

# Comparing Warm Up & Cool Down rates of different wraps

Melissa Sim-Hollister

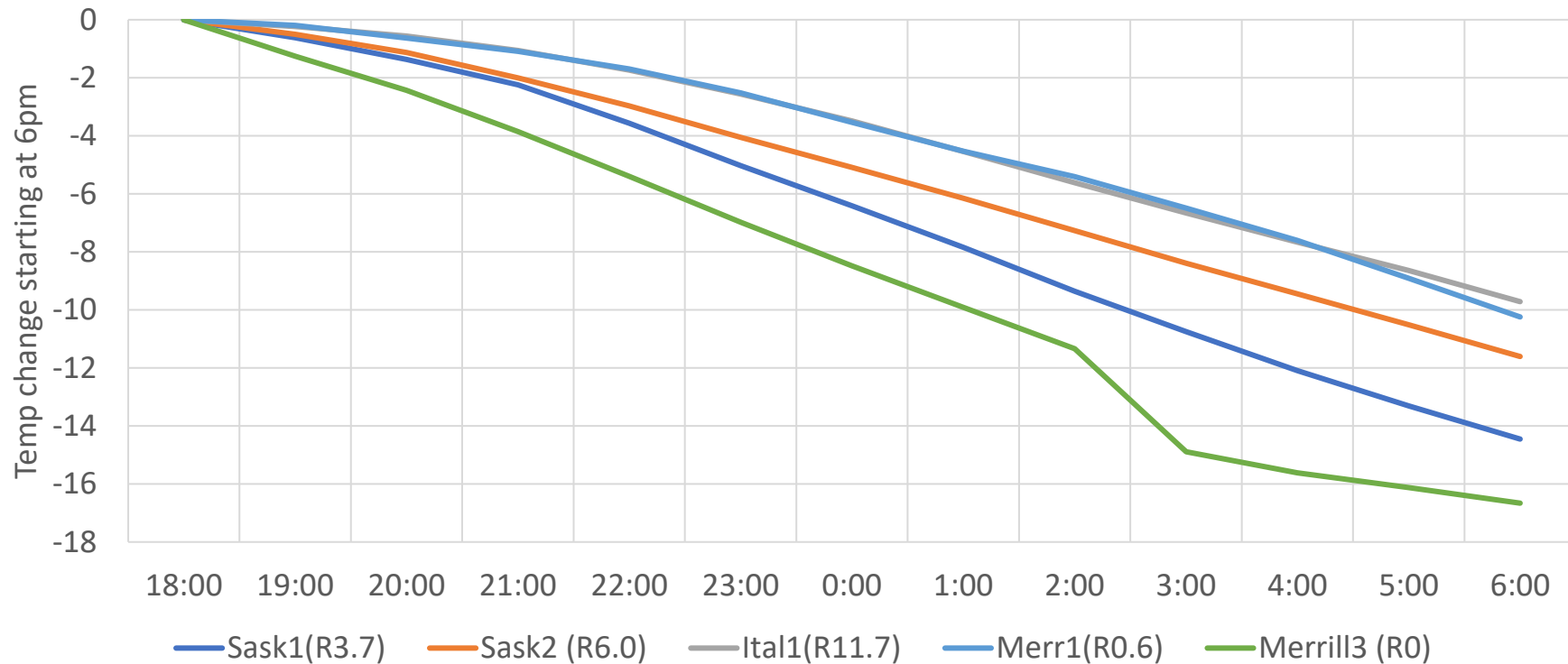
Heather Achilles

# Compare the cooldown rates of different wraps

1. Because the apiaries are in different locations, to compare data across Apiaries:
  1. Choose Hives that appear to have no bees near the middle sensor (Sask1, Sask2, Ital1, Merrill3, Lilly, Merr1)
  2. For each day: calculate the Outdoor temp cool downrate (degrees/hour) of each apiary using this formula:
    - $(\text{Temp at 6pm} - \text{temp at 6am the next day})/12$
  3. Find the set of days where the cooldown rates are the same across the apiaries
    - For example, for an outside cooldown rate of 1.34 degrees/hour. Apiary1 has this rate on Jan14-15, Apiary2 has that on Jan17-18 and Apiary3 has it on Jan16-17.
  4. Create a graph that shows how much each hive cools down every hour starting at 6pm.

