The source/sink distribution of scalars in vegetation canopies:

key to the understanding of co-variances of passive and reactive compounds

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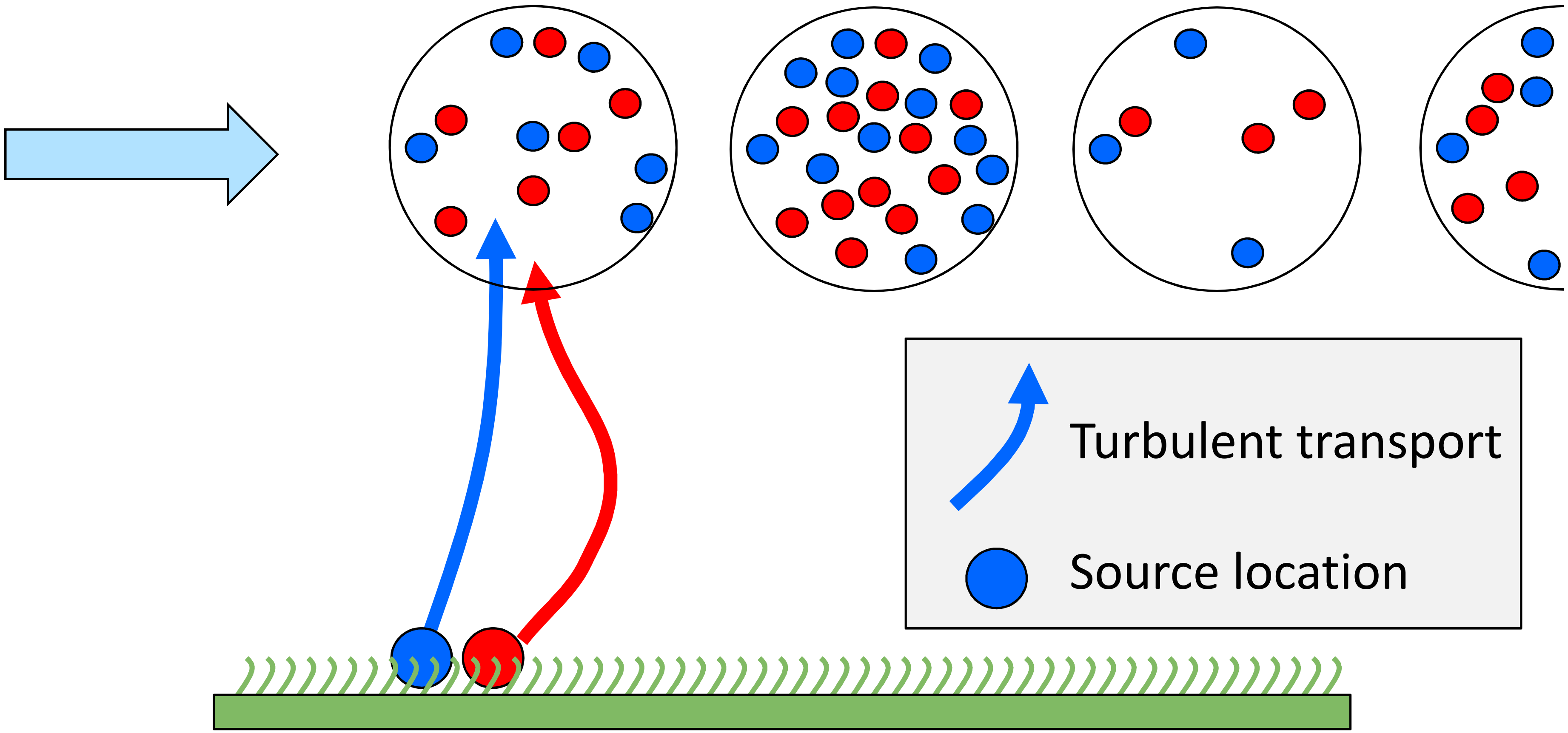

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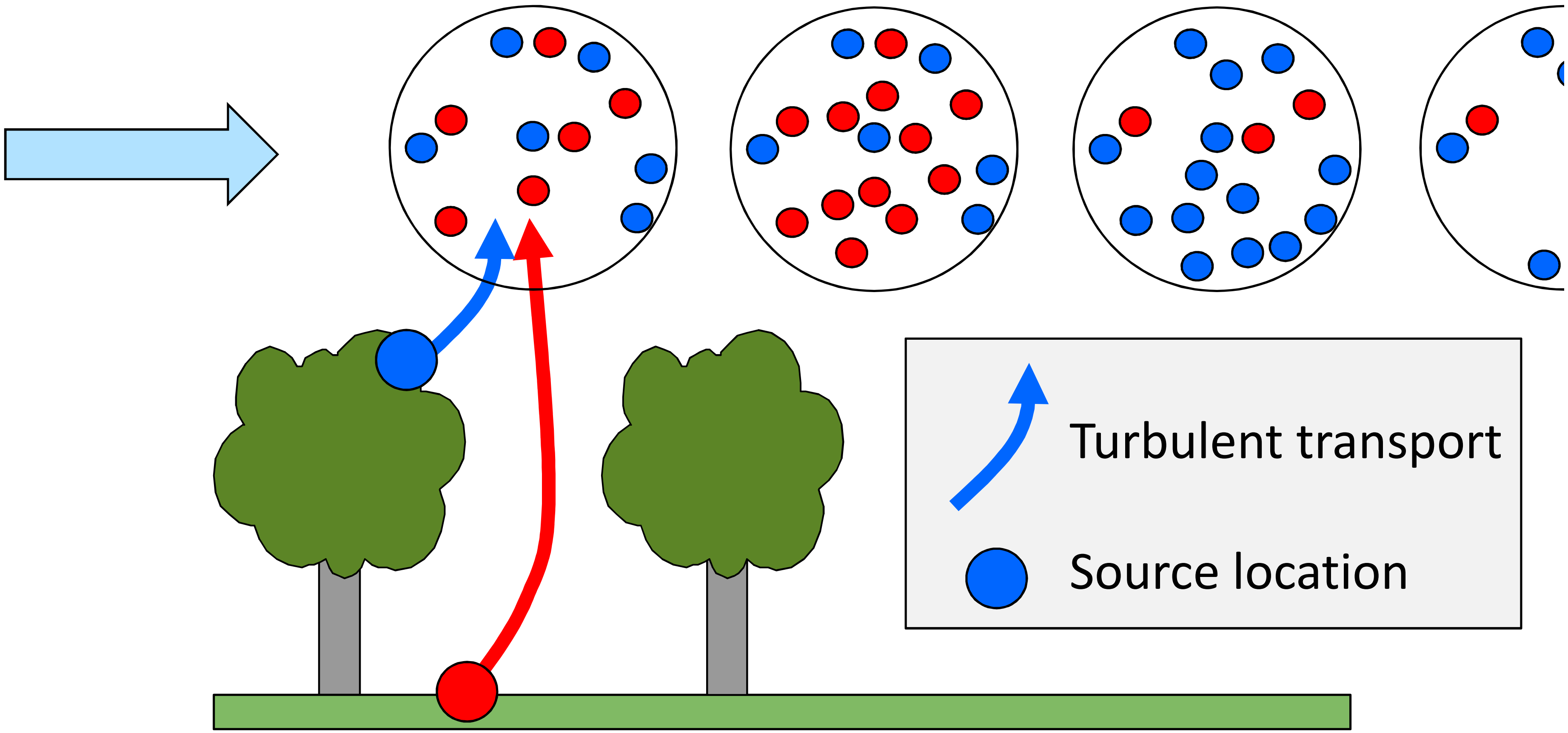

