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SOME ASPECTS OF HYDROLOGY IN THE GLAS GCM

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ABSTRACT

The response of hydrology in the GLAS GCM has been evaluated. The results show that the distribution of precipitation agrees fairly well with observations and that the model tends to maintain the hydrological balance.

INTRODUCTION

The performance of the GLAS GCM (Laboratory for Atmospheric Sciences General Circulation Model) in handling some of the hydrological parameters has been evaluated. Specifically, the distributions of precipitation and evaporation are examined in order to see how well they agree with each other and with observations, and in what manner, if any, they are associated with other related parameters such as cloudiness and vertical velocity. For the purpose of the present discussion, the results of one winter month, namely, February, are selected. With the initial state of the atmosphere as of January 1, 1975, the model has been run for the month of January and the run extended further through February.

Figure 1 shows the global distribution of precipitation as computed by the model. The observed distribution for winter (December-January-February) compiled by Schutz and Gates (1972) is represented in Figure 2. The precipitation associated with the ITCZ over the land and sea and also with Icelandic and Aleutian lows is very well reproduced. The model fails to produce the ITCZ rainfall over the Atlantic. Also, the computed precipitation appears to be overestimated, especially over the land mass. However, the monthly mean data for the period concerned from other independent sources do show a few individual land stations having high values of precipitation in the range of 14-16 mm/day.

Figure 3 shows the zonally-averaged distribution of two major types of precipitation, namely: a) the supersaturation precipitation and b) precipitation due to penetrative convection.

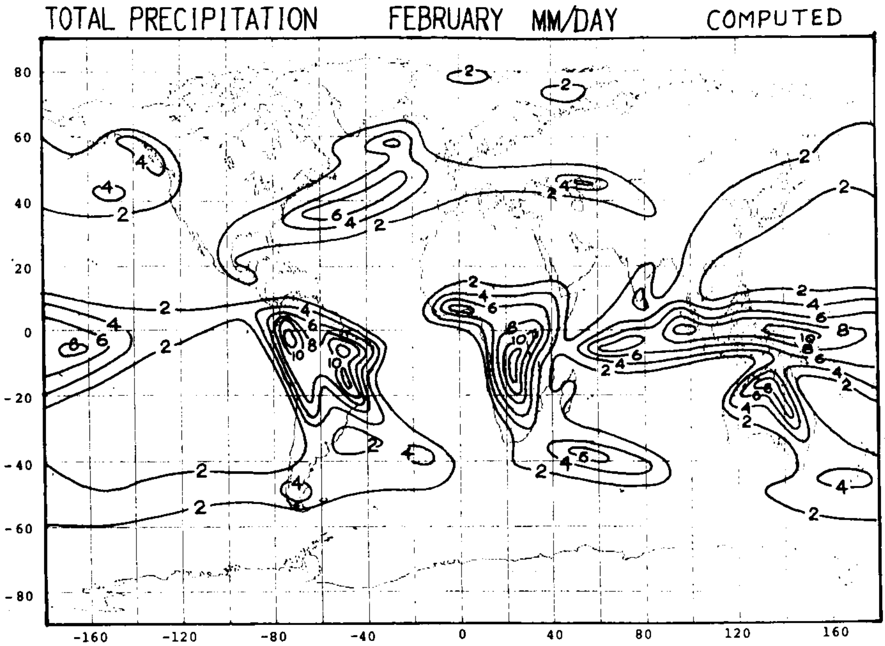

Fig. 1. Distribution of computed precipitation (mm/day) in February.

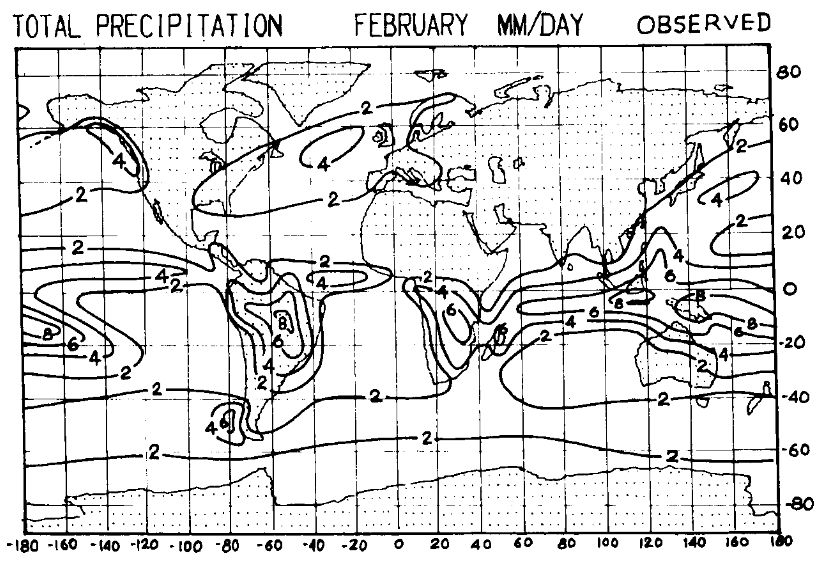

Fig. 2. Observed distribution of precipitation (mm/day) for winter (December-January-February).

