Super-oceanic Winds over a Narrow Coastal Estuary in Onshore Flow Events

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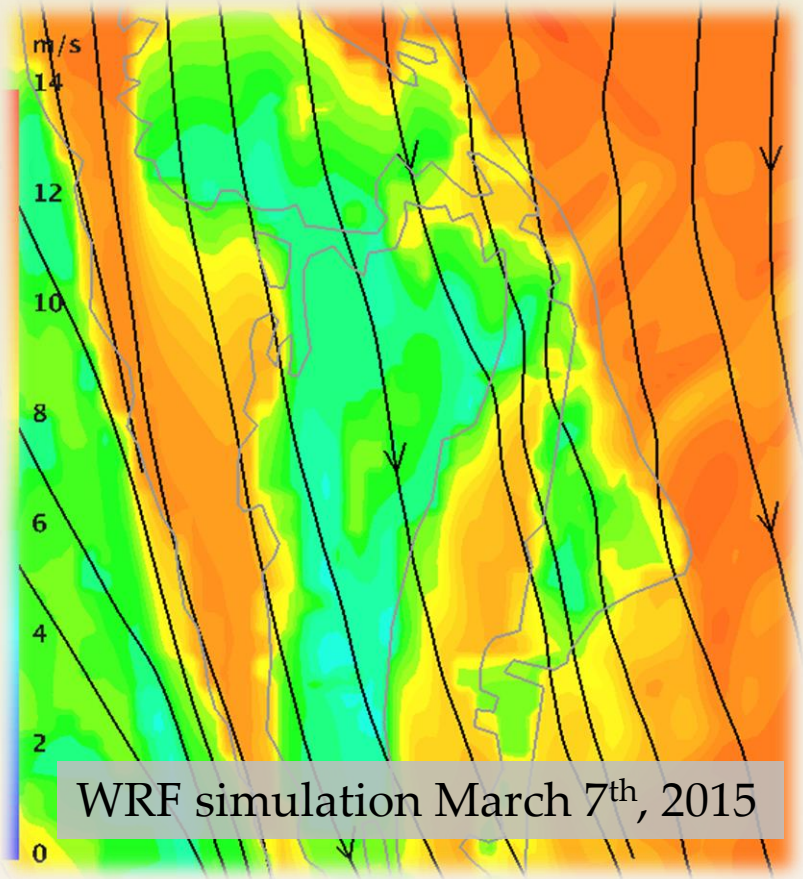
Indian River Lagoon Winds

- Shallow water estuary
  - Average depth ~ 1 m
  - Fetch limited except NNW/SSE
  - Stretches 150 miles north/south
  - Limited exchange with ocean via inlets
- Improvement of wind forcing
  - Wind set-up and surge forecasting
  - Significant wave height forecasting
  - "cheaper" solutions for ensemble forecasts
  - Protection of life & property (NWS)
  - Ecological system impacts (local science)

Indian River Lagoon Winds



WRF simulation March 7th, 2015

- Can we verify wind speed analyses & predictions over the estuary?
  - Peak winds over the lagoon
    - Large open fetch
  - Wind accelerations
    - Transitions
      - Land to water
      - Water to land
      - Multiple transitions

IRL Field Work Summer 2015

- Studying winds crossing the from the Atlantic Ocean across a barrier island and over the Indian River Lagoon.
  - Lagoon surface winds (pontoon boat, Airmar weather unit)
  - Surface wind observations (Kestrel, 10 m)
  - ZephIR wind profiling lidar

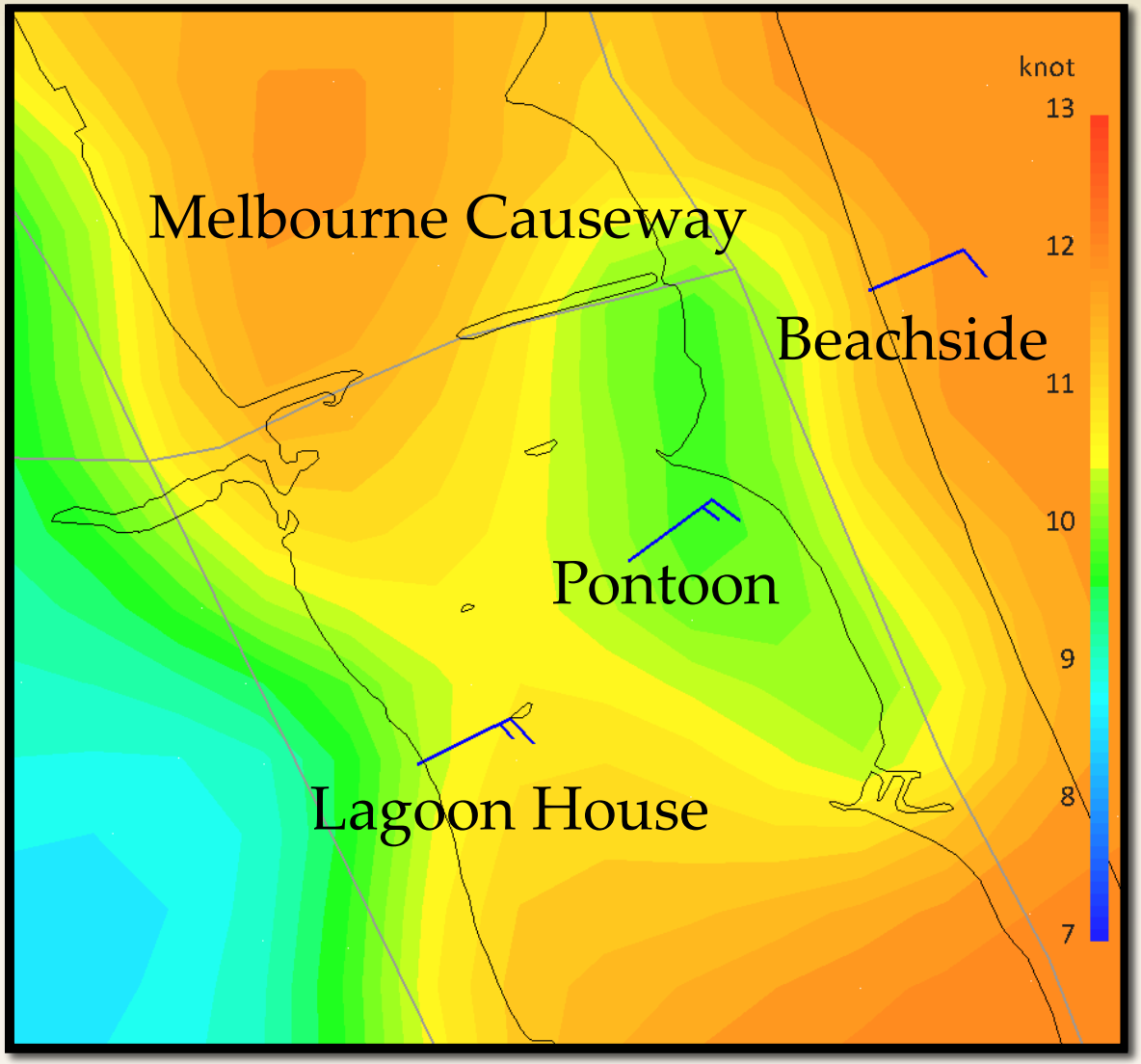
An interesting observation

Expectation:

The onshore flow at the beach will be greater than at the Lagoon House.

