

Evapotranspiration (1/9)



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In 2023, the New ET subgroup has been established

- The increasing number of available ET products underscores the need for a concerted effort in defining the standards and protocols for validation and evaluation exercises.*

Evapotranspiration (2/9)

Remote Sensing Based ET Algorithms:

Energy Balance

$$\text{Available energy} \\ \lambda E = (R_n - G) - H$$

Penman-Monteith

$$\lambda E = \frac{\Delta (R_n - G) + \frac{\rho_a C_p (e_s - e_s RH)}{r_a}}{\Delta + \gamma \left(1 + \frac{r_s}{r_a}\right)}$$

and many variations

Priestley-Taylor

$$\lambda E = \frac{\Delta}{\Delta + \gamma} (\lambda E_n - \lambda E)$$

Psychrometric

$$ETf = 1 - \gamma^S (T_s - T_c)$$

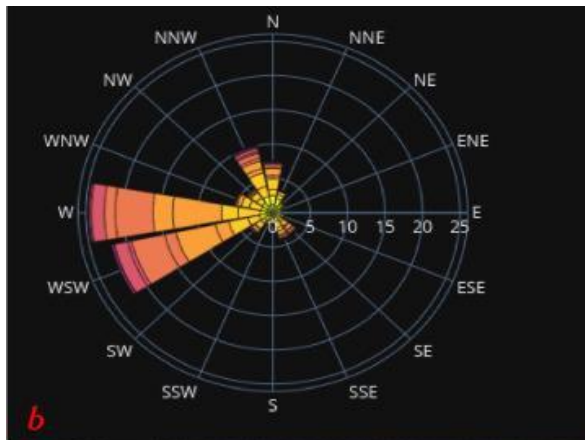
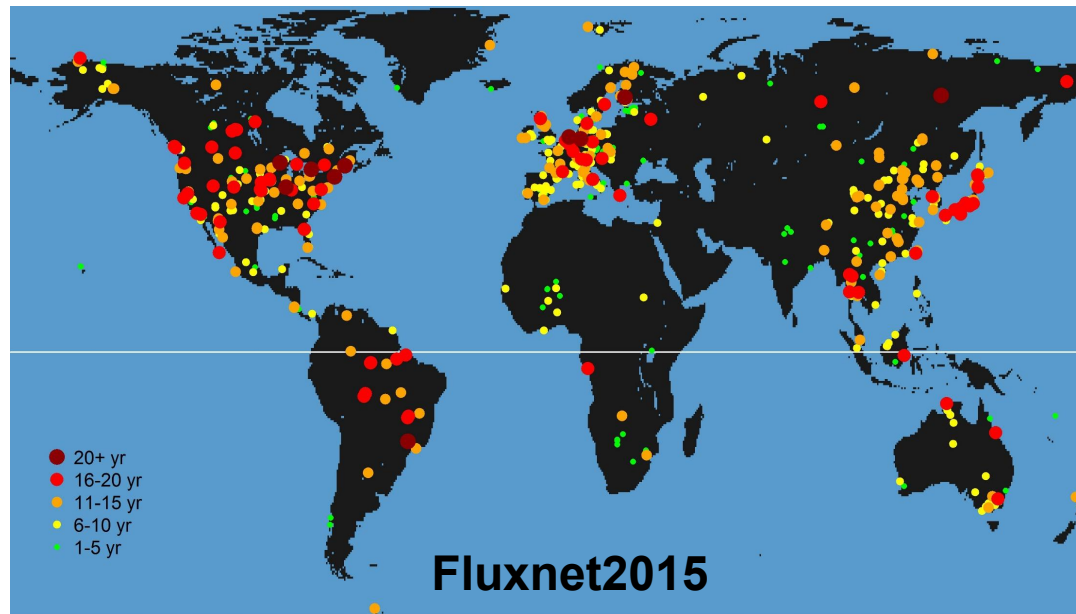
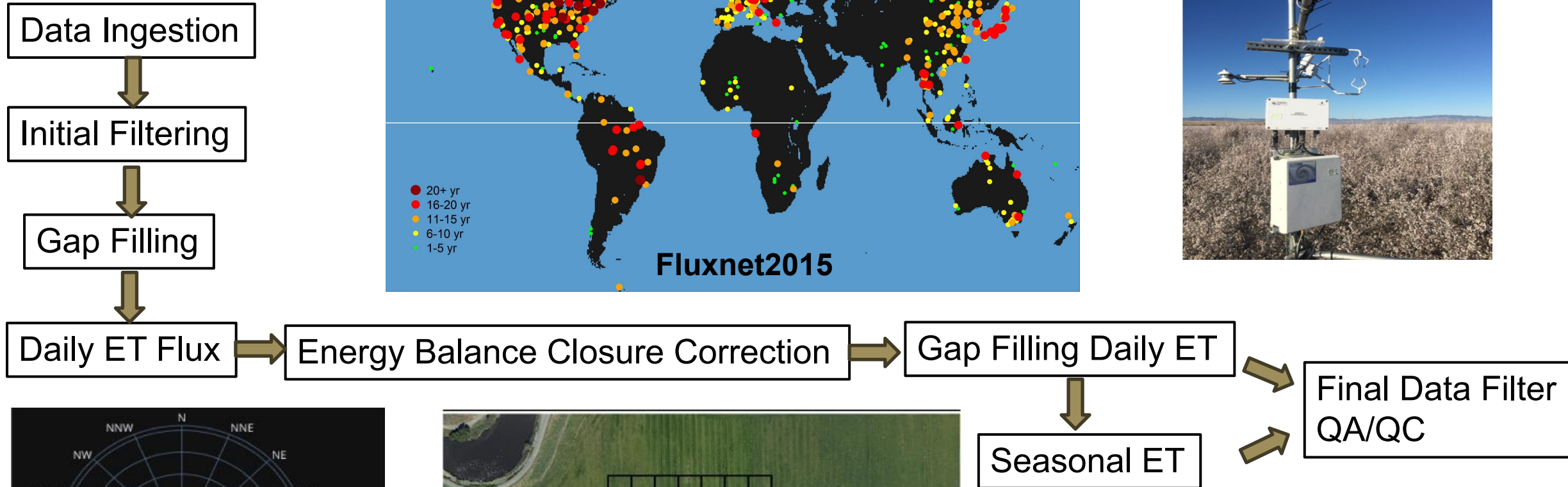
Reflectance-Based

