Integrating Airborne DWL and PBL Models in Real Time

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WGSBLW
Miami 2007

Overview

- The Twin Otter Doppler Wind Lidar (TODWL)
  - Current plans for Monterey, CA
    - Towed platform
    - Coastal long flight legs
    - WindSat & QuickScat underflights
    - Prospecting for UAV atmospheric advantages
- Review of 2003 model/TODWL profile comparisons
- Recent start for Army sponsored realtime DWL/model validation and initialization

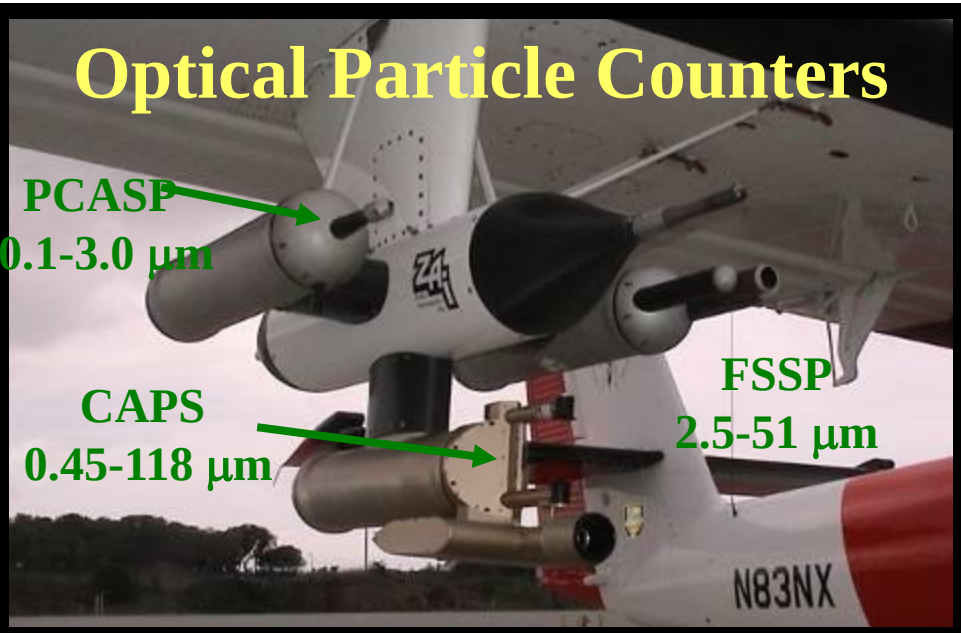
Airborne Doppler Wind Lidar

Aircraft Platform

NPS CIRPAS Twin Otter

Naval Postgraduate School
Center for Interdisciplinary Remotely-piloted Aircraft Studies

Optical Particle Counters



TODWL Instrument

2.0125 µm, coherent detection

2 mJ, 330 nsec (FWHM), 500 Hz

10 cm telescope

two axis scanner, ±30 & ±120 deg, side door mount

Weight: 425lb Power: 1.5KW

~7-10% total system efficiency

TODWL Scanner

TODWL Characteristics

Wavelength (microns)	2.05 (eyesafe)
Energy per pulse (mJ)	2-3
Pulse repetition frequency (Hz)	500
Scanner	2 axis (+- 120; +- 30)
Range resolution (meters)	50-100
LOS measurement accuracy (m/s)	< .05 per single shot w/ground calibration
Wind component accuracy (m/s)	u,v,w < .1 m/s nominal using a 30 degree VAD and LADSA
Aerosol backscatter threshold sensitivity	Range dependent: ~ 10 -08 m sr-1 at 10km
Nominal range to insensitivity (km)	Aerosol dependent: nominal 15-20 km in PBL and 2-5 km above PBL

The Twin Otter Aircraft

- Navy Twin Otter operated by CIRPAS out of Marina, CA
- Unpressurized (~ 10 ft normal operations)
- Cruise speeds 100 - 140 kts
- Equipped with:
  - GPS/INS
  - Dropsonde
  - aerosol probes
  - temperature, water vapor, turbulence sensors

Smart Towed Platform

Zivko Aeronautics and CIRPAS

Near term flight plans

- Support Towed Platform experiments
- IPO/NESDIS(OSD) funded experiments
  - Undeflights of WindSat and QuickScat
  - Long baseline profiles for assimilation into NCEP models
- SkyWalker exploratory flights: Prospecting for UAV atmospheric advantages (next paper)

March 2003 profile set

Summary of Observation Comparisons

- The TODWL soundings have been processed to obtain accuracies of <.10 m/s in each component (u,v,w).
- Comparisons with other sounders must be interpreted with caution since integration times and sample volumes are different.
- Comparisons with model predictions suggest a significant effort is needed to understand the differences.

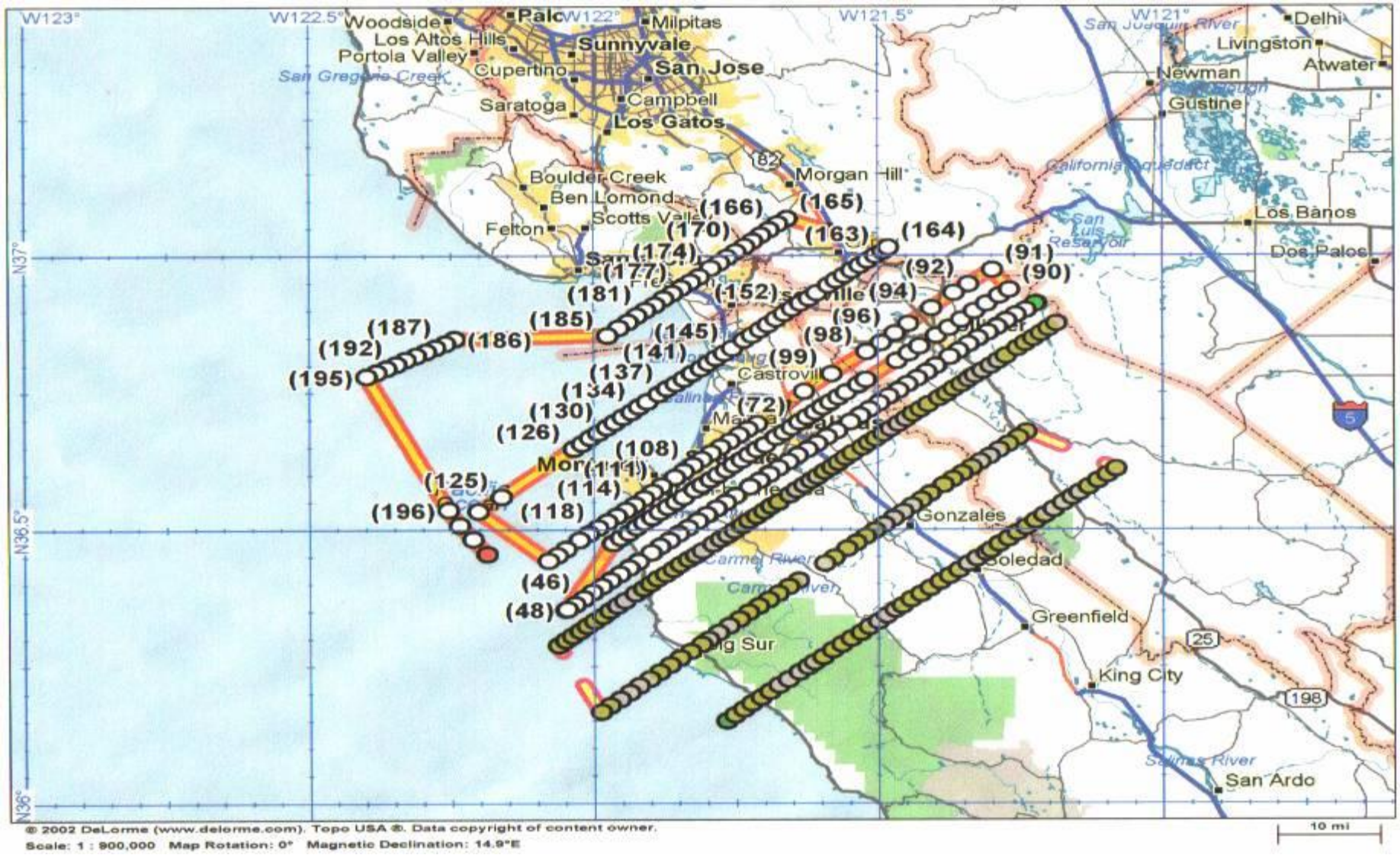
MM5 Model Validation

- Working with Nuss and Miller at NPS
- TODWL collected ~3000 profiles over a period of 4 hours with 50 m vertical resolution, ~ 600 m horizontal resolution and ~ .10 m/s accuracy (over cycloid)
- Comparison with 4 km MM5 runs