Unexpected observation:

Wind speeds over the IRL and at the Lagoon house were greater than at the beach.



Surface wind speed observations and WRF wind speeds (kt, color contours),at 19 UTC 4 June 2015.

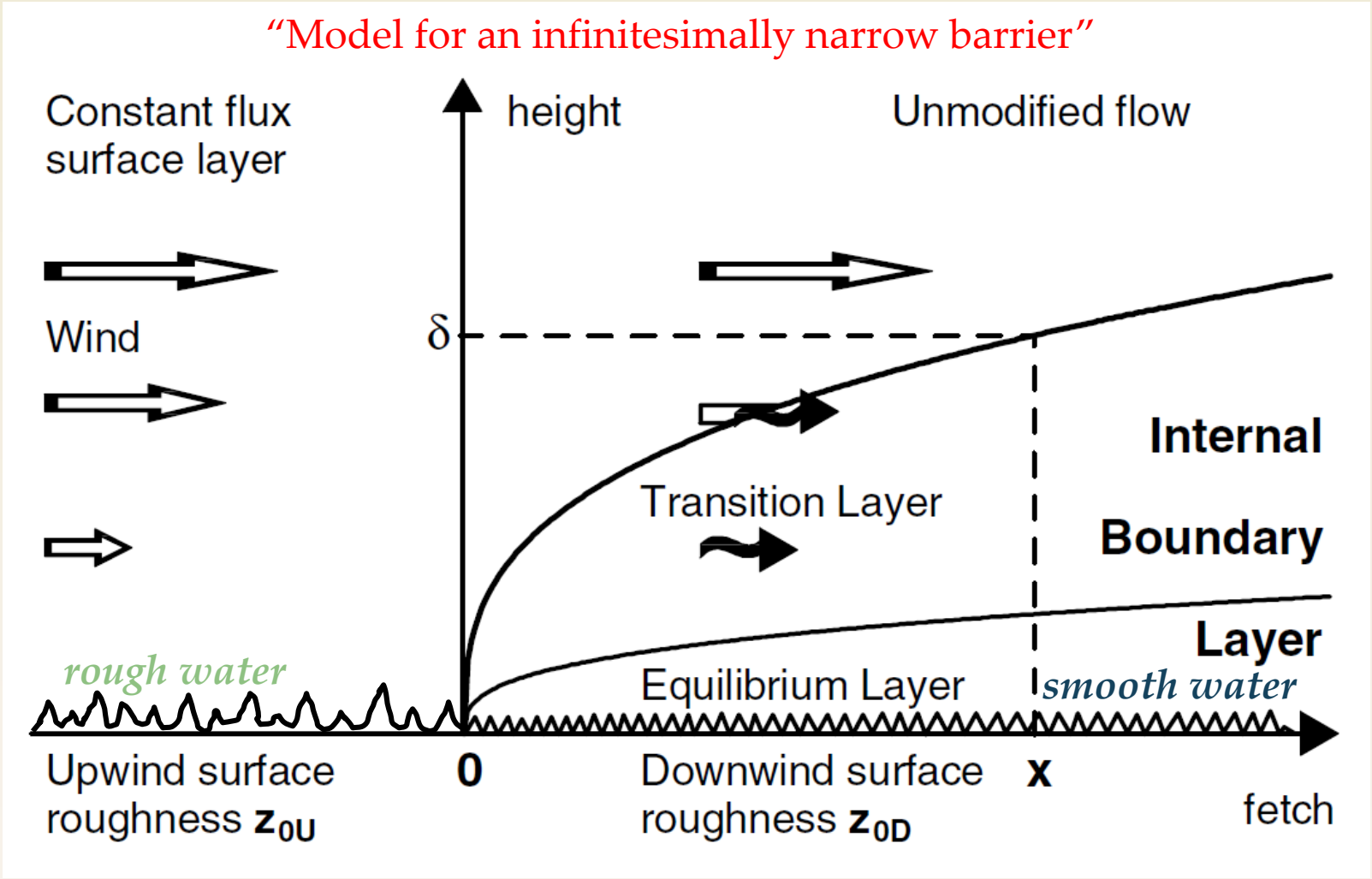
Working hypothesis

- Roughness lengths over the Indian River Lagoon waterways will be lower than over the ocean given the waves will be fetch/depth limited.
- Surface winds will be higher over the IRL than over the ocean given the lower roughness
  - If The interruption of the winds over the barrier islands is small and the surface winds have time to accelerate as they cross the waterway
- A "potential wind" argument based on the log wind profile.

$$ECF = \frac{U_{\mathrm{p}}}{U_{\mathrm{m}}} = \frac{\ln\left(z_{\mathrm{b}}/z_0\right)\ln\left(z_{\mathrm{ref}}/z_{0,\mathrm{ref}}\right)}{\ln\left(z_{\mathrm{m}}/z_0\right)\ln\left(z_{\mathrm{b}}/z_{0,\mathrm{ref}}\right)}$$

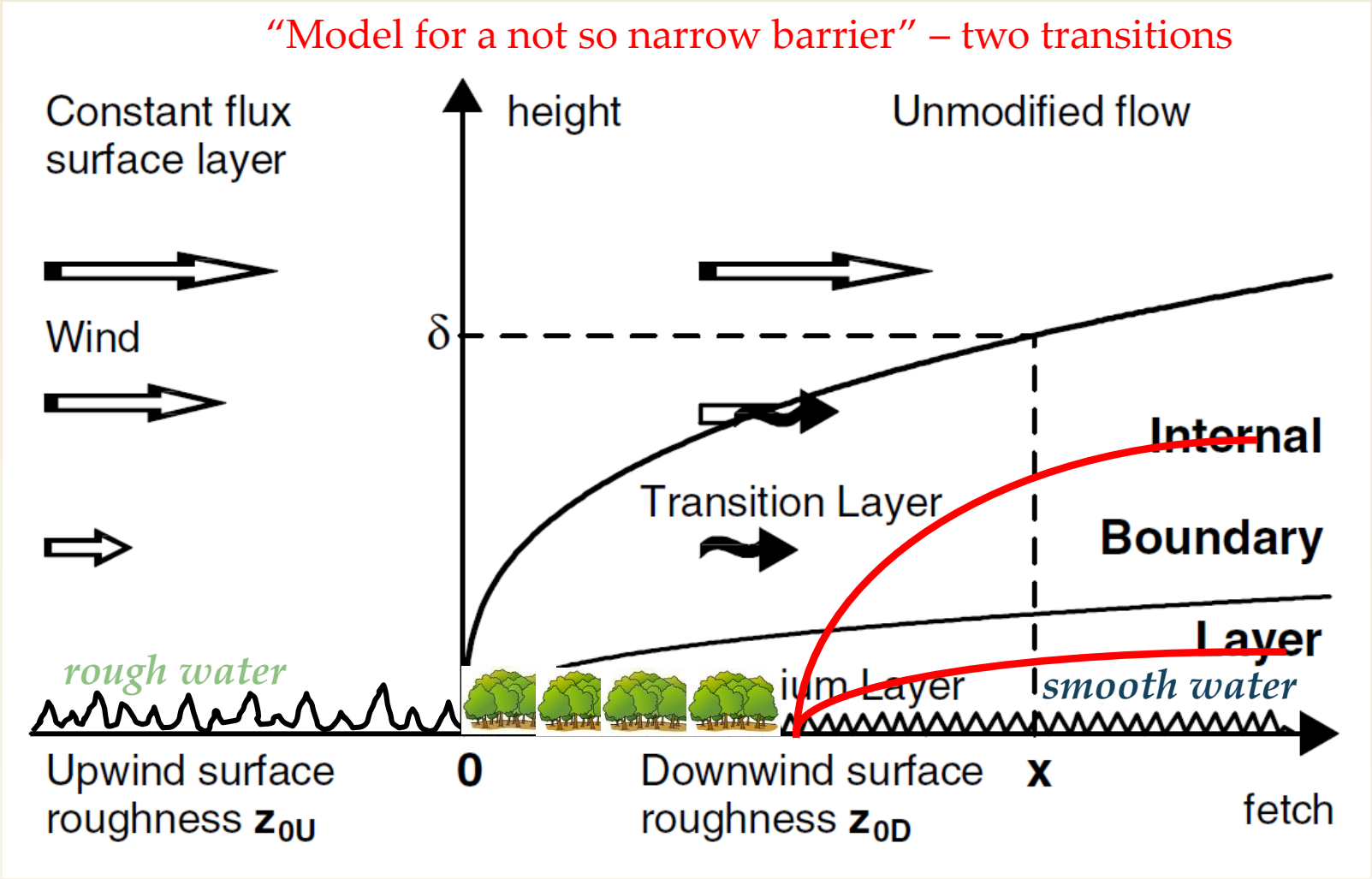
Exposure correction factor (Wever and Groen, KNMI, 2009).

