Estimation about Snow in Japan under the Global Climate Change

Satoshi INOUE, National Institute of Agro-Environmental Sciences, Japan

Abstract Global climate change may affect significantly on the winter climate of Japan,especially on snow. I estimated the several aspects of snow in Japan, i.e. the snowfall, the maximum snow depth and the condition of snowcover. I used some global climate change scenarios (10 km size mesh data) derived from the numerical experiments of general circulation models by Meteorological Research Institute, Geophysical Fluid Dynamics Laboratory, etc., as the input data. The estimation procedure is: 1. estimate the monthly snowfall by an empirical model using the monthly average temperature and the monthly precipitation as the input data. 2. estimate the maximum snow depth and the condition of snowcover from the monthly mean temperature and the estimated snowfall statistically. 3. Estimate the condition of snowcover from the monthly mean temperature of January. The estimated results from the MRI scenario varied according to the geographic location as follows. 1. In Hokkaido and at the high elevations of Honshu Island, no significant change was resulted, but the maximum snow depth decreased. 2. In Tohoku district (north-eastern part of Honshu Island) except for the high elevations, the snowfall and the maximum snow depth decreased considerably. The snowcover condition changed from dry to wet. 3. At the low elevations of the Japan Sea side of Honshu Island south of Hokuriku district, no snowfall occurred and no snowcover was consequent. 4. Those change became clear after 50 years from now.

1. INTRODUCTION

Snowfall and snowcover have much influence on its covered area, for example, agriculture, water resources, ecological system, and life style of residents. It is very important to estimate the snowfall and snowcover under the global climate change.

The global warming may cause high air activity, and then it may affect on increase of precipitation and snowfall. On the other hand, the high temperature leads to decrease snowfall and snowcover. Only little knowledge have been obtained concerning about snow in Japan under the global climate change.

In this paper, I would like to make clear the several aspects of snow in the future in Japan under the global climate change.

2. MATERIALS AND METHODS

2.1 Data

I used a global climate change scenario MRI-CGCM (Meteorological Research Institute) under gradual increasing in atmospheric CO2 concentration 1%/year. The scenario had been interpolited to 10km grid size (Yokozawa and Toritani,1997).

The outline of the scenario was as follows:

1. The surface air temperature increase in the high latitudes in the northern hemisphere is not dominant up to the year 50. And the mean temperature of Japan in January after 100 years from now increases 4.4C, and the most increased point is 6.1C high from now.
2. The fluctuation of precipitation is about 10% in winter, and no trend of increasing or decreasing is expected.

2.2 Estimation algorithm for snowfall depth

The estimation algorithm for snowfall depth was as follows:

a). Separate of snow water equivalent from precipitation data using the empirical relation between monthly mean temperature and precipitation form. A simple relation was found from the meteorological data. If the monthly mean temperature was lower than 0.5C, all case of precipitation were snow. If the monthly mean temperature was higher than 4.5C, all case of precipitation were rain. For the intermediate case, the ratio between snow and rain probabilities was proportional to the monthly temperature.b). Review the snow water equivalent by catch ratio as 0.8 of rain gage. The catch ratio of Japanese official rain gages were measured in Hokuriku national agricultural experiment station (Ohno et al.; 1998).

c). Convert the snow water equivalent into snow depth by the density of 0.1g/cm3.

2.3 Maximum snow depth

The maximum snow depth was estimated from the monthly mean temperature and the estimated snowfall statistically. I used the relation between the condition of snowcover and the monthly mean temperature in January (Ishizaka; 1995), All snowcovered grid points were classified into three conditions of snow (wet,middle,dry), and the maximum snow depth was estimated using the regression line in each condition.

2.4 Snow condition

I estimated the condition of snowcover from the monthly mean temperature in January using the Ishizaka's method(Ishizaka, 1995). The wet snow area was determined by the temperature higher than 0.3C. The dry snow area was determined by lower than -1.1C. And the middle snow area, which meaned sometime dry and sometime wet, was determined between the wet and dry border.

