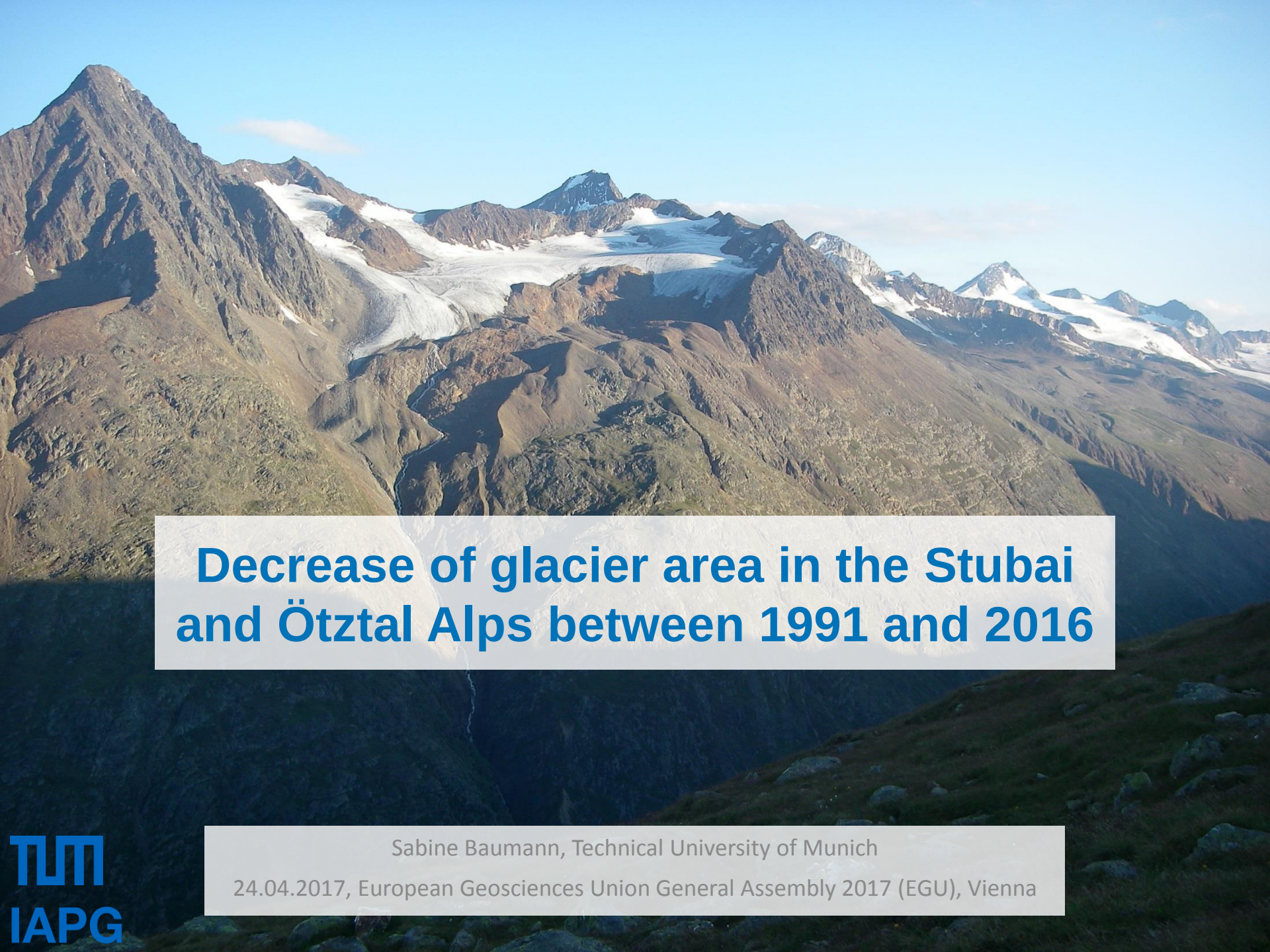


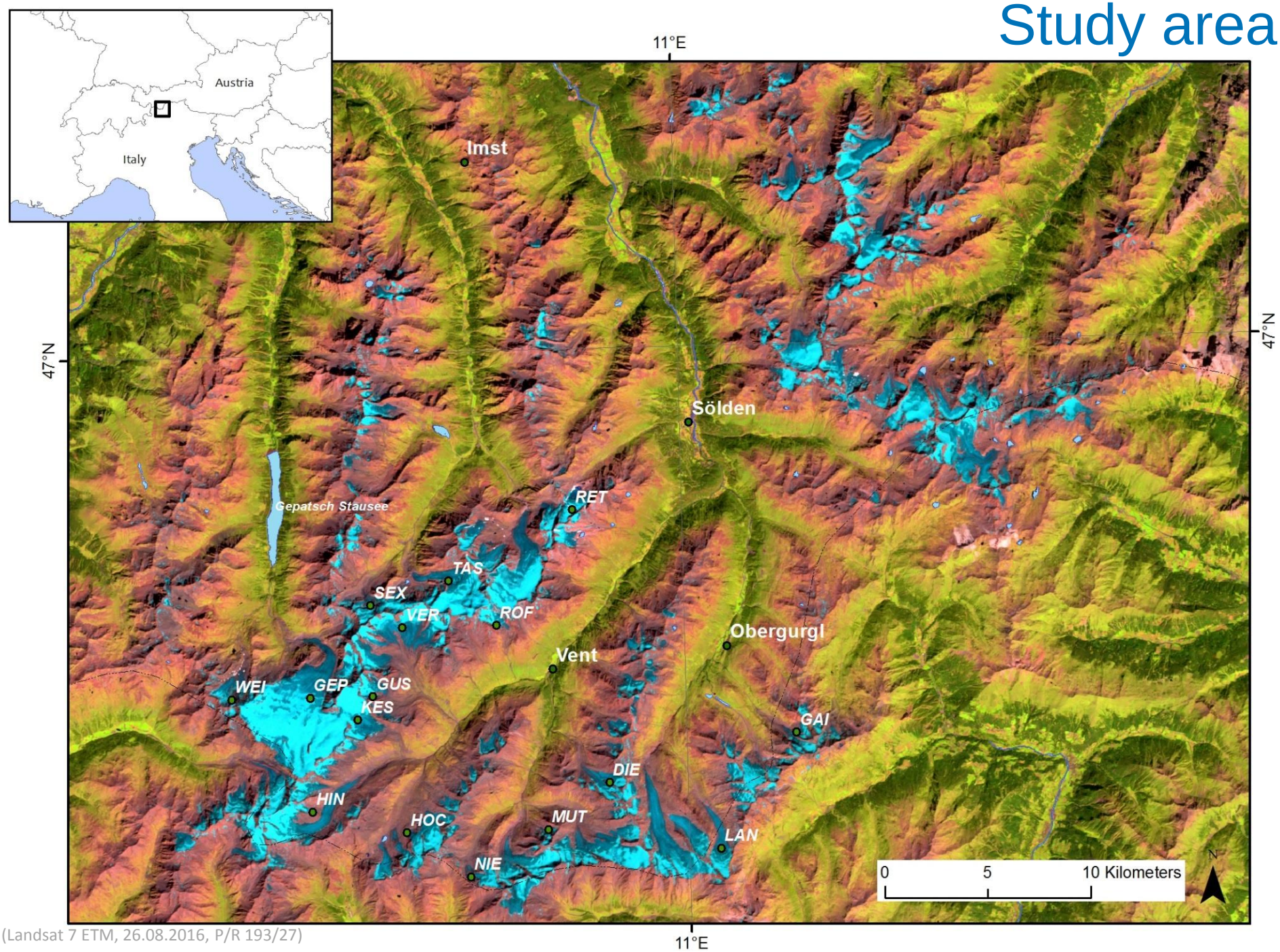
Decrease of glacier area in the Stubai and Ötztal Alps between 1991 and 2016

Sabine Baumann, Technical University of Munich

24.04.2017, European Geosciences Union General Assembly 2017 (EGU), Vienna

TUM IAPG

Study area



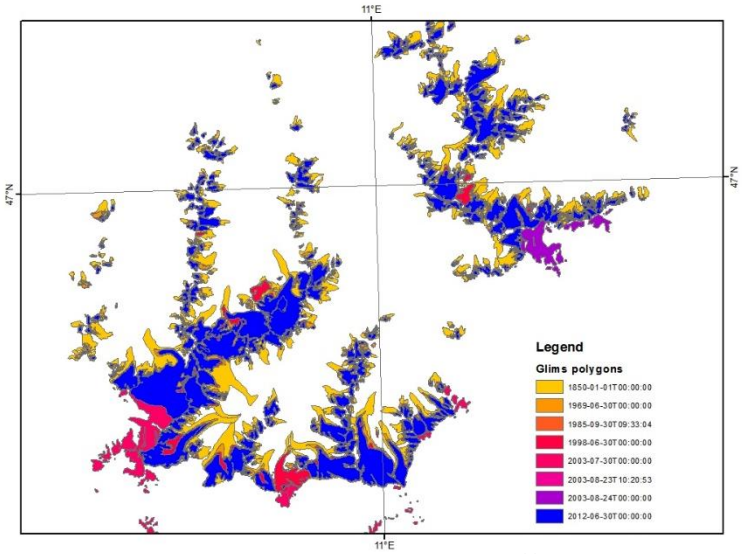
(Landsat 7 ETM, 26.08.2016, P/R 193/27)

