**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 loss, 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 while uptake is relatively low for the same reason. 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 compensate policyholders for added feed and operation costs resulting from grazing and haying shortages due to drought. Here, we apply the same approach as Muneepeerakul et al (2017) to quantify the risk of non-indemnification given loss. 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 correlate with grassland impacts due to drought and because of its utility and familiarity to rangeland managers.

The 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. A gridded variety of the USDM was created to associate drought categories to the grid cell system that the PRF uses to associate rainfall with policy locations. Because the rainfall index is based on rainfall data average over bi-monthly intervals, this USDM was created to reflect drought conditions over that same span of time.

Because it is categorical, each bimonthly period was associated with the modal drought severity category of the 8 values reported for each grid cell. This potentially excludes the influence of possible spikes in drought severity, but this method is simple and easy to explain and is expected to generally reflect accumulated drought impacts given the slow and gradual nature of drought. There is currently work on the development of a non-discrete USDM product using probabilistic methods for use in climate forecasting that may serve as a more precise measurement for cumulative drought impacts (Lorenz et al, 2017), so this method has potential for improvement.

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 USDMstrike 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.

…This leads to misleadingly high values for locations with few PRF payment triggers. Gathering a simple sum of “missed payments” accounts for this, but makes it difficult to compare risks between locations.