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

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- Methods
  - Air Quality Model (WRF-CMAQ) Settings
  - Brute-force method for estimation of PM$_{2.5}$ source contribution

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  - *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 (AQM)
- Long-range transport of BB pollutants in Japan remains unknown
- Current AQMs cannot sufficiently reproduce PM$_{2.5}$ in Japan

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**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 annual 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)

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.**)

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

- **Weather Research and Forecasting model**
- **Community Multiscale Air Quality model**
Brute-force method (BFM)

CMAQ with Brute-force method (CMAQ/BFM)

- Base: Baseline case
- noBB: BB emission set to be zero

\[ C_{BB} = \text{base} - \text{noBB} \]

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

- Target Area: BB (Fire spot) hotspot: **Northeast China 17 sites**
  - Downwind area: **Noto peninsula in Japan**
- BB emission:
  1. Baseline case
  2. BB emission × 5 (FINN05)
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 annual meeting of Tokai-Kinki-Hokuriku branch of the Japan Environmental Laboratory Association (JELA), Fukui (in Japanese).
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Large underestimation was revealed in Northeast China during the last 10 days 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.
Three cases of AQMs were implemented for CMAQ/BFM-estimated BB contribution.

- Base, FINN05 (x5 boosted BB emissions), noFINN (no BB emissions)

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 annual 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.**).
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
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!!
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）
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出る
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？