Validation of the new CLMS Actual Evapotranspiration and Heat Fluxes product

Land Monitoring

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9th Sentinel-3 Validation Team Meeting
30 March - 1 April 2026, ESA-ESRIN, Frascati, Italy

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Copernicus ETA and HF product

New ETA and HF product released in December 2025

https://land.copernicus.eu/en/products/evapotranspiration

Copernicus Europe's eyes on Earth

Land Monitoring Service

CLMS portfolio | Dataset catalogue | Data viewer | Use cases

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CLMS unveils new evapotranspiration products

09.12.2025

What if we could read the landscape the way an experienced farmer does, sensing how much water plants draw from the soil, how heat moves across the ground, and how energy shifts between the land and the atmosphere? With the new Evapotranspiration (ET) and Heat Flux products from the Copernicus Land Monitoring Service (CLMS), this level of understanding is now within reach.

Why evapotranspiration is a game changer

Actual evapotranspiration is not just another measurement, it is a powerful indicator of the planet's health. Recognised by the Global Climate Observing System (GCOS) as an Essential Climate Variable (ECV), ET is fundamental for analysing the global water and energy cycles. It is also a direct indicator of plant water use, making it indispensable for monitoring progress toward

Copernicus ETA and HF product

New ETA and HF product released in December 2025

- 300m resolution, global, near real-time
- Dekadal actual evapotranspiration (ET), Transpiration (T) and Evaporation (E)
- Instantaneous latent (LE) and sensible (H) heat flux
- Biophysical parameters (LAI, albedo, …) + drivers (LST) derived from Sentinel 3 OLCI and SLSTR sensors
  - Note: existing CLMS LAI and C3S albedo products were not used

Irrigation in Wadi Sirhan basin, Saudi Arabia

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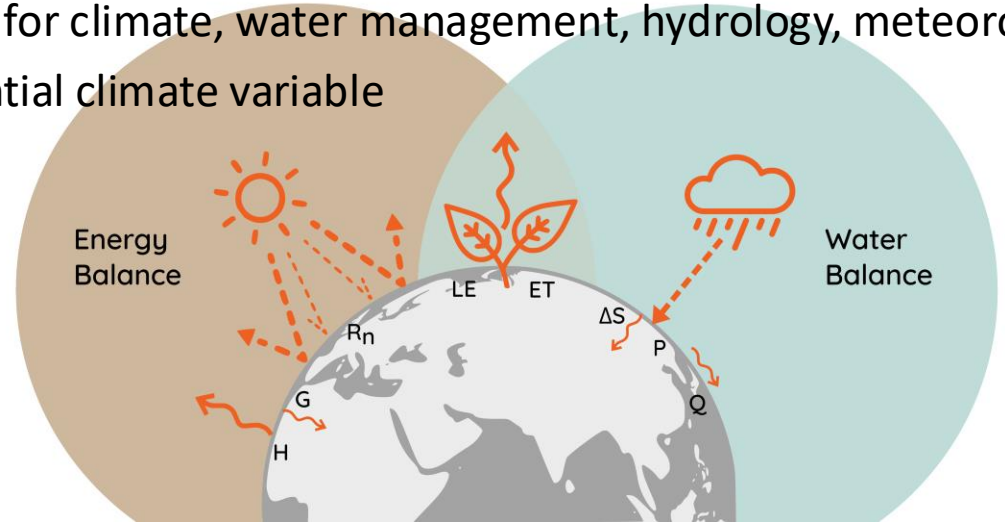
Evapotranspiration

- Water evaporated from land surface
  - Evaporation: from bare soil
  - Transpiration: via vegetation canopy (through stomata)
- Key component of water cycle
  - Roughly 65% of all precipitation over land
- Nexus of water, energy and carbon cycle
- Monitoring for climate, water management, hydrology, meteorology, …
- GCOS essential climate variable



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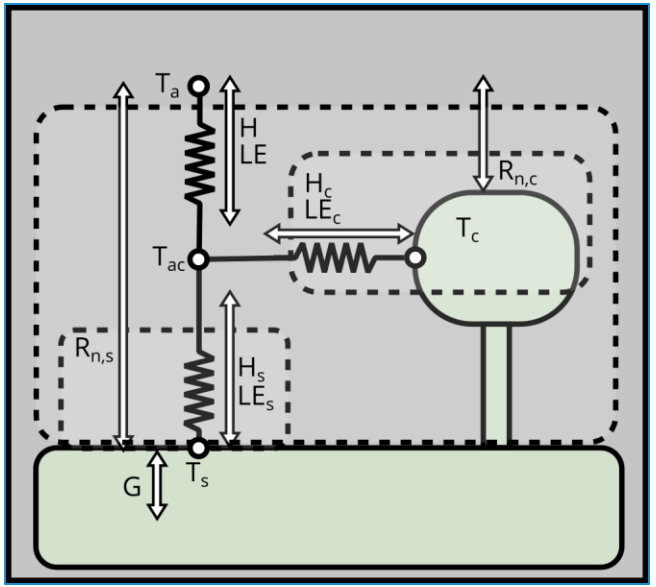
CLMS ETA product

Ensemble of 2 models: ETLook and TSEB-PT

TSEB-PT

- Two-Source Energy Balance (Norman et al., 1995)
- Used in Sen-ET framework (Guzinski et al., 2020)
- Open source release pyTSEB (Nieto et al., 2025)
- Computes energy balance, based on LST



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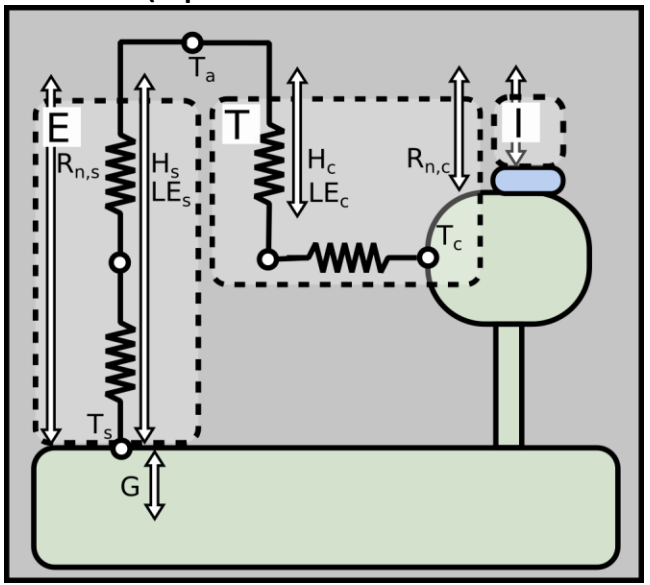
CLMS ETA product

