

BAYES VS. THE INVADERS

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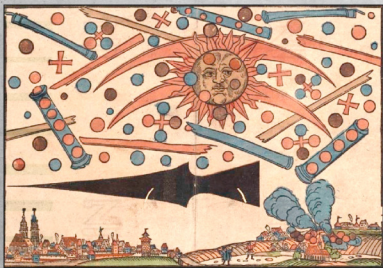
FORGOTTEN HISTORY

- Humanity has been subject to strange celestial manifestations throughout history.
 - ▶ Aerial phenomena and angelic beings.
 - ▶ Humans carried off by fiery chariots in the sky.
- Livy's "Ab urbe condita" (27-9 BCE) recorded portents in the year 218 BCE:
 - ▶ "navium speciem de caelo adfulsisse" ("phantom ships had been seen gleaming in the sky").
- Plutarch's "Lucullus" (c. 100 CE):
 - ▶ "... on a sudden the sky opened, and a large luminous body fell down in the midst between the armies, in shape like a hog's head, but in colour like melted silver... This wonderful prodigy happened in Phrygia, near Otryae."



"Helios" from Hyginus - "Poeticon
Astronomicum". (1485).

NUREMBERG. 1561



Hans Glaser - Himmelserscheinung über Nürnberg vom
14. April 1561

"At first there appeared in the middle of the sun two blood-red semi-circular arcs, just like the moon in its last quarter. And in the sun, above and below and on both sides, the color was blood, there stood a round ball of partly dull, partly black ferrous color."

"Likewise there stood on both sides and as a torus about the sun such blood-red ones and other balls in large number, about three in a line and four in a square, also some alone... "

BASEL. 1566

"It happened in 1566 three times, on 27 and 28 of July, and on August 7, against the sunrise and sunset; we saw strange shapes in the sky above Basel."

"At the dawn of August 7, we saw large black spheres coming and going with great speed and precipitation before the sun and chattered as if they led a fight. Many of them were fiery red and, soon crumbled and then extinguished."



Samuel Koch. Samuel Apiarius - Seltzame Gestalt so in
diesem M. D. LXVI. Jar. gegen auffgang und nidergang.
under dreyen Malen am Himmel...

WASHINGTON, D.C. 1952.



Saucers over Washington D.C.
(1952)

- Seven flying objects detected on radar moving rapidly over Washington, D.C.
- Observed by pilots as "white, tailless, fast-moving lights".
- "... their movements were completely radical compared to those of ordinary aircraft."

RENDLESHAM FOREST INCIDENT.

RENDLESHAM FOREST. UK. 1980.

- Series of reported sightings of strange lights near Rendlesham Forest, Suffolk in late December 1980, close to RAF Woodbridge - a base being used by the US Air Force.
- "Servicemen initially thought it was a downed aircraft but, upon entering the forest to investigate they saw... what they described as a glowing object, metallic in appearance, with coloured lights."
- "The UK Ministry of Defence has stated the event posed no threat to national security, and therefore, it was never investigated as a security matter."



Dore - Adam and Eve Driven Out
of Eden (1866)

ROSWELL, NEW MEXICO. 1947



Arthur Rackham - Pandora
(c. 1910)

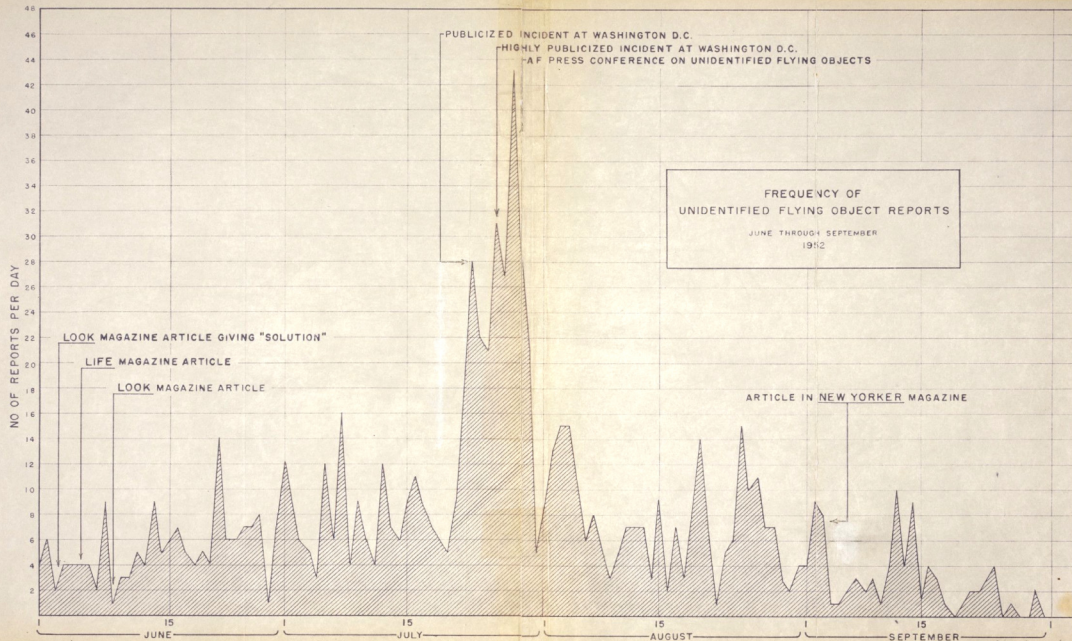
- Reported crash and recovery of debris from a "flying saucer" near Corona, New Mexico.
 - ▶ Gathered by personnel from nearby Roswell Army Air Field.
 - ▶ Initially claimed to be a weather balloon and, eventually, a high-altitude surveillance balloon as part of US Project Mogul.
- Later interviews with participants claimed the materials as "nothing made on this earth".
- Associated with a wave of over 800 related sightings in 1947.

