GL Garrad Hassan

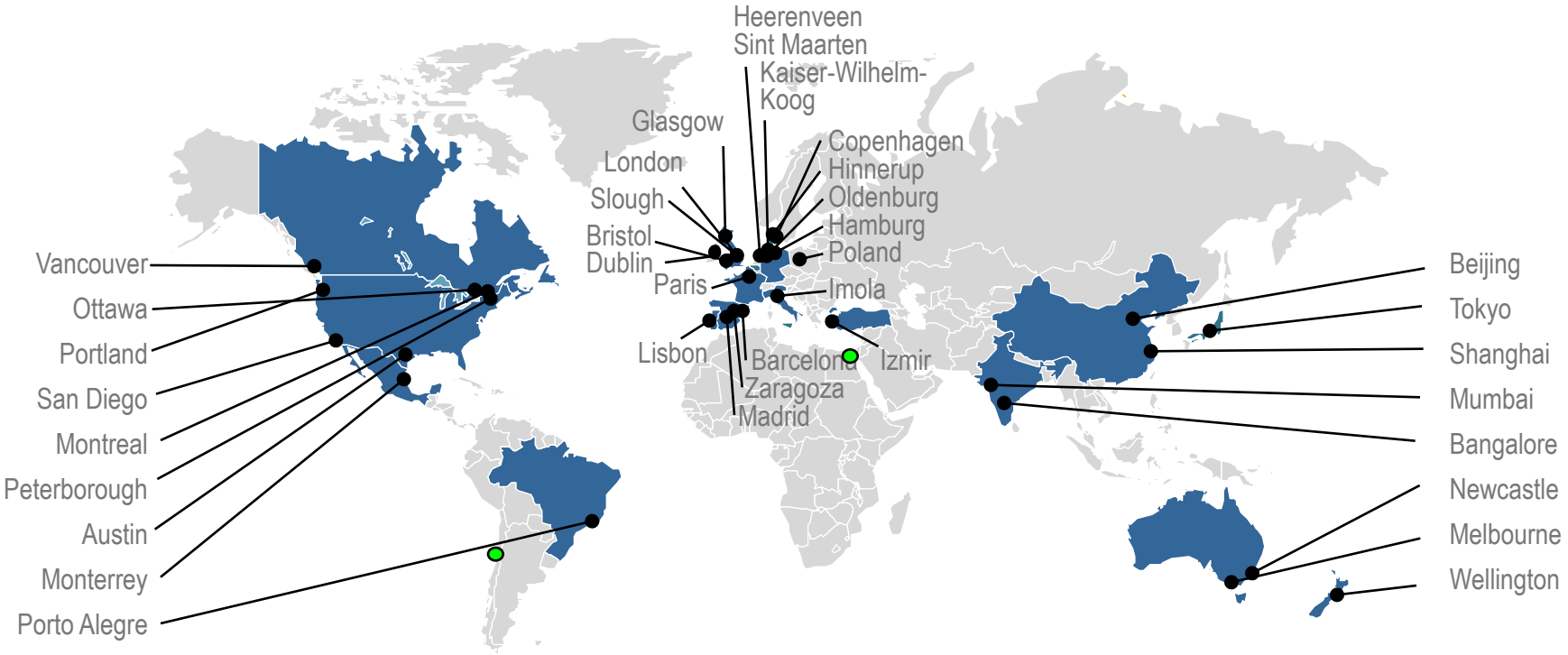
Mesoscale Wind Mapping

Andrew Tindal and Jessica Ma

24th April 2012

GL GARRAD HASSAN

780 staff, in 42 locations, across 23 countries



Overview

Types of wind maps

Mesoscale modelling:

Required Inputs;

Outputs;

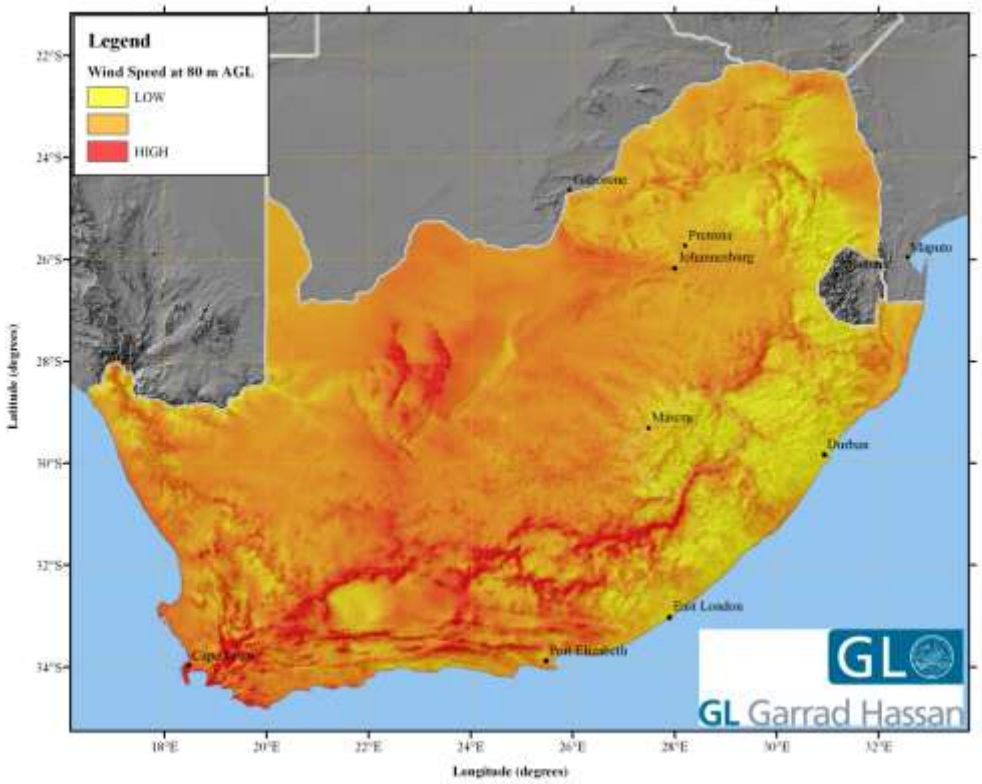
What value does it provide;

