Influence of wind speeds on flux exchange across water-atmosphere interface under different stability conditions

Wind-classes and Atmospheric Stability Ranges

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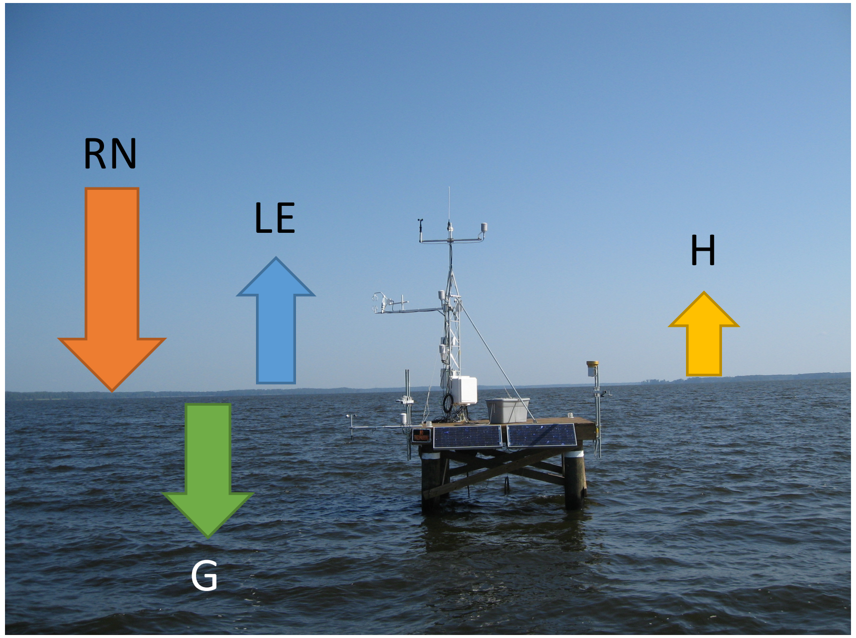
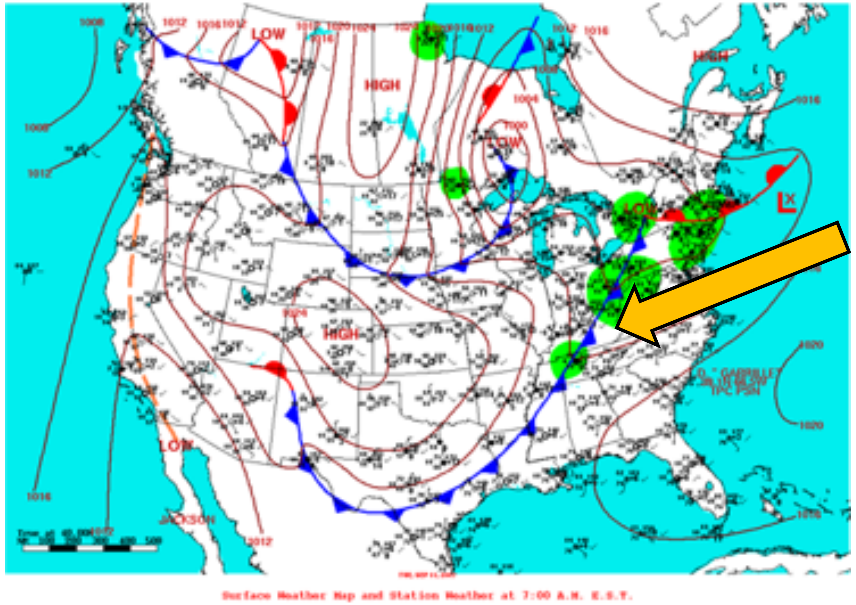
The energetic life over inland water bodies systems

- Understanding air-water interactions of inland water bodies is critical to ascertain the role inland water bodies have in regulating local and regional weather and its impact to the hydrological balance.
- Wind is one of the main drivers of energy exchange between the atmosphere and water bodies.
- High-wind weather events would dramatically increase energy exchanges (latent heat, LE, and sensible heat, H, fluxes) by 100-200%.