# Outdoor Cooldown rate of 1.34-1.35 degrees/hour

Middle of Hive cooldown

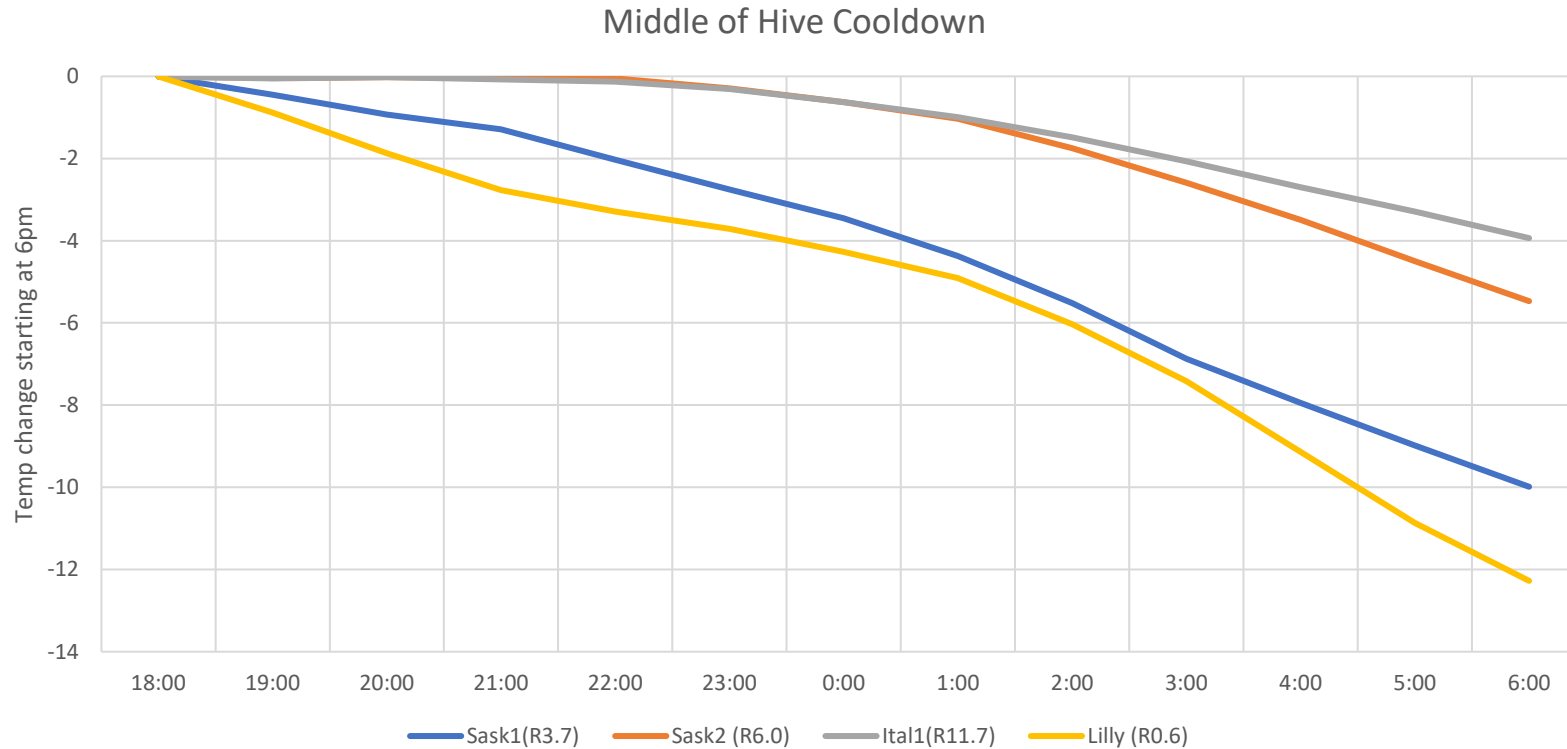


|          | Data from<br>6pm-6am |        |
|----------|----------------------|--------|
| Sask1    | Jan 2/Jan 3          | Cloudy |
| Sask2    | Jan 2/Jan 3          | Cloudy |
| Itai1    | Jan 2/Jan 3          | Cloudy |
| Lilly    | n/a                  |        |
| Merr1    | Jan 7/Jan 8          | cloudy |
| Merrill3 | Jan 2/Jan 3          | Cloudy |

For Sask1, Sask2, Merrill3 and Itai1, as expected temps with lower R-values cooldown faster than those with higher R-values

