Life and Health in a Changing Climate

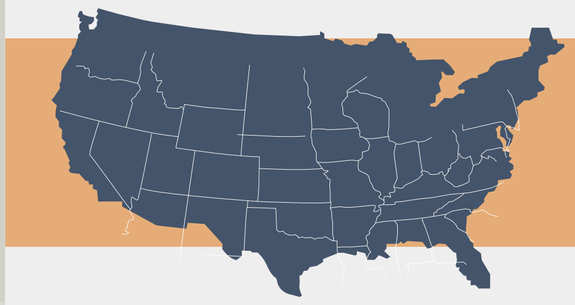
Yuchen Cao

Mike Jin

Swiss Re Advisor: Christian Klose
Faculty Advisor: Carine Simon

Takeaways

Within the U.S.
Bacterial Infectious Disease



No. 1 Factor: Human Development Index

Lower HDI → Higher Mortality

- High HDI + Low Precipitation (past 2-3 months) → Lower Disease Mortality
- Low HDI + Low Temperature / High Water Vapor (past 2-3 months) → Higher Disease Mortality

Globally
Hypertensive Heart Failure

Risk Group Change by 2030:

1 Country:
Low → Medium Risk

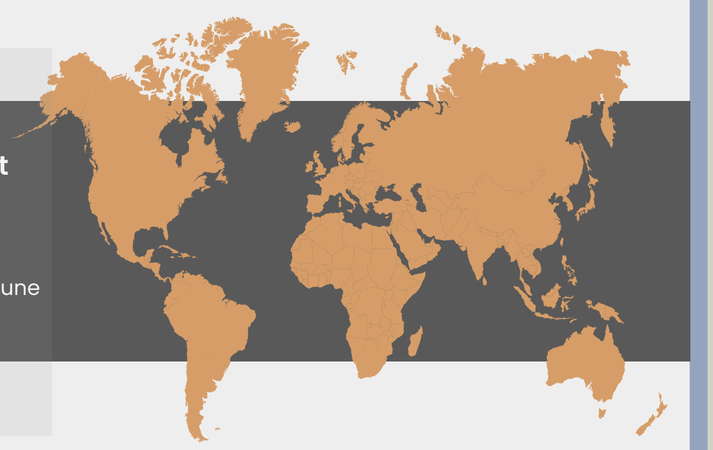
12 Countries:
Medium → High Risk

4 Countries:
High → Medium Risk

All other countries stay within the same risk group.

2nd Quarter Climate Events have Greatest Impact on Deaths

High Temperature / High Precipitation from April to June → Higher Disease Mortality



Problem Statement

Every year,
1 Million die from Hypertensive Heart Failures,
600 Thousand die from Malaria,
extreme climate events can aggravate the situation.

How will healthcare systems and the insurance industry adapt to changing climatic conditions?

Business & Social Impact

Offer insights for making **effective disease-related insurance plans** that fit regional climate and socio-economic conditions.

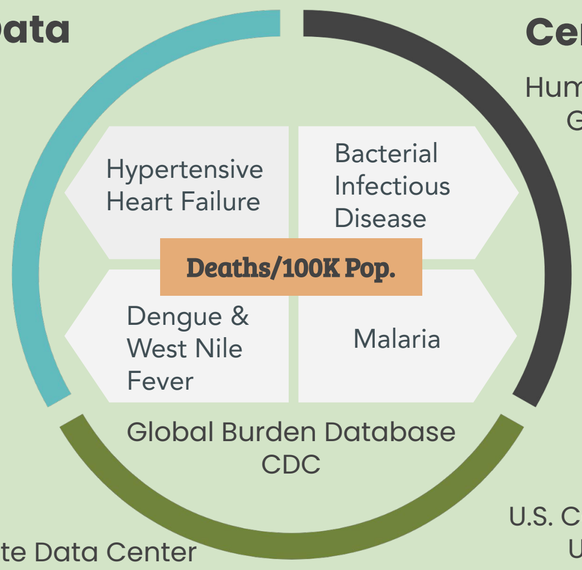
Help the general public understand climate impact on disease mortality and **take timely preventive initiatives.**

Scope

U.S. Analysis	State Monthly	Precision Interpretability
Global Analysis	Country Annual	Generalizability Feature Importance

Data

Climate Data
Temperature
Water Vapor
Precipitation

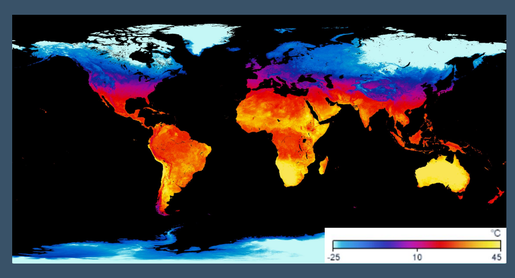


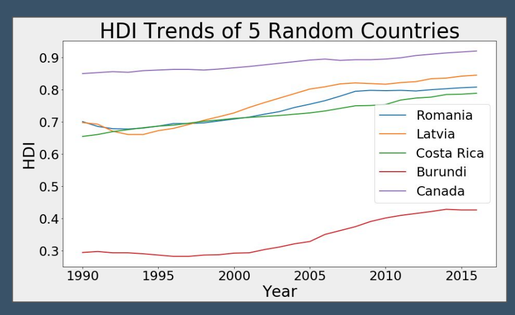
Census Data
Human Dev. Index
GDP per capita
Population

NASA
World Bank
National Climate Data Center

U.S. Census Bureau
United Nations

35 States[1]
184 Countries
6.5 M Climate Data per day





1) Satellite Image Processing
Use color mapping algorithm to get the numerical values of climate features from satellite images.

2) Time-Series Feature Detrend
Eliminate the trend to help machine learning models capture the deviation of a feature w.r.t its trend.

