H18-191

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Impact of field biomass burning on local pollution and long-range transport of $PM_{2.5}$ in Northeast Asia in autumn 2014

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Outline

- Background
- Methods
  - Air Quality Model (WRF-CMAQ) Settings
  - Brute-force method for estimation of $PM_{2.5}$ source contribution
- Results
  - *Local pollution from BB*: Performance for Simulating $PM_{2.5}$ in China
  - *Long-range transport from BB*: Comparison of the two models (PMF vs. CMAQ/BFM)
- Conclusion

Background

- Biomass burning (**BB**) emission is highly uncertain for Air Quality Models (AQMs)
- Long-range transport of BB pollutants in Japan remains unknown
- Current AQMs cannot sufficiently reproduce $PM_{2.5}$ in Japan

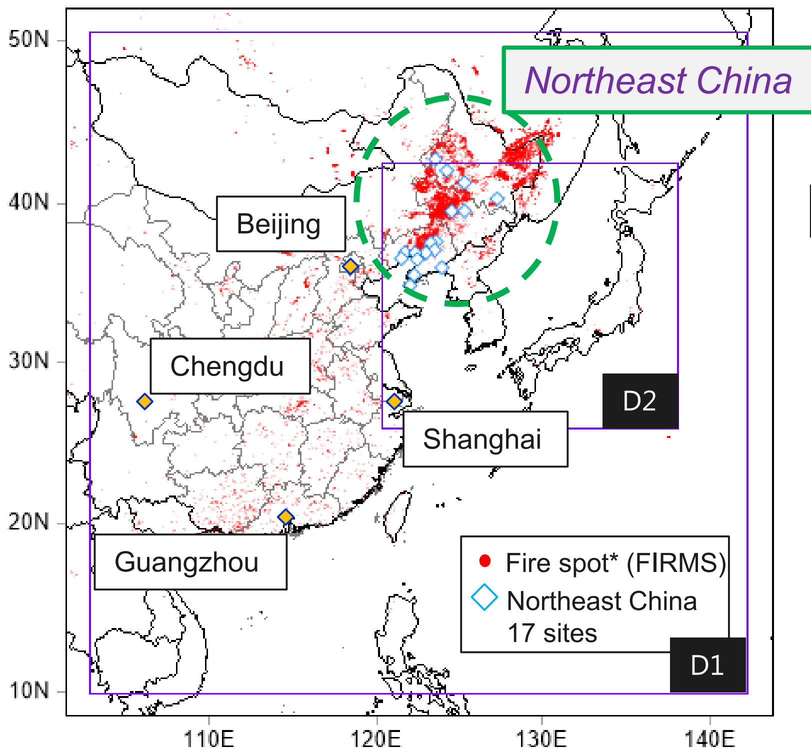
The impact of BB on local pollution and long-range transport of $PM_{2.5}$ was evaluated with CMAQ and PMF

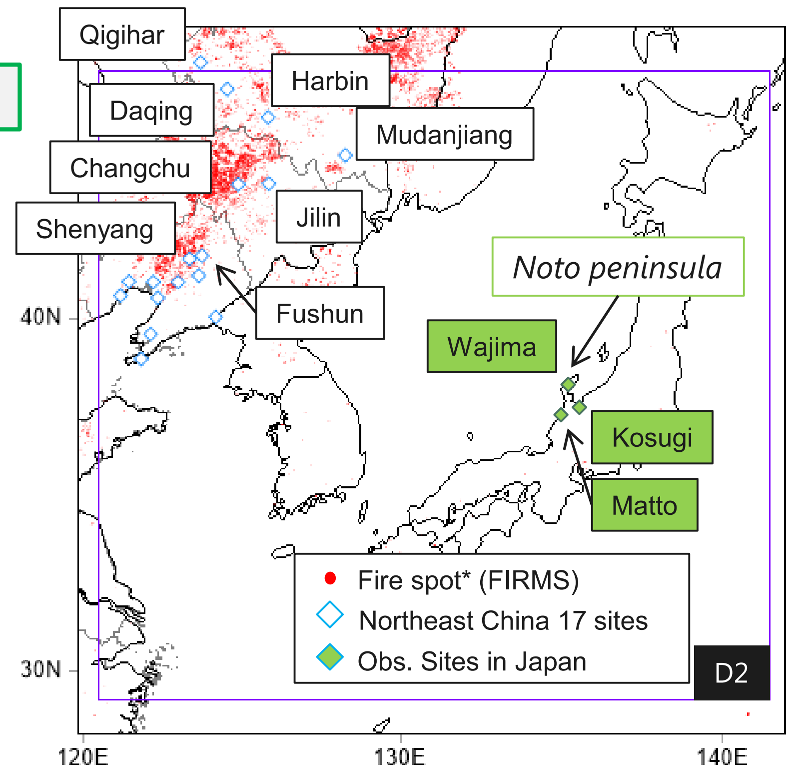
- *Target episode*
  - Autumn (10/20 – 11/9) in 2014 in Northeast Asia
  - Long-range transport of BB pollutants in Noto peninsula in Japan was observed and analyzed by Positive Matrix Factorization (PMF)*

* **Ikemori et al**. 2017: *The 31th annnual meeting of Tokai-Kinki-Hokuriku branch of the Japan Environmental Laboratory Association (JELA), Fukui* (in Japanese).

Simulation domains

- East Asia (D1): 45km grid, 107 x 107 (CMAQ)
- Japan (D2) : 15km grid, 132 x 126 (CMAQ)
- Surface to 100hPa (34 layers, 1st mid layer height ≈ 26m)





(* Fire spots from 20 Oct to 9 Nov.)

- **Numerous fire spots** are found in Northeast China.

AQM (WRF/CMAQ) configuration

- Simulation period: Jan. 2014 to Dec. 2014 (Target period: **20 Oct. ~9 Nov.**)

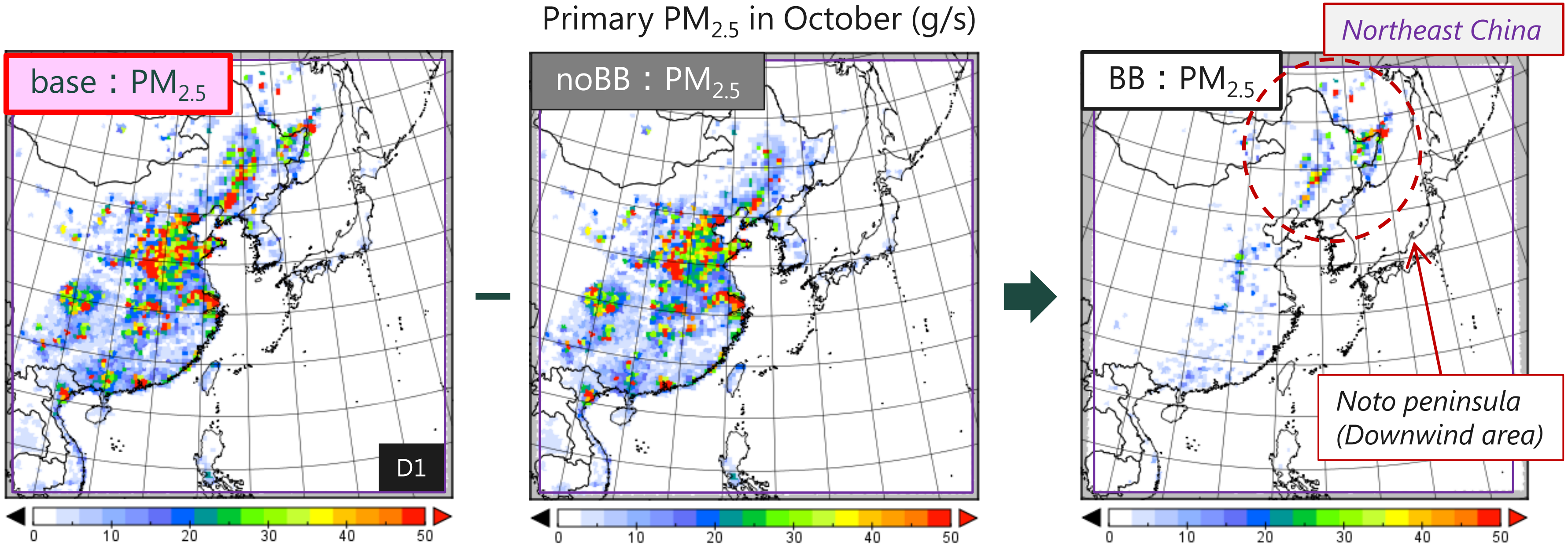
		Configuration
WRF v3.8.1	Geography Data	USGS (30sec)
	Analysis Data	JMA MSM-GPV (0.125x0.1deg, 3hr), NCEP FNL (1deg, 6hr), NCEP/NOAA RTG_SST_HR (1/12deg, daily)
	Physics Option	Kain-Fritsch, WSM6, YSU PBL, Noah LSM, Dudhia(SW, LW), FDDA: $G_{t,\ q,\ uv} = 3.0\text{x}10^{-4}\ s^{-1}$
CMAQ v5.0.2	Meteorology Processor	MCIP v4.3
	Initial & Boundary	Default
	Emission Data	Asia: HTAPv2(2010) Japan: EAGrid2010 & JEI-DB(Vehicle) & OPRF2010(Ship), Biogenic: MEGANv2.04, Biomass burning: FINN v1.5, Volcano: JMA & Aerocom
	Advection, Diffusion	Yamartino/WRF-based scheme, Multiscale/ACM2
	Chemistry Option	SAPRC07 & AERO6 with Aqueous chemistry

WRF-CMAQ

- **W**eather **R**esearch and **F**orecasting model
- **C**ommunity **M**ultiscale **A**ir **Q**uality model

Brute-force method (BFM)

