Comparison of Dispersion Model Case Studies using Numerical Weather Prediction or Synoptic Observations

Harmo 12, Session 6, H12-106 8th October 2008

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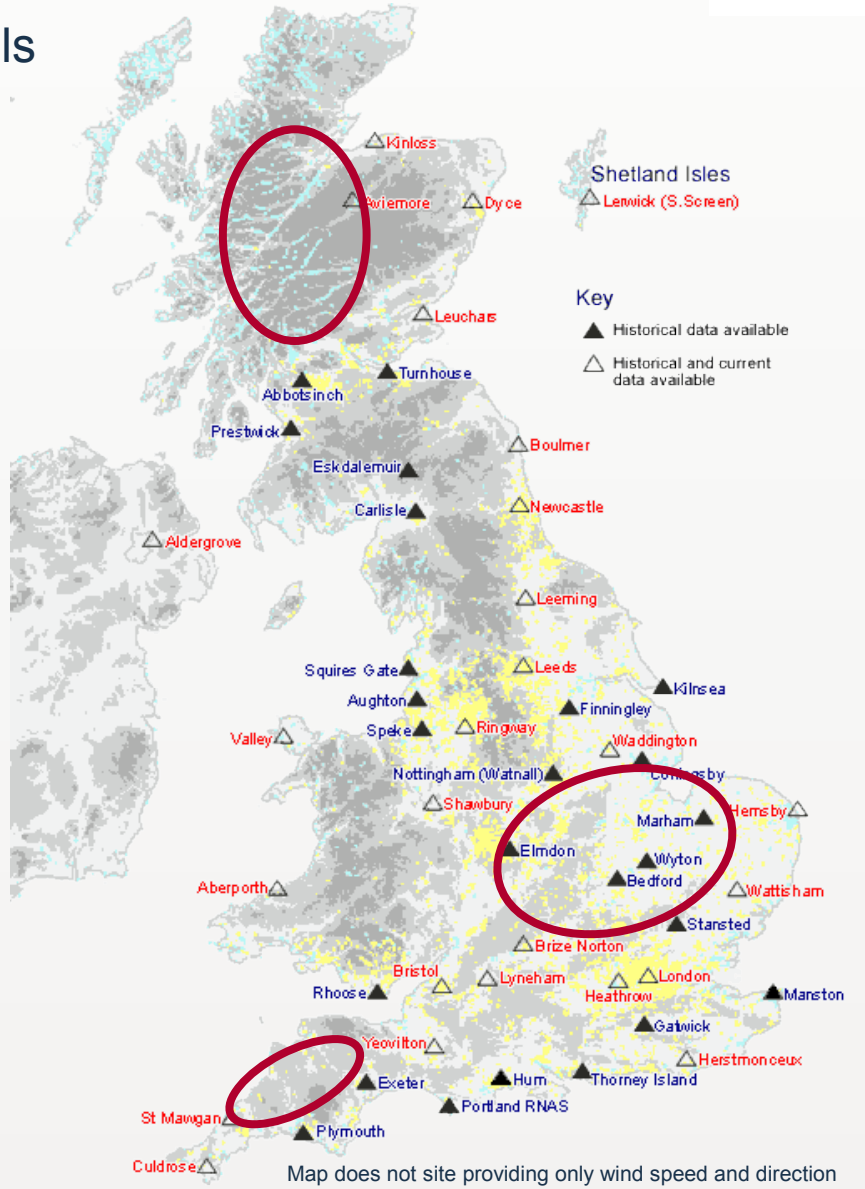
Availability of Meteorological Data

- Key parameters required by dispersion models such as ADMS and AERMOD include:
  - Wind speed and direction
  - Temperature
  - Cloud cover

- Availability of synoptic meteorological stations providing key model parameters have reduced in the UK
- Potential gaps forming in coverage >50km where only historical data



Availability of Meteorological Data

- It is most often the cloud cover estimates that are missing
- These are required by dispersion models to estimate key boundary layer parametes and stability conditions
- Commonly used methods to obtain meteorological data for modelling studies where there is no appropriate site available providing cloud cover include:
  - Mixing cloud cover measurements from nearest available site with a site providing wind speed and direction etc
  - Obtaining measurements (rare for consulting purposes and possible QA/QC issues)
  - Using measurements obtained from LCBR
    - Some debate as to how LCBR estimates of cloud cover compare with manual observations
- New approach may be to use the UK Met Office Numerical Weather Prediction datasets

What is NWP?

- Models are used for the day to day forecasting of weather and to model climate change
- Uses available weather observations measured both globally, regionally, and more locally to produce the weather patterns and forecast data
- The NWP data is produced by the Unified Model
  - Contain atmospheric and ocean models
  - Allows both horizontal and vertical resolution to be varied
    - Global or Regional Model (40km)
    - Mesocale Model (12km)
    - Local scale (4km)
- UM and NWP undergo continuous development – important to know scale and version
- More information is available at http://www.metoffice.gov.uk/research/nwp/numerical/unified_model/unified_model.html

What does NWP provided?

- NWP can provide datasets which replicate the standard meteorological inputs required by dispserion models including ADMS and AERMOD
- Data can be site specific for your site location
- Enhanced datasets provide UM (Unifed Model) predicted estimates of additional meteorological parameters including:
  - Cloud cover (scale 0 – 8, not integer)
  - Surface sensible Heat flux (W/m^2)
  - Boundary Layer Depth (H)
  - Precipitation (mm/hour)
- Typical parameters such as wind speeds and direction can be compared against available observations
  - May include local site measurements and/or Met Office synoptic stations

Things to remember

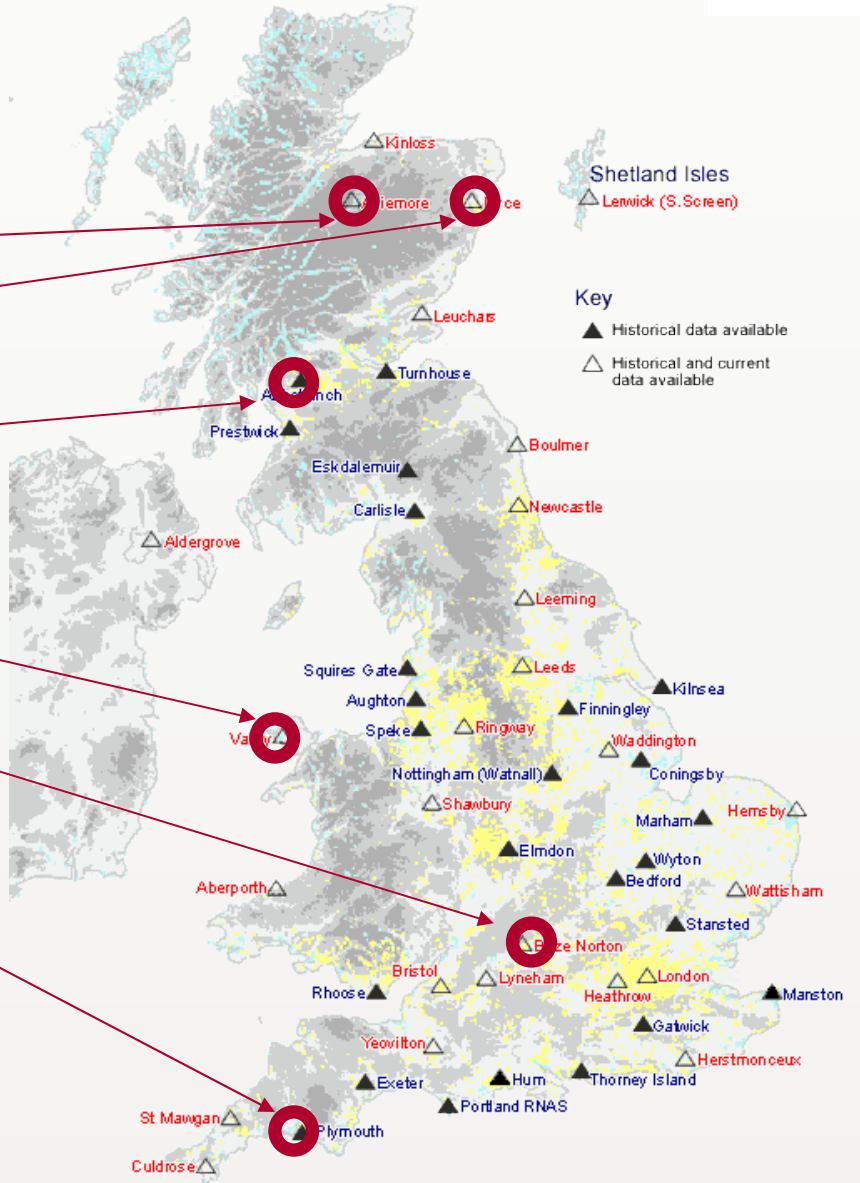
- Whilst NWP data is site specific only larger scale orography is taken into account
- Individual hills and terrain are not yet represented within the datasets
  - Model runs can include local terrain
  - Sensitivity tests needed for complex model runs
- Senstivity Testing required for all modelling undertaken using NWP in order to understand your specific model sensitivities
  - Where buildings are included – differences in wind directions between datasets may have large impact
  - How to boundary layer height and heat flux estimates provided by UM compared with those produced by your meteorological pre-processors
    - UM and ADMS preprocessors are very similar
    - But you will get different estimates if you use observed cloud cover in the pre-processor

