Table 1. Description of test sites. Canada and USA sites are referred to in the document by their local site name (“site name”).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Site | Average field size (hectare, ha) | Number ofcrop classes | Main crop | Additional crop | Growing season | Cropping system |
|  |  |  | Maize | Soya beans | Wheat | Barley | Rye | Oats | Rapeseed/canola | Potatoes | Sunflower | Hay and pasture | Alfalfa |  |  |  |
| Argentina | 27.9 | 3 | X | X |  |  |  |  |  |  |  |  |  | Wheat-soya | August to May | Multiple harvests per year |
| Brazil  | 16.6 | 8 | X | X |  |  |  |  |  |  |  | X |  | Eucalyptus, oranges, sugar cane, pine, fallow | Full year | Multiple harvests per year |
| Canada “Carman” | 37.6 | 10 | X | X | X | X | X | X | X | X |  | X |  | Peas & beans | April to September | One harvest per year |
| Canada “Casselman” | 3.0 | 6 | X | X | X | X |  |  |  |  |  | X |  | Other cereals | May to September | One harvest per year |
| France | 3.4 | 5 | X | X | X |  |  |  | X |  | X |  |  |  | May to September | One harvest per year |
| Germany | 37.2 | 8 | X |  | X | X | X |  | X | X |  | X |  | Sugar beets | May to September | One harvest per year |
| USA “Georgia” | 8.7 | 8 | X | X |  |  |  |  |  |  |  | X |  | Cotton, peanuts, fallow, other cereals, vegetables | February to December  | One harvest per year |
| USA “Iowa” | 64.0 | 4 | X | X |  |  |  |  |  |  |  | X | X |  | April to October | One harvest per year |
| USA “Michigan” | 7.9 | 6 | X | X | X |  |  | X |  |  |  | X | X |  | April to November | One harvest per year |
| USA “North Dakota” | 20.4 | 8 | X | X | X |  |  | X |  |  | X | X | X | Flaxseed | April to September | One harvest per year |

Table 2. Number of field samples, training and validation polygons (poly) and pixels for maize, soya bean and wheat classes for the ten sites. Greyed areas indicate that crop is not present at that site. Reference data were split based upon polygon count. Some data for rare classes were weighted to ensure an adequate training and/or validation set.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Site | Total number of field samples | Maize | Soya bean | Wheat |
|  |  | Training | Validation | Training | Validation | Training | Validation |
|  |  | Pixel | Poly | Pixel | Poly | Pixel | Poly | Pixel | Poly | Pixel | Poly | Pixel | Poly |
| Argentina | 157 | 10562 | 17 | 3913 | 7 | 52302 | 69 | 18452 | 28 |  |
| Brazil | 237 | 4667 | 7 | 3180 | 3 | 1624 | 7 | 956 | 3 |  |
| Carman | 792 | 75031 | 59 | 32988 | 35 | 155119 | 129 | 120617 | 70 | 107367 | 122 | 48787 | 56 |
| Casselman | 801 | 16358 | 233 | 8872 | 104 | 15395 | 198 | 7320 | 88 | 1059 | 16 | 152 | 2 |
| France | 375 | 7584 | 55 | 4243 | 29 | 491 | 7 | 478 | 5 | 7609 | 55 | 3878 | 29 |
| Germany | 376 | 13931 | 39 | 7144 | 14 |  | 90815 | 72 | 38952 | 32 |
| Georgia | 401 | 3538 | 17 | 637 | 4 | 3105 | 12 | 522 | 2 |  |
| Iowa | 853 | 328286 | 177 | 247746 | 96 | 181277 | 172 | 74830 | 68 |  |
| Michigan | 599 | 32824 | 62 | 18488 | 30 | 15418 | 56 | 1575 | 16 | 2463 | 14 | 3674 | 11 |
| North Dakota | 771 | 24061 | 58 | 10196 | 23 | 19195 | 32 | 7910 | 16 | 16428 | 54 | 8762 | 26 |