Limitations;

Case Study;

Conclusions;

Next step;



Types of Wind Maps

Wind maps based on ground measurements

- Measurements are usually obtained from meteorological stations at low heights ~10 m
- Issues include: instrumentation, data consistency and extrapolation methods

Wind maps based mesoscale simulations

- Low resolution but good for large areas
- Captures large terrain features but will not account for local terrain effects

Wind maps based on microscale simulations

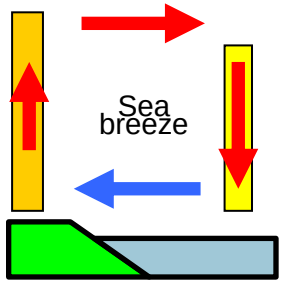
- High resolution but limited to small areas
- May not account for unique flow mechanisms

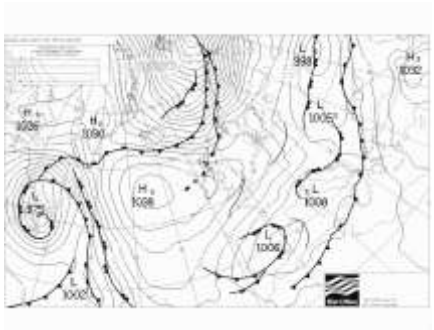
Wind maps based on mesoscale/microscale coupling

- Computationally expensive for large areas
- Similar limitations as many linear microscale models; however , usually accounts for unique flow mechanisms as these models are generally initiated for every meso-grid cell

What is mesoscale modelling?

- 1 km – 100 km horizontal resolution
- Accounts for sea breeze circulation, hurricanes, tropical storms, thermal flows, large scale mountain breezes, etc
- Resolves meteorological conditions within the modelling domain by solving a set of equations describing the atmosphere.





Required inputs

Informat

- h
- r
- a

Topogra

- r

Land co

- W

Model c

- F

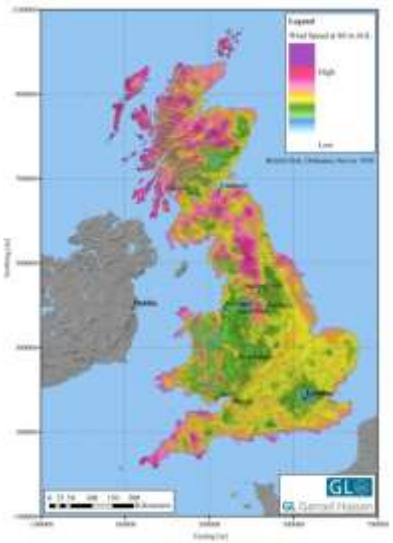
torical

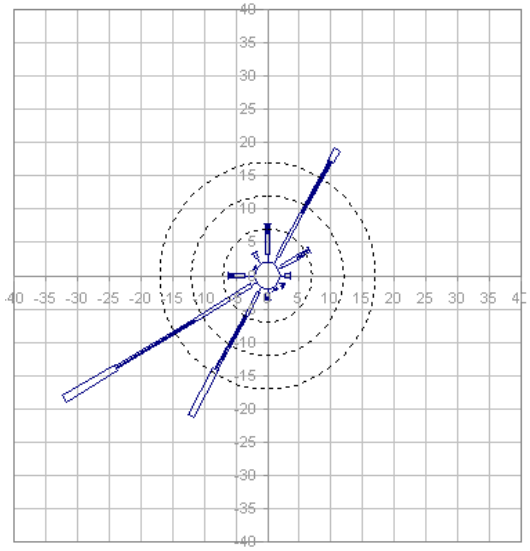
year Re-

n size

Outputs

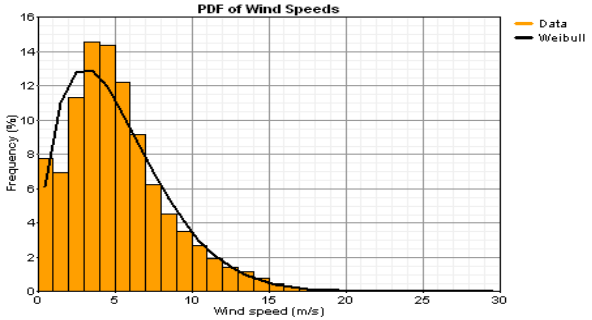
- Wind speed
- Pressure
- Temperature
- Precipitation
- Solar irradiation
- And more





Depending on the model these outputs can be provided as

- Long-term mean values
- Long-term frequency of occurence
- Timeseries



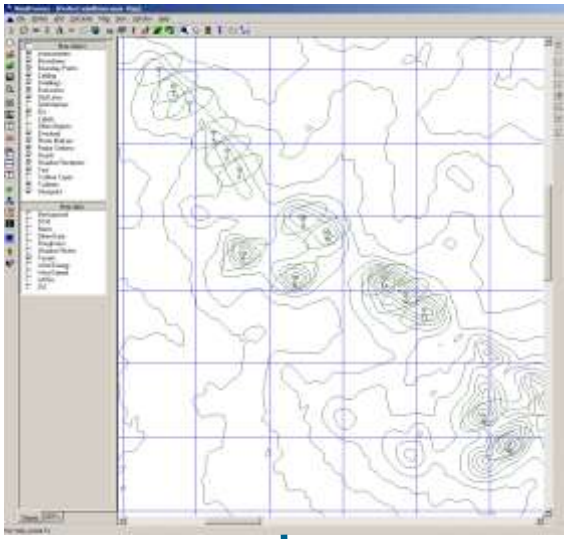
What value does it provide?

