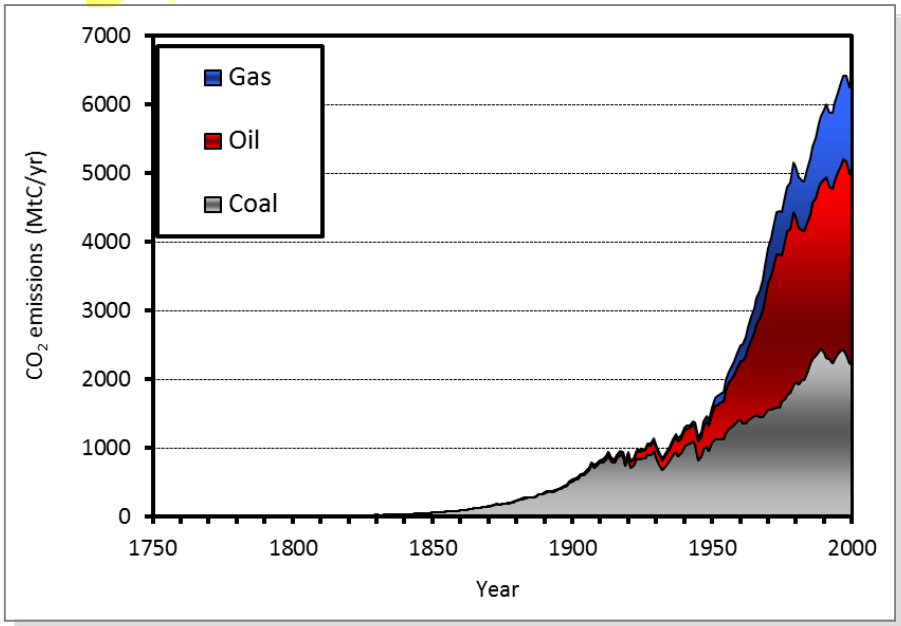
Global Warming

— Cause, Impact and Mitigation —

RITE
Research Institute of Innovative Technology for the Earth

Observation of Climate Change

《Point》 Global warming is caused by anthropogenic activities.



Source: Carbon Dioxide Information Analysis Center, ORNL

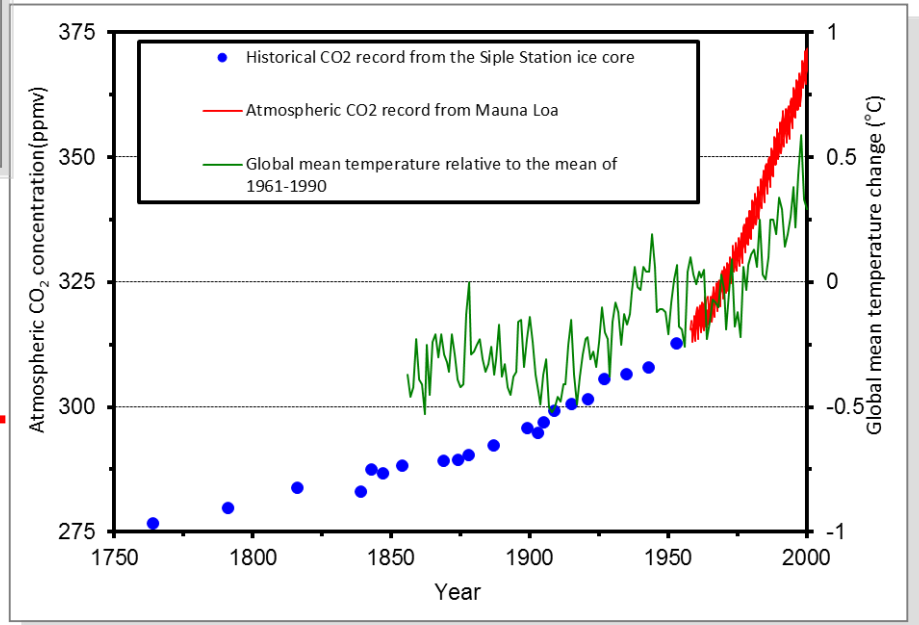
CO_2 Emission by Fuel Type

Fossil fuel consumption is increasing rapidly to satisfy growing energy demand after the Industrial Revolution, which started in the late 18th century.

