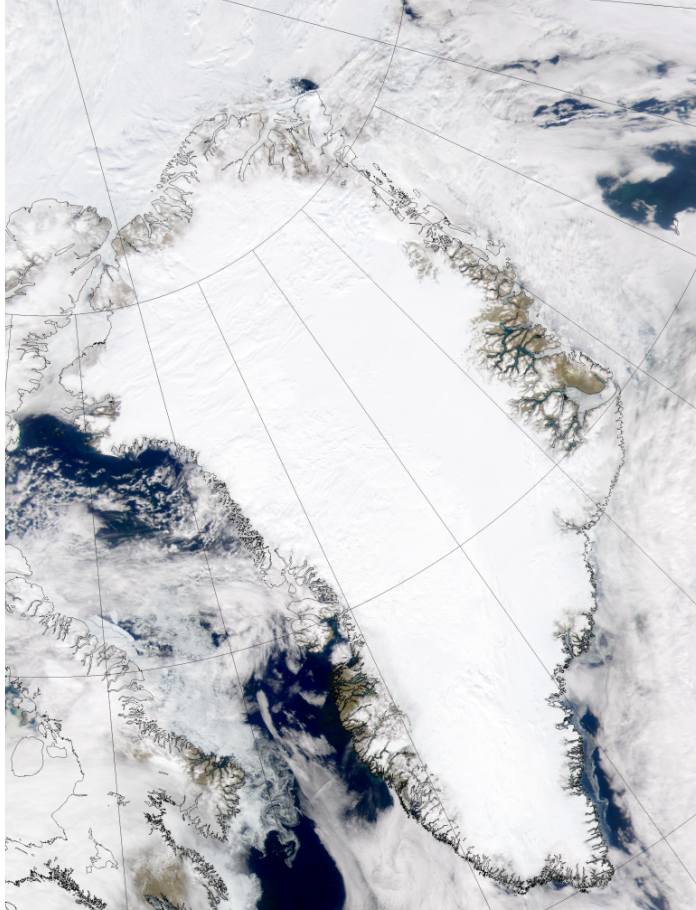


Iskerner og klimaet før og nu

Bo M. Vinther, Centre for Ice and Climate, Niels Bohr Institutet

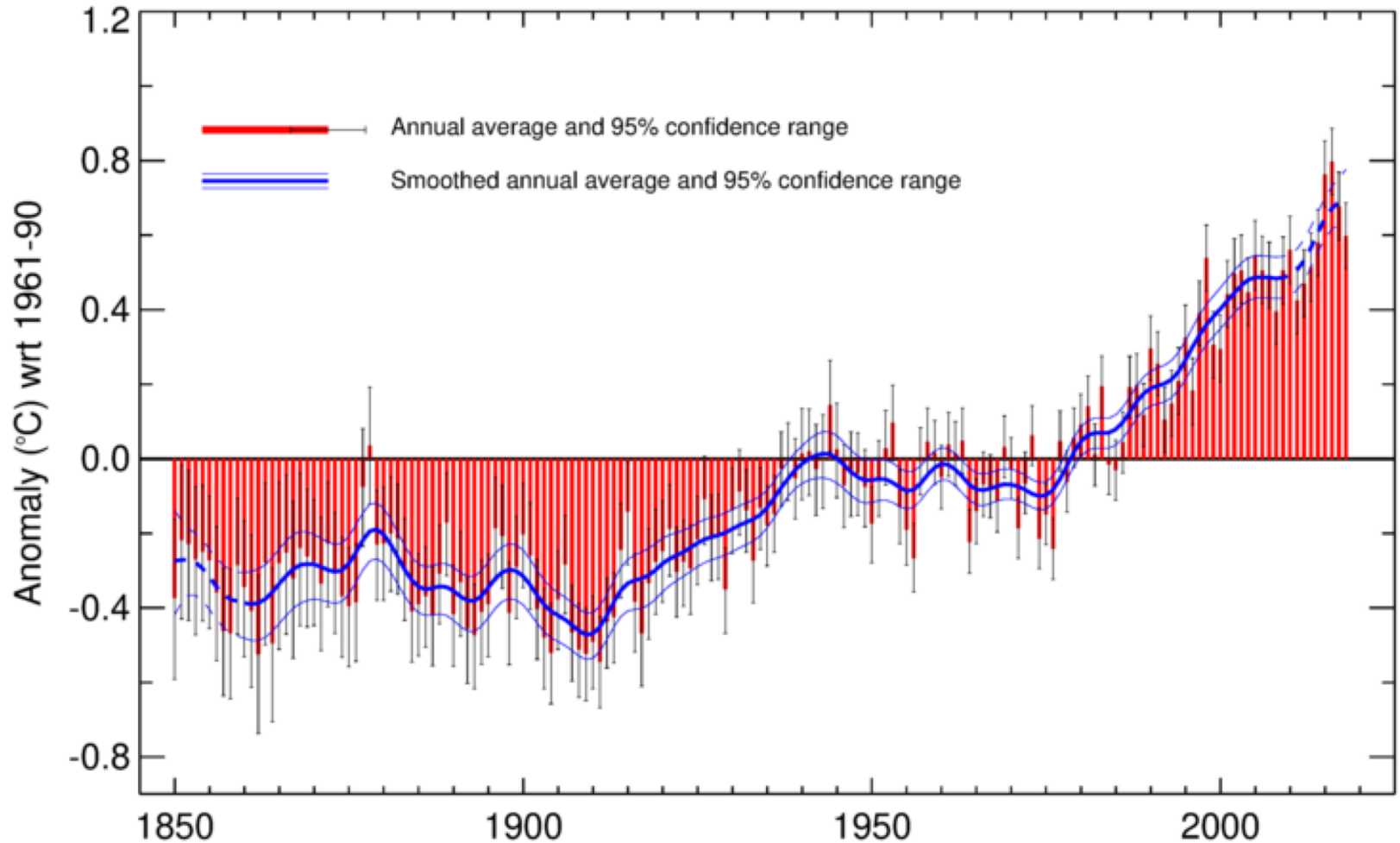


Foredrag til "Big Bang", København 27. januar 2020.



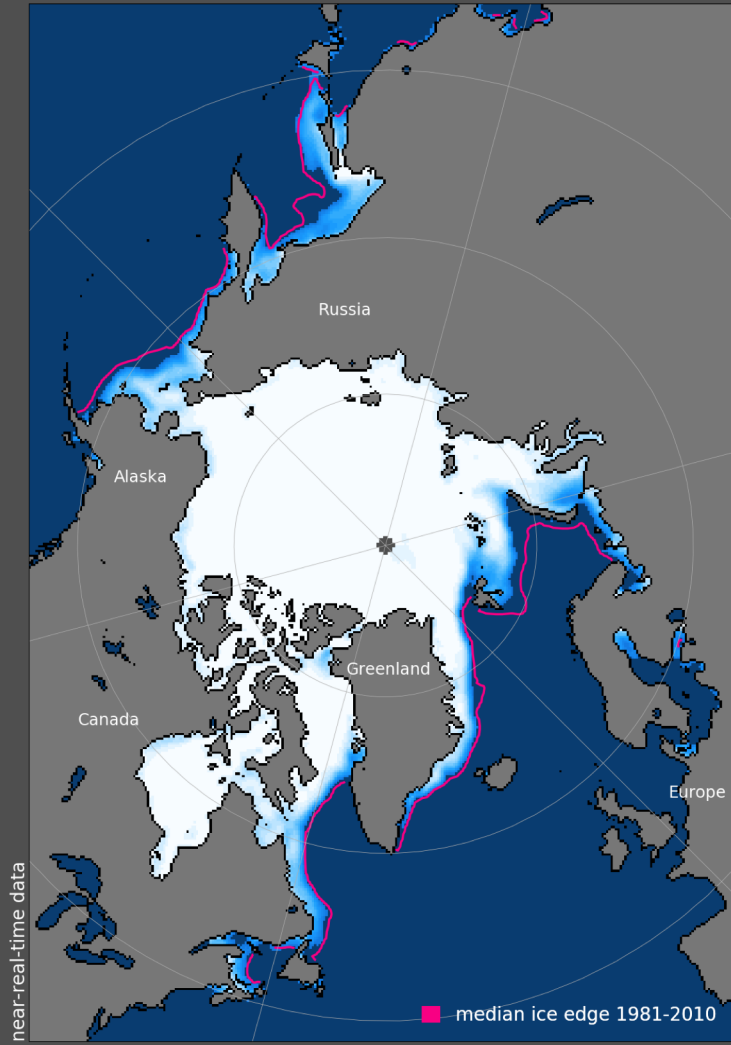
Global average temperature 1850-2018

Updated from Morice et al. 2012



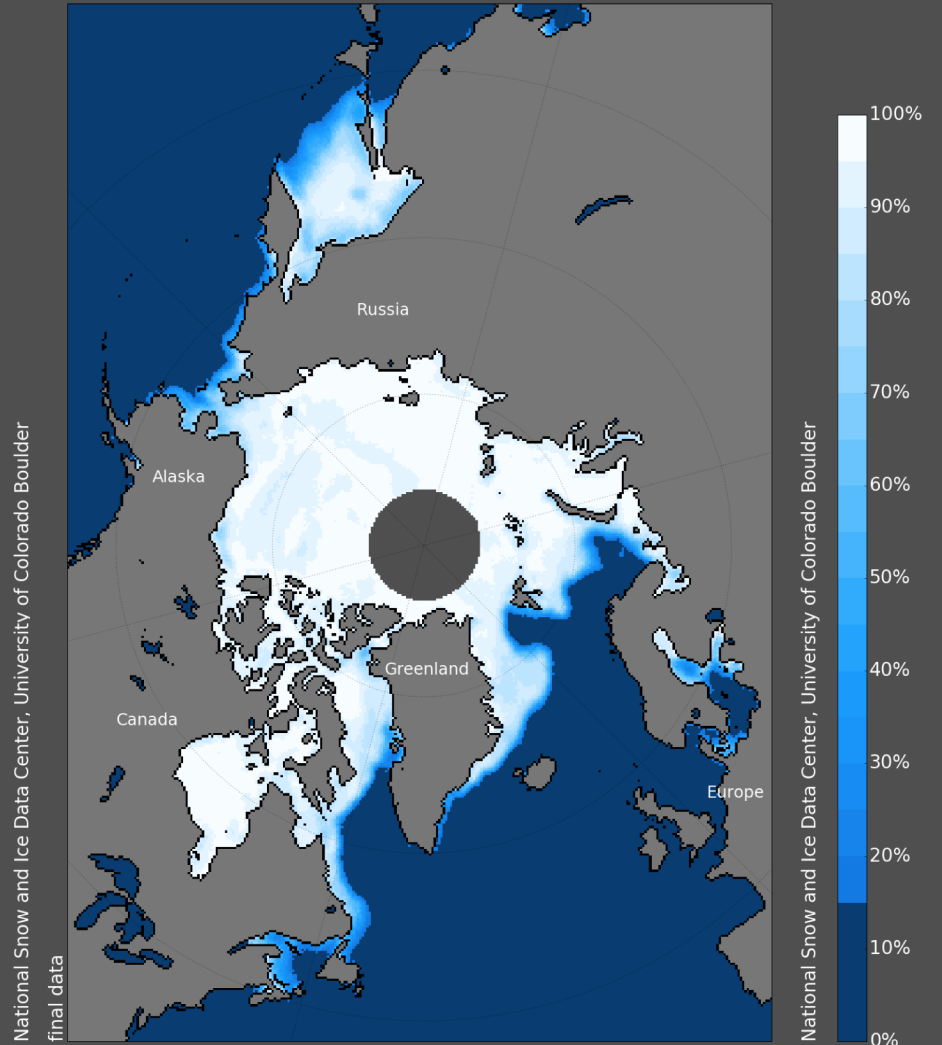
Vinter-havis på nordpolen – i 2019 og for 40 år siden

Sea Ice Concentration, Jan 2019



Total Area = 12.1 million sq km

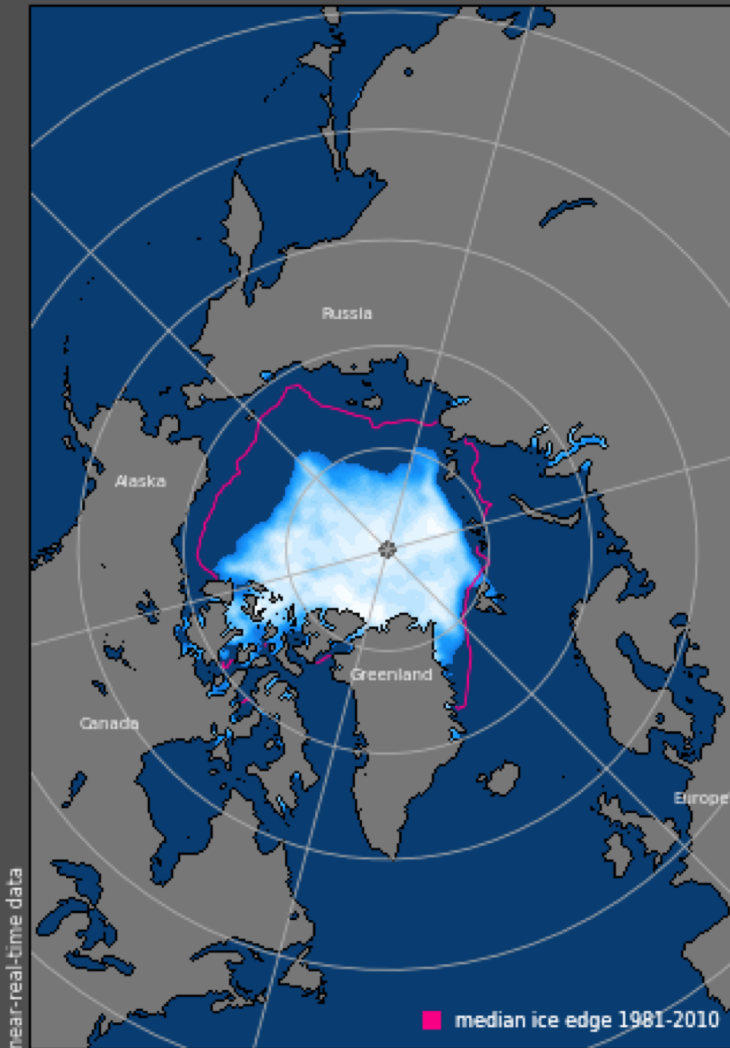
Sea Ice Concentration, Jan 1979



Total Area = 12.4 million sq km

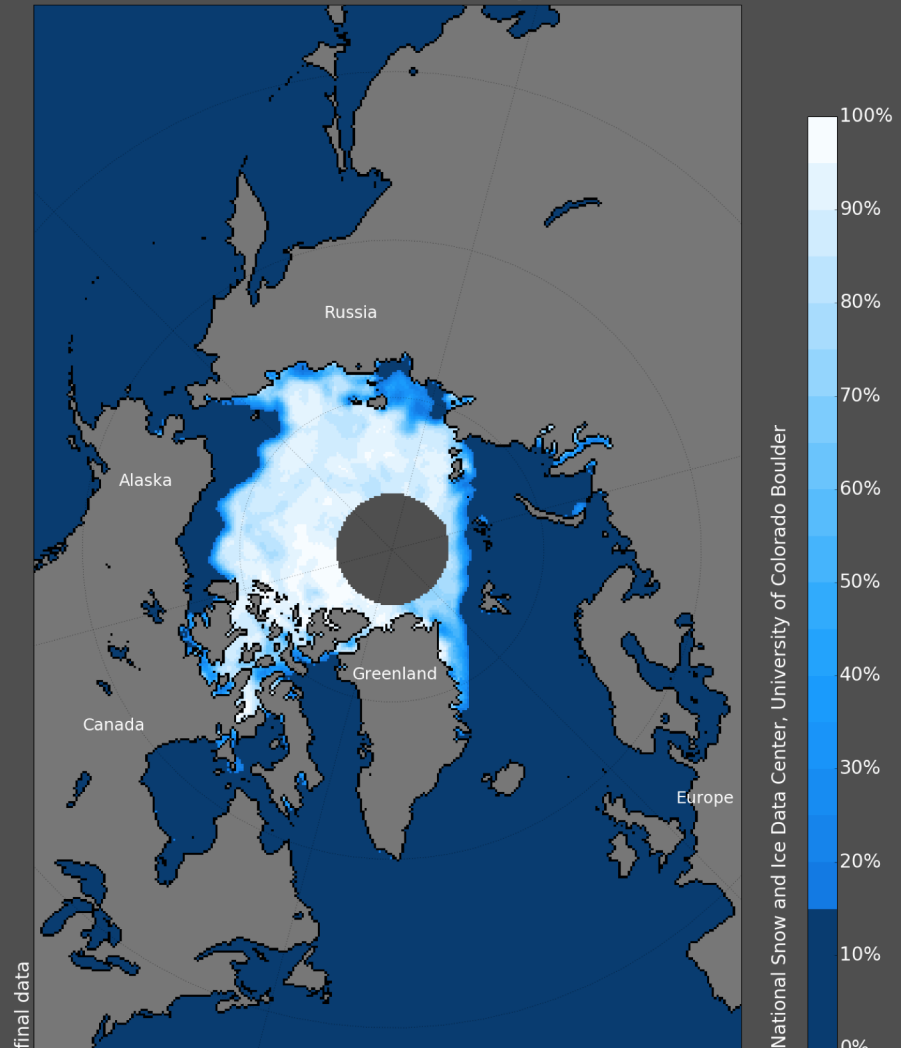
Efterårs-Havis på nordpolen – i 2019 og for 40 år siden

