INCORPORATING SATELLITE DATA INTO WEATHER INDEX INSURANCE

BY EMILY BLACK, HELEN GREATREX, MATTHEW YOUNG, AND ROSS MAIDMENT

Farmers are highly vulnerable to weather shocks, particularly in regions such as Africa, where there is a high reliance on rain-fed agriculture. It is therefore unsurprising that much attention has been paid to developing climate risk management tools for farmers to mitigate and transfer the risk of weather shocks such as drought and flood. In recent years, agricultural insurance has become part of this tool kit, particularly weather index-based insurance (WII). Rather than compensating observed damage, compensation in WII is determined on the basis of an independent index (such as the cumulative precipitation falling in a certain window of time or the average yield over a district). The trigger for this index is determined in advance of the season.

WII has shown to be a cost-effective tool for agricultural climate risk management, particularly for "single peril" situations where there is one overriding and externally measurable peril impacting farmers (e.g., low rainfall at the start of the season). Millions of farmers are now covered by WII contracts (Greatrex et al. 2015). A major challenge to scaling WII has been the absence of comprehensive ground-based rainfall and crop data, which are necessary for index design, pricing, and validation. WII cannot be extended to regions with low gauge density if it only works in areas covered by existing rain gauges with long histories (Norton et al. 2012).

Remotely sensed data, such as satellite-based rainfall estimates, have become a key tool in allowing WII to scale to levels where it could meaningfully impact poverty. They have been used directly in the creation of indices, in validating existing indices, in tracking insured seasons, and in assessing basis risk (where the compensation does not match the damages). Hundreds of thousands of farmers are

THE FIRST TAMSAT/IRI WEATHER INDEX INSURANCE WORKSHOP

WHAT: Twenty-three people from six countries came together to discuss how drought insurance based on remotely sensed data can reduce the impact of weather shocks on some of the poorest people in the world. Participants were drawn from financial and agricultural sectors, nongovernmental and governmental organizations, and universities.

WHEN: 16–17 February 2016

WHERE: Reading, United Kingdom

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DOI:10.1175/BAMS-D-16-0148.1

In final form 6 June 2016

now insured under indices based on remotely sensed datasets, particularly across Africa (Greatrex et al. 2015). For example, the R4 Rural Resilience Initiative currently insures 32,000 poor smallholder farmers using satellite-based rainfall and vegetation data. Commercial companies such as the Agriculture and Climate Risk Enterprise (ACRE), the Ghana Agricultural Insurance Pool, and PlaNet Guarantee are also investing heavily in satellite-derived indices, covering hundreds of thousands of farmers.

Satellite-derived WII is still a very new field however, with many challenges to overcome. Addressing these requires collaboration between academic and industrial actors, including data providers, agrometeorologists, insurance aggregators (who design and implement indices), insurance and reinsurance companies (who price them), and nongovernmental organizations (NGOs) who can link directly to farmers.

To bring these communities together, the Tropical Applications of Meteorology Using Satellite Data and Ground-Based Observations (TAMSAT) group and the International Research Institute for Climate and Society (IRI) led a workshop on index insurance at the University of Reading in the United Kingdom during 16–17 February 2016. Twenty-three people participated, including scientists specializing in rainfall and land surface remote sensing, experts in climate risk management and index insurance, insurance aggregators, and reinsurers. The workshop consisted of short introductory talks followed by in-depth discussion in breakout groups. A key output is an extension of the TAMSAT/IRI's Practitioners' Guide to Using Satellite Data for Index Insurance.

A challenge when using satellite data involves choosing which of the many satellite products to select (see Table 1 in Maidment et al. 2014). Satellite rainfall providers are, moreover, keen to facilitate the use of their data by the insurance industry. Such datasets include TAMSAT (Tarnavsky et al. 2014; Maidment et al. 2014), Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS; Funk et al. 2015), Enhancing National Climate Services (ENACTS; Dinku et al. 2016), and the Africa Rainfall Climatology (ARC2; Novella et al. 2013). The characteristics that make remotely sensed data suitable for WII was a recurring theme of the workshop. For a dataset to be useful to the insurance industry, it must have adequate temporal and spatial resolution, low latency, and sufficient length of record, and it must be easily accessible. The exact requirements depend on the context. For example, although a horizontal resolution of 0.5° might be suitable for a national insurance program, finer resolution is required for schemes administered at the community level.

Beyond the basic criteria listed above, datasets must also represent variability in the insured index skillfully enough to pay out at the appropriate time. During the insured season, missing data affect the decision as to whether the index has triggered. A sensitivity study presented at the meeting showed that even a low proportion of missing data (<5%) significantly denigrates the accuracy of the payouts. Unlike gauge-based datasets, satellite-based rainfall datasets, such as TAMSAT and CHIRP/CHIRPS, rarely contain missing values operationally—a clear advantage of using such data. TAMSAT, for example, has had no missing days since 2006. All African rainfall datasets, however, contain missing historical records. This has the potential to distort pricing because historical data are used to assess how often payouts occur (a historical "burn analysis"). Average payouts can then be used to establish premium levels. Missing historical data impacts the historical burn analysis. If the missing data would have triggered the index, then the premium should have been higher.

