Lighting and behavioural investigations at an extreme latitude

J. Alstan Jakubiec

University of Toronto & Solemma, LLC

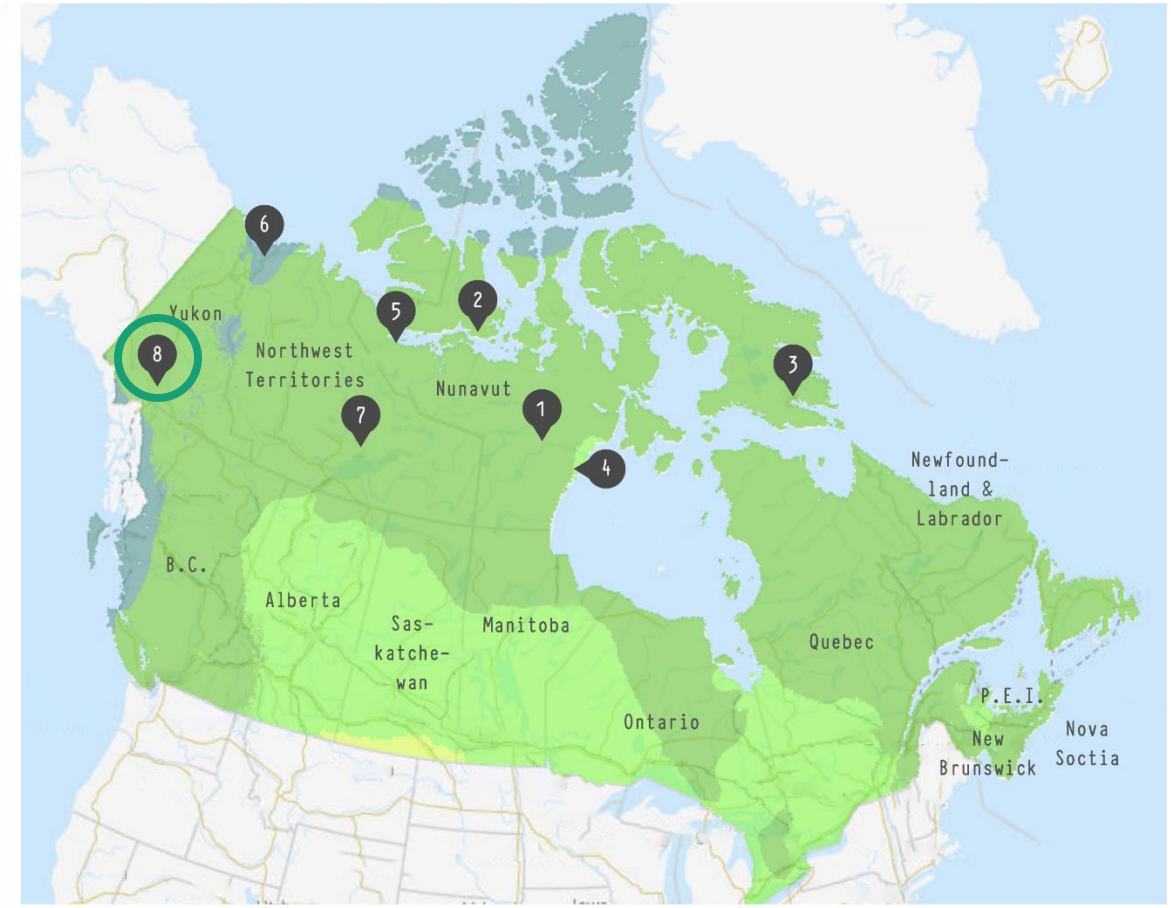
alstan.jakubiec@daniels.utoronto.ca

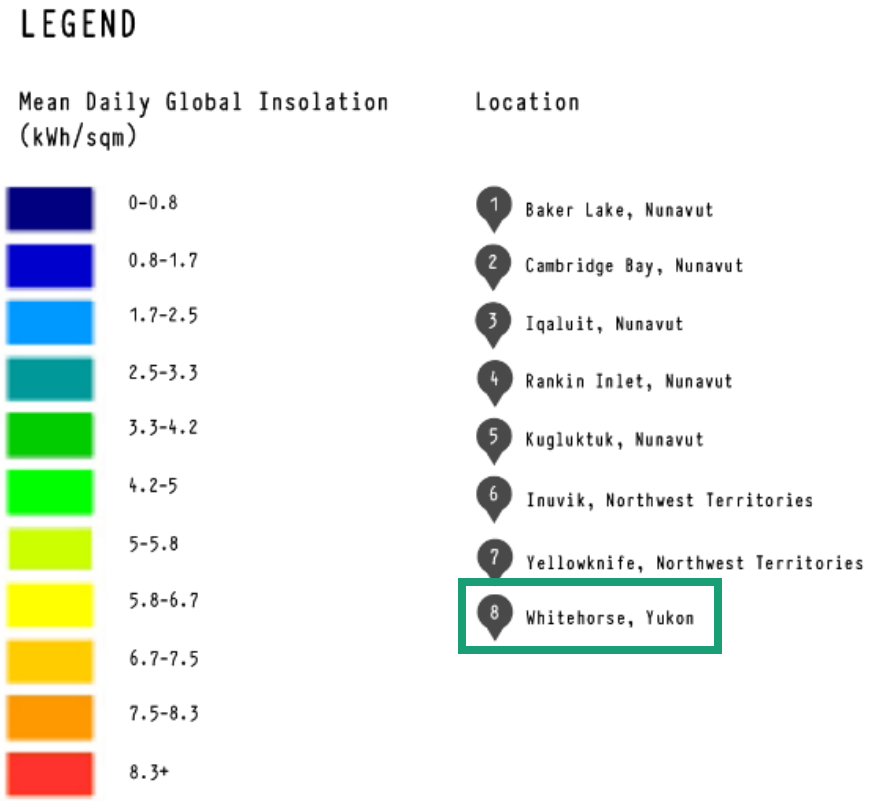
Athina Alight

University of Alberta

Introduction

Northern climates in Canada

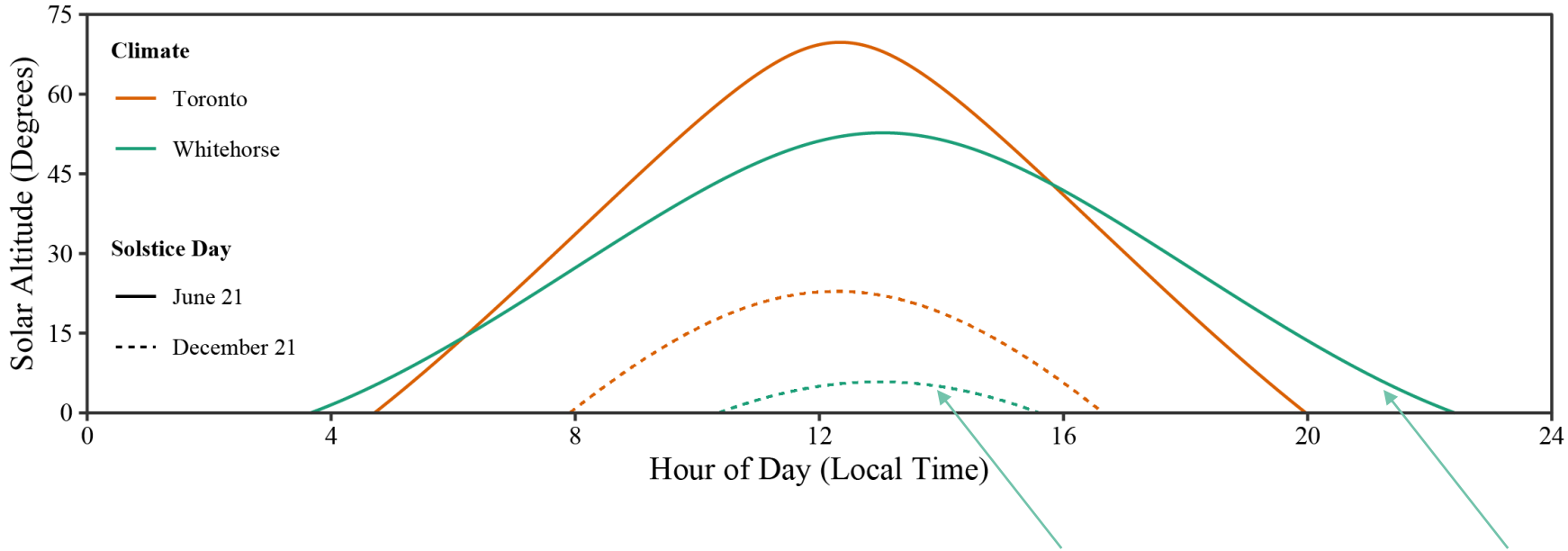




This presentation takes place in Whitehorse, The Yukon.

- Population: 28,201 Whitehorsers
- Mean annual temperature: 0.2 °C, 32.4 °F

Whitehorse: Daylight hours

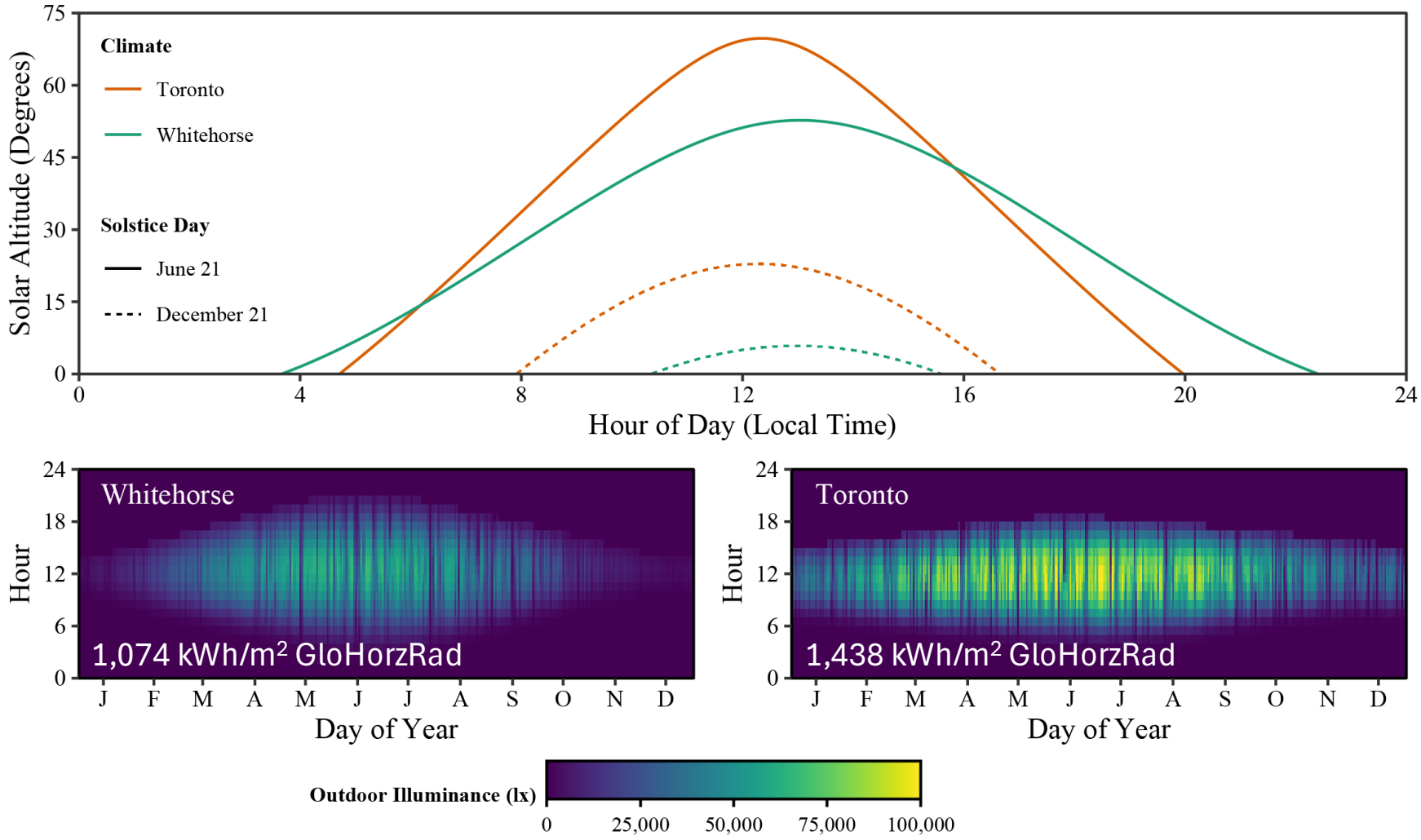


5.2 hrs (winter)

