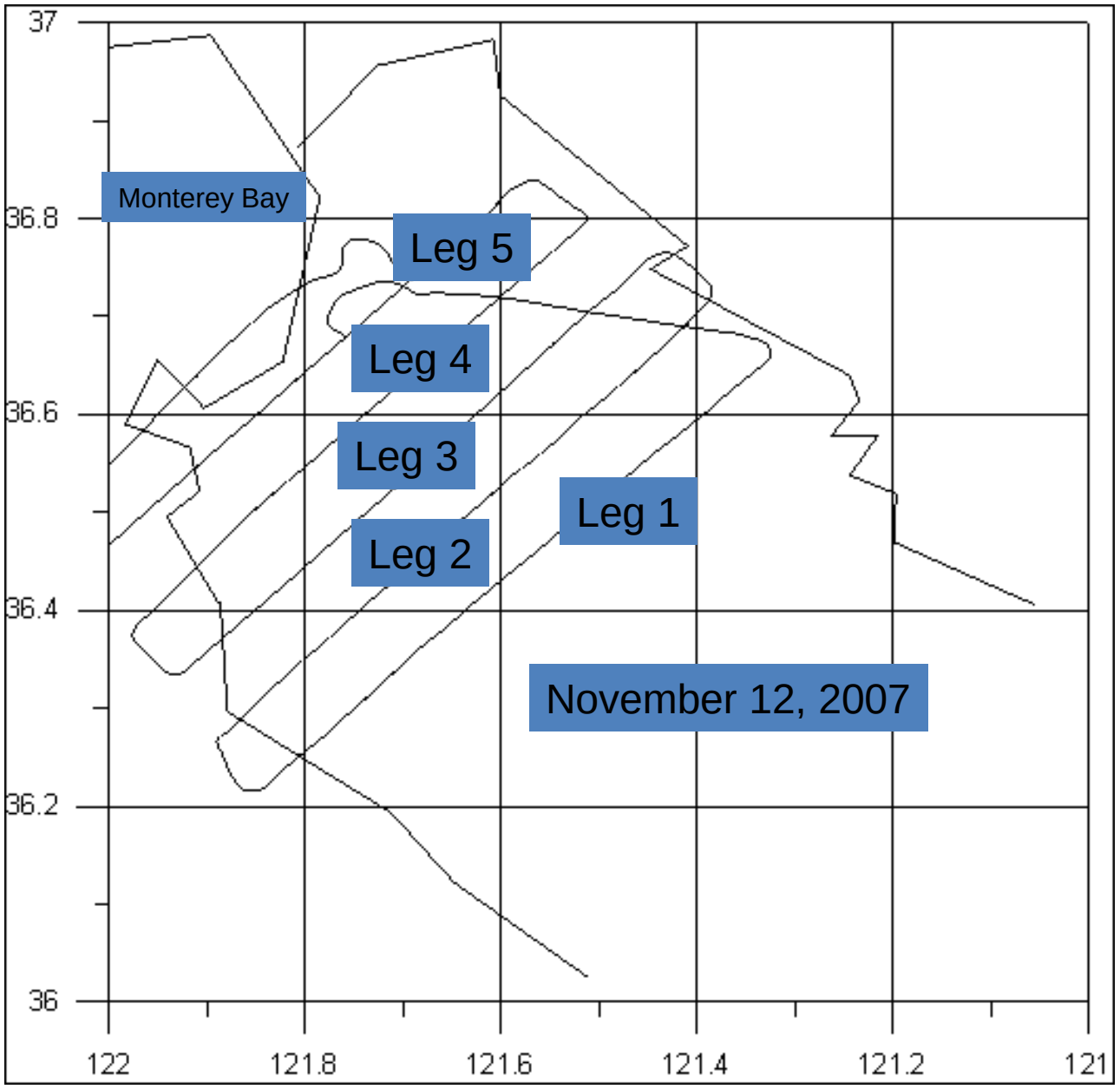
# TODWL

- **TODWL - Twin Otter Doppler Wind Lidar**
- Joint ONR and NPOESS IPO research project
- Flown aboard the Navy CIRPAS Twin Otter aircraft
- Flights supported by Army, Navy and DARPA
- Series of seven flight missions conducted near the coast of Monterey, CA since 2002 (125 hours)
- **Most recent campaign in November 2007**
- **Develop calibration/validation procedures for all wind profiling systems**

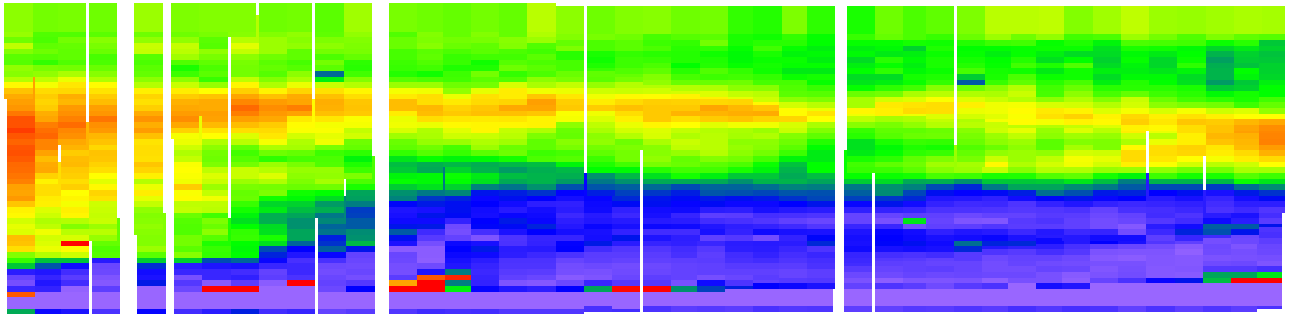
# TODWL DATA & OBSERVATIONS

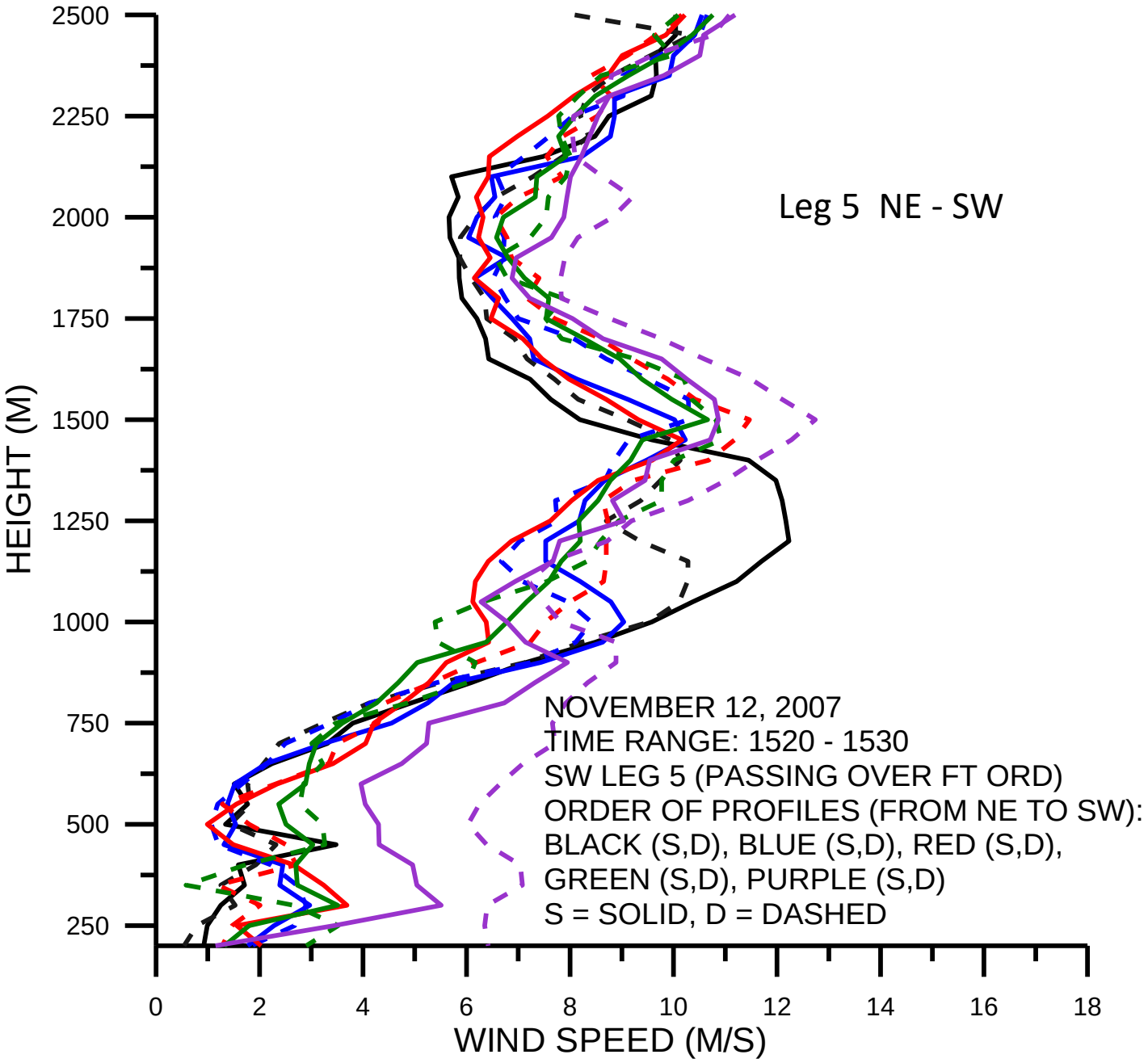
- Corrected for aircraft induced pointing errors
- Corrected for lidar beam pointing errors
- Employ threading near ground
- **Complete wind profiles every 250m**
- **Accuracy of .05 m/s for wind observations**
- **25-50 m vertical resolution**


