NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Institute of Catastrophe Risk Management

Spatiotemporal Patterns of Rainfall Extremes in Southeast Asia: Implications for Flood Risk Assessment

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INTRODUCTION

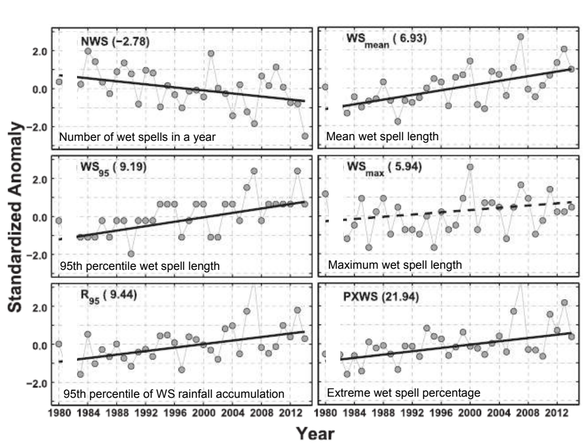
Extreme precipitation and associated flooding cause severe damage to society and the environment. Future climate projections suggest an intensification of precipitation extremes in many regions. Southeast Asia (SEA) is highly vulnerable to extreme events (e.g. 2011 Thailand flood, 2012 flood in Peninsular Malaysia and 2013 flood in Jakarta) and it is home to about 620 million people with many densely populated cities and low elevation coastal regions. Rapid urbanization in SEA further exacerbates the flood risk.

GOALS: **To conduct quantitative assessment of trends in SEA precipitation for the historical and future time periods at a resolution finer than the typical GCM resolution**
To integrate information about the changes in precipitation and urban growth into an in-house flood risk assessment framework and assess flood risk as demonstrated for Jakarta.

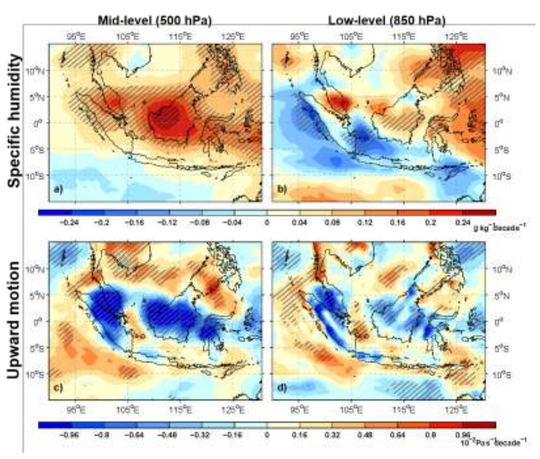
1. HISTORICAL RAINFALL TRENDS

Analyzed wet spell (defined as the number of consecutive rainy days) characteristics in Singapore during 1980 to 2014 and examined if the observed trends can be explained by the behaviour of large-scale dynamic and thermodynamic variables over the region.

Datasets: Rain gauge data from Singapore and reanalysis data from ERA-Interim.



Trends in wet spell indices over Singapore estimated using rain gauge observations. Significant trends (shown in solid lines) are observed in wet spell indicators. Numbers in parenthesis indicate decadal change (%) w.r.t. the mean value

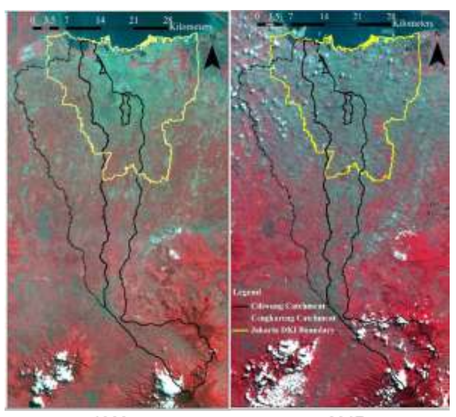


Decadal trends in specific humidity and upward motion at two pressure levels estimated using reanalysis data. Significant increase in humidity and upward motion is observed over Borneo, Malay Peninsula and Philippines