Merr1 cooldown rate is much slower than expected since it has such a low R-value. A couple possibilities are: 1) heat from the cluster is radiating down to the middle sensor and slows the cooldown rate 2) On 12/17 bees started moving up. The bees are smart and clustering where they can generate heat with the polystyrene on top of the inner cover. Because of this event, the honey was probably left behind. The honey will hold heat so it slows down the cooling rate. (Honey's estimated R value is 0.25 per frame)

# Outdoor Cooldown rate of 1.13 degrees/hour



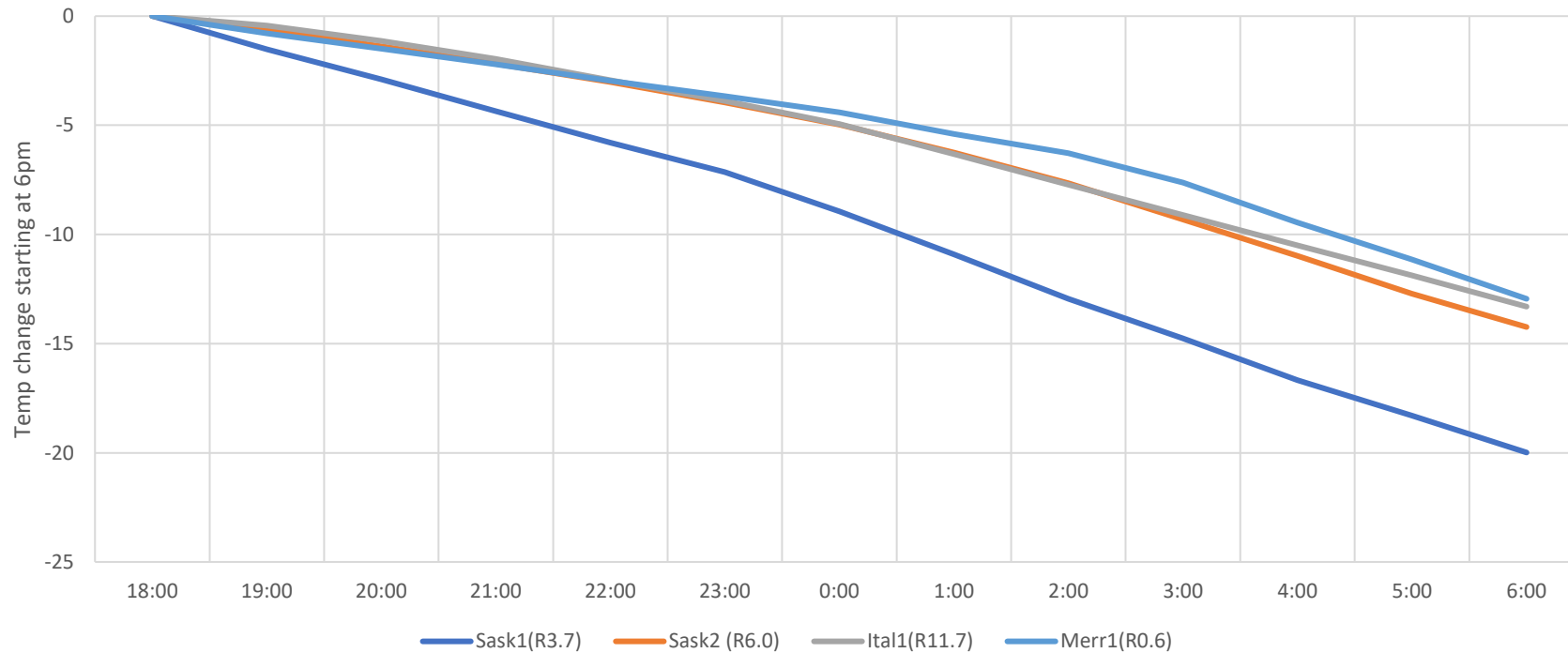
|          | Data from 6pm-6am |         |
|----------|-------------------|---------|
| Sask1    | Jan 23/ Jan24     | Cloudy  |
| Sask2    | Jan 23/Jan 24     | Cloudy  |
| Ital1    | Jan 23/ Jan24     | Cloudy  |
| Lilly    | Jan 23/ Jan24     | Cloudy? |
| Merr1    | n/a               |         |
| Merrill3 | n/a               |         |

For Sask1, Sask2, Ital1 and Lilly, as expected temps with lower R-values cooldown faster than those with higher R-values

It is interesting that Sask2 rate of cooldown is the same as Ital1 for a while and then speeds up

