14

Communication and Dissemination of V3 Data and Products

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14.1 Introduction

It is now well recognised in the national and international community that the gap between scientific data producers and users needs to be reduced in order to make climate science information more usable for various stakeholders ranging from policymakers to the public. In this chapter, we present the various elements of the V3 communications and dissemination plan. Communicating the key messages, data, and products is an essential dimension of the V3 study. For the V2 study, we did not have a systematic communication plan, and hence, having such a plan is an important addition to the overall V3 planning and delivery process.

The V3 communications strategy has various dimensions:

1. Topical Brochures and Videos
2. Infographics
3. Scientific Publications
4. V3-Data Sharing and Visualisation Portal
5. V3 Public Release
6. Engagement with Singapore Ministries
7. Engagement with Singapore Government Agencies
8. Engagement with Singapore Media Houses
9. Engagement with Regional and International Media Houses
10. International Engagement

14.2 Topical Brochures and Videos

As a part of the V3 communications plan, topical brochures and videos have been planned on the following eight topics:

1. V3 Explained
2. Climate Change - From Global to Local
3. Past and Future Sea-level Change
4. Understanding Climate Extremes
5. Using Climate Change Projections in Risk Assessments
6. Probabilistic Climate Change Projections Explained
7. Weather and Climate Drivers for Singapore Explained
8. Application-ready Datasets Explained

Out of the eight brochures, the first three are already completed and are presented below.

14.2.1 V3 Explained

Figures 14.1 to 14.4 show the thumbnails of the 'V3 Explained' brochure. The cover page gives a high-level introduction to the context in which V3 is carried out and its importance (Figure 14.1). To give readers a more comprehensive overview of the V3 project, the rest of the brochure presents:

- Key outputs of V3
- Main areas of climate change impact research underpinned by V3
- Value proposition compared with V2
- Various stages in the V3 project
- Types of data and products that readers can expect
- Data and product categories and how the data will be disseminated

Definitions of SSPs, along with some abbreviations and acronyms used in the brochure, are provided for readers who are unfamiliar with the terminology (e.g., stakeholder agencies).

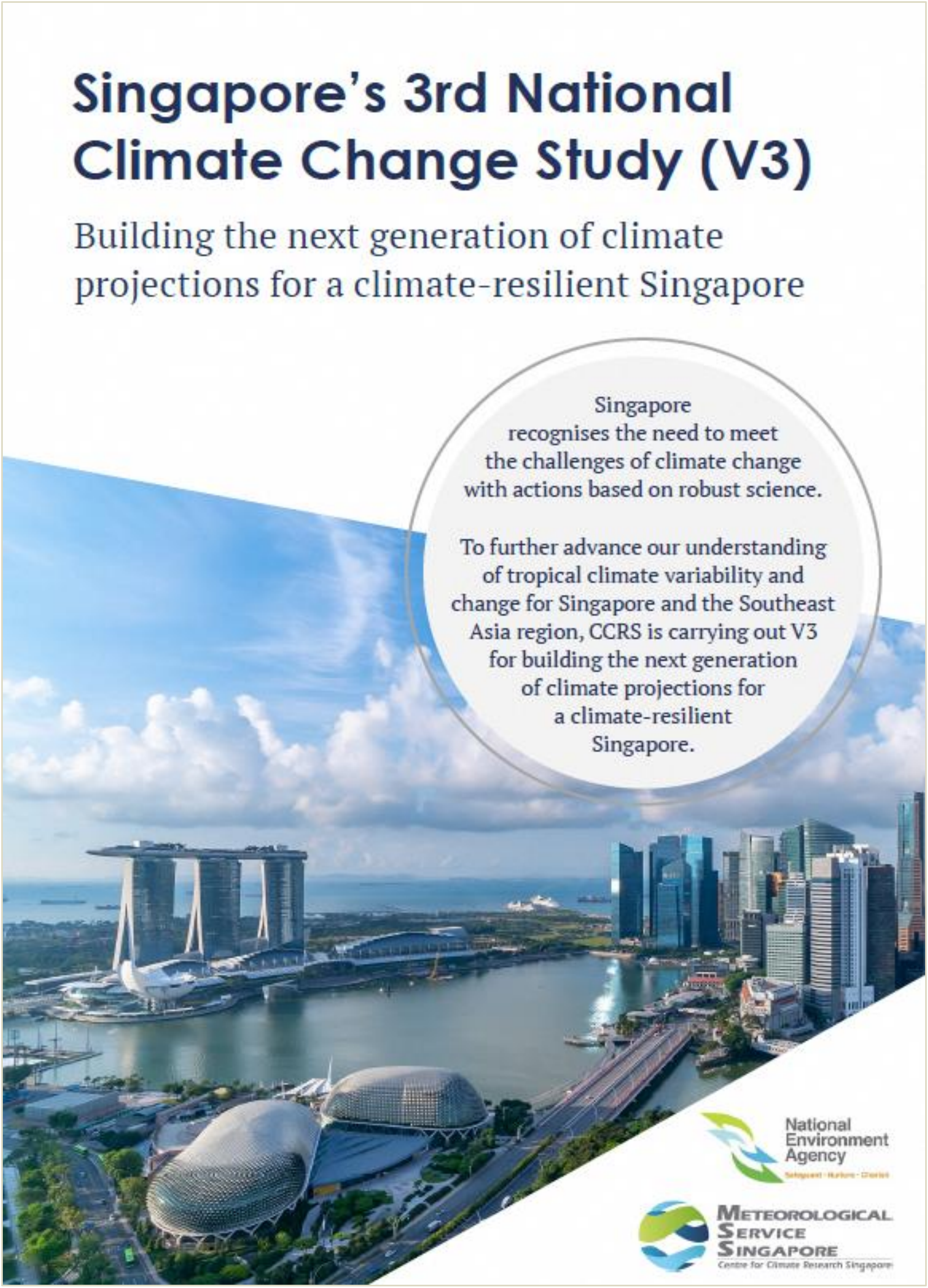
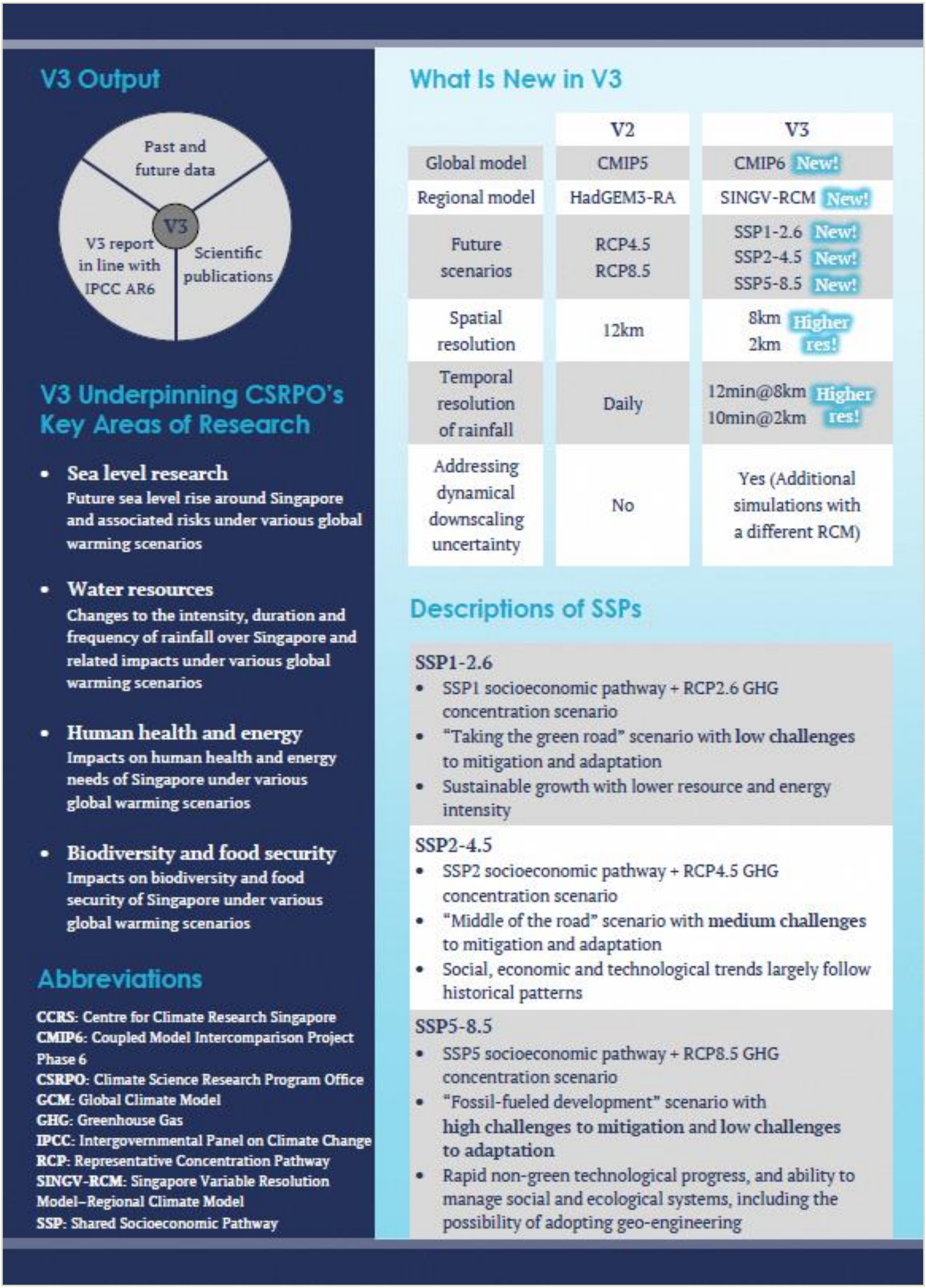