Sea Ice Concentration, Sep 2019



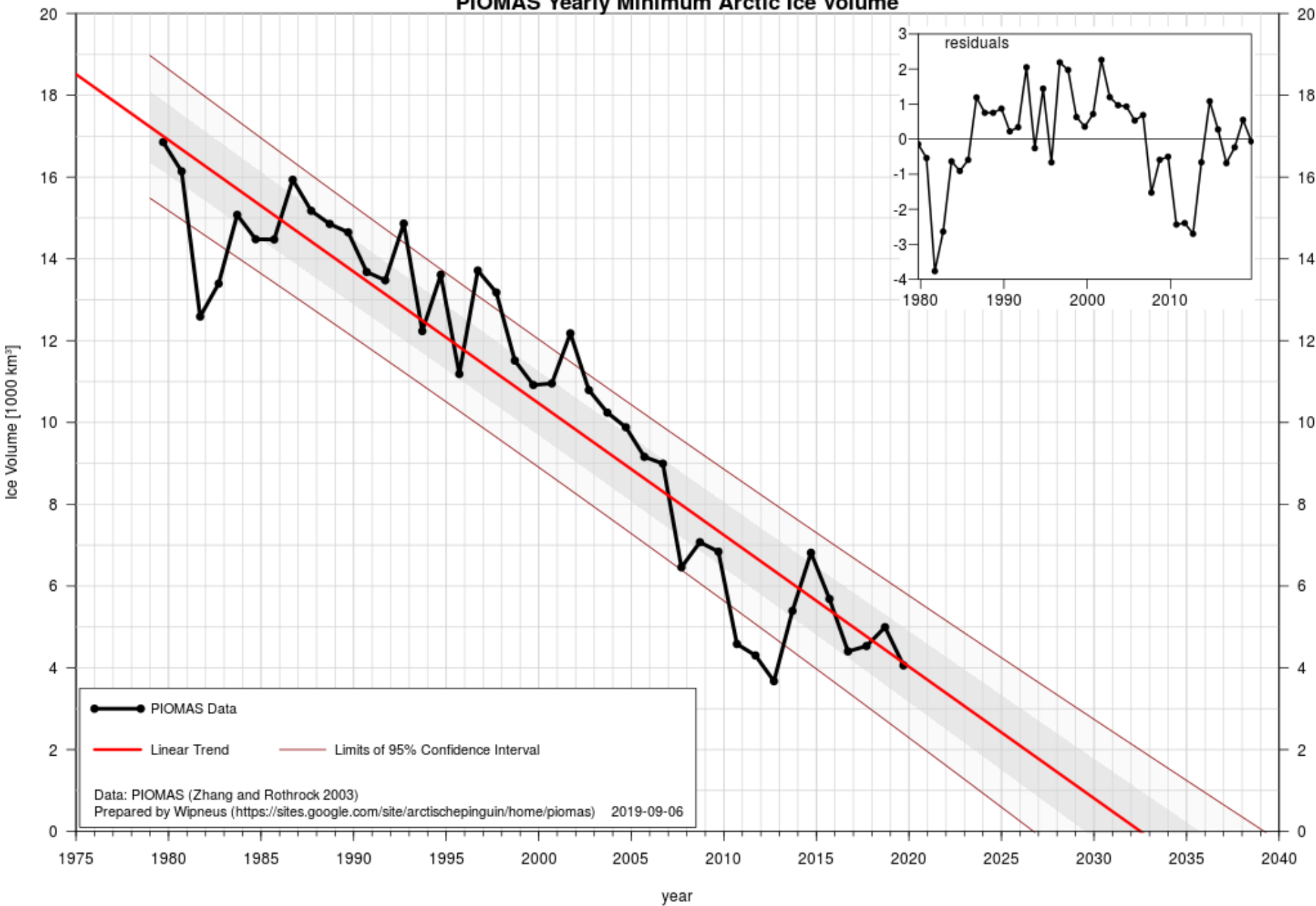
Total Area = 3.1 million sq km

Sea Ice Concentration, Sep 1979



Total Area = 4.5 million sq km

PIOMAS Yearly Minimum Arctic Ice Volume

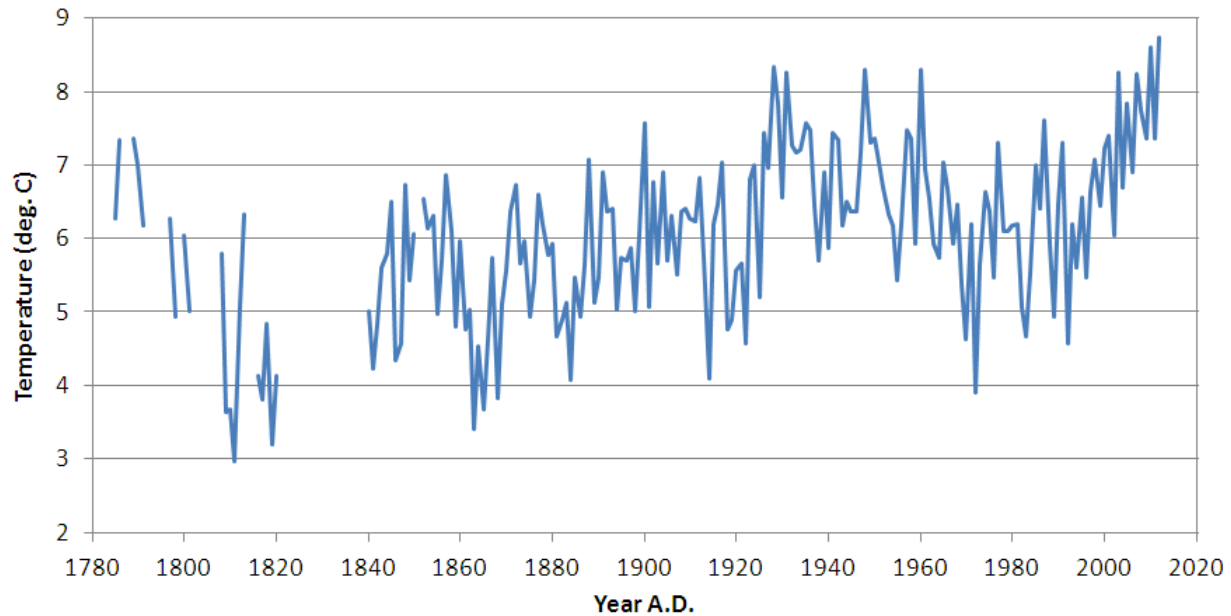


2012 – Smeltning i Kangerlussuaq

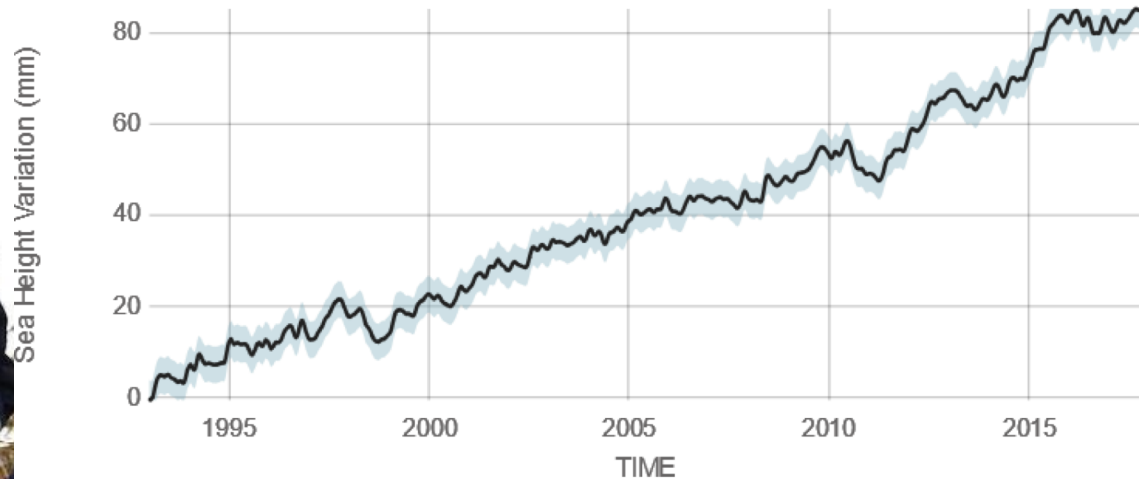


PHOTOS: GERTH KREUTZMANN

SW Greenland JJA Temperatures 1785-2012



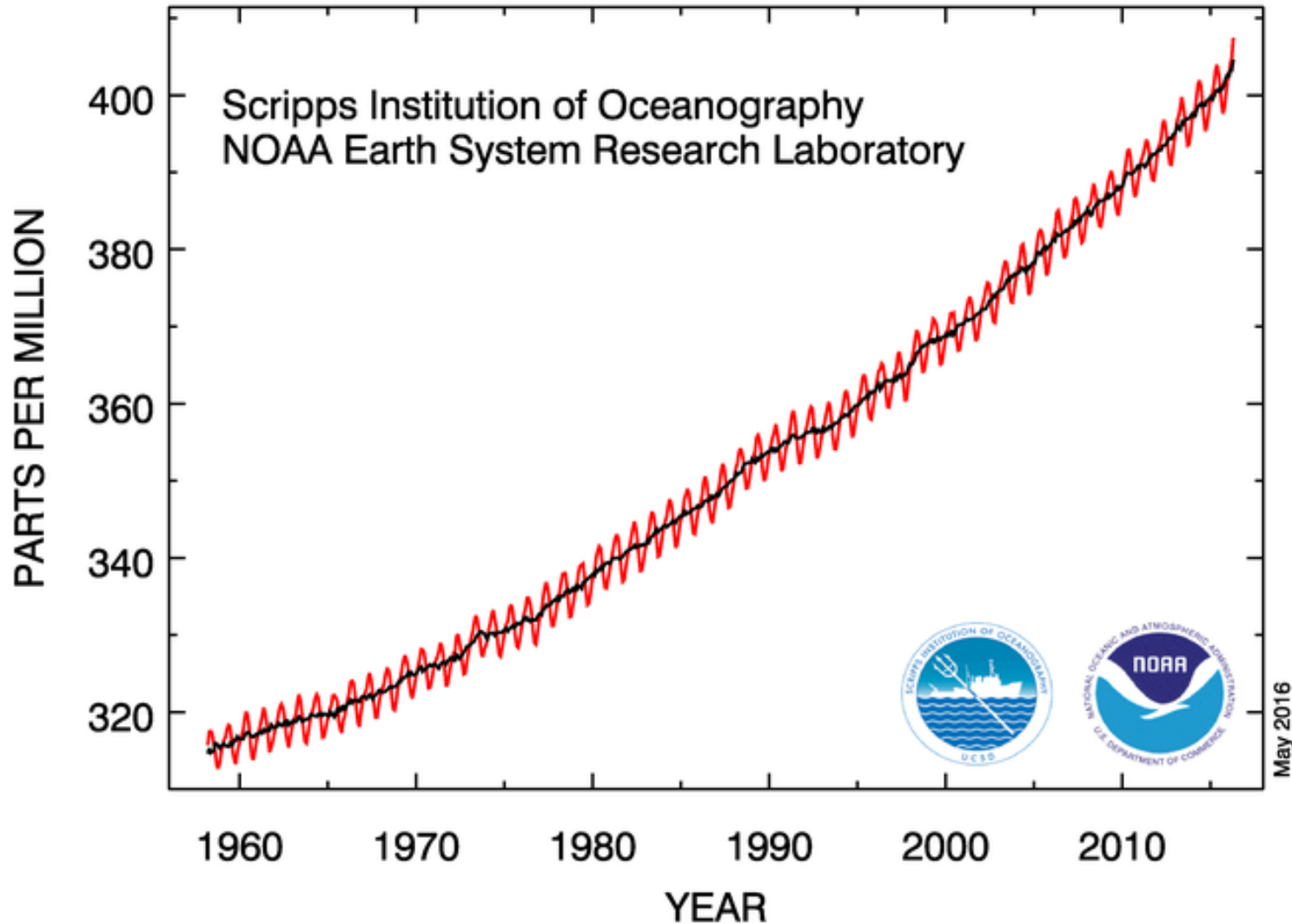
Konsekvens af et varmt Arktisk Ocean – afsmeltning fra Grønland!



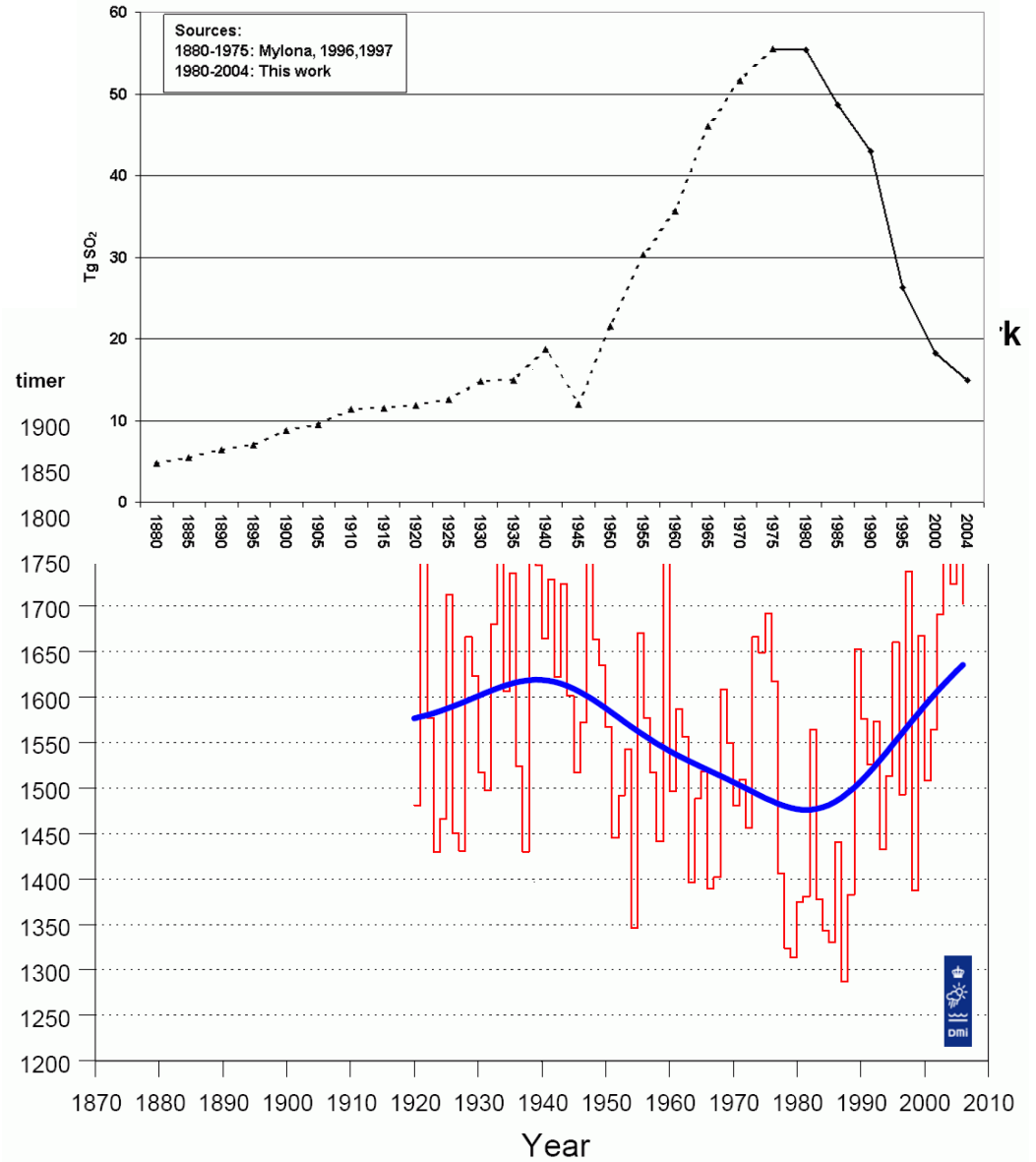
Source: climate.nasa.gov



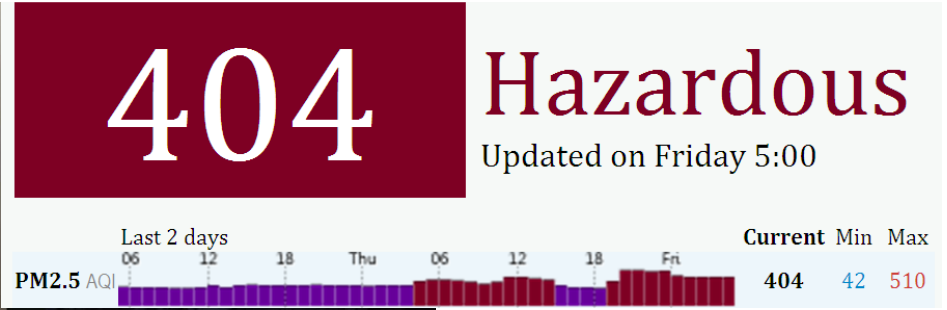
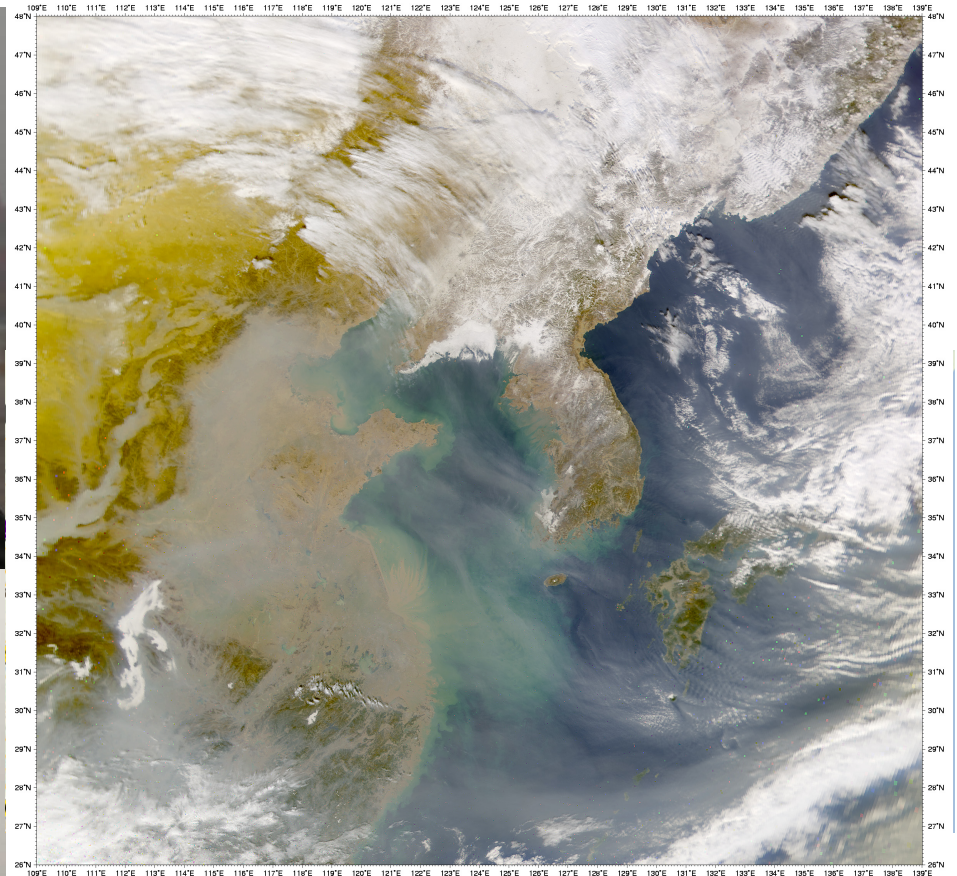
Atmospheric CO₂ at Mauna Loa Observatory



SO₂ udledninger blokerer for solen!

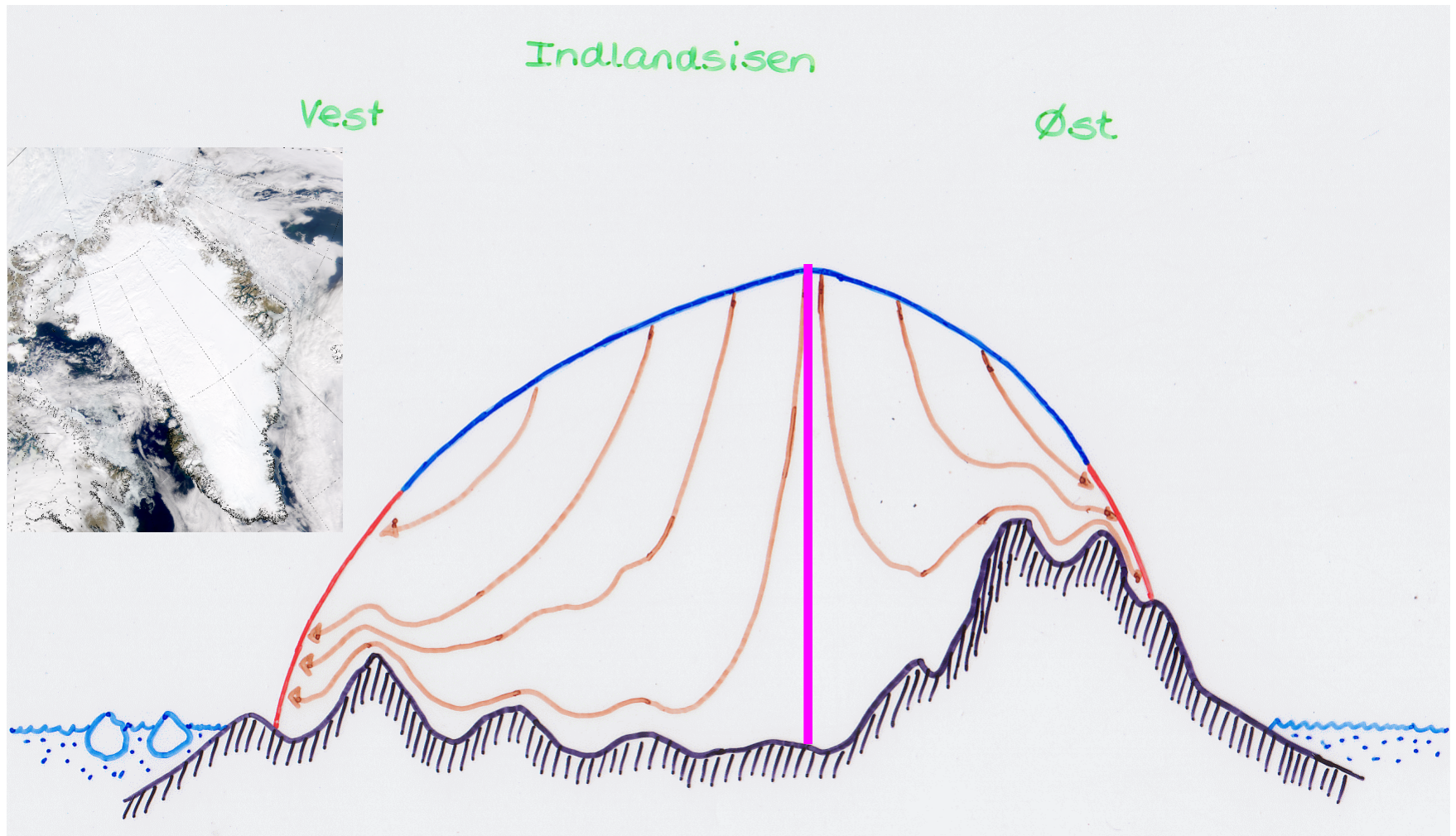


SO2 udledningner nu i Kina...



Iskerner...