Fossil fuel combustion ：

$$\underline{C} \quad + \quad \underline{O_2} \quad \rightarrow \quad CO_2$$

(Carbon in Fossil fuel) (Atmospheric Oxygen)



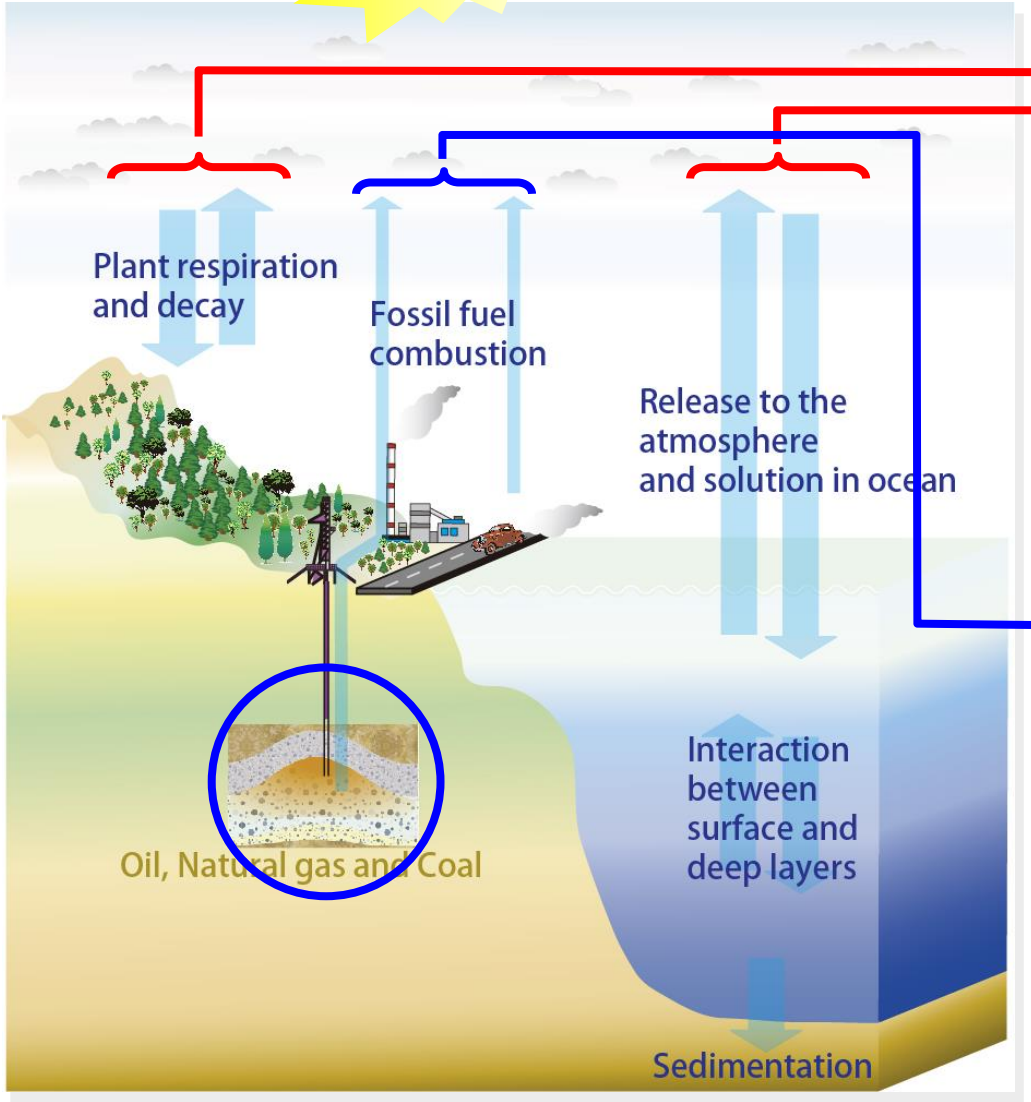
Source: Carbon Dioxide Information Analysis Center, ORNL

Atmospheric CO_2 Concentration and Temperature Rise

Atmospheric CO_2 concentration and global mean temperature are increasing along with the rapid increase of CO_2 emission.

Carbon Cycle

《Point》 Carbon（C）circulates in the earth.



The carbon (C) circulates among terrestrial plants, the atmosphere and the ocean, undergoing various reactions.