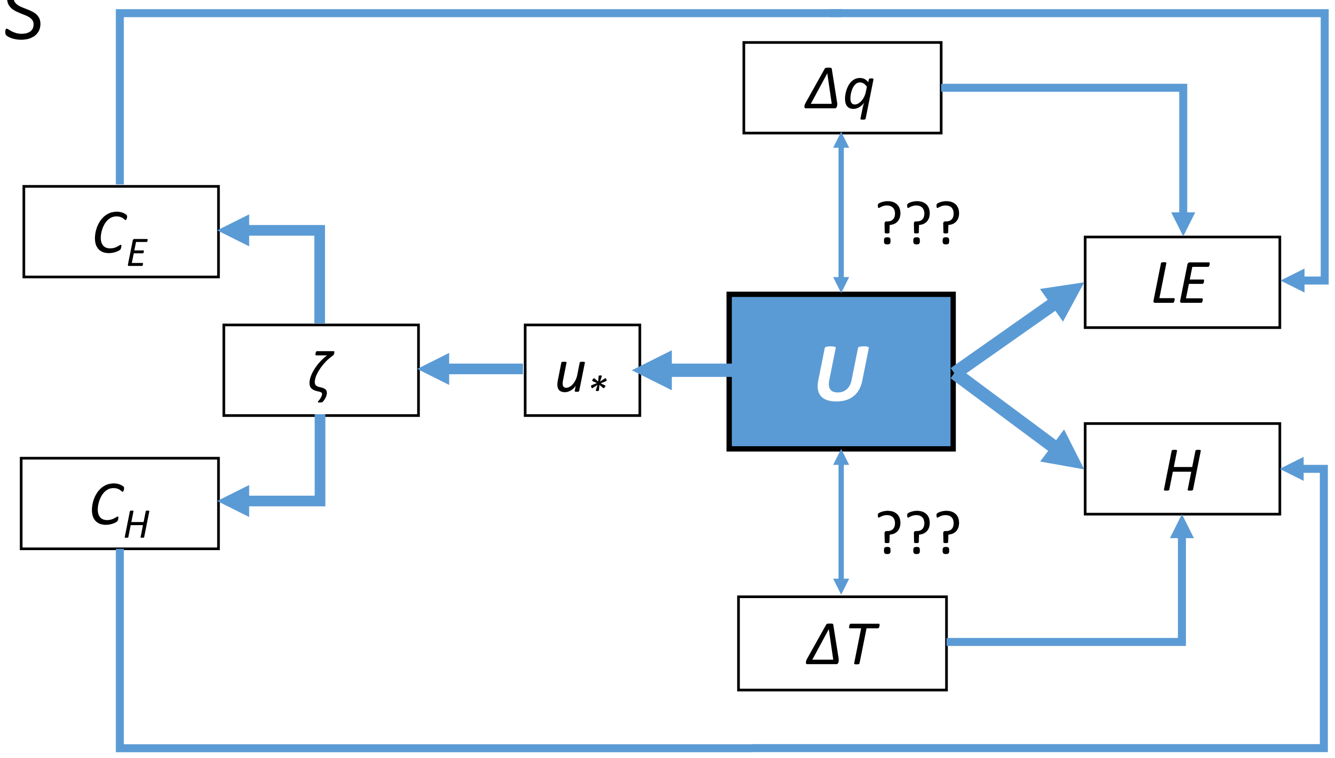




The noisy relationships between *LE* & *H* and its drivers

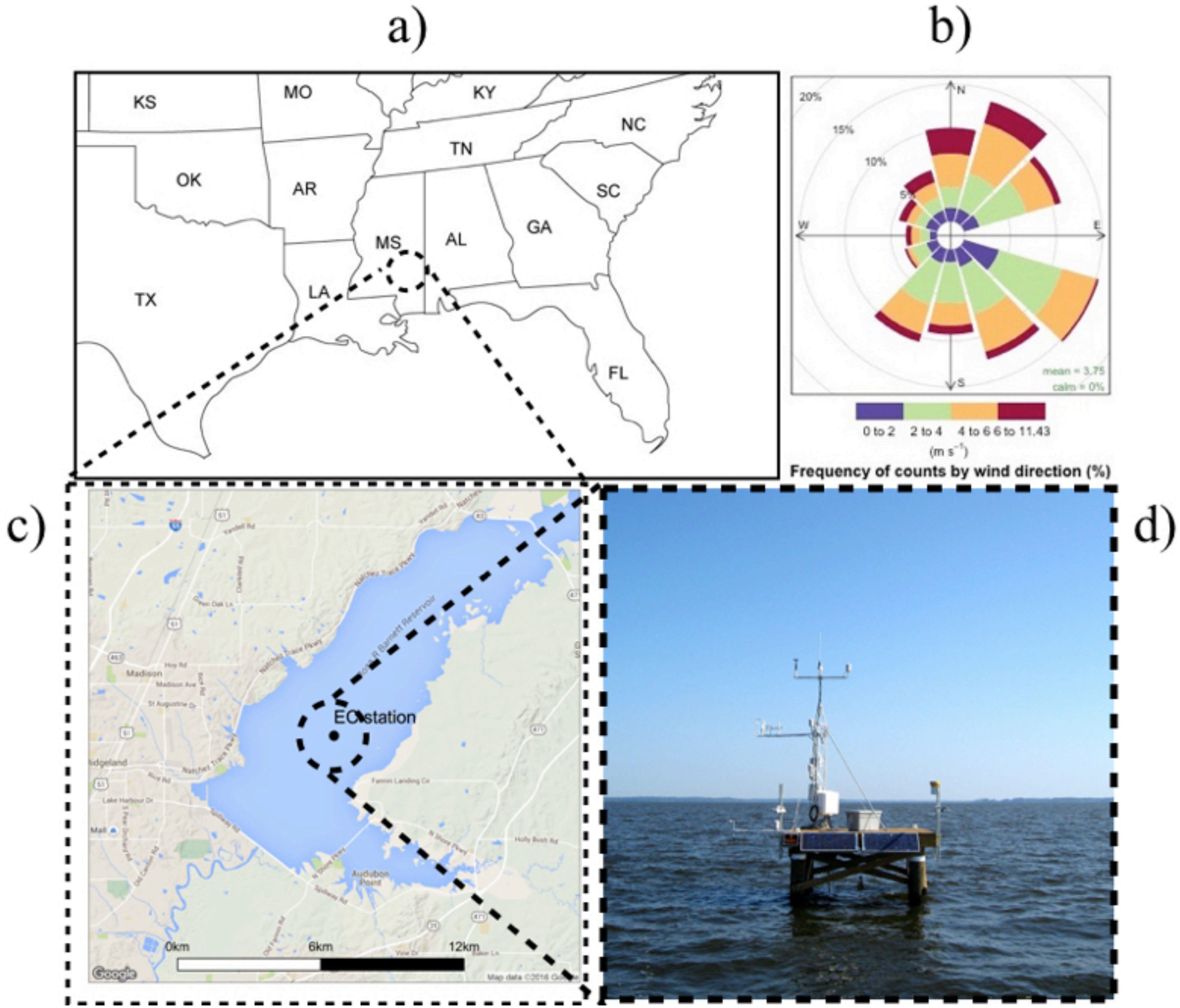
$$LE = (\rho_a L_v)\, C_E\, U\, \Delta q$$

