

renewable energy renewable energy



## **Validation of SODAR measurements on a complex, forested site**

Olivia Tomkins

**Airtricity**  
The Natural Programme

## Validation of SODAR on a complex, forested site

- Introduction
- Mast 1 to Mast 2 Calibration
- Mast 2 removed and replaced by SODAR
- SODAR v synthesised mast data
- Results
- Conclusions



# Introduction

## ISSUES

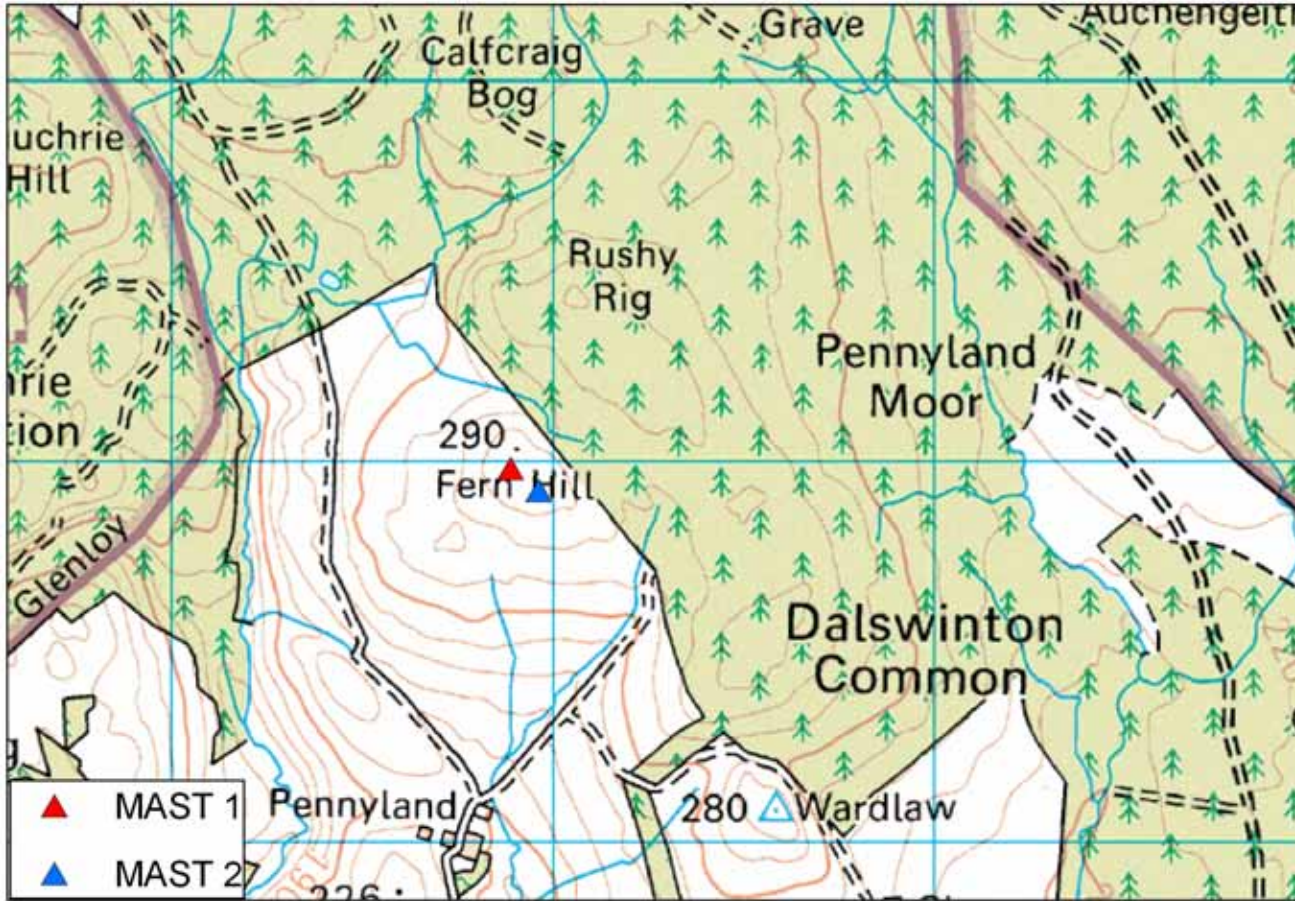
- Typically UK development in complex terrain
- Increasingly complex terrain with forestry
- Wind flow not wholly understood

## SODAR

- Potential to improve understanding
- Portable
- Measurements above typical mast heights
- Measurements at a large number of heights



# Site



- 1x50m mast (Mast 1)
- 1x70m mast (Mast 2)
- North to south east winds largely tree affected
- Open to the SW

# Method – Step 1

## Site calibration carried out between 50m and 70m mast

- 10 months concurrent data
- Mast 1 measures wind speeds at 50m and 10m
- Mast 2 measures wind speed at 70m, 60m, 50m and 40m.
- Speed ups calculated per sector
- Mast 2 removed from site
- Further Mast 2 data can be synthesised from Mast 1 data



