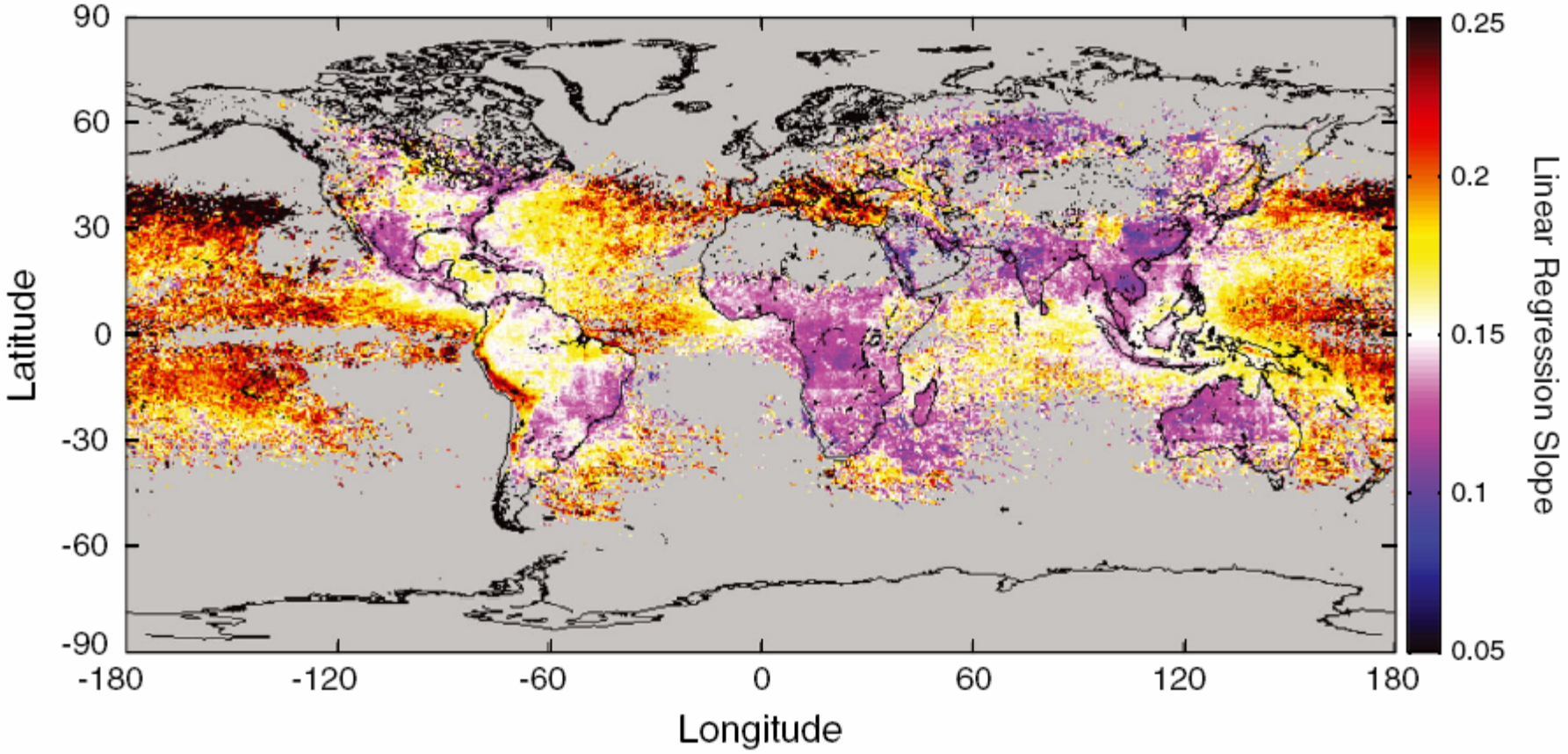
World Wide Lightning Location Network: Recent Results

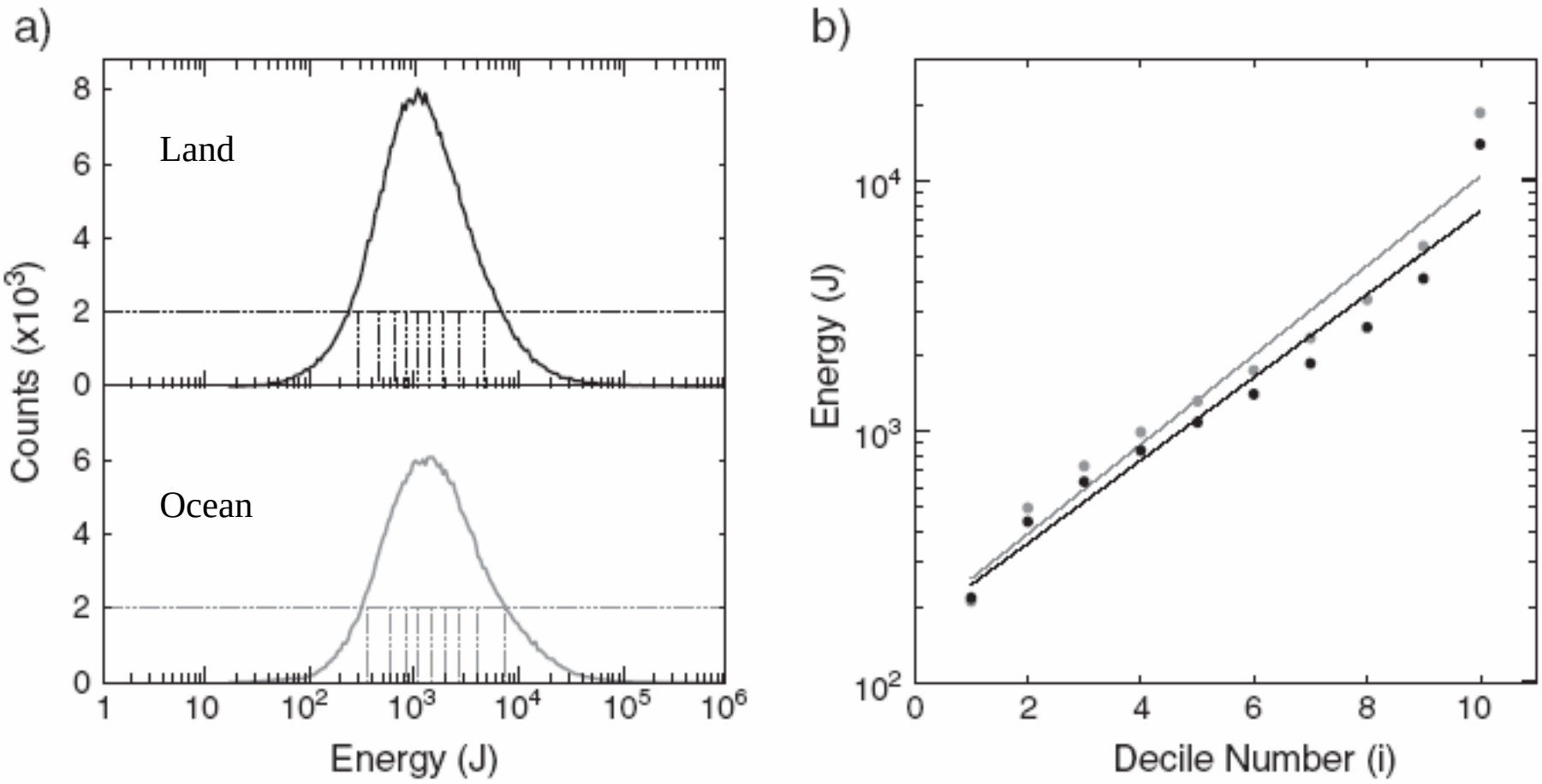
By R. H. Holzworth, Univ. of Washington with M.L. Hutchins, A. R. Jacobson, J. B. Brundell, K.S. Virts, J. M. Wallace, S. Heckman, C.F. Mass, K. Dixon

