Mitigating the impact of complex terrain on Lidar wind resource assessment accuracy

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Introducing SgurrEnergy

- Leading independent engineering consultancy
- International
  - Based in Glasgow, Vancouver, Beijing, Pune (India), Ireland & Wick
- Experienced
  - Over 80 professional staff
- Professional
  - ISO 9001 & 14001 certified
  - Progressing OHSAS 18001 registration

FS 85385 ISO 9001:2000
EMS 85386 ISO 14001:2004

- Award Winning

  Glasgow Business Award for International Activity 2007 &
  Best Business Achievement 2007 at The Scottish GREENENERGY Awards success in renewable energy

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Overview of Capability

Wind

Wave & tidal

Hydro

Solar

Bio-energy

Micro-generation

- Due diligence
- Lenders engineer
- Energy yields
- Technology audits & reviews
- Hybrid systems

Project management

Noise & vibration

- Technical advisor

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Experience

We have consulted on over 30,000 MW of renewable energy in over 20 countries covering both project development and due diligence

Europe

- Belgium
- Estonia
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- Germany
- Greece
- Republic of Ireland
- Italy
- Malta
- The Netherlands
- Poland
- Portugal
- Spain
- Sweden
- GB & NI

Asia

- China
- India
- Korea
- Philippines
- Turkey

North America

- Canada
- USA

South America

- Galapagos Islands

Africa

- Kenya
- South Africa

Oceania

- New Zealand

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Lidar

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Mature technology, new application
Compact and portable for rapid and easy deployment
Acquires wind speed, direction, shear, veer, TI, and inclination data
Measures at proposed turbine locations and operational assets
Wind resource assessment and model validation
Performance monitoring and assessment of operational turbines

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How it works

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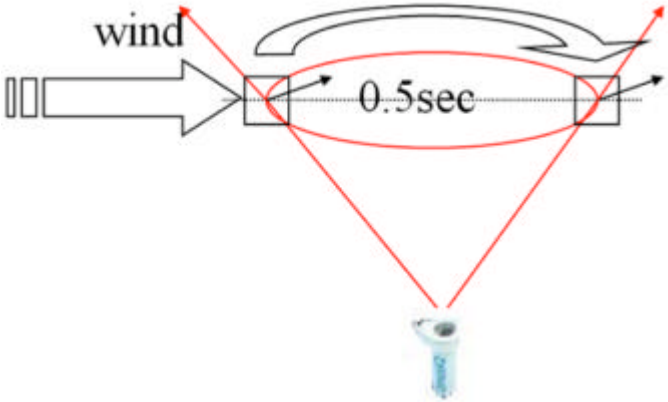

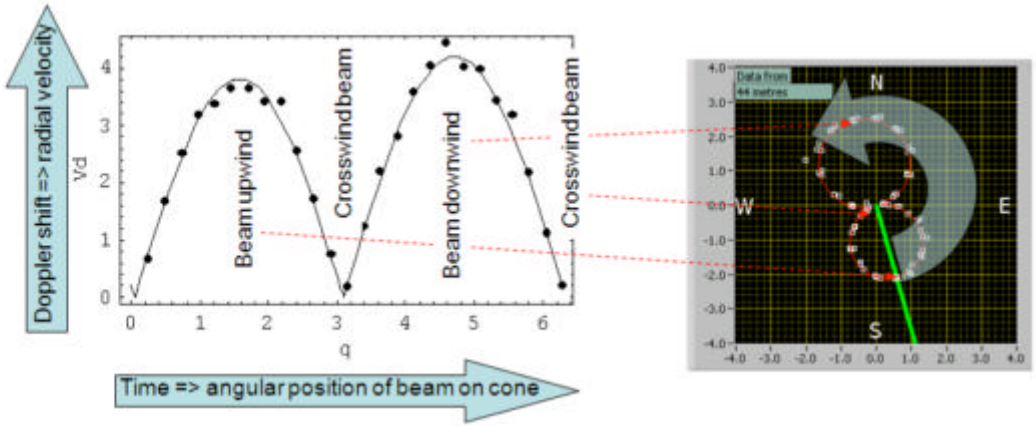

Laser emission in different directions are back-scattered by aerosols. The Doppler shift of the scattered light gives the velocity in the line of sight.

A VAD (Velocity Azimuth Display) scan shows a sinusoidal variation in Doppler shift as the laser beam is swept around a series of directions. The parameters of this sinusoid give the wind velocity.

Height is resolved, in the case of a pulsed device, by ToF

A continuous wave device select height by focussing detector optics

CW devices need cloud correction algorithms due to signal contamination

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Benefits

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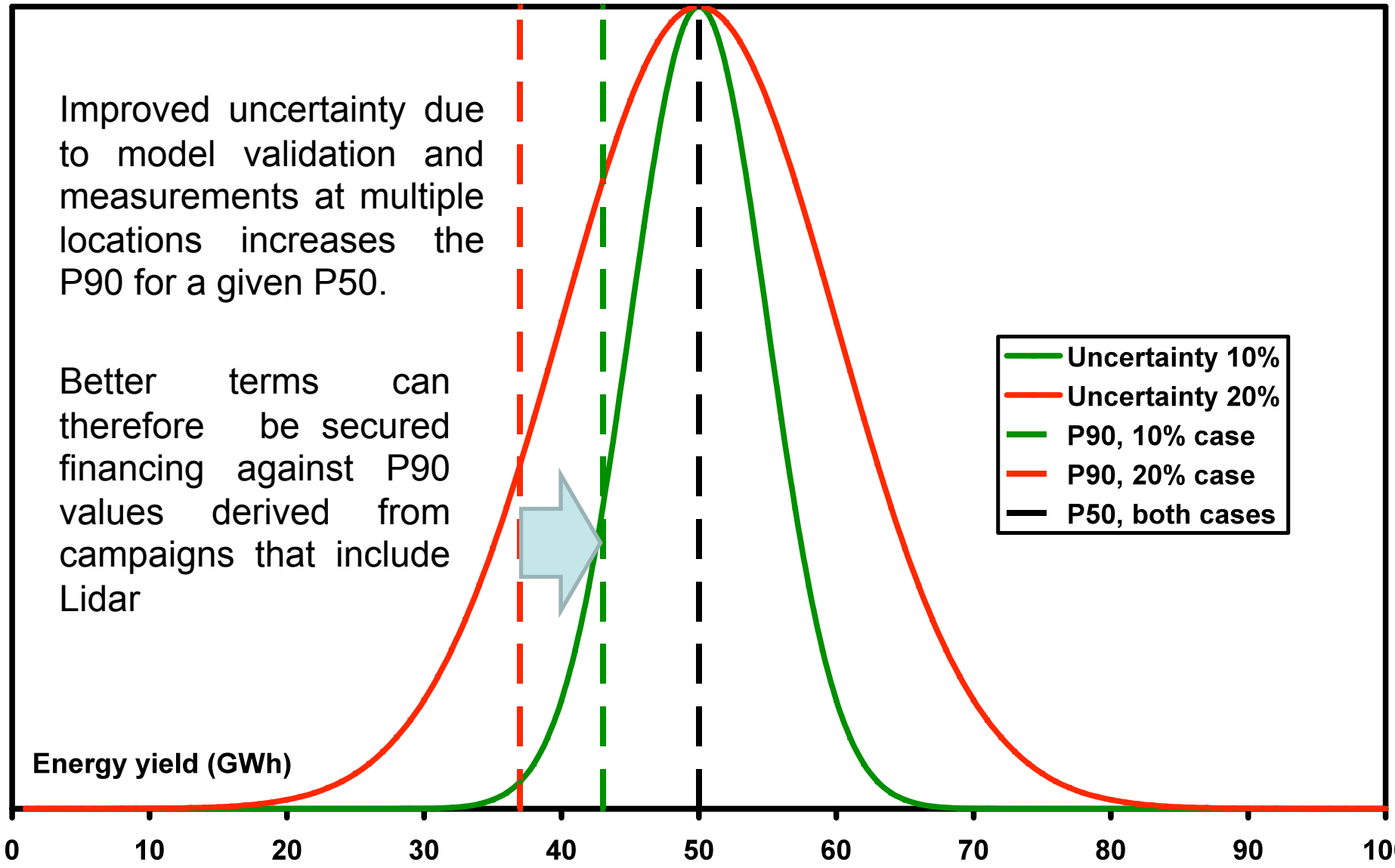
Improved uncertainty due to model validation and measurements at multiple locations increases the P90 for a given P50.

