JP1.4 INFLUENCE OF THE NORTH ATLANTIC OSCILLATION ON SPATIAL DISTRIBUTION OF MOISTURE CHARACTERISTICS

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1. INTRODUCTION

The North Atlantic Oscillation (NAO) is the dominant pattern of the atmospheric circulation variability over North Atlantic basin (Barnston and Livezey 1987). Its pronounced seasonal variation in position, intensity and shape reflects the strength of westerlies across the Atlantic basin into Europe. The northern center of the NAO is in the subpolar gyre, while its southern center of opposite strength is in subtropics, near the Azores Islands. NAO has strong fluctuations on interannual and longer timescales: NAO index, defined as a pressure difference between Stykkisholmur, Iceland, and Ponta Delgada, Azores, has reversed its sign from the end of 1960s to the late 1980s (Hurrell 1995).

A positive NAO index describes a pattern where the subpolar gyre has lower pressures than normal and the pressures are higher than normal in the subtropics. The NAO is associated with a large-scale net displacement of air between the subtropical high near the Azores and the low-pressure region near Iceland and the Arctic region. High index winters have stronger mean westerly flow over the North Atlantic and Western Europe associated with a deeper than normal Icelandic low and a stronger than normal Azores high. Stronger westerly flow advects more warm maritime air over Europe and more cold Arctic air over Greenland and the northwest Atlantic.

A significant relationship between the precipitation variability and the NAO was found for many regions of the Europe (see e.g., Rodrigo et al. 2000, Spellman 2000, Busuioc et al. 2001, Herrera et al. 2001, Philips and McGregor 2001, Quadrelli et al. 2001, Rogers et al. 2001). However, using canonical correlation analysis, Qian et al. (2000) have shown that the NAO pattern seems to be responsible only for the second empirical orthogonal function in precipitation, while the most important spatial mode of precipitation corresponds to the third EOF of monthly mean sea level pressure (North Sea pattern).

In this work the spatial structure of total precipitation (TP), surface evaporation (SE), total cloud fraction (CF) and precipitable water (PW) is considered in a context of negative and positive phases of the North Atlantic Oscillation (NAO).

2. DATA

Analyzed geographical area is bounded with 20 N - 80 N latitudinally and 80 W - 40 E longitudinally. The

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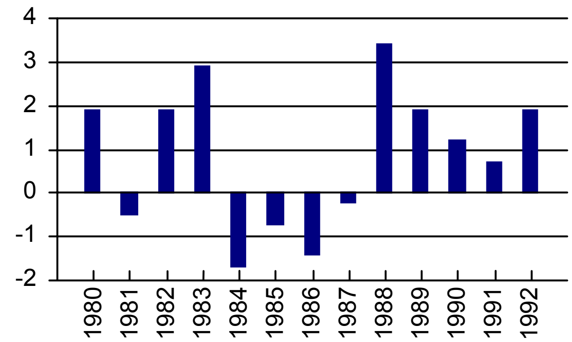

Fig. 1. Winter NAO indices over North Atlantic.

GDAAC archive was used for the analysis of winter mean data on TP, SE, CF and PW during winters of 1980-1992. Let's note that one of shortcomings of the GDAAC dataset is too much rain over continental Europe in July and too little over the Mediterranean during January.

The seasonal NAO indexes were obtained from http://www.cgd.ucar.edu/~jhurrell/nao.html. Considered period is characterized by winter positive phases of the NAO and substantial negative phase of the pattern appeared only twice, in winters of 1984-85 and 1986-87 (Fig. 1).

3. RESULTS

According to a location of north-south dipole the North Atlantic have been divided by latitude 50 N into two approximately equal parts. Figure 2 shows winter

