Geoengineering representation in an integrated assessment model - preliminary assessment -

Atsushi Kurosawa (*1) Kazuhiro Tsuzuki (*1)
Ryo Moriyama(*1) Yuki Ishimoto(*1)
Masahiro Sugiyama (*2) Kooiti Masuda(*3)

(*1) The Institute of Applied Energy (IAE)
(*2) Central Research Institute of Electric Power Industry (CRIEPI)
(*3) Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Part of research activities were supported by the Environment Research and Technology Development Fund (S-10) of the Ministry of the Environment, Japan.

Objective and Overview

■Objective

Inclusion of geoengineering and adaptation options to the integrated assessment model.

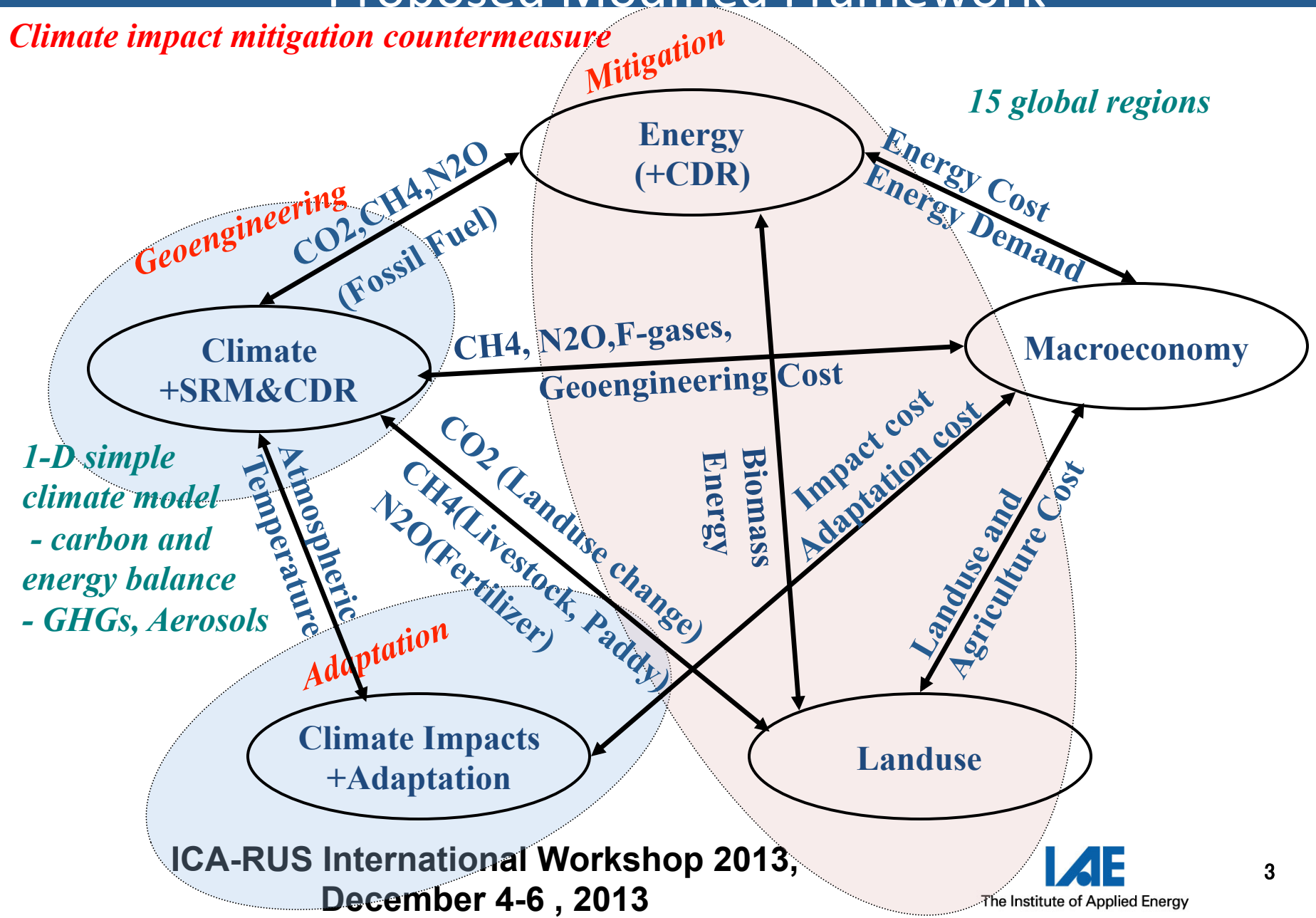
■Geoengineering

- ➢Solar radiation management (SRM) and carbon dioxide
- ➢SRM - aerosol scattering in stratosphere, etc.
- ➢CDR – BECCS, air capture, etc.

