Infectious diseases and climate: Leptospirosis in northeastern Argentina as study case

Dra. Andrea Gómez
Centro de Estudios de Variabilidad y Cambio Climático
OUTLINE

- Variability and Climate Change (CC)
- Global Phenomena
- What happened in the last 100 years?
- Future Climate Scenarios
- Impact of CC on Health
- Impacts in our region: Leptospirosis
- Modelling of Leptospirosis
Climatic Variability

It refers to variations in the *average state* and other statistical properties (standard deviation, occurrence of extremes) of the weather on all *temporal and spatial scales* excluding individual weather events (IPCC, 2014).
Change in the **average state** of the climate that can be identified by changes in the average or in the variability of its properties and that **persists for an extended period**, typically decades or more extensive (IPCC, 2014).

**Corollary:** Climate change may be due to **internal** natural processes of the climate system or to **external** forces such as modulations in solar cycles, volcanic eruptions and persistent anthropic changes in the composition of the atmosphere or land use.
WHAT IS PHENOMENA EL NIÑO (ENSO)?

Recurring weather pattern that implies changes in the surface temperature of the ocean in the central and eastern part of the tropical Pacific.
HOW THE EL NIÑO AFFECTS SOUTH AMERICA?

Precipitation **higher** than normal:
- South of Brasil
- East of Paraguay
- **Northeast of Argentina**
- Uruguay

Precipitation **below** normal:
- Brasil (Norht of 20ºS)
- West of Paraguay
- Northwest of Argentina
- Bolivia
GLOBAL PHENOMENA THAT INFLUENCE IN THE EAST SOUTH AMERICA CLIMATE

Then, NIÑO = FLOOD and NIÑA = DROUGHT?

NOT NECESSARILY!

ENERO 2017: WEAK NIÑA

CONVECTIVE INTENSE RAINS

INTRA-SEASONAL FORCING SIS:
ASSOCIATED WITH WEEK PHENOMENA AND STRONG CONVECTIVE ACTIVITY
IS THE PHENOMENA “EL NIÑO” THE ONLY FORCING?

NO!

GLOBAL PHENOMENA THAT INFLUENCE IN THE EAST SOUTH AMERICA CLIMATE

ATLÁNTICO (OSCILACION MULTIDECADAL)
When the concentration of greenhouse gases increases in the atmosphere, the amount of energy that cannot escape into space is increasing, and it returns reflected to the surface by increasing the temperature.
OBSERVED CHANGES

1. CA-NSA: Central America, northern South America
2. AMA: Amazonia
3. TAnd: Tropical Andes
4. CAnd: Central Andes
5. PAT: Patagonia

Magrin et al. (2014)
WHAT HAPPENED IN THE LAST 100 YEARS?

Increase in extreme precipitation and temperature events

**Tendencia hacia condiciones más cálidas**
Santa Fe. Enero 2014

**Mayor frecuencia y severidad en las crecidas e inundaciones**
Santa Fe (La Guardia). 1983

**Incremento en frecuencia de sequías estacionales**

**Lluvias intensas más asiduas**
Maiz. Enero 2012. San Cristóbal

Concordia. Enero 2019

Fuente: Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata (CIC)
FUTURE CLIMATIC SCENARIOS

Annual Temperature changes (°C) (RCP4.5, stabilization)

Annual Precipitation changes (%) (RCP4.5, stabilization)
FUTURE CLIMATIC SCENARIOS

Temperature

Precipitation

Mitigation

Estabilization

Very high emission level
**Resiliency**: is the ability to recover and adapt to changes that the climate could potentially generate, without adverse effects being definitive.
HEALTH IMPACTS

- Mental Illness
- Undernutrition
- Injuries
- Respiratory Disease
- Allergies
- Cardiovascular Disease
- Infectious Diseases
- Poisoning
- Water-Borne Diseases
- Heat Stroke
PARADOX: CC, HEALTH, NH and SH

Deaths from climate change

CC deaths/million
- 0 - 2
- 2 - 40
- 40 - 80
- 80 - 120

Copyright WHO 2005. All rights reserved.
Global risk mapping for major diseases transmitted by Aedes aegypti and Aedes albopictus

Samson Leta\textsuperscript{a,}\textsuperscript{*}, Tariku Jibat Beyene\textsuperscript{a}, Eva M. De Clercq\textsuperscript{b}, Kebede Amenu\textsuperscript{a}, Moritz U.G. Kraemer\textsuperscript{c,}\textsuperscript{d,}\textsuperscript{*}, Crawford W. Revie\textsuperscript{f}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{map.png}
\caption{Disease risk for Zika, Dengue, Yellow fever, Chikungunya, and RVF.}
\end{figure}
Incidence of confirmed cases of Leptospirosis in the provinces of Santa Fe and Entre Ríos (2009-2018).

Leptospirosis is a zoonosis caused by the spirochete bacteria *Leptospira interrogans* and its principal vector are rats.
Impacts in our region: Leptospirosis

Impacts in our region: Leptospirosis

Impacts in our region: Leptospirosis

Dynamic epidemiological modeling as a tool for monitoring, prediction, evaluation and early warning of the response of infectious diseases to different hydroclimatic phenomena.

CLIMATIC SERVICES APPLIED ON HEALTH

To be effective:
- Reliable data
- Interdisciplinary work (health professionals, biologist, engineers, programmers, decision makers, etc.)
MATHEMATICAL MODELLING

SIR model of leptospirosis

- $S_H$ (Susceptible Human)
- $I_H$ (Infected Human)
- $R_H$ (Recovered Human)
- $S_V$ (Susceptible vector)
- $I_V$ (Infected Vector)

$$\beta_H(t) = k\Gamma(t, a, loc)\Delta FA(t)$$

$\Gamma(t, a, loc)$: gamma distribution for precipitation (from Triampo et. al 2007)

$\Delta FA(t)$: variation of flooded area in function of hydrometric levels.

Although the behavior of the rats is based on the availability of food in the garbage or similar, they prefer to be far from humans. However, in flood time their space is contracted then the chances of coming into contact with humans increases.
MATHEMATICAL MODELLING

\[ \Delta FA = f(h, t) \]
Results for 2010 outbreak

Santa Fe  
Rosario  
Paraná
Estatistical modelling of leptospirosis

Comparison of semiparametric methods:
- Classic ARIMA
- A new alternative ARIMAX.
- Semi-Functional Partial Linear Regression (SFPLR)

In particular, SFPLR is a method that allow the use of (hydroclimatic) covariables (non.-stationary) which could improve the prediction of outbreaks of leptospirosis.
Well, I don't understand this about climate change …

Bem, ainda eu não entendo isso sobre mudanças climáticas …


El 25 de septiembre de 2015, los líderes mundiales adoptaron un conjunto de objetivos globales para erradicar la pobreza, proteger el planeta y asegurar la prosperidad para todos como parte de una nueva agenda de desarrollo sostenible. Cada objetivo tiene metas específicas que deben alcanzarse en los próximos 15 años.

Para alcanzar estas metas, todo el mundo tiene que hacer su parte: los gobiernos, el sector privado, la sociedad civil y personas como nosotros.