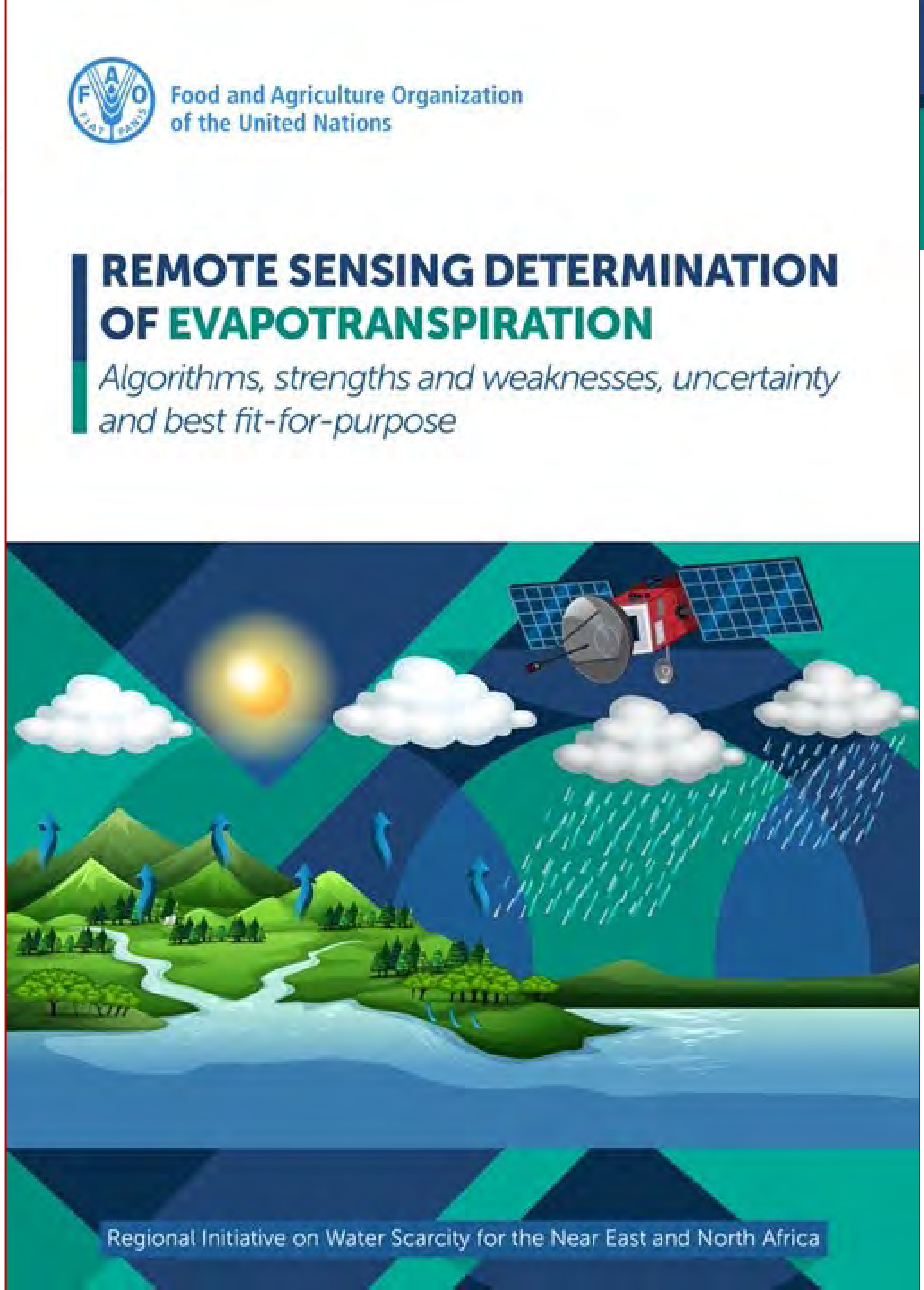
CAIRO WATER WEEK 2023

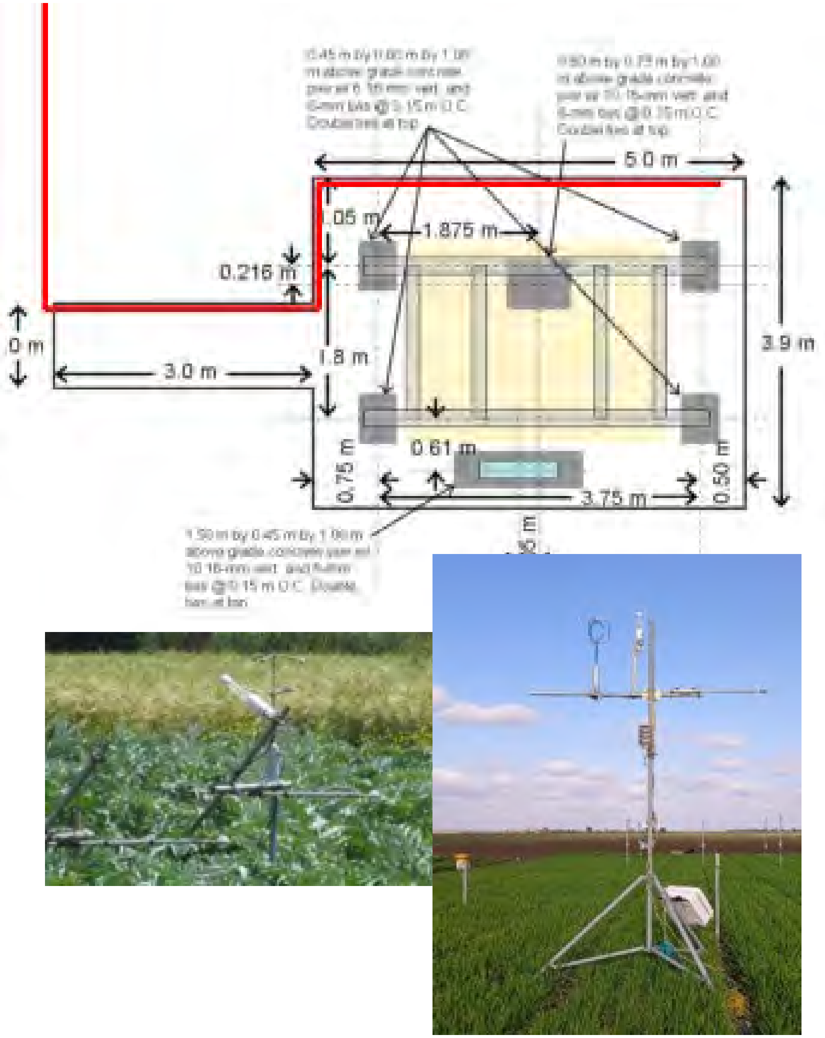


Launching

Evapotranspiration (ET)

- keystone climate variable linking the water, energy and carbon cycles
- represents nearly always the largest share of water outflow (consumption) from agricultural and other vegetated lands

Quantifying ET in space and time is therefore extremely relevant for several purposes in water resources management from national water accounting all the way to farm irrigation



Satellite remote sensing (RS) represents the most suitable method to capture the large variability in ET over extensive areas and over time

Though, the determination of ET through RS comes with *several challenges*, while ample and diversified RS models and platforms are provided

Users concerns with operational issues, including: appropriate spatial and temporal scales for given applications; accuracy; criteria for selecting RS ET data sources that best fits a given purpose; testing and validation of RS ET data

Objective of this publication is addressing these challenges and users' concerns

Two major enterprises undertaken:

- a series of 25 webinars
- the present publication (based on the webinars outcomes + further insights + enriched literature review >220 refs)

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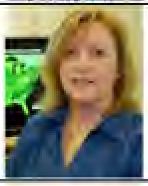	Martha C. Anderson	USDA Agricultural Research Service - Hydrology and Remote Sensing Laboratory Beltsville, Mariland, USA
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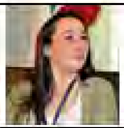
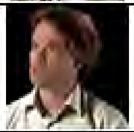
	Annemarie Klaasse	**eLEAF** Wageningen, The Netherlands
	Benjamin Koetz	**European Space Agency (ESA-ESRIN)** Frascati, Italy
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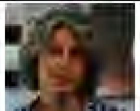	Livia Peiser	**FAO-HQ** (Food and Agriculture Organization of the United Nations)

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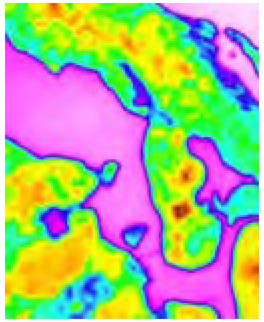
Content