$$\lambda E = \frac{\Delta}{\Delta + \gamma} (\lambda E_n - \lambda E)$$

$$\lambda E = \lambda E_n \times \lambda E$$

Group	Module	Spatial Resolution	Inputs	Data Source	Coverage	Reference
Energy balance	ALEXI/DisALEXI	~4km (ALEXI) 30m (DisALEXI)	^a Surface reflectance, ^b Thermal radiation, ^c Land cover data, ^d Meteorological variables	^a Landsat, MODIS; ^b GOES (ALEXI) and Landsat (DisALEXI); ^c NLCD; ^d CFSR	CONUS/Global	Anderson et al. (2007, 2018)
	eeMETRIC	30m	^a Surface reflectance, ^b Thermal radiation, ^c Land cover data, ^d Meteorological variables, ^e DEM, ^f Soil data,	^{a, b} Landsat; ^c NLCD (for USA) GlobCover (for the globe); ^d CIMIS, NLDAS, CFSV2, gridMET; ^e SRTM; ^f SURGO (USA) and FAO Harmonized World Soil Database v 1.2 (globe)	CONUS	Allen et al. (2005, 2007, 2011); Kilic et al. (2021)
	geeSEBAL	30m	^a Surface reflectance, ^b Thermal radiation , ^c Land cover data, ^d Meteorological variables, ^e DEM,	^{a, b} Landsat; ^c CDL; ^d gridMET and NLDAS; ^e SRTM	CONUS/Brazil	Bastiaanssen et al. (1998); Laipelt et al. (2021)
Penman-Monteith	ETMonitor	1km	^c Land cover data, ^d Meteorological variables, ^e DEM, ^f Surface soil moisture, ^g Land surface albedo, ^h LAI, ⁱ Fractional vegetation cover, ^j Precipitation, ^k Canopy height	^c MODIS; ^d ERA5; ^e SRTM; ^f ESA CCI; ^{g, h, i} GLASS; ^j GPM; ^k GLAS	Global	Hu & Jia (2015) Zheng et al. (2022)
Priestley and Taylor	PT-JPL	70m/1km	^a Surface reflectance (NDVI, SAVI), ^b Thermal radiation, ^d Meteorological variables, ^f fAPAR	^{a, b} Landsat; ^b ECOSTRESS; ^d CIMIS and NLDAS; ^f MODIS	CONUS	Fisher et al. (2008)
Psychrometric	SSEBop	30m	^b Thermal radiation, ^d Meteorological variables, ^e DEM, ^f NDVI,	^{b, f} Landsat; ^e SRTM; ^d CIMIS and gridMET;	CONUS/Global	Senay et al. (2013, 2022, 2023); Senay (2018)
Reflectance-based	SIMS	30m	^a Surface reflectance, ^c Land cover data, ^d Meteorological variables	^a Landsat, MODIS, Sentinel-2A/2B, S-NPP VIIRS; ^c CDL and state crop mapping data products; ^d CIMIS and gridMET	CONUS	Melton et al. (2012); Pereira et al. (2020)
	CMRSET	30m	^a Surface reflectance (EVI, GVMi), ^d Meteorological variables	^a Landsat, MODIS, S-NPP VIIRS , Sentinel-2A/2B; ^d Australia Bureau of Meteorology	Australia	Guerschman et al. (2022)

Flux Tower



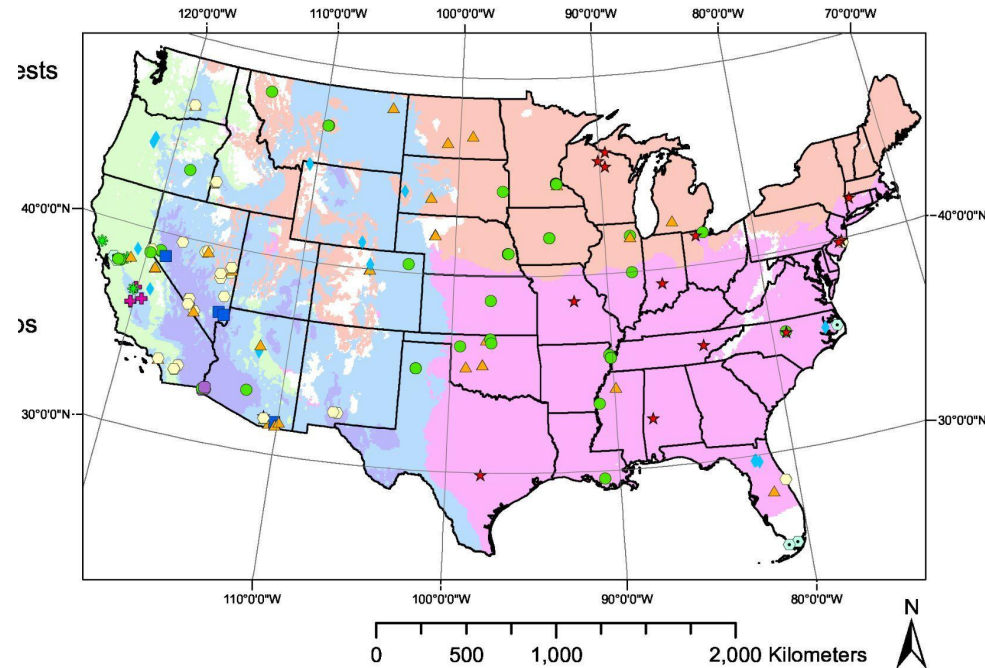
Volk et al., Agricultural and Forest Meteorology, 2023