■Adaptation

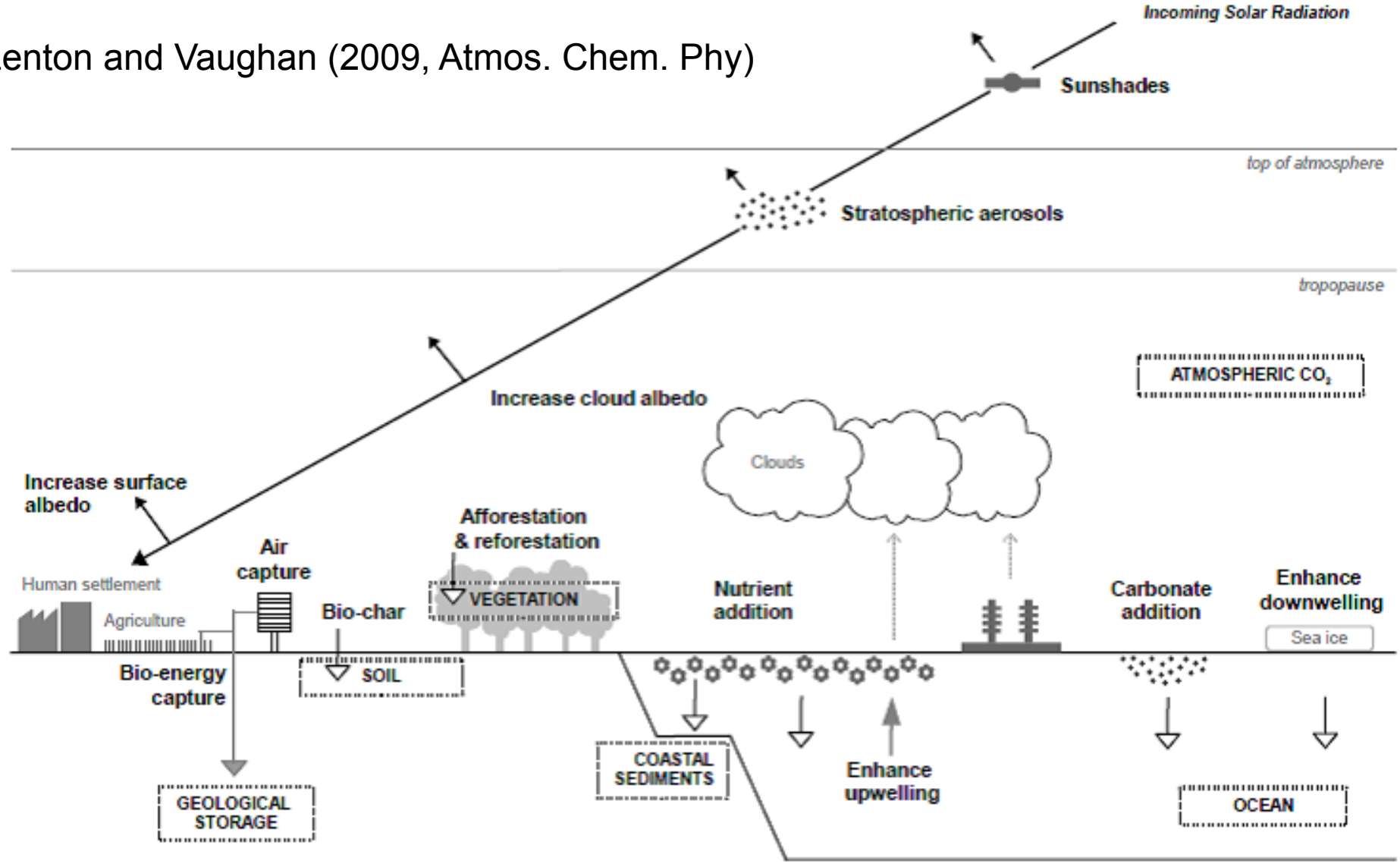
- ➢Information exchange with NIES

Integrated Assessment Model GRAPE
- Proposed Modified Framework -



