Next presentation at:
Wed 11 Dec 4:30 pm

Modeling wildfire dynamics using FLAM coupled with deep learning methods on the Google Earth Engine platform

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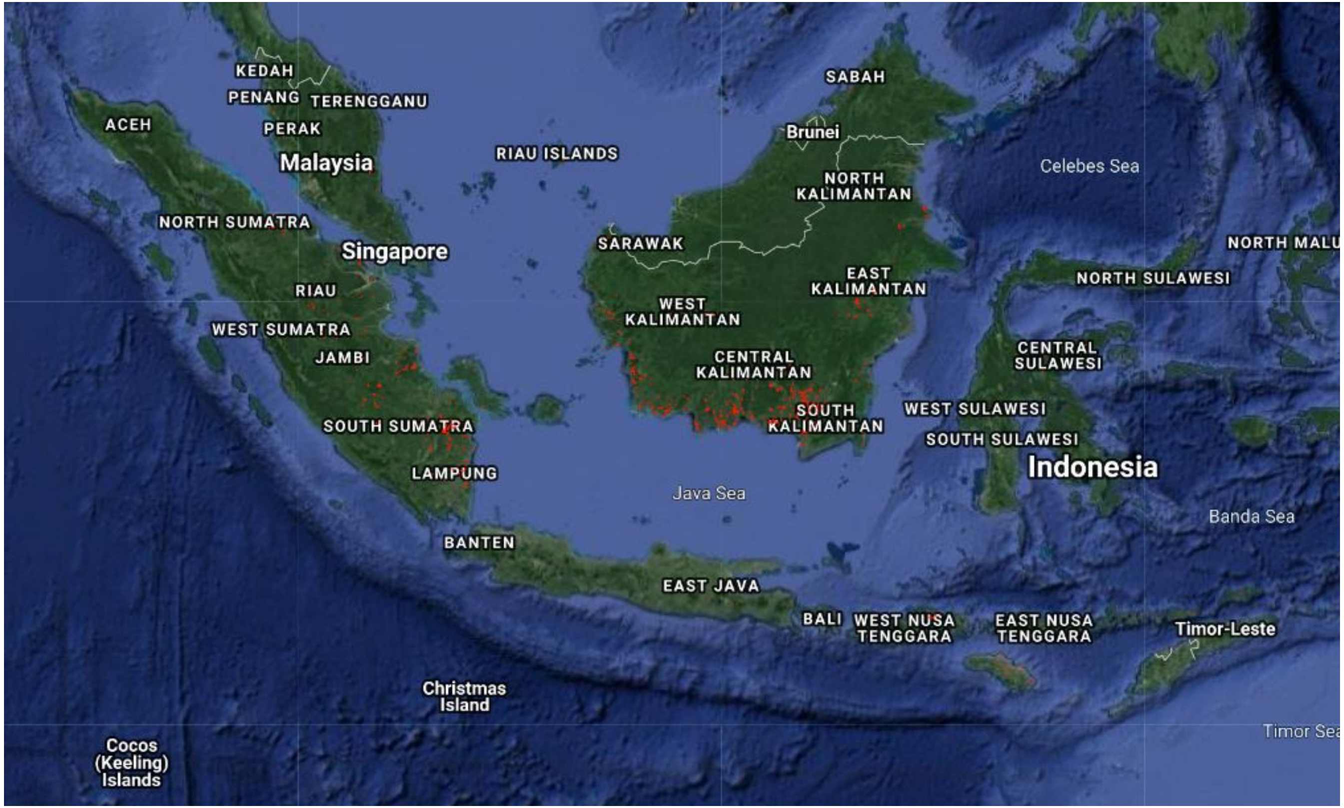
Large-scale wildfires affect millions of hectares

Fire is a global problem, frequency and scale are projected to increase with climate change

Average global emissions from wildfires between 1997-2015 estimated around 8 Gt CO_2/yr

Severe smoke haze pollution and carbon emissions, negative impacts on climate change, health, economy & biodiversity

