Impact of Long-Range Wildfire Smoke Plumes on NYC Air Quality

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Introduction

Hundreds of wildfires burn through the western US and Canada every year in recent decades. Climate change is increasing the prevalence and severity of wildfires, resulting in longer fire seasons and larger area burned (Westerling et al. 2006). Large wildfires can inject smoke kilometres into the troposphere, where it can be transported in plumes for long distances, even on continental scales. Depending on their height and atmospheric dynamics, plumes can either pass over cities above the boundary layer with little to no effect on local air quality or subside into the planetary-boundary-layer (PBL) and mix with surface air, impacting local air quality. Evidence has shown that the adverse health effects (e.g., significant increase in mortality and hospitalization rates for respiratory outcomes) were associated with smoke exposure in impacted areas both close to and far away from the fires (Naeher et al. 2007). In this study, local LiDAR data, EPA AirNow hourly polluted data, and IMPROVE daily data were combined to investigate the impact of wildfire smoke plume on local air quality in NYC and Mohawk Mountain, Connecticut.

Data

◆Wildfire Smoke Plume

NOAA HMS smoke and fire data determine the geographical extent of wildfire smoke plumes, presenting the extent of smoke plumes based on visible bands of satellite imagery. The data were downloaded from http://www.ospo.noaa.gov/Products/land/hms.html.

◆Hourly $PM_{2.5}$ Concentration

Hourly $PM_{2.5}$ & O_3 from EPA monitoring sites in NYC were downloaded from https://aqs.epa.gov/aqsweb/airdata/download_files.html.

◆IMPROVE Aerosol Composition

IMPROVE aerosol composition data (one 24-hour sample collected every 3 days), were downloaded from http://views.cira.colostate.edu/fed/DataWizard/Default.aspx. 19 components were considered in our study.

◆Global Data Assimilation System (GDAS) Data

GDAS meteorological data produced by NOAA's Air Resources Laboratory (ARL) – 3-hour, global, 1 degree dataset. The data are downloaded from ARL (ftp://arlftp.arlhq.noaa.gov/pub/archives/gdas1).

◆CCNY-LiDAR Data

The LiDAR data, collected by the Optical Remote Sensing Laboratory (ORSL) at the City College of New York (CCNY), include three level products: range-corrected elastic-scattering, planetary-boundary-layer height, aerosol extinction coefficients and aerosol optical depth. The data are downloaded from http://sky.ccny.cuny.edu/wc/lidar2.html

References

Black, C., et al. 2017. Wildfire smoke exposure and human health: Significant gaps in research for a growing public health issue. *Environmental Toxicology and Pharmacology* 55:186-195

Park, R.J., et al. 2007. Fire and biofuel contributions to annual mean aerosol mass concentrations in the united states. *Atmospheric Environment* 41:7389-7400.

Westerling, A.L., et al. 2006. Warming and earlier spring increase western US forest wildfire activity. *Science* 313:940-943

Method

Eight events (from 2007 to 2016) were first determined by HMS smoke and fire products, local LiDAR profiles, and HYSPLIT model. HMS products inform time and locations of wildfire events and the local LiDAR data confirm the mixing of the plumes with surface air in NYC (Fig. 1-4). Based on plume heights, HYSPLIT back-trajectory was used to track whether the plumes were originated from wildfires.

For these 8 events, EPA hourly data (including $PM_{2.5}$ and O_3) and IMPROVE aerosol composition data were compared for one week before, during, and one week after the events. Since 2011, IMPROVE stopped data collection in NYC, and we used Mohawk Mt. CT station for comparison. While the CT station may not represent NYC air quality exactly, it fits the purpose of this study nicely for determining the plume composition.

Results

Confirmation of the mixing of the plumes with surface air and impacts on local air quality in NYC