3. RESULTS

The snowfall depth was estimated using the meteorological data obtained from the 154 stations from 1991 to 1995. The estimation error was 27.0cm, which was reasonable compared with the observed depths. The observed maximum depth was 413cm, and the mean data was 50.1cm. The estimated maximum snow depths were verified by the 3164 points grid data. The standard error was under 31.8cm. The result was reasonable compared with the variation of years.

Figure 1 shows the change in the snowfall depth in winter now and after 100 years from now in Japan. The heavy snowfall area, which located nothern part of Honshu Island of Japan, decreased except for the high elevations.

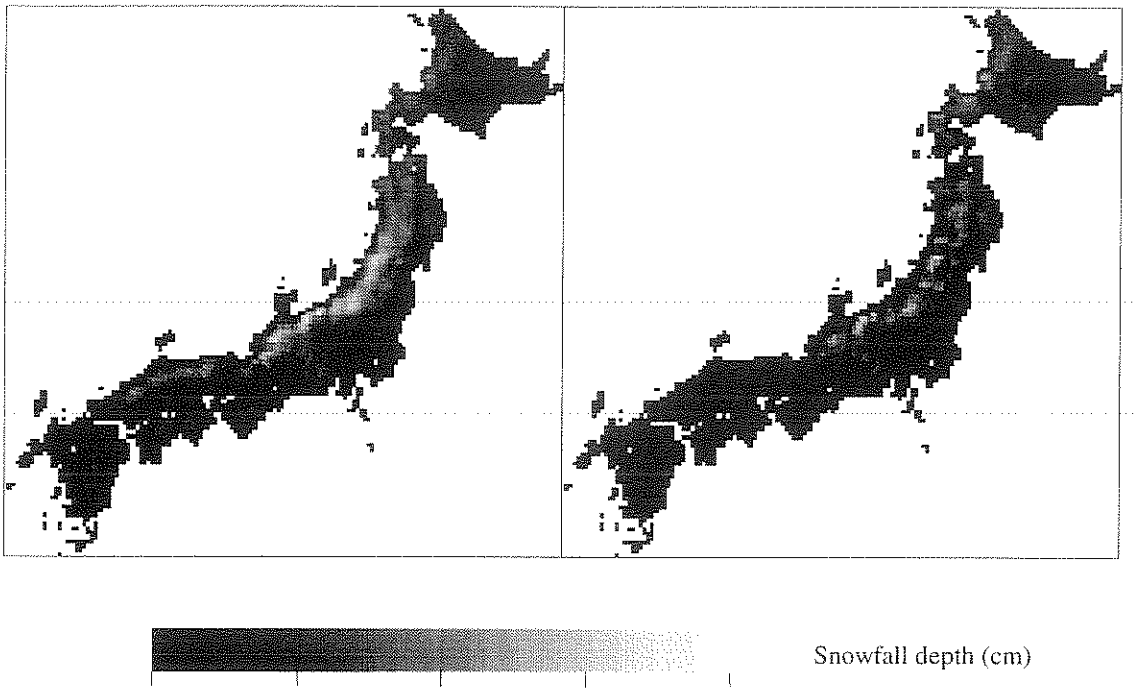

Figure 1. The change in snowfall depth in winter
(left: now, right: after 100 years from now)

The fluctuation of precipitation, total amount of snow and rain was about 10% in winter, and no trend of increasing or decreasing was expected. Hense the decrease of snowfall means the ratio of snow in precipitation decrease except for the high elevations and Hokkaido Island in Figure 2.

Figure 3 shows the maximum snow depth in winter now and after 100 years from now in Japan. Some places might have 100cm or more of maximum snow depth, but the maximum snow depth decreased the whole Japan. Especially, in the southern part of Hokuriku district, that faces to the Sea of Japan, no snowcover was consequent.