Table 3. RADARSAT-2 and Sentinel-1 SAR data acquired per site.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Site | Number of images | Satellite | Year | Date(day month year) |
| Argentina | 29 | RADARSAT-2 | 2016 to 2017 | 31 August 2016; 24 September 2016; 18 October 2016; 11 November 2016; 15 November 2016; 2 December 2016; 29 December 2016; 2 January 2017; 22 January 2017; 15 February 2017; 19 February 2017; 11 March 2017; 4 April 2017; 8 April 2017; 28 April 2017; 22 May 2017; 26 May 2017. |
|  |  | Sentinel-1 |  | 17 October 2016; 11 November 2016; 22 November 2016; 21 January 2017; 2 February 2017; 14 February 2017; 26 February 2017; 10 March 2017; 3 April 2017; 27 April 2017; 9 May 2017. |
| Brazil | 31 | Sentinel-1 | 2016 to 2017 | 2 September 2016; 9 September 2016; 21 September 2016; 2 October 2016; 14 October 2016; 26 October 2016; 7 November 2016; 19 November 2016; 20 November 2016; 1 December 2016; 2 December 2016; 13 December 2016; 14 December 2016; 25 December 2016; 6 January 2017; 18 January 2017; 19 January 2017; 30 January 2017; 31 January 2017; 11 February 2017; 12 February 2017; 23 February 2017; 24 February 2017; 7 March 2017; 8 March 2017; 19 March 2017; 23 March 2017; 24 March 2017; 1 April 2017; 12 April 2017; 31 May 2017. |
| Carman | 32 | RADARSAT-2 | 2016 | 29 May 2016; 5 June 2016; 29 June 2016; 2 July 2016; 3 July 2016; 9 July 2016; 10 July 2016; 16 July 2016; 17 July 2016; 20 July 2016; 23 July 2016; 24 July 2016; 10 August 2016; 16 August 2016; 17 August 2016; 19 September 2016; 20 September 2016; 22 September 2016. |
|  |  | Sentinel-1 |  | 13 May 2016; 25 May 2016; 6 June 2016; 13 June 2016; 3 July 2016; 7 July 2016; 15 July 2016; 24 July 2016; 31 July 2016; 12 August 2016; 17 August 2016; 10 September 2016; 28 September 2016; 10 October 2016.  |
| Casselman | 22 | RADARSAT-2 | 2016 | 14 April 2016; 18 April 2016; 21 April 2016; 1 May 2016; 15 May 2016; 29 May 2016; 4 June 2016; 8 June 2016; 23 July 2016; 12 August 2016; 15 August 2016; 25 September 2016; 29 September 2016; 23 October 2016.  |
|  |  | Sentinel-1 |  | 23 April 2016; 27 June 2016; 28 July 2016. |
| France | 13 | Sentinel-1 | 2015 | 24 April 2015; 17 May 2015; 18 May 2015; 30 May 2015; 10 June 2015; 23 June 2015; 4 July 2015; 5 July 2015; 16 July 2015; 28 July 2015; 21 August 2015; 14 September 2015; 26 September 2015.  |
| Germany | 13 | Sentinel-1 | 2015 | 13 March 2015; 16 May 2015; 2 June 2015; 9 June 2015; 20 July 2015; 1 August 2015; 13 August 2015; 1 September 2015; 18 September 2015; 30 September 2015; 12 October 2015; 24 October 2015.  |
| Georgia | 11 | RADARSAT-2 | 2016 | 20 June 2016; 22 July 2016; 31 July 2016; 24 August 2016.  |
|  |  | Sentinel-1 |  | 11 May 2016; 23 May 2016; 4 June 2016; 28 June 2016; 27 August 2016; 20 September 2016; 8 October 2016.  |
| Iowa | 45 | RADARSAT-2 | 2016 | 2 May 2016; 3 May 2016; 6 May 2016; 9 May 2016; 13 May 2016; 16 May 2016; 20 May 2016; 2 June 2016; 6 June 2016; 9 June 2016; 13 June 2016; 20 June 2016; 23 June 2016; 26 June 2016; 30 June 2016; 3 July 2016; 7 July 2016; 10 July 2016; 13 July 2016; 14 July 2016; 17 July 2016; 20 July 2016; 24 July 2016; 27 July 2016; 31 July 2016; 3 August 2016; 6 August 2016; 7 August 2016; 10 August 2016; 13 August 2016; 17 August 2016; 20 August 2016; 20 August 2016; 24 August 2016; 27 August 2016; 30 August 2016; 31 August 2016. |
|  |  | Sentinel-1 |  | 27 May 2016; 13 June 2016; 12 July 2016; 14 July 2016; 24 July 2016; 26 July 2016; 7 August 2016; 19 August 2016; 12 September 2016.  |
| Michigan | 18 | RADARSAT-2 | 2016 | 13 April 2016; 20 April 2016; 13 May 2016; 14 May 2016; 31 May 2016; 6 June 2016; 7 June 2016; 1 July 2016; 4 September 2016; 5 October 2016.  |
|  |  | Sentinel-1 |  | 24 April 2016; 18 May 2016; 30 May 2016; 17 July 2016; 10 August 2016; 22 August 2016; 3 September 2016; 15 September 2016.  |
| North Dakota | 10 | Sentinel-1 | 2016 | 24 April 2016; 6 May 2016; 18 May 2016; 4 June 2016; 11 June 2016; 5 July 2016; 17 July 2016; 22 July 2016; 15 August 2016; 3 September 2016.  |