Particle probes
TODWL scanner
STV
Surface Temperature Sensor


37
36.8
36.6
36.4
36.2
36
122
121.8
121.6
121.4
121.2
121
Monterey Bay
Leg 5
Leg 4
Leg 3
Leg 2
Leg 1
November 12, 2007

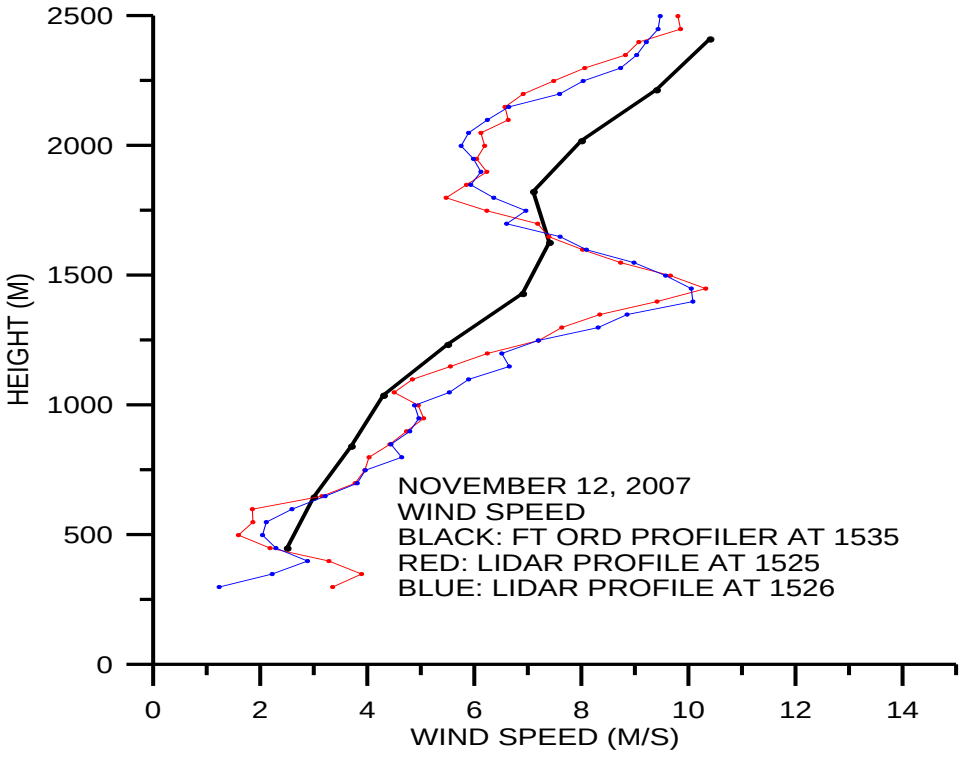
November 12, 2007
Wind Speed (m/s) vs Height
SW Leg 5 (1520 - 1530)

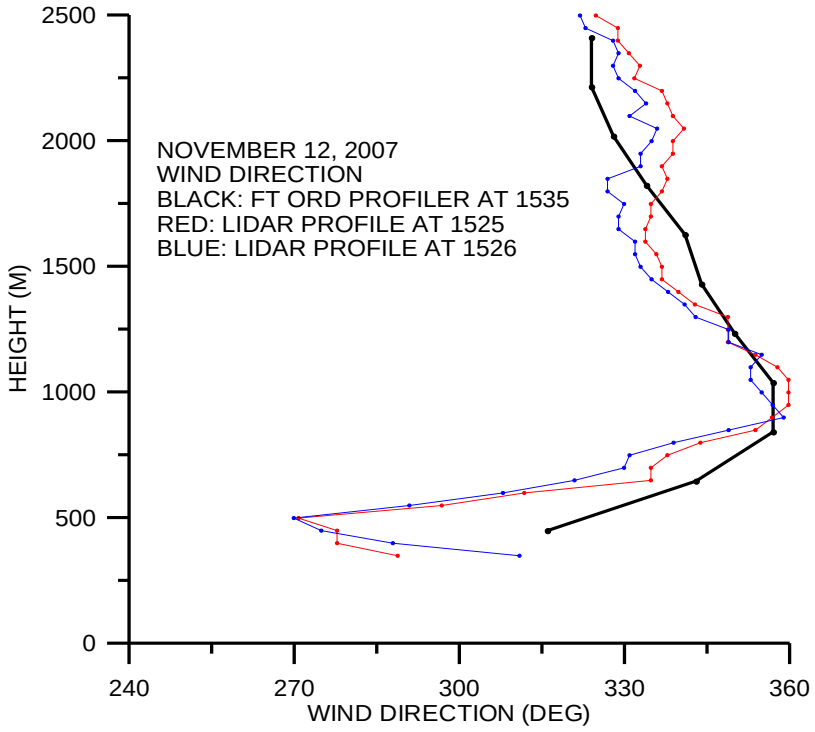



Leg 5 NE - SW
NOVEMBER 12, 2007
TIME RANGE: 1520 - 1530
SW LEG 5 (PASSING OVER FT ORD)
ORDER OF PROFILES (FROM NE TO SW):
BLACK (S,D), BLUE (S,D), RED (S,D),
GREEN (S,D), PURPLE (S,D)
S = SOLID, D = DASHED
HEIGHT (M)
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
2
4
6
8
10
12
14
16
18
WIND SPEED (M/S)

