REFINING AIR-SEA INTERACTIONS USING FLOATING WIND PROFILERS

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MAKING COMPLEX EASY

RPS MetOcean



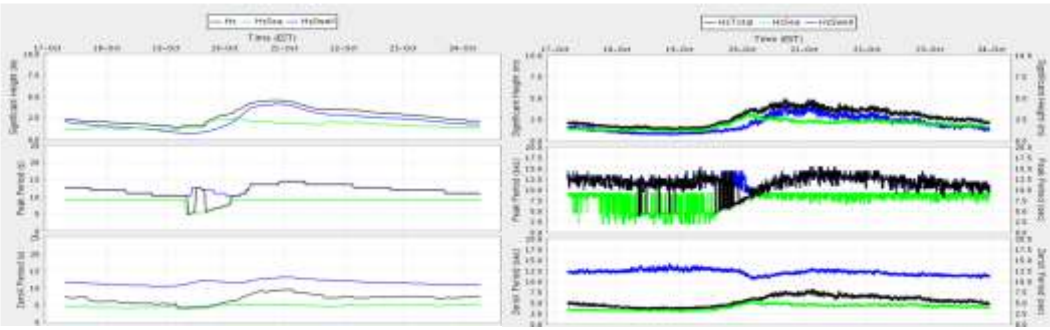
- Engaged in continuous oceangraphic measurement since 1976
- 95% of all oceanographic data collection for the offshore oil&gas industry in Australia has been done by RPS. Also quality assurance, audit, quality control, and data management.
- Design criteria, tropical cyclone circulation modelling, synthetic storm studies, pipeline route studies, etc

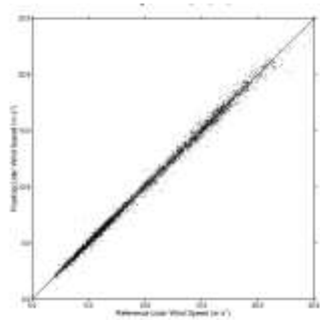
- RPS improve, design, and fabricate new instrumentation as required to correctly detect and measure metocean phenomena – Currents, Solitons, Tides, Waves, Wind, etc
  These devices are becoming the industry standard worldwide

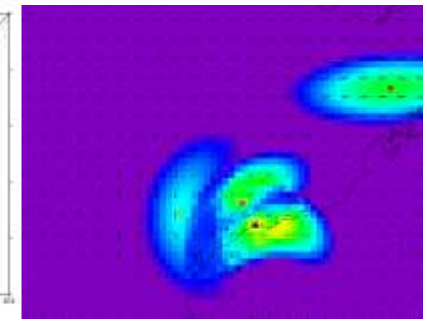
- MetBuoy – ultra-robust platform for wind/wave/current/etc
- M200 logger – custom-built programmable logger
- CM04 – now leading current meter for design measurement
- Floating LiDAR Buoy 4.5 – latest development

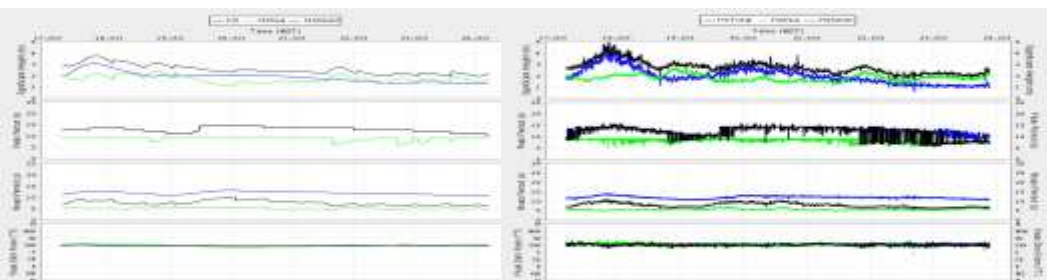
Wind and Waves (also Wind and Currents)

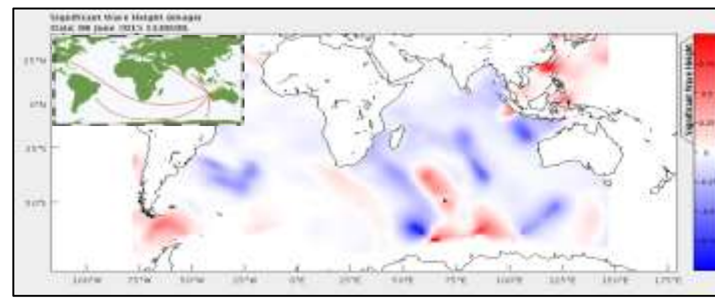
- ITWS (it's the winds, stupid) and GI-GO (garbage-in = garbage-out)
- Calibrated WW3 with perfect inputs gives (perfect?) outputs

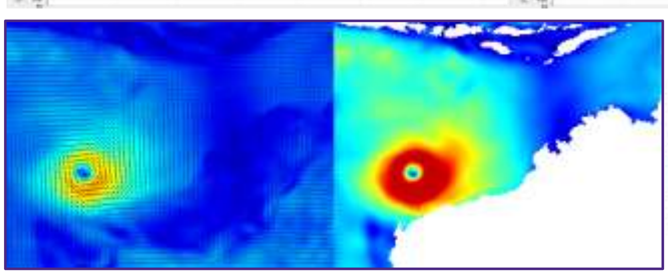


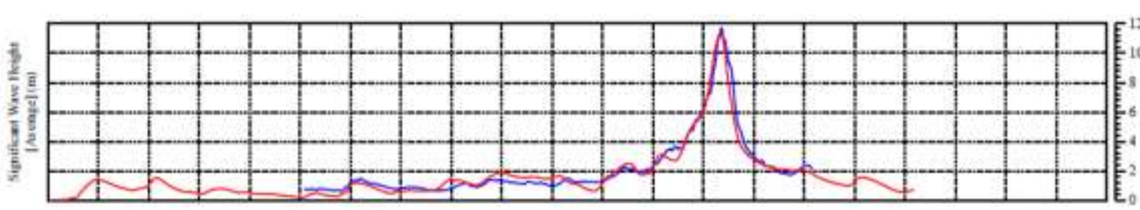












Getting it right is important to oil&gas operators..

