The AIR Crop Hail Model for the U.S.

In 2014 the crop hail insurance program experienced the largest single-year hail losses in its history. Several hail outbreaks throughout the Midwestern states during the growing season made 2014 the third year since 1948 with an overall countrywide loss ratio in excess of 100%. A single hail outbreak on June 3 caused insured losses of USD 144.9 million in Nebraska alone.

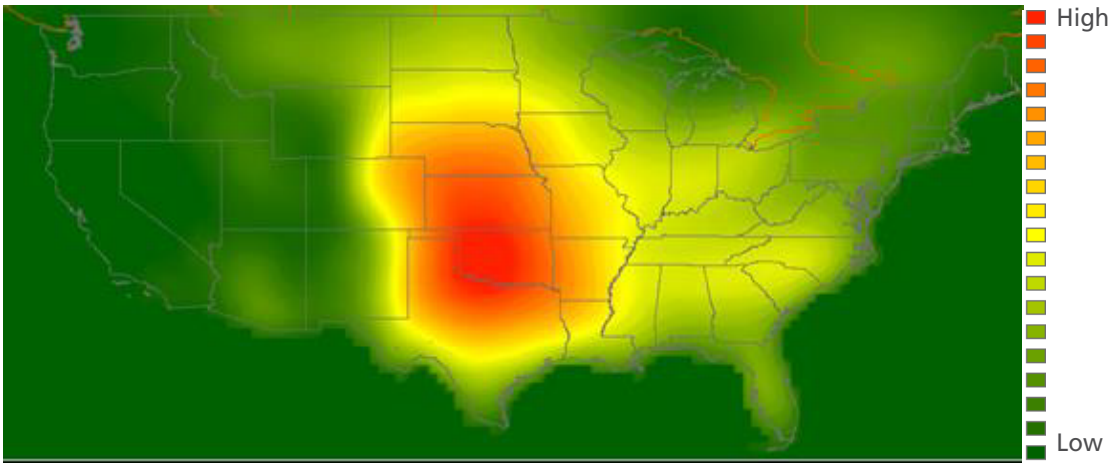
AIR WORLDWIDE®

Every year, crops in the U.S. are damaged by hail, but the nature of the peril—and the available data—make it challenging for crop insurers and reinsurers to assess their risk. The AIR Crop Hail Model for the United States is the industry's first probabilistic model that captures the effects of hail on insured crops, providing companies with a comprehensive view of their crop hail risk.

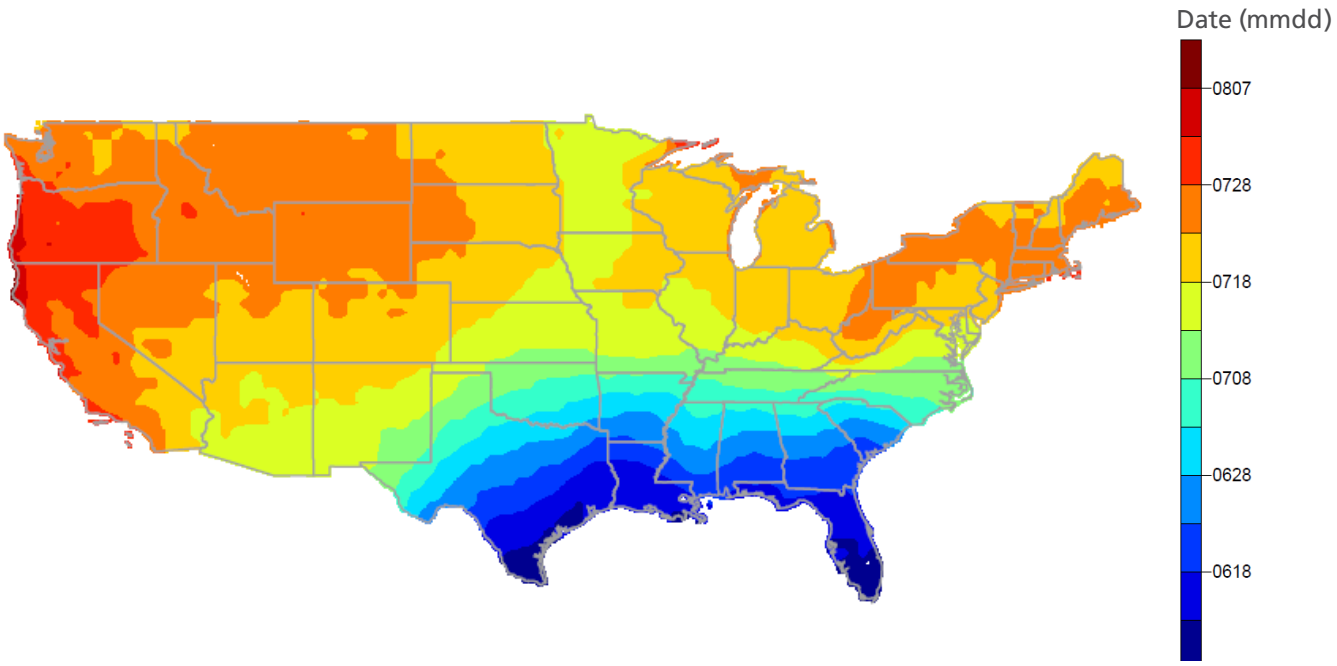
INTEGRATES STATISTICAL MODELING WITH THE LATEST METEOROLOGICAL RESEARCH FOR A ROBUST VIEW OF CROP HAIL RISK

