Influences on Low-Level Clouds over Eastern North Carolina

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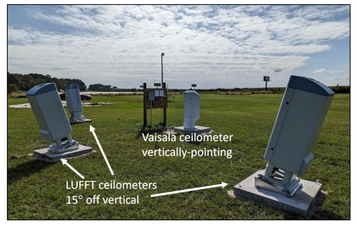
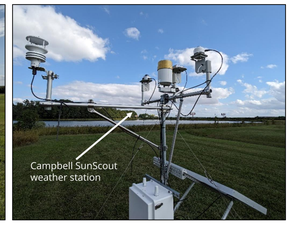
Motivation

Cloud formation and dissipation are strongly influenced by the atmospheric boundary layer—the part of the atmosphere directly influenced by the Earth's surface. The sizes, spacing, and persistence of low-level clouds impact temperatures, solar and infrared radiation, aviation, and remote sensing.

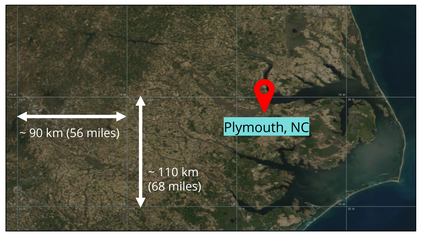
Data and Methods

We use data from NCSU's Eastern Carolina Atmospheric Observing Site (ECAOS) in Plymouth, North Carolina (59 miles from the Atlantic coast) to examine variations in meteorological variables and in LiDAR ceilometer backscatter profiles which detect aerosol and cloud particles in the lower atmosphere. Key controls on cloudiness and boundary layer characteristics are the daily solar cycle and whether the regional air properties change gradually or abruptly. Cold fronts bring a shift from warmer, moister air to cooler, drier air behind the front. Storm outflows yield evaporatively cooled air and increased wind speed ahead of a storm. Cloud dissipation is faster when there is drier air and/or more stable air in the boundary layer.

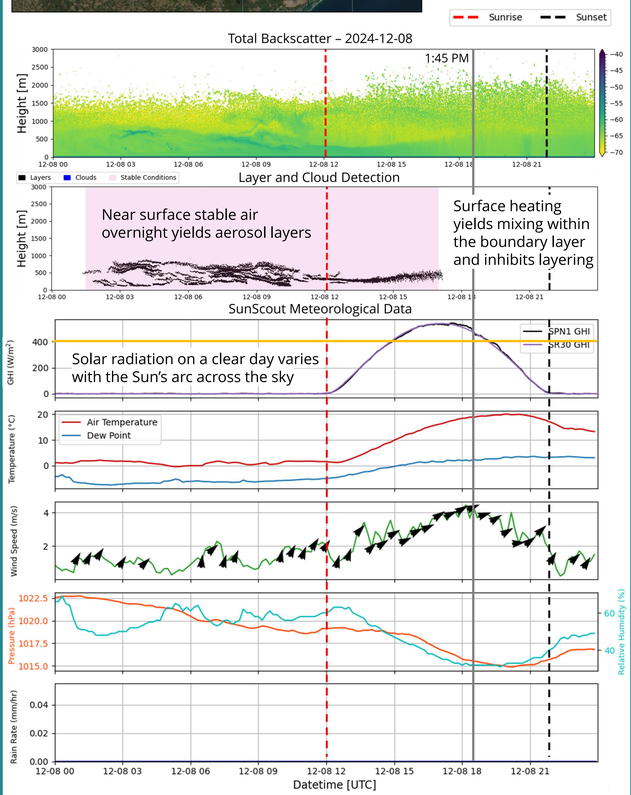




Gradual Changes in Air Mass Properties: No Clouds

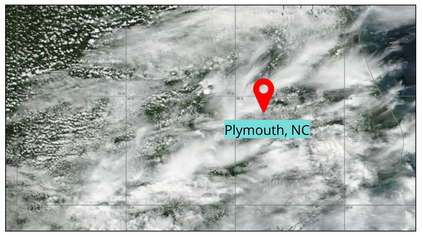


Visible satellite image from 2024-12-08 1:45 PM local time. No clouds.

