



A COMPARATIVE STUDY OF CLOUD FORMATION OVER MOUNTAINOUS AND LOWLAND AREAS IN MUEANG DISTRICT, CHIANG MAI PROVINCE, THAILAND

KUNYANUT KERDPHOPOUNG NATTHITA THAUN PEERAYAPAT SOTHORNTAWEEPONG PAKIN BANGKHOMNED
ADVISOR : BANNARUCK TANJAPHATKUL VAREE CHIANGMAI SCHOOL



ABSTRACT

This study investigates differences in cloud formation over mountainous and lowland areas in Mueang District, Chiang Mai Province, and examines atmospheric factors influencing these differences. Sky images above Doi Suthep and nearby lowland areas were recorded simultaneously four times per day from November 2024 to February 2025. Cloud cover was quantified using ImageJ, and meteorological data including air temperature, relative humidity, and wind speed were analyzed using weather station records and Google Earth Engine.

The results indicate that cloud formation over mountainous areas generally exhibits higher cloud cover than over lowland areas, particularly on clear-sky days. This pattern is associated with orographic lifting, in which air is forced to rise over mountainous terrain. However, during certain periods, cloud cover over lowland areas was comparable to or greater than the over mountainous areas. These cases are likely related to increased relative humidity during cooler conditions and wind patterns that transport moisture into lowland regions. Overall, the findings suggest that both topography and local atmospheric conditions, especially relative humidity, temperature, and wind play important roles in controlling cloud formation in the study area.

Keywords Mountain cloud formation, lowland cloud formation, weather conditions, cloud formation, topography



RESEARCH QUESTION

How does different topography influence cloud formation over mountainous and lowland areas?



INTRODUCTION

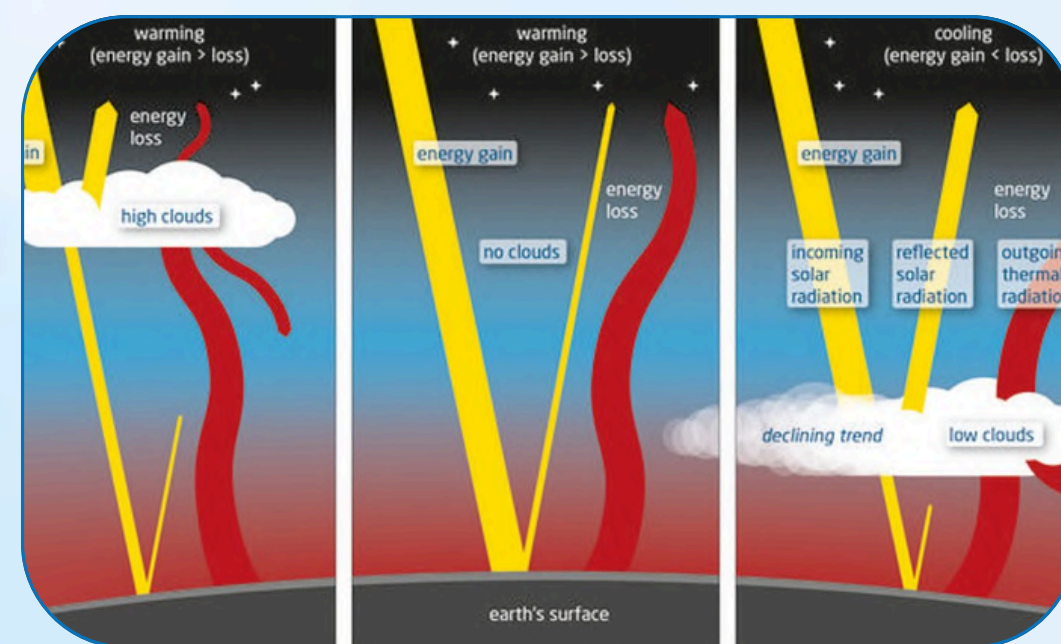


Figure 1 The role of clouds in Earth's energy balance, source: Phys.org (2024)

Clouds play an important role in the Earth's atmospheric system by influencing weather, climate, and the planet's energy balance. During the daytime, clouds reflect part of the Sun's radiation back into space, while at night they absorb and re-emit infrared radiation, helping to regulate surface temperature (NASA, 2023). Cloud cover and cloud type are therefore key indicators of atmospheric conditions and climate variability (IPCC, 2021).

Cloud formation occurs when moist air rises and cools, causing water vapor to condense into cloud droplets. This uplift can occur through several mechanisms, including surface heating, frontal lifting, convergence, and orographic lifting over mountainous terrain (UCAR, 2022). These processes produce different cloud characteristics depending on topography and local atmospheric factors.

