Food and Agriculture Organization of the United Nations

Regional Initiative on Water Scarcity

Sweden
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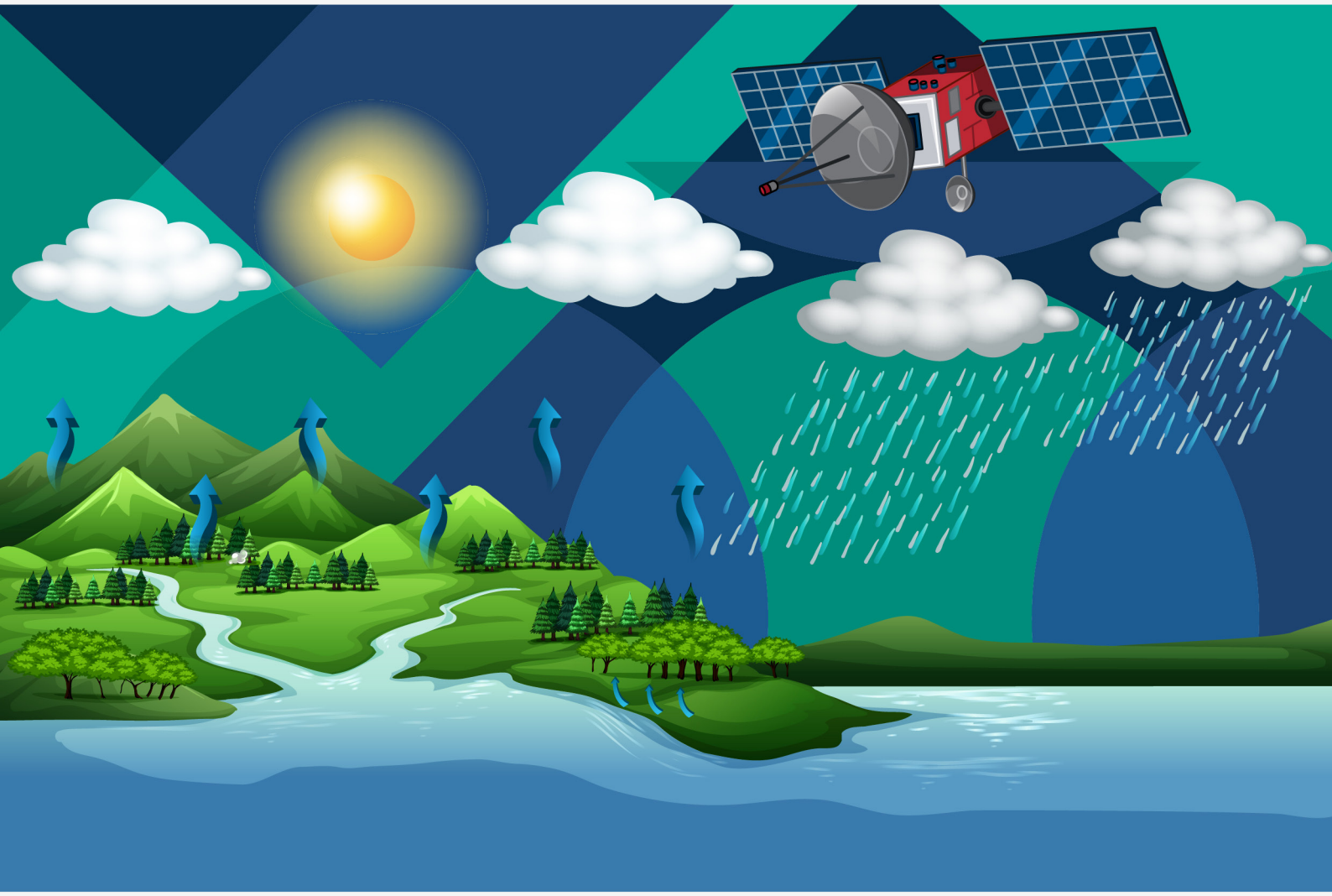
WEBINAR SERIES

REMOTE SENSING DETERMINATION OF EVAPOTRANSPIRATION

Algorithms, strengths and weaknesses, uncertainty and best fit-for-purpose

LAUNCHING, 24 MARCH 2021



Regional Office for the Near East and North Africa

INTRODUCTION

In agricultural and other vegetated lands, evapotranspiration (ET) nearly always represents the largest share of water outflow, identified as the 'consumptive' fraction of water used within the system.

