

**VARIABILITY OF THE CLOUD COVER  
IN LAOAG, ILOCOS NORTE**

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## ABSTRACT

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Clouds are one of the most important factors in meteorology and forecasting since clouds are directly linked to weather phenomena. The variation of cloud cover affects the amount of energy received and released by the Earth which results in the variation of other weather parameters. Cloud cover impact varies over different regions which makes it harder to understand. In this study, the variability of cloud cover over the northern Luzon region was investigated.

The following data were used: Cloud cover from the ERA-5 reanalysis cloud products, interpolated outgoing longwave radiation (OLR) and monthly climate index data from NOAA, and 850-hPa wind from ERA-5 reanalysis data on single levels.

Composite analysis was used to investigate the variability of cloud cover. It was found that cloud cover exhibits a seasonal cycle with its peak during June-August, corresponding to the occurrence of southeast monsoon or Habagat. ONI are found to be strongly correlated in the colder months which correspond to peaks in anomaly values in the annual cycle. High TCC can also be seen on seasons with prevalent south-western winds. The spatial distribution of TCC and OLR were also investigated and found to have a negative correlation.

Keywords: total cloud cover; variability; spatial variability; temporal variability; ENSO

## LITERATURE CITED

- American Meteorological Society. (2012, April 25). *Cloud*. Glossary of Meteorology. <https://glossary.ametsoc.org/wiki/Cloud>
- Brooks, C. F. (1951). The Use of Clouds in Forecasting. In *Compendium of Meteorology* (1st ed.). American Meteorological Society.
- Costa, S. M. S., & Shine, K. P. (2007). An estimate of the global impact of multiple scattering by clouds on outgoing long-wave radiation. *Quarterly Journal of the Royal Meteorological Society*, *132*(616), 885–895. <https://doi.org/10.1256/qj.05.169>
- Danso, D. K., Anquetin, S., Diedhiou, A., Lavaysse, C., Koba, A., & Touré, N. E. (2019). Spatio-temporal variability of cloud cover types in West Africa with satellite-based and reanalysis data. *Quarterly Journal of the Royal Meteorological Society*, *145*(725), 3715–3731. <https://doi.org/10.1002/qj.3651>
- Ghasemifar, E., Farajzadeh, M., Perry, M. C., Rahimi, Y. G., & Bidokhti, A. A. (2018). Analysis of spatiotemporal variations of cloud fraction based on geographic characteristics over Iran. *Theoretical and Applied Climatology*, *134*(3–4), 1429–1445. <https://doi.org/10.1007/s00704-017-2308-1>
- Guo, Z., Zhou, T., Wang, M., & Qian, Y. (2015). Impact of cloud radiative heating on East Asian summer monsoon circulation. *Environmental Research Letters*, *10*(7), 074014. <https://doi.org/10.1088/1748-9326/10/7/074014>
- Harrop, B. E., & Hartmann, D. L. (2016). The role of cloud radiative heating within the atmosphere on the high cloud amount and top-of-atmosphere cloud radiative effect. *Journal of Advances in Modeling Earth Systems*, *8*(3), 1391–1410. <https://doi.org/10.1002/2016MS000670>
- Houze, R. A., Geotis, S. G., Marks, F. D., & West, A. K. (1981). Winter Monsoon Convection in the Vicinity of North Borneo. Part I: Structure and Time Variation of the Clouds and Precipitation. *Monthly Weather Review*, *109*(8), 1595–1614. <https://doi.org/10.1175/1520-0493>

- Joshi, M. M., Gregory, J. M., Webb, M. J., Sexton, D. M. H., & Johns, T. C. (2008). Mechanisms for the land/sea warming contrast exhibited by simulations of climate change. *Climate Dynamics*, 30(5), 455–465. <https://doi.org/10.1007/s00382-007-0306-1>
- Koch, S. E., McQueen, J. T., & Karyampudi, V. M. (1995). A Numerical Study of the Effects of Differential Cloud Cover on Cold Frontal Structure and Dynamics. *Journal of the Atmospheric Sciences*, 52(7), 937–964. <https://doi.org/10.1175/1520-0469>
- Marsh, N., & Svensmark, H. (2000). Cosmic Rays, Clouds, and Climate. *Space Science Reviews*, 94, 215–230. <https://doi.org/10.1023/A:1026723423896>
- Matuszko, D., Bartoszek, K., & Soroka, J. (2022). Long-term variability of cloud cover in Poland (1971–2020). *Atmospheric Research*, 268, 106028. <https://doi.org/10.1016/j.atmosres.2022.106028>
- Meteoblue. (2020). *ERA5 · Technical Documentation*. <https://docs.meteoblue.com/>
- Segal, M., Physick, W. L., Heim, J. E., & Arritt, R. W. (1993). The Enhancement of Cold-Front Temperature Contrast by Differential Cloud Cover. *Monthly Weather Review*, 121(3), 867–873. <https://doi.org/10.1175/1520-0493>
- Taylor, P. C. (2012). Tropical Outgoing Longwave Radiation and Longwave Cloud Forcing Diurnal Cycles from CERES. *Journal of the Atmospheric Sciences*, 69(12), 3652–3669. <https://doi.org/10.1175/JAS-D-12-088.1>
- Teixeira, J., & Hogan, T. F. (2002). Boundary Layer Clouds in a Global Atmospheric Model: Simple Cloud Cover Parameterizations. *Journal of Climate*, 15(11), 1261–1276. [https://doi.org/10.1175/1520-0442\(2002\)015<1261:BLCIAG>2.0.CO;2](https://doi.org/10.1175/1520-0442(2002)015<1261:BLCIAG>2.0.CO;2)
- Tiedtke, M. (1993). Representation of Clouds in Large-Scale Models. *Monthly Weather Review*, 121(11), 3040–3061. <https://doi.org/10.1175/1520-0493>
- Tompkins, A. M. (2002). A Prognostic Parameterization for the Subgrid-Scale Variability of Water Vapor and Clouds in Large-Scale Models and Its Use to Diagnose Cloud Cover. *Journal of the Atmospheric Sciences*, 59(12), 1917–1942. <https://doi.org/10.1175/1520-0469>
- Trossmann, D. S., Palter, J. B., Merlis, T. M., Huang, Y., & Xia, Y. (2016). Large-scale ocean circulation-cloud interactions reduce the pace of transient climate change.

*Geophysical Research Letters*, 43(8), 3935–3943.  
<https://doi.org/10.1002/2016GL067931>

Twomey, S. (1971). The Composition of Cloud Nuclei. *Journal of the Atmospheric Sciences*, 28(3), 377–381. <https://doi.org/10.1175/1520-0469>

Waliser, D. E., Graham, N. E., & Gautier, C. (1993). Comparison of the Highly Reflective Cloud and Outgoing Longwave Radiation Datasets for Use in Estimating Tropical Deep Convection. *Journal of Climate*, 6(2), 331–353.  
<https://doi.org/10.1175/1520-0442>

Webb, E. J., & Magi, B. I. (2022). The Ensemble Oceanic Niño Index. *International Journal of Climatology*, 42(10), 5321–5341. <https://doi.org/10.1002/joc.7535>

Wheeler, M., & Kiladis, G. N. (1999). Convectively Coupled Equatorial Waves: Analysis of Clouds and Temperature in the Wavenumber–Frequency Domain. *Journal of the Atmospheric Sciences*, 56(4), 374–399. <https://doi.org/10.1175/1520-0469>