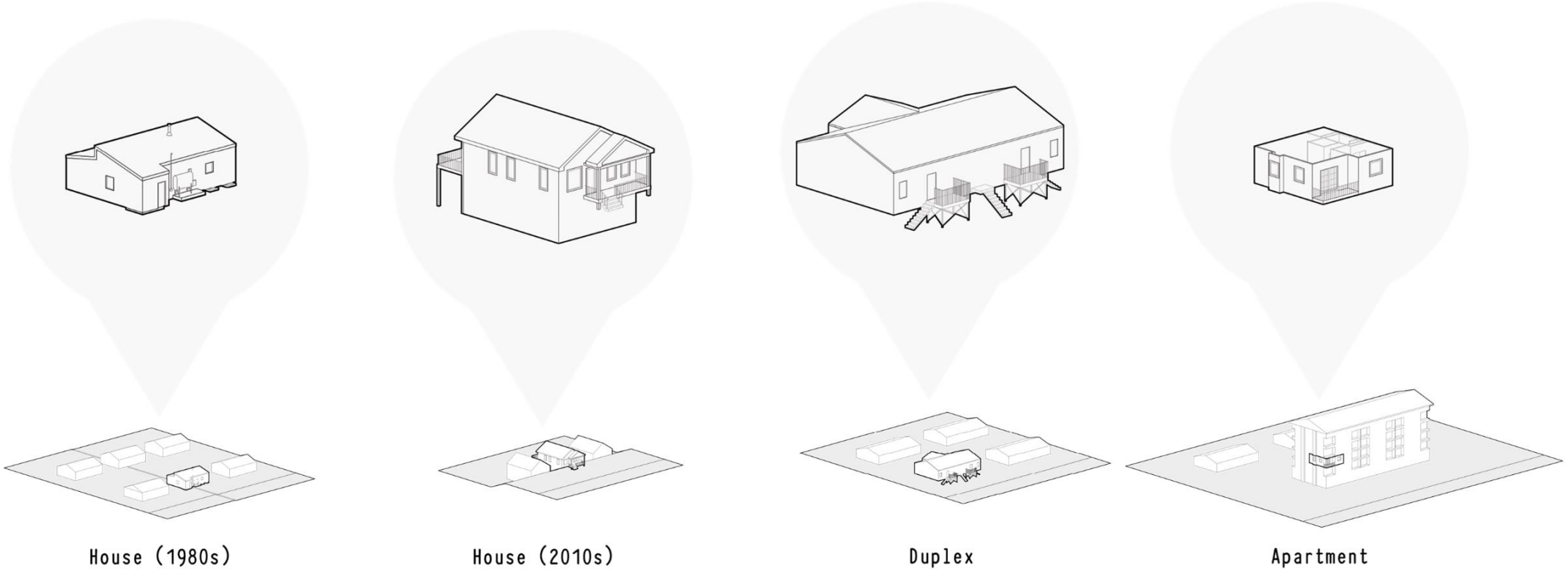
18.7 hrs (summer)

Compare to 8.7 hrs (winter) and 15.3 hrs (summer) in Toronto.

Whitehorse: Daylight Hours / Irradiance

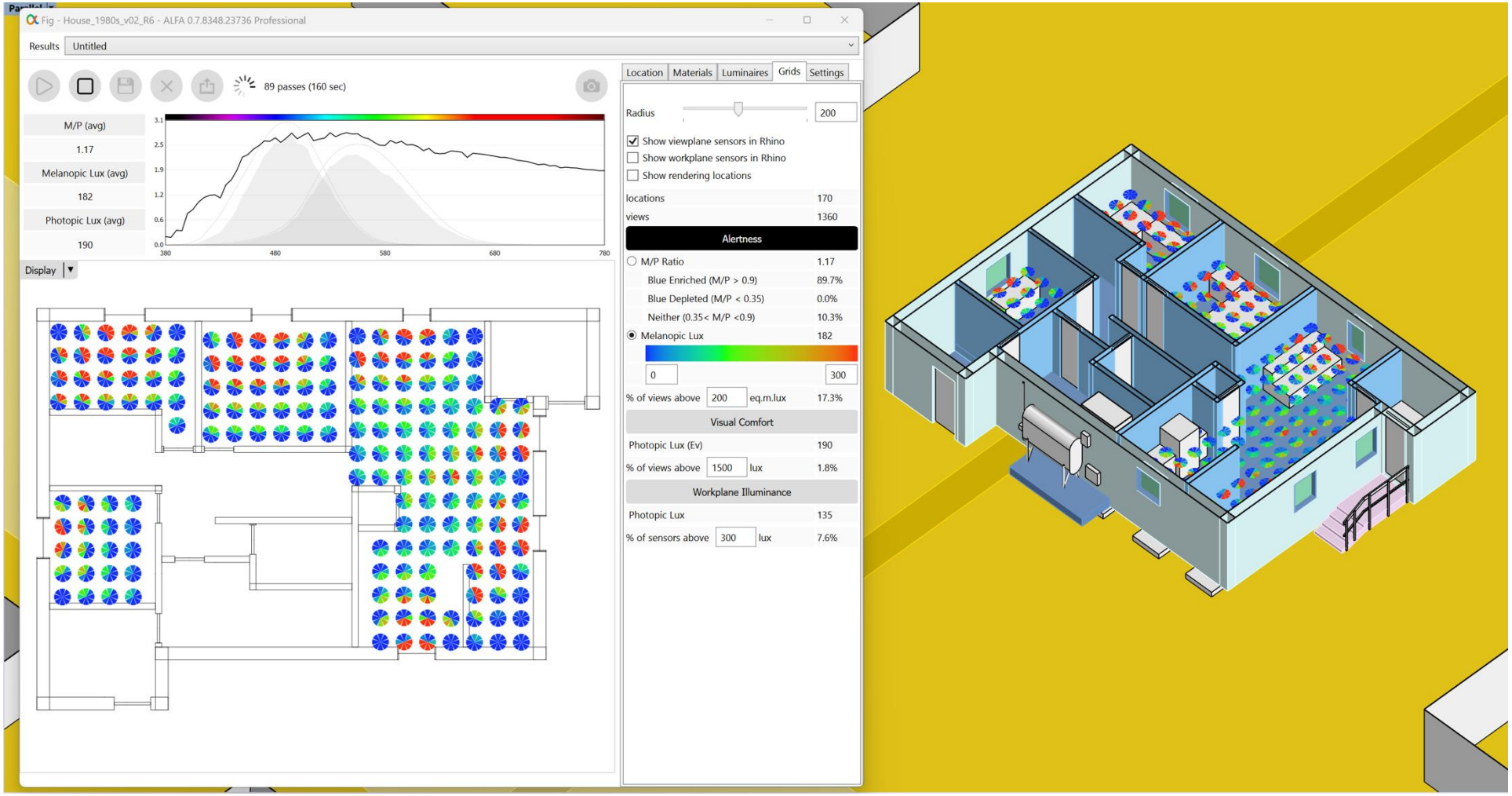


Housing Typologies in Northern Canada



Sources: Canada Mortgage and Housing Corporation, 2017; Sheppard & White, 2017; Nunavut Housing Corporation, n.d.; Wong, 2018; City of Whitehorse, n.d.; Government of Northwest Territories, 2021; Government of Nunavut, 2005

Housing Typologies in Northern Canada



Methodology

Participant Demographics

- **Age**
  mean: 45.6 years
  max: 67.0 years
  min: 35.0 years

- **Gender**
  5 female
  4 male
  1 not reported

- **Employment**

Social worker	Crisis line worker
Teacher	Shipping / receiving
Government	Self-employed (WFH)
Software manager	Electrician
Mine machine operator	School principal

- **Night shift**
  4 participants work night shifts at least occasionally

- **Home ownership**
  4 own
  6 rent

Administration · 2 Times / Summer & Winter

Brief Facebook messenger discussions on basic demographics, interest

May 2023

Survey &
Interview

June-August 2023

2nd Survey &
2nd Interview

December 2023 – February 2024

Seasonal Surveys

- **<u>Home disruptions, size</u>**
  How many other people live in your home?

  Do you share a home with babies or children?

  How many other people sleep in the same room as you?

  Do you feel that your home is cramped due to too many residents?

Seasonal Surveys

- **Home disruptions, size**
  How many other people live in your home?

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  Do you feel that your home is cramped due to too many residents?

- **Sleep preparation, ease**
  During the past 4 weeks, what time did you turn off your electric lights?

  During the past 4 weeks, what time did you stop using electric devices with screens?

  Time-related factors: time of sleep, length of time to fall asleep, sleep duration

  Medications influencing sleep

Seasonal Surveys

- **Sleep quality questions**
  10 Sleep quality questions

- **Depression scale questions**
  50% of the Center for Epidemiologic Studies Depression Scale (CES-D)

- **Sleep preparation, ease**
  During the past 4 weeks, what time did you turn off your electric lights?

  During the past 4 weeks, what time did you stop using electric devices with screens?

  Time-related factors: time of sleep, length of time to fall asleep, sleep duration

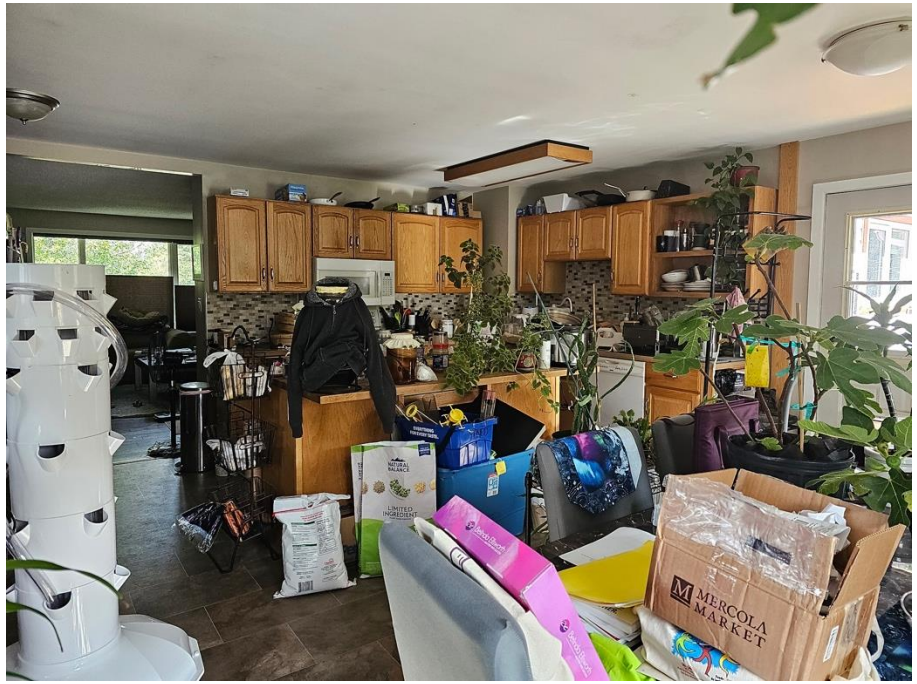
  Medications influencing sleep

Seasonal Surveys

- **<u>Shared images of rooms and lighting within</u>**: Discussed during interview