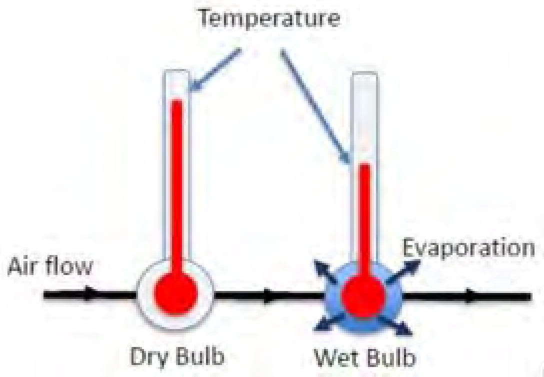
Introduction

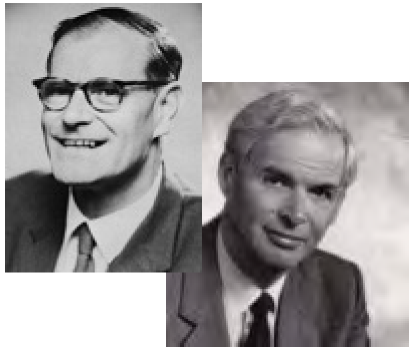
- The necessity to enter the new era of RS-ET
- Challenges
- How to respond

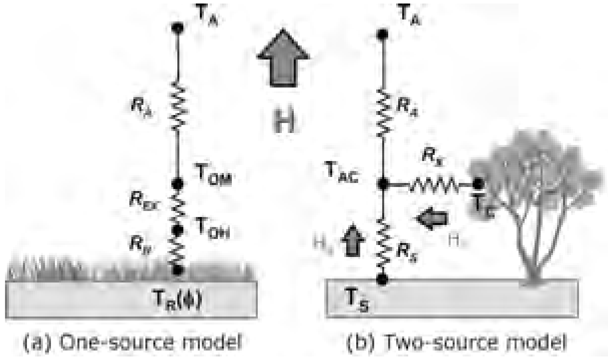
Background on the RS-ET Models



$$ET = \alpha \frac{\Delta}{\Delta + \gamma}(R_n - G)$$







- Theory
- Strengths
- Weakness

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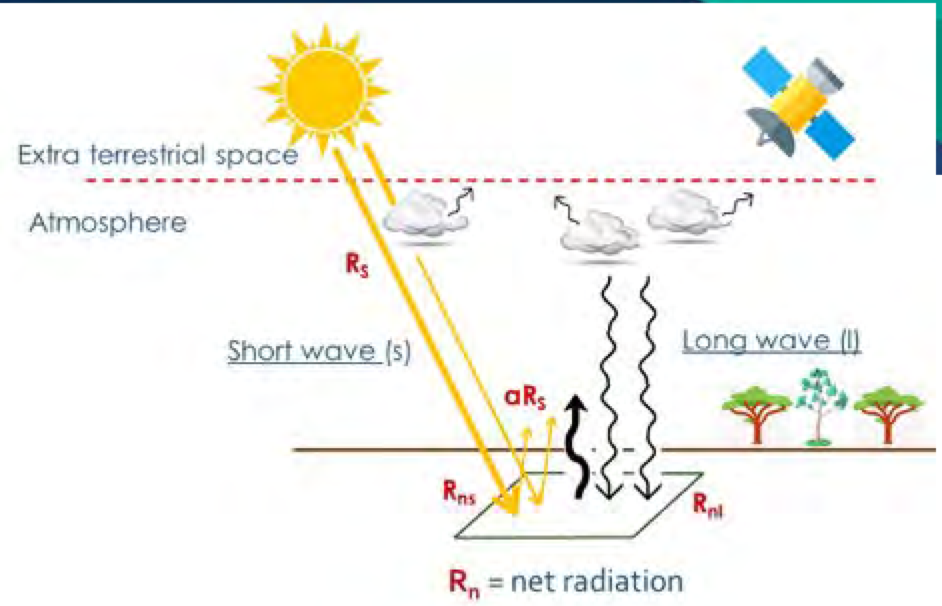
The RS-ET Models



SEBAL (Surface Energy Balance Algorithm for Land)

METRIC (Mapping ET at high Resolution with Internalized Calibration)

ALEXI – DisALEXI (Atmosphere-Land Exchange Inverse)

