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Influence of future climate and emissions on air quality in Northeast Asia
: Recent and ongoing studies of Korea

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Outline

1. Background and objectives

2. Ozone and PM air quality in Northeast Asia (NEA) under the recent climate change scenarios

3. Ongoing collaborative works on new NEA climate change scenarios

- Development of new NEA climate change scenarios

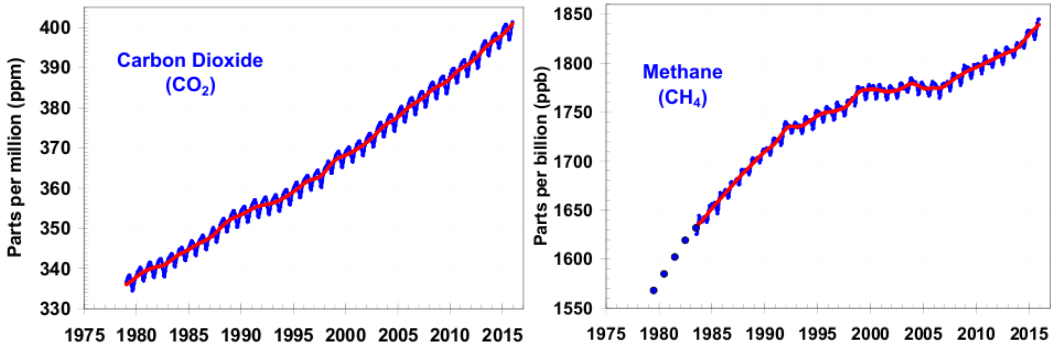
4. Summary

1. Backgrounds and objectives

Human involved emissions → Atmospheric concentrations → Radiative Forcing → Climate change

Green house gases (GHGs) **Change in energy flux (W/m^2)**

(IPCC, 2013)

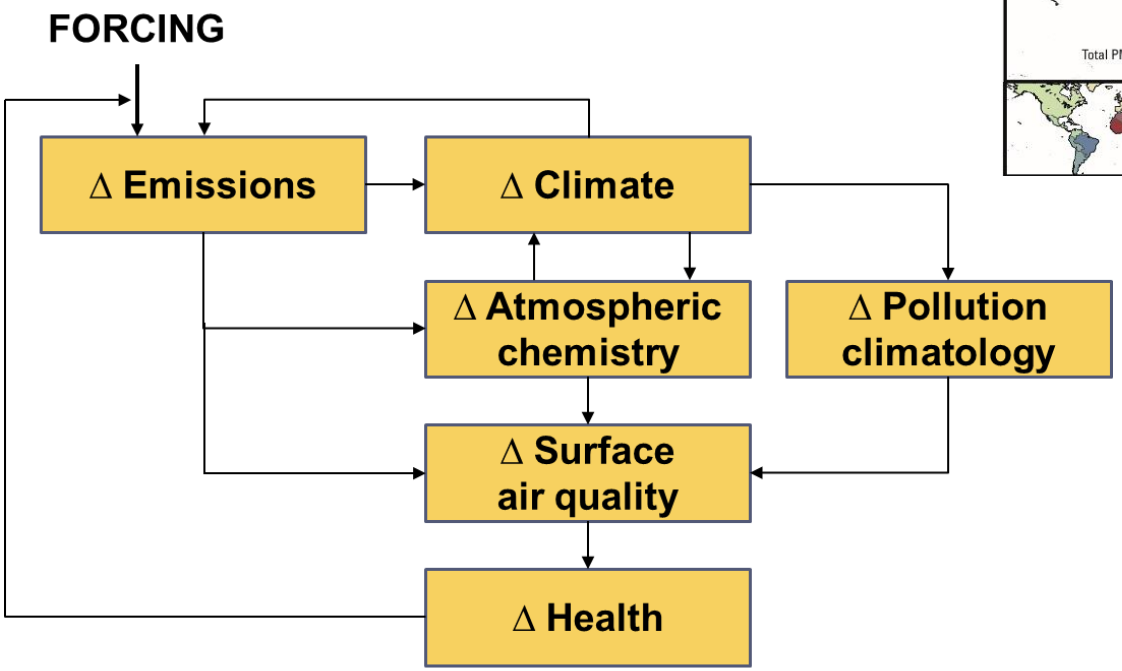


Global average abundances of CO_2 and CH_4 the NOAA global air sampling network (NOAA, 2013)

- Adverse effects of global climate change
  - Rising temperature
  - Rising sea level
  - Increased intensity, frequency, and duration of typoon (or hurricanes)
  - Increased drought
  - Increased extreme precipitation and floods
  - More frequent wildfires
  - More frequent heat waves
  - Increased winter storms
  - Poor air quality

