



## **Controlling Mechanisms of the Quasi-Biennial Oscillation to the Madden-Julian Oscillation for Boreal winter: A Role of vertically propagating Kelvin waves**

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The Madden-Julian Oscillation (MJO) is an eastward propagating disturbance of convection and circulation from the Indian Ocean to the dateline with the intraseasonal time scale in tropics. Although the MJO is known as a coupled atmosphere-ocean phenomenon, recent studies find that the MJO convection for boreal winter is closely correlated to the Quasi-Biennial Oscillation (QBO) rather than the El Nino Southern Oscillation. However, their mechanisms are still unclear.

This study demonstrates how the QBO controls the MJO convection using Reanalysis datasets and finds that the vertically propagating Kelvin wave plays a crucial role to connect the QBO to the MJO activity: 1) Easterly QBO intensifies the eastward tilting temperature structure with height near the tropical tropopause layer, which is the vertically propagating Kelvin wave-like structure. 2) This temperature distribution makes the warm advection vertically and horizontally expanded. 3) This zonal advection results in the adiabatic cooling upward motion to compensate the dynamically induced warming. 4) This upper upward wind promotes the MJO convection. In contrast, the processes mentioned above are not working, since westerly QBO does not strengthen the Kelvin wave.