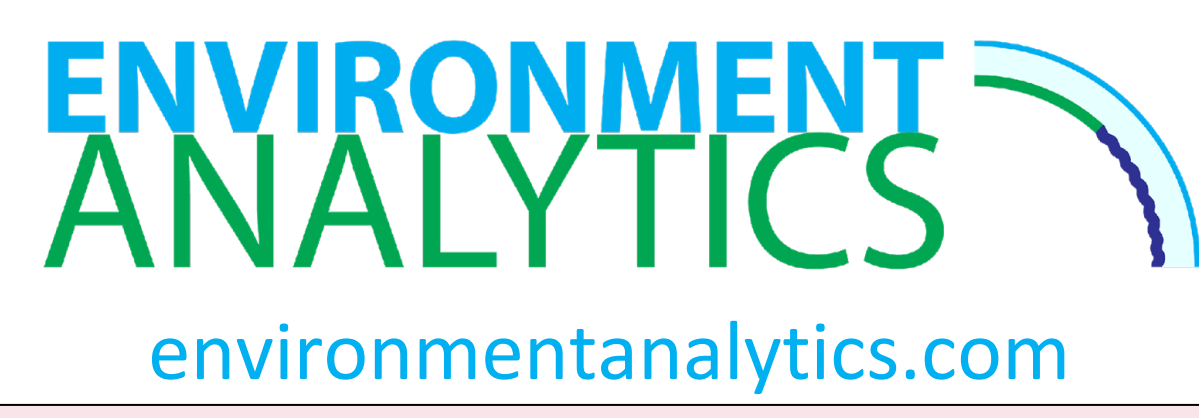




Time and Spatial Cloudiness Variations Across NC

Evelyn M. Hannah, Sandra E. Yuter, and Matthew A. Miller
Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University

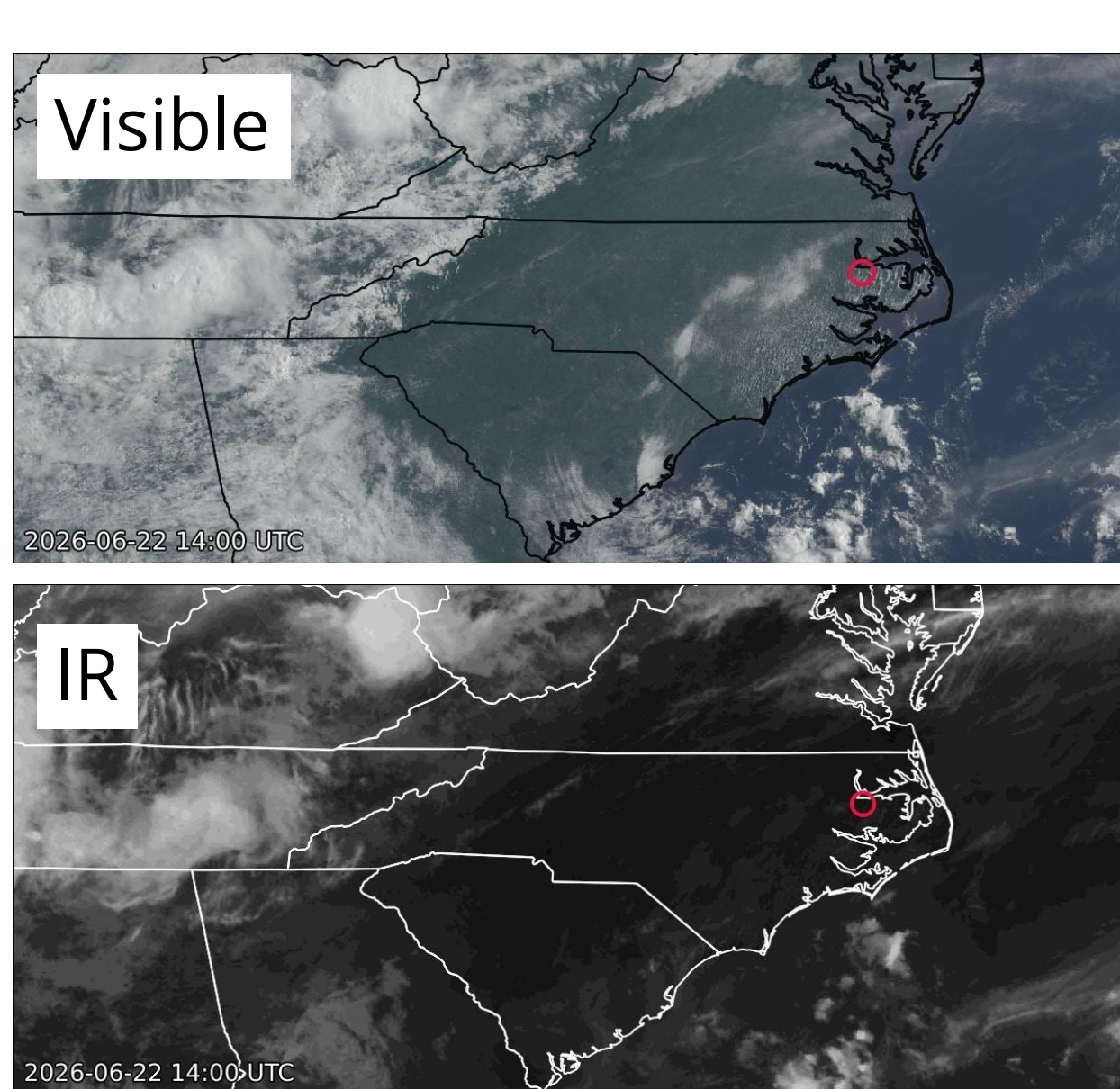


Motivation

Information on cloudiness and how fast it changes has applications to aviation, surface air temperatures, and solar energy generation. Cloud fraction describes what percentage of the sky is covered by clouds. A perfectly clear sky would have a cloud fraction of 0, and an overcast sky would have a cloud fraction of 1. In conditions of partial cloudiness, the cloud fraction value is sensitive to the size of the area over which it is measured. Cloud fraction characteristics in different geographical areas are compared on various time and spatial scales.

Methods

The National Oceanic and Atmospheric Administration GOES East weather satellite total cloud fraction product is used to assess variations in cloudiness across the North Carolina region. The total column cloud fraction is computed for 10 km x 10 km grid boxes based on 2 km x 2 km IR (day and night) and visible (day only) data.

