

An Ultra-High Resolution Sailing Forecast System for San Francisco Bay

WRF Users' Workshop

June 25, 2014

Mike Dvorak

Sailor's Energy

Sail Tactics

Adriano Quiroga

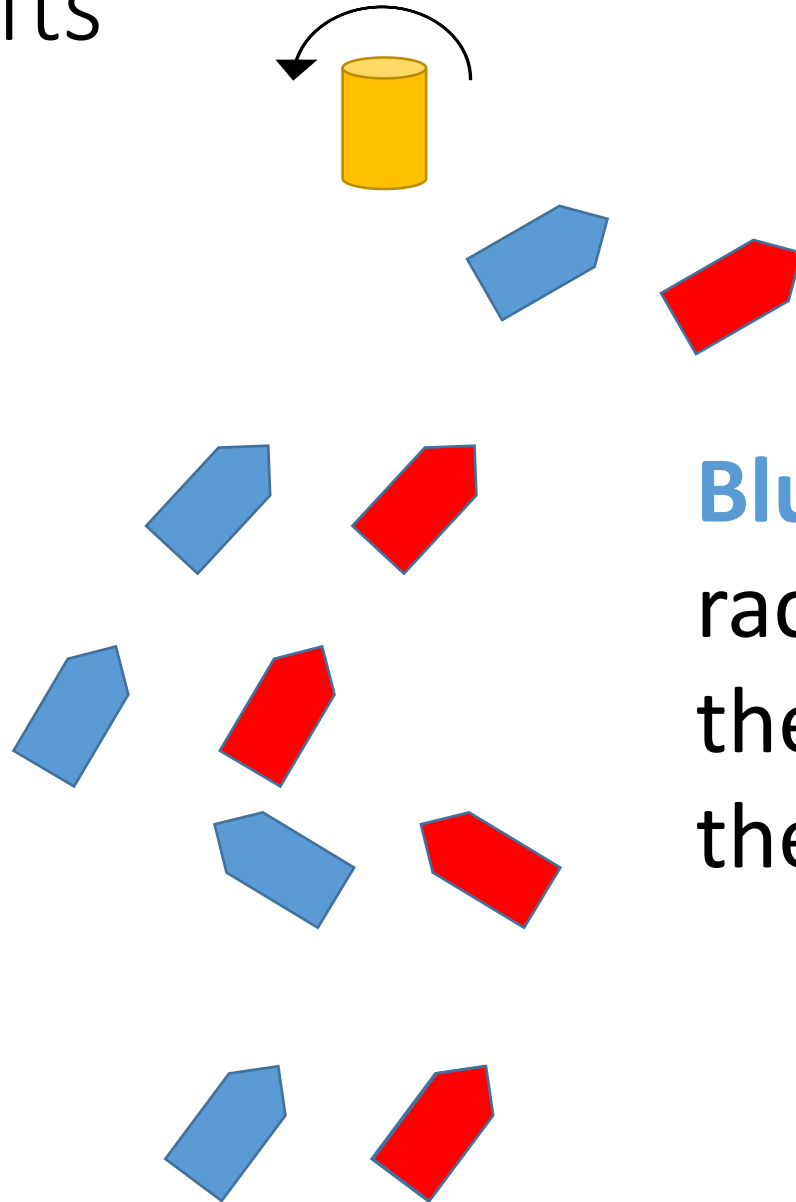
Stanford University



Motivation

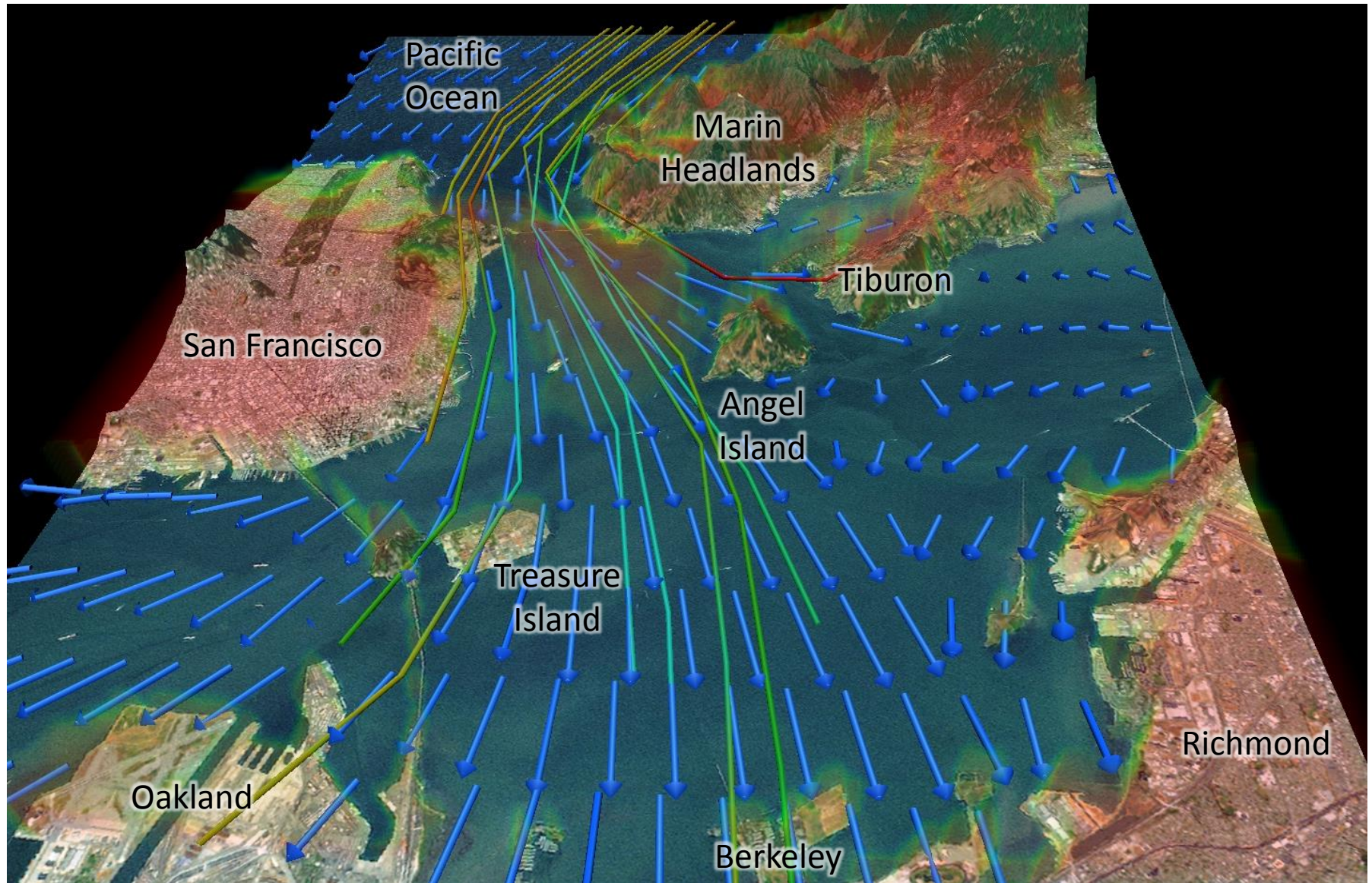
- SF Bay is the best place to sail in the world
- America's Cup – 2013
- Sailboat racing
 - Knowing wind speed/direction change
 - Huge advantage
- Crowdsourced field campaign

