Climate Change – From Global to Local

Transforming global-scale climate projections into local-scale for a climate-resilient Singapore

METEOROLOGICAL SERVICE SINGAPORE
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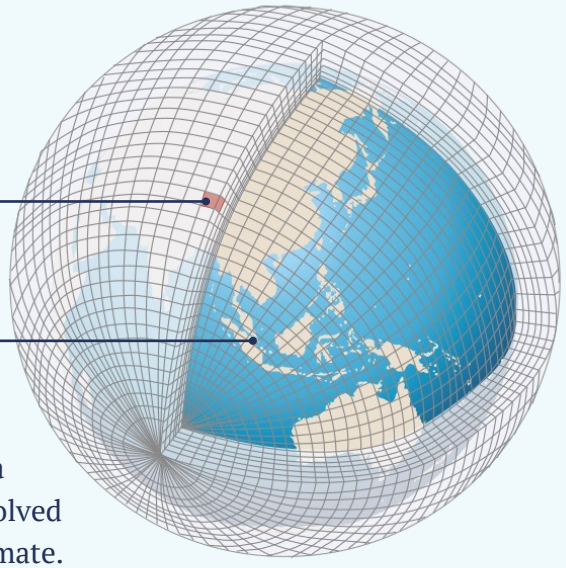
Global Climate Models

- Developed by leading climate research centres around the world, global climate models (GCMs) consist of computer code that solves mathematical equations used to represent the physical processes in Earth's climate system.

- Generally, the latest GCMs have a resolution of 75–250 km, which means that Earth's atmosphere is divided into grid cells that are 75–250 km along each side.



- GCMs are the primary tools for providing climate projections. Once a climate simulation has been initiated, mathematical equations are solved by supercomputers over a number of time-steps to project future climate.

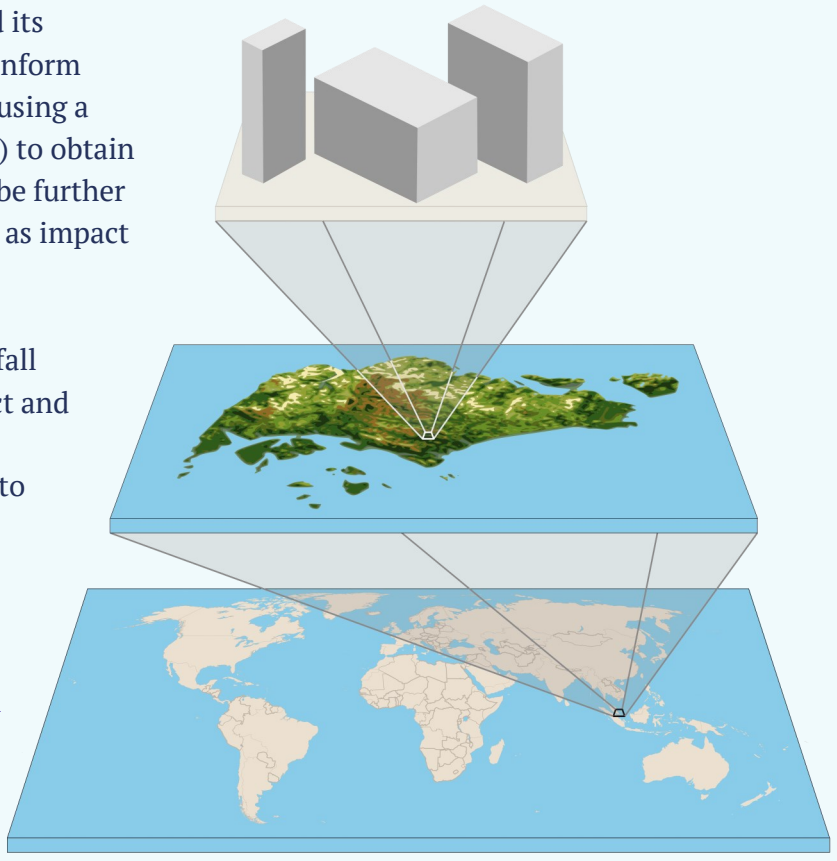
The Need for Finer-resolution Regional and Local Climate Information

- Most climate change impacts (especially those resulting from extreme events) take place at regional and/or local scale.

- Due to the coarse resolution of GCMs, they cannot be used to understand details of climate processes occurring at more modest regional and local scales.

