



*Supplement of*

## **Application and validation of long-range terrestrial laser scanning to monitor the mass balance of very small glaciers in the Swiss Alps**

**Mauro Fischer et al.**

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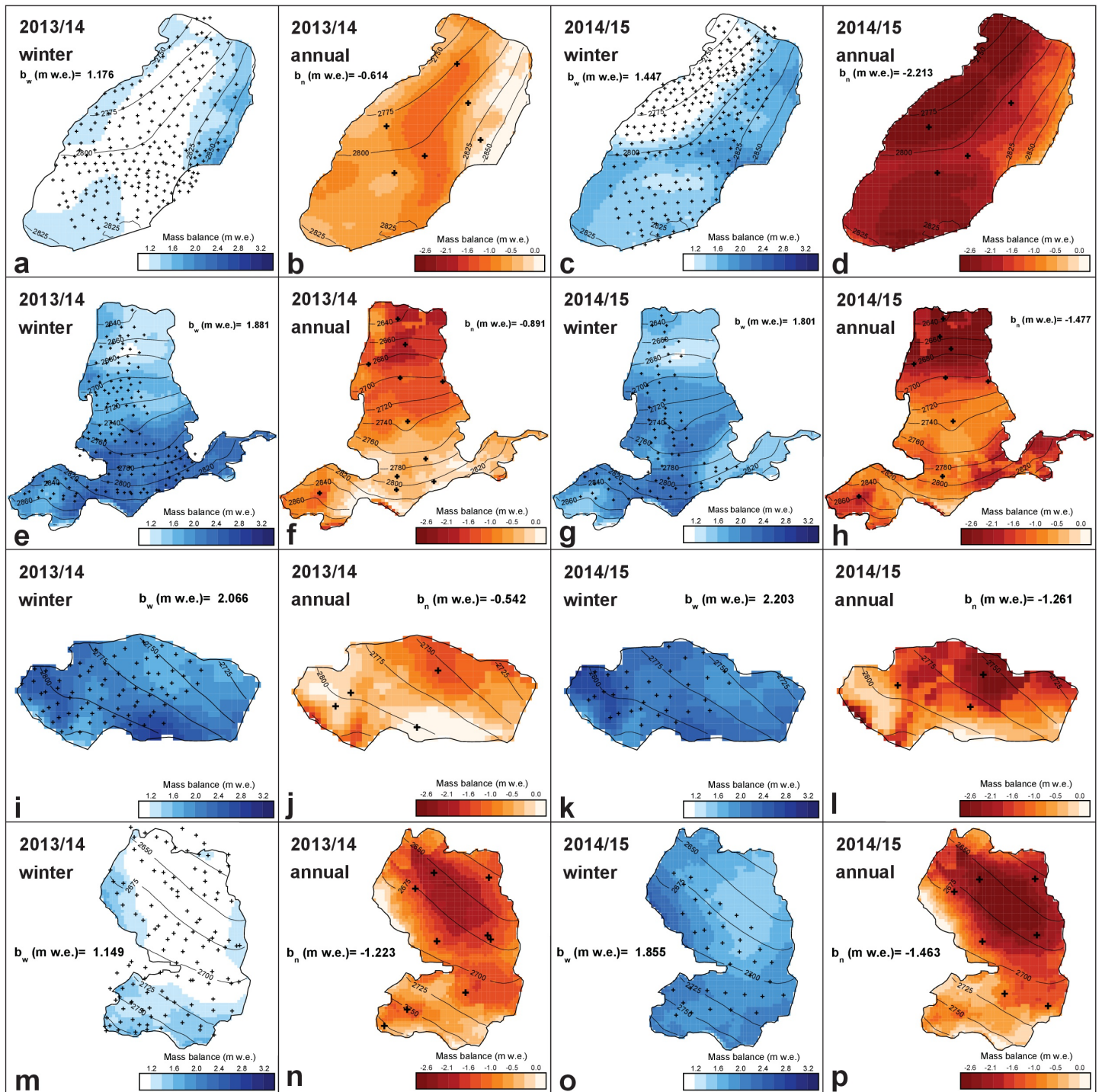
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**Supplementary Table S1.** TLS survey parameters for the individual surveys of Glacier de Prapio (PRA), Glacier du Sex Rouge (SER), St. Annafirm (STA), Schwarzbachfirm (SWZ), and Pizolgletscher (PZL).

