RC1

With interest I have read this manuscript addressing a new drought index. The topic issued by the manuscript "Multi-scale EO-based agricultural drought monitoring system for operative irrigation networks management" is relevant and the structure of the manuscript is well organized. I personally think the manuscript has potential to be published, but there some aspects that need to be clarified by the authors, before I can recommend this work for publication. Based on this is that I recommend major revisions.

General comments:

- Based on the title of this manuscript, please further discuss the added information of the ADMOS index for both (Chiese and Capitanata) operative irrigation networks. In particular, how this index can improve the water management? Is it applicable only for irrigated crop regions? On this later aspect it is also important to be clear in regard to the objective of ADMOS, it is meant only for monitoring or also for predicting droughts?

Answer: ADMOS is conceived as a monitoring tool, to be employed in order to follow more closely the evolution of possible drought dynamics. The index might be useful in a on-demand irrigation scheme (as the Capitanata case study), to know the evolution of water availability as well as crops conditions and to infer the possible increase or decrease of irrigation water requests from the farmers allowing to better manage the water at Consortium scale.

ADMOS data requirements, encompassing easy-to-obtain EO observations, make its applications extremely simple to all kinds of crop regions. The use over irrigated areas which was described in this study is mainly due to the possibility of involving the irrigation volumes in the monitoring evaluation, but does not restrict the validity of ADMOS to such cases thanks to the world-wide availability of remote sensing data. The ADMOS index, as described in this work, is meant for monitoring of droughts even in real-time with daily to weekly scale. We will include this in the new introduction.

- Another aspect which needs to be clarified and justified is related with the performing part of the evaluation of the ADMOS index against crop yield, is this evaluation valid if crops receive water through irrigation?

Answer: the evaluation over irrigated crops was a precise intent of this work. More than the link between ADMOS values and final yield, we wanted to show how the different irrigation regulations, management and volume of water used for irrigation in the two consortia correlate (or not) with the annual drought conditions: high correlation in areas where water is provided on demand at relative higher cost (Capitanata irrigation consortium) and lower correlation where water is provided on a fixed-schedule and on a fixed yearly cost, independently of the meteorological conditions (Chiese irrigation consortium).

- From the manuscript, it is not clear on what temporal scale the ADMOS index works, is the monthly, weekly? In addition and related to this, discuss what temporal scales which are needed by operative these different irrigation networks.

Answer: we thank the reviewer for this question, which helps us to clarify this point that has been also raised by other reviewers. The anomalies are computed using the daily data (when available according to satellite acquisition time) and normalized according to the long-term mean daily values. The only index computed at monthly scale is the SPI-1 which, by its own definition, is related to 1 month anomaly.

Regarding the temporal scales of operation of the irrigation systems, these are different from North to South Italy, mainly due to the irrigation management schedule (weekly and up to daily, respectively). In the Chiese

area, a priori fixed-schedule is defined before the start of the irrigation season with turns every 7.5 days from April to September. On the other hand, in the Capitanata area, irrigation is provided on demand so that irrigation volumes are regulated on a daily scale variation. The ADMOS index is updated daily, so that the time scale evolution is consistent with water management.

- A particular concern is related with the high vs. low resolution analysis. The results are based on a small sample of data which show a considerable dispersion in the relationship between ADMOS and rainfall and rainfall+irrigation. Why the authors seek for a linear relationship? Should the relationship be linear? How robust or significative are these results? Please discuss the potential drawbacks of all these considerations in the analysis.

Answer: The main idea is to compare the anomalies and ADMOS estimates which come from the available remote sensing datasets, which have a opposite performance in terms of temporal and spatial resolutions: high spatial resolutions mainly correspond in low temporal one (especially true for LST) and vice-versa. Moreover, very few applications of drought indices are based on high spatial resolution (30 m) which can provide very detailed information. We will add this comment in the discussion section, highlighting that it's a first application which could be improved by enlarging the time series of data.

Specific comments:

- Improve in general the figure caption descriptions.

Answer: We will improve the figure captions enlarging the description of Figure content.

Figure 3. SPI-1 monthly index for Capitanata and Chiese Consortia using the ERA-5 dataset from 2000 to 2020

Figure 4. Daily SM anomalies in the Capitanata area with data from: ESA-CCI Combined, ESA-CCI Active, SMOS, SMOS root zone, SMAP, Copernicus, FEST-EWB from 2000 to 2020

Figure 5. Monthly Pearson correlations between the different SMAI products (ESA-CCI Active, SMOS, SMOS root zone, SMAP, Copernicus, FEST-EWB) and the ESA-CCI Combined SMAI data, for Chiese and Capitanata from 2000 to 2020. Bigger circles correspond to higher correlations values, while red circles are indicative of negative values.