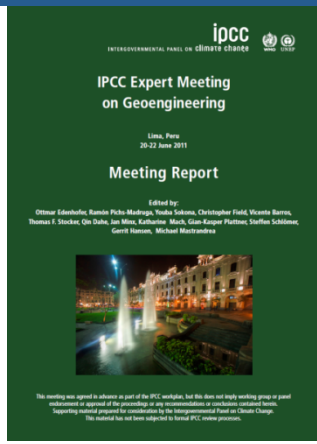
Geoengineering Options

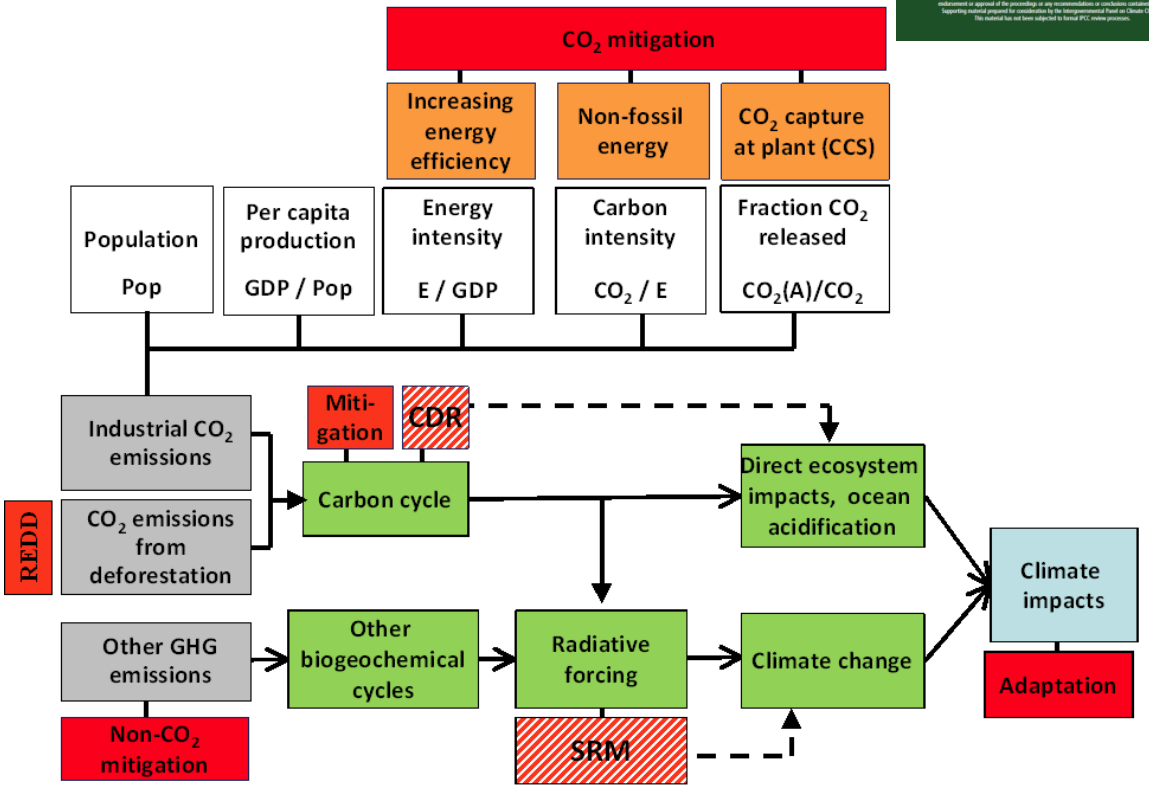
Lenton and Vaughan (2009, Atmos. Chem. Phy)