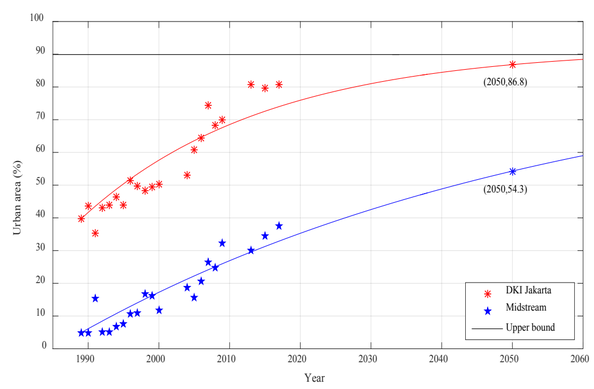
3. URBANIZATION TRENDS FROM LANDSAT IMAGERY

Extracted urban areas in Jakarta region using supervised classification of Landsat imagery in ArcGIS environment and parameterized and extrapolated to year 2050.

Datasets: Landsat 4-5 Thematic Mapper (TM) for 1989-2009 and Landsat 8 Operational Land Imager (OLI) for years 2013, 2015 and 2017.



Changes in landuse-landcover for Jakarta region as evident in Landsat false color composite images for years 1989 and 2017

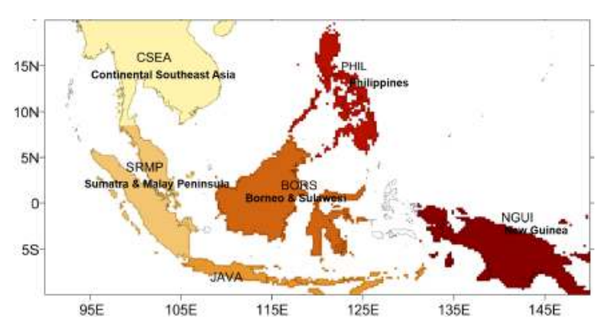


Percentage urban extent for DKI Jakarta and midstream regions extracted from Landsat imagery and corresponding future (year 2050) projections are derived from the fitted models. The percentage urban extent for midstream region is projected to increase from 38% in 2017 to 54% in 2050

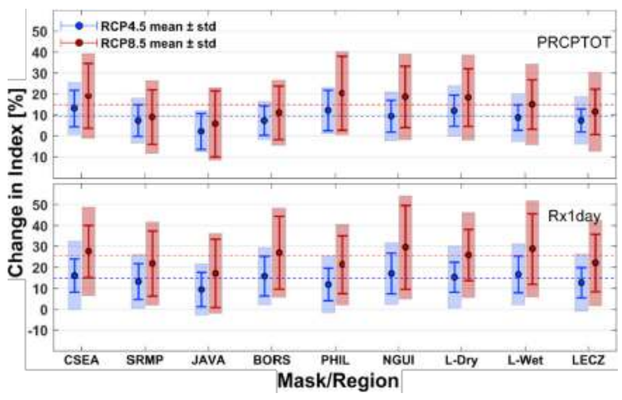
2. FUTURE RAINFALL PROJECTIONS AND TRENDS

Analysed high resolution future projections from an ensemble of 20 climate models under two emission scenarios RCP4.5 and RCP8.5 and trends (if any) are quantified.

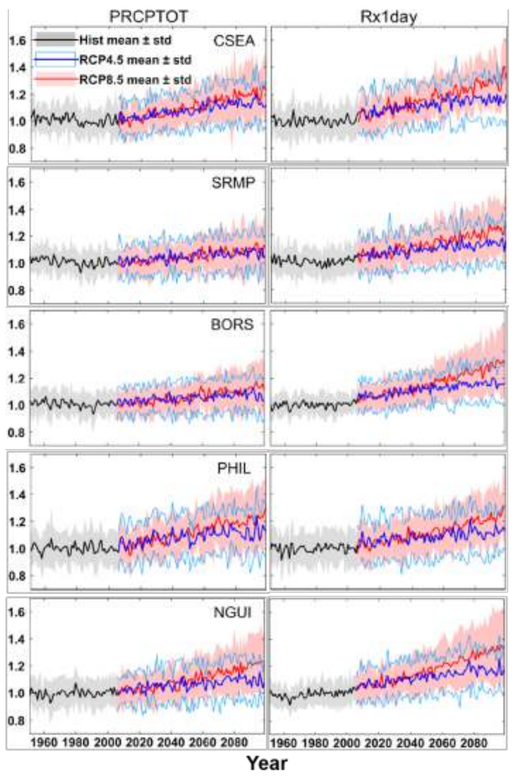
Datasets: NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) with a spatial resolution of 0.25°.



