Summary from Fire/Smoke Haze Monitoring Case Study

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OVERVIEW

Fires and smoke haze become annual hazard for Thailand and the Upper ASEAN (or Lower Mekong River region) during the dry season of the region, particularly Norther Thailand and most part of the Lower Mekong River region (LMR).

The surface fire is a common fire type in Thailand and this region. Forest fires in Thailand and this region occur annually during the dry season from December to early May and with the most occurrences in March.

The forest fire situation in Upper ASEAN is more concerned to the people with increasing accessibility to information through rapid development of cyber-technologies.
OVERVIEW

The ASEAN transboundary haze has been ASEAN flagship tasks after 1997-98 El Nino since 1999. Lately, there was a goal of ASEAN Haze Free 2020 which was already passed, but we still have transboundary smoke haze problem annually. The problem will persist and continue as long as member states could not improve standard of living within their own countries.

Nevertheless, there are common fire causes in the Upper ASEAN which are agricultural land preparation, slash and burn agriculture (or shifted cultivation practice), and hunting. It is clear that those causes are all related to human’s activities.
OVERVIEW

The lacking of the Science to Policy Makers (SOP) is also one of the main obstacles as delivering and communicating findings of forest fire, open burning and smoke haze studies and researches to policy makers are very crucial. SOP is very important and needed as usually those high level officers and politicians do not understand the scientific facts clearly. The lacking utilization of suitable and effective fundamental existing knowledge of fire and smoke haze science including tools and advanced technologies based on scientific proves as the part of Control, Management and Planning (strengthen Science-Policy Interface – SPI) is still there. Policy makers do not usually ask, so there is a need to create an effective mechanism to deliver messages to them. When they are creating any policy or have any discussion they have the right information and fact to cope with their decision process.
Case Study  Upper ASEAN 2018 Fire Season

Model domains and configures

Version WRF-Chem 3.9
Emissions: Taiwan-TEDS 9.0 (2013),
China- MISC Asia (2010)
Met. IC, BC: NCEP GFS (0.25 degree)
Microphysics : Lin et al.
Long-wave radiation : RRTMG
Short-wave radiation : RRTMG
Surface layer : Monin-Obukhov
Land-surface model : Unified Noah LSM
Boundary layer scheme : MYJ TKE scheme
Cumulus : Grell 3D ensemble scheme
Chemistry model : NOAA/ESRL RACM
Aerosol model : MADE/VBS aerosols use KPP library
Urban canopy model : Yes

Chuan-Tao Lin, DMWG APAN47, 2019
Upper ASEAN 2018 Fire Season

Data analysis and forecast platform

Effect of Megacities on the Transport and Transformation of Pollutants on the Regional to Global Scales

@ Taiwan

Chuan-Tao Lin, DMWG APAN47, 2019

Upper ASEAN 2018 Fire Season
Biomass burning tracer simulation

925 hPa Tracer Simulation
2018-03-19 00Z

700 hPa Tracer Simulation
2018-03-19 00Z

Chuan-Tao Lin, DMWG APAN47, 2019
Upper ASEAN 2018 Fire Season

Chuan-Tao Lin, DMWG APAN47, 2019
Upper ASEAN 2018 Fire Season

Chuan-Tao Lin, DMWG APAN47, 2019
(data from Veerachai)

Data Source: Pollution Control Department

76T at Tak Province (2018 March)

PM10  PM2.5
Upper ASEAN 2018 Fire Season

OC at 700 hPa
Upper ASEAN 2018 Fire Season

OC horizontal and cross-section distributions during 19-20 March, 2018
Upper ASEAN 2018 Fire Season

Ozone sounding at Taipei (20 March–4 April)

Ozone

Temperatur

RH

Observation

modeling
Upper ASEAN 2018 Fire Season

Observed Asian dust transport identification

CAFÉ station

Tainan station

Forecast 5 days in advance (init: 12Z 01 April)

Forecast 3 days in advance (init: 12Z 03 April)
Upper ASEAN 2018 Fire Season

Biomass burning emission in Indochina:

• According to Lin et al (2014), we assumed the mean concentration of Fire Inventory in March 2008 from NCAR (FINN1, http://bai.acd.ucar.edu/Data/fire/) (Wiedinmyer et al., 2011) was employed to examine biomass-burning.

