TPM11 - Session 3

Current Status and Countermeasure for Particulate Matter in Korea

Current Status and Countermeasure for Particulate Matter in Korea

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Outline

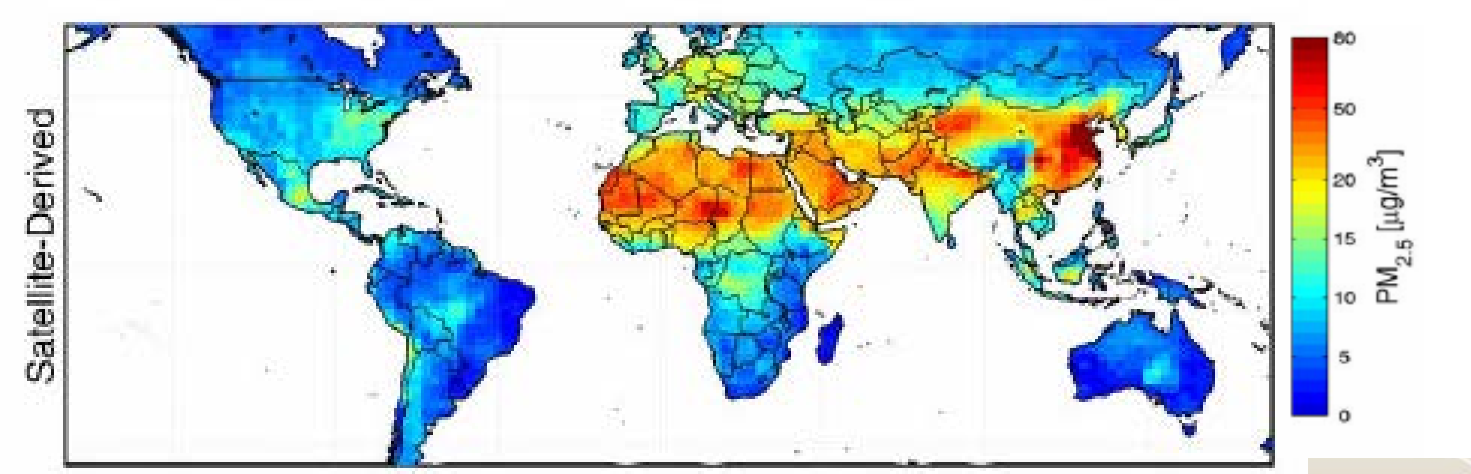
I Air Quality Trend in Korea

II Scientific Design of $PM_{2.5}$ Management

III Recent Progress in Air Quality Forecasting

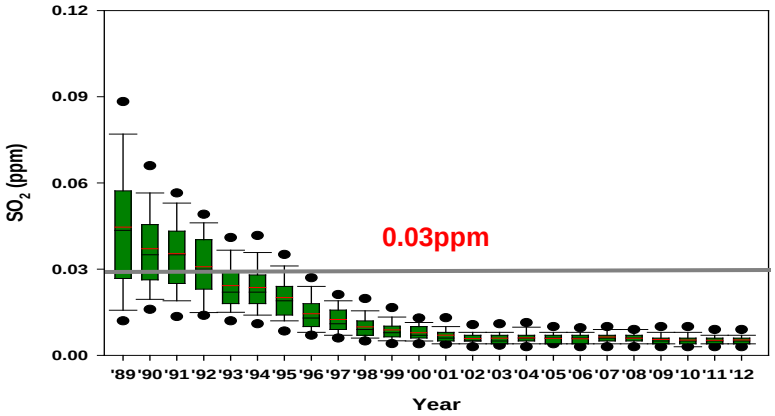
Environmental Performance Index (EPI)

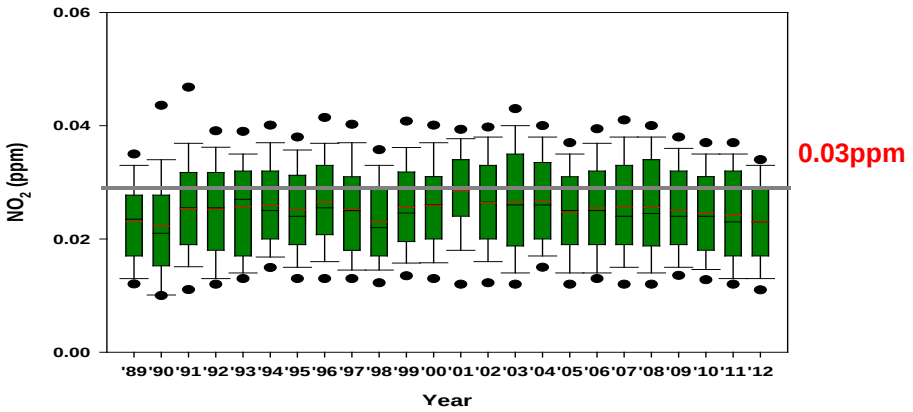
- **T**he Yale Center For Environmental Law and Policy issued 2014 EPI scores at World Economic Forum on January of this year (**Swiss Davos)**
  - Korea EPI score ranking was 43 grade among 178 countries on 2014 (43 grade among 132 countries on 2012)
- **But, $PM_{2.5}$ EPI ranking of Korea scored 171 grade among 178 countries**
  - $PM_{2.5}$ data derived AOD(Aerosol Optical Depth) measured by MODIS sensor installed in Terra satellite
  - **$PM_{2.5}$ EPI was determined by $PM_{2.5}$ population weighting average exposure and $PM_{2.5}$ excess exposure** (WHO guideline excess rate)

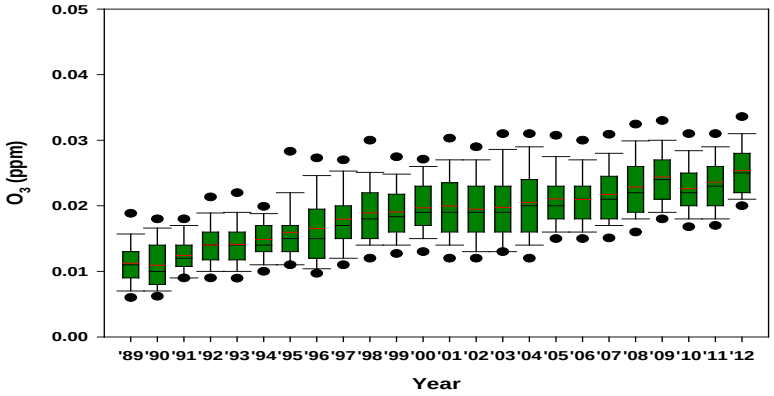


<$PM_{2.5}$ Distribution by MODIS>

Annual Air Quality Trend of Korea

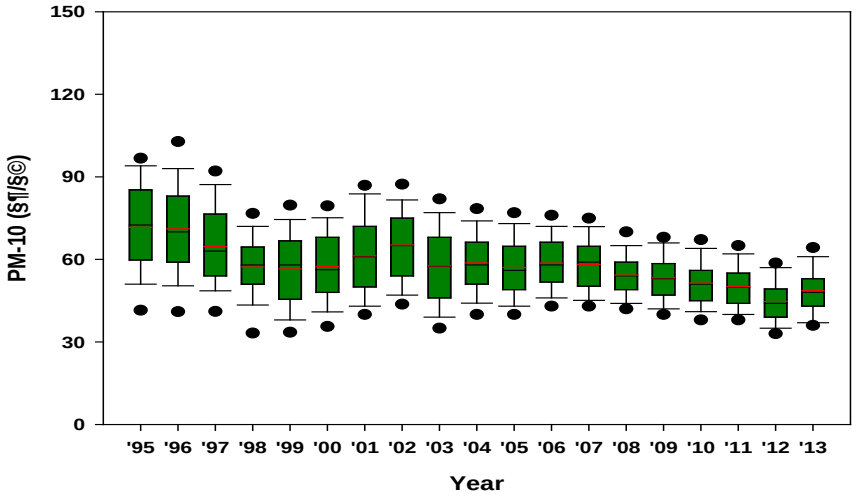




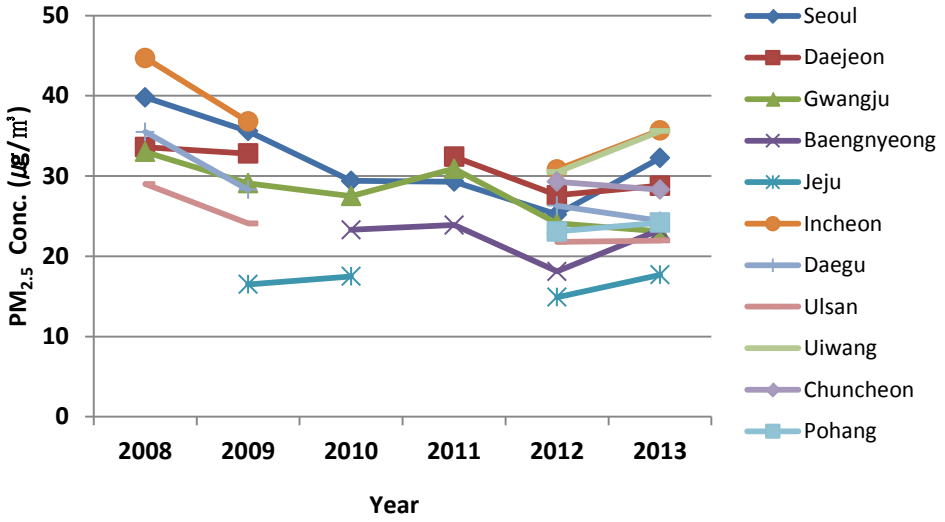


- Sulfur Dioxide decreased gradually since 1989 because of the environmental policies such as ‘Surfur Content Control’, ‘Mandatory Use of Clean Fuel’ and ‘Restriction of Solid Fuel’ etc.
- Nitrogen Dioxide maintained a stable state
- Ozone is increasing gradually and this trend is similar to the registration number of vehicle

