Modeling Multiple Peril Crop Insurance Worldwide

Jack Seaquist
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www.air-worldwide.com

AIR Agricultural Model Applications

The AIR Agricultural Model for the Multiple Peril Crop Insurance is a state-of-the-art fully probabilistic model, accounting for:

- Changes in technology over time
- The evolution of crop insurance programs
- Commodity price volatility
- Weather impact
Probabilistic Agricultural Model Components

HAZARD
- Commodity Price Risk
  - AWI Weather Risk
- Stochastic Event Set Catalog

DAMAGE
- Crop Damage / Yield Estimation
  - Exposure Information
  - Policy Conditions
  - Crop Insurance Program

FINANCIAL
- Insured Loss Calculations
- Government Reinsurance
- Private Reinsurance

Crop Requirements
- Temperature
- Crop Requirements
- Soil
- Precipitation
- Land Use Land Cover (Satellite)
- Historical Yields
- Historical Prices
- Typhoon Catalog

Exposure Information
- Policy Conditions
- Crop Insurance Program
AWI (Agricultural Weather Index) is a Measure of Yield Variability Due To Weather

- Daily Temperature
- Daily Precipitation
- Crop Specific Data
- Available Water Capacity (Soil)

County-Specific AWI Index

In a Normal Year Water Supply and Water Requirements Are Balanced and AWI Indicates Positive Yield Outcome

- Temperature
- Evapotranspiration
- Precipitation
- Runoff
- Soil Moisture
- AWI

Favorable for Yields
Detrimental to Yields
In a Normal Year Water Supply and Water Requirements Are Balanced and AWI Indicates Positive Yield Outcome

In a Drought Year Water Requirements Exceed the Water Supply and AWI Indicates Plant Damage
AWI Measures County-level Crop Performance During the Season

End of Season AWI estimates yield variation from normal:
- AWI proportional to flood damage
- AWI indicates significant drought damage

AWI Removes Weather Variability from the Historic Yields to Reveal True Technology Trend

Yield Time Series:
- Trend Line Influenced by Weather Variability
- True Technology Trend with Weather Variability Removed
- 17 Bushels
The Choice of Methodology Can Have a Large Impact on Insurance Contracts

Probability Density Function of Detrended Yield Time Series

Yield Guarantee

Yield – Bushels/Acre

With AWI

Without AWI

In The US Model AWI Technology Adjusts Historic Time Series of County Level Yields to Current Production Levels

- The catalogue is based on spatially correlated county level yield distributions
- All weather events are summarized by the final modeled harvest yield
- 10,000 outcomes based on variation from historical data
- Current technology level
- Not biased by recent event years
The Price Risk Component Takes Into Account Correlations Between Total US Production and Harvest Price

CORN - PRICE RATIO
- Stochastic Catalog
- Historical

Harvest Price

Yield - % of Normal

New SRA Reduced the Overall Profitability of the Industry and Increased Protection for Catastrophic Events

Loss Ratio

Average 2 years (Median) 10 yr (10%) 20 yr (5%) 50 yr (2%) 100 yr (1%) 500 yr (0.2%)

Return Period

Old SRA
New SRA
Impact of 2011 SRA Change - Illinois

Loss Ratio

Return Period

- 11% Old SRA, 16% New SRA
- 7% Old SRA, 8% New SRA
- 8% Old SRA, 3% New SRA
- 3% Old SRA, 1% New SRA
- -2% Old SRA, 2% New SRA

Impact of 2011 SRA Change - Iowa

Loss Ratio

Return Period

- 12% Old SRA, 19% New SRA
- 4% Old SRA, 5% New SRA
- 5% Old SRA, 6% New SRA
- 6% Old SRA, 1% New SRA
- -3% Old SRA, 3% New SRA
Impact of 2011 SRA Change – North Dakota

Impact of 2011 SRA Change - Texas
New 2011 SRA Fund Allocation Rules

- Minimum of 25% of premium in each State
- Maximum of 75% of premium in each State
- 35% minimum
- Assigned Risk Fund (by State)
- Total Net Retained Premium

Fund Allocation Process with AIR MPCI Model

- Policy Records
- State-Level Fund Limits
- Allocation Strategies
- Alternative Retention Levels
- Calculate Pre-SRA and Post-SRA Loss Distributions
- AIR MPCI Model Catalog
Crop Insurers’ SRA Fund Allocation Strategies Greatly Impact Reinsurer Risk

Gain/Loss Exceedance Probability Comparison (percentage of premium)

China Crop Insurance Program Covers Cost of Production Rather than the Value of the Crop

- Separate programs by province
- Perils covered and policy terms vary by crop and province
- Named perils might include
  - Rainstorm, flood, windstorm, hail, waterlog, drought, frost, diseases, insect pests, tornado, mud-rock flow, landslide, low temperature
- Indemnity varies by plant growing stage
- Losses shared and limited by governments
AWI (Agricultural Weather Index) is a Measure of Crop Damage Due to Weather

- Daily Temperature
- Daily Precipitation
- Available Water Capacity (Soil)

Crop Specific Data
- Land Use Land Cover
- Terrain Elevation

A Comprehensive Approach Captures Flood Losses from Multiple Sources

- Derived from historical years 1980-present
- Derived from Asia-Pacific Typhoon model

- Snowmelt
- Locally Excessive Moisture
- Typhoon

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Higher Resolution Damage Estimates Based on AWI
Are Validated against Province Level Losses

Losses for 2007 Drought by Province

Damage to Crops on Local Level

AWI Model for Local Effects

Accumulated Effects

High Resolution Crop Mask

Closing Thought – What if the 1993 Flood Happened in 2011?

1993 Corn Yield
(Percent of Expected Value)

<table>
<thead>
<tr>
<th>State</th>
<th>Actual 1993 RMA Gross Loss Ratios</th>
<th>AIR Modeled (Recasted) Gross Loss Ratios</th>
<th>AIR Modeled (Recasted) Post-SRA Loss Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>465%</td>
<td>247%</td>
<td>166%</td>
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<tr>
<td>Illinois</td>
<td>63%</td>
<td>21%</td>
<td>66%</td>
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<tr>
<td>Indiana</td>
<td>55%</td>
<td>22%</td>
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<tr>
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<td>91%</td>
<td>54%</td>
<td>61%</td>
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<td>Minnesota</td>
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<td>214%</td>
<td>161%</td>
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<tr>
<td>Nebraska</td>
<td>188%</td>
<td>80%</td>
<td>83%</td>
</tr>
<tr>
<td>US Total</td>
<td>219%</td>
<td>106%</td>
<td>97%</td>
</tr>
</tbody>
</table>

Key Differences Between 1993 Flood and 2011 Flood: Timing, Location, Policy Mix, Premium Rates, SRA Program Terms