Ensemble of 2 models: ETLook and TSEB-PT

ETLook

- Potential ET via Penman-Monteith and down-throttling with stress factors (Bastiaanssen et al., 2012)
- Modified and used in the WaPOR framework from FAO (open source codebase)
- Soil moisture via LST-Fc Trapezoid method



(intercepted water not considered in CLMS ETA)

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Data sources

Key remote sensing input from Sentinel 3:

Data Type	Sensor/Model	Product	Source	Res.
Thermal imagery	Sentinel-3 SLSTR	SL_2_LST	Copernicus Data Space Ecosystem	~1 km
Shortwave imagery	Sentinel-3 OLCI + SLSTR	cgl_TOC v2.3.4	Copernicus Land Monitoring Service	300 m
Meteorological data	ECMWF IFS	CAMS global atmospheric composition forecasts	Copernicus Atmosphere Monitoring Service	0.4°
Landcover map	PROBA-V (Sentinel-2)	Global Dynamic Land Cover 2019	Copernicus Land Monitoring Service	100 m
Digital elevation model	TanDEM-X	Copernicus DEM	Copernicus Data Space Ecosystem	90 m
Canopy height map	GEDI LiDAR + Sentinel-2	ETH_GlobalCanopyHeight_10 m_2020_version1	ETH Zurich	10 m

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Preprocessing

- S3 cloudmasking & filtering on VZA < 45 degrees
- Biophysical traits: vectorized PROSPECT-D (Féret et al., 2017) + 4SAIL (Verhoef et al., 2007) RTMs
- SWrad + albedo (soil / canopy): Campbell & Norman (1998) RTM
- LST sharpening: Data mining sharpener (Gao et al., 2012)
- Meteo processing
- Structural + ancillary parameters

Group	Variable
Biophysical Parameters	Leaf Area Index (LAI)
	Fraction of LAI that is green
	Mean leaf inclination angle (LIDF)
	Leaf PAR reflectance
	Leaf PAR transmittance
	Leaf NIR reflectance
	Leaf NIR transmittance
Soil Properties	Soil PAR reflectance
	Soil NIR reflectance
Canopy structure	Canopy height
	Fractional cover of clumped canopy
	Canopy width to height ratio
	Effective leaf size
	Maximum stomata conductance

Group	Variable
Boundary condition	Land surface temperature
Weather	Air temperature
	Wind speed
	Water vapour pressure
	Surface pressure
	Direct PAR irradiance
	Diffuse PAR irradiance
	Direct NIR irradiance
	Diffuse NIR irradiance
	Longwave irradiance
	Daily shortwave irradiance
	Daily reference ET
	Daily precipitation

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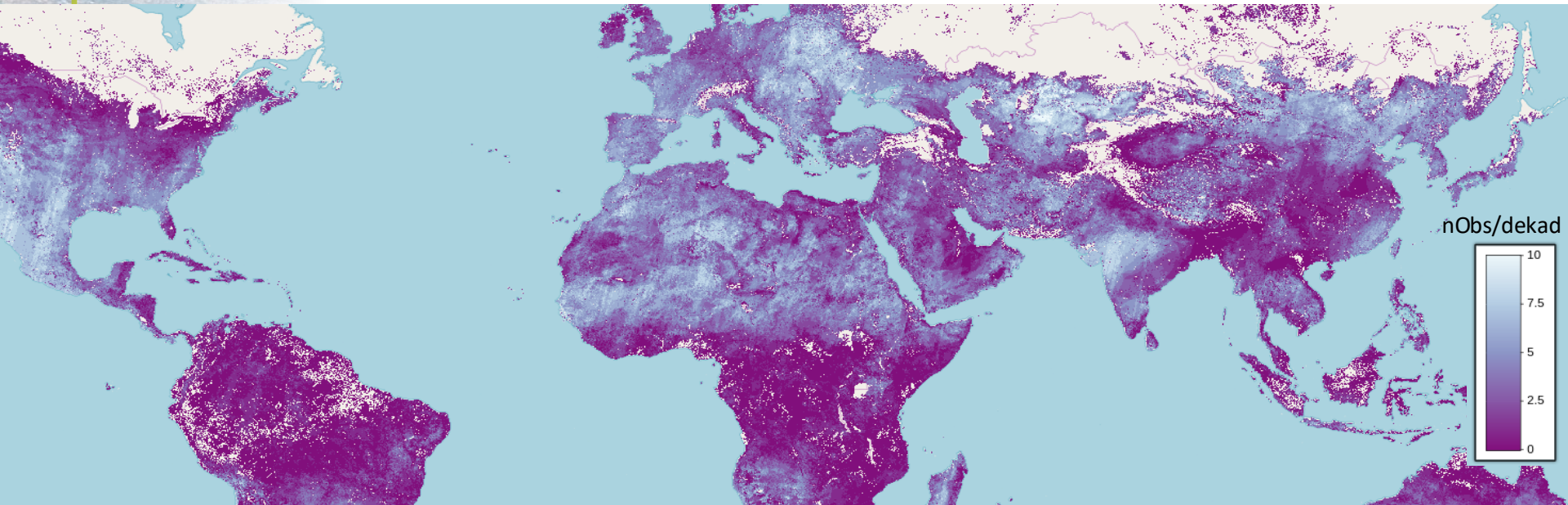
Postprocessing

Only for dekadal ETA variables

- Output (temporal) gapfilling
  - Using scaled reference ET and precipitation
- Temporal compositing



