Winter-time Lightning during Cold-Air Outbreaks over the North Pacific Ocean

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During the winter, there are frequent episodes of cold air outbreaks over the Gulf of Alaska where cold arctic air from interior Alaska and the Arctic pours out over the relatively warm North Pacific Ocean. Fluxes of heat and moisture from the ocean destabilize the lower atmosphere and convective clouds form. Occasionally these convective cloud elements further organize into larger structures such as comma clouds. Comma clouds are often sources of significant precipitation for the coastal regions of western North America and their structure and intensity are not always adequately represented in numerical models. Since the comma clouds are relatively small in horizontal extent and since there are relatively few direct observations of meteorological parameters available over the ocean, it can be difficult to adequately observe these systems. It is necessary to utilize alternative data sources such as passive microwave instruments on satellite platforms and lightning networks.

One such data source is the World Wide Lightning Location Network (WWLLN), which provides continuous maps of lightning activity over the entire Earth. In this work, we focus on two episodes of cold air outbreaks that formed a series of comma clouds over the North Pacific during the winter season of 2009-2010. The distribution and frequency of lightning during these two episodes are distinctly different with one event exhibiting frequent and extensive lightning within each comma cloud, and the other having much less lightning activity. Each case will be characterized by several meteorological parameters, such as upper level vorticity, temperature structure and winds to distinguish if the large-scale environment was different for these two cases. In
addition, the mesoscale and micro-scale environment will be compared using Weather Research and Forecasting (WRF) mesoscale model runs of the events along with satellite – derived passive microwave parameters such as ice water path and precipitation intensity. The goal of this work is to determine which meteorological parameters are most closely related to lightning activity in order to best utilize the WWLLN network to observe comma cloud systems and to ultimately use the WWLLN as a data source for model initialization to improve numerical forecasts of these events.