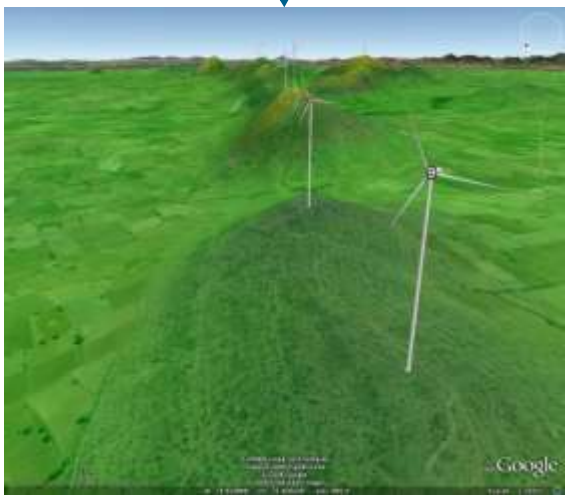
- Provides an indication of the wind speed across a very large area
    - National wind maps
    - Site selection/site ranking
    - Indication of wind energy potential

By conducting further microscale modelling:

- Preliminary indication of energy yield and layout of a site
    - Helpful for measurement campaign definition

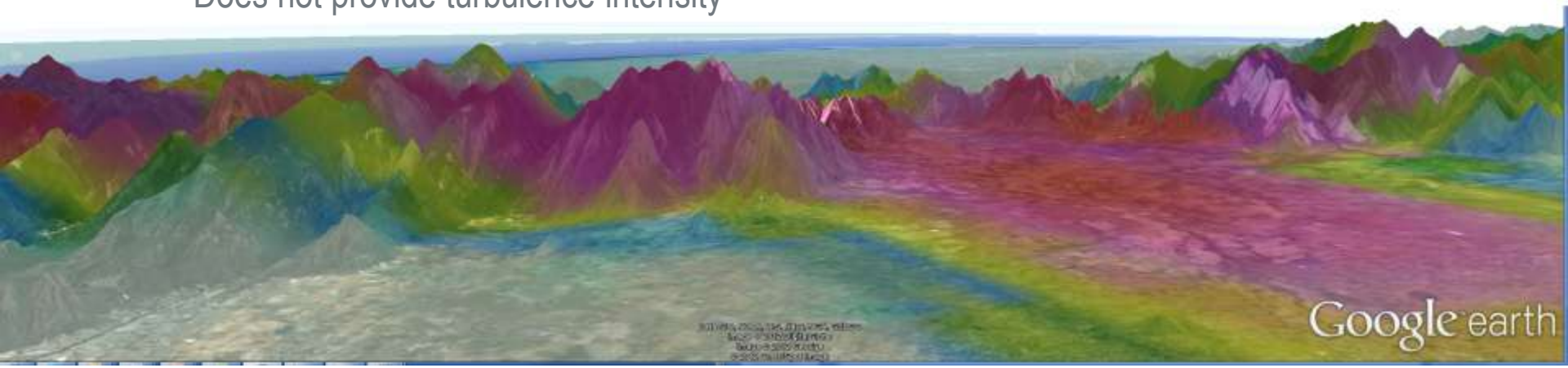
- Once measurements have been conducted on site the mesomap variation can also help identify complex flow patterns not captured by linear microscale models



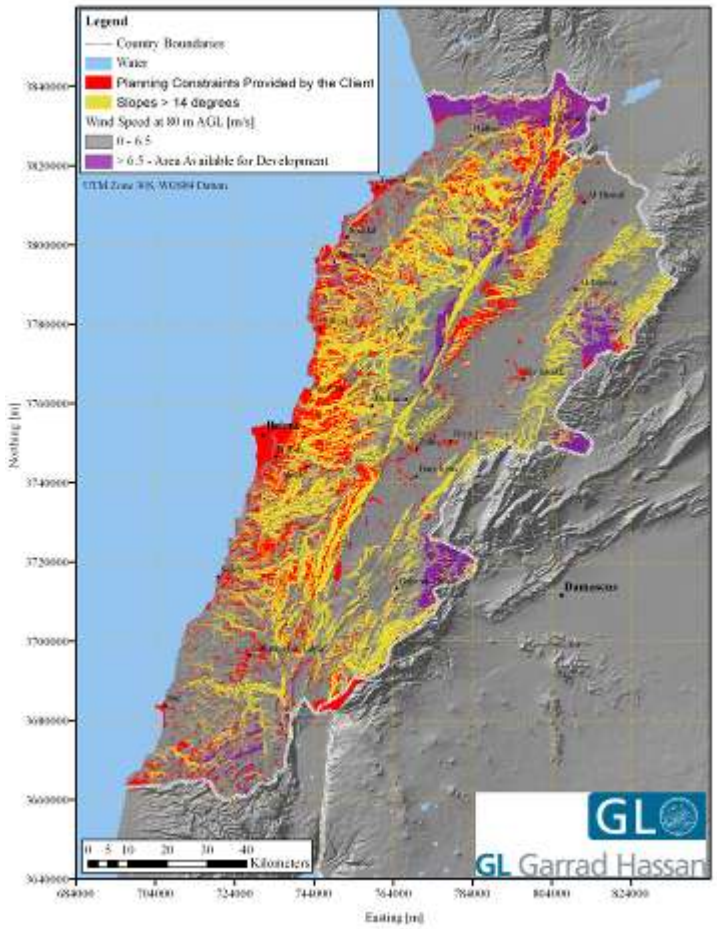


Limitations

- Results depend on quality and consistency of the input data.
- Low grid resolution, does not account for local terrain features
- Certain assumptions and simplifications may be required to resolve equations within the model and for computational efficiency. As a result some physical processes may not be captured.
- Good for capturing variation, however absolute values might be inaccurate. Verification/calibration with ground measurements is recommended.
- Does not provide turbulence intensity



Case Study : Developing market



Produced a wind map showing the variation in wind speed across Lebanon considering all available measured data