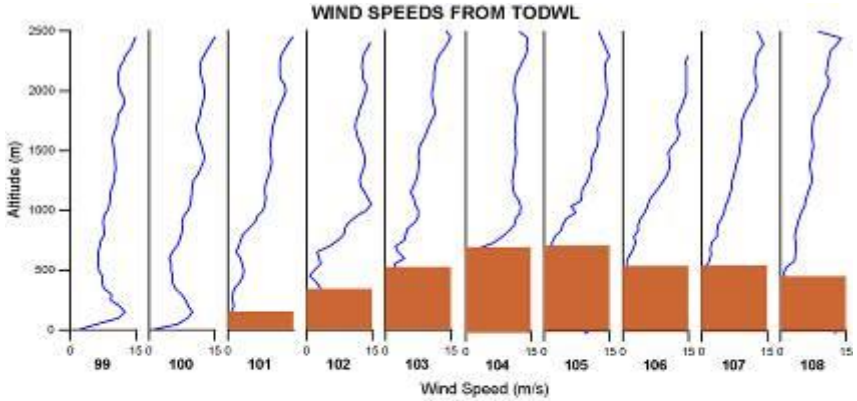
NPS MM5

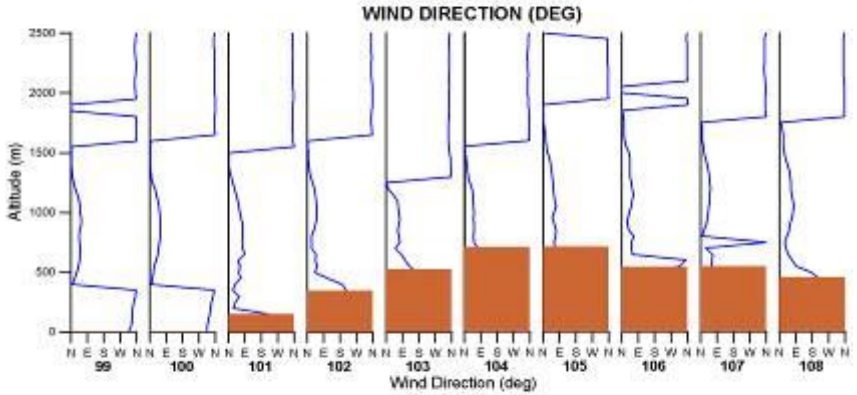
- Run twice daily at the Naval Postgraduate School
- 30 vertical levels, 12 at or below 850 mb level
- Triple nest (108, 36, and 12 km); 4 km nest special run for this case
- “Warm” start (initial conditions generated blending 12-h MM5 forecast with observations)
- MRF PBL scheme
- http://www.weather.nps.navy.mil/~dkmiller/MM5

