WAsP prediction errors due to site orography

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WAsP prediction errors due to site orography

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Outline

• Accumulation of orographic prediction errors
• WAsP basics in complex terrain
  • Size of map
  • Contour line interval
  • Spot height elevations
• Wind speed correlations
• Site ruggedness
  • Speed-up ratio
  • Relative relief
  • Std. dev. of elevations
  • Flow separation
  • Site ruggedness index RIX
  • Orographic performance indicator ΔRIX
Background


Accumulation of orographic prediction errors

- Application procedure
  \[ U_A + (\Delta U_2 + E_2) = U_{Pe} \]

- Analysis procedure
  \[ U_M - (\Delta U_1 + E_1) = U_A \]

- Combined procedure, eliminating \( U_A \)
  \[ (U_M - \Delta U_1 + \Delta U_2) + (E_2 - E_1) = U_{Pe} \]

- The correct estimation is then made up of
  \[ U_{Pm} = U_M - \Delta U_1 + \Delta U_2 \] (perfect prediction)
  \[ U_{Pe} = U_{Pm} + (E_2 - E_1) \] (prediction error!)
Case study in northern Portugal
Modelling errors and map size I

![Graph showing wind speed prediction error vs. map diameter for different RIX values.](image)

**Regional wind speed**
- RIX = 10% (Port09)
- RIX = 33% (Port07)

**Predicted wind speed**
- RIX = 10% (PORT09)
- RIX = 33% (PORT07)
Modelling errors and map size II
The similarity principle – revisited

The predictor and the predicted site should be as similar as possible

- Topographical setting
  - Ruggedness index (RIX)
  - Elevation and exposure
  - Distance to significant roughness changes (coastline)
  - Background roughness lengths
- Climatic conditions
  - Same regional wind climate (synoptic and meso-scale)
  - General forcing effects
  - Atmospheric stability

This means that the basic input data should also be similar

- WAsP map
  - Map size
  - Contour interval
  - Accuracy and detail
  - Roughness classification
  - …
Cross-correlation of wind speeds

Coastal-plain / hill site pairs

Hill / hill site pairs

Error in predicted wind speed, %

Cross-correlation of wind speed, %
Prediction error vs. speed-up ratio
Prediction error vs. relative relief difference
Prediction error vs. RMS height difference
Prediction error vs. RIX difference

Wind-speed prediction error %

Orographic performance indicator

-40 -30 -20 -10 0 10 20 30

-40 -30 -20 -10 -20 -30 40

-30 -20 -10 10 20 30 40

-40 -30 -20 -10 -20 -30 40
The Ruggedness Index – revisited

• Reanalyses of the Portuguese data set
  • Larger, more detailed and accurate maps
  • Improved RIX calculation (WAsP or ME)
  • More calculation radii: 72 rather than 12
  • RIX configuration corresponds to BZ-model

• Data analysis and presentation
  • Asymmetry in plot of speed error vs. ΔRIX
  • speed error was defined as \( (U_p/U_m - 1) \)
  • not obvious which trend line(s) to fit…
  • Substitute \( \log(U_p/U_m) \) for \( (U_p/U_m - 1) \)
  • Easier to fit a trend line…?
Maps for RIX calculation and test

- Hand-digitised map
  - 8 by 8 km²
  - 50-10-m contours

- SRTM-derived map
  - 20 km radius
  - 50-, 10- and 5-m contours
Wind speed error vs. $\Delta$RIX (new maps etc.)
\[ \log\left(\frac{U_p}{U_m}\right) \text{ vs. } \Delta RIX \]

\[ y = 1.508x \]
\[ R^2 = 0.975 \]

\[ U_p = U_m \exp(\alpha \Delta RIX) \]
where \( \alpha = 1.5 \)
\[ R = 3500 \text{ m and } \theta_c = 0.3 \]
Things to test…

- Wind speed prediction error is (almost) fixed…
  - Number of sectors
  - Modelling parameters
- RIX configuration can be varied easily
  - Original configuration somewhat arbitrary
  - Different calculation radii (3, 3.5, 4, and 5 km)
  - Calculation radius that provides max. RIX?
  - Different critical slopes (0.30, 0.35, 0.40, 0.45)
  - Matrix of $R^2$ for different set-up’s
- Weighting RIX with wind rose frequencies
Influence of RIX radius and critical slope

<table>
<thead>
<tr>
<th>Radius $R$ [m]</th>
<th>Critical slope $\theta_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>3000</td>
<td>0.960</td>
</tr>
<tr>
<td>3500</td>
<td>0.972</td>
</tr>
<tr>
<td>4000</td>
<td>0.971</td>
</tr>
<tr>
<td>5000</td>
<td>0.969</td>
</tr>
</tbody>
</table>

$R^2$ for different values of the calculation radius and critical slope.
Recalculation – best fit values

\[ y = 2.406x \]
\[ R^2 = 0.984 \]

\[ U_p = U_m \exp(\alpha \Delta RIX) \]
where \( \alpha = 2.4 \)

\( R = 3500 \text{ m} \) and \( \theta_c = 0.4 \)
Recalculation – weighted with wind rose

\[
\ln(\frac{U_p}{U_m}) = y = 2.370x
\]

\[
R^2 = 0.977
\]

\[
U_p = U_m \exp(\alpha \Delta RIX)
\]

where \( \alpha = 2.4 \)

\( R = 3500 \) m and \( \theta_c = 0.4 \)

Weighted with wind rose
Conclusions

- The similarity principle
  - WAsP inputs (maps) should also be similar, of course
- Performance indicator $\Delta$RIX
  - Concept reinforced using new and better data
- Relation between wind speed error and $\Delta$RIX
  - Linear relation between $\log(U_p/U_m)$ and $\Delta$RIX
  - Relation not very sensitive to calculation radius $R$
  - Relation not very sensitive to the critical slope $\theta_c$
  - $\Delta$RIX weighted with the wind rose does not improve the relation between $\log(U_p/U_m)$ and $\Delta$RIX