



2009.2.4-6, 3rd GEOSS AP
Symposium, Kyoto, Japan



Theme and Task of Parallel Session: Monitoring and Predicting Climate Change

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National Institute for Environmental Studies (NIES)
Center for Global Environmental Research (CGER)

GEOSS Climate SBA

Understanding, assessing, predicting, mitigating, and adapting to climate variability and change

- The climate has [REDACTED].
- Coping with climate change and variability demands good scientific understanding based on sufficient and reliable observations.
- GEOSS outcomes will enhance the capacity to [REDACTED] [REDACTED] to climate change and variability.
- Better understanding of the climate and its impacts on the Earth system, including its human and economic aspects, will contribute to improved climate prediction and facilitate sustainable development while avoiding dangerous perturbations to the climate system.

WG1: Monitoring and Predicting Climate Change

February 5 (Thu) February 2009

Co-Chair: Dr.Yukihiro Nojiri and Dr.Nobuko Saigusa
(National Institute for Environmental Studies)

09:30-9:40 Opening Climate Change Session (GEO Secretariat and Co-Chair)

9:40-10:05

Yasunori Tohjima (National Institute for Environmental Studies, Japan)

“Terrestrial and oceanic CO₂ budget from atmospheric O₂/N₂ ratio measurement”

10:05-10:30

Patra Prabir (Frontier Research Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Japan)

“Top-down estimation of CO₂ fluxes: lesson learnt and challenges ahead”

WG1: Monitoring and Predicting Climate Change

10:30-10:55

Yan Xiaoyuan (Institute of Soil Science, Chinese Academy of Sciences, China)

“Trace gas emissions from croplands in Monsoon Asia”

10:55-11:20

Akio Kitoh (Meteorological Research Institute, Japan Meteorological Agency, Japan)

“Climate modeling for adaptation to climate change in Asia”

11:20-12:00

General Discussion and wrap-up (Chair: Y. Nojiri)

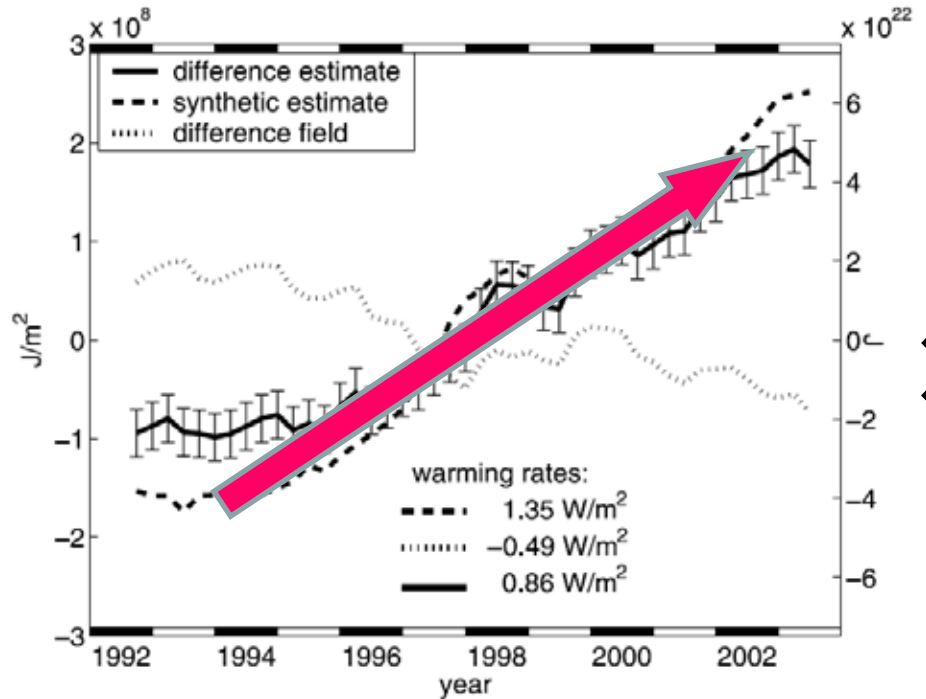
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Enhancement of collaboration of different observation community

- Ocean surface temperature/heat content
ocean oxygen flux terrestrial and
oceanic CO₂ sink
- Enhancement of collaboration/information exchange by GEOSS as an integrated scheme

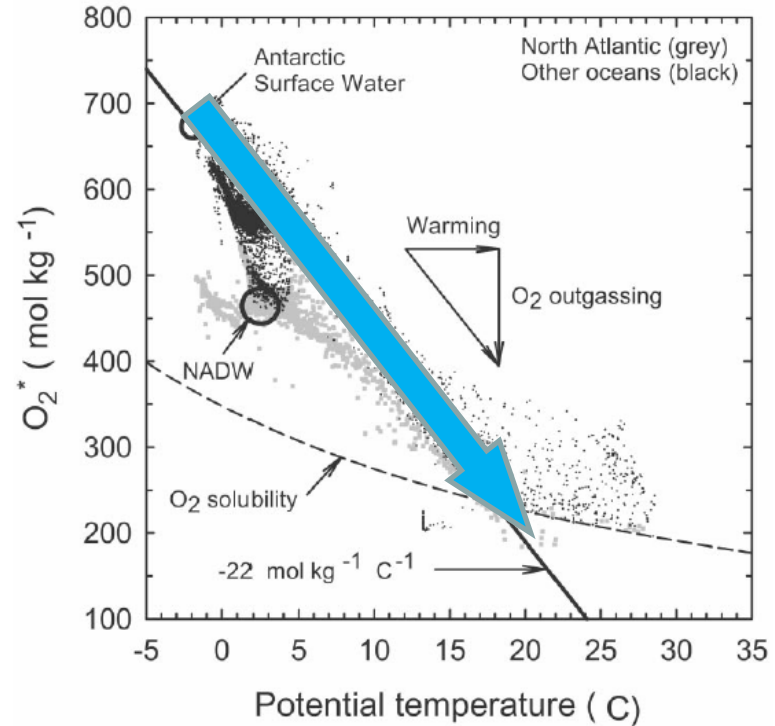
Estimation of the ocean outgassing effect

Willis et al. (2004)



×

Keeling & Garcia. (2002)

