



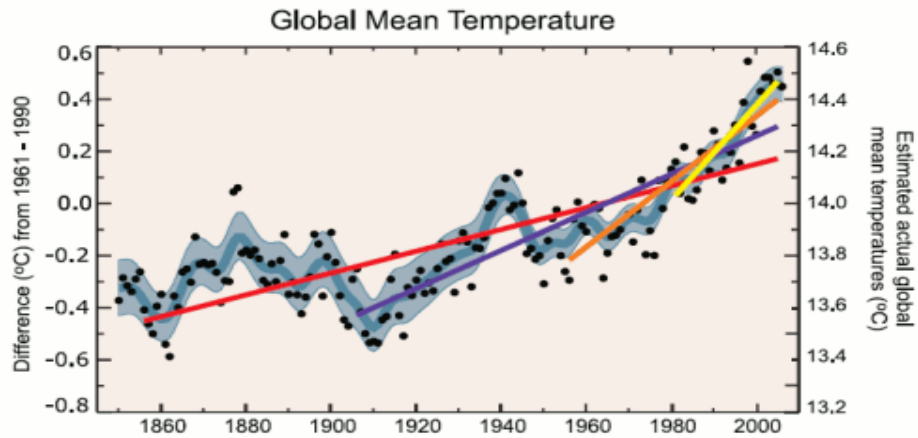
Climate Change Impact and Adaptation Assessment in Agriculture

Kwang-Hyung Kim

APEC Climate Center

Recent Climate Change → Increased Climate Variability

Temperature increase



Arctic Ice Extent

1979-2015

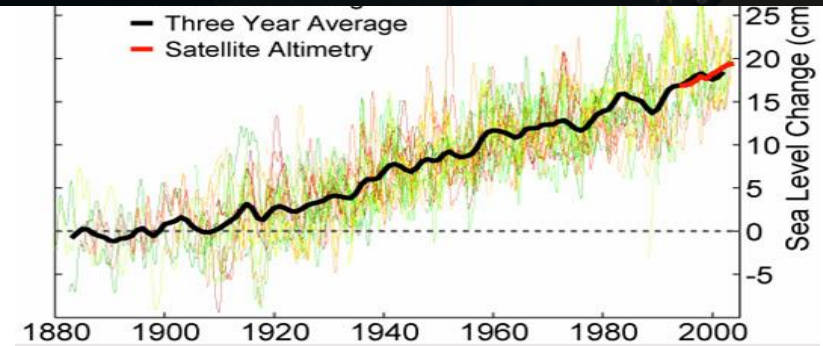
September 1979



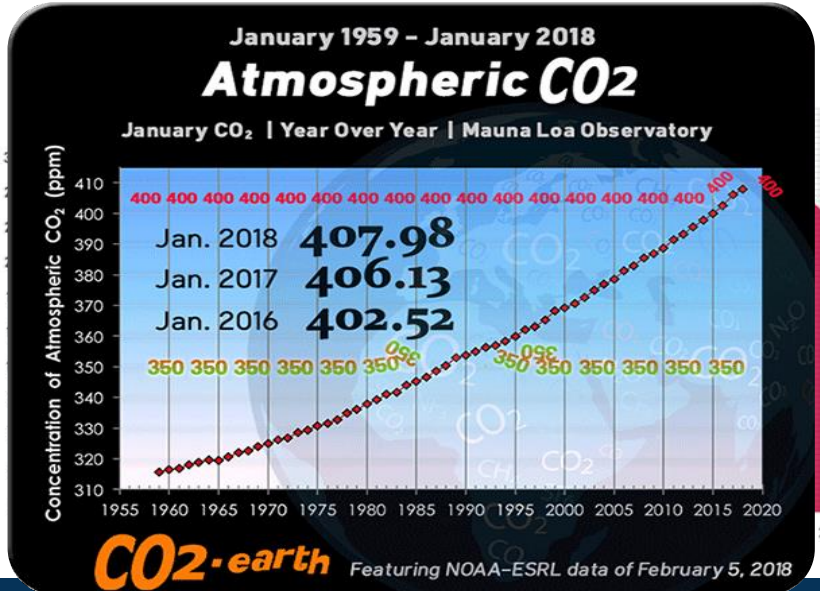
Data source: www.nsidc.org

Mapping: Alasdair Rae

Sea level rise



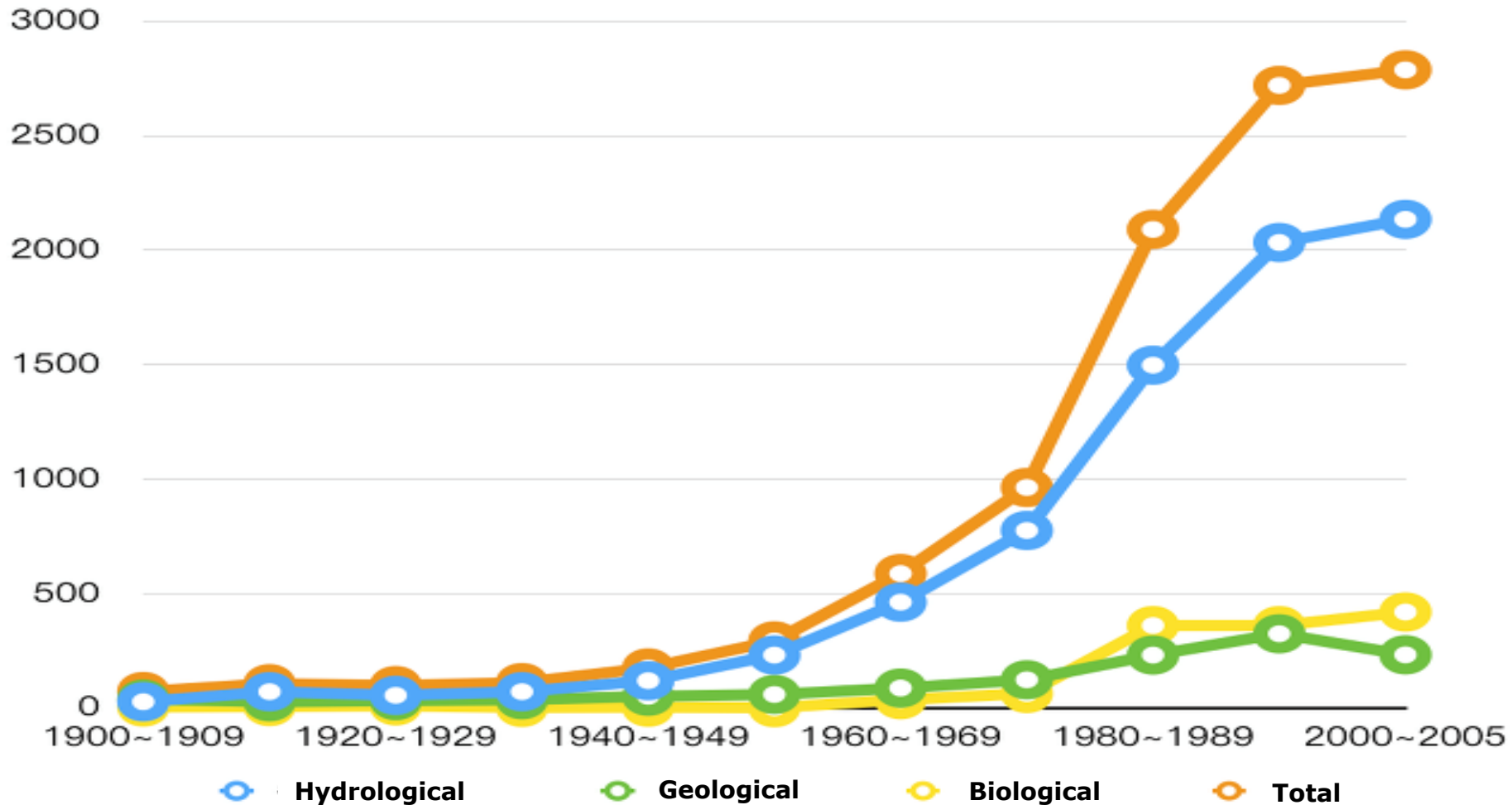
Source: NOAA http://www.cop.noaa.gov/stressors/climatechange/current/sea_level_rise.htm



(IPCC 2007)

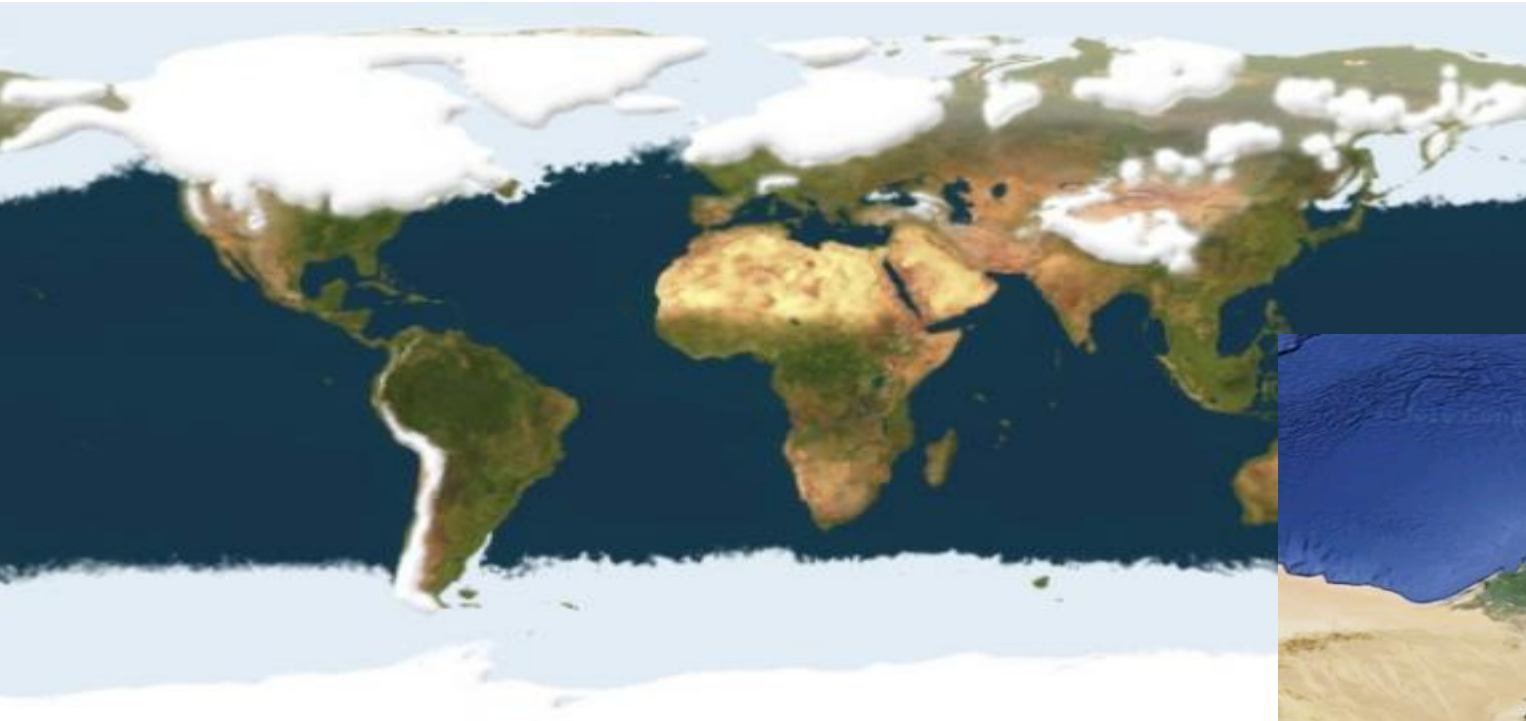
Recent Climate Change → Increased Climate Variability

Number of Natural Extreme Disasters Worldwide



Impacts of Climate Change from the History

● ICE AGE (10000~2000 BC?)



ICE AGE

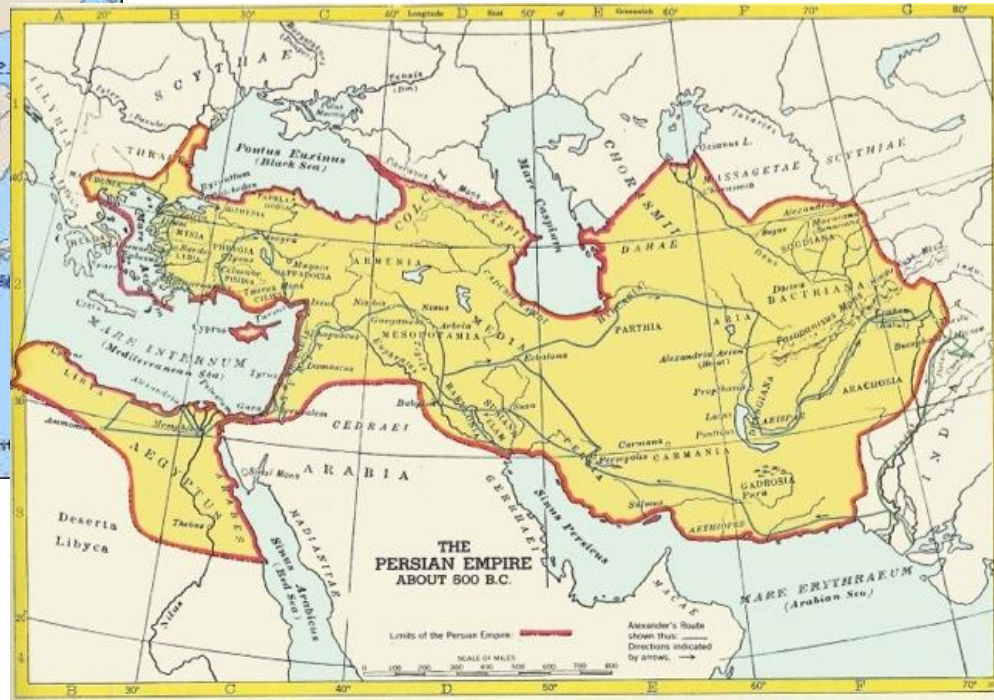
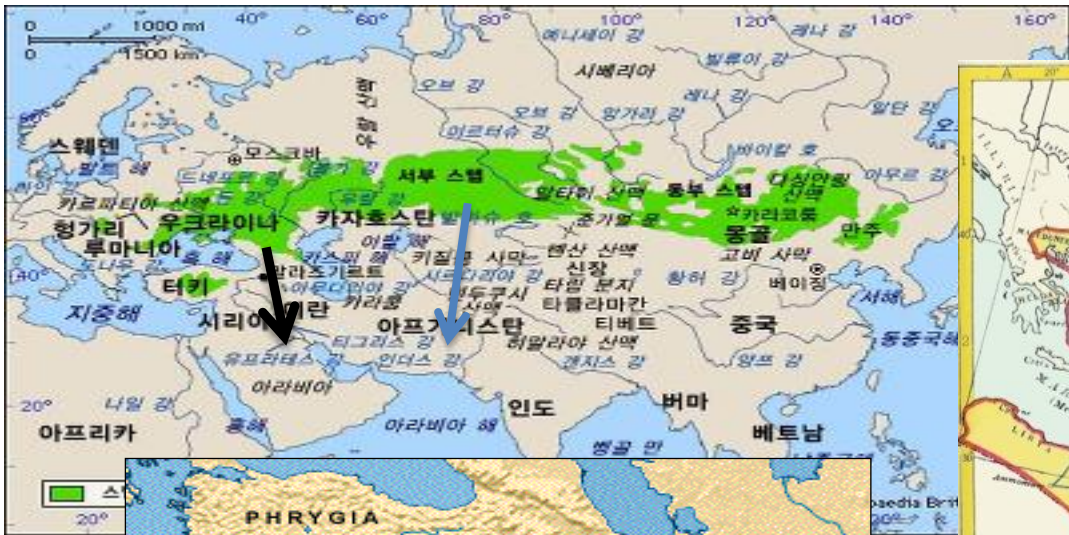


Where Job in the Bible lived

- (Job 6: 16-17) If the **ice** melts and the water darkens and the **snow** hides in it....
- (Job 9:30) I wash my body with **snow melted water**...
- (Job 24:19) Drought and heat soon take away **snowy water**...
- (Job 37:9-10) The cold rides the northern wind and **freezes the ice** ...
- (Job 38:29-30) The surface of the deep sea is **frozen**....

