Water and Sediment-Related Problem/Disaster Projections in Western Japan Under Climate Change

Apip

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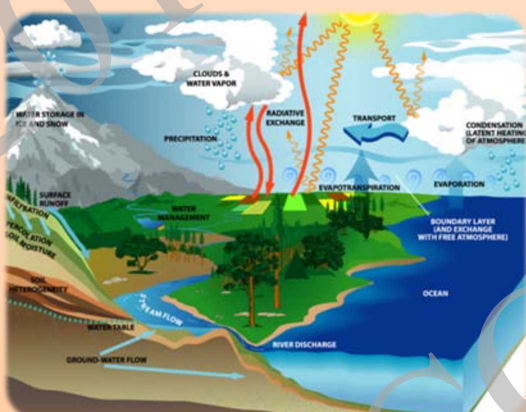

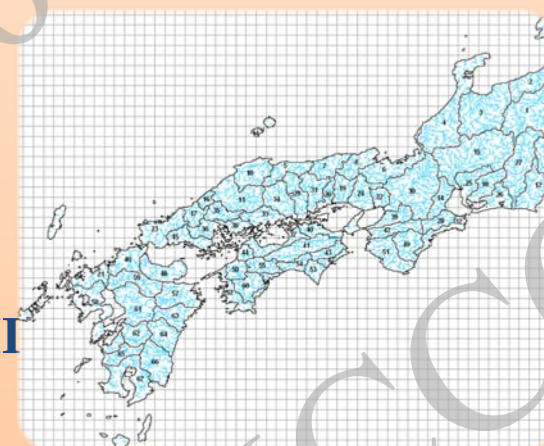

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SOSEI Program,
Program for Risk Information on Climate Change,
Disaster Prevention Research Institute (DPRI),
Kyoto University (京都大学防災研究所）

DPRI-KU

contents

- **Background, model and used projected data**
- Analysis of rainfall tendency with
  - AGCM3.1S, AGCM3.2
  - Bias corrected AGCM3.1S, AGCM3.2
  - ARCM5
- Example of assessing potential impacts on
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  - For Chikugo river basin in Kyusyu

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Prediction and Evaluation of Disaster Environment in Japan
(Kakushin and Sosei Programs)

DPRI / Kyoto-Univ.

Slope Mountains River Habitable Area Coastal Area

Output from GCM

Precipitation, temperature, water vapor, wind velocity, radiation and air pressure
(30-years time series (20km) and ensemble predictions (60km) for current, near future and century end)

Interpreta-tion of output

Regional climate model（RCM_5km, RCM_1km)

Surface hydrological model

Stochastic typhoon model

Probability density function of extreme value（depending on spacio-temporal scales）Stochastic precipitation model (time series depending on spacio-temporal scales)

Various Models（with long-term run）

Soil production

Reservoir operation

Soil runoff

Sedimentation and transportation of soil

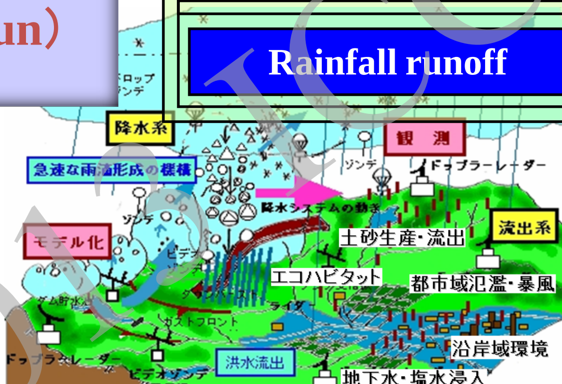
Rainfall runoff

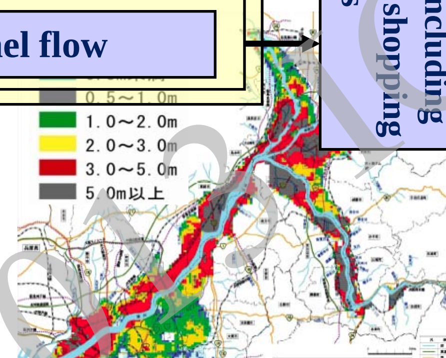
River channel flow

Inundation including underground shopping malls

Building damage by strong wind

Storm surge





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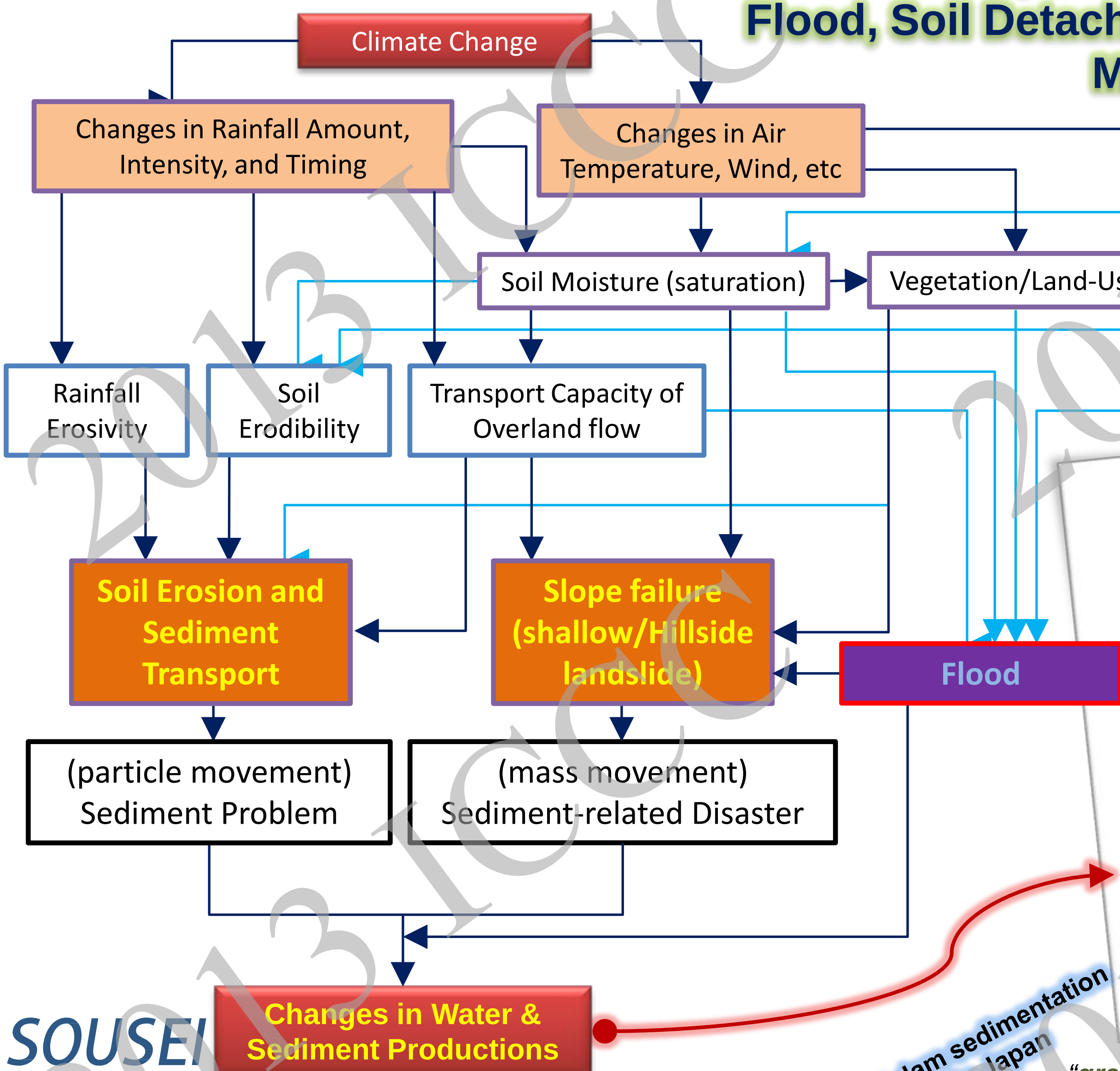
Evaluation

Decreasing of safety against landslide, debris flow, flood, drought, storm surge and stro[ng wind].
Assessment of current protection system and proposal of alternatives

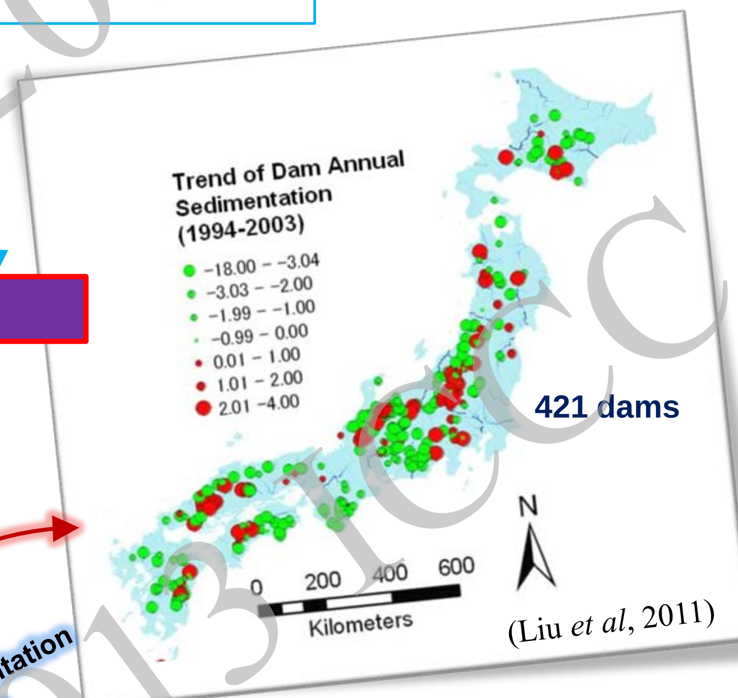
Minimum Target of DPRI

- **Precipitation** (Asian Monsoon Region)
- **River Discharge**; Japanese major river basins (with fine resolution), all Japanese River basins (with medium resolution)
- **Soil Production, Landslide and Debris Flow**; Mainly Western Japan
- **Inundation**; Some Major Cities
- **Storm Surge and Wave**; Tokyo, Ise and Osaka Bays, Global
- **Damage by Strong Wind**; Whole Japanese Archipelago

Relationship between Climate Change and Flood, Soil Detachments & Shallow Landslide Mechanisms



Present dam sedimentation trend in Japan



"green" decreasing trend of annual sedimentation
"red" increasing trend of annual sedimentation

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Impacts Asessment of Climate Change (and Land-use Change) on Hydrology, Soil Production and Shallow Landslide in Western Japan

Climate Change Projection Data (Present, Near Future, Future)

1. **Single MRI-GCM Model** (MRI-AGCM3.2S 20km)
2. **Single MRI-GCM Model Ensemble** (MRI-AGCM3.xS 20km, Adjusted MRI-AGCM3.xS 20km, MRI-ARCM 5km)
3. **Multi GCM Model Ensemble** (CMIP5)
4. Data Analyses (extreme events)

Rainfall Frequency Analysis

Conventional Method (Basin Scale) and Regional Frequency Analysis (Regional Scale)

Selection of Frequency Distribution

Assessment of Design Rainfall Estimates

Land-Use Change Projection

Landuse Planning by MLIT, Japan

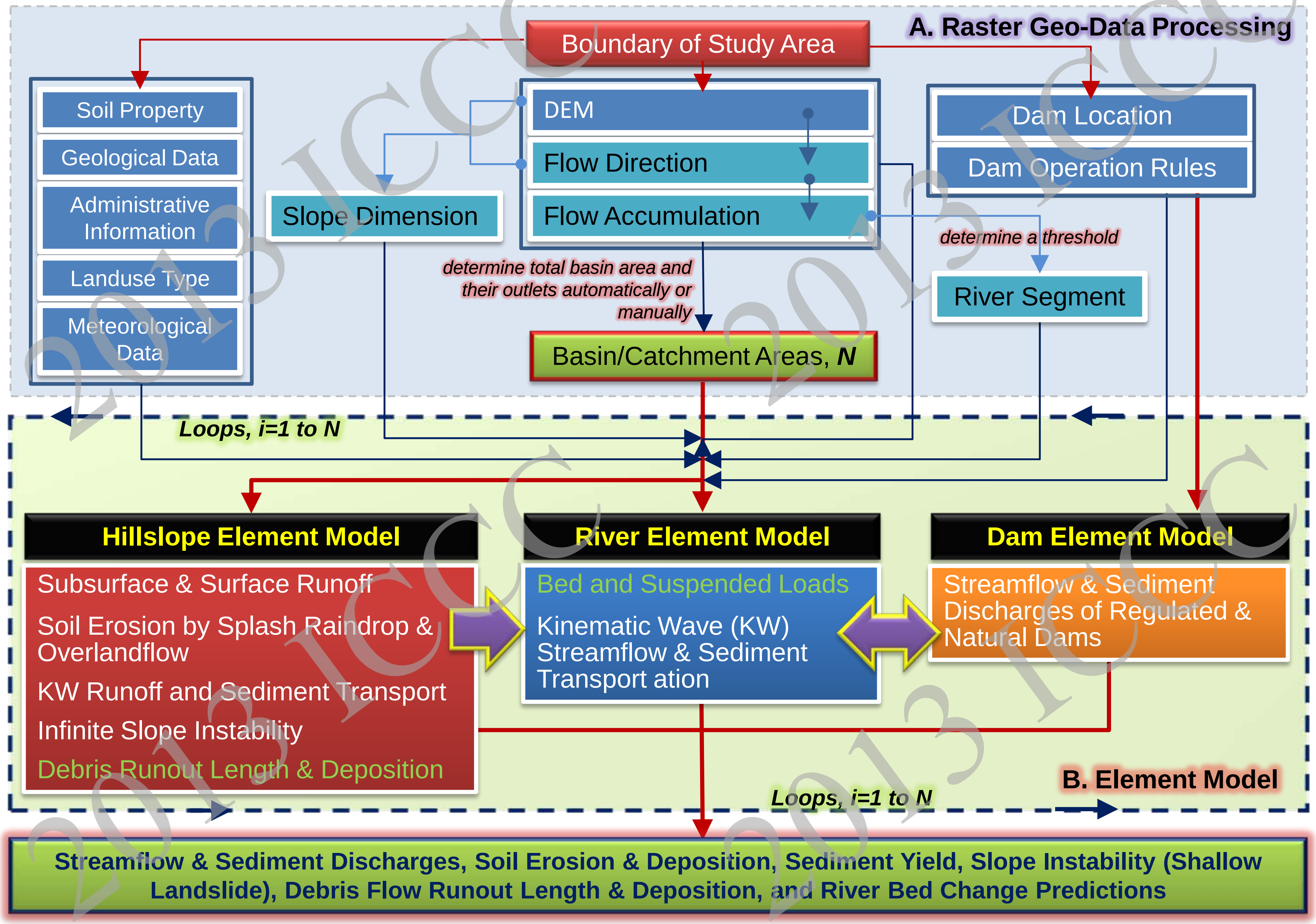
Dyna-Clue Landuse Modeling

Long Term Simulations
(regional scale)

