Analysis of Sask1 Data from Nov12-Mar4 2022

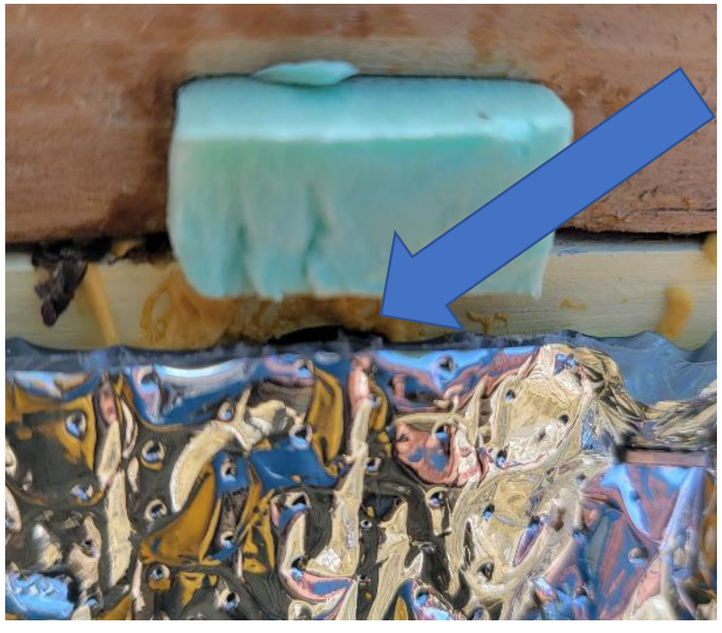
Colony	Entrance faces	Wrap	Slatted Rack?	Upper Entrance With wind block	Lower Entrance
Sask1	South	Cozy (R8)	Yes	No	1.8”x3/8”
Sask2	South	Cozy (R8)	No	No	1.8” x 3/8”
Ital1	South	Cozy (R8)	Yes	1/2” x 3/8”	½ oval – 1” x 3/8”
Sask3	South	Cozy (R8)	No	1/2” x 3/8”	½ oval – 1” x 3/8”
Stalker	North	3 layers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

Sask1: bottom entrance only; slatted Rack

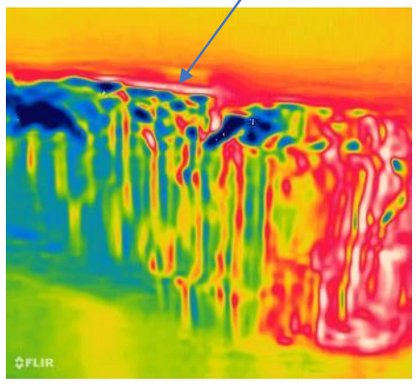
11/12/22@ noon:
- returned sensors to under inner cover & added shim with weather stripping
- total height between 1 1/2"--> 1 3/4" depending on compression of weather stripping

11/17/22@ noon :
- wrapped colony & reduced entrances

12/12/22 – bees at top-south – added ~ 1lb sugar bricks
1/1/23 – *insulation that filled the hole in the shim has been completely chewed away. Opening is mostly covered by the reflectix. (see picture) most of sugar brick is still there
1/11/23 (10:30ish) - bricks ¾ gone – added another 1 lbs
1/19/23 (3:15pm) – bees in dead center of box 4 – bees at top of colony. Flying using the entrance they made.
1/30/we (noonish) – 2nd sugar brick not touched; top cluster in center of top box
2/8/23 (9:30ish) – some bees on 2nd sugar brick; closer to east & north sensors
2/15/23 (1:15pm) – bees on northeast side near sugar brick – only see some bees
2/27/23 – bees eating sugar brick – on northeast side; added ½ pollen patty
3/3/23 – lots of cleansing flights in apiary – wasn't home so didn't see which colonies
3/9/23 (noonish) – bees in southeast corner. Hadn't touched food, moved it closer to top of cluster
3/18/23 (10:30ish) – bees in southeast corner, eating sugar, not as active as other colonies
3/27/23 (4:15ish) – bees alive – but lethargic – looks like very small cluster in southeast corner.
4/5/23 – bees were dead; necropsy showed:
- plenty of honey (20 partial or full frames), little/no pollen
- very small cluster at the end, dead bees at front of slatted rack and bottom board
- NO mold
- 15 mites on 300 dead bees in alcohol wash.



Taken 3/9/23 at 5am – some warm air is coming out this hole



Mite Test Data (Alcohol Wash)

Date	Sask1	Notes
5/24/2022	2.00%	treated Sask1 - Formic
6/27/2022	0.80%	
7/22/2022	2.00%	Treated with Formic
8/31/2022	1.20%	
10/8/2022	20.00%	Treated Sask1 with OA dribble

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)

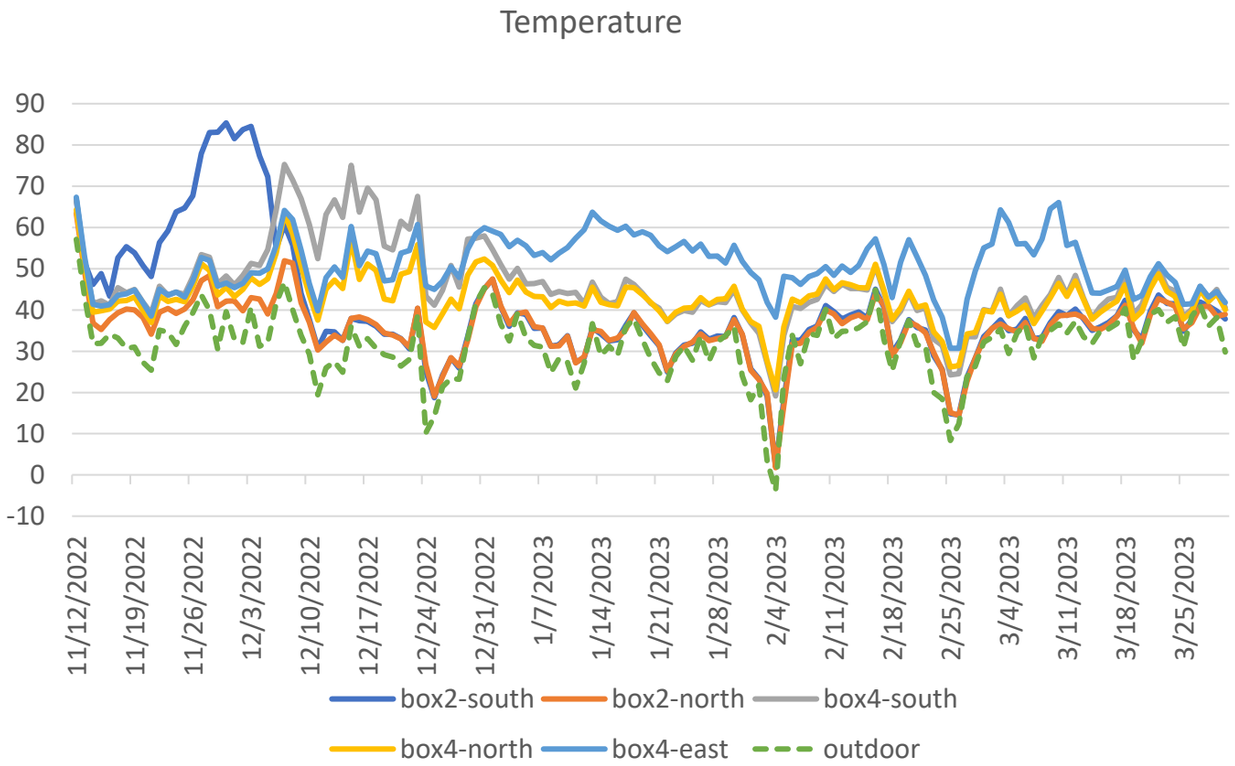
- **Vapor Pressure Deficit (VPD)** is a measure of how much more “room” there is for humidity (water vapor) in the air, at the current temperature

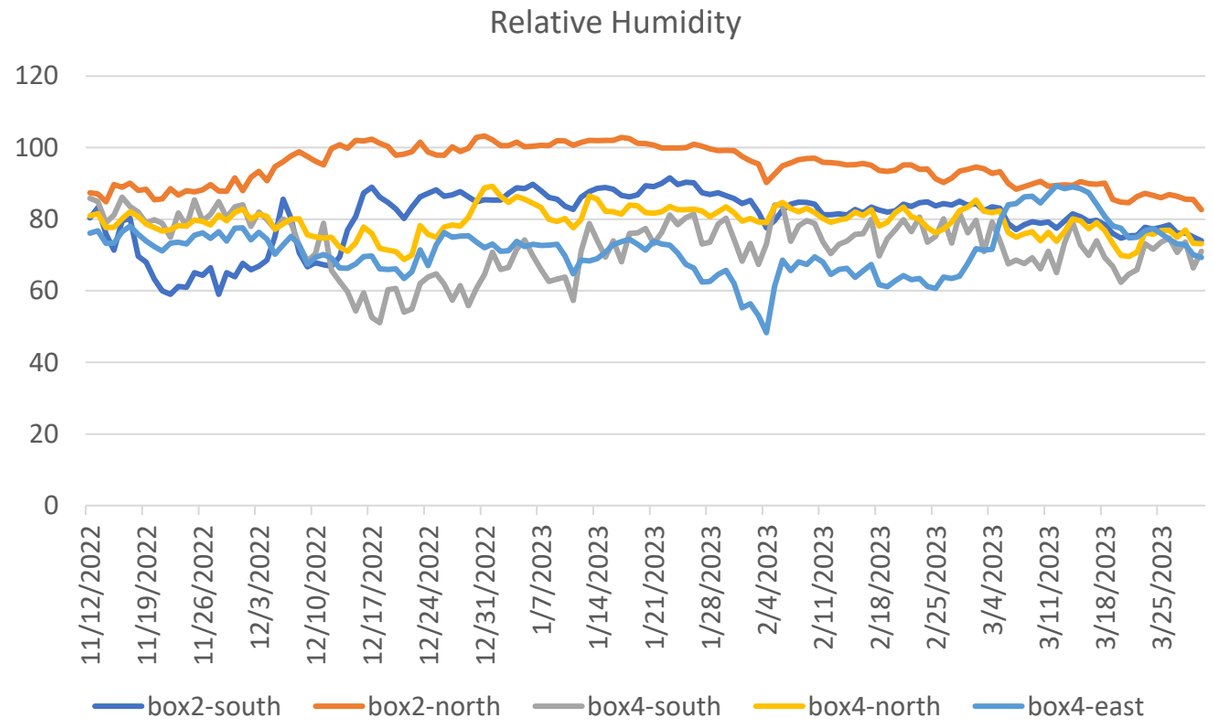
Notes from Etienne Tardif on Bee-L forum

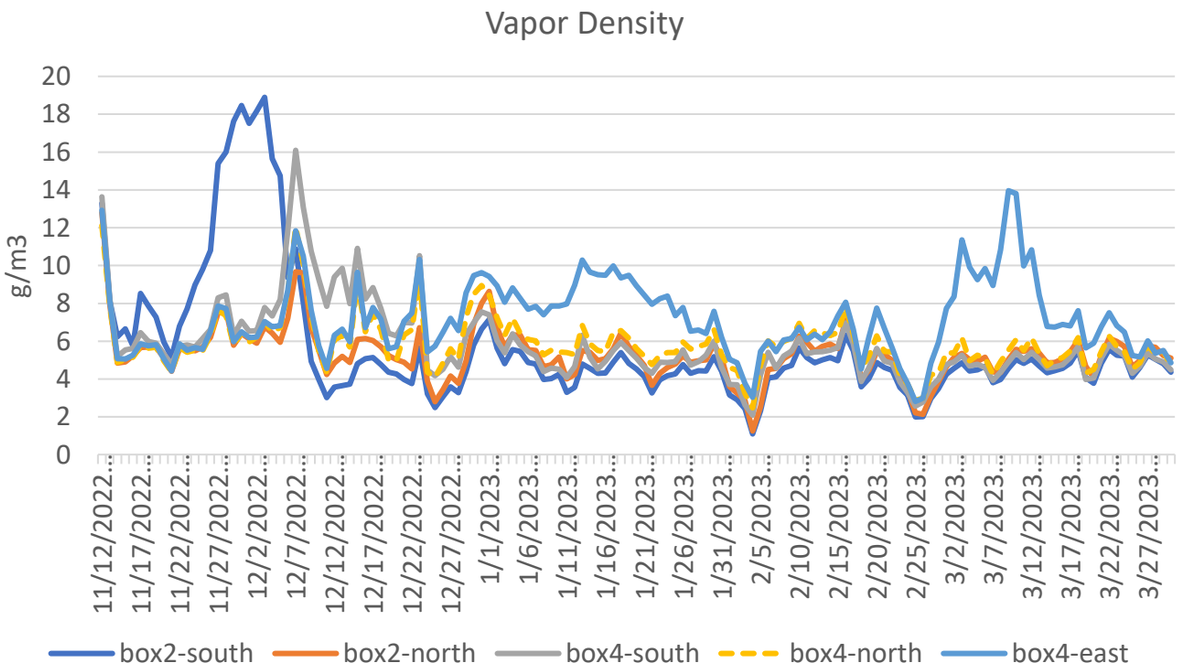
- 1) Moisture conservation - Bees seem to prefer 60-75%RH (@18C) 10-15g/m3 (moisture content) in cluster or in the "hot“ hive.
- Remember that air at 100%RH 0C only contains 4.85g/m3, so even in warmish very humid winters, bees are required to up regulate moisture via metabolic processes to maintain their setpoint. I believe bees under certain conditions purposefully generate moist heat for the purpose of humidifying which also results in internal condensation both of which increases the in hive RH during very dry cold periods -30C Air @100% RH 0.46g/m3 .
- We do know that bees have mastered evaporative cooling which can also be used to humidify air at cooler temperatures, ok in a hot hive but not practical when bees are tightly clustered.