Better terms can therefore be secured financing against P90 values derived from campaigns that include Lidar



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Variable flow inclination (1)

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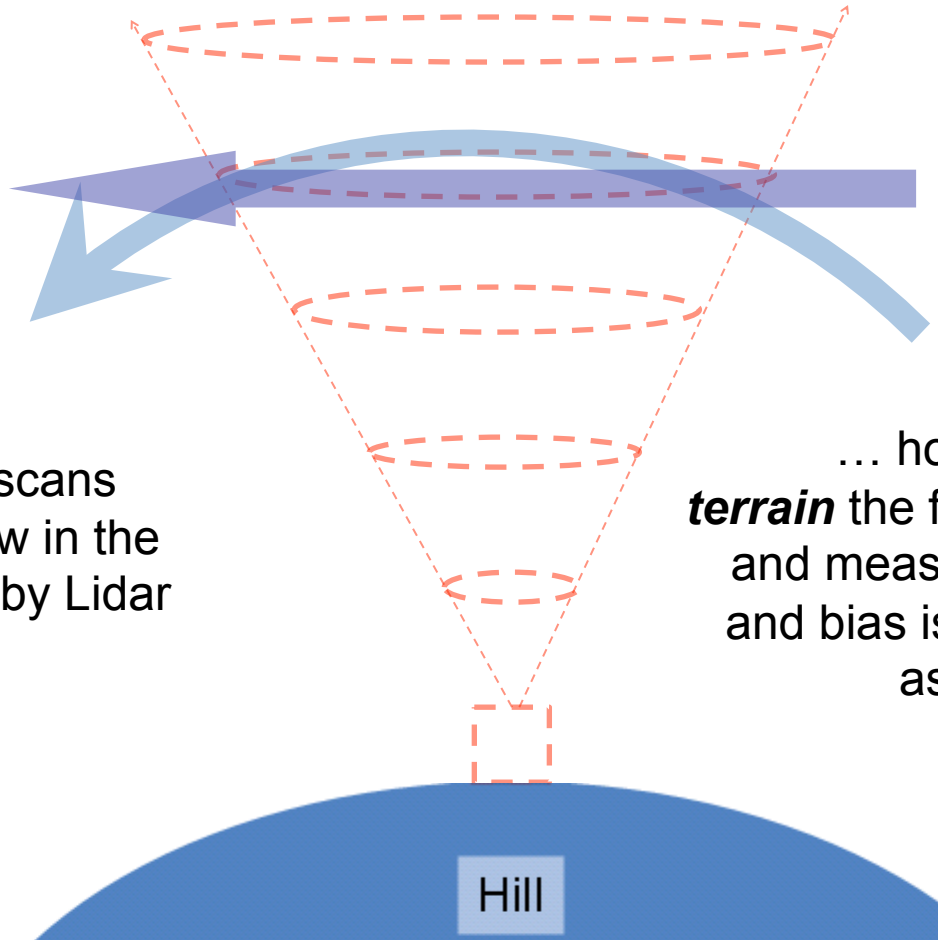

Conventional VAD scans assume uniform flow in the volume penetrated by Lidar measurements …

… however in ***complex terrain*** the flow is ***not*** uniform, and measurement ambiguity and bias is introduced by the assumption that it is.

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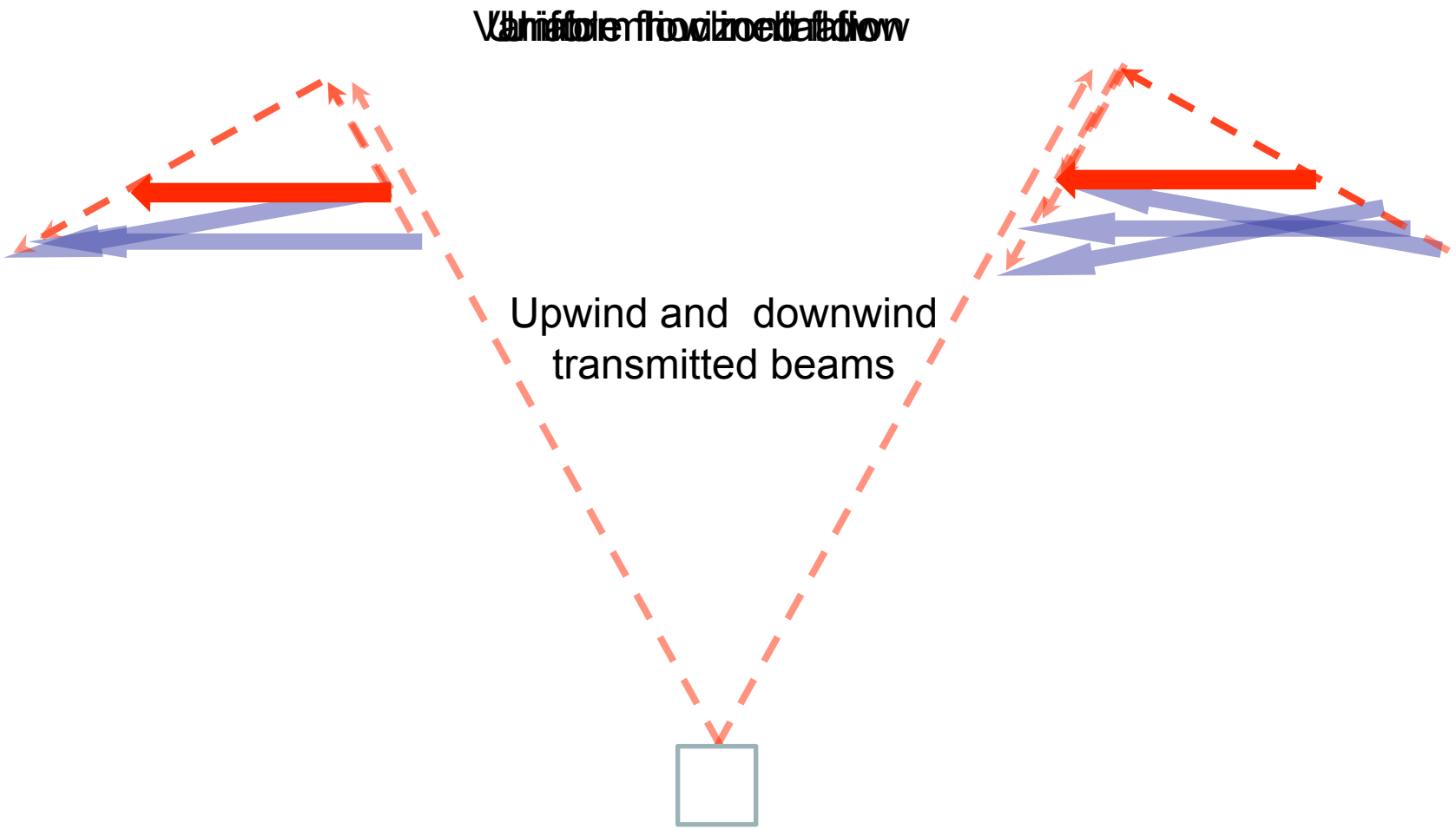
Variable flow inclination (2)



