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Emission Inventory of Air Pollutants for East Asia and Regional Air Quality Modeling

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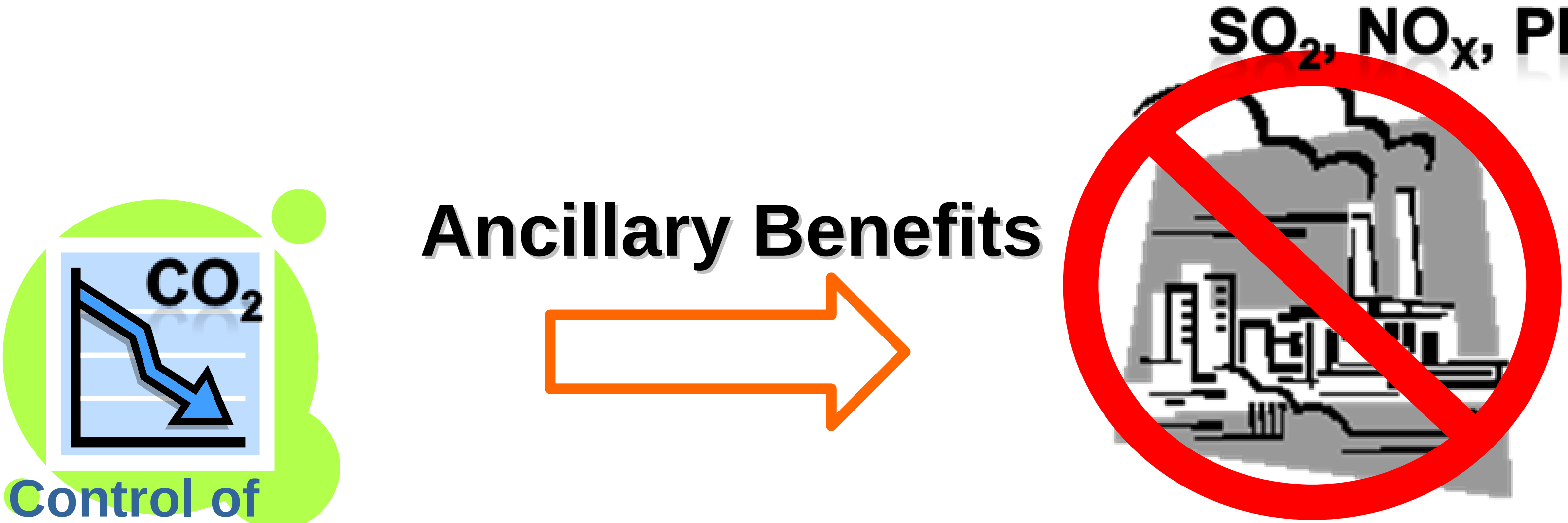
Contents

- Background of the study
  (Ancillary Benefits / Co-Benefits)
- Model outline
- Development of the Calibration Method by Source – Receptor Analysis.
- Results
- Challenges for future

Background (1)

- **"Ancillary Benefits of Climate Change Policies to the Air Quality" (or Co-benefits between both policy) is considered to be very important to promote the installation of countermeasures of climate change, especially for developing countries.**



SO_2, NO_X, PM

Ancillary Benefits

Control of GHG Emission

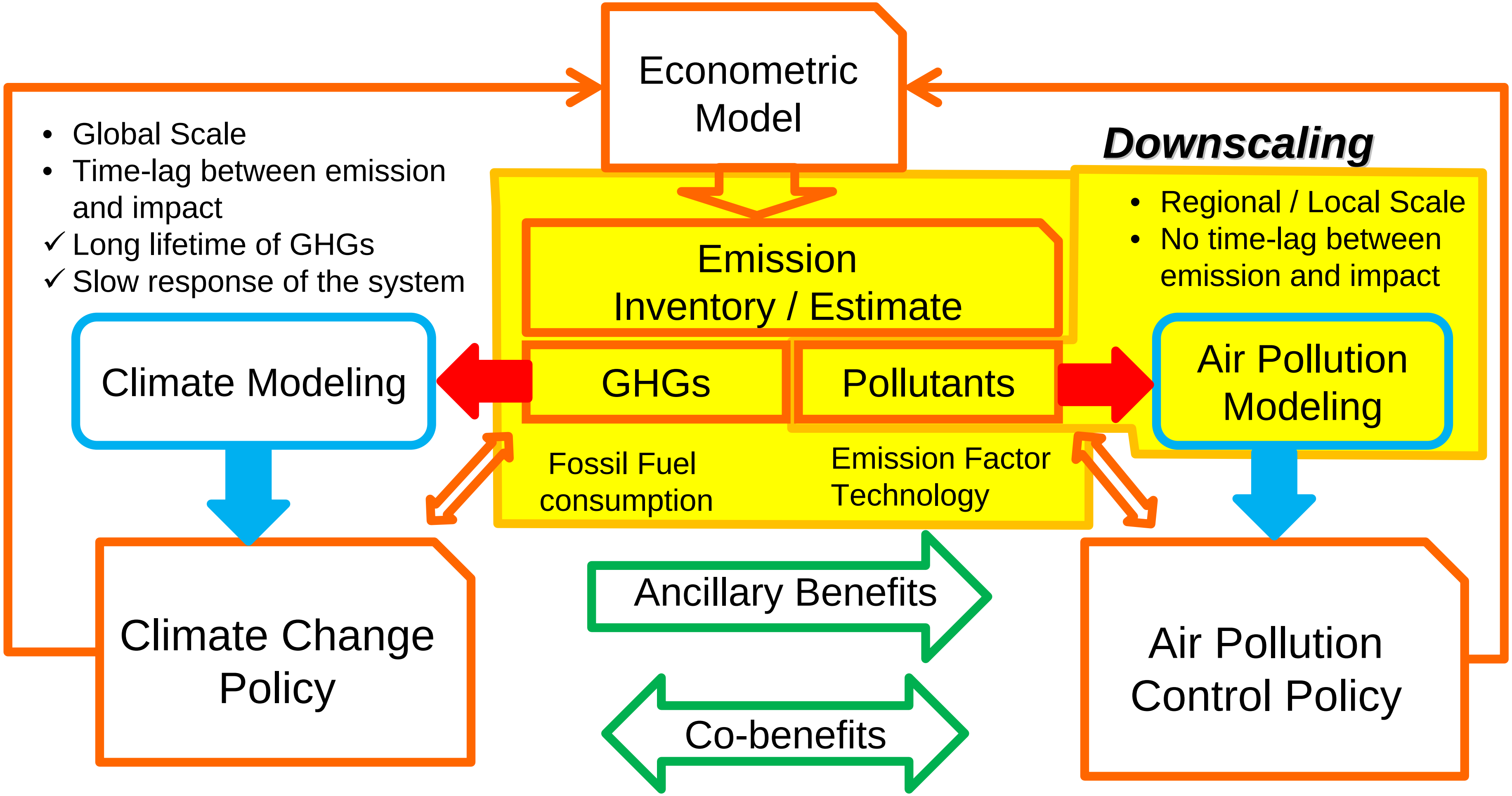
Decrease the cost of Air Pollution Control

Background (2)

- To evaluate the "Ancillary Benefits of Climate Change Policies to the Air Quality", it is necessary to integrate the air pollution control policy into climate change policy.
- IPCC 4th assessment report suggest more research for ancillary benefits (or Co-benefits) between GHG and air pollution policies. (There are still many uncertainties; Change in emission of gaseous and particulate species in the future, human and ecological impact of air pollutants, future cost for air pollution control, etc.)

Outline of the study

How to integrate the ancillary benefits into the current model framework.