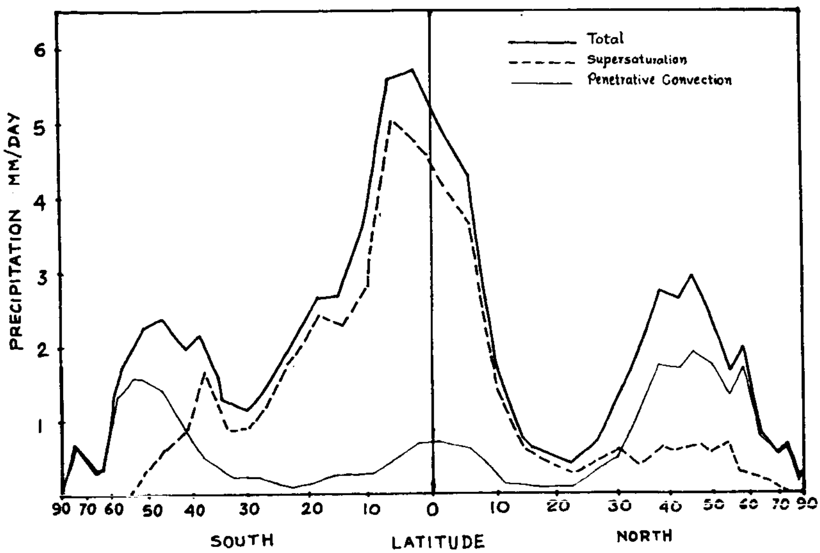

Fig. 3. Supersaturation precipitation (broken line) and penetrative convective precipitation (thin line) in relation to the total precipitation (thick line).

The zonally-averaged total precipitation is also shown in the figure. In the tropical belt where the atmosphere is convectively unstable, the penetrative convection dominates and accounts for most of the total precipitation. In the middle and high latitudes, the supersaturation processes overtake the convective processes. Supersaturation condensation arises largely due to the frontal systems which are more active in the winter hemisphere due to strong baroclinicity, a feature well reflected in the figure.

Figure 4 shows the distribution of various types of clouds generated by the model. Clouds are expressed as percentage of time they are present. It is interesting to observe that the frequency of the formation of the supersaturation clouds is very high at all the latitudes irrespective of the amount of its precipitation. On the contrary, the penetrative convective clouds form less frequently than the supersaturation clouds even in the tropical belt where its associated rainfall is maximum. This means that given the same amount of supersaturation and penetrative convective clouds, the actual realization of water from the former is less than that from the latter.

Figure 5 shows a relationship between precipitation, vertical velocity (p-coordinate) and cloudiness as a function of latitude. All the quantities are model generated. It is seen that between

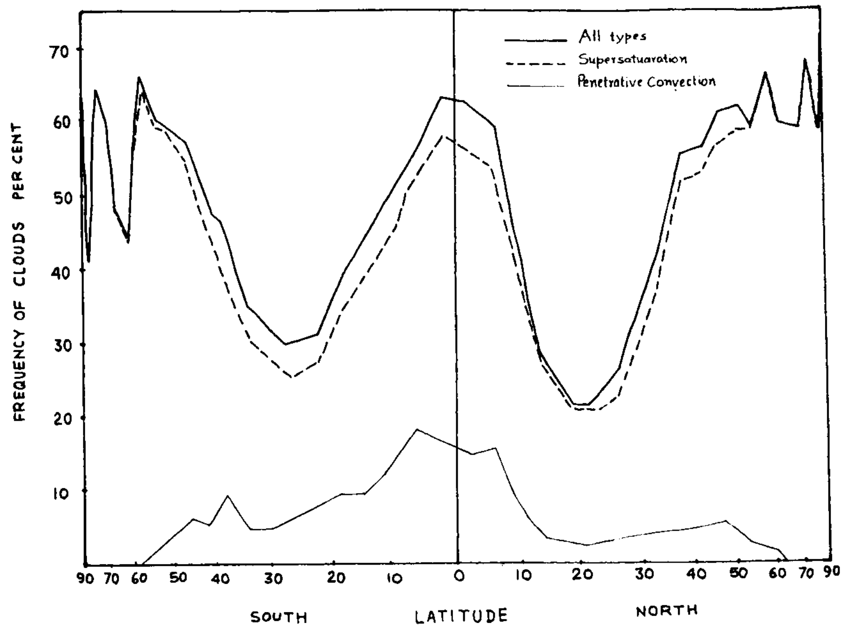

Fig. 4. Frequency of the formation of clouds; all types (thick line), supersaturation type (broken line) and penetrative convective type (thin line).

