Spatial Modelling Using

SPECIES

Sistema Para la ExploraCión de Información ESpacial

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CONABIO

Who are we?

Grupo de Trabajo

C3 - Centro de Ciencias de la Complejidad, UNAM; CONABIO;

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2.- Dr. Raúl Sierra Alcocer
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Publications

Competitive interactions between felid species may limit the southern distribution of bobcats Lynx rufus
V Sánchez-Cordero, D Stockwell, S Sarkar, H Liu, CR Stephens, ...
Ecography 31 (6), 757-764, 2008

Using biotic interaction networks for prediction in biodiversity and emerging diseases
CR Stephens, JG Heau, C González, CN Ibarra-Cerdeña, ...
PLoS One 4 (5), e5725, 2009

Exploratory analysis of the interrelations between co-located boolean spatial features using network graphs
R Sierra, CR Stephens
International Journal of Geographical Information Science 26 (3), 441-468, 2012

Constructing ecological networks: a tool to infer risk of transmission and dispersal of Leishmaniasis
C González-Salazar, CR Stephens
Zoonoses and public health 59 (s2), 179-193, 2012

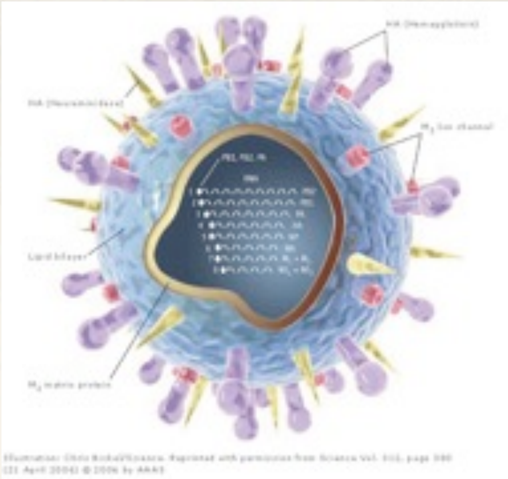
Comparing the relative contributions of biotic and abiotic factors as mediators of species' distributions
C González-Salazar, CR Stephens, PA Marquet
Ecological Modelling 248, 57-70, 2013

Leishmania (L.) mexicana Infected Bats in Mexico: Novel Potential Reservoirs
M Berzunza-Cruz, Á Rodríguez-Moreno, G Gutiérrez-Granados, ...
PLoS neglected tropical diseases 9 (1), e0003438-e0003438, 2015

Predicting the potential role of non-human hosts in Zika virus maintenance
C González-Salazar, CR Stephens and V. Sanchez-Cordero
submitted to Eco-health

UNDERSTANDING TRANSMISSIBILITY PATTERNS OF CHAGAS DISEASE THROUGH COMPLEX VECTOR-HOST NETWORKS
Laura Rengifo-Correa, Constantino González-Salazar, Juan J. Morrone, Juan Luis Téllez-Rendón, Christopher Stephens, submitted to PLoS Neglected Tropical diseases

Can you judge a disease host by the company it keeps? Predicting disease hosts and their relative importance using complex networks
CR Stephens et al, submitted to PLoS Neglected Tropical diseases

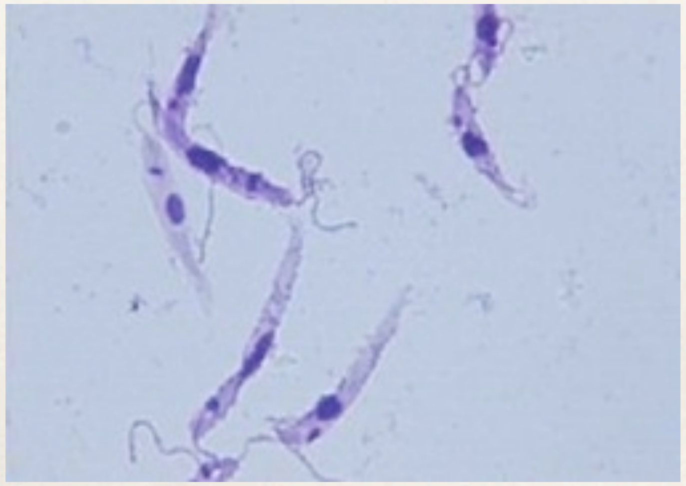


Ecology is the scientific analysis and study of interactions among organisms and their environment