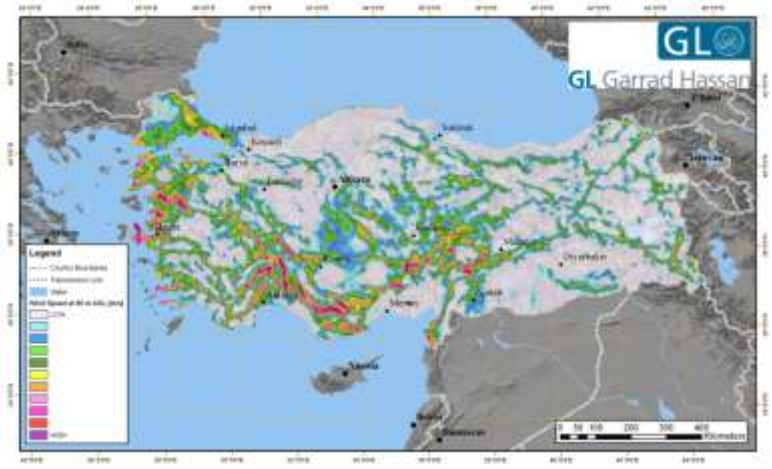
Wind power potential estimation

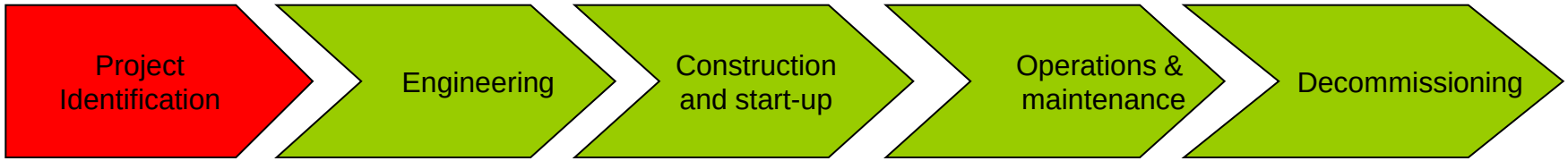
- 6.5 m/s at 80 m height assumed to be minimum for a viable wind farm
- Planning constraints provided
- Maximum terrain gradient assumed feasible for construction assumed – 14 degrees
- Assumed installation density 8MW/km2
- Based on the above potential capacity is ~6GW

Source: http://www.cedro-undp.org/content/news/Wind%20mapping%20for%20Lebanon-20110204-094208.pdf

Conclusion

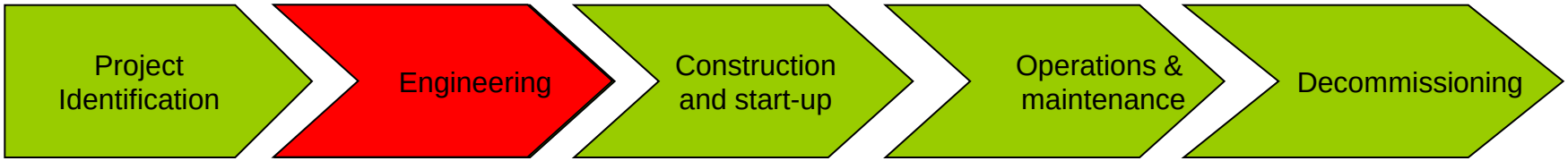
Mesoscale maps are primarily considered at an early stage for project identification and measurement campaign definition purposes.





Next step

Once a site is identified masts should be installed to acquire a more accurate picture of the site wind regime and assess project feasibility.



Thank you

Andrew Tindal
Head of Energy, Senior Vice President
Andrew.Tindal@GL-Garradhassan.com

Jessica Ma
Specialist Engineer, Energy and Development Services
Jessica.Ma@GL-Garradhassan.com

www.**gl-garradhassan**.com

Case Study: Unique flow mechanisms

mesoscale modelling can produce value for a microscale wind resource assessment by introducing flow mechanisms that are not included in microscale models

e.g. funnel flows

katabatic flows

large scale mountain effects

Look at the example of a real funnel flow

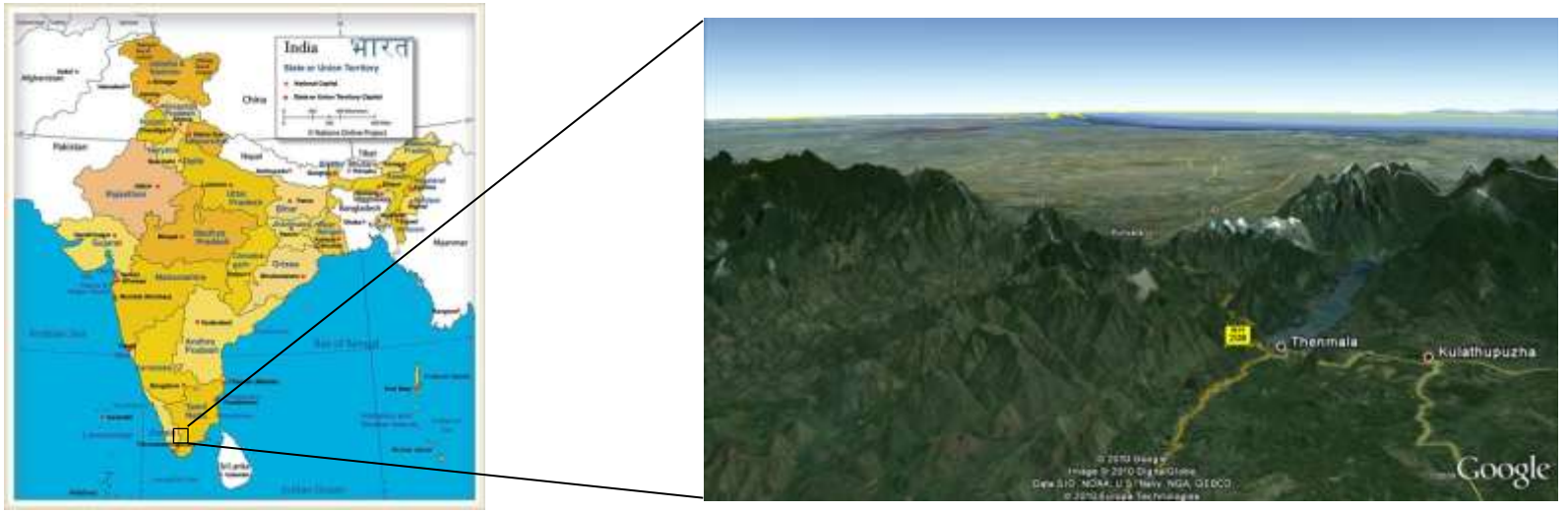
Senkotta Pass – Southern India

Compare mesoscale informed modelling with standard WAsP- based technique

Case Study: Unique flow mechanisms

Senkotta pass

- A pass across the Western Ghats which separate the states of Kerala and Tamil Nadu in Southern India