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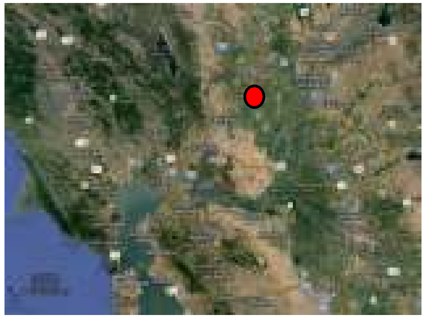
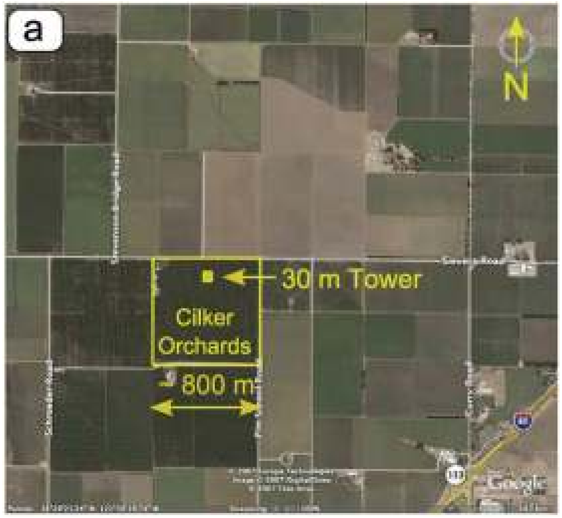
What are the (related) questions?

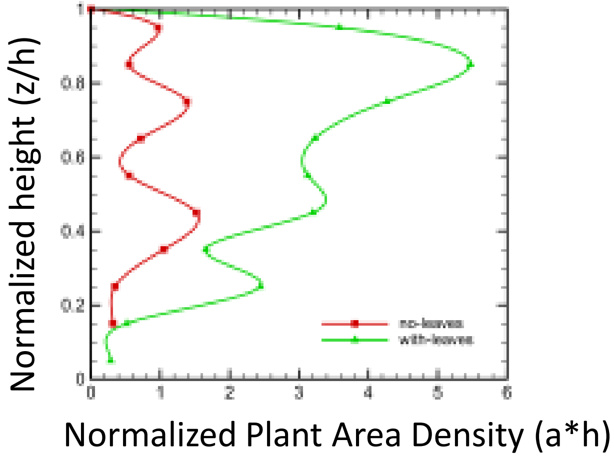
- Variations of source distribution with:
  - canopy state
  - stability
- Effect of source distribution on:
  - scalar-scalar correlation

Canopy Horizontal Array Turbulene Study (CHATS)

- Walnut tree orchard in Dixon, California
- Canopy height 10 m
- March-June 2007:







Source: Patton et al. (2011), Dupont and Patton (2012)

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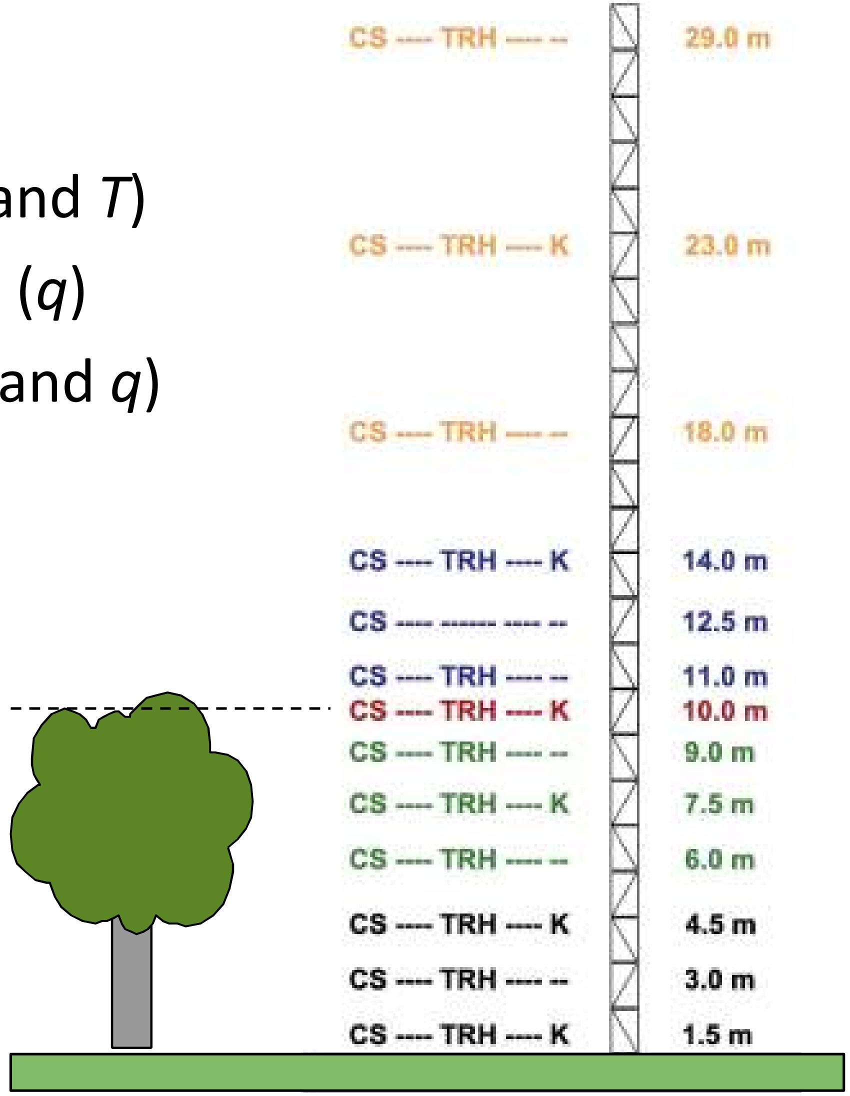
CHATS instrumentation