Working hypothesis



Modified figure 1 Savelyev & Taylor (2005)

Working hypothesis



Modified figure 1 Savelyev & Taylor (2005)

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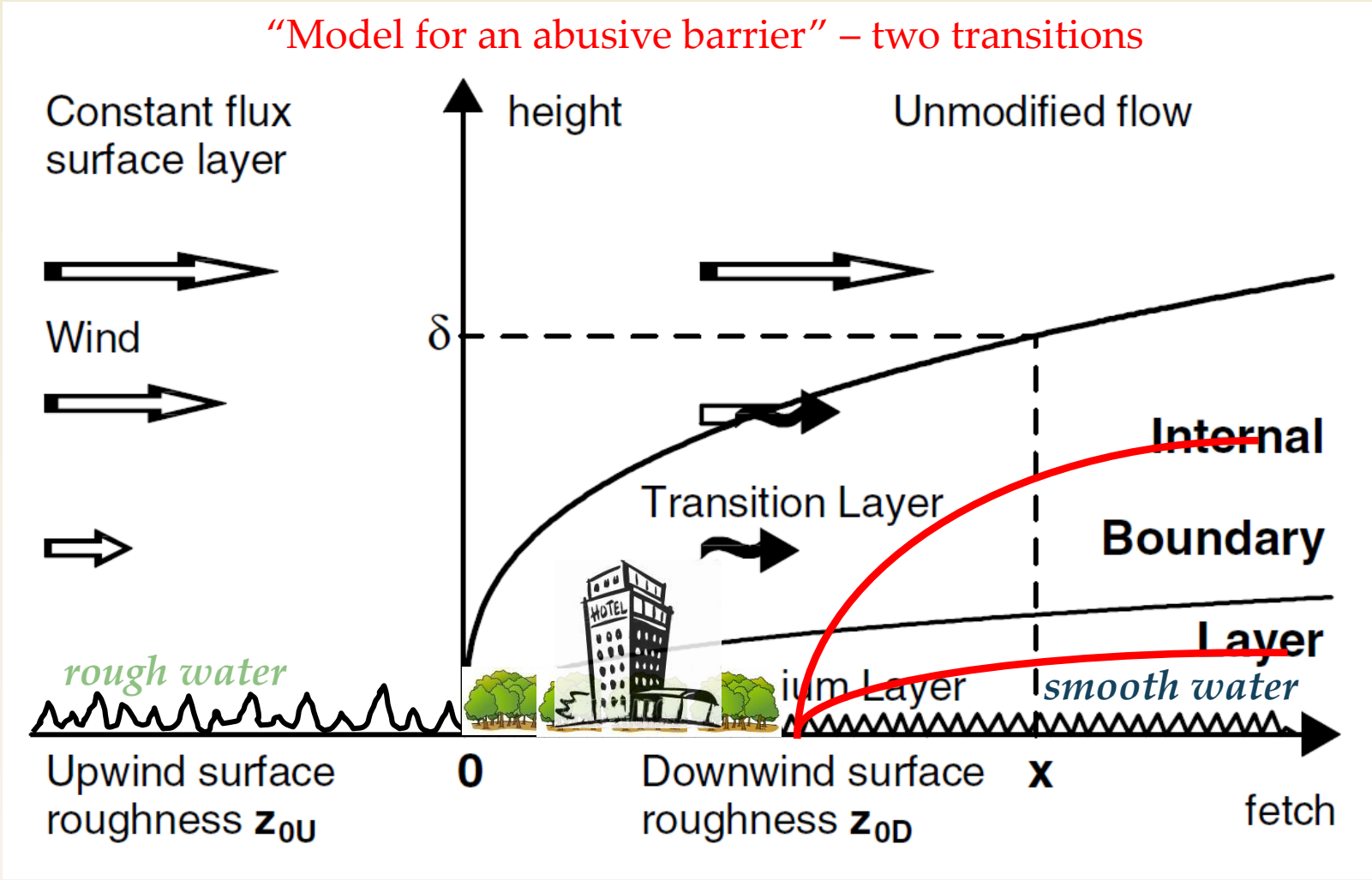
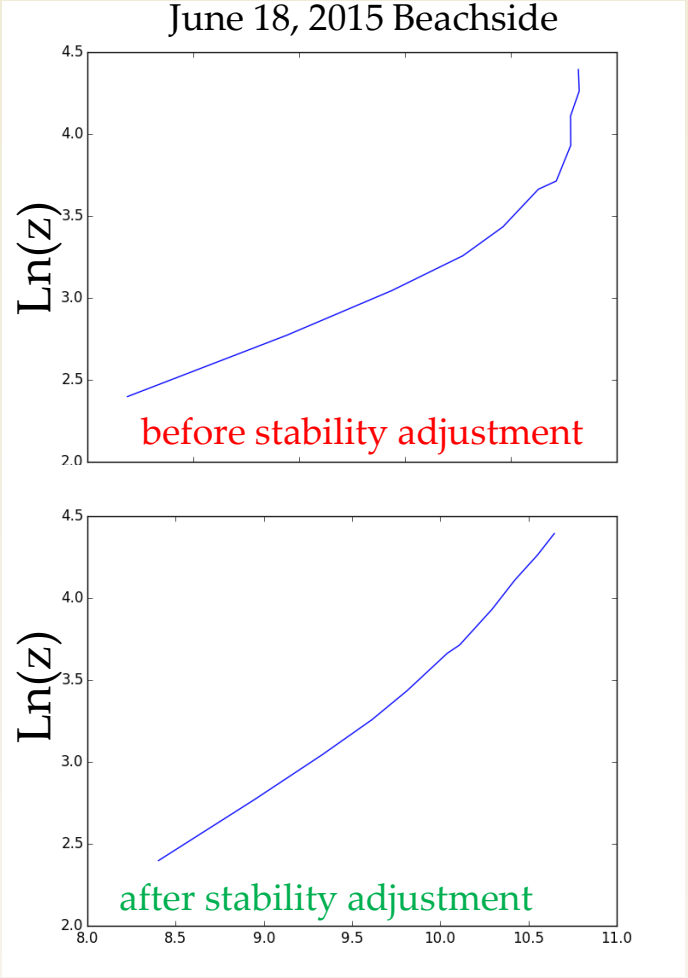