2019 Southeast Asian haze burned 1.6 million ha



MODIS Burned Area monthly aggregated from 2010 to 2019 Google Earth Engine

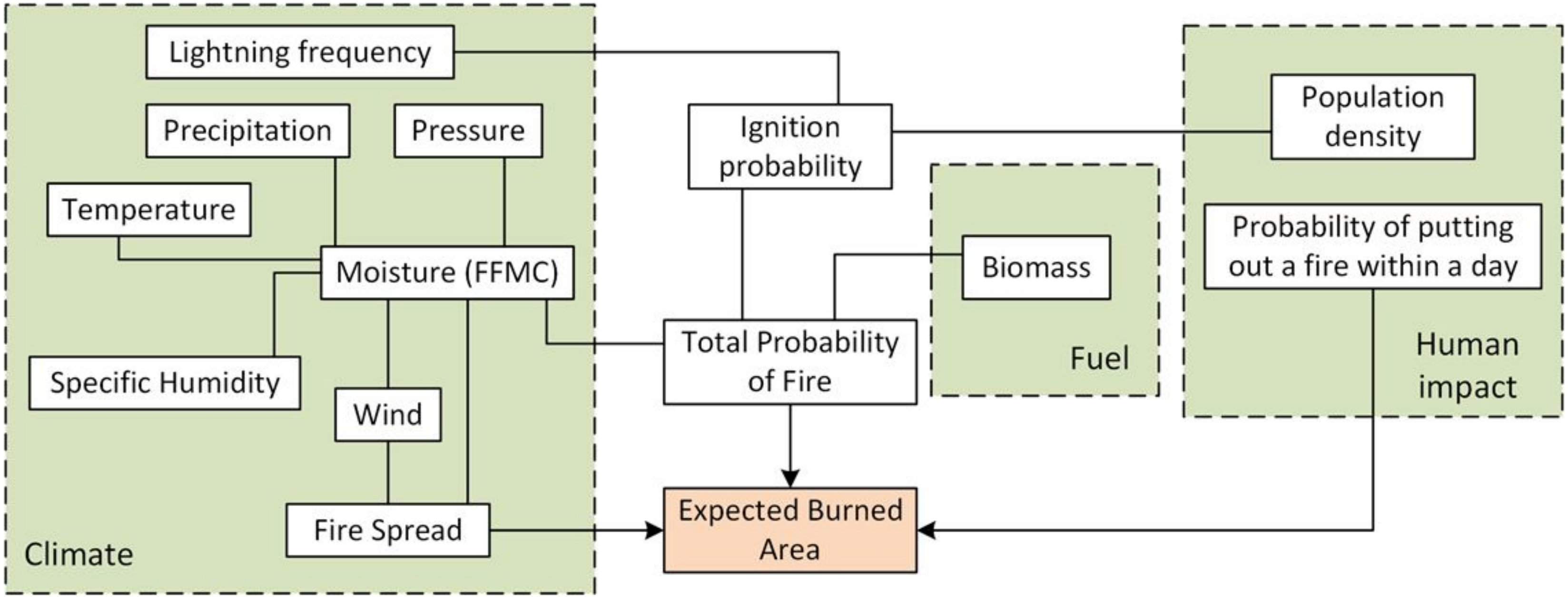
Indonesian tropical **peatlands hold 36%** of the world's total, with estimated 28.1 Gt C

highly combustible during the dry season drained wetlands converted to oil palm

The wildfire climate impacts and adaptation model

FLAM

The wildFire cLimate impacts and Adaptation Model (FLAM)