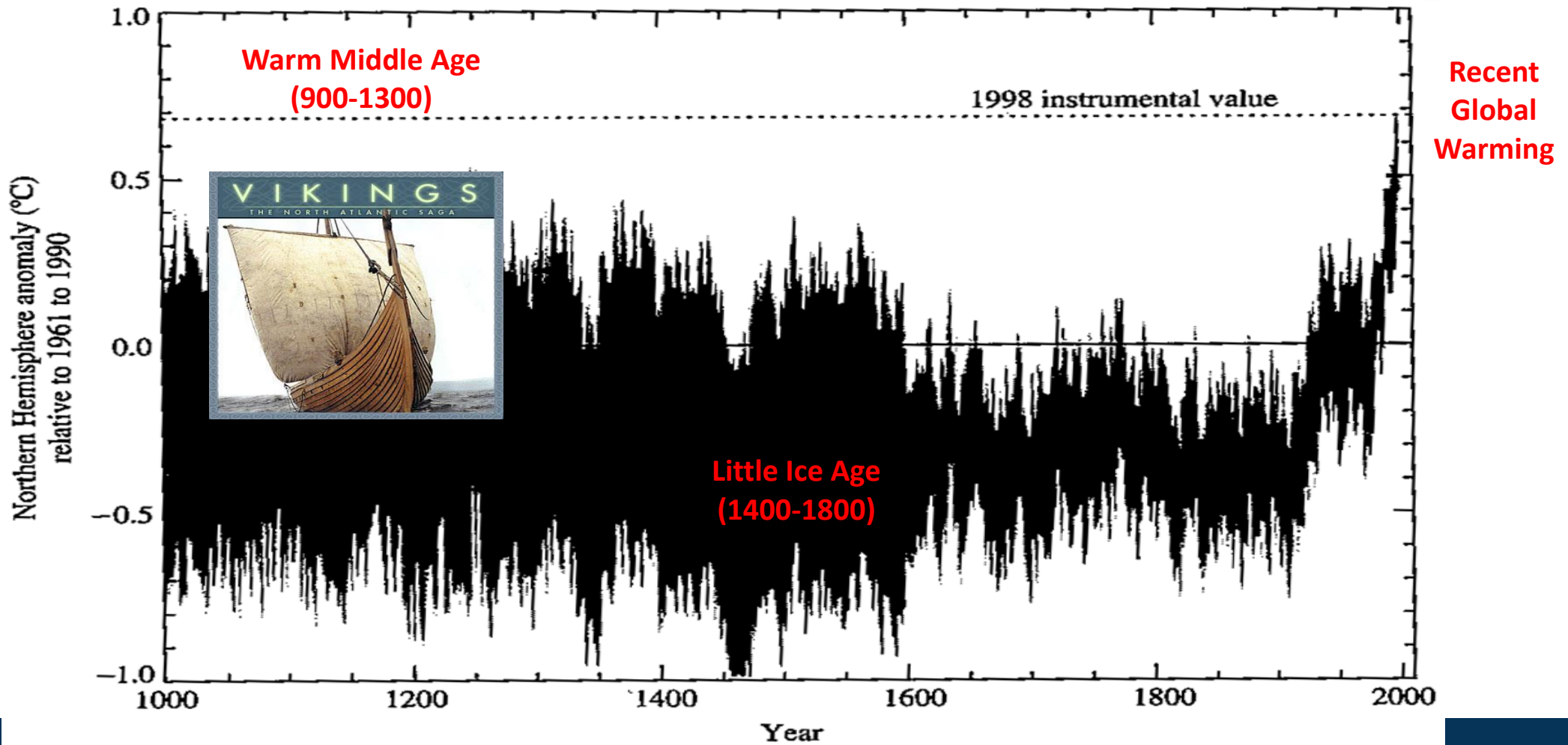
Impacts of Climate Change from History

- The major movements of the Aryans started in the 17th century BC are caused by the desertification of Central Asia due to climate change → **Founding of Babylon and Persia**



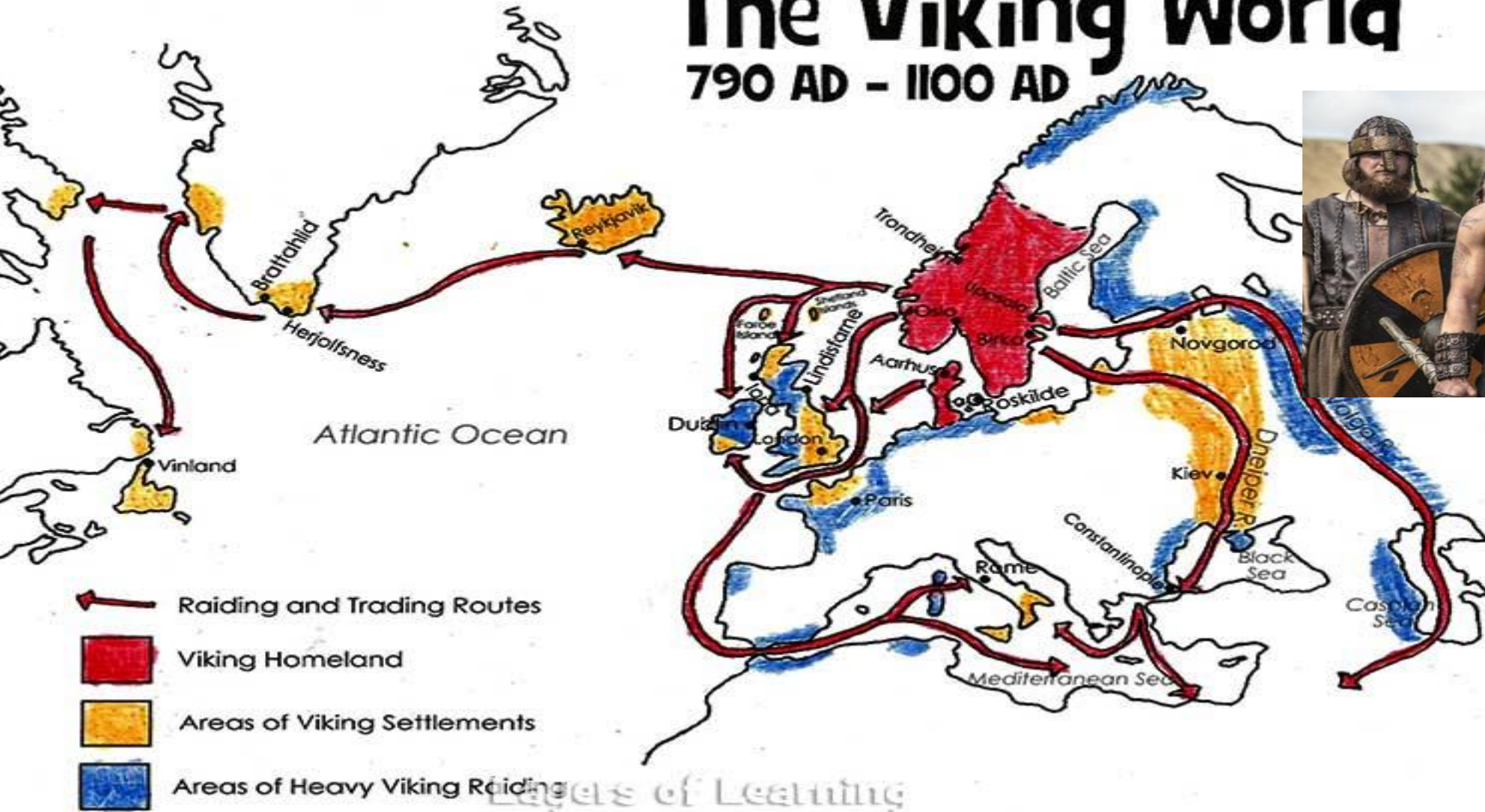
Impacts of Climate Change from History

- In the 12th-14th centuries, Europe was warm enough to grow grapes in England and Norway, but in the 15th-16th centuries, it rapidly turned into a cold climate.



Impacts of Climate Change from History

The Viking World 790 AD - 1100 AD



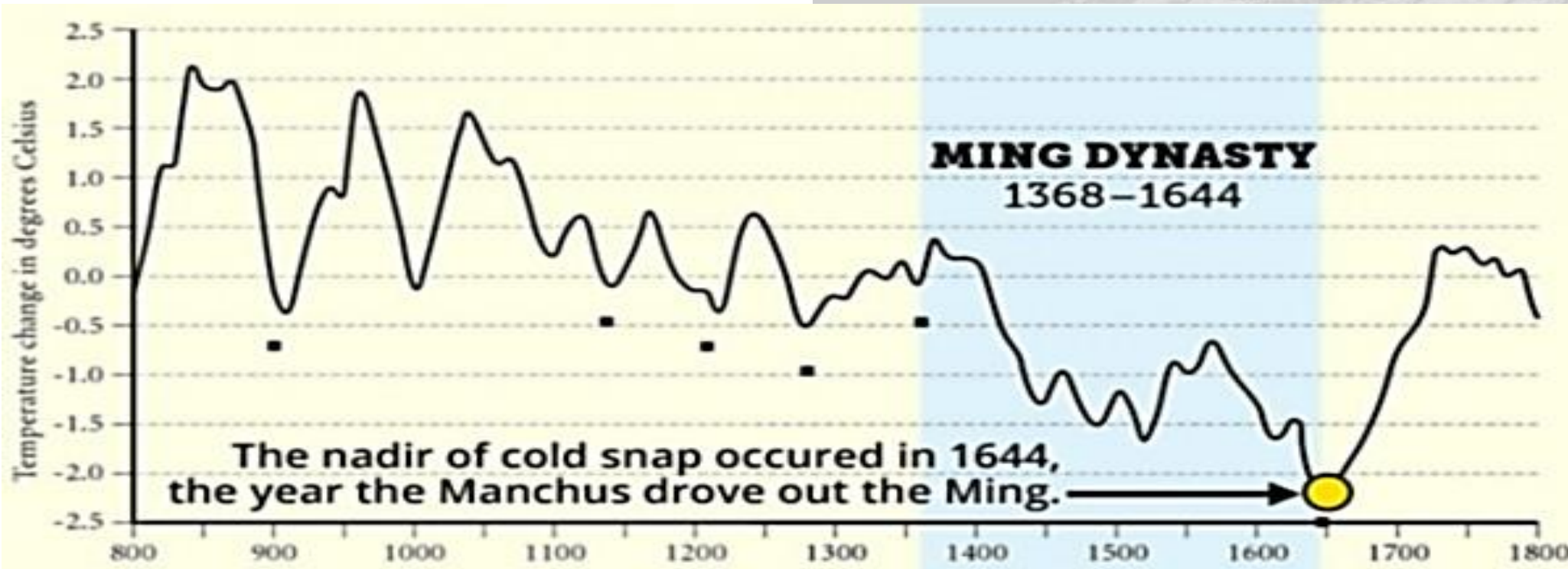
the Vikings



However, the Vikings have fallen as they have just undergone temporary glaciation (Little Ice Age)

Impacts of Climate Change from History

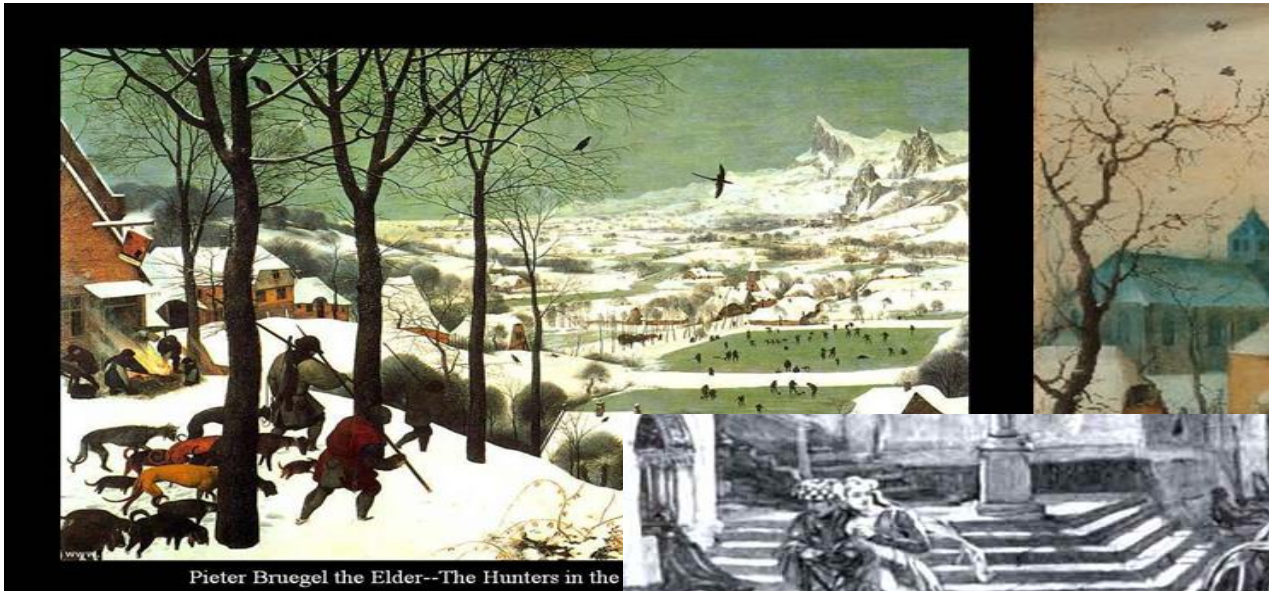
- The greatest cause of the decline of the Ming Dynasty is the record droughts and cold climate around 1630s, leading to severe epidemics and famines played a decisive role.



1415
Ming Dynasty

Impacts of Climate Change from History

Little Ice Age (1400-1800)



Pieter Bruegel the Elder--The Hunters in the Snow



French Revolution (1790s)



Plague (The Black Death)





Impacts of Climate Change from History

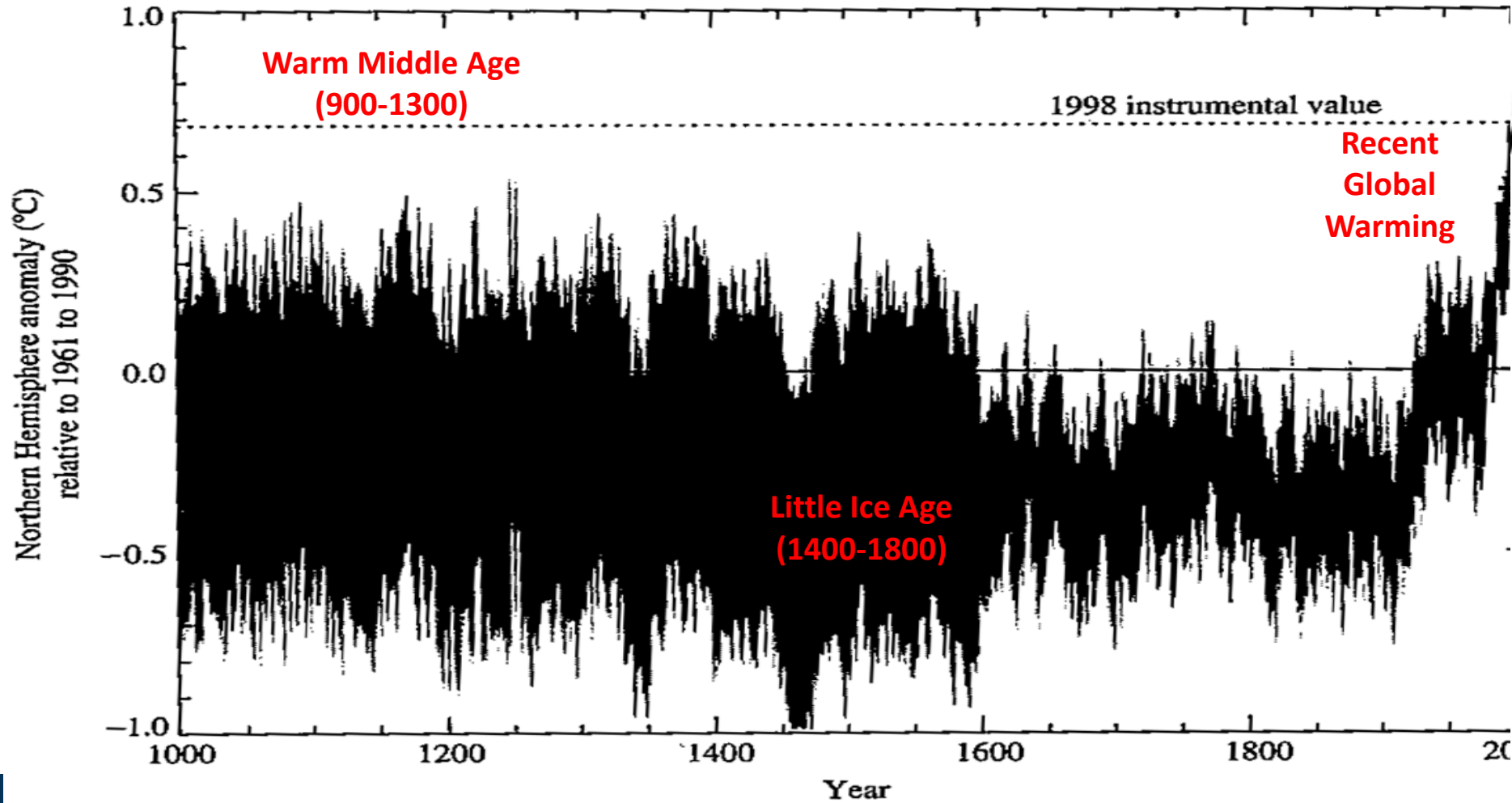
● Little Ice Age (1400-1800)

After?