# Outdoor Cooldown rate of 1.88 degrees/hour

Middle of Hive Cooldown

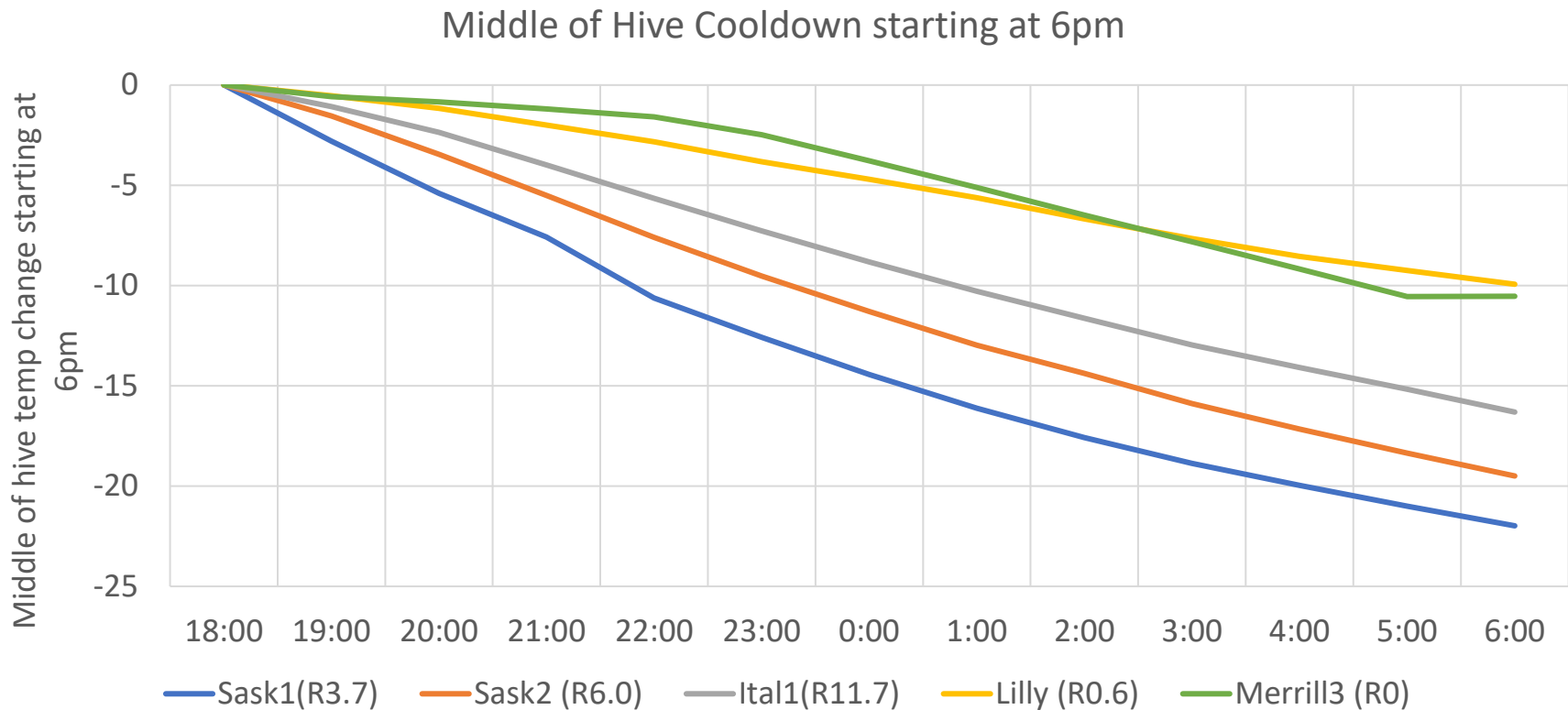


|          | Data from 6pm-6am |        |
|----------|-------------------|--------|
| Sask1    | Jan 25/ Jan26     | Cloudy |
| Sask2    | Jan 25/Jan 26     | Cloudy |
| Ital1    | Jan 25/ Jan26     | Cloudy |
| Lilly    | n/a               |        |
| Merr1    | Jan10/Jan11       | Cloudy |
| Merrill3 | n/a               |        |

For Sask1 decays faster than the Sask2 & Ital1 as expected.  
The cooldown rates of Sask2 & Ital1 are closer than expected.