- Vertical tower (30 meter)
  - 13 CSAT sonics (*u*, *v*, *w*, and *T*)
  - 6 Krypton hygrometers (*q*)
  - 12 T-RH sensors (slow *T* and *q*)



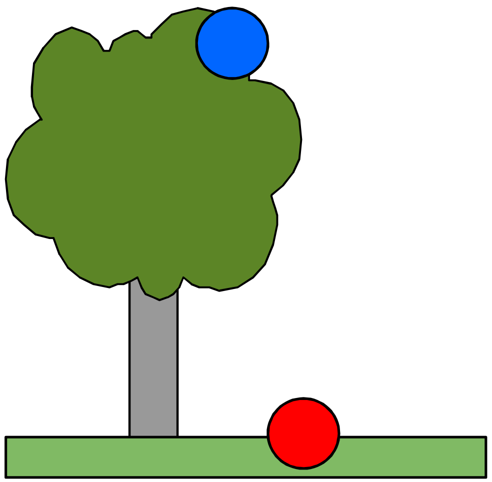
Source: Dupont and Patton (2012)

Grouping of data

- Leaf state:
  - 1 (no leaves)
  - 2 (intermediate)
  - 3 (full leaf)

- Stability: z/L at canopy top:
  - Free convection (FrC): $-20 < h_c/L \leq -1$
  - Unstable (U): $-1 < h_c/L \leq -0.2$
  - Forced convection (FoC): $-0.2 < h_c/L \leq -0.01$