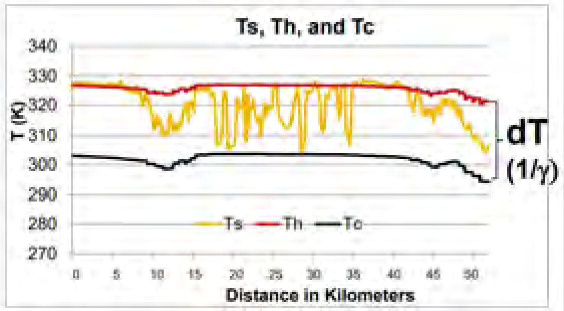
SSEBop (Simplified Surface Energy Balance – Operational)

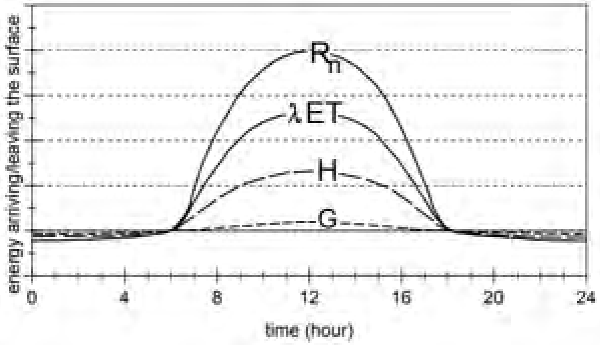
PT-JPL (Priestley-Taylor from Jet Propulsion Lab)

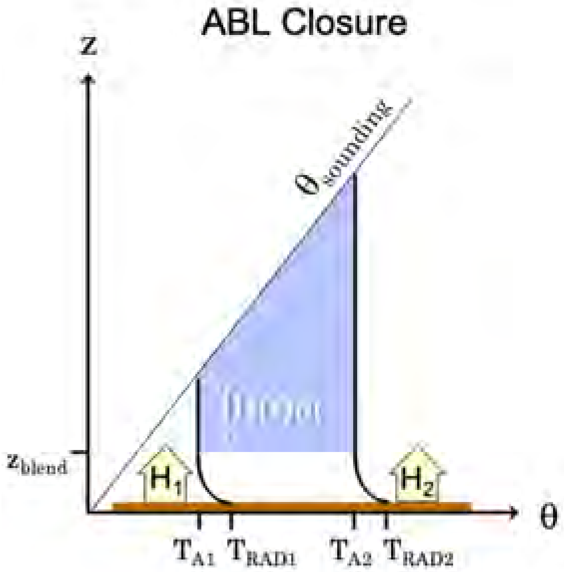
ETLook

ETMonitor

ETWatch







RS ET models are then compared

- Distinctive *features* and peculiarities (e.g., strengths, weakness, sensitivities)
- Output *spatial* and *temporal scales* (10, 30, 70, 375, 1000 m; 1, 2-5, 8 days)
- *Input variables* (e.g., LST, NDVI, albedo, cloud cover; elevation; wind ; etc.)
- *Satellite* data source (e.g., Landsat, VIIRS, MODIS, ECOSTRESS, Sentinel, etc.)
- Major *applications* (e.g., national water accounting, district water balance; on-farm irrigation; etc.)

RS ET Databases/Portals

FEWSN (USGS Famine Early Warning Systems Network, with ET data from SSEBop)

FEWS NET FAMINE EARLY WARNING SYSTEMS NETWORK

WaPOR (The FAO Water Productivity Open-access portal, with ET data from ETLook)

WAPOR

GloDET (Global Daily ET; with ET data from ALEXI)

GloDET Global Daily Evapo-Transpiration

EEFlux (Earth Engine ET Flux; with ET data from METRIC)

EEFlux

OpenET (with ET data from an ensemble of models, currently including SEBAL, METRIC, SSEBop, ALEXI-DisALEXI, PT-JPL and SIMS)

OPENET

RS ET database/portals are then compared

- Minimum *spatial* and *temporal resolutions* (30, 100, 250, 1000 m; 1, 10 days)
- *Geographical coverage* (e.g., by project, basin, regional, continental, etc.)
- *Latency* (e.g., 2-3 days, etc.)
- Major *use* (e.g., drought monitoring, national water accounting, water management; irrigation; water productivity; etc.)