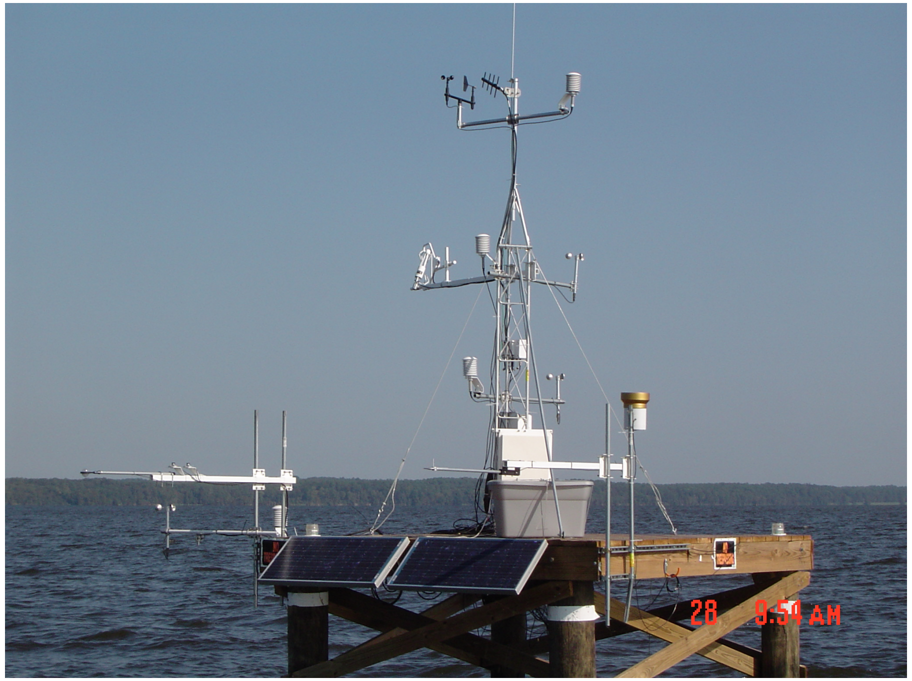
$$H = (\rho_a C_p)\, C_H\, U\, \Delta T$$



- Simple linear relationships between *LE* & *H* and its drivers through the bulk transfer equations
- Possible correlations between drivers, U and Δq and ΔT
- Atmospheric stability, ζ, influence on both C_E and C_H while U (u_*) would affect ζ
- U is central to the inter-relationships between *LE* & *H* and its drivers

The study location, instrumentation, and dataset



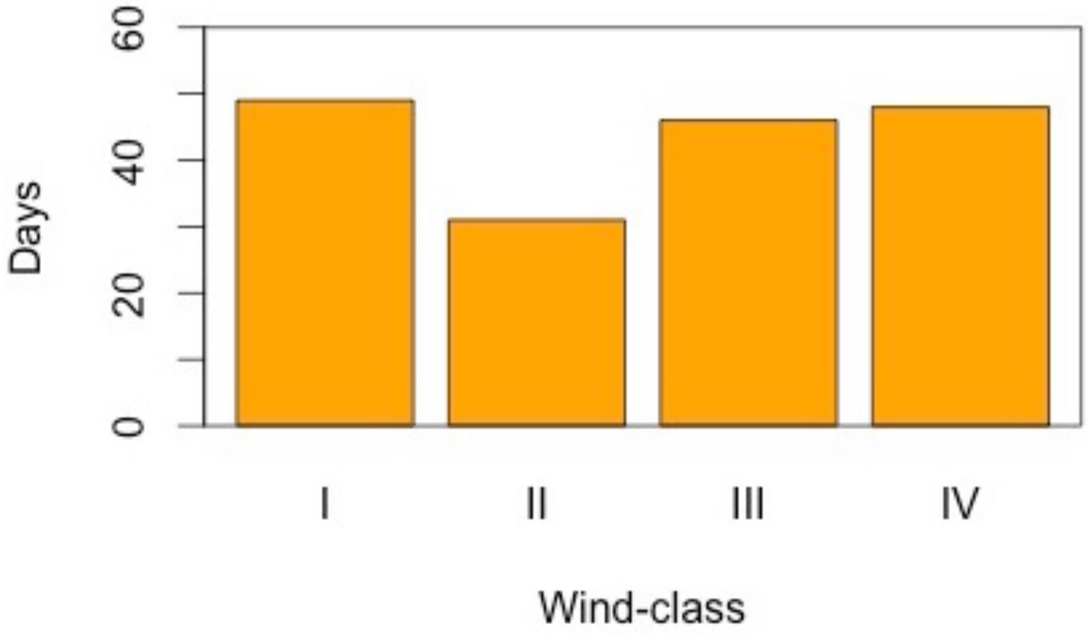


- **Location:** Ross Barnett Reservoir, Mississippi, 134 km^2, depth 4 – 8 m.
- **Duration:** 174 days (August 24, 2007 to March 5, 2008)
- **Cold front days:** 12 days
- **Warm front days:** 5 days

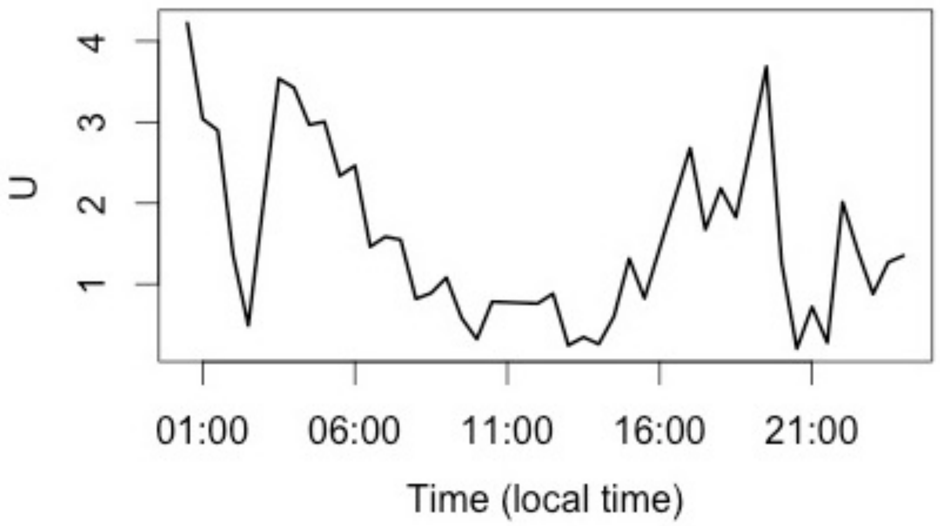
Wind-classes I, II, III, & IV

To classify, more than 50% of half-hourly U in the below wind ranges:

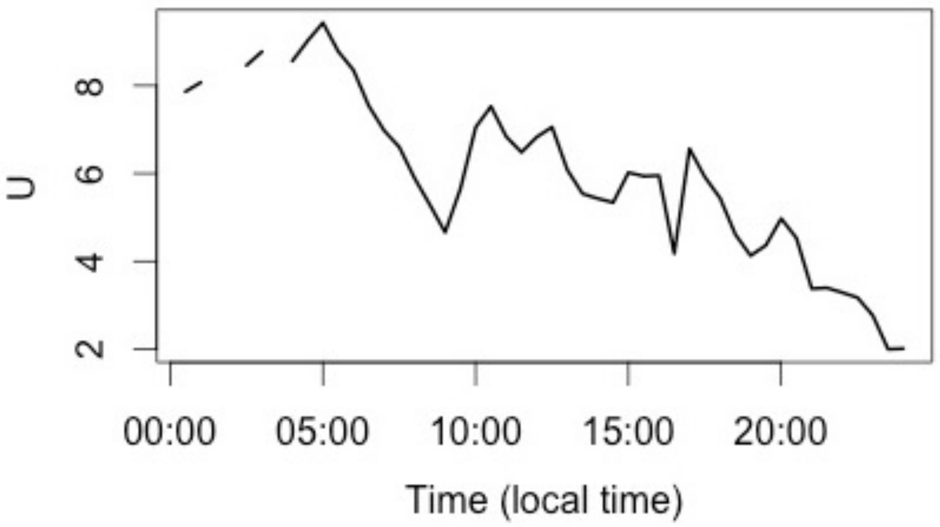
- Wind-class I: U < 2.316 m s^{-1}
- Wind-class II: 2.316 ≤ U < 3.693 m s^{-1}
- Wind-class III: 3.693 ≤ U < 5.125 m s^{-1}
- Wind-class IV: U > 5.125 m s^{-1}



