P2.3 THE MADDEN-JULIAN OSCILLATION SIGNAL IN THE ARCTIC OSCILLATION

Jee-Hoon Jeong* , Chang-Hoi Ho
Seoul National University, Seoul, Korea

1. Introduction

The Madden-Julian Oscillation (MJO) is the dominant mode of subseasonal variability in the tropics [Madden and Julian 1971]. It is manifested as large-scale eastward propagating circulation anomalies and associated convective anomalies with timescale of 30-60 days.

It is well known that MJO significantly affects the atmospheric circulation throughout the global tropics and subtropics, and also strongly affects the wintertime jet stream and atmospheric circulation features [Madden and Julian 1971; Weickmann et al. 1985; Lau and Phillips 1986; Knutson and Weickmann 1987; Ferranti et al. 1990].

In this respect, this study suggests that the convective activities related to MJO modulates Arctic Oscillation (AO) which is regarded as an annular mode of internal dynamics in the extratropical Northern Hemisphere.

2. Data

MJO indices (MJOI) are determined by extended empirical orthogonal function (EEOF) analysis of pentad 200-hPa velocity potential anomalies equatorward of 30°N during ENSO-neutral and weak ENSO winters (November-April) in 1979-2000. The leading mode is composed of ten time-lagged patterns, principal components of each pattern are used as MJO indices. Each pattern represents eastward propagation of MJO phase and related center of convection region. The MJOI are provided by Climate Prediction Center, National Prediction Center [http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_mjo_index/mjo_index.html].

AO indices (AOI) are determined by the leading principal component of monthly mean Sea Level Pressure (SLP) poleward of 20ºN in Northern Hemisphere [Thompson and Wallace 1998]. Pentad AOI are produced by regressing the anomalous sea level pressure data onto the leading mode.

* *Corresponding author address:* Jee-Hoon Jeong, School of Earth and Environmental Sciences. Seoul National University, Seoul, 151-742, Korea, Tel. +82-2-880-8861, Fax. +82-2-876-6795, e-mail: jjeehoon@cpl.snu.ac.kr

Daily wind, temperature and pentad Outgoing Longwave Radiation (OLR), SLP data are taken from NCEP/NCAR reanalysis [Kalnay et al. 1996].

3. MJO signal in the Arctic Oscillation Index

Our analysis focuses on the modulation of AOI by convective activities related to MJO, the MJOI are determined to be representative for occurrence of the most active convection. Figure 1 (a) shows standard deviation of 30-60 days band-passed Outgoing Longwave Radiation Anomalies (OLRA).

The average of indices 10 and 1, which represent the center of convection near 70°E and 80°E respectively, is defined as MJOI since the region of maximum variability of OLRA is located in tropical Indian ocean.

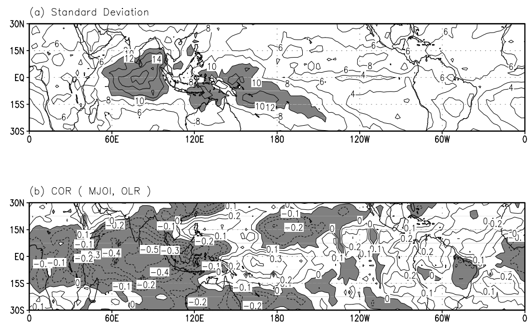

Figure 1. Standard deviation of 30-60 days band-passed anomalous OLR (a), Correlation coefficient between MJO index and OLR (b)

Positive MJOI means convection activities related to eastward propagation of MJO are centered in 70~80°E, so that correlation coefficient between MJOI and OLRA shows widespread negative values over Indian ocean, maritime continent and middle Africa. (Fig. 1b)

As shown Table.1, AO shows strong variability in wintertime (November-April) especially in DJF because AO activity is related to polar vortex, developed in fall and lasted late spring in northern hemisphere. MJO also represents strong variability in wintertime, but the strongest period is from March to May (MAM). It is easily recognized that the modulation of AO by MJO, if possible, is the most distinct during MAM. Also, explained variance by 30-60 days band of AOI shows the highest percentage in MAM. Thus, here we focused on MAM.

Table 1. Variance of MJO and AO index, Explained Variance of AO index by 30-60 days band

Period	**Variance**		**30-60 days**
	MJOI	**AOI**	**AOI (%)**
DJF	0.89	3.12	14.41
MAM	1.14	2.00	20.62
JJA	0.83	0.69	17.33
SON	0.73	1.45	19.18
Year	0.91	1.81	16.82

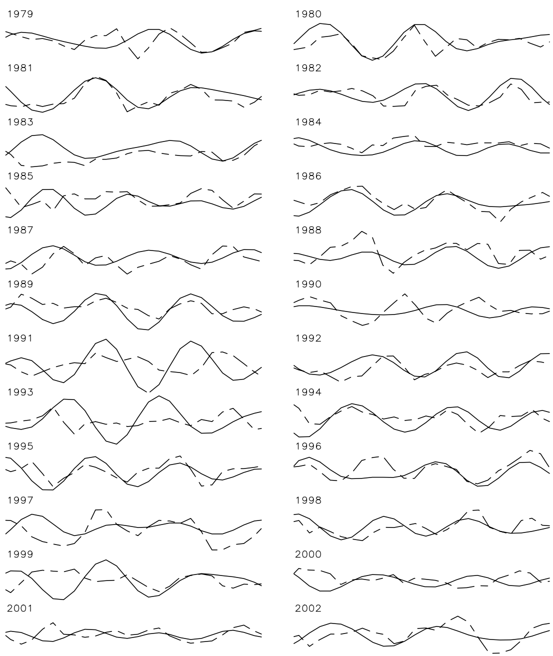

Figure 2. Normalized time series of MJO (dashed) and 30-60 days band-pass filtered AO (solid) indices during MAM.