The workshop provided a forum for data providers and insurers to discuss the treatment of missing data and to agree on revised guidelines for data providers. Data providers and insurers have different priorities when accounting for missing data. Data providers aim to estimate missing points as accurately as possible. Insurers, of course, need accurate data. However, they also need to constrain the effect of missing data on pricing, for example, by carrying out burn analyses with missing data filled using several different techniques. Following the workshop discussion, it was agreed that data providers should fill in missing data as accurately as possible, but that all filled points should be clearly flagged. In addition, dataset documentation should contain a description of the methodology used for filling the datasets.

Reduced missing data are clearly an advantage of satellite-based rainfall products. However, remotely sensed rainfall is only a proxy for actual rainfall. It is crucial that indices based on satellite-based rainfall are designed to maximize the skill of the estimation methodology. Aggregation over space as well as over time generally improves skill (e.g., Maidment et al. 2013). It is important, however, that indices represent the local conditions experienced by the policyholders. It is therefore necessary to balance the improvements in skill gained by aggregating against the loss of representativity of local conditions (Black et al.

2016). For instance, satellites may represent rainfall aggregated over a 1000 km × 1000 km box accurately (i.e., have good skill), but the aerially averaged rainfall is not representative of conditions experienced by an individual farmer living within the region (i.e., representativity is low).

At the workshop, the scientific community and data providers emphasized the need to aggregate satellite-based rainfall to maximize skill. The insurance industry participants and other stakeholders highlighted the need for clear guidance from data providers as to the spatial scale that can "trusted." The participants agreed that the final choice of scale for aggregation is highly context dependent. The need to evaluate both the skill and the representativity of the aggregated indices was acknowledged by all.

The workshop closed with a discussion of new products, platforms, and datasets. A range of datasets was discussed, including ENACTS (Dinku et al. 2016), CHIRPS (Funk et al. 2015), and the Climate Change Initiative soil moisture (Liu et al. 2012). The discussion focused on the importance of using multiple data sources for validation of WII indices, especially in regions where ground-truth data are sparse. Cross comparison of data is a challenge for the insurance industry, and this has motivated the development of a number of platforms, including the National Aeronautics and Space Administration's (NASA) Interdisciplinary Research in Earth Science (IDS) Remote Sensing for Agricultural Insurance platform, and the Satellite Technologies for Improved Drought-Risk Assessment (SATIDA; Enenkel et al. 2016). These platforms complement training resources, such as the IRI Weather Index Insurance Educational Tool (WIIET; http://wiiet.iri.columbia.edu/WIIET/) and more general drought early warning systems, such as the Famine Early Warning Systems Network (FEWSNET) Early Warning Explorer (EWX; http://earlywarning.usgs.gov:8080/EWX/index.html).

In conclusion, remotely sensed data can be used to extend weather index insurance to millions of farmers in Africa and beyond—potentially mitigating their exposure to climate-related risk. On the other hand, inappropriate use of these data could cause great harm. This workshop enabled key players in the weather index insurance industry to engage directly with data providers and scientists. As a result, data providers now have a clearer idea of the ways in which their products are being used. The insurance industry, moreover, has a better understanding of both the opportunities and pitfalls of using remotely sensed data. Following the success of this workshop, the participants agreed that deeper engagement between data providers, scientists, and the weather index insurance industry would be of benefit to all parties. Further workshops, projects, and collaborations are planned.

ACKNOWLEDGMENTS. This workshop was supported by the Natural Environmental Research Council SatWIN-Scale project (NE/M008797/1), as well as the Climate Division of the U.K. National Centre for Atmospheric Science (NCAS-Climate) core program. The work presented was also implemented as part of the Consultative Group for International Agricultural Research (CGIAR) Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is a strategic partnership of CGIAR and Future Earth. It was carried out with funding by CGIAR Fund Donors, the Danish International Development Agency (DANIDA), the Australian Government (ACIAR), Irish Aid, Environment Canada (now known as Environment and Climate Change Canada), the Ministry of Foreign Affairs for the Netherlands, the Swiss Agency for Development and Cooperation (SDC), the Instituto de Investigação Científica Tropical (IICT), U.K. Aid, the government of Russia, the European Union (EU), and the New Zealand Ministry of Foreign Affairs and Trade, with technical support from the International Fund for Agricultural Development (IFAD). The views expressed in this document cannot be taken to reflect the official opinions of CGIAR or Future Earth. We are grateful to the University of Reading Statistical Services Centre for hosting the meeting and, also to all the participants for their hard work during the workshop.

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