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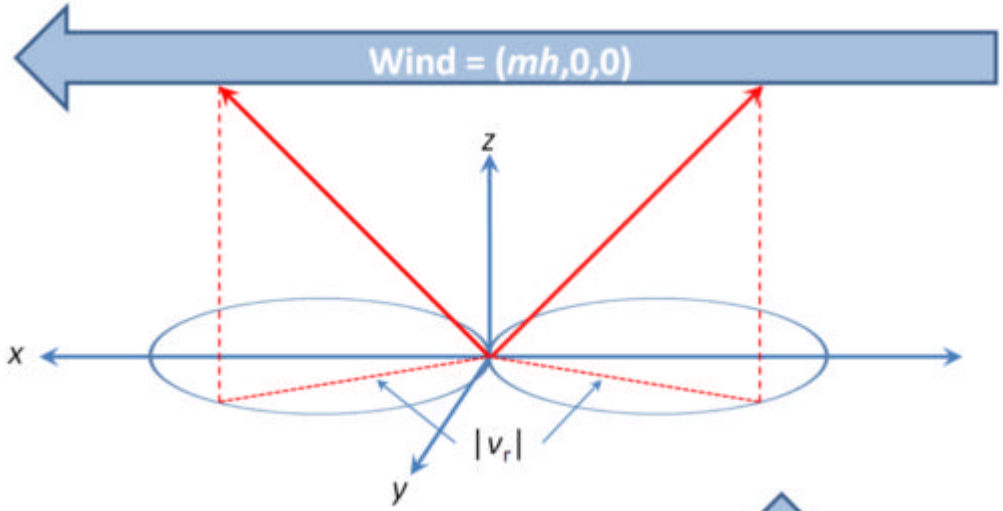
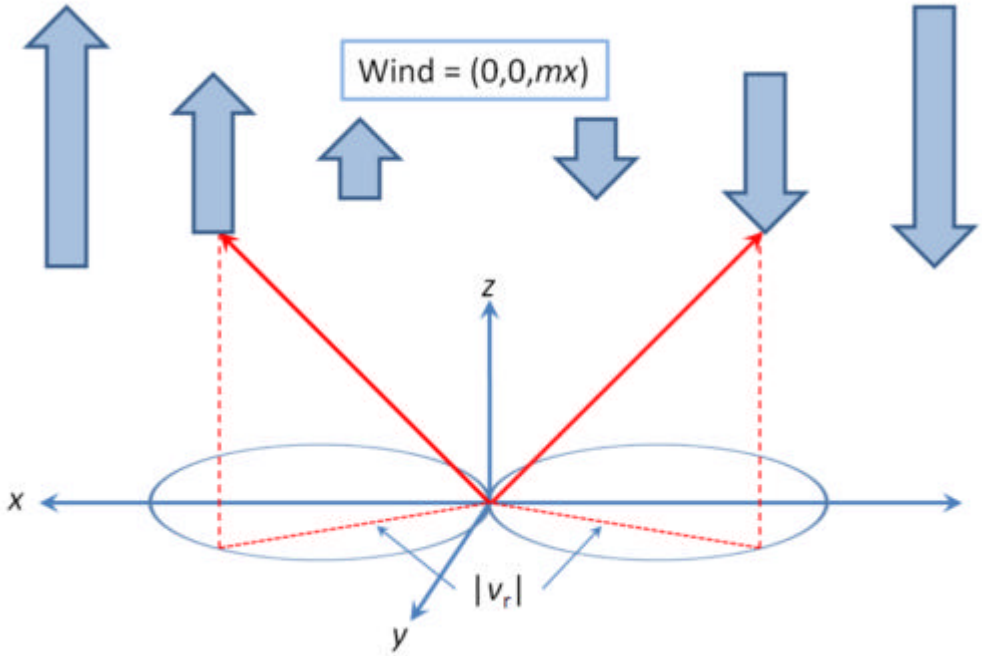
Variable flow inclination (3)



Variation in flow inclination can lead to spurious results. An unrealistic but simple and instructive example serves to illustrate the origin of this anomaly. It is seen that calculating wind vectors based on measurements made at a single height will fail to distinguish between the two cases shown here.

In order to discriminate between uniform horizontal flow components and variable vertical components it is necessary to incorporate radial velocity measurements made at more than one height in the calculation of the resultant wind vector.



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Variable flow inclination (4)

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One proposed approach is to use modelling to mitigate the impact of complex topography and the resulting flow distortion

- Predict the variation in flow inclination and other flow distortions arising from the complex terrain

- Adjust the Lidar measurements to correct for these distortions

However

- One of the principal benefits of Lidar is the ability to confirm or correct models relative to direct measurement

- You cannot validate with Lidar the model you are using Lidar to validate: circular logic with self-selecting conclusions

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Beam steering (1)

