Seasonal forecasting of water resources at Landsvirkjun

ARCTIC REGIONAL CLIMATE CENTRE (ArcRCC) NETWORK
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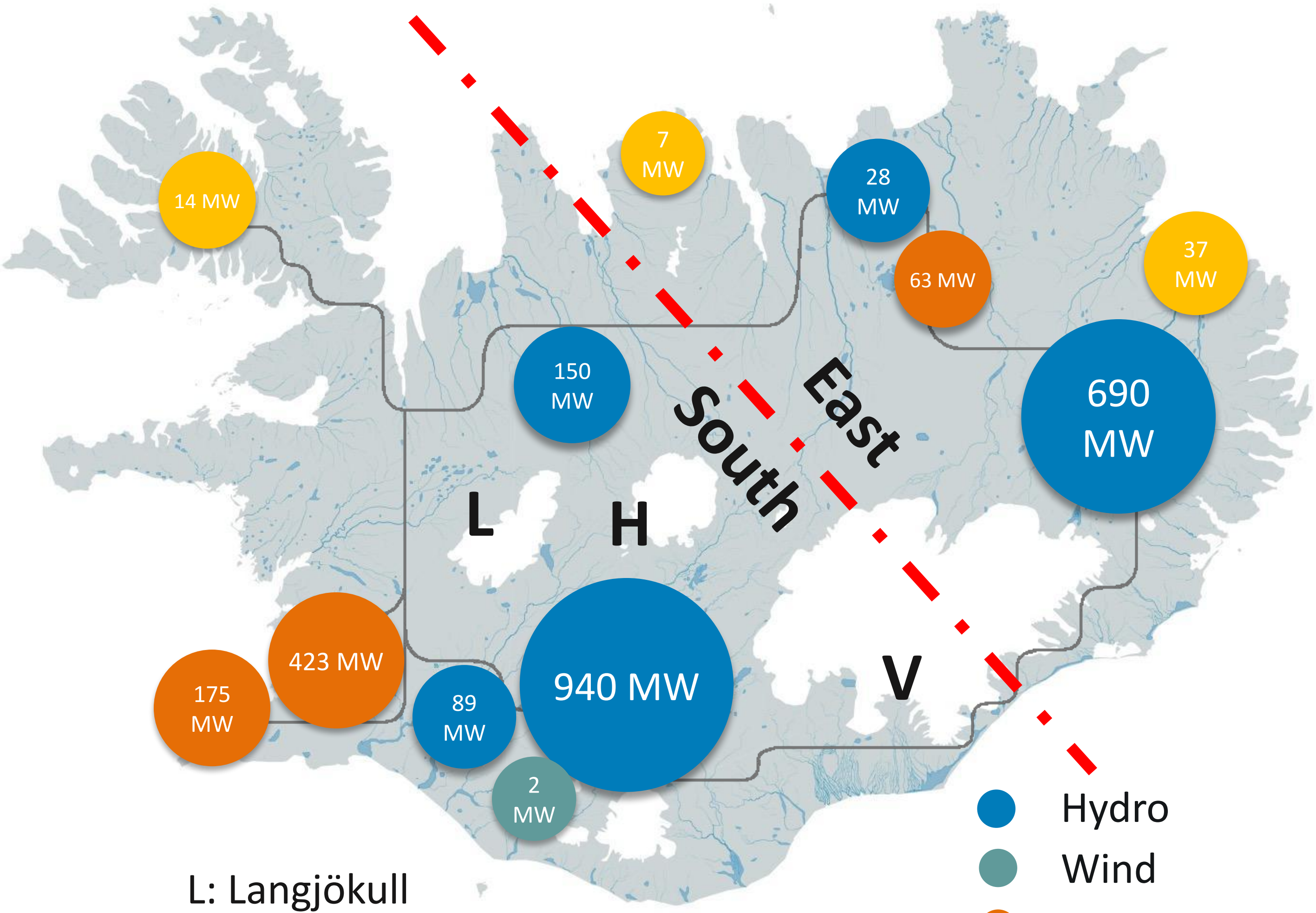
Landsvirkjun / R&D

Landsvirkjun

Energy system in Iceland…
…from the perspective of resource forecasting

- **100% renewable sources**
- **+80% power intensive load**
- **No interconnections**
- **Annual natural variability high**
- **Climate is changing**
  - More glacier melt observed since 1995
  - Provide opportunities for increased production
  - Less seasonal snow
  - Dynamical changes in timing of water



L: Langjökull
H: Hofsjökull
V: Vatnajökull

Installed Power 2650 MW
Source Orkustofnun, National Energy Authority

Hydrology of the hydropower system in Iceland

- **Glacier melt** is on average 50-60% of inflow energy (33% of total production)
- **Seasonal snow** is about 5-15% of inflow energy
- Knowledge and understanding of winter snow extent and magnitude is important both on land and glaciers
- **Groundwater / baseflow** important in southern highlands
  - Provides inflows during winter