Width: 1000 km

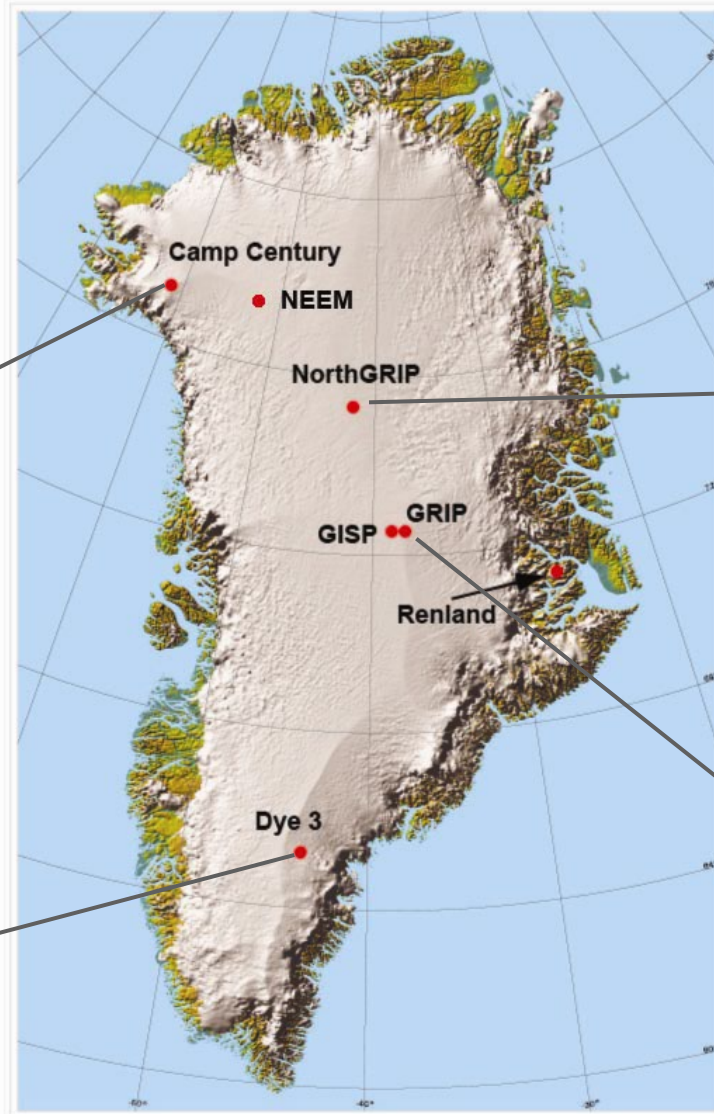
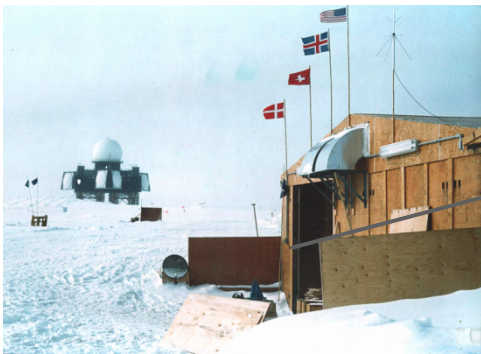
Thickness: 3 km

Iskerner fra Grønland

Camp Century, 1962-66, 1390 m



Dye-3, 1979-80, 2037 m



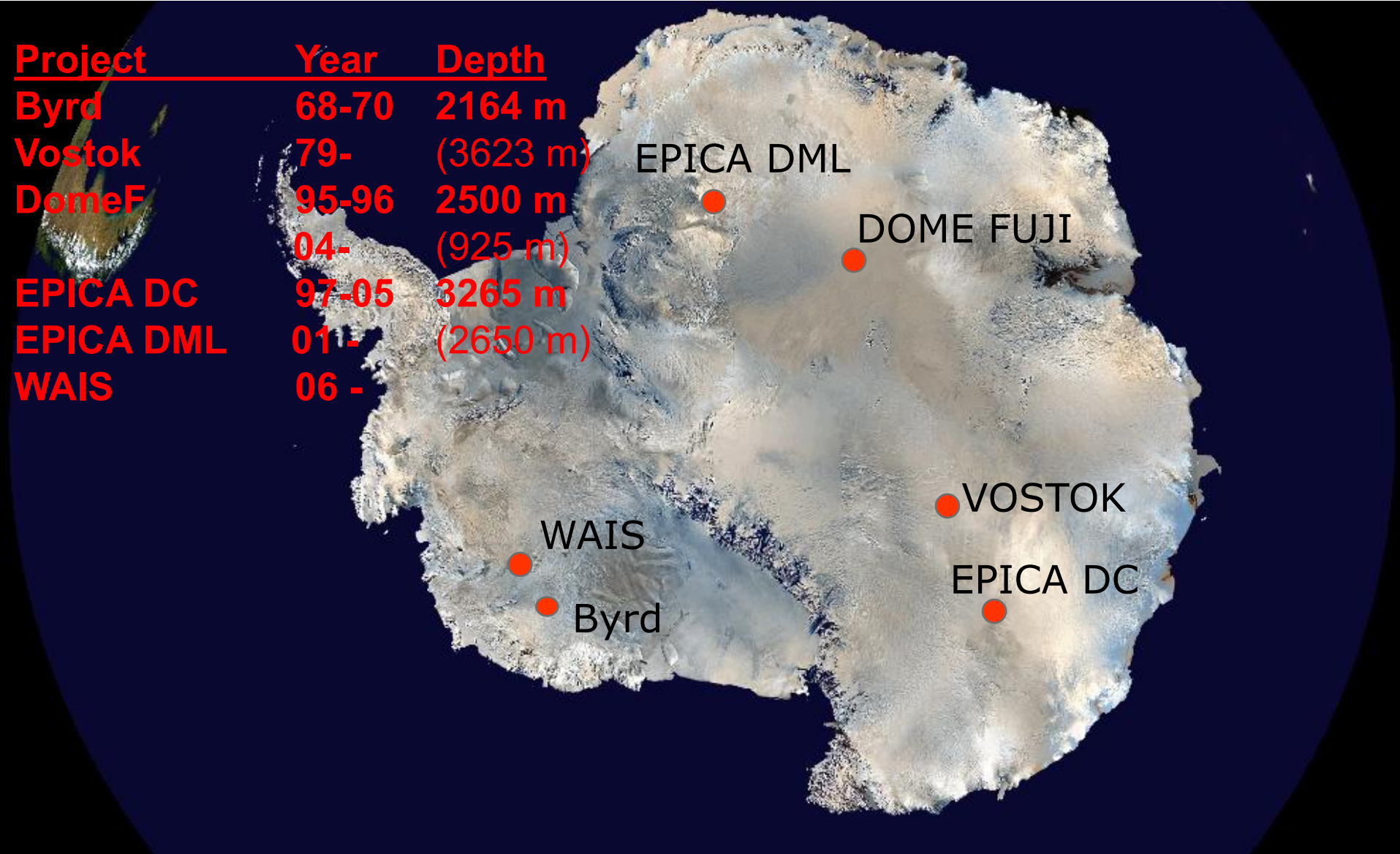
NGRIP 1996-2004, 3085 m



GRIP 1989-92, 3029 m



Iskerner fra Antarktis

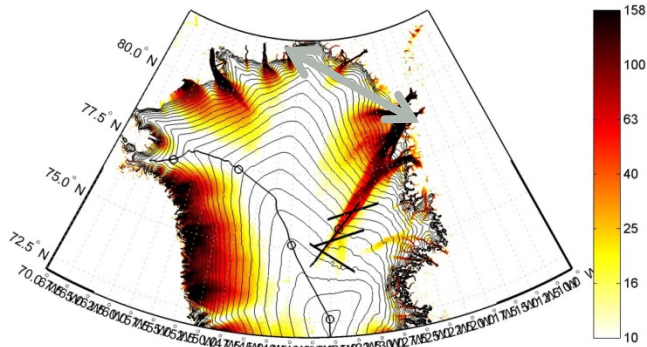


<u>Project</u>	<u>Year</u>	<u>Depth</u>
Byrd	68-70	2164 m
Vostok	79-	(3623 m)
DomeF	95-96	2500 m
EPICA DC	04-	(925 m)
EPICA DML	97-05	3265 m
WAIS	01 -	(2650 m)
	06 -	














Drilling a deep ice core: EastGRIP tentative time line

TIME LINE

- 2015: Move equipment, skiway
- 2016: Establish facilities, drill to 120 m
- 2017: Drilling from 120m to 900m.
- 2018: Drilling from 900m to 1750m
- 2019: Drilling from 1750m to 2120m
- 2020: Drilling to bedrock !!**



EastGRIP partners

Nation	Steering Committee member name	Steering Committee member address
 China	Cunde Xiao	State Key Laboratory of Cryospheric Sciences, Institute of Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI), Chinese Academy of Sciences (CAS), Lanzhou.
 Denmark	Dorthe Dahl-Jensen	Centre for Ice and Climate Niels Bohr Institute Juliane Maries Vej 30 DK-2100 Copenhagen Ø Denmark
 France	Fabien Gillet-Chaulet	Le Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE) 54, rue Molière, BP 96 F-38402 Saint-Martin d'Hères cedex France
 Germany	Ilka Weikusat	Alfred-Wegener-Institute Columbusstrasse 27568 Bremerhaven Germany
 Iceland	Árný Sveinbjörnsdóttir	Institute of Earth Sciences University of Iceland Sturlugata 7 IS-107 Reykjavik Iceland
 Italy	Carlo Barbante	Institute for the Dynamics of Environmental Processes - CNR Department of Earth System Science and Environmental Technologies via Torino, 155 30172 Venice-Mestre Italy
 Japan	Kumiko Goto-Azuma	National Institute of Polar Research 10-3 Midori-cho Tachikawa Tokyo 190-8518 Japan
 Norway	Kerim H. Nisancioglu	Bjerknes Centre for Climate Research Geophysical Institute, University of Bergen Allegaten 70 5007 Bergen Norway
 South Korea	Soon Do Hur	Korea Polar Research Institute (KOPRI) 26, Songdomirae-ro Yeonsu-gu Incheon Korea
 South Korea	Jinho Ahn	Laboratory for Ice Core and Paleoclimate School of Earth and Environmental Sciences, Seoul National University 599 Kwanak-ro, Kwanak-gu Seoul 151742 Korea
 Sweden	Margareta Hansson	Department of Physical Geography and Quaternary Geology Stockholm University S-10691 Stockholm Sweden
 Switzerland	Thomas Stocker	University Bern Climate and Environmental Physics Sidlerstrasse 5 CH-3012 Bern Switzerland
 USA	Jim White	Institute of Arctic and Alpine Research University of Colorado Boulder, Colorado 80309 USA

Logistics hub: Kangerlussuaq



Kangerlusuaq: The field Office



Kangerlusuaq: Getting organized..?



EastGRIP - landing on the ice



EastGRIP 2016 – camp...



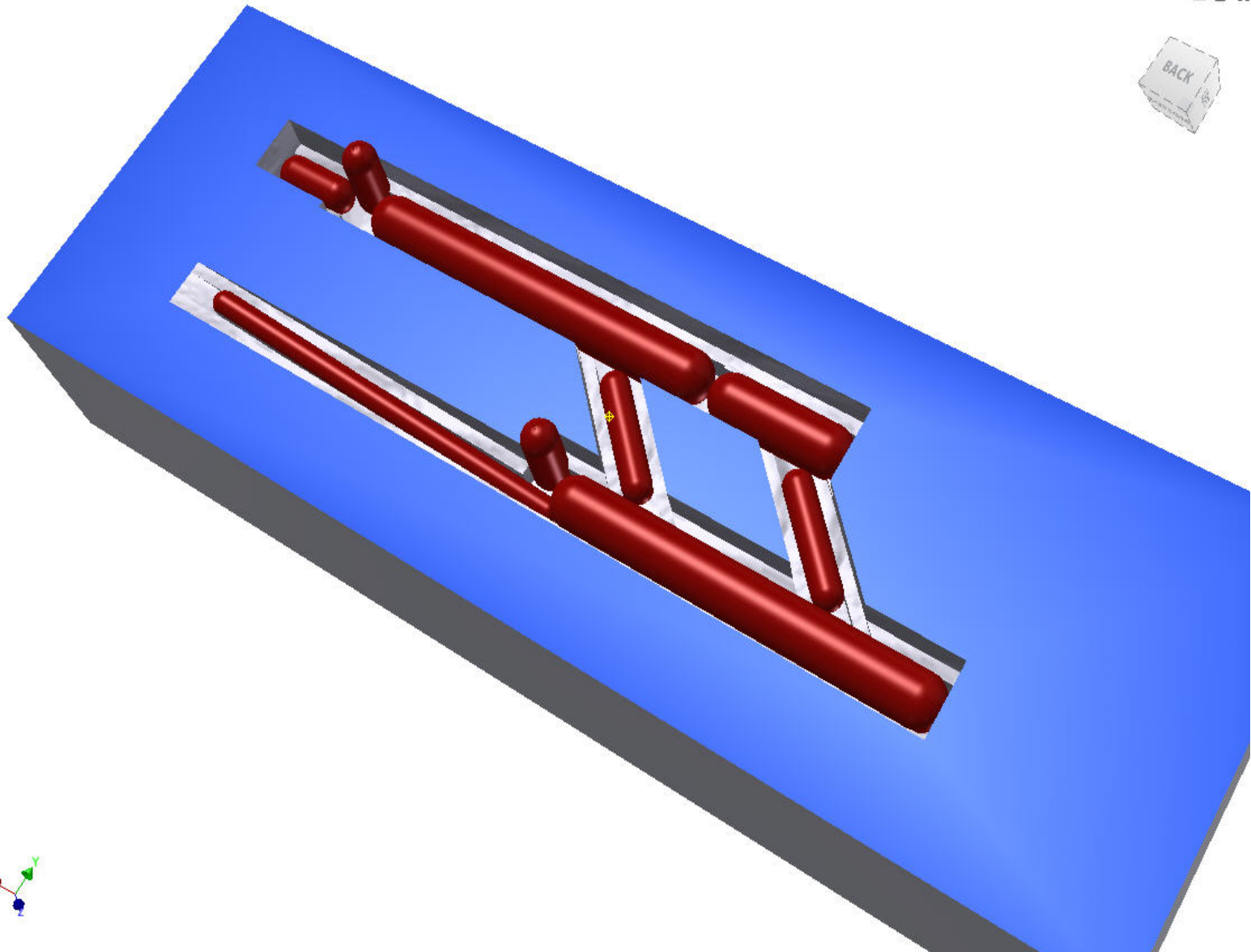
Inside the Black Dome



The importance of running water...



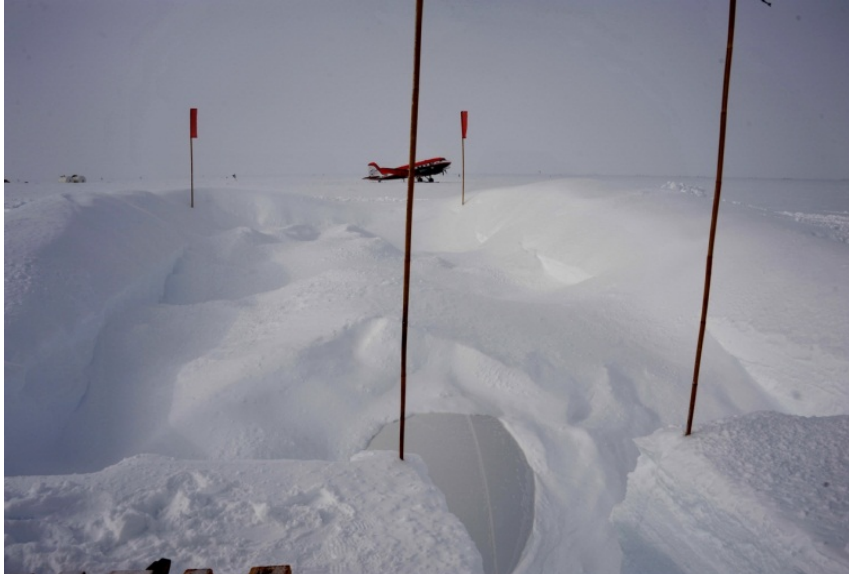
Constructing Balloon trenches



Constructing Balloon trenches



Constructing Balloon trenches









EastGRIP - Saturdays



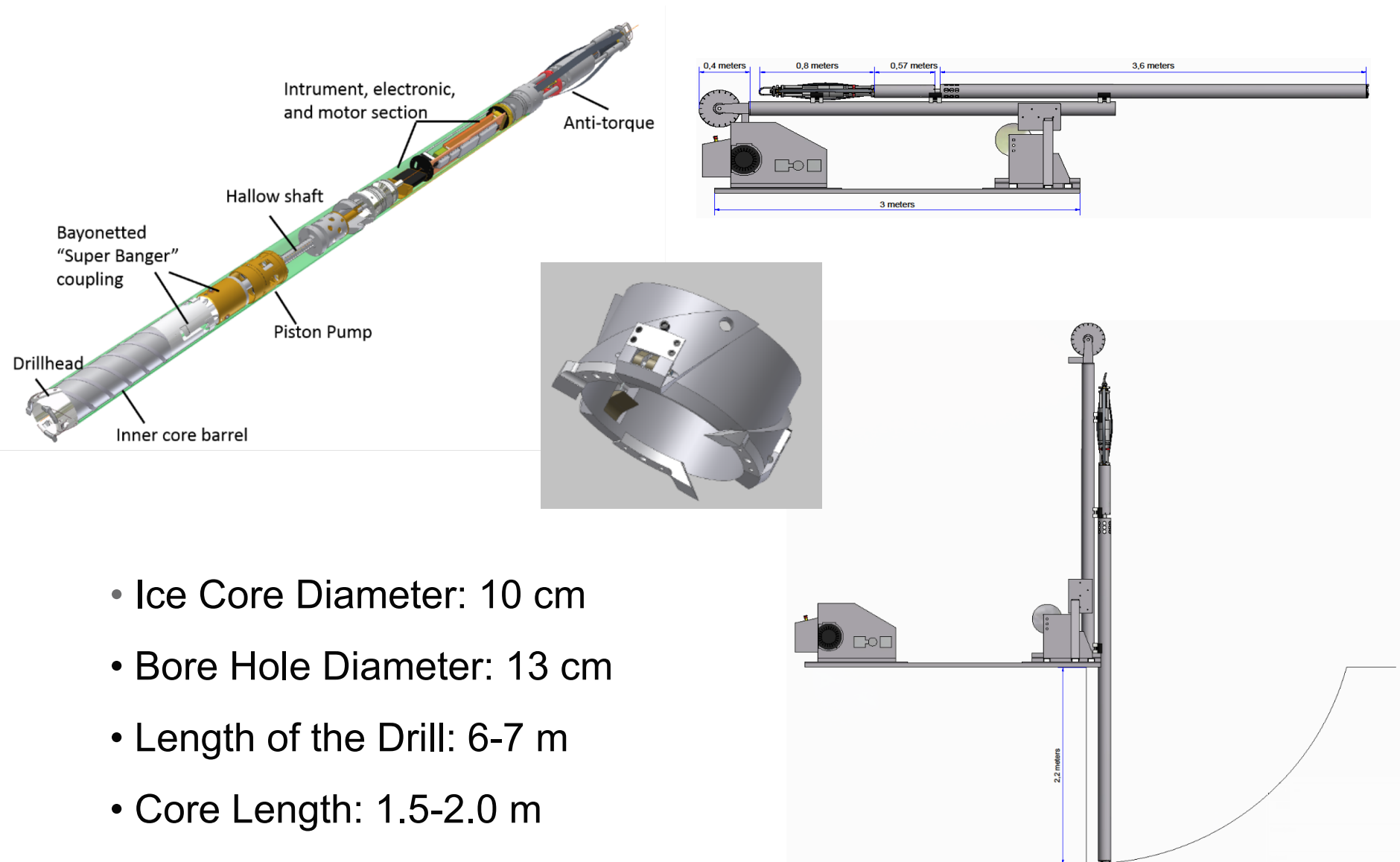
EastGRIP 2016 – Polar bear



EastGRIP looking out from below



The ice core drill



- Ice Core Diameter: 10 cm
- Bore Hole Diameter: 13 cm
- Length of the Drill: 6-7 m
- Core Length: 1.5-2.0 m