Modified figure 1 Savelyev & Taylor (2005)

Wind lidar derived z_0

- Roughness lengths were estimated using the "wind profile" method
- Averaged winds (~ 1-2 hours)
- **u^*, z_0** derived from best fit (slope * κ and intercept)
  - unstable conditions, an **iterative approach** was used assuming no displacement height
  - For a given L (MO length) the friction velocity was adjusted until the input value matched the fit value – used a range of L values
    - R^2 ~ 0.995



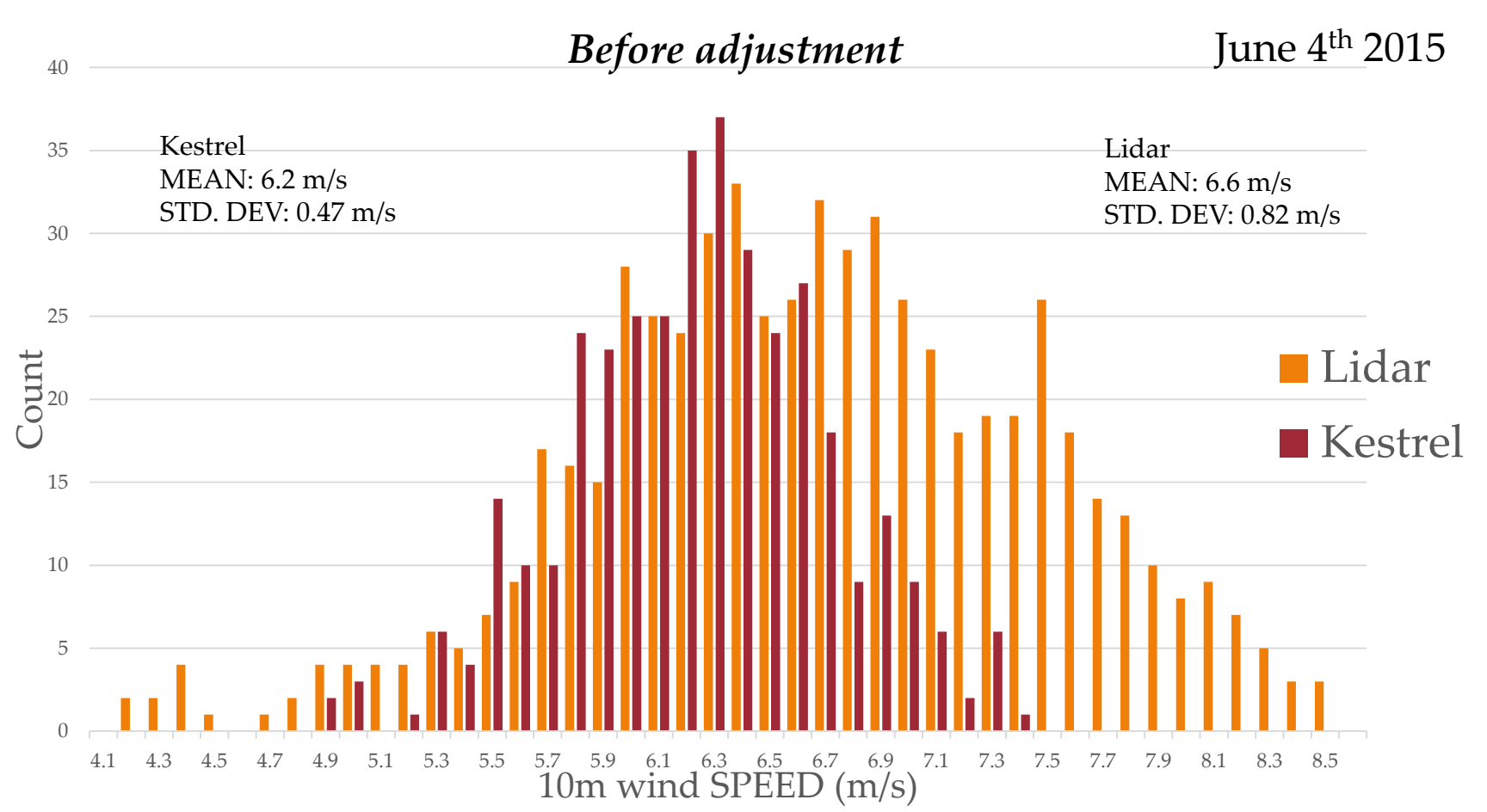
Wind lidar derived z_0

Table 2.2 Values (approximate) of surface roughness length for various types of terrain

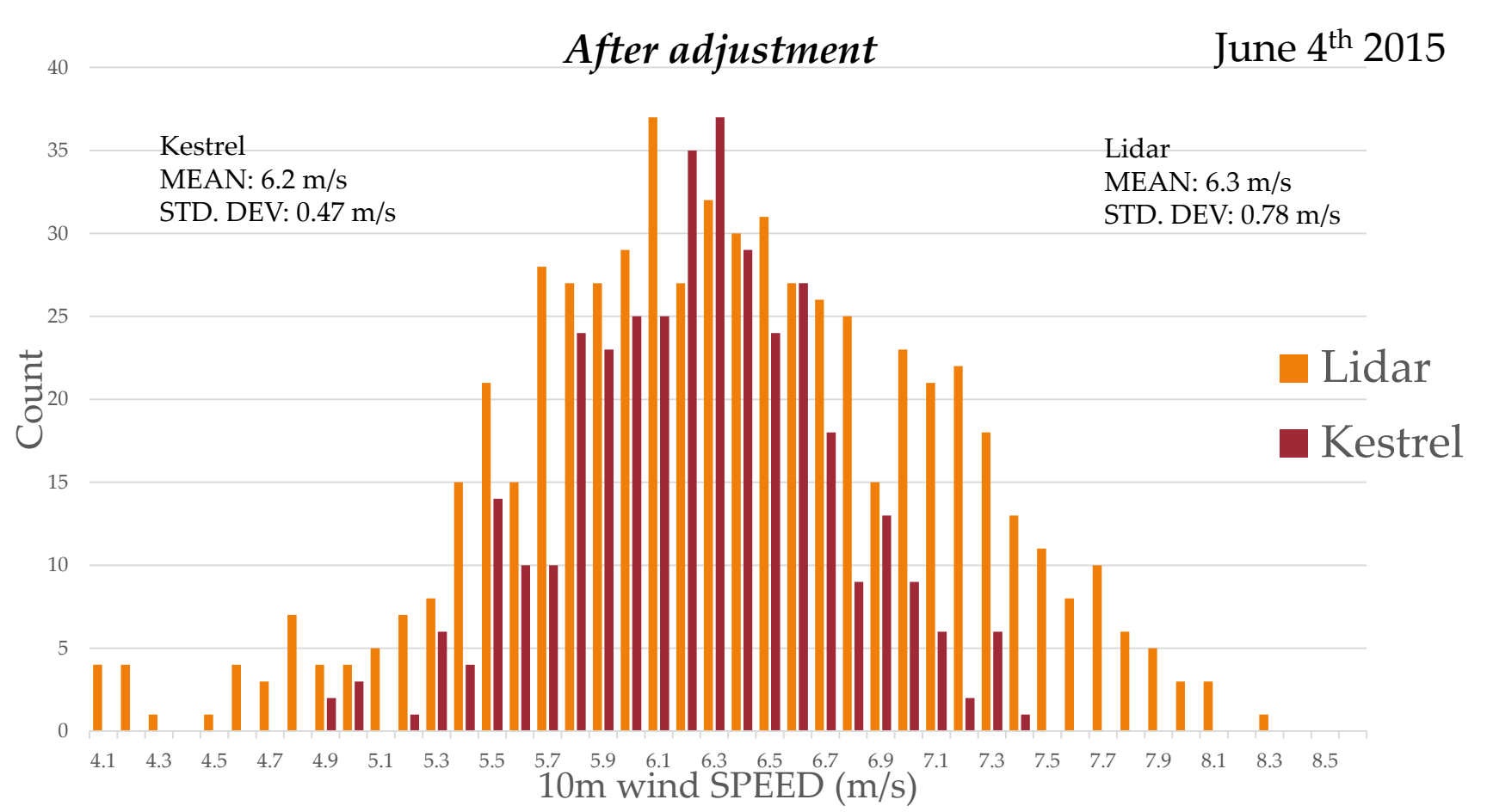
Terrain description	z_0 (mm)
Very smooth, ice or mud	0.01
Calm open sea	0.20
Blown sea	0.50
Snow surface	3.00
Lawn grass	8.00
Rough pasture	10.00
Fallow field	30.00
Crops	50.00
Few trees	100.00
Many trees, hedges, few buildings	250.00
Forest and woodlands	500.00
Suburbs	1500.00
Centers of cities with tall buildings	3000.00