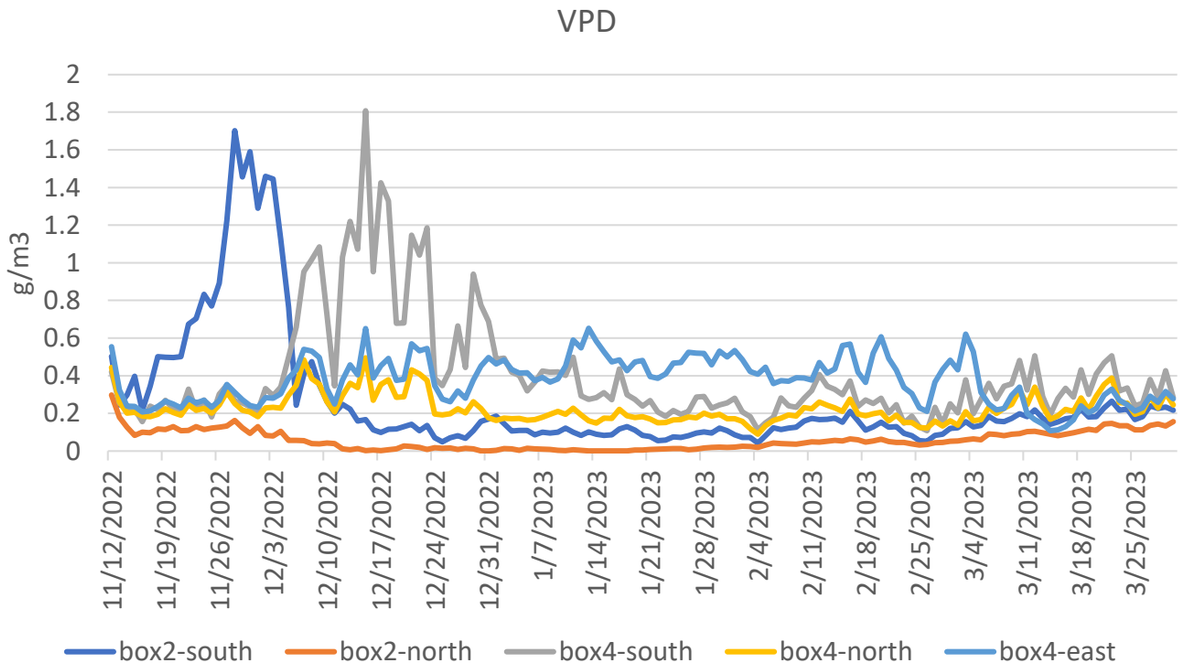
Daily **mean** values

Mean Daily Values - Sask1 (slatted rack, bottom entrance only*)





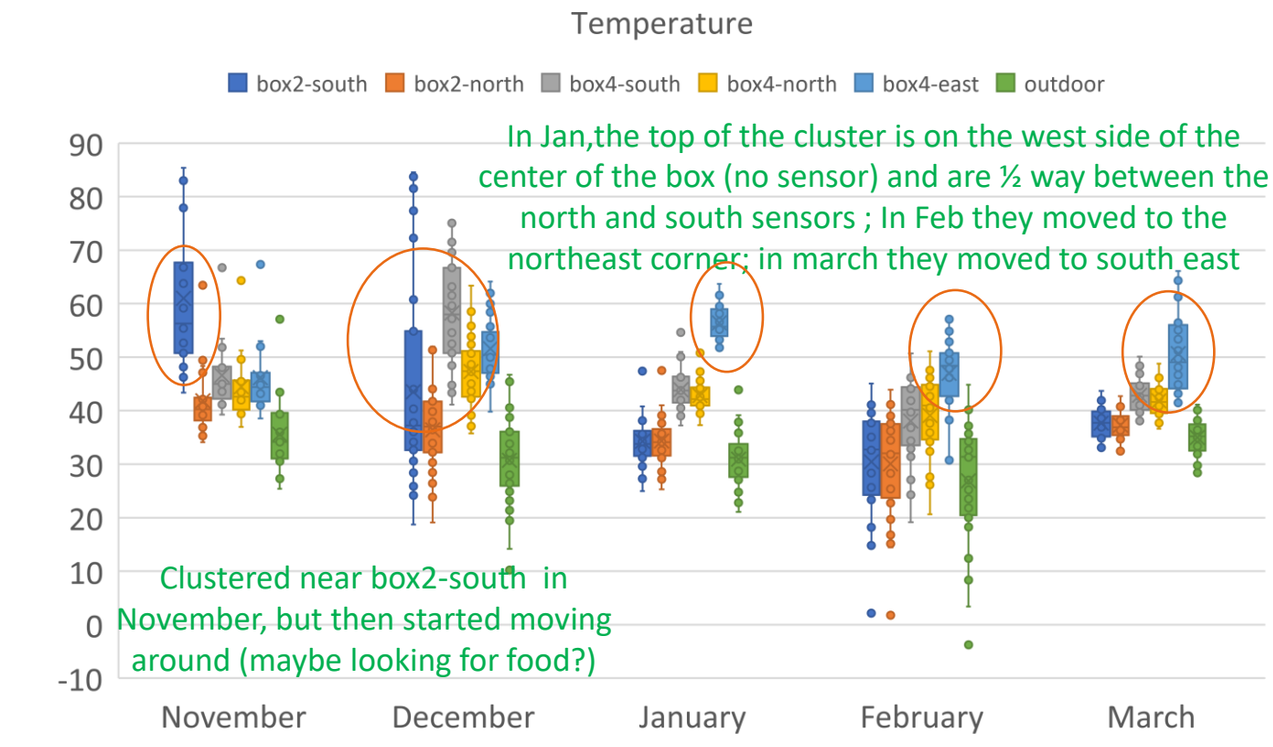


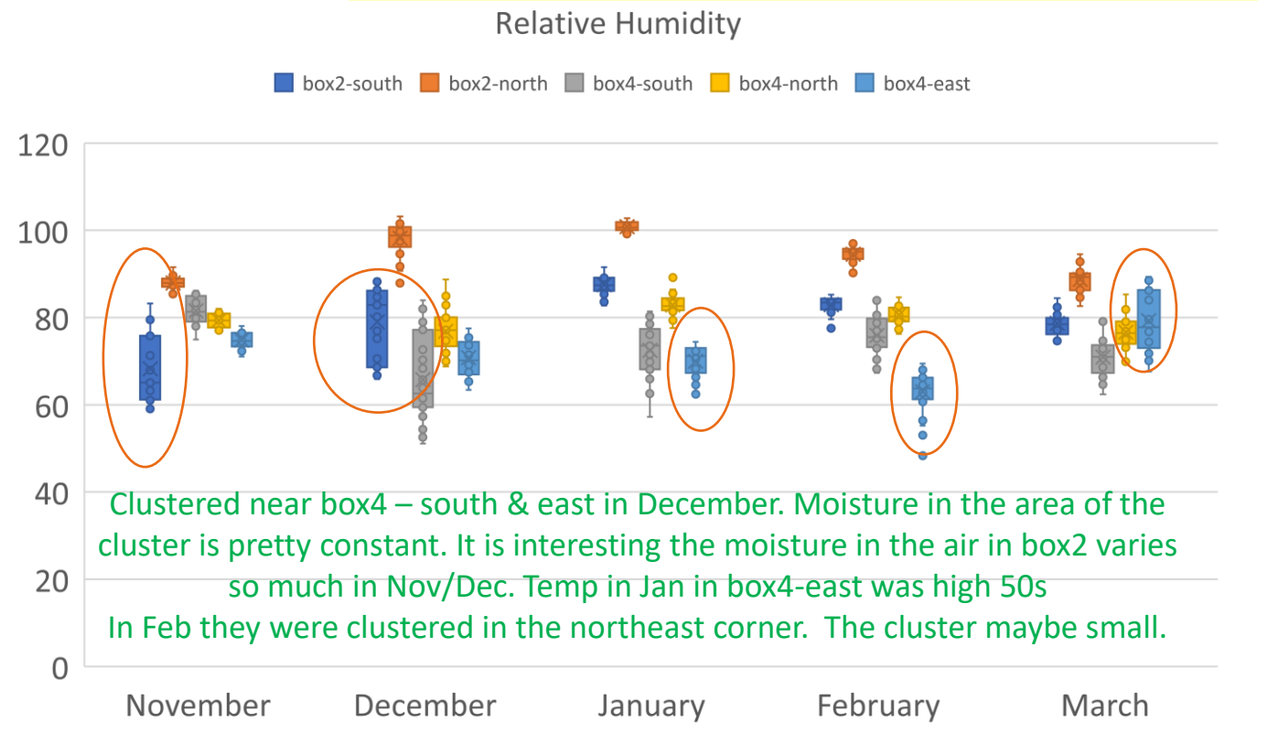


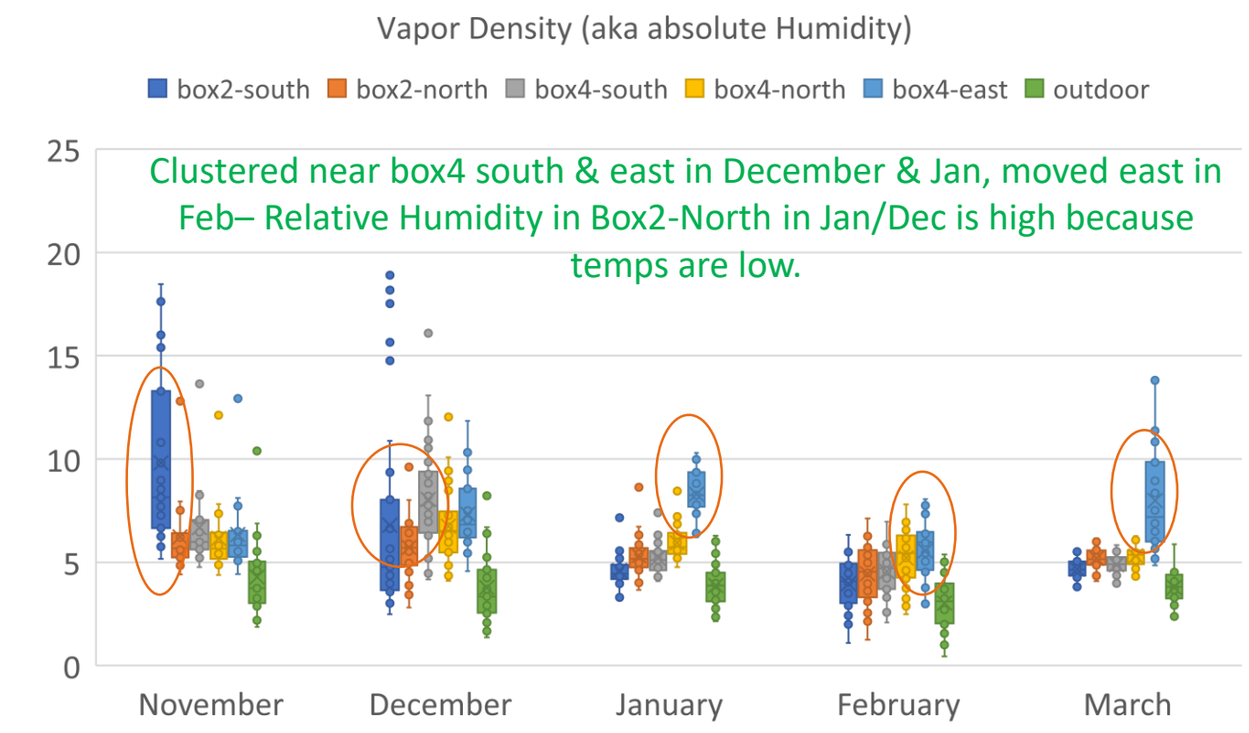
*Bees made their own top opening in Late Dec/early Jan

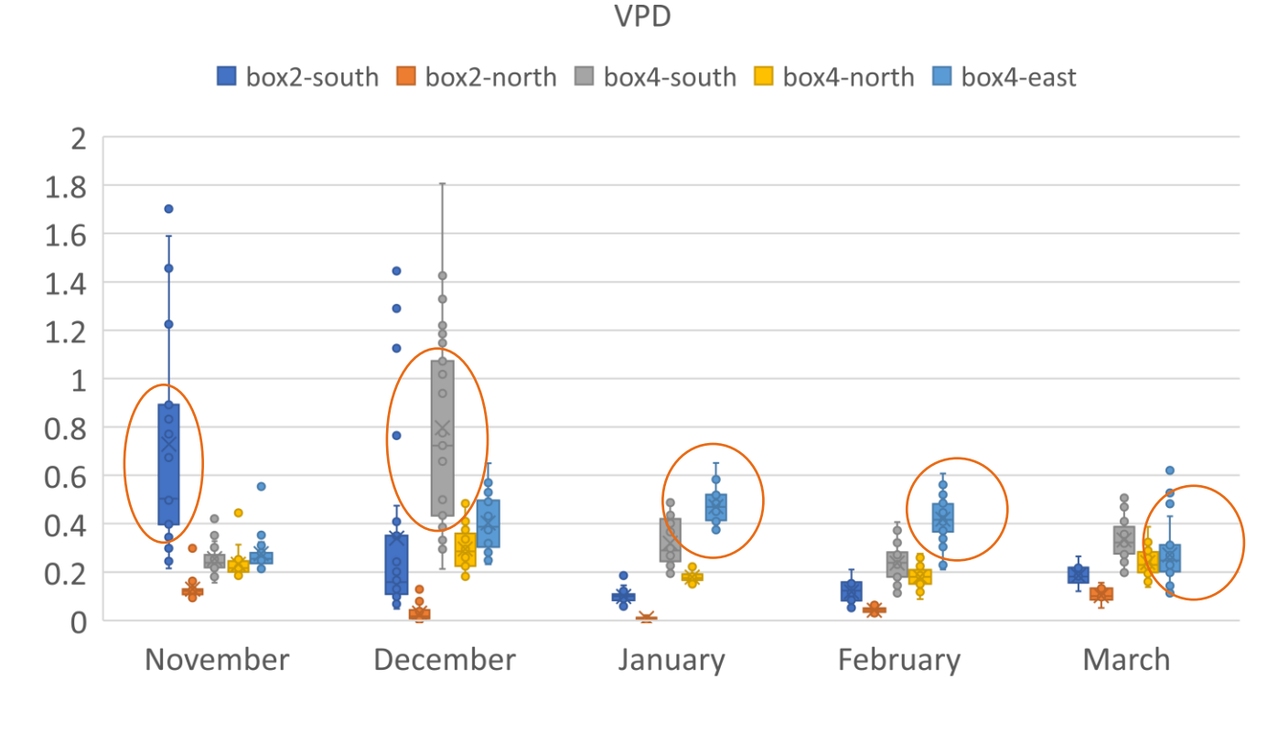
Mean Daily Values - Sask1 (slatted rack, bottom entrance only*)

