Introducing a framework to improve estimation of actual evapotranspiration using MODIS images with SEBAL algorithm

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Introduction

The SEBAL algorithm can be used to model spatial distributed actual evapotranspiration by using MODIS or Landsat images as input.

Although Landsat images have a better spatial resolution than MODIS images (30 m instead of 1000 m), the temporal resolution is not sufficient (2 images per months).

MODIS, on the other hand, have daily images, however, under cloudy condition, it can be difficult to have usable images and additionally it is also a time-consuming process to interpret all the images.

In this research we aim to develop a framework for SEBAL to use a minimum number of MODIS images, while not losing important information of the daily MODIS images in orderto obtain better ETa stimates.

Proposed framework

Step 1 and 2 are tested to shorten the computation time of SEBAL. Successively, three different interpolation techniques are investigated to interpolated between the MODIS images in order to get monthly ET-estimates.

Step1- **Determination of minimum number of required MODIS images:** choosing the images before and after a precipitation event, choosing images when ΔT between two days is more than 20% of the average seasonal temperature range.

Step 2- **Quicker algorithm for hot-cold pixel selection:** employing the statistical procedure for automated selection of cold and hot pixels (Allen et al. 2013). Also visually reviewing the location of hot and cold pixels using land cover image to ensure that the most appropriate hot and cold pixels had been selected.

$$ET_rF_{cold} = aNDVI_1 - b \qquad if\ NDVI_1 < 0.75$$

$$ET_rF_{cold} = 1.05 \qquad if\ NDVI_1 \geq 0.75$$

$$ET_rF_{hot} = f_c ET_rF_{cold} + (1 - f_c) ET_rF_{bare}$$

$$With \quad f_c = \left(\frac{NDVI_{hot} - NDVI_{bare}}{NDVI_{full} - NDVI_{bare}}\right)$$

Based on the LANDSAT data, the relationship between ET_rF and NDVI for NDVI<0.75 was obtained as follow (Figure 1):

$$ET_rF = 1.16NDVI - 0.01$$

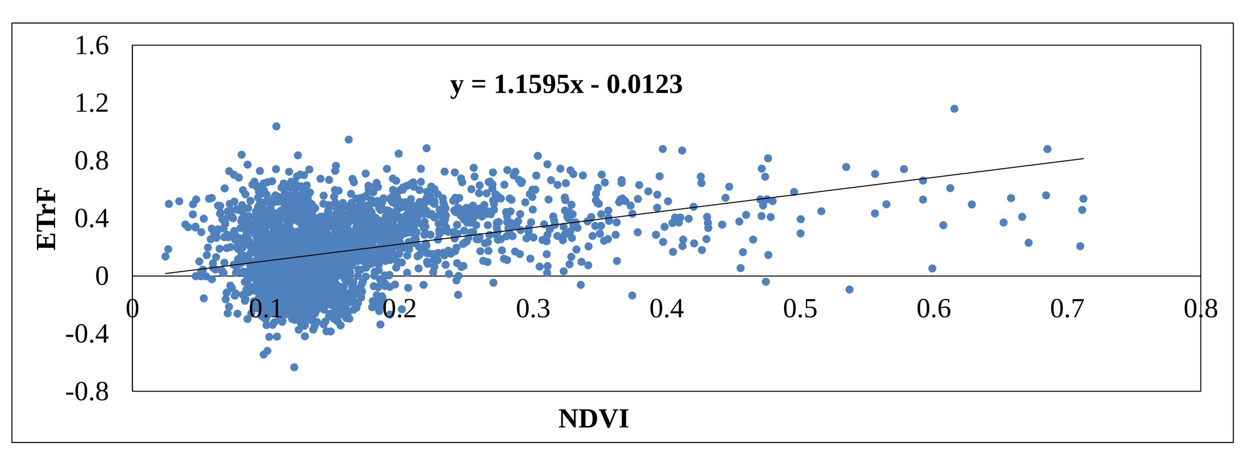

Figure 1- ETrF vs. NDVI relationship by aggregating SEBAL-derived ETrF from 30m resolution Landsat images into MODIS scale data (1000m).