Wind Energy Explained: Theory, Design and Application

Potential wind adjustment



Potential wind adjustment



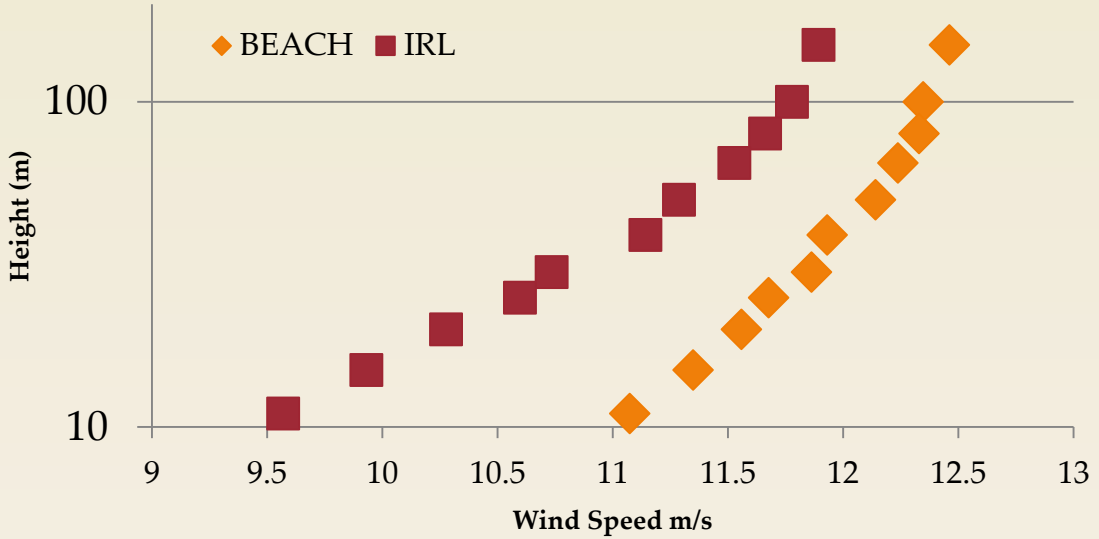
- Beach side z_0 = .008 m
  Lagoon House z_0 = .001 m