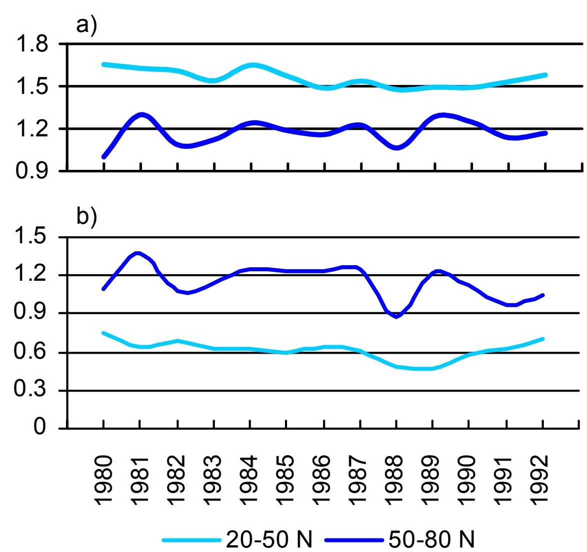

Fig. 2. Winter surface evaporation (a) and total precipitation (b) over Northern Atlantic (units: mm day^{-1}).

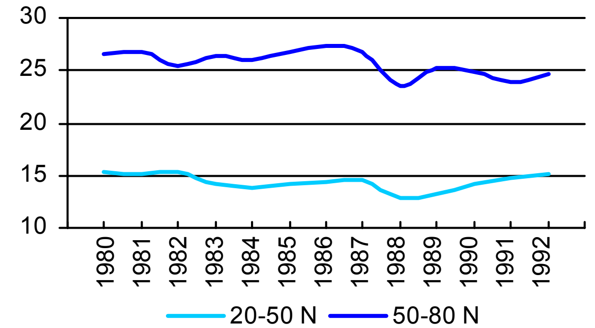

Fig. 3. Winter total cloud fraction (%) over North Atlantic.

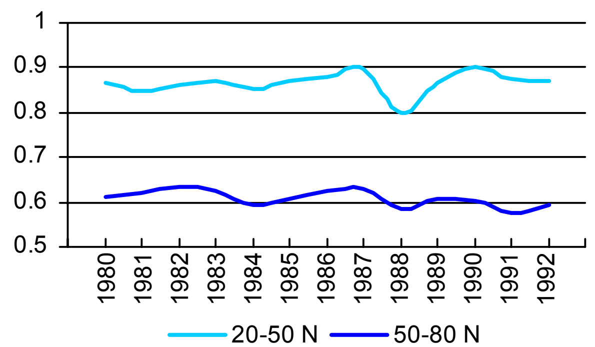

Fig. 4. Winter precipitable water (g cm^{-2}) over North Atlantic.

SE and TP during 1980-1992 years. This figure displays the known fact that the greatest evaporation is observed in a southern part and precipitation (on atmospheric front) – in northern one. Sharpest changes of these characteristics were observed in winters of 1981-82 and 1988-89 and in the northern part of analyzed region only. The increase of SE and TP values was concurred with decreasing of the NAO index absolute magnitude. It can be explained by reduction of atmospheric circulation zonality over above region and, as consequence, by polar front intensification.

Minimal values of CF both in northern and in southern part were observed in winters 1988-89 (see Fig. 3), i.e. when the maximal NAO index was registered. Maximal fluctuation of PW in southern part was also registered in winter of 1988-89 (Fig. 4).

Thus, the strongest (for above period) positive phase of the NAO (index was equaled 3.4) in winter of 1988-89 was concurred with decrease of TP, SE, CF and PW (in latitudinal belt 50-80 N mainly).

Spatial distribution of above quantities is considered for winters of 1987-88 and 1988-89 that have been characterized with change of the NAO phase from small negative to large positive one.

Against a background of common reduction of precipitation over North Atlantic in the winter of 1988-89 (see a zone with TP < 3 mm day^{-1} in Fig. 5) in some areas they have increased in comparison with winter of 1987-88. The precipitation seat was displaced from southern Greenland on Iceland and the center above Scandinavia was formed. At the same time the TP have considerably decreased over Mediterranean. Such time variations of the TP spatial distribution were assigned with changes of total cloud fraction (Fig. 7) over mentioned regions. The rainfall maximum over the Sargasso Sea has practically not changed, i. e. the relationship between precipitation variability and the NAO is small in this region. Also the evaporation in the centre of the Azores high has decreased, while SE over Iceland it has increased (Fig. 6). Spatial distribution of PW (Fig. 8) poorly depends on fluctuations of the NAO indices and has a kind of a ridge with an axis that is directed from the Gulf of Mexico toward the British Isles.

