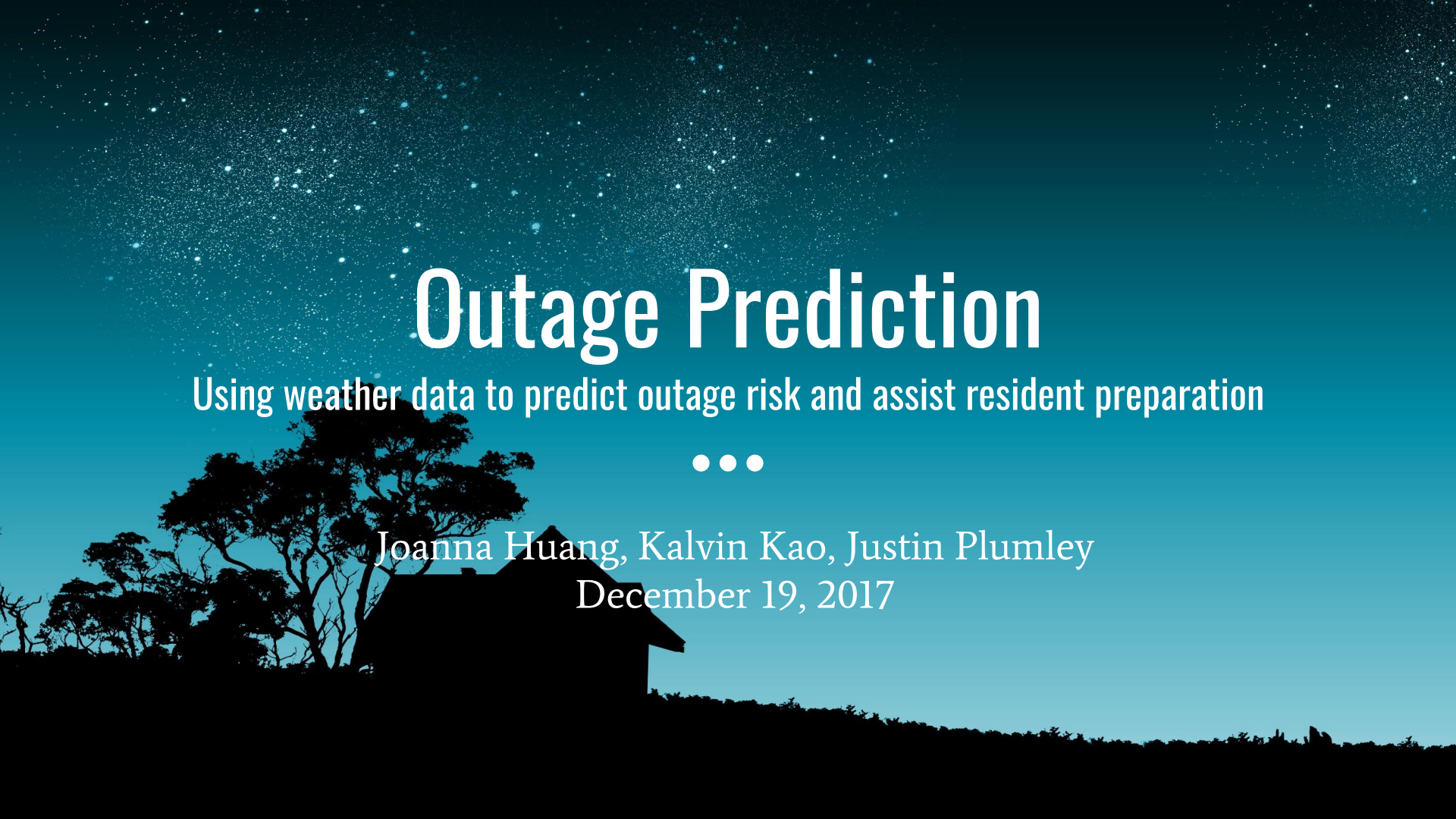


Outage Prediction

Using weather data to predict outage risk and assist resident preparation

Joanna Huang, Kalvin Kao, Justin Plumley

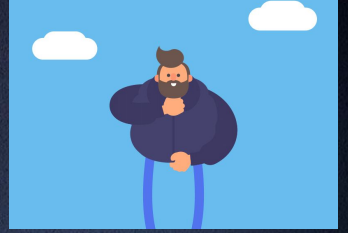
December 19, 2017

Background:

- Power outages due to downed power lines are a frequent occurrence in the US
- Extreme weather events result in economic, social, and physical disruptions
    - Aging power grid
    - Potential cost of $150 billion per year

Project objective:

- Use weather and power datasets to predict outages and their potential magnitude to inform residents and assist in preparation



Acquisition and Organization of Information for Analytics

NOAA

(National Oceanic and Atmospheric Administration)

Provides weather history over a long period of time and / or locations

Data fields: sky conditions, visibility, temperature, humidity, wind speed, pressure