- **Strong Land-Ocean interface change in average stroke energy: stronger strokes over the ocean**
- **VLF attenuation strongly varies with azimuth, Attenuation rates change with distance from source**
- **Lightning Assimilation into WRF predictions: using lightning for water vapor nudging gives great forecast improvement**

Radiated VLF energy differences of land and oceanic lightning

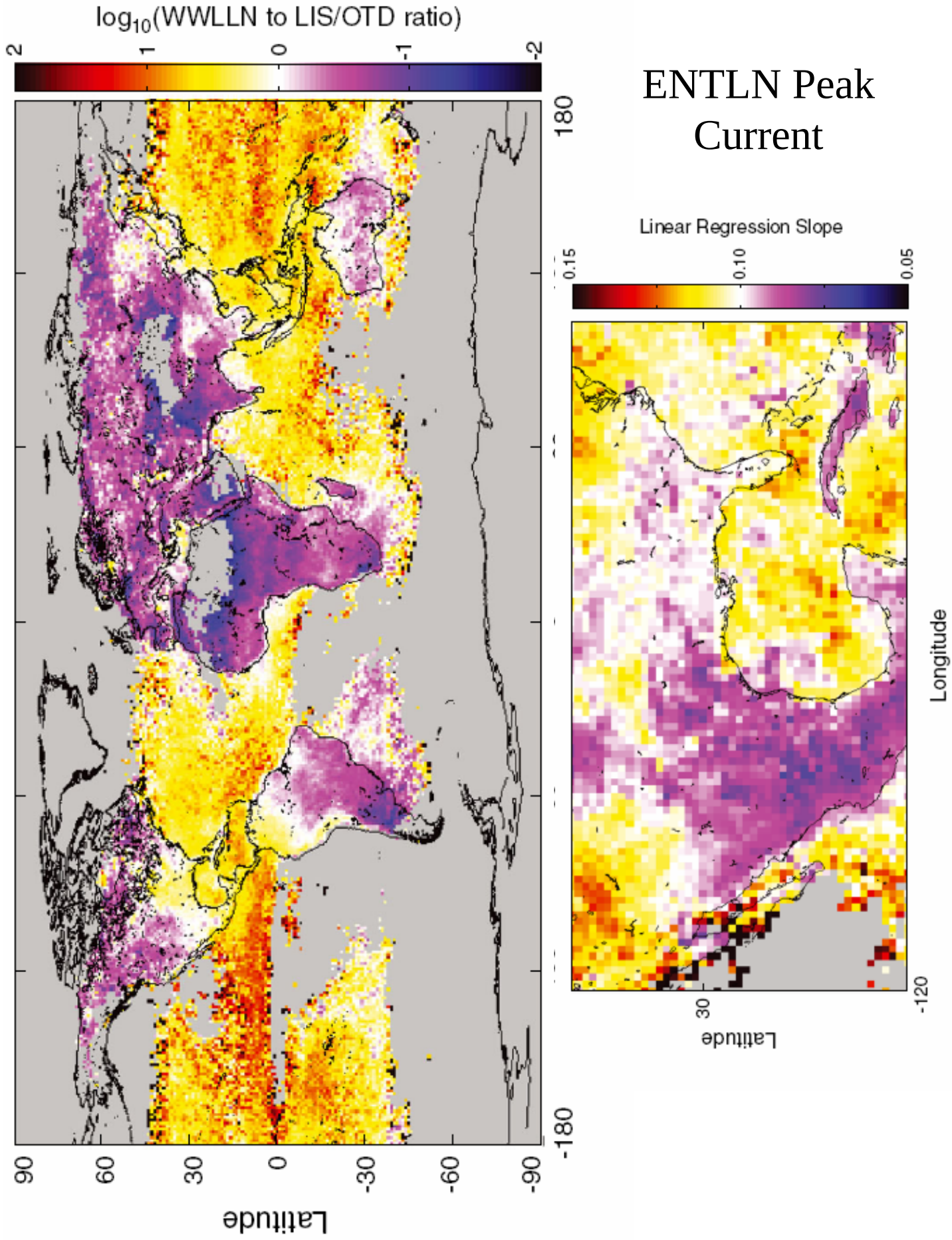


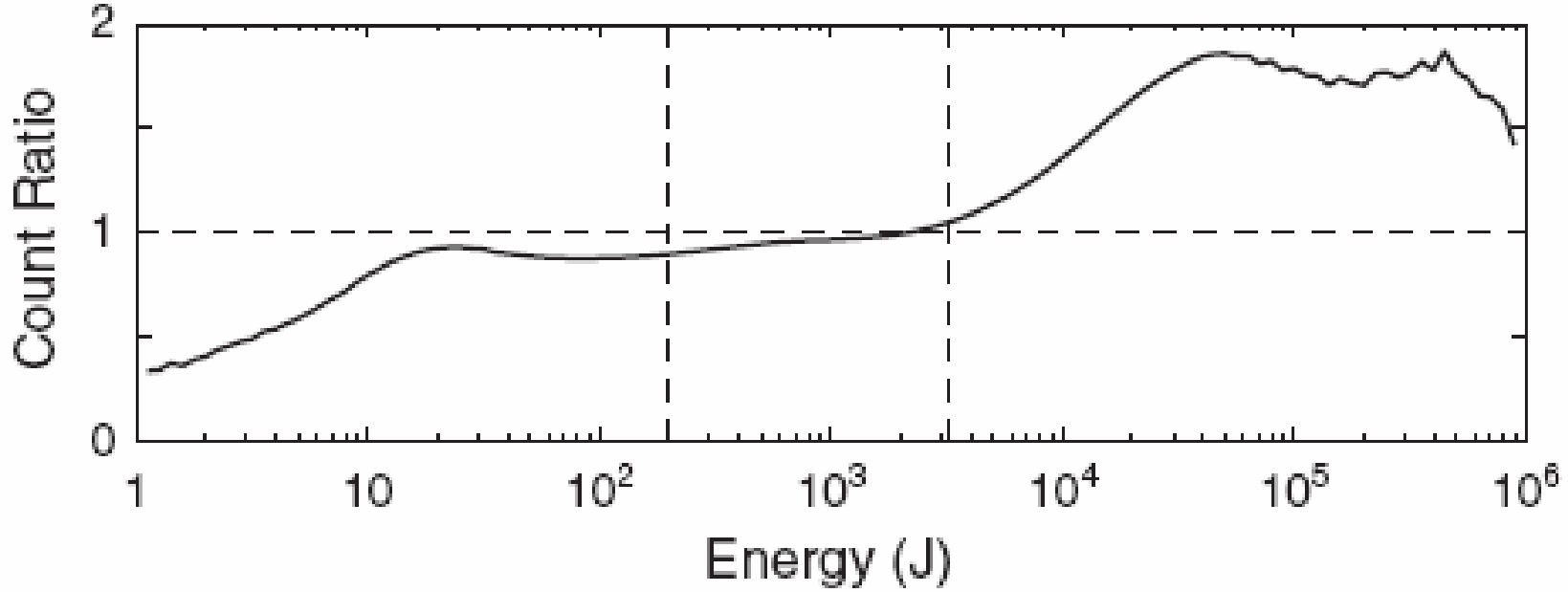
M. L. Hutchins, R. H. Holzworth, K. S. Virts, J. M. Wallace, and S. Heckman, *Geophs. Res. Lett*, V. 40, 1–5, doi:10.1002/grl.50406, **2013**