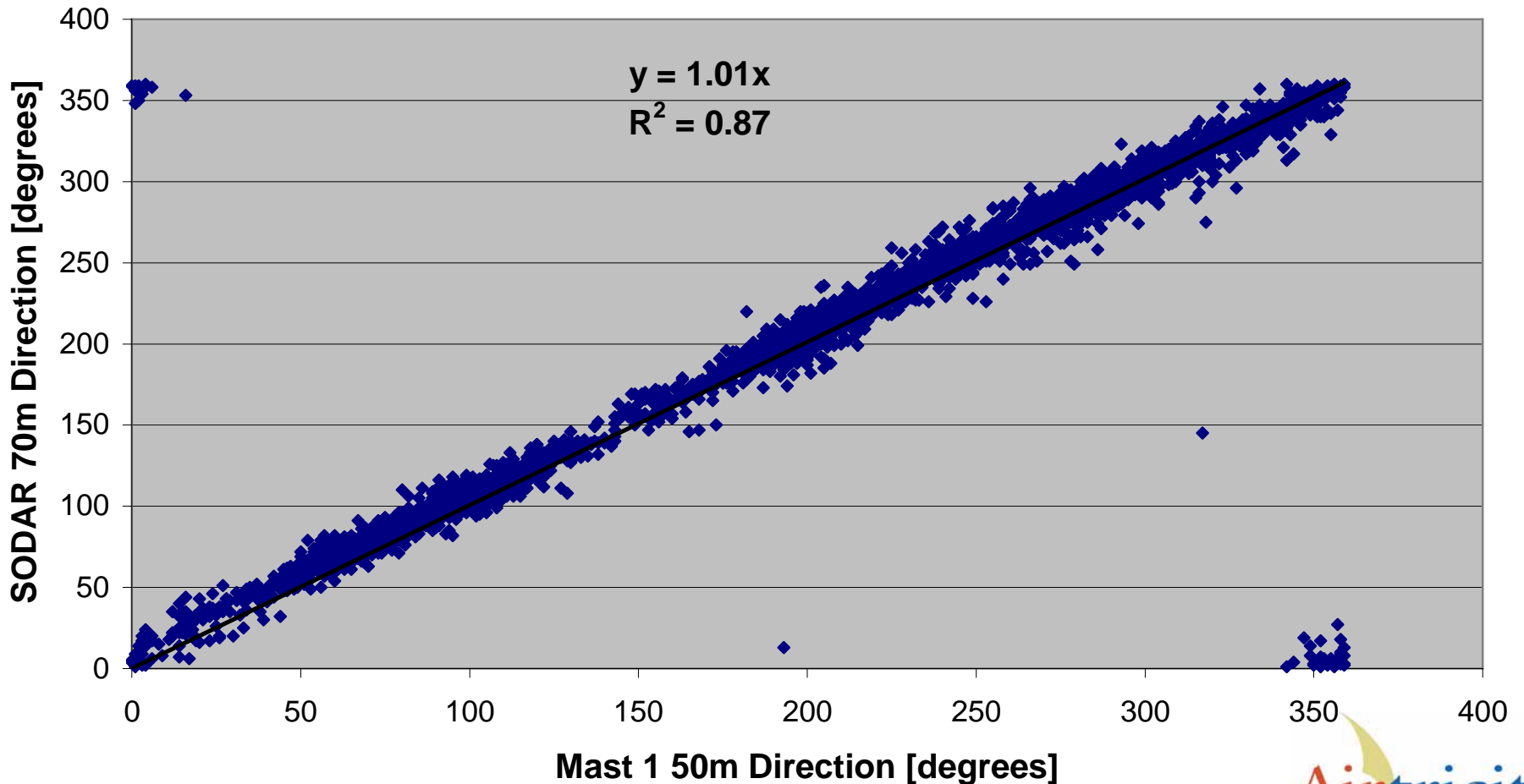
## Method – Step 2

- SODAR installed exactly where Mast 2 once stood
- Data recorded March to June 06
- Wind speeds at 5m intervals from 20m up to 150m