Data base

6 Satellite images

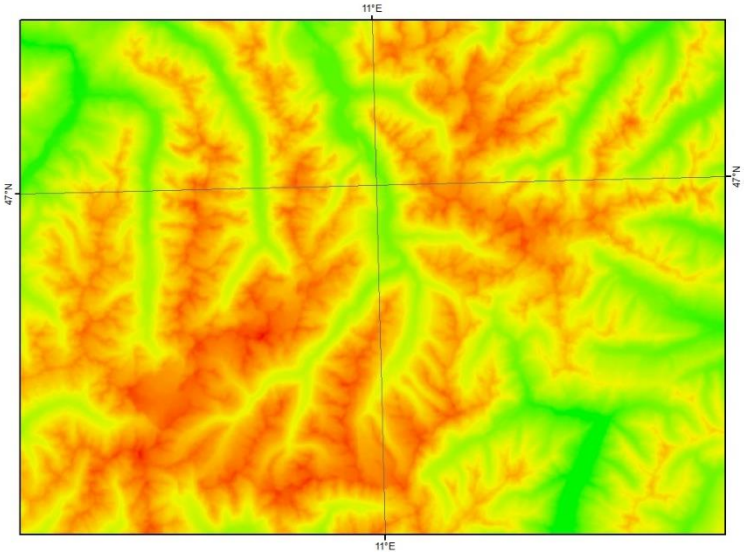
Parameter / Scene	Satellite	Date	Path/Row	Cloud cover [%]
LT51930271991242XXX01	LS 5 TM	30.08.1991	193/27	0.00
LT51930272004246KIS00	LS 5 TM	02.09.2004	193/27	0.00
LE71930272010238ASN00	LS 7 ETM	26.08.2010	193/27	1.00
LE71930272016239NSG00	LS 7 ETM	26.08.2016	193/27	0.00
LC81930272016247LGN00	LS 8 OLI/TIRS	03.09.2016	193/27	27.62
S2A_OPER_BWI_MSIL1C_PDMC_20160828T215543_R022_V20160827T101022_20160827T101025	Sentinel-2A	27.08.2016	about 193/27	0.79

GLIMS glacier data



(http://www.GLIMS.org)

EU-DEM



(European Environment Agency 2013)

4 time steps:

- 1991
- 2004
- 2010
- 2016

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Methods

- Glacier mapping: NDSI (threshold >= 0.5)

  →Manual mapping in cast shadow and deleting misclassified lakes

- Debris-cover: identification of locations with Matlab routine (Smith et al. 2015, supplement) using

  – glacier area, slope (threshold < 24°), low elevation ($H_{min,glacier}$ - threshold), NDWI (threshold >= 0.1)

  →Manual mapping of debris-covered part

- Merging all glacier areas of one year and clipping with GLIMS outline to get glacier ice-divides between connected ice bodies and GLIMS ID

- Deleting of all glaciers (unique ID) < 0.01 km² in first year of appearance

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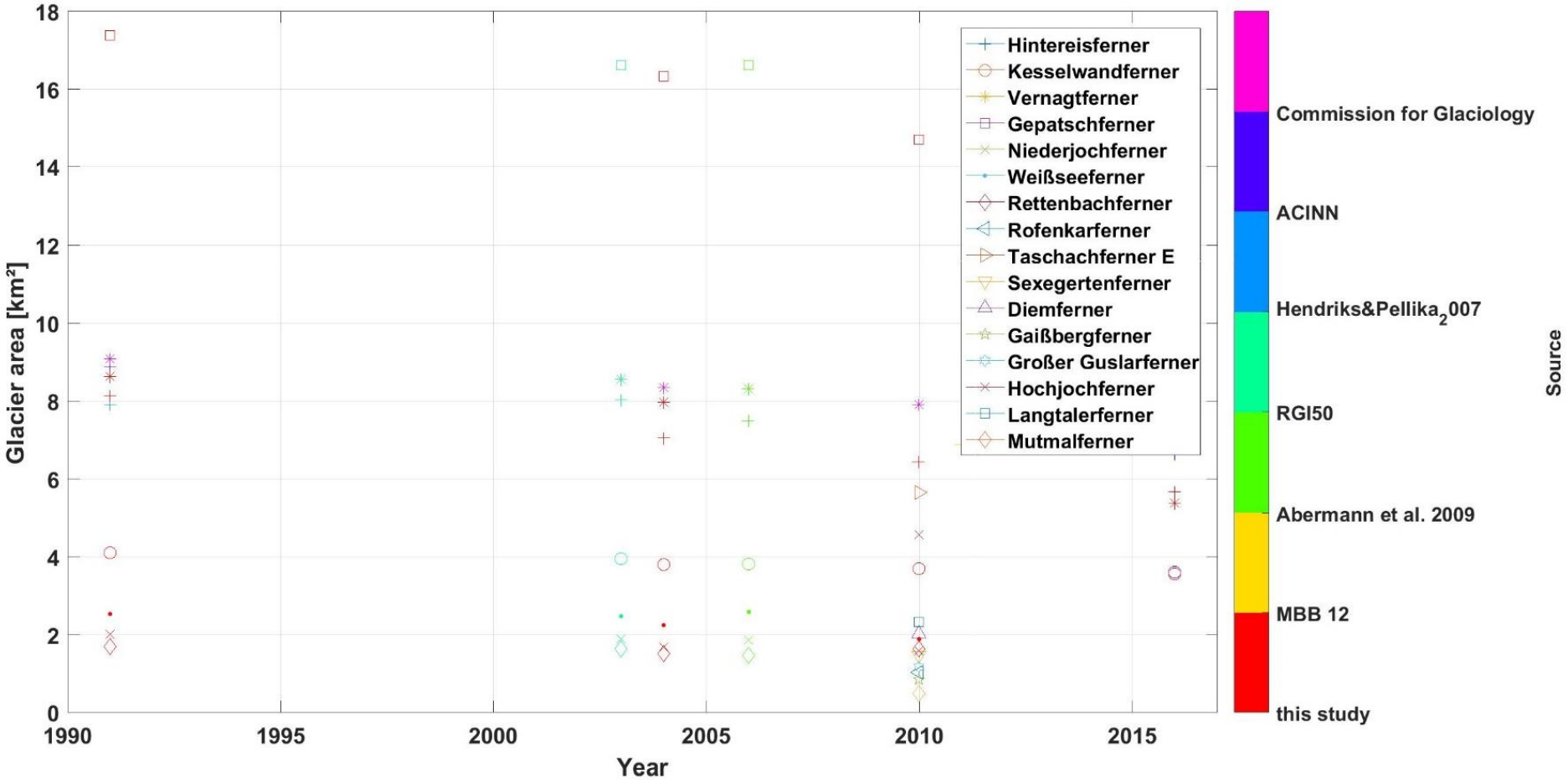
Validation



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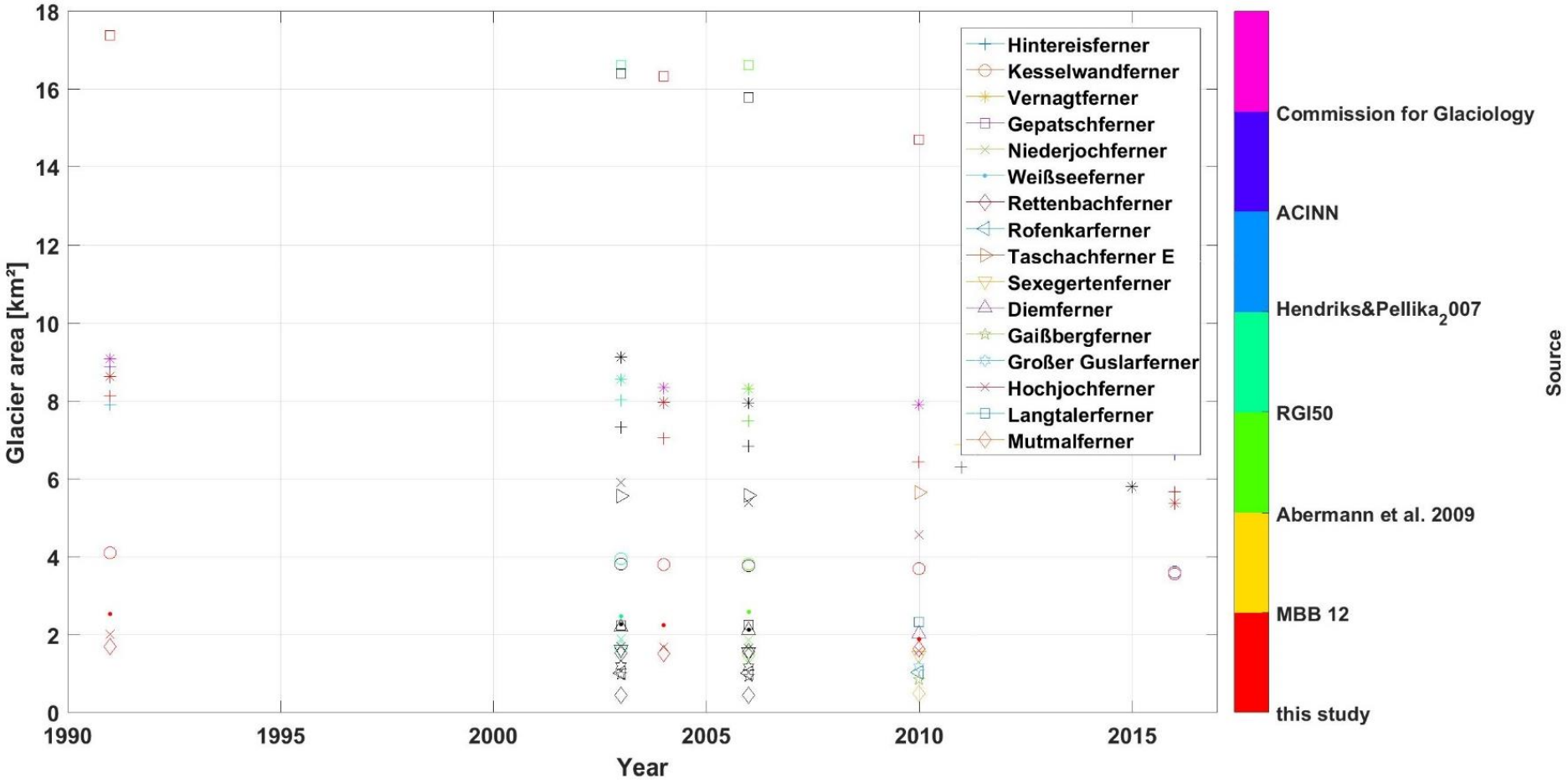
Validation