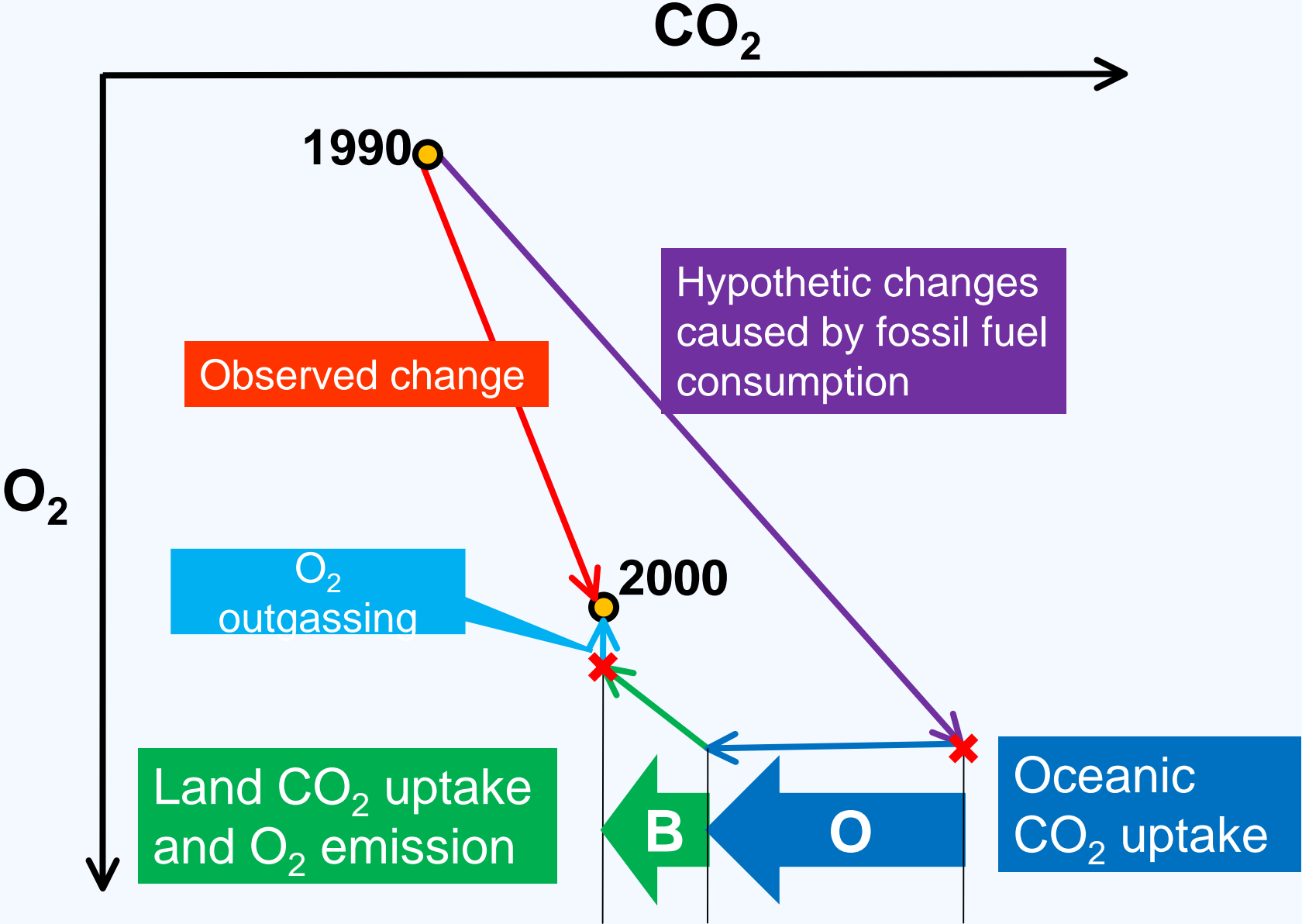


O_2 outgassing = Net Ocean Heat Flux

×

Oceanic $\frac{O_2 \text{ Flux}}{\text{Heat Flux}}$ Ratio

Graphical explanation of budget calculation



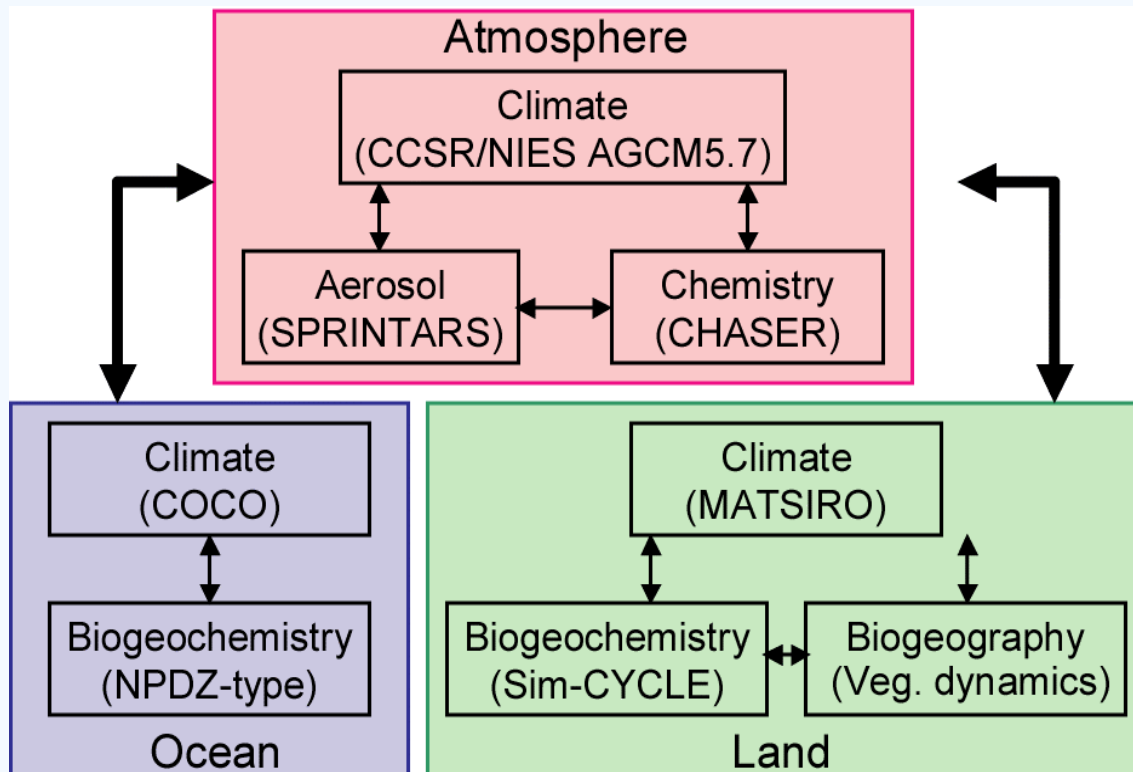
Existing Data Exchange Platforms for greenhouse gas observations

- Atmosphere
 - WDCGG
- Ocean
 - CDIAC/Ocean Carbon
 - IOCCP (GCP), GOSHIP, SOCAT
- Terrestrial
 - CDIAC/FLUXNET
- Needs of inter-connection with GEOSS and existing platforms

Process study/model prediction

- Primitive stage for process study data base and data circulation mechanism
 - Process study data base is necessary in formation for improvement of prediction models
- Data assimilation Evaluation of uncertainty of observed data set

CCSR/NIES/FRCGC Earth System Model (ESM)



AGCM

CCSR/NIES/FRCGC

T42 (~2.8°x2.8°)

L80 (TOA:80km)

OGCM

COCO (CCSR/FRCGC)

“Bended axis” grid system

(0.5-1.0)° x 1.4°

Also T85 without chemistry?

