AN UPDATE OF CLIMATE CHANGE AND SEA LEVEL RISE SCENARIO FOR VIET NAM

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Abstract

This paper presents results of updated climate change and sea level rise scenarios for Vietnam. The lastest method introduced in IPCC-AR5, global climate models, dynamical downscaling using regional model combining with statistical bias correction are employed for high resolution climate and sea level projection for Vietnam. In this version of Climate change and sea level rise scenario, we project for several elements including temperature, precipitation (average, seasonal, extreme), extreme events (storms, monsoons, heatwave, frost days, droughts), sea-level rise for coastal provinces and island, inundation risk in case of sea level rise. Three specific periods in the 21st century are considered including: (i) beginning of century (2016 - 2035), (ii) mid-century (2046-2065), and (iii) end of the century (2080-2099).

1. Introduction

Climate change and sea level rise scenario for Vietnam was firstly published by Ministry of Natural Resources and Environment in 2009 on the basis of synthetizing domestic and international researches. However, the detail level of that scenario was confined that only information of 7 climatic regions and coastal areas along Vietnam were provided to timely serve ministries, agencies, sectors and provinces to implement the National Target Programme to Respond to Climate Change.

In 2011, National Strategy on Climate Change was issued to identify targets for selected periods and priority projects. Ministry of Natural Resources and Environment updated climate change and sea level rise scenario based on specific datasets and climatic conditions of Vietnam as well as products of climate models.

Climate change and sea level rise scenario for Vietnam version 2015 is updated according to the defined schedule in National Strategy on Climate Change that aims to provide the latest information about manifestation and trend climate change in the past and climate change and sea level rise scenario in the 21st century for Vietnam.

This version of scenario has been inherited and supplemented from published scenario in 2012. The calculation is based on: The new findings in the Fifth Assessment Report of the IPCC (AR5); hydro-meteorological data updated to 2014; recent trends of climate change in Vietnam, the global climate models, high resolution regional climate models for Vietnam; related studies from Vietnam Institute of Meteorology, Hydrology and Climate change (including project on climate change coded BDKH43 belonged Program coded "KHCN-BDKH/11-15"), the Advisory Council of the National Commission on climate change, research institutes and universities in Vietnam.

2. Climate change and sea level rise scenario for Vietnam

2.1. Methodology

1) Greenhouse gas concentration scenarios

In the 5th report, IPCC has developed scenarios based on the new approach on emissions scenarios, that was standard emission scenarios (benchmark emissions scenarios) or Representative Concentration Pathways - RCP.

RCP scenarios focus on the concentration of greenhouse gases, not on emissions process based on assumptions about economic - social, technological, demographic development, etc. as in SRES. In other way, RCP make assumptions about the destination, create conditions for more choices in the process of economic, technology, population development, etc. There are 4 RCP scenarios (RCP2.6, RCP4.5, RCP6.0, and RCP8.5) as shown in *Figure 1* and *Table 1*.