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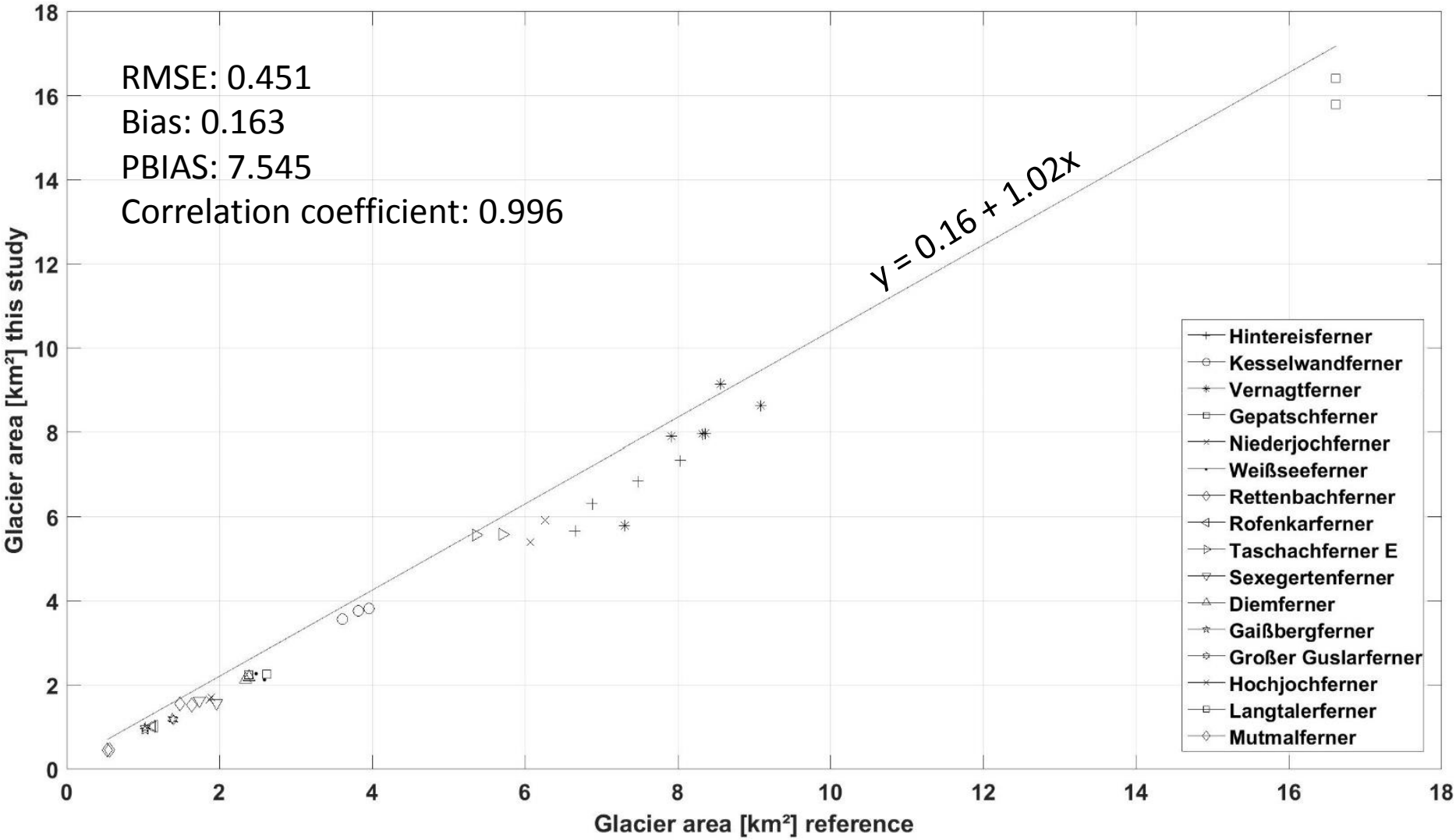
Validation



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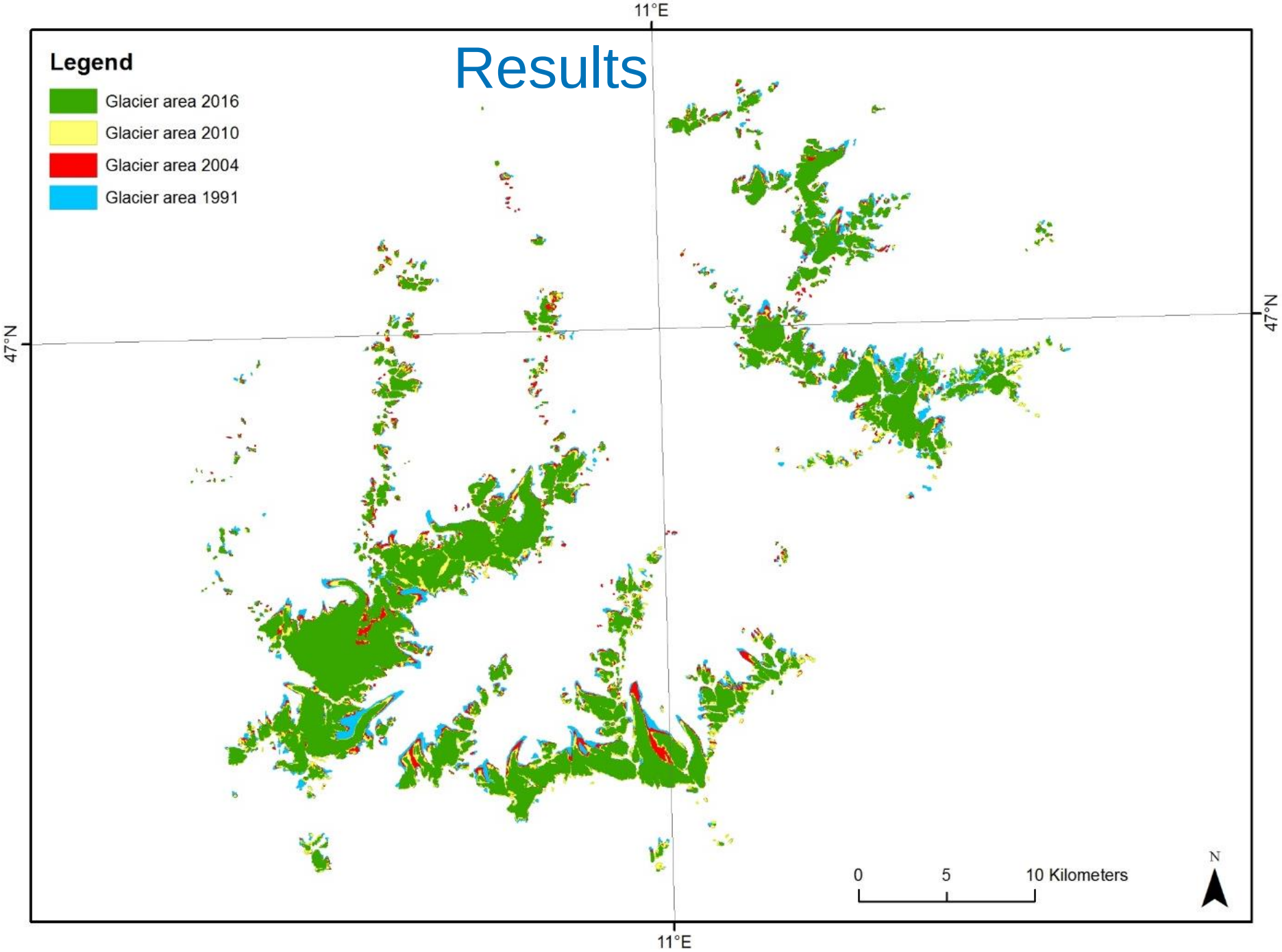
Results


Legend
Glacier area 2016
Glacier area 2010
Glacier area 2004
Glacier area 1991
11°E
47°N
47°N
11°E
0
5
10 Kilometers
N

Results

Year \ Parameter	# glacier entities	# single glaciers	Area [km²]	$Area_{max}$ [km²]	$Area_{mean}$ [km²]	H_{max} [m a.s.l.]	H_{mean} [m a.s.l.]	H_{min} [m a.s.l.]
1991	368	493	219	17.38	0.59	3701	3022	2081
2004	348	552	191	16.35	0.51	3706	3054	2136
2010	327	557	183	15.99	0.49	3706	3069	2197
2016	323	646	159	15.37	0.43	3703	3079	2298

Year \ Parameter	Area [km²]	Change [km²]				Change [%]				Areal change [km²] / year				Areal change [%] / year			
1991	219	-28	-36	-32	-60	-12.8	-16.4	-16.6	-27.4	-2.2	-1.9	-2.6	-2.4	-1.0	-0.9	-1.4	-1.1
2004	191	-8				-4.2				-1.2				-0.6			
2010	183	-24				-13.1				-4.1				-2.2			
2016	159																

