Interactive comment on "Remote sensing in an index-based insurance design for hedging economic impacts on rice cultivation" by Omar Roberto Valverde-Arias et al.

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Anonymous Referee #2

General comments: The paper is within the scope of the journal. The paper is characterized by scientific innovation and generality, since the methodology can be applied in different regions and climatic environments. In that sense, it is extremely useful presentation of a new approach. The paper is very well and analytically presented with detailed description of the steps followed and explanation of the corresponding results.

Thank you very much for your positive comments, questions and suggestions for improvement. Below we answer to them and explain the changes made to the manuscript.

Technical-scientific comments:

1) Lines 79 and 118. In reviewing the existing remote sensing literature, it is worth to mention the system Copernicus, with Sentinel 1, or 2 or 3, which is very promising with improved resolution (20-30 m) and what is the expected improvement in the accuracy of the analysis. The authors should add comments and and/or comparisons.

We agree with the comment. We have included some examples of using Sentinel imagery in crop monitoring; and for sure, it will be an important source of data in future applications of IBI. But so far, there are not enough historical data available of Sentinel (since 2014) for being used in an IBI design. However, once we have designed the IBI application, it can be used for monitoring the crop state due to its high temporal and spatial resolution (10 days and 10-60m respectively).
The improvement of Sentinel imagery in temporal and spatial resolution with respect to MODIS imagery, could allow us to discriminate much better the extreme climatic events' impact over crops. Additionally, it could be used for IBI design for other crops that are cultivated in small and scattered parcels, as maize in Ecuador.

We explained this in lines 129-139:
Satellite imagery data were obtained from the MODIS MOD13Q1V6 product (NASA LP DAAC, 2015) (See Didan et al. (2015) for a description of its characteristics). MODIS imagery was selected due to its long temporal coverage (imagery data available since 2001), which is necessary for constructing a historical sequence of NDVI. MODIS's spatial resolution 250 m is moderate, but for regional applications of crop monitoring this resolution is sufficient (Jiao et al., 2019; Sánchez et al., 2018). Since 2015, Sentinel 2 imagery is available with a resolution of 10 to 60 m depending on the bands. Many studies have used Sentinel for monitoring crops state with very positive results (Inglada et al., 2015; Van Tricht et al., 2018; Veloso et al., 2017). However, current time data series availability of Sentinel does not allow its use for IBI design, as at least 10 years of historical data are needed for an insurance design (Rao, 2010). Despite this, Sentinel will become in the coming years an important alternative in the insurance field. Also, Sentinel 1, which is a radar sensor, could be an interesting option for rice monitoring in those zones where steadily presence of clouds represent a problem, as Torbick et al., (2017) mentioned in their study

2) Lines 73, 83-84 and 113. Agroecological zones. The proposed methodology uses principal component analysis (PCA) for classification. The subject of agro climatic classification and zoning is large, which considers different methodologies, including combinations of satellite indices, besides PCA. The authors should mention the main existing literature in the subject, since there might be potential improvement of the conducted agroecological zoning.

Thank you for the comment that we fully support. However, the agro-ecological zoning was the main subject in our first article (Arias et al., 2018), where our methodology was compared with other zoning methodologies. Further, this zoning was evaluated through satellite imagery for validating our resulting AHZs in a second article (Valverde-Arias et al., 2019). We did not explain this in the paper in order to focus on the IBI design. However, now we have clarified this in lines 123-124:

This zoning was evaluated through NDVI imagery in the study of Valverde-Arias et al., (2019), which proved that this zoning is adequate and necessary for designing an efficient IBI, reducing basis risk

3) Line 127. A clarification is required about the NDVI_ave data used: (1) these are annual values?, (2) which means that for each pixel there are 17 values? (3) How the sample points of 30% are selected? randomely? Why only 30%? (4) the rest are used for validation or not used at all?

NDVI_ave is the average of all NDVI measures of rice crop cycle (January to May) for each observation point, i.e. the average of the 10 NDVI measures obtained every 16 days from January to May (5 months, 2 measures per month). This means that we have one average value per year (i.e. 17 values, from 2001 to 2017) that correspond to an average of NDVI measures along 5 months. See lines 140-143 and 150-151.

With respect to the sample size, we followed the equation below (Olofsson et al., 2014), which is used for calculating the adequate sample size in a stratified random sampling of geographic products. As result of this evaluation, we obtained that the adequate stratified sample size is 12,77% of the total pixels in each AHZ. We wanted to make sure not to use a lower sample size than 12%. Thus, just for researching purposes, we decided to use 30% to ensure the representativeness of the sample. However, in our former paper in which we assessed the optimum sample size in a practical Index based insurance application, we found that even the 10% is significant representative, because the homogeneity within AHZs is very high.