Advantage: Knowing Wind Shifts

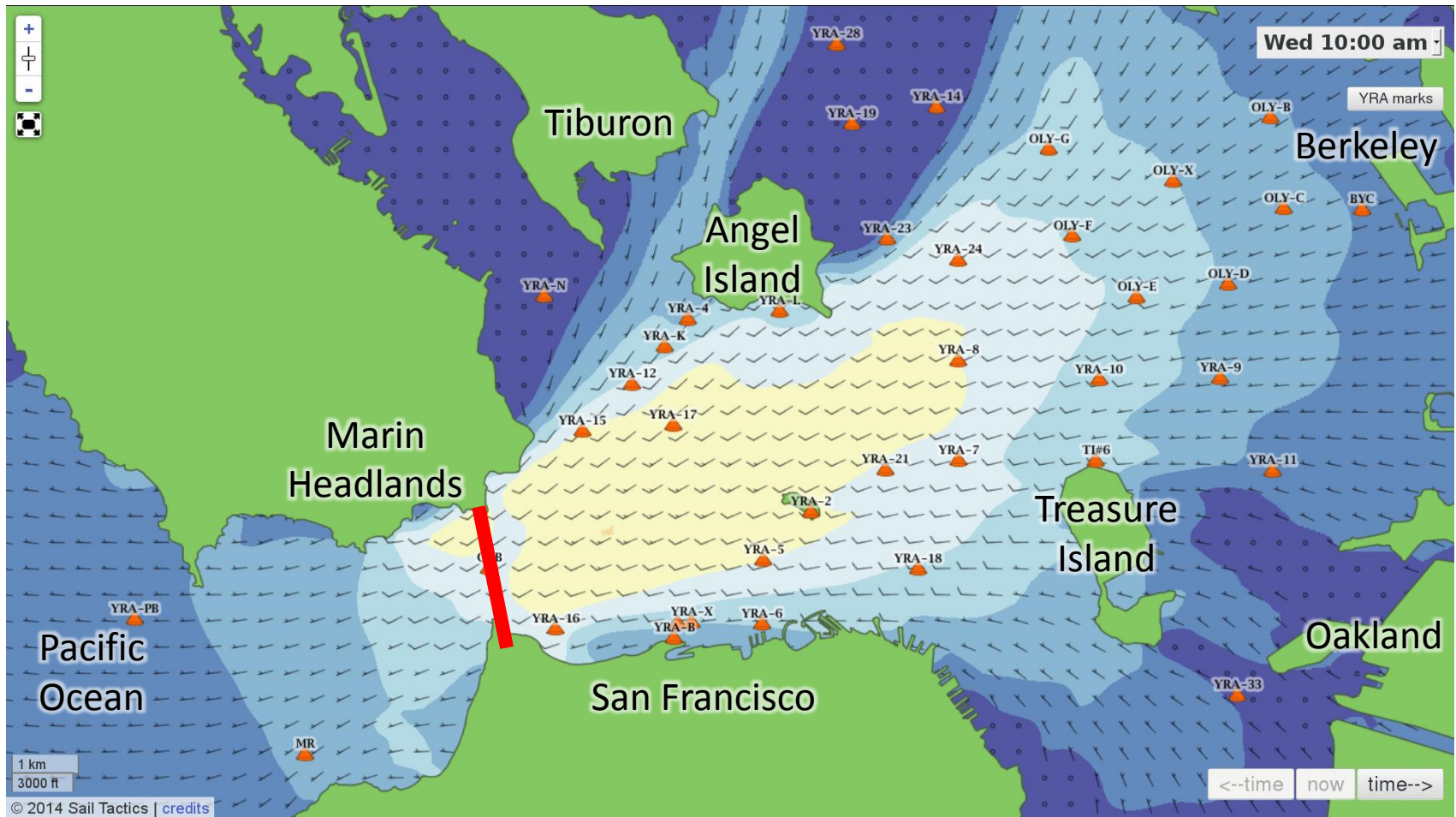


Blue is closer to race mark because they anticipated the wind shift

What 200-meter Resolution Gets You



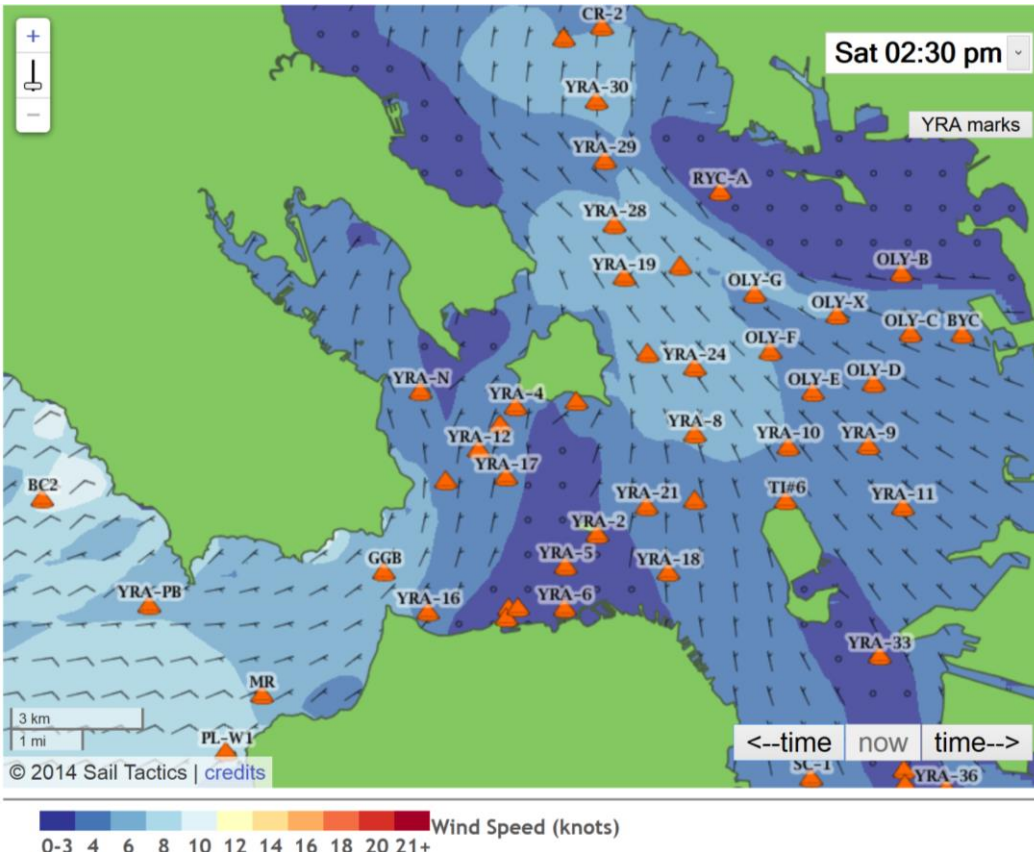
Typical summer sea breeze conditions



Wind Speed (knots)