In Fig. 2 and Table. 2., Relationship between AOI by MJO is well presented. In 13 years of 1979~2002, MJOI and AOI is in phase relationship, highly correlated in 95% confidence level.

Most in-phase relationship is occurred during neutral and weak ENSO years except 1998, 1992 and 1989. There are two ways to interpret. The first one is SST anomaly related to ENSO prohibits activities of MJO itself. The other one is SST forced global scale atmospheric variation distorts linkage of MJO and AO.

We perform composite analysis of zonal wind, SLP and surface temperature. Days of above or below 1 standard deviation of MJOI are composed separately and subtracted. In Fig. 3a, Zonal wind indicates AO-like feature that barotropic positive and negative centers are located in 50°N and 30°N similar to Limpusuvan and Hartmann (2000). SLP shows AO pattern clearly, but Pacific center of SLP is stronger than Atlantic. Surface temperature composite difference mostly resembles AO related variation except north Siberia region which shows negative sign.

Table 2. Correlation coefficients between MJOI and 30-60 band-passed AOI, Lead time of MJOI indicates a number of pentad between -2~ 0 when maximum correlation occurs. Moderate, weak cold/warm years are shaded. *, + indicates above 99%, 95% confidence level respectively.

Year	**C.C.**	**Lead**	**ENSO**
1979	0.13	0	N
1980	0.65*	0	W-
1981	0.86*	0	N
1982	0.57*	0	W-
1983	0.04	0	W+
1984	0.66*	1	C-
1985	-0.10	0	C-
1986	0.78*	0	N
1987	0.11	0	W
1988	0.58*	0	N
1989	0.64*	0	C
1990	-0.19	1	W-
1991	-0.05	0	W-
1992	0.52^{+}	0	W+
1993	0.24	1	W
1994	0.63*	1	N
1995	0.61*	0	N
1996	0.36	0	N
1997	0.47^{+}	1	W-
1998	0.58*	0	W
1999	-0.06	0	C+
2000	-0.35	1	C-
2001	-0.09	1	C-
2002	0.50^{+}	0	W-

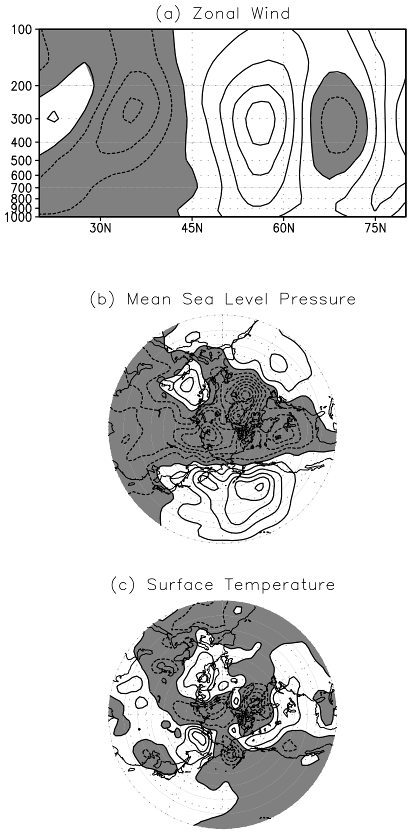

Figure 3. Composite of (a) zonal wind [m/s], (b) mean sea level pressure [hPa] and (c) surface temperature [°K], Contour interval is 0.5 m/s, 1 hPa, 1 °K respectively. Negative values are shaded.

References

Ferranti, L., T. N. Palmer, F. Molteni, and E. Klinker, 1990: Tropical-extratropical interaction associated with the 30-60 day oscillation and its impact on medium and extended range prediction. *J. Atmos. Sci.,* **47**, 2177-2199.

Kalnay, E., M. and co-authors, 1996: The NCEP/NCAR 40-year Reanalysis Project. *Bull. Am. Meteorol. Soc.,* **77**,437-471.

Knotson, T. R., and K. M. Weickmann, 1987: 30-60 day atmospheric oscillations: Composite life cycles of convection and circulation anomalies. *Mon. Wea. Rev.,* **115**, 1407-1436.

Lau, K.-M., and T. J. Phillips, 1986: Coherent fluctuations of extratropical geopotential height and tropical convection in intraseasonal time scales. *J. Atmos. Sci.,* **43**, 1164-1181.

Li, L., and T. R. Nathan, 1994: The global atmospheric respinse to low-grequency tropical forcing: Zonally averaged basic states. *J. Atmos. Sci.,* **51**, 3412-3426.

Limpasuvan, V., and Hartmann., D. L., 2000: Wave-Maintained Annular Modes of Climate Variability. *J. Climate.,* **13**, 4414-4429.

Madden, R. A., and Julian, P. R., 1971: Detection of a 40-50 day oscillation in the tropical Pacific. *J. Atmos. Sci.,* **28**, 707-708.

Madden, R. A., and Julian, P. R., 1994: Observations of the 40-50-Day Tropical Oscillation-A Review. Mon. Wea. Rev., **122**, 814-837

Thompson, D. W. J., and J. M. Wallace, 1998: The Arctic Oscillation signature in the wintertime geopotential height and temperature fields. *Geophy. Res. Lett.,* **25**, 1297-1300

Wallace, J. M., 2000: North Atlantic Oscillation/Annular Mode: two paradigms-one phenomenon. *Q. J. Royal Met. Soc.,* **126**, 791-805.

Weickmann, K. M., and S. J. S. Khalsa, 1990: The shift of convection from the Indian Ocean to the western Pacific Ocean during a 30-60 day oscillation. *Mon. Wea. Rev.,* **118**, 964-978.