Strong sesquiterpene emissions from Amazon soils

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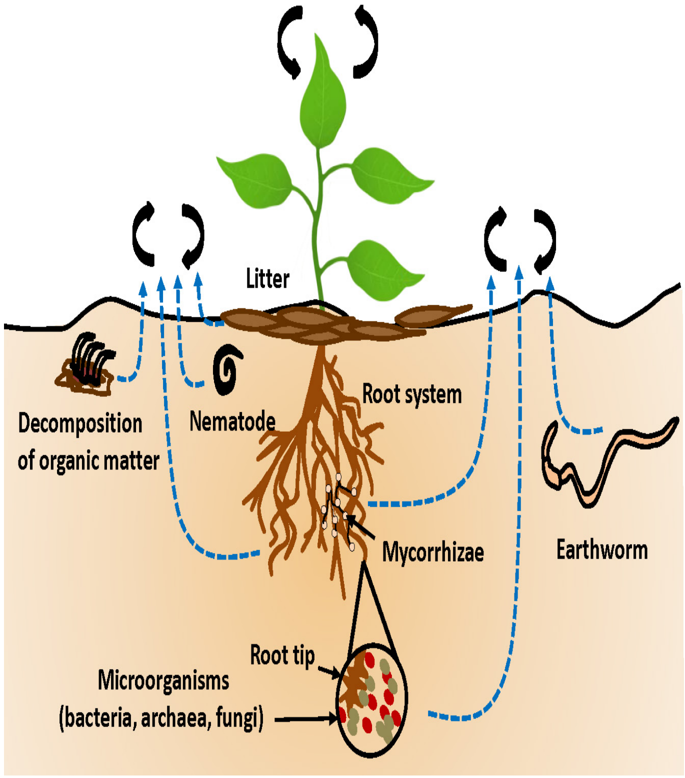
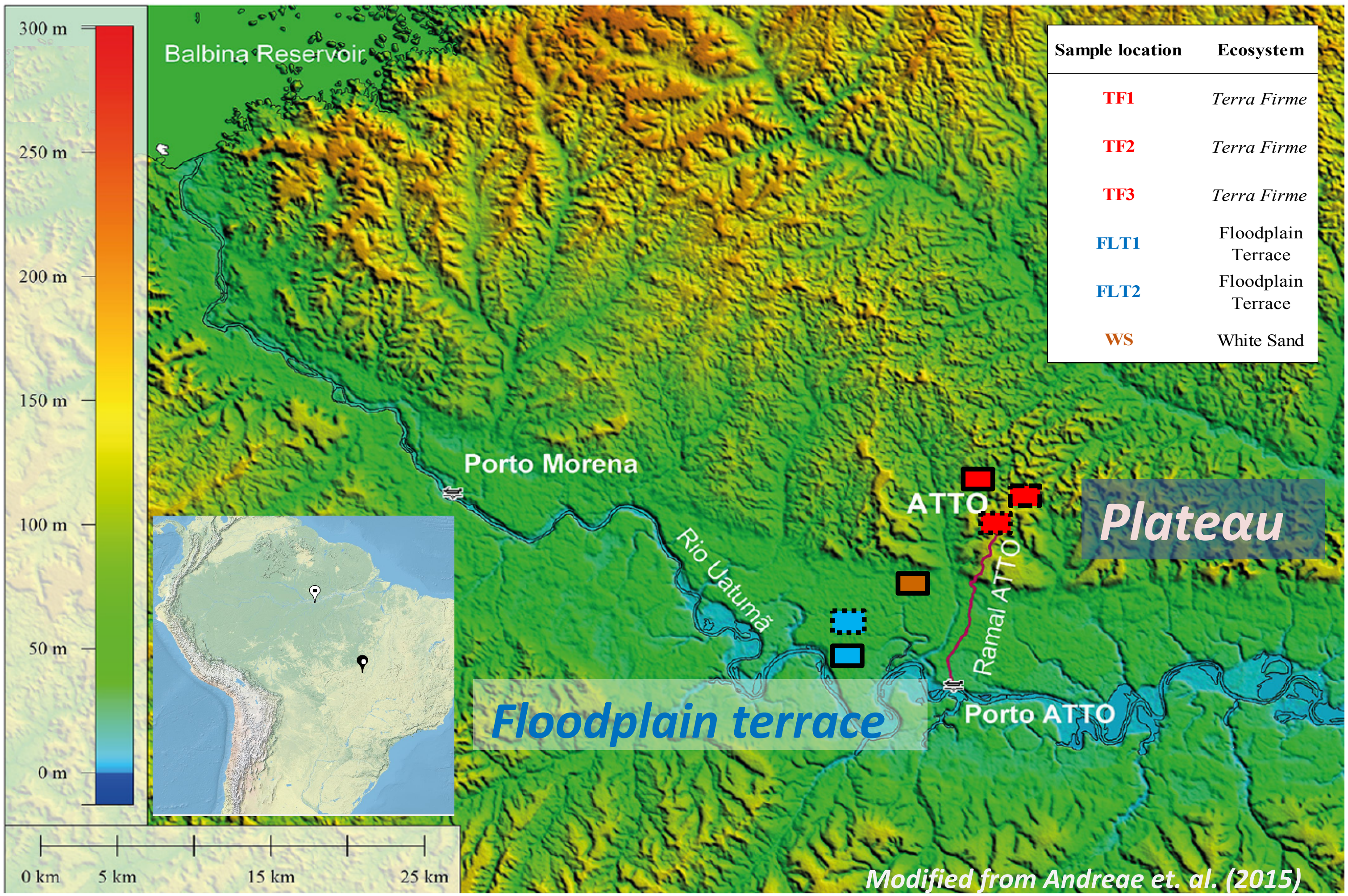
Emissions from forest soils