Type of interaction	Sign	Effects
mutualism	+/+	both species benefit from interaction
commensalism	+/0	one species benefits, one unaffected
competition	-/-	each species affected negatively
predation, parasitism, herbivory	+/-	one species benefits, one is disadvantaged

Multifactorial with changing interactions

An Ecology is a Complex Adaptive System




Just how many interactions can we directly observe?
Can we infer interactions without direct observation?
Importancia médica
T. Infestans
T. barberi
T. pallidipennis
T. longipenis
T. recurva
T. neotomae
Culex quinquefasciatus
gettyimages
Frank Lukasseck
SCIENCE photo LIBRARY
ARKive

Ecology is the scientific analysis and study of

<u>interactions</u>

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among organisms and their environment

Physics is the scientific analysis and study of

<u>interactions</u>

between matter and energy

How have we understood <u>interactions</u> in physics?

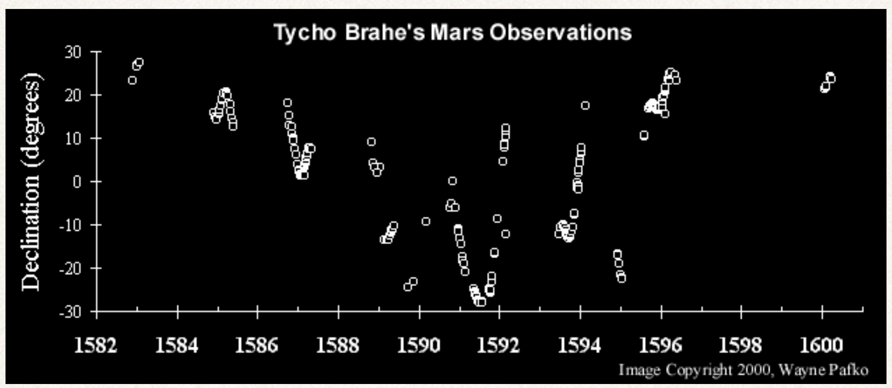
Through Spatial Modeling!

Studying where things are, and when,

relative to each other.

Spatial Modeling in the past…

Data —> Phenomenology —> Taxonomy —> Theory



Data ➔ **Phenomenology**

Kepler's Laws

1. The orbit of a planet is an ellipse with the Sun at one of the two foci.
2. A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time.
3. The square of the orbital period of a planet is proportional to the cube of the semi-major axis of its orbit.

Isaac Newton computed the acceleration of a planet moving according to Kepler's first and second law.

1 The *direction* of the acceleration is towards the Sun.
2 The *magnitude* of the acceleration is inversely proportional to the square of the planet's distance from the Sun (the *inverse square law*).

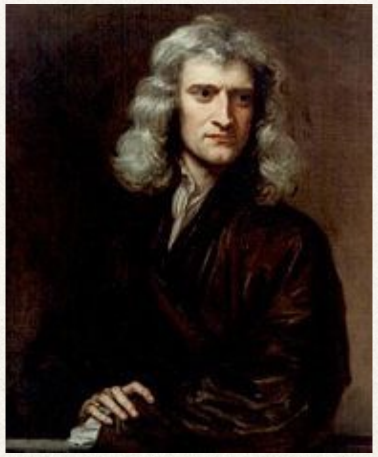
This implies that the Sun may be the physical cause of the acceleration of planets.
Newton defined the force acting on a planet to be the product of its mass and the acceleration. So:

1 Every planet is attracted towards the Sun.
2 The force acting on a planet is in direct proportion to the mass of the planet and in inverse proportion to the square of its distance from the Sun.