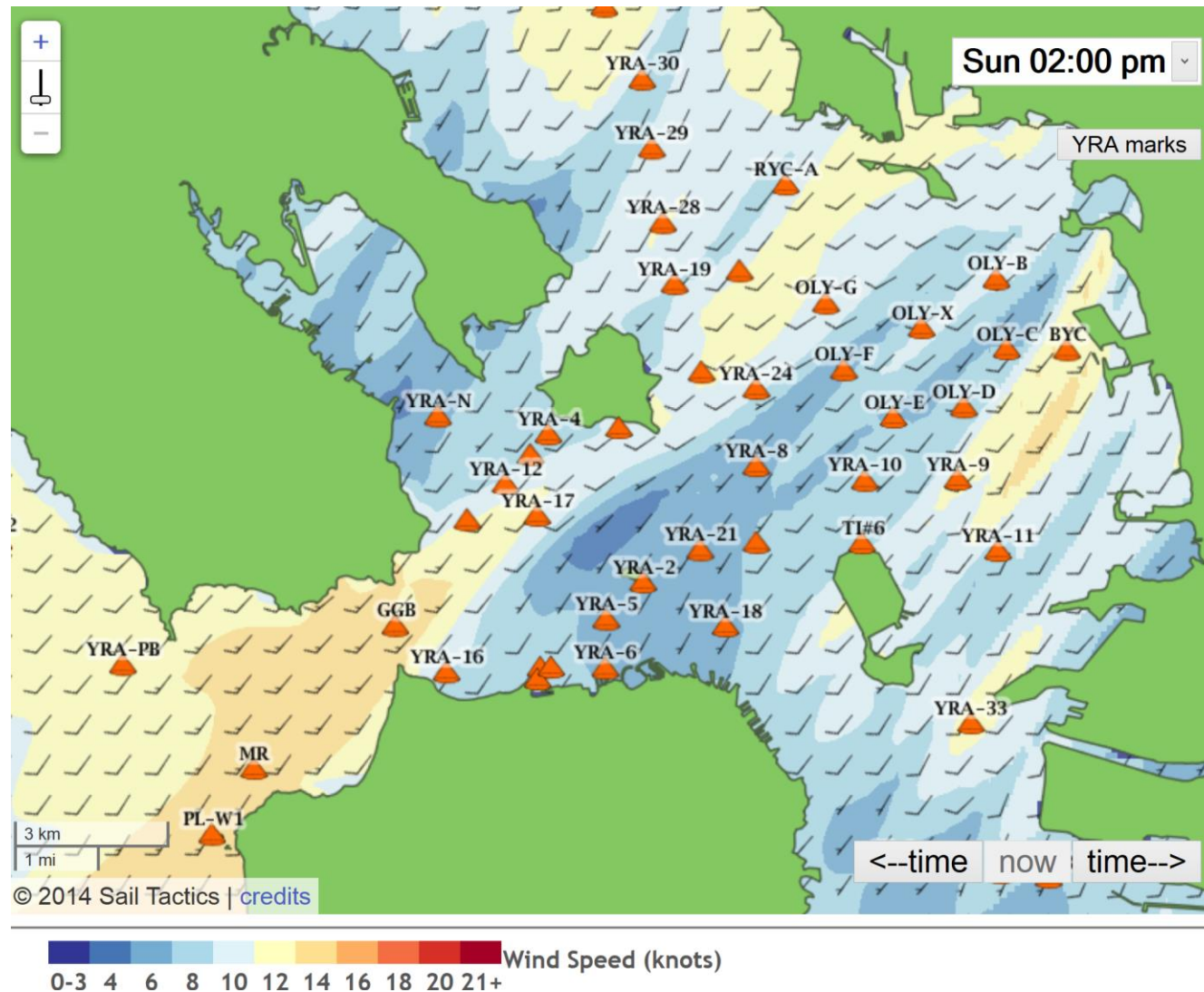
Wintertime Offshore Flow



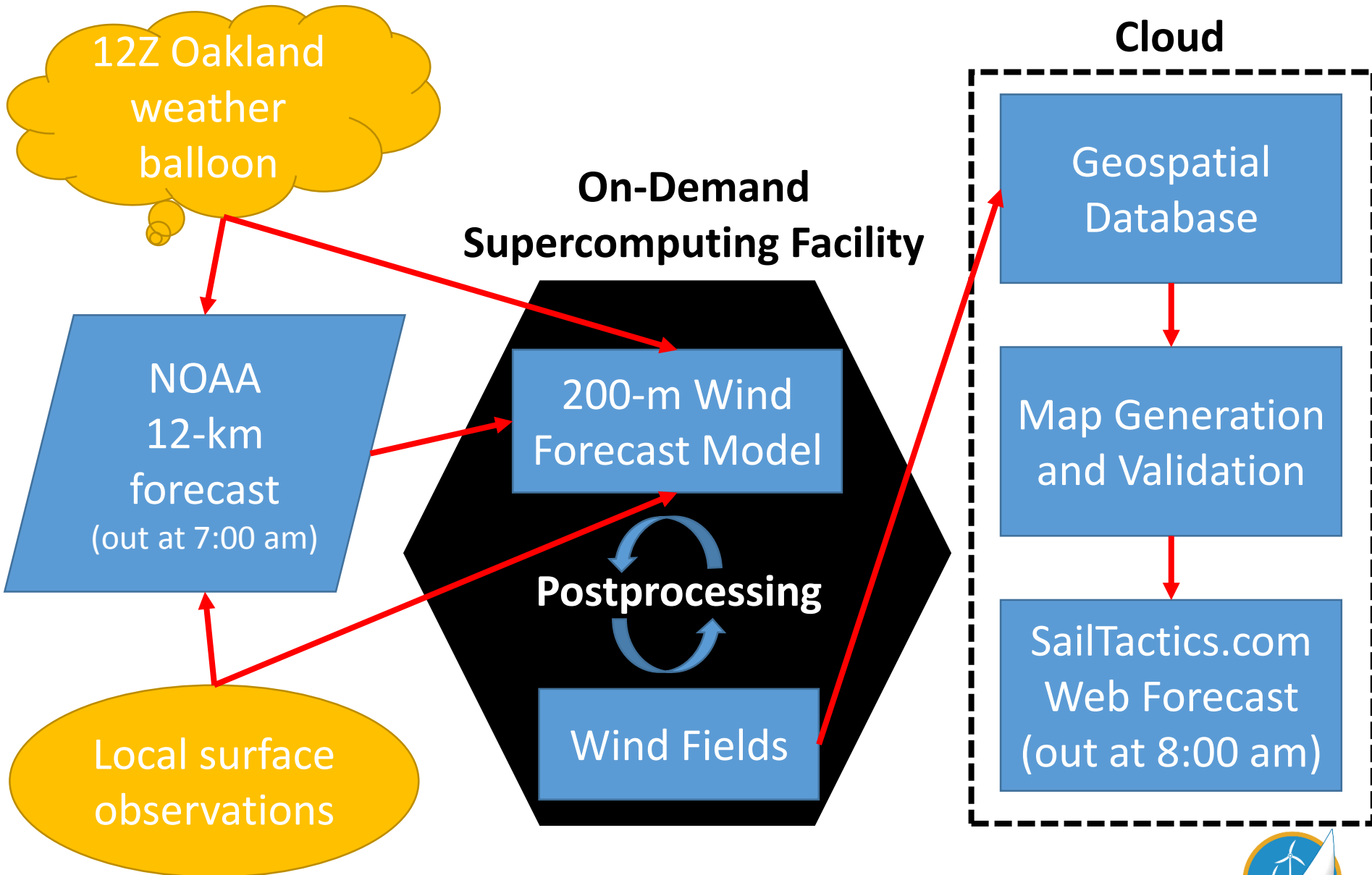
- Light, northerly winds
- Land breeze
 - Cool Central Valley
 - Warm ocean
- Often counteracted by a late arriving sea breeze