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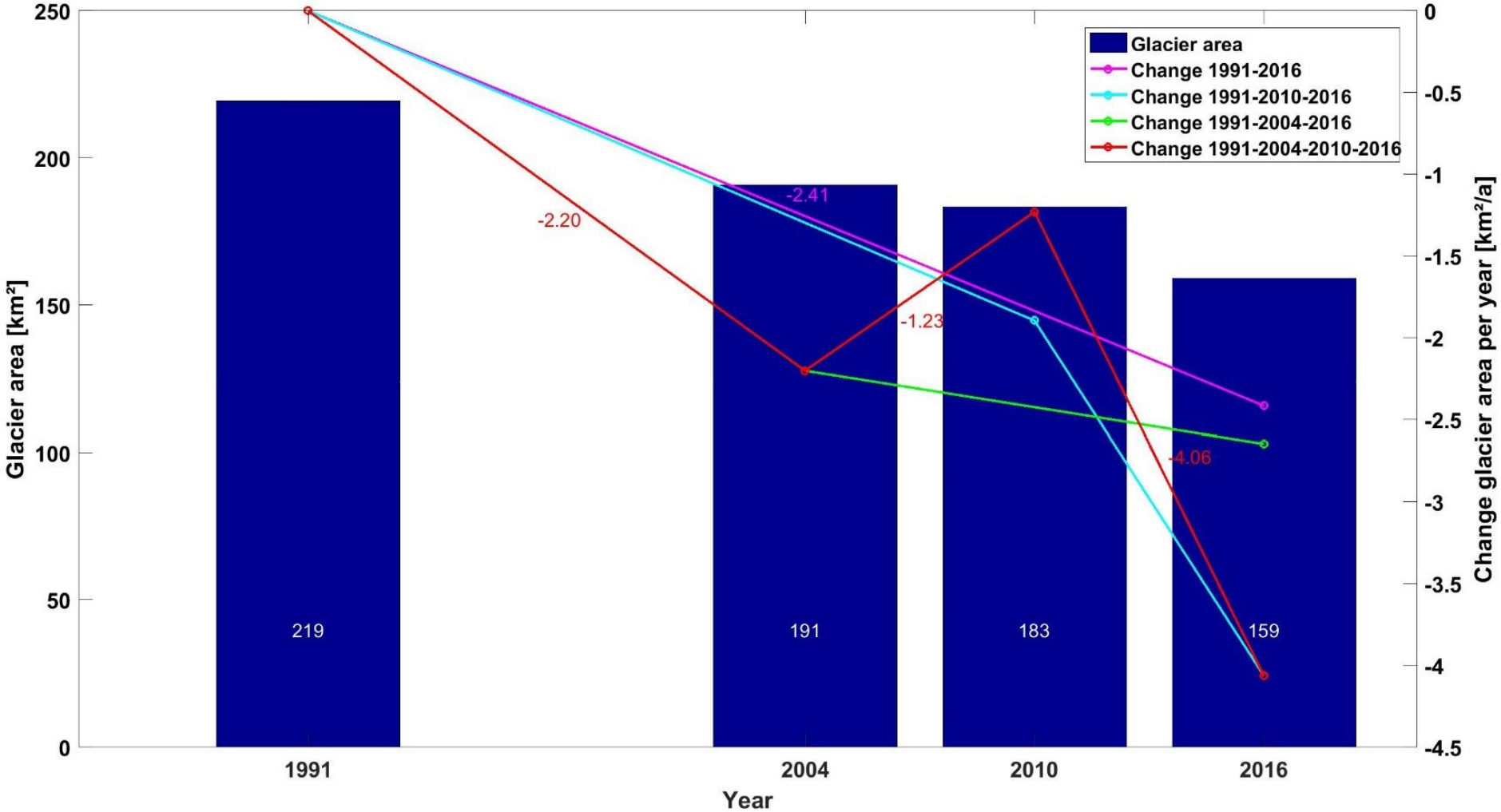
Glacier area



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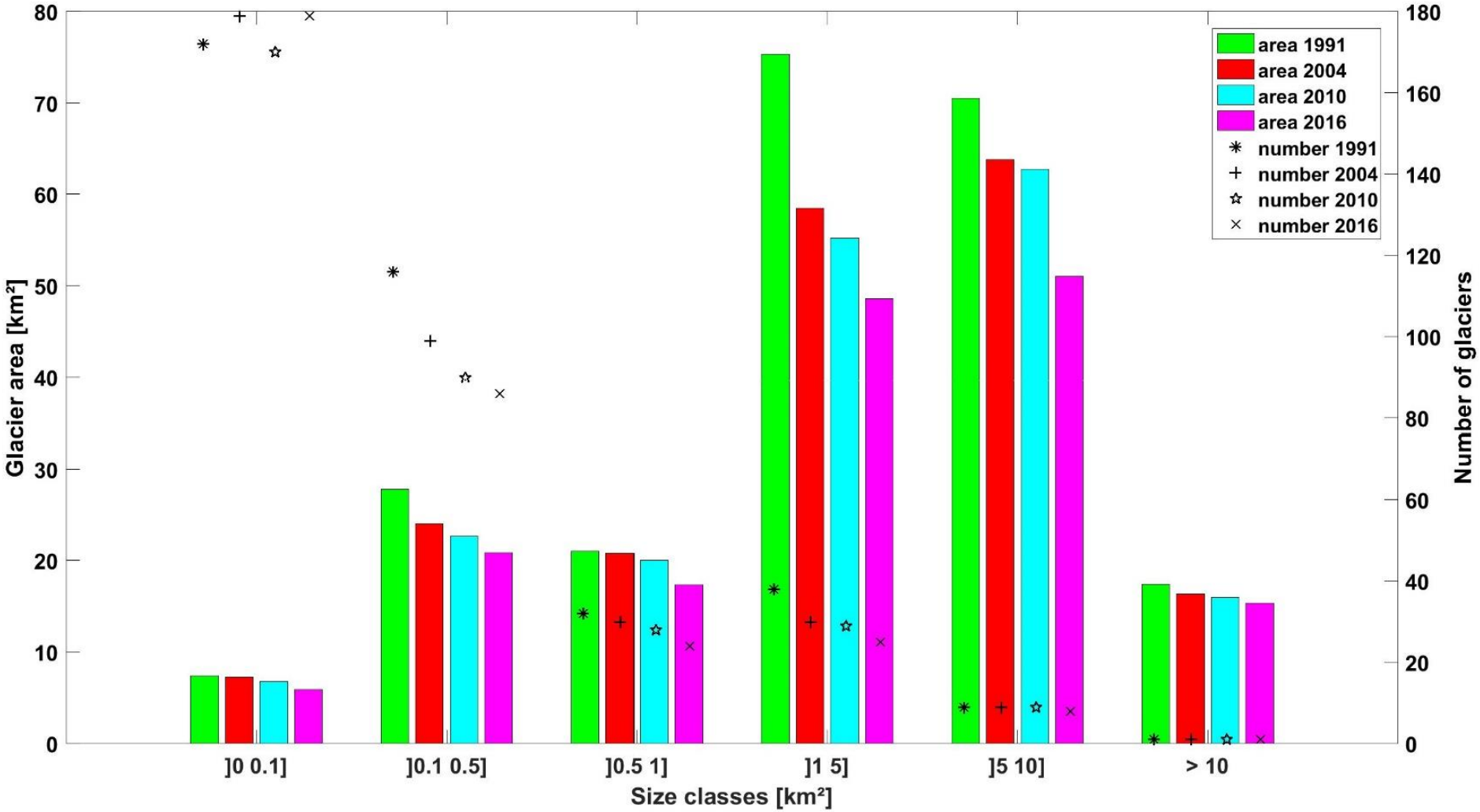
Glacier area by size classes