Econometric Model

- Global Scale
- Time-lag between emission and impact

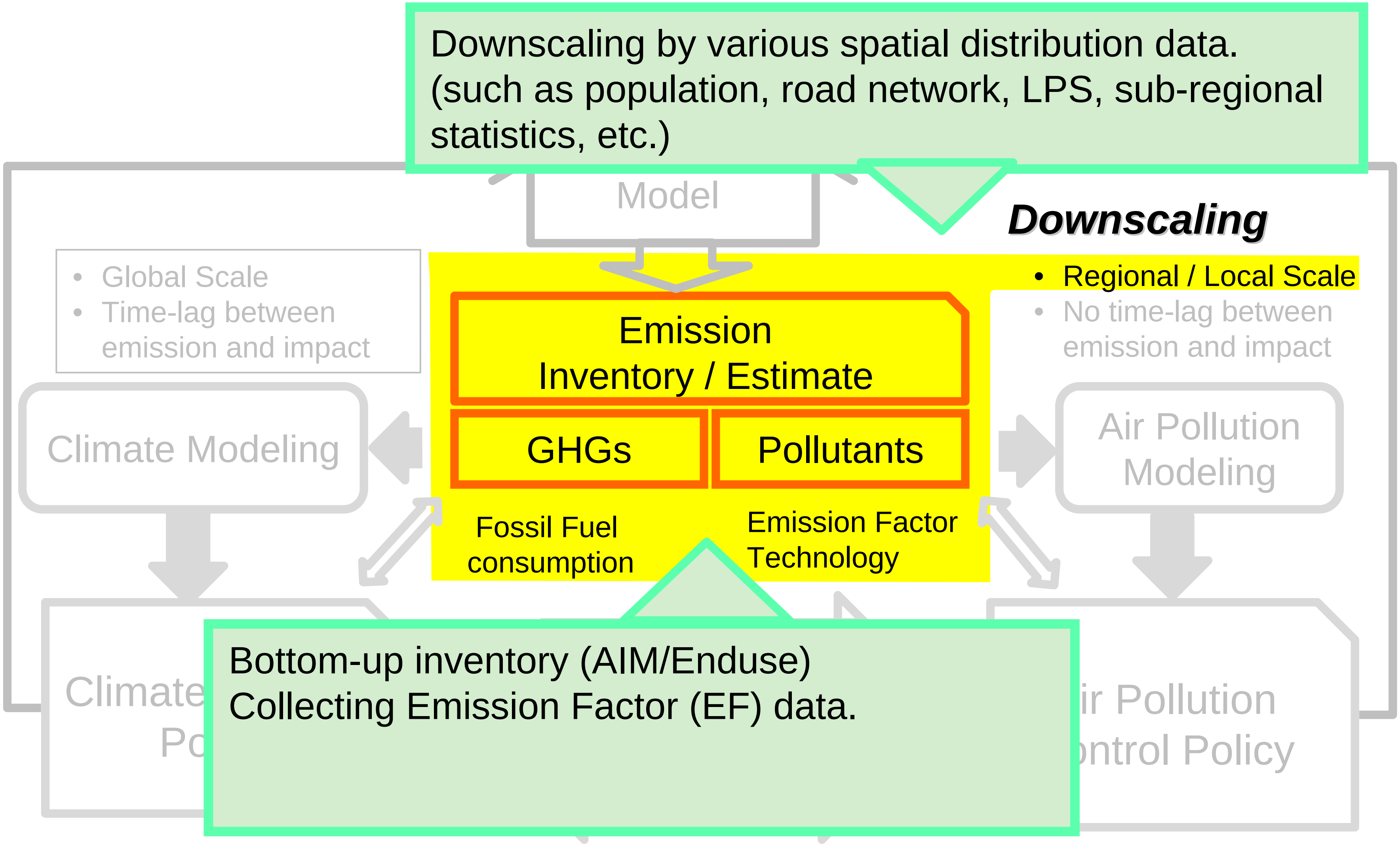
✓ Long lifetime of GHGs
✓ Slow response of the system

Downscaling

- Regional / Local Scale
- No time-lag between emission and impact

Emission Inventory and Downscaling

Downscaling by various spatial distribution data. (such as population, road network, LPS, sub-regional statistics, etc.)



Model

Downscaling

- Global Scale
- Time-lag between emission and impact

- Regional / Local Scale
- No time-lag between emission and impact

Emission Inventory / Estimate

GHGs

Pollutants

Climate Modeling

Air Pollution Modeling

Fossil Fuel consumption

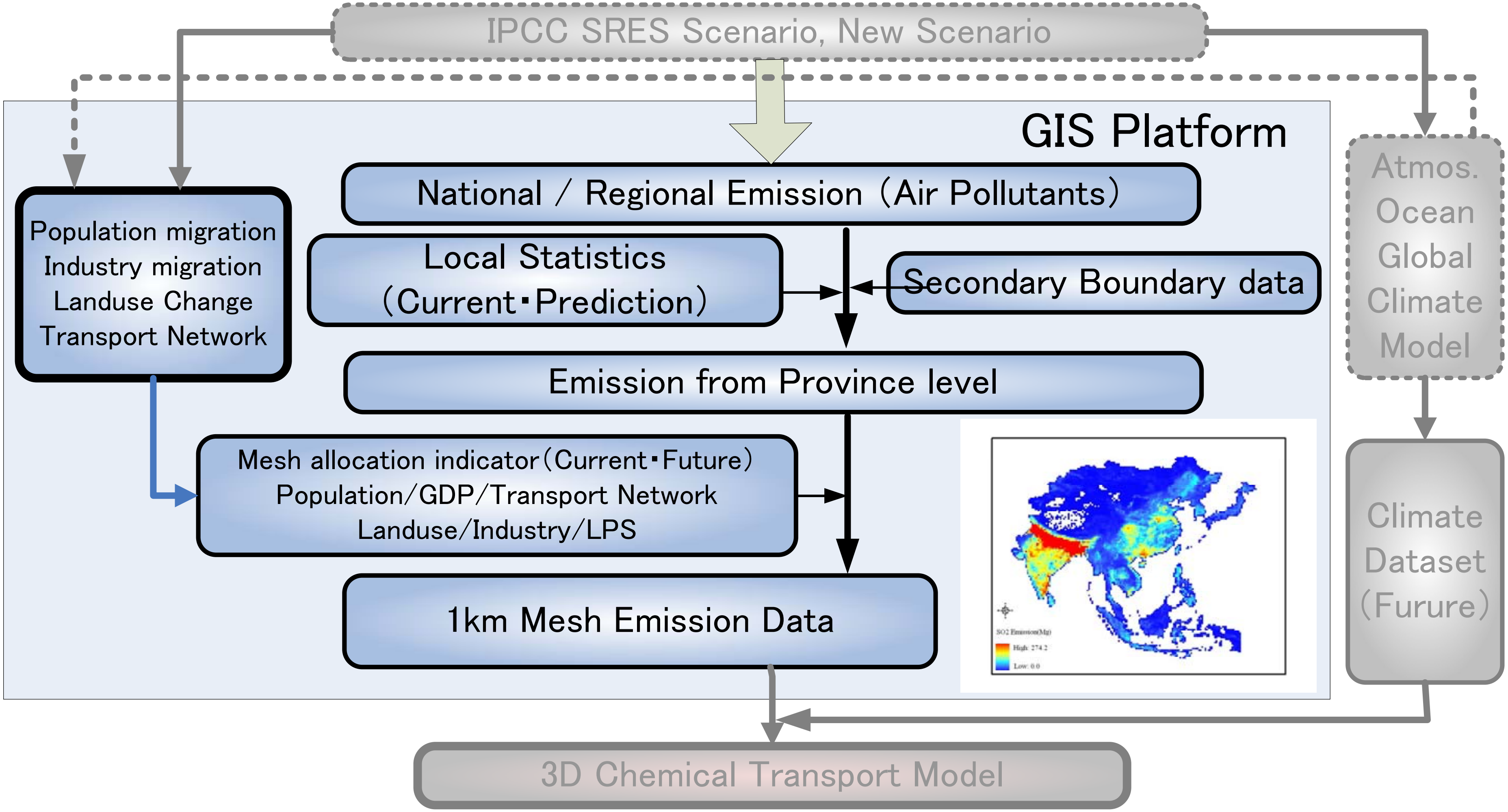
Emission Factor Technology

Climate Po

ir Pollution ntrol Policy

Bottom-up inventory (AIM/Enduse)
Collecting Emission Factor (EF) data.

GIS Platform for Downscaling



IPCC SRES Scenario, New Scenario

GIS Platform

National / Regional Emission（Air Pollutants）

Population migration
Industry migration
Landuse Change
Transport Network

Local Statistics
（Current･Prediction）

Secondary Boundary data

Emission from Province level

Mesh allocation indicator（Current･Future）
Population/GDP/Transport Network
Landuse/Industry/LPS