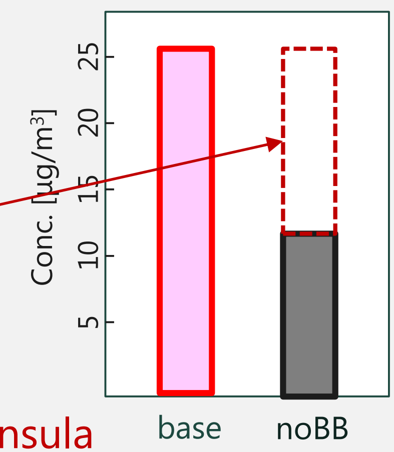
Primary $PM_{2.5}$ in October (g/s)



CMAQ with Brute-force method (CMAQ/BFM)

- Base: Baseline case
- noBB: BB emission set to be zero
- **C_{BB} = base – noBB**

: Contribution of Long-range transport from BB on Noto peninsula

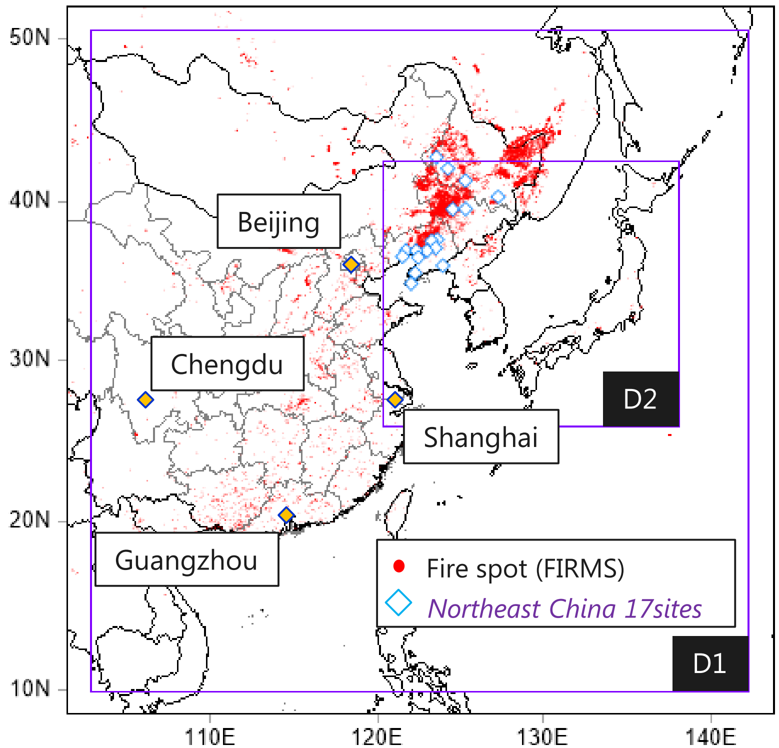


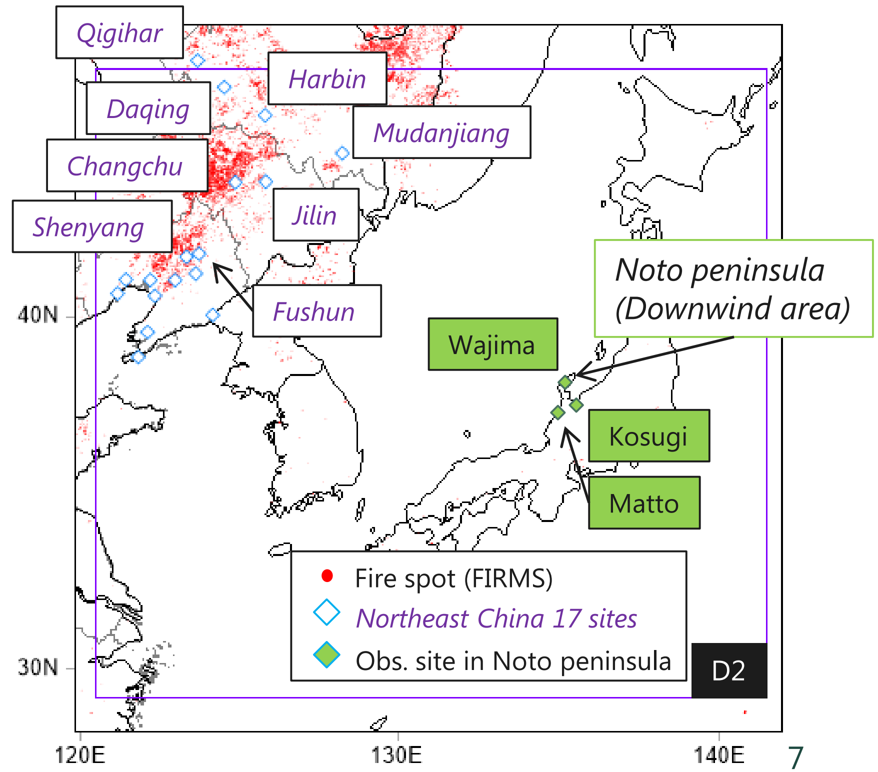
Simulation Case

- Target Period: 2014/10/20 ～ 2014/11/9
- Target Area ：BB（Fire spot） hotspot: ***Northeast China 17 sites***

  Downwind area: **Noto peninsula in Japan**
- BB emission：①Baseline case

  ②BB emission ×5（FINN05）





Analysis procedure

- Three cases of simulations were implemented for CMAQ/BFM-estimated BB contribution.
  - Base, FINN05 (x5 boosted BB emis.), noFINN (no BB emis)

1. AQMs performance with Air quality data of **China** was evaluated for **a local pollution from BB**

2. PMF-estimated BB contributions in **Japan** (Ikemori et al., 2017) was compared with CMAQ/BFM-estimated BB contributions for **a long-range transport from BB**

Ikemori et al. 2017: *The 31th annnual meeting of Tokai-Kinki-Hokuriku branch of the Japan Environmental Laboratory Association (JELA), Fukui* (in Japanese).

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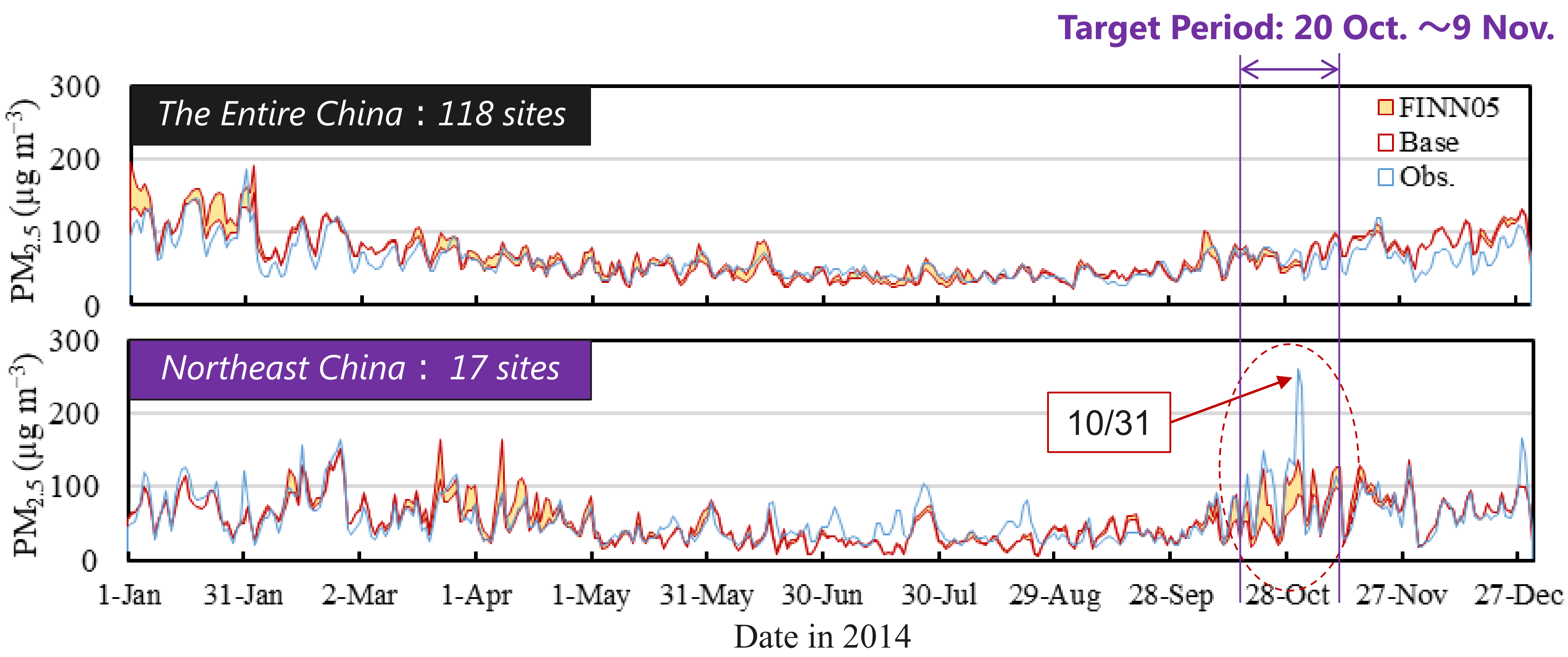
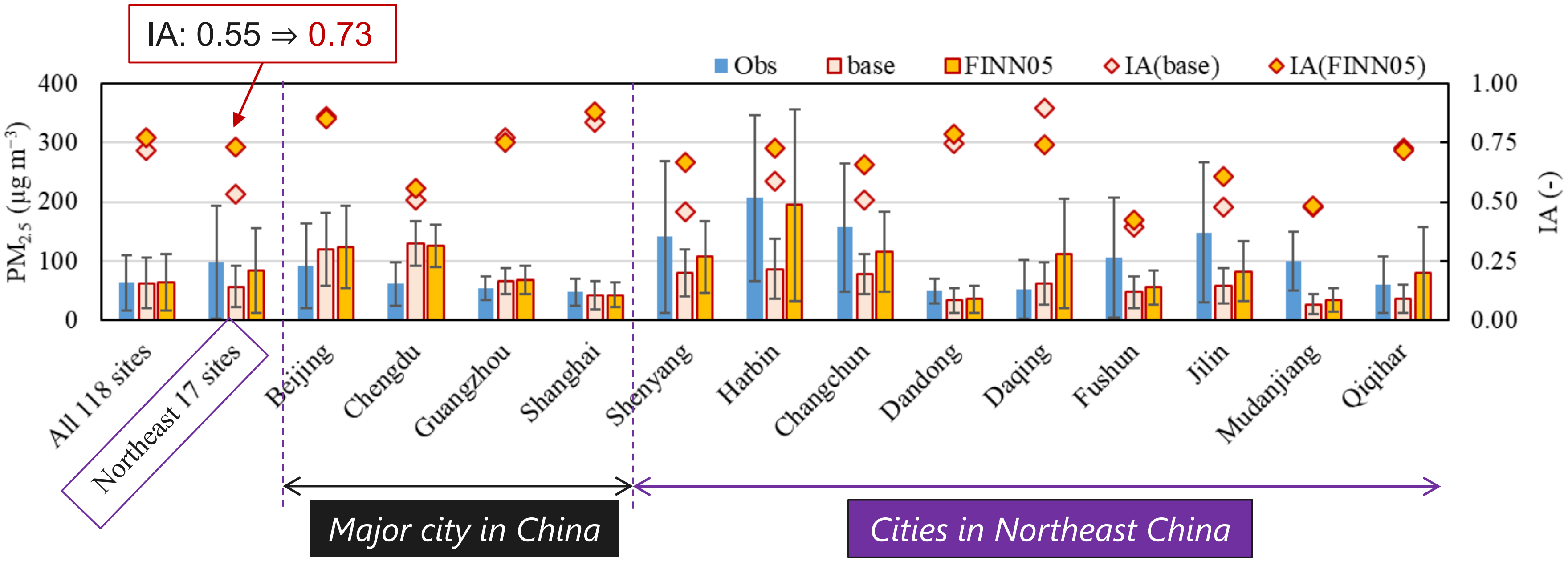
Daily mean $PM_{2.5}$ concentration in D1 in 2014