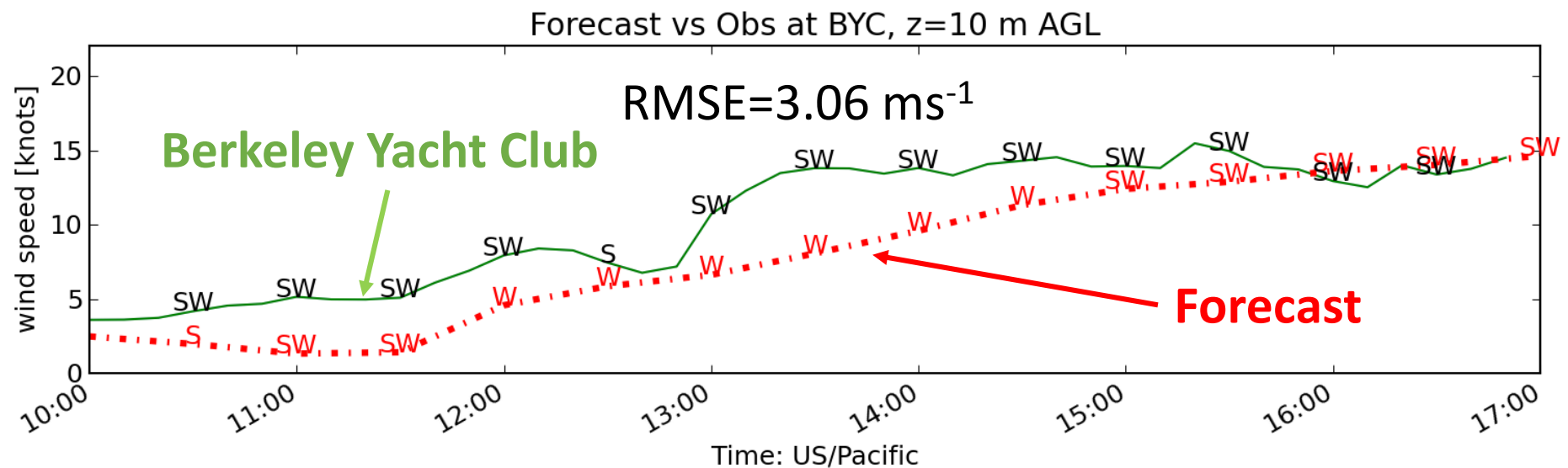
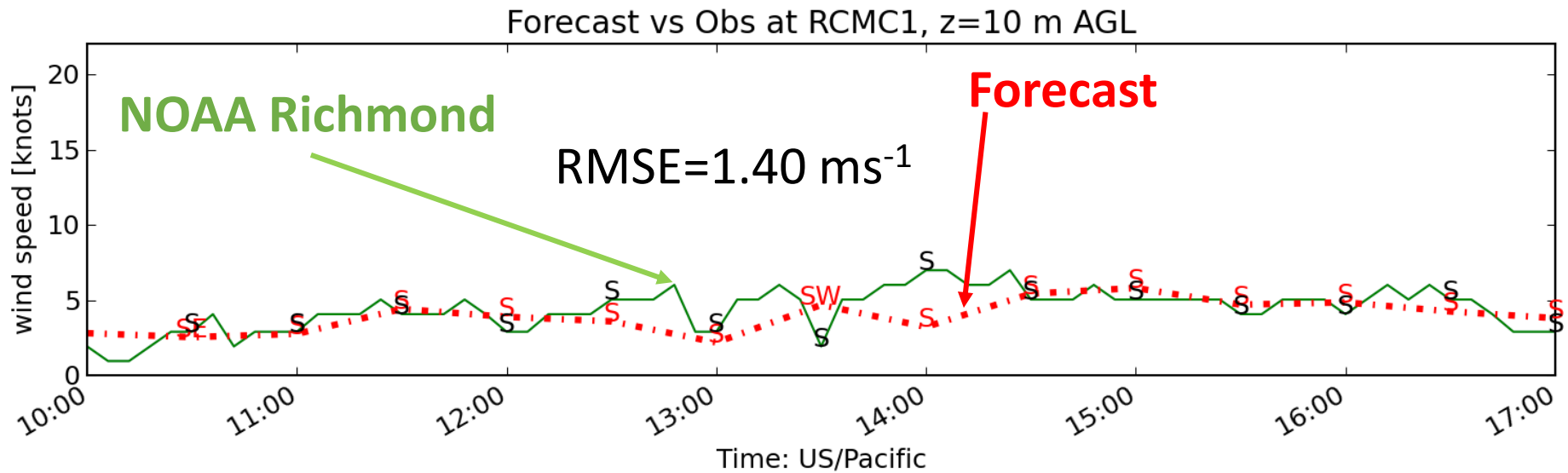
Stormy Forecast: Sail the Streaks