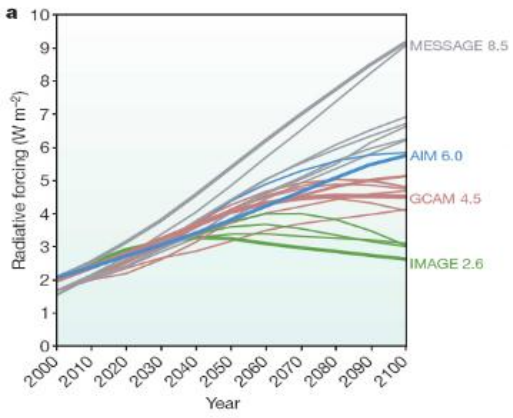


Figure 1. Change in radiative forcing

Table 1. Features of scenarios

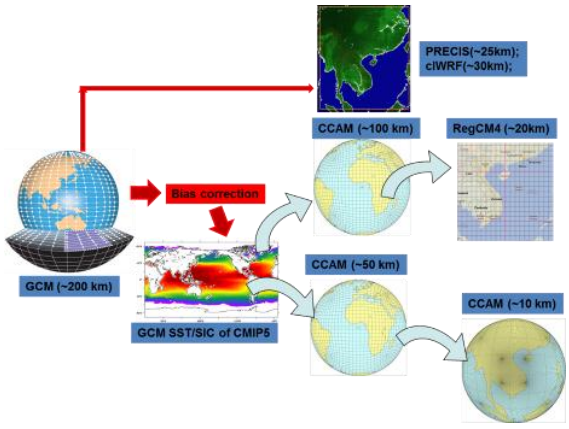
RCP	Radiative forcing in 2100	CO_{2e} concentration in 2100 (ppm)	Increase of global temperature in 2100 (^oC) compare to 1986-2005 period	Features of radiative forcing path to 2100	Equivalent SRES scenarios
RCP8.5	8.5 W/m^2	1370	4.9	Continuous increase	A1F1
RCP6.0	6.0 W/m^2	850	3.0	Ascending and stability	B2
RCP4.5	4.5 W/m^2	650	2.4	Ascending and stability	B1
RCP2.6	2.6 W/m^2	490	1.5	Maximum at 3.0 W / m2 and lower	None

2) Dataset

The data used in the calculation was updated to 2014, including: (i) The data of 150 meteorological observed stations on the mainland and islands; (ii) The data of sea level in 17 coastal oceanographic station and islands; (iii) sea level data from satellite measurements; (iv) Data topographic maps with a scale of 1: 2,000, 1: 5,000 and 1: 10,000 measured by the projects of National Target Programme to Respond to Climate change.

3) Methodology of construction of climate change and sea level rise scenarios

Dynamical downscaling method based on five high-resolution regional climate models, including: AGCM / MRI, PRECIS, CCAM, RegCM, and clWRF (*Figure 2*).



There are total of 16 calculated member acording to the lastest updated results of global climate models (project " Coupled Model Intercomparison Project Phase 5" - CMIP5), including: NorESM1-M, CNRM-CM5, GFDL-CM3, HadGEM2-ES, ACCESS1-0, CCSM4, CNRM-CM5,

GFDL-CM3, MPI-ESM-LR, NorESM1-M, ACCESS1-0, NorESM1-M, NCAR, SSTHadGEM2, SSTGFDL- SST, and a combination of the SST.

Figure 2. Dynamical downscaling chart

Statistical methods are used to correct calculated results of dynamics model according to measured data at observed stations, aim to reflect the specific conditions of the locality and reduce systematic errors of the models.

Sea level rise scenarios for Vietnam is built on the basis of guidance from the IPCC AR5 report including the findings of Church et al (2013) and Slagen et al (2014). By using these methods, sea level rise scenarios have been developed for several developed countries such as Australia, the Netherlands and Singapore. Sea level is calculated from the components contributing to sea level in the region. They consist of 8 principal components which are: 1) Dynamics/thermal expansion; 2) Mountain glaciers and continental ice; 3) Balanced with the amount of ice at Greenland; 4) Ice dynamics at Greenland; 5) Balanced with the amount of ice at the Antarctic; 6) Ice dynamics at the Antarctic; 7) Water storage on the continents; 8) Isostatic adjustment tape.

Baseline period for comparison of climate change in the future with present climate is in the period 1986-2005 (baseline period), this is also the period used in the IPCC's AR5 (IPCC, 2013).

2.2 Key results

Climate change scenario for Vietnam can be summarized as follows:

1) For mean temperature

Annual and seasonal (winter, spring, summer, autumn) surface air temperature (temperature) in all regions of Vietnam tend to increase compared to the baseline period (1986-2005); the increase depends on RCP scenarios and climate regions.

With RCP4.5 scenario, the increase in annual mean temperature is from 1.3 to 1,7^{o}C in the mid-21st century; from 1.7 to 2,4^{o}C at the end of the century. In general, northern temperatures increase higher than the southern. Acording to RCP8.5 scenario, in the middle of the 21st century, the annual mean temperature increase from 2.0 to 2,3^{o}C in the northern and from 1.8 to 1,9^{o}C in the southern. By the end of the century, annual mean temperature increase from 3.3 to 4,0^{o}C in the northern and from 3.0 to 3,5^{o}C in the southern (*Figure 3*).

