Static Electric Fields and Lightning Over Land and Ocean in Florida Thunderstorms

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Overview

• Objective
• Peak Current Analysis
• Buoy 41009 and 41010 instrumentation Calibration
• On-shore and off-shore cell comparisons
• Conclusions
Objective

• To test the hypotheses that natural lightning, as well as the associated electric fields over the ocean behave differently than over land
  – the peak current and fields aloft are expected to be higher
  – Potential differences in the static field magnitude and polarity as a function of range from the EFMs (differences in the magnitude of the lower positive charge region over land and ocean)
Instrumentation Locations
Cumulative distributions of negative CG strokes in **pre-existing channels**, for four different locations
Peak Current Comparisons

Cumulative distributions of negative CG strokes in pre-existing channels, for four different locations
Peak Current Comparisons

Distant Ocean distribution scaled by its effective detection efficiency.
Peak Current Comparisons

First in Flash with the DE correction scaling set to 0.76 to match the Ocean curve between 10 and 12 kA.
Origin of the Effect

• What is the source of this peak current enhancement?
  – *Surface conductivity?* ( $\sigma_{\text{land}} \ll \sigma_{\text{sea}}$ )
  – *Attachment mechanism(s)*?

• Recent work points to **within-cloud** (Cooray et al., 2014; Nag & Cummins, 2016 AGU)
  - Shorter (20-40%) time between *Preliminary Breakdown* in the cloud and *Return Stroke* reaching the ground
    - Likely higher leader line-charge density in descending leader channels
    - Likely altered charge structure in lower portion of the cloud
On-Shore Electric Field Mills

• KSC Network Electric Field Mill
  – Measures fields aloft at constant rate of 50 samples/sec
  – Data uploaded to the KSC weather archive every 15 min in 30 min data folders: kscwxarchive.ksc.nasa.gov
  – Operational network, therefore no expected data outages.
Buoy Electric Field Meter

• Campbell Scientific Electric Field Meter
  – Measures fields aloft at variable rate of 1 sample per 10 sec during clear skies (fields below +/- 500 V/m) and 1 sample per sec during elevated fields above +/- 500 V/m
  – Data transmitted via Iridium modem in daily files archived for NASA
  – Mill preformed well beyond expectations. No failures for 1st deployment (8 months) and 6+ months of continuous operations during 2nd deployment.
Buoy
Calibration

• Campbell Scientific calibration test stand set-up

• Buoy was the closest tall structure to calibration mill at ~50m separation

• 3 day calibration test through a frontal passage 10/21/13 – 10/23/13 while dry docked at Coast Guard Station

• Field enhancement was 1.68.
On-shore Off-shore comparison 2/21/14
Strong Lower Positive Charge (LPC) structure is reflected in the fall-off of foul-weather field magnitude within ~5 km of the static field measurement site.
Strong Lower Positive Charge (LPC) structure is reflected in the polarity reversal of field-changes for CG first strokes within ~3 km of the static field measurement site.

10 of 12 isolated cell over KSC in this study exhibited at least one of these two behaviors.
07-28-2014 Ocean (20 mi)
10/31/14 Deep Ocean
Conclusions to date

1. Statistically larger Ip’s for both First In Flash originate over the ocean but Ip’s for Pre-Existing Channel were equivalent to those on-shore.

2. Storms consistently show higher E-fields over ocean during both high reflectivity and active lightning as compared to on-shore E-fields using the same criteria.

3. The influence of the classic lower positive charge layer that appears in on-shore electrified clouds was reduced or absent in isolated cells over the buoy during this study.
Back-up slides
10/22/13 0400-2300 GMT