The sample points were generated by an ArcGis tool that produces random sample points homogeneously distributed in the different strata (AHZs f7 and f15) in the study area. We didn't use a higher sample size or the total pixels because statistically it is not necessary, and it would increase our data processing and storage requirements. If we consider that we processed data of 17 years that increment could overcome our analysis capacity.

$$n=\frac{(\sum W_i S_i)^2}{[S(\hat{O})]^2+(\frac{1}{N})\sum W_i S_i{}^2}\approx\left(\frac{\sum W_i S_i}{S(\hat{O})}\right)^2$$

Where,

N is number of units in the area of interest (number of overall spatial units (pixels)

$S(O)$ is the standard error of the overall accuracy that we would like to achieve

Wi is the mapped proportion of area of class *i*, and
Si is the standard deviation of stratum *i*

We clarified this in lines 152-163

4) Line 142. For rice estimation, what NDVI_ave values are used? annual per pixel?III.

We used the pixels' NDVI average during rice-crop cycle of rainy season (Jan-May) that corresponds temporary (same year) and spatially with the geo-referenced point of the rice-yield data. This means there is one value of NDVI_ave per year and pixel.

Technical corrections:

1. Line 102. Never a sentence starts with number...: insteadof 84%, write: " , where 84%...".
   It was corrected

2. Line 120. Instead "... the precipitations", write"rainy season".
   It was corrected

3. Line 277. Instead of "Once that...", write "Since..."
   It was corrected

4. Line 304.Never a sentence starts with number...: instead of 25%, write: " , where 25%..."
   It was corrected

Mentioned references

Arias, O. V., Garrido, A., Villeta, M. and Tarquis, A. M.: Homogenisation of a soil properties map by principal component analysis to define index agricultural insurance policies, Geoderma, 311, 149–158, doi:https://doi.org/10.1016/j.geoderma.2017.01.018, 2018.

Didan, K., Barreto, A., Solano, R. and Huete, A.: MODIS Vegetation Index User's Guide (MOD13 Series) Version 3.00, (Collection 6), , 32 [online] Available from: https://vip.arizona.edu/documents/MODIS/MODIS_VI_UsersGuide_June_2015_C6.pdf, 2015.

Inglada, J., Arias, M., Tardy, B., Hagolle, O., Valero, S., Morin, D., Dedieu, G., Sepulcre, G., Bontemps, S., Defourny, P. and Koetz, B.: Assessment of an Operational System for Crop Type Map Production Using High Temporal and Spatial Resolution Satellite Optical Imagery, Remote Sens., 7(9), 12356–12379, doi:10.3390/rs70912356, 2015.

Jiao, W., Tian, C., Chang, Q., Novick, K. A. and Wang, L.: A new multi-sensor integrated index for drought monitoring, Agric. For. Meteorol., 268, 74–85, doi:https://doi.org/10.1016/j.agrformet.2019.01.008, 2019.

NASA LP DAAC: MOD13Q1: MODIS/Terra Vegetation Indices 16-Day L3 Global 250m Grid SIN V006, USGS Earth Resour. Obs. Sci. Center. Sioux Falls, South Dakota, doi:10.5067/MODIS/MOD13Q1.006, 2015.

Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V, Woodcock, C. E. and Wulder, M. A.: Good practices for estimating area and assessing accuracy of land change, Remote Sens. Environ., 148, 42–57, doi:https://doi.org/10.1016/j.rse.2014.02.015, 2014.

Rao, K.: International Conference on Agricultural Risk and Food Security 2010, Agric. Agric. Sci. Procedia, 1, 193–203, doi:10.1016/j.aaspro.2010.09.024, 2010.

Sánchez, N., González-Zamora, Á., Martínez-Fernández, J., Piles, M. and Pablos, M.: Integrated remote sensing approach to global agricultural drought monitoring, Agric. For. Meteorol., 259, 141–153, doi:https://doi.org/10.1016/j.agrformet.2018.04.022, 2018.

Torbick, N., Chowdhury, D., Salas, W. and Qi, J.: Monitoring rice agriculture across myanmar using time series Sentinel-1 assisted by Landsat-8 and PALSAR-2, Remote Sens., 9(2), doi:10.3390/rs90201019, 2017.

Van Tricht, K., Gobin, A., Gilliams, S. and Piccard, I.: Synergistic Use of Radar Sentinel-1 and Optical Sentinel-2 Imagery for Crop Mapping: A Case Study for Belgium, Remote Sens., 10(10), doi:10.3390/rs10101642, 2018.

Valverde-Arias, O., Garrido, A., Saa-Requejo, A., Carreño, F. and Tarquis, A. M.: Agro-ecological variability effects on an index-based insurance design for extreme events, Geoderma, 337, 1341–1350, doi:https://doi.org/10.1016/j.geoderma.2018.10.043, 2019.

Veloso, A., Mermoz, S., Bouvet, A., Toan, T. Le, Planells, M., Dejoux, J.-F. and Ceschia, E.: Understanding the temporal behavior of crops using Sentinel-1 and Sentinel-2-like data for agricultural applications, Remote Sens. Environ., 199, 415–426, doi:https://doi.org/10.1016/j.rse.2017.07.015, 2017.