The AIR Multiple Peril Crop Insurance (MPCI) Model for the United States

According to the National Climatic Data Center, widespread flooding or extreme drought are primary drivers of crop loss. The 2012 drought cost the crop insurance program more than USD 17 billion and the “Great Flood of 2019” resulted in USD 4.2 billion in payouts.

AIR

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 and volatility. In addition, premium rates and farmer participation have significantly changed over recent years.

Given these significant changes over time, 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:

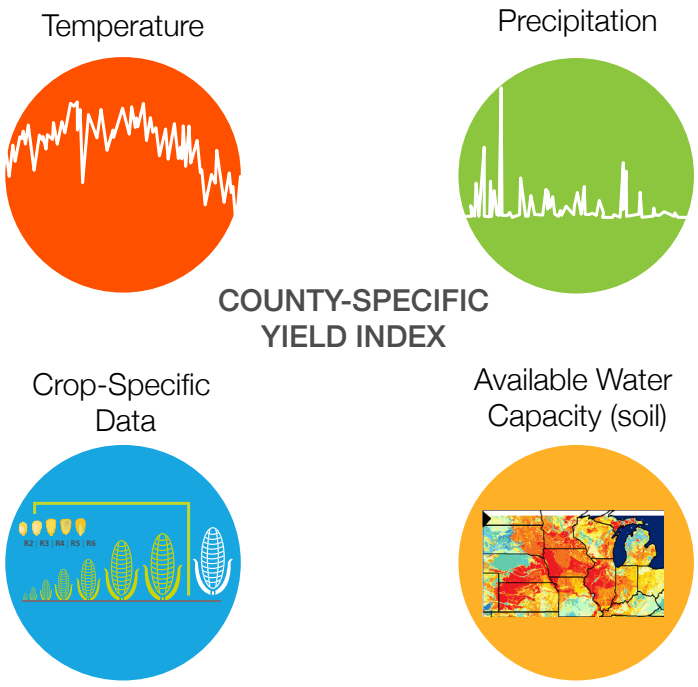
- Changing exposures (geographic locations and areal extent of insured crops) from year to year
- An evolving crop insurance program (e.g., the introduction of new products into the market)
- Changes in take-up of risk-reducing technologies (e.g., reduced till, transgenic seeds, and precision agriculture)
- Annual premium rate adjustments
- 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.

Accounting for the Impact of Technological Improvements on Yield

Many technologies lead to increased production and improved crop tolerance of natural perils. As these improvements are introduced gradually over time, they result in a generally positive trend in average yields over time. To isolate effects of interannual variation in weather on year-to-year changes in yield, it is necessary to remove the yield trend driven by technological improvements.

Therefore, AIR detrends historical yield time series with an approach that explicitly accounts for the impact of weather events on yields that may otherwise be conflated with the technological trend. More accurate quantification of weather impacts on yields means more accurate loss estimation under current technology and policy conditions.



Key components of AIR's location-specific and crop-specific approach to quantifying relationships between weather and yield include high-resolution temperature, precipitation, and soil data, along with crop-specific phenological data.

Weather Impact on Yield Variability

Losses in the U.S. 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. For a given crop management strategy, the primary determinant of a yield outcome is the weather. Depending on a crop's developmental stage, drought, heat, excessive moisture, frost and freeze, hail, and high wind can all significantly reduce yields. Adverse weather effects can be highly localized and can affect different crops in different ways.

AIR's location-specific and crop-specific approach to understanding variation in yield of U.S. crops leverages high-resolution temperature, precipitation, and soil data, as well as crop-specific phenological data. For temperature and precipitation, AIR uses high-resolution daily data dating back to 1974, which contributes to accurate spatial and temporal yield simulation.

The result of the AIR analysis is a weather-based index value for each year for every crop and county modeled. These index values are used along with county-level yield data to determine the year-to-year changes in yield that are due to improving technology and farmer skill. Detrended yield data are then used to create county-based yield probability distributions trended to current technology that more accurately reflect the effects of variation in weather on variation in yield, thus providing improved risk estimates for policies insuring yield in the county.

For each major crop insured in the United States, AIR models yield stochastically using the detrended county yield distributions, which could indicate either higher or lower risk than indicated by other estimates—including RMA-established premium rates, particularly for a defined county yield guarantee.