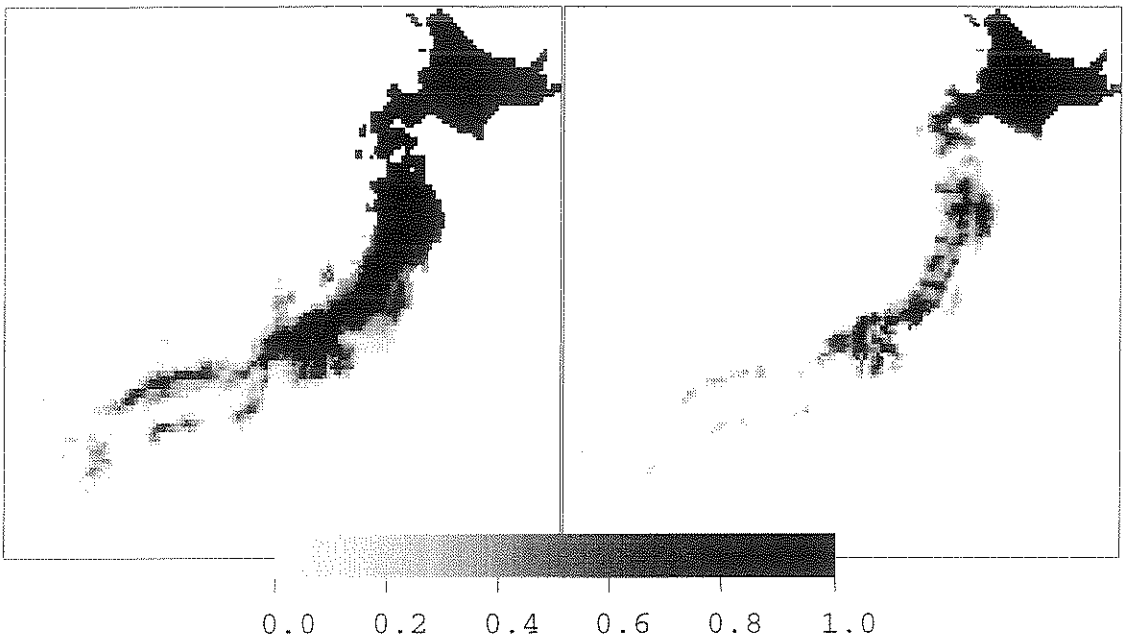

Figure 2. The ratio of snow water equivalent in winter.
(left: now, right: after 100 years from now)

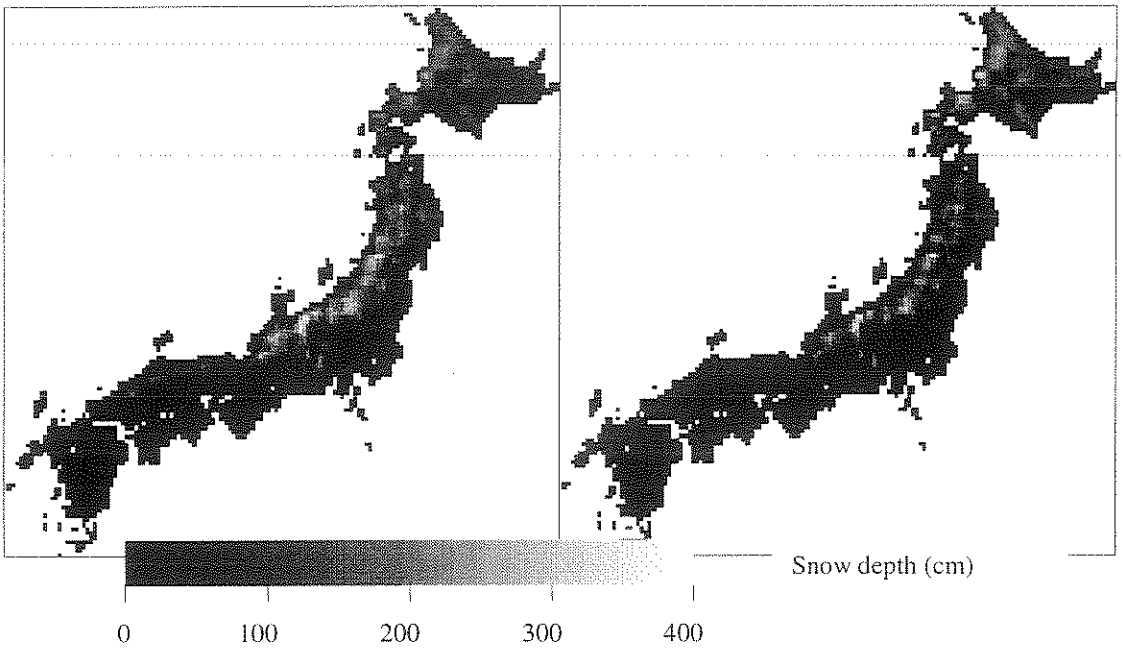

Figure 3. The maximum snow depth in winter.
(left: now, right: after 100 years from now)