ORANGE CIRCLE indicates approximate cluster location









Bees moved from box2-south to box4 in late December. They were stressed and created their own top entrance chewing through foam insulation in the hole of the feeding shim(which is under reflectix). Colony was alive in March – but weak

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

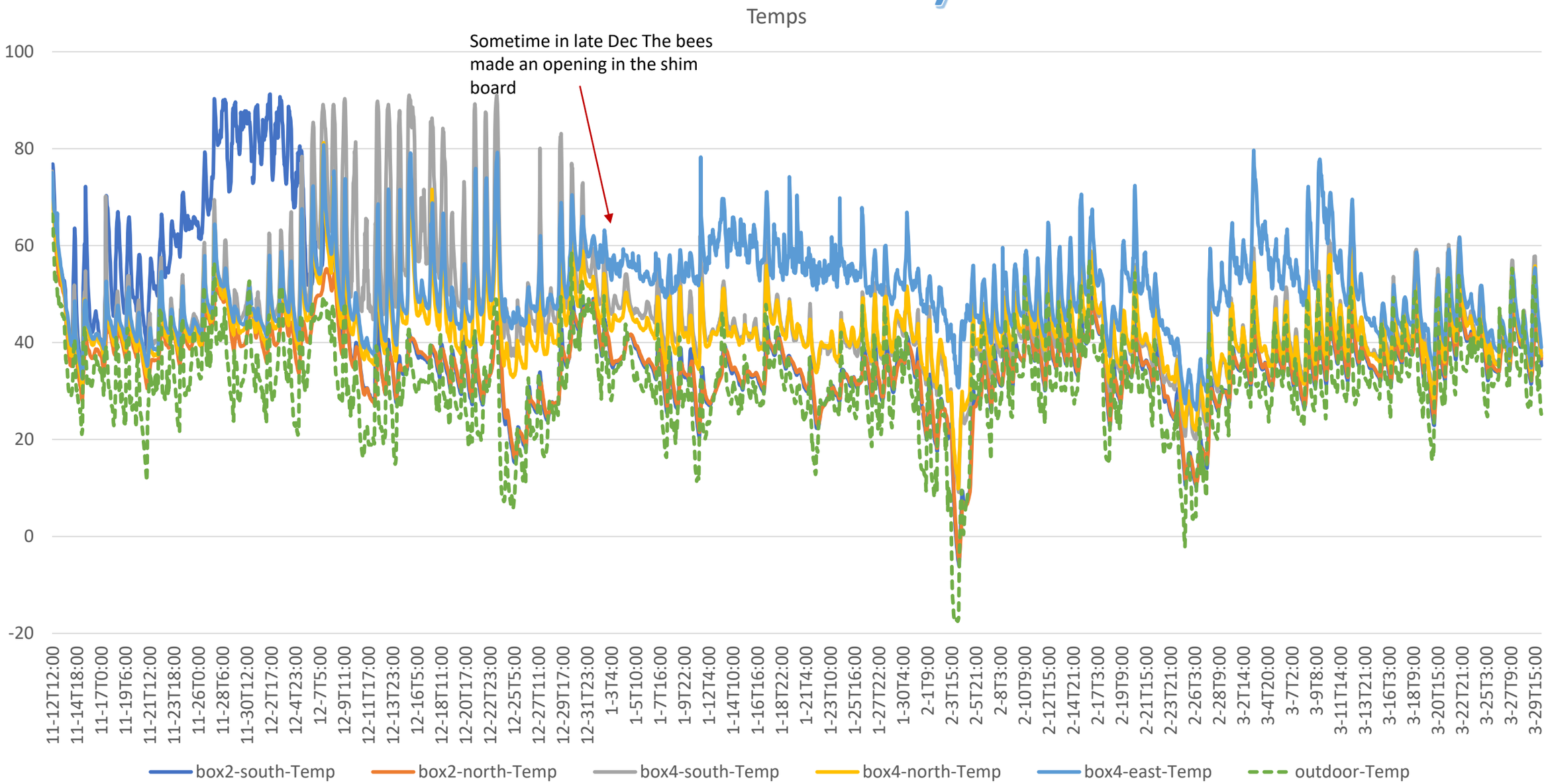
*Late December the bees chewed away the insulation opening up a small entrance at the top of Sask1 Outdoor vapor density is NOT measured in the apiary but derived from data from Broodminder.

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
  - if the temps at the sensor are in the low 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)

All data points

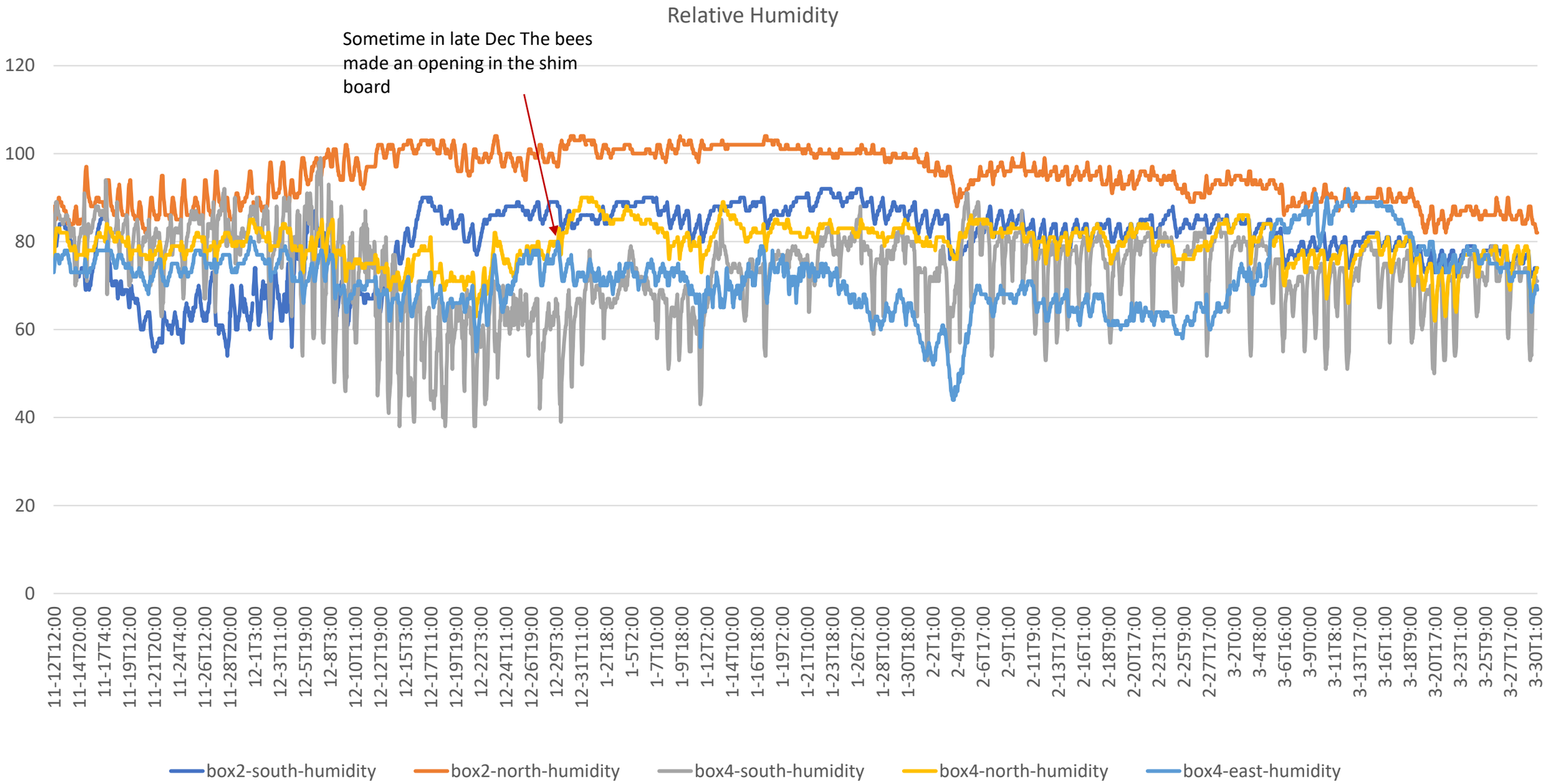
Temperature Sask1 (slatted rack, no top entrance*)



- Bees moved from box 2 to box 4 in early December. Sometime in late December they opened up the hole in the feeding shim.
- Start in January the bees clustered closer to the east sensor – possibly because that is closer to where the sugar bricks were located.
- This cluster may be small but still is hanging in there as of the end of March. It was dead on April 5.

*Bees chewed a hole in the feeding shim so there is a small entrance under the top reflectix

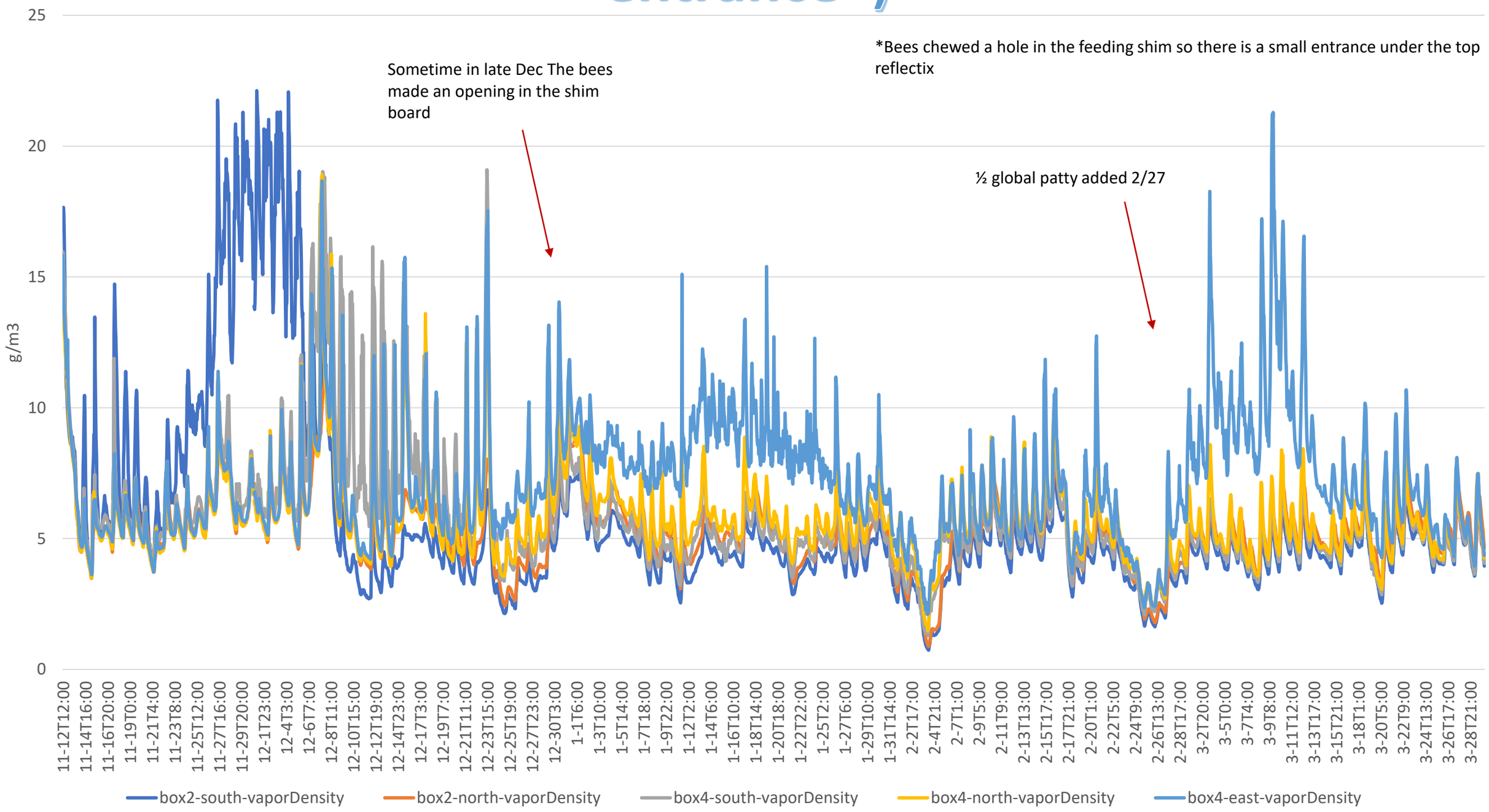
Relative Humidity Sask1 (slatted rack, no top entrance*)



*Bees seem to be controlling the humidity around the cluster (box4-east since December)

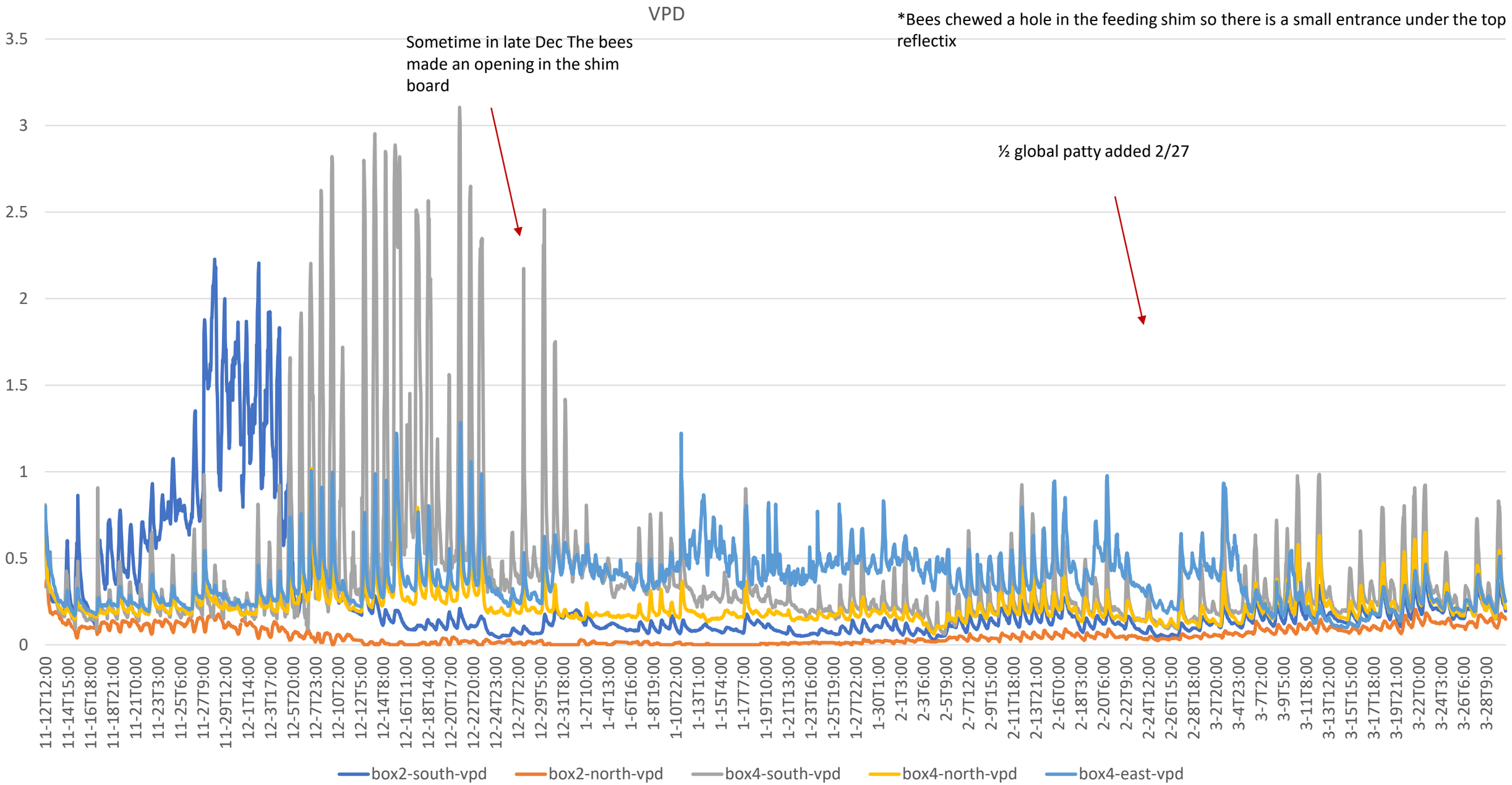
*Bees chewed a hole in the feeding shim so there is a small entrance under the top reflectix

