

Feasibility of Burned Area Mapping based on ICESAT-2 Photon Counting Data

a) Forest cover mapping

Table S1. Confusion matrix of forest map classification based on Sentinel-2 data and Landsat 8 data in two study areas, where R_sum means row sum, C_sum is column sum, U_Acc is user's accuracy and P_Acc is producer's accuracy.

| Northern California forest | | | | | | | | | | |
|----------------------------|-----------|------------|-------|-------|---------------|-----------|------------|-------|--------|--|
| Sentinel-2 map | Reference | | | | Landsat 8 map | Reference | | | | |
| | Forest | Non-forest | R_sum | U_Acc | | Forest | Non-forest | R_sum | U_Acc | |
| Forest | 92 | 8 | 100 | 92% | Forest | 103 | 23 | 126 | 81.75% | |
| Non-forest | 16 | 84 | 100 | 84% | Non-Forest | 5 | 69 | 74 | 93.24% | |
| C_sum | 108 | 92 | 200 | | C_sum | 108 | 92 | 200 | | |
| P_ACC | 85.19% | 91.30% | | | P_Acc | 95.37% | 75% | | | |

| Western New Mexico forest | | | | | | | | | | |
|---------------------------|-----------|------------|-------|-------|---------------|-----------|------------|-------|--------|--|
| Sentinel-2 map | Reference | | | | Landsat 8 map | Reference | | | | |
| | Forest | Non-forest | R_sum | U_Acc | | Forest | Non-forest | R_sum | U_Acc | |
| Forest | 80 | 20 | 100 | 80% | Forest | 83 | 26 | 109 | 76.15% | |
| Non-forest | 7 | 93 | 100 | 93% | Non-Forest | 4 | 87 | 91 | 95.60% | |
| C_sum | 87 | 113 | 200 | | C_sum | 87 | 113 | 200 | | |
| P_ACC | 91.95% | 82.30% | | | P_Acc | 95.40% | 76.99% | | | |

Table S2. Confusion matrix of burn maps based on Sentinel-2 data and Landsat 8 data in two study areas.

| Northern California forest | | | | | | | | | | |
|----------------------------|-----------|--------|-------|-------|---------------|-----------|--------|-------|--------|--|
| Sentinel-2 map | Reference | | | | Landsat 8 map | Reference | | | | |
| | Unburn | Burned | R_sum | U_Acc | | Unburn | Burned | R_sum | U_Acc | |
| Unburn | 98 | 2 | 100 | 98% | Forest | 103 | 1 | 104 | 99.03% | |
| Burned | 27 | 73 | 100 | 73% | Non-Forest | 22 | 74 | 96 | 77.08% | |
| C_sum | 125 | 75 | 200 | | C_sum | 125 | 75 | 200 | | |
| P_ACC | 78.4% | 97.33% | | | P_Acc | 82.4% | 98.66% | | | |

| Western New Mexico forest | | | | | | | | | | |
|---------------------------|-----------|--------|-------|-------|---------------|-----------|--------|-------|--------|--|
| Sentinel-2 map | Reference | | | | Landsat 8 map | Reference | | | | |
| | Unburn | Burned | R_sum | U_Acc | | Unburn | Burned | R_sum | U_Acc | |
| Unburn | 99 | 1 | 100 | 99% | Unburn | 102 | 4 | 109 | 96.22% | |
| Burned | 24 | 76 | 100 | 76% | Burned | 21 | 73 | 91 | 77.65% | |
| C_sum | 123 | 77 | 200 | | C_sum | 123 | 77 | 200 | | |
| P_ACC | 80.48% | 98.70% | | | P_Acc | 82.92% | 94.80% | | | |

b) Logistics regression

Based on the stepwise procedure and removal of those insignificant metrics using training samples, four metrics, namely, RH95, mean canopy height, the number of canopy photons and apparent surface reflectance, were selected in logistic regression with Sentinel-2 derived data. Table S3 shows the coefficients and 95% confidence intervals. Variance inflation factors (VIF) are lower than 10, indicating that there may be multicollinearity among the five metrics, but not enough to cause concern. Coefficients of mean (mean canopy height), n_ca_photons (the number of canopy photons) and asr (apparent surface reflectance) are negative, which means they are negatively correlated with burn probability. When n_ca_photons increases, the probability that the current segment was burned decreases.