Things to remember

- Important that you know your model!!
- What datasets are used when and what is switched on and off?
  - For ADMS if the meteorological dataset you provide is from NWP and includes boundary layer height and sensible heat flux
    - ADMS will not calculate these parameters but will use them directly
    - This means your normal understanding of model sensitivity to the meterological data will change
    - Using NWP – model is less sensitive (not completely insensitive) to your inputs on surface roughness
- Recommend comparisons between processed meteorological data are compared against those provided within NWP datasets to assist in understanding of differences in results
  - Boundary layer height estimates
  - Cloud cover differences (may be key to differences in boundary layer height esimates)
  - Stability estimates if possible

OBS and NWP Comparisons

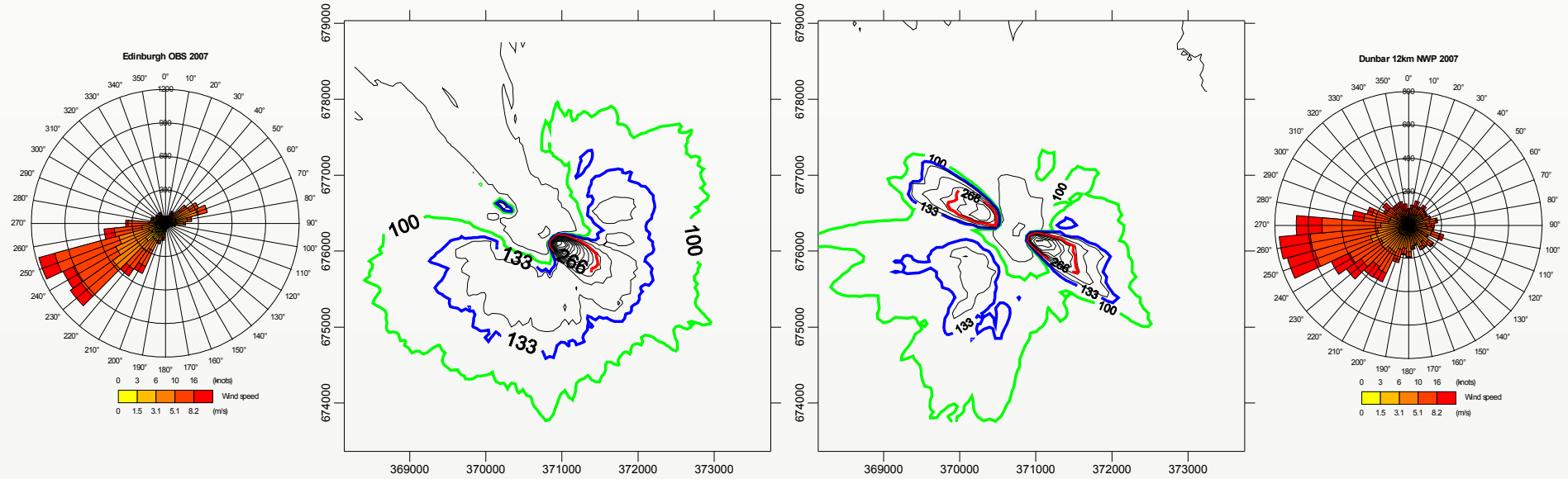
- 6 UK sites providing standard observations (OBS) data plus NWP data at 40km (REG) and NWP at 12km (MES)
  - Aviemore – Scotland Cairgorm Mountains
  - Dyce – Scotland east coast
  - Abottsinch – Glasgow Scotland
  - Valley – Anglesey Wales
  - Brize Norton – central England
  - Plymount – south west England – south coast
- Focus today on Brize Norton, Glasgow and Aviemore



Windrose comparisons

- Will immediately help you to identify where differences will occur
  - Maximum impact areas – especially longer term predictions (annual and daily)
  - Consider your expsosure issues in dominant downwind directions
  - Significant differences in wind speeds
- Use your windrose when considering where buildings may come into play in terms of building downwash
  - The effects due to different wind directions (and speeds) can be significant where buildings are included
  - Likely to be important to provide patterns of predictions with and without buildings for OBS and NWP data for any regulatory modelling so the difference is demonstrated
  - The differences are likely to be greater than the comparisons you might be used for the same met station but different years

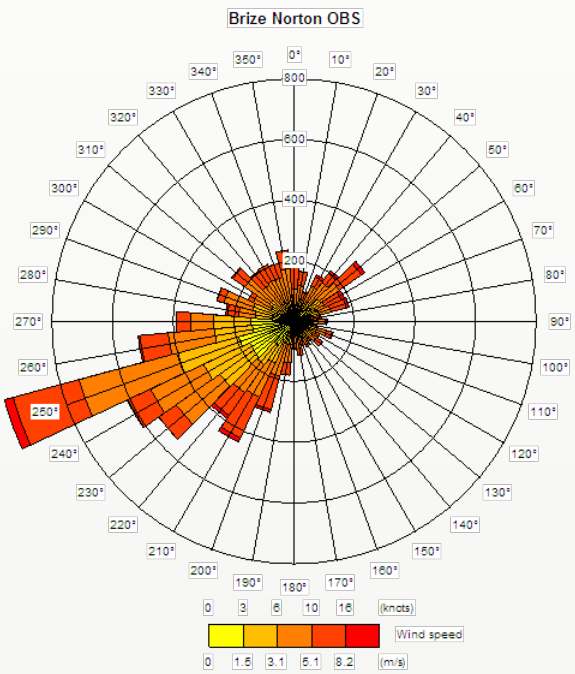
Windrose comparisons

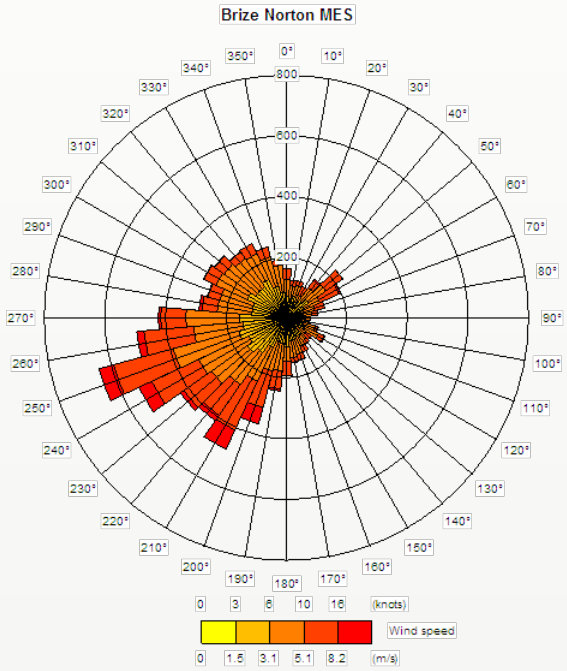


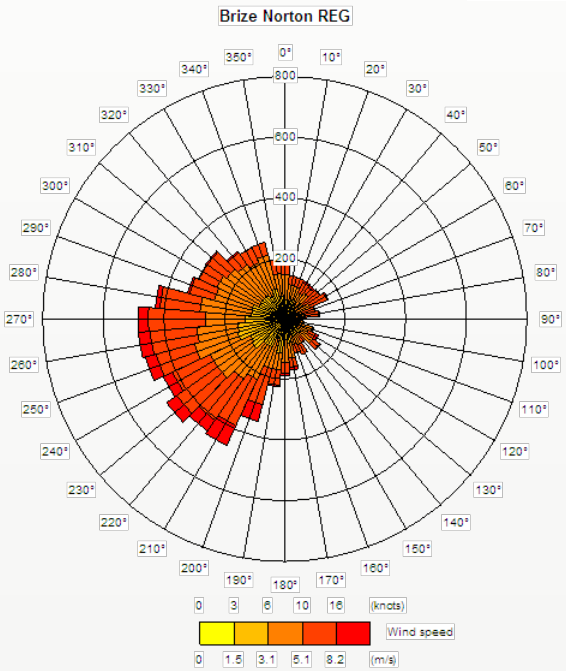
OBS Data | **NWP Data**

- An example from another study Bureau Veritas have carried on behalf of a client using NWP data.
- Not a comparison of OBS and NWP from the same site – is OBS from the nearest station about 50km from site and site specific NWP data
- In this case – observations of plume diary supports NWP data
- Note that the windrose don't look hugely different – need to look in more detail (BLD etc)

Brize Norton - windrose

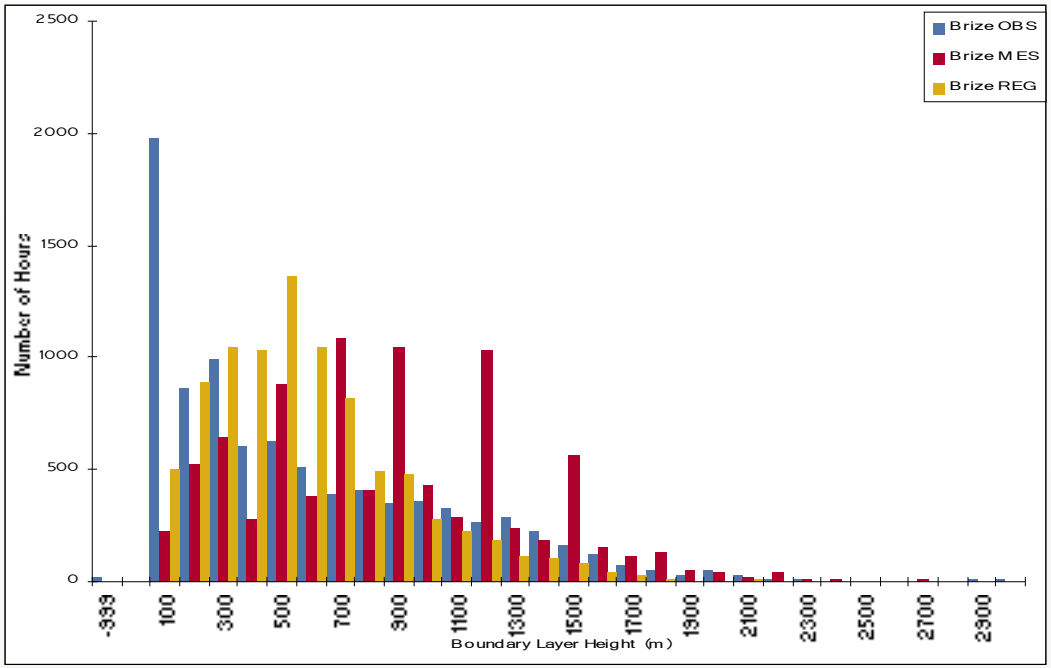






- Generally lower wind speeds represented by NWP MES and REG data
- MES tends to provide better estimate of “local” wind directions – REG seems more smoothed so higher speeds generally not included
- Neither MES or REG will provide the more extreme wind speeds measured locally