OpenET Effort

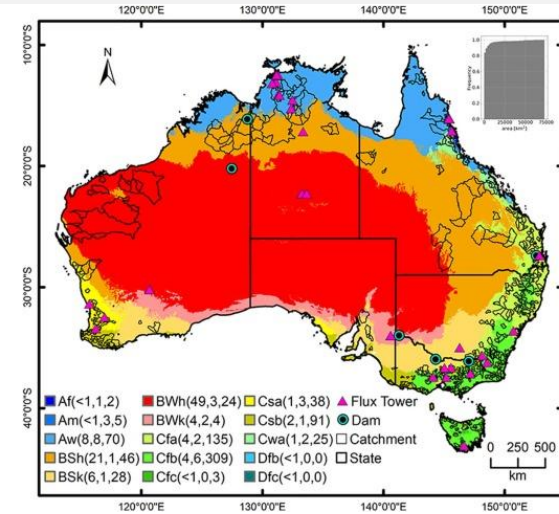
Energy Balance Closure Issue – AGU Chapman Meeting in September 2025 at Denver, CO

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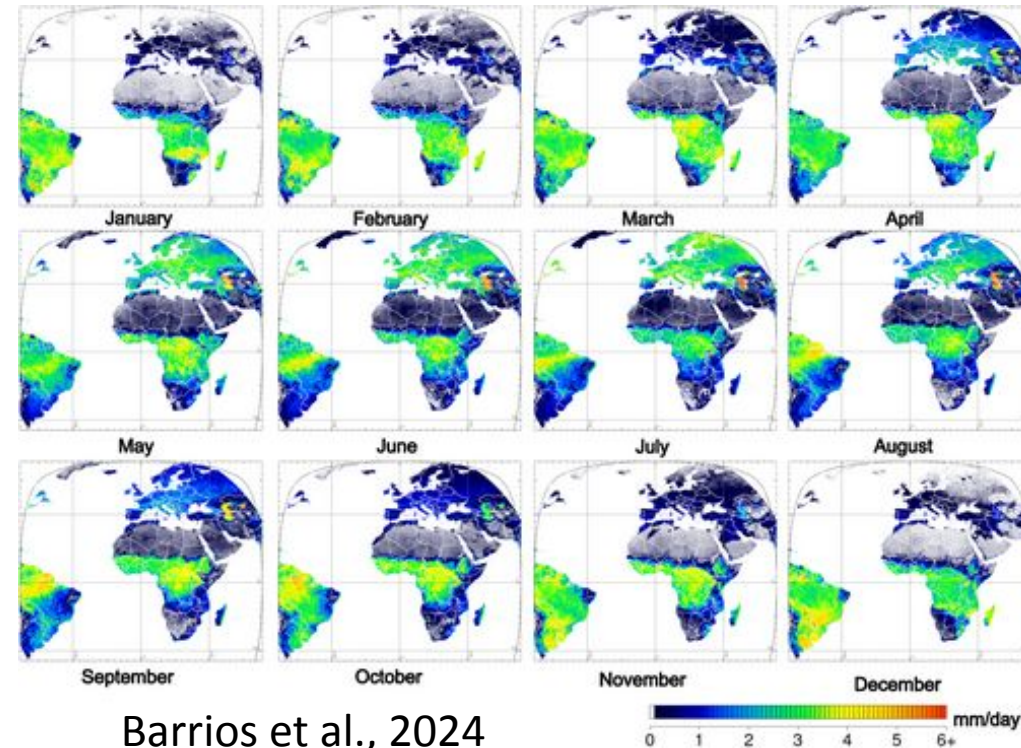
Evaluation with Flux Tower Observations



