Atmos. Chem. Phys. Discuss., 10, C7390–C7396, 2010
www.atmos-chem-phys-discuss.net/10/C7390/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Components of near-surface energy balance derived from satellite soundings – Part 1: Net available energy" *by* A. Jarvis et al.

A. Jarvis et al.

k.mallick@lancaster.ac.uk

Received and published: 11 September 2010

Components of near-surface energy balance derived from satellite soundings – Part 1: Net available energy. A. Jarvis et al.

Referee 1 (R1) Background An attempt is being made to estimate near surface net available energy defined as the difference between net radiation and surface heat storage. Used are simplified formulations for each term and observations from AIRS and MODIS. The formulation is at monthly time scale and at 1 degree spatial resolution. The results are evaluated using point measurements from tower sites.

General Comments Net radiation is derived by adding the components of net shortwave and net longwave radiation while the estimates of surface heat accumulation are obtained from day-night surface temperature difference at 12 hour discrete times.

I have several issues with this paper:

1. It is claimed that a methodology is presented to derive the above referenced parameters while in fact, all that was done is taking simplistic formulations of each parameters and using satellite information of input parameters and plugging these numbers in the equations to obtain global fields of net radiation and heat storage.

Response: The paper presents a clear methodology and uses this methodology to produce results which are both presented and discussed. Therefore, although R1 is at liberty criticize the methodology as presented it is not correct to say that no methodology has been used. We agree the methodology we have used is simple and exploits many commonplace expressions. However, the aim is to develop a methodology whose complexity is commensurate with the simple Bowen ratio approach which exploits these satellite Net Available Energy (NAE) estimates to specify satellite latent heat in the companion paper Mallick et al. (this issue). We are also trying to avoid over-reliance on a more complex modeling paradigm given the satellite products we are after producing are intended for the evaluation of such models. In reviewing the literature we have been unable to find publications which report explicit methodologies for producing satellite NAE and hence we conclude the work is broadly novel.

2. The formulations are extremely simplistic as compared to current efforts to derive similar information. For instance, in eq. 4 used is one value of clear sky transmissivity for the entire globe for every month and the same constant transmissivity for any cloudy condition. The same simplistic approach is taken in the computation of net longwave.

Response: Without knowing which “current efforts” R1 is referring to in particular it is difficult to comment in detail. We accept that a fixed clear sky transmissivity is a gross simplification. However, a constant clear sky transmissivity is widely used in this area (e.g. Massaquoi, 1988; Bindi et al., 1992; Choudhury, 2001; Hildebrandt et al.,

ACPD
10, C7390–C7396, 2010

2007; Mallick et al., 2009) in recognition of the absence of a robust alternative. In addition, exploiting the AIRS cloud cover fraction data in equation (4) should accommodate the effects of variations in both the aerosol optical depth (Kaufman and Koran, 2006; Quass et al., 2010) and atmospheric water vapor (Adhikari et al., 2006). Again, we believe the approach we have taken is in sympathy with the simple yet robust stance of the paper. We acknowledge recent satellite net radiation retrieval studies (e.g. Bisht et al., 2005, Bisht and Bras, 2010) have used explicit schemes for water vapor effects although the universality of these schemes has yet to be established given they were specifically developed for use over oceans where water vapor effects are significantly more prominent than over land. For the net longwave radiation we presume R1's concerns relate to the specification of the downwelling component. Again, the approach is both widely accepted and in current use (e.g. Bisht et al., 2005; Bisht and Bras, 2010; Mallick et al., 2009; Niemela et al., 2001). In addition, the analysis of the results in the paper show that the critical step in the specification of NAE is the correct specification of the shortwave input not the longwave. The above arguments will be incorporated into the revised paper.

3. In the formulation of the heat storage again, assumptions are being made that at 01:30 one can assume that $\Phi = 0$ so that heat capacity can be estimated.

Response: This is declared in the paper (P14394 L3) and a citation given in support of this. For the 30 tower sites considered in this study Φ(01:30) never exceed 5% of Φ(13:30). This will be emphasized in the revised paper.

4. The evaluation is done as follows: net radiation is being measured on the tower; G is not measured however, sensible and latent heats are measured. Therefore one can estimate Φ (from the sensible and latent heat) and therefore, G can be estimated as the difference between the net radiation and Φ.

The above approach raises a lot of questions. On monthly time scale, G is quite small.

Response: Although the monthly average 01:30 and 13:30 data are used in the analysis, the time step of equation (10) is 12 hours NOT one month. On this timescale G is significant as testified by our results and numerous previous studies.

5. The errors in estimating and measuring net radiation are quite high, as well as the errors in the other measurements. No discussion is presented regarding the possibility that the computed values of G are at the error level.

Response: This is an important point that was not satisfactorily addressed in the original submission. Following this and Reviewer 2's suggestion we have now conducted a sensitivity analysis to identify the predominant sources of uncertainty in the NAE (and G) estimates for inclusion in the revised paper. This analysis, which will be incorporated into the revised paper, shows the estimates of G are well above the error level for standard conditions with a standard deviation of approximately 5 W/m2. 6. The various parameters are measured at different levels. There is no discussion what impact this has on the results when they are assigned to one level.

