Where There’s Smoke: (Application of) Satellite Data for Smoke and Fire

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Seasonality of Fire Occurrence

2017 MODIS Fire Detections

Data from NASA
The 2017 Northern California Wildfires Tiger Team Project

- October 8-20, 2017. Five wildfires. 200K acres
- Major Components
  - Fire Emission Inventory (MODIS, VIIRS, GOES-16)
  - Air Quality Modeling (WRF/CMAQ/Dispersion)
  - Satellite Observations to Improve and Evaluate Model Predictions
  - Health Impact Analysis
- Project Organization – Seven sub-teams, 80 Stakeholders/Collaborators,
  - Co-leads: Susan O’Neill, Minghui Diao
  - Fire Emission Inventory & Modeling – Susan O’Neill (USDA FS), BAAQMD
  - Dispersion and Plume Rise – Joe Wilkins (EPA)
  - Satellite and Data Fusion – Mohammad Al-Hamdan (NASA)
  - Health Impacts – Jason West (UNC), Pat Kinney (Boston University)
- Communications
  - Monthly Stakeholder Calls
  - Sub-team calls more often
  - Google Docs, data storage, Webpage
  - Online Training Video

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Calculating Emissions from Wildland Fire

- Vegetation/Land-based: BlueSky Framework
- The two methods share many similarities and make similar assumptions
- Every box is an area of research, with notable uncertainty/variability
- EPA NEI. Combining reported and remotely-sensed fire activity. Larkin et al. 2020

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2017 Northern California Wildfires, 10 fuel types
10% of the area burned responsible for 62% of the PM2.5 emissions
Fire Area and PM2.5 emissions not necessarily directly related – need to account for fuel type
Comparison of Fire Emission Methods

- Five 2017 Northern California wildfires
- Blue – NASA FEER Emissions Estimate (FRP-based)
- Orange – BlueSky Emissions Estimate (bottom up approach)
Calculating Emissions from Wildland Fire

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• Motivation – Sundowner winds and nighttime fire activity
• Whittier Wildfire July 16, 2017 0400 PDT
• GOES-16 data newly available
• Working one on one with the Air Resource Advisor deployed on the fire doing smoke forecasting
The GOES Fire And Smoke Tool (GoFAST)

• Using GOES-16 to create a diurnal profile of fire emissions
• Sean Raffuse
• Camp wildfire November 8, 2018
• Figure: 24-hr diurnal profile of emissions
• Motivation: The default diurnal profile obviously does not apply
• Smoke forecasting systems failed
Product: June-November 2018 Fire Emissions Inventory California

- GOES-16 Detections for 18 Wildfires greater than 12K acres
  - Mendocino, Carr, Camp, Woolsey, Ferguson, Lions, Delta etc.
  - 1.48 million acres total
Product: June-November 2018 Fire Emissions Inventory California

Daily satellite detects by source (8/20/2018)

Create ‘box’ around each detect. Size based on source

Dissolve each box, resulting in a fire ‘location’

Now that we have a fire location, need a size (acres) estimate

Using the number of detects… … and a reduced number of detects based on 1 km grid

Number of detects: 59
Number of reduced detects: 21

A size (acre) estimate is applied to each reduced detection. The size is based on vegetation type, e.g. 200 acres for grassland, 50 acres forest.

For modeling purposes, detections are aggregated up until a threshold value. Currently 5000 acres.

Approximately 300K acres total
• Deployment of Air Resource Advisors (ARA) with Incident Management Teams (IMT) or Geographic Area Coordination Centers (GACC)

• Provide: Modeling, Monitoring, Messaging

• MODIS statistical method to initialize the Smoke Outlooks for “today”. Marsha and Larkin, 2019.

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What is a polar orbiting versus geostationary satellite?
What are the instruments on commonly used satellites?
What are the products from these instruments?