Volk et al., 2024



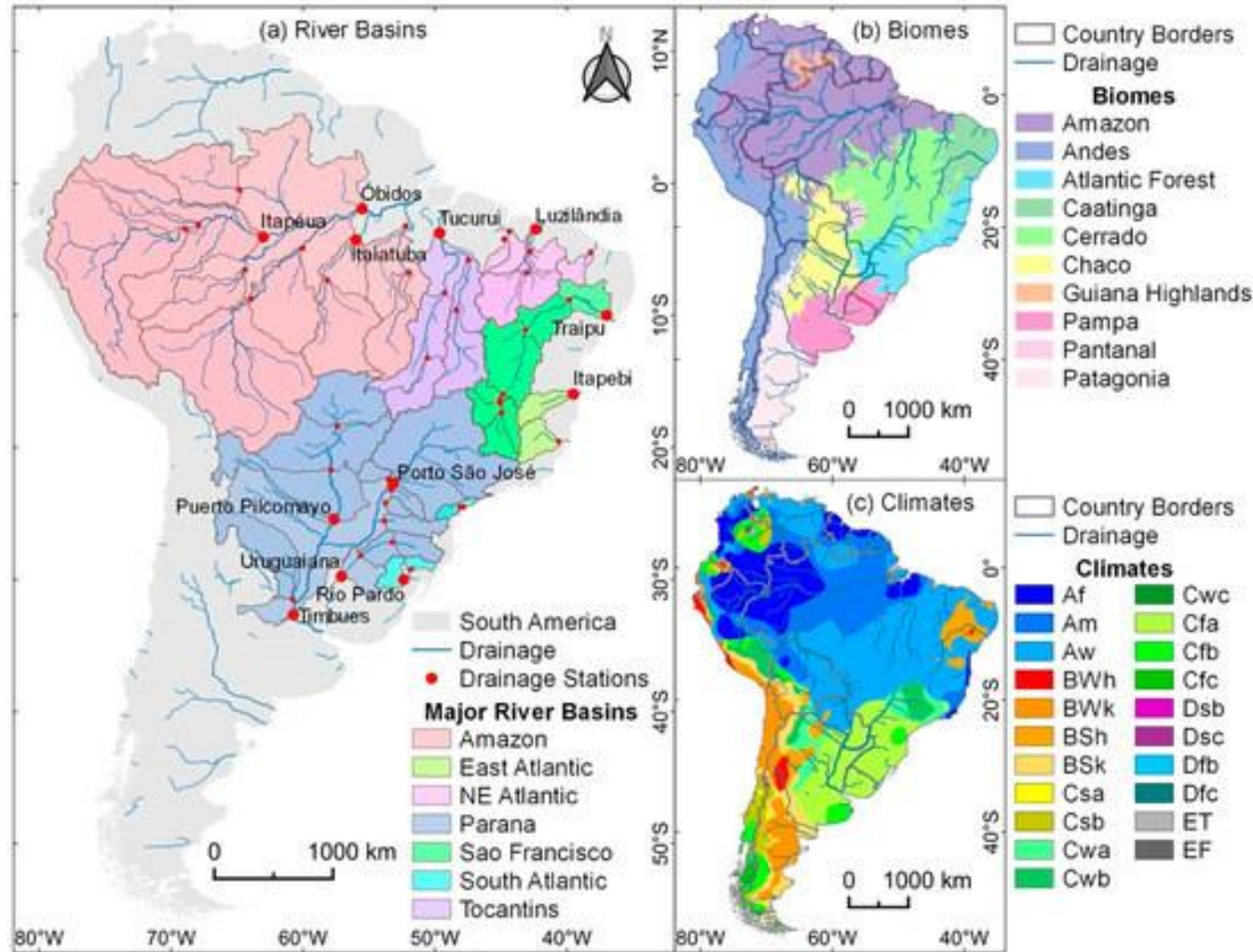
Guerschman et al., 2022



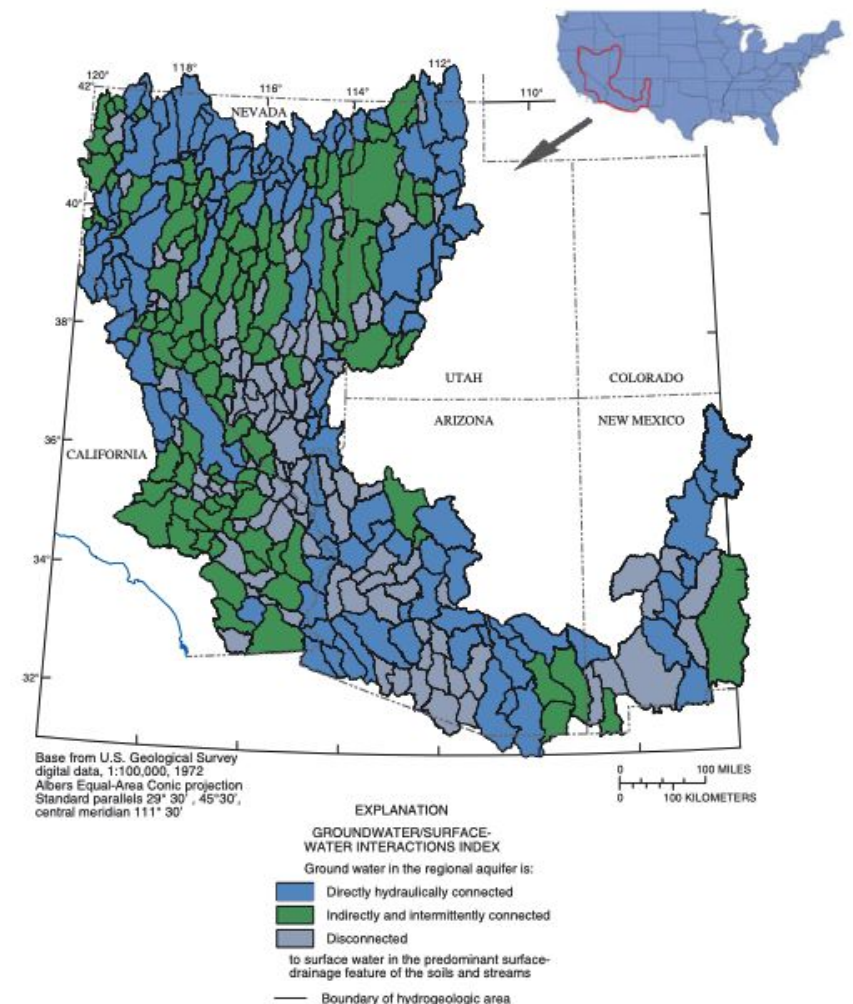
Barrios et al., 2024

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Evaluation with Water Balance Method