- **Base**: Large underestimation was revealed in Northeast China during the last 10 day of October.
- **FINN05**: Boosted BB case showed favorable performance.

- Underestimation of BB emission may be implied.

Model performance in China during 20 Oct. – 9 Nov.



- **Base**: Large underestimation was revealed in Northeast China during the target period.
- **FINN05**: Boosted BB case showed favorable performance.
  - IA for Northeast 17 sites = 0.73 (vs. 0.55 in Base case)
  - IA and mean concentration for major cities were almost same.

- Underestimation of BB emission was also illustrated.

Analysis procedure

- Three cases of AQMs were implemented for CMAQ/BFM-estimated BB contribution.
  - Base, FINN05 (x5 boosted BB emis.), noFINN (no BB emis)

1. AQMs performance with Air quality data of China was evaluated for **a local pollution from BB**

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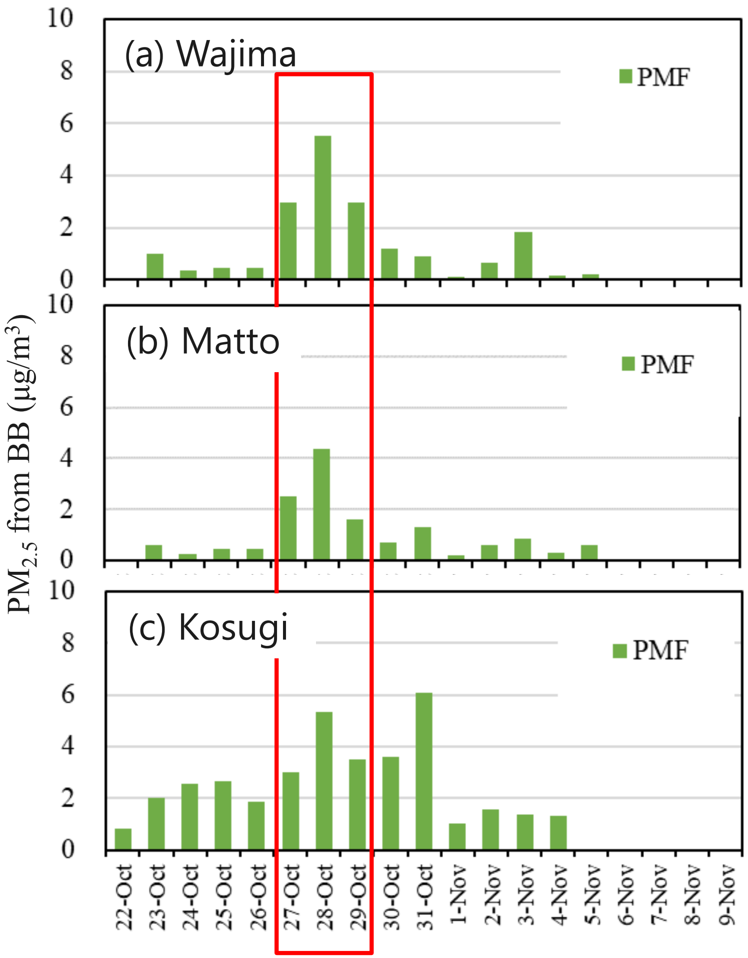
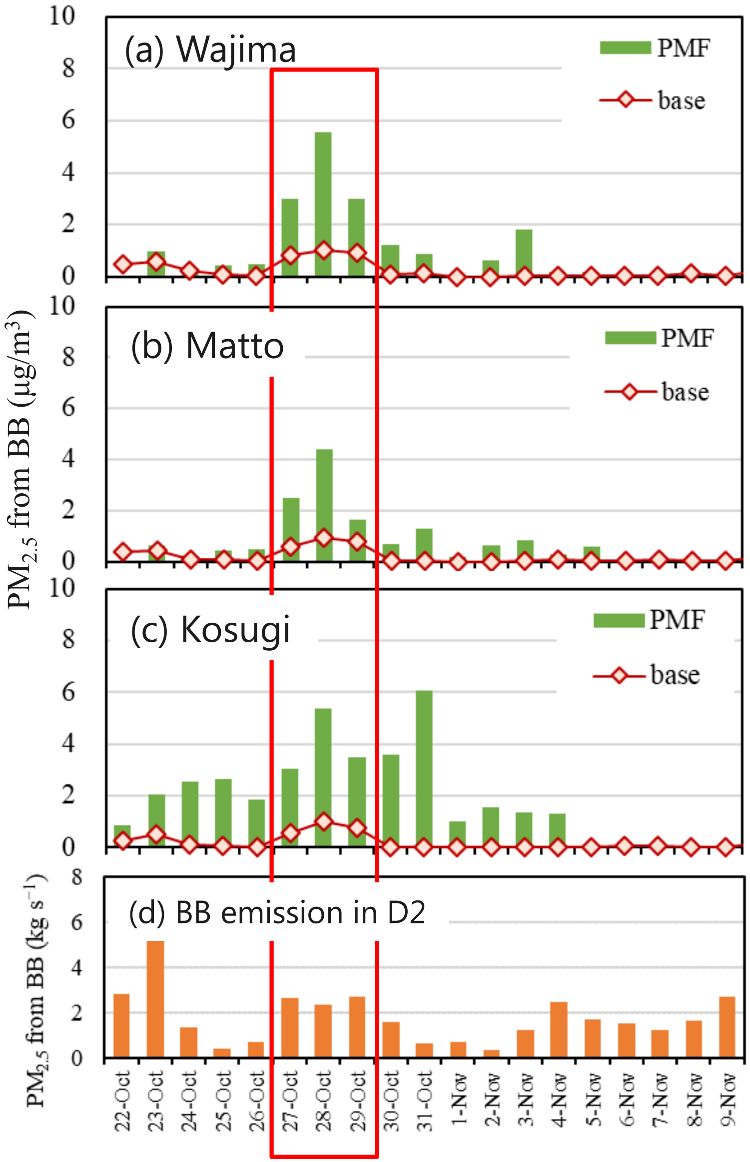
Ikemori et al. 2017: *The 31th annnual meeting of Tokai-Kinki-Hokuriku branch of the Japan Environmental Laboratory Association (JELA), Fukui* (in Japanese).

Comparison of the two models (PMF and CMAQ/BFM): 1



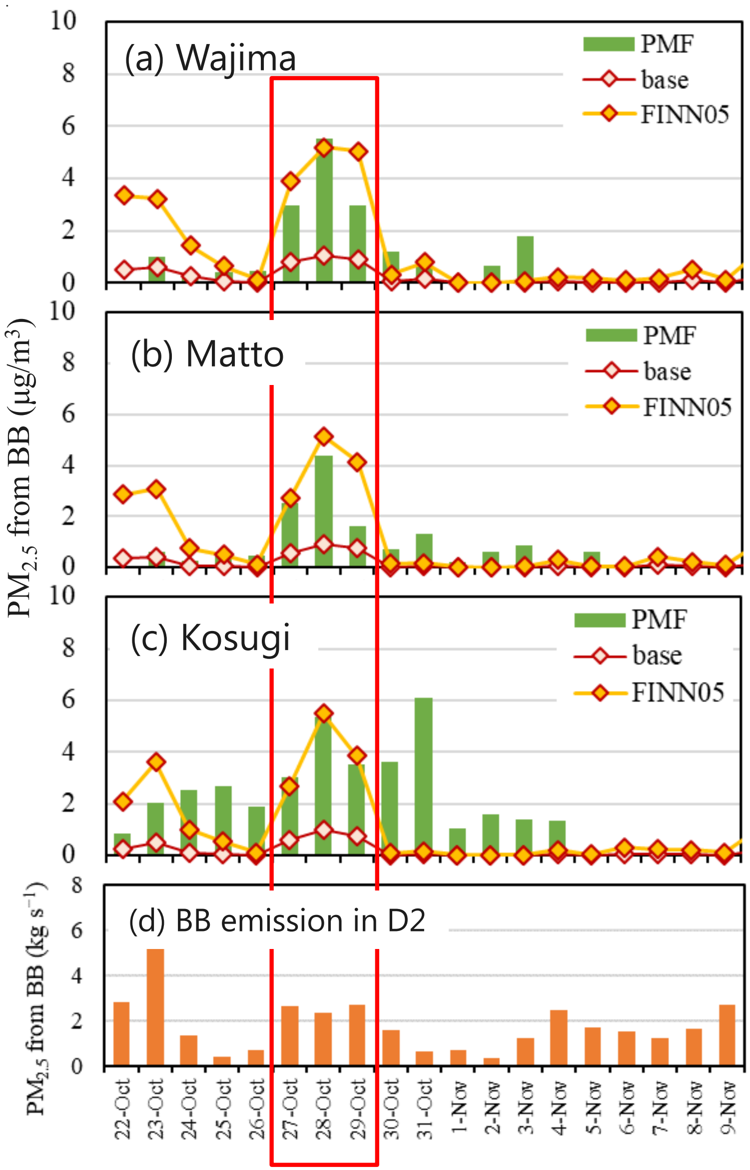
- PMF identified clearly high BB contributions in Noto peninsula during the 3 days (27 to 29 Oct.).