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Some Field Applications

Experience from the NENA Region

- **Iran** with the use of SEBAL and METRIC
- **Jordan** with the use of SEBAL
- **Syria** with the use of WaPOR
- **Tunisia** with the use of ALEXI

SIMS (Satellite Irrigation Management Support)

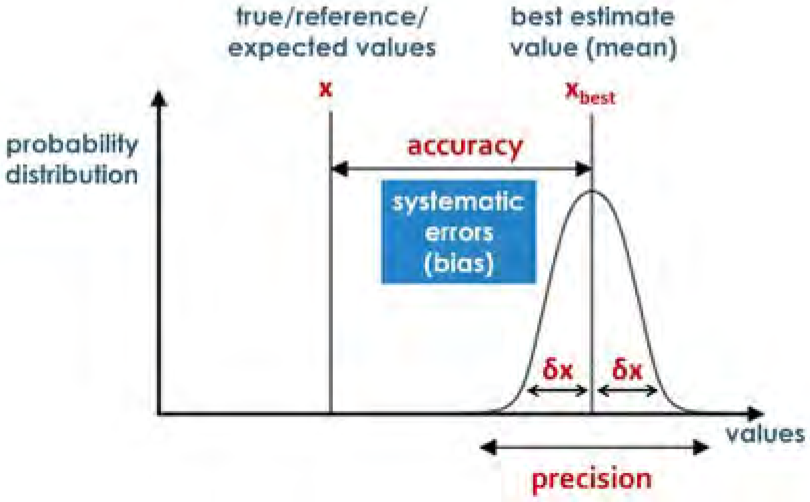
IrriWatch

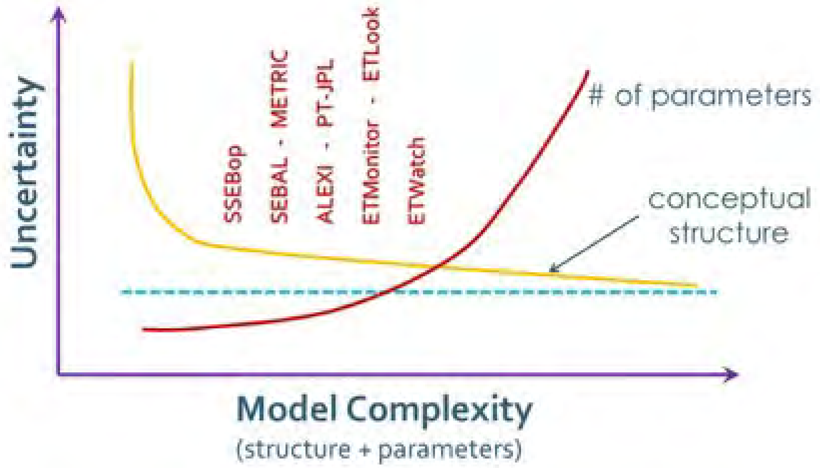
Uncertainty Review on RS ET Determination

