Global Lightning Research and status of WWLLN

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Ken Pickering (NASA and UMD) **Dale Allen** (UMD)
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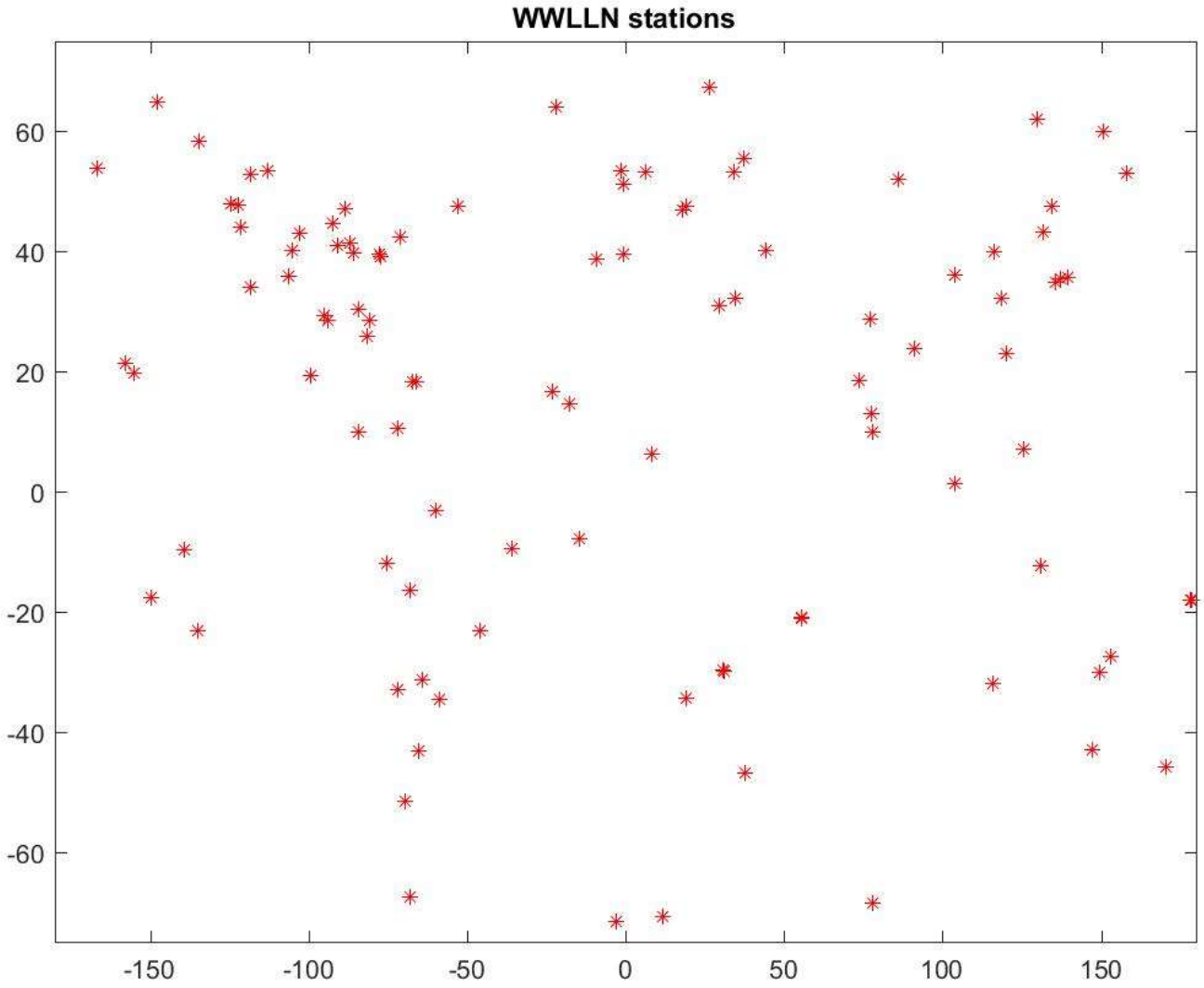
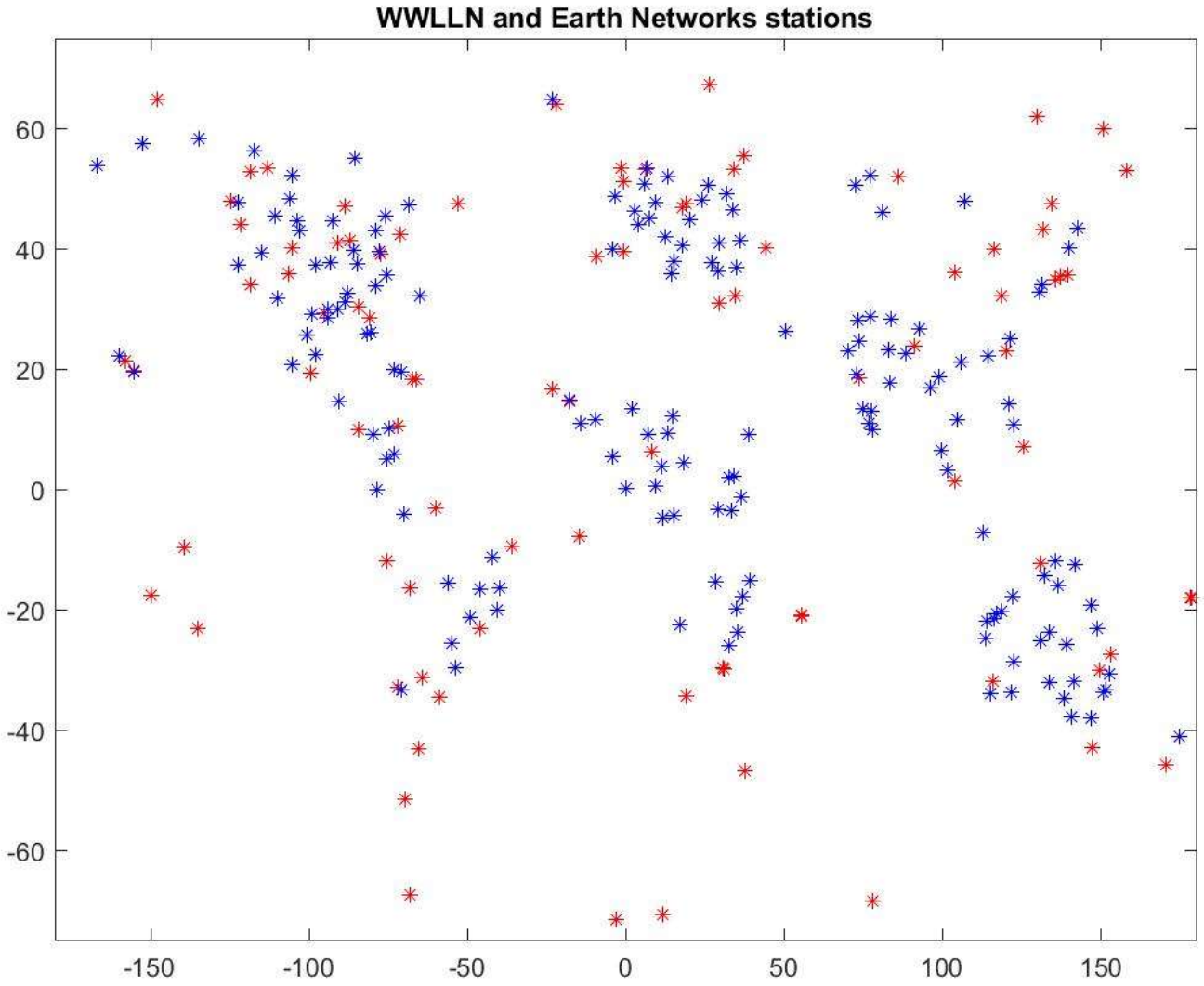
Global Lightning Research and status of WWLLN