For example,

Solution in the ocean :

$$CO_2 + H_2O \rightleftarrows 2H^+ + CO_3^{2-}$$

Photosynthesis :

$$6CO_2 + 6H_2O \rightarrow 6O_2 + C_6H_{12}O_6$$

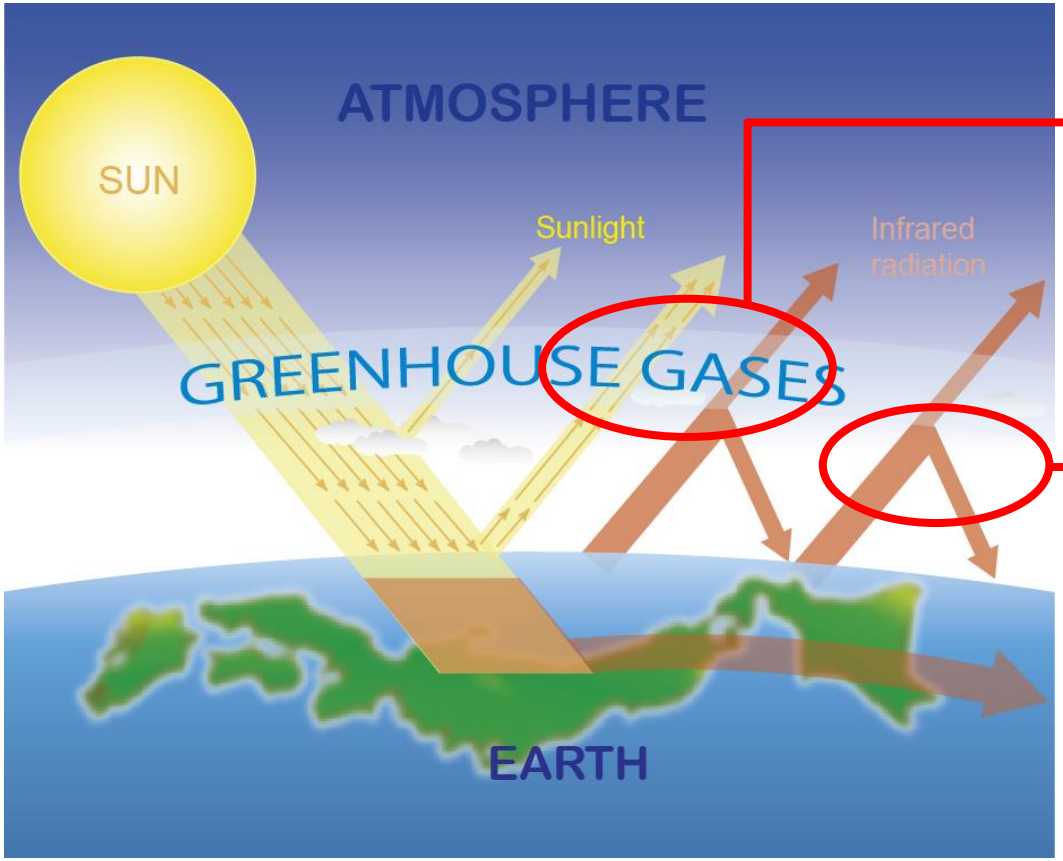
However, combustion of massive fossil fuel is causing a release of underground carbon (C) to the atmosphere and disrupting this cycle.

Combustion : $C + O_2 \rightarrow CO_2$

This carbon increase in the atmosphere leads to the global warming.

Greenhouse Effect

《Point》 CO_2（carbon dioxide）plays an important role to keep the earth warm.