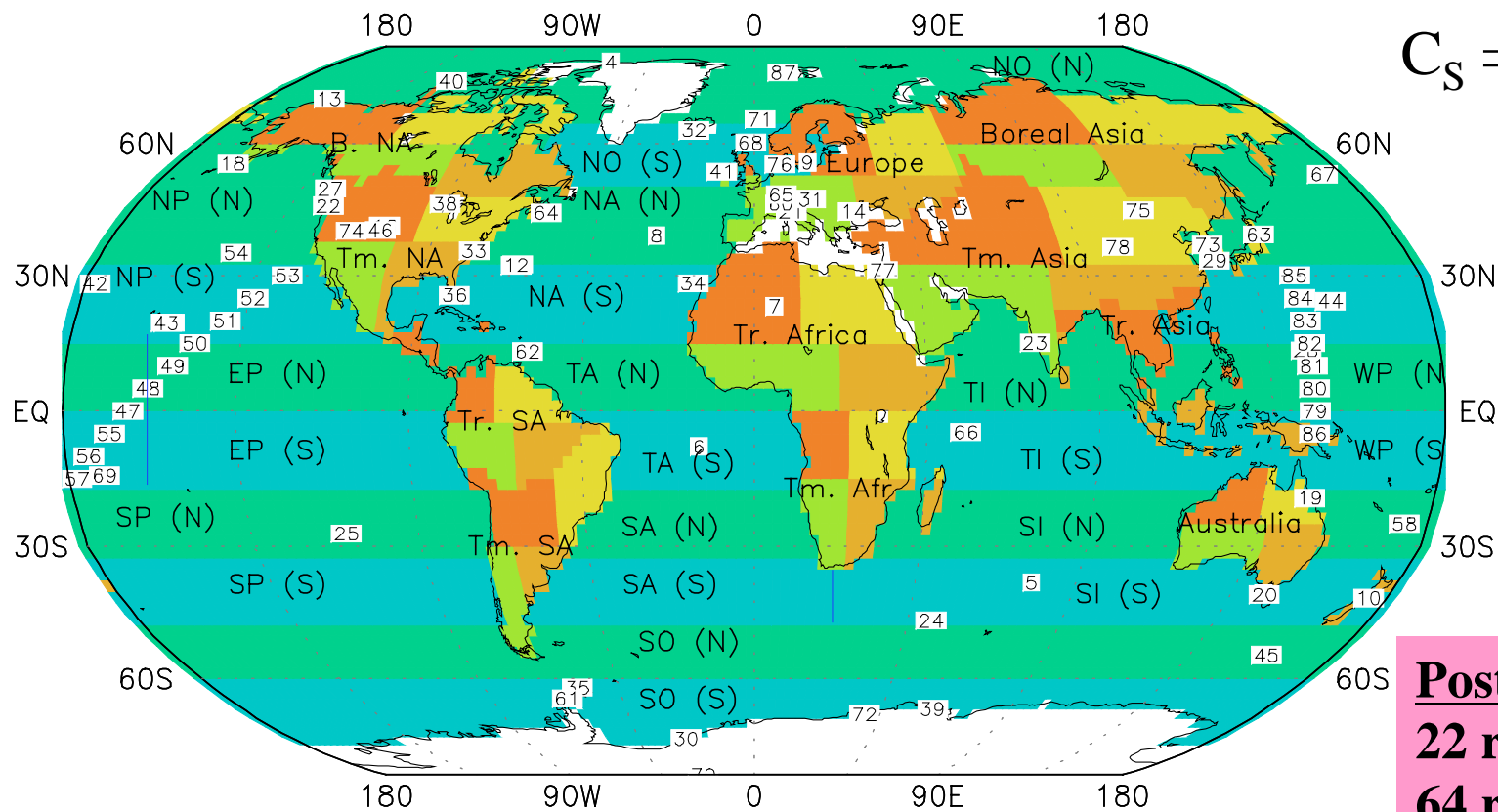


Observational Gap for data assimilation/inverse analysis

- Regional gap for atmospheric CO₂ observation: South America, Africa, Siberia, South and South East Asia
 - Inverse model needs extensive observation network
- Scale gap: e.g. Flux tower/Tall tower
 - point scale to regional scale Validation of estimated flux by inverse technique
- Combination of top down and bottom up approach
 - Decrease of uncertainty of CO₂ sink and source distribution/seasonal change/annual change
- Validation by multi-scale observational data set under GEOSS frame work

64-Regions Inverse Model

(using NIES/FRCGC CTM and interannually varying NCEP/NCAR reanalysis meteorology)



$$C_S = c_{s1} + c_{s2} \dots$$

Post Inversion χ^2

22 reg 2.15

64 reg 1.11

64+IAV 0.99

$$\chi^2 = \frac{1}{T} \left[\frac{1}{N} \sum_1^N [(D - D_{\text{predicted}})^2 / C_D + \frac{1}{M} \sum_1^M (S_0 - S)^2 / C_S] \right]$$

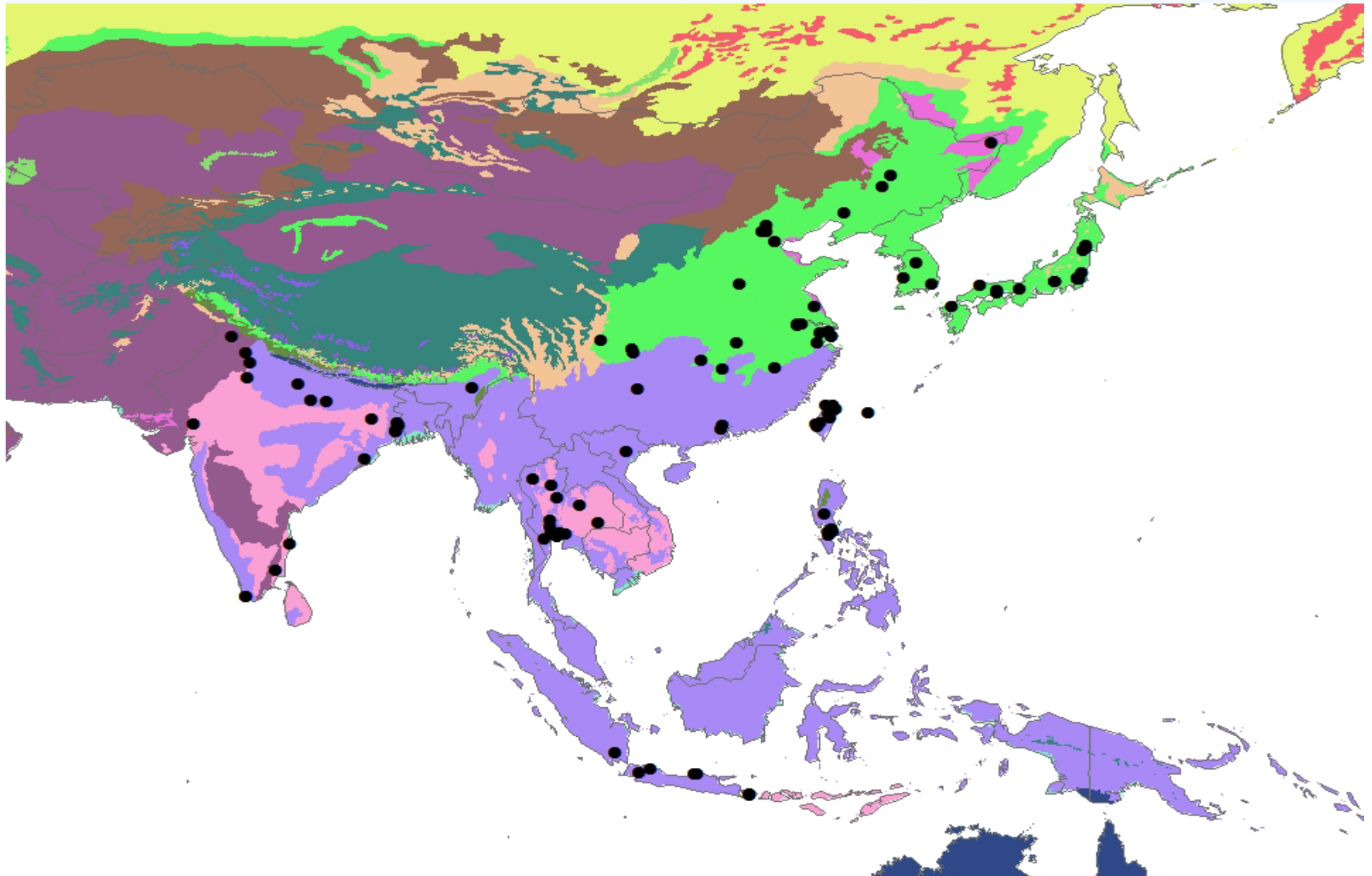
Patra et al., Global Biogeochem. Cycles., 2005a,b

From Patra's talk

Trace greenhouse gases (CH₄, N₂O)

- Difficulty in inverse technique
 - Possibility of top down approach? GOSAT?
- No observation network Just emission factor data base by IPCC inventory task force

Data documentation



Transfer of scientific understanding to developing countries

- Various groups of people
 - Researcher, Policy maker, Students, Citizen
- Translation of IPCC reports/GEOSSE product
 - local language, various media