Figure 4 shows the snow condition and the area without snow in winter now and after 100 years from now in Japan. The area without snow spreaded in wide extent. The dry snow area deceased especially in the nothern part of Tohoku district.

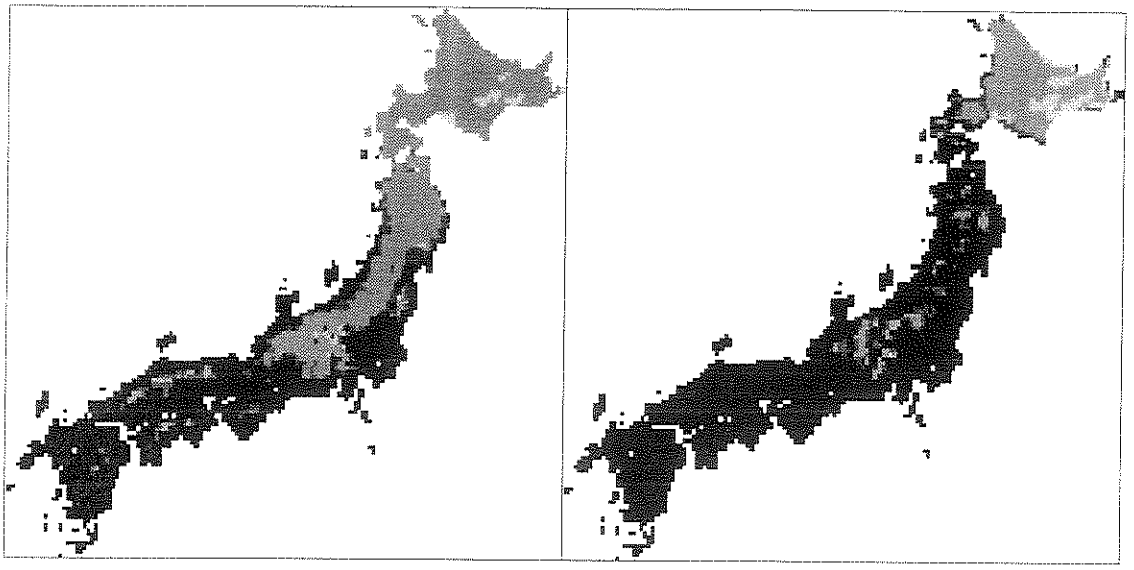

Figure 4. The snow condition now in winter.
(left: now, right: after 100 years from now)

4. DISCUSSION

The estimated results varied according to the geographic location as follows:

1) Hokkaido and high elevation area in Honshu Island: No significant change is expected, but the maximum snow depth is expected to decrease. Because this area is very cold and have sufficient degree below freezing in winter now, a few degree's rise may have little influence on snowfall conditions.

2)Tohoku district (north-eastern part of Honshu Island) except for the high elevations: the snowfall and the maximum snow depth are expected to decrease considerably. The snowcover condition may change from dry to wet. Because there are a few degree below freezing in winter now, a few degree rising may affect on snow conditions extremely.

3)Low elevation area in the southern part of Hokuriku district faced the Sea of Japan: No snowfall is expected. And the area without snow spreads considerably.

Those changes will become clear after 50 years from now based on the MRI-CGCM scenario.

5. REFERENCES

Tokioka,T., Noda,A., Kitoh,A., Nikaidou, Y., Nakagawa,S., Motoi,T., Yukimoto, S., and Takata,K., A transient CO2 experiment with the MRI CGCM -Quick Report-. *Journal of the Meteorological Society of Japan*, 73, 817-826, 1995.