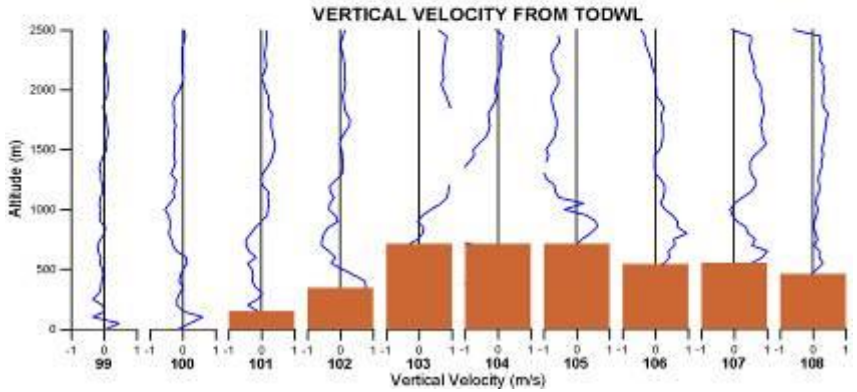
TODWL Flight Patterns

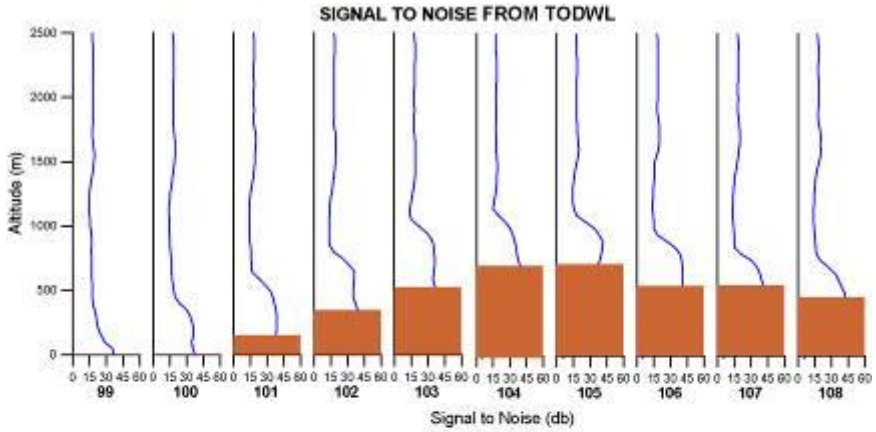


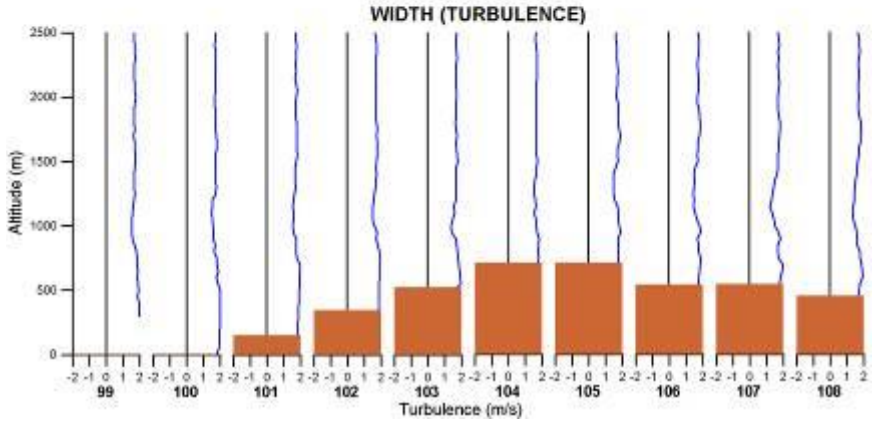
TODWL OBSERVATIONS



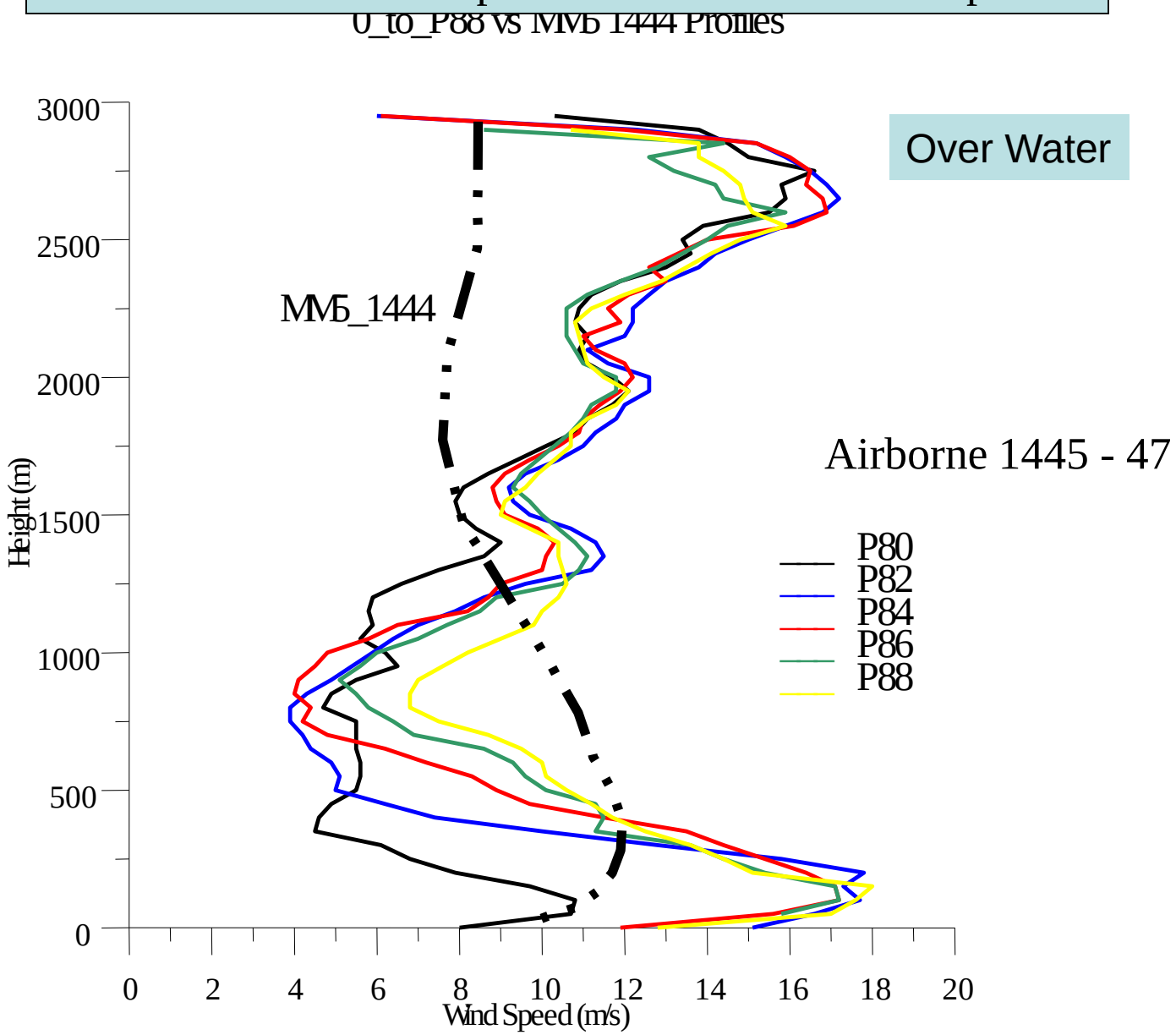


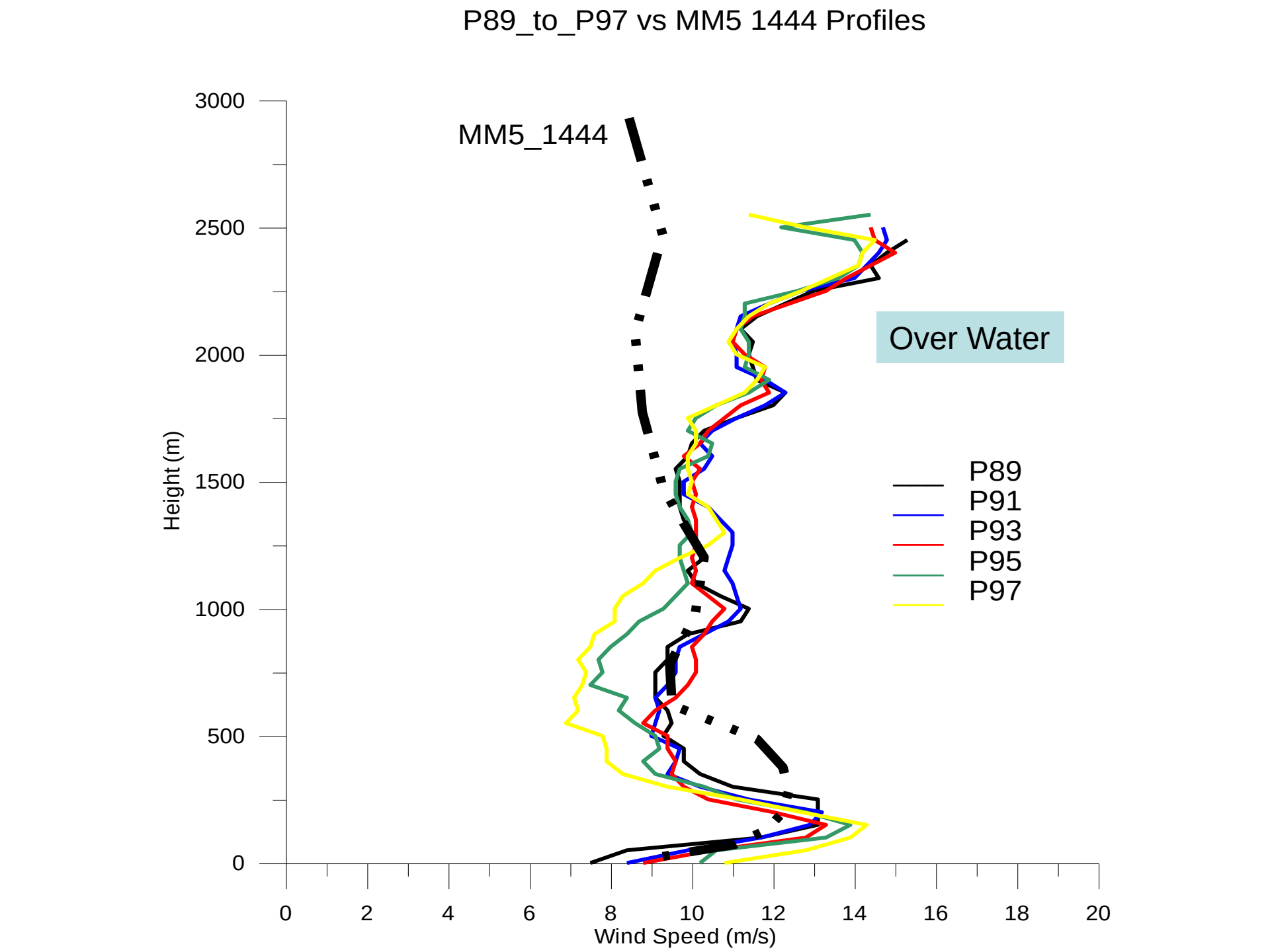




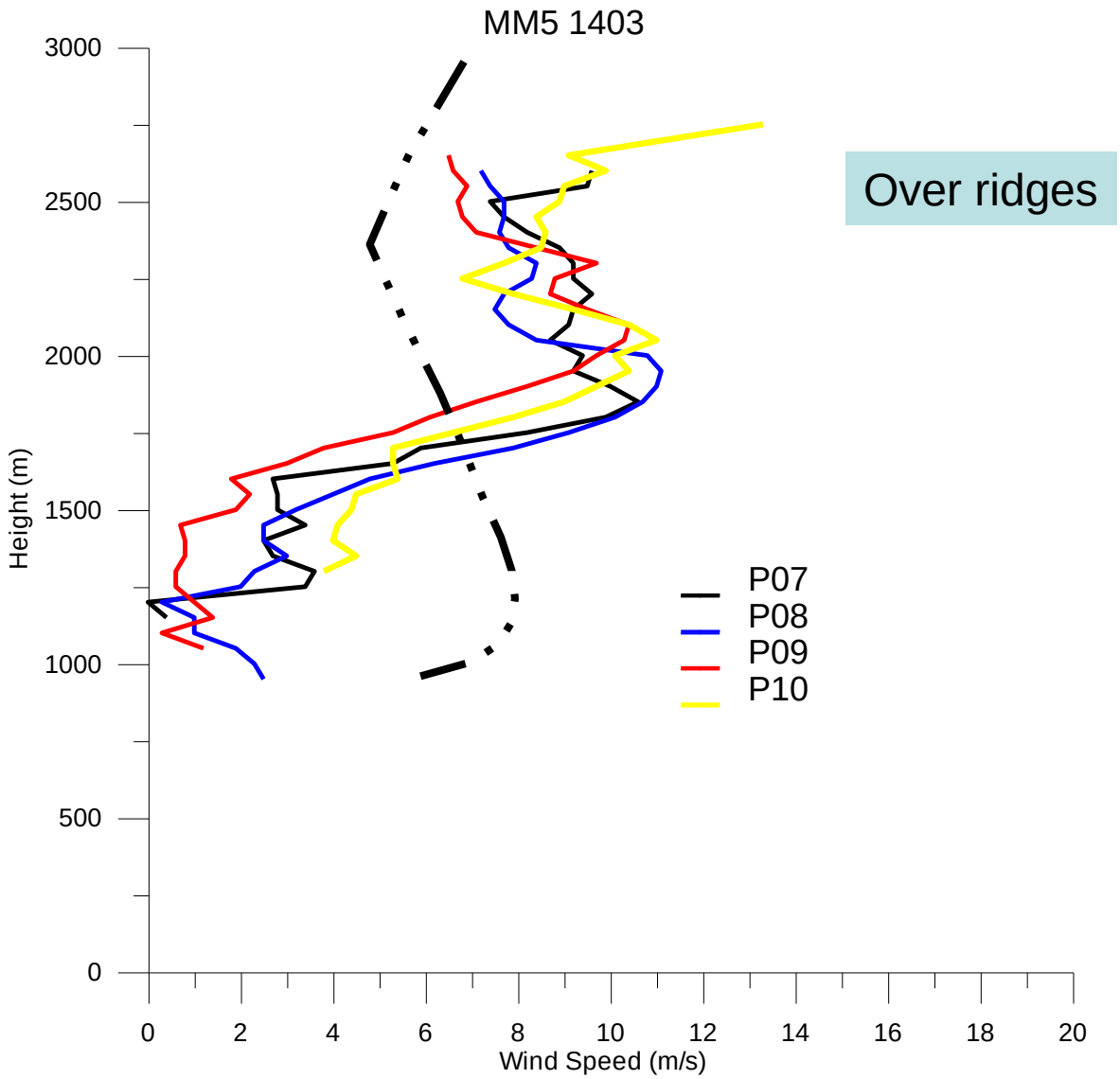