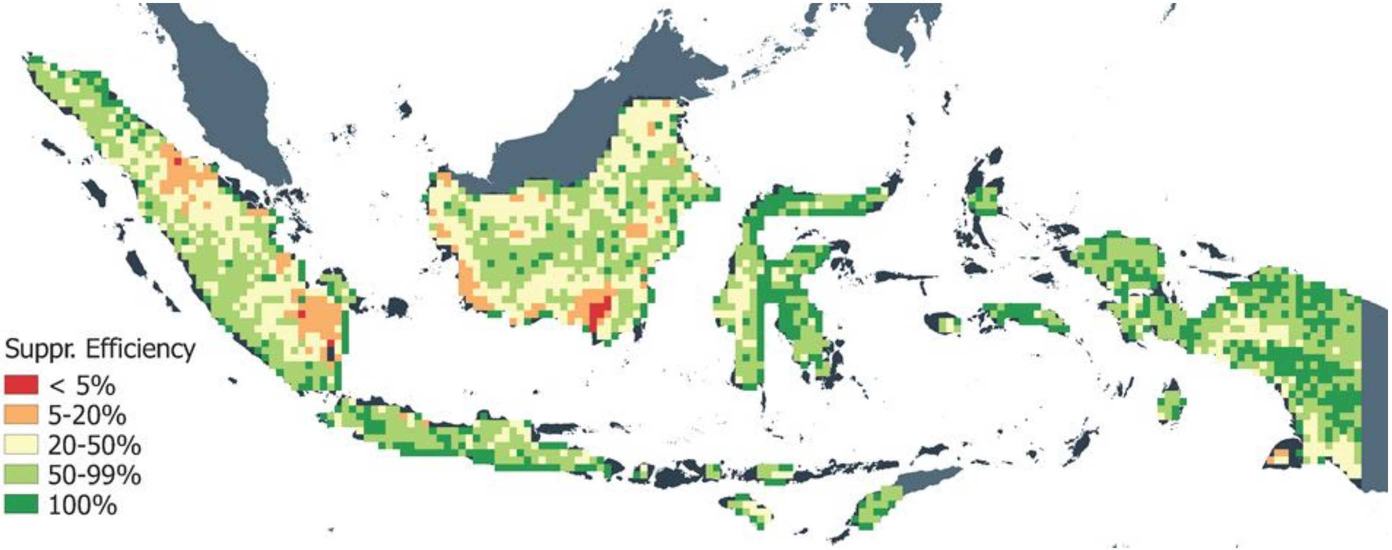


FLAM operates with a daily time step

FLAM - parameterization for Indonesia

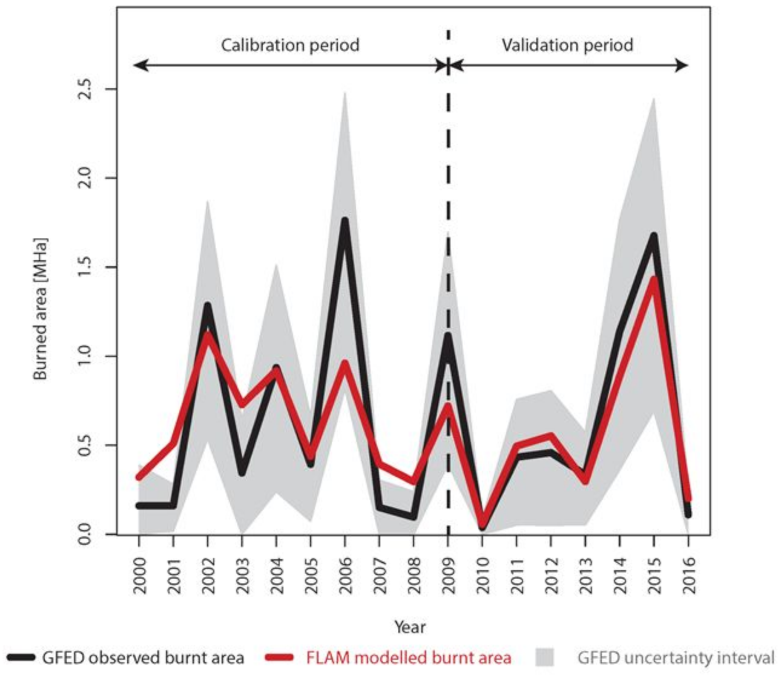
Variable	FLAM usage
Fuel moisture content based on Fine Fuel Moisture Code (FFMC) from Canadian Forest Fire Weather Index (FWI) and Global fire weather database (GFWED)	Daily moisture content, 2000-2016
Wind speed at 10 m from NASA MERRA-2	Daily fire spread rate, 2000-2016
NASA **Lightning** Imaging Sensor/Optical Transient Detector product (LIS/OTD)	Daily probability of ignition conditional on lightning frequency
Pan-tropical **Biomass** map for calculation of plant litter stock and coarse woody debris (from Avitabile et al. GCB 2016)	Probability of ignition conditional on fuel availability
Gridded **Population** of the World, v4; 2000, 2005, 2010, 2015	Probability of human ignition /suppression, updated every 5 years

FLAM - captures spatial hot spots in Indonesia



Spatial suppression efficiency (at 25 km^2 resolution) calibrated in FLAM using burned area reported in GFED for wildfire in Indonesia, accumulated over 2000-2009

