GLD360 Global Peak Current Measurements

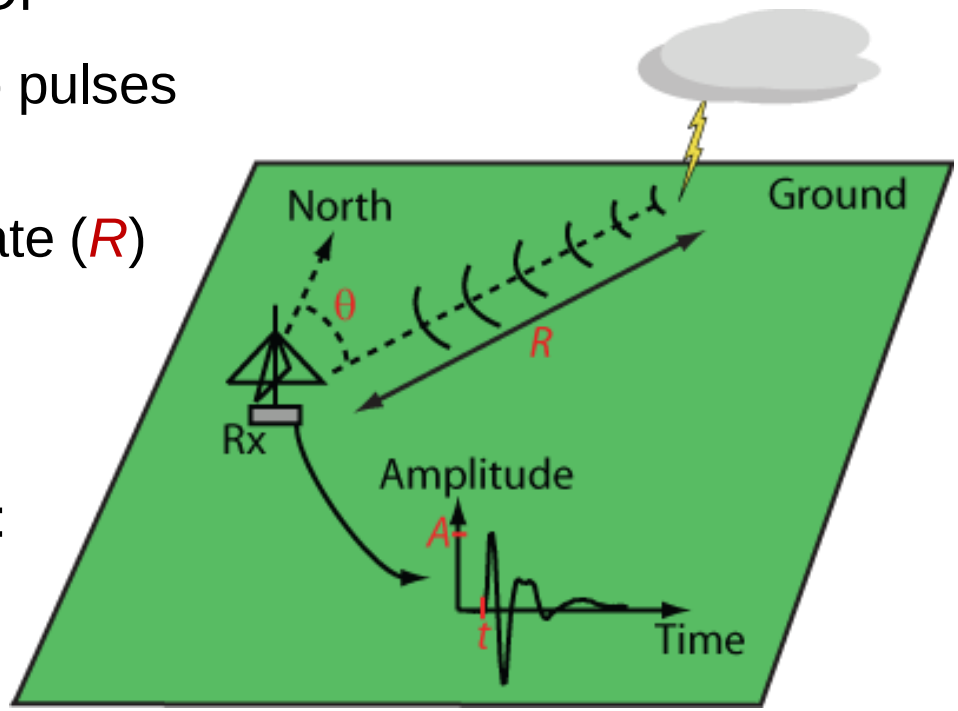
September 25, 2013
GLM 2013 Science Meeting

Ryan K. Said
Vaisala Inc.

VAISALA

GLD360 methodology

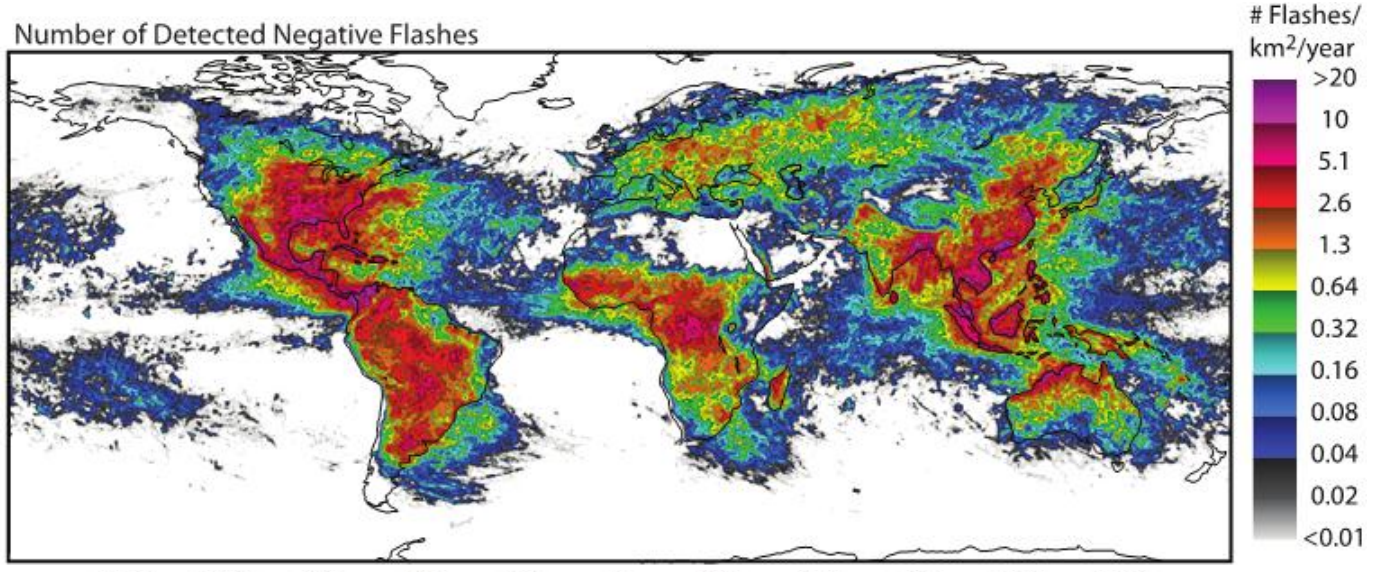
- VLF (~500 Hz – 48 kHz) on two orthogonal magnetic loop antennas:
  - Arrival angle (θ) through MDF
- Cross-correlates individual radio pulses with waveform bank
  - Propagation distance estimate (R)
  - Arrival time (t)
  - Polarity
- Calibrated B-field measurement:
  - Peak Amplitude (A)