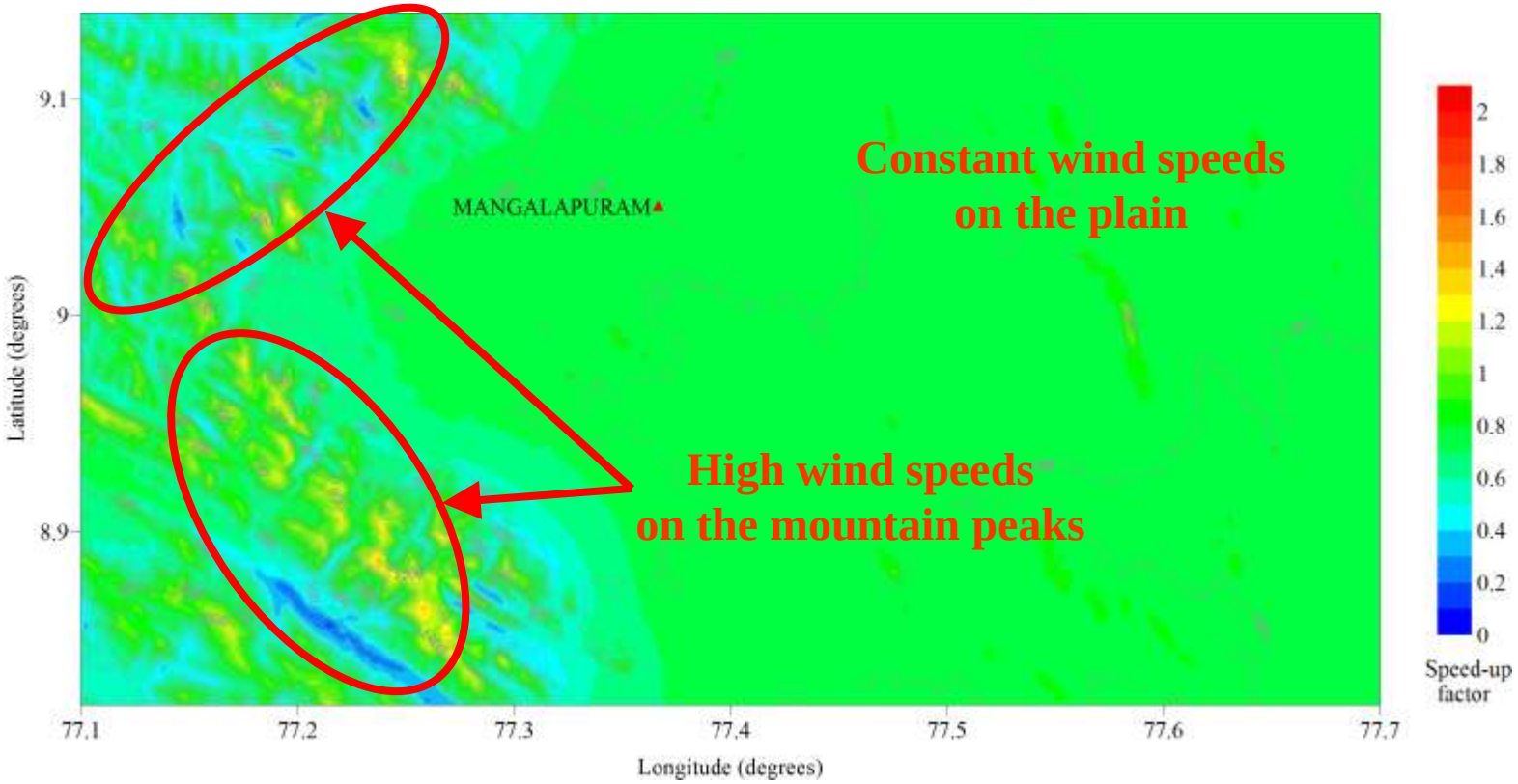


- ~20km wide and 800m lower than surrounding peaks
- Large high wind speed area on the downwind plain which is a region of great interest for wind power development

Case Study: Unique flow mechanisms

Senkotta pass (Standard Approach)

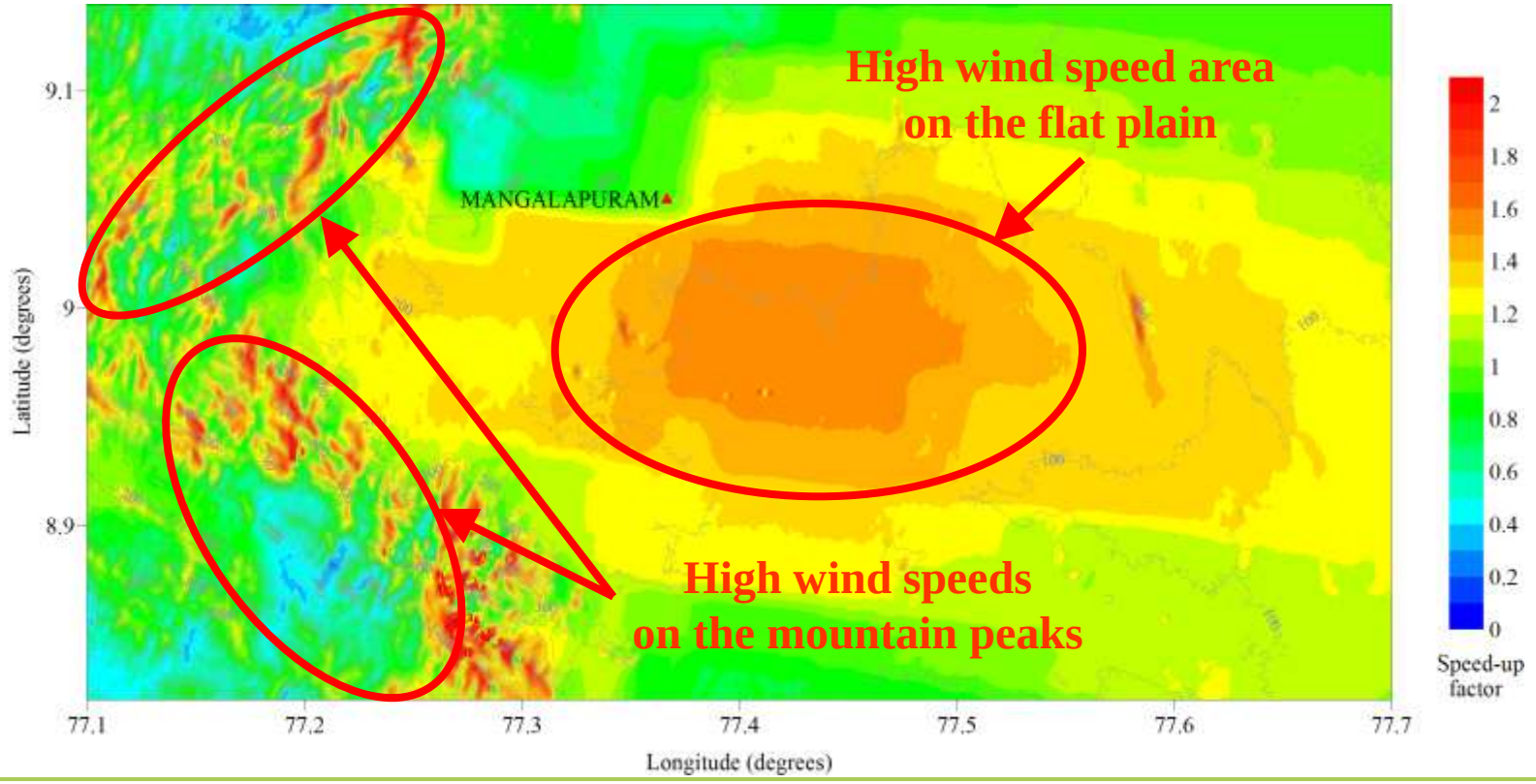
- WAsP is initiated using data from the Mangalapuram CWET mast