1km Mesh Emission Data

Atmos.
Ocean
Global
Climate
Model

Climate
Dataset
（Furure）

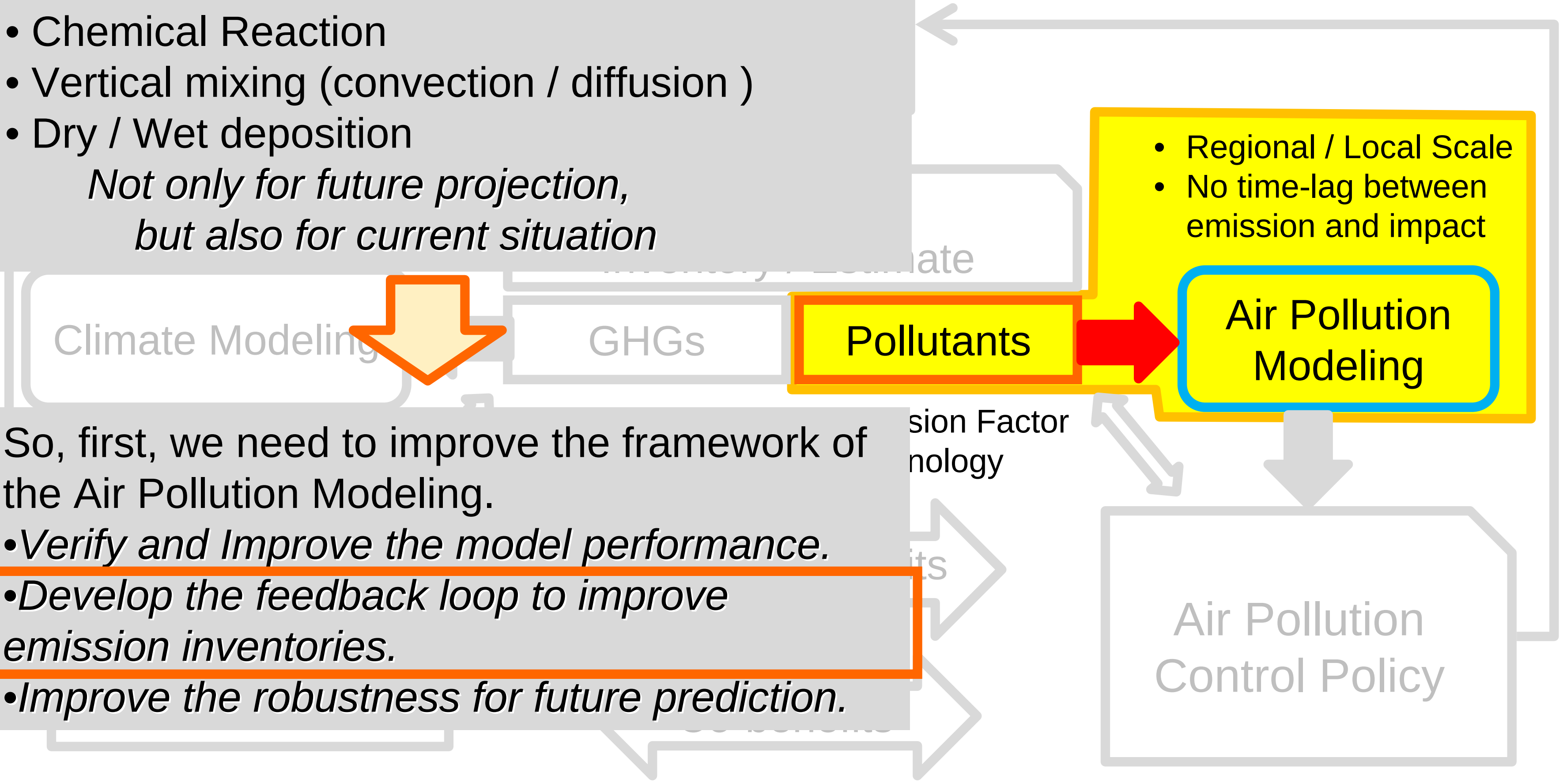
3D Chemical Transport Model

Air pollution modeling

There are still very large uncertainties …

- Activities
- Emission Factor
- Chemical Reaction
- Vertical mixing (convection / diffusion)
- Dry / Wet deposition

Not only for future projection,
but also for current situation



- Regional / Local Scale
- No time-lag between emission and impact

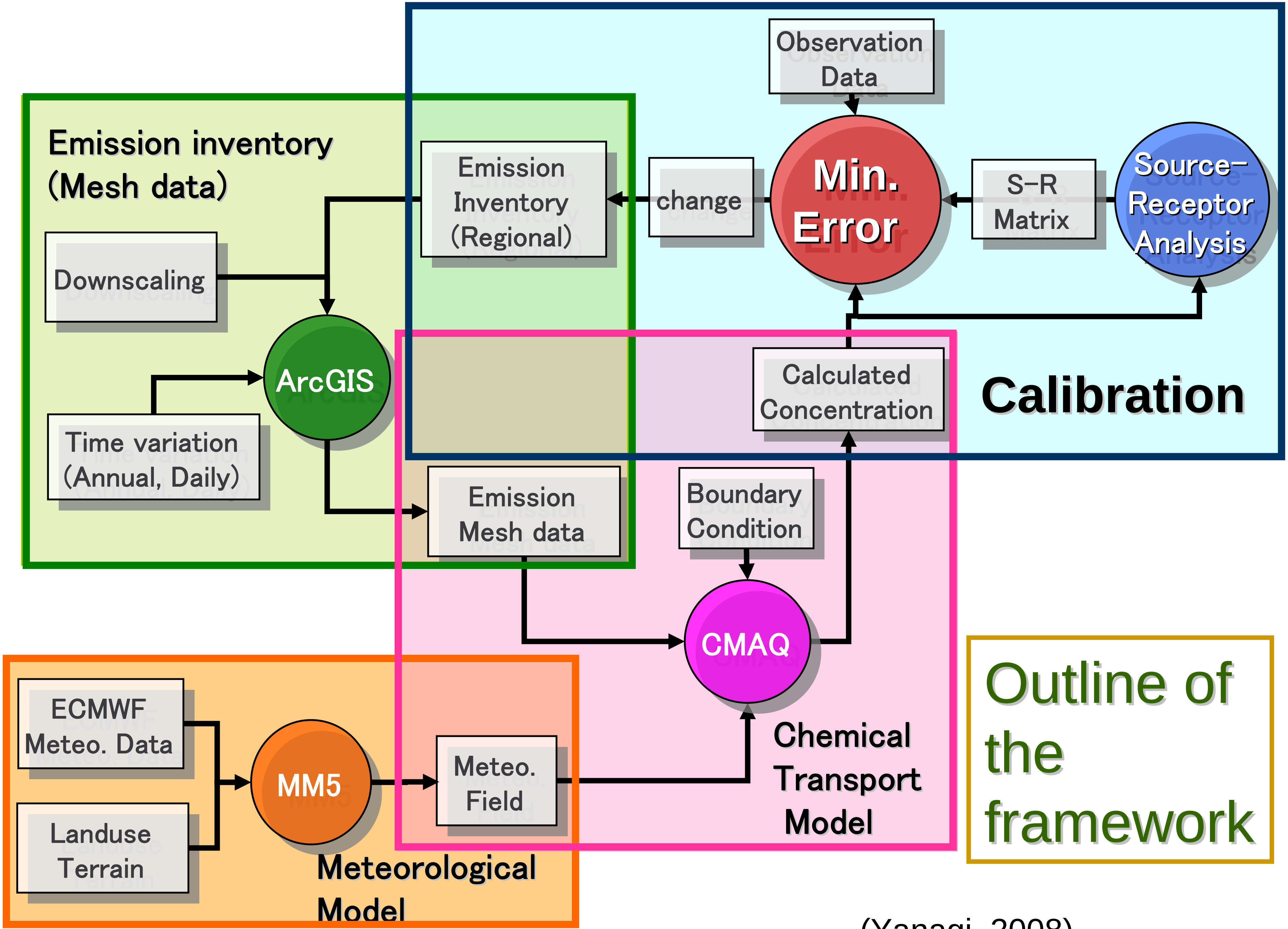
So, first, we need to improve the framework of the Air Pollution Modeling.

•*Verify and Improve the model performance.*

•*Develop the feedback loop to improve emission inventories.*

•*Improve the robustness for future prediction.*

Outline of the framework



Emission inventory (Mesh data)

Downscaling

Time variation (Annual, Daily)

ArcGIS

Emission Inventory (Regional)

Emission Mesh data

Calibration

Observation Data

change

Min. Error

S-R Matrix

Source-Receptor Analysis

Calculated Concentration

Boundary Condition

CMAQ

Chemical Transport Model

ECMWF Meteo. Data

Landuse Terrain

MM5

Meteo. Field

Meteorological Model

(Yanagi, 2008)

