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Relationships between Stratospheric Quasi-Biennial Oscillation (QBO) and Precipitation Activities in Asia

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Abstract

The influence of stratospheric quasi-biennial oscillation (QBO) on global precipitation features was studied over a 25-year period. The years from 1980 to 2004 are classified into easterly and westerly phases of QBO. Composite analyses in Asia reveal noteworthy pluvial anomalies near the Philippines, and inactive front activity and typical drought events due to adiabatic descent over Japan during the easterly phase of QBO. Cool summers and extreme rainfall events in Japan tend to prevail in the westerly phase. In particular, ten Typhoons struck Japan in 2004 accompanied by the westerly phase of QBO.

Key words : stratospheric quasi-biennial oscillation (QBO), precipitation, Asian monsoon region, meridional circulation

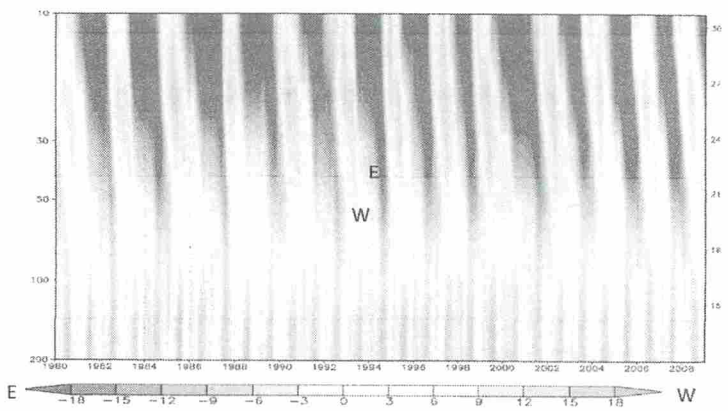

Fig. 1 Time-height cross-section of the monthly zonal-mean zonal wind (positive value is westerly) near the equator (5° N-5° S). Left and right axes indicate air pressure (hPa) and altitude (km), respectively. The unit of zonal wind is m s^{-1}.

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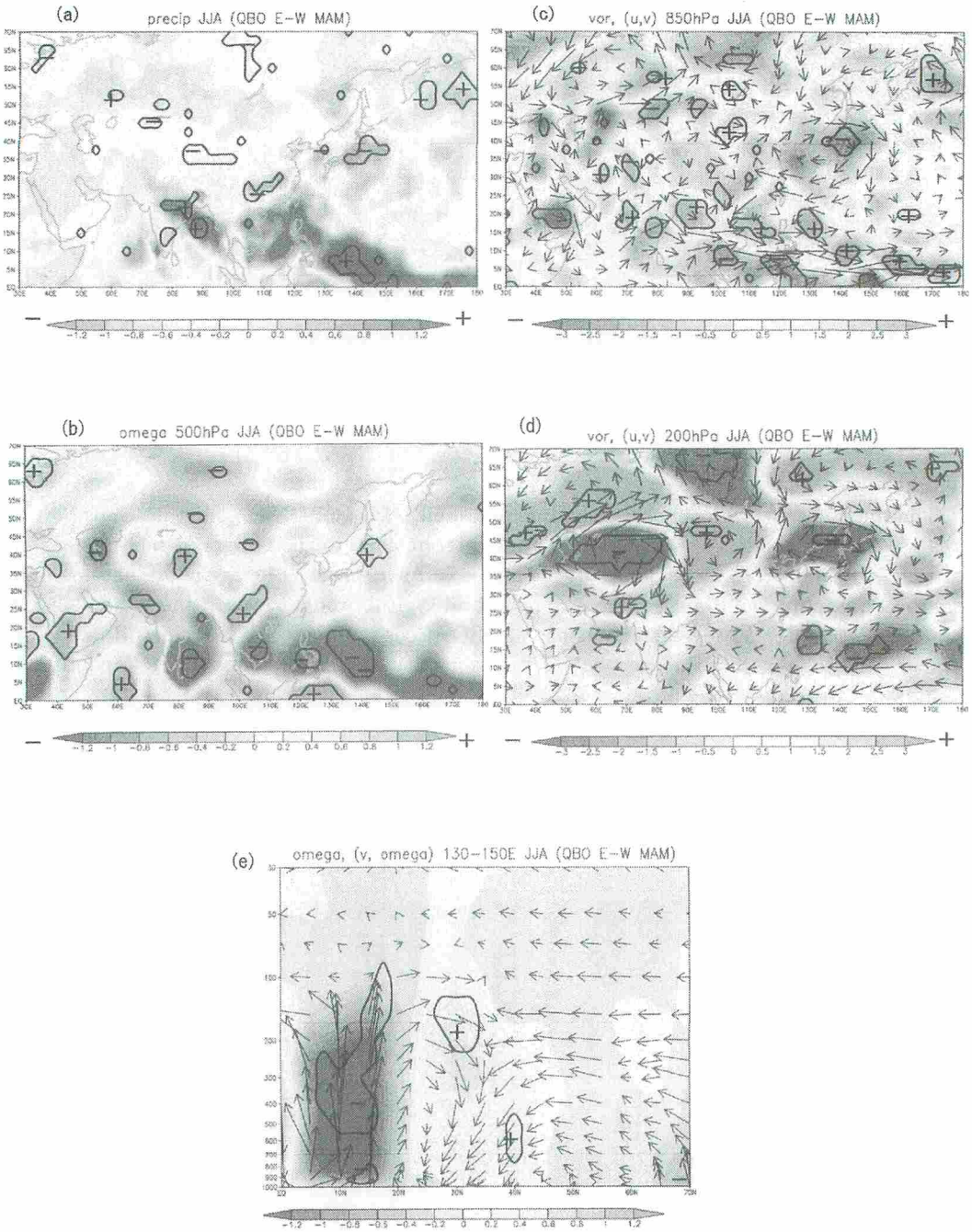