Figure 14.1: Cover page of the 'V3 Explained' brochure



V3 Output

Past and future data
V3
V3 report in line with IPCC AR6
Scientific publications

V3 Underpinning CSRPO's Key Areas of Research

- **Sea level research**
  Future sea level rise around Singapore and associated risks under various global warming scenarios
- **Water resources**
  Changes to the intensity, duration and frequency of rainfall over Singapore and related impacts under various global warming scenarios
- **Human health and energy**
  Impacts on human health and energy needs of Singapore under various global warming scenarios
- **Biodiversity and food security**
  Impacts on biodiversity and food security of Singapore under various global warming scenarios

Abbreviations

CCRS: Centre for Climate Research Singapore
CMIP6: Coupled Model Intercomparison Project Phase 6
CSRPO: Climate Science Research Program Office
GCM: Global Climate Model
GHG: Greenhouse Gas
IPCC: Intergovernmental Panel on Climate Change
RCP: Representative Concentration Pathway
SINGV-RCM: Singapore Variable Resolution Model–Regional Climate Model
SSP: Shared Socioeconomic Pathway

What Is New in V3

	V2	V3
Global model	CMIP5	CMIP6 New!
Regional model	HadGEM3-RA	SINGV-RCM New!
Future scenarios	RCP4.5 RCP8.5	SSP1-2.6 New! SSP2-4.5 New! SSP5-8.5 New!
Spatial resolution	12km	8km 2km Higher res!
Temporal resolution of rainfall	Daily	12min@8km 10min@2km Higher res!
Addressing dynamical downscaling uncertainty	No	Yes (Additional simulations with a different RCM)

Descriptions of SSPs

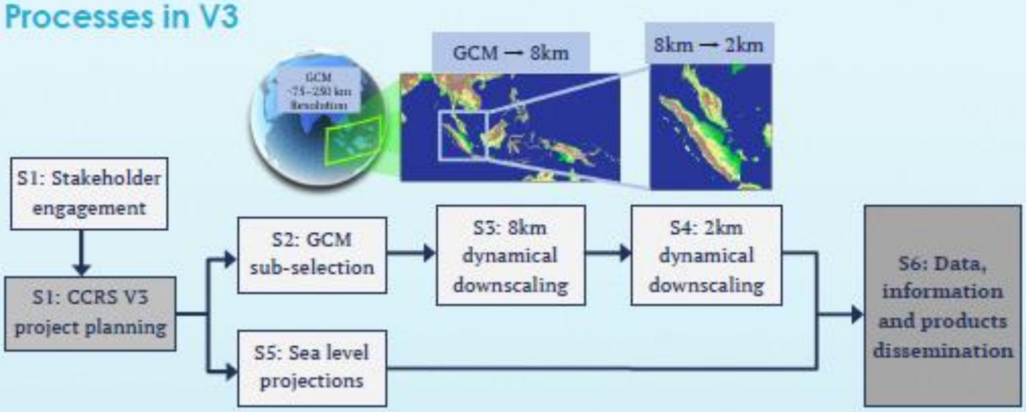
SSP1-2.6
- SSP1 socioeconomic pathway + RCP2.6 GHG concentration scenario
- "Taking the green road" scenario with **low challenges** to mitigation and adaptation
- Sustainable growth with lower resource and energy intensity

SSP2-4.5
- SSP2 socioeconomic pathway + RCP4.5 GHG concentration scenario
- "Middle of the road" scenario with **medium challenges** to mitigation and adaptation
- Social, economic and technological trends largely follow historical patterns

SSP5-8.5
- SSP5 socioeconomic pathway + RCP8.5 GHG concentration scenario
- "Fossil-fueled development" scenario with **high challenges to mitigation** and **low challenges to adaptation**
- Rapid non-green technological progress, and ability to manage social and ecological systems, including the possibility of adopting geo-engineering

Figure 14.2: The 'V3 Explained' brochure shows the key outputs of V3, key areas of research that it underpins, and key differences from V2. Definitions of SSPs, along with some abbreviations used, are provided for readers who are unfamiliar with the terminology.

Processes in V3



Expected V3 Data

	Rainfall	Temperature	Winds	Relative humidity
Domain (Resolution)	SG (8km, 2km)			
Models	5 CMIP6 GCMs downscaled by SINGV-RCM			
Scenarios	Historical, SSP1-2.6, SSP2-4.5, SSP5-8.5			
Timeline	1955–2100 @ 8km resolution; 1995–2014, 2040–2060, 2080–2100 @ 2km resolution			
Temporal resolution	• 12 min @8km • 10 min @2km • 1 hr @8km & 2km • Daily mean @8km & 2km • Monthly mean @8km & 2km	• Daily mean • Daily maximum • Daily minimum • Monthly mean • Monthly mean profiles (pressure levels)	• Daily mean 10m wind speed • Daily maximum 10m wind speed • Daily mean 10m wind direction • Monthly mean wind profiles (pressure levels) • Daily maximum wind gusts	• Daily mean • Daily maximum • Daily minimum • Monthly mean • Monthly mean profiles (pressure levels)
Vertical levels	Surface	1.5m (daily) Pressure levels (monthly)	10m (daily) Pressure levels (monthly)	1.5m (daily) Pressure levels (monthly)
Products	• Frequency and intensity of extreme rainfall events • Dry spells • Wet spells	Frequency and intensity of extreme temperature events (e.g. hot days, warm nights)	Frequency and intensity of extreme winds	–
Solar radiation	Projections of net incoming solar radiation will be provided for SSP1-2.6, SSP2-4.5 and SSP5-8.5 scenarios at daily frequency over Singapore at 8km and 2km spatial resolutions.			
Sea level projections	Probabilistic sea level projections with SSP1-2.6, SSP2-4.5 and SSP5-8.5 scenarios. Projections of wave and storm surge will be made available as a part of V3+ (pending additional resources).			

