Analysis of Data from Nov 12, 2022-Mar 30 2023

Colony	Entrance faces	Wrap	Slatted Rack?	Upper Entrance With wind block	Lower Entrance
Sask1	South	Cozy (R8)	Yes	No	1.8”x3/8”
Sask2	South	Cozy (R8)	No	No	1.8”x3/8”
Ital1	South	Cozy (R8)	Yes	1/2” x 3/8”	½ oval – 1” x 3/8”
Sask3	South	Cozy (R8)	No	1/2” x 3/8”	½ oval – 1” x 3/8”
Stalker	North	3 layers of R3.7 Colony quilt (R11.1)	No	1/2” x 3/8”	½ oval – 1” x 3/8”

Definitions

- **Vapor Density = Absolute humidity :** (expressed as grams of water vapor per cubic meter volume of air) is **a measure of the actual amount of water vapor (moisture) in the air, regardless of the air's temperature**. (from weather.gov).
  - Absolute humidity is also referred to as vapor density of the air.
  - The equation used to calculate this is :
    - (0.611*10) * Power(2.71828,(17.502*T)/(T+240.9)) * (RH*2.18647)/(273.15+T)
    - Where RH is the relative humidity as measured by broodminder and T measured temp In Celsius

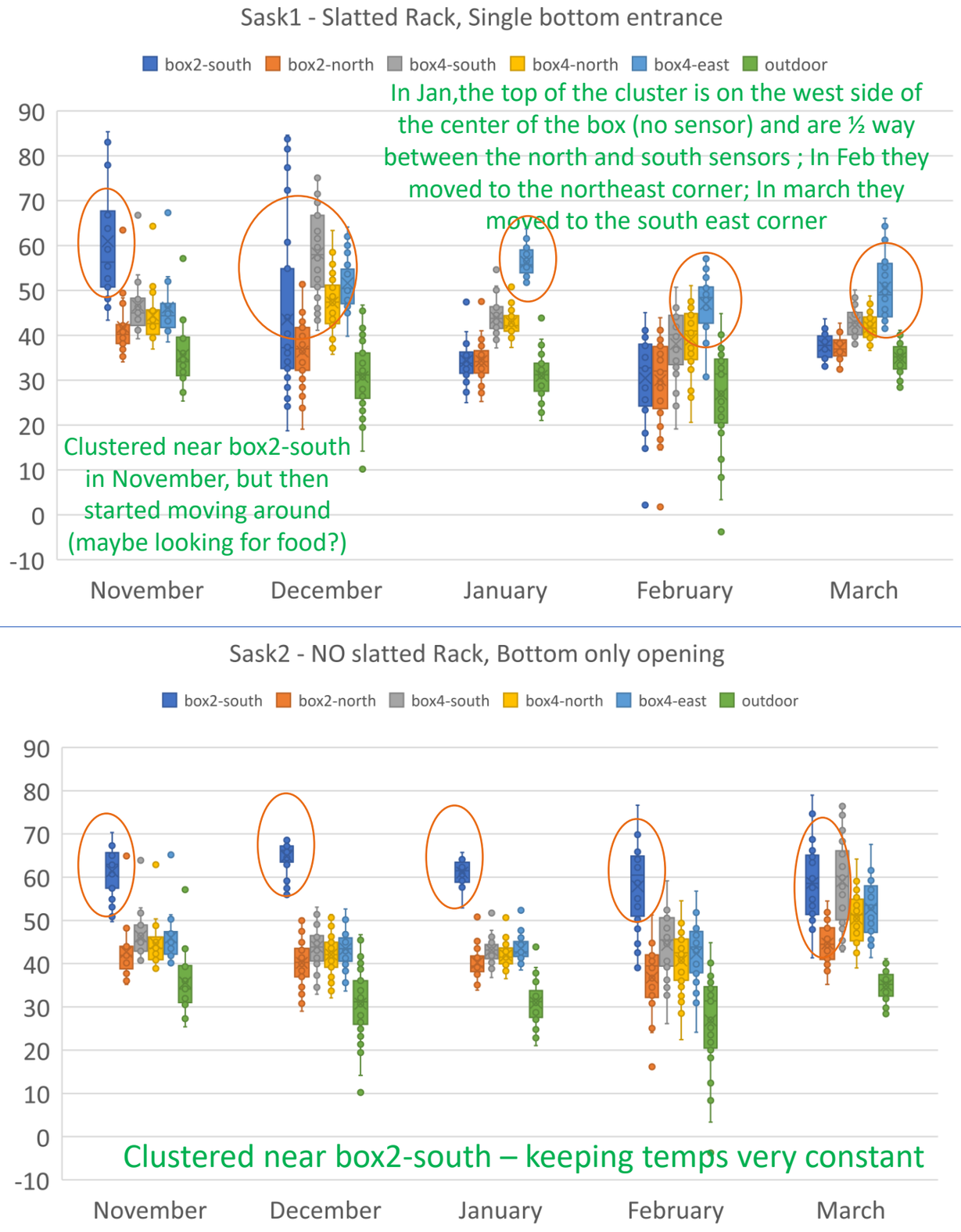
- **Relative humidity** also measures water vapor but **RELATIVE** to the temperature of the air. It is expressed as the amount of water vapor in the air as a **percentage** of the total amount that **could** be held at its current temperature. (www.zehnderamerica.com)

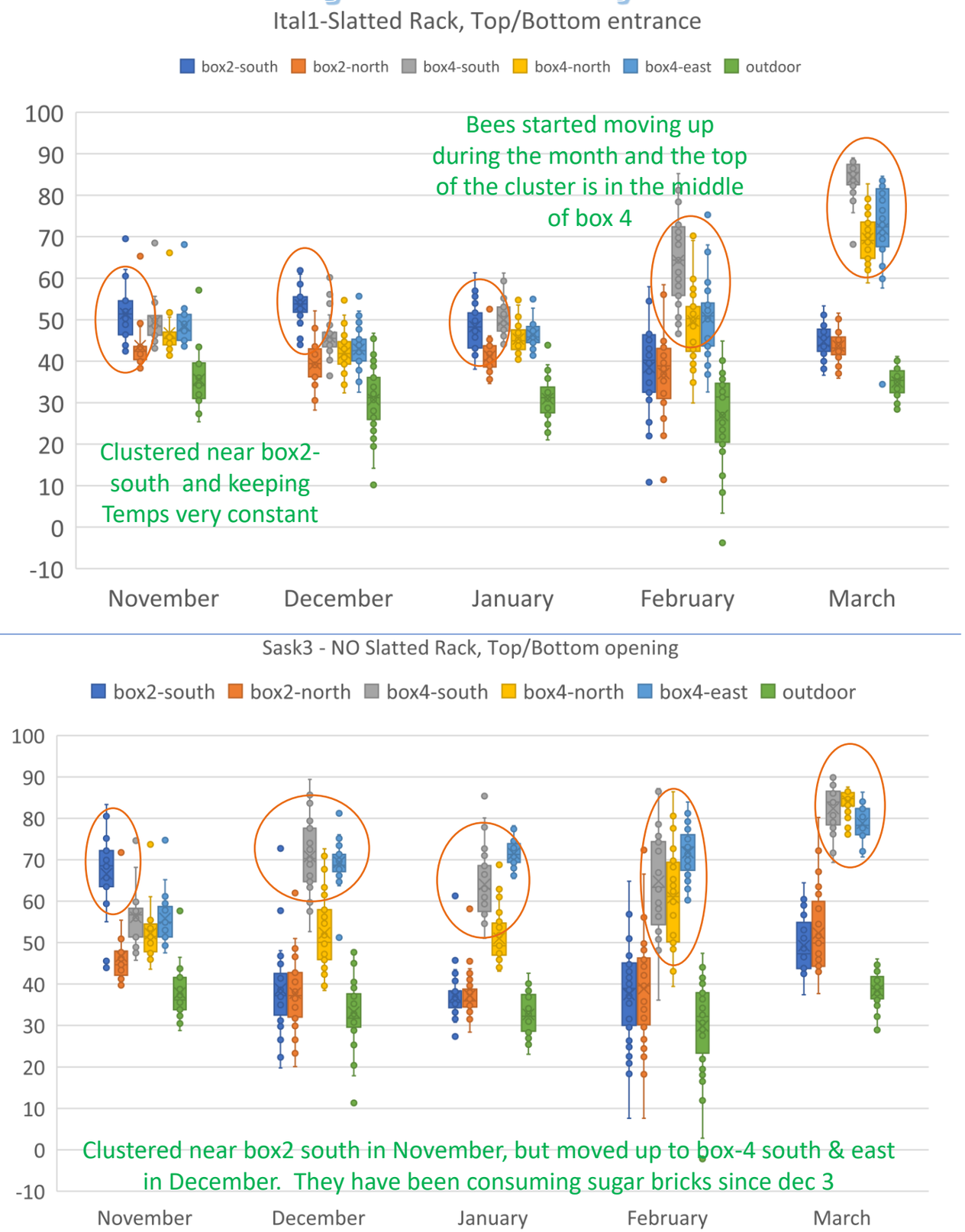
- **Vapor Pressure Deficit (VPD)** is a measure of how much more “room” there is for humidity (water vapor) in the air, at the current temperature

Box & Whisker graphs
Daily **mean** values

ORANGE CIRCLE indicates approximate cluster location

Temperature – (Mean daily values)

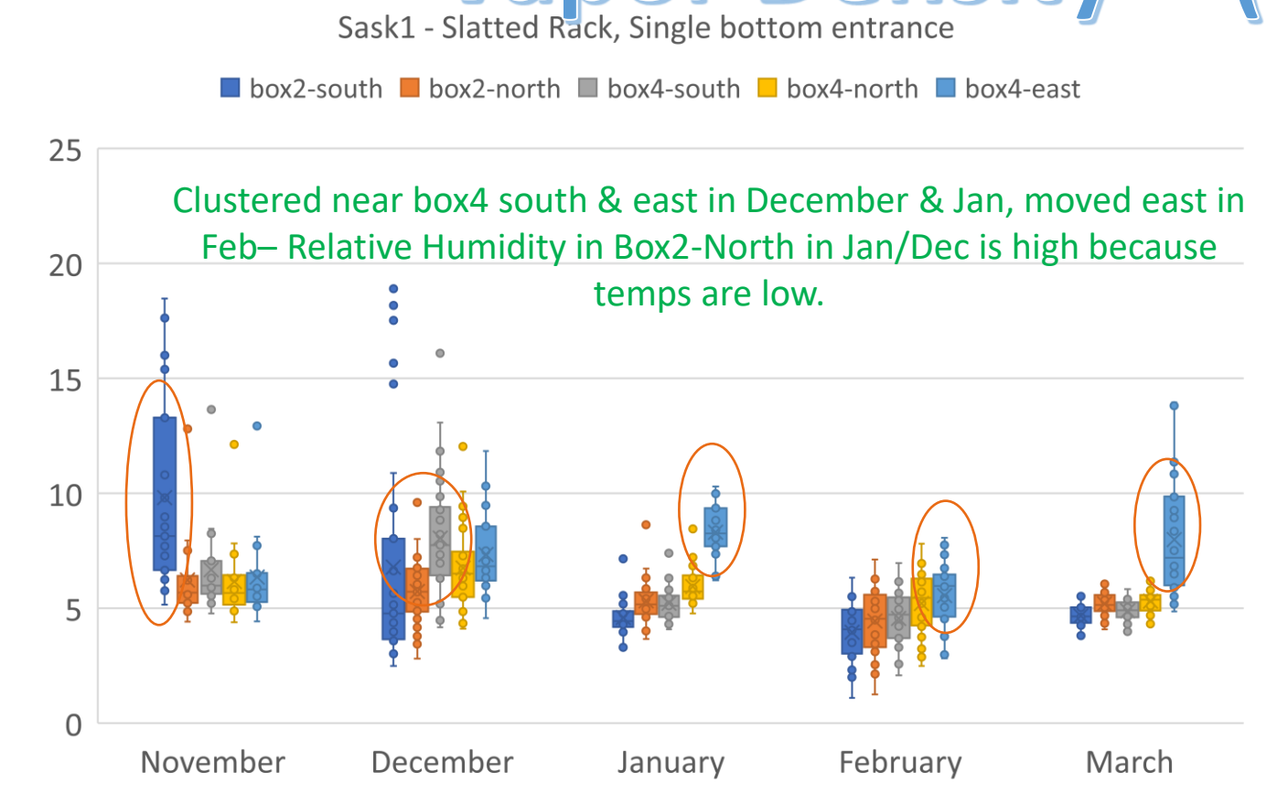


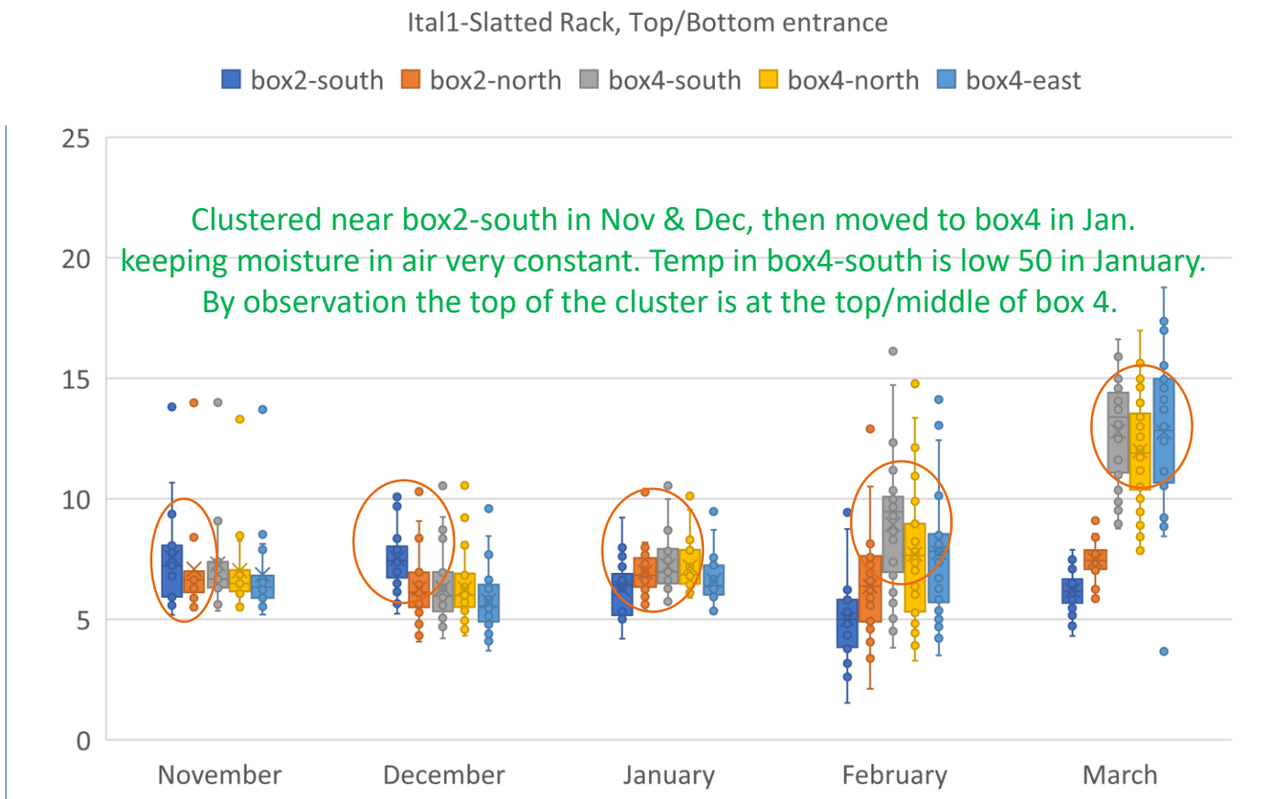


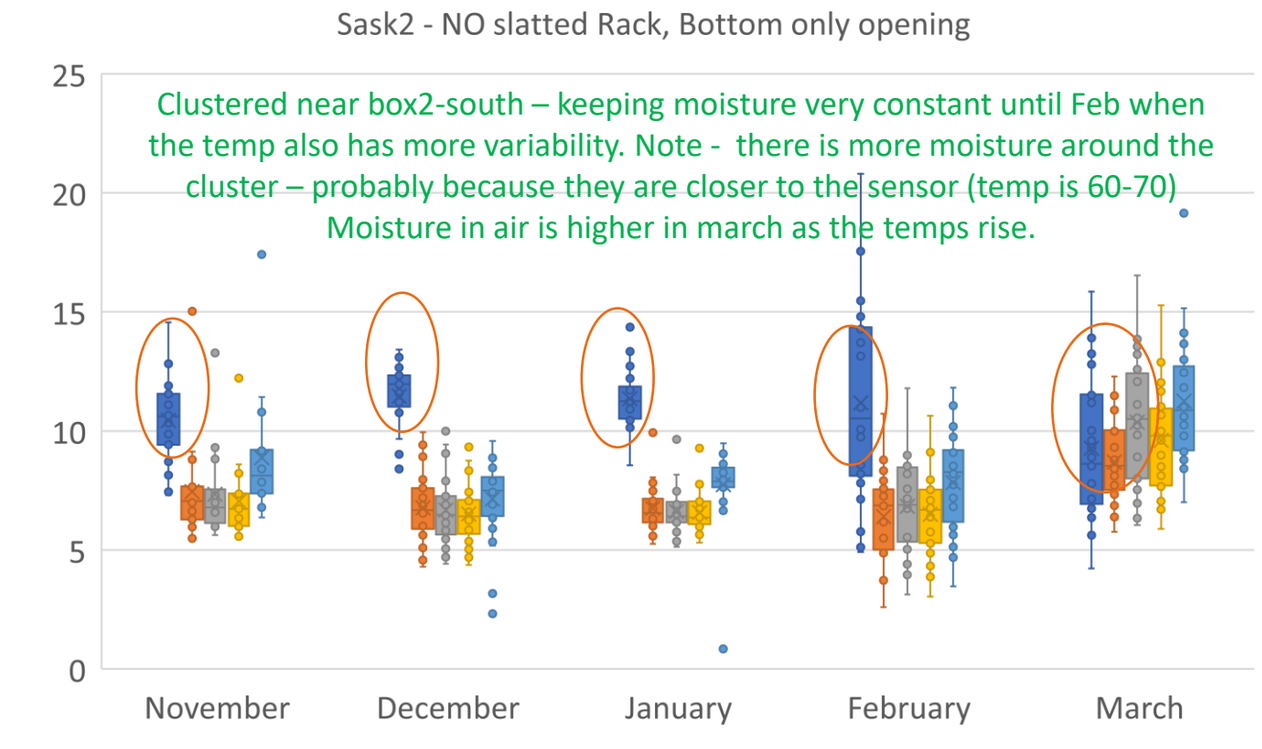
Interesting that there isn't any commonality in the patterns between the mean temps in the colonies

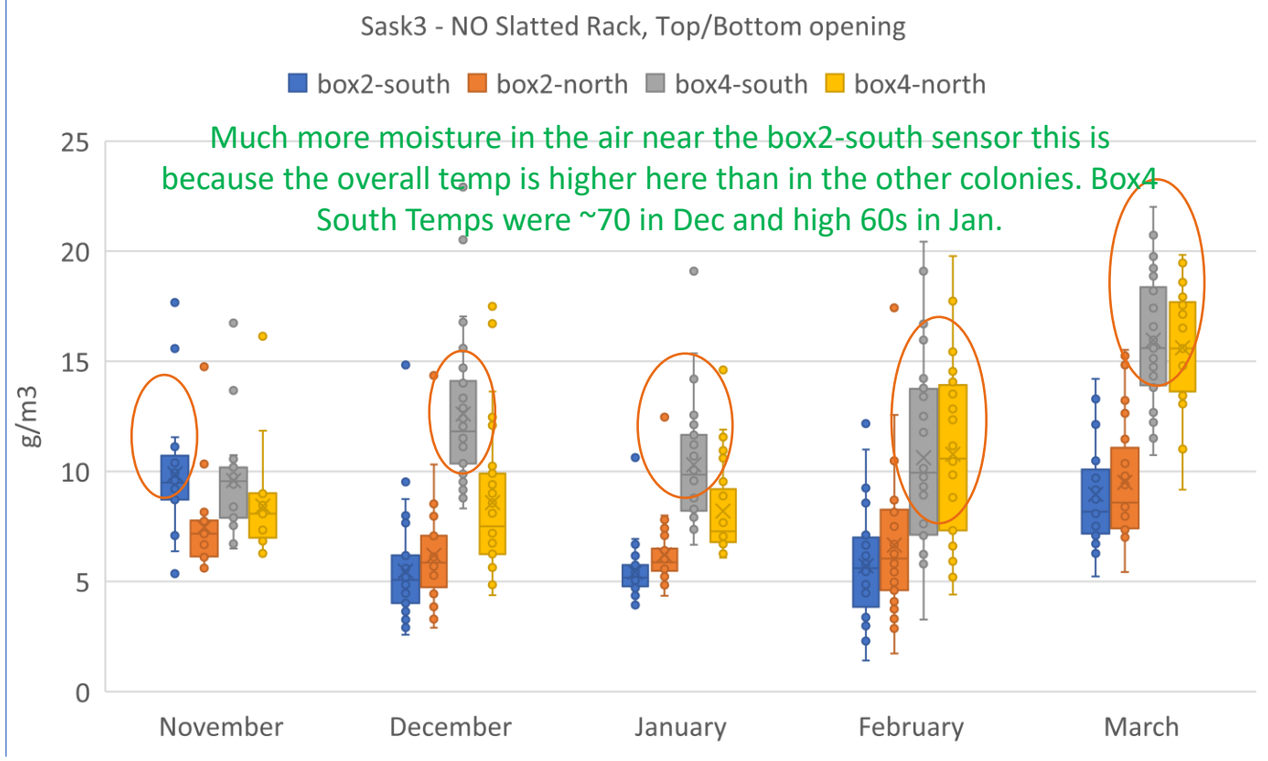
ORANGE CIRCLE indicates approximate cluster location

Vapor Density – (Mean daily values)







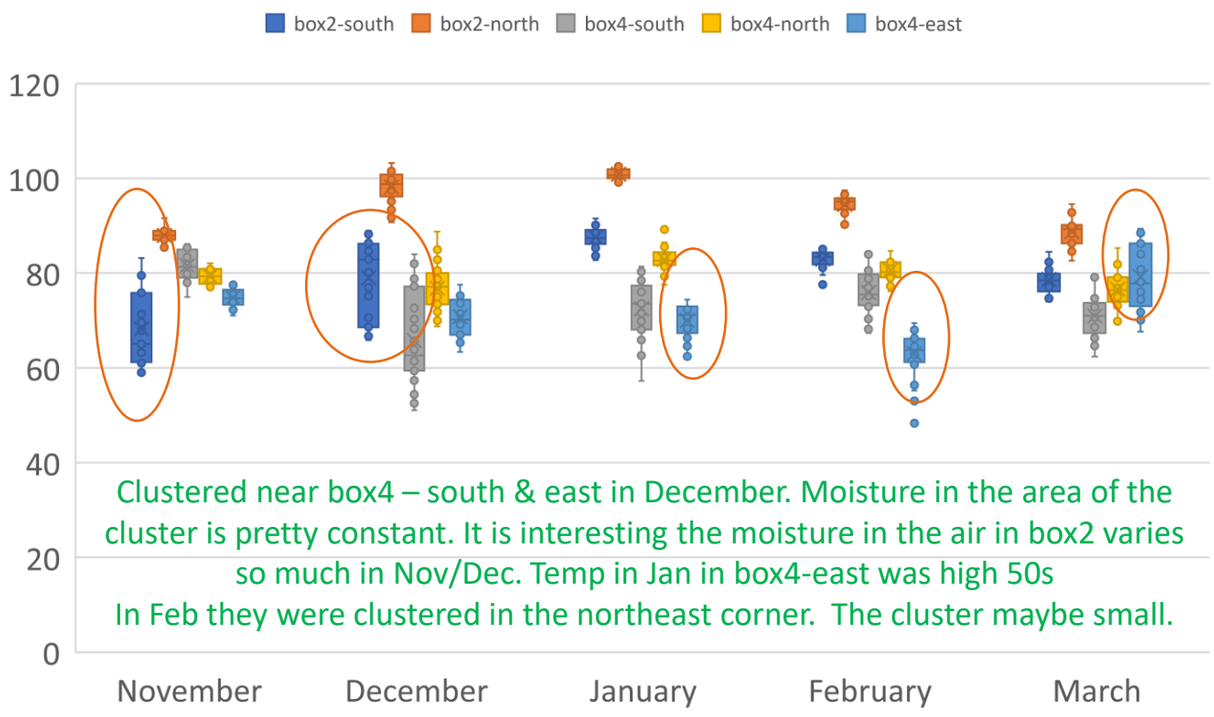


The colonies clustered at the top in Jan (Sask1 & Sask3) have much more variability in Dec… why? Ital1 moved up in 2nd half of Jan – but we don't see the variability. Interesting 3 of the colonies have much more variability in Feb. The one less variability maybe a small cluster.

