ASMC
ASEAN SPECIALISED METEOROLOGICAL CENTRE

Multi-Satellite Fire Detection Composite FRED

CSB Meeting

17 Mar 2020

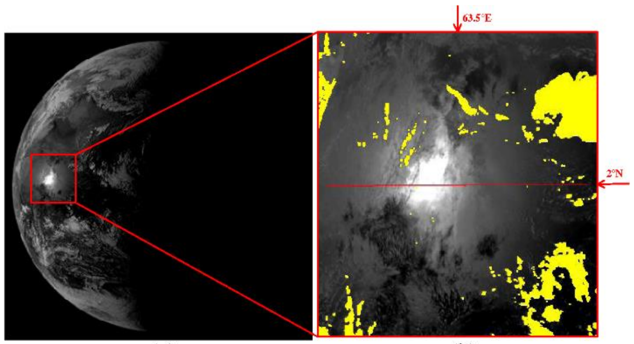
Progress Update

- Sun glint filter for Himawari-8/9
- Use of logistic regression
- Validation Results
- New approach in ground-truthing

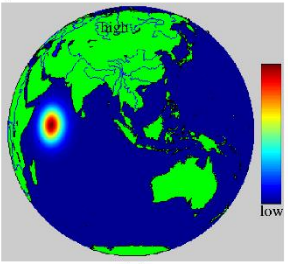
Himawari-8/9 Sun Glint Rejection

- Sun glint angle
  - the angle difference between reflected solar beam and the satellite view/zenith angle, from the satellite reference frame. If the angle is small, it means that the outgoing solar reflection is directed at the sensor of satellite.
- Calculation done using pyorbital and satellite metadata

$$\boxed{\cos\theta_g = \cos\theta_v \cos\theta_s - \sin\theta_v \sin\theta_s \cos\phi}$$



(a) (b)



(c)

where

θ_g = sun glint angle

θ_v = satellite view/zenith angle

θ_s = solar zenith angle

ϕ = relative azimuth angle (difference between solar and satellite azimuth angle)

Himawari-8/9 Sun Glint Rejection

- The following rules are used in the MODIS/VIIRS fire detection algorithm

$$\theta_g < 2^\circ \tag{8}$$

$$\theta_g < 8^\circ \text{ and } \rho_{0.65} > 0.1 \text{ and } \rho_{0.86} > 0.2 \text{ and } \rho_{2.1} > 0.12 \tag{9}$$

$$\theta_g < 12^\circ \text{ and } (N_{aw} + N_w) > 0 \tag{10}$$

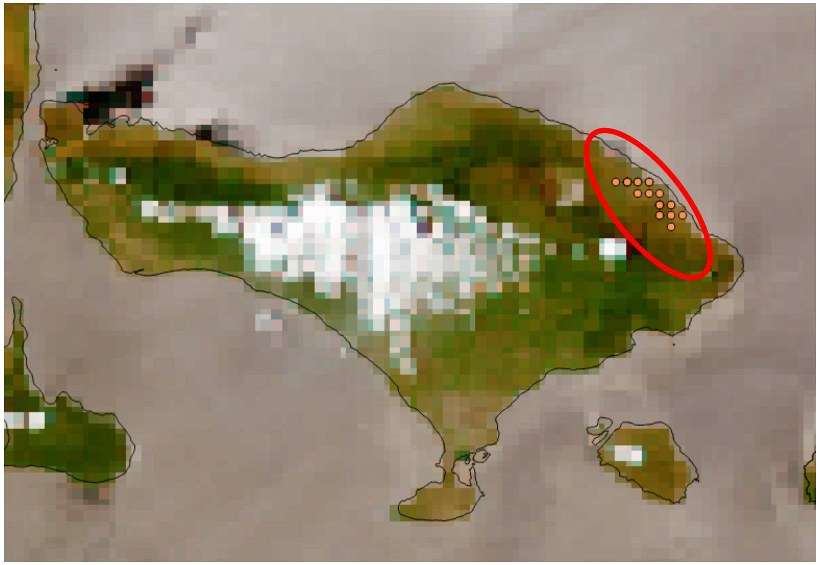
- Opt for a simple thresholding method in (8)
- Criterion (9) and (10) involves processing of original HSD data, efforts akin to producing fire hotspot product ourself

For more info, refer to "An Enhanced Contextual Fire Detection Algorithm for MODIS" by Louis Giglio et al 2003
https://doi.org/10.1016/S0034-4257(03)00184-6

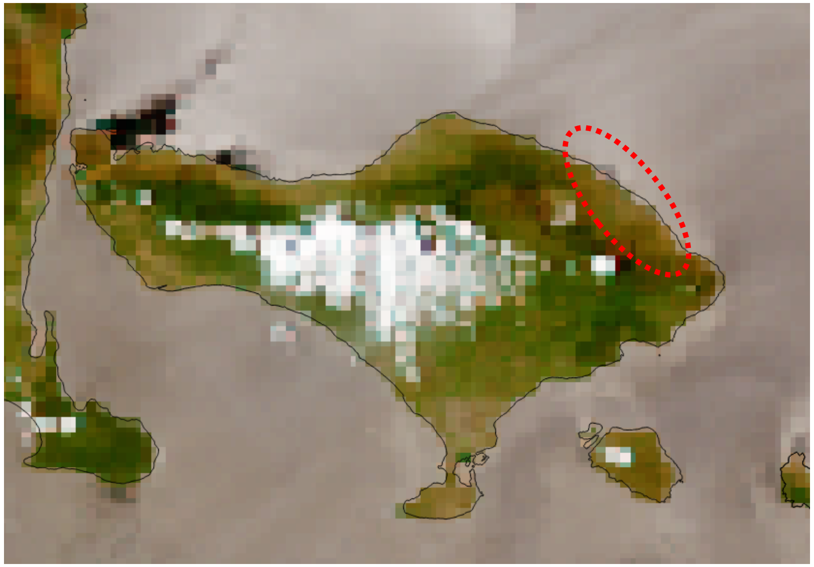
Himawari-8/9 Sun Glint Rejection

- Very effective in eliminating sun-glint induced fire hotspots
- Initial exploration found that majority of false alarms can be easily rejected
- Optimal threshold is determined during the validation phase

