The AIR Multiple Peril Crop Insurance (MPCI) Model for the U.S.

According to the National Climatic Data Center, widespread flooding or extreme drought are primary drivers of crop loss. The 2012 drought, the worst since 1988, cost more than USD 17 billion to the crop insurance program.
Multiple Peril Crop Insurance (MPCI) covers a wide range of crops, geographic areas, climatic zones, insurance terms, and policy conditions. The U.S. MPCI program is always evolving: farmers can choose between yield- and revenue-based policies; new production and price risks have been introduced; crop yield risk changes over time due to technological advancements and climatic variability and change; and price risk changes with commodity prices. In addition, premium rates and farmer participation have significantly changed over recent years.

Given these complexities, simply relying on historical losses to assess today’s risk is insufficient. Reinsurers and insurers need a robust, up-to-date risk assessment model to ensure maximum profit within risk tolerance levels.

The AIR U.S. MPCI model is used by all leading crop reinsurers, as well as leading crop insurers, and has become the independent pricing model for the U.S. crop insurance industry.

The Leading Probabilistic Approach to Modeling Crop Insurance Losses

Estimating the likelihood and magnitude of future losses presents challenges. Traditional approaches are largely actuarial, relying on historical losses to project future outcomes. The usefulness of past loss data as a surrogate for the future is limited because of the constantly changing crop insurance market, including:

- Changing exposures (geographic locations and areal extent of insured crops) from year to year
- An evolving crop insurance program (e.g., the introduction of new products into the market following the 2014 Farm Bill)
- New risk-reducing technologies (e.g., minimum till, transgenic seeds, and precision agriculture)
- Changing premium rates
- Crop price volatility and corresponding impacts on premium rates and price risk

Because traditional methods that rely solely on historical losses are unreliable in quantifying and managing this complex risk, AIR released the industry’s first probabilistic Multiple Peril Crop Insurance Model in 2007. Since then, it has evolved along with the industry and is regularly updated.

Weather Impact on Yield Variability

Losses in the MPCI program occur when yields and/or prices fall below a threshold set by the U.S. Department of Agriculture’s Risk Management Agency (RMA) for the coverage level selected by the policyholder. The primary determinant of a yield outcome for non-irrigated crops is the weather. Depending on a crop’s developmental stage, drought, heat, excess moisture, frost and freeze, and wind can all significantly reduce yields. Although often regional in scale, adverse weather effects can be highly localized and can affect different crops in different ways.

AIR scientists use crop- and county-specific relationships between weather and yield to ascertain probability distributions of yield outcomes, which reflect the full range of potential yield losses that could occur in a growing season.
The AIR Agricultural Weather Index (AWI)
Basing yield estimation analysis on prior history is further complicated by technological improvements, which lead to increased production and improved tolerance to natural perils. These improvements are introduced gradually, resulting in a secular trend in yield that may obscure the true impact of weather on yields.

Therefore, to accurately isolate and quantify the effects of weather on today’s crop yield potential, it is necessary to remove the long-term impact of technological improvements. To this end, AIR developed the Agricultural Weather Index™ (AWITM), which is used to detrend historical yield time series before obtaining accurate yield distributions. The AWI explicitly accounts for the impact of weather events on yields that may otherwise be attributed to a technological trend.

The AWI is county- and crop-specific. The key components of the AWI are high-resolution temperature, precipitation, and soil data with crop-specific phenological data. For temperature and precipitation, AIR uses high-resolution gridded data of daily observations spanning more than 40 years.

The result of the AWI analysis is a county-based yield probability distribution trended to current technology that more accurately reflects the effects of weather, thus providing improved risk estimates for policies insuring yield in the county.

For each major crop insured in the U.S., AIR models yield stochastically using the AWI detrended county yield distributions. AWI-based yield probability distributions could indicate either higher or lower risk than indicated by other estimates, including RMA-established premium rates, particularly for a defined county yield guarantee.
Price Uncertainty Adds to Crop Insurance Risk Exposure
AIR combines the AWI-based yield probability distributions with a price model. A price modeling component is necessary because revenue-based policies dominate today’s U.S. crop insurance market. Modeling price risk is particularly important, considering large changes in commodity price volatilities in the futures markets in recent years.

For crop insurance, the prices at planting and at harvest are the only prices that can affect losses. To account for the fact that these prices are dependent on overall U.S. production for a given crop, the AIR U.S. MPCI price model assesses the historical relationship between the planting price and harvest price and how that relationship is affected by the difference between expected and actual yield on a nationwide basis.

The historical data are then augmented with four levels of price volatility—historical, low, medium, and high—for the four stochastic catalogs of AIR’s U.S. MPCI model. The historical volatility catalog exhibits price volatilities closest to the historically observed price swings from 1974 to 2017. In the low, medium, and high catalogs, the model uses the RMA-established price volatility from 2003 to 2017 to determine the associated price volatility.