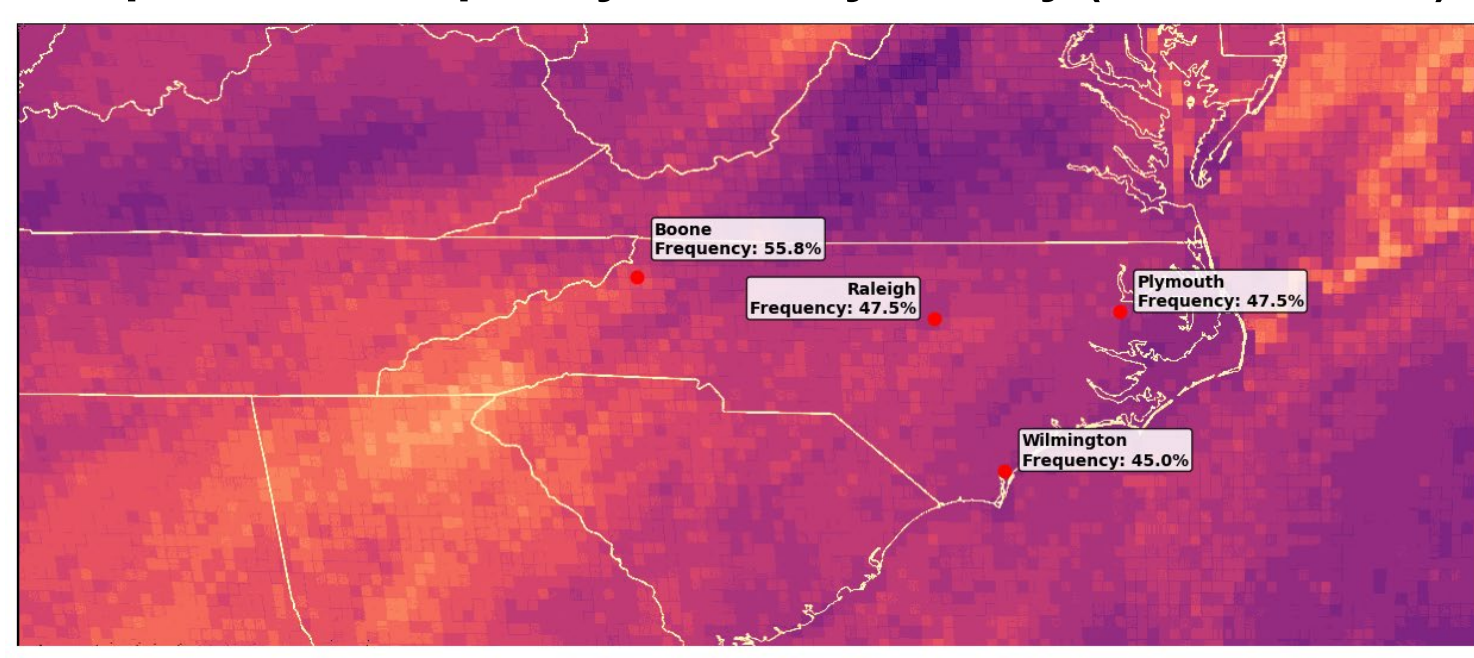


Cloud Fraction

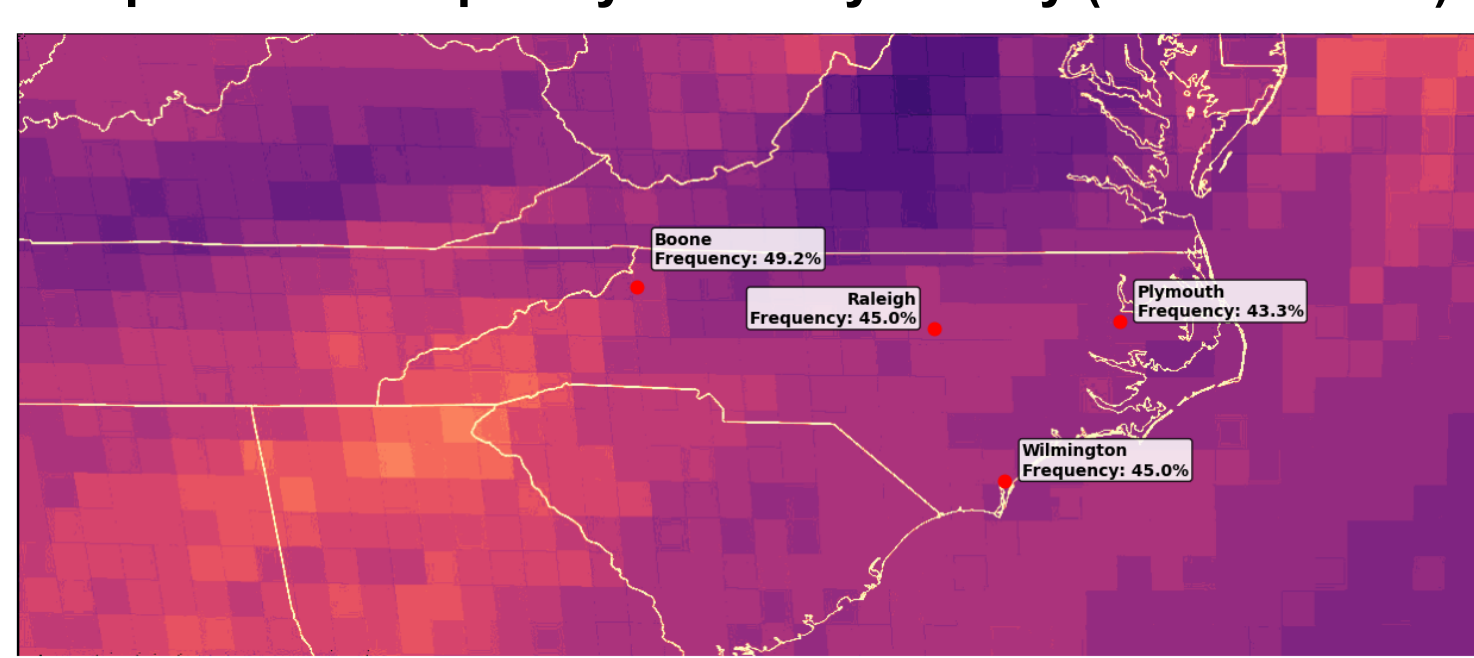
NOAA GOES Total Cloud Fraction product, the NOAA GOES Visible product, and the NOAA GOES Infrared Product for 26 May 2026 at 14 UTC (10 am local time). The total cloud fraction product misses some clouds and overestimates the size of others.