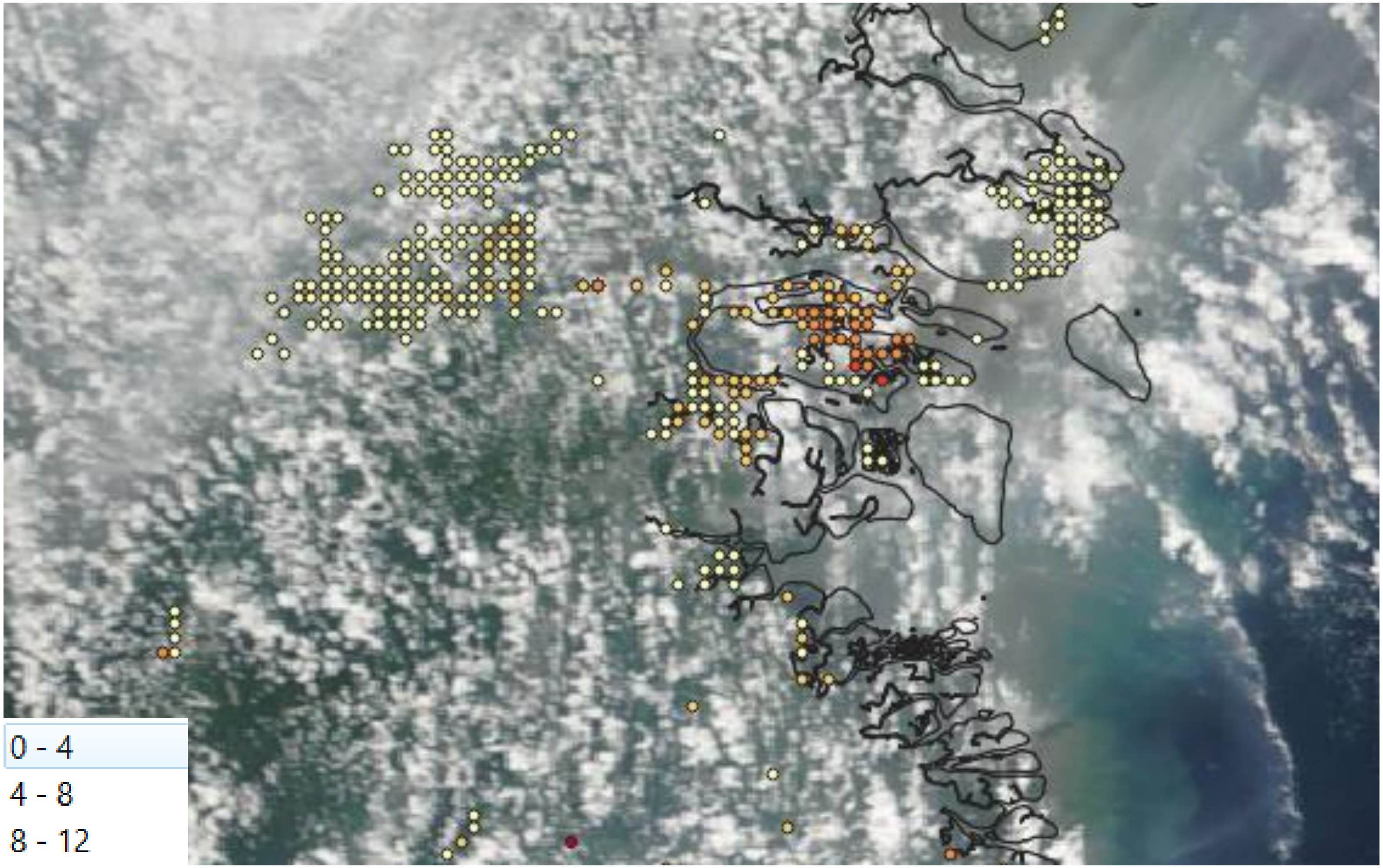
Before



After



H-8 hotspots at different sun glint angles



0 - 4
4 - 8
8 - 12
12 - 16
16 - 999

Sun glint angle

Sun glint induced hotspots removed (minimum angle of 12°)

Overview

Satellite hotspot data

TERRA	AQUA	NOAA-20	Suomi-NPP	Himawari-8

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Pre-processing

Sun glint filter	Regridding	Temporal Aggregation

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Feature Engineering

Compute hotspot weight

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Machine Learning Model

Logistic Regression

↓

Training & Validation

Fitted parameters for Logistic Regression model	Find optimal parameters for sun glint angle, hotspot weight