Case Study: Unique flow mechanisms

Senkotta pass (Mesoscale based approach)

- Coupled mesoscale mircroscale simulation
  - 5km resolution mesoscale simulation
  - 100m resolution microscale simulation

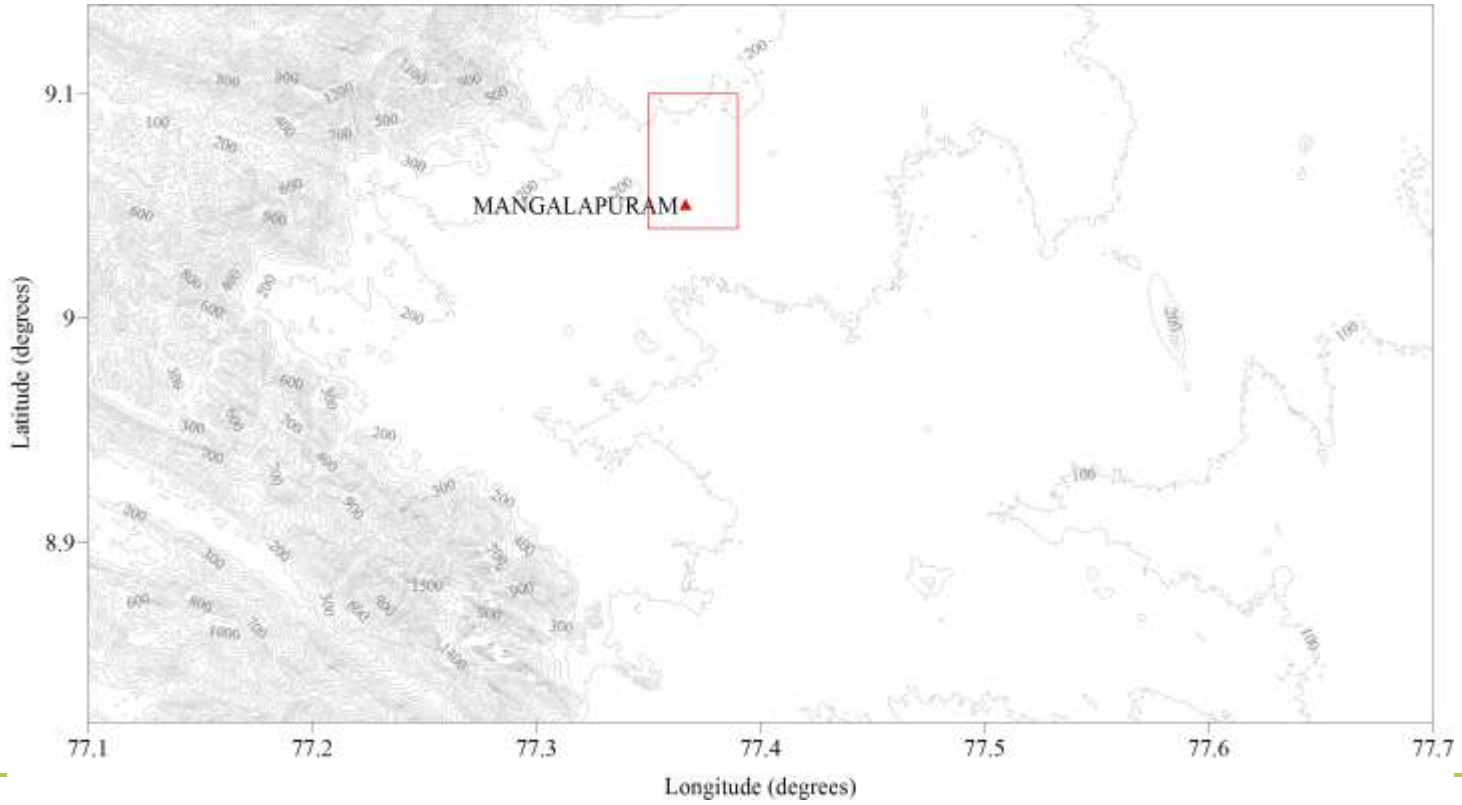


80 m agl

Case Study: Unique flow mechanisms

What does this mean for a proposed site?