- Myriad emitted species
- Myriad sources
- Myriad environmental drivers
- Myriad potential impacts on chemistry, climate, Earth system processes
- Incredibly poorly understood; incredibly poorly modelled



©diagram of dirt

Emissions in the Amazon



Emissions in the Amazon

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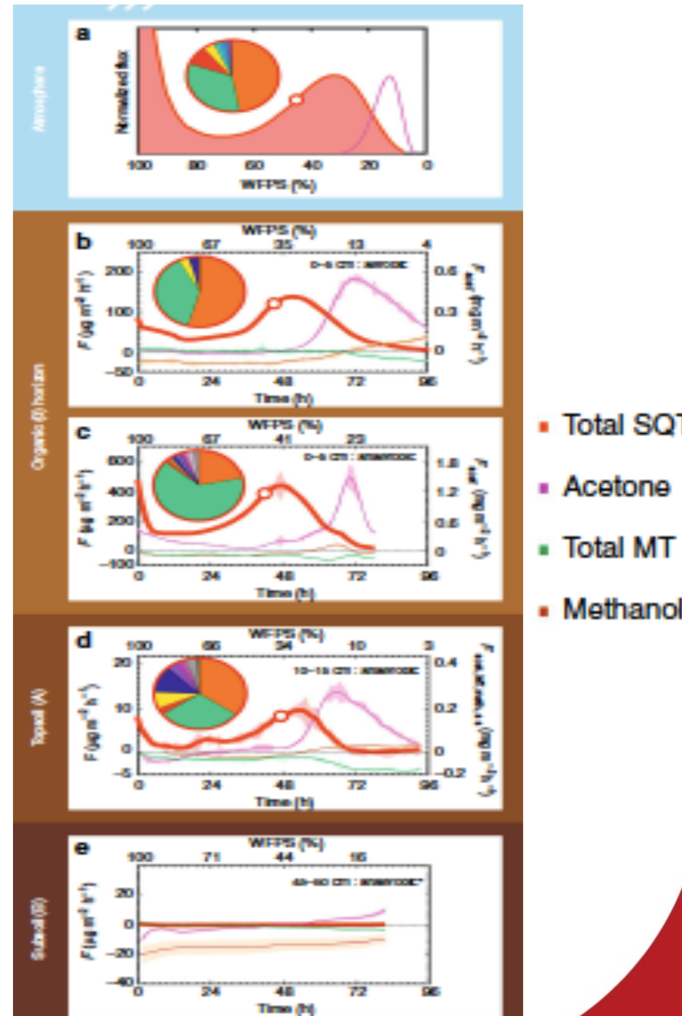
Sample number	Depth	Ecosyst.	Pit	Coordinates	Elev. (m)	Soil type	BD (g/cm^3)	pH	Clay (%)	Σ_{RB}(m mol kg^{-1})	Sum of bases (cmol kg^{-1})	Index Π	T (°C)	Conditions
1													30	Aerobic
2													30	Aerobic
3		Terra Firme	Pit 1	02 08'06" S, 59 00'07"W	127	Ferralsol	0,51	3,6	81	7,79	2,45	0	30	Aerobic
4													30	Aerobic
5													30	Anaerobic
6													20	Aerobic
7		Terra Firme (TF2)	Pit 2	02 08'13" S, 58 59'31"W	145	Ferralsol	0,53	3,5	81	7,8	3,41	0	30	Aerobic
8													30	Anaerobic
9													30	Aerobic
10		Terra Firme (TF3)	Pit 3 (ATTO)	2 08'38.8"S, 58 59'59.6"W	126	Ferralsol	0,52	n.d.	n.d.	n.d.	n.d.	n.d.	20	Aerobic
11													30	Anaerobic
12	0 - 5 cm												20	Flood
13		Terra Firme (TF4)	Pit 4	13 04'35.53"S, 52 22'36.61"W	246	Ferralsol	0,86*	4,6	48,9*	28,3*	2,32*	0*	30	Aerobic
14													30	Aerobic
15		Terra Firme (TF5)	Pit 5	13 04'44.73"S, 52 23'10.21"W	378	Ferralsol	0,86*	4,5	48,9*	28,3*	2,32*	0*	30	Aerobic
16													30	Aerobic
17													20	Aerobic
18		Floodplain Terrace	Pit 6	02 13'24" S, 59 01'56"W	40	Alisol	0,83	3,7	65	20,59	2,38	2	30	Aerobic
19													30	Anaerobic
20													20	Aerobic
21		Floodplain Terrace (FLT2)	Pit 7	02 14'03.5" S, 59 01'58,4"W	30	Alisol	0,87	3,5	64,5	22,57	4,18	1	30	Aerobic
22													30	Anaerobic
23													20	Aerobic
24		White sand	Pit 8	2 11'24.9"S, 59 01'13"W	36	Podzol / Arenosol	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	20	Aerobic
25													20	Aerobic