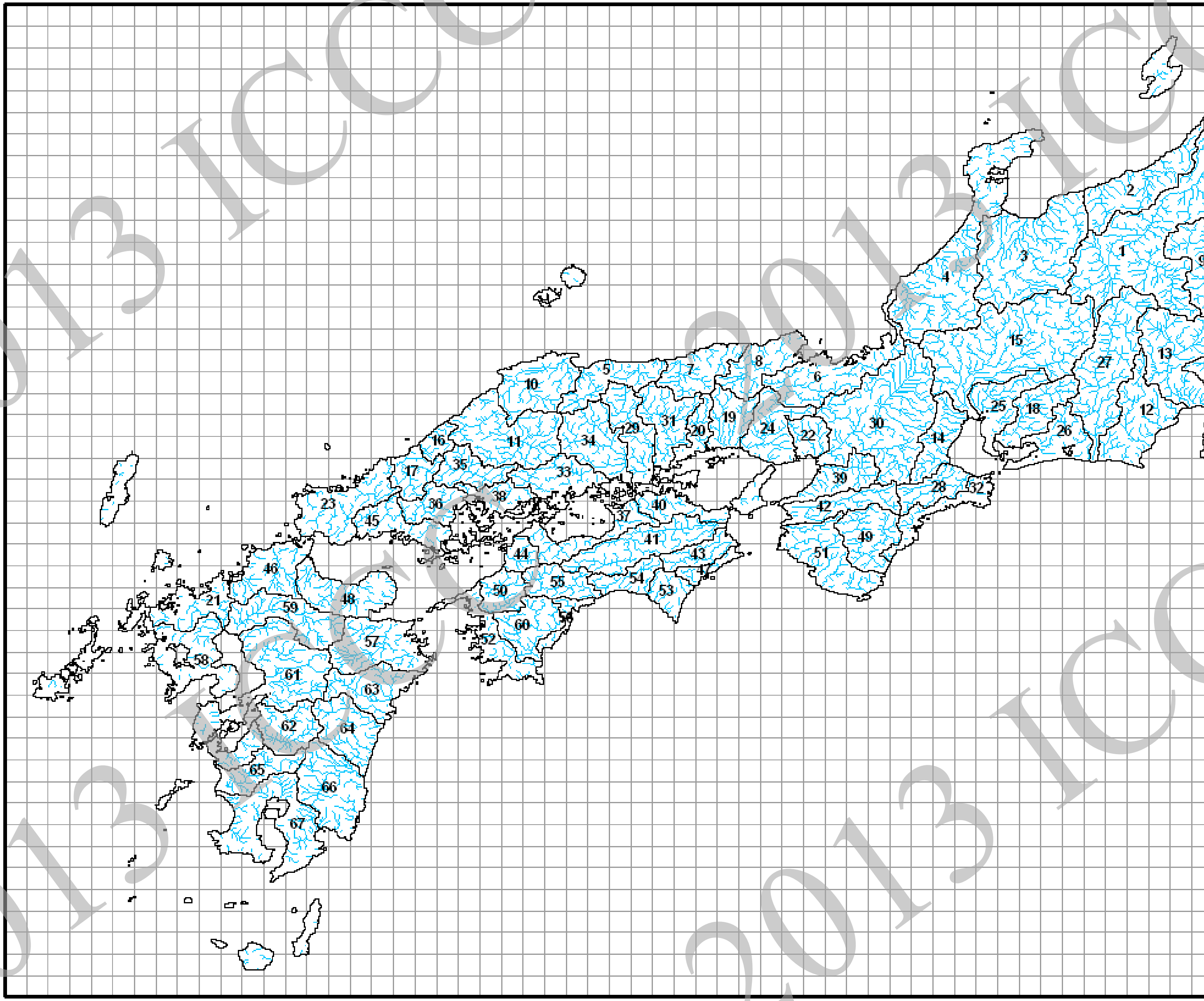
Extreme-Short Term Simulations
(subbasin, basin, or regional scale)

Grid-Cell-Based Sediment-Runoff and Shallow Landslide Model

Structure of the GeoHydrological Modeling System (Regional Scale)



Target Area of Western Part of Japan



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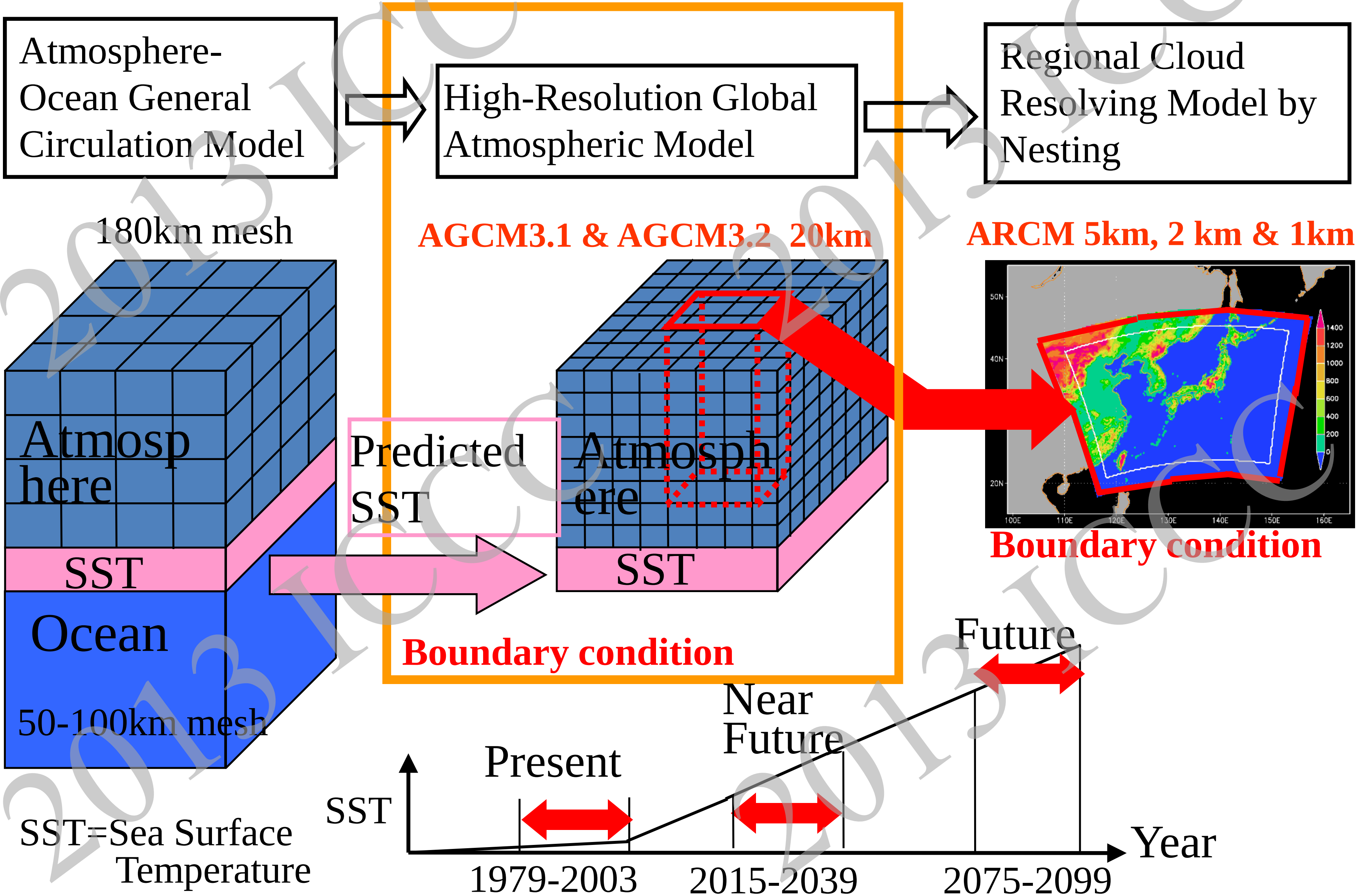
Climate Projection with Very-high Resolution Atmospheric Models

MRI / JMA / AESTO



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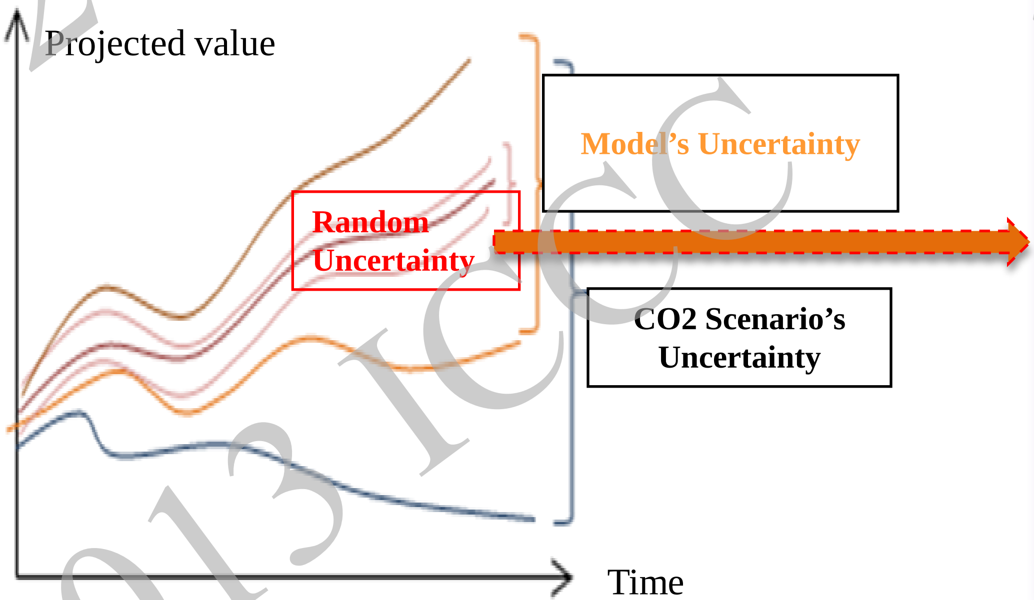
Uncertainty Inherent to GCM Projection

1. **Uncertainty in Model Parameterization (Random Uncertainty): Single GCM Model Ensemble**
2. **GCM Model's Uncertainty: Multi GCM Model Ensemble**
3. **Uncertainty in CO_2 Release Scenarios: Scenario-based Ensemble**
   – Japanese GCMs are using most likelihood A1B scenario (very rapid economic growth, low population growth, rapid introduction of new and more efficient technologies)