Step 3- **Integrated methods:** Integrate evapotranspiration over time using linear, spline and logarithmic interpolation.

The results will be compared to ground observations and model results of SWAT for 3 years including 2004-2005 (wet), 2005-2006 (normal) and 2007-2008 (dry) in the Neyshaboor watershed in Iran.

Results & Discussion

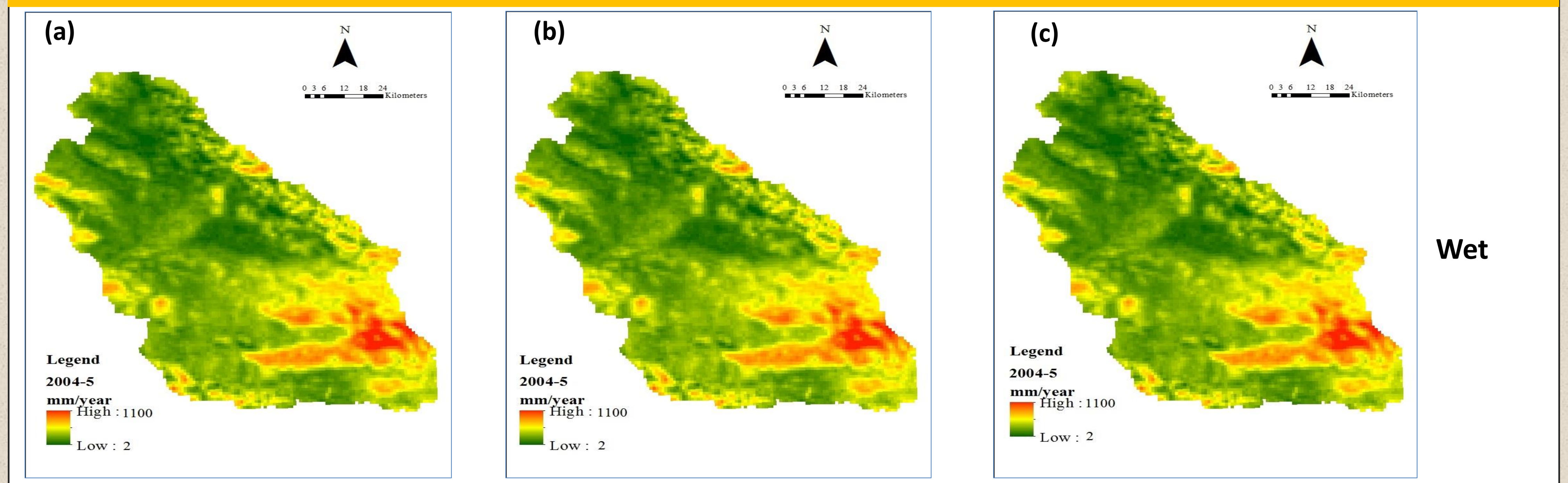

Figure 2- The spatial distribution of ETa for Neyshaboor watershed for 2004-2005 (a) Linear Method, (b) Spline Method and (c) Logarithmic Method.