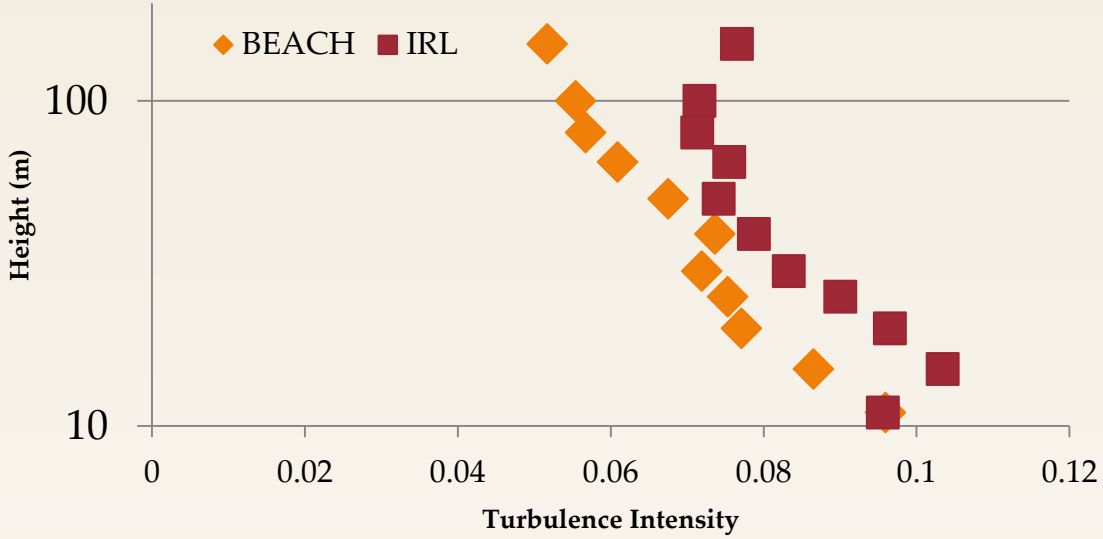
Back to the field – October 2015

West side of
Banana River

Beach @ Patrick
Air Force Base

Back to the field – October 2015



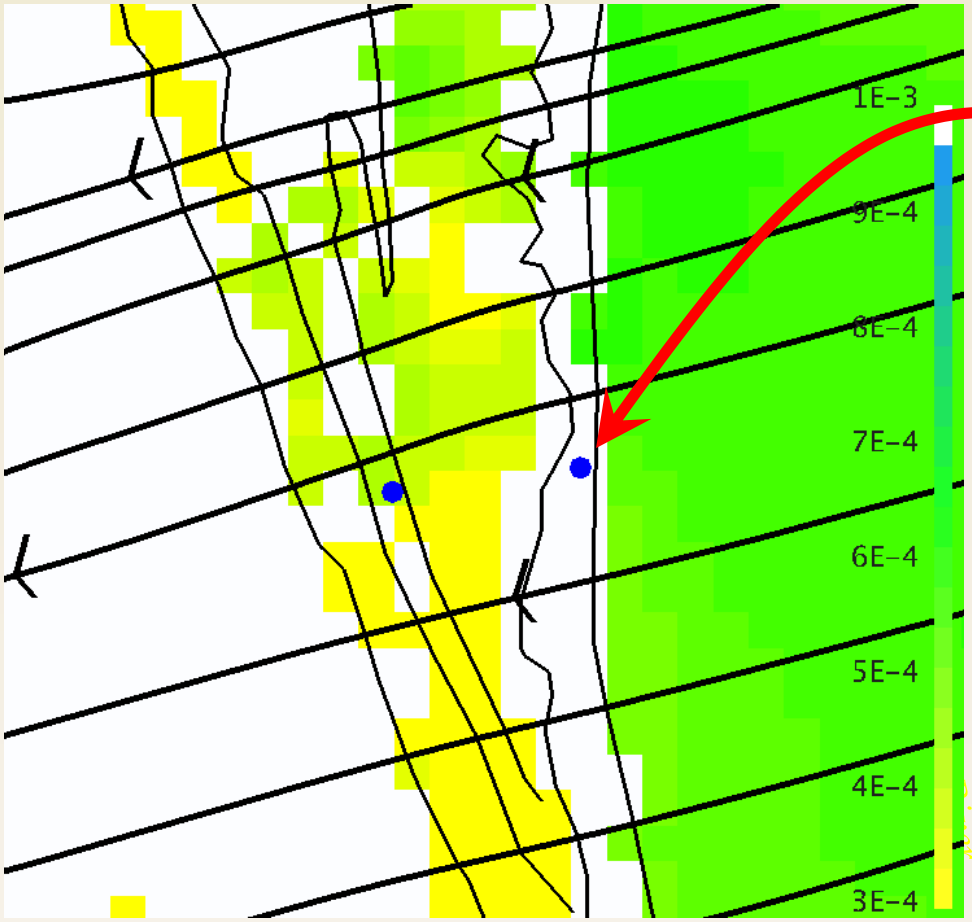


Beachside roughness length estimate:
~ 0.0001 m (1E-4 m)

West side of the IRL roughness estimate:
~ 0.005 m (5E-3), but representative?).

TI suggestive of barrier island generated turbulence and a smoother IBL developing.