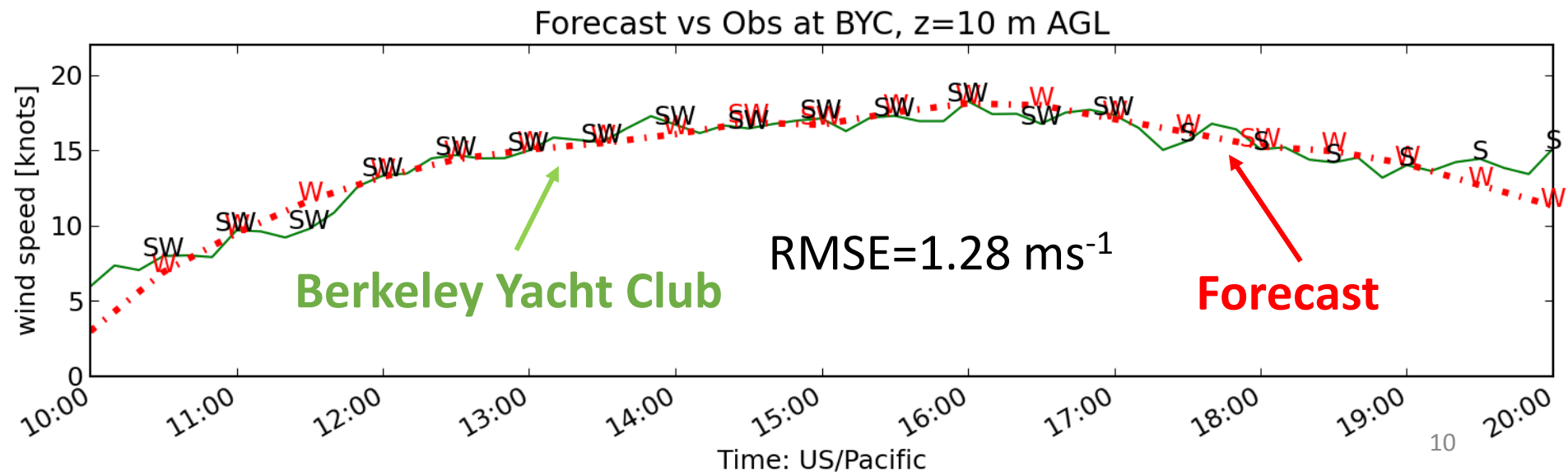
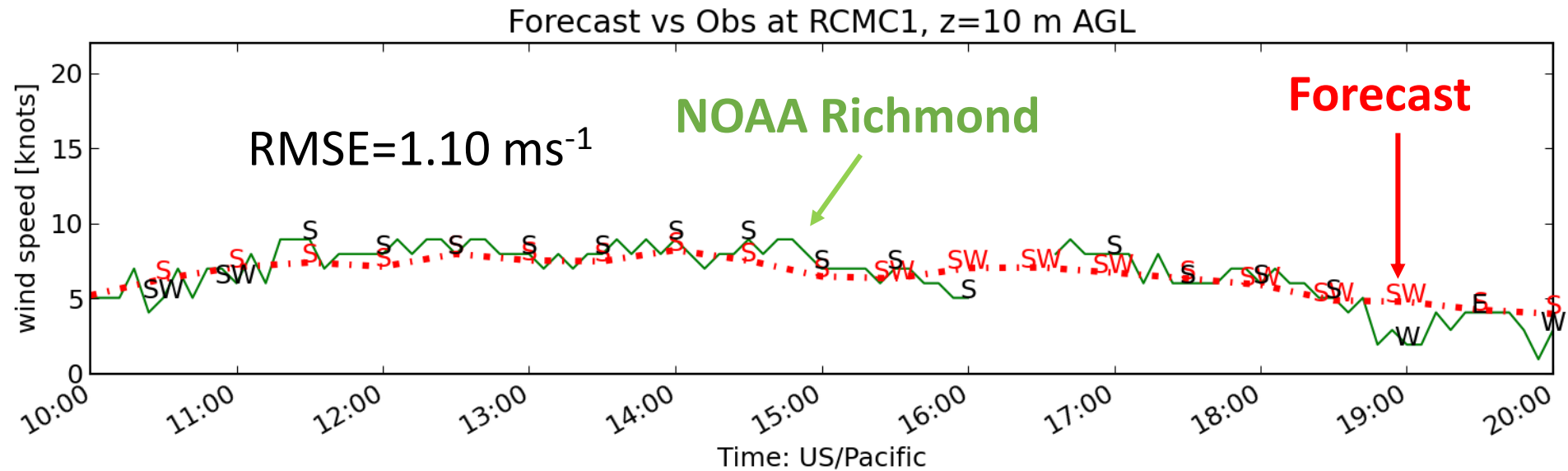
SF Bay Wind Forecasts – Just in Time