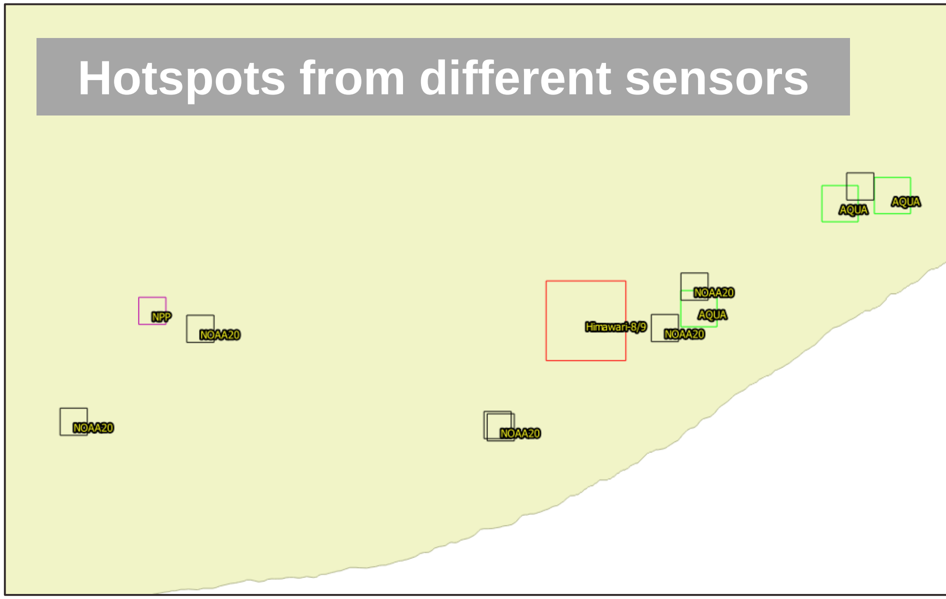
↓

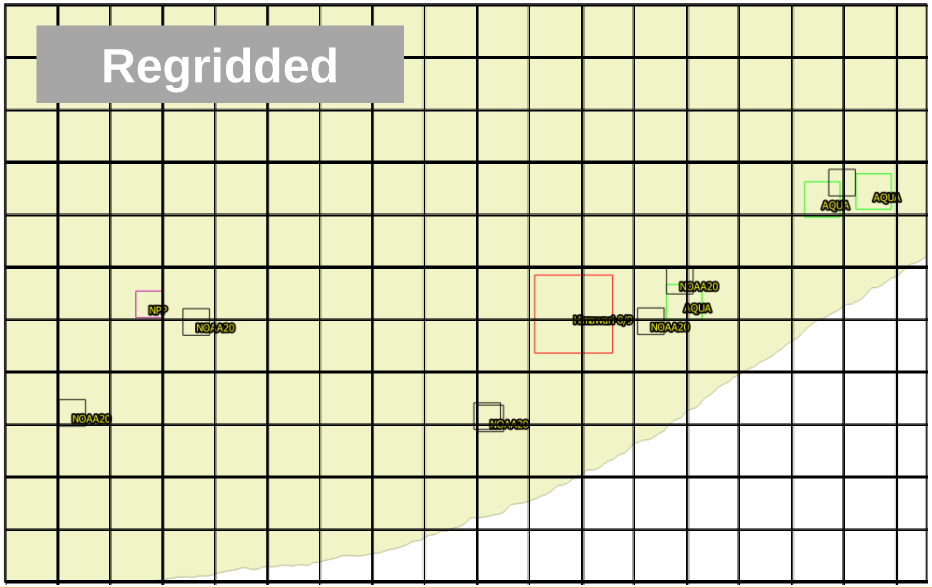
Final Product

Probabilistic estimates for fire hotspot grid

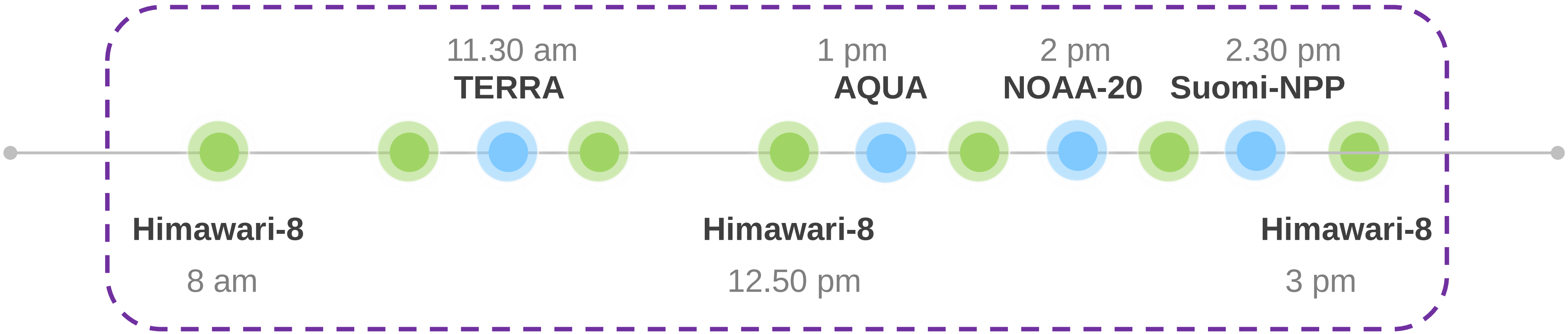
Regridding

- Different satellite hotspot data has different resolutions or grid size (0.75 - 2 km)
- Harmonisation to standardise grid resolution
- All data is gridded to 2 km resolution



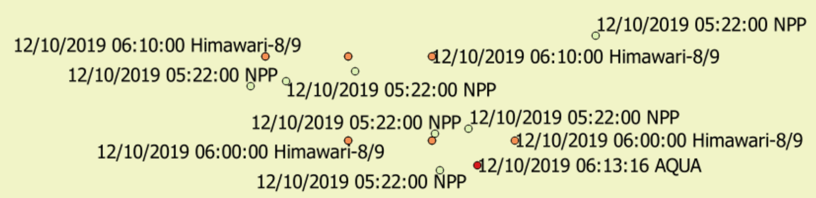


Temporal Aggregation



- Aggregate fire hotspot detected within a certain observation window period
- Observation period used:
  - 00:00 - 08:30 UTC

Aggregated Hotspots (00 – 09 UTC)



Feature Engineering – Hotspot Weight

Let W_i to be total weight based on hotspots detected by geostationary and polar-orbiting satellites, and i is the position of grid

$$W_i = \sum_{j}^{n_g} (1-\alpha)\frac{1}{n_g} + \sum_{k}^{n_p} \alpha \frac{1}{n_p} c_j$$

where

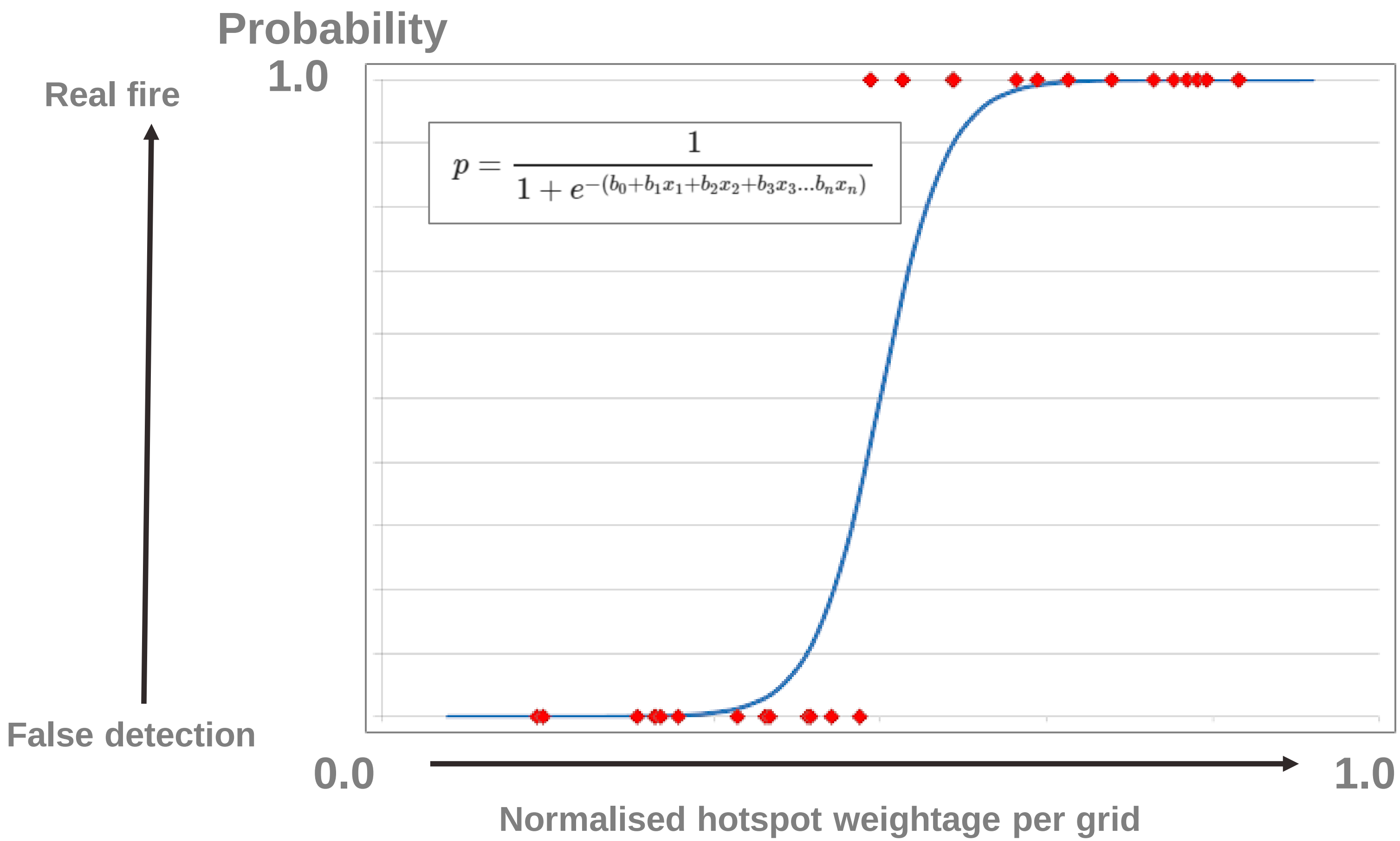
α is the ratio of contribution by geostationary and polar orbiters. If $\alpha = 0$, it means there are no polar orbiters included. If $\alpha = 1$, it means there are no geostationary satellites included.

n_g is the maximum number of geostationary observations made during the window period.

c_j is the normalized confidence level (scaled to 1.0)

n_p is the number of polar orbiting satellites (4 - N20, TERRA, AQUA, NPP), k is the identifier of the polar satellite

Machine Learning – Logistics Regression



- Probabilistic version of linear regression y = mx + c
- Simple model for easy interpretation