4. CONCLUSIONS

The carried out analysis has shown that most essential change of examined moisture characteristics occurred when the absolute values of the NAO indices vanished primarily and then sharp risen. Considered sharp increase of the NAO index value during winter of 1988-89 shows that together with general reduction of the precipitation over North Atlantic in some regions the essential increase of rainfall was observed. At that, both

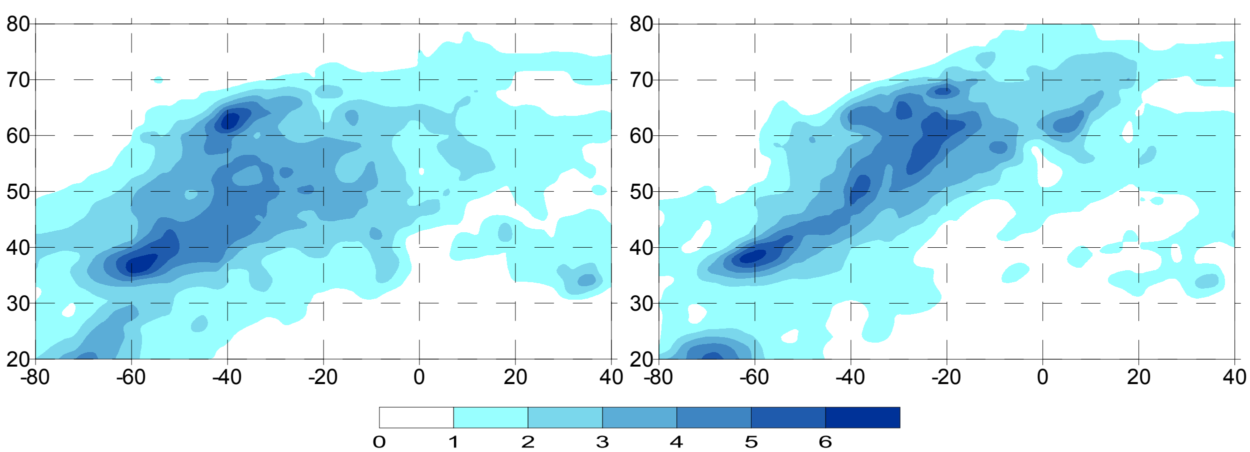

Fig. 5. Spatial distribution of total precipitation (mm day^{-1}) in winters of 1987-88 (left panel) and 1988-89 (right panel). (X axis – latitude, Y axis – longitude; negative longitudes are west).

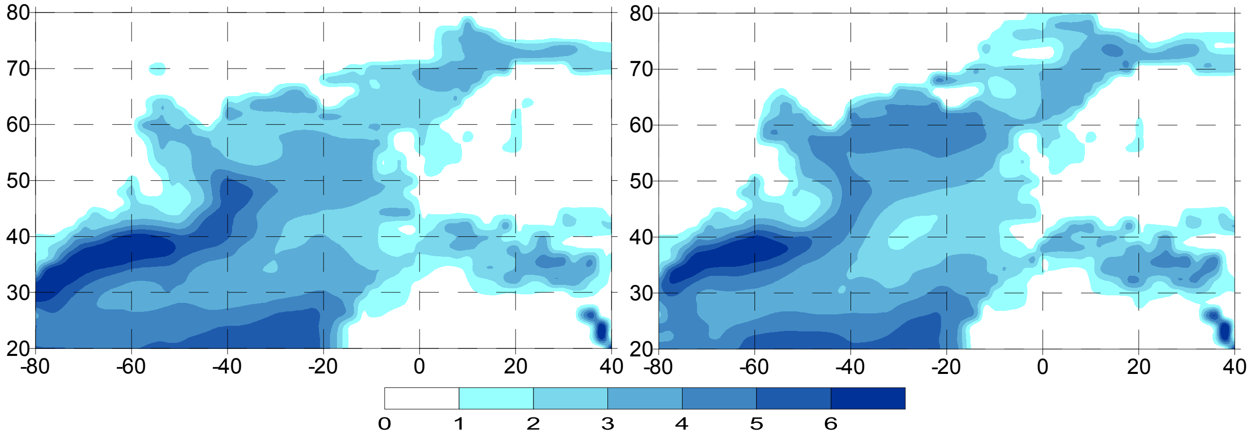

Fig. 6. As in Fig. 5 but with surface evaporation.