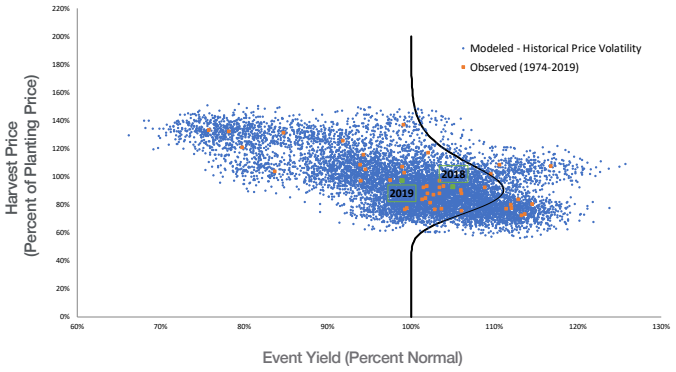
Price Uncertainty Adds to Crop Insurance Risk Exposure

AIR combines the detrended county 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.

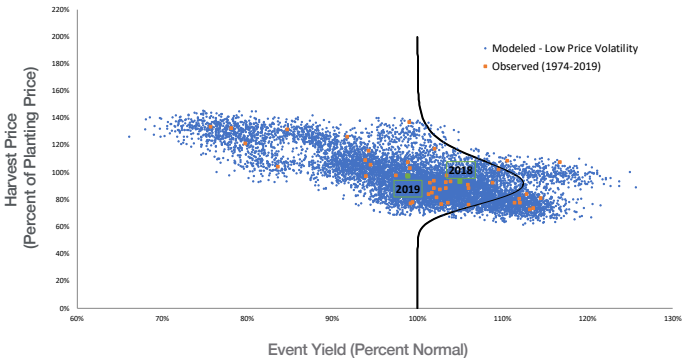
For crop insurance, the prices at planting and at harvest are the only prices that can affect losses. To account for the fact that these prices are dependent on overall U.S. production for a given crop, the AIR U.S. MPCI price model assesses the historical relationship between the planting price and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

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.