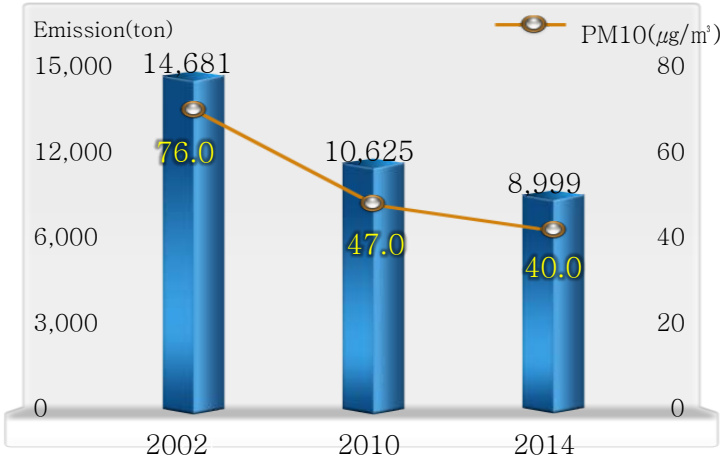
Annual PM_{10} and $PM_{2.5}$ Trend



■ Annual $PM_{2.5}$ Trend (City)



■ Emission and PM_{10} in SMA

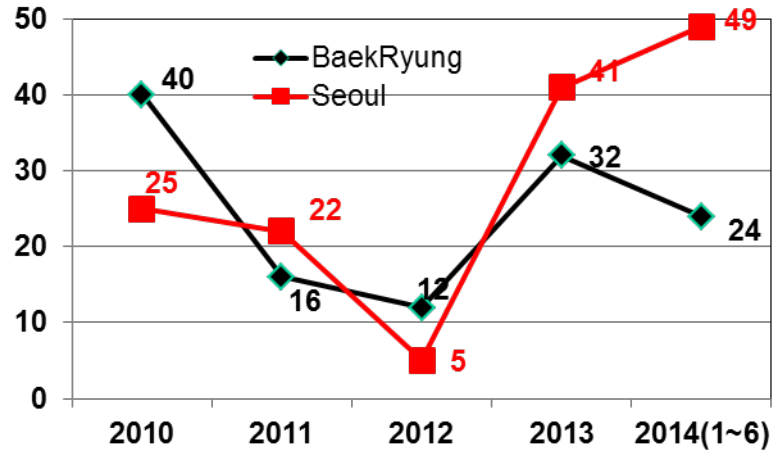


- PM_{10} has declined steadily over the past decade
  - Korea : 61ug/m³ (2002) → 45ug/m³(2012) → 49ug/m³(2013)
  - Seoul : 76ug/m³ (2002) → 41ug/m³(2012) → 45ug/m³(2013)

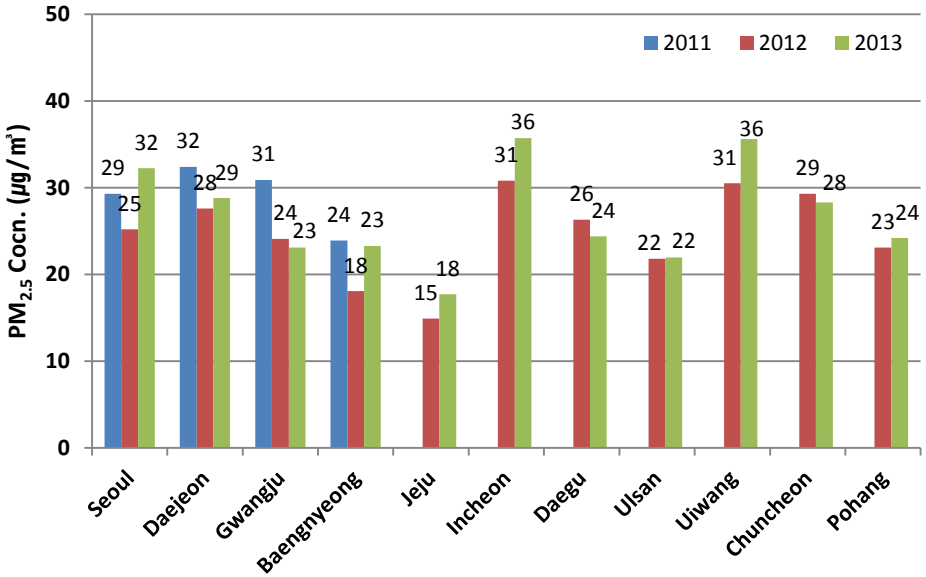
Annual PM_{10} and $PM_{2.5}$ Trend

Air Pollution Episode of Seoul ('13.12)

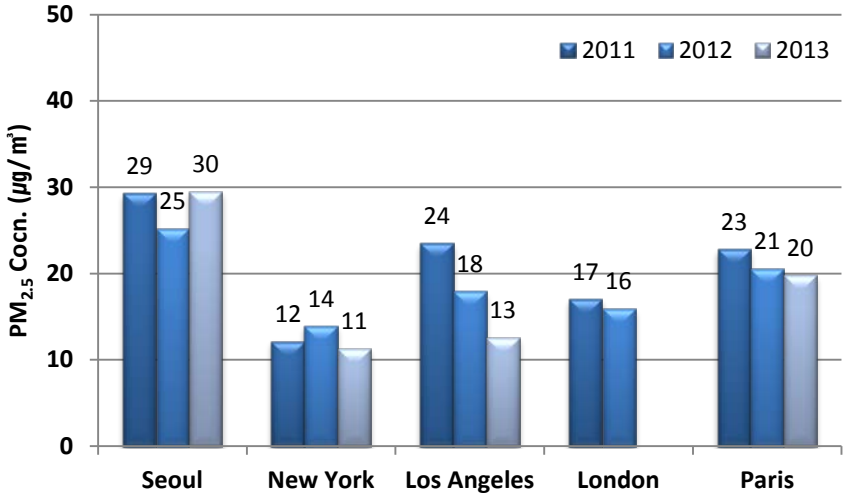
Number of Days over 100μg/m³ (PM_{10} 24hr Standard)



Annual $PM_{2.5}$ of Cities in Korea



Annual $PM_{2.5}$ of Seoul and Other Cities



National Air Quality Standard for $PM_{2.5}$ (Jan. 2015)

Air Quality Standard	Korea	USA	Japan	Australia	EU	WHO	
Annual Average (ug/m^3)	25 [4]	15 [1]	15 [3]	8	25	AQG	10
						Intrim Target-3	15
						Intrim Target-2	25
						Intrim Target-1	35
24 hr Average (ug/m^3)	50 [4]	35 [2]	35	25	-	AQG	25
						Intrim Target-3	37.5
						Intrim Target-2	50
						Intrim Target-1	75

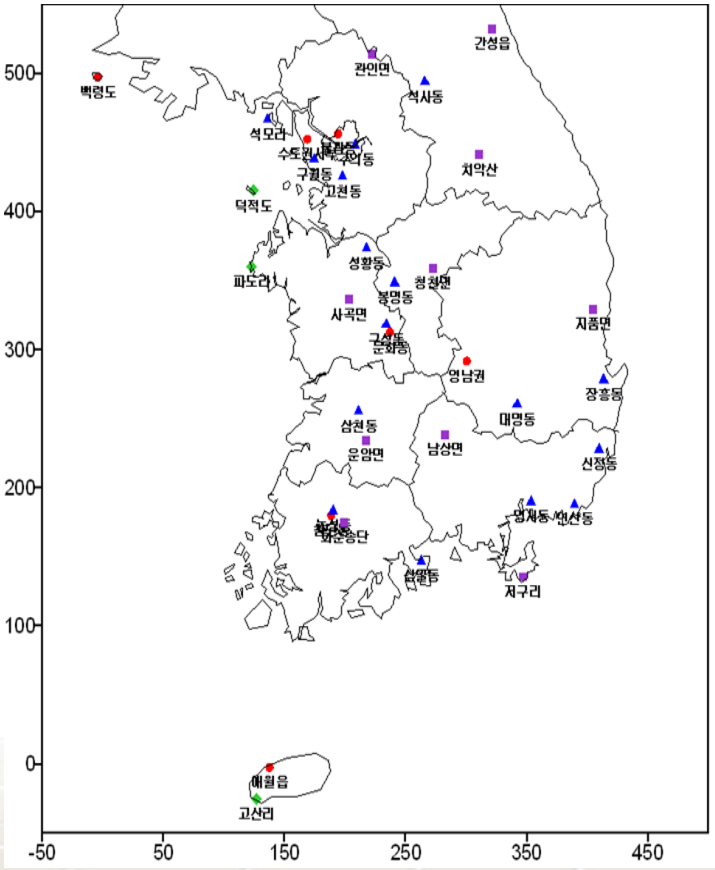
1) Annual mean of averaged over 3 years should not to be exceed $15ug/m^3$