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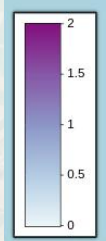
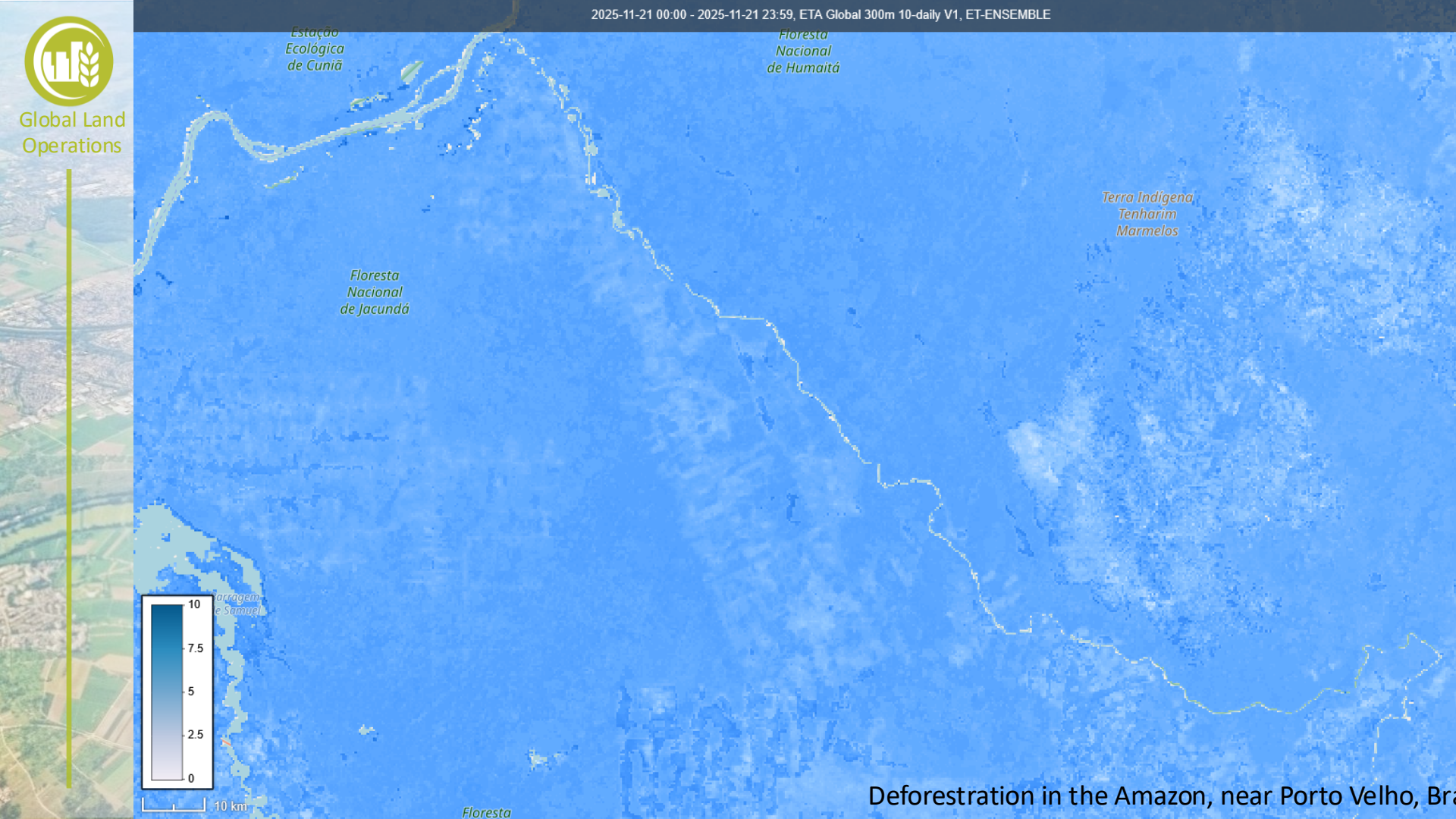
2026-03-11 00:00 - 2026-03-11 23:59, ETA Global 300m 10-daily V1, ET-STD



Data available in CDSE browser
https://dataspace.copernicus.eu/



Deforestration in the Amazon, near Porto Velho, Bra

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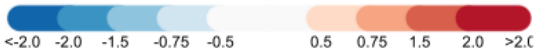
ETLook vs TSEB

- ET: fair agreement
  - Differences usually < 1 mm/d
  - No clear patterns

Evapotranspiration

01/01/2021

01/07/2021



Difference ETLook – TSEB-PT

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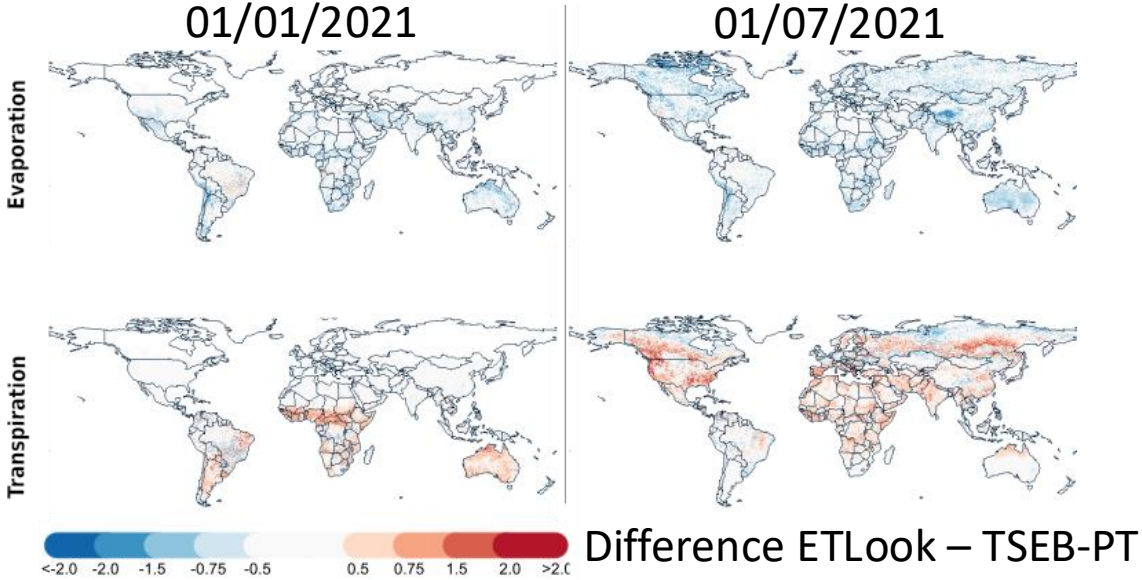
ETLook vs TSEB

