Long-term forecasting of changes of snowiness and avalanche activity in the world due to the global warming

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ABSTRACT. The technique of definition of depth of the snow cover, number of days with the snow cover, number of days with intensive snowfalls, duration of avalanche prone period by the standard meteorological data (precipitation and temperature) is developed (Glazovskaya, T.G., S.M. Myagkov and V.F.Okolov. 1978). It has allowed to estimate changes of snowiness and avalanche activity using Global Circulating Model GFDL (USA) for a CO_2 - doubling (2050 year). The results of accounts are submitted as maps on all continents. The possible increase almost of all characteristics of snowiness and avalanche activity is expected in today's low-snow continental areas, reduction - in the heavy snow regions. Depth of the snow cover maximum can increase up to 40-50 cm, decrease - up to 30-40 cm; the number of days with the snow cover will decrease almost everywhere for 1,5-2 months. The computed changes correspond to maximum changes, because in GFDL Model maximum expected changes of air temperature (3,5 - 4 degrees) are taken into account.

INTRODUCTION

In the past there were only the natural changes of a climate; in the future its antropogenic modifications are also possible. A possible reaction of a snowiness and avalanche activity in northern hemisphere on the forecasted in the middle of the twenty-first century warming the authors studied in two papers (Glazovskaya, 1996, 1998). In the present work we have tried to give the glaciologic prognosis on the whole world being not limited mountain areas. In contrast to the previous works maps are constructed in relative magnitudes, that allows to estimate more obvious the possible changes. Certainly, because of climatic prognosis on the whole world it is possible to make inferences only about the most common tendencies of a modification of a snowiness and avalanche activity.

RESULTS

For our estimations we used the general circulation model constructed by Geophysical Fluid Dynamics Laboratory of NOAA, Princeton (GFDL 1988 (Q-flux Model)), which takes into account surface air temperature, surface ground temperature, total monthly averaged precipitation per day, winds, etc. The model calculates a monthly average air temperature and precipitation for the present and for when atmospheric CO_2 will be doubled.

The following parameters of snowiness and avalanche activity were determined:

- Depth of the snow cover,
- Number of days with snow cover,
- Number of days with snowfall > 10 mm d^{-1},
- Duration of the avalanche-prone period.

Scenario of a possible change in snow cover depth is shown on the map (Fig. 1). In Eurasia the changes of a snow cover depth is expected in continental areas of Siberia and Central Asia with a maximum (> 50 %) in east Kun-Lun. In Western Europe, in the south of East Europe, in Central Asia, along the southern boundary of distribution of an unstable snow cover (Turkey, Zagros, and Himalayas) the depth of a snow cover will decrease. In North America the modification of a snow cover depth will be less, than in Eurasia: increasing - up to 20 %; decreasing - up to 50%. In the north of Africa in Atlas mountains the depth of a snow cover can decrease more than on a half. In all snow areas of a Southern Hemisphere the snow cover will decrease on 20-50 %.

The number of days with a snow cover almost everywhere will decrease (Fig. 2), except Middle Siberia and Central Asia. The maximum reduction is expected in Mediterranean, in the south of USA, in Patagonia, Dragon Mountains, Australia and New Zealand.

The change in number of days with intensive snowfall (more than 10 mm d^{-1}) is shown in Figure 3. The greatest increase (> 50 %) is found in Zabaikalie, in Tibet and along the eastern coast of Greenland. In southern Andes, in Europe, in the west and in the south of North America, in the east of China one might expect a reduction of this parameter. No change is predicted in south Mediterranean, in Dragon mountains, in Australia and New Zealand.

It is hard to show on a small-scale map the values of change in duration of avalanche-prone period. That is why in Figure 4 one can observe only the tendency of this change.