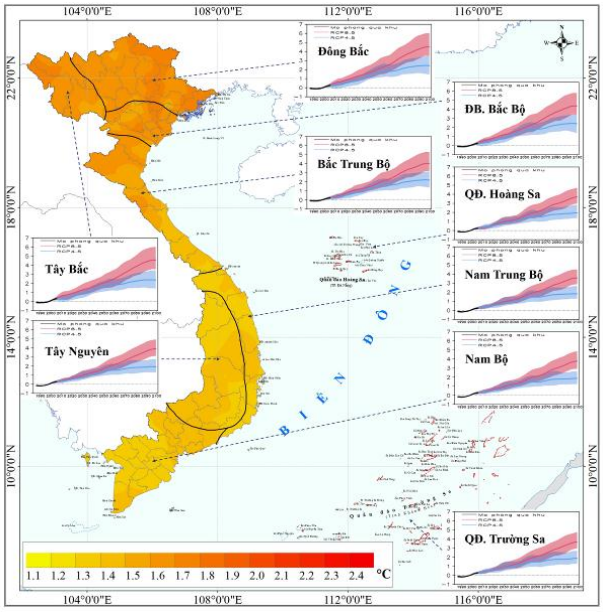


Figure 3. Mean temperature scenario (^{o}C)

2) For extreme temperature: In the 21st century, extreme temperatures tend to increase compared to average of 1986-2005 period in all regions of Vietnam, with all the scenarios. For RCP4.5 scenario, by the end of the 21st century, annual mean maximum temperature tend to increase from 1.7 to 2,7^{o}C, the highest increase is in Northeast region, North Delta Area;

the lowest is in the South Central region and the Southern region. Meanwhile, the mean minimum temperature tend to increase from 1.8 to 2,2^{o}C in the end of the century.

3) For annual rainfall and extreme rainfall:

Annual rainfall in the future may increase in all regions over Vietnam under every considering RCP. Meanwhile rainfall in dry season may decrease in some regions. Extreme rainfall may have the similar trend to annual rainfall.

The annual rainfall may increase in most area of Vietnam by the end of century under RCP4.5. The upturn rate ranges popularly from 5 to 15% excluding coastal areas of The Central, the North Central and the Mid-Central of Vietnam whose increasing rate may be over 20% (*Figure 4*). The increase in extreme rainfall may be much higher than annual rainfall. Specifically, daily maximum rainfall (Rx1day) may increase at the rate from 10 to 70%. The highest increase in Rx1day may occur in the Northeast, the South Central and the East-South of Vietnam.

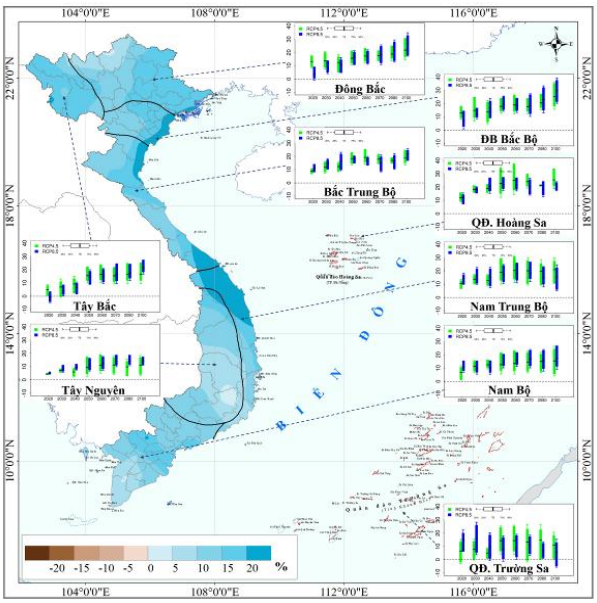


Figure 4. Annual rainfall scenarios (%)

4) For sea level rise:

The highest rise in sea level may occur in Hoang Sa and Truong Sa islands at the end of 21st century under RCP4.5. The projected rise for these areas is 58 cm (33cm ÷ 83cm); meanwhile the lowest rise is 53 cm (32cm ÷ 75cm) which may occur from Mong Cai to Hon Dau area. For RCP8.5, the highest and lowest rises in sea level are 78 cm (52 cm ÷ 107 cm) and 72 cm (49 cm ÷ 101 cm) which may occur in Hoang Sa, Truong Sa islands and from Mong Cai to Hon Dau areas by the end of century, respectively (*Figure 5*).