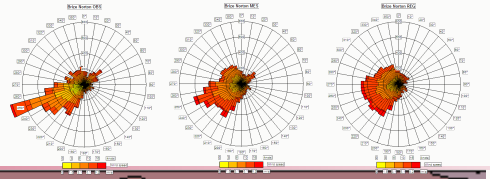
Brize Norton – boundary layer heights



- OBS provides much greater tendancy for low boundary layer heights ~ 100m
  - May have implications for predicted concentrations
  - Stack height importants (tall stacks repeatedly modelled with effective stack height above boundary layer and higher plume penetration of boundary layer

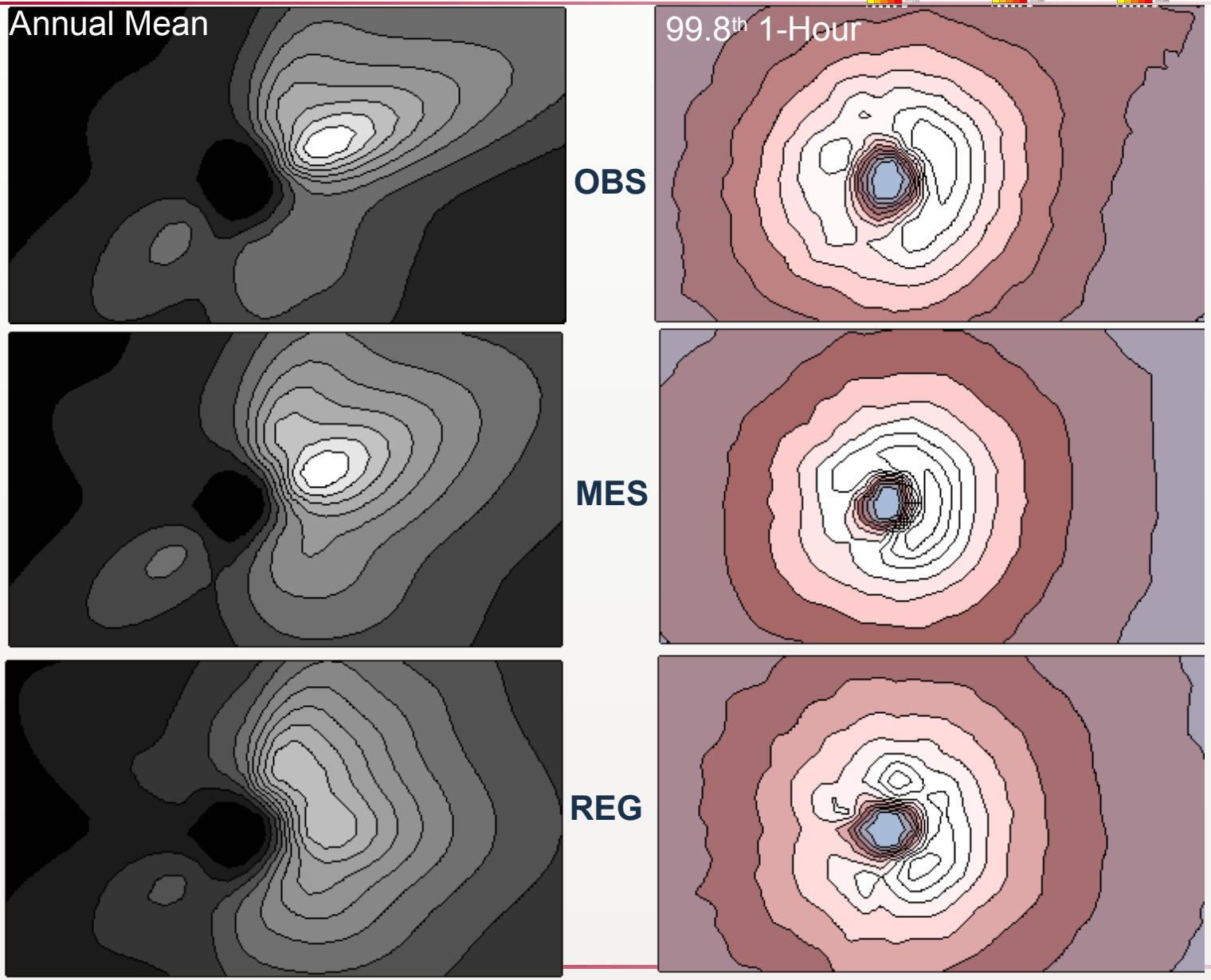
- Some skewing of boundary layer heights?
- MES data – possible stepping in boundary layer height estimation (esp at 1100m and 1500m)
- REG data – generally more compact shape with tendancy towards lower boundary layer heights (300 – 700m dominates)
- We'll see later if these patterns are seen in other comparisons

Brize Norton – predicted patterns



Annual Mean

99.8th 1-Hour



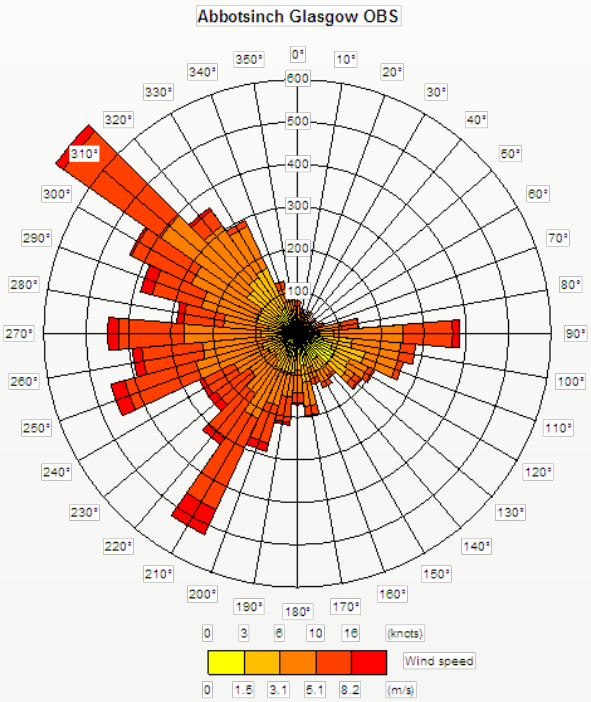
OBS

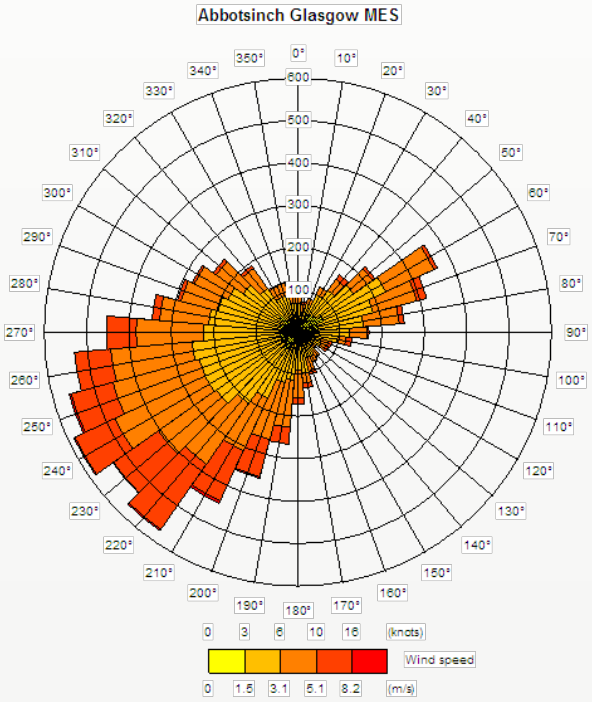
MES

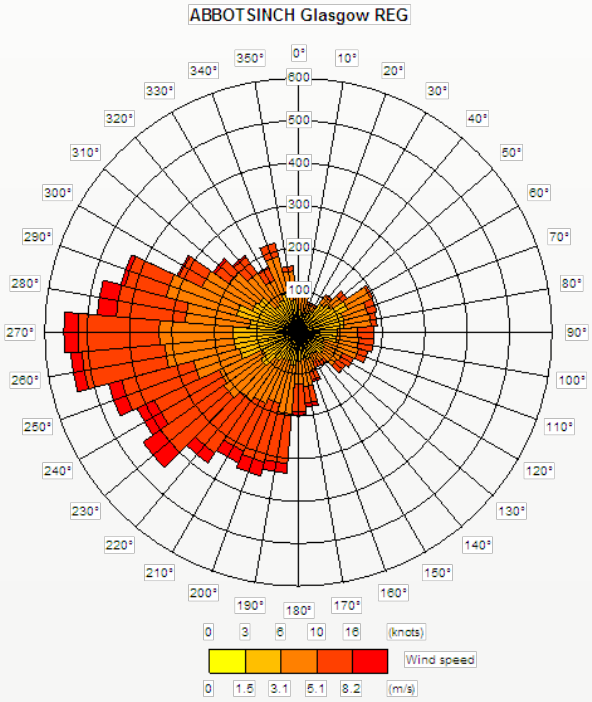
REG

- Scales similar all datasets
- Similar patterns for annual but impact area widens
- Highest hourly predictions vary
- Buildings will be very important and must be included in the sensitivity testing

