Near-surface turbulent wind characteristics measured during Tropical Cyclones Ita (2014) and Nathan (2015)

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Motivation & Introduction

Understanding of turbulent characteristics

- Turbulence at near-surface where buildings are $\implies$ Better understanding of turbulence characteristics will allow engineers to design buildings to resist wind loads.

- Turbulent characteristics different at 3 m (embedded within roughness elements)? Existing theories still applicable to near-surface wind characteristics?

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- Surface Weather Information Relay and Logging Network = SWIRLnet developed in 2013 at Cyclone Testing Station, James Cook University [Henderson et al., 2013]

→ Six towers (3.2 m height), measuring:

- Wind speed and direction at 3.2 m (logged locally at 10Hz)

- Temperature, pressure, relative humidity at 1.3 m

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Figure 1: SWIRLnet Tower with RM Young anemometer

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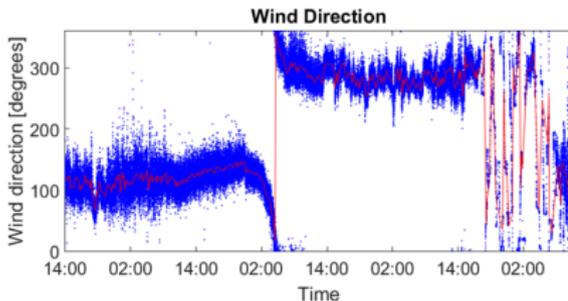THE UNIVERSITY OF QUEENSLAND
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Deployments

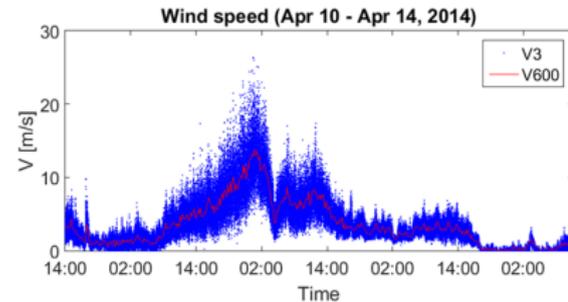- Deployments during tropical cyclone events Ita (2014) and Nathan (2015)

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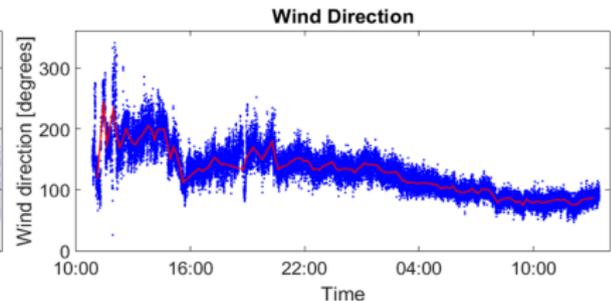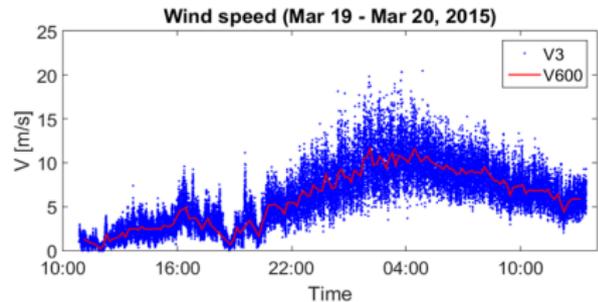- Deployments during tropical cyclone events Ita (2014) and Nathan (2015)