ORANGE CIRCLE indicates approximate cluster location

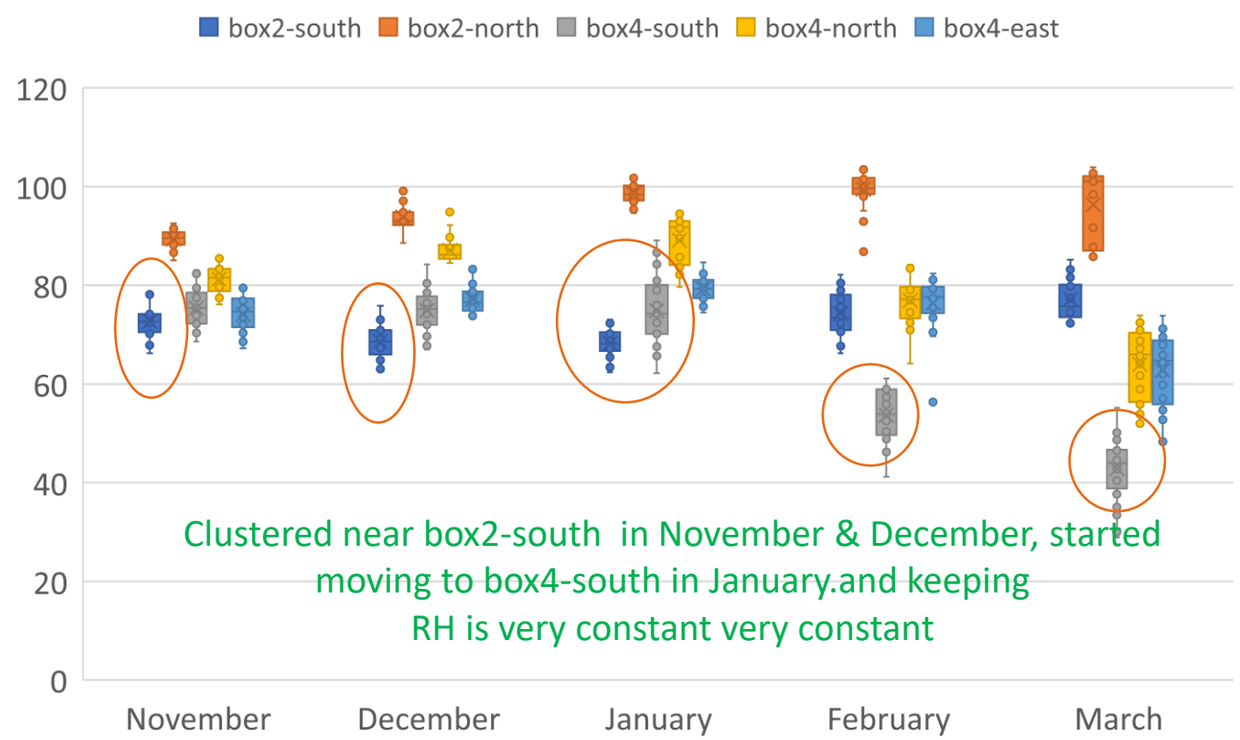
Relative Humidity– (Mean daily values)

Sask1 - Slatted Rack, Single bottom entrance



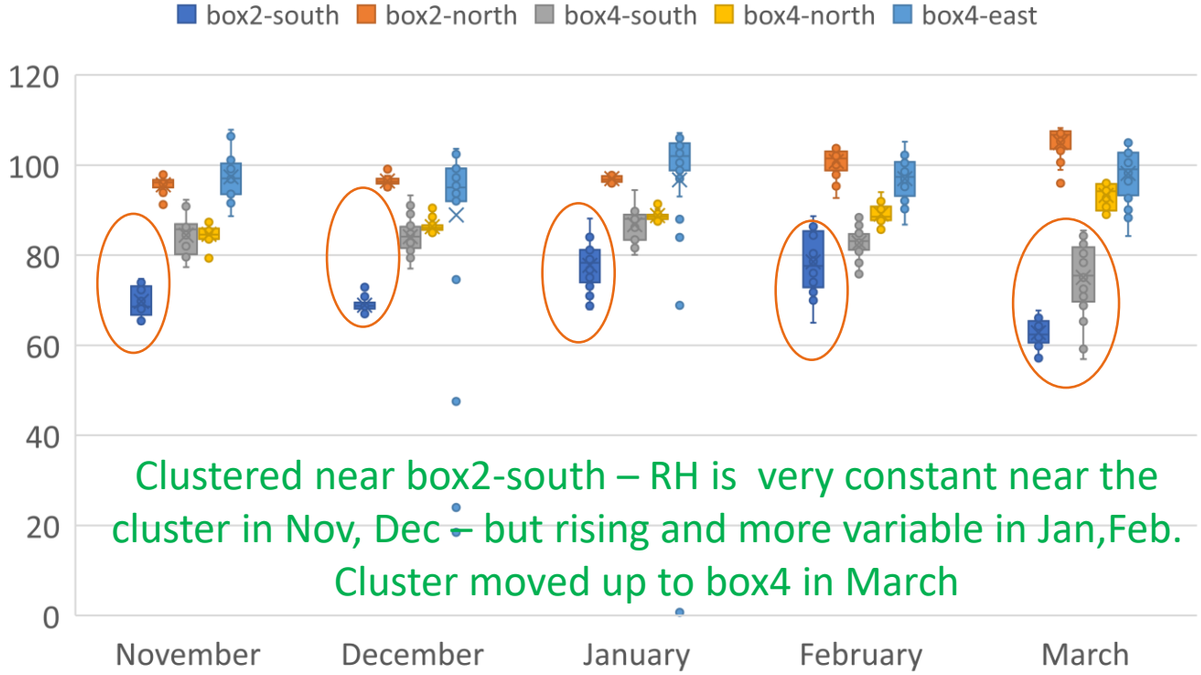
Clustered near box4 – south & east in December. Moisture in the area of the cluster is pretty constant. It is interesting the moisture in the air in box2 varies so much in Nov/Dec. Temp in Jan in box4-east was high 50s
In Feb they were clustered in the northeast corner. The cluster maybe small.

Ital1-Slatted Rack, Top/Bottom entrance



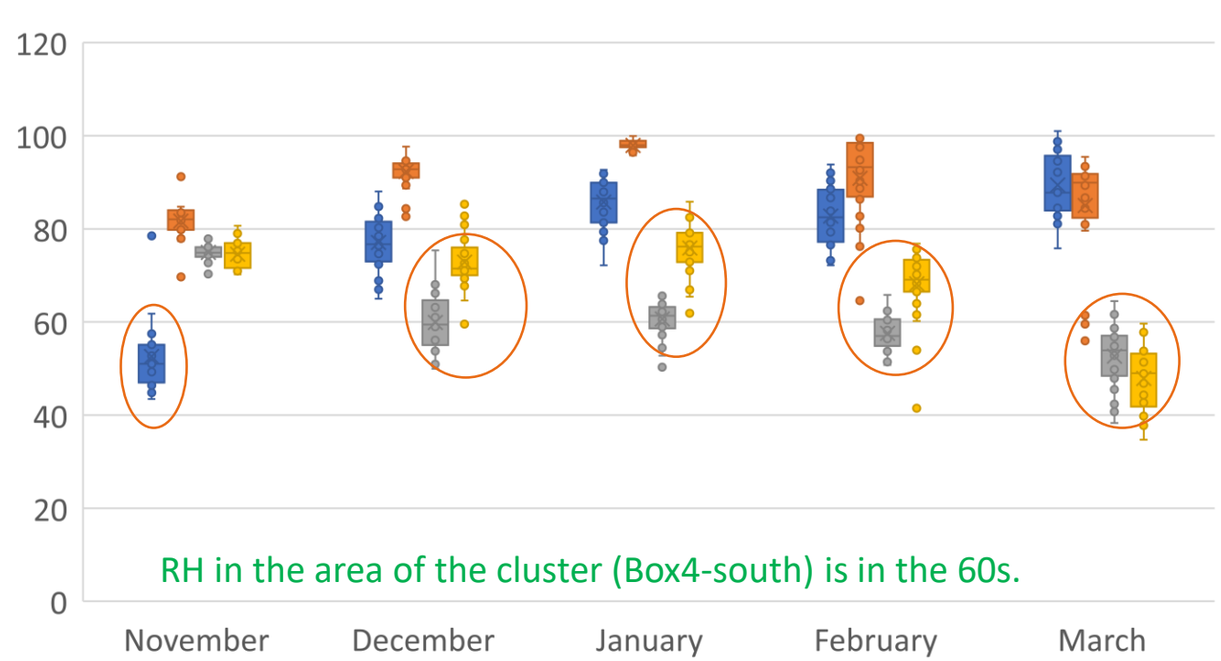
Clustered near box2-south in November & December, started moving to box4-south in January.and keeping
RH is very constant very constant

Sask2 - NO slatted Rack, Bottom only opening



Clustered near box2-south – RH is very constant near the cluster in Nov, Dec – but rising and more variable in Jan,Feb.
Cluster moved up to box4 in March

Sask3 - NO Slatted Rack, Top/Bottom opening

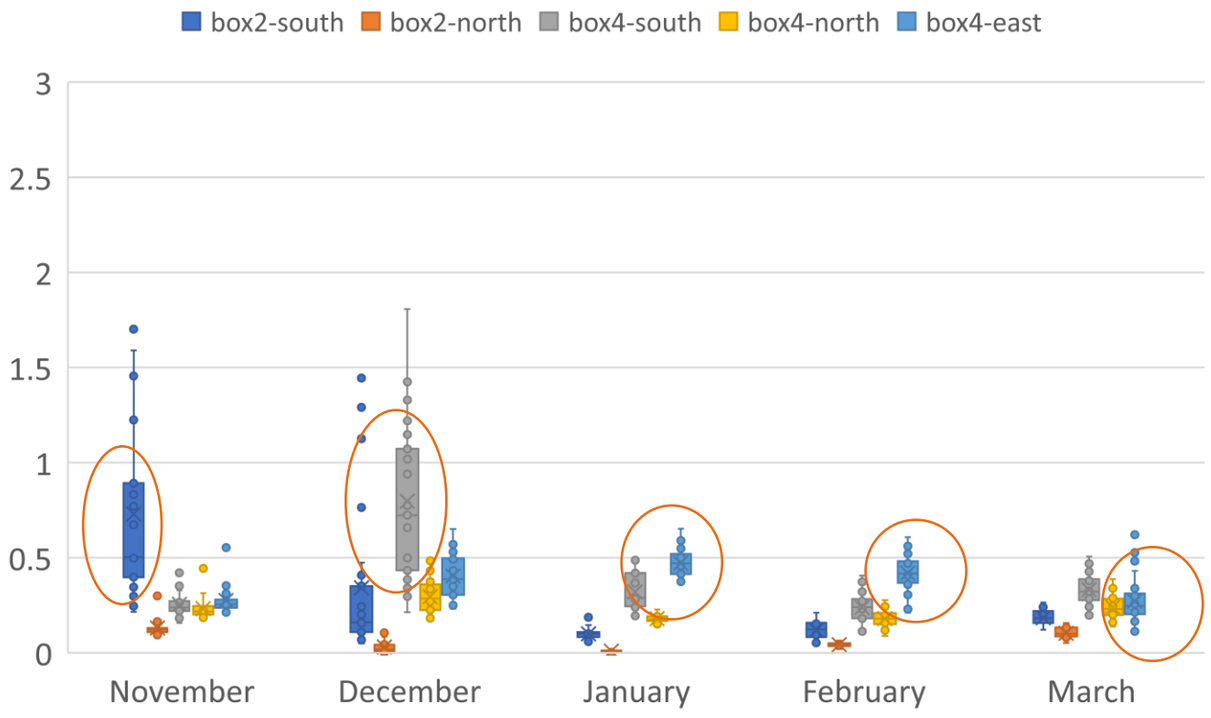


RH in the area of the cluster (Box4-south) is in the 60s.

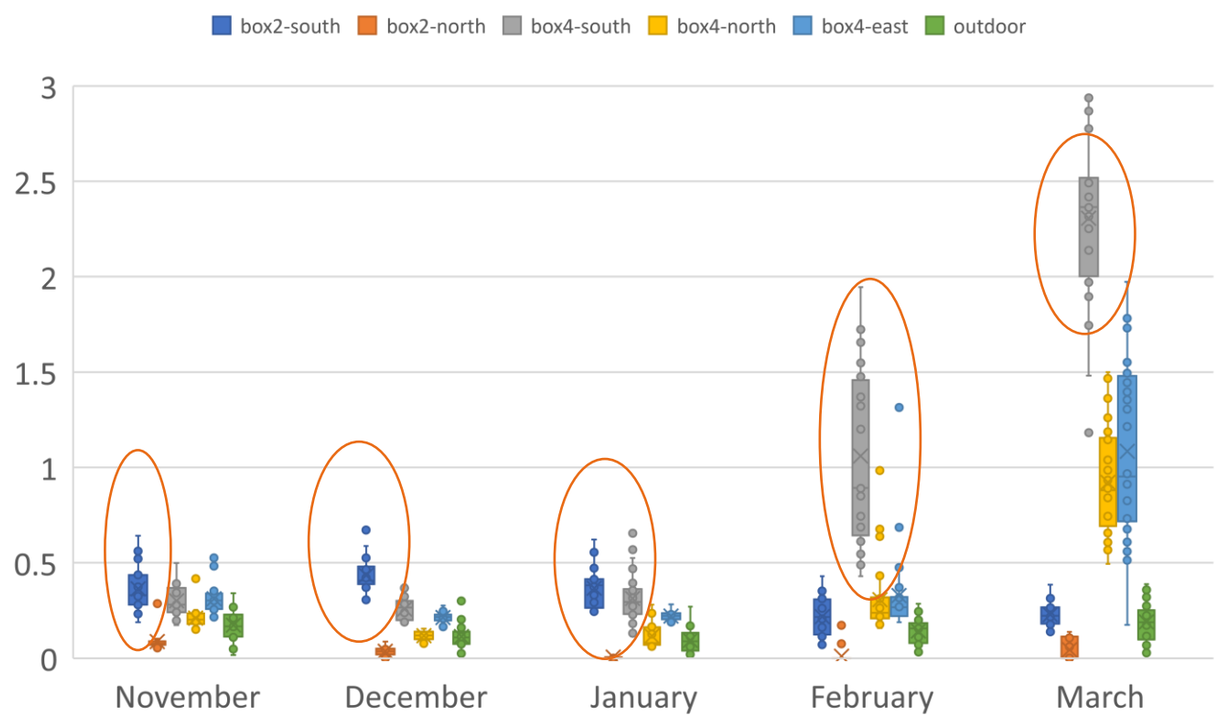
ORANGE CIRCLE indicates approximate cluster location

VPD– (Mean daily values)

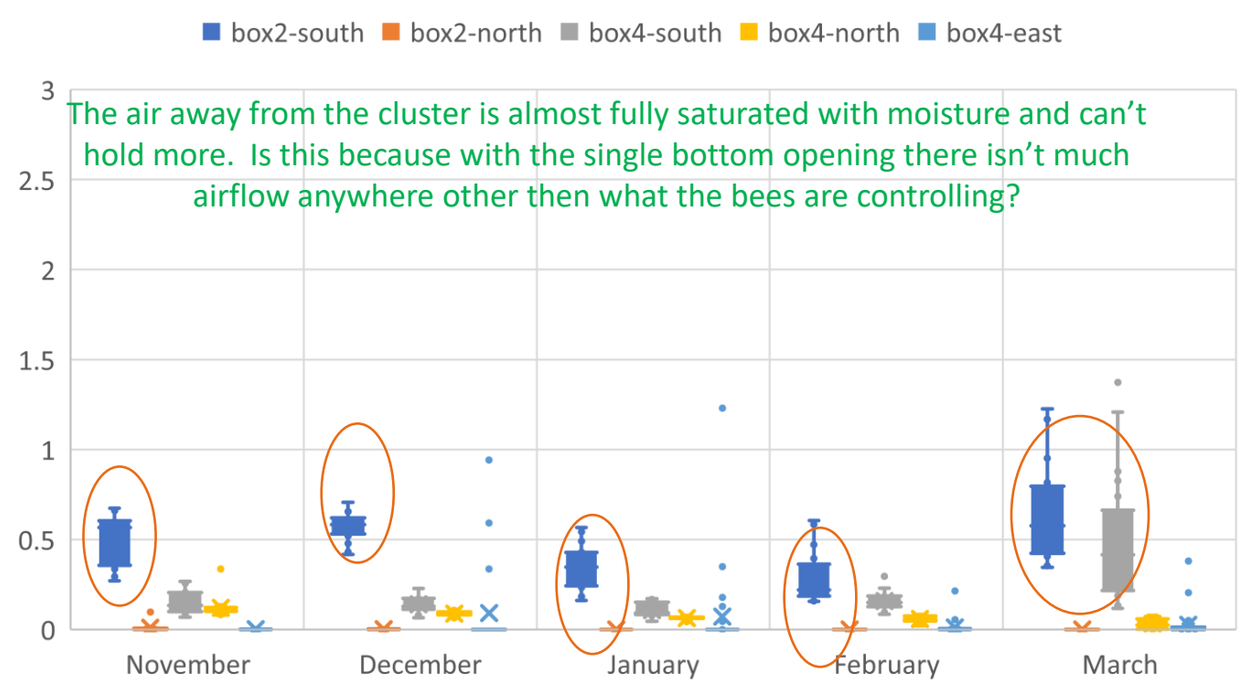
Sask1 – slatted rack, bottom only*



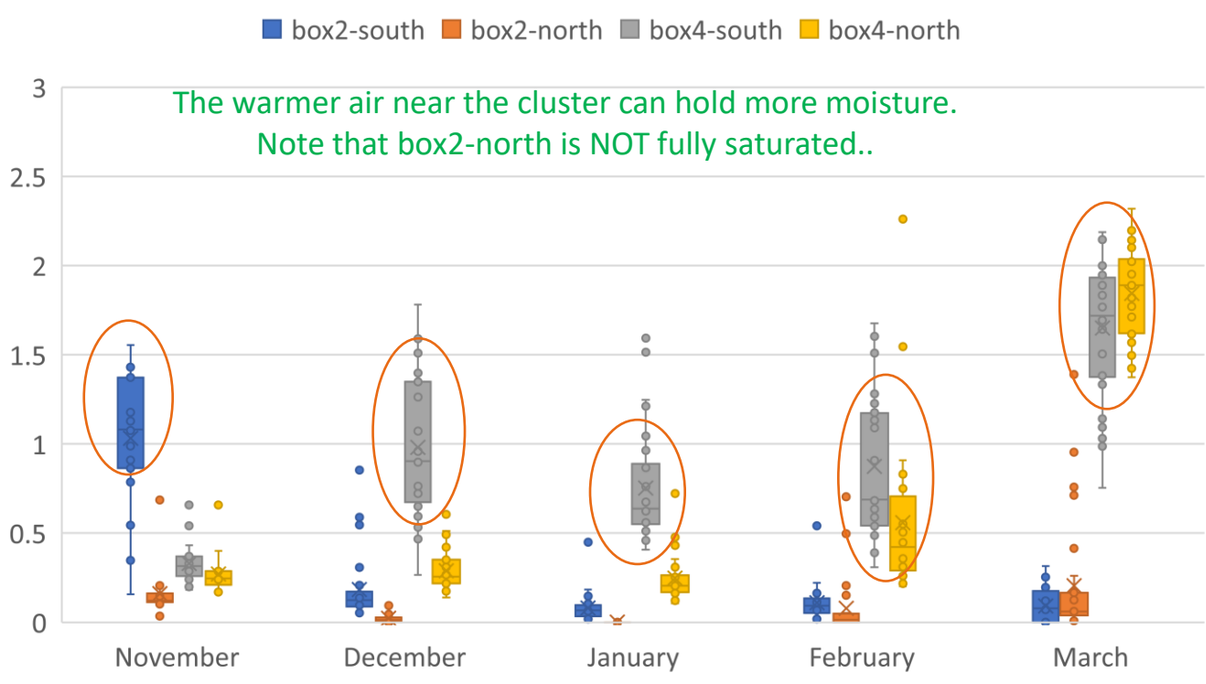
Ital1 – rack, top/bottom opening



Sask2 - NO slatted Rack, Bottom only opening



Sask3 - NO Slatted Rack, Top/Bottom opening



PINK indicate approximate area of the cluster

Monthly Stats – Mean Values

Slatted – Bottom entrance only* (Sask1)

Sask1	Temp(F)					Vapor Density (g/m3)				
	Nov	Dec	Jan	Feb	Mar	Nov	Dec	Jan	Feb	Mar
box2-south	60.81	43.51	34.31	30.46	37.69	9.71	6.79	4.60	3.95	4.67
box2-north	41.18	36.40	34.33	30.03	37.25	6.03	5.72	5.32	4.44	5.19
box4-south	46.06	58.28	44.02	38.06	42.90	6.49	8.04	5.23	4.55	4.89
box4-north	43.92	47.29	42.86	39.07	41.87	6.00	6.75	5.96	5.21	5.31
box4-east	45.58	51.61	56.48	46.99	50.81	6.17	7.34	8.35	5.55	8.04
outdoor	35.03	30.74	31.13	26.90	35.09	4.12	3.78	3.91	3.02	3.78

Slatted – Top & Bottom Entrance (Ital1)

Ital1	Temp(F)					Vapor Density(g/m3)				
	Nov	Dec	Jan	Feb	Mar	Nov	Dec	Jan	Feb	Mar
box2-south	51.00	53.61	48.47	38.47	44.78	7.41	7.54	6.29	4.98	6.21
box2-north	43.19	39.37	41.24	37.06	43.68	6.89	6.28	6.97	6.37	7.48
box4-south	49.03	45.84	49.85	64.24	84.44	7.11	6.30	7.22	8.93	12.87
box4-north	46.30	41.98	45.34	49.72	69.35	6.85	6.27	7.20	7.70	11.94
box4-east	48.11	42.84	46.22	50.52	73.76	6.66	5.76	6.61	7.76	13.30
outdoor	35.03	30.74	31.13	26.90	35.09	4.12	3.78	3.91	3.02	3.78

*Late December the bees chewed away the insulation opening up a small entrance at the top of Sask1 Outdoor vapor density is NOT measured in the apiary but derived from data from Broodminder.

Looking at the temps corresponding vapor densities, all colonies look pretty similar :

- if the temps at the sensor are in the 70s/80s Vapor density is 12-14
- temps in the 60s, vapor density is 9-11
- temps in the 50s , vapor density is 7-8
- temps in the 40s,vapor density is 6-7 (There is one case – sask2, box4 east that is closer to 8 in Nov)
- temps in the 30s,vapor density = 5-6 (but outdoor vapor density is in the 4 rang)

PINK indicate approximate area of the cluster

Monthly Stats – Mean Values

NOT Slatted – Bottom entrance only (Sask2)

Sask2	Temp(F)					Vapor Density(g/m3)				
	Nov	Dec	Jan	Feb	Mar	Nov	Dec	Jan	Feb	Mar
box2-south	61.14	64.80	61.11	57.90	58.50	10.34	11.47	11.35	11.18	9.25
box2-north	42.13	40.10	40.28	36.85	44.62	7.25	6.75	6.76	6.41	8.70
box4-south	44.16	42.08	41.93	40.71	59.15	6.90	6.51	6.59	6.50	10.41
box4-north	45.83	43.90	43.13	44.30	50.27	7.17	6.67	6.62	6.84	9.57
box4-east	45.48	43.44	43.54	42.37	52.58	8.64	7.13	7.74	7.83	11.25
outdoor	35.03	30.74	31.13	26.90	35.09	4.12	3.78	3.91	3.02	3.78

NOT Slatted – Top & Bottom Entrance(Sask3)

*This colony has a temp-only sensor at box4-east

Sask3	Temp(F)					Vapor Density(g/m3)				
	Nov	Dec	Jan	Feb	Mar	Nov	Dec	Jan	Feb	Mar
box2-south	64.00	37.17	36.45	35.89	47.46	8.99	5.20	5.34	5.49	8.53
box2-north	44.83	36.73	36.82	37.44	50.60	6.89	5.89	6.12	6.35	8.87
box4-south	53.47	68.07	61.96	61.43	79.35	8.81	11.79	9.72	9.56	14.62
box4-north	50.13	50.38	49.58	58.51	82.81	7.73	7.84	7.76	10.01	14.83
outdoor	35.03	30.74	31.13	26.90	35.09	4.12	3.78	3.91	3.02	3.78

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- temps in the 30s,vapor density = 5-6 (but outdoor vapor density is in the 4 rang)

PINK indicate approximate area of the cluster

Monthly Stats – Mean Values

Stalker - NOT Slatted – Top & Bottom Entrance(stalker) – R11.1, north facing

stalker	Temp(F)					Vapor Density(g/m3)				
	Nov	Dec	Jan	Feb	Mar	Nov	Dec	Jan	Feb	Mar
box2-south	44.54	40.39	41.49	41.80	54.26	6.06	5.58	5.97	5.66	7.79
box2-north	46.93	44.05	51.07	64.62	81.65	7.38	6.82	8.52	12.58	16.28
box4-south	46.07	41.30	41.86	42.06	55.51	8.33	6.49	4.59	6.28	12.09
box4-north	45.99	41.59	42.42	43.01	70.15	6.30	2.00	1.50	2.22	16.27
box4-east	55.49	43.79	42.79	43.25	60.16					
outdoor	35.03	30.74	30.95	26.90	35.09					

Stalker has much more moisture in the air for the March temp readings on the north side than the other colonies

Looking at the temps corresponding vapor densities, all colonies look pretty similar :

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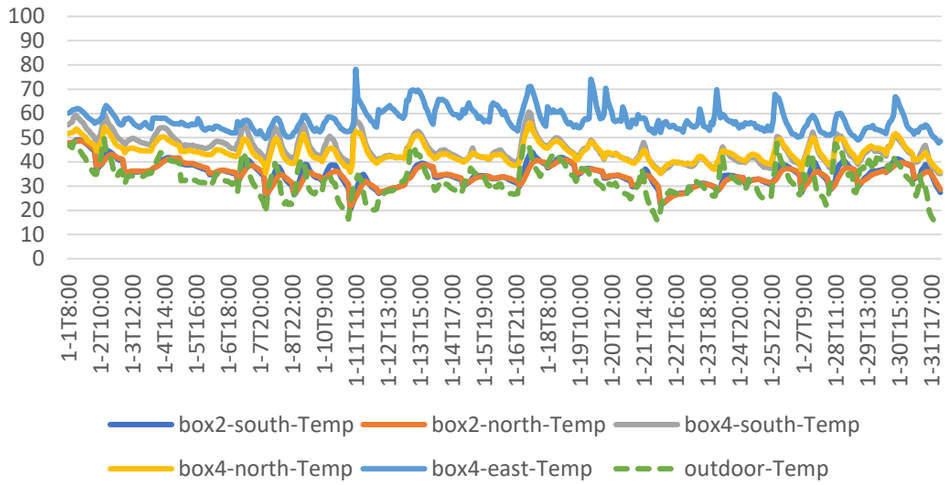
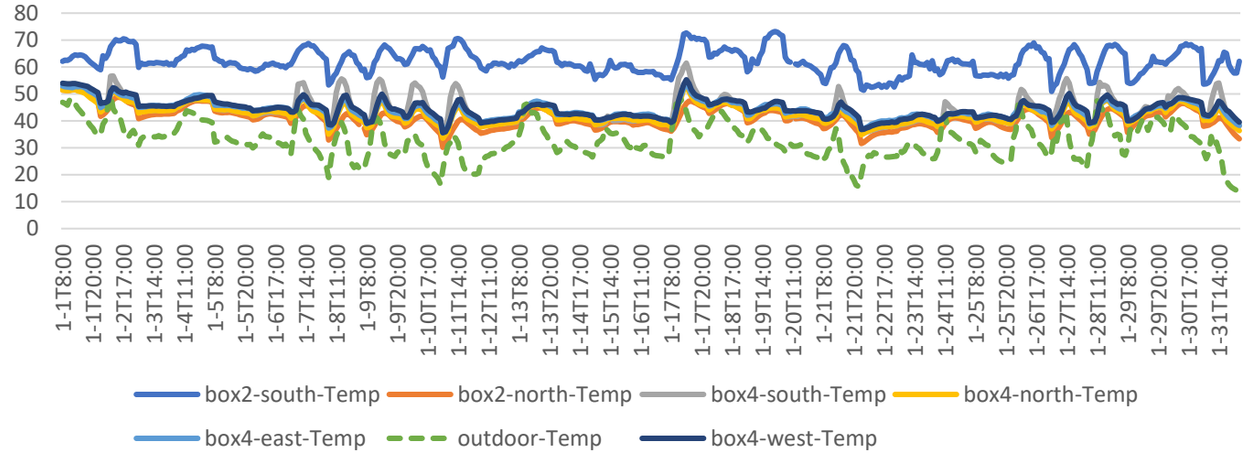
Monthly
Daily mean values