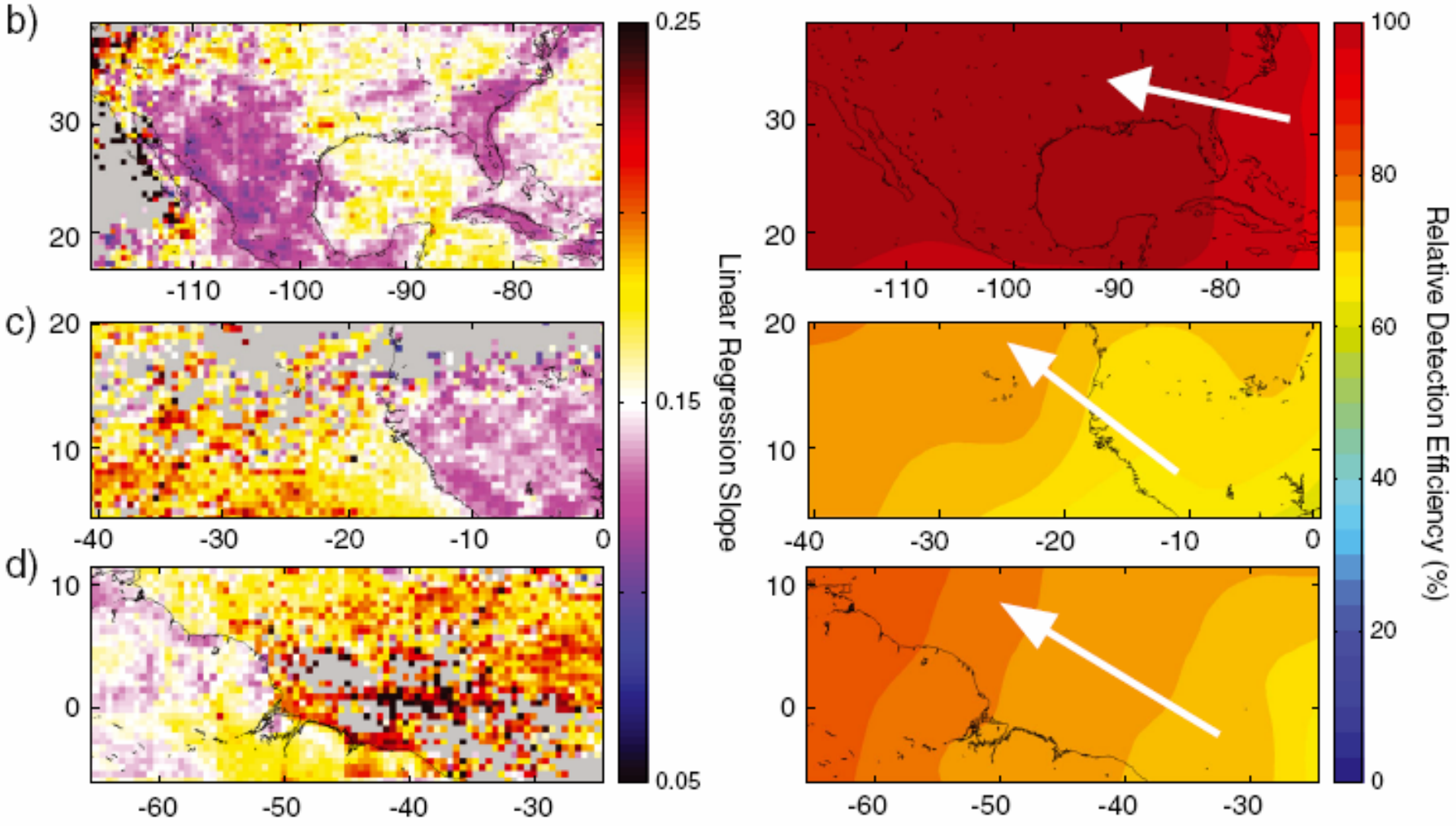


Please see details in Hutchins et al, *Geophs. Res. Lett*, V. 40, 1–5, doi:10.1002/grl.50406, **2013**

