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Discussions

Interactive comment on "Large-scale vegetation responses to terrestrial moisture storage changes" *by* Robert L. Andrew et al.

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Dear Reviewer #2.

Thank you for taking the time to read our manuscript and to provide your valuable comments. Major comments:

-We agree that the 100km x 100km is not the true GRACE resolution, however gridded GRACE data is provided by NASA at a resolution of roughly 100km x 100km (1 degree) and freely accessible online (http://grace.jpl.nasa.gov/data/get-data/). So long as an appropriate scaling function has been applied to the gridded it is considered accurate, as extensively discussed in Landerer and Swenson (2012) and we have applied such a scailing function as supplied by NASA. Gridded GRACE data are used in most publications concerning GRACE such as in Yang et al. (2014), Feng et al. (2013),

Tajdarul et al. (2008), Mulder et al, (2015) and Becker et al. (2011).

Tasmania is split into 3 different land use types based on the MODIS data set (MDC12Q1). Hence, we are confident that it is reasonable to use this GRACE product in combination with the MODIS data set for categorising land use types.

-For variables with strong seasonality, a statistical relationship between them does not necessarily mean a physical relationship exists. For example, temperature and precipitation of an area, without removing the seasonality, may have very strong correlation, but physically they are both a result of Earth's revolution of the Sun. They do not necessarily have a direct physical relationship with one another. Thus, to examine the physical relationship between seasonal variables, it is a common approach to remove seasonality before the correlation analysis, as found in many previous studies such as Yang et al. (2014), Zaitchik et al. (2008), Crowley et al. (2006). Specifically for vegetation, its condition is likely related to soil moisture, but may also be influenced by temperature and solar radiation. Without removing the seasonality, the statistical relationship between NDVI and TWS may include the influences of other seasonal variables (e.g., solar radiation and temperature).

The decomposition of the GRACE data allows utilisation of GRACE information at different temporal frequencies. Generally, low frequency signals should correspond to deeper rooted vegetation where moisture changes are less dynamic and higher frequency signals should correspond to shallower rooted vegetation where moisture changes are more dynamic (though it is entirely possible for high frequency signals to also exist in forests and low frequency signals to exist in grasslands etc). We use this method to reveal the moisture dependence of different vegetation types at these temporal frequencies, this is a new and innovative method and has not been used for explaining NDVI changes. In the revised version (section 3 methodology) we emphasise the anomaly calculation and its relevance.

-Because we analyse so many cells it is not practical to show time series of data.

However, in the revised version we add in a time series of one cell to help further demonstrate the concept. An example of this inclusion is shown in Figure 1 (actual figure will appear on final page).

Figure 1. An example of the time series from a single cell. The new estimate uses the coefficients from A40, A46 and D4 as chosen by the stepwise regression. Pearsons coefficient (r) between the decomposed GRACE estimate and NDVI* is 0.872, compared with 0.665 when using raw GRACE TWS*.

-We are confident that the further explanation of the method in the paper and in the replies to the comments above shows the validity of the method.

- In this manuscript we show (1) An advancement in understanding the moisture dependence of vegetation types in Australia and (2) The application of a novel method expanding the use of GRACE data, both innovative and making contributions to the wider scientific community. This study builds on previous works that have linked NDVI with precipitation, soil moisture and GRACE (Chen et al., 2014, Huxman, 2004, Méndez-Barroso et al, 2009, Wang et al., 2007, Yang et al., 2014). Yang et al. (2014) is the first study using GRACE TWS to examine large-scale moisture storage effect on terrestrial vegetation performance. It has been cited by papers published in Review of Geophysics, JGR, Remote Sensing of Environment, Journal of Hydrology and Environmental Research Letters. However, part of GRACE TWS is beyond the reach of root zones, which is irrelevant to vegetation functioning. In our manuscript, we address this issue by proposing a method to use more shallow water storage signals in GRACE data. We clearly make an additional scientific advance by way of above points 1 and 2. The last paragraph in section 5 further discusses specific results. We have revised section 4 and 5 and taken care that the significance is more clearly stated, given that we used a new method we believe that the results are not 'trivial', rather, they support our hypothesis. The last paragraph of section 5 highlights the application and contribution of the study presented.

The significance of this study can be also seen from the number of views and downloads having occurred to the discussion paper. As of Janurary 19th 2017, this discussion paper was downloaded 251 times compared to 101, 126, and 185 times for three other papers (with subjects in ecohydrology, and remote sensing and GIS) published within the similar time frame in HESS for discussion.

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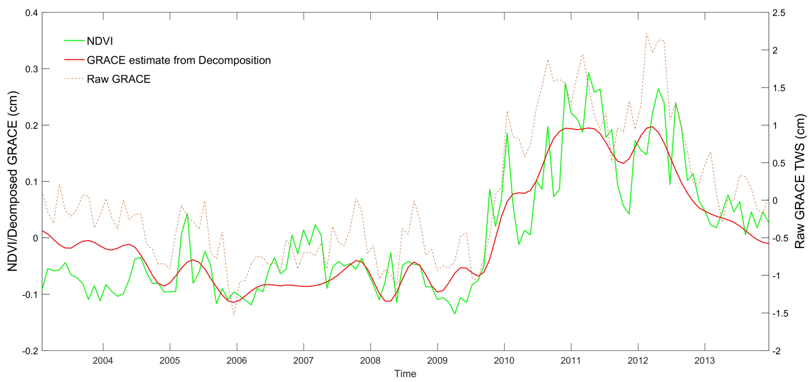

Fig. 1.