Impacts of Climate Change in the FUTURE

● Based on Climate Change Projections from Global Climate Models



Climate Change Projections From Most GCMs

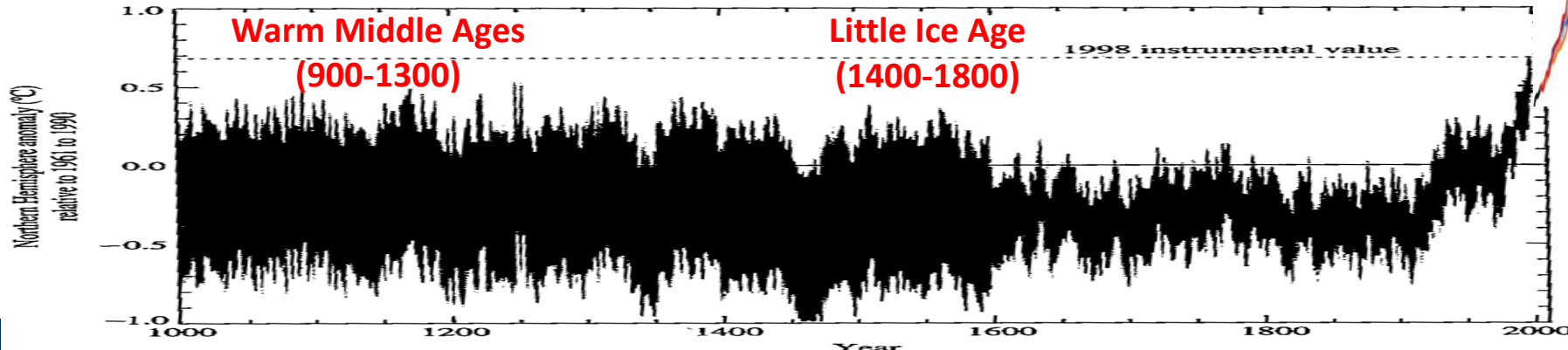
Impacts of Climate Change **in the FUTURE**

Based on Climate Change Projections from Global Climate Models

Now~~ It is getting interesting~!!!

Uncertainty matters!

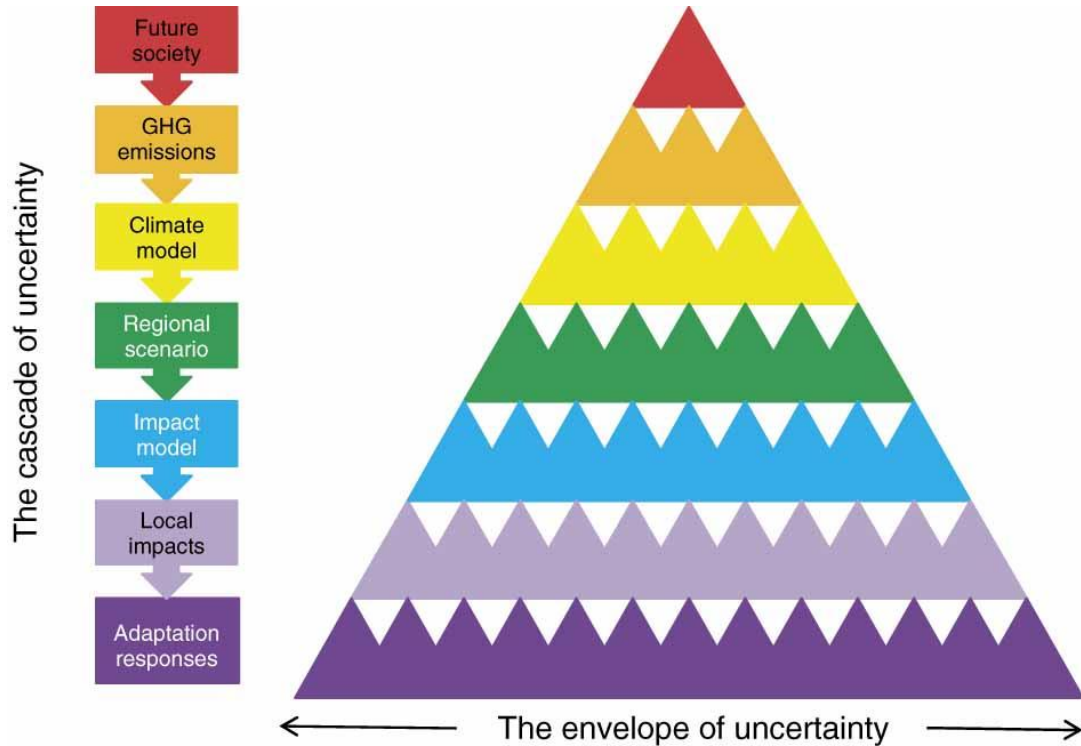
- Multiple scenarios
- Multiple GCMs
- Multiple ensemble members



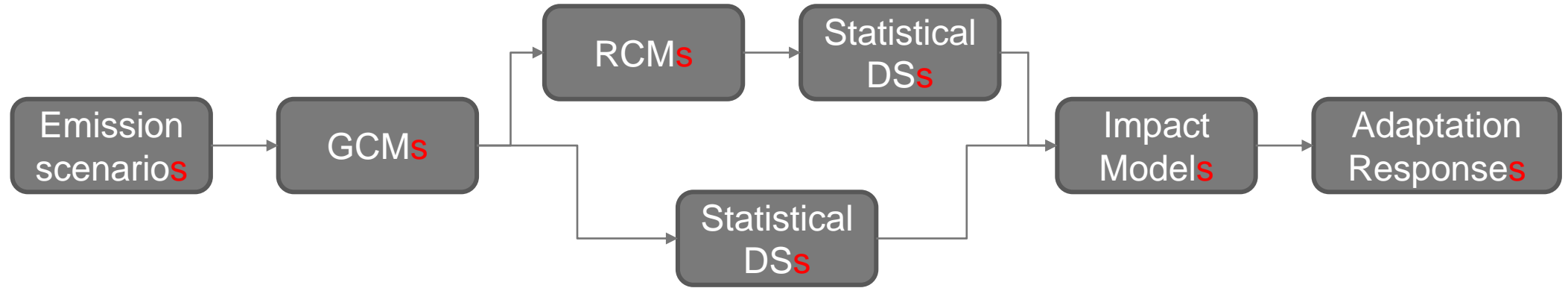
Climate Change Impact Assessment – in relation to uncertainty

Top-down approach

Bottom-up approach (adaptation)



Top-down approach



Heat stress
2080-2099

High

Mid-high

Medium

Low

Low

Rainfall-Runoffs
2080-2099

Low

Mid-high

High

Medium

Low

Water supply
2080-2099

Low

High

High

Low

Low

Crop yield
2040-2050

Medium

High

Medium

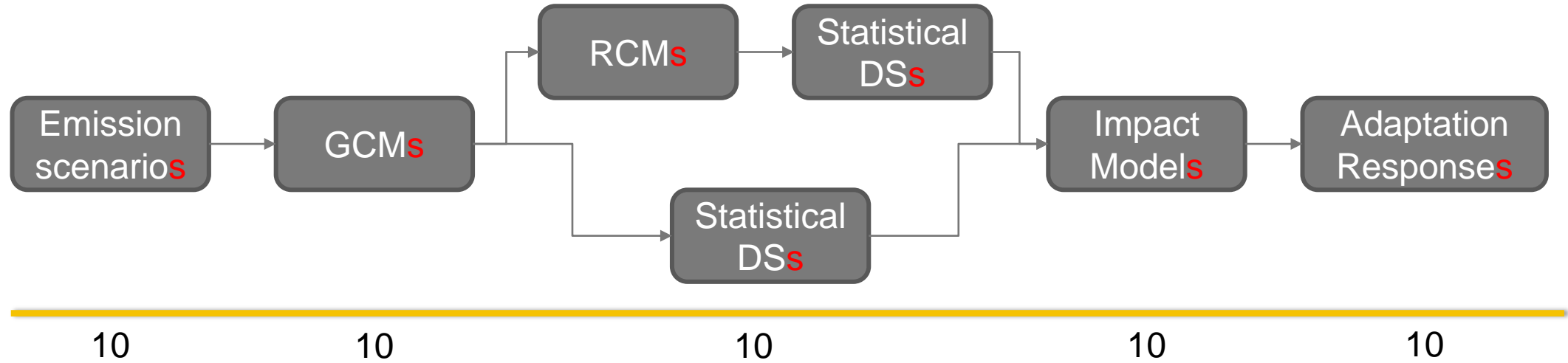
High

Medium

Why 's' ? → No Best Option → Multiple Possibilities → Uncertainty

(Ekstrom et al. 2016; Rosenzweig et al. 2013)

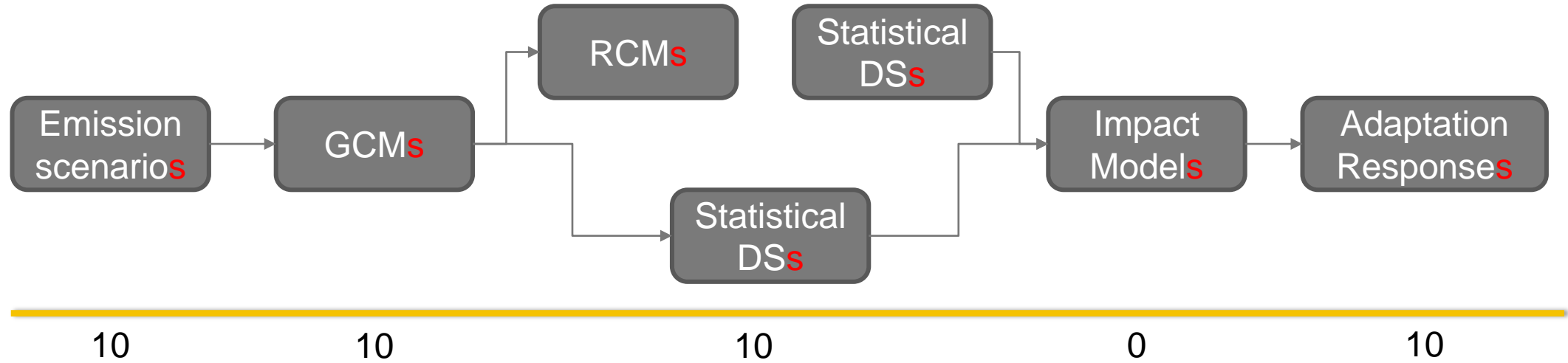
Top-down approach



I am growing a wheat.
Whether my climate resiliency in 2050s can be assured?



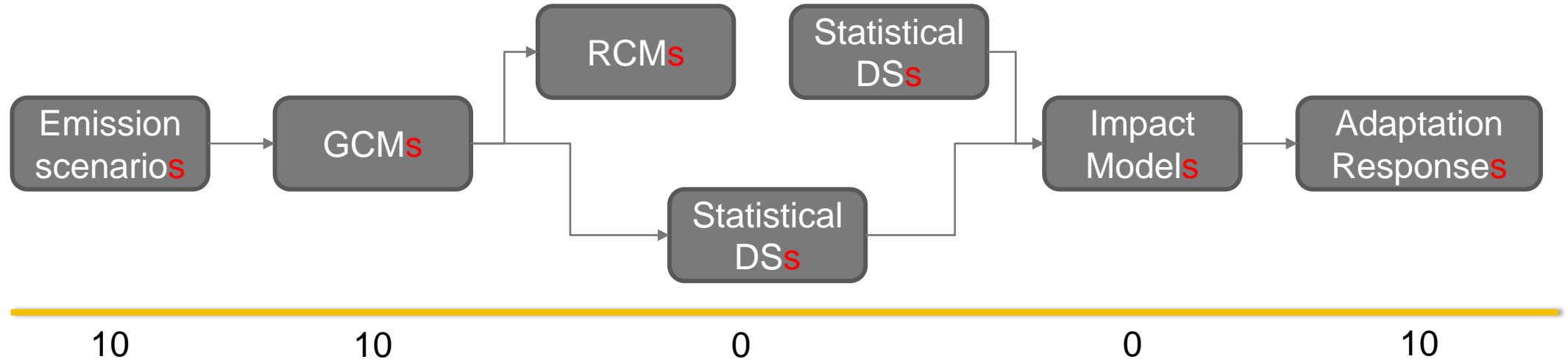
Top-down approach



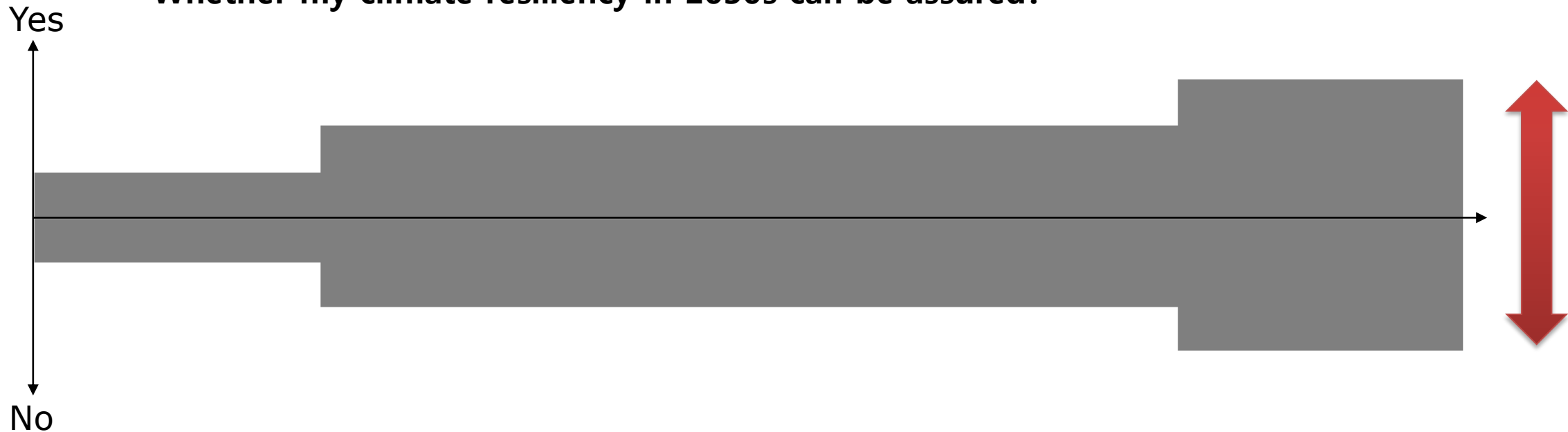
I am growing a wheat.
Whether my climate resiliency in 2050s can be assured?



Top-down approach



I am growing a wheat.
Whether my climate resiliency in 2050s can be assured?



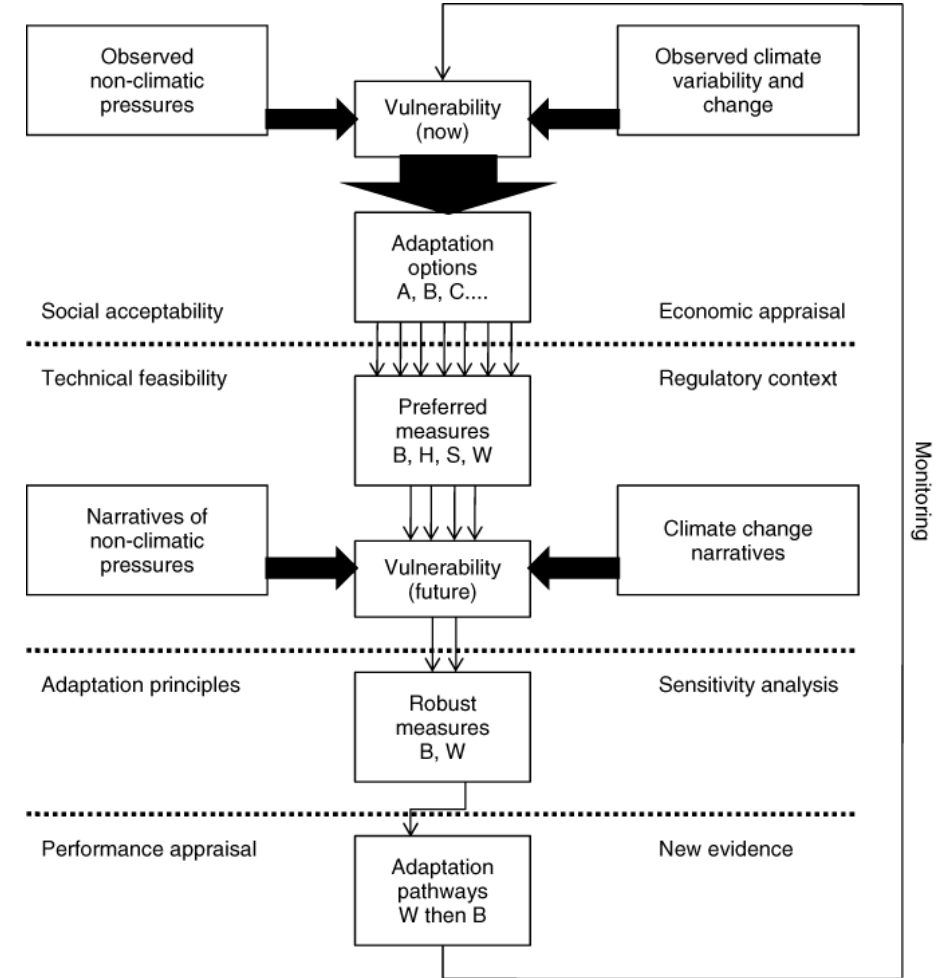


Bottom-up approach

Top-down approach

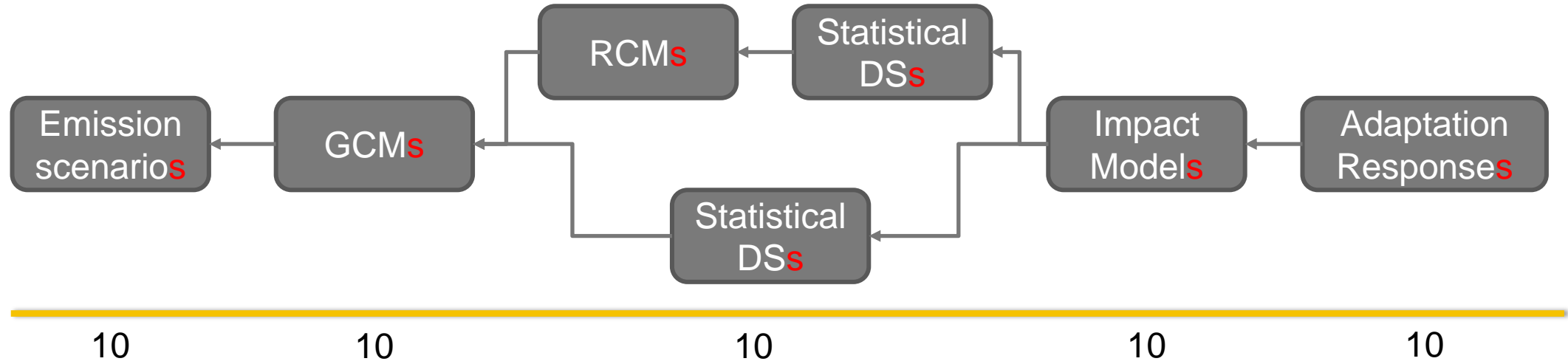


Bottom-up approach (adaptation)