Compare Colonies - Jan Day(8am-10pm) - Temps

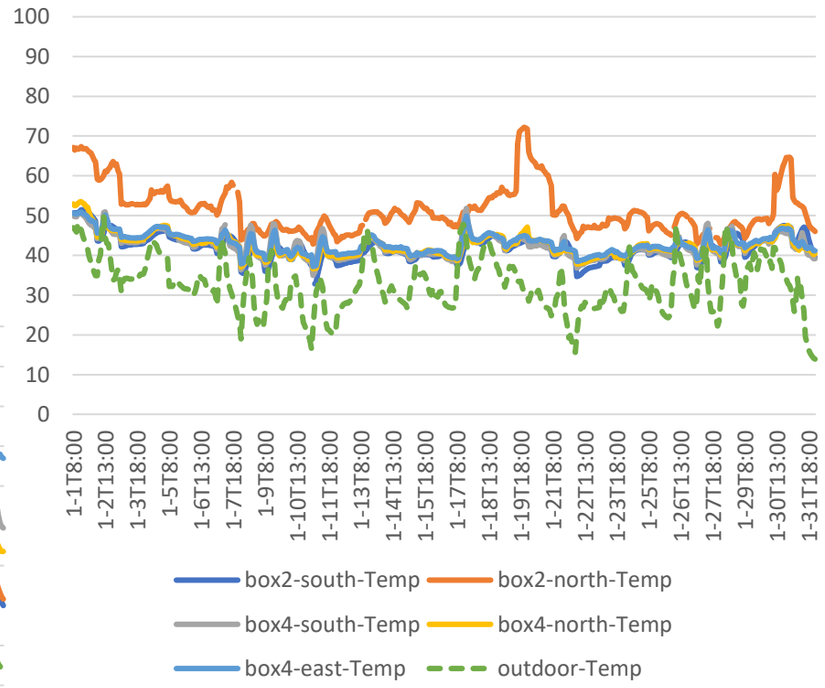
Sask1 – bottom-only*, slatted Rack



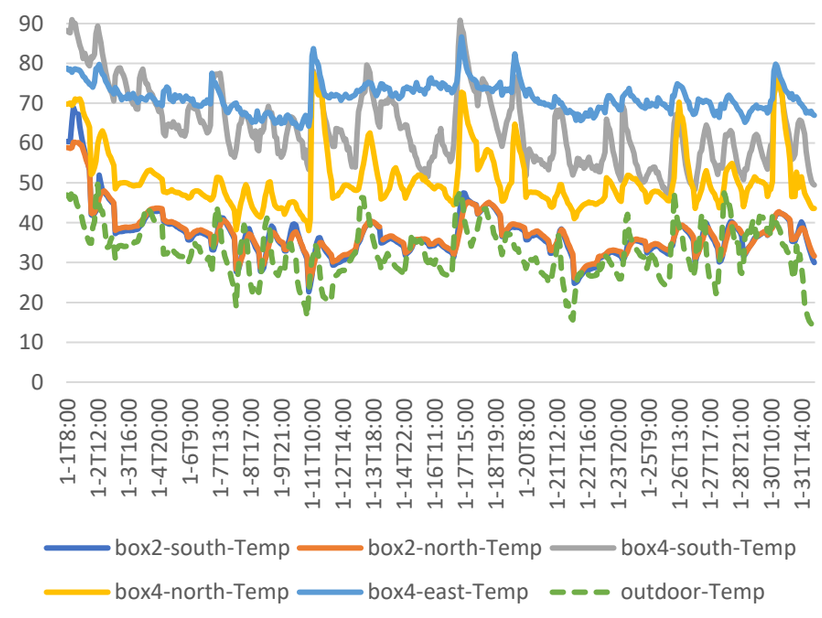
Sask2- Bottom only, no rack



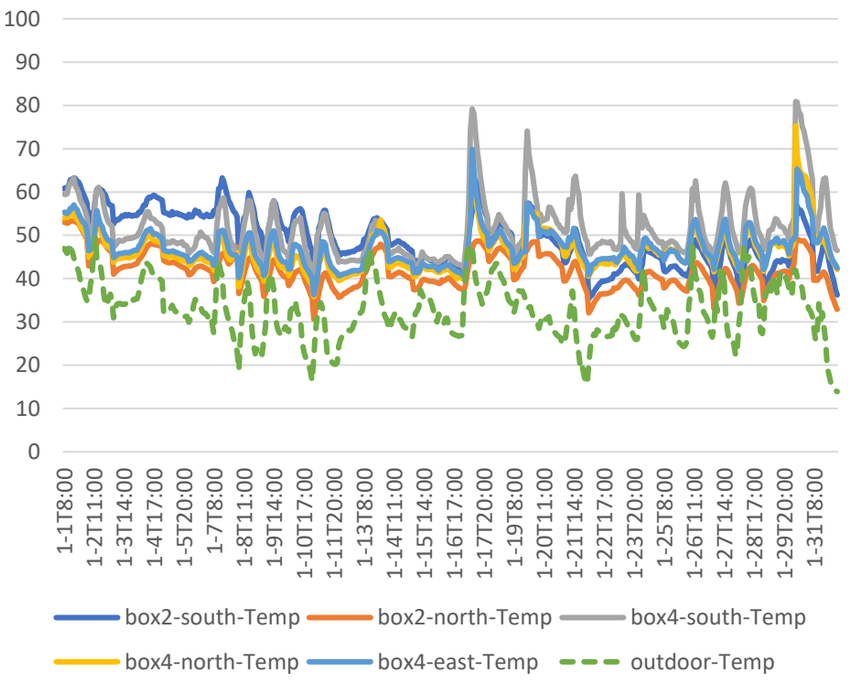
Stalker top/bottom, no rack, faces north



Sask3 – top/bottom, no rack

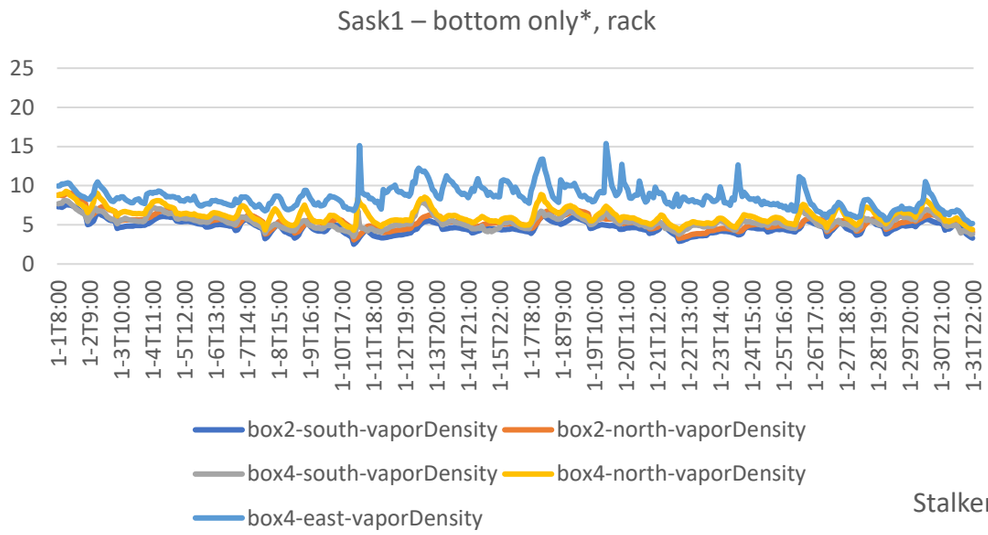


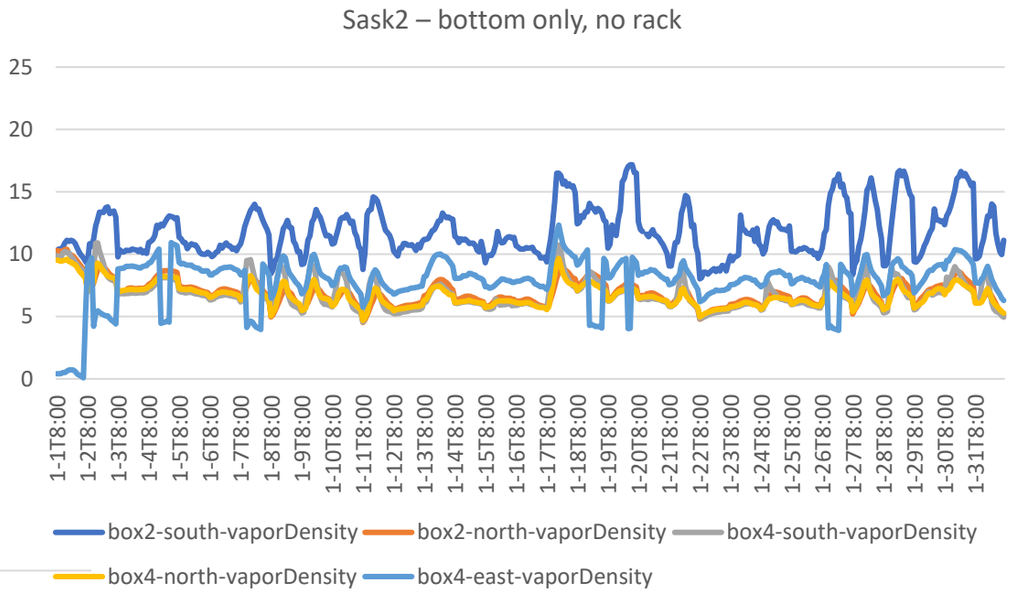
Ital1 – top/bottom, slatted rack

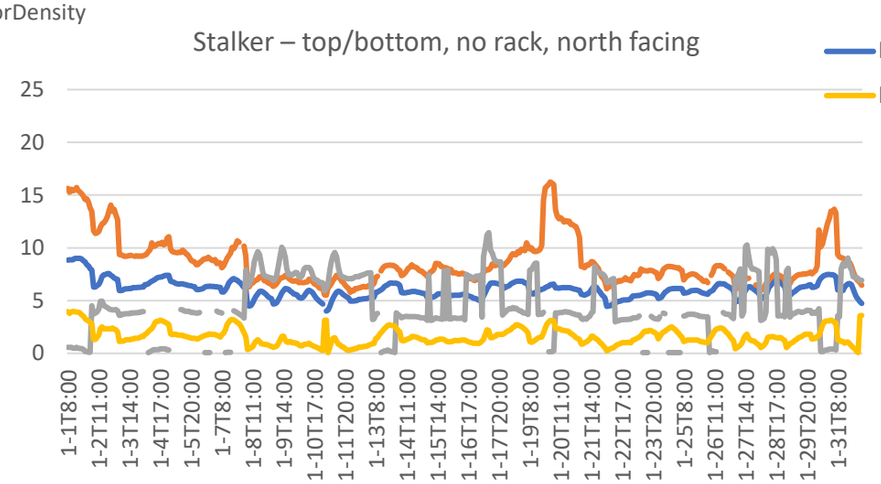


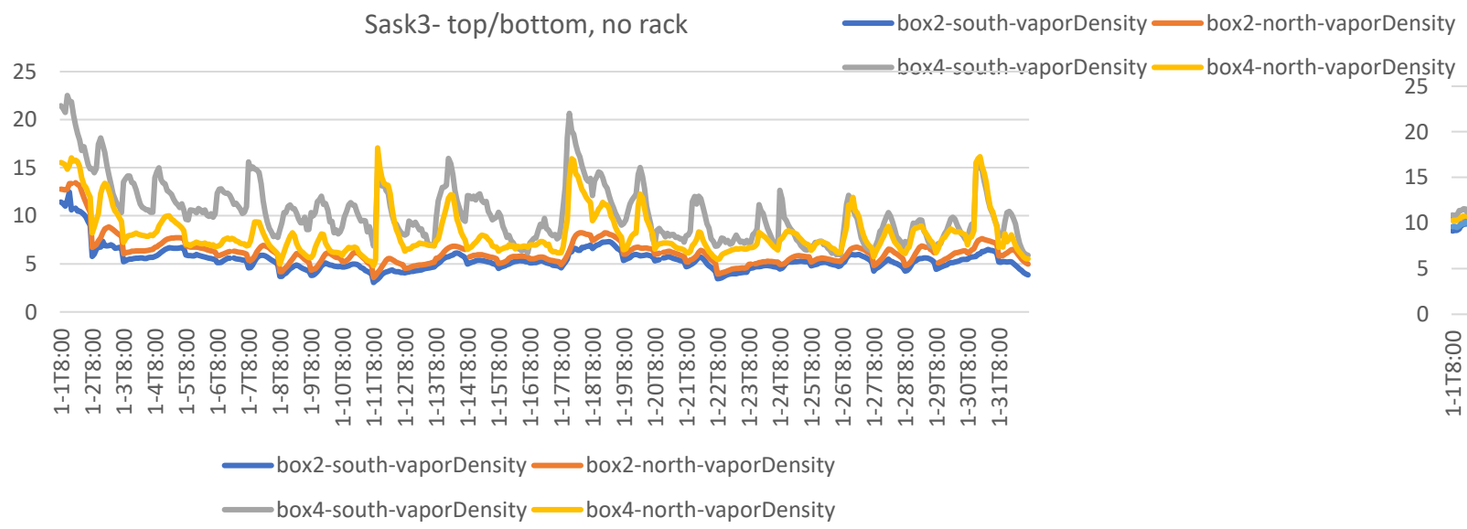
- Sask1 & Sask3 are at the top of the box
- Stalker & Sask2 are in box2 – but Stalker is on the north side & Sask2 is on the south side. Are the Stalker bees on the north because it is in the airflow path? This is the 2nd year in a row we've observed this.
- Ital1 – is in box4 south/east side.

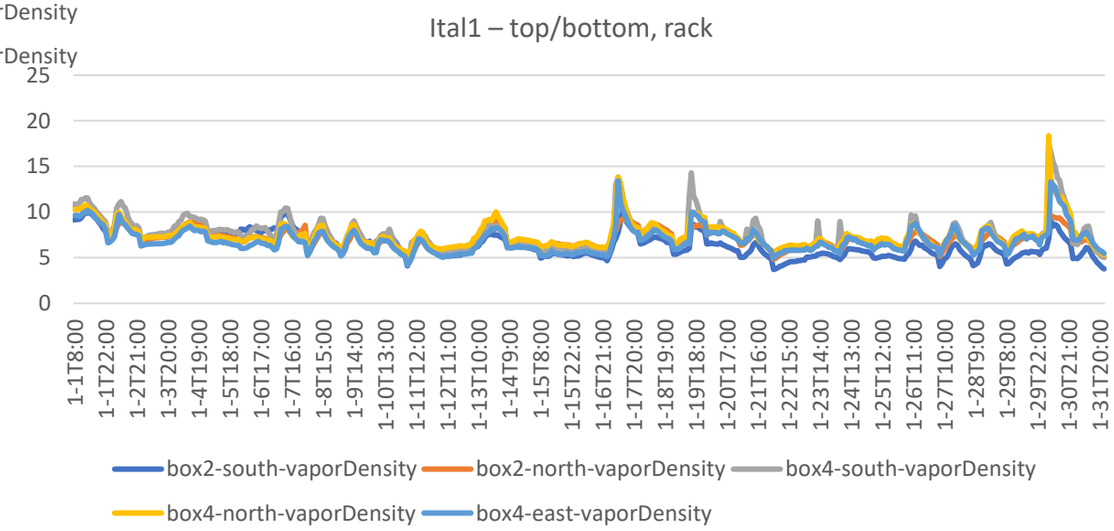
Compare Colonies - Jan Day(8am-10pm) – Vapor Density







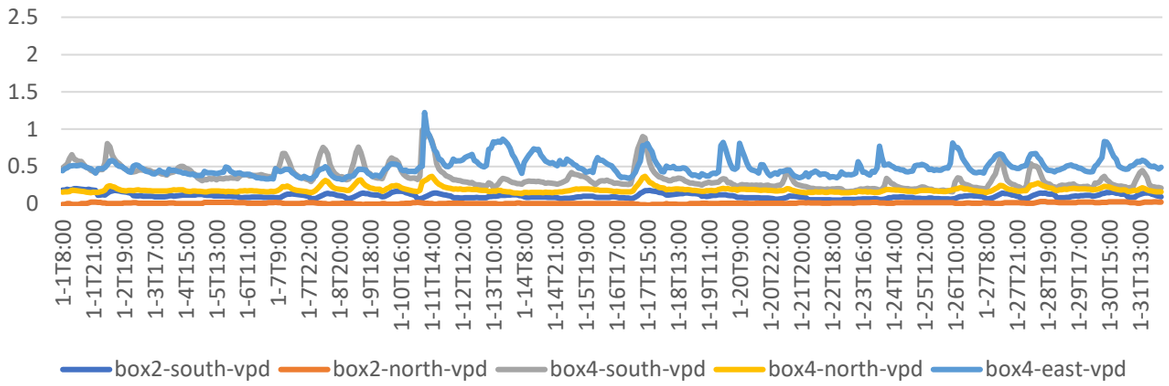




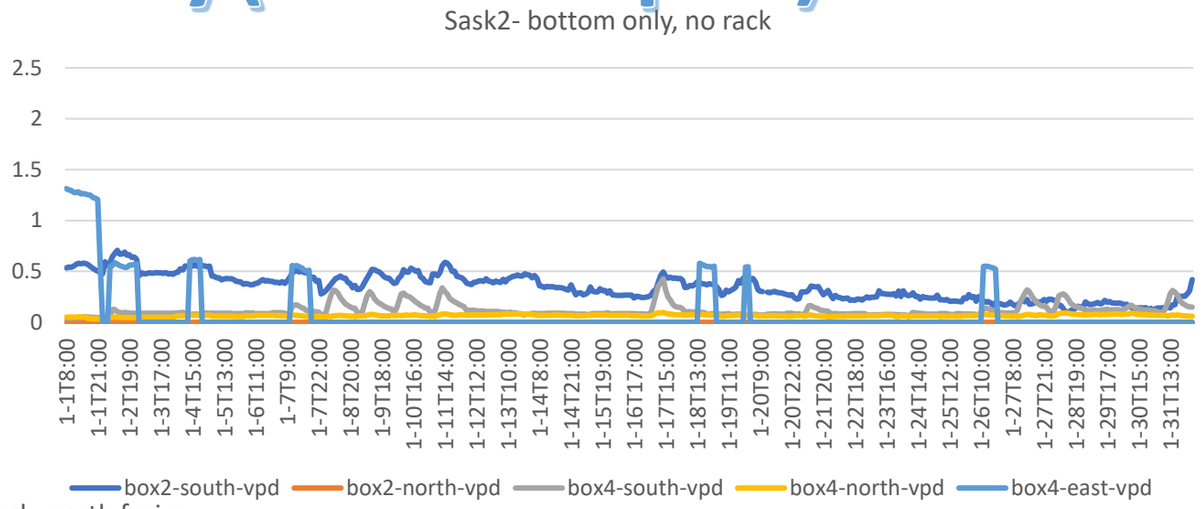
- Stalker – box4 north & south humidity readings are suspect
- It is unclear if the dips in Sask2 box4-east vapor density are real
- It is interesting that stalker is on the north side of the colony – in the air flow
- Vapor densities in Ital1 are consistent at all of the sensors. The cluster may be in between the sensors and not on top of any of them

Compare Colonies - Jan Day(8am-10pm) – VPD

Sask1 – bottom only*, rack

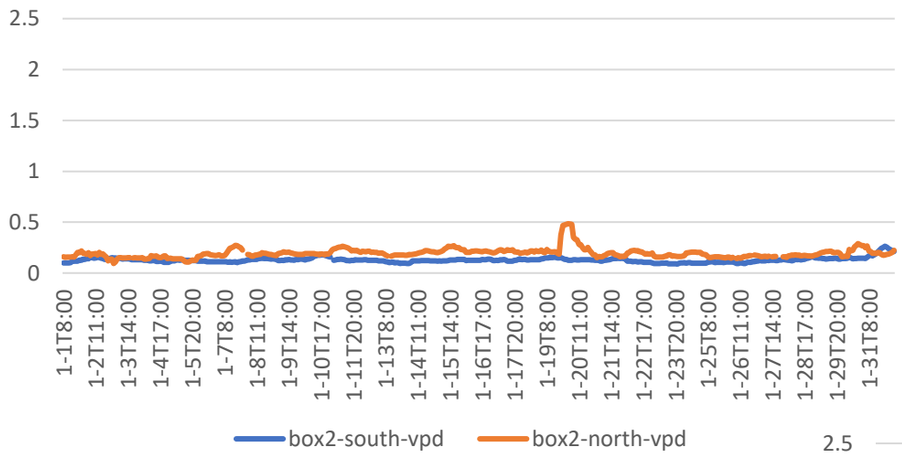


Sask2- bottom only, no rack



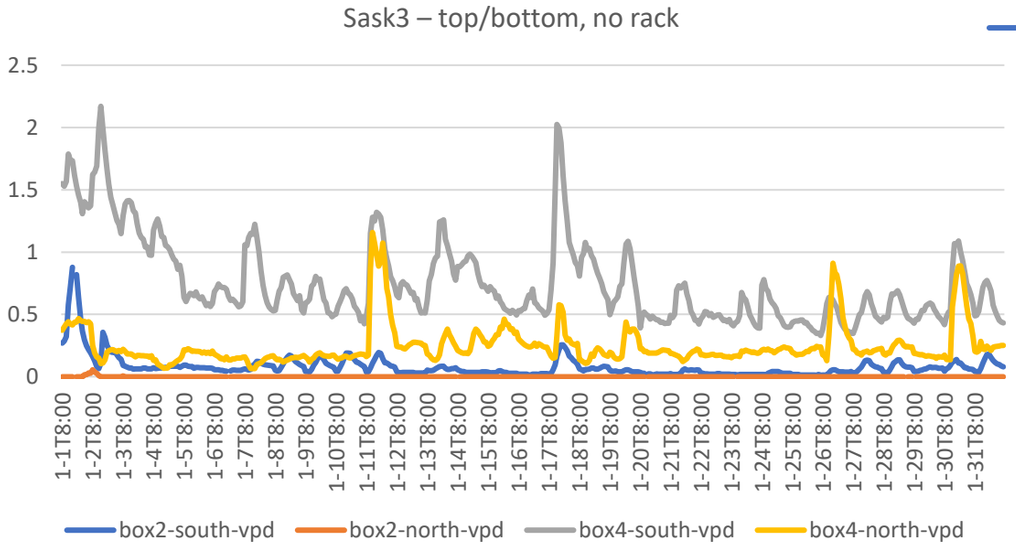
Box2-north has essentially VPD = 0 except for stalker that is clustered there. This is probably because the airflow doesn't hit that area so it is fully saturated. It is also the coldest sensor

Stalker, top/bottom , no rack, north facing

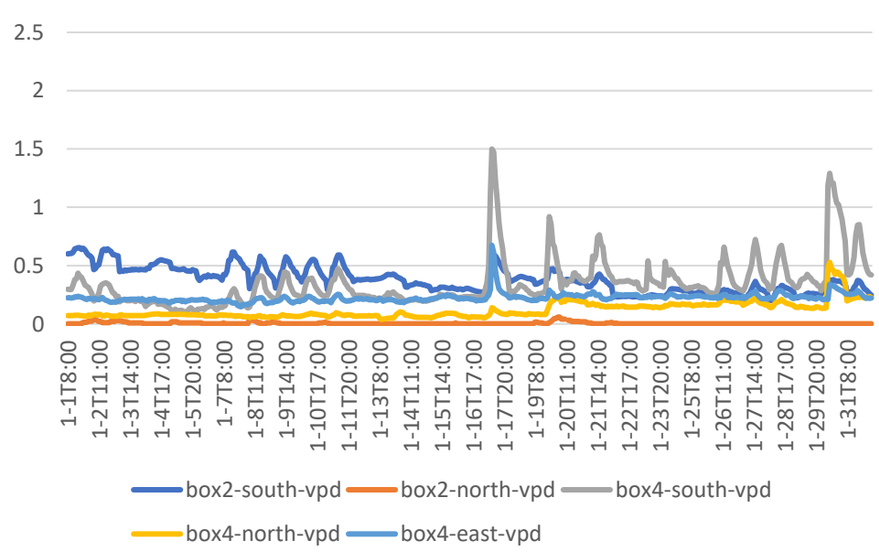


In Sask2 - Except for box2-south area – the air is fully saturated (VPD ~=0)
Is this because with the single bottom opening there isn't as much air flow?
Bees in Sask1 made their own upper entrance in box4. Is this why we don't see the same pattern as we see in Sask2?

Sask3 – top/bottom, no rack



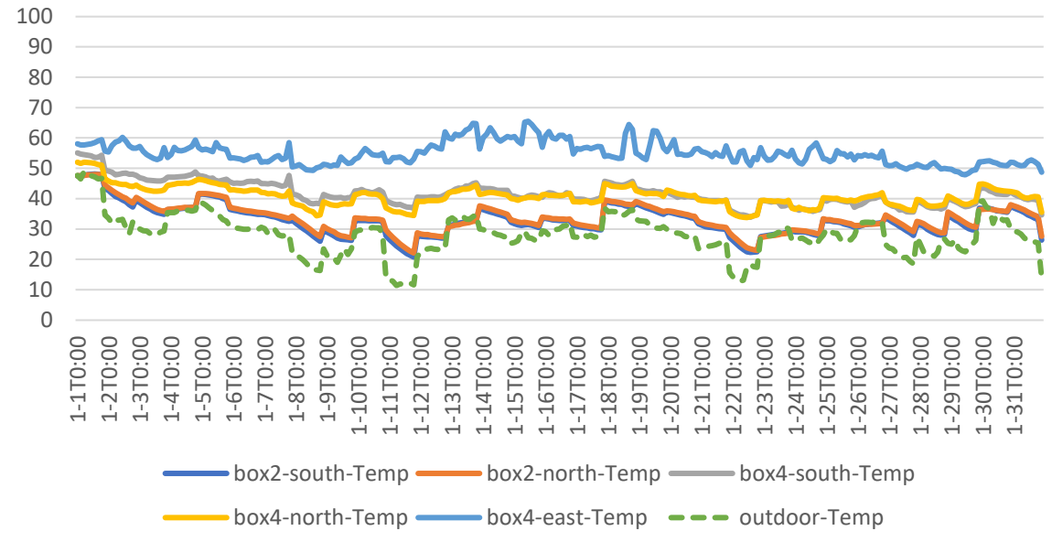
Ital1- top/bottom, rack



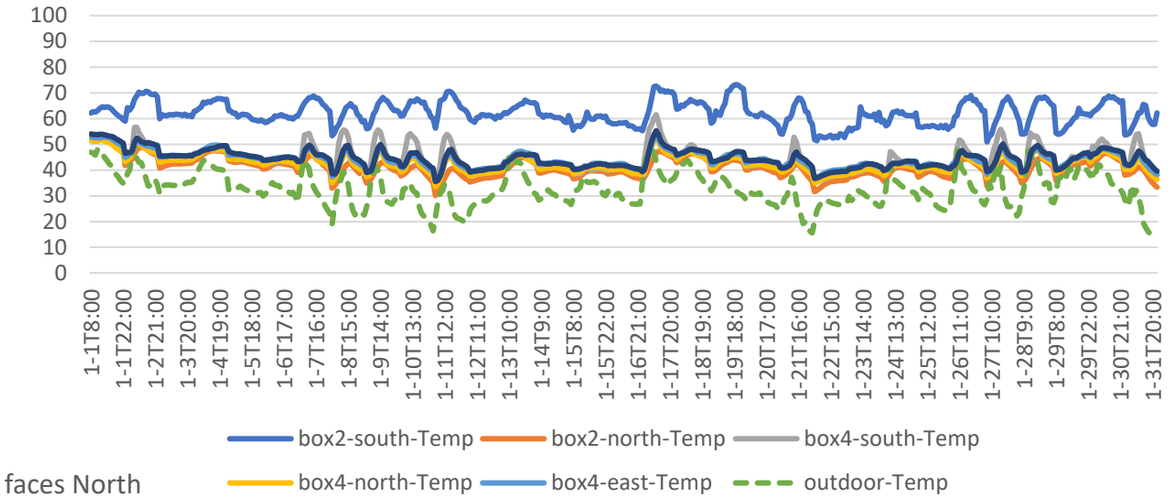
- Stalker – box4 north & south humidity readings are suspect so they are removed.
- Sask3 – box4-south sensor has the highest VPD