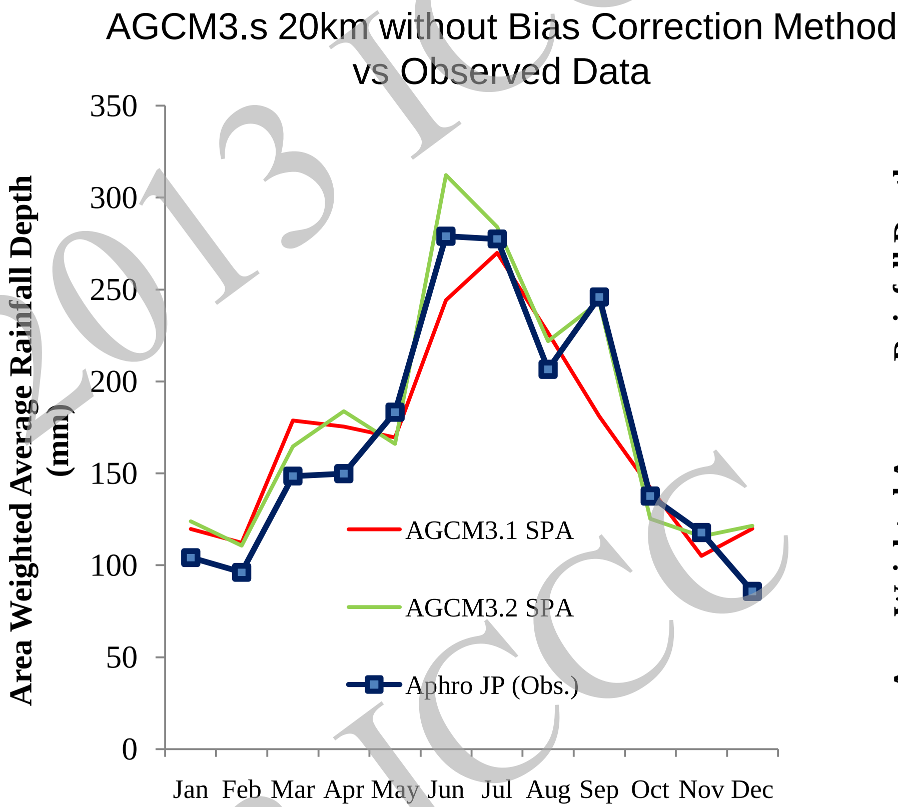
Multi GCM Model Ensemble

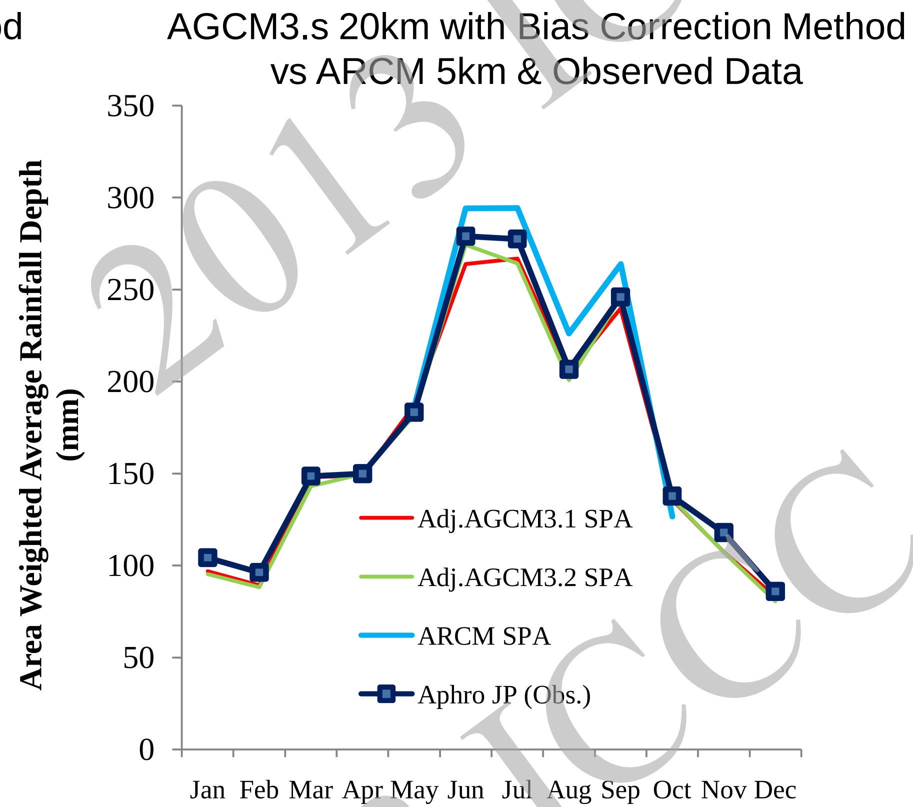
1. AGCM3.1 & AGCM3.2
2. Adjusted AGCM3.1 & 3.2
3. ARCM 5km

- Present/SPA (1979-2003)
- Near Future/SNA (2015-2039)
- Future/SFA (2075-2099)

AGCM3.s 20km, Bias-Corrected (Adjusted) AGCM3.s 20km, and Observed Data under PRESENT Climate Condition

Bias-Corrected (Adjusted) AGCM3.s 20km (daily-based) developed by ICHARM group team (Inomata et al., 2011): Hybrid Quantile Method



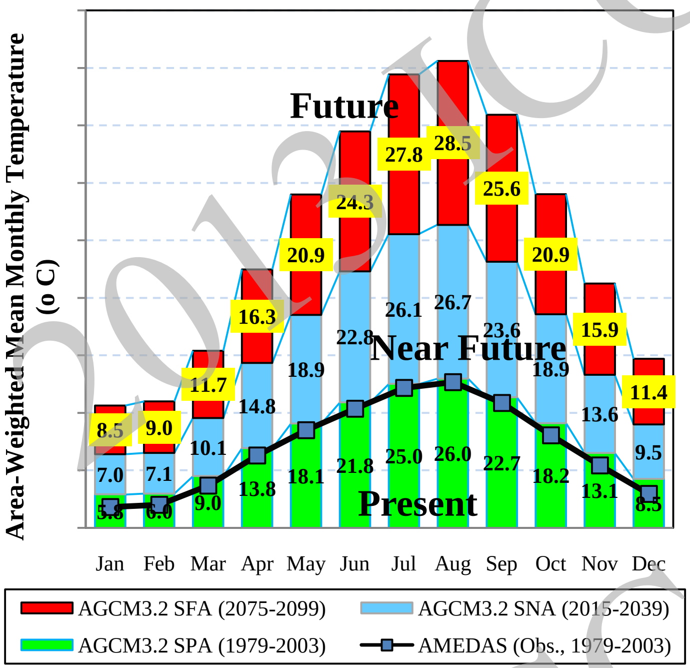


For the present climate condition: Bias correction method improved significantly the rainfall performance of AGCM3.s 20km; and the performance of bias-corrected AGCM3.s 20km could be represented by RCM 5km-based rainfall product without a bias correction method

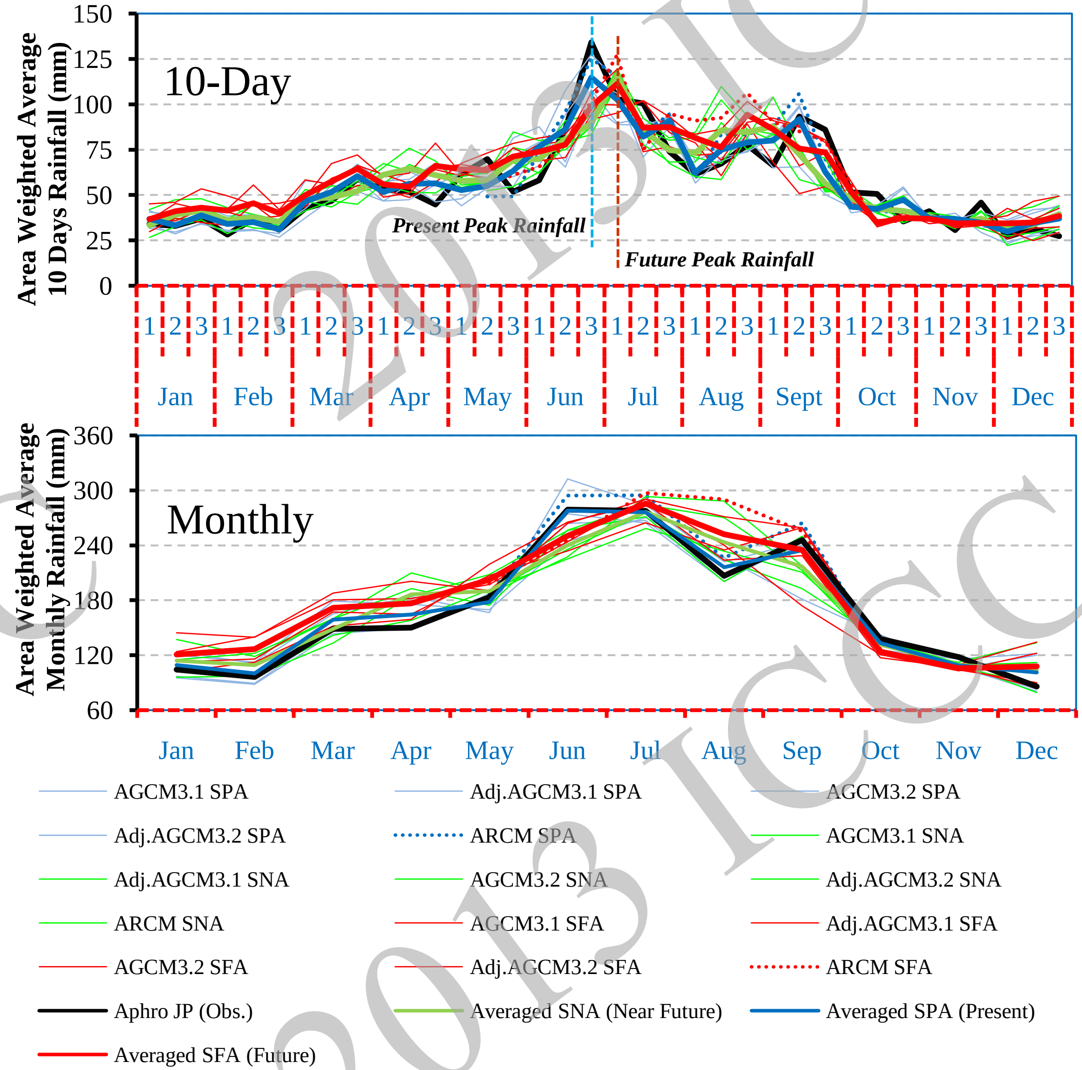
- SPA = Present Climate (1979-2003)

Climate Change in Western Japan

Air Temperature
Using AGCM 3.2 20km



Rainfall
Using AGCM 3.s 20km, Bias Corrected AGCM3.s 20km & ARCM 5km



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- SNA = Near Future (2015-2039)
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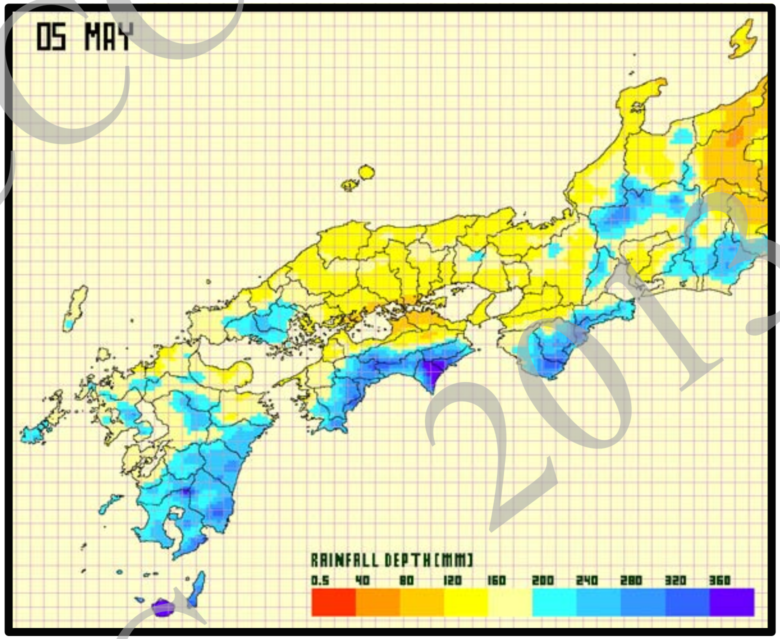
Observed and AGCMs Precipitation Data Comparison

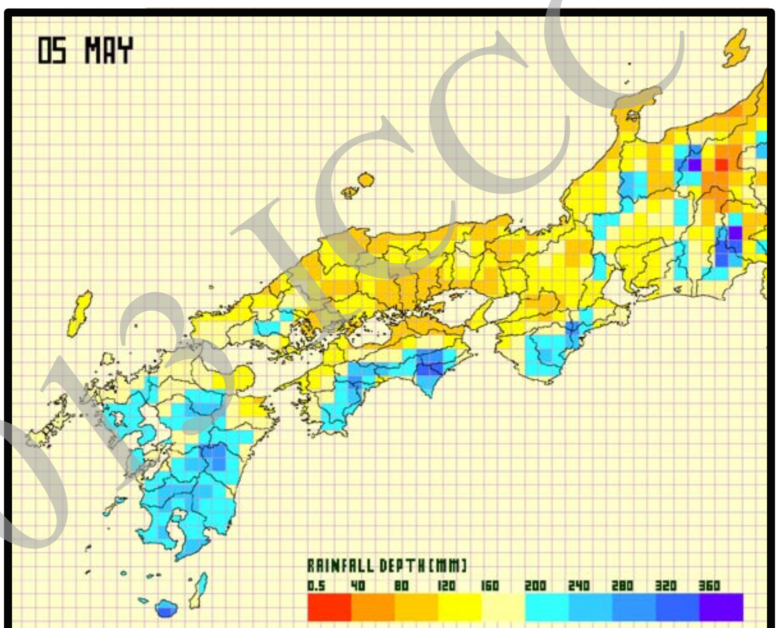
Monthly Averaged Precipitation (1979-2003)