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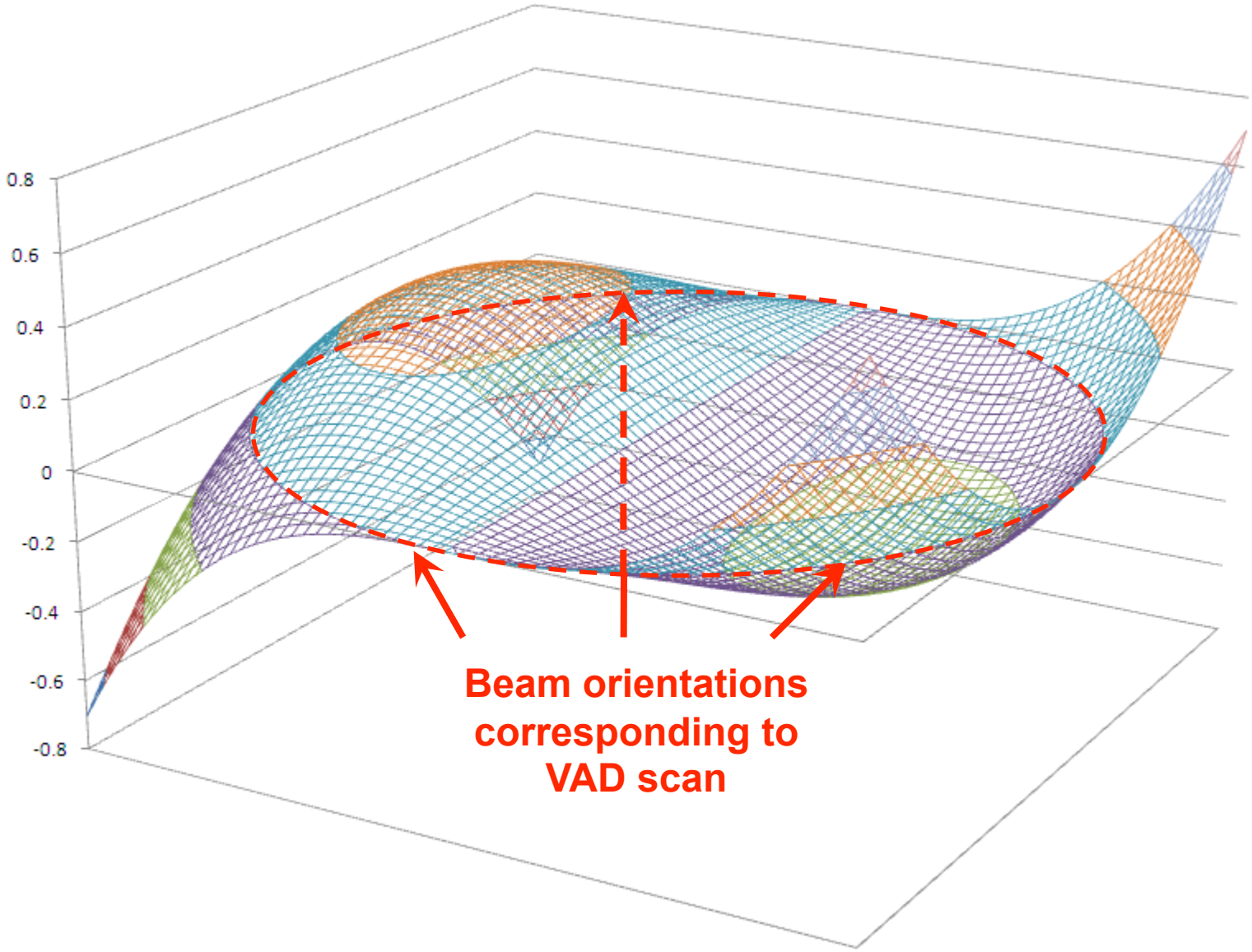

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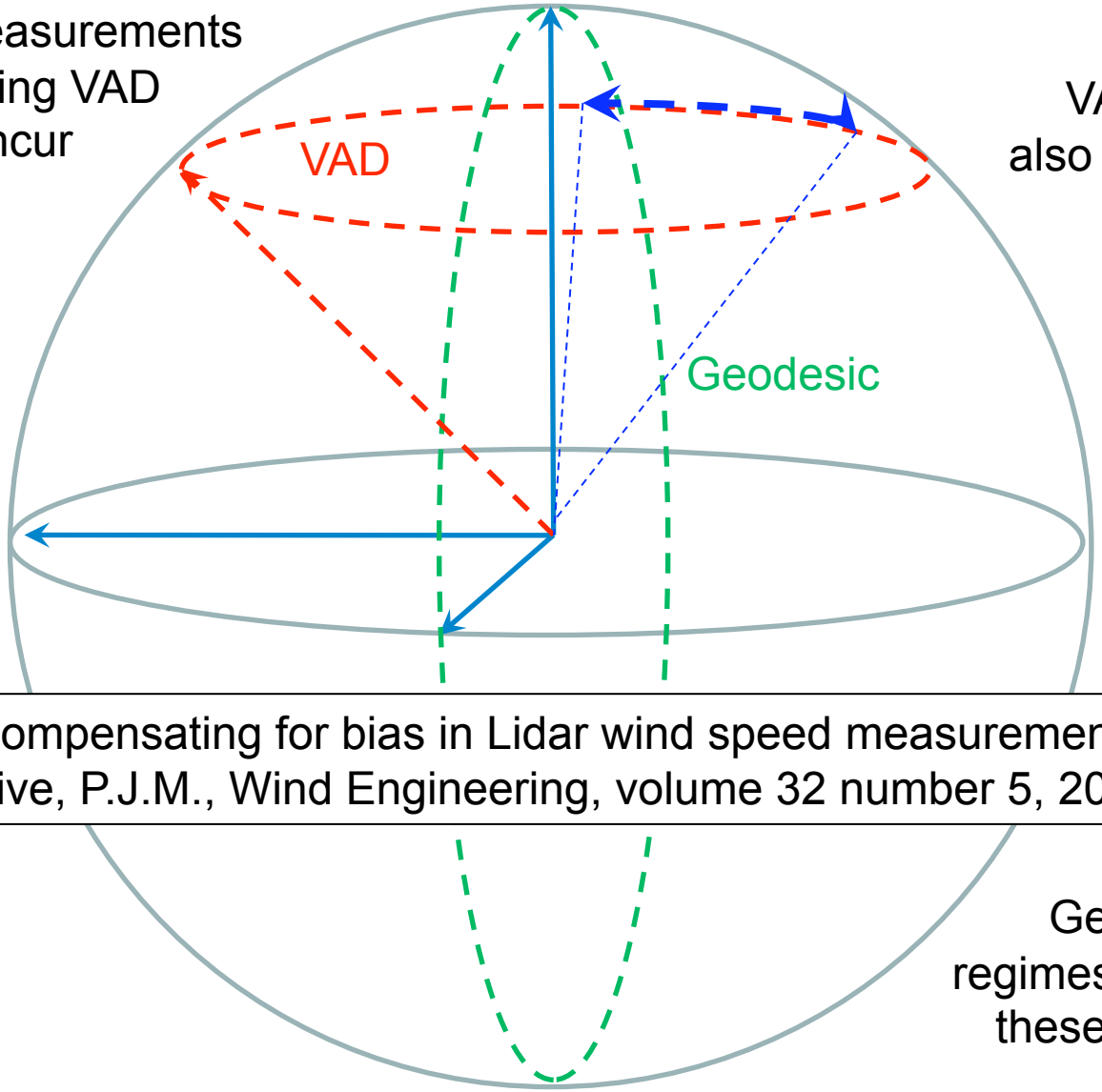
Beam steering (2)

Coplanar measurements obtained during VAD scans may incur ambiguity



VAD arcs may also prove useful

"Compensating for bias in Lidar wind speed measurements"
Clive, P.J.M., Wind Engineering, volume 32 number 5, 2008

Geodesic scan regimes will resolve these ambiguities

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Beam steering (3)