EastGRIP 2016 – starting the drilling

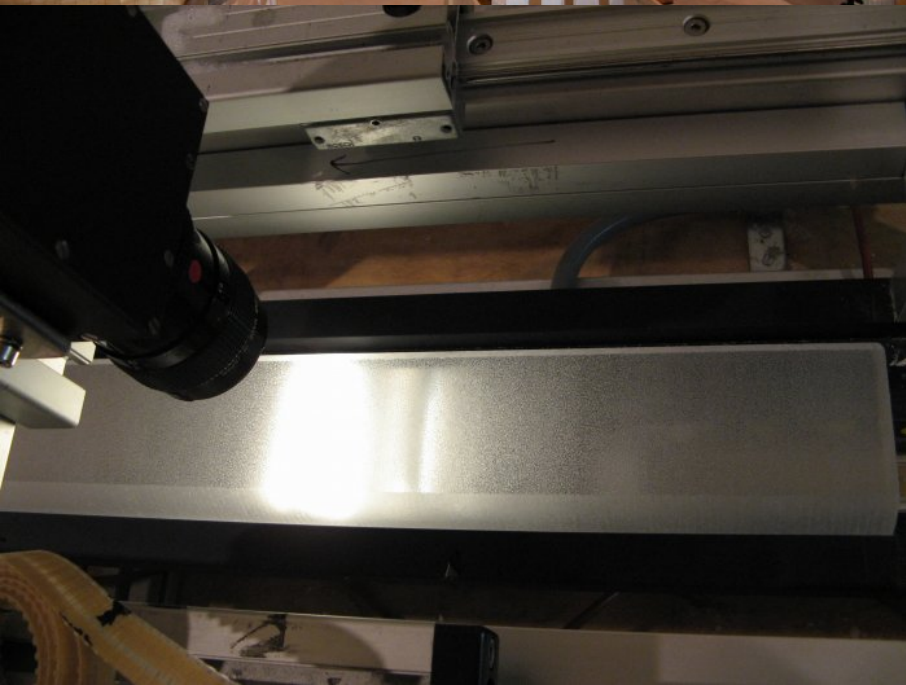


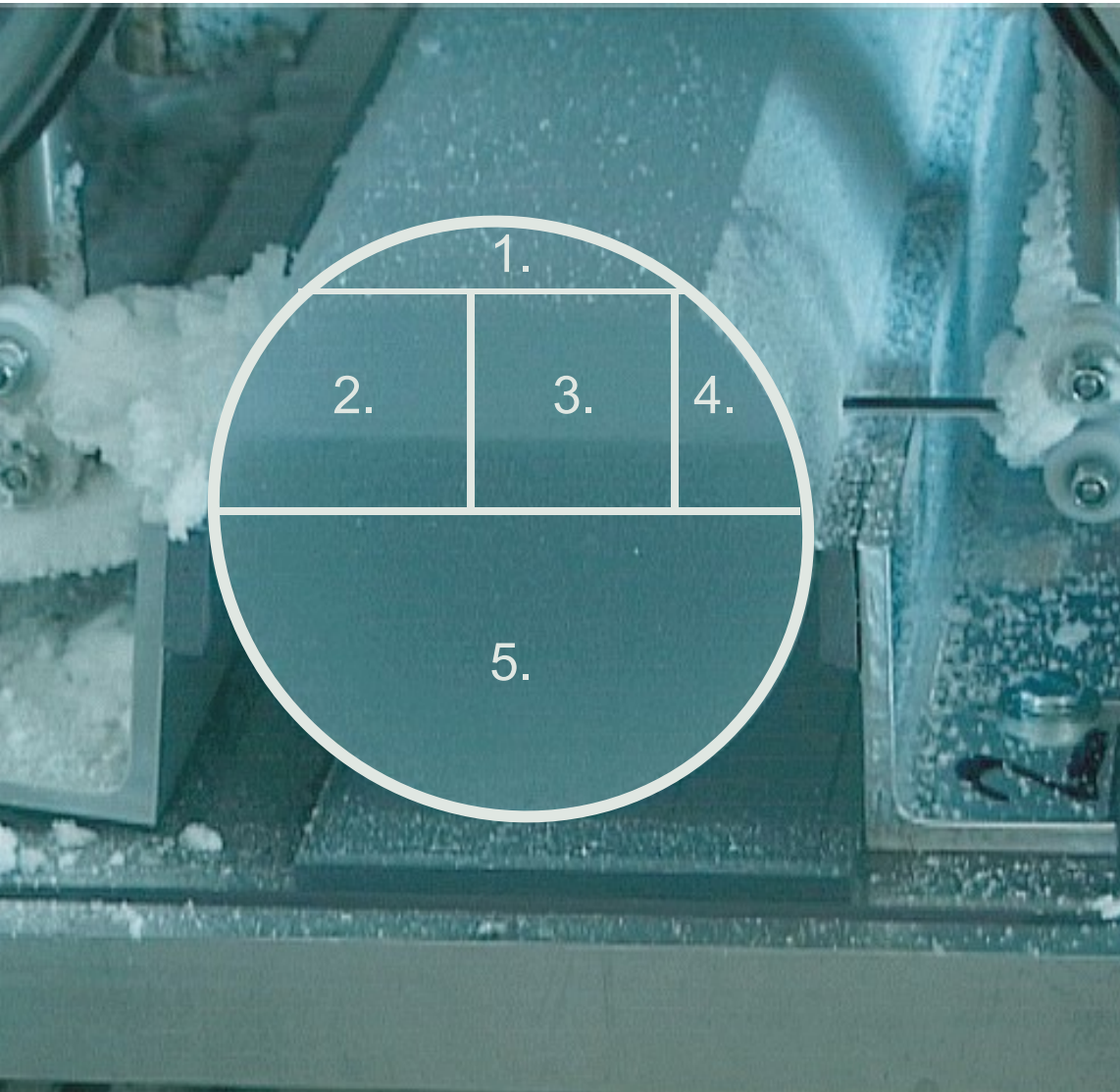
EastGRIP 2016 – the science guy!



The drill head with step cutters

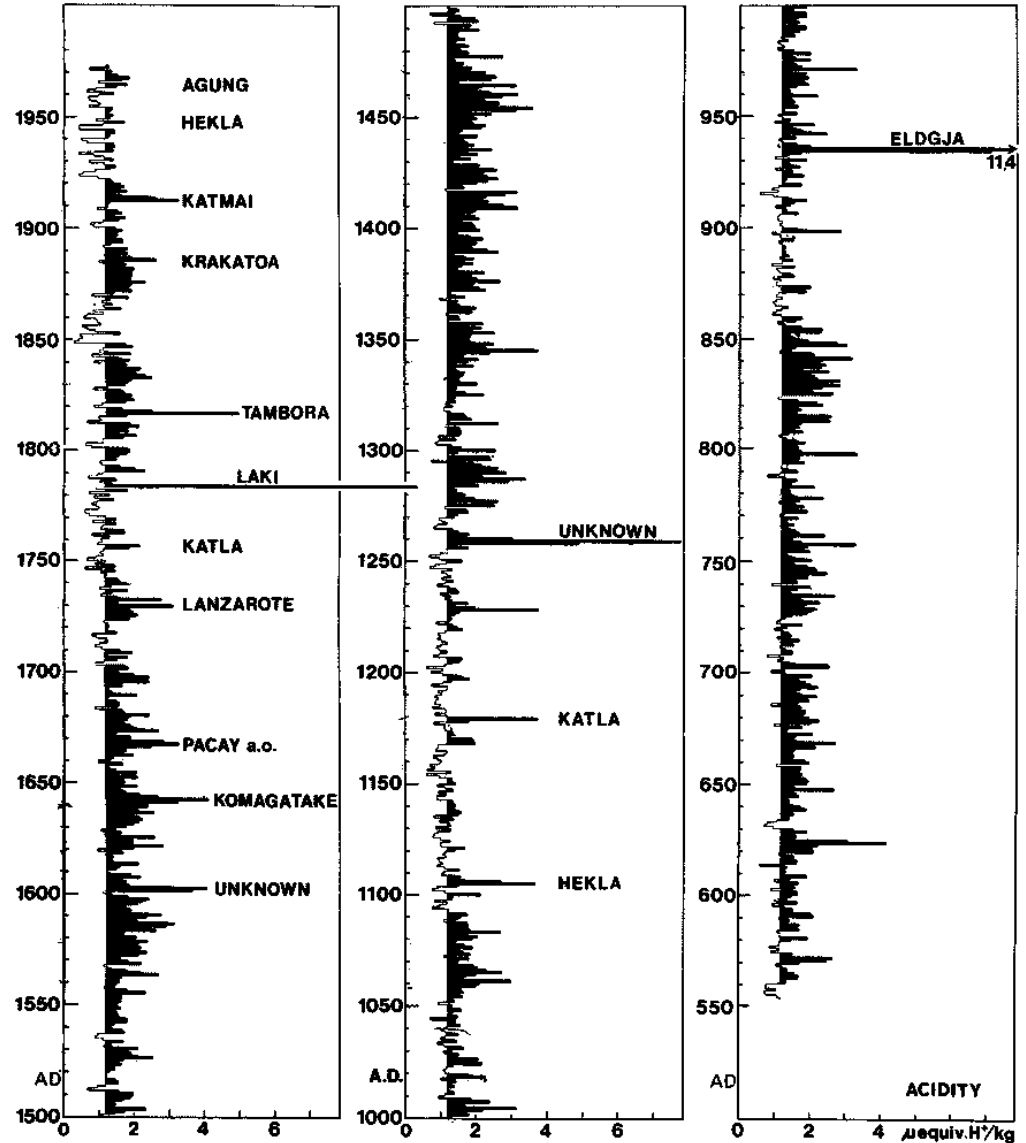




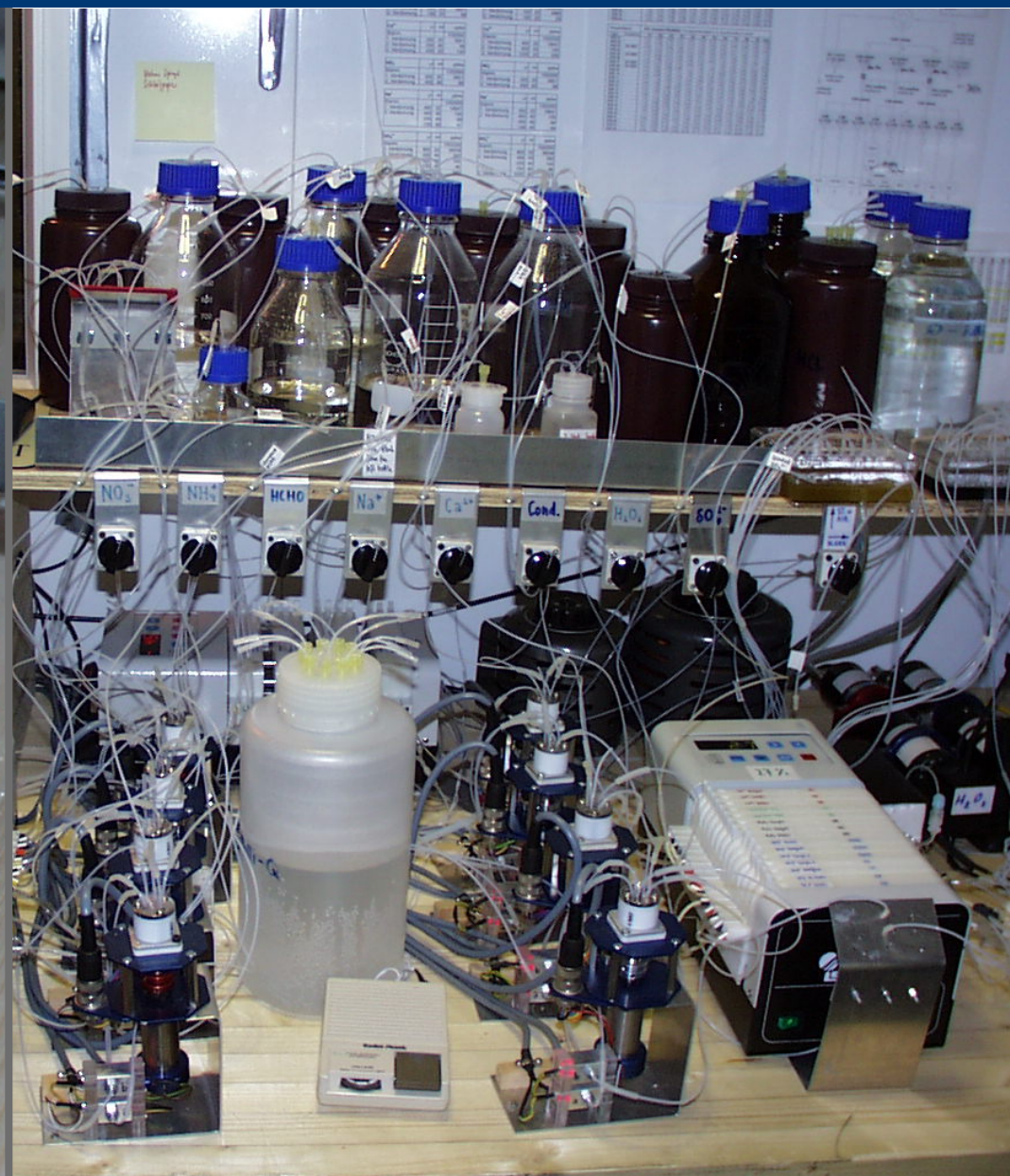
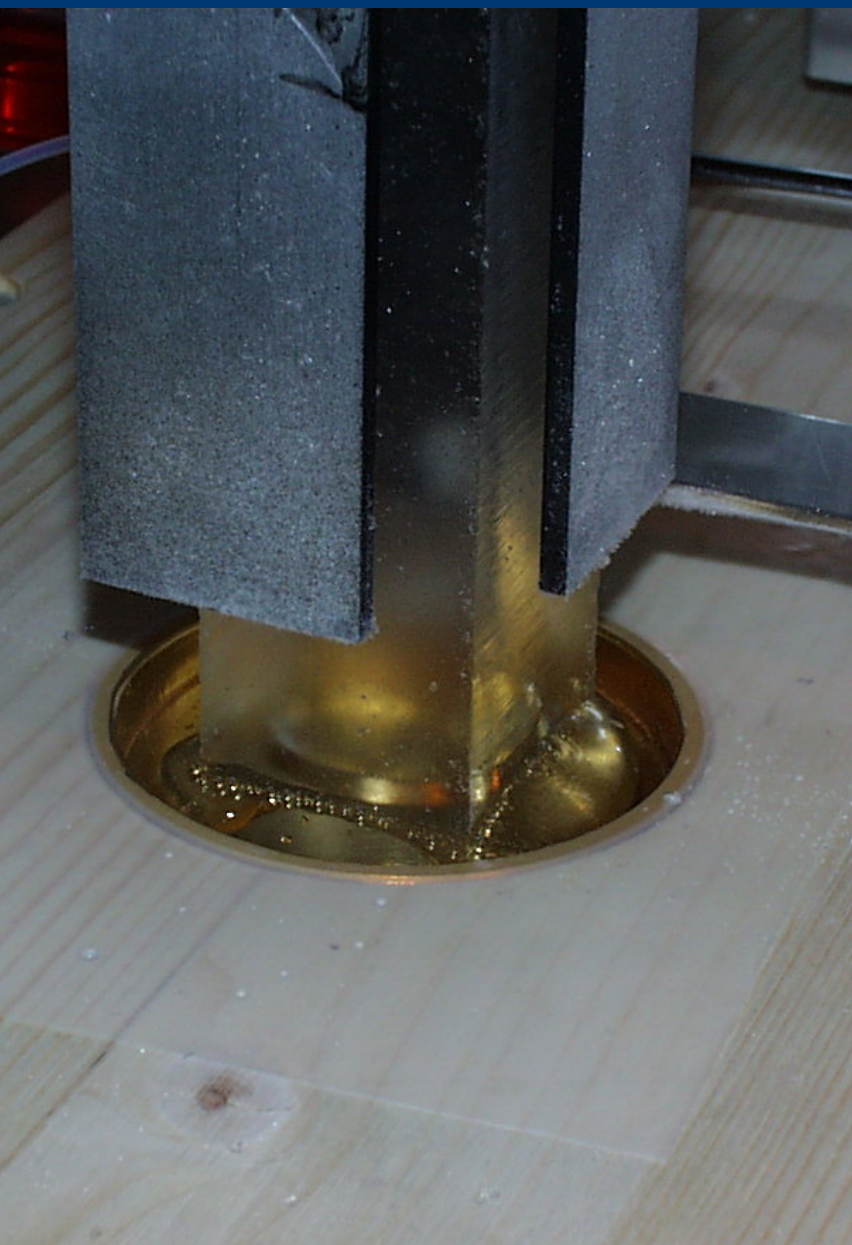


1. Fysiske egenskaber
2. Gasanalyser
3. Urenheder og støv
4. Stabile isotoper
5. Arkivstykke

Elektrisk ledningsevne

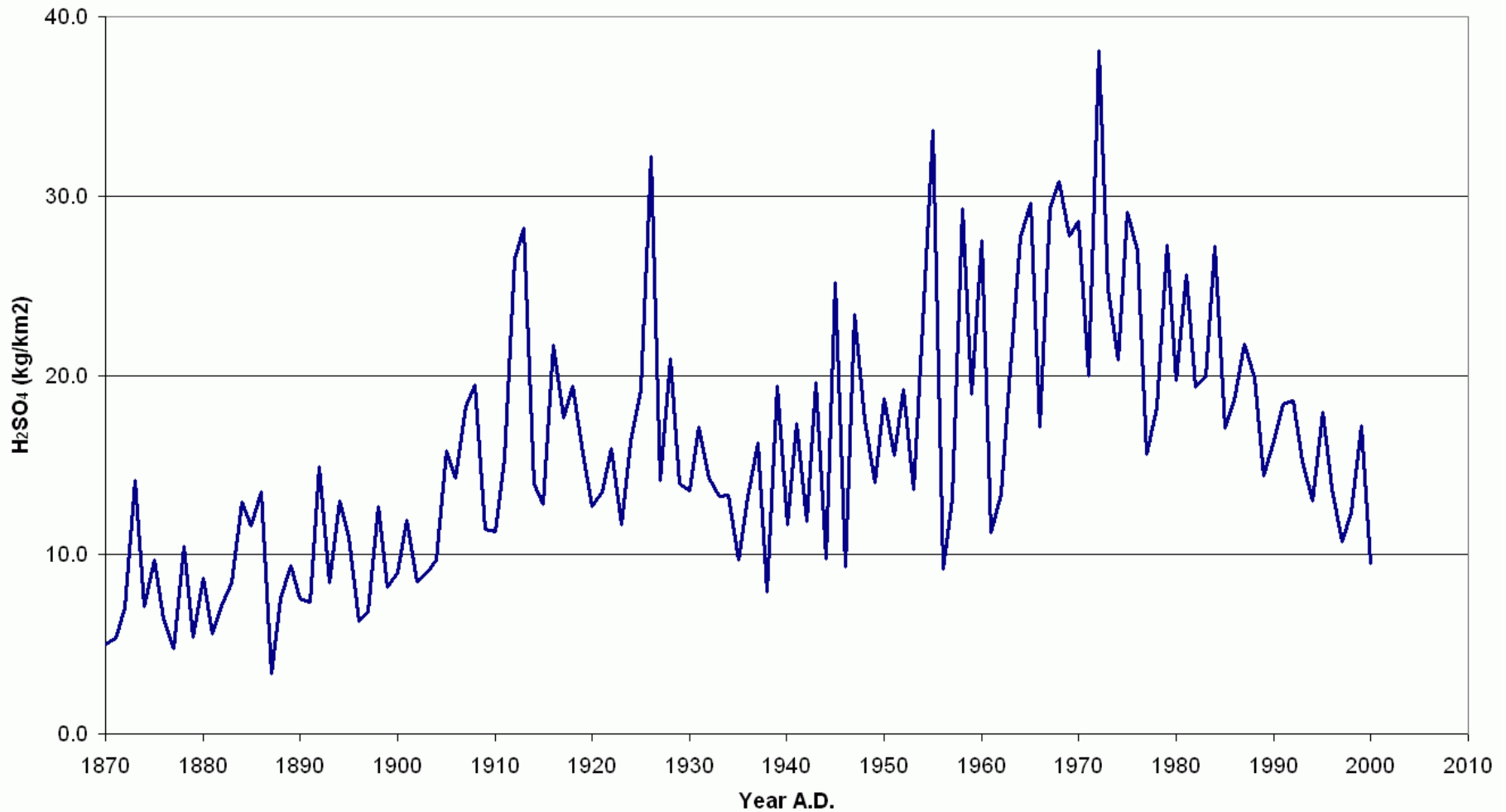


Urenheder og støv



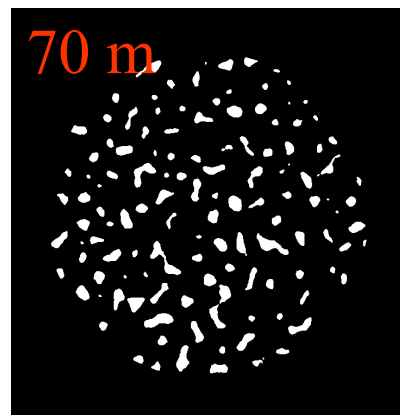
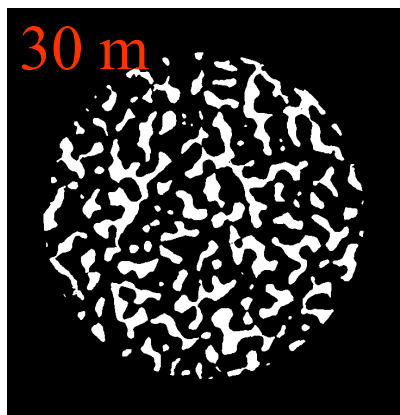
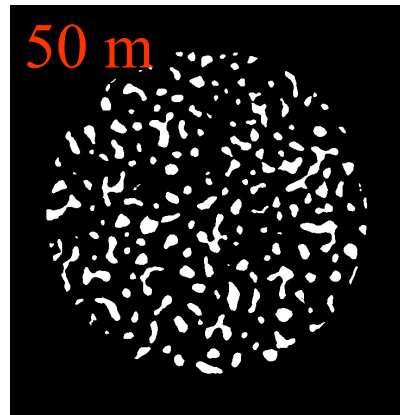
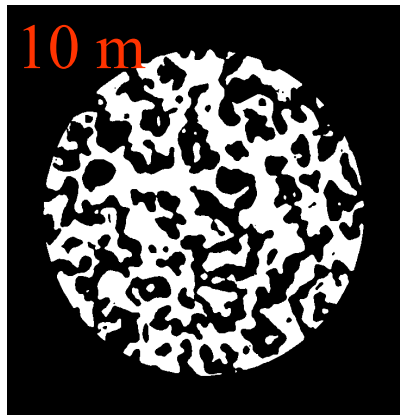
SO₂ emissioner blokerer for solen!