- For scientists to understand climate change and its impacts at regional and local scales in order to inform climate change adaptation, downscaling GCMs using a higher-resolution regional climate model (RCM) to obtain more details is necessary. The RCM output can be further processed to provide even more local info, such as impact of buildings and hills (illustrated on the right).

- Typically, GCMs are also unable to capture rainfall and temperature extremes. The ability to predict and project these extremes is important for climate change adaptation in Southeast Asia (SEA) due to the region's topography, complex coastlines, and thousands of small islands. RCMs are often much more skilful in capturing extreme events.



A schematic of how coarse-scale climate information from a GCM can be translated to fine-scale regional and local information through downscaling. This is done using a RCM that can represent more details (e.g. topography and coastlines) and the corresponding physical processes.

Dynamical Downscaling

Dynamical downscaling uses output from a GCM as input into a RCM that operates over a small part of the globe. As a RCM has higher resolution, it provides more details over that area, and it is more efficient and economical to run computationally than running a GCM of similar resolution over the whole globe.

In V3, a number of GCMs are selected based on stringent criteria. For each GCM, the dynamical downscaling process is illustrated below.

The GCM provides the initial condition (including winds, air temperature, etc. at each grid cell) to start the RCM simulation of physical processes in the region's climate system.

- Mathematical equations are solved computationally to calculate how the climate information in each grid cell of the RCM changes with time.
- The calculations take into account the interactions, such as exchange of energy, between each individual cells and surrounding cells.

Start of simulation: 1 Jan 2015

End of simulation: 31 Dec 2099

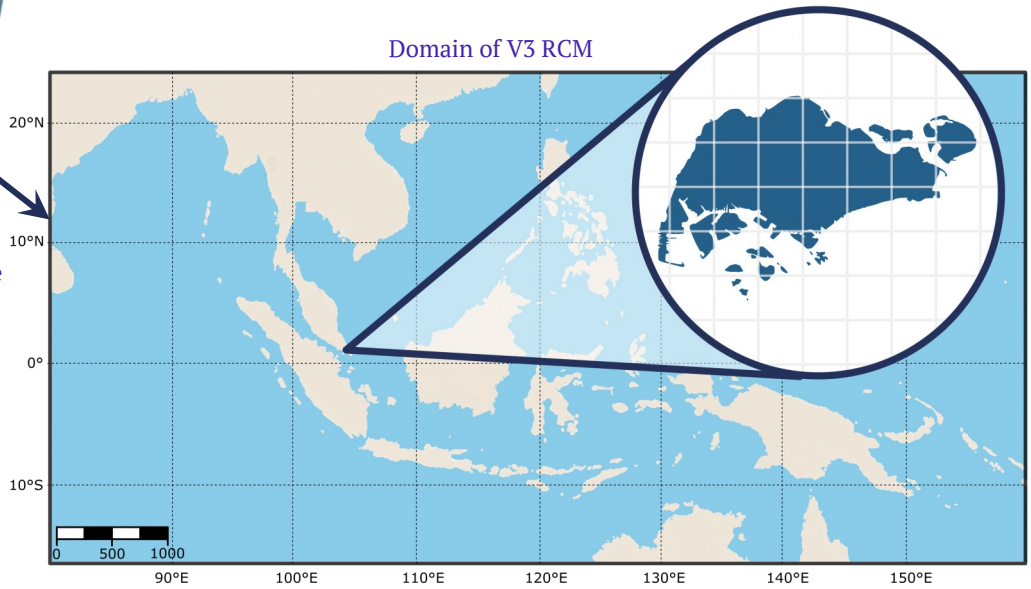
Throughout the simulation, latest information derived from the GCM is routinely fed into the RCM to update the regional climate projections.

GCM

Every 6 hours, the climate information (e.g. winds, air temperature, sea surface temperature) at the edges of the RCM is derived from the GCM.