Table 4. List of Landsat-8 and Sentinel-2 optical data acquired per site.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Site | Number of images | Satellite | Year | Date (day month year) |
| Argentina | 10 | Landsat-8 | 2016 to 2017 | 28 October 2016; 15 December 2016; 17 February 2017; 14 March 2017; 15 April 2017; 17 May 2017.  |
|  |  | Sentinel-2 |  | 17 August 2016; 26 September 2016; 26 November 2016; 15 December 2016.  |
| Brazil | 11 | Landsat-8 | 2016 to2017 | 12 June 2016; 14 July 2016; 23 September 2016; 14 February 2017; 11 March 2017; 28 April 2017.  |
|  |  | Sentinel-2 |  | 28 August 2016; 26 November 2016; 6 December 2016; 15 May 2017; 4 June 2017.  |
| Carman | 5 | Landsat-8 | 2016 | 18 July 2016; 20 September 2016.  |
|  |  | Sentinel-2 |  | 21 May 2016; 20 June 2016; 22 August 2016.  |
| Casselman | 5 | Landsat-8 | 2016 | 16 June 2016; 26 August 2016. |
|  |  | Sentinel-2 |  | 24 April 2016; 24 May 2016; 30 June 2016.  |
| France | 5 | Landsat-8 | 2015 | 13 April 2015; 7 June 2015; 23 June 2015.  |
|  |  | Sentinel-2 |  | 16 July 2015; 25 August 2015.  |
| Germany | 4 | Landsat-8 | 2015 | 17 April 2015; 13 June 2015; 23 August 2015.  |
|  |  | Sentinel-2 |  | 6 August 2015. |
| Georgia | 6 | Landsat-8 | 2016 | 18 April 2016; 21 June 2016; 23 July 2016; 9 September 2016.  |
|  |  | Sentinel-2 |  | 7 May 2016; 27 May 2016.  |
| Iowa | 5 | Landsat-8 | 2016 | 20 June 2016; 22 July 2016; 8 September 2016. |
|  |  | Sentinel-2 |  | 5 May 2016; 13 August 2016. |
| Michigan | 5 | Landsat-8 | 2016 | 23 April 2016; 26 May 2016; 29 August 2016; 14 September 2016.  |
|  |  | Sentinel-2 |  | 2 June 2016.  |
| North Dakota | 5 | Landsat-8 | 2016 | 9 July 2016; 25 July 2016; 27 September 2016.  |
|  |  | Sentinel-2 |  | 4 May 2016; 1 September 2016.  |

Table 5. OA (%) for DT and RF classifications of dense C-band data stacks. Included is McNemar’s Test *p*-values showing significant (greater than 0.05, indicated ‘\*’) and non-significant results (less than 0.05).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Site | DTOA (%) | RFOA (%) | Number of SAR images | Number of classes | McNemar’s *p*-value |
| Iowa | 95.6 | 96.2 | 45 | 4 | 0.00000 |
| Argentina | 94.4 | 94.8 | 29 | 3 | 0.02792 |
| France | 90.3 | 91.0 | 13 | 5 | 0.09807\* |
| Casselman | 89.0 | 90.5 | 22 | 6 | 0.00000 |
| Carman | 85.8 | 88.0 | 32 | 10 | 0.00000 |
| Georgia | 84.8 | 85.8 | 11 | 8 | 0.00278 |
| Germany | 82.3 | 83.1 | 13 | 8 | 0.00000 |
| North Dakota | 80.7 | 81.2 | 10 | 8 | 0.00336 |
| Michigan | 76.8 | 78.2 | 18 | 6 | 0.00000 |
| Brazil  | 62.0 | 64.3 | 31 | 8 | 0.00599 |