Vapor Density – Sask1 (slatted rack, no top entrance*)



- The vapor density at all the sensors is very similar from 2-8 to 2/17.. Then the area around the cluster (box4-east) starts showing more moisture in the air.
- Vapor Density Seems to vary quite around the cluster which is surprising – is this due to temps changing during the day?
- Bees were still alive on 3/27 – but the cluster looked small. They were dead on 4/5

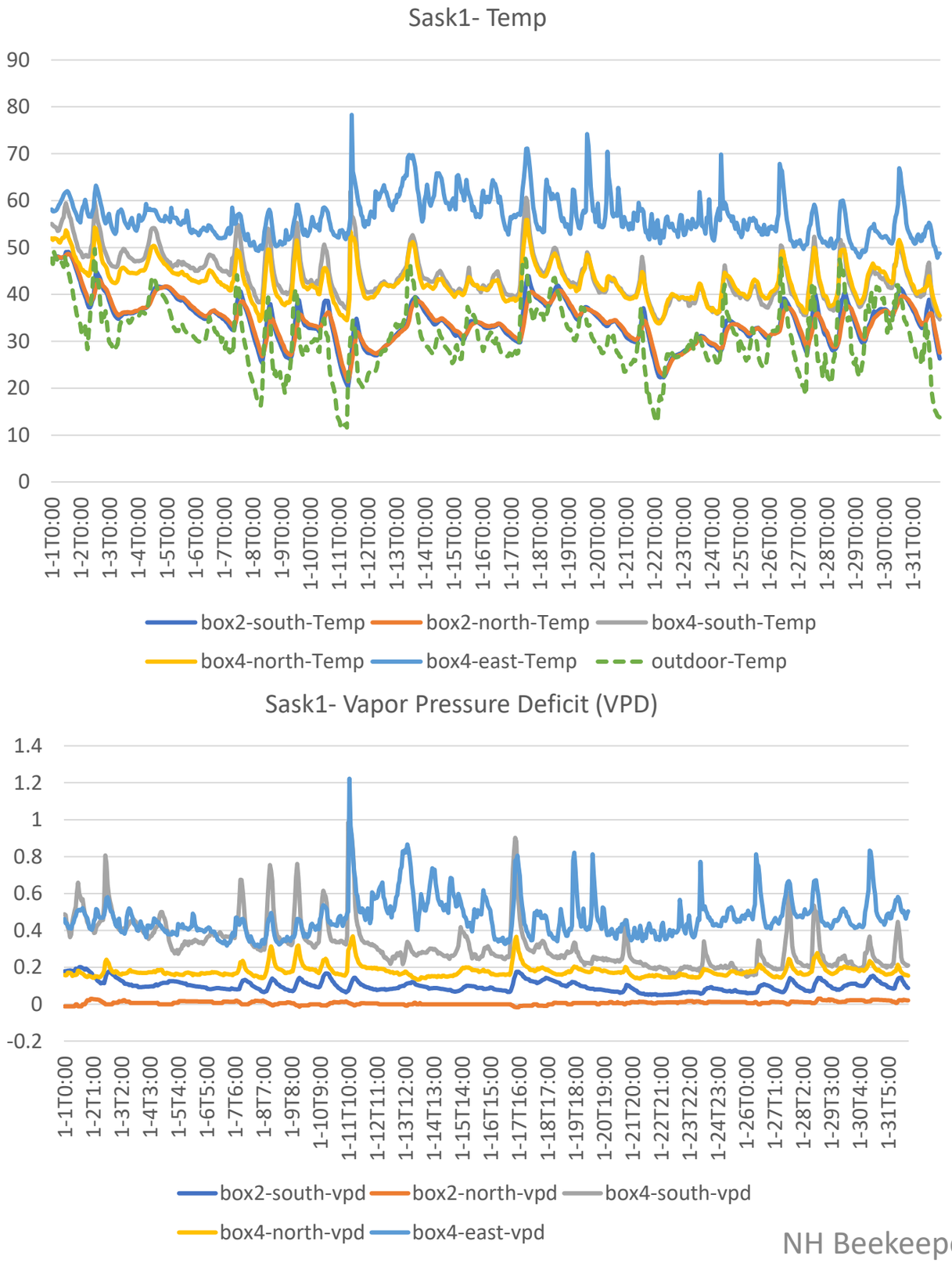
VPD– Sask1 (slatted rack, no top entrance*)

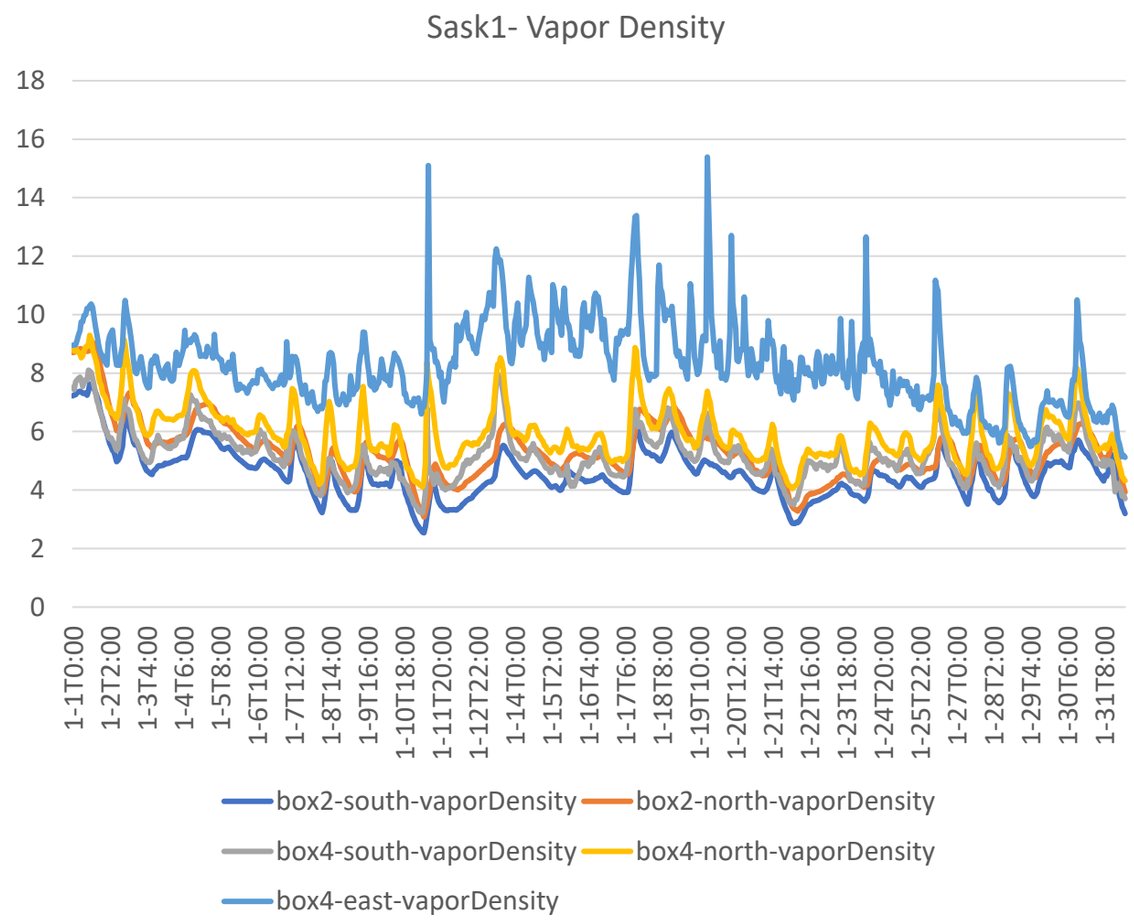


- The difference in the VPD is due to the temps at the various sensors. The warmer the air, the more moisture it can hold.
- It is interesting the box2-north sensor is showing that the air can hold more moisture. We don't see that in Ital1 which also only has a bottom opening.
- Bees were still alive on 3/27 – but the cluster looked small. They were dead on 4/5

Day vs Night Data
By Month

January -Sask1 (slatted rack, no top entrance*)