Data size: up to 13,000+ observations/year (per city)

https://www.ncdc.noaa.gov/

STATION	STATION_NAME	ELEVATION	LATITUDE	LONGITUDE	DATE	REPORT TPYE	HOURLY SKY CONDITIONS	HOURLY VISIBILITY	HOURLY DRY BULB TEMPF	HOURLY WET BULB TEMPF	HOURLY Dew Point TempF	HOURLY Relative Humidity	HOURLY Wind Speed	HOURLY Wind Direction	HOURLY Wind Gust Speed	HOURLY Station Pressure
WBAN:14765	PROVIDENCE RI US	16.8	41.7225	-71.4325	12/1/2015 0:51	FM-15	CLR:00	10	31	30	27	85	3	300		30.32
WBAN:14765	PROVIDENCE RI US	16.8	41.7225	-71.4325	12/1/2015 1:00	FM-12			31	30	27	85	3	300		30.32
WBAN:14765	PROVIDENCE RI US	16.8	41.7225	-71.4325	12/1/2015 1:51	FM-15	CLR:00	10	30	29	26	85	0	0		30.32
WBAN:14765	PROVIDENCE RI US	16.8	41.7225	-71.4325	12/1/2015 2:51	FM-15	CLR:00	10	30	29	27	88	5	360		30.32
WBAN:14765	PROVIDENCE RI US	16.8	41.7225	-71.4325	12/1/2015 3:51	FM-15	CLR:00	10	30	29	27	88	8	360		30.3
WBAN:14765	PROVIDENCE RI US	16.8	41.7225	-71.4325	12/1/2015 4:51	FM-15	CLR:00	10	29	28	26	89	0	0		30.3
WBAN:14765	PROVIDENCE RI US	16.8	41.7225	-71.4325	12/1/2015 5:51	FM-15	CLR:00	10	29	28	26	89	3	360		30.3
WBAN:14765	PROVIDENCE RI US	16.8	41.7225	-71.4325	12/1/2015 6:51	FM-15	SCT:04 50 BKN:07 250	10	30	29	27	88	6	360		30.29

Acquisition and Organization of Information for Analytics

EIA Electric Power

Major Disturbances and Unusual Occurrences, Year-to-Date 2016

Data fields: Year, Month, Event Date and Time, Restoration Date and Time, Duration, Utility/Power Pool, NERC Region, Area Affected, Type of Disturbance, Loss (megawatts), Number of Customers Affected

Data size: 50-100 observations a year

https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_b_1

Year	Month	Event Date and Time	Restoration Date and Time	Duration	Utility/Power Pool	NERC Region	Area Affected	Type of Disturbance	Loss (megawatts)	Number of Customers Affected
2016	1	01/10/2016 8:46 PM	01/11/2016 5:25 AM	8 Hours, 39 Minutes	ISO New England	NPCC	Maine: Connecticut: Massachusetts: Vermont: New Hampshire: Rhode Island:	Loss of electric service to more than 50,000 customers for 1 hour or more-Weather	Unknown	59859
2016	1	01/22/2016 3:52 PM	01/24/2016 12:30 PM	44 Hours, 38 Minutes	Duke Energy Progress	SERC	North Carolina: South Carolina:	Loss of electric service to more than 50,000 customers for 1 hour or more-Weather	Unknown	150000
2016	1	01/23/2016 7:49 AM	01/23/2016 9:05 AM	1 Hours, 16 Minutes	FirstEnergy Corp. Jersey Central Power & Light	RFC	New Jersey:	Loss of electric service to more than 50,000 customers for 1 hour or more-Weather	Unknown	50900
2016	2	02/05/2016 11:21 AM	02/06/2016 3:48 PM	28 Hours, 27 Minutes	ISO New England	NPCC	Connecticut: Massachusetts: Rhode Island:	Loss of electric service to more than 50,000 customers for 1 hour or more-Weather	Unknown	115057
2016	2	02/13/2016 12:44 PM	02/13/2016 4:27 PM	3 Hours, 43 Minutes	Pacific Gas & Electric Co	SERC	California	Electrical System Separation (Islanding) where part or parts of a power grid remain(s) operational in an otherwise blacked out area or within the partial failure of an integrated electrical system-Islanding	7	4300
2016	2	02/16/2016 8:35 AM	02/16/2016 5:28 PM	8 Hours, 53 Minutes	American Electric Power - (RFC Reliability Region) (8400 Smiths Mill Road, New Albany Ohio 43054)	RFC	Virginia: Roanoke County, Montgomery County; West Virginia: Kanawha County, Cabell County; Tennessee: Sullivan County;	Loss of electric service to more than 50,000 customers for 1 hour or more-Weather	Unknown	52640
2016	2	02/19/2016 10:00 PM	02/20/2016 11:13 PM	25 Hours, 13 Minutes	Detroit Edison Co	RFC	Michigan	Loss of electric service to more than 50,000 customers for 1 hour or more-Weather	Unknown	145314
2016	2	02/24/2016 2:45 PM	02/25/2016 5:00 AM	14 Hours, 15 Minutes	Duke Energy Carolinas	SERC	North Carolina: South Carolina	Loss of electric service to more than 50,000 customers for 1 hour or more-Weather	400	284610