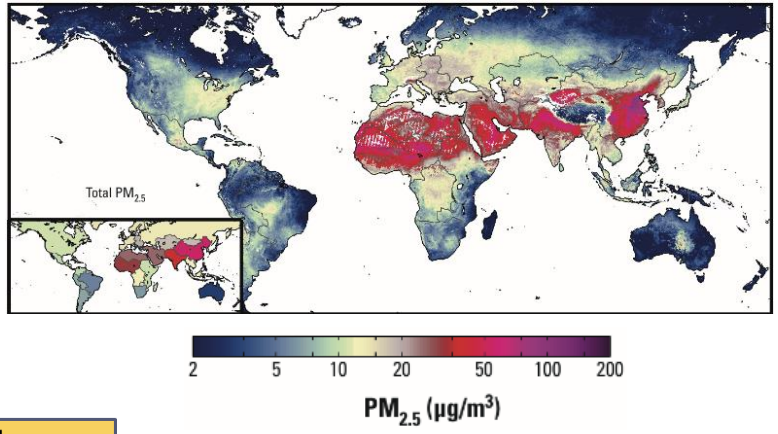
Implications for air quality and health

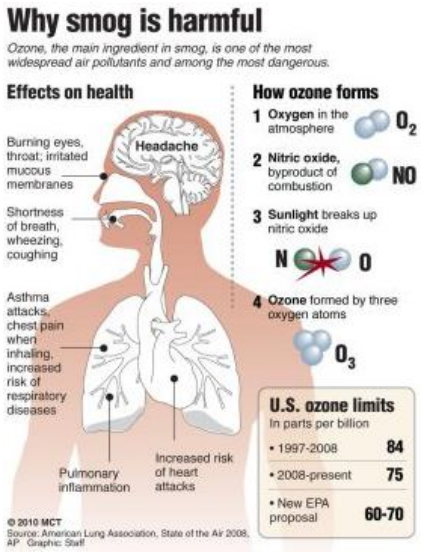
Interconnections between climate change, air quality and health



Reconstructed by Kim (2016) based on Jacob and Winner (2009)

Mean $PM_{2.5}$ concentrations (2001–2010)





https://howweseetheenvironemnt.wordpress.com

Objectives

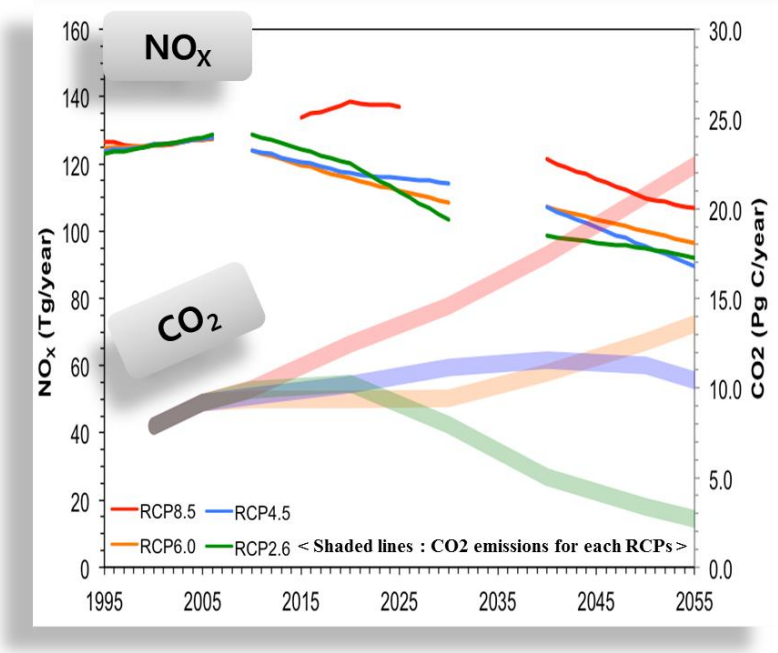
- To construct the base information for the vulnerability assessment of air quality change with climate change

- To prepare the scientific base to develop the national air quality and climate policies

2. Ozone and PM air quality in NEA

Used climate change scenarios and emissions

	Descriptions	Reference RF
RCP8.5	High range emissions (possible development for high populations, high fossil/coal use)	8.5 W/m^2 by 2100
RCP6.0	Medium range emissions (low-medium baseline scenario or high mitigation scenario)	6 W/m^2 at stabilization after 2100
RCP4.5	Medium range emissions (high mitigation scenario)	4.5 W/m^2 at stabilization after 2100
RCP2.6	Low range mitigation scenario	Peak at ~3 W/m^2 before 2100 and decline to 2.6 W/m$_2$ by 2100)