Vertical source distribution

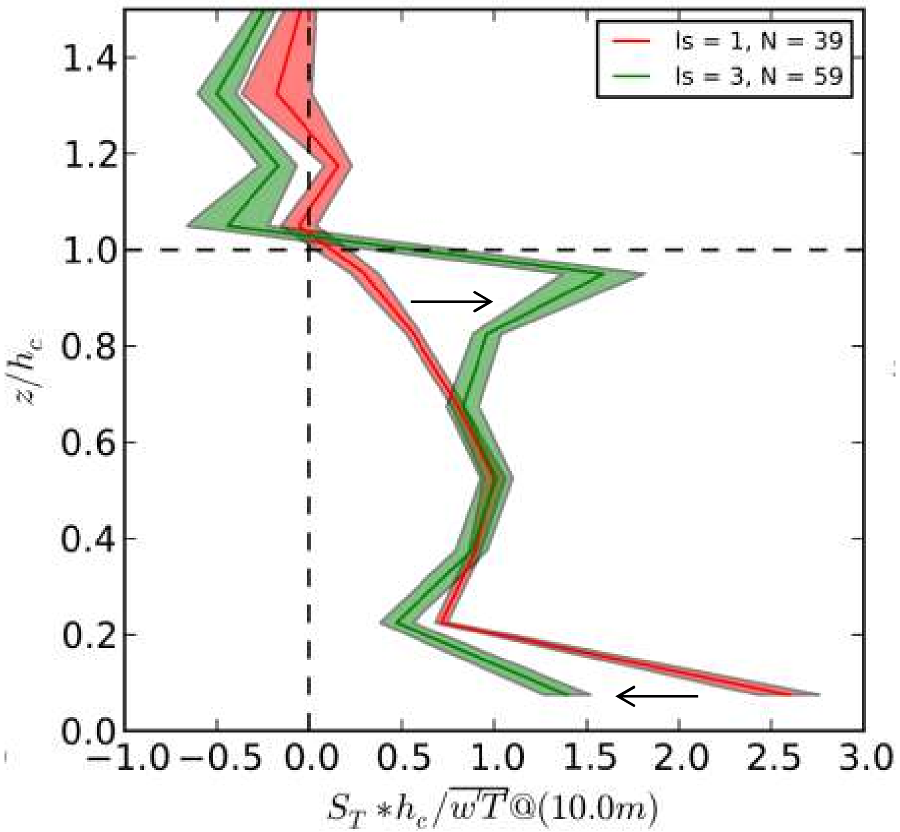


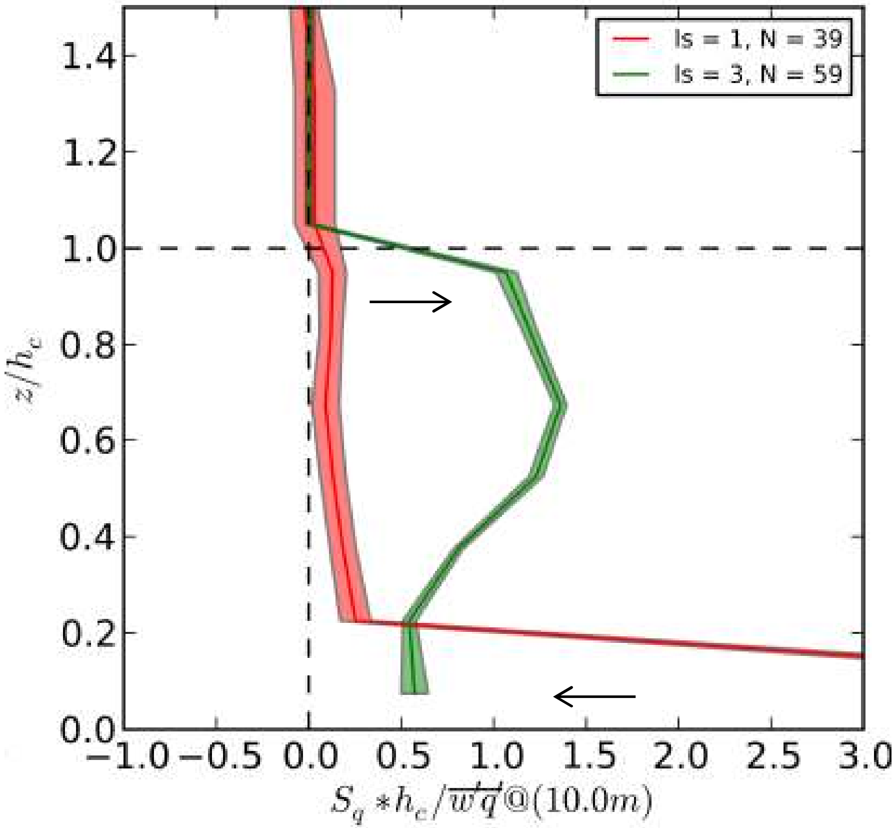
Leaves decrease importance of soil source

heat

$$S_X = \frac{\partial \overline{w'X'}}{\partial z}$$

moisture





unstable data : -1 < h_c/L < -0.2

No leaf Full leaf

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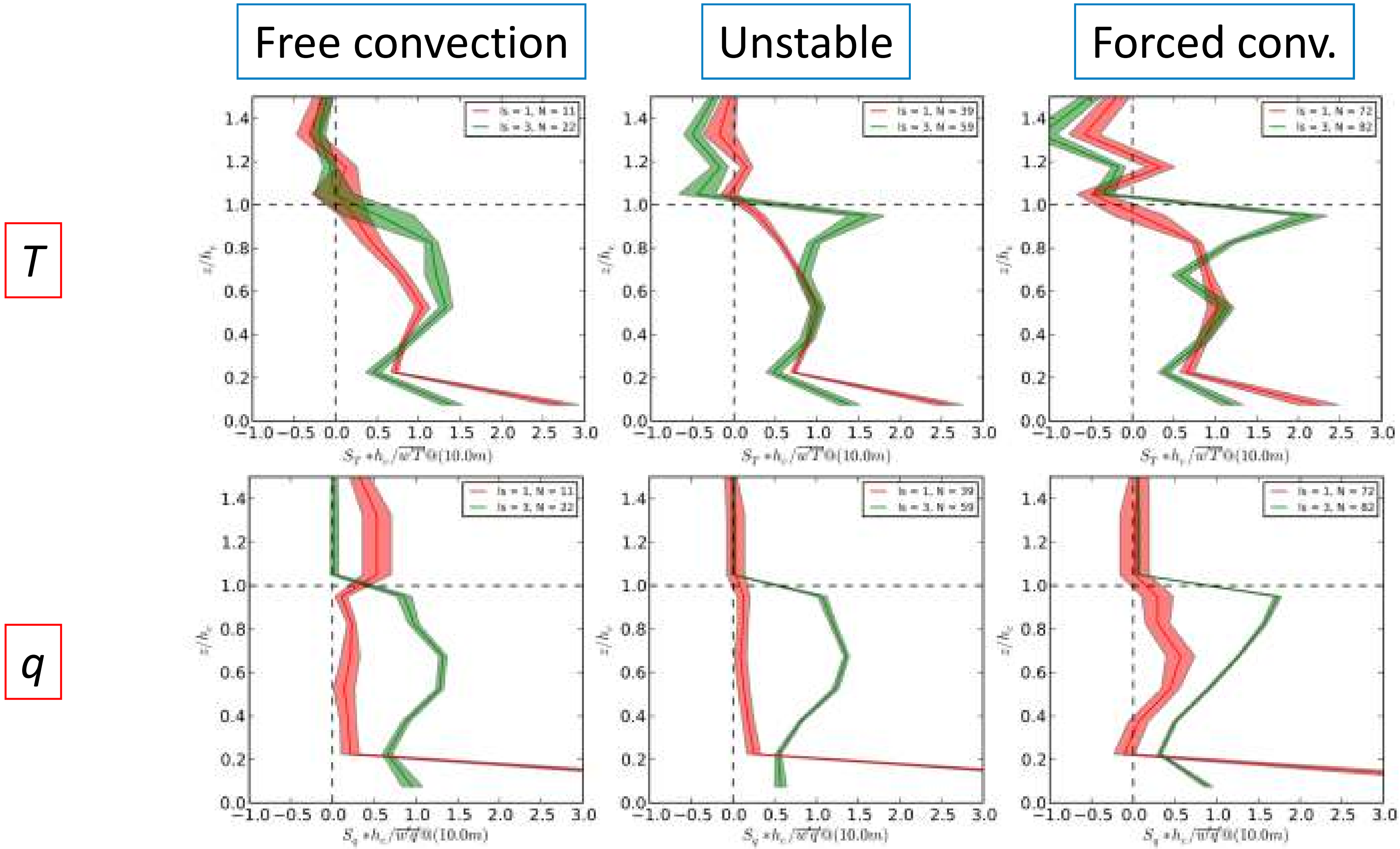
Source peak moves upward when more neutral



