*Article*

# Optimizing Drone-Based Surface Models for Prescribed Fire Monitoring

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**Supplementary Materials:**

**Table S1**. Summary of the main characteristics of the RGB camera used.

| Camera Model | Sony ILCE-7RM2 |
|---|---|
| Image width | 7952 px. |
| Image height | 5304 px. |
| Sensor width | 35.9 mm |
| Sensor height | 24 mm |
| Sensor length | 15 mm |
| Field of vision | 90º |

**Table S2**. Overview of the UAV flight plan as configured. Along with the use of the digital RGB camera, the covered area, the set of GSD, flying altitude, the number of strips and their respective orientations, and the adjusted side (S) and forward (F) overlaps, the survey's date is also noted.

| Camera Model | Sony ILCE-7RM2 |
|---|---|
| Date | 06 July 2020 |
| Camera Model | Sony ILCE-7RM2 |
| Coverage area (ha) | 18 |
| GSD (cm/px) | 2 |
| Flight altitude | 66 |
| Nb. of strips | 11 |
| Orientation of strips | West-East |
| Overlaps | 75% (Forward) – 75% (Side) |

**Table S3**. Overview of the UAV flight plan as configured. Along with the use of the digital RGB camera, the covered area, the set of GSD, flying altitude, the number of strips and their respective orientations, and the adjusted side (S) and forward (F) overlaps, the survey's date is also noted.

| Environmental conditions | Value |
|---|---|
| Start time UTC | 11:31 a.m. |
| Weather conditions | Sunny (100%) |
| Sun elevation | 54.51º |
| Sun azimuth | 111.05º |
| **Camera parameter settings** | **Value** |

| | |
|---|---|
| Camera orientation | 0º |
| F-stop (Aperture | F/8 |
| ISO | 500 to 1600 |
| Shutter speed | 1/1000 |

**Table S4**. Metashape image alignment parameters setting for sparse cloud generation.

| **Alignment parameters** | **Value** |
|---|---|
| Accuracy | High |
| Key point limit | 40000 |
| Tie point limit | 4000 |
| Generic preselection | yes |
| Reference preselection | yes |
| Adaptive camera model fitting | yes |

**Table S5**. Camera parameters and coefficients used during the sparse cloud re-optimizing process.

| **Camera parameters** | **Coefficients** |
|---|---|
| Focal length | f |
| Main point coordinates | cx, cy |
| Aspect transformation and tilt coefficients | b1, b2 |
| Radial distortion coefficients | k1, k2, k3, k4 |
| Tangential distortion coefficients | p1, p2 |

**Table S6**. Definition of the quality attributes of the sparse cloud. Source: Metashape User Manual (Version 1.7.3).

| Metric | Equation | Elements of the equation | Description |
|---|---|---|---|
| Reprojection error (RE) | $R = x_i^{!} - x_i \vee / S_i$ | Where $x_i^{!}$ is the point projection according to adjusted orientation parameters on the i-th image in pixels. $x_i$ refers to the measured point projection coordinates on the i-th image in pixels and. $S_i$ is the image scale at which corresponding projection was measured on the i-th image. | Low values of RE indicate good location accuracy of the corresponding point projection. Filtering points with high RE improves the accuracy of the sparse cloud optimization step. |
| Reconstruction uncertainty (RU) | $RU = \sqrt{(k_l/k_3)}$ | Where $k_l$ is the largest eigenvalue of the tie point covariance matrix for the bundle adjustment calculations and $k_3$ is the smallest eigenvalue of the tie point covariance matrix for the bundle adjustment calculations. | Ratio of the largest semi-axes to the smallest semi-axis of the error ellipse of the triangulated 3D point coordinates.<br>Higher values of RU error indicate that the points deviate significantly from the surface of the object. introducing noise in the point cloud |
| Projection accuracy (PA) | $PA = \sum i\, S_i \,/\, n$ | Where $S_i$ is the image scale at which corresponding, projections were measured on the i-th image and. $n$ is a few images where tie points were measured. | Ratio between the average scale of the image at which the projection was measured and the number of images on which the tie points were measured.<br>This filter allows to remove those points whose projections were worse located due to their larger scale size |