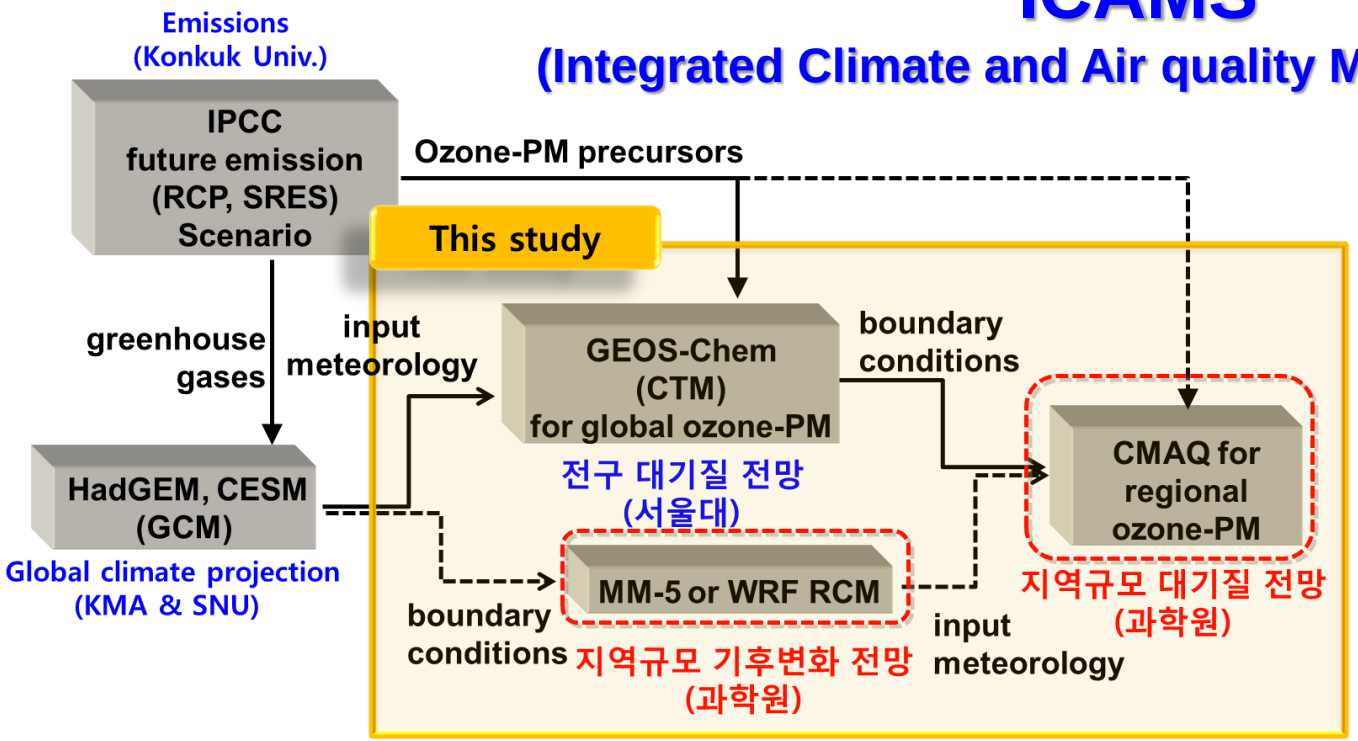
Source : NIER (2013)

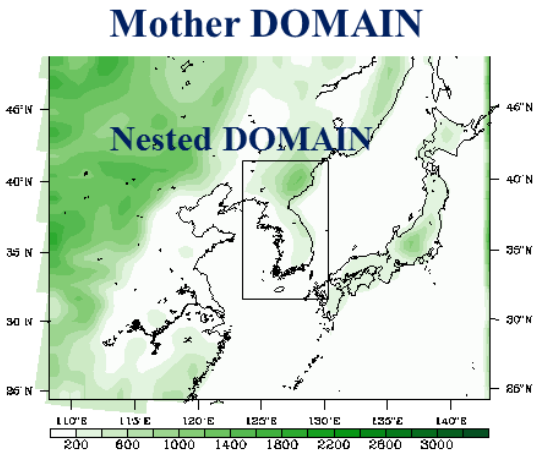
Source : Raiahi et al., 2011, Thomson et al., 2011, Masui et al., 2011, Van Vuuren et al., 2011, Van Vuuren et al., 2013

Simulation framework

ICAMS

(Integrated Climate and Air quality Modeling System)





Scenarios

- RCPs: 8.5, RCP6.0, RCP4.5, RCP2.6

Simulation periods

- Present: 2000s (1996~2005)
- Short-term future, 2020s (2016~2025)
- Medium-term future: 2050s (2046~2055)

Future climate in NEA

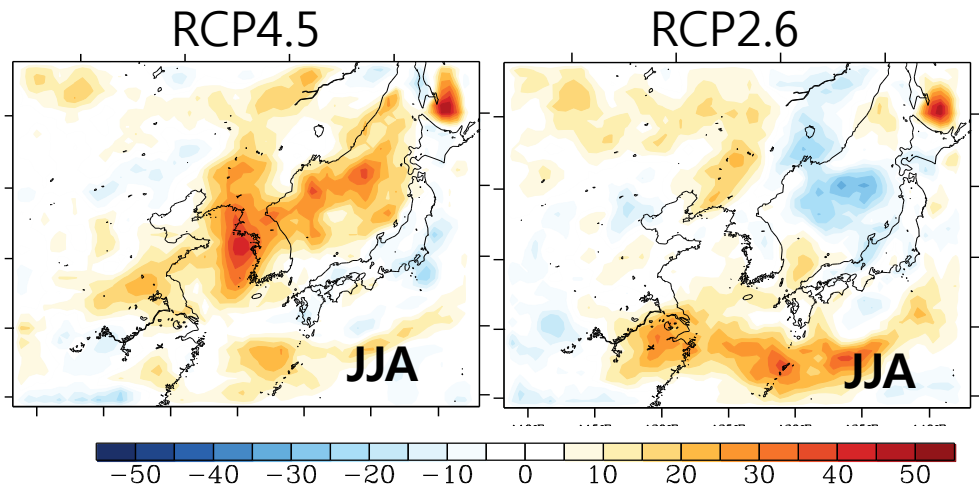
Δ T (°C)

