Data-driven Impact Projections for Climate Risk Management

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Asset-specific Impacts for Climate Risk Management

• We estimate changes in:
  – Energy needs
  – Heat stress
  – Equipment downtime, performance, etc.
  – Health impacts
  – Electrical power plant cooling limits

• This list changes in breadth and level of detail depending on specific concerns of different industry sectors or government missions

• Risk approach informs resilience and adaption measures
Applied Resilience Toolkit – Screening Level

- Initial assessment of relative risk
- Identifies where to do detailed analysis
- Fast processing of thousands of locations using 27 indices from 31 models
- Calculates surrogates for specific risks (energy use, heat stress, etc.)
- GIS for rapid display of results and integration with other information (drainage basins, population distributions, storm surge data, etc.)

Change in Electrical Plant Cooling Capacity (%)
- $-42.6762 \text{ to } -40.0000$
- $-40.0000 \text{ to } -35.0000$
- $-35.0000 \text{ to } -30.0000$
- $-30.0000 \text{ to } -25.0000$
- $-25.0000 \text{ to } -20.0821$
Applied Resilience Toolkit – Detailed Level

- Localized statistics for 1950-2100 anywhere on the globe.
- All CMIP5 models and variables
- Downscaled data from NEX-GDDP, NARCCAP, etc.

- Location-specific decadal averages for each month throughout the year.
- Distributions for any month/year based on all models.
- Distributions for any period based on all models, or on selected model.
Risk: Increases in Energy Needs (Screening Level)

- Risk metric: Change in frost days plus tropical nights at 400 public-sector facilities
- For example, compare 2026-2045 to 2006-2025 for RCP 8.5 climate scenario

Adaptation planning implications:
- Weight by energy use and source
- Prioritize infrastructure upgrades
- More detailed risk estimates needed
Energy Risk Refined Based on Energy Use Related to Weather (Screening Level)

- Utilized detailed energy billing records (100K records for 790 facilities)
- Heating/cooling energy-usage surrogate (frost days + tropical nights)
- Compare 2026-2045 to 2006-2025 for RCP 8.5 using 10 models

**Percent Change in Heating/Cooling Energy Surrogate**

**Percent Change in Heating/Cooling Energy Surrogate Times Percent of Energy Use That Is Weather Related**
Risk: Increases in Energy Needs (Detailed Level)

- Risk metric: location-specific Cooling Degree Days (CDD) and Heating Degree Days (HDD) 1950-2100:

Approximate Changes in Degree Days:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cool</th>
<th>Heat</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>+ 5%</td>
<td>- 5%</td>
<td>-</td>
</tr>
<tr>
<td>2045</td>
<td>+20%</td>
<td>-10%</td>
<td>+ $15000</td>
</tr>
<tr>
<td>2065</td>
<td>+40%</td>
<td>-15%</td>
<td>+ $38000</td>
</tr>
<tr>
<td>2085</td>
<td>+60%</td>
<td>-20%</td>
<td>+ $60000</td>
</tr>
</tbody>
</table>

Adaptation planning implications:
- plan for higher energy needs;
- modify infrastructure

- Distribution of estimates for each year and each month give probabilities of exceeding decision-specific thresholds.

* Area of facility is 248,000 sqft. Average annual energy consumption is 6 kWh/sqft, so the annual energy use is about 1.5M kWh. At $0.10/kWh, the annual cost is $150,000.
Risk: Increases in Heat Stress

- Risk metric: Heat impacts on persons based on hot days and hot nights (above historical 90th percentile values) at 600 cities and towns in Mali
- For example, compare 2026-2045 to 2006-2025 for RCP 8.5 climate scenario

Percent Change in Hot Days and Nights

- 54.8 – 56.0
- 56.0 – 58.0
- 58.0 – 60.0
- 60.0 – 62.0
- 62.0 – 64.0
- 64.0 – 66.0
- 66.0 – 66.6

Adaptation planning implications:
- Local opportunities to mitigate?
- More detailed risk estimates needed
Risk: Decreases in Electricity Plant Cooling Capacity

- Plant data: location, cooling type, water source/sink, flow rates, etc.
- Screening results using surrogate for decreases in cooling capacity (total precipitation divided by high-temperature days, prcptot/tx90p)
- Compare 2026-2045 to 2006-2025 for RCP8.5 scenario.