Areal Variability (5 Days)

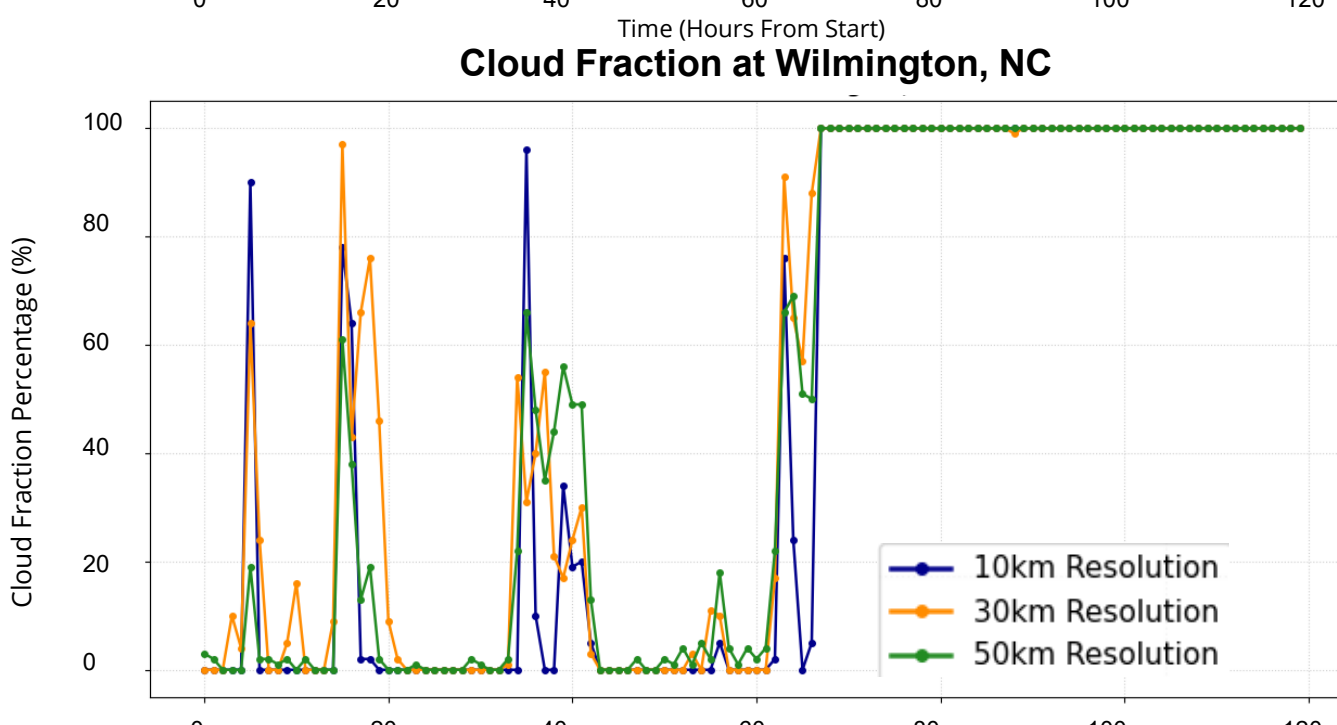
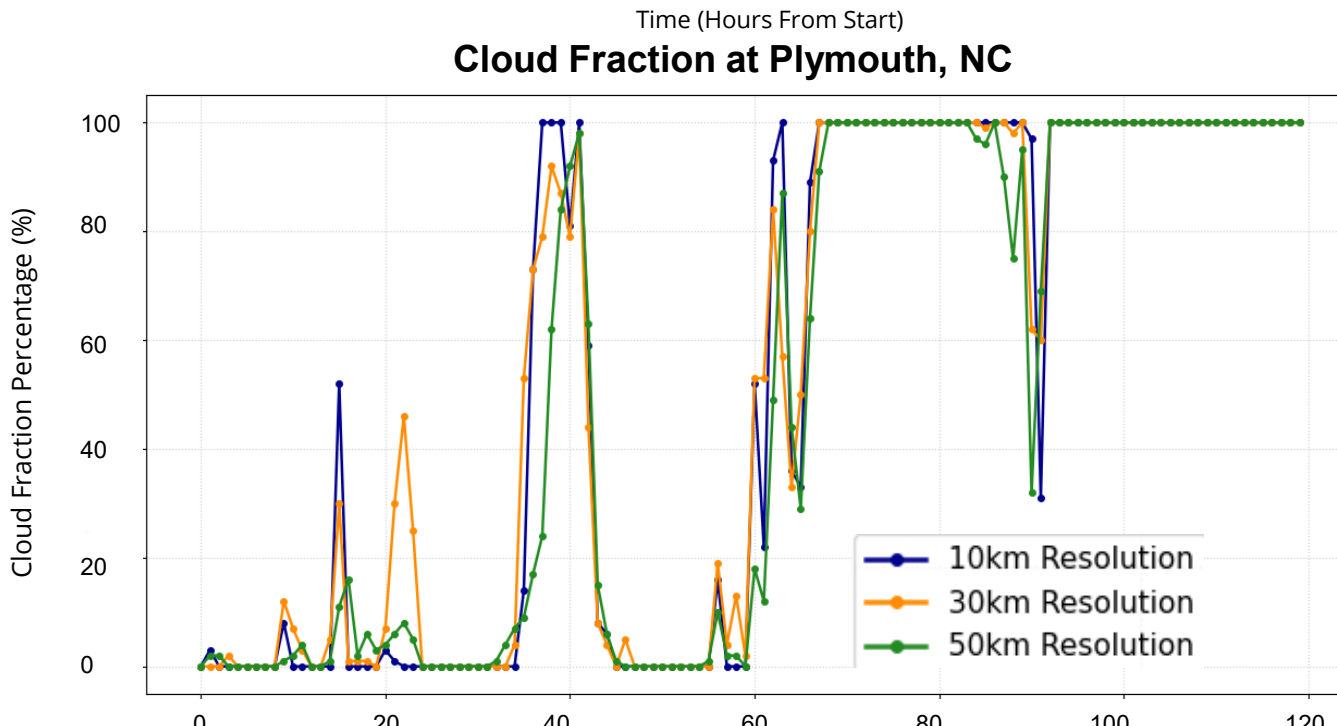
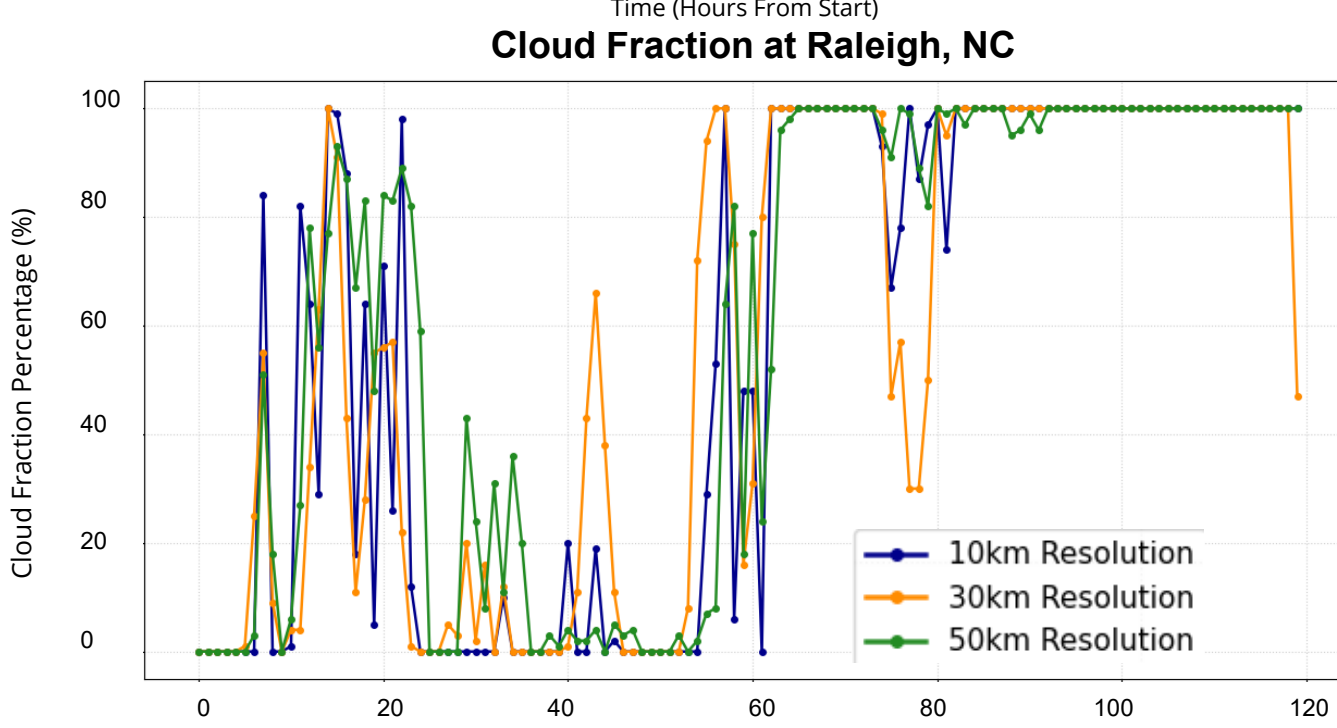