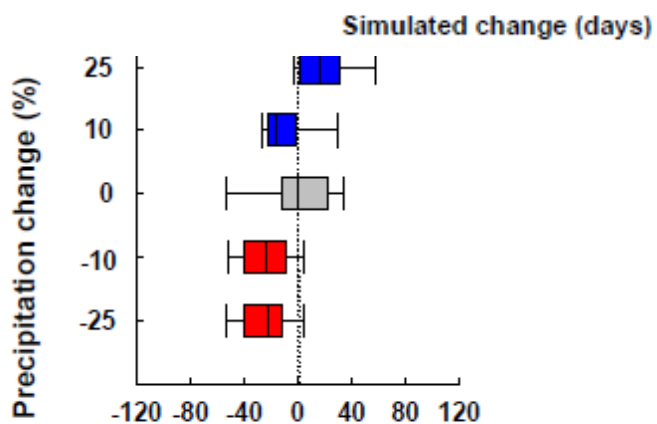
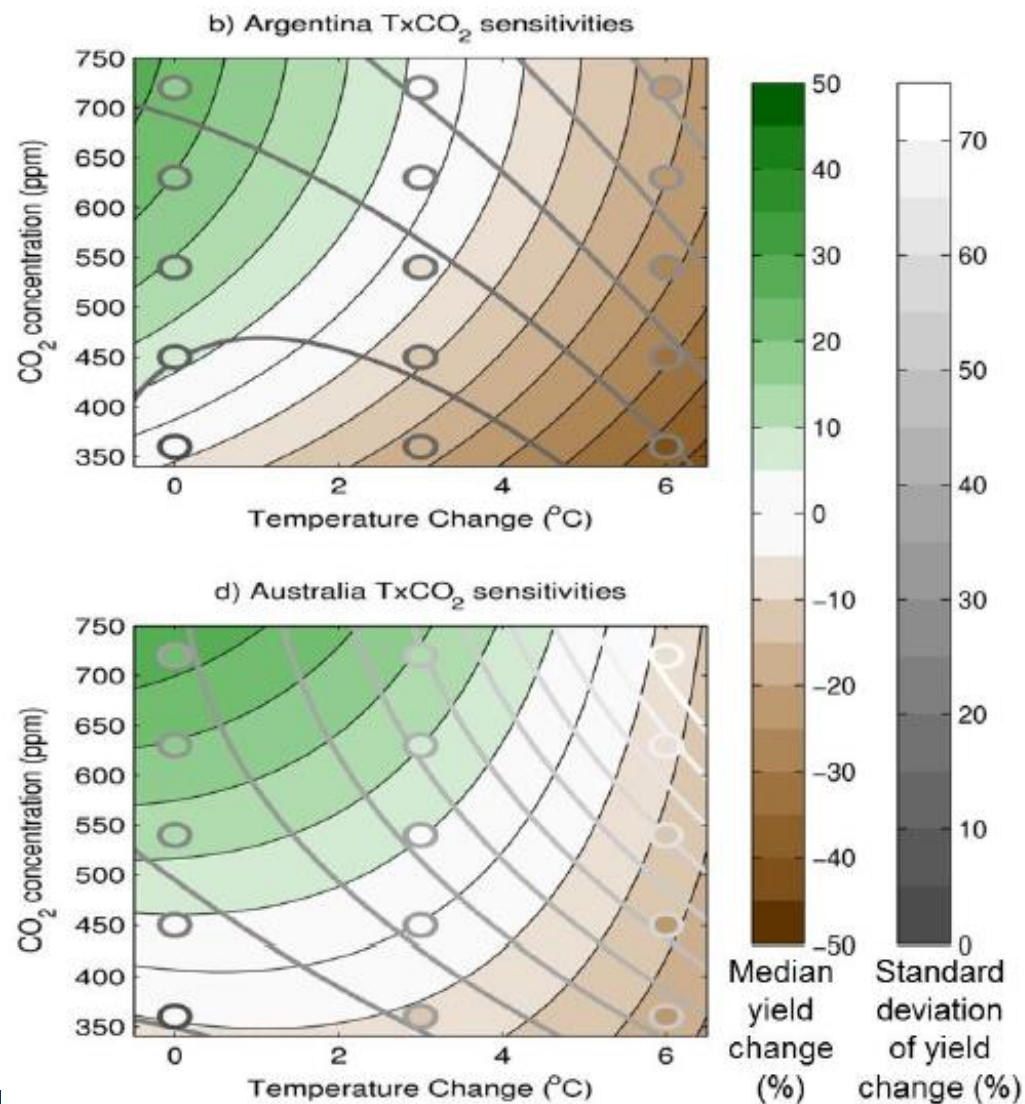
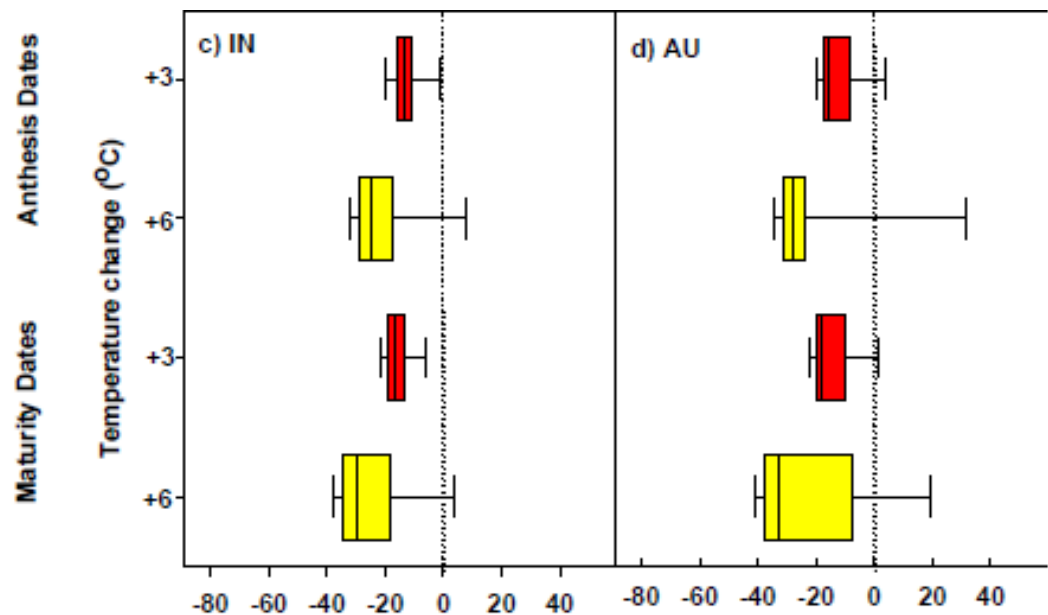
Review options that make sense today and are likely to be beneficial in the future, whatever the climate outlook!

Bottom-up approach



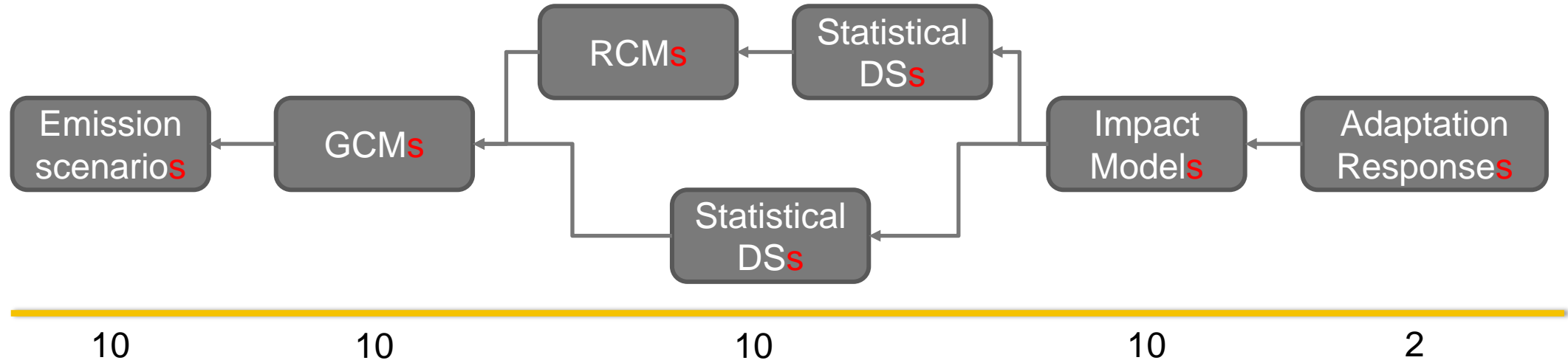
Bottom-up approach (examples)

Asseng et al. (2013), Wilby and Dessai (2010)



Simulated relative change in yield (%)

Bottom-up approach



Yes

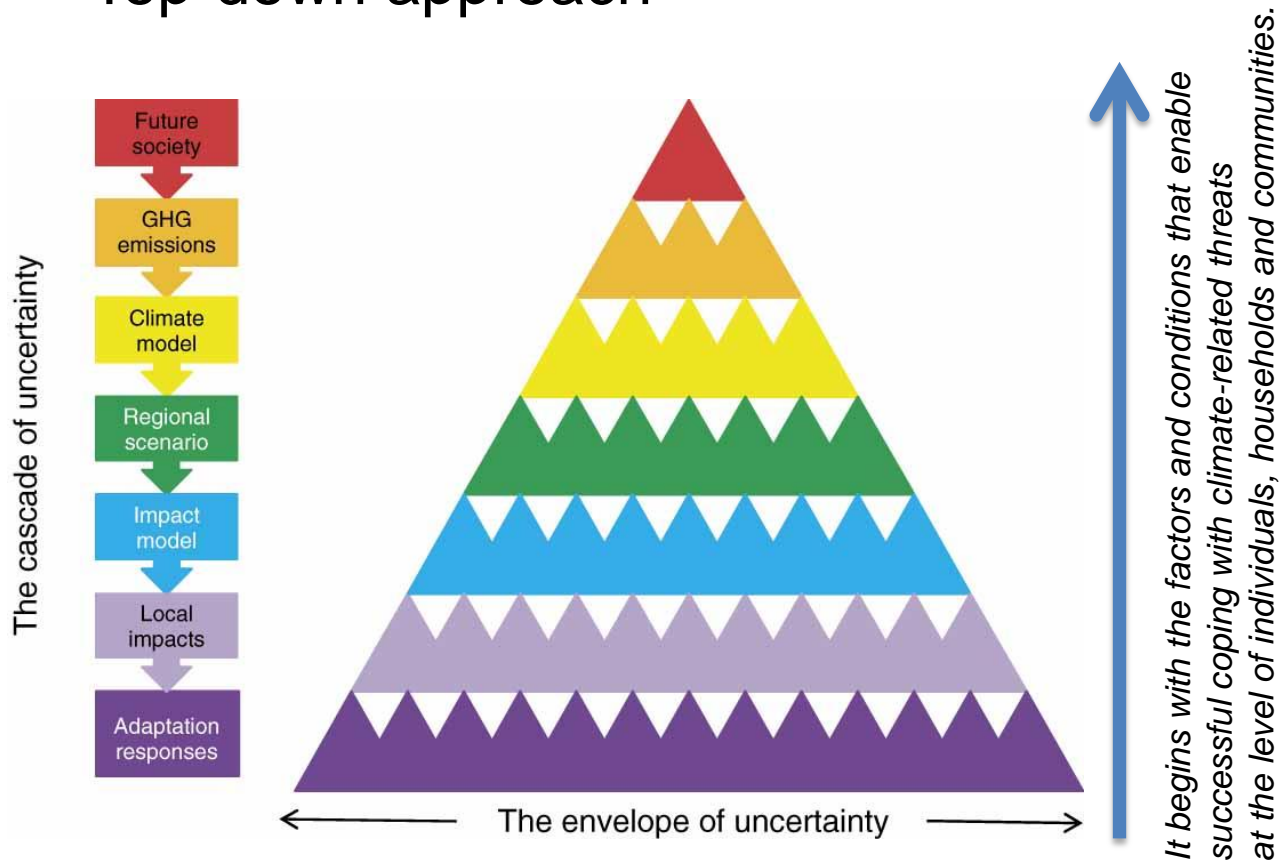
Robust adaptation measures

- low regret
- employ 'soft' solutions
- flexible and mindful of actions being taken by others to adapt to climate change

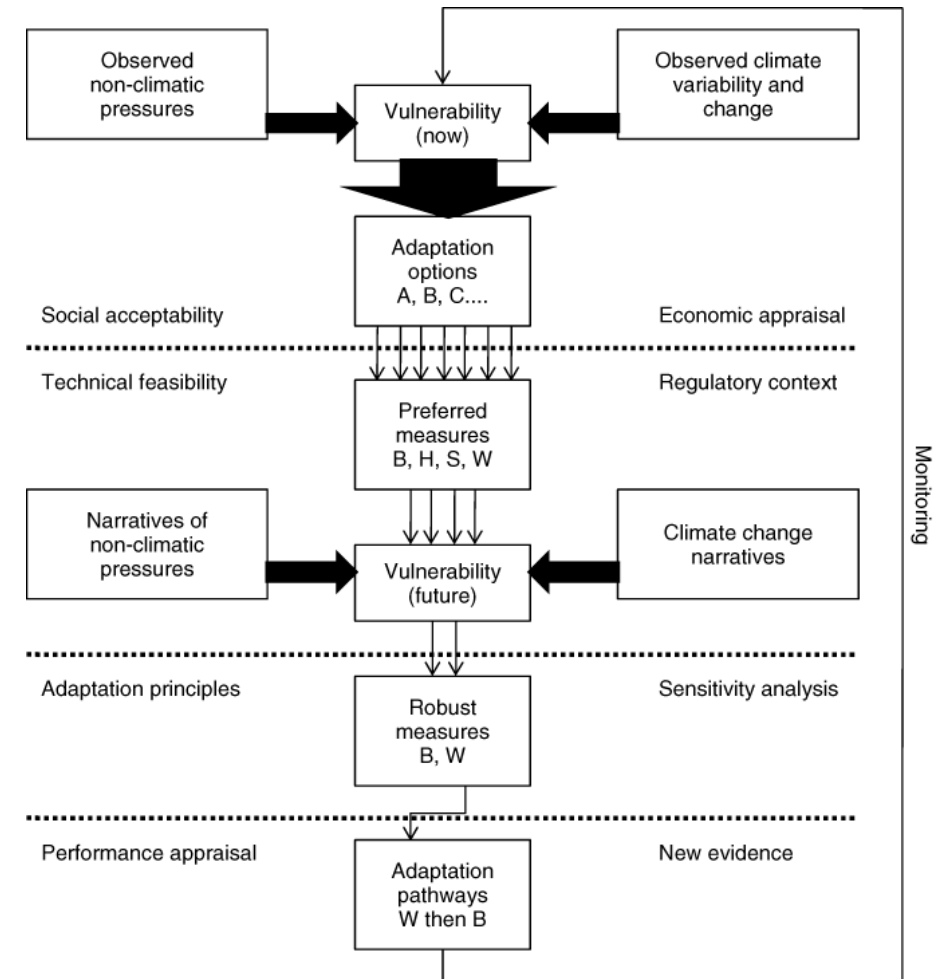
No

Climate Change Impact Assessment – in relation to uncertainty

Top-down approach



Bottom-up approach (adaptation)