2) 98^{th} percentile(24hr) of averaged over 3 years should not to be exceed $35ug/m^3$

3) 98^{th} percentile(24hr) of one year should not to be exceed $35ug/m^3$

4) Korea adopted Intrim Target – 2 of WHO (Annual ave. $25ug/m^3$

$PM_{2.5}$ Monitoring Station in Korea

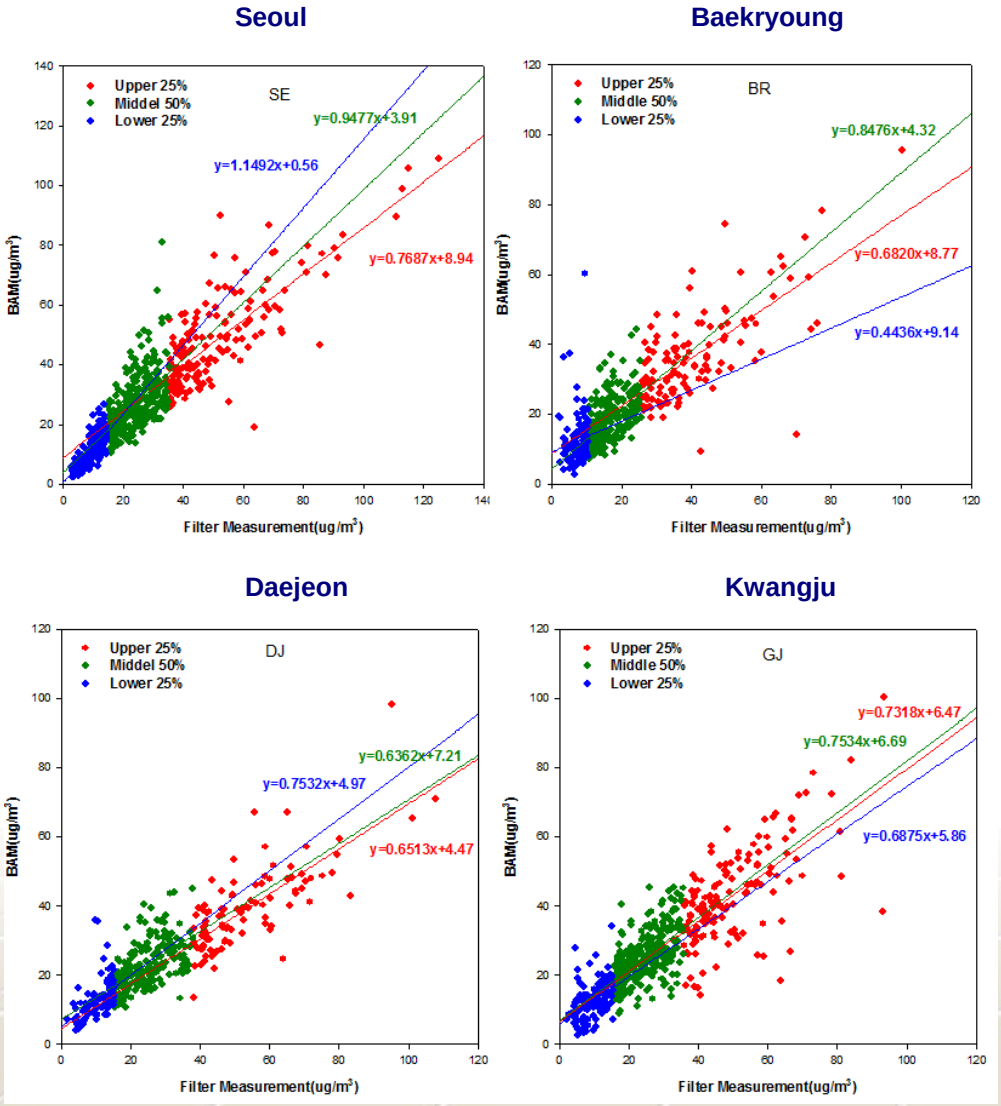


< Site description of gravimetric monitoring stations>

- **Gravimetric monitoring stations for $PM_{2.5}$**
  - **Mass concentration(36 sites)**
  - **Chemical composition(23 sites, Ion, EC/OC, Metal)**
- **Gravimetric monitoring stations are operated by Ministry of Environment(MoE)**
- **Gravimetric monitoring data are used to confirm the compliance with the national air quality standard and to conduct component analysis to determine the contribution ratio for emission sources**

- **Automatic monitoring stations are 155 sites**
  - **34 sites are operated by MOE**
  - **121 sites are operated by Local Government**
- **Automatic monitoring data are used to understand the real time trend of $PM_{2.5}$ and used for high-episode alert system**

Gravimetric Method and Automatic Continuous Method

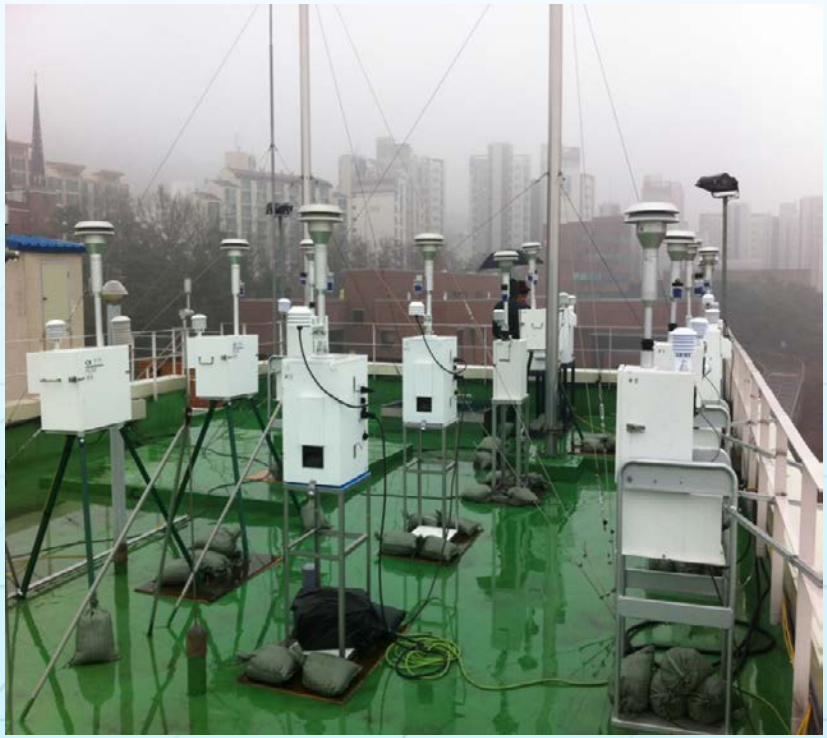


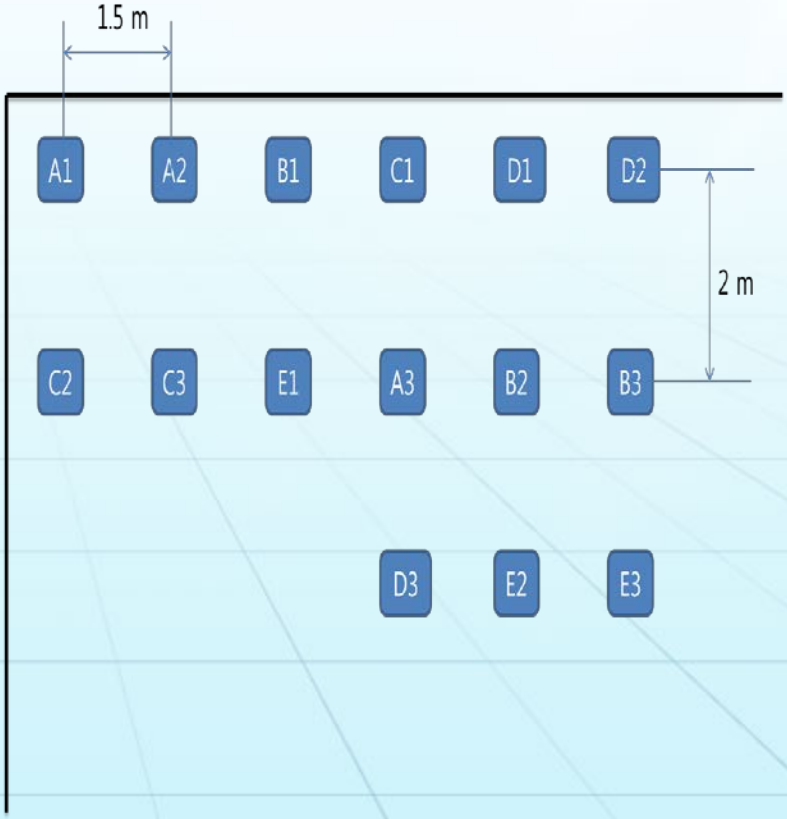
- **There are difference between gravimetric method and automatic continuous method(beta-ray, TEOM) according to chemical composition of $PM_{2.5}$, meteorological condition (temperature, humidity)**
- **Gravimetric method has less bias than automatic method**
  - **So, most countries have adopted the gravimetric method as the main method for PM $_{2.5}$**
- **Korea also adopted gravimetric method as the main method**
  - **And, Gravimetric method is used as the National Reference Method for Type approval of automatic method**