Living rooms

Bedrooms

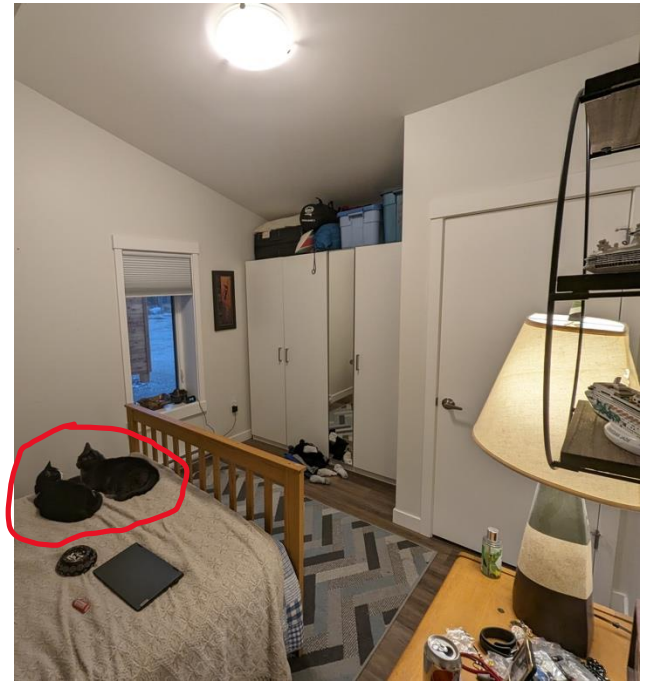


Kitchens

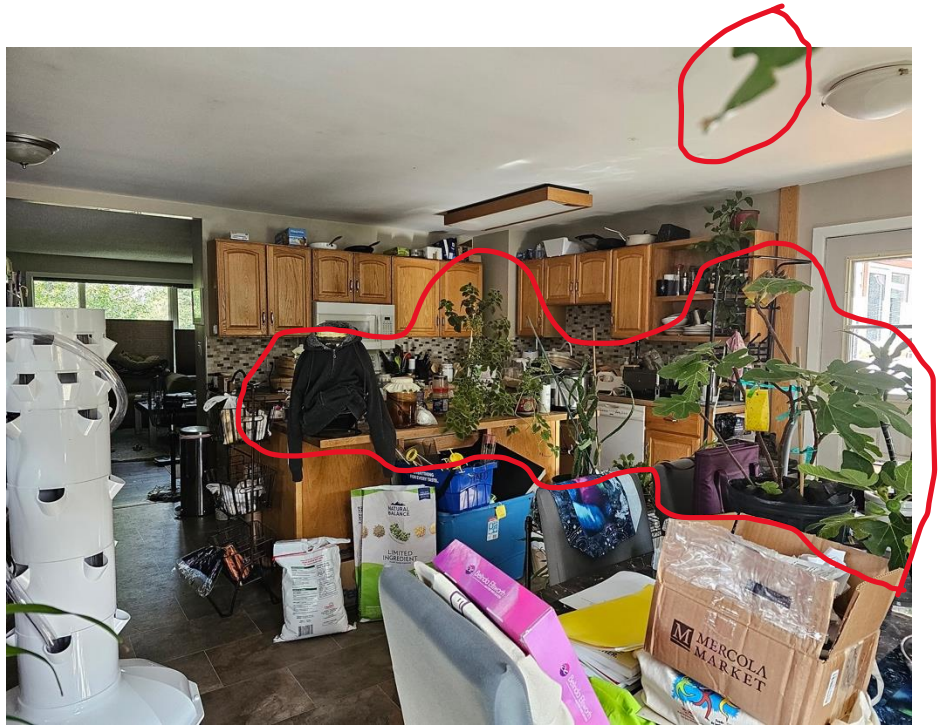
Seasonal Surveys

- **<u>Shared images of rooms and lighting within</u>**: Discussed during interview

Living rooms



Bedrooms



Kitchens

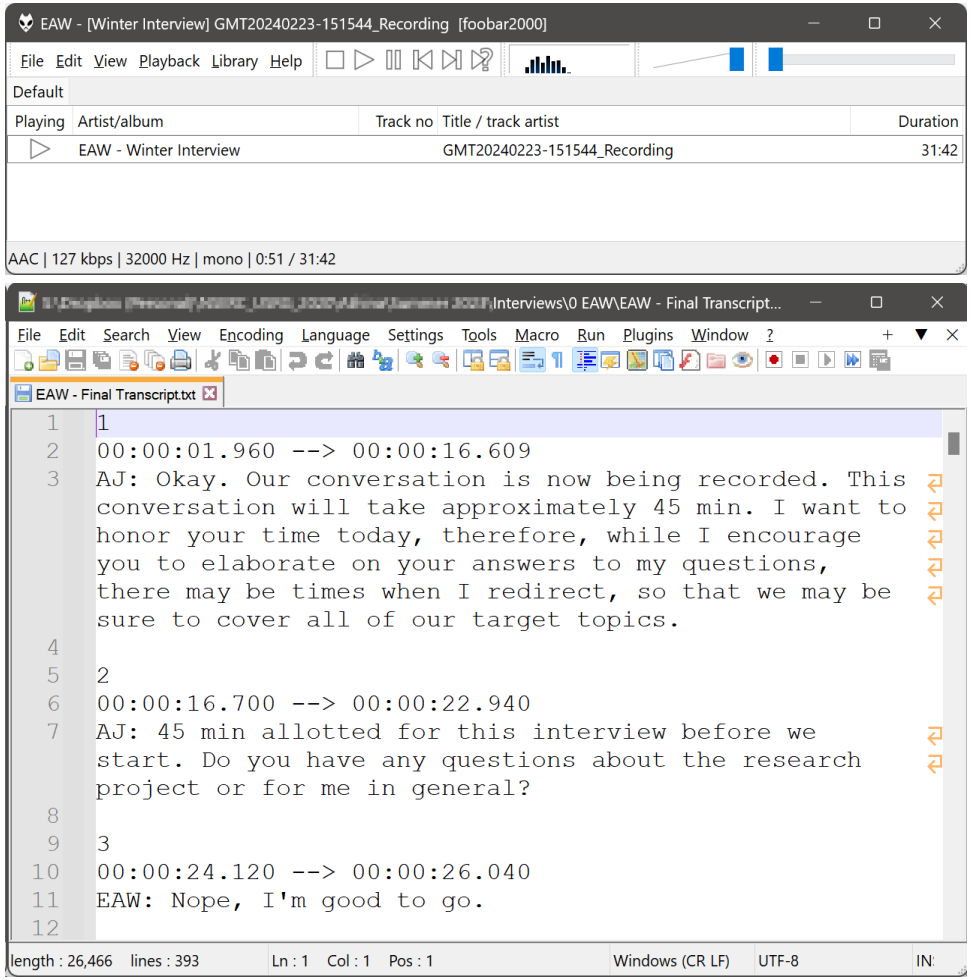
Seasonal Structured Interviews

- Typical weekday time of use data

- Discussion of images / lighting for each room
  - Physical description: colour, orientation

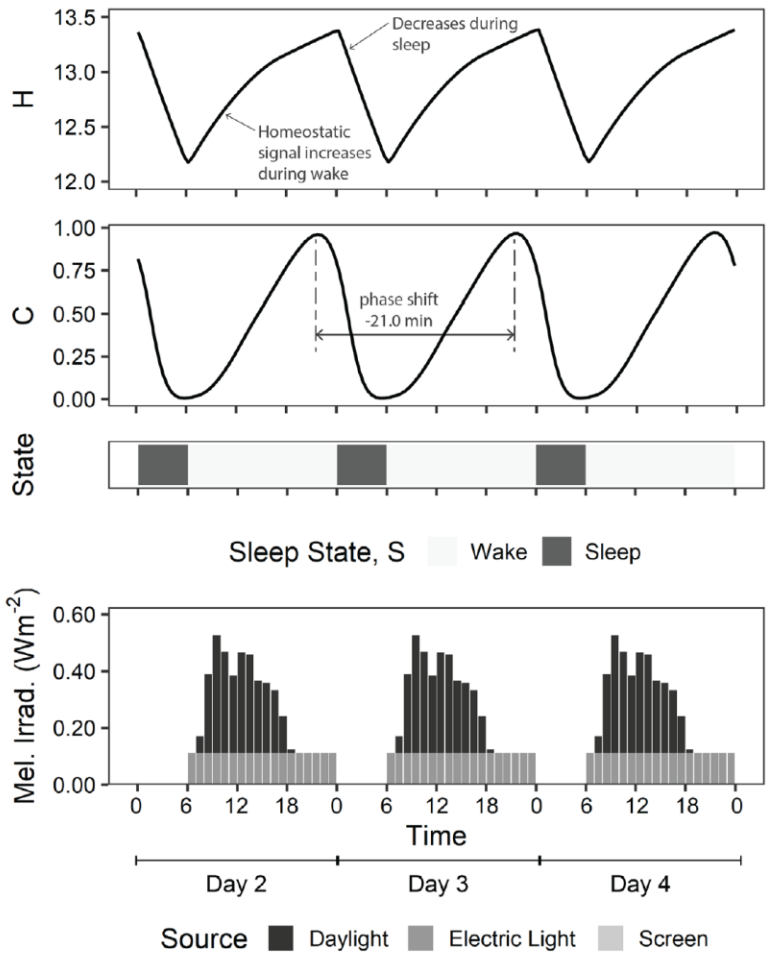
  - Use patterns of lights, shades

- Discussion of reported…
  - Daylight quality
  - Electric lighting quality
  - Sleep and health quality



Each interview is recorded, auto-transcribed and checked for accuracy

Postnova et al. model



← Homeostatic system
Controlled by sleep/wake

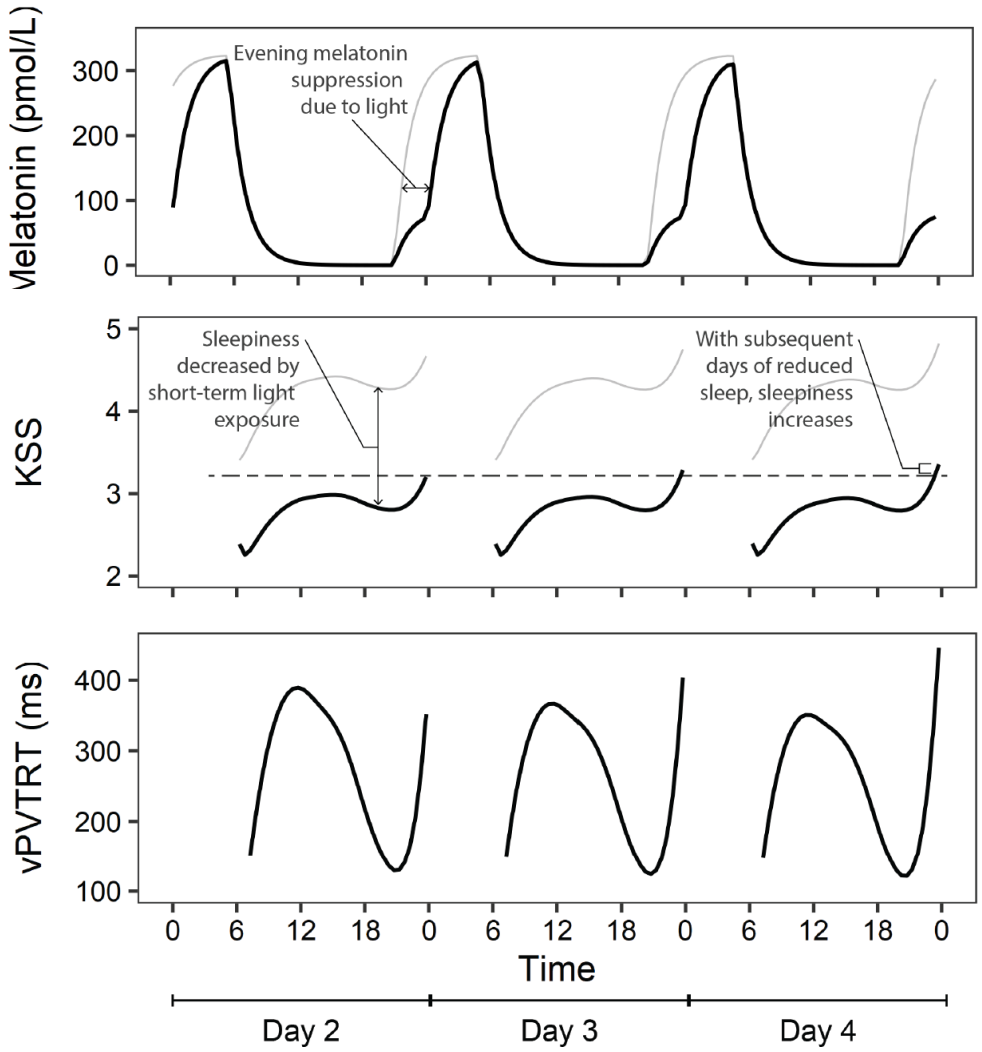
← Circadian system
Controlled by light and
Non-photic factors (sleep/wake)

← Sleep
Scheduled
Wake: 6 - 24
Sleep: 0 - 6

← Melanopic Irradiance
Calculated from daylight, electric light, monitor screen use, and control schedules

- We implement the photobiological effects model by Postnova et al. (2018), Abeysuriya et al. (2018) and Tekieh et al. (2020).
- The model predicts homeostatic and circadian effects on alertness and productivity.
- See Our 2022 Radiance Workshop presentation (Alight and Jakubiec) for more details.

Postnova et al. model: Outputs



- Melatonin suppression
  Expressed as the percentage of melatonin suppressed compared to no light exposure.

