APPENDIX 13.3
REFLECTIVE SOLAR GLARE ASSESSMENT

3. Appendix 13.3 – Reflected Solar Glare Assessment

3.1 Introduction

It is considered that the effects of reflected sunlight from the proposed buildings envelopes should be predicted and understood. The purpose of the study is to investigate whether sunlight reflections could be experienced by the train drivers. The study will aid planners and Network Rail to understand the location and duration of any sunlight reflections from the envelope of the proposed development

3.2 Methodology and assumptions

A reflected solar glare assessment has been carried out. This is to assess the frequency of reflected sunlight being visible on each of the tracks adjacent to the proposed development, and, in the instances when reflected sunlight lies within a 30° angle to the sight line of the train driver, to carry out a veiling luminance assessment. By doing so it is possible to evaluate the effects of the proposed development for reflected solar glare. The assessment of veiling luminance is based on the Hassall method (*Dealing with Rogue Solar Reflections* (1996)).

In details, the following method is used:

- The first step is to identify the track location, their direction of travel and setup the train positions. Each train observer is located at 10m spacing along each track, and 2.75m above the ground. Assumptions are made for location and solar geometry using longitude and latitude of the site, as for the sunlight and daylight assessment. The effects of weather are ignored.
- Once the observers are defined, a ray tracing algorithm is used to determine the instances of reflected sunlight to each observer, from the reflective surfaces of the proposed building. These surfaces are not yet characterised in their physical properties, but are either considered reflective or not, and thus analysed or disregarded. The test is as follows: Is reflected sunlight visible on the reflective surface? If so, when is the time at which such reflection become visible?
- The resulting data is collected and processed to create a series of diagrams which illustrate, for each observer, the instances in which the sunlight is reflected. These instances are further analysed and filtered. Only the instances in which reflected sunlight is within 30° angle to the line of sight of the observers are processed further. In fact, when reflected sunlight is beyond such angle, the likeliness of glare is extremely low. The diagrams show this by differentiating the data points in red (within the 30° angle) and black (outside this angle).
- The instances of reflected sunlight when the reflected images are within the 30° angle are further processed. A ray tracing simulation which accounts for the physical properties of the building surfaces is carried out, for each instance and for each view. These images are then processed to derive the value of veiling luminance corresponding to each instance. These values are compared to the target of 500 cd/sqm.
- Instances in which the veiling luminance exceeds 500 cd/sqm are considered critical and further reviewed. The instances in which both reflection of sunlight and direct view of the sun are present, are not considered problematic, whilst instances in which reflected sunlight is the only source of glare present are.
- When instances of veiling luminance exceeding 500 cd/sqm mitigation measures or other considerations are necessary as this is considered critical.

The following assumptions have been made in respect to the material of the proposed building and surrounding areas:

- Surrounding landscape, matte material with 20% reflectance
- Existing buildings, matte material with 50% reflectance
- Proposed buildings, matte material with 50% reflectance
- Glazed areas, glass surface, transmission of 70% and refraction index of 1.5

- Metallic finishes, material with 50% semi specular reflectance.

The tracks analysed are shown in the following image and include 351 observers.

These include the following observer designation:

- Track 1: 272 to 351, direction South.
- Track 2: 78 to 154, direction North.
- Track 3: 221 to 271, directions North/South.
- Track 4: 155 to 220, directions North/South.
- Track 5: 1 to 77, directions North/South.

Figure 30 - Image of site showing location of tracks with designation and direction. North is upward.

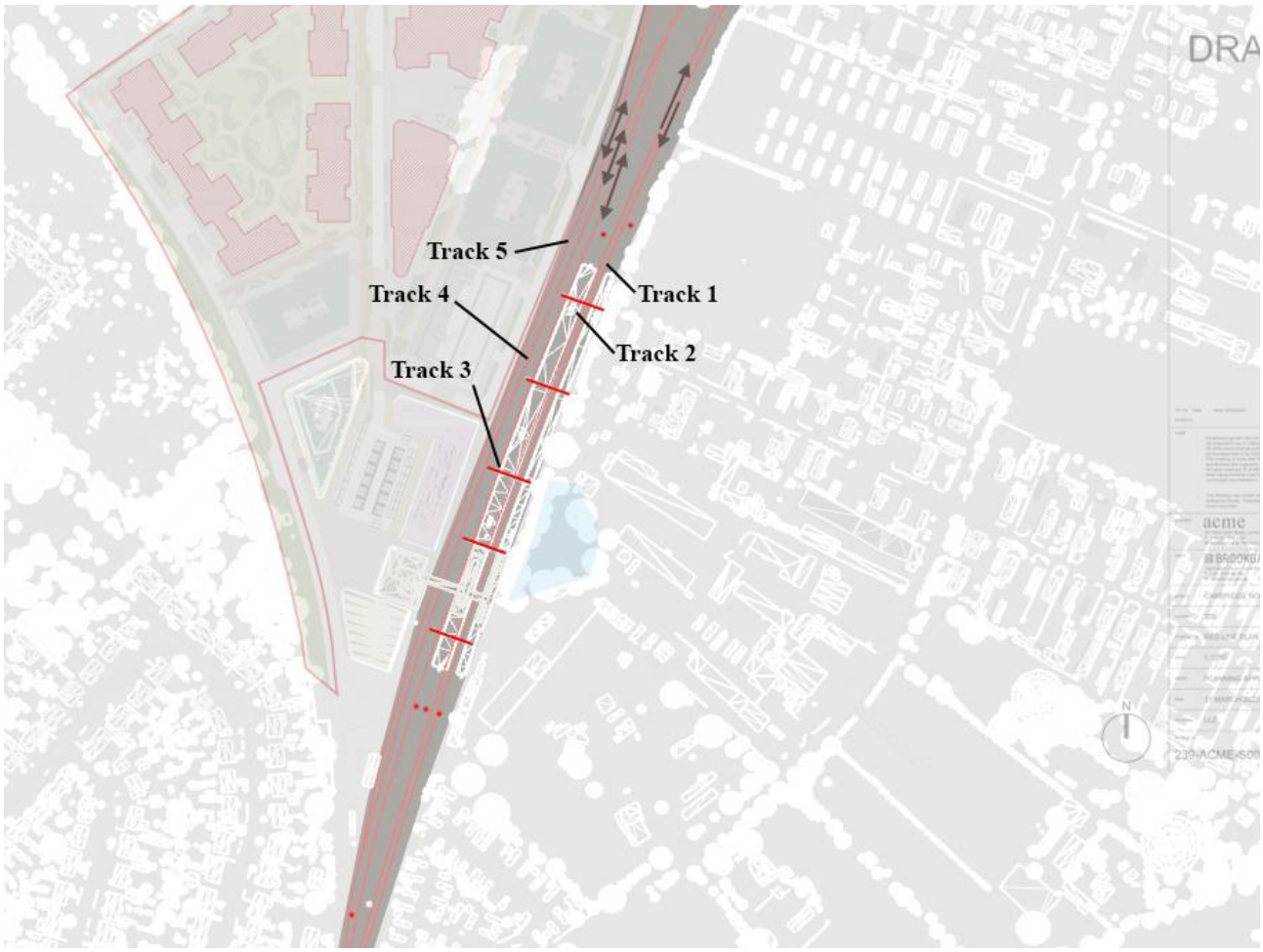


Figure 31 – Designation and position of the observers in each track, detail

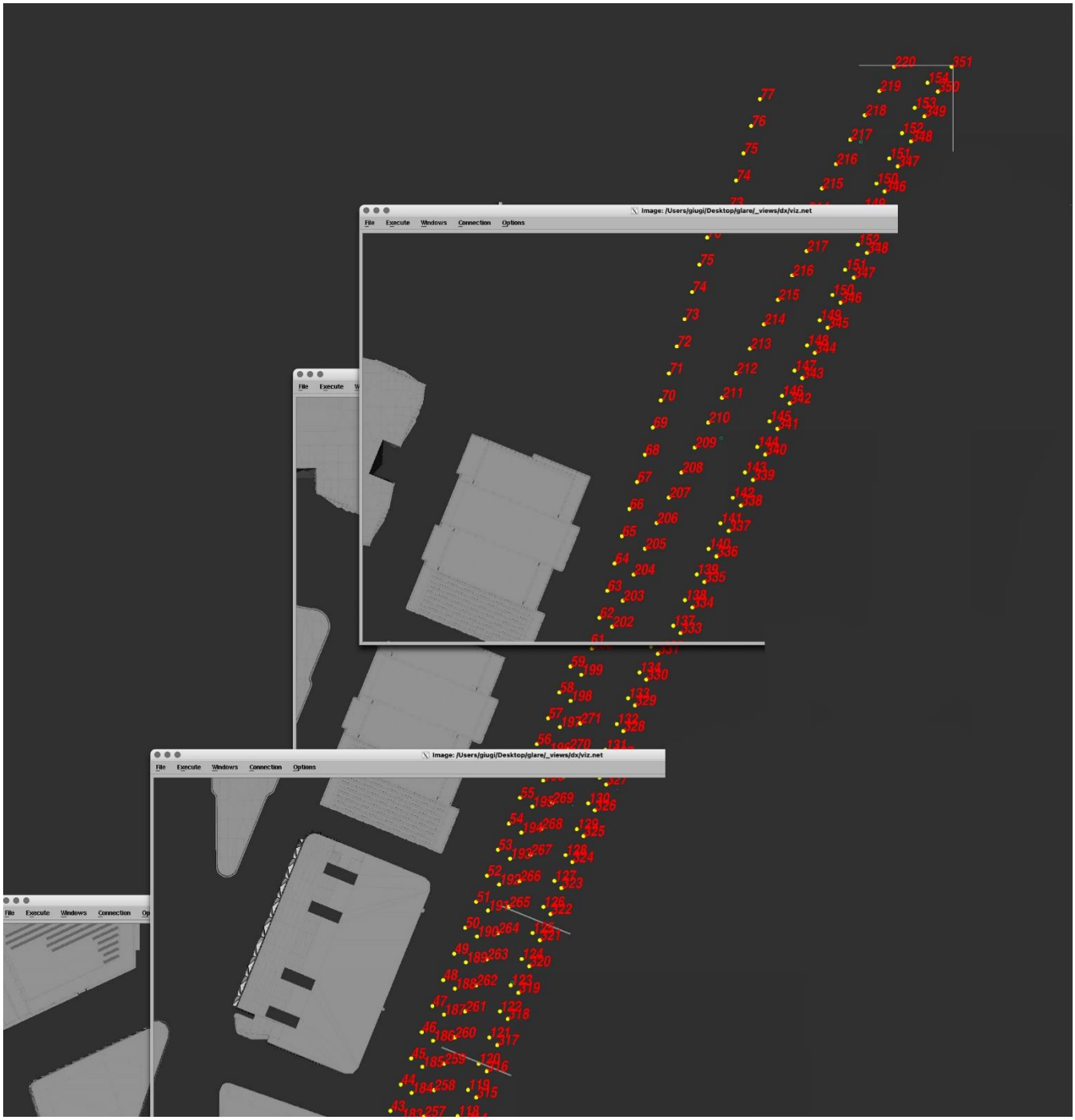
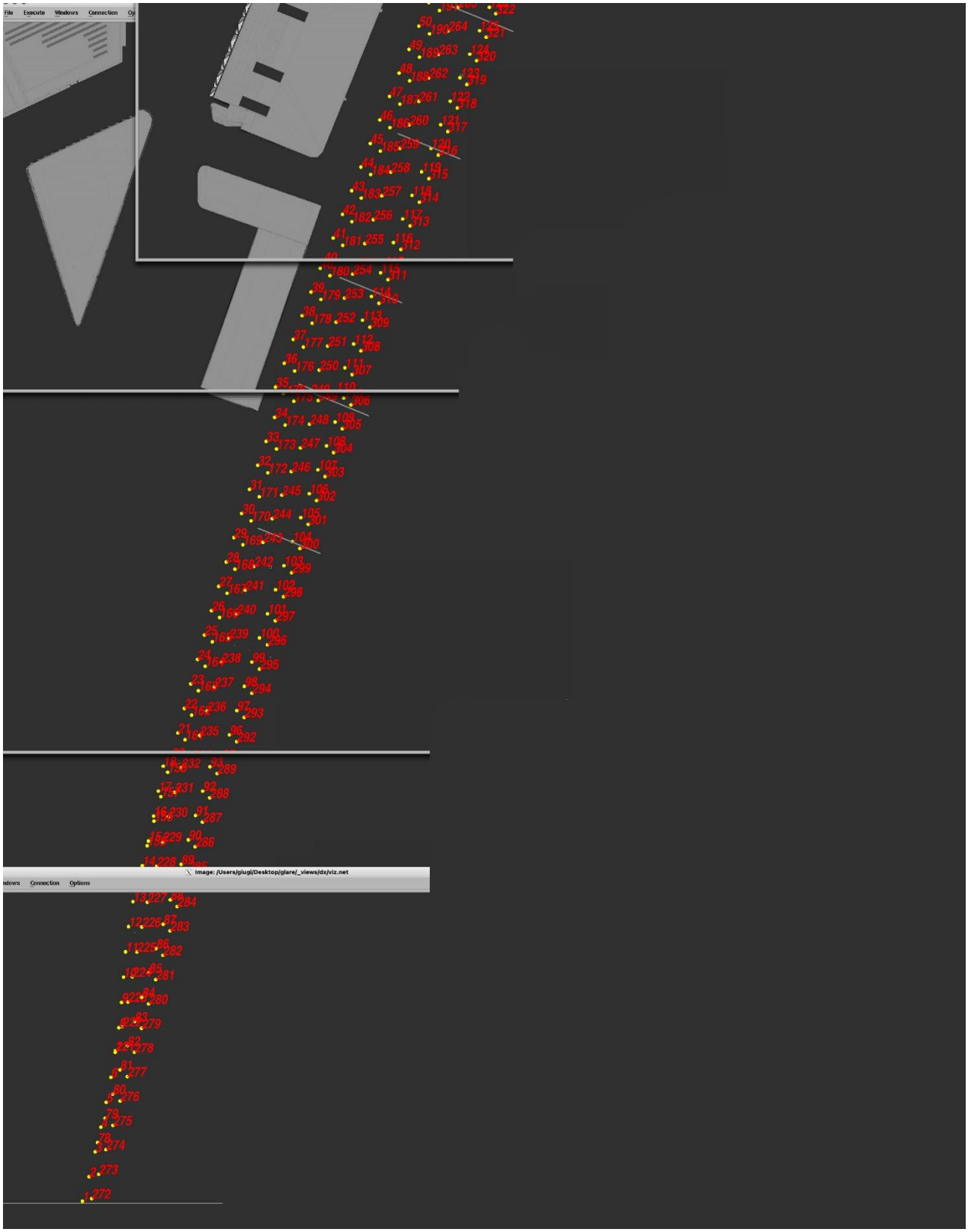


Figure 32- Designation and position of the observers in each track, detail



3.3 Instances of reflected glare to track through the year

The following diagrams show the distribution of reflected glare for each position of the track, when such reflections are visible. Receptors where no reflections are recorded do not have a diagram.

Each diagram shows in black instances of reflected light outside of the main viewing direction 30° angle, red dots show instances when reflected light is within the 30° angle to the viewing direction. Red dots are the instances when there is a potential for exceeding veiling luminance threshold and are further analysed in the next section.

Figure 33 - Diagrams overview. Direction South.

Figure 34 - Selected diagrams for track 1. Direction South.

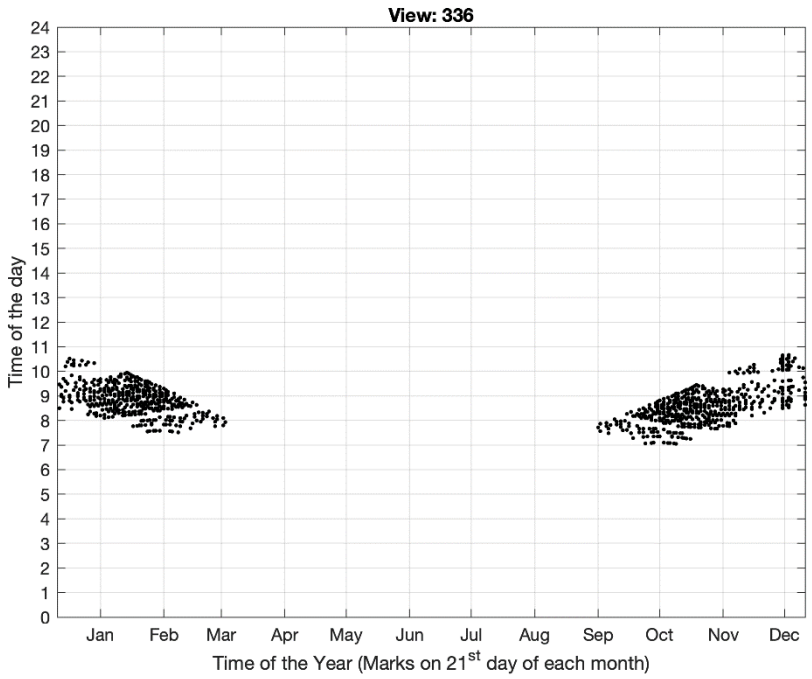


Figure 35 - Selected diagrams for track 3. Direction South.

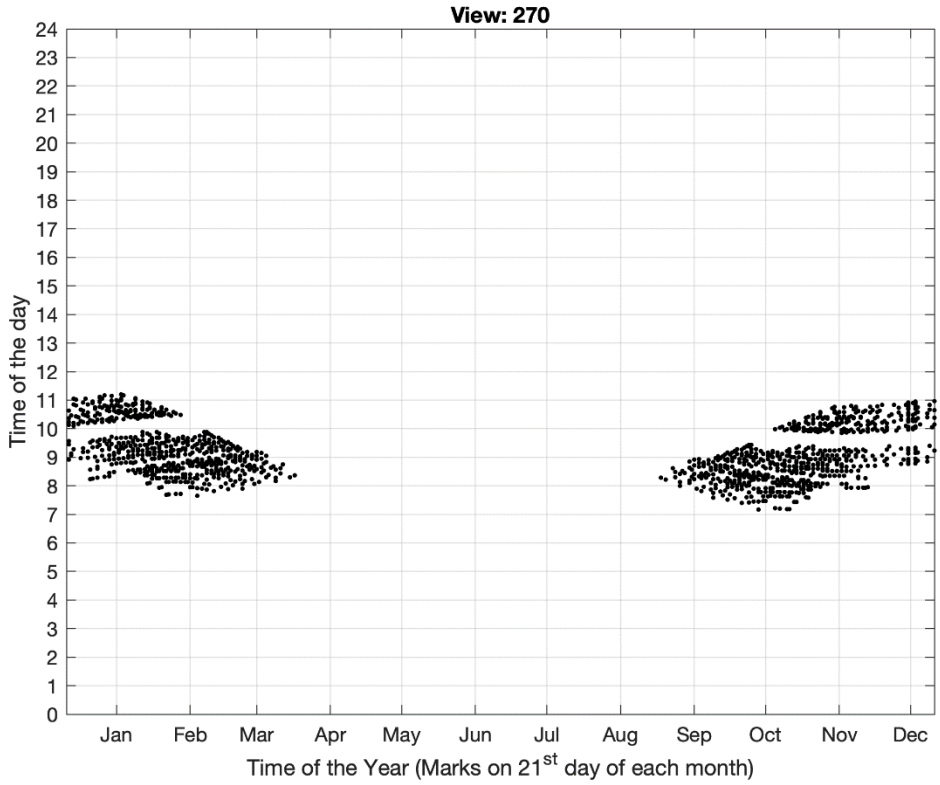


Figure 36 - Selected diagrams for track 4. Direction South.

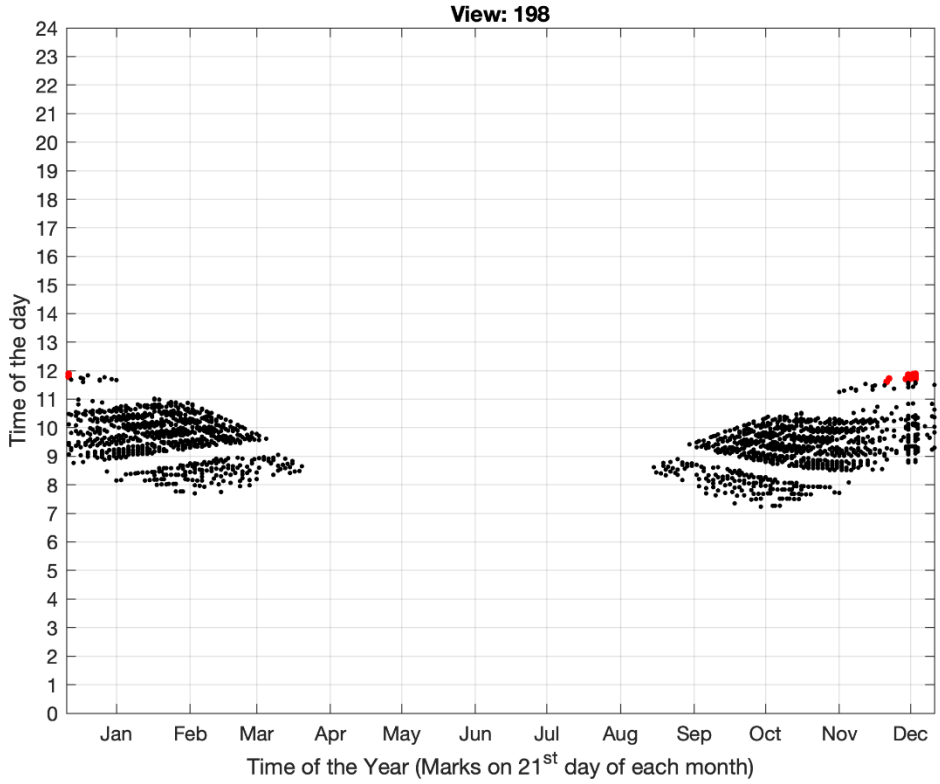


Figure 37- Selected diagrams for track 5. Direction South.

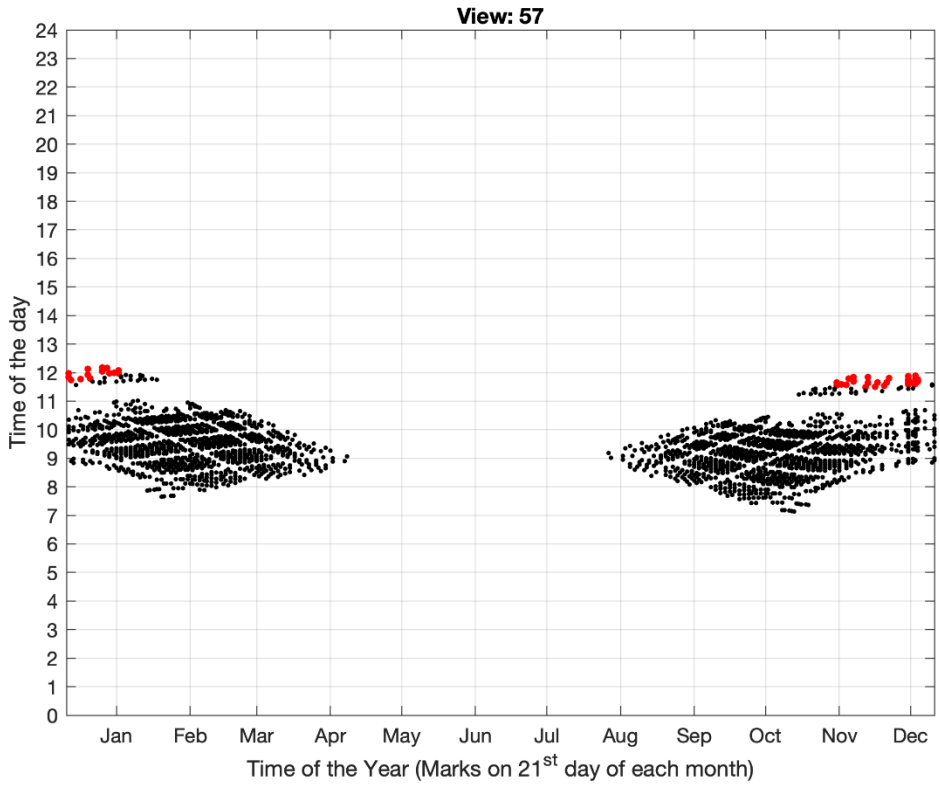
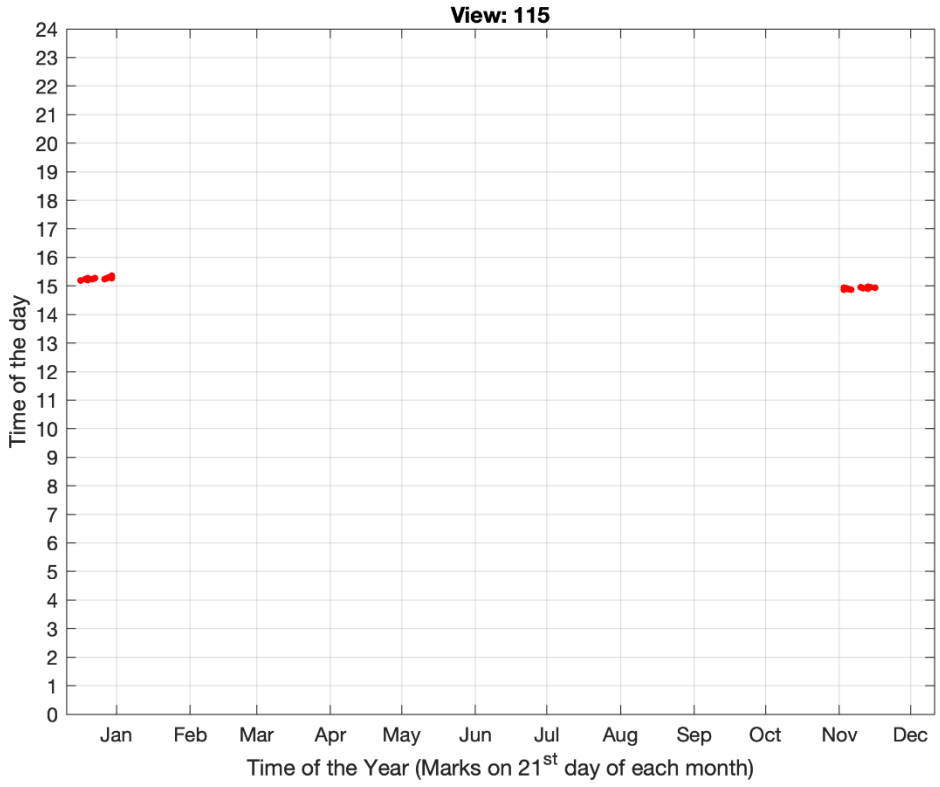


Figure 38 - Diagrams overview. Direction North.

Figure 39 - Selected diagrams for track 2. Direction North.



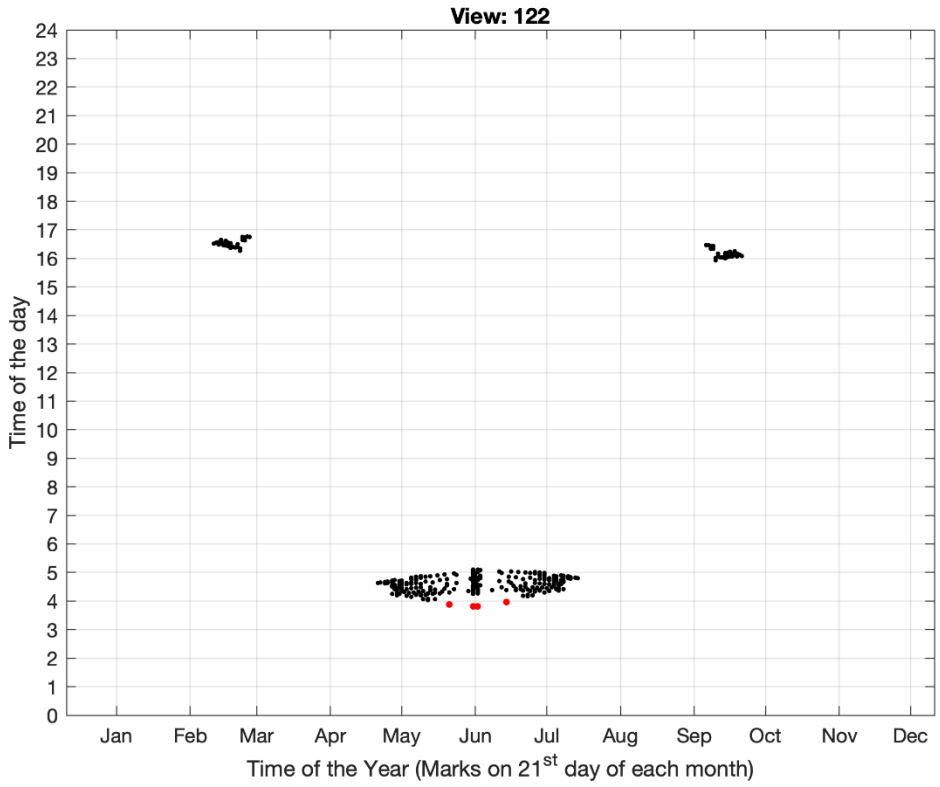
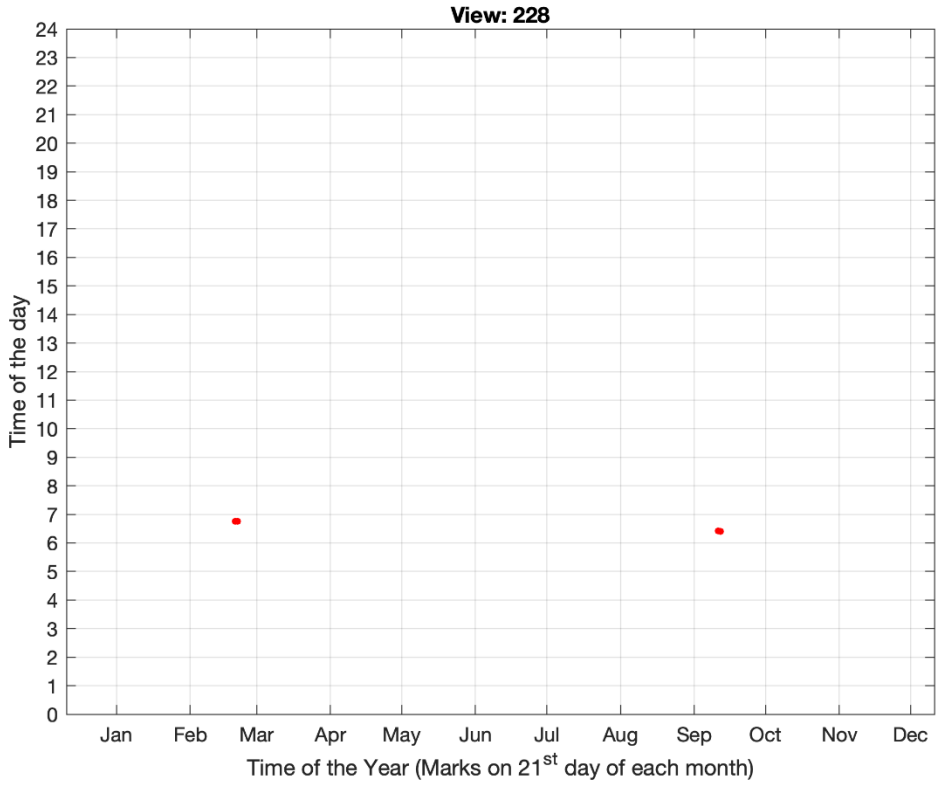
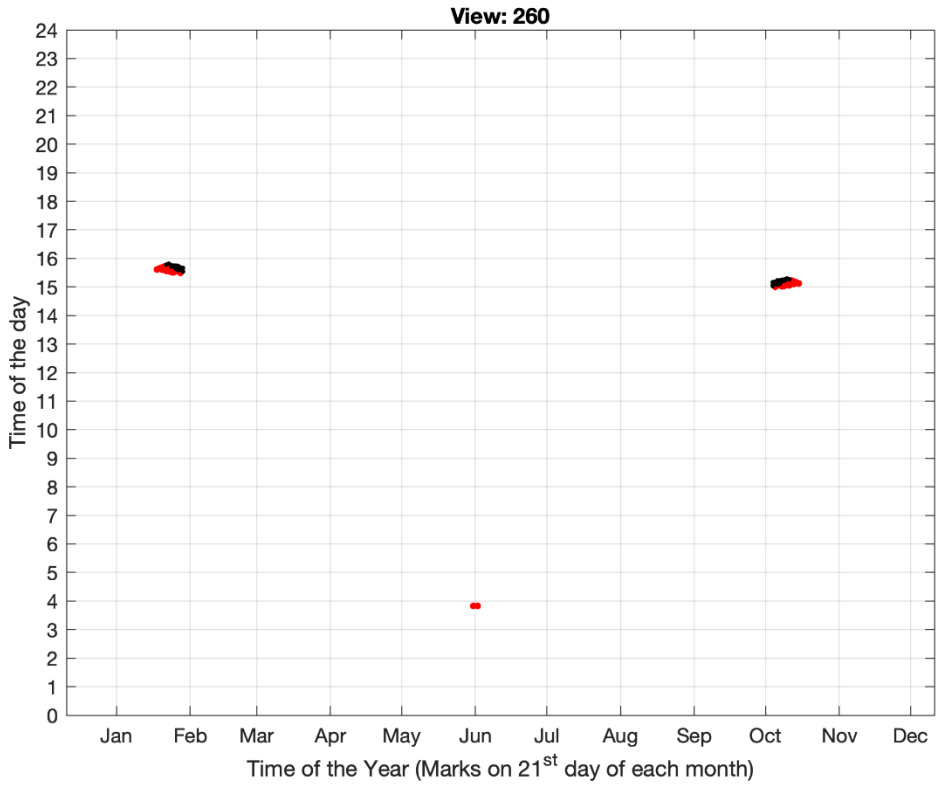
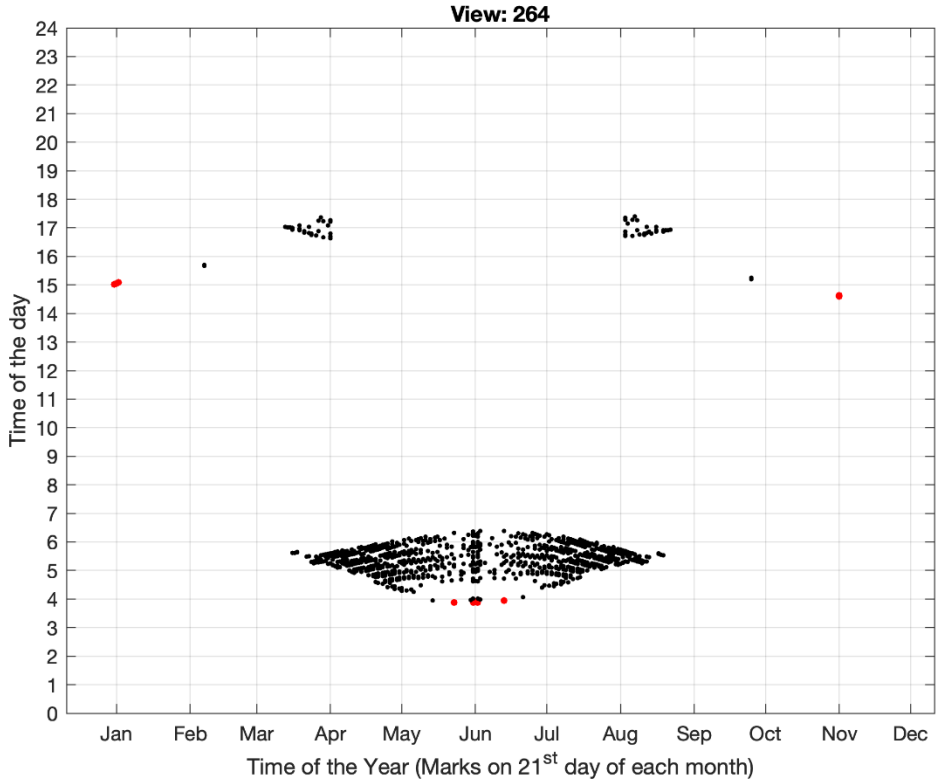


Figure 40 - Selected diagrams for track 3. Direction North.






View: 264
Time of the day
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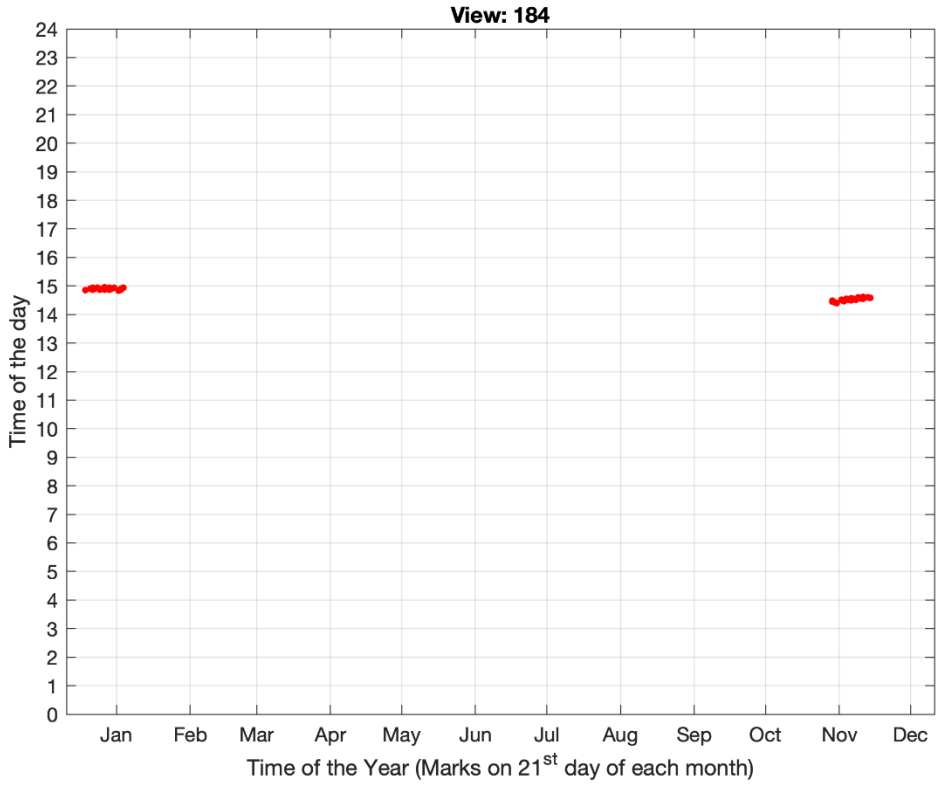
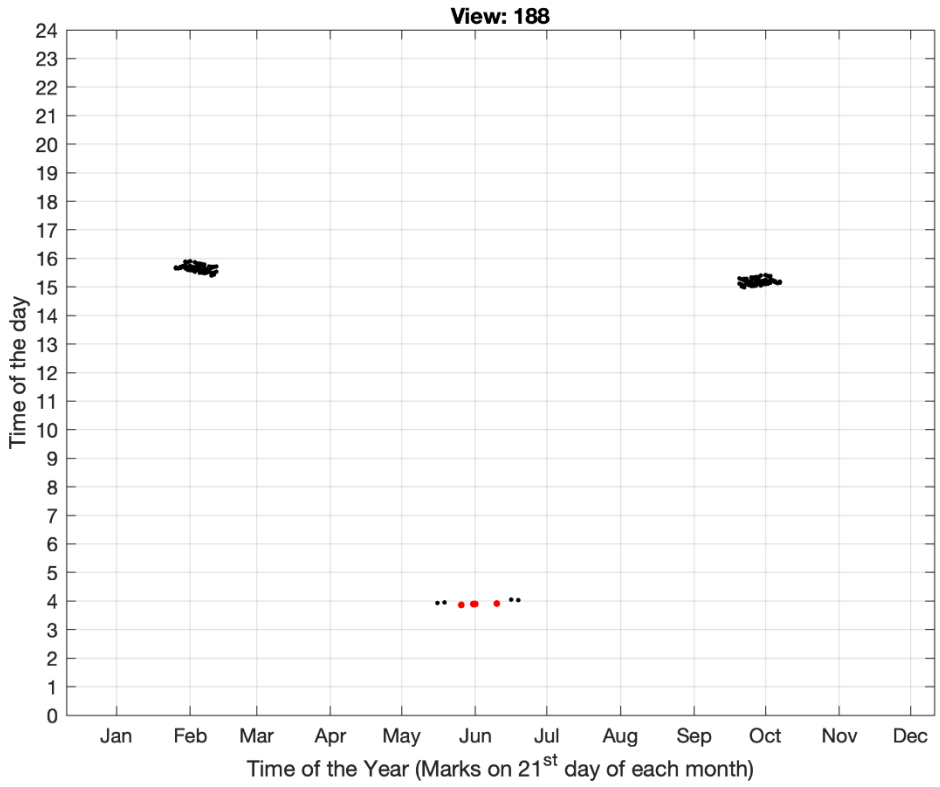
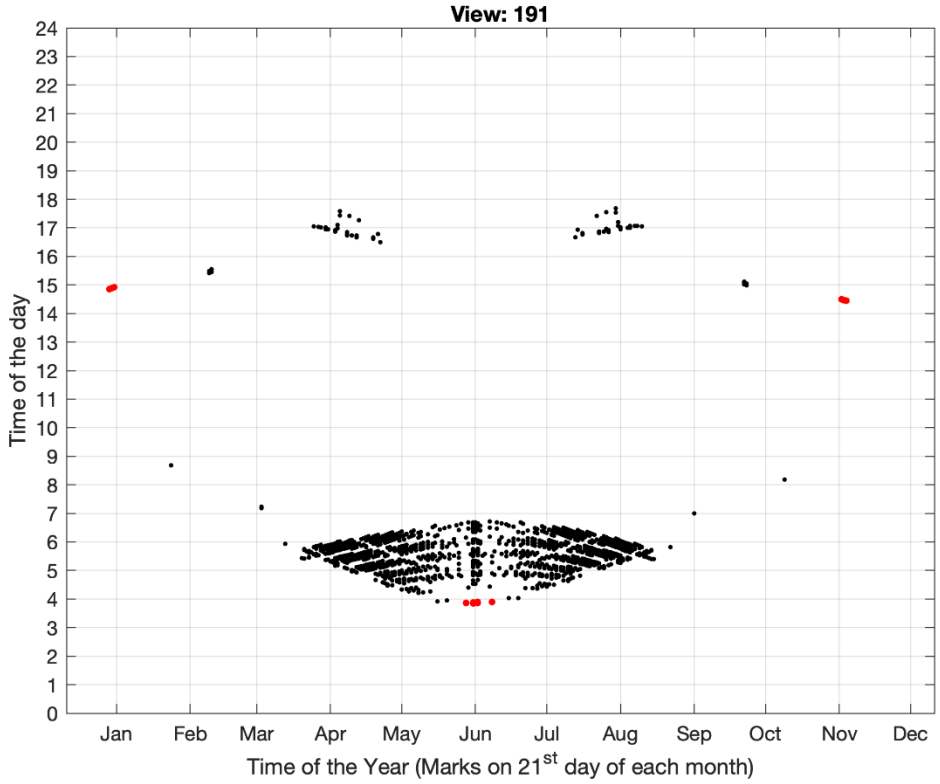
Time of the Year (Marks on 21st day of each month)

Figure 41 - Selected diagrams for track 4. Direction North.






View: 191
Time of the day
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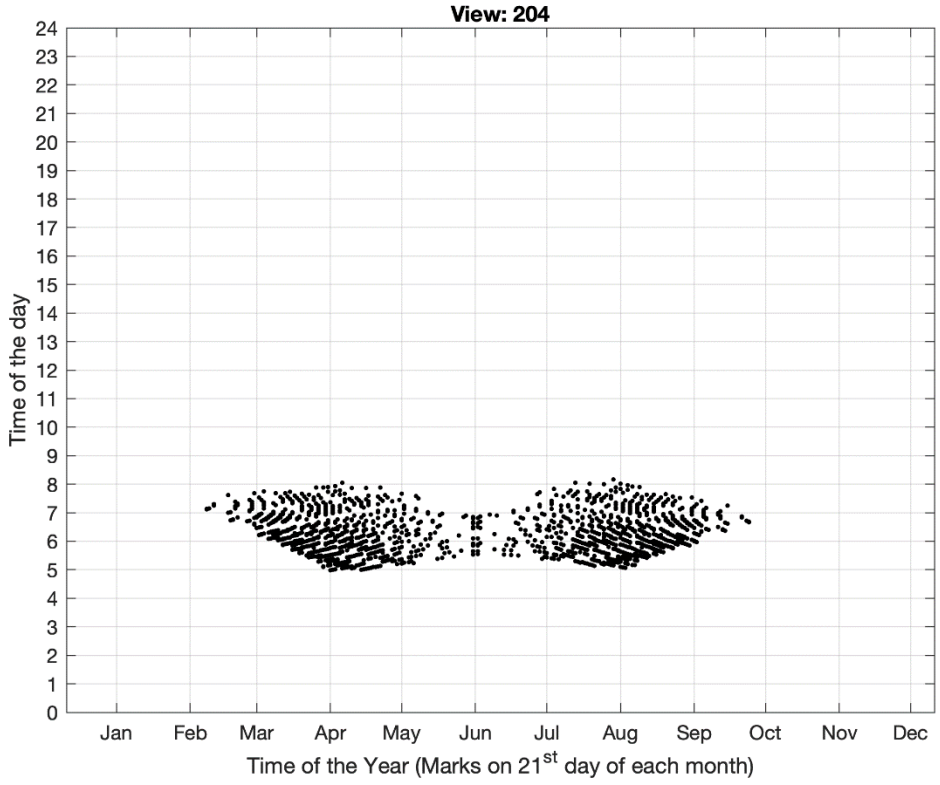
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Time of the Year (Marks on 21st day of each month)


View: 204
Time of the day
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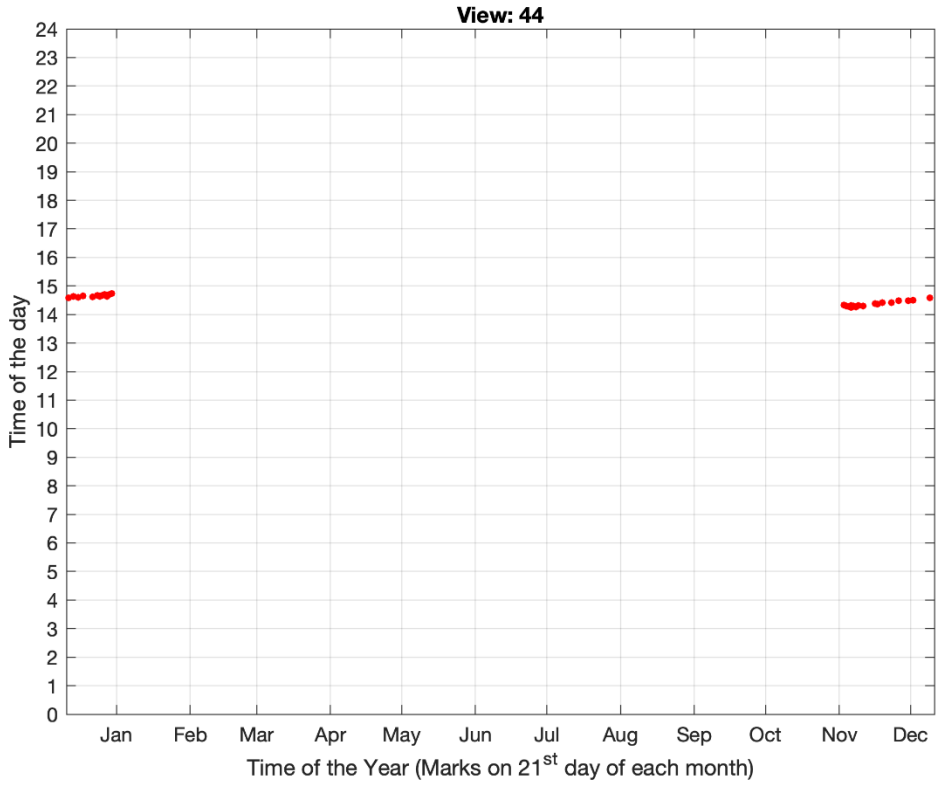
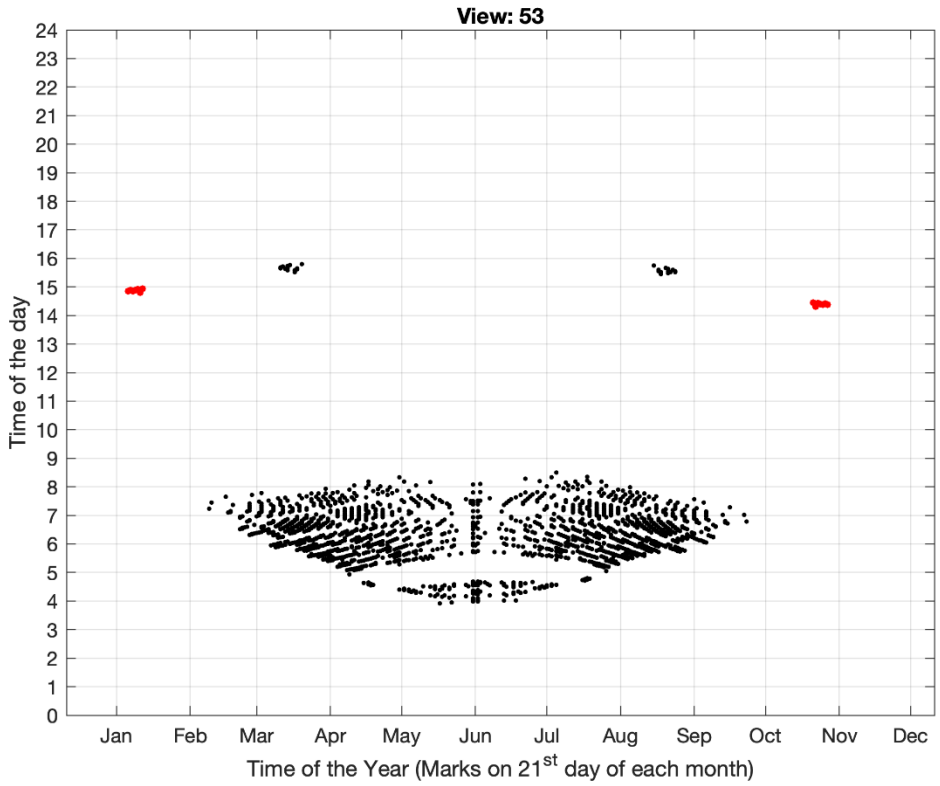
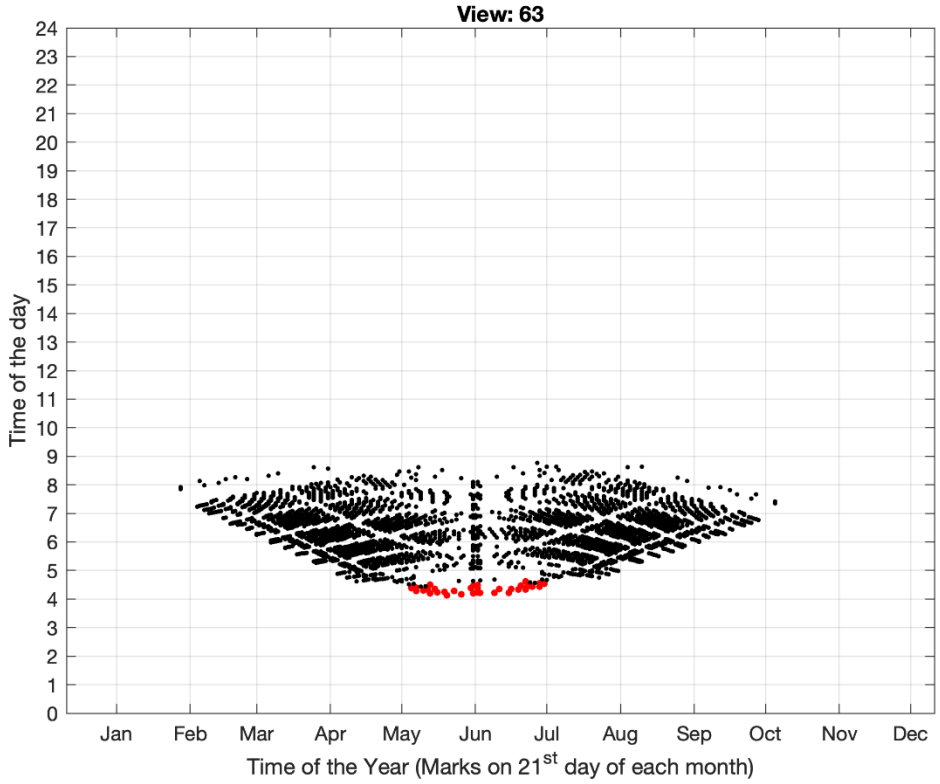
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Time of the Year (Marks on 21st day of each month)

Figure 42- Selected diagrams for track 5. Direction North.






View: 63
Time of the day
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Time of the Year (Marks on 21st day of each month)

3.4 Selected instances of reflected glare to train driver at selected positions

The following images correspond to instances in which reflected sunlight is visible within a 30° angle to the line of sight of the train driver. More than 2000 images have been calculated to account for all instances of reflected sunlight within the 30° angle and for all tracks and direction. For practical reasons only a selection is shown in this report. The data derived from the images, which is used to calculate the veiling luminance, is plotted in the next section.

Figure 43 - Diagrams for Track 4, going South. Position 198. Simulated driver's eye.

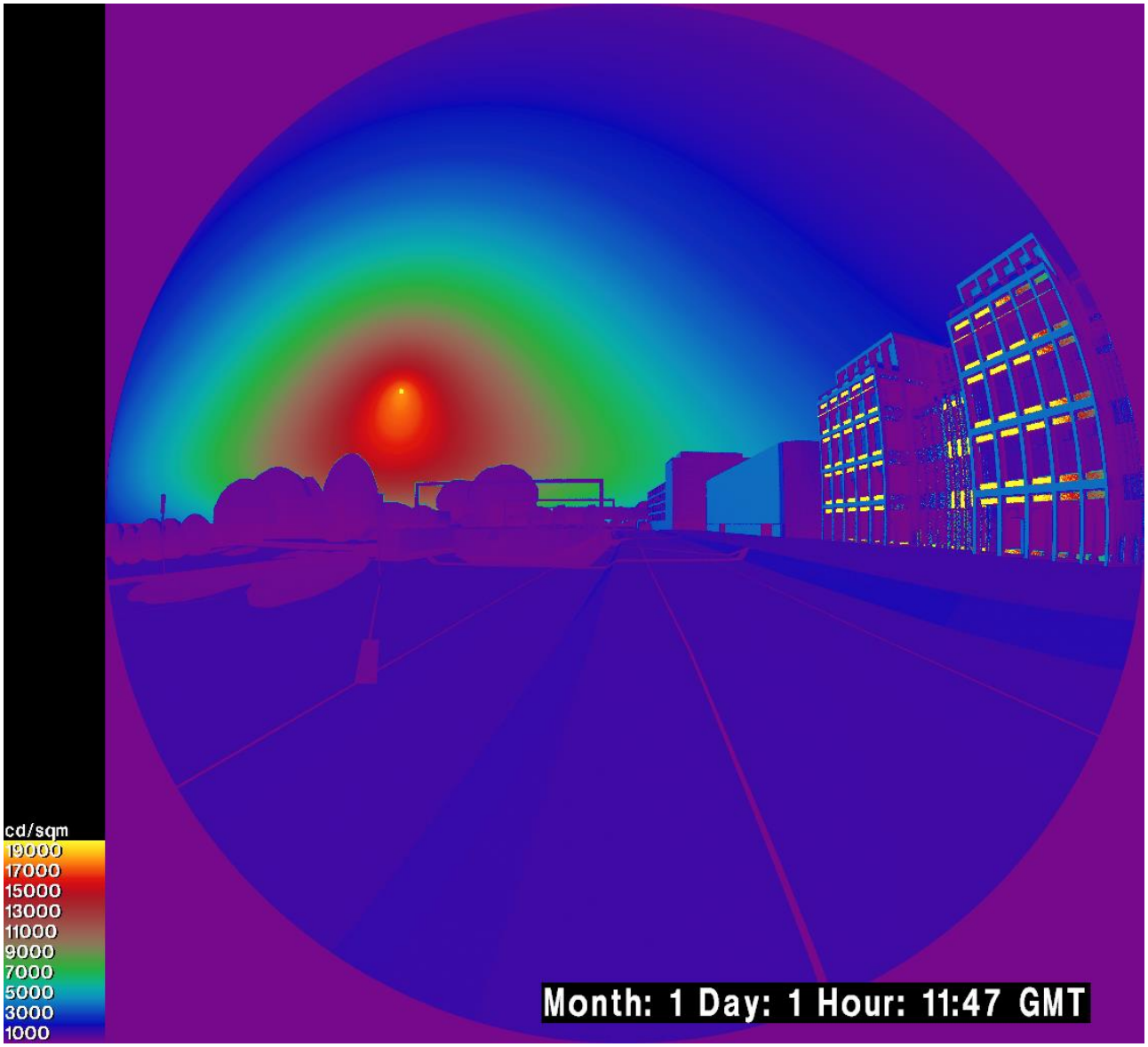


Figure 44 - Diagrams for Track 5, going South. Position 57. Simulated driver's eye.

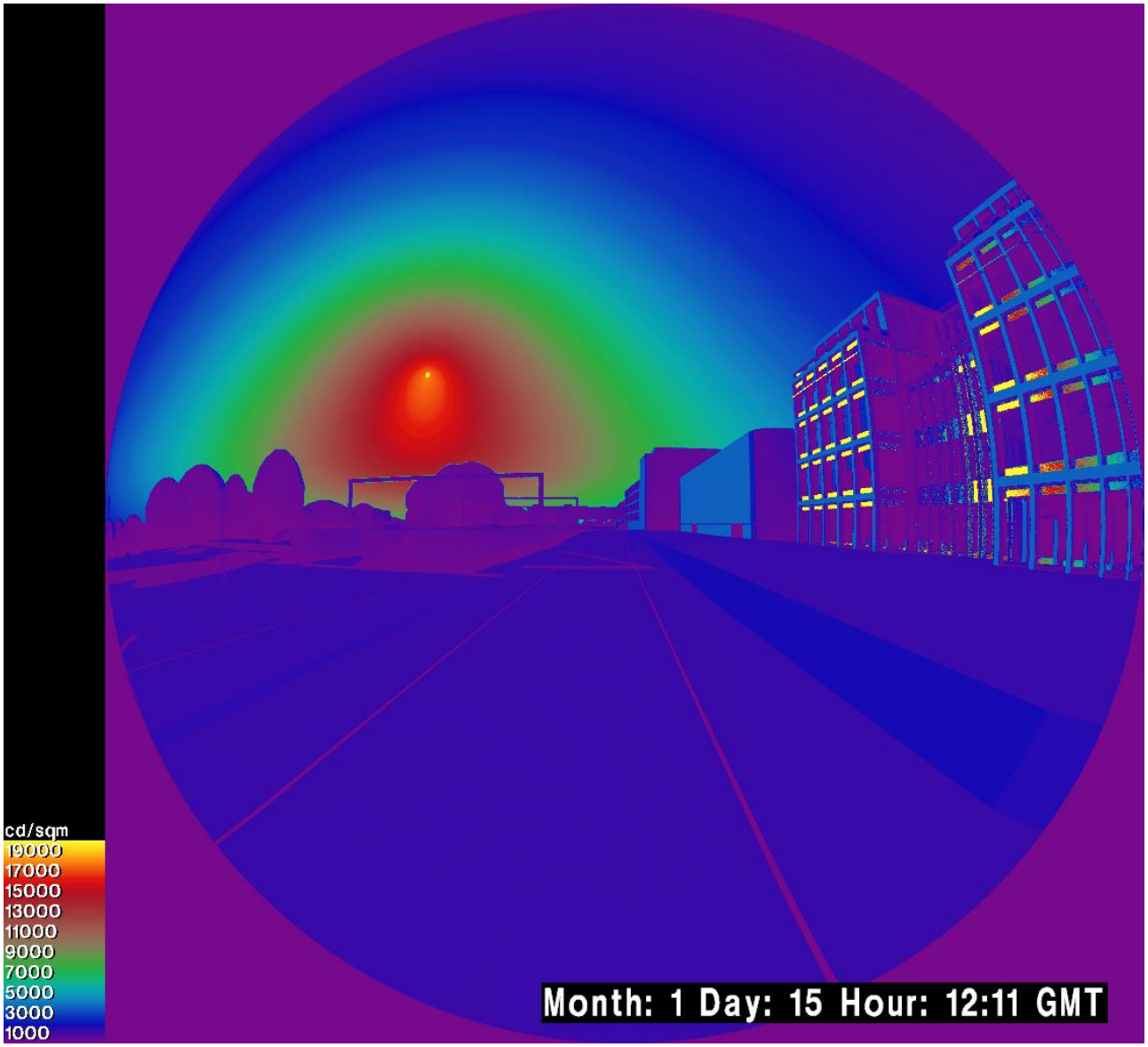


Figure 45 - Diagrams for Track 2, going North. Position 115. Simulated driver's eye.

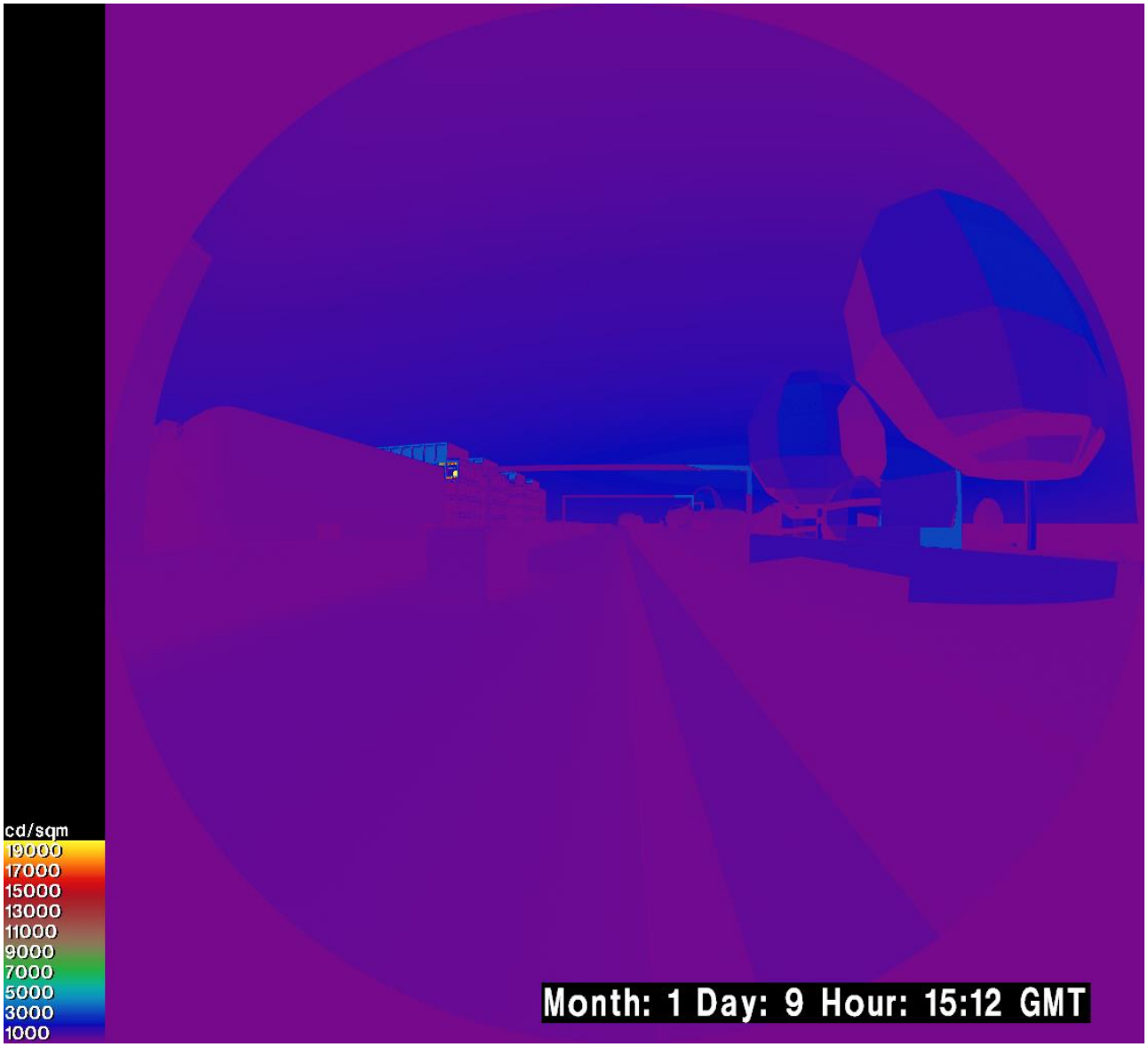


Figure 46 - Diagrams for Track 2, going North. Position 122. Simulated driver's eye.

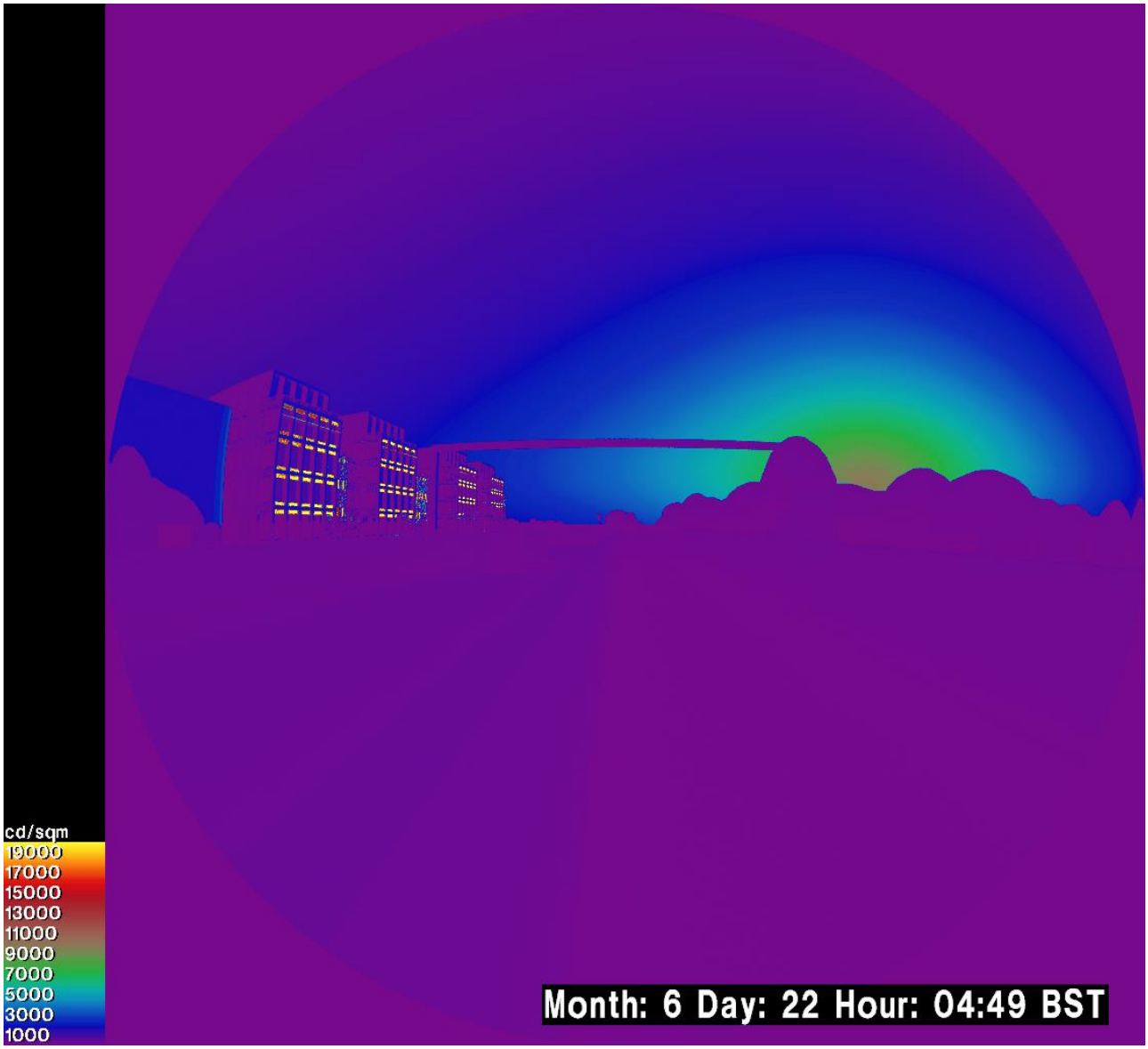


Figure 47 - Diagrams for Track 3, going North. Position 228. Simulated driver's eye.

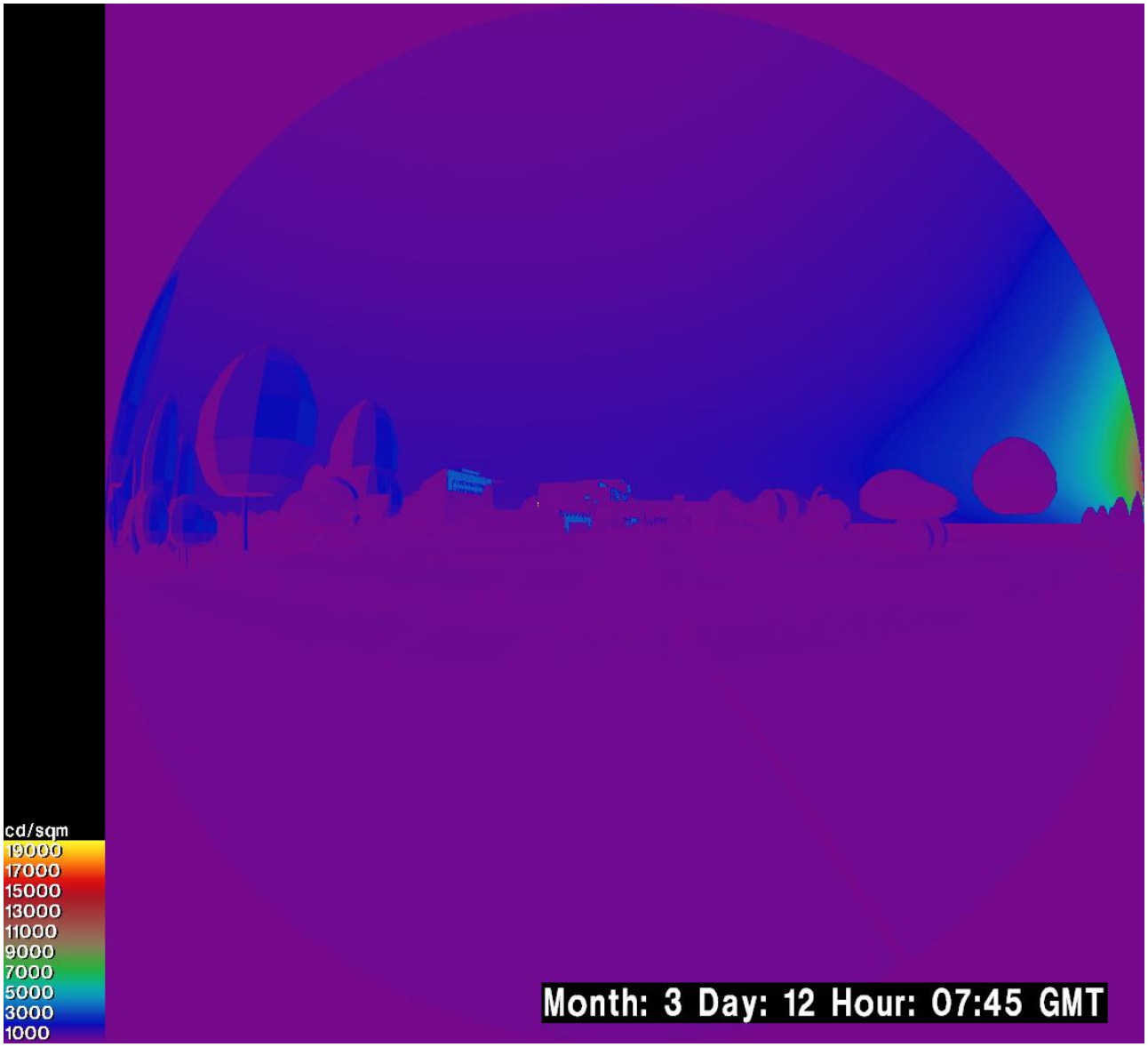


Figure 48 - Diagrams for Track 3, going North. Position 260. Simulated driver's eye.

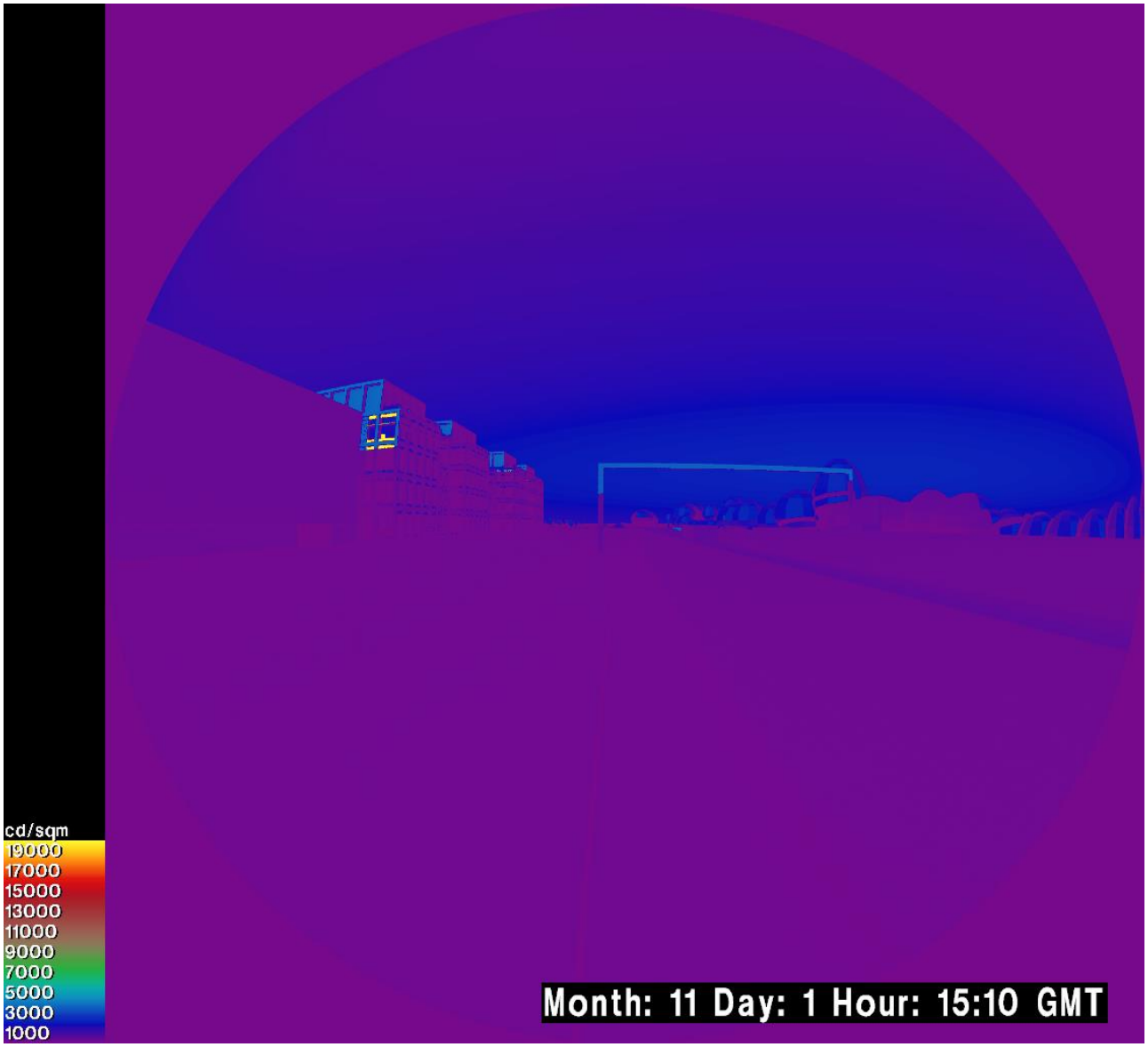


Figure 49 - Diagrams for Track 3, going North. Position 264. Simulated driver's eye.

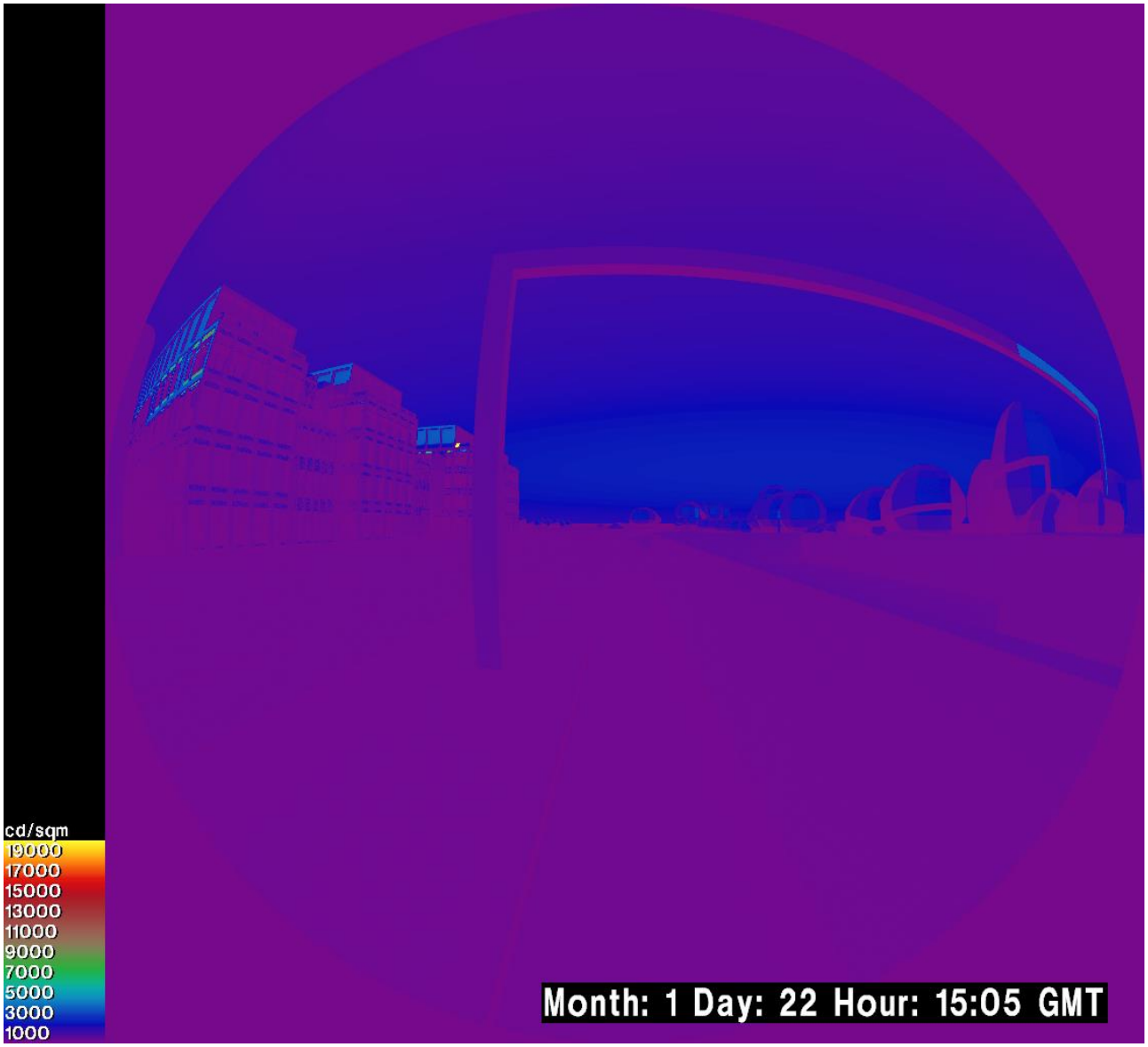


Figure 50 - Diagrams for Track 4, going North. Position 184. Simulated driver's eye.

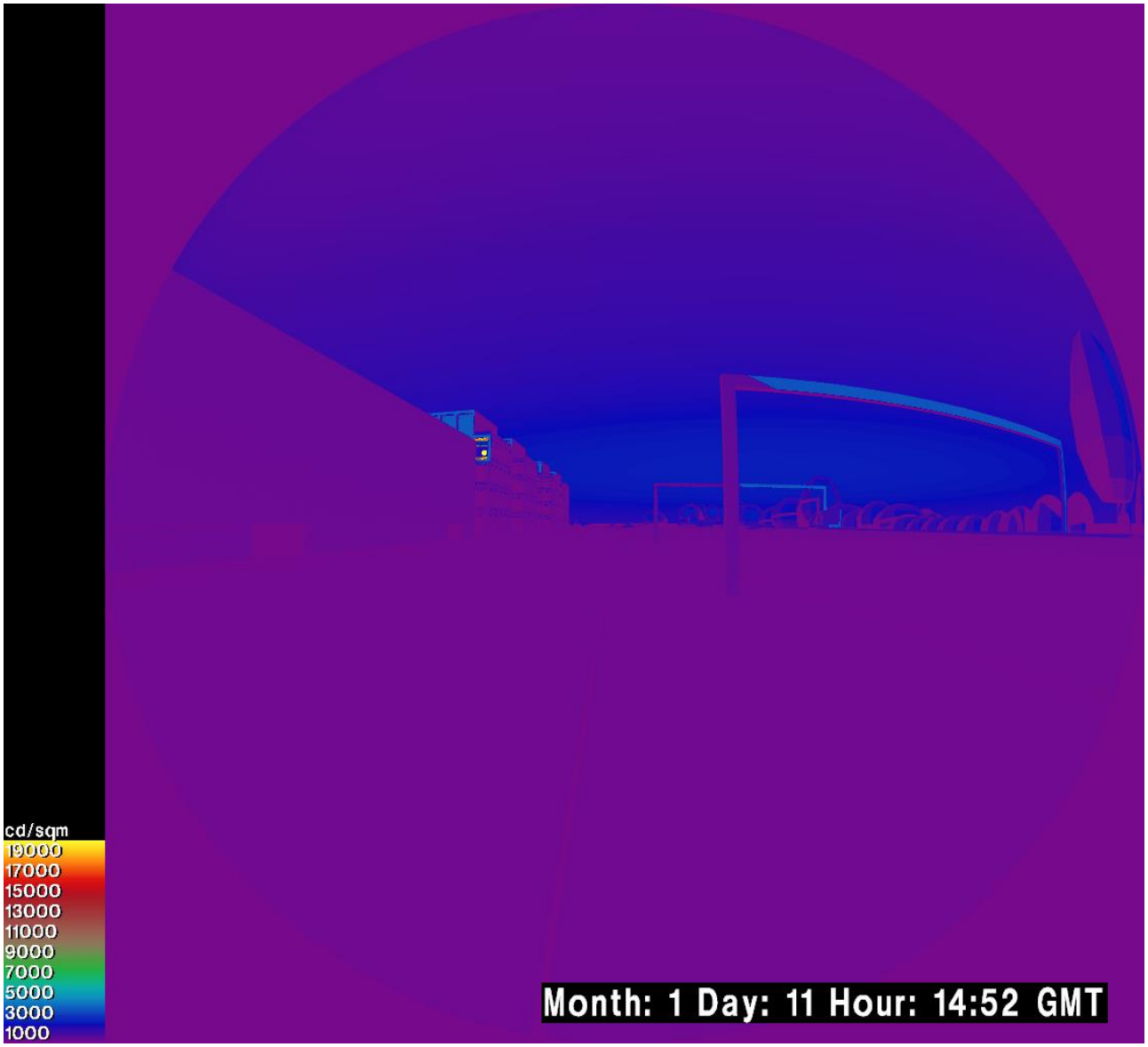


Figure 51 - Diagrams for Track 4, going North. Position 188. Simulated driver's eye.

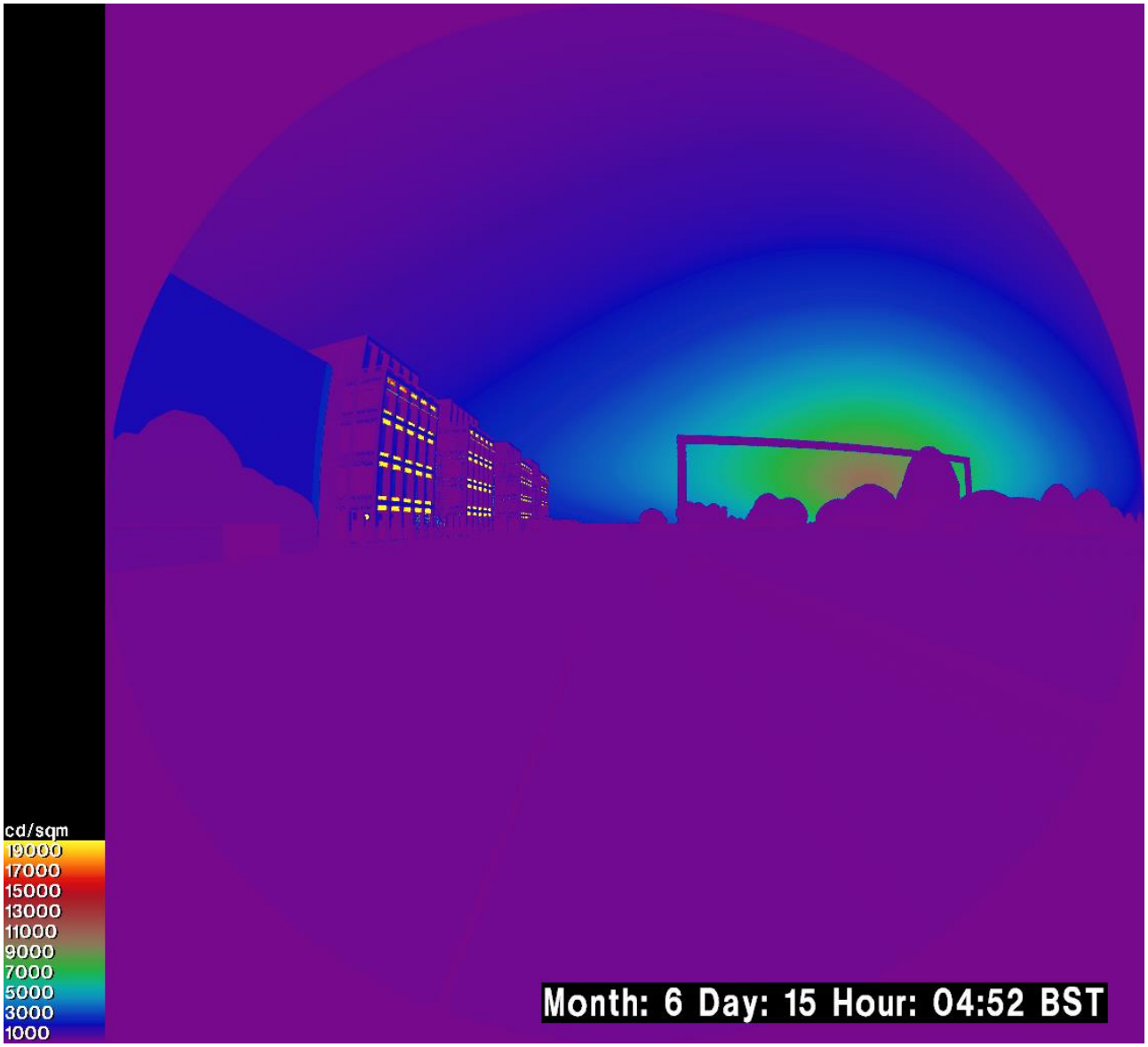


Figure 52 - Diagrams for Track 4, going North. Position 191. Simulated driver's eye.

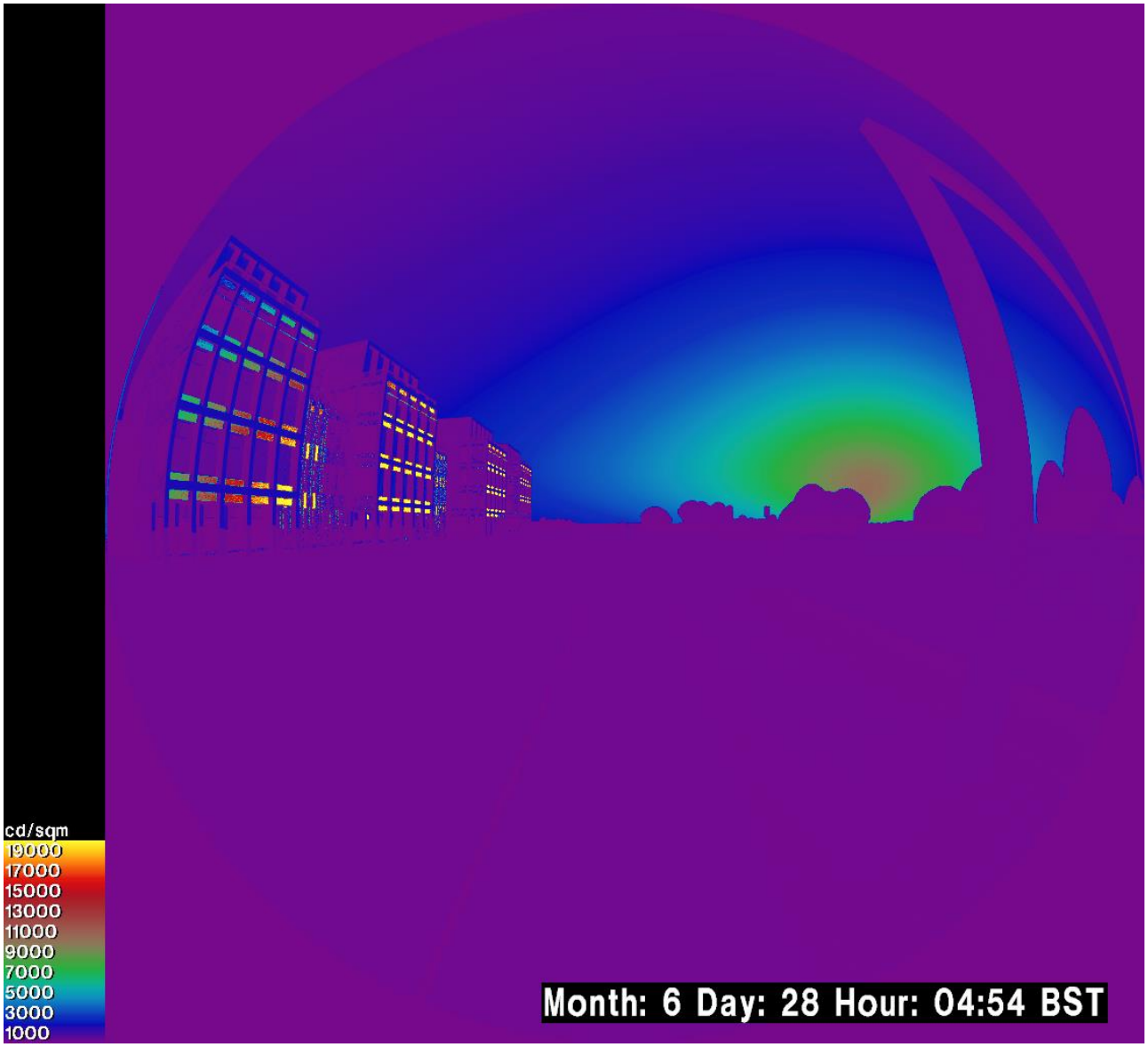


Figure 53 - Diagrams for Track 5, going North. Position 44. Simulated driver's eye.

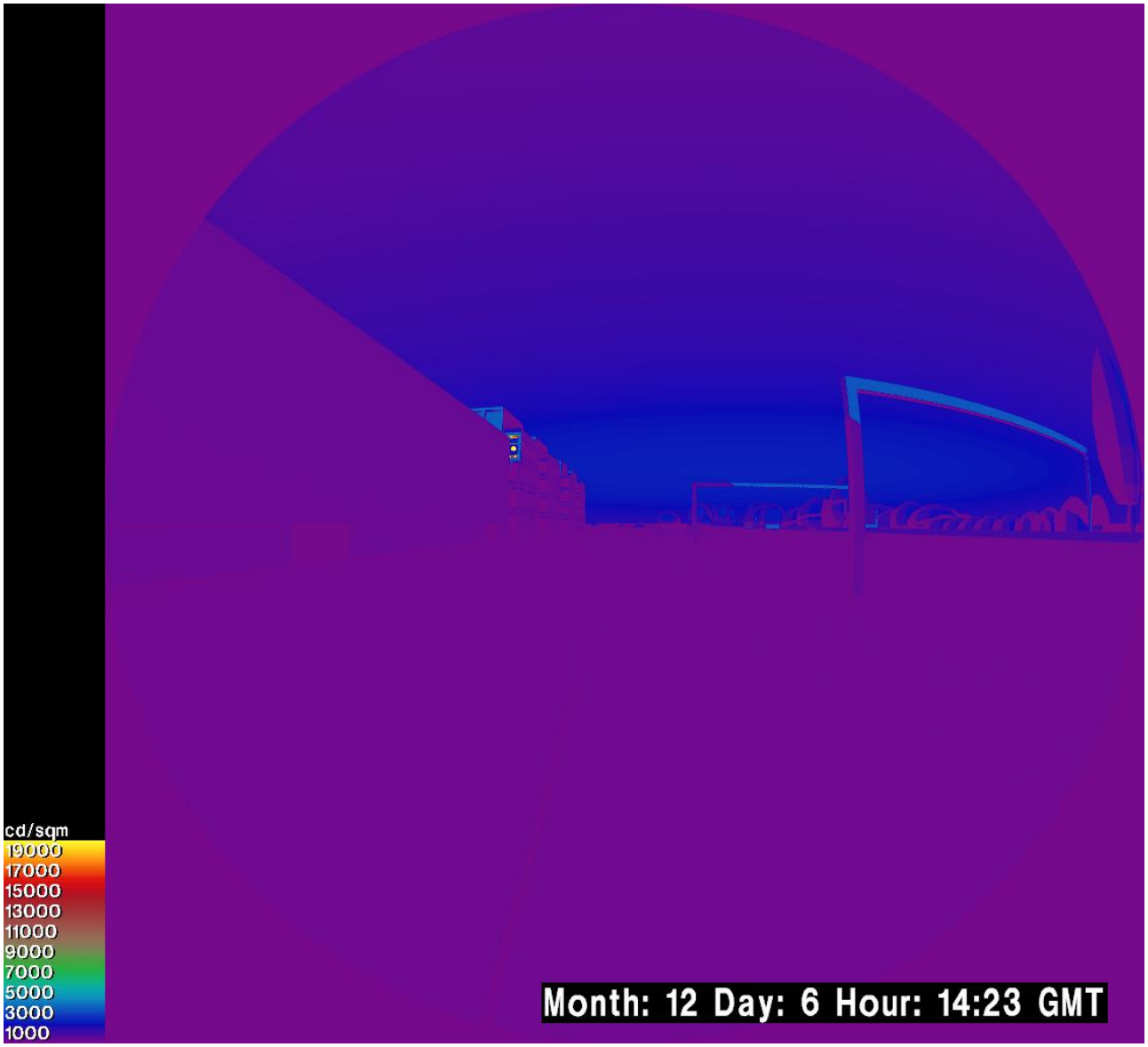


Figure 54 - Diagrams for Track 5, going North. Position 53. Simulated driver's eye.

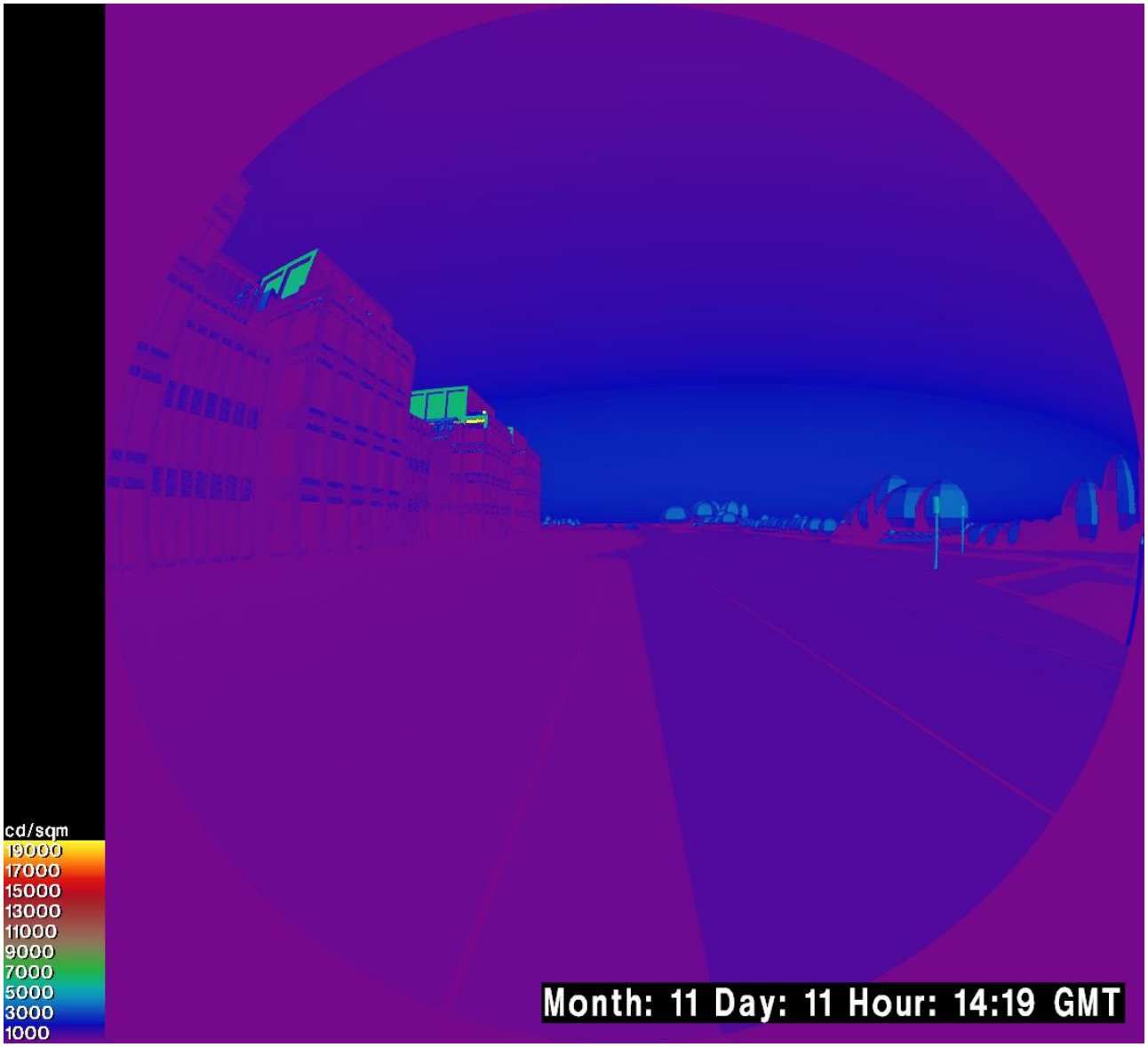
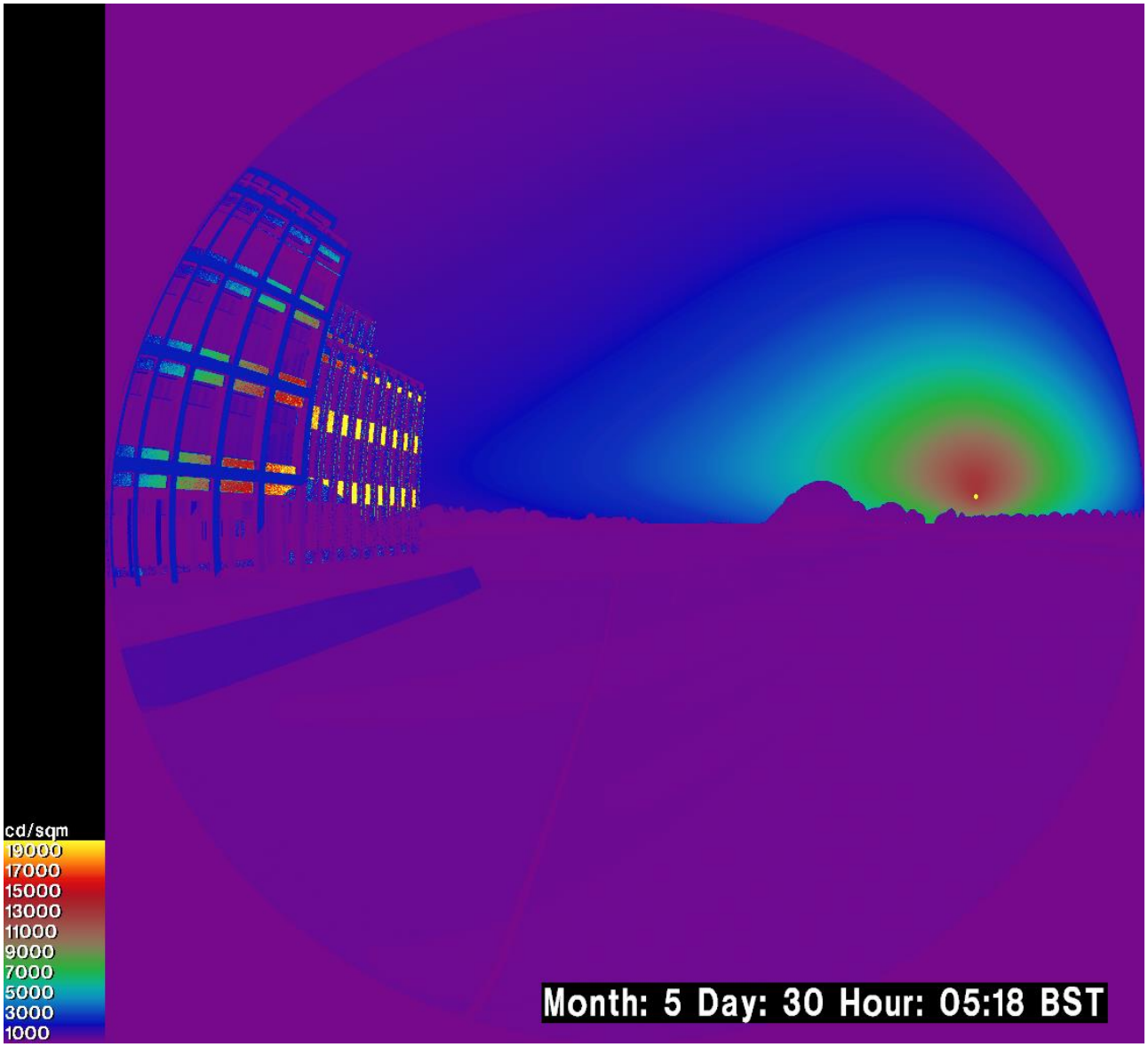


Figure 55 - Diagrams for Track 5, going North. Position 63. Simulated driver's eye.



3.5 Veiling luminance analysis for all instances and positions considered

The following diagrams show the value of veiling luminance along all tracks at once, in the North and South viewing directions for instances in which the reflected sunlight is within the 30° angle to the line of sight of the train driver.

The red dots represent instances when sunlight is visible at the same time in which reflected sunlight is, these are not considered problematic and conclusions of the assessment are based on the blue dots, which represent the effects of reflected sunlight alone.

From the diagrams it can be observed that the calculated maximum veiling luminance for any train driver of any track, at any time, when no direct sunlight is visible, is below 500 cd/sqm.

Figure 56 - Veiling luminance for observers moving North, red are instances in which direct sunlight is visible. The upper values for instances when only reflected sunlight is visible are 200 cd/sqm, which is below the threshold of 500 cd/sqm by a considerable margin. Track 4 is Southbound only, thus excluded from the plot.

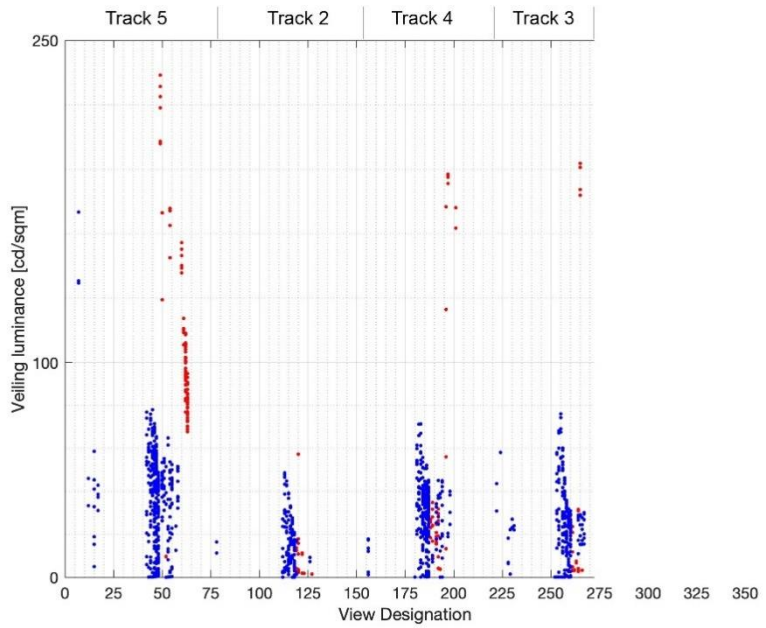


Figure 57 - Veiling luminance for observers moving South, red are instances in which direct sunlight is visible. Note that there are no blue instances, sunlight and reflected sunlight are visible at the same time for all instances found. Track 2 is Northbound only, thus excluded from the plot.