3) Lag Analysis
1 ~ 3 months of delays are found between climate variables and disease mortality for **70%** of U.S. states.

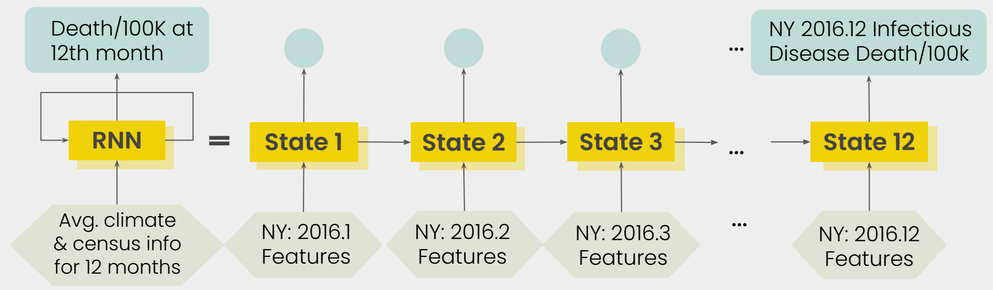
Feature Engineering

Project Overview

1 → 2 → 3 → 4

Model

U.S. Analysis - Recurrent Neural Network



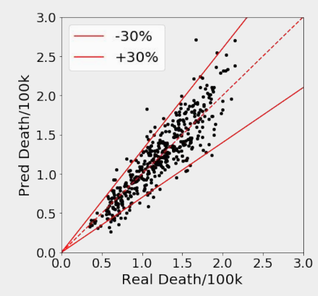
Sample Model Results[2]

U.S. Analysis

Model	Bacterial Infectious
ARIMA	0.59 R^2
Regression Tree	0.70 R^2
Gradient Boosting	0.76 R^2
RNN	**0.80 R^2**

Global Analysis

Model	West Nile Fever
Time Series	0.23 R^2
Regression Tree	0.37 R^2
Gradient Boosting	0.74 R^2
Ensemble + Clustering	**0.92 R^2**



RNN Cross Plot
30% error coverage: 91.0% test data

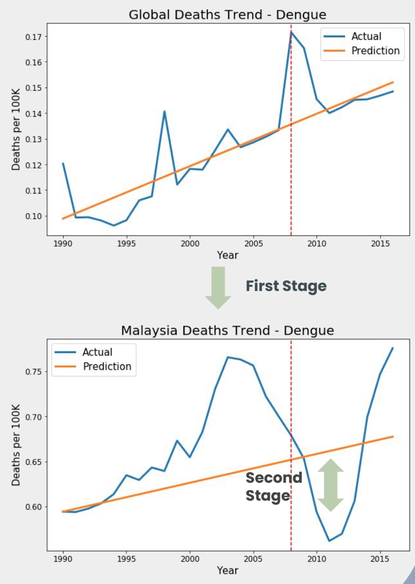
Global Analysis - Ensemble Model

First Stage (Time Series)

- Fit **global trend** from 1990 – 2007 (training year) with a **linear function**
- Use **slope** of global trend to predict deaths of each country from 1990 – 2016

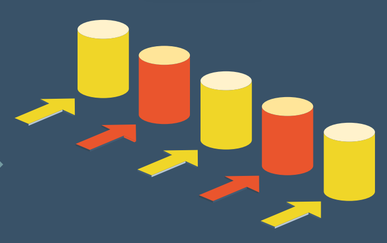
Second Stage (Machine Learning)

- **Approach 1:** use results of the 1st stage prediction as a feature to predict **deaths**
- **Approach 2:** predict **errors** of 1st stage prediction and then recover **deaths**



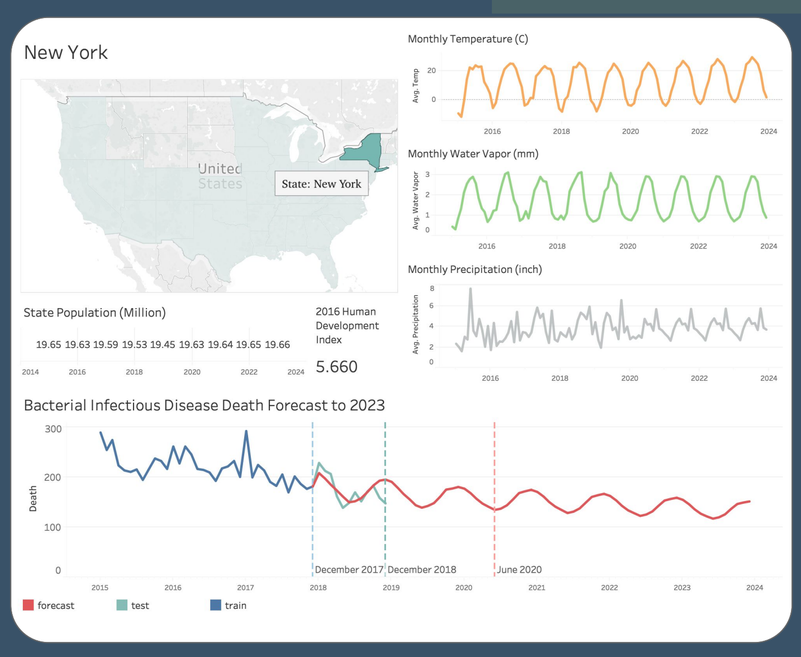
Application

Past Climate & Census Data



Our Forecast Models

Estimate Future Disease Deaths



Generate disease forecasts for the next 5-10 years, helping Swiss Re understand the key factors of risk exposure over time.

[1] States with available disease information. [2] Model results are non-exhaustive. [3] Poster Template Reference: Michigan Economic Impact Report 2012.