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CLOUDINESS CHARACTERISTICS OVER NORTHERN HEMISPHERE: AN ANALYSIS BASED ON ISCCP D2 CLOUD DATA SET

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1. INTRODUCTION

Cloud cover is an extremely important climate parameter. Though only some clouds bring precipitation, all affect the heat exchange between the Sun, Earth and cold space, and they are also quite variable in time, from region to region, and in the effects they produce. Clouds modulate the insolation and this affects the productivity of plants both on land and in the water as well as the surface temperature and heat budget. Numerous efforts to produce cloud climatologies from both surface and satellite observations have been made. At present the most important of these is the ongoing International Satellite Cloud Climatology Project (ISCCP). A combination of satellite-measured radiances, TOVS atmospheric temperature/humidity and ice/snow data are used by ISCCP to produce a global data set on cloud and surface variables. An overview of the ISCCP D-series, the algorithm and its effectiveness are described by Rossow et al. (1996).

2. DATA

Recent years the ISCCP data set were used frequently both for revealing characteristic cycles of different time scales (e.g., Wylie and Woolf 2002) and for comparison with the data of another experiments (Karlsson 2000; Maslanik et al. 2001;Zhang et al. 2001; etc). Numerous early works have shown shortcomings and advantages of the ISCCP cloud data set. The results obtained by Schweiger et al. (1999) show that in the Arctic the cloud observations in the ISCCP data set differ significantly from surface observations and the annual cycle of cloudiness is reversed from what is observed from the surface. On the other hand, Hatzianastassiou et al. (2001) have shown that ISCCP D2 data set better than C2 for investigating polar cloud climatology. Also, it is necessary to take into account that ISCCP low clouds are only those low clouds that are not obstructed by higher cloud (see Weare 2000). Nevertheless, ISCCP data set is used in many GCM (e.g., Gordon et al. 2000; Rossow et al. 2002) and essentially improves their quality.

The cloud fraction data, which are small part only of whole ISCCP data set, are used in this work for period January 1989 – December 1993. These data were latitudinally averaged for Northern Hemisphere and analysis was carried out for period and monthly mean values of all cloud fractions, which are included in ISCCP data set.

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3. RESULTS

The zonal mean total cloud fraction for whole year has two almost equivalent maximums (Fig. 1) over Northern Hemisphere, which are well correlated with correlated with the distribution of precipitation and evaporation (Khokhlov 2001). The first maximum is associated with intertropical convergence zone (ITCZ) (6 N, 72%) and the second one is connected to location of polar front (55 N, 76%). At that in tropics this large value consists of almost equal low (23%), mid (21%) and high (24%) cloud fractions, but in middle latitudes the mid cloud fraction makes largest contribution (32%). In Arctic the middle level clouds are main cloudiness. Tropical cloud maximum consists mainly of liquid cumulus (10%), stratocumulus (8%), altocumulus (8%) and altostratus (7%), ice cirrus (21%) and cirrostratus (10%) (see Figs 2 – 4). Polar front cloud maximum consists mainly of liquid cumulus (8%) and stratocumulus (10%), ice altocumulus (12%), altostratus (10%), cirrus (12%) and cirrostratus (7%). Although the quantity of nimbostratus is not great (Fig. 3), they have maximal optical

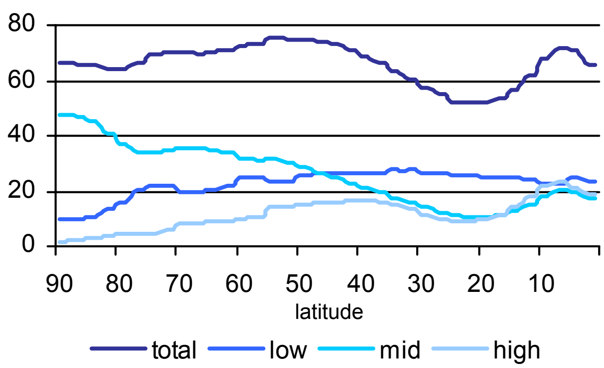

Fig. 1. Latitudinal distributions of the yearly mean cloud fraction (%) for Northern Hemisphere.