• The original FINNv1 (version 1.0) provides daily, 1-km resolution, global estimates of the trace gas and particle emissions from open burning of biomass, which includes wildfire, agricultural fires, and prescribed burning and does not include biofuel use and trash burning.
Main AF Information & Data Sources 1

![Diagram of NASA's Fire Information for Resource Management System](image)

**Figure 10:** Overview of NASA’s Fire Information for Resource Management System.

**Source:** Draft of Active Fire by the Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC/GOLD) Fire Programme, March 2019.
Main AF Information & Data Sources 2

NOAA-National Environmental Satellite, Data, and Information Service, NESDIS (https://www.nesdis.noaa.gov/)

Reduce latency time from NASA 3 hrs to 1 hr or so for both Suomi-NPP and NOAA-20 as Dr. Wilfrid Schroeder is the PI of Global VIIRS Active Fire Products began 14 Mar 19

Dr. Wilfrid Schroeder (wilfrid.schroeder@noaa.gov)
Dr. Davida Streett (davida.streett@noaa.gov)

VIIRS NightFire Thailand All Region Daily Summary 2021-04-18

[CSV][KML] Note: These links are valid for 14 days.

Total detections: 12

Alert is sent because at least one orbit is complete.

Chris Elvidge and Feng-Chi Hsu

Source: https://eogdata.mines.edu/products/vnf/
http://air4thai.pcd.go.th/webV2/
After the 19\textsuperscript{th} March 2021 National Meeting at PCD, a test combination webpage was created from 6 air quality measurement sources.

https://cusense.net/map
Asi@Connect & TEIN CC Project

4 Countries Thailand, Laos, Indonesia and Philippines

https://xn--l3ckl2byc3b2g.xn--o3cw4h/v2/map.html#
Asi@Connect & TEIN CC Project

https://xn--l3ckl2byc3b2g.xn--o3cw4h/v2/map.html#
วัดฝุ่น

https://www.ecowitt.net/home/index?id=23387
An ongoing collaboration among Royal Forest Department, Office of Information Technology Administration for Educational Development (UniNet), Upper ASEAN Wildland Fire Special Research Unit, Forestry Research Center, Faculty of Forestry, Kasetsart University, Webster University Thailand and Chulalongkorn University.
Data are 3 days latency.

Mobile App for both IOS and Android will be developed by the end of 2021

Source: http://wildlandfire.thairen.net.th/pm2.5.html
CAMS REAN (Reanalysis Data) Surface PM 2.5 Concentration Anomaly of Thailand Validation between Dr. Mark Parrington CAMS-ECMWF and PCD using PCD's field measurement data from 11 air quality measurement stations

http://air4thai.pcd.go.th/webV2/
Both Hotspot and Burned Areas Information together

Source: https://firms.modaps.eosdis.nasa.gov/map/
MODIS Burned Areas Info by Earth Map FAO

Cambodia

Myanmar

Lao PDR

Thailand

Source: earthmap.org
Google Earth Engine

Search places and datasets...

**Get Link**  **Save**  **Run**  **Reset**  **Apps**

**Owner (1)**
- users/iamtanpipat/default
  - CR Modified from Hanse...
  - Forest Change (copy)
  - Charts
  - Flood S1 Ubun 2019 Inter...

**Inspection**
- Console
- Tasks

Use print(...) to write to this console.

Data selected for analysis: Sentinel-2

Fire incident occurred between 2019-12-3...

