Precise Program Development of 3-dimension Analysis That Can Calculate Local Weather such as Down Winds

Background

As Japan is composed of 70% mountainious area, the topography changes complexly and winds become intensely turbulent. There is concern that particularly strong wind lords affected by local topography during typhoons are exerted on transmission towers or windmills built in mountain areas. Wind calculation program (L-WIND), which assumes that density and temperature of wind are uniform and can analyze winds under complicated topography, has been developed to estimate such wind loads. It is able to precisely reproduce the wind fields taken in wind tunnel experiments by this program, but there are some differences that give slower wind velocity than observation results on site. It is thought that this is because of not considering the natural atmospheric conditions whereby pressure deteriorates and air density shrinks in the sky. In the wind calculations generaly used for the daily weather forecasts, it is necessary to largely shorten calculation time, to simplify basic equations and to smooth the topography. Development of precice analysis code for local weather behavior under the complicated topography peculiar to our country is expected.

Objectives

Considering changes of density and temperature of air, strict formulation was carried out for wind velocity, atmospheric pressure, temperature, density and turbulent states. By using highly precise methods of numerical analysis, those equations were programmed in expressions. The program calculated near-like natural conditions of wind blowing over complicated topography and the characteristics of the program were grasped.

Principal Results

1. Development of analysis program (M-WIND) for wind blowing over complicated topography

Conservation of energy, mass, momentums and internal energy of compression/expansion was taken into account. In addition, turbulent state expressed with turbulence model introducing shear strength and buoyancy was expressed. They were converted into curved coordinates along ground surface to express the complicated topography. Using finite difference method and implicit scheme of highly advanced precision, it is coded in a program (M-WIND) to demand the numerical solution with high precision and stability.

2. Characteristics of M-WIND

Some horizontal flow circulations (Fig.1) and rise, down winds (Fig.2) occurred around a mountain of a single peak in 3-dimensional calculations by M-WIND. By interaction with a density effect to push back a flow that may run up a upwind slope of the mountain, a rise wind also occurred at the front of the mountain. It was able to reproduce periodical outbreaks of strong flow circulations, fast rise wind and straight down wind blowing down the slope of the mountain (Fig.2).

In the calculations (Fig.3) by L-WIND that did not consider changes of temperature and density, the wind velocity at ground level of point ③ was late compared with observations, and the wind velocity at point ② showed a tendency to approach observation values (Fig.4).

On the other hand, in the calculations by M-WIND that considered actual atmospheric conditions, the wind velocity in a hollow downward ridge showed a tendency to agree with observation values, so it was confirmed that the down wind blowing down a ridge was expressed well (Fig.4) by M-WIND.

Future Developments

Relation between strong wind loads acting on transmission towers and topography conditions will be estimated by using M-WIND. In addition, it will be applied to the estimation of wind velocity for wind-power facilities. Furthermore, to elucidate local weather phenomenon such as outbreaks of heavy rain, it is planned to estimate the effects of different vegetation and wet, dry conditions on the ground surface by newly adding cloud/rain model to M-WIND.

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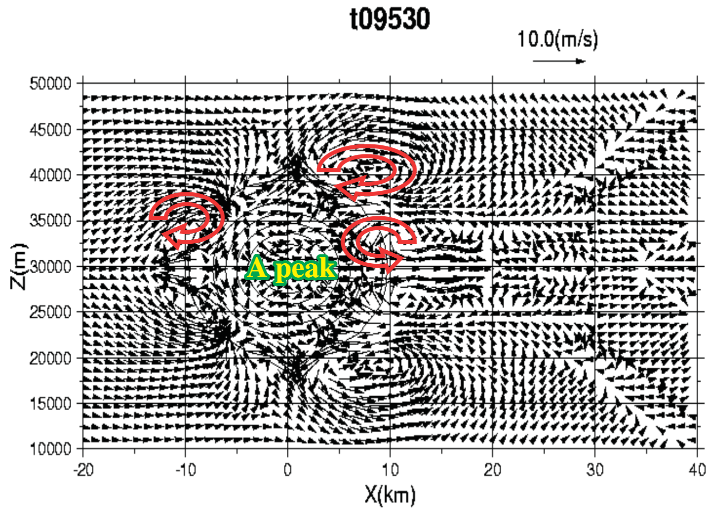
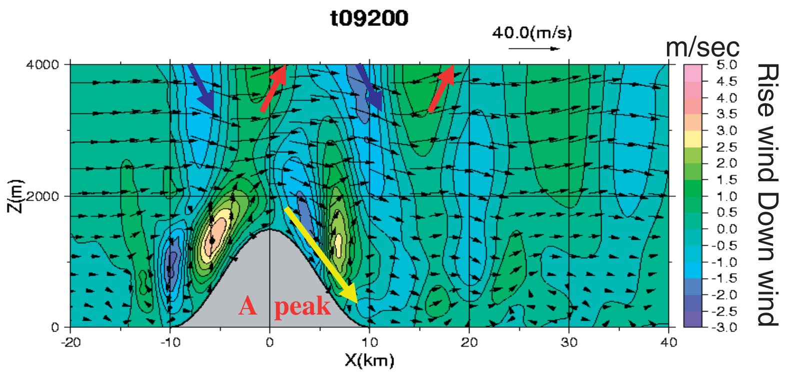
Reference