Six regional masks for which the changes in precipitation are quantified



Changes in precipitation indices averaged over regional masks for the 2070-2099 period relative to 1970-1999 period. Vertical bars depict intermodel variability (standard deviation) and shading represents intermodel and spatial variability.

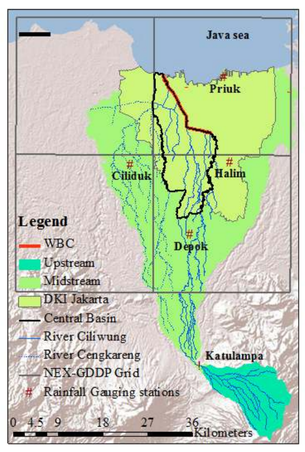


Time series of normalized annual precipitation total and annual maximum daily precipitation for each region. The solid thick lines represent ensemble mean and the shaded regions denote intermodel variability (standard deviation)

4. FLOOD RISK ASSESSMENT

Integrate the information about intensification of precipitation extremes and urbanization into a flood risk assessment framework developed in ICRM, and demonstrate it over Jakarta.

Data and models: Rain gauge data, surveys, loss curves from ICRM, Jakarta flood model



Three study regions in Jakarta along with rain gauges and NEX-GDDP grids used

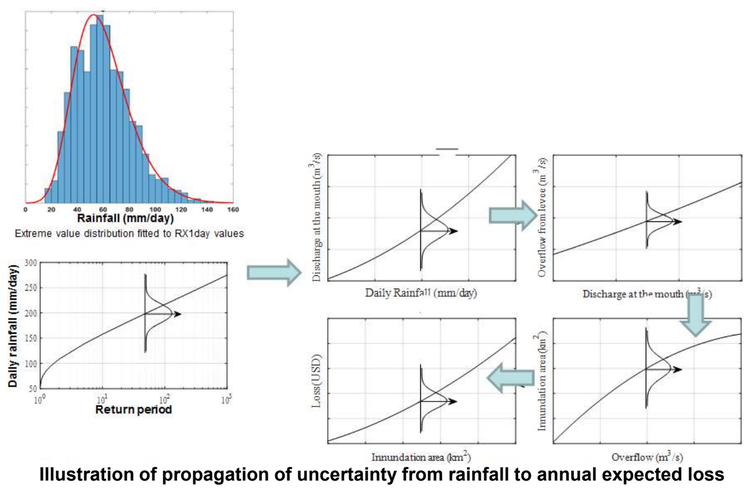
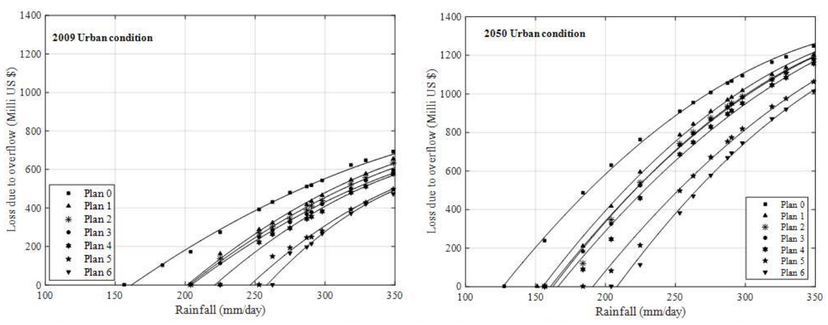


Illustration of propagation of uncertainty from rainfall to annual expected loss



Flood loss values for different daily rainfall values (2-5000 year return period) under current (year 2009) and future (year 2050) projected urban conditions

KEY CONCLUSIONS

- Significant trends in wet spell indices observed for Singapore. Mean, 95th percentile, and the maximum wet spell length increased at 0.18, 0.64, and 1.2 days decade^{-1}, respectively.
- Strengthening of low-level convergence, vertical motion, increase in moisture availability and instability explain the upward trends observed in wet spells over Singapore.
- The projected centennial increase in total annual precipitation relative to 1970-1999 period when averaged over all land grid cells in SEA is about 15% under RCP8.5 scenario.
- The rate of urbanization is stronger in midstream Jakarta region (32% in 2009 to 54% in 2050) compared to the DKI Jakarta (70% in 2009 to 87% in 2050).
- The flood loss for 100-year return period rainfall is projected to increase by 172% in year 2050 compared to the year 2009 value.

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