GLD Global Lightning Climatology

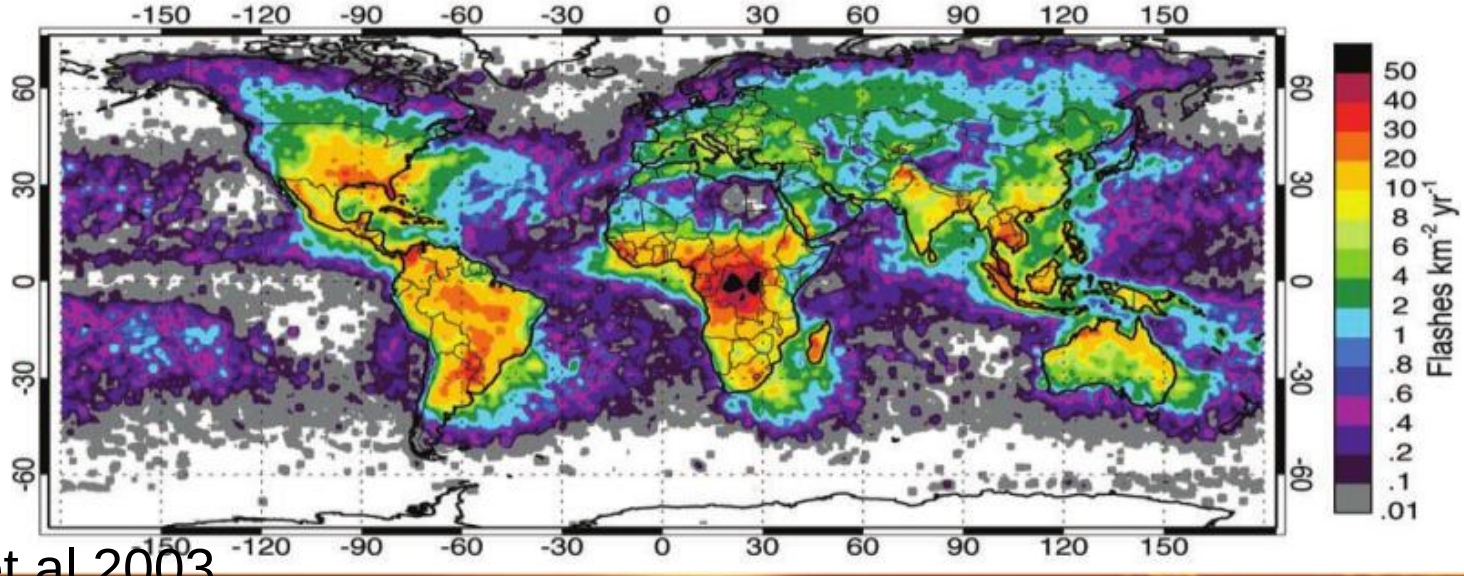
GLD360

(1 year)



OTD

(5 years)

