A Nonlinear Model for Prediction of Turbulent Flow Over Steep Terrain

Numeral model

- **Microclimate Analysis System for Complex Terrain** (MASCOT) was developed for the prediction of local wind in complex terrain

**Governing Equations**

\[
\frac{\partial u_i}{\partial x_i} = 0
\]

Finite Volume Method was used for discretization. The Reynolds averaged navier-stokes equations were solved by SIMPLE algorithm. The Residual Cutting Method was used for the linear wind in complex terrain at the sites are strongly affected

**Numerical Methods**

- Arbitrary non-orthogonal coordinate along the terrain surface was adopted.

**Verification**

To verify the performance of the non-linear model, numerical simulation was carried out for the flow over a 3D hill and the predicted mean wind velocity and turbulence were compared with experimental results.

- **Mean wind speed**

  • Predicted wind speed by MASCOT shows good agreement with the experimental results.

- **Turbulent kinetic energy**

  • MASCOT is also be able to predict the turbulent kinetic energy with high accuracy.

**Application to Tappi Wind Park**

Tappi Wind Park consists of ten wind turbines, all of which are installed on complex terrain.

- The wind speeds and directions at the sites are strongly affected by steep terrain.

**Prediction of Annual mean wind speed**

Annual mean wind speed for all the turbines are simulated by WAsP and MASCOT using the wind data observed at the lighthouse as a reference value.

- The prediction by MASCOT shows good agreement with the measurement while WAsP overestimates the annual mean wind speed at the turbines No.2-5.

**Conclusions**

- Mean velocity and turbulent are simulated by MASCOT show good agreement with the wind tunnel on a steep hill.
- Annual mean wind speed predicted by MASCOT agree with those measured at the turbine nacelles, while WAsP gives for some sites which are located at relatively low elevations.
- New boundary treatments of wind flow over real terrain give more accurate results than conventional ones.
- Analysis of wind flow with an area of 10km x 10km was performed by a PC within one hour.