Example for SWIRLnet observations

Measurements & Analyses
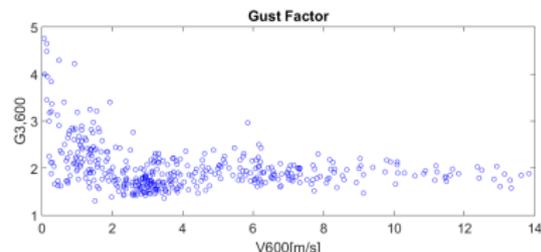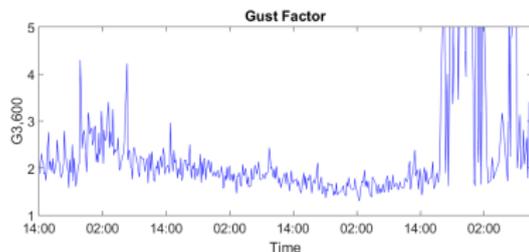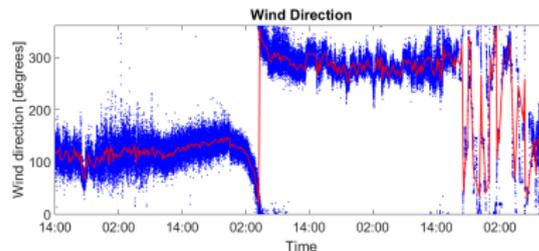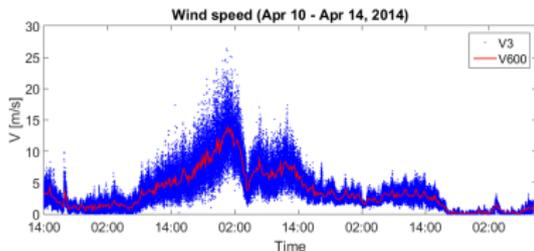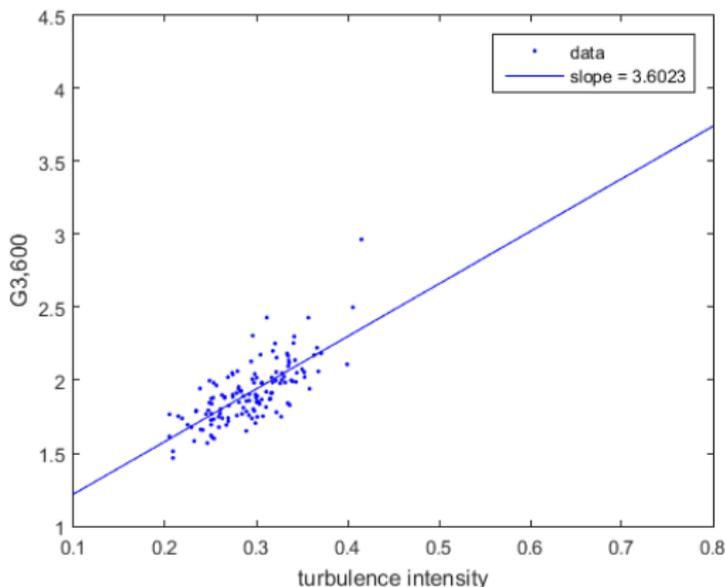
Wind and gust factor profile

$$\text{Gust factor}: \quad G_{3,600} = \frac{V_{3,600}}{V_{600}}$$

Gust factor - turbulence intensity relationship

- Low wind speed filtering $(v > 5m/s)$
- Higher turbulence $\Rightarrow$ Higher gust factors
- Spread: coherent structures?
- Constant through roughness regimes