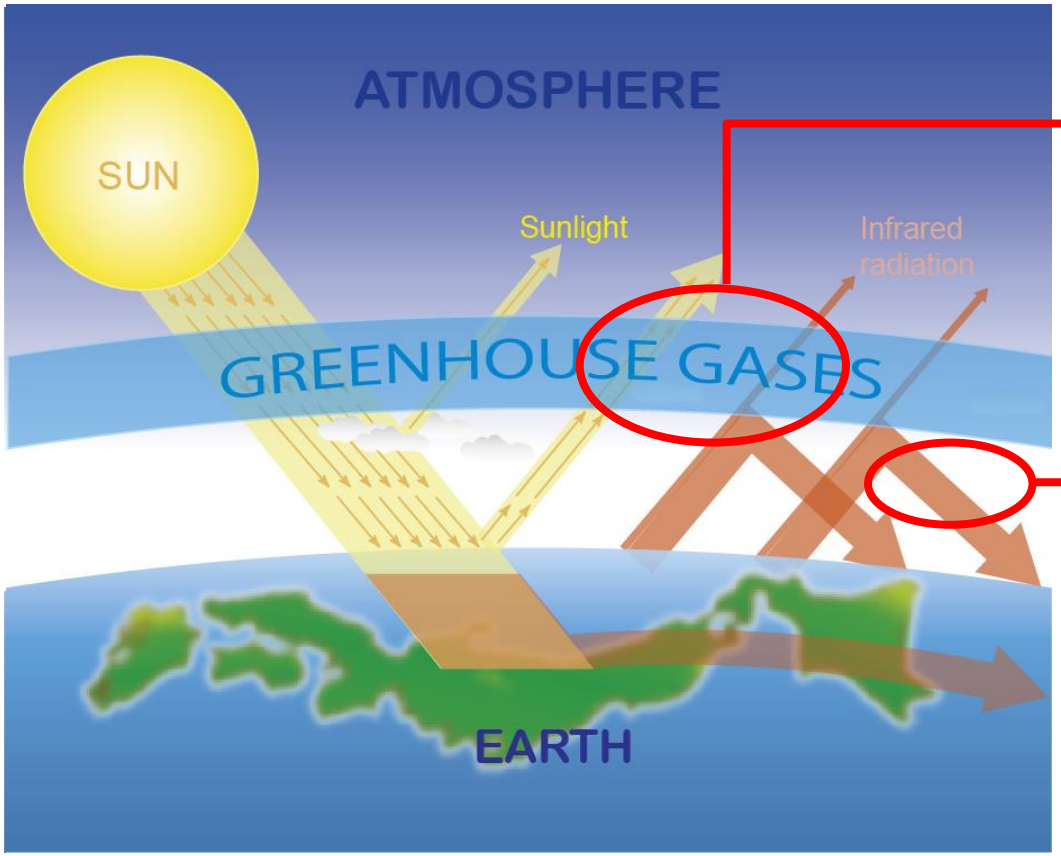


Greenhouse gases like CO_2 absorb infrared radiation (heat), while letting sunlight go through itself.

Appropriate amounts of greenhouse gases (such as CO_2) are reflecting infrared radiation (heat) back to the earth to keep it warm.

Global Warming

《Point》 However, increase in atmospheric CO2 concentration is causing global warming.

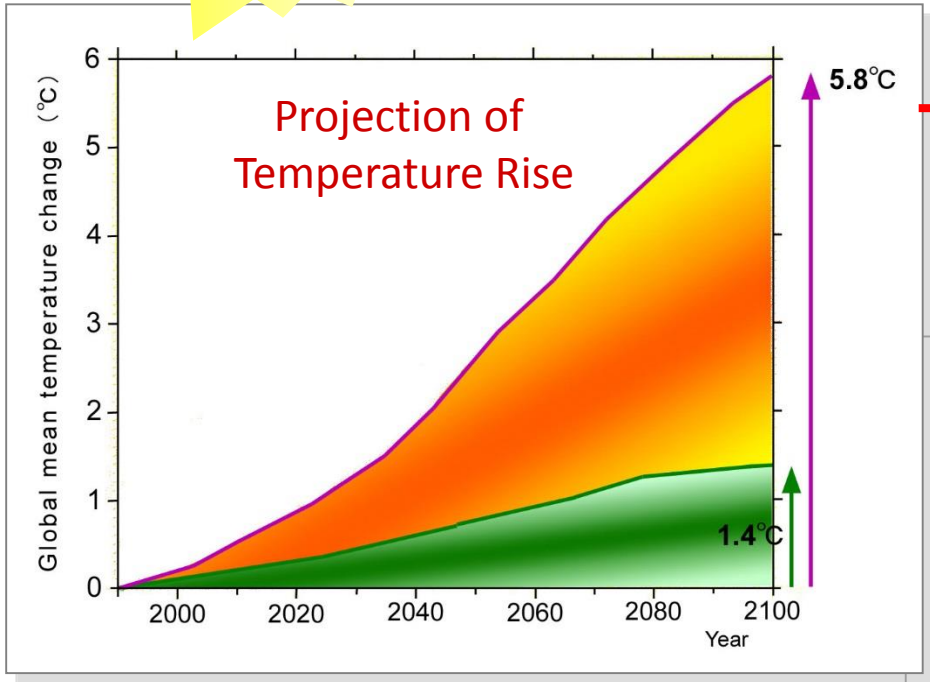


CO_2 increase in the atmosphere "thickens" the infrared radiation reflection layer.