Target Area

- Domain

  East and South Asia

  - ☐ **Grid size**

    80km

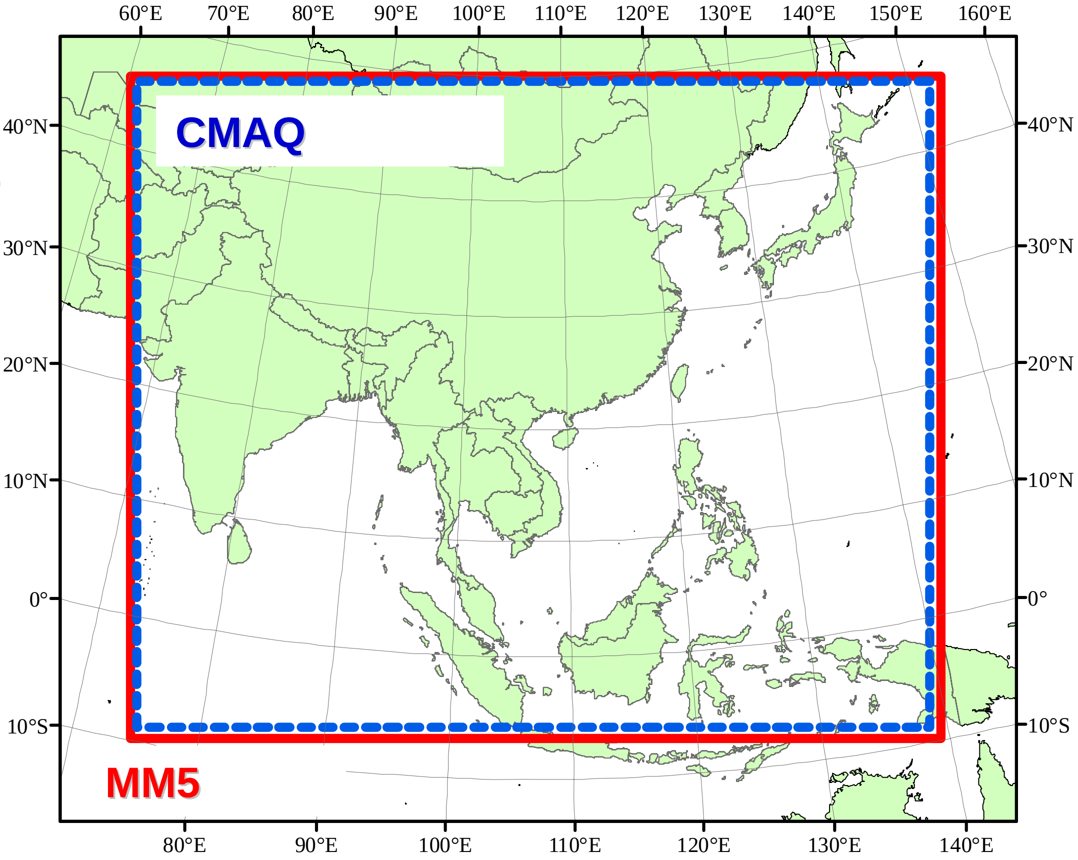
  - ☐ **Number of Grids**

    MM5 100 x 82

    ▭

    CMAQ 97 x 79

    ⬚



(Yanagi, 2008)

- Target species

  CO(Carbon monoxide)

  reason: lifetime in the free troposphere is about 1-2 month

  →Suitable for calibration

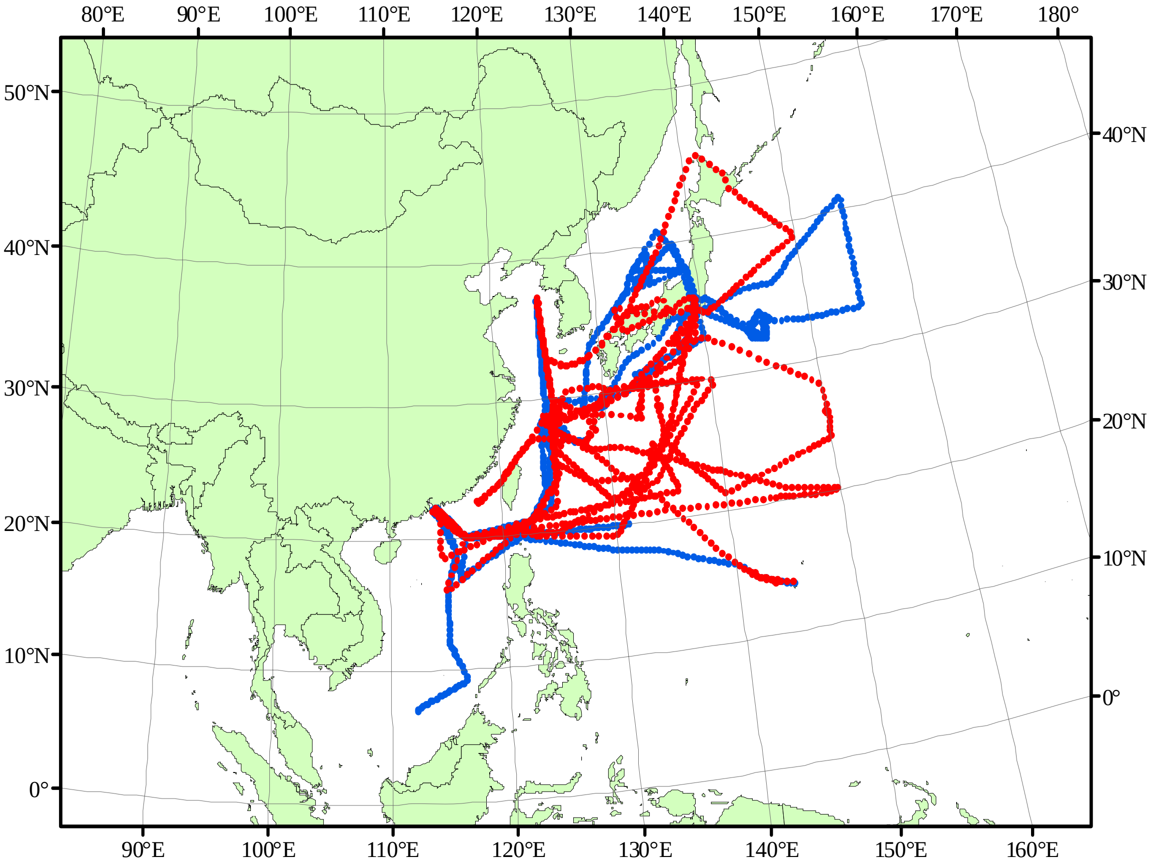
Used observation data

- **TRACE-P** **:Transport and Chemical Evolution over the Pacific**
  - Feb. – Apr. 2001
  - NASA GTE
    - DC8

    - P3B

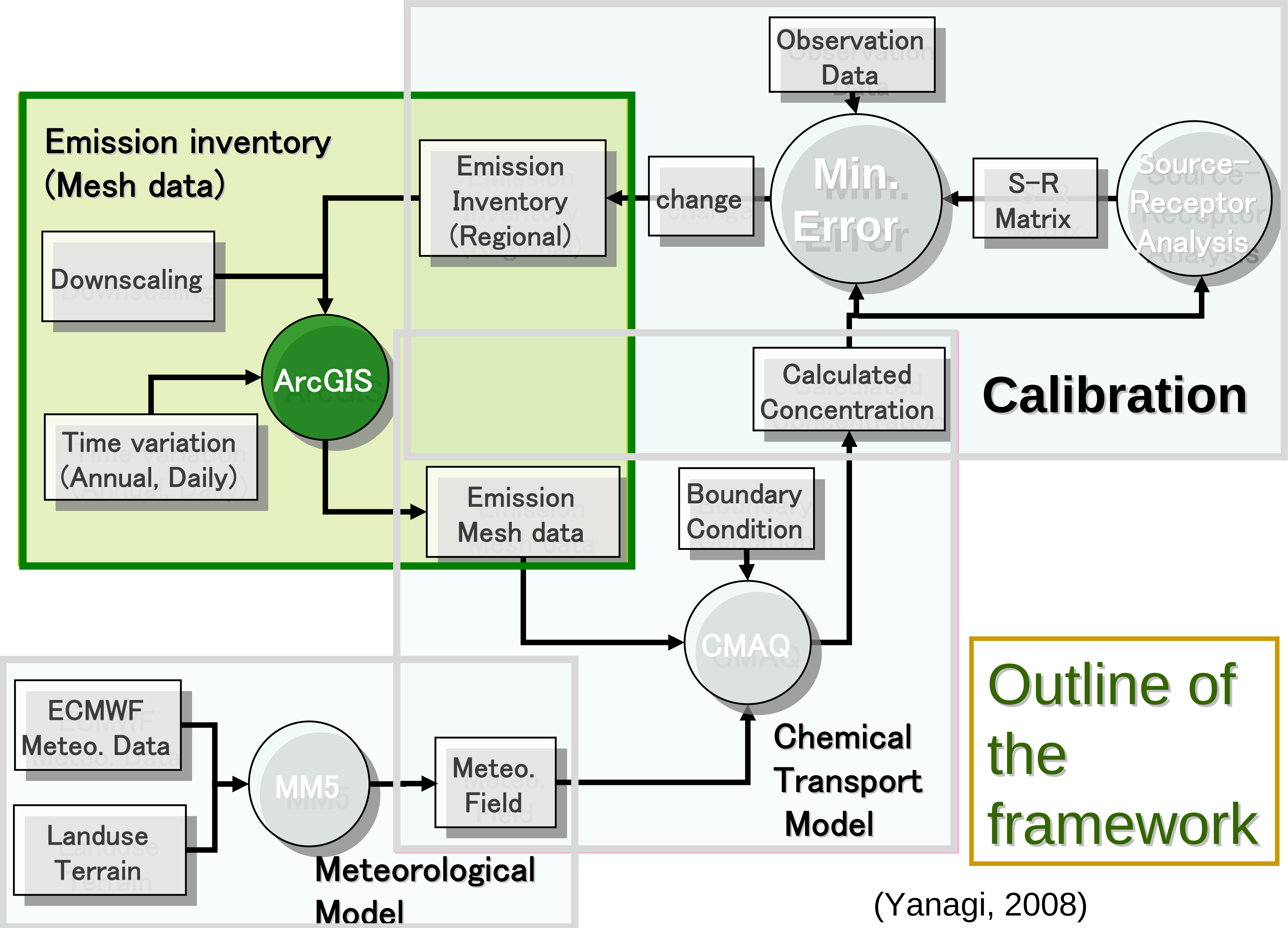
Flight Truck of ;

