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Outstanding Student & PhD candidate Presentation contest

EGU General Assembly 2022

Mon, 23 May 2022 | 14:44 – 14:50 | EGU22 – 7287

Partitioning of evapotranspiration based on flux variance similarity theory for an urban forest land

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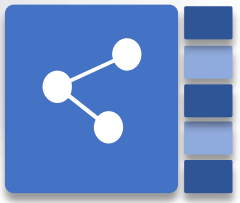
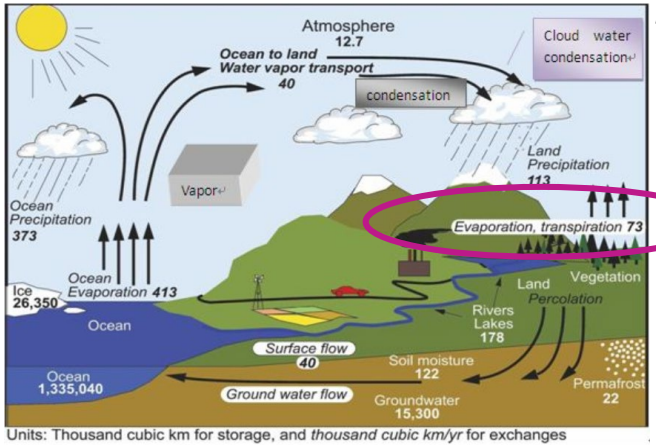


Session HS10.3 – *Evapotranspiration estimates from in-situ measurements – challenges in comparison, scaling and uncertainty assessment'*