NGRIP Annual H₂SO₄ deposition

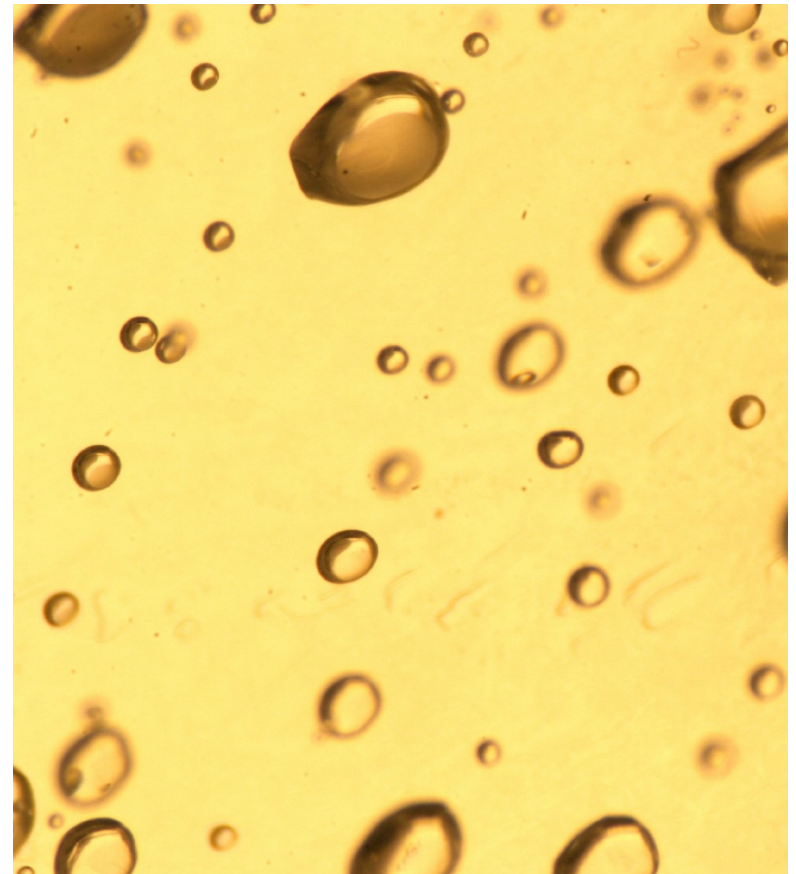


Luft-bobler i iskernerne

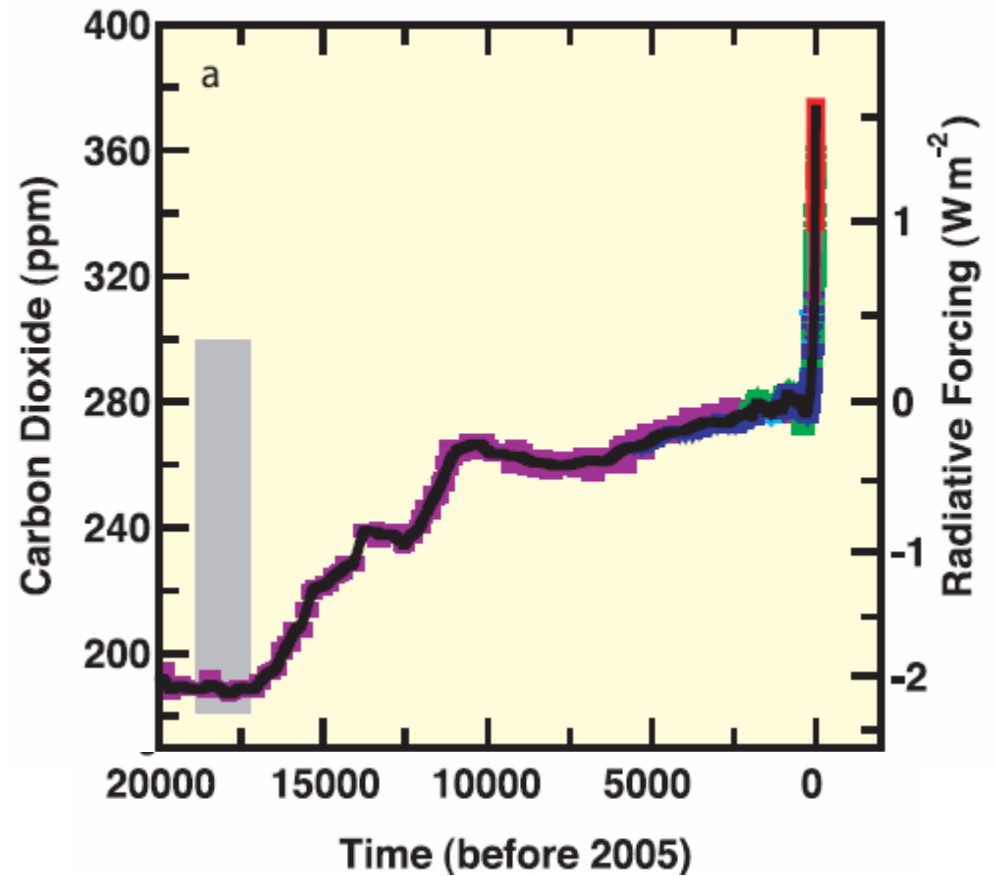
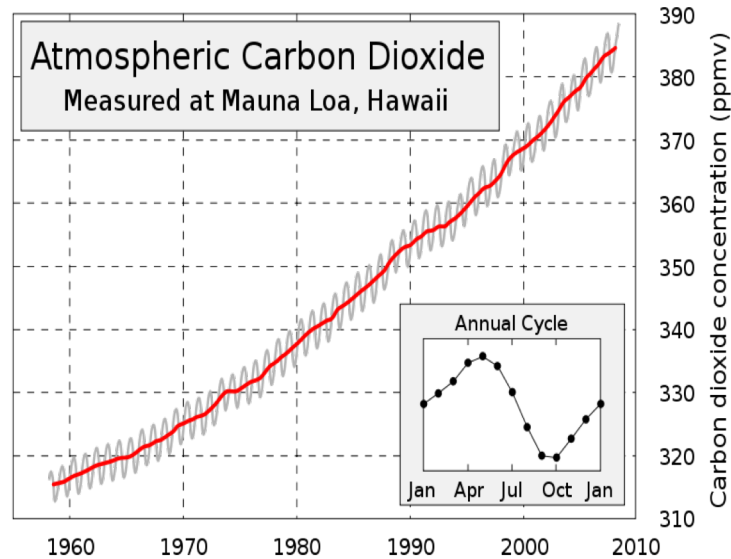
Fire tværsnit af en iskerne – luft er
Markeret med hvid – is med sort



Luft-bobler fanget i 2500 år gammel is



Målinger på bobler i isen giver os CO₂-historien langt tilbage i tiden



$\delta^{18}\text{O}$ – og temperature tilbage i tiden

S

N

$$\delta^{18}\text{O} = \frac{\left(\frac{^{18}\text{O}}{^{16}\text{O}}\right) - \left(\frac{^{18}\text{O}}{^{16}\text{O}}\right)_{\text{SMOW}}}{\left(\frac{^{18}\text{O}}{^{16}\text{O}}\right)_{\text{SMOW}}} \cdot 1000\text{‰}$$

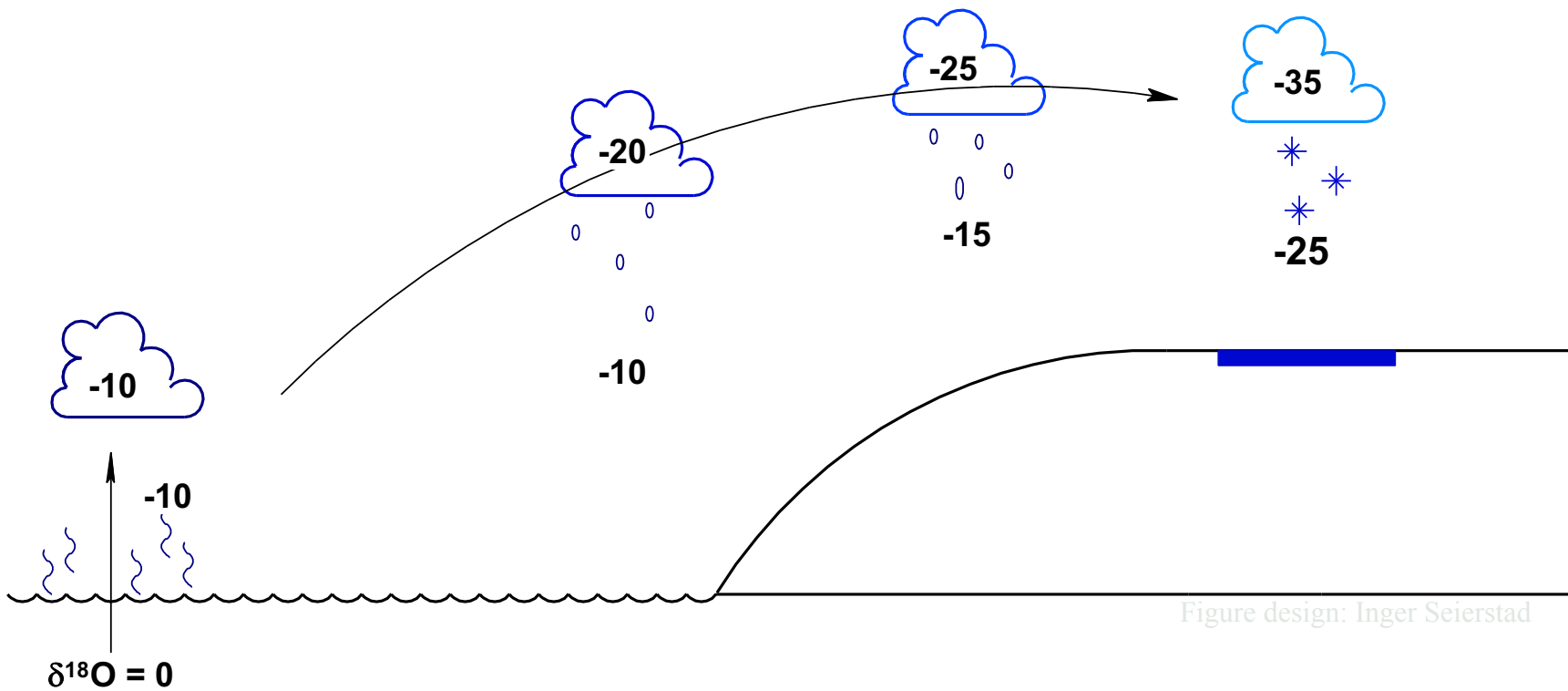


Figure design: Inger Seierstad

$\delta^{18}\text{O}$ – og temperature tilbage i tiden

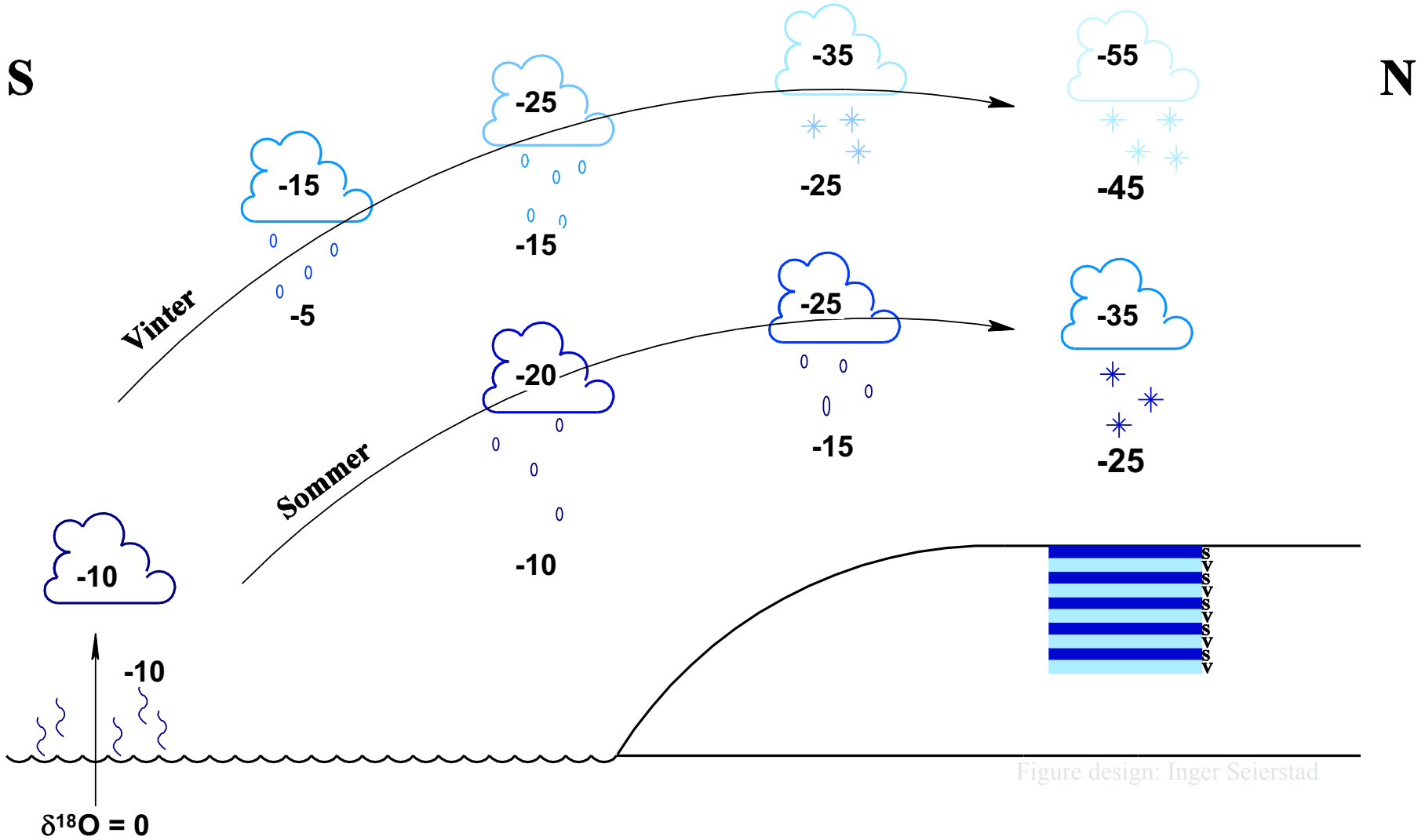
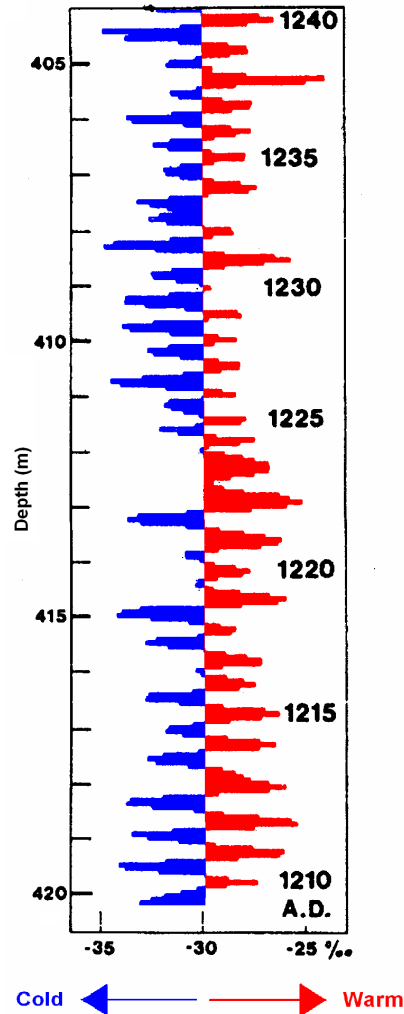
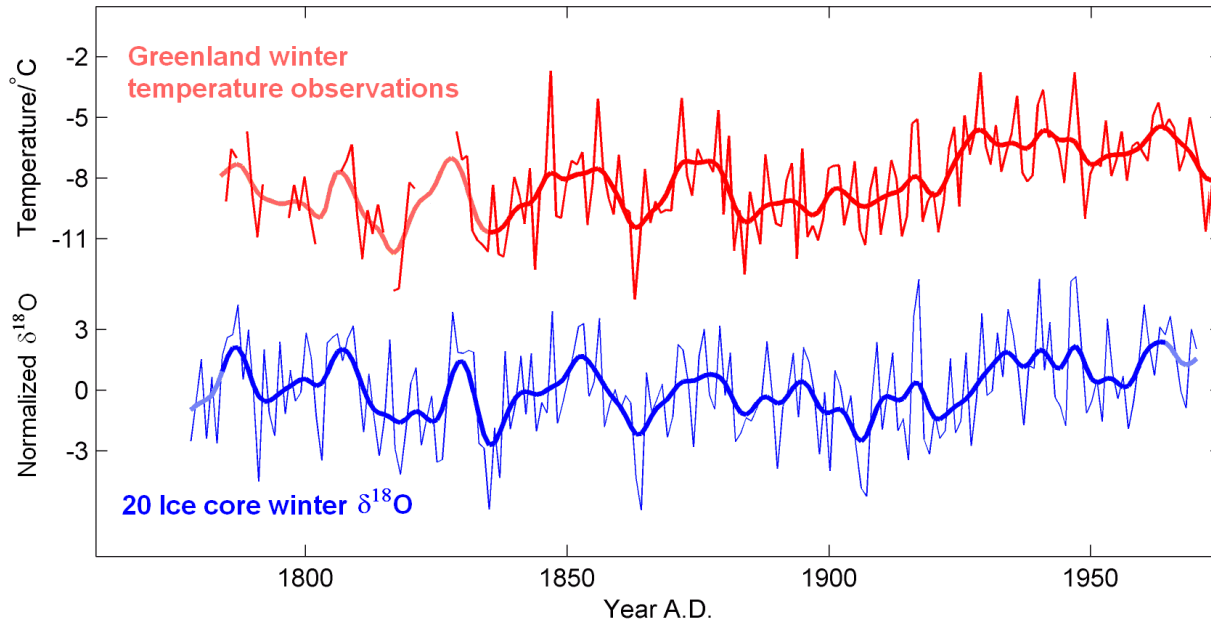


Figure design: Inger Seierstad

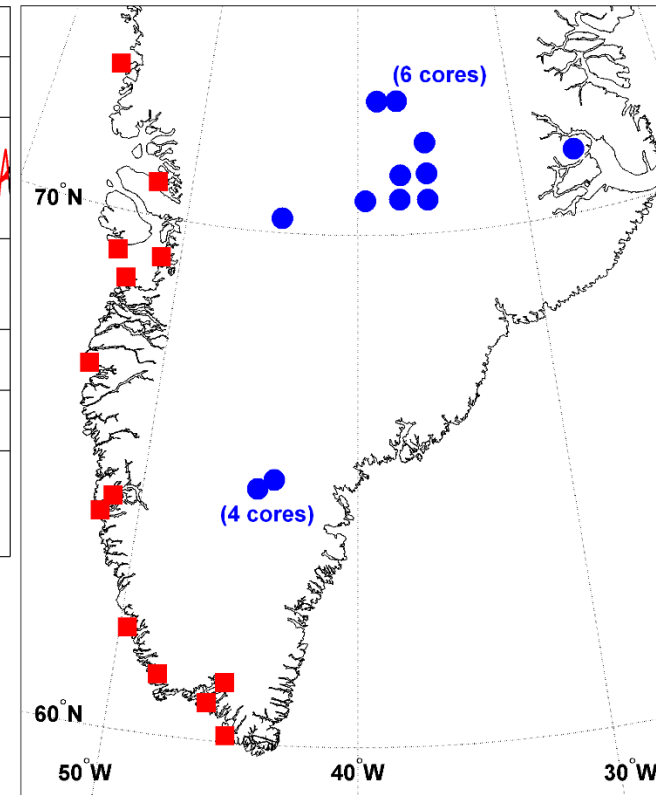
Annual oscillations



Iskerne $\delta^{18}O$ – en sammenligning med Grønlandske temperature-målinger



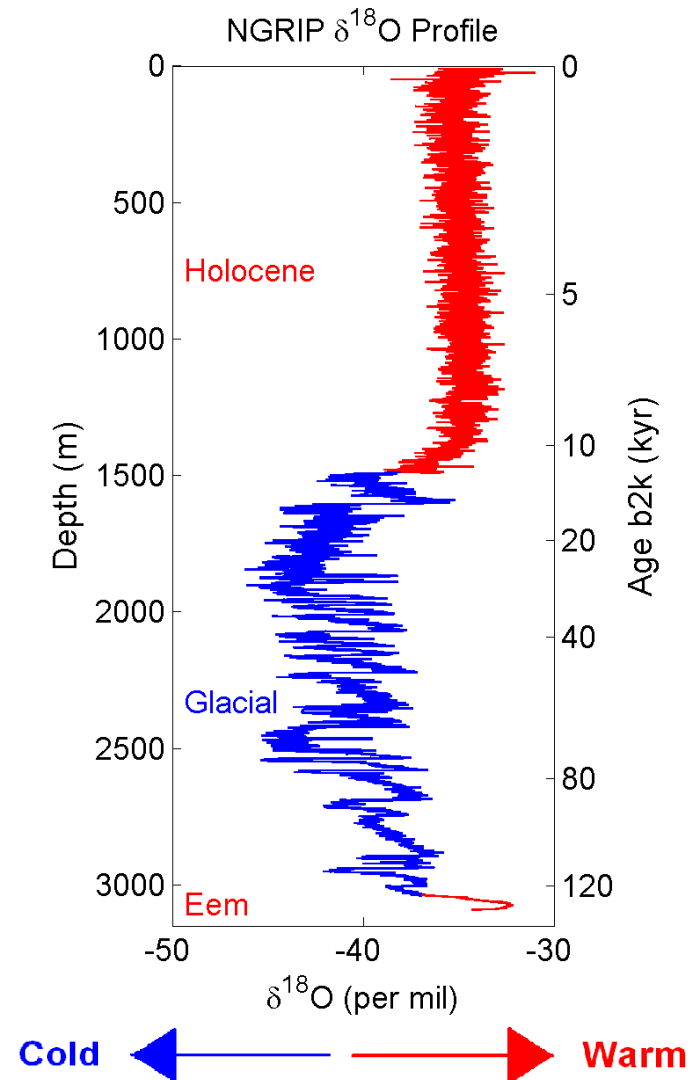
$$\delta^{18}O = \frac{\left(\frac{^{18}O}{^{16}O}\right) - \left(\frac{^{18}O}{^{16}O}\right)_{SMOW}}{\left(\frac{^{18}O}{^{16}O}\right)_{SMOW}} \cdot 1000\text{‰}$$



Reference

Vinther, B.M., Jones, P.D., Briffa, K.R., Clausen, H.B., Andersen, K.K. and Johnsen, S.J., Climatic signals in multiple highly resolved Greenland stable isotope records, QSR, 2010.