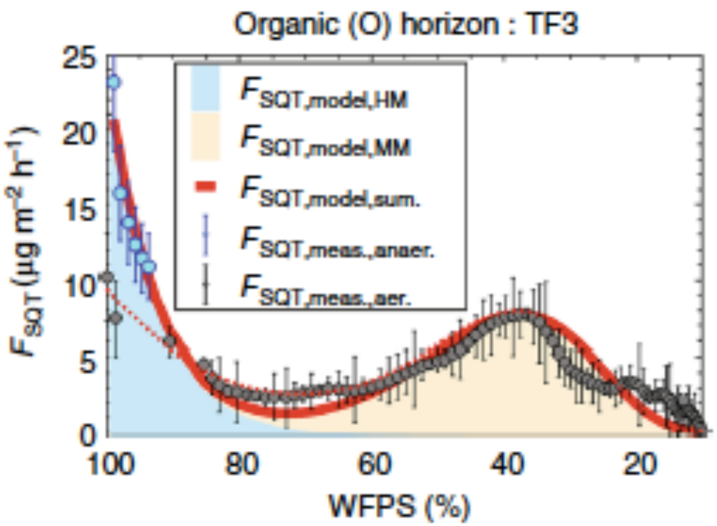
Repeated at :
10-15 cm
45-50 cm

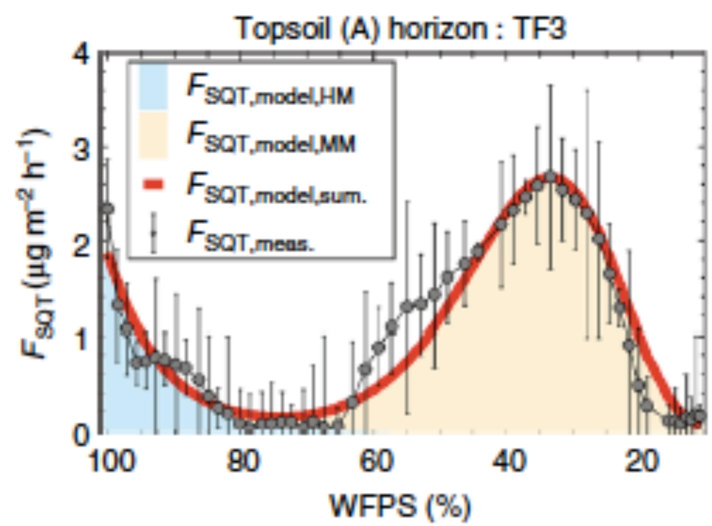
Laboratory experiments

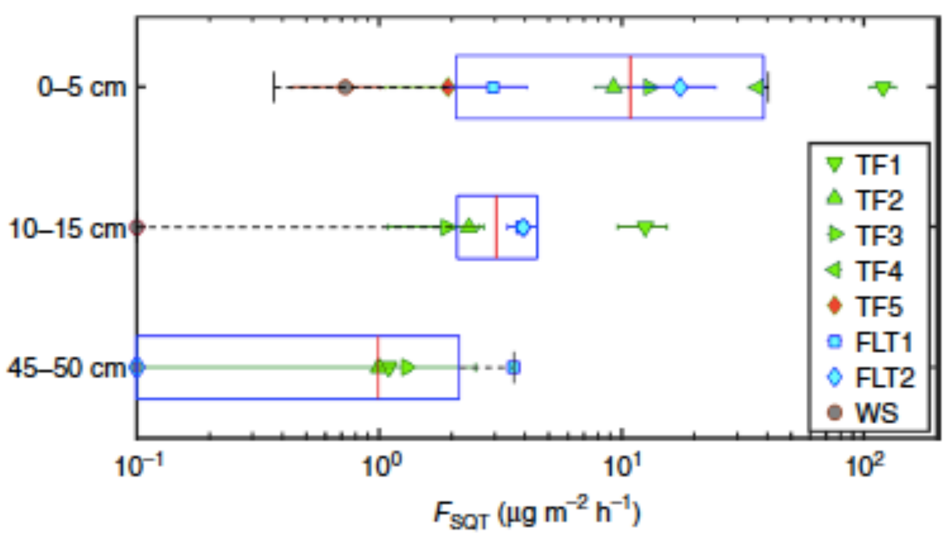
- 42 soil samples; 3 depths, 8 sites
- Soils wetted to 100% water-filled pore space (WFPS)
- Controlled dessication
- Initial burst of **SQTs** with strong fluxes of **SQTs** and **acetone** later
- Clear optimum WFPS:
  - **SQTs** @31.3±6.3%
  - **Acetone** @10.2±6.7%
- Other drivers: soil type, depth, O_2 BUT not T