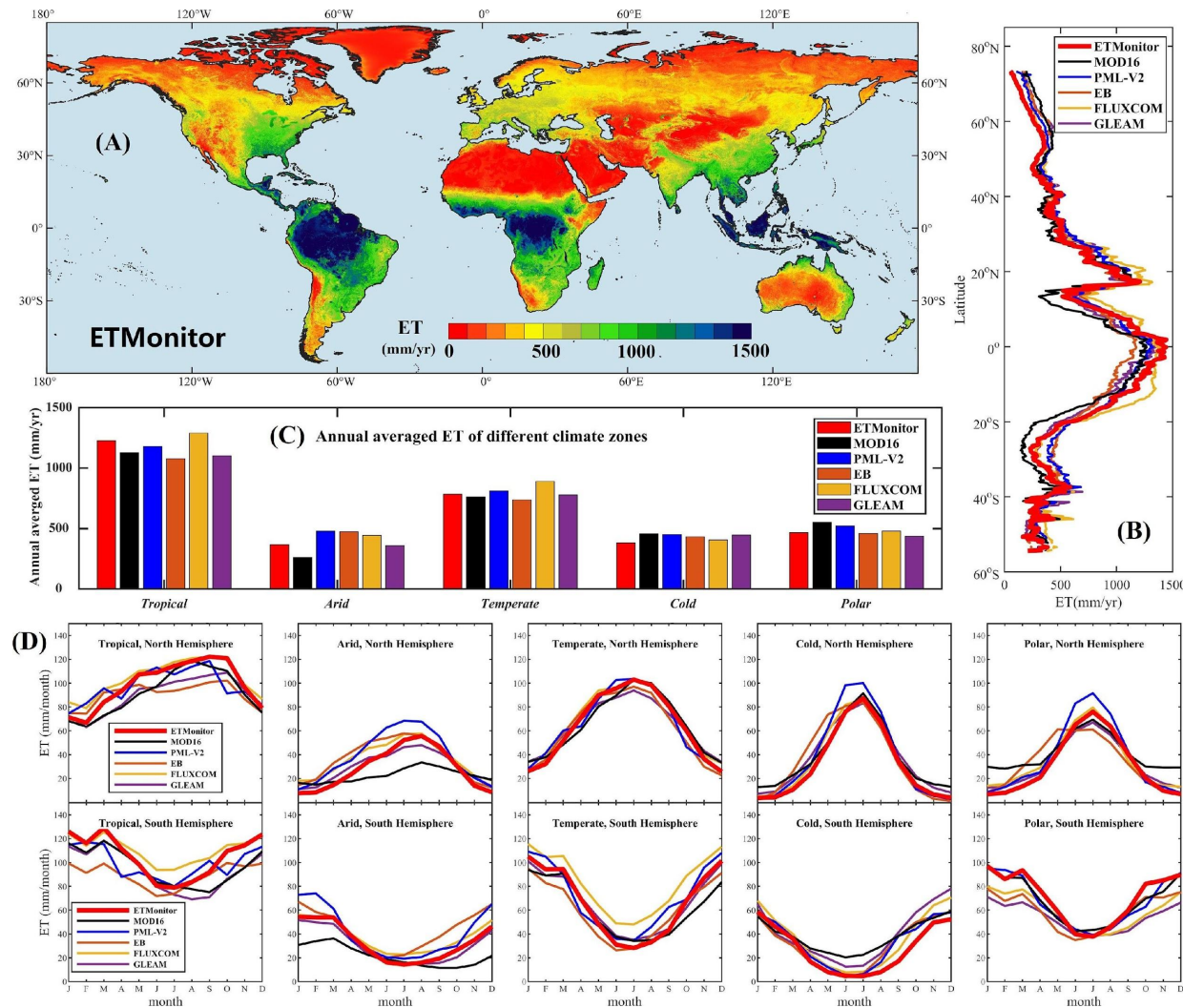
Ruhoff et al., 2022



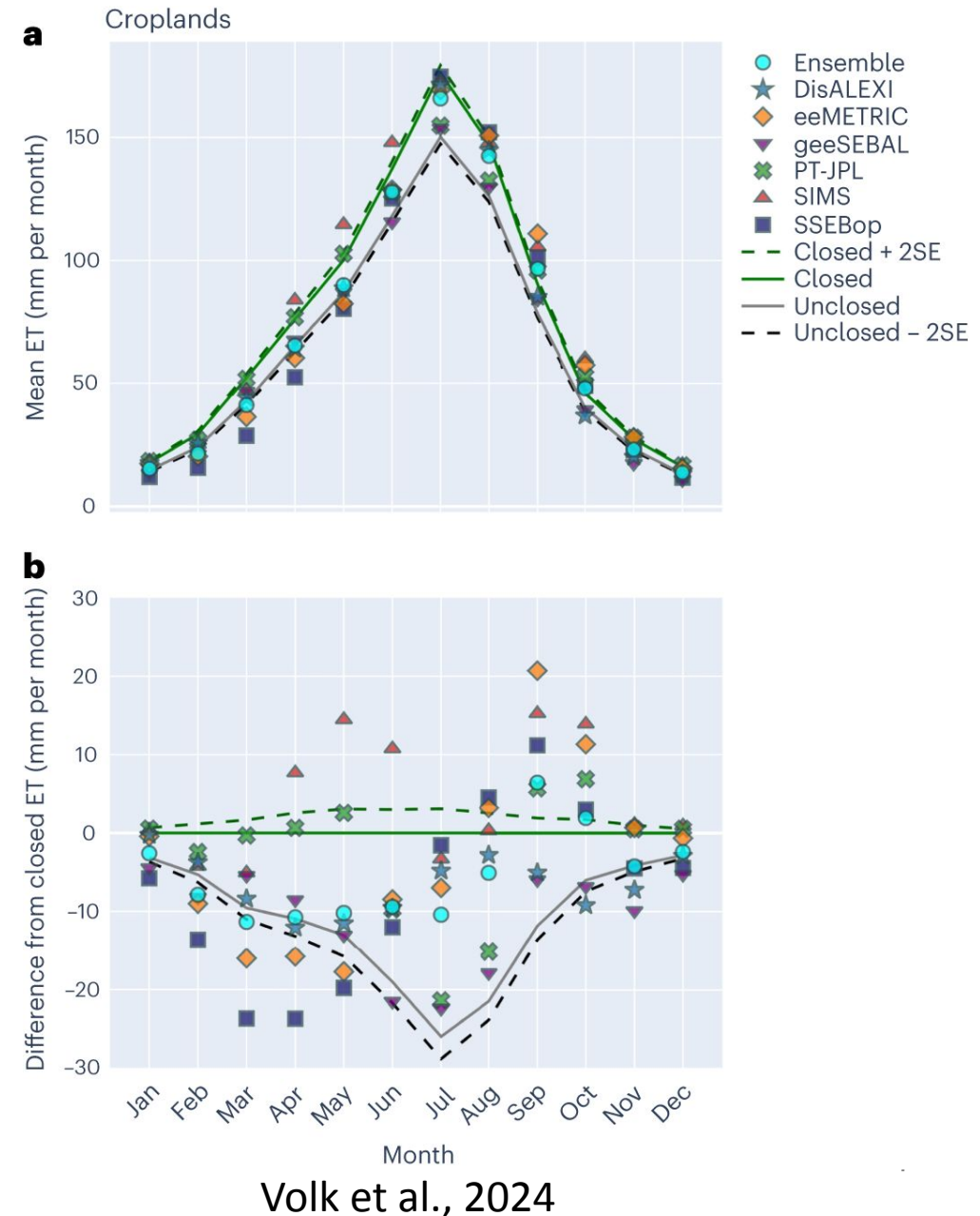
Senay et al., 2011

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Evaluation Comparing with Other Models



Zheng et al., 2022



Volk et al., 2024

Evapotranspiration (8/9)

Updates:

- *ET webpage went alive online*
- *ET product list version 1*
- *ET contact list version 1*
- *ET validation protocol outline*

Outreach:

- *AGU presentation at the LPV session in December 2024*
- *EGU presentation in April 2025*
- *Group of ET scientists (~20) from various continents involved in the process*

Focus Area on Evapotranspiration Product Validation

Yun Yang, Cornell University, USA
Carmelo Cammalleri, Politecnico di Milano, Italy



Evapotranspiration Definition

Evapotranspiration (ET) is the water transferred from the land surface to the atmosphere, which includes evaporation from the soil and other surfaces, and transpiration from plants. ET is an essential part of the water cycle and plays a critical role in weather and climate patterns. It is also a key factor in agriculture related to crop condition monitoring and irrigation scheduling and in forest related to forest health, drinking water supply and other ecosystem services.

Units:

Evapotranspiration is expressed in units of mm/time-step. The time-step can vary from hourly, daily, monthly, annual and multi-years. The associated latent heat is expressed in units of energy flux density (commonly referred to as energy flux), for example W/m².

Highest Validation Stage Currently Reached for Satellite-Derived ET Products

Validation stage 2 (LPV validation stage hierarchy) - Validation stage 2 - The highest LPV validation stage reached for satellite-derived evapotranspiration products.

Validation Good Practices

Evapotranspiration (9/9)

Next Steps:

- *Better define satellite-ET products (Definition)*
 - *Email exchange and online workshop – after we send out the outline, Fall 2025*
- *Continue refining ET product list and ET contact list through the process*
- *ET validation protocol extended outline – End of 2025 Summer*
- *Seek feedbacks for the protocol outline from the group – End of 2025*

Long-term:

- *Energy balance closure issue with flux tower observations*
- *More validation sites over the areas that currently have limited number of sites*
- *Preparing for the potential upcoming ET product (commercial satellite, new missions)*