ENTLN Peak Current



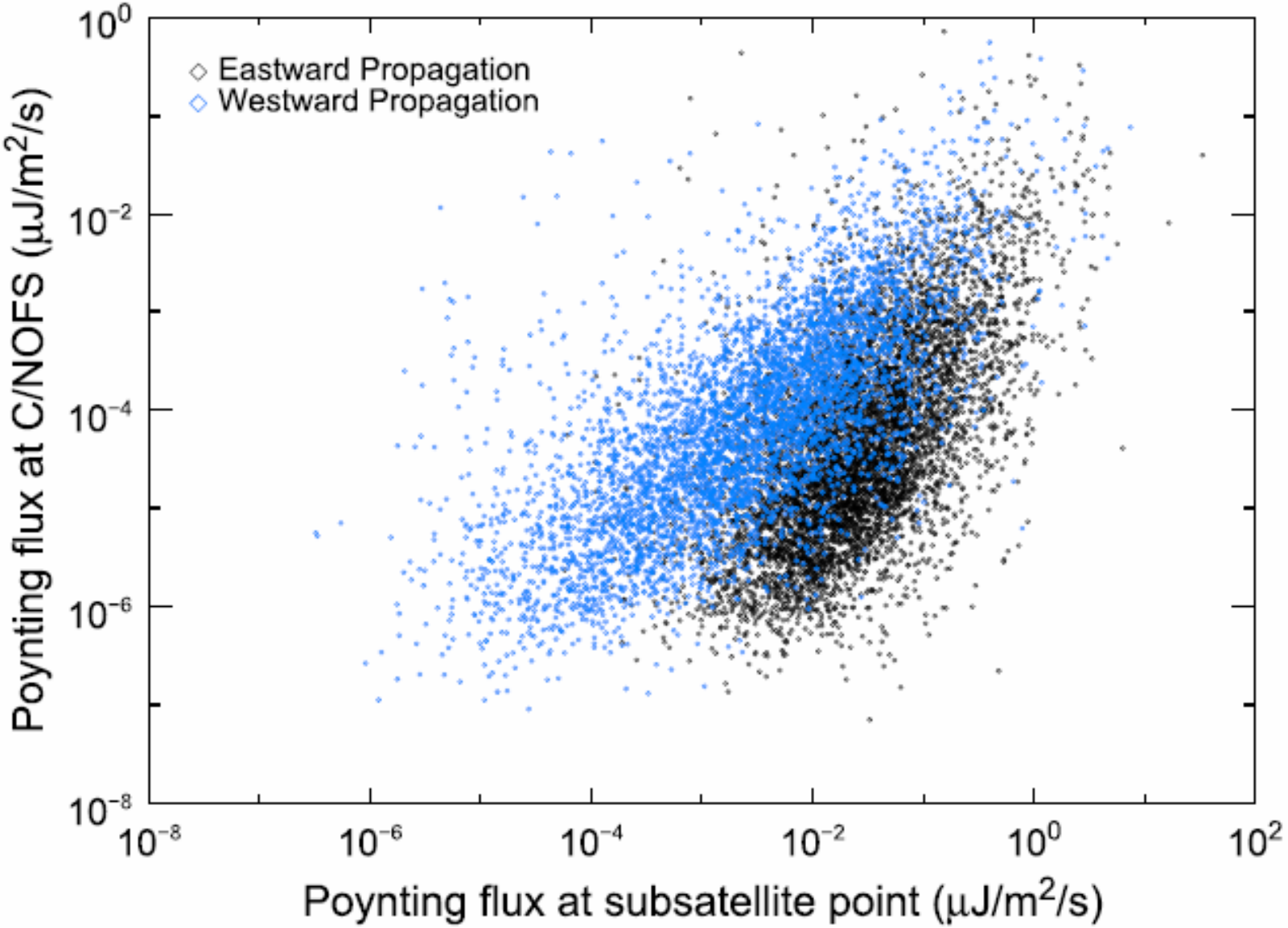

Count Ratio
2
1
0
1
10
10^2
10^3
10^4
10^5
10^6
Energy (J)


b)
c)
d)
30
20
10
0
-110
-100
-90
-80
-40
-30
-20
-10
-60
-50
0.25
0.15
0.05
Linear Regression Slope
100
80
60
40
20
0
Relative Detection Efficiency (%)

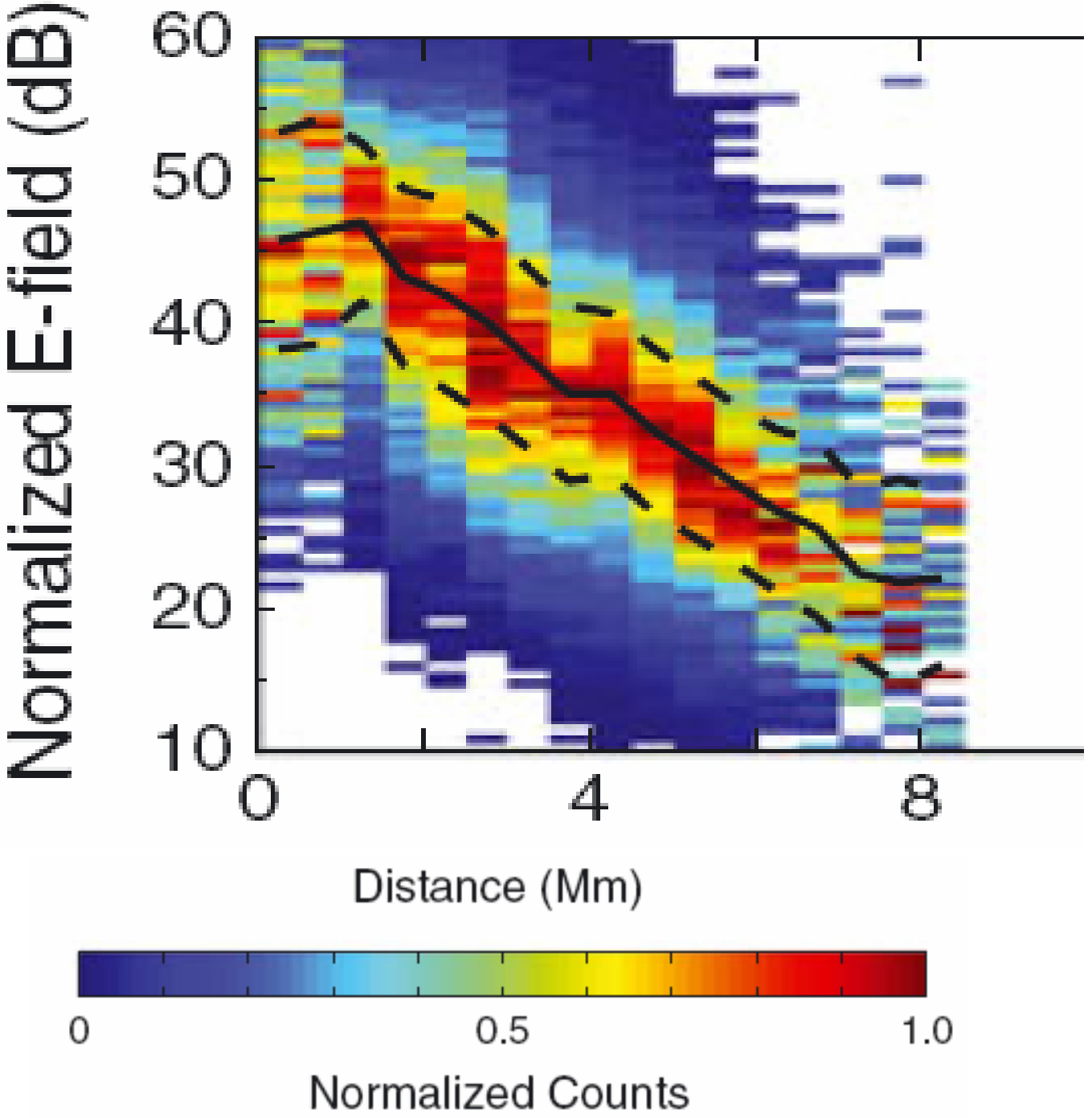
- **6. Conclusion**
- [23] A linear regression method is developed and applied
- to the WWLLN data set in order to examine global and
- regional changes of lightning stroke strength over several
- years of network data. Through comparing WWLLN,
- ENTLN, and LIS/OTD, the difference between stroke
- strength is seen to be **highly dependent on whether the**
- **storms occur over land or over ocean with a sharp boundary**
- **occurring along most coastlines**. Smaller regions are examined
- to show that the contrast along coastlines is not due to
- abrupt changes in the detection efficiency of the networks.
- The sharpness of the coastal changes, less than 100 km,
- suggests the effect is due to a local phenomena and not
- be caused by large-scale changes in the convective landocean
- regions. Changes exist within continental regions,
- but these transition were not examined, as the underlying
- change between regimes is not as sharp as for coastlines.