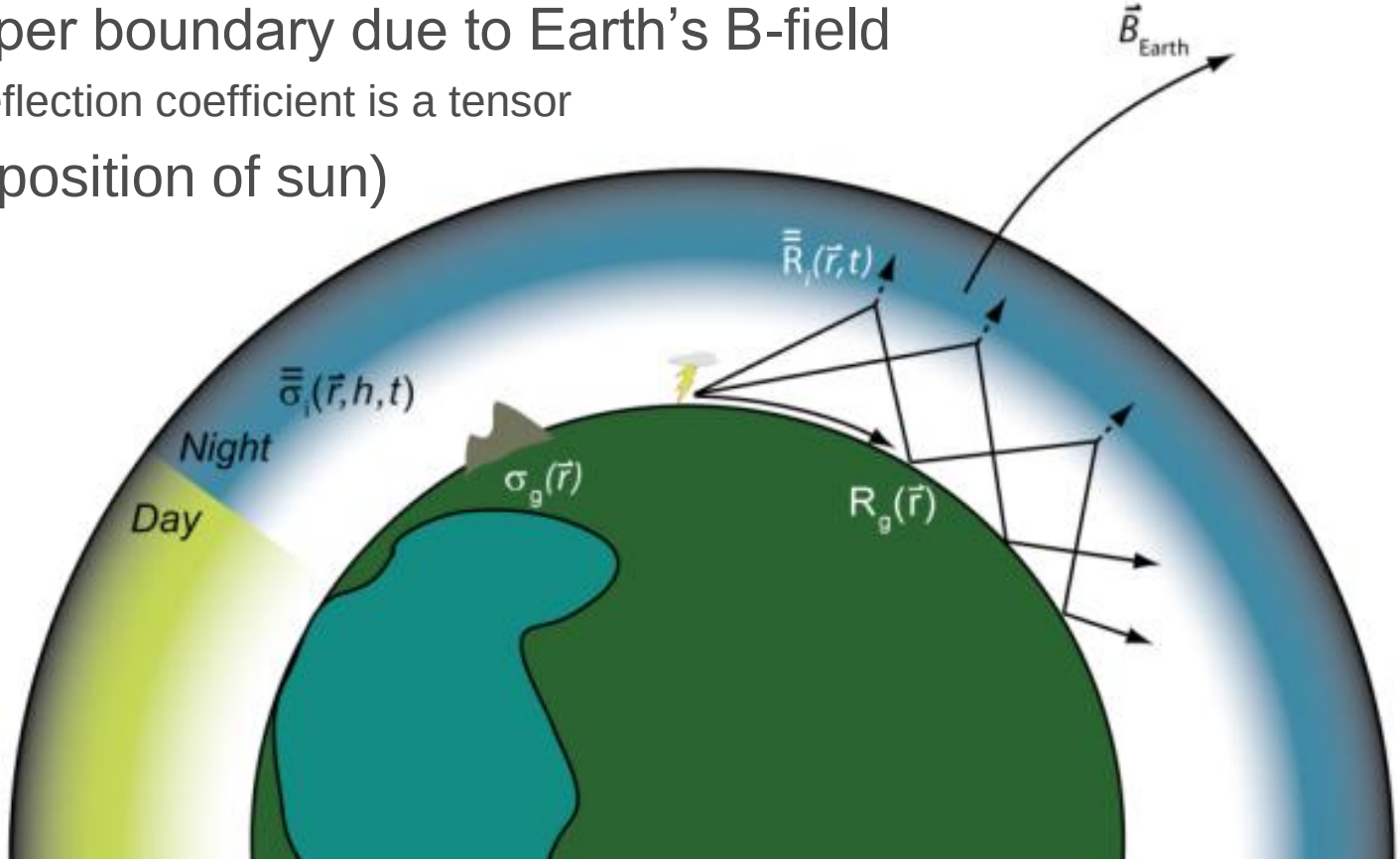


Christian et al 2003

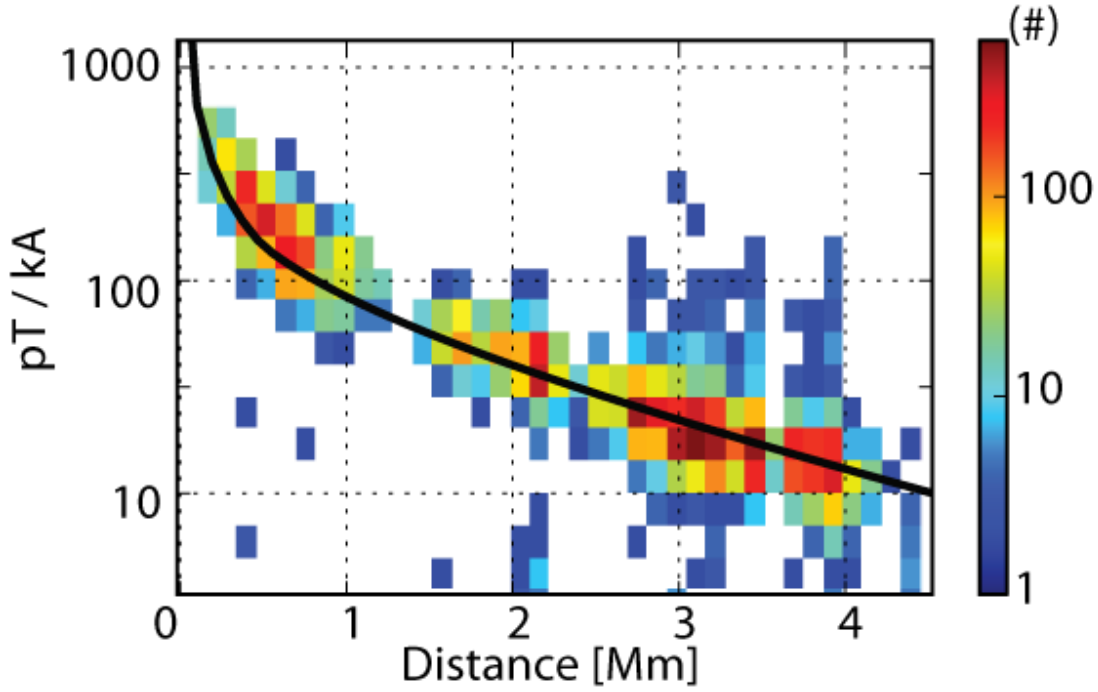
VAISALA

Complicated Waveguide

- Spherical
- Vertically and horizontally inhomogeneous ionosphere
- Anisotropic upper boundary due to Earth's B-field