For PRESENT Climate Period

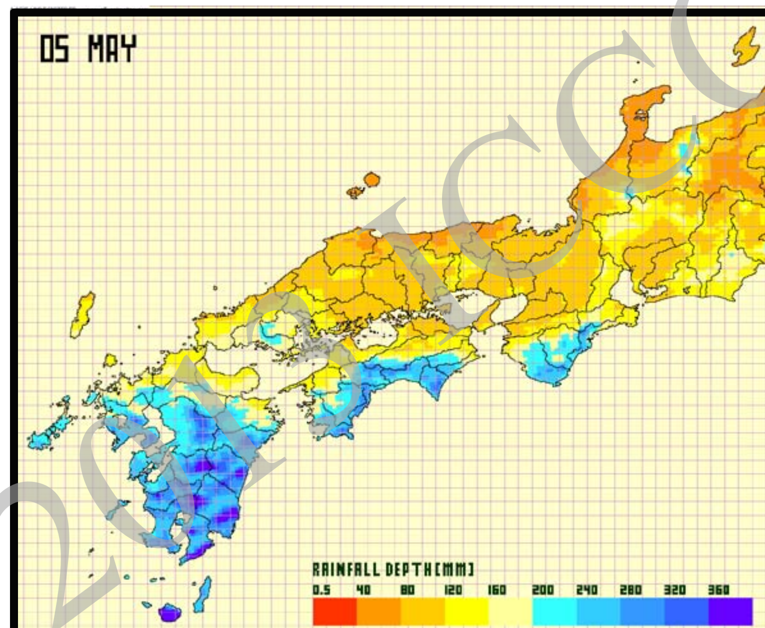
AprhoJP5km
(Observed)



AGCM3.2 20km

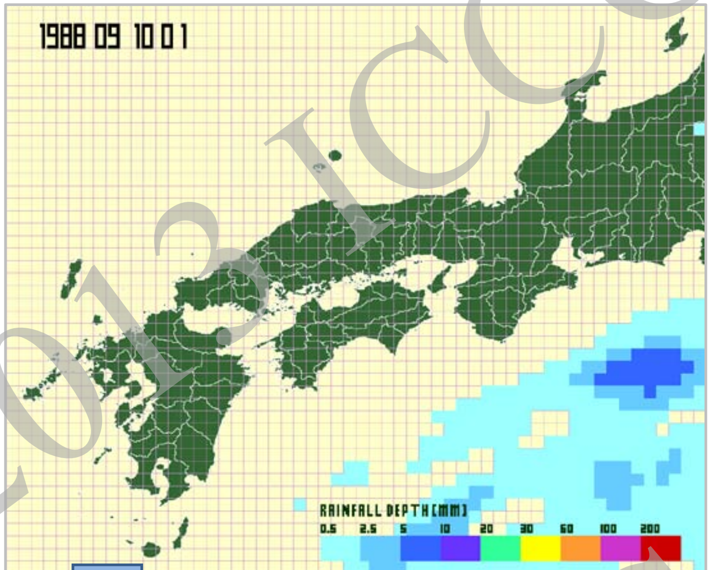


ARCM 5km

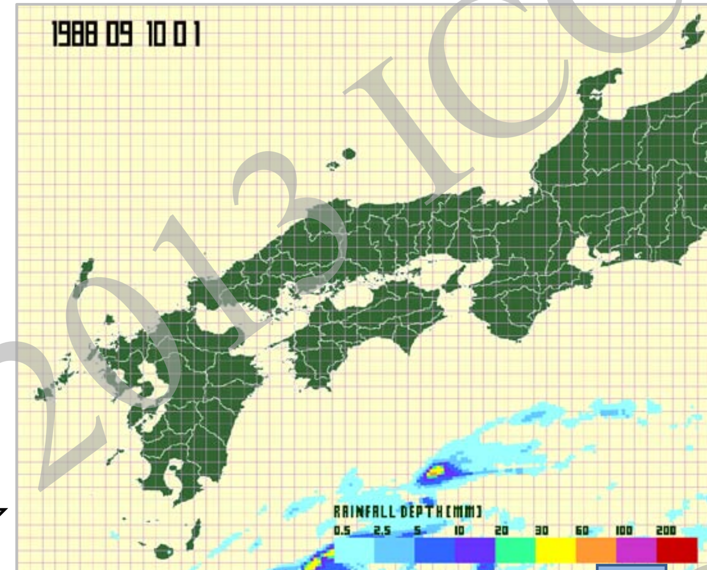


MRI-AGCM 20 km and MRI-ARCM 5km Comparison at a Simulated Typhoon Event (September 10-19, 1988)