Setup the National Reference Method System for $PM_{2.5}$

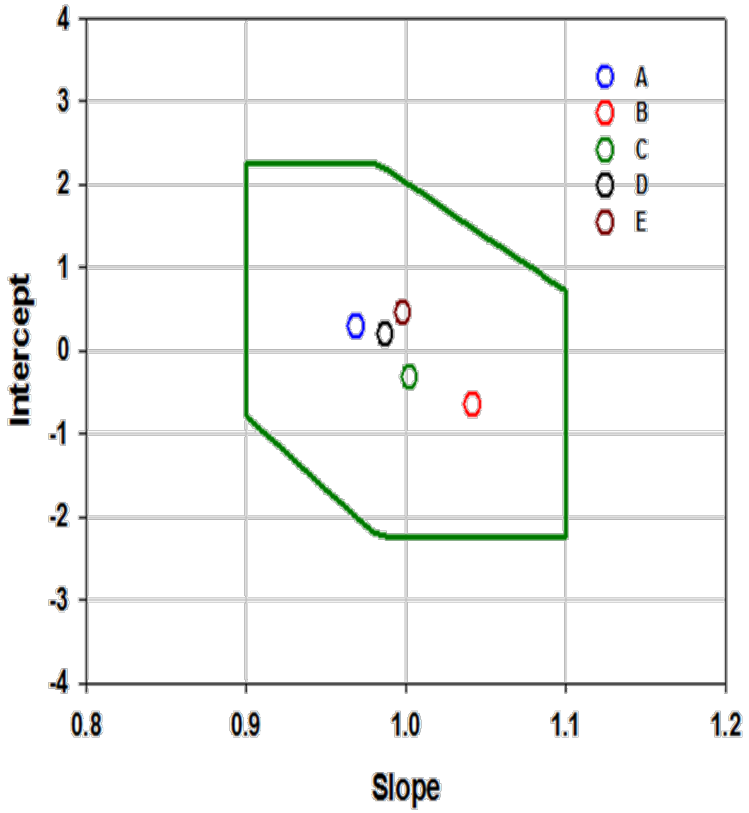
Performance Field Test

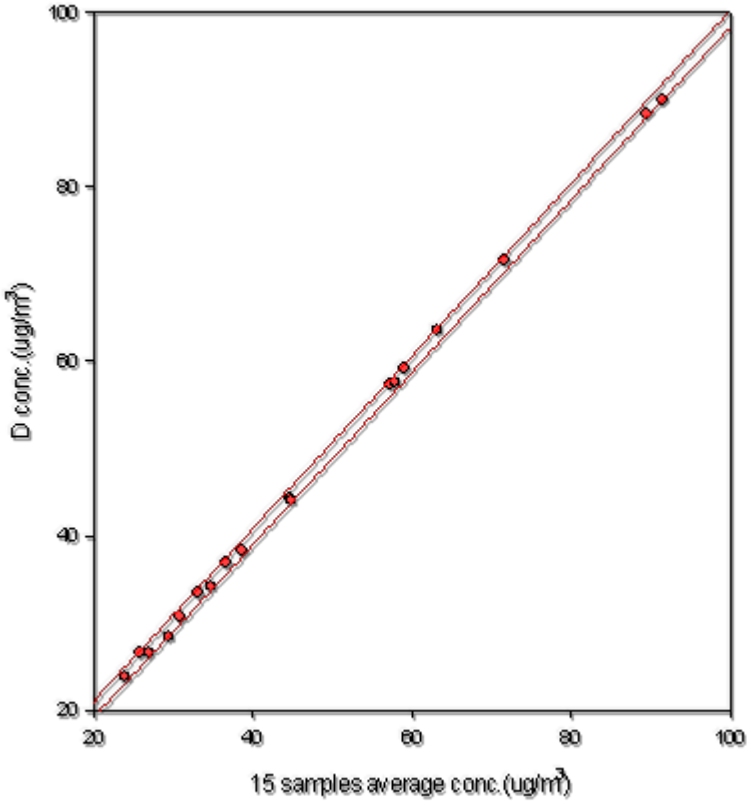
- 5 $PM_{2.5}$ gravimetric method equipments
- Period : 2014.1.~2014.3 (3month)
- Site : Bulkwang Intensive Monitoring Station in Seoul





Performance Test Results of the Five $PM_{2.5}$ NRM Candidates





National Reference Method and Equivalent Method for $PM_{2.5}$

■ Class identification

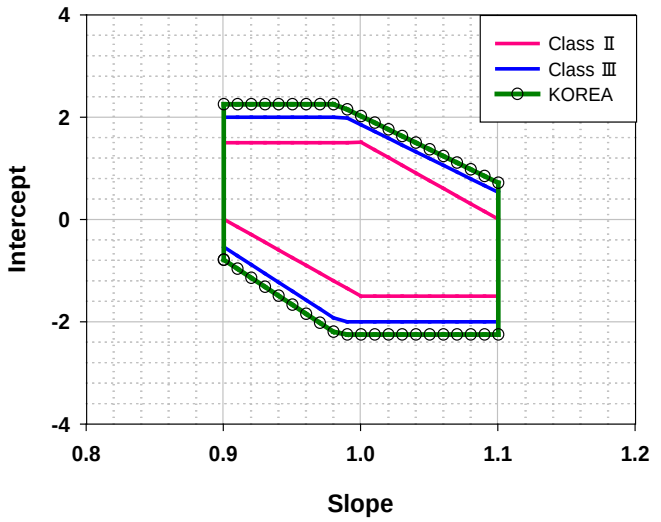
- US EPA : FRM, FEM (Class 1, 2, 3)
- Korea : NRM(National Reference Method). FEM (Class 1, 2)

■ Korea establishes 2 NRM stations

- Location : Seoul, Kwangju
- Considering a regional characteristics

■ Criteria

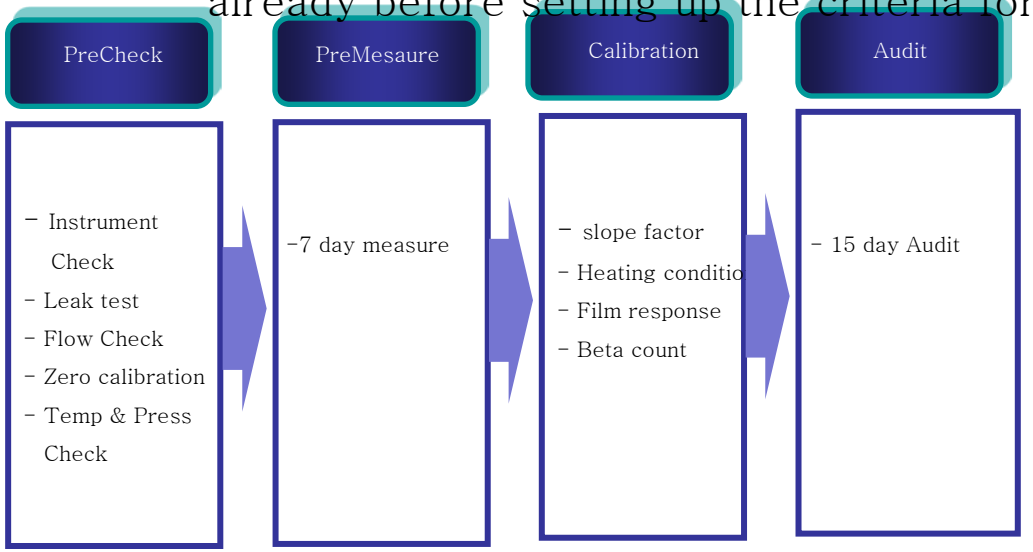
- Referenced USA CFR 50 part 53, a little modified



USA	FRM	Class 1	Class 2	Class 3
	`Gravimetric manual method	Gravimetric manual method	Gravimetric modified method	Automatic method (B-ray)
	Impactor	Impactor (Single stage)	Impactor (Sequential Type)	Impactoc, Cyclone
KOREA	NRM	Class 1		Class 2
	Gravimetric manual method	Gravimetric manual method		Automatic method (B-ray)
	Impactor	Single + Sequential type		Impactor, Cyclone

Equivalent Test Campaign between NRM and Class II for $PM_{2.5}$

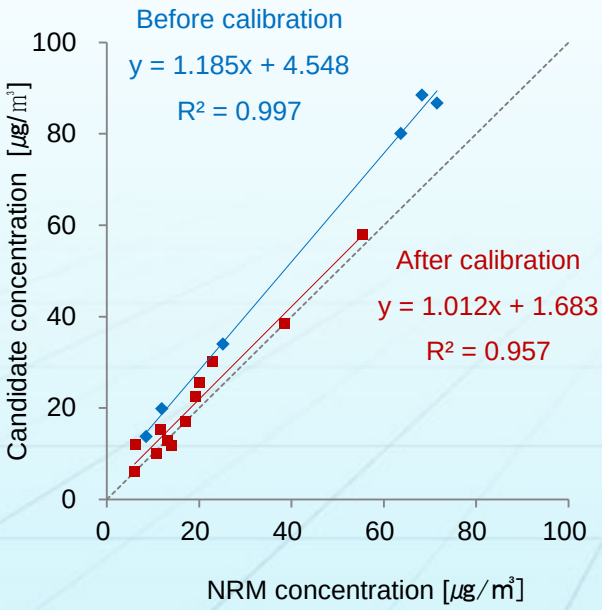
- Object : To assess the PM2.5 automatic equipment'equipvalence with the NRM which have used already before setting up the criteria for PM2.5 automatic equipment by MOE