Winds need to be measured accurately and cyclones represented correctly,
or else wind and waves are under-forecast – compromising safety and operations.

Getting it right is important to ports and shipping..

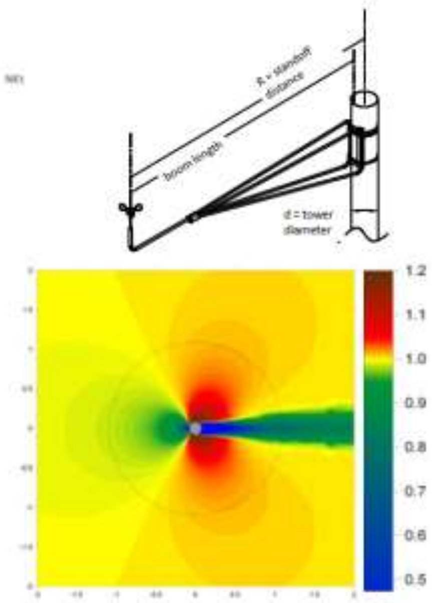
Wind and wave interactions need to be well represented…

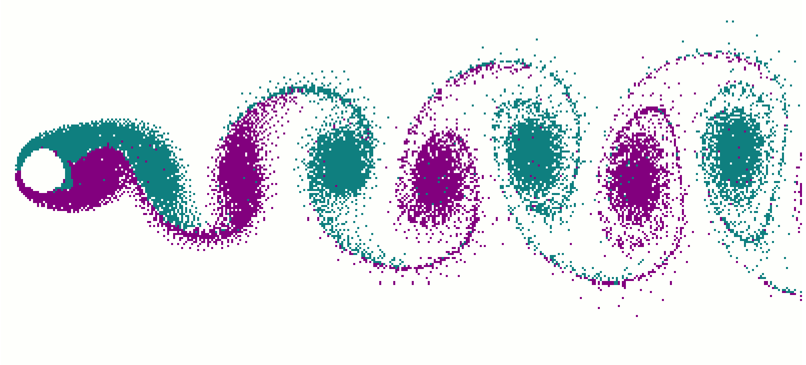
Getting it right is important to wind farm operators…

Winds need to be measured accurately, or else risk under-production (loss) or possible turbine damage!

Measuring Wind is Difficult

- Three dimensional variable
- Consists of small-scale fluctuations and large scale flow
- Easily corrupted
- A clear fetch is needed
- Note this is nearly impossible (but you should at least try!)

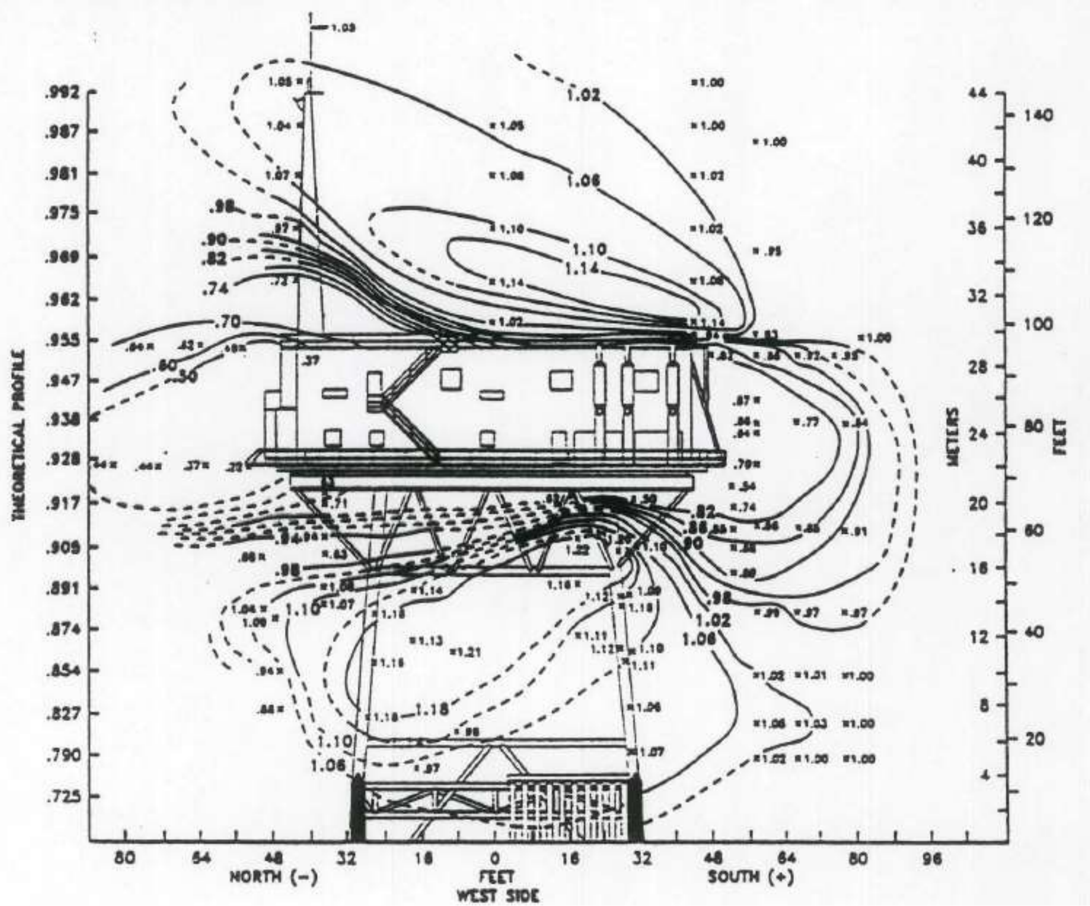




Due to fluctuations, wind speed is only meaningfully accurate to 0.01 m s^{-1}

Measuring Wind on an Offshore Platform is Difficult

FIGURE 3. Disturbed airflow around Argus Island for southerly flow expressed as the ratio of observed to undisturbed wind speeds (adapted from Thornthwaite et al., 1965).