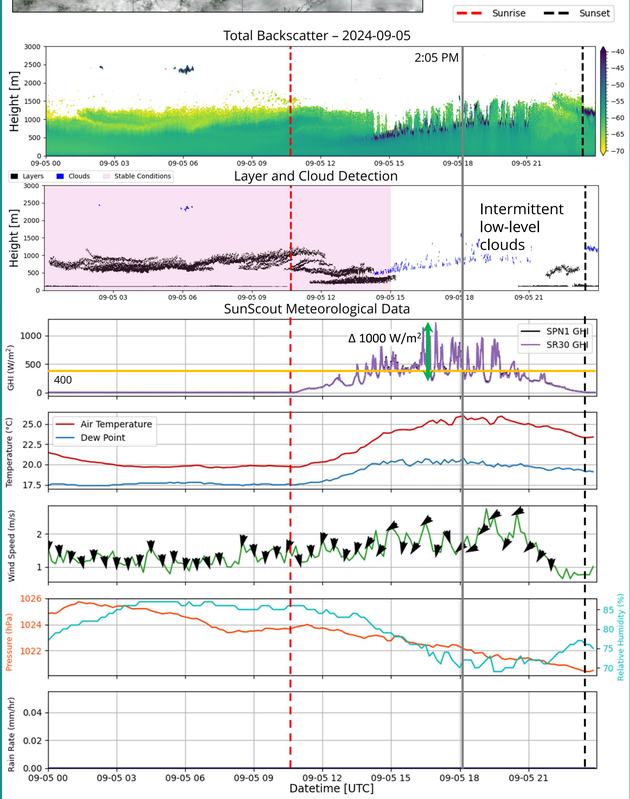


- Diurnal cycle of incoming solar radiation is a dominant factor in controlling the weather on this clear winter's day.
- Very low dew points (near 0°C) indicate dry air near surface.
- Horizontal orange line in plots indicates solar radiation of 400 W/m^2 to compare ranges among examples.

Gradual Changes in Air Mass Properties: Clouds

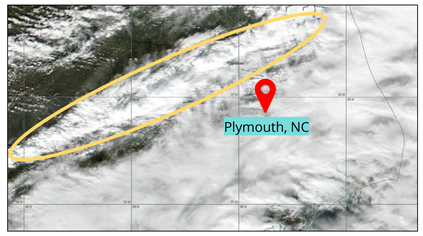


Visible satellite image from 2024-09-05 2:05 PM local time. Small cumulus clouds and high-altitude cirrus.

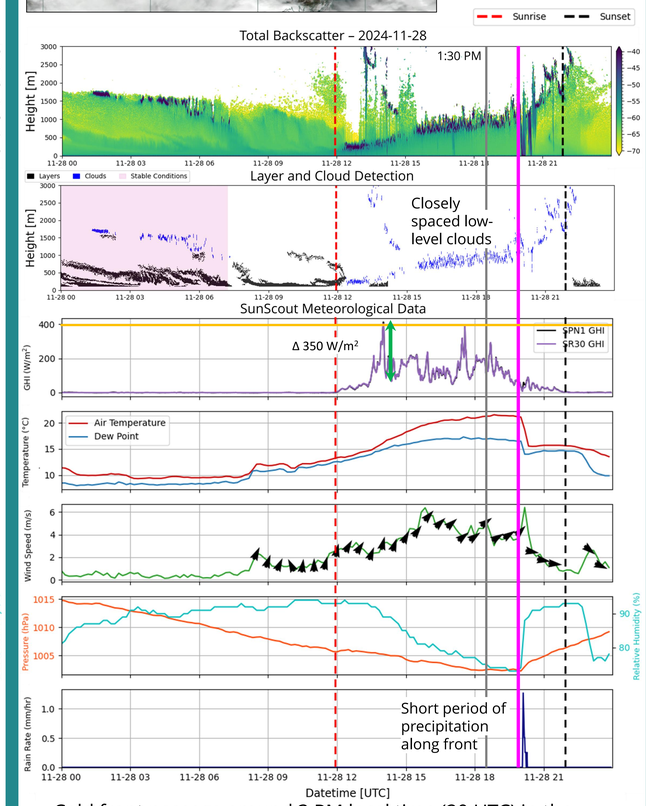


- Low-level clouds form throughout the afternoon, increasing in height as temperature in the near surface layer increases.
- Short-time variations in solar radiation of up to 1000 W/m^2 during the day due to intermittent clouds.