| Date       | Surface area scanned<br>m <sup>2</sup> | Number of points measured | Point density<br>m <sup>-2</sup> | Total measurement time<br>min |
|------------|----------------------------------------|---------------------------|----------------------------------|-------------------------------|
| PRA        |                                        |                           |                                  |                               |
| 14.09.2013 | 1085207                                | 1036512                   | 0.955                            | 4                             |
| 22.09.2014 | 824338                                 | 30573624                  | 37.089                           | 21                            |
| 21.09.2015 | 1102932                                | 28267120                  | 25.629                           | 20                            |
| SER        |                                        |                           |                                  |                               |
| 14.09.2013 | 1554719                                | 1405526                   | 0.904                            | 6                             |
| 22.09.2014 | 1281187                                | 29516688                  | 23.039                           | 24                            |
| 21.09.2015 | 1309371                                | 58373504                  | 44.581                           | 37                            |
| STA        |                                        |                           |                                  |                               |
| 06.09.2013 | 780497                                 | 8245020                   | 10.564                           | 7                             |
| 26.09.2014 | 901390                                 | 29901956                  | 33.173                           | 21                            |
| 28.09.2015 | 1160962                                | 77473844                  | 66.732                           | 54                            |
| SWZ        |                                        |                           |                                  |                               |
| 07.09.2013 | 259828                                 | 601234                    | 2.314                            | 2                             |
| 26.09.2014 | 273159                                 | 20420736                  | 74.758                           | 17                            |
| 28.09.2015 | 290835                                 | 27396352                  | 94.199                           | 24                            |
| PZL        |                                        |                           |                                  |                               |
| 23.09.2013 | 148557                                 | 2350828                   | 15.824                           | 3                             |
| 20.09.2014 | 295283                                 | 2148581                   | 7.276                            | 2                             |
| 09.09.2015 | 989954                                 | 20752611                  | 20.963                           | 22                            |

**Supplementary Table S2.** Dates, number ( $n$ ), and spatial density of winter and summer glaciological mass balance measurements on Glacier du Sex Rouge (SER), St. Annafirn (STA), Schwarzbachfirn (SWZ) and Pizolgletscher (PZL).  $n$  refers to snow probings (winter survey) and ablation stake or accumulation pit measurements (summer survey).

| year | Winter survey |     |                                 | Summer survey |     |                                 |
|------|---------------|-----|---------------------------------|---------------|-----|---------------------------------|
|      | Date          | $n$ | density<br>( $\text{km}^{-2}$ ) | Date          | $n$ | density<br>( $\text{km}^{-2}$ ) |
| SER  |               |     |                                 |               |     |                                 |
| 2012 | 03.04.        | 21  | 78                              | 24.09.        | 1   | 4                               |
| 2013 | 23.04.        | 138 | 510                             | 14.09.        | 5   | 19                              |
| 2014 | 17.04.        | 224 | 828                             | 22.09.        | 6   | 22                              |
| 2015 | 22.04.        | 245 | 906                             | 20.09.        | 4   | 15                              |
| STA  |               |     |                                 |               |     |                                 |
| 2012 | 12.04.        | 31  | 143                             | 03.10.        | 4   | 18                              |
| 2013 | 13.03.        | 41  | 189                             | 02.10.        | 10  | 46                              |
| 2014 | 10.04.        | 153 | 705                             | 23.09.        | 11  | 51                              |
| 2015 | 15.04.        | 80  | 369                             | 28.09.        | 9   | 47                              |
| SWZ  |               |     |                                 |               |     |                                 |
| 2013 | 14.04.        | 60  | 1026                            | 07.09.        | 2   | 34                              |
| 2014 | 11.04.        | 76  | 1299                            | 24.09.        | 4   | 68                              |
| 2015 | 15.04.        | 31  | 530                             | 28.09.        | 3   | 60                              |
| PZL  |               |     |                                 |               |     |                                 |
| 2006 | 14.04.        | 61  | 689                             | 13.09.        | –   | –                               |
| 2007 | 02.04.        | 86  | 972                             | 03.09.        | 2   | 23                              |
| 2008 | 02.04.        | 43  | 486                             | 25.09.        | 4   | 45                              |
| 2009 | 07.04.        | 91  | 1028                            | 13.09.        | 6   | 68                              |
| 2010 | 02.04.        | 111 | 1254                            | 22.09.        | 9   | 102                             |
| 2011 | 26.04.        | 102 | 1153                            | 24.09.        | 8   | 90                              |
| 2012 | 30.04.        | 38  | 429                             | 21.09.        | 8   | 90                              |
| 2013 | 29.04.        | 119 | 1345                            | 23.09.        | 9   | 102                             |
| 2014 | 31.04.        | 118 | 1333                            | 20.09.        | 9   | 135                             |
| 2015 | 11.05.        | 50  | 565                             | 27.09.        | 7   | 105                             |



**Supplementary Figure S1.** Spatial distribution of direct glaciological annual and winter balance of (a-d) Glacier du Sex Rouge, (e-h) St. Annafirn, (i-l) Schwarzbachfirn, and (m-p) Pizolgletscher in 2013/14 and 2014/15 (measured periods, coinciding with start and end of LiDAR surveys). Cross symbols indicate the location of snow probings (winter) and mass balance measurements at stakes or firn pits (annual).