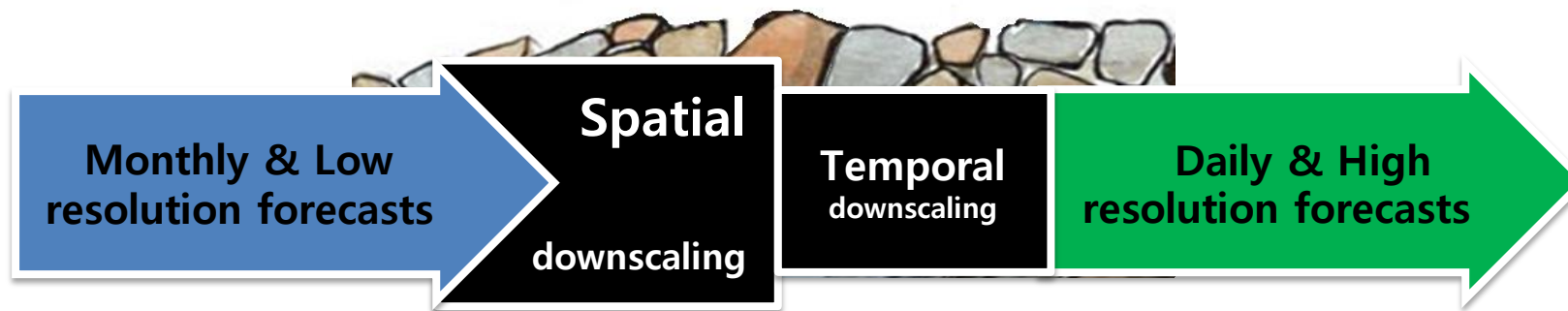
Translating climate information to agricultural information

Climate Information (Climate models)

- Global scale, low spatial resolution (2.5° x 2.5°)
- Monthly scale, low temporal resolution
- temperature, precipitation (seasonal forecast)

Agricultural Information (Agro-models)

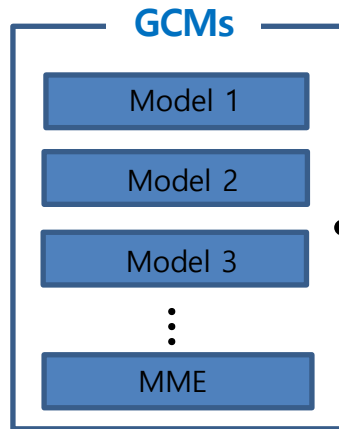
- Field scale, high spatial resolution (=paddy field, individual farms)
- Daily or hourly scale, high temporal resolution
- temp., prec., relative humidity, solar radiation...



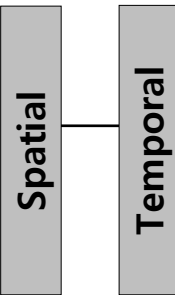
Translating climate information to agricultural information

Climate Information (Climate models)

Climate Change Projection



Downscaling
Bias Correction



Agricultural Information (Agro-models)

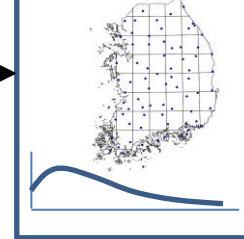
Impact and Adaptation Assessment

Agro-Modeling

Crop
Disease
Pest
Phenology
Livestock

Simulations

Yield/Risk
Changes



Understanding
plausible impacts

Adaptation
to
Climate Variability
Climate Change



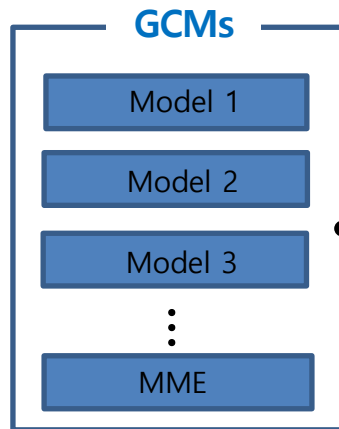
Various methods of combining multi-model climate change scenarios

- **Multi-Model Ensemble - Averaging**
 - Kim and Cho, 2016
- **Multi-Model Ensemble - Weighting**
 - Stocker et al., 2010
- **Principle or better performing model group**
 - **Subset of models selected**
 - Lee and Kim, 2017
- **Worst model(s) removal**
 - **Subset of models left**
 - Cho et al., 2018
- **A best model selection**
 - Lee, 2013; Lee and Kim, 2018

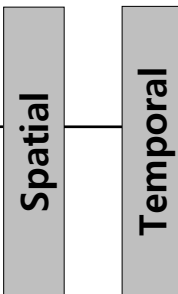
Translating climate information to agricultural information

Climate Information (Climate models)

Climate Change Projection



Downscaling
Bias Correction



Agricultural Information (Agro-models)

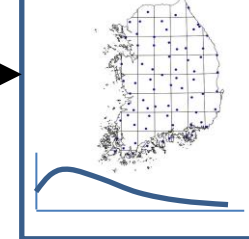
Impact and Adaptation Assessment

Agro-
Modeling

Crop
Disease
Pest
Phenology
Livestock

Simulations

Yield/Risk
Changes



Understanding
plausible impacts

Adaptation
to
Climate Variability
Climate Change



Selection of appropriate downscaling methods

General guidelines:

- Whether the methods have capability to capture the full plausible range of change of interest
- Whether the methods make sure that key uncertainties are considered in a final assessment that could be used to guide policy development

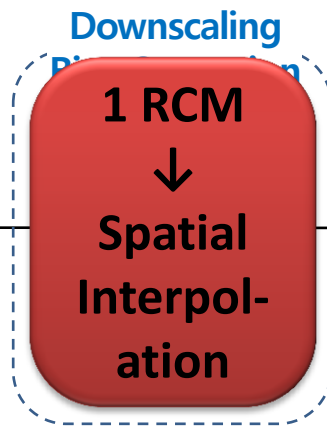
Application specific guidelines:

- Appropriateness of the dataset relative to simulating change for the far or near future
- Is there marked topography in the region or otherwise high contrast in the land-surface environment
- Is temporal sequencing or extremes important to the application
- Is daily spatially coherent information needed
- How well is multiple emission scenarios and GCMs sampled

CASE 1: Predicting potential epidemics of crop diseases

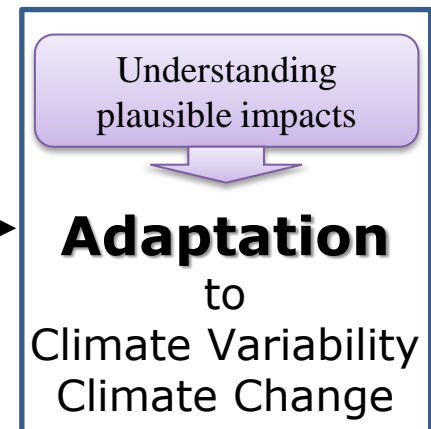
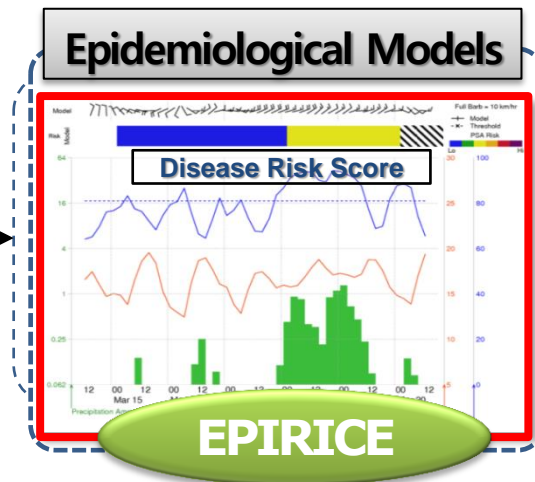
Climate Information (Climate models)

Climate Change Projection



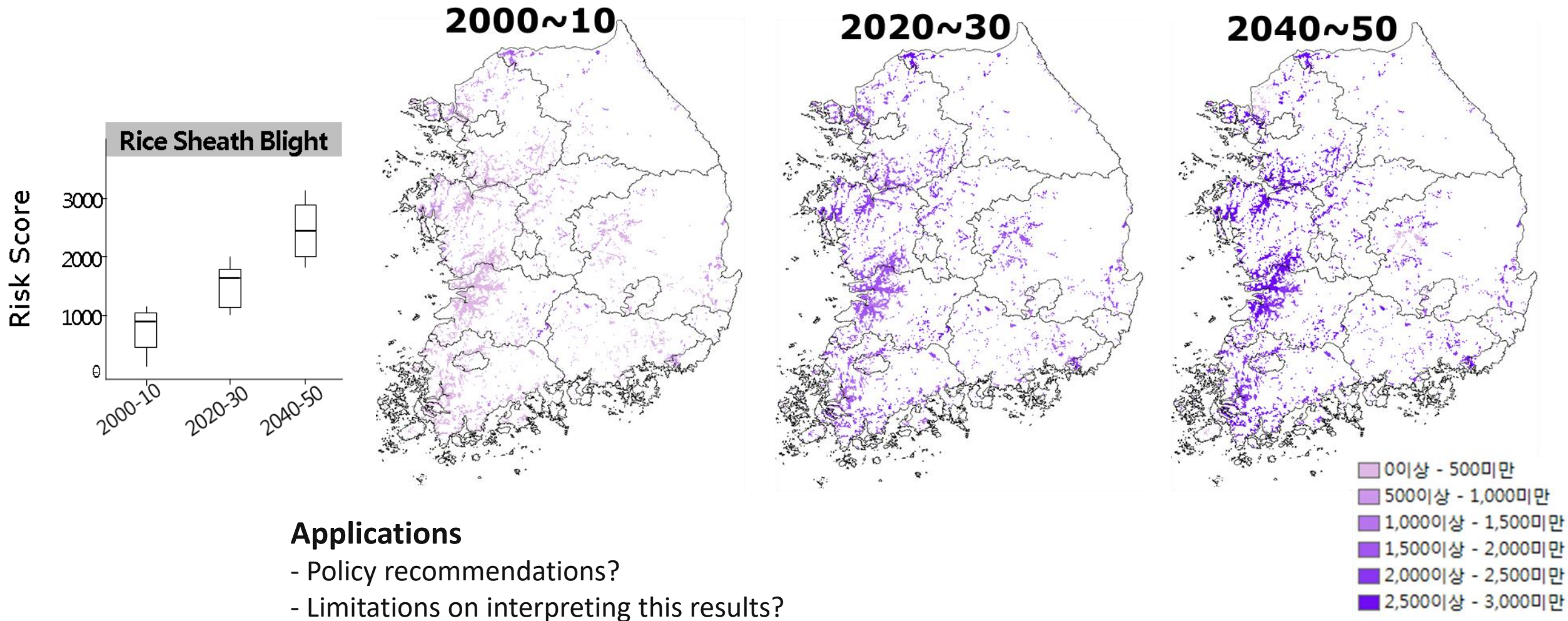
Agricultural Information (Agro-models)

Impact and Adaptation Assessment



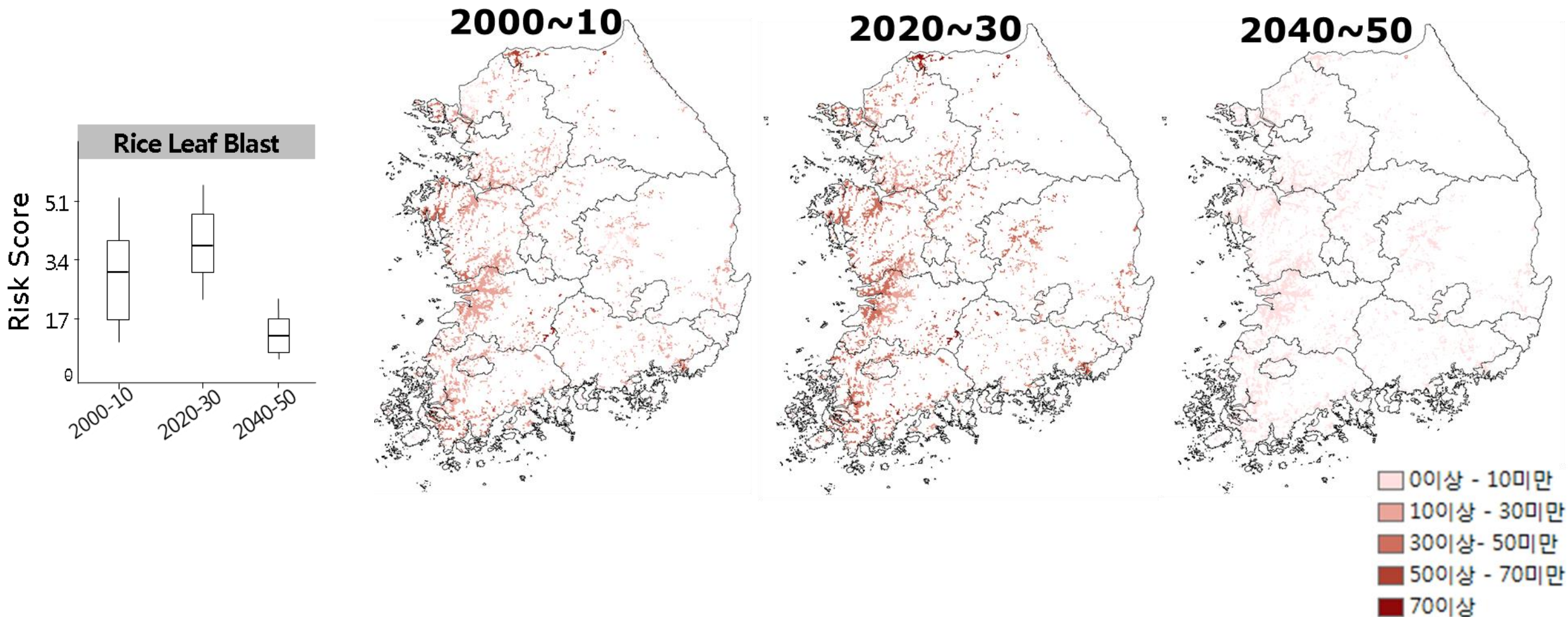
CASE 1: Predicting potential epidemics of crop diseases

Future epidemic risk for rice sheath blight disease



CASE 1: Predicting potential epidemics of crop diseases

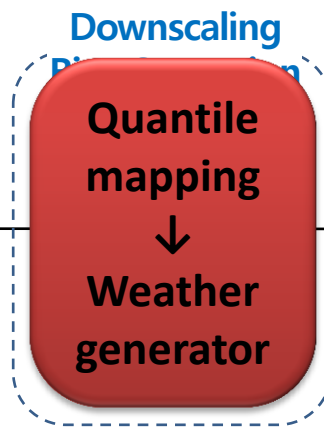
Future epidemic risk for rice leaf blast disease



CASE 2: Predicting potential epidemics of crop diseases

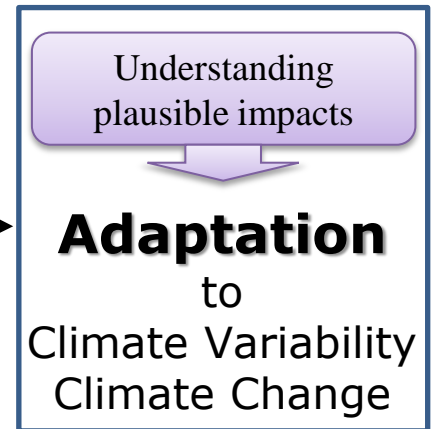
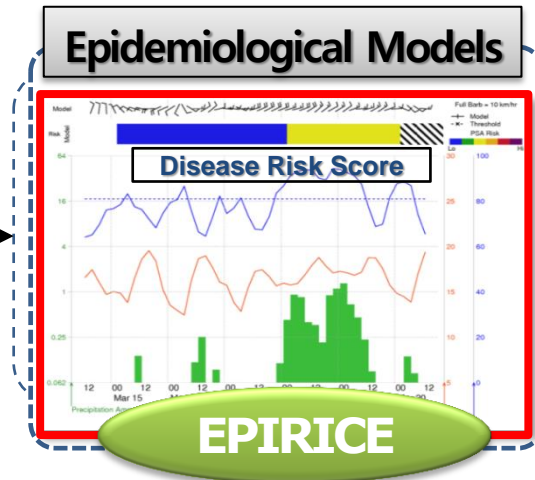
Climate Information (Climate models)