Pre-fire Image Collection:

**DNR Classes**
- Enhanced Regrowth, High
- Enhanced Regrowth, Low
- Unburned
- Low Severity
- Moderate-low Severity
- Moderate-high Severity
- High Severity
- NA

**Layers**  **Map**  **Satellite**

Map data ©2020 10 km 1008 1088 Terms of Use Report a map error
Forecast Fire Danger Rating for Upper ASEAN and Thailand


Source: http://www2.dnp.go.th/gis/FDRS/FDRS.php/
Forecaster Fire Danger Rating for Upper ASEAN and Thailand


Source: https://wildfire.forest.go.th/fdrs/FDRS.php

การพยากรณ์ระดับชั้นอันตรายของไฟที่ความละเอียดสูง
Fine-Resolution Forecast Products of Fire Danger Rating

คำนวณเพื่อการวางแผนเพื่อป้องกัน
FDRS Table for Fire Risk Signs

อากาศท้องถิ่น
Upper Northern Thailand

ลาว
Laos

เอเซียตะวันออกเฉียงใต้บน
Upper Southeast Asia

จังหวัดเชียงใหม่
Chiang Mai

คAMBODIA
Chiang Mai
Upper ASEAN Forecast FDRS
http://www2.dnp.go.th/gis/FDRS/FDRS.php

Provided new Upper ASEAN calibrated thresholds to Dr. Bill de Groot for Global Fire Early Warning System (http://canadawildfire.ualberta.ca/gfews/)

!!!Still Need Further Calibration!!!
Upper ASEAN Forecast FDRS Co-ordinating with Met.Malaysia and ASEAN Secretory to combine the North and South ASEAN FWI products!!!!!!!
NASA Micro-Pulse Lidar
Network-MPLNET


Photos from the plane

Source: https://mplnet.gsfc.nasa.gov/data?v=V3&s=Princess_Sirindhorn_AstroPark&t=20200304
Open and Sharing Data Working Group (OSDWG)

Chair: Veerachai Tanpipat [veerachai AT hii.or.th]
Co-Chair: Basuki Suhardiman [basuki AT itb.ac.id]
Co-Chair: Markus Buchhorn [markus AT apan.net]
Co-Chair: Eric Yen [Eric.Yen AT twgrid.org]
Co-Chair: J. Adinarayana [adi AT csre.iitb.ac.in]
Co-Chair: Kiura Takuji [kiura.naro AT gmail.com]
Mailing List: osdwg@apan.net

https://apan.net/node/197
Must Needed Smoke Haze Forecast Information

**BlueSky Daily Run** ([https://tools.airfire.org/websky/v1/#status](https://tools.airfire.org/websky/v1/#status))

<table>
<thead>
<tr>
<th>Model</th>
<th>Forecast Time</th>
<th>Atmospheric Resolution</th>
<th>Model Type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CMAG Modeled Western US 4-km</strong></td>
<td>00Z</td>
<td>4-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
<tr>
<td><strong>Southwest 4-km</strong></td>
<td>00Z</td>
<td>4-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
<tr>
<td><strong>CMAG Modeled CA/NV 1.33-km</strong></td>
<td>00Z</td>
<td>1.33-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
<tr>
<td><strong>CA/NV 1.33-km</strong></td>
<td>12Z</td>
<td>1.33-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
<tr>
<td><strong>FireWx 1.27-km (Colorado/Wyoming for Brett)</strong></td>
<td>00Z</td>
<td>1.27-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
<tr>
<td><strong>FireWx 1.27-km (Northern California)</strong></td>
<td>06Z</td>
<td>1.27-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
<tr>
<td><strong>FireWx 1.27-km (Central California)</strong></td>
<td>12Z</td>
<td>1.27-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
<tr>
<td><strong>FireWx 1.27-km (Northern California)</strong></td>
<td>18Z</td>
<td>1.27-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
<tr>
<td><strong>Arizona/New Mexico 1.8-km</strong></td>
<td>00Z</td>
<td>1.8-km</td>
<td>Fire_dispersion</td>
<td>Scheduled (1)</td>
</tr>
</tbody>
</table>