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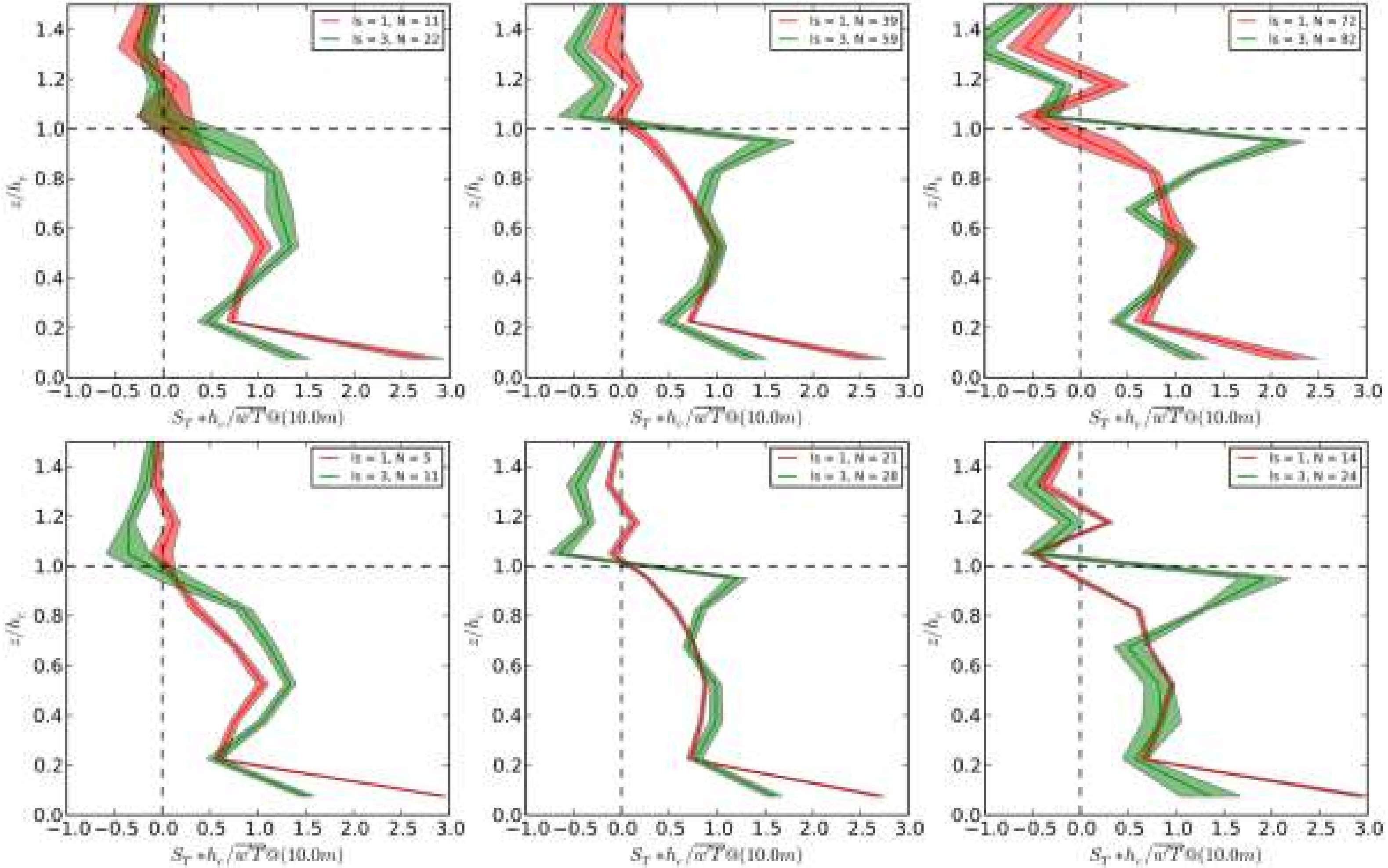
Change with stability: not due to time-of-day

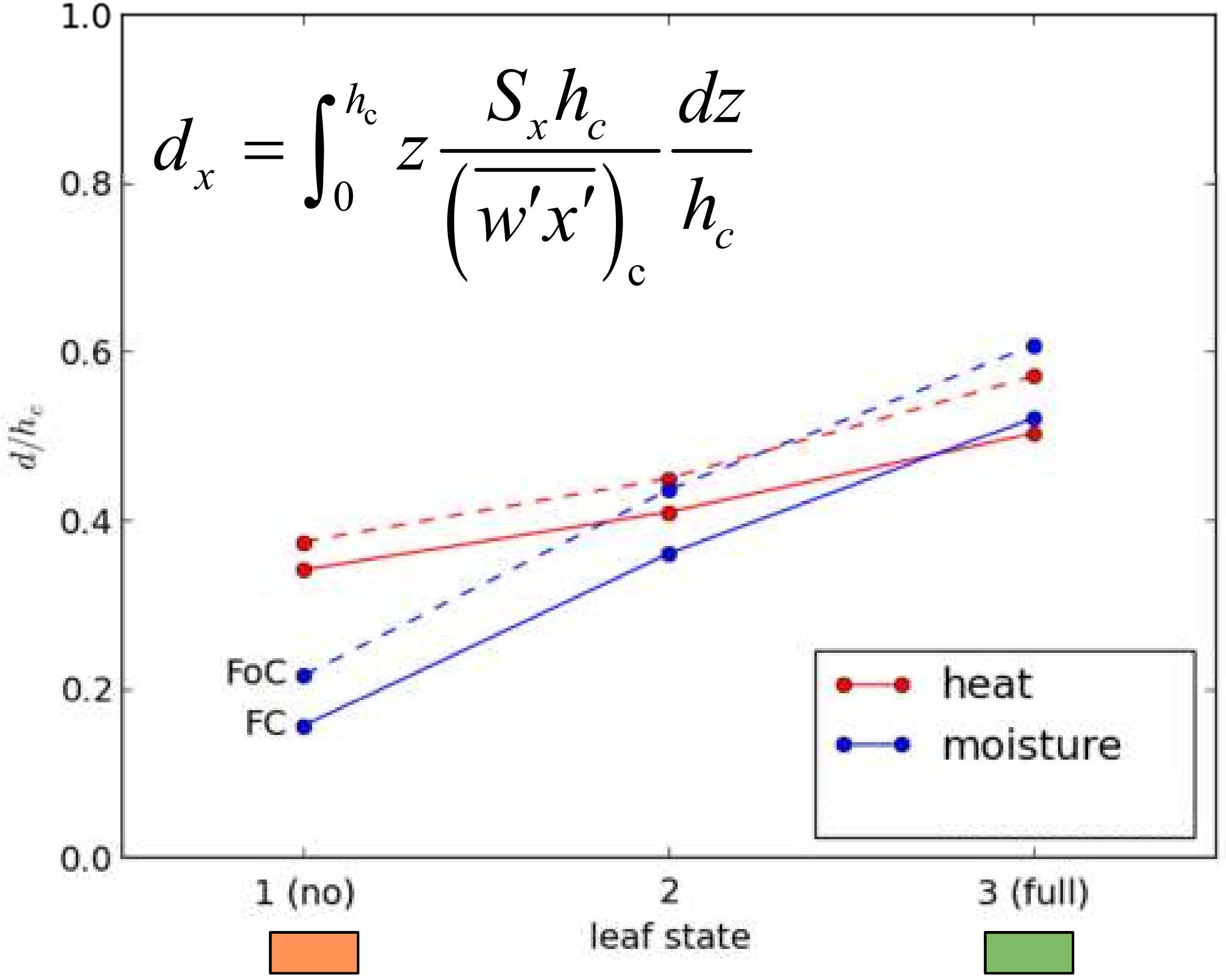
Free convection | Unstable | Forced conv.