  - Ionospheric reflection coefficient is a tensor
- Time-varying (position of sun)



Peak Current Determination



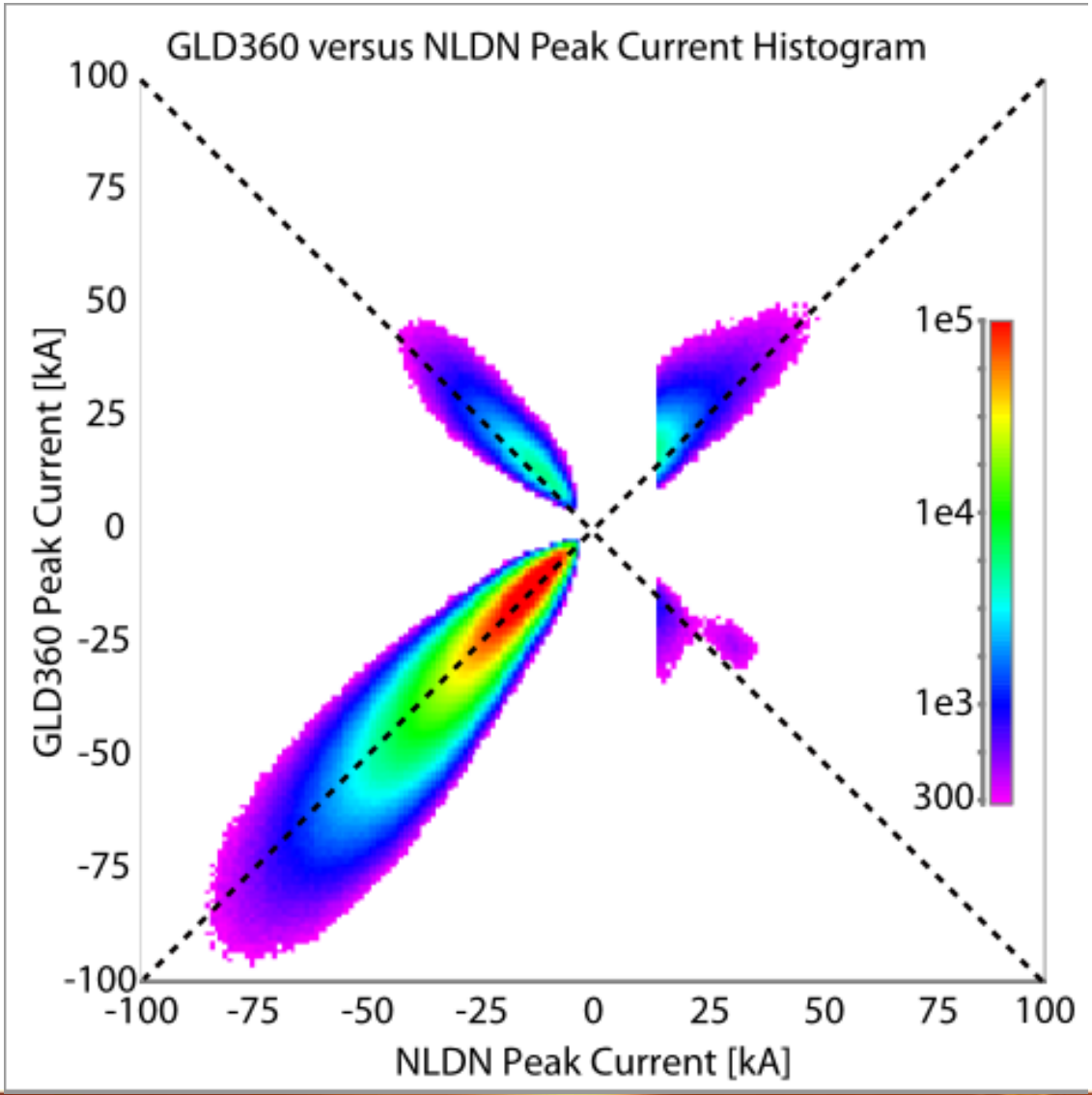
- Parameters *C*, *A* depend on ionospheric profile, ground conductivity
- Largest effect: Day/Night path (correction applied at Central Processor)