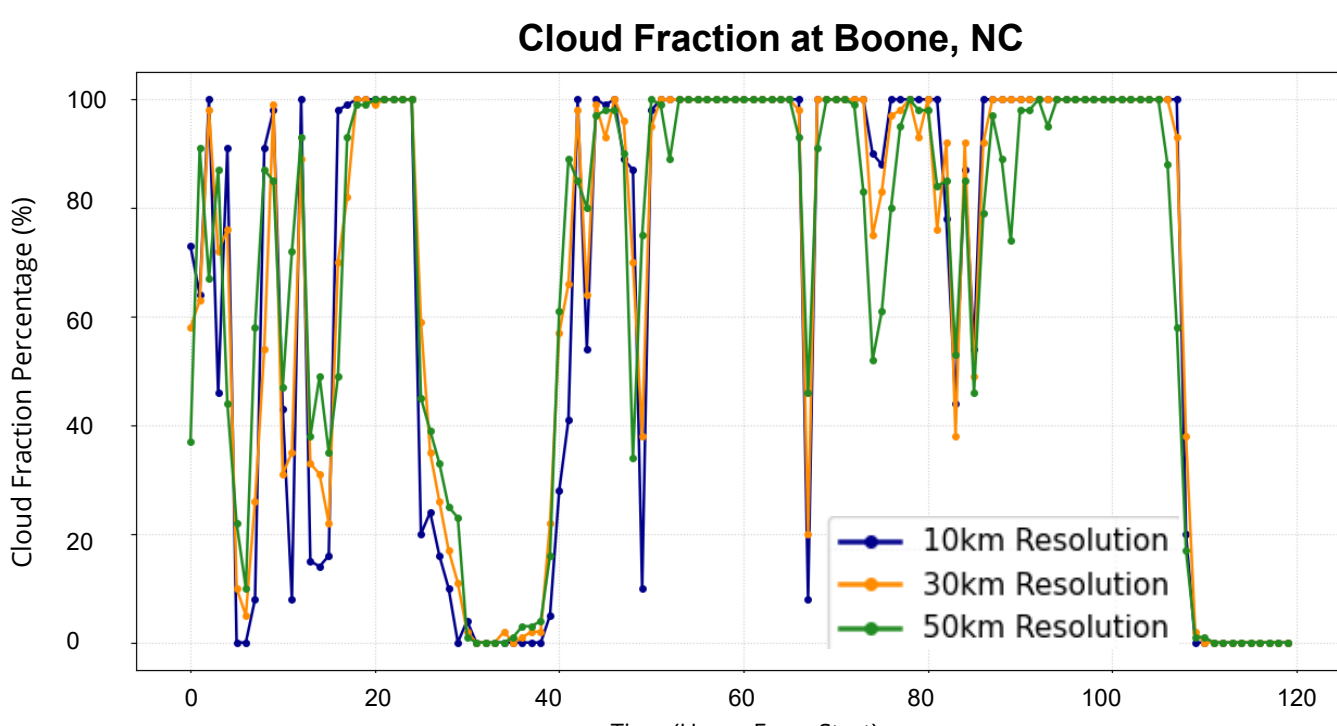
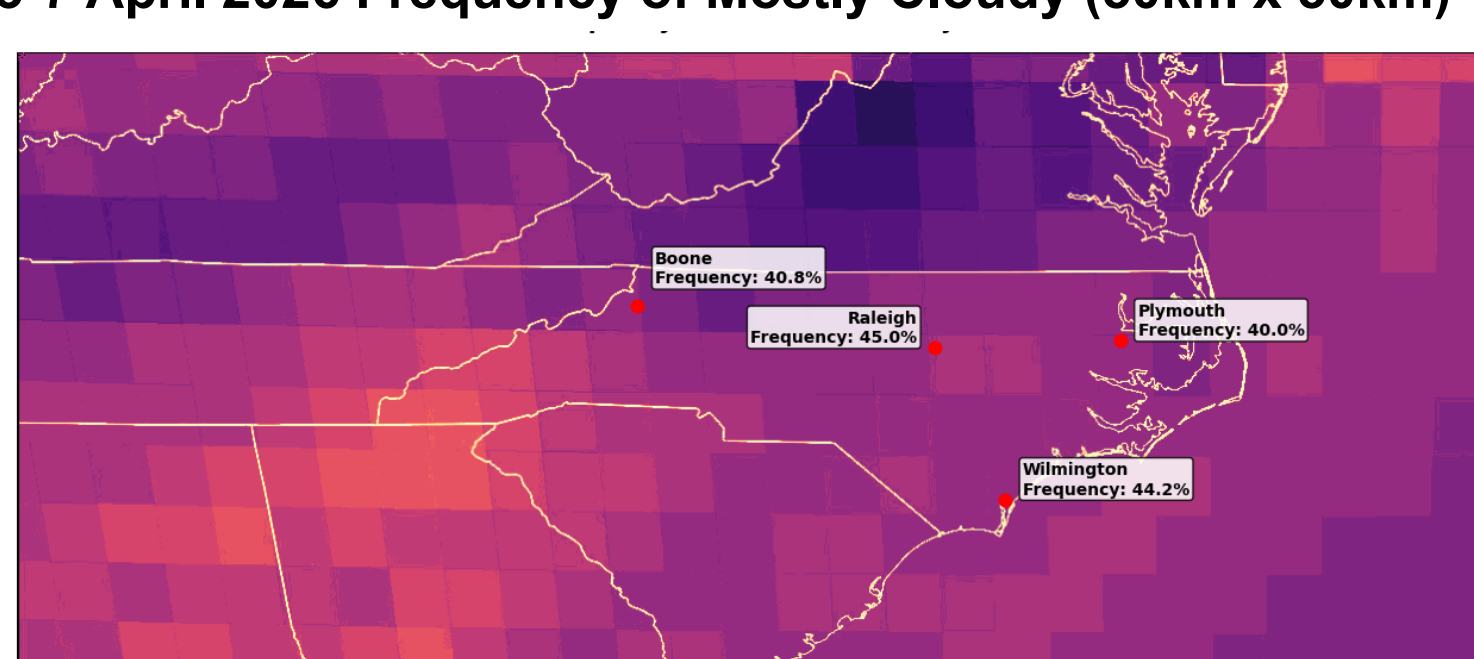
3-7 April 2026 Frequency of Mostly Cloudy (10km x 10km)



