Climate Change in Mega-City Shanghai and its impacts

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Outline

- Background
- Observed Climate Change in Shanghai
- Impacts and Challenges of Climate Change for Shanghai
- SMB Work on Climate Change
Shanghai (Chinese: 上海) is the largest city in China in terms of population and one of the largest urban areas in the world, with over 20 million people in its extended metropolitan area. Located on China’s central eastern coast near the mouth of the Yangtze River, the city is administered as a municipality with province-level status.
## Mega Cities in the World in terms of population

<table>
<thead>
<tr>
<th>Rank</th>
<th>Metropolitan area</th>
<th>Country</th>
<th>Population</th>
<th>Area (km²)</th>
<th>Population Density (People/km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tokyo</td>
<td>Japan</td>
<td>32,450,000</td>
<td>8,014</td>
<td>4,049</td>
</tr>
<tr>
<td>2</td>
<td>Seoul</td>
<td>South Korea</td>
<td>20,550,000</td>
<td>5,076</td>
<td>4,048</td>
</tr>
<tr>
<td>3</td>
<td>Mexico City</td>
<td>Mexico</td>
<td>20,450,000</td>
<td>7,346</td>
<td>2,784</td>
</tr>
<tr>
<td>4</td>
<td>New York City</td>
<td>United States</td>
<td>19,750,000</td>
<td>17,884</td>
<td>1,104</td>
</tr>
<tr>
<td>5</td>
<td>Mumbai</td>
<td>India</td>
<td>19,200,000</td>
<td>2,350</td>
<td>8,170</td>
</tr>
<tr>
<td>6</td>
<td>Jakarta</td>
<td>Indonesia</td>
<td>18,900,000</td>
<td>5,100</td>
<td>3,706</td>
</tr>
<tr>
<td>7</td>
<td>São Paulo</td>
<td>Brazil</td>
<td>18,850,000</td>
<td>8,479</td>
<td>2,223</td>
</tr>
<tr>
<td>8</td>
<td>Delhi</td>
<td>India</td>
<td>18,600,000</td>
<td>3,182</td>
<td>5,845</td>
</tr>
<tr>
<td>9</td>
<td>Osaka-Kobe-Kyoto</td>
<td>Japan</td>
<td>17,375,000</td>
<td>6,930</td>
<td>2,507</td>
</tr>
<tr>
<td>10</td>
<td>Shanghai</td>
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<td>16,650,000</td>
<td>5,177</td>
<td>3,216</td>
</tr>
<tr>
<td>11</td>
<td>Metro Manila</td>
<td>Philippines</td>
<td>16,300,000</td>
<td>2,621</td>
<td>6,486</td>
</tr>
<tr>
<td>12</td>
<td>Hong Kong-Shenzhen</td>
<td>China</td>
<td>15,800,000</td>
<td>3,051</td>
<td>5,179</td>
</tr>
<tr>
<td>13</td>
<td>Los Angeles</td>
<td>United States</td>
<td>15,250,000</td>
<td>10,780</td>
<td>1,415</td>
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<tr>
<td>14</td>
<td>Kolkata</td>
<td>India</td>
<td>15,100,000</td>
<td>1,785</td>
<td>8,459</td>
</tr>
<tr>
<td>15</td>
<td>Moscow</td>
<td>Russia</td>
<td>15,000,000</td>
<td>14,925</td>
<td>1,005</td>
</tr>
<tr>
<td>16</td>
<td>Cairo</td>
<td>Egypt</td>
<td>14,450,000</td>
<td>1,600</td>
<td>9,031</td>
</tr>
<tr>
<td>17</td>
<td>Buenos Aires</td>
<td>Argentina</td>
<td>13,170,000</td>
<td>10,888</td>
<td>1,210</td>
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<tr>
<td>18</td>
<td>London</td>
<td>United Kingdom</td>
<td>12,875,000</td>
<td>11,391</td>
<td>1,130</td>
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<tr>
<td>19</td>
<td>Beijing</td>
<td>China</td>
<td>12,500,000</td>
<td>6,562</td>
<td>1,905</td>
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<tr>
<td>20</td>
<td>Karachi</td>
<td>Pakistan</td>
<td>11,800,000</td>
<td>1,100</td>
<td>10,727</td>
</tr>
</tbody>
</table>

Rapid Large-scale Urbanization of Shanghai

![Map and Graphs showing urban expansion from 1975 to 2005.](image)

- **Legend**:
  - Urban land
  - Green land
  - Water body
  - Cropland

- **Graph**:
  - Area of urban land, green land, and water body (km²)
  - Area of cropland (km²)
  - Year (1975 to 2005)

![Area Change](image)
From 1873, when instrumental records in Shanghai starting, the annual mean surface air temperature has increased by 1.4°C.