Comparison of the two models (PMF and CMAQ/BFM): 2



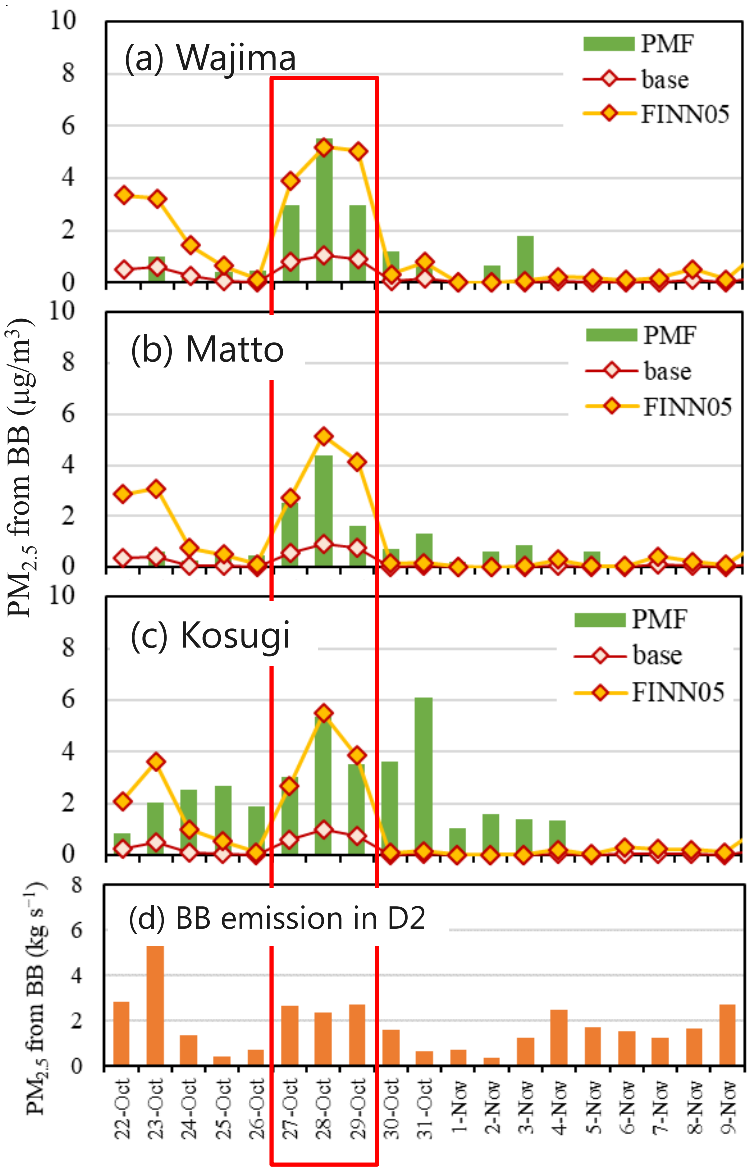
- BB contribution by CMAQ/BFM in Base case was **underestimated**

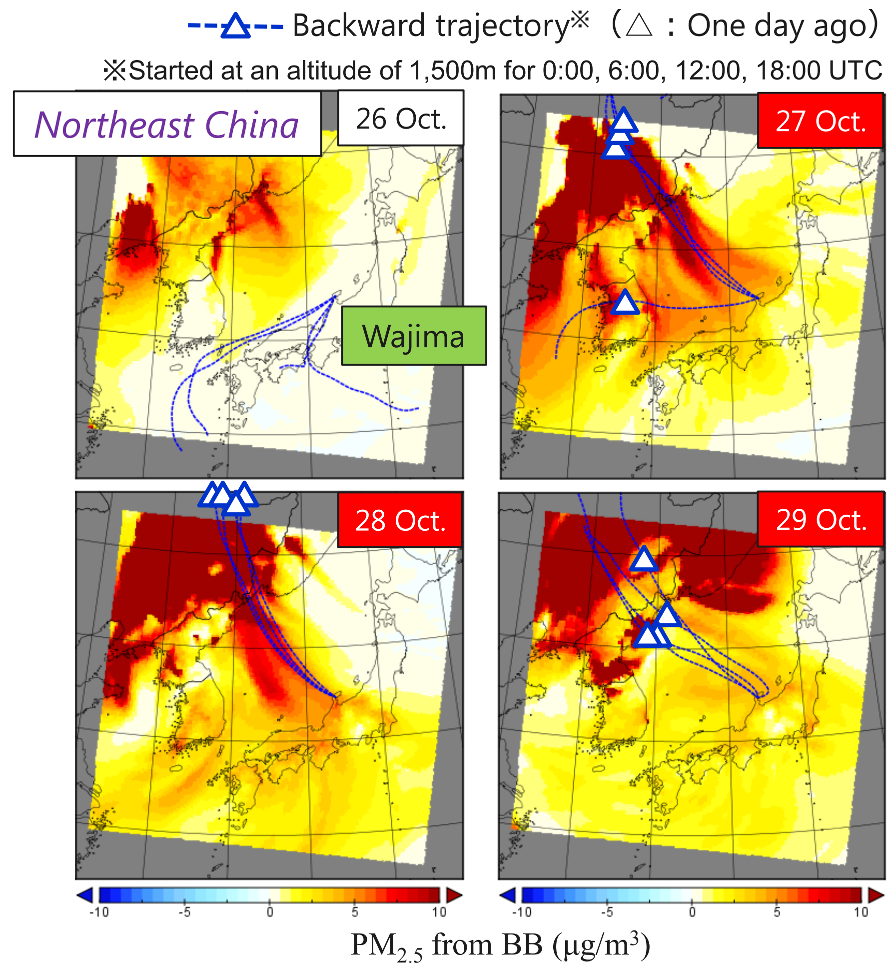
Comparison of the two models (PMF and CMAQ/BFM): 3



- CMAQ/BFM in boosted BB case (FINN05) produced better BB contribution harmonized with PMF

Comparison of the two models (PMF and CMAQ/BFM): 4





- BB pollutants were directly transported to Wajima from Northeast China during 27–29 Oct.

Conclusion

<Local pollution>

1. Five times boosted BB suggests substantial improvement of $PM_{2.5}$ simulation in autumn in Northeast Asia.

<Long-range transport>

2. Comparison between PMF and CMAQ/BFM-estimated contributions implies BB emission was underestimated.

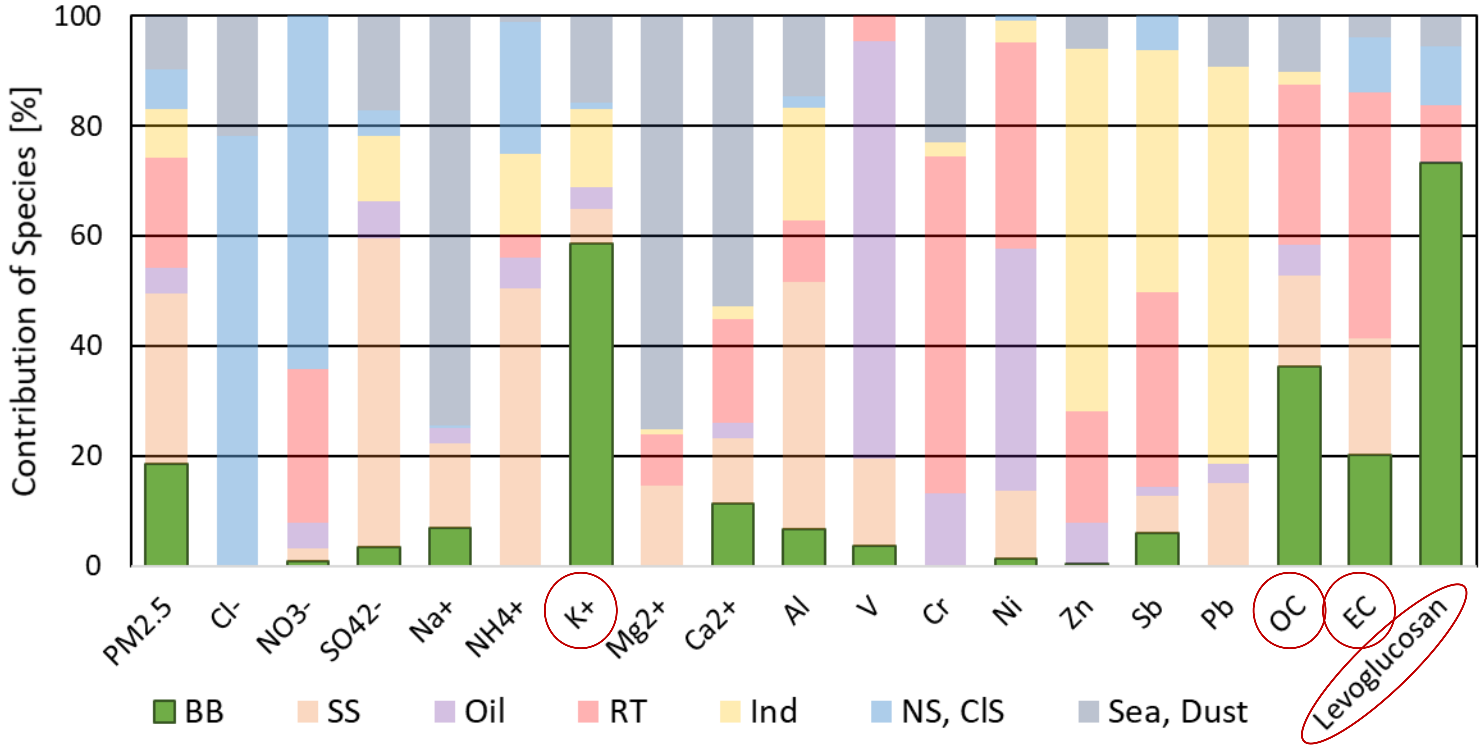
The comparison approach by using PMF and CMAQ/BFM allows us to illustrate that a boosted BB emission is preferable in this study.