	NEA		Global	
	2020s	2050s	2020s	2050s
RCP8.5	0.7	2.3	0.3	1.5
RCP6.0	0	1.2	0.1	0.9
RCP4.5	**0.9**	2	0.5	1.4
RCP2.6	**0.6**	1.7	0.2	0.8

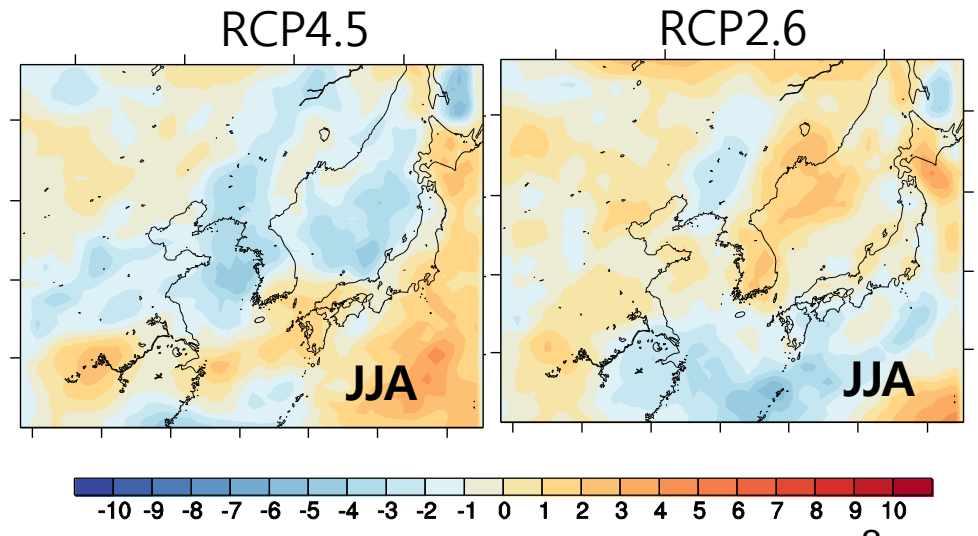
Δ Percent of precipitation days (%)

	NEA		Global	
	2020s	2050s	2020s	2050s
RCP8.5	1.9	5.8	2.3	3.3
RCP6.0	-0.4	4.5	1.5	1.6
RCP4.5	**-1.4**	6.8	1.3	2.8
RCP2.6	**2.5**	8.5	2.2	3.5

Δ Solar radiation (2020s- 2000s) (W/m2)

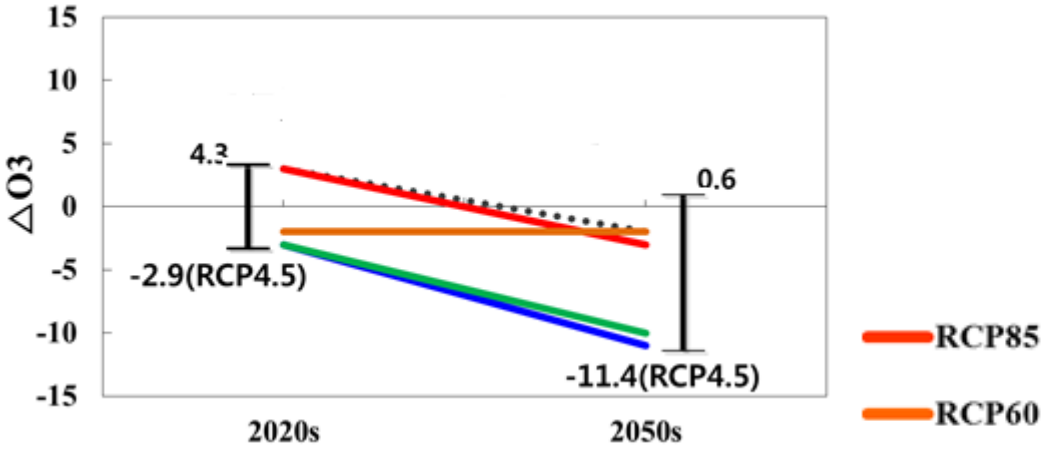


Δ Cloud amount (2020s-2000s) (%)