Source: [http://haze.airfire.org/bluesky-daily/output/test/FW00Z-1km/2020110500/smoke_dispersio.kmz](http://haze.airfire.org/bluesky-daily/output/test/FW00Z-1km/2020110500/smoke_dispersio.kmz)
Must Needed Smoke Haze Forecast Information

Source: https://tools.airfire.org/airtools/v1/#/traj
Ventilation Climate Information System (Beta)

Summary Table

January AM

<table>
<thead>
<tr>
<th>Stats on January monthly averages</th>
<th>Wind Speed (m/s)</th>
<th>Mixing Height (meters agl)</th>
<th>Ventilation Index (m³/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.1</td>
<td>130</td>
<td>453 (Total)</td>
</tr>
<tr>
<td>Max</td>
<td>7.8</td>
<td>2371</td>
<td>8256 (Total)</td>
</tr>
<tr>
<td>Mean</td>
<td>3</td>
<td>572</td>
<td>1992 (Marginal)</td>
</tr>
</tbody>
</table>

Average Wind Direction: SW
Most Frequent Wind Direction: S

January PM

<table>
<thead>
<tr>
<th>Stats on January monthly averages</th>
<th>Wind Speed (m/s)</th>
<th>Mixing Height (meters agl)</th>
<th>Ventilation Index (m³/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0</td>
<td>306</td>
<td>810 (Total)</td>
</tr>
<tr>
<td>Max</td>
<td>8</td>
<td>3175</td>
<td>8431 (Total)</td>
</tr>
<tr>
<td>Mean</td>
<td>2.8</td>
<td>941</td>
<td>2499 (Marginal)</td>
</tr>
</tbody>
</table>

Average Wind Direction: SW
Most Frequent Wind Direction: NNW

Source: https://tools-2.airfire.org/vcis/v1/#/
Smoke modeling with WRF-SFIRE
recent advances and applications

Adam Kochanski, Angel Farguell Caus, Chase Porter, Jack Drucker
Derek Mallia, Jan Mandel, Kyle Hilburn
San Jose April 9, 2021
Smoke modeling with coupled fire-atmosphere model

WRF-SFIRE

AIR TEMPERATURE
RELATIVE HUMIDITY
PRECIPITATION

WRF atmospheric model
- ARW atmospheric core
- WPS preprocessing system

WRF-Chem chemical transport model
- tracer dispersion
- chemistry of fire-emitted chemical species
- aerosol physics

FIRE-AFFECTED WINDS
FIRE HEAT AND MOISTURE

Fuel Moisture Model
- drying and moistening due to changes in T and RH
- effects of precipitation

Fire Spread Model
- Rothermel fire spread model
- Fire front tracking based on the level set method
- Canopy parameterization

Fire Emission Model
- Emission of a passive scalar
- Emission of chemical species and aerosols for RADM2, MOZART or GOCART

SMOKE AS PASSIVE TRACER
FLUXES OF CHEMICAL SPECIES PM2.5, PM10 etc.

PyroCu on top of the smoke layer forecasted during the Creek Fire Sept 6th 2020.

Forecasted plume top > 12km
WRFx Applications

Wildfires

A forecast for Bay Area Fires, September 2020

Prescribed burns

WRFx forecasts for Anabella Reservoir burn Utah, November 5th 2020
Simulation in developing process

Gernot Rucker,
Firemaps.net,
2019

Output: fire perimeter
Fuel Type: New Deciduous Forest (based on Leafless Aspen Type)
Parameter: Custom from ISI-ROS regression tuned for faster spread
a: 5 / b: 0.0001 / c: 0.2

Background Landsat 8 OLI: 15.02.2016 03:43:29
Firemaps dashboard

Dashboard updated every 15 minutes with latest fire detections, weather forecast information

Gernot Rucker, Firemaps.net, 2020
Lessons Learned:

- Users do not clearly understand the limitations of information given (most of the time resulting in information misused and lead to further complicated problems as active fires detected by polar orbit satellites are only snapshots during a short period of time e.g. using number of hotspot detected as a government agencies' KPIs is not appropriated as people know how to ignite fires after satellites already passed over to pass such KPIs.