Wind-class I



Wind-class IV

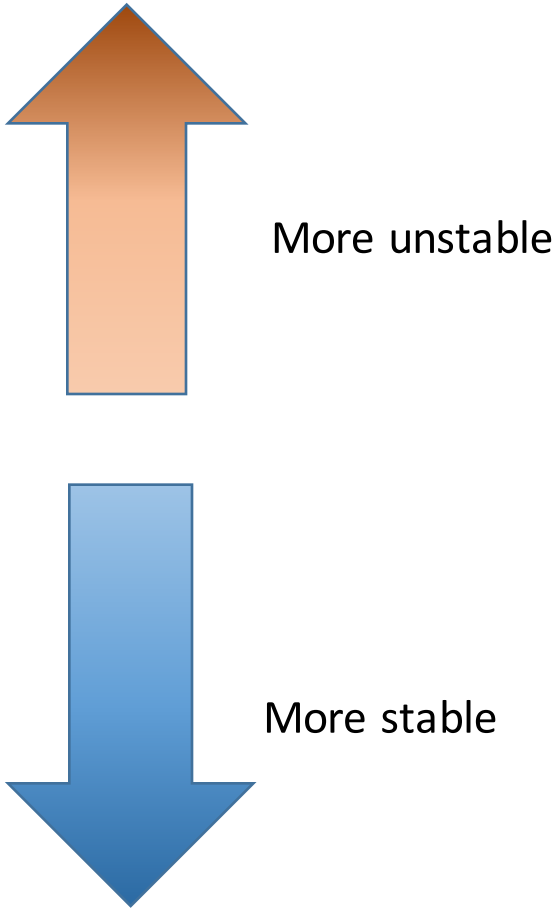


Atmospheric stability, ζ, ranges

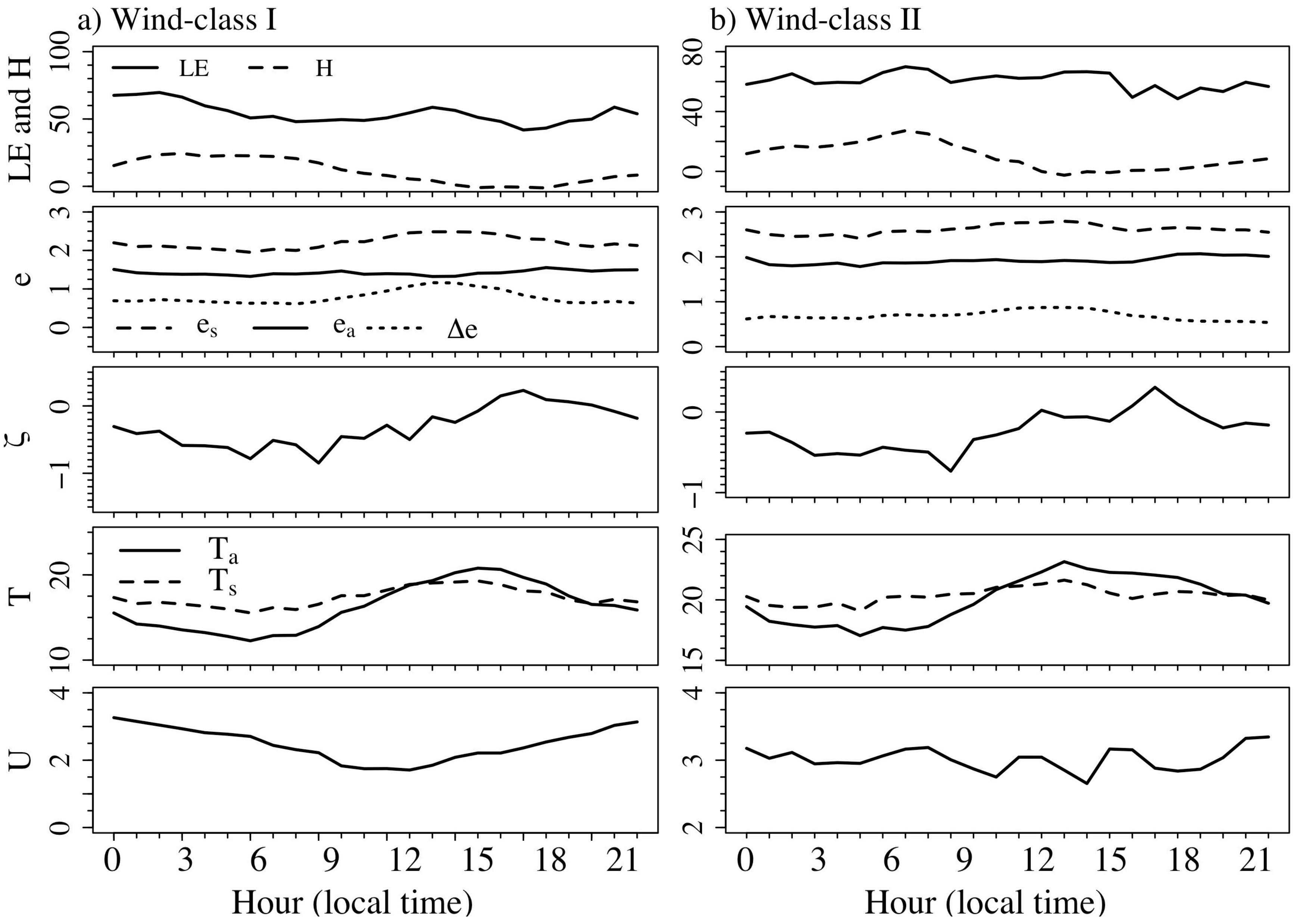
Categorized atmospheric stability, ζ, into 10 classes of ranges:

1. $-10 \le \zeta < -1$ (557) **– very unstable**
2. $-1 \le \zeta < -0.5$ (636)
3. $-0.5 \le \zeta < -0.1$ (2519)
4. $-0.1 \le \zeta < -0.05$ (648)
5. $-0.05 \le \zeta < 0$ (589) **– near-neutral**
6. $0 \le \zeta < 0.05$ (687) **– near-neutral**
7. $0.05 \le \zeta < 0.1$ (333)
8. $0.1 \le \zeta < 0.5$ (796)
9. $0.5 \le \zeta < 1$ (204)

