

# FLOWSTAR

## A Model of Airflow over Complex Terrain

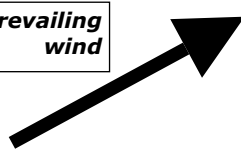


### FLOWSTAR applications include...

- Assessment of sites for wind farms.
- Assessment of sites for other constructions in hilly terrain, for example telephone masts and bridges.
- Calculation of the location of possible forest damage in upland regions during periods of high winds.
- Input into air dispersion models such as ADMS 4.

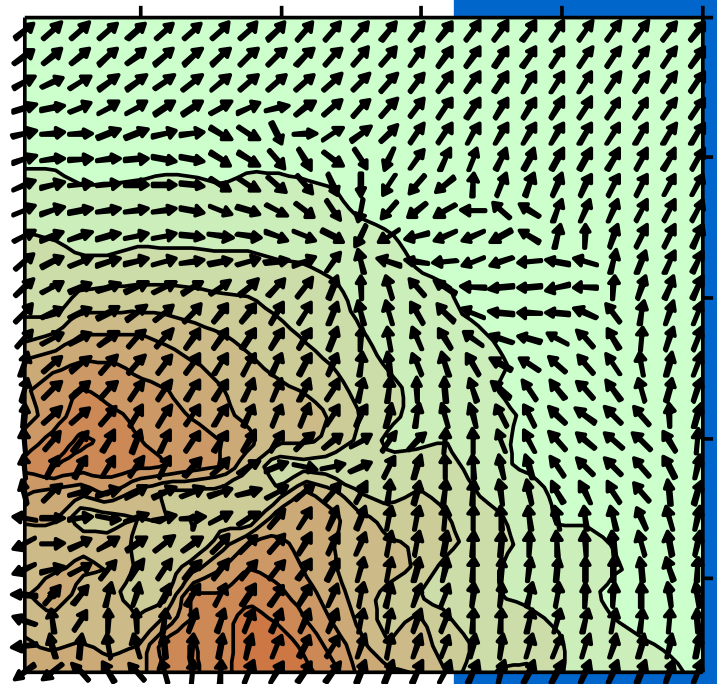
*Example flow field plot created from FLOWSTAR output*

*Prevailing wind*



*Increased flow speed over hilltops*

*Reverse flow region in lee of hill*



*Chanelling through the valley*

### FLOWSTAR...

- Predicts the changes in local meteorological conditions due to surface characteristics.
- Is able to calculate annual mean flow field values, in addition to shorter time scale flow fields.
- Agrees well with observed data for slopes as great as 1 in 3; it also gives useful predictions for even steeper slopes.
- Has an easy-to-use interface, and runs on a standard PC with a Windows operating system.
- Includes a link to the Surfer graphics package.

**CERC**  
**Environmental**  
**Software**

# Technical Specification

## The FLOWSTAR Approach

The FLOWSTAR model is based on the theoretical work of Jackson and Hunt<sup>1</sup>, and Hunt *et al.*<sup>2,3</sup>. The model is based on the premise that different processes dominate the flow dynamics in layers at different heights above the ground; thus in the inner layer shear stress perturbations are locally important and are described by a mixing length closure, whilst the flow is also impacted upon by pressure gradients. These can be determined from the outer layer flow where stratification plays an important role but where shear stress perturbations have little influence. There is a transitional or middle layer between the inner and outer

<sup>1</sup> P.S. Jackson and J.C.R. Hunt, 1975; Turbulent wind flow over a low hill. *Quart. J. R. Met. Soc.* **101**, 929 to 955.

<sup>2</sup> J.C.R. Hunt, S Leibovich and J.L. Lumley, 1981: Prediction method for the dispersal of atmospheric pollutant in complex terrain. Technical Report P85-81-04, Flow Analysis Associates, Ithaca, NY.

<sup>3</sup> J.C.R. Hunt, S Leibovich and K.J. Richards, 1988: Turbulent shear flow over hills. *Quart. J. Roy. Meteo. Soc.*, **114**, 1435 to 1470.

## Input requirements

- Digital terrain data (XYZ format)
- Utility included to convert from standard OS NTF and French IGN data
- Standard hourly sequential or statistical meteorological data in 'ADMS' format, available from UK Met Office

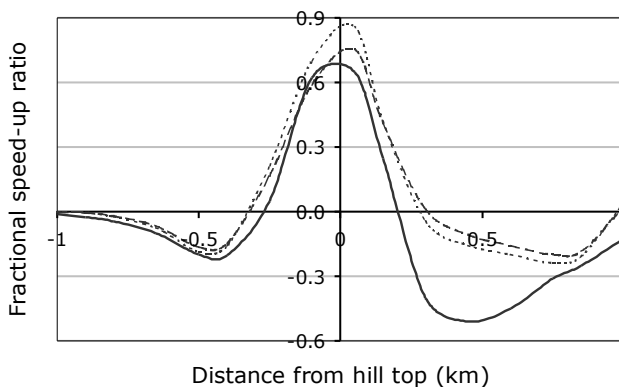
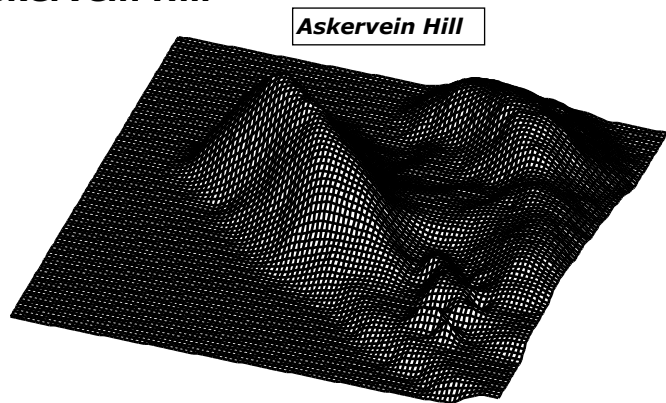
## Output

- Wind speed and turbulence data at user-specified heights, either on a grid or at particular locations within the domain
- Output given for each met condition, and/or averaged over all met conditions
- Utility included to produce contour and vector plots of gridded data in Surfer

## Case study: Flow field around Askervein Hill

Askervein Hill is a hill on the west coast of the island of South Uist in the Outer Hebrides of Scotland. During September and October of 1983 an experiment was conducted on and around the hill, with measurements made of the speed-up over the hill under neutral atmospheric stability conditions.

Askervein is a relatively isolated hill. The summit of the hill is at a height of 116m above sea level. The terrain is covered mostly with heather, grass, low scrub and flat rocks, plus some small lochs (lakes). Surface roughness values of 0.03m and 0.1m have been investigated.



The graph to the left shows the fractional speed-up ratio for the flow over the hill. The full line gives shows the observed data, the dashed and dotted lines give the model predictions for roughness lengths of 0.03m and 0.1m respectively.

The comparison between the modelled and observed data are good, in particular with regard to the speed up on the top of the hill. The model does not fully capture the magnitude of flow deceleration on the lee side of the hill.

## Use of FLOWSTAR

In the period following the initial development of the model, FLOWSTAR was used by clients that included the Forestry Commission, National Power plc, University of Manchester Institute of Science and Technology, BNFL plc, ICI Zeneca and British Gas plc.

## Prices

For an up-to-date price list, please visit the CERC website <http://www.cerc.co.uk/environmental-software/prices.php>

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