1. **Network status/Combination of new data set with Earth Networks**
   200 to 300 % increases over WWLLN-only
2. **Research**
   Lightning Assimilation into forecast models
   NOx from lightning using OMI and WWLLN
   Volcanic lightning studies (Calbuci and Kelud)
   Lightning Whistlers in Magnetosphere (NASA Van Allen Probes)
   Lightning Whistler propagation Study using C/NOFS – multiple whistler dispersions
   Global climatology
   Lightning Clusters as proxy for thunderstorms

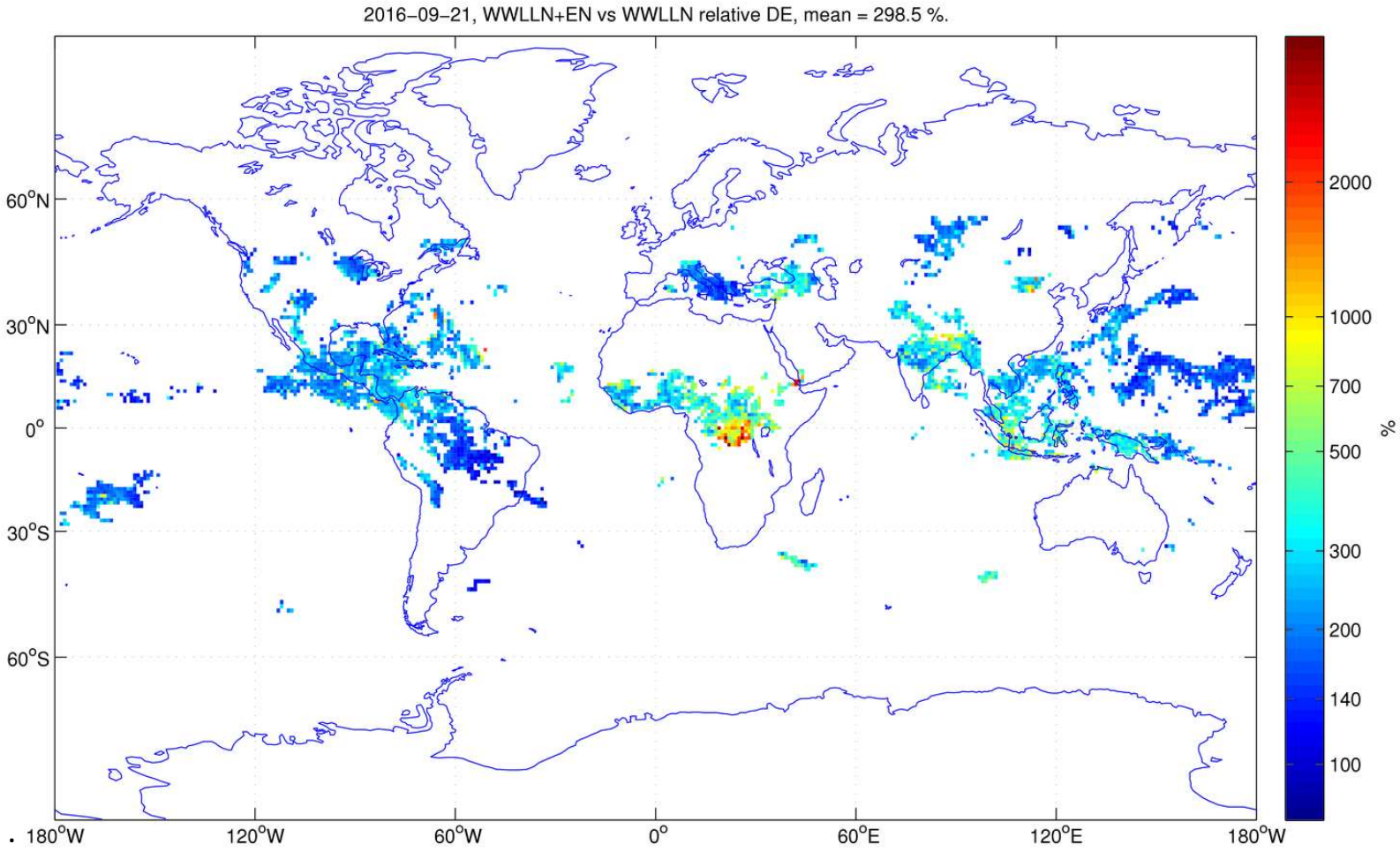
For the record;

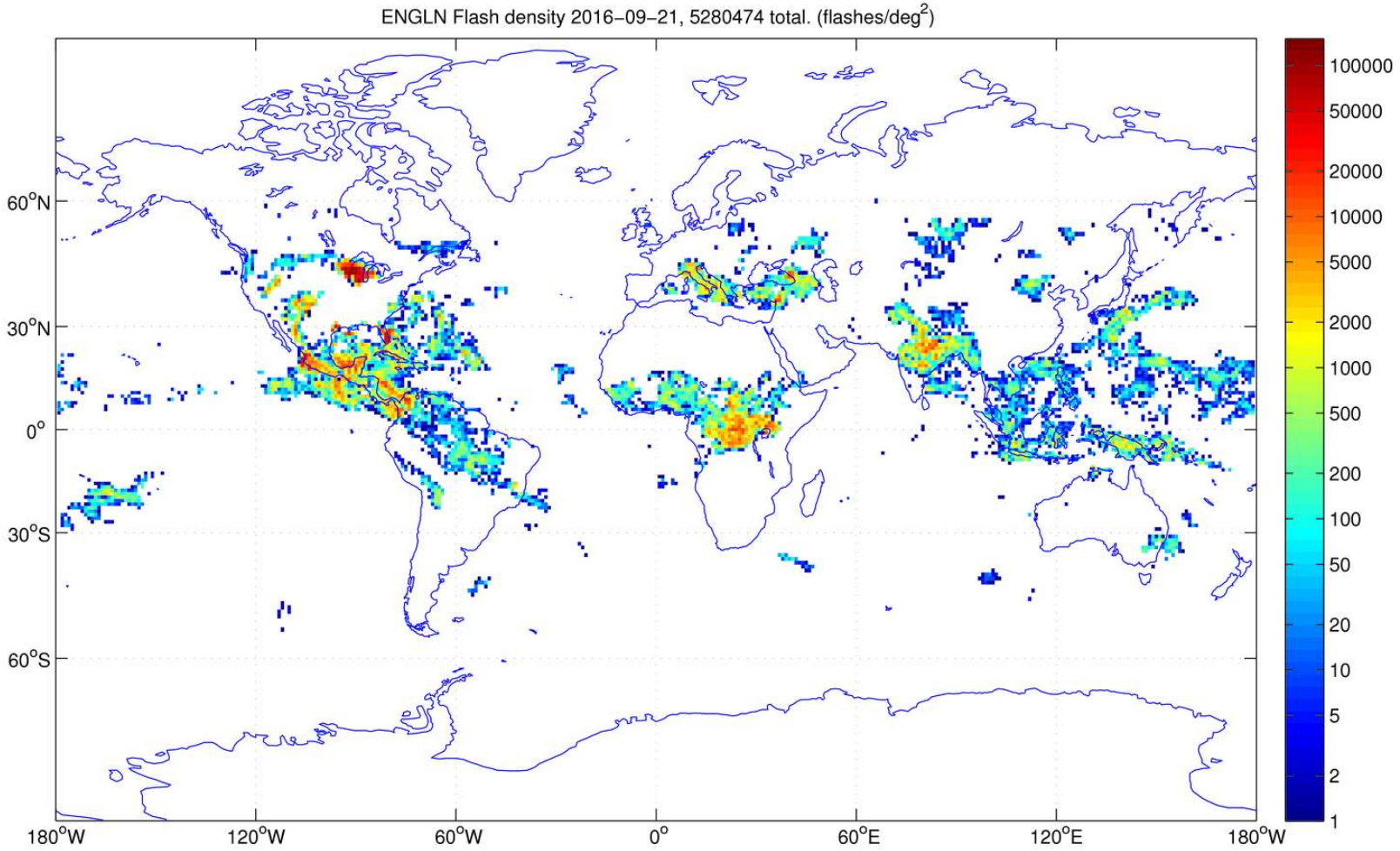
WWLLN has 76 active stations (over 100 Host scientists)
WWLLN located in 2015: 170 x 10^6 strokes (1.4 billion from 2005 through 2015)
Projected for next year WWLLN+EN(vlf): 350 x 10^6 strokes
101 peer reviewed papers (see http://wwlln.net/publications)
No government or private grants (operations paid by data sales)


