Modeling Sri Lanka Wind

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Abstract

The wind pattern in the atmosphere is important because it is the one factor, involving the climate. Wind would change the entire natural situation in the Boundary Layer. In addition, wind can be used to generate electricity by using windmills. It is an environmental friendly, cost effective method to generate power. This model is useful to determine high wind speed regions to establish wind machines. Further more wind effects plant growth, in three significant ways: transpiration, CO_2 intake and mechanical breakage of leaves and branches.

This model is based on mass consistent. Mass-consistent model is widely used for wind profiles. The equation of mass conservation or continuity equation is used. That is,

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$$

The continuity equation is used to correct an initial field. This mass consistent model is generally formulated in three-dimensional discrete grids and does not require slopes to be much smaller.

The wind observations are first extrapolated vertically using a power law profile, that is,

$$u(z)=u_1\left(\frac{z}{z_1}\right) \quad , z < z_{sl} \quad , z_{sl} \approx 100 \approx 200m$$

The exponent was externally specified. These profiles are interpolated horizontally to generate a three component wind field defined at the grid points of a two dimensional mesh. The grid lines are useful, practical tools for estimating wind speed variation caused by small-scale topography and surface roughness changes. They can be applied to hill top or valley bottom locations or to flat terrain with roughness changing situations.

For the upper wind, the logarithmic profile is applied. It is interpolated vertically between the surface data and the wind at the top of the region. The law is

$$u = a \log(z) + b \, , \, v = c \log(z) + d$$

This permits the wind to change in both direction and its speed with height.

For regions, in which the terrain varies substantially, conformal co-ordinates, also called "Conformal" or "Sigma" can be used. In this case, the orography determines the co-ordinates of the mesh. The use of the conformal transformation (or sigma space) has several advantages; terrain surface is more accurately represented due to the characteristics of the transformation itself and also implies simple boundary conditions and makes a use of variable vertical zoning easier, allowing higher resolution near the terrain surface with out penalizing efficiency. Sigma space is defined as,

$$\xi = x, \eta = y, \sigma(x, y) = \frac{z - h(x, y)}{H(x, y) - h(x, y)}$$

Where h (x, y) = Height of the terrain above a reference level
H (x, y) = Corresponding height of the top of region

However, horizontal spacing is calculated by using Cartesian coordinates and constant grid spacing is used for both horizontal directions.

Dimensions of the region of application are typically from 10 to few hundred kilometers for horizontal extension and from 1 to 3 kilometers for vertical extension. In any case, in choosing the exact boundaries of area, There should be no terrain features outside the region. Therefore horizontal spacing varies from 50 meter to 72 kilometers and the top of the region is placed between 1500 meter and 3000 meter from the lowest height of the terrain and number of conformal levels varies from 3 to 20.

Using computer language Fortran, a program has been developed to model this. In addition, outputs were obtained three level of the atmosphere. From that, wind speed can be read at each level and at each grid point.

The National Atlas of Sri Lanka gives average wind speed for the period 1931 to 1960. I have compared that with model wind speed in two main monsoons.

South West Monsoon period	Average wind (m/s)	Model wind (m/s)
Colombo	3.1	3.39
Hambantota	6.1	3.24
Puttalam	3.5	3.77
Trincomalee	4.1	3.79
Batticaloa	3.3	3.52
Nuwara Eliya	2.5	3.89
Maha Illuppallama	1.4	3.14

North East Monsoon period	Average wind (m/s)	Model wind (m/s)
Colombo	3.6	3.96
Hambantota	6.3	3.72
Puttalam	4.7	4.57
Trincomalee	5	3.91
Batticaloa	2.5	3.38
Nuwara Eliya	3.3	3.69
Maha Illuppallama	4.1	4.14

In southwest monsoon period Colombo, Puttalam, Trincomalee and Batticaloa region wind speed are almost significant values as the model wind speeds. However, Hambantota and Maha Illuppallama have highly different values. Here sea breeze and direction of the wind effect for this situation. Because of the topography of Nuwara Eliya region average wind less than model.

Northeast monsoon period-predicted wind speeds are acceptable without Hambantota, Trincomalee and Batticaloa regions. We are in believed that this change depends on the sea breeze.