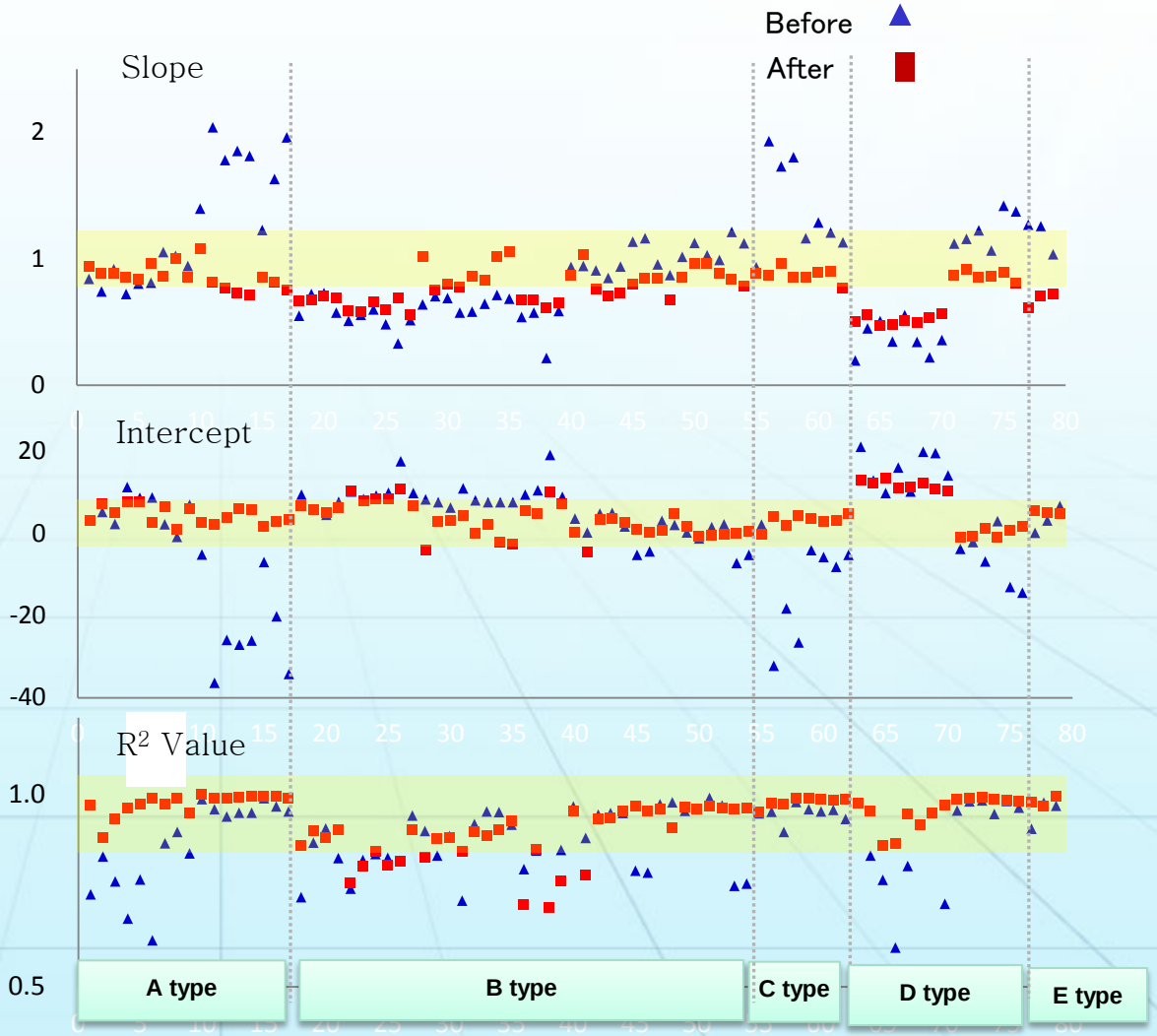


	Period	Local Government	Number
1	'14.4.29~5.24	Seoul, Incheon, Gyeonggi	40
2	'14.5.26~6.19	Seoul, Incheon, Gyeonggi	38
3	'14.6.21~7.15	Jeonnam, Jeonbuk, Gyeongnam, Gyeongbuk, Gwangju, Jeju	38
4	'14.7.17~8.13	Choongnam, Choongbuk , Gangweon, Busan, Daejeon, Ulsan, Daegu	37
	16 Local Government		155

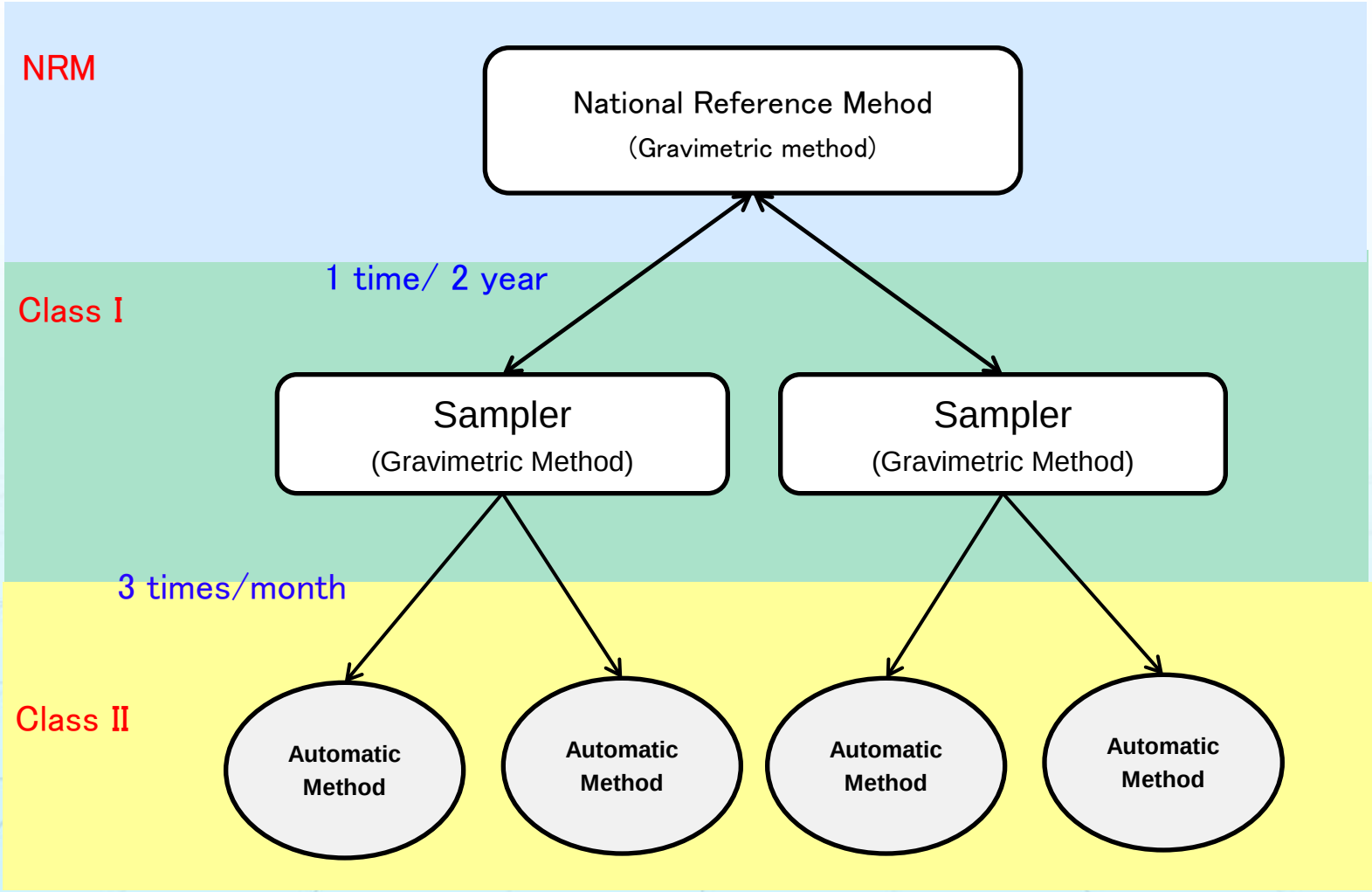
Summary of Equivalent Field Campaign Results

- Regression slope, intercept and R^2 between NRM and 155 automatic equipments were checked
  - About 90% were satisfied acceptance limit or return to normal range by QA/QC procedure





Ensuring Traceability Procedure for $PM_{2.5}$



Air Quality Forecasting

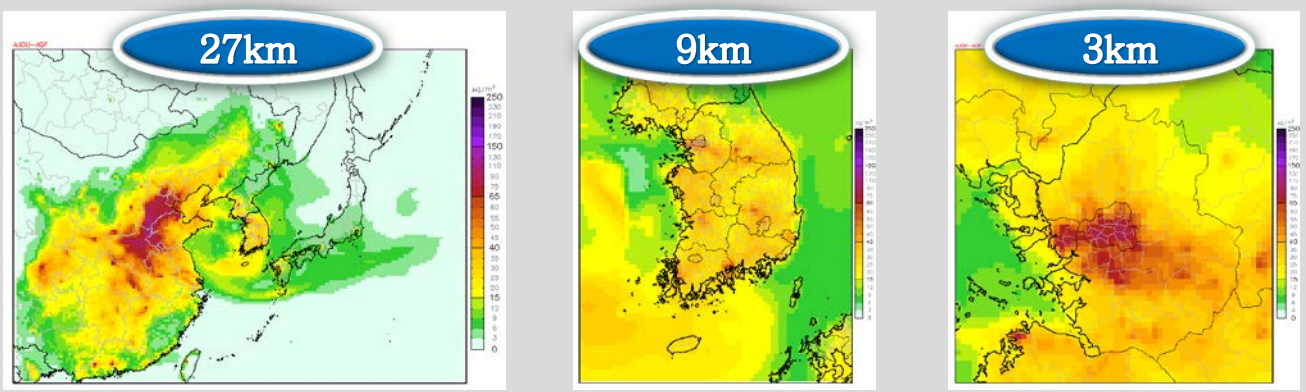
OBJECT : Air Quality Forecasting provides the people with PM, Ozone with enough accuracy and advance to take action to prevent or reduce adverse effects