10.$1 \le \zeta < 10$ (118) **– very stable**

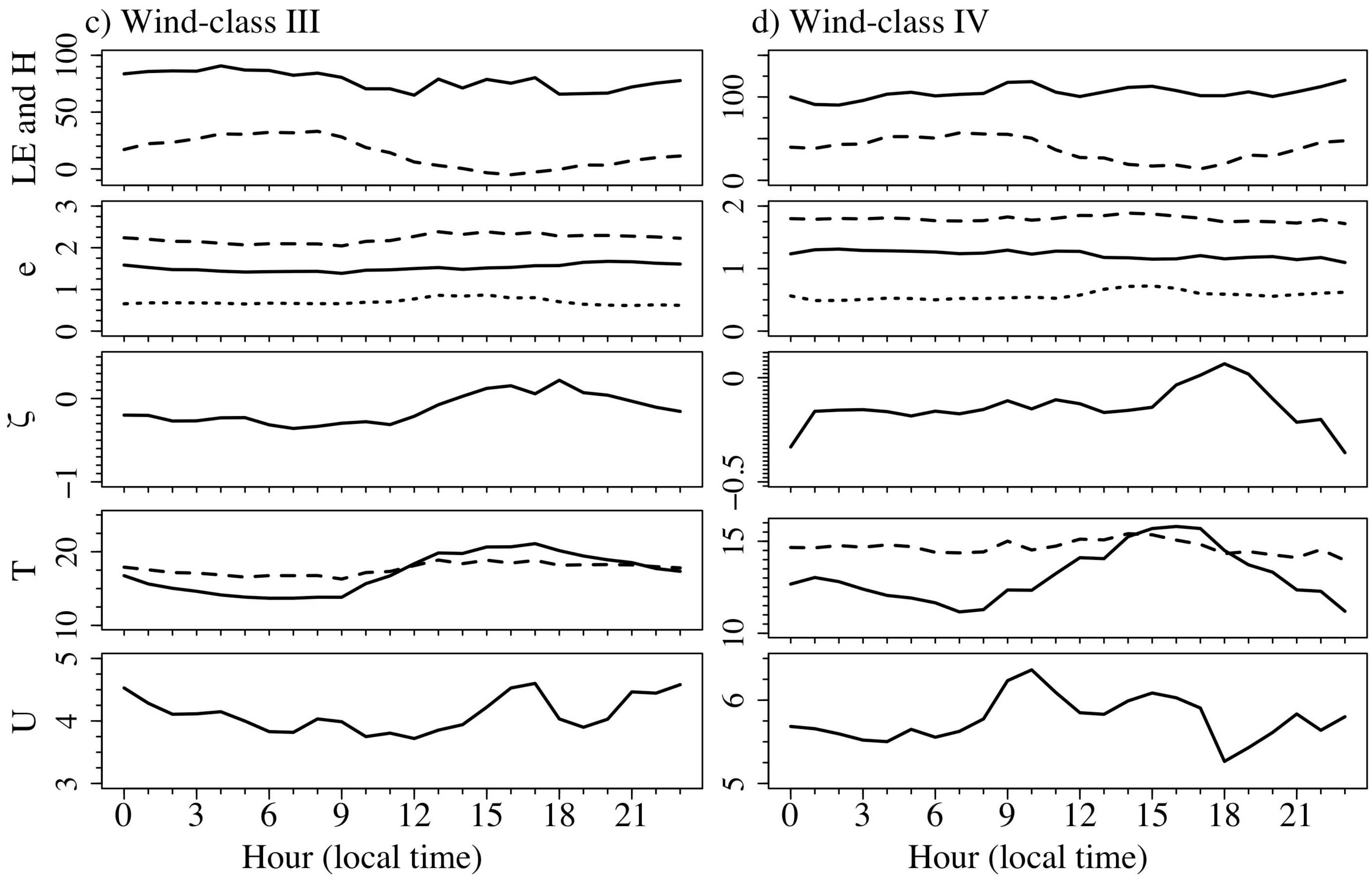


Diurnal changes in *LE*, *H*, & its drivers part 1



- Wind has been reported to change the influence of *Δe* and *ΔT* on *LE* and *H*.
- *H* closely follows the diurnal pattern of *ΔT* in contrast to *LE*.
- Diurnal *Δe* changes with wind-class – it decreased in high wind-classes.
- Diurnal *ΔT* did not behave the same as *Δe*.

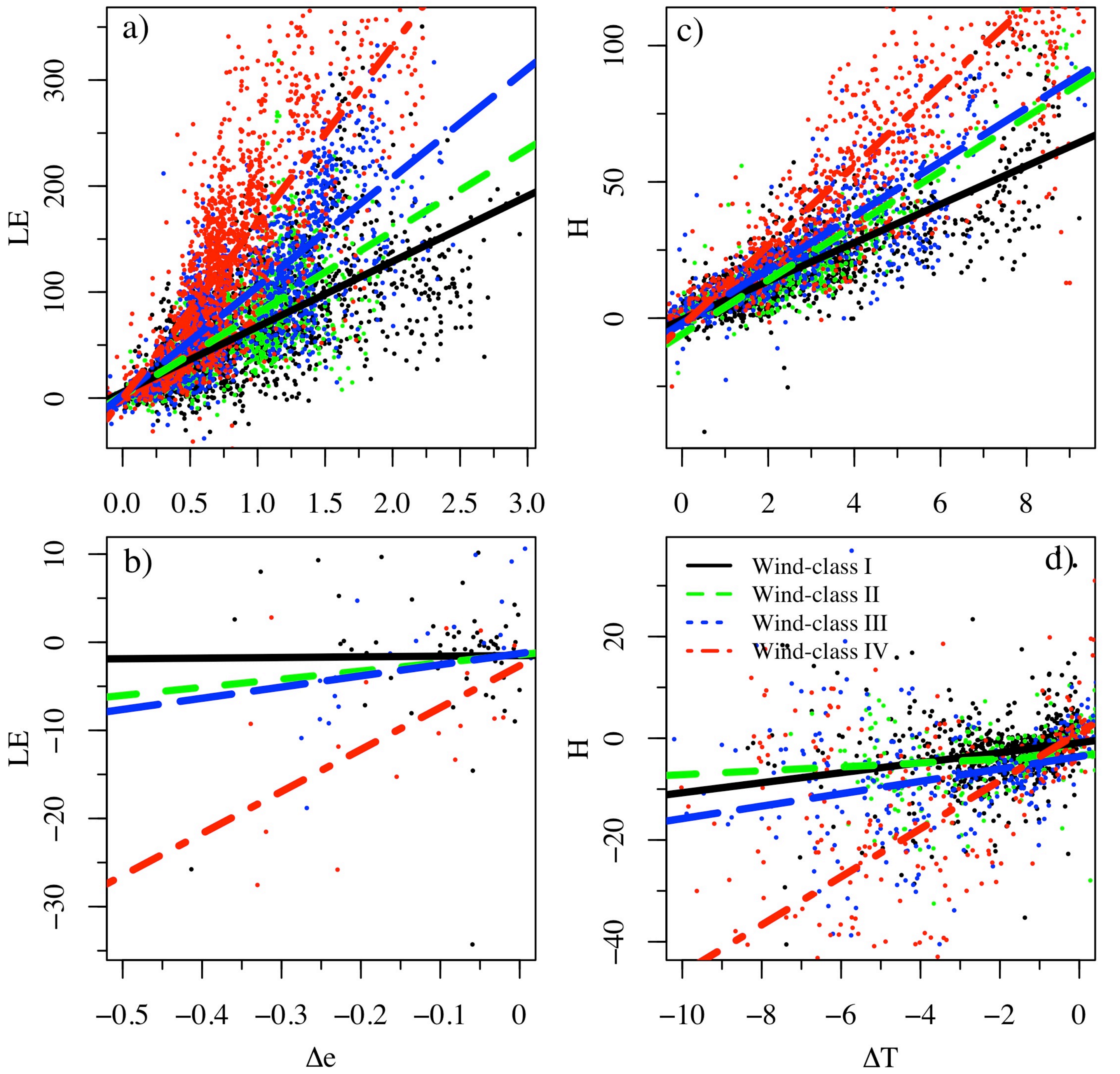
Diurnal changes in *LE*, *H*, & its drivers part 2



- Diurnal *Δe* was relatively constant in wind-class IV.
- *LE* and *H* doubled in wind-class IV compared to wind-class I.
- **Persistent wind conditions changes the atmospheric drivers of *LE* and *H* above water surfaces.**

Increased wind-class enhances *LE* & *H*

- For positive gradients, higher wind-classes would increase the correlation between *LE* and *Δe* and between *H* and *ΔT*.
- Negative *Δe* and *ΔT* cases would not behave the same as positive *Δe* and *ΔT*
- Regression slopes would dramatically increase after wind-class III.
- Wind-class III is the initial point where *LE* becomes more correlated with *Δe*.