The AIR U.S. Crop Hail Model leverages AIR's 10,000-year stochastic catalog of simulated hailstorms. This is the same catalog that is used by AIR's U.S. Severe Thunderstorm Model, in which hailstorms are a modeled peril. The catalog is based on a large historical data set from NOAA's Storm Prediction Center (SPC), which includes daily reports of hailstorms from local authorities and trained weather spotters. Despite recent increases in hail reports, however, this data set shows a bias skewed to urban areas, meaning that hailstorms in rural areas—where crops are planted—are underreported.

To compensate for urban bias in the historical data and to create a spatially complete catalog of simulated (stochastic) events, AIR "smart-smoothed" the SPC reports to physically realistic locations. Smart-smoothing allows the model to account for crop hail risk in areas that may not show major activity in the brief historical record by combining statistical and physical methods that leverage the high-resolution meteorological parameter called *significant hail parameter* (SHiP) to determine when and where conditions were favorable for hailstorm formation. Smart-smoothing also enables the model to capture major outbreaks very similar to those that occurred outside the historical record used in model development. Crop claims data are then used to validate the smart-smoothing result.



Spatial distribution of average annual stochastic hailstorm frequency in the U.S. Crop Hail Model.



The average onset of the tassel stage of corn growth is later as one moves from south to north. Crop damage varies based on the growth stage at the time of the hailstorm and, as shown here, the growth stages vary by geographic location and crop type. Growth stages within the model are based on typical planting and harvest dates from the USDA and Growing Degree Days.

CAPTURES THE HIGHLY LOCALIZED EFFECTS OF HAILSTORMS

Hailstorms can be highly localized and last for just minutes. Because the SPC does not provide footprint dimensions for hail, AIR scientists group reports that are close in space and time into clusters—the dimensions of which form the basis for developing high resolution footprints of the simulated events that are realistic in size and shape. The hail swath dimensions are further refined following a detailed analysis of radar data showing the footprints of large historical hail outbreaks.

AIR's event footprints, whose dimensions are based on historical observation rather than on an artificially imposed grid size, are the key to the model's ability to generate robust tails of the exceedance probability curve. Losses from individual storms are then aggregated to the county and state level.

PROVIDES A REALISTIC REPRESENTATION OF HAILSTORM FREQUENCY

The extreme variability observed in hailstorm occurrence from year to year makes risk management challenging. The AIR model simulates daily hailstorm activity based on realistic historical occurrence rates and weather patterns for a particular location and season, explicitly capturing the regional and seasonal variability displayed in the historical record of hailstorm losses. The daily simulation enables the model to capture both large outbreaks with the potential to produce large insured losses as well as smaller events that may produce much lower losses but could still impact a company's portfolio on an aggregate basis.