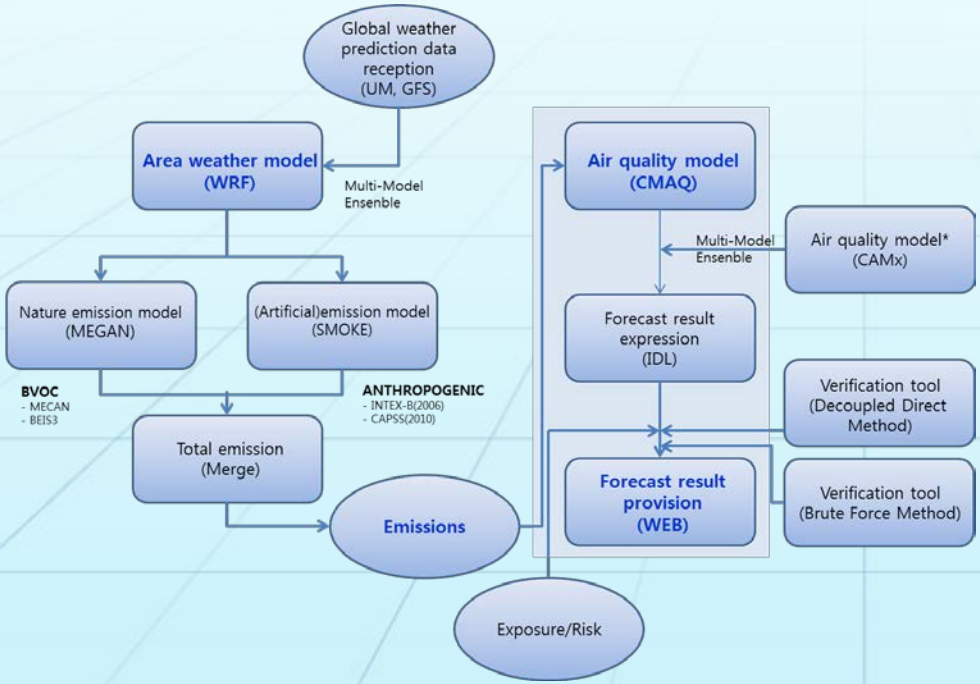
- Forecasting Air Pollutants : PM_{10}, $PM_{2.5}$, O_3
- Forecasting Region (6 Regions) → (10 Regions)
  - Metropolitan Area(1), Kangwon Area(2), Chungcheong Area(3) Honam Area(4) , Youngnam Area(5) , Jeju Area(6)
  - → Seoul(1), Incheon(2), North of Kyunggi(3),South of Kyunggi(4) West of Kangwon (5), East of Kangwon (6), Chungcheong (7) Honam (8), Youngnam(9), Jeju(10)
- Foecasting Schedule
  - '13.8~ : Forecasting on a trial basis (PM_{10})
  - '14.2~ : Main Forecasting (PM_{10})
  - '15.1~ : Main Forecasting ($PM_{2.5}$, O_3)
- Forecasting Time : 2times/day (5PM, 11AM) → 4times/day(5AM, 11AM, 5PM, 11PM)
- Forecasting Period : 24hrs averaged concentration forecasting for tomorrow
- Forecasting Steps : 5Step s (Good, Moderate, Bad a little, Bad, Very Poor)
- → 4Steps (Good, Moderate, Bad, Very Poor)

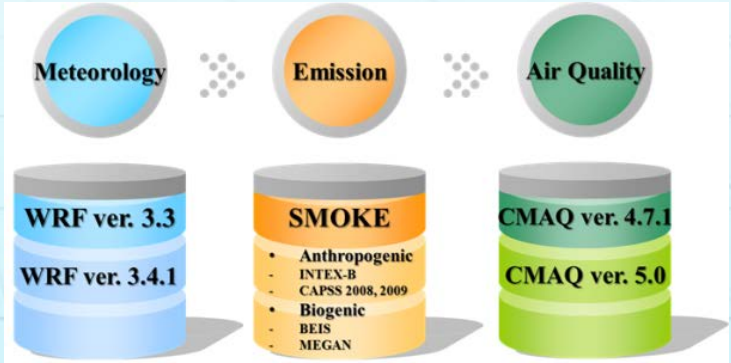
	Forecasting Steps				
Forecasting Conc. (㎍/㎥.day)	Good	Moderate	Bad a little	Bad	Very Poor
	0~30	31~80	81~120	121~200	201~

Air Quality Forecasting Procedure

Forecasting Region







Forecasting Accuracy

■ Forecasting Period (2014) : February ~ September

	Total	Over 80ug/m^3 (Bad a little)
Forecasting Accuracy	**82.6 %**	**48.1 %**

* Forecasting accuracy was not good in the high episode cases

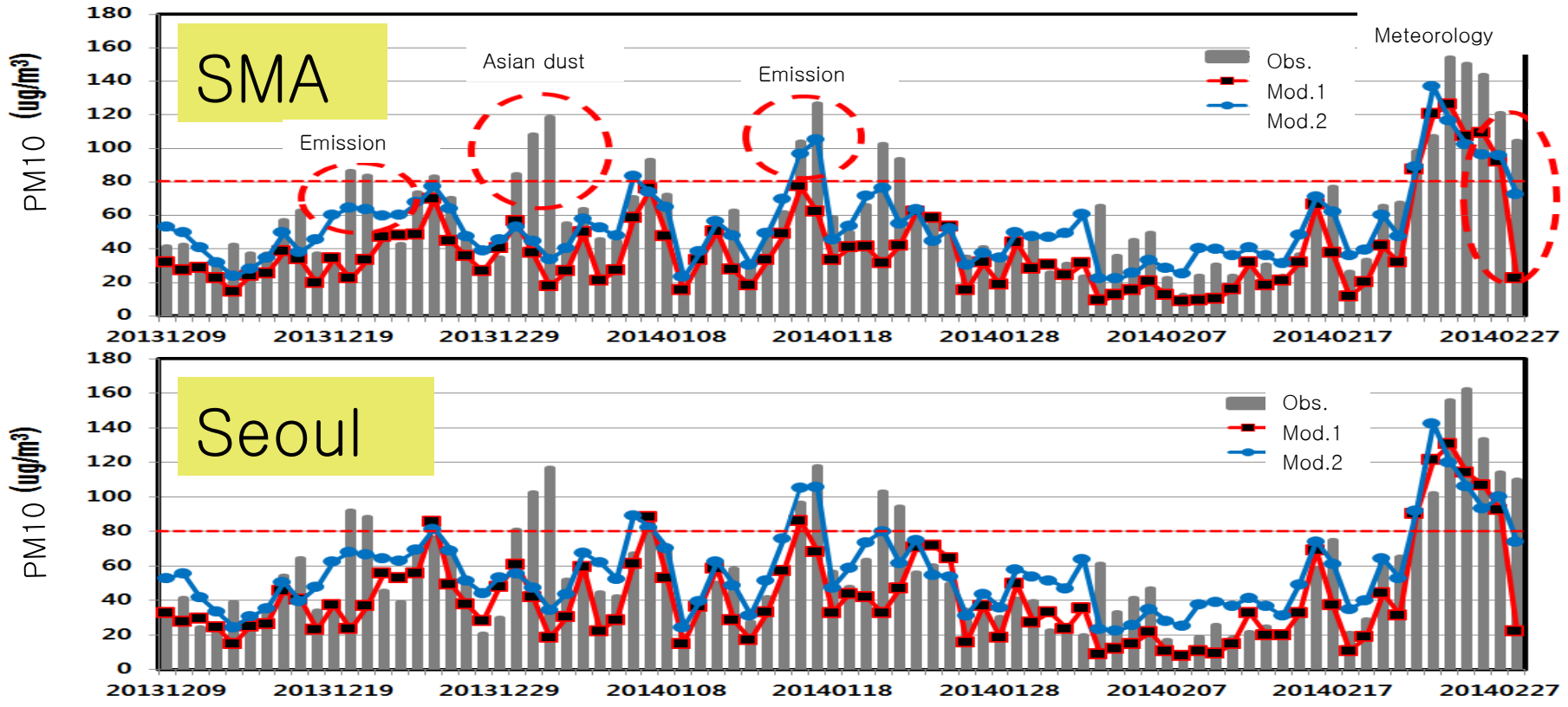
□ ■ Forecasting accuracy by region

Month	SMA	Chung-cheong	Kwang-won	Youngnam	Honam	Jeju
Total	77.5%	83.8%	82.9%	85.8%	84.0%	81.6%
Over 80ug/m^3	46.5%	51.5%	44.1%	56.5%	45.5%	50.0%