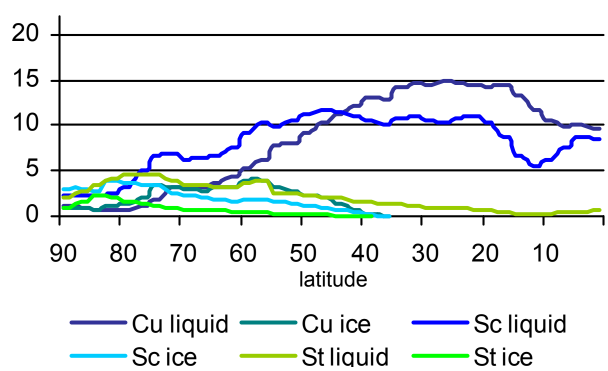

Fig. 2. Latitudinal distributions of the yearly mean low cloud fraction (%) for Northern Hemisphere.

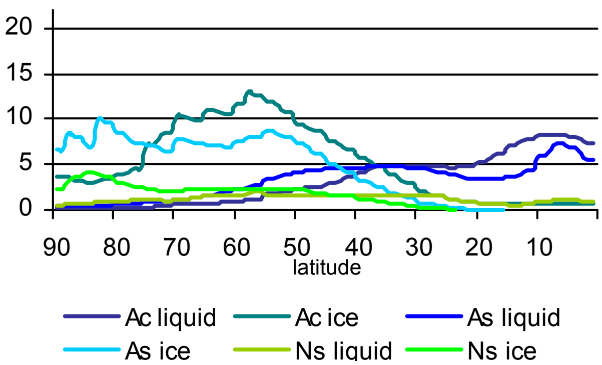

Fig. 3. Latitudinal distributions of the yearly mean mid cloud fraction (%) for Northern Hemisphere.

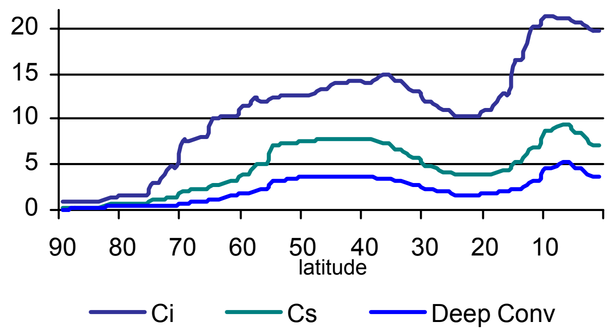

Fig. 4. Latitudinal distributions of the yearly mean high cloud fraction (%) for Northern Hemisphere.

thickness and cloud-top pressure especially in the ITCZ (Hahn et al. 2001).

Cirrus, liquid cumulus and stratocumulus, ice altocumulus have maximal hemispherical mean values (11.0, 8.4, 8.1 and 5.2 % correspondingly). Also only liquid stratocumulus and altostratus, cirrus, cirrostratus and deep convective clouds have maximums connected with ITCZ and tropical front. In high latitudes the ice altostratus and nimbostratus have maximums, i.e. arctic front consists of frozen clouds mainly.

Largest values of total cloud fraction are observed in equatorial zone and in middle latitudes and these are low and high clouds mainly (Fig. 5). If in tropics the highest value cloud fraction is observed in summer only, in moderate latitudes the cloudiness achieves a maximum in autumn also, i.e. in the polar front intensification period. At the same time in area that is under influence of a descending branch of the Hadley cell the total cloud fraction is minimal. In Arctic the cloudiness maximum is registered in cold season only and it consist of mid