Figure 14.3: The 'V3 Explained' brochure presents the various stages in the V3 project, as well as the types of data and products that readers can expect.

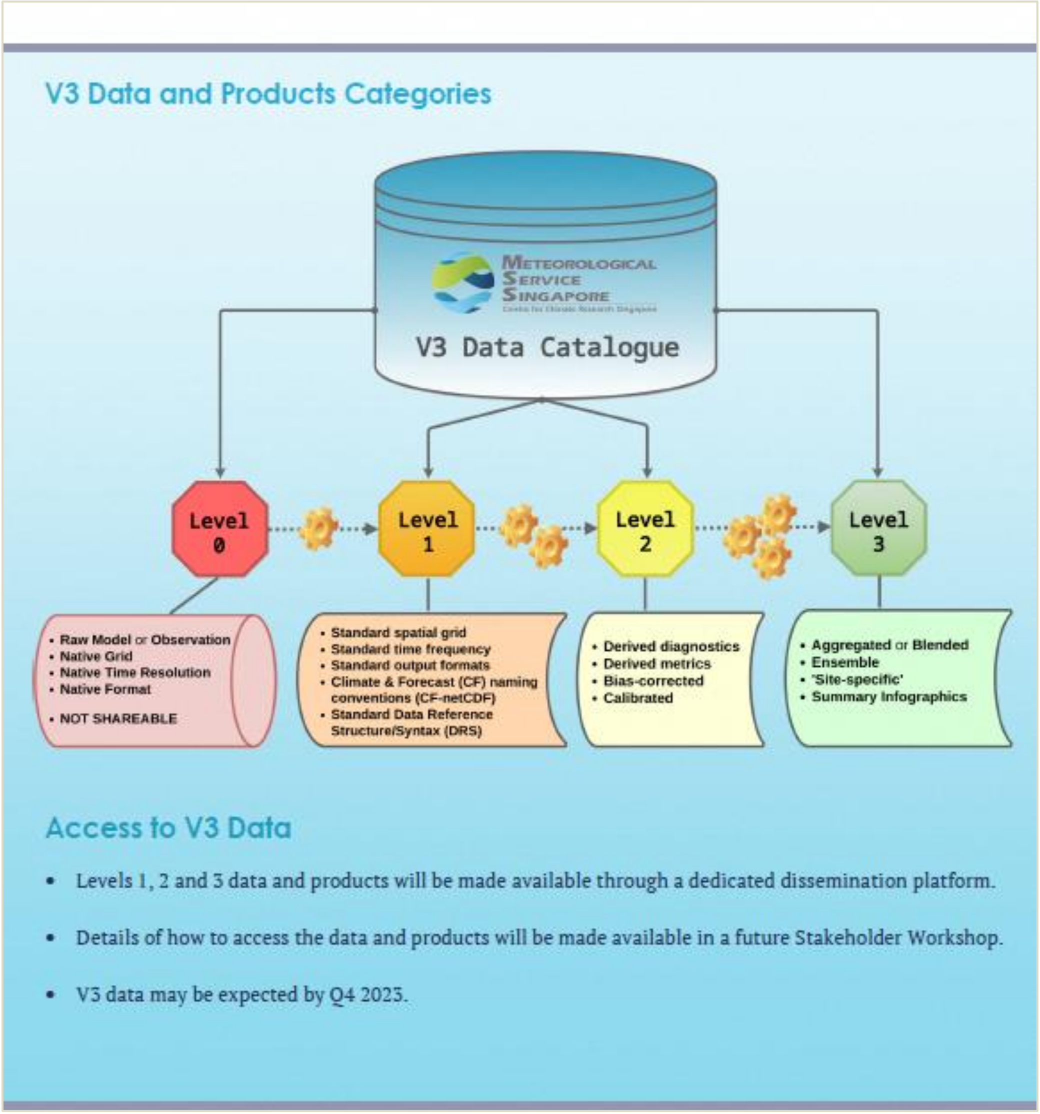


Figure 14.4: The 'V3 Explained' brochure gives an overview of the data and product categories and explains how the data can be accessed.

14.2.2 Climate Change - From Global to Local

Climate model downscaling is a scientific concept that is challenging to grasp for readers and stakeholders with whom CCRS has been engaging. There are various downscaling methods. For targeted communications with key stakeholders to enhance their understanding, a brochure is developed to specifically explain dynamical downscaling, the method adopted in the V3 project.

Figures 14.5 to 14.8 show the thumbnails of the 'Climate Change - From Local to Global' brochure.

The cover of the brochure visually illustrates the idea of transforming global climate information to regional and then local climate information, with the subtitle reinforcing the key message that the V3 project plays a critical role in building a climate-resilient Singapore. The brochure first introduces what GCMs are and how their limitations lead to the need for finer-resolution regional and local climate information, which is required for climate change adaptation planning in Singapore and the surrounding region. Readers are then introduced to dynamical downscaling using the V3 project as an example, in line with the objective of the brochure. Finally, the brochure presents the two-stage downscaling process in V3 (i.e. from global to 8km resolution to 2km resolution) and explains how the reliability and robustness of V3 climate change projections are demonstrated by comparing V3 climate simulations with observational data and ERA-5 data.

