Precipitation Parameters Of Stochastic Climate Models
For A Changing Climate
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Outline

- Background
- Relationships for precipitation
- Example application
Sediment Control

Timing: Minimize Blanket Ripening (1000 bales)

Silt Fences

Ponds (44 ponds)
Computational Framework

<table>
<thead>
<tr>
<th>Rank</th>
<th>Y</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.0</td>
<td>1%</td>
</tr>
<tr>
<td>2</td>
<td>4.8</td>
<td>2%</td>
</tr>
<tr>
<td>100</td>
<td>0.3</td>
<td>100%</td>
</tr>
</tbody>
</table>

Plant growth

Y_{1991}
WINDS Model

Weather

Inputs for Nonpoint Data

Simulations
Part 1: Compute statistics

Max Temperature

- Mean
- St. Dev
- Skew
- Serial Correlation

Min Temperature

- Cross Correlation
Climate Change

Stochastic Climate Parameters

Climate Change Parameters?

Estimates Available From Climate Predictions

Annual Precipitation Depth (in)

Year

1830 1880 1930 1980 2030 2080
Climate Change: Non-Precipitation

Multiplicative:

\[ X_n = \lambda X_o \]

Addictive:

\[ X_n = X_o + \beta \]

Straightforward if only interested in changing to new mean
Continued ...

\[
\mu = \mu_0 \left[ 1 + \alpha \sin \left( \frac{\text{year} - 1}{\beta} \right) \right] \\
\mu = \mu_0 \left[ 1 + \beta (\text{year} - 1) \right]
\]
Richardson’s Precipitation Approach

\[ E(P_T) = E(r) E(n_w) \]

Total Depth

\[ E(P_{Tn}) = \lambda_T E(P_{To}) \]

New depth = f(# events, depth per event) from climate model
Precipitation Depth

\[ E(r_n) = \lambda_r E(r_o) \]

\[ b_0 + b_1 \cos\left(\frac{\text{day}(2\pi)}{365} + \phi_1\right) + b_2 \cos\left(\frac{2\text{day}(2\pi)}{365} + \phi_2\right) + b_3 \cos\left(\frac{3\text{day}(2\pi)}{365} + \phi_3\right) \]
Number of Wet Events

\[ E(n_{w,n}) = \lambda_w E(n_{w,o}) \]

Climate model \( \lambda_T \) and specified \( \lambda_r \):

\[ \lambda_w = \frac{\lambda_T}{\lambda_r} \]
Number of Wet Days: Markov Chain

- $P(d/d)$
- $P(w/w)$

Current Day

- Dry
- Wet

Probability

0 1

Uniform Random
Transitional Probabilities

Predicted $p(w/w)$

Predicted $p(w/d)$

Day
Derivations

User-specified parameter:

\[ \gamma = \frac{n_{ww,o}}{n_{ww,n}} \]

Proper Transitional Probabilities

\[ P_n(d/d) = 1 - \frac{\lambda_w P_o(w) - \gamma [P_o(d) P_o(d/d) + P_o(w) - P_o(d)]}{(1 - \lambda_w) P_o(w) + P_o(d)} \]

\[ P_n(w/w) = \left( \frac{\gamma}{\lambda_w} \right) P_o(w/w) \]

where

\[ P_o(d) = \frac{P_o(d/w)}{1 + P_o(d/w) - P_o(d/d)} \]
Illustration

- Insight into user parameter $\gamma$
- Stillwater, OK – April, 1900-1979
- One-half of change in depth
- $\gamma=1$ (constant number wet-wet days)
- $\gamma=\lambda_w$ (ratio new to old wet days)
New storms develop more often on dry days and dissipate more rapidly on wet days.

The graph shows the change in transitional probabilities ($\Delta P(d/d)$), $\Delta P(w/w)$, and $\Delta n_{ww}$ as a function of the fraction change in total precipitation depth. The constant number of wet-wet days, $n_w$, is indicated by an upward arrow. The change in number of wet-wet days is shown on the x-axis, and the change in transitional probabilities is shown on the y-axis.
Equal Ratio of New to Old Wet Days
Persistence of storm systems remains constant

\[ \Delta P(d/d) \]
\[ \Delta P(w/w) \]
\[ \Delta n_{ww} \]

Fraction Change In Total Precipitation Depth

Change in Transitional Probabilities

Change in Number of Wet-Wet Days
Summary

- Framework to adjust parameters in stochastic climate models
- Precipitation more difficult
- Transitional probabilities use additional parameter $\gamma$
- depended on persistence of storms
- Other possible applications
Questions?