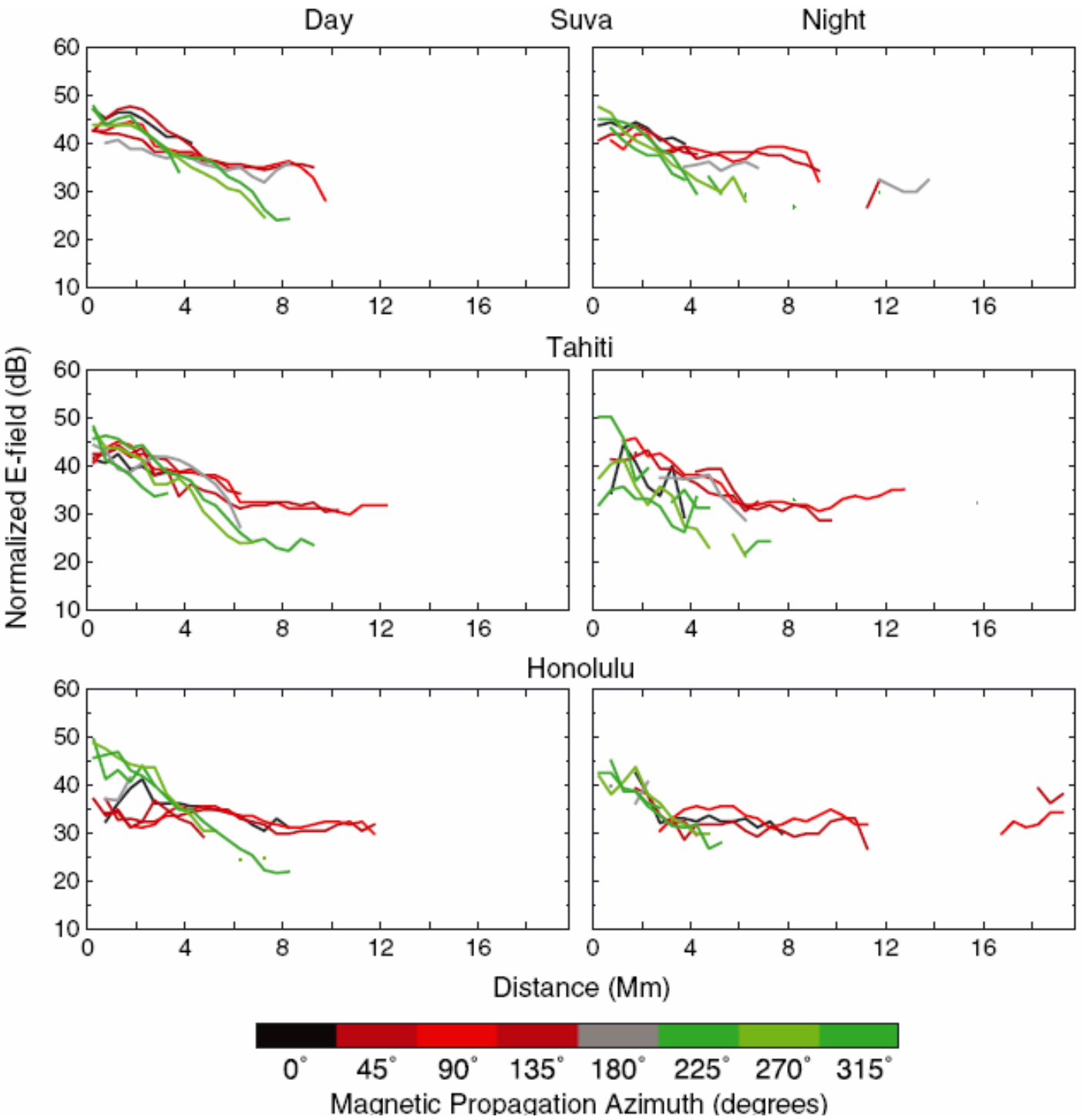
Azimuthal dependence of VLF propagation

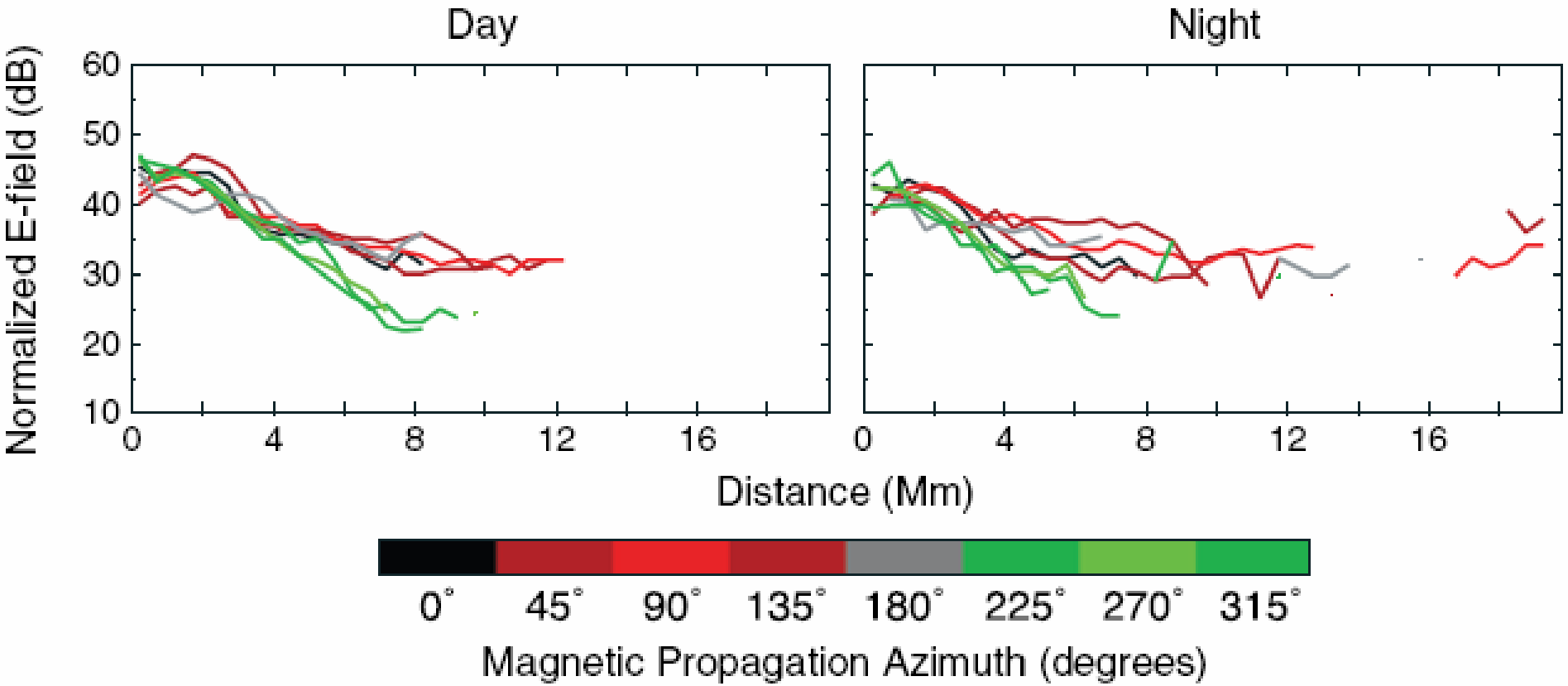
- M. L. Hutchins, Abram R. Jacobson, Robert H. Holzworth and James B. Brundell, *J. Geophys. Res*, *Space Physics*, V. 118, 1–5, doi:10.1002/jgra.50533, 2013