Merr1 cooldown rate is much slower than expected since it has such a low R-value. A couple possibilities are: 1) heat from the cluster is radiating down to the middle sensor and slows the cooldown rate 2) On 12/17 bees started moving up. The bees are smart and clustering where they can generate heat with the polystyrene on top of the inner cover. Because of this event, the honey was probably left behind. The honey will hold heat so it slows down the cooling rate. (Honey's estimated R value is 0.25 per frame)

# Outdoor Cooldown rate of 0.99 degrees/hour



|          | Data from 6pm-6am |               |
|----------|-------------------|---------------|
| Sask1    | Jan 22/ Jan23     | Sunny         |
| Sask2    | Jan 22/ Jan23     | Sunny         |
| Ital1    | Jan 22/ Jan23     | Sunny         |
| Lilly    | Jan2/Jan 3        | Partly sunny? |
| Merr1    | N/a               |               |
| Merrill3 | Jan 23/Jan24      | Cloudy??      |

| hour  | Sask1, Sask2, Ital apiary temps | Lilly Apiary Temps | Merrill Apiary temps |
|-------|---------------------------------|--------------------|----------------------|
| 18:00 | 7.3                             | 33.37              | 25.05                |
| 19:00 | 5.16                            | 32.4               | 24.76                |
| 20:00 | 3.97                            | 31.15              | 24.51                |
| 21:00 | 0.93                            | 31.71              | 24.19                |
| 22:00 | -0.02                           | 28.71              | 23.54                |