PROJECT BLUE BOOK

- Systematic study of UFO phenomena in the US from 1952-1969.
- Chiefly concerned with national security implications of UFO reports.
- Concluded by the Condon Report in 1968, drawing on both civilian and Blue Book data; concluded that the study of UFOs was unlikely to result in significant scientific discoveries.



Gustave Dore - The Adventure
with the Windmills. from
Illustrations to Don Quixote.
(1863)



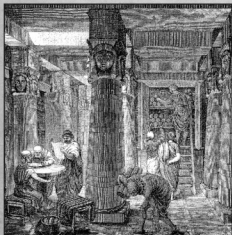
PROPOSAL: PARANORMAL DATA SCIENCE

- Past studies of UFOs, UAPs, and similar fringe phenomena, have been largely qualitative.
 - ▶ Focus on deep, but narrow, analysis of individual cases.
- Despite our primordial fear of the unknown, we can apply emerging statistical tools to large citizen science datasets.



Louis Le Breton - Buer, the
"demon who teaches Moral and
Natural Philosophy" from de
Plancy's "Dictionnaire
infernale". (1863).

FORBIDDEN ARCHIVES



O. von Corven -- The Great
Library of Alexandria. (19th
Century)

- Several citizen science projects have gathered UFO reports dating back to the 1950s, particularly in the US.
 - ▶ National Investigations Committee On Aerial Phenomena (NICAP).
 - ▶ Mutual UFO Network (MUFON).
 - ▶ National UFO Reporting Center (NUFORC).
- NUFORC is relatively comprehensive, and convenient to scrape.

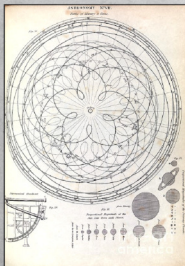
EXPLORATORY VISUAL ANALYSIS

- In exposing our minds to any dataset, no matter how horrifying, visualisation is an important initial step.
- Immediately establish a tremulous feel, and dread terror, of the world into which we have chosen, recklessly, to plunge.



Edmund Dulac - The Alchemist.
From "The Wind's Tale" by Hans
Christian Andersen. (1911)

SPATIAL DISTRIBUTION

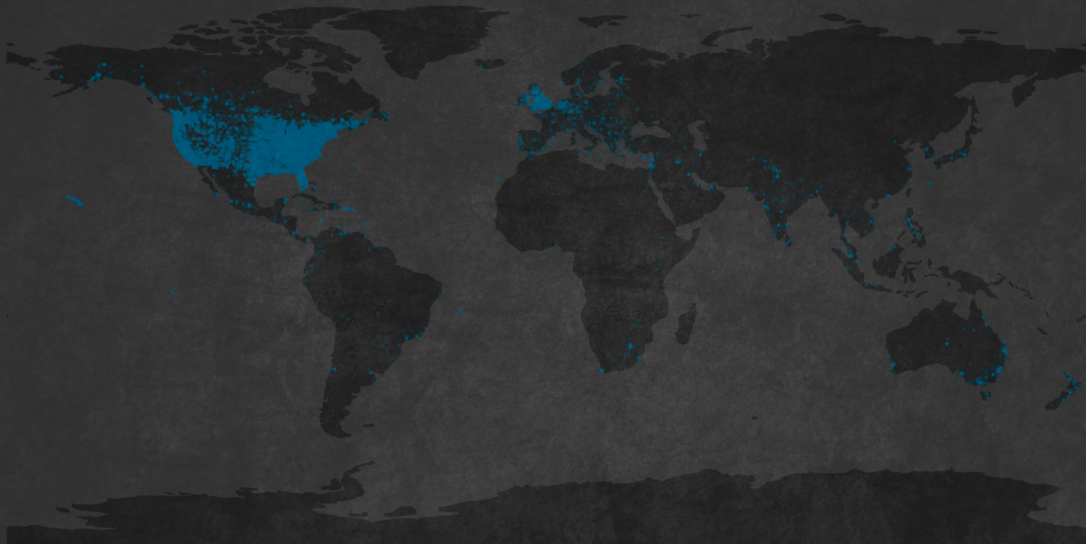


George Crabb - Universal
Technical Dictionary
(1823)

- What shadow is cast over our world by the encroaching alien threat?
- Are sightings independent of geography, or are there unsettling implications in the location of these events?
- How has ubiquitous personal surveillance equipment affected documentation of extraterrestrial visitations?