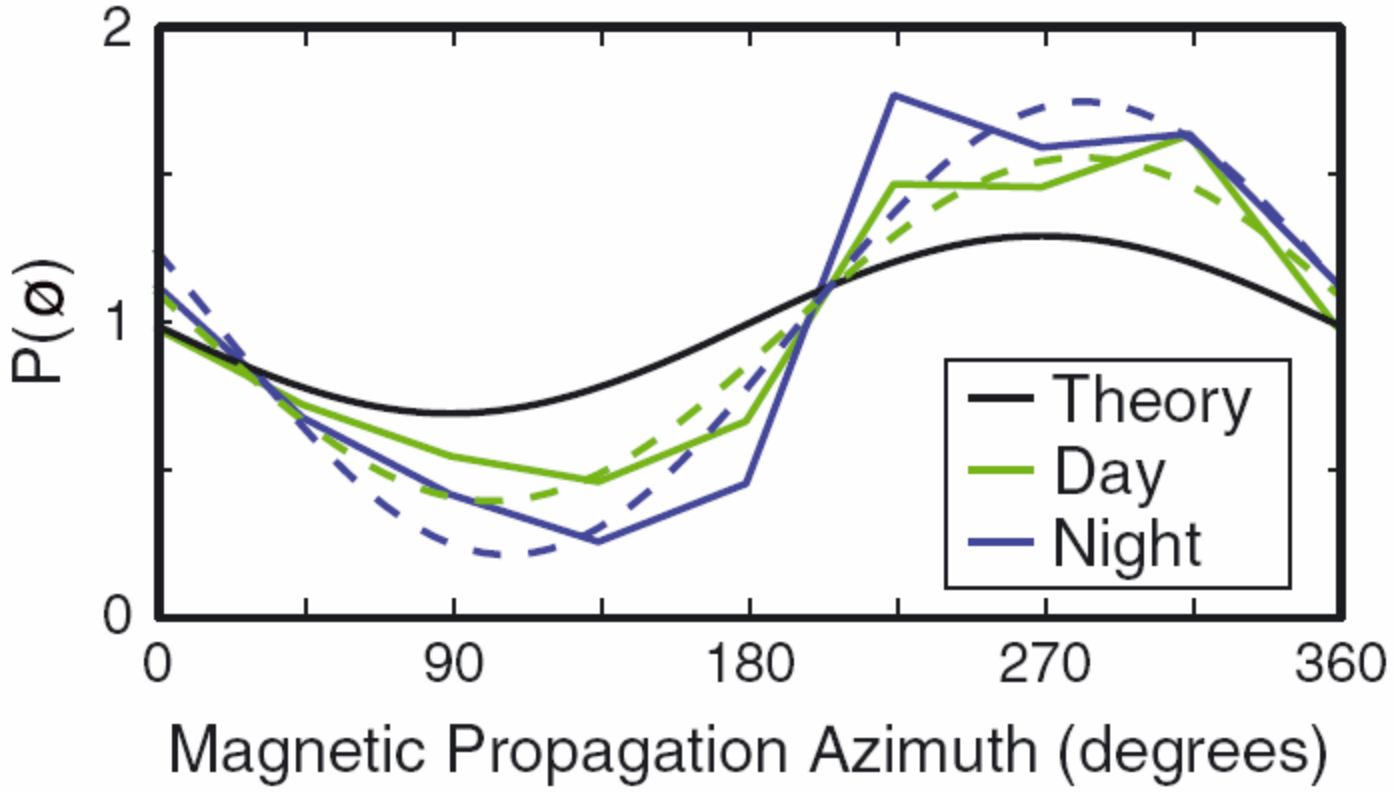
Burkholder et al, ***JGR, Space Physics,*** V. 118, 3692–3699, doi:10.1002/jgra.50351, **2013**


Normalized E-field (dB)
60
50
40
30
20
10
0
4
8
Distance (Mm)
0
0.5
1.0
Normalized Counts


Day
Suva
Night
Tahiti
Honolulu
Normalized E-field (dB)
Distance (Mm)
0°
45°
90°
135°
180°
225°
270°
315°
Magnetic Propagation Azimuth (degrees)



Westward propagating sferics have higher attenuation in both day and night, especially seen beyond 4Mm.



Wait and Spies[1960] (black)

day paths (green), and night paths (blue).

- **5. Conclusion**
- [19] Four years of WWLLN data were used to analyze the
- normalized VLF electric field from lightning at three island
- stations, with the variation with magnetic azimuth compared
- to theoretical results. The electric fields were used to
- calculate the average attenuation in the 8–18 kHz band at different
- propagation azimuths. The stroke-receiver paths were
- selected for sferics propagating over at least 95% water and
- under either 90% day or 90% night ionospheric conditions.
- [20] It was found that compared to day propagation,
- **night propagating sferics have higher attenuation close to**
- **the stroke** (2.09 +- 1.02) with less attenuation farther out
- (0.24 +- 0.48). Similarly, **attenuation of night sferics have a**
- **higher dependence on magnetic azimuth compared to day**
- sferics. Variations with magnetic azimuth showed that **westward** ←
- **propagation had 1.9–2.0 dB/Mm more attenuation than**
- **eastward propagation** for both day and night ionospheric
- conditions.

Assimilating Lightning into WRF

- Lightning indicates a relatively deep cloud
- **Nudge water vapor** toward 100% RH
  - Force model to reproduce the cloud
  - Encourage ascent at nudged locations (LCL↓,CAPE↑)
  - Basic model variable, avoid microphysics

Based on AMS paper: Impact of Lightning Data Assimilation on High-Resolution Numerical Forecasts:29 June 2012 Derecho, K. Dixon, C.F. Mass and R. H. Holzworth, AMS 15th Conference on Mesoscale Processes 9 August 2013