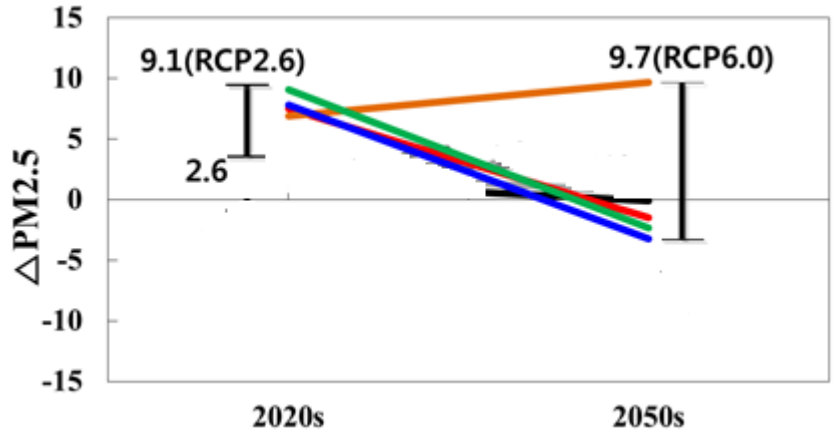


Future air quality in NEA

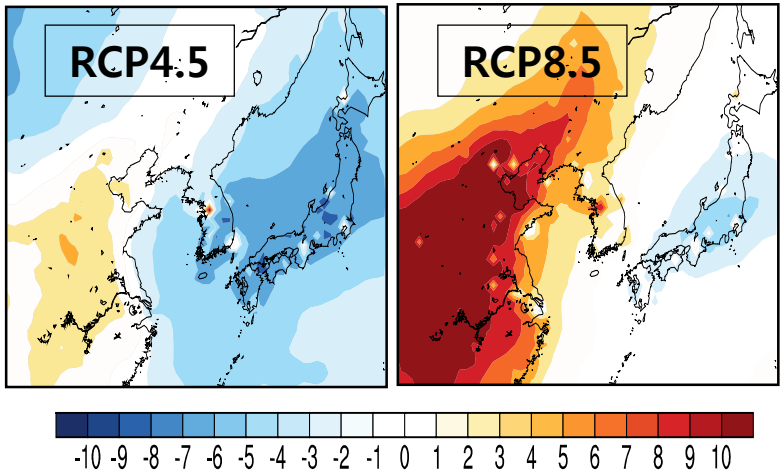
Against 2000s (42.1 ppb O_3)



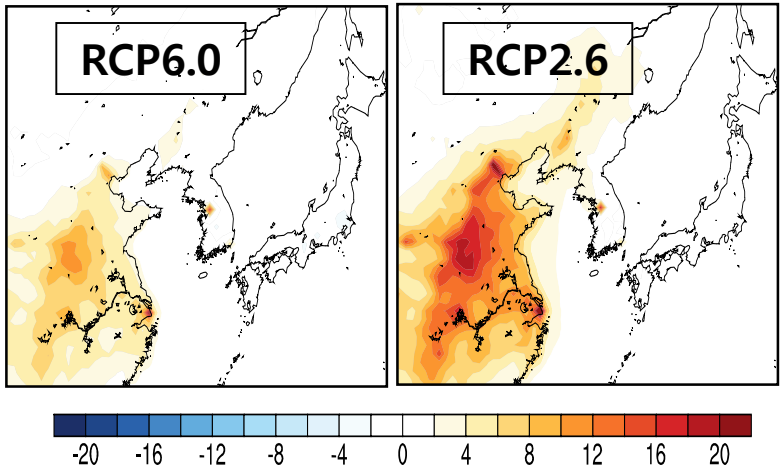
Against 2000s (7.3 ug/m³ $PM_{2.5}$)



O_3 2020s – 2000s (ppb)