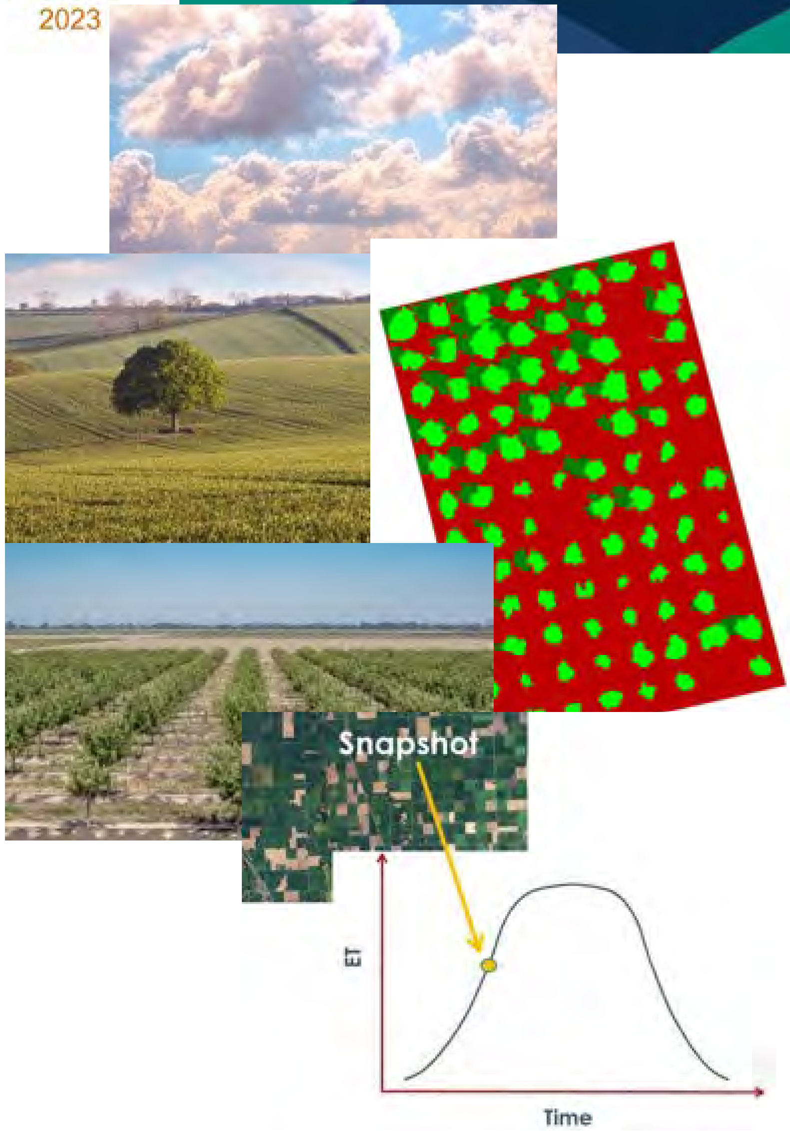
Methods addressing uncertainty analysis

Overview of the RS ET Models' uncertainty

Ways of inimizing errors







Different ***sources of error*** affecting the RS ET models:

- cloudiness and contamination of the atmosphere
- variability of the underlying land surface
- wind patterns
- vapor pressure of the atmosphere
- uncertainty of surface roughness
- atmospheric stability
- propagation and compounding of uncertainties due to computational procedures such as data fusion, data sharpening, could masking, gap-filling and time integration/interpolation.
- others (e.g., calibration of parameters)

Chapter on the acceptable limits of uncertainty depending on purpose

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Prospects for the near future

Towards higher spatial, temporal and spectral resolutions, and higher accuracy

ECOSTRESS

ECOsystem **S**paceborne **T**hermal **R**adiometer **E**xperiment on **S**pace **S**tation

Copernicus — Europe's eyes on Earth

Sentinel Satellite Constellation

Hydrosat

WAPOR Phase II

Concluding Remarks

The *purpose* for which the ET data are going to be used is the *primary determinant* in the selection of a suitable RS ET models and Platforms *(>> scales; one/two-sources; acceptable uncertainty, etc.)*

In turn, the assumptions, theory and data sources will be the *further determinants* in the selection of a suitable RS ET models and Platforms *(>> representation of local conditions; exposure to errors, etc.)*

The likelihood to obtain accurate ET with any RS model is with mostly uniform landscape *(e.g., flat and extensive field crops)* and fairly even meteorological conditions *(e.g., clear sky, moderate wind, etc.)*

The likelihood to obtain accurate ET is reduced with irregular landscape *(e.g., variable elevation, slope, aspect, vegetation cover)* and substantially uneven meteorological conditions *(e.g., cloudiness, fluctuating wind speed, etc.)*. The ET accuracy will depend on the specific model and how well it is able to capture the local conditions (uncertainty varies in space and time)

It is part of the research nature to describe and project models in the most positive ways and present comparisons that show the most promising results

Though, estimation of error and bias is imperative to the acceptance and adoption of remotely derived estimates of ET into operational practice

Therefore, a way to proceed is to always perform some tests, comparing model and/or platform ET data with some 'references' *(e.g., trusted field measurements of ET; inter-comparison with higher-standard models, etc.)*, considering that these 'references' have in turn their own limitations

We need to appreciate that the complexity of the systems we are dealing with cannot be a justification for not becoming more aware of such RS technologies, their benefits, challenges, and limitations

We cannot proceed blindly into the decision-making process involving the sustainable management of such a precious resource as water

The new missions and technology of satellites are unfolding at a rapid pace so that RS applications are broadening, accuracy is increasing, and spectral, temporal and spatial resolutions are becoming more granular

Thus, the future of RS ET determination appears to be bright, offering continuously new opportunities

It is upon the user to move on these opportunities wisely

Access

The Publication can be downloaded at the following links

www.fao.org/documents/card/en/c/cc8150en

http://www.fao.org/3/cc8150en/cc8150en.pdf

https://doi.org/10.4060/cc8150en

Recording of the Webinar series can be found at the following links

https://www.fao.org/in-action/water-efficiency-nena/webinars/rs-et/es/

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THANK YOU

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