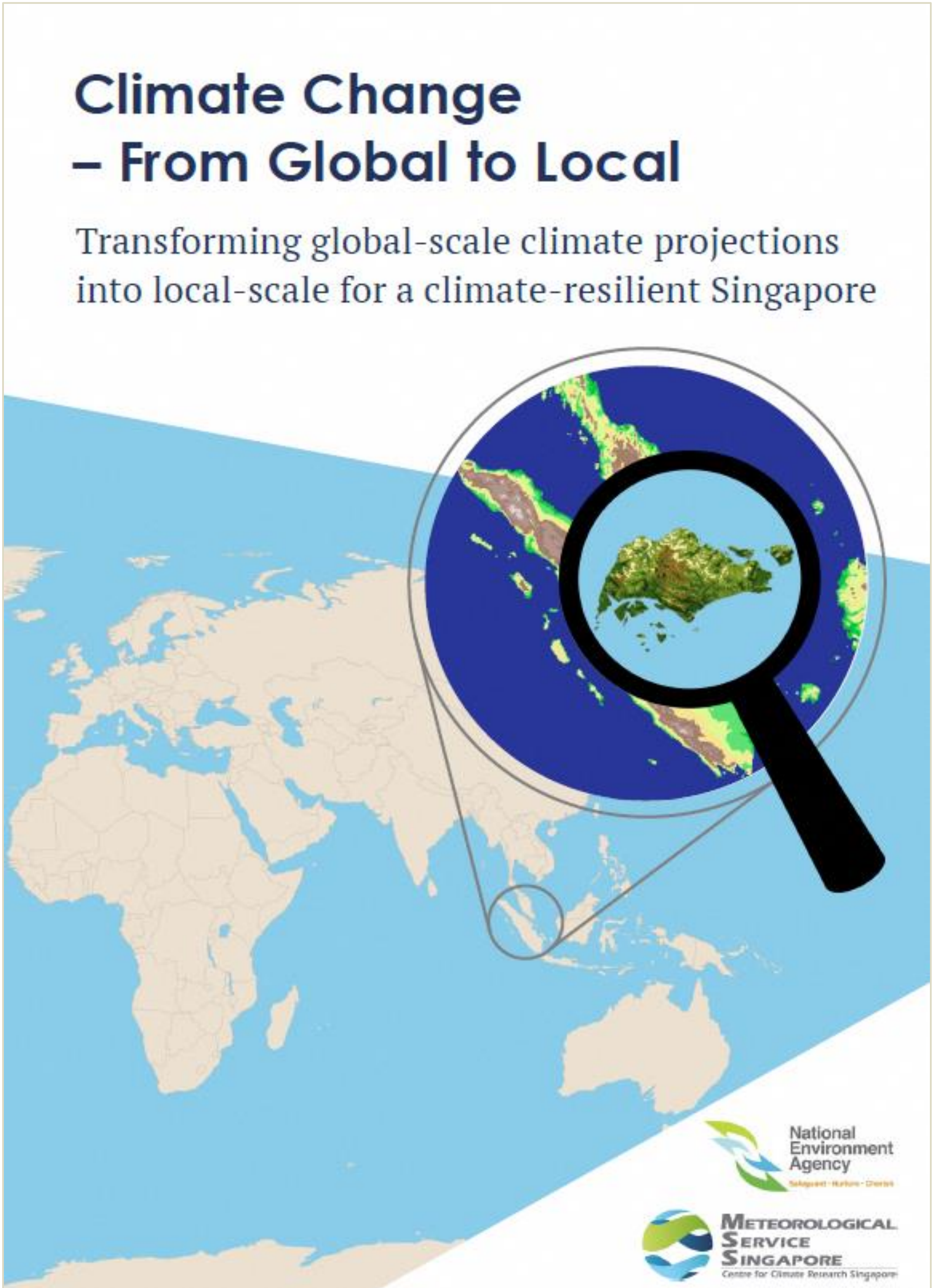
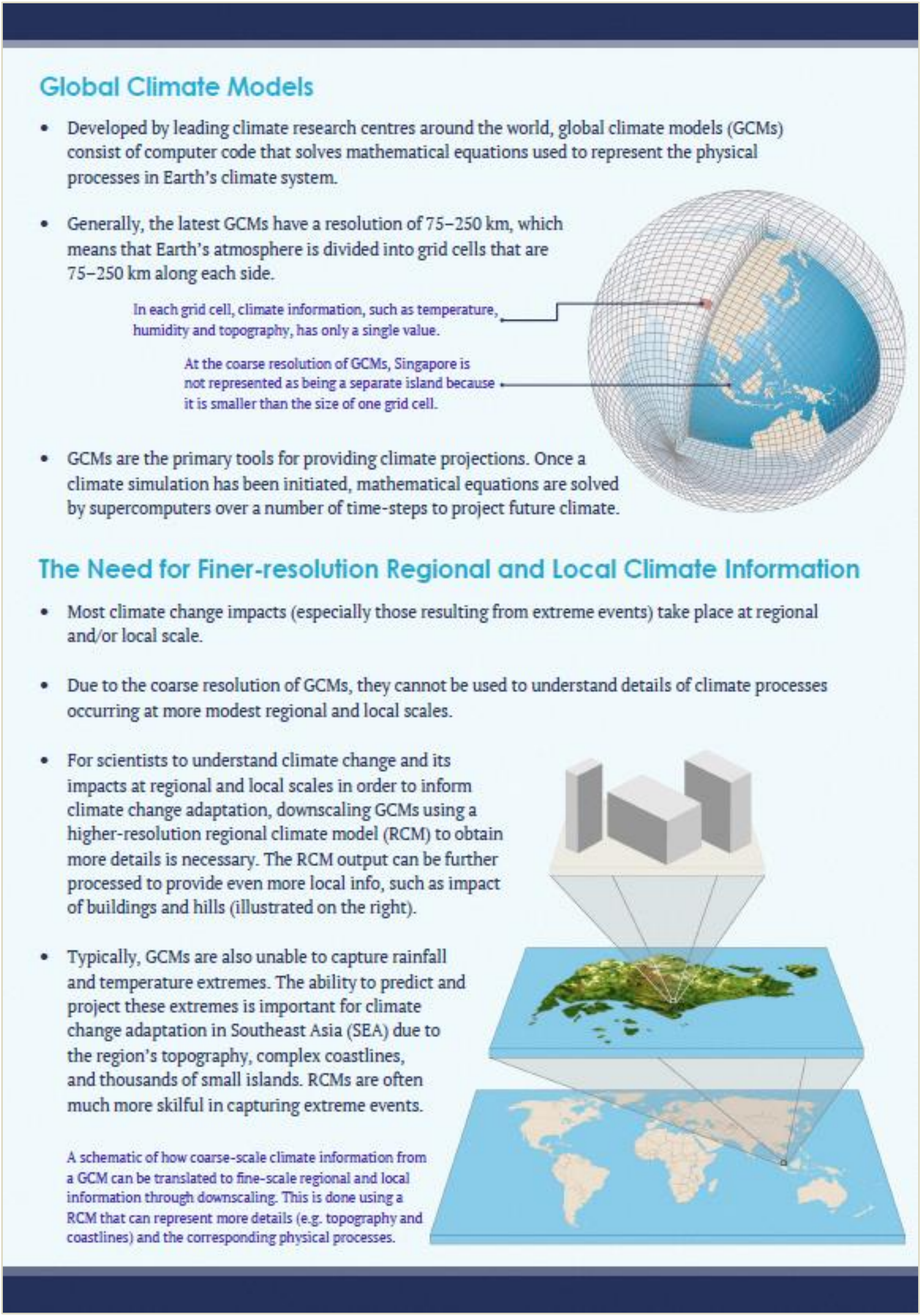


Figure 14.5: Cover page of the 'Climate Change - From Global to Local' brochure



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.

In each grid cell, climate information, such as temperature, humidity and topography, has only a single value.

At the coarse resolution of GCMs, Singapore is not represented as being a separate island because it is smaller than the size of one grid cell.

- 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.

Figure 14.6: The 'Climate Change - From Global to Local' brochure begins with a brief introduction to GCMs and their limitations, explaining the need for finer-resolution climate information for climate change adaptation.

