



## Changes in Tropical Cyclone Number in the Western North Pacific in a Warming Environment as Implied by Classical Thermodynamics

PDF (Size: 2223KB) PP. 29-35 DOI: 10.4236/ijg.2011.21003

### Author(s)

Xiaogang Zhou, Chongjian Liu, Ying Liu, Hui Xu, Xiuming Wang

### ABSTRACT

Observational analyses show that the equatorial trough in the western North Pacific (WNP) is a well-known origin for tropical cyclones (TC) which have tended to weaken in intensity and decrease in number during the last several decades under global warming. A scientific problem then arises as to why higher sea surface temperatures (SSTs), one of the necessary conditions for typhoon genesis, can cause a weakened equatorial trough and a decreased TC number. In this paper, the WNP is taken as an example to illustrate a possible mechanism for the above-mentioned seemingly counterintuitive phenomena and explain the causality between the unusually heterogeneous pattern of SSTs in a warming environment and TC number in the WNP. This mechanism is based substantially on the second law of thermodynamics.

### KEYWORDS

Second Law of Thermodynamics, Global Warming, Thermal Wind Relation, Sea Surface Temperature

### Cite this paper

X. Zhou, C. Liu, Y. Liu, H. Xu and X. Wang, "Changes in Tropical Cyclone Number in the Western North Pacific in a Warming Environment as Implied by Classical Thermodynamics," *International Journal of Geosciences*, Vol. 2 No. 1, 2011, pp. 29-35. doi: 10.4236/ijg.2011.21003.

### References

- [1] D. R. Easterling, J. L. Evana, P. Y. Grosman, T. R. Karl, K. E. Kunkel and P. Amberje, " Observed Variability and Trends in Extreme Climate Events: A Brief Review," *Bulletin of the American Meteorological Society*, Vol. 81, No. 3, 2000, pp. 417-425. doi:10.1175/1520-0477(2000)081<0417:OVATIE>2.3.CO;2
- [2] T. R. Karl, G. Kukla, V. N. Razuvayev, M. J. Changery, R. G. Quayle, R. T. Heim Jr, D. R. Easterling and C. B. Fu, " Global Warming: Evidence for Asymmetric Diurnal Temperature Change," *Geophysical Research Letters*, Vol. 18, No. 12, 1991, pp. 2253-2256. doi:10.1029/91GL02900
- [3] M. Manton and J. Eral, " Trends in Extreme Daily Rainfall and Temperature in Southeast Asia and the South Pacific: 1961-1998," *International Journal of Climatology*, Vol. 21, No. 3, 2001, pp. 269-284. doi:10.1002/joc.610
- [4] S. W. Wang and D. Y. Gong, " Enhancement of the Warming Trend in China," *Geophysical Research Letters*, Vol. 27, No. 16, 2000, pp. 2581-2584. doi:10.1029/1999GL010825
- [5] R. S. Cerveny, J. Lawrimore, R. Edwards and C. Landsea, " Extreme Weather Records," *Bulletin of the American Meteorological Society*, Vol. 88, No. 6, 2007, pp. 853-860. doi:10.1175/BAMS-88-6-853
- [6] C. Wang, S. K. Li and D. B. Enfield, " Atlantic Warm Pool Acting as a Link between Atlantic Multidecadal Oscillation and Atlantic Tropical Cyclone Activity," *Geochemistry, Geophysics, Geosystems*, Vol. 9, 2008, pp. 1-17. doi:10.1029/2007GC001809
- [7] H. von Storch, " An Attempt to Homogeneously Describe 60 Years Statistics of TC Activity in East Asia: 1948- 2007," Presented in 2008 Taiwan Climate Workshop, 18 November 2008, Taipei,

- [Open Special Issues](#)
- [Published Special Issues](#)
- [Special Issues Guideline](#)

[IJG Subscription](#)
[Most popular papers in IJG](#)
[About IJG News](#)
[Frequently Asked Questions](#)
[Recommend to Peers](#)
[Recommend to Library](#)
[Contact Us](#)

Downloads:	165,284
------------	---------

Visits:	394,253
---------	---------

[Sponsors, Associates, and Links >>](#)