- **Relevant timescales of forecasting**
  - Short term (1-12 days) → Operational control
  - Outlook (1-6 months) → Maintenance / short term energy contracts
  - Long term (> 3-5 years) → Medium/long term energy contracts
  - Future flows, climate change (> 10-50 y) → Investments/refurbishment

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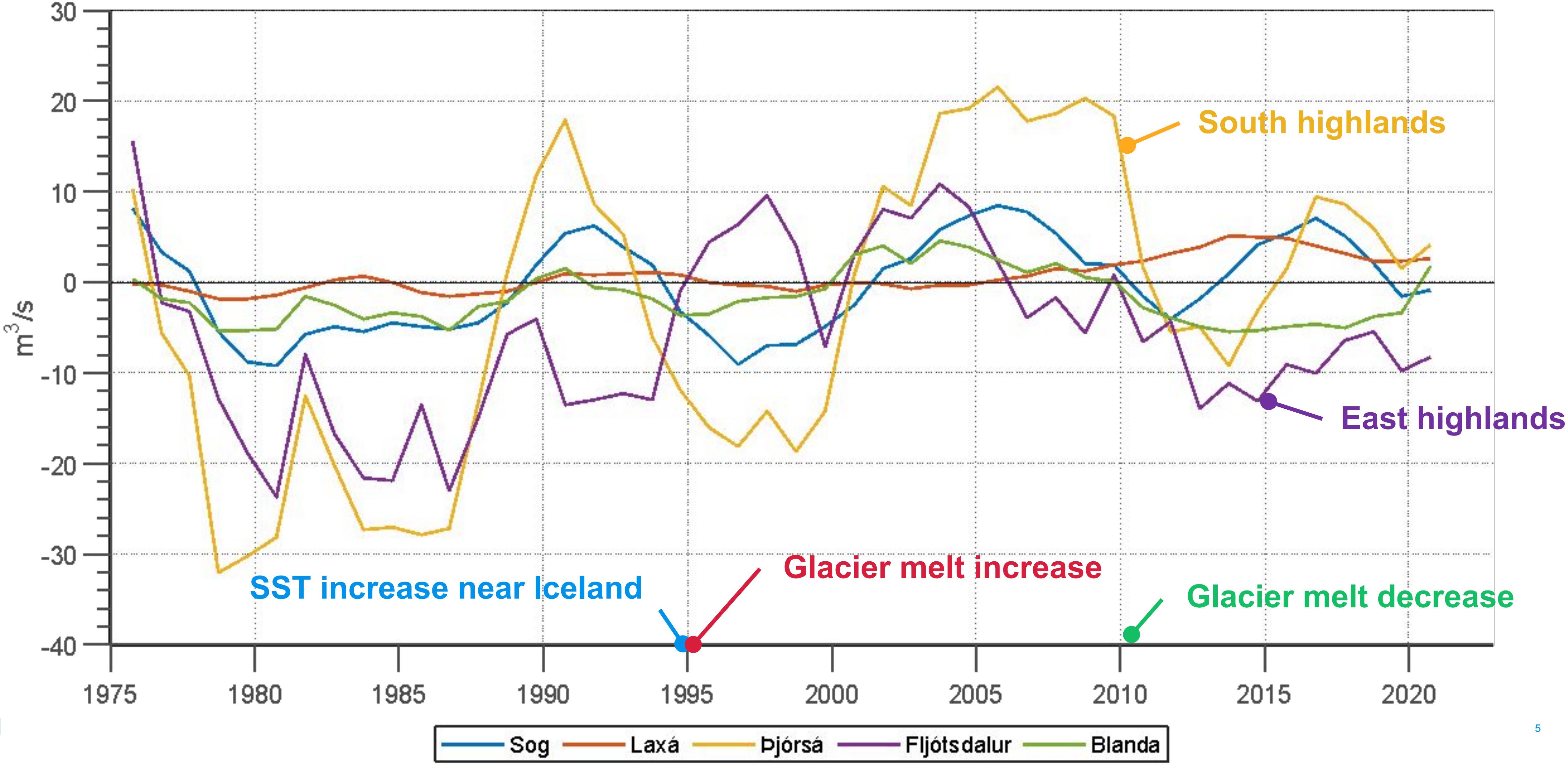
Discharge anomalies at operational areas Landsvirkjunar