Typical Forecast Accuracy: 2014-03-23



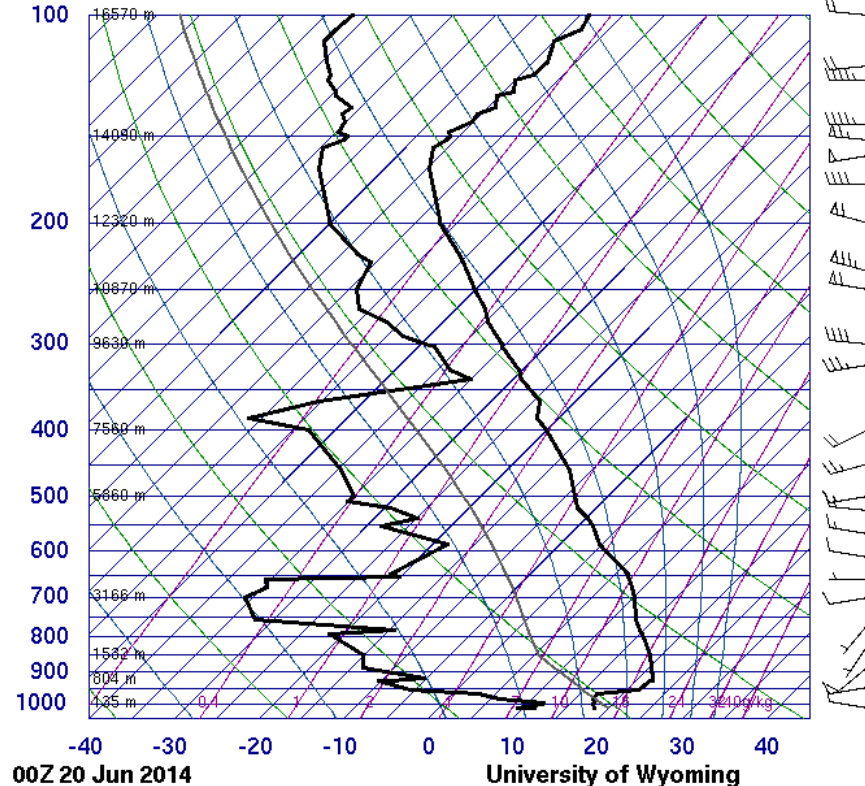
Atypical Forecast Accuracy: 2014-05-31



Marine Boundary Layer

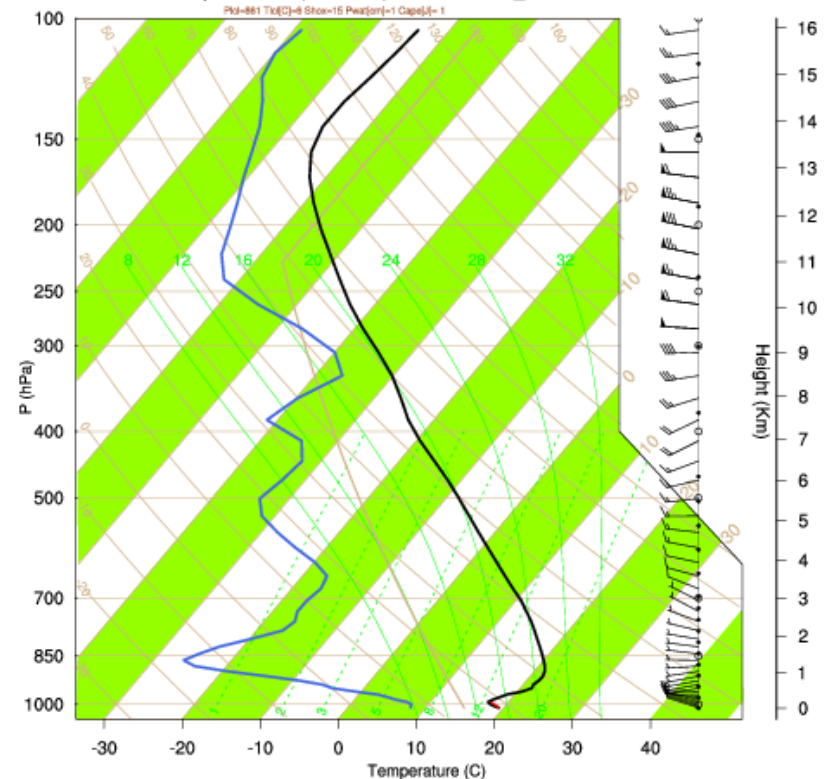
WRF 1000-m resolution domain 12 hours after init. (0Z sounding)