- ET: fair agreement
- Clear Differences in partitioning:
  - T higher in ETLook (in regions with high vegetation cover)
  - E higher in TSEB-PT (mostly in arid regions)



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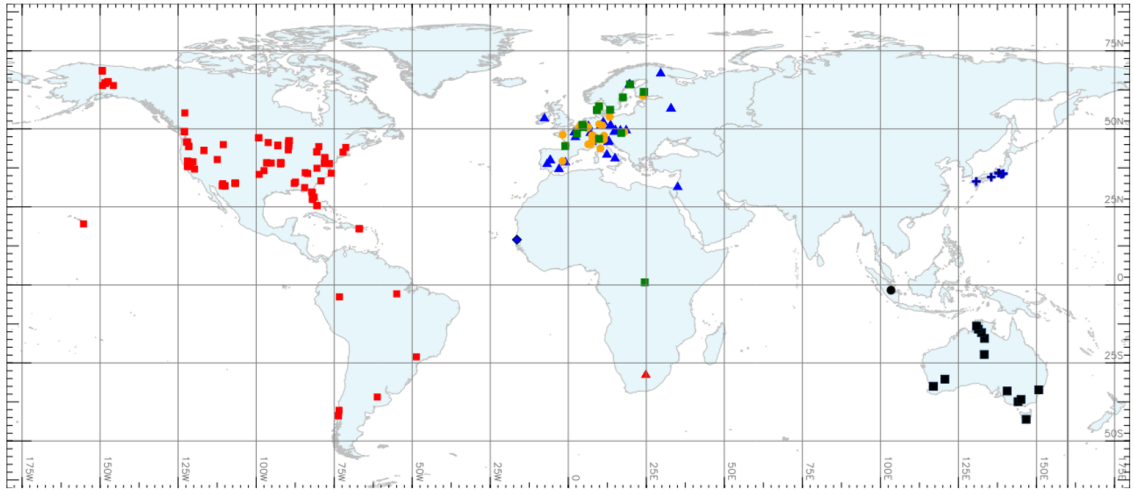
Direct validation

- Eddy covariance data
  - 206 stations, covering 2020-2022, totalling ~13000 records of decadal ET
  - Energy balance closure correction in most sites, dataset extended with non-EBC corrected sites to increase global coverage
  - Validation limited to ET, LE and H (not T and E partitioning)



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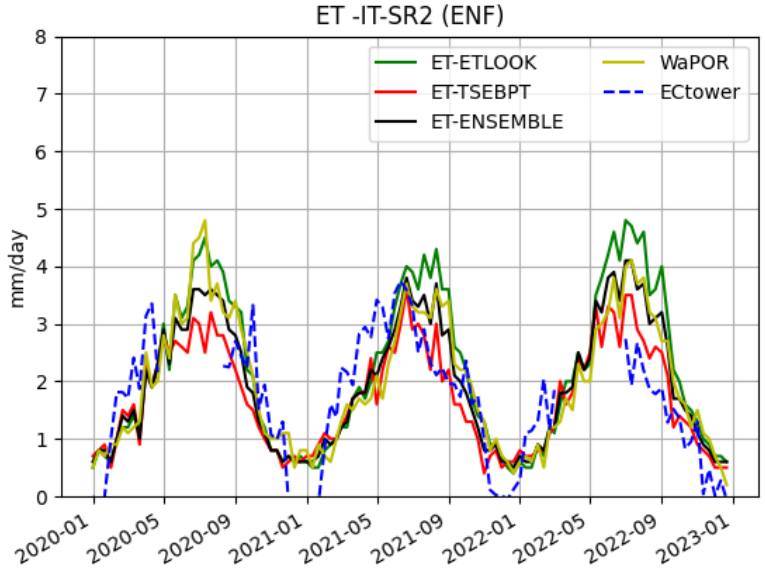
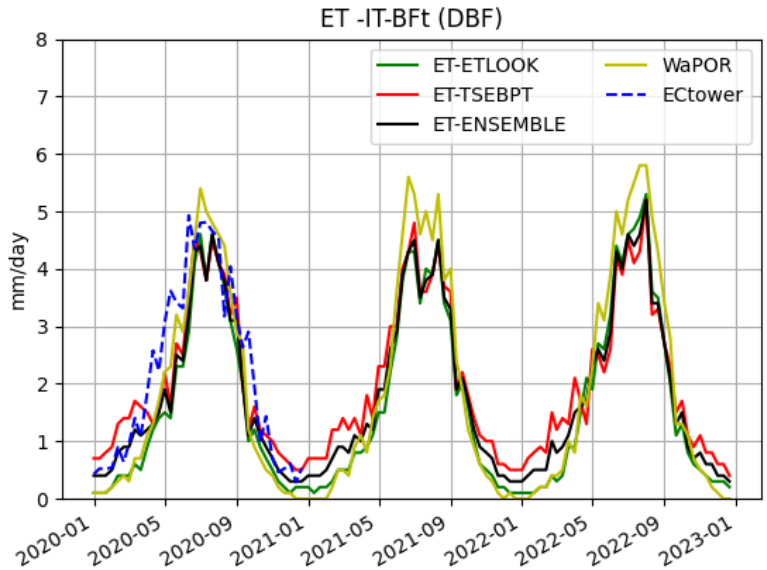