WWLLN stations
60
40
20
0
-20
-40
-60
-150
-100
-50
0
50
100
150


WWLLN and Earth Networks stations
60
40
20
0
-20
-40
-60
-150
-100
-50
0
50
100
150

One Day, showing percent INCREASE with EN and WWLLN




ENGLN Flash density 2016−09−21, 5280474 total. (flashes/deg^2)
60°N
30°N
0°
30°S
60°S
180°W
120°W
60°W
0°
60°E
120°E
180°W
100000
50000
20000
10000
5000
2000
1000
500
200
100
50
20
10
5
2
1

Some Recent Research Results

- Lightning Assimilation into forecast models (Published 2016)
- NOx from lightning using OMI and WWLLN (2016)
- Volcanic Lightning at Calbuck, Chile (2016)
- Lightning whistlers in Magnetosphere (NASA Van Allen Probes) (2015)
- Lightning Whistler propagation Study using C/NOFS – multiple whistler dispersions (2016)

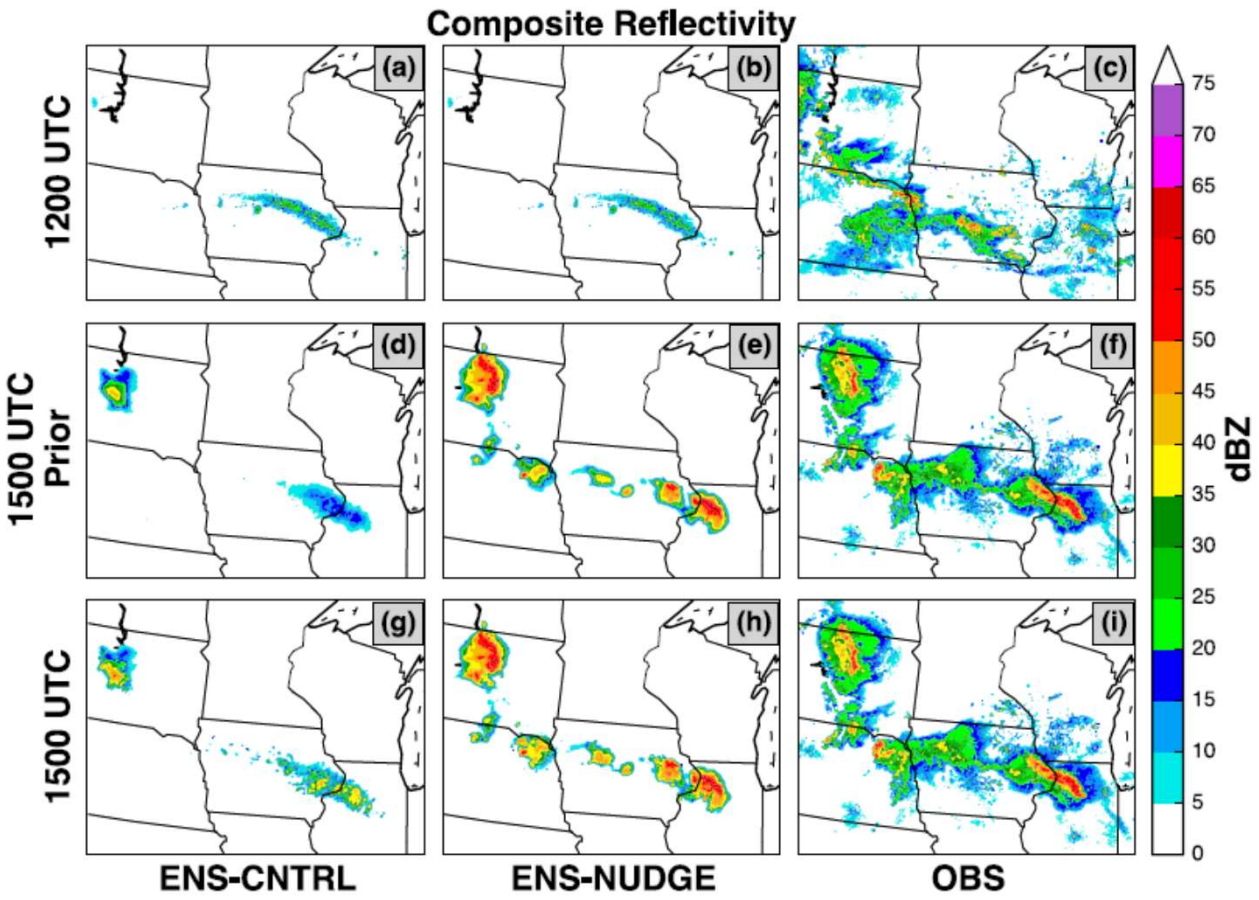


FIG. 10. Ensemble-mean and observed composite reflectivity (top row) after the 1200 UTC 29 Jun 2012 EnKF assimilation step and (middle row),(bottom row) before and after the 1500 UTC 29 Jun 2012 EnKF assimilation step, respectively. The columns correspond to (left) ENS-CNTRL, (center) ENS-NUDGE, and (right) observed reflectivity. The northwest portion of the model domain is displayed.

New technique for lightning assimilation

into forecast model using WWLLN Lightning to nudge water vapor towards saturation