Acquisition and Organization of Information for Analytics

Weather Underground

Hourly forecasts accessed via API

Data fields: location, observation time, weather description, temperature, humidity, wind (dir, mph, pressure), precipitation)

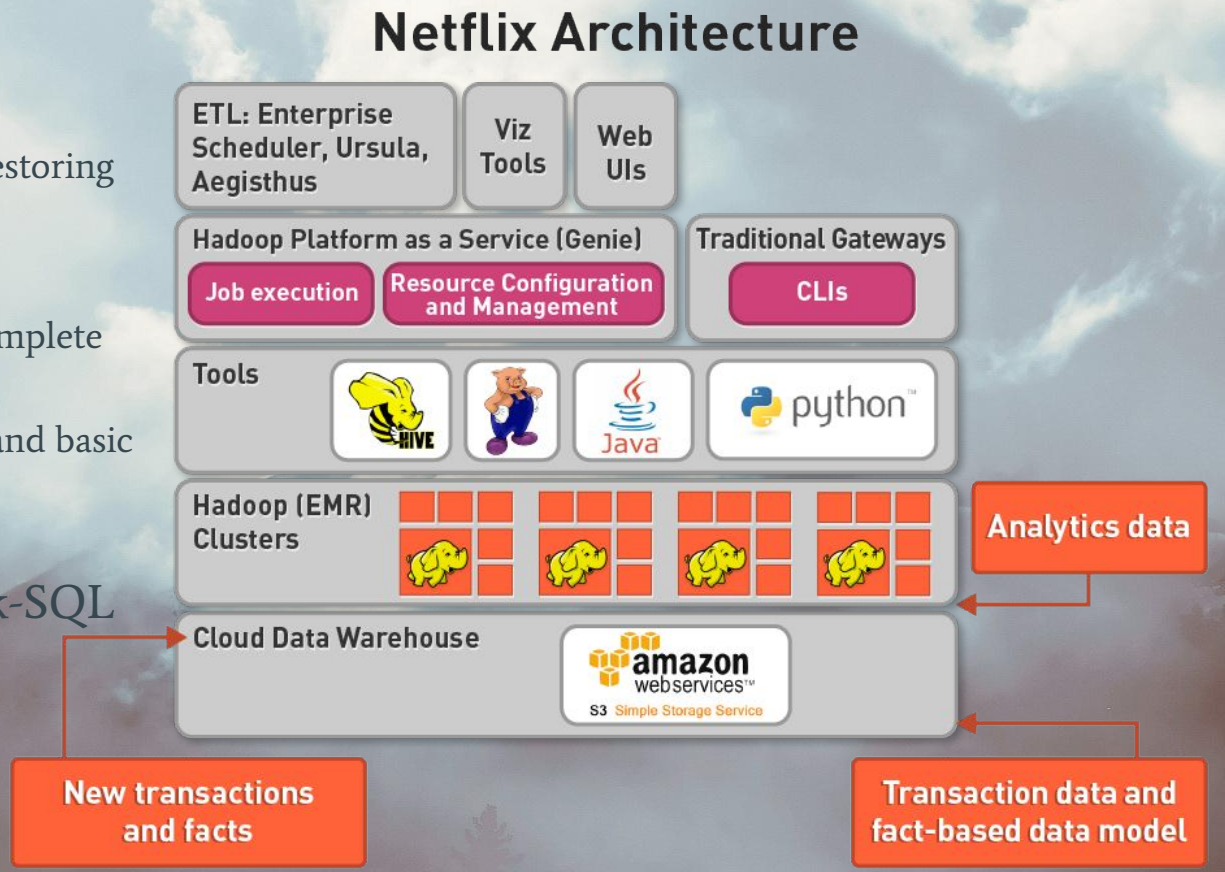
Data size: Depends on number of cities

http://www.wunderground.com/weather/api/


```
{
  "response": {
  "version":"0.1",
  "termsofService":"http://www.wunderground.com/weather/api/d/terms.html",
  "features": {
  "forecast": 1
  }
        }
                ,
        "forecast":{
                "txt_forecast": {
                "date":"3:25 PM EST",
                "forecastday": [
                {
                "period":0,
                "icon":"partlycloudy",
                "icon_url":"http://icons.wxug.com/i/c/k/partlycloudy.gif",
                "title":"Monday",
                "fcttext":"Clouds early, some clearing late. Lows overnight in the low 30s.",
                "fcttext_metric":"Skies clearing overnight. Low 0C.",
                "pop":"20"
                }
                ,
                {
                "period":1,
                "icon":"nt_partlycloudy",
                "icon_url":"http://icons.wxug.com/i/c/k/nt_partlycloudy.gif",
                "title":"Monday Night",
                "fcttext":"Cloudy early with some clearing expected late. Low 32F. Winds light and variable.",
                "fcttext_metric":"Cloudy skies early, then partly cloudy after midnight. Low around 0C. Winds light and variable.",
                "pop":"20"
                }
                ,
                {
                "period":2,
                "icon":"partlycloudy",
                "icon_url":"http://icons.wxug.com/i/c/k/partlycloudy.gif",
                "title":"Tuesday",
                "fcttext":"Sunshine and clouds mixed. High 48F. Winds WSW at 10 to 15 mph.",
                "fcttext_metric":"Sunshine and clouds mixed. High 9C. Winds WSW at 15 to 25 km/h.",
                "pop":"10"
                }
```

Future Architecture

- Architecture: Netflix
  - One data warehouse for restoring predictive analyses
- Storage: HDFS
  - Small, structured, semi-complete data
  - Low latency, low quality, and basic query requirements
  - Scales out
- Processing: Apache Spark-SQL
  - MLlib, RDDs, pySpark