🔴 : DC8
🔵 : P3B



(Yanagi, 2008)

Outline of the framework



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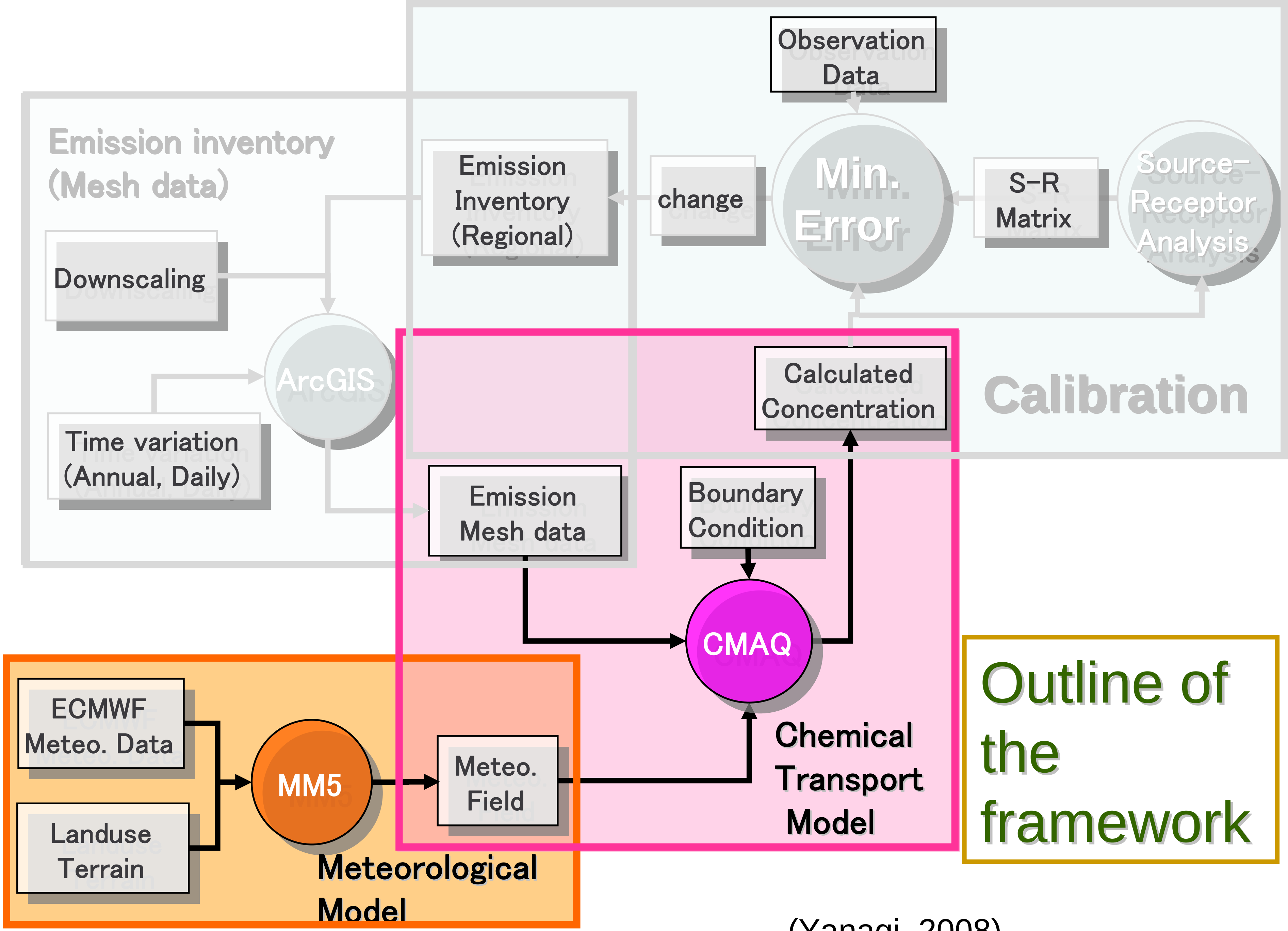
(Yanagi, 2008)

Emission inventory

- Used inventories
  - **Anthropogenic**･･･Streets *et al*.(2003), EDGAR3.2 Fast Track (Olivier *et al*.2005)
  - **Daily Biomass Burning** ･･･ABBI (Asian Biomass Burning Inventory) (Michel *et al*., 2005)

- We classified emission source to four group.
  - **Anthropogenic (China / Other countries)**
  - **Biomass Burning**
  - **Background**（i.e. Boundary condition）

Outline of the framework



Emission inventory (Mesh data)

Downscaling

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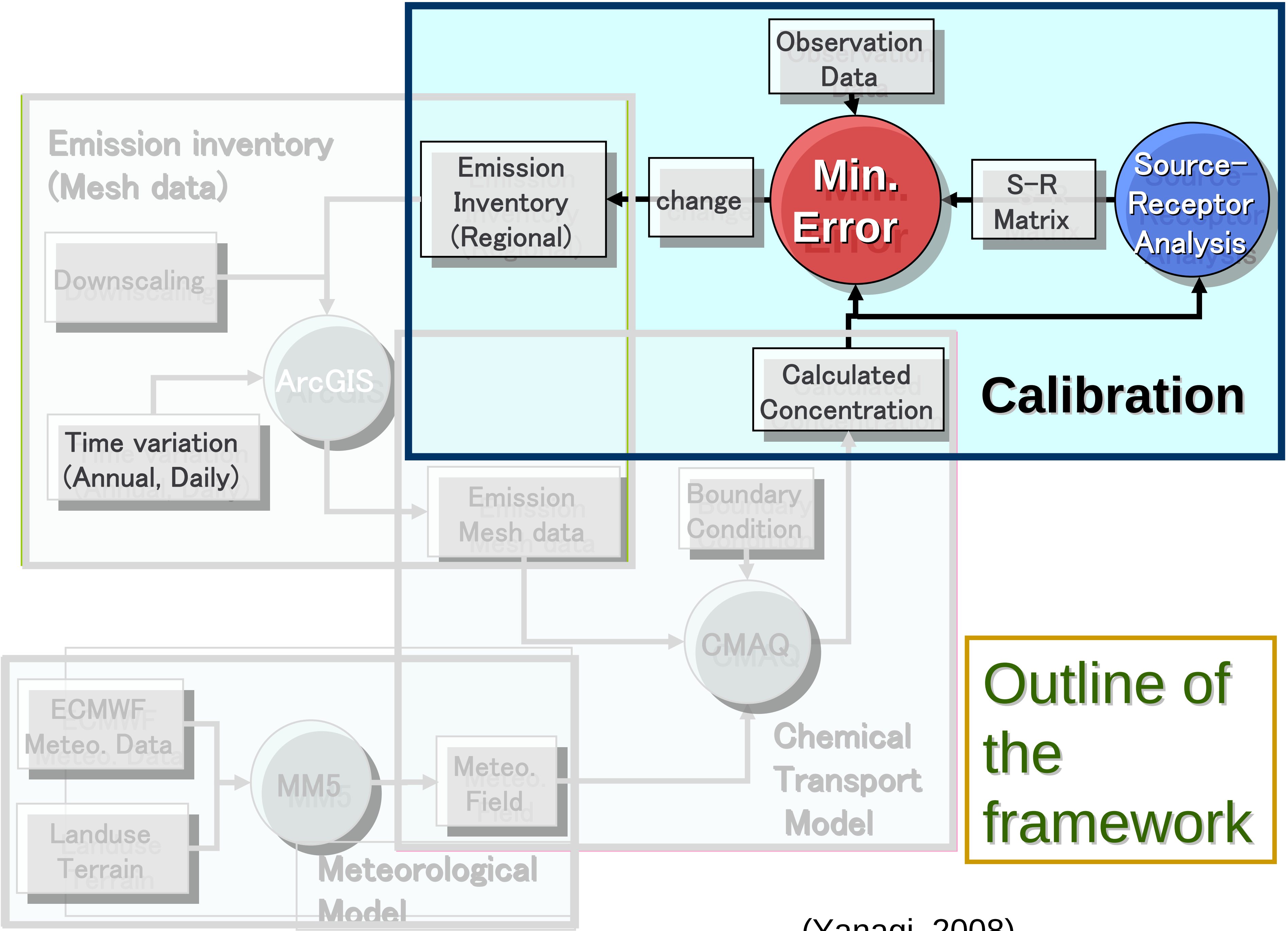
Meteorological Model