Acknowledgement

- This research was conducted as Type II joint research of the **National Institute for Environmental Studies** (**NIES**) and **environmental research institutes of local government in Japan**.
- The computational resources were provided by **NIES**.
- We acknowledged the use of data and imagery from LANCE FIRMS operated by the **NASA/GSFC/Earth Science Data and Information System (ESDIS)** with funding provided by **NASA/HQ**.

Thank you for your attention!!

<Reference> BB Profile in PMF analysis (by Ikemori et al., 2017)

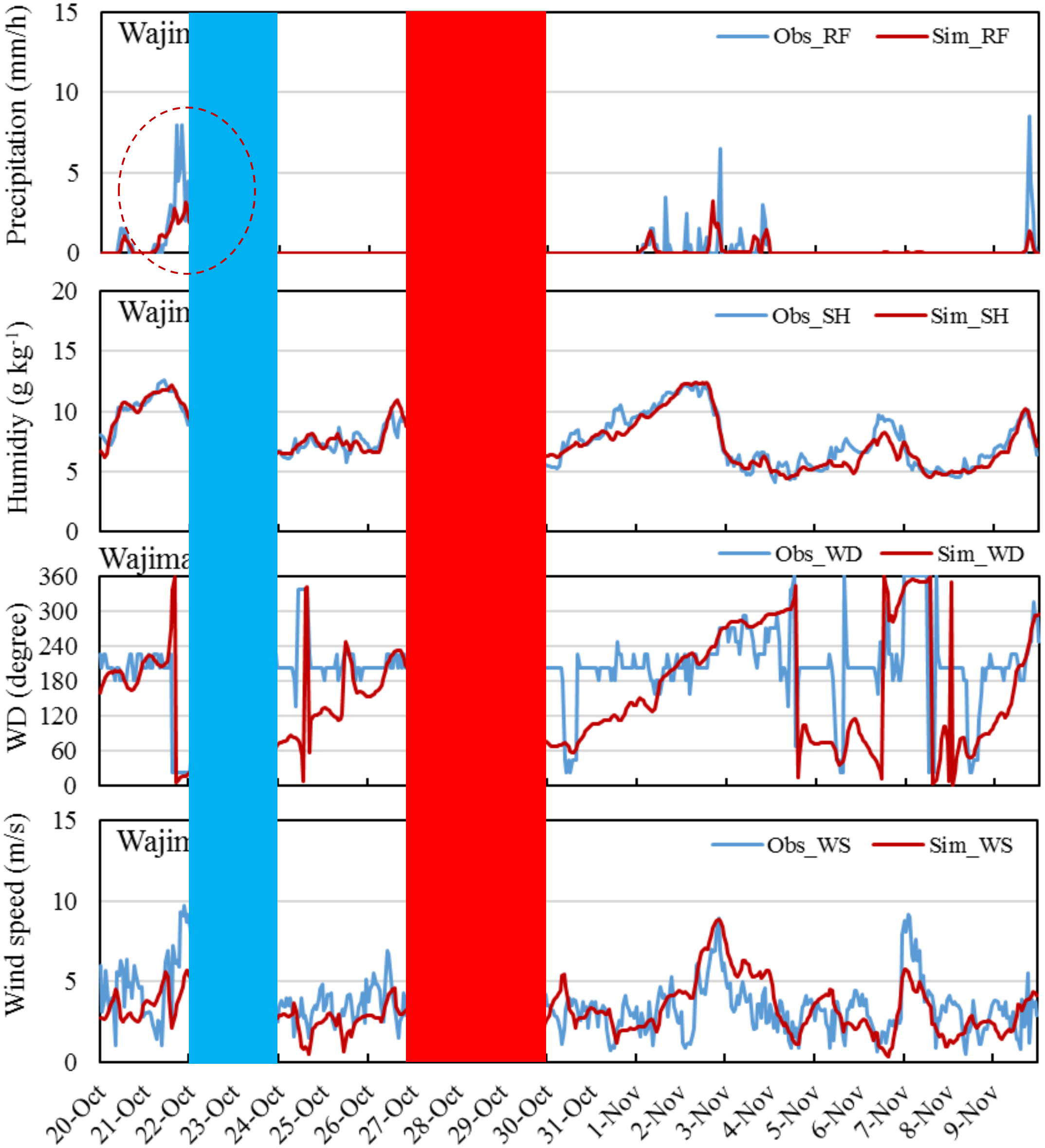


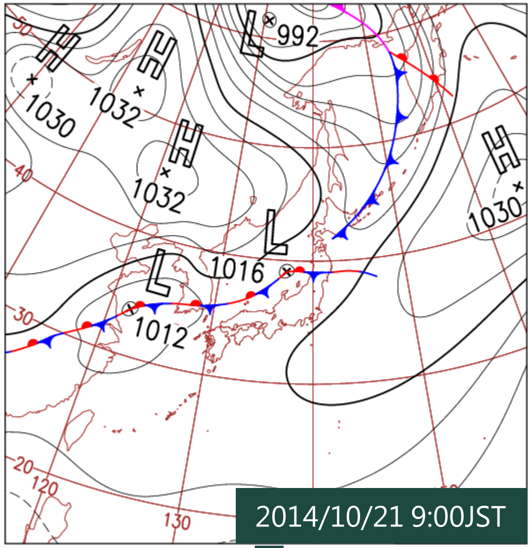
- **BB profile** was identified by **tracer chemicals** (K^+, OC, EC, **Levoglucosan**) as well as concentration profile.

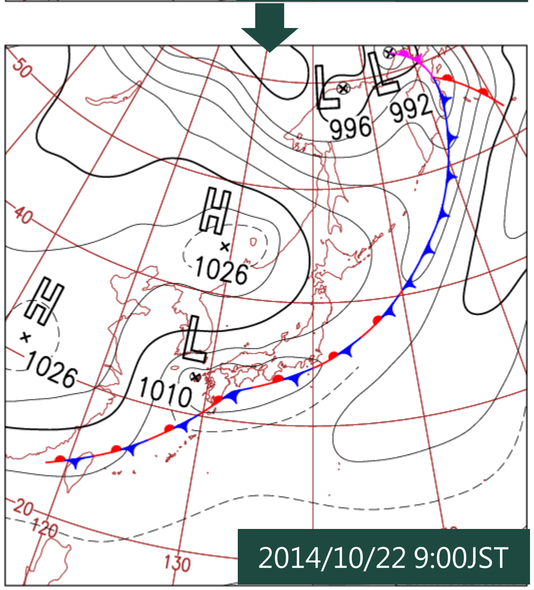
<Other PMF factors>

SS: sulfate aerosol, **Oil**: oil combustion, **RT**: road transportation,
Ind: industrial dust, **NS, CIS**: nitrate aerosol etc, **Sea, Dust**: sea salt particle and dust