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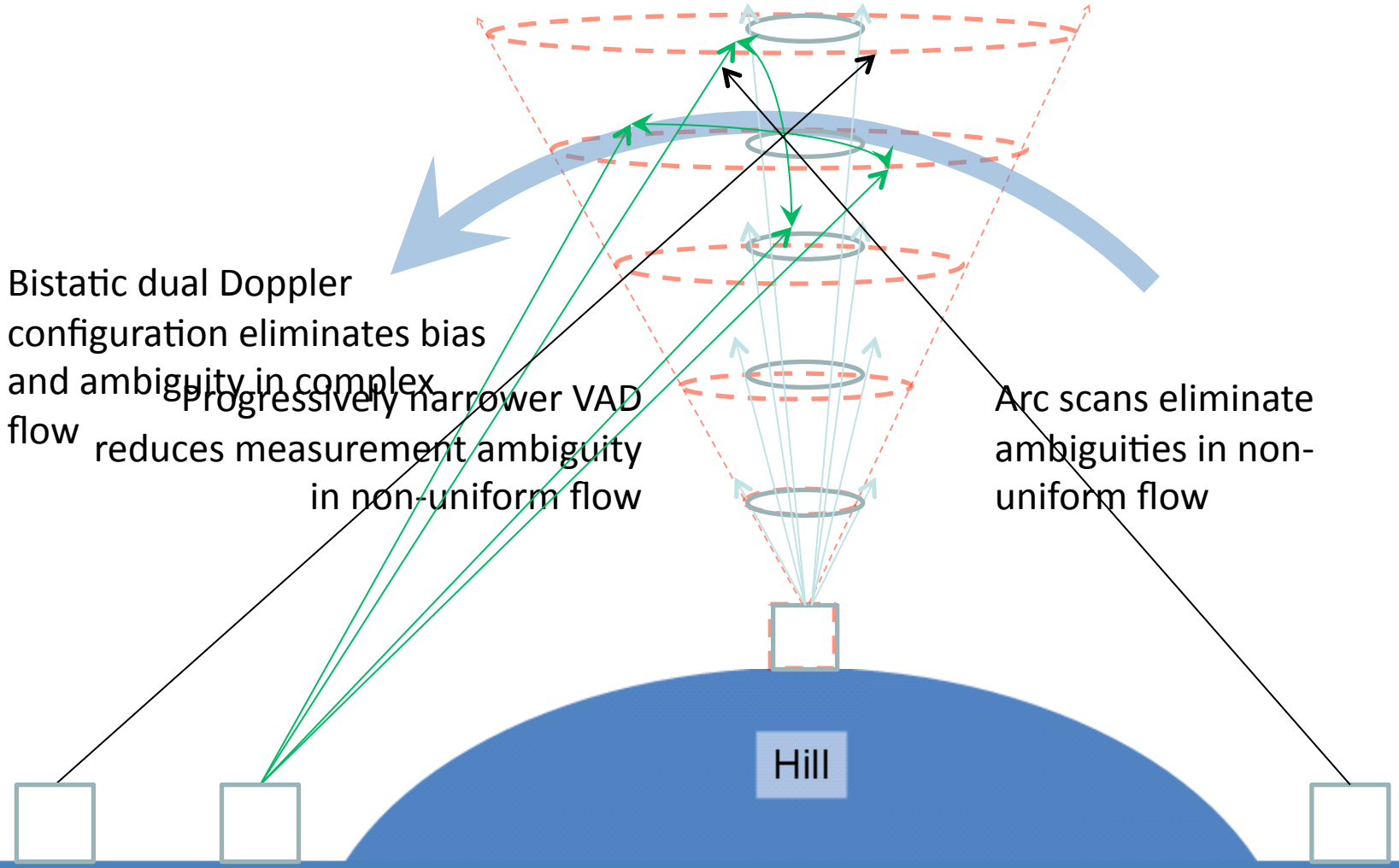

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Galion

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Comparison study (1)

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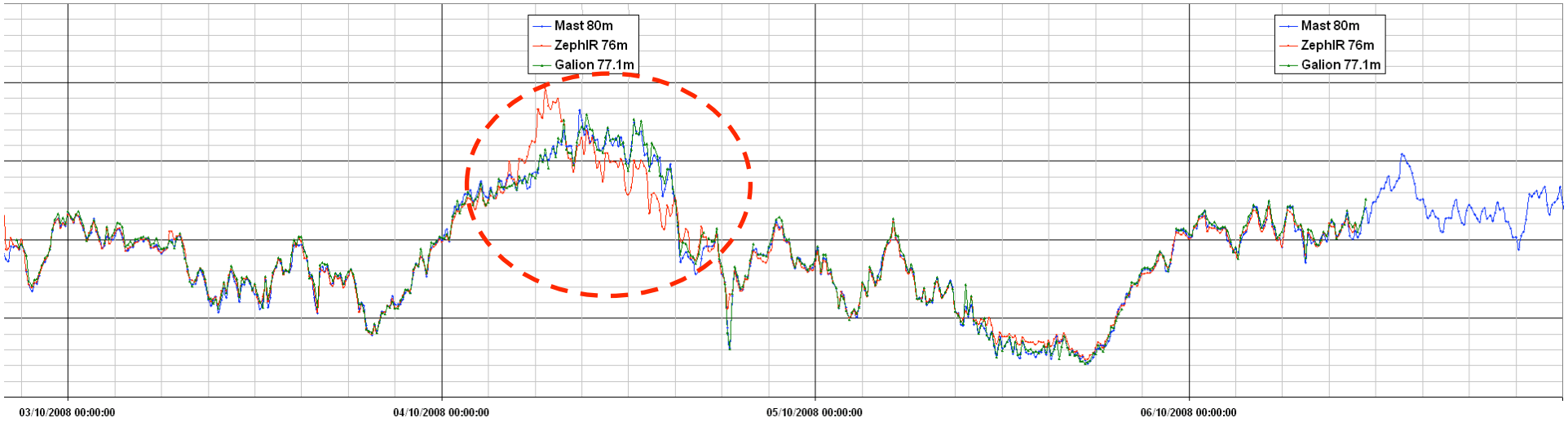

Time series

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Cloud correction

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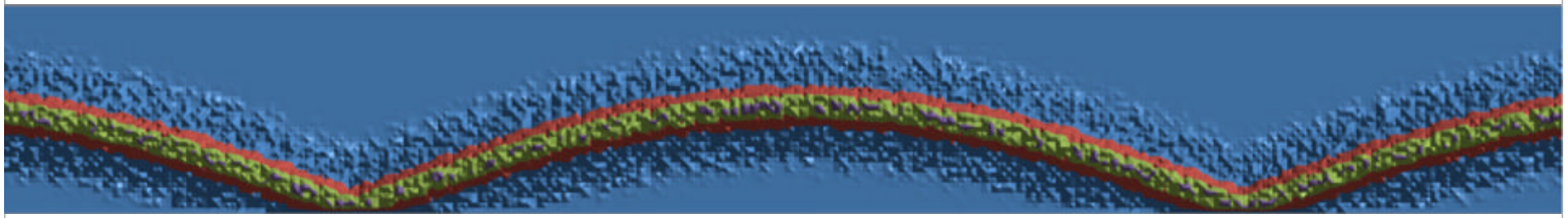