Change in Electrical Plant Cooling Capacity (%)
- Red: -42.6762 – -40.0000
- Orange: -40.0000 – -35.0000
- Yellow: -35.0000 – -30.0000
- Light: -30.0000 – -25.0000
- Dark: -25.0000 – -20.0821
Risk: Decreases in Electricity Plant Cooling Capacity (Cont’d)

- Drainage basins* merged with plant data to prepare for more detailed analysis.
- Screening results as on previous slide.

Value of the Approach

• Interpret climate data within specific end-user context
• Improves allocation of adaptation resources:
  – Decision-specific risk metrics with probabilities
  – Localized and time-specific
  – World-wide coverage
• Bridges gap between latest climate-projection data and needs of planners for risk-based decision-making on asset-level resilience investments
Questions?

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Effective Adaptation Planning Must Be Driven by Detailed Climate Data

- Adaptation resources will always be limited
- Need to prioritize allocation according to best available data
- We bridge the gap between general changes in climate and specific risks to local assets

Changes in Climate Variables
- Temperature
- Humidity
- Sea level
- Extreme events

Impacts on Specific, Localized Assets
- People
- Infrastructure
- Energy needs
- Supply chain

Sector-specific Adaptation Planning
- Capital planning
- Aid/assistance planning
- Infrastructure design
- Supply chain design
How LMI Determines Asset-specific Impacts

- Integrate enormous amounts of climate data from observations and models to get good statistics.
- Develop statistics for specific asset locations and time periods.
- Use the uncertainty in these statistics systematically in our risk-management decisions.
- Link the statistics to real-world measures of employee and infrastructure risk, tailored to client management processes.
LMI Toolkit Integrates Climate-model Data

- Projected climate statistics for specific locations
- Based on all available climate-model outputs (CMIP5)

CLIMATE MODELS - DAILY MAXIMUM SURFACE TEMPERATURE

ANALYZE MAXIMUM TEMPERATURES FOR A SPECIFIED PART OF THE YEAR.

Choose a location:
Spotsylvania, VA

Temperature threshold (degK):
250
300
350

Choose a month:
Jan

Range of Years:
1960
1970
1980
2000
2001
2010
2020
2030
2040
2050
2060
2070
2080
2090

Choose temperature units:
degK

Select model/scenario:
model1
LMI Toolkit Derives Local Statistics

- Location-specific decadal averages for each month throughout year.
- Distributions for any month/year based on all models.
- Distributions for any period based on all models, or on selected model.
### Extremes Indices Overview

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN10p</td>
<td>Cold nights</td>
<td>TN90p</td>
<td>Warm nights</td>
</tr>
<tr>
<td>TX10p</td>
<td>Cold days</td>
<td>TX90p</td>
<td>Warm days</td>
</tr>
<tr>
<td>WSDI</td>
<td>Warm spell duration</td>
<td>CSDI</td>
<td>Cold spell duration</td>
</tr>
<tr>
<td>TXx</td>
<td>Max TX</td>
<td>RX1day</td>
<td>Max 1-day precipitation</td>
</tr>
<tr>
<td>TXn</td>
<td>Min TX</td>
<td>RX5day</td>
<td>Max 5-day precipitation</td>
</tr>
<tr>
<td>TNx</td>
<td>Max TN</td>
<td>SDII</td>
<td>Simple daily intensity</td>
</tr>
<tr>
<td>TNn</td>
<td>Min TN</td>
<td>R1m</td>
<td>Number of wet days</td>
</tr>
<tr>
<td>FD</td>
<td>Frost days</td>
<td>R10mm</td>
<td>Heavy precipitation days</td>
</tr>
<tr>
<td>ID</td>
<td>Ice days</td>
<td>R20mm</td>
<td>Very heavy precipitation days</td>
</tr>
<tr>
<td>SU</td>
<td>Summer days</td>
<td>CDD</td>
<td>Consecutive dry days</td>
</tr>
<tr>
<td>TR</td>
<td>Tropical nights</td>
<td>CWD</td>
<td>Consecutive wet days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R95p</td>
<td>Very wet days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R99p</td>
<td>Extremely wet days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PRCPTOT</td>
<td>Total wet-day precipitation</td>
</tr>
</tbody>
</table>