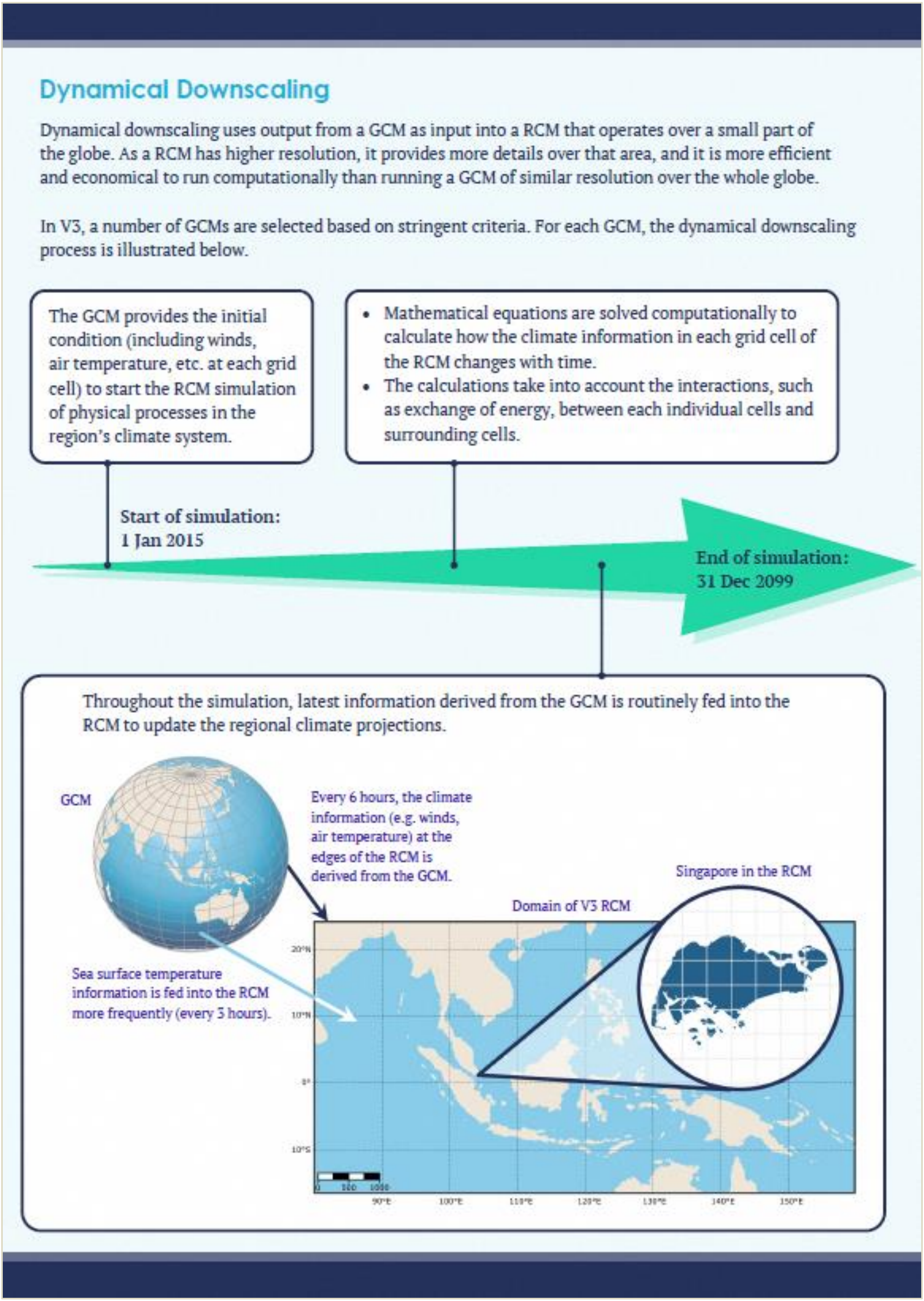
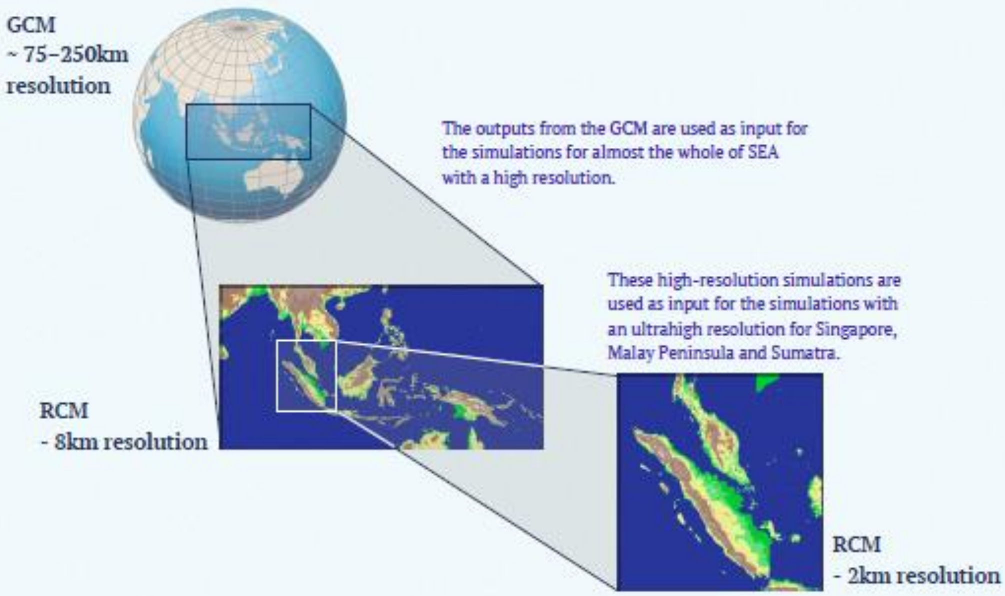


Figure 14.7: The 'Climate Change - From Global to Local' brochure introduces the concept of dynamical downscaling, using the V3 project as an example to illustrate the concept.

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.

Figure 14.8: The 'Climate Change - From Global to Local' brochure presents the two-stage downscaling process in V3 and explains how the reliability and robustness of V3 projections are demonstrated.

14.2.3 Past and Future Sea-level Change

As a low-lying island country, Singapore is particularly vulnerable to sea-level rise. While this fact is widely accepted in Singapore, understanding the various drivers of sea-level change, especially at the local and regional scale, is generally lacking. PUB, Singapore's national coastal protection agency, has been leading the efforts to save Singapore's shores through different measures such as sea walls and mangroves. V3 sea-level projections in the Singapore region are essential to inform the adaptation design parameters. To enhance readers' knowledge of sea-level drivers and raise awareness of the type of sea-level information available in V3, a brochure 'Past and Future Sea-level Change' is developed.

Figures 14.9 to 14.12 show the thumbnails of the brochure. The photo on the cover visually conveys Singapore's vulnerability to sea-level rise, with the subtitle reiterating V3's position in building a nation resilient to climate change. The brochure begins by listing several impacts of sea-level rise on Singapore to set the context and remind readers of the dire consequences. Some visually appealing illustrations are then used to explain the drivers of sea-level change at the global, regional and local scale, to raise awareness of the lesser-known drivers such as land water storage and dynamical sea-level change. The brochure ends with an overview of the past and future sea-level information that will be provided by V3, such as the locations at which data sets are available.