Glasgow - windrose

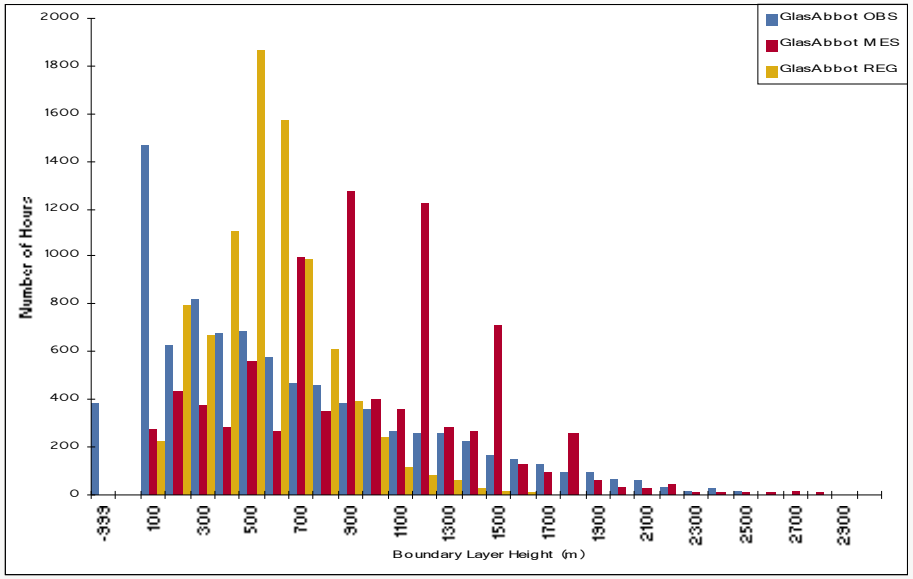






- Signifcant differences between windroses for all three datasets – including between MES and REG
- Windspeeds not too dissimilar overall, but highest speeds not represented in NWP. More so in the MES data – but not in the same directions
- Differences in the north west sector between OBS and NWP warrant investigation

Glasgow – boundary layer heights



- Similar tendency for OBS providing much higher occurrence of low boundary layer heights ~ 100m (as seen for Brize Norton

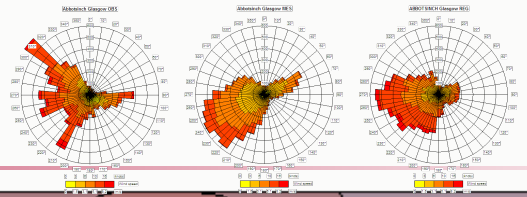
•Similar skewing of boundary layer heights?

•MES data – possible stepping in boundary layer height estimation (esp at 1100m and 1500m) – continuity of parameterisation of UM??

•REG data – generally more compact shape with tendancy towards lower boundary layer heights (300 – 700m dominates) – as for Brize Norton

•MES data represents the spread of upper boundary layers better than REG

Glasgow – predicted patterns



Annual Mean

99.8th 1-Hour

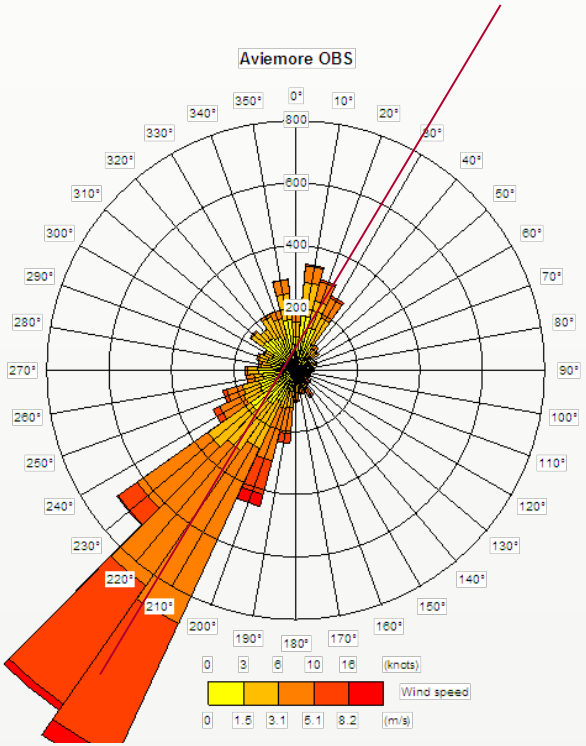
OBS

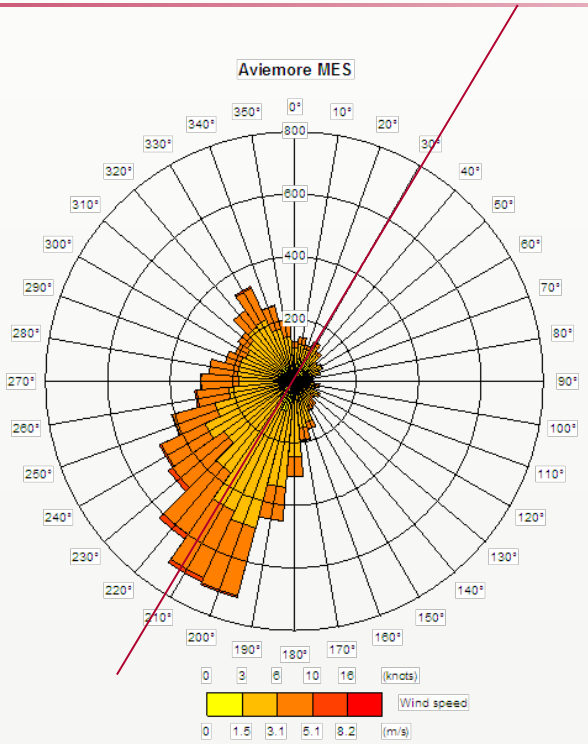
MES

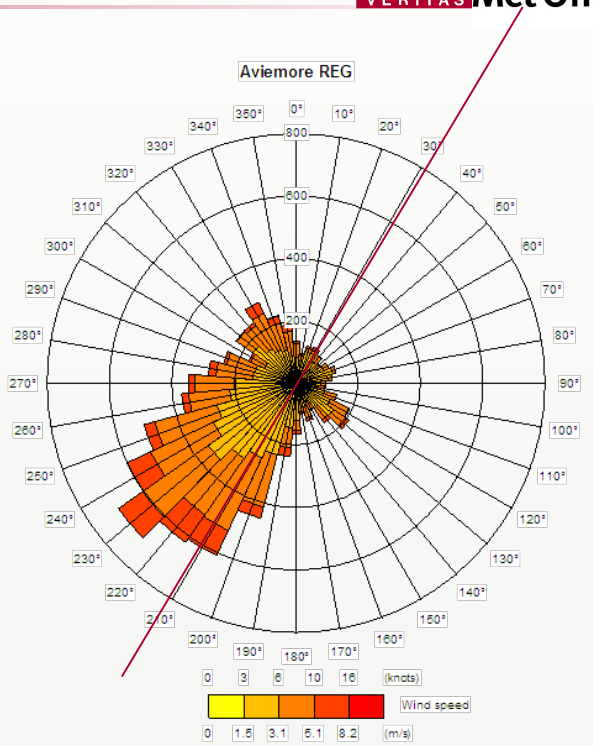
REG

- Scales similar all datasets
- Significant difference for annual means and hourly patterns
- Building sensitivity especially southwest area

Aviemore - windrose

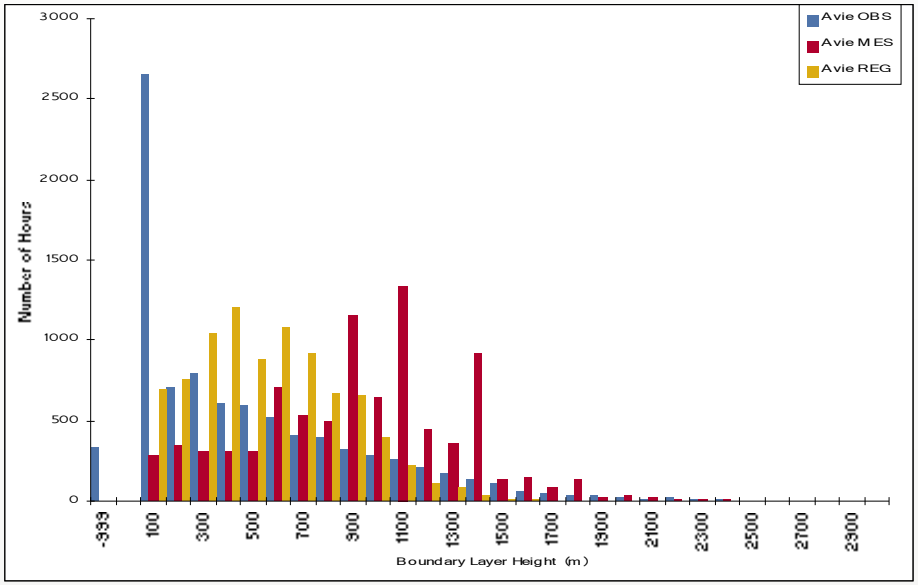






- Effect of the valley clearly seen in OBS data, dominant SSW in both MES and OBS. Shift in REG data. MES and REG have NNW component, REG additional SE component.
- Windspeeds vary across all three datasets
- Much higher speeds in OBS not represented in REG > we should expect this