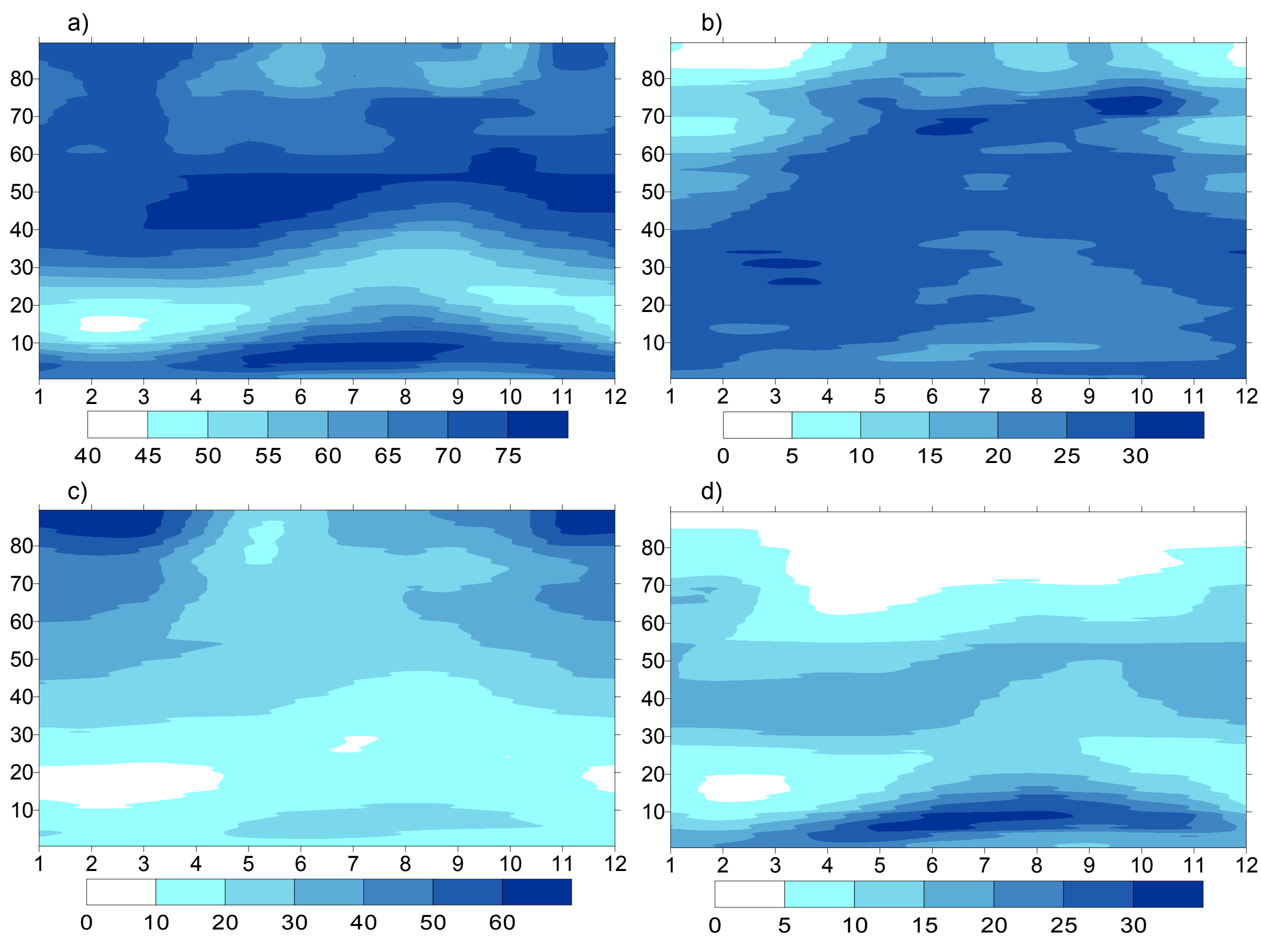

Fig. 5. Hovmöller diagrams of the total (a), low (b), mid (c) and high (d) cloud fraction (%) for Northern Hemisphere. (X axis – months, Y axis – latitude).

clouds.

Figure 6 shows the spatial-time distribution of main clouds. Maximal cloud fraction of the liquid cumulus is observed in the tropics when total cloud fraction is decreasing. Liquid stratocumulus is registered mainly in summer at high and middle latitudes and their locations can be associated with atmospheric fronts. Liquid altocumulus has maximal values of cloud fraction during whole year in ITCZ while AC ice is observed mainly in cold season in Temperate Zone and Arctic as well as ice altostratus. Also, cirrus has summer maximum in ITSZ and secondary maximums connected to location of frontal zone.