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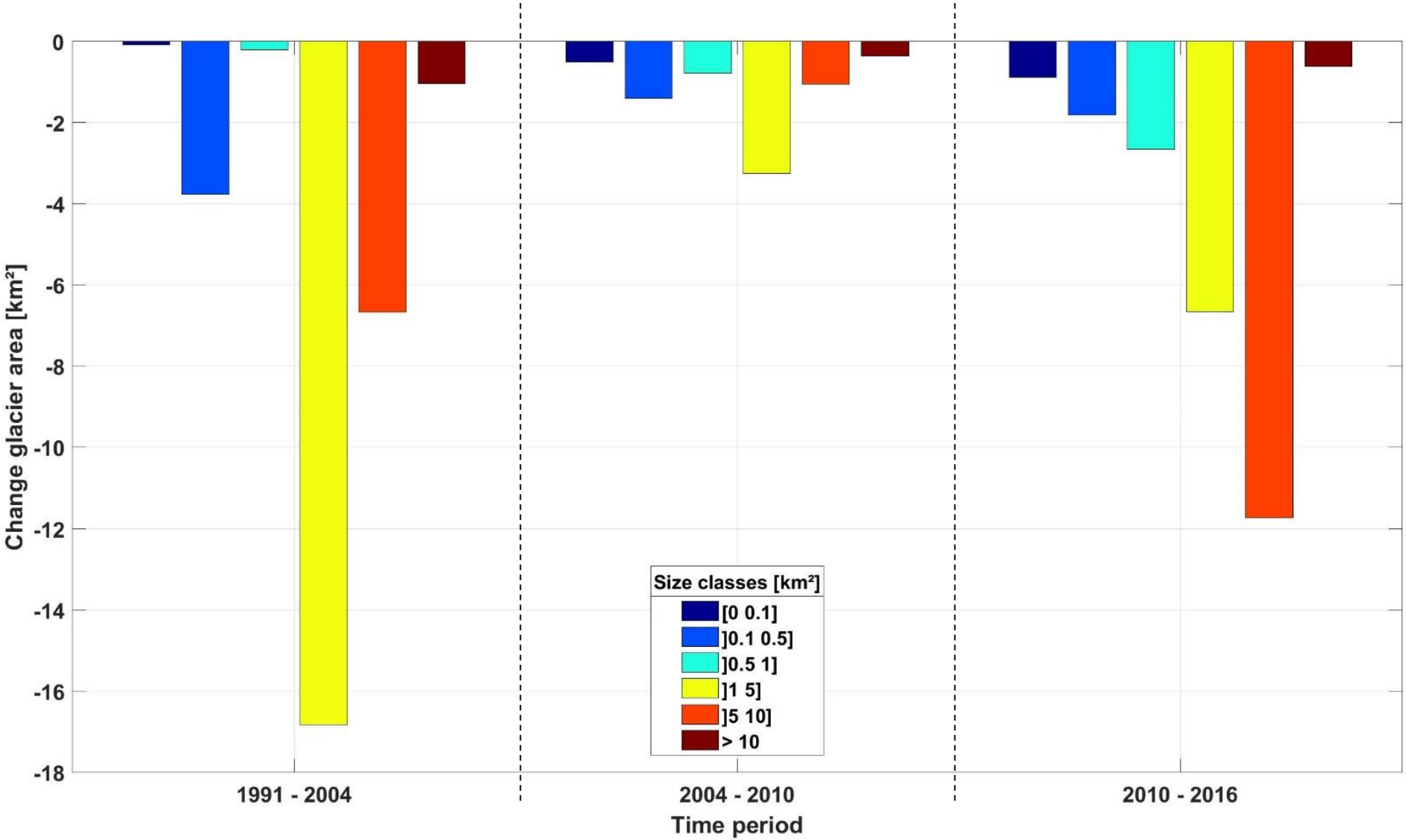
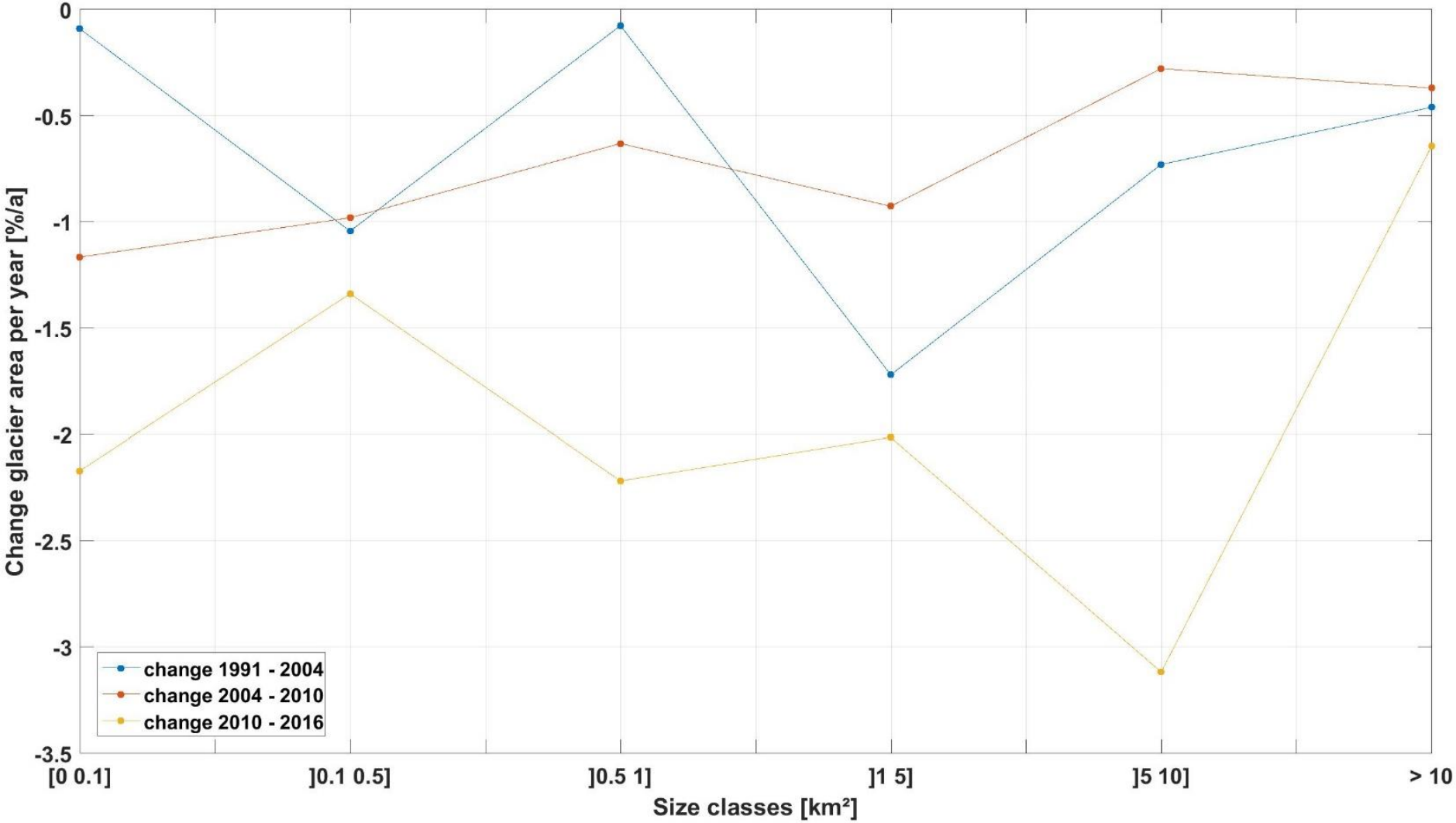
Absolute change



Change per year



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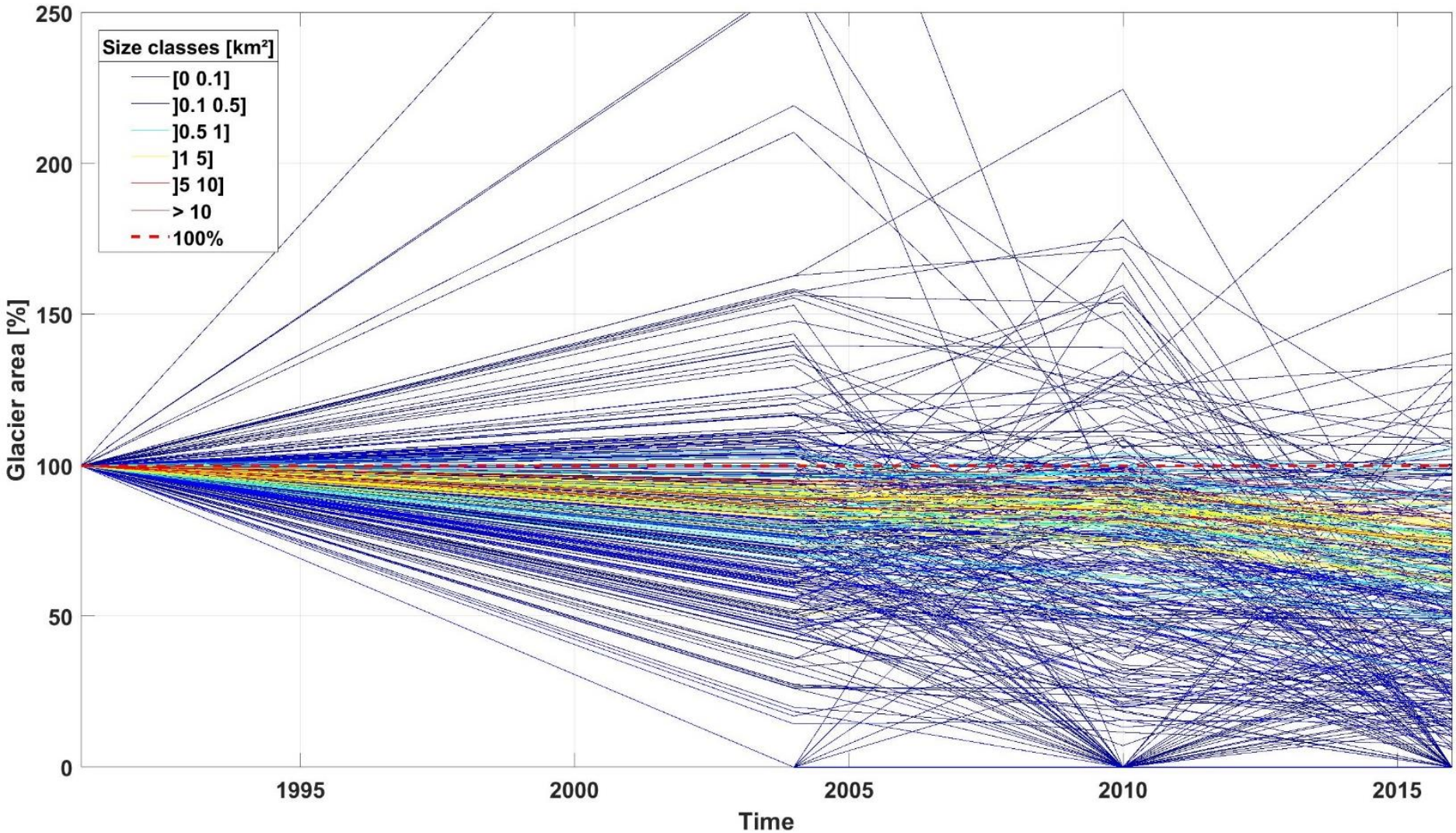
Glacier area of all glacier entities



