Generation of Typical Weather Data for Future Climate Change for South Korea

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Purpose

• Generate typical weather data

• Suggest future climate change needs for South Korea

• Assess the performance of buildings in the future

• Improve consistency and reliability of simulation weather data
Contents

• Future South Korea temperature change

• Estimation of temperature trend for Seoul and Ulsan

• Climate change test reference years

Future South Korea temperature change

mean temperature (1961-1990) average +
value of change between the 20th(1961-1990) and 21th(2070-2099) centuries according to the sixteen scenarios ×
rate of change using the scalers for a period (2001-2000)
### Climate Change Scenarios

<table>
<thead>
<tr>
<th>Economic development (World GDP: 10^12US$/yr)</th>
<th>Global population (2100)</th>
<th>Technological development</th>
<th>Cumulative carbon dioxide, total (1990-2100:Gt(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 More fragmented and slower than other scenarios (243)</td>
<td>Continuously increasing (15.1billion)</td>
<td>Fragmented and slower</td>
<td>1862 (1352-1938)</td>
</tr>
<tr>
<td>B1 Rapid change toward a service and information (328)</td>
<td>Very rapid growth peak in mid-century declines afterward (7.0billion)</td>
<td>Introduction of clean and resource efficient</td>
<td>983 (772-1390)</td>
</tr>
<tr>
<td>B2 Intermediate level (235)</td>
<td>Continuously increasing (10.4billion)</td>
<td>Less rapid and more diverse than B1 and A1</td>
<td>1164 (1164-1686)</td>
</tr>
</tbody>
</table>

* Summary for Policymakers – Emission Scenarios

### Observed(1901-2000) and calculated(2100) annual South Korea mean air temperature

![Temperature Graph](chart.png)
Climate grids of South Korea

We have both Hadley model data (HadCM3) and Tyndall Centre data (TYN SC2.0 of Ulsan and Seoul (2001-2100))

- TYN SC2.0
- HadCM3
  - 127.5, 37.5
  - 127.5, 35
- Seoul: 127.5, 37
- Ulsan: 129.5, 35.5

The Hadley Centre model (HadCM3)

- Daily weather parameters: maximum, minimum and average temperature, humidity, wind speed and downward short-wave flux (solar radiation)
- Year: 360 days, month: 30 days
- Size of each grid-box: 2.5° X 3.75°
- Weather data: 1860 to 2099
TYN SC2.0 of Ulsan and Seoul (2001-2100)) is *monthly* data from HadCM3 *(HadCM3 is daily data)*

For TYN SC2.0:

\[ x = c + r + (p \times t) \]

- X : future meteorological parameter
- c : observed climatological mean from 1961–90
- r : residual from the observations after anomalising relative to 1961–90 and detrending against global temperature
- p: pattern of response to radiative forcing (expressed as anomalies relative to 1961–90, per degree of global temperature change)
- t: the global temperature change (relative to 1961–90)

Changes of the annual mean air temperature for TYN SC 2.0
There are different climate models besides Hadley. This shows the US PCM results (from the Tyndall Centre)

Selection of Test Ref. Year using the F-S statistic (based on the cumulative frequency distribution, CDF) CDFs for different January comparisons for Ulsan
This is the F-S method

\[
S_n(x) = \begin{cases} 
  0 & \text{for } x < x_1, \\
  (k-0.5)/n & \text{for } x_k \leq x < x_{k+1}, \\
  1 & \text{for } x \geq x_n.
\end{cases}
\]

**Finkelstein-Schafer (FS) statistics**

\[
FS(y,m) = \left( \frac{1}{n} \sum_{i=1}^{n} |CDF_{m}(x_i) - CDF_{y,m}(x_i)| \right)
\]

TRY = min(FS)

**Test Reference Year (1961-1990) and climate change (2061-2090)**

![Graph showing temperature over months with markers for different years and scenarios.]
Comparison of Hadley data with actual data for Ulsan for 1961-1990

TRYs for 2020, 2050 and 2080 for the South Korea (127.5, 35 : HadCM3)
### Mean dry bulb temperature, standard deviation and maximum hourly dbt

<table>
<thead>
<tr>
<th>Grid Box</th>
<th>Year</th>
<th>Mean dry bulb temperature (dbt)</th>
<th>Standard deviation of dbt</th>
<th>Maximum hourly dbt in the TRYs</th>
</tr>
</thead>
<tbody>
<tr>
<td>127.5, 36</td>
<td>1970</td>
<td>12.55</td>
<td>6.66</td>
<td>24.86</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>13.74</td>
<td>7.02</td>
<td>26.01</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>14.77</td>
<td>6.40</td>
<td>26.52</td>
</tr>
<tr>
<td></td>
<td>2080</td>
<td>15.90</td>
<td>6.42</td>
<td>27.48</td>
</tr>
<tr>
<td>127.5, 37.5</td>
<td>1970</td>
<td>4.77</td>
<td>13.84</td>
<td>30.44</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>6.89</td>
<td>13.17</td>
<td>37.31</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>8.43</td>
<td>12.82</td>
<td>36.28</td>
</tr>
<tr>
<td></td>
<td>2080</td>
<td>10.79</td>
<td>12.71</td>
<td>41.15</td>
</tr>
</tbody>
</table>

### Conclusion

- **Global warming is happening in South Korea**
- The trend is for the temperature in Seoul to rise faster than in Ulsan. [Seoul is further North than Ulsan, but Ulsan is near the sea.] (South Korean grid is in between).
- Summer maximum temperature and winter minimum temperature have been rising steeply in Seoul and Ulsan
- Due to the climate change there will be a substantial rise in energy consumption and CO₂ emissions due to air conditioning. Further work will establish how much.