- 3090 meter lang iskerne
- Næsten 100,000 $\delta^{18}\text{O}$ prøver
- 125.000 års historie



Sommer-solindstrålingen i Arktis er afgørende for klimaet:

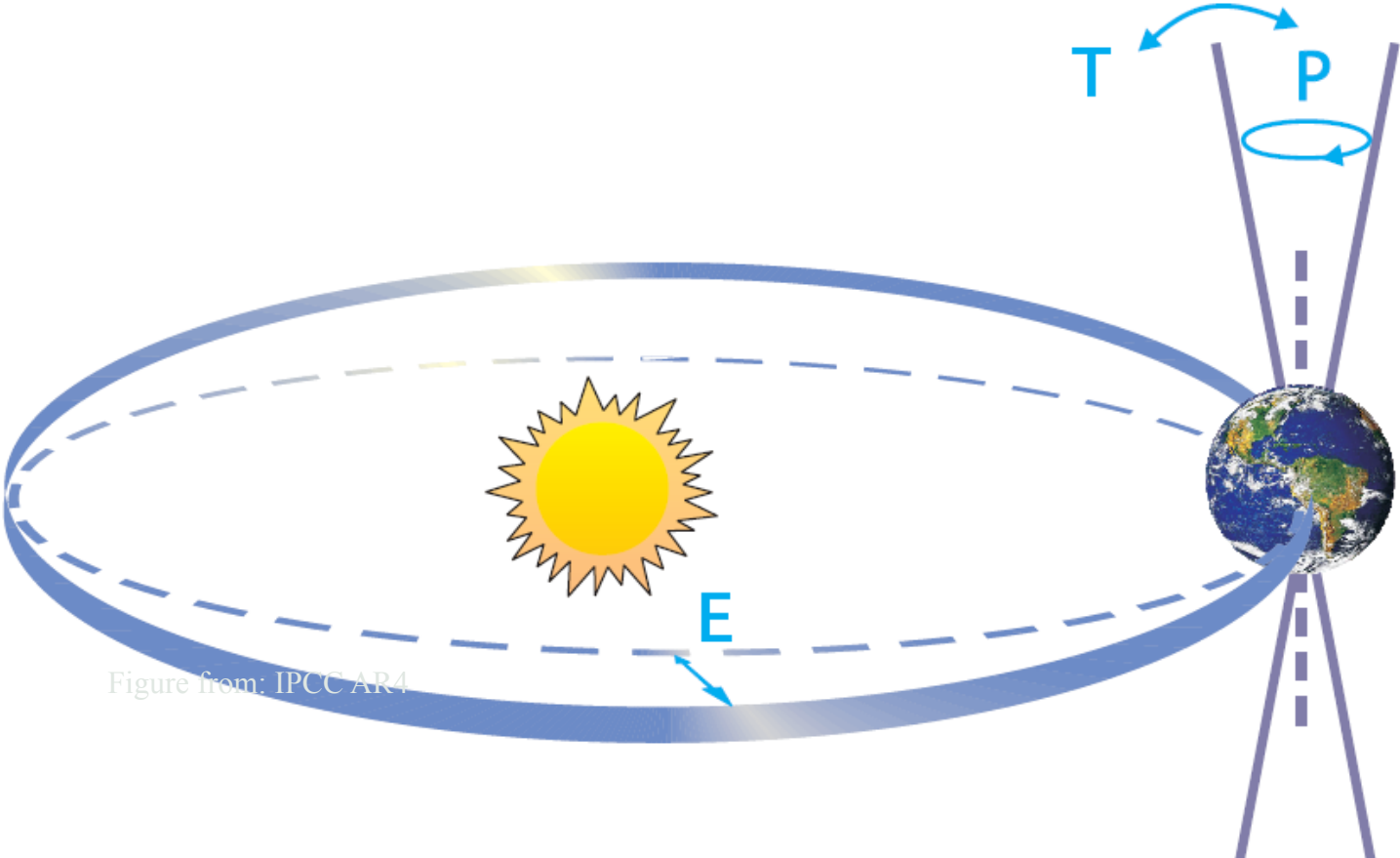
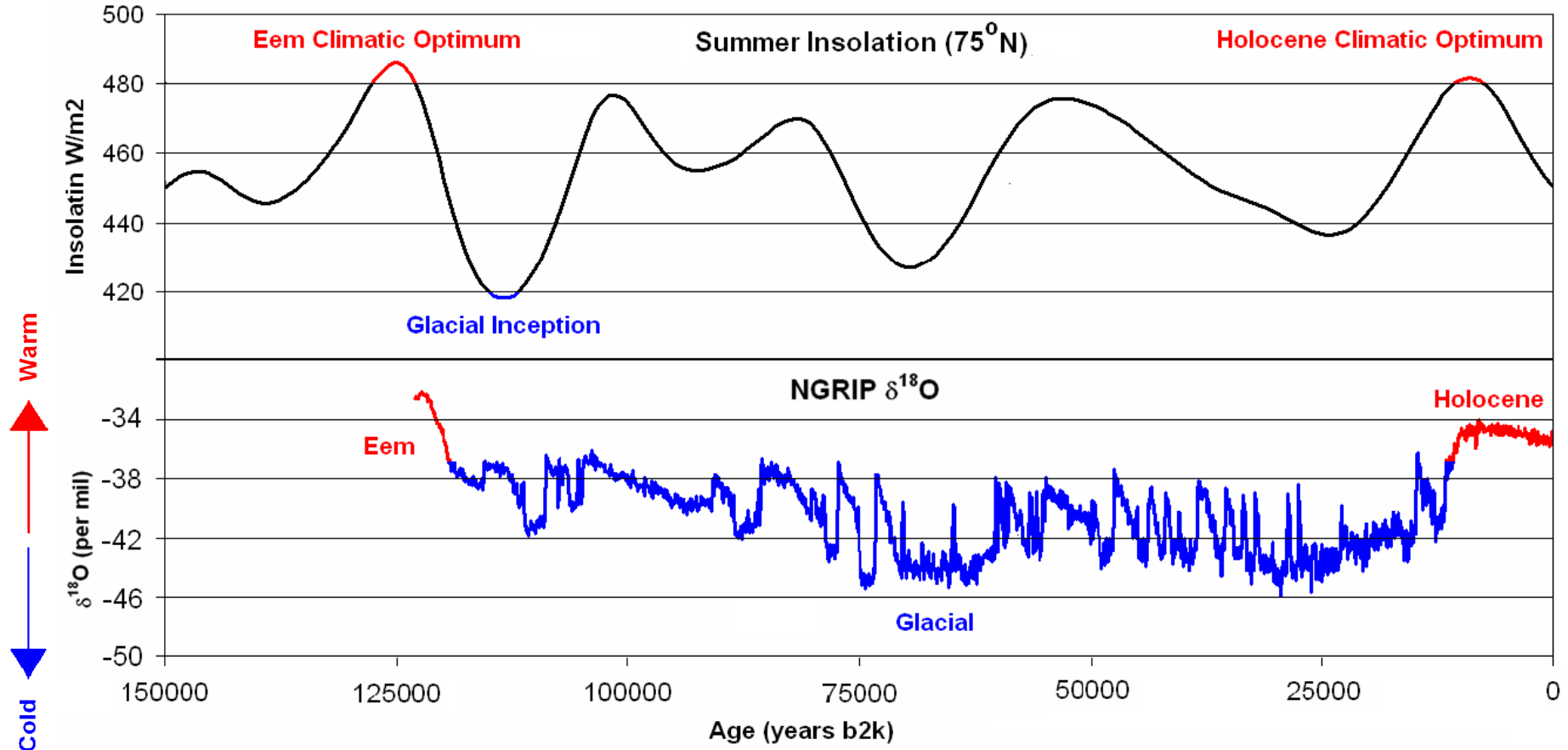


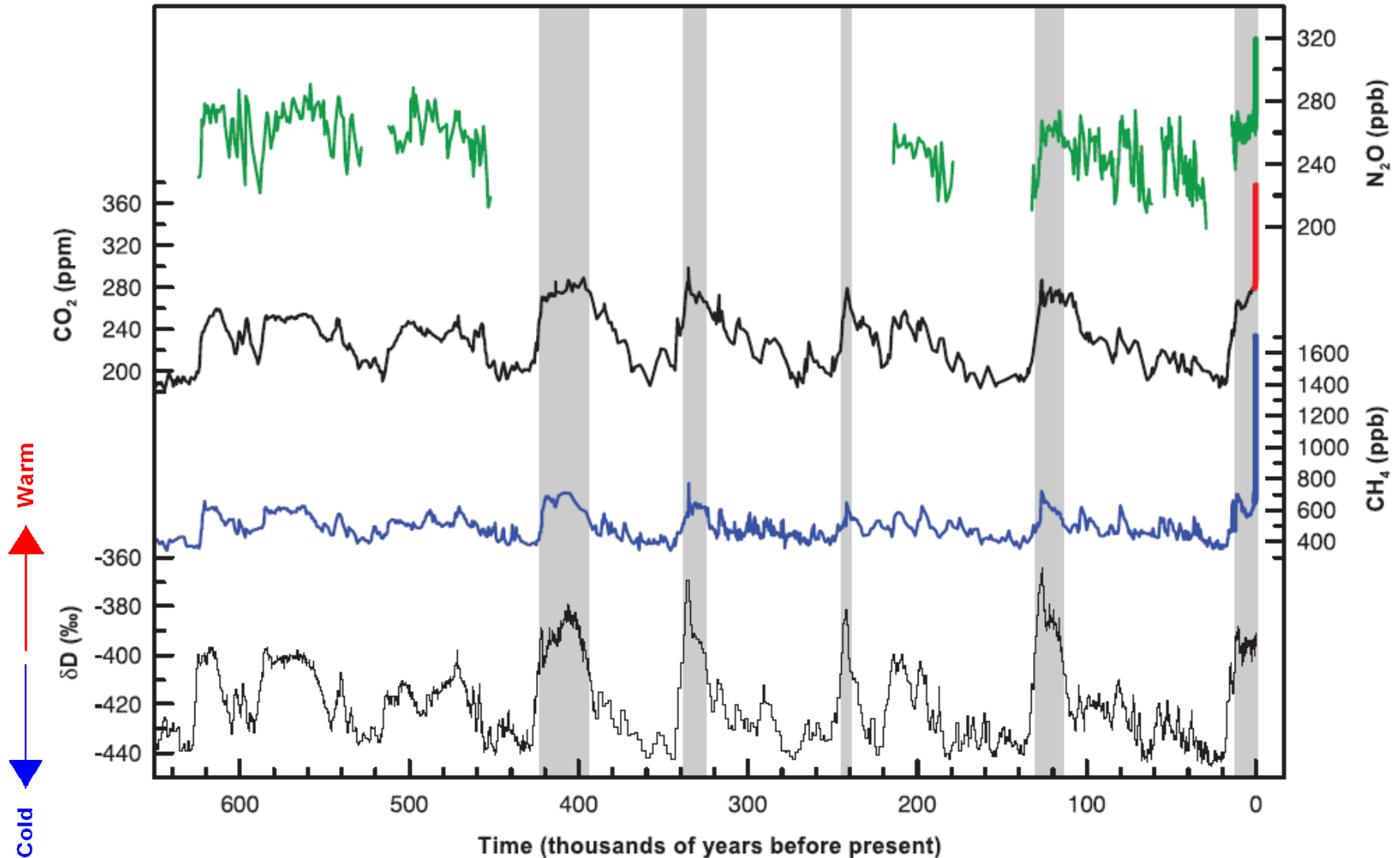
Figure from: IPCC AR4

Klimaet gennem den seneste istid

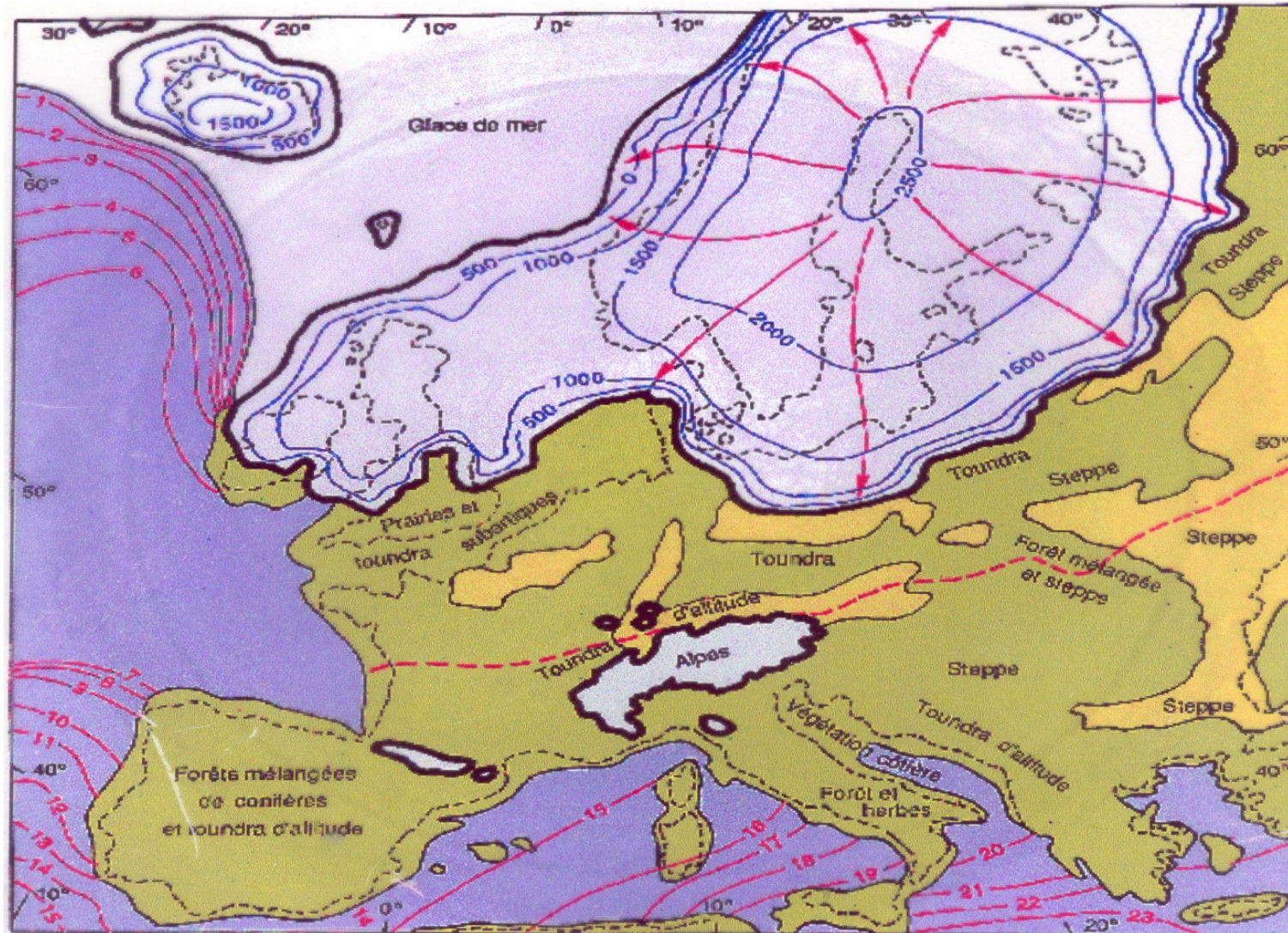


Faktisk hele 650000 år tilbage i tiden...

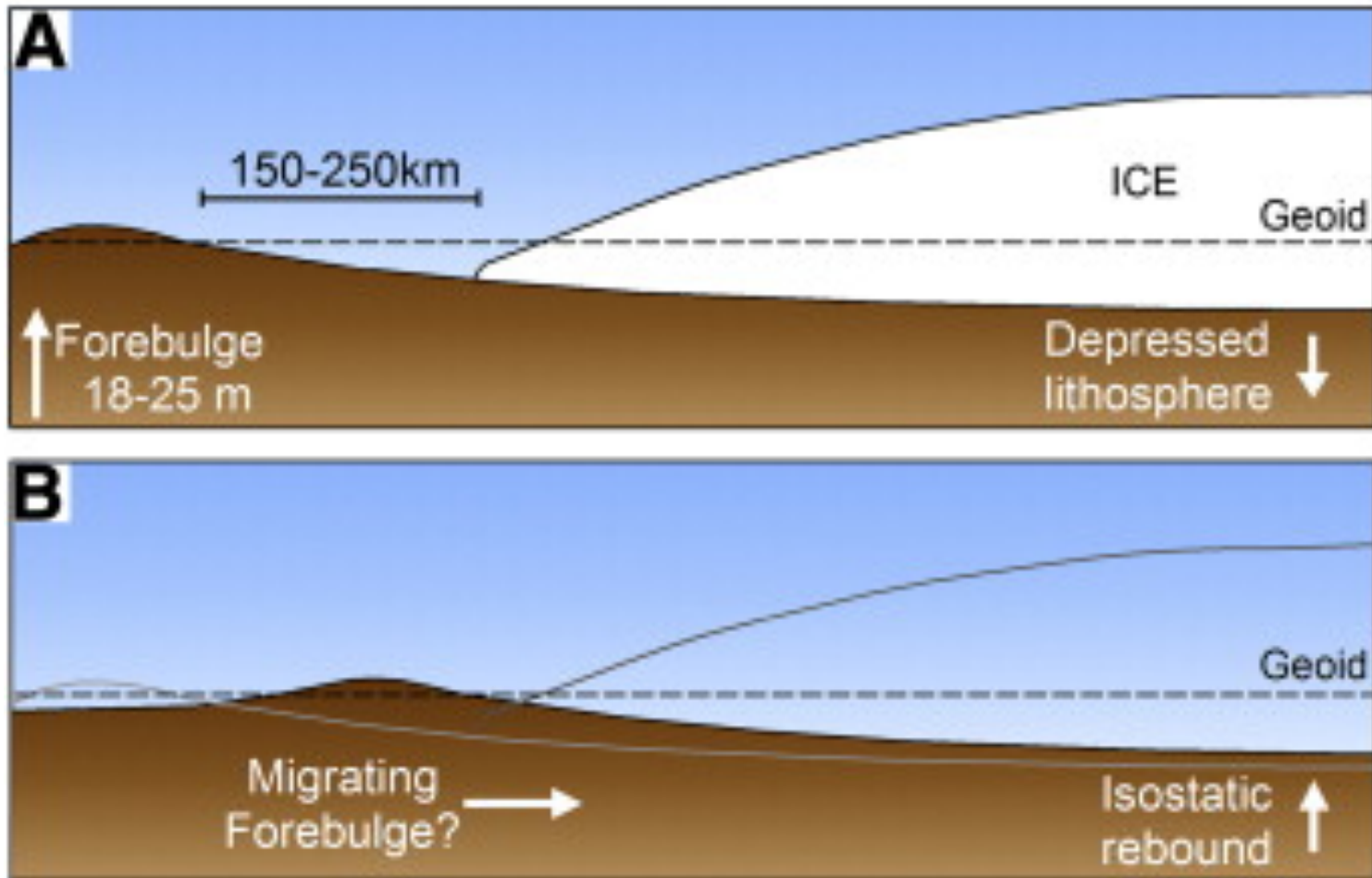
GLACIAL-INTERGLACIAL ICE CORE DATA



Seneste istid – en helt anden verden!