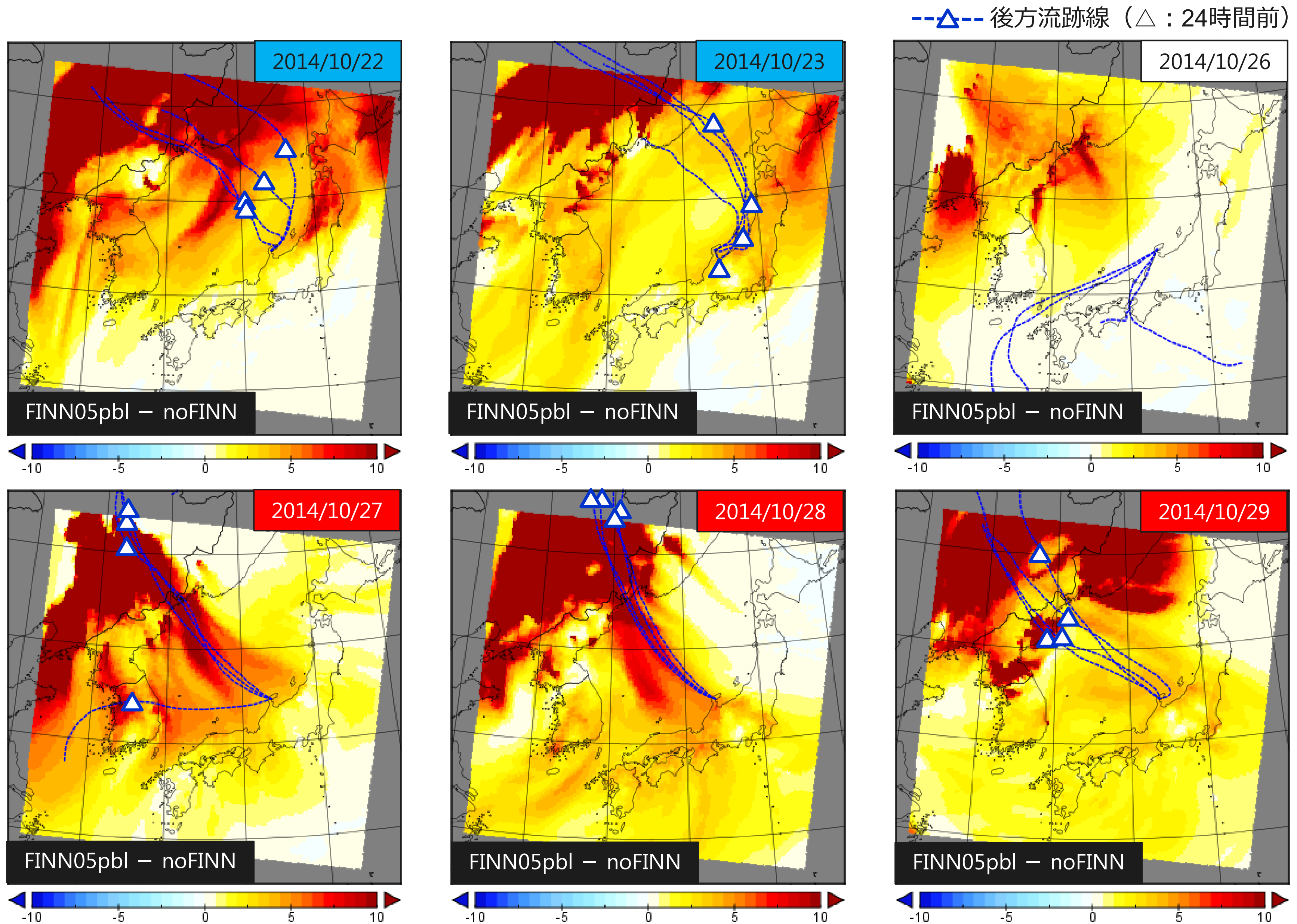
WRF model performance of at Wajima



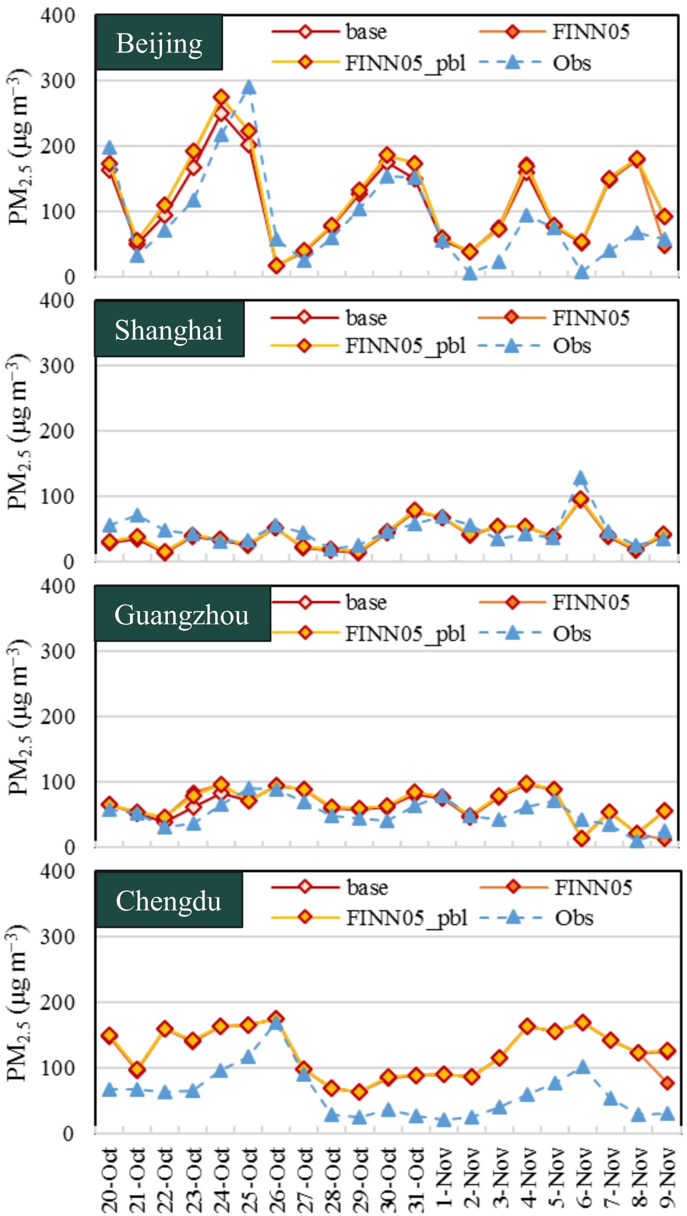


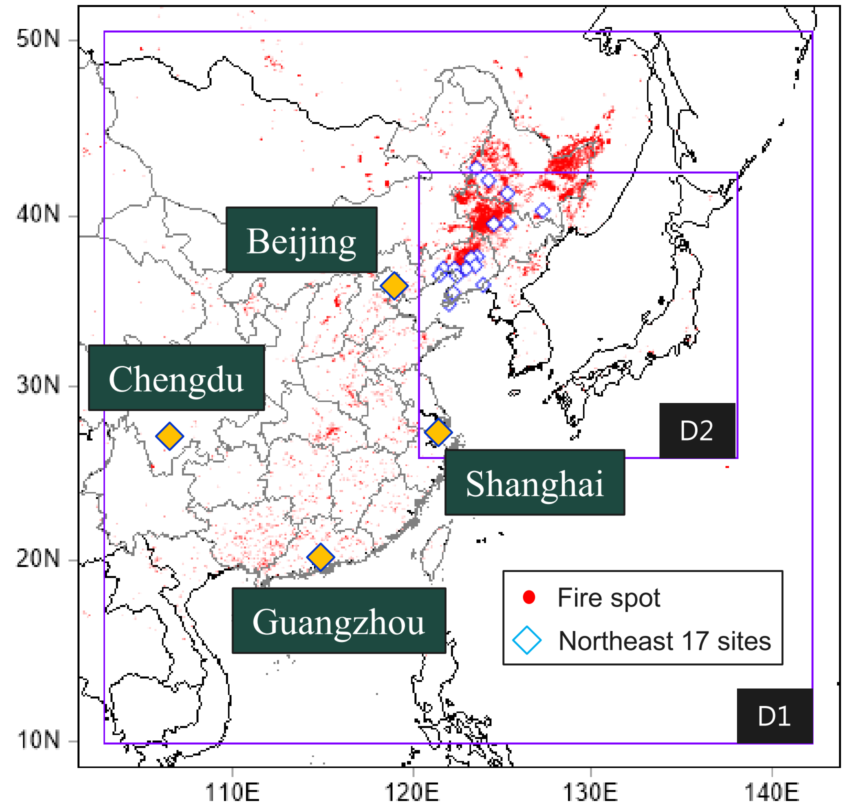


輪島における後方流跡線（毎00, 06, 12, 18時、48時間、到着高度1,500m）



中国国内の地点ごとの再現性（D1：中国主要都市）

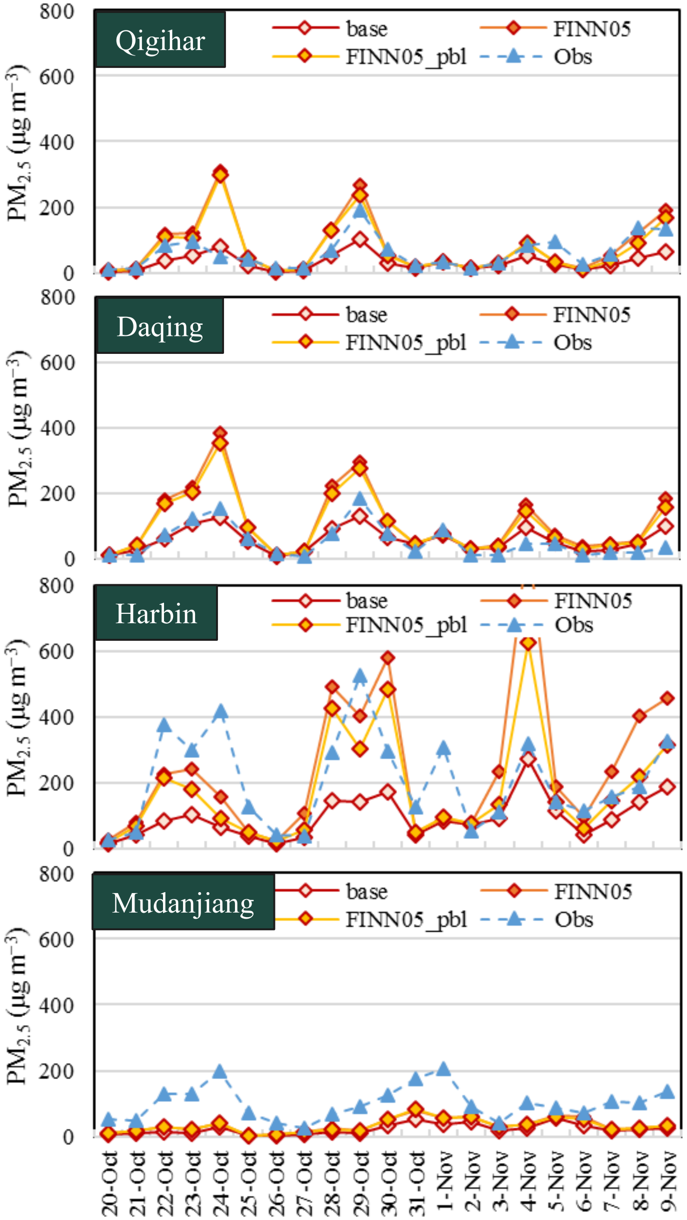


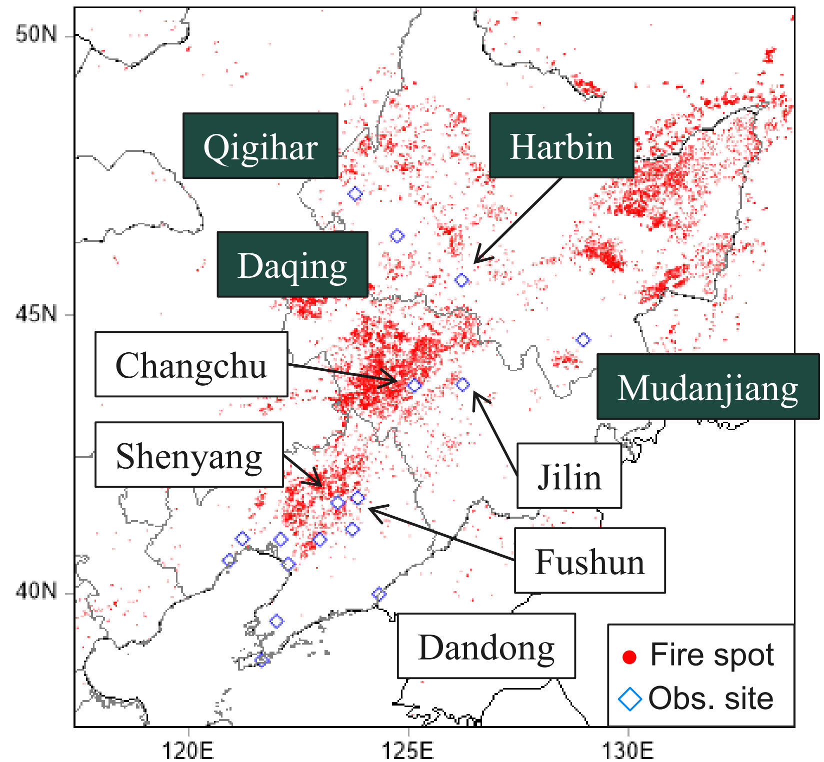


- Beijing以外、FINNの濃度を変化させても10/20～11/9の間は大差なし