$$I_{\text{peak}} = A \cdot \begin{cases} C\left(\frac{d}{I_0}\right), d < d_0 \\ C\left(\frac{d_0}{I_0}\right)^{\frac{1}{2}} \sqrt{\frac{d}{I_0}} \sqrt{\frac{\sin(d/R_0)}{d/R_0} \frac{d_0/R_0}{\sin(d_0/R_0)}} \exp\left(\frac{d-d_0}{A}\right), d \geq d_0 \end{cases}$$

Comparison Against NLDN

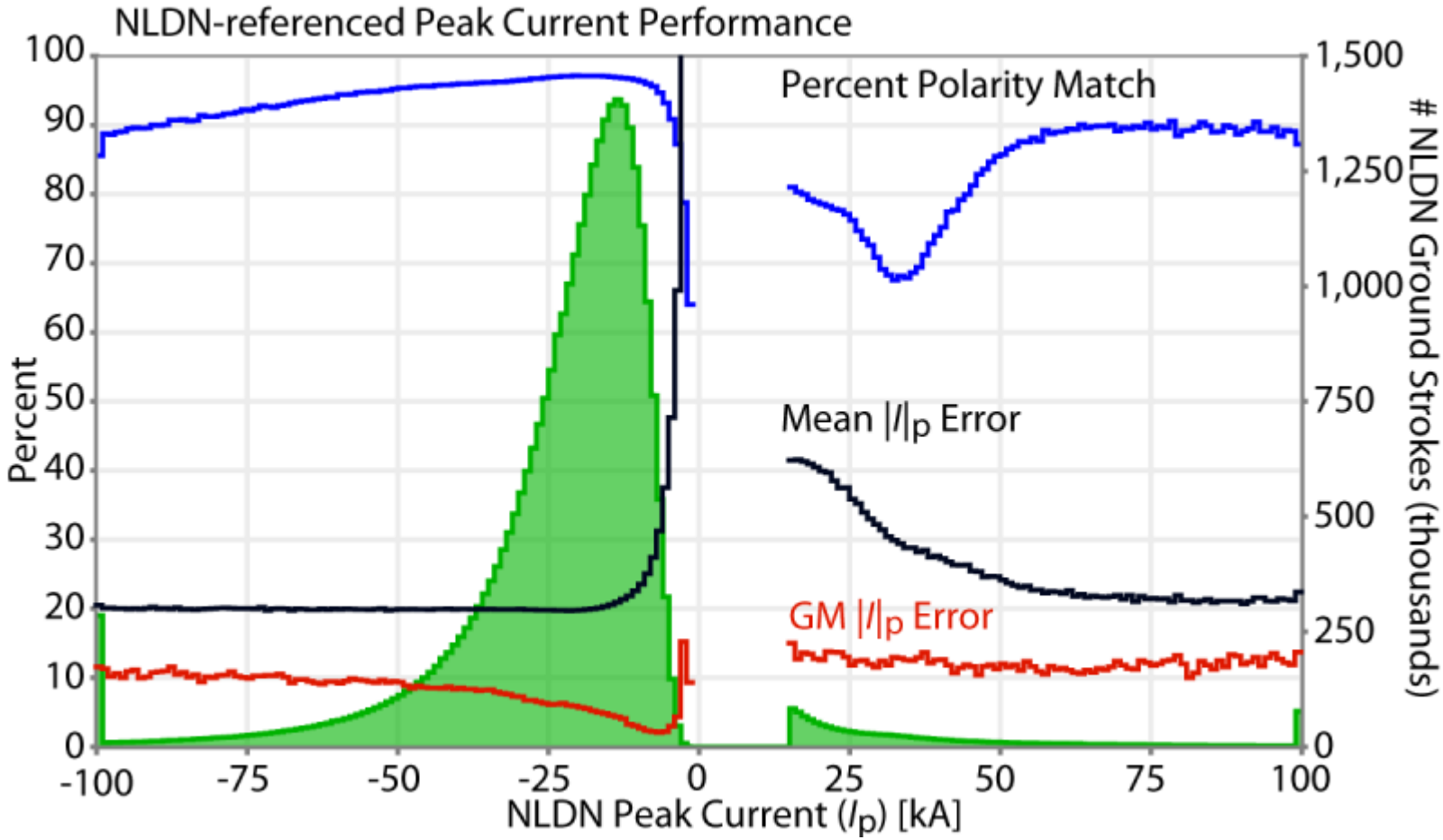
- Reference precision networks
  - DE, LA typically better for local precision networks with relatively high sensor density
  - Enables larger comparison area
- Eg. Compare against NLDN (*Said et al*, 2013):
  - 2.5 km median location error
  - 57% ground flash DE
  - 21% mean peak current error
  - 96% matched polarity
  - Review peak current results, next 3 slides