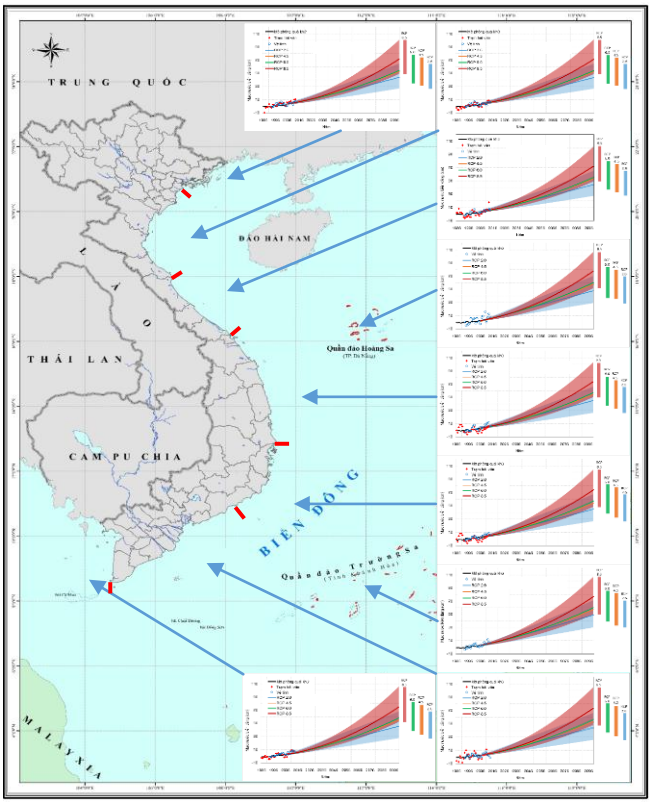


Figure 5. Sea level rise scenarios

In case sea level rise 1m, the area of inundation for the Red river basin, coastal area from Thanh Hoa to Binh Thuan, Ho Chi Minh city and Ba Ria – Vung Tau are 17.57%, 1.47%, 17.84% and 4,79%, respectively. The risk of inundation in Mekong river delta is quite high with 39.4% area including Kien Giang province which has the

highest inundation risk (75% area of province) (*Figure 6*)

Islands which are at the highest risk from inundation are Van Don, Con Dao and Phu Quoc islands. The inundation risk of natural island belonging Truong Sa island is not high. The inundation risk of islands belonging Hoang Sa island is higher than Truong Sa island. The highest risk is at Luoi Liem and Tri Ton islands.