- Chengdu以外は再現性は良好

※Chengduは2013年のINTEX-Bによる計算でも再現性は不良

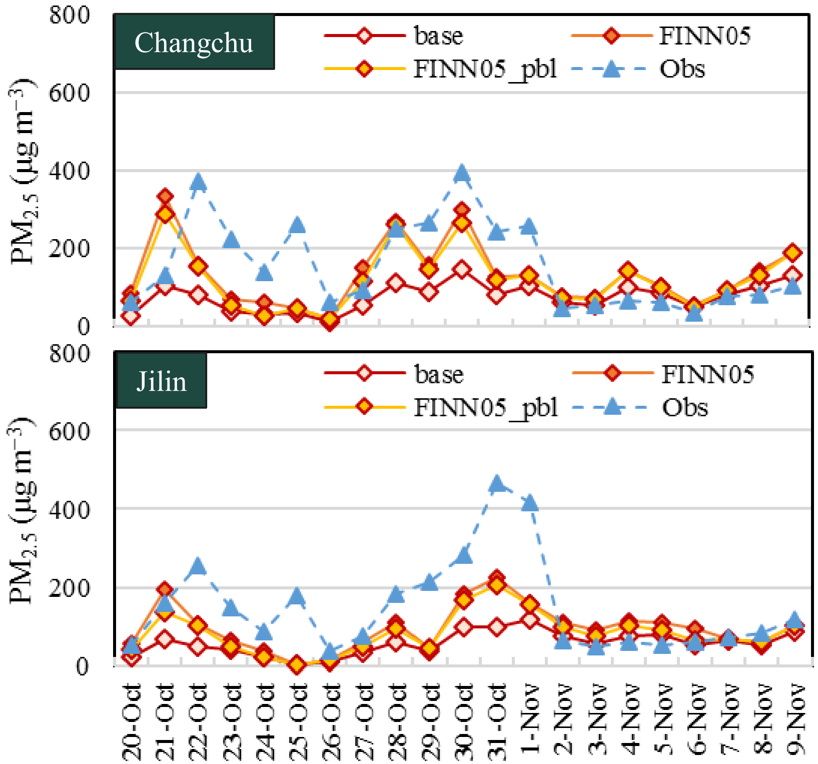
中国国内の地点ごとの再現性（D1：Heilongjiang省）

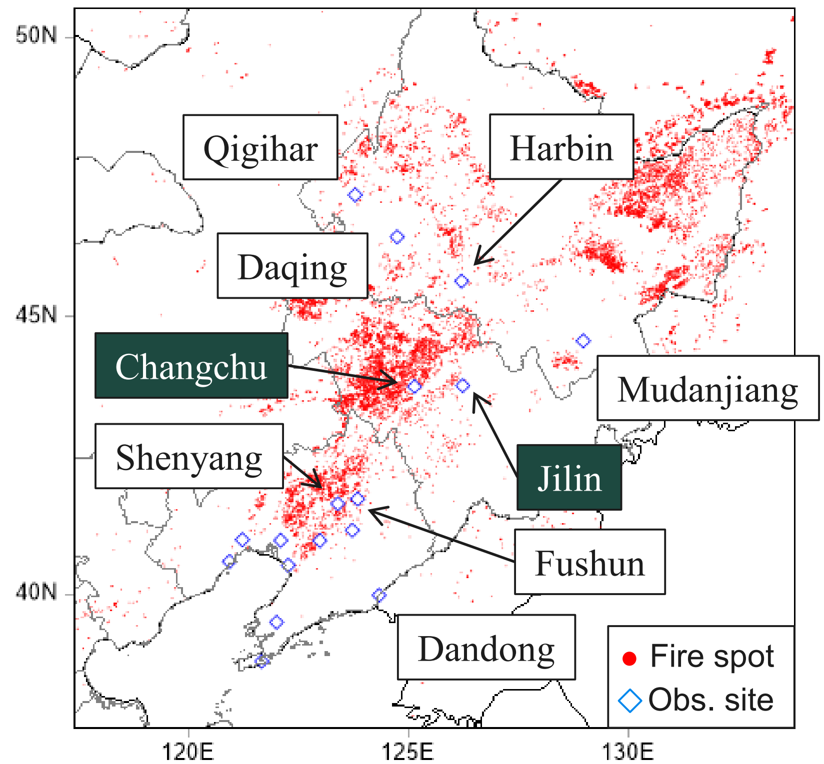




- Baseケースは過小評価傾向が強くFINN排出量不足を裏付け
- 野焼き発生地点付近では、PBL均等割した場合、地表面濃度が低めに算出

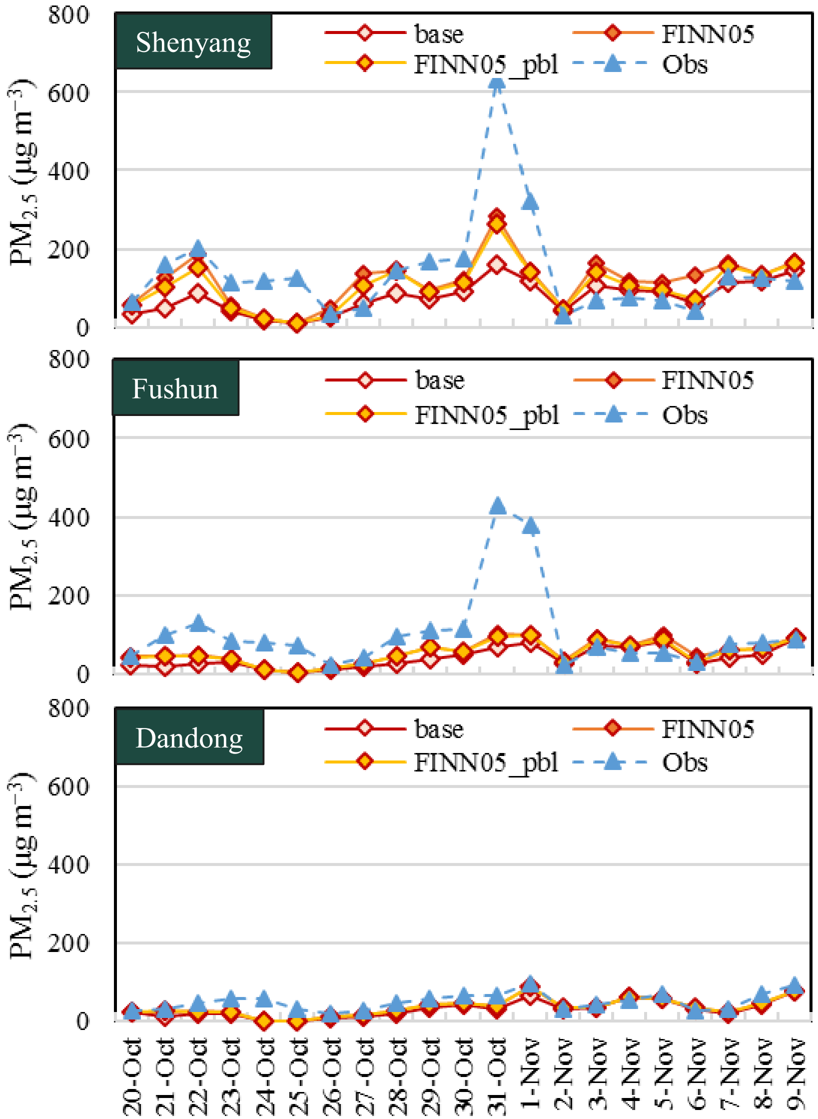
中国国内の地点ごとの再現性（D1：Jilin省）

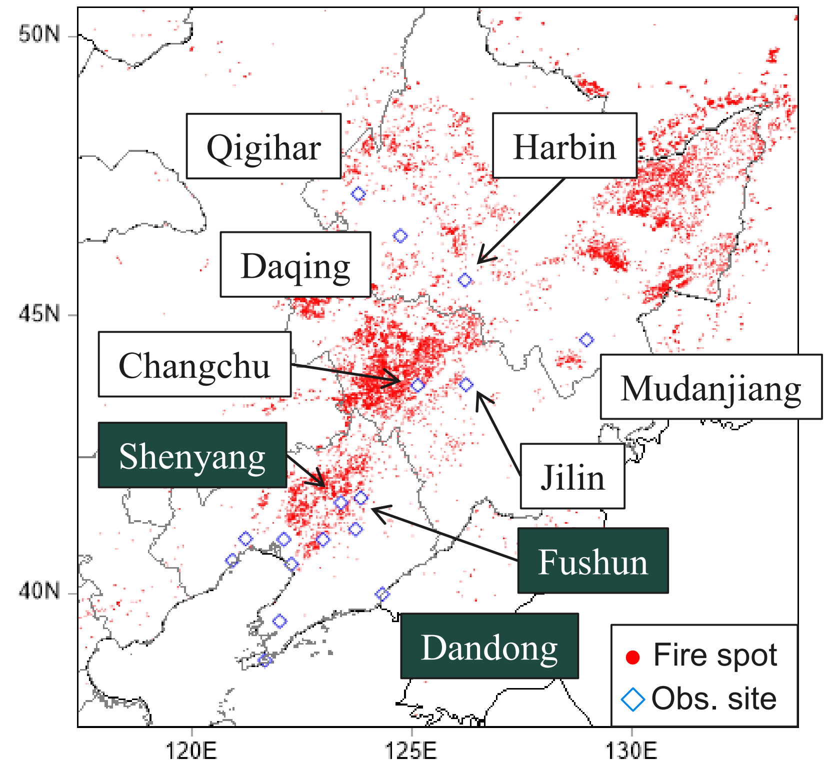




- Baseケースは過小評価傾向が強い（Heilongjiangと同傾向）