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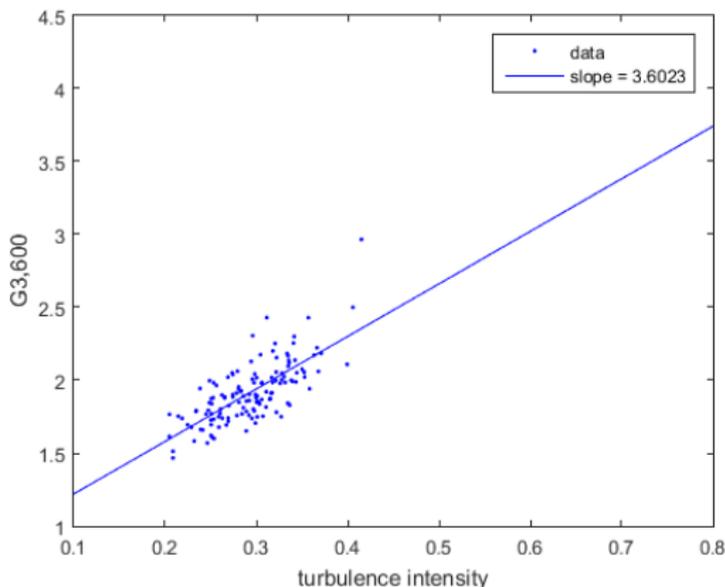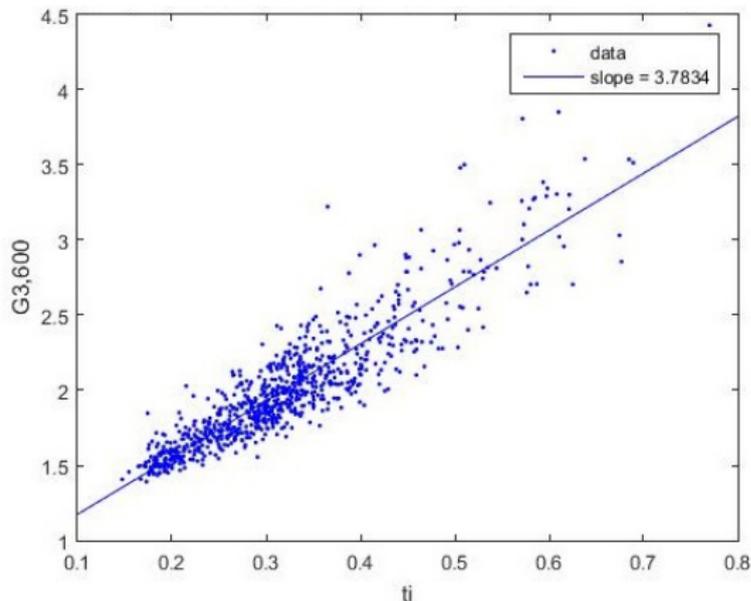

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Peak factor comparison to theoretical models

Gust factor - turbulence intensity relationship [Masters et al., 2010]

$$G = 1 + g \cdot I_u$$

G - Gust factor, g - Peak factor, I_u - Turbulence intensity

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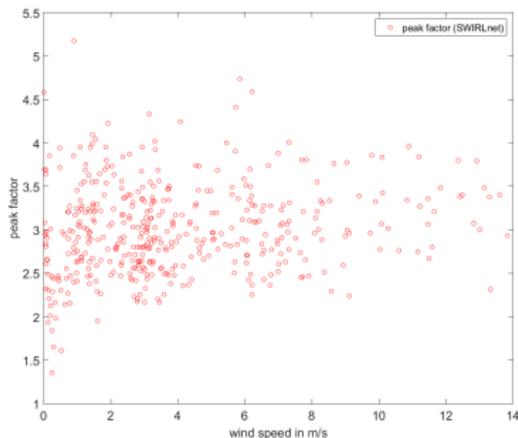
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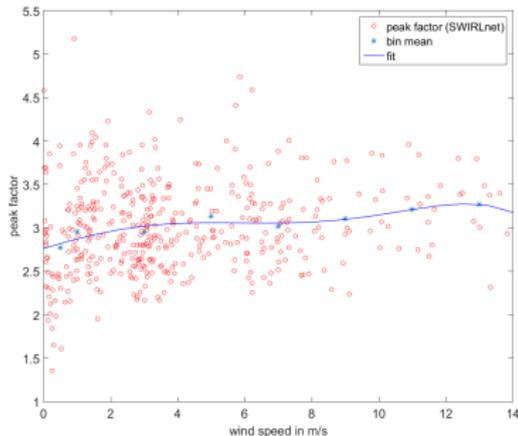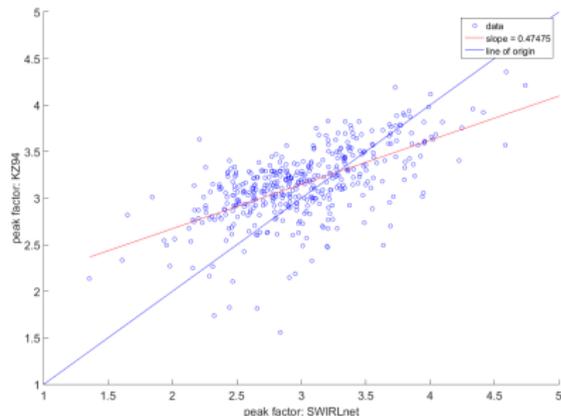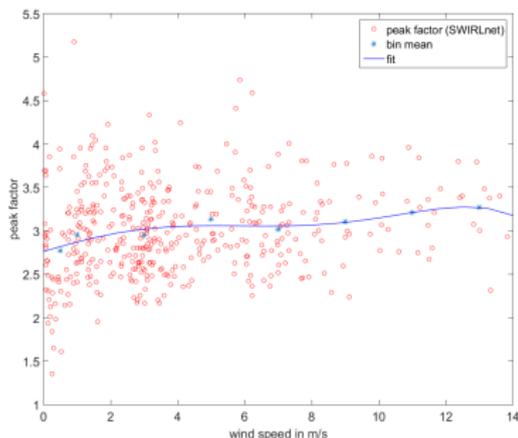G - Gust factor, g - Peak factor, I_u - Turbulence intensity