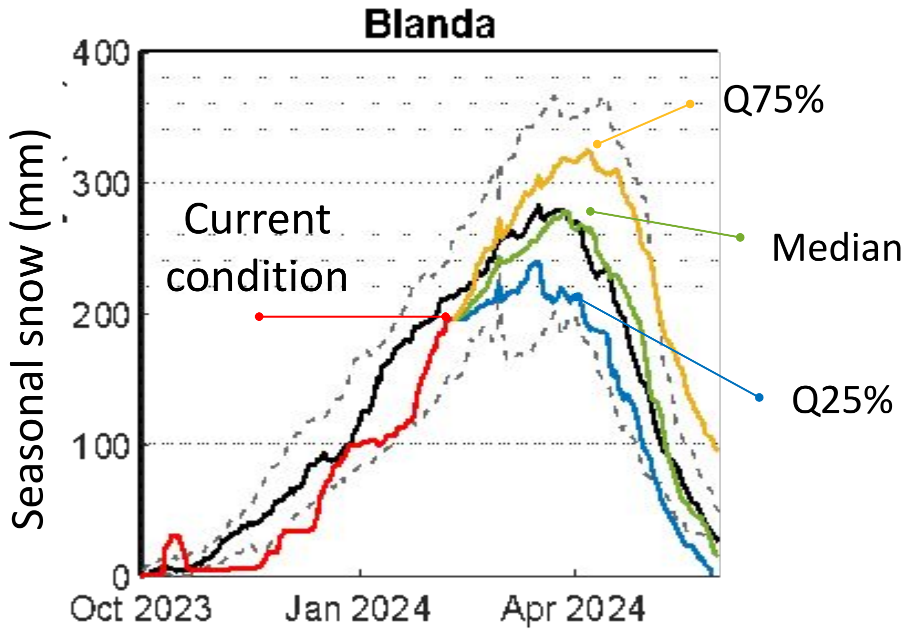
5 year running mean – Ref. preiod: 1986-2006



Water resources forecasting

Principle of operational decisions

- Models are used to forecast resource development to support operational decisions
  - Data driven, conceptual, physically based
- Field observations and remote sensing is used to provide real time estimates
- The challenge is to reduce variability in the forecast
  - **Historical approach:** Statistical representation of know history / climate adjusted (1956-2019)
    - Current hydrological conditions not considered
  - **Future approach :** Cross-scale integration of ground-based and remotely sensed observations

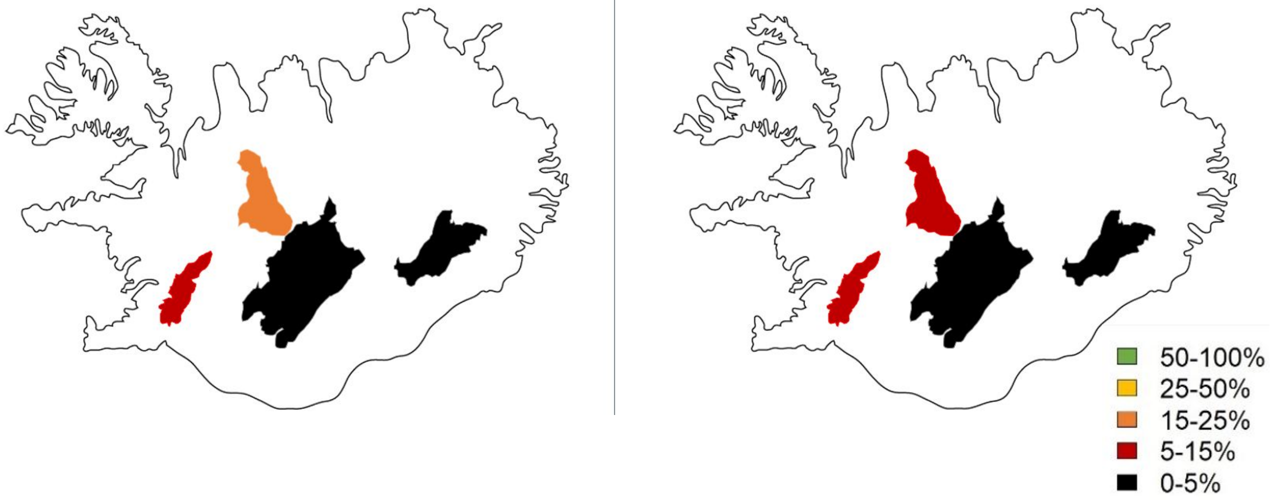


Hydrological conditions at operational areas

Example of current conditons estimates

- ***Hydrological conditons (Past month)***
  - Reconstruted flows compared to obs.
  - Reported as quantiles/percentailes
- ***Hydrological outlook (1-3 months)***
  - Placement in „history“
  - Emphasis on „relevant“ flow component

Desember (01.12.2023-31.12.2023)	Vatnsárið (01.10.2023-31.12.2023)
342 GWh / 271 GWh undir miðgildi	1431 GWh / 867 GWh undir miðgildi



	2019-2020											
GWh	Okt	Nóv	Des	Jan	Feb	Mar	Apr	Maí	Jún	Júl	Ágú	Sep
Landið	20	-230	-163	-70	-6	-194	-43	128	313	-394	76	-435
S	-88	-122	-118	-38	-1	-122	19	154	150	-95	22	-17
A	130	-88	-27	-13	8	-38	-63	21	104	-303	32	-385
N	-24	-19	-10	-3	-4	-23	58	3	18	-33	4	-1