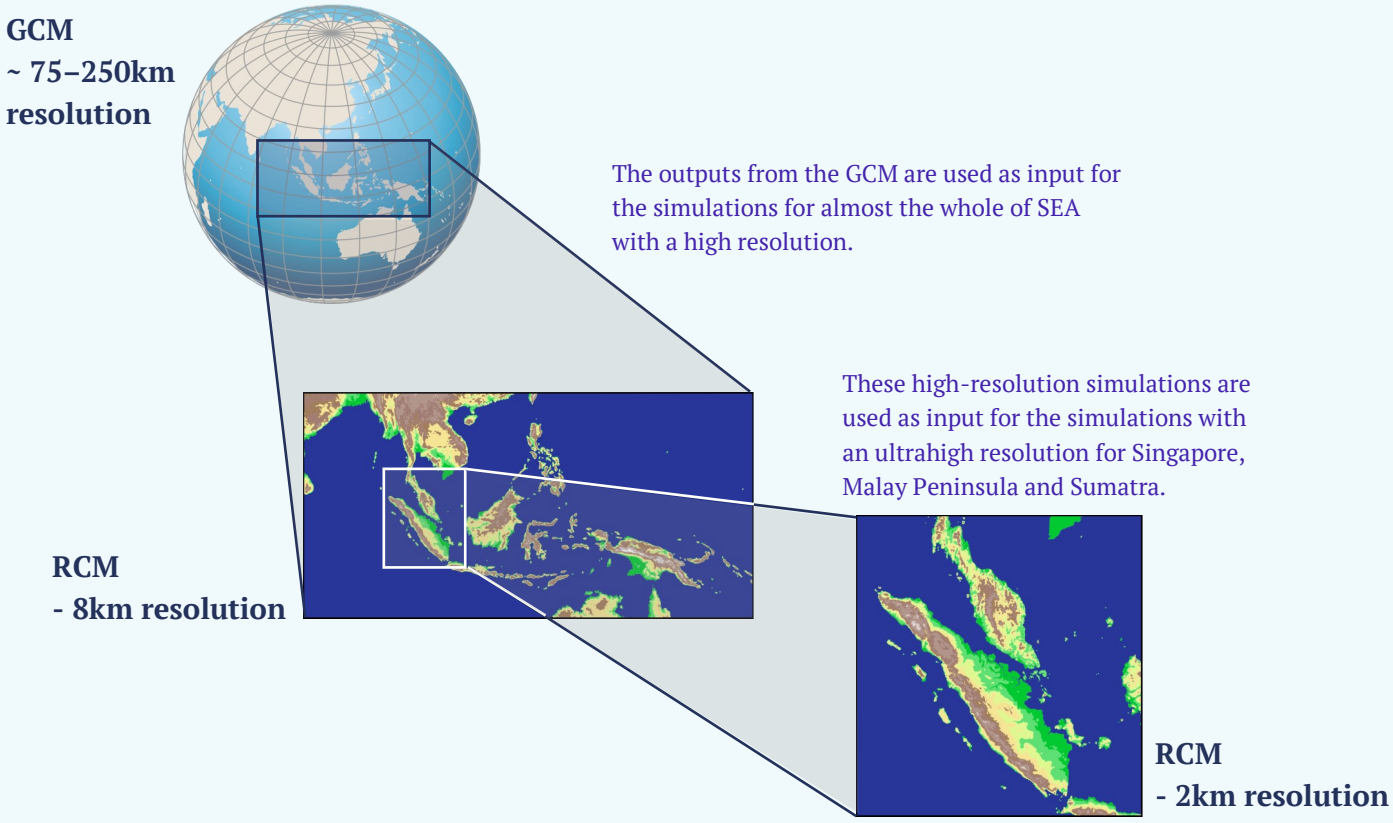
Domain of V3 RCM

Singapore in the RCM



Two-stage Downscaling Process in V3

The downscaling model employed by CCRS for V3 is called SINGV-RCM[1], which is the RCM. The downscaling is performed in two phases to reach first 8km resolution and then finally 2km resolution (illustrated below).



Building Trust in V3 Data

- To test whether V3 climate projections are reliable, V3 historical simulations are compared against observational and reanalysis[2] data over the period 1995–2014. This is in accordance with the Intergovernmental Panel on Climate Change's (IPCC) recommendations. A generally accepted view is that if a model simulates historical climate well, it can be more trusted for simulations of future climate.

- V3 data agrees with observational and reanalysis data over the SEA region better than the GCMs, indicating higher accuracy and reliability. This results in higher confidence to use V3 data for climate change impact modelling over Singapore and the SEA region.

1 SINGV-RCM is adapted from CCRS' SINGV operational numerical weather prediction model that is extensively validated with local and regional observations, thus giving higher confidence in its ability to simulate key weather and climate processes over the region.
2 To address observational data scarcity at many locations on the globe, reanalysis combines GCMs' past weather forecasts with observations to create global data that describe the recent history (several decades) of Earth's climate system more comprehensively than observations.

Centre for Climate Research Singapore

A research centre under the Meteorological Service Singapore and part of the National Environment Agency. It was officially launched in March 2013, with the vision to be a world leading centre in tropical climate and weather research focusing on the Southeast Asia region.

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