72493 OAK Oakland Int



Observation

Oakland Intl. Airport - OAK (CA, USA) at 2014-06-20_00:00:00



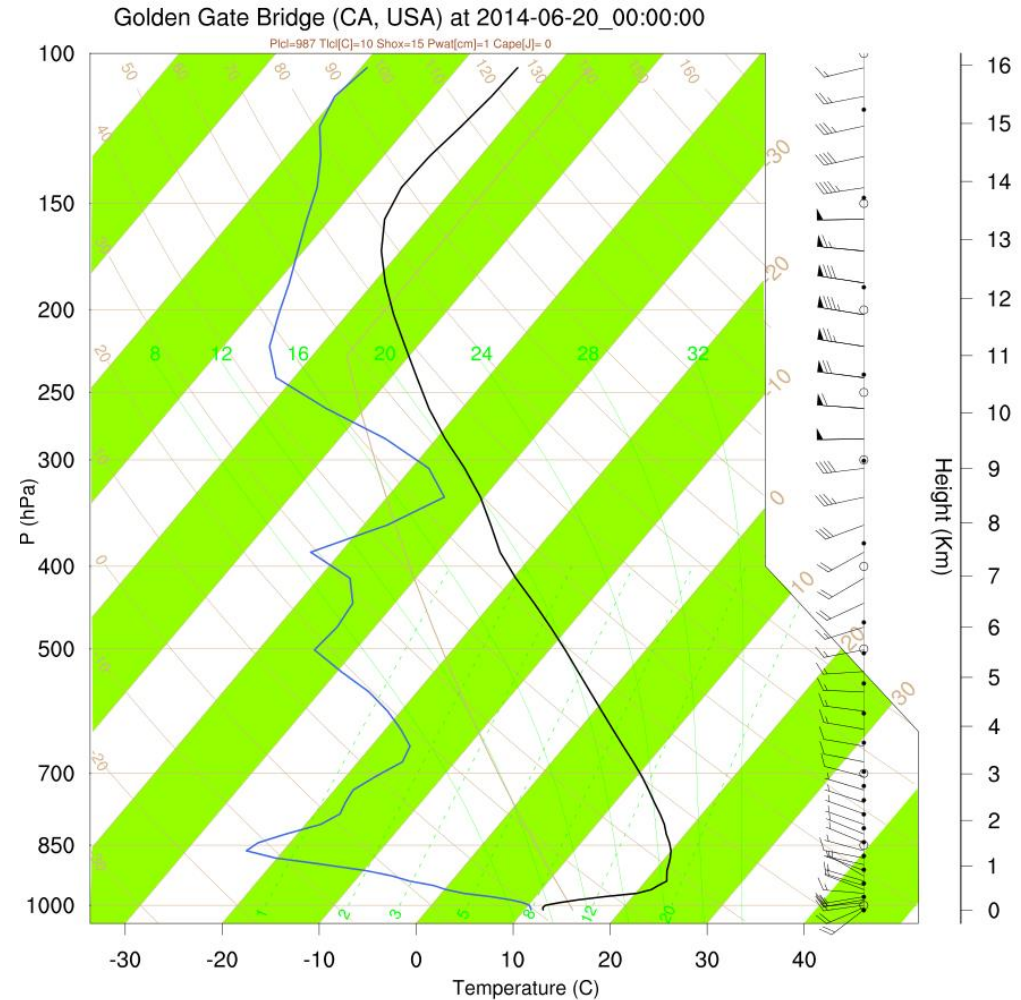
WRF 1000-m
resolution domain

WRF seems to be resolving MBL which is critical for SF Bay flows



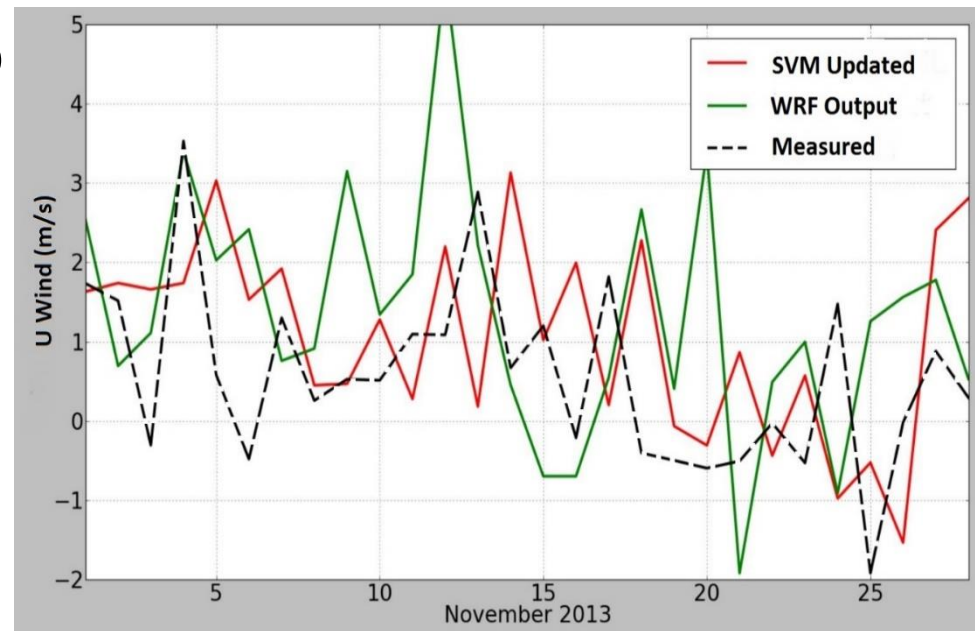
Golden Gate Bridge Sounding

- WRF 200-m domain from Jun 20, 2014
- Strong 13 K inversion
 - ~250 m height
 - Coastal range ~300-500 m
 - Forces flow thru Golden Gate
- Moist, fog forming sea air present



Machine Learning Forecast Improvement

- Support vector machine to update WRF forecasts
- Sliding window approach
 - 14 days training
 - 15th day as target
 - 16th day as prediction
- 20% RMSE improvement



SVM updated forecast for
18:00 UTC, Nov 2013



Future of SF Bay Wind Forecasting

Near-term

- On-the-water observations/validation (Sea Star)
- Using RAP and 3DVAR for initialization
- Open source WinDB geospatial database

Longer-term

- Using drones/boats to measure at optimal locations (Quiroga, Stanford)
- Tide forecasts overlain with winds
- Wind power forecasting

Conclusions

- Created a 200-m res. WRF forecasting system
- Created a responsive website and GIS backend at SailTactics.com
- WRF often shows good skill at 200-m res.
- Sail Tactics racers have won 1st place in every major race of 2014 in the San Francisco Bay

Thanks! Questions?

Mike Dvorak

mike@sailorsenergy.com

Sailor's Energy

Sail Tactics



Photo credit: Sharon Hind-Smith

Sea Star finishing a race at the
Berkeley Marina

View example forecasts at *SailTactics.com*