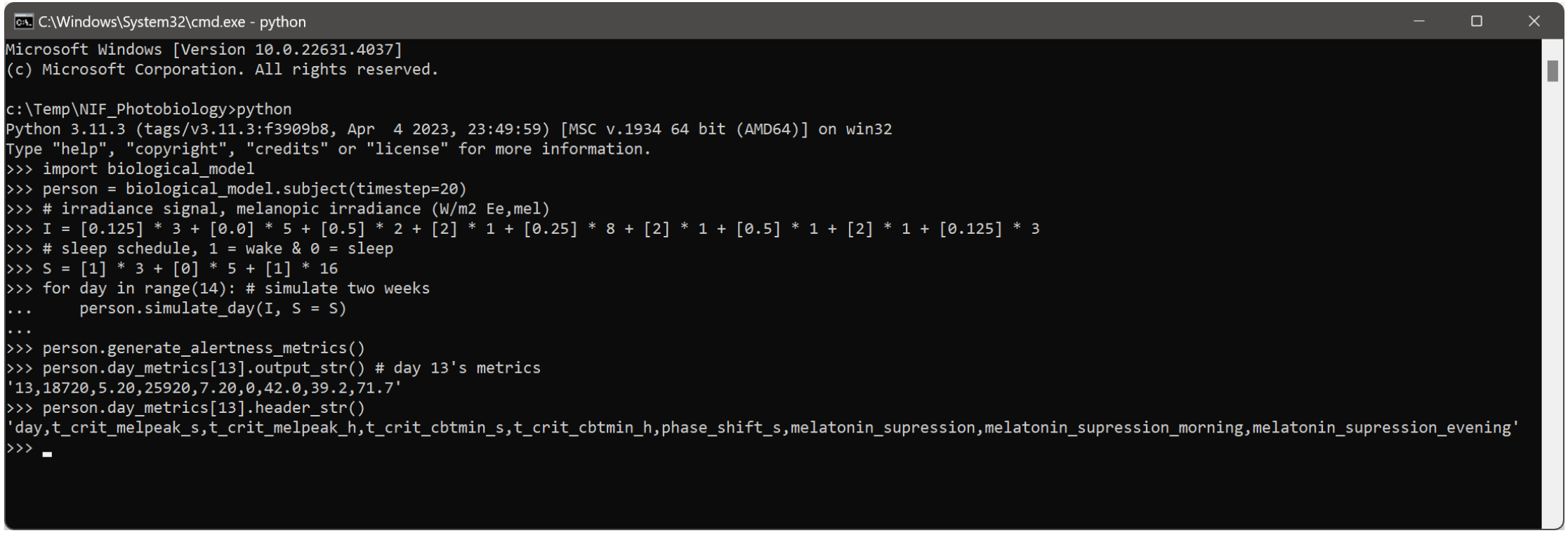
- KSS - Karolinska Sleepiness Scale

  1 - Extremely alert
  5 - Neither alert nor sleepy
  9 - Very sleepy, fighting sleep

- Average reaction time on a visual Performance Vigilance Test (vPVTRT)

  Lower is better / more alert

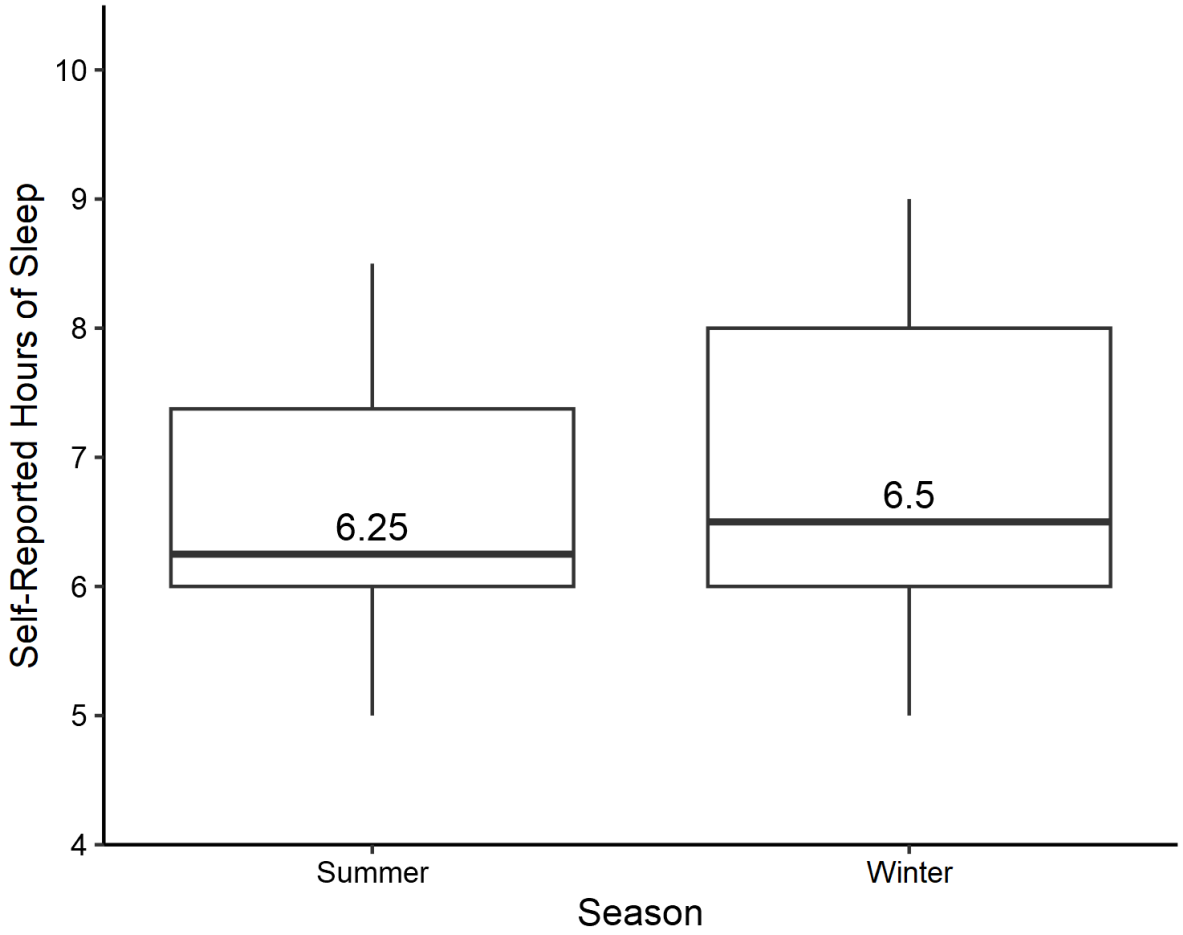
Postnova et al. model: Our Python module



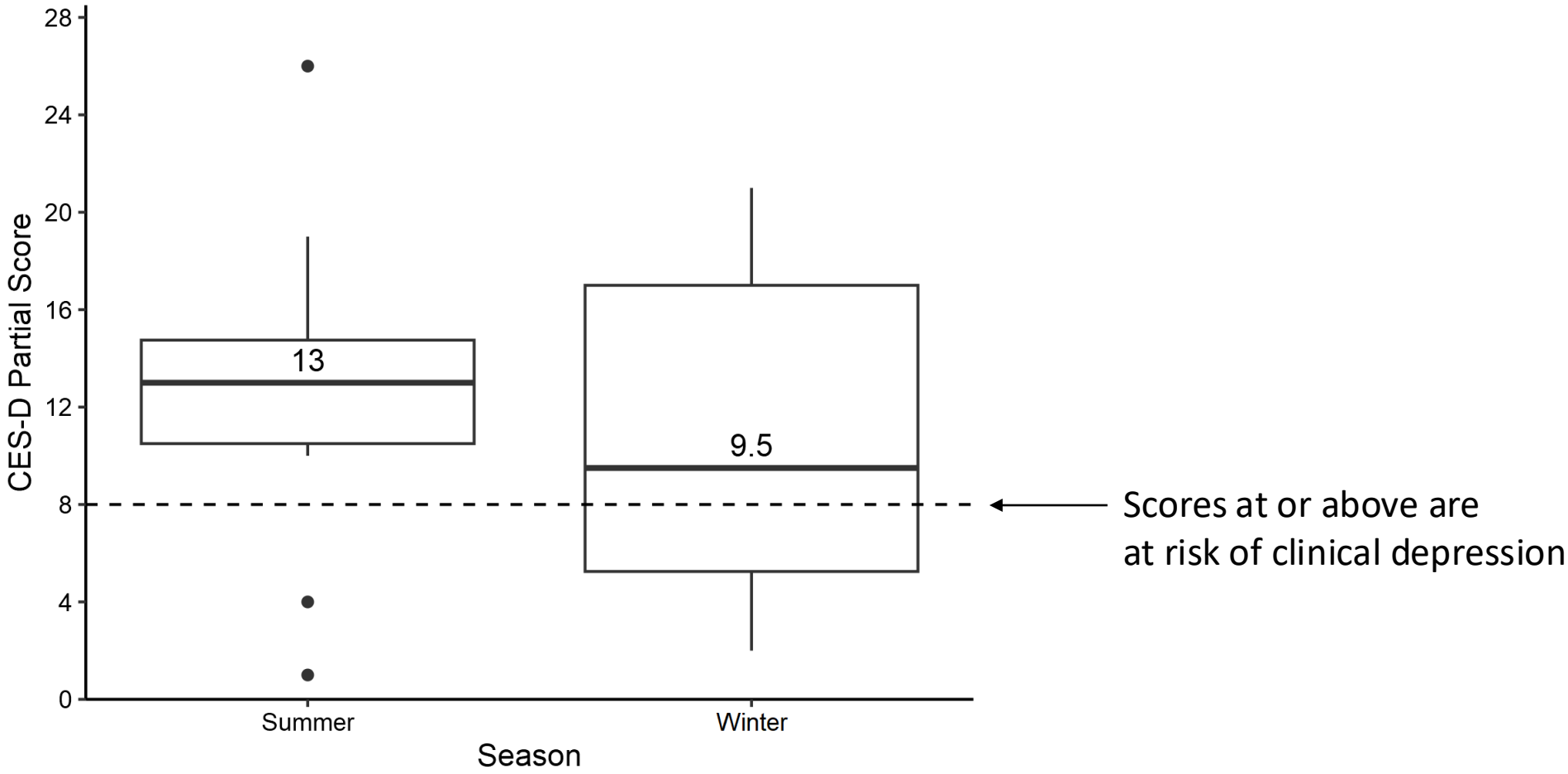
https://github.com/C38C/NIF_Photobiology