The "thicker" reflection layer is keeping too much heat around the earth.

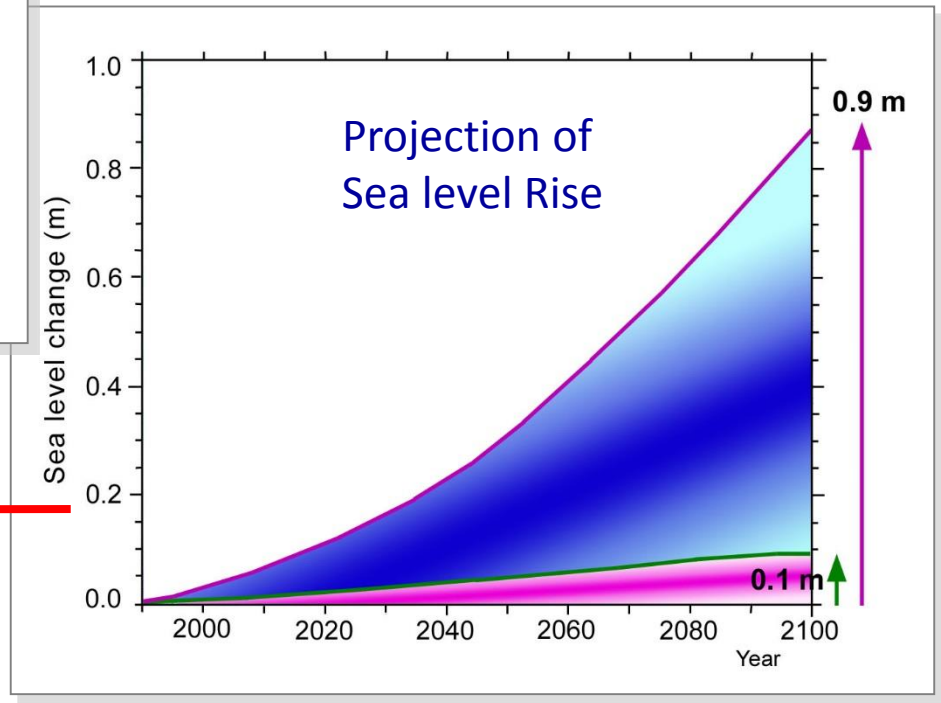
Projection of Climate Change

《Point》 Continuing current increase of CO_2 concentration causes the rises of the global temperature and sea level.



Source: The Third Assessment Report by Intergovernmental Panel on Climate Change(IPCC)

If no action is taken towards CO_2 emission reduction, projected temperature rise in 2100 is 1.4 deg.C at a minimum, and 5.8 deg.C at a maximum.

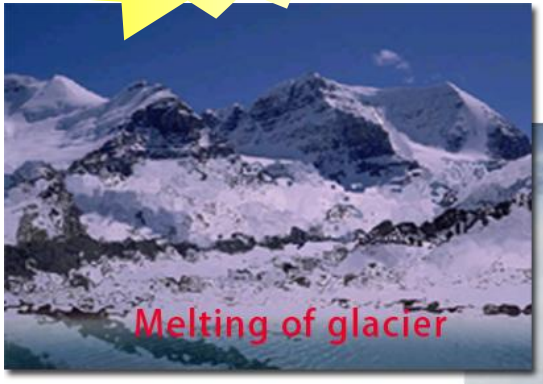


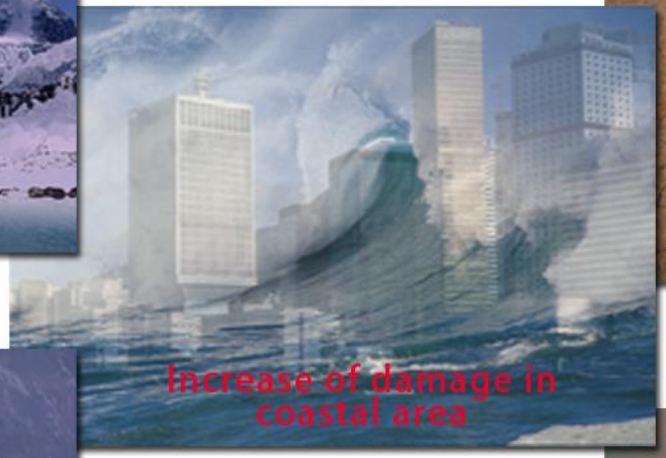
If no action is taken towards CO_2 emission reduction, projected sea level rise in 2100 is 0.1m at a minimum, and 0.9m at a maximum.