CROP-SPECIFIC DAMAGE FUNCTIONS PROVIDE THE MOST ACCURATE LOSS ESTIMATES

Hail damage is a function of hail impact energy, which takes into account storm duration, the density of individual hailstones and their size, the number of hailstones by diameter per cubic meter, and the accompanying wind speed. Because hail affects different crops differently, the AIR U.S. Crop Hail Model features crop-specific damage functions—for corn, soybeans, wheat, cotton, rice, and barley—that account for the unique damage mechanisms imposed by hail at various stages of each crop's growth.

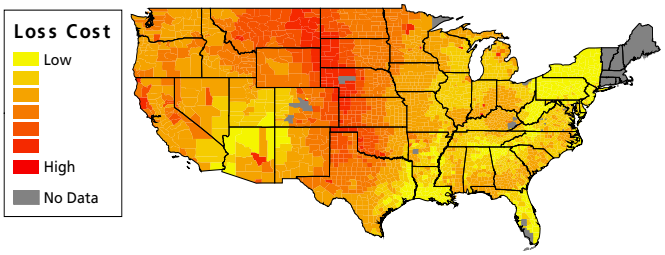
The extent of crop damage depends on what stage of growth the crop is in, which varies by geographic location. For example, the greatest reduction in corn yields is caused by defoliation, and the severity of corn defoliation from hail is directly linked to the growth stage of the corn at the time of the hailstorm. Damage functions that vary by crop and by growth stage of each crop are critical factors in the estimation of crop losses.

CROP INDUSTRY'S FIRST MODEL TO INCORPORATE CROP HAIL AND PRODUCTION PLAN

The AIR Crop Hail Model for the U.S. is the only model that provides loss estimates for two types of insurance products—Crop Hail and Production Plan. Crop Hail policies pay when crop damage occurs from a hailstorm, regardless of the final production outcome at harvest. Production Plan policies pay when the actual yield at harvest is below a guaranteed yield.The U.S. Crop Hail model provides probabilistic loss estimates, thereby enabling insurers and reinsurers to make better underwriting decisions and model portfolios more reliably.

CONVENIENT DAMAGE ESTIMATION TO BOTH CROPS AND PROPERTY WITH CATRADER

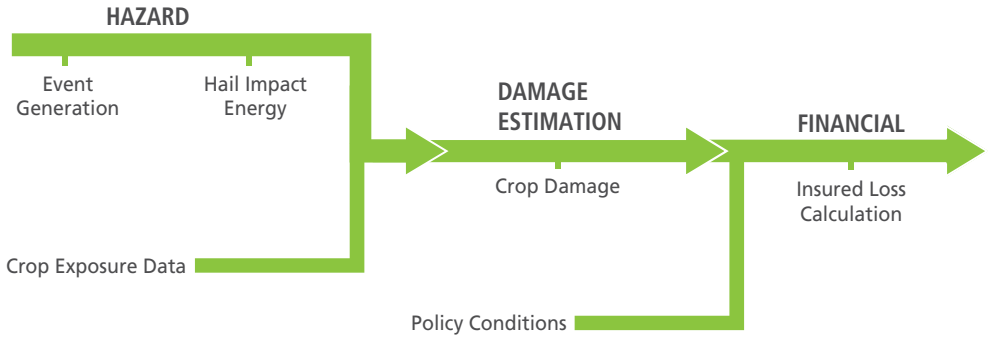
Because hailstorms are such localized events, they can inflict damage on crops while leaving nearby property unaffected—and vice versa. In addition, some hailstorms have no effect on crops because they occur outside of the crop growing season. Because the Crop Hail Model and the AIR Severe Thunderstorm Model for the United States use the same hail catalog, users of AIR's CATRADER® software can easily compare property and crop losses on an annual basis by state or county.