Take-Home-Message(s)

Research

- Assessment of near-surface turbulent characteristics during TC events

Outcomes

- Gust factor variability due to roughness changes
- Gust factor variability in vicinity of (almost) constant wind directions
- Gust factor - turbulence intensity linear relationship constant through all roughness regimes
- Non-gaussian peak factor model approach fails to reproduce the observations

Further research

- Which physical mechanisms drive the extreme gust factors?
- How does the peak factor relationship carry through higher wind speeds?

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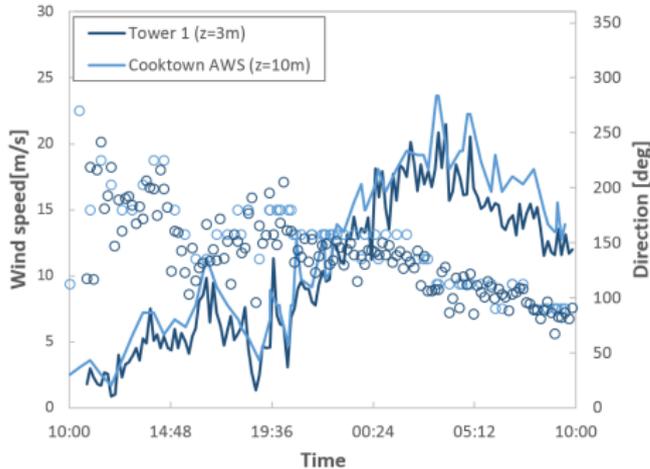- Non-gaussian peak factor model approach fails to reproduce the observations

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Henderson, D., Mason, M., and Ginger, J. (2013). SWIRLnet : portable anemometer network for wind speed measurements of land-falling tropical cyclones. In *The 12th Americas Conference on Wind Engineering (12ACWE)*, Seattle, Washington, USA.

Kareem, A. and Zhao, J. (1994). Analysis of non-gaussian surge response of tension leg platforms under wind loads. *Journal of Offshore Mechanics and Arctic Engineering*, 116(3):137–144.

Masters, F. J., Tieleman, H. W., and Balderrama, J. A. (2010). Surface wind measurements in three gulf coast hurricanes of 2005. *Journal of Wind Engineering and Industrial Aerodynamics*, 98(10–11):533 – 547.
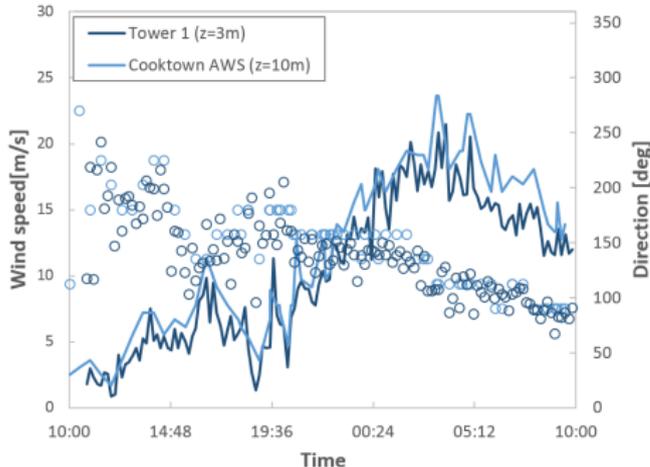
shape of the wind profile