Table 6. OA (%) of RF classifications of optical only, SAR only and optimized optical and SAR combined data stacks.

|  |  |
| --- | --- |
|  | OA (%) of RF classification |
| Site | SAR only | Optical only | Optimized combined data |
| Iowa | 96.2 | 96.7 | 96.8 |
| Argentina | 94.8 | 84.4 | 92.6 |
| France | 91.0 | 97.6 | 97.4 |
| Casselman | 90.4 | 89.4 | 92.7 |
| Carman | 87.9 | 87.4 | 87.4 |
| Georgia | 85.8 | 83.0 | 86.0 |
| Germany | 83.1 | 81.5 | 82.3 |
| North Dakota | 81.0 | 86.0 | 85.8 |
| Michigan | 78.2 | 87.6 | 87.1 |
| Brazil | 64.3 | 86.8 | 77.5 |

Table 7. User’s and producer’s accuracies for maize, soya bean and wheat using RF classification. Highest user’s and producer’s accuracies are highlighted, for each site.

|  |  |  |  |
| --- | --- | --- | --- |
| Crop | SAR only | Optimized combined | Optical only |
|  | User's accuracy (%) | Producer's accuracy (%) | User's accuracy (%) | Producer's accuracy (%) | User's accuracy (%) | Producer's accuracy (%) |
| Maize |  |  |  |  |  |  |
| Argentina | 99.0 | 81.7 | 50.9 | 91.1 | 50.8 | 90.7 |
| Brazil | 87.2 | 35.5 | 88.4 | 46.4 | 87.5 | 49.4 |
| Carman | 90.7 | 92.3 | 92.2 | 93.2 | 90.7 | 93.1 |
| Casselman | 90.7 | 93.2 | 93.6 | 96.0 | 92.9 | 93.9 |
| France | 91.3 | 98.2 | 97.9 | 99.0 | 96.7 | 98.7 |
| Germany | 78.0 | 81.1 | 66.6 | 73.1 | 66.1 | 71.5 |
| Iowa | 99.0 | 97.4 | 99.0 | 97.3 | 98.9 | 97.1 |
| Georgia | 50.0 | 31.7 | 68.9 | 71.7 | 67.0 | 64.2 |
| Michigan | 94.5 | 90.5 | 96.4 | 93.5 | 96.1 | 93.2 |
| North Dakota | 78.1 | 88.9 | 87.0 | 94.4 | 86.9 | 93.8 |
| Soya bean |  |  |  |  |  |  |
| Argentina | 93.5 | 99.6 | 96.0 | 81.4 | 95.6 | 81.3 |
| Brazil | 0.0 | 0.0 | 76.2 | 1.7 | 33.3 | 1.3 |
| Carman | 92.1 | 97.1 | 93.0 | 96.3 | 92.7 | 95.7 |
| Casselman | 91.4 | 90.5 | 92.4 | 90.8 | 87.7 | 89.0 |
| France | 100.0 | 23.4 | 100.0 | 93.9 | 98.6 | 88.1 |
| Georgia | 10.3 | 12.6 | 4.9 | 12.8 | 4.0 | 9.4 |
| Iowa | 95.6 | 97.9 | 95.3 | 97.8 | 95.4 | 97.8 |
| Michigan | 54.9 | 57.2 | 61.6 | 72.5 | 60.4 | 73.8 |
| North Dakota | 82.8 | 86.7 | 93.1 | 82.2 | 94.4 | 77.8 |
| Wheat |  |  |  |  |  |  |
| Casselman | 47.7 | 94.1 | 52.6 | 99.3 | 55.3 | 99.3 |
| Carman | 80.5 | 82.3 | 76.9 | 83.2 | 77.8 | 83.3 |
| France | 98.3 | 91.3 | 99.0 | 99.6 | 98.2 | 99.4 |
| Germany | 80.4 | 97.9 | 85.5 | 94.7 | 86.6 | 96.0 |
| Michigan | 97.7 | 47.6 | 99.9 | 77.3 | 99.7 | 76.6 |
| North Dakota | 78.1 | 51.9 | 90.7 | 68.4 | 89.6 | 65.6 |