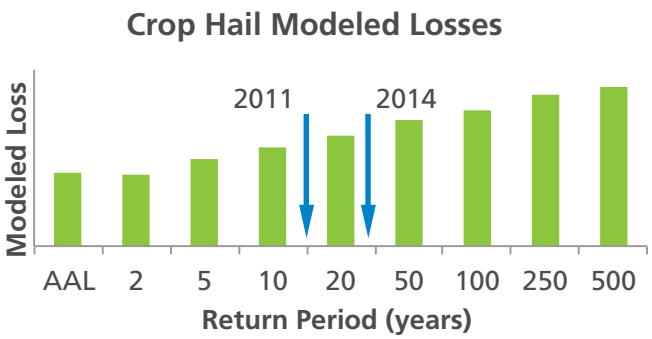
Modeled loss cost of the insurable exposure of the six main U.S. crops (corn, soybeans, wheat, barley, rice, and cotton). The maximum loss risk occurs in a large north-south swath in the mid-western states, which is in agreement with historical industry loss experience.

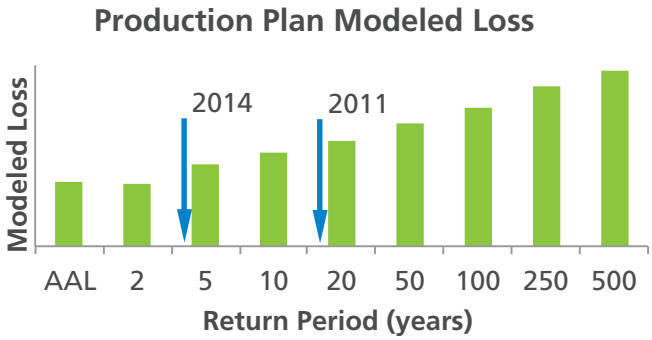
EXTENSIVE LOSS VALIDATION

Modeled losses are extensively validated by calculating loss costs for the individual modeled crops and comparing those against both the hail frequency pattern in the 10,000-year hail catalog as well as historical industry experience reported by the National Crop Insurance Services (NCIS) and data provided by crop insurers. The total losses for all modeled crops are then combined and validated against industry experience (see loss cost map). This ensures that the seasonality of damage for each individual crop is accounted for in the model, as the areas of major crop damage are shifted from the areas of maximum hail frequency (see spatial distribution map for tassel stage of corn). Losses from the remainder of U.S. crops are added statistically on the county level and total loss cost for all crops is calculated for both the crop hail line of business and production plan line of business for validation against respective industry losses (see Crop Hail Loss Costs figure).



Components of the AIR Crop Hail Model for the United States





Modeled insurable losses for Crop Hail and Production Plan lines of business for the whole United States. Large industry insurable losses are shown for each line of business. Several states experienced high Production Plan loss costs in 2011 whereas only a few states experienced high loss costs in 2014, which is why 2014 appears at a lower return period than 2011 for Production Plan.

MODEL AT A GLANCE

MODELED PERILS	Hail
MODEL DOMAIN	42 U.S. states (excludes the 6 New England states, Hawaii, and Alaska)
SUPPORTED GEOGRAPHIC RESOLUTION	County and state
VULNERABILITY MODULE	Vulnerability varies by hail impact energy (hailstone size), crop type, and crop growth stage at time of hailstorm
COVERED CROPS	Corn, soybeans, durum wheat, spring wheat, and winter wheat, cotton, rice, and barley (losses to all other crops are accounted for statistically)
SUPPORTED LINES OF BUSINESS	Crop Hail and Production Plan

MODEL HIGHLIGHTS

- Utilizes AIR's 10,000-year stochastic hail catalog, which is also used by the AIR Severe Thunderstorm Model for the United States, in which hailstorms are a modeled peril
- Employs sophisticated statistical techniques—data smoothing and augmentation—to compensate for urban bias of historical hailstorm reporting
- Crop-specific damage functions account for the unique damage mechanisms imposed by hail at various stages of growth
- Extensively validated against loss estimates issued by the National Crop Insurance Services (NCIS), data provided by crop insurers, and published research

ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) provides catastrophe risk modeling solutions that make individuals, businesses, and society more resilient. AIR founded the catastrophe modeling industry in 1987, and today models the risk from natural catastrophes and terrorism globally. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, site-specific engineering analyses, and agricultural risk management. AIR Worldwide, a Verisk Analytics (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.

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