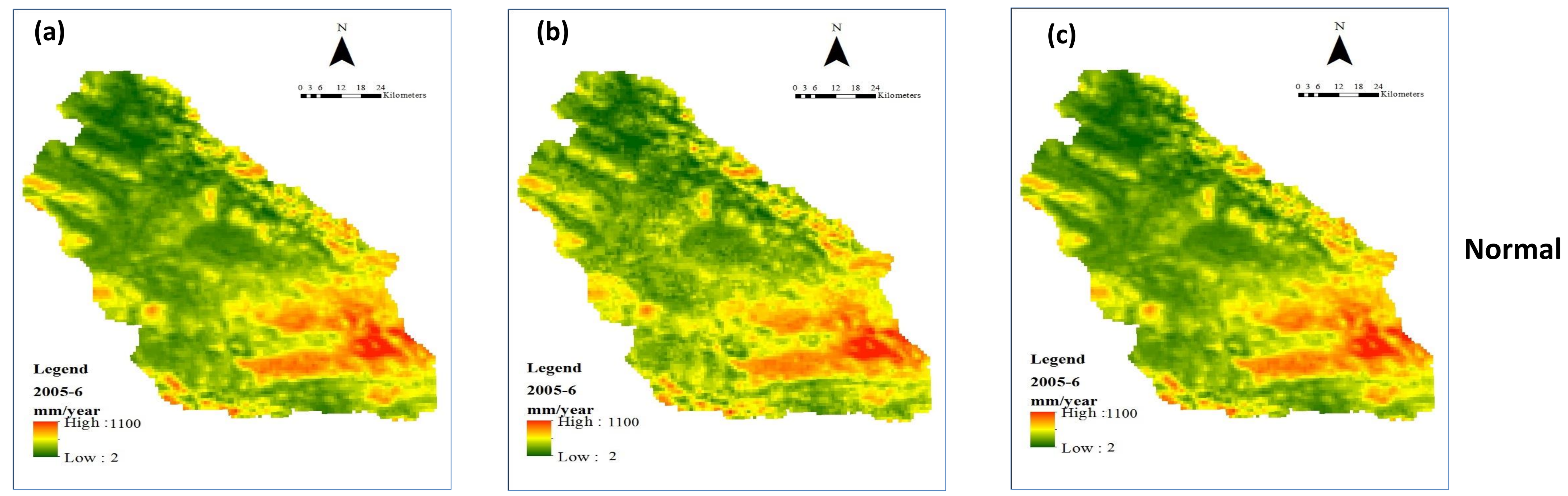

Figure 3- The spatial distribution of ETa for Neyshaboor watershed for 2005-2006 (a) Linear Method, (b) Spline Method and (c) Logarithmic Method.

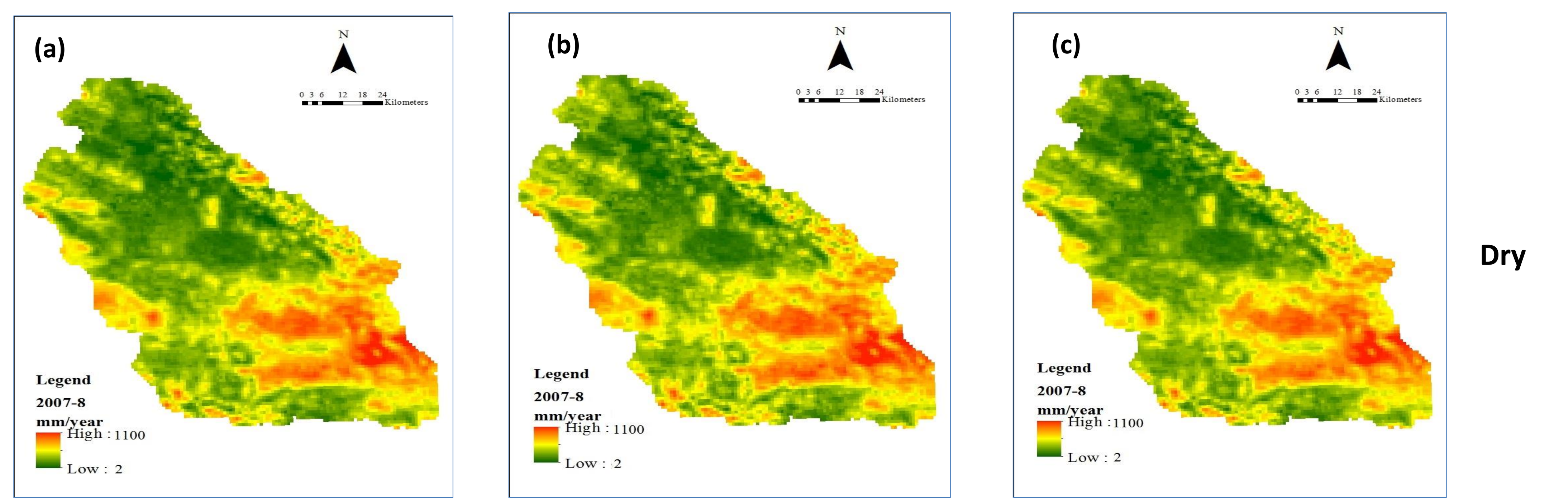

Figure 4- The spatial distribution of ETa for Neyshaboor watershed for 2007-2008 (a) Linear Method, (b) Spline Method and (c) Logarithmic Method.