T all data

T mid-day (10-14 LT)



Displacement height: mean source height

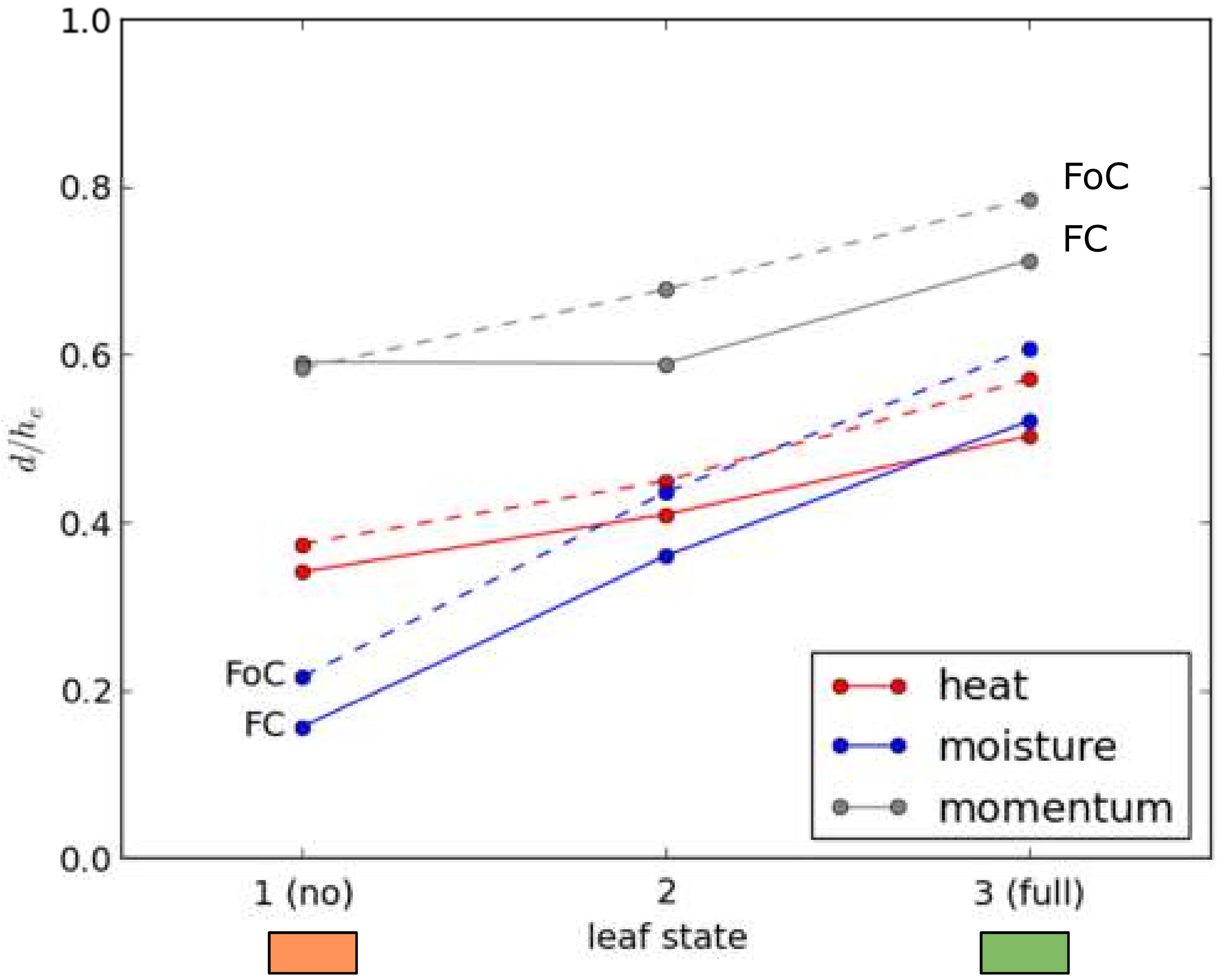


$$d_x = \int_0^{h_c} z \frac{S_x h_c}{\left(\overline{w'x'}\right)_c} \frac{dz}{h_c}$$

Displacement height varies:

- with variable
- with canopy structure
- with flow characteristic

Displacement height: mean source height

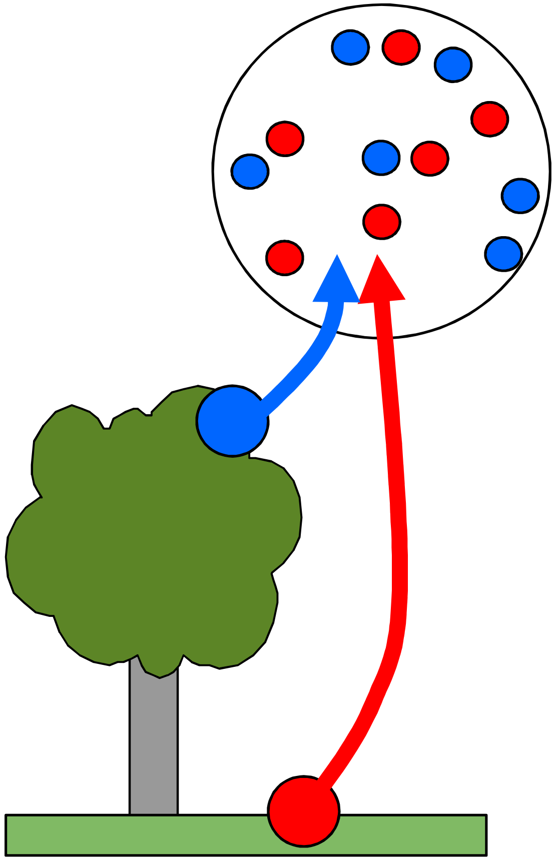


Displacement height varies

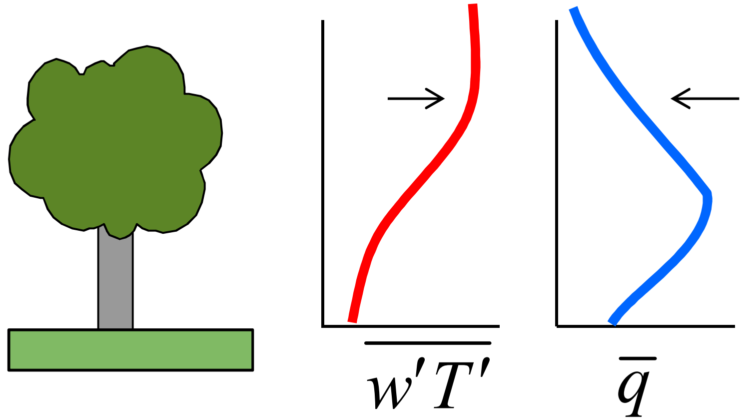
- with canopy structure
- with flow characteristic (stability)

Consistent with
Harman & Finnigan (2007)

Effect on scalar correlation



Where is scalar-scalar covariance produced?

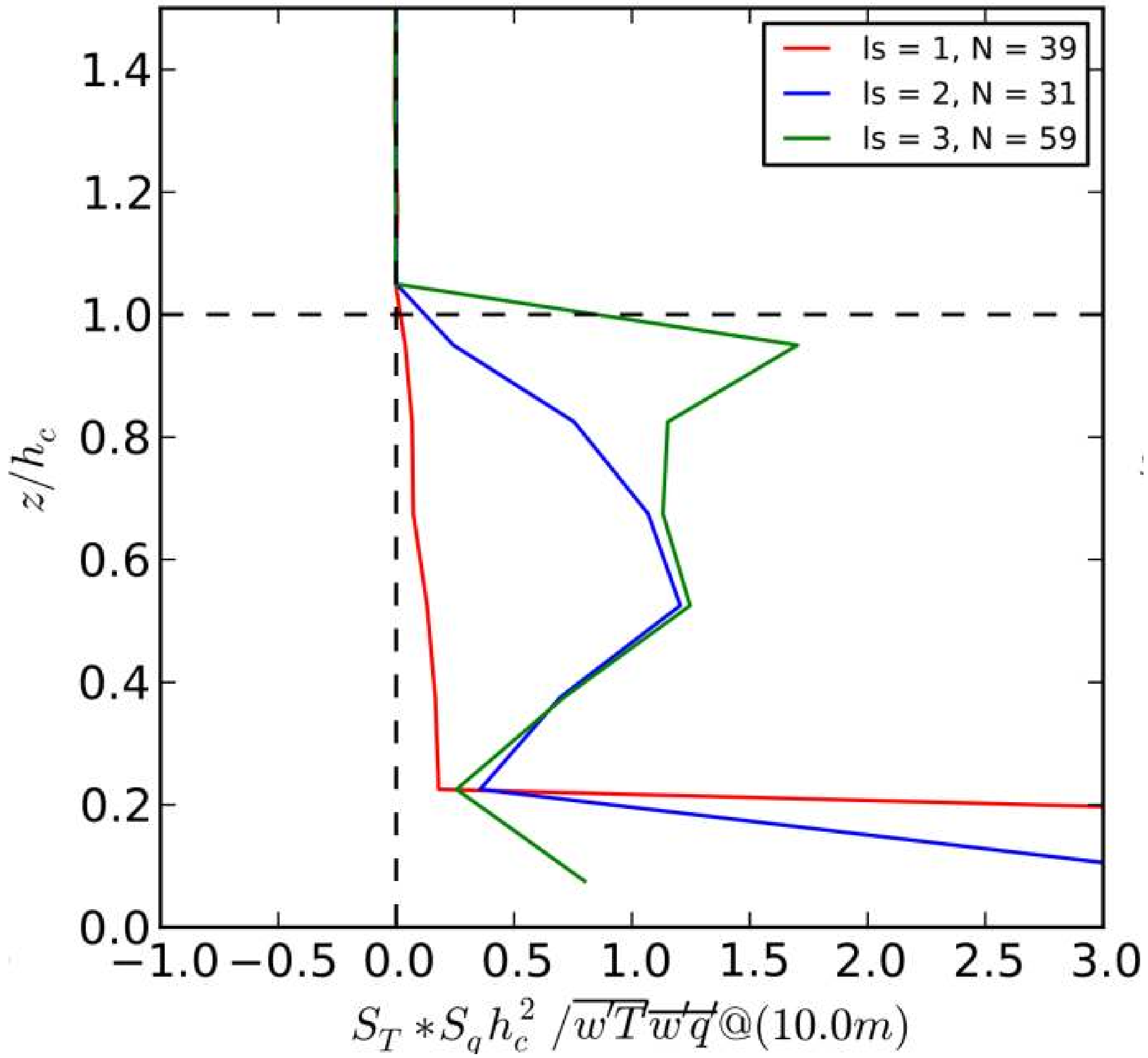


$$\frac{\partial \overline{T'q'}}{\partial t} + \mathrm{adv} = -\overline{w'T'}\frac{\partial \overline{q}}{\partial z} - \overline{w'q'}\frac{\partial \overline{T}}{\partial z} + \ldots$$