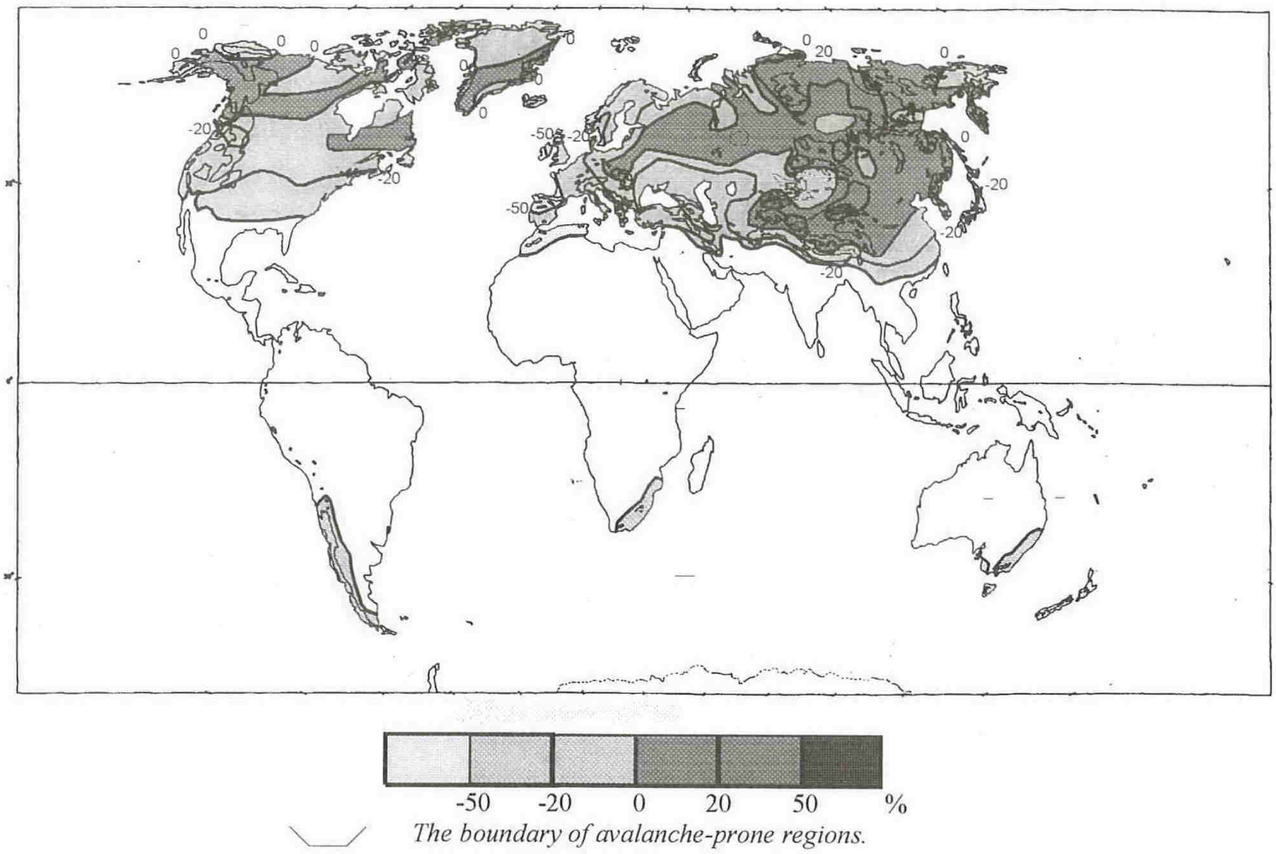

Fig.1. Possible change of snow depth (%) due to a global warming ($2xCO_2$).