SCWE

Research background

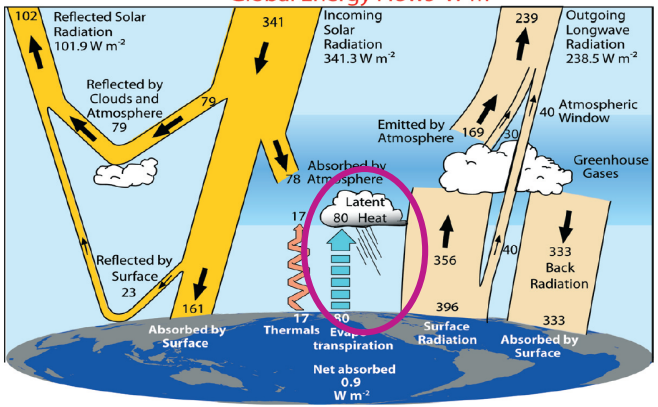


Units: Thousand cubic km for storage, and *thousand cubic km/yr* for exchanges

Source:China Meteorological News Press17-03-2017

Over 60%

$$P = ET + R + \Delta S$$

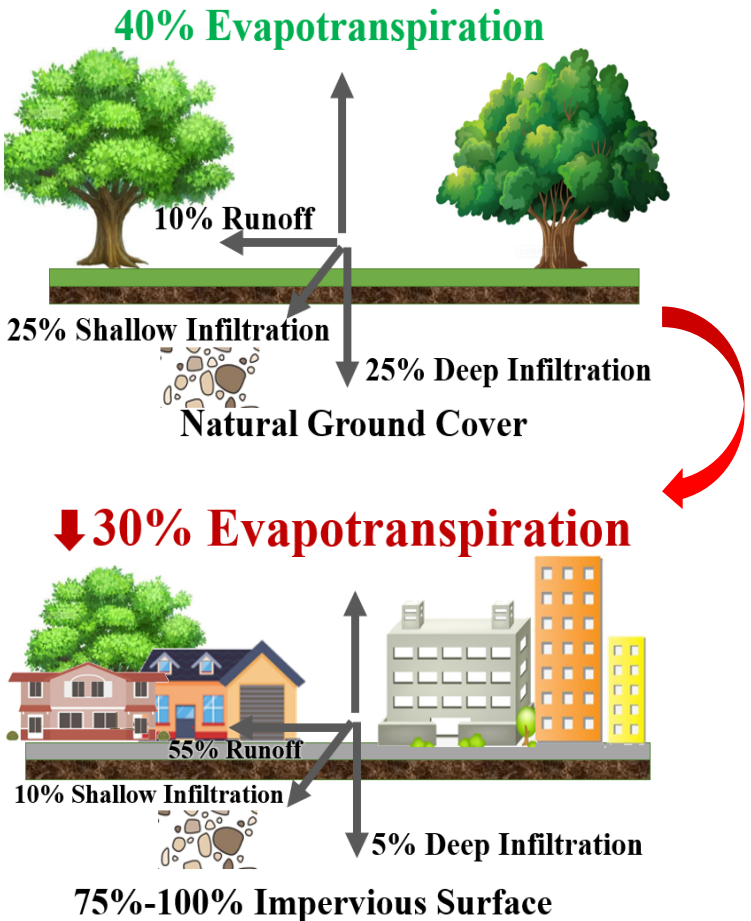


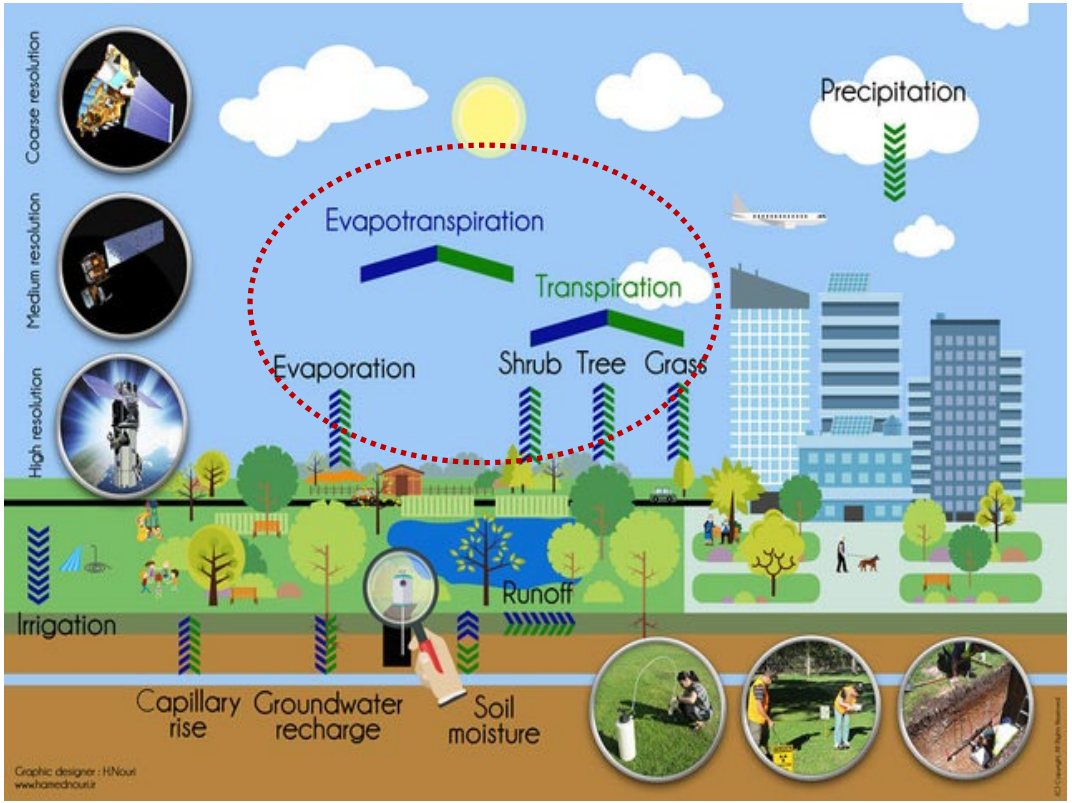
$$R_n = LE + H + G$$

Over 50%

Trenberth K E , Fasullo J T , Kiehl J . Earth's Global Energy Budget[J]. Bulletin of the American Meteorological Society, 2009, 90(3):311-323.