(Yanagi, 2008)

Meso-scale Meteorological Model and Chemical Transport Model

- **MM5** : **5th Generation Mesoscale Model**
  - Developed by Pennsylvania State Univ.(PSU) and National Center for Atmospheric Research(NCAR, USA)
- **CMAQ** : **Community Multiscale Air Quality Model**
  - Developed by US/EPA
  - 3D Eulerian type Chemical Transport Model

Outline of the framework



(Yanagi, 2008)

Calibration Method

Following 4 Steps

1. Minimize the model error.
2. Source – Receptor Analysis
3. Minimize the error between model and observation.
4. Correction of Emission Inventory

- ## Minimization of Model errors
  - Selection of Chemical Mechanism
  - Improve the spatial resolution
  - Improve the time-step of Input / Output

- ## Source – Receptor Analysis
  - We assumes the linear relationship between emission amount and concentration, because the reaction rate of CO is small.
  - Contributions of each source category were calculated by source – receptor analysis.

Minimization of the Errors.

① Improved Model concentration.

$$\underbrace{C_{M\,n}}_{\text{Modified Concentration}} = \sum_i \underbrace{p_i}_{\text{Correction Coefficient}}\underbrace{k_{i,n}}_{\text{S-R matrix}}\underbrace{x_i}_{\text{CO emission}}$$

i : **Source category**

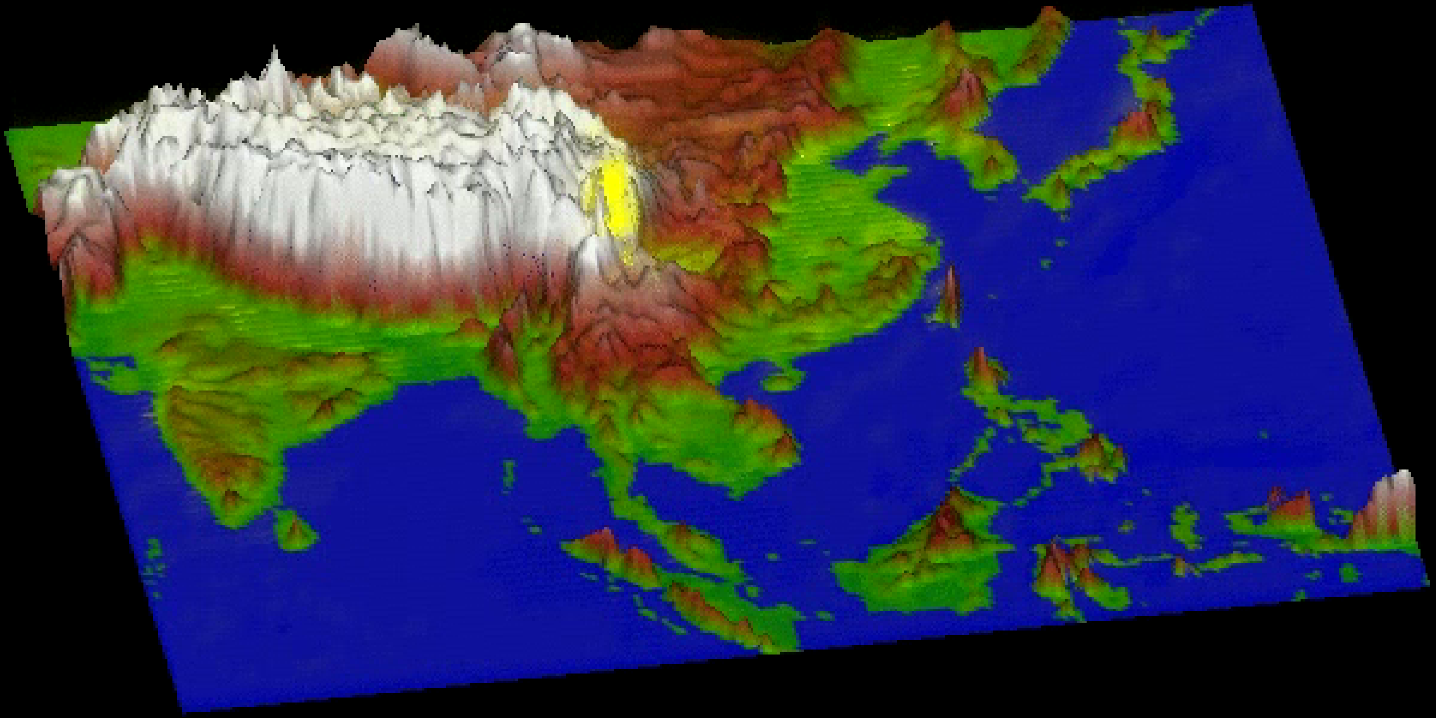
n : **each observation**

② Minimization of the error after modification.

$$Min \sum_n \left(\underbrace{C_{M\,n}}_{\text{Modified concentration}} - \underbrace{C_{O\,n}}_{\text{Observation}}\right)^2$$

(Yanagi, 2008)

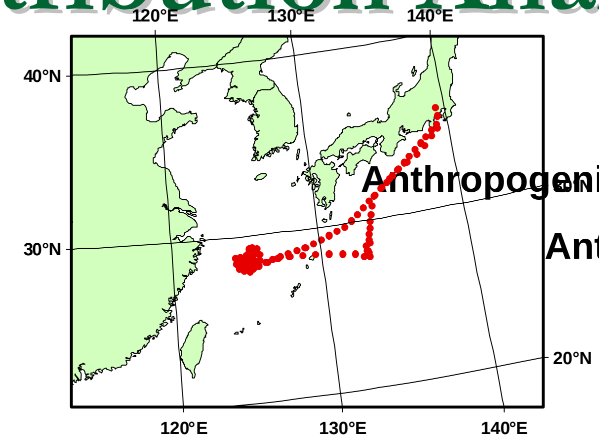
Example of the calculation
(March 2001, one month; CO)



