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Hydrology and Earth System Sciences Discussions

Interactive comment on "Combined use of optical and radar satellite data for the monitoring of irrigation and soil moisture of wheat crops" *by* R. Fieuzal et al.

Anonymous Referee #1

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This paper addresses the possibility of using combined optical visible/near-infrared and radar C-band dada for monitoring the phenological development of wheat crops, and in particular soil moisture evolution with the ultimate potential objective of optimization of irrigation practices.

The selected area is especially adequate for testing such methodologies, due to the adequate surface conditions, homogeneity, lack of topographic disturbances, adequate climatic conditions, convenient for acquisition of time series of optical data, and availability of field measurements as required for validation purposes.

However, the case is rather unique, because the methodology is based on the availability of a large time series of high resolution optical data (FORMOSAT in this case) which are not easily available in most places. ENVISAR/ASAR is used in this case to provide the time series of radar data.

One first question is about the criticality of having such as dense time series of optical data, and how critical is to have such series on such high spatial resolution. Since the radar data have 30 m spatial resolution, and the accuracy in geolocation is of about 50 m (as reported in the paper) one could use other optical data, even Landsat TM or other similar data, which are much more easily available, at such spatial resolution of 30-50 m. In fact, all what is used from the optical data is just NDVI, for which only two spectral bands are required, and those bands are available is almost every satellite. In this way the method becomes less dependent on the particular availability of FORMOSAT time series of data for this purpose.

Having such availability of a time series of optical data, the whole approach is still based on looking for time evolution of NDVI, to retrieve Green Leaf Area index (GLA) by using an empirical relationship with NDVI. This information is used together with the SAFY model to drive the overall crop temporal evolution model, by using GLA as the driving variably to constraint the model parameters describing such crop temporal evolution. Is there another way of constraining the model by using more information from optical satellite data beyond NDVI? The limitations of NDVI are well known, then some argument must be given to justify that in this case the information provided by NDVI is enough to track the temporal evolution with the required accuracy.

Concerning ASAR data, the processing is quite standard, using finally HH polarization to retrieve topsoil moisture, as the best option among the different polarizations available, for such purpose. The empirical relationship used to retrieve soil moisture from radar data is extremely simple, just a linear relationship. The two coefficients of the linear relationship are derived from extreme values of soil moisture, and extreme values of HH backscattering, but it is still a linear relationship. Such linear scaling of

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radar variations to moisture variations seems a rather simple assumption, as all such relationships tend to be non-linear, with saturation in the signal. The linear approach assumes authors are looking for a limited range of signal variability, which is consistent with the idea that the method is applicable only in some stages of crop evolution, but this aspect need some explanation in the paper.

The main problems with this paper come from the somehow controversial results, opposite to the evidences reported in previous studies. This may be due to the particular characteristics of the study site, or most probably to the particular methodology used in this case, where the radar data are analysed using the results of a model fitted to inputs derived from optical data. In any case, it is somehow surprising to observe the following results:

(a) At the beginning of the agricultural season, when the soil is mostly visible as the fractional cover by vegetation is still very low, there is no relationship between the radar backscattering and the soil moisture. The expected behaviour would be that the sensitivity of radar signal to soil moisture would be better when fractional vegetation cover is low, with the possible complication coming from soil roughness variations as well. The authors attribute the variability to canopy water content instead of soil roughness, but no relationship to soil moisture changes. However, if in such stage of crop evolution the rather signal is more sensitive to canopy water content than to soil conditions, it will be difficult to believe that later on when the canopy biomass increases and thus has a much larger canopy water content, the sensitivity of radar signal to soil moisture will however then increase. It is understood that the reported in the paper are the observed results, but it must be some credible explanation or justification for such results.

(b) For mature and senescent canopies, one would expect that since the canopy has lost most of the water content, then the radar signal will become more sensitive to the soil background, but the method described in this paper provides poor results at the end of the agricultural season. The explanation given is the presence of dry litter after harvest, but the arguments are not very solid to explain such behaviour.

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(c) The best results in terms of correlation between topsoil moisture observations and the inversion results are obtained for intermediate case, when vegetation cover is high enough, but before the start of senescence, for biomass water content larger than 5 t/ha. This is again a rather surprising result, because one would expect that at C-band frequency the presence of a significant vegetation layer would prevent retrievals of soil moisture. Some explanation for this behaviour must be given. Either this is due to the particular method used in this case (the usage of optical imagery to fix the model to which radar data are later inverted), or due to the peculiar behaviour of the given study area.

(d) The independence of soil moisture retrievals from soil roughness conditions and varying incidence angle is reported as a nice feature of the algorithm, but the reason for that should be better explained. This is probably a feature of the study area, or the way the retrievals are implemented in this case.

(e) The reported relation between soil moisture evolution and irrigation events also need some better description. The anomalies reported for fields 1 and 3 seem to indicate some potential problems with data collection and / or heterogeneous soil behaviour in the area.

Since the idea of such methodologies based on remote sensing data should be to extrapolate them to larger areas or to other geographical sites, the limitations in the applicability of such methodology for an area with large fields, flattened and cropped with modern mechanized agricultural practices, should be properly explained in a more specific way.

Some minor aspects also require attention:

(a) Equation (1) and (2) are general for ASAR data. Authors must give the actual values of the different variables (NLeff, Npaz, Npra, etc.) for this particular case of this study, otherwise such equations are useless.

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(b) In the abstract and later in the text the absolute accuracy in retrieving soil moisture is of 9% (0.09 m3 m-3), with 35% as relative value. Such relative values should be explained.

(c) In Section 2.2, second line, “agricultural pratices” should be “agricultural practices”.

(d) The relationship between simulated soil moisture and measured soil moisture plotted in Figure 8 shows some systematic behaviour, not just random around the 1:1 line but some kind of curvilinear relationship, with overestimation for intermediate values. The simple linear scaling approach between C-HH backscattering and soil moisture is probably the reason. A plot of the residuals would probably be better to show such systematic deviations.

(e) Figure 9 shows a weak dependence of HH backscattering on vegetation water content. A similar plot with VV backscattering would help to understand the effect of vegetation signal (HV not available in this case).

(f) Figure caption for Figure 10 is somehow unclear, particularly when referring to rainfall lines in the plot (along the y-axis?).

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