Reasons of Bad Forecasting

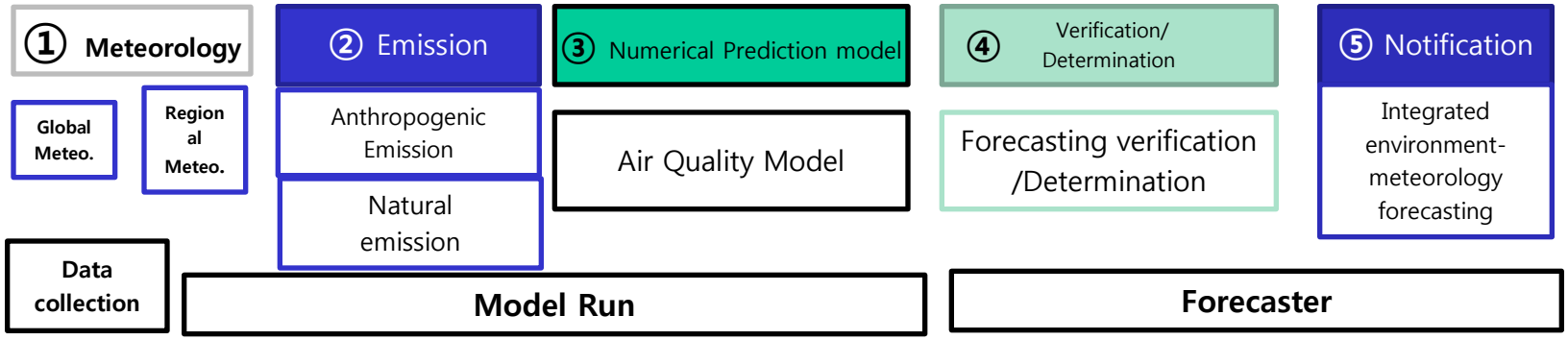
Analysis period
(2013.12.9.~
2014.02.28)

The correlation between AQM and observation is in the range of 0.75~0.77
but failed in high pollution episode
The bad forecasting was due to incompleteness of emission, uncertainty of meteorology, missing of Asian dust, the lack of experienced forecasters



Reason and Improvement Countermeasure during Forecasting procedure by Cause Analysis

■ (Forecasting Procedure)



■ (Bad forecasting) In analysis of bad forecasting cases(61times), main reasons are classified 4 categories.

<Bad forecasting in high pollution episodes by types >

Frequency of bad forecasting	Meteorology data[1] Uncertainty (wind/rain)	Emission[2] incompleteness (Domestic · foreign)	Air quality[3] forecasting limitation (model/computation)	Lack of experienced forecasters[4] (Verification/Determination)
Accuracy(%)	22.9%	24.6%	27.9%	24.6%

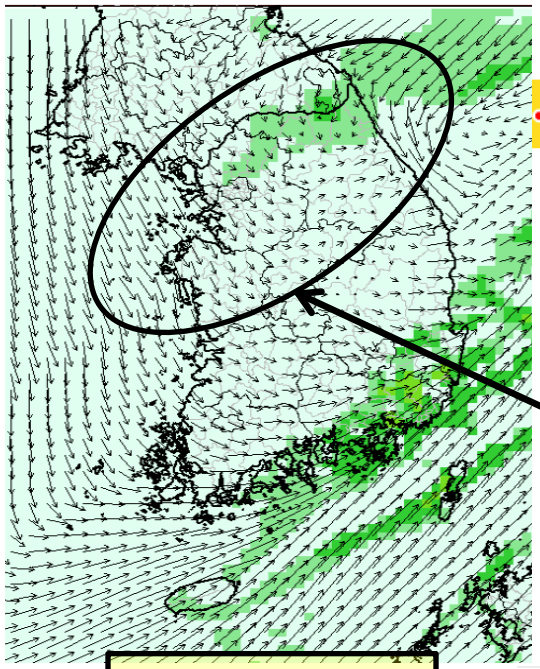
* 1) Uncertainty of weather forecasting such as wind direction/speed, precipitation and snowfall, etc
2) Uncertainty of domestic emission, incompleteness of emission of China and North Korea
3) multi-model operation, limitation of comparison,
4) Lack of experience in correction to numerical prediction in case of pollution and Asian dust, and etc

Accuracy of PM Prediction depends on Forecast of Precipitation

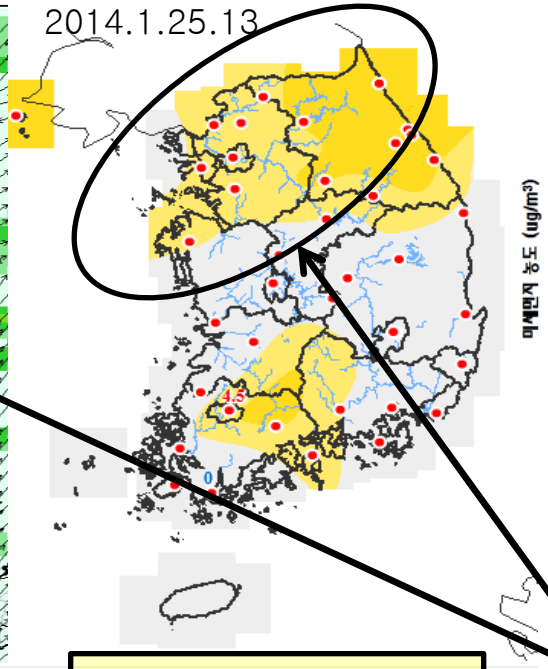
Case 1
14.1.25

(Forecast) Bad a little → Moderate

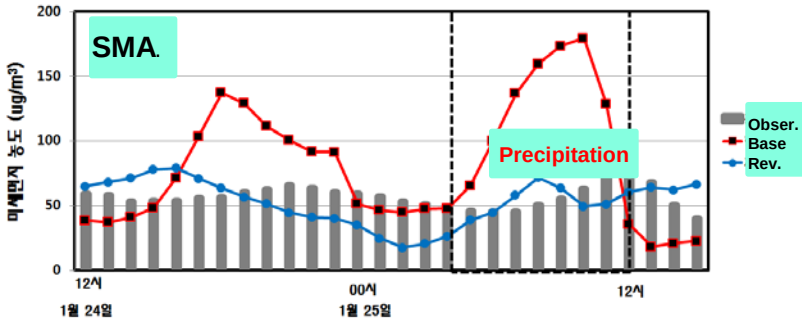
(Reason) Meteorological model(WRF) forecasted insufficient rain
※ MM: 1mm (Kyunggi), Observation : 3mm (SMA)



(a) Model (mm/h)



(b) Observation(mm/h)



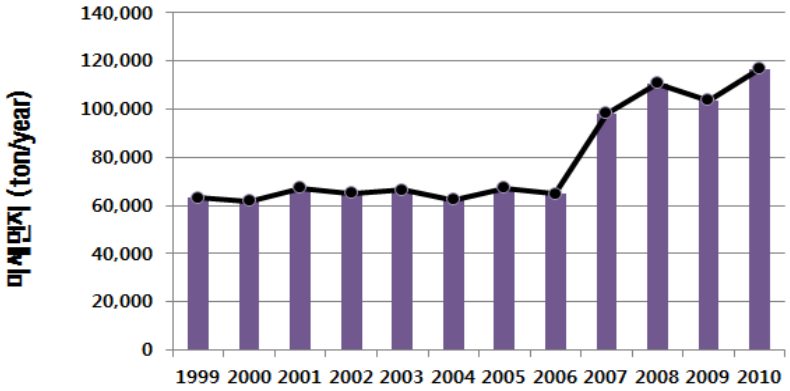
High bias of PM_{10} prediction is mainly due to the wrong forecasting in precipitation

Incompleteness of Emission

Case 2
14.1.17

(**Forecast**) Moderate → Bad a little

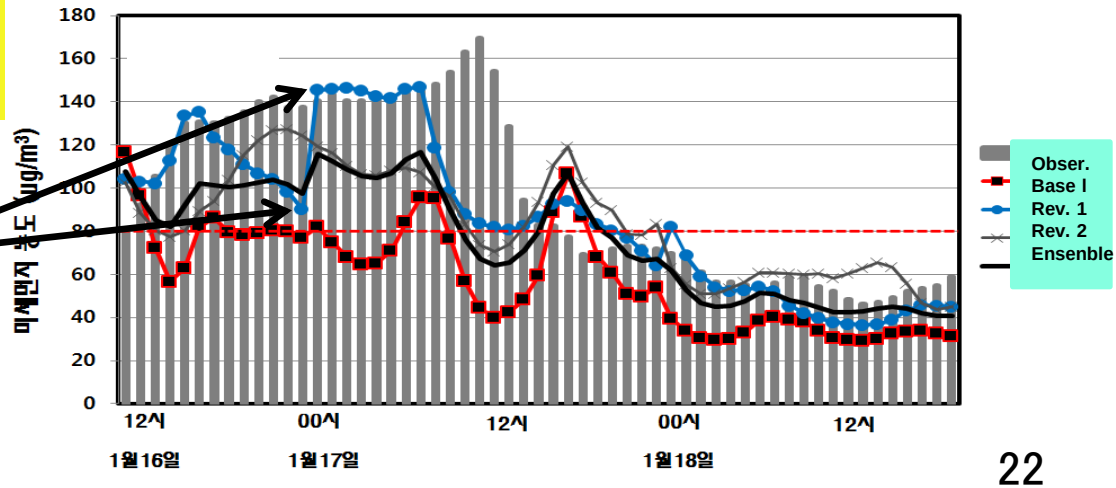
(**Reason**) Emission was underestimated