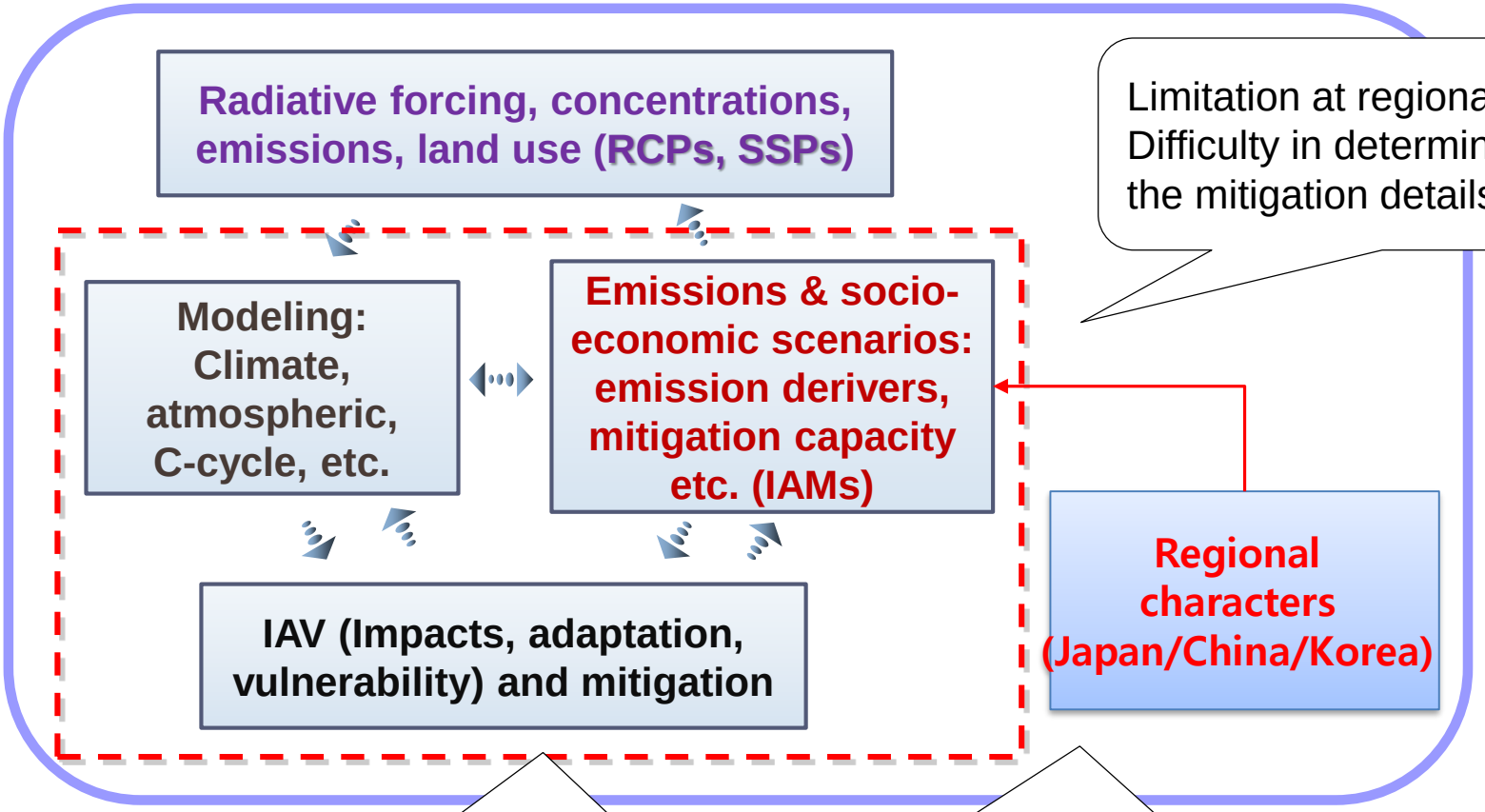


$PM_{2.5}$ 2020s – 2000s (ug/m³)



2. Ongoing collaborative works

Need of new regional climate change scenarios



※ RCPs: The Representative Concentration Pathways
SSPs: The Shared Socioeconomic Pathways

New future emission scenarios in NEA

- Participating countries and institutions:

S. Korea China Japan

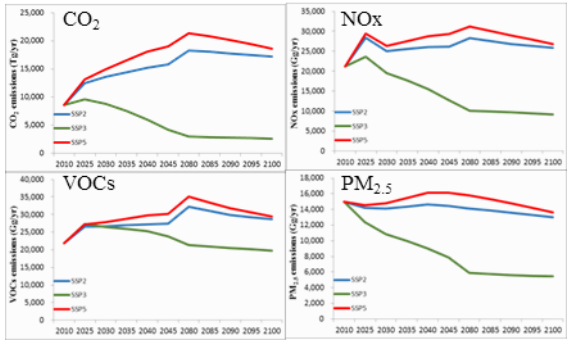
National Institute of Environmental Research

National Institute for Environmental Studies, Japan

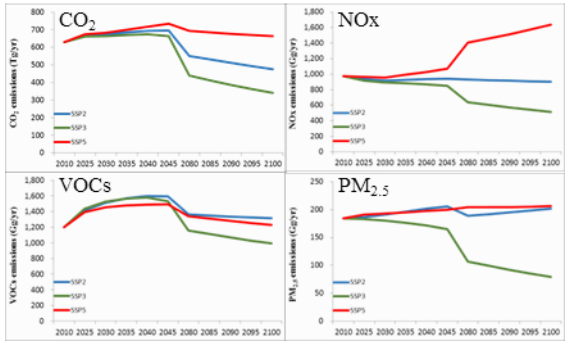
- Used IAMs: MESSAGE for China and AIM for S. Korea and Japan

- Reflects current status and future plans on national-oriented-specific socio-economic situation, environmental regulations, climate mitigation programs, and SSPs (Shared Socioeconomic Pathways)
- Considers emissions of LLGHG (CO_2, CH_4, N_2O, etc.) and SLCP (NOx, VOCs, SO_2, PM, etc.)