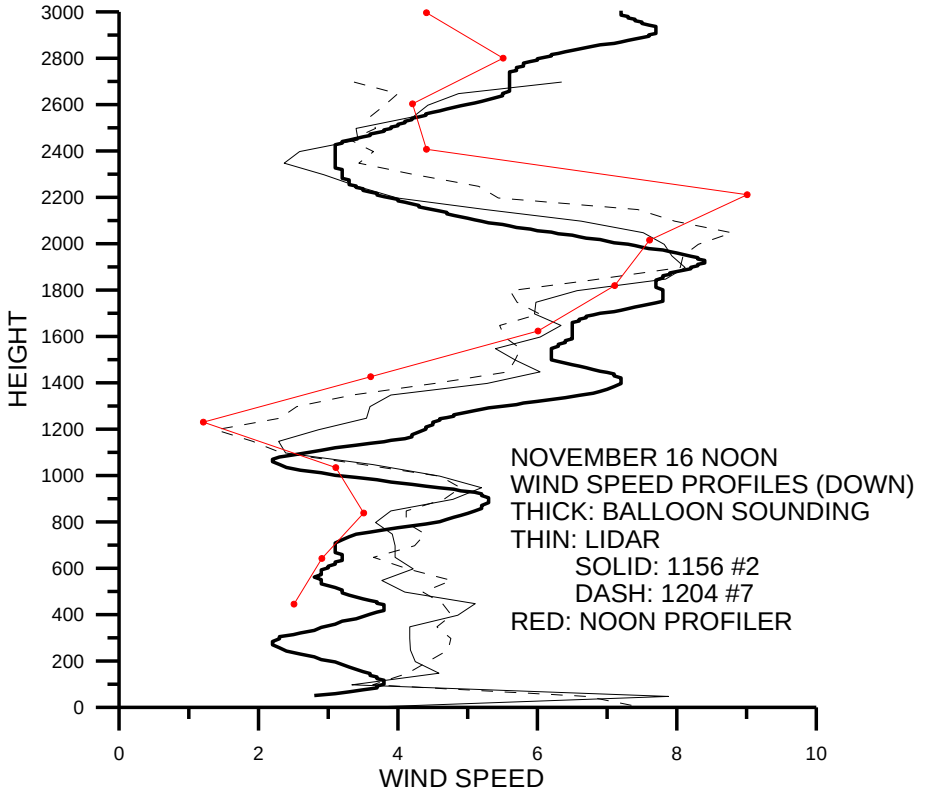
# Intercomparisons

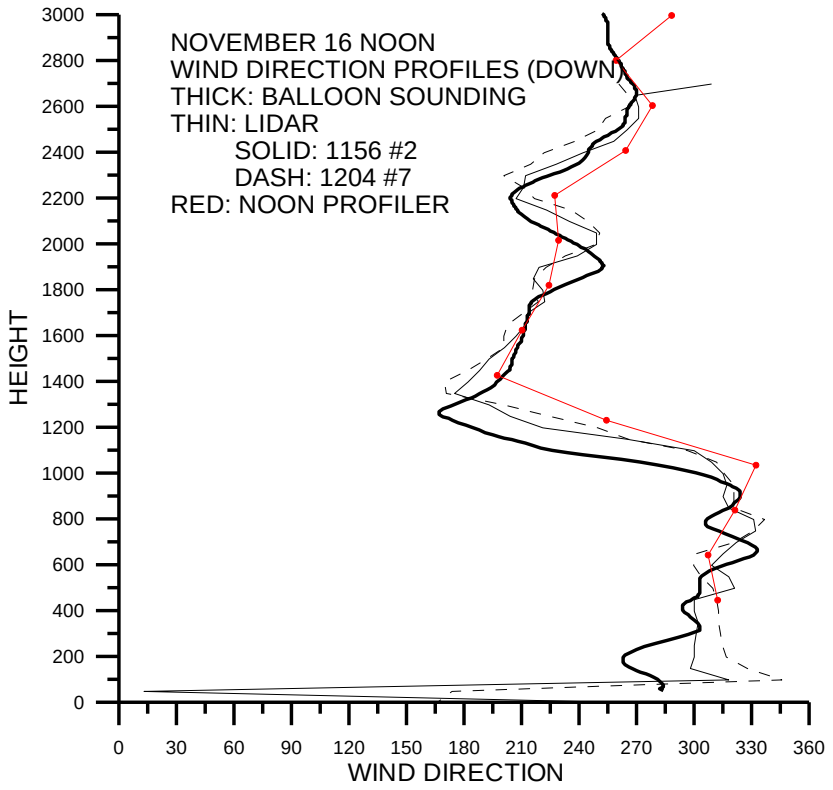
# TODWL vs. microwave sounder



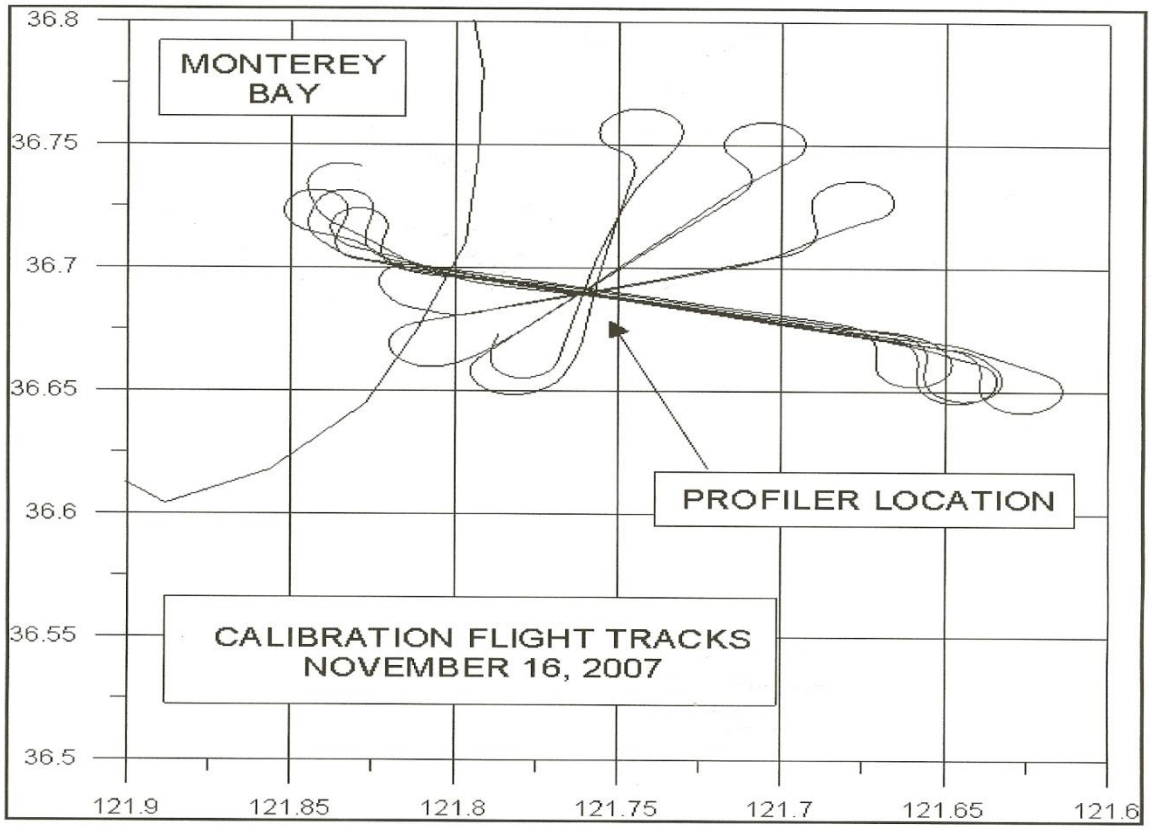



# TODWL vs. Rawinsondes

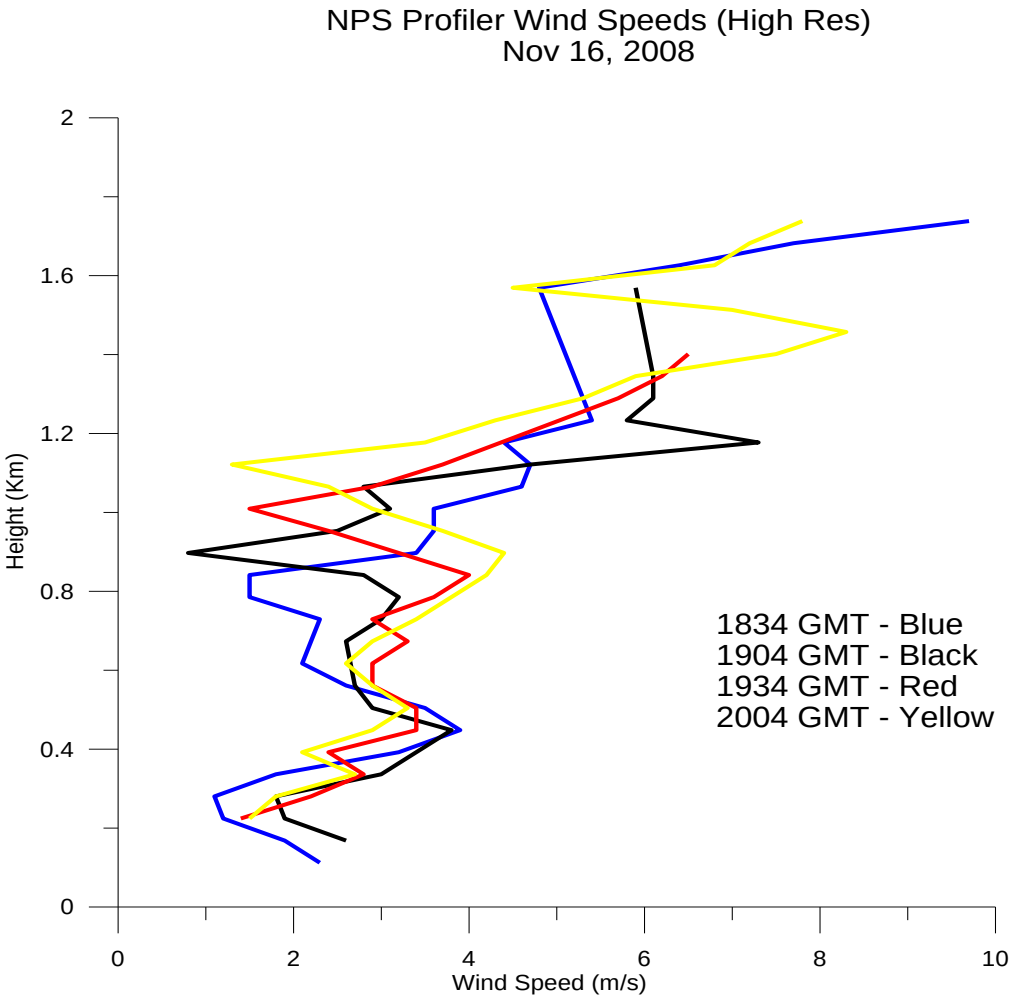


