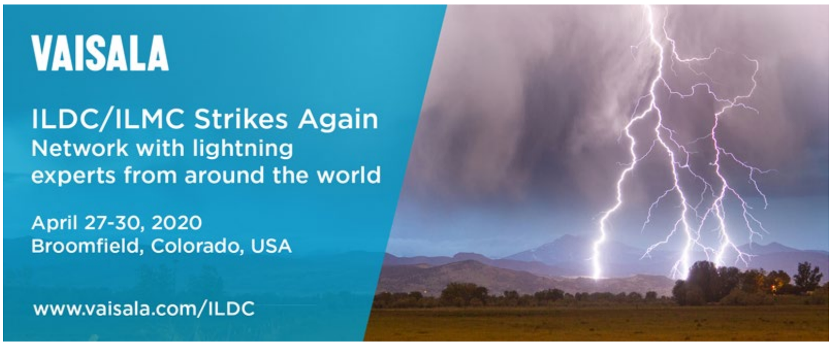

Aerosol Effects on Lightning Characteristics over the South China Sea

Authors

Dr. Yakun Liu - MASSACHUSETTS INSTITUTE OF TECHNO

Dr. Earle Williams - MASSACHUSETTS INSTITUTE OF TECHNO

Dr. Jeff Lapierre - Earth Networks

Dr. Michael Stock - Earth Networks

Dr. Stan Heckman - Earth Networks

Abstract

Aerosol effects are inevitably intertwined with thermodynamic effects in influencing continental lightning behavior. But over adjacent oceanic regions, the thermodynamic contrast is indistinct and its effects can be isolated from aerosol effects. This makes the oceanic lightning a sensitive indicator for assessing aerosol effects on lightning characteristics. Thornton et al., (2017) have produced key evidence that locally increased aerosol traced to seacontainer traffic over the Indian Ocean and South China Sea (SCS) can invigorate lightning activity in moist convection, but their study was limited to contrasting cloud-to-ground (CG) events from the World Wide Lightning Location Network (WWLLN). Fortunately, the southeastern SCS is surrounded by wideband (1 Hz to 12 MHz) electric field sensors in Vietnam, Cambodia, Philippines, Indonesia, Singapore, Malaysia, and China as part of the Earth Networks Total Lightning Network (ENTLN). These sensors specifically detect both intra-cloud (IC) and CG strokes and record entire waveforms, enabling ENTLN to distinguish IC and CG strokes together with their peak current and polarity. Compared to the lightning data from the Lightning Imaging Sensor on the International Space Station in Low Earth Orbit, ENTLN has a high (>90%) and uniform lightning detection efficiency over the entire southeastern SCS region. In addition, the Moderate Resolution Imaging Spectroradiometer (MODIS, aboard the Sun-synchronous Terra and Aqua platforms) and the European Centre for Medium-Range Weather Forecasts interim reanalysis (ERA-Interim, ECMWF) database provide meteorological data over the southeastern SCS.

Therefore, this study focuses on quantitative comparisons among the lightning characteristics, sulfur dioxide, aerosol optical depth (AOD), and thermodynamic and cloud microphysical parameters over two years (2017-2018) between the polluted and clean open oceanic regions to understand aerosol effects on lightning characteristics. The distribution maps of sulfur dioxide (SO_2, precursor for sulfate aerosol) and AOD clearly show the locations and boundaries of the polluted and clean regions. Biennial lightning data show the total stroke number over the polluted ship track is 3.7-fold larger than over the adjacent clean ocean, while the data on Sea Surface Temperature (SST) and Convective Available Potential Energy (CAPE) conversely support slightly stronger convection from sea surface to cloud base over the clean ocean. The mean statistics on cloud base temperature and cloud top height show little contrast.

These comparisons discount thermodynamic effects in supporting the lightning enhancement over the polluted ocean. The mean IC/CG ratio is 2.35 over the polluted ocean compared to 0.96 over the clean ocean, supporting the stronger vertical development and invigoration of the upper dipole of the tripole electrical structure. The aerosol appears to endow the maritime convection with continental characteristics and is consistent with the TRMM radar reflectivity evidence shown in Thornton et al. The +IC stroke count is 75.0% of the total IC strokes over the polluted ocean and 61.5% over the clean ocean. The +CG fraction in total CGs increases substantially to 6.4% over the polluted ocean from 1.1% over the clean ocean. The cloud effective particle radius of ice and liquid water are consistently smaller over the polluted ocean, supporting the idea that the aerosol modifies the cloud droplet size spectrum. The charge reversal temperature and cloud charge structure are suspected to be altered by the aerosol enhancement and will be addressed in detail in the following full paper.

Topic Areas

Lightning Physics, Characteristics and Measurements, Lightning Climatology

Submission Format

Oral