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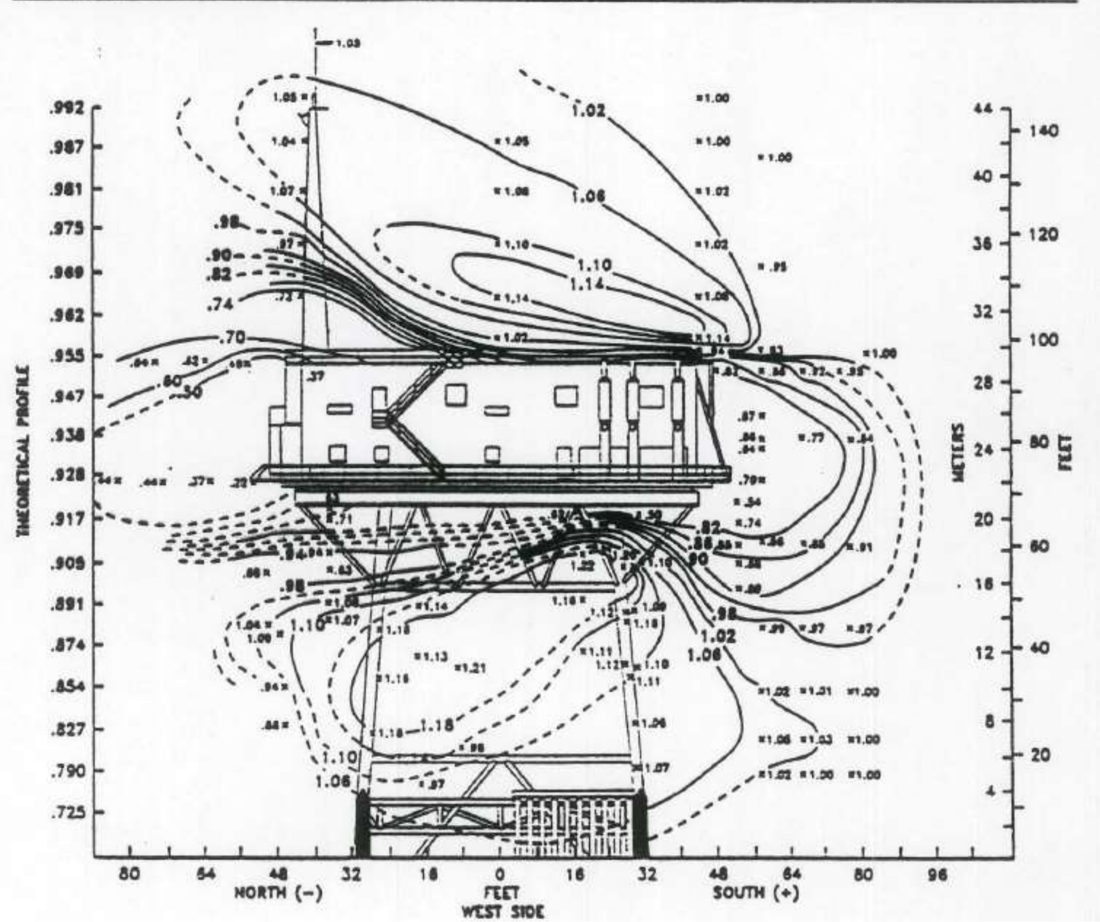
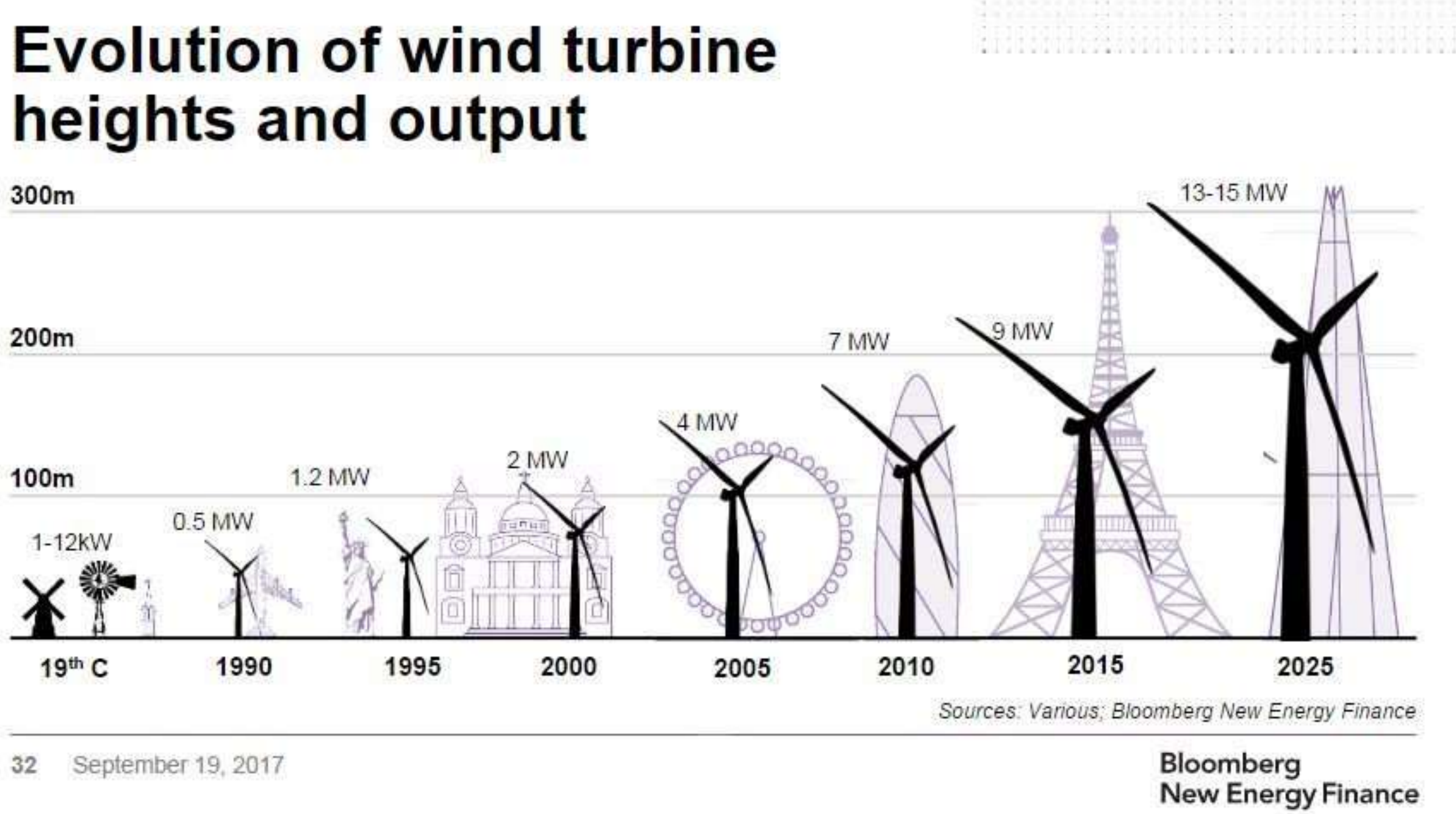


