Building Bridges Between Environmental Science and Business Operations
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Amith Singhee
Senior Technical Staff Member
Manager, Environmental Analytics and Cognitive Operations
IBM Research, India
The Environment Impacts Many “Businesses”

Environmental Science: weather forecasts, observations, remote sensing, etc.

- Difficult for business stakeholders to directly quantify and predict impacts, and take precise decisions.
  - Stakeholders: storm director, farmer, city administrator, building manager, etc.

- How can we bridge this gap?
Storm Impacts on Power Distribution Grid: What was the Gap?

- Difficult for a business user, or even meteorologist to quantify 1-2 days ahead of time:
  - How many damages and outages should I expect in each service region?
  - How will those damages be distributed over time?
  - How much work effort will be have to be spent in each service region?
  - How may resources of different types should I stage in each service center?
  - Should I ask for mutual aid, if so how many, when and for how long?
Bridging the Gap With Coupled Models: Basic Flow

**Weather Model**
Physics based and statistical

**Damage Model**
Machine Learning Model

**Pre-Positioner**
Optimization Model

High Precision Weather Prediction

Damage/Outage Prediction

Pre-Planning (~3 days lead)

Wind Gusts, Snow, ...

Expected Damage Locations & Timing

Resource Mobilization

Restoration Response Scenarios
Customized Weather Model

- **Regional domain, nested grid customized to target business needs.**
- **Calibrated to best match historical weather events relevant to the business.**
Damage Forecasting Model

- Predict spatial and temporal distribution of weather-driven damages

- Damage behavior influenced by many factors:
  - Weather: wind gust speed, direction, precipitation, temperature, etc.
  - Vegetation relative to infrastructure
  - Infrastructure characteristics: underground/overhead, age, type
  - Soil conditions
  - Electrical operating conditions

- Challenges overcome:
  - Data sparsity
  - Variety of weather: thunderstorm, heat wave, clear sky, ice storm, etc.
  - Noise for low damage/clear sky

**Damage Model**

- Machine learning model

**Input**
- High precision weather prediction (gust, rainfall, temp., etc.)

**Training Input**
- Historical damage data
- Weather hindcasts/observations
- Substation area polygons
- Damage categorization

**Output**
- Probability distribution of damages
- Per day/shift
- Per damage type
- Per substation area
Impact Metrics Understandable by the Business: Damage Forecast
Storm Impact Summary Dashboard

Medium Storm
Jan 15th, 7:00 PM - Jan 16th, 7:00 PM
41807 Customers Affected
3698 Jobs

Damage Prediction

Weather

<table>
<thead>
<tr>
<th>DateTime</th>
<th>01/15 AFT</th>
<th>01/16 EVE</th>
<th>01/16 DAY</th>
<th>01/17 AFT</th>
<th>01/17 EVE</th>
<th>01/17 DAY</th>
<th>01/18 AFT</th>
<th>01/18 EVE</th>
<th>01/18 DAY</th>
<th>01/18 AFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation (in inch)</td>
<td>0.02</td>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.02</td>
<td>0.08</td>
<td>0.05</td>
<td>0.03</td>
<td></td>
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<tr>
<td>Temp Max (in Fahrenheit)</td>
<td>32.33°</td>
<td>31.39°</td>
<td>23.63°</td>
<td>19.79°</td>
<td>20.58°</td>
<td>39.64°</td>
<td>39.95°</td>
<td>37.73°</td>
<td>34.69°</td>
<td>32.97°</td>
</tr>
<tr>
<td>Temp Min (in Fahrenheit)</td>
<td>13.81°</td>
<td>4.36°</td>
<td>5.10°</td>
<td>-5.60°</td>
<td>-2.70°</td>
<td>11.70°</td>
<td>33.24°</td>
<td>23.28°</td>
<td>24.02°</td>
<td>25.62°</td>
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<tr>
<td>Gust (in miles/hour)</td>
<td>43.96</td>
<td>37.47</td>
<td>32.82</td>
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<td>41.66</td>
<td>45.86</td>
<td>49.11</td>
<td>40.22</td>
<td>36.46</td>
<td>31.02</td>
</tr>
</tbody>
</table>
Difficult for growers to answer “business” questions precisely and easily:

- How many liters of water should I input this week?
- Should I spray some pesticide? If yes, which?
- Is one farm lagging behind others in health? Why?
Stepping Back: What Do These Bridge All Look Like?

Data
1. Co-curate: Remote sensed, locally sensed, forecast, static
2. Big data, query-able

People/orgs
1. Joint projects – cross-disciplinary team
2. Industry track workshops
3. Private – public – academic – NGO

Knowledge
1. Just “what is available”? 2. Needs in the target domain: e.g. wind gust for damages 3. Geo-specific needs

Science/models
1. Model customization
2. Models in the Cloud – converged infrastructure with downstream applications
3. Coupled models (numerical, machine learning, optimization, domain-specific)
1. Engage with industries across geographies for local relevance and global scalability.
2. Bring comprehensive skills and roles together to translate all the way from idea to production.