Quantifying ET in space and time, thus, is extremely relevant for water resources management, including applications for: monitoring water consumption by various land use systems; management of irrigation at scheme and on-farm level; determination of crop water productivity; prediction of yield through models; assessment of agricultural drought indexes; performing water balance and water accounting within hydrologic systems at a wide range of scales.

Occurring when liquid water is converted to the vapor phase, ET is regulated by complex land-plant-atmosphere interactions that are primarily impacted by weather and additionally influenced by variability in topography, wind patterns, soil moisture and vegetation type. As a result, ET is the most challenging to be quantified among all variables' of the hydrological balance.

Several methods for ET determination have been developed over time, generally at field scales, that include: soil-moisture depletion; weighing lysimeters; the Penman Monteith equation; the Bowen-ratio/energy balance; the Eddy covariance; and the Large Aperture Scintillometer.

However, these methods are generally complex, expensive, focused on one field, and are therefore mostly confined to academic and research environments. Scaling them up to larger areas becomes prohibitive due to cost. For large scales (e.g., irrigation schemes, watershed, sub-national, national and basin scales) the only feasible and affordable methods for accurate ET determination are through satellite Remote Sensing (RS), where the spatial distribution of ET is revealed. Thanks to the progress and advances in availability of moderate resolution earth observation over recent years and evolution of sophisticated algorithms, determination of the spatial distribution of ET is now possible.

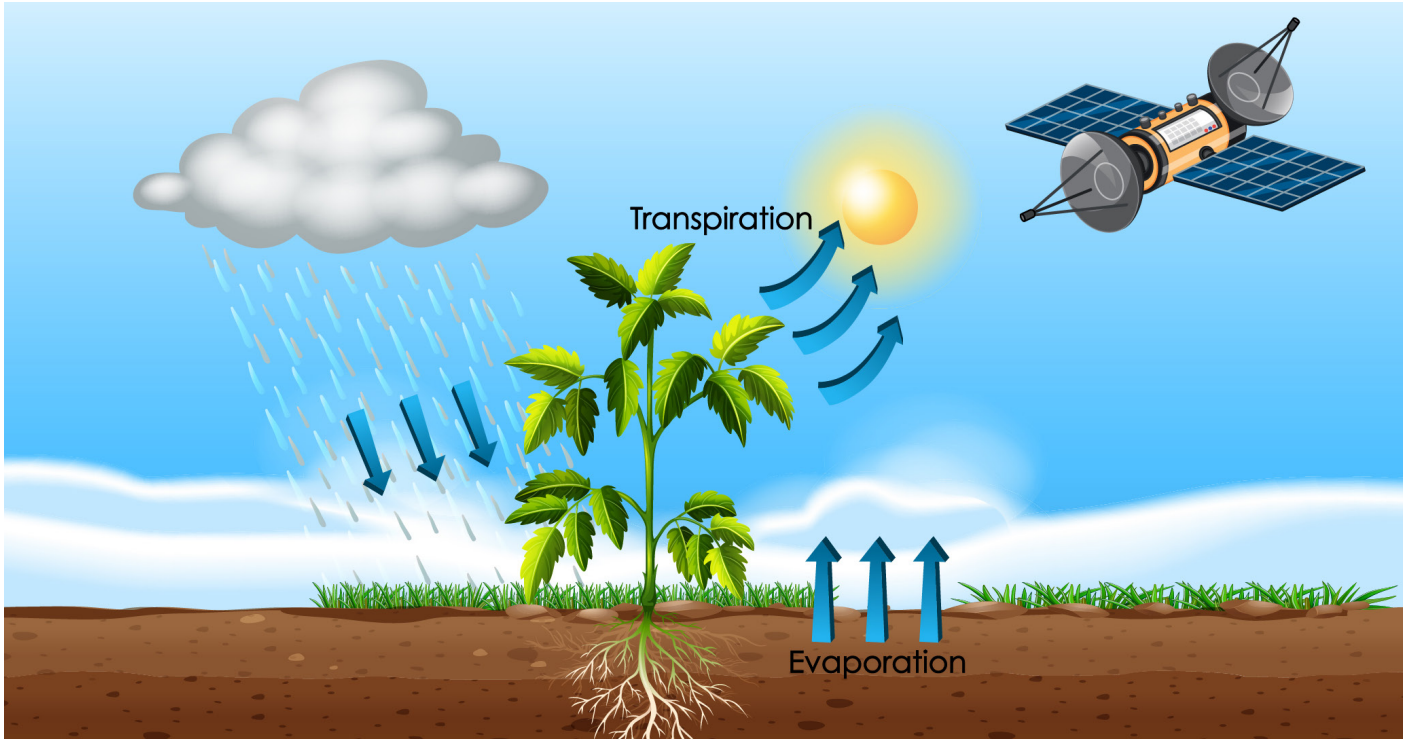
In fact, there are several well-established RS-based algorithms for the determination of ET, including: (i) those based on Surface Energy Balance like SEBAL (Surface Energy Balance Algorithm for Land), METRIC (Mapping Evapotranspiration at high Resolution with Internalized Calibration), and ALEXI (Atmosphere-Land Exchange Inverse); (ii) algorithms that use simple relationships between land surface temperature (LST) and ET such as SEBS (Surface Energy Balance System) and SSEBop (Simplified Surface Energy Balance – Operational), or integration of field reference ET (ETo) and RS crop coefficients to derive ET of irrigated agriculture, such as SIMS (Satellite Irrigation Management Support); (iii) those based on the Penman Monteith equation, like ETLook and ETMonitor; and (iv) those based on a combination of energy balance and the PM equation, like ETWatch. Some of the algorithms are referred to as 'one-source' models (treating the 'surface' as a single layer, like SEBAL and METRIC) or as 'two-source' models (treating the 'surface' as two components, i.e., soil and vegetation, like ALEXI and ETLook). Some data processing procedures use variable approaches to solve specific problems, e.g., 'data fusion' (that combines imagery from different satellite platforms to generate higher spatial/temporal resolutions) or automated 'cloud masking' (to remove interference due to the presence of clouds on the RS images), etc.