Often the best we can do is surface measurement transformed to equivalent wind-at-height

Measuring Wind Profiles for an Offshore Wind Turbine



Log vs Power Law (and other height-approximations)

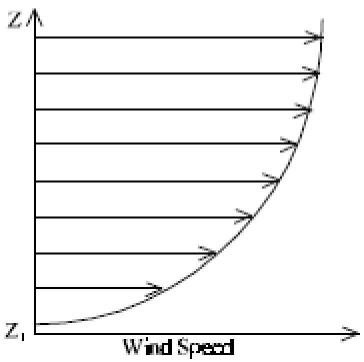
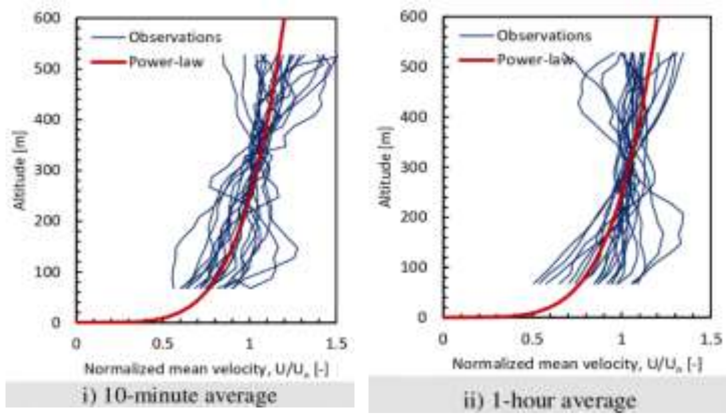


Figure 3.5.1 Typical logarithmic variation of wind speed with height in a neutral atmospheric boundary layer (after Stull, 1988).



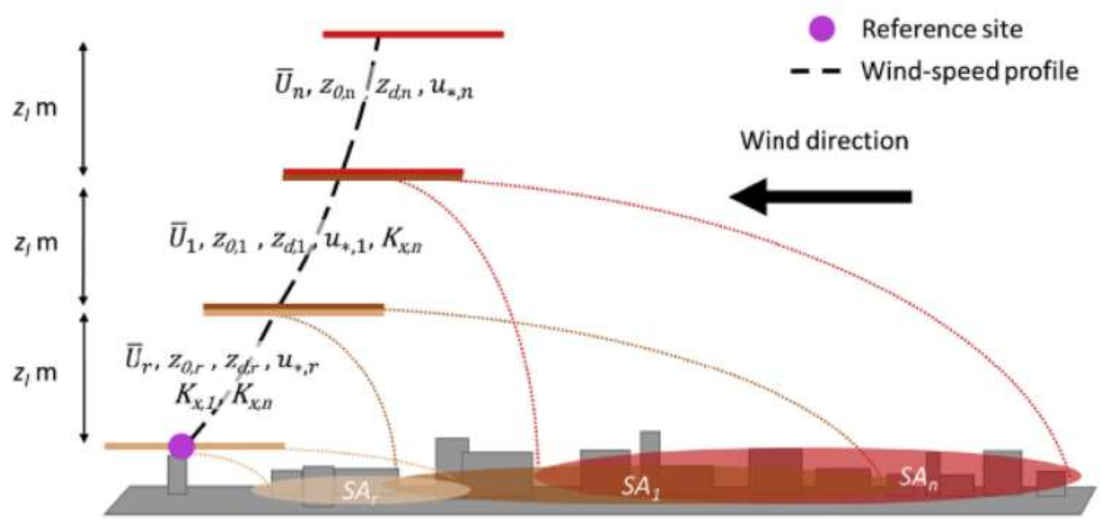
$$u = u_r \left(\frac{z}{z_r}\right)^{\alpha}$$

$\alpha = 0.11$

Assumes neutral stability over open water in calm seas !!