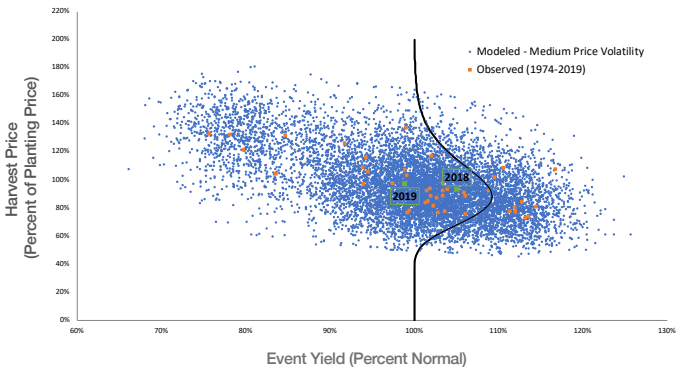
HISTORICAL PRICE VOLATILITY



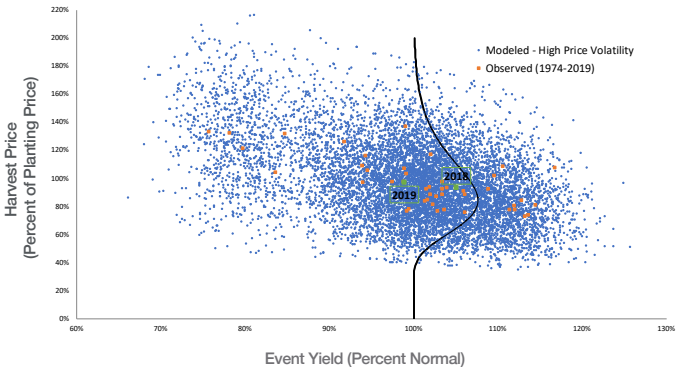
LOW PRICE VOLATILITY



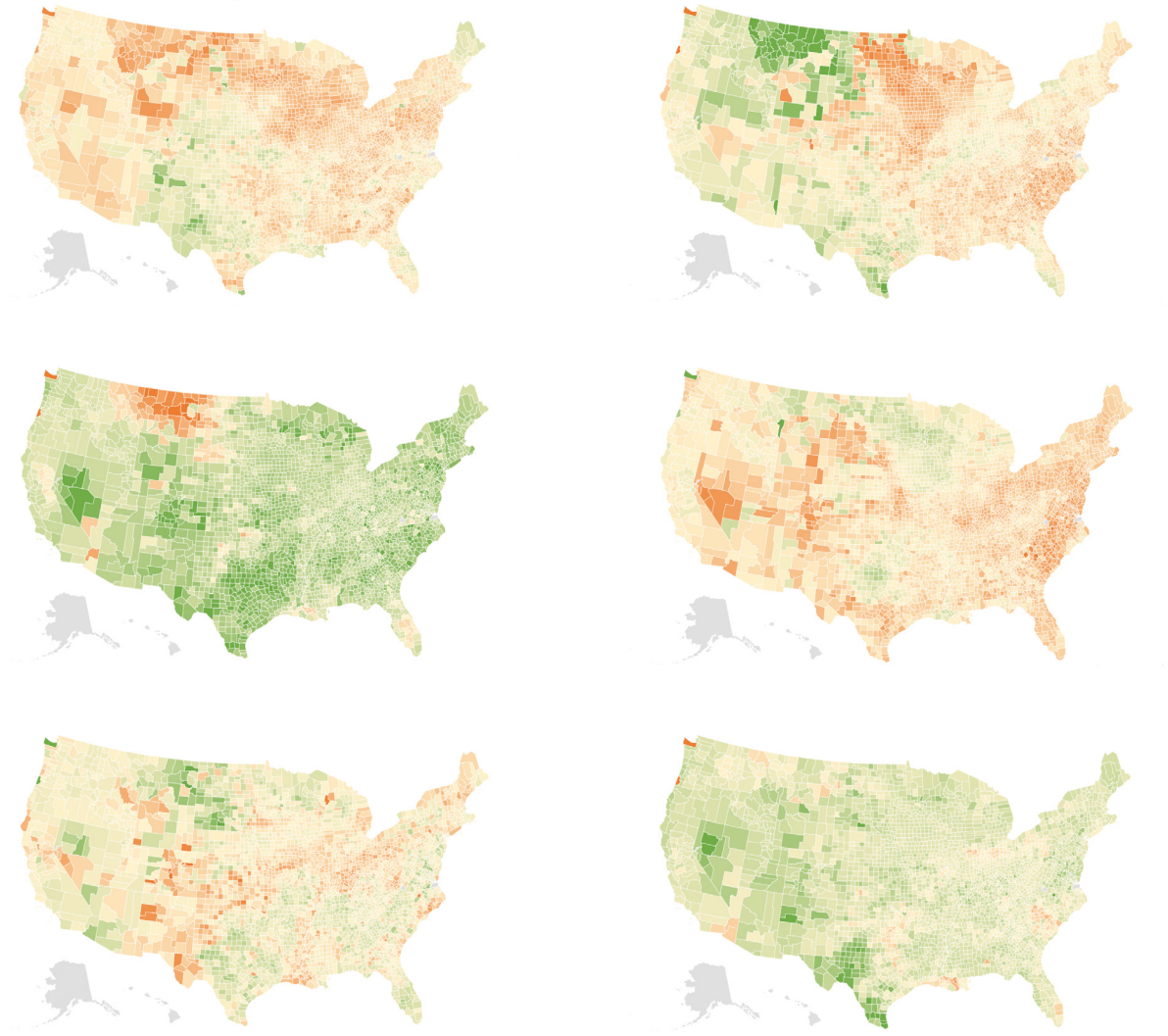
MEDIUM PRICE VOLATILITY



HIGH PRICE VOLATILITY



Four levels of price volatility for the four stochastic catalogs of AIR's U.S. MPCI model.



The stochastic catalog captures spatial yield correlations among neighboring counties.

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.

Maintaining Correlations Is Critical for Effective Portfolio Risk Management

The AIR stochastic catalog generation process effectively maintains correlations—correlations between neighboring counties, correlations between different 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.

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).

Model at a Glance

Model Domain	48 U.S. states (excludes Hawaii and Alaska)
Supported Geographic Resolution	County and state
Vulnerability Module	Vulnerability varies by county, crop type, and stage of development
Supported Policy Conditions	The AIR U.S. MPCI model reflects the 2019 policy mix in terms of state, county, crop, insurance plan, coverage level, and coverage type.

Model Highlights

- Provides a probabilistic view of yield that maintains spatial and temporal correlations of crop losses
- Leverages award-winning weather-based detrending methodologies 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, supply chain disruptions, 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. For more information about Verisk, a leading data analytics provider serving customers in insurance, energy and specialized markets, and financial services, please visit www.verisk.com.

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