Compare Colonies - Jan Night (11pm-7am) - Temps

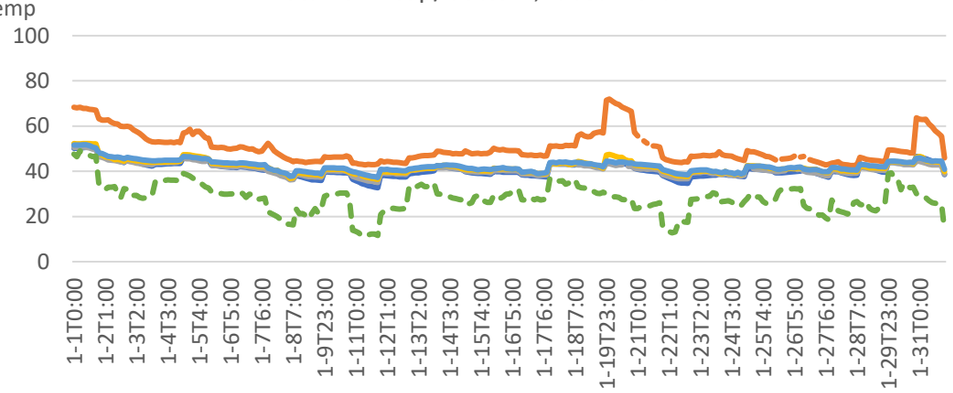
Sask1 – bottom only*, rack



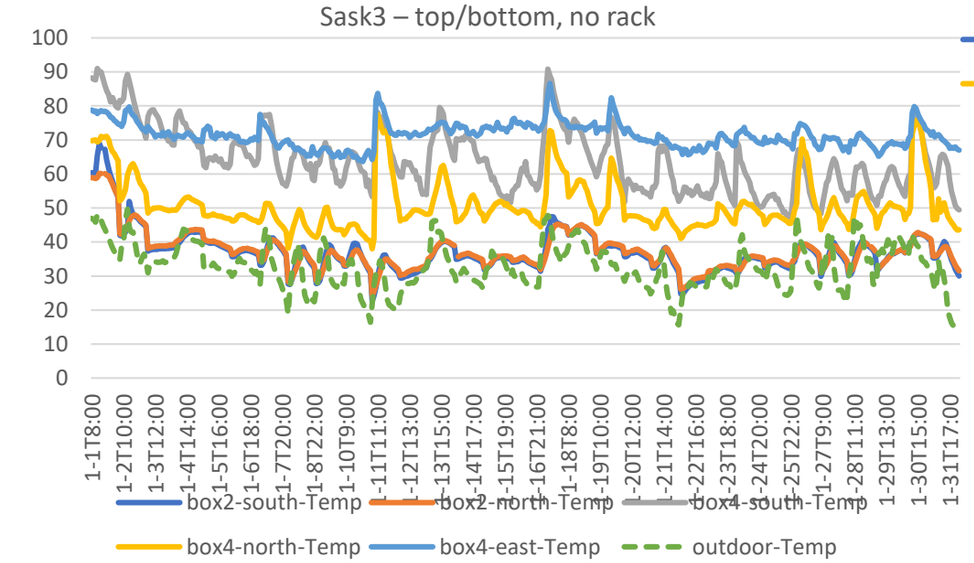
Sask2 – bottom only, no rack



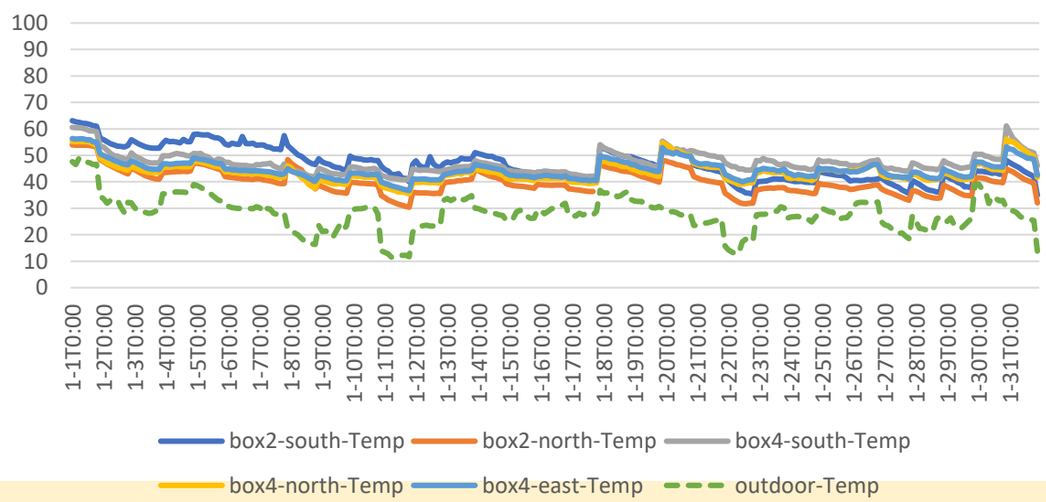
Stalker – top/bottom, faces North



Sask3 – top/bottom, no rack



Ital1 – top/bottom, rack



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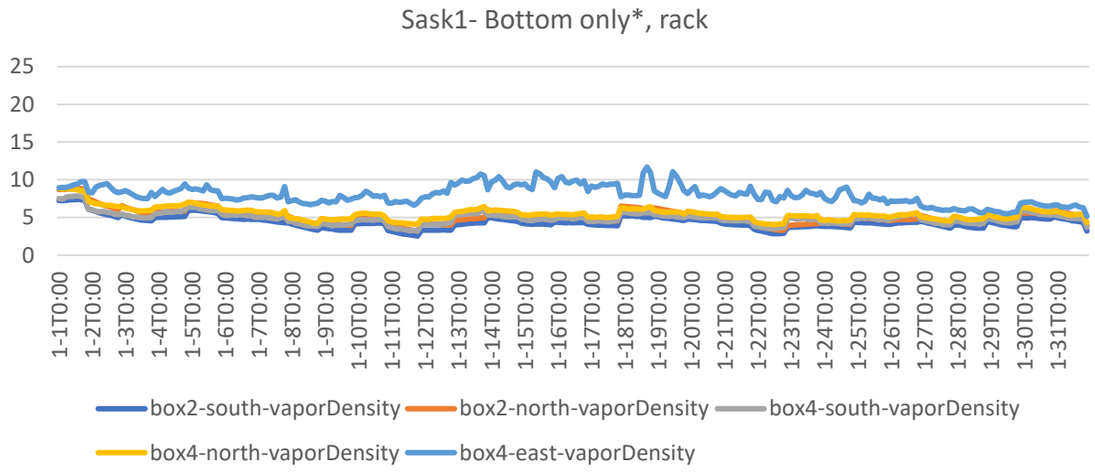
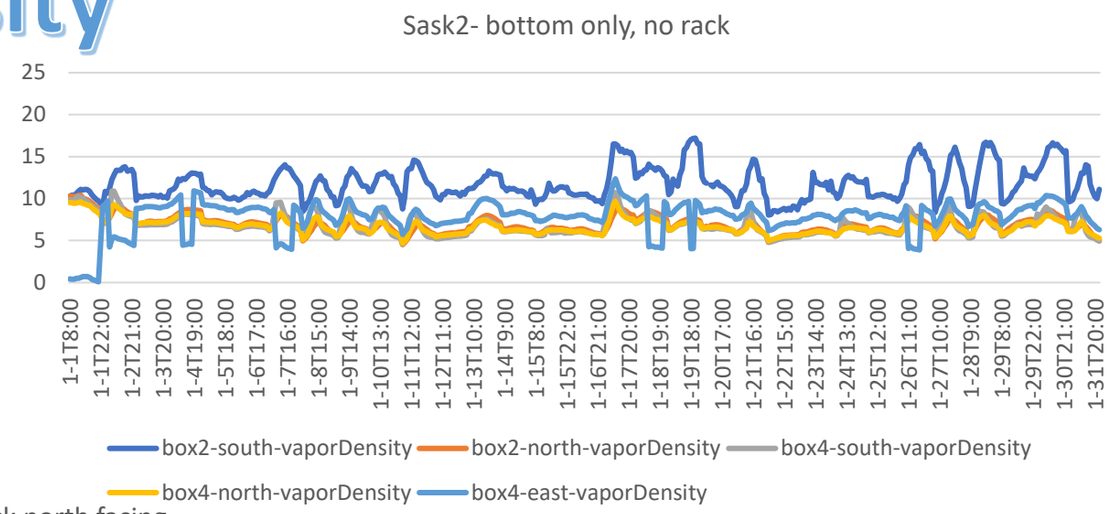
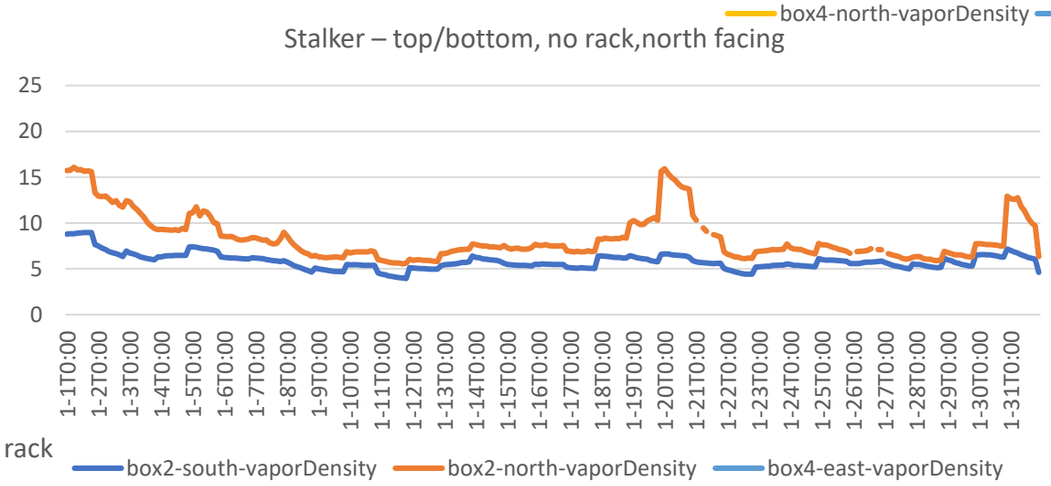
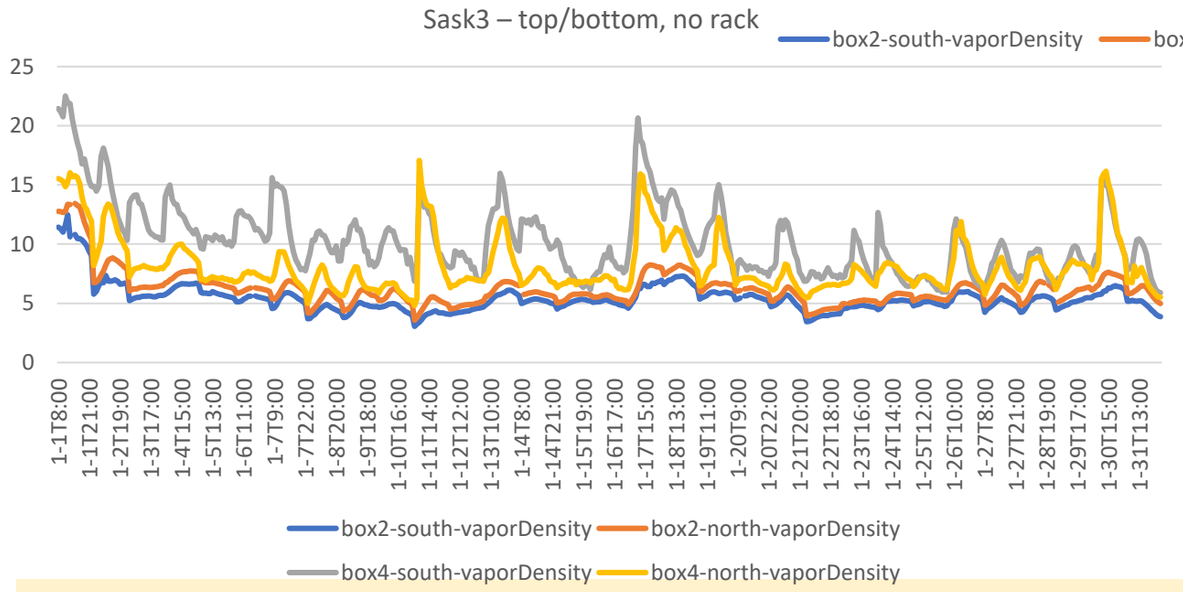
- Ital1 – is in box4 south/east side by mid jan – but all of the sensors are essential the same reading so the cluster is probably in between them

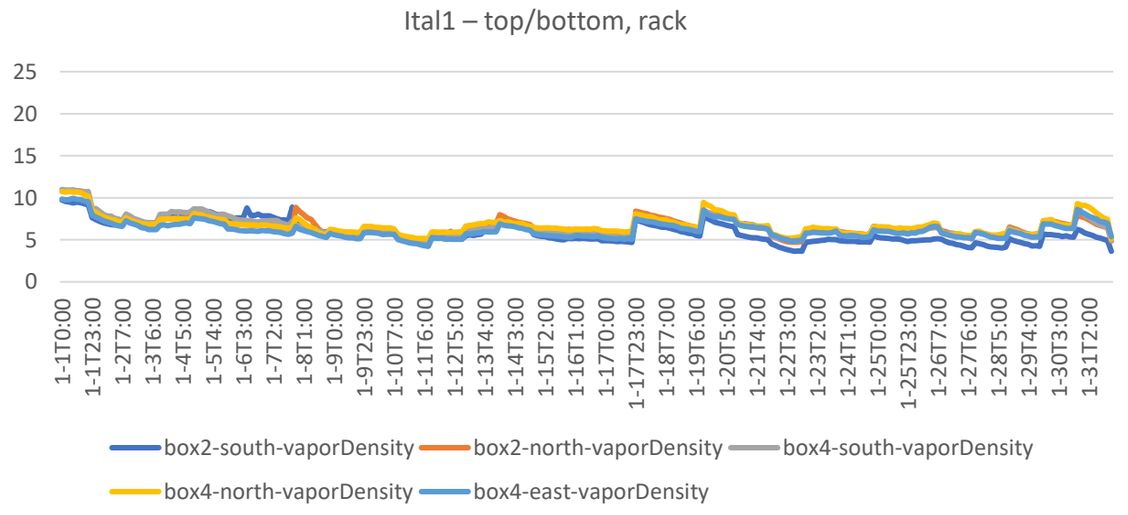
Compare Colonies - Jan Night (11pm-7am)– Vapor Density





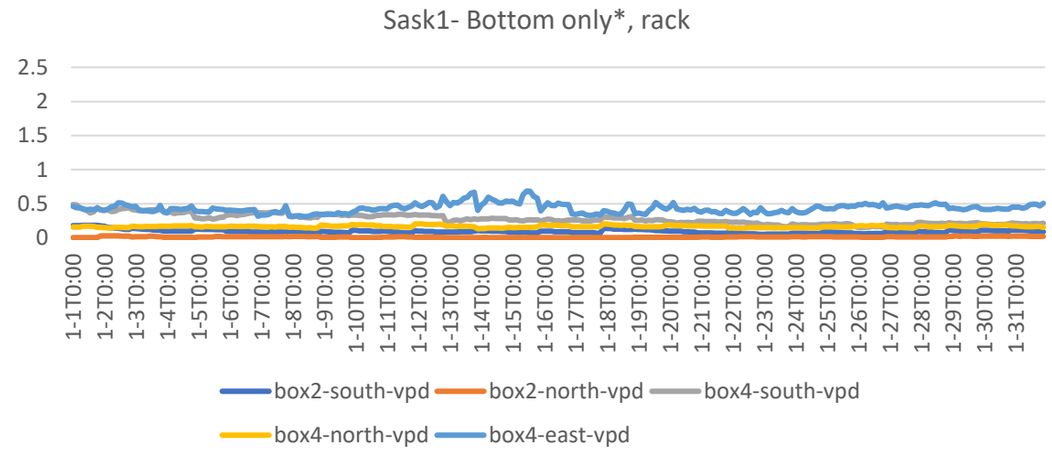


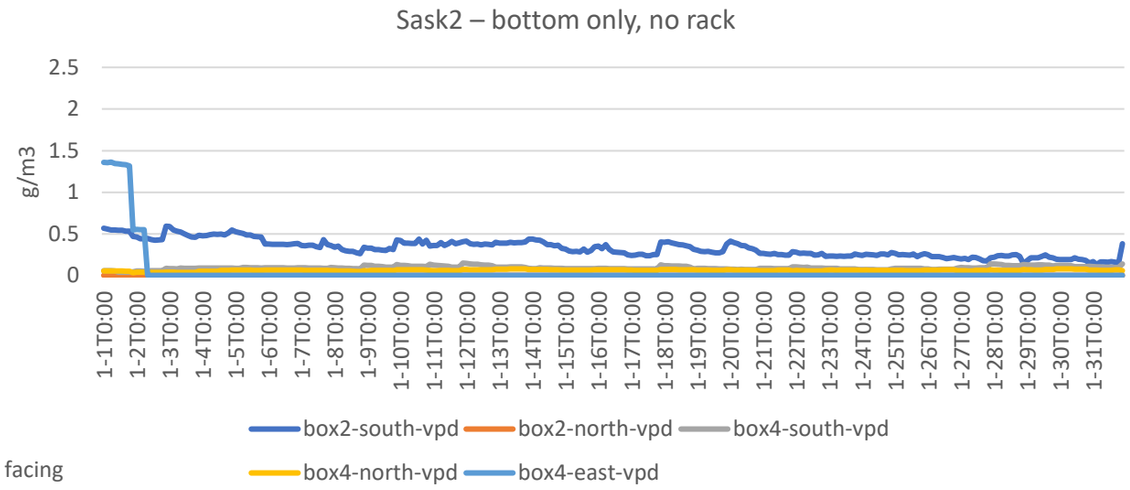




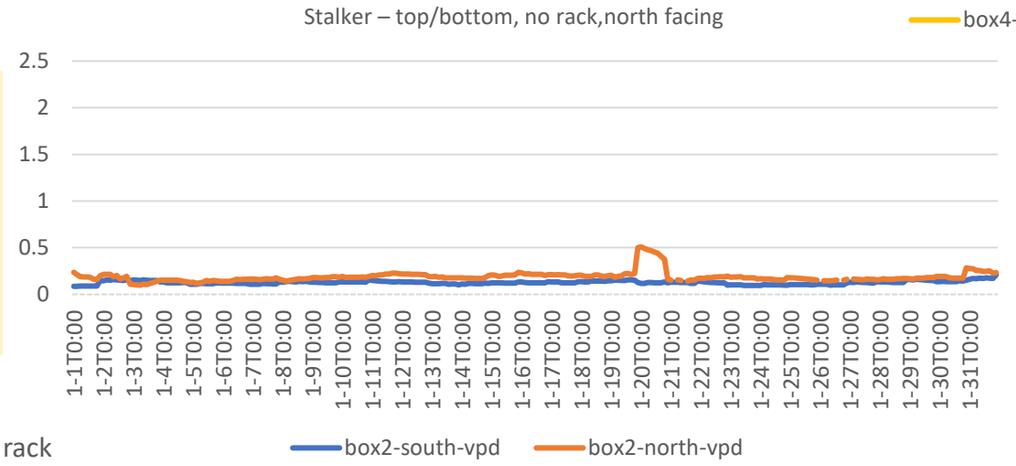
- Stalker – box4 north & south humidity readings are suspect so they are removed
  - It is unclear if the dips in box4-east vapor density are real in Sask2
  - It is interesting that stalker is on the north side of the colony – in the air flow
- Vapor densities in Ital1 are consistent at all of the sensors. The cluster may be in between the sensors and not on top of any of them

Compare Colonies - Jan Night (11pm-7am)– VPD

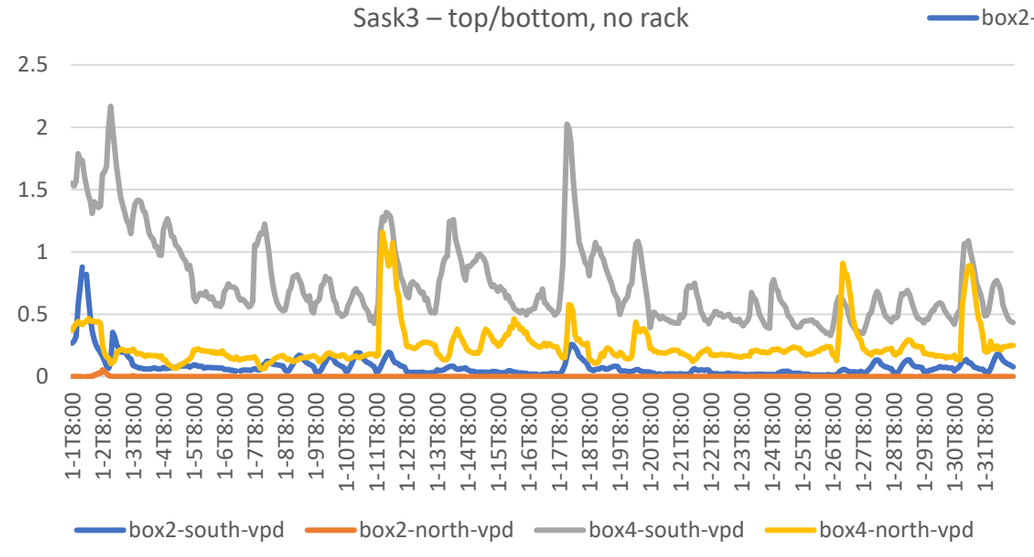


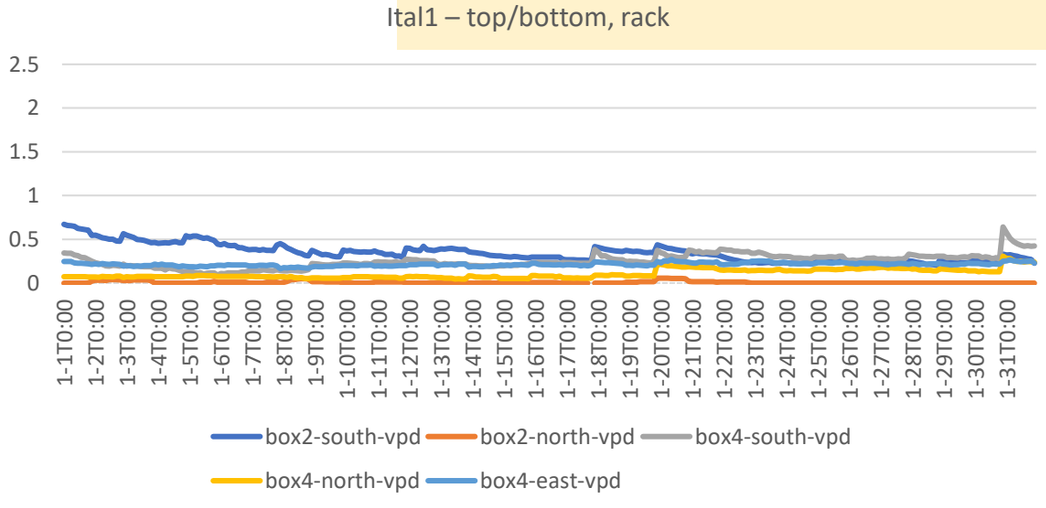


Box2-north has essentially VPD = 0 except for stalker that is clustered there. This is probably because the airflow doesn't hit that area.



In Sask2 - Except for box2-south area – the air is fully saturated (VPD ~=0)
Is this because with the single bottom opening there isn't as much air flow?
Bees in Sask1 made their own upper entrance in box4. Is this why we don't see the same pattern as we see in Sask2?

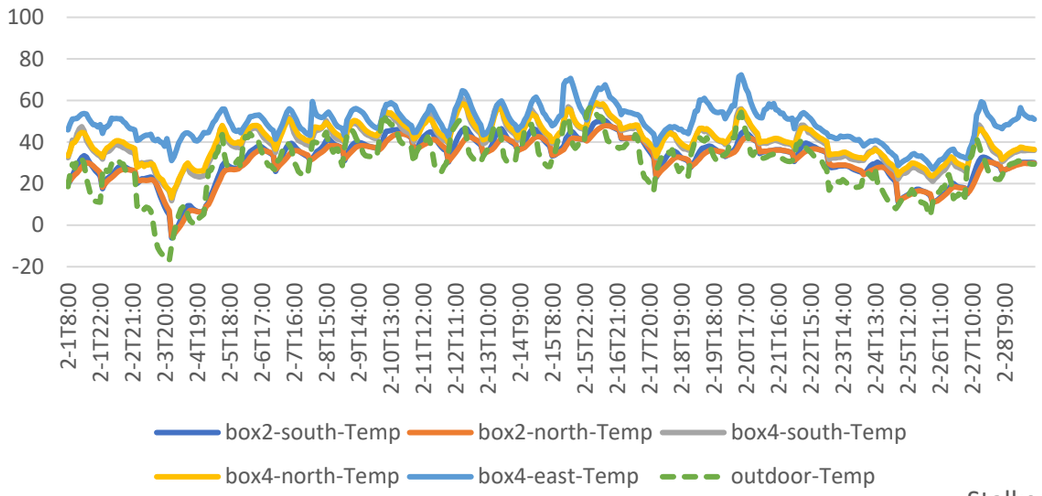




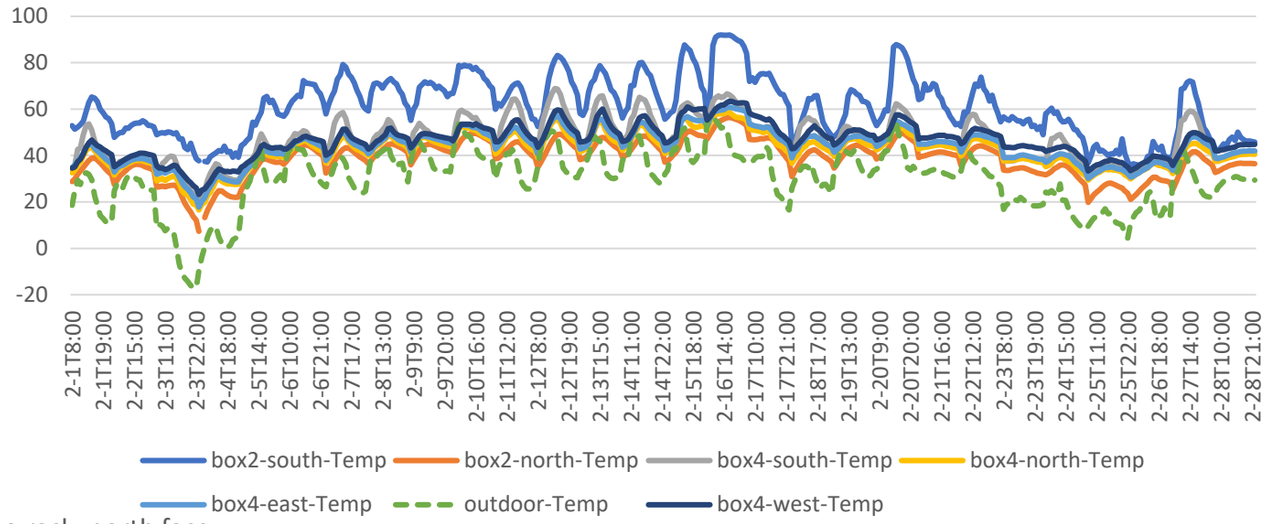
- Stalker – box4 north & south humidity readings are suspect so they are removed.
- Sask3 – box4-south sensor has the highest VPD.