Abrupt Change in Air Mass Properties: Cold Front

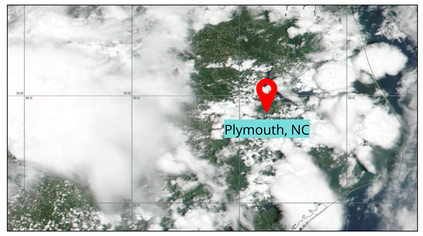


Visible satellite image from 2024-11-28 1:30 PM local time. Tall clouds along cold front are within oval.

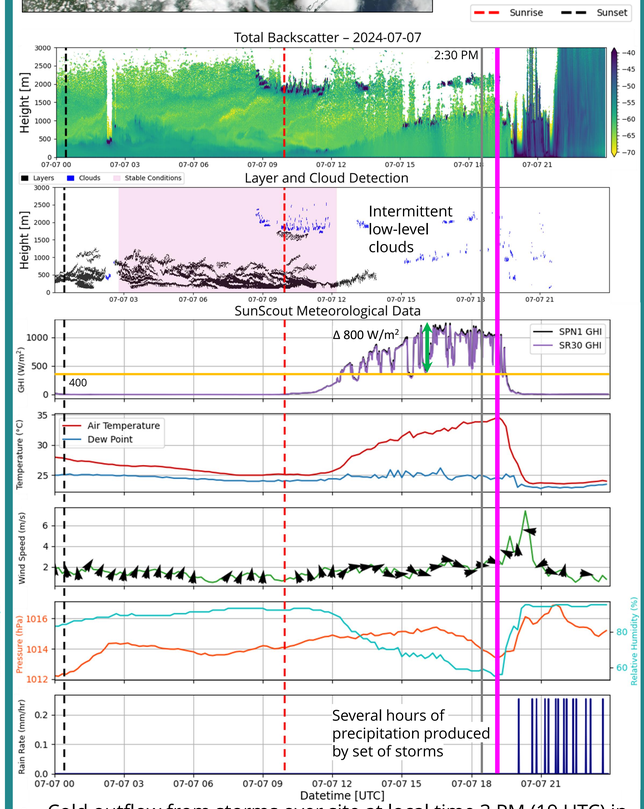


- Cold front passage around 3 PM local time (20 UTC) in the afternoon associated with drops in temperature and dew point and shifting wind direction.
- Cloud base heights increase after cold front associated with drier near surface air compared to conditions before cold front.

Abrupt Air Mass Change: Cold Outflow from Storm



Visible satellite image from 2024-07-07 2:30 PM local time. Cumulus and cumulonimbus clouds near site.



- Cold outflow from storms over site at local time 3 PM (19 UTC) in the afternoon indicated by a drop in temperature and short period of increased wind speed.
- Short-time scale variations in solar radiation of up to 800 W/m^2 during the day due to intermittent cloud cover.

Summary and Future Work

The characteristics of low-level clouds are expected to vary with changes in the boundary layer related to the diurnal cycle and air mass transitions such as cold fronts, storm outflows, and sea breezes. Low-level clouds have a significant impact on the amount of solar radiation reaching the surface. Depending on the sizes and lifetimes of individual clouds, variations from near 1000 W/m^2 to a few 100 W/m^2 can occur at hourly and subhourly time scales. The examples above illustrate a few distinct weather conditions. Future work will examine many more examples to assess the joint variations of naturally occurring distributions of cloud characteristics across different weather conditions and the transitions between them.

Acknowledgements

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