Introduction
The environmental stressors placed on buildings are getting more severe with the progress of climate change [1]. As a result, structures that work well in 2020 may no longer be sufficient in 30 years. This rapid change necessitates civil engineers to design buildings for the conditions of tomorrow. Hygrothermal simulation is used by building scientists to determine the heat, air and moisture (HAM) behavior within a building’s components. Over the last few decades, scientists have been researching the future hygrothermal performance of buildings; however, research is mostly limited to small areas around large cities [1]. This is a problem for Victoria, BC, as it is too small to be included in these studies. The seaside town also has a different climate type from its neighbors, so findings are not transferable between cities.

CanRCM4 climate data was fed into the hygrothermal simulation tool WUFI Pro to determine the water content of a stucco clad, wood-framed building envelope for the years 2020 and 2050. This data will help to indicate future trends for building envelope performance in Victoria.

Background
The CanRCM4 large ensemble is a Canadian climate model running from the years 1950-2100 and consisting of 50 members. It was created in 2005 and is a child of the CanESM2 global climate model. It was created to downscale CanESM2 data into a higher spatial fidelity for North America [2].

Data Extraction
Ten variables were extracted from CanRCM4 (temperature, relative humidity, precipitation, windspeed, sea level air pressure, wind direction north and east, solar longwave radiation, solar shortwave radiation, and cloud index) using a custom MATLAB script. CanRCM4 simulates most of these variables at a frequency of 3 hours so linear approximations were used to increase this frequency to 1 hour. For monthly data such as radiation and cloud index values cubic functions were used to approximate missing data.

Simulation
For both years, 2020 and 2050, three simulations were run using parallel climate realizations. The purpose of these parallel realizations is to account for uncertainty within the climate model. These six simulations calculated the water content in every material layer for all 8760 hours in the year.

Material Layers
1. 22mm STUCCO
2. 19mm air cavity
3. Sheathing Paper
4. 12mm Wood Sheathing
5. Insulation in stud space
6. 6mil Polyethylene
7. 12mm interior gypsum board

Figure 1. Building Envelope Construction [3]

Analysis of Results
Comparing the results form the 2020 simulations and 2050s simulation reveals that the 2050 simulation has significantly higher maximum water content however contained less water at the end of the year. This trend is true for every material layer in the envelope. The difference in maximum water content between the years ranges from 0% to 22.3%. For the end of year data the difference ranges from -0.7% to -21.4%.

Table 1. Total Water Content of Building Envelope

<table>
<thead>
<tr>
<th>Case</th>
<th>Start</th>
<th>End</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020 avg [kg/m²]</td>
<td>2.57</td>
<td>3.28</td>
<td>4.90</td>
</tr>
<tr>
<td>2050 avg [kg/m²]</td>
<td>2.57</td>
<td>3.13</td>
<td>4.63</td>
</tr>
<tr>
<td>Difference [%]</td>
<td>0</td>
<td>-4.6</td>
<td>+7.7</td>
</tr>
</tbody>
</table>

Conclusion
As climate change progresses the moisture in stucco clad wood-frame building envelopes in Victoria will fluctuate to higher highs and lower lows. In summers the maximum water content of building envelopes will be higher. In winters however they will have less moisture. This difference could cause material stress from the expansion and contraction of wall components. Additionally, the risk of mould will increase as building envelopes carry more water and summers get warmer. Improved construction materials as well as shielding from wind driven rain could mitigate some of these risks [3].

Discussion
This limited set of six simulations is enough to identify trends however for more statistically significant data simulations outside of the scope of this internship would need to be run. This data would require multiplier simulation using a larger set of climate realizations. This internship has laid the groundwork for such projects by creating the programs and structures required to use CanRCM4 data for hygrothermal simulation.

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References

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