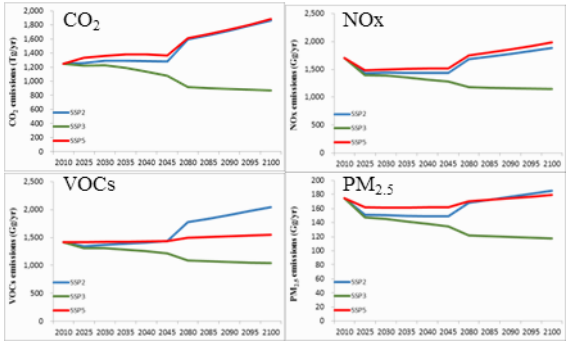
China



Korea



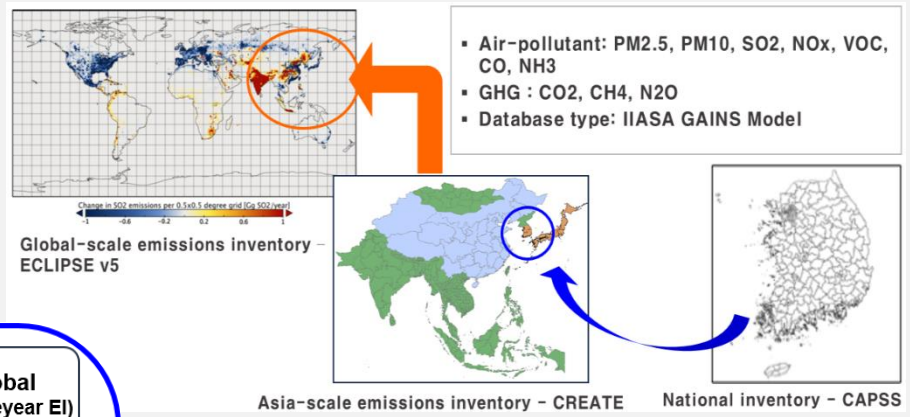
Japan



Development of modeling emission inventory

Gridded emission inventory for the base year

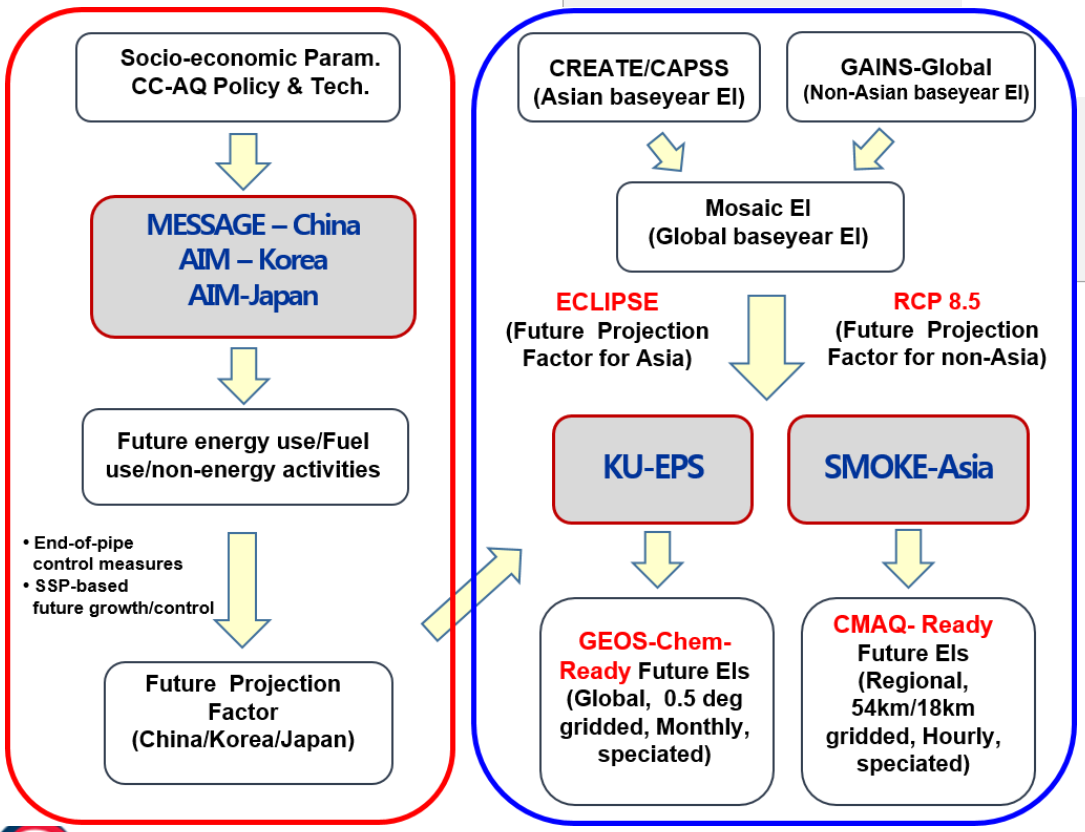
ECLIPSE v5 (IIASA)



- Air-pollutant: PM2.5, PM10, SO2, NOx, VOC, CO, NH3
- GHG : CO2, CH4, N2O
- Database type: IIASA GAINS Model

CREATE (NIER-KU)

CAPSS (NIER)