Early Days Results

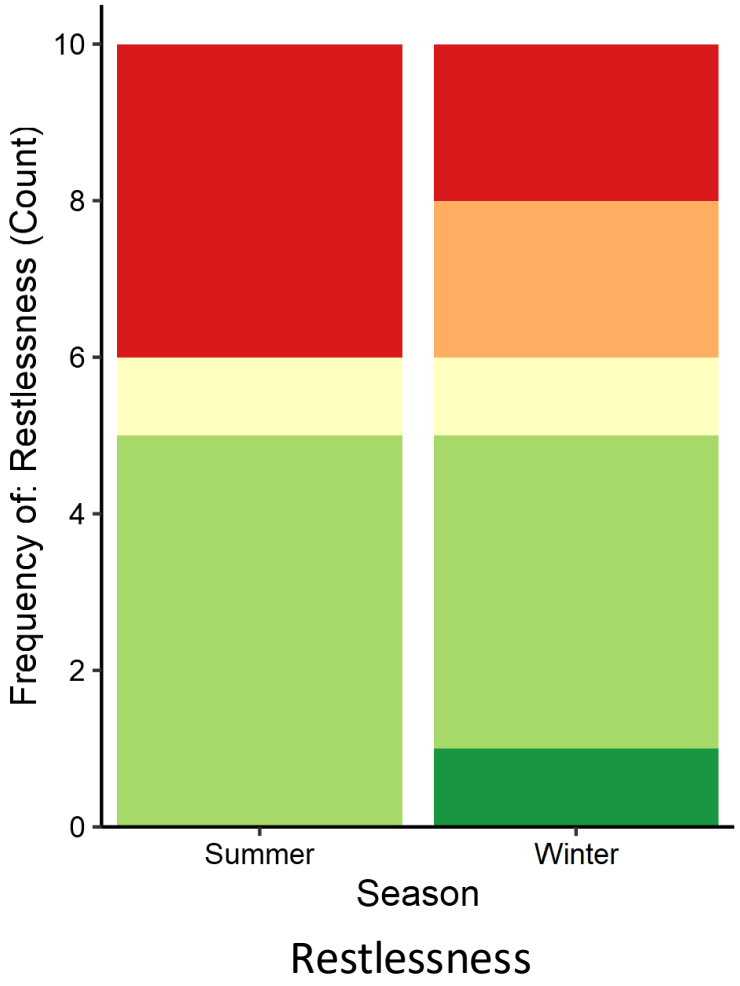
Overall seasonality: Hours of sleep



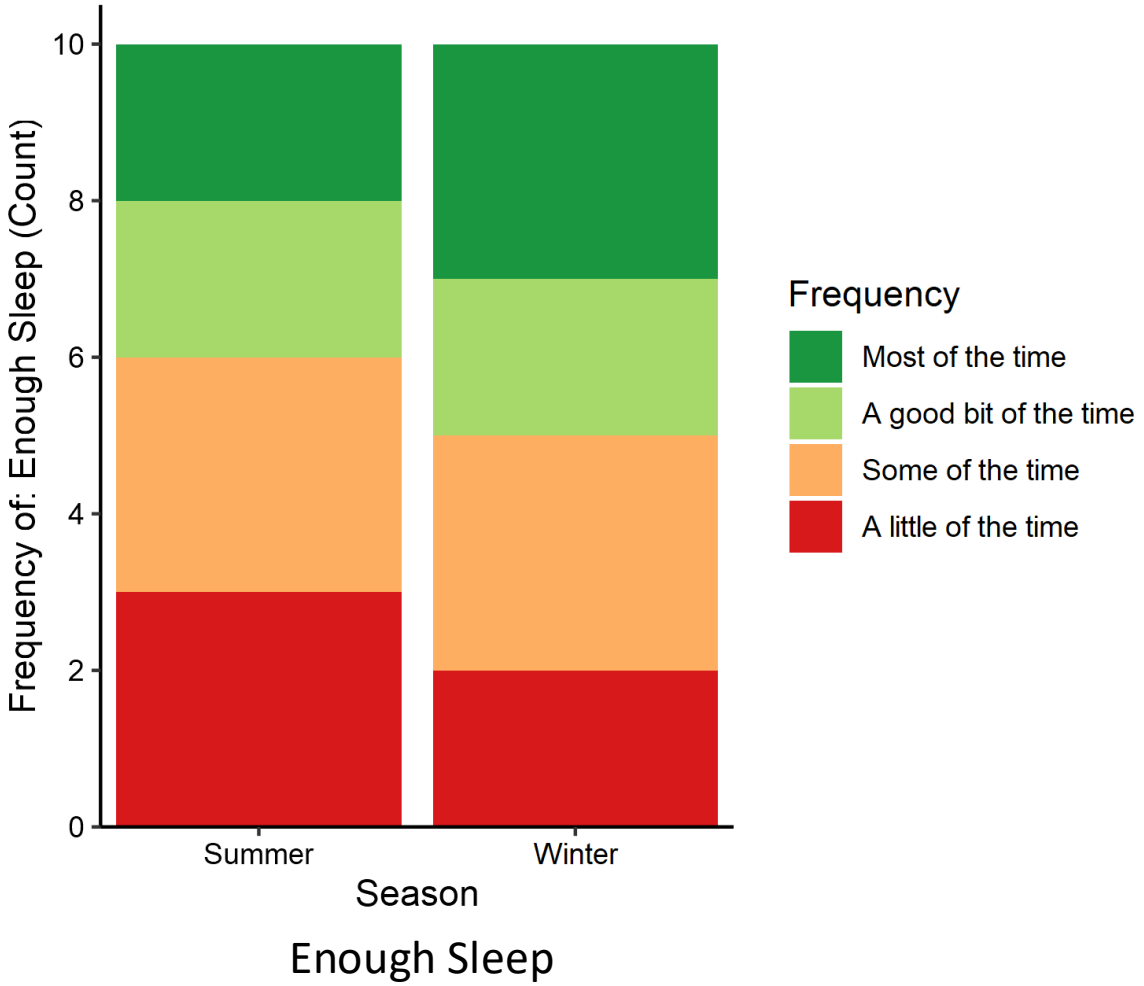
Overall seasonality: CES-D depression risk score