	2020-2021											
GWh	Okt	Nóv	Des	Jan	Feb	Mar	Apr	Maí	Jún	Júl	Ágú	Sep
Landið	-287	-195	-172	-125	-159	18	-35	-629	-345	198	466	423
S	-88	-117	-126	-94	-122	-18	0	-322	-118	22	83	125
A	-185	-64	-33	-14	-21	17	11	-216	-259	129	333	282
N	-16	-13	-5	-2	-7	28	11	-40	-10	10	31	48

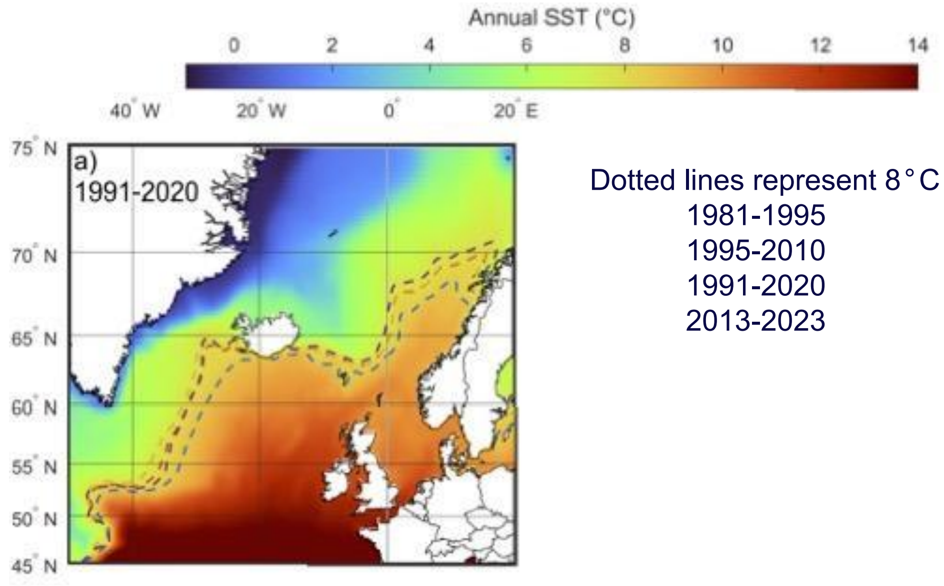
	2021-2022											
GWh	Okt	Nóv	Des	Jan	Feb	Mar	Apr	Maí	Jún	Júl	Ágú	Sep
Landið	-284	-175	-239	-115	-175	51	423	332	123	13	-503	191
S	-93	-115	-175	-80	-132	-10	269	253	164	123	-34	85
A	-188	-55	-54	-22	-24	70	110	103	-99	-145	-467	103
N	-6	-4	-1	3	-10	2	101	27	14	-3	-21	35

	2022-2023												2023-2024		
GWh	Okt	Nóv	Des	Jan	Feb	Mar	Apr	Maí	Jún	Júl	Ágú	Sep	Okt	Nóv	Des
Landið	-103	214	-173	-135	67	-119	786	102	527	-697	-5	-167	-240	-260	-271
S	-69	23	-159	-104	5	-83	467	-49	-33	-209	-112	-107	-86	-107	-160
A	-44	227	7	-26	19	-34	279	191	561	-443	73	-18	-147	-102	-90
N	4	3	-15	-7	33	-15	72	-32	10	-35	10	-2	-14	-10	-16