| 23:00 | -0.13                           | 26.46              | 22.23                |
| 0:00  | -0.67                           | 25.05              | 20.75                |
| 1:00  | -0.86                           | 24.42              | 19.22                |
| 2:00  | -1.28                           | 23.29              | 17.8                 |
| 3:00  | -2.29                           | 22.48              | 16.45                |
| 4:00  | -2.36                           | 22.26              | 15.08                |
| 5:00  | -3.11                           | 22.14              | 13.77                |
| 6:00  | -4.66                           | 21.38              | 14.25                |

The rate of cooldown of Lilly & Merrill3 is just slightly less than the outside temp which is what you'd expect Both of these colonies were up early leaving their honey behind. Both Lilly & Merrill are dead on the dates shown.

For Sask1, Sask2, Ital1 – It was a sunny day so the interior of the hive heated up, when the sun went down the outside temp dropped quickly so by 6pm there was a big temp difference (19-20F) between the inside & outside the hive. The rate of heat transfer (aka cool down) is directly proportional to the difference between the inside and outside temps. So a bigger difference means a faster cooldown.

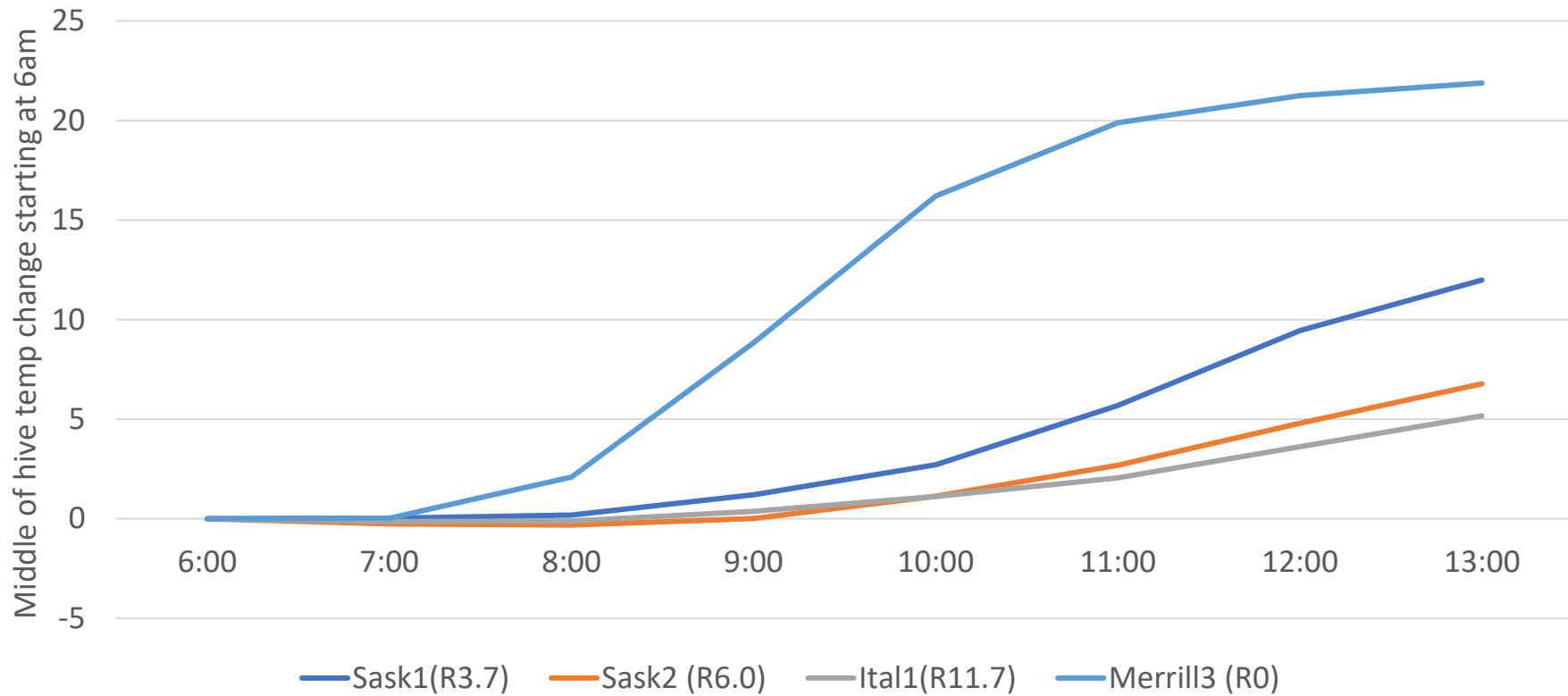
Lilly & Merrill's interior temps were much closer to the outside temps & therefore didn't have a fast a cooldown rate