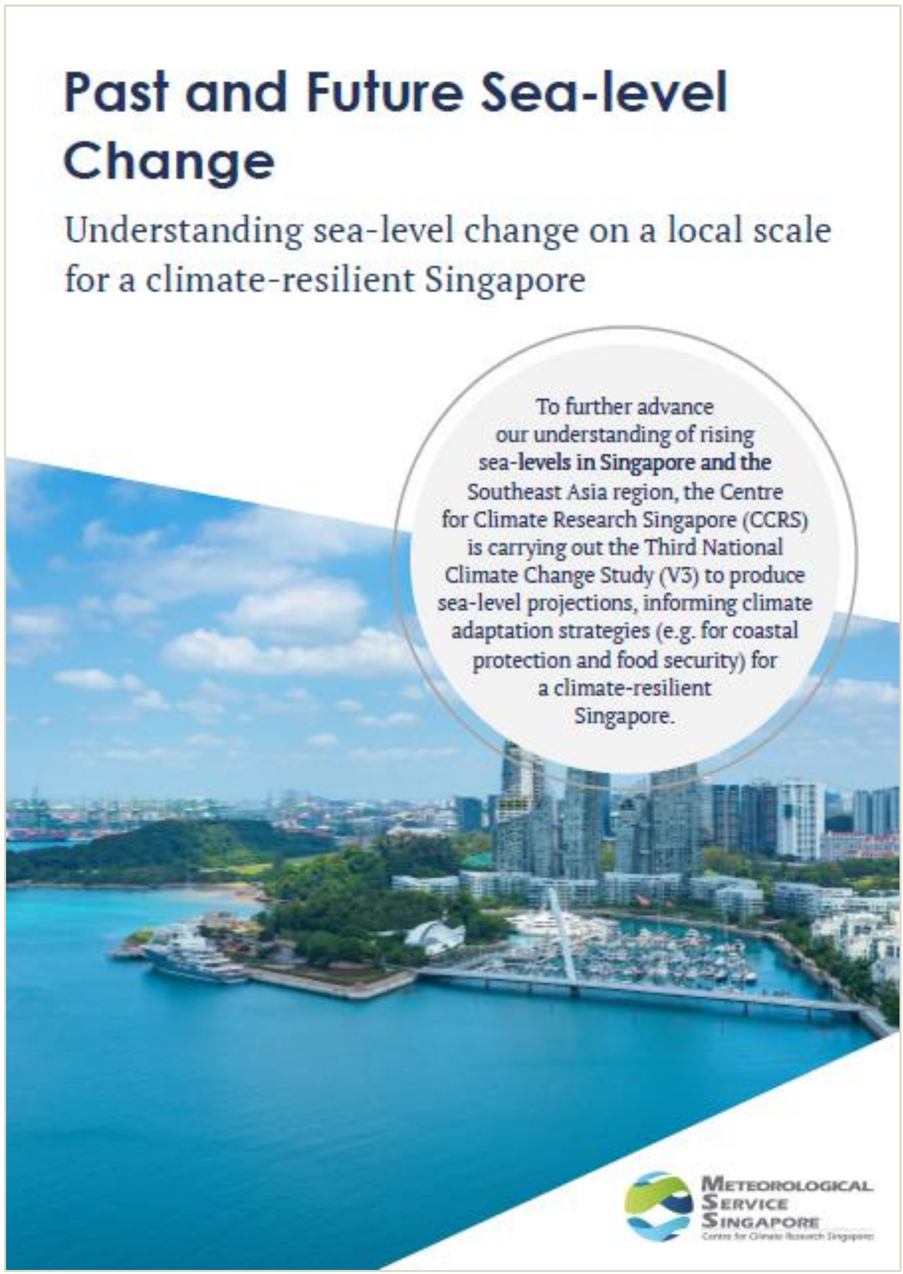


Figure 14.9: Cover of the 'Past and Future Sea-level Change' brochure

Figure 14.10: To set the context, the 'Past and Future Sea-level Change' brochure begins with some examples of sea-level rise impacts on Singapore before explaining the drivers of global sea-level rise.

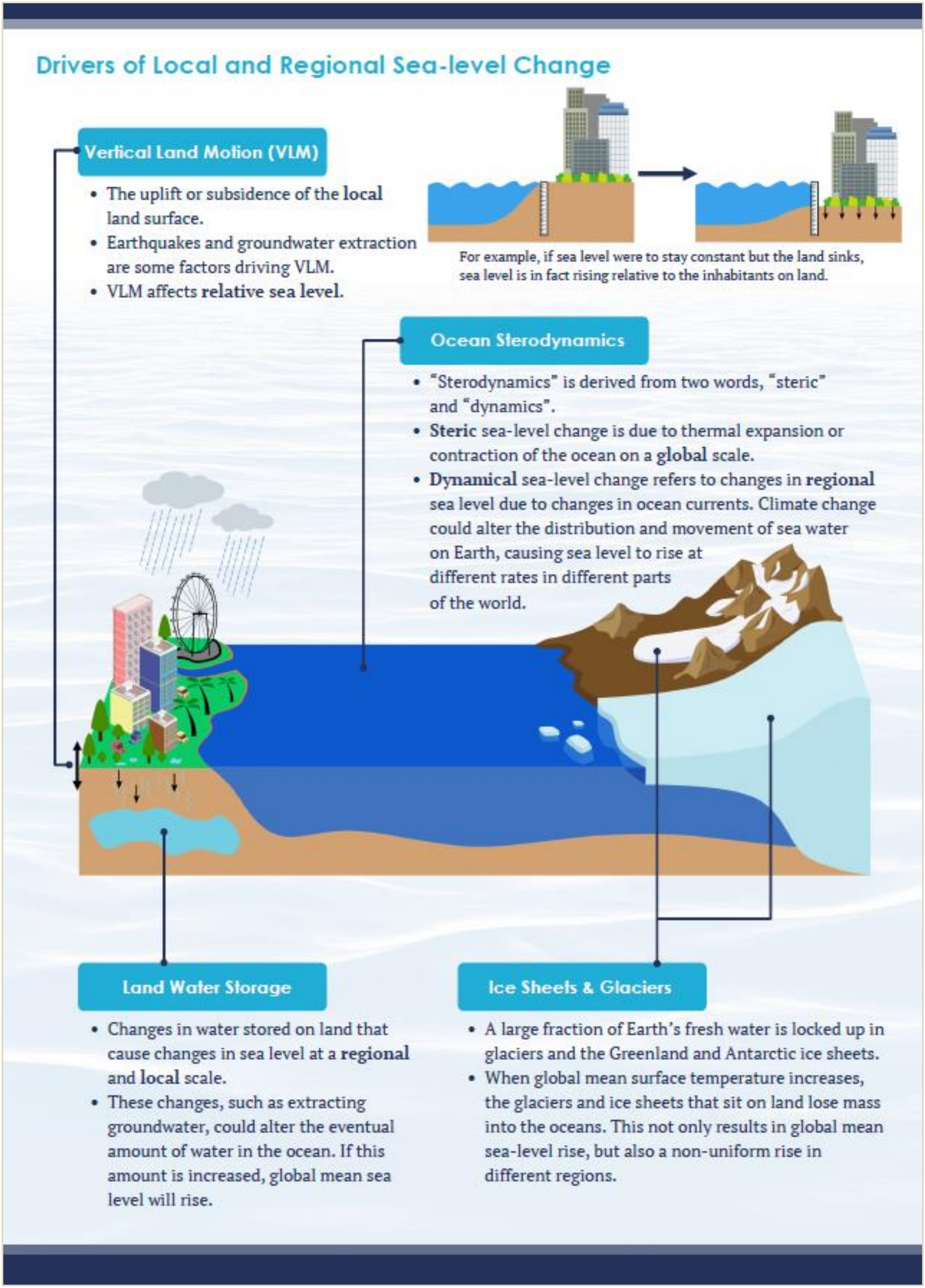


Figure 14.11: The 'Past and Future Sea-level Change' brochure explains the drivers of local and regional sea-level change that are less commonly known.