Existing Data Exchange Platforms

- Atmosphere
 - WDCGG
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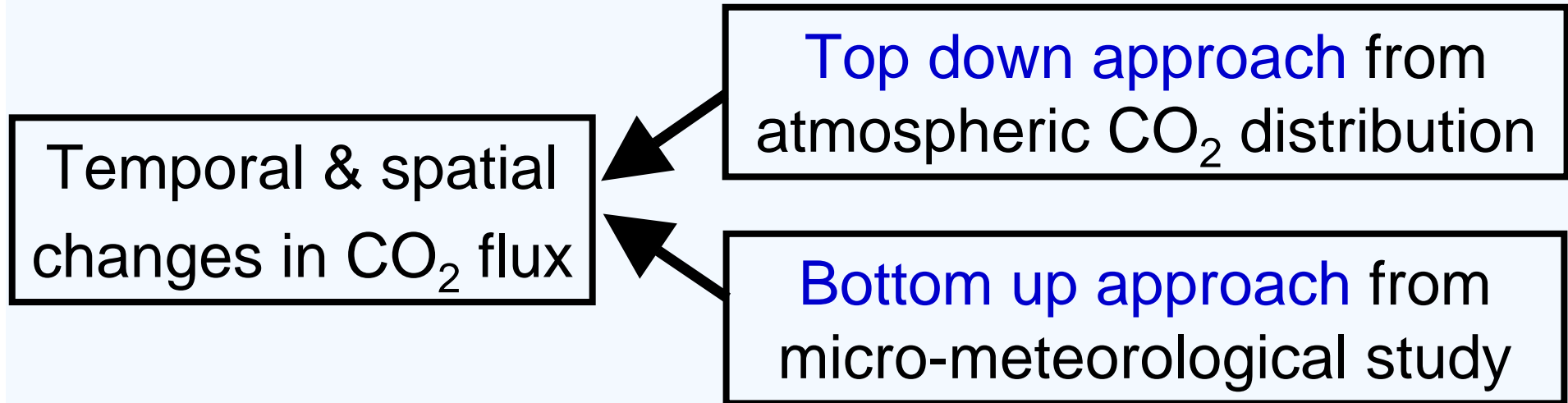
Stages of Observation

- Process study
- Research observation
- Operational observation

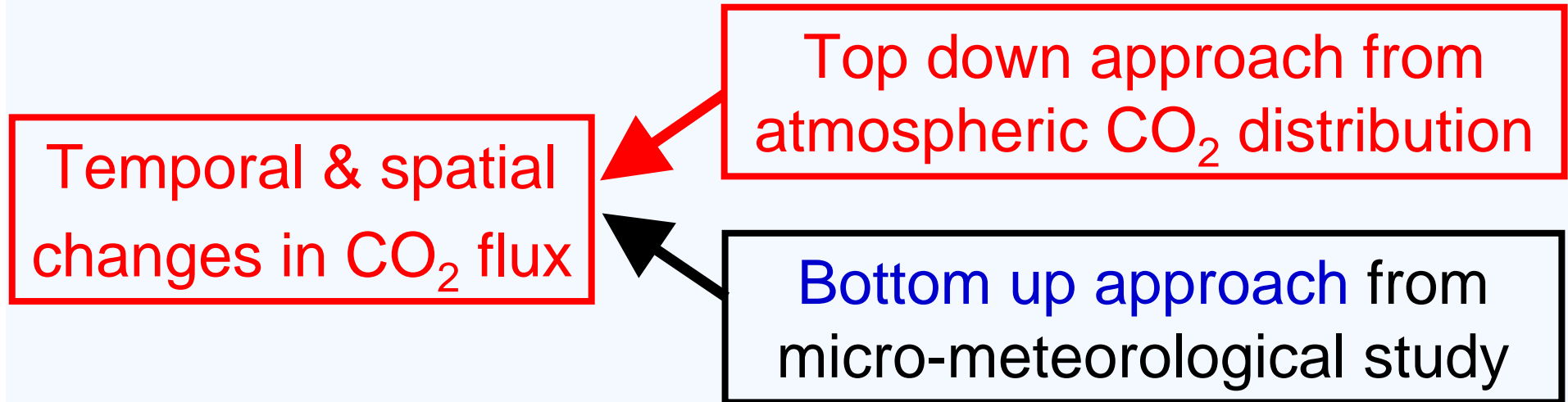
Complementary Relationship

- In-situ observation
- Remote sensing

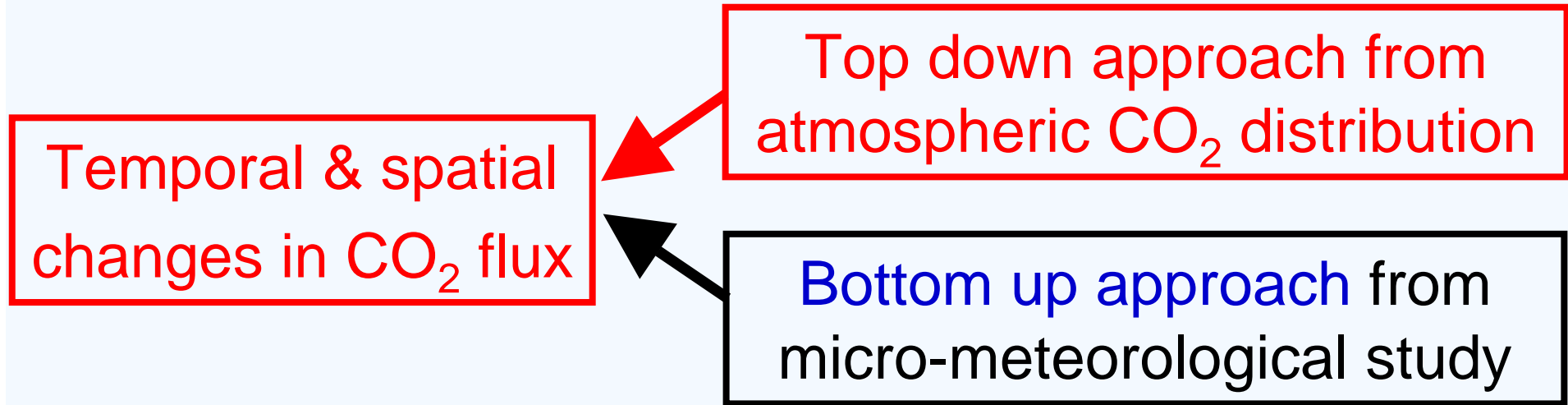
CO₂ flux estimation from atm. observation



CO₂ flux estimation from atm. observation



CO₂ flux estimation from atm. observation



Top down approach using:

Tracers

Global atmospheric CO₂

CO₂ flux estimation from atm. observation

Top down approach from atmospheric CO₂ distribution

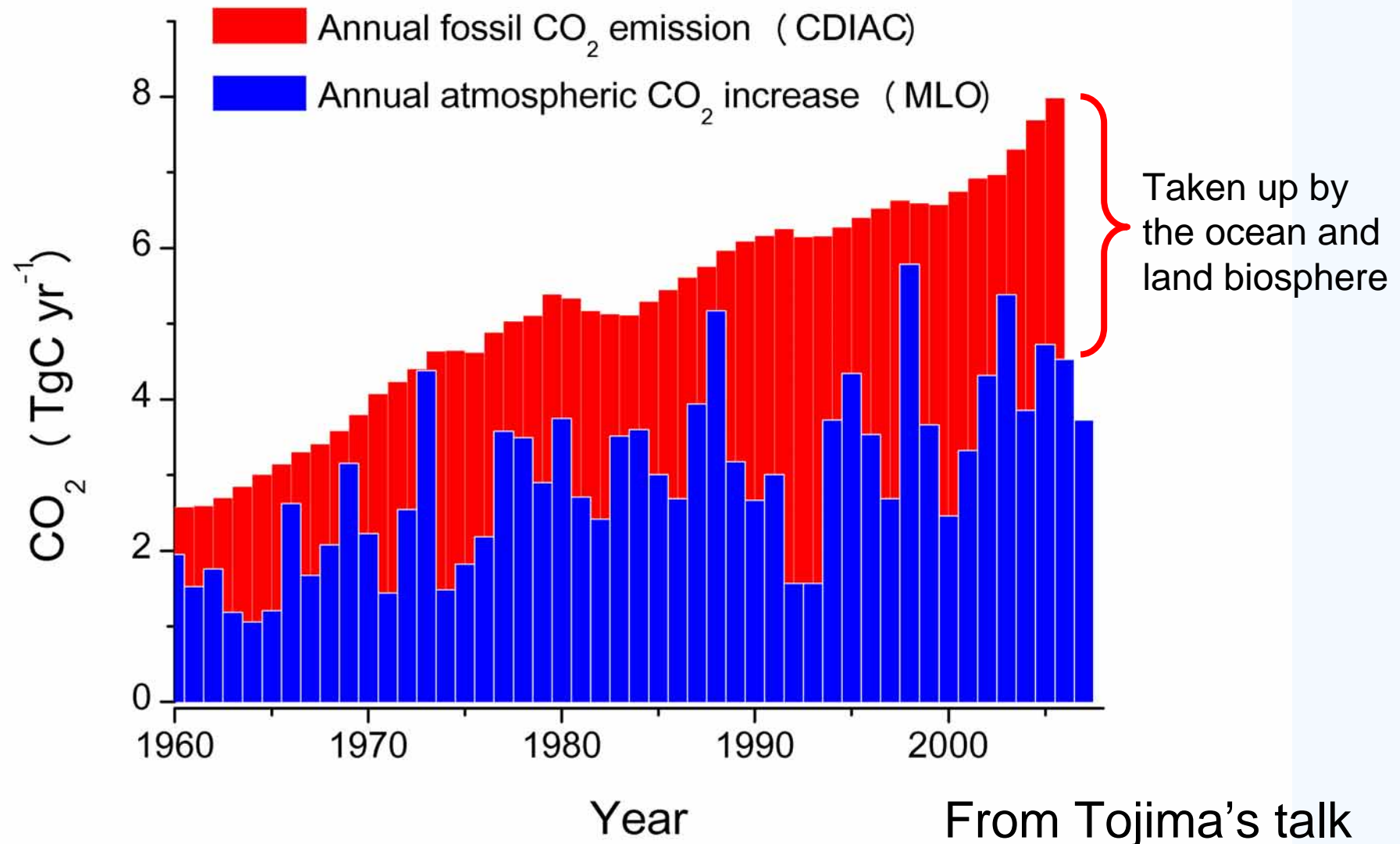
Temporal & spatial changes in CO₂ flux

Bottom up approach from micro-meteorological study

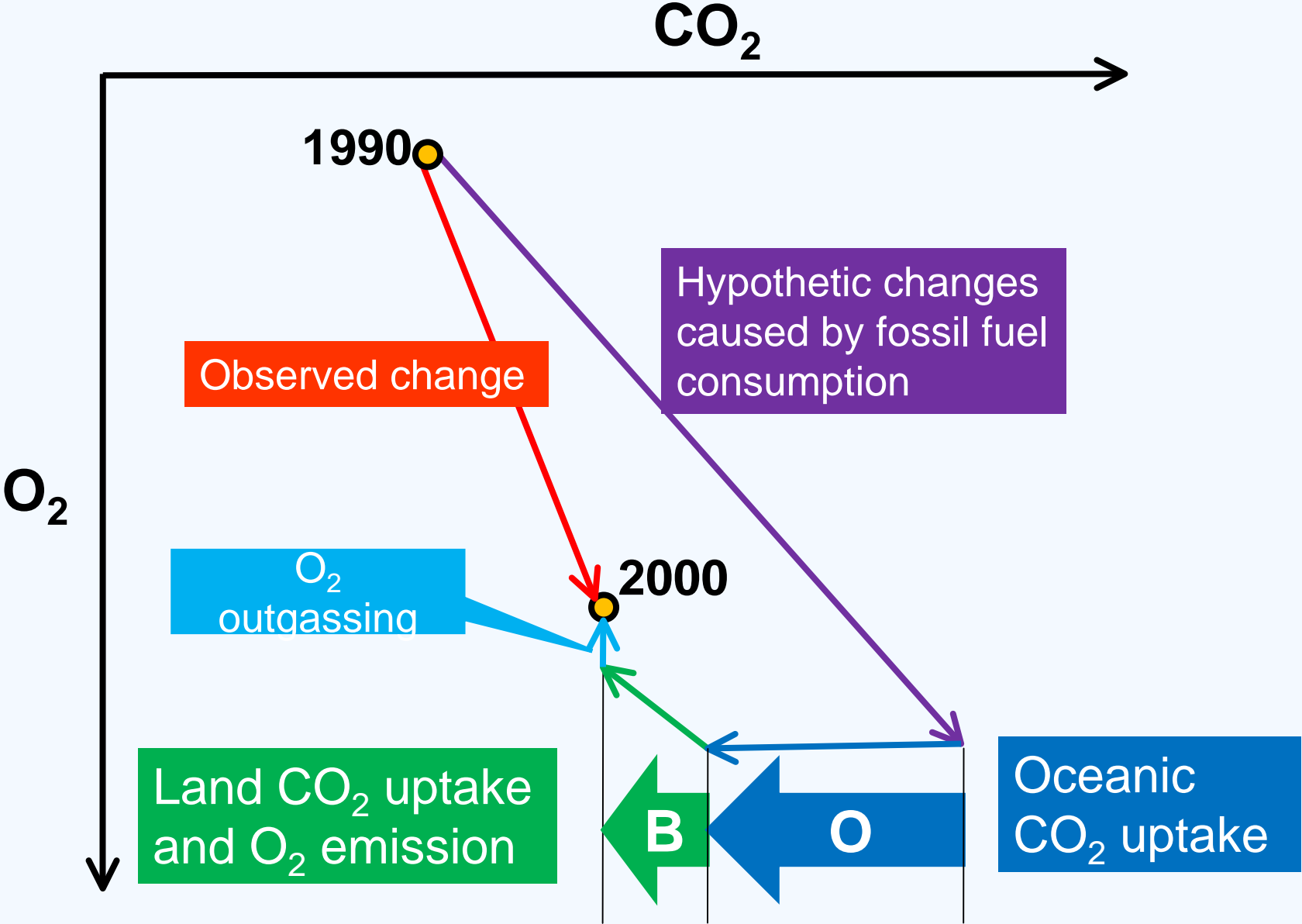
Tracers (← mass balance)

- Difference in isotopic fractionation of ¹³C
- Difference in O₂ efflux between terrestrial & oceanic ecosystems