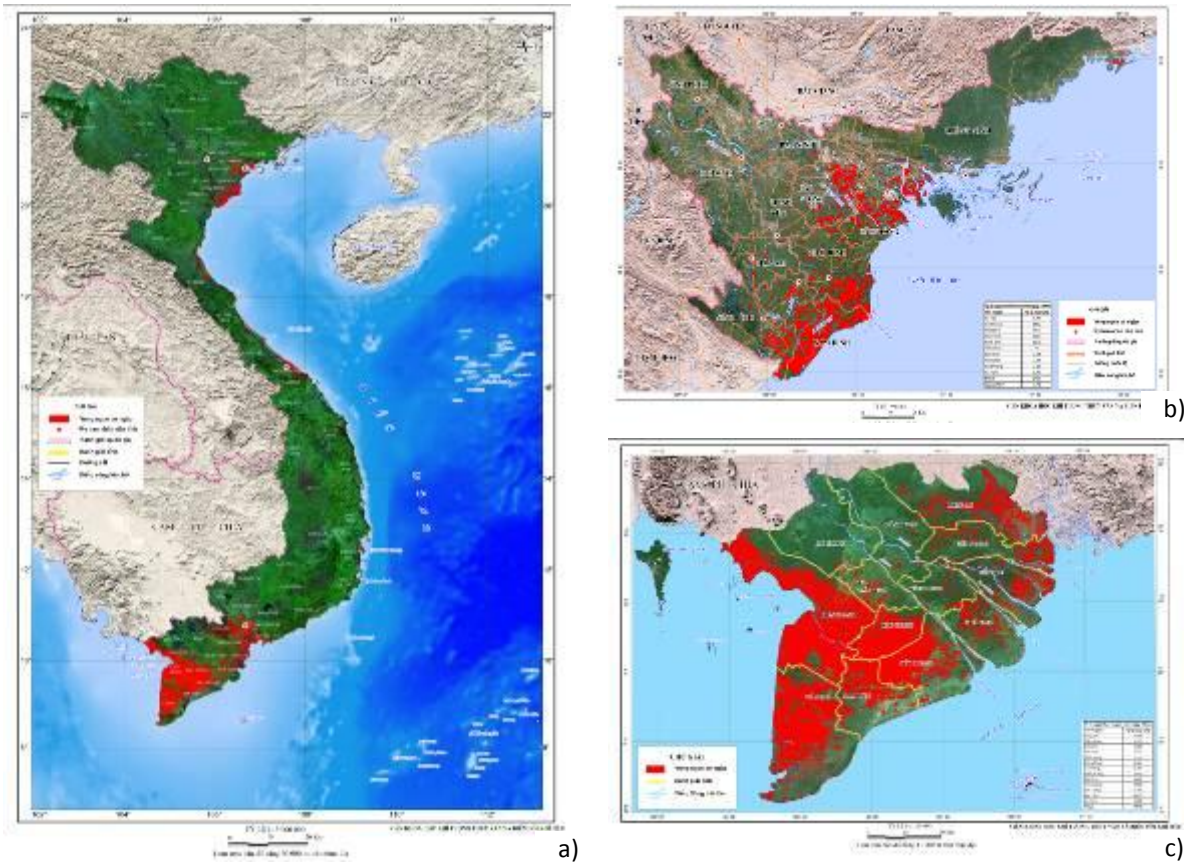


Figure 6. Inundation risk in case sea level rise by 100cm

a) Vietnam; b) Red river basin and Quang Ninh; c) Mekong river basin

3. Conclusion and Recommendation

Climate change and sea level rise scenarios version 2015 is constructed base on the inheritance and supplementation of climate change and sea level rise scenario version 2012. The hydro-meteorologycal and oceanographic observations are up-to-date until 2014. We use the lastest method that is introduced in IPCC-AR5 to update this version of scenarios. In addition, we employ dynamical downscaling using regional model combining with statistical bias correction for climate and sea level projection for Vietnam.

It is indispensable to consider and select appropriately for every sector, field and local province in using climate change and sea level rise scenario for Vietnam for the purpose of assessment impact and contruction of solution to respond to climate change. Criterias are recommended including: (i) Typical characteristics (for sector, field and local, etc.); (ii) Multi-Goal; (iii) Multi-Efficiency (for economy, society, environment); (iv) Sustainability; (v) Possibility, ability to intergrate scenario to strategy, policies and plans for development.

We also provide several recommendations for applying scenarios to local including: (i) Determining appropriate climatic elements and research object to sector and local; (ii) Selecting climate change and sea level rise scenario for local from national scenario; (iii)

Employing hydrological/hydrolic model as well as assessing model to provide important input such as flow change, flood, salinity intrusion, sea level rise due to storm, shoreline change, etc. for constructing and implementing action plans.

It is not necessary to get the ball rolling, construct and conduct solutions to respond to climate change in century scale, but it should be implemented in specific period; It is required to identify priorities base on pratical demands, available resources in each period to select the most appropriate scenario.

Global conference on climate change in 2015 is successfully with the adoption of Paris agreement on climate change. All nations over the world agree to act for keeping global mean temperature increase under 2^oC by the end of century in comparison with pre-industrial period. This means that RCP4.5 is the most possible compared to other scenarios. Therefore, it can be used for short-term planning as well as design of impermanent building. Otherwise, RCP8.5 can be used for long-term planning and design of permanent building.

The uncertainty always exists in climate change and sea level rise scenrios because of many reasons including dependence on identifying grees house gas scenario (global socio-economy development, increase in population, global consumption, living standard and lifestyle, global energy consumption, technology tranfering among developed and developing countries, change in land use, etc.), limit in understanding in global and regional climatic system, melting glaciers processes and method used for construction of scenario, etc. Therefore, it is necessary to consider carefully all possibility of climate in the future once using climate change scenario for assessment impact of climate change. Users should consult for advises from climatic experts and other experts in order to determine suitable range of change in climate for planning process.

Climate models has been developing to enhance certainty of climate change and sea level rise scenario. The scenarios will be updated continuously following scheduler of IPCC. Thus, assessment of impacts and vulnerability should be reviewed and up-to-date when updated scenarios are published.

Global conference on climate change in 2015 proponed IPCC to publish special report on grees house gas scenarios and impact when global temperature increases by 1.5^oC by the end of century compared to pre-industrial period. Consequently, Vietnam will have corresponding updated version.

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