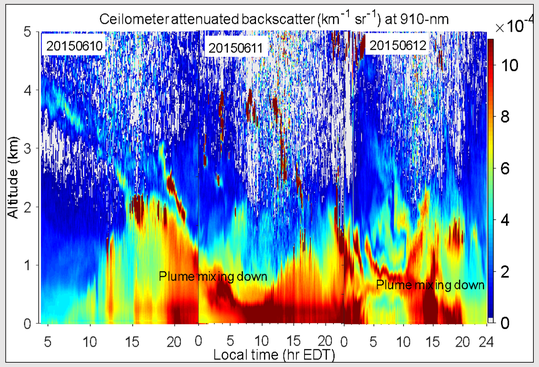


Fig. 1: LiDAR data during the event in June 2015

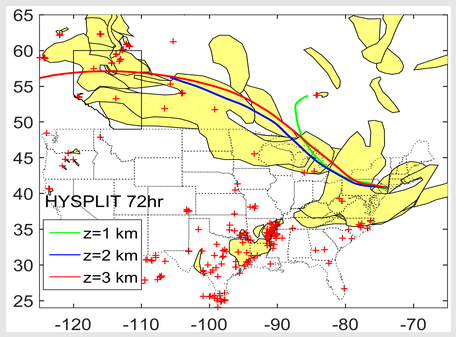


Fig. 2: HYSPLIT back trajectory

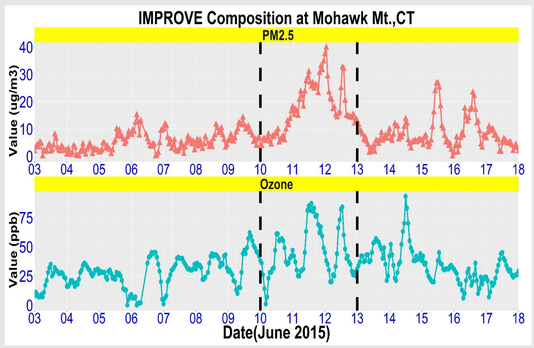


Fig. 3: EPA hourly data during this period

	May	June	July	Aug	Sep	Oct
2015	3	4	5	8	6	4
2016	8*	6*	4	6	6	4
2017	2	3	4	7**	3	5

Table 1: The day counts of aloft smoke plume mixing down into PBL/surface. Note: * The wildfires in Fort McMurray, Alberta, Canada in May-July 2016; ** The wildfires in the Northwest US and Southwest Canada in August 2017.

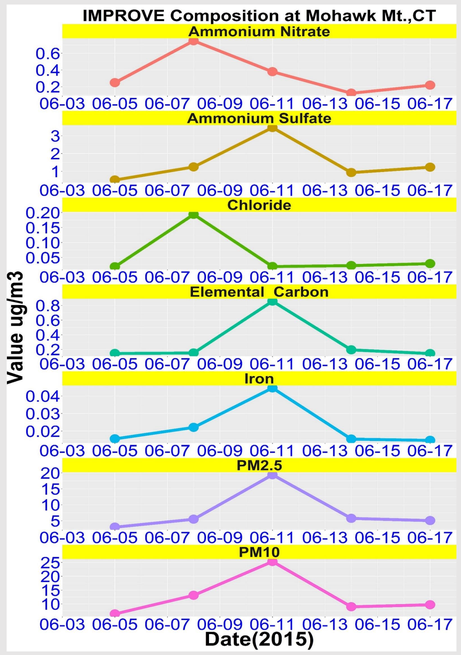
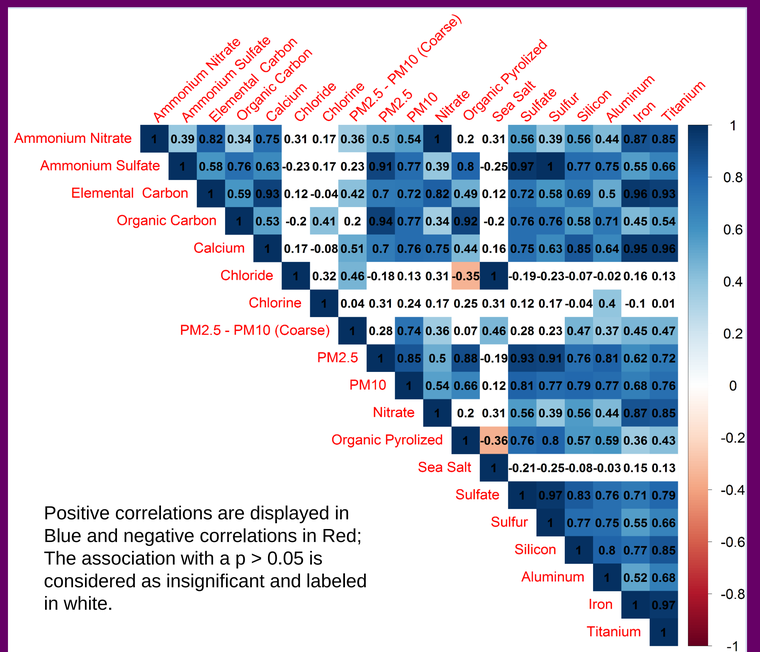


Fig. 4: IMPROVE Aerosol composition data



Positive correlations are displayed in Blue and negative correlations in Red; The association with a p > 0.05 is considered as insignificant and labeled in white.

Fig. 5: Correlation coefficients of components in 13 affected samples

Conclusions

1) LiDAR can unambiguously identify the mixing of plumes with local air in NYC;

2) Wildfire smoke plumes impact NYC about 3 to 6 times a year, totaling a duration of 20 to 30 days. Plume contributes about 20% of total $PM_{2.5}$ in NYC, consistent with 20 to 30% estimated in Park et al. (2007);

3) During these events, $PM_{2.5}$ can reach to 40 to 60 μg/m^3 for several days, above the 35 μg/m^3 NAAQS standard;

4) Plumes contain elevated levels of PM, EC, iron, soil components, ammonium sulphate, etc;

5) During the event, two other components, ammonium nitrate and sea salt were suppressed, possibly due to the change of wind direction;

6) Given the substantial impact of long-range of wildfire smoke plumes on air quality in NYC and other cities (such as Chicago, Denver, and Baltimore), wildfire smoke heath impact studies are needed.

Acknowledgement:

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