How to differentiate nighttime transpiration and water recharge in nocturnal sap flow?

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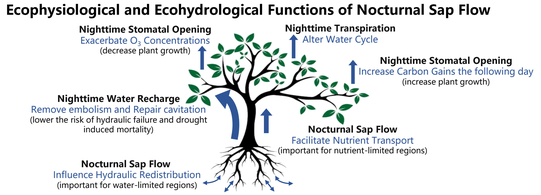
INTRODUCTION

Backgrounds

- Nocturnal sap flow (Q_n) accounts for an average of 12% of the total water uptake across a range of tree species and forest ecosystems and can affect not only forest carbon and water budgets but also their responses to water and nutrient stress.
- Q_n consists of two ecophysiological and ecohydrological significant components: nighttime transpiration (E_n) and nighttime water recharge (R_n).



- Q_n is mainly considered as R_n when stomata tend to be closed, and E_n is thought to be promoted by nighttime vapor pressure deficit (VPD_n). Accordingly, a VPD_n based method has been developed to estimate E_n, which is normally quantified through the discretely measured nighttime stomatal conductance, from the widely and continuously measured sap flow.

However, the environmental control of Q_n was not fully understood.

OBJECTIVES

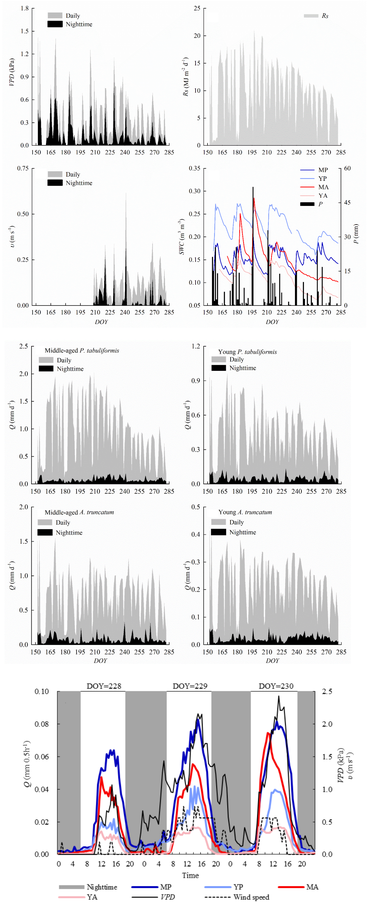
- Testify whether Q_n is positively responded to VPD_n
- Clarify how environmental factors concurrently influence Q_n
- Explore how to differentiate E_n and R_n

METHODS

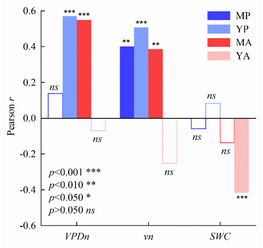
- In a semi-arid mountainous area of northern China
- Measured growing season sap flow of a 45-year-old *Pinus tabuliformis* (MP), a 10-year-old *P. tabuliformis* (YP), a 34-year-old *Acer truncatum* (MA), and a 6-year-old *A. truncatum* stand (YA) by Granier-type thermal dissipation sensors

RESULTS

1. Daily and diurnal variations of nocturnal sap flow and environmental factors

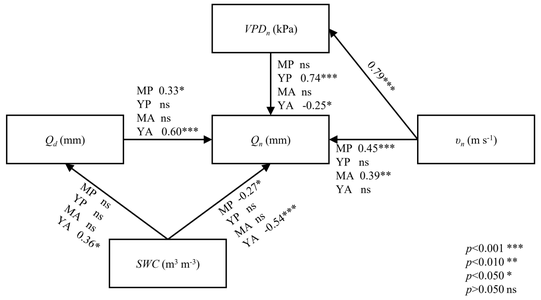


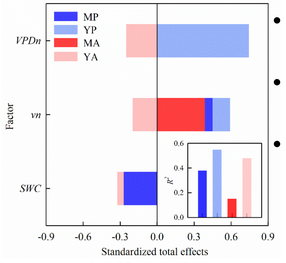
2. Correlations between nocturnal sap flow and environmental factors



- Q_n was not always significantly correlated to VPD_n
- Q_n could also be significantly correlated to wind speed (u_n) and soil water content (*SWC*)

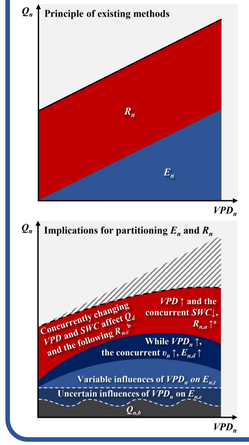
3. Effect of concurrently changing environmental factors on nocturnal sap flow





- Influence of VPD_n on Q_n conditioned by soil moisture
- Wind speed had considerable impacts on Q_n
- Both increased and decreased soil moisture was able to promote Q_n through two distinct ways
- Total effect of concurrent environmental controls was limited

IMPLICATIONS



Abbreviation	Denotation
Q_d	Daytime sap flow reflecting variations of daytime transpiration
Q_n	Nocturnal sap flow
$Q_{n,b}$	Q_n controlled by biotic factors
E_n	Nighttime transpiration, referred as nighttime plant water loss
$E_{n,t}$	Stomatal water loss physiologically influenced by exogenous environment factors
$E_{n,e}$	Stomatal water loss physiologically regulated by plant endogenous processes
$E_{n,d}$	Physical water diffusion through both cuticles and 'leaky' stomata
R_n	Nighttime water recharge
$R_{n,c}$	R_n for capacitance refilling
$R_{n,a}$	R_n for avoiding hydraulic failure
VPD	Daily vapor pressure deficit, which always has a same pattern with VPD_n
VPD_n	Nighttime vapor pressure deficit
u_n	Nighttime wind speed
SWC	Daily soil water content with no significant difference between daytime and nighttime

- Uncertain physiological influences of VPD_n on nighttime stomatal water loss
- Overlooked nighttime water loss induced by wind
- Region-specific nighttime water recharge responses to *VPD*
- Importance of biotic controls on Q_n

CONCLUSIONS

- Soil moisture conditioned the influence of nighttime vapor pressure deficit on nocturnal sap flow in semi-arid regions.
- Concurrently changing environmental factors (i.e., VPD_n, u_n, and *SWC*) affected nocturnal sap flow through various direct and indirect ways, and their total effect was limited.
- Nocturnal sap flow partitioning method requires further improvements.

ACKNOWLEDGEMENTS

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REFERENCES

Chen, Z., Zhang, Z., Sun, G., Chen, L., Xu, H., Chen, S., 2020. Biophysical controls on nocturnal sap flow in plantation forests in a semi-arid region of northern China. *Agricultural and Forest Meteorology* 284, 107904. doi: 10.1016/j.agrformet.2020.107904