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# Towards operational estimation of Evapotranspiration from Remote Sensing

## A case study applying MODIS data for Kyeamba Creek, New South Wales, Australia

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### Method

We applied a modified version of the "triangle approach" to estimate regional evapotranspiration for an area close to Kyeamba Creek, New South Wales, Australia. The approach is based on the assumption that the Priestly-Taylor parameter can be derived directly from a plot of NDVI vs Land Surface Temperature (LST) for a given region. In this case we apply a temperature difference between midday and morning LST instead of using the actual LST at midday.
Combined with knowledge of the air temperature the evaporative fraction can then be directly estimated from the satellite information. To calculate the evapotranspiration (ET), the average net radiation has to be estimated, which was done using a combination of MODIS products and data from standard meteorological stations in the area.

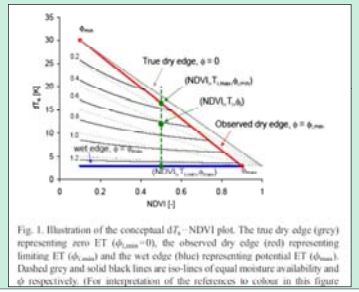
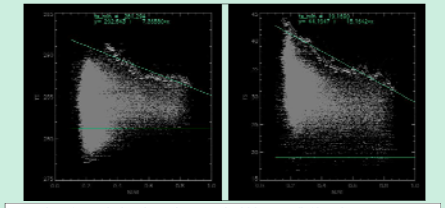


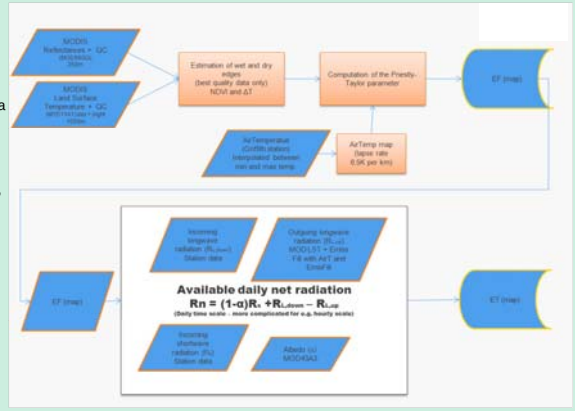

Fig. 1. Illustration of the conceptual $dT_s$ - NDVI plot. The true dry edge (grey) representing zero ET ($\phi_{T,min}=0$), the observed dry edge (red) representing limiting ET ($\phi_{T,max}$) and the wet edge (blue) representing potential ET ($\phi_{max}$). Dashed grey and solid black lines are iso-lines of equal moisture availability and $\phi$ respectively. (For interpretation of the references to colour in this figure

Conceptual model of the modified triangle approach (Source: Stisen et al 2008)



Examples of actual triangles using actual midday LST (left) and temperature difference dTs calculated as the MYD_day minus MYD_night temperatures (right)

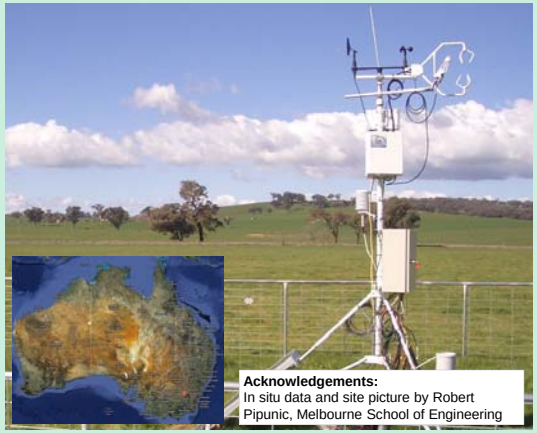
| Required data Parameter | Data source / ata product | Spatial resolution | Temporal resolution |
|---|---|---|---|
| LST | MYD11A1 / MOD11A1 | 1000 metres | Daily |
| NDVI | MOD09GQ | 250 metres | Daily |
| Surface albedo | MOD43A3 | 500 metres | 8-16 days |
| Air temperature | Met. station | Point value | Daily min and max |
| Relative humidity | Met. station | Point value | Daily mean. |
| Solar exposure / incoming shortwave | Met.station or geostationary data | Point value / 5 km grid or coarser | Daily sum |




Flowchart showing the data input, the processing steps and an outline of the method used for the calculation of the evaporative fraction and evapotranspiration.

### Validation data

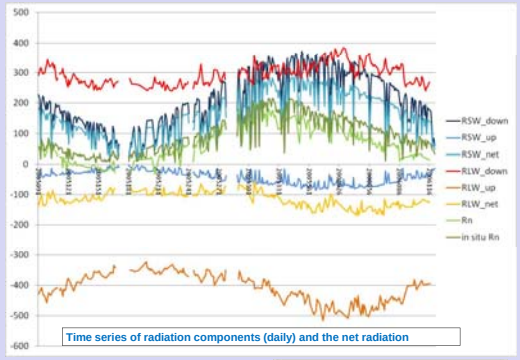
Validation data was available from a flux station operated by Robert Pipunic, Melbourne School of Engineering. The flux tower records latent and sensible heat flux using a CSAT 3D sonic anemometer and a Licor 7500 gas analyzer, both mounted on a tripod three meters above the ground. Data are measured at 10Hz and 30 minute averages are recorded. The components of the radiation balance is also measured at the station with a CNR1 Kipp & Zonen instrument. The incoming shortwave radiation has been used as input to the net radiation estimation, while data for the other components has only been used for the validation of applied approach. For comparison with the results, the data has been aggregated to daily values.