Research background

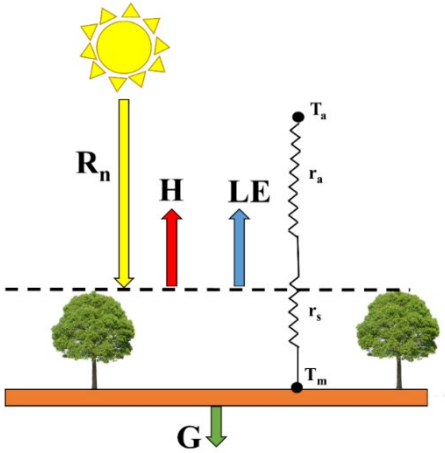




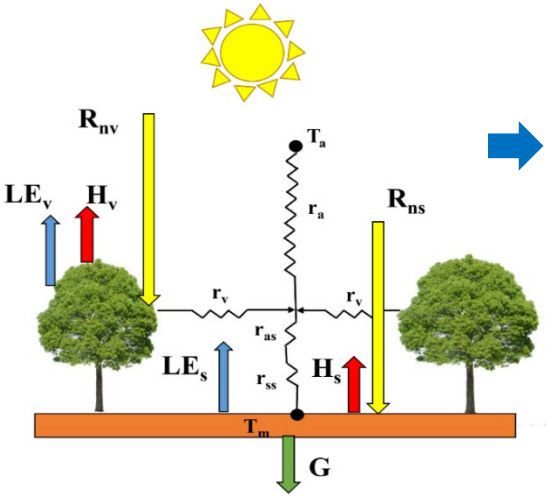
Evapotranspiration, water demand and water footprint of urban green spacesHamideh NouriGoal: .Date: 22 August 2010