- 野焼き発生地点付近では、PBL均等割した場合、地表面濃度が低めに算出

中国国内の地点ごとの再現性（D1：Liaoning省）

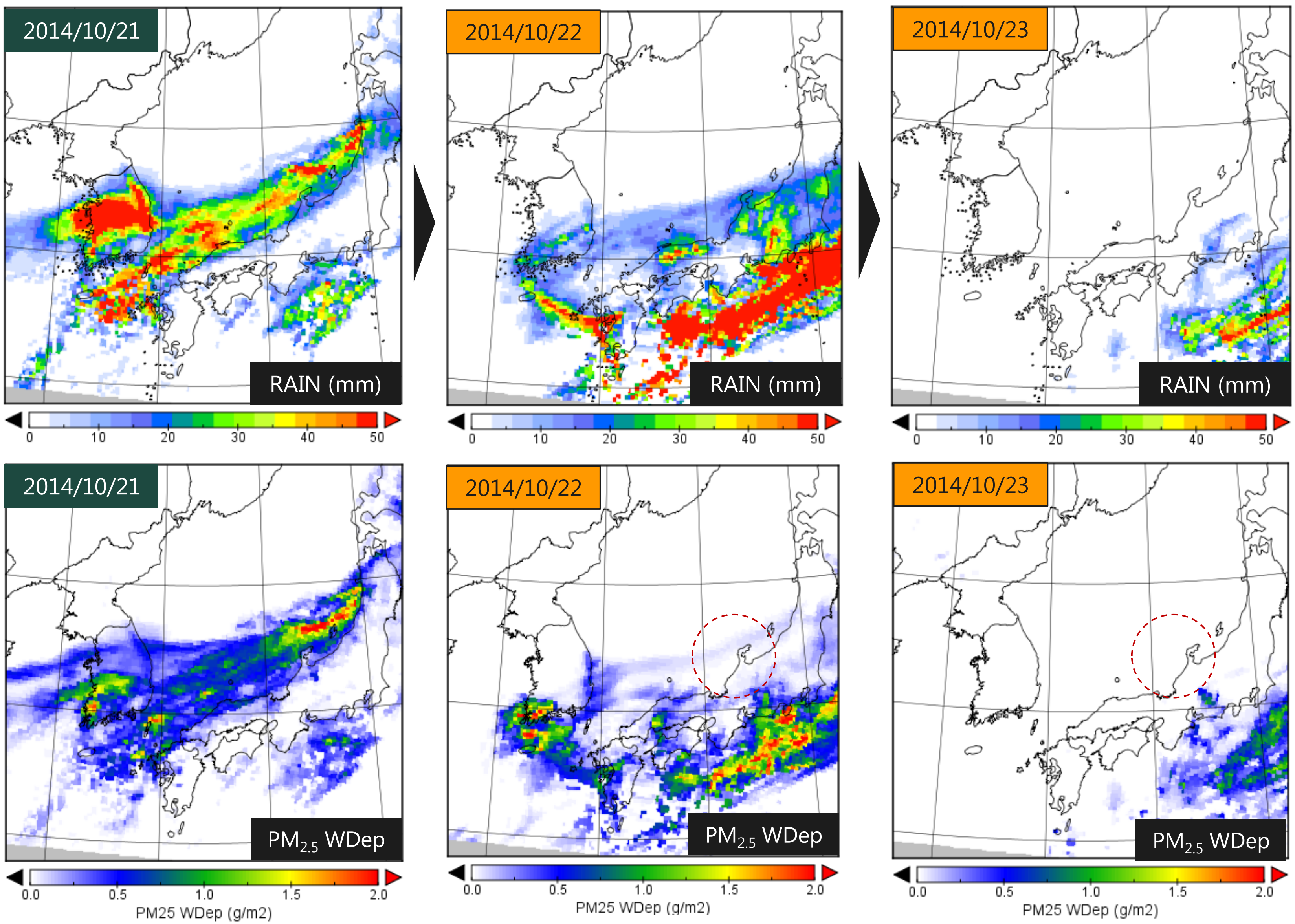




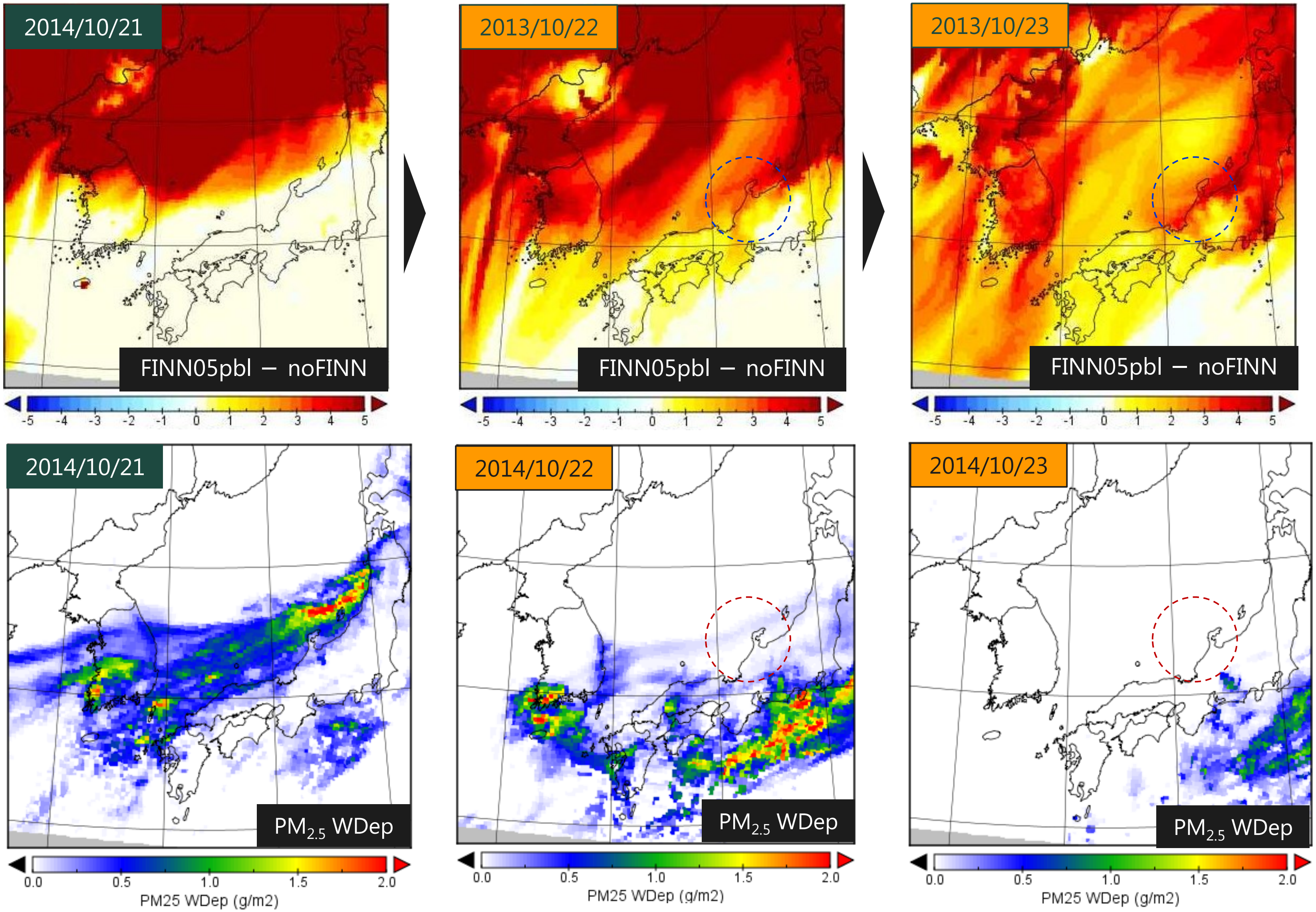
- Baseケースは過小評価傾向が強い（Heilongjiangと同傾向）
- 10/31, 11/1の$PM_{2.5}$濃度が大きくかい離（Shenyang, Fushun）

⇒　バイオマス燃焼とは別要因？

越境汚染の再現性不良の考察１（D2: 日平均降水量、湿性沈着量）



越境汚染の再現性不良の考察２（D2: FINN感度解析、湿性沈着量）



❖ 湿性沈着量の不足により能登半島は汚染？