IPCC Expert Meeting on Geoengineering: Meeting Report

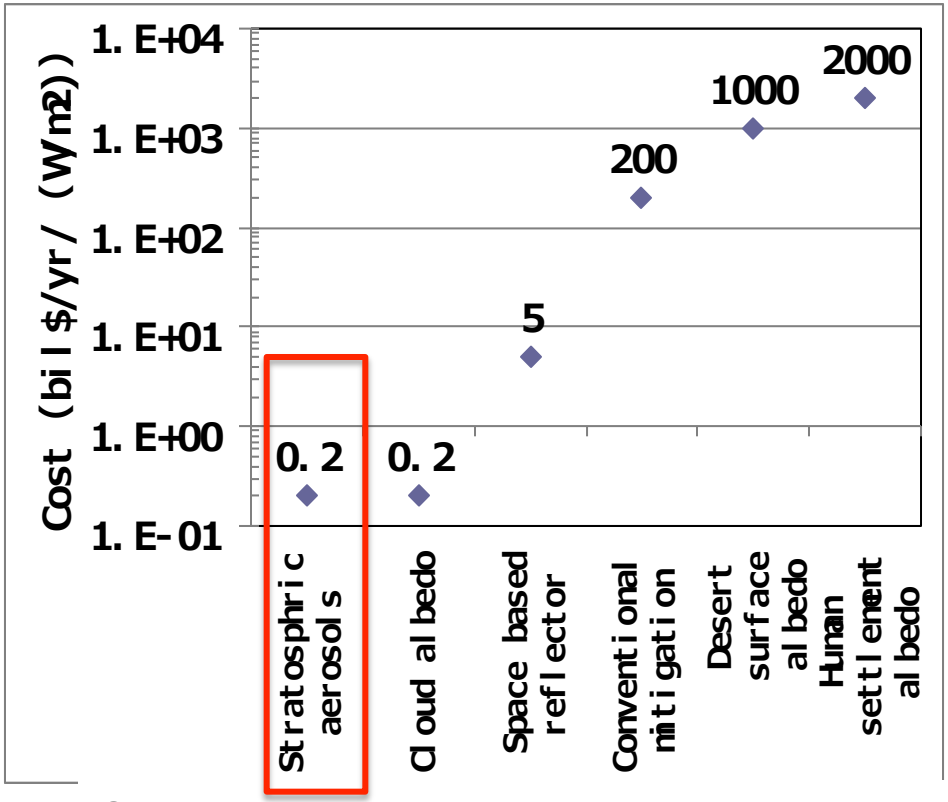
- Terminology
  - ‘SRM’ is not included in ‘Mitigation’ or ‘Adaptation’.
  - There is no clear definition of difference between ‘CDR’ and ‘Mitigation’
- Criteria
  - Effectiveness
  - Feasibility
  - Scalability
  - Environmental risks
  - Costs and affordability
  - Detection and attribution
  - Governance challenges
  - Ethical issues
  - Social acceptability
  - Uncertainty