# Compare the warmup rates of different wraps

1. Because the apiaries are in different locations, to compare data across Apiaries:
  1. Choose Hives that appear to have no bees near the middle sensor (Sask1, Sask2, Ital1, Merrill3, Merr1)
  2. For each day: calculate the Outdoor temp cool down/warmup rate (degrees/hour) of each apiary using this formula:
    - $(\text{Temp at 6am} - \text{temp at 1pm})/7$
    - 1pm was chosen because it was the most common time to see the highest outdoor temps in our apiaries
  3. Find the set of days where the warmup rates are the same across the apiaries
    - For example, for an outside warm rate of 1.34degrees/hour. Apiary1 has this rate on Jan14, Apiary2 has that on Jan17 and Apiary3 has it on Jan16-.
  4. Create a graph that shows how much each hive warms down every hour starting at 6am.

# Outdoor warmup rate of 1.57 degrees/hour

Warm up rate of the middle of the hive



|          | Data from 6am-1pm |
|----------|-------------------|
| Sask1    | Jan25             |
| Sask2    | Jan25             |
| Ital1    | Jan25             |
| Merr1    | N/a               |
| Merrill3 | Jan16             |

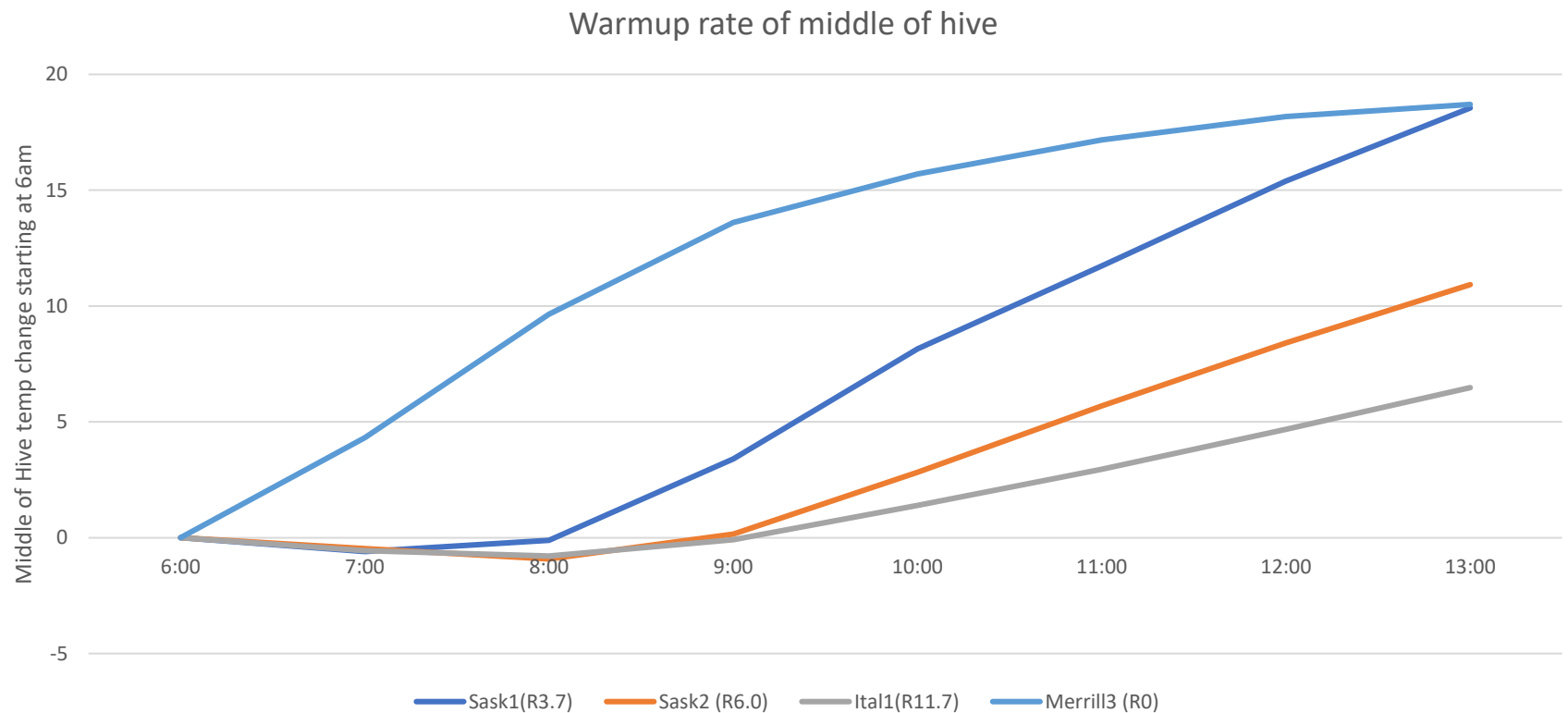
| hour  | Sask1, Sask2, Ital1 apiary Temps | Merrill Apiary Temps |
|-------|----------------------------------|----------------------|
| 6:00  | 20.62                            | -3.98                |
| 7:00  | 21.61                            | -3.95                |
| 8:00  | 24.04                            | -1.53                |
| 9:00  | 28.22                            | 5.34                 |
| 10:00 | 32.73                            | 12.18                |
| 11:00 | 39.14                            | 16.09                |
| 12:00 | 42.65                            | 17.2                 |
| 13:00 | 34.8                             | 17.65                |

As expected, the hives with the higher R value do not heat up as fast.  
Sun hits the Sask1, Sask2, Ital1 apiary starting at ~ 8am

Interesting that we don't see more difference between the R6 and R11.7 wrap.