$$U(z) = \frac{u_*}{k}\ln\left(\frac{z}{z_0}\right)$$

Attempts to factor in surface roughness length and stress-scaling



Deaves and Harris (DH_V) non-equilibrium profile - composite based on source surface roughness

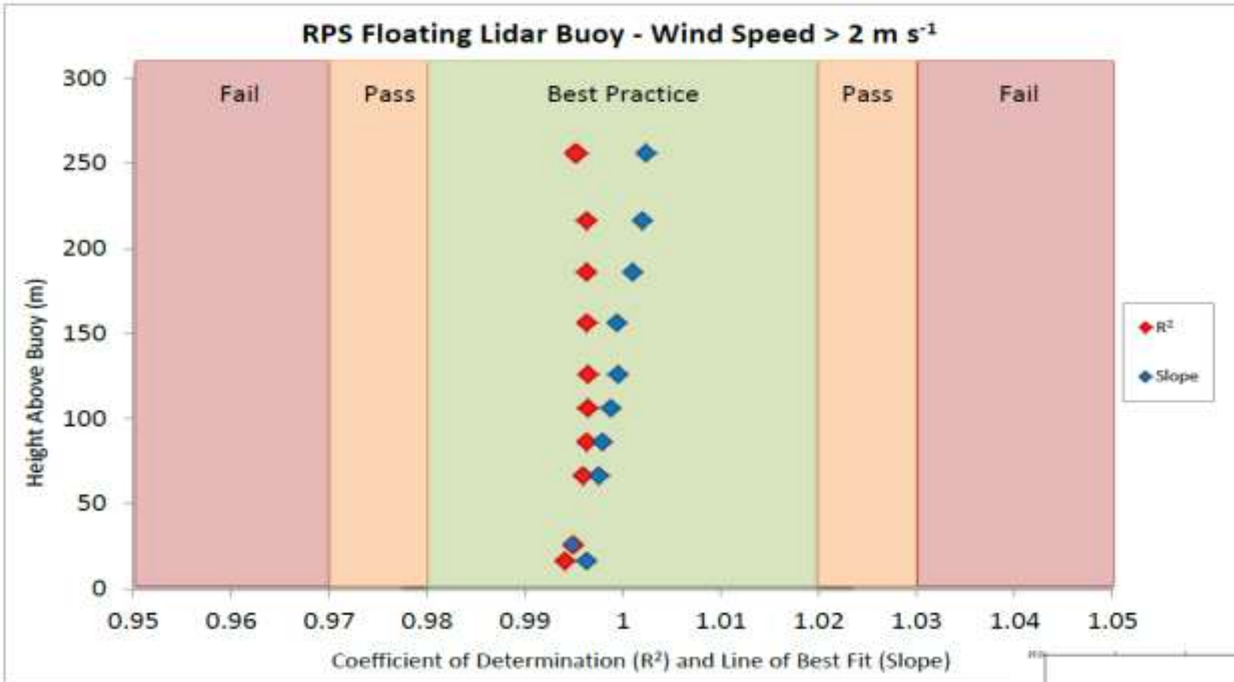
Renewables Industry

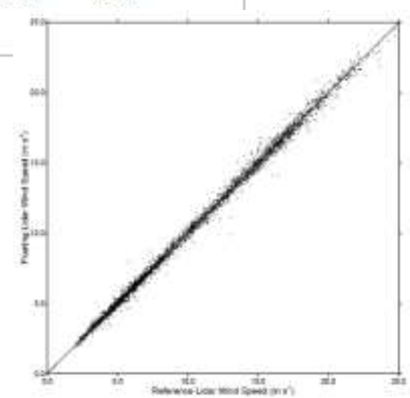
- Wind farms shifted offshore, first in 1991
- Why? Higher wind speeds, cleaner winds, no (or less) land permitting issues

- LiDAR used onshore since 2004 to measure wind profiles
- Proven technology and industry-accepted
- Cheaper, faster, easier to install and maintain
- 2009 world's first offshore floating LiDAR deployment for offshore wind energy assessment