Geoengineering Cost Estimates: Survey

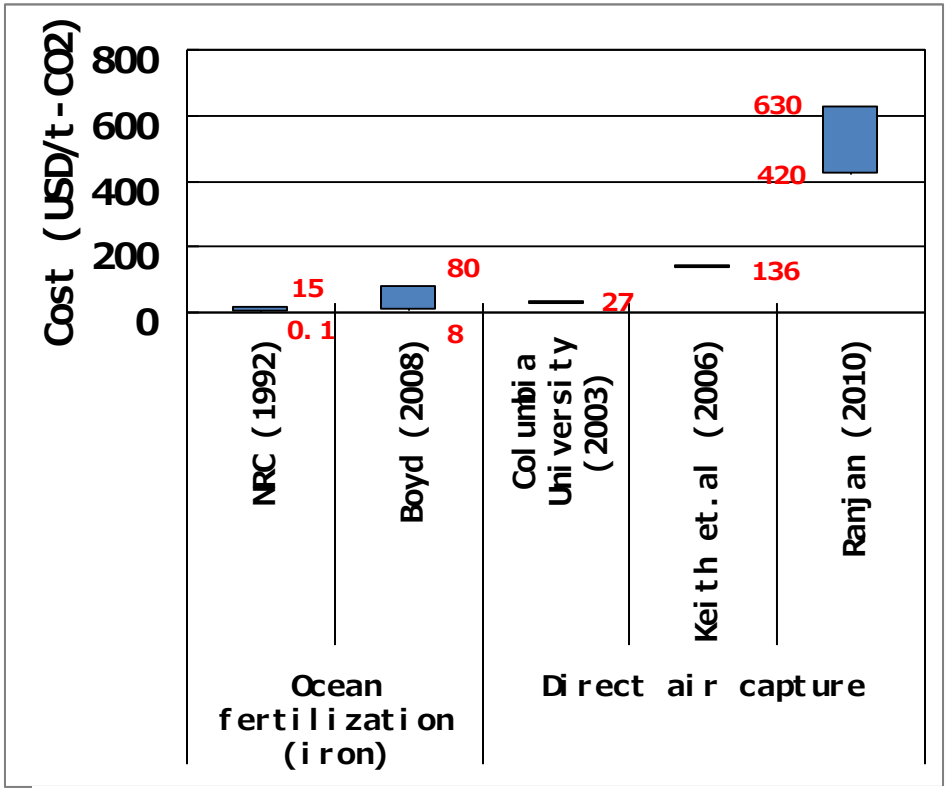
SRM cost



Order estimate. Environmental damage is not included in the estimate.

Source: The Royal Society (2009)