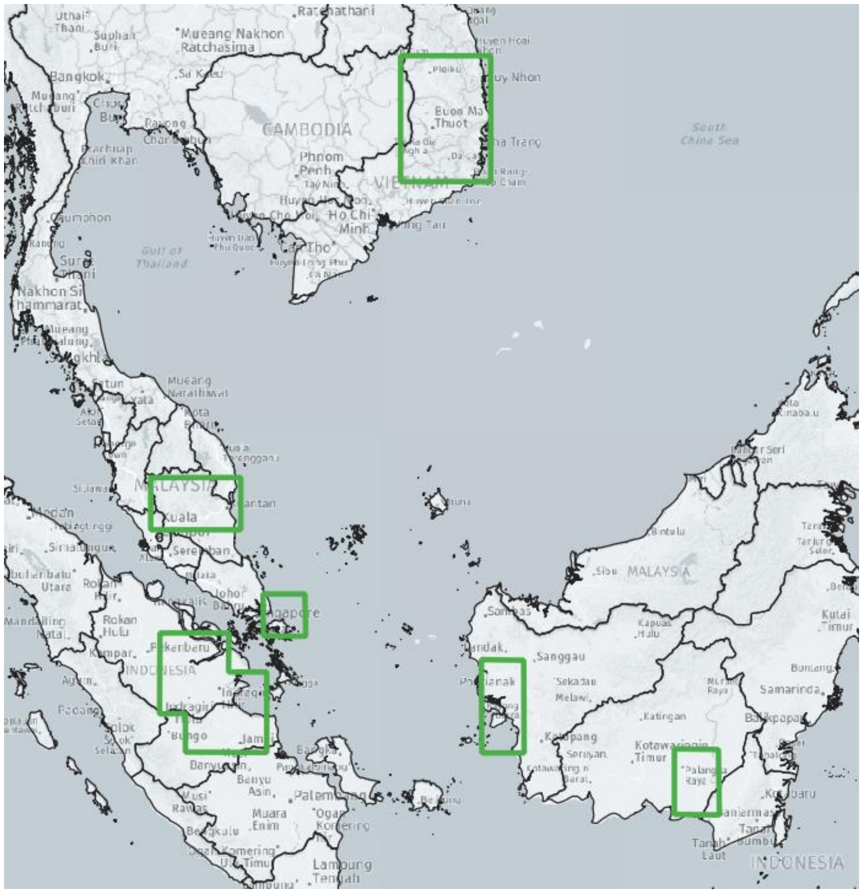
Model Training, Verification & Validation

- Purpose:
  - To fit the logistic regression curve with the data
  - Find optimal parameters for
    - **Alpha** – weight ratio of polar and geostationary satellite hotspot
    - **Sun glint angle**

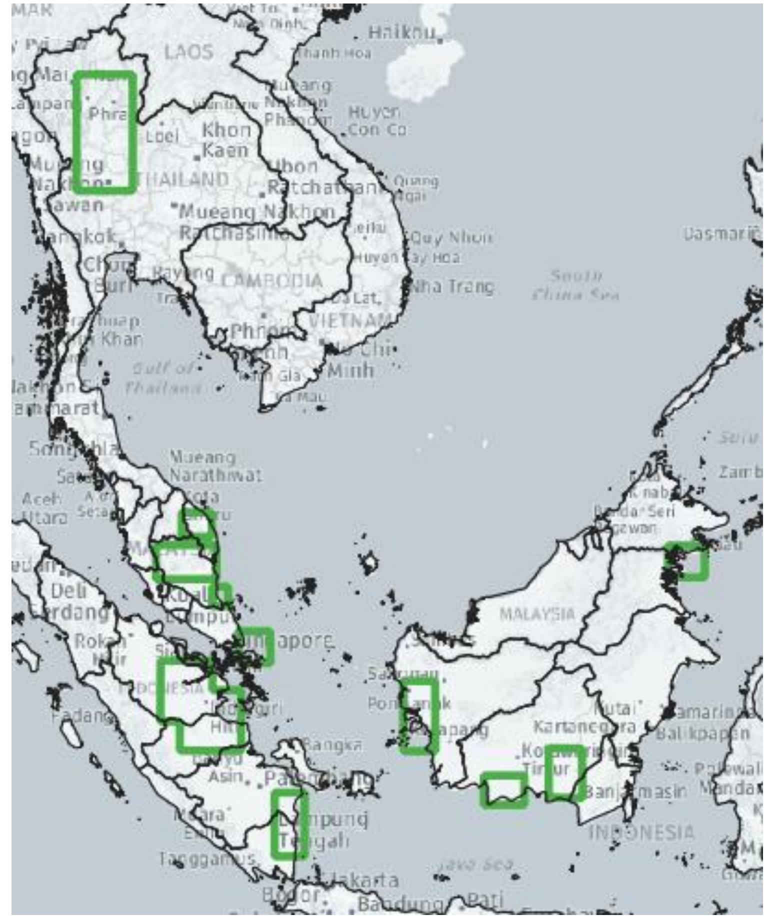
- Group A: July 2019 ground-truth data prepared by Effy
  - Used earlier for N20 validation
  - Early part of hotspot season
  - Sentinel-2 data and NUS CRISP
  - Date of burning estimated based on burnt mark
  - Num of labels - **342**

- Group B: 1-4 Sep 2019
  - Peak of hotspot season
  - Integrated various API/plugins on QGIS to visualize sat data very quickly
  - Sentinel-2, NUS CRISP, MODIS, VIIRS, Planet
  - Less uncertainty with date of burning estimation
  - Num of labels – **622**

Verification Area



Group A: July 2019



Group B: 1- 4 Sep 2019

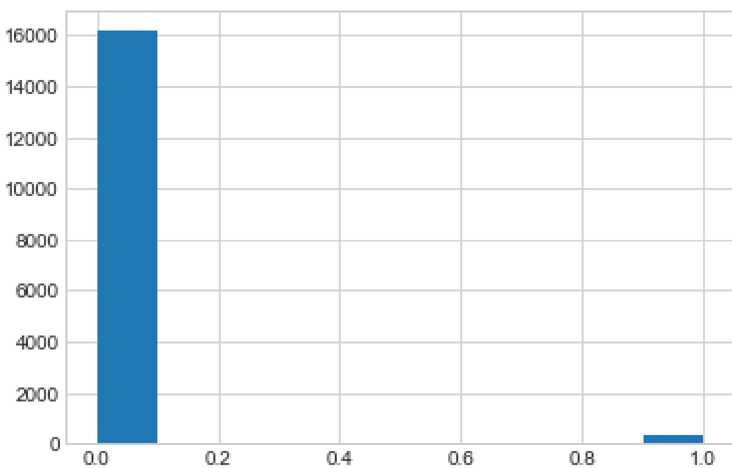
Handling of validation data

Class imbalance problem

- Number of false alarms > number of true positive
- Resampling is done to ensure 50:50 ratio

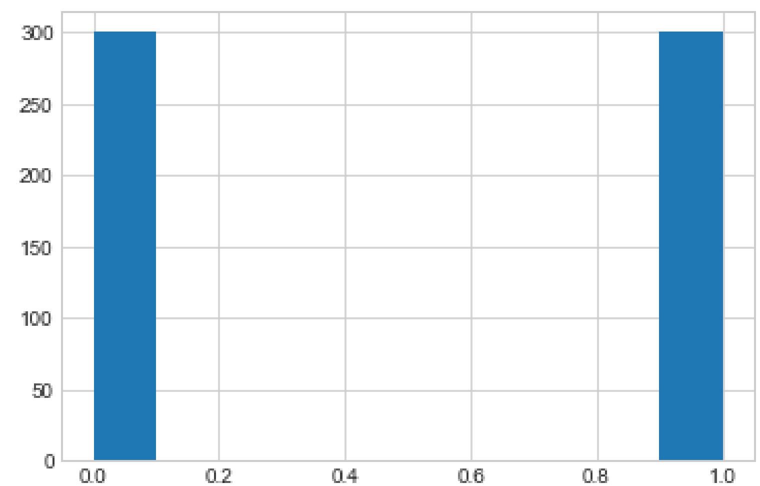
- 1 km buffer is added for verification
- 75:25 split for training and test data