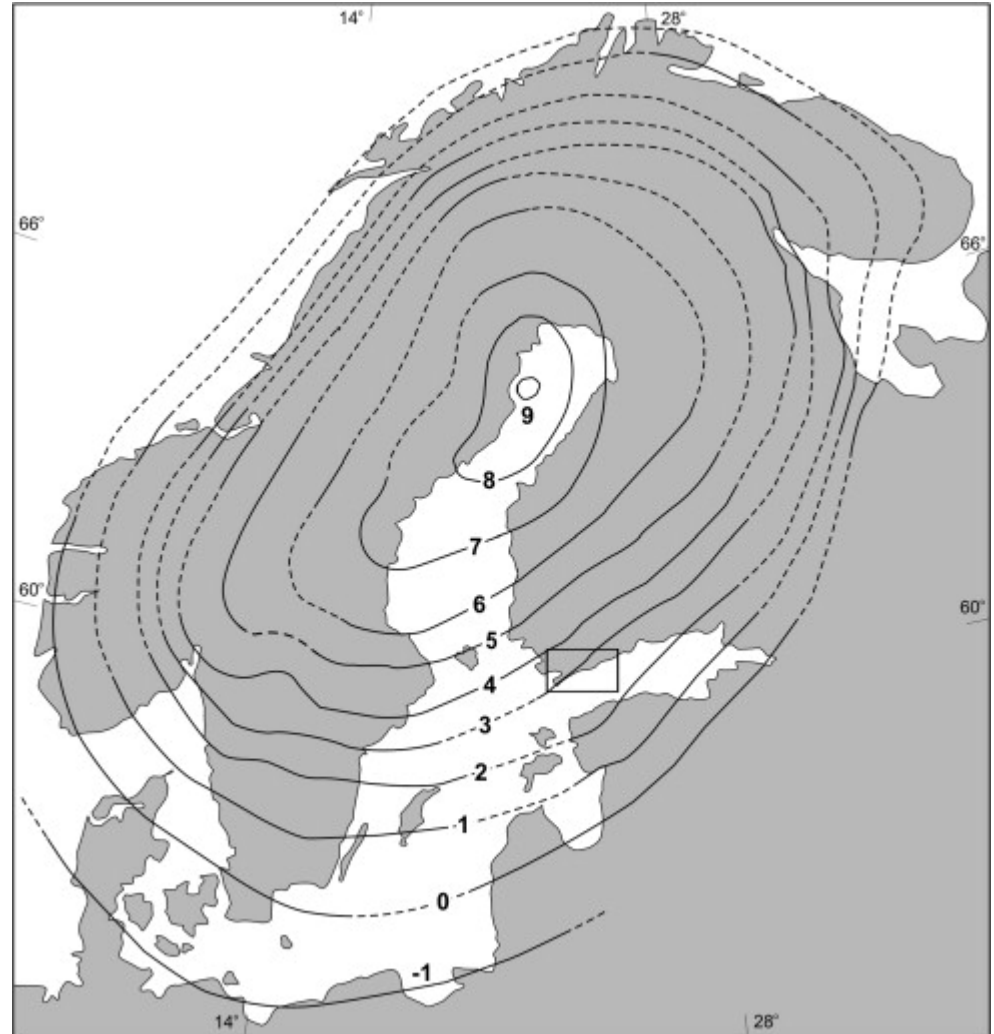
Men så forsvandt isen over Skandinavien



Og der er stadig landhævning...

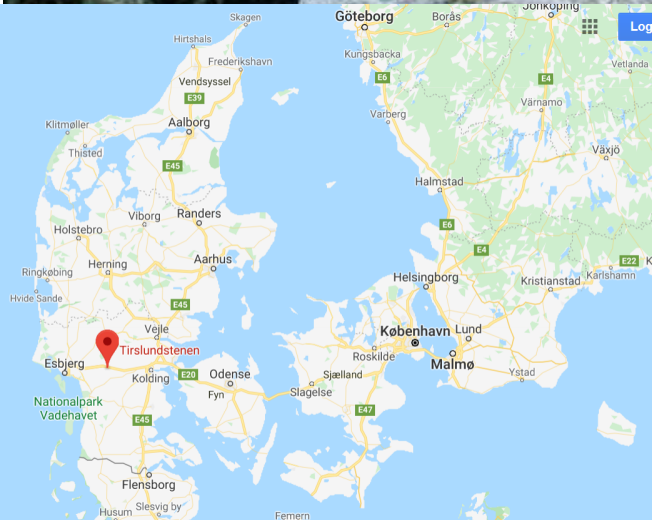
- Nuværende rater for landhævning i mm/år.

Fra: Miettinen et al.,
Marine Geology 2007.

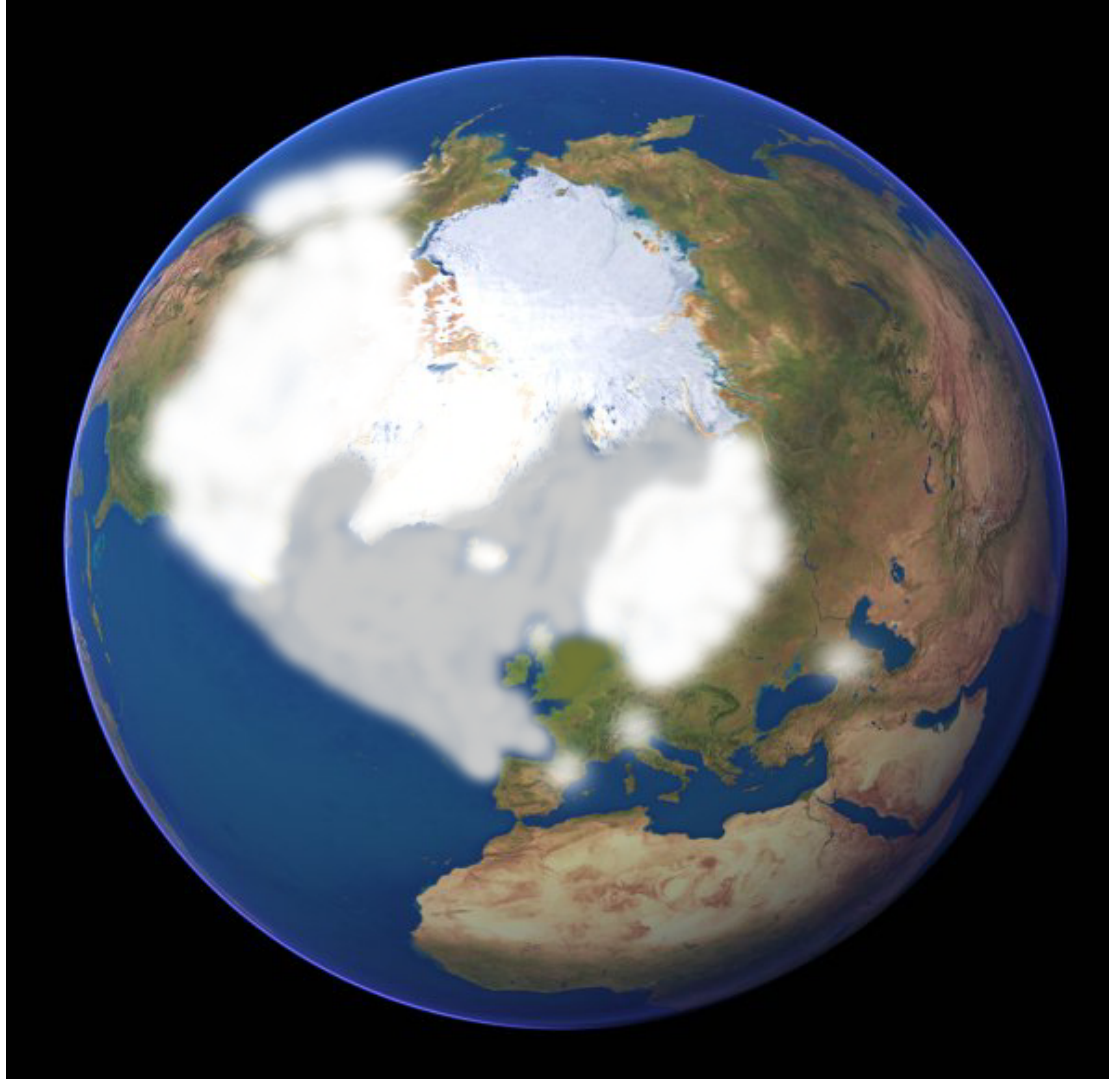


Og efterladen-skaber fra iskappen!

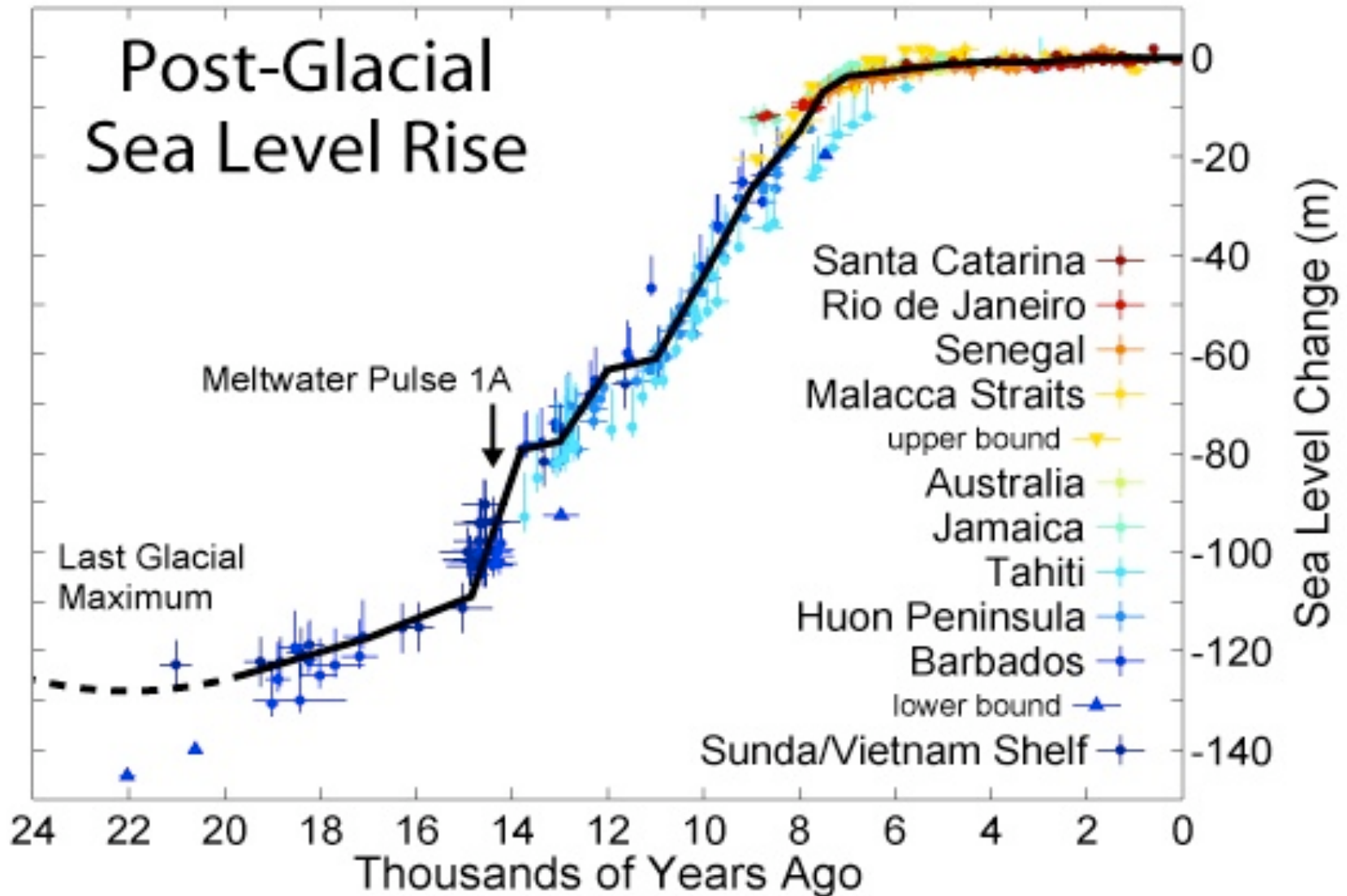
Tirslundstenen



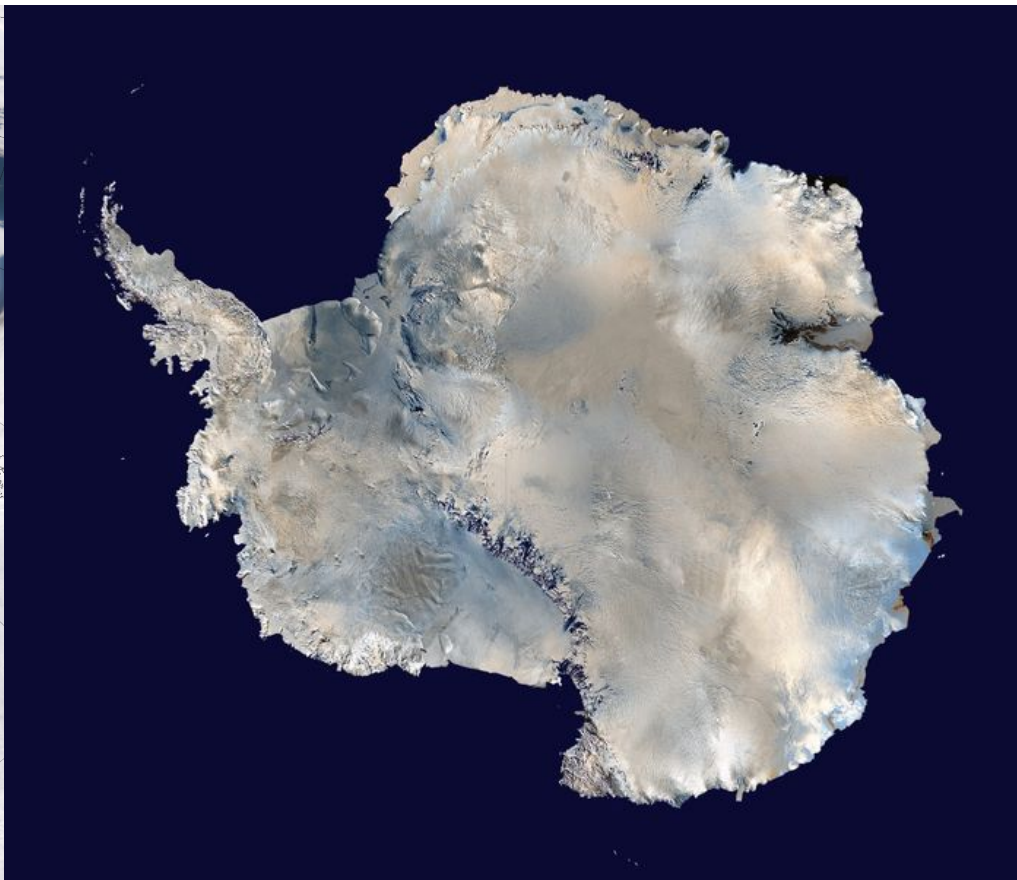
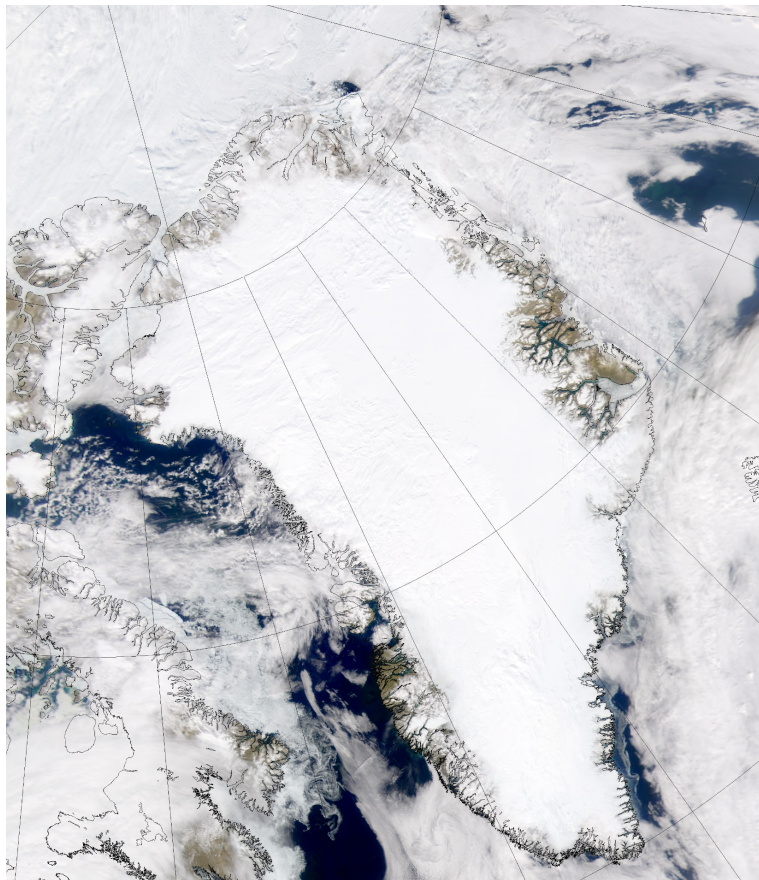
Istiden havde enorme iskapper



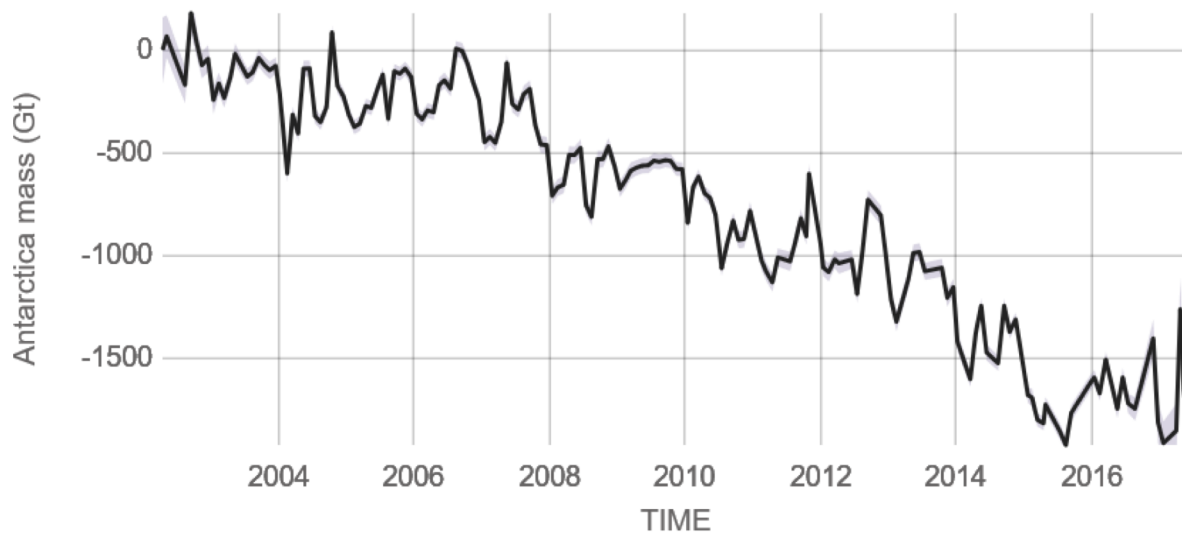
Da de smeltede steg havet med 120m !!



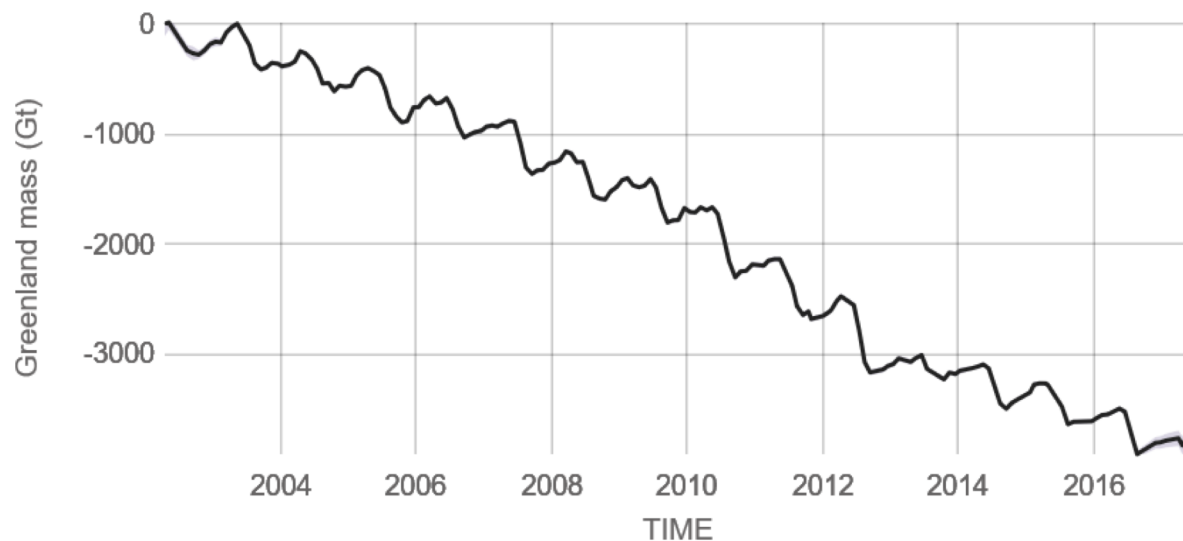
Stadig ca. 70m vand bundet i iskapper...