Soil SQT emissions model

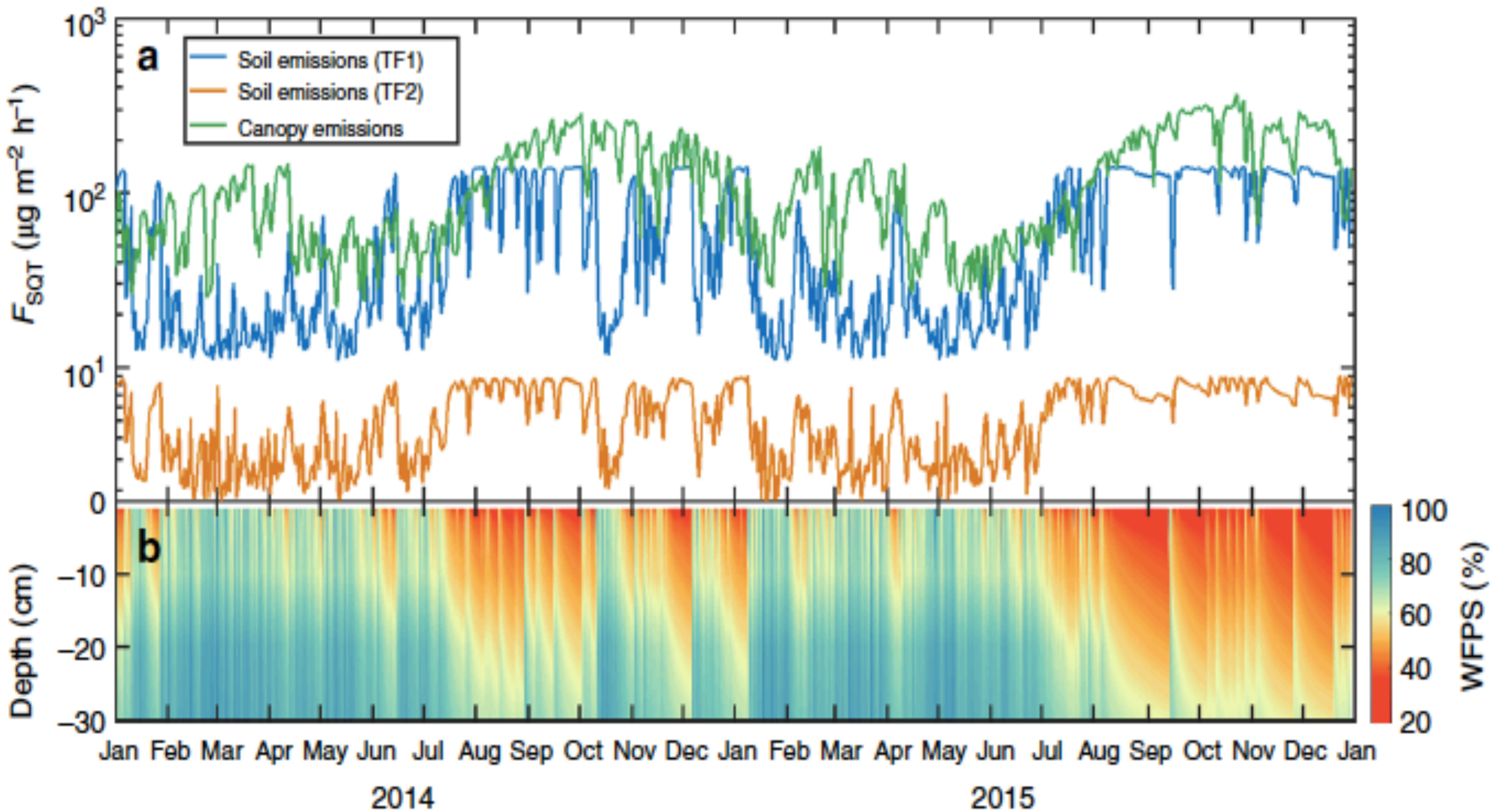






Ave (TF) optimum = 44.9 μg m^{-2} h^{-1}

Are soil SQTs important?