Vis5D

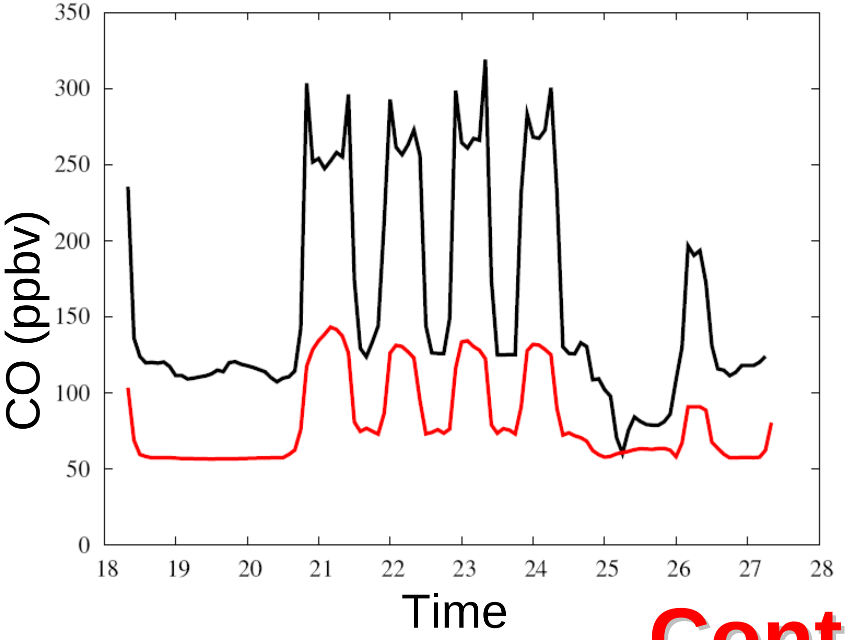
Result of Contribution Analysis

- **DC8 Flight #16**

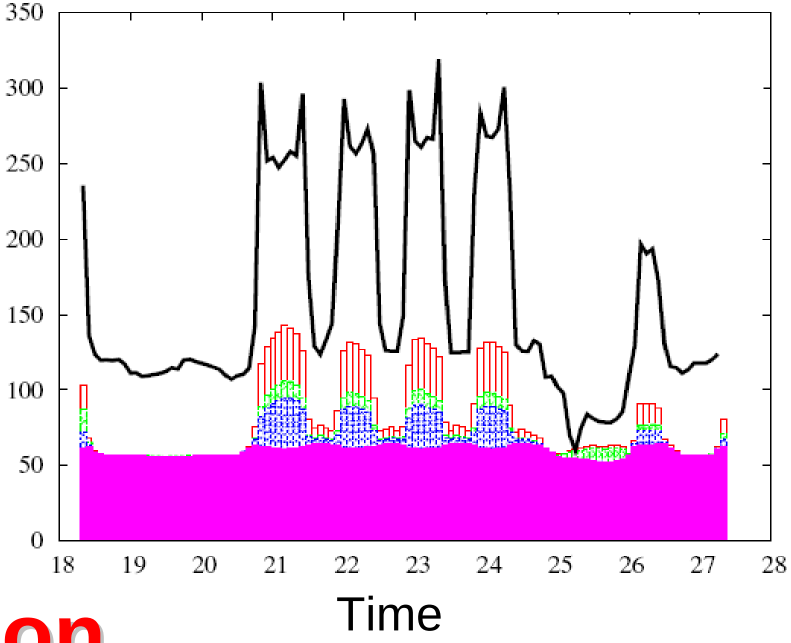


Biomass Burning	🟥
Anthropogenic（Other countries）	▨
Anthropogenic（China）	▨
Background	■
Observation	━

Observation	━
Calculation	━



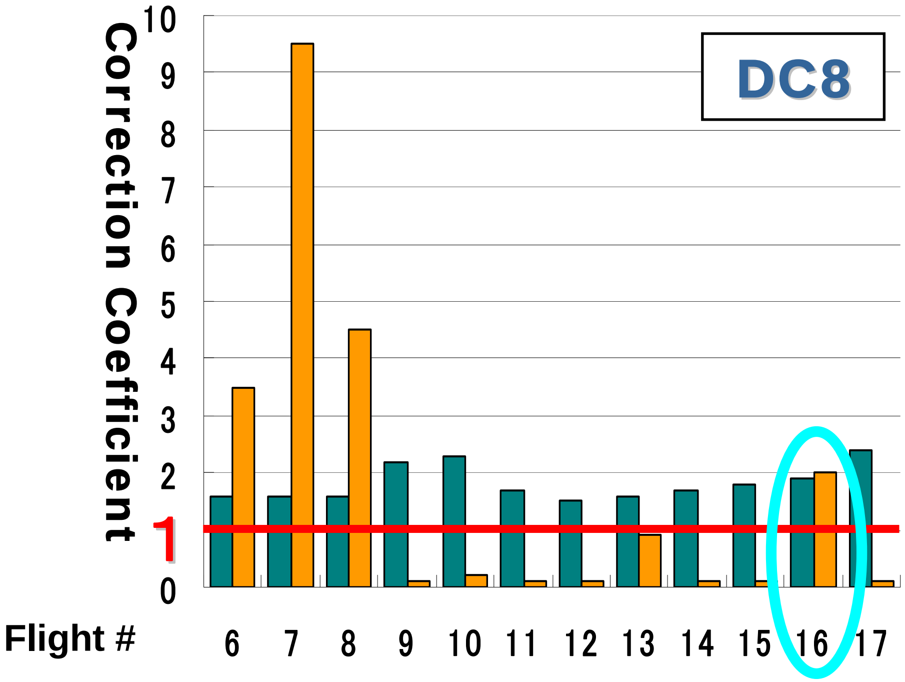
Contribution

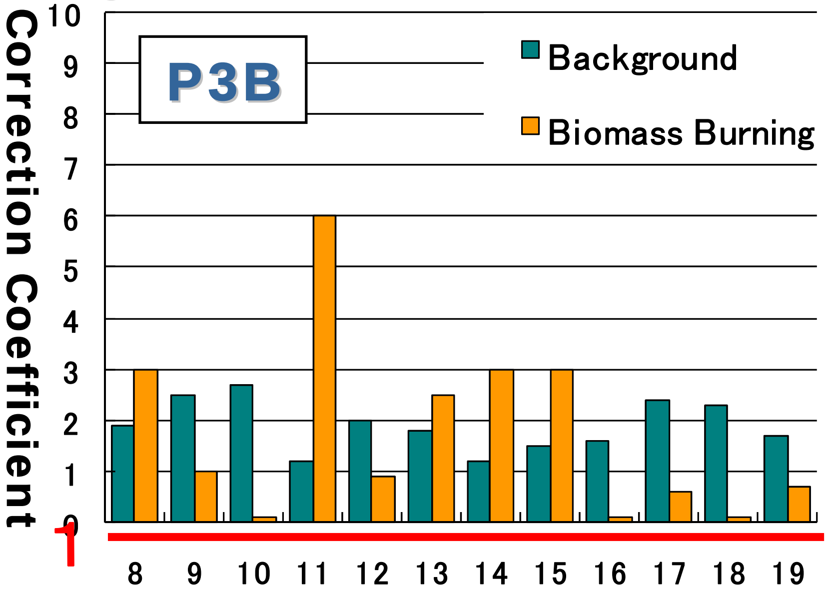


(Yanagi, 2008)

Obtained correction coefficient

- **Anthropogenic**（constant during all flight）
  - China･･･2.7
  - Other countries･･･2.5
- **Background ･Biomass Burning**（varied for each flight）





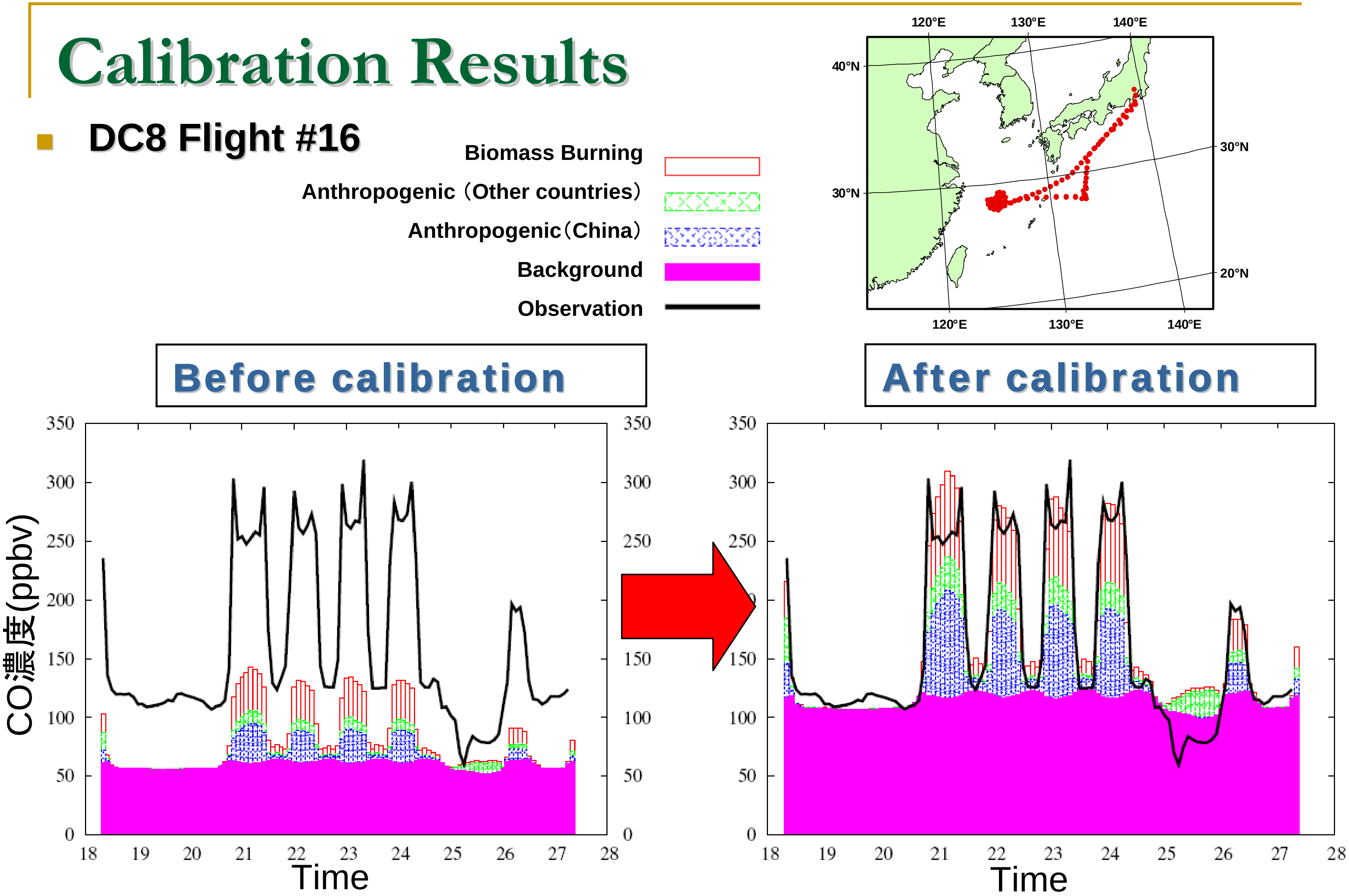
(Yanagi, 2008)