# Outdoor warmup rate of 1.38 degrees/hour



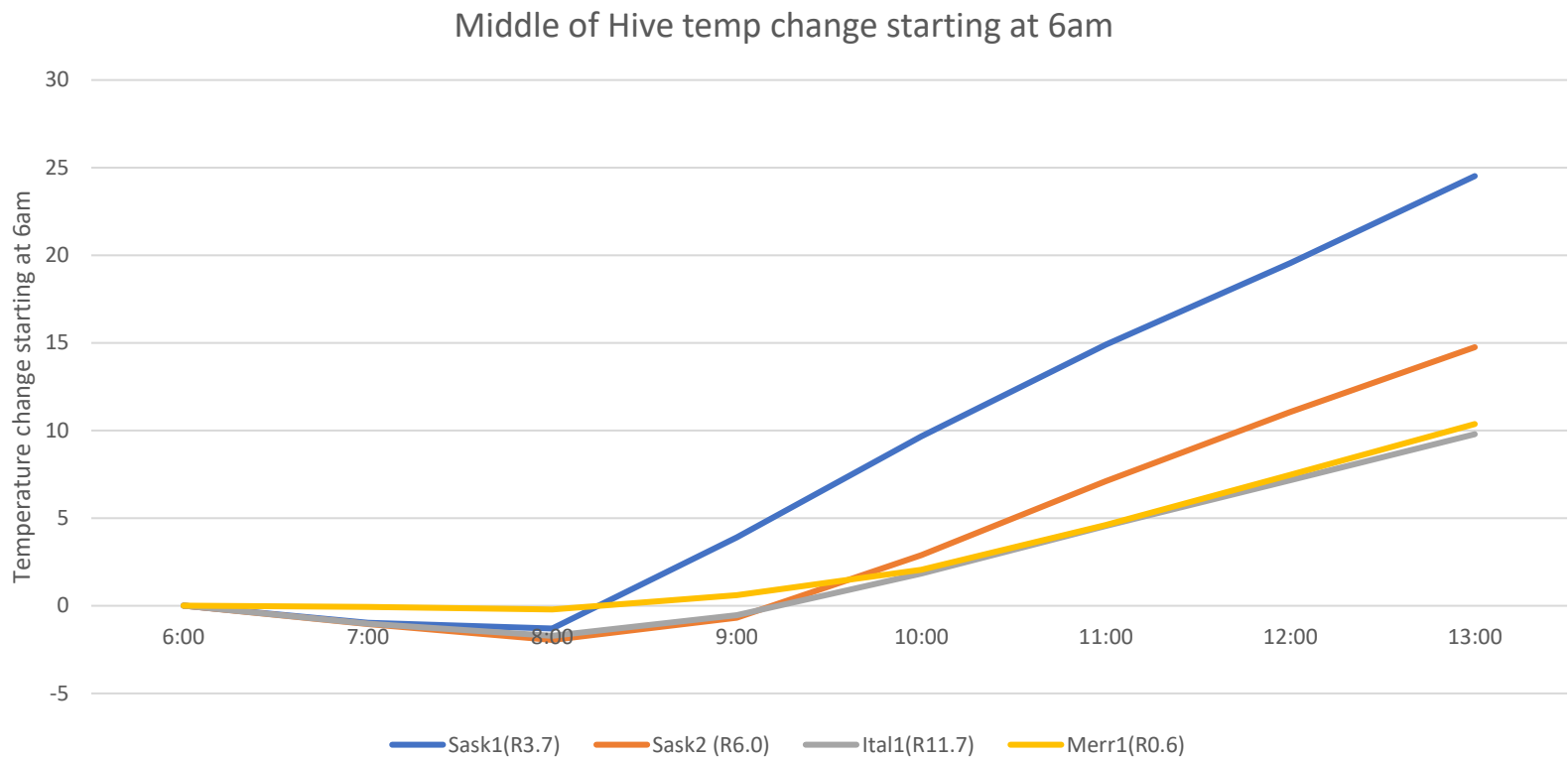
|          | Data from 6am-1pm |
|----------|-------------------|
| Sask1    | 30-Jan            |
| Sask2    | 30-Jan            |
| Ital1    | 30-Jan            |
| Merr1    | N/a               |
| Merrill3 | 27-Jan            |

|       | Sask1, Sask2, Ital1 apiary temps | Merrill Apiary Temps |
|-------|----------------------------------|----------------------|
| 6:00  | 1.43                             | -1.8                 |
| 7:00  | 1.72                             | 3.25                 |
| 8:00  | 4.36                             | 8.92                 |
| 9:00  | 13.35                            | 12.96                |
| 10:00 | 17                               | 14.81                |
| 11:00 | 19.09                            | 16.18                |
| 12:00 | 19.63                            | 17.2                 |
| 13:00 | 20.8                             | 17.58                |

As expected, the hives with the higher R value do not heat up as fast. Sun hits the Sask1, Sask2, Ital1 apiary starting at ~ 8am.

Note: We suspect Merrill3 was dead in mid-January.

# Outdoor warmup rate of 2.38 degrees/hour



|          | Data from 6am-1pm |
|----------|-------------------|
| Sask1    | 22-Jan            |
| Sask2    | 22-Jan            |
| Ital1    | 22-Jan            |
| Merr1    | 23-Jan            |
| Merrill3 | n/a               |

|       | Sask1, Sask2, Ital1 apiary temps | Merr1 Apiary Temps |
|-------|----------------------------------|--------------------|
| 6:00  | -4.66                            | 2.26               |
| 7:00  | -4.73                            | 3.11               |
| 8:00  | -1.8                             | 7.3                |
| 9:00  | 16.59                            | 13.77              |
| 10:00 | 20.37                            | 24.06              |
| 11:00 | 21.81                            | 28.33              |
| 12:00 | 24.56                            | 29.08              |
| 13:00 | 28.36                            | 33.85              |

Merr1 does not get much direct sun so you can see it doesn't warm up inside  
 The combination of limited sun, coolest location, wrapped in tar paper all making this hive challenged.

Sask1, Sask2, Ital1 apiary gets direct sun starting at 8am. NH Beekeepers Association