Current method

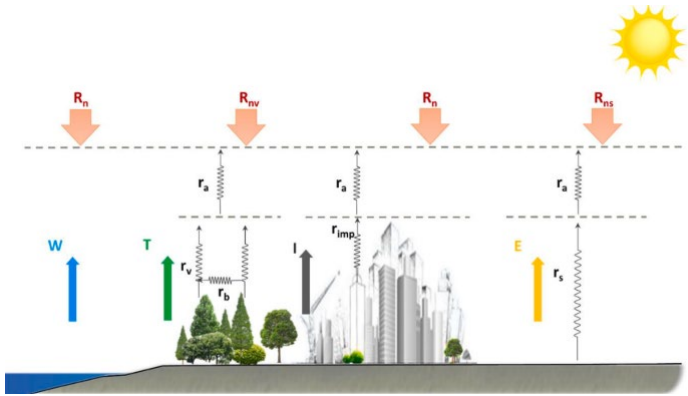
Single-source model



Two-source model



Three/Four-source model

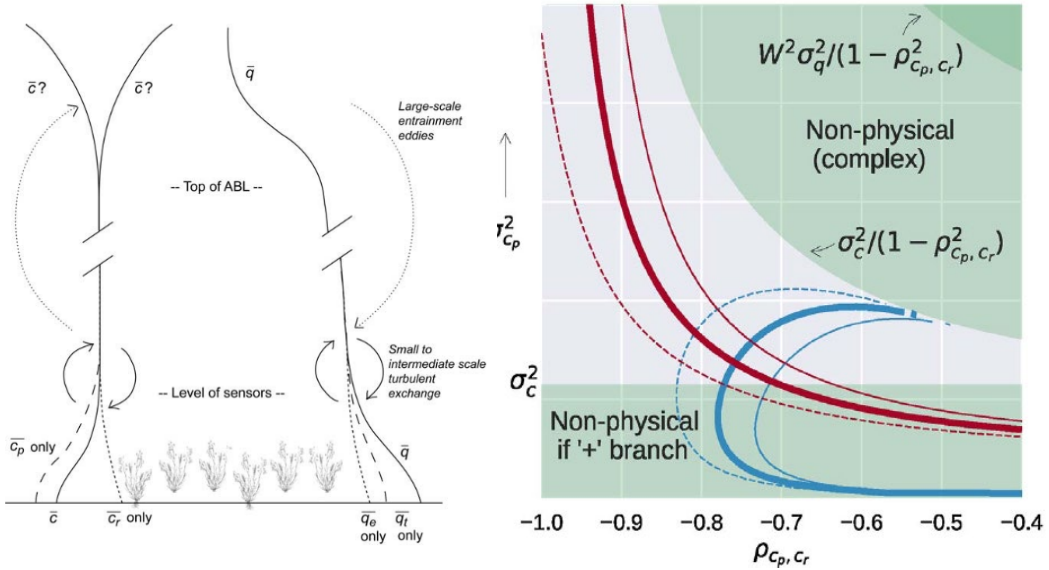


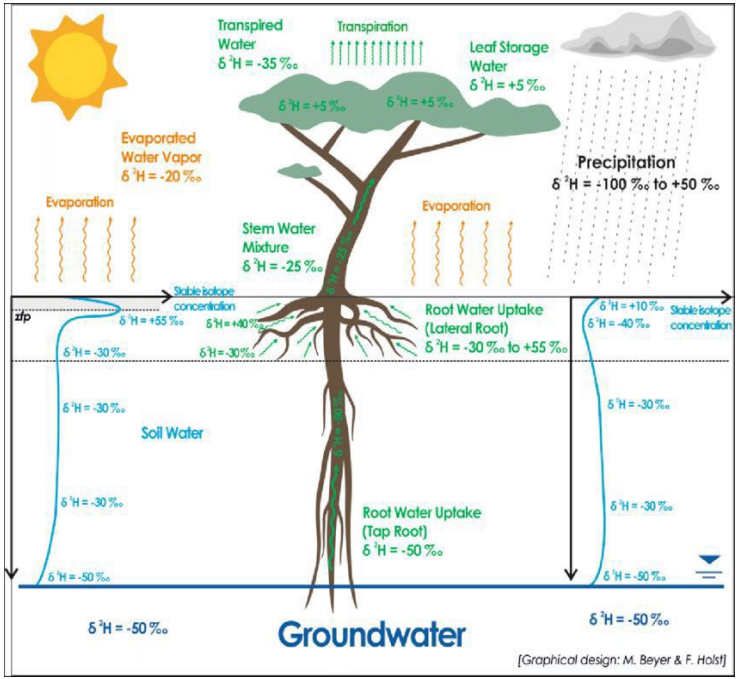
The two-source model can determine individual components, and is more widely used

Chen et al, 2021, Journal of Hydrology
Chen et al, 2022, Agricultural and Forest Meteorology
Chen et al, 2021, Advancence in water resources

Research method

The flux variance similarity(FVS) theory-only EC date + **The Stable hydroxide isotopes**





- **Scanlon, T. M., and P. Sahu (2008).** On the correlation structure of water vapor and carbon dioxide in the atmospheric surface layer: A basis for flux partitioning, Water Resour. Res., 44, W10418
- **Skaggs, T. H., Anderson, R. G., Alfieri, J. G., Scanlon, T. M., & Kustas, W. P. (2018).** Fluxpart: Open source software for partitioning carbon dioxide and water vapor fluxes. Agric For Meteorol, 253–254, 218–224.
- **Zahn E, Bou-Zeid E, Good SP et al (2022).**Direct partitioning of eddy-covariance water and carbon dioxide fluxes into ground and plant components. Agric For Meteorol,315(108):790.

$$\delta_E = \frac{\alpha_{V/L}\delta_S - h\delta_V - \varepsilon_{V/L} - \Delta\xi}{(1-h) + \Delta\xi/1000}$$

C-G

$$\delta_V = C_a(\delta_a - \delta_{ET})\left(\frac{1}{C_V}\right) + \delta_{ET}$$