Airborne wind lidar comparisons with MM5 model profiles

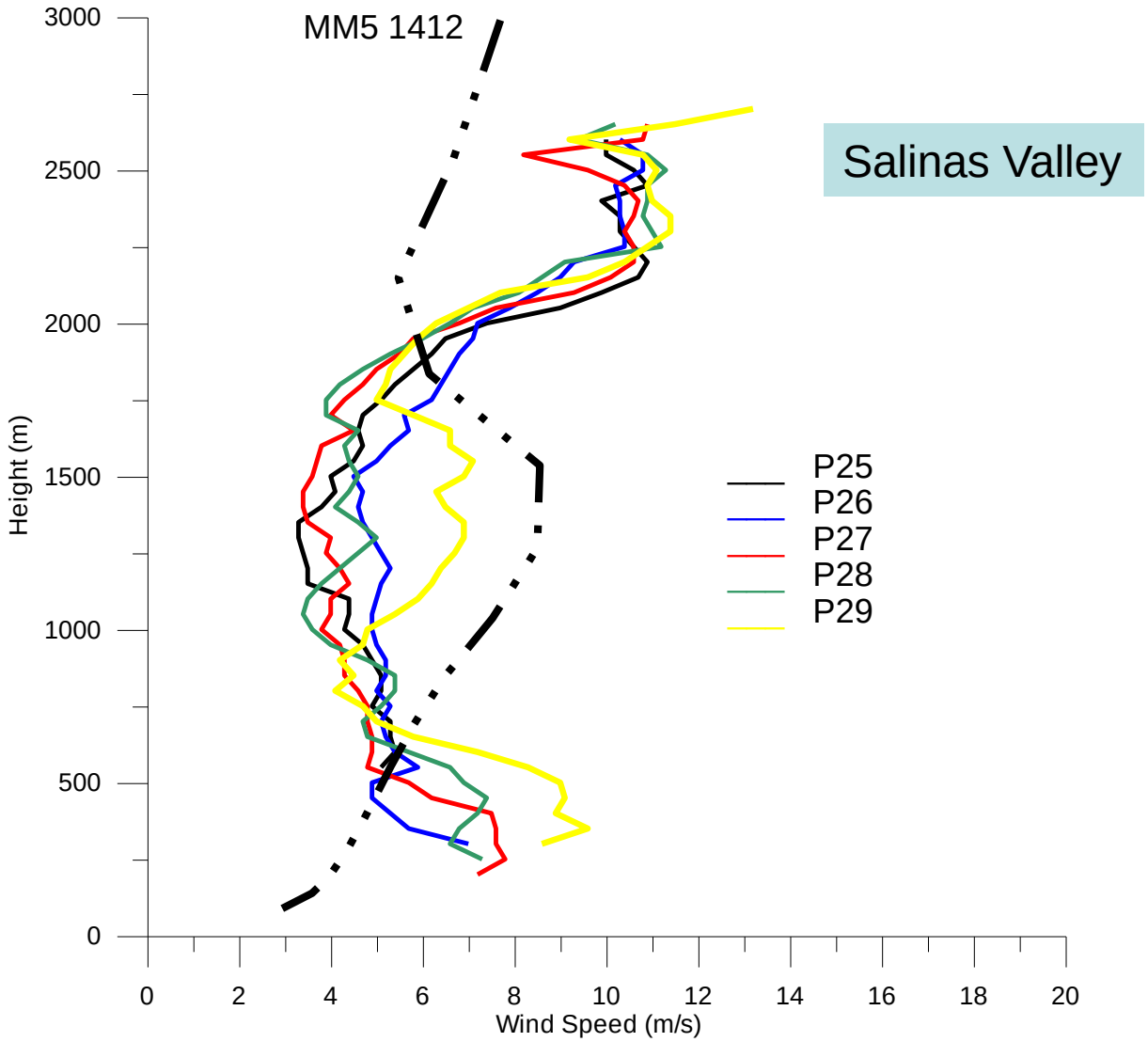


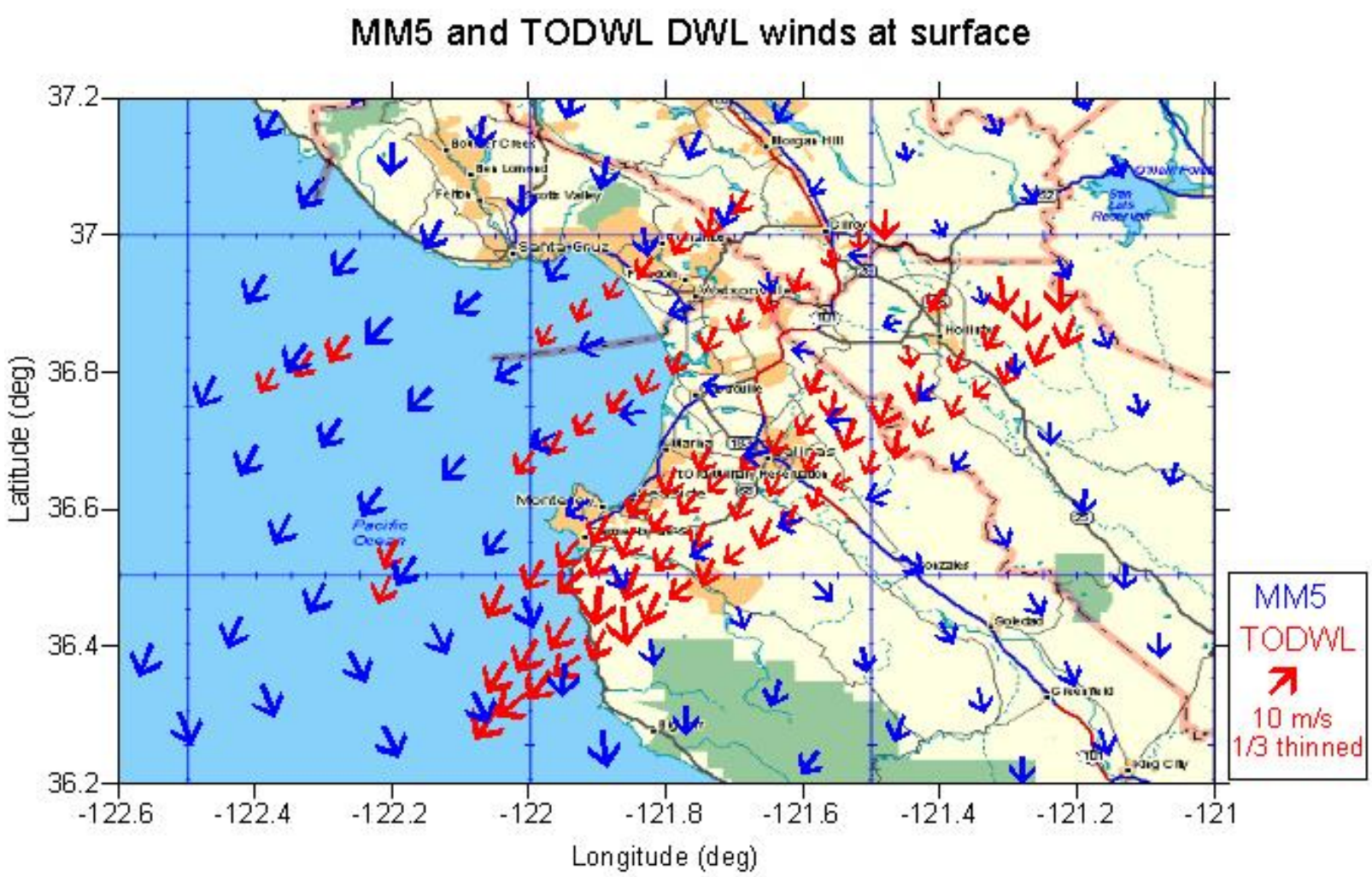

P89_to_P97 vs MM5 1444 Profiles
MM5_1444
Over Water
P89
P91
P93
P95
P97
Height (m)
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
Wind Speed (m/s)