ONDJFM **SONDJF** **ONDJF** **DJM** **ASOND**

Sea surface temperatures near Iceland

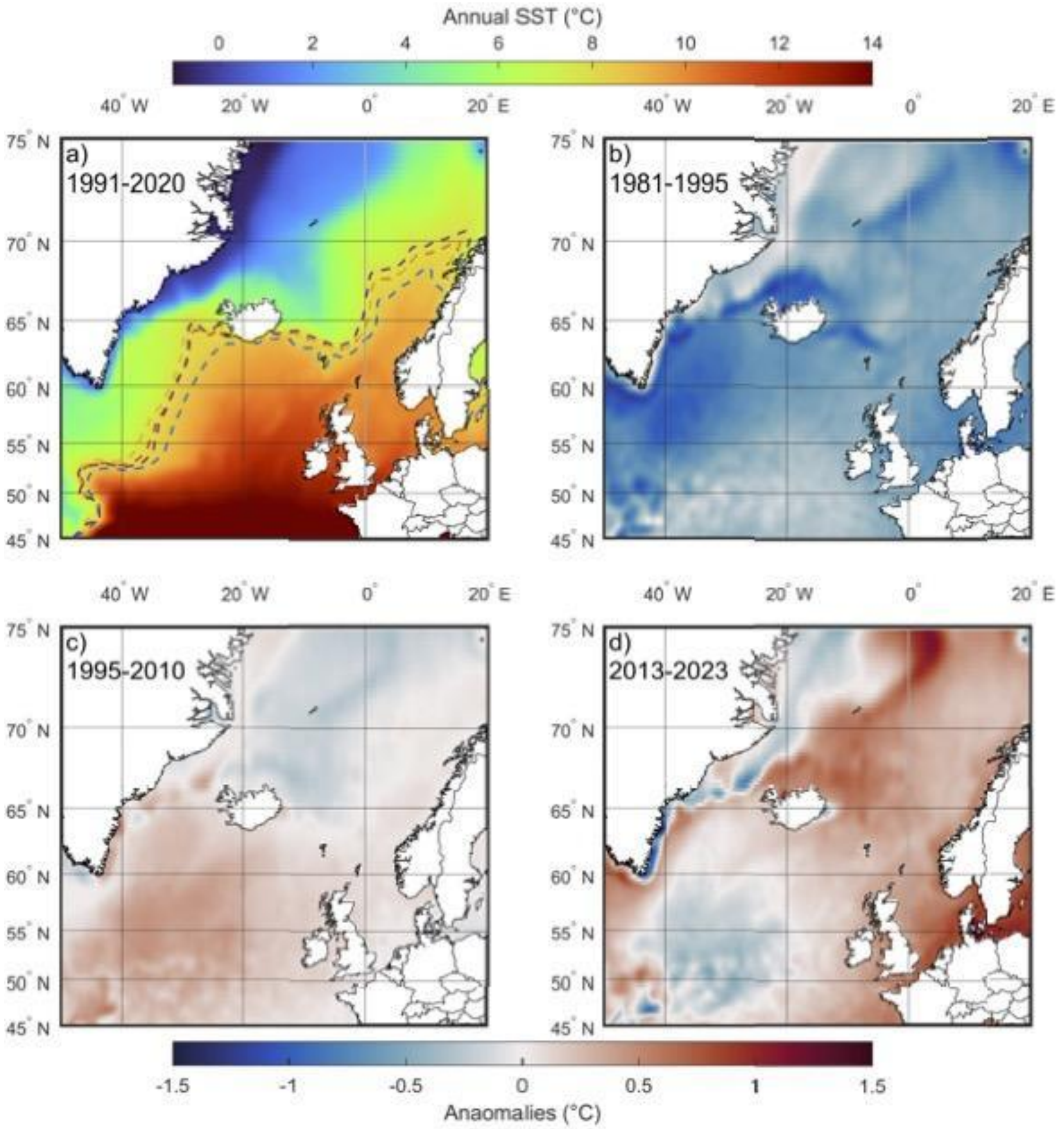
- SST increase in 1995-97 (~1°C)
  - Air temperatures rise
  - Less seasonal snow, more glacier melt