Climate Change Projection



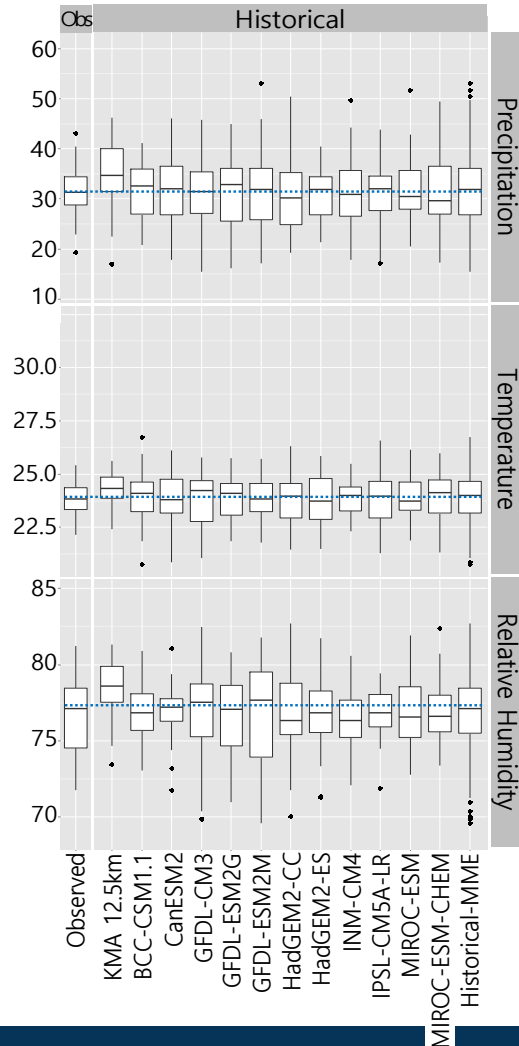
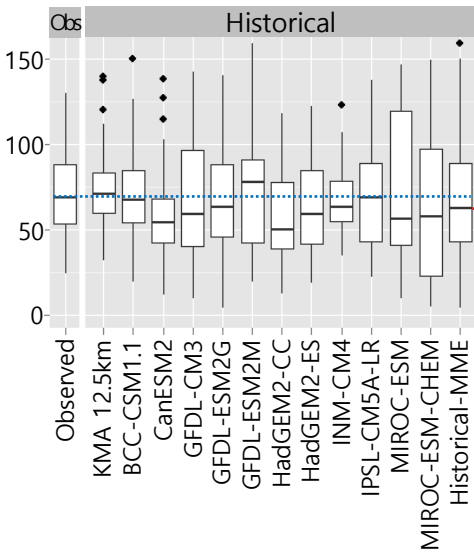
Agricultural Information (Agro-models)

Impact and Adaptation Assessment



CASE 2: Predicting potential epidemics of crop diseases

Future epidemic risk for rice leaf blast in the Southern Area of Korea



Based on EPIRICE model infection algorithms:

- (1) Mean temperature;
- (2) Mean relative humidity;
- (3) Daily frequency of precipitation over 1 mm

for the 100-day EPIRICE simulation period were extracted

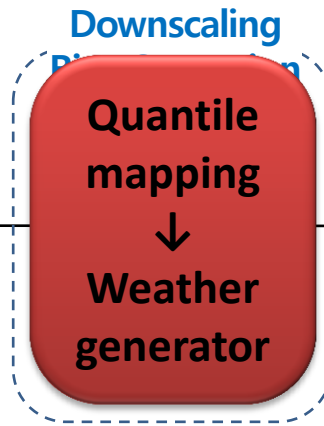
Applications

- Higher explanation power for the disease risk among variables
- Selection of best GCMs based on reproducibility for each weather variable, or model simulation results?
- Limitation of the applied bias-correction method

CASE 3: Predicting potential epidemics of crop diseases

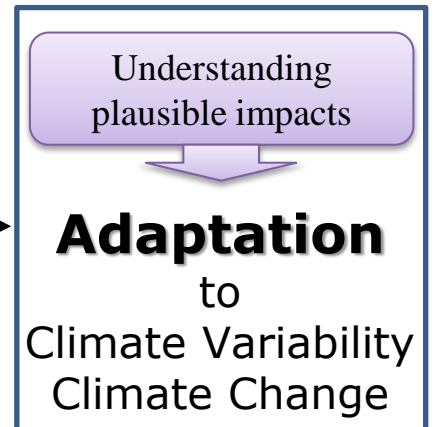
Climate Information (Climate models)

Climate Change Projection



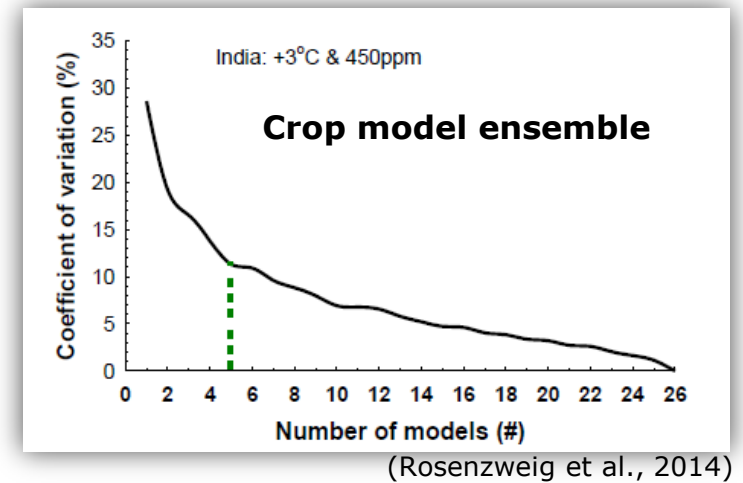
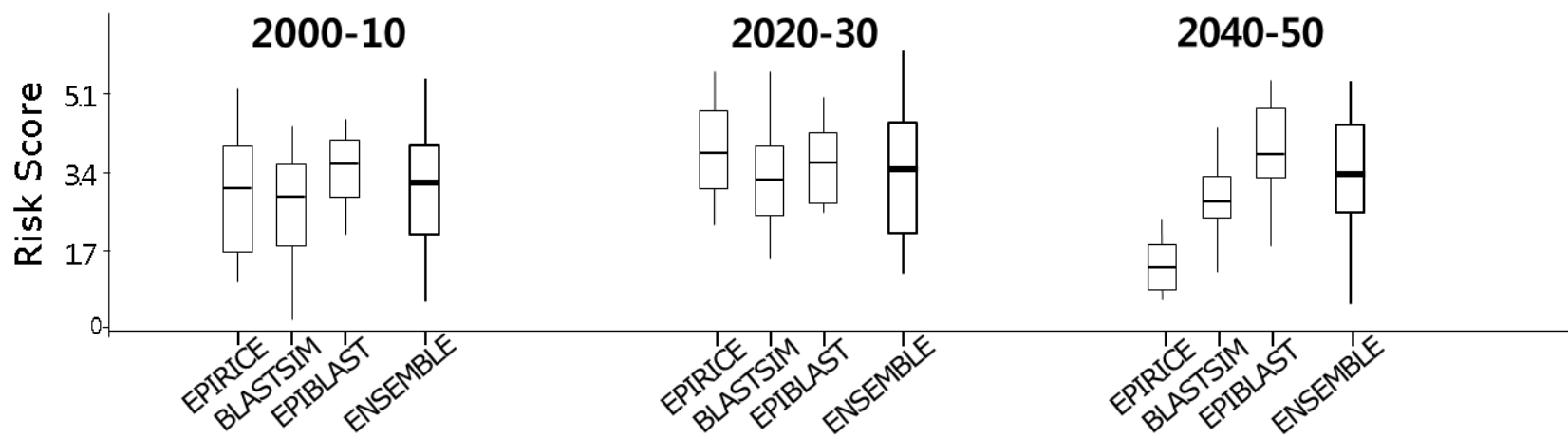
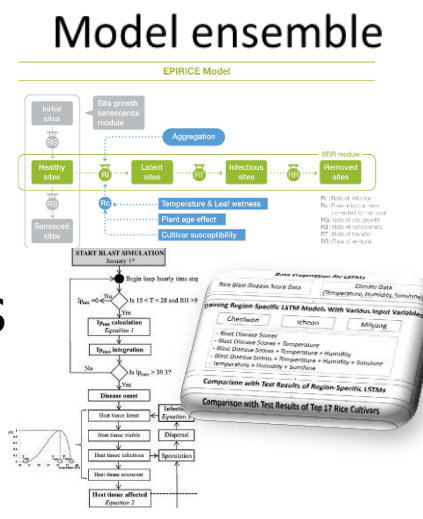
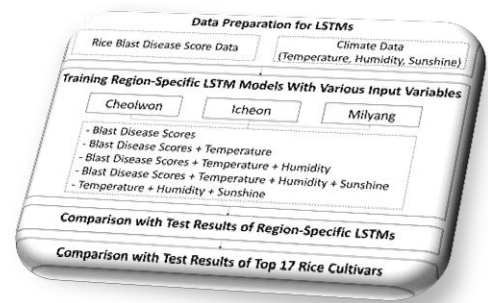
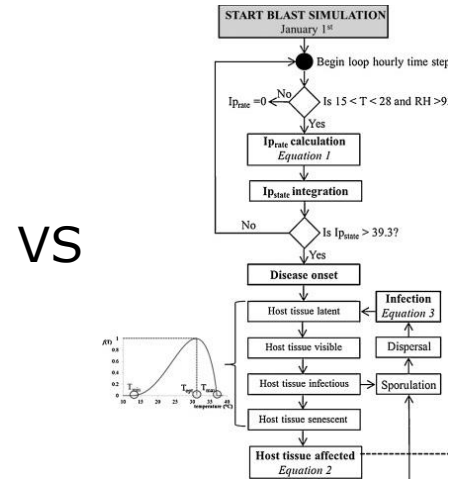
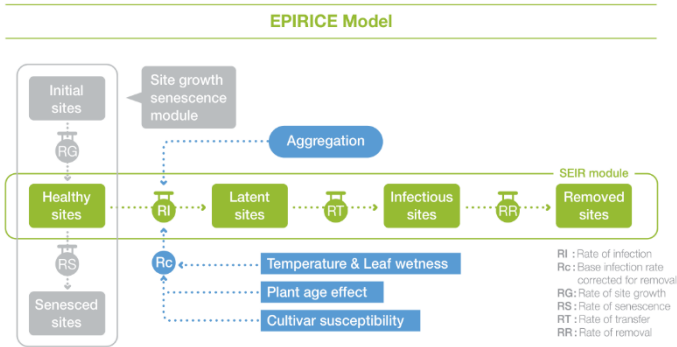
Agricultural Information (Agro-models)

Impact and Adaptation Assessment



CASE 3: Predicting potential epidemics of crop diseases

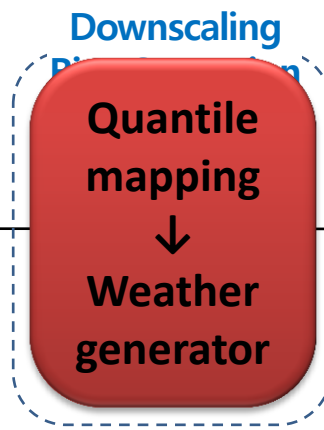
Future epidemic risk for rice leaf blast in Korea



CASE 4: Predicting potential yield losses due to crop diseases

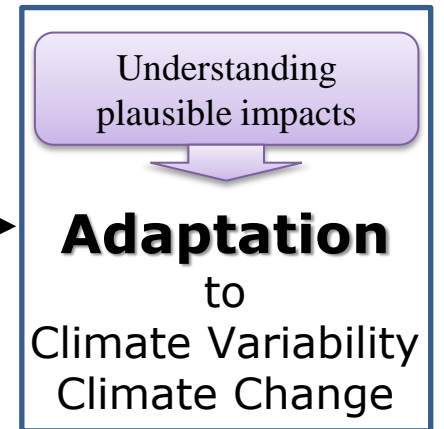
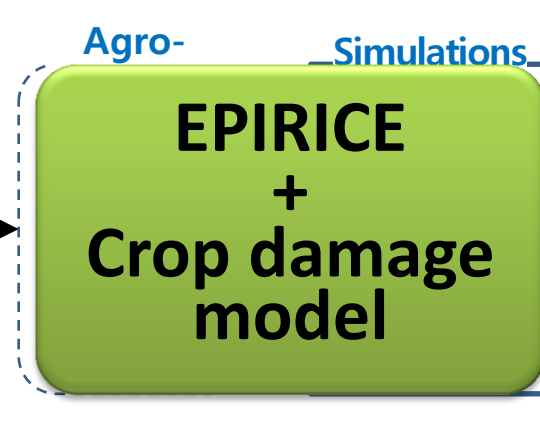
Climate Information (Climate models)

Climate Change Projection



Agricultural Information (Agro-models)

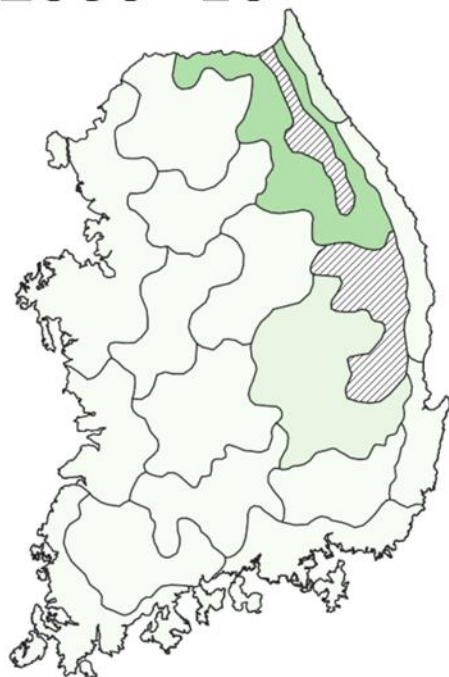
Impact and Adaptation Assessment



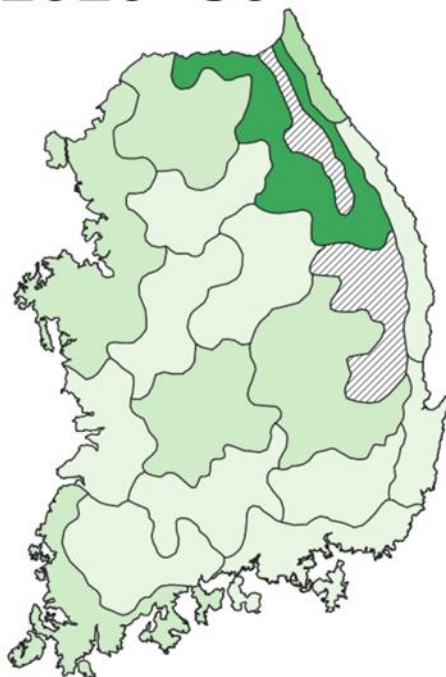
CASE 4: Predicting potential yield losses due to crop diseases

Future yield loss projections due to rice sheath blight disease

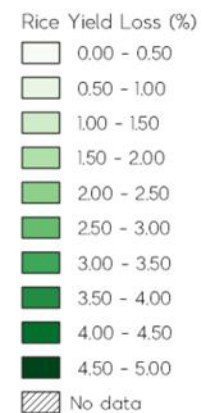
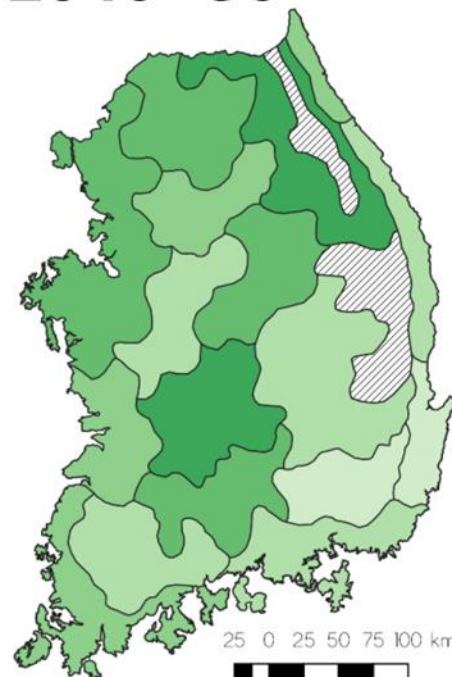
2000~10



2020~30



2040~50

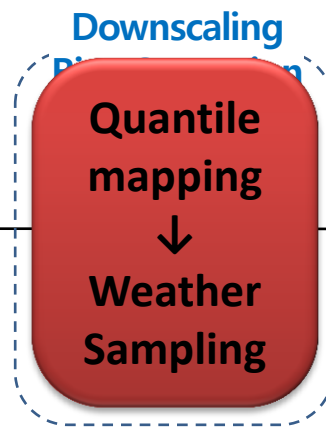


25 0 25 50 75 100 km

CASE 5: Predicting major agro-met indices for plant growth

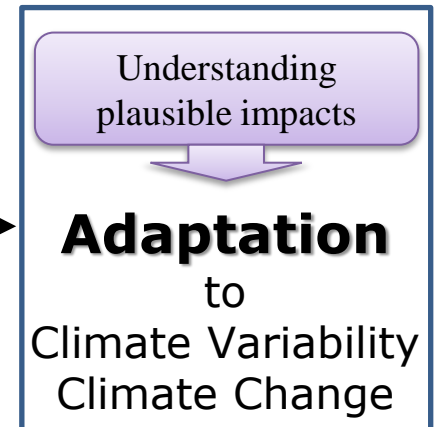
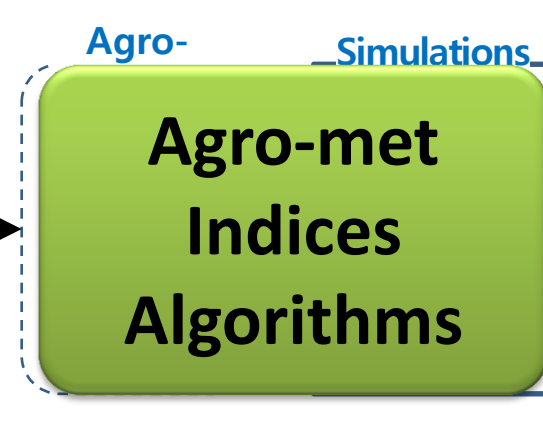
Climate Information (Climate models)