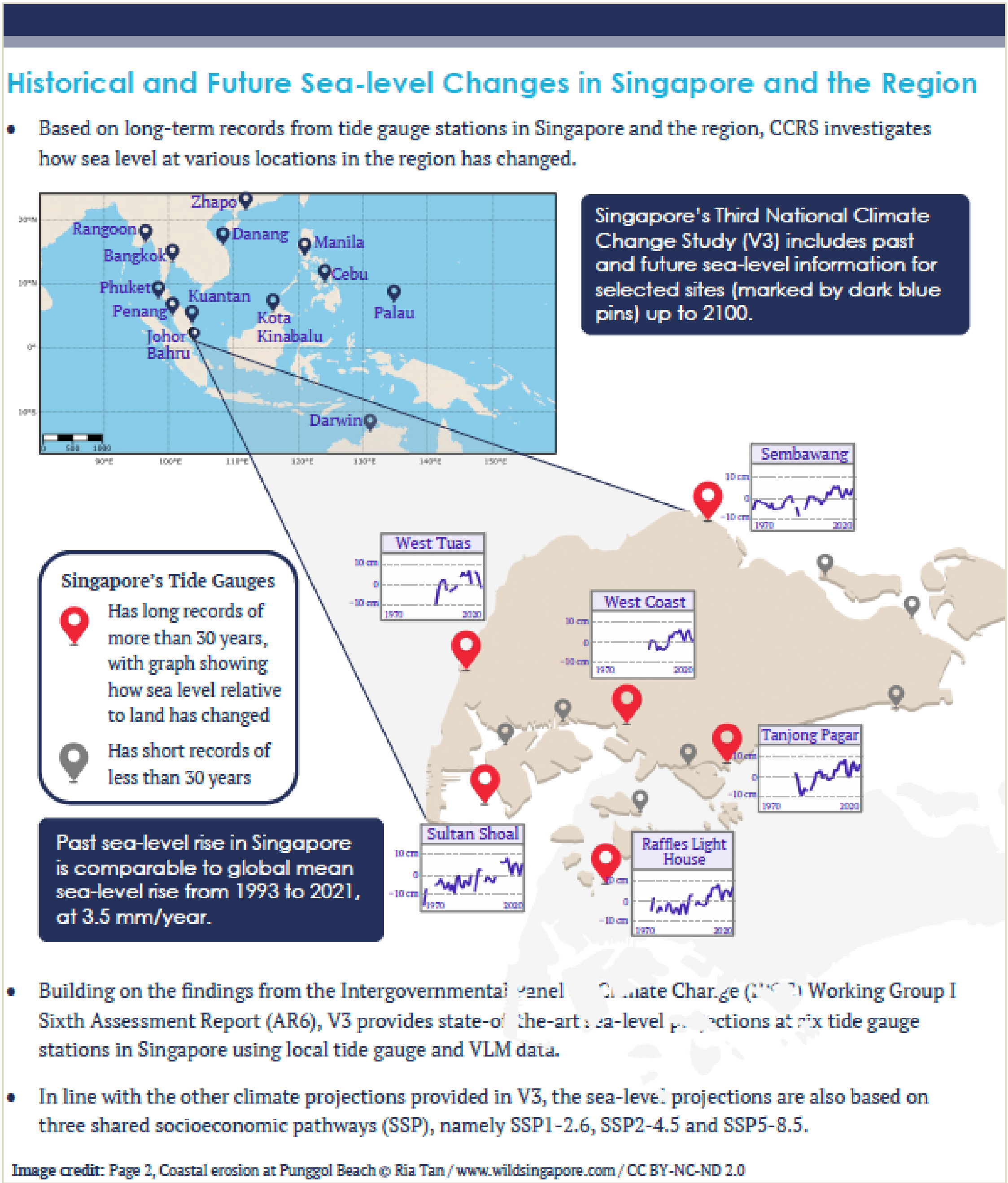


Figure 14.12: The 'Past and Future Sea-level Change' brochure presents the available past and future sea-level information from V3 for Singapore and the surrounding region.

The other brochures and videos are in various stages of preparation.

14.3 Infographics

The findings of the V3 study will be presented in the form of infographics for various climate variables and processes, including some impact-related metrics such as heat stress. One infographic was produced as a part of V2 as well (shown below), but we plan to have multiple infographics conveying various key messages related to physical climate change and impacts as a part of the V3 communications. As a part of this effort, we are also working with the local media houses to make the infographics more appealing and engaging for the public.

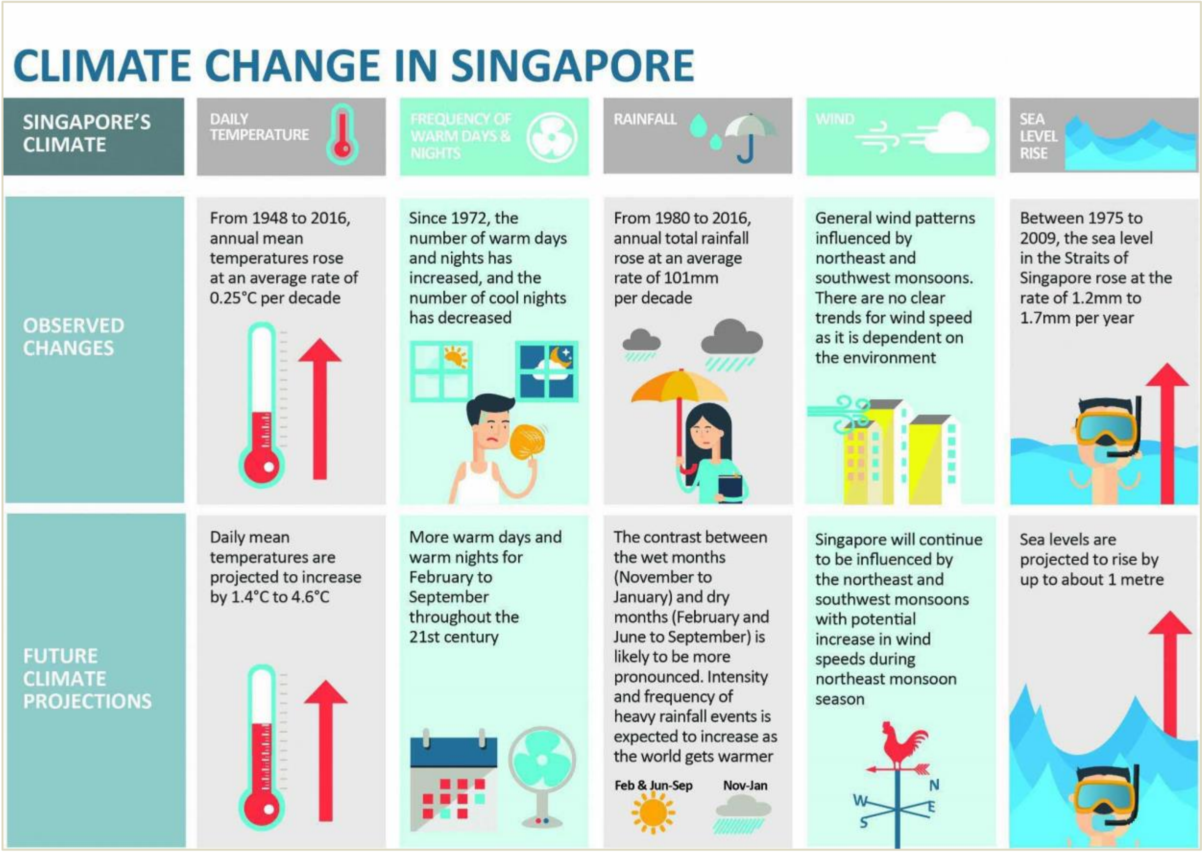


Figure 14.13: Previous V2 infographic

14.4 V3-Data Visualisation Portal (V3-DVP)

The V3-DVP is a key deliverable of the V3 Project and the primary tool for data and products dissemination both nationally and internationally. The design and development of the V3-DVP is an important advancement over the V2 data dissemination method which was primarily done via the Amazon Web Server (AWS) for a duration of 2 years (2015-2017). The data hosted on the AWS had a simple data catalog to display data availability which enabled registered users to select using checkboxes the data they are interested in and download them as Microsoft Excel spreadsheets.

The V3-DVP is intended for local government agencies, researchers in institutes of higher learning (local and abroad) and the general public. The aim of V3-DVP is to present and share future climate change information for Singapore and the wider Southeast Asia region through a custom-built website comprising a visualisation interface and data sharing portal that is 1) easily accessible through any standards-compliant web browser, 2) simple and intuitive to use and 3) highly interactive, in order to engage a wide range of end-users from stakeholder government agencies, institutes of higher learning (local and abroad) and the general public. It also acts as a gateway to facilitate data sharing of standardised, precomputed data products to registered end users, depending on their access credentials.

The following schematic outlines the desired high-level system elements for the V3-DVP. The following capabilities are desired: 1) dedicated website with a landing page, 2) interactive visualisation and 3) data sharing/download portal.

Through the interactive visualisation functionality users will have the flexibility to select the variable, time period, scenario, time-scale (annual and different seasons) and domain (whole of SEA or individual countries) they are interested in and the corresponding pre-generated figure will be displayed. They will also have the option to download the figure in png format.

In addition, commonly used climate variables will be hosted on the portal and users will be able to search the data catalog and download the desired data after completing a simple registration process. There will be tiered access to data during the initial 2-3 years, before it is made open for all. During the initial phase, the data will be restricted to Singapore Government agencies and local Institutes of Higher Learning and Research Institutions. For advanced users there will also be scope for some data analytics capability.