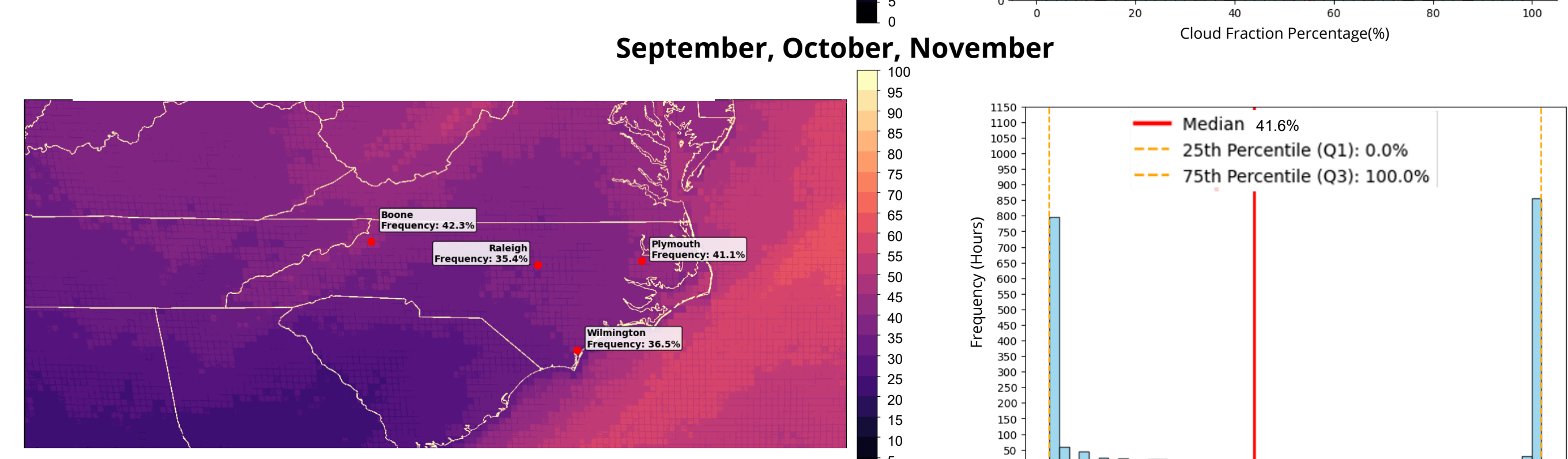
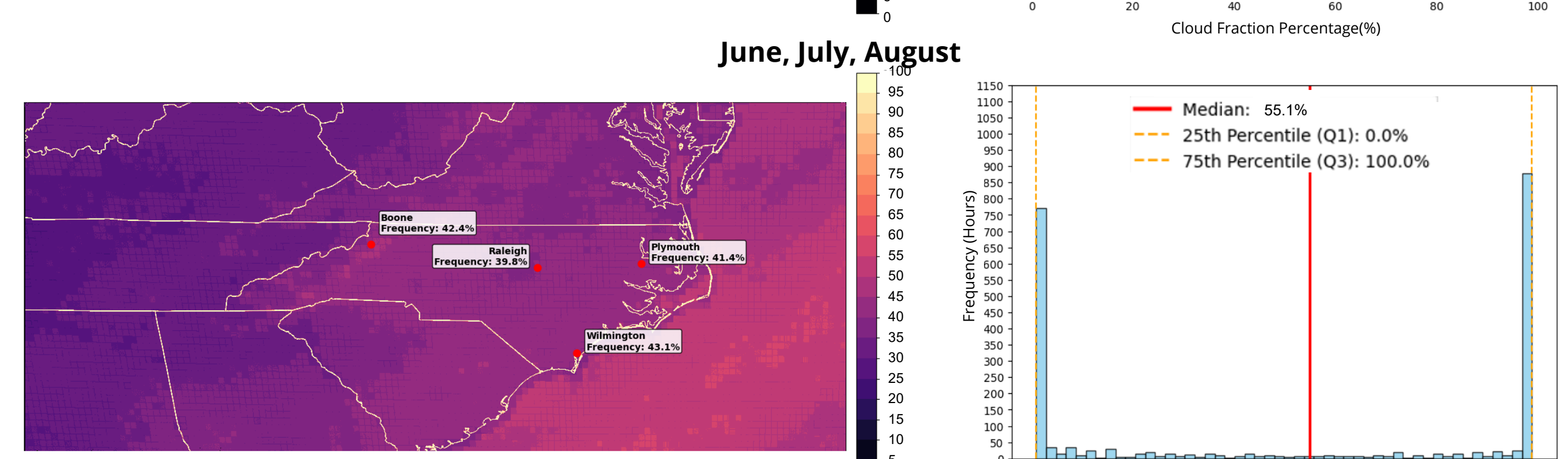
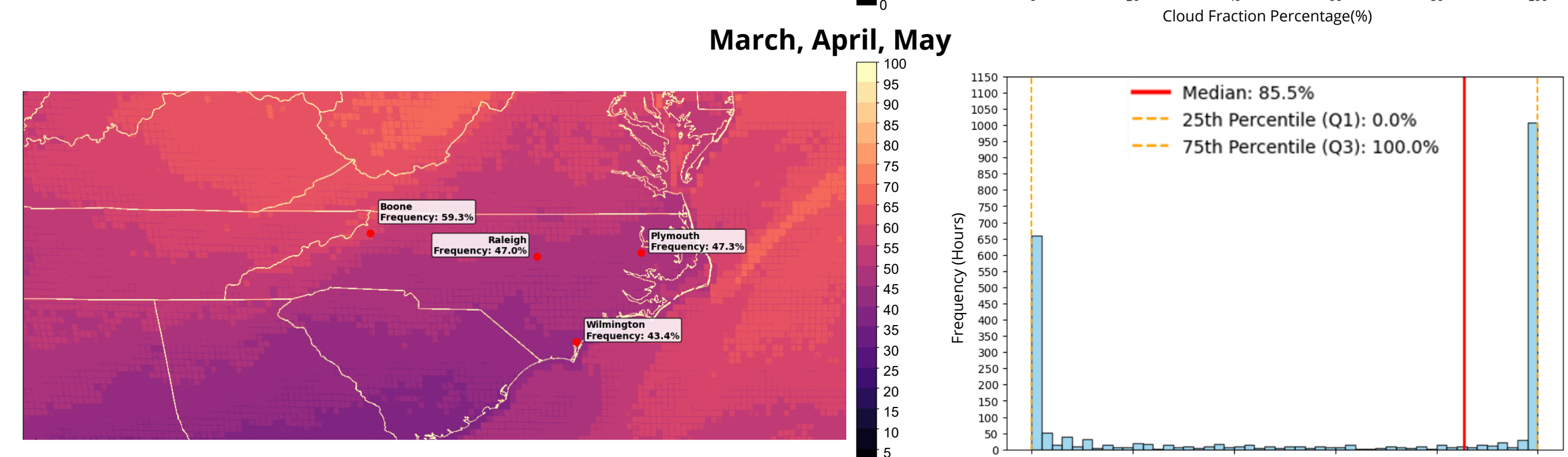