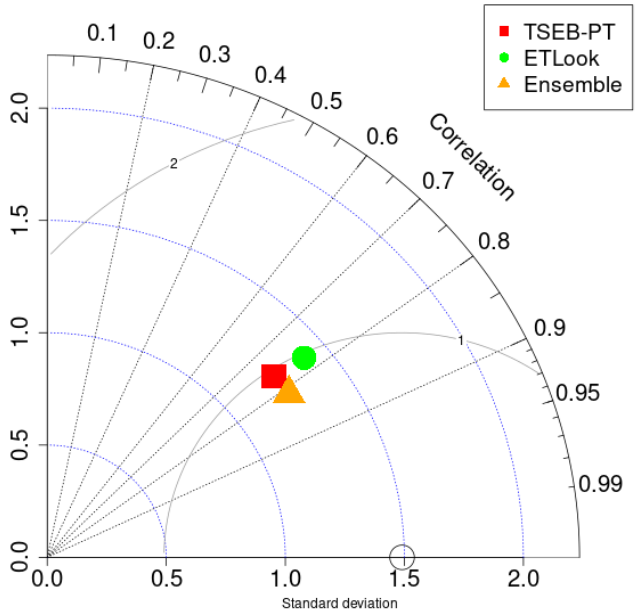


Global Land Operations

Global statistics ETA

- High correlation (r > 0.75) with in situ data for all models
- Ensemble outperforms individual models
  - significantly higher r, lower RMSE and smaller bias
- The bias of all three datasets is small (relative bias below 4%) with Ensemble showing negligible bias

All sites together							
Dataset	**RMSE**	**bias**	**rRMSE**	**rBias**	**r**	**%B**	**%T**
Ensemble	0.870	0.012	0.473	0.006	0.812	1.0	43.2
TSEB-PT	0.971	0.073	0.529	0.039	0.764	0.5	26.7
ETLook	0.981	-0.049	0.533	-0.027	0.771	1.0	34.0



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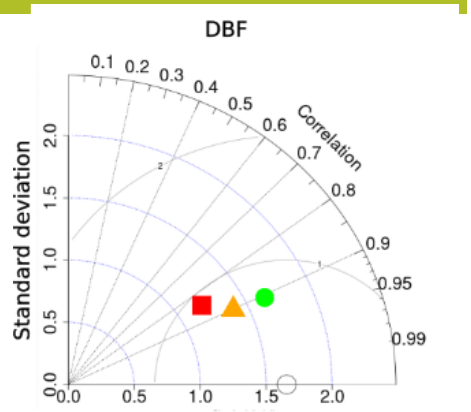
Plant functional types/Climates

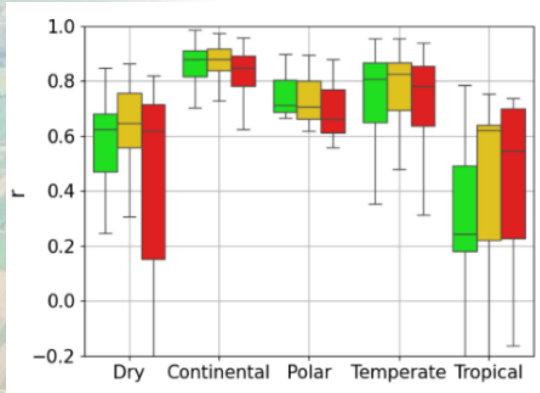
Worst scores in Tropical and Dry areas

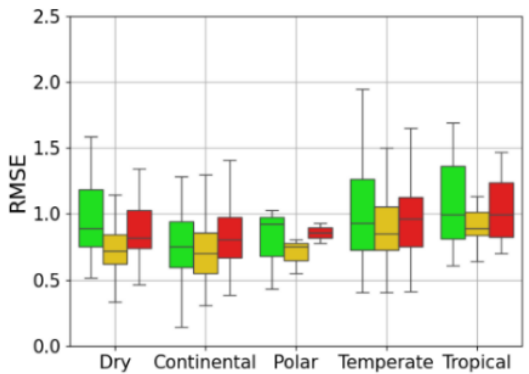
- Typical in all ET models

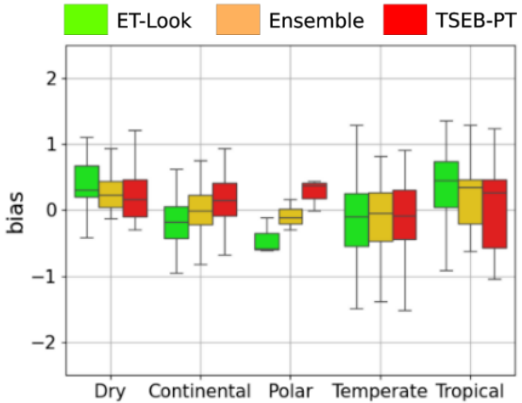
Divergence between ETLook and TSEB:

- TSEB-PT: underestimated variability in Forests (DBF and MF)
- ETLook: large positive bias in Savannas









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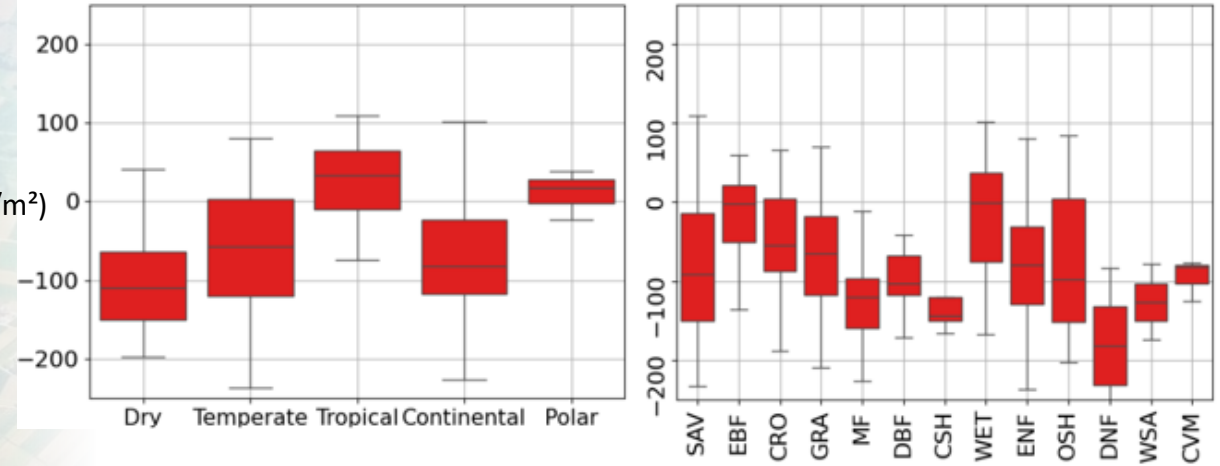
Heat Fluxes