Pilot Architecture

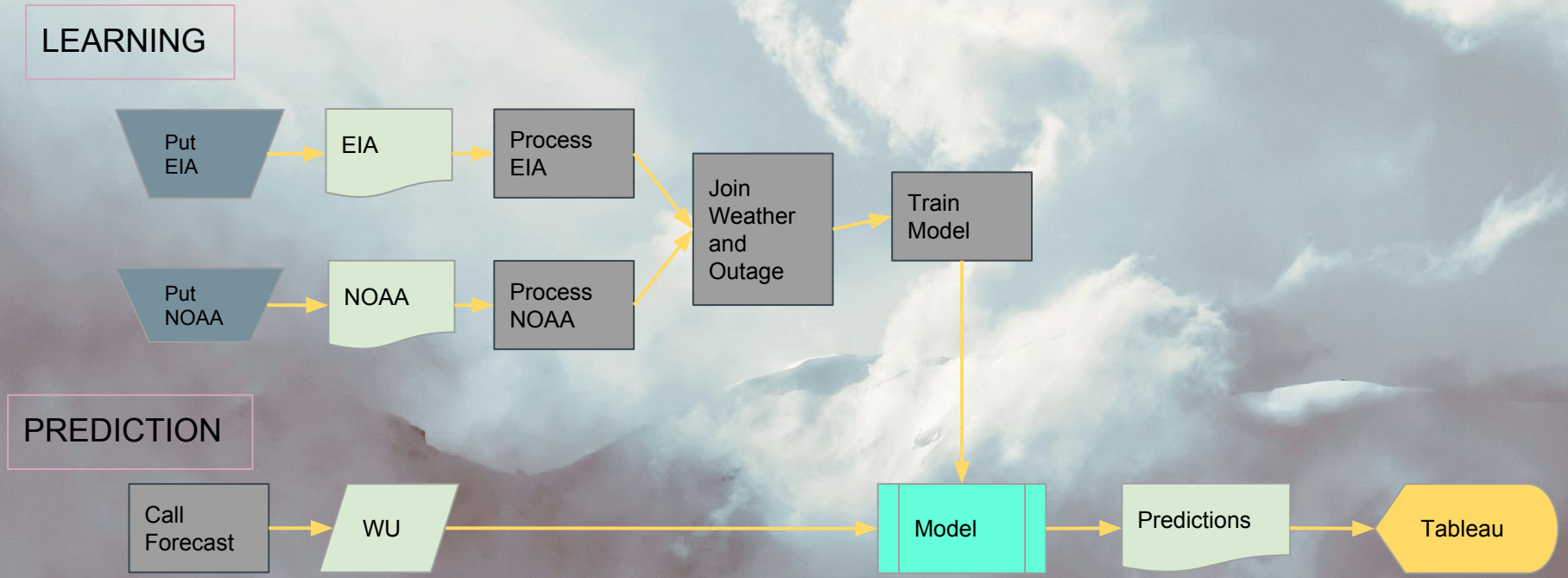
Storage Layer

Processing Layer

Streaming Layer

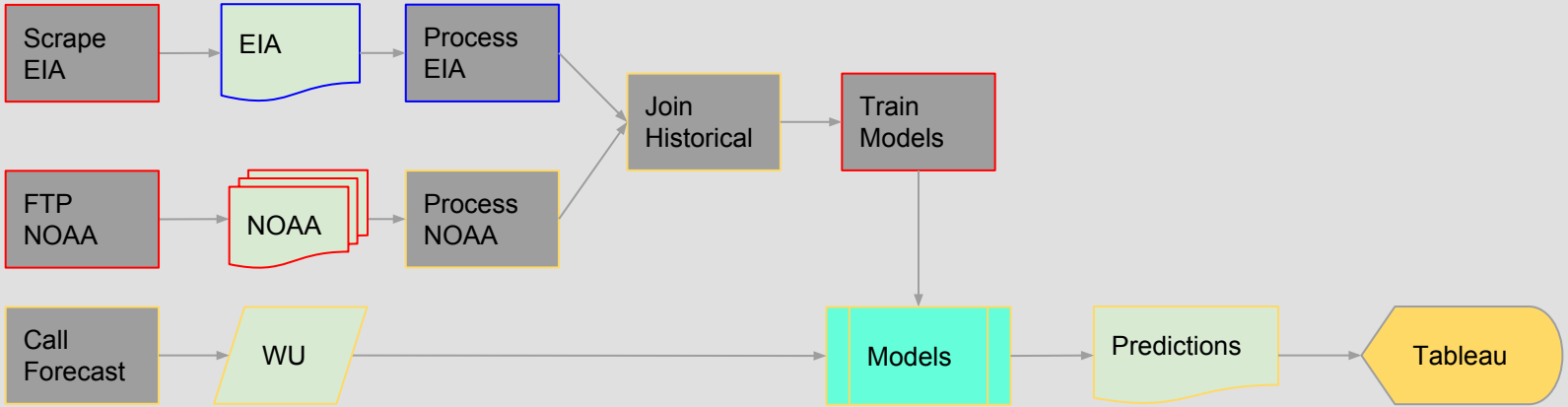
Serving Layer

Process: Pilot



