Covariance of Meiyu Front and Tropospheric Jet Variability on Daily and Interannual time scales

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This abstract must be 150 words or less.

1. Introduction

China receives about 60% of its rainfall from May to August, a phenomenon referred to as the East Asian Summer Monsoon. Regional peak rates occur from the end of May to the middle of July, when precipitation occurs in continuous frontal bands induced by the Tibetan Plateau upstream. This feature is known as the Meiyu Front, and the duration of its appearance as Meiyu Season. In the annual mean, the Meiyu Front has been claimed to show northward progression and abrupt transitions between preferred latitudes[**?**]. Anecdotal evidence suggests an abrupt shift in rainfall patterns beginning in the 1970s, with Northern China experiencing severe droughts and Southern China flooding ("North Dry South Wet"), leading the Chinese government to embark on one of the most expensive engineering products in the history of mankind, the South-North Water Transfer Project. In spite of attempts to attribute observed change to global warming, no mechanism has been agreed on.

Regional prediction of climate change under global warming presents greater difficulty than global projection. In the 5th edition of the IPCC report, the CMIP 5 model suite does not come to a consensus on the sign of future summer rainfall changes in East Asia. Several authors have proposed templates for regional mechanisms resulting from CO2 forcing. The"rich get richer" mechanism anticipates increased rainfall in regions of net precipitation and decreases in regions of net evaporation due to amplified moisture transport[**?**]. Lintner and Neelin**?** and Chou et al.**?** proposed a more comprehensive set of phenomena based on model projection of changes in convective regions. These include not only the"rich get richer" but also the "upped ante" mechanism, wherein convective margins see droughts because increased humidity in convective regions raises the threshold for convection and moisture gradients are stronger. This framework has been used to understand ENSO-related rainfall variability in South America. However, it is difficult to apply these existing theories to a region with high spatial and temporal heterogeneity such as East Asia.

A new paleoclimate study proposes the tropospheric jet as an indicator of past rainfall patterns in China [?][?]. The authors study a marine sediment core in the Sea of Japan, downstream from both the Taklamakan Desert and Gobi Desert, and are able to differentiate between dust from each of these sources using electron spin resonance (ESR) and grain size. In the present day, Gobi Desert dust is only advected during spring before the tropospheric jet passes north of the Tibetan Plateau and [?], whereas the mechanism of transport of Taklamakan Desert dust remains active in summer when the jet occupies a low variability position on the northern flank of the Tibetan Plateau. Therefore, they attribute increases in Gobi Desert dust to longer springs and shorter summers. Since Holocene changes in precipitation match the timing of abrupt changes in their record, they therefore conclude that the tropospheric jet controls precipitation variability over millennial time scales.

The present work aims to test this apparent coupling of the jet and Meiyu Front in the present-day. Current theory suggests that the tropospheric jet plays a major role in Meiyu formation, either by zonal advection of sensible heat from the Tibetan Plateau upwind [?], or as part of the orographically forced circulation that produces meridional wind convergence over China[?]. Past work has compared jet and Meiyu variability over shorter time periods or with coarse resolution?, but none has systematically performed a comparison with daily data. Since the behavior of the tropospheric jet is coupled to global climate variability, our work holds the promise of attributing rainfall trends in China to global change via the jet.

The climatology of the Meiyu Front has been studied[?] but no full catalog of interannual and daily variability has previously existed. We use 57 years of rain gauge data over China at .25 by .25 degree resolution[?]. These data were processed with a Meiyu detection algorithm. Our algorithm uses a convergent algorithm to detect continuous zonal precipitation structure and returns information about whether a Meiyu Front is visible on each day, as well as the position, meridional tilt and intensity if a front exists. Poor fits are isolated by using a quality score Q which measures the percentage of rainfall occurring within 300 km of our attempted fit. Our method shows good preliminary ability to reproduce known properties of the jet and northward progression during Meiyu Season.

For tropospheric jet variability, we employ a database based on ERA-40 reanalysis data developed by Schiemann et al.?. Their database includes every appearance of a tropospheric jet in East Asia for 1958-2001 at 6-hourly intervals using simple criteria: Positive zonal wind and local maximum in excess of 30 m/s.

