**Rapid and synchronous response of outlet glaciers to ocean warming on the Barents Sea coast, Novaya Zemlya.**

**Authors: \***Rachel Carr, Zoe Murphy, Peter Nienow, Livia Jakob and Noel Gourmelen

\*Contact author: Rachel.carr@newcastle.ac.uk

**Journal of Glaciology**

**Supplementary Information**

**Table S1**. List of glacier IDs, terminus types, parent ice mass, coast, full names and Randolph Glacier Inventory (RGI) IDs. Glacier locations are given in Figure 1. Glacier ID’s were determined from the names in the World Glacier Inventory, where available. Where glaciers have multiple termini, they are numbered sequentially, with 1 as the main terminus and 2 as the secondary terminus, as determined from ice flow. Unnamed land-terminating outlet glaciers were given the ID ‘NZL’, for the main ice mass, LED for Sub1 and YUZ for Sub2 plus a sequential number.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Glacier ID** | **Full name** | **Terminus type** | **Ice mass** | **Coast** | **Randolph Glacier Inventory ID** |
| ARK | Arkhangelskolgu | Land | Northern ice cap | Barents | RGI30-09.00060 |
| BRO | Brounova | Marine | Northern ice cap | Barents | RGI30-09.00141 |
| CHA | Chaveva | Marine | Northern ice cap | Barents | RGI30-09.00935 |
| CHE | Chernysheva | Marine | Northern ice cap | Barents | RGI30-09.00136 |
| GLA | Glazov | Marine | Northern ice cap | Barents | RGI30-09.00132 |
| INO | Inostrantseva | Marine | Northern ice cap | Barents | RGI30-09.00070 |
| KRA1 | Kraynij 1 | Marine | Northern ice cap | Barents | RGI30-09.00134 |
| KRA2 | Kraynij 2 | Marine | Northern ice cap | Barents | RGI30-09.00134 |
| KRI | Krivosheina | Marine | Northern ice cap | Barents | RGI30-09.00088 and RGI30-09.00060 |
| KRO | Kropotkina | Marine | Northern ice cap | Kara | RGI30-09.00114 |
| LED1 | N/A | Lake | Sub1 | N/A | RGI30-09.00079 |
| LED2 | N/A | Lake | Sub1 | N/A | RGI30-09.00099 |
| LED3 | N/A | Lake | Sub1 | N/A | RGI30-09.00127 |
| LED5 | N/A | Land | Sub1 | N/A | RGI30-09.00096 |
| MAK | Maka | Marine | Northern ice cap | Barents | RGI30-09.00080 |
| MG | Moshnyj | Marine | Northern ice cap | Kara | RGI30-09.00065 |
| NAL | Nalli | Land | Northern ice cap | Kara | RGI30-09.00073 |
| NII | Niiga | Land | Northern ice cap | Kara | RGI30-09.00115 |
| NIZ | Nizkiy | Marine | Northern ice cap | Barents | RGI30-09.00051 |
| NOR | Nordenskjold | Marine | Northern ice cap | Barents | RGI30-09.00077 |
| NZL1 | N/A | Land | Northern ice cap | Kara | RGI30-09.00113 |
| NZL2 | N/A | Land | Northern ice cap | Kara | RGI30-09.00114 |
| NZL3 | N/A | Land | Northern ice cap | Kara | RGI30-09.00112 |
| NZL4 | N/A | Land | Northern ice cap | Barents | RGI30-09.00932 |
| NZL5 | N/A | Land | Northern ice cap | Barents | RGI30-09.00138 |
| NZL6 | N/A | Land | Northern ice cap | Barents | RGI30-09.00138 |
| NZL7 | N/A | Land | Northern ice cap | Barents | RGI30-09.00144 |
| NZL8 | N/A | Lake | Northern ice cap | Barents | RGI30-09.00083 |
| NZL9 | N/A | Lake | Northern ice cap | Barents | RGI30-09.00086 |
| OGA1 | Oga 1 | Marine | Northern ice cap | Kara | RGI30-09.00120 |
| OGA2 | Oga 2 | Land | Northern ice cap | Kara | RGI30-09.00071 |
| POL | Polisadova | Marine | Northern ice cap | Kara | RGI30-09.00118 |
| ROZE | Roze | Marine | Northern ice cap | Kara | RGI30-09.00111 |
| ROZH | Rozhdestvenskogo | Marine | Northern ice cap | Kara | RGI30-09.00094 |
| RYK | Rykachova | Marine | Northern ice cap | Barents | RGI30-09.00139 |
| SH | Shokalskogo | Marine | Northern ice cap | Barents | RGI30-09.00081 and RGI30-09.00059 |
| SHU1 | Shury 1 | Marine | Northern ice cap | Kara | RGI30-09.00116 |
| SHU2 | Shury 2 | Marine | Northern ice cap | Kara | RGI30-09.00116 |
| SRE | Srednij | Marine | Northern ice cap | Kara | RGI30-09.00055 |
| TAI1 | Taisija 1 | Marine | Northern ice cap | Barents | RGI30-09.00927 |
| TAI2 | Taisija 2 | Marine | Northern ice cap | Barents | RGI30-09.00927 |
| VEL | Vel’Kena | Marine | Northern ice cap | Barents | RGI30-09.00066 |
| VER | Vershinskogo | Marine | Northern ice cap | Kara | RGI30-09.00087 |
| VIJ | Vil’kitskogo Juz | Marine | Northern ice cap | Barents | RGI30-09.00069 |
| VIS | Vil’kitskogo Sev | Marine | Northern ice cap | Barents | RGI30-09.00057 |
| VIZ | Vize | Marine | Northern ice cap | Barents | RGI30-09.00064 |
| VOE | Voejkova | Marine | Northern ice cap | Barents | RGI30-09.00090 |
| VYL1 | Vylki 1 | Marine | Northern ice cap | Kara | RGI30-09.00116 |
| VYL2 | Vylki 2 | Marine | Northern ice cap | Kara | RGI30-09.00116 |
| YUZ1 | N/A | Land | Sub2 | N/A | RGI30-09.00369 |
| YUZ2 | N/A | Land | Sub2 | N/A | RGI30-09.00352 |
| YUZ3 | N/A | Lake | Sub2 | N/A | RGI30-09.00368 |
| YUZ4 | N/A | Land | Sub2 | N/A | RGI30-09.00362 |