Four levels of price volatility for the four stochastic catalogs of AIR’s MPCI model.
AIR developed a set of 10,000 potential yield outcomes that can occur across crops in each county. By pairing these yield outcomes with four different sets of 10,000 harvest price/planting price ratios, which reflect historical, low, medium, and high price volatility levels, AIR has produced four stochastic catalogs of crop yield and price ratio that allow clients to choose the catalog that best reflects their view of price volatility for the current year.

The stochastic catalog captures spatial yield correlations among neighboring counties.

**Maintaining Correlations Is Critical for Effective Portfolio Risk Management**

The AIR stochastic catalog generation process carefully maintains correlations—correlations between neighboring counties, correlations between crops within a county, and price correlations across crops. These correlations are extremely important from a risk management perspective because they are the basis of any risk protection available from a well-diversified crop insurance portfolio.
Starting in the 2011 crop year, structural changes to the Standard Reinsurance Agreement have had a substantial impact on MPCI risk and profitability. Updated SRA fund designations and gain/loss sharing mechanisms further limit the usefulness of relying on past historical loss experience. The AIR U.S. MPCI model is the only tool in the marketplace that accurately accounts for these and other deviations from recent yield and price history that affect crop insurance risk, including technological improvements, price fluctuations, and the direct effects of weather.

Losses are Protected by the Standard Reinsurance Agreement
The AIR MPCI model computes losses to insured exposures based on the application of crop insurance policy conditions. Each policy type is unique and may be based on combinations of county average yields, actual yields, planting price, harvest price, and coverage levels. The portfolio loss calculation has two steps: 1) calculation of the gross losses—the insured losses prior to consideration of the protection offered by the government’s Standard Reinsurance Agreement (SRA); and 2) calculation of the post-SRA losses once the government protection has been applied.

MPCI Model Applications for Crop Insurers and Reinsurers
SRA fund allocation strategies and MPCI programs are evaluated by applying each of the 10,000-event catalog outcomes and determining the insured retained loss. The probability distribution of total losses across the 10,000 simulated outcomes provides the measure of the risk of loss. This is expressed in terms of an exceedance probability distribution, characterized by the average (expected) annual gain/loss, and losses at selected exceedance probability levels, such as 10% (10-year return period), 5% (20-year return period), 1% (100-year return period), and 0.4% (250-year return period).

AIR’s CATRADER software provides crop insurance program risk evaluation for all MPCI insurance programs.
Crop insurers can evaluate alternative SRA fund allocations in terms of expected profit versus potential risk. These evaluations are performed through AIR’s Fund Designation Service.

Crop reinsurance evaluations are performed in AIR’s CATRADER® software platform. Reinsurers can price excess of loss and quota share programs and manage their entire portfolio.

The MPCI Model Is Kept Current
Regular model updates ensure that analyses reflect the latest available weather, yield, price, and exposure information. In each update, AIR incorporates new crop yield data from the National Agricultural Statistics Service (NASS) and the RMA, and new loss and exposure information from the RMA. In addition, AIR calculates a new set of AWI values. Changes to the crop insurance program are also incorporated, following the government’s publication of these changes.

Enhanced User Flexibility
User flexibility is a hallmark of the AIR MPCI Model for the United States. Collected premiums for a given risk depend on market price volatility. In a low price volatility environment, lower premiums are collected than in a high price volatility environment. Users can choose from four different volatility scenarios to best account for their view of price volatility. Users can also adjust premium rates to reflect current rating structures. This keeps the model current for each crop year and allows users to obtain loss estimates consistent with current conditions.

Model at a Glance

<table>
<thead>
<tr>
<th>Model Domain</th>
<th>42 U.S. states (excludes the six New England states, Hawaii, and Alaska)</th>
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<tbody>
<tr>
<td>Supported Geographic Resolution</td>
<td>County and state</td>
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<tr>
<td>Vulnerability Module</td>
<td>Vulnerability varies by county, crop type, and stage of development</td>
</tr>
<tr>
<td>Supported Policy Conditions</td>
<td>The AIR U.S. MPCI model reflects the 2017 policy mix in terms of state, county, crop, insurance plan, coverage level, and coverage type, including the Supplemental Coverage Option (SCO), Stacked Income Protection Plan (STAX), and Yield Exclusion (YE).</td>
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Model Highlights
- Provides a probabilistic yield and price catalog that maintains spatial and temporal correlations of crop losses
- Leverages the award-winning AWI to accurately isolate the impact of weather on crop yields from long-term technology trends
- Incorporates four stochastic catalogs of crop yield and price ratio that allow (i) exploration of the effect of price volatility on modeled losses and (ii) choice of a catalog that best fits the user’s view of the current year’s volatility
- Updated regularly with new crop yield data, new loss and exposure information, and the latest changes to the insurance program
ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, AIR Worldwide founded the catastrophe modeling industry and today models the risk from natural catastrophes, terrorism, pandemics, casualty catastrophes, and cyber incidents. Insurance, reinsurance, financial, corporate, and government clients rely on AIR’s advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, longevity modeling, site-specific engineering analyses, and agricultural risk management. AIR Worldwide, a Verisk (Nasdaq:VRSK) business, is headquartered in Boston, with additional offices in North America, Europe, and Asia. For more information, please visit www.air-worldwide.com.