MRI-AGCM3.2 20km

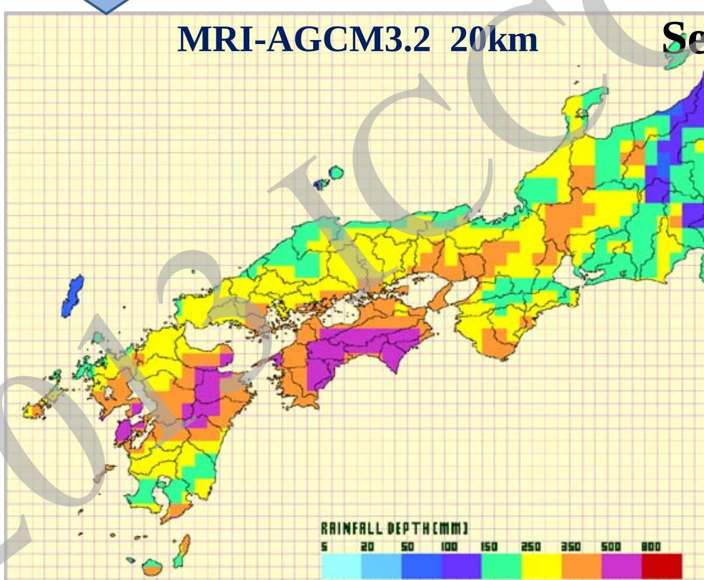


MRI-ARCM 5km

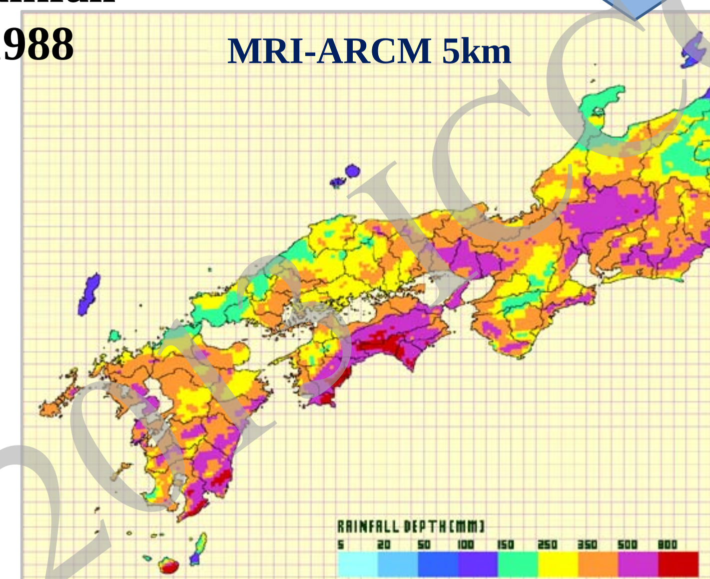


Cumulative Rainfall
Sept 10-19, 1988

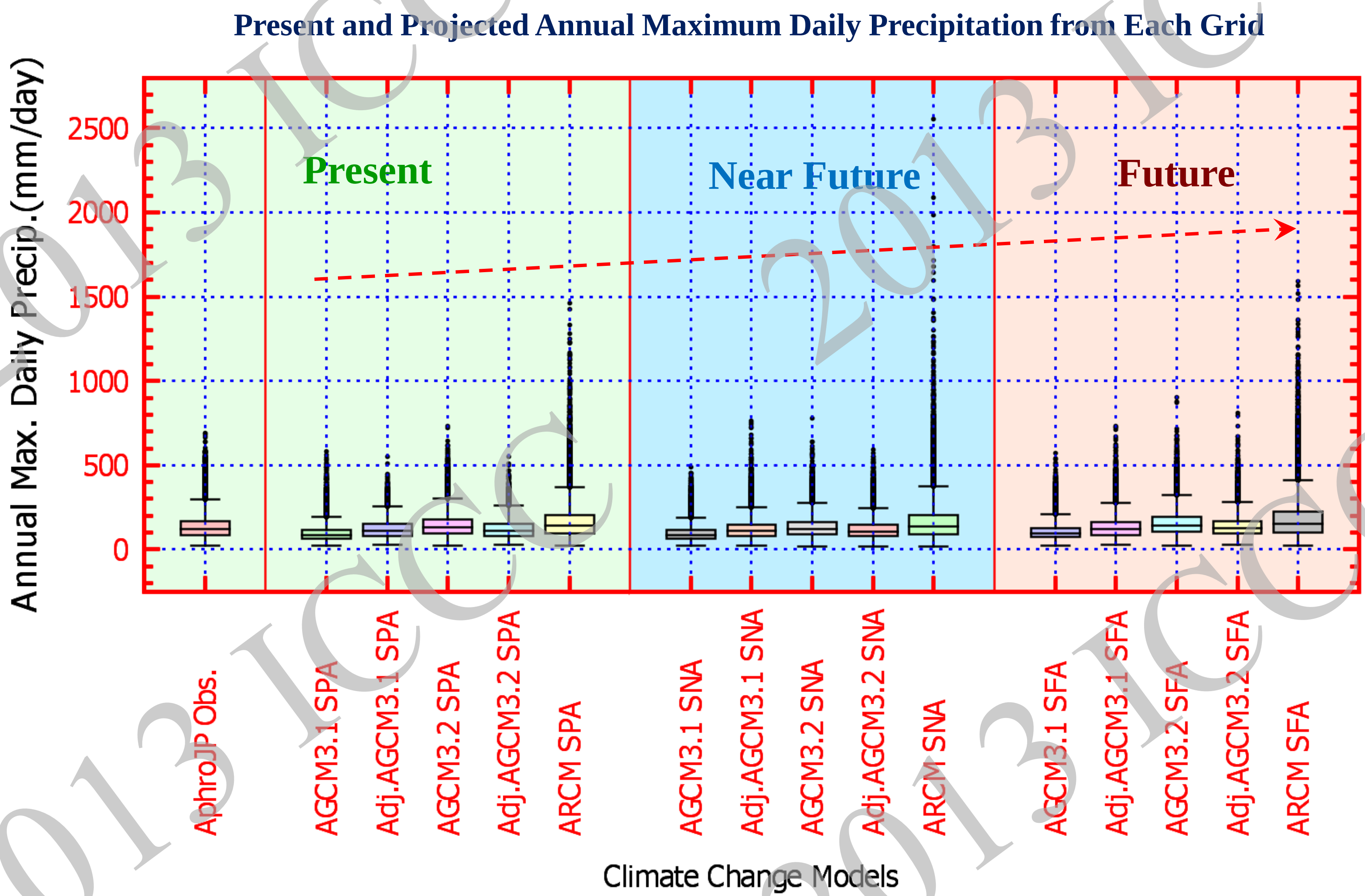
MRI-AGCM3.2 20km



MRI-ARCM 5km



Extreme Precipitation Change in Western Japan



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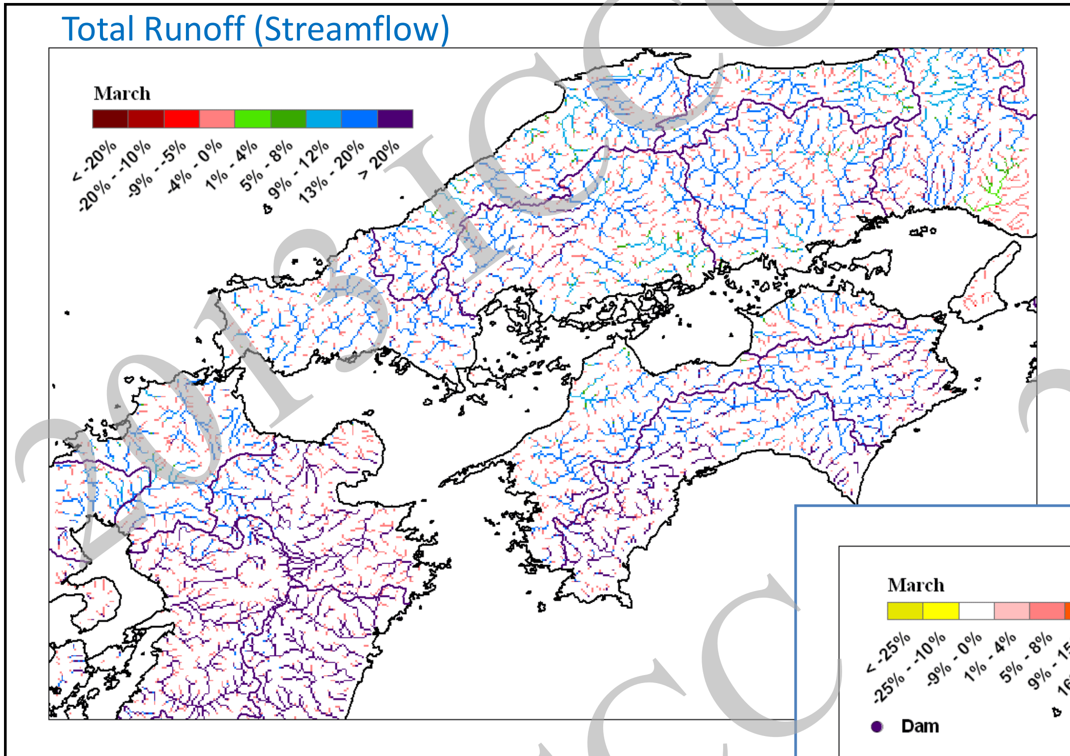
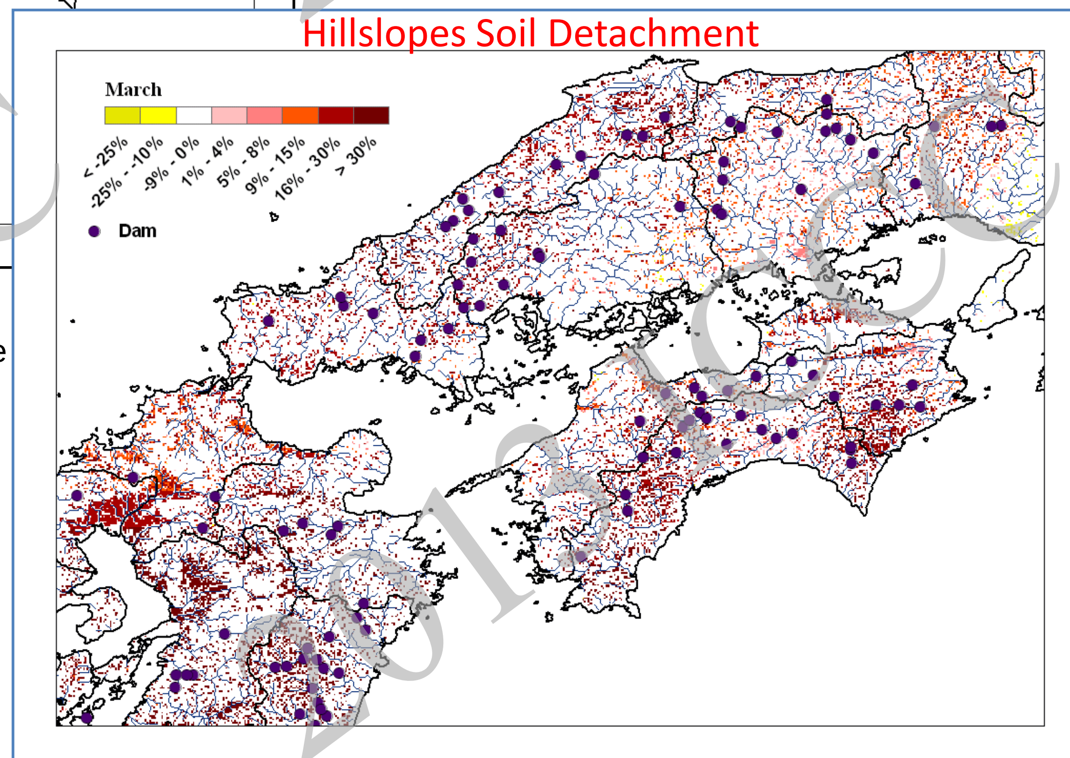
Projected Future Changes in Mean Monthly Streamflow Discharge and Soil Detachment (2075-2099) Compared to the Present Condition (1979-2004)



(March-October, in animation)

$$\frac{Future - Present}{Present} \times 100.$$



Rainfall, overlandflow, landuse, topography, and soil type control the soil detachment rate

The degree of changes differs according to location and time

No consistent changes for the west japan, mostly increases (i.e., April, May. August, Oct)

Projected Future Changes in Mean Monthly Streamflow Discharge and Shallow Landslide Occurring Probability (2075-2099)

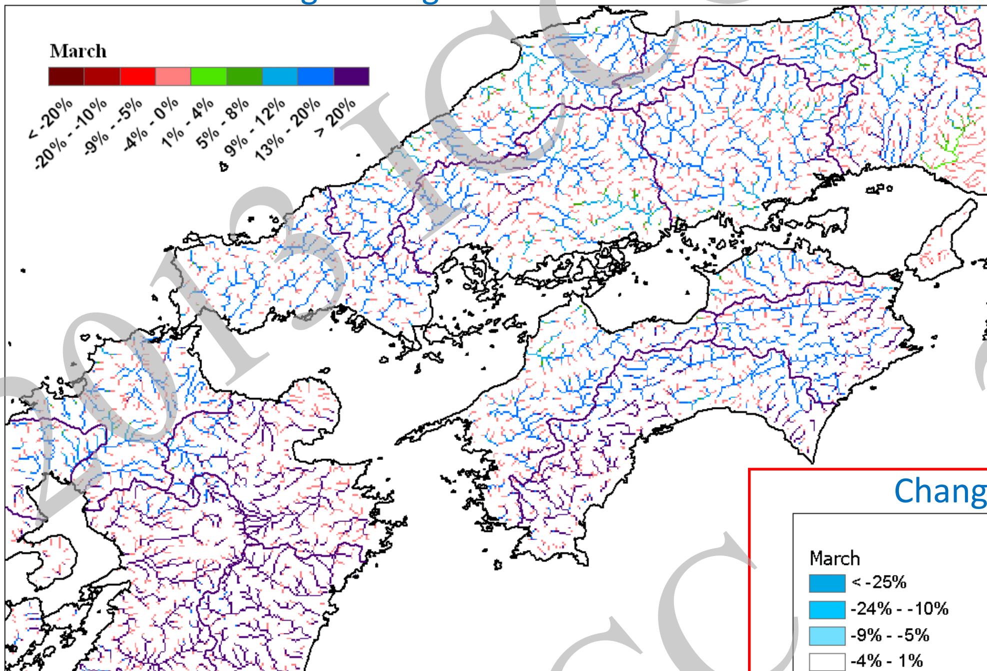
(March-October, in animation)

Factor of Safety (FS) < 1.0 → Unstable Slope Condition

$$P(\%)_{mean} = \frac{\sum_{i=1}^{N}\left(\frac{\sum_{j=1}^{m} FS_j}{n} \times 100\right)_i}{N}$$

N is the total year (25); n is the total time in a year (365x24); m is the total time in a year with FS<1.0

Streamflow Discharge Changes



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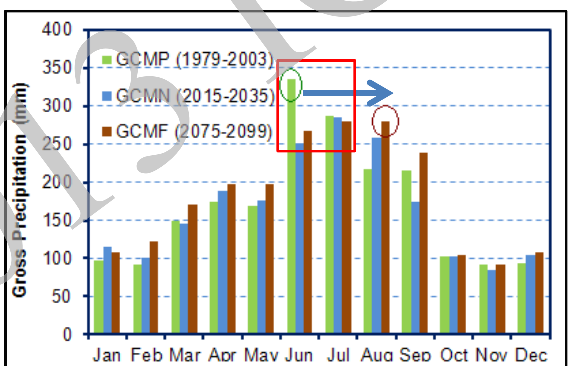
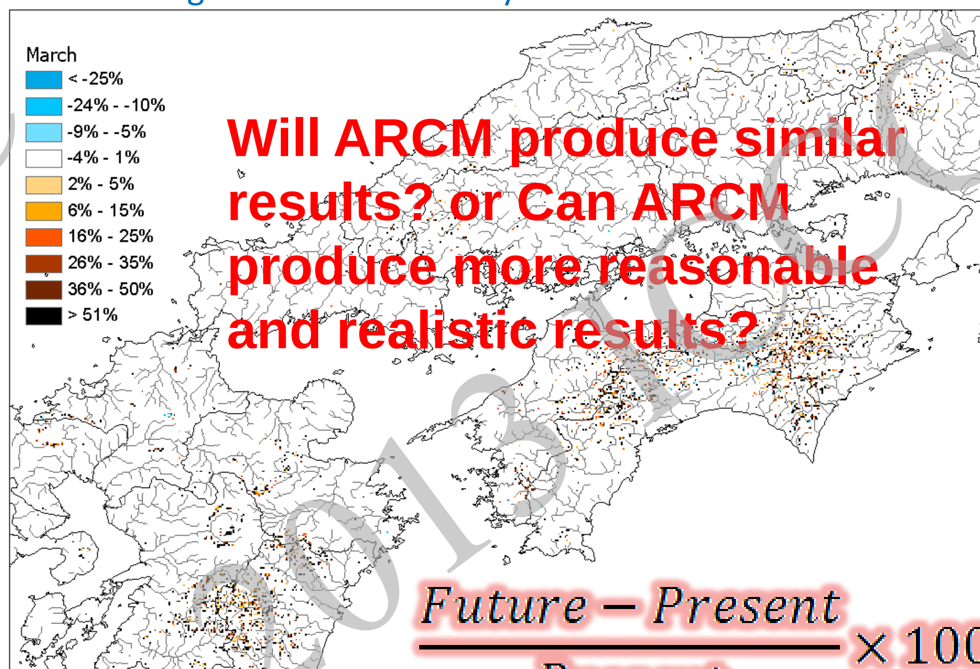


Changes on the Probability of Shallow Landslide Occurrence



Will ARCM produce similar results? or Can ARCM produce more reasonable and realistic results?

$$\frac{Future - Present}{Present} \times 100.$$

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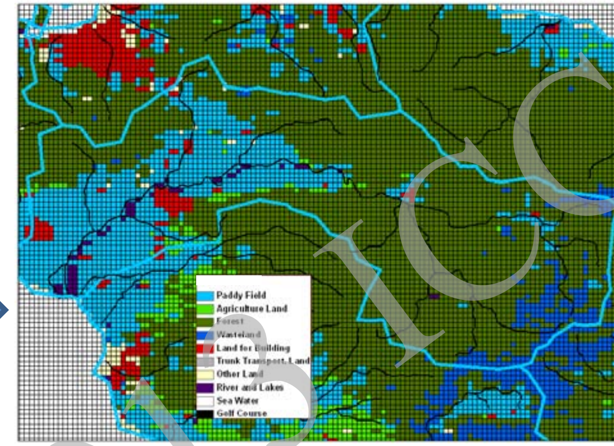
Land-use Change Scenario in the Chikugo River basin

Three Land-use Projection Scenarios

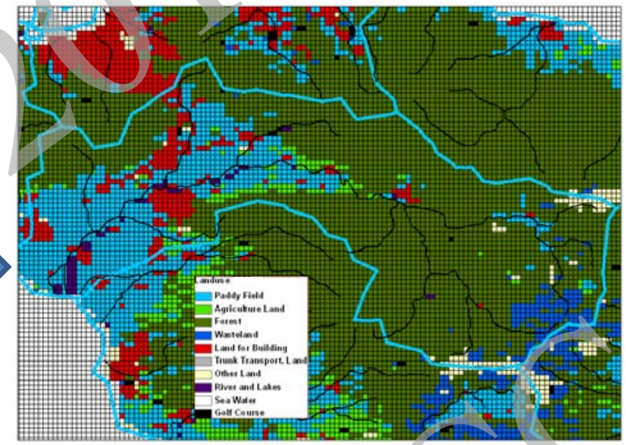
Land-use in 1976

Corservation -case Scenario (LU 1)



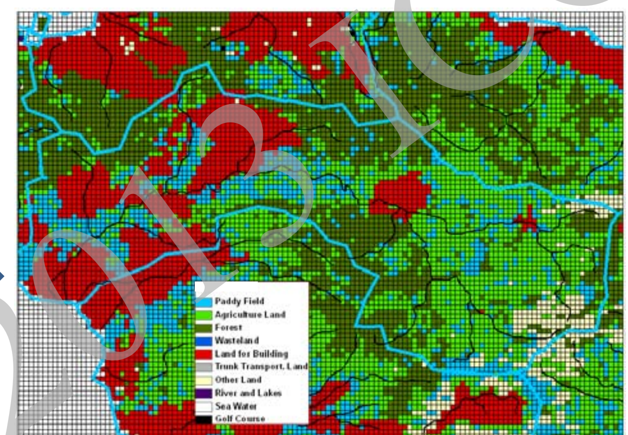
Land-use in 2006 (as Present Land-use)

No Change-case Scenario (LU 2)



Land-use in 2006 + Land-use Plan

Worst-case “Rapid Development” Scenario (LU 3)