**Table S2**. Start and end dates of seasonal retreat for the six selected study glaciers on the Barents Sea coast, for the period 2016-2020. Full glacier names and RGI IDs are given in Table S1. ND indicates that the transition between retreat / advance was not captured, due to missing data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Glacier ID** | **2016** | **2017** | **2018** | **2019** | **2020** |
|  | **Start** | **End** | **Start** | **End** | **Start** | **End** | **Start** | **End** | **Start** | **End** |
| CHA | 08/07 | 12/12 | 22/06 | 25/11 | 05/06 | 04/10 | 24/06 | 03/11 | 19/04 | 03/12 |
| KRI | 14/07 | 27/12 | 24/08 | 22/12 | 19/06 | ND | 03/07 | ND | 07/07 | 06/12 |
| NOR | 06/07 | 08/01 | 25/06 | 02/10 | 07/07 | ND | 15/07 | ND | 13/07 | 24/11 |
| SH | 13/07 | 18/11 | 28/07 | 13/11 | 03/07 | 20/11 | 25/04 | 07/10 | 30/06 | 28/10 |
| VIJ | 18/07 | 03/12 | 13/06 | 28/11 | 08/07 | ND | 15/07 | 24/12 | 21/06 | 12/11 |
| VIS | 08/07 | 09/11 | 19/07 | 22/12 | 08/07 | ND | 10/07 | ND | 21/06 | 06/12 |

**Table S3**. Start and end dates of seasonal retreat for the six selected study glacierson the Kara Sea coast, for the period 2016-2020. Full glacier names and RGI IDs are given in Table S1. ND indicates that the transition between retreat / advance was not captured, due to missing data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Glacier ID** | **2016** | **2017** | **2018** | **2019** | **2020** |
|  | **Start** | **End** | **Start** | **End** | **Start** | **End** | **Start** | **End** | **Start** | **End** |
| KRO | 22/05 | 18/11 | 04/07 | 13/11 | 16/06 | 15/10 | 07/05 | 10/10 | 06/06 | 16/10 |
| POL | 01/07 | 25/10 | 13/07 | 20/10 | 18/06 | 27/10 | 03/08 | 02/01 | 05/07 | 22/09 |
| ROZE | 01/07 | 25/10 | 04/07 | 14/09 | ND | 27/10 | 22/07 | 22/10 | 01/06 | 16/10 |
| SHU1 | 28/07 | 03/12 | 29/06 | 01/11 | 18/06 | 08/11 | 10/07 | 03/11 | 01/06 | 21/11 |
| VER | 05/06 | 25/10 | 10/07 | 01/11 | 09/07 | 03/10 | 03/07 | 22/10 | 05/07 | 09/11 |
| VYL2 | 01/07 | 03/12 | 08/07 | 20/10 | 18/06 | 15/10 | 15/07 | 03/11 | 05/07 | 09/11 |



**Figure S1**. Relative frontal position change of the study glaciers between 1973/76 and 2020, grouped according to terminus type: A) Marine-terminating outlets on the Barents Sea coast; B) Marine-terminating outlets on the Kara Sea coast C) Land-terminating outlets on the Barents Sea coast; D) Lake-terminating outlets on the Barents Sea coast. Frontal positions are relative to 1986, which is the earliest date common to all glaciers. Frontal positions are colour-coded according to glacier name and given in alphabetical order. Glacier locations are shown in Figure 1.