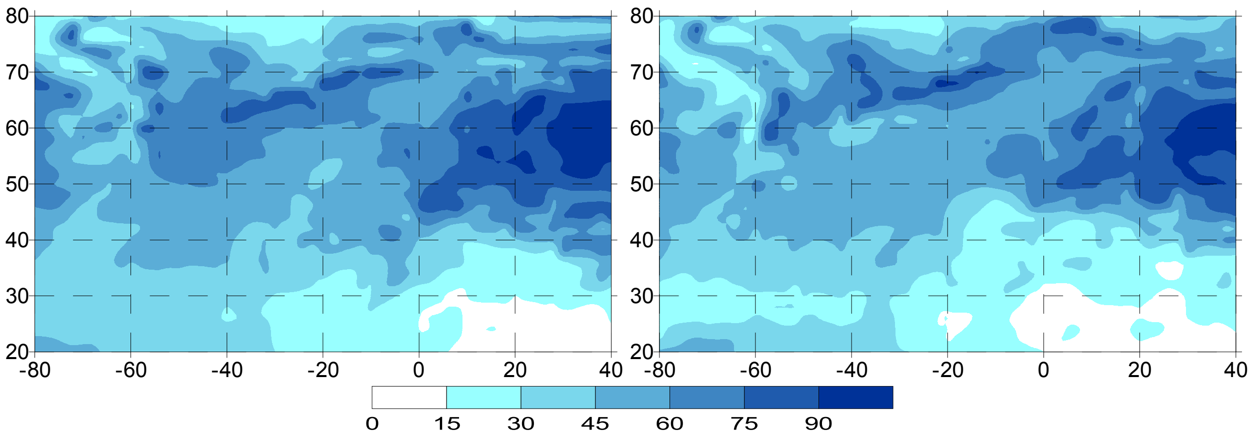

Fig. 7. As in Fig. 5 but with total cloud fraction and unit is percent.

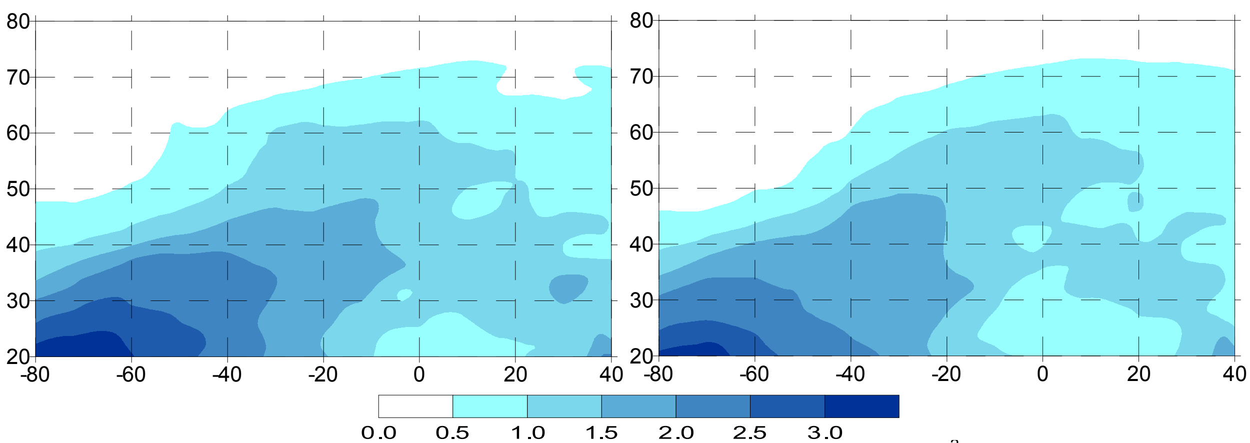

Fig. 8. As in Fig. 5 but with precipitable water and unit is g cm^{-2}.

precipitation and cloudiness changed.

Thus, if the relationship between the NAO indices and precipitation was obtained for large territory, e.g. as in present work or in Qian et al. (2000), it does not mean that the similar relationship was also registered for smaller regions within this territory.

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