De er nu – så småt – begyndt at smelte...

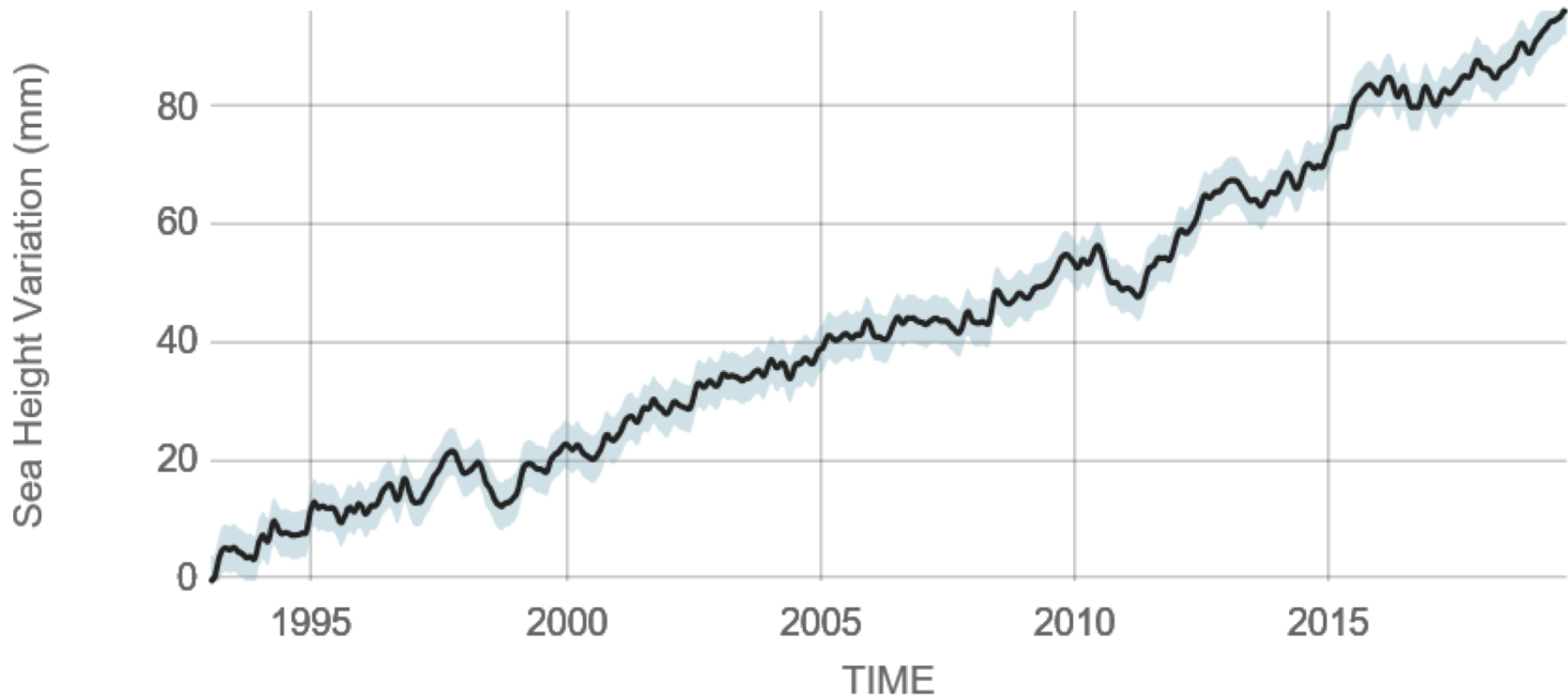


Source: climate.nasa.gov



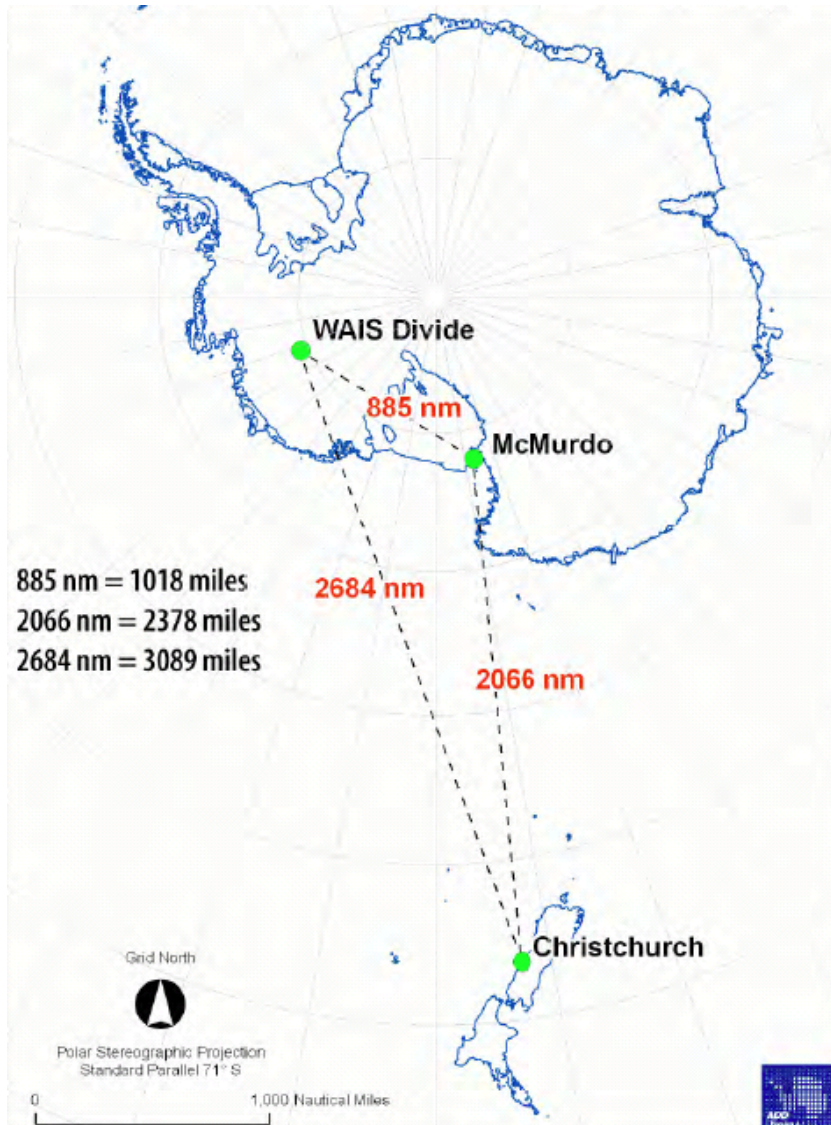
Source: climate.nasa.gov

Og havet stiger med ca. 3,3mm om året



Source: climate.nasa.gov

WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010

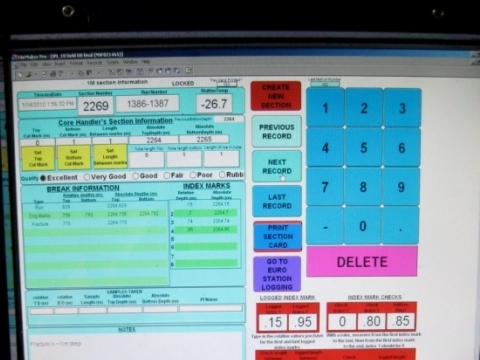
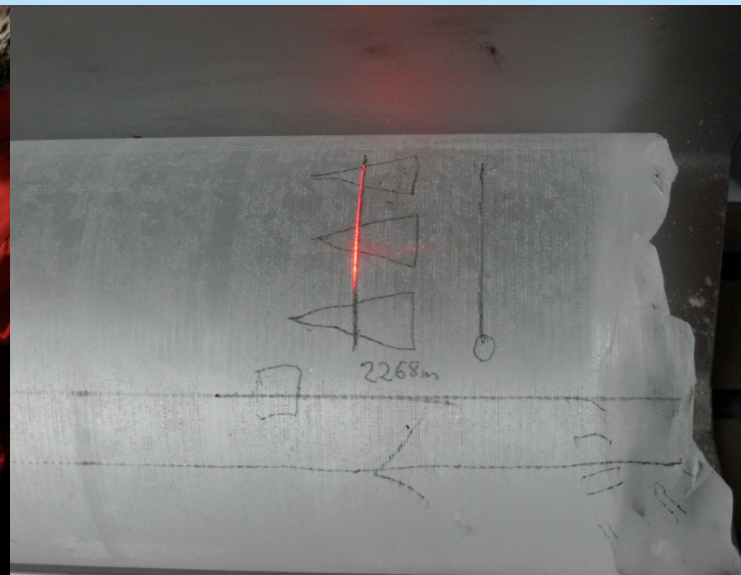
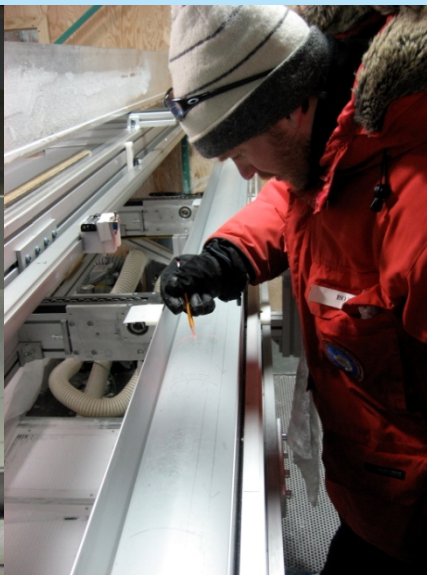


WAIS Divide 2009-2010

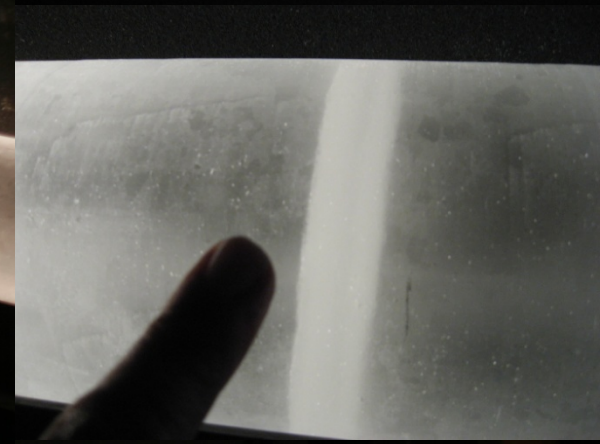
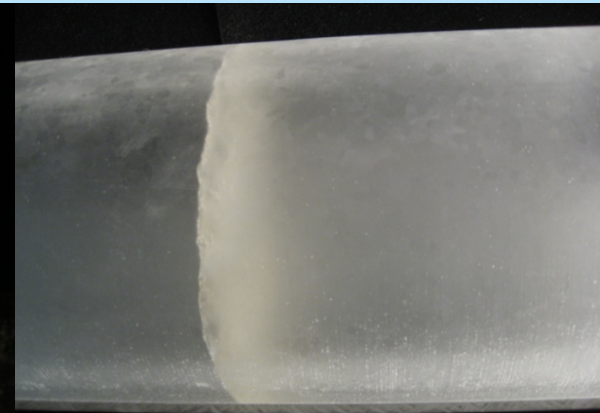
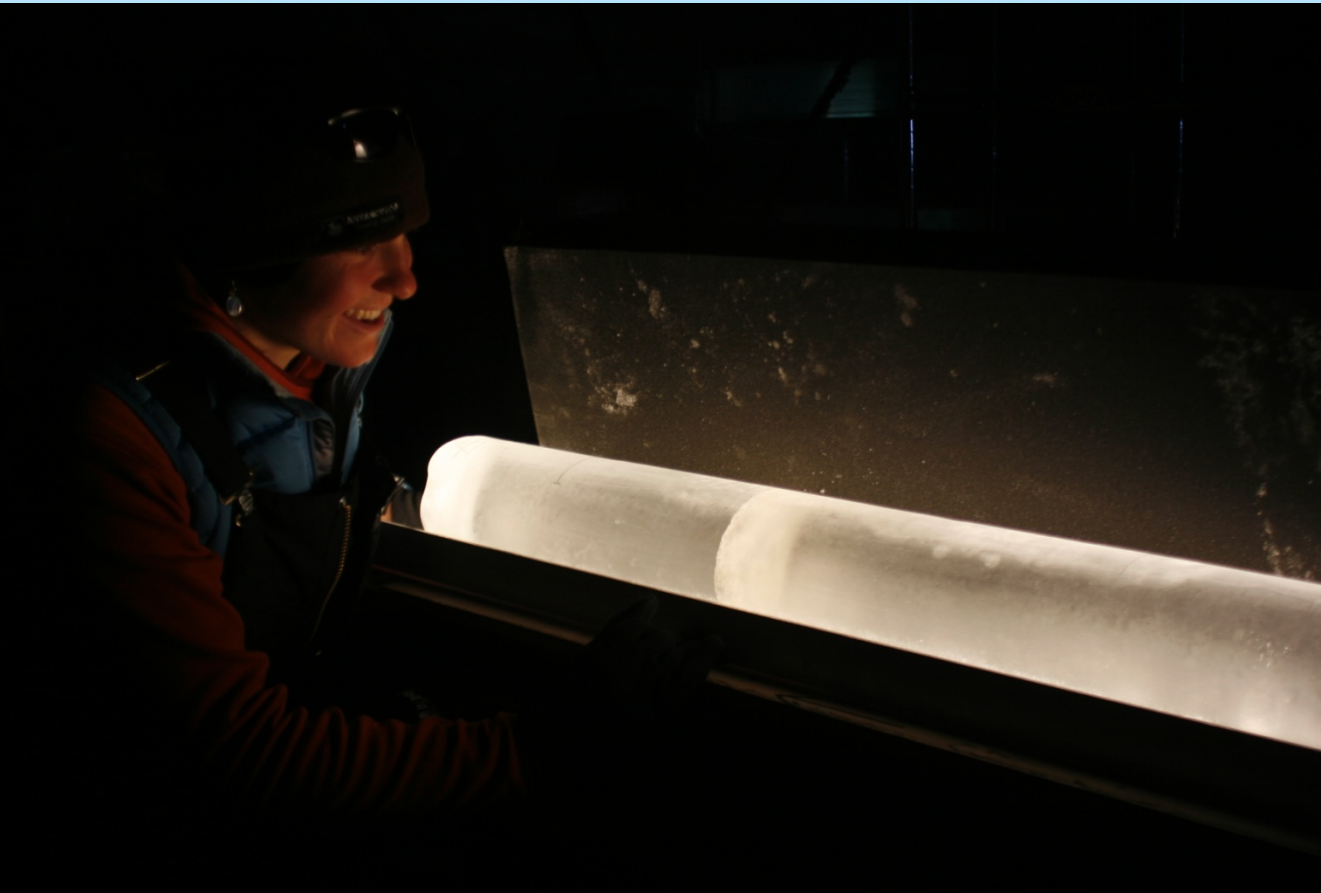


RECEIVING STATION											
DATE	TIME	TEMPERATURE	LOCATION	STATUS	1	2	3	4	5	6	
1385	-25.5	7:42:31 AM	1/14/2010	1/14/2010 7:30:36	1	2	3	4	5	6	
ICE INFUSION											
AMOUNT	RELATIVE HUMIDITY	WATER VAPOR	WATER WEIGHT	WATER VOLUME							
0	3.302	3.302	-151	2261.059							
ACCEPTED BY (LAB/STATION)											
DATE	TIME	TEMPERATURE	LOCATION	STATUS							
1/14/2010	7:30:36	121.52	-33.6								
QUALITY											
Excellent ● Very Good ● Good ● Fair ● Poor ● Bubble											
NOTES (You are being recording notes into the data station system)											
CHECKS											
Count	Calculated	Count	Calculated	Count	Calculated	Count	Calculated	Count	Calculated	Count	Calculated
0		0		0		0		0		0	

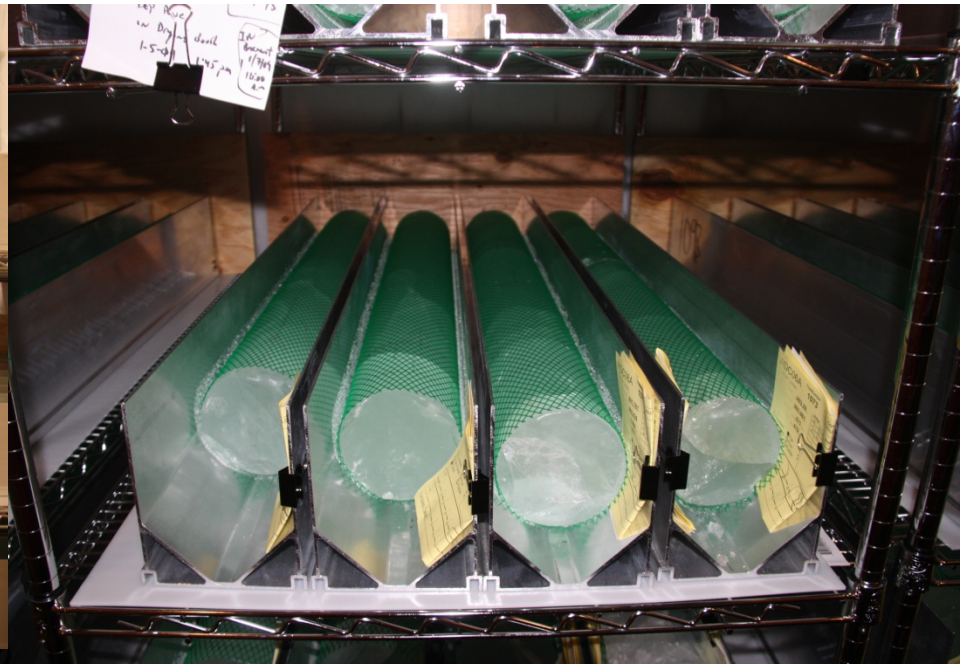
WAIS Divide 2009-2010



WAIS Divide 2009-2010



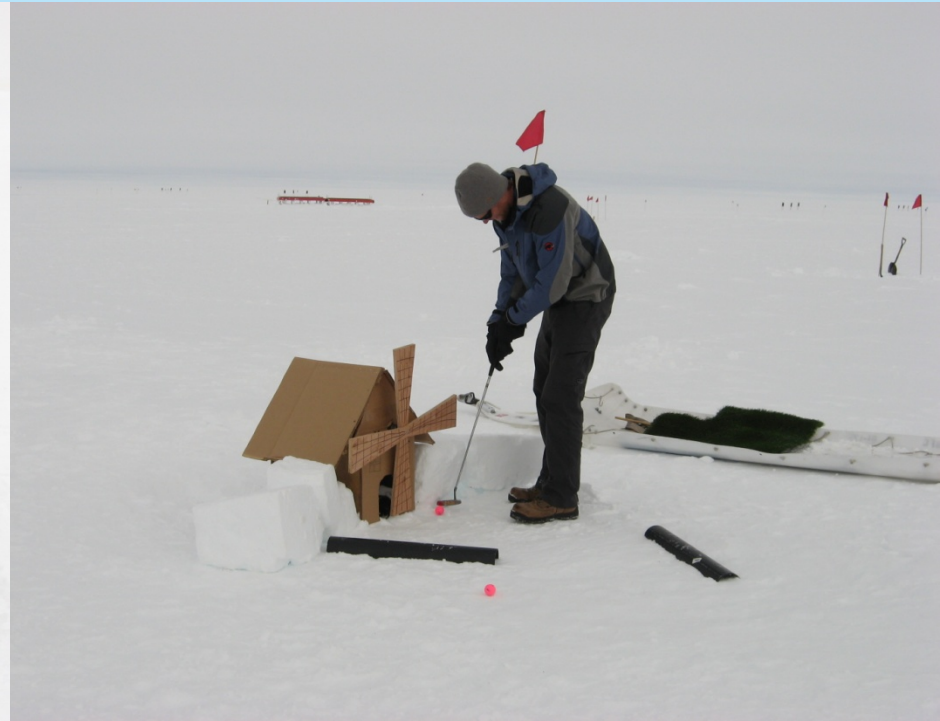
WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010



WAIS Divide 2009-2010





Tak for opmærksomheden!