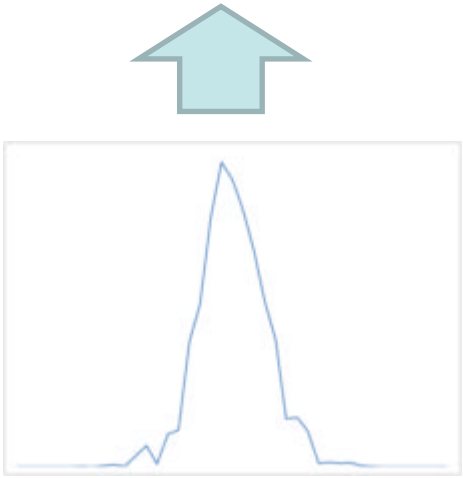

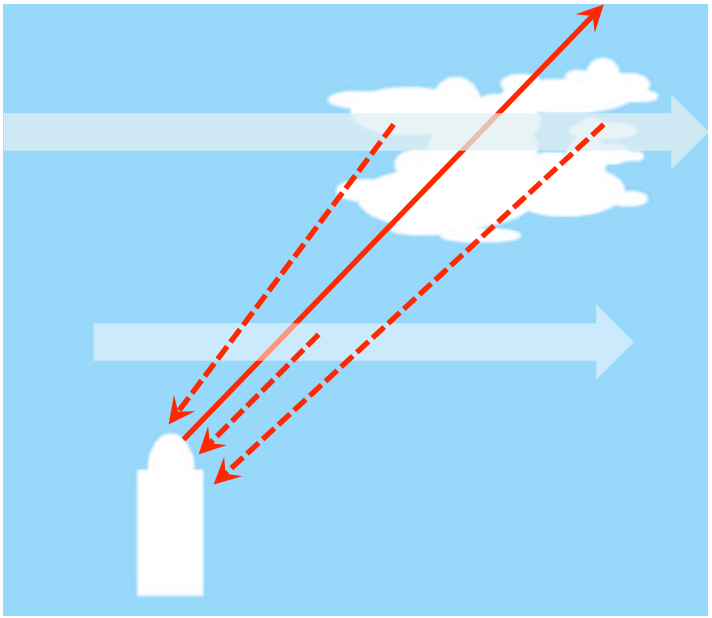

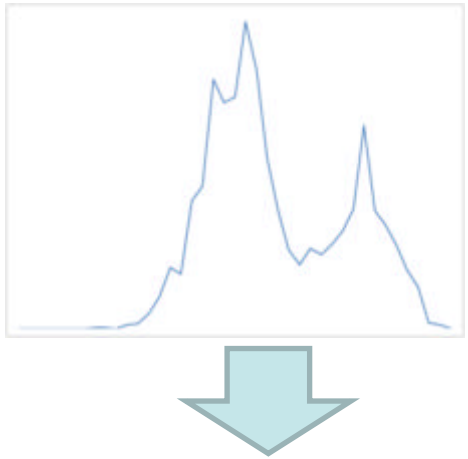

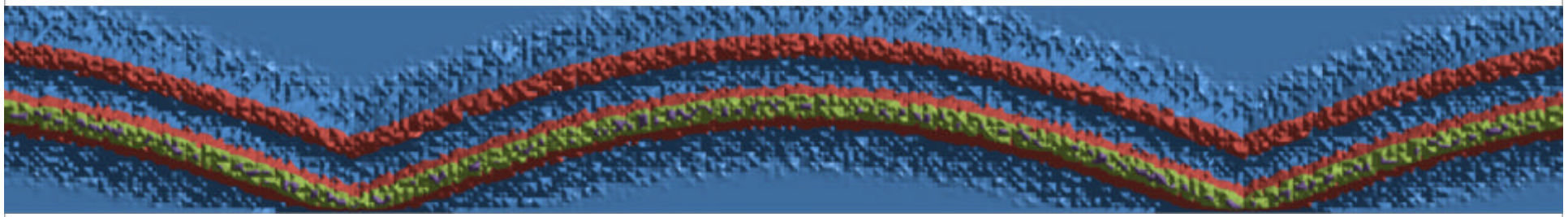

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Comparison study (1)

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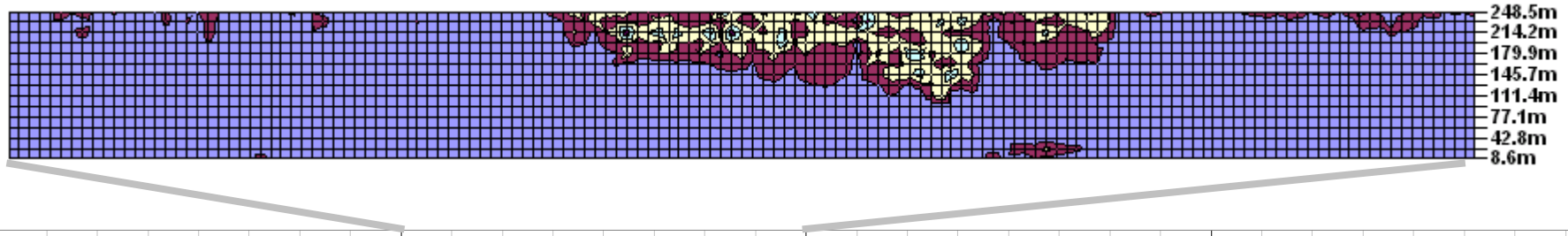

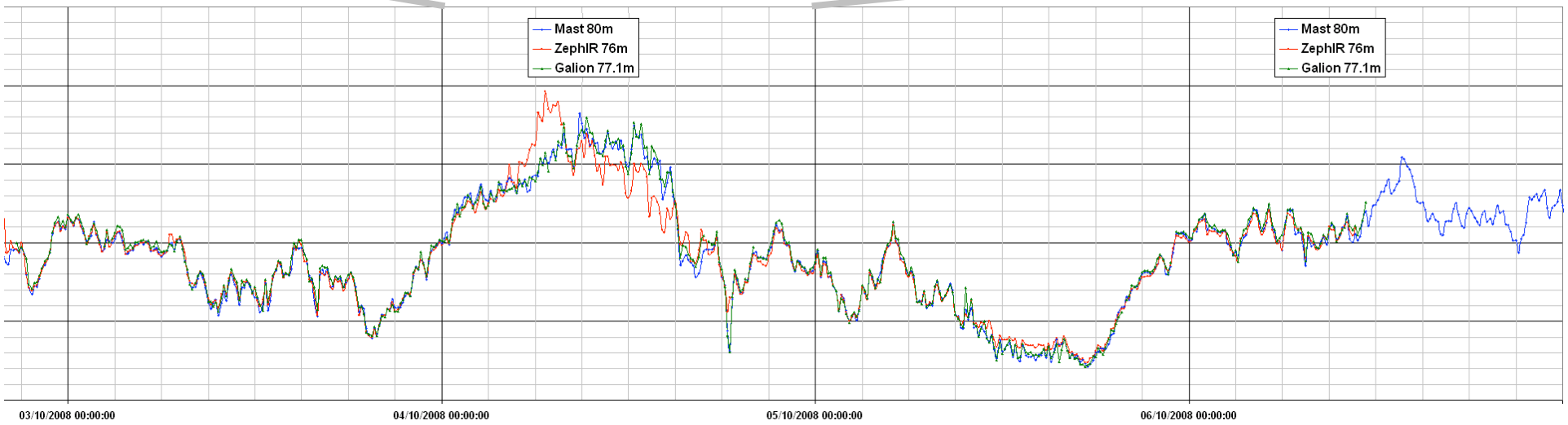

Time series

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Comparison study (2)