Keeling-Plot

$$T/ET = \frac{\delta_{ET} - \delta_E}{\delta_T - \delta_E}$$

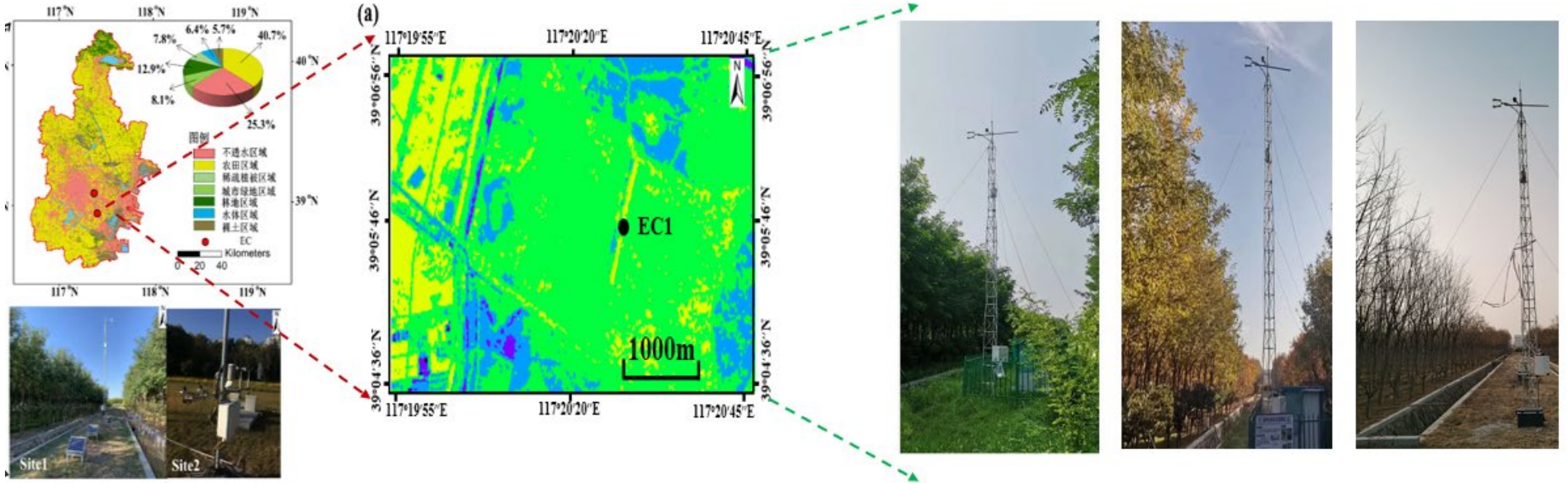
Research objectives and scientific problems

1. Whether the FVS theory could be well applied to partition urban ET?

2. Can we find a water use efficiency model that is applicable to estimate for the urban forest land?

Study Area

The growing season of locust is from April to October with leaf area index(LAI) between 0.25-5.92, tree height at 5-8 m. The main components of the underlying surface include 57% of urban forest, 15% of impervious surface and 25% of buildings.



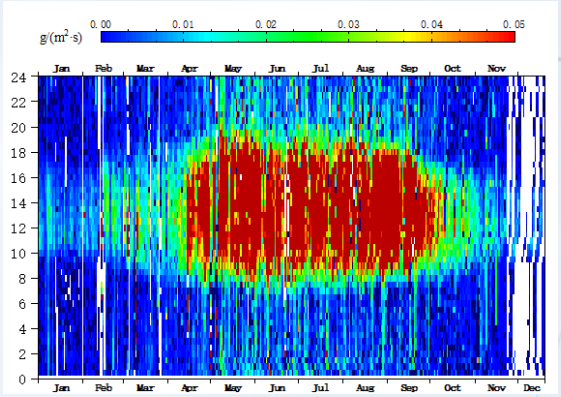
Study area location at Nankai university campus and eddy correlation(EC) tower