Figure 2: 10min mean wind speed and direction observations from tower T1 (3.2 m) and Cooktown AWS (10 m), TC Nathan

- similar direction recorded at both heights during maximum intensity of storm

- 10m $V_{3,600} >$ 3m $V_{3,600}$, but:
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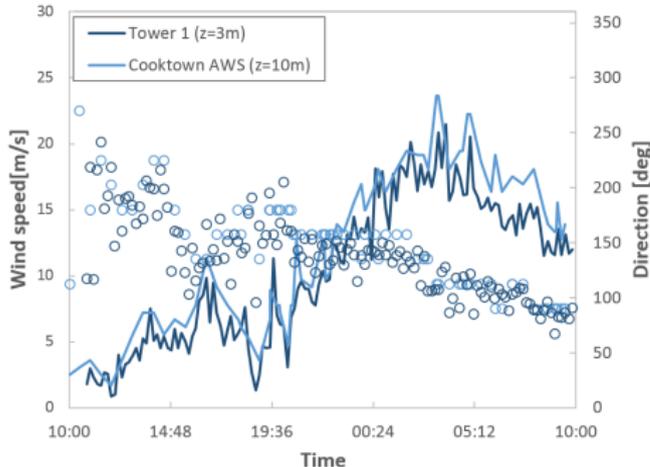
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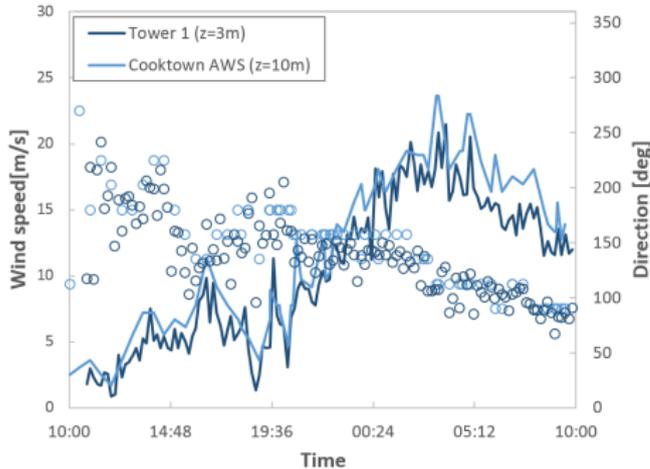
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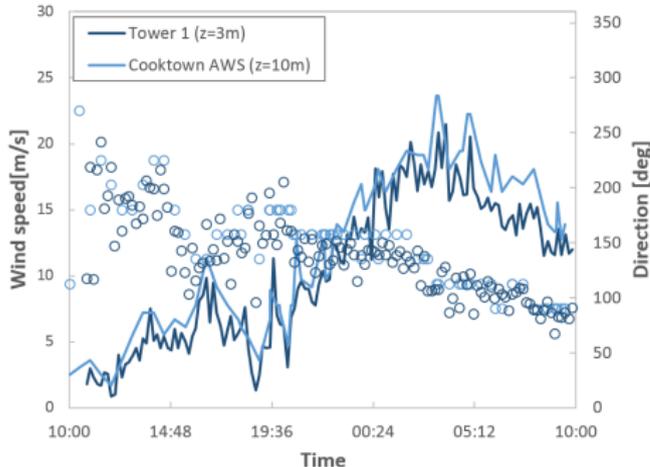
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