Fig. 2 Horizontal maps of (a) precipitation, (b) vertical p-velocity at 500 hPa, and vorticity at (c) 850 hPa and (d) 200 hPa in northern summer (June-July-August). Vectors on the vorticity maps indicate horizontal wind. (e) Latitude-height cross-section of vertical p-velocity (shade) and meridional circulation (vector) over East Asia (130-150° E) in northern summer (June-July-August). All values are evaluated as easterly phase years minus westerly phase years. The units are mm day^{-1} for precipitation, 10^{-2} Pa s^{-1} for vertical p-velocity, 10^{-6} s^{-1} for vorticity, and m s^{-1} for horizontal wind. Thick lines indicate the borders of the regions reaching a 95% significant level.

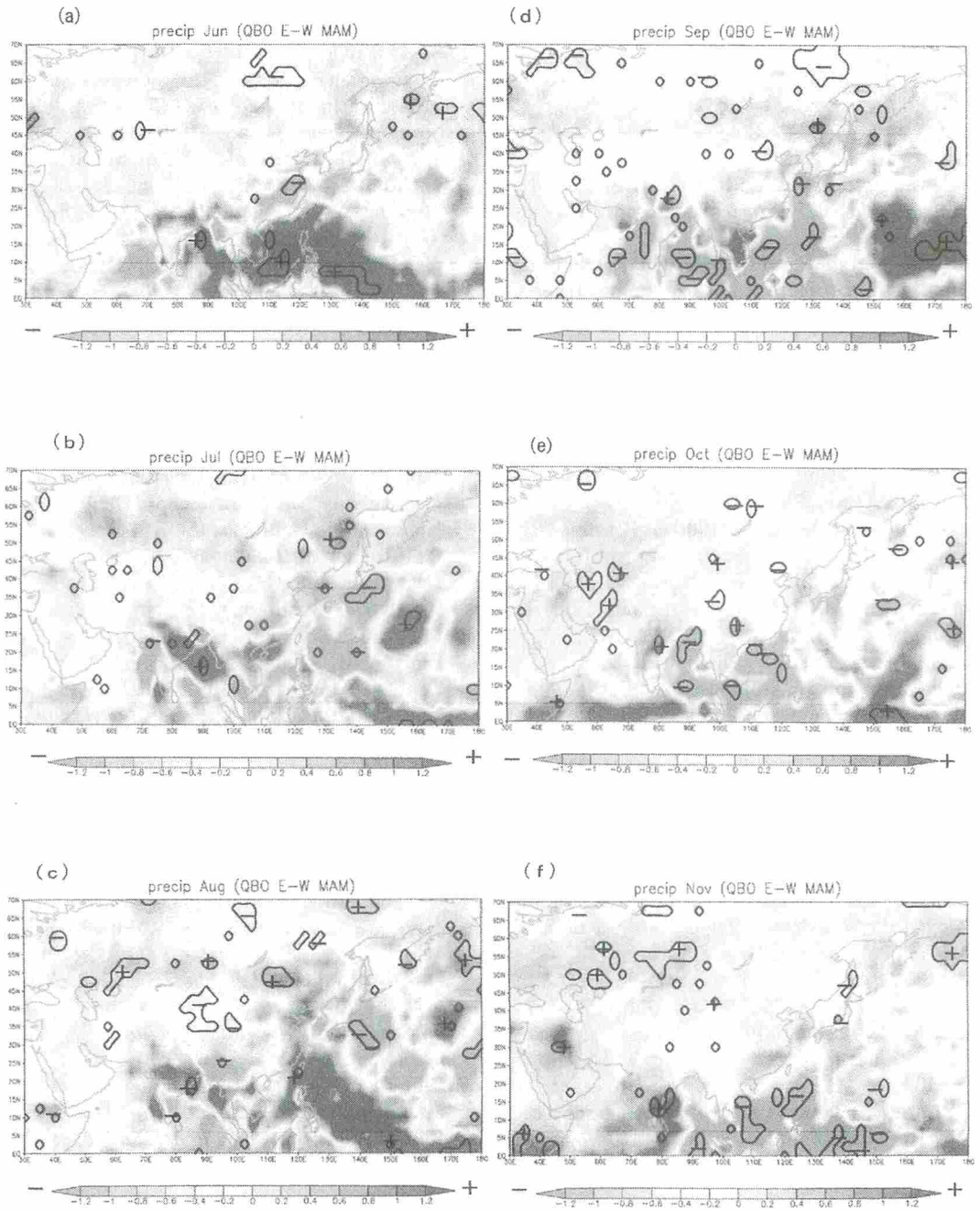

Fig. 3 Horizontal maps of precipitation in (a) June, (b) July, (c) August, (d) September, (e) October, and (f) November. All values are evaluated as easterly phase years minus westerly phase years. The unit is mm day^{-1}. Thick lines indicate the borders of regions a reaching 95% significant level.

文　献

Andrews, D.G., Holton, J.R. and Leovy, C.B. (1987): *Middle Atmosphere Dynamics*. Academic Press, 489p.

Angell, J.K. and Korshover, J. (1964): Quasi-biennial variations in temperature, total ozone, and tropopause height. *Journal of the Atmospheric Sciences*, **21**, 479–492.

Baldwin, M.P., Gray, L.J., Dunkerton, T.J., Hamilton, K., Haynes, P.H., Randel, W.J., Holton, J.R., Alexander, M.J., Hirota, I., Horinouchi, T., Jones, D.B.A., Kinnersley, J.S., Marquardt, C., Sato, K. and Takahashi, M. (2001): The quasi-biennial oscillation. *Reviews of Geophysics*, **39**, 179–229.

Chattopadhyay, J. and Bhatla, R. (2002): Possible influence of QBO on teleconnections relating Indian summer monsoon rainfall and sea-surface temperature anomalies across the equatorial Pacific. *International Journal of Climatology*, **22**, 121–127.