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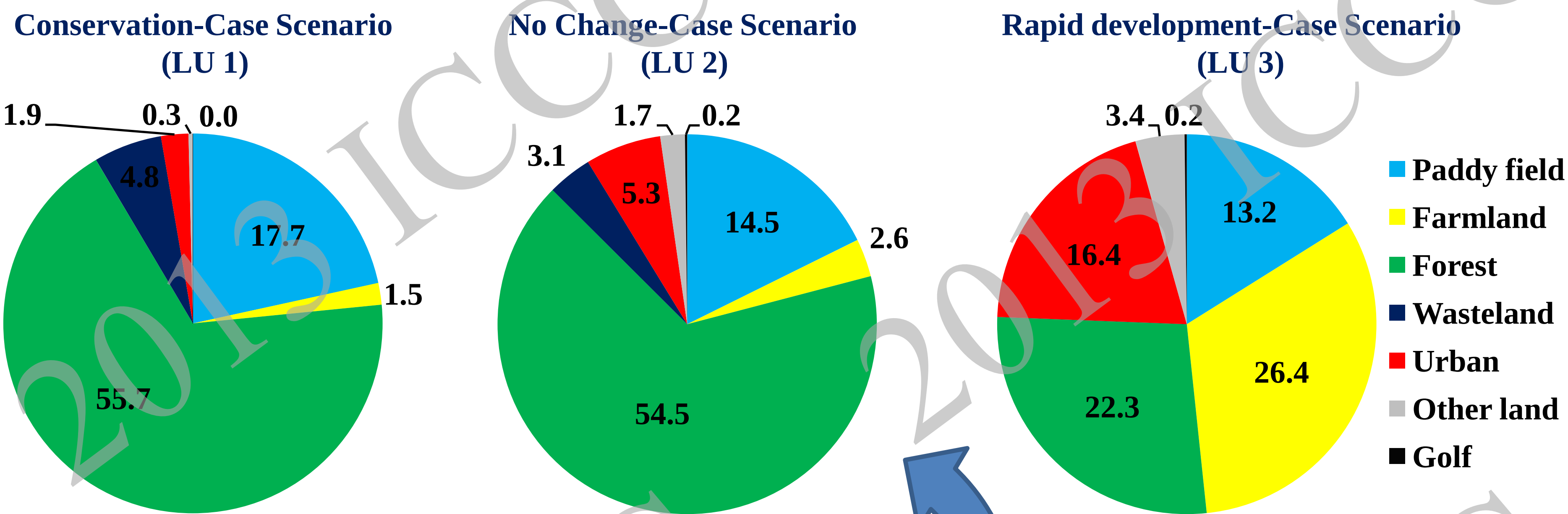
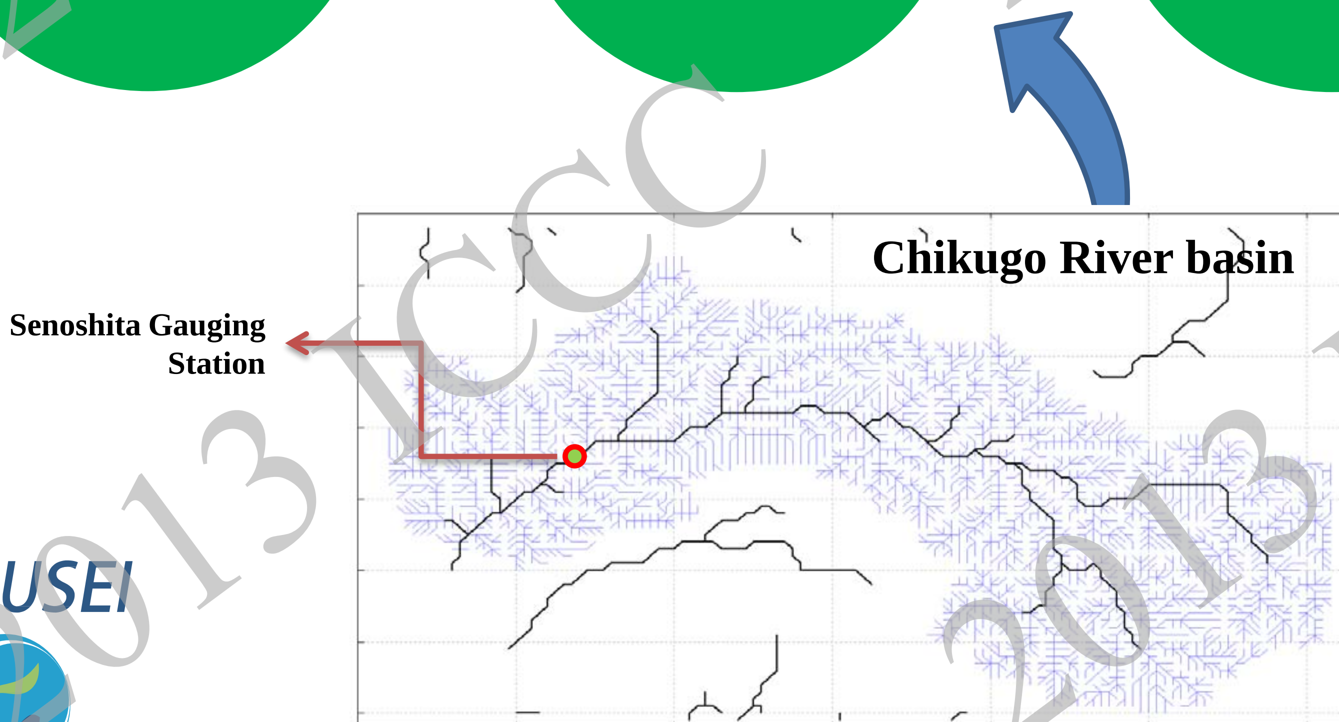
Land-use Projection Scenarios: **-Land-use Area in Percentage (%) -**





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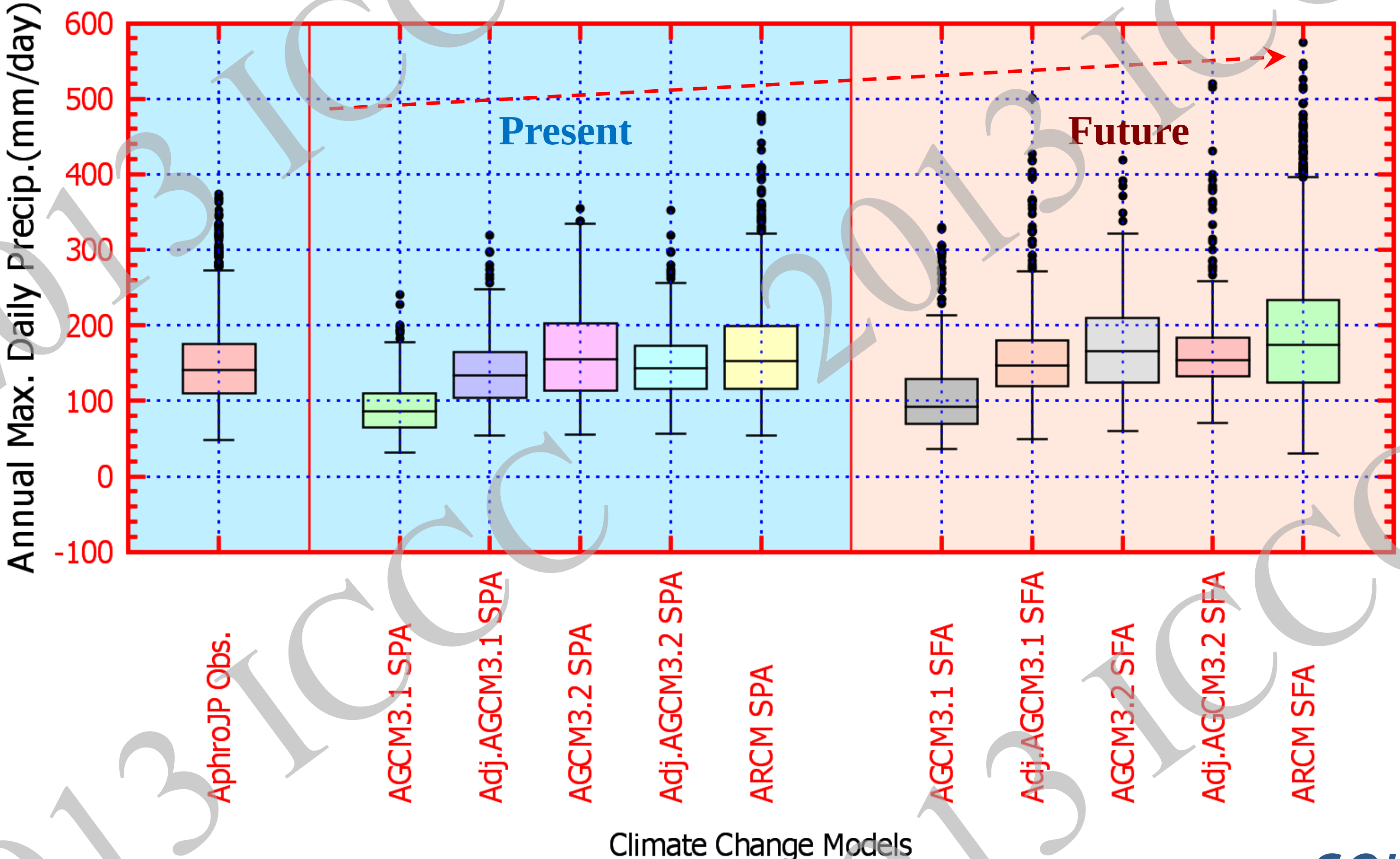
Present and Projected Annual Maximum Daily Precipitations from Each Grid in the Chikugo River basin



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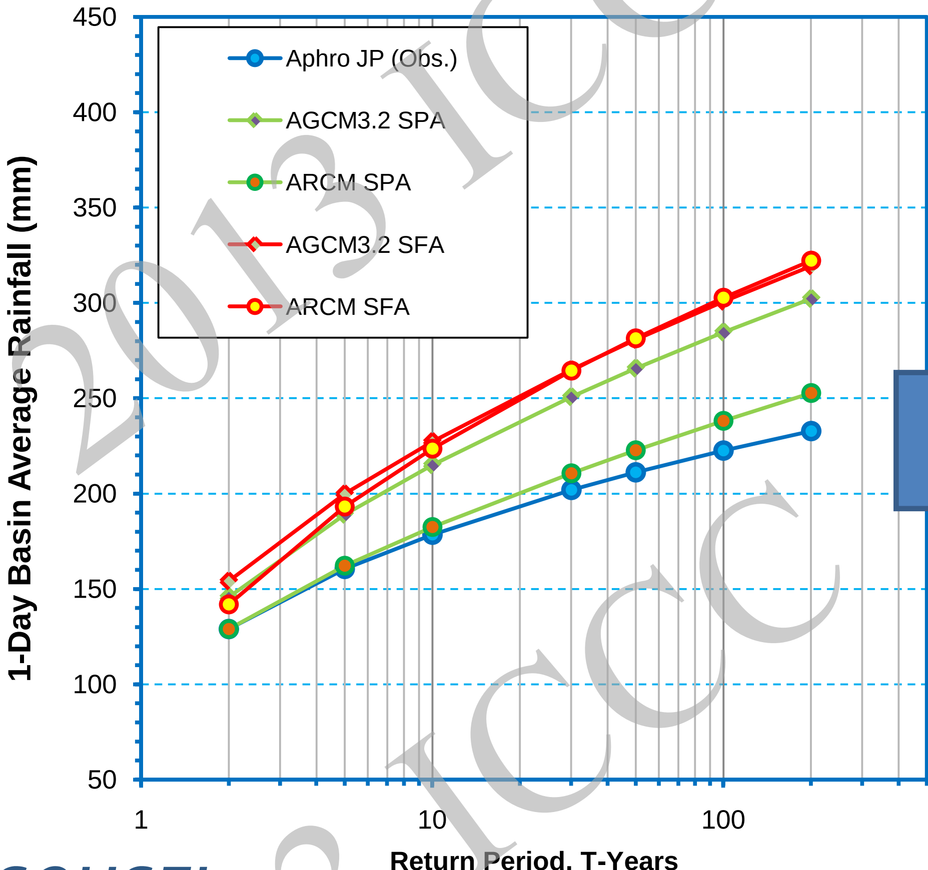
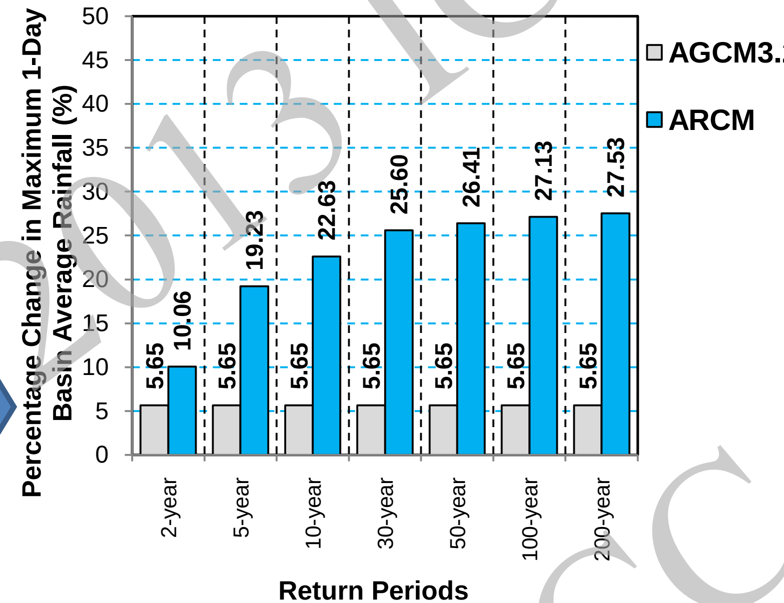
Return Periods of Maximum Daily Rainfall at the Chikugo River basin





30-year return period:
On summary, the percentage change of Maximum 1-day Rainfall using RCM 5km: **25.60%**

100-year return period:
On summary, the percentage change of Maximum 1-day Rainfall using RCM 5km: **27.13%**