Dotted lines represent 8 ° C isotherms
1981-1995
1995-2010
1991-2020
2013-2023

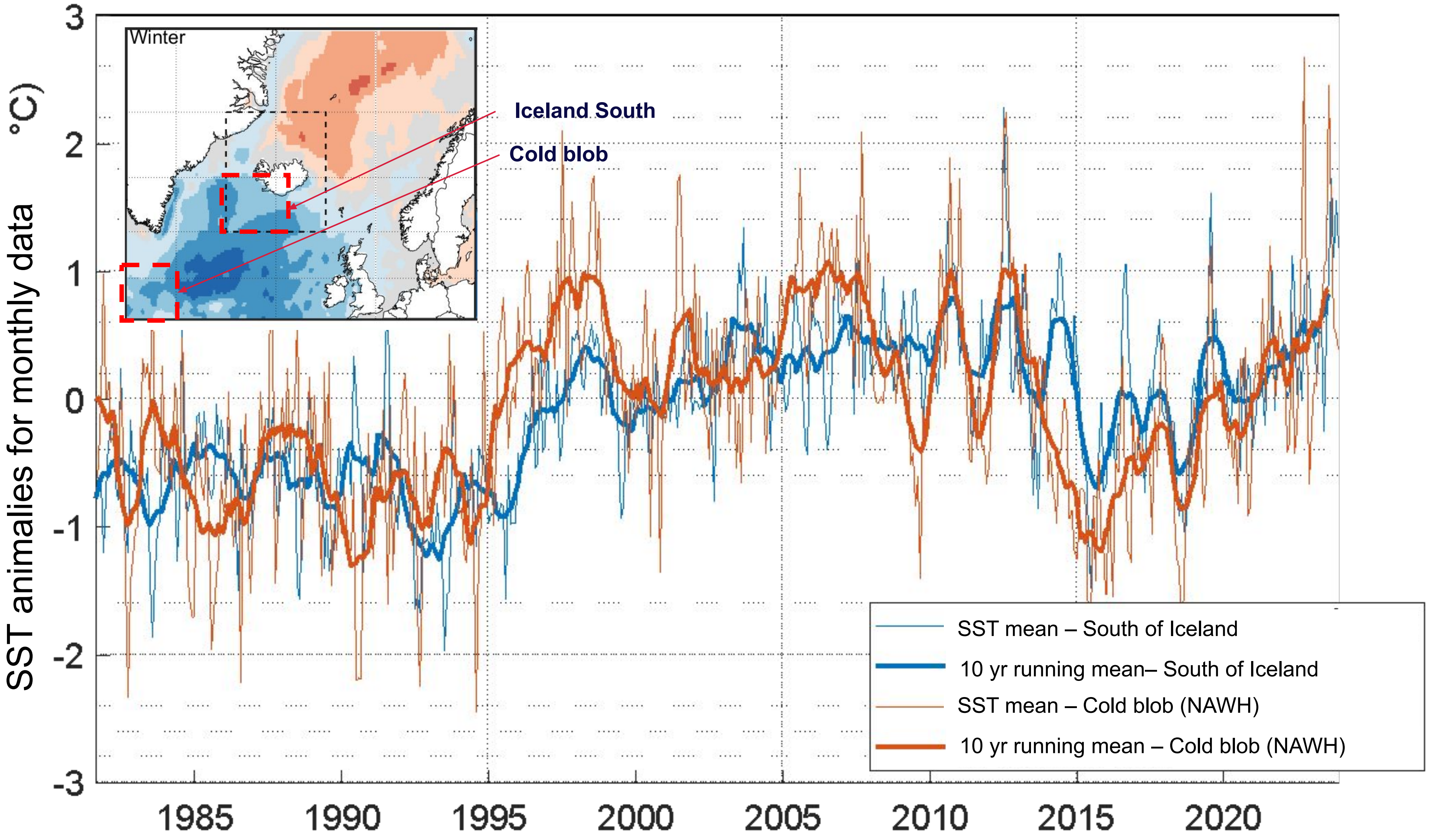
Sea surface temperatures near Iceland

- SST increase in 1995-97 (~1°C)
  - Air temperatures rise
  - Less seasonal snow, more glacier melt
- Different patterns from 1995-2010 and 2013-2023
  - Strong significant correlation to glacier mass balace
  - Low lovel clouds associated with cold blod anomalie
    - Impacts on surface energy balance of glaciers



What has changed ?

SSTs on the rise again



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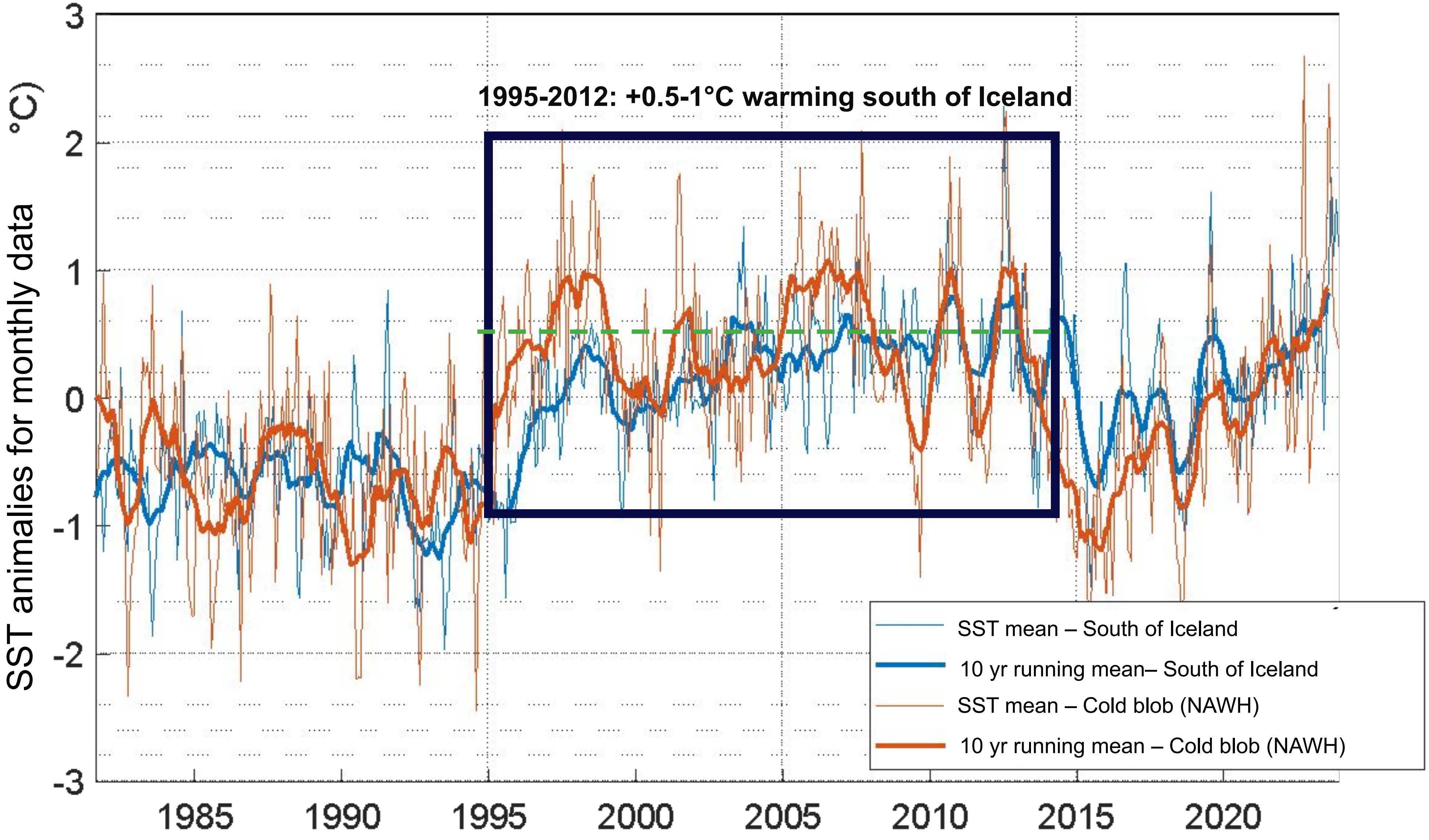

