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*Supplement of*

## **Satellite monitoring of glaciers in the Karakoram from 1977 to 2013: an overall almost stable population of dynamic glaciers**

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## Supplement: Error assessment

### Calculation of error in total area

**Formula:**  $A_{er} = \pm 100\% \cdot (f_s \cdot n \cdot m) / A_{gl}$

where,  $A_{er}$  = error of glacier area,  $A_{gl}$  is digitized glacier area,  $n$  is the number of pixels defining the perimeter of the glacier,  $m$  = spatial resolution of the image expressed as area of a pixel (e.g., 900 m<sup>2</sup> for a 30 x 30 m TM image),  $f_s$  is the systematic fractional pixel error (e.g.  $f_s = 0.5$  for half a pixel error).

<b>1977</b> Pixels on Perimeter: 15573316.3/80 = 194666  =0.5*194666*80*80*100/7895 = 8%	<b>1990</b> Pixels on Perimeter: 15526515/30 = 517550  =0.5*517550*30*30*100/7885000000 = 3%
<b>2001</b> Pixels on Perimeter: 15548721/30 = 518290  =0.5*518290*30*30*100/782000000 = 3%	<b>2010</b> Pixels on Perimeter: 15530623/30 = 517687  =0.5*517687*30*30*100/7885000000 = 3%

### Calculation of error in change in area

**Formula:**  $A_{ch,er} = \pm 100\% \cdot (2/j)^{1/2} \cdot (f_r \cdot n_p \cdot m) / A_{gl}$ ,

where  $j$  = the number of manual vertices of the vectorized polygon,  $n_p$  = is the modified perimeter of the snout area, and  $f_r$  now is the random pixel error, perhaps still around 1.

<p><b>1977-1990</b>  <b>Retreating glacier</b>            Pixels on Perimeter: 281530.3/80                                              = 3519.1/2  <b>Note: Two poly lines at snout, thus divided by 2</b>                                              = 1759            Vertices: 316.2/j = 2/316 = 0.006                      <math>(2/j)^{1/2} = (0.006)^{1/2} = 0.0775</math>                      = <math>0.0775 * 1759.5 * 80 * 80 * 100 / 13600000</math>                      = 6%  <b>Advancing glacier</b>            Pixels on Perimeter: 67506/80                                              = 843.8/2                                              = 421.9            Vertices: 95. 2/j = 2/95 = 0.021                      <math>(2/j)^{1/2} = (0.021)^{1/2} = 0.145</math>                      = <math>0.145 * 421.9 * 80 * 80 * 100 / 3620000</math>                      = 10%</p>	<p><b>1990-2001</b>  <b>Retreating glacier</b>            Pixels on Perimeter: 370383/30                                              = 12346/2                                              = 6173            Vertices: 515. 2/j = 2/515 = 0.004                      <math>(2/j)^{1/2} = (0.004)^{1/2} = 0.063</math>                      = <math>0.063 * 6173 * 30 * 30 * 100 / 23000000</math>                      = 1.5%  <b>Advancing glacier</b>            Pixels on Perimeter: 282536.8/30                                              = 9417/2                                              = 4708.9            Vertices: 305. 2/j = 2/305 = 0.007                      <math>(2/j)^{1/2} = (0.007)^{1/2} = 0.084</math>                      = <math>0.084 * 4708 * 30 * 30 * 100 / 20160000</math>                      = 1.8%</p>
<p><b>2000-2010</b>  <b>Retreating glacier</b>            Pixels on Perimeter: 133356.2/30                                              = 4445/2                                              = 2222            Vertices: 207. 2/j = 2/207 = 0.0097                      <math>(2/j)^{1/2} = (0.0097)^{1/2} = 0.098</math>                      = <math>0.098 * 2222 * 30 * 30 * 100 / 7040000</math>                      = 2.8%  <b>Advancing glacier</b>            Pixels on Perimeter: 149163/30                                              = 4972/2                                              = 2486            Vertices: 203. 2/j = 2/203 = 0.0099                      <math>(2/j)^{1/2} = (0.0099)^{1/2} = 0.0994</math>                      = <math>0.0994 * 2486 * 30 * 30 * 100 / 10600000</math>                      = 2.1%</p>	<p><b>2010-2013</b>  <b>Retreating glacier</b>            Pixels on Perimeter: 33874/30                                              = 1129/2                                              = 564            Vertices: 40. 2/j = 2/40 = 0.05                      <math>(2/j)^{1/2} = (0.05)^{1/2} = 0.22</math>                      = <math>0.22 * 564 * 30 * 30 * 100 / 2700000</math>                      = 4%  <b>Advancing glacier</b>            Pixels on Perimeter: 65419/30                                              = 2180/2                                              = 1090            Vertices: 43. 2/j = 2/43 = 0.041                      <math>(2/j)^{1/2} = (0.041)^{1/2} = 0.20</math>                      = <math>0.2 * 1090 * 30 * 30 * 100 / 5500000</math>                      = 3.6%</p>