Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC030-01 Room:102 Time:May 24 14:15-14:30

The signals of anomalous snow accumulation brought about by the Arctic Oscillation as seen with space geodetic data

Koji Matsuo[1*], Kosuke Heki[1]

[1]Natural History Sciences, Hokkaido Univ.

The Arctic Oscillation (AO) is a seesaw like fluctuation in sea-level pressure (SLP) between polar and mid-latitude region across 60N, and is a dominant pattern of atmospheric circulation in northern hemisphere in winter season. The trend and scale of AO is represented by the AO index derived from EOF analysis of SLP. When SLP around north polar region becomes lower than usual, the AO index indicates positive values. Then the cold weather is brought to high latitude region and the warm weather to mid-latitude region due to the retention of Arctic cold wave in polar region. Additionally, precipitation anomaly occurs in high latitude region with the enhancement of westerly jet above there. When SLP becomes higher, the AO index indicates negative values. Then it's found the reverse weather changes from positive AO phase. The active outflow of Arctic cold wave makes the weather in high latitude region warm and that in mid-latitude region cold, and the southward meandering of westerly jet brings precipitation anomaly in mid-latitude region. The AO mainly influences winter weathers. Unprecedented extreme negative phase of AO in winter of 2010 brought unusual cold weather and heavy snow in various region of mid-latitude region.

In this study, we have tried to detect the signals of anomalous snow accumulation brought about by the AO in the three pillars of geodesy, i.e. gravity change, surface displacement, and the earth's polar motion. The data used in this study are time-variable gravity change observed by GRACE satellite, surface displacement measured by IGS continuous GPS point, and excitation pole provided by Paris astronomical observatory between 2002 and 2011. Here the secular and seasonal component were removed from all data sets by least square method. First, computing the correlation between the gravity changes and the AO indices in each winter (January to March) throughout all grids of north hemisphere, the regions with latitudes higher than 55N show positive correlations, i.e. higher gravity changes there as the AO index takes larger values, and those from 30N to 55N behave in an opposite way. The regions showing especially high correlation are Western Siberia (+0.94), Black sea (-0.88), Pamir highland (-0.78), and southeastern US (-0.77). The correlations between snow accumulation changes derived from gravity changes and the AO indices were +0.73 in high latitude region (from 55N to 80N) and -0.79 in mid-latitude region (from 30N to 55N). It's recognized that the AO brings a dipole like fluctuation in the distribution of snow accumulation according to its positive and negative phase. Next, computing the correlation between the vertical displacement of GPS point near Pamir (mid-latitude) and the AO indices in each winter, they show strong positive correlation, that is, the ground surface uplifts in positive AO and depresses in negative AO. This kind of vertical displacement is assumed to be the elastic deformation due to the anomalous snow accumulation by the AO. So we calculated the surficial load deformation from the gravity change and compared it with the GPS vertical displacement, and found that they show good agreements both in the phase and amplitude. Lastly, we'll discuss the earth's polar motion. The AO causes large mass redistribution between high and mid-latitude region. The peak-to-peak value of mass movements between there amounts to ˜1000 Gt during the studied period. Such a large mass redistribution should excite the earth's polar motion. Here, we compared the excitation pole derived from total mass change of snow accumulation and that provided by Paris astronomical observatory obtained by VLBI and GPS. Then they show in good agreement in phase but the former is about one half in amplitude. Though the cause of disparity in amplitude should need further inspection, there is no doubt that a large mass redistribution brought about by the AO accounts for the excitation of the earth's polar motion.

Keywords: Arctic Oscillation, snow accumulation, space geodesy, gravity change, surface displacement, polar motion