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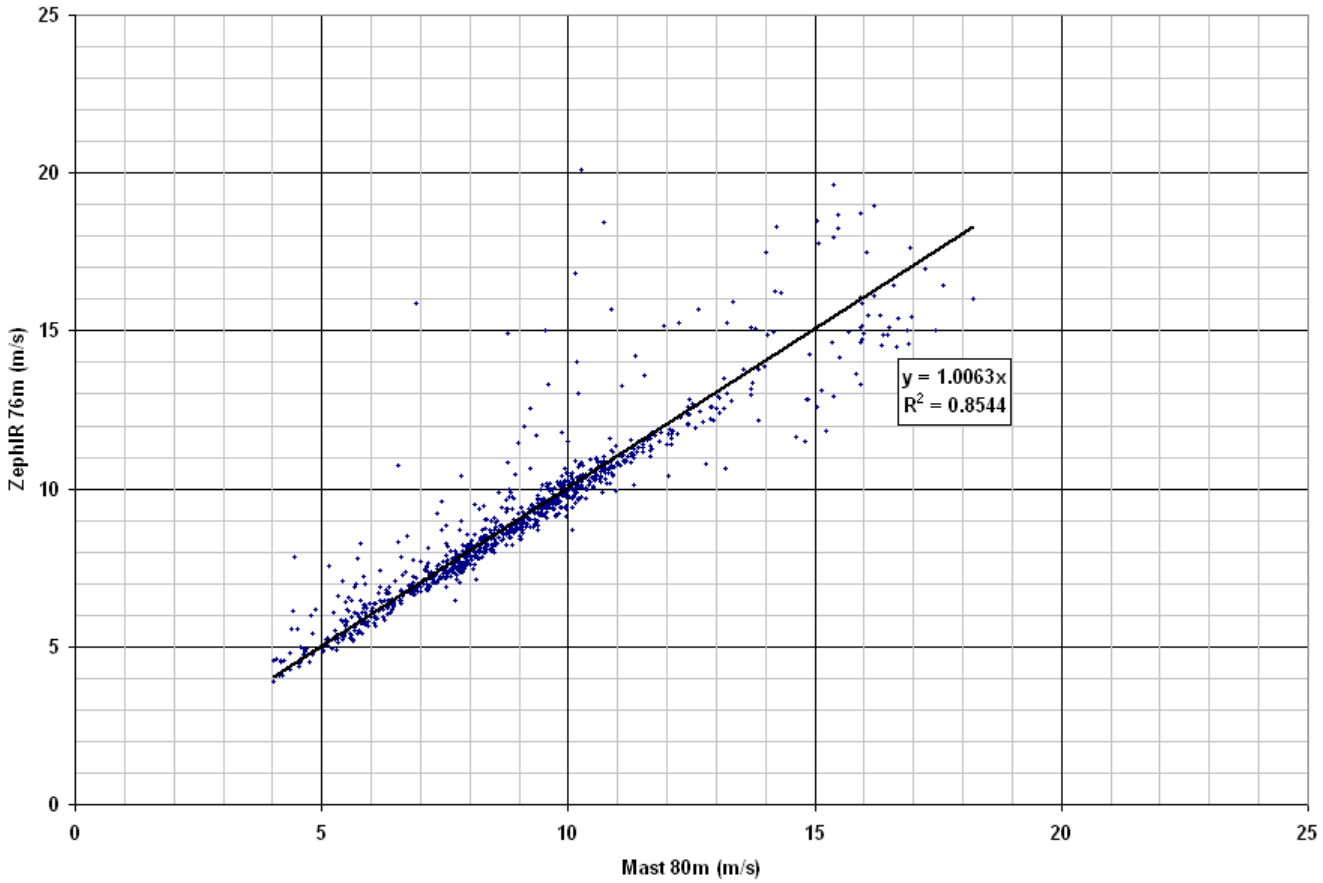
Linear regression – ZephIR v Mast



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Comparison study (3)

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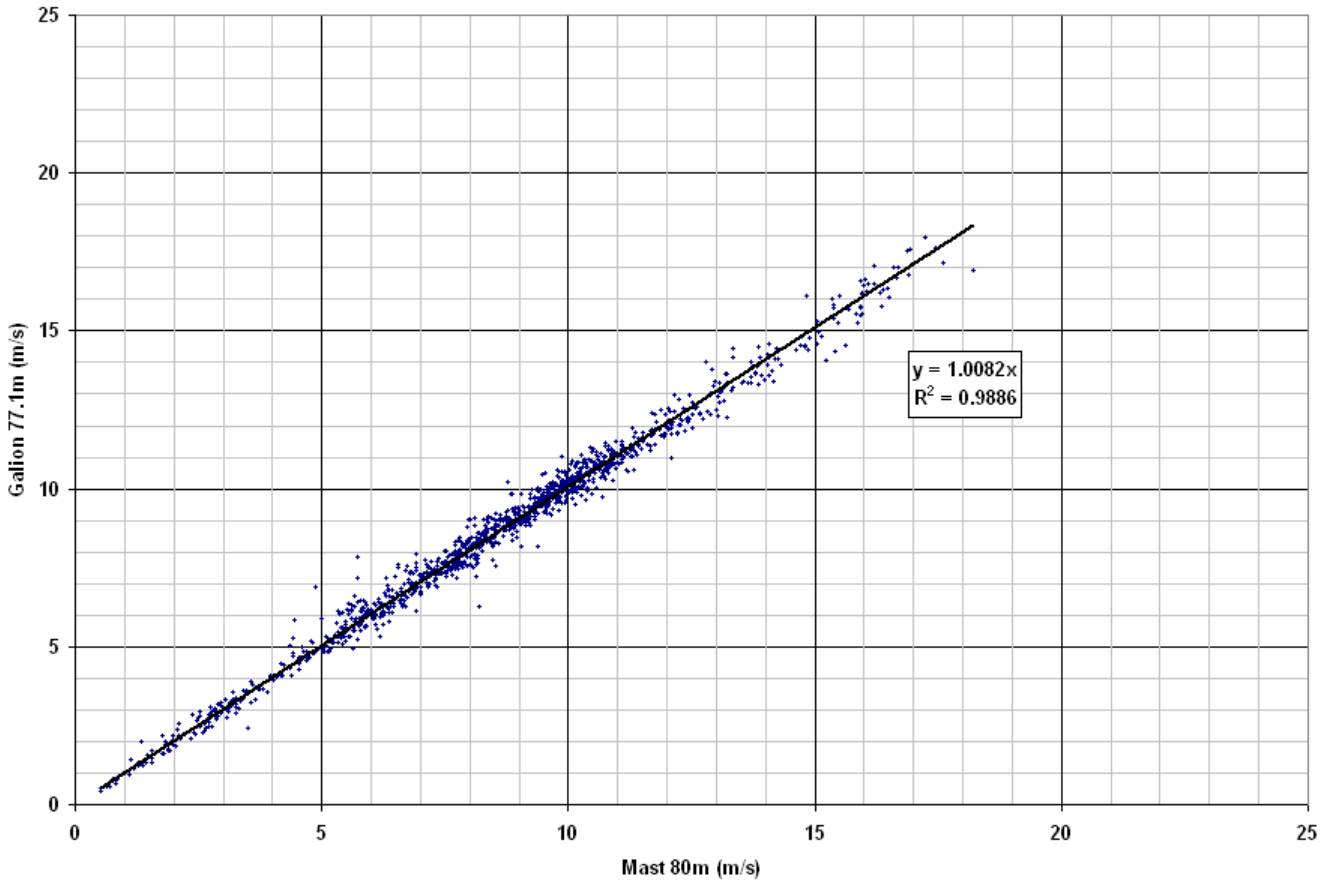
Linear regression – Galion v Mast