Global Distribution of UFO Sightings 1910-2013

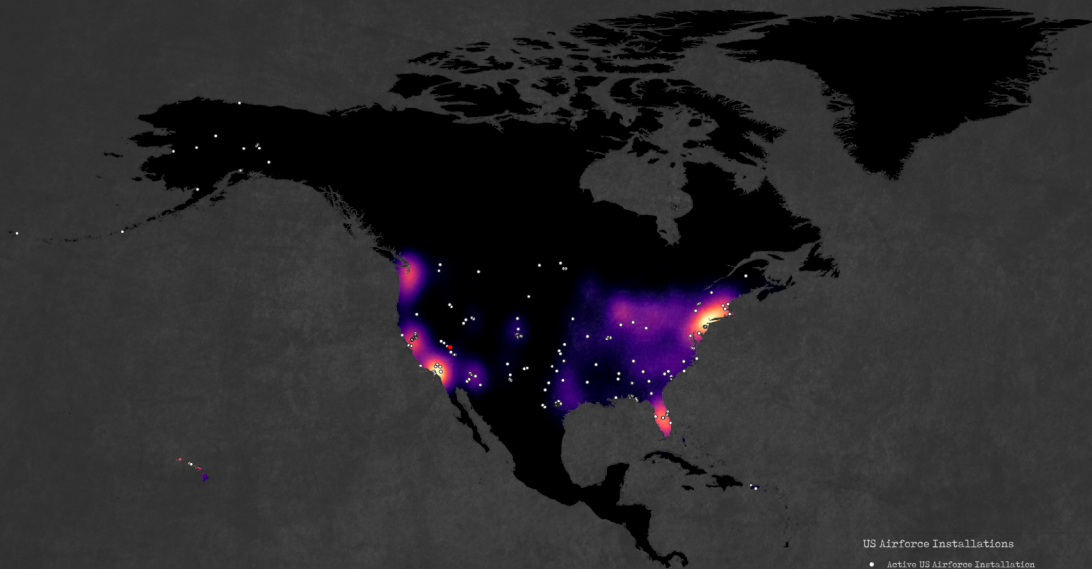
<http://www.weirddatascience.net>



Data: <http://www.nuforc.org>

Frequency of UFO Sightings near US Airforce Installations

<http://www.weirddatascience.net> | @WeirdDataSci



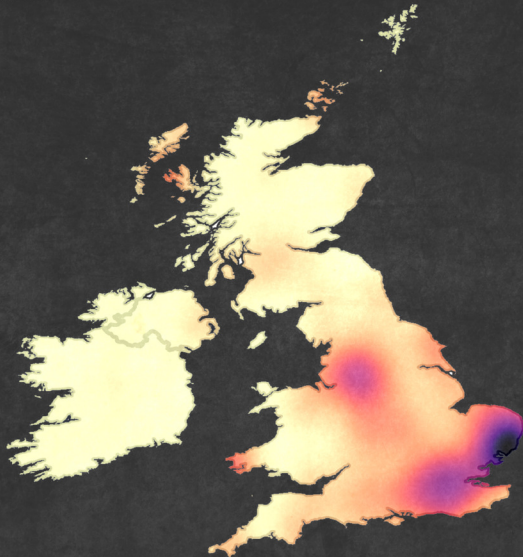
US Airforce Installations

- Active US Airforce Installation
- Area 51: Location of wreckage from 1947 Roswell crash

Data: <http://www.nuforc.org> | <https://catalog.data.gov/dataset/military-bases-national>

Density of UFO Sightings in the United Kingdom

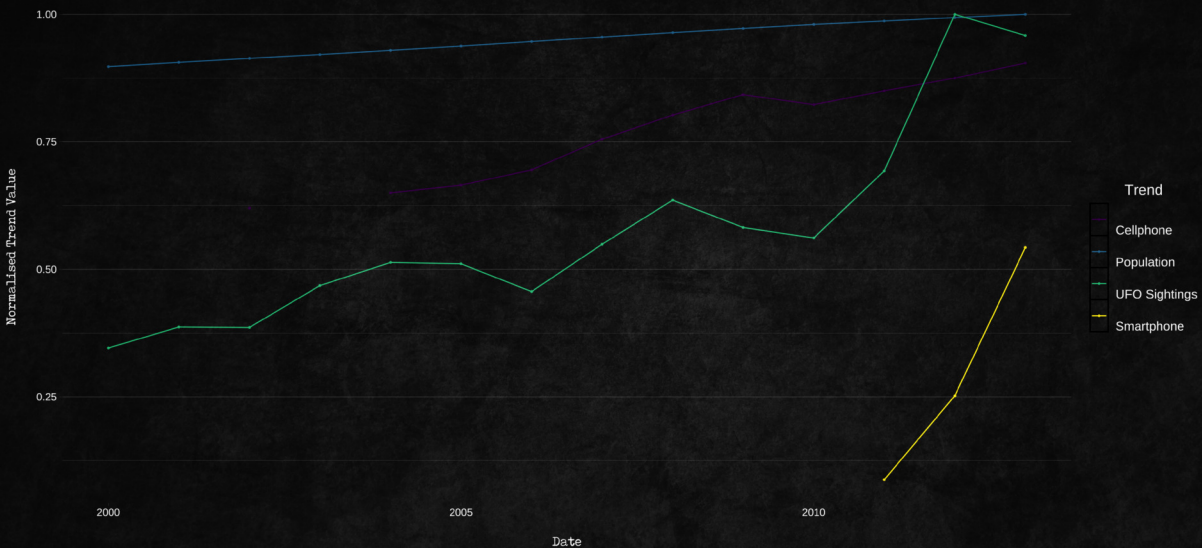
@WeirdDataSci | <https://www.weirddatascience.net>



Data: <http://paranormaldatabase.com>

UFO Sightings against Smartphone and Cellphone Penetration (2000-2013)

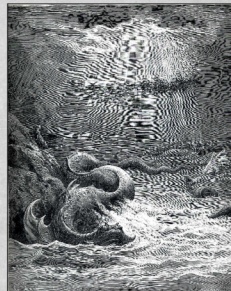
<http://www.weirddatascience.net> | @WeirdDataSci



Data: <http://www.nuforc.org> | <https://www.pewinternet.org> | <https://fred.stlouisfed.org>

THE SHAPE OF THE OTHER

- Unidentified Aerial Phenomena have been reported in a wide variety of shapes and sizes throughout history.
- Plutarch's silvery "pithos", or wine-jar; to the now-dreaded flying saucer; and beyond.
 - ▶ Do alien craft shift and evolve over time?
- NUFORC logs the reported shape of its sightings.

