

Review by Matthew McCabe

The manuscript presents an overview of the ambitious WACMOS project, a collaboration between ESA and GEWEX-WCRP to characterise water cycle behaviour at global scales. WACMOS is an important and much needed activity, with potential for both research and operational use of its products, and implications for better understanding of the water cycles. Considerable group effort has been expended in attempting to bring together an array of water-cycle components to enable process description. It is obviously a very worthwhile project. It is clear fairly early on that the manuscript is more a summary document on the WACMOS project than an effort to comprehensively evaluate recently developed products. Neither does it really report on the major findings of the project as stated in the abstract – presumably because this is an ongoing activity with outcomes still under research. As a purely scientific contribution, it lacks an effective accounting of the global scale nature of the project, with only a few snap-shots of various products and no rigorous evaluation of these being discussed. Clearly that is not the aim of this paper, but it is an obvious criticism. While this could potentially cause some concern as to the scientific merit of reporting on an incomplete project (i.e. little in the way of actual results or outcomes being described), it can perhaps be balanced by considering the considerable relevance to the community of this activity and the broad interest that is likely to exist in circulating the activity within the HESS audience. Perhaps a title change to “Preliminary results from the WACMOS” would be appropriate – or even a refocus on evaluations over a reduced spatial extent? I can certainly see value of a WACMOS project description and overview in HESS – but perhaps as an invited editorial rather than as a unique scientific contribution? A consideration for the editor rather than the reviewer!

Specific Comments.

While there will always be some discussion on the suitability, or otherwise, of the particular approaches that are being used within WACMOS, these are necessarily driven by the participants in the project. Ultimately, the utility of the WACMOS products will be determined by its uptake in the community: but to inform this, a thorough evaluation strategy is required. How individual product evaluation will be undertaken within WACMOS is alluded to, but not clearly described here. It would be a difficult task to outline these for each of the elements described (and it seems that some product evaluations have been reported in the literature) but some overall evaluation strategy might be worthwhile. The web-link (wacmos.org) takes one to a PDF presentation which focuses on the soil moisture theme.

Reply:

We wish to thank Matthew McCabe for the constructive comments. In the following, we provide replies related to each WACMOS theme separately where relevant.

The validation of the Evapotranspiration is performed using data from Fluxnet/CarboEurope field sites. This has been added in the text. More details are given in the corresponding sections in the text and explained below as answers to specific comments.

Concerning the soil moisture part; several major editing were made in the results and validation section. An example showing the improved performance was included in Figure 8. We also added a reference to recent evidence (Jung et al., 2010 in Nature) that the trend map shown in Figure 10 shows realistic values. Also reference made to the work of Liu et al., 2011 which shows the improved performance (especially in terms of temporal coverage) of the merged product.

A few particular comments on these follow:

For the evapotranspiration product, WACMOS is using a well-established technique that has been reported upon extensively in the literature. SEBS is a retrieval approach with a solid heritage that has seen it validated at multiple locations and at different spatial and temporal scales (some additional reference to this might be warranted). While a global evaluation of the product is not attempted here, the authors should be aware of related international efforts (under the banner of the GEWEX LandFlux project) that have recently been reported on. Linking WACMOS efforts with those being undertaken elsewhere would seem a natural step in developing a robust global product for the community (see references below);

Reply: For evapotranspiration, we have added an overview of the current evapotranspiration products. It would be indeed very useful to compare these products against each other in the near future.

For soil moisture, the project is focused on developing a seamless record using an existing product rather than developing a new retrieval approach. It is not clear to the reader precisely what ‘existing data-sets’ are actually being used here though. While the approaches to merge and rescale the data are described – principally with reference to already published papers – some detail on the actual products being employed would be useful, especially since there are a number of these available. Merging, rescaling and ascribing error to the retrievals is a challenging task. Since I am a minor co-author on one of these papers, it is probably not useful for me to comment on this aspect of the project. However I agree that (pg 7919, line 27) “...these trend maps need to be studied in more detail before final conclusions can be drawn”. Presumably individual product assessment through the WACMOS project is an impending task?

Reply:

We included an additional table to provide an overview of the existing soil moisture products that can be potentially assimilated in the merged product. In the text, we also added details on the observation frequency/wavelength and the effects that this choice potentially has on the retrievability of soil moisture.

Regarding the last comment: so far no structural cross-comparisons with other, independent components of the water cycle have been carried out. Nevertheless, spatiotemporal trends observed in the merged soil moisture product seem to be strongly related to variations in evapotranspiration (Jung et al., 2010)

Evaluation of the cloud product is undertaken using ground based BSRN data. Why was there no comparison with other satellite products? Perhaps the key satellite based global products is the NASA/GEWEX SRB data set. Although I am not sure whether the same time period was available for assessment, it would be useful to see some comparison between SEVIRI and this – or CERES for instance?

Validating these different approaches is an inherently difficult task – made all the more so by the fact that no benchmark or reference data set exists. A common point in the following comments refers to the authors attempts at validating the different data sets. Some of these are attempted at point scales while others at larger spatial scales. To gain some confidence in the

WACMOS products, a useful approach might be to compare spatial and temporal patterns (whether local/global or daily/monthly) with other satellite based products that might be available. A number of these are listed below. Likewise, there now seems a good opportunity to explore the concept of “hydrological consistency” – particularly where soil moisture, ET and rainfall data sets overlap? Perhaps a more focused regional scale evaluation of this preliminary reporting of the WACMOS project would be useful.