**Acknowledgements:**
In situ data and site picture by Robert Pipunic, Melbourne School of Engineering

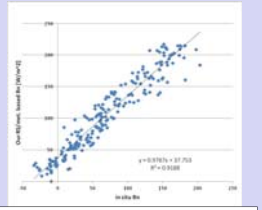
### Results – Net radiation

The net radiation (Rn) and the individual radiation components were estimated using a combination of MODIS products and data from meteorological data.

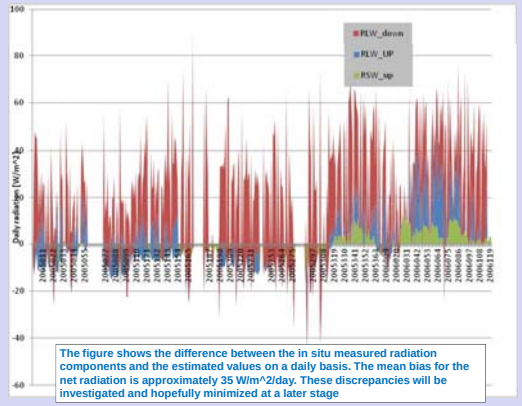



Time series of radiation components (daily) and the net radiation

Overall, the agreement between in situ measurements and our method was good, but with a bias of approximately -35 W/m^2/day. The discrepancies show some seasonal variation, but occur mainly for the long-wave components. Currently, a simple air-temperature based approach is used for the down-welling long-wave component, more other approaches will be investigated to minimize the errors.

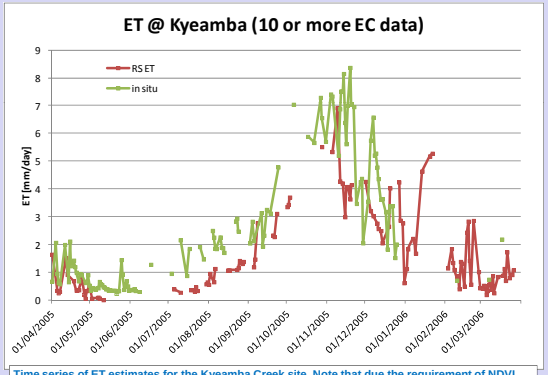


Scatterplot comparing in situ and RS-based Rn




The figure shows the difference between the in situ measured radiation components and the estimated values on a daily basis. The mean bias for the net radiation is approximately 35 W/m^2/day. These discrepancies will be investigated and hopefully minimized at a later stage

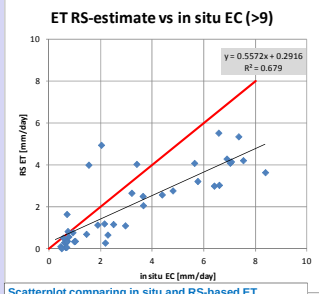
### Results - Evapotranspiration




Time series of ET estimates for the Kyeamba Creek site. Note that due the requirement of NDVI and two LST estimates from MODIS, there are significant gaps in the time series. The in situ data has also been filtered and scaled to account for periods with either missing data or large uncertainties in the estimation of the fluxes.

The results show that it is possibly to catch the seasonal variations in the ET rates, but not the exact level. This could be explained by the problems with estimating the net radiation. Also, especially the evaporative fraction time series (not shown) is noisy, resulting in more significant jumps from day to day in the ET rates than present in the in situ measurements.

The triangle-based ET estimates also show a tendency for not catching the highest ET-values, which could be caused either by actual underestimation or by scaling issues when comparing point measurement with RS-based estimates that represent a much larger area.




Scatterplot comparing in situ and RS-based ET estimates

### Conclusions:

- Good agreement between triangle-based and in situ ET estimates
- Some negative bias in our ET estimates, which is thought to be due to inaccuracies in the estimation of especially the long-wave components of the radiation balance
- Underestimation especially on days with high ET-rates, which could be caused by scaling issues
- Potential for operational application, as the method is easily implementable and only require MODIS data and standard meteorological data.

### References:


- S. Stisen et al. Remote sensing of Environment 112 (2008), 1242-1255. *Combining the triangle method with thermal inertia to estimate regional evapotranspiration – Applied to MSG-SEVIRI data in the Senegal River Basin.*
- I. Sandholt et al. Remote Sensing of Environment 79 (2002), 213-224. *A simple interpretation of the surface temperature/vegetation index space for assessment of surface moisture status.*