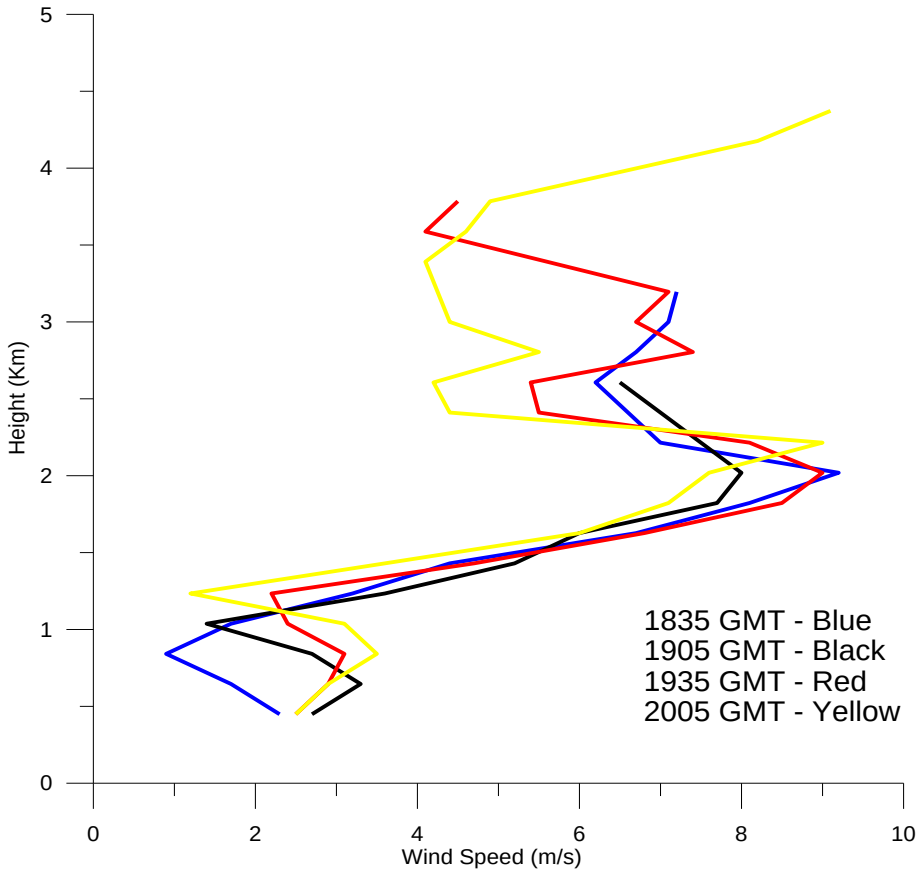
# November 16, 2007 Calibration Flight


MONTEREY BAY
PROFILER LOCATION
CALIBRATION FLIGHT TRACKS
NOVEMBER 16, 2007
36.8
36.75
36.7
36.65
36.6
36.55
36.5
121.9
121.85
121.8
121.75
121.7
121.65
121.6