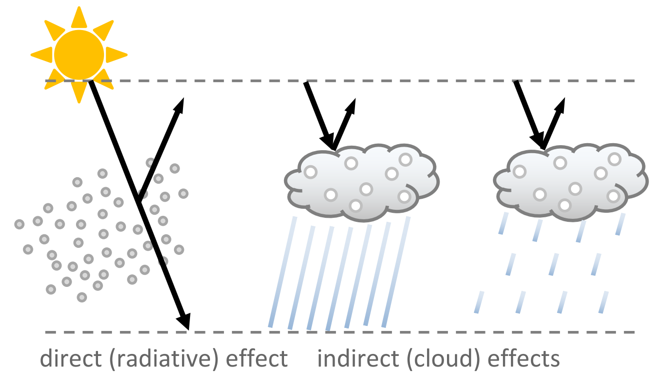


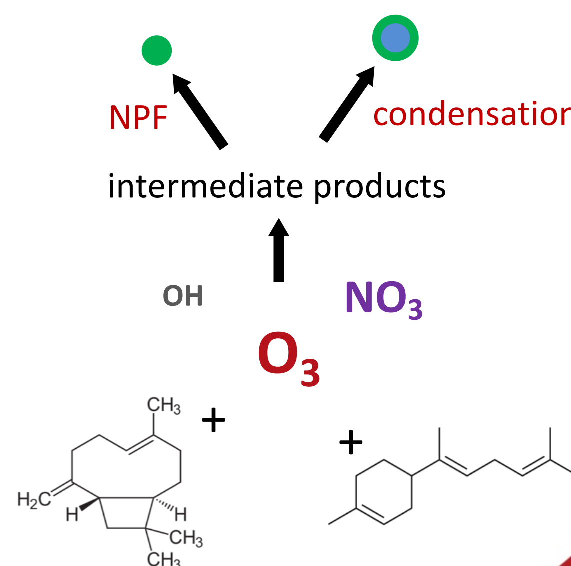
SQTs and the Atmosphere

Why do these emissions matter?