Compare Colonies - Feb Day(8am-10pm) - Temps

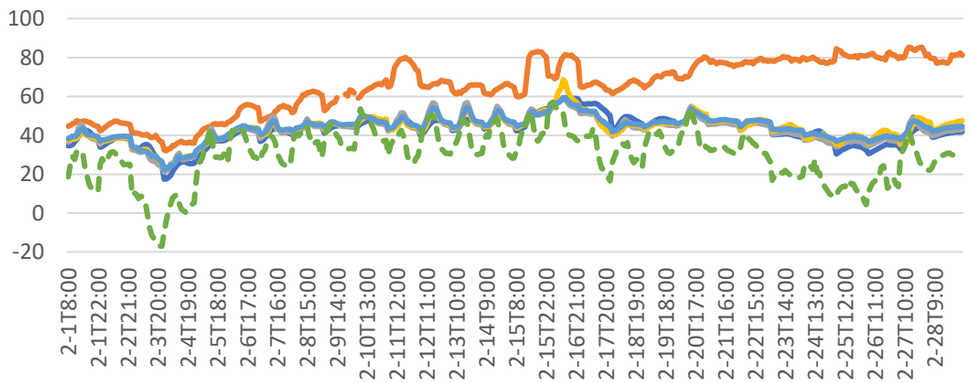
Sask1- bottom only*, rack



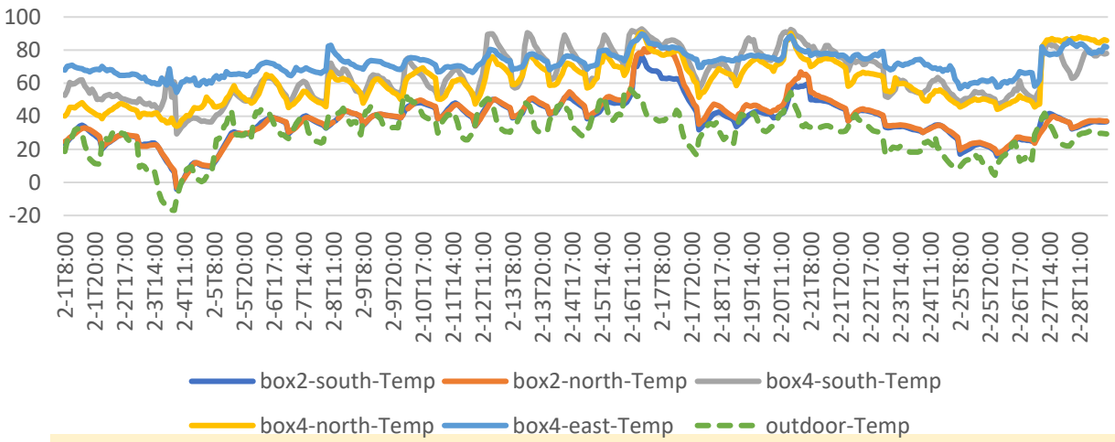
Sask2- bottom only, no rack



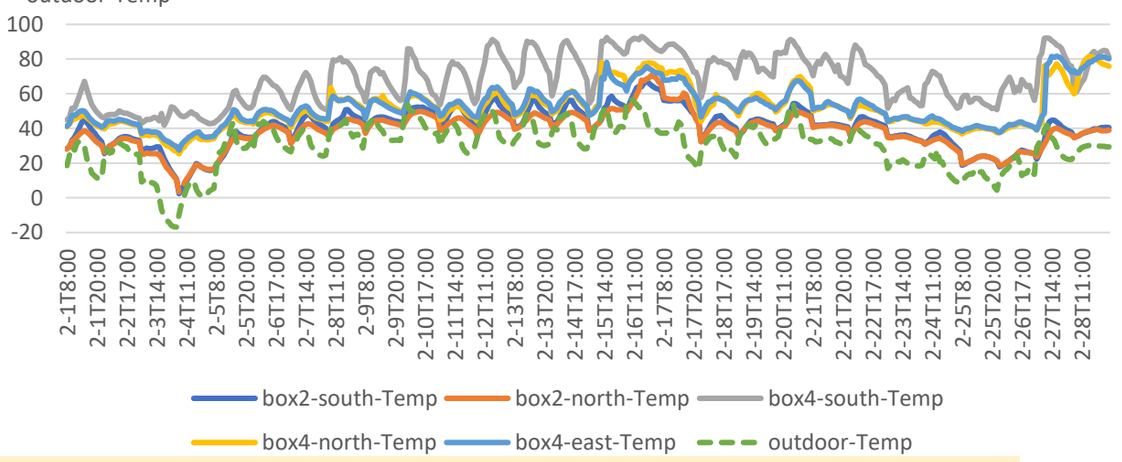
Stalker – top/bottom, no rack, north face



Sask3-top/bottom, no rack



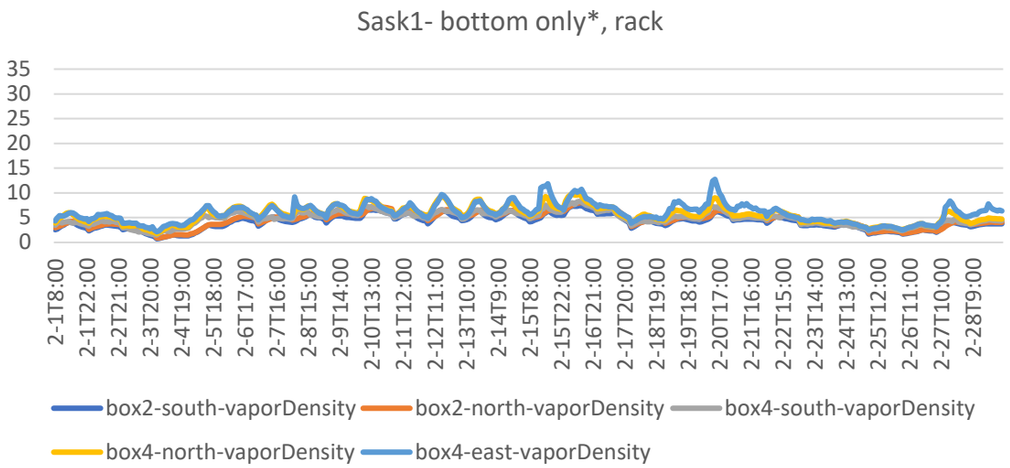
Ital1- top/bottom, rack

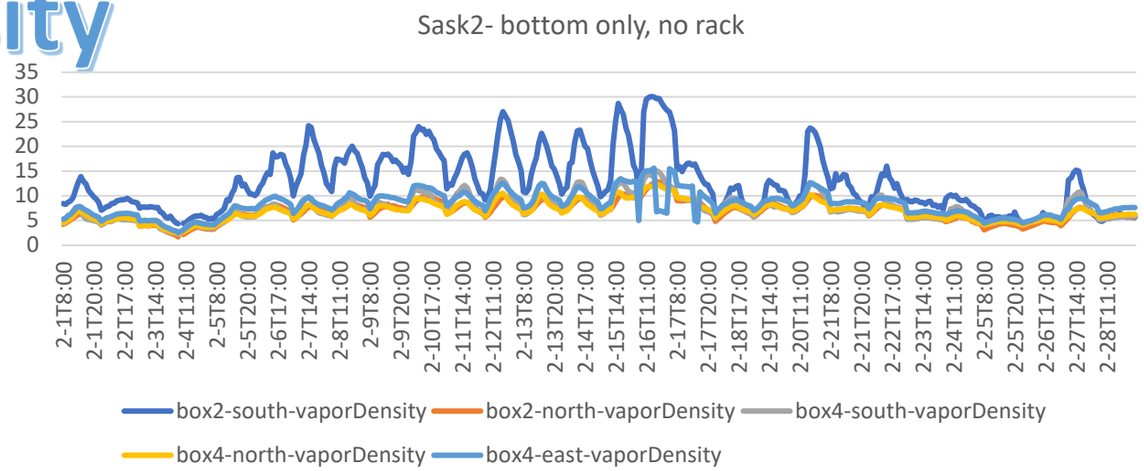


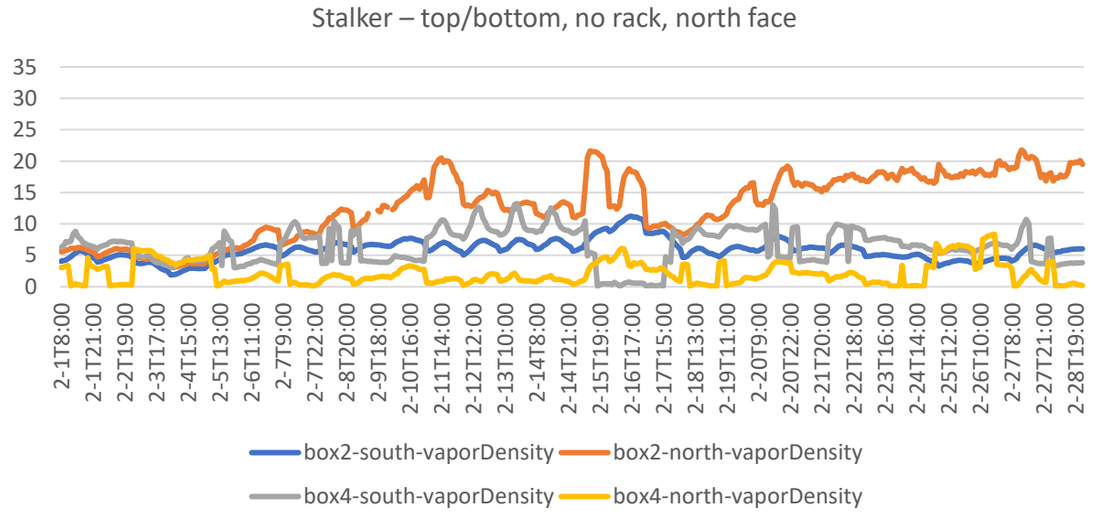
½ pollen patty added to all colonies on 2/27

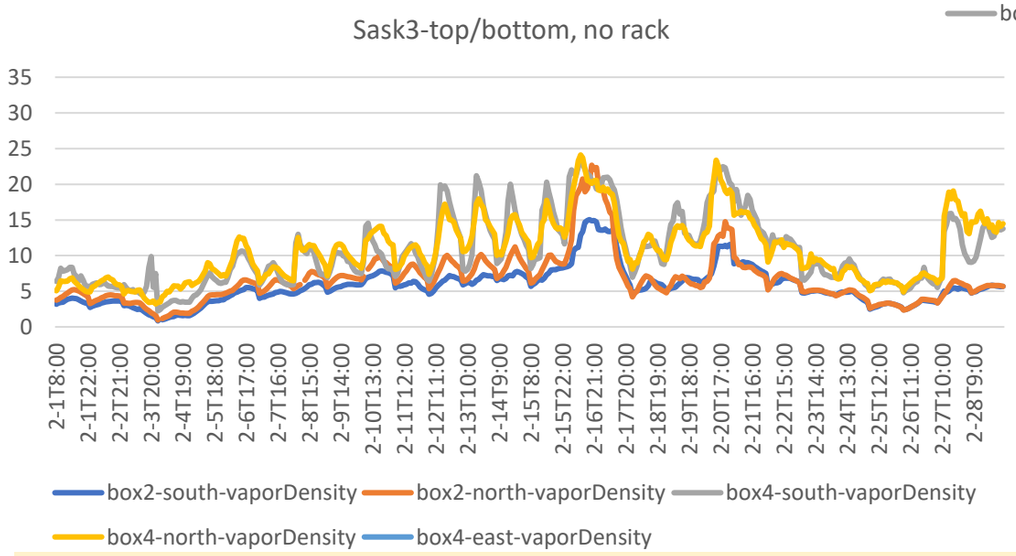
- Sask1,Ital1 & Sask3 are at the top of the box
- Stalker & Sask2 are in box2 – but Stalker is on the north side & Sask2 is on the south side. Are the Stalker bees on the north because it is in the airflow path? This is the 2nd year in a row we've observed this.
- Bees in Sask1, Ital1, Sask3 moved to the pollen patty when added

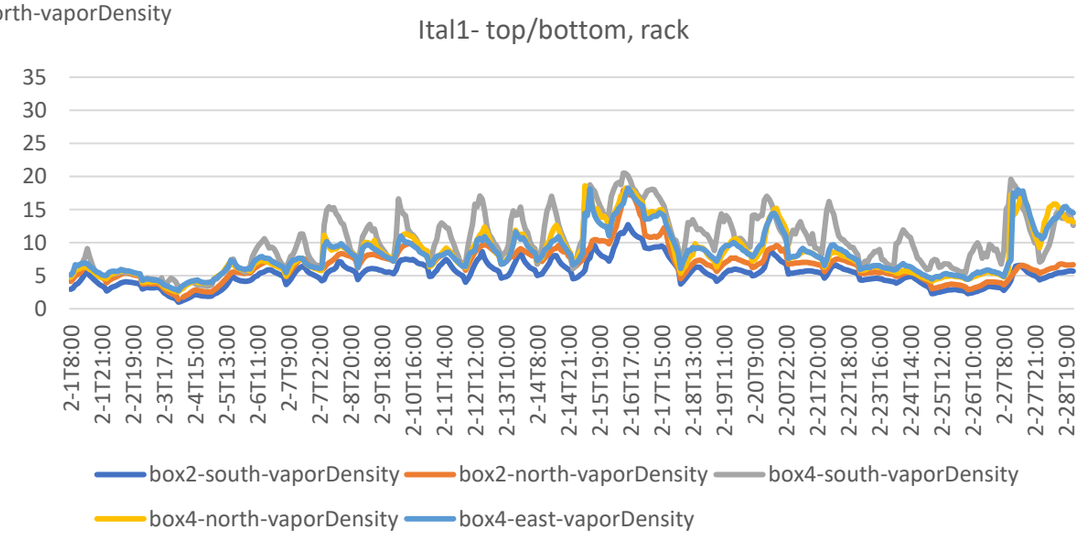
Compare Colonies - Feb Day(8am-10pm) – Vapor Density







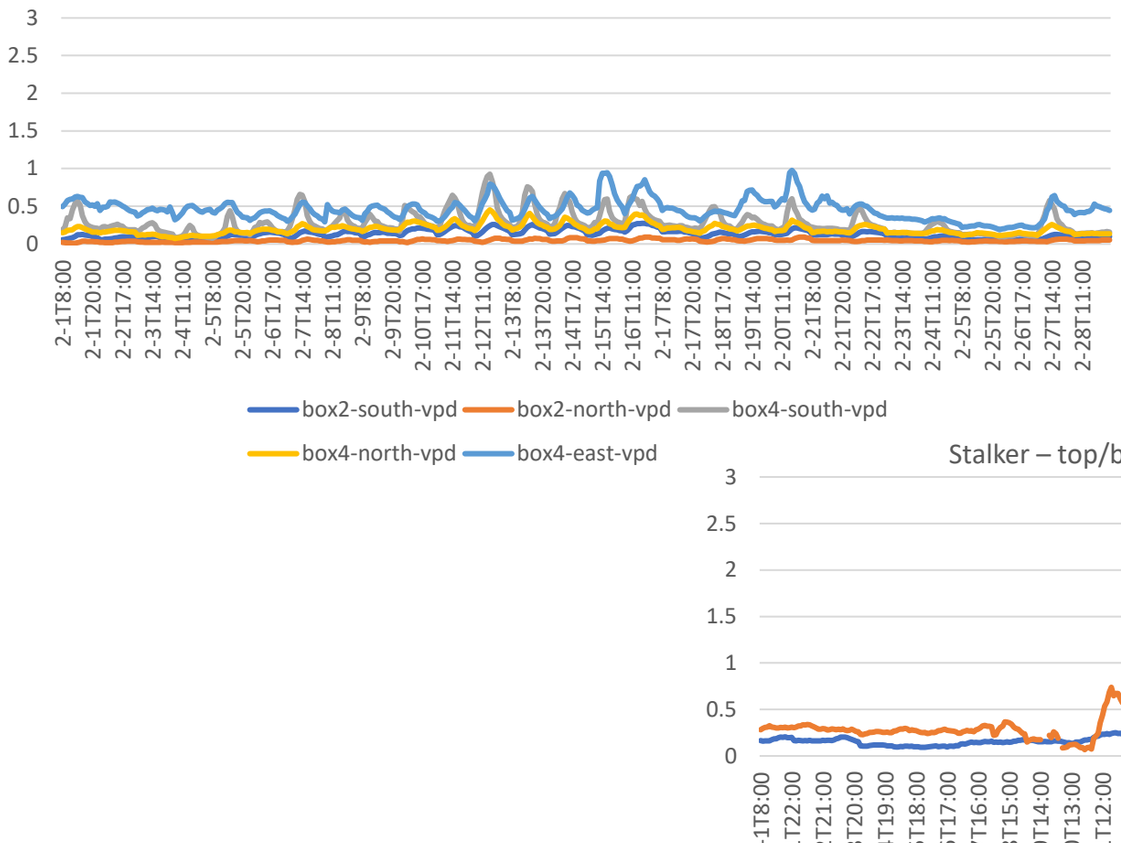




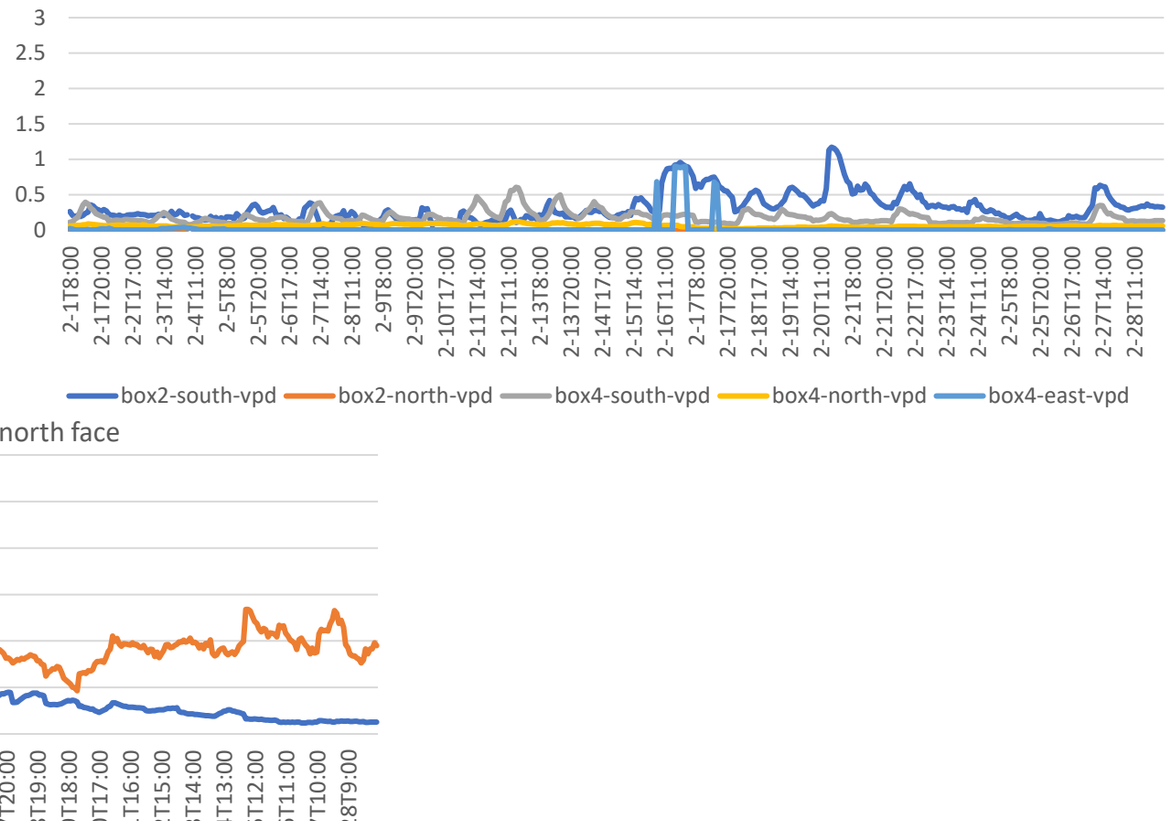
- Vapor density increases on sunny days. All colonies had a dip in Vapor density on 2/17-18. Temps were in the 20s instead of the 30s over those days.
- Sask1 has very low vapor density. I think that cluster is pretty small.

Compare Colonies - Feb Day(8am-10pm) – VPD

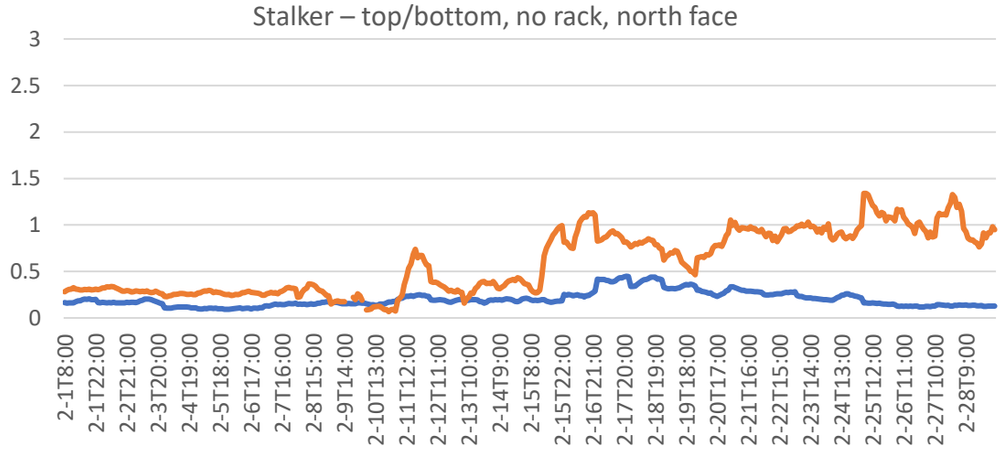
Sask1- bottom only*, rack



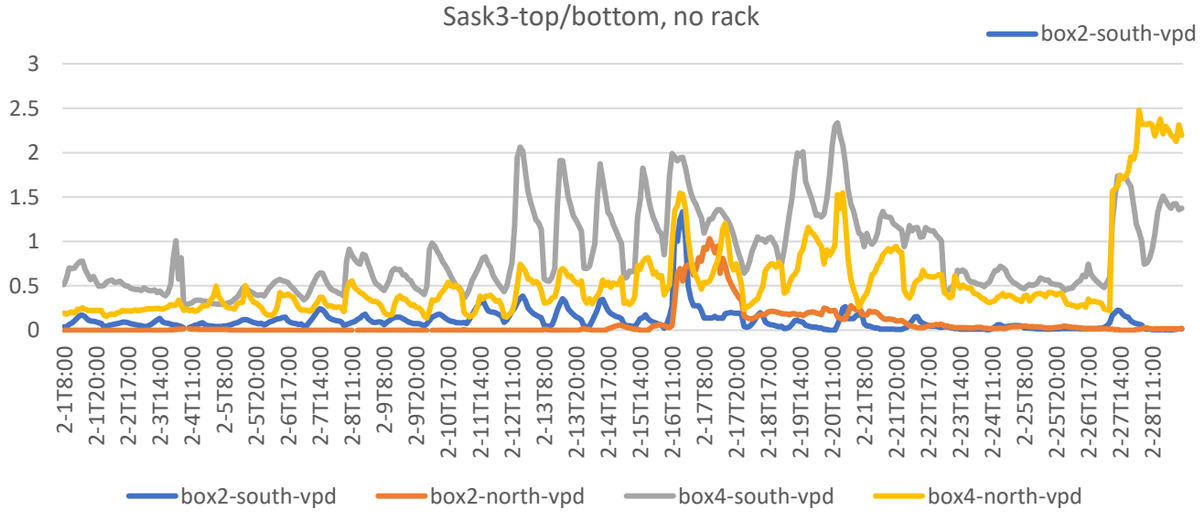
Sask2- bottom only, no rack



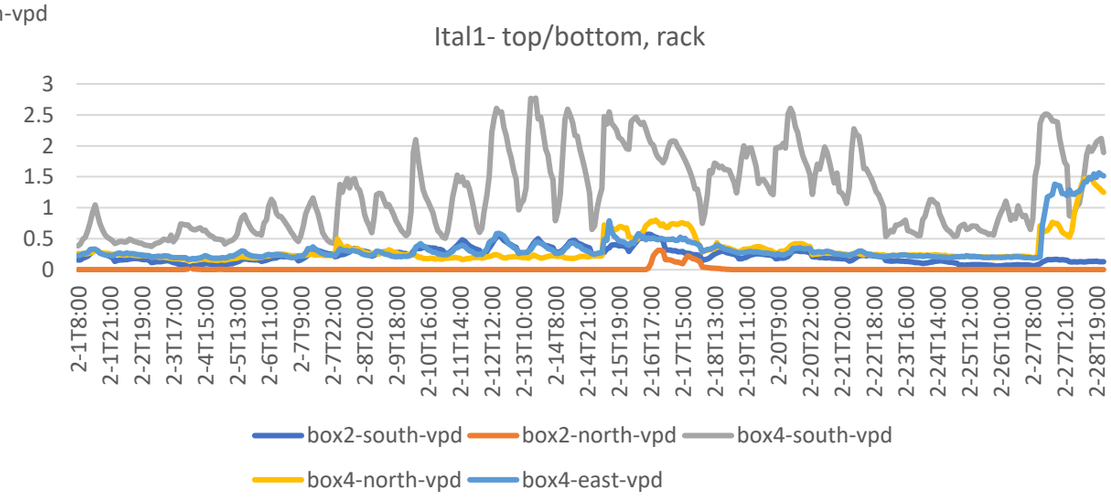
Stalker – top/bottom, no rack, north face



Sask3-top/bottom, no rack



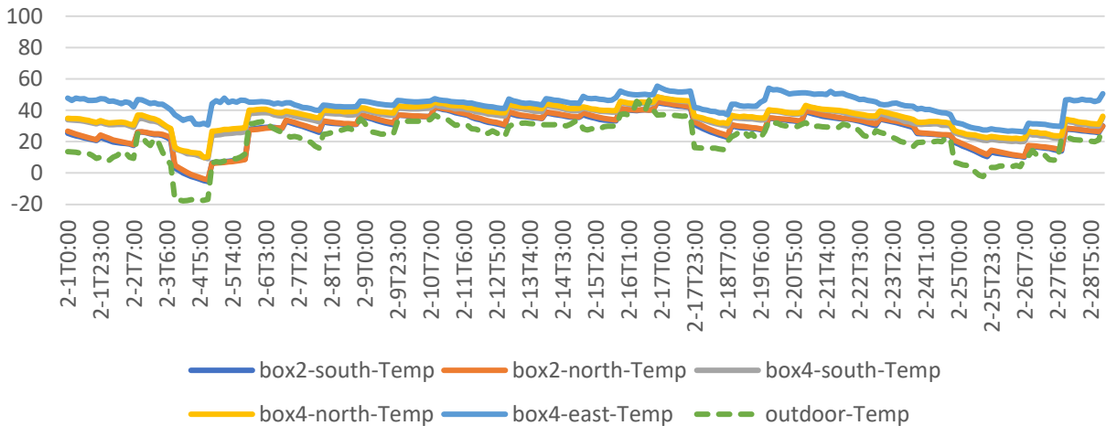
Ital1- top/bottom, rack



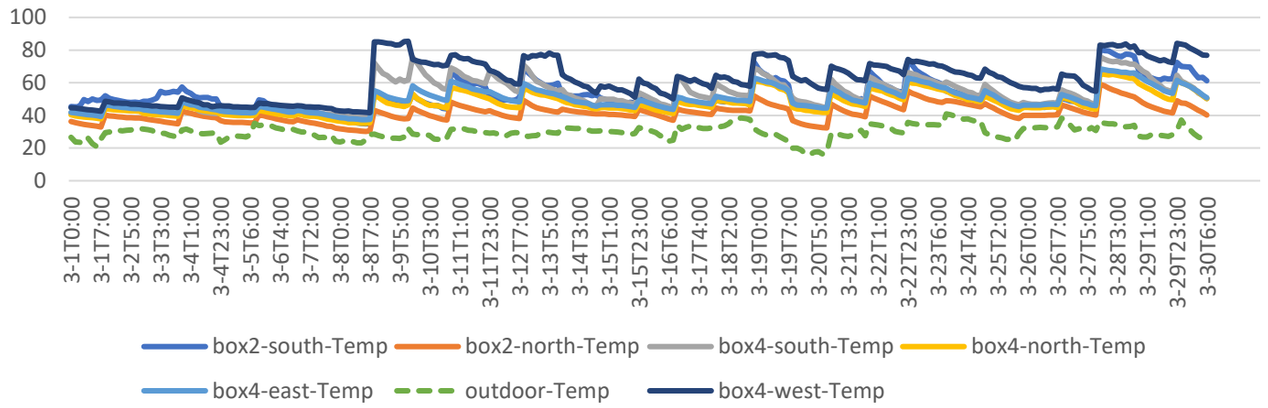
- Stalker – At the end of the month the temps rose (raising brood?) on box2-north – so there is more room for moisture in the air.
  - Sask3- Bees moved down to box2-north on 2/17 – so there was room for more moisture in the sir.
- Sask2 – continues to have almost fully saturated air (not sure I trust the box4 east reading – but they may be correct).