Climate Change Projection



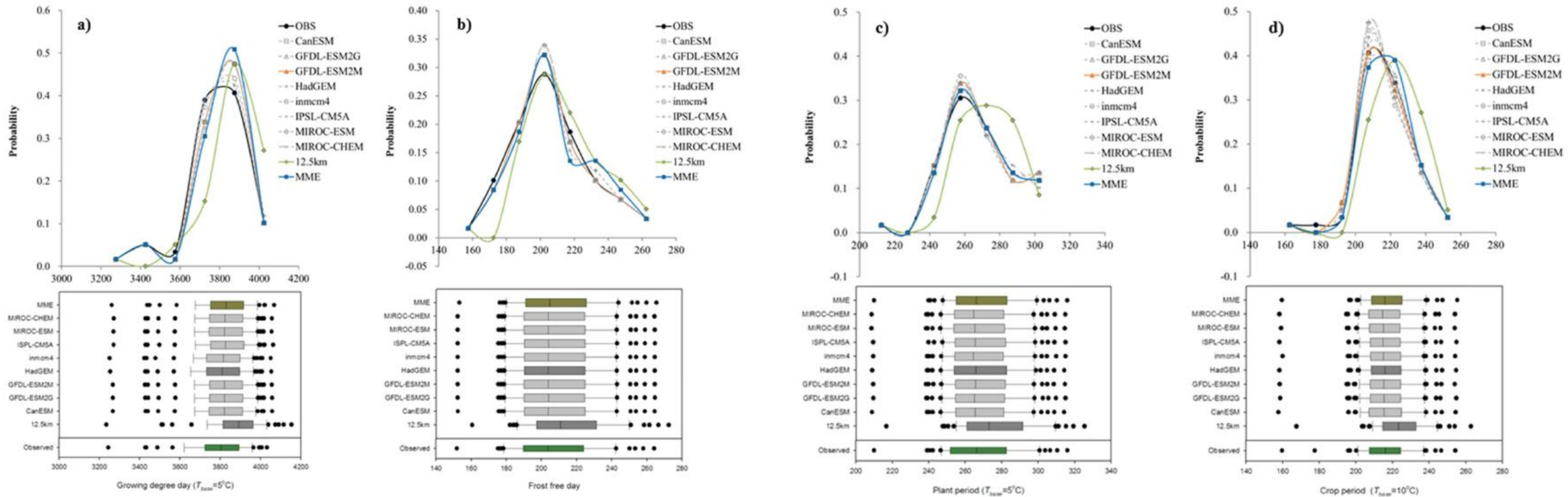
Agricultural Information (Agro-models)

Impact and Adaptation Assessment



CASE 5: Predicting major agro-met indices for plant growth

- PDFs and boxplot of (a)growing degree days (GDD), (b)frost free days, (c)plant period ($T_{base}=5^{\circ}\text{C}$), and (d)crop period ($T_{base}=10^{\circ}\text{C}$)

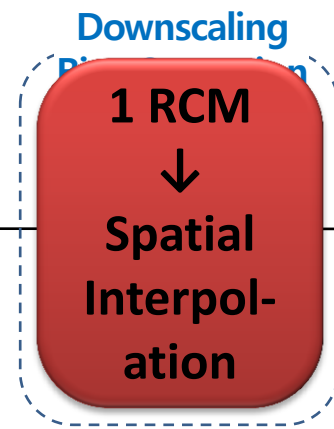


(Chung *et al.*, 2015)

CASE 6: Predicting frost damages of fruit trees

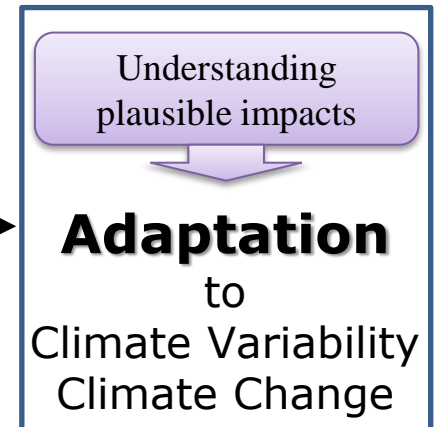
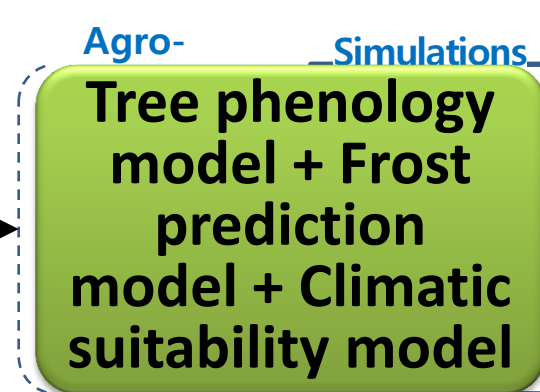
Climate Information (Climate models)

Climate Change Projection



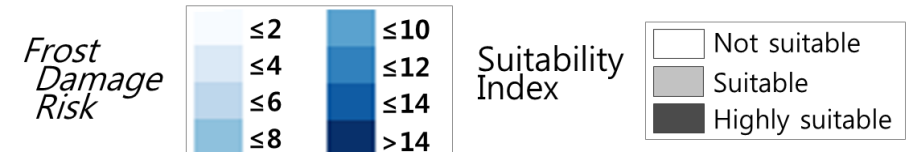
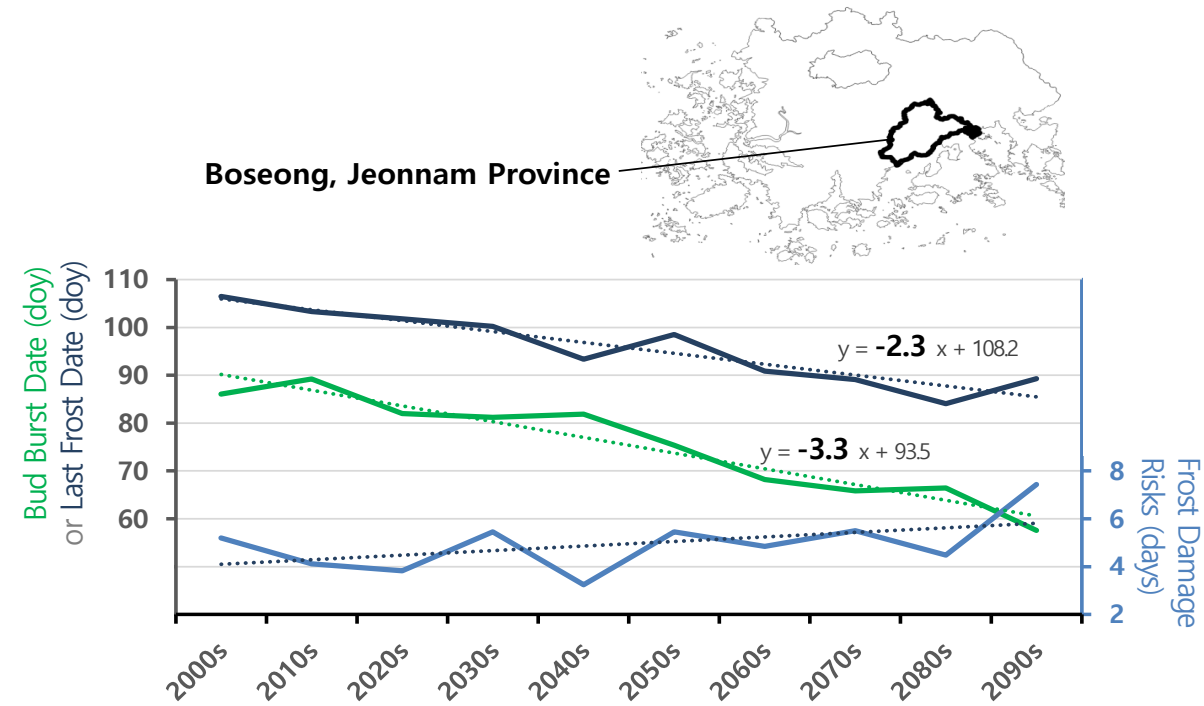
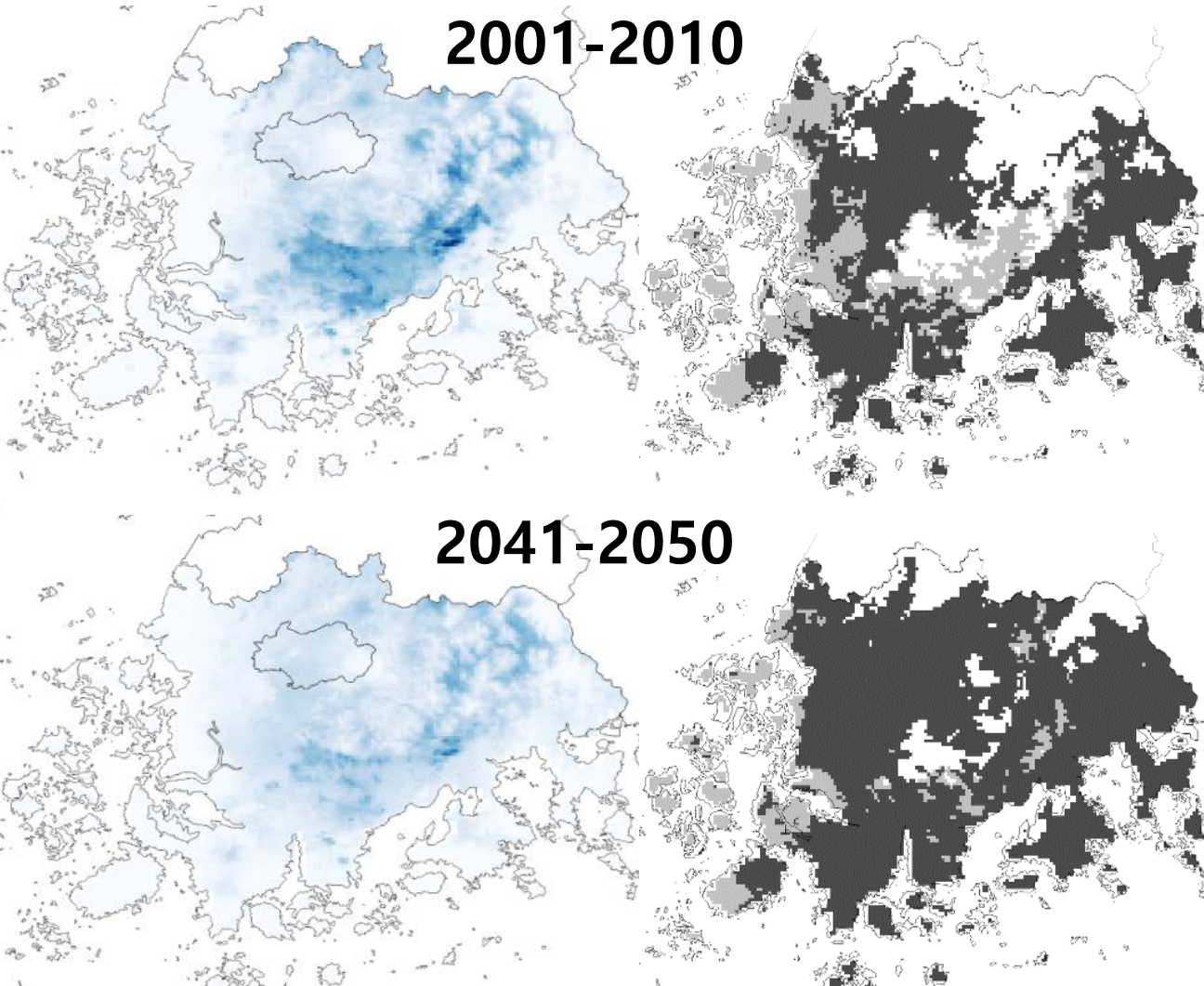
Agricultural Information (Agro-models)

Impact and Adaptation Assessment



CASE 6: Predicting frost damages of fruit trees

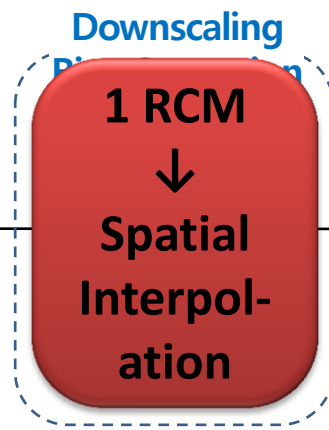
Future frost damage projections on kiwifruit in a province in Korea



CASE 7: Predicting potential disease risks of fruit trees

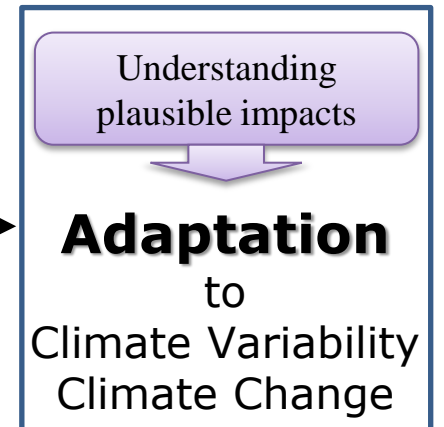
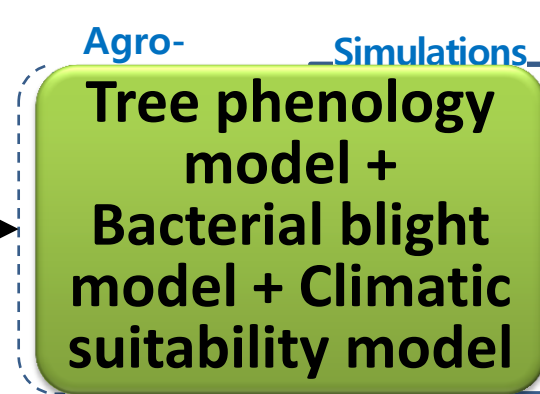
Climate Information (Climate models)

Climate Change Projection



Agricultural Information (Agro-models)

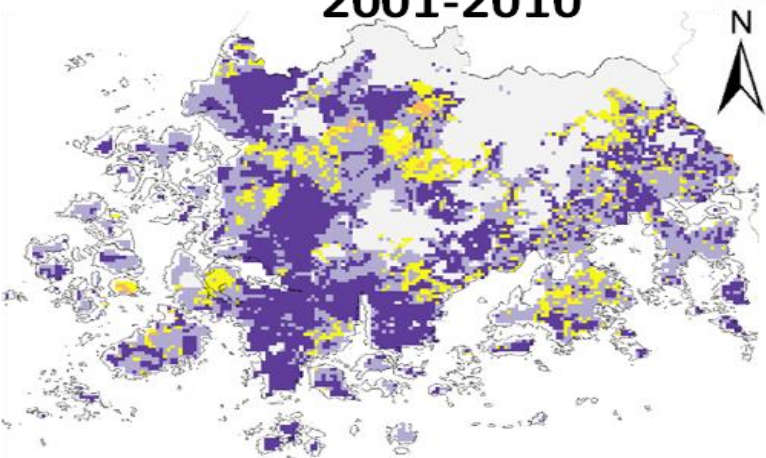
Impact and Adaptation Assessment



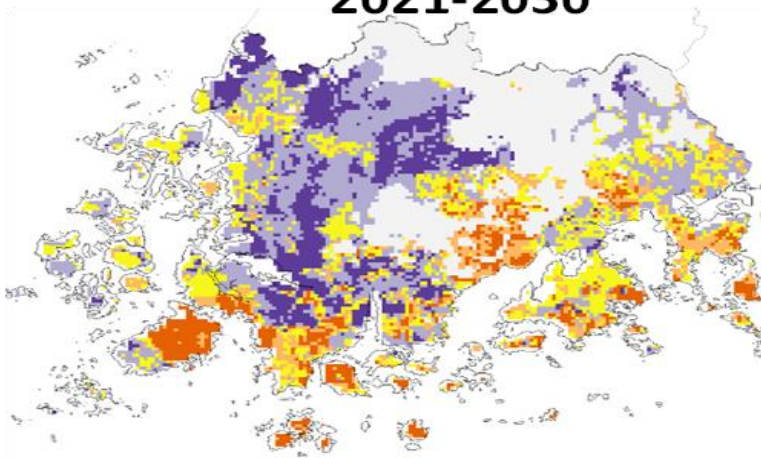
CASE 7: Predicting potential disease risks of fruit trees

Future bacterial blight epidemic risk projections on kiwifruit in a province in Korea