As can be expected, each method has specific advantages and limitations, spatial and temporal resolutions, strengths and weaknesses, uncertainties and best-fitting domains of application.

Most of the ET algorithms have been used to generate ET databases over different time series that have been made available through the public domain and accessible from the web, like USGS FEWSN (Famine Early Warning Systems Network with data from SEBS – e.g., SSEBop-V4), WaPOR (with ET data derived from ETLook), GloDET and ECOSTRESS (with ET data derived from disALEXI), EEFlux (with ET data derived from METRIC), and OpenET (with ET data derived from an ensemble of algorithms including METRIC, SSEBop, ALEXI-disALEXI, among others).

Confronted with this quite ample and diversified offer of RS ET data, users ask specific questions requiring proper and clear answers. Among those questions are: How does one conduct a qualitative (and at least partially quantitative) error analysis of RS-ET determinations for the various algorithms/models? What is the uncertainty (or accuracy) of the ET data provided by the various sources (databases, portals, etc.)? How does one deal with variable uncertainties of ET determination over time (e.g., during different phases of a crop cycle)? How does one test the RS ET with field ET measurements? How does one know which ET data sources best fit one's purpose? etc.

Against this backdrop, the FAO Water Scarcity Initiative (WSI) of the NENA Region, with the support of the Sida Project (see below) and in consultations with various countries' stakeholders in the Region, partners, and major experts in this domain, has elaborated a plan of webinars addressing these various questions.



OBJECTIVE OF THE WEBINAR SERIES

The objectives of this webinar series are multiple, including:

1. updating and upgrading the knowledge regarding current RS ET determination, the most common and adopted algorithms and approaches and the latest advances;
2. increasing the capacity of key water professionals in the assessment of RS ET uncertainty and related acceptable limits for their field of application;
3. building awareness on the strengths, limitations and fits-for-purpose for the range of RS ET models and databases available;
4. providing the participants with a complete and advanced set of documentation on the various topics treated during the webinar series.

STRUCTURE OF THE WEBINAR SERIES

A series of logically and consecutive webinar presentations that, comprehensively, provide clarity and complete answers to lingering questions and doubts regarding the adequacy and accuracy of remote sensing determination of ET.

After the launching on 24 March 2021, the various webinars are planned to occur every week on Wednesday, over a few months. The specific scheduling of each webinar will be provided in due time.

The webinar series develops in the form of four Modules:

Module I

- This module is composed of one 'setting-the-scene' webinar plus eight key-note webinars that introduce the most widely used RS ET models (SEBAL, METRIC, ALEXI/Dis-ALEXI, SSEBop, ETLook, ETMonitor, SIMS and ETWatch). Each model key-note presentation, provided by the major authors of the models, will be then followed by a presentation reporting on the experience of its application, mostly within countries of the NENA Region.