- Better scores for LE than H (strong underestimation)
  - Strongest bias in arid and forest sites

All sites together							
Dataset	**RMSE**	**bias**	**rRMSE**	**rBias**	**r**	**%B**	**%T**
LE	127.05	-1.74	0.67	-0.009	0.62	0	9.5
H	164.57	-85.33	0.61	-0.314	0.48	0	8

Bias H (W/m²)



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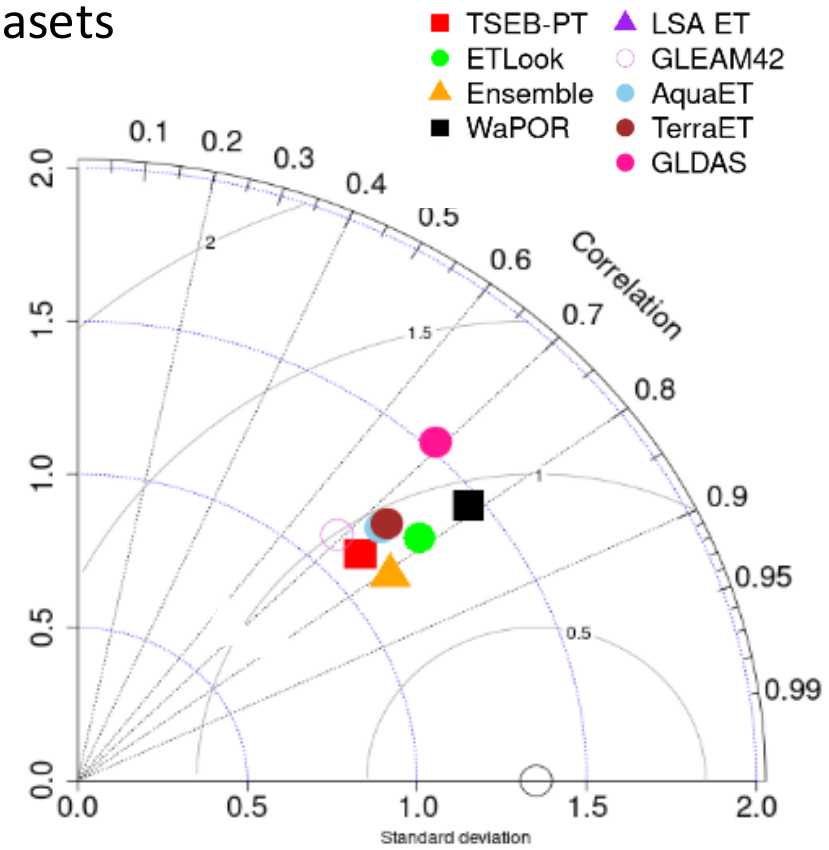
Comparison to other ET products

Comparison with other global ET datasets

Ensemble ET among the best models



Note:

- Only for 2020
- Native temporal and spatial of other ET products varies (resampled to dekadal)

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Conclusions

- New ETA & HF products are overall of high quality, and state of the art in comparison to other global ET products
- Model ensemble performs best, though depending on PFT, climate, phenological state, an individual model might perform better. Users have access to all model outputs
- Excellent addition to the CLMS portfolio, highly valuable for climate scientists, hydrologists, agronomists, policy makers and beyond.

Thank you for your attention

Questions?