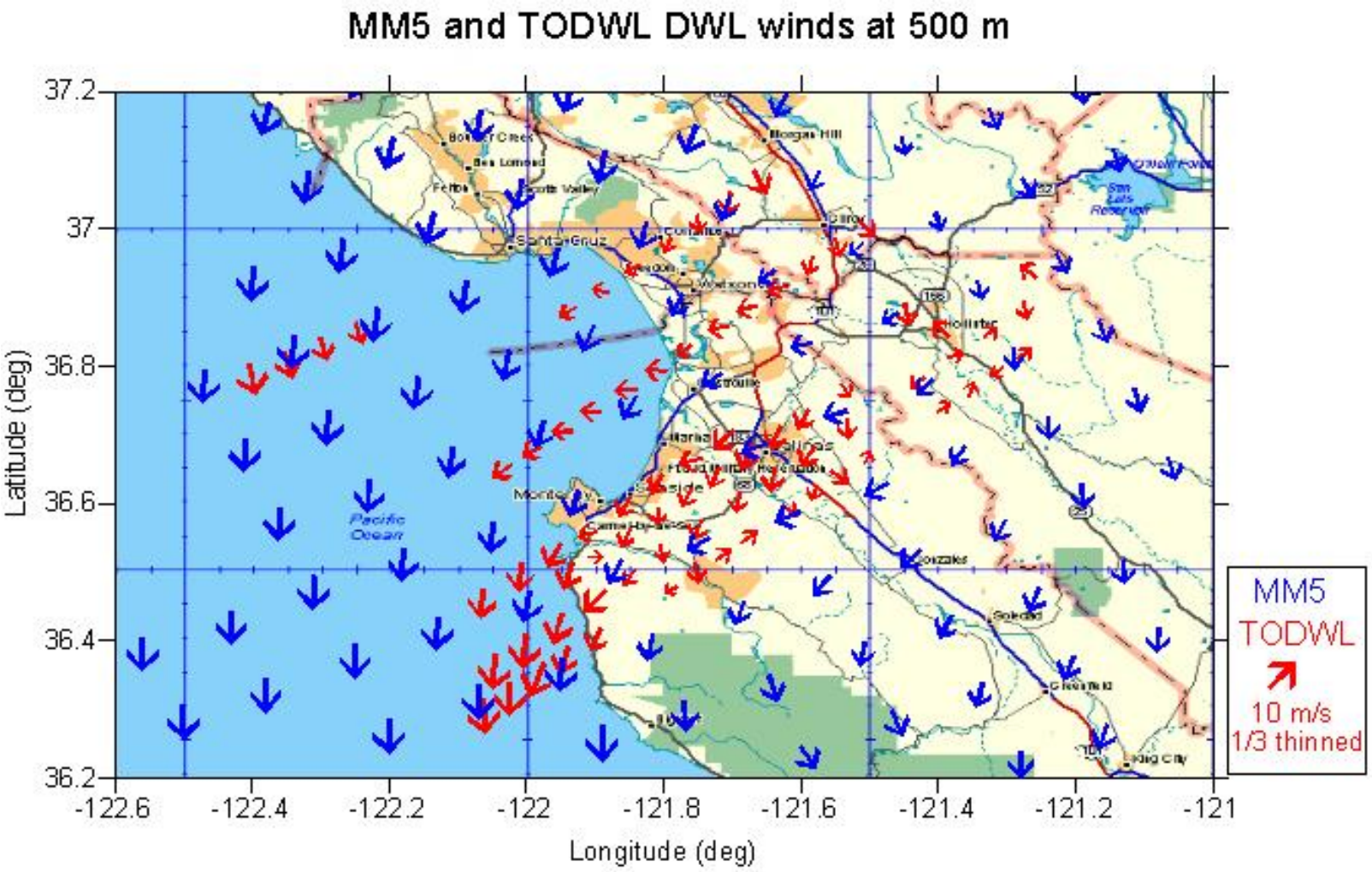
P07_to_P10 vs MM5 1403 Profiles

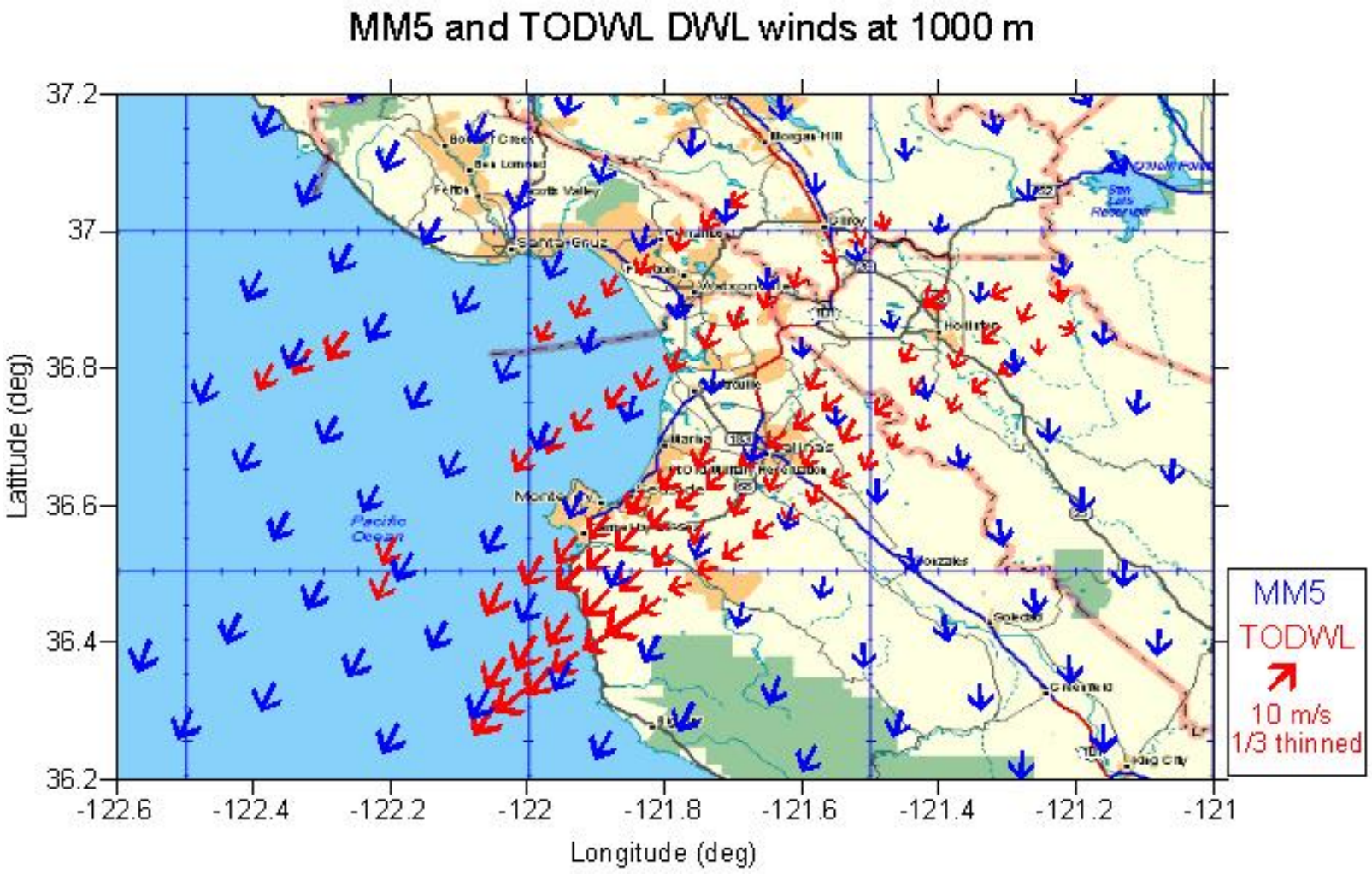


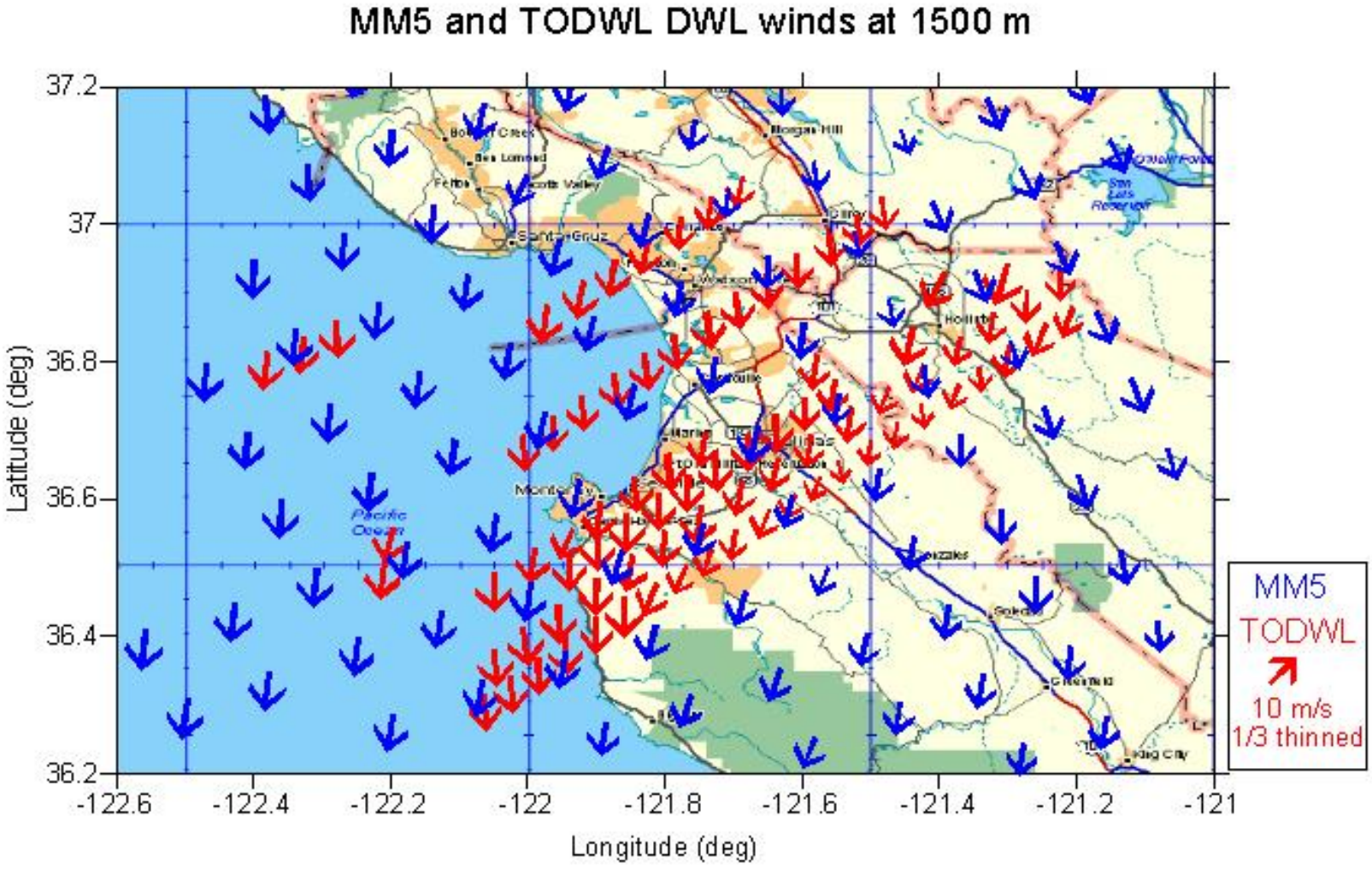
P25_to_P29 vs MM5 1412 Profiles

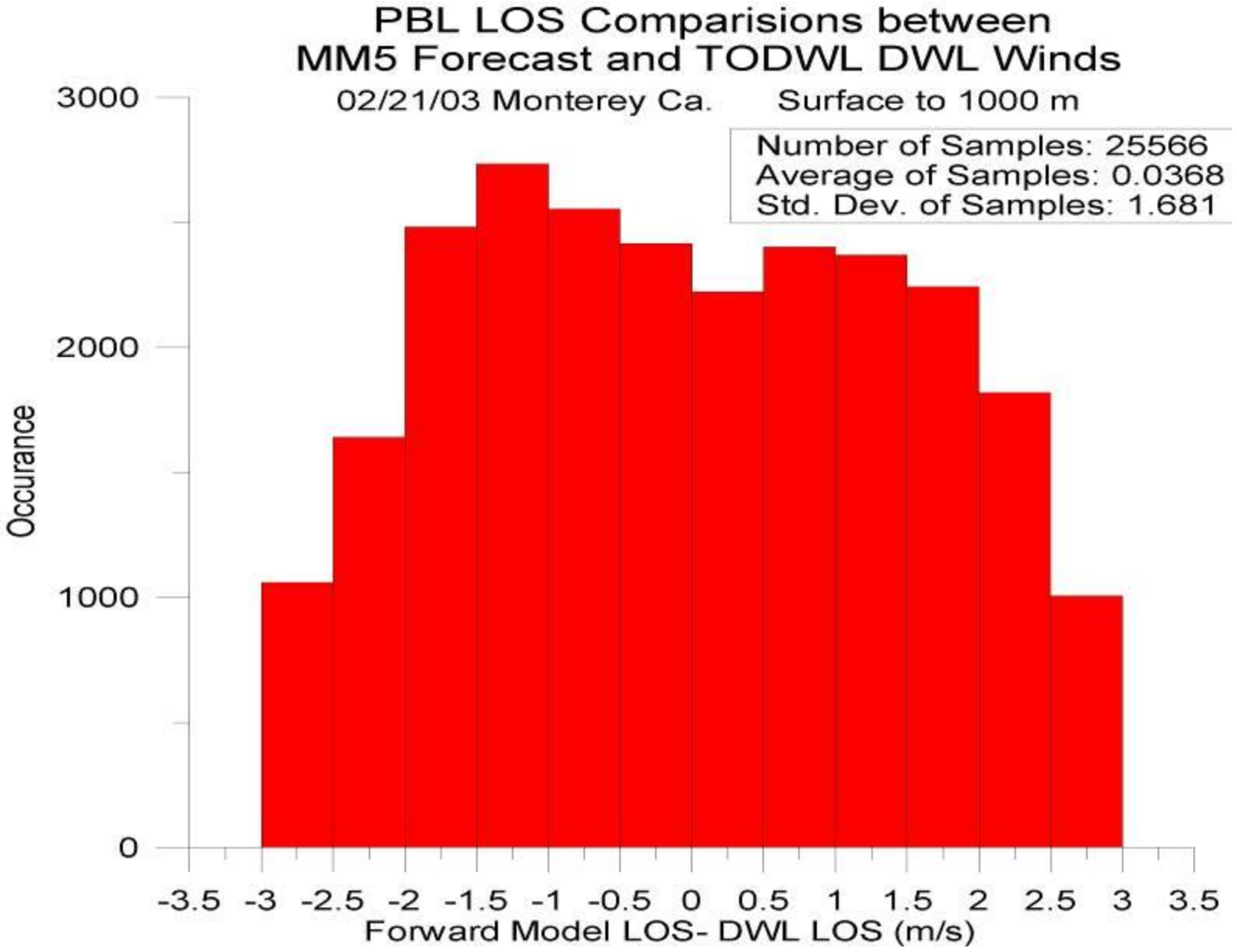


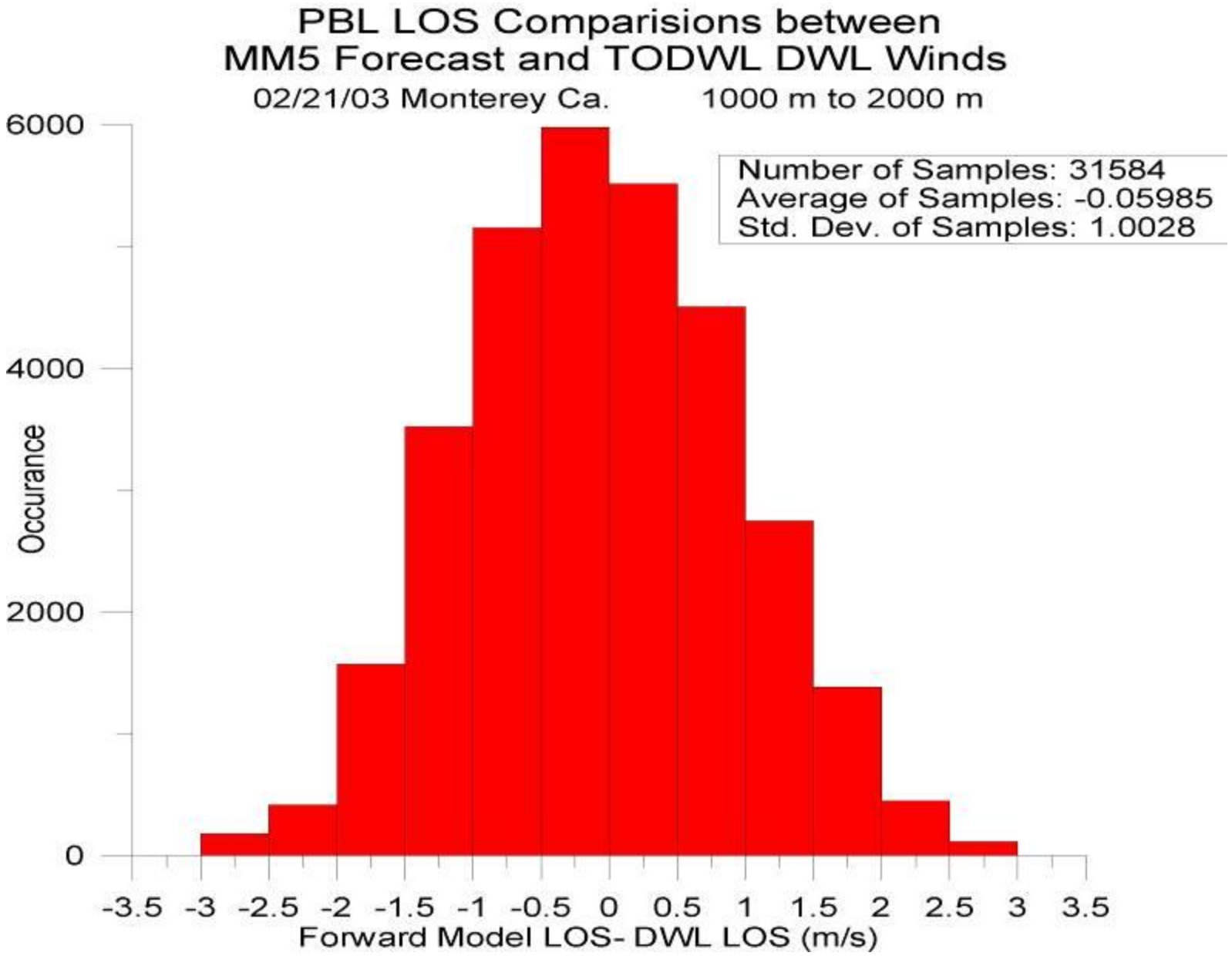

MM5 and TODWL DWL winds at surface
37.2
37
36.8
36.6
36.4
36.2
Latitude (deg)
-122.6
-122.4
-122.2
-122
-121.8
-121.6
-121.4
-121.2
-121
Longitude (deg)
Pacific Ocean
MM5
TODWL
10 m/s
1/3 thinned


MM5 and TODWL DWL winds at 500 m
37.2
37
36.8
36.6
36.4
36.2
Latitude (deg)
-122.6
-122.4
-122.2
-122
-121.8
-121.6
-121.4
-121.2
-121
Longitude (deg)
Pacific Ocean
MM5
TODWL
10 m/s
1/3 thinned


MM5 and TODWL DWL winds at 1000 m
37.2
37
36.8
36.6
36.4
36.2
Latitude (deg)
-122.6
-122.4
-122.2
-122
-121.8
-121.6
-121.4
-121.2
-121
Longitude (deg)
Pacific Ocean
MM5
TODWL
10 m/s
1/3 thinned