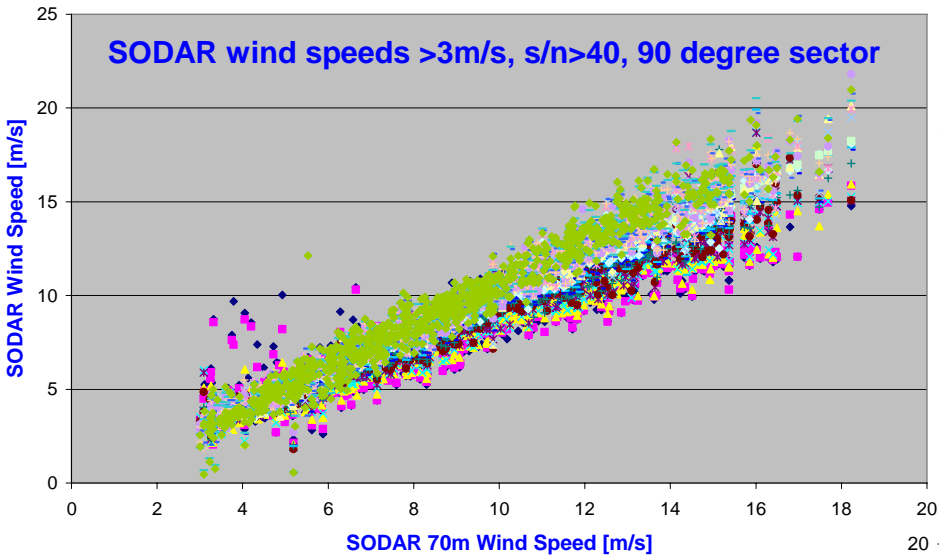


# Wind direction

## Mast 1 50m Direction vs SODAR 70m Direction



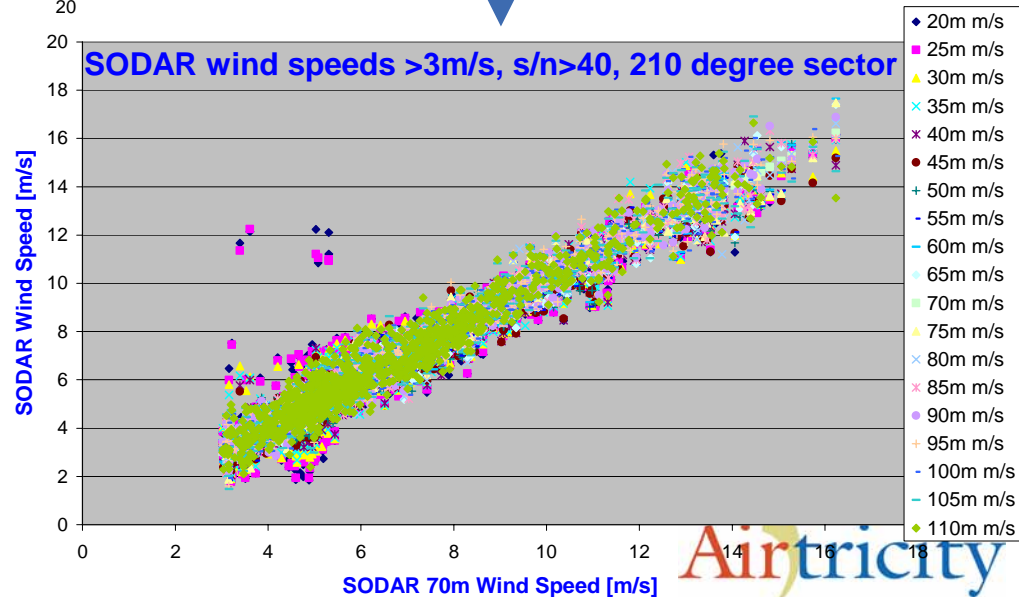
# SODAR wind speeds



90 degree sector  
influenced by  
forestry

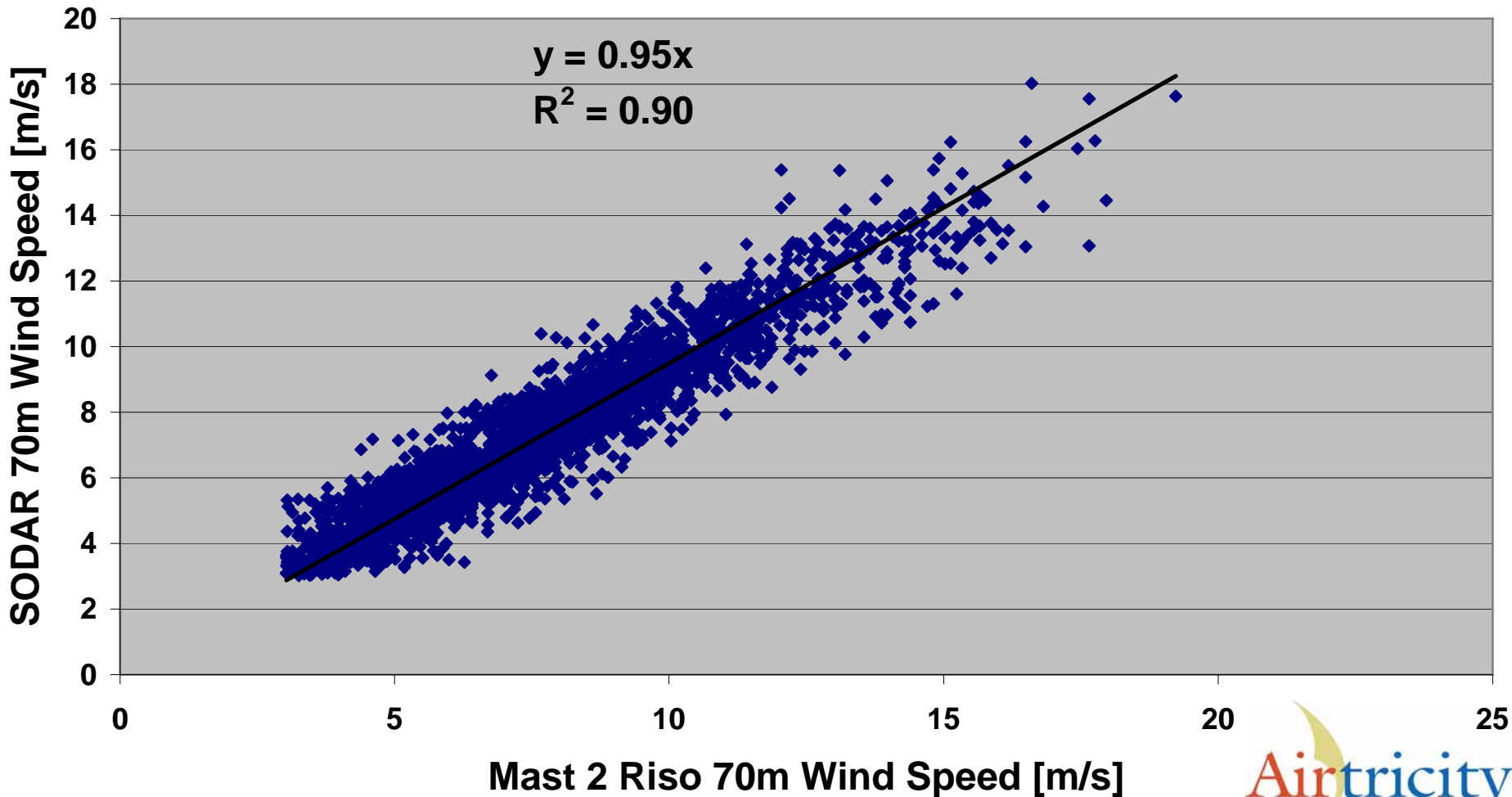
210 degree sector free

SODAR measuring  
increase in shear  
from presence of  
forestry as we would  
expect



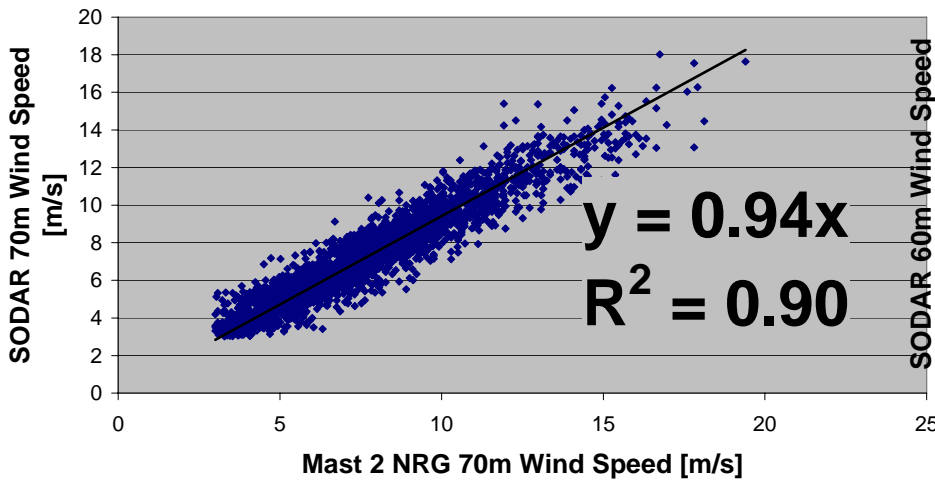
# SODAR 70m v Mast 2 Riso 70m synthesised wind speed