Based on the Landsat 8 forest cover map and burn map, the fitted logistic model selected four metrics, namely, RH50, n_ca_photons, asr and n_te_photons (the number of terrain photons). Variances of inflation factors (VIFs) show that there was no multicollinearity. Moreover, all coefficients are negative, which means that the increase of these three metrics will cause the decrease of burn probability.

Table S3. Coefficients and 95% confidence intervals of logistic regression based on Sentinel-2 based samples and Landsat 8 based samples. VIF means variance of inflation factors.

| Sentinel-2 | Coefficient | Standard error | VIF | Lower bound | Upper bound |
|--------------|-------------|----------------|--------|-------------|-------------|
| Intercept | 5.9403 | 0.7424 | - | 4.4851 | 7.3955 |
| RH95 mean | 0.0787 | 0.0390 | 7.8605 | 0.0021 | 0.1553 |
| n_ca_photons | -0.2095 | 0.0624 | 7.6397 | -0.3318 | -0.0872 |
| asr | -0.0203 | 0.0040 | 1.3118 | -0.0281 | -0.0123 |
| | -58.3731 | 7.1268 | 1.2859 | -72.3413 | -44.4048 |
| Landsat 8 | Coefficient | Standard error | VIF | Lower bound | Upper bound |
| Intercept | 6.4587 | 0.6239 | - | 5.2358 | 7.6815 |
| RH50 | -0.1066 | 0.0210 | 1.4777 | -0.1478 | -0.0654 |
| n_ca_photons | -0.0215 | 0.0034 | 1.3068 | -0.0283 | -0.0146 |
| asr | -43.6604 | 6.5347 | 1.4487 | -56.4682 | -30.8525 |
| n_te_photons | -0.0144 | 0.0041 | 2.0388 | -0.0225 | -0.0063 |

Figure S1 shows the probability of each testing sample derived from corresponding logistic regression model. For those burned segments, values of asr (apparent surface reflectance) tend to be small and burned probabilities are high. Moreover, unburned points and burned points are mixed when probabilities range in 0.25 and 0.75. Therefore, both Sentinel-2 derived samples and Landsat 8 derived samples have large uncertainties when probability locates between 0.25 and 0.75.

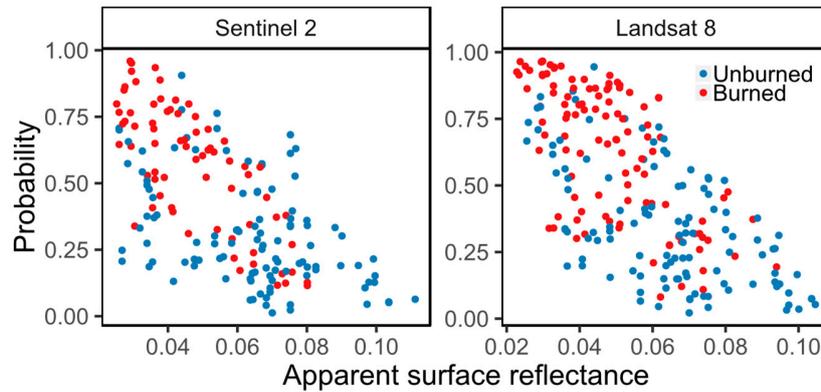


Figure S1. Scatterplot of asr (apparent surface reflectance) to probabilities calculated by logistic regression models using testing samples from Sentinel-2 derived samples and Landsat 8 derived samples, respectively.