Adapting the city to heavier rainfall and increased flood risk

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Overview of case study

Adapting the city to heavier rainfall and increased flood risk

The Bureau of Construction

Flood Control Facilities
Principal projects are river channel improvements and development of underground regulating reservoirs and diversion channels.

Measures in River Basins
Comprehensive flood control measures including infiltration facilities

Flood Warning System
Notification of flood risks and provide real-time information

Because of the level of flood control facilities in East Tokyo, flooding of rivers and flooding of houses are frequently occurring.
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Overview of case study

- Safety level of flood control is still less 5 years return period in East Tokyo.
- In the next 30 years, the level will be promoted up to 20 years return period.
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• The change in the future hourly rainfall intensity will be 1.3 times as present.

• Climate change will affect the frequency and intensity of heavy rainfall events.

• The risk of flooding will increase due to Climate change and decision support for maintaining future flood safety mitigation is required.
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Regional Climate data
NHRCM:
Non-hydrostatic regional climate model (developed by JMA's Meteorological Research Institute (MRI)).

- Data NHRCM 5Km
- SRES A1B
- Present 1980-1999
- Near Future 2016-2035
- Future 2076-2095
- Time Resolution: 10 min
- Spatial Resolution: 5Km

For more details, a full document is available on the JMA’s website http://ds.data.jma.go.jp/tcc/tcc/index.html
Global essential climate variables

Objective
- Investigate how well the NHRCM projection agrees with the empirical relationship
- Evaluate the NHRCM projection to assess whether it can be considered a low, medium or high scenario with respect to sub-daily precipitation extremes
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What indicators are you going to calculate?

Global Climate impact indicators
- Daily extreme precipitation

Local Climate impact indicators
- Rainfall Intensity-Duration-Frequency (IDF) curves
- Change of frequency until reaching danger level in the channel
- Change of runoff speed, e.g. reaching time to overflow from the river.
- Change of frequency over the 0.5m inundation depth at catchment
Work Flow Progress

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Step 1: Collect rainfall data from climate projection for Tokyo
Step 2: Compare the RCM projection with the GCM ensemble
Step 3: Calculate IDF curves design rainfalls
Step 4: Compare the results with historical observation
Step 5: Flood Risk Analysis by IDF design rainfall
Step 6: Flood Risk Analysis by Event Base Rainfall
Step 7: Visualize rainfall and flood risk change

Present->
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S1: Collect rainfall data

Maximum 10 minute rainfall by NHRCM in 2076

SRES A1B
Present 1980-1999
Near Future 2016-2035
Future 2076-2095

Number of Grid: 211 × 691

NHRCM Calculation grid in Tokyo (5Km)

Calculate maximum 10, 20, 30, 60, 120, 180 minutes rainfall for each year
Select the rainfall data inside Tokyo
Calculate Rainfall Return Periods of 3 to 15 years by GEV
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Work Flow Progress

S3: Calculate IDF curves design rainfalls

Return Periods for East Tokyo: 5 years

IDF Curve

Return Periods: 3 Year
Return Periods: 5 Year
Return Periods: 10 Year

Design Rainfall

East Tokyo

West Tokyo

Duration (min)

Rainfall (mm/hr)

Max

Average
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S4: Compare the results with historical observation

Periods: 1980 - 1999

The reanalysis data generally reproduces historical observation data.

10 minutes: Gauge $\approx 1.4\sim1.5 \times$ NHRCM

60 minutes: Gauge $\approx 1.0\sim1.1 \times$ NHRCM
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Impact / importance of your results for the client / issue to be addressed

Change of return period in 75 mm/her rainfall intensity

Historical observation : 20 Years
Near Future (2016-2035): 11 Years
Far Future (2076-2095) : 8 Years
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We planned to use Rainfall Intensity-Duration-Frequency (IDF) curves

- **IDF Curve by NHRCM**
- **Design Rainfall**
- **Calculate Runoff**

- **Advantage**: Reduce the number of rainfall runoff calculation

- **Disadvantage**: No consideration of rainfall pattern and distribution
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Apply 10 minutes rainfall time series from NHRCM to the TSR model

- **Advantage**
  Considering rainfall pattern and distribution
  A realistic river channel water level hydrograph could be calculated.

- **Disadvantage**
  The lot of rainfall runoff calculation are needed.

We chose 10 minutes rainfall events from NHRCM and run the TSR model for all the rainfall events.
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Study Area

(a) Surface

<table>
<thead>
<tr>
<th>Element</th>
<th>Number</th>
<th>Area(%)</th>
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</thead>
<tbody>
<tr>
<td>Building</td>
<td>40,241</td>
<td>30%</td>
</tr>
<tr>
<td>Road</td>
<td>45,874</td>
<td>16%</td>
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<tr>
<td>Green area</td>
<td>2,249</td>
<td>13%</td>
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<tr>
<td>Other</td>
<td>12,054</td>
<td>41%</td>
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<tr>
<td>Total</td>
<td>100,418</td>
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</table>

(b) Sewer drainage

Manholes 9,638
Pipes 9,909
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TSR
(Tokyo Storm Runoff)

Rainfall
Parameter, Initial condition

Rainfall

Direct flow
(Discharge for road and river elem.)

Surface flow + infiltration
Inflow to sewer system through inlet

Sewer drainage flow

River flow

Result

End

Direct runoff
Surface flow
Flood Inundation

Rainfall
Sewer drainage flow
River flow
Result
End
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Rainfall Runoff and Inundation analysis by the TSR model

Maximum Inundation map by the TSR model
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Case Study Work Flow

Step 1: Collect rainfall data from climate projection for Tokyo
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    Flood Risk Analysis by Event Base Rainfall
Step 6: Visualize rainfall and flood risk change

We are in Step 5 and creating the Local CII. Future plan to Step 2 as follows.
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Global essential climate variables

Methods
- Collect daily extreme precipitation from GCMs in the CDS, e.g. the 3- or 10-year value
- Estimate future changes in shorter-duration extremes, based on the GCM ensemble
- Assess how differences in daily extremes between two periods are related to differences in shorter-duration extremes
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How to select Global essential climate variables from GCMs in the CDS

- Use APHRODITE (Daily precipitation grid data by Asian region rain gauge observation) in order to archived for integrated use.
- Bias correction of the model's daily rainfall is performed using this rain gauge observation data.

Results of APHRODITE

<table>
<thead>
<tr>
<th>Model</th>
<th>Score</th>
<th>RMSE</th>
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<tbody>
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Results of Bias Correction by APHRODITE

Under Review
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Thank you for your attention !!