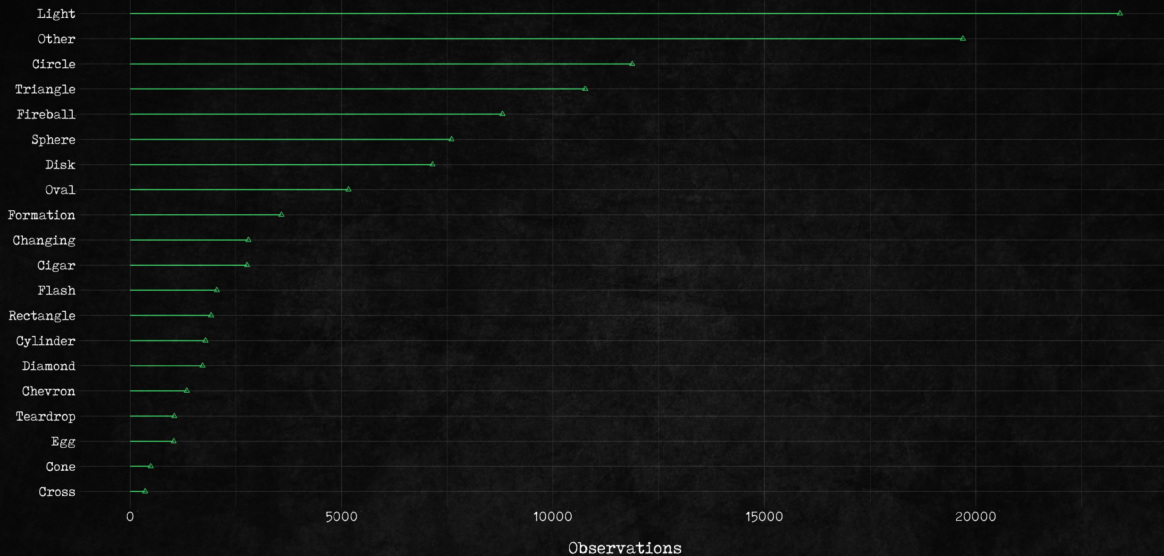


Dore - The Creation of Fish and
Birds (1868)

Proportion of UFO Sightings by Shape (Detailed)

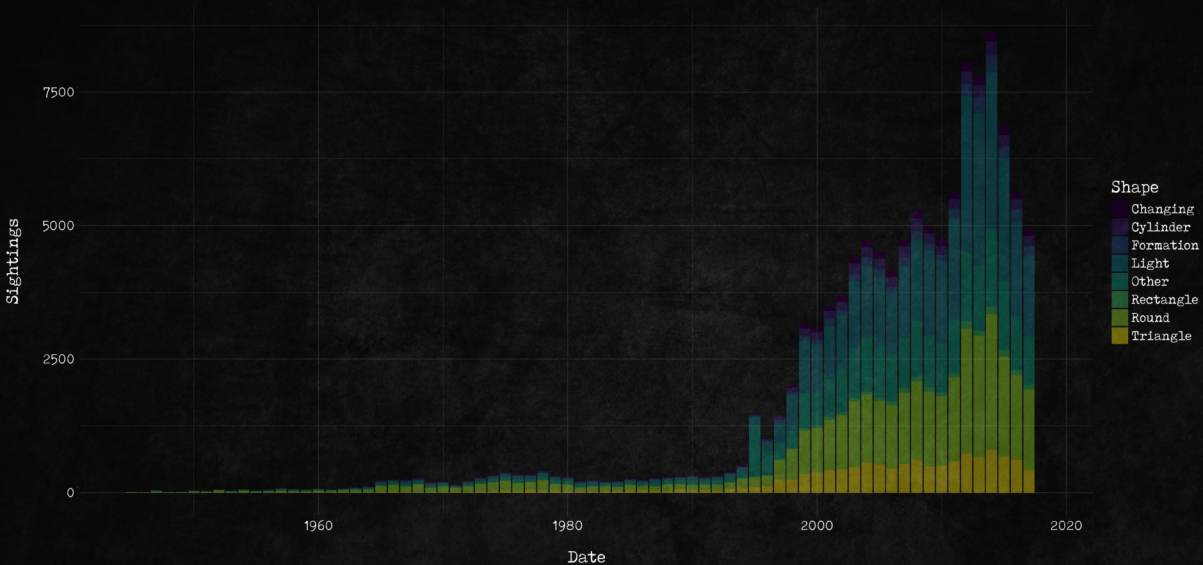
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UFO Shape