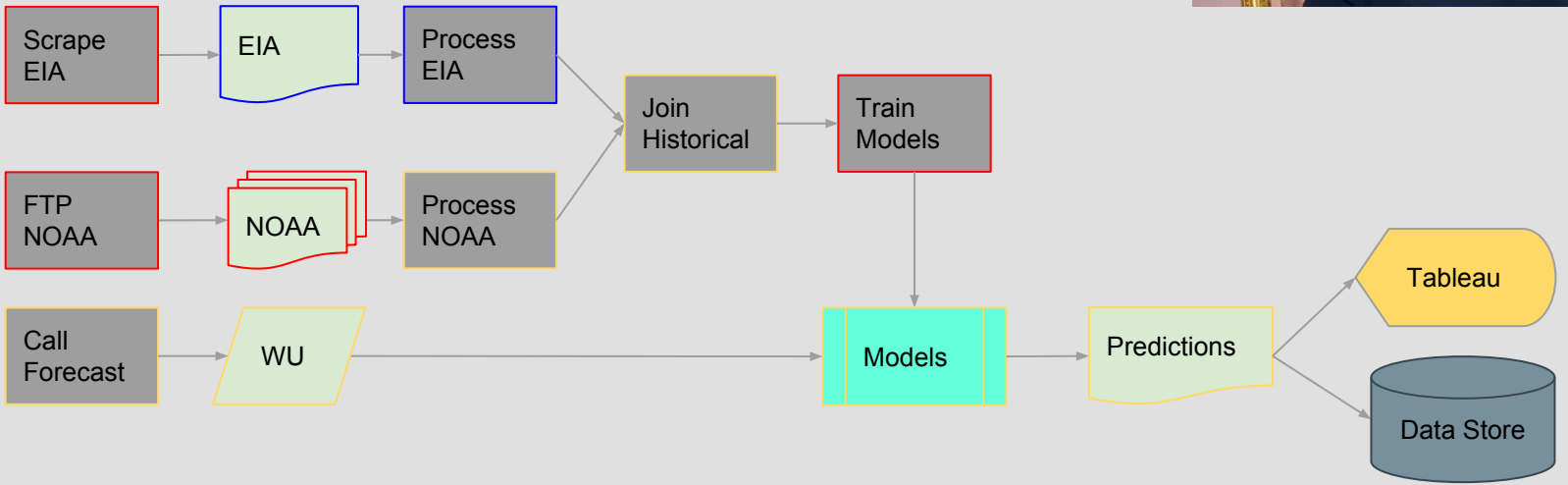
Demo

Process: Next Iteration



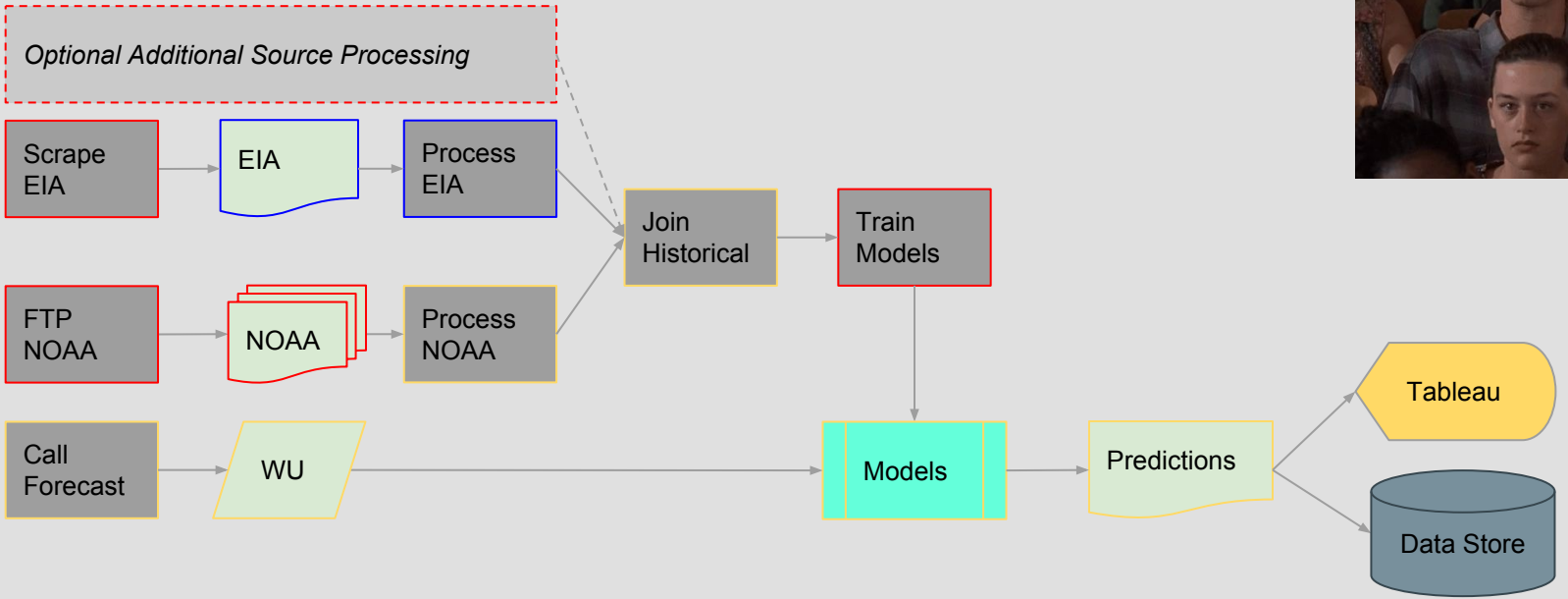
Process: Next Iteration

Live Class Reaction

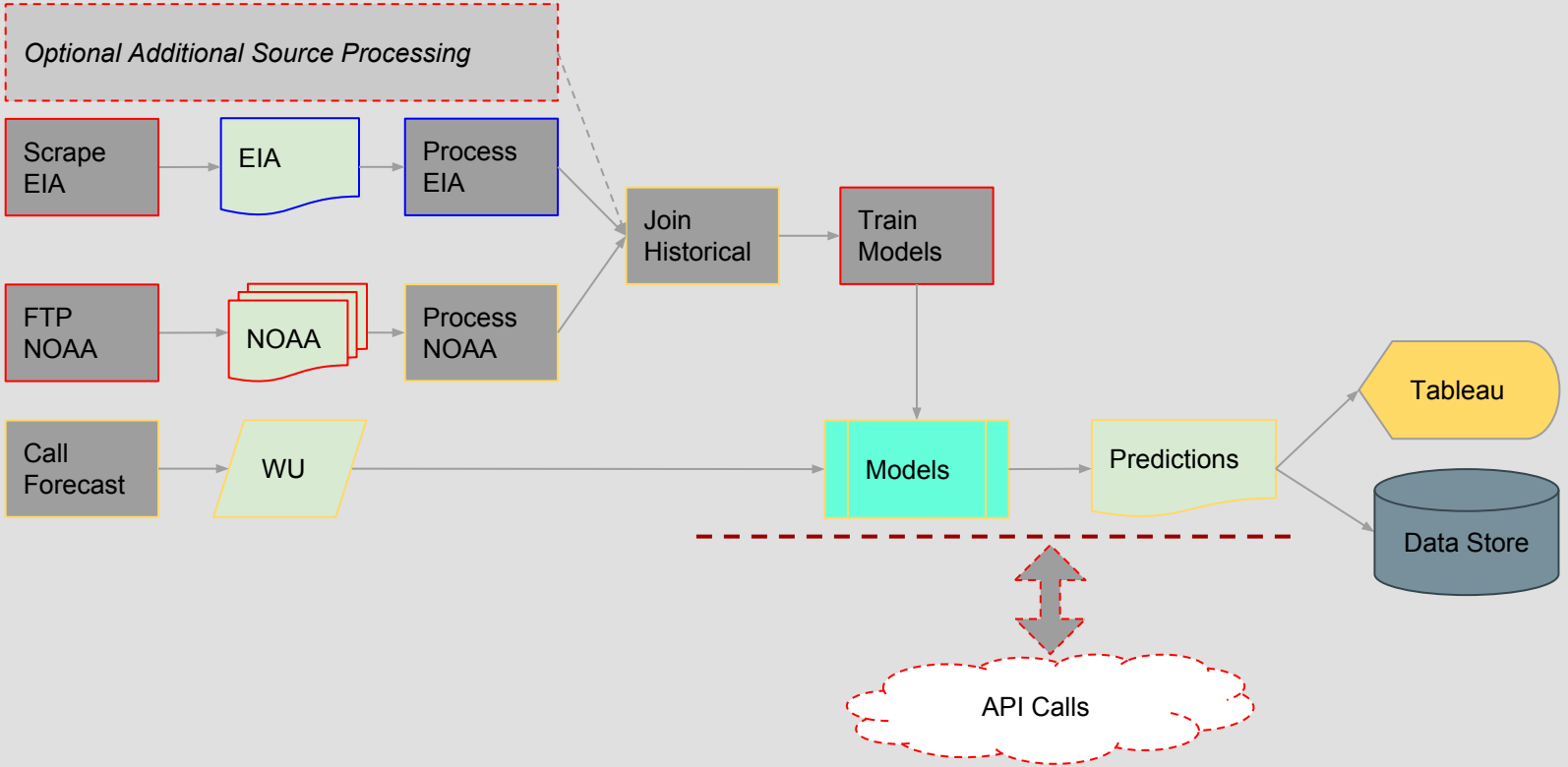