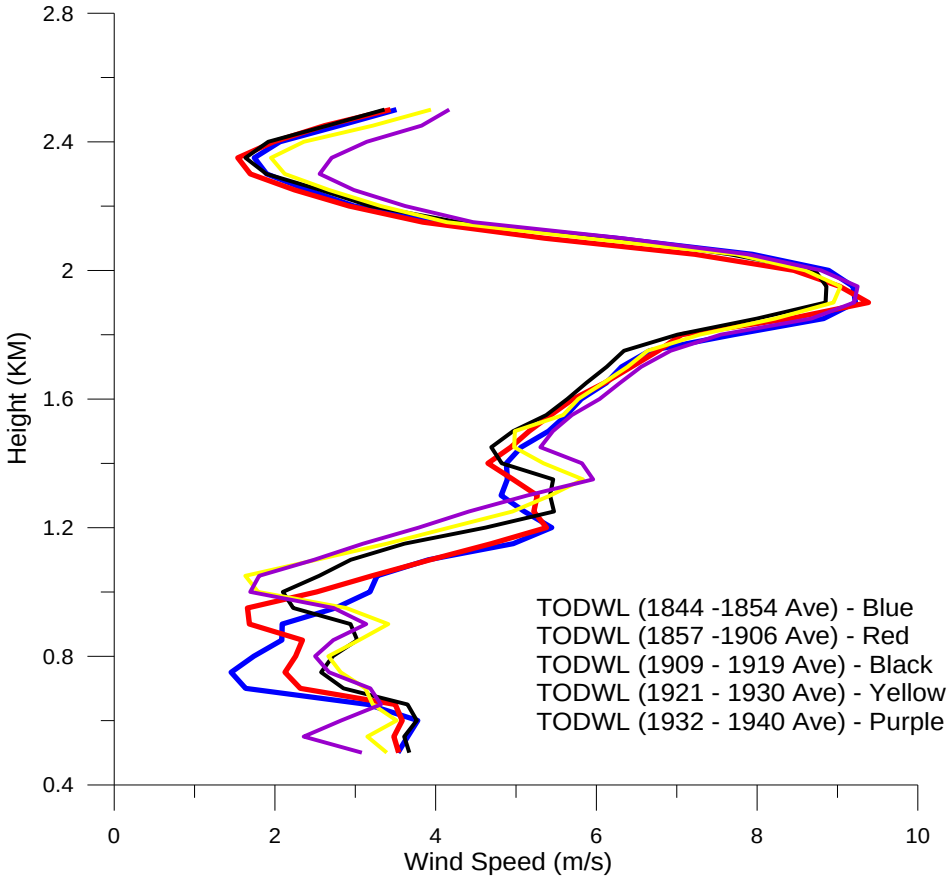
2/20/2008

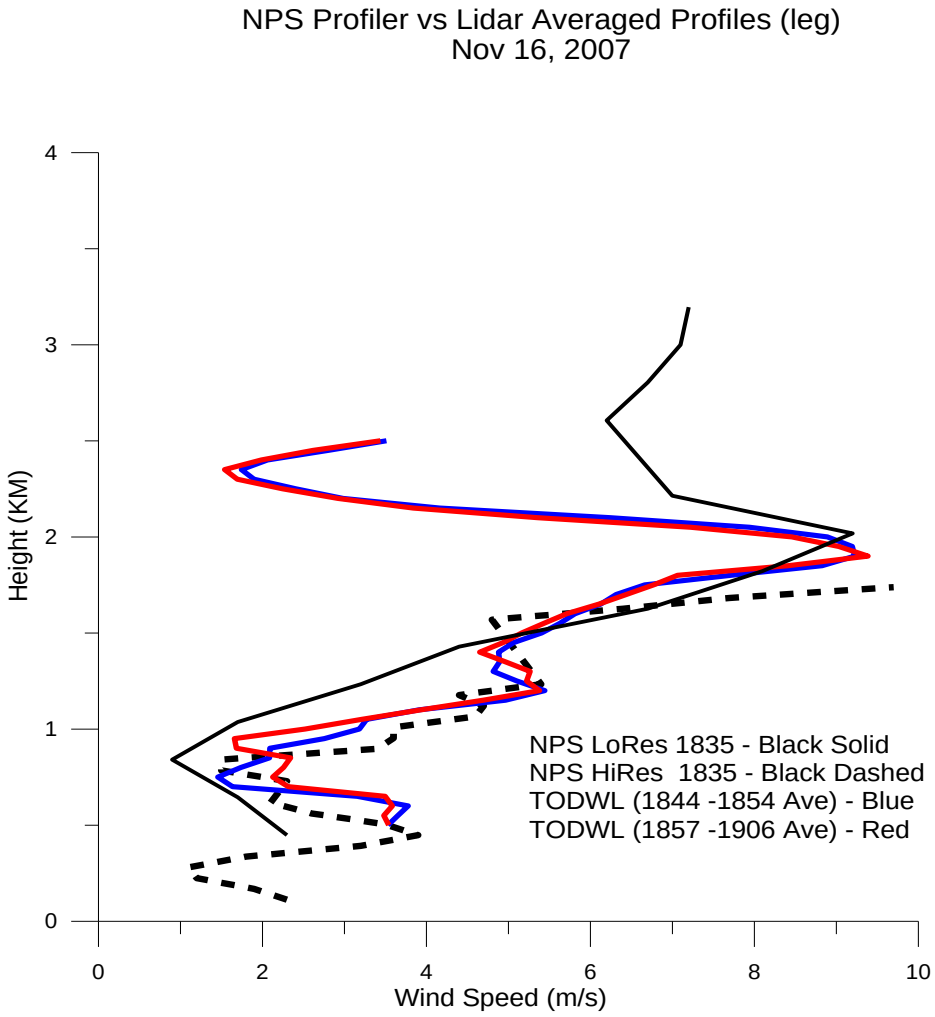

NPS Profiler Wind Speeds (High Res)
Nov 16, 2008
Height (Km)
2
1.6
1.2
0.8
0.4
0
0
2
4
6
8
10
Wind Speed (m/s)
1834 GMT - Blue
1904 GMT - Black
1934 GMT - Red
2004 GMT - Yellow

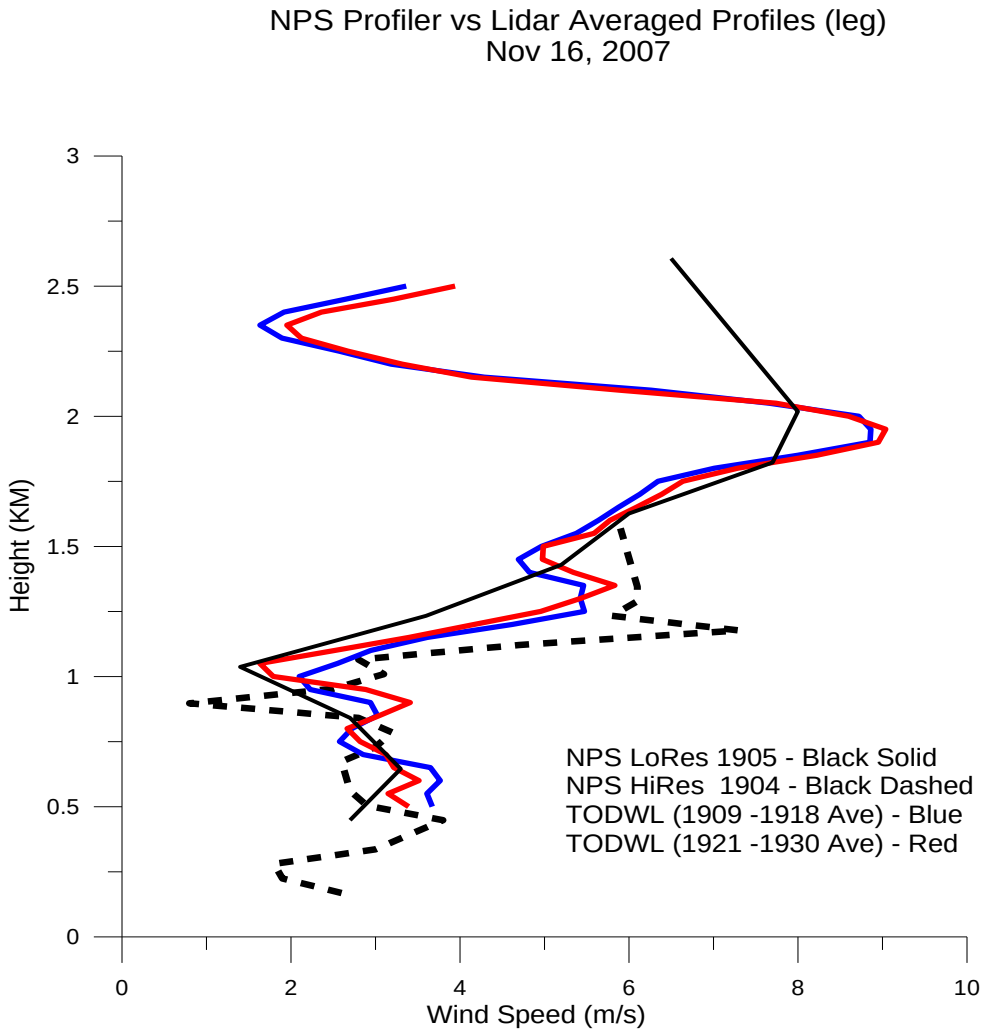
NPS Profiler Wind Speeds (Low Res)
Nov 16, 2008



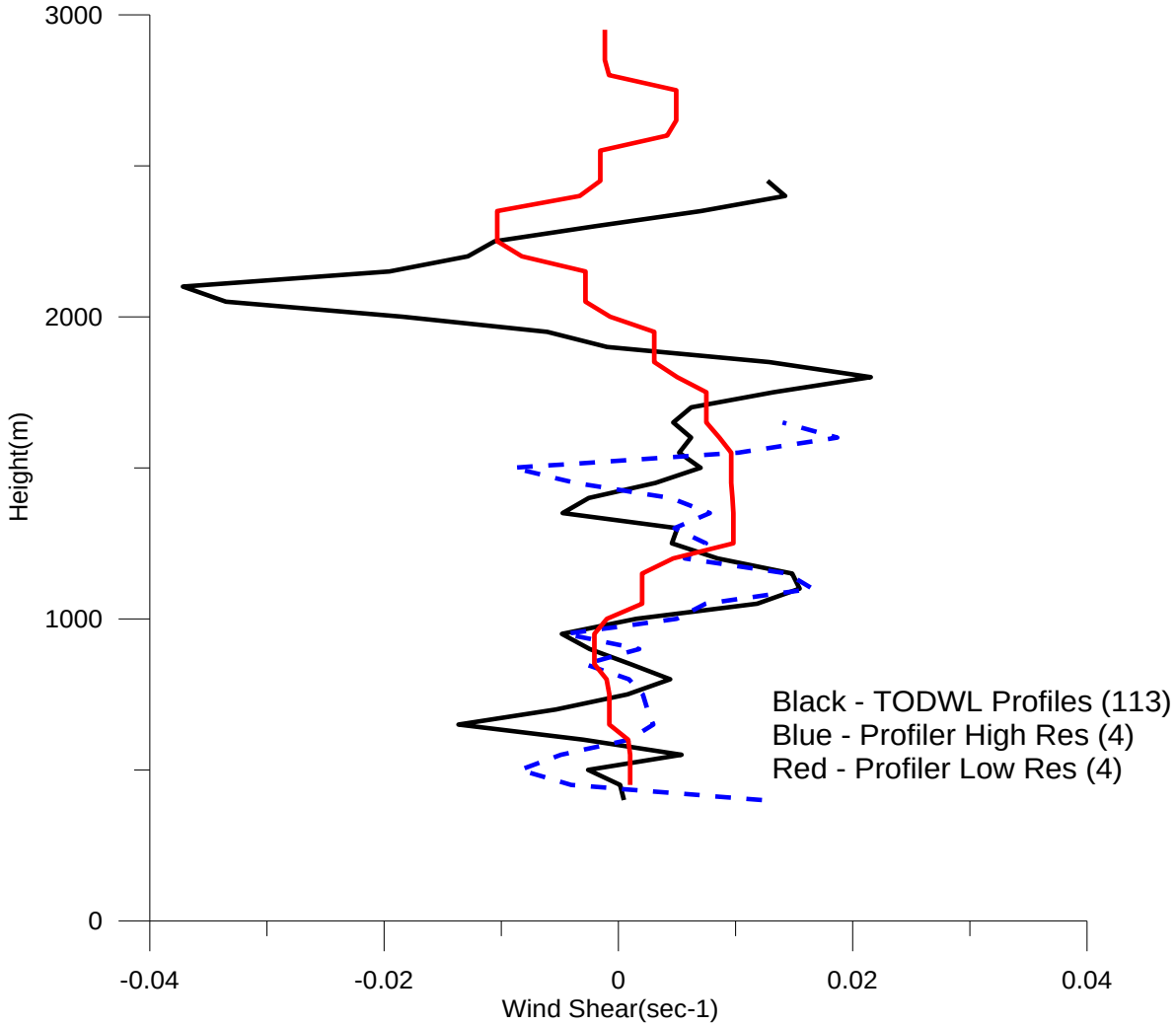
Lidar Averaged Profiles (leg)
Nov 16, 2007