Dixon et al, JATP, doi: 10.1175/JTECH-D-15-0188.1, Sept 2016

Estimating NOx from lightning for world

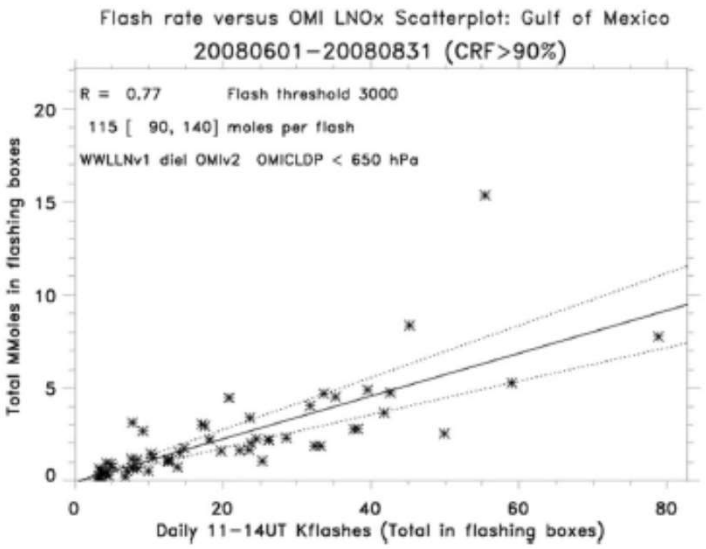
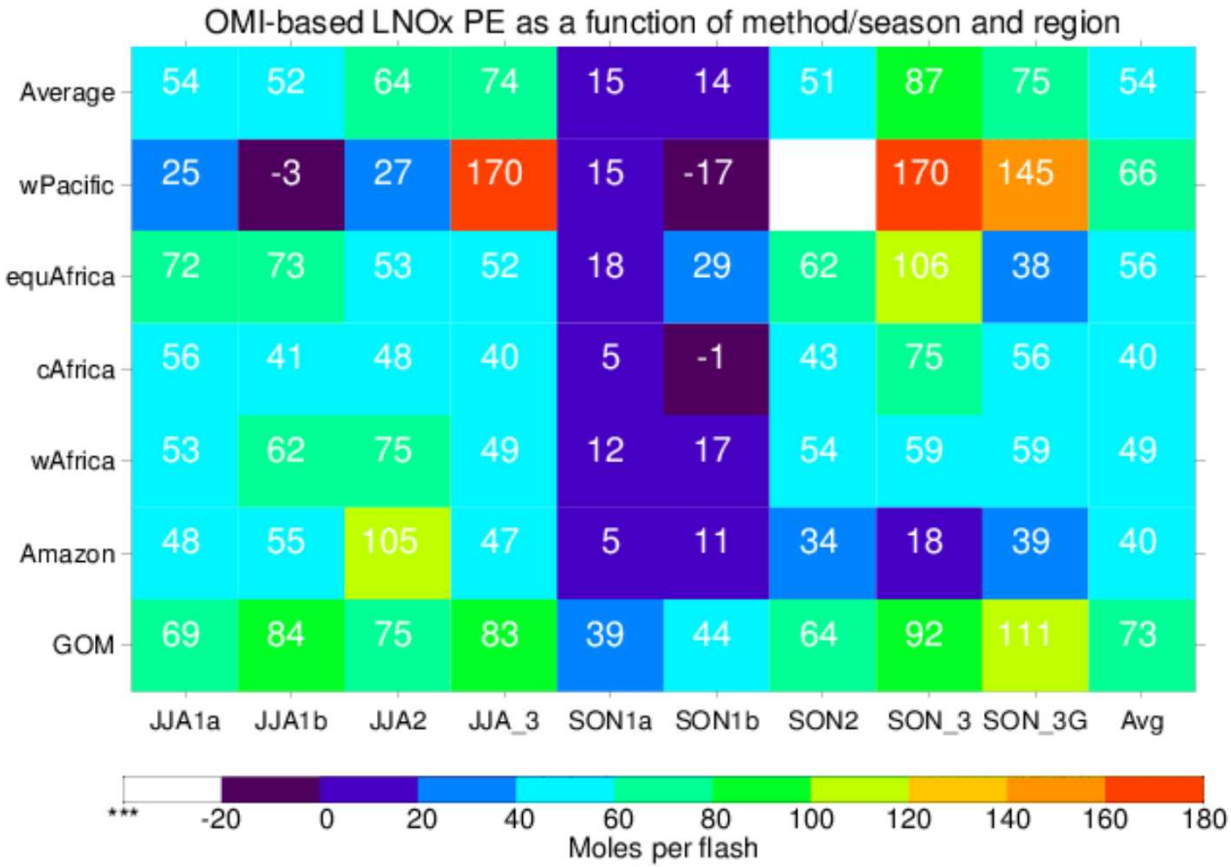
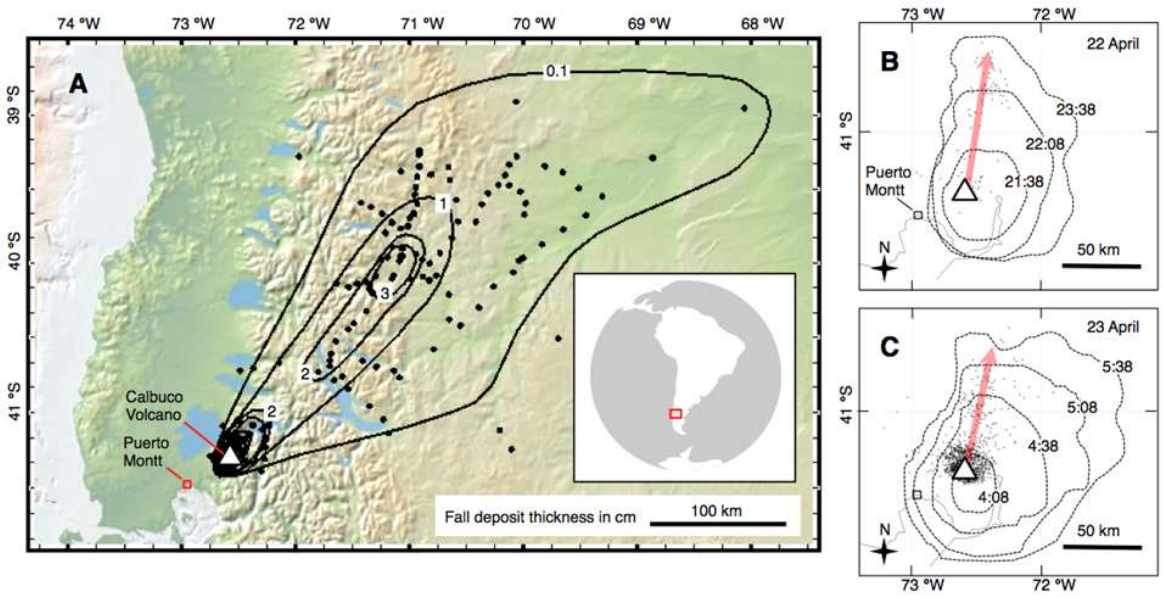


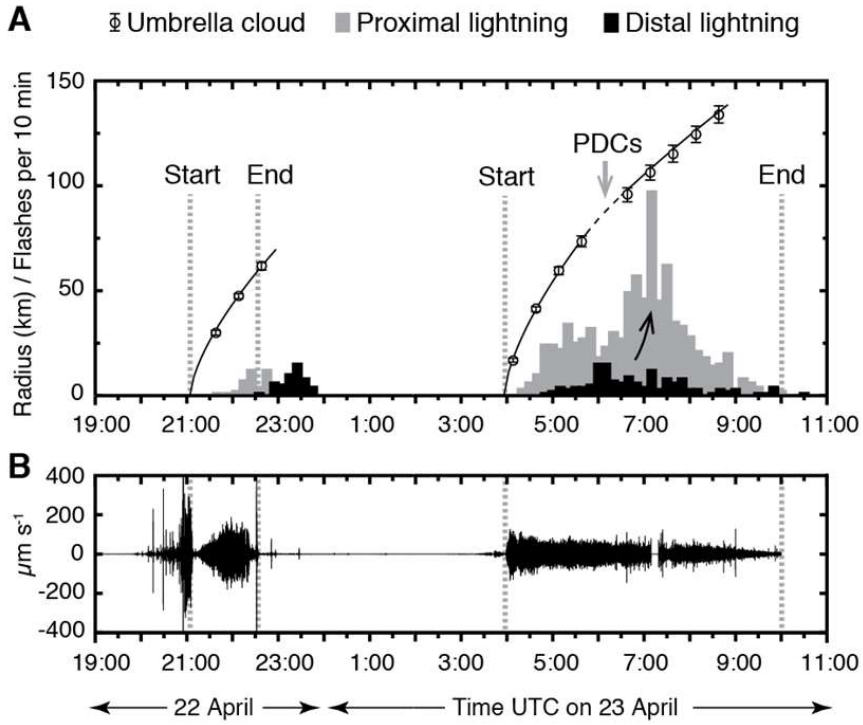
Figure 10. Scatterplot and linear regression of daily values of total MMoles LNO_x summed over grid cells with flashes versus Kflashes in the 3 h prior to OMI overpass for JJA 2008 with CRF > 90% and flash threshold of 3000 flashes.