Overall seasonality: Sleep quality

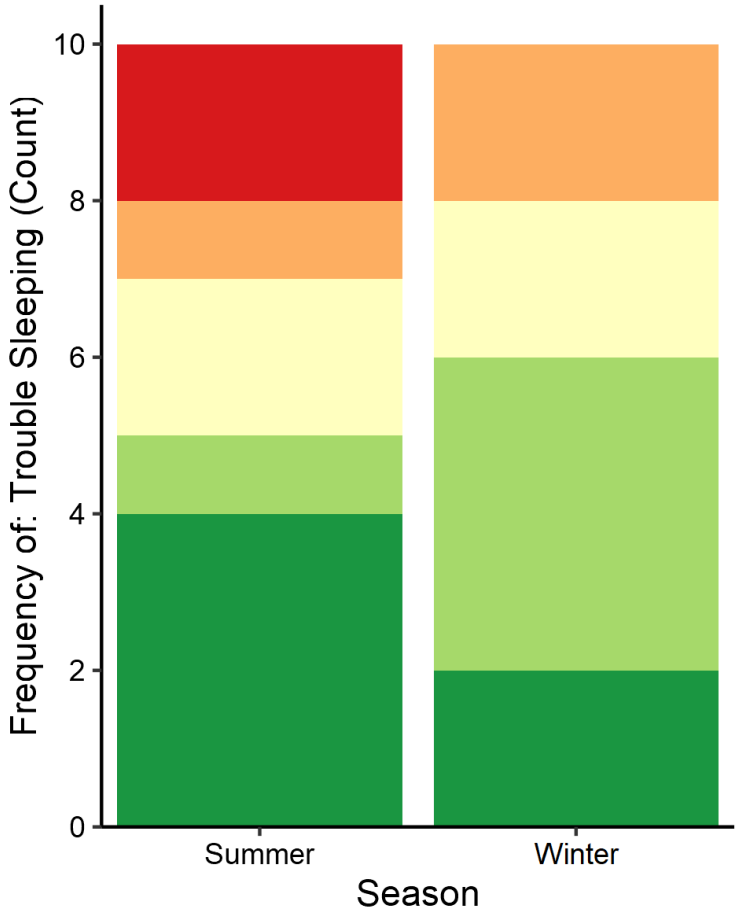


Restlessness

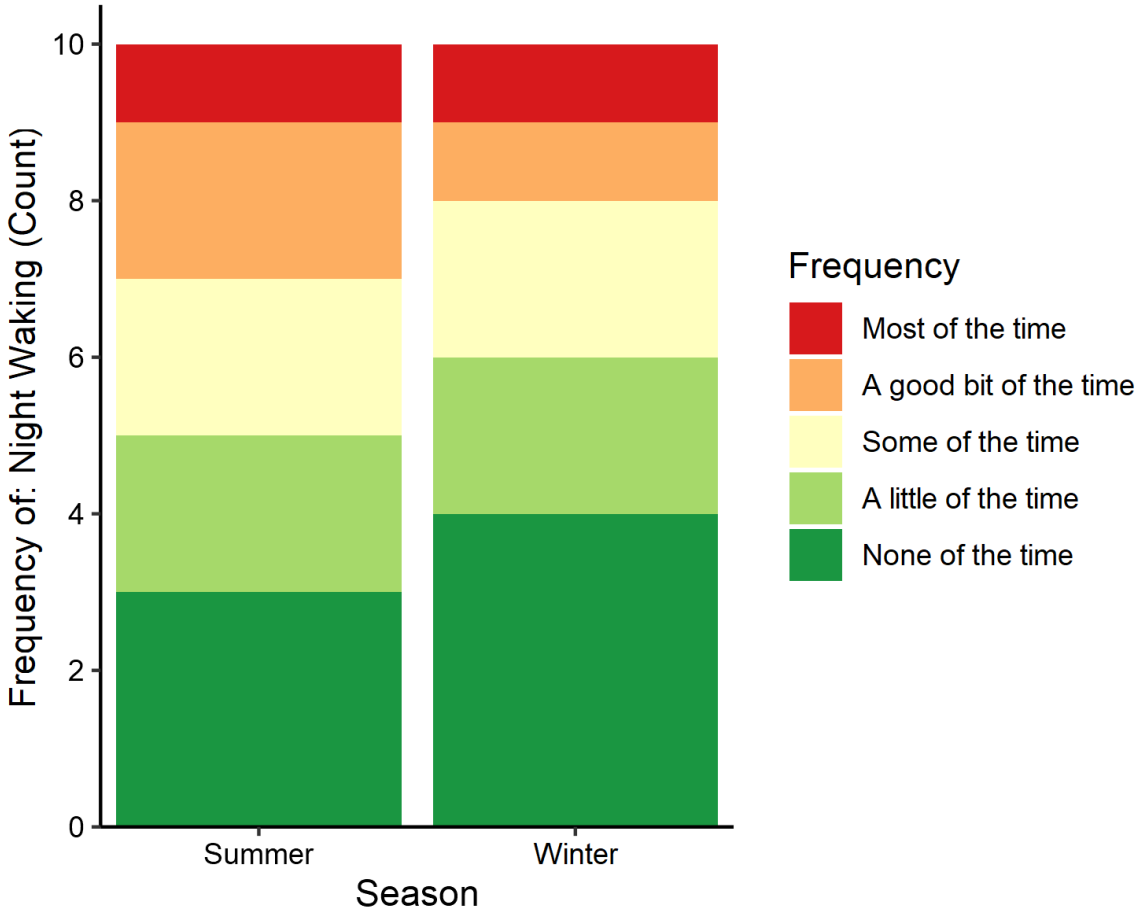


Enough Sleep

Overall seasonality: Sleep quality

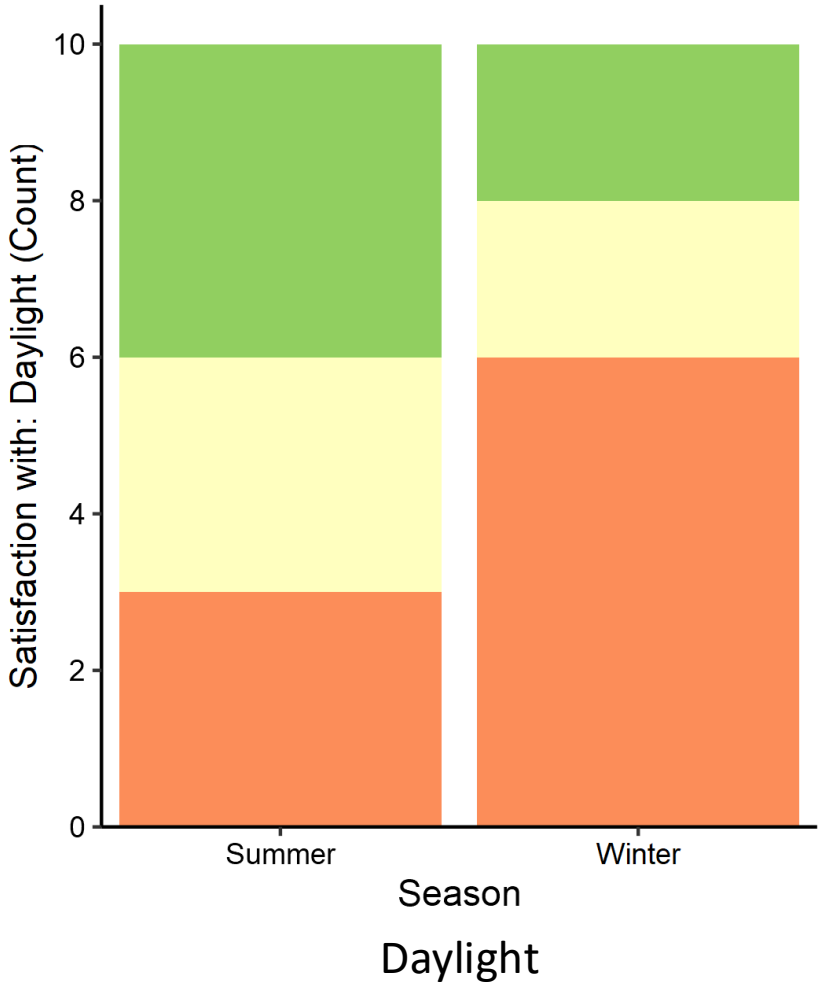


Trouble Sleeping

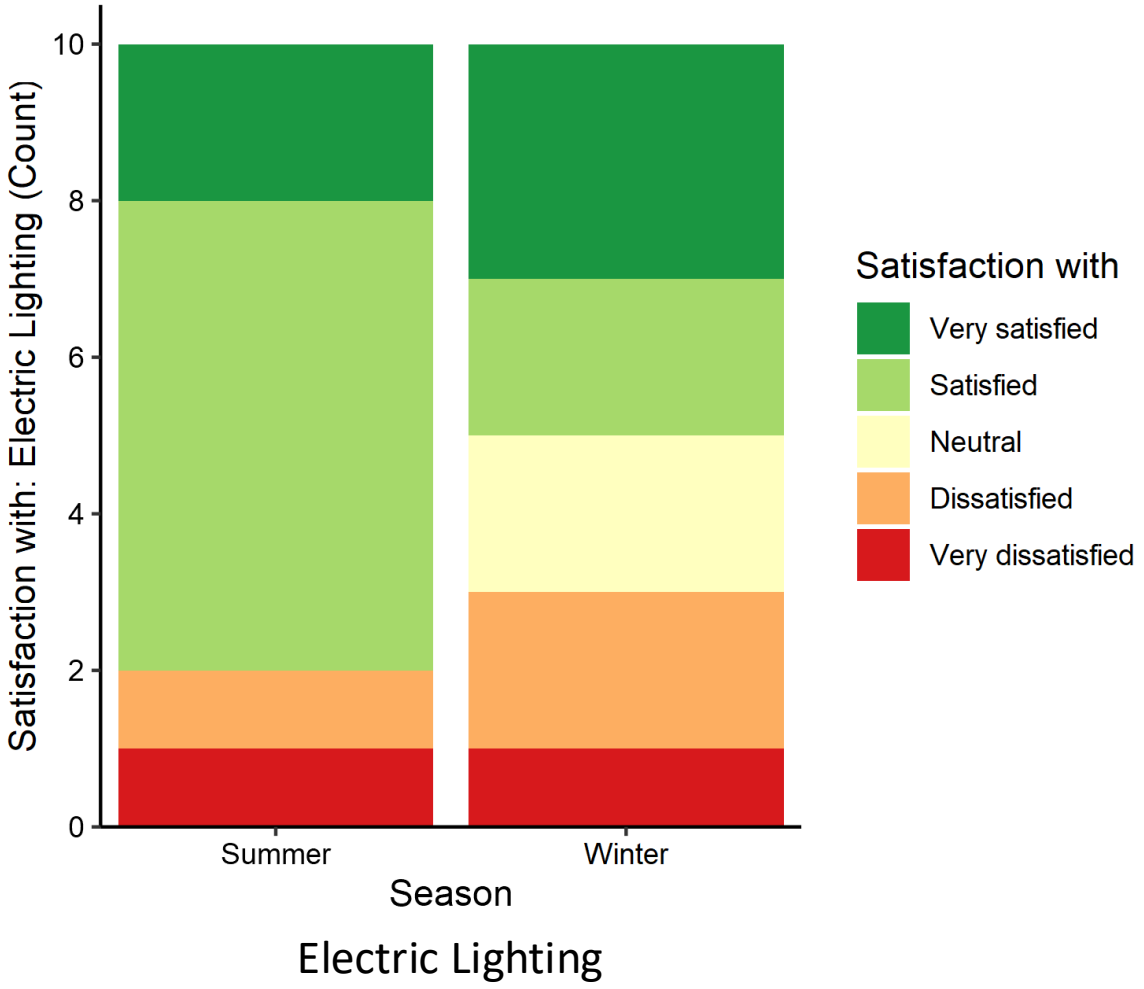


Waking at Night

Overall seasonality: Subjective satisfaction

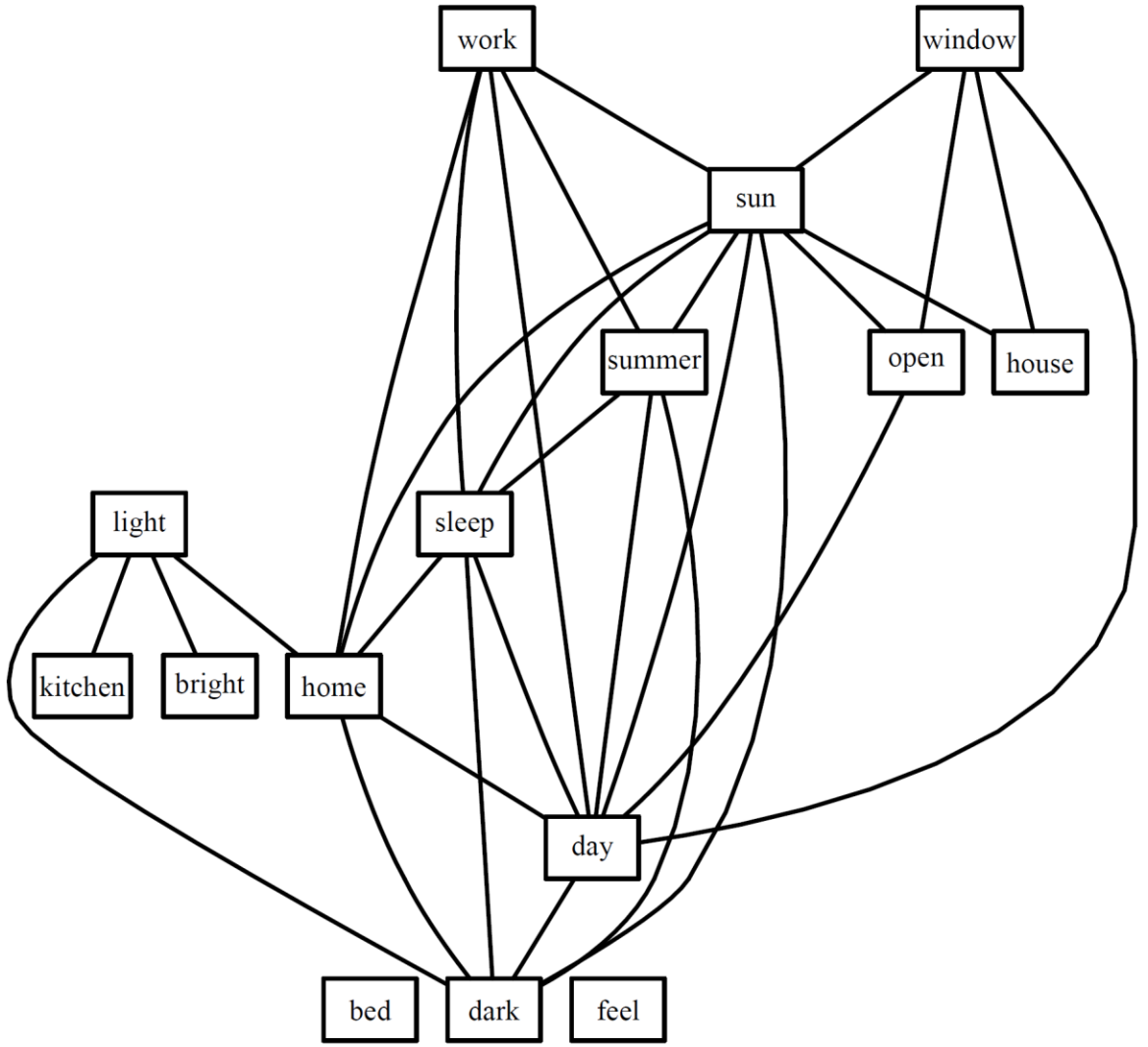


Daylight

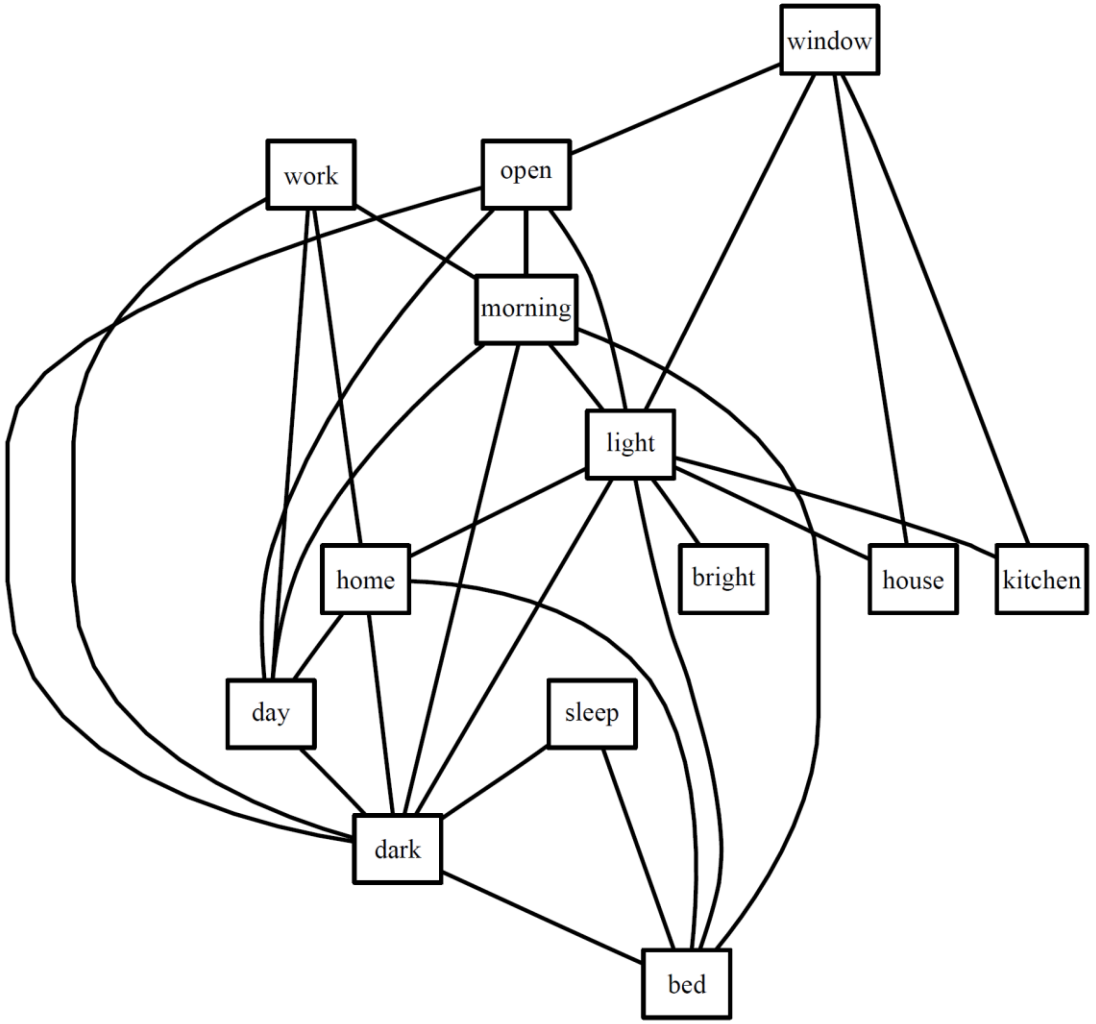


Electric Lighting

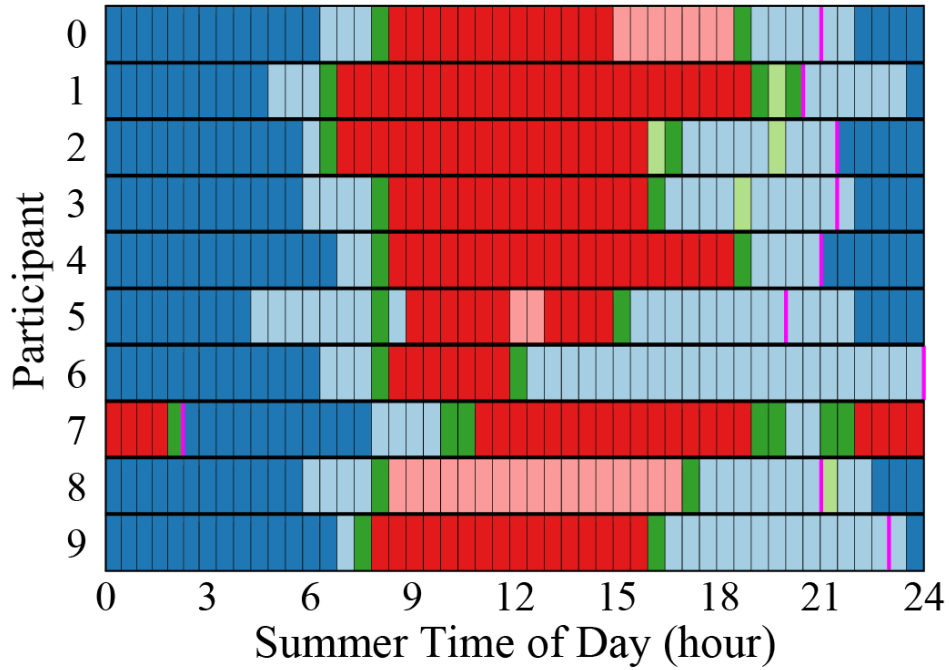
Seasonal Discussion Points Map: Summer



Seasonal Discussion Points Map: Winter

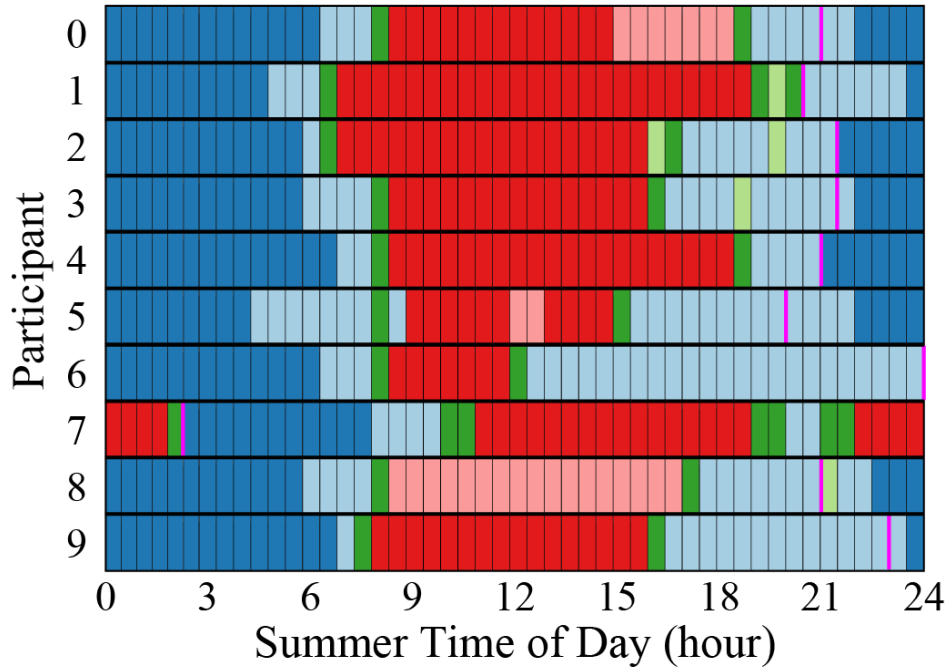


Seasonal sleep / wake / activity schedules



Participant Summer Schedules

Seasonal sleep / wake / activity schedules



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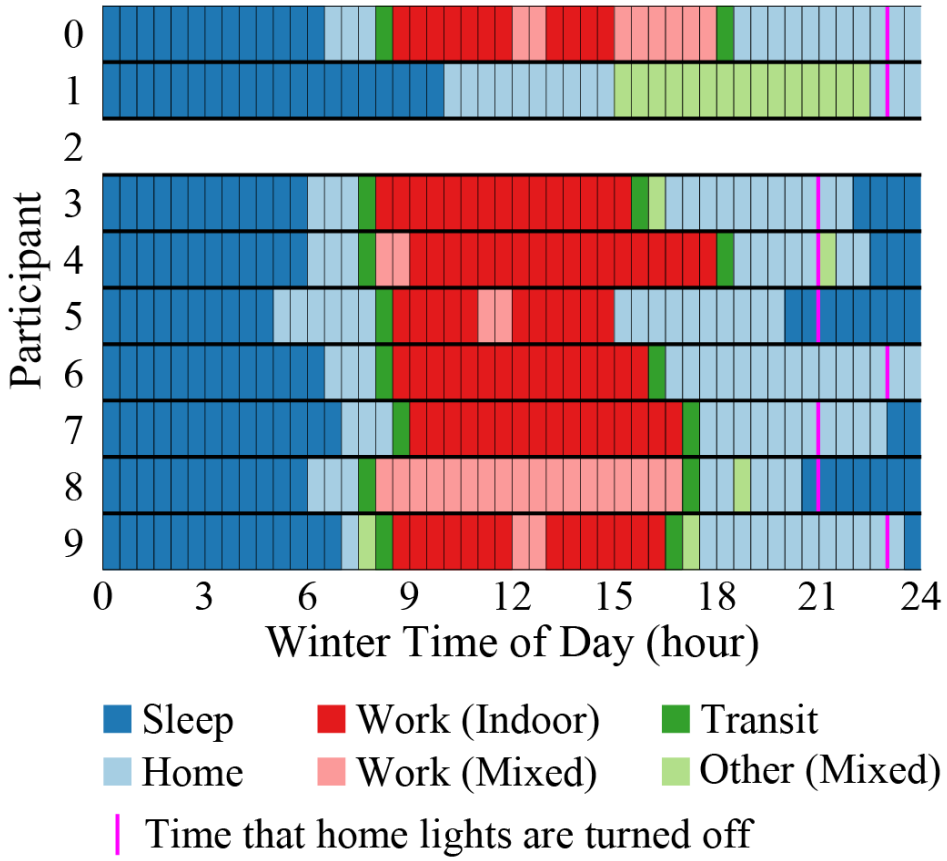
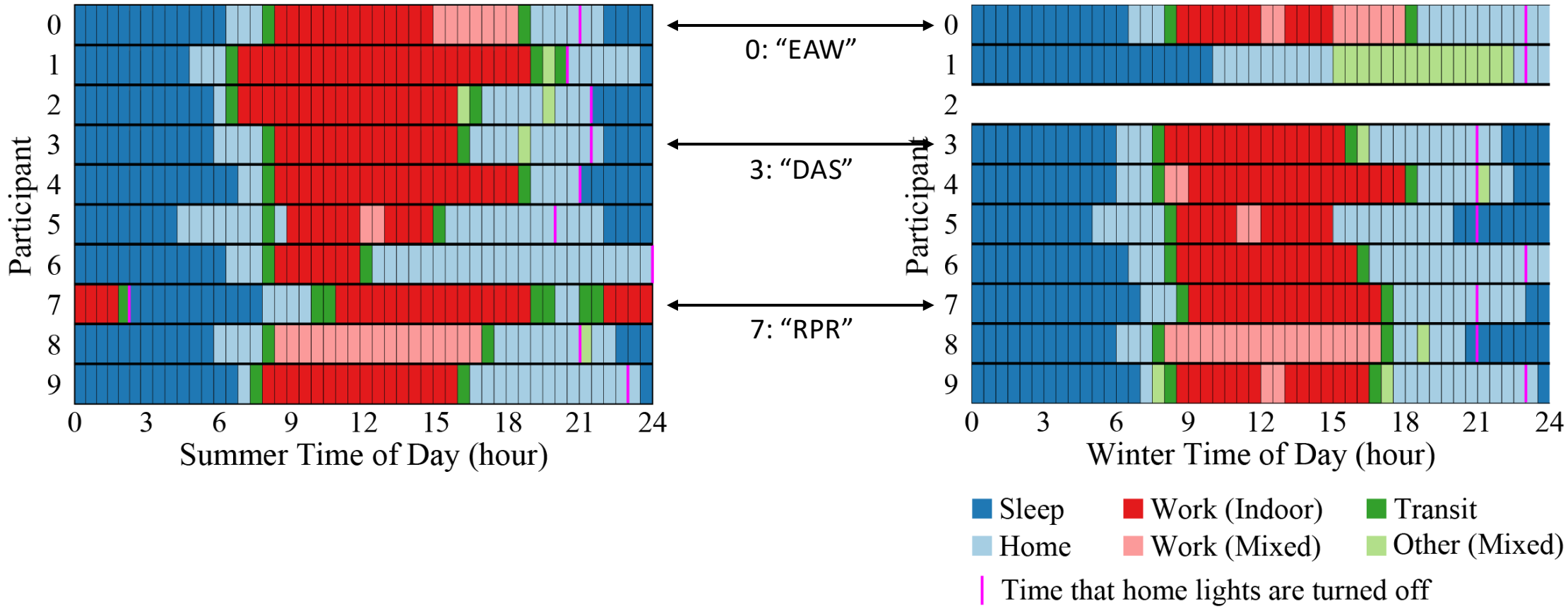


Participant Winter Schedules

Seasonal sleep / wake / activity schedules



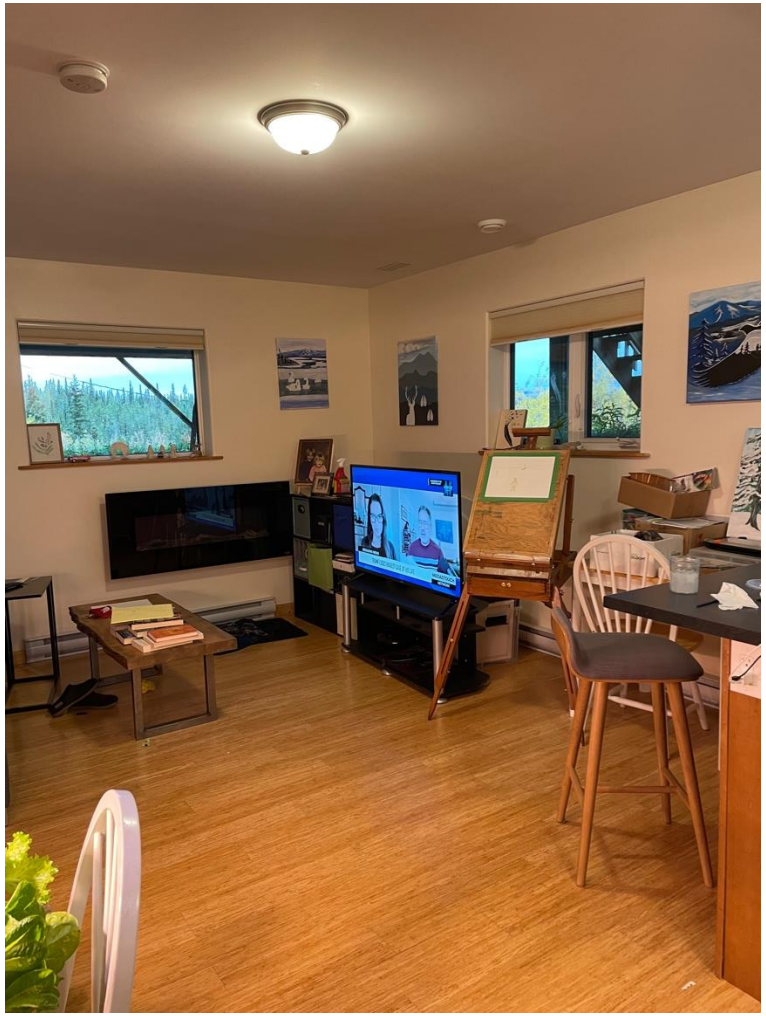
Participant Summer Schedules

Participant Winter Schedules

Seasonal differences

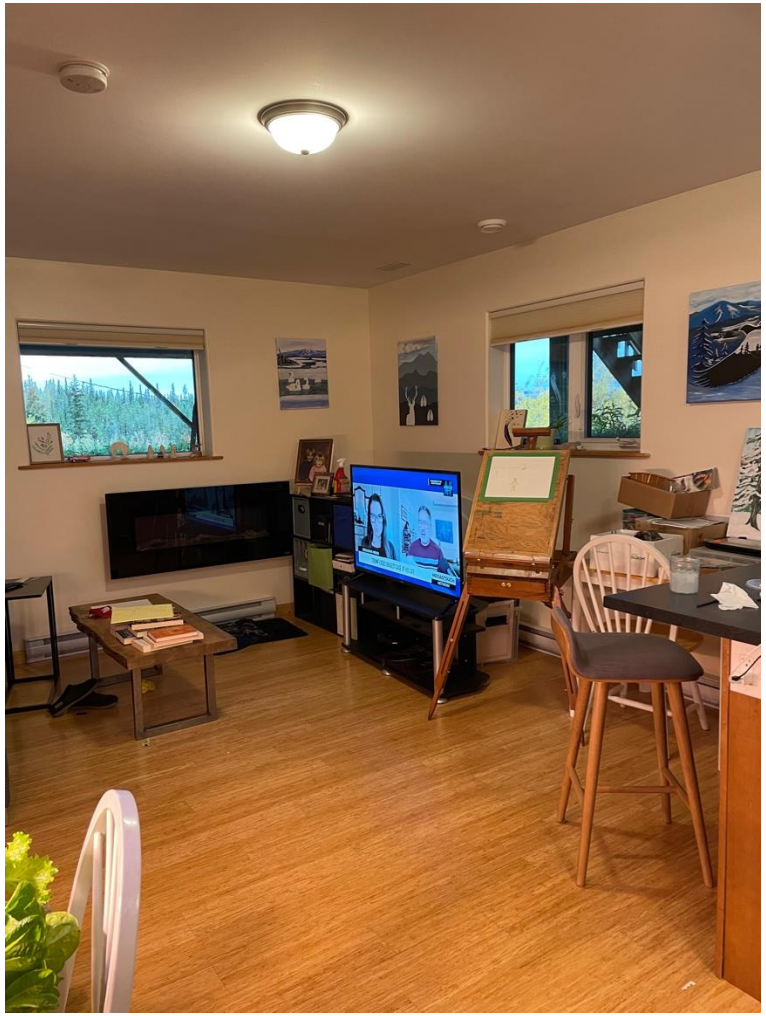
	0: “EAW”	3: “DAS”	7: “RPR”