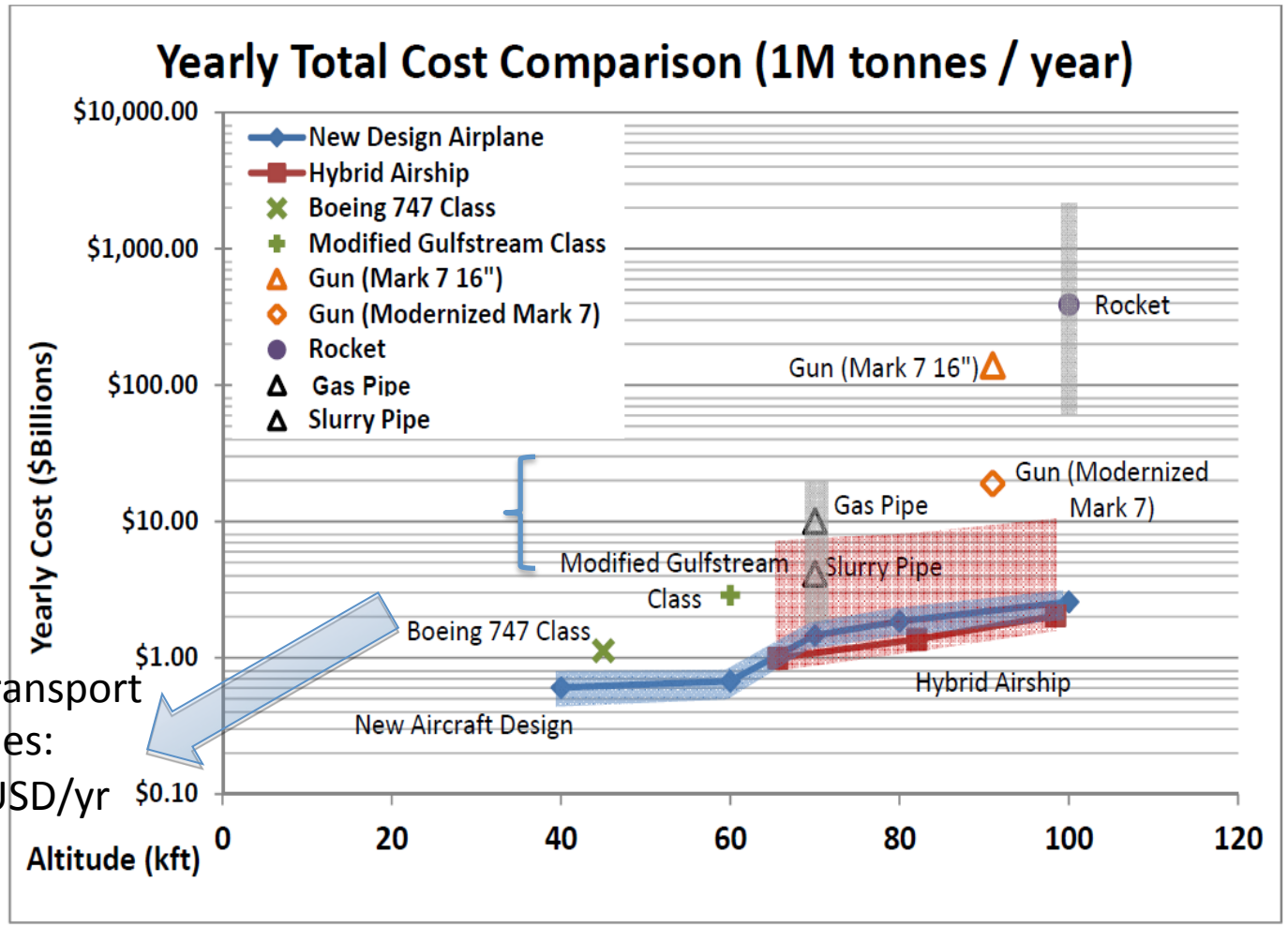
CDR cost



Including order estimate.

Source: Sugiyama (2009)