Pickering et al, J. Geophys. Res, Atmospheres, V. 121, doi: 10.1002/2015JD024179 (July 2016)

Volcanic lightning and plume behavior reveal evolving hazards during the April 2015 eruption of Calbuco Volcano, Chile





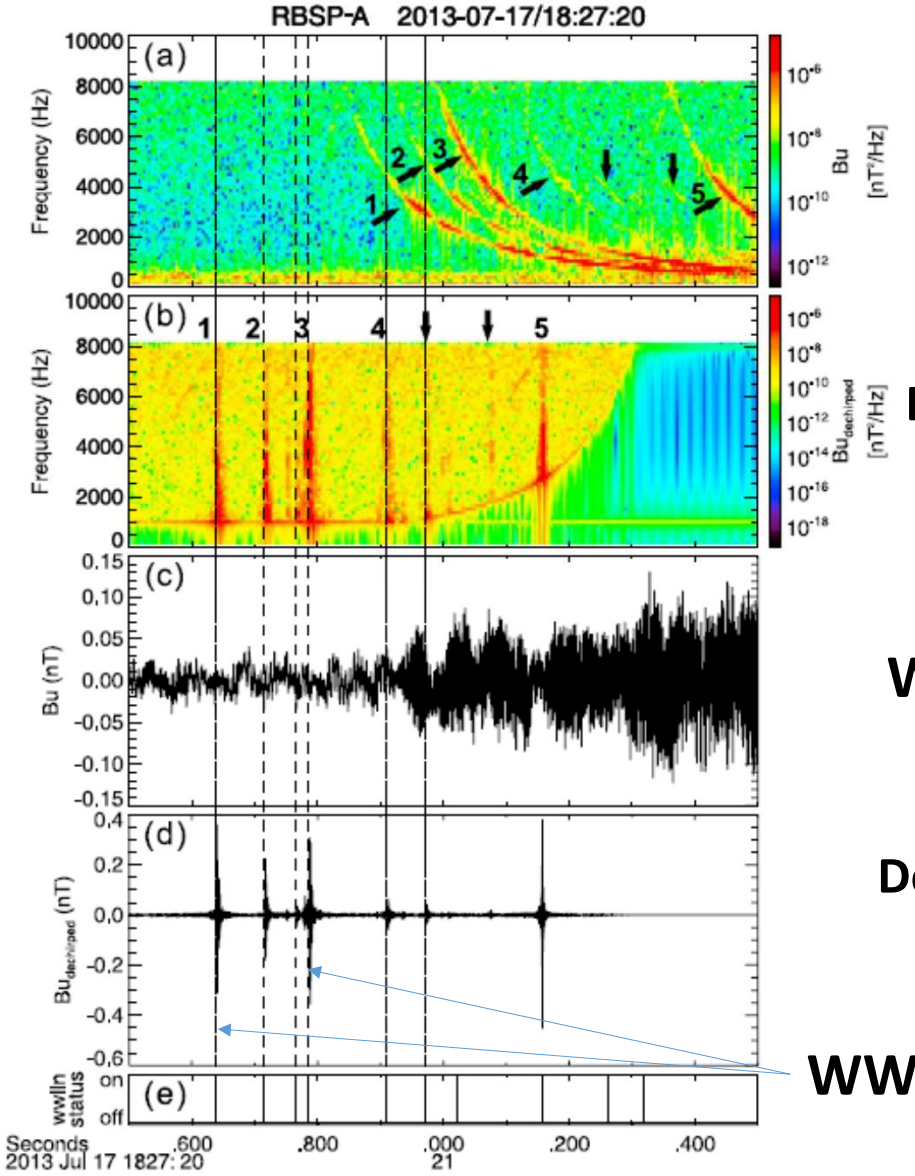
Formation of hazardous pyroclastic density currents signaled by a sharp increase in proximal lightning and slower upwind plume expansion
WWLLN detects strokes

Van Eaton et al, Geophysical Research Letters, v 43, n 7, 3563-71, **16 April 2016**; **DOI:**10.1002/2016GL068076

MAGNETOSPHERIC
Lightning Whistlers

NASA Van Allen
Probe Wave Data

17 July 2013
L=3



Spectrogram

De-chirped Spectrogram

Waveform (used above)

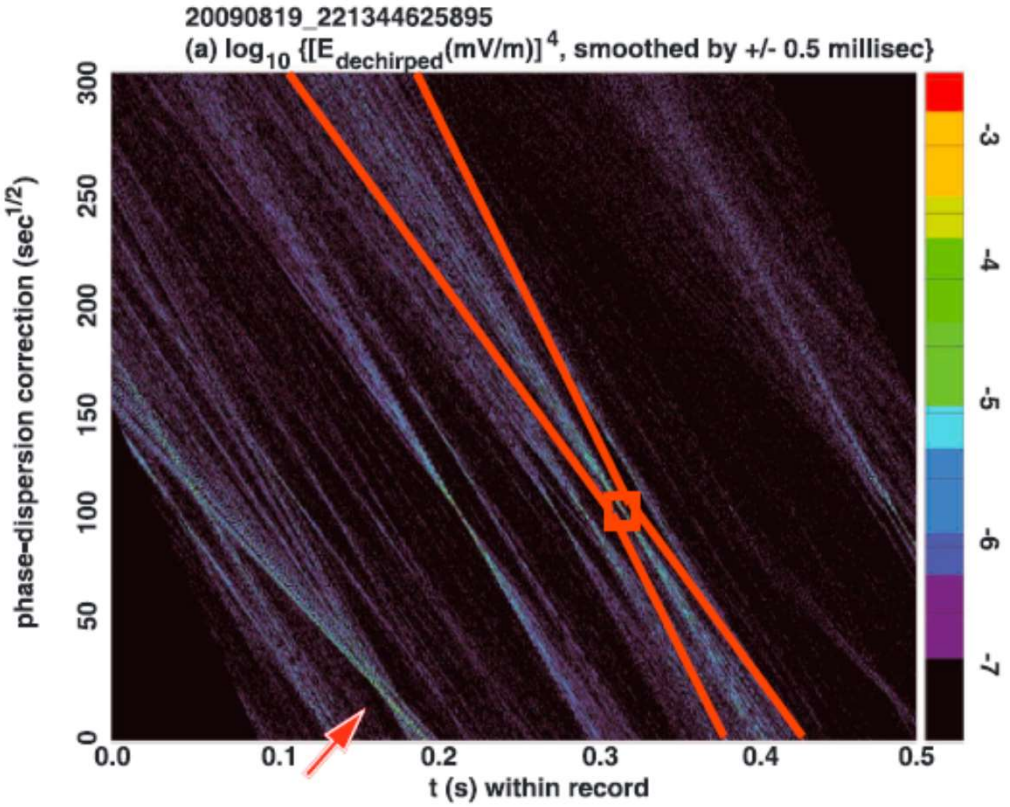
De-chirped Waveform

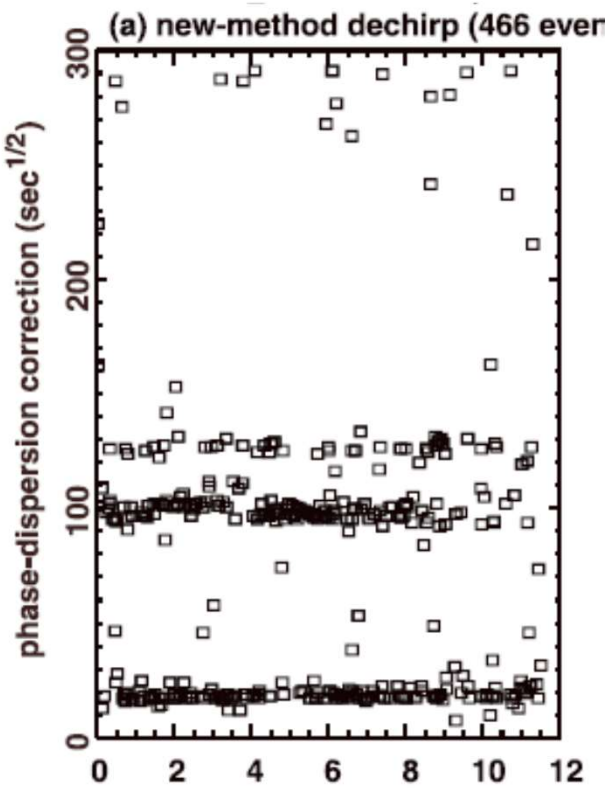
WWLLN located Strokes

Zheng, H et al, J. Geophys. Res., Spacew Physics, V. 121, doi:10.1002/2015JA022010 (Oct 2015)

New whistler propagation code can find multiple DIFFERENT dispersions, automatically