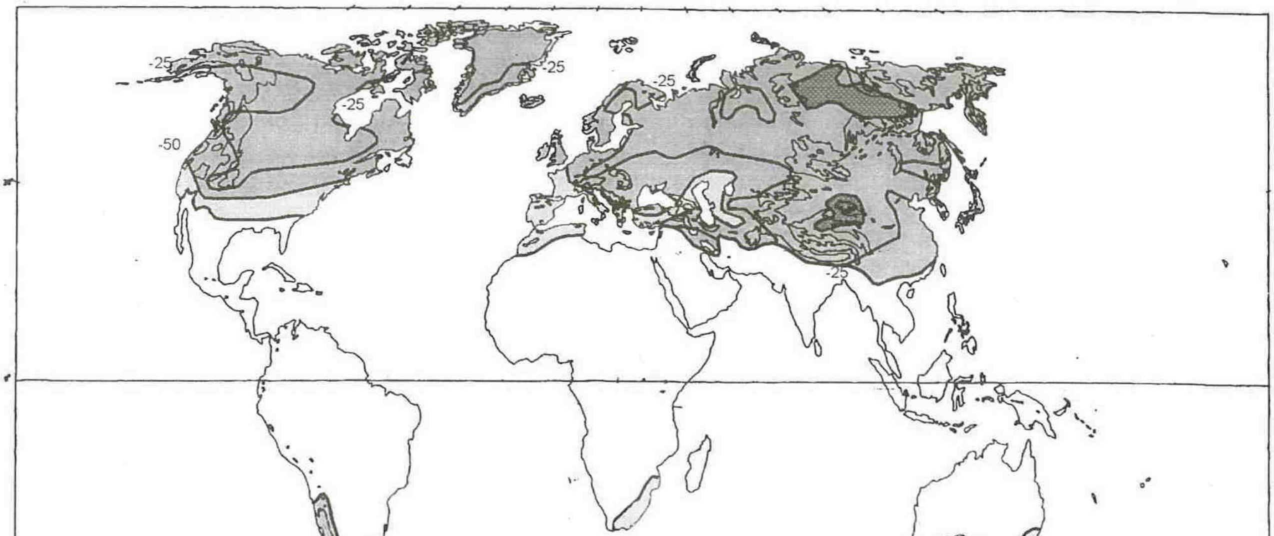

Fig.2. Possible change in number of days with snow cover (%) due to the global warming ($2xCO_2$).

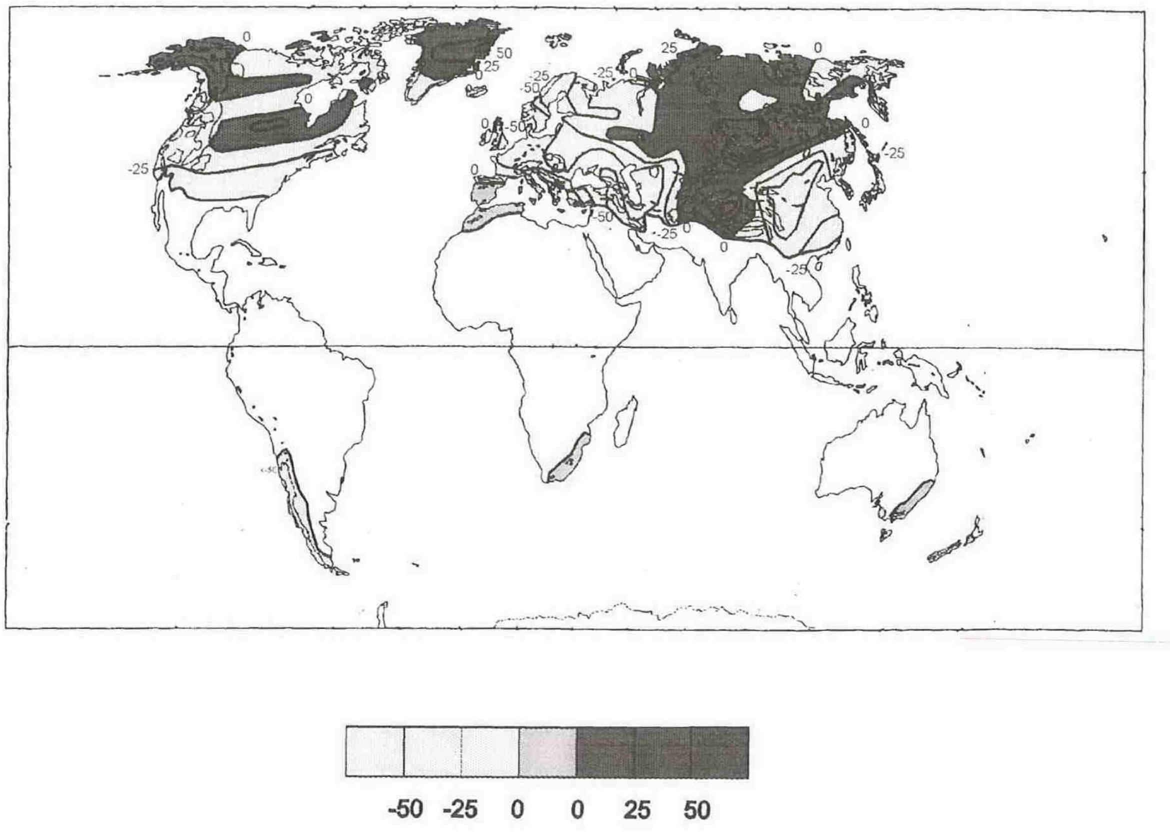

Fig.3. Possible change in number of days with snowfall more than 10 mm (%) due to a global warming ($2xCO_2$).