The Sun plays an unsymmetrical part, which is unjustified. So he assumed, in Newton's law of universal gravitation:

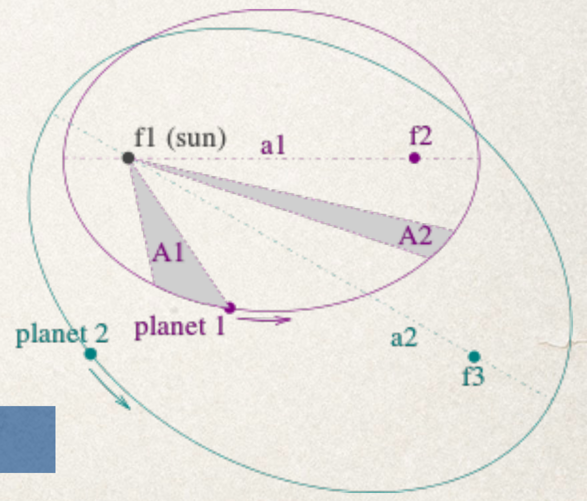
1 All bodies in the solar system attract one another.
2 The force between two bodies is in direct proportion to the product of their masses and in inverse proportion to the square of the distance between them.

As the planets have small masses compared to the Sun, the orbits conform approximately to Kepler's laws. Newton's model fits actual observations more accurately.



$$F = ma$$

$$F = GMm/r^2$$



Theory

The Difference between Physical and Complex Adaptive Systems

In Complex Adaptive Systems…

To say a lot, you need to have a lot of data…

g a lot

Big Data, Deep Data…

Imagine what you can say about a city

versus

a crystal as big as a city!

A Data Revolution!

Multifactoriality

Adaptation

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"Keplerian" Ecological models

What do we want to predict?
C = (C1, C2, C3, …, CN)
the presence, or abundance, or,… of one or more populations or taxa

What affects it?
The "niche"
X = (X1, X2, X3, …, XM)

P(C | X)

S(C | **X**)
Risk score

Characterizes niche and "anti-niche"

A large part of the complexity is in the multi-factoriality of both C and X. Adaptation is inherent in the fact that P(C | X) can change in time.

X = X(sd)+X(se)+X(n)+X(ev)+X(g)+X(af)+X(hm)+X(i)+X(sp)+...

Macro-Climactic factors

Behavioural characteristics

Micro-Climatic factors

Phenotypic characteristics

Hydrography

Competitor species

Prey species

Predator species

Human activity

Problems of co-dependence and causality

What can we do with SPECIES?

- Data Validation
  - Outliers, anomalies,…; SNIB, GBIF,…
- Risk analysis
  - Emerging diseases
    - Zika, Leishmania, Chagas, West Nile, Lyme, Chikungunya, Dengue, Influenza,…
  - Natural disasters
    - Fires, floods,…
  - Scenario generation
    - Climate change, human activity, deforestation,…
  - Species risk
    - Extinction, endangered,…
- Theory
  - Hypothesis testing
  - Causal chains
  - Direct versus indirect interactions, Actionability,…

Decision support systems:

Interface, data, user,…

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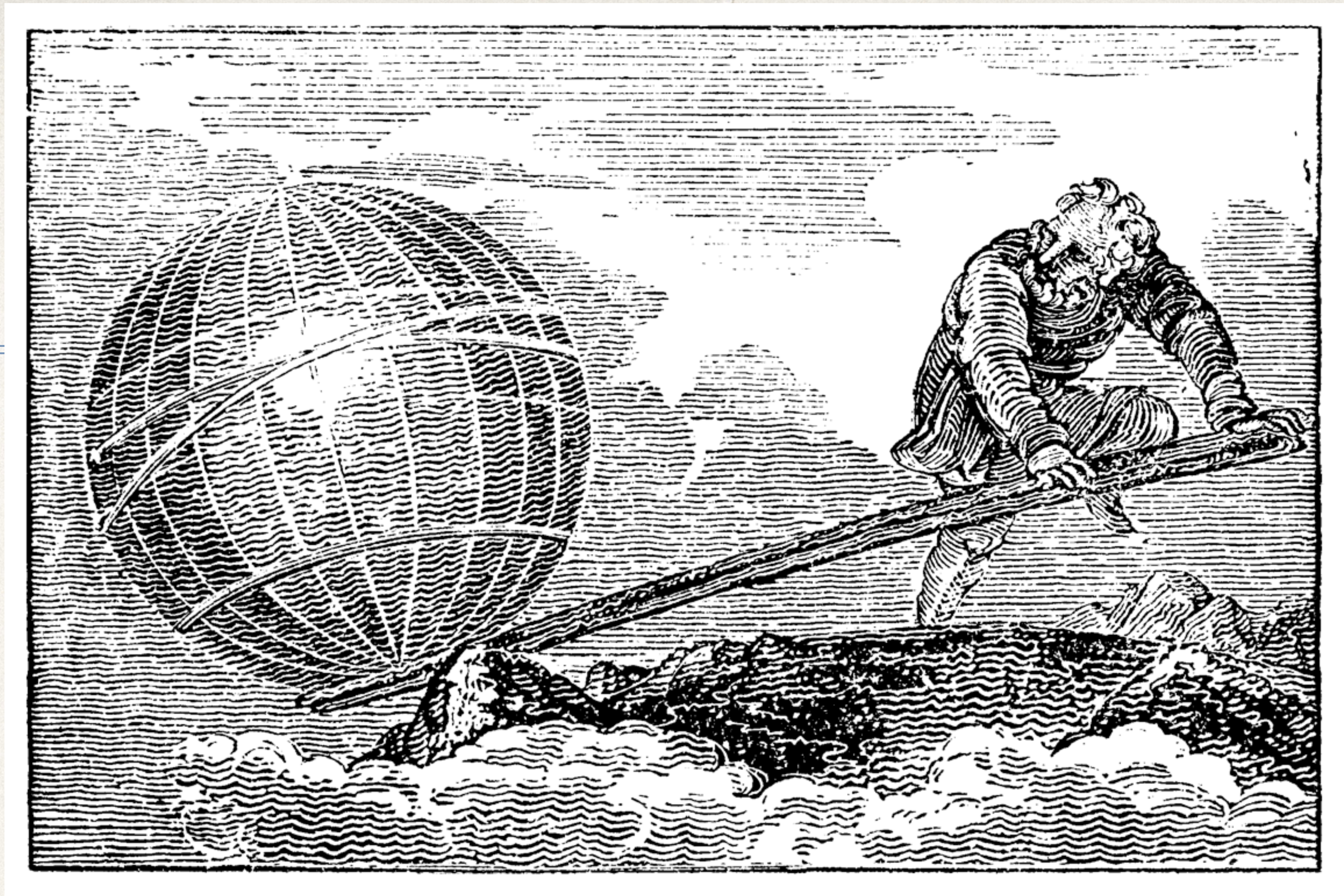
Road Map

- Short term goals:
  - Data extension to the Americas —> GBIF;
  - Data validation —> CONABIO
  - Disease risk: Chagas (Fundacion Slim);
  - Leishmania, Chagas, Lyme, Dengue, Zika and other Flavivirus (PAPIIT, collaboration with FM, UNAM/FVZT, UNAM/IBT, UNAM/UANL/UAG/UJAT - field work)
  - Theory
- Medium term goals:
  - Global data —> GBIF
  - Other data sets: INEGI, Sec. de Salud,…
  - Scenario generation: climate change, deforestation, other human activity, extinction risk
- Long term goal:
  - To create the most powerful open source platform for spatial modeling, with customized interfaces for decision support at multiple levels and for multiple uses

Principal needs:

Resources: Financial; Human; Use cases; Users;…



δῶς μοι πᾶ στῶ καὶ τὰν γᾶν κινάσω

Give me a place to stand on and I´ll move the earth

Give me enough data and I´ll predict anything

The Data Revolution will revolutionise our ability to model and understand ecology