Claud, C. and Terray, P. (2007): Revisiting the possible links between the quasi-biennial oscillation and the Indian summer monsoon using NCEP R-2 and CMAP fields. *Journal of Climate*, **20**, 773–787.

Collimore, C.C., Martin, D.W., Hitchman, M.H., Huesmann, A. and Waliser, D.E. (2003): On the relationship between the QBO and tropical deep convection. *Journal of Climate*, **16**, 2552–2568.

Gray, W.M., Sheaffer, J.D. and Knaff, J.A. (1992): Influence of the stratospheric QBO on ENSO variability. *Journal of the Meteorological Society of Japan*, **70**, 975–995.

Hasebe, F. (1980): A global analysis of the fluctuation of total ozone, II. Non-stationary annual oscillation, quasi-biennial oscillation, and long-term variations in total ozone. *Journal of the Meteorological Society of Japan*, **58**, 104–117.

Holton, J.R. and Lindzen, R.S. (1972): An updated theory for the quasi-biennial cycle of the tropical stratosphere. *Journal of the Atmospheric Sciences*, **29**, 1076–1080.

Holton, J.R. and Tan, H.C. (1980): The influence of the equatorial quasi-biennial oscillation on the global circulation at 50 mb. *Journal of the Atmospheric Sciences*, **37**, 2200–2208.

Inoue, M. and Takahashi, M. (2009): Connection between the Asian summer monsoon and stratosphere-troposphere circulation over the Asian region. *Journal of the Meteorological Society of Japan*, **87**, 119–138.

Iwao, K. and Takahashi, M. (2008): A precipitation seesaw mode between northeast Asia and Siberia in summer caused by Rossby waves over the Eurasian continent. *Journal of Climate*, **21**, 2401–2419.

Kalnay, E., Kanamitsu, M., Kistler, R., Collins, W., Deaven, D., Gandin, L., Iredell, M., Saha, S., White, G., Woollen, J., Zhu, Y., Chelliah, M., Ebisuzaki, W., Higgins, W., Janowiak, J., Mo, K.C., Ropelewski, C., Wang, J., Leetmaa, A., Reynolds, R., Jenne, R. and Joseph, D. (1996): The NCEP/NCAR 40-year reanalysis project. *Bulletin of the American Meteorological Society*, **77**, 437–471.