wind speeds over 3m/s, S/N >4, least mast effected sectors

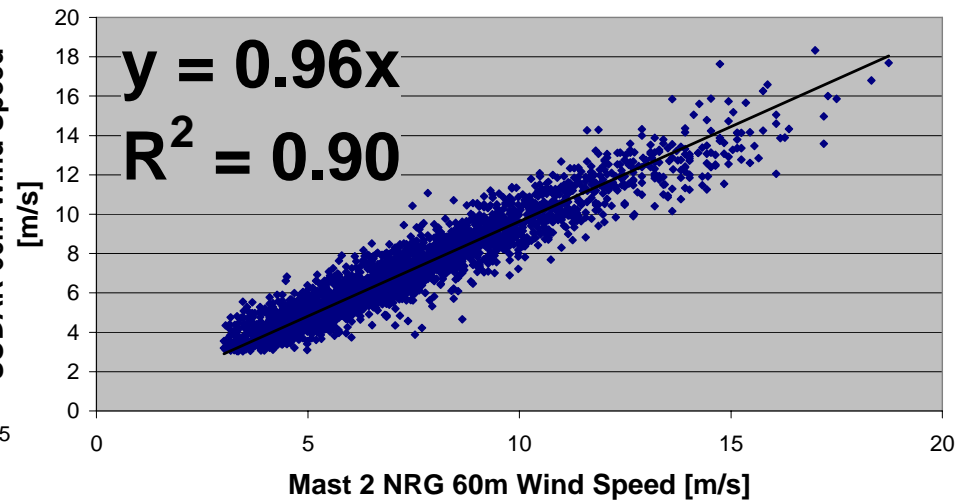


# SODAR v Mast 2 synthesised wind speeds – NRG 70m, 60m, 50m and 40m

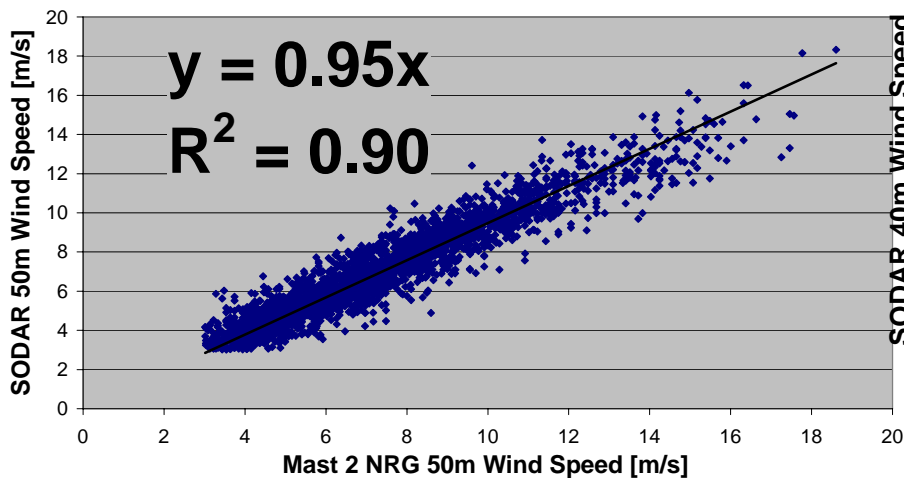
### SODAR 70m vs Mast 2 NRG 70m



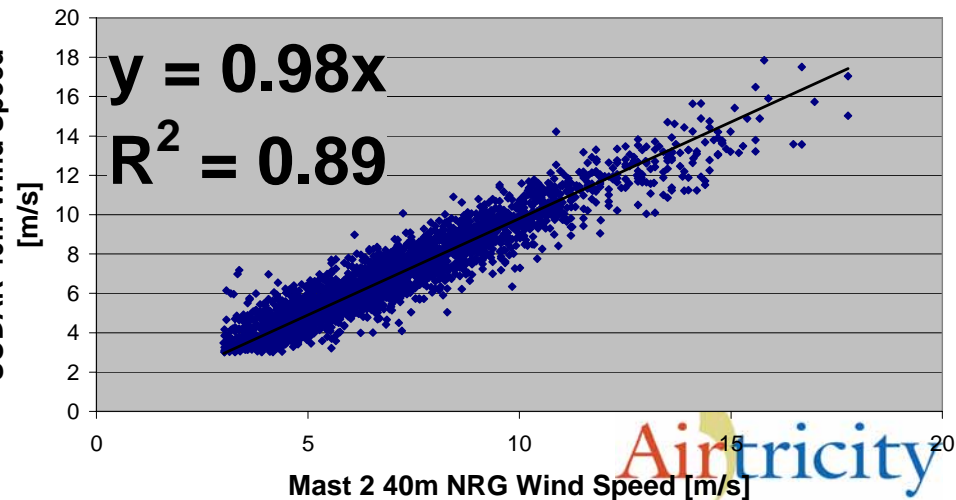
### SODAR 60m vs Mast 2 NRG 60m



### SODAR 50m vs Mast 2 NRG 50m



### SODAR 40m vs Mast 2 NRG 40m

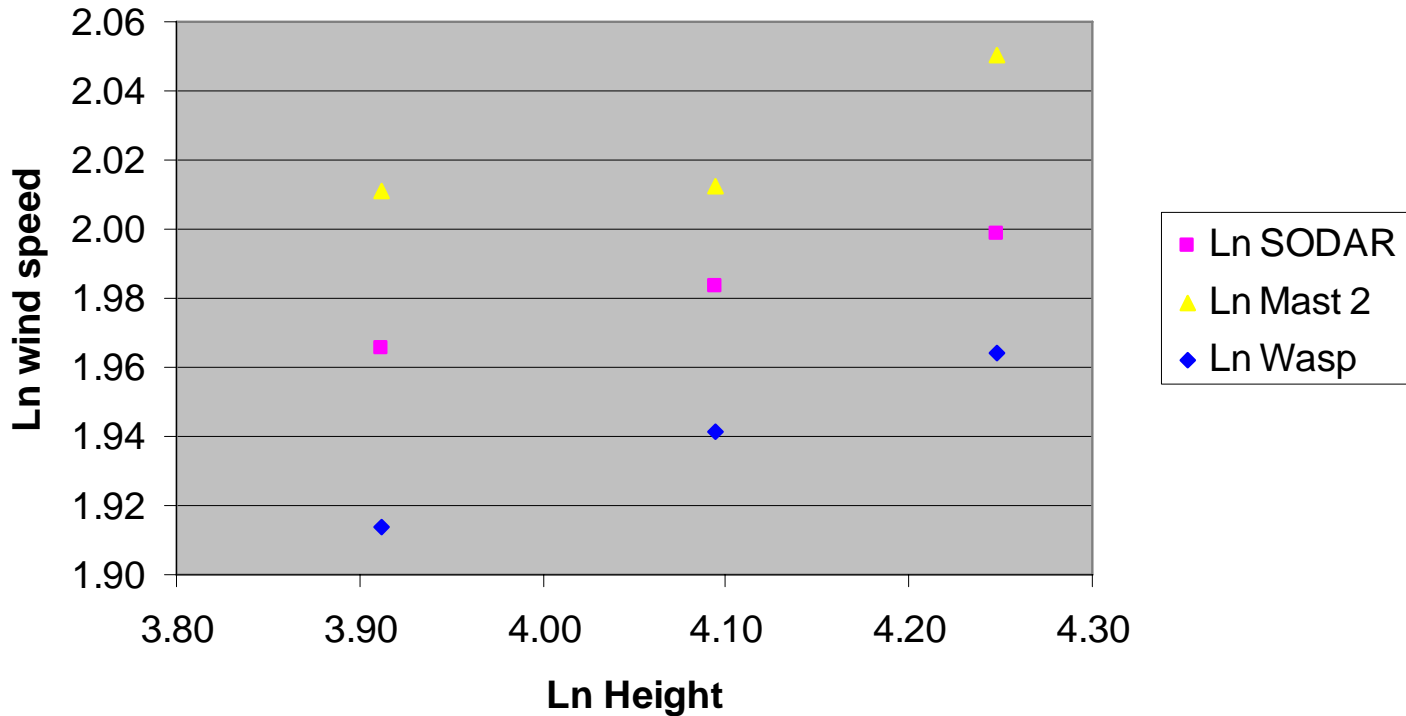


# Wind Speed Conclusions

- SODAR is measuring wind speed lower than would be expected at the anemometers at the same location and height by around 4%
- Wind speed comparisons show consistency at all heights suggesting a bias

# Wind Speed with Height

**Ln Height vs Ln wind speed SODAR and Mast 2 concurrent data, Wasp from measured data**



**Calculated  
Shear  
Exponents**