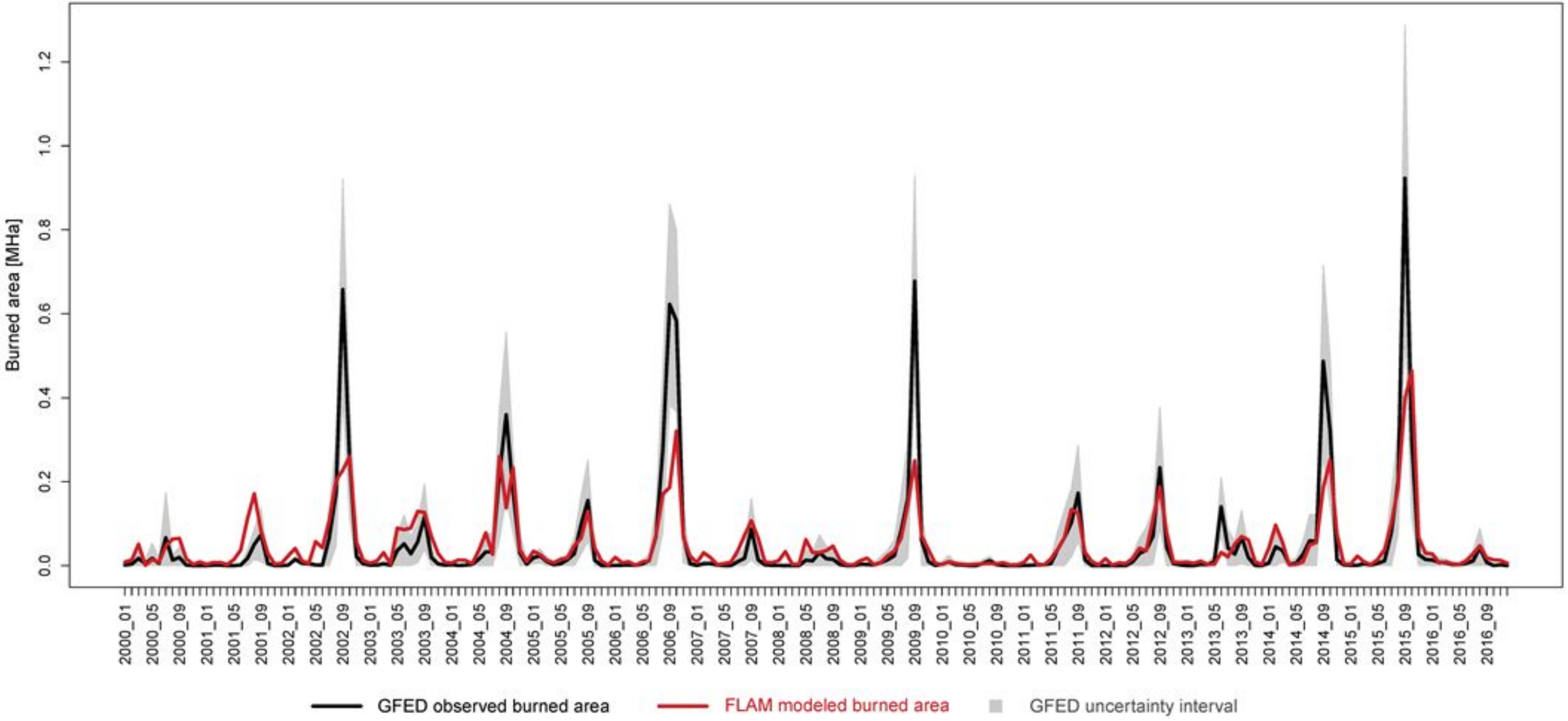
FLAM - captures temporal dynamics



Annual dynamics of burned area (wildfire) in Indonesia [MHa]. During the calibration period GFED burned area (**black line**), accumulated over 2000-2009, is used for FLAM calibration. In 2010-2016 GFED data is used for validation of the burned area estimated by FLAM (**red line**).
GFED uncertainty (**grey area**).