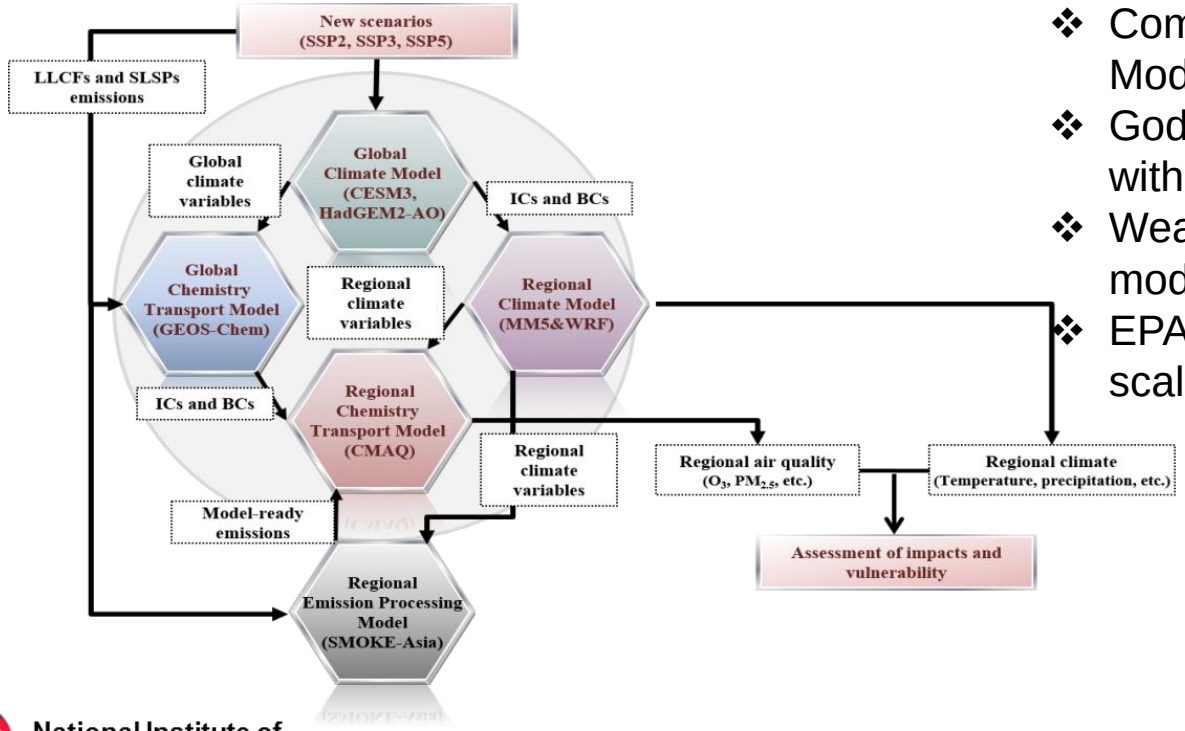
- To provide the emission inventory for the chemical transport modeling

National Institute of Environmental Research

Climate and air quality assessments

- Goal: drawing optimized scenario that minimizes the adverse effect of climate change and acquiring political priorities
- Schedule: prediction of climate and air quality changes under new scenarios (2016~2018)

Integrated Climate and Air Quality Modeling System (ICAMS)

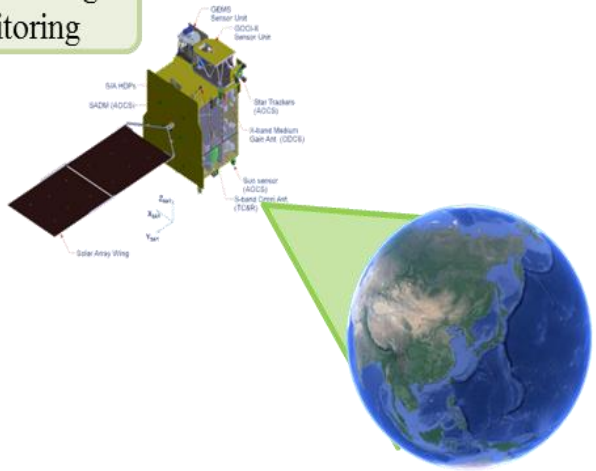


- ❖ Community Earth System Model(CESM)
- ❖ Goddard Earth Observing System with Chemistry model(GEOS-Chem)
- ❖ Weather Research and Forecasting model(WRF)
- ❖ EPA Models-3 Community Multi-scale Air Quality Model(CMAQ)

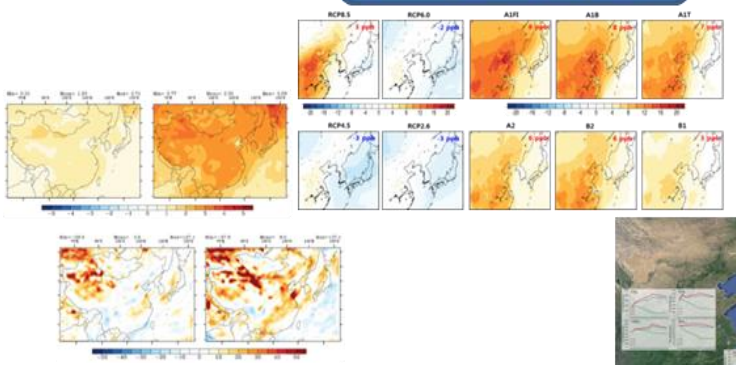
Research activities of NIER on climate change

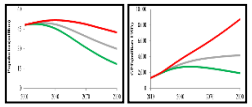
Assessment report of climate change, impact and adaptation in Korea

Climate Change Monitoring



Prediction of Climate Changes and impacts





Development of emission inventory

4. Summary

- Presented future trends of climate and air quality variables in NEA at given broad range of global scenarios, RCPs
  - temperature, precipitation, ozone and $PM_{2.5}$

- Introduced the ongoing collaborative works
  - development of new NEA climate change scenarios
  - predictions of climate and air quality changes
  - further research activities

- Expect a number of broader impacts in NEA
  - enhancing current integrated climate and air quality modeling approaches
  - providing a new basis for the vulnerability and risk assessment of climate change effects

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Thank you!