We first attempt to define a transition date from spring to summer behavior in the jet database, and equivalently from Meiyu Season to post-Meiyu in our new catalog. Preliminary evidence suggests a long-term perturbation in mean jet path in East Asia from the 1960s to present with later onset of summer jet and shorter total duration of summer jet. In our Meiyu database it is more difficult to extract an exact transition date due to high-frequency variability in space and time. However, we observe an apparent shift in the timing of northward progression of the Meiyu Front between 1951-1970 and 1988-2007. If both databases demonstrate a robust decadal shift, they may provide an explanation for the anecdotal South Wet-North Dry pattern of rainfall change.

Finally, we use our knowledge of daily Meiyu positions to isolate preferred configurations for different dates, as well as probability distributions of the tropospheric jet associated with each configuration. If a robust change in mean jet progression is detected, we may be able to isolate a corresponding shift in Meiyu distribution that may have previously gone unnoticed due to extreme temporal variability in the data.

Acknowledgments. APHRODITE is...

References

Chen, J., and S. Bordoni (2014), Orographic Effects of the Tibetan Plateau on the East Asian Summer Monsoon: An energetic perspective, *J. Climate*, p. 140113153908002, doi:10.1175/JCLI-D-13-00479.1.

Chou, C., J. D. Neelin, C.-A. Chen, and J.-Y. Tu (2009), Evaluating the rich-get-richer mechanism in tropical precipitation change under global warming, *J. Climate*, *22*(8), 1982–2005, doi:10.1175/2008JCLI2471.1.

Ding, Y., and J. C. L. Chan (2005), The East Asian summer monsoon: an overview, *Meteorol. Atmos. Phys.*, *89*(1-4), 117–142, doi:10.1007/s00703-005-0125-z.

Held, I., and B. Soden (2006), Robust responses of the hydrological cycle to global warming, *J. Climate*, *19*(21), 5686–5699.

Liang, X., and W. Wang (1998), Associations between China monsoon rainfall and tropospheric jets, *Q. J. R. Meteorol. Soc.*, *124*(May), 2597–2623.

Lintner, B., and J. D. Neelin (2007), A prototype for convective margin shifts, *Geophys. Res. Lett.*, *34*(5), L05,812, doi:10.1029/2006GL027305.

Nagashima, K., R. Tada, A. Tani, Y. Sun, Y. Isozaki, S. Toyoda, and H. Hasegawa (2011), Millennial-scale oscillations of the westerly jet path during the last glacial period, *J. Asian Earth Sci.*, *40*(6), 1214–1220, doi:10.1016/j.jseaes.2010.08.010.

Nagashima, K., R. Tada, and S. Toyoda (2013), Westerly jet-East Asian summer monsoon connection during the Holocene, *Geochemistry, Geophys. Geosystems*, *14*(12), 5041–5053, doi:10.1002/2013GC004931.

Roe, G. (2009), On the interpretation of Chinese loess as a paleoclimate indicator, *Quat. Res.*, *71*(2), 150–161, doi:10.1016/j.yqres.2008.09.004.

Sampe, T., and S.-P. Xie (2010), Large-Scale Dynamics of the Meiyu-Baiu Rainband: Environmental Forcing by the Westerly Jet, *J. Climate*, *23*(1), 113–134, doi:10.1175/2009JCLI3128.1.

Schiemann, R., D. Lüthi, and C. Schär (2009), Seasonality and Interannual Variability of the Westerly Jet in the Tibetan Plateau Region, *J. Climate*, *22*(11), 2940–2957, doi:10.1175/2008JCLI2625.1.

Yatagai, A., K. Kamiguchi, O. Arakawa, A. Hamada, N. Yasutomi, and A. Kitoh (2012), APHRODITE: Constructing a Long-Term Daily Gridded Precipitation Dataset for Asia Based on a Dense Network of Rain Gauges, *Bull. Am. Meteorol. Soc.*, *93*(9), 1401–1415, doi:10.1175/BAMS-D-11-00122.1.