Compare Colonies - Feb Night (11pm-7am) - Temps

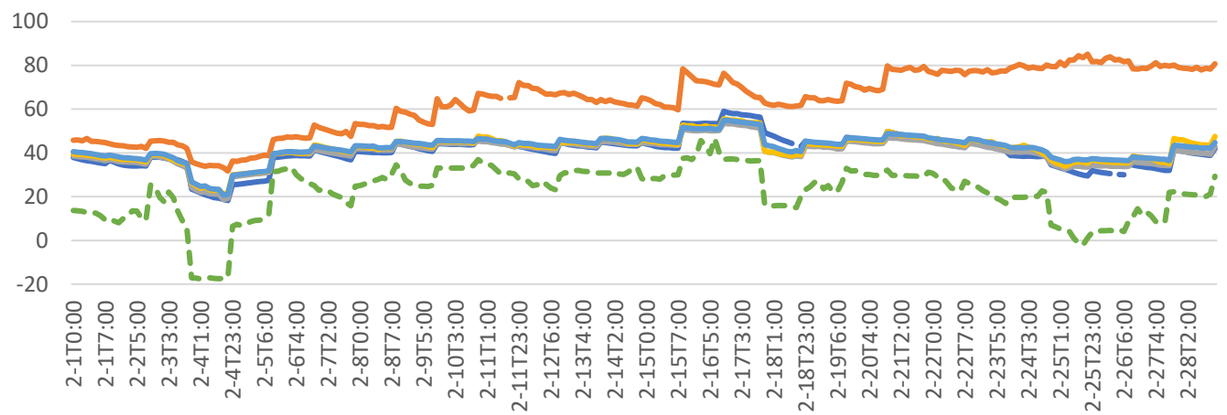
Sask1- bottom only*,Rack



Sask2, no rack, bottom only

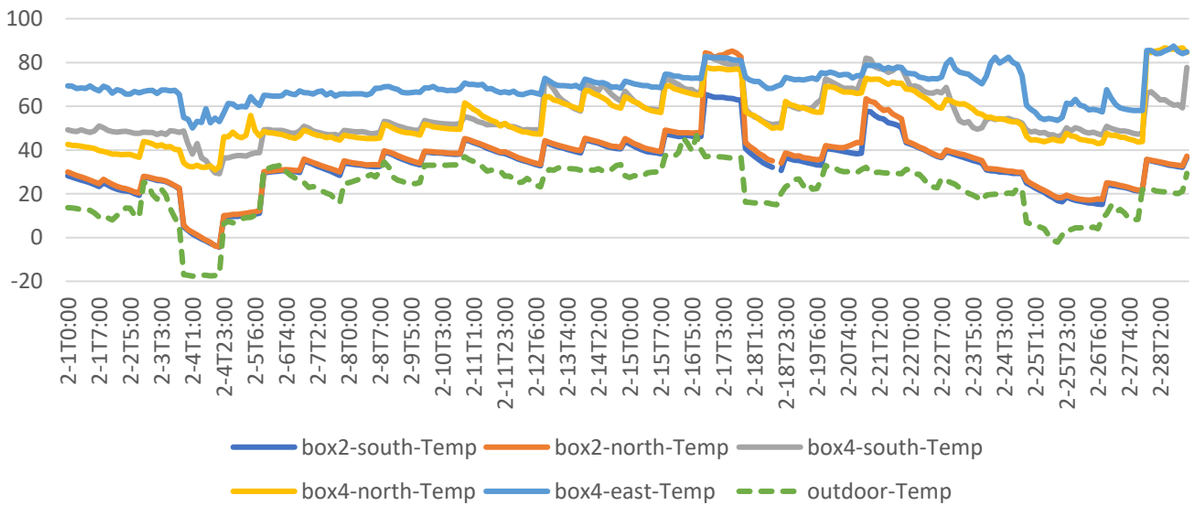


Stalker, top/bottom, no rack, north facing

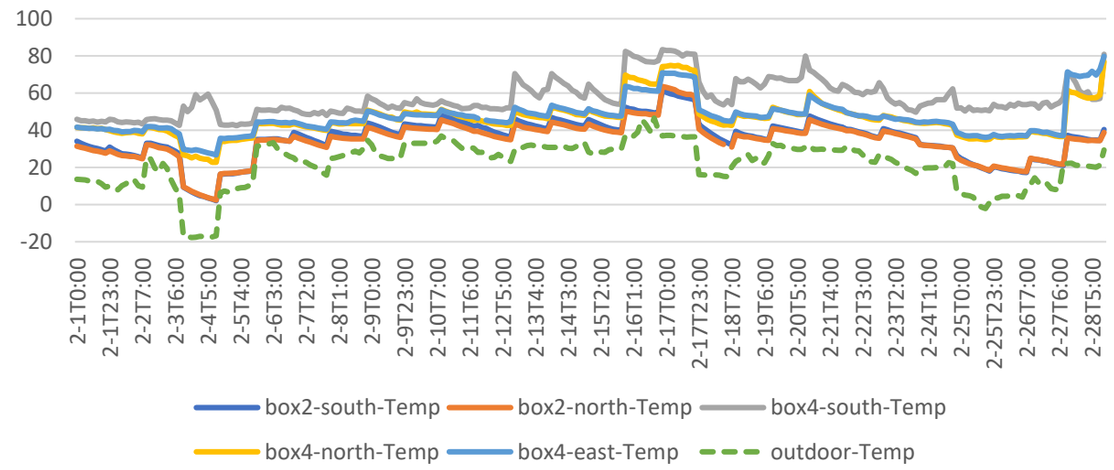


½ pollen patty added to all colonies on 2/27

Sask3 – top/bottom, no rack

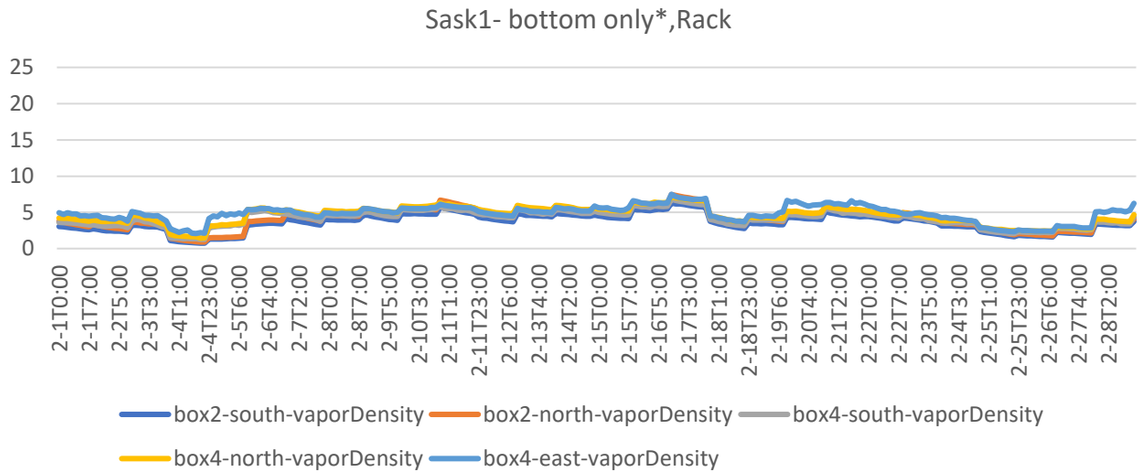


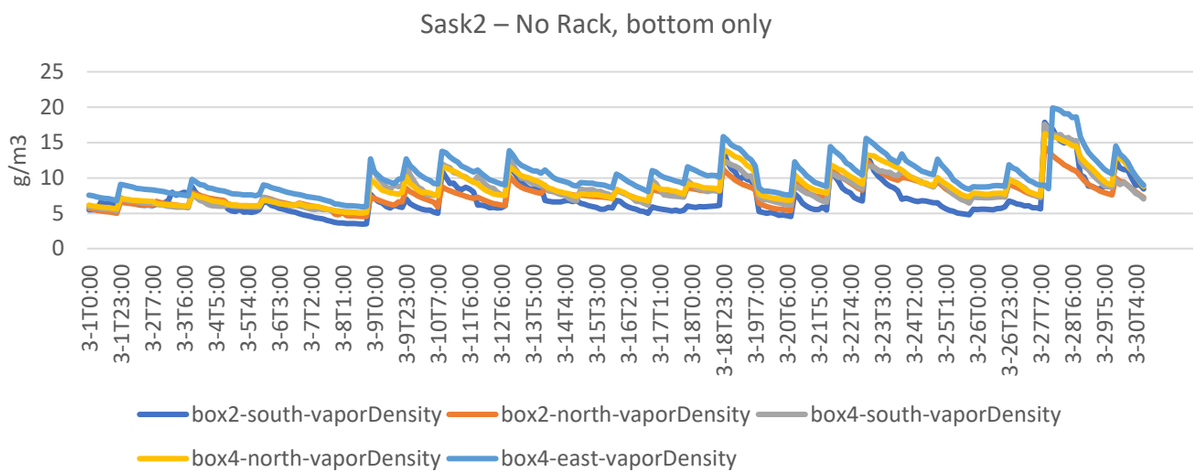
Ital1- top/bottom, rack

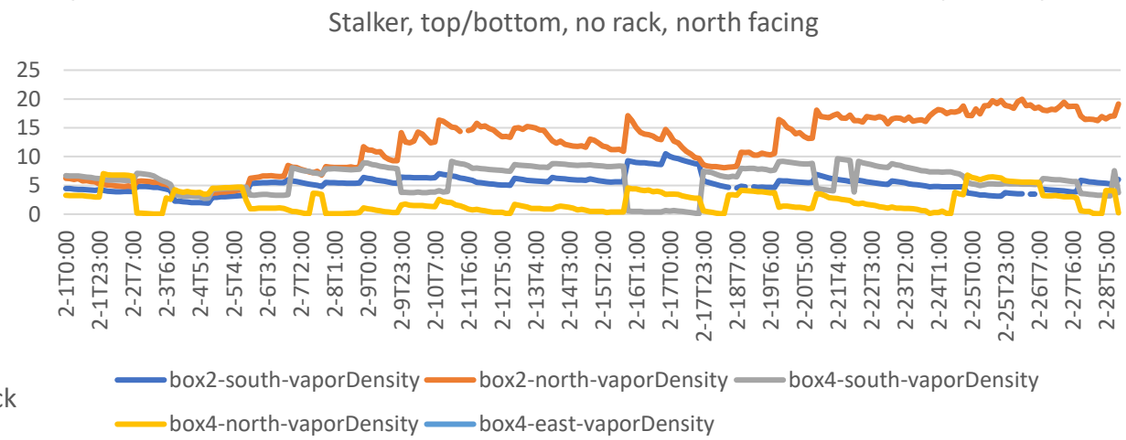


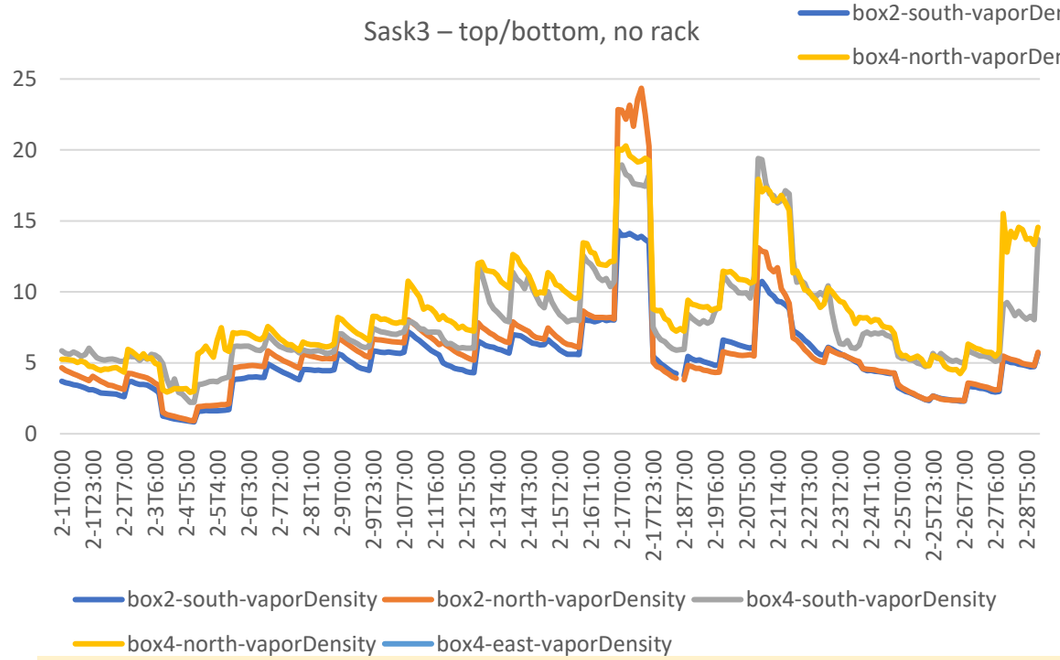
- Jan16-18 were some of the warmest days – so the bees moved around the colonies
- Did they go down to the box2-north sensor to get some moisture?

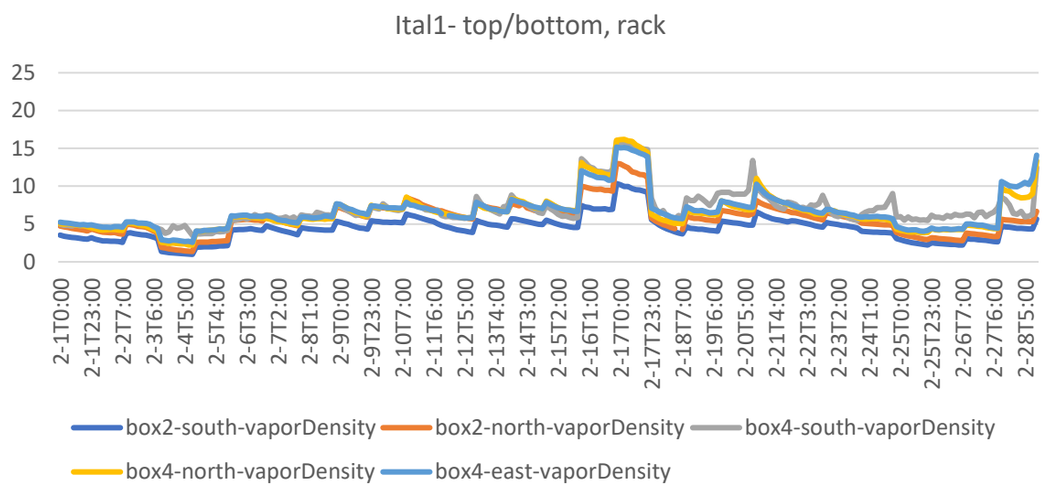
Compare Colonies - Feb Night (11pm-7am)– Vapor Density





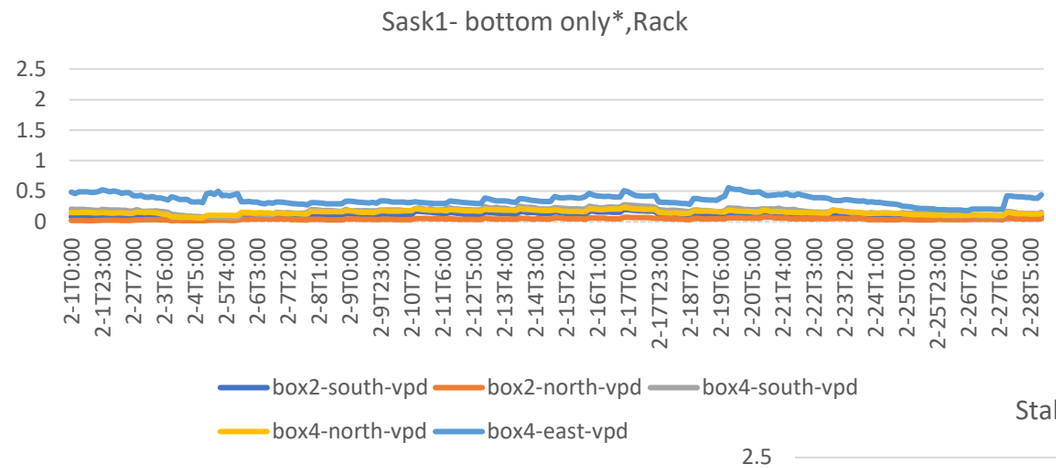


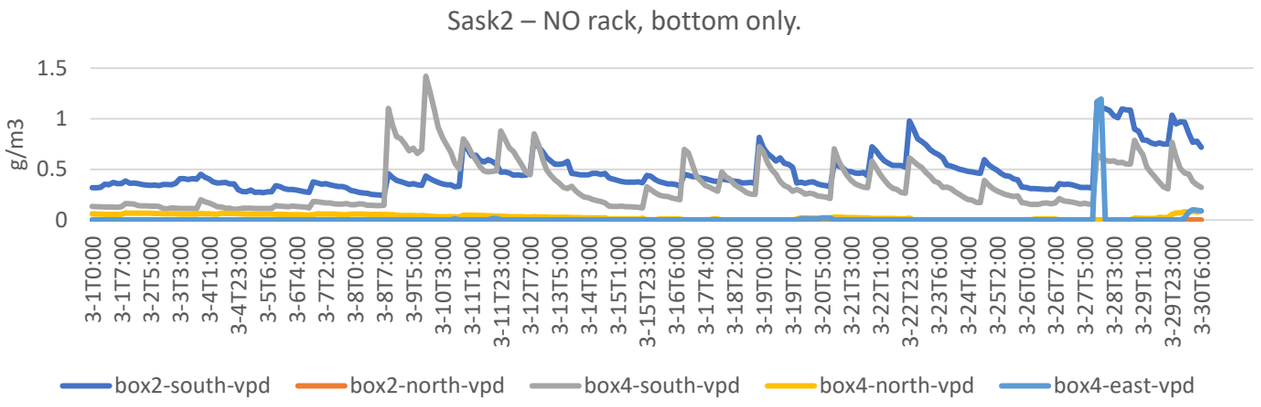


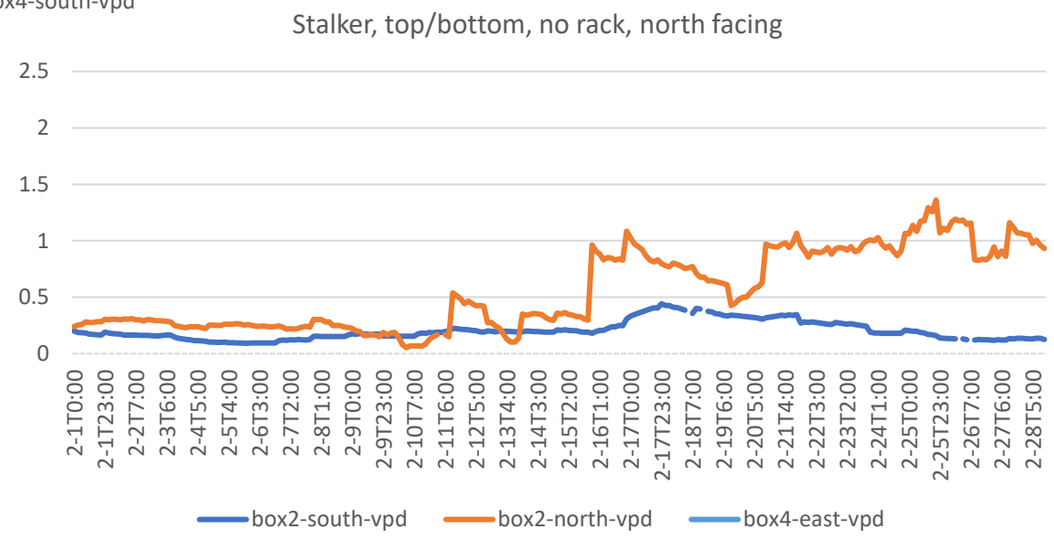


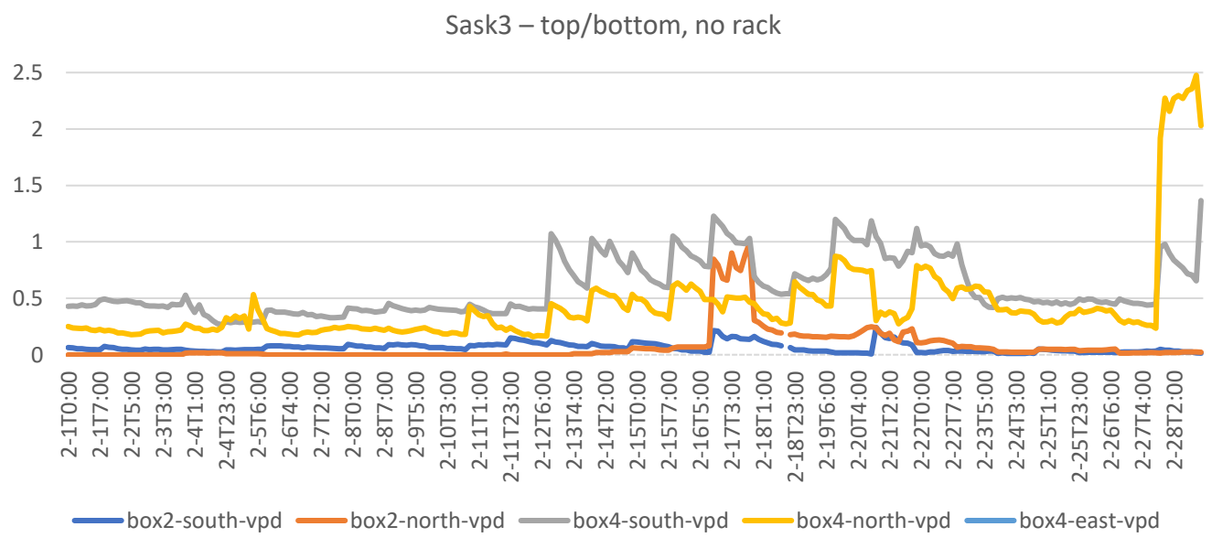
- The amount of moisture in the air on 2/16-2/18 increased because the bees were moving around due to the warmer temps.
  - Sask3 also experienced a smaller version of that on 2/20 . It isn't as obvious in the other colonies
  - Sask1's air is much drier and less variable in the area of the sensors .. I'm guessing this is because the cluster is small

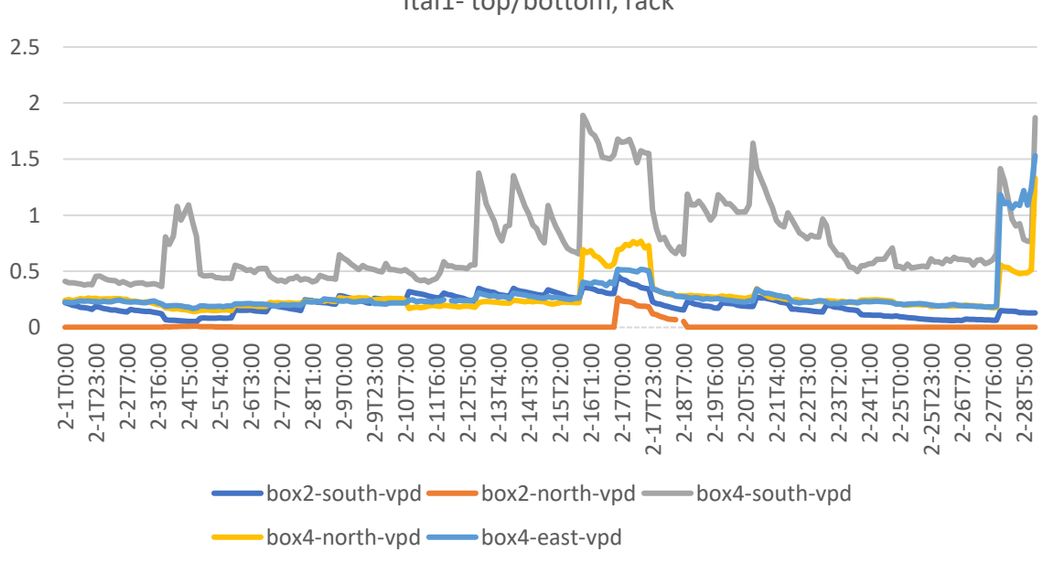
Compare Colonies - Feb Night (11pm-7am)– VPD







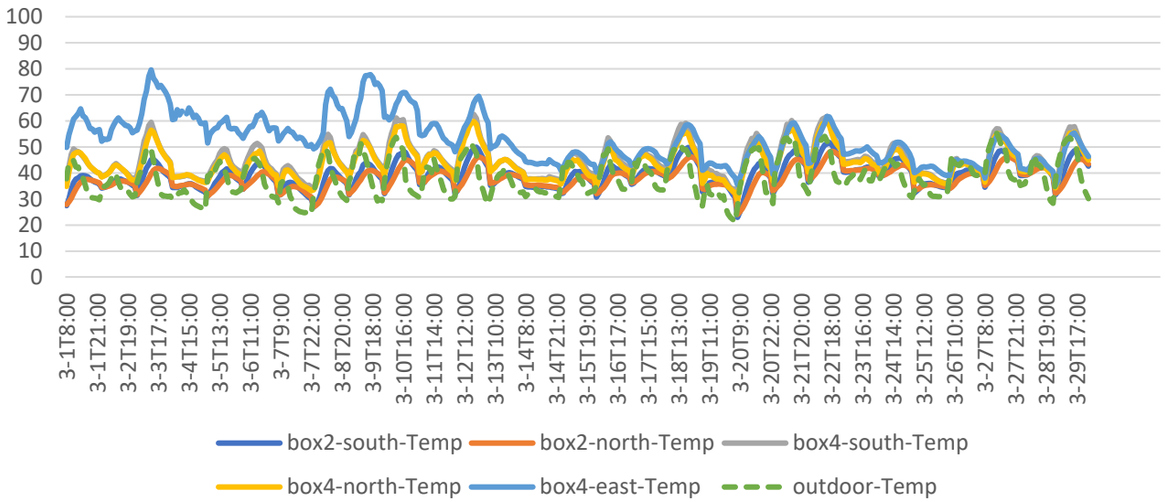




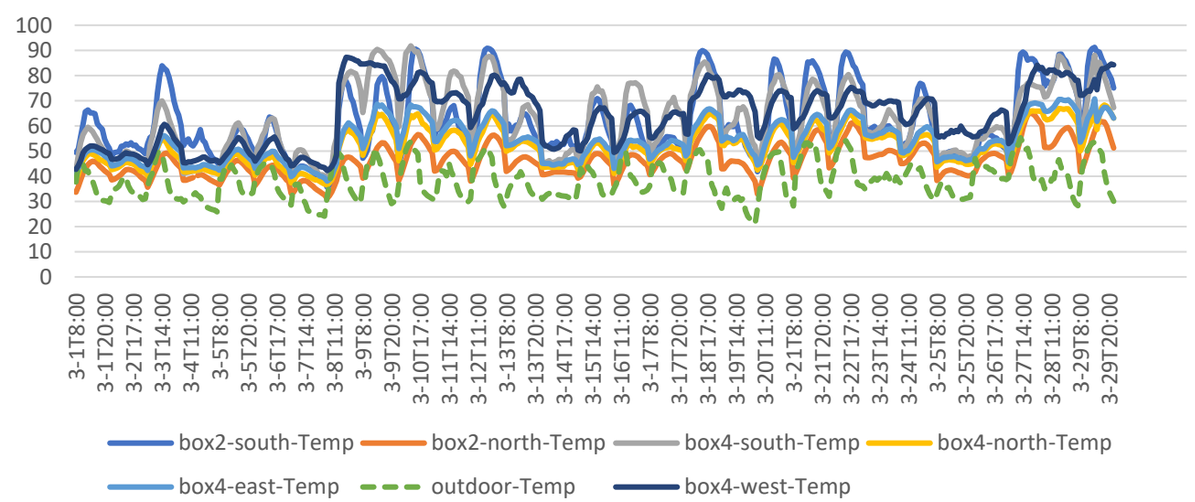
- The two colonies with the bottom only opening appear to have more saturated air Te temps around Sask2-box2-south sensor are similar to those of box Ital1-box4-east – but the VPDs are much lower.