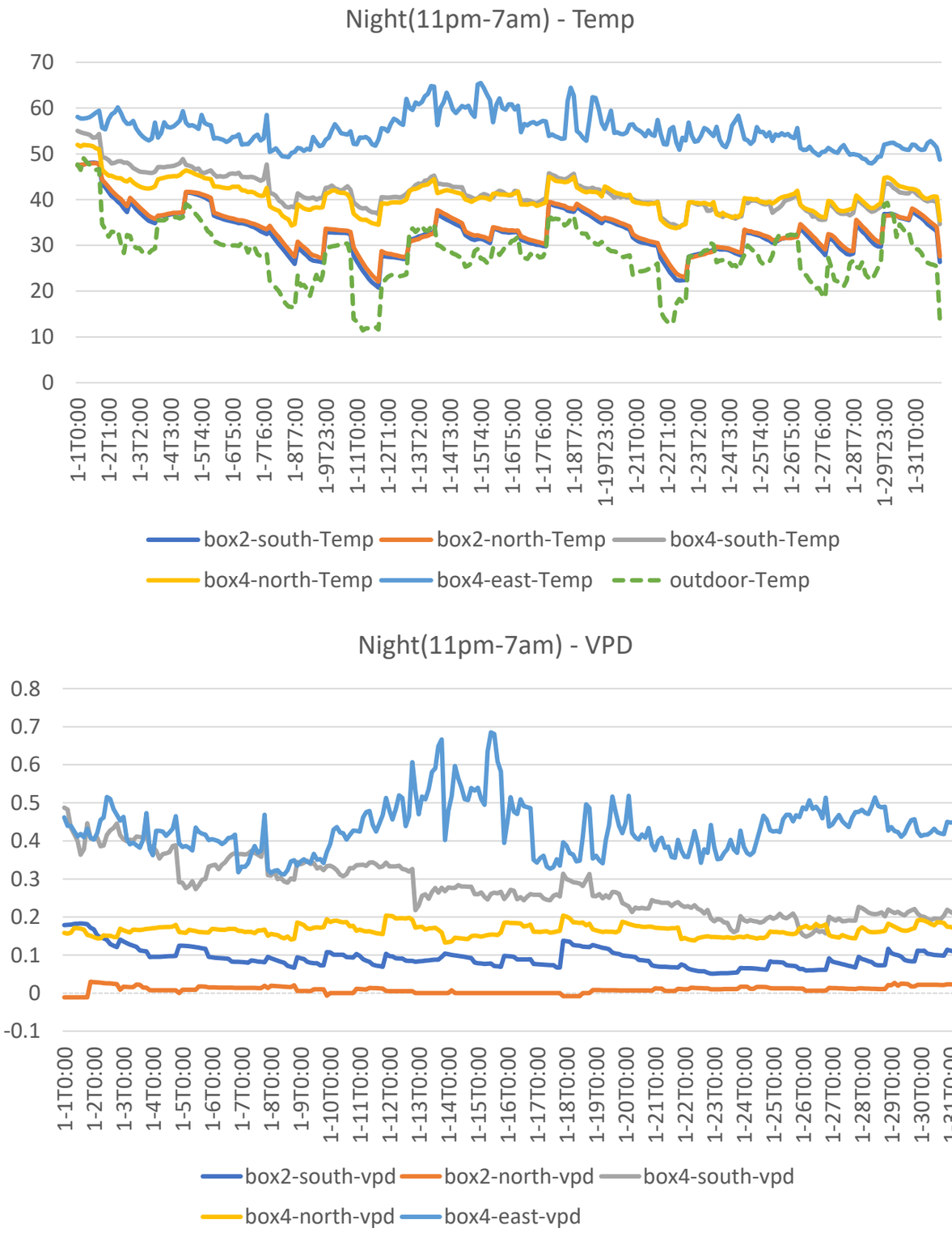


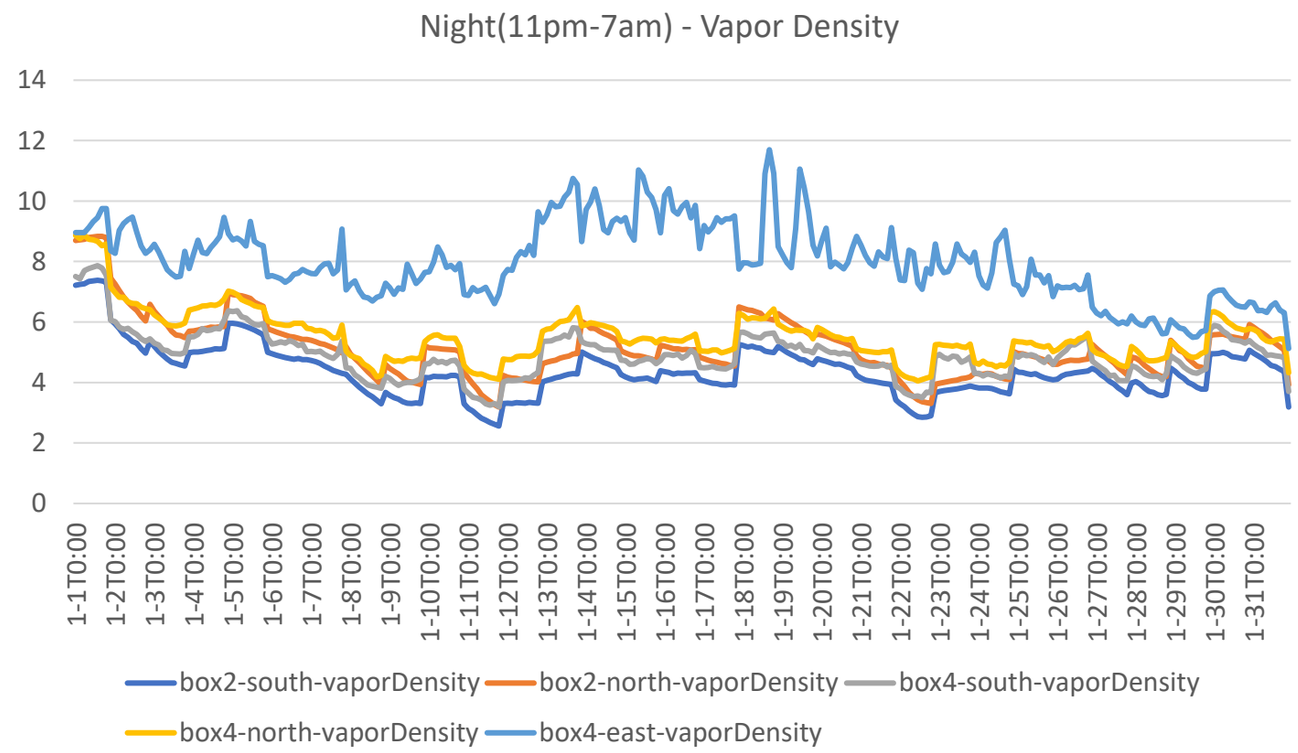


- Bees are near the box4-east sensor.
- The vapor density & VPD vary as the temp warms up
- The spikes in temp are dues to sunny days (see next charts).

*Bees chewed a hole in the feeding shim so there is a small entrance under the top reflectix

January –Night - Sask1 (slatted rack, no top entrance*)





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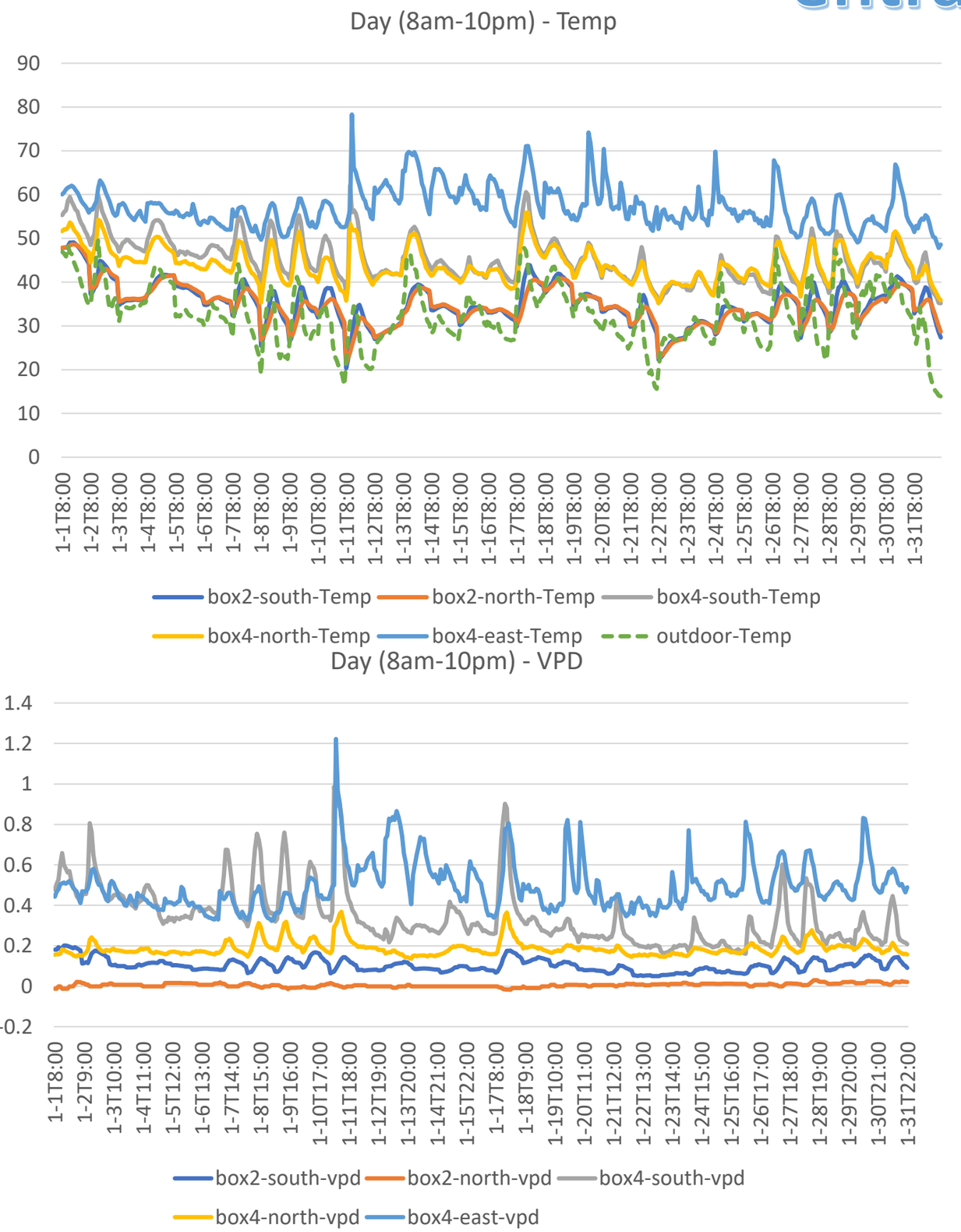
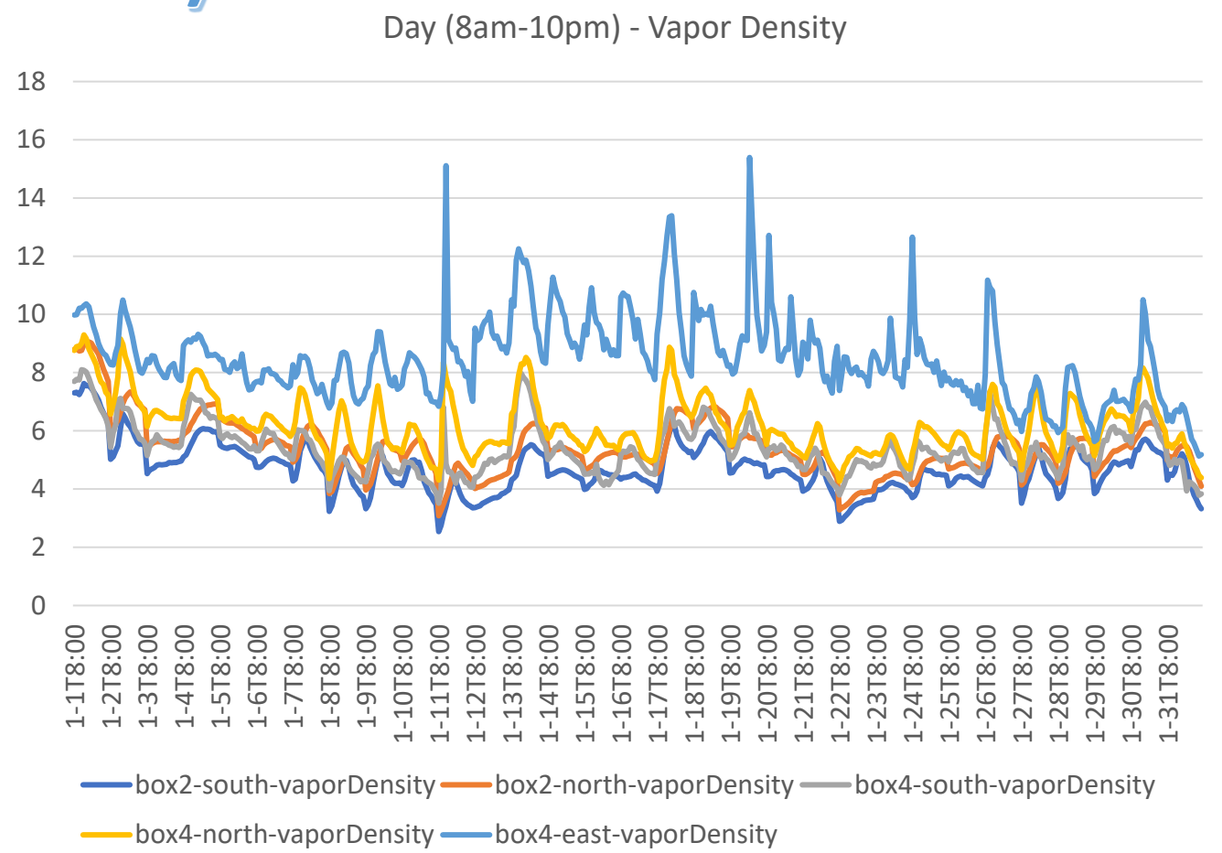
- Bees are near the box4-east sensor.
- The temp stays between 50-60 during January.
- When the temp drops to 50 (~1/8 & 1/26-31), there is less moisture in the air –
- but at the end of the month, there is less,moisture in the air than on 1/8 (6 vs 7 g/mm3)
- We also see this in the VPD – on 1/8, the VPD is ~0.3 and is between 0.4 & 0.5 at the end of the month – this means the air can hold more moisture
- VPD of box2-North indicates that area is almost completely saturated. Box2-south isn't quite as saturated, but close.

January –Day - Sask1 (slatted rack, no top entrance*)