- [8] J. L. McBride and H. Ramsay, "Relationship between Tropical Cyclone Activity and Sea Surface Temperature in the Southern Hemisphere," Presented in 2nd International Summit on Hurricanes and Climate Change, May 31–June 5, 2009, Corfu, Greece (in "Aegean Conferences Series-Vol. 41" ; p. 23).
- [9] J. B. Elsner and J. T. Hagger, "Hurricanes and Climate Change," Springer, 2009. doi:10.1007/978-0-387-09410-6
- [10] L. Ma and L. Chen, "The Relationship between Global Warming and the Variation in Tropical Cyclone Frequency over the Western North Pacific," *Journal of Tropical Meteorology*, Vol. 15, No. 1, 2009, pp. 38-44.
- [11] W. M. Gray, "Global View of the Origin of Tropical Disturbances and Storms," *Monthly Weather Review*, Vol. 96, No. 4, 1967, pp. 669-700.
- [12] J. R. Bates, "Dynamics of Disturbances on the Intertropical Convergence Zone," *Quarterly Journal of the Royal Meteorological Society*, Vol. 96, No. 410, 1970, pp. 677-701. doi:10.1002/qj.49709641010
- [13] J. G. Charney, "Tropical Cyclonegenesis and the Formation of the Intertropical Convergence Zone, in *Mathematical Problems of Geophysical Fluid Dynamics*," In: W. H. Reid, Eds., *Lectures in Applied Mathematics*, American Mathematical Society, New York, Vol. 13, 1971, pp. 335-368.
- [14] L. M. Briegel and W. M. Frank, "Large-Scale Influences on Tropical Cyclogenesis in the Western North Pacific," *Monthly Weather Review*, Vol. 125, No. 2, 1997, pp. 1397-1413. doi:10.1175/1520-0493(1997)125<1397:LSIOTC>2.0.CO;2
- [15] E. A. Ritchie and G. J. Holland, "Large-Scale Patterns Associated with Tropical Cyclogenesis in the Western Pacific," *Monthly Weather Review*, Vol. 127, No. 9, 1999, pp. 2027-2043. doi:10.1175/1520-0493(1999)127<2027:LSPAWT>2.0.CO;2
- [16] S. C. Cha and J. L. Evans, "Comparison of the Structure of the ITCZ in the West Pacific during the Boreal Summers of 1989–93 Using AMIP Simulations and ECMWF Reanalysis," *Journal of Climate*, Vol. 15, No. 24, 2002, pp. 3459-3568.
- [17] E. Kalnay, et al., "The NCEP/NCAR 40-Year Reanalysis Project," *Bulletin of the American Meteorological Society*, Vol. 77, No.3, 1996, pp. 437-471. doi:10.1175/1520-0477(1996)077<0437:TNYRP>2.0.CO;2
- [18] J. Bjerknes, "Atmospheric Teleconnections from the Equatorial Pacific," *Monthly Weather Review*, Vol. 97, No. 2, 1969, pp. 163-172. doi:10.1175/1520-0493(1969)097<0163:ATFTEP>2.3.CO;2
- [19] J. R. Holton, J. M. Wallace and J. A. Young, "On Boundary Layer Dynamics and the ITCZ," *Journal of the Atmospheric Sciences*, Vol. 28, No. 2, 1971, pp. 275-280. doi:10.1175/1520-0469(1971)028<0275:OBLDAT>2.0.CO;2
- [20] C. -R. Ho, X. -H. Yan and Q. Zheng, "Satellite Observations of Upper-Layer Variabilities in the Western Pacific Warm Pool," *Bulletin of the American Meteorological Society*, Vol. 76, No. 5, 1995, pp. 669-679. doi:10.1175/1520-0477(1995)076<0669:SOOULV>2.0.CO;2
- [21] N. E. Graham and T. P. Barnett, "Sea Surface Temperature, Surface Wind Divergence and Convection over Tropical Oceans," *Science*, Vol. 238, No. 4827, 1987, pp. 657-659. doi:10.1126/science.238.4827.657
- [22] K. -M. Lau, H. -T. Wu and S. Bony, "The Role of Large-Scale Atmospheric Circulation in the Relationship between Tropical Convection and Sea Surface Temperature," *Journal of Climate*, Vol. 10, No. 3, 1997, pp. 381-392. doi:10.1175/1520-0442(1997)010<0381:TROLSA>2.0.CO;2
- [23] R. S. Lindzen and S. Nigam, "On the Role of Sea Surface Temperature Gradients in Forcing Low Level Winds and Convergence in the Tropics," *Journal of the Atmospheric Sciences*, Vol. 44, 1987, pp. 2440-2458. doi:10.1175/1520-0469(1987)044<2418:OTROSS>2.0.CO;2
- [24] I. Prigogine, "Introduction to Thermodynamics of Irreversible Processes," Charles C. Thomas, 1955.
- [25] S. R. de Groot and P. Mazur, "Non-Equilibrium Thermodynamics," North-Holland Publishing Company, 1962.
- [26] C. Liu and Y. Liu, "An Attempt at Improving a Global Spectral Model by Incorporating the Second Law

- [27] C. Liu, Y. Liu and H. Xu, " A Physics-Based Diffusion Scheme for Numerical Models," Geophysical