Kanno, H. (2004): Five-year cycle of north-south pressure difference as an index of summer weather in northern Japan from 1982 onwards. *Journal of the Meteorological Society of Japan*, **82**, 711–724.

Kawatani, Y., Tsuji, K. and Takahashi, M. (2005): Zonally non-uniform distribution of equatorial gravity waves in an atmospheric general circulation model. *Geophysical Research Letters*, **32**, L23815, doi:10.1029/2005GL024068.

Kistler, R., Kalnay, E., Collins, W., Saha, S., White, G., Woollen, J., Chelliah, M., Ebisuzaki, W., Kanamitsu, M., Kousky, V., van den Dool, H., Jenne, R. and Fiorino, M. (2001): The NCEP-NCAR 50-year reanalysis: Monthly means CD-ROM and documentation. *Bulletin of the American Meteorological Society*, **82**, 247–267.

Kwan, K.F. and Samah, A.A. (2003): A conceptual model relating the quasi-biennial oscillation and the tropospheric biennial oscillation. *International Journal of Climatology*, **23**, 347–362.

Marshall, A.G. and Scaife, A.A. (2009): Impact of the QBO on surface winter climate. *Journal of Geophysical Research*, **114**, D18110, doi:10.1029/2009JD011737.

Maruyama, T. and Tsuneoka, Y. (1988): Anomalously short duration of the easterly wind phase of the QBO at 50 hPa in 1987 and its relationship to an El Nino event. *Journal of the Meteorological Society of Japan*, **66**, 629–633.

Meehl, G.A. (1993): A coupled air-sea biennial mechanism in the tropical Indian and Pacific regions: Role of the ocean. *Journal of Climate*, **6**, 31–41.

Naito, Y. and Hirota, I. (1997): Interannual variability of the northern winter stratospheric circulation related to the QBO and the solar cycle. *Journal of the Meteorological Society of Japan*, **75**, 925–937.

Nitta, T. (1987): Convective activities in the tropical western Pacific and their impact on the Northern Hemisphere summer circulation. *Journal of the Meteorological Society of Japan*, **65**, 373–390.

Niwano, M. and Takahashi, M. (1998): The influence of the equatorial QBO on the northern hemisphere winter circulation of a GCM. *Journal of the Meteorological Society of Japan*, **76**, 453–461.

Pawson, S. and Fiorino, M. (1999): A comparison of reanalyses in the tropical stratosphere. Part 3: Inclusion of the pre-satellite data era. *Climate Dynamics*, **15**, 241-250.

Plumb, R.A. and Bell, R.C. (1982): A model of the quasi-biennial oscillation on an equatorial beta-plane. *Quarterly Journal of the Royal Meteorological Society*, **108**, 335-352.

Randel, W.J., Wu, F., Swinbank, R., Nash, J. and O'Neill, A. (1999): Global QBO circulation derived from UKMO stratospheric analyses. *Journal of the Atmospheric Sciences*, **56**, 457-474.

Randel, W.J., Wu, F. and Gaffen, D.J. (2000): Interannual variability of the tropical tropopause derived from radiosonde data and NCEP reanalyses. *Journal of Geophysical Research*, **105**, 15509-15523.

Sato, K. and Dunkerton, T.J. (1997): Estimates of momentum flux associated with equatorial Kelvin and gravity waves. *Journal of Geophysical Research*, **102**, 26247-26261.

Trepte, C.R. and Hitchman, M.H. (1992): Tropical stratospheric circulation deduced from satellite aerosol data. *Nature*, **355**, 626-628.

Ueda, H. and Yasunari, T. (1996): Maturing process of the summer monsoon over the western North Pacific—A coupled ocean/atmosphere system—. *Journal of the Meteorological Society of Japan*, **74**, 493-508.

Xie, P. and Arkin, P.A. (1997): Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. *Bulletin of the American Meteorological Society*, **78**, 2539-2558.

Yamakawa, S. (1997): The impact of the Pinatubo eruption on global and regional climatic systems. *Journal of Agricultural Meteorology*, **52**, 713-716.

山川修治 (2005): 季節～数十年スケールからみた気候システム変動. 地学雑誌, **114**, 460-484.

山川修治 (2009): 気候気象災害. 日本第四紀学会 50 周年記念 CD 出版.

Yamakawa, S. and Suppiah, R. (2009): Extreme climatic events in recent years and their links to large-scale atmospheric circulation features. *Global Environmental Research*, **13**, 69-78.

Yasunari, T. (1989): A possible link of the QBOs between the stratosphere, troposphere and sea surface temperature in the tropics. *Journal of the Meteorological Society of Japan*, **67**, 483-493.

Yoshino, M. (1965): Four stages of the rainy season in early summer over East Asia (Part 1). *Journal of the Meteorological Society of Japan*, **43**, 231-245.

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