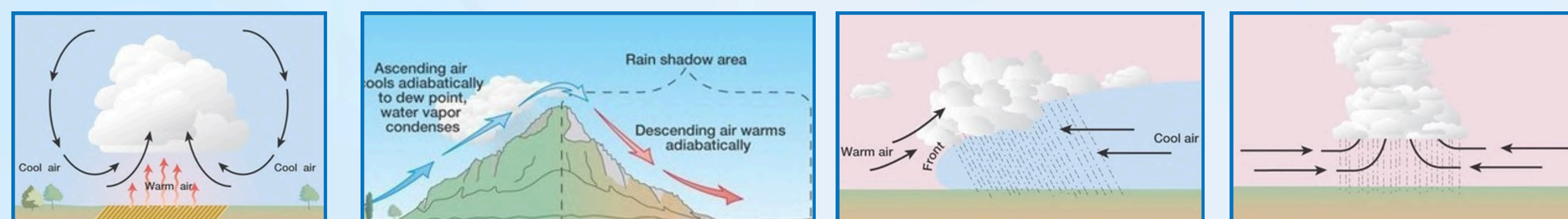


Figure 2 Cloud lifting mechanisms, including convective, orographic, frontal, and convergent processes. Adapted from Pecimotika et al. (accessed via ResearchGate, 2026).



RESEARCH METHODS

From regular sky observations at our school, we noticed clear differences in cloud formation over mountainous areas and nearby lowland areas. Based on this observation, we conducted a comparative study of cloud formation over Doi Suthep and adjacent lowland areas in Chiang Mai Province, following the principles of citizen science and the GLOBE Program.

- Selected observation point where both mountainous nearby lowland areas could be seen clearly from the same location.
- Take a photo of sky at four different times: **8:00AM 10:00AM 12:00AM and 14:00PM.**
- Analyzed cloud cover over using ImageJ software and identified cloud type with cloud chart.
- Compared cloud characteristics in terms of cloud cover and cloud types, together with meteorological data obtained from weather station observations and ERA5-Land (ECMWF) accessed via Google Earth Engine, including temperature, relative humidity, wind direction, and wind speed.
- Discussion and conclusions were drawn from the findings.

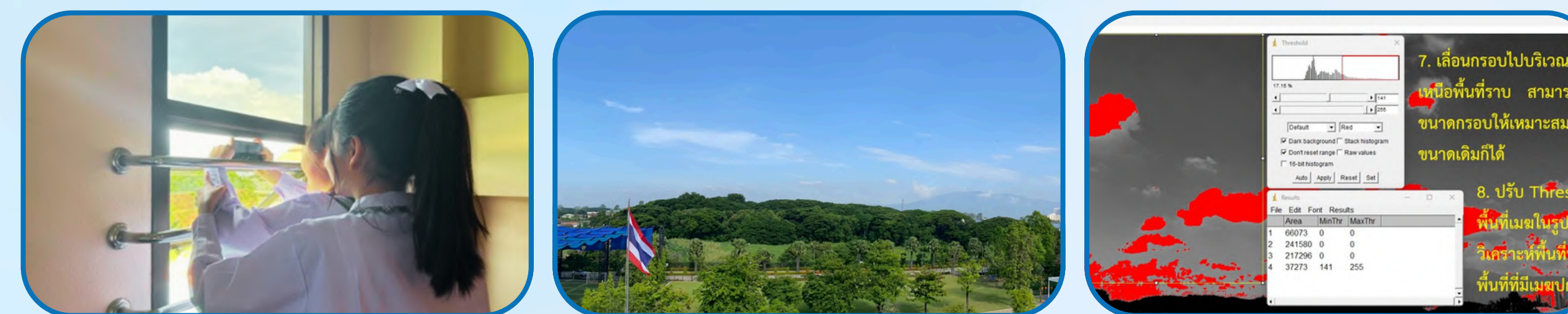


Figure 3 Sky photograph and cloud cover analyzing



RESULTS

Cloud cover analysis over mountainous and lowland areas between November 2024 and February 2025 revealed that **mountainous areas had a slightly higher average cloud cover of 52.7%. In comparison, the average cloud cover over the lowland area was 50.4%.** Both areas showed similar variability in cloud cover, with standard deviation of 35.8 for mountainous areas and 37.4 for lowland areas.