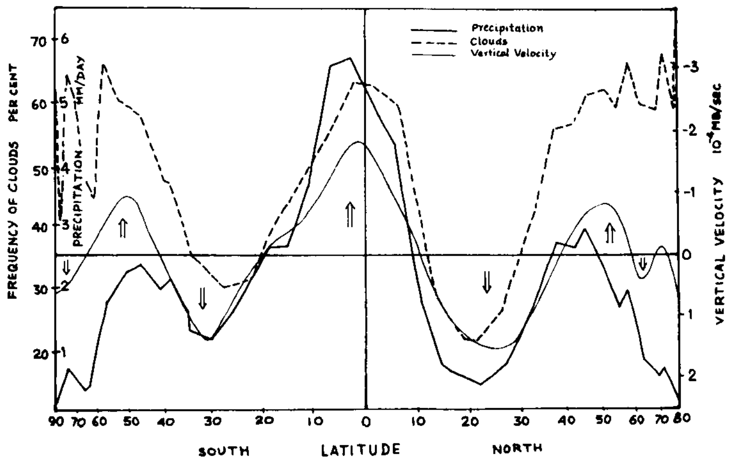

Fig. 5. Zonally-averaged distribution of precipitation, cloudiness and vertical velocity as computed by the model.

40N and 50S all three curves follow each other very closely, meaning thereby that the upward motion is associated with relatively more cloudiness and more precipitation and vice versa. Over the polar latitudes, this conventional relationship apparently does not hold good. Specifically, the relationship between cloudiness and precipitation is reversed, more cloudiness being associated with less precipitation. This is due to the fact that, over the polar latitudes, the almost saturation conditions would favor frequent formation of clouds, but the realization of moisture in the form of precipitation would be insignificantly small.

The computed surface evaporation is shown in Figure 6 along with the observed evaporation (for January) which is derived by Shutz and Gates (1971) indirectly on the basis of other hydrological data. The computed evaporation rate is largely underestimated except at the equator where it is comparable with observations. However, the point of some concern here is the failure of the model to reproduce the distribution pattern. The model shows peak in evaporation rate at the equator instead of a slight dip as observed. This aspect needs further examination which is under way.

Figure 7 shows the important result of the investigation, namely, the hydrological balance of the model. Five hourly values of precipitable water, evaporation, and precipitation were extracted from the history tape and plotted as time series. The values represent the global mean. We find that the precipitation exceeds the evaporation and the difference between the two, which is very small, remains practically constant through the month of February. The global mean precipitable water of the atmosphere also remains constant with time. The model, therefore, tends to maintain the hydrological balance within a reasonable degree of accuracy.

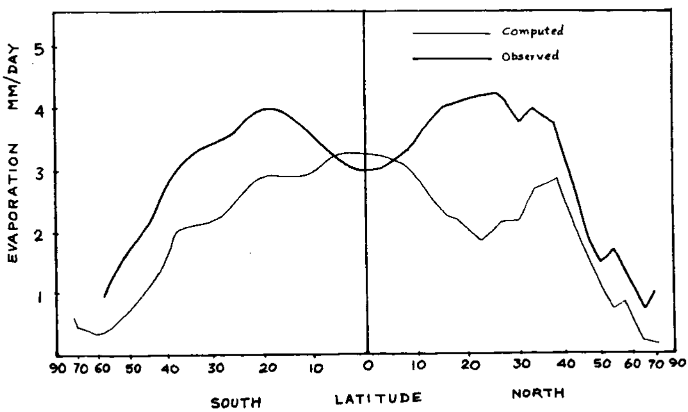

Fig. 6. Zonally-averaged surface evaporation (mm/day); computed (thin line), observed (thick line).

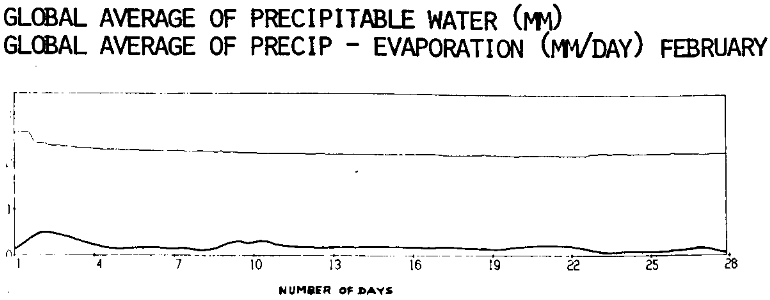

Fig. 7. Time series of global mean precipitable water (thin line) and precipitation minus evaporation (thick line).

REFERENCES

Schutz, C., and W. L. Gates, 1971: Global climate data for surface 800 mb, 400 mb: January. Report R-915-ARPA Rand., Santa Monica, Calif.

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