Land Monitoring

More details available in
the PUM, ATBD and VR

https://land.copernicus.eu/en/products/evapotranspiration

Hydrology and Earth System Sciences preprint
Currently under review

https://egusphere.copernicus.org/preprints/2025/egusphere-2025-4342/

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Extra slides

Copernicus
Europe's eyes on Earth

European Commission

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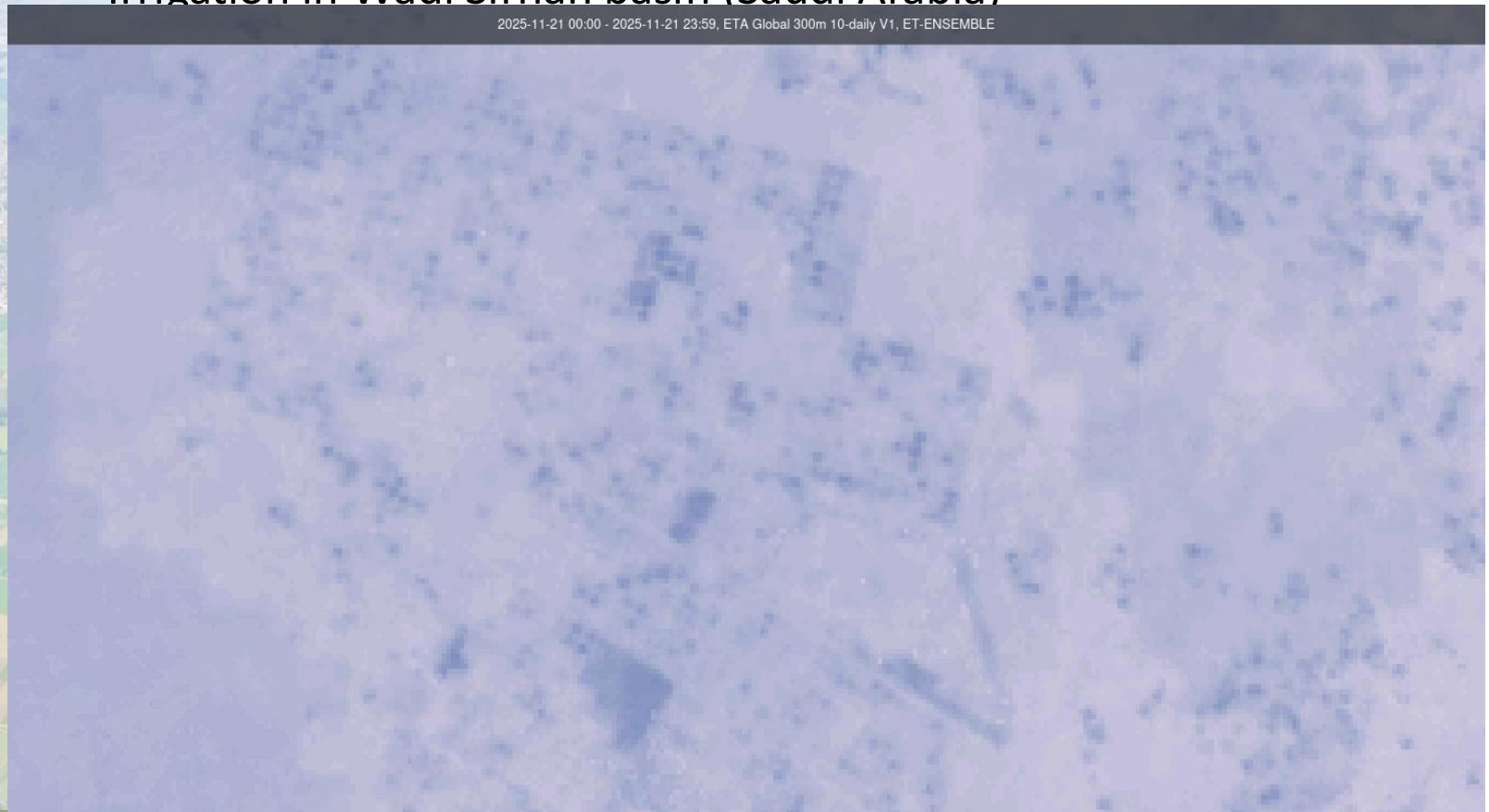
Illustration

- Irrigation in Wadi Sirhan basin (Saudi Arabia)



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Global statistics

- High correlation (r > 0.75) with in situ data for all models
- Ensemble model had a significantly higher r, lower RMSE and smaller bias, compared to TSEB-PT and ETLook
- The bias of all three datasets is small (relative bias below 4%) with Ensemble showing negligible bias

Summary scores at site level

Dataset	RMSE				Bias				r			
	min	max	mean	std	min	max	mean	std	min	max	mean	std
Ensemble	0.31	1.96	0.81	0.30	-1.39	1.50	0.03	0.45	-0.32	0.98	0.77	0.20
TSEB-PT	0.39	2.03	0.91	0.30	-1.51	1.71	0.08	0.50	-0.28	0.96	0.71	0.24
ETLook	0.14	2.40	0.91	0.35	-1.50	1.58	-0.08	0.53	-0.38	0.99	0.74	0.23

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Global statistics HF

All sites together								
Dataset	**RMSE**	**bias**	**rRMSE**	**rBias**	**r**	**N sites**	**%B**	**%T**
LE	127.05	-1.74	0.67	-0.009	0.62	200	0	9.5
H	164.57	-85.33	0.61	-0.314	0.48	200	0	8

Summary scores at site level

Dataset	**RMSE**				**Bias**				**r**			
	min	max	mean	std	min	max	mean	std	min	max	mean	std
LE	54.4	364.9	118.4	44.9	-221.5	270.3	6.9	63.7	-0.44	0.88	0.53	0.24
H	59.45	344.2	146.6	53.8	-304.7	109.8	-67.4	80.3	-0.47	0.87	0.46	0.22

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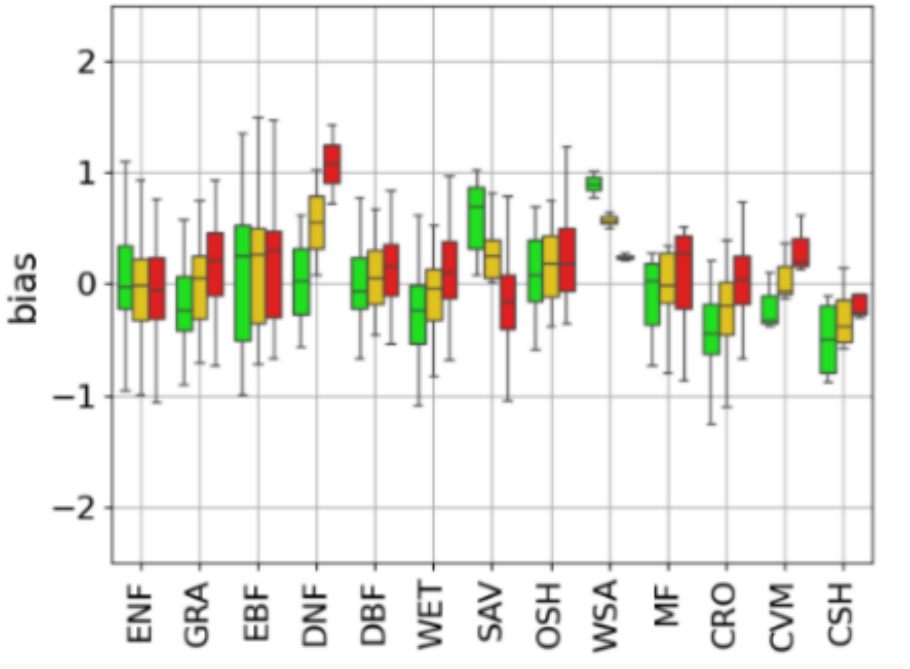