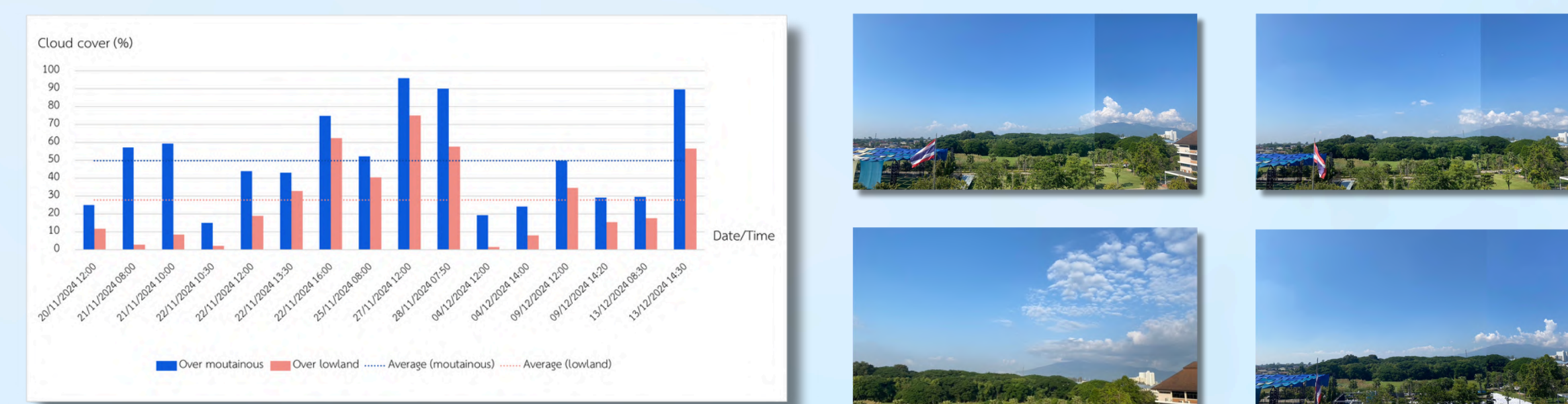


Figure 4 Difference of cloud cover between over mountainous areas and lowland areas on clear-sky days.

Additional analysis shows that cloud formation occurs more frequently over mountainous areas than over lowland areas, especially **on clear-sky days. The average cloud cover was 49.8% over mountainous areas, compared to 27.9% over lowland areas.** Cumulus clouds were most commonly observed, with Altostratus occurring occasionally. This pattern is consistent with the mechanism of orographic lifting, in which air is forced to rise over mountainous terrain, leading to cooling and condensation of water vapor.

In some cases, cloud cover over lowland areas was similar to or greater than that over mountainous areas, likely due to higher relative humidity during specific periods. During winter mornings, lower temperatures increase relative humidity and allow clouds to form more easily. This effect may have been enhanced by La Niña, which increased moisture transport from the sea into northern Thailand, leading to cloud formation even in typically dry seasons. On such days, Stratus, Stratocumulus, and Altostratus clouds were commonly observed.

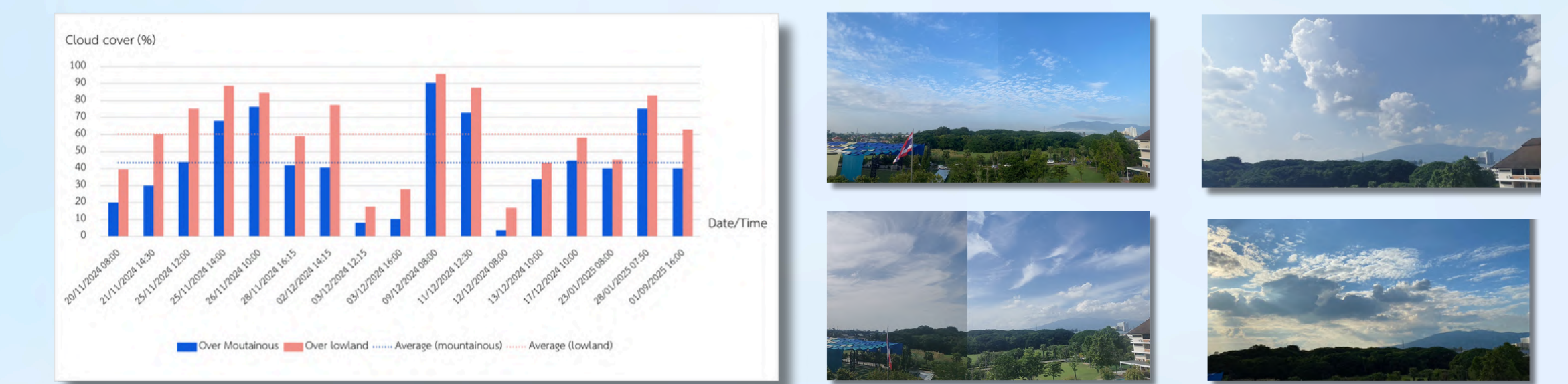


Figure 5 Example of days when cloud cover over lowland areas was greater than that over mountainous areas