Fossil CO₂ emission and atmospheric accumulation

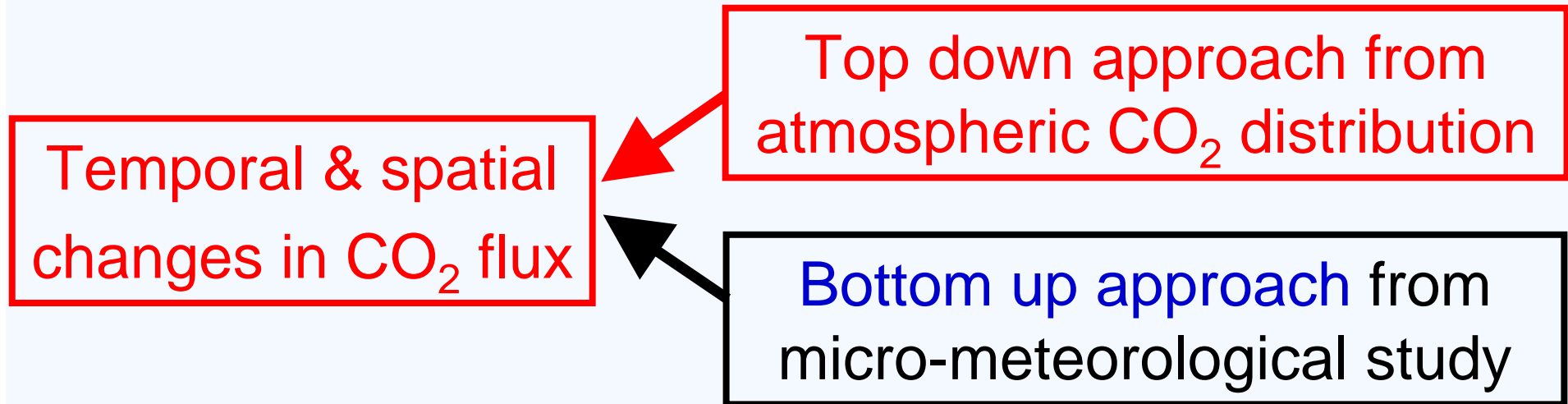


Graphical explanation of budget calculation



From Tojima's talk

CO₂ flux estimation from atm. observation



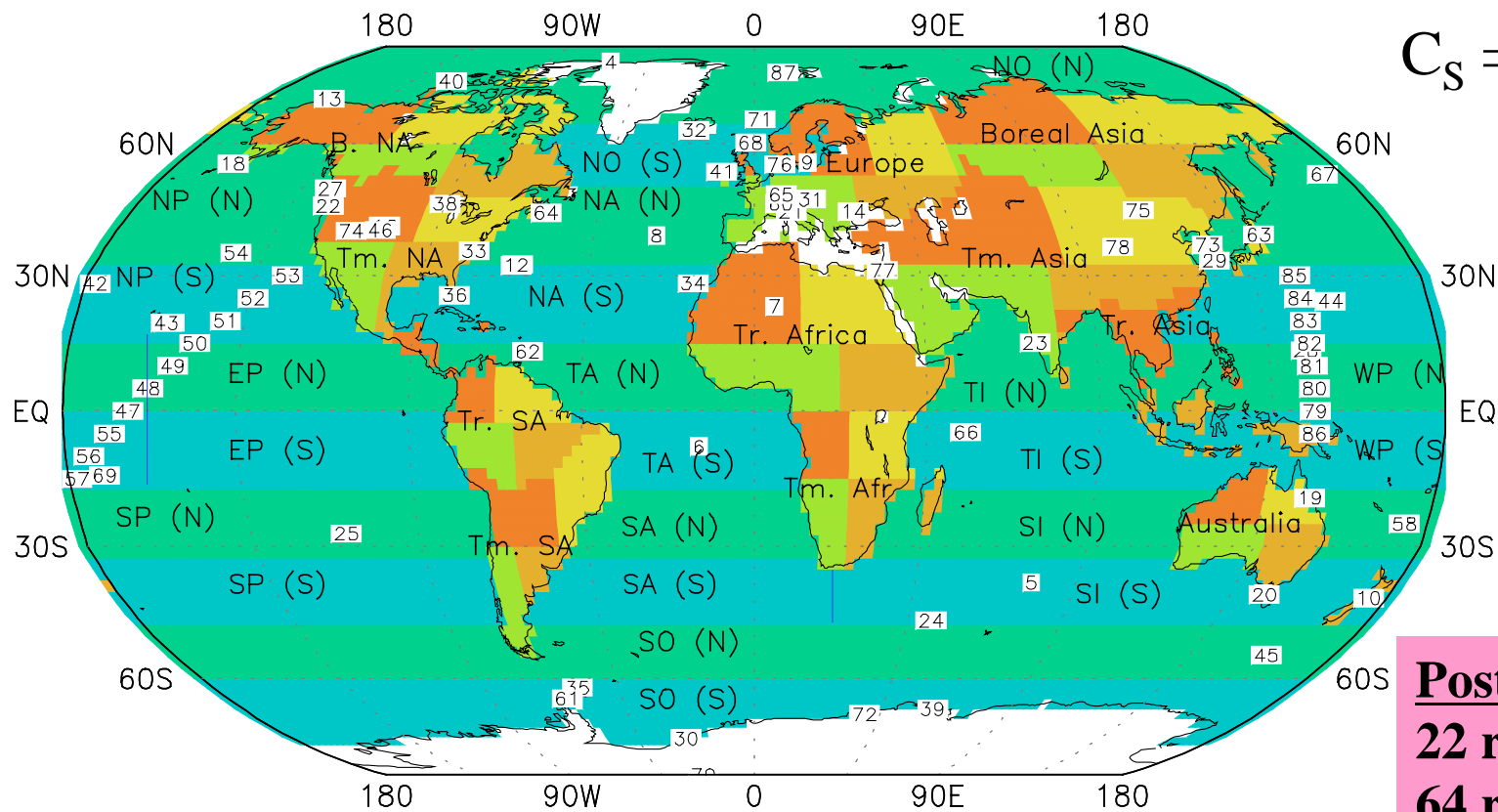
Global atmospheric CO₂

- Seasonal amplitude of atm. CO₂
- Inverse calculation of semi continental scales using atm. transportation model

Less quantitative

64-Regions Inverse Model

(using NIES/FRCGC CTM and interannually varying NCEP/NCAR reanalysis meteorology)



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Post Inversion χ^2

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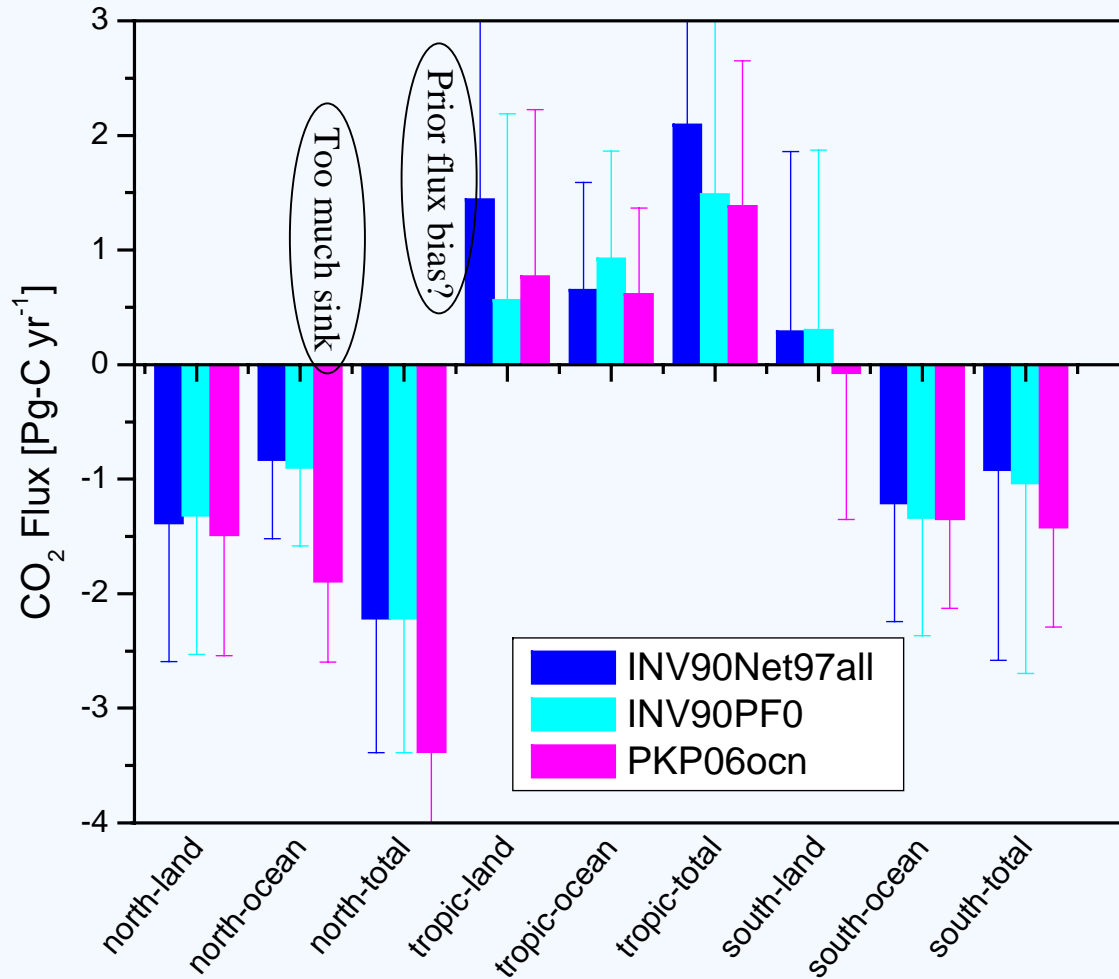
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Patra et al., Global Biogeochem. Cycles., 2005a,b

From Patra's talk

Importance of increased observation network and well validated model transport



INV90Net97all:
90region Inv. mod.,
97-site obs. Network,
Incl. land & ocean sites

INV90PF0: As above,
But with 0 Prior Flux

PKP06ocn: From
Patra et al. (GRL, 2006),
22-region Inv. mod.,
16 transport mod.,
Ocean only network

Patra et al., work in progress

From Patra's talk

Looks like, we can ingest data from the both Land & Ocean sites,
and Inverse model results can be free of initialization (prior flux)