RPS Floating LiDAR Buoy 4.5



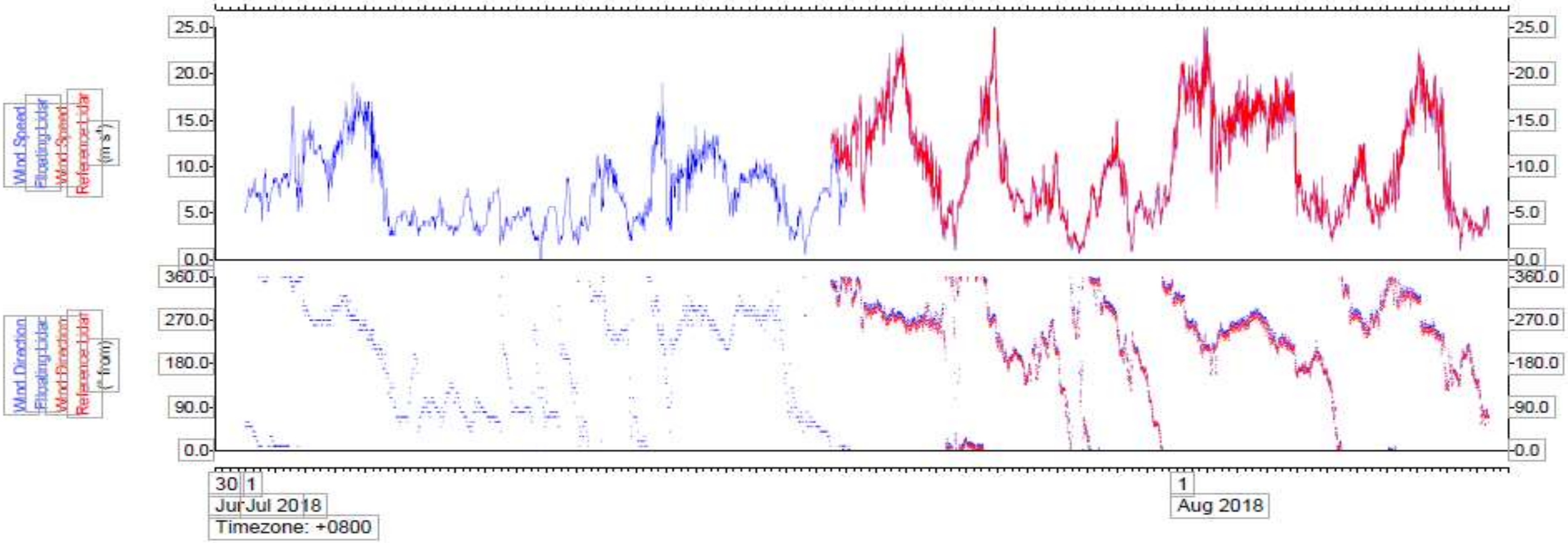


RPS Floating LiDAR Buoy 4.5

		Measurement Heights (m AMSL)										
		19	29	38	69	89	109	129	159	189	219	259
> 2 (m s $^{-1}$)	X_{mws}	0.996	0.995	0.986	0.998	0.998	0.999	1.000	0.999	1.001	1.002	1.002
	R^2_{MWS}	0.994	0.994	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.996
4 – 16 (m s $^{-1}$)	X_{mws}	0.998	0.997	0.989	0.999	1.000	1.001	1.002	1.003	1.005	1.007	1.009
	R^2_{MWS}	0.992	0.992	0.992	0.994	0.994	0.994	0.994	0.994	0.992	0.992	0.988

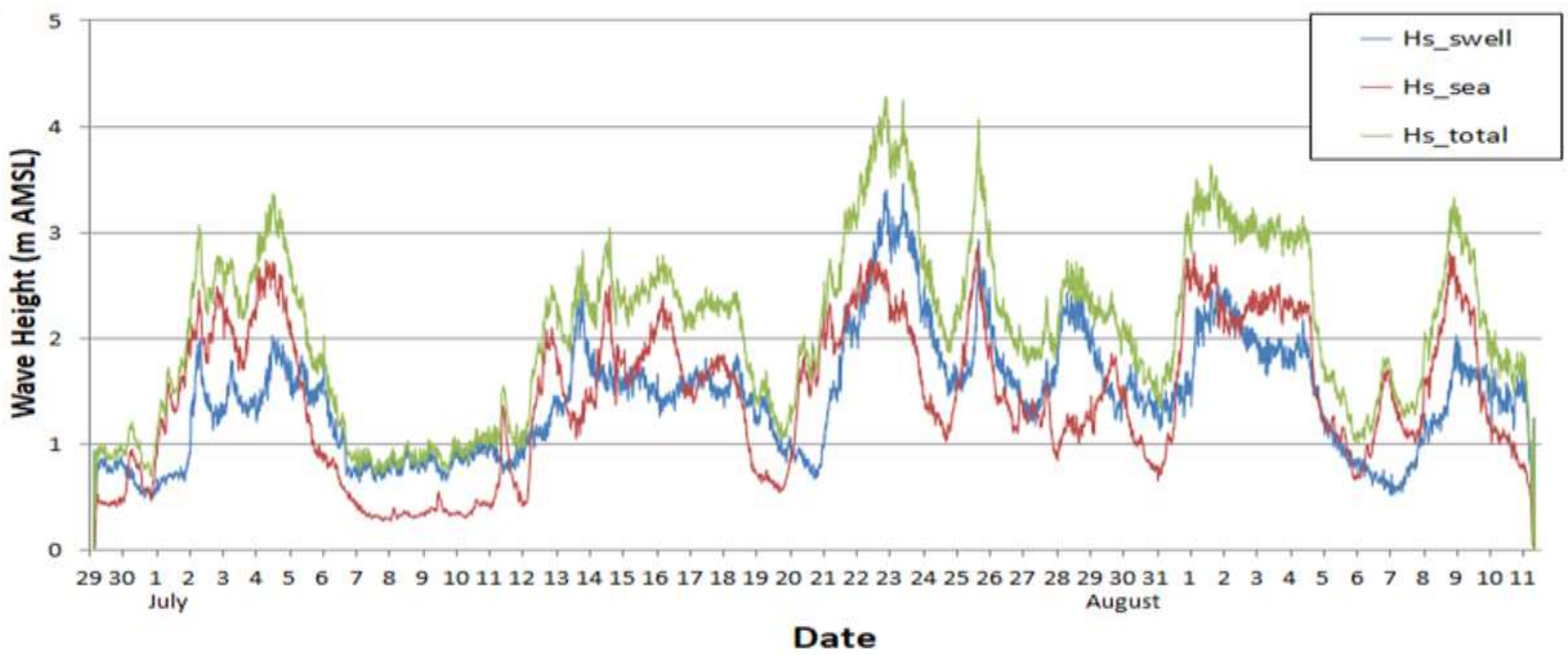
RPS Floating LiDAR Buoy 4.5

- Our Floating LiDAR Buoy is now L2 certified (ie. accuracy suitable for investment decisions)
- The unit validation results were nothing short of astounding
- RPS very surprised that two instruments can agree so well, never mind having one floating!
- Reference winds during unit validation (red = Reference LiDAR)



RPS Floating LiDAR Buoy 4.5

- Rough conditions had no impact on the accuracy of vertical wind profiling
- Waves during unit validation (green = Total Hs)