- ONLY Numbers of fire hotspots detection do not reflect the total picture of smoke haze situation which affects air quality, there are other factors such as wind, air pressure, etc.

- More active fires detected in near by countries do not simply mean those are sources of bad air quality of the concerned country. The movement of smoke is the key.

- Users do not know what a fire ‘hotspot’ really is, but they always think they know.

- Users become too much obsessed with fire hotspot information, so they depend on and wait for it too much.
What still needs to be known:

- Quicker delivery time active fire information to users as the fundamental of fire control depends on that. In the future, additional satellites in the EOS with better than VIIRS’ capabilities with faster delivery time, within 10-15 minutes, are needed to provide more complete information for more efficient forest fire control. The faster delivery time of high quality active fire products reach fire managers, the better problems can be managed and controlled; therefore, the less damage it can cause.

- Combination with traditional fire detection methods is still needed to reflect the real situation as close as possible.

- The online analysis tools with all the statistics and data of active fire, burned areas, fire emissions and other related information could be analyzed on the same platform is essential.
What still needs to be known:

- Closer and Better international collaborations on forest fire control and smoke haze management as it is also a transboundary issue.
- Improvement of geostationary thermal detection sensors and systems within the region.
- Faster estimated size of burned areas information (by both optical and microwave data) is needed as all assessment and mitigation cannot wait that long.
- Fire spread direction and speed including intensity are needed for more efficient fire control and suppression.
- Faster fire emissions information from satellites and models for smoke haze and air quality management is also needed.
- Smoke movements simulation of both local (< 1 km grid) and larger scale (1 km grid) are needed for smoke haze and prescribed burning management.
Conclusions and Challenges

• Need to put fire early warning (Forecast FDRS) info into forest fire control planning process and daily operation including begin to develop the 2nd version.

• Need to develop better and higher accuracy of high resolution medium range weather forecast inputs (DA and Ensemble) for FDRS, so we can plan further ahead and be more efficient.

• Need to develop, calibrate and validate Forecast Ventilation or Dispersion Index to use during prescribed burning planning and smoke haze management.

• Need to study and understand on “Fire Weather” for Thailand and the Upper ASEAN.

• Need to study and understand more on “Smoke Behavior.”

• Need prescribed burning and smoke management decision support system in place.

• Need to clearly identify and understand the sources of smoke haze.
Conclusions and Challenges

• Need to have a reliable and scientific proved Fire Decision Support System

• Need to understand behaviors of people who use fire as a tool better for more efficient prevention

• Need to find feasible and possible alternatives incomes for people, so they can reduce their fire ignition habit and change from monocrop like maize to multi-crops with sure incomes and sustainable market

• Need to find easier and simpler communication schema to deliver scientific information to decision and policy makers or so call Science-Policy Interface (SPI) and be able to educate them including the people!!

• How to get economic feasible solutions for people to use fire as a tool less?

• Find out the fact of burned areas type and burn period.
Take Home Messages

• Case studies are important information to have, but we do not have enough.

One Good Up To Date Source--https://confluence.ecmwf.int/display/FCST/Severe+Event+Catalogue--

• Actually, it does not matter much that we really have reliable decision support systems to use as long as people who use them do not understand and use them properly or as they suppose to be used for.

• With Climate Change, there will be a lot more of natural adjustments and changes until it reached a new stable state that we do not know which have to be studied, learned, understood and adapted.

• Open and Sharing Data & Information is the fundamental and essential approach to cope with, mitigate and adapt to future Climate - Weather Disasters we will face.

• If you cannot explain something in simple terms, you do not understand it enough yet, so keep studying, researching and learning.