Anthropogenic & Background ･･･Underestimate

Biomass Burning ･･･Over estimate (but varied)

Calibration Results

- **DC8 Flight #16**



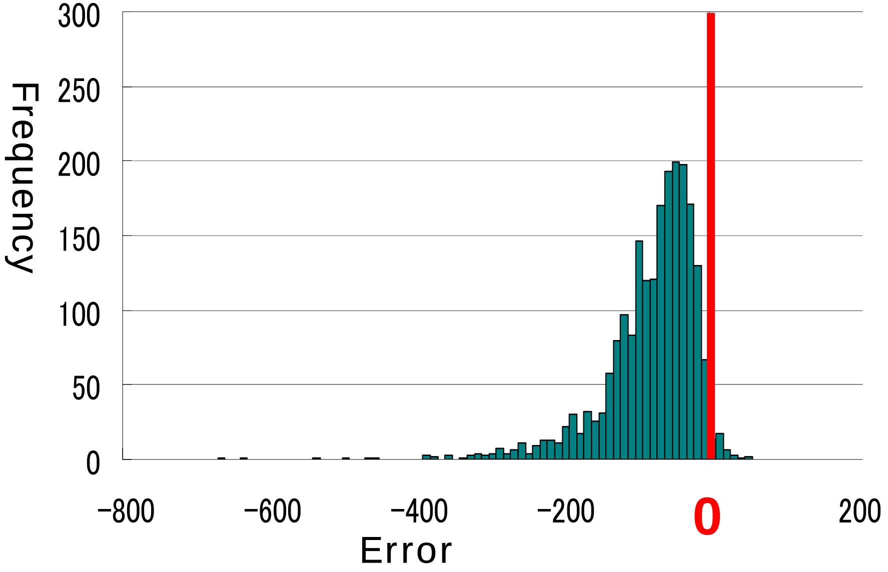
(Yanagi, 2008)

Change of errors

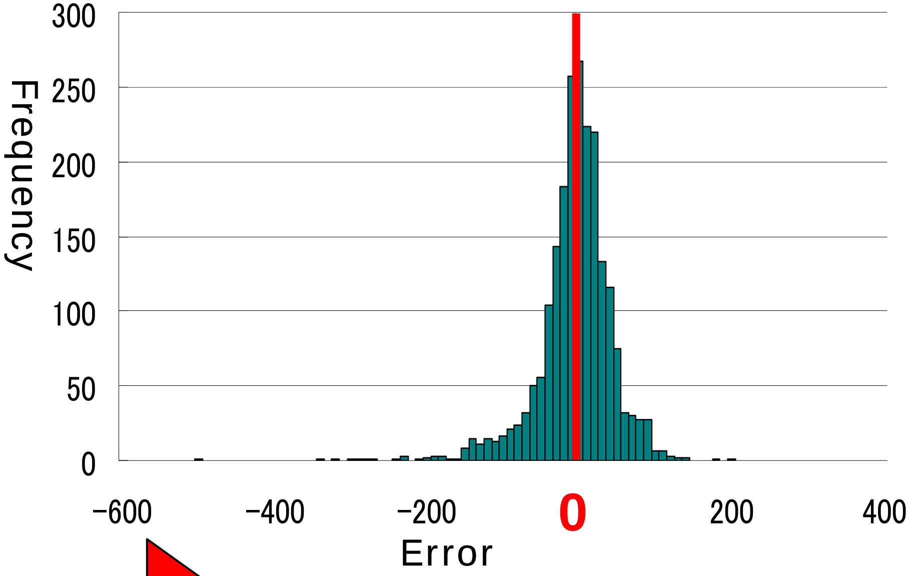
Histogram of "Calculation－Observation"

- Histogram from all flight data.

Before calibration



After calibration



Bias	-79.542
Variance	4331.043
Error	42.60%

Improved

Bias	-0.187
Variance	2464.217
Error	7.45%

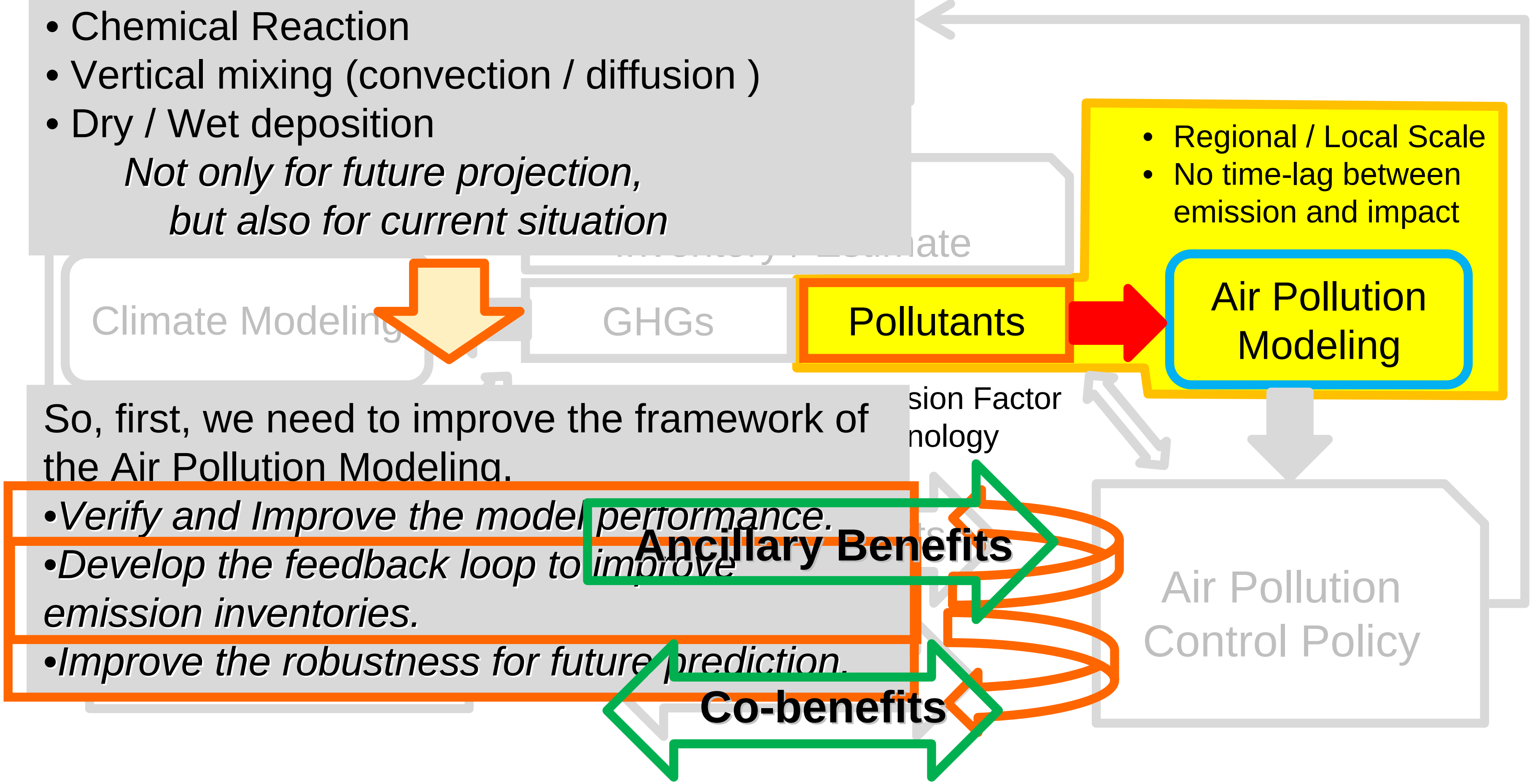
(Yanagi, 2008)

Air pollution modeling

There are still very large uncertainties …

- Activities
- Emission Factor
- Chemical Reaction
- Vertical mixing (convection / diffusion)
- Dry / Wet deposition

Not only for future projection,
but also for current situation



So, first, we need to improve the framework of the Air Pollution Modeling.

- *Verify and Improve the model performance.*
- *Develop the feedback loop to improve emission inventories.*
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Challenges for future

- Improve the model performance
- Develop the calibration method for NOx, SO_2, VOC (more reactive species)
- Develop a calibration method to sectoral activities.
- Long-term prediction of Regional / Local Air Quality under several scenarios.
- Estimation of Ancillary Benefits of Climate Change Policy to Air Quality.