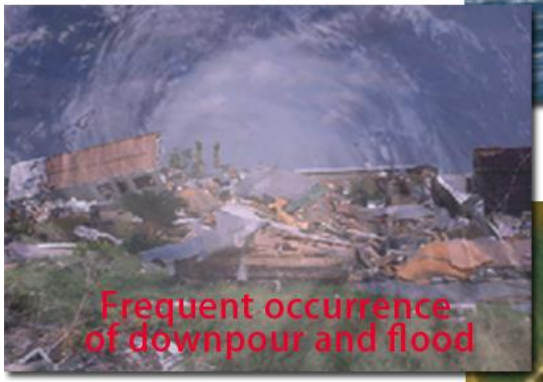
Source: The Third Assessment Report by Intergovernmental Panel on Climate Change(IPCC)

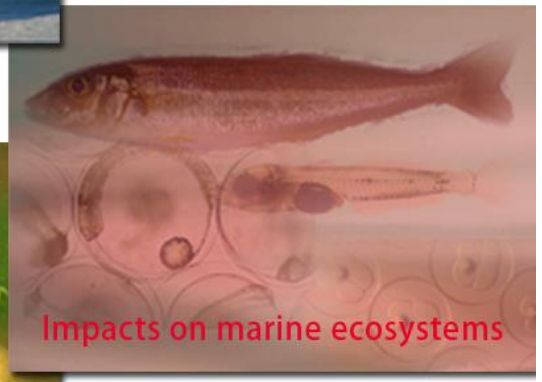
Global Warming Impacts

《Point》 Extreme weather events are projected to occur in various regions worldwide.