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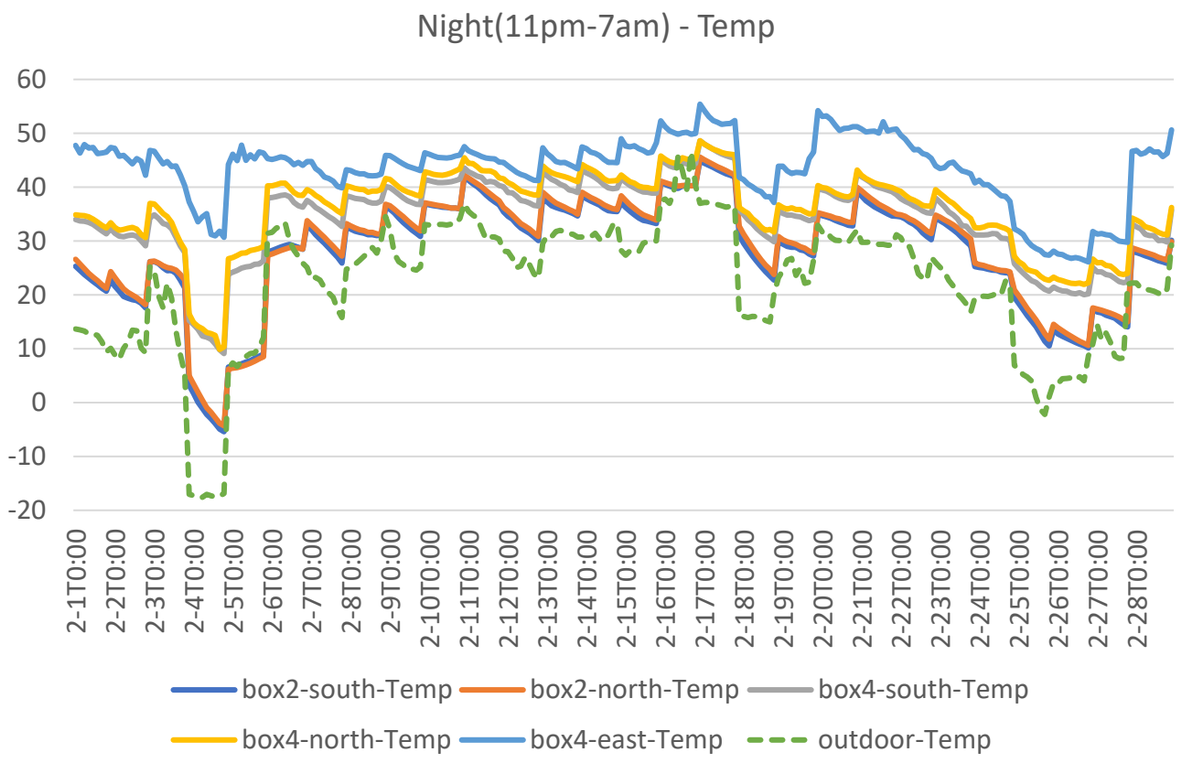
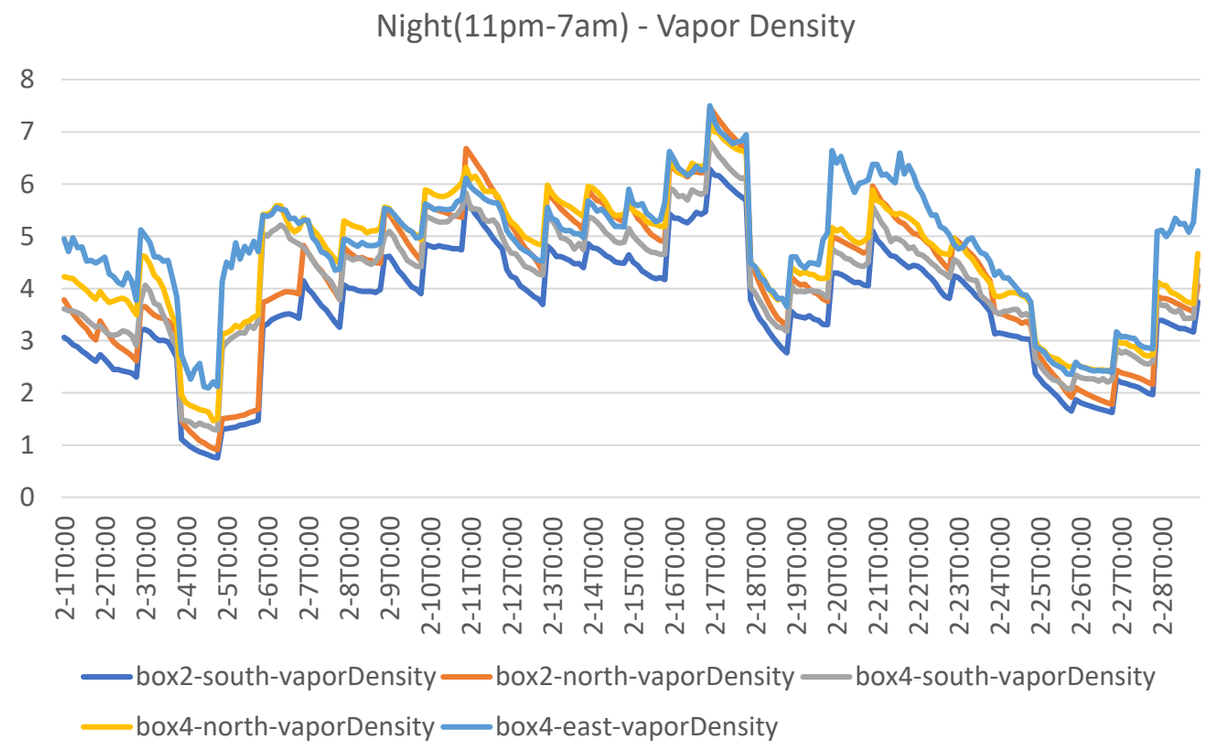
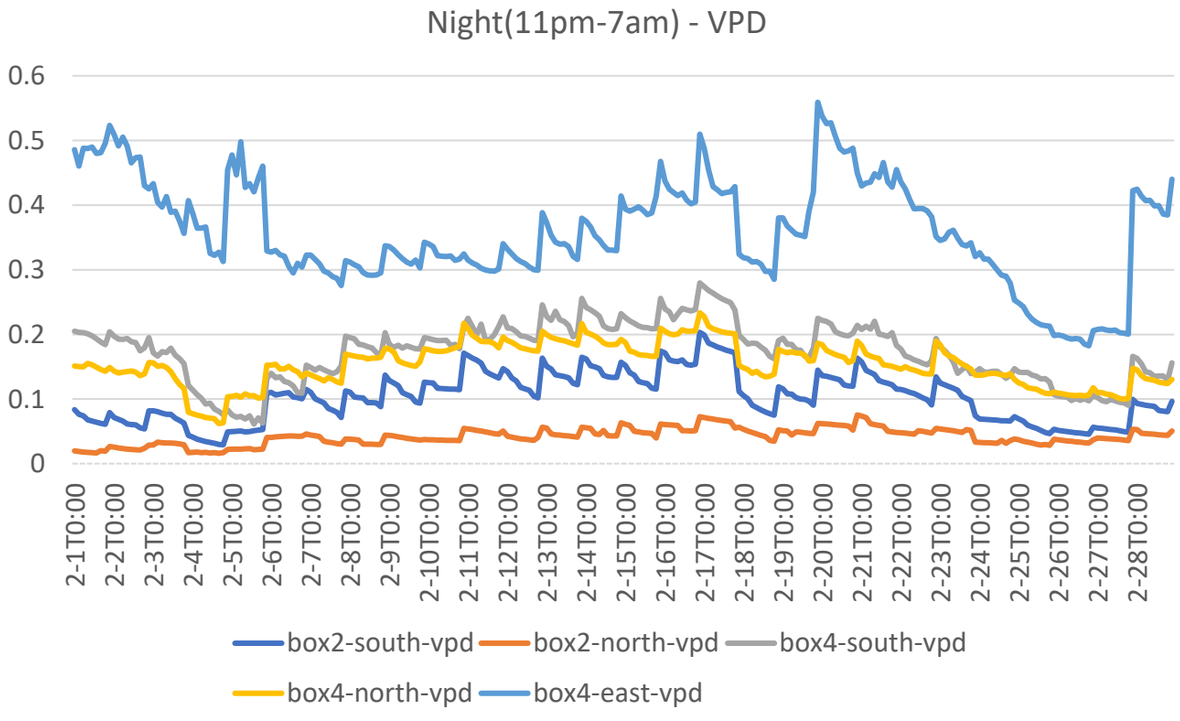
- Bees are near the box4-east sensor.
- During the day there's a lot more variability in temp and vapor density/VPD because the sun is warming the colony – increasing interior temp and there fore more moisture can be absorbed into the air.

Feb –Night - Sask1 (slatted rack, no top entrance*)





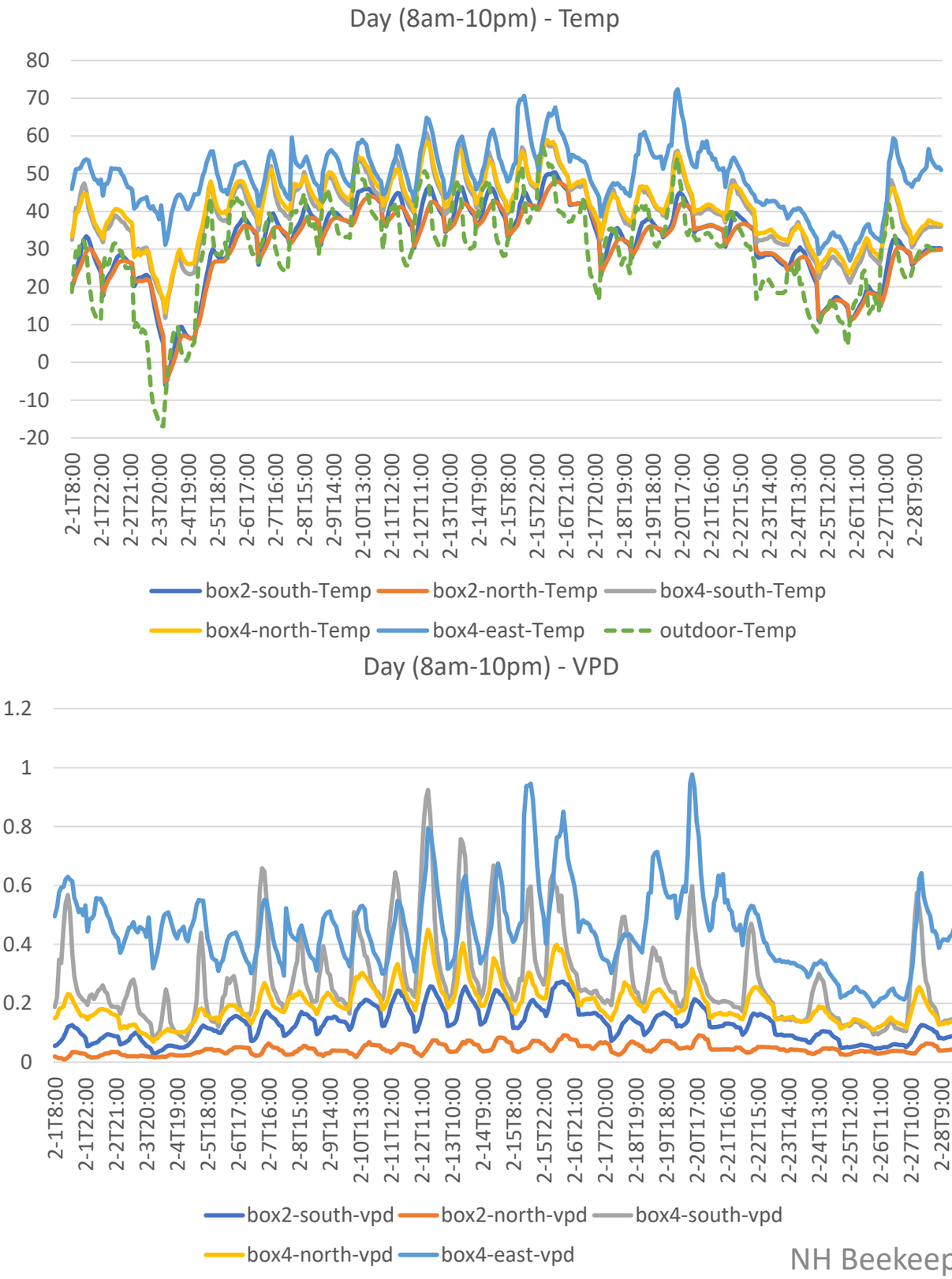


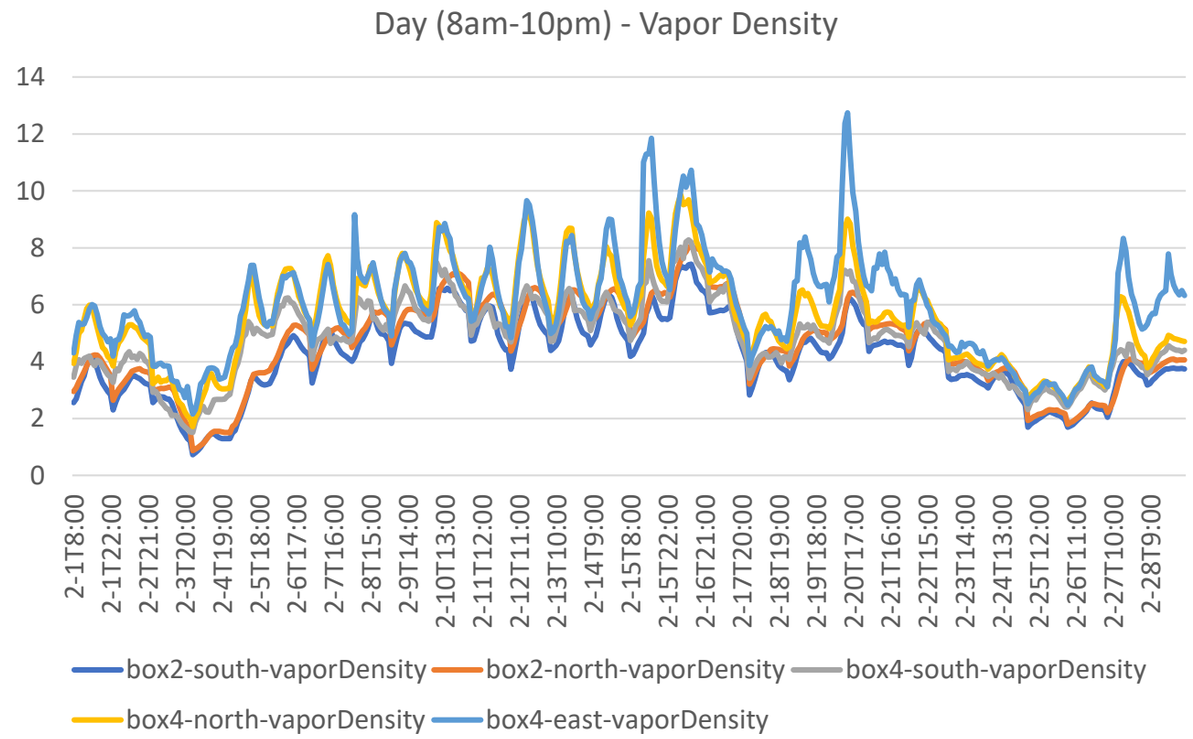
*Bees chewed a hole in the feeding shim so there is a small entrance under the top reflectix

- Bees are between the box4-east and box4-north sensors
- The temp by the box4 east sensor says generally between 40-50

- The moisture in the air/vapor density tracks the temperatures. However, we see that the VPD of the box4-east sensor indicates that the air could hold a lot more moisture than the areas near the other sensors

Feb –Day - Sask1 (slatted rack, no top entrance*)