Figure 6. Daily LSTA anomalies from MODIS and Landsat for Capitanata and Chiese from 2000 to 2020

Figure 7. Daily vegetation indices anomalies (NDVI, EVI, SAVI and NDWI) from MODIS data for the Capitanata Consortium from 2000 to 2020

Figure 8. Daily NDVI anomalies from MODIS and Landsat data for Capitanata and Chiese from 2000 to 2020

Figure 9. Synchronicity among the anomalies of SPI, SMA, LSTA, NDVIA in the Capitanata Consortium from 2000 to 2020

Figure 10. Synchronicity among the anomalies of SPI, SMA, LSTA, NDVIA in the Chiese Consortium from 2000 to 2020

Figure 11. ADMOS daily values and cumulative yearly values for Capitanata and Chiese Consortia: low resolution series (SM ESA CCI Combined – LST and NDVI MODIS) and high spatial resolutions series (SM Copernicus – LST and NDVI Landsat).

Figure 12. Seasonal cumulated ADMOS index correlation with irrigation volumes and with rainfall plus irrigation for the Capitanata and the Chiese Consortia for the low and high resolutions series

Figure 13. Seasonal cumulated ADMOS index and crop production correlation, for tomatoes in the Capitanata Consortium and for summer crops in the Chiese Consortium

- On several parts of the manuscript the word trend is used, but it remains unclear the particular meaning of it. Like for example "seasonal trend" and the examples listed below. Please clarify this aspect across all the manuscript.

Answer: thanks for the comment, which is explained below for each point all the manuscript.

- Why is that the authors start the abstract section with "Drought prediction" if they will focus on monitoring? Of course both topics are of major important for a drought early warning system, but in this case I would suggest using the word monitoring.

Answer: we agree that the monitoring is the main focus of the work, we will change the word in question in the revised version of the manuscript.

- I suggest modify "electromagnetic frequencies" for spectral bands

Answer: thanks, we agree on this modification

- Are they Drought monitoring systems for irrigation regions i other regions of the planet? If they are, I consider that a paragraph related to irrigation networks background and how they use drought indices is needed.

Answer: thank you for this observations, we will add a paragraph on this in the final version of the manuscript. For instance, Luan et al. (2015) designed a drought monitoring/forecasting approach coupled with an irrigation management system, encouraging its application in northern China. Ozelkan et al. (2016) focused more on the sensing aspect of drought detection, discussing the differences between rainfed and irrigated cropland when using satellites to monitor droughts over a semi-arid agricultural area (south-eastern Anatolia, Turkey). Finally, Wu et al. (2015) applied MODIS data over the US corn belt (midwestern US, from Nebraska to Ohio) to identify the best index that could capture the local agricultural drought of 2012. In particular, they identified in the normalized difference infrared index (NDII6) a powerful and promising tool to monitor drought conditions over irrigated land.

1. Luan, Qingzu, et al. "An integrated service system for agricultural drought monitoring and forecasting and irrigation amount forecasting." 2015 23rd International Conference on Geoinformatics. IEEE, 2015.
2. Ozelkan, Emre, Gang Chen, and Burak Berk Ustundag. "Multiscale object-based drought monitoring and comparison in rainfed and irrigated agriculture from Landsat 8 OLI imagery." International Journal of Applied Earth Observation and Geoinformation 44 (2016): 159-170.
3. Wu, Di, John J. Qu, and Xianjun Hao. "Agricultural drought monitoring using MODIS-based drought indices over the USA Corn Belt." International Journal of Remote Sensing 36.21 (2015): 5403-5425.

- On what temporal window is the ADMOS working? Weekly, monthly? Please clarify this

Answer: we thank the reviewer for this question, as also clarified on the previous comment the anomalies are computed using the daily data (when available according to satellite acquisition time) and normalized according to the long-term mean daily values. The only index computed at monthly scale is the SPI-1 as for its definition related to 1 month anomaly.

- Line 76 Is the Global Integrated Drought Monitoring and Prediction System (GIDMaPS, http://drought.eng.uci.edu) still operational?

Answer: the GIMaPS is indeed not operational, with the most recent data referred to 2016. However, we wanted to include it as an effective example of EO-powered monitoring.

- Line 79: CDI index should be an indicator and not an index following the WMO definition as it uses different indices separately and not combined in only one index as the SMADI (Soil Moisture Agricultural Index) for example. It is also important to highlight that the CDI uses different time dates for each variable, which is different to the USDM approach.

