Irrigation Requirement Estimation Using MODIS Vegetation Indices and Inverse Biophysical Modeling

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Introduction

We combine remote sensing data from Landsat and MODIS and an inverse biophysical modeling methodology to detect irrigated agricultural lands in arid and semi-arid regions and to quantify the amount of irrigation water required for agricultural production as influenced by climate, crop type, soil characteristics and irrigation efficiencies. This satellite-supported inverse modeling approach will provide unique information on the minimum physiological water requirement for each crop type and climate conditions and may be used for an priori planning of cropping as function of soil characteristics and water supply. Furthermore, the methodology also applies different irrigation efficiencies and takes into account soil salinity to estimate the total water allocated to irrigation.

Algorithm

MODIS data are used to estimate the seasonal cycle of LAI, FPAR and other biophysical parameters of a crop canopy. The inverse modeling approach consists of comparing the carbon and water flux modeled under both equilibrium (in balance with prevailing climate) and non-equilibrium (irrigated) conditions.

We postulate that the degree to which irrigated lands vary from equilibrium conditions is related to the amount of irrigation water used.

Results

The use of the drip irrigation method reduced both the canopy and ground interception compared to spray irrigation. This water delivery method results in less frequent irrigation events (about every 48 hours) with an average water requirement amount of about 0.6 mm per occurrence, that’s about 43% of that simulated for spray irrigation.

Irrigation Efficiency

Along with the minimum physiological water requirement, several efficiencies apply when computing the total water use for irrigation.

• Transport (Conveyance) Efficiency
• Transpiration Efficiency

For this North African region, the conveyance efficiency for all transport types has degraded since 2000, due to the aging of the irrigation system, leading to transport efficiency values around 50% for 2006.

Field data and Validation

We believe the methodology is a good first order algorithm to estimate the total water used for irrigation in dry lands. However, it still needs further refinements and validations. Most importantly it is amendable to satellite data and can be expanded to compute global estimates of irrigation water.

We will refine the model estimate of the minimum physiological water requirement for observed agricultures and further develop it to quantify the total amount of water used for irrigation, including losses to transport and transpiration efficiencies, soil salinity and delivery methods. The transport efficiencies vary with farming practices and regions and will be determined through field campaigns. We will validate the methodology over multiple focal sites over the different regions and apply the validated algorithms over large scale agricultural areas in the arid and semi-arid regions.

The following is a sample field campaign report collected from a country in North Africa (Algeria). This report can provide detailed information of crop types and density, soil salinity, crop phenology as well as irrigation type and amount.

Temperature: 15C-25C
Soil salinity: 2-3 mhos/cm
PH 5.5-6.8
Phenology • Emergence • Flooding • Maturation

Temperature: 15C-25C
Soil salinity: 3.5 mhos/cm
PH 5.8-6.5
Phenology • Emergence • Flooding • Maturation

Temperature: 15C-25C
Soil salinity: 3-5 mhos/cm
PH 5.6-6.9
Phenology • Emergence • Flooding • Maturation