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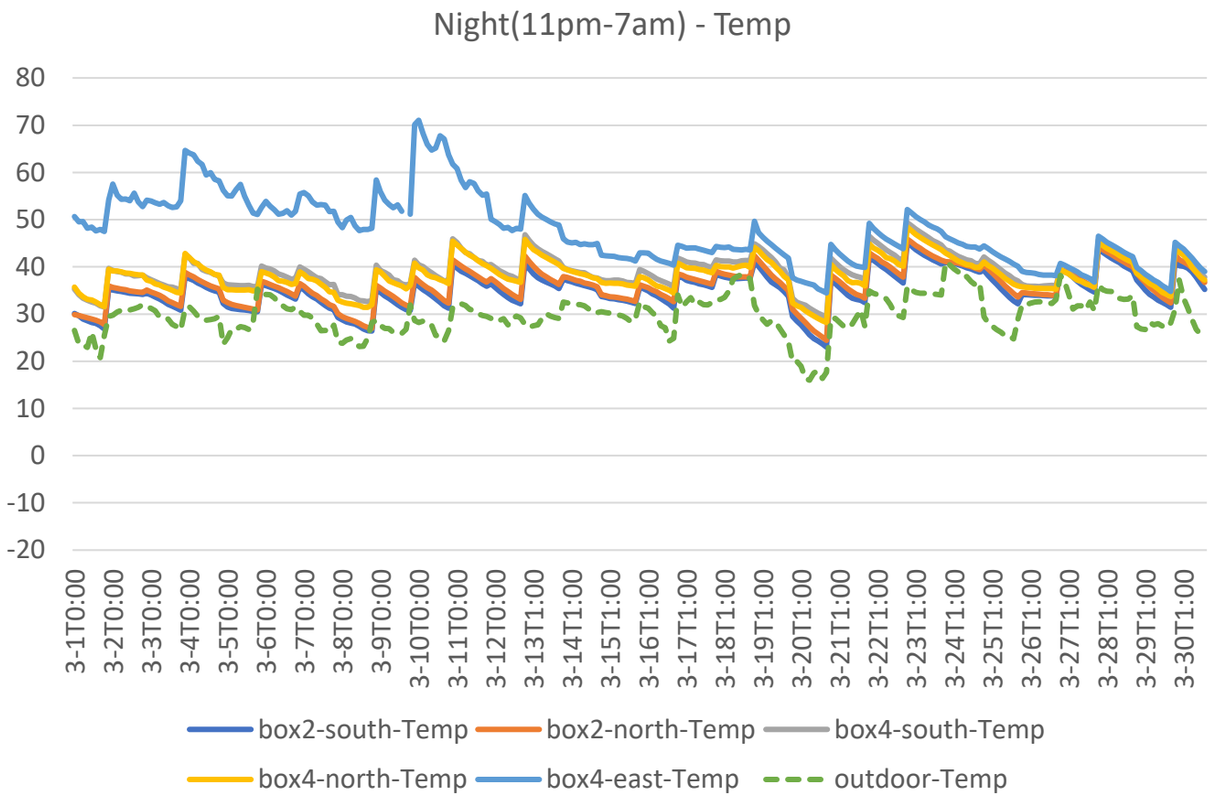
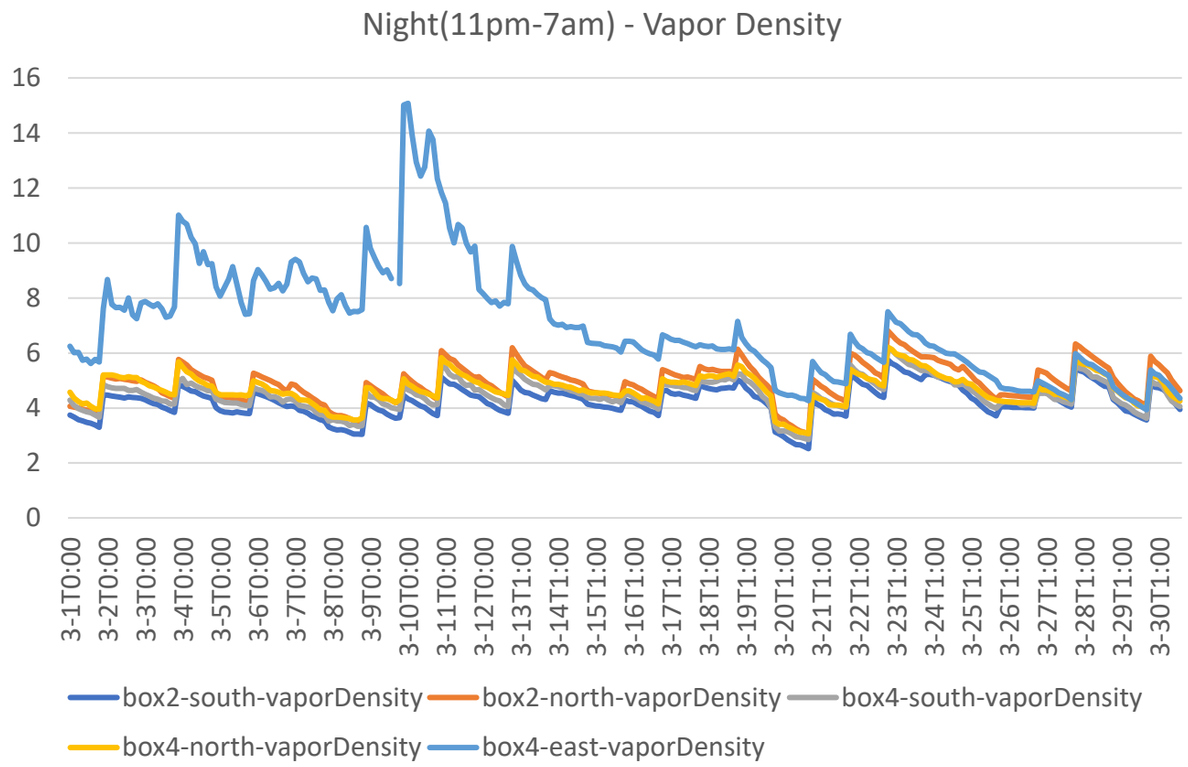
- Bees are between the box4-east and box4-north sensors
- The temp by the box4 east sensor says generally between 40-50
- The sunny days heats up the colony as shown by the spikes in the temps.
- The increasing temps means the air can hold more moisture so we see the variability in the vapor density

Mar –Night - Sask1 (slatted rack, no top entrance*)





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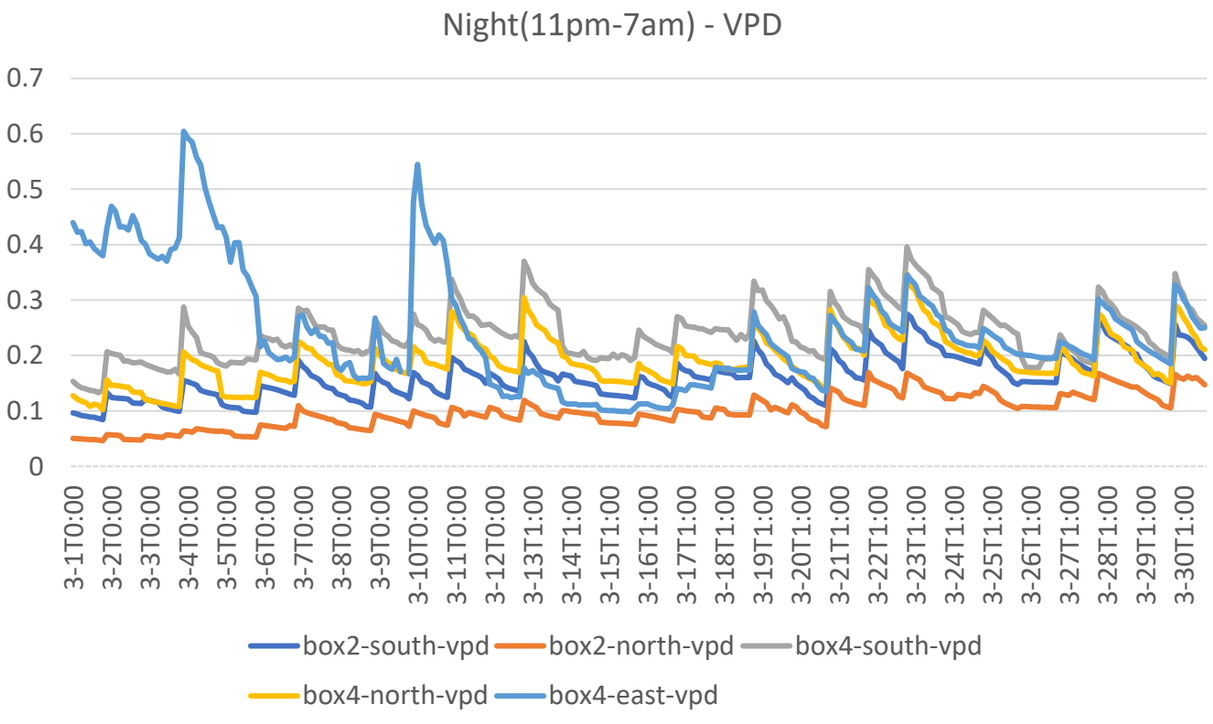
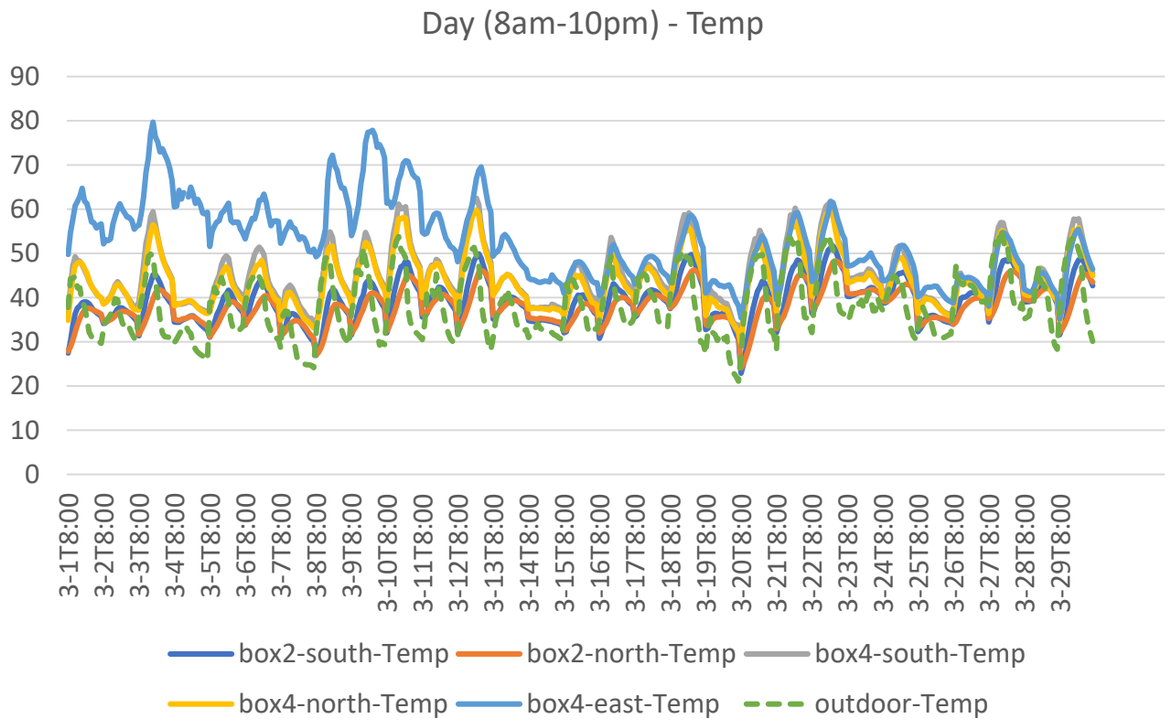
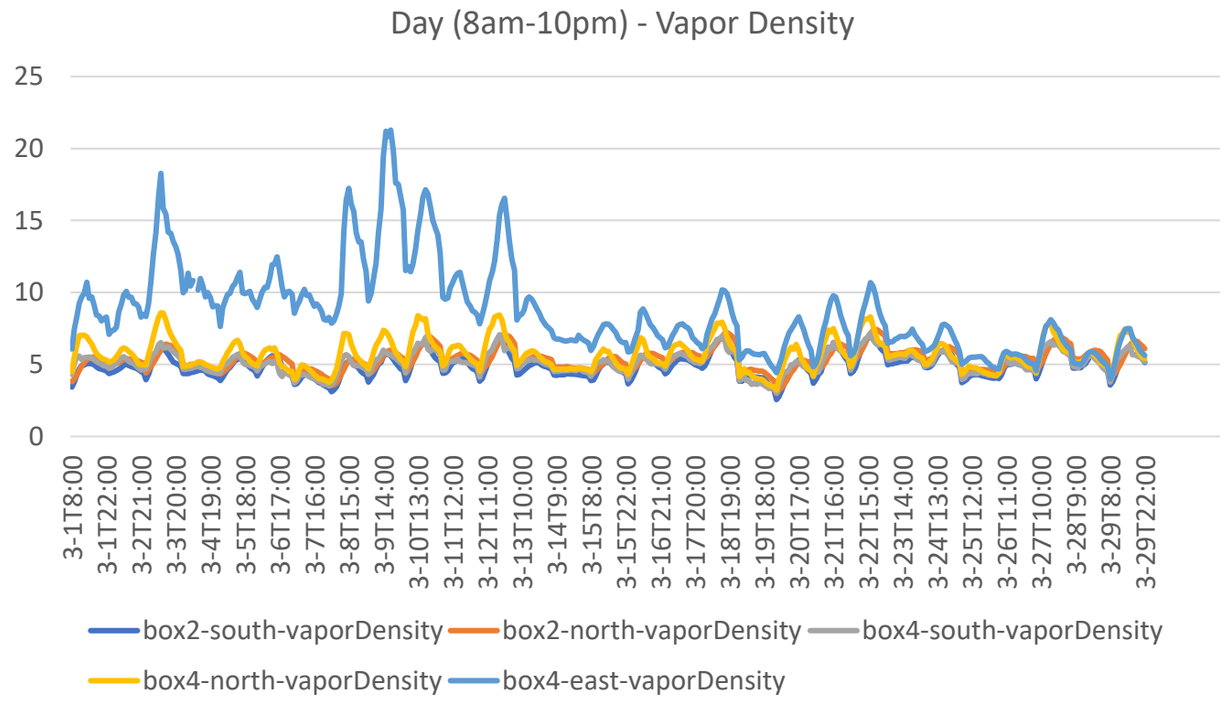
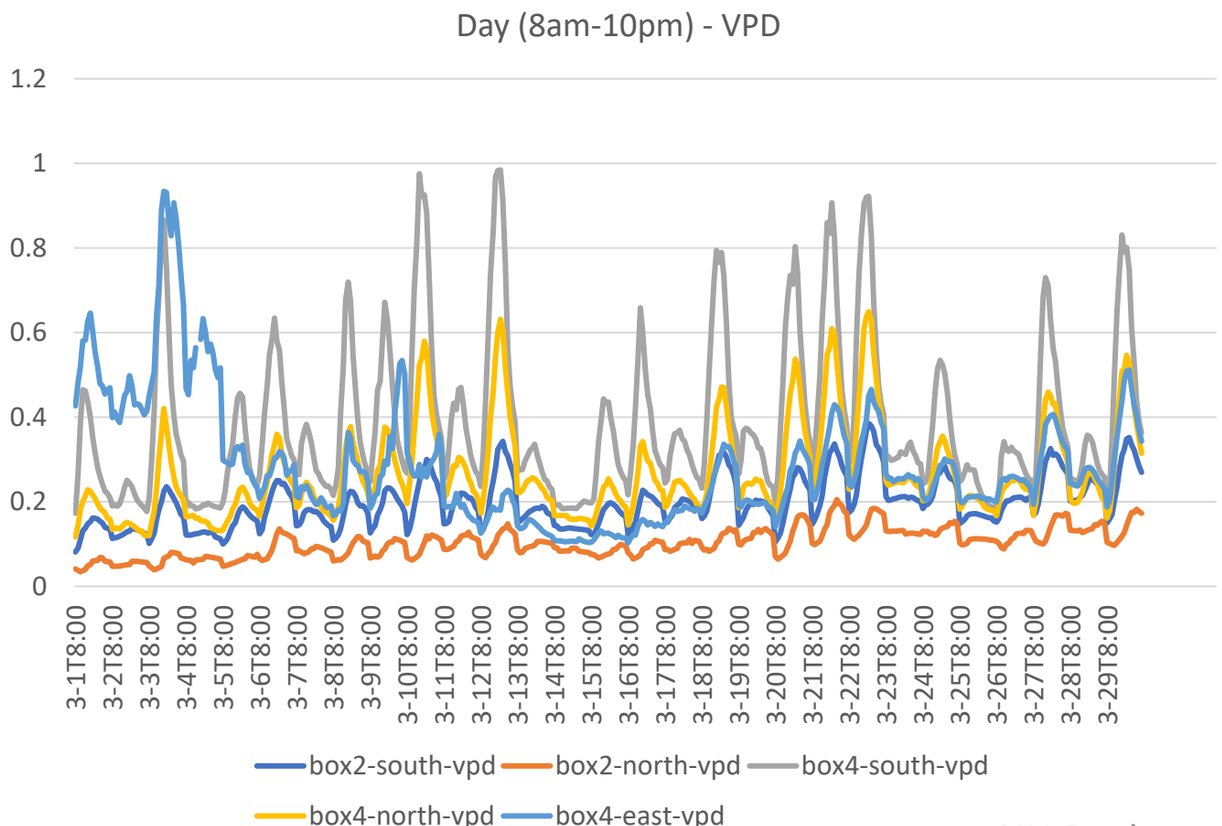


- Bees are in the south-east corner (by observation) for most of March and was alive on 3/27/23 (dead on 4/5)
- The fact the temps are only slightly above the outdoor temps indicate the cluster is probably very very small.
- The area around the north sensor has more moisture in the air than the other areas which makes sense as it would be the furthest away from the airflow.
- The north sensor area is not fully saturated as you can see from the VPD.