Summer	11 pm bedtime Has trouble falling asleep 6 hours duration of sleep Feels sleepy during the day Takes melatonin CES-D score: 19	10 pm bedtime 8 hours duration of sleep CES-D score: 1	2 am bedtime Has trouble falling asleep 5 hours duration of sleep Feels sleepy during the day Takes melatonin, other drugs CES-D score: 26
Winter	11 pm bedtime Has trouble falling asleep 5 hours duration of sleep Feels sleepy during the day Takes melatonin, vit. D, steroids CES-D score: 21	9:30 pm bedtime 8 hours duration of sleep Feels sleepy during the day sometimes CES-D score: 2	10 pm bedtime Has trouble falling asleep 6 hours duration of sleep Feels sleepy during the day CES-D score: 20

Summer interview [0: EAW]



- Rents basement suite under deck of landlord. Views to the mountains.
- No direct sunlight due to orientation. Would prefer south rather than north (existing) exposure.
- Blackout curtains on windows during long summer days.
- Electric lights in rental unit aren’t bright enough and cast shadows on artwork. Tries not to use during Summer.
- Expresses problems sleeping due to early / late sunlight.
- Presence of light significantly changes pet care behaviour, transit to work.
- Controls noise (earplugs), evening light (timers), use of screens (sometimes unsuccessfully) to improve sleep.
- Chronic pain due to medical condition influences sleep, depression.