Stratospheric Aerosols: Transportation Cost

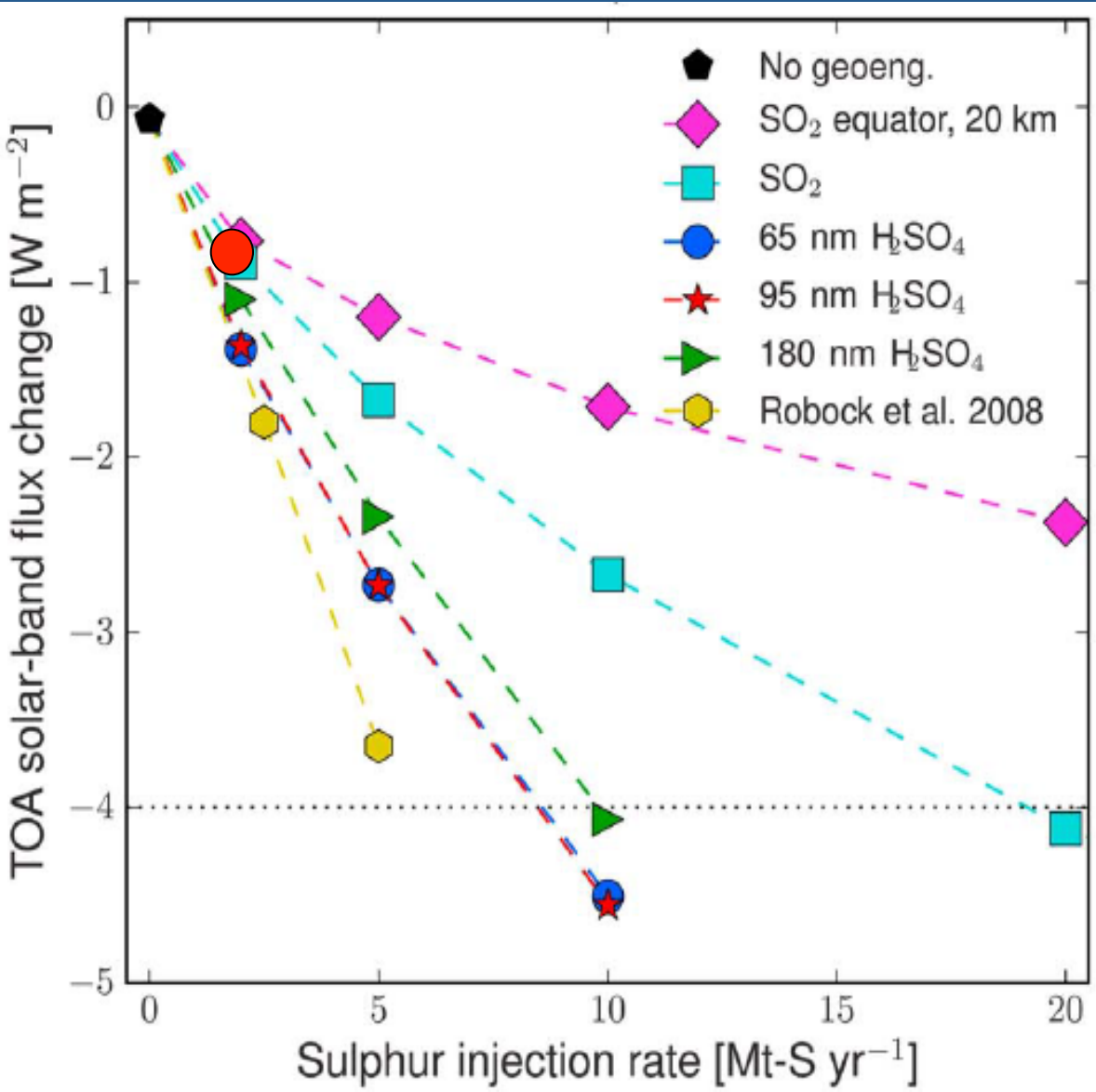


Aerosol transport by airplanes: 0.6-3 bil USD/yr

Figure 2: Yearly cost (including depreciation, interest, and operations costs) for 1M tonne per year geoengineering

Source: Geoengineering Cost Analysis (Final report)(Aurora Flight Sciences Corp., 2011)

How Much Aerosol Needed?



Source: Pierce et al.,
***Geophys. Res. Lett.*, 37, (2010)**

About 2Mt-S/yr →1W/m^2
(6.1 Mt H_2SO_4/yr)

The cost of stratospheric aerosol injection depends on uncertain factors

Cost uncertainty

Aerosol injection cost($/yr) = **Unit cost of aerosol injection [$/kg]**

(material cost + transport&injection)