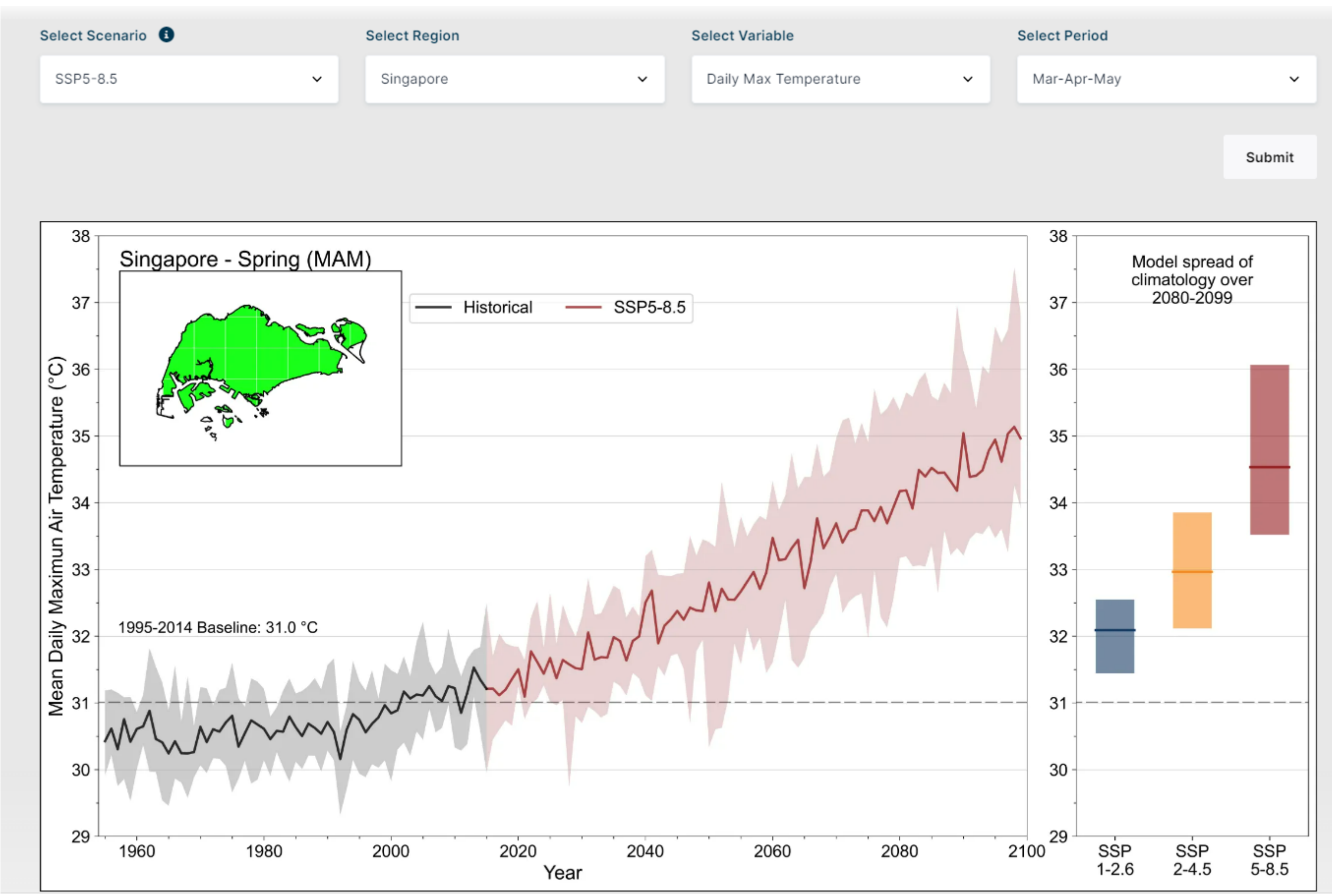


Figure 14.14: Screenshot of the interactive climate visualiser in V3-DVP

The DVP with static and interactive visualisation capability, with around 4000 pre-generated images, will be launched as a part of the V3 release.

14.5 Engagement with Singapore Government Agencies

Engagement with Singapore Government Agencies has been a key strength of the overall V3 planning process. The first Stakeholder engagement workshop was organised by the Climate Science Research Programme Office (CSRPO) in November 2020, and the second workshop was organised in January 2022. Both these workshops were attended by over 21 Singapore Government agencies from various Ministries, and had over 100 participants. Various aspects of V3 from the V3 workflow were shared with stakeholders along with the data that will be produced and shared with the agencies. Stakeholder inputs were also sought on the various level-2 and level-3 data and products and also aspects on conveying uncertainty of the climate change projections in the V3 technical and stakeholder reports.

In addition to the large annual workshops, there are various ad-hoc engagements with agencies throughout the year by means of working groups, for example, with PUB (Singapore's National Water Agency) and Singapore Food Agency (SFA). CCRS has also been working closely with agencies such as MINDEF and NParks around climate change topics and the uptake of V3 data and products for various impacts and vulnerability studies and adaptation planning. A climate 101 was conducted in June 2023 to share climate science with the Singapore Government agencies.

Agencies are also working with Singapore IHLs on various projects that use V3 data through the 23M SGD Climate Impact Science Research funding, coordinated by the CSRPO. The first CISR SAP meeting concluded in May 2023 that met to finalise the projects that will be funded under the programme.

14.6 Engagement with Singapore Media Houses

Engagement with local media is essential to communicate V3 and its key findings with the public. Supported by NEA Corporate Communications Division (CCD), CCRS has been interacting with media through answering media queries and also being interviewed by news channels on topics of interest. A media technical briefing session was organised in December 2023 to align the media with V3, share what is the kind of information that may be expected at the official V3 launch, and understand the materials needed for media to cover V3 in their news stories. Various media houses such as The Straits Times, Channel NewsAsia, etc. will be invited to the event.

14.7 International Engagement

Singapore organised its inaugural Singapore Pavilion at the 2022 United Nations Climate Change Conference 27th Conference of the Parties (COP27), from 6 to 18 November 2022 in Sharm el-Sheikh, Egypt. Themed around 'Building a Future of Green Possibilities', the Singapore Pavilion showcased how Singapore is actively planting the seeds of change in its economy, environment, and society to achieve a net zero future by 2050: (https://www.nccs.gov.sg/media/press-releases/inaugural-singapore-pavilion-cop27/). V3 was featured under the Green Initiatives as a part of the Singapore pavillion at COP28, held during 30 Nov 2023 – 12 Dec 2023 in Dubai.

Regional engagements will also be happening through the Asean Specialised Meteorological Centre (ASMC). Specifically, the V3 portal, findings from the study and data availability information will be shared with the ASEAN countries through the ASEAN Regional Climate Data Analysis and Projections-4 (ARCDAP-4) workshop. In addition, basic Python-based data analytics training will also be carried out as a part of the workshop to enable some of the ASEAN member countries to use the V3 data in the future for both physical climate change assessment and impact modelling.

The Coordinated Regional Climate Downscaling Experiment-South East Asia (CORDEX-SEA) is an important regional branch of the global CORDEX community focusing on providing regional climate change projections in the SEA region. We are a formal member of the CORDEX-SEA and have been engaging with the research community associated with it. While there are overlaps between the two efforts (CORDEX-SEA CMIP6 regional projections and V3) there are important differences too that make them complement each other for carrying out more robust physical climate change assessment and impact studies over the SEA region.

There are overlaps such as (1) some similar CMIP6 GCMs, (2) similar domain with small differences in latitudinal and longitudinal extents, and (3) some common scenarios (SSP1-2.6 and SSP2-4.5). There are some important differences such as (1) CORDEX-SEA uses SSP3-7.0 as their highest emission scenario, whereas V3 uses SSP5-8.5, and (2) the CORDEX-SEA primary spatial resolution for regional climate change projections is 25 km, whereas for V3 it is 8 km. Thus, the 2 datasets are highly complementary and we are engaging with the CORDEX-SEA community to discuss how to share our high-resolution regional projections data from V3 through the CORDEX-SEA Earth System Grid Federation (ESGF) data nodes.

CCRS has also been engaging with the United Nations Food and Agriculture Organisation (UNFAO) to increase the regional uptake of V2 and V3 data for food security planning over the SEA region. A joint statement by MSE and UNFAO was issued at COP27 around V2/V3 data sharing.