**Mast = 0.11**

**SODAR = 0.10**

**Wasp = 0.15**

# renewable energy renewable energy rene

## Bias in wind speed

- Consistency across all 5 anemometers and heights suggest bias
- Nature of bias is critical for how SODAR can be used

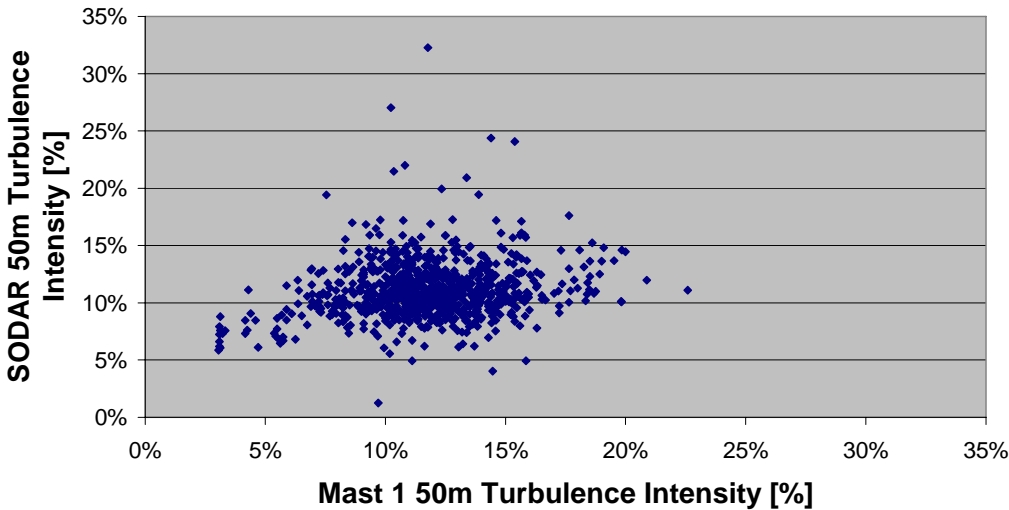
Possible type of Bias	Implications
<b>Generic</b> – 4% downward bias at every site	Very useful tool – can be used at various sites with good degree of certainty
<b>Site specific</b> – 4% downward bias at this site, bias needs to be determined per site	Useful tool but will require similar set up to this test, ie two temporary masts located close together
<b>Specific to that location on the site</b> – at different locations on the same site, bias will vary	Little use

- If bias generic then scatter suggests accuracy of (+/-) 1-2%
- Further tests required