- SQTs ($C_{15}H_{24}$) are highly reactive
  $\tau \approx$ s to mins
- Rapidly oxidised by OH, O_3, NO_3
- Reaction products are low volatility
- Yield of aerosols high: ~40%+
- SOA = fine PM => implications for
  - air quality
  - climate

Do soil SQT emissions affect local climate?

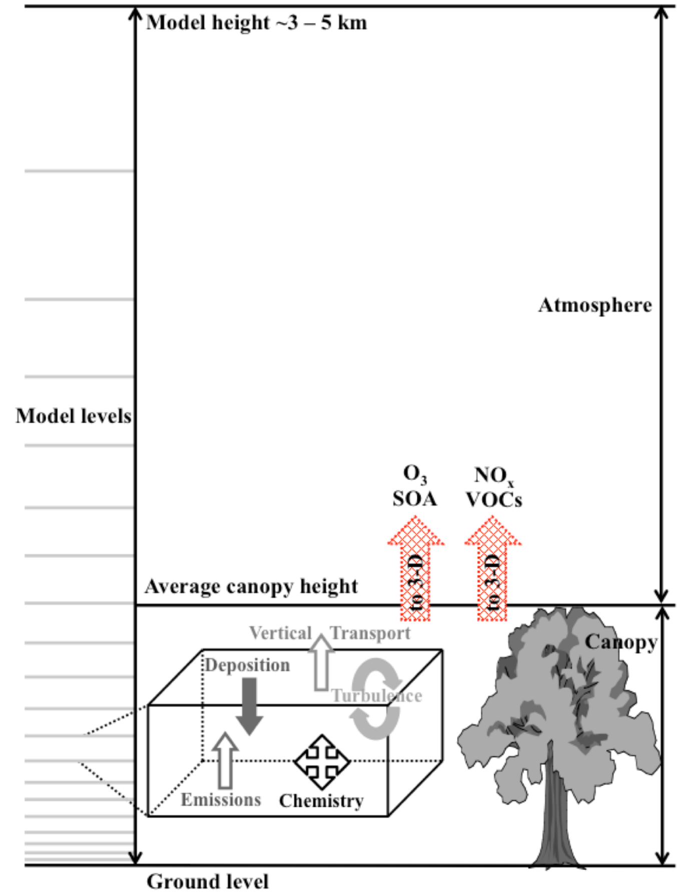




FORCAsT canopy exchange model

FORest Canopy-Atmosphere Transfer model

- 1-D column model
- Multiple levels in soil, canopy & atmosphere
- Emphasis on atmospheric processes within the canopy …
- … and their impacts above



Research Qs for FORCAsT

Do soil SQTs escape the canopy?

How do soil SQTs affect the oxidant budget within the canopy?
[O_3 (and OH) reactivity]

How do their reaction products affect canopy top fluxes?

How do soil SQTs alter the “condensable products” formed?

Do soil SQT emissions have the potential to affect local climate?