Total UFO Sightings by Shape, 1945-2017

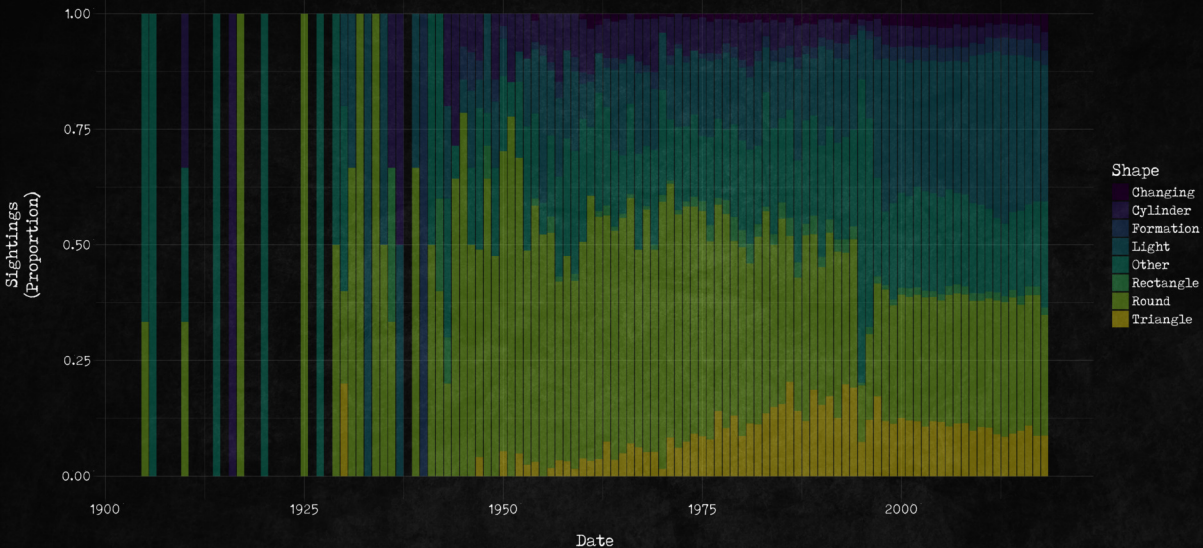
<http://www.weirddatasience.net> | @WeirdDataSci



Data: <http://www.nuforc.org>

Proportion of UFO Sightings by Shape, 1900-2017

<http://www.weirddatascience.net> | @WeirdDataSci



INFERNETIAL STATISTICS

- Simple descriptive statistics can only take us so far in our descent into madness.
- Inferential statistics twist and distort raw observations to predict future phenomena.
- Two major schools of inferential statistics.
 - ▶ Frequentist statistics have dominated the last century,
 - ▶ Bayesian statistics provide an increasingly popular alternative.



Eugène Delacroix - Lycargus Consulting the
Pythia. (c.1840)

BAYES THEOREM



Rev. Thomas Bayes

Bayes' theorem is a tool to update our beliefs in the presence of data.

$$P(\theta|\text{Data}) = \frac{P(\text{Data}|\theta)P(\theta)}{P(\text{Data})}$$

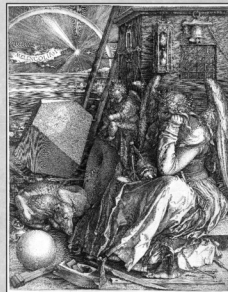
$$\text{Posterior} = \frac{\text{Likelihood} \times \text{Prior}}{\text{Evidence}}$$

Fundamental result in probability theory; core to Bayesian inference.

BAYESIAN WHISPERS

Bayesian inference, and its philosophical approach to hidden values, provides a number of advantages.

- Easy incorporation of new data - a posterior becomes a prior as new evidence arrives.
- Results are a full probability distribution over chilling unknowns, not point estimates.
- Lends itself to hierarchical models, in which correlated phenomena become locked in insidious mutual influence.



Albrecht Dürer - Melancholia

TOOLS



Rubens - Vulcan
Forging the
Thunderbolts of Jove

- Significant computational effort is required to determine the evidence, or "marginal likelihood", term.
- Computational approaches fit models by arcane explorations of the multidimensional space of hyperparameters.
- Probabilistic programming languages convert a statistical model to code.
 - ▶ Stan: <https://www.mc-stan.org>