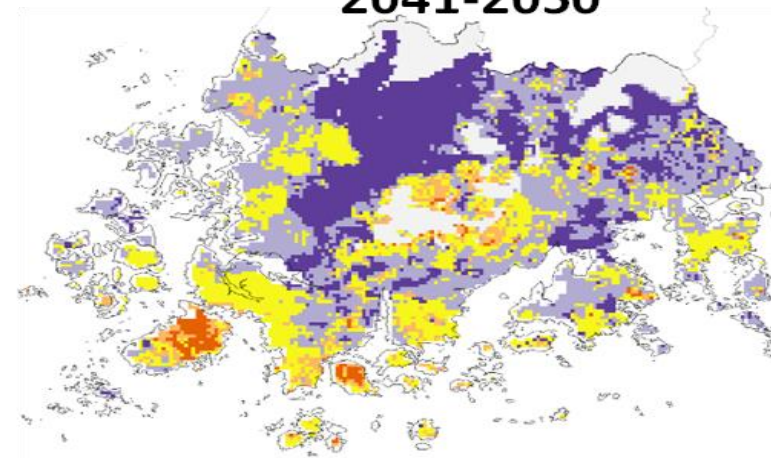
2001-2010



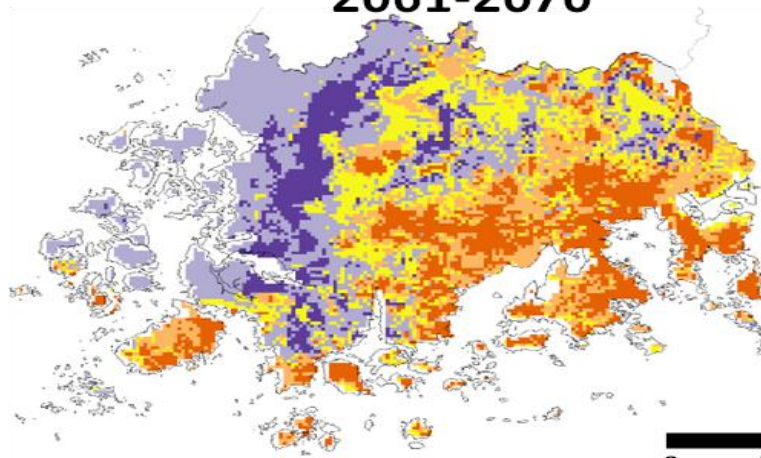
2021-2030



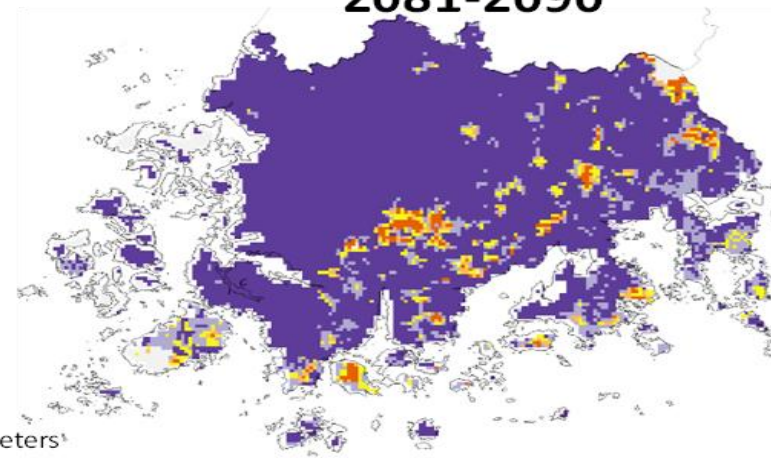
2041-2050



2061-2070

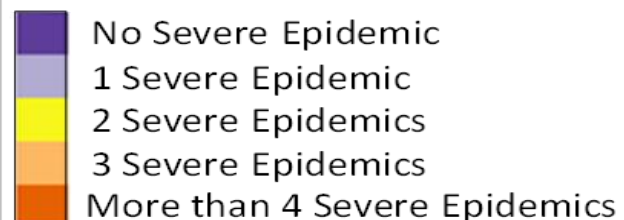


2081-2090



Blossom Blight Severity Index

Over the 10-year-period,

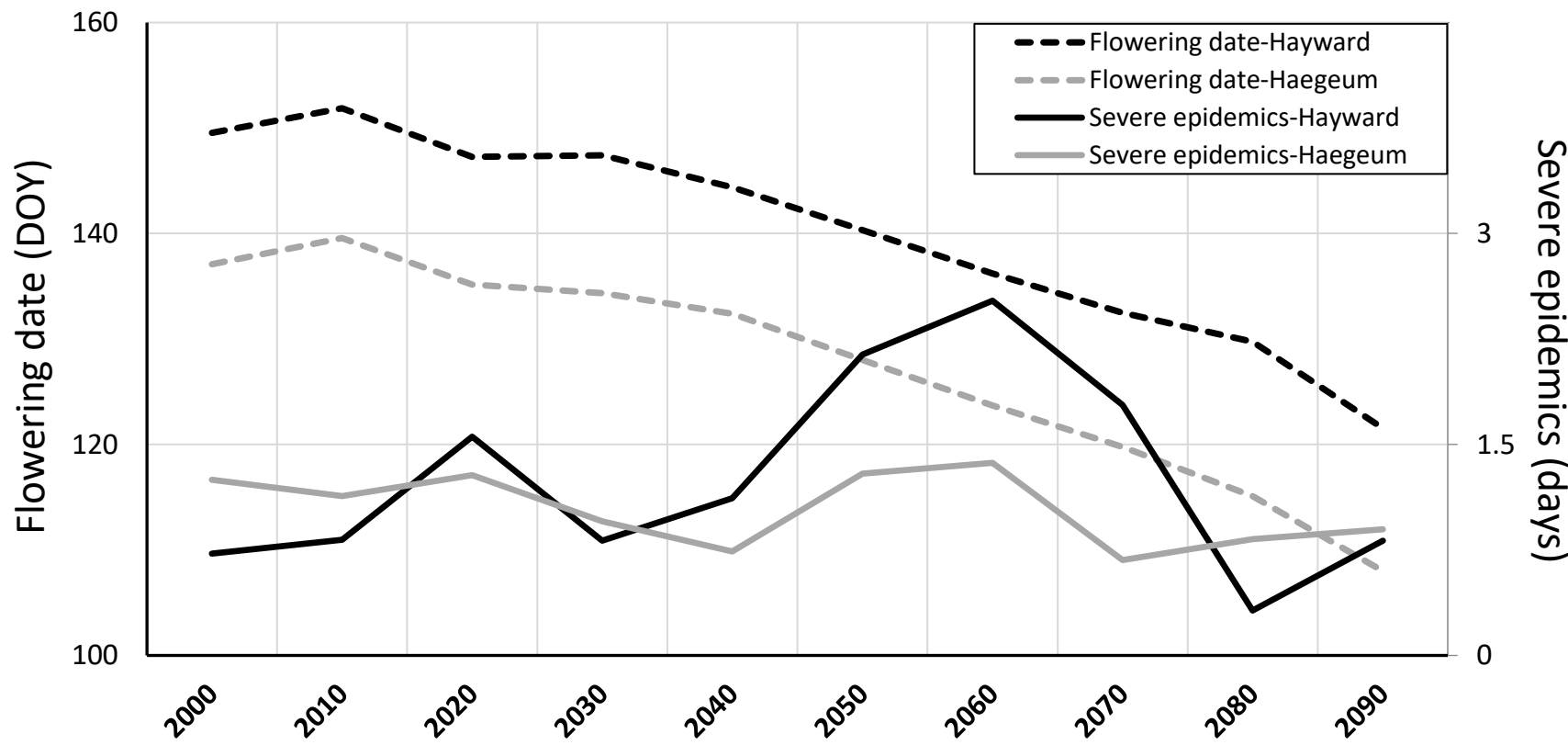


(Kim & Koh, 2016 @ KSPP)

0 30 Kilometers

CASE 7: Predicting potential disease risks of fruit trees

Future bacterial blight epidemic risk projections on kiwifruit in a province in Korea



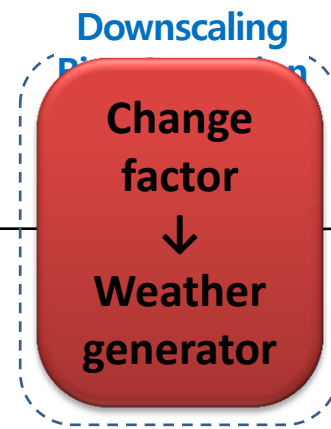
To avoid future disease pressure, different maturity cultivars were examined

Hayward VS Haeguem

CASE 8: Predicting attainable and actual yields of crops

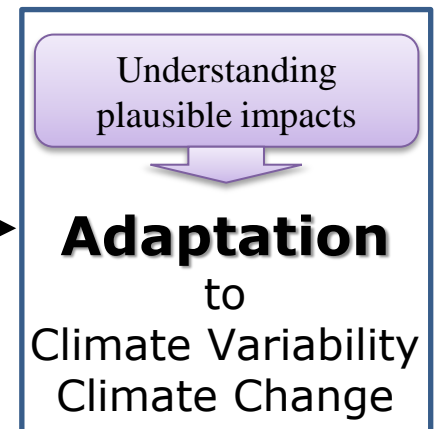
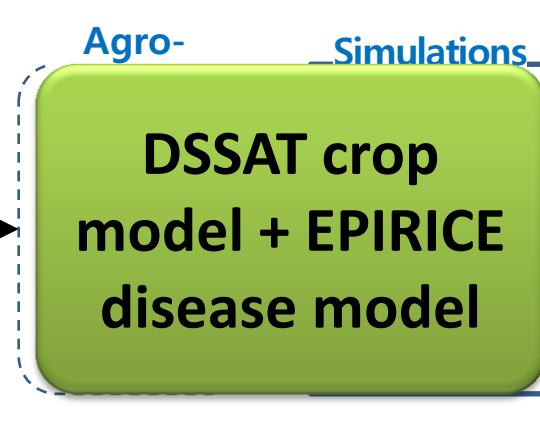
Climate Information (Climate models)

Climate Change Projection



Agricultural Information (Agro-models)

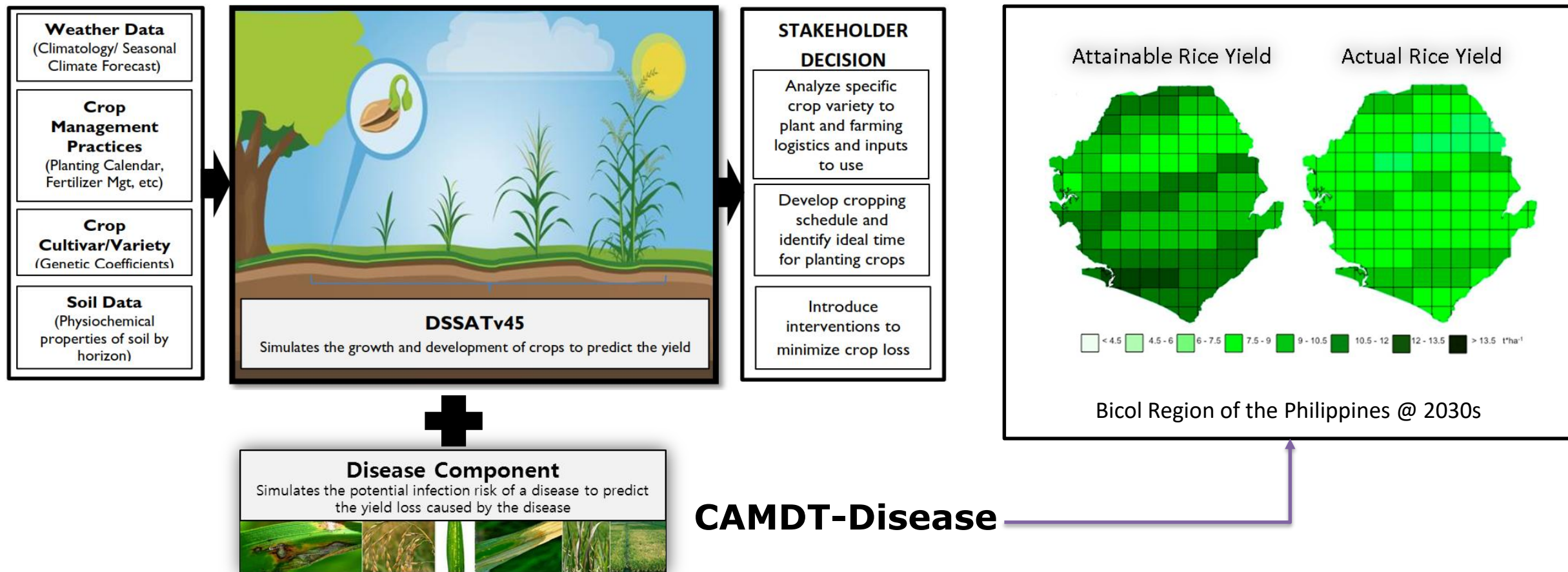
Impact and Adaptation Assessment



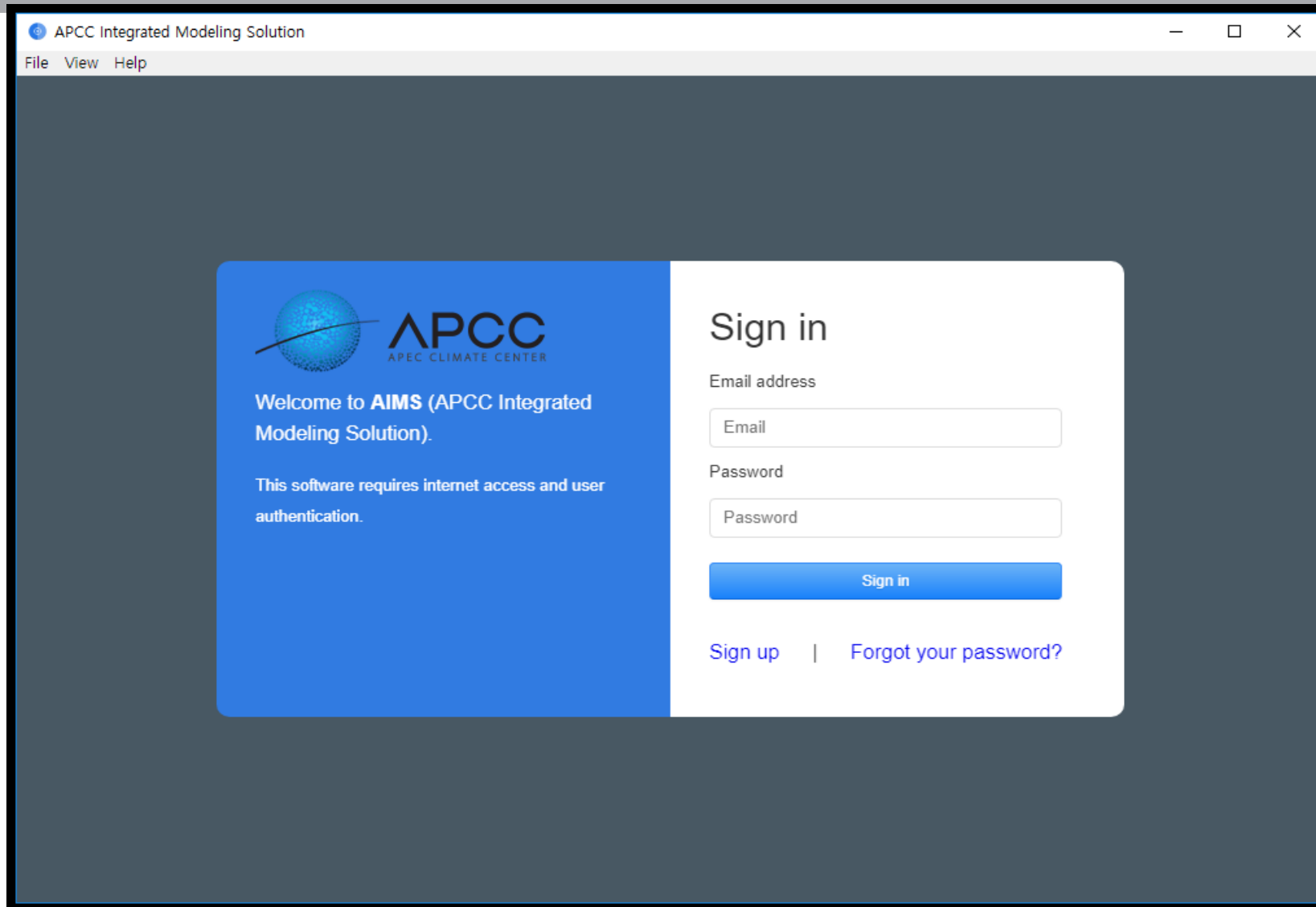
CASE 8: Predicting attainable and actual yields of crops

- Future attainable and actual yields of rice crop due to rice diseases in the Philippines

Climate-Agriculture Model Decision Tools (CAMDT)



Application ready, Local-specific dataset from the APCC Integrated Modeling Solution



Thank-you

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