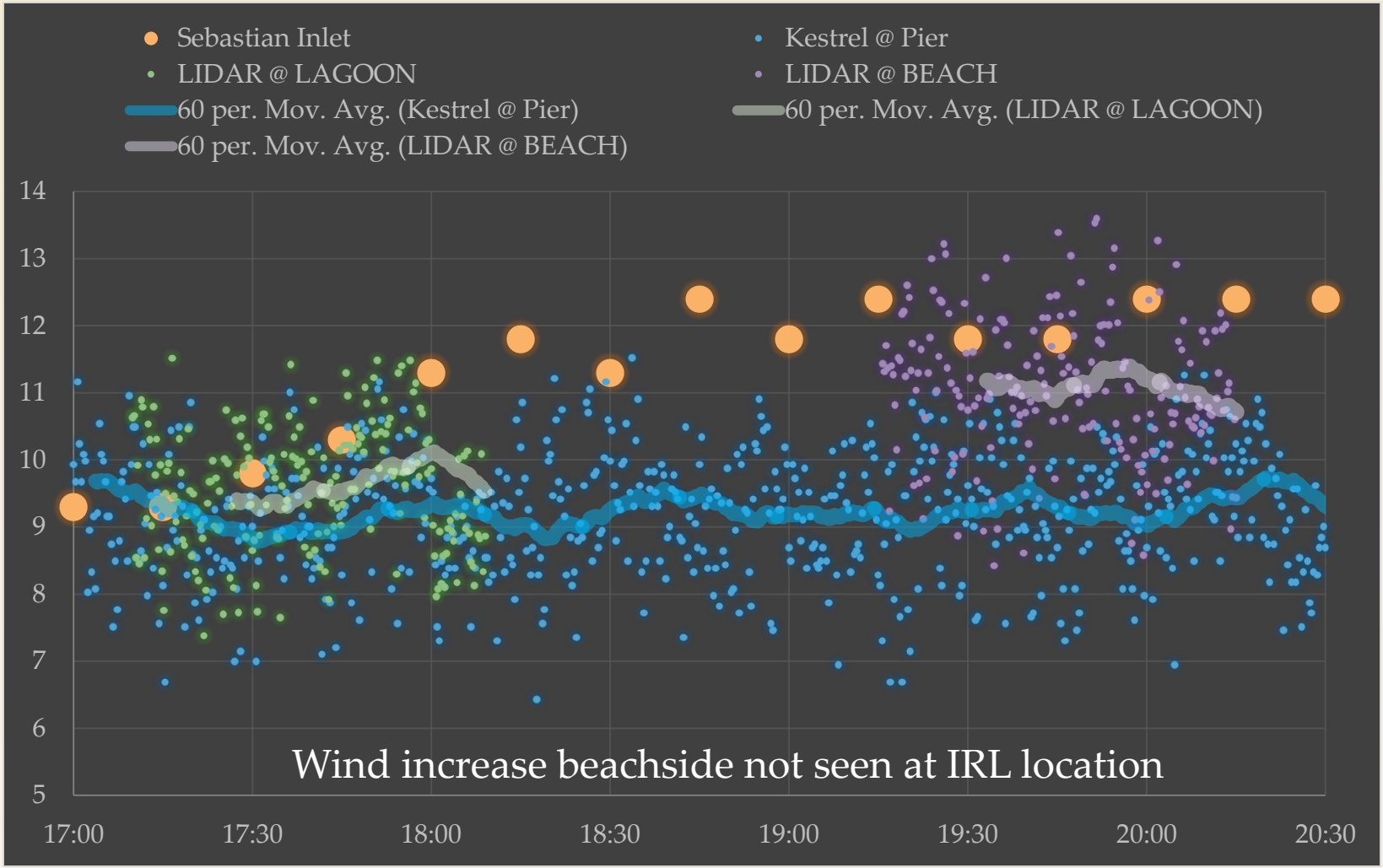
Back to the field – October 2015



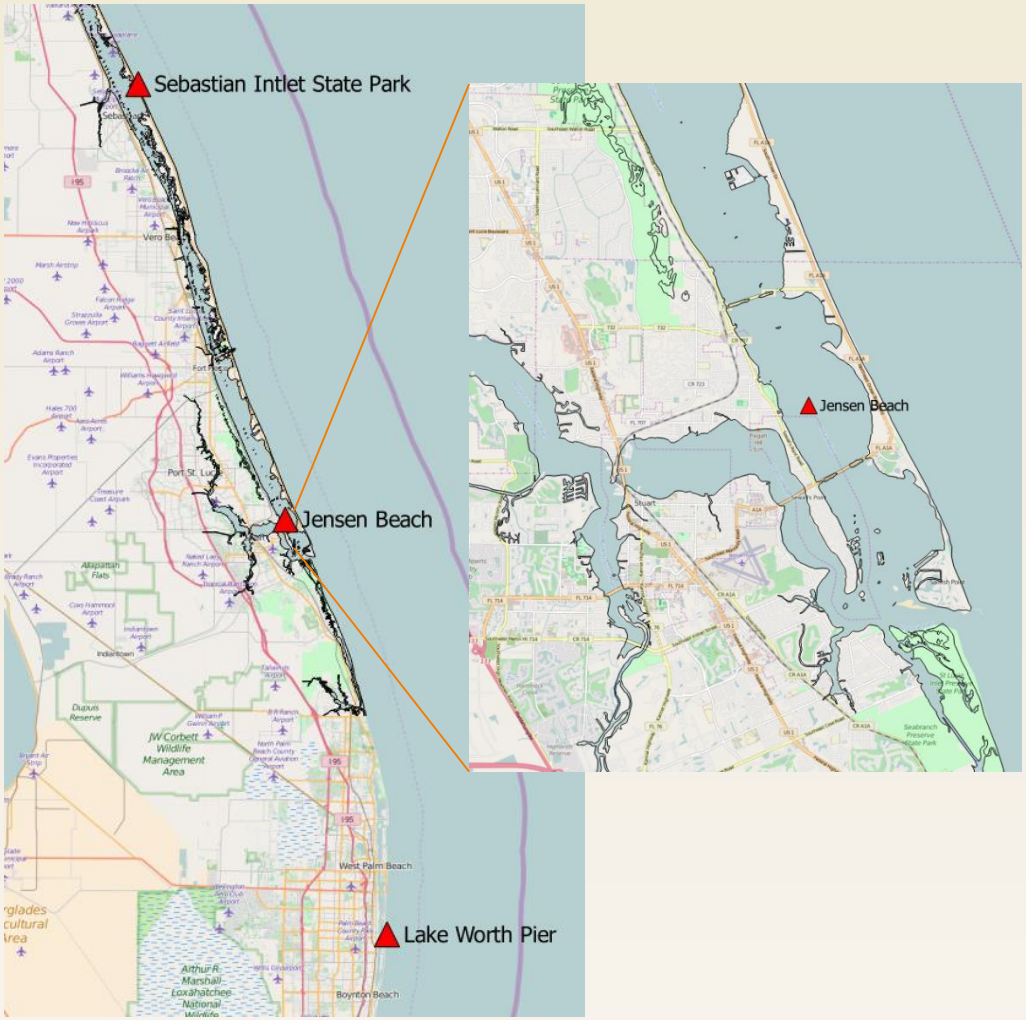
WRF simulation roughness length (m)

- Upwind roughness could include large row of hotels – subtle trajectory changes.
- Very low roughness at the beach observed with rough surf

Back to the field – October 2015



Long term data sets

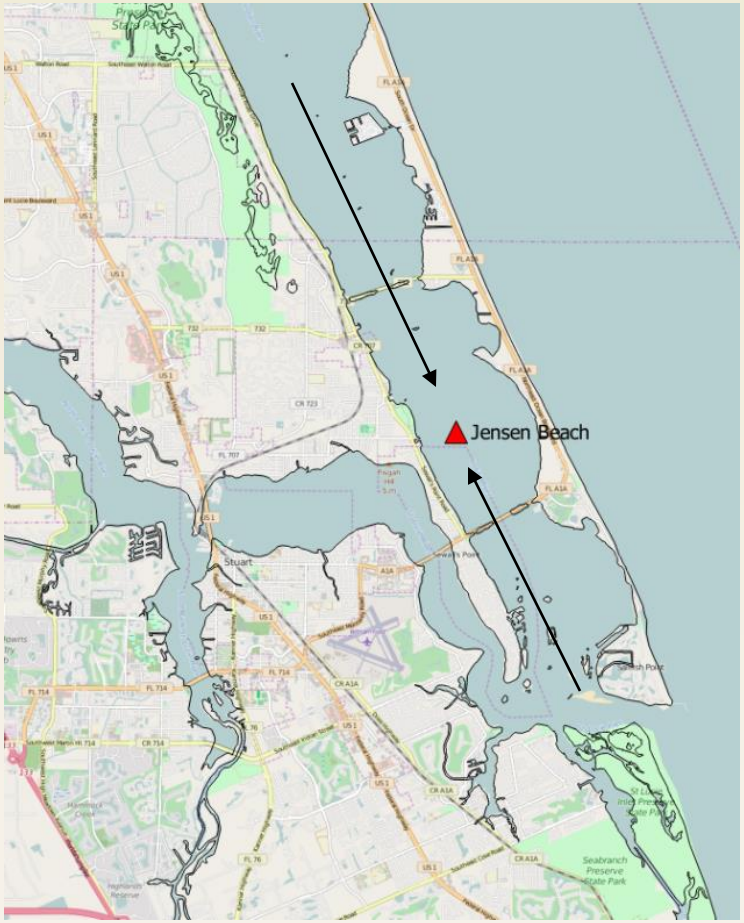


~ 2 years of data comparison between a WeatherFlow site in the south IRL (Jensen Beach) and two NDBC sites

Mean wind vs. wind direction (wind > 2.0 m/s)

Orientation of coast/lagoon changes!

