**Quantifying PRF Basis Risk using the USDM**

Weather-based index insurance is a relatively novel type of plan whereby payouts are based on an independent indicator of harm, rather than on direct measurements. The index quantifies deviations from a baseline average value for a specific location and indemnifies when an observed value falls below a certain percentage of this normal value. Such products are useful where there is no readily available measurement of direct loss, or where problems of moral hazard and adverse selection preclude a traditional loss-based insurance design. Cumulative rainfall is often used as the basis for loss in weather-based index insurance programs. It is most often used in scenarios where rainfall is assumed to correlate well with an agricultural commodity such as grain crop yields, hay, or rangeland forage production. Many studies, though, have found that simple cumulative rainfall is poorly correlated with plant production which also depends on additional factors such as patterns of rainfall and evapotranspiration. This discrepancy is common in weather-based index insurance and is generally referred to as basis risk.

Basis risk can be quantified if a tertiary measure of loss is employed, ideally a sample of direct measurements, though where this is not available alternative metrics can be established. In Muneepeerakul et al (2017) researchers quantify the basis risk involved with cumulative rainfall insurance for corn producers using a calculated measure of minimum yield required to “break-even” based on production costs and commodity price. Basis risk here is defined as the probability that the rainfall index does not fall below a percentage of normal (strike), and fails to indemnify, when the revenue metric indicates yields below the chosen threshold. This can be expressed as,

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Where RF is the observed rainfall index value, RFstrike is the level of rainfall that triggers payout, Y is the observed yield and Ystrike is yield needed to recover production expenses.

The Pasture Rangeland and Forage insurance program (PRF) of the USDA’s Risk Management Agency uses a rainfall index to indemnify grazing and haying shortages due to drought. Here, we apply the same approach as Muneepeerakul et al (2017) to quantify basis risk. We do not, however, have the access to any sort of yield data for this industry as would be available for grain production. Instead we are using the United States Drought Monitor (USDM) which is referred to as the “standard operational drought monitor for the United States” and commonly used by ranchers to inform management strategies. We decided that the USDM is a viable option for the quantification of basis risk both because we are assuming it to better correlated with grassland impacts due to drought and because of its utility to rangeland managers.

PRF allows policyholders to select from a set of optional payment threshold levels: 70, 75, 80, 85, and 90% of average rainfall. Insurance periods are binned into overlapping bi-monthly intervals; January to February, February to March, etc. The USDM categorizes drought by increasing levels of severity which is informed by drought index values, such as the Palmer Drought Severity Index, and expert assessments of local professionals. These categories range from mild drought (D0) to exceptional drought (D4) and are updated weekly.

To calculate basis risk, we assume that the five threshold levels in the PRF correspond to the 5 levels of drought severity in the USDM, such that, for any location,

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where RF is a vector PRF rainfall index values, RFstrike is one of the five threshold payment levels, USDM is a corresponding vector of observed USDM category, and USDMsatike is the USDM level that is assumed to correspond RFstrike. Therefore, basis risk is defined as the probability, for a given location, that the PRF will not payout when the USDM indicates a drought.