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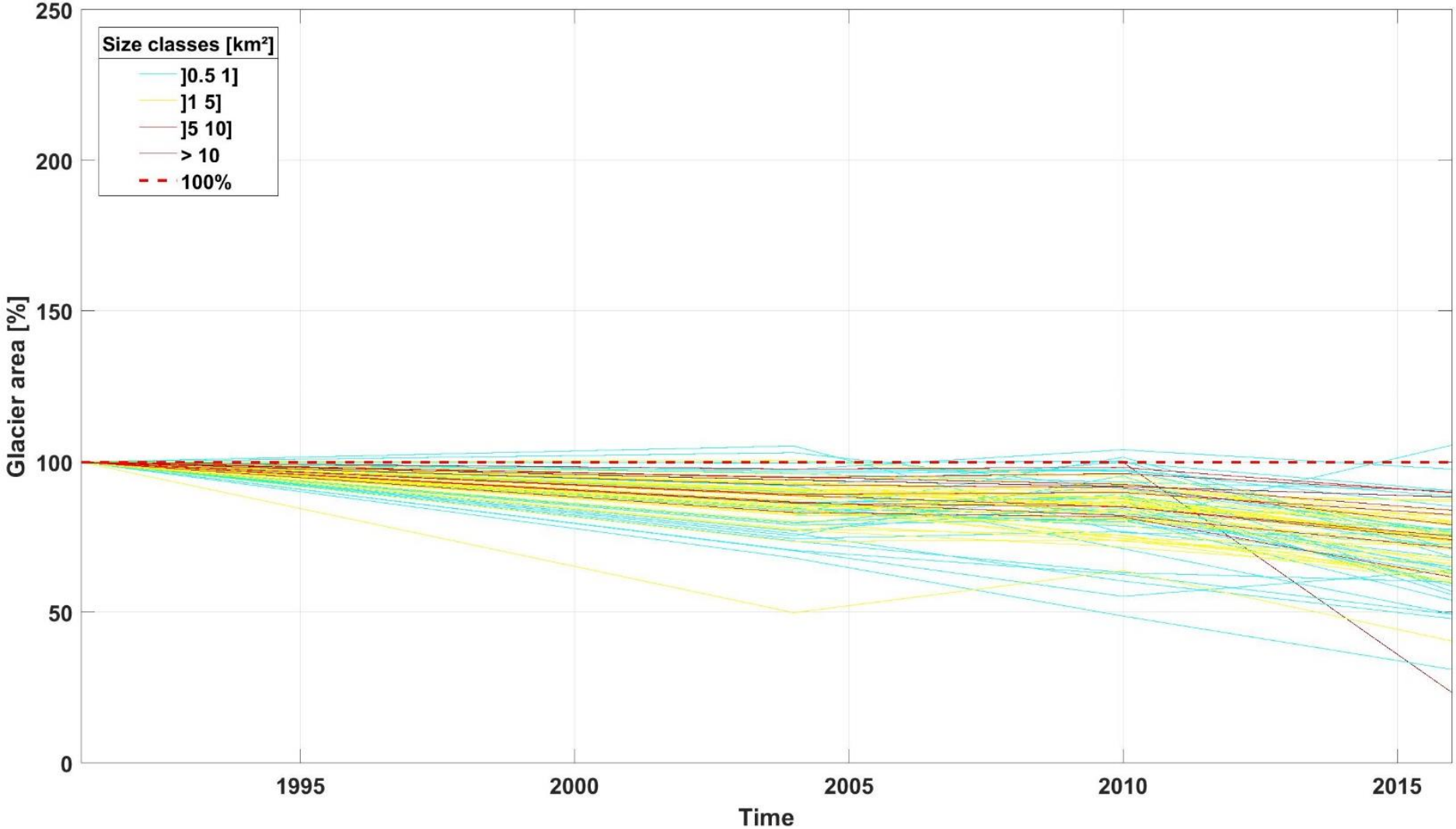
Glacier area of glacier entities > 0.5 km²



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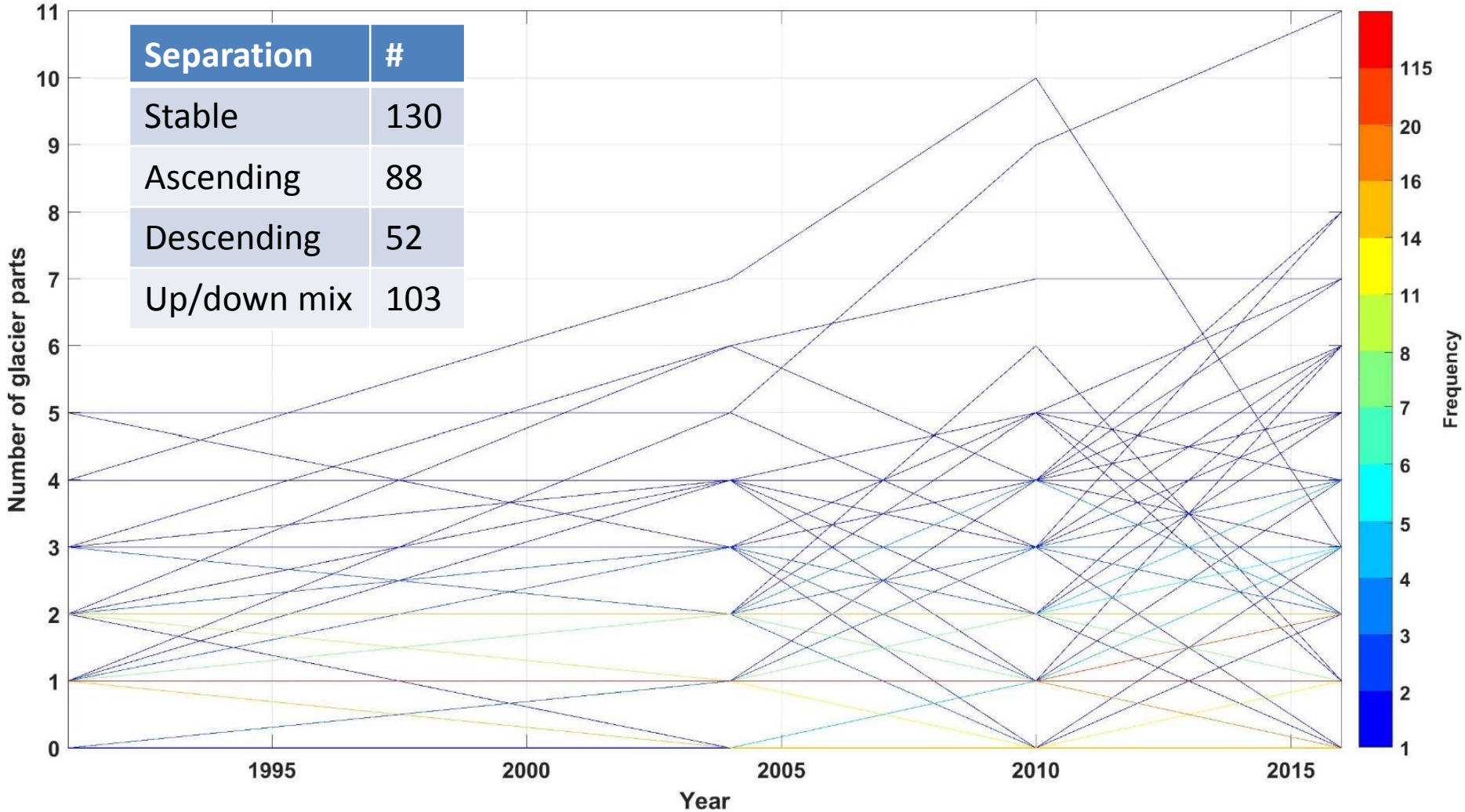
Separation of glaciers