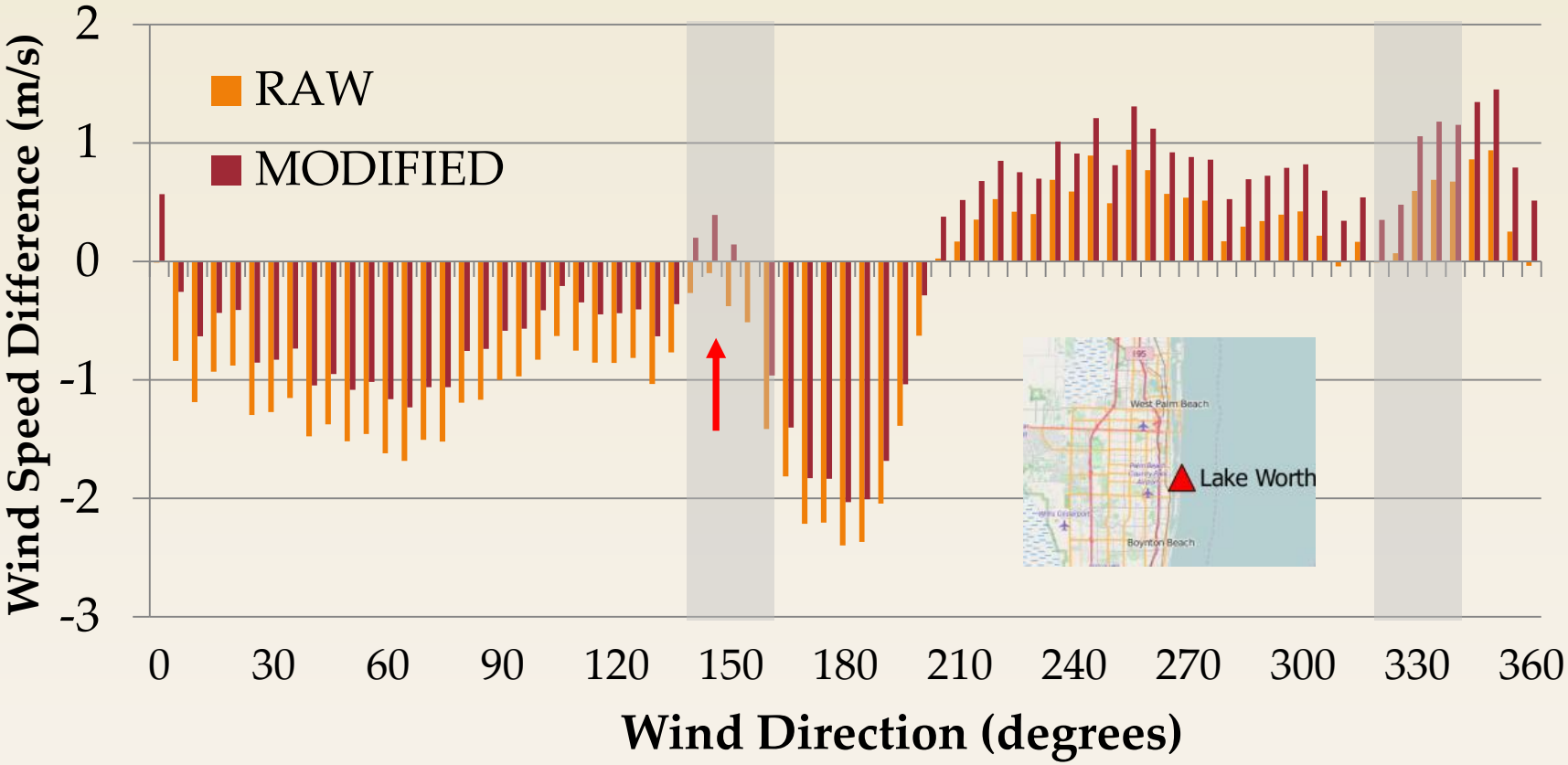
Long term data sets



Open fetch at the WeatherFlow Jensen Beach site from NNW or SSE.

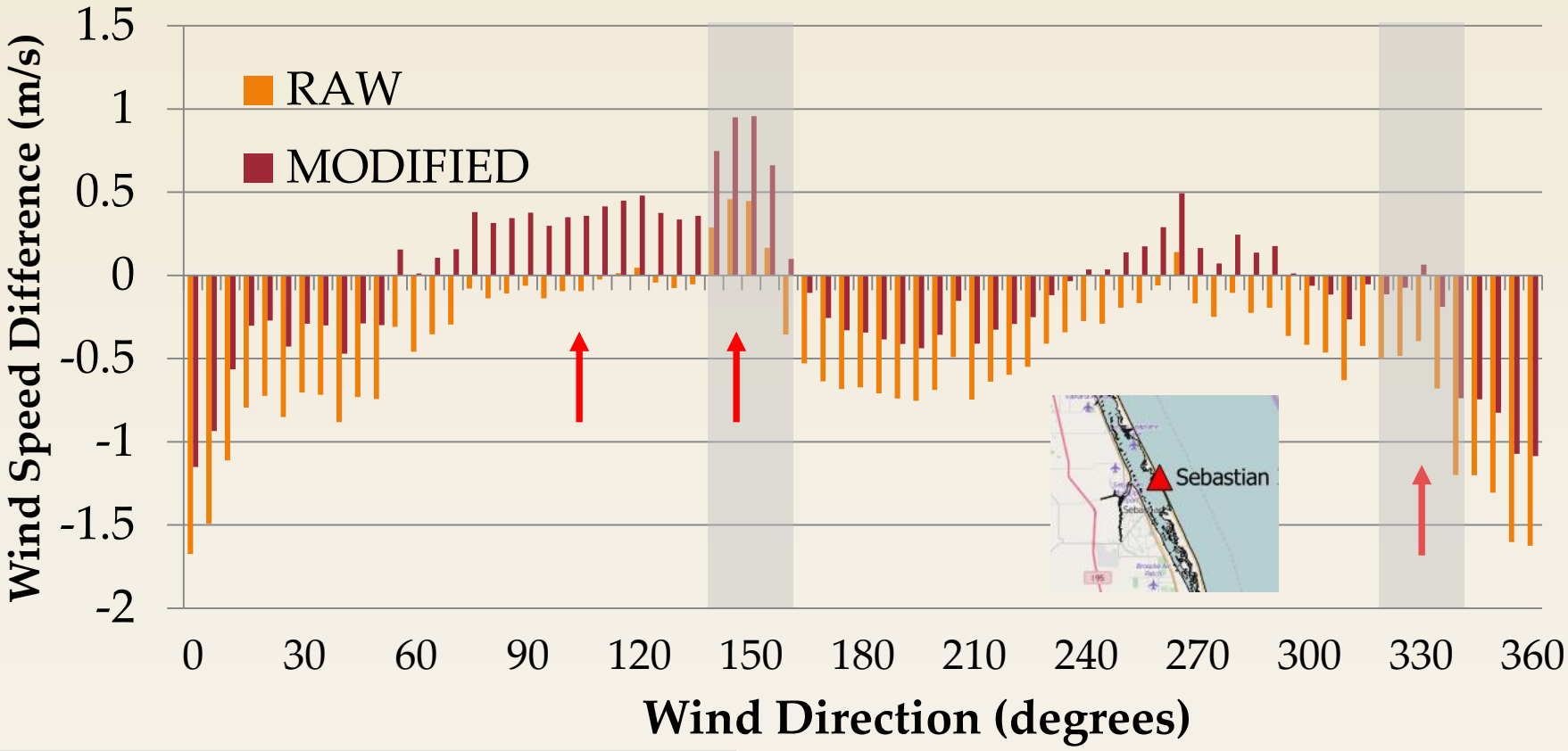
Fairly significant development exists on the barrier island to the east.

Jensen Beach vs. Lake Worth



Alongshore winds at Jensen Beach

Jensen Beach vs. Sebastian Inlet



Alongshore winds at Jensen Beach

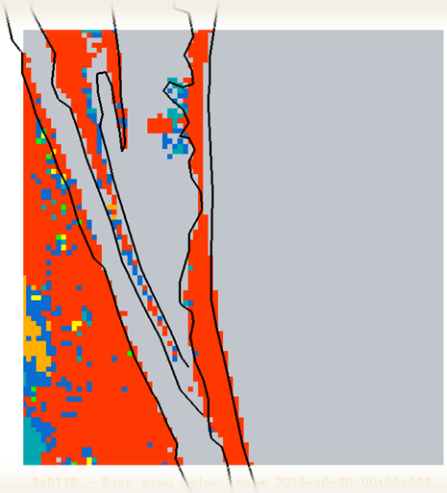
Results Summary

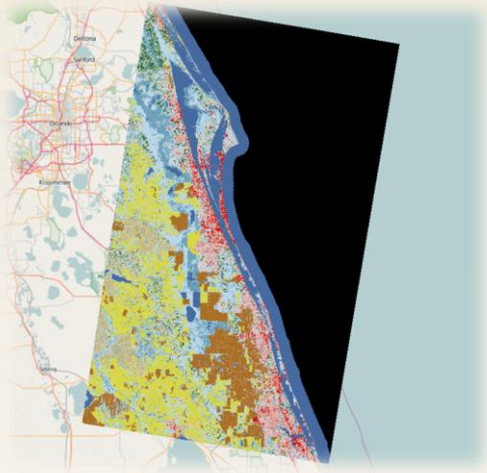
- ***Super-oceanic winds*** are proposed as a concept to describe winds in estuaries greater than nearby oceanic winds due to changes/differences in surface roughness (e.g. depth/fetch limited waves)
- Evidence is suggestive that these winds exist if not theoretically plausible.
  - **Adequate fetch** needed
  - **Alongshore** super-oceanic winds are more probable than **cross shore** super-ocean winds

Future Work

- Further observational studies required.
  - Ideal sites such as undeveloped regions of South Padre Island

- Modeling studies with modified roughness algorithms
  - for depth/fetch limited wave development in estuaries





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