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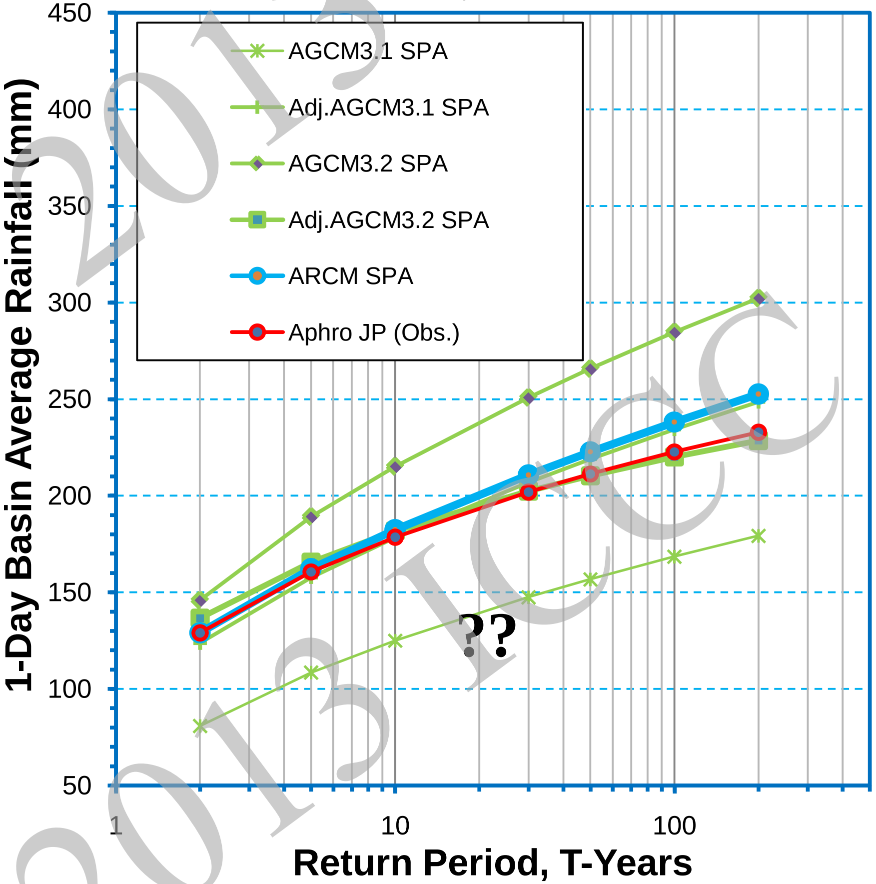
- SPA = Present (1979-2003); SFA = Future (2075-2099

Rainfall Frequency Analysis:

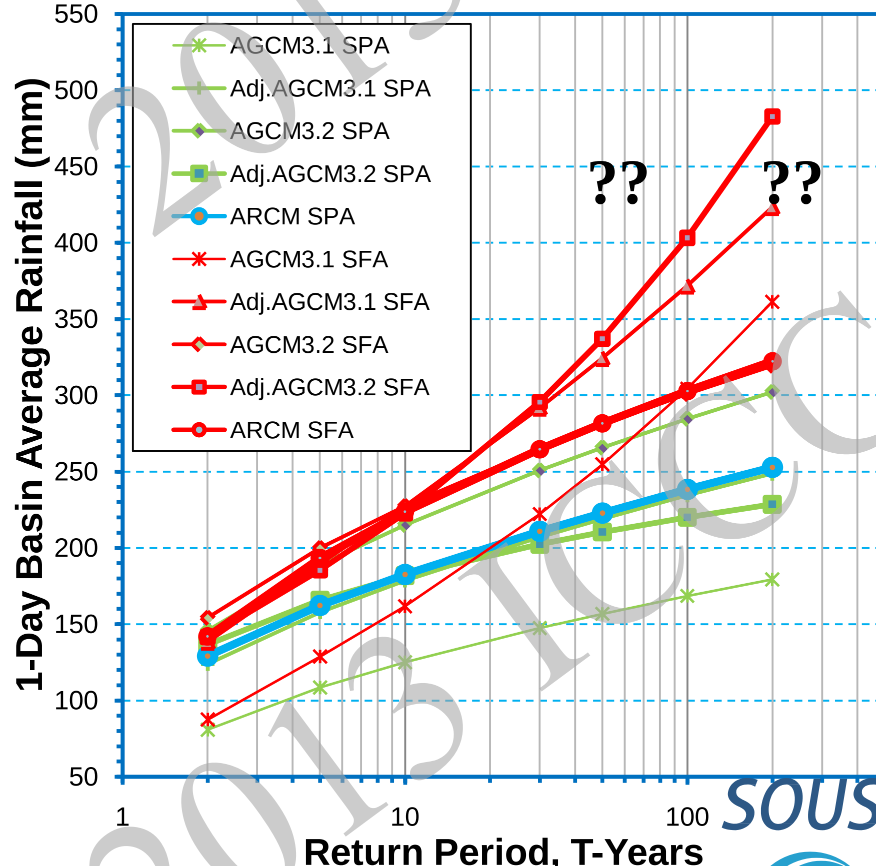
24-h max. rainfall/ year/GCM data/period → Frequency Analysis (conv. method), L-moment Method → Design Rainfall Depth for Different Return Periods

Return Periods of Maximum Daily Rainfall at the Chikugo River basin

Present vs Observed



Present vs Future



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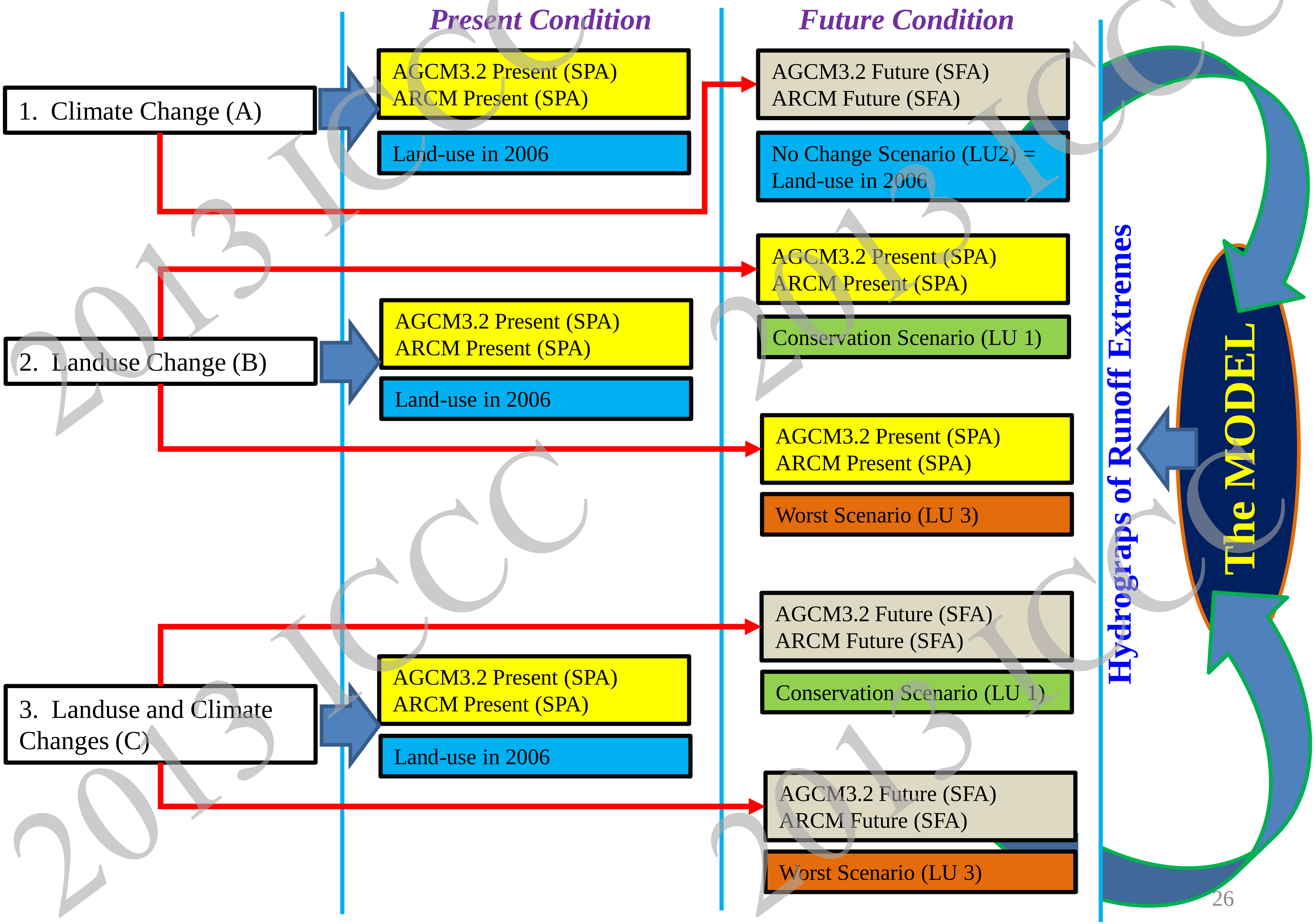
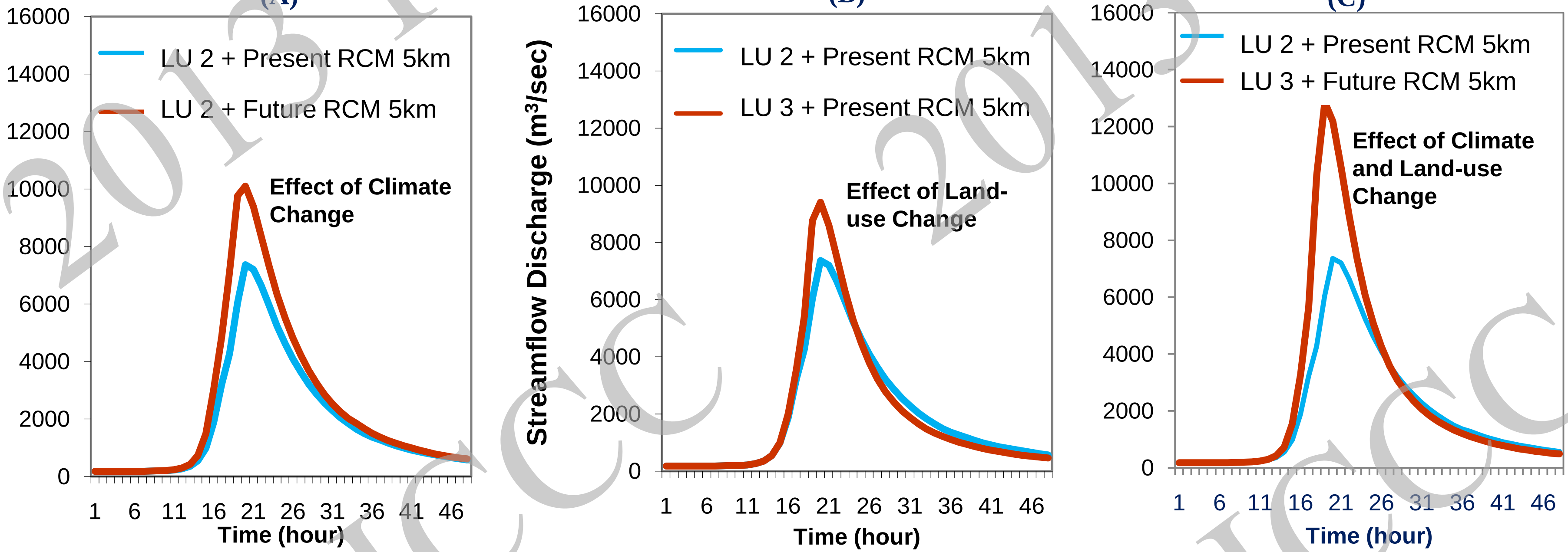
Scenario-Based Simulations *for Conversion of Rainfall Intensity, Duration, Frequency (IDF) into hydrographs*



An Example Result of Design Extreme Runoff (Flood) for 30-Year Return Period at Senoshita Station Using RCM 5km and Land-use Scenario 2 & 3

Climate Change Scenario (A) | **Land-use Change Scenario (B)** | **Climate & Land-use Change Scenario (C)**



= Present Condition

= Future Condition

LU 2 = No Change-case Land-use Scenario (Land-use 2006)