Annual emission trend of PM_{10} in Korea (CAPSS)

Model results in 14 Jan., 2014

Lower bias



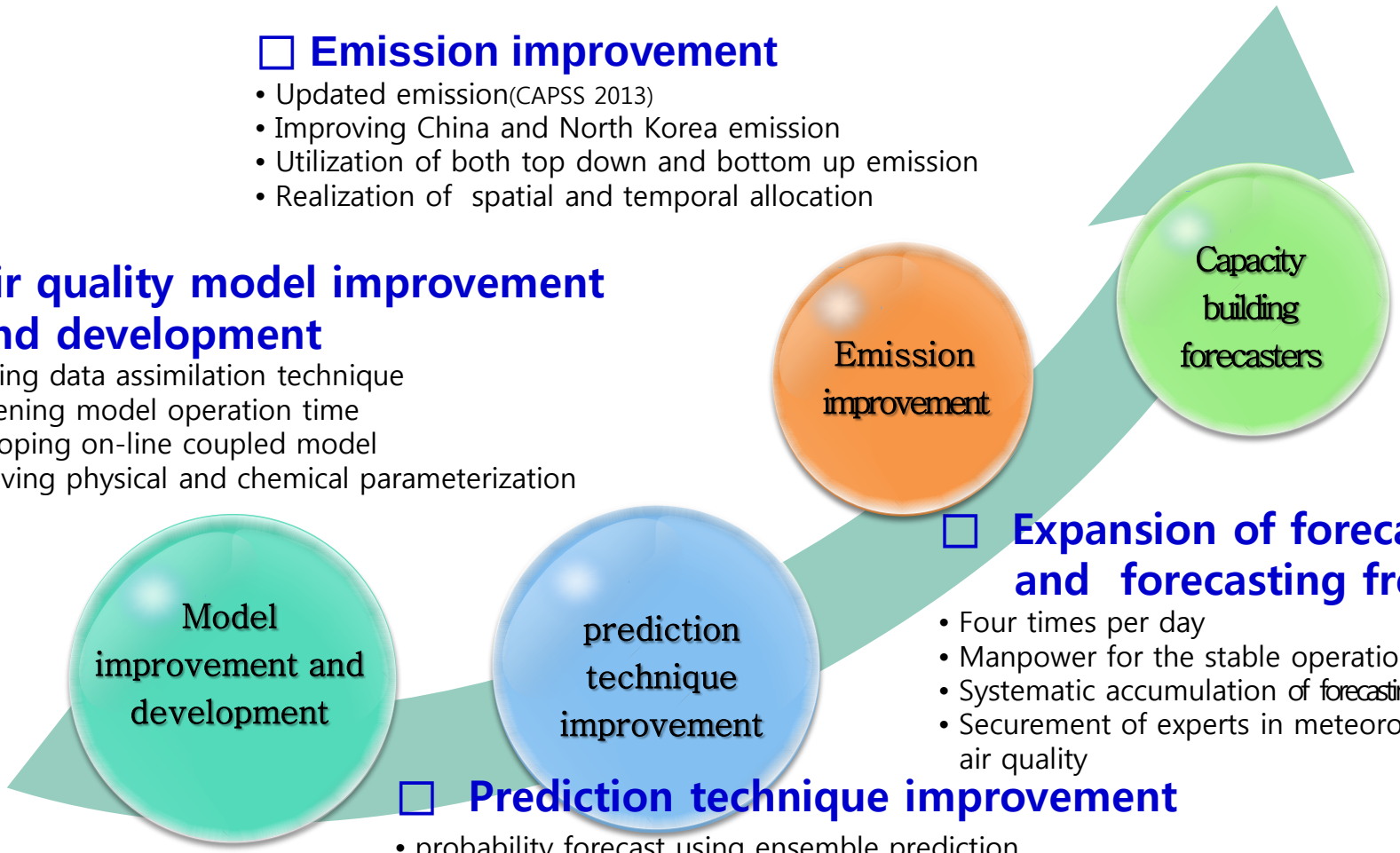
Improvement of the Accuracy for Air Quality Forecasting

□ Emission improvement

- Updated emission(CAPSS 2013)
- Improving China and North Korea emission
- Utilization of both top down and bottom up emission
- Realization of spatial and temporal allocation

□ Air quality model improvement and development

- Applying data assimilation technique
- Shortening model operation time
- Developing on-line coupled model
- Improving physical and chemical parameterization



□ Expansion of forecasters and forecasting frequency

- Four times per day
- Manpower for the stable operation
- Systematic accumulation of forecasting experience
- Securement of experts in meteorology and air quality

□ Prediction technique improvement

- probability forecast using ensemble prediction
- Statistics-dynamics forecasting technique application
- Prediction technique improvement by expansion of region and species
- providing customized information to the public

Systematic/organized/scientific development strategy for the stablization and accuracy improvement of national air quality forecast

Air Pollution Alert

OBJECT : Air Pollution Alert means that air pollution concentration may become unhealthy for sensitive groups, including children, people suffering from athma, other lung disease or elderly. The effect of air pollution can be minimized by avoding strenuous activity or excise outdoors.

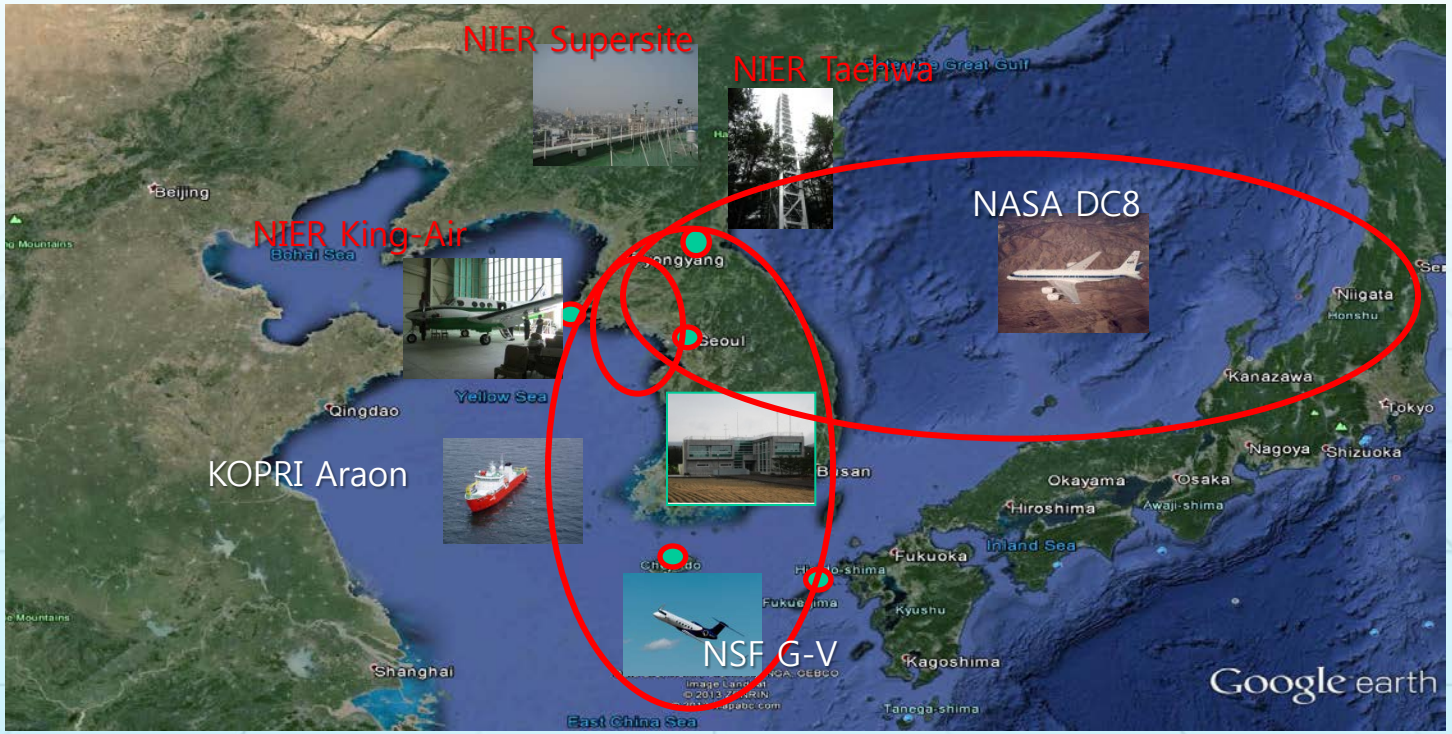
Operation of Emission sources, such as vehicle, factoty, should be banned as well

- Air Pollutants : PM_{10}, $PM_{2.5}$
- Region : 16 Local Government
  - City (7), Province (9)
- Air Pollution Alert Schedule
  - '15.1~ : National Government

* Before Jan. 2015, Local government can enforce Air Pollution Alert to protect the citizen against air pollution

International Cooperation Campaign

- Object : Enhance the understanding for Megacity-Biosphere- Atmosphere Interaction in East Asia and to improve air quality forecasing accuracy
- Period : 4years (2015-2018)
- Main participants : NIER, NASA, NCAR, PNNL
- Surface monitoring, Aircraft/Ship measurement, Satellite measurement



Thank you for your attention !!!