1.4 million whistlers processed using C/NOFS wave data



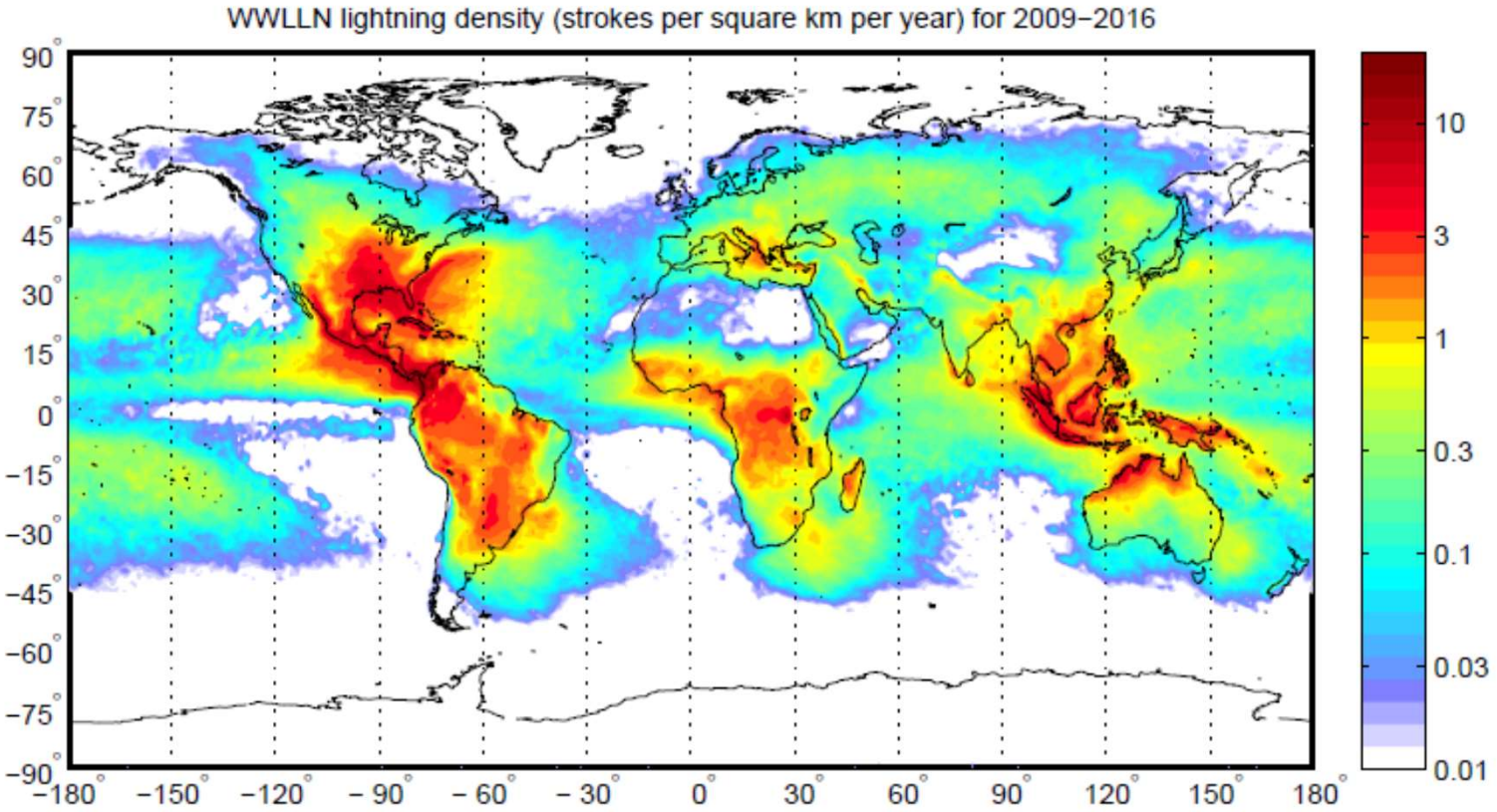


Different dispersions for different whistlers during the same 12 s record

i.e. Whistlers took DIFFERENT paths to satellite

Jacobson et al, Radio Science, V51, doi:10.1002/2016R5005989 (Sept 2016)

Newly Updated WWLLN Global Climatology

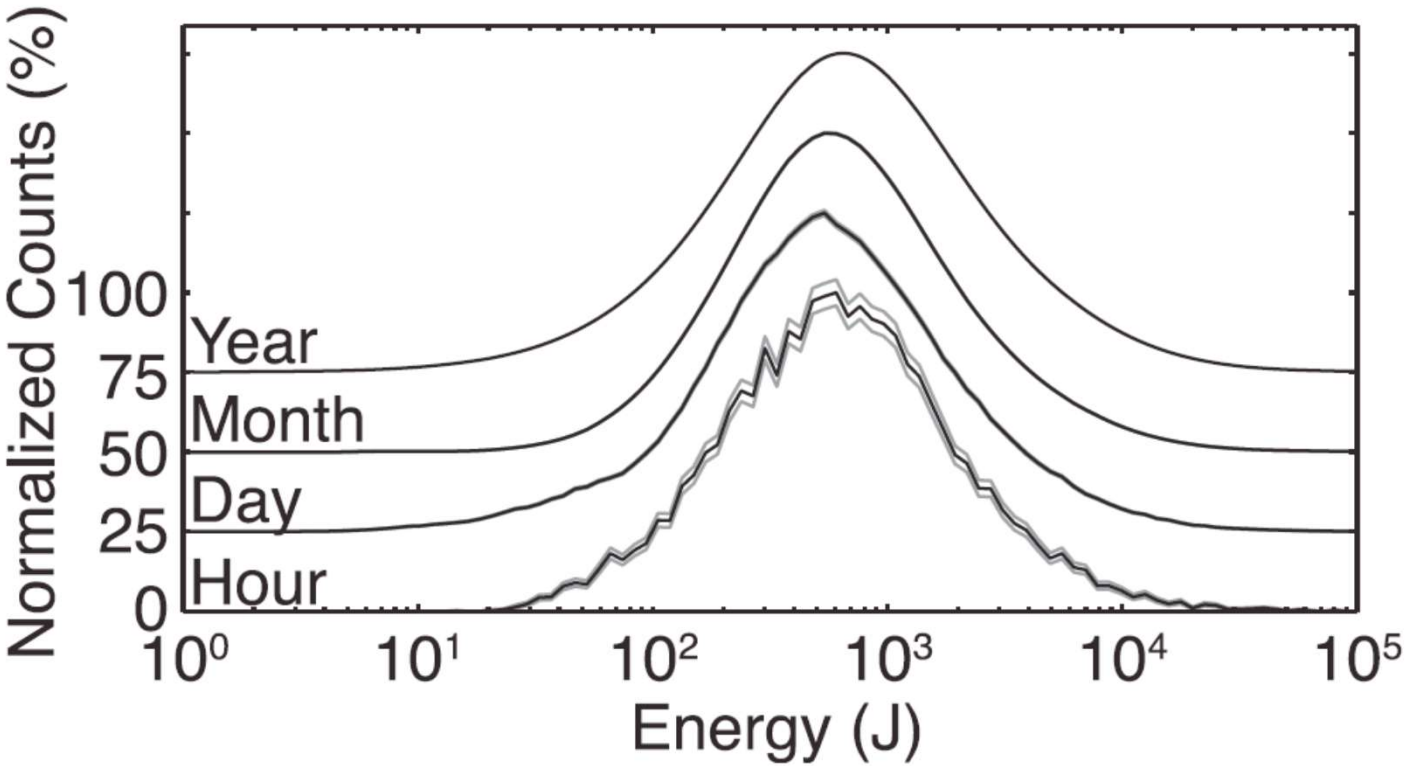


Based on 1.1 Billion Strokes Densities at 0.25, 0.5 and 1.0 degree pixels, **relative detection efficiency** corrected

Mean Annual, and mean monthly (Jan – Dec) and diurnal variability available

A Word about relative detection efficiency:

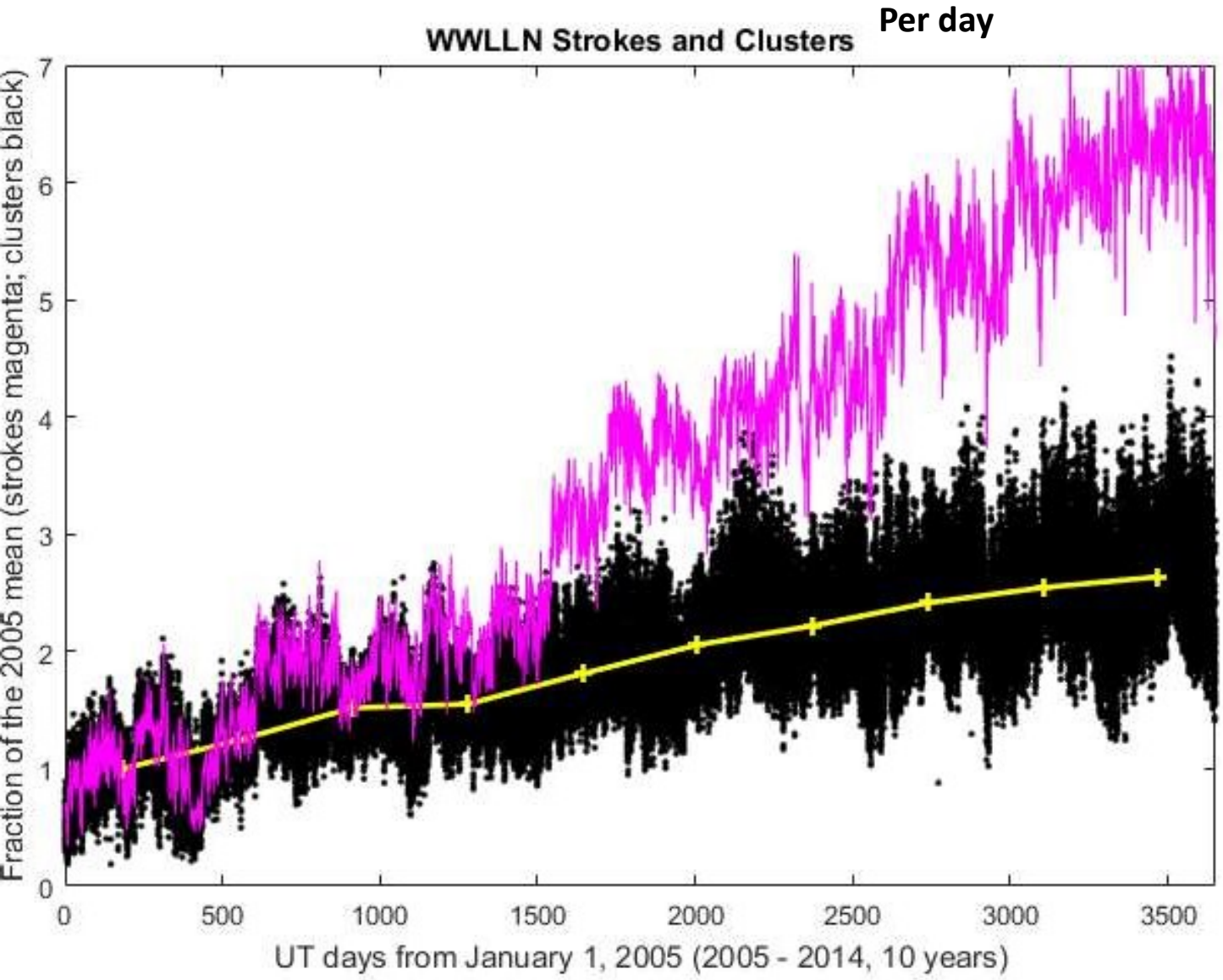
It is based on Far Field VLF radiated Energy/stroke which is directly related to peak current



NOTE: within 1 hour the global energy distribution is stable in our data.

Relative detection efficiency is calculated GLOBALLY every hour

Figure 1b from: Hutchins, M. L., R. H. Holzworth, J. B. Brundell, and C. J. Rodger, Relative Detection Efficiency of the World Wide Lightning Location Network, Radio Science, 2012RS005049, 2012



Strokes

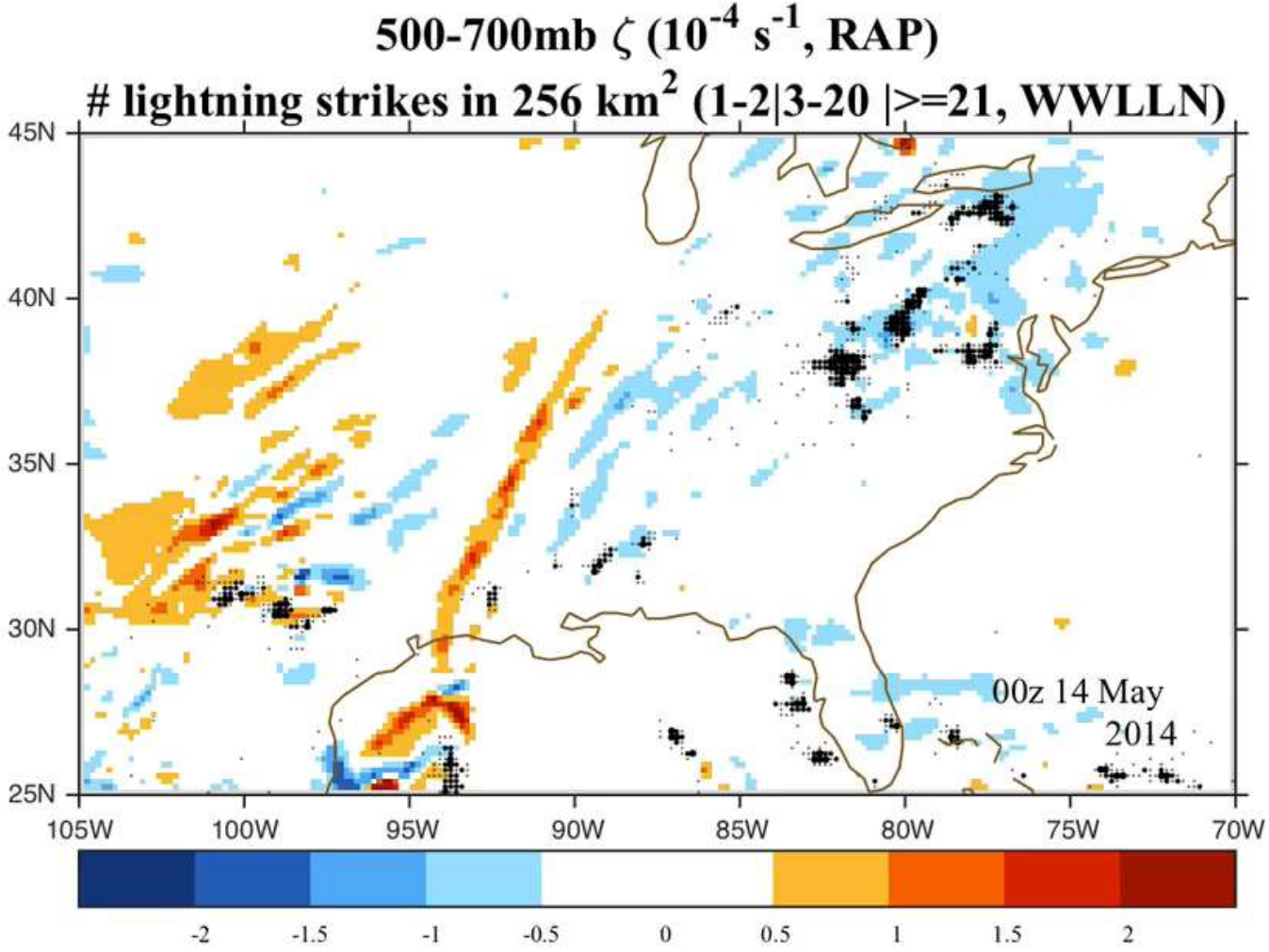
(6.5 times increase)
(mostly from adding new stations)