Source: Krasovskii et al, Modeling Burned Areas in Indonesia: The FLAM Approach. *Forests* **2018**, *9*, 437. https://doi.org/10.3390/f9070437

FLAM - captures seasonal dynamics

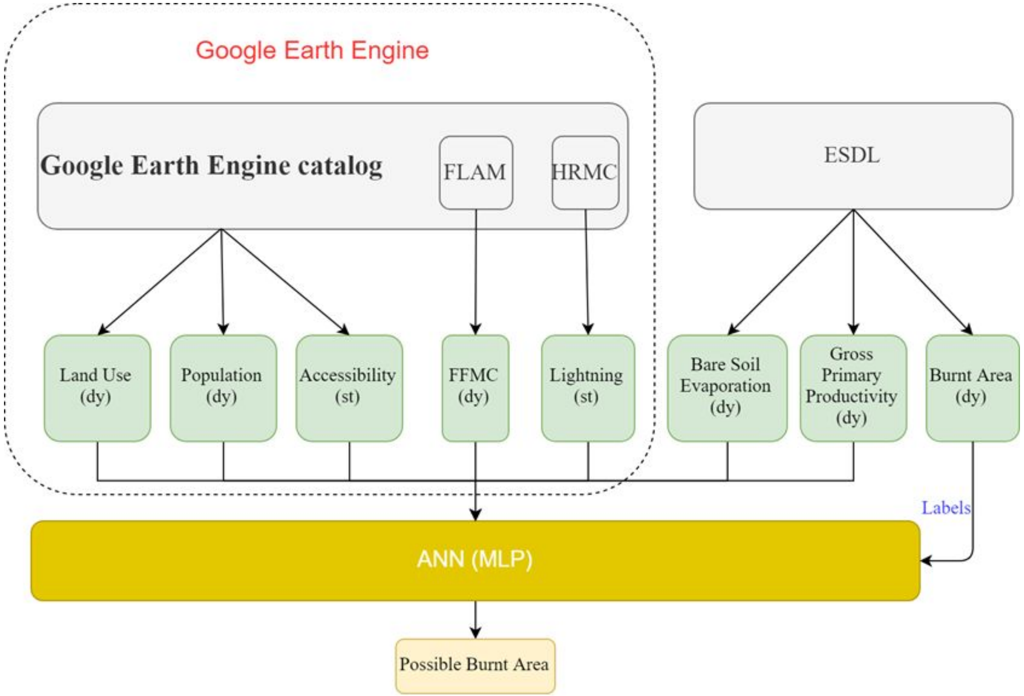


Monthly dynamics of burned area (wildfire) in Indonesia [MHa]. (FLAM: **red line**, data: **black line**)

See recurring start of dry season in Indonesia each September

Implementation on Google Earth Engine platform

Integration of FLAM & GEE using machine learning



Google Earth Engine (GEE) could be used to complement **FLAM** with additional factors:

- \+ Land-use,
- \+ Population density
- \+ Accessibility

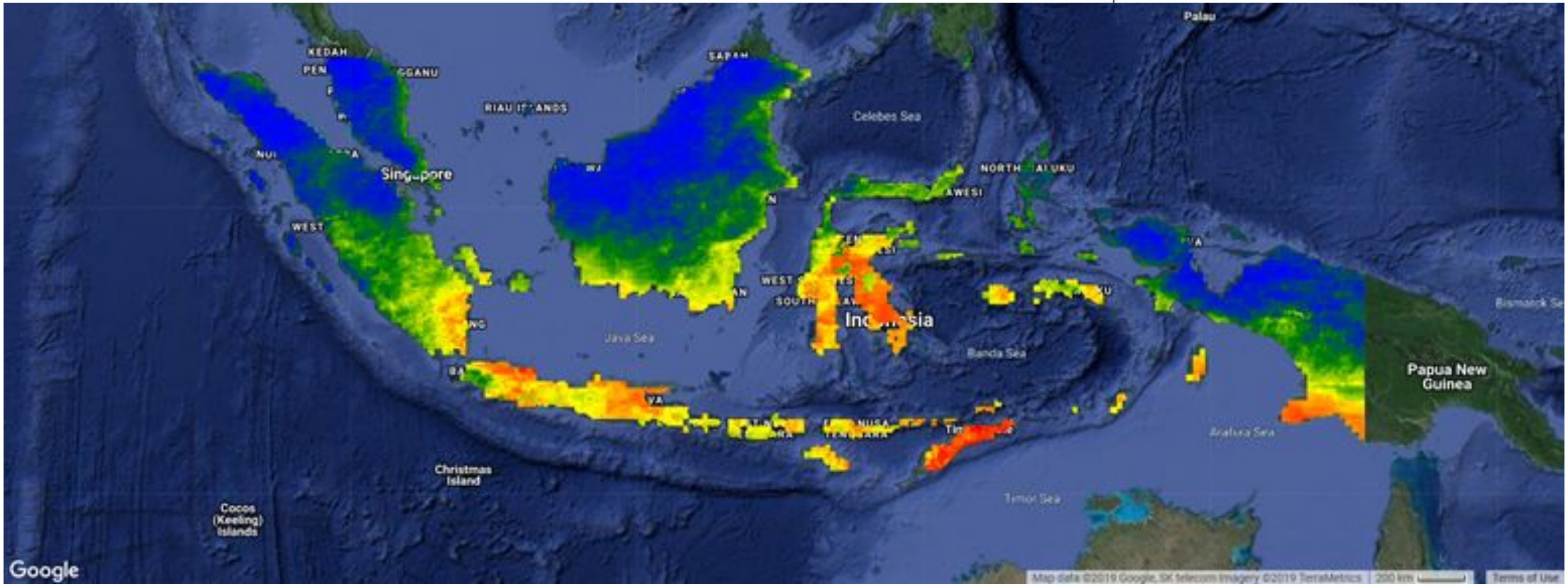
Earth System Data Lab (ESDL) data:

- \+ Climate
- \+ GPP
- \+ Burnt area

Artificial Neural Network (ANN) based on Machine Learning Platform (MLP)

Fire probability in GEE based on FFMC

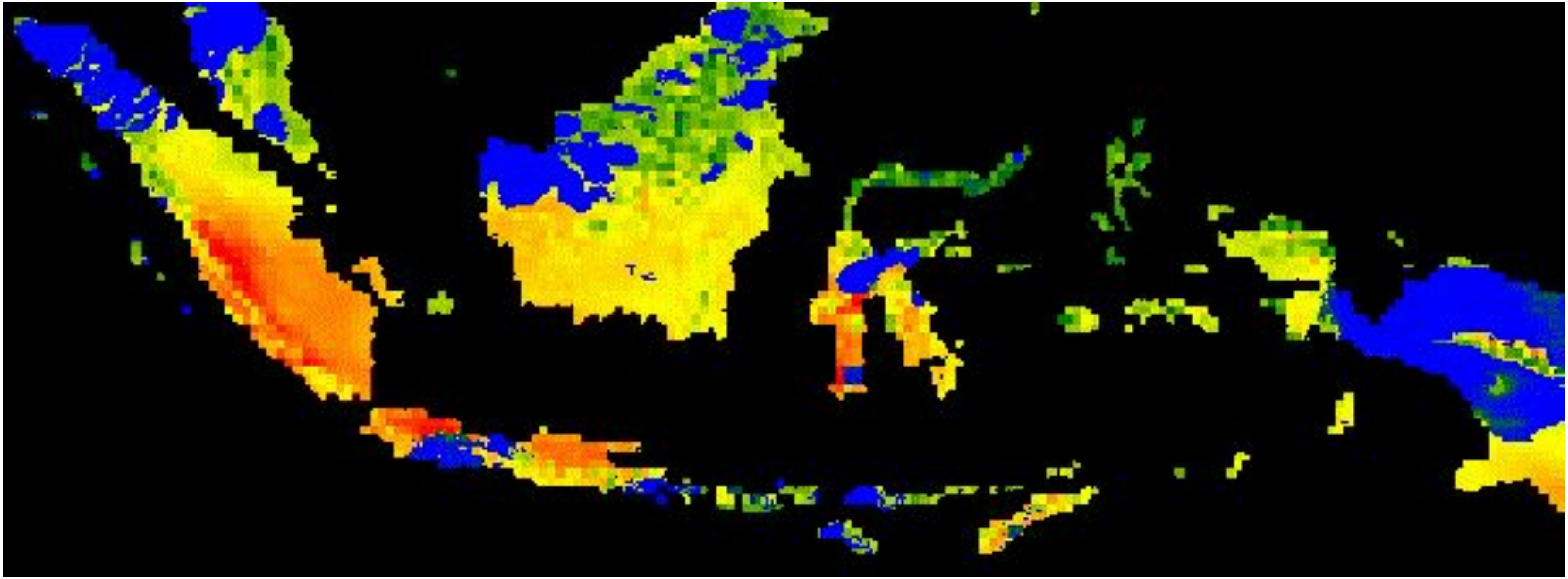
```
//////////// daily probability based on m of ffmc
function pm(image){
  image = setProj(image)
  var m = ee.Image(image.select('m'))
  var me = 0.35 // moisture of extinction
  var Pm_1 = ee.Image(1.75).multiply(m.divide(ee.Image(me)));
  Pm_1 = Pm_1.pow(ee.Image(2))
  var Pm_2 = Pm_1.tanh();
  // Pm_2 = Pm_2.pow(ee.Image(2))
  var Pm = ee.Image(1).subtract(Pm_2);
  return image.addBands(Pm.rename('Pm'))
}
```