Winter interview [0: EAW]



- Snowpile from owner's deck in Winter blocks natural light.
- Recent hip replacement prevents clearing of snow.
- Uses 'daylight' lamps at work and home and plant grow lights as additional light sources during winter.
- Effected by SAD: uses electric light, vitamin D, and trips outside in Winter to treat. Mobility issues prevent too much outdoors activity.
- Low sun angle in Winter is a benefit, because it comes under the deck. Still, too dark due to length of day.
- Onset of darkness comes with anxiety, loss of garden, increased pet care supervision (wolves, moose outdoors).
- Uses growlights to create ambiance and indoor garden. Preferred to overhead lights.
- Sometimes wakes very early, 3 am. Also hard to get out of bed when it is still dark.
- Began taking antidepressants in Winter.
- Work also has poor natural light during Winter / recently moved to a cubicle with no view.
- "The darkest of dark, deepest part of the winter is the hardest part of the year."

Summer interview [3: DAS]

- Closes blinds only for thermal comfort and privacy reasons.
- Electric lights are too bright (recessed can lights), to the point where they are only turned on in adjacent rooms.
- Would prefer dimming controls or more diffuse luminaires. Plans to buy floor lamps to replace.
- Relatively large, unobstructed windows leads to good daylighting.
- Spend a lot of time outdoors in Summer: hiking, swimming.

Winter interview [3: DAS]

- Feels less energized, motivated in Winter.
- Uses light therapy (blue light device) to manage.
- Less motivated to go outside.
- Closes window shades for privacy in morning, evening but ends up leaving them closed all day.
- Electric lights are glaring, and in the Winter there is a conflict between daylight and privacy.
- As Winter comes to an end, natural light returning is satisfying.
- Still plans to supplement electric lighting with lamps.

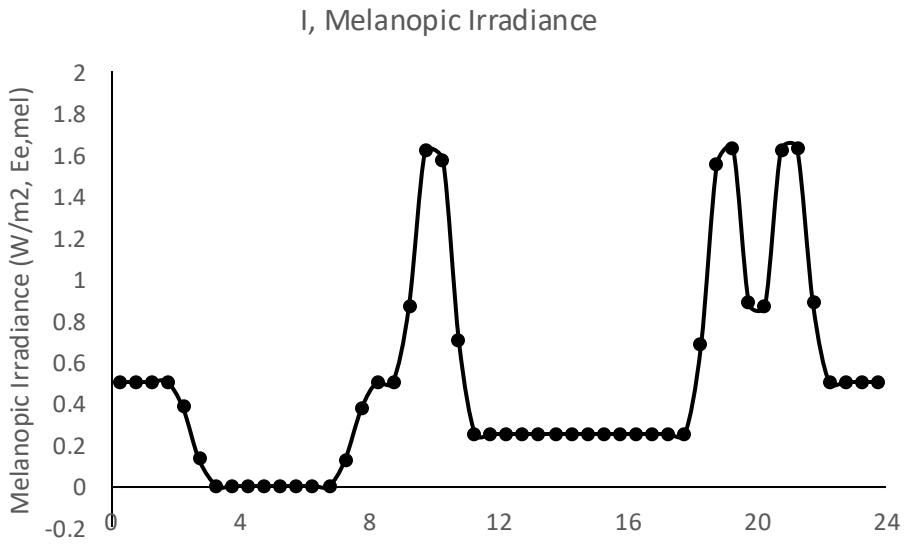
Summer interview [7: RPR]

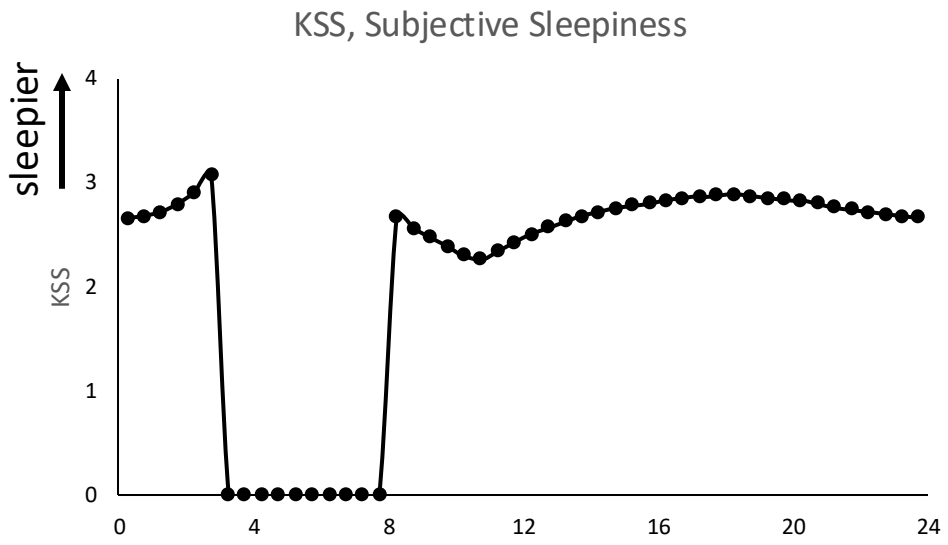
- Keeps curtains and window open for cat and for ventilation, when warm.
- In evening, TV is predominant light source. Disability prevents moving to turn on / off lights.
- Ceiling lights are too bright, so decorative string lights were purchased (but destroyed by cat).
- Would prefer dimming controls on light.
- Wakes up early in summer (4-5am) even with blackout shades and due to circadian rhythms of cat.
- Falling asleep is a long ritual taking 2-3 hours (de-stress, yoga, sleeping pill).

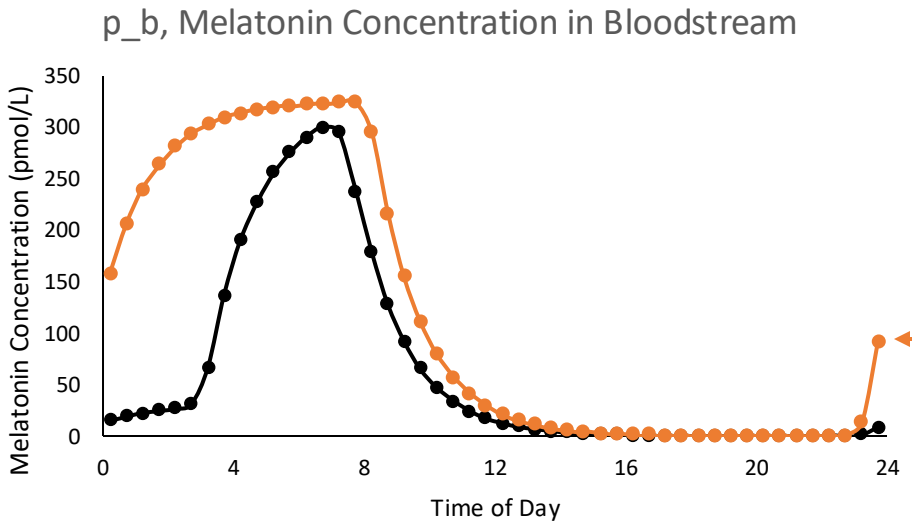
Winter interview [7: RPR]

- Curtains are predominantly closed in Winter, to provide additional insulation against cold. Opens when warmer (>-10 C).
- Cloudy winter climate doesn't provide enough light even with curtains open.
- Reports severe difficulties waking up during Winter and feeling less functional until the sun is up. Feels less energized.
- Limited in improving lighting by rental limitations and cat destruction.
- Lights are often on in Winter, but feel too harsh and uncomfortable. Would prefer dimming.
- Tries to reduce screen devices at night (e.g. laptop use, TV).
- Struggles with mood, depression in Winter.

Loose simulation of participant RPR in summer

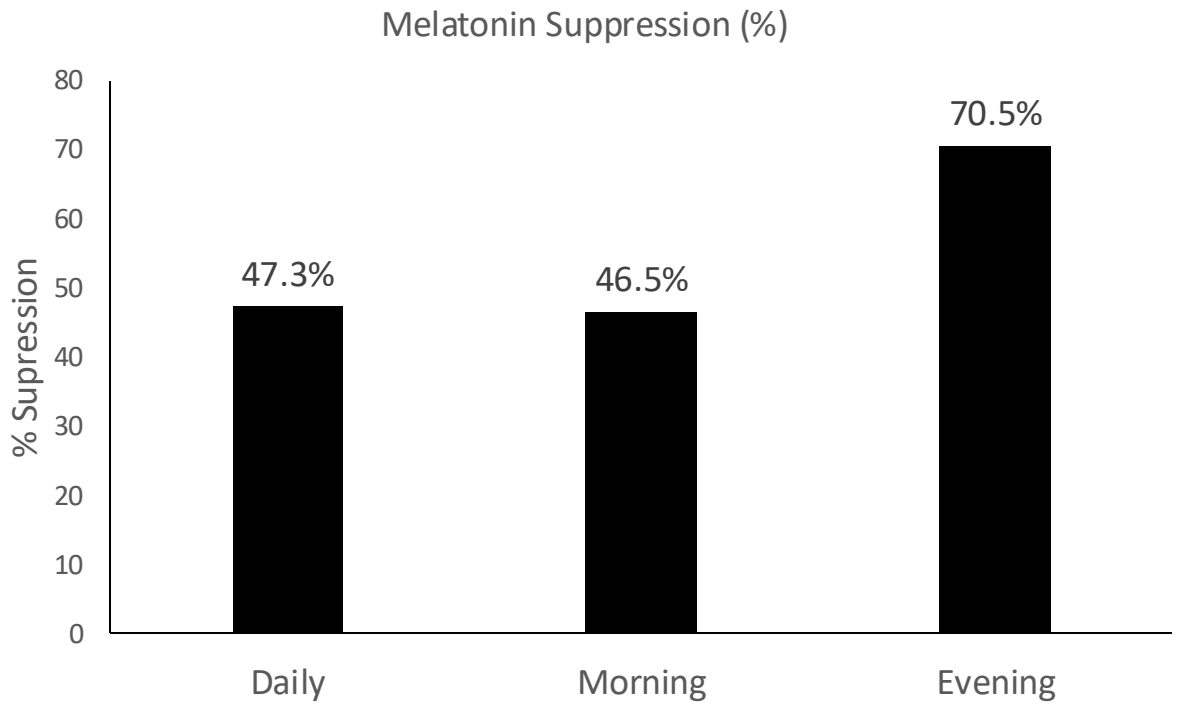






Max. Melatonin in bloodstream

Loose simulation of participant RPR in summer



- Phase shifted +2 hours 10 minutes compared to a ‘regular’ sleep / wake / light schedule.
- Extreme predicted melatonin suppression of 47.3% (not accounting for melatonin pill consumption).

Future work / discussion (and Radiance??)

- More systematic parsing, interpretation of interview transcripts using something like NVivo.

- Take advantage of our Radiance simulation models and photobiological calculations in combination with behavioural, health, preference archetypes from our study.

- Test:
  - Individual reported behaviours → light levels & photobiological outputs
  - Architectural types / materiality → indoor light levels
  - Electric lighting design (from observations) → indoor light levels

- Large data collection vs. individual, detailed collection

Thank you!

J. Alstan Jakubiec

University of Toronto & Solemma, LLC

alstan.jakubiec@daniels.utoronto.ca

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