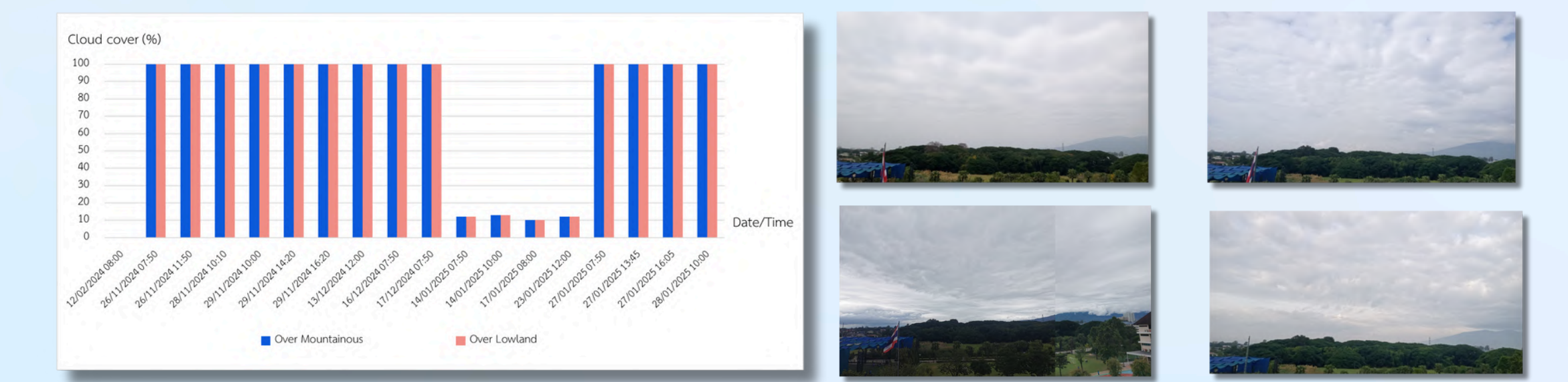


Figure 6 Example of days when cloud cover over lowland areas was similar to that over mountainous areas



CONCLUSION

The results of this study indicate that **cloud formation is influenced by both topographic characteristics and local atmospheric factors**, including temperature, humidity, and wind. Higher temperatures enhance water evaporation, increasing atmospheric water vapor and promoting cloud formation when air rises. High relative humidity further contributes to greater cloud cover. However, wind also plays an important role by transporting moisture between areas. **Cloud formation was also influenced by large-scale atmospheric conditions.** During periods affected by La Niña, increased moisture transport from the sea led to widespread cloud cover over both mountainous and lowland areas, even during the winter season. On such days, low-level clouds such as Stratus and Stratocumulus were commonly observed. Overall, this study highlights that **cloud formation results from the interaction of multiple factors.** Future studies should collect data throughout the entire year to allow seasonal comparisons and a more comprehensive understanding of cloud variability.

REFERENCES

Chariya, P., et al. (2022). A study of cloud characteristics and cloud cover in Huai Mun Village, NamPat District, Uttaradit Province through scientific inquiry-based learning. *Journal of Technology and Innovation, Uttaradit Rajabhat University*, 5(2), 12–21.

Pleungwatana, R. (2015a). Clouds and cloud formation (Part 1): Convective lifting. Institute for the Promotion of Teaching Science and Technology (IPST). <https://earthscience.ipst.ac.th/wp-content/uploads/sites/19/2015/04/uuua-ms-keuaew-2.pdf>.

Pleungwatana, R. (2015b). Clouds and cloud formation (Part 2): Forced lifting. Institute for the Promotion of Teaching Science and Technology (IPST). <https://earthscience.ipst.ac.th/wpcontent/uploads/sites/19/2015/02/uuua-ms-keuaew-2.pdf>.

Phailoblai, S. (2023, June). Clouds, fog, and dew. *MitrEarth*. <http://www.mitrearth.org/23-2-clouds-fog-dew/>.

University Corporation for Atmospheric Research. (2025). Clouds and how they form. <https://scied.ucar.edu/learning-zone/clouds/how-clouds-form>.

NASA Langley Research Center. (2025). Analyzing cloud effects on Earth's energy budget. <https://mynasadata.larc.nasa.gov/mini-lessonactivity/analyzing-cloud-effects-earths-energy-budget>.