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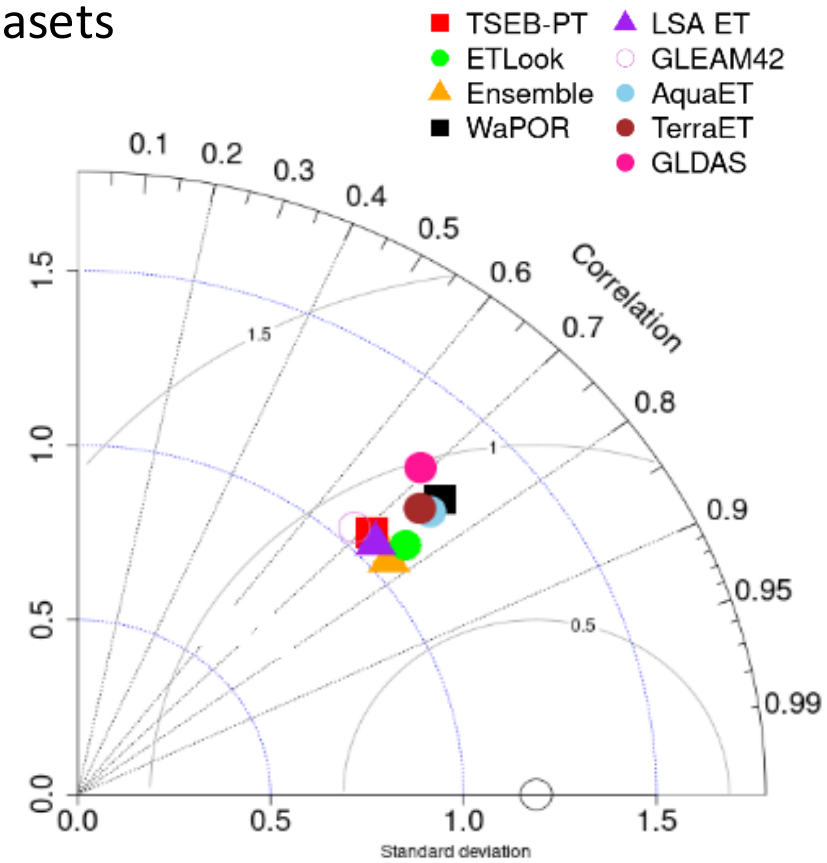
Comparison to other ET products

Comparison with other global ET datasets

Ensemble ET among the best models



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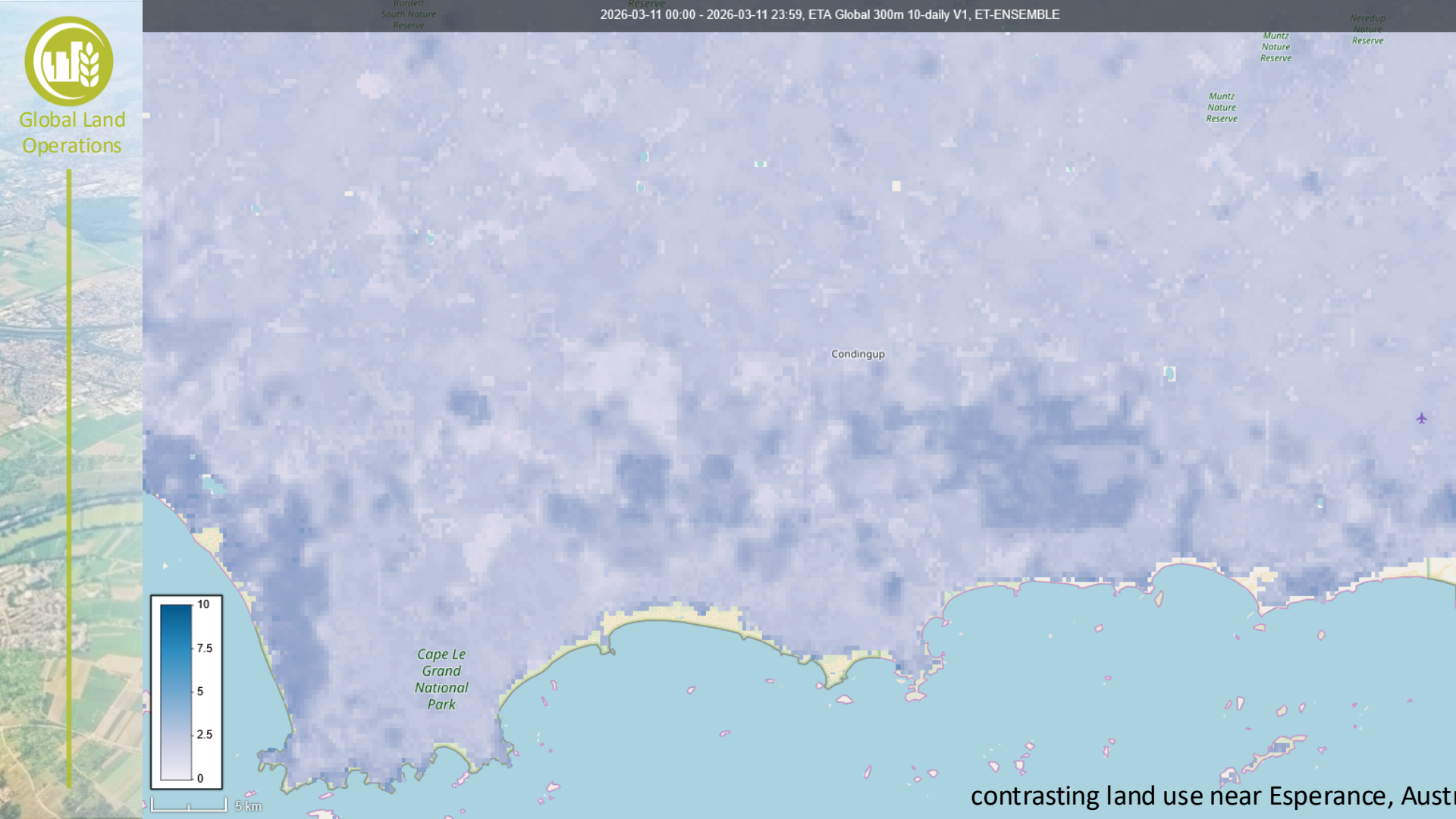

contrasting land use near Esperance, Austr

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Biophysical processor