Separation	#
Stable	130
Ascending	88
Descending	52
Up/down mix	103



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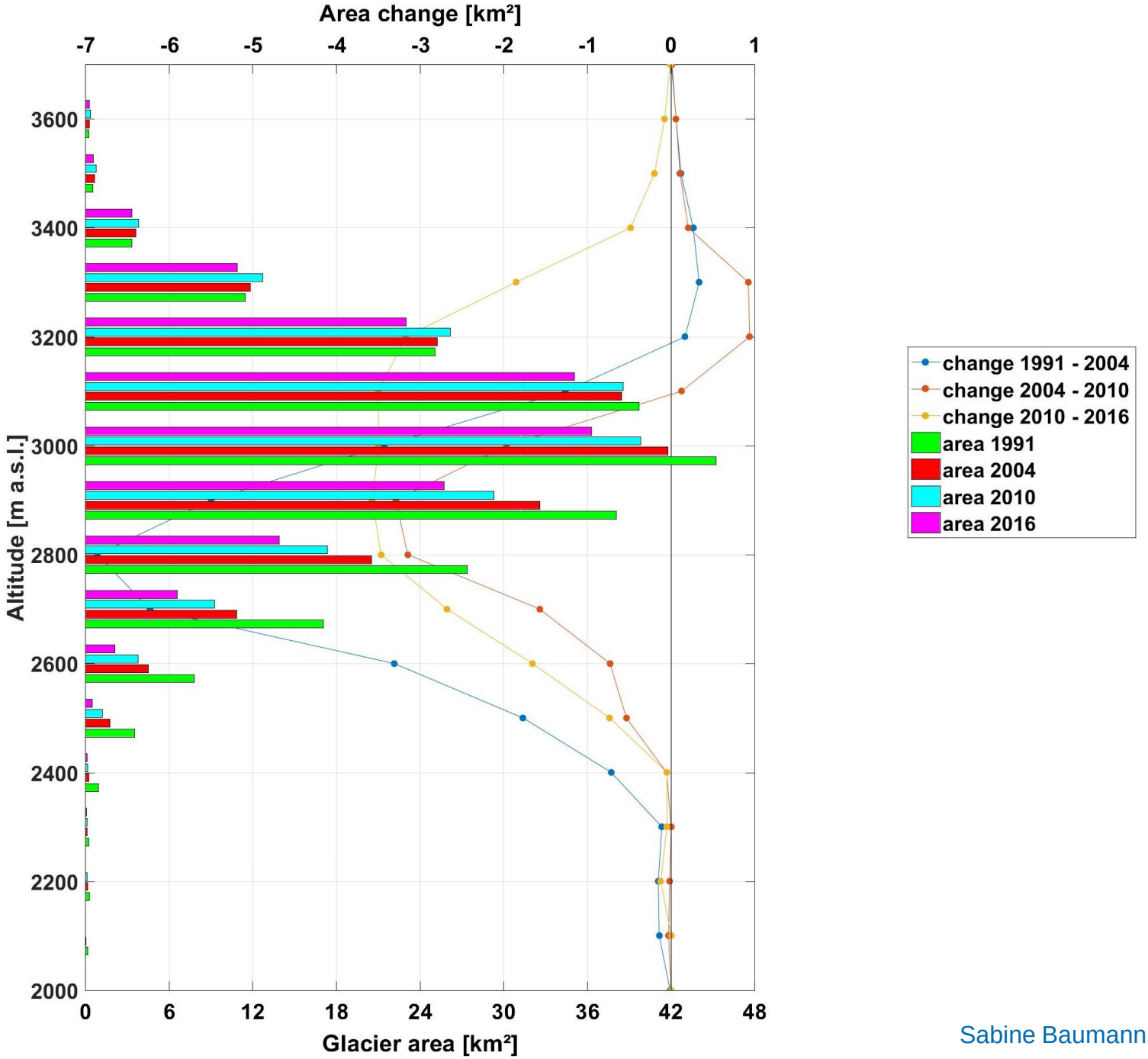
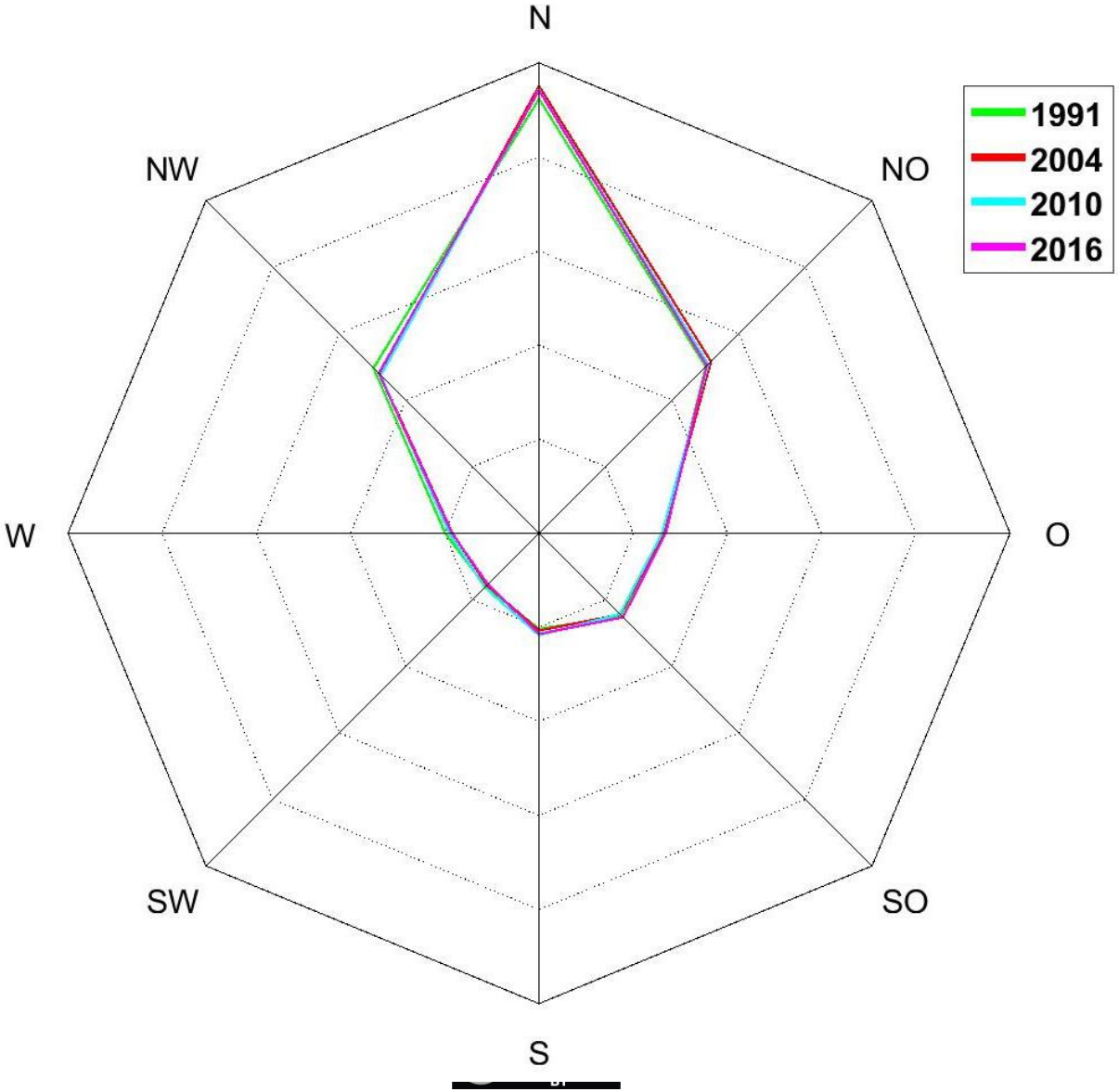
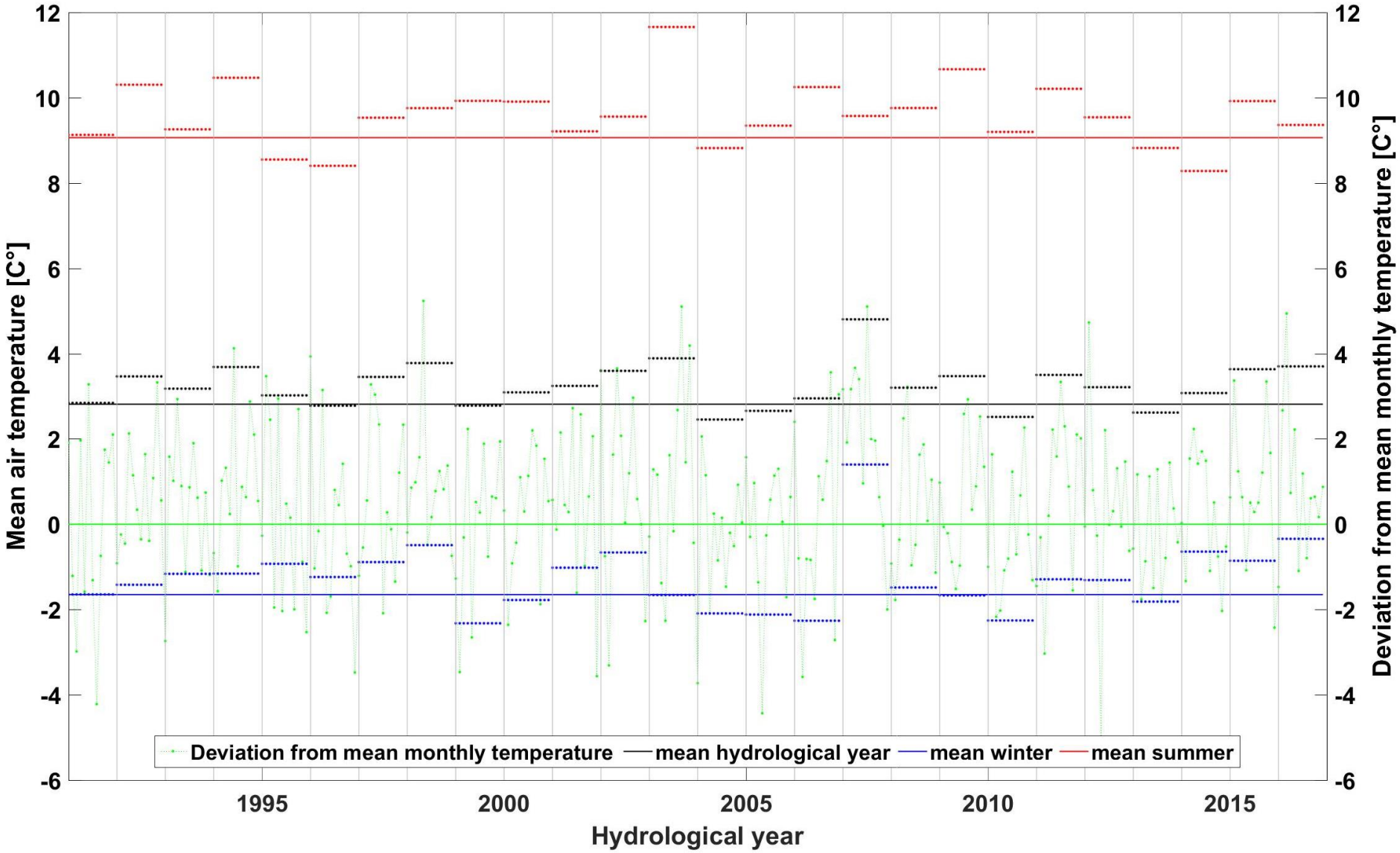