NPS Profiler vs Lidar Averaged Profiles (leg)
Nov 16, 2007
Height (KM)
Wind Speed (m/s)
0
1
2
3
4
0
2
4
6
8
10
NPS LoRes 1835 - Black Solid
NPS HiRes 1835 - Black Dashed
TODWL (1844 -1854 Ave) - Blue
TODWL (1857 -1906 Ave) - Red

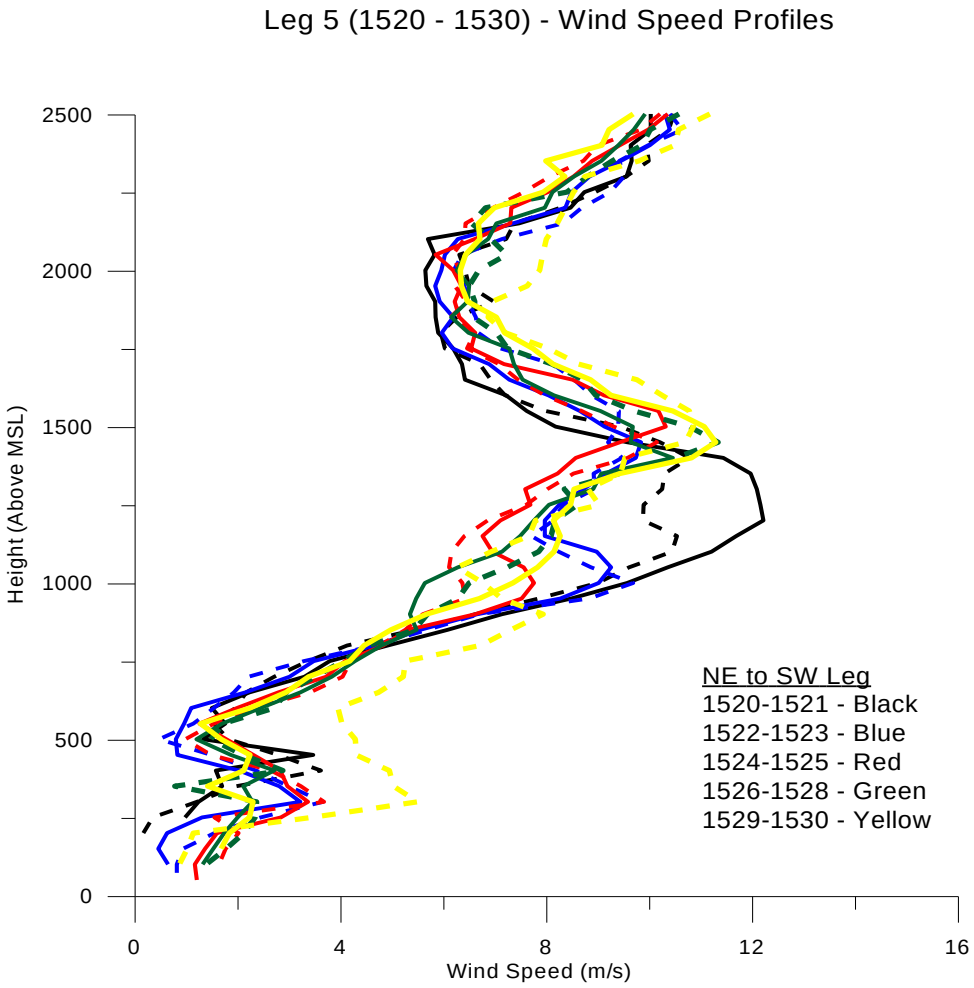

NPS Profiler vs Lidar Averaged Profiles (leg)
Nov 16, 2007
Height (KM)
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
Wind Speed (m/s)
NPS LoRes 1905 - Black Solid
NPS HiRes 1904 - Black Dashed
TODWL (1909 -1918 Ave) - Blue
TODWL (1921 -1930 Ave) - Red

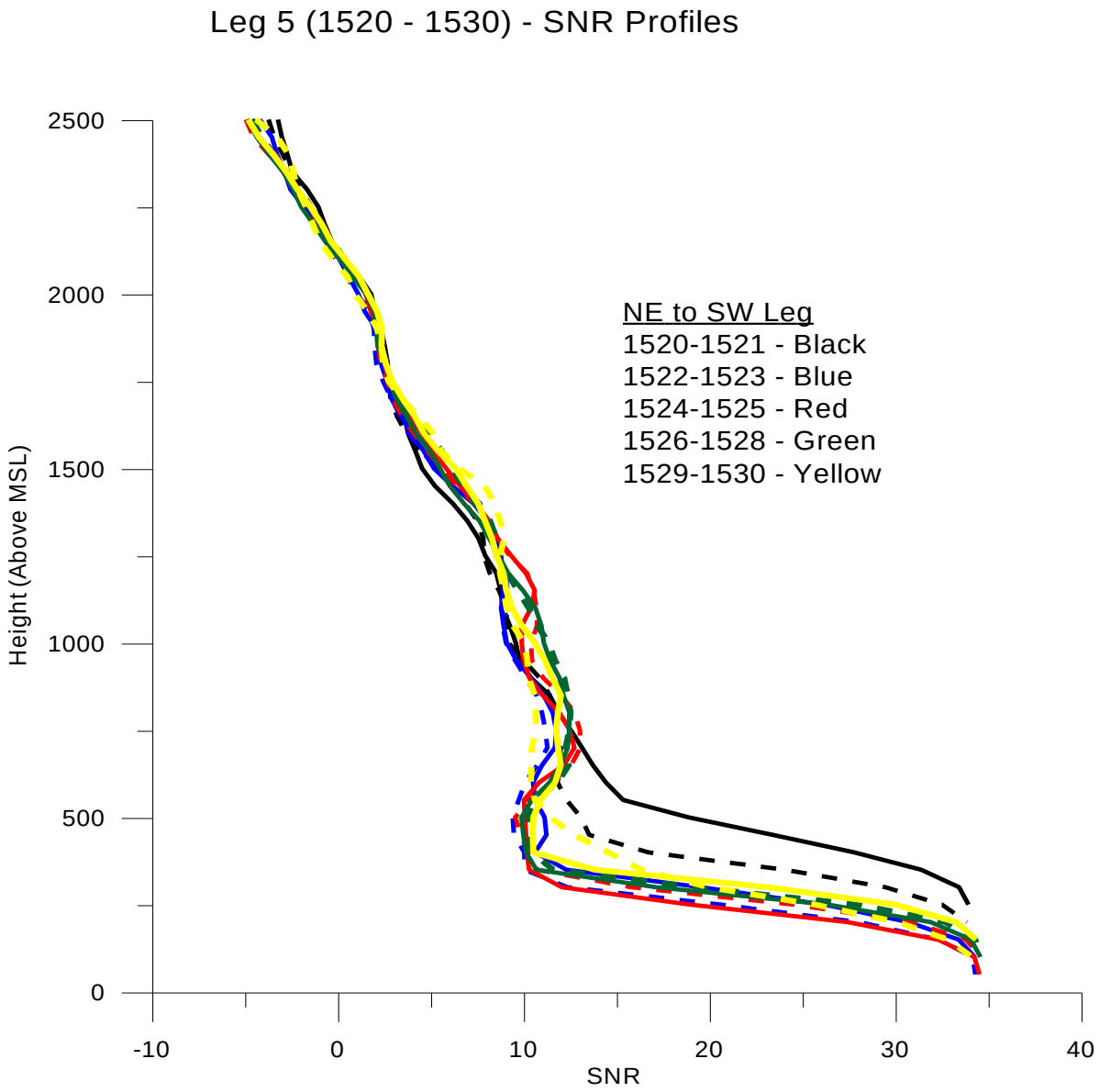
Nov 16, 2007
TODWLS vs Fort Ord Profiler (calibration mission)
1835 - 2005 GMT