Answer: Thanks for the comment, we agree with this definition which will be updated in the revised paper version.

https://www.droughtmanagement.info/literature/GWP_Handbook_of_Drought_Indicators_and_Indices_2016.pdf

- Line 149: An average irrigation volume of about 1200 mm is provided during the crop season, over a mean precipitation value of 250 mm. How are the irrigations estimated?

Answer: they are provided by the irrigation consortia authorities, and are known for the whole areas with daily frequency.

- Line 283: "SMOS and SMAP anomalies do not show a seasonal trend as clear as that of the ESA-CCI datasets." But ESA-CCI considers a longer time period. What is meant with seasonal trend?
- Line 307: "less peaked SM trend" As the authors don´t mention a trend analysis, please clarify what is meant with trend?

Answer: thanks for the comments, which help to correct the improper use of the statistical term "trend". What we mean here is that generally in these two case studies we have negative SM anomalies during summer which can been seen in the ESA-CCI datasets from 2000 to 2010, while it is less visible in the other datasets. We will better explain this in the revised paper version.

- Why the authors use SPI-1 and not SPI-3 or SPI-6?

Answer: if SPI is computed for 1 month it can be used as an indicator for immediate impacts such as reduced soil moisture. For more agriculture related impacts, we are then analyzing directly the effects on vegetation to see eventual crop stress conditions.

- Please specify what is the SMOS Root zone product.

Answer: indeed we have neglected a description of this product in the appropriate section (2.2.1.2), we will add it for the final version. The SMOS root zone soil moisture product is provided by the CESBIO SMOS team (Al Bitar et al. 2013). It employs SMOS L3 surface soil moisture and other data (e.g., NDVI from MODIS, climate data from ECMWF) to derive soil moisture at root level using an exponential filter for the first soil layer and a physical model for the second. This model is a simple formulation of the 1D Richards equations that describe water motion in unsaturated porous media. The product is available with a 0.25° spatial resolution.

- Line 483: Please modify (Figure not shown) for (not shown)

Answer: thanks, we will correct this error

- Figure 12. In this figure is not clear while the ADMOS varies from 0 to -500, please explain clarify with more detail this values as the index form its definition varies from 1 to -4. Add also these details in the figure caption. Is it the accumulation value? Also, use the same amount of decimals for the R2, and I recommend changing the units of m3 to millions of m3 or equivalent.

Answer: Yes, the "ADMOS" shown in fig.12 is the accumulation (or cumulated) value, like the one shown on the right-hand vertical axis of Fig.10. All the other elements you mentioned have been homogeneized.

- Line 532: What are the crop impacts of this "too much water is probably provided to the crops "? Please discus how would the ADMOS help to this.

Answer: in this part, we wanted to highlight how, in some years, the drought conditions were not so important as to require the high water amounts used in reality. Indeed, since ADMOS was not signalling particularly heavy drought conditions, a part of that water could have been saved. It is not within the scopes of this work to estimate the exact amount of irrigation water required in each year, but to show how ADMOS can provide an indirect estimate of the necessity to employ lower or higher irrigation water volumes.

- Line 555: Please clarify this sentence: "In particular, seven to eight soil moisture products anomalies have been compared and generally low Pearson correlation values are found with a better correlation in the Chiese area, probably due to higher average yearly rainfalls which correspond with a more stable, less peaked SM trend, easier to reproduce from products working at different resolutions and with different algorithms." What is meant with 7 to 8 SM products? Is not clear what is meant with less peaked SM trend? What is meant with low Pearson correlation values are found with a better correlation in the Chiese area?

Answer: it refers to the fact that 8 products were involved in the comparisons for the Chiese test case, whereas the Capitanata case did not feature the ESACCI passive product (because of frequent unavailability of the data). By "less peaked SM trend", we meant that the SM values in the Chiese consortium are quite stable at relatively high values, due both to the frequent rainfall and irrigation events. This behaviour is quite homogeneous and probably easier to represent with similar accuracy across different scales than what happens in the Capitanata consortium. Here, both rainfall and irrigation are more sparse in time and more heterogeneous in space, causing the SM time series to have greater variance. Such a complex dynamic could be more difficult to portray, and may be reflected differently in different SM products with different spatial resolutions. We believe this to

be the reason why Pearson correlation values were higher in the Chiese consortium (higher agreement between the different SM products), as opposed to the Capitanata one (higher variability among the products).

- Line 567: Change “plat” for plant

Answer: thanks, we will correct this error

- Figure 11. Please clarify on what temporal scale the index was accumulated? Monthly, Yearly?

Answer: in this case, the ADMOS was accumulated over the whole year, in exactly the same way as was shown in Fig.10.