Daily fire probability based on FFMC and weather conditions

Spatial pattern due to high fuel moisture (north) - low fuel moisture (south)

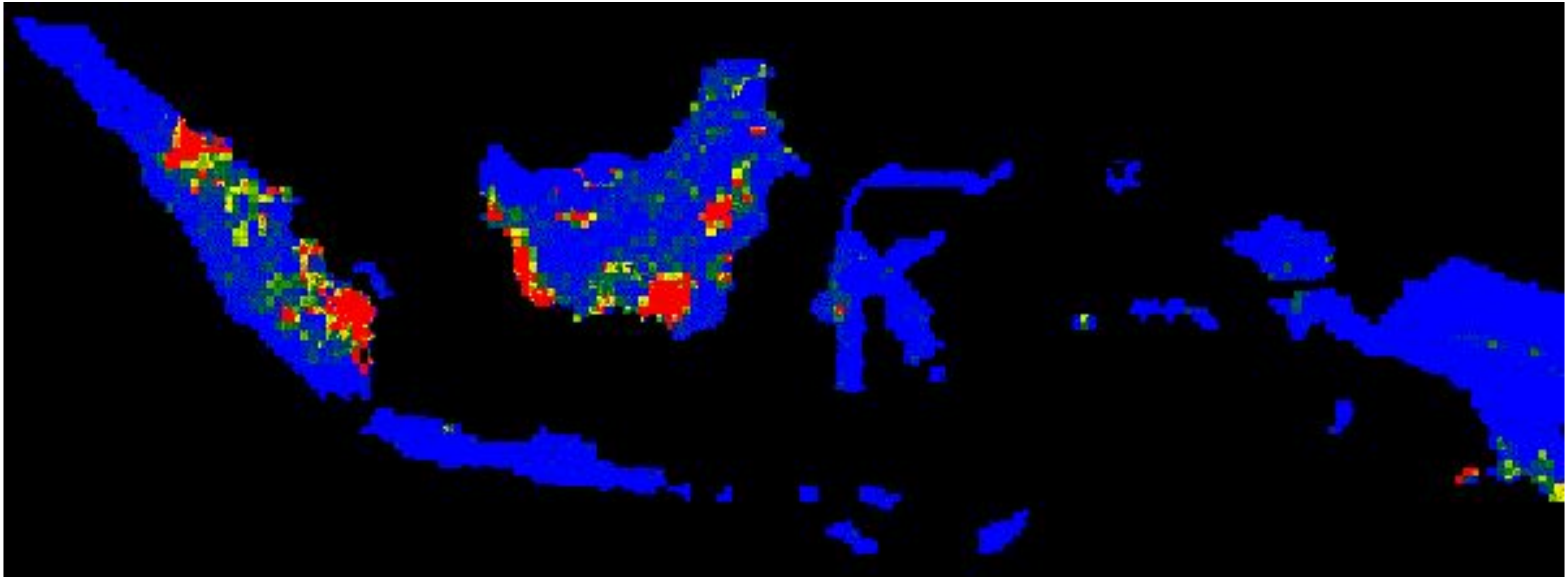
Fire probability dependent on daily weather



Probability of fire ignition (derived from **FFMC**) between 2015-09-01 and 2015-09-30

During El-Nino in 2015, mega-fires actually happened - probability of fire was high

Projection of daily burned area (FLAM)



Expected Burned Area (projected by **FLAM**) between 2015-09-01 and 2015-09-30

Low suppression efficiency of peatland fires; High suppression efficiency in other areas

Thank you for your attention!

Further information:

Krasovskii, et al. 2018. Modeling Burned Areas in Indonesia: The FLAM Approach. Forests, 9(7), 437–22. http://doi.org/10.3390/f9070437

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