MM5 and TODWL DWL winds at 1500 m
37.2
37
36.8
36.6
36.4
36.2
Latitude (deg)
-122.6
-122.4
-122.2
-122
-121.8
-121.6
-121.4
-121.2
-121
Longitude (deg)
Pacific Ocean
MM5
TODWL
10 m/s
1/3 thinned


PBL LOS Comparisions between
MM5 Forecast and TODWL DWL Winds
02/21/03 Monterey Ca.
Surface to 1000 m
Number of Samples: 25566
Average of Samples: 0.0368
Std. Dev. of Samples: 1.681
Occurance
3000
2000
1000
0
-3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5
Forward Model LOS- DWL LOS (m/s)


PBL LOS Comparisions between
MM5 Forecast and TODWL DWL Winds
02/21/03 Monterey Ca.
1000 m to 2000 m
Number of Samples: 31584
Average of Samples: -0.05985
Std. Dev. of Samples: 1.0028
Occurance
6000
4000
2000
0
-3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5
Forward Model LOS- DWL LOS (m/s)

PHASE II SBIR

- Started in September 2006
- Two year study with Field Program
- Work in concert with a NAVY SBIR effort focused on developing an In-flight Lidar Integrated Mission Management System (I-LIMMS)
  - Real-time 4D visualization of airborne lidar and in-situ data
  - Utilize ADLAATS for mission management

Numerical Models

- Possible models:
  - WRF (WSMR)
  - MM5 (NPS)
  - 3D Wind Model (Wang at ARL)
  - NOAA LAPS (ARL)
- What lidar information is required by model(s)? LOS? U,V profiles?
- Potential for model validation study in April 2007? (3D Wind Model)

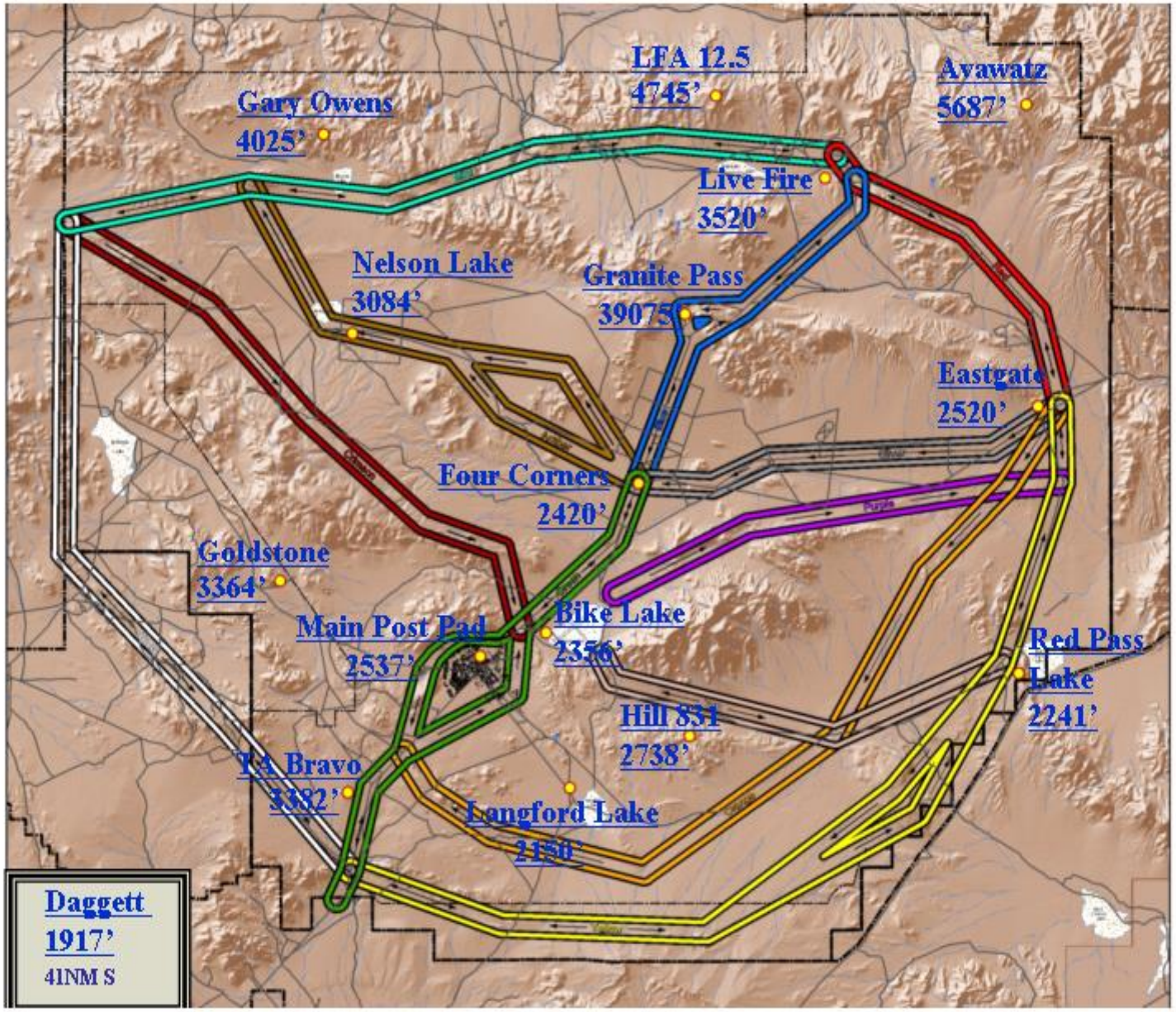
Model Validation/Initialization

- Need guidance from modelers on how to best conduct validation studies and capture known issues of the model:
  - When is agreement sufficient to continue validation mode?
  - Recognize time and space displacement issues
  - Vertical variation in comparison differences