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Comparison study (4)

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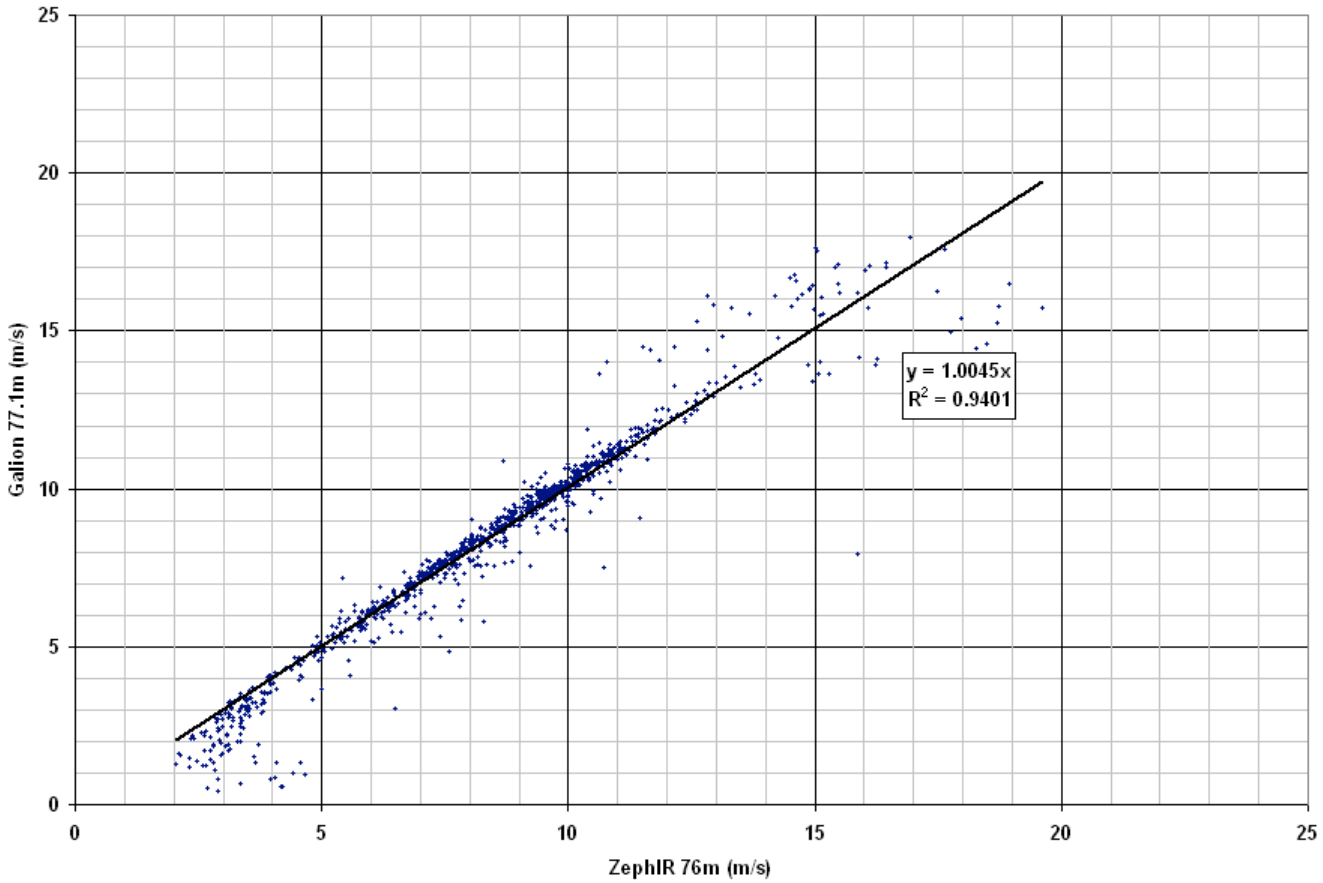
Linear regression – Galion v ZephIR



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Thank you for listening

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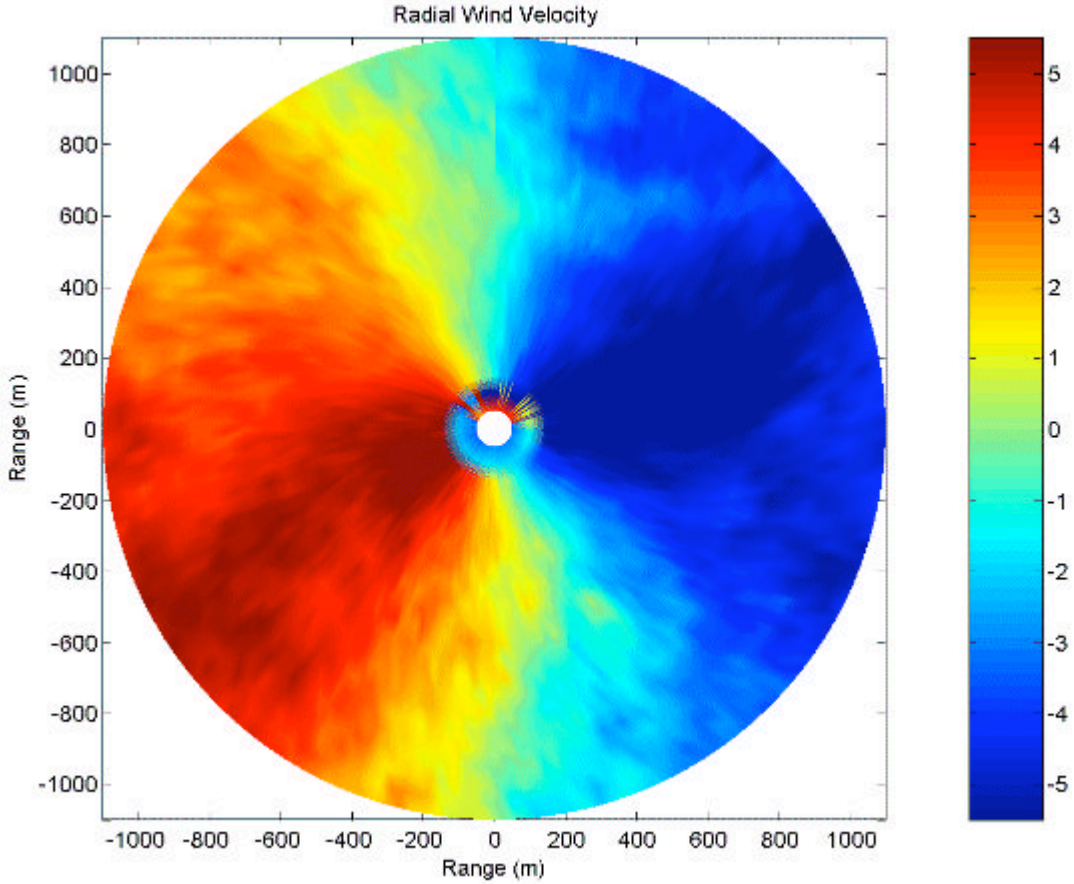
Any questions?



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