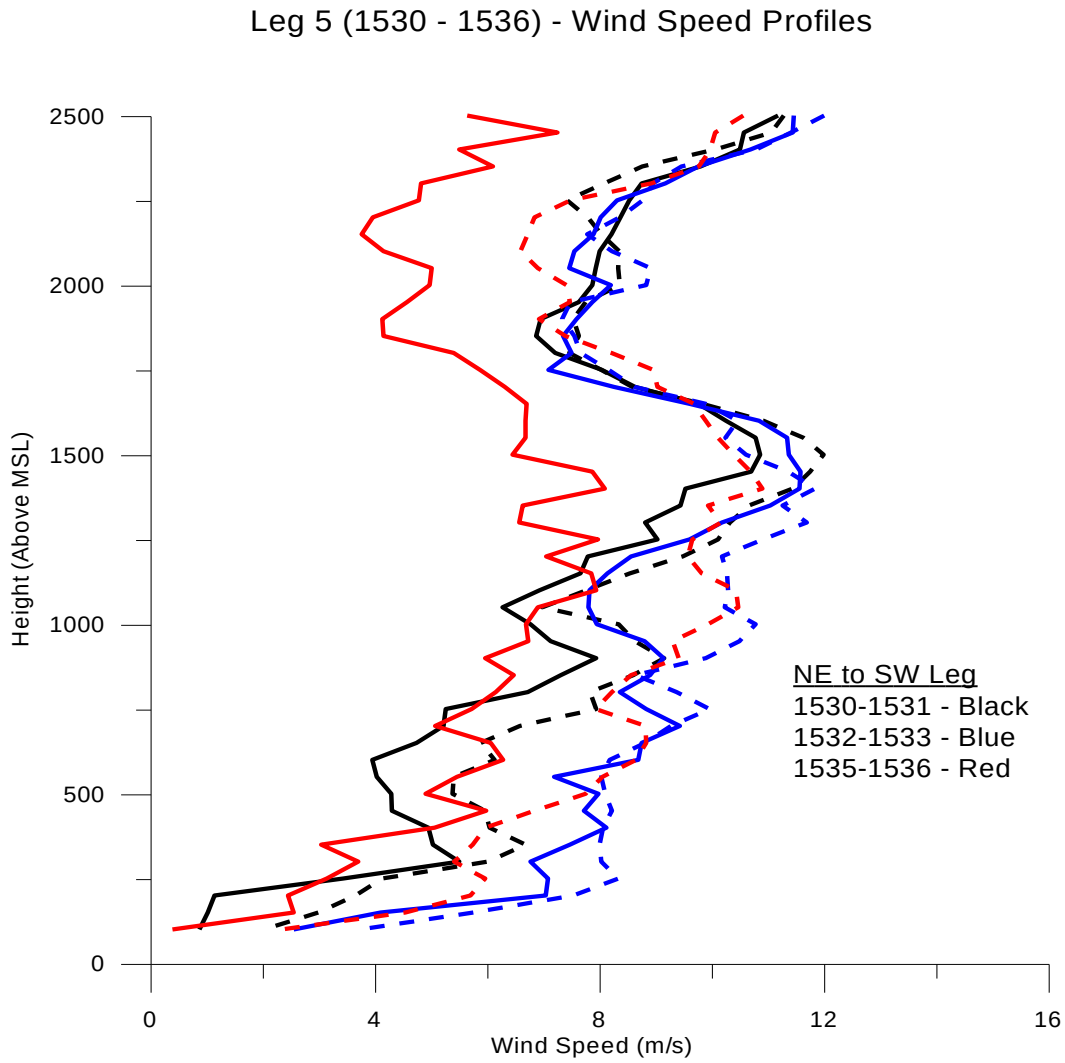


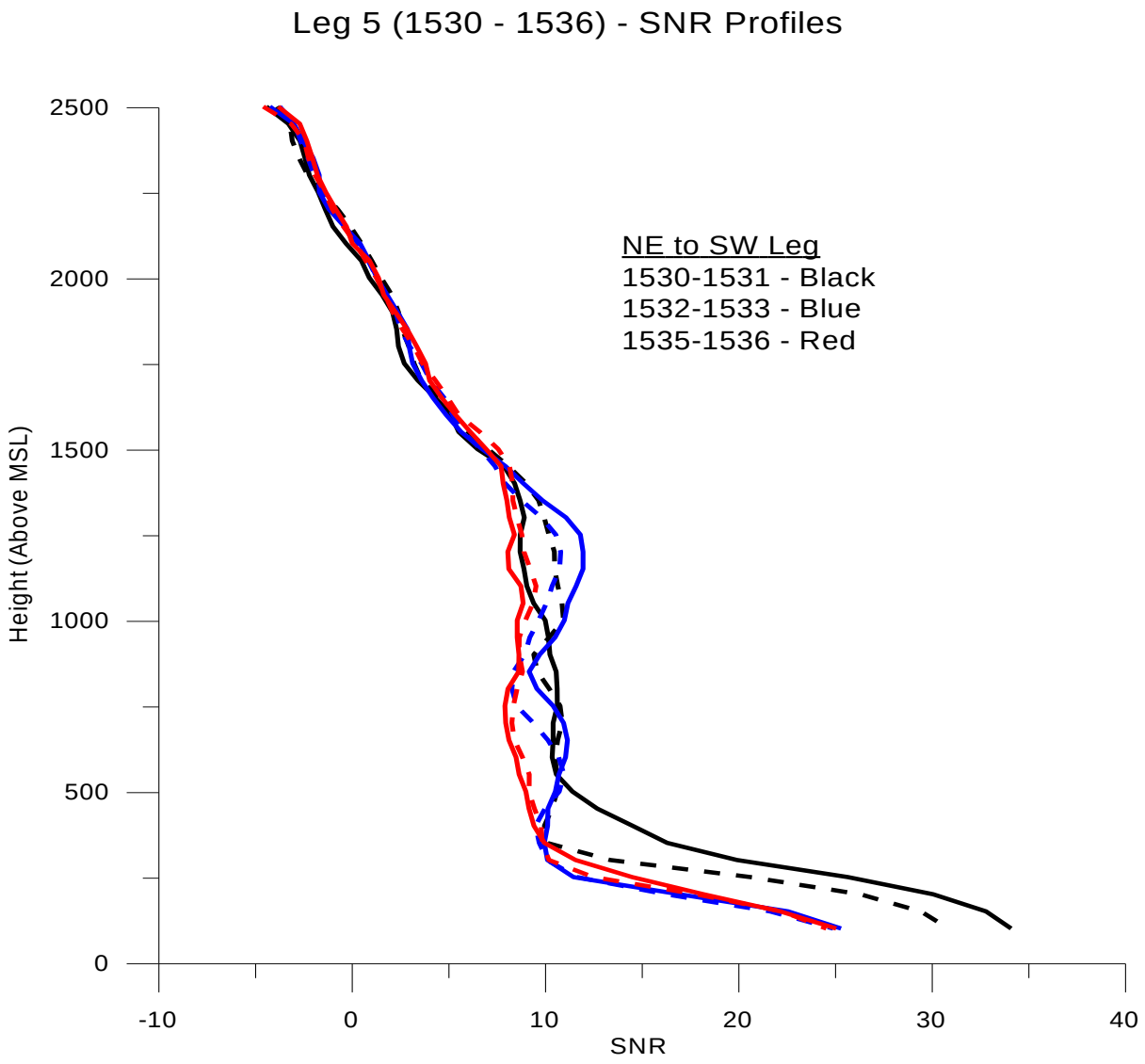
# Concluding Thoughts

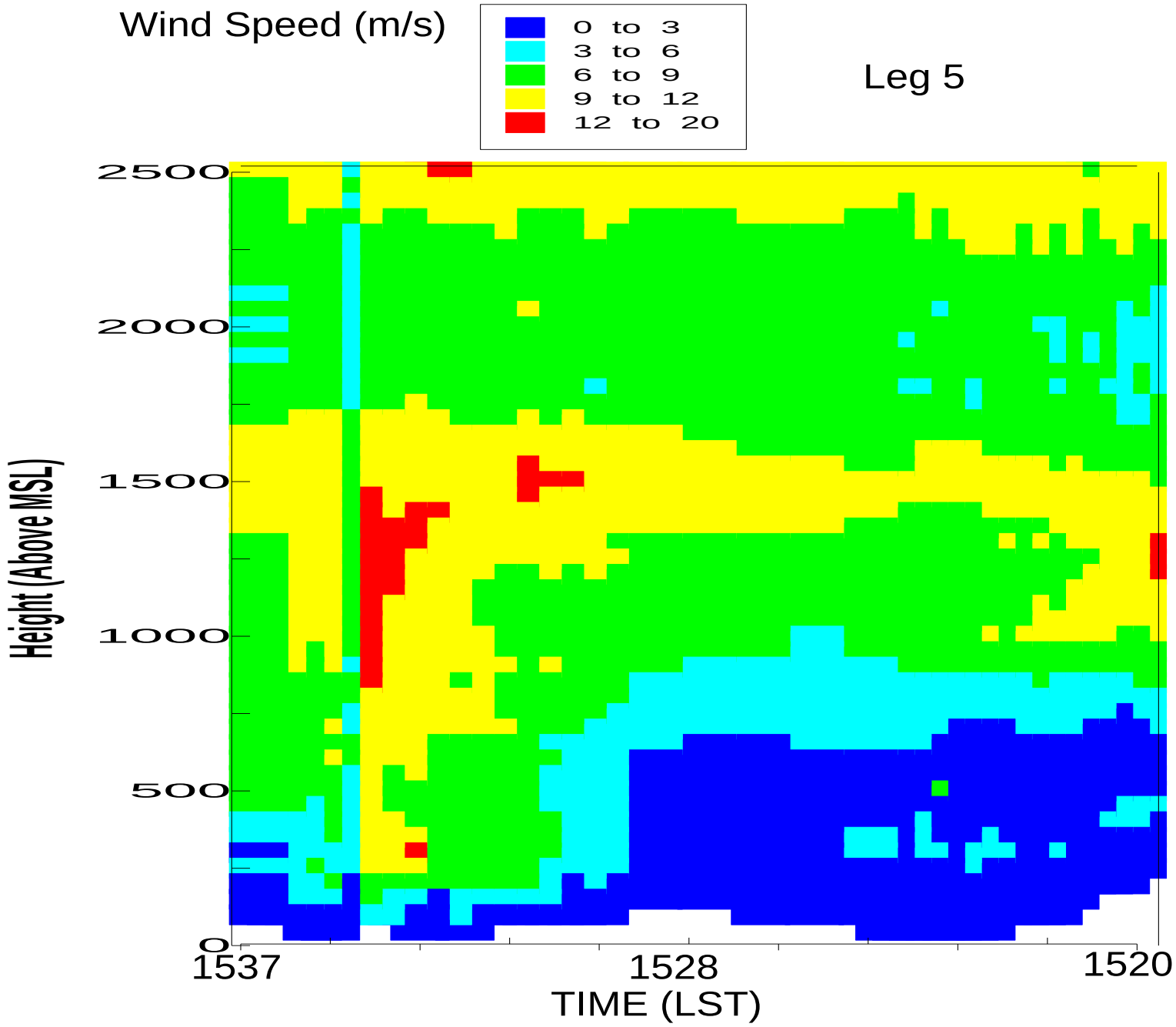
- High resolution shear measurements represents a primary target of both current airborne and future space-based observations and a challenge to signal processing
- Shear represents a major source of bias and possible error in estimating an average wind over a layer
- Airborne lidar provide excellent data bases for simulating space-based DWL observations of shear.

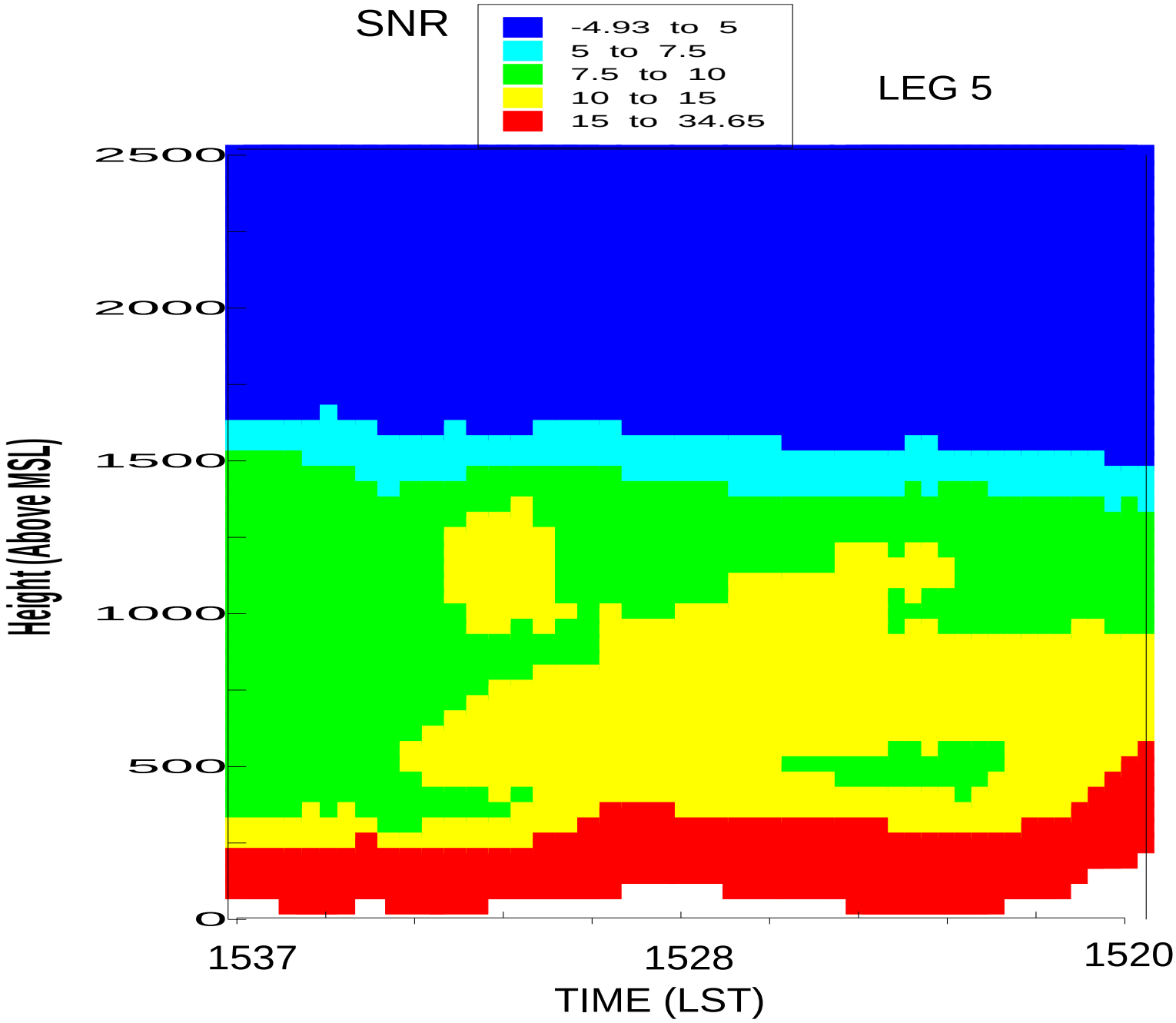

Leg 5 (1520 - 1530) - Wind Speed Profiles
Height (Above MSL)
2500
2000
1500
1000
500
0
0
4
8
12
16
Wind Speed (m/s)
NE to SW Leg
1520-1521 - Black
1522-1523 - Blue
1524-1525 - Red
1526-1528 - Green
1529-1530 - Yellow


Leg 5 (1520 - 1530) - SNR Profiles
Height (Above MSL)
2500
2000
1500
1000
500
0
-10
0
10
20
30
40
SNR
NE to SW Leg
1520-1521 - Black
1522-1523 - Blue
1524-1525 - Red
1526-1528 - Green
1529-1530 - Yellow


Leg 5 (1530 - 1536) - Wind Speed Profiles
Height (Above MSL)
2500
2000
1500
1000
500
0
0
4
8
12
16
Wind Speed (m/s)
NE to SW Leg
1530-1531 - Black
1532-1533 - Blue
1535-1536 - Red


Leg 5 (1530 - 1536) - SNR Profiles
NE to SW Leg
1530-1531 - Black
1532-1533 - Blue
1535-1536 - Red
Height (Above MSL)
2500
2000
1500
1000
500
0
-10
0
10
20
30
40
SNR


Wind Speed (m/s)
0 to 3
3 to 6
6 to 9
9 to 12
12 to 20
Leg 5
2500
2000
1500
1000
500
0
Height (Above MSL)
1537
1528
1520
TIME (LST)


SNR
-4.93 to 5
5 to 7.5
7.5 to 10
10 to 15
15 to 34.65
LEG 5
2500
2000
1500
1000
500
0
Height (Above MSL)
1537
1528
1520
TIME (LST)