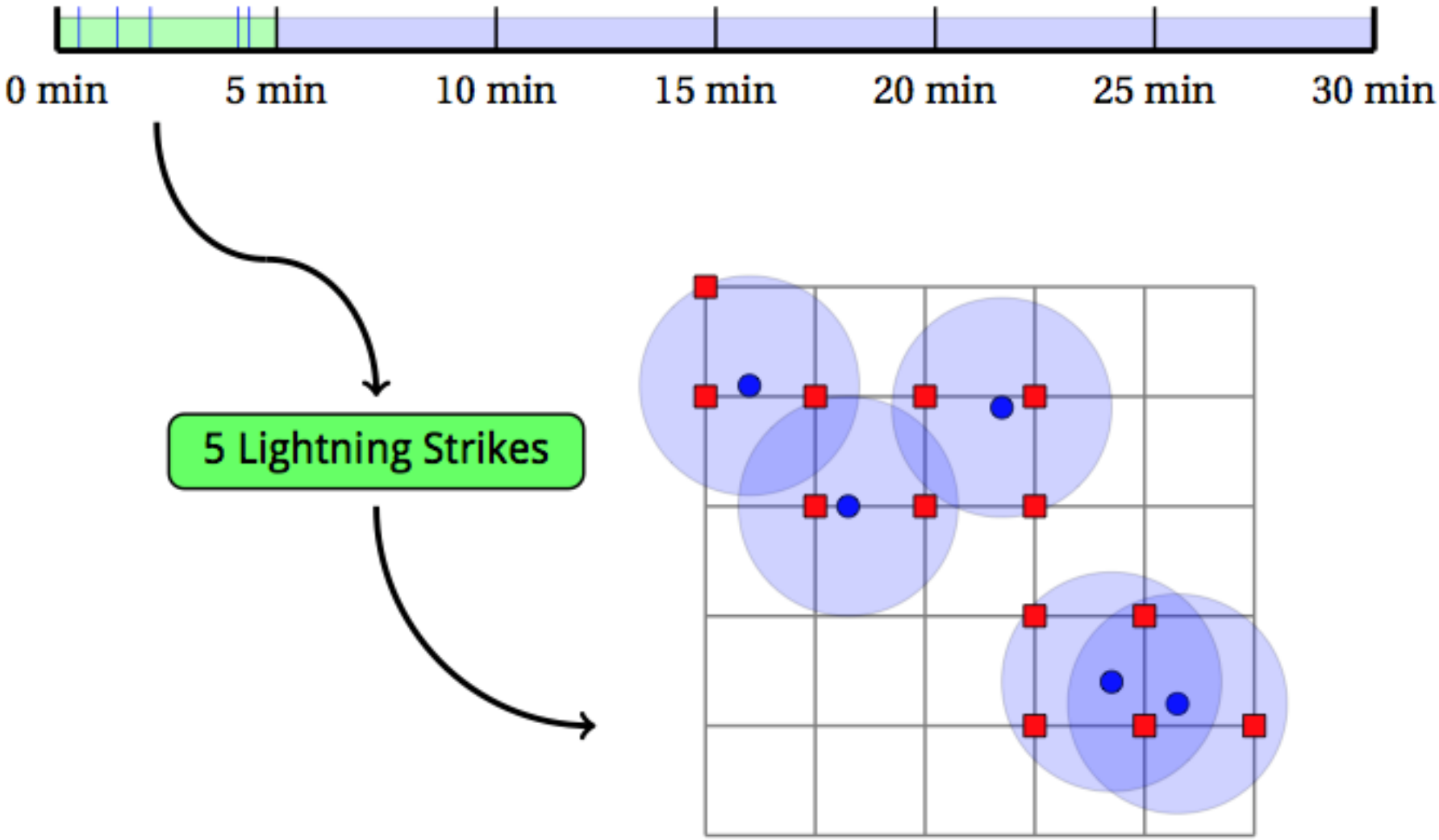
Assimilation Technique
(with K. Dixon, C.F. Mass)

AMS 15th Conference on Mesoscale Processes, **9 August 2013**

- Observation nudging
  - Modified version of built-in WRF functionality[1]
  - When?
    - Lightning grouped into **5min** chunks
  - Where?
    - Grid points **within 3km** of strike
    - Grid points **below 200hPa**
  - How much?
    - Relaxation timescale of **300 sec**
    - Flash rate irrelevant