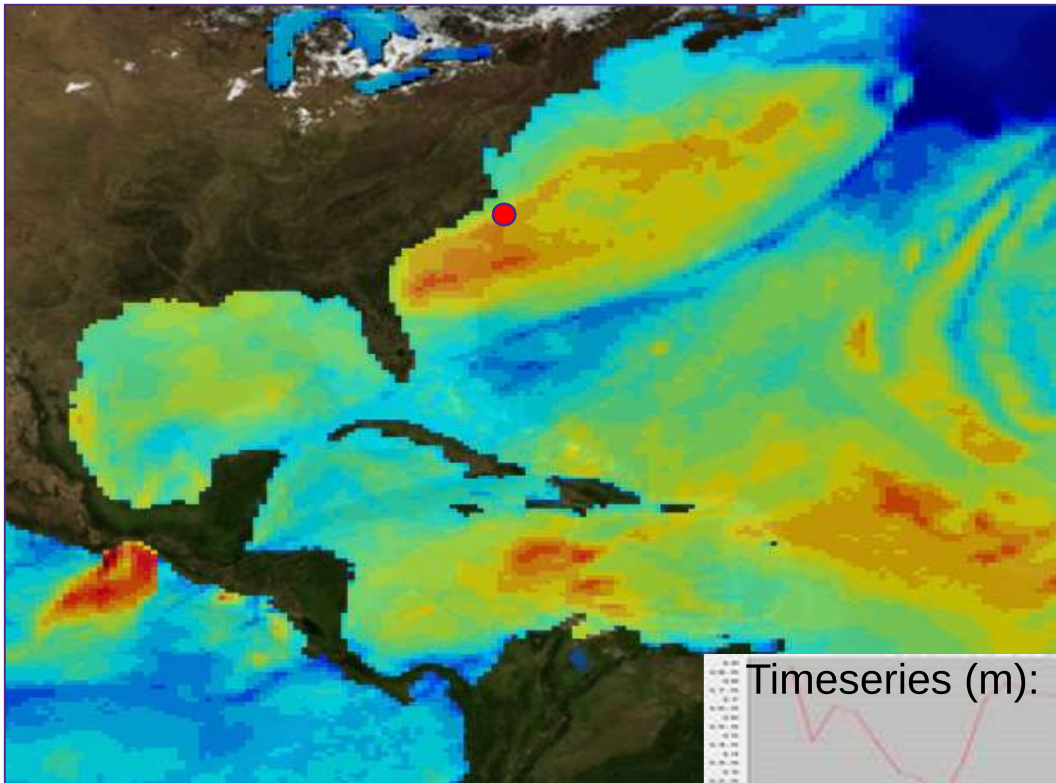
Typical LiDAR Configuration

- ZX300M LiDAR (wind profiler)
- M200 (AT, BP, RH, WS)
- MRU-5 and MOSE-G (waves)
- CM04 current meters
- CT loggers (salinity)
- Tide Gauge

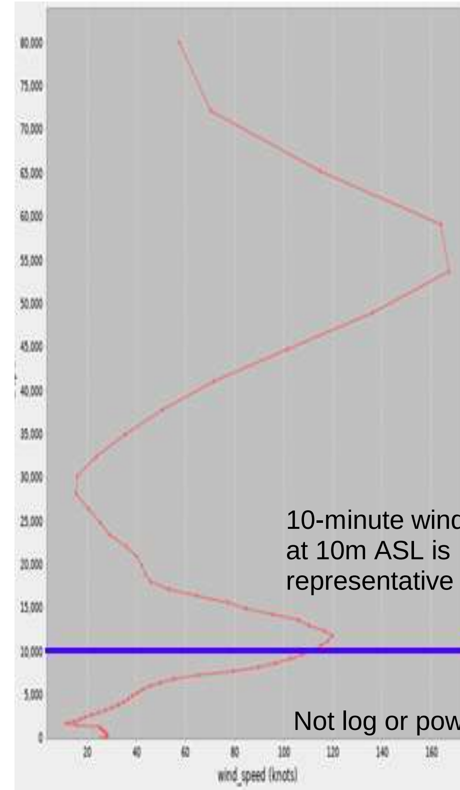
Configured height (m)	Bin height relative to AMSL (m)
247	250
207	210
177	180
147	150
117	120
97	100
77	80
57	60
38*	41*
17	20
10	13

Evaporation Ducts and Surface Wind

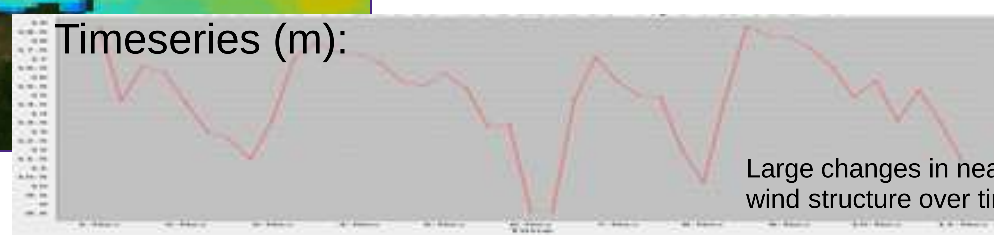
- Formed by rapid change in humidity/temperature over water
- Useful indicator of ‘interesting’ near-surface wind profiles



Vertical wind profile (m/s):

