Integrating multiple satellite observations into a coherent dataset to monitor the full water cycle – Application to the Mediterranean region

Reviewer 1

COMMENTS

- **The MS presents a substantial effort in integrating multiple satellite observations into a coherent data set for monitoring the water cycle of the Mediterranean basin. From a technical point of view, many data products and acronyms are introduced but the reader is rather overwhelmed by the details and misses the central message the MS is trying to convey**

- Thank you for your valuable comments, we tried to simplify a bit the presentation but the introduction of complex notations is necessary. Several updates have been done to make the manuscript simpler:

1. The abstract now focuses on the SW, SW+PF and INT methodologies, which represent the central message of the manuscript : *Several EO integration methods are presented and compared: The Simple Weighting (SW) is a weighted sum of the datasets to reduce the uncertainty of a particular water component estimate. Two other techniques introduce a closure-constraint on the WC budget: (1) The SW plus Post-Filtering (PF) is very efficient but it is applied at the basin level, not at the pixel scale. (2) By using a spatial interpolation scheme, the INTegration (INT) solution allows obtaining a pixel-scale database for the common period of the all the water components.*

2. The Optimal Selection (OS) Section 3.2 is now suppressed, this method is simply described at the beginning of the SW section 3.3: *A general approach to deal with EO datasets in the analysis of the WC is to chose the best individual dataset for each one of the water components. This*

is the approach developed, for example, in the GEWEX project. In Pellet et al. (2018) an Optimal Selection (OS) was based on the minimization of the water budget residuals to select the best combination of individual dataset. On the contrary, the SW approach relies on the merging of several EO datasets for each water component, in order to reduce their uncertainty.

We hope that the new version of the manuscript is now easier to understand.

• **Since the described project and the MS aims to produce a satellite observations of water cycle, I would suggest that the logic and methods proposed for generating climate data records be followed and organized as such (see e.g. Su et al.,2018, BAMS).**
- At this stage, the authors do not pretend yet to produce a Climate Data Record (CDR). The generation of a CDR as presented in Su et al.,2018 (BAMS) is complex, and raises many issues related to long time records (such as absolute or inter-calibration, evaluation procedures, etc.). In our manuscript, we would like to present several EO dataset merging methodologies, discuss their pros and cons. The fact that our dataset is available to the community is for research purpose, and we will consider the full CDR task only after more evaluation, and when we get enough funding to implement such a framework. The abstract is now clearer and does not propose the database anymore, only the conclusion does. Nevertheless, the production of CDR based on a the constrain of the water cycle might be a perspective of our work and this is now explicit in the conclusion: *This multiple-components dataset shows promising aspect for forcing, calibrating or constraining regional models with a water conservation constraint (as required by the community). Some developments and evaluation need are still required before the production of a Climate Data Record (Su et al.,2018, BAMS) can be started. The two databases (INT and CAL) can however be obtained under request to the corresponding author.*

• **There is a need to make sure that the used datasets are independent of each other. For example, the GLEAM v3c evaporation dataset is used, but the GLEAM dataset uses also precipitation dataset as input. Could the authors check and verify the independence of such datasets?**
- Thank you for this remark. Indeed, the version of GLEAM used in our work is the v3.b (1980-2014) that used multi-source precipitation inputs (TMPA

3B42.v7, MSEP and ERA-I). The independence of the EO datasets used in an analysis is theoretically desirable, but in practice, this is always difficult to obtain. For instance, most water cycle analyses use a reanalysis (such as ERA-Interim) that does not assure independency between precipitation and evapotranspiration. The merging methodologies that we present are based on the idea that multiple observations should reduce the uncertainties in the estimation of a water component. This is for instance the strategy that is used by ensemble climate models (even if these models are not independent to each other since they use similar physical parameterisations or forcings). It is not a perfect solution but it has advantages. Using the Optimal selection principle could facilitate finding more independent datasets (like in the NEWS project) but we would not benefit from this multiplicity of information. This is now clearer in the text : *Using the Optimal Selection principle facilitates finding more independent datasets (Rodell et al. 2015) but this kind of strategy limits the use of several source of information to reduce the uncertainties. On the orther hand, SW approach benefit for the multiplicity of the observations.*

• **In the first ESA WACMOS project (Su et al., 2014, JAG), an independent evaporation product was generated and is updated continuously. The monthly evapotranspiration for global land area from satellite data (global land 5 km spatial resolution monthly ET dataset, 2000-2017) is produced with a revised SEBS algorithm (Su et al., 2002, HESS; Chen et al. 2013, JAMC) with input as MODIS LST, NDVI, Global forest height, GlobAlbedo and meteorology from ERA-I. A recent comparison of the SEBS ET has reported by Bhattarai et al, 2018, HESS, with the MOD16 ET and a method by integrating radiometric surface temperature (TR) into the Penman-Monteith (PM) equation (STIC). The authors are advised to take a look. The data may be accessed at: http://en.tpedatabase.cn/portal/MetaDataInfo.jsp?MetaDataId=249454.**
- Thank you. The SEBS evapotranspiration estimate (Su et al., 2002) presents the major advantage of not computing the relative evaporation based on a surface index, precipitation is not used as an input. This estimation is different to others evapotranspiration estimates based on PM and PT equation. The use of such dataset is a nice perspective that is now mentioned in the conclusion section in the context of closing the water cycle within the energy cycle: *There are still large uncertainties on the water cycle components but the INT methodology appear to be a valuable approach, in particular to include coherency among these components. Several im-*

provements will be considered in the near future: (1) more accurate in situ observations (e.g. Bosporus netflow estimate or coastal discharges) should lead to improved estimates. (2) New water cycle inputs could be considered (e.g. ground water exchange or horizontal exchange at oceanic sub-basin scale) to better characterize the flux and stock terms in the WC. (3) The use of other source of EO estimate would be considered. For example, the evapotranspiration estimate based on the closure of the energy cycle (SEBS algorithm, Su et al., 2002, HESS; Chen et al. 2013, JAMC)) could be tested. This dataset could be a opportunity to (4) close simultaneously the water and the energy cycles and should lead to a better estimate of the evapotranspiration over land that is of major importance of the region (Rodell et al. 2015; L'Ecuyer et al. 2015).

- **The authors presented statistics as a quality criteria of the WC closure. I suggest spending some effort in checking the dynamics and physics of the different datasets. I am not sure the correlation coefficients and RMSDs are the most suitable relevant statistical criteria for spatial-temporal datasets.**

- The correlation coefficient and RMSD are classic quality criteria. For example, Pan and Wood (2012), Sahoo et al. (2011), and Zhang et al. (2016) use correlation and RMSD to compare spatial dataset. We also considered the R^2 and Mean Absolute Error (not shown) but this was adding no information, just adding confusion. To evaluate the dynamics of the products, we used in Section 4.2 the EOBS precipitation dataset. Beyond the evaluation of the coherency in the water cycle closure (Section 4.1) at monthly scale, the coarse temporal resolution limits deeper evaluation of the dynamic such as extreme rainfall which can hardly be analyzed at monthly scale.

- **The English needs improvement. There are lots of typos and awkward expressions.**

- The typos and English writing have been improved, we hope that the manuscript is now in a better shape.