Validation Results: Peak Current



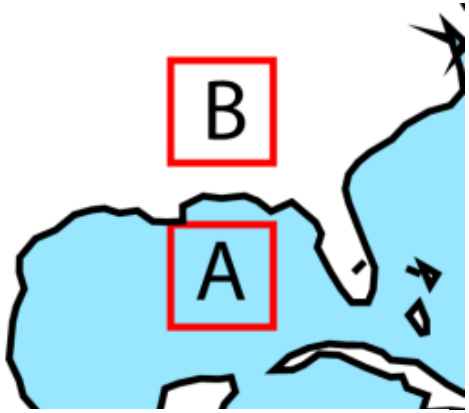
VAISALA

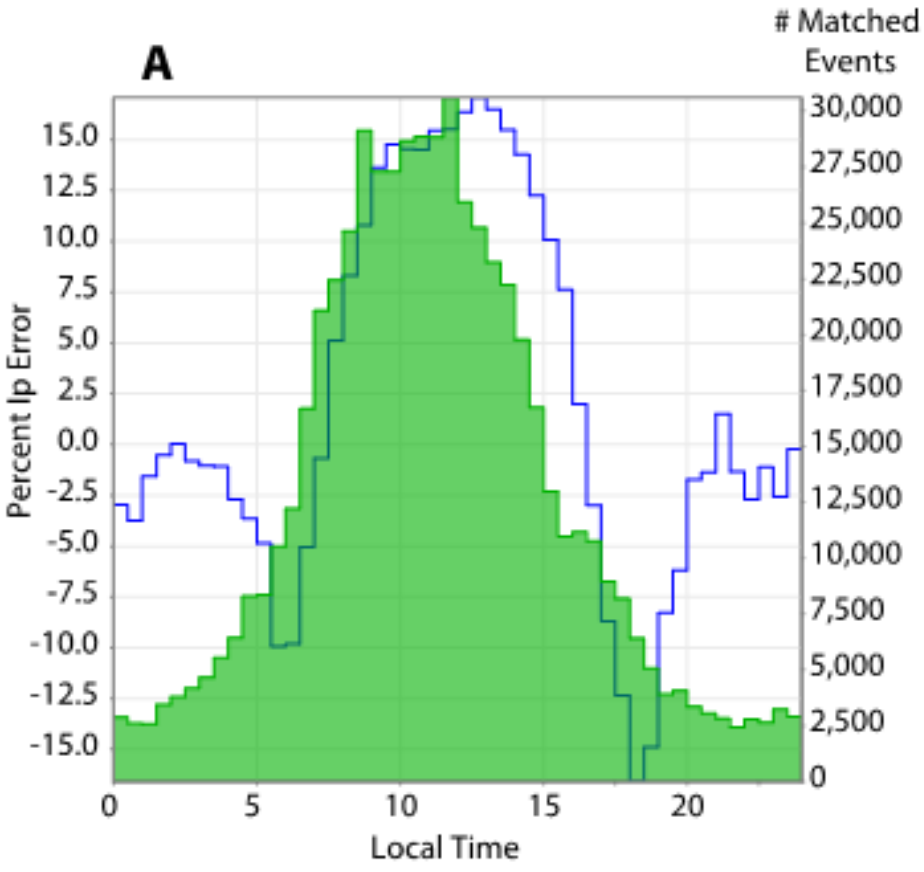
Validation Results: Peak Current

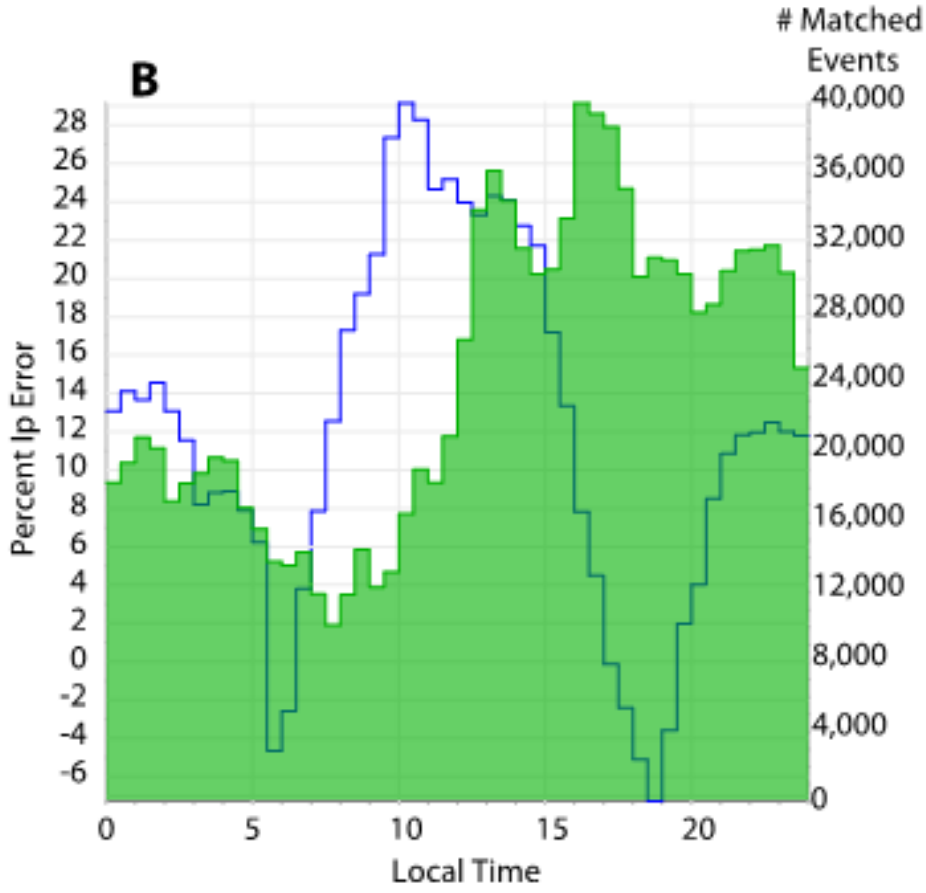


Diurnal Variation

- Still room for peak current accuracy improvements





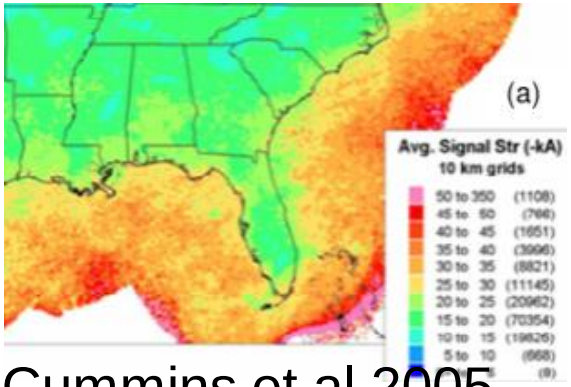


VAISALA

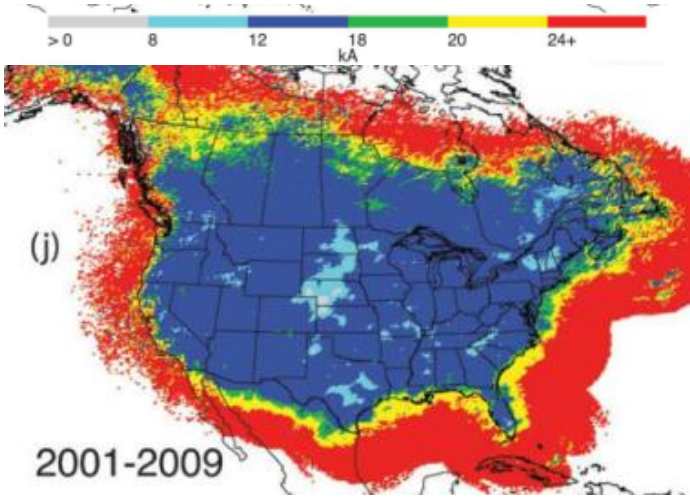
Question: Are Peak Currents Larger Over Ocean?

Previous results:

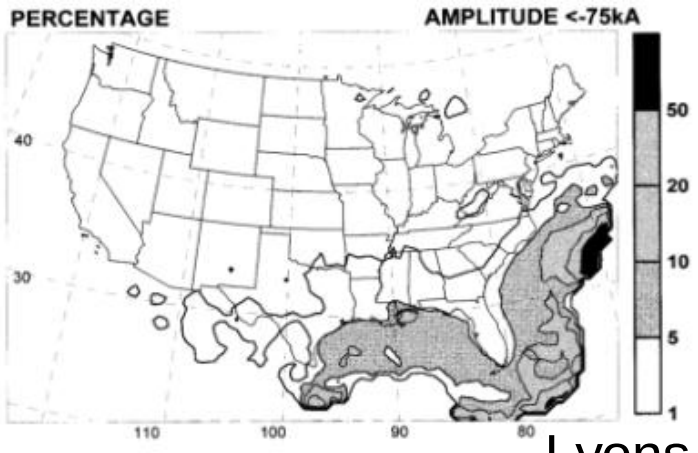
Network-reported Ip enhancement for first negative strokes