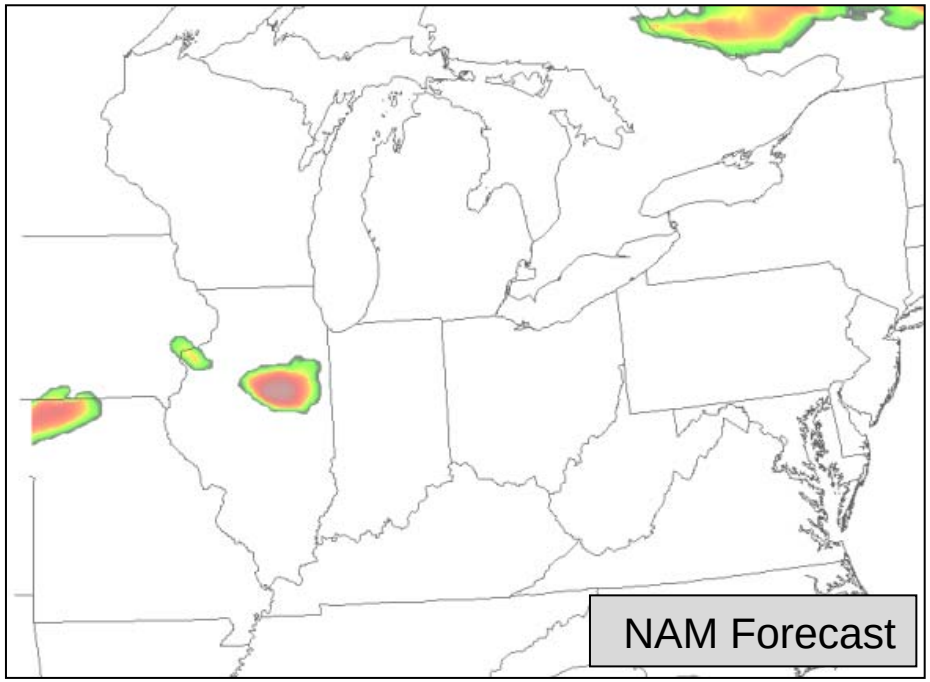
[1] Stauffer and Seaman, 1994

Assimilation Technique

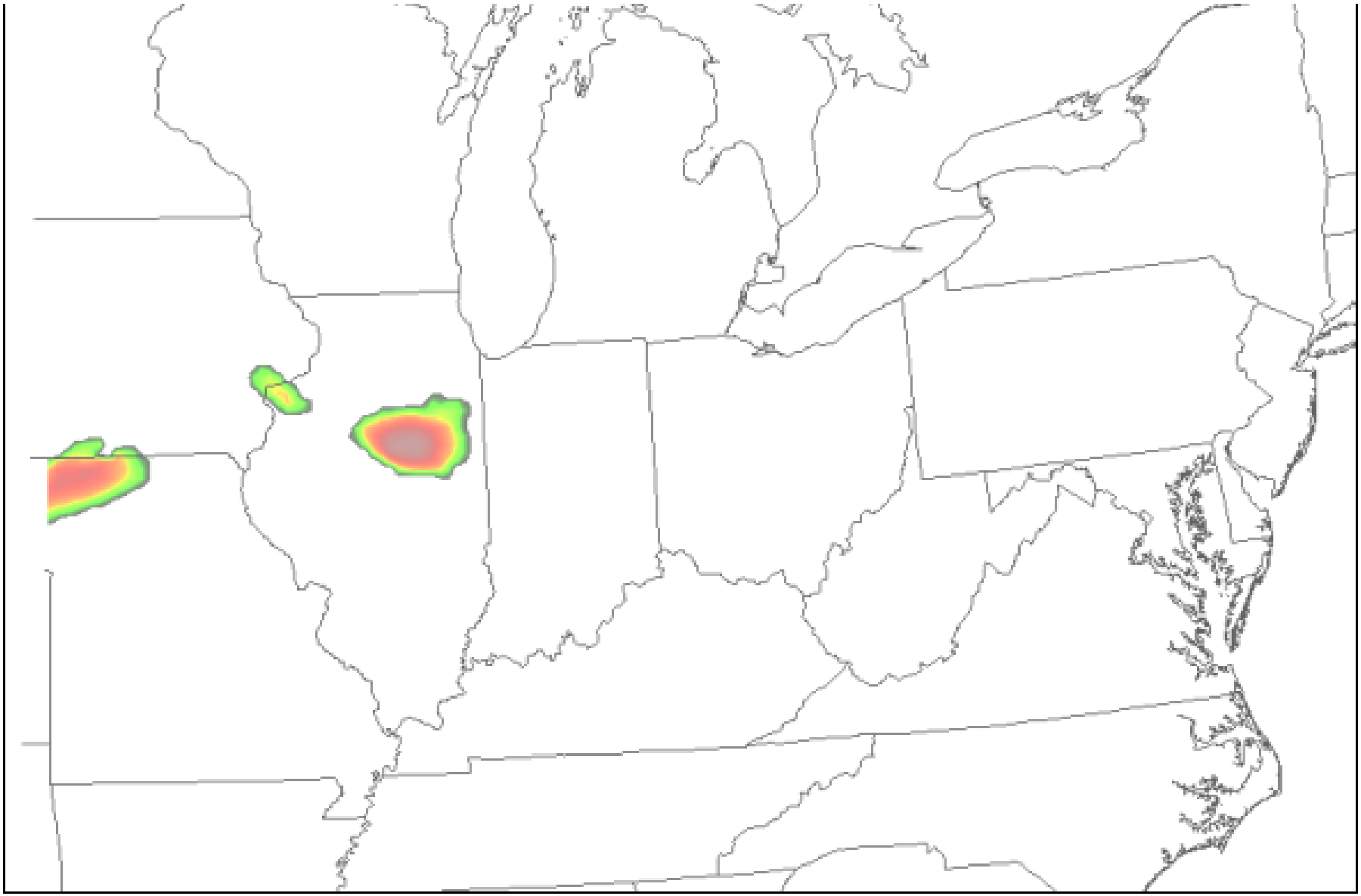


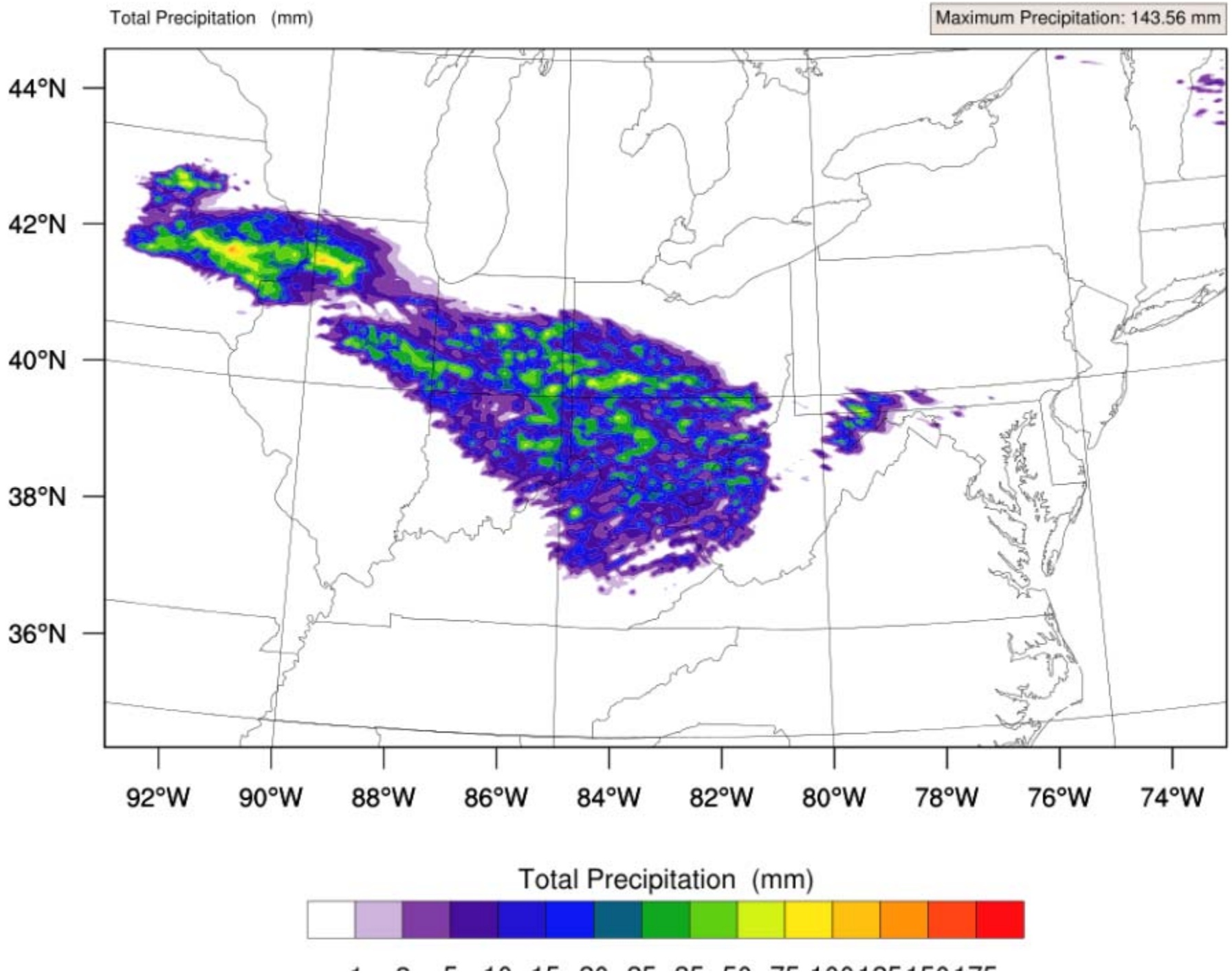
Why 29 June 2012?

- Operational modeling difficulties
- Progressive derecho
  - Weak large scale forcing
  - MCS evolution depends on early convection



NAM 12hr
precipitation forecast
(Valid 00z 30 June)




Total Precipitation (mm)
Maximum Precipitation: 143.56 mm
44°N
42°N
40°N
38°N
36°N
92°W
90°W
88°W
86°W
84°W
82°W
80°W
78°W
76°W
74°W
Total Precipitation (mm)

Thank you