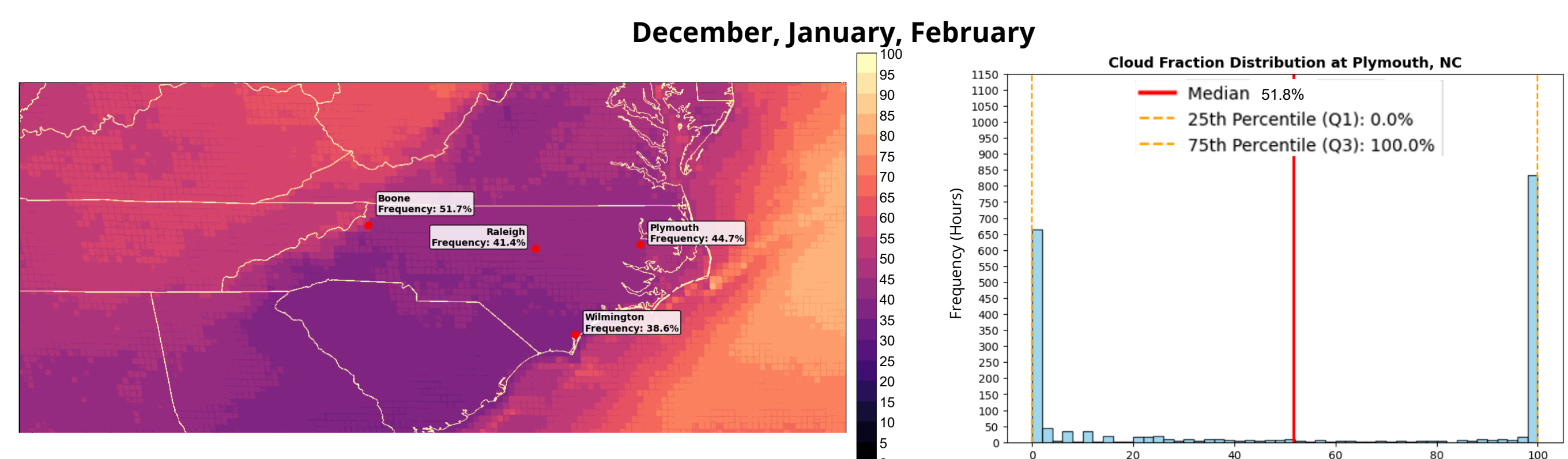
3-7 April 2026 Frequency of Mostly Cloudy (30km x 30km)