Before resampling

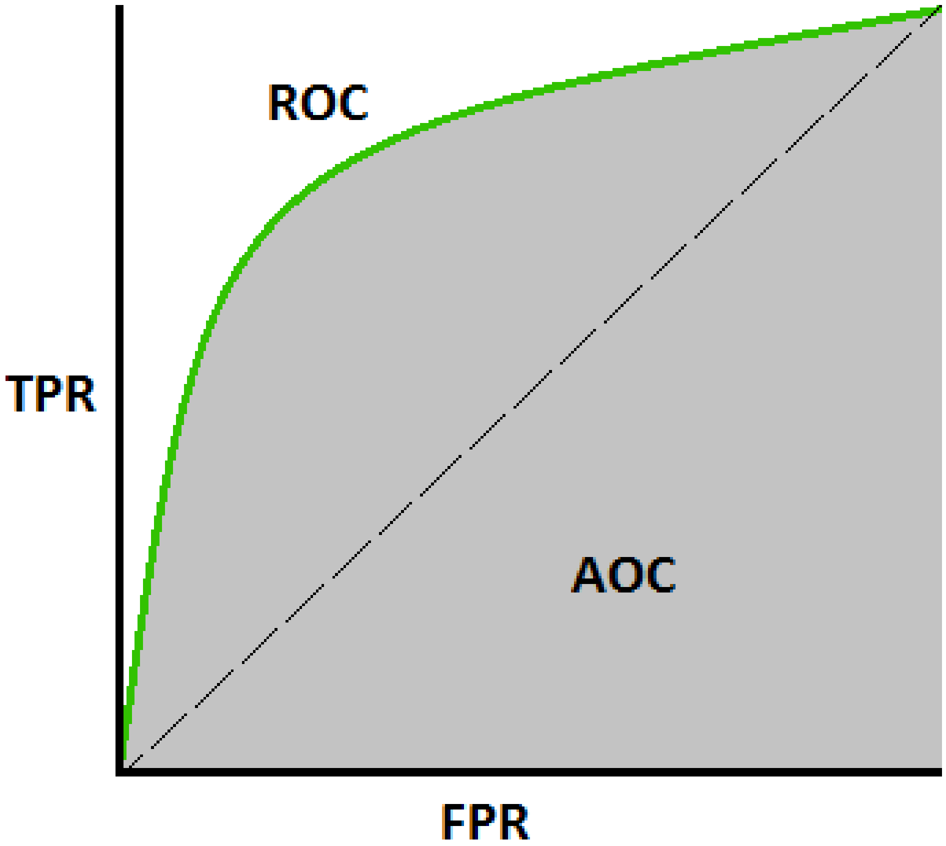


Non-fire Fire

After resampling



Non-fire Fire



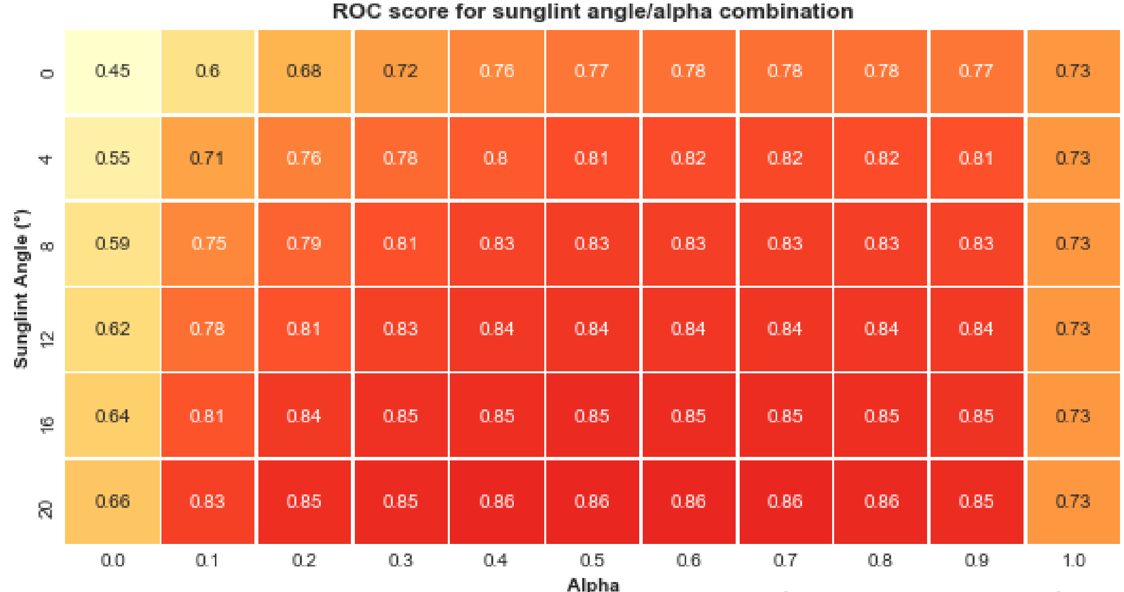
ROC = Area under the curve

1.0 is perfect, 0.5 is no better than random guess.

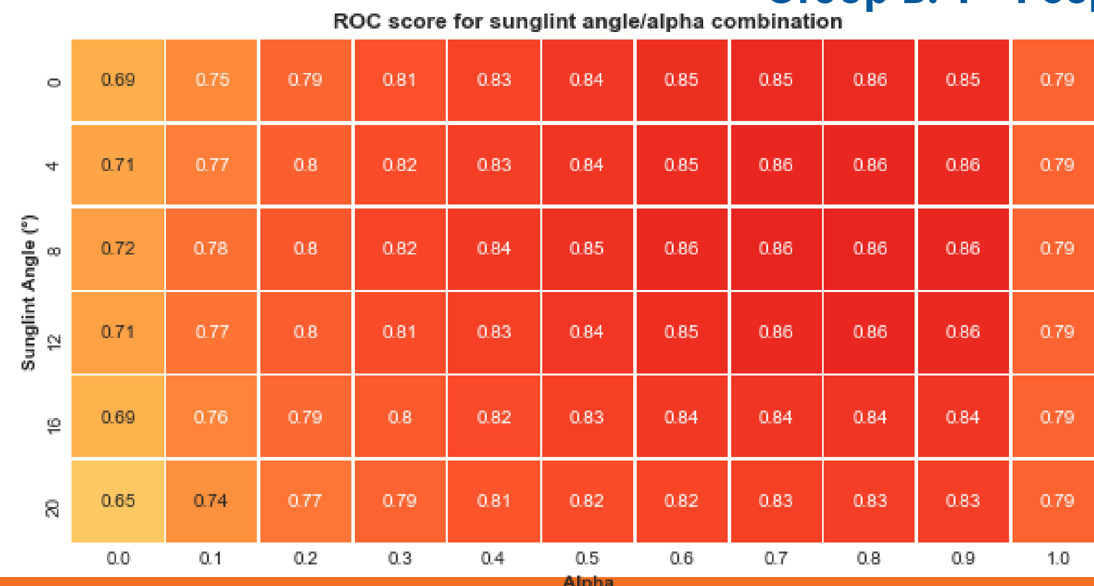
Model Training, Verification & Validation

