

An aerial photograph of a tundra landscape in Greenland, showing a complex network of braided rivers. The water is a milky turquoise color, and the surrounding ground is a mix of light-colored rocks and low-lying vegetation. The rivers flow in various directions, creating a dense, interconnected pattern.

Grönland: Klimawandel und Auswirkungen auf den Eisschild

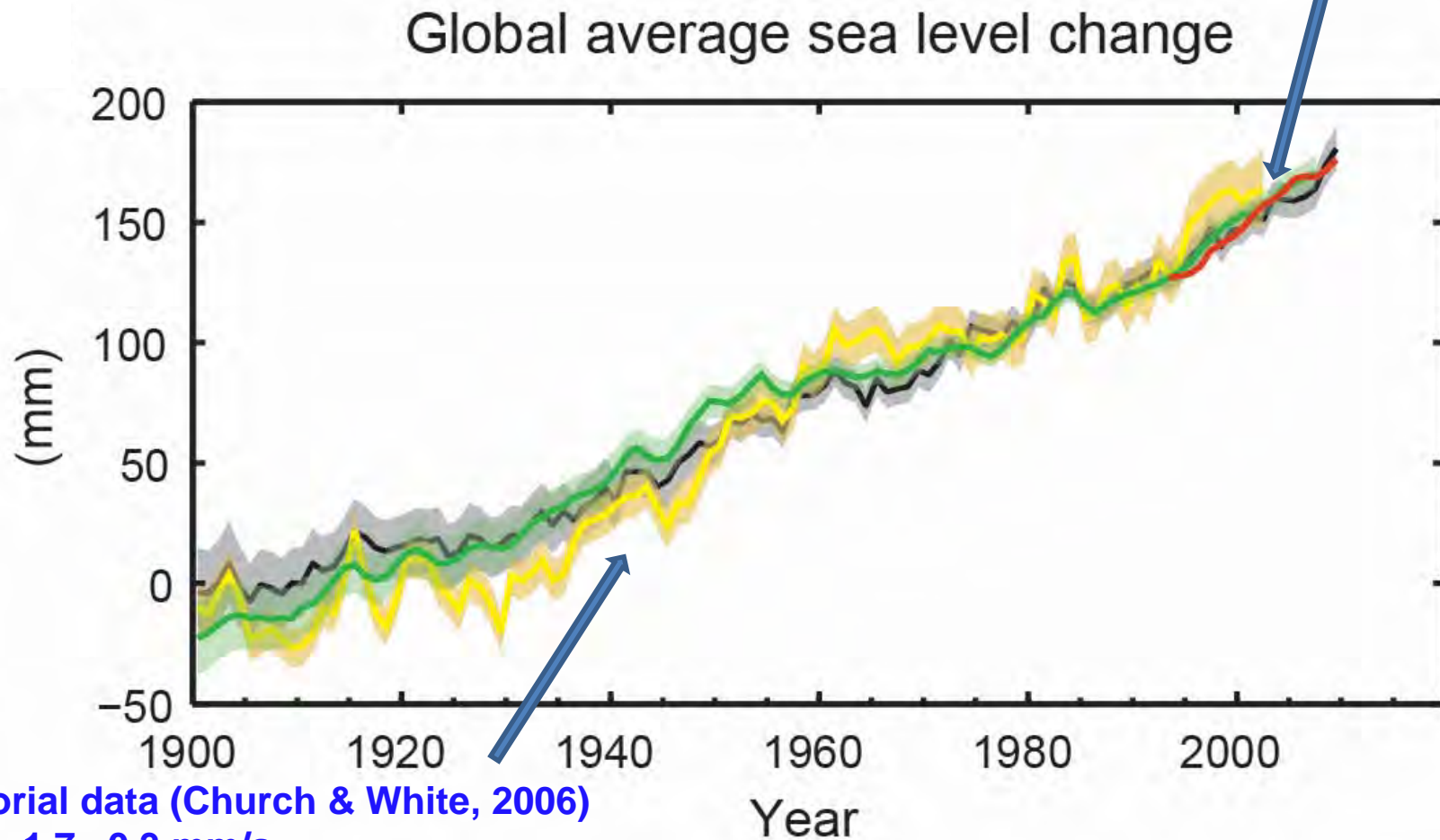
Konrad Steffen

Swiss Federal Research Institute WSL

IAC-ETH, ENAC-EPFL

Globale mittlere Meeresspiegel seit 1900