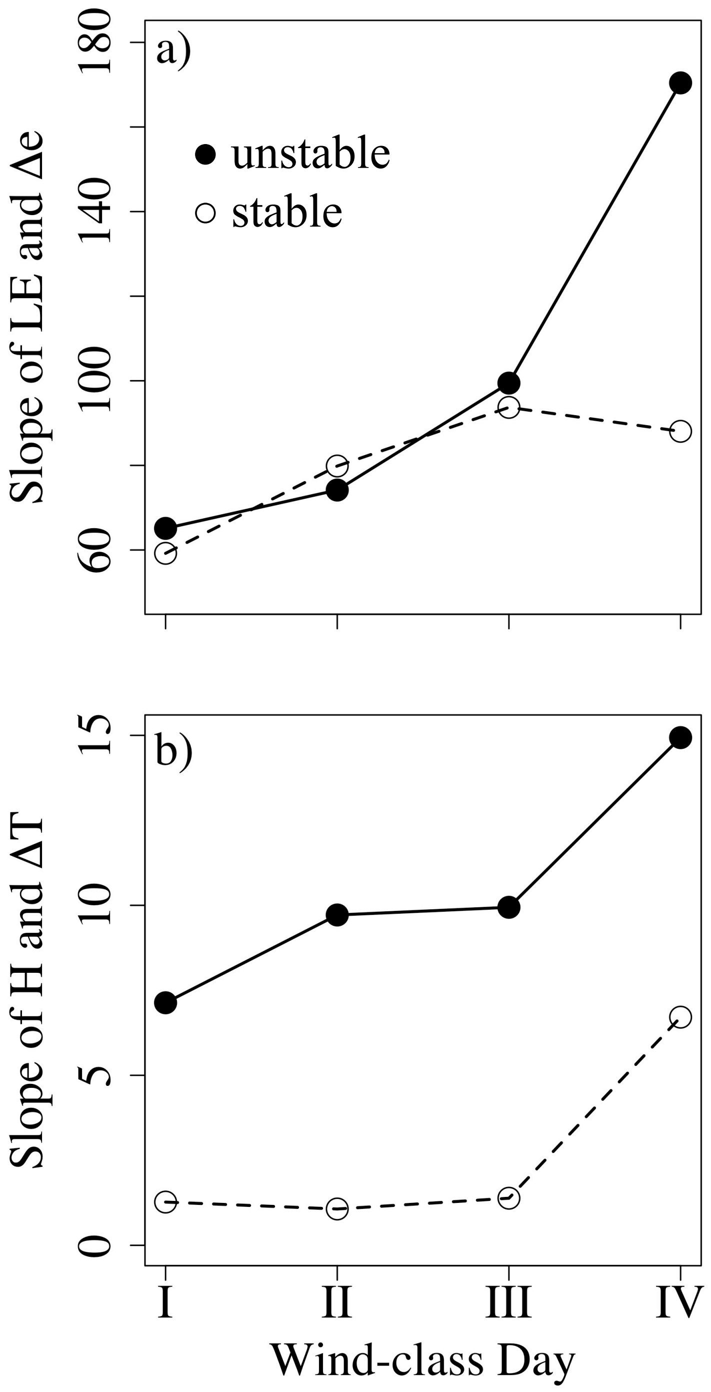


Slopes of *LE/Δe* & *H/ΔT*

$$LE/\Delta e = (\rho_a L_v)\, C_E\, U$$

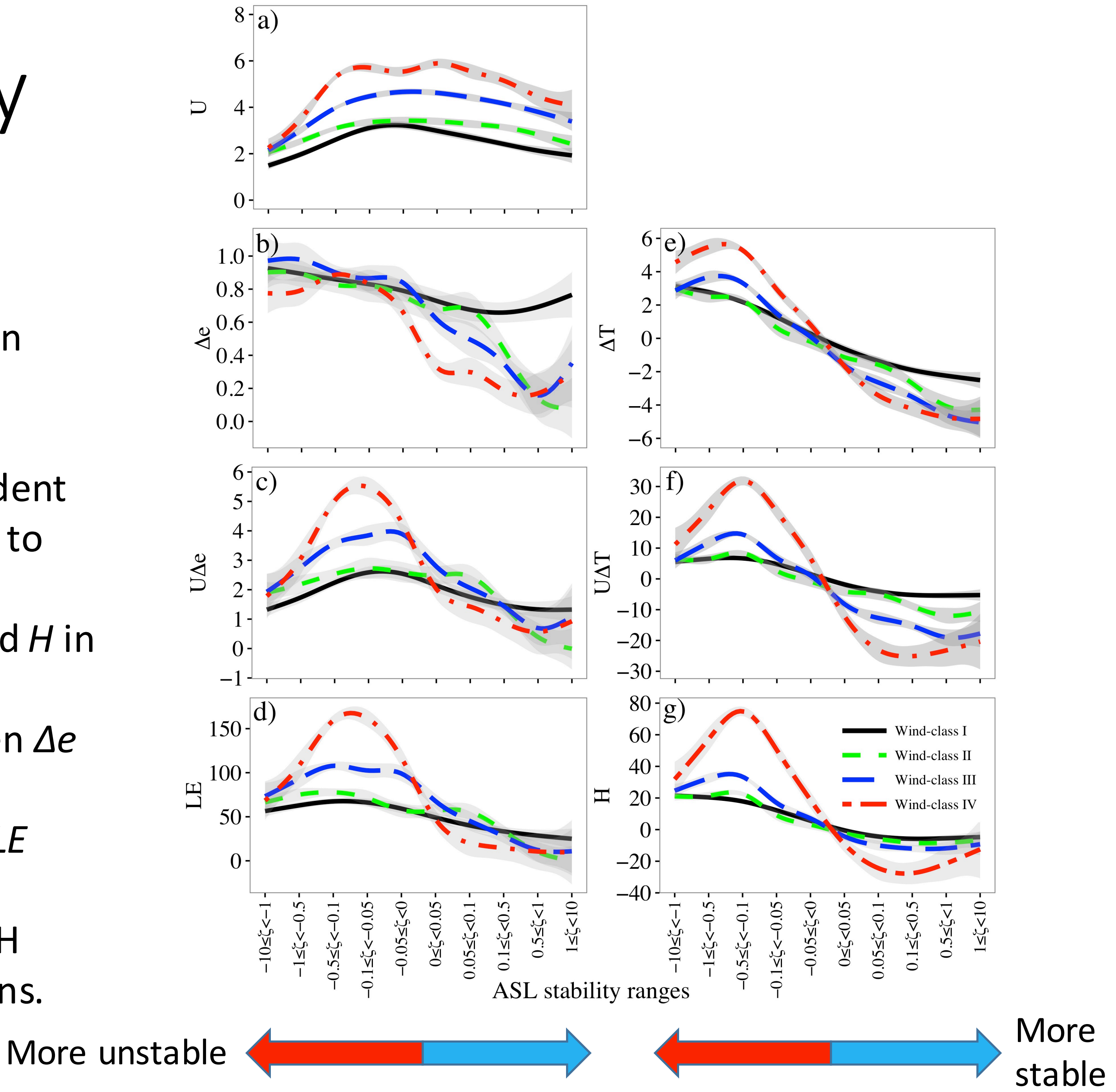
$$H/\Delta T = (\rho_a C_p)\, C_H\, U$$

- In wind-class IV, *LE/Δe* was greatly influenced by atmospheric stability.
- In other lower wind-classes, atmospheric stability did not play an important role in changing *LE/Δe*.
- Persistent high wind conditions and atmospheric stability enhanced the role of UC_E on *LE*.
- Under both unstable and stable conditions, *H* was influenced by UC_H but with increased effect in wind-class IV.



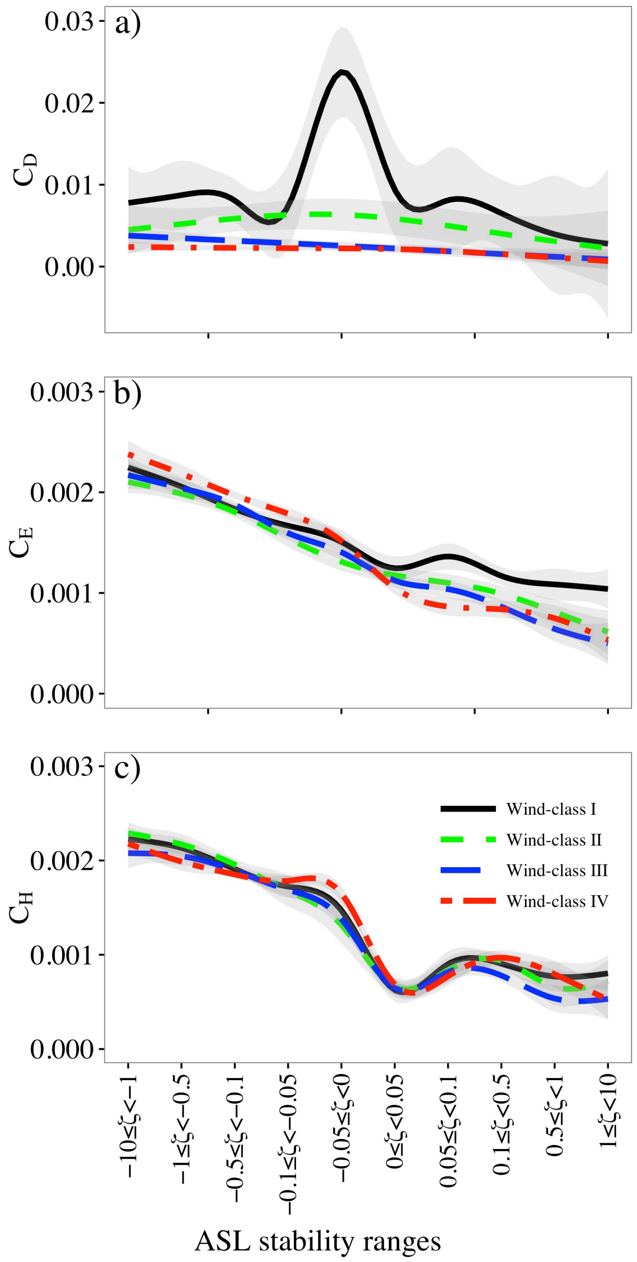
Atmospheric stability ranges on *LE* & *H*

- Maximum *LE*, *UΔe* and *H*, *UΔT* occurred in moderately unstable conditions due to maximum *U*.
- *LE* under unstable conditions are dependent on persistent wind conditions compared to stable conditions or *H*.
- Under weakly unstable conditions, *LE* and *H* in wind-class IV more than doubled in magnitude than in wind-class I even when *Δe* or *ΔT* is elevated.
- *U* interacts and enhances C_E to increase *LE* only under unstable conditions.
- *U* interacts and enhances C_H to increase H under both unstable and stable conditions.



Bulk transfer coefficients

- The bulk transfer coefficients (C_E and C_H) behaved similarly in all wind-classes and ζ ranges.
- The increase in *LE* under weakly unstable conditions are due to the interaction of *U* and C_E.
- The increase in H under both unstable and stable conditions are due to the interaction of *U* and C_H.



More unstable

More stable

Conclusions

- Persistent wind speed conditions would modify the atmospheric drivers of *LE* and *H* and increased the correlation between them.
- Evaporation (*LE*) and *H* would be greatly promoted when sufficient wind conditions are met by 2.5 and 2 times, respectively.
- The increase in *LE* under weakly unstable conditions are due to the interaction of *U* and C_E.
- The increase in H under both unstable and stable conditions are due to the interaction of *U* and C_H.

Thank you