DREAD EXPERIMENTS

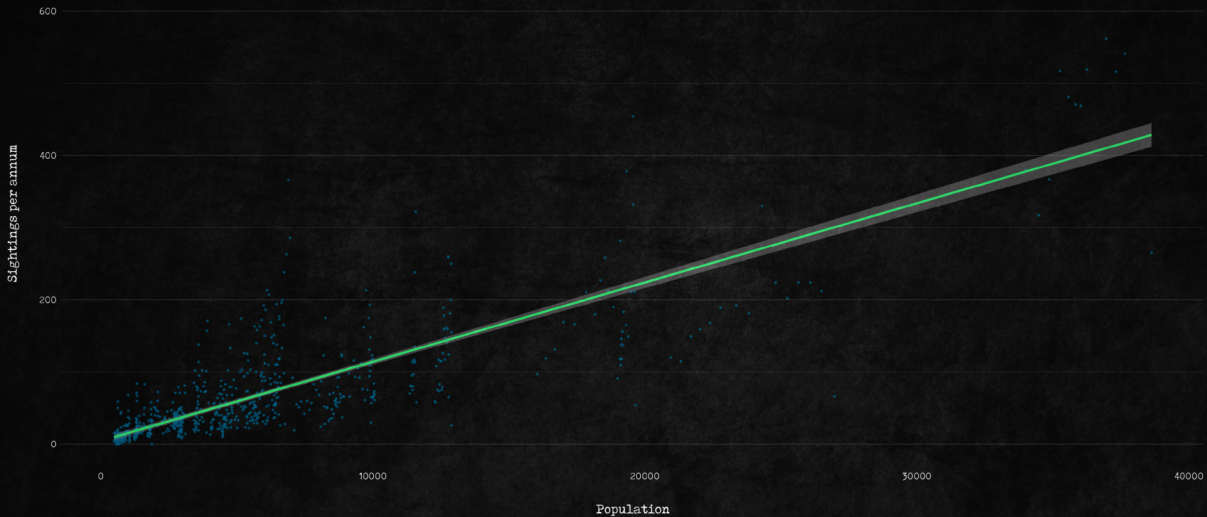
- How, then, do dread glimpses of pan-dimensional reality relate to human populations?
 - ▶ Do extraterrestrial visitors favour one location over another, regardless of human habitation?
 - ▶ As human populations grow, to what extent are interstellar visitors drawn to them?
- A series of mathematical models of increasingly deranged complexity to peel back the indescribable veil of this unsanctioned experimentation.
 - ▶ More specifically, from naive linear regressions to weirdly complex generalized linear models (GLM).



Van Bentum - Explosion in the
Alchemist's Laboratory. (c.1680)

UFO Sightings against State Population (1990-2014)

<http://www.weirddatascience.net> | @WeirdDataSci



Data: <http://www.nuforc.org>

A TEDIOUS MUNDANITY

The linear regression does not venture far from its simplistic assumptions of normality.

$$\mathbf{y} \sim \mathcal{N}(\mu, \sigma)$$

$$\mu = \alpha + \beta \mathbf{x}$$

$$\alpha \sim \mathcal{N}(0, 1)$$

$$\beta \sim \mathcal{N}(0, 1)$$

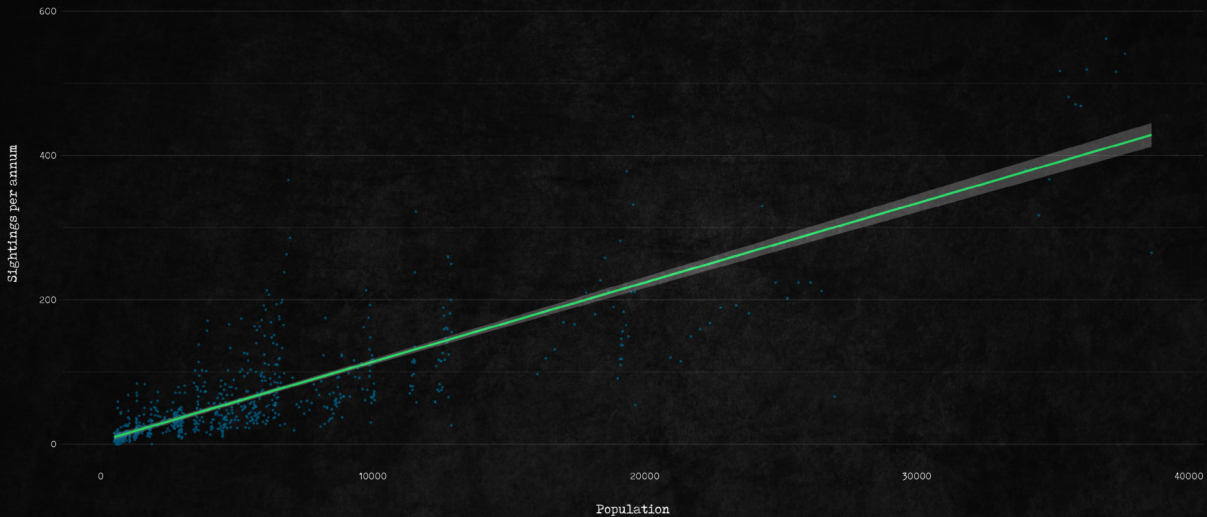
$$\sigma \sim \text{HalfCauchy}(1)$$



Giovanni Battista Piranesi -
Carceri. Folder 7 (1745)

UFO Sightings against State Population (1990-2014)

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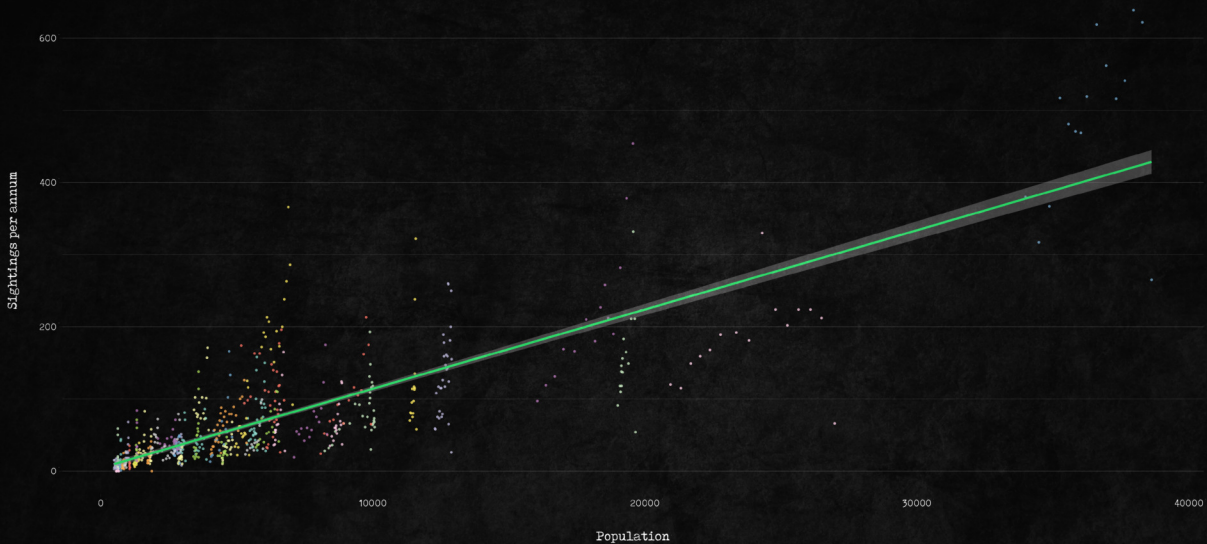