4. CONCLUSIONS

The carried out analysis has shown that cloudiness data in ISCCP D2 display well-known geographical and

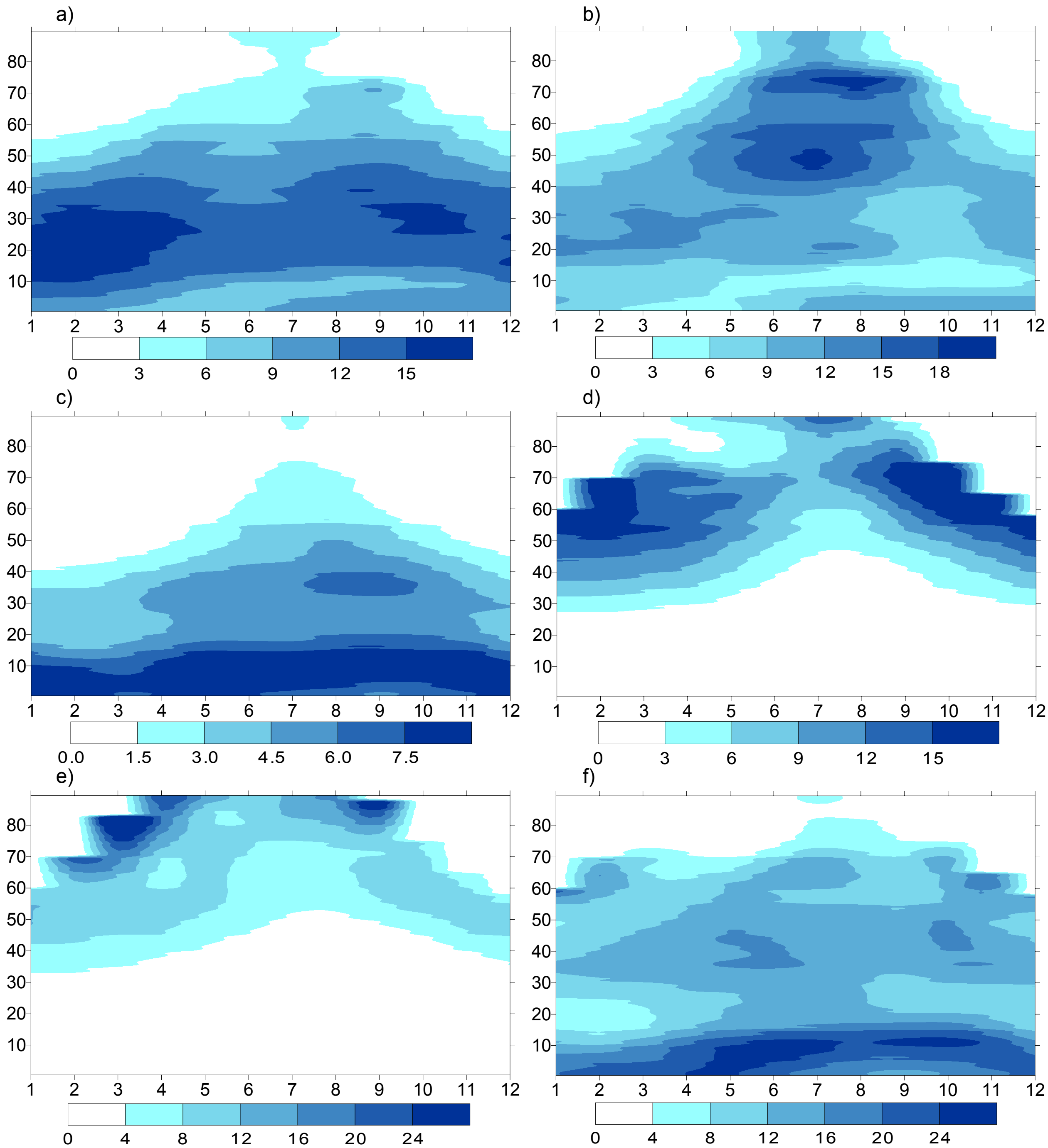

Fig. 6. Hovmöller diagrams of the Cu liquid (a), Sc liquid (b), Ac liquid (c), Ac ice (d), As ice and Ci (e) cloud fraction (%) for Northern Hemisphere. (X axis – months, Y axis – latitude).

time distribution of different cloud types. However, from our point of view the contribution of some clouds, for example nimbostratus and deep convective, is underestimated in the mentioned data set. It can be explained by (i) obstruction of low clouds and (ii) large size of grid box containing observation. Using methods of analysis of satellite image (see e.g., Baum et al., 1997) it is possible to get out of the latter.

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