Process: Next Iteration

Live Class Reaction



Process: Next Iteration



Usage

Local Residents (Public Service)

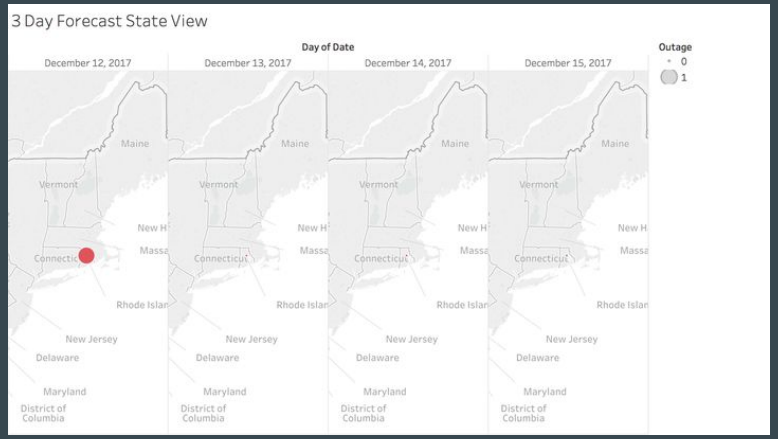
Direct or through Media Channels

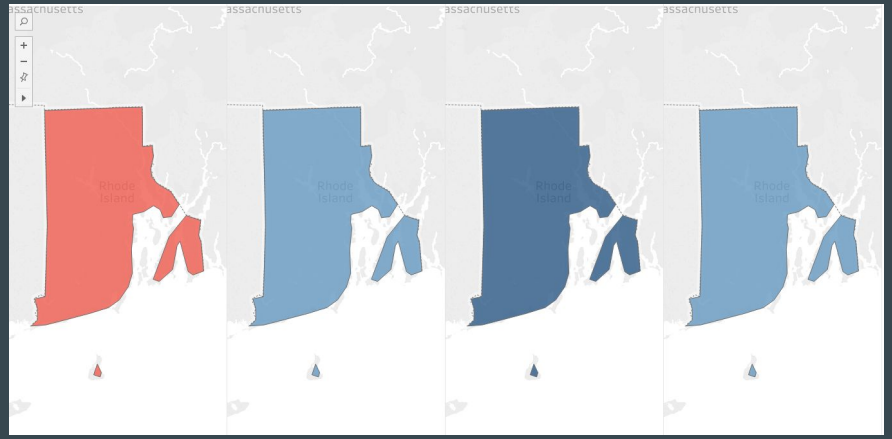
Warning / Preparation

3 Day Forecast Table View

State	Day of Date: December 12, 2017	December 13, 2017	December 14, 2017	December 15, 2017
Rhode Island	1	0	0	0