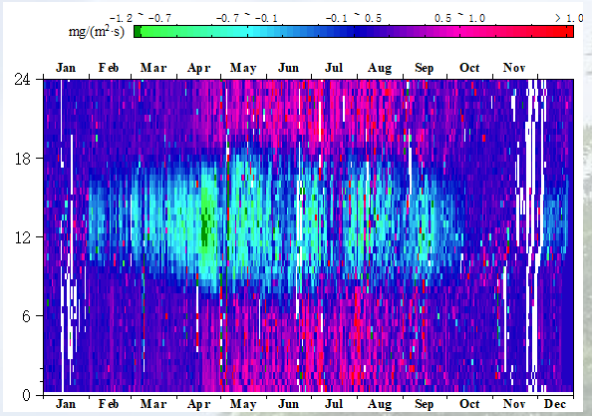
Result

Water vapor fluxes changes

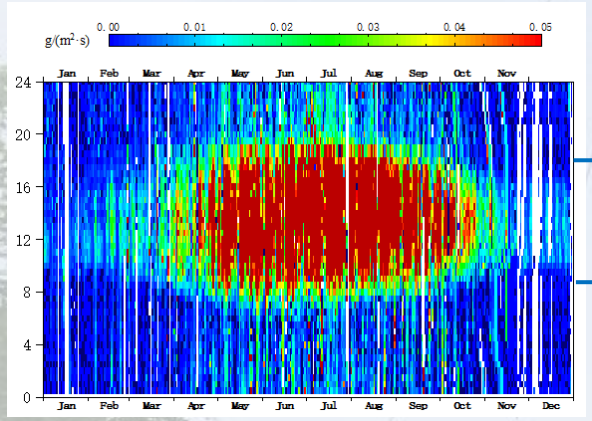
Carbon dioxide fluxes changes

2020

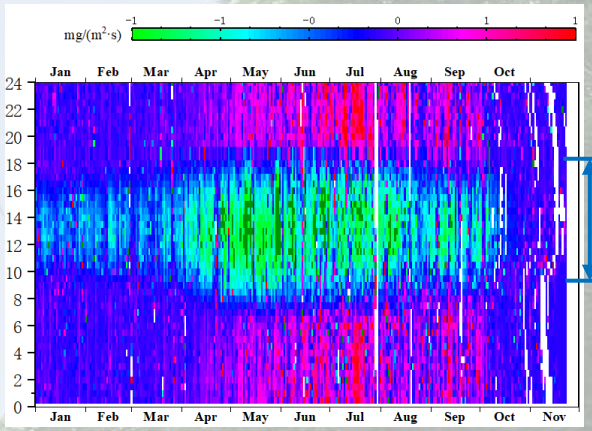




2021



06:00-20:00



08:00-18:00

April-October

February-October

the FVS operational key parameters—water use efficiency (WUE)

the FVS mathematical solution：

$$\sigma_{c_p}^2 = \frac{(1-\rho_{q,c}^2)(\sigma_q\sigma_c W)^2\left(\sigma_q^2\langle w'c'\rangle^2 - 2\rho_{q,c}\sigma_q\sigma_c\langle w'q'\rangle\langle w'c'\rangle + \sigma_c^2\langle w'q'\rangle^2\right)}{\left[\sigma_c^2\langle w'q'\rangle + \sigma_q^2\langle w'c'\rangle W - \rho_{q,c}\sigma_q\sigma_c(\langle w'c'\rangle + \langle w'q'\rangle W)\right]^2}$$

$$\rho_{c_p,c_r}^2 = \frac{(1-\rho_{q,c}^2)\,\sigma_q^2\sigma_c^2\,(\langle w'c'\rangle - \langle w'q'\rangle W)^2}{\left(\sigma_q^2\langle w'c'\rangle^2 - 2\rho_{q,c}\sigma_c\sigma_q\langle w'c'\rangle\langle w'q'\rangle + \sigma_c^2\langle w'q'\rangle^2\right)\left(\sigma_c^2 - 2\rho_{q,c}\sigma_c\sigma_q W + \sigma_q^2 W^2\right)}$$

Two equations, three unknowns:

$$WUE = \left(\frac{1}{DR}\right)\left(\frac{c_a - c_i}{q_a - q_i}\right)$$

To determine the leaf-level WUE:

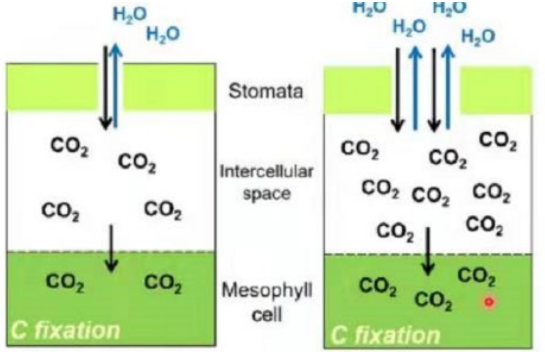
$$W_1 = \frac{0.625}{q_a - q_i} \times 0.3c_a \qquad W_3 = \frac{0.625}{q_a - q_i} \times \left[1-(b - a \times VPD)\right]c_a$$

$$W_2 = \frac{0.625}{q_a - q_i} \times (c_a - 280) \qquad W_4 = \frac{0.625}{q_a - q_i} \times \sqrt{1.6\lambda\frac{VPD}{c_a}} \times c_a$$

$$W_5 = m - \frac{\sqrt{1.6 \times VPD \times m \times (c_a + 1.6 \times VPD \times m)}}{1.6 \times VPD}$$

$$m = -\frac{\sigma_c^2 F_q - R_{cq}\sigma_q\sigma_c F_c}{\sigma_q^2 F_c - R_{cq}\sigma_q\sigma_c F_q}$$