- Performance of a hotspot composite is clearly better than using solely geostationary or polar-orbiting satellite
- Improvement in score shown when sunglint filter is applied
- Choice of optimal parameter of alpha and sun glint angle sensitive to training data
    - (training data not representative enough yet)

Group A: July 2019

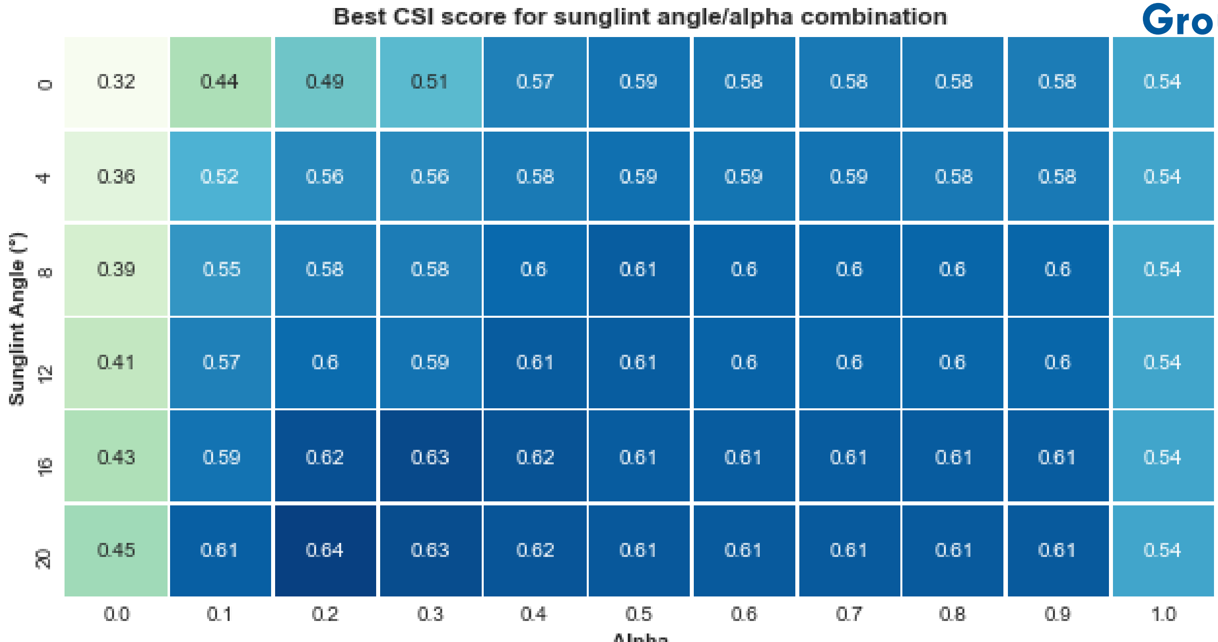


Group B: 1- 4 Sep 20

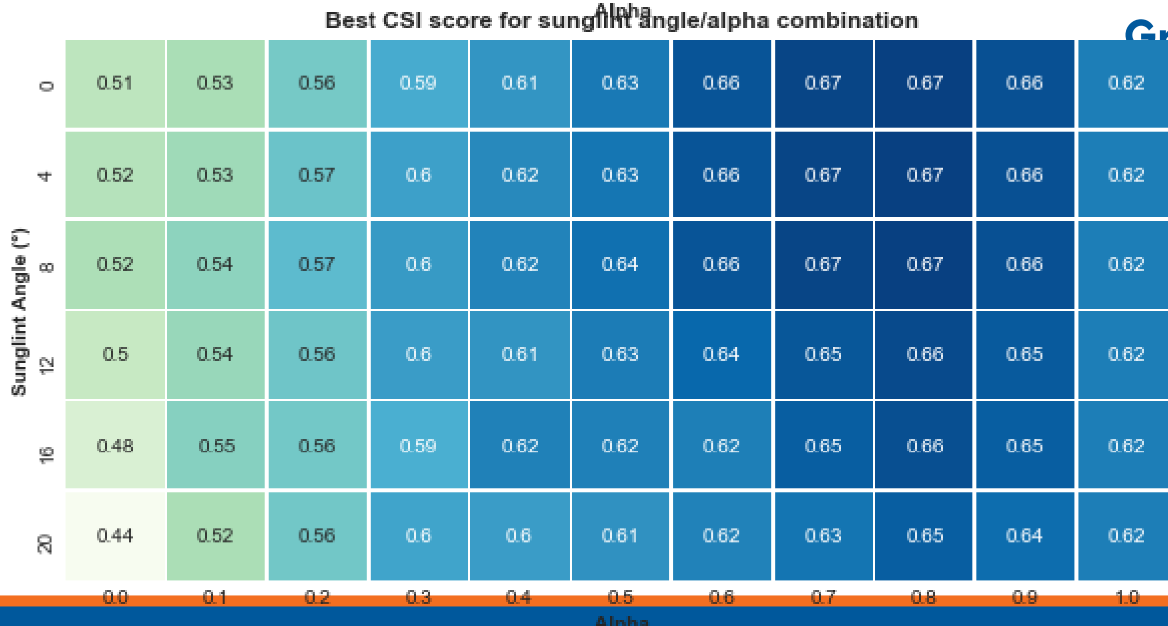


Model Training, Verification & Validation

Group A: July 2019



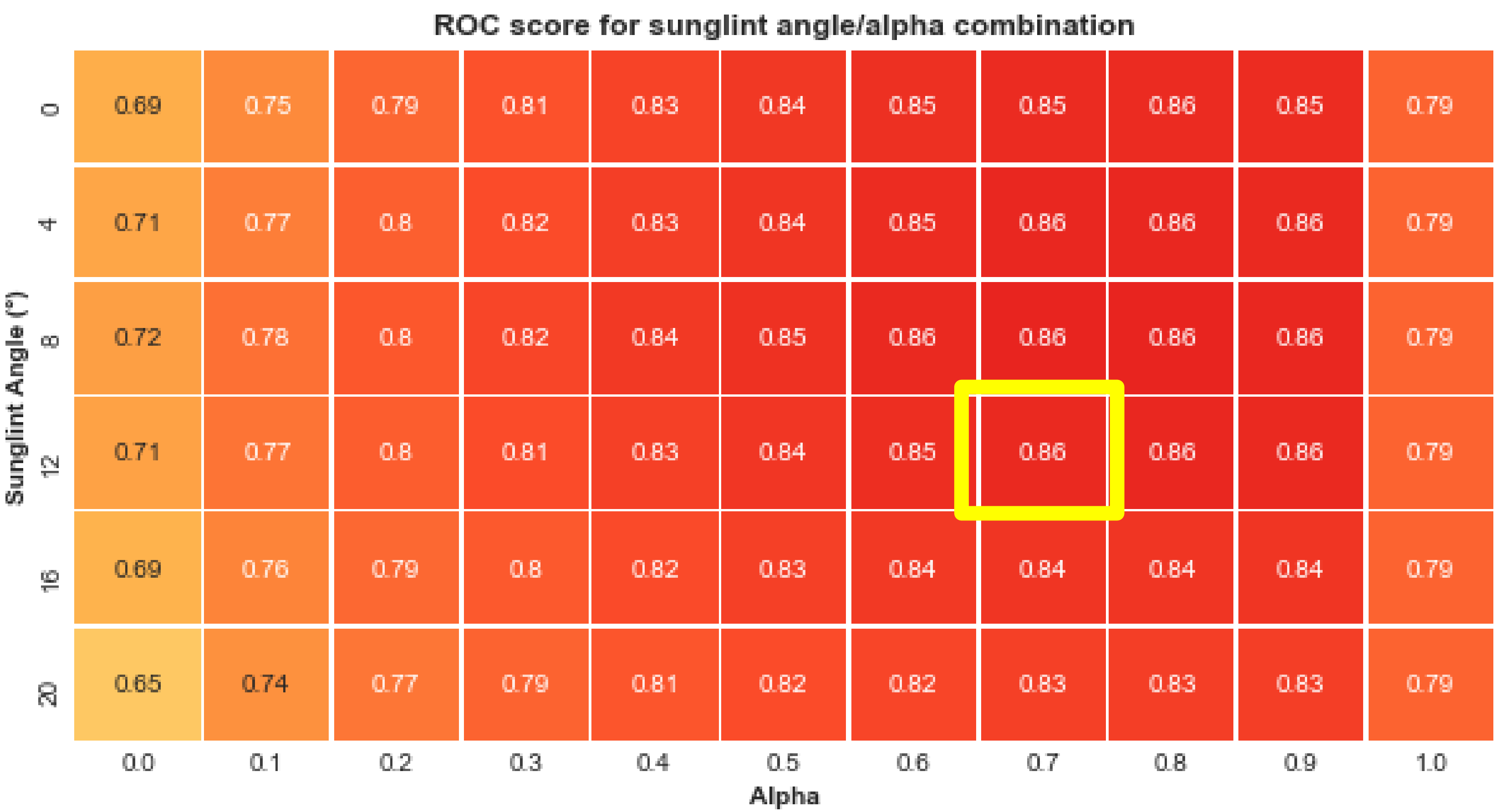
Group B: 1- 4 Sep 2019



Model Training, Verification & Validation

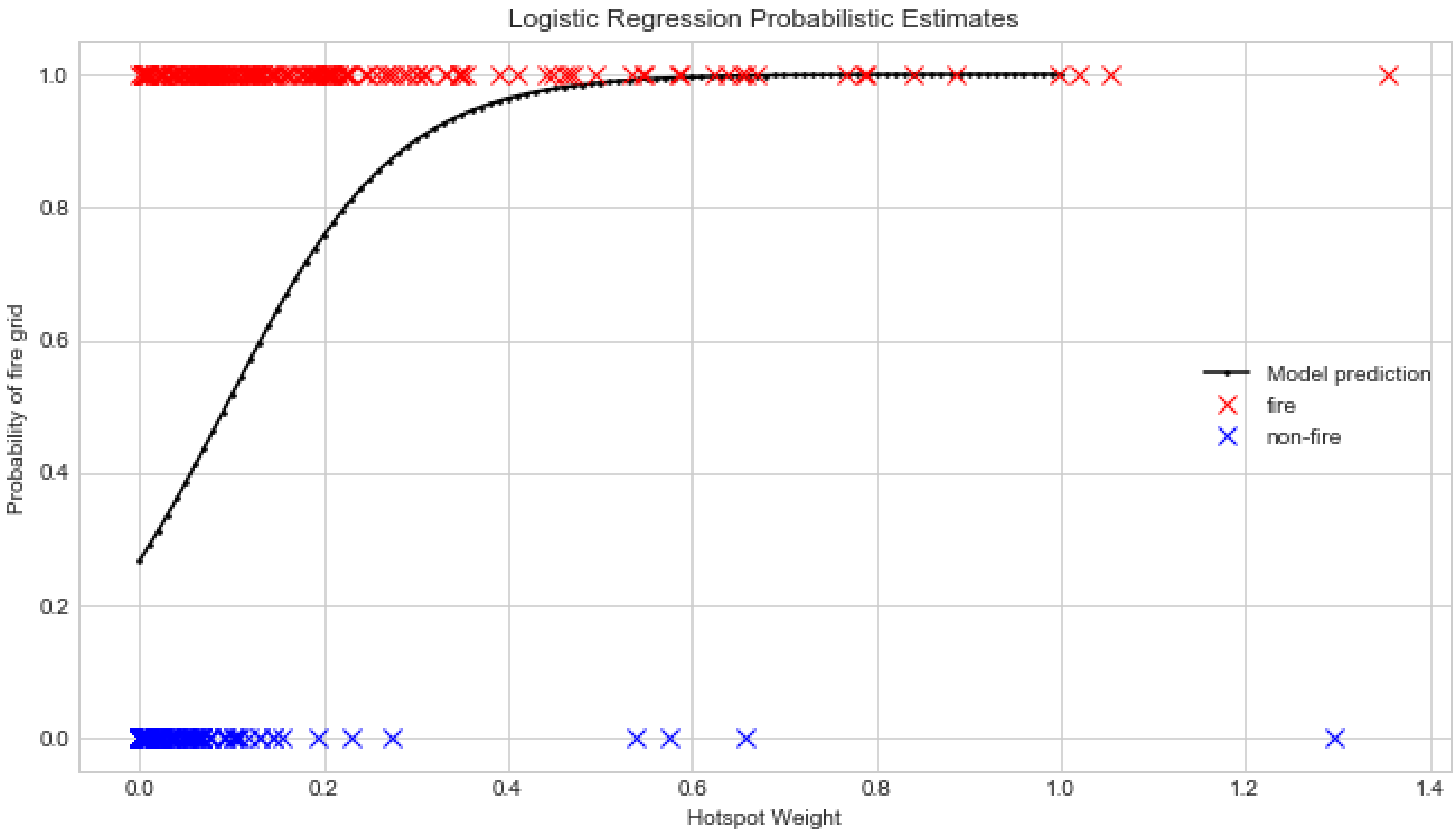
- How to pick the optimal parameter ?