3-7 April 2026 Frequency of Mostly Cloudy (50km x 50km)

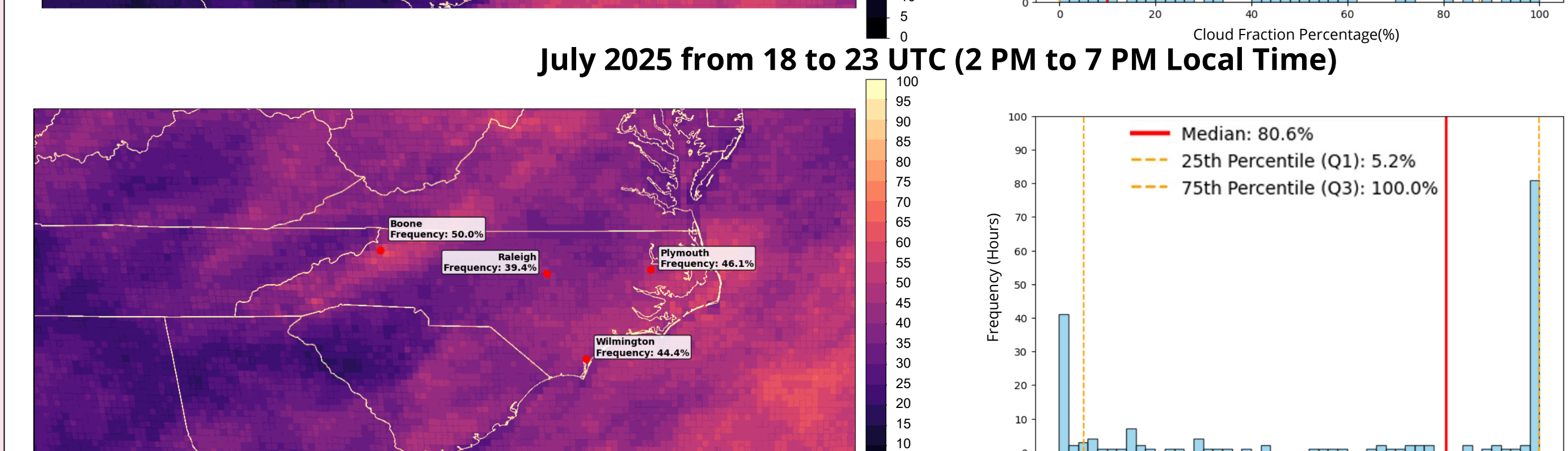
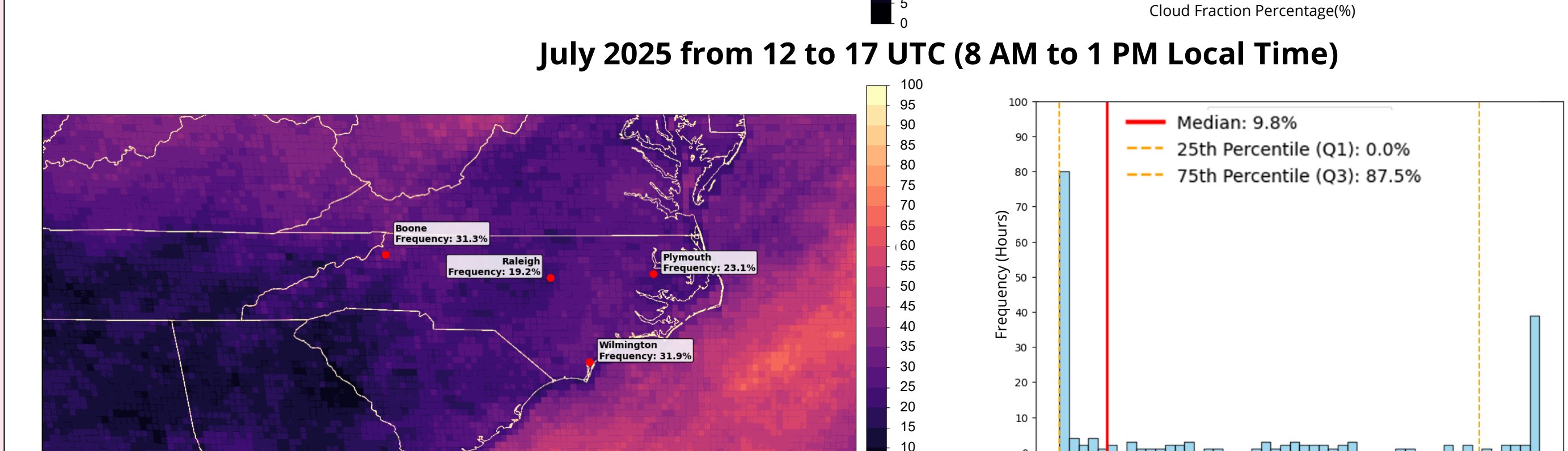
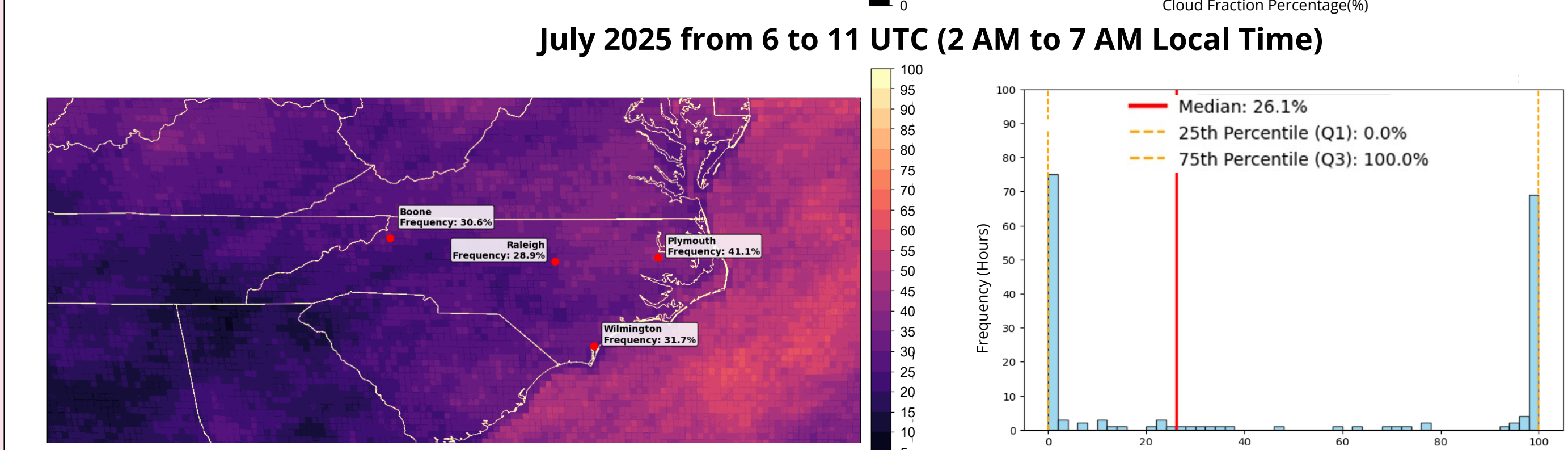
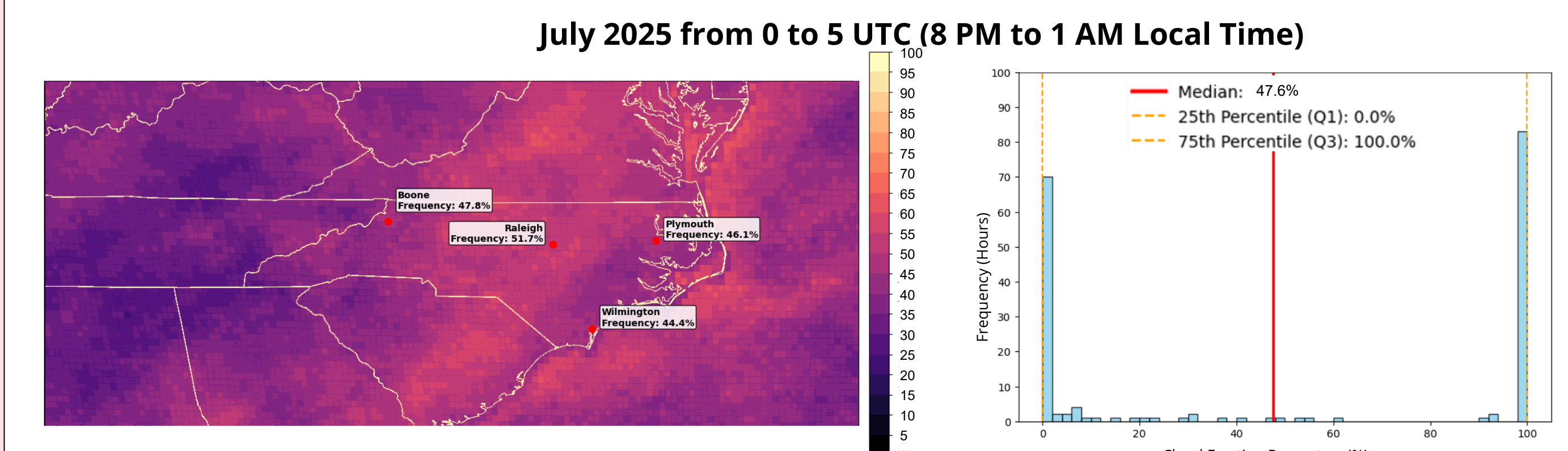