- Consider example site…
- Add a site boundary around the mast region…



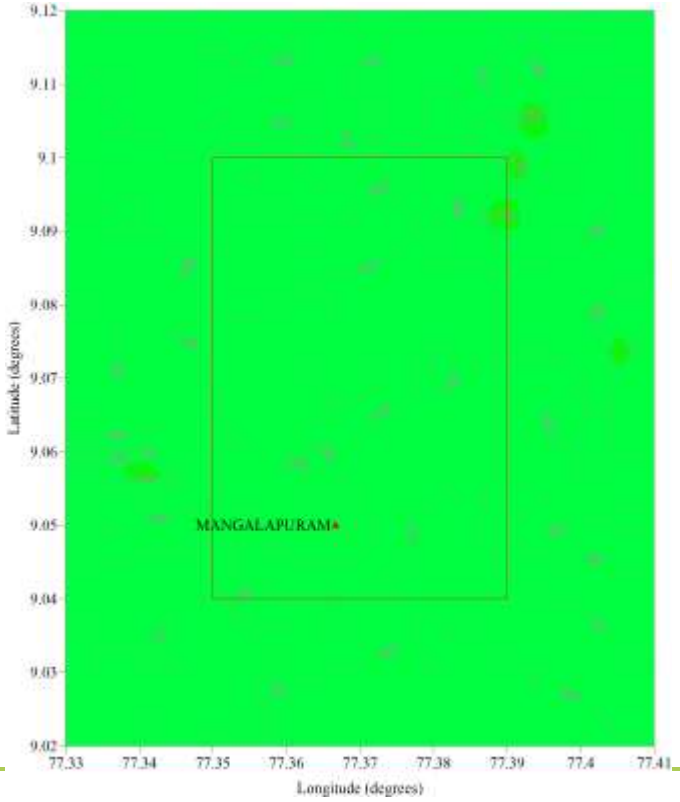
Case Study: Unique flow mechanisms

What does this mean for a site?

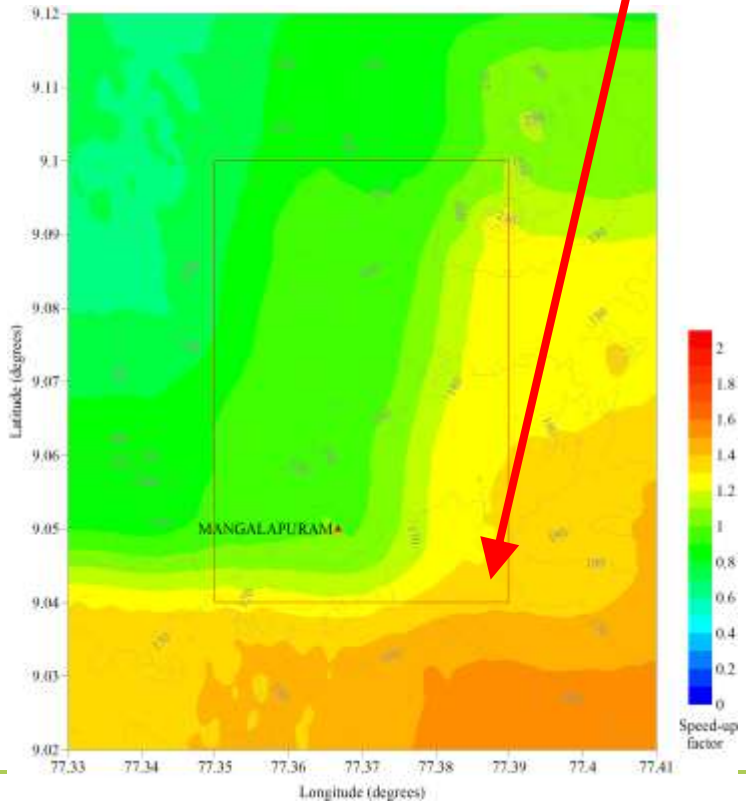
- Significant wind speed variation can be missed even in close proximity to the mast

40% increase in wind speed!