Module II

- This module will address the major databases and portals providing ET as derived by some of the models presented in the Module I. The database presented are: FEWS (by USGS with ET data derived from SSEBop); WaPOR (by FAO with ET data derived from ETLook); GloDET (by the University of Nebraska, Water for Food Institute, with ET data derived from ALEXI); and EEFlux (by the University of Nebraska with ET data derived from METRIC).

Module III

- This module will address the expected prospects for the near future, in terms of: improvements of RS ET determinations (both accuracy and resolutions); new development of databases/portals available to the public (like WaPOR II and OpenET); new programmes, proposed satellite missions and associated sensors and resolutions (e.g., Copernicus, Agenzia Spaziale Italiana, ECOSTRESS, etc.).

Module IV

- This module will address the RS ET errors, testing and field data validation. The module assumes particular importance as the focus of the webinars will be: on the source of errors encountered in RS ET determinations and relative significance; the way to mitigate these errors and reduce biases; the challenges to benchmark, validate and calibrate the RS ET algorithms; the limitations of using field data for RS ET testing; the benefits of CIMEC ('Calibration using Inverse Modelling of Extreme Conditions') approaches to reduce impacts of bias in energy balance components.

- Furthermore, the time integration of RS ET data will be discussed, illustrating: the various methods to develop daily and monthly ET estimates from the ET provided on infrequent satellite over pass days; the role of reference ET (ETo) and ET/ETo ratios for interpolation; the importance of ETo and removal of biases in ETo from gridded weather data sets; linear vs. spline interpolation, etc.

- Special attention will be paid to the ET data accuracy and the acceptable limits of uncertainty in order to better fit the RS ET algorithms/models to specific purposes and applications.

- A key feature of this module is the contribution by the NENA-ET Network, with experiences from field ET measurements and preliminary comparison with RS ET determinations carried out in Countries from the NENA Region.

- The module will also include some examples of current applications of RS ET in various domains (e.g., water resources management, water rights management, irrigation management, and hydrologic water balances and accounting for sustainability).

- A final webinar will then be dedicated to reflections on the overall webinar series, the lessons learned and some suggestions for the way forward.

The webinars will be accompanied by 'suggested readings' to be provided sufficiently ahead of the webinar date, in order to allow the participants to read basic material and get prepared for an effective attendance and for preparing relevant questions during the discussion session.

Additional documentation will be prepared following the webinars series so that a set of 'Webinar Reports' will remain available on the web site, along with the recordings of the various sessions.

This webinar series is developed under the Sida funded regional project 'Implementing the 2030 Agenda for water efficiency/ productivity, and water sustainability in NENA countries'.

Project website: http://www.fao.org/in-action/water-efficiency-nena/en/

WATER
Efficiency, Productivity, and Sustainability
in the Near East and North Africa countries

A small brief about the Near East and North Africa Network on EvapoTranspiration (NENA ET-Net)

The NENA ET-Net is a Regional Network of specialized institutions with the objective to conduct field measurements of actual ET (ETa), over selected crops using field methods like lysimeters, eddy covariance, Bowen-ratio/energy-balance, and soil-water depletion, in order to evaluate the accuracy of existing Remote Sensing-based ET estimates. Established within the work programme of the FAO Water Scarcity Initiative (WSI) for the NENA Region, supported by the Sida Project, and coordinated by ICARDA, the NENA ET-Net intends to build common knowledge, standards and protocols on field ETa determinations and on accuracy assessments of RS ETa data, analyses and use for agriculture-related applications (e.g., water accounting, water productivity, water management, etc.). Initiated in 2019 with five countries (Egypt, Jordan, Lebanon, Morocco and Tunisia), the Network is expected to extend to other countries of the NENA Region and to become a valuable reference for field ETa determination among several institutions.

Near East and North Africa Regional Network For Evapotranspiration (ET)
NENA ET-Net

LIST OF SPEAKERS*

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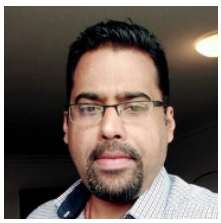

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Ihab Jnad

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*Additional speakers are joining at a later stage

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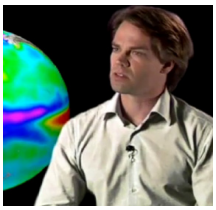

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