Mar –Day - Sask1 (slatted rack, no top entrance*)







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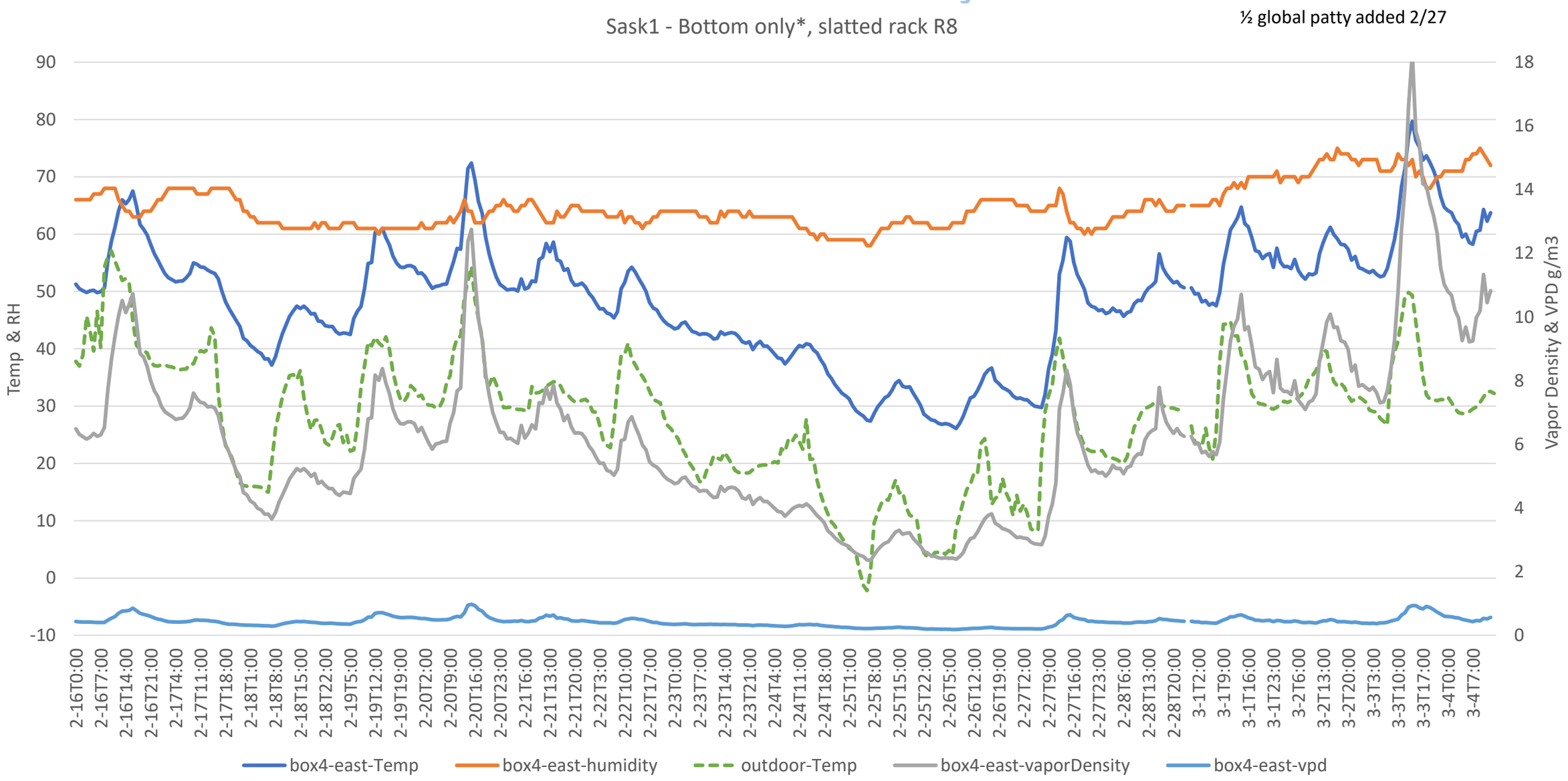
- Bees are in the south-east corner (by observation) for most of March – the cluster appears to be very small – but is alive on 3/27.
- The sunny days heats up the colony as shown by the spikes in the temps.
- The increasing temps means the air can hold more moisture so we see the variability in the vapor density

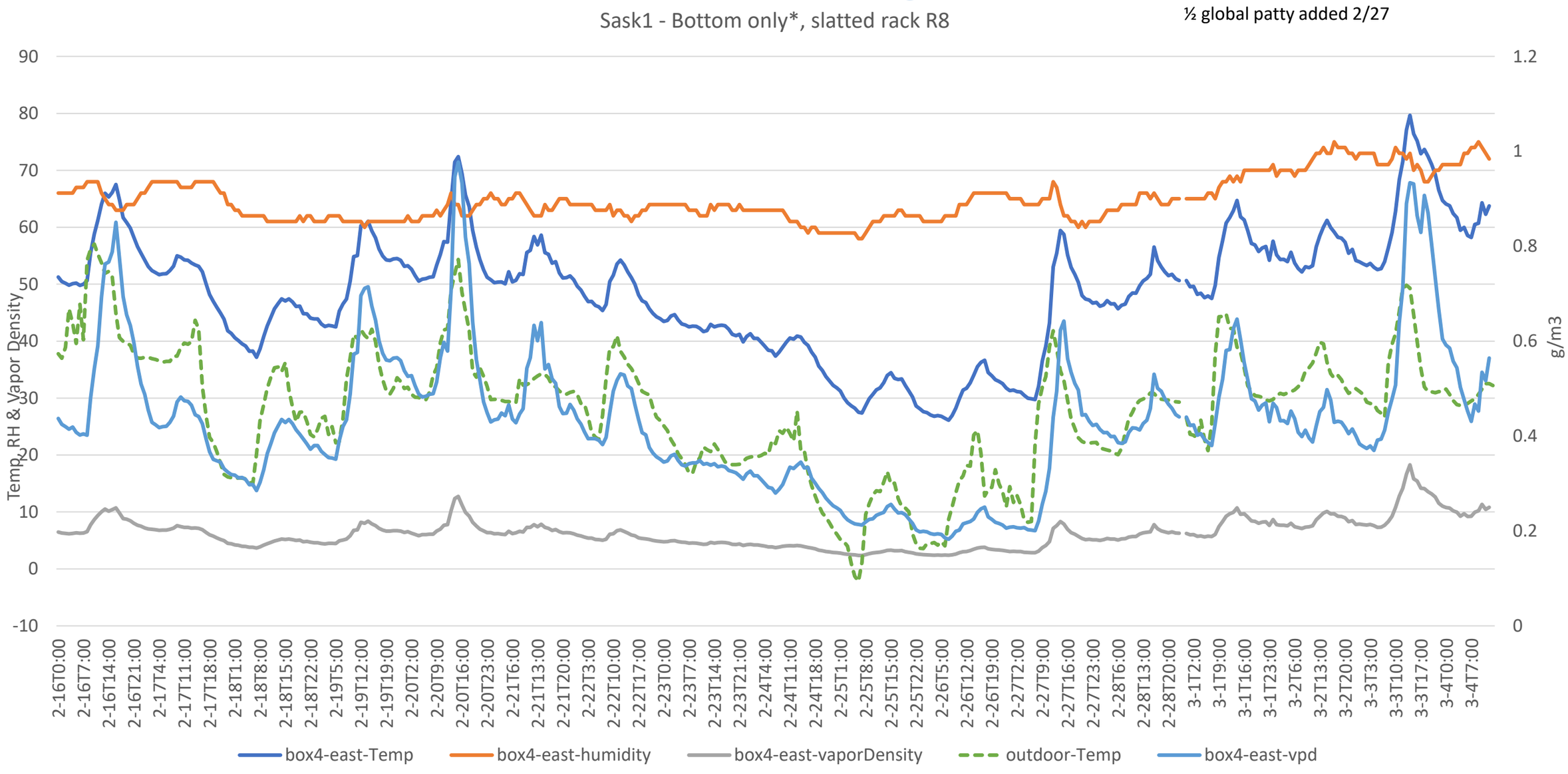
Box4-east sensor Sask1 (slatted rack, no top entrance)



The vapor density & VPD are plotted using the y-axis on the right

- Generally, variation in the vapor density corresponds to changes in the temp.
- 2/24-26 the temp dropped to the 30s – but RH stayed relatively constant. Meaning the amount of moisture in the air is reducing because the lower temps can't hold as much moisture. The vapor density shows there isn't much water in the air – how did it drop so fast? Was their condensation?..
- Also, after that there is more moisture in the air (rise in both RH & vapor density – why??)
- A ½ pollen patty was added on 2/27.. Could this by the reason???

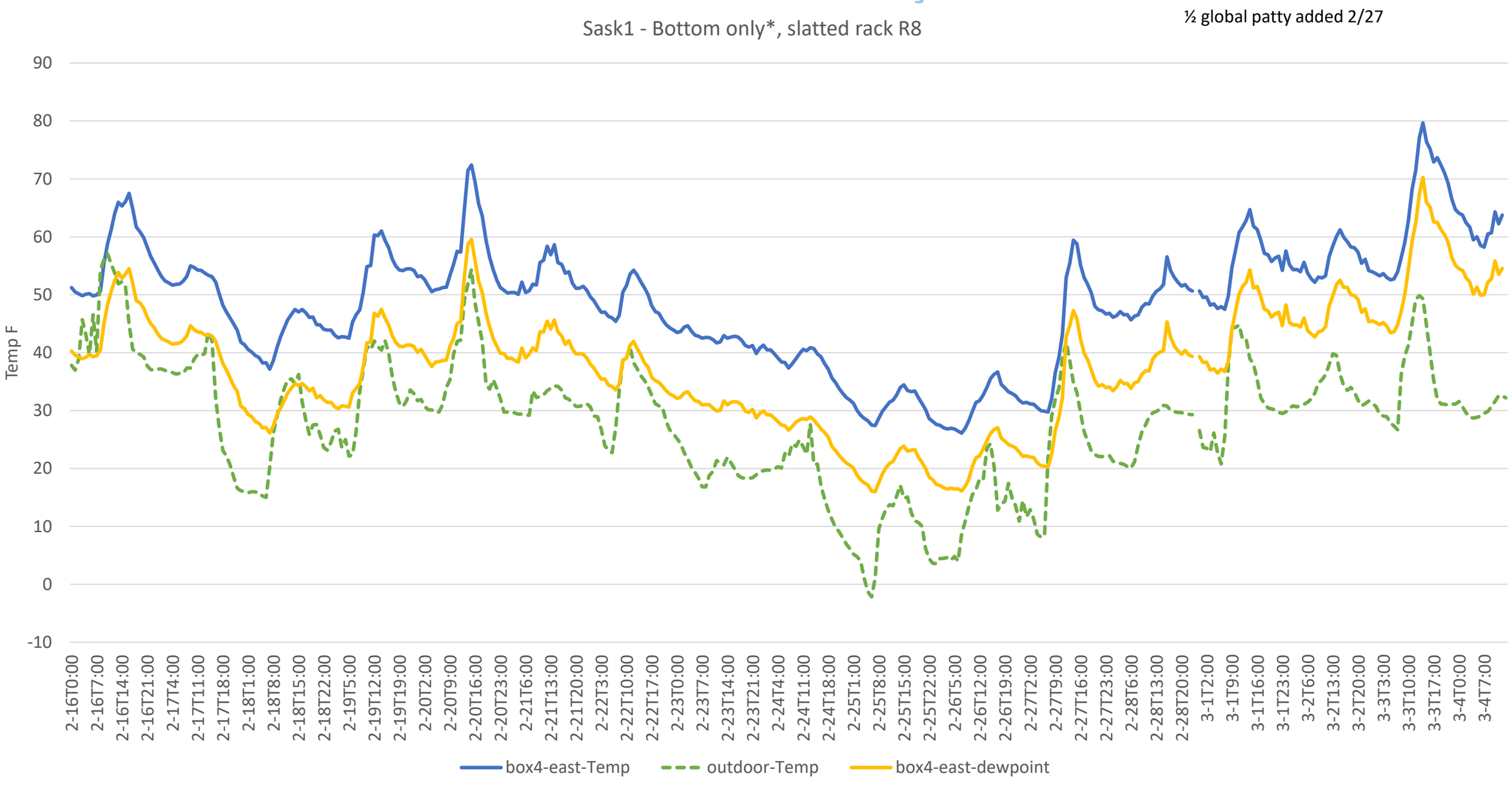
Box4-east sensor Sask1 (slatted rack, no top entrance)



The VPD is plotted using the y-axis on the right
Vapor density, Temp & RH use left axis

- Generally, variation in the vapor density corresponds to changes in the temp.
- 2/24-26 the temp dropped to the 30s – but RH stayed relatively constant. Meaning the amount of moisture in the air is reducing because the lower temps can't hold as much moisture. VPD indicates this too. During that time frame, the air is almost fully saturated and can't hold much more water – but it isn't 100% saturated so the vapor didn't condense.
- Also, after that there is more moisture in the air (rise in both RH & vapor density – why??)
- A ½ pollen patty was added on 2/27.. Could this by the reason???

Box4-east sensor Sask1 (slatted rack, no top entrance)



- Dewpoint during the time of 2/23-2/27 is always below the actual temp at this sensor indicating that the moisture didn't condense