Clusters

(2.3 times increase from 2005 and just)

10 Years
WWLLN DATA

Three months comparison of vorticity and lightning
(by Wallace and Mitchell (UW))



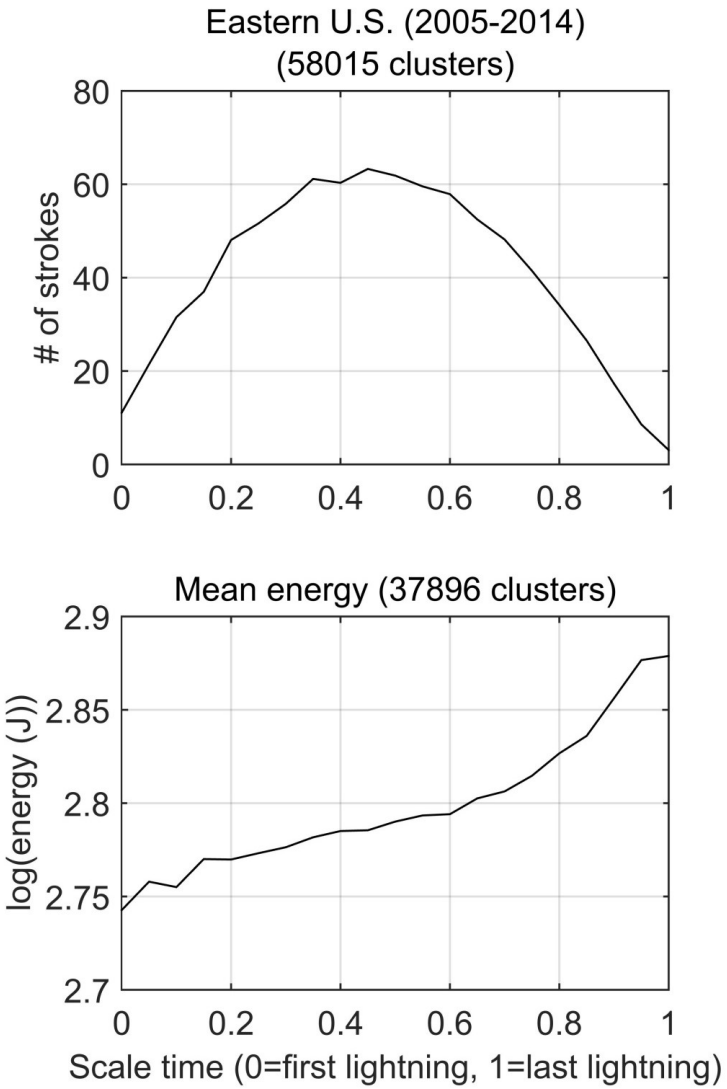
WWLLN cluster evolution statistics

- Calculate every 10 minutes:
  - Number of strokes
  - Mean stroke energy
  - Convex hull and area

- Define cluster scale time

  0 = time of first lightning in cluster

  1 = time of last lightning

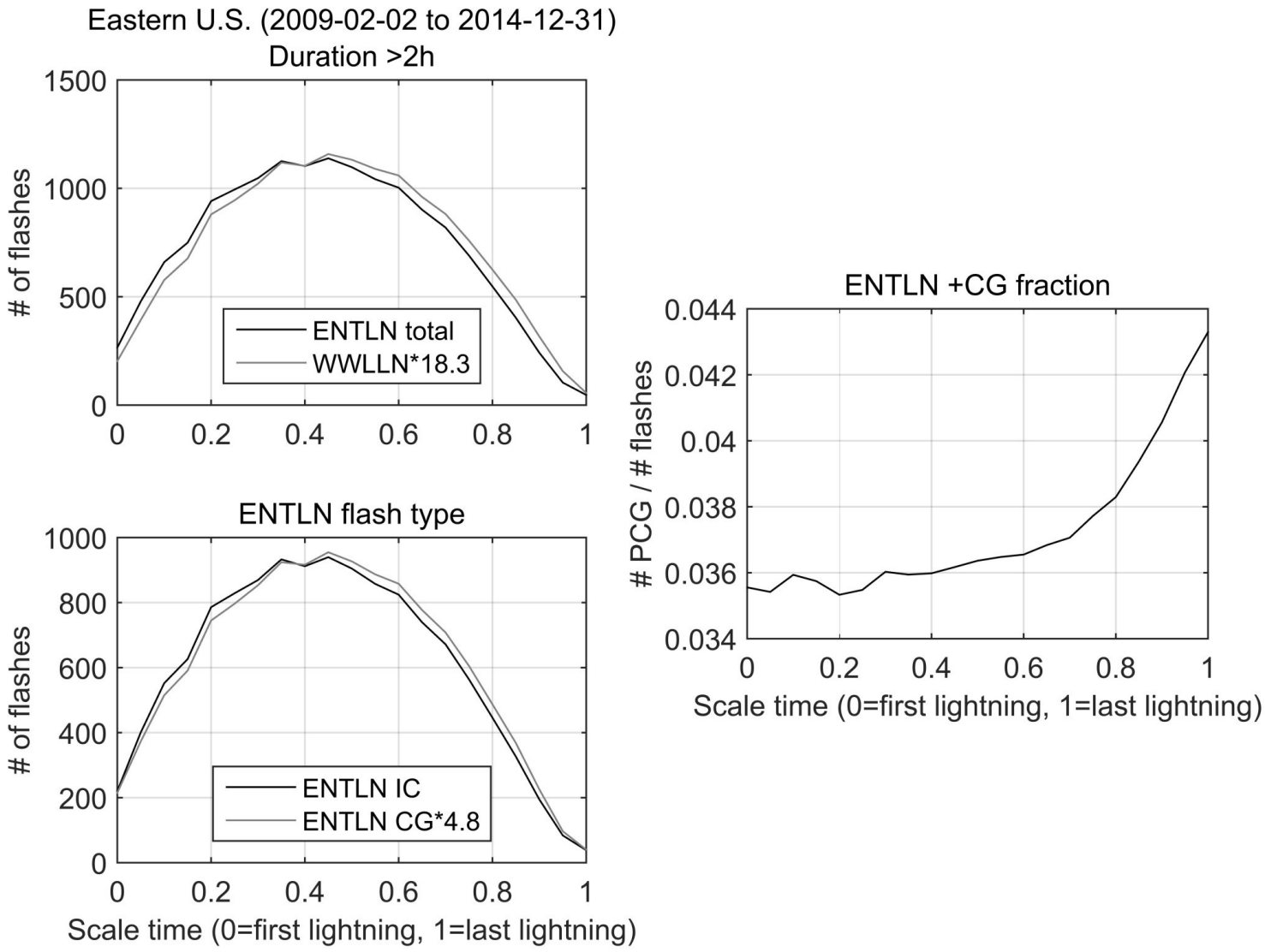


Results consistent for:

- Warm vs. cold season
- Short (<30 min), medium (2-6h), and long-lived (>12h) clusters
- Small and large clusters
- Other land regions

ENTLN cluster evolution statistics

- Assign ENTLN flashes to WWLLN clusters
  - Look for flashes within 0.15° and ±15 minutes
- Calculate every 10 minutes:
  - Number of total, CG, and IC flashes
  - Mean flash energy
  - Polarity


Eastern U.S. (2009-02-02 to 2014-12-31)
Duration >2h
# of flashes
ENTLN total
WWLLN*18.3
ENTLN flash type
ENTLN IC
ENTLN CG*4.8
Scale time (0=first lightning, 1=last lightning)
ENTLN +CG fraction
PCG / # flashes
Scale time (0=first lightning, 1=last lightning)

Thank you

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