Outage: 0 – 1





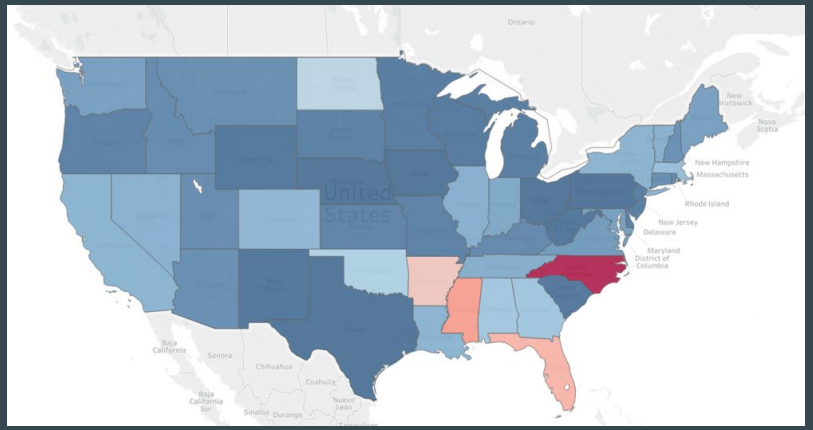
Usage

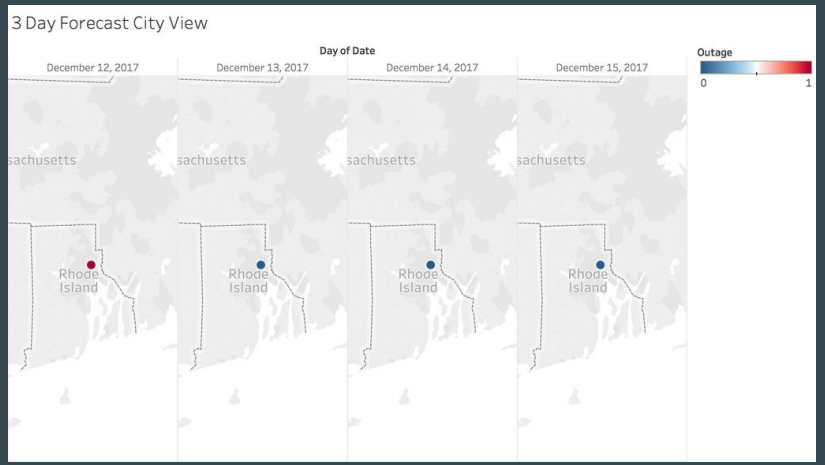
Utilities

- Complement Existing Process (labor, capital costs)

Private Sector

- Demand Forecasting
- Supply Chain Risk





Recap

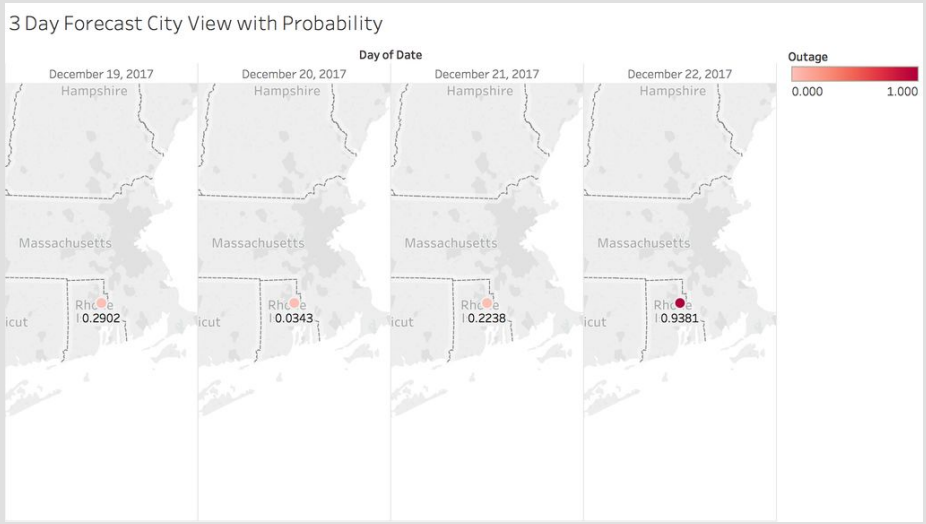
- Pilot designed for ease of scaling
  - Prepared for Volume and Velocity increases
  - Workstream supports various sources and can support Variety growth

- Suggested Developments in the Future
  - Increase breadth and depth of geographic areas served
  - Scale parts of solution separately, need-based
  - Add serving layers
  - Expand sources -> more predictors

Thank You!

Appendix

Additional Visualizations



Reference of Previous Work

High-speed winds during a thunderstorm may cause trees around an electric grid to crash into the distribution system feeders causing an outage in that area. This model predicts potential vulnerability to ensure the trees in the most critical areas with the highest risk to be trimmed first.

"Power outages in the distribution system are primarily caused by **wind blowing trees and limbs onto power lines**," says Guikema. "Therefore, our model includes a number of different measures of **wind, the type of trees, and the soil moisture conditions**, which provides a measure of the stability of the soil and the likelihood of a tree being uprooted."

A group of researchers led by Seth Guikema at the University of Michigan has created a model that predicts the number of power outages "based on **wind speed estimates, population density, soil moisture levels, drought indices, and information about trees in each census tract.**"

Solution Architecture Draft

Learning Data

xlsx → csv → RDD

csv → RDD

1) query for past outages due to severe weather

2) label historical weather data

3) teach power outage classifier

Prediction Data

json → raw data → RDD

4) predict outages based on current forecast

5) surface predictions in viz layer