Response: We are not clear what R1 is eluding to here. The satellite data relate to different locations in the sample profile, but the rationale for choosing these appears self evident and no attempt is made to "assign parameters to one level". However, the objective is to derive "near surface" estimates of NAE as stated in the title and throughout the paper.

7. What about the applicability of the same formulas to high elevations? Snow conditions? Deserts?

Response: Clearly these extreme cases would provide useful tests for the generality of the scheme being proposed. Unfortunately, without tower data to evaluate against we are unable to report results for these situations. The Discussion will be expanded to qualitatively consider the effects of these extreme cases on albedo, transmisivity, emissivity etc.

8. What about scale issues when comparing satellite measurements to point observa-

ACPD

10, C7390–C7396, 2010

Interactive Comment

tions? No effort was made to reconcile scales or discuss implications of mixing scales. Is it possible that the results compare to the measurements as good as they do due to error cancellations?

Response: A significant proportion of the discussion (P14400 onwards) is given over to considering scaling issues in relation to the observed differences between the satellite and tower data. . We concede that this discussion is not exhaustive given every single observation used in this study is subject to scaling issues. For example, for EC instruments alone there are errors associated with different footprints for different instruments: Rn has a footprint typically ∼10m2; air properties (e.g. temp) has a footprint of several km2. Indeed, the different footprints of instruments on EC towers is partially responsible for the lack of closure of the EC estimated energy budget (JGR V.113, D16114, 2008 – - Lin B et al.). We believe the current scope of the discussion of scaling in the paper is appropriate given it focuses on the perceived core issues. However, we will add an additional statement to highlight the breadth of this issue in relation to the approach being advocated. As for mixing scales, this is of little or no relevance to this NAE paper, but instead is of relevance to the companion latent heat flux manuscript where again scaling issues are discussed.

9. No discussion of diurnal integration issues and the fact that the surface temperature is not observed between min and max.

Response: We presume R1 means the 01:30 and 13:30 temperature samples rather than the “min” and “max” temperatures. The issues around discrete-time approximation are discussed (P14394 L9 onwards) although we expand this discussion to outline the integration issues more explicitly. Clearly, the linear first-order-hold assumed in a backward difference approximation is coarse, as highlighted in the paper. However, the timing of the AIRS passes very much lends to this approach and the results appear entirely reasonable when evaluated against the tower data.

REFERENCES

ACPD

10, C7390–C7396, 2010

Interactive Comment

Adhikari, L., Wang, Z., and Whiteman, D.: Cloudy Assessment within an Atmospheric Infrared Sounder Pixel by Combining Moderate Resolution Spectroradiometer and Atmospheric Radiation Measurement Program Ground-Based Lidar and Radar Measurements, Sixteenth ARM Science Team Meeting Proceedings, Albuquerque, NM, March 27 - 31, 2006

Bindi, M., Miglietta, F., and Zipoli, G.:, Different methods for separating diffuse and direct components of solar radiation and their application in crop growth models, Climate Res., 2, 47 – 54, 1992.

Bisht, G., Venturini, V., Islam, S., and Jiang, L.: Estimation of net radiation using MODIS (Moderate Resolution Imaging Spectroradiometer) data for clear sky days, Remote Sens. Environ., 97, 52 – 67, 2005.

Bisht, G., and Bras, R.: Estimation of net radiation from the MODIS data under all sky conditions: Southern Great Plains case study, Remote Sens. Environ., 114, 1522 – 1534, 2010.

Choudhury, B. J.: Estimating gross photosynthesis using satellite and ancillary data: approach and preliminary results, Remote Sens. Environ., 75, 1 – 21, 2001.

Hildebrandt, A., Aufi, M. A., Amerjeed, M., Shammas, M., and Eltahir, E. A. B.: Ecohydrology of a seasonal cloud forest in Dhofar: 1. Field experiment, Water Resourc. Res., 43, doi:10.1029/2006WR005261, 2007.

Kaufmann, Y.J., and Koran, I.: Smoke and Pollution Aerosol Effect on Cloud Cover, Science, 313, 655 – 658, 2006.

Lin, B., Stackhouse Jr., P. W., Minnis, P., Wielicki, B. A., Hu, Y., Sun, W., Fan, T. – F., Hinkelman, L. M.: Assessment of global annual atmospheric energy balance from satellite observations, J Geophys. Res., 113, D16114, doi:10.1029/2008JD009869, 2008

Mallick, K., Bhattacharya, B. K., Rao, V. U. M., Reddy, D. R., Banerjee, S., Hoshali, V., Pandey, V., Kar, G., Mukherjee, J., Vyas, S. P., Gadgil, A. S., and Patel, N. K.: Latent heat flux estimation in clear sky days over Indian agroecosystems using noontime satellite remote sensing data, Agric. For. Meteorol., 149 (10), 1646 – 1665, 2009.

Massaquoi, J.G.M.: Global solar radiation in Sierra Leone (West Africa), Solar and Wind Tech., 5 (3), 281 – 283, 1988.

Niemela, S., Raisanen, P., and Savijarvi, H.: Comparison of surface radiative flux parameterizations Part I: Longwave radiation, Atmos. Res., 58, 1–18, 2001.

Quaas, J., Stevens, B., Stier, P., and Lohmann, U.: Interpreting the cloud cover – aerosol optical depth relationship found in satellite data using a general circulation model, Atmos. Chem. Phys., 10, 6129–6135, 2010.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 14387, 2010.