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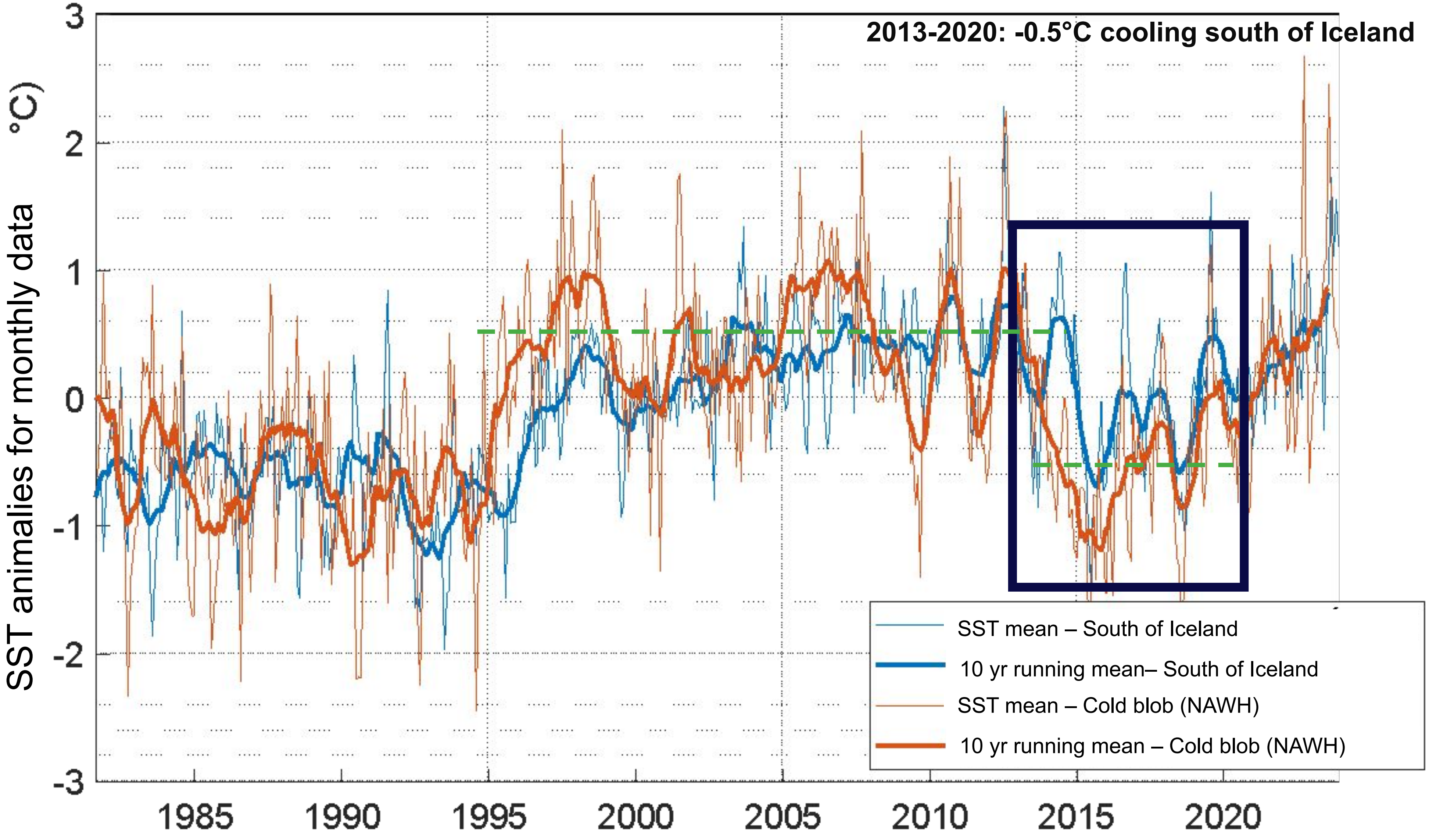