Compare Colonies - Mar Day(8am-10pm) - Temps

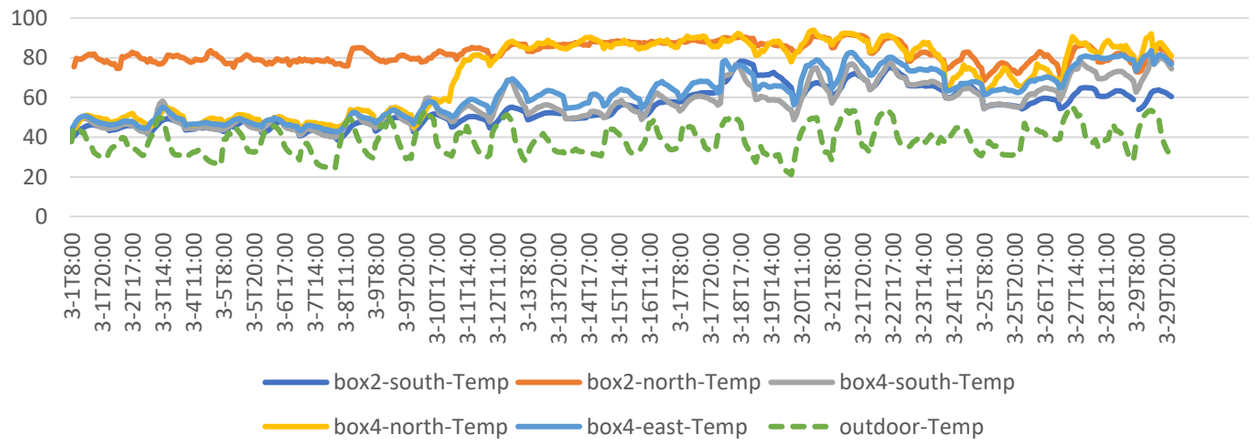
Sask1-bottom only*, rack



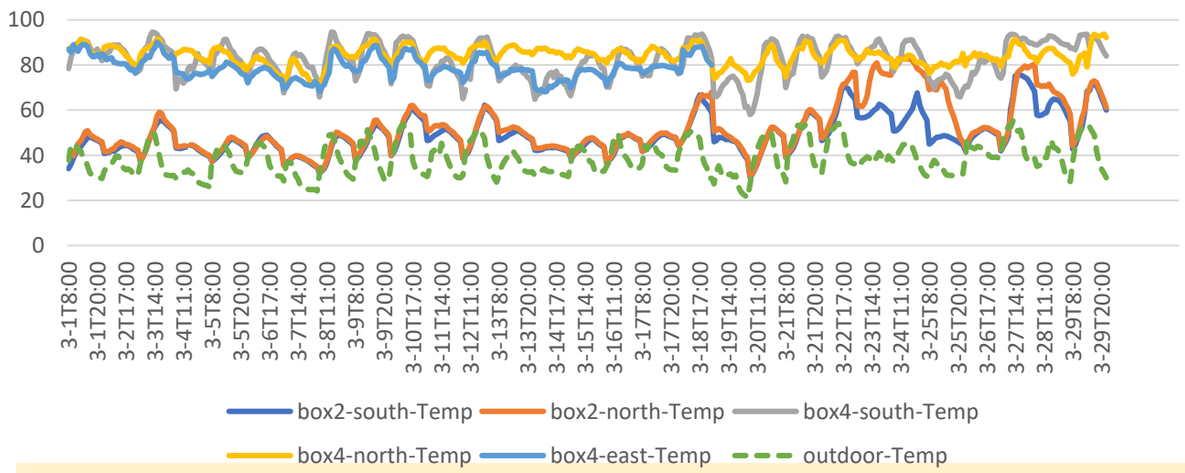
Sask2- NO rack, Bottom only



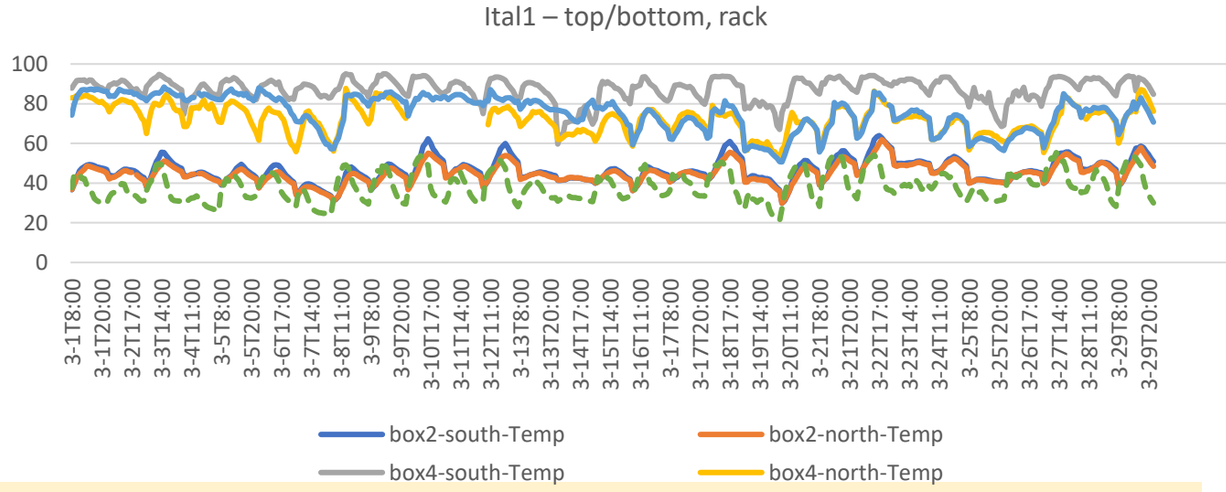
Stalker,top/bottom, no rack, north facing



Sask3- top/bottom no rack

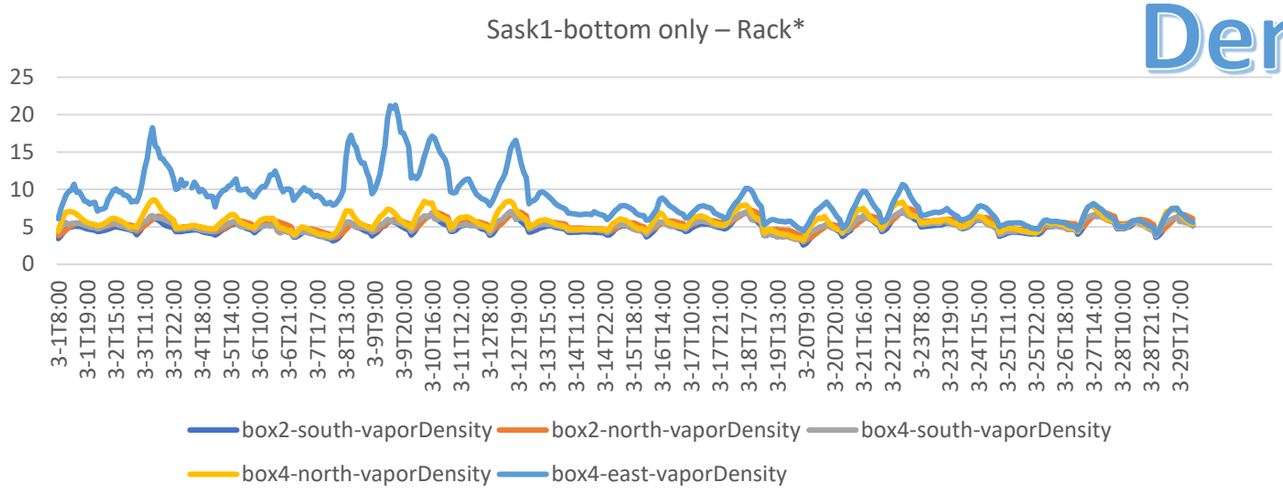


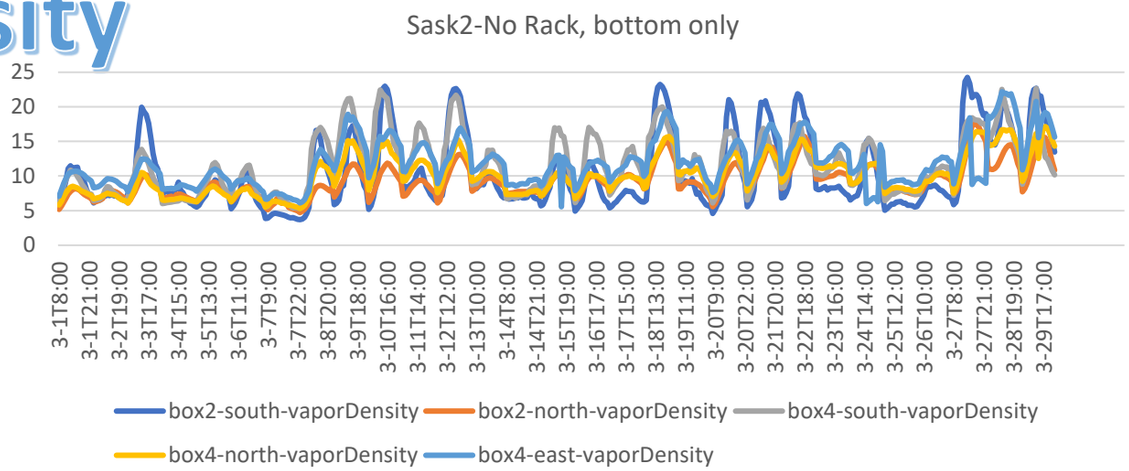
Ital1 – top/bottom, rack

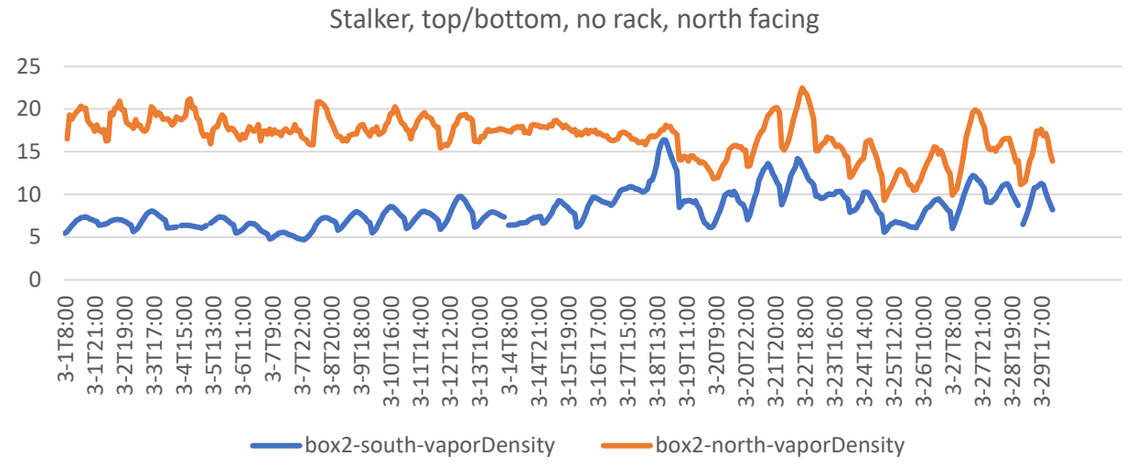


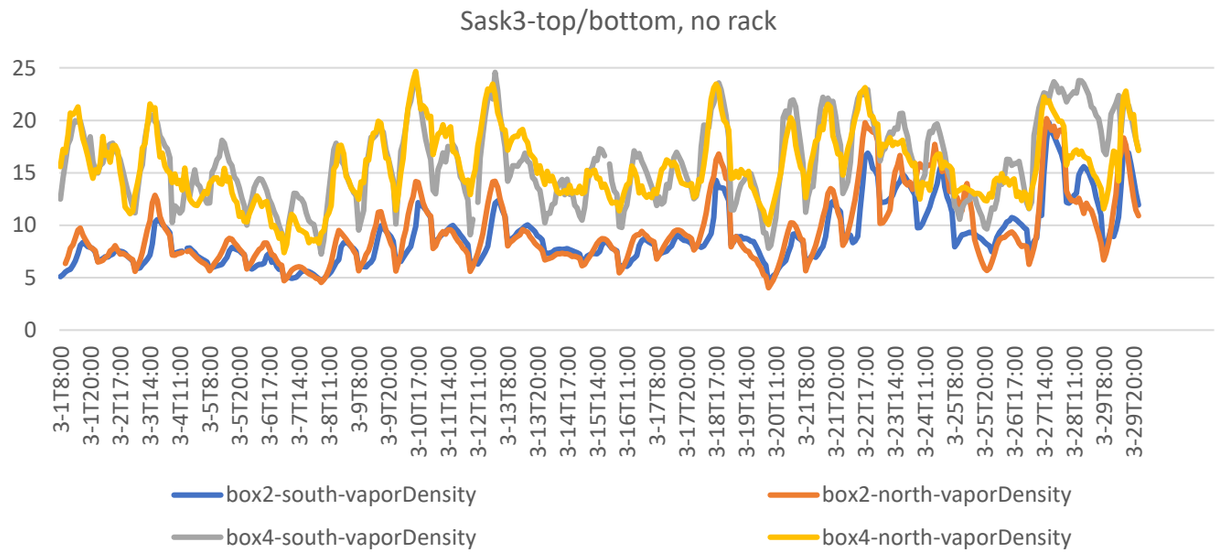
- Sask1,Ital1 & Sask3 are at the top of the box
- Stalker & Sask2 are in box2 – but Stalker is on the north side & Sask2 is on the south side
  - On 3/9 Stalker bees moved into box4 and dispersed between the 2 north sensors

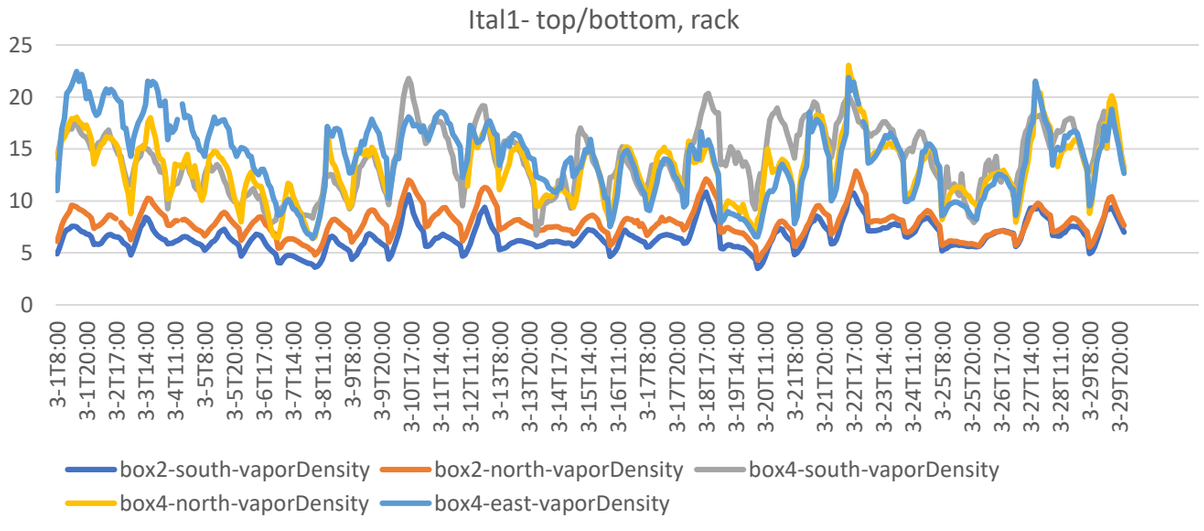
Compare Colonies - Mar Day(8am-10pm) – Vapor Density







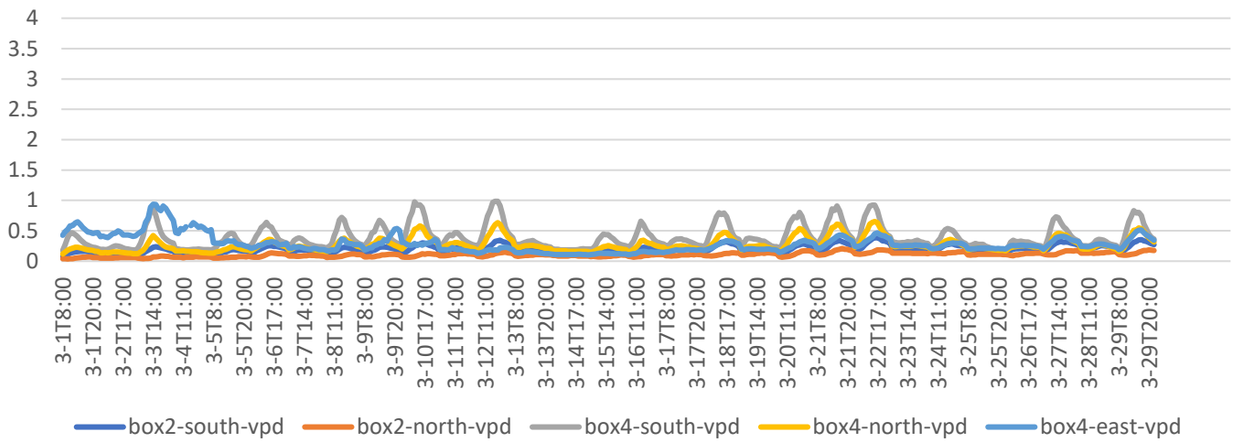




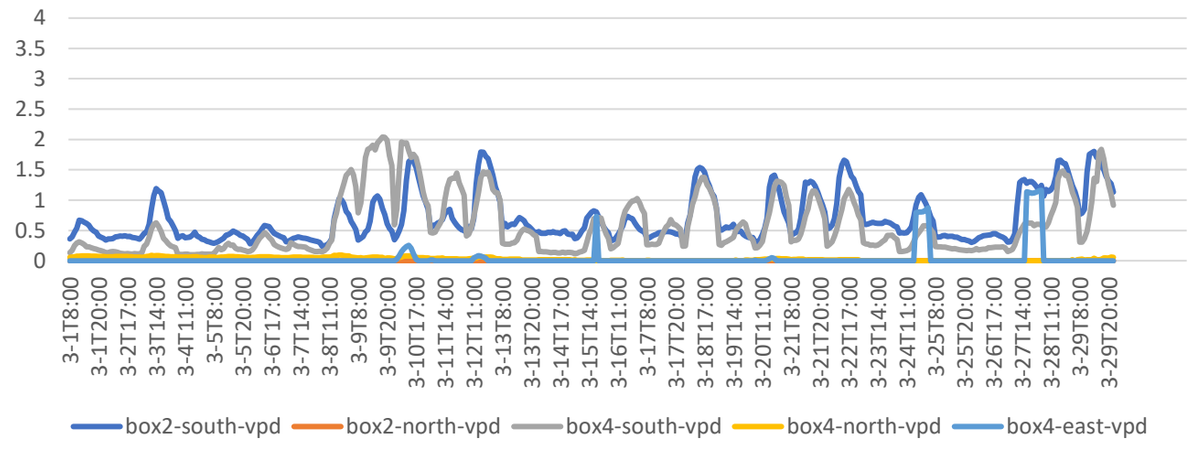
- Vapor density increases on sunny days.
- Sask1 dwindled nd died at the end of March; Stalker has a much more moisture near the cluster compared to Sask3 & Ital1 – even though temps are similar in the area. Also, stalker was much steadier – is this because it was on the north side?

Compare Colonies - Mar Day(8am-10pm) – VPD

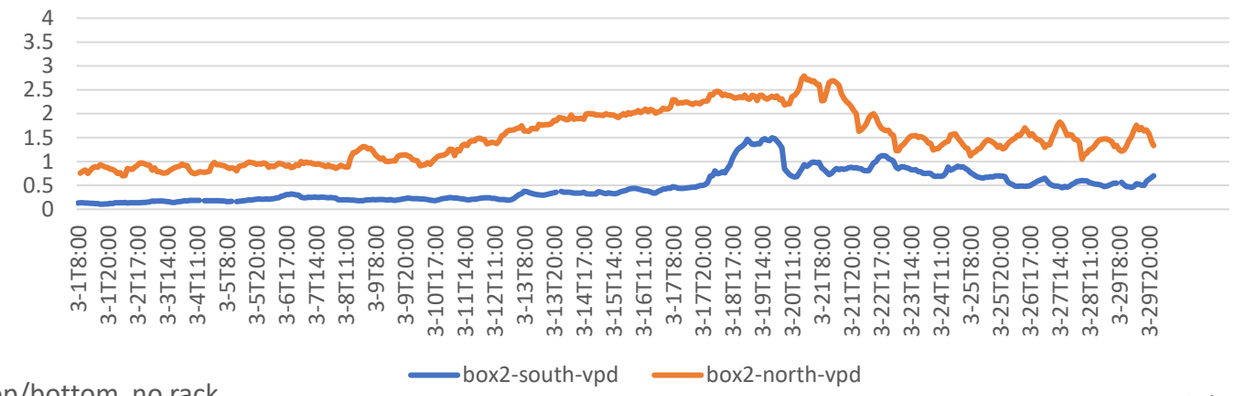
Sask1- bottom only, rack*



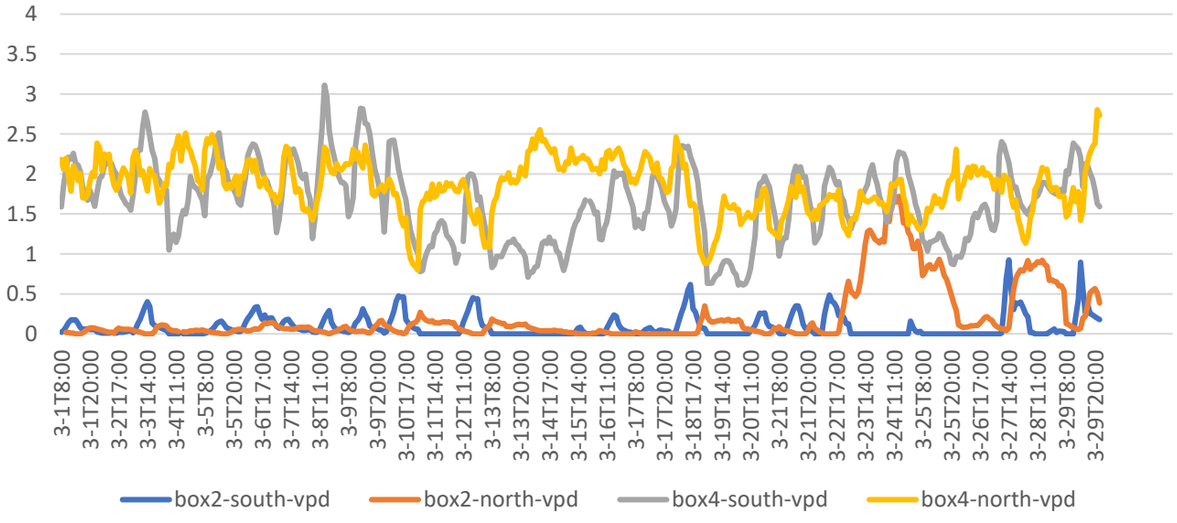
Sask2- NO rack, bottom only.



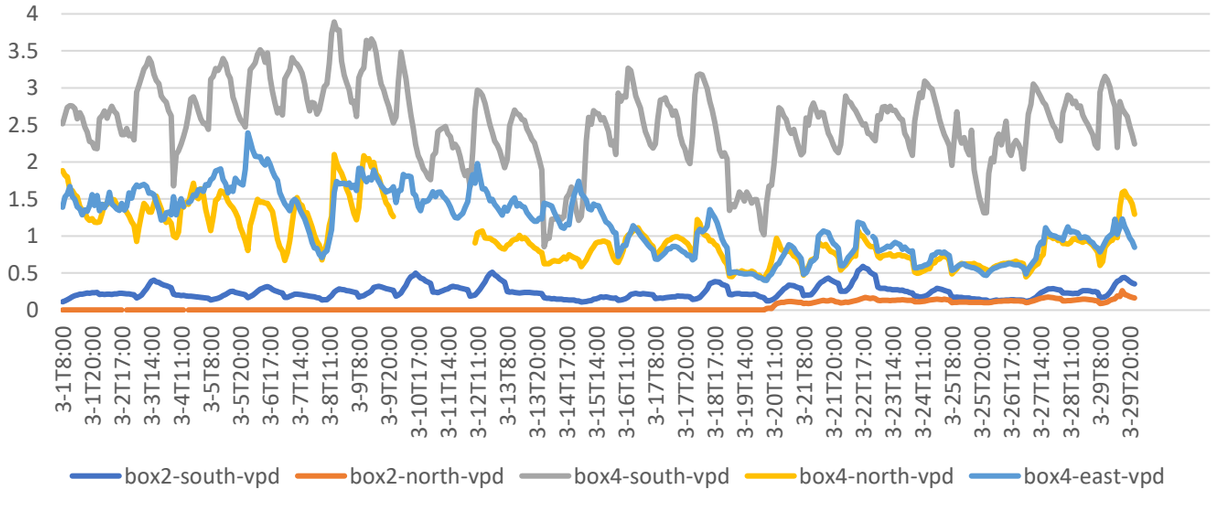
Stalker, top/bottom, no rack, north facing



Sask3- Top/bottom, no rack



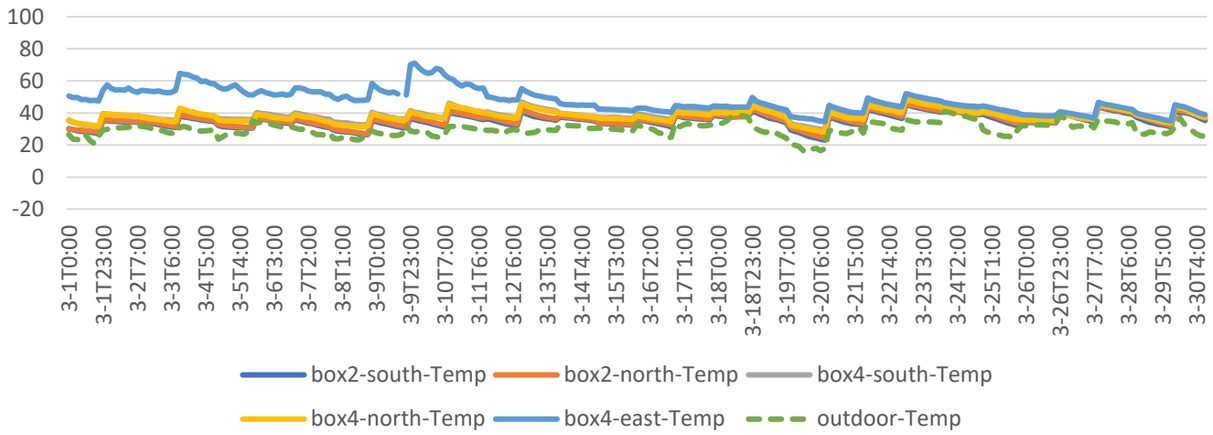
Ital1 – top/bottom, rack



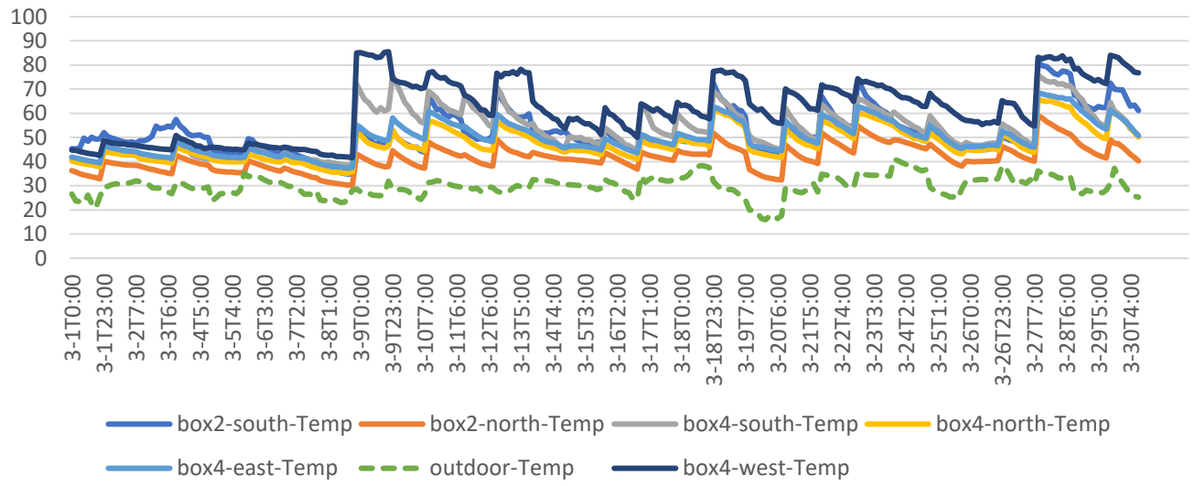
- Sask1 is cold due to small/dieing cluster and the air can't hold much moisture.
- Sask2 are is pretty saturated – only the south sensor areas are not saturated. ITal1 box2-north sensor is saturated until 3/20.