Seasonal Variability (2025)



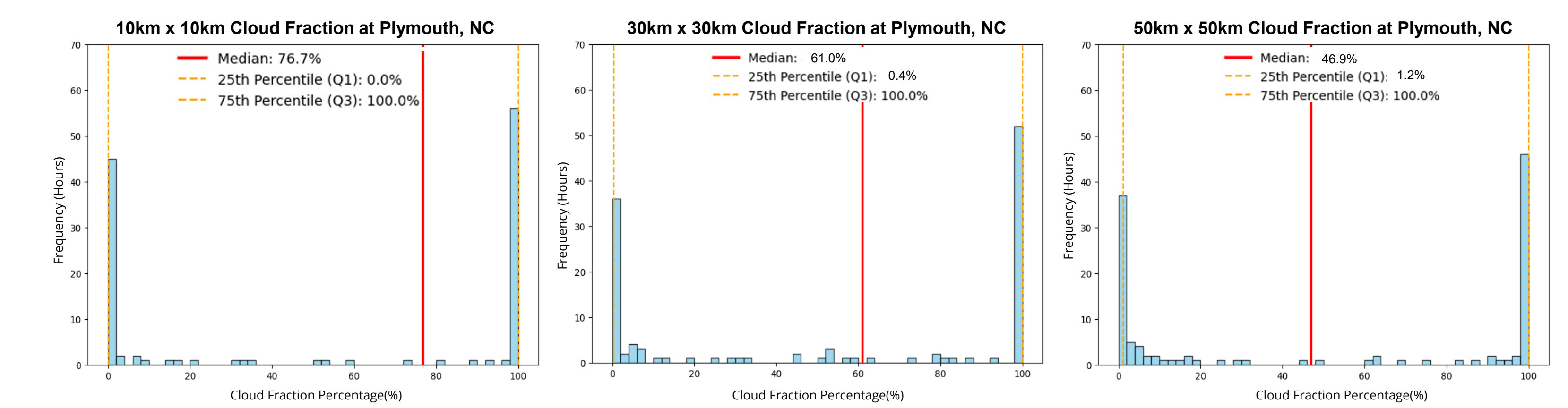
Seasonal maps (left) show frequency of mostly cloudy ($\geq 95\%$ cloud fraction) over the North Carolina region. The histograms (right) show the distribution of cloud fraction over Plymouth, NC during each season.

Diurnal Cycle Variability (July 2025)



Variations in cloudiness during the month of July 2025 across the diurnal cycle (every 6 hours) in terms of frequency of mostly cloudy conditions (left column) and histograms of cloud fraction (right column).

Variations of cloudiness with spatial scale for a 5-day period. Maps show frequency of mostly cloudy days for 10 km x 10 km, 30 km x 30 km and 50 km x 50 km grid spatial scales. The graphs on the right show the time series of cloud fraction at 4 locations for each spatial resolution. Below, the histograms illustrate frequency (hours) of cloud fraction in Plymouth, NC for each spatial scale.



Summary of Findings

- The distributions of cloud fraction are highly bimodal with the majority of points either clear or mostly cloudy.
- The spring season has the highest percentage of mostly cloudy hours and fall has the lowest.
- In July, afternoon and early evening (2 pm to 7 pm) hours have more frequent mostly cloudy conditions over coastal and mountainous regions of North Carolina than other time periods.
- Along the edges of a large cloud expanse, as areal size of the cloud fraction product increases, the frequency of mostly cloudy hours decreases.

Acknowledgements Special thanks to Morgan Roe, Bronsyn Wyant, Philip Zimmer and Warren Lewis for their feedback and support. This work was motivated by discussions with Jason Nachamkin (NRL-Monterey) and is funded by the US Office of Naval Research grant N00014-24-1-2216.