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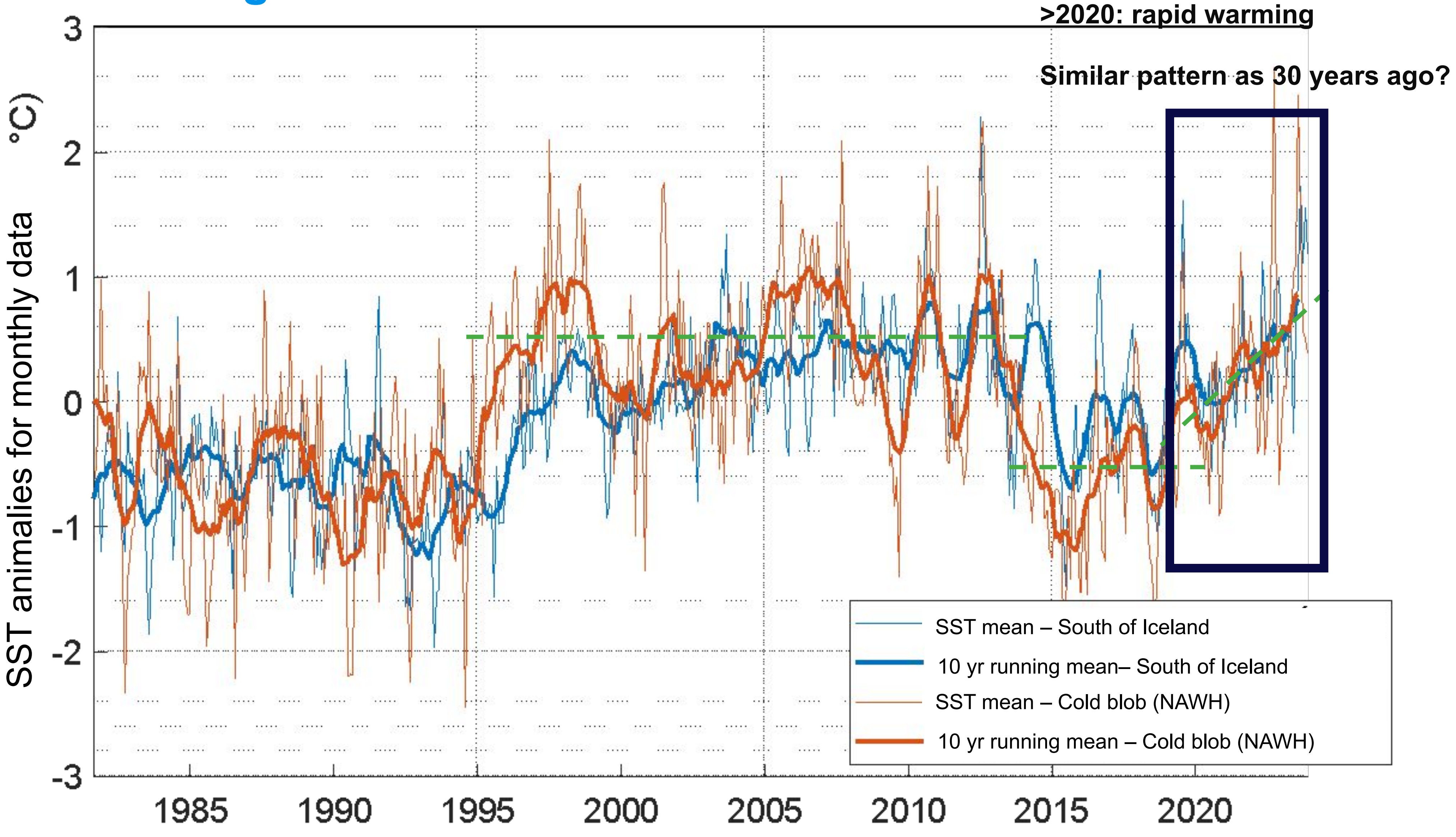

Large scale atmospheric variability

Relationships to hydrology

Atmospheric

Climate

- Understanding of large-scale circulation variability and its relationship to surface mass balance of glaciers in Iceland.
- Climate and large scale atmosperic variables
- Winter and summer mass balance for glaciers
  - **Winter mass balance**
    - Driven by precip input (tp)
    - Cold blob SST have a significant correlation
  - **Summer mass balance:**
    - Strong significant relationships to SST
- Coupling to ECMWF seasonal forecasting system

Large scale atmospheric variability

First results for Vatnajökull