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日射に対する地形の効果の解像度依存性
The resolution dependency of the topographic effect on solar radiation flux on a complex topography

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Introduction

The solar radiation flux is the fundamental energy source for carbon, heat and water cycle. The topographic condition affects the radiation amount over complex topography by its shadow and inclination. The in-situ observation in the mountainous area often suffers from such topographic effects. On the other hand, the scale of the meteorological consideration still stays more than km scale or just one point observation. The resolution does not seem to be enough for mountainous area. Here, the solar radiation flux on the surface of mountainous area was studied, where we have many studies relating to ”Japanese Alps Inter-University Cooperative Project”.

Data and method

The global solar radiation was estimated for 360x160 points with 100m distance in 36 km x 16 km area including Mt. Norikura in central mountainous area in Japan. The altitude ranges from 600 m to 3000 m. The Takayama field station of Gifu University is located at 1342 m. The hourly global solar radiation flux, temperature and pressure data there in 2010 were used to estimate the solar radiation flux in the area. Digital Map 50 m Grid (Elevation) by Geospatial information authority of Japan was also used. The elevation data are averaged in 100 m, 200 m, 500 m, 1000 m, 2000 m and 5000 m to know resolution dependency. The skylines from each target point were calculated using elevation data in the area of 70 km distance for 50 m grid and about 200 km for larger grids. The difference is due to the computational power, but almost all points in fine scale elevation data catch the skyline near area because fine elevation data resolves mountains well. The sky view factor was calculated using the skyline data, but the sky was projected onto the inclined surface. It often shows lower value than it for horizontal plain. The observed solar radiation was divided into direct and diffusive components using Spitters et. al. 1984 or Liu and Jordan 1960. The latter includes air mass consideration. The shadows of mountains are considered for the direct component flux and sky view factor of the diffusive component and the reflection from ground surface from other area are assumed to reach the target area. The total solar radiation received under horizontal unit area, that means large inclined area, was computed.

Results and discussion

The standard deviation for annual mean solar radiation flux distribution is increased from several Wm^{-2} for 5000 km grid to 30 Wm^{-2} for 50 m grid with forest albedo (0.15). The mean solar radiation is about 150 Wm^{-2}. The increasing tendency does not show saturation. The finer scale produces larger variation. The increasing is rapid for valley area under 500 m grid. The tendency is strengthen by higher albedo. The above results are for inclined surface under unit horizontal area. Heat is exchanged in inclined surface but usual observation of global radiation is done horizontally. In such a case, the standard deviation stays only about 6 Wm^{-2}. The inclination of surface is a major reason of the spacial variation. The difference between horizontal and inclined surface can be a reason of the imbalance of heat budget analysis over slope and it is necessary to be counted in observational data analysis.

The comparison between the observed global radiation of Takayama evergreen coniferous site (TKC) at 800m and the estimated one for horizontal plain shows 10% mean bias error for fine days, but the difference become much larger for cloudy days. Sometimes TKC observation shows larger value than Takayama station in spite of altitude difference due to local weather condition. The facts indicate the limitation of the approach here. Finally, the estimated results with snow albedo in winter and with forest albedo in other seasons are produced hourly with 50m grid elevation data for 2010 in the area. It may be useful for the solar radiation data in the area.

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