Cummins et al 2005



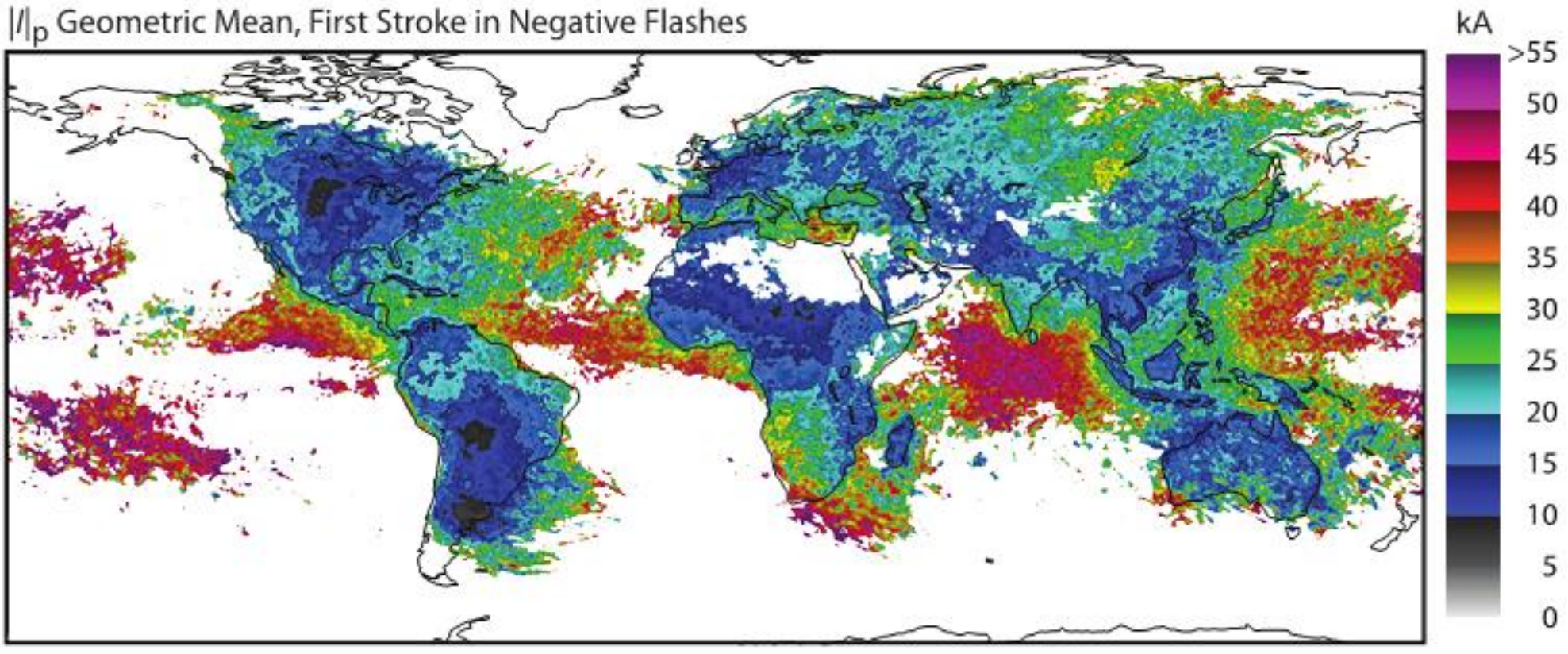
Orville et al 2011



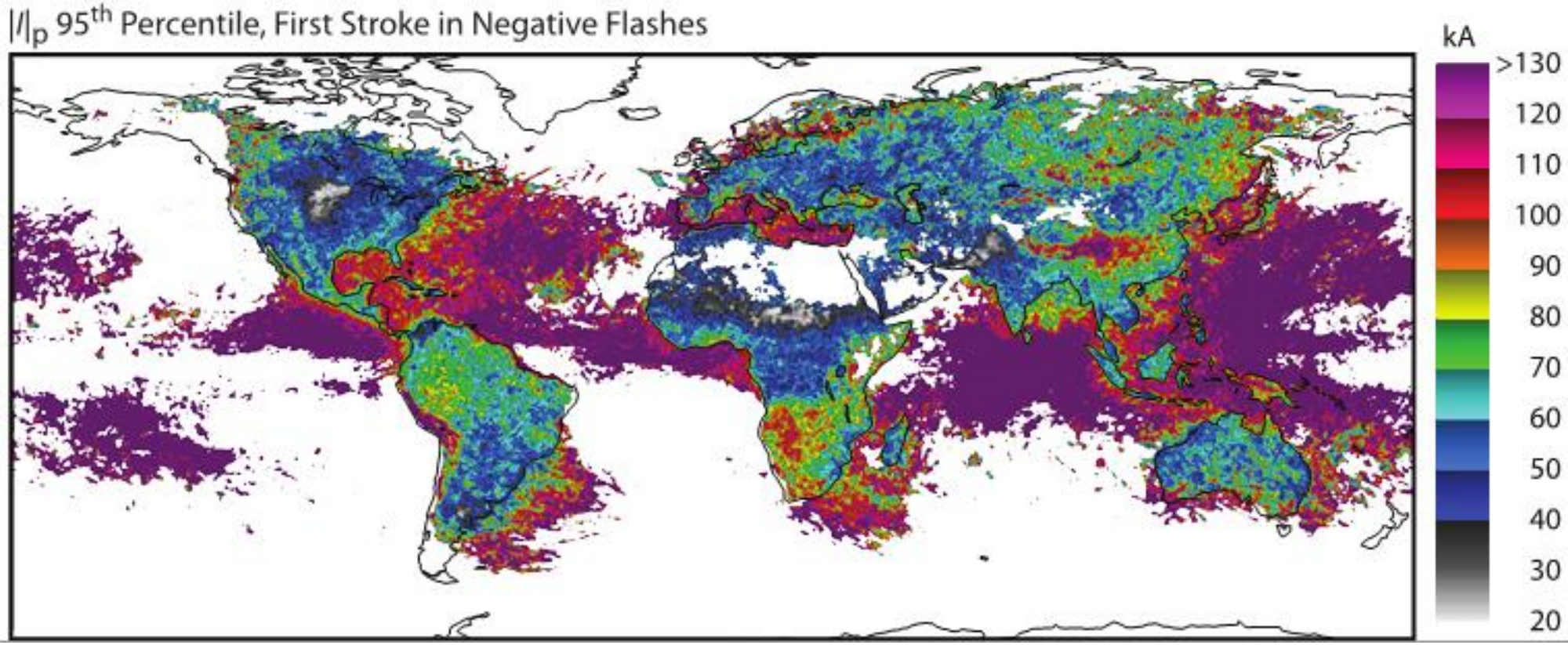
Lyons et al 2007

VAISALA

Global I_p GM of First Negative Strokes

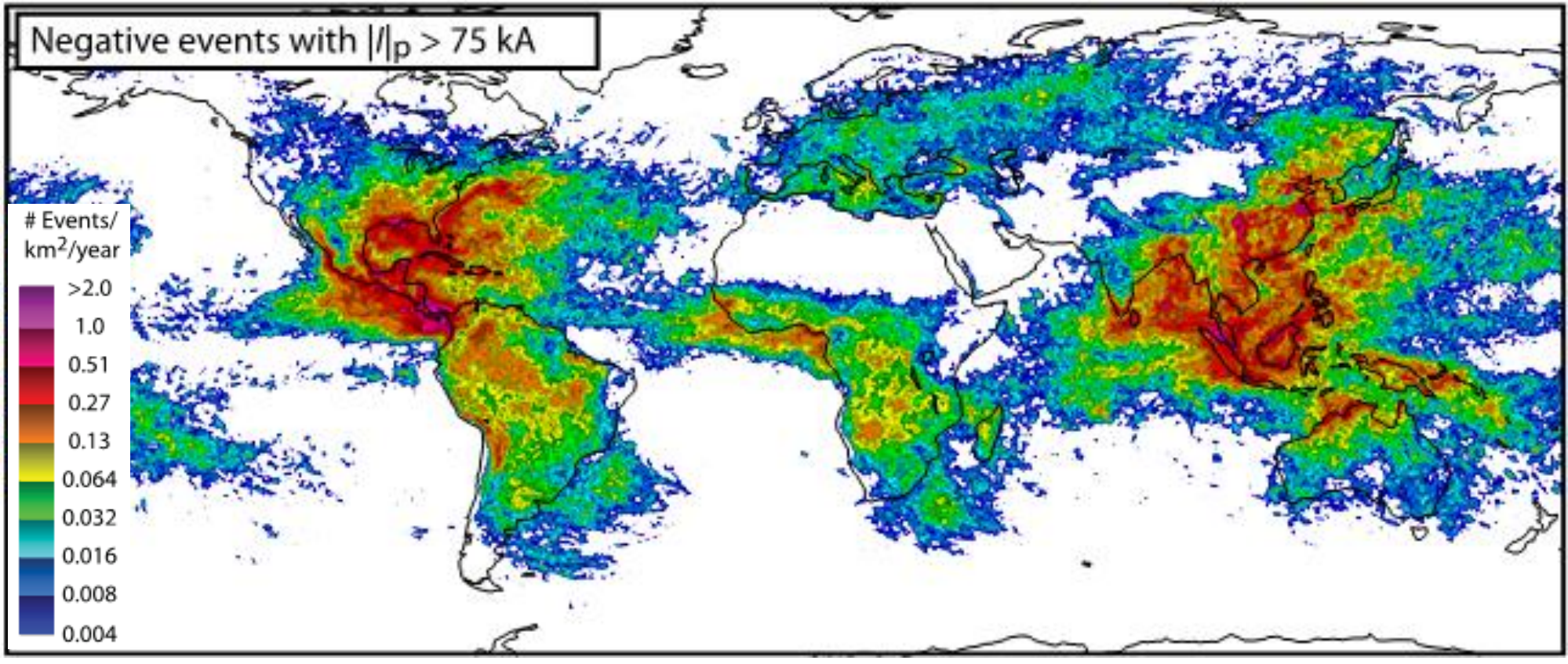


Global Ip 95th Percentile of First Negative Strokes



VAISALA

Climatology of $|I_p|$>75 kA events



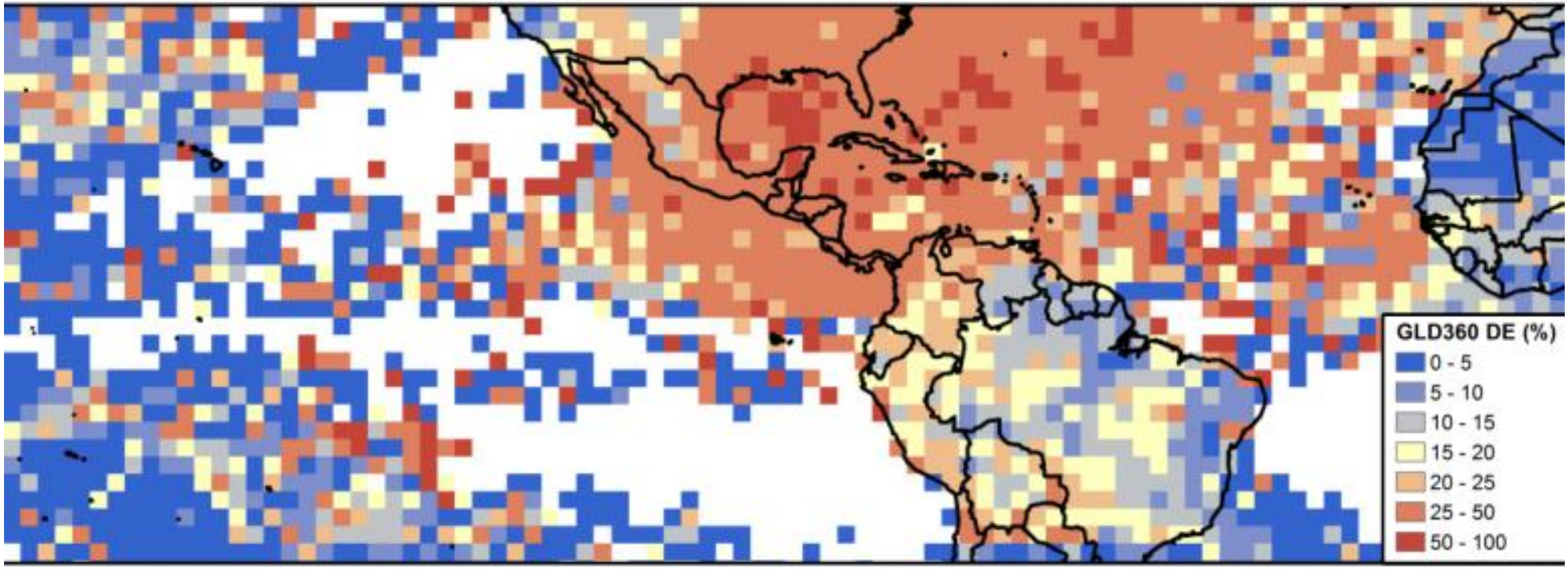
VAISALA

GLD360 Analysis (2012)

- GLD360 performance relative to the TRMM Lightning Imaging Sensor(LIS)
- White grid cells indicate no LIS flashes

Metric	GLD360
DE (%)	25.3
LD (km)	12.6
Multiplicity	1.85

Regional DE (%)	GLD360
North America	33.4
South America	17.5
Oceans	33.0



$2^{\circ} \times 2^{\circ}$ Grid

Compiled by Scott Rudlosky
NESDIS/STAR/SCSB

VAISALA

References

- Christian, Hugh J., et al. (2003), Global frequency and distribution of lightning as observed from space by the Optical Transient Detector, *Journal of Geophysical Research* 108.D1: 4005.
- Cohen, M. B., U. S. Inan, and E. W. Paschal (2010), Sensitive broadband ELF/VLF radio reception with the AWESOME instrument, *IEEE Trans. Geosci. Remote Sens*., 48, 3–17.
- Cummins, K. L., J. A. Cramer, W. A. Brooks, and E. P. Krider (2005), On the effect of land:sea and other Earth surface discontinuities on LLS-inferred lightning parameters, in *VIII International Symposium on Lightning Protection*, pp. 106-111, University of Sao Paulo, Sao Paulo, Brazil.
- Lyons, W. A., M. Uliasz, and T. E. Nelson (1998), Large peak current cloud-to-ground lightning flashes during the summer months in the contiguous United States, *Mon. Weather Rev*., 126, 2217–2233
- Orville, R. E., G. R. Huffines, W. R. Burrows, and K. L. Cummins (2011), The North American Lightning Detection Network (NALDN)—Analysis of flash data: 2001–09, *Mon. Weather Rev*., 139, 1305–1322.
- Said, R. K., U. S. Inan, and K. L. Cummins. (2010), Long-range lightning geolocation using a VLF radio atmospheric waveform bank. *Journal of Geophysical Research: Atmospheres (1984–2012)* 115.D23.
- Said, R. K., M. B. Cohen, and U. S. Inan (2013), Highly intense lightning over the oceans: Estimated peak currents from global GLD360 observations. *Journal of Geophysical Research: Atmospheres*.