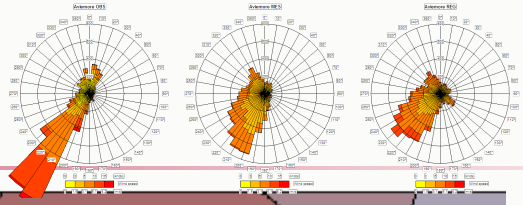
Aviemore – boundary layer heights

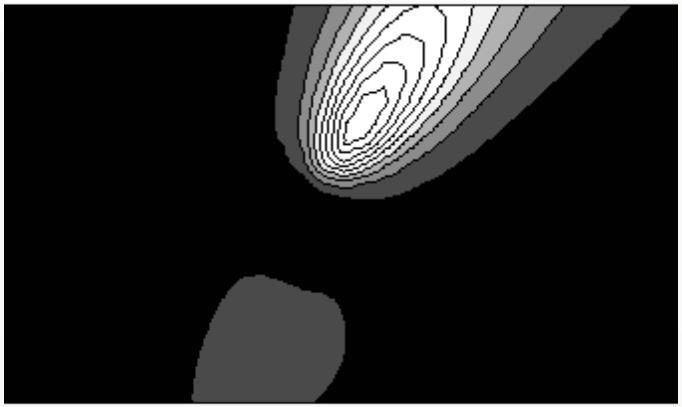


- Similar tendency for OBS providing much higher occurrence of low boundary layer heights ~ 100m (as seen for Brize Norton and Glasgow

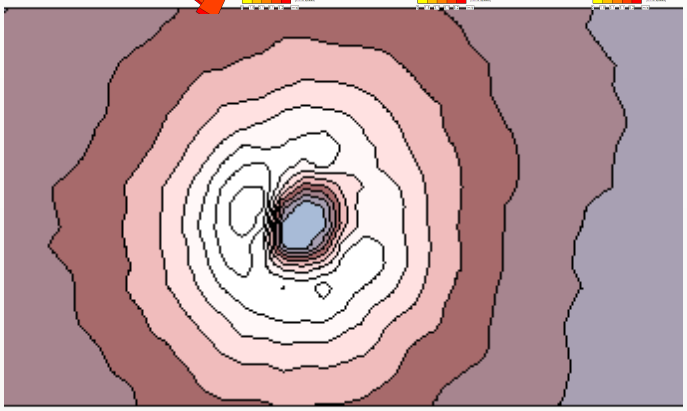
- Similar skewing of boundary layer heights?
- Stepping of boundary layer heights seems dominant in MES dataset??
- REG data – generally more compact shape with tendancy towards lower boundary layer heights (300 – 700m dominates) – as for Brize Norton and Glasgow
- MES data represents the spread of upper boundary layers better than REG

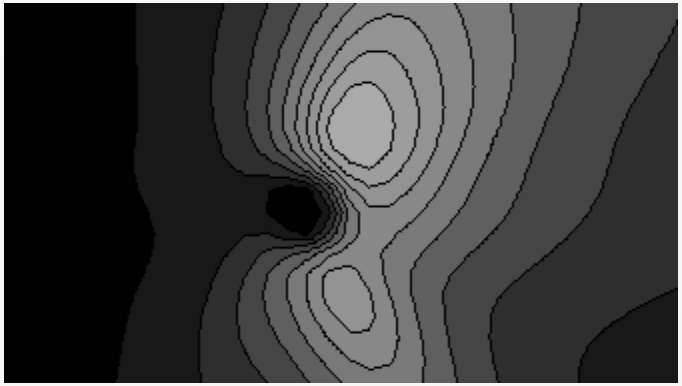
Aviemore – predicted patterns



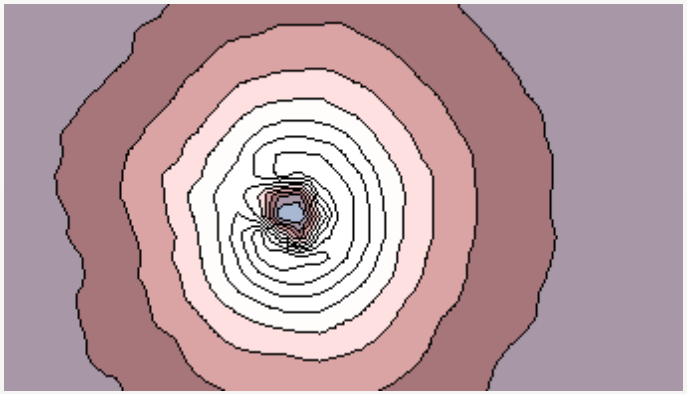


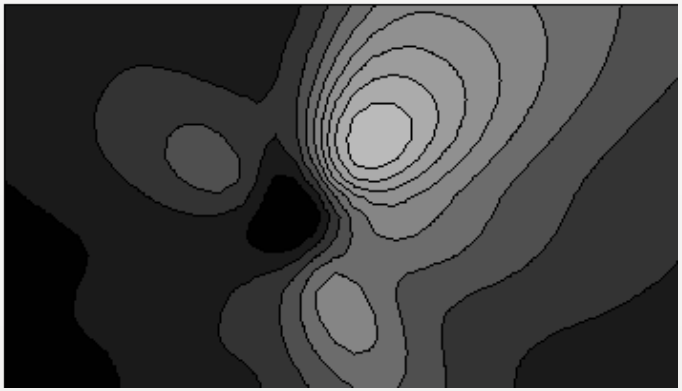
OBS



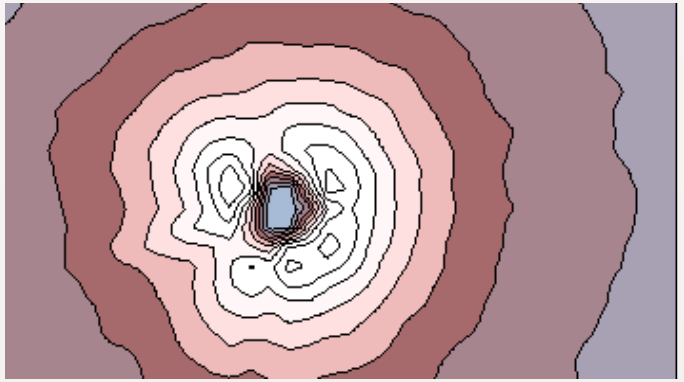


MES





REG



- Scales and Patterns different
- Much higher annual means with OBS
- Hourly patterns different – higher concentrations OBS and REG
- Building sensitivity will result in very different patterns

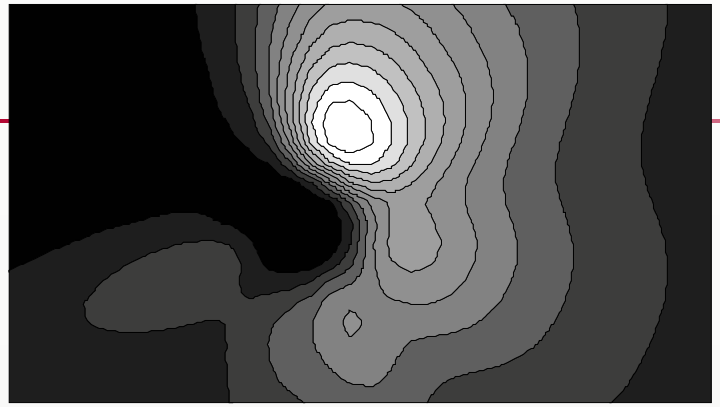
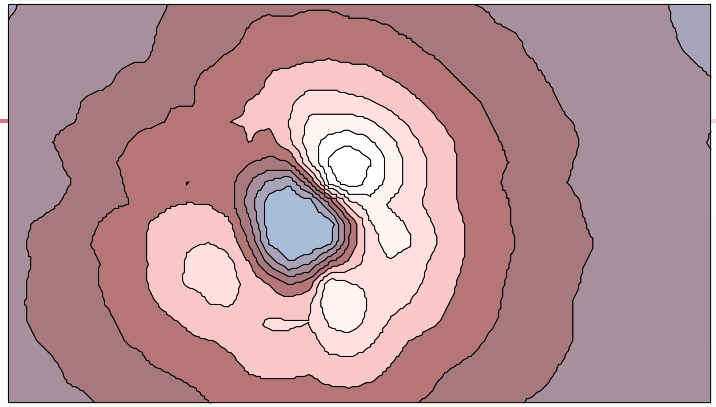
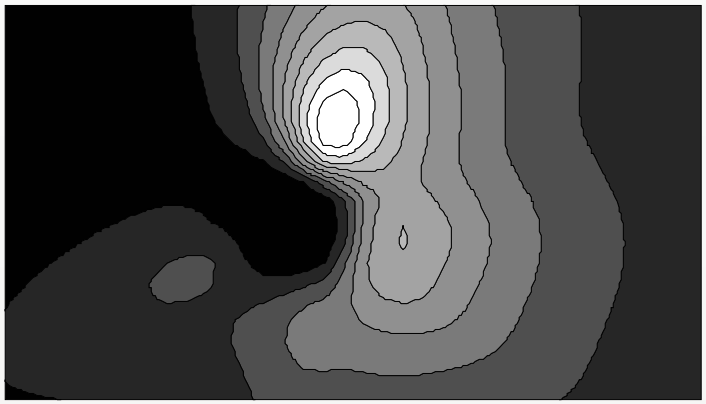
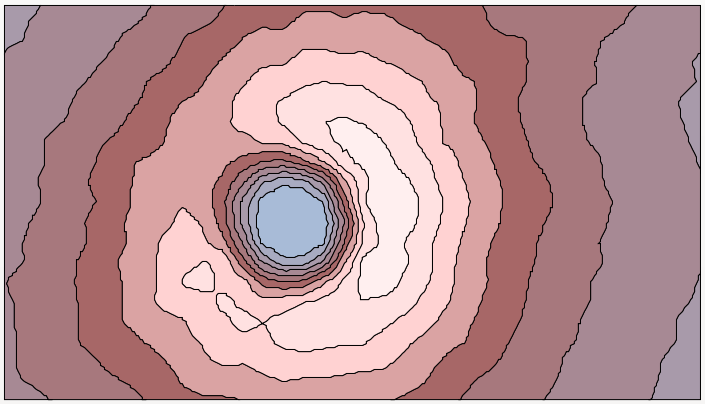
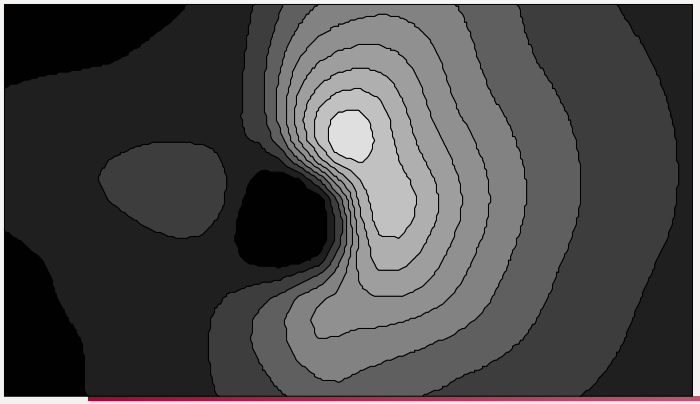
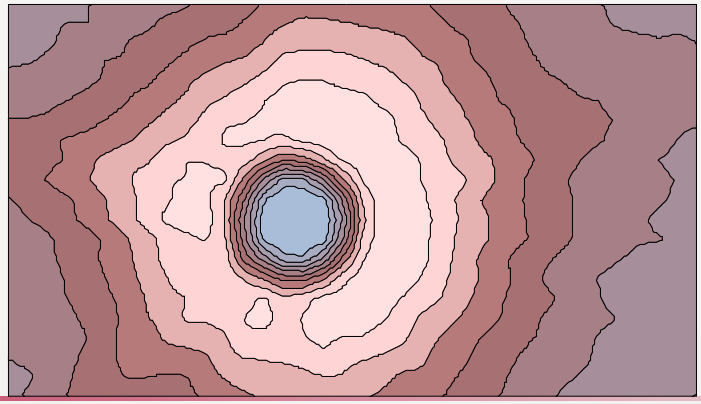
Initial Outcomes and Questions