Successful Launch of GOSAT (Jan. 23, 2009), a new tool for top down approach



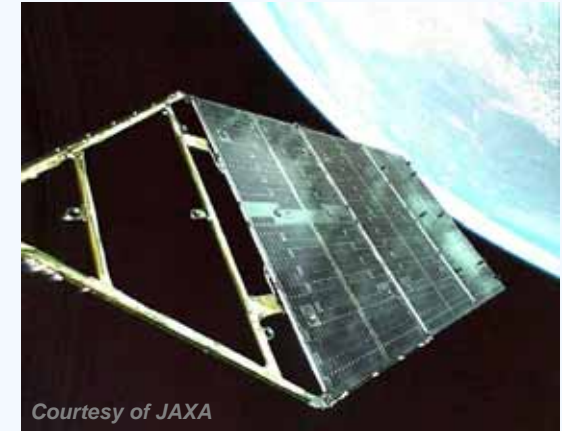
***Launch of H-IIA No. 15
at 12:54 (JST) on Jan. 23, 2009***

National Institute for Environmental Studies



***GOSAT in orbit
(CG)***

Courtesy of JAXA



***Successful deployment of
a solar paddle***

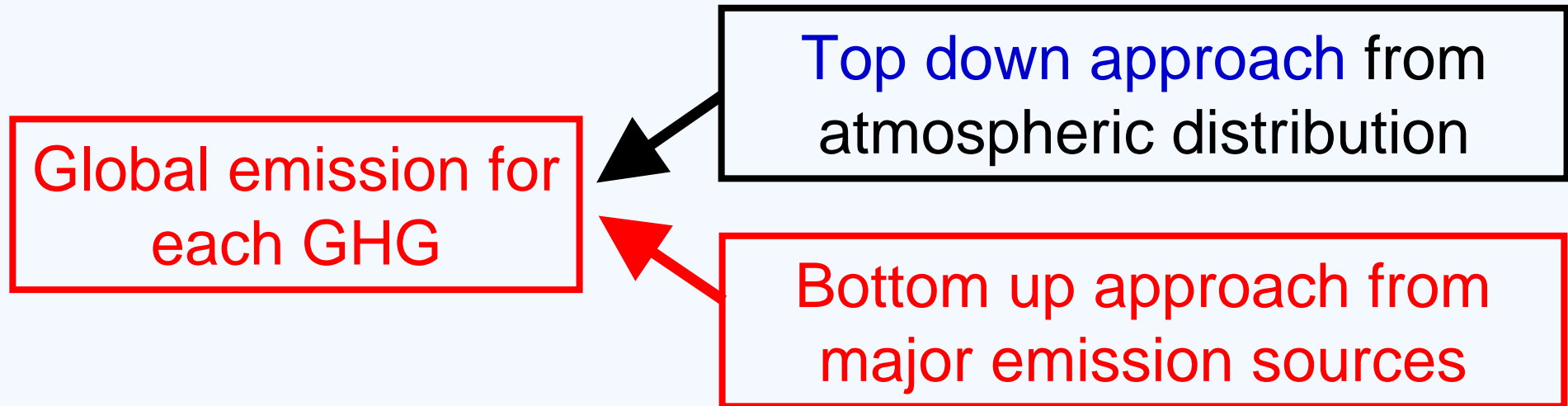
Courtesy of JAXA

GOSAT (Greenhouse Gases Observing Satellite) was launched successfully from JAXA's Tanegashima Space Center on January 23, 2009.

GOSAT completed its critical phase operation and started the initial functional verification phase operation which will last for three months.

GOSAT Level 2 products including atmospheric column CO₂ and CH₄ amounts will be freely available from NIES GOSAT website twelve months after the launch.

Flux estimation for GHG other than CO₂



Bottom up approach based on:

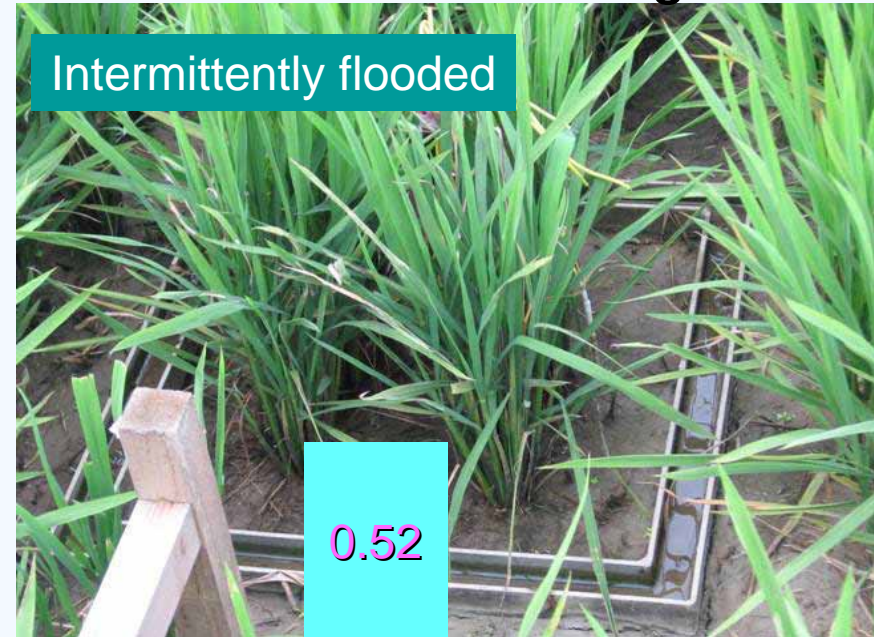
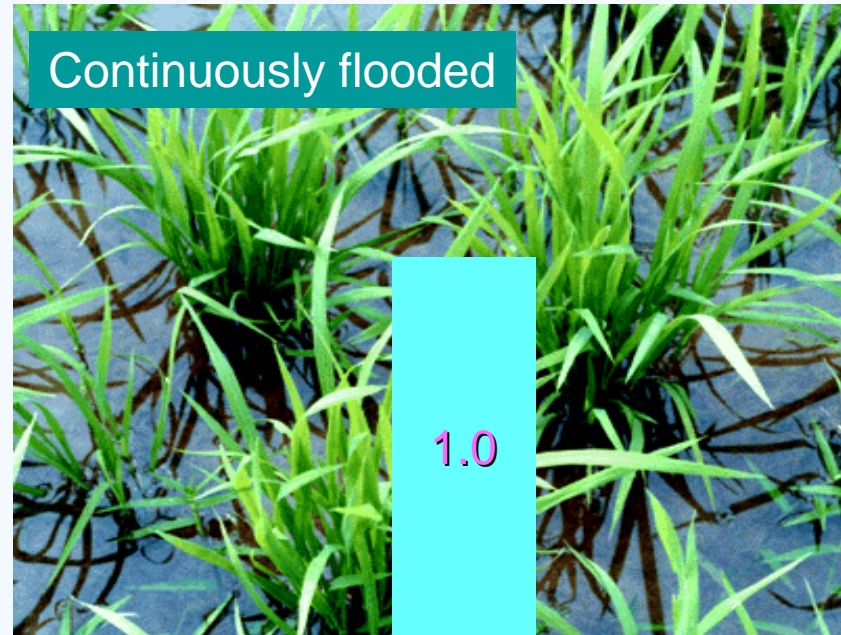
- Emission factors
- Activities of major sources