# Turbulence Intensity

### Mast 1 50m TI v SODAR 50m TI

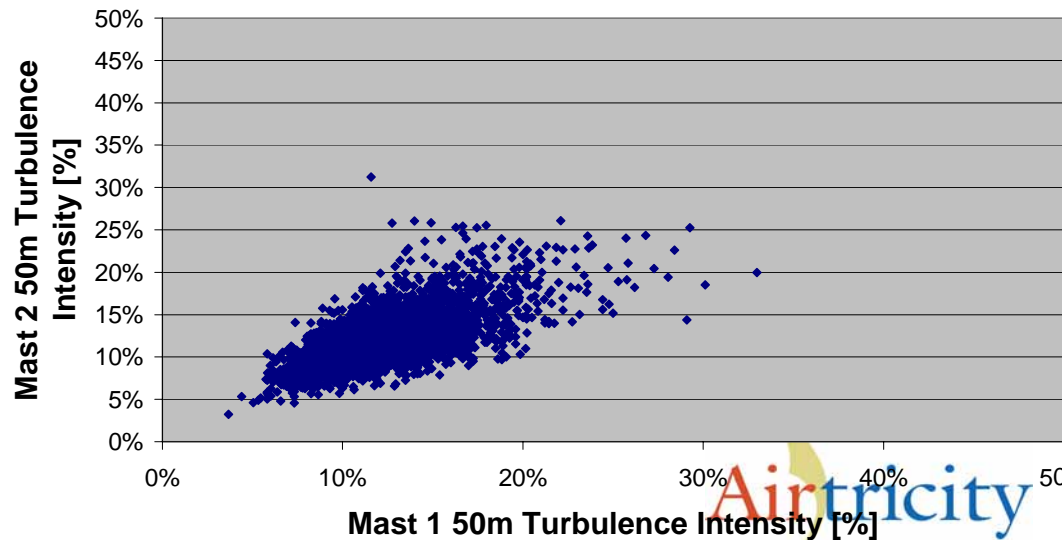


Over 8m/s, least mast affected sectors

No correlation between Mast 1 and SODAR TI from 10 min raw data

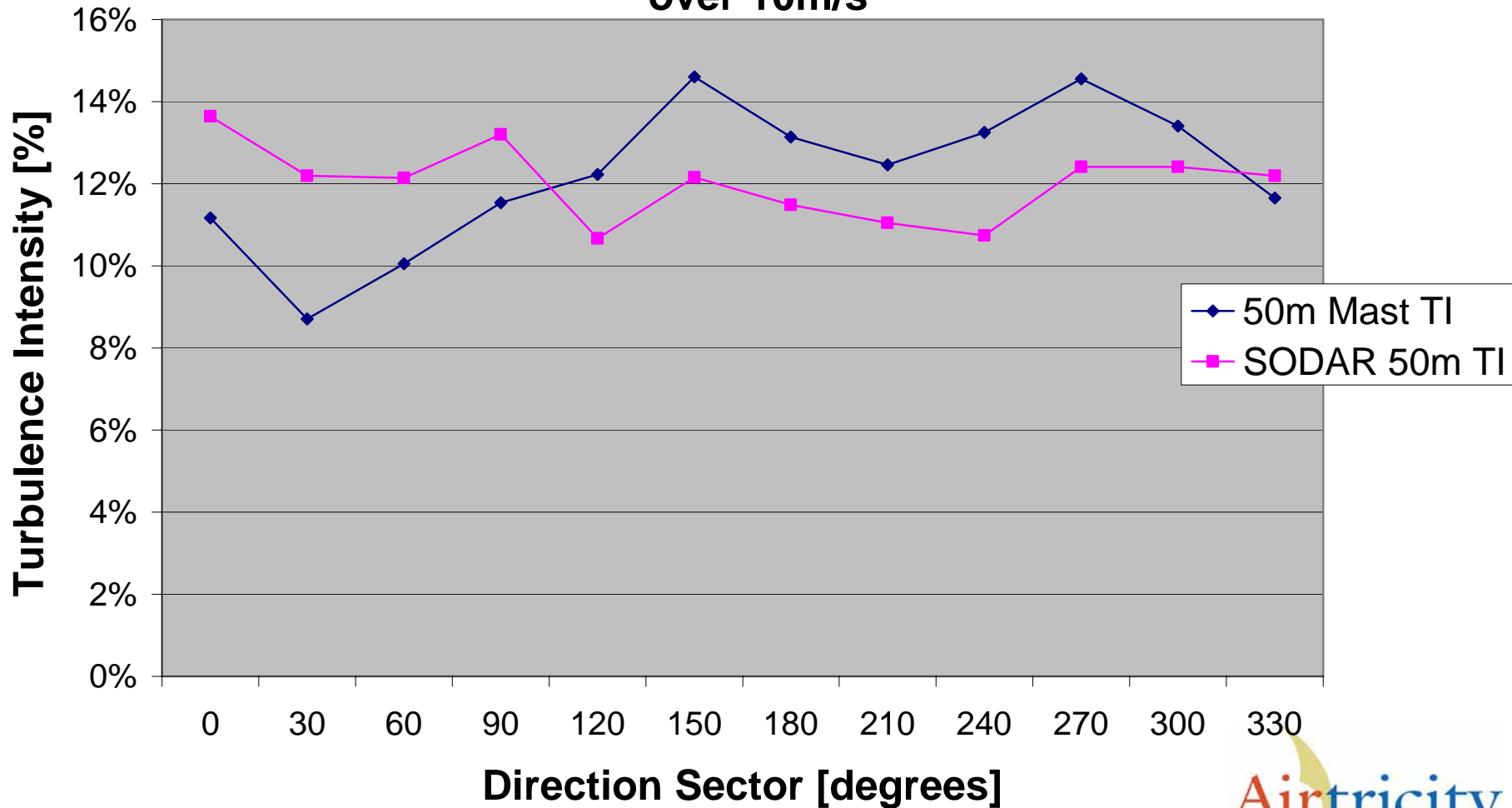


### Mast 1 50m TI vs Mast 2 50m TI



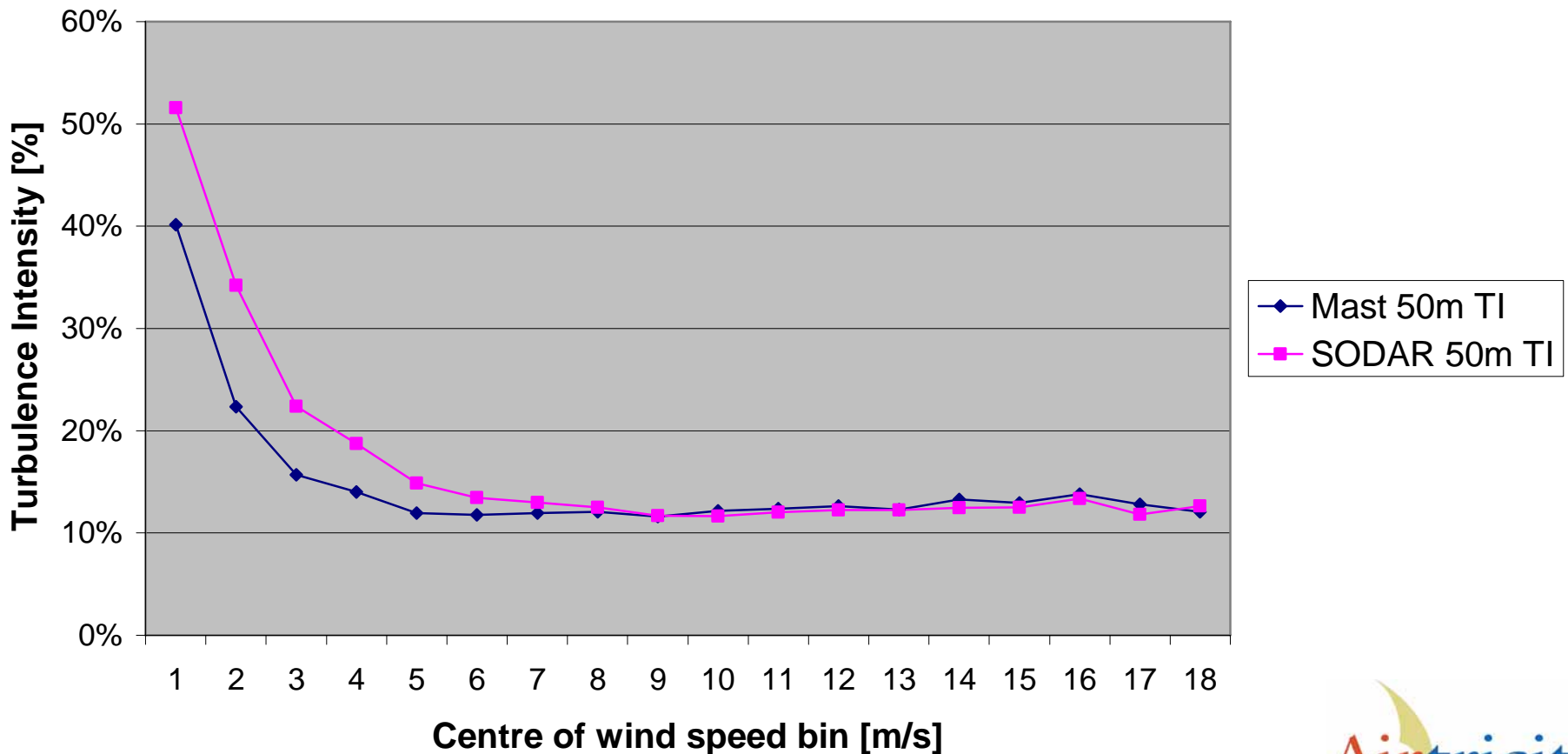