- Predicted patterns of concentrations will vary, but scales of predictions are similar
- Building sensitivity will be essential when using NWP data
- Which site is best to use??
  - Some large differences have been highlighted and we don't yet understand if these are related to positioning of the OBS stations
  - Do you want local effects from OBS stations to be modelled for sites not in that location? (eg Aviemore)
  - Big differences at Glasgow – we need to do further work to understand why – differences not expected given location. Any potential Airport influence??
  - Frequency of low boundary layer heights presented in OBS data needs further consideration
    - Are there any boundary layer height measurements available?
  - If the OBS station is too far away, or suggest very strong local effects (eg. Aviemore) we need to consider if its suitable for use for anything outside the immediate area. Using options for meteorological data representivity related to surface roughness/bowen/albedo – are not sufficient as local wind effects at OBS station will dominate model predictions.

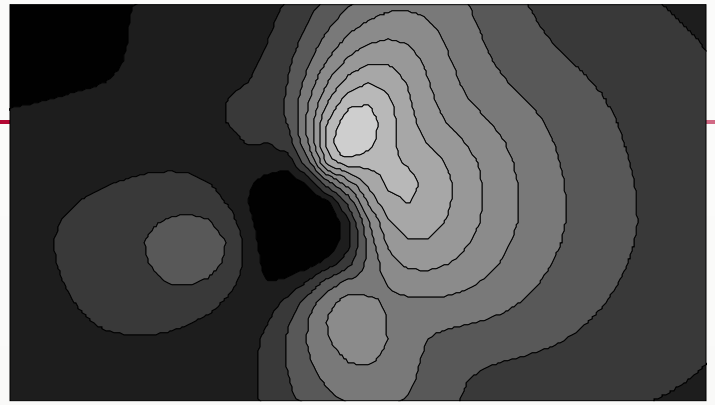
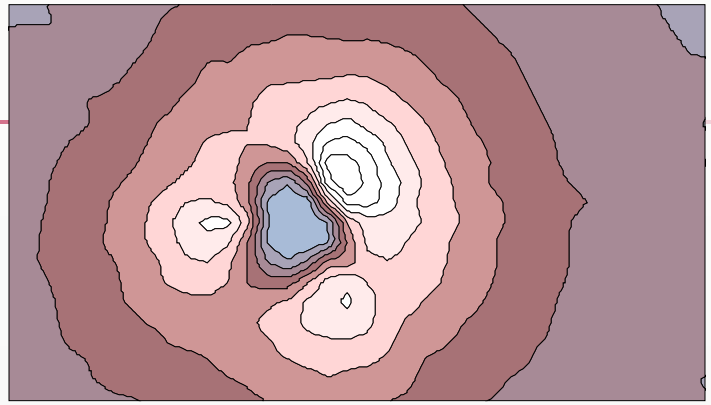
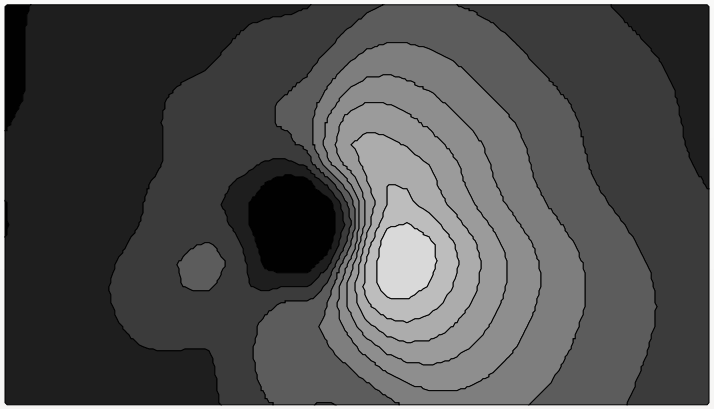
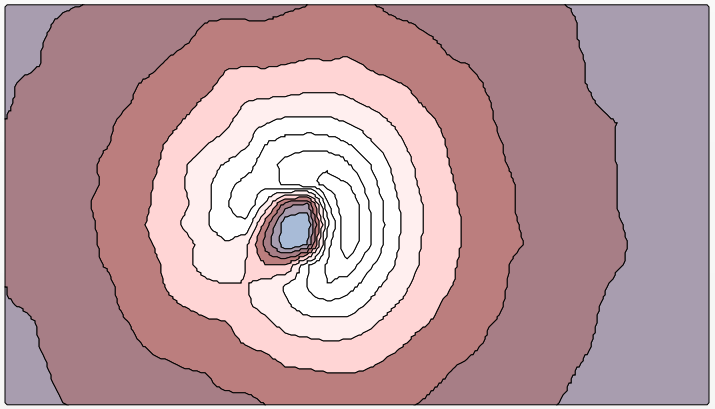
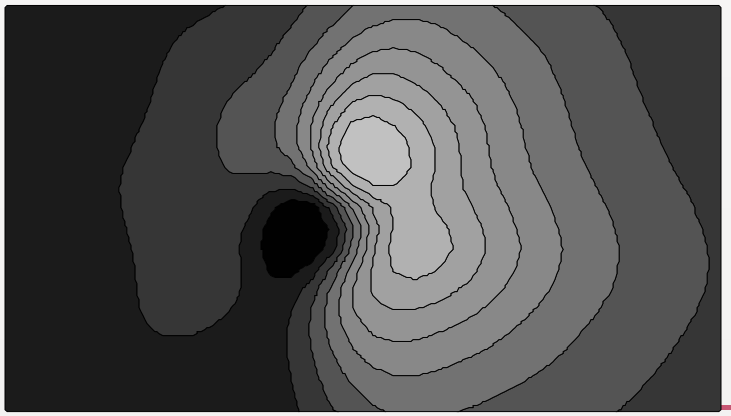
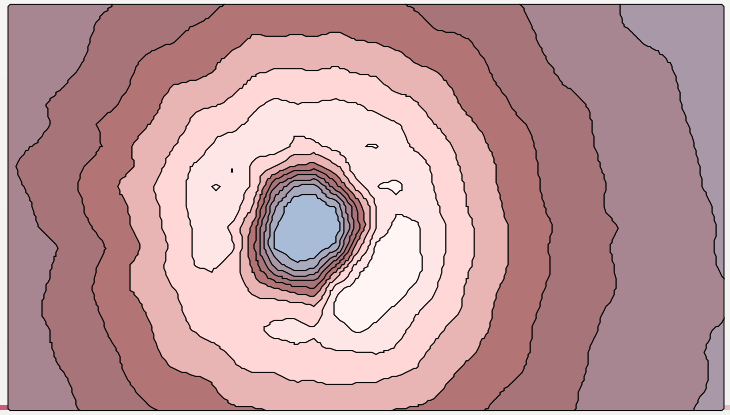
Initial Outcomes and Questions

- NWP could be an extremely useful resource but any use will need a lot of comparisons
  - Especially where regulatory modelling involved
- Improving all the time – we have looked at 40km and 12km data – now 4km data available.
- Some areas such as coastal sites may benefit from NWP data (representation of cross-shore wind patterns
- Coastal sites – difficult to model, NWP may also enhance datasets by providing sea temperatures from oceanic model
- Other benefits not investigated yet are provision of wind profiles at different heights (not just 10m winds)
- Bureau Veritas are investigating use of NWP for urban modelling such are road traffic sources as difference between datasets may be more enhanced with low level sources?