WAsP results



Mesoscale results

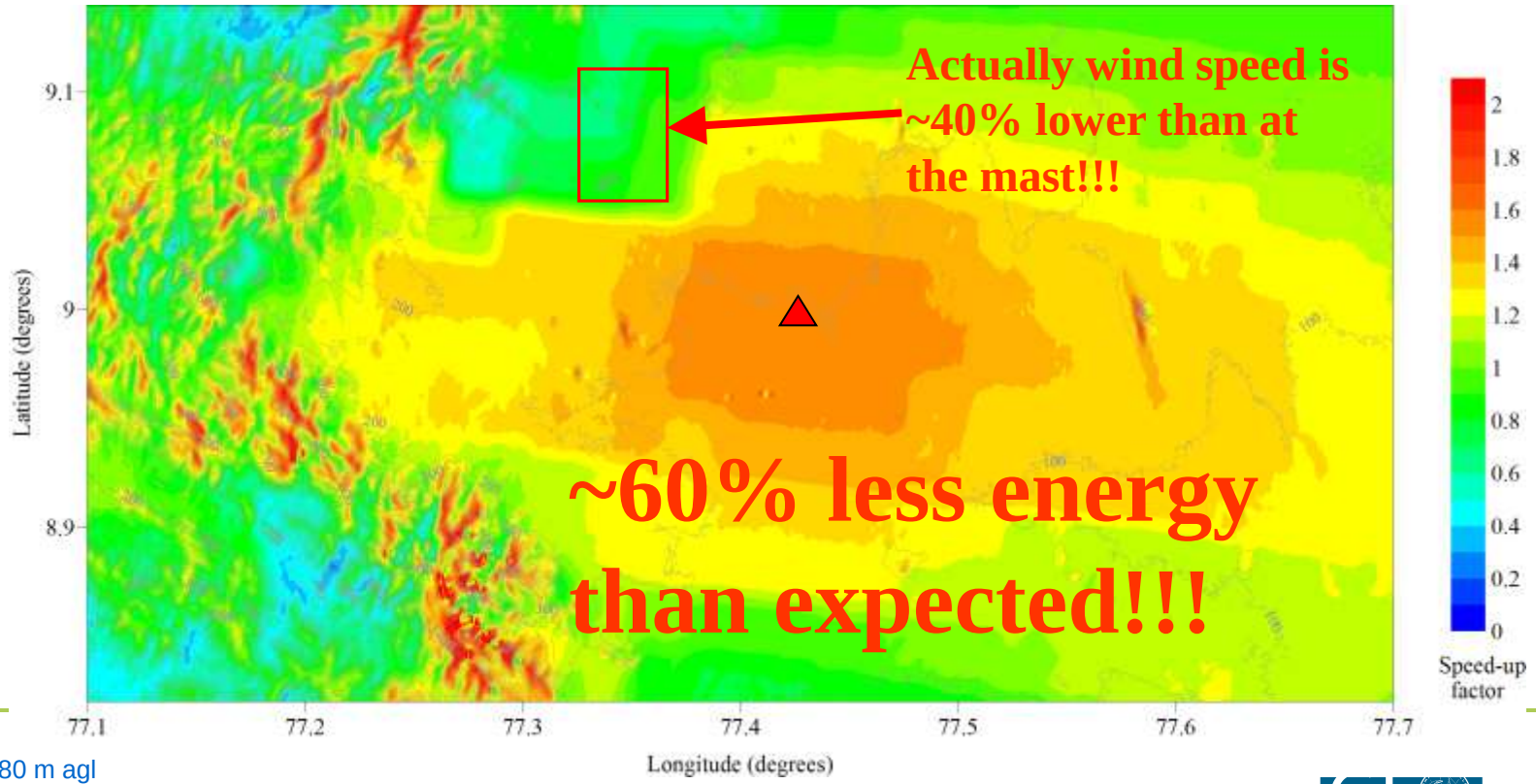


80 m agl

Case Study: Unique flow mechanisms

Horror Scenario!!

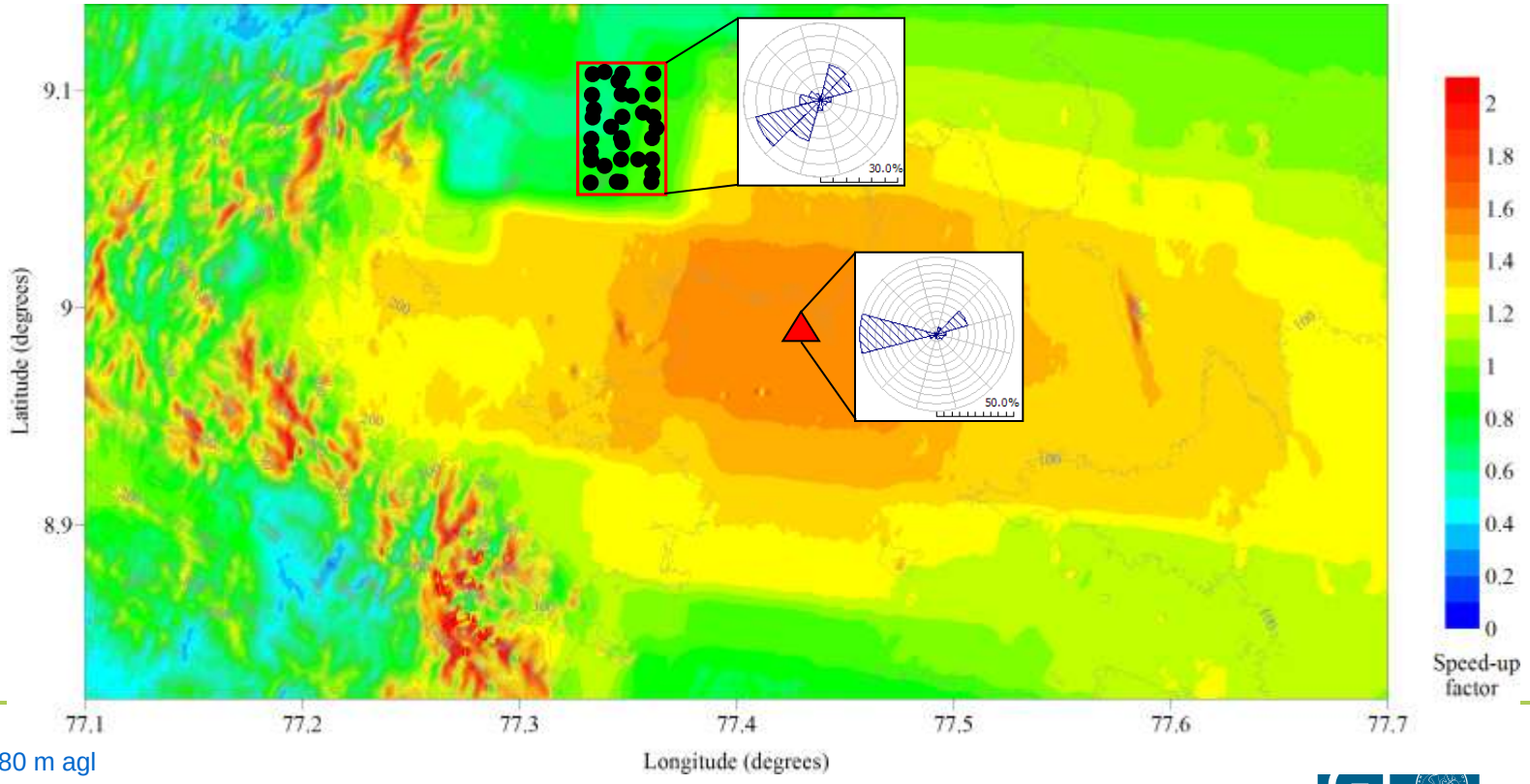
- Data is available from a mast located in the centre of the high wind speed area
- Sensibly, the Client is expecting a consistent wind speed across the plain…



80 m agl

Case Study: Unique flow mechanisms
Consideration of Direction

- WAsP does not predict any significant change in the wind rose across a flat plain
- The mesoscale model predicts that the wind rose changes significantly due to the location of the mountain pass



80 m agl

Case Study: Unique flow mechanisms

Concluding remarks

- Mesoscale modelling (even with significant simplifications) is able to provide real value for studies at sites that are influenced by funnel flows
  - Enables a better informed site selection
  - Better identification of windiest locations at a site
  - Enables more efficient measurement campaign design
  - Targeted land acquisition

- Mesoscale wind modelling results are subject to significant uncertainties so…
- **Measurements are still required to confirm the modelling results and produce ‘bankable’ analyses**