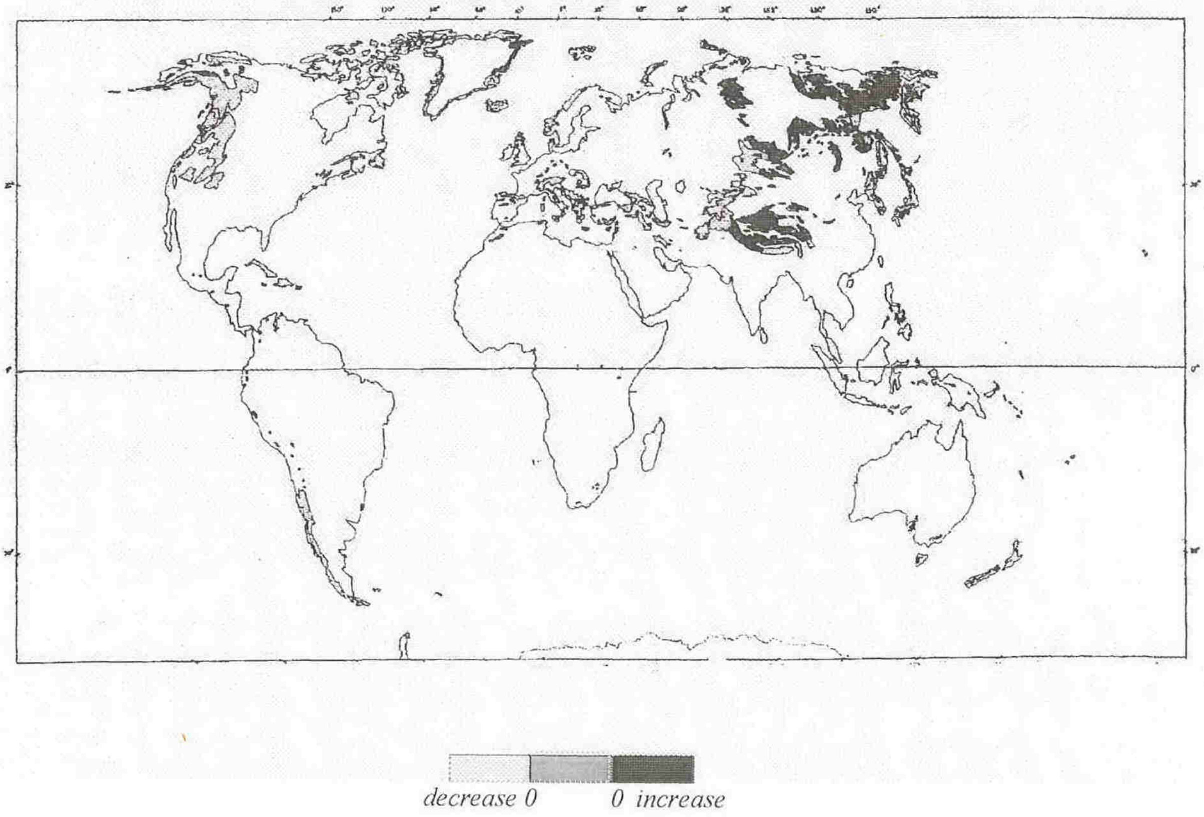

Fig.4. Possible change of avalanche-prone period duration due to the global warming ($2xCO_2$).

An increase is expected in the avalanche regions of Siberia, Central Asia, Alaska and eastern Greenland. In Africa, Australia and New Zealand the duration of an avalanche period will remain the same as today. In the other avalanche-prone regions of the World the reduction of this parameter is expected.

CONCLUSION

As a conclusion we can infer that with a Global Warming all studied parameters will change:

- An increase there will be mainly in continental, today's low-snow regions,
- Reduction is expected mainly in the present heavy-snow regions,
- No change is predicted in relatively small areas.

On the basis of this study we conclude that in the middle of the twenty-first century, differences in snowiness and avalanche activity between various regions of the World will be smoothed.

These changes of snowiness and avalanche activity are necessary for taking into account in plans of economic development (agriculture, stockbreeding, road and power construction, recreation etc.). But it is necessary to remember, that as the antropogenic modifications of a climate do not exclude natural, the course of changes of an avalanche activity and snowiness will be rather complicated; the short-term extreme deviations can appear larger, than mean annual changes.

ACNOWLEDGEMENTS

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