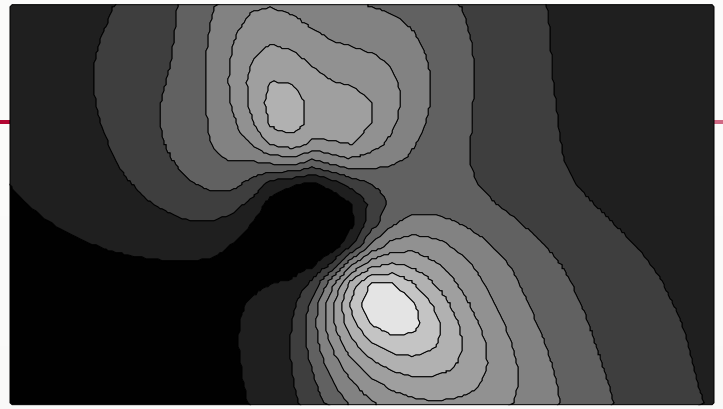
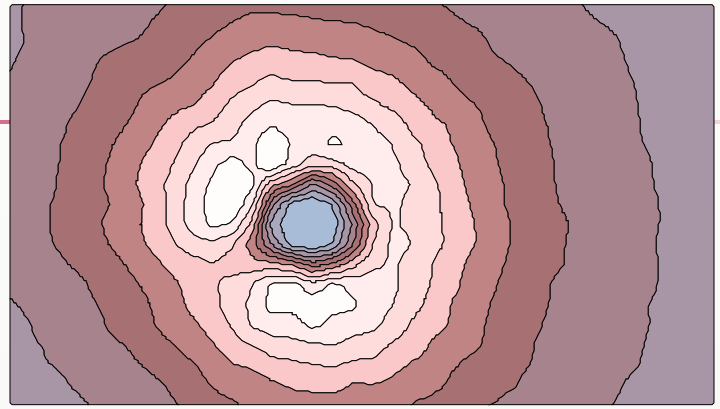
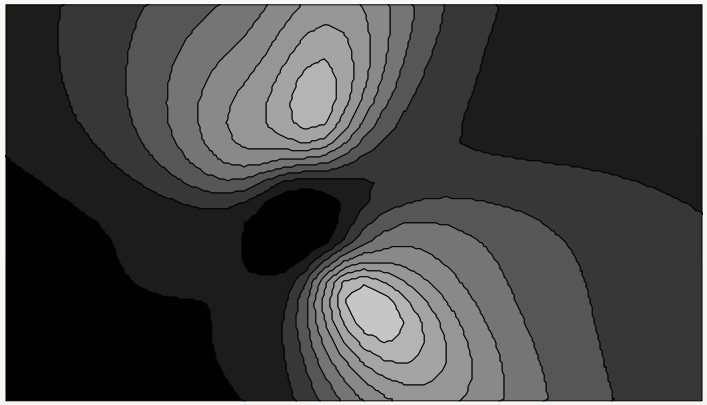
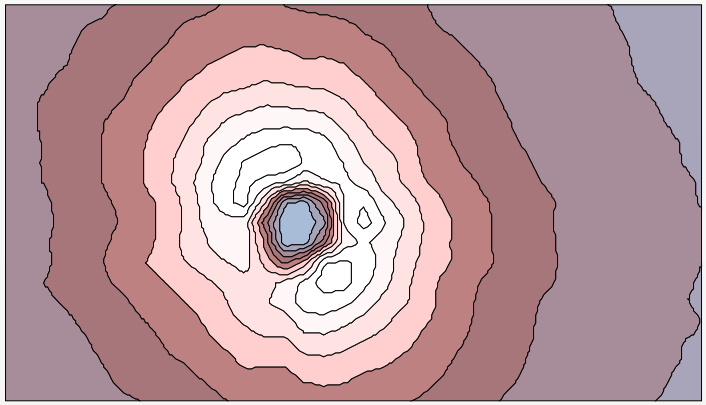
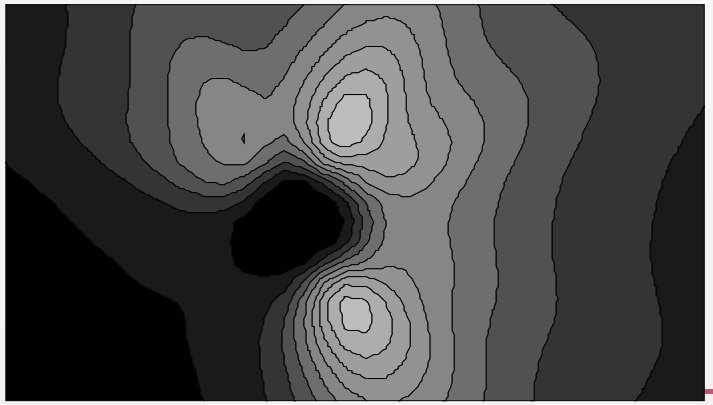
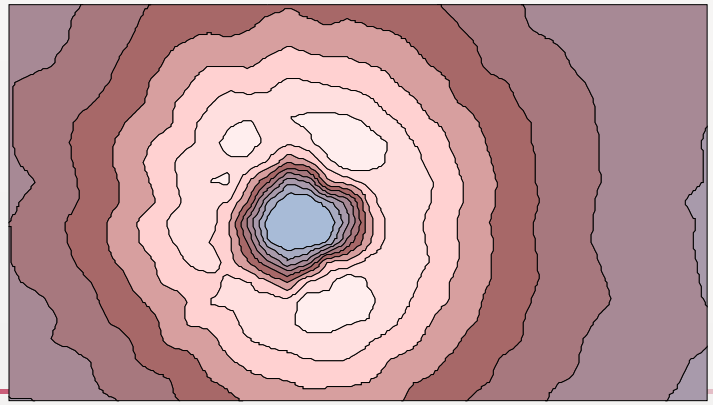
Move Forward with Confidence