Data: <http://www.nuforc.org>

UFO Sightings against State Population (1990-2014)

(Per-state sightings)

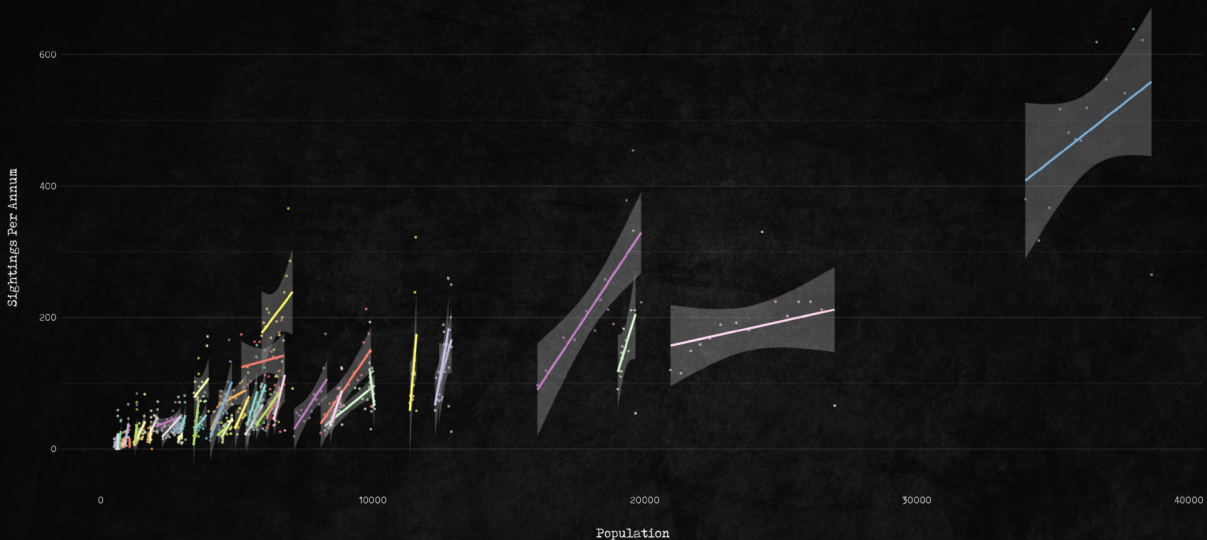
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UFO Sightings against State Population (1990-2014)

(Per-state trends)

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CASTING OVERDISPERSIONS

Casting aside the stifling simplicity of the Normal distribution, we recklessly embrace the complexities of a more subtle and flexible accounting.

$$\begin{aligned} y &\sim \text{NegBinomial}(\mu, \phi) \\ \log(\mu) &= \alpha + \beta x \end{aligned}$$

$$\begin{aligned} \alpha &\sim \mathcal{N}(0, 1) \\ \beta &\sim \mathcal{N}(0, 1) \\ \phi &\sim \text{HalfCauchy}(2) \end{aligned}$$



atlas bearing the heavens in
the form of an armillary
sphere. from William
Cunningham. The
Cosmographical Glasse.
London 1559.

DARK FORBIDDING POOLS

Turner - Fishermen at Sea
(1796)

Further twisting our statistical model, we allow data from each state to subtly influence the horrifying predictions of others, creating a partially-pooled model:

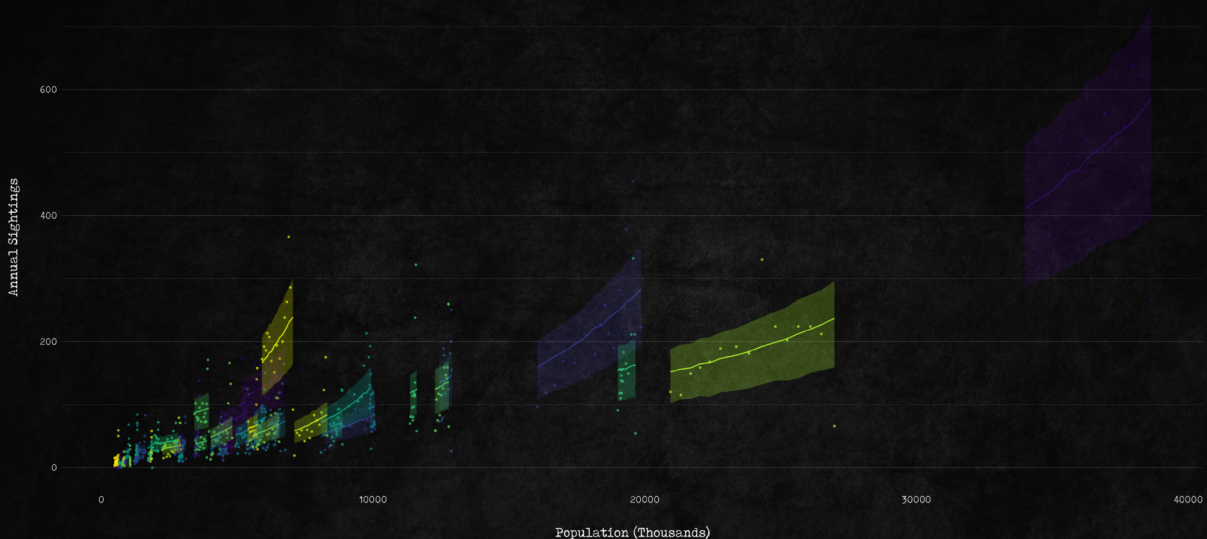
$$\begin{aligned} \mathbf{y} &\sim \text{NegBinomial}(\mu, \phi) \\ \log(\mu) &= \alpha_1 + \beta \mathbf{x}_1 \end{aligned}$$

$$\begin{aligned} \begin{bmatrix} \alpha_1 \\ \beta_1 \end{bmatrix} &\sim \mathcal{N}\left(\begin{bmatrix} \mu_\alpha \\ \mu_\beta \end{bmatrix}, \Omega\right) \\ \Omega &\sim \text{LKJCorr}(2) \\ \phi &\sim \text{HalfCauchy}(2) \end{aligned}$$

UFO Sightings against State Population (1990-2014)

Negative Binomial Hierarchical GLM. Varying slope and intercept. 50% credible intervals.

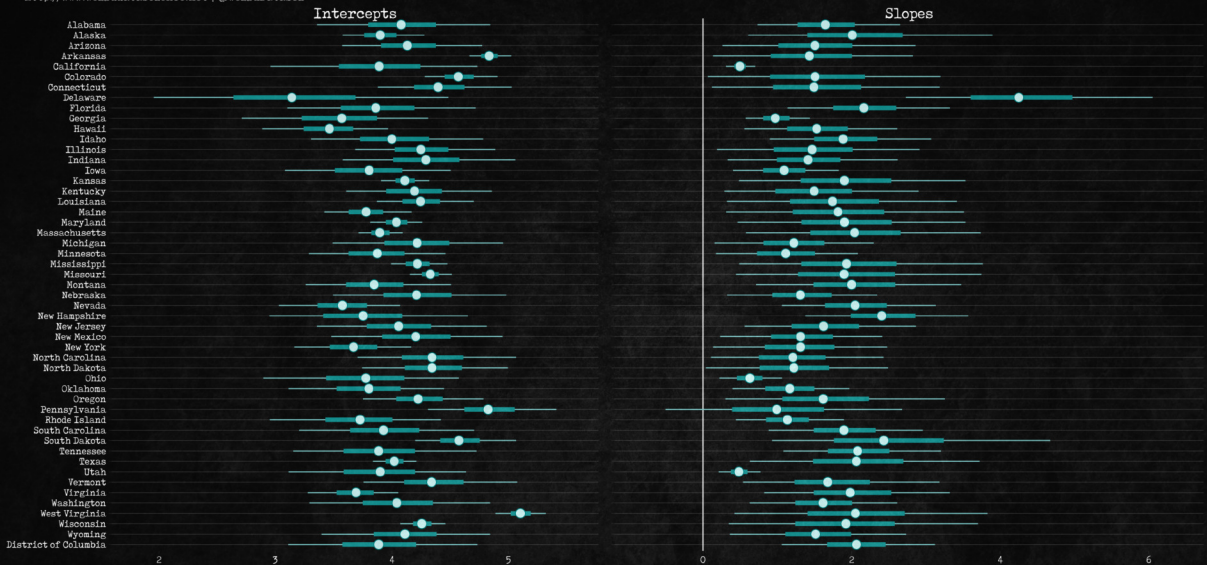
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Per-State UFO Intercepts and Slopes

Mean value, 50% credible interval, and 95% credible interval shown.

<http://www.weirddatascience.net> | @WeirdDataSci



UNSOLVED MYSTERIES

- Descending through deeper data sources.
- Further monstrous spatial implications.
 - The horrors of the 37th Parallel.
- Relentless seasonal variations and eerily significant moments of change.
- Inference into dread causes of madness-tinged visits by extradimensional beings.



Francisco Jose de Goya y
Lucientes - The Sleep of
Reason Produces Monsters!!
from 'Los Caprichos'.
(1797-1799)

HORRIFYING CONCLUSIONS



Dore - The Inferno. Canto XXXIV. Satan,
trapped in the frozen central zone in
the Ninth Circle of Hell.

- The real horror was the statistics we learned along the way.
- Increased documentation has not resulted in decreased UAP sightings.
- Data, analysis, visualisation, interpretation are subject to our prejudices.
 - ▶ Trust the methods, no matter what terrors they tell us.
 - ▶ Be aware of our priors.
 - ▶ The truth is out there, within a given credible interval.
- AVOID DELAWARE. GET OUT. IT'S NOT TOO LATE.