FORCAsT model set-up

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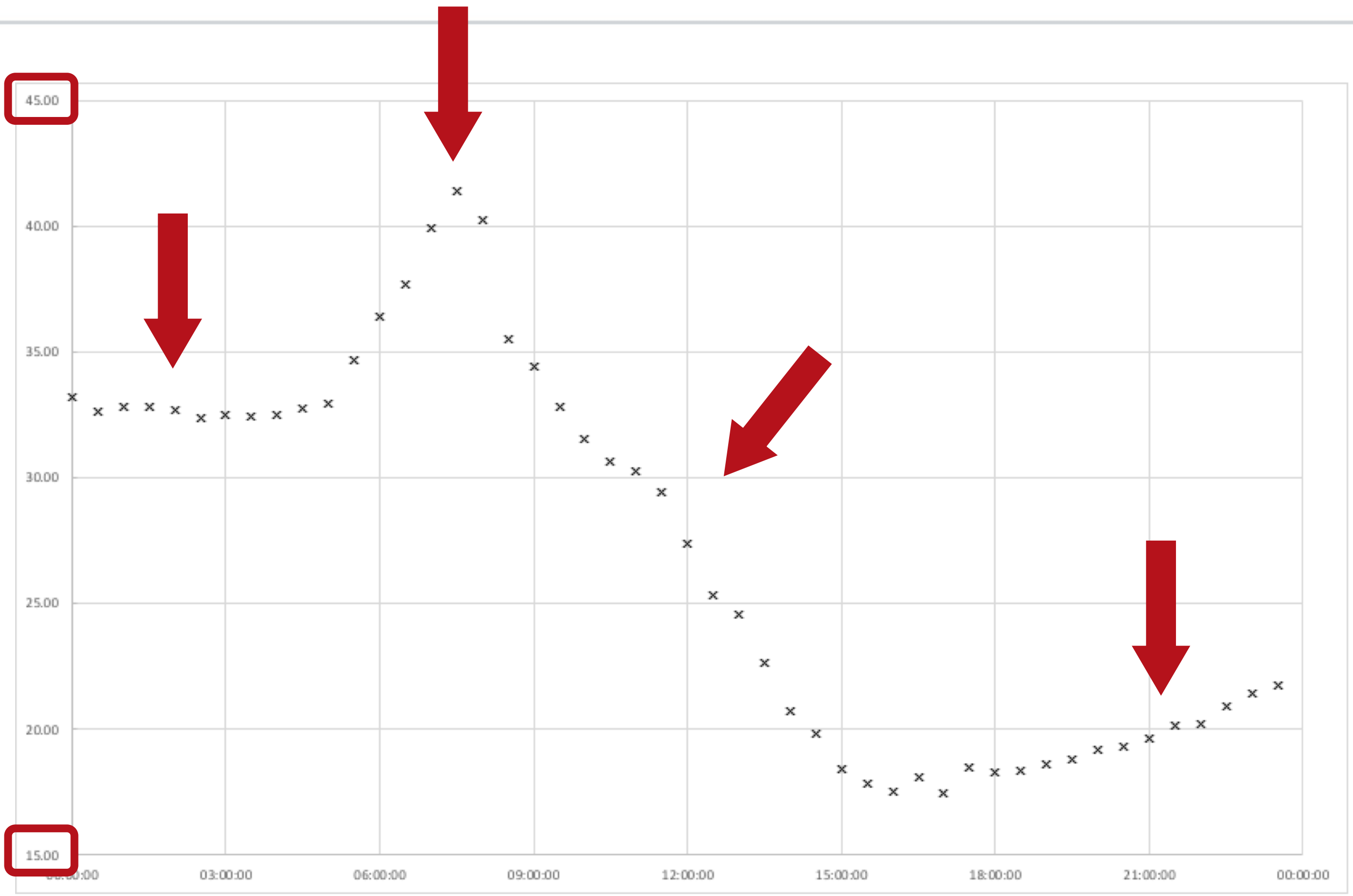
Initial & boundary conditions

- Canopy: average values from previous campaigns at ATTO
- Meteorology:
  - average T (air), RH, PAR, wind speed & direction at multiple heights measured at ATTO during period of sampling
  - friction velocity, turbulence calculated from relationships previously observed at ATTO
- Concentrations of trace gases:
  - average values from other groups at ATTO
- In-situ emissions:
  - foliage VOCs & soil NO from literature for the site

Results

Do soil SQT emissions have the potential to affect local climate?

Condensable products



top 40m

Percentage increase in “SOA” due to SQTs from soil at ATTO in Sept 2014

Conclusions

Do soil SQT emissions have the potential to affect local climate?

Yes!

What next?

VOCs from soils

- Other VOCs: monoterpenes, isoprene, methanol, acetone, …
- Other locations
- Global impacts

Other species

- NO, NO_2, NO_x, …
- Amines
- Site-specific & global

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