Compare Colonies - Mar Night (11pm-7am) - Temps

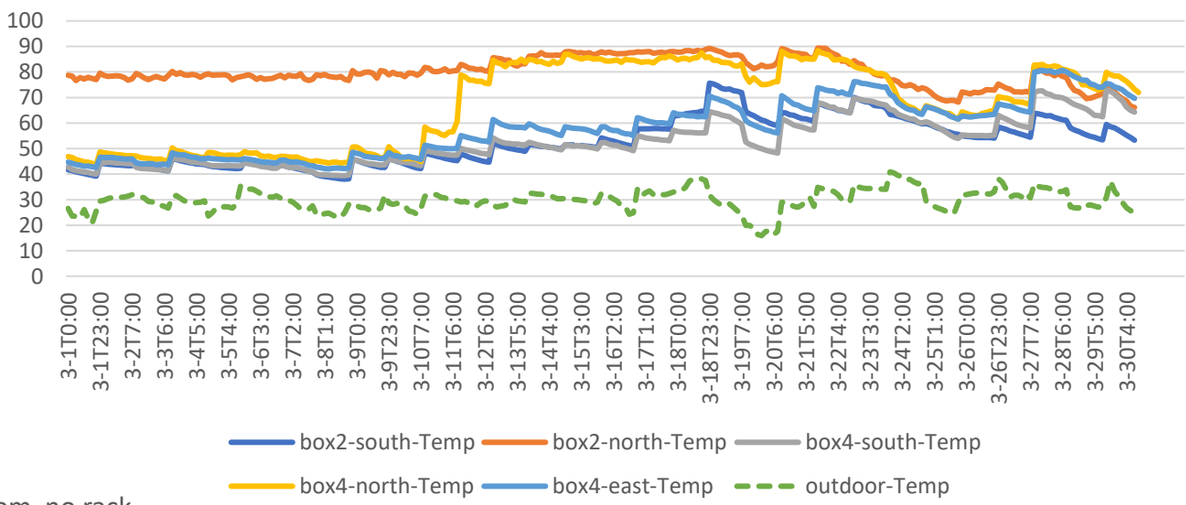
Sask1-Bottom only, rack*



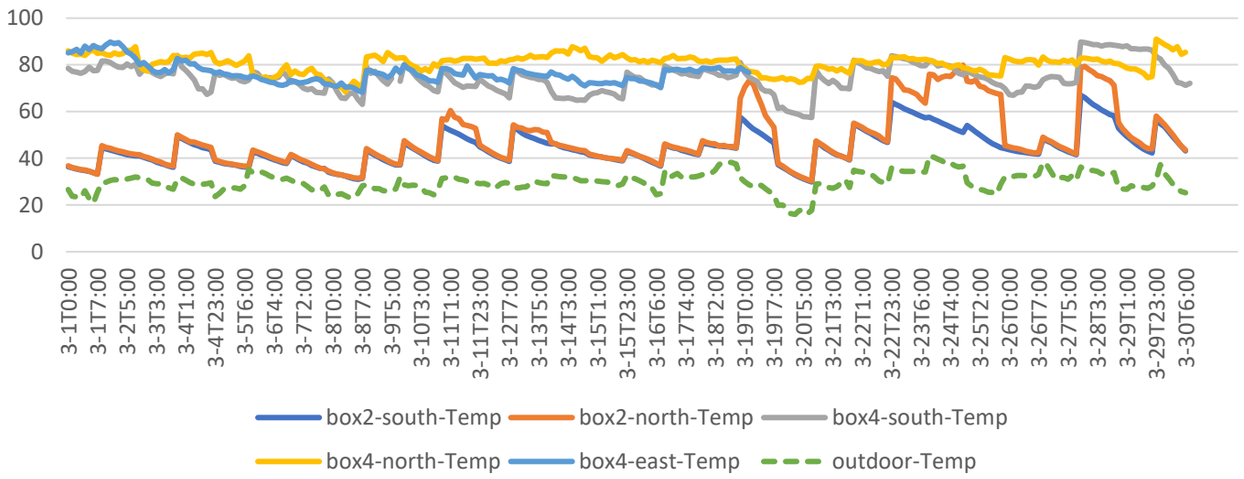
Sask2 – bottom only, no rack



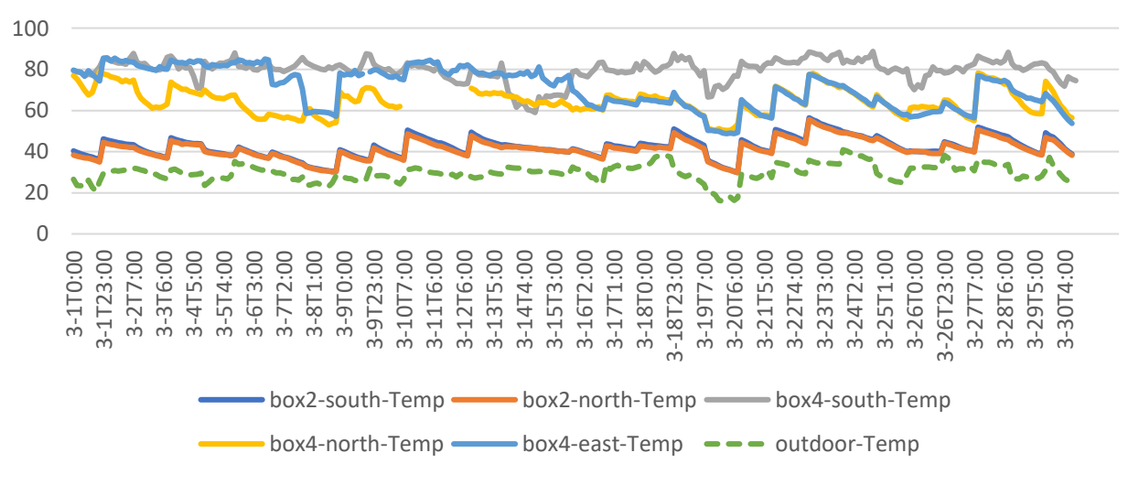
Stalker



Sask3 – top/bottom, no rack

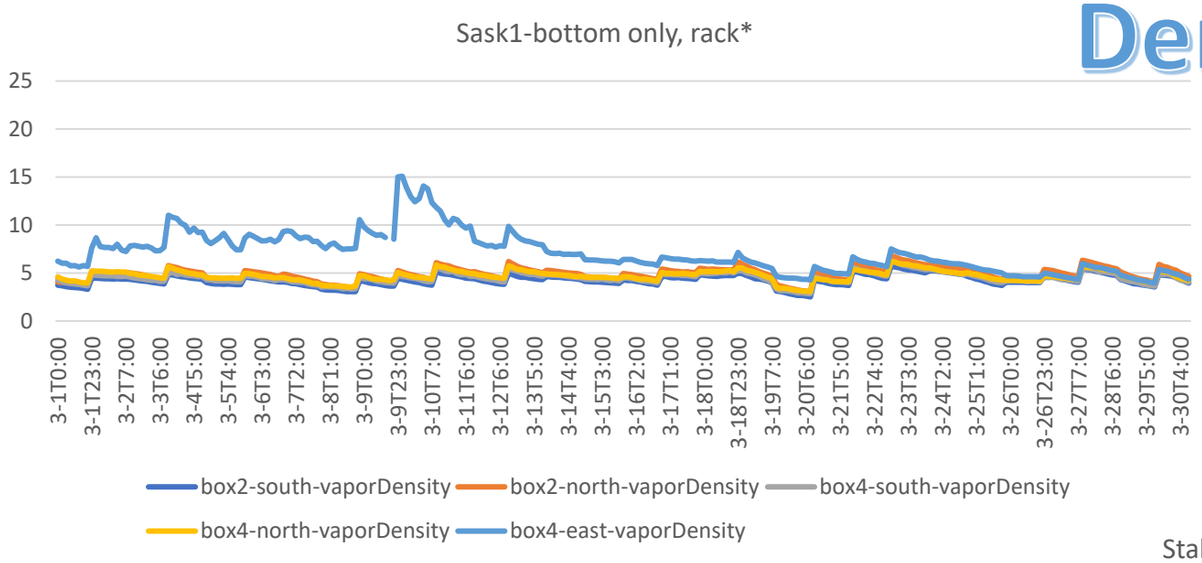


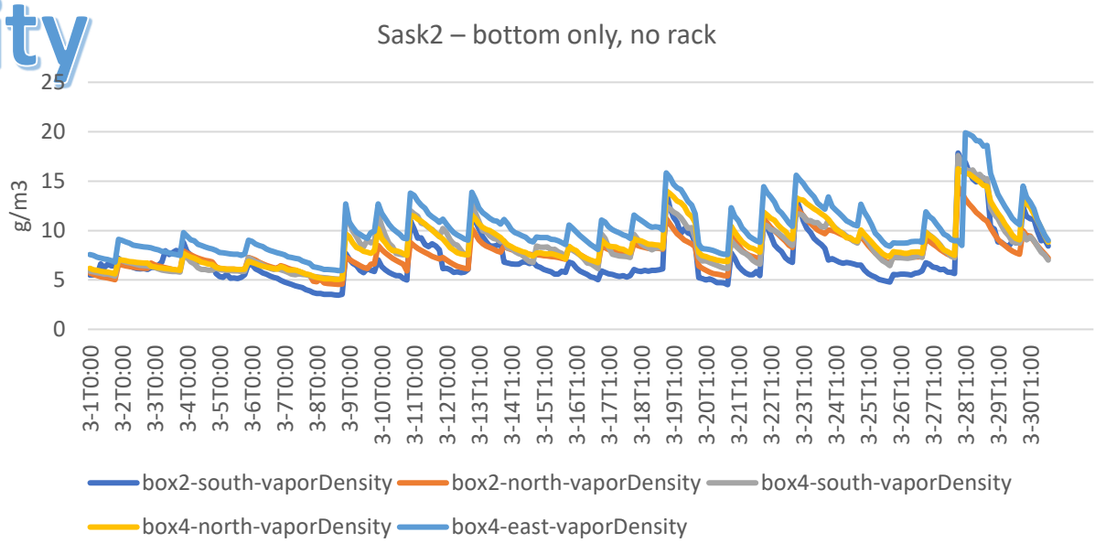
Ital1- top/bottom, rack

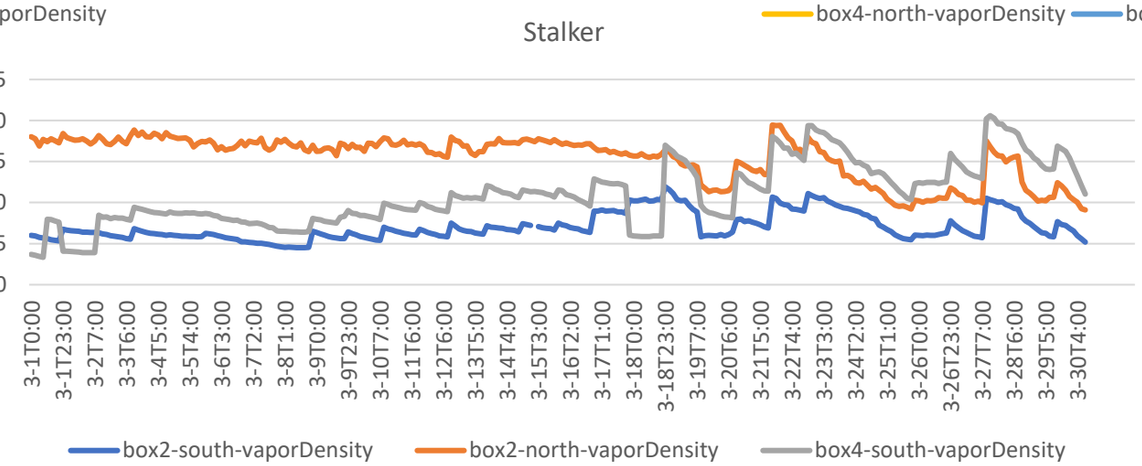


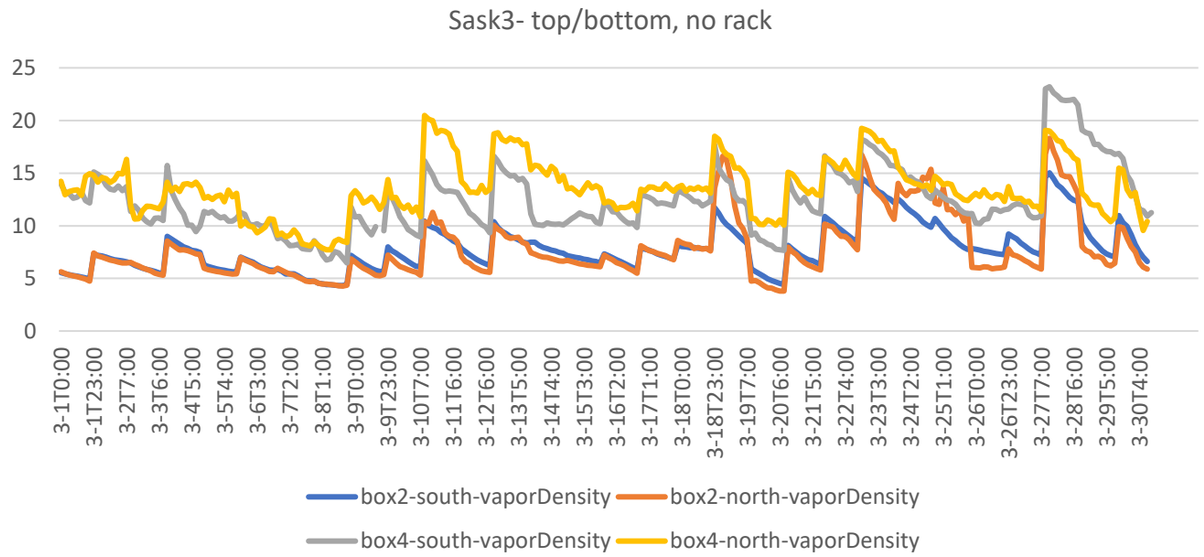
- Sask1 dwindled to die in late March, Sask2 cluster moved up to box4 south & west on 3/9; Stalker clustered in box2-north and also in box4-north starting 3/10. Sask3 clustered near box4 north and south, Ital1 clustered near box4 east and south

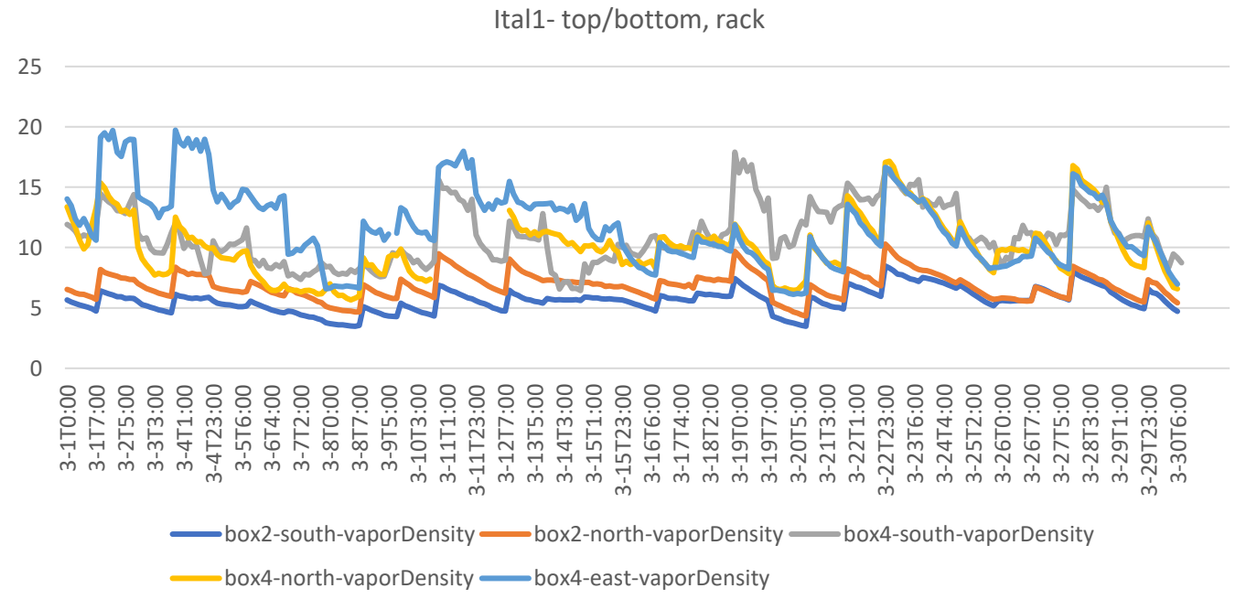
Compare Colonies - Mar Night (11pm-7am)– Vapor Density







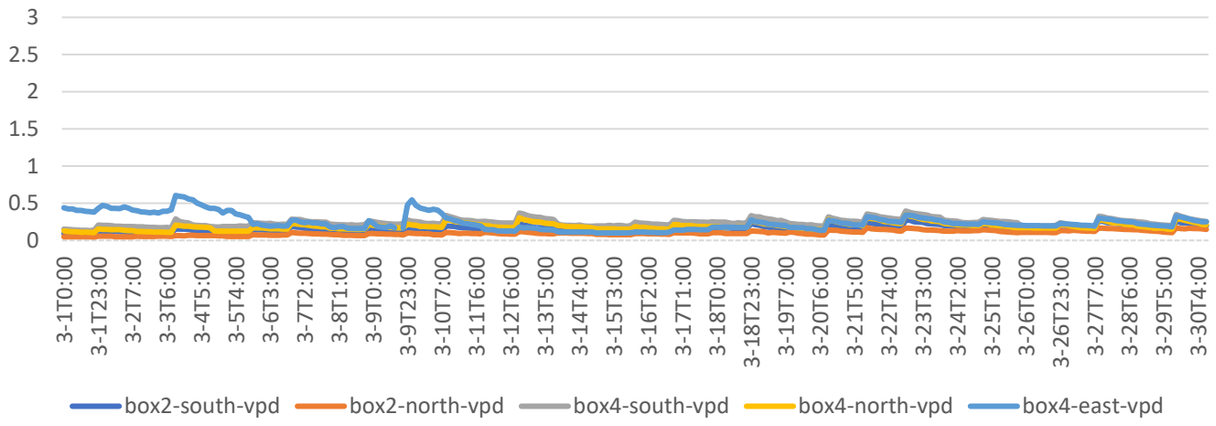




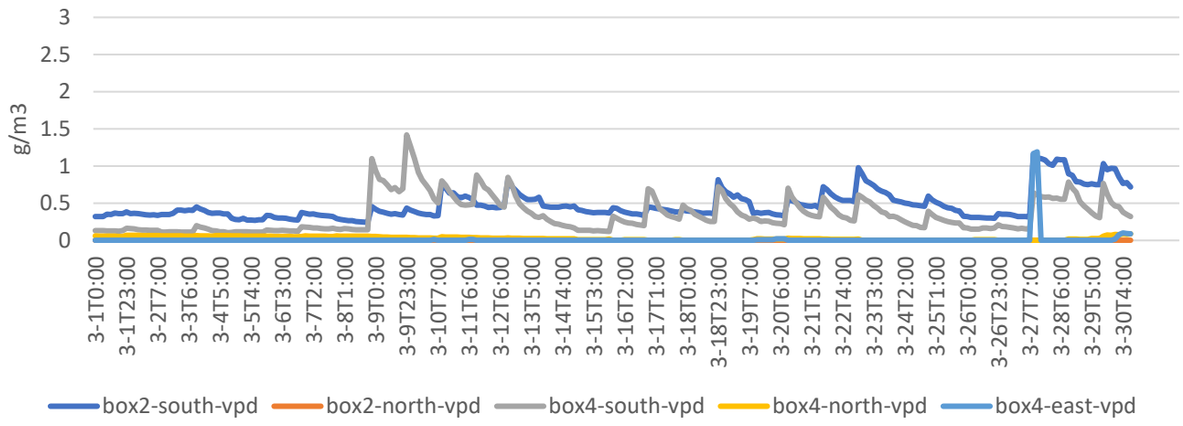
- Moisture near Stalker cluster (box2-north) is much higher than near Sask3(box4-north/south) and Ital1(box4-east/south) clusters even though the temps were similar (80F).
- Sask1 wasn't controlling moisture because of the small cluster. Sask2 moisture is lower – but so is air temp so it can't hold more

Compare Colonies - Mar Night (11pm-7am)– VPD

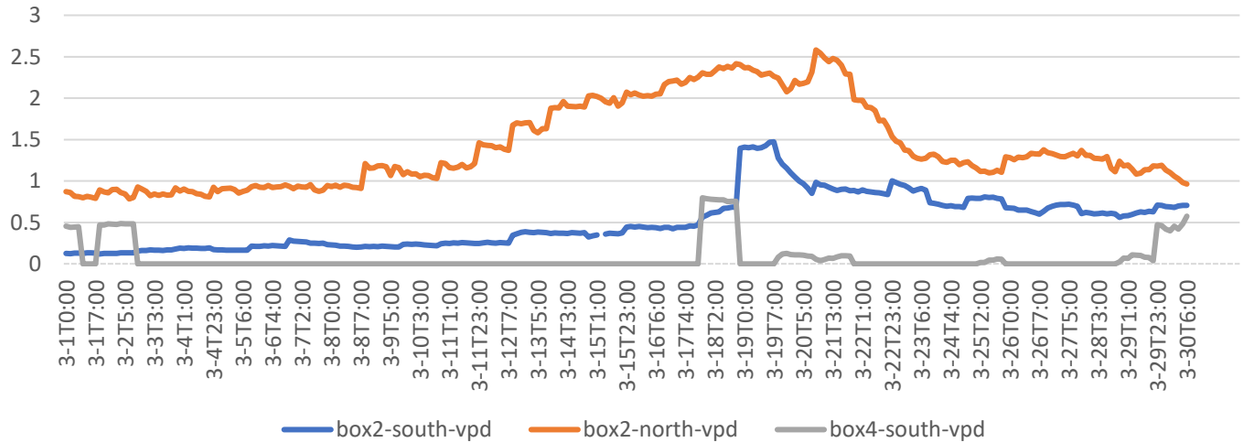
Sask1-bottom only, rack



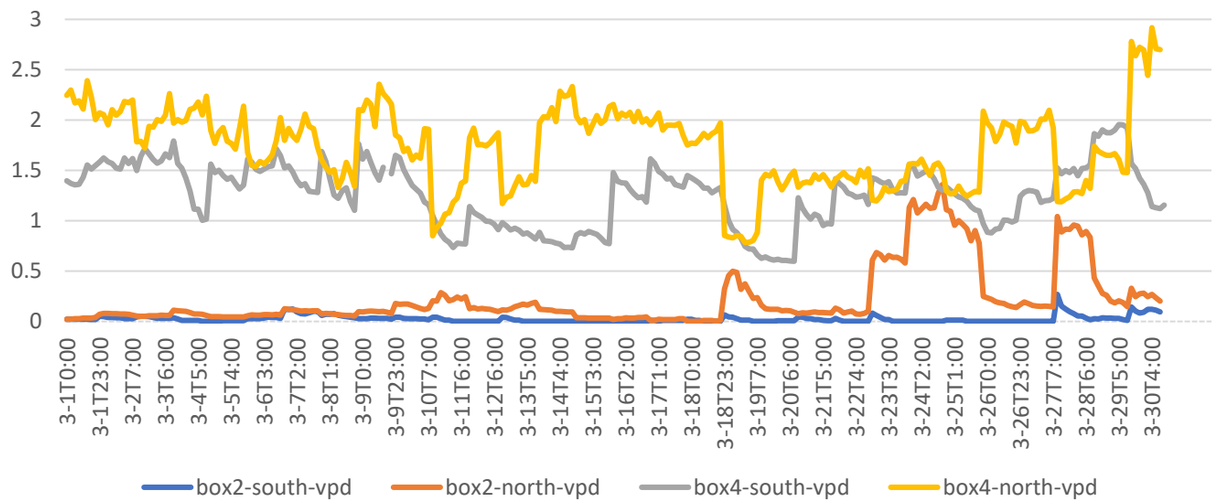
Sask2- bottomonly, no rack



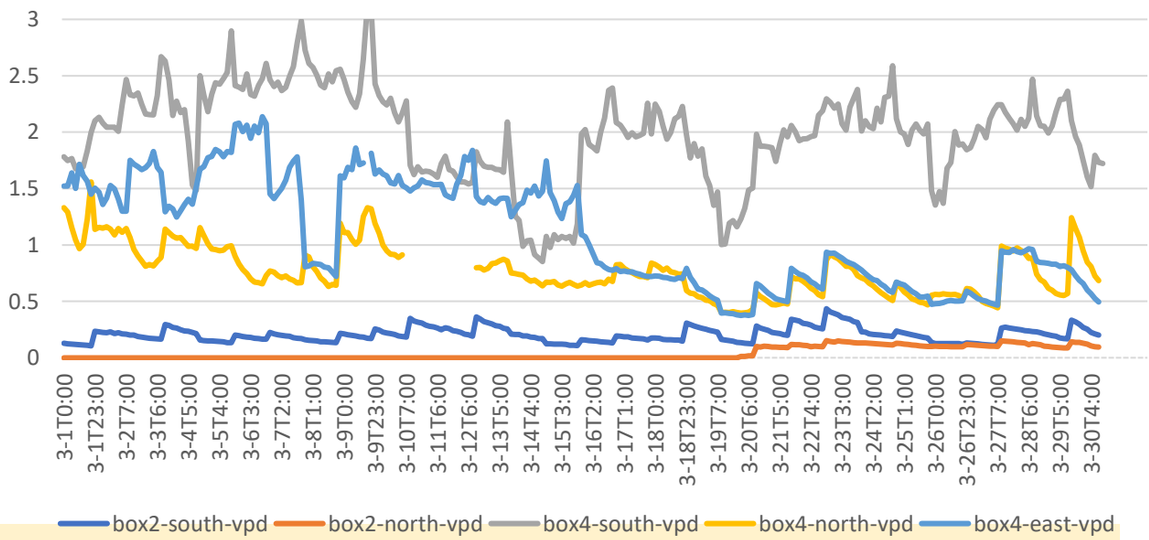
Stalker



Sask3-top/bottom, no rack



Ital1- top/bottom, rack



- The two colonies with the bottom only opening appear to have more saturated air temps around Sask2-box2-south sensor are similar to those of box Ital1-box4-east – but the VPDs are much lower. (Stalker Box4-readings are suspect)

Misc thoughts & notes

- VPD seems to be a good way to compare the various configurations.
- It seems like the colonies that have a bottom only sensor have much moisture air than those with a top/bottom opening.
- The box2-north sensor in Sask1,2,3 & Ital1 and (aka furthest from the ventilation) seems to have completely saturated air most of the time.
- The Stalker bees have stayed on the north side of the hive (the side with the ventilation) all winter (and did the same last year).. Is this because they can control the moisture in the air??
- Sask1 colony died at the end of March – Necropsy showed”
  - Plenty of food, small cluster at the end, 15 mites/300 dead bees sampled from last of cluster, NO mold