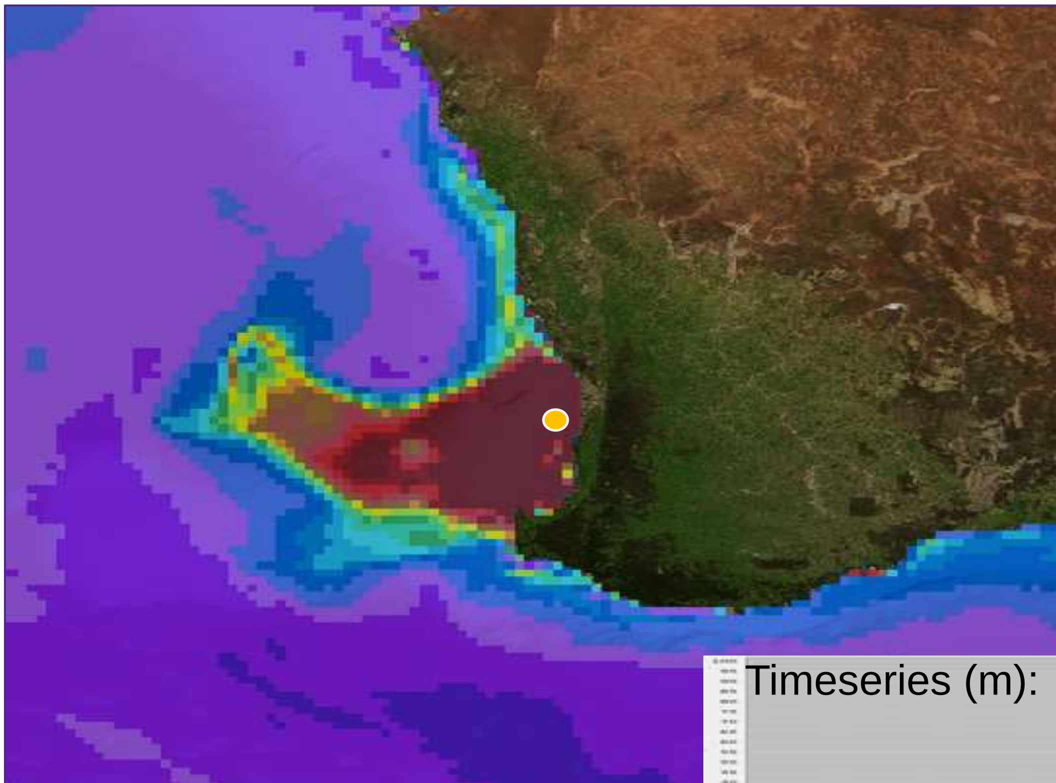


Timeseries (m):

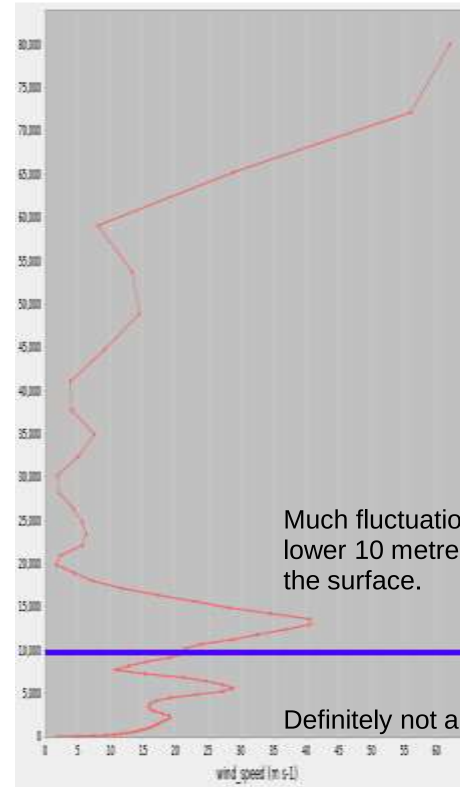


Evaporation Ducts and Surface Wind

- Surface profile features persist over the period of hours
- Alter density and available surface energy over large areas



Vertical wind profile (m/s):



Much fluctuation in the lower 10 metres near the surface.

Definitely not a log fit

Timeseries (m):

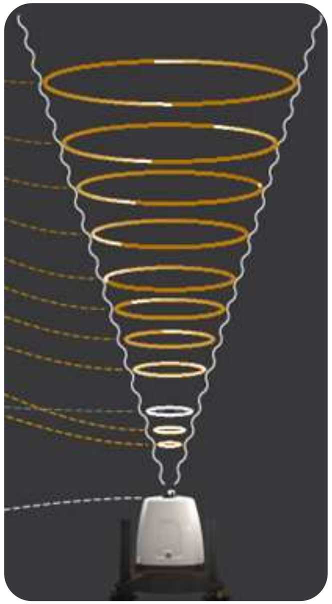
Large density changes over time (surface up to 80m height)

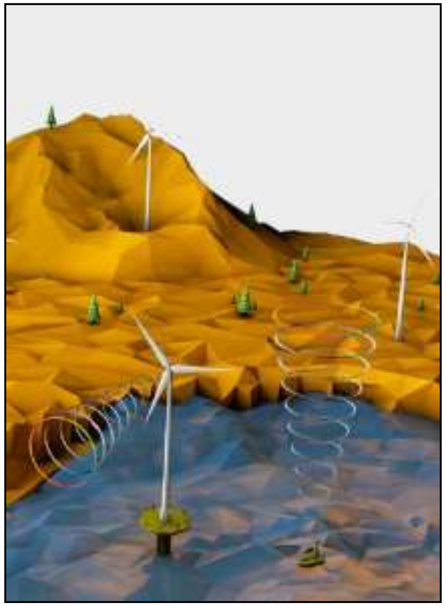
Continuum – What Next?

- Established, certified, wind profiling devices are becoming common
- For the first time, we have the ability to measure wind offshore in clear air!
  (and matching wave energy spectra via MRU-5 and Datawell MOSE-G sensors)

- RPS has already collected and analysed 2 years of profile data in 3 regions
- Ongoing offshore wind-profiling is helping to better understand near-surface winds, and refine wind height corrections
- Now able to challenge arbitrary coefficients, roughness lengths, and improve general parameterisations against measurement
- Better near-surface wind (or multi-level profiles) as source input for wave models

- Obvious benefits to the renewables sector
  …and the metocean modelling community





Questions?

For further information:
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