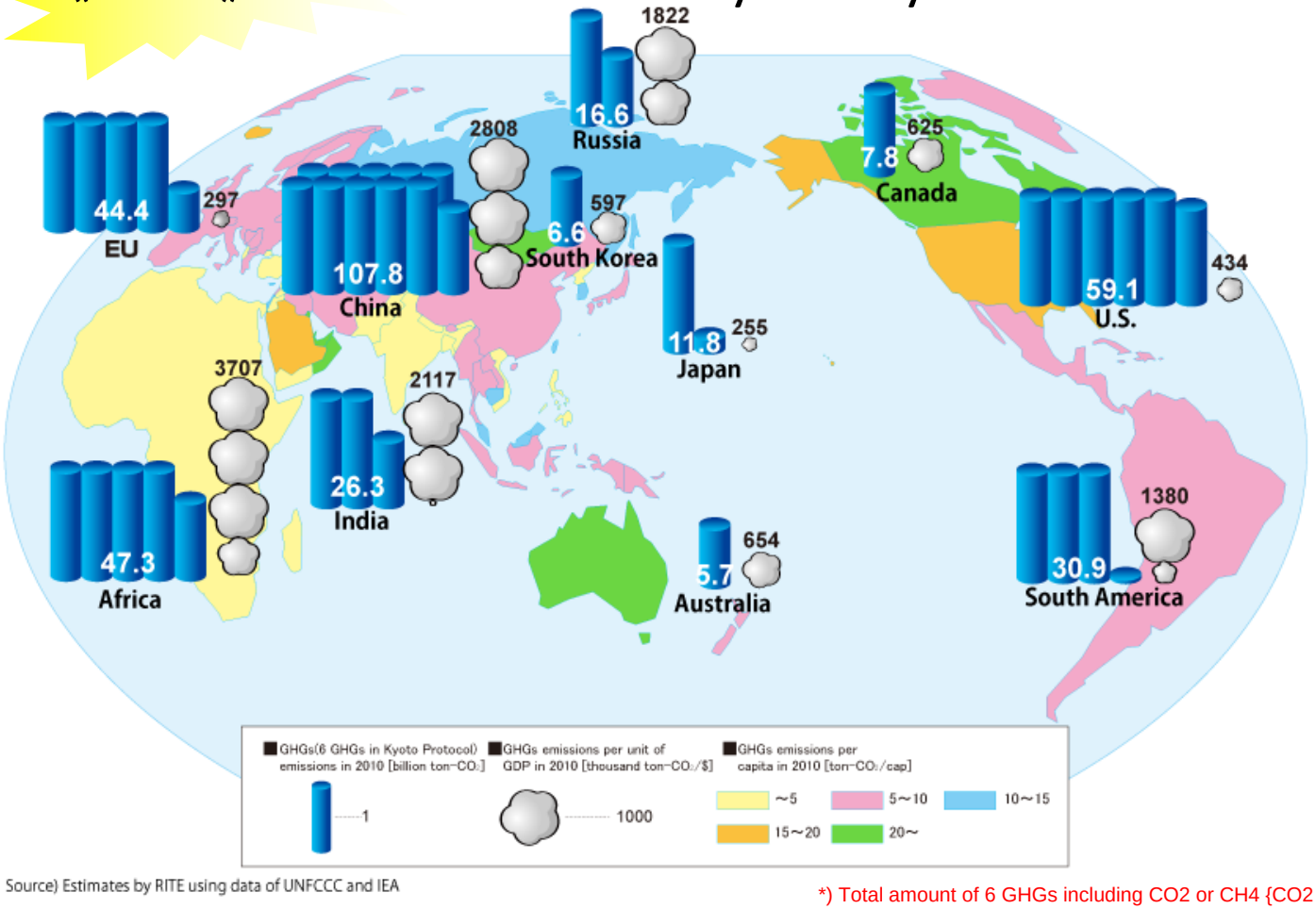






CO_2 Emission

《Point》 CO_2 emissions vary widely across countries.



Source) Estimates by RITE using data of UNFCCC and IEA

*) Total amount of 6 GHGs including CO2 or CH4 {CO2 equivalent}

・Currently emissions from China and U.S. are notably large.
・In the future, GHG emissions are projected to increase from developing countries, due to their population increase and economic growth.
・Emissions per unit of GDP (GHGs emitted per 1-unit production of GDP) are small in developed countries, and large in developing countries.

Global Warming Mitigation

CO_2 emission reduction technologies

- **Energy Saving**
- **Fuel Switching among Fossil Fuels** — Fuel switching from coal to oil, from oil to natural gas, etc.
- **Nuclear Power** — CO_2-free power generation
- **Renewable Energy**
  - **Hydro Power**
  - **Solar Thermal**
  - **Photovoltaics** — Solar cells
  - **Wind Power**
  - **Biomass Energy** — Combustion, conversion to gaseous fuels, or liquid fuels (e.g., wood residues, black liquor, household wastes)

CO_2 capture and storage

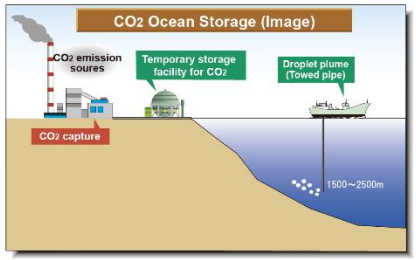
- **Ocean Storage** — CO_2 storage in the ocean by utilizing CO_2 solution capacity of ocean
- **Geological storage** — CO_2 storage underground by utilizing geological features (e.g., aquifer, depleted gas well, oil well, coal bed, mineral)

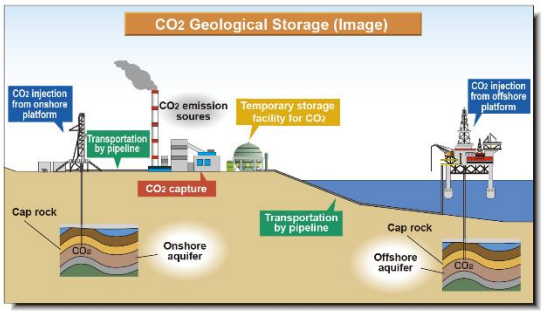
Expansion of CO_2 sink

- **Forestation, Large-scale greening** — Fixation of atmospheric CO_2 by photosynthesis of terrestrial plants

Photovoltaics

Wind power





《Point》

There are various countermeasures to reduce CO_2 emissions. Unless they are implemented in combination, global warming shall not be constrained.

Global Warming Mitigation Scenario

《Point》 Economic consideration is important in selecting a combination of the countermeasures.