Reply:

Thank you very much for this suggestion. This is indeed the intention in a follow up phase of the project. At present, the data sets are generated from different sensors covering different spatial and temporal resolution because the emphasis was on the consistency of the algorithms and individual data products. We hope to be able to develop a scientific roadmap that will describe a comprehensive framework of applying the data products to several scientific and application areas, including exploring the “hydrological consistency” or the water budget closure at basin scales.

Table 1. In ET, does HR and LR refer to High Resolution and Low Resolution? Why is MODIS at 25km instead of 1km? Where are the accuracy (bias) and precision (RMSE) values derived from?

Reply:

References for accuracy (bias) and precision (RMSE) are explained in the text for all 4 topics and are described in the following.

Evapotranspiration:

Indeed the HD/LR refer to high resolution and low resolution, this has been corrected in the manuscript. Requirements on ET products depends the applications intended for and are derived from literature review as explained in the modified text. The requirement for the proposed evapotranspiration product is created from the most stringent of requirements of different applications.

Soil moisture:

Concerning the soil moisture part, precision values have been obtained through various validation studies (e.g. Gruhier et al, 2010, Wagner et al., 2007) and triple collocation (Scipal et al., 2008, Dorigo et al., 2010).

Clouds:

For the SSI-SEVIRI and SSI-SCIAMACHY product the bias and RMSE values were derived from the validation efforts carried out for this paper. The values for PRP were taken from an evaluation study over the Netherlands of Roebeling and Holleman (2009) and over Africa from Wolters et al. (2010).

Water Vapour:

The reference for the bias and RMSE of the water vapour products, namely WMO/ReqObs (2001) and WMO/GCOS (2006) are given in Section 3.4, where the technical specifications are described.

Table 1 is updated.

WMO/ReqObs: Requirements for observations for global NWP. WMO, Expert team on observational data requirements and redesign of the global observing system, Reference Number CBS/OPAG-IOS (ODRRGOS-4)/INF. 4, 11 October 2001.

WMO/GCOS: Systematic Observation Requirements for Satellite-based Products for Climate - Supplemental details to the satellite-based component of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (GCOS-107, WMO/TD. No 1338, September 2006).

Fig 2. Are ocean retrievals being considered? If so, how? Some reference to the GEWEX SeaFlux project might be warranted. Perhaps mask out the oceans if these are not being considered in the product – it would certainly make the figure easier to interpret.

Reply:

The WACMOS product does incorporate the evapotranspiration over oceans. The division is made using an ocean mask. The kB^{-1} algorithm is adapted to follow the parameterization for the roughness length of heat and momentum from Beljaars 1994 and Brutsaert, 1982. The Envisat satellite was launched in 2002, while the Seaflux project only delivers data up till 1998. Consequently the measurements cannot be used to validate the WACMOS project. Currently we are searching for alternative data and will be reported later.

Beljaars, A.C.M., 1994. The parametrization of surface fluxes in large-scale models under free convection. . Q. J. R. Meteorol. Soc. 121, 255-270.

Brutsaert, W., 1982a. Evaporation in the Atmosphere. . D. Reidel.

Fig 3. Shouldn't this figure be providing correlation between in-situ measured and SEBS (or SCOPE), rather than between two models (SEBS and SCOPE)? What about the high resolution and low resolution products? It would also be good to see a more thorough ET evaluation: access to the FLUXNET data set would facilitate this?

Reply:

There are missing measurements of latent heat and sensible heat over that specific field site. Figure 3 is meant as an evaluation of the SEBS algorithm using the validated SCOPE to generate 'observations', but not as a validation tool. The validation is performed using CarboEurope ground measured data as illustrated in Fig. 4.

Fig 4. The apparent high correlations in Fig 3 are off-set by considerable differences in flux estimates of H and LE (difficult to see G values in this figure). Any comment on this? What is the RMSE of these results?

Reply:

The RMSE of the sensible and latent heat fluxes decreased after the implementations of the tall vegetation parameterizations from respectively 100 Wm^{-2} to 56 Wm^{-2} and 123 Wm^{-2} to 94 Wm^{-2} . As the correlation of the fluxes also goes up from -0.06 to 0.68 we are confident that this parameterization is correct. The full explanation on this investigation is shown in Timmermans et al 2011. Following suggestions by C. Prigent, we have replaced this figure with some updated results on continental scale.

Timmermans, J., Van der Tol, C., Verhoef, A., Verhoef, W., Su, Z., Van Helvoirt, M., Wang, L.: Quantifying the Uncertainty in Estimates of Surface Atmosphere Fluxes by evaluation of SEBS and SCOPE models, Hydrol. Earth Syst. Sci. Discuss., 8, 2861-2893, 2011.

Fig 11. Why the large circular data gap over Africa? This would seem to be in the very centre of the geostationary satellite.

Reply:

This is related to the MSG observation geometry .In the vicinity of sunglint, the cloud property retrievals become unreliable. Therefore we chose to mask out any retrievals with scattering angles larger than 155°. We added the following sentence in the manuscript:

“Note that the gap in the centre of the image corresponds to sunglint viewing geometries for which the SSI retrievals are omitted.”

References:

Jimenez et al (2011) “Global intercomparison of 12 land surface heat flux estimates” Journal of Geophysical Research, Vol. 116, D02102, doi:10.1029/2010JD014545

Mueller et al (2011) "Evaluation of global observations-based evapotranspiration datasets and IPCC AR4 simulations" Geophys. Res. Lett., doi:10.1029/2010GL046230 (in press).

<http://www.agu.org/journals/pip/gl/2010GL046230-pip.pdf>

Reply: both are added in the references.