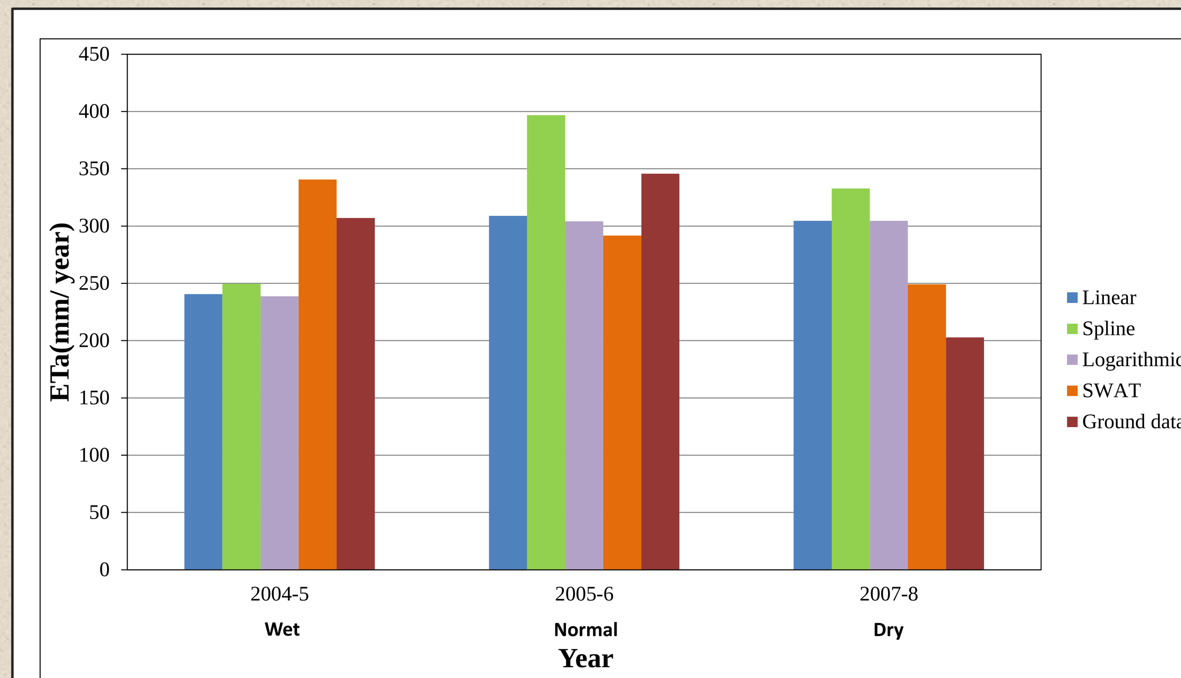

Figure 5- Comparison of ETa estimated by SEBAL using linear, spline and logarithmic method to ETa drived by SWAT model and ground data.

The results show that the linear integrated method results in higher ETa estimates than the logarithmic method for wet and normal years, but in dry years, because of lack of precipitation, the amount of ETa is the same.

The SWAT results show the more precipitation, the more ETa. The ground-based data shows that the amount of ETa is a result of a balance between precipitation rate (atmosphere capacity for moisture) and temperature.

The dry, wet and normal years were determined using the SPI which is a precipitation-based index. But the average temperature of the normal year was higher than the two other years. Therefore the amount of ETa was higher in normal year.

Conclusion

- The linear and Logarithmic method give similar results and the spline method provides higher ET-estimates.
- Compared to the SWAT model, the improved SEBAL algorithm underestimates for the wet year, and overestimates for the normal and dry year.
- Compared to the ground data, the improved model underestimated for the wet and normal year, and largely overestimates for the dry year.
- The ground-based data were obtained from the difference between precipitation and runoff (Eta=P-Q). But having a more accurate ground data such as lysimeter data could lead to a better comparison of the results.

Future research

- Investigating another integrated method.
- Testing the framework for the data more than 3 years.
- Testing the framework for other catchments.
- Testing the framework using microlysimeters.

References

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