Peaks around heat source

Peaks around humidity source

…. so look at co-source distribution

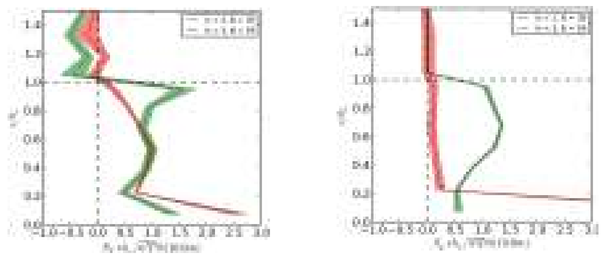


No leaf

Some leaf

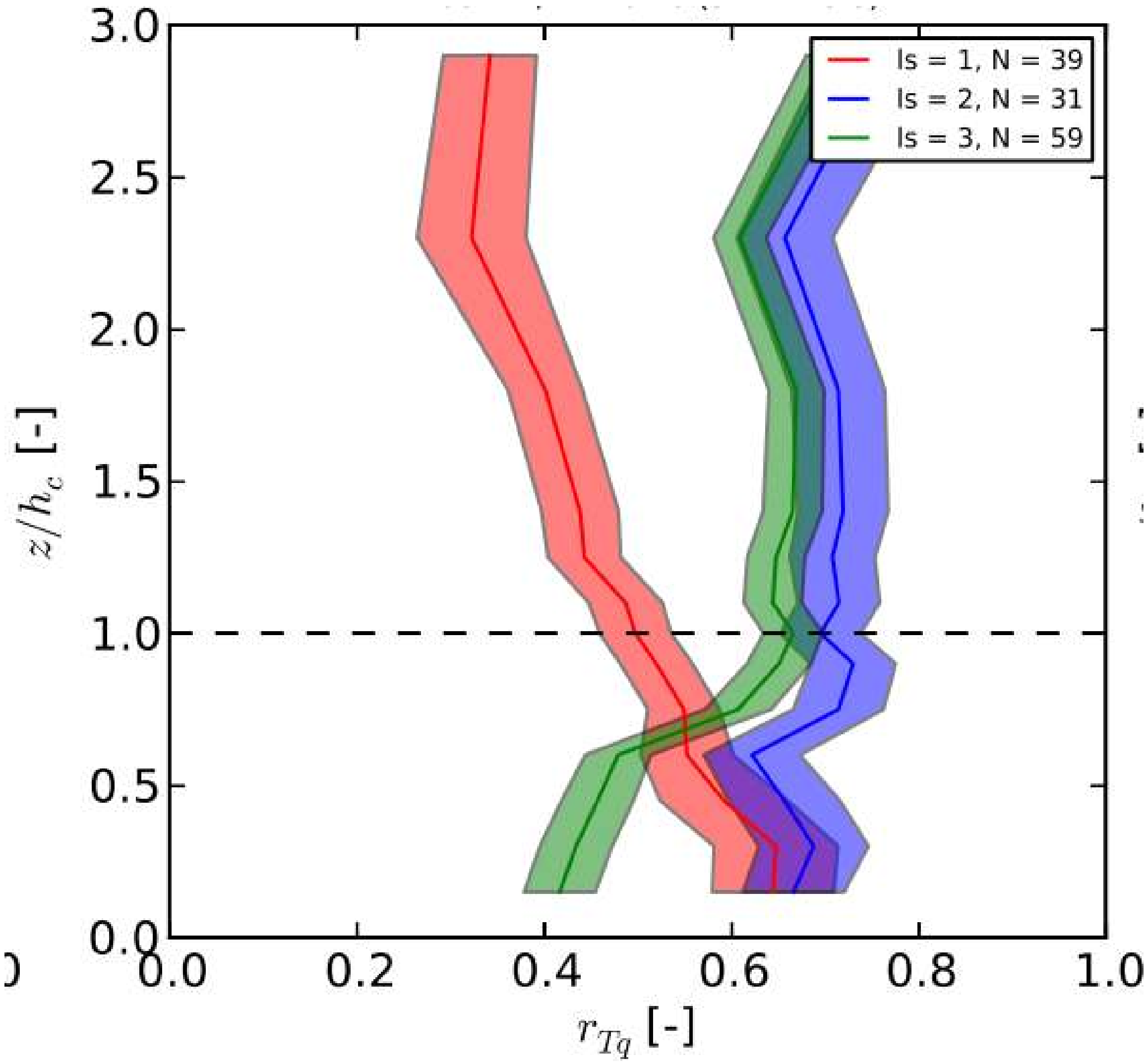
Full leaf

S_T x S_q



unstable data : -1 < h_c/L < -0.2

T-*q* correlation: canopy = (de-)correlator



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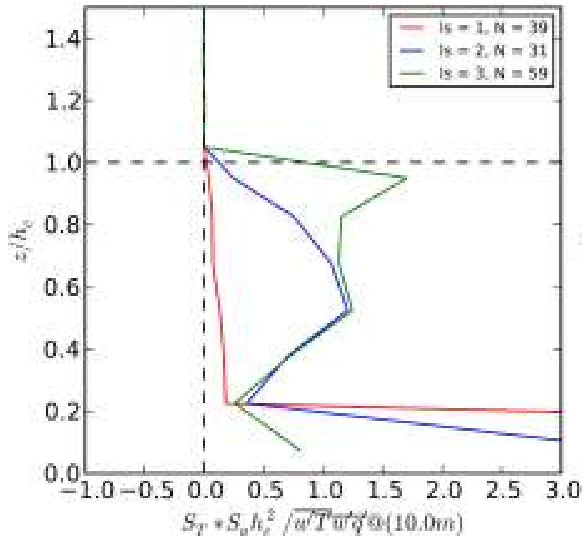

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Conclusions

- Unique data set (instruments + leaf state variation)

- Vertical source distribution
  - differs between scalars
  - varies with stability

- Co-source distribution explains covariance profiles
- Canopy acts as a (de-)correlator:
  correlation @ top-of-canopy determines above-canopy correlation

Thank you

Thanks to:

- NCAR - Advanced Study Program
- all people involved in CHATS

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