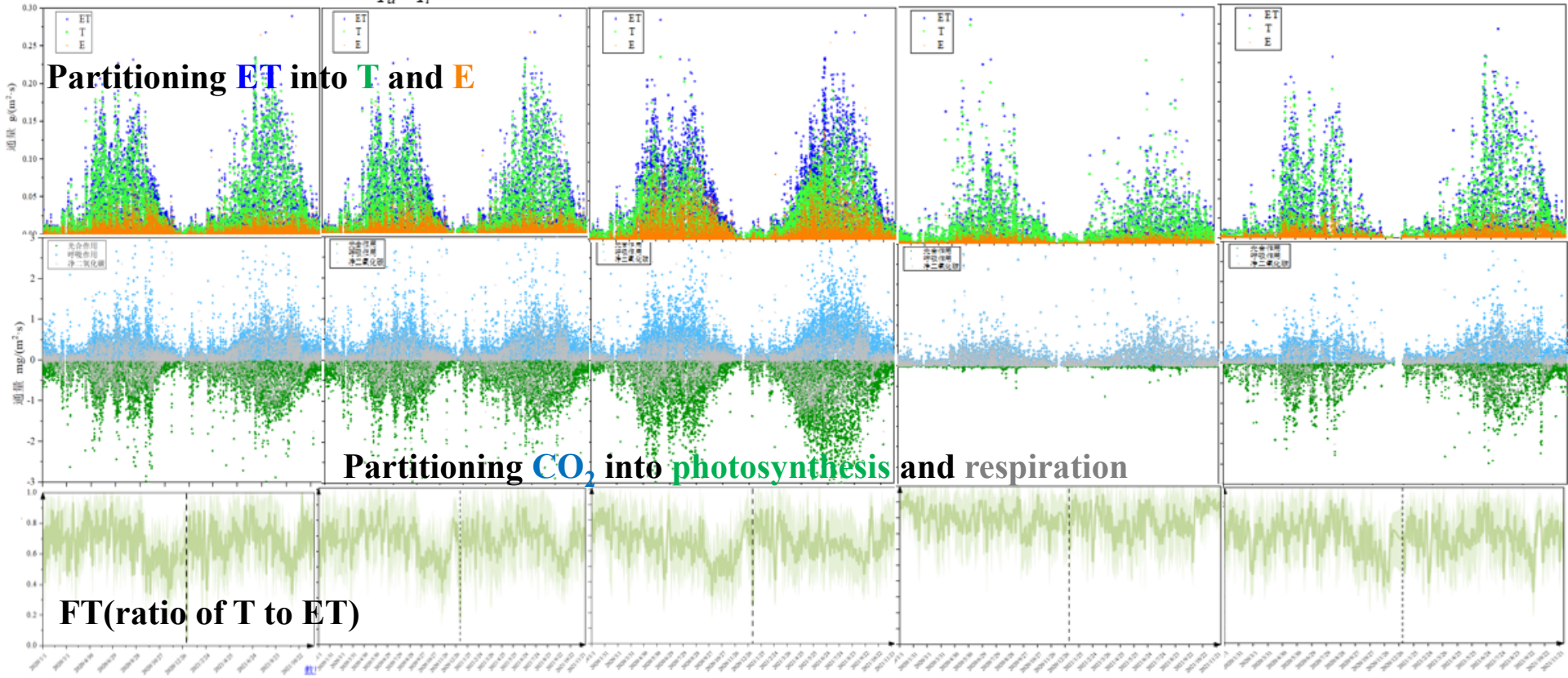
Some methods to estimate WUE

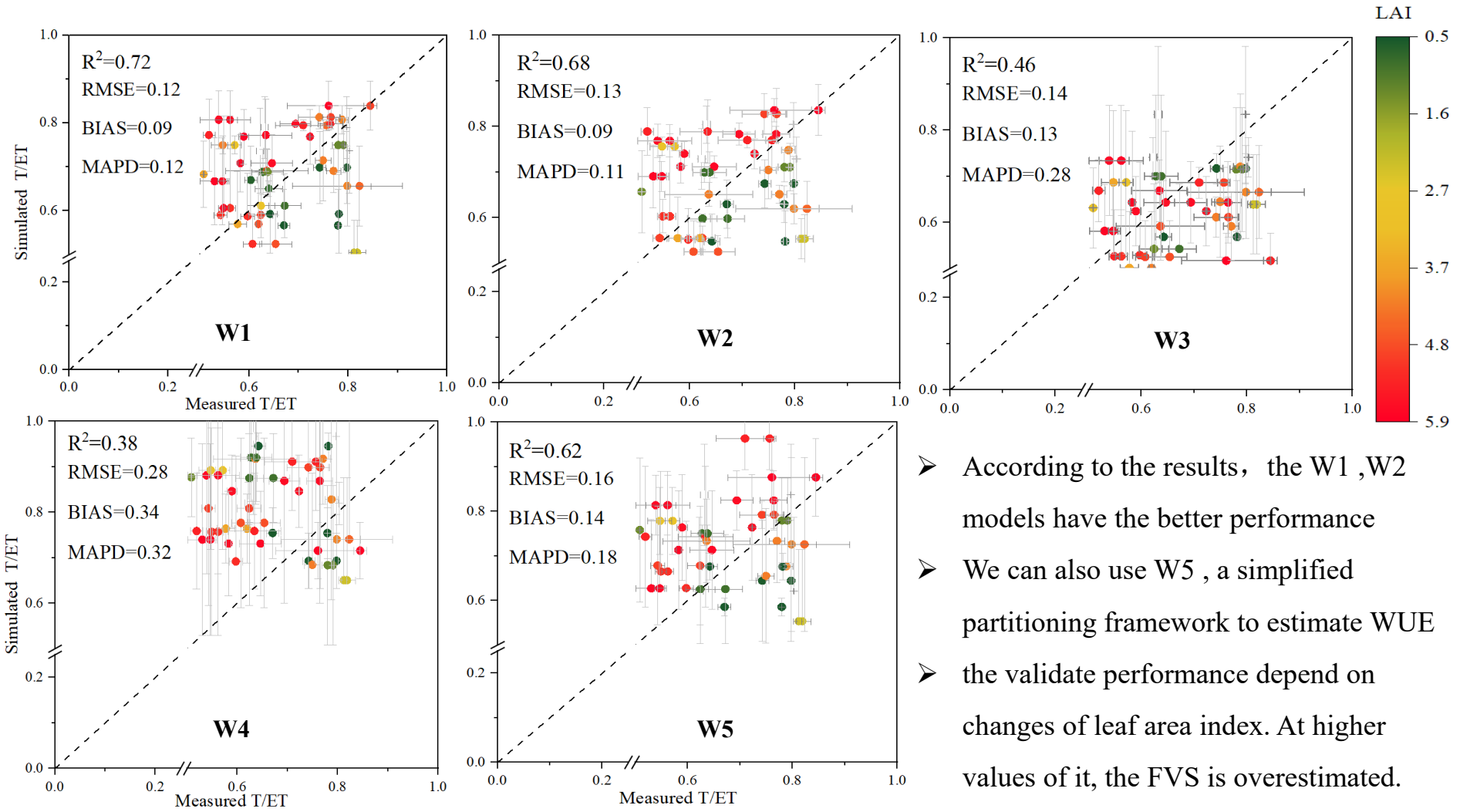


Zhang et al，2021，Nature Communications

Result

$$W_1 = \frac{0.625}{q_a - q_i} \times 0.3 c_a \qquad W_2 = \frac{0.625}{q_a - q_i} \times (c_a - 280) \qquad W_3 = \frac{0.625}{q_a - q_i} \times [1 - (b - a \times VPD)]\, c_a \qquad W_4 = \frac{0.625}{q_a - q_i} \times \sqrt{1.6\lambda \frac{VPD}{c_a}} \times c_a \qquad W_5 = m - \frac{\sqrt{1.6 \times VPD \times m \times (c_a + 1.6 \times VPD \times m)}}{1.6 \times VPD}$$





- According to the results，the W1 ,W2 models have the better performance
- We can also use W5 , a simplified partitioning framework to estimate WUE
- the validate performance depend on changes of leaf area index. At higher values of it, the FVS is overestimated.

Summary

1. We observed changes in water vapor and carbon dioxide fluxes and the flux variance similarity (FVS) theory based on five water use efficiency(WUE) models was applied to partition urban ET.
2. The growing season average FT ranges from 0.68 to 0.96, this results was partially consistent with the isotope-based approach.
3. Not every WUE was applicable to urban forest, and the performance of the same model was also affected by the leaf area index during the growing season

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Thank you!