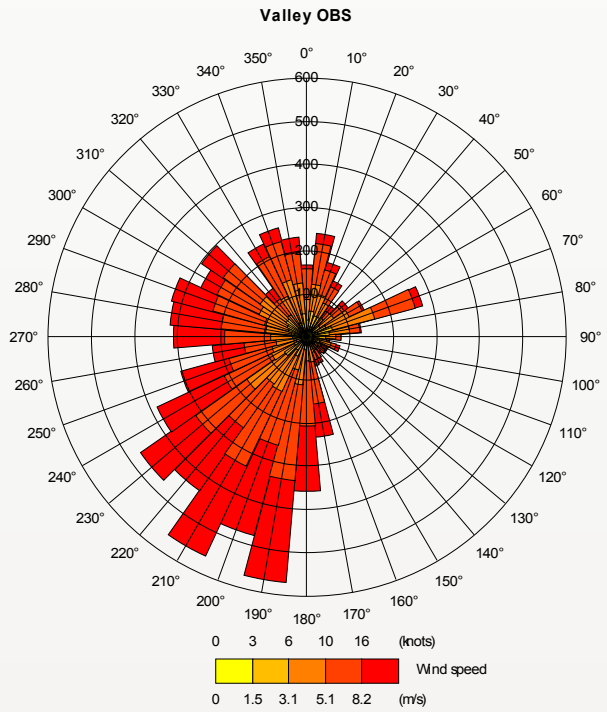
Valley

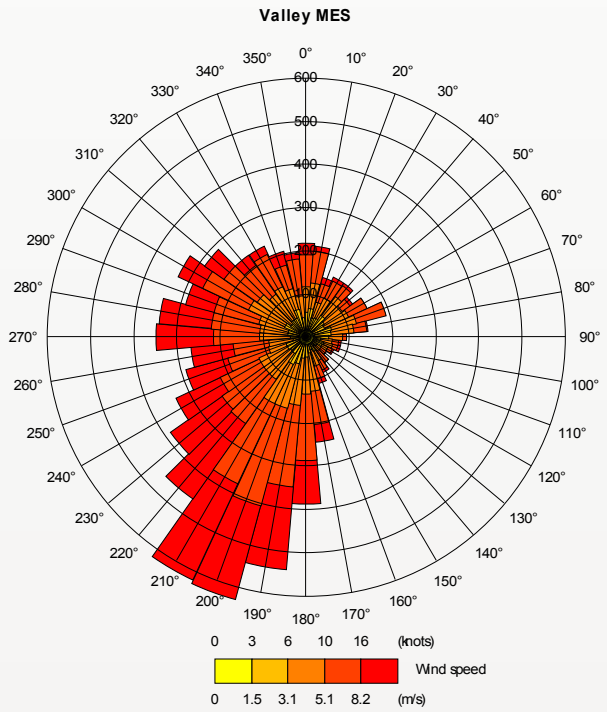







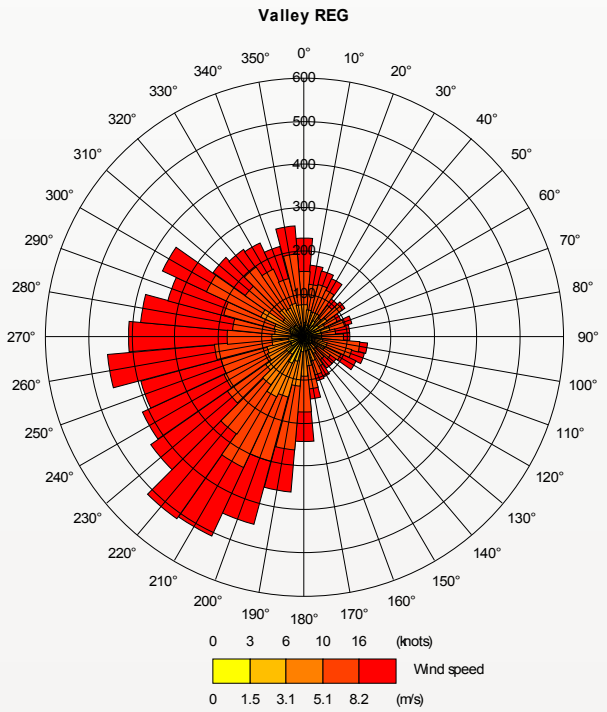
Plymouth

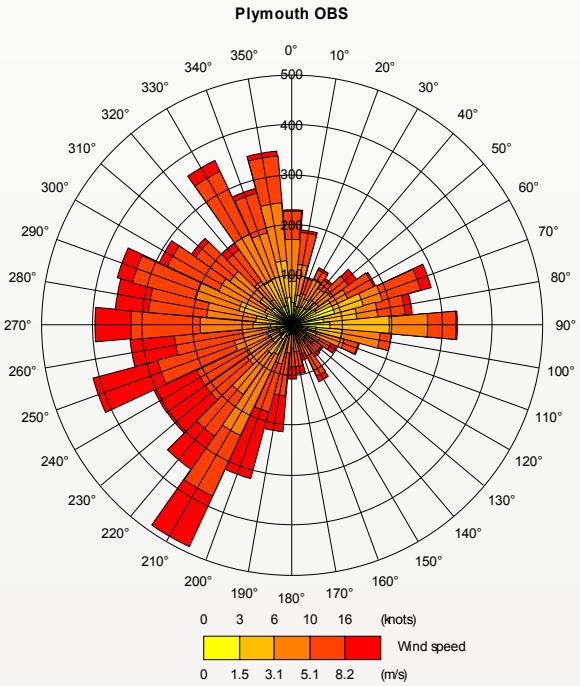







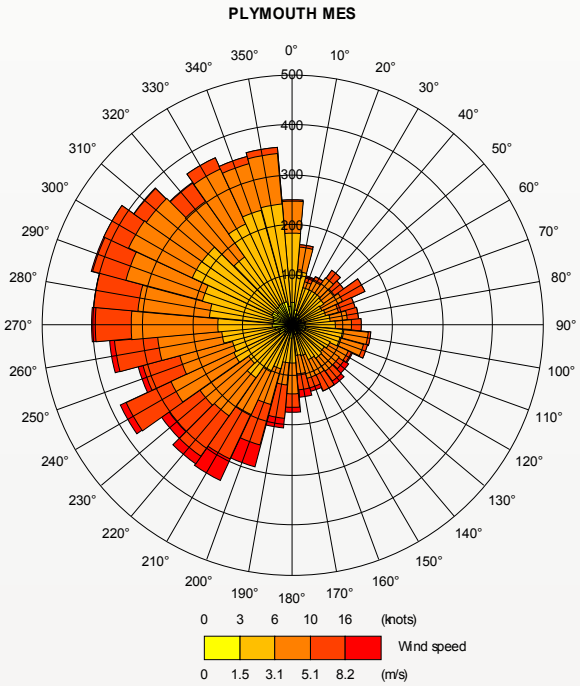
Dyce


Valley OBS
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350°
600 500 400 300 200 100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


Valley MES
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350°
600 500 400 300 200 100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


Valley REG
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350°
600 500 400 300 200 100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


Plymouth OBS
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350°
500
400
300
200
100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


PLYMOUTH MES
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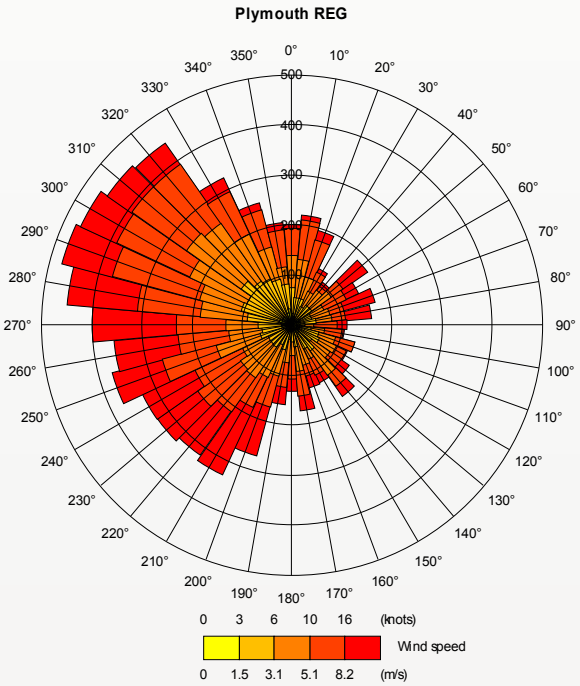
500
400
300
200
100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


Plymouth REG
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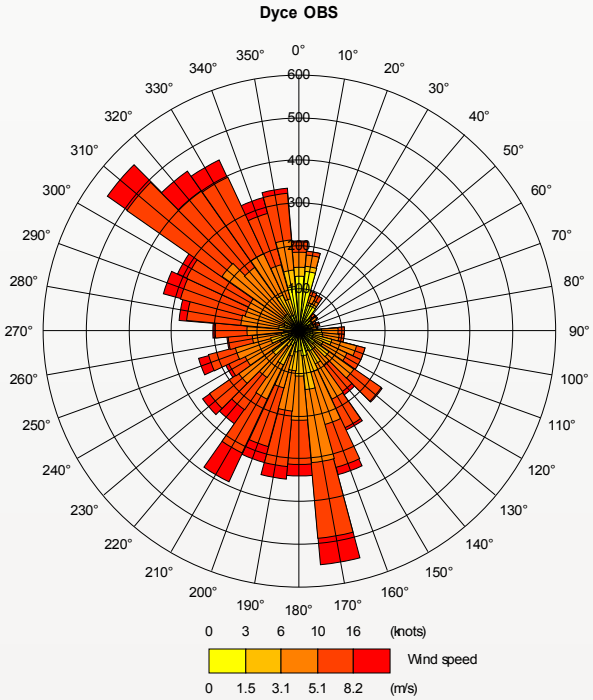
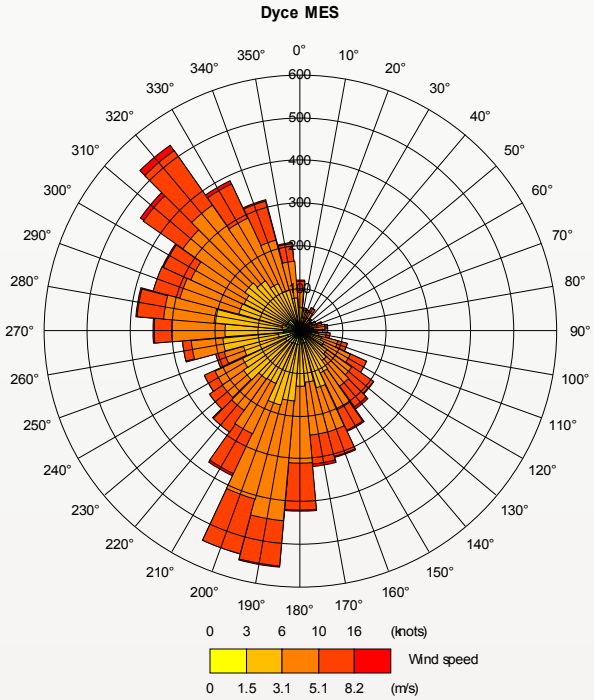
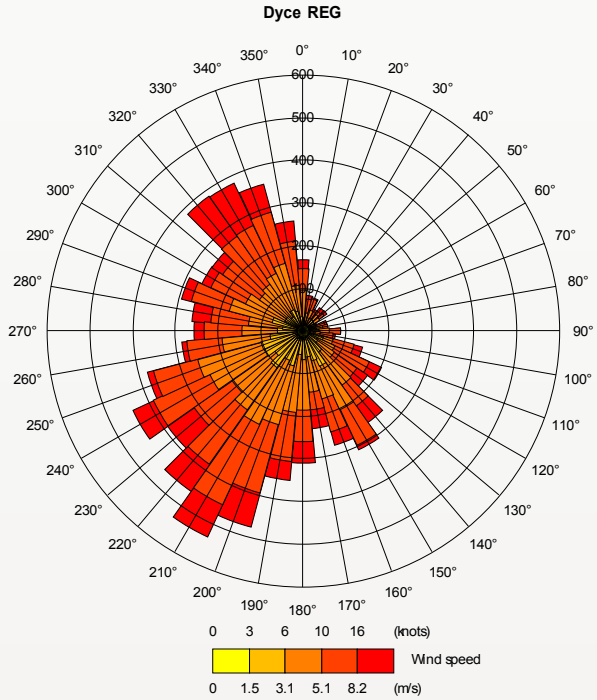
500
400
300
200
100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


Dyce OBS
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350°
600 500 400 300 200 100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


Dyce MES
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350°
600 500 400 300 200 100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)


Dyce REG
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350°
600 500 400 300 200 100
0 3 6 10 16 (knots)
Wind speed
0 1.5 3.1 5.1 8.2 (m/s)

Boundary Layer Heights