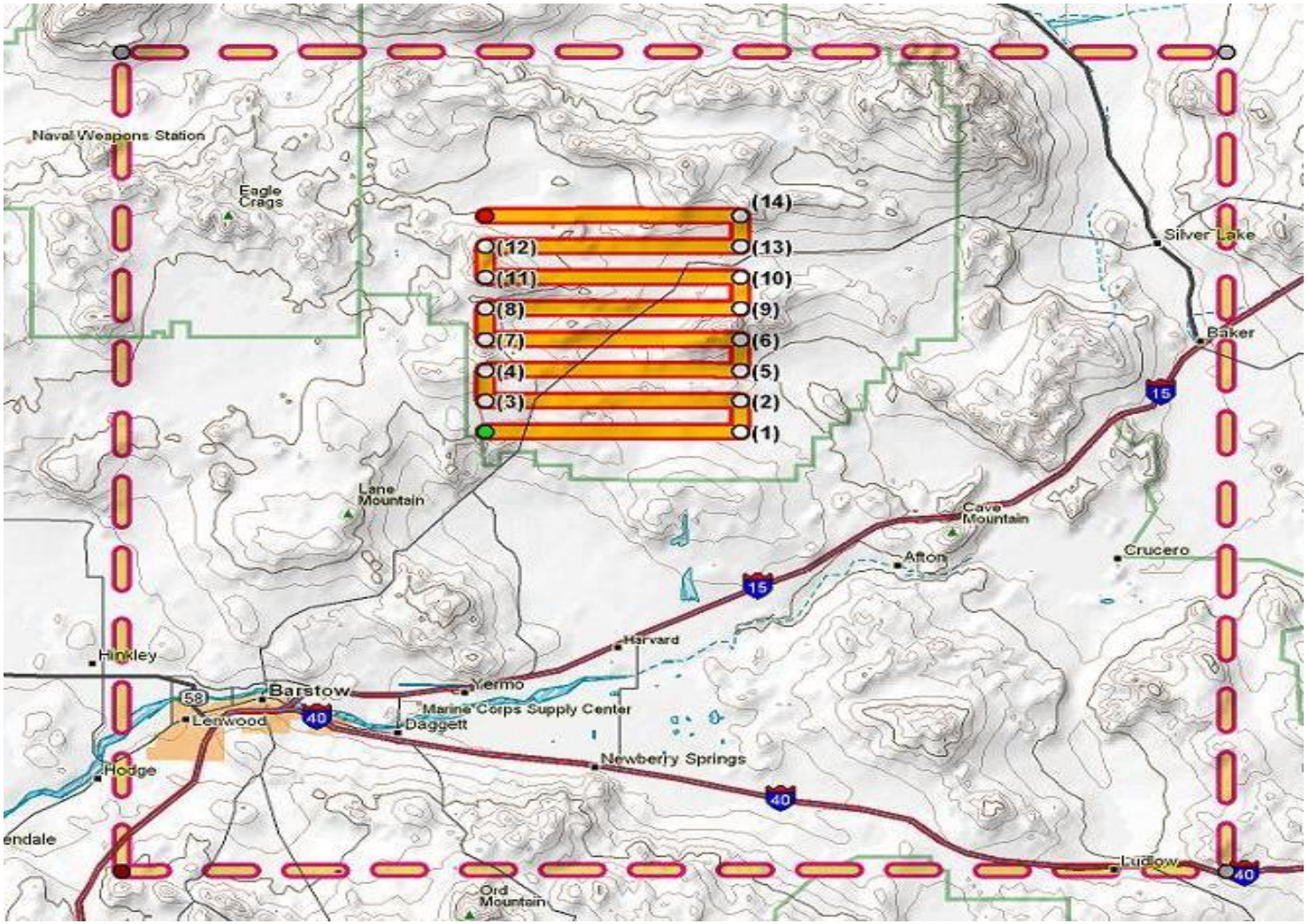
Field Testing

- Use 2003 data to establish baseline validation metrics
- Conduct new flights in April 2007 with modeling support in real time
  - Monterey, CA
- Conduct first demonstration flights for on-board system in Spring 2008
  - Monterey, CA
- Conduct final demonstration in Fall 2008
  - Ft Irwin, CA

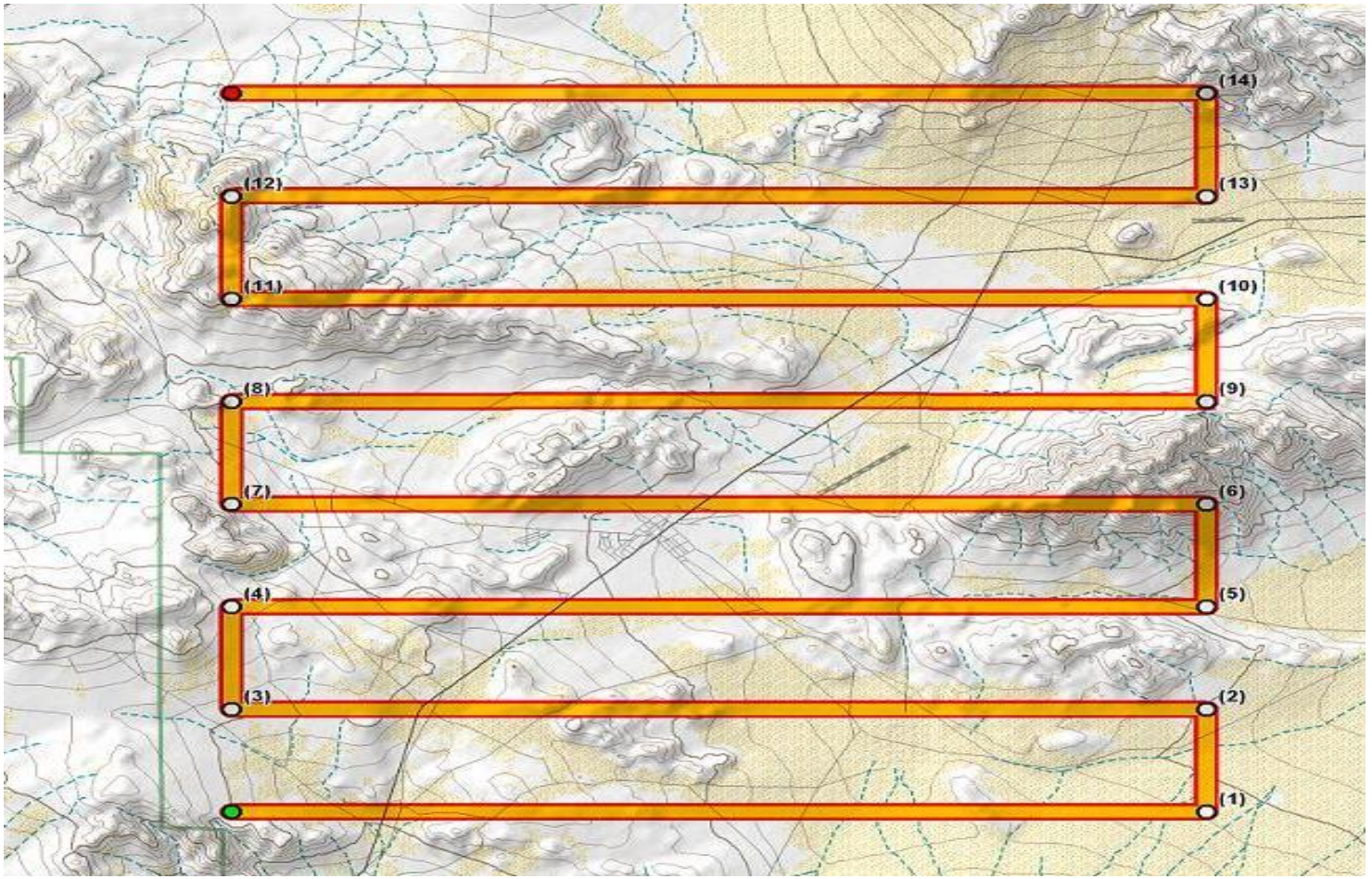
Fort Irwin HANDAR stations



ADLAATS Potential Flight Patterns



ADLAATS Potential Flight Patterns



ADLAATS Potential Flight Patterns