Area change [km²]
-7
-6
-5
-4
-3
-2
-1
0
1
Altitude [m a.s.l.]
3600
3400
3200
3000
2800
2600
2400
2200
2000
0
6
12
18
24
30
36
42
48
Glacier area [km²]
change 1991 - 2004
change 2004 - 2010
change 2010 - 2016
area 1991
area 2004
area 2010
area 2016

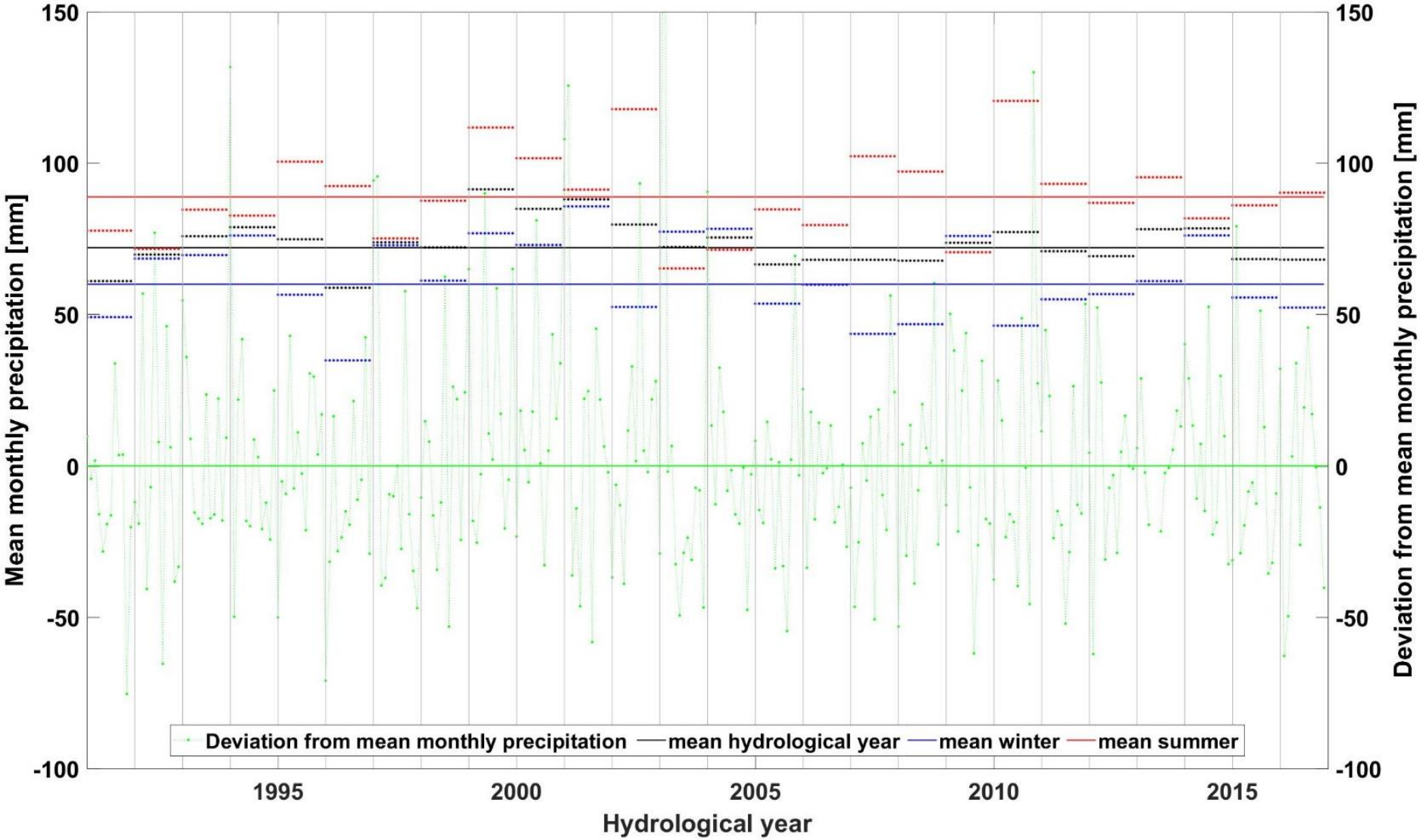
Aspect



Air temperature Obergurgl



Precipitation Obergurgl



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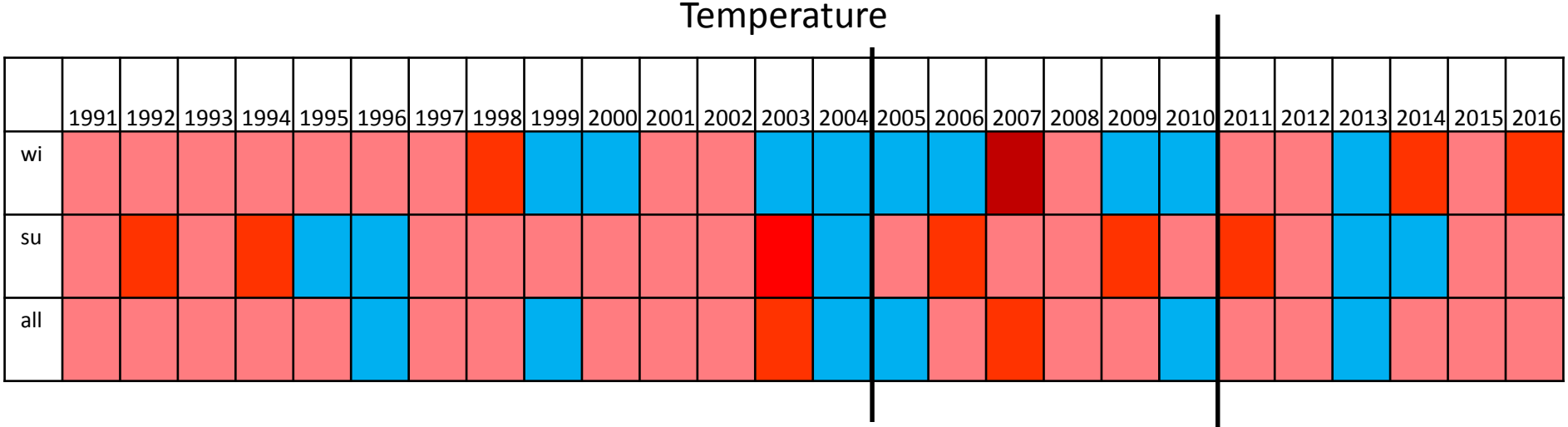
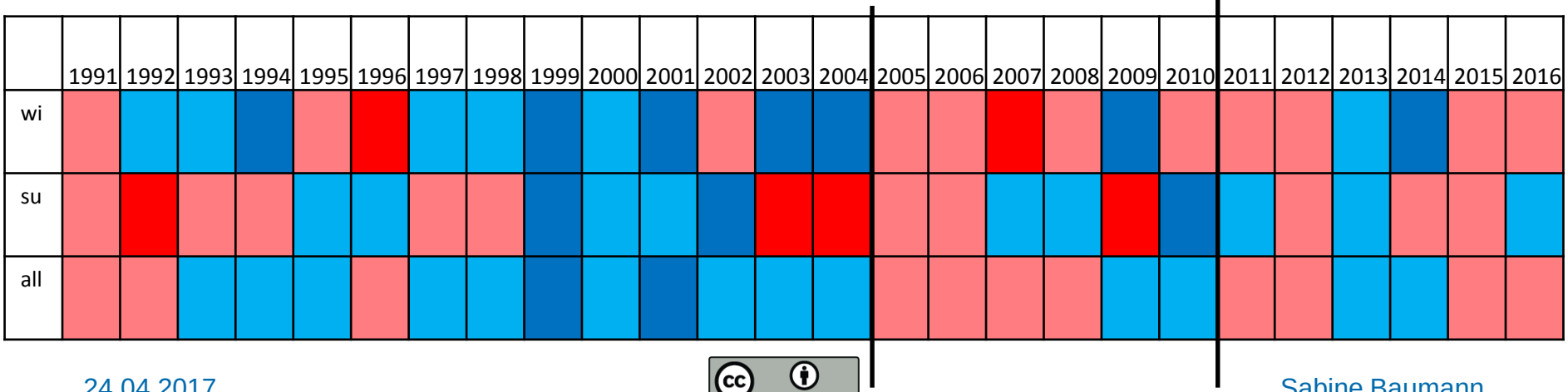
Climate data

Temperature



Precipitation



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Summary

- Constant underestimation of glacier area
- Glacier area reduction for all time steps
- Highest acceleration in 2010-2016
- Increasing separation of glacier area for all time steps
- Size classes
  - 1991-2004: highest loss in]1 5]
  - 2010-2016: highest loss in]5 10]
- Reduction of glacier area especially between 2500 and 3100 m a.s.l. for all years
- Aspect stable for all years
- Climate data:
  - 1991-2004: higher T + higher P
  - 2010-2016: higher T + lower P

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Thank you for your attention!

I want to thank the students of the Master course ‚Remote sensing‘ at the Munich University of Applied Sciences for their basic work in glacier mapping and Prof. Kammerer for giving me the opportunity to work with them.