LU 3 = Worst-case "Rapid Development" Land-use Scenario

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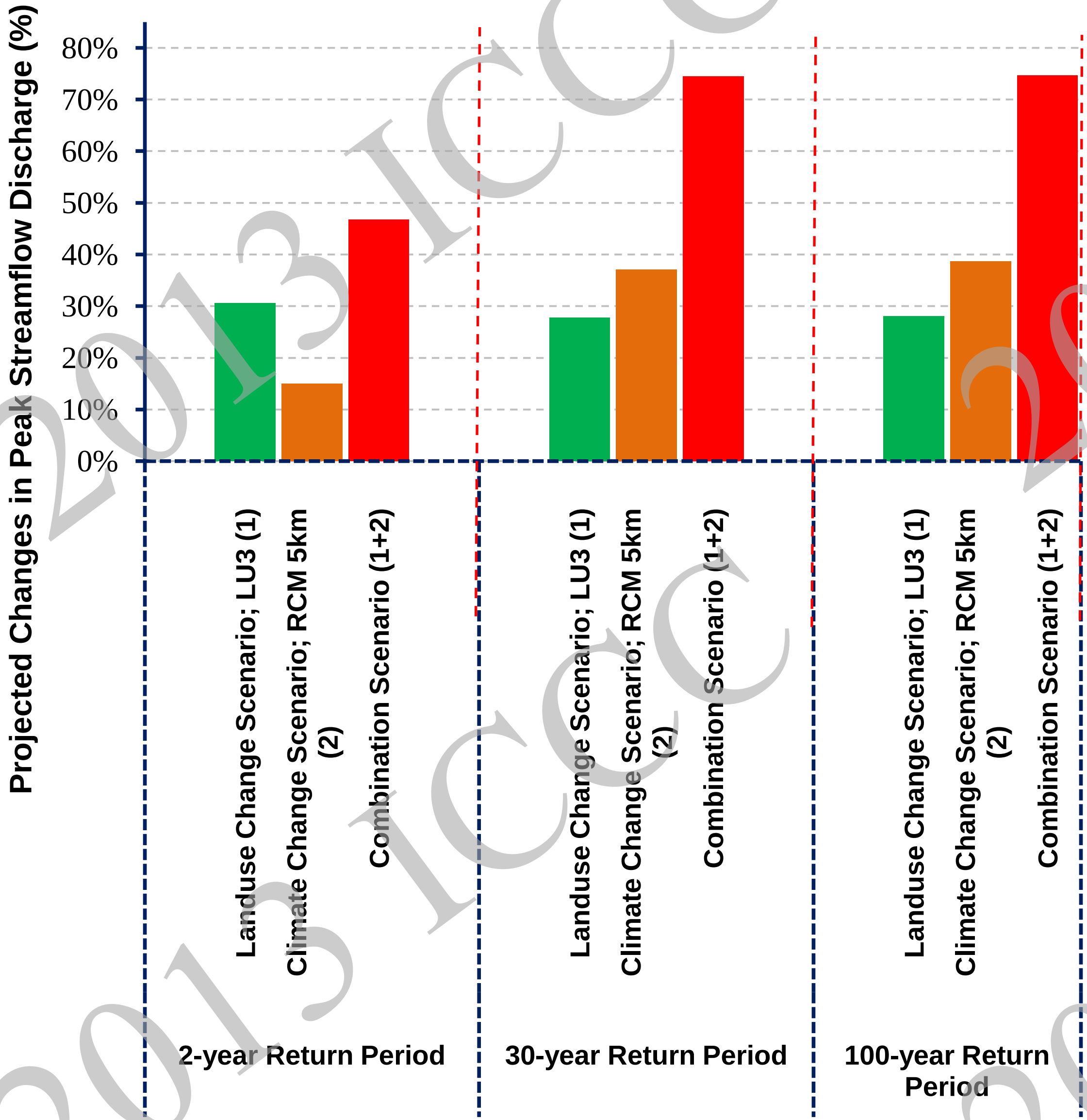
An Example Result of Projected Change in the Magnitude of Peak Runoff (Flood) for Different Return Periods at Senoshita Station Using RCM 5km and Land-use Scenario 3



There is a tendeny that the relative changes due to climate change (**using RCM 5km**) is higher than land-use change, particularly in response to the longer return periods

Combination of climate change and the local effect of landuse change under “rapid development” scenario (LU3) shows higher increase in the magnitude of peak runoff in compare to the individual scenarios

LU 3 = Worst-case “Rapid Development” Land-use Scenario

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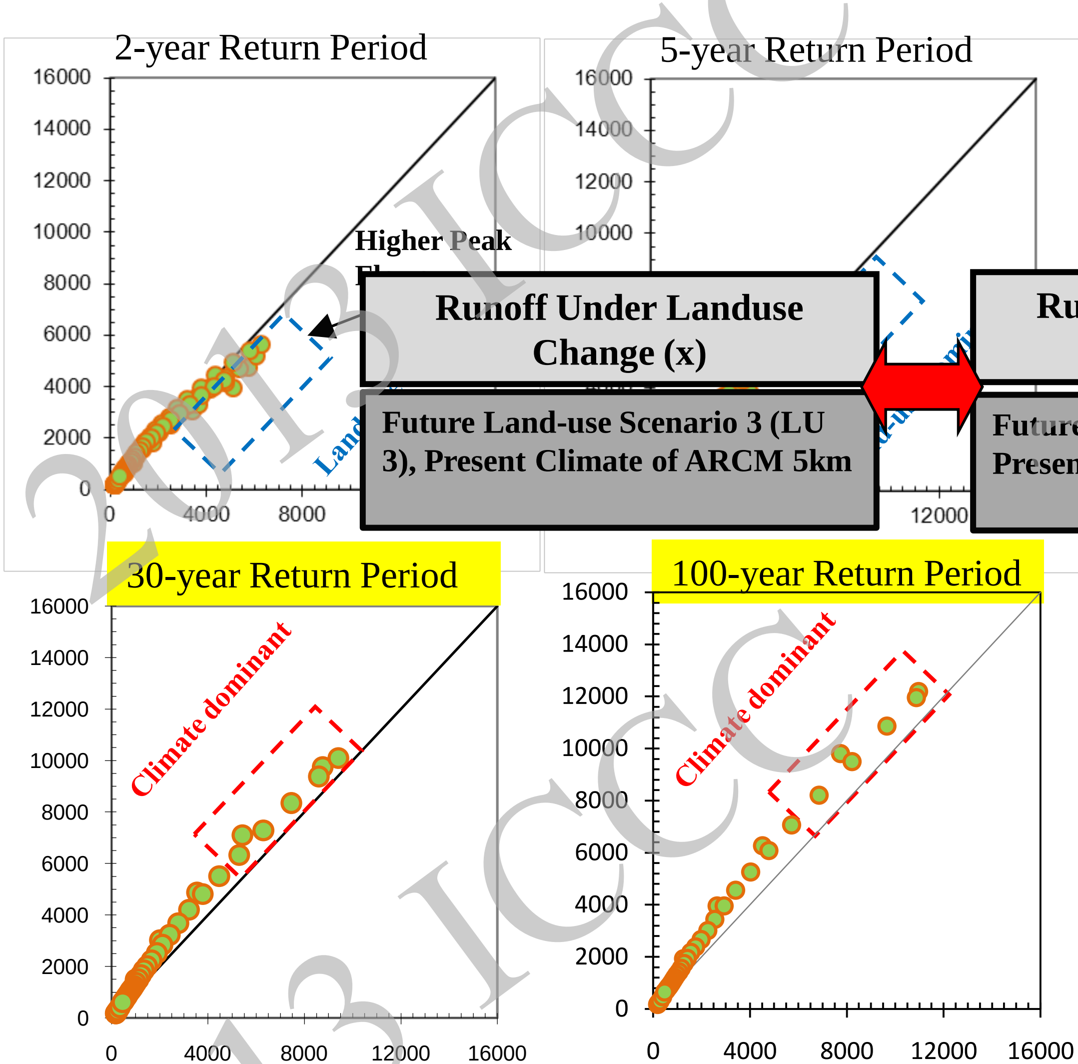
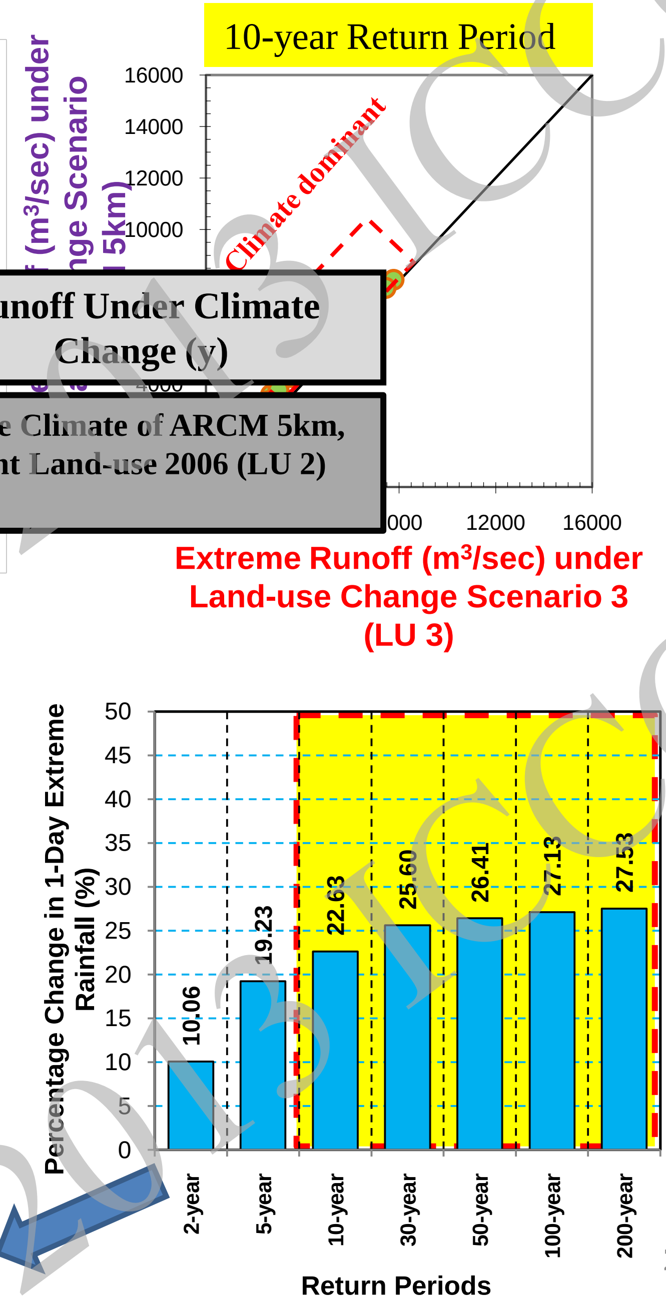
Plots of Runoff Discharge (at Senoshita St.) Simulated Under:
Land-use Change Scenario (LU 3) Vs Climate Change Scenario (ARCM 5km)





1. **From 10-year Return Period, projected extreme rainfall using ARCM 5km produces higher peak discharge and becomes more dominant than impact of land-use change under scenario 3 (LU 3)**
2. **If the relative change of future extreme rainfall > 22% then the climate change will be more dominant**

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SUMMARY（1）

- The future changes on precipitation and river basins hydrological responses would have direct & indirect impacts on soil productions and shallow landslide. Hotspots of significant changes differ according to the time and location. Kochi, Tokushima, Miyazaki, Kumamoto, Hiroshima, Yamaguchi, Ehime, Shimane and Okajama Prefectures are expected to be hotspots.

- Regional atmospheric model of ARCM 5-km simulates more frequent local heavy rainfall over the region/basin in compare to others AGCMs 20-km. The changes of rainfall abnormality in various recurrence intervals were detected more clearly than as changes in the mean climate, such as monthly rainfall

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SUMMARY(2)

- Expected future changes in variability of rainfall and land-use have important implication on the timing and magnitude of extreme runoff events. For the shorter-term recurrence intervals such as 30-years, the influence of "development" land-use catagory on projected changes in the magnitude of peak discharge is relatively higher than climate change, and for longer-term extremes are more likely to be affected by climate change than land-use change.

- Compared with individual scenarios, the combination of climate change scenario and the local effect of landuse change under development scenario shows higher increase in the magnitude of runoff extremes.

love your add-ons.

ENGLISH

GIS ホームページ 国土交通省国土政策局 国土情報課

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国土数値情報ダウンロードサービス

JPGIS1.0準拠データのダウンロード(平成22年度をもって更新停止)

ダウンロードしたい国土数値情報のデータ項目を選択してください。
データの種類について:○○メッシュという名称のデータはメッシュデータです。データ名の後に(点)(線)(面)とあるのは、それぞれ、点データ、線データ、面データを表します。

過去にダウンロードの多いデータ項目

● ベクトルデータ

鉄道(線)	地価公示(点)	行政区域(面)

● メッシュデータ

土地利用3次メッシュ	標高・傾斜度3次メッシュ	道路密度・道路延長メッシュ

全データ一覧(大項目別一覧)

大項目	種類			
指定地域	● ベクトルデータ	三大都市圏計画区域(面)	都市地域(面)	自然公園地域(面)
		自然保全地域(面)	農業地域(面)	森林地域(面)
		鳥獣保護区(面)	人口集中地区(面)	過疎地域(面)
		半島振興対策実施地域(面)	離島振興対策実施地域(面)	奄美群島(面)
		小笠原諸島(面)	豪雪地帯(面)	特殊土壌地帯(面)
		振興山村(面)	特定農山村地域(面)	土砂災害危険箇所(面、線、点)
		小学校区(点、面)	世界自然遺産(面)	
沿岸域	● ベクトルデータ	漁港(点、線)		
自然	● メッシュデータ	標高・傾斜度3次メッシュ	標高・傾斜度細分メッシュ	
土地関連	● ベクトルデータ	地価公示(点)	都道府県地価調査(点)	工業用地(面)
	● メッシュデータ	土地利用3次メッシュ	土地利用細分メッシュ	
国土骨格	● ベクトルデータ	行政区域(面)	海岸線(線)	湖沼(面)
		河川(線、点)	鉄道(線)	空港(面、点)
		港湾(点、線)		
	● メッシュデータ	道路密度・道路延長メッシュ	流域メッシュ	