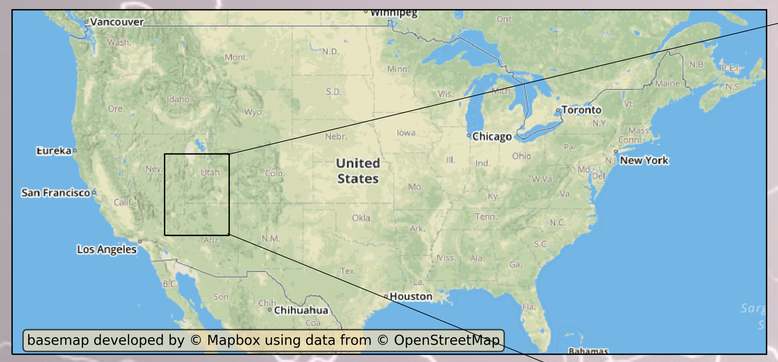
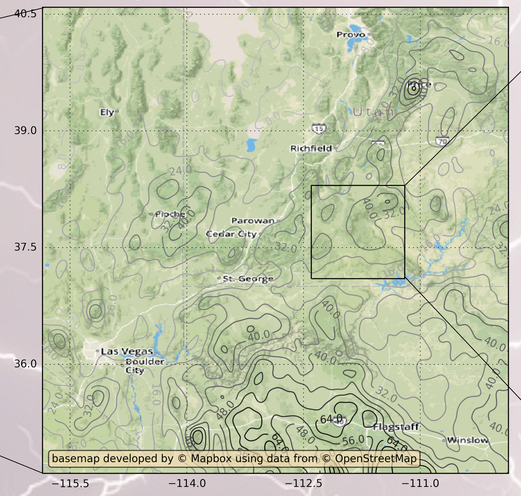
Storm Tracking in the Southwest using 2D Lightning Fields (H43C-1444)

Julia Signell, James Smith, Mary Lynn Baeck
Hydrometeorology Group, Civil and Environmental Engineering, Princeton University

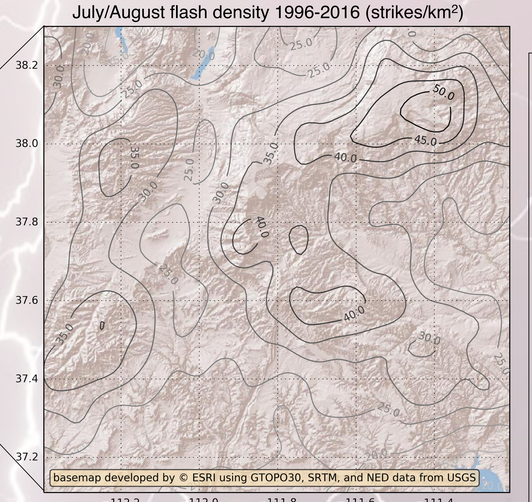


The National Lightning Detection Network Consists of an array of ground based sensors that cover the continental US and record the amplitude, location, and timing of lightning strikes. Using these data, we investigate methods of tracking warm season storms in the Southwest.

July/August flash density 1996-2016 (strikes/km^2)



July/August flash density 1996-2016 (strikes/km^2)



Point Process Modelling

The most common point process model is the Poisson process. Lightning strikes constitute a space-time Poisson process if the number of strikes in disjoint time and space intervals are independent and have a Poisson distribution. This independent increment assumption does not hold, because lightning strikes are strongly “clustered”.

Our models build on Cox process models, which are conditional Poisson models in that the rate of occurrence is not a deterministic function of space and time, but a random process, termed the stochastic intensity.

We model CG $N_{ij}(t, A)$ (number of CG strikes during $[0, t]$ in domain A on day j of year i) as a Cox process with randomly varying rate of occurrence:

$$\tilde{\lambda}(t,x) = \sum_{i=1}^{M} g(x, Y_i(t), Z_i(t) \mid \theta)\, 1\,(U_i < t \le V_i)$$

We construct a parametric form of the stochastic intensity:

$$g(x, Y_i(t), Z_i(t) \mid \theta) = I_i(t) \frac{1}{\gamma\,(2\,\pi)^{\frac{1}{2}}} \exp\{-\frac{1}{2}\frac{||x - Y_i(t)||^2}{\gamma^2}\}$$

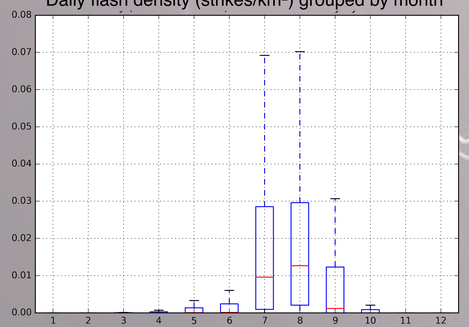
where θ is a vector of unknown parameters, γ represents the effective radius of influence of a storm and peak intensity is given by:

$$I_i(t) = \alpha \times [\, Z_i(t) - \beta]$$

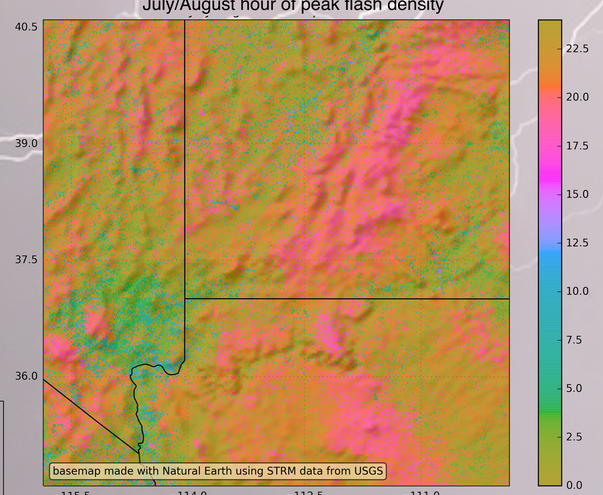
and $Z_i(t)$ is a vector characterizing convective intensity, such as max reflectivity. We estimate the parameters (α, β, γ), by minimizing the difference between counts and integrated rate of occurrence:

$$N_{ij}(t, A) - \Lambda_{ij}(t, A)$$

Daily flash density (strikes/km^2) grouped by month



July/August hour of peak flash density

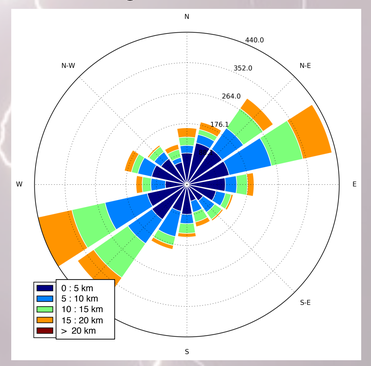


Traditional Tracking Methods Reapplied

We compare storm tracking using software developed at NCAR – SpatialVx (an R tool designed for 2D rainfall forecast validation) for 2D lightning and TITAN (used as designed) for 3D radar reflectivity.

Palm Functions

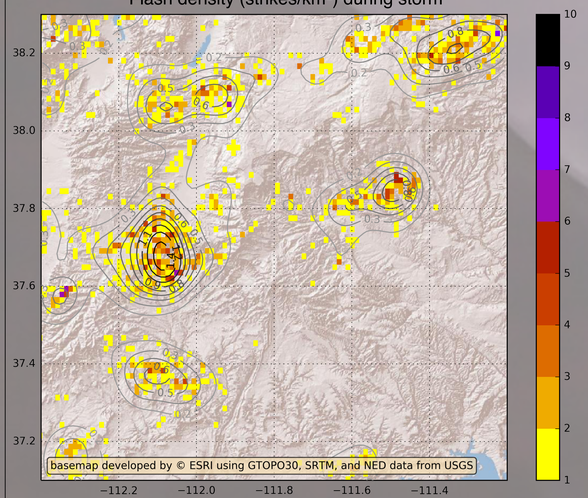
Given a strike at a particular location, what is the rate of occurrence of strikes within 20km in a 2 minute window surrounding the time of strike?



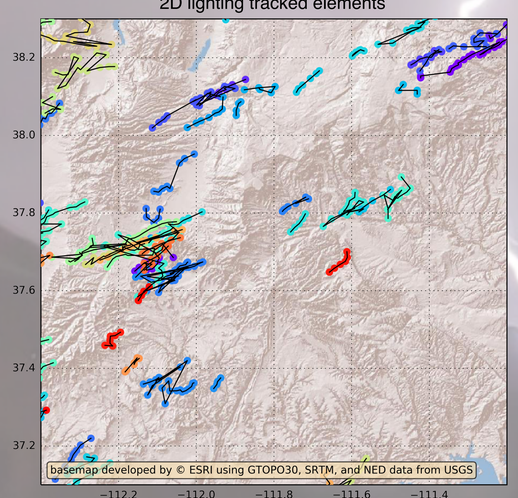
Case Study

We focus on a particular storm that occurred on July 20th, 2010 with a peak rain rate of 4 inches in 2.5 hours. This storm led to flooding in the Paria River.

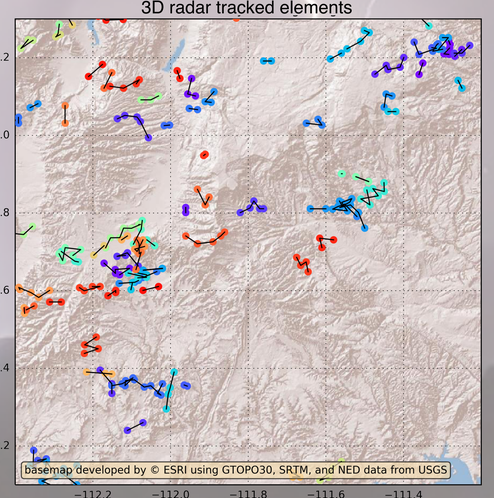
Flash density (strikes/km^2) during storm



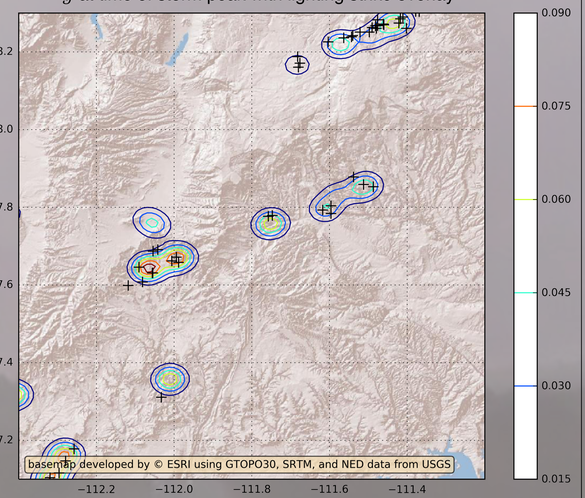
2D lighting tracked elements



3D radar tracked elements



g at time of storm peak with lighting strike overlay



hydrometeorology.princeton.edu
jsignell@gmail.com
github.com/jsignell/lightning-tools