Group B: 1- 4 Sep 2019



Model Training, Verification & Validation

Group B: 1- 4 Sep 2019



Model Training, Verification & Validation

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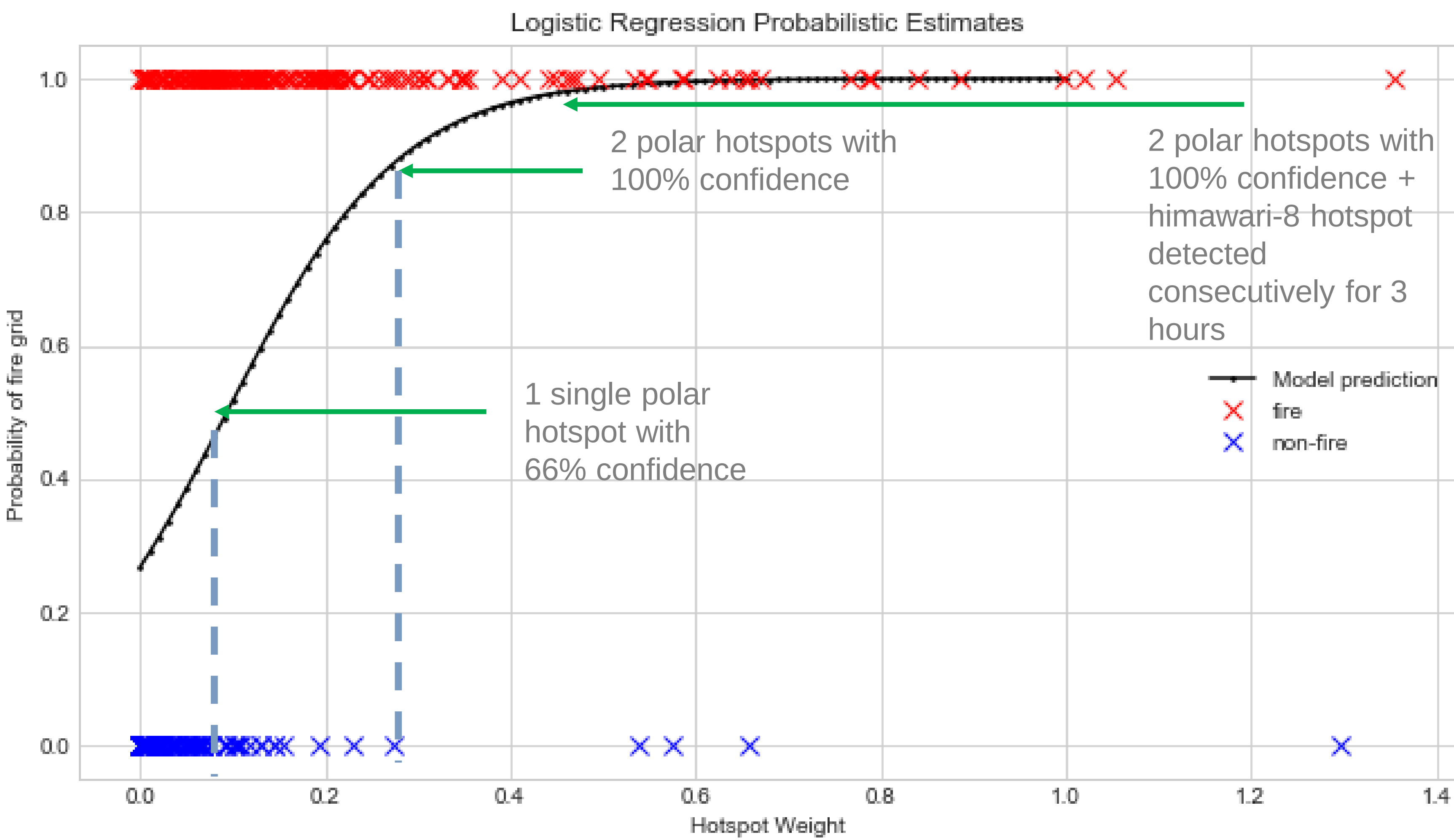
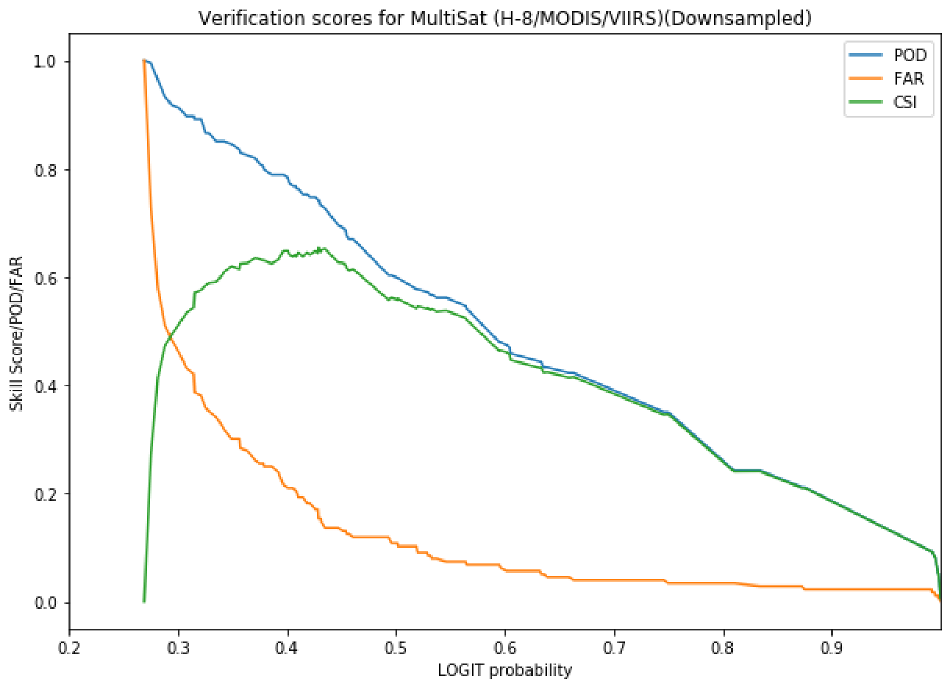
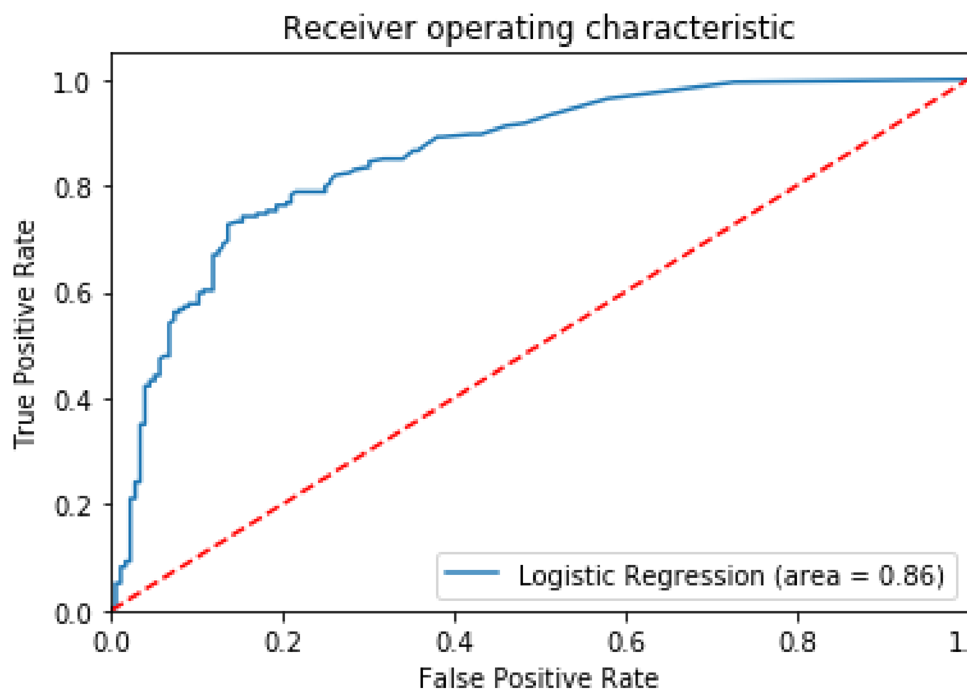


Model Training, Verification & Validation

Group B: 1- 4 Sep 2019





Conclusion

- Multi-sat hotspot composite clearly superior over single source hotspot data
- Sun glint filter brought major improvement
- Optimisation of model parameters still on-going as they are sensitive to model data but modelling approach is more or less finalised