Nobukazu Tanaka, et al, 2004, “Development of Meteorological Wind Simulation Code considering both Local Geometries and Atmospheric Density-Dry Air Version-”, CRIEPI Report, N04001



Three pairs of horizontal flow circulations occur around a single peak of 1,500m with radius of 10km (A point of X = 0 and Z = 30km shows a concentric center).
Those flow circulations are related to rise and down winds shown in figure-2, which change periodically. Convergence of wind occurs downward 30km from a peak. At the left edge of figure-1, there is an inflow with wind velocity distribution of 25m/second at 3,000m high.

Fig.1 Wind velocity vector at 50m height around a single peak circumference judging from figure 1 air space



Wind blown over a peak of figure-1 produces rise wind by reflection from a slope, and downward wind down the peak. At the front of the peak, wind running up the slope is pushed back by the density effect, and it does not go over the peak, and it is spread in horizontal flow circulation. It is repeated by about 2,000 seconds.

Fig.2 Wind velocity vector and vertical wind velocity contour

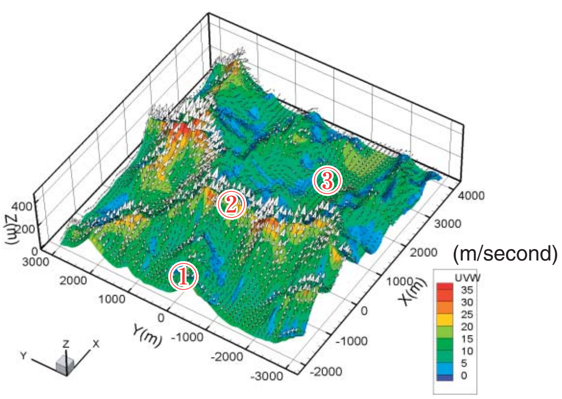


Fig.3 Topography of mountain level, observation points and distributions of the wind velocity calculated by M-WIND

1: flatness place, 2: ridge top, 3: hollow
color: an absolute value of the wind velocity
arrow: a wind velocity vector along the ground

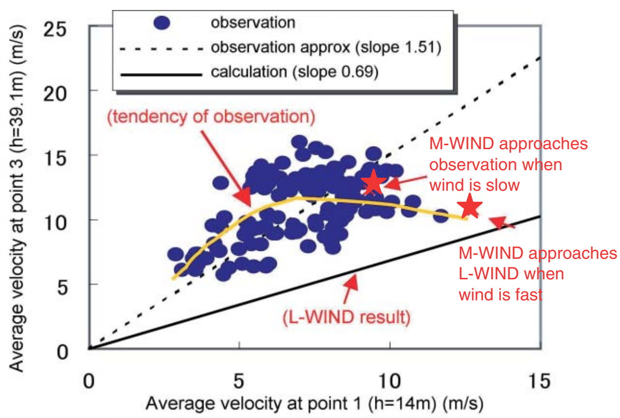


Fig.4 Actual observed values and comparisons of calculated results
(h: height of a point to observe)

★: M-WIND
Solid line: result of constant temperature and density (L-WIND)