x **Amount required for unit aerosol radiative forcing [kg/yr/(W/m^2)]**

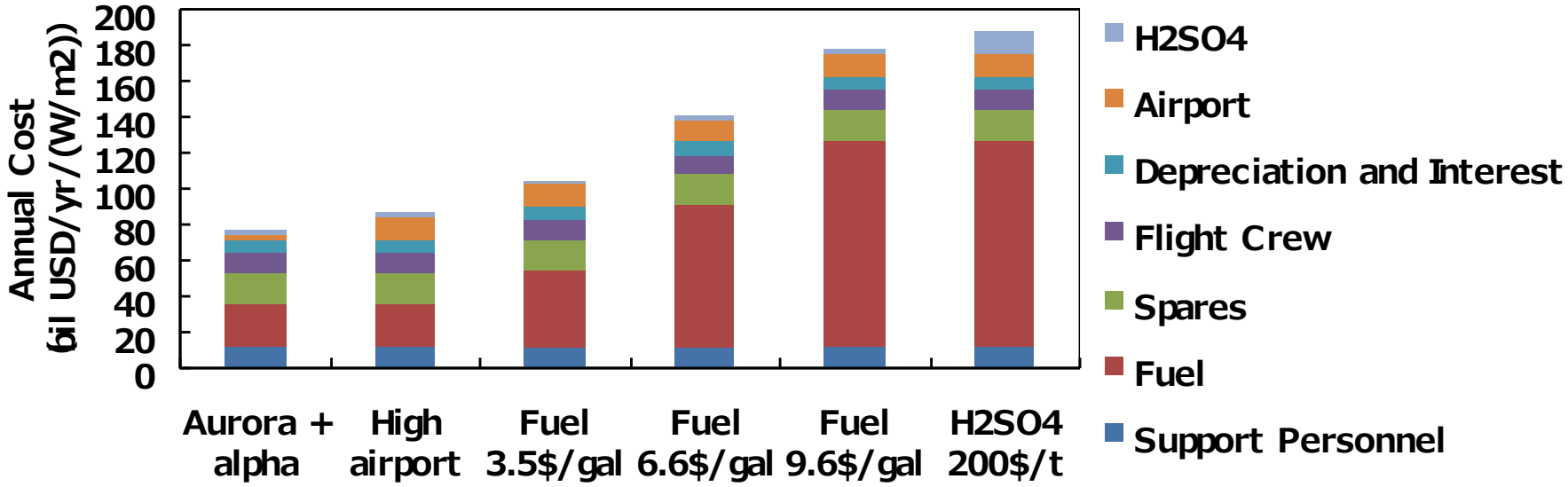
x **Radiative forcing required to counteract climate change [W/m^2]**

Depends on engineering consideration (e.g. vehicle, fuel, material injected, injection device)

Depends on forcing stabilization scenarios.

Sugiyama, et. al. (2012) and Moriyama, et.al. (2013)

Revised Cost Estimates



- In the Aurora (2011), only the aircraft and fuel cost is assessed.
- Sulphuric acid aerosol cooling effect is the same as that of Aurora(2011) (i.e. 6.1Mt/yr/(W/m2))
- Royal Society (2009) stratospheric aerosol injection cost differs.
- Inclusion of fuel and other factors and their fluctuations would widen the uncertainty range.
- Extension to materials other than H_2SO_4.

Moriyama, et.al. (2013)

Works in Progress (other than SRM)

- CDR – BECCS, Air capture
- Adaptation
- Integration to IAM

References

- M.Sugiyama, A.Kurosawa, K.Masuda, K.Tsuzuki, R.Moriyama and Y.Ishimoto, Climate Engineering and Climate Policy: A review, Proc. 2012 annual meeting of Society for Environmental Economics and Policy Studies, Sep. 2012. (in Japanese)
- M.Sugiyama, A.Kurosawa, K.Masuda, K.Tsuzuki, R.Moriyama and Y.Ishimoto, Assessing benefits and costs of climate geoengineering for an integrated assessment model, AGU, Fall Meeting, Dec. 2012
- R.Moriyama, A.Kurosawa, M.Sugiyama, K.Masuda, K.Tsuzuki and Y. Ishimoto, Cost Analysis of Climate Engineering -Solar Radiation Management, Proc. 29th conf. on energy, economy, and environment, Japan Society of Energy and Resources, Jan. 2013 (in Japanese)
- A. Kurosawa, R.Moriyama, Y.Murakami, Bioenergy with CCS, Journal of Japan Institute of Energy, vol.92, pp211-215, 2013 (in Japanese).
- A. Kurosawa, Biomass-Energy R&D and CCS Status in Japan, Workshop on Bio-energy and CCS(BECCS) - Options for Brazil, University of Sao Paulo, June 2013
- M. Sugiyama, Engineering consideration on stratospheric aerosol injection. Short presentation at 4th Interdisciplinary Summer School on Geoengineering, Harvard University, August 2013
- M. Sugiyama, Geoengineering research in Japan. Short presentation at 4th Interdisciplinary Summer School on Geoengineering, Harvard University, August 2013