Need: Improvement of accuracy

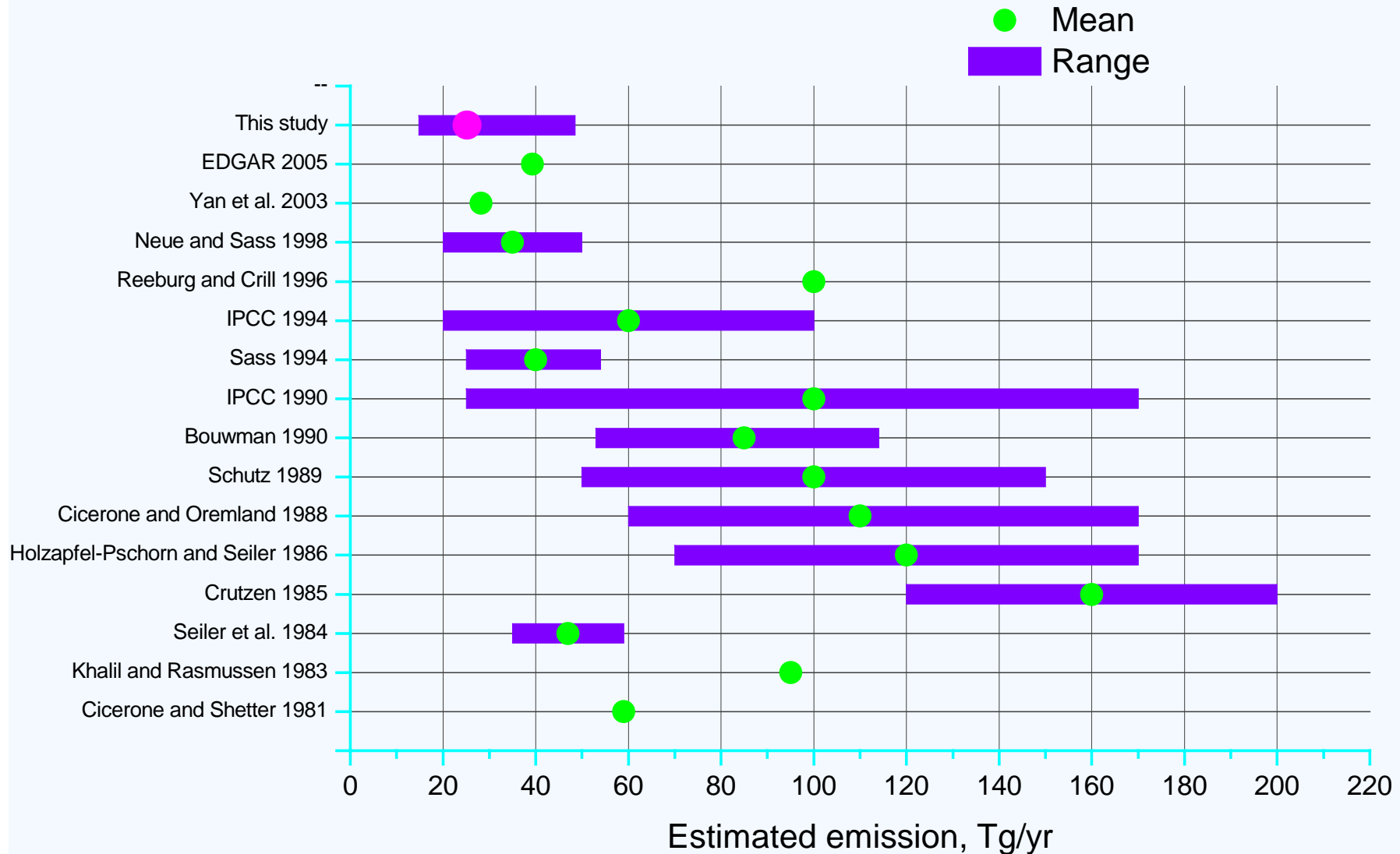
Top down approach is still difficult

Emission factor of CH₄ from rice paddy

From Yang's talk

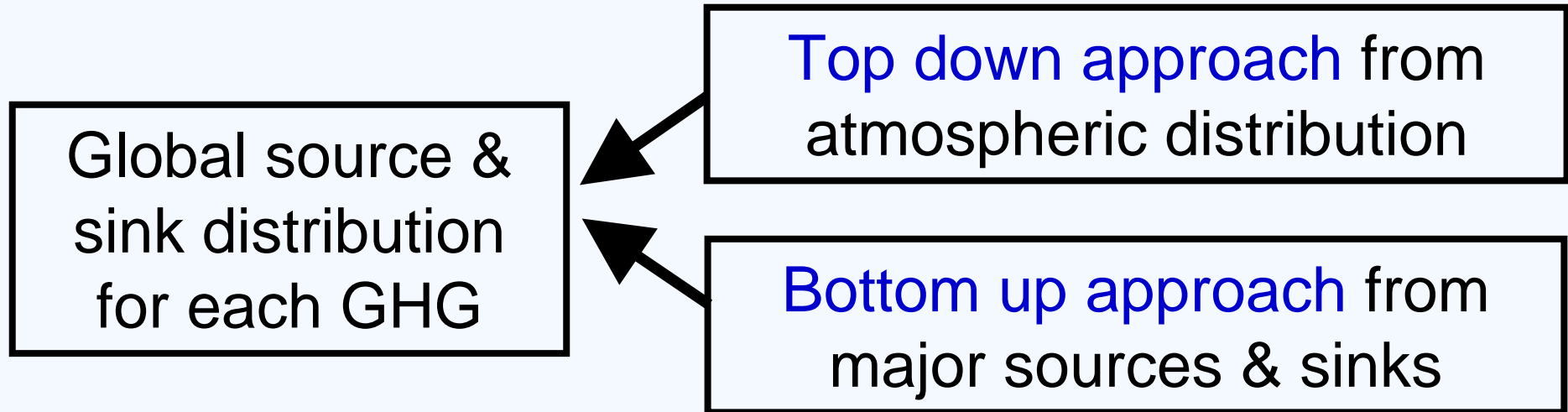


Comparison global CH₄ emission estimates



From Yang's talk

Prediction of future GHG exchanges



Needs:

- ✓ Prediction of climate feedback
- ✓ Adaptation strategy
- ✓ Uncertainty reduction in ocean & terrestrial processes

Research needs and issues to be addressed

- ◆ Better simulation of physical and biogeochemical processes sufficiently reflecting feedbacks
→ *Advancing climate modeling and projection*
- ◆ Addressing uncertainties in climate model projection
→ *Quantification and reduction of uncertainty*
- ◆ Impact assessment on natural disasters by extreme events through sufficiently high resolution projection
→ *Application of regional projection to natural disasters*

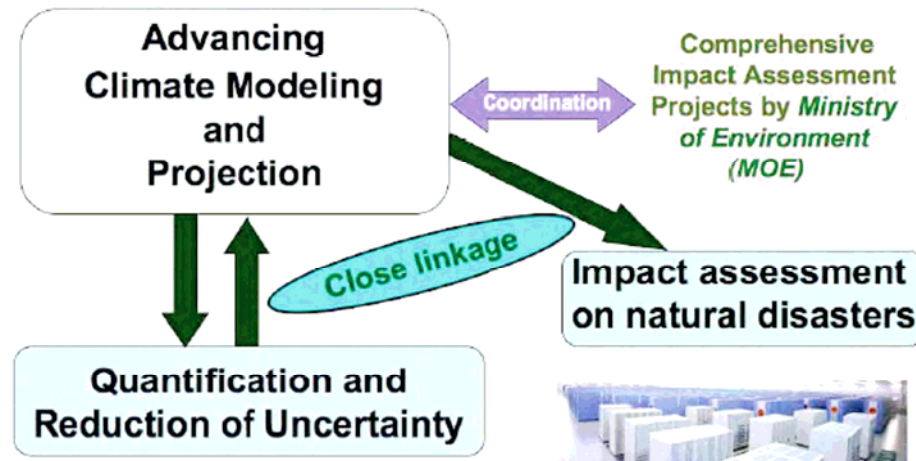
Innovative Program of Climate Change Projection for the 21st century (KAKUSHIN Program)

FY2007-FY2011



KAKUSHIN

Program structure



Participating groups and their studies

- ◆ *Long-term global environmental projection with an earth system model*
 - Frontier Research Center for Global Change (FRCGC) et al.
- ◆ *Near-term climate prediction with a high-resolution coupled ocean-atmosphere GCM*
 - Center for Climate System Research (CCSR) of the University of Tokyo et al.
- ◆ *Projection of changes in extremes in the future with super-high-resolution atmospheric models*
 - Meteorological Research Institute (MRI) et al.

<http://www.kakushin21.jp/eng/index.html>

From Koto's talk