Required training for Air Resource Advisors
https://sites.google.com/firenet.gov/wfaqrp-airfire/projects/haqast/2017NorthernCAWildfiresTT/training
<table>
<thead>
<tr>
<th>Name</th>
<th>Instrument</th>
<th>Products</th>
<th>Spatial Resolution</th>
<th>Polar/Geo</th>
<th>Launch Date</th>
<th>Operational Date</th>
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<tbody>
<tr>
<td>GOES-16</td>
<td>ABI</td>
<td>Visible, FRP, AOD, Fire Hot Spot, Smoke Mask</td>
<td>5-min CONUS, 10/15-min Full Disk</td>
<td>Geo</td>
<td>November 2016</td>
<td>December 2017</td>
</tr>
<tr>
<td>GOES-17</td>
<td>ABI</td>
<td>Visible, FRP, AOD, Fire Hot Spot, Smoke Mask</td>
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<td>Geo</td>
<td>November 2018</td>
<td>February 2019</td>
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<tr>
<td>Terra</td>
<td>MODIS</td>
<td>Visible, FRP, AOD, Fire Hot Spot</td>
<td>Equator Overpass 10:30 am local time</td>
<td>Polar</td>
<td>December 1999</td>
<td>November 2000</td>
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<tr>
<td>Aqua</td>
<td>MODIS</td>
<td>Visible, FRP, AOD, Fire Hot Spot</td>
<td>Equator Overpass 13:30 pm local time</td>
<td>Polar</td>
<td>May 2002</td>
<td>July 2002</td>
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<tr>
<td>Suomi-NPP</td>
<td>VIIRS</td>
<td>Visible, FRP, AOD, Fire Hot Spot, Smoke Mask</td>
<td>Equator Overpass 13:30 pm local time</td>
<td>Polar</td>
<td>October 2011</td>
<td>November 2011</td>
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<tr>
<td>NOAA-20</td>
<td>VIIRS</td>
<td>Visible, FRP, AOD, Fire Hot Spot, Smoke Mask</td>
<td>Equator Overpass 12:40 pm local time</td>
<td>Polar</td>
<td>November 2017</td>
<td>May 2018</td>
</tr>
<tr>
<td>Landsat (note: there are 8 current Landsat satellites)</td>
<td>Variable, depending on satellite. For Landsat 8, OLI and TIRS</td>
<td>Visible, surface temp</td>
<td>Equator Overpass 10:00am local time</td>
<td>Polar</td>
<td>Feb, 2013</td>
<td>April, 2013</td>
</tr>
</tbody>
</table>
Satellite Information for Smoke

- NASA Worldview
  https://worldview.earthdata.nasa.gov/
  - VIIRS, MODIS
  - Visible smoke imagery, AOD, Fire Detections
  - Easy to add many layers
  - LOTS more

- College of Dupage https://weather.cod.edu/satrad/
  - GOES-16 (fast)

- CSU CIRA http://rammb-slider.cira.colostate.edu/
  - GOES-16, GOES-17 (be patient)

- NOAA AerosolWatch
  https://www.star.nesdis.noaa.gov/smcd/spb/aq/AerosolWatch/
  - GOES-16/17, VIIRS
  - AOD, Fire Detections, Surface Monitors

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Satellite Information for Smoke

- NOAA Hazard Mapping System
  https://www.ospo.noaa.gov/Products/land/hms.html
- USFS Geospatial Technology and Applications Center
  https://fsapps.nwcg.gov/afm/googleearth.php
  - VIIRS, MODIS Fire Detections
  - Google Earth
- JPSS JSTAR Mapper
  https://www.star.nesdis.noaa.gov/jpss/mapper
  - Suomi NPP, NOAA-20, Sentinel 5P (CO, NO2)
- University of Wisconsin RealEarth
  https://realearth.ssec.wisc.edu
- NASA ARSET Training
  https://arset.gsfc.nasa.gov/

… others
Upcoming Conferences and HAQAST2020

13th Fire and Forest Meteorology Symposium
Track on Santa Ana, Diablo, Sundowner Winds

HAQAST2020 Webinars
- **Minghui Diao.** 3/10/2020. The Air in Your Community: Estimating Surface PM2.5 in California with a Fusion of Monitor Data, Satellite Observations, and Downscale Modeling

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12-14 May 2020, Palm Springs, CA

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Smoke Emissions Reference Application (SERA)

- North American Emission Factor (EF) Standardization Project
- Emission factors are a critical component in calculating fire emissions
- Update systems such as CONSUME, FOFEM, BlueSky
- Significant literature review.
- Approximately 300 trace gas and aerosol species. Over 12K records in database.
- User Interface. Sort and summarize EF data by:
  Combustion Phase
  Burn Type (Wildfire, Rx, Lab)
  Region
  Vegetation Type
  Pollutant Category
- Download raw data.
- NWCG and SERDP funded work.