**Table S7**. Summary of the elevation measurement accuracy and density metrics of the 30 Dense Terrain Point Clouds (DTPC) versions according to image quality resolution levels (Ultra-High Quality (UHQ) and High Quality (HQ)) and depth filters levels (mild, moderate and aggressive) and varying the maxdist parameter by 1, 2.5, 5, 7.5 and 10 mm. Includes linear regression between the observed *GNSS-Validation points* elevation values and the predicted elevation values at the respective closest point of each DTPC ($R^2$, and standard metrics of linear regressions such as MAE) and DTPC density metrics such as grid density and low point density area.

| Image Quality Resolution | Depth filter | Maxdist (mm) | Number samples | $R^2$ | Elevation MAE (m) | Grid density (pts/m$^2$) | Low point density area (%) |
|---|---|---|---|---|---|---|---|
| UHQ | Mild | 10 | 41 | 0.9992 | 0.039 | 1119.18 | 0.309 |
| | | 7.5 | 41 | 0.9992 | 0.033 | 909.95 | 0.710 |
| | | 5 | 39 | 0.9993 | 0.030 | 655.49 | 2.673 |
| | | 2.5 | 37 | 0.9993 | 0.046 | 374.43 | 6.381 |
| | | 1 | 37 | 0.9993 | 0.052 | 183.32 | 10.645 |
| | Moderate | 10 | 44 | 0.9991 | 0.052 | 1118.36 | 0.540 |
| | | 7.5 | 40 | 0.9990 | 0.056 | 907.80 | 0.834 |
| | | 5 | 37 | 0.9992 | 0.041 | 653.03 | 2.595 |
| | | 2.5 | 38 | 0.9993 | 0.052 | 371.16 | 6.705 |
| | | 1 | 33 | 0.9991 | 0.042 | 182.30 | 10.815 |
| | Aggressive | 10 | 42 | 0.9991 | 0.049 | 1118.47 | 0.355 |
| | | 7.5 | 41 | 0.9992 | 0.044 | 912.08 | 0.726 |
| | | 5 | 39 | 0.9994 | 0.040 | 656.04 | 2.920 |
| | | 2.5 | 41 | 0.9994 | 0.050 | 373.15 | 7.416 |
| | | 1 | 36 | 0.9991 | 0.048 | 183.87 | 11.480 |
| HQ | Mild | 10 | 41 | 0.9993 | 0.043 | 220.90 | 0.309 |
| | | 7.5 | 40 | 0.9993 | 0.048 | 170.72 | 0.509 |
| | | 5 | 35 | 0.9992 | 0.043 | 118.75 | 2.240 |
| | | 2.5 | 28 | 0.9990 | 0.048 | 68.27 | 5.747 |
| | | 1 | 26 | 0.9994 | 0.054 | 34.76 | 8.760 |
| | Moderate | 10 | 38 | 0.9991 | 0.048 | 221.35 | 0.278 |
| | | 7.5 | 38 | 0.9992 | 0.042 | 170.56 | 0.509 |
| | | 5 | 33 | 0.9993 | 0.044 | 118.72 | 1.730 |
| | | 2.5 | 32 | 0.9994 | 0.037 | 68.21 | 5.207 |
| | | 1 | 26 | 0.9998 | 0.028 | 34.60 | 8.050 |
| | Aggressive | 10 | 42 | 0.9989 | 0.054 | 221.32 | 0.278 |
| | | 7.5 | 39 | 0.9990 | 0.044 | 170.28 | 0.571 |
| | | 5 | 35 | 0.9992 | 0.037 | 118.22 | 1.699 |
| | | 2.5 | 31 | 0.9991 | 0.052 | 68.23 | 5.547 |
| | | 1 | 23 | 0.9985 | 0.064 | 34.46 | 7.957 |