# Turbulence Intensity per Direction

**Mast 1 50m TI and SODAR 50m TI per sector, windspeeds over 10m/s**



# Turbulence Intensity per wind speed bin

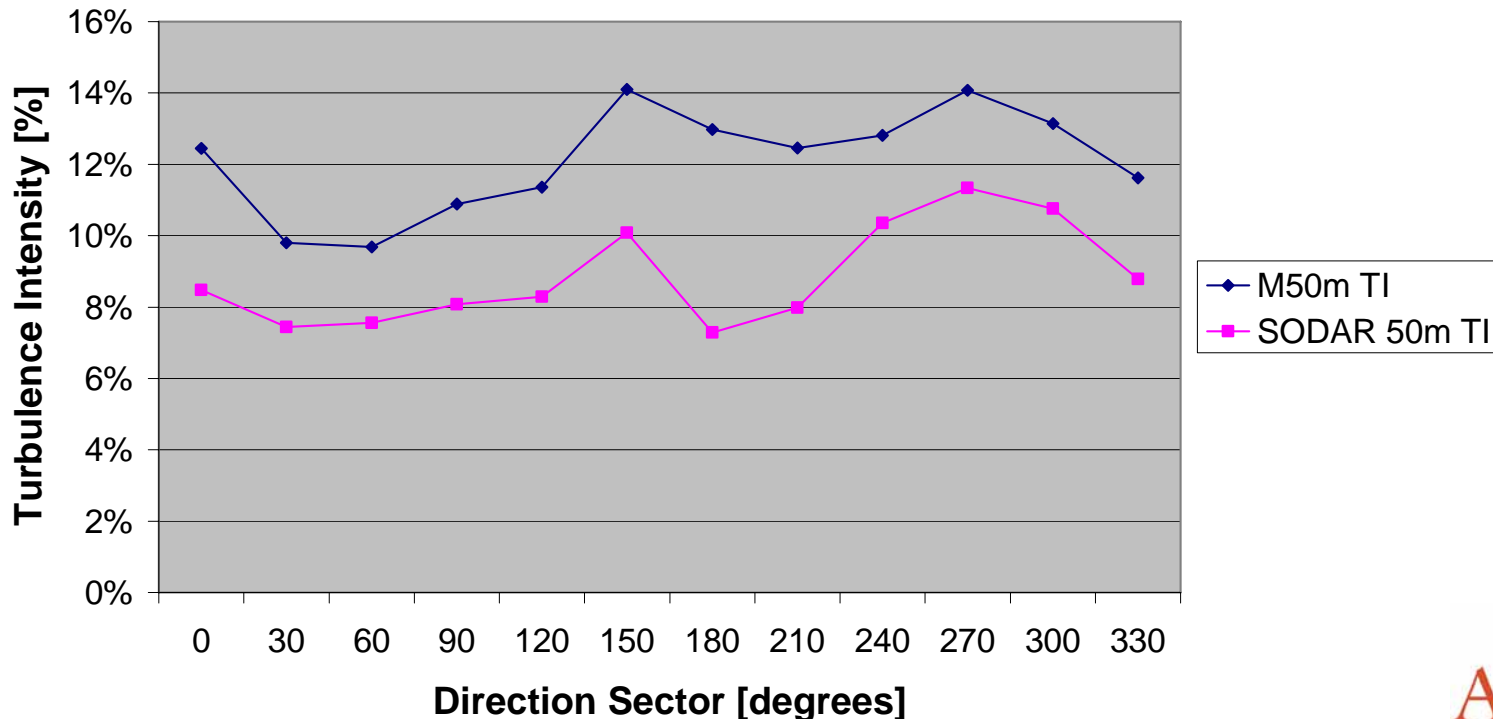
## SODAR and Mast 1 50m Turbulence Intensity per wind speed bin



# Turbulence intensity using SODAR sigma -w

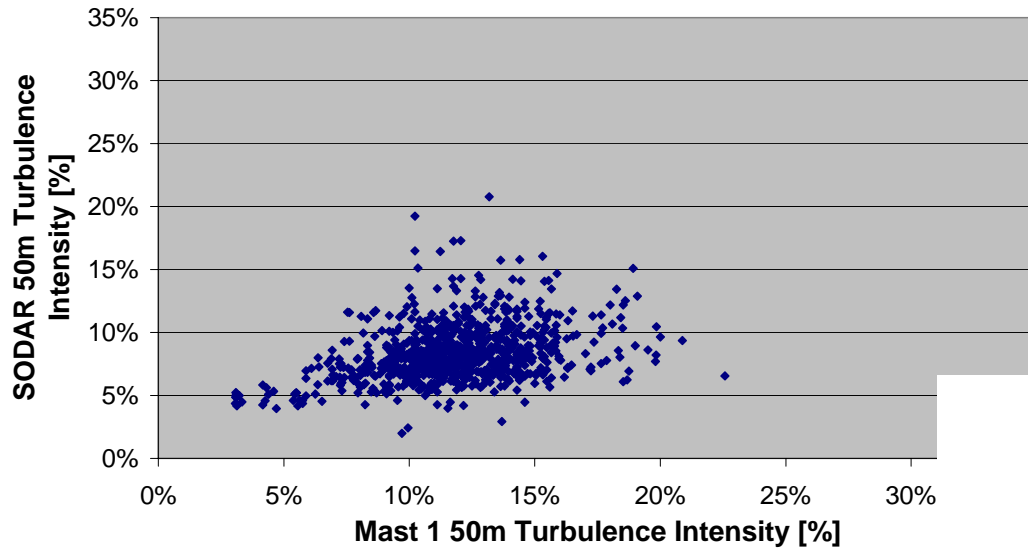
- Recent publication suggests a relationship between turbulence intensity at the SODAR using the vertical component SD and cup anemometer measured turbulence intensity

**Mast 1 50m and SODAR 50m Turbulence intensity per direction sector**

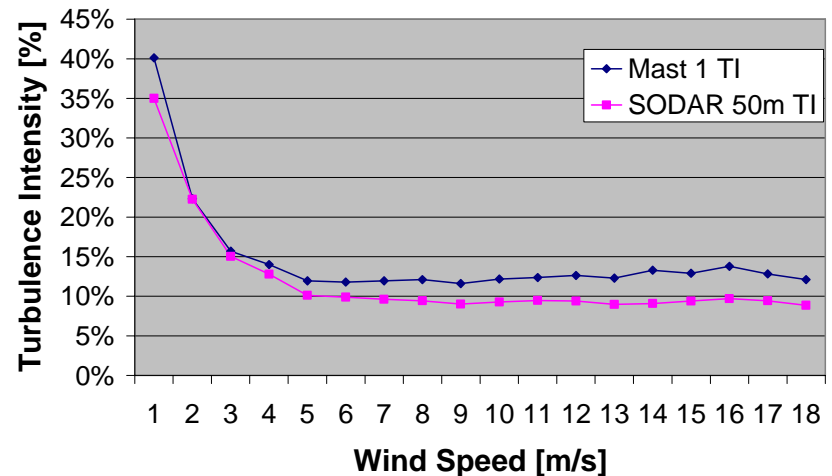


# Turbulence Intensity using SODAR sigma -w

## SODAR 50m TI v Mast 1 50m TI



## SODAR 50m and Mast 1 50m Turbulence Intensity per wind speed bin



## Conclusions – SODAR in complex, forested terrain

- SODAR measuring wind speed 4% lower than mast – bias
- If bias can be applied to adjust the SODAR wind speeds then scatter suggests accuracy of (+/- )1-2%
- Further tests of this kind will allow identification of type of bias - generic, site specific or site location specific. CRITICAL
- SODAR can successfully measure variation of wind speed with height and increased shear with presence of trees
- Turbulence intensity variation with wind speed appears comparable with mast but not with direction – work ongoing
- If bias in wind speed measurements is found to be generic or even site specific we will be able to benefit from use of SODAR



**Thank you!**