Positive Temperature trend in the center of city is much larger than its surroundings.

During the last 10-year, temperature increased by 0.5°C, i.e., a rate of 5°C/100y, much larger than the global average (0.74°C/100y).
Shanghai Surface Air Temperature Anomalies

- Trend of 1980-2007: 0.104 °C/yr
- Trend of 1948-2007: 0.037 °C/yr

Global Mean Surface Air Temperature Anomalies

- Trend of 1980-2007: 0.019 °C/yr
- Trend of 1948-2007: 0.013 °C/yr

Data Source: GISS Surface Temperature Analysis
Heat Waves around Shanghai Area

Average temperature and dew point during Shanghai heat waves. To qualify, the maximum temperature needs to be greater than 35°C, and the minimum temperature has to be greater than 25°C for three days in a row.

Typical Climate Effects due to Urbanization
Estimation of effects of urbanization on surface warming in Shanghai

OMR Approach: OBSERVATION MINUS REANALYSIS


In the NNR (a statistical combination of 6-hour forecasts and observations), surface observations of temperature, moisture and wind over land are not used. However, atmospheric vertical soundings of wind and temperature (rawinsondes and satellite soundings) strongly influence the NNR, and surface temperatures are estimated from the atmospheric values. As a result, the NNR should not be sensitive to urbanization or land-use effects, although it will show climate changes to the extent that they affect the observations above the surface.
High correlation in the inter-annual and inter-decade scales between NNR and OBS

<table>
<thead>
<tr>
<th>Year</th>
<th>OBS</th>
<th>NNR</th>
<th>DIF</th>
<th>COR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>-0.59</td>
<td>-0.06</td>
<td>-0.53</td>
<td>0.86</td>
</tr>
<tr>
<td>1970</td>
<td>-0.67</td>
<td>-0.11</td>
<td>-0.56</td>
<td>0.84</td>
</tr>
<tr>
<td>1980</td>
<td>-0.5</td>
<td>-0.51</td>
<td>-0.01</td>
<td>0.82</td>
</tr>
<tr>
<td>1990</td>
<td>0.54</td>
<td>0.23</td>
<td>0.31</td>
<td>0.89</td>
</tr>
<tr>
<td>2000</td>
<td>1.52</td>
<td>0.57</td>
<td>0.95</td>
<td>0.81</td>
</tr>
</tbody>
</table>
Last decade, 2/3 of the surface warming in Shanghai may be due to changes in land surface (urbanization).
Change of Rainfall Type

- Light rainfall decreased
- Heavy rainfall increased
Climatic Changes of Landfall Tropical Cyclones in China over the past 58 Years

Based on the data from the Tropical Cyclone (TC) Yearbooks, Changes of landfall TCs in China over the past 58 years (1949-2006) including tracks, numbers, duration, intensity as well as their probability distributions were examined.

Compared with 1949—1981, during 1982-2006:

- More tropical cyclones making landfall
- Less tropical cyclones making landfall
Climate Change Impact on Energy Using

Shanghai electric power consumption from 1985 to 2005

The relationship between The Urban heat island (UHI) and energy consumption effects from 1985 to 2005
The peach blossom day had advanced 12.3 day for 1990s. The normal peach blossom day in Shanghai is 6 April, now is 25 March.
The Death frequency in Shanghai during heat waves

If the mean high temperature during the heat waves is higher than 36.5°C, the death frequency increase largely.

The death frequency is also have strong relationship with the heat wave holding days.
Now more and more extremely weather events had occurred during the climate change in Shanghai.

The heavy rain attacked Shanghai at 25 Aug, 2008.

One hour 117.5 mm pp

It is now recorded in Shanghai’s history.
Climate Change Vulnerability Assessment for Yangtze Estuary City

Risk

Vulnerability

Project finished by Fudan University and financially supported by the WWF
Double Challenges:
1. Local climatic effects due to rapid large-scale urbanization;
2. Climatic changes associated with the global warming;

The related local government agencies, joined by universities, research institutions and others, are actively address the issues of climate change, and making various action plans to face these challenges.
SMB’s Work on Climate Change

Closely following the China’s National Climate Change Programme (CNCCP) and the Action Plan on Climate Change of Chinese Meteorology Administration (CMA):

◆ To carry out scientific research on local climate effects associated with rapid large-scale urbanization of Shanghai area and climate changes related to the global warming;

◆ To outline objectives and basic principles, identify areas of actions, as well as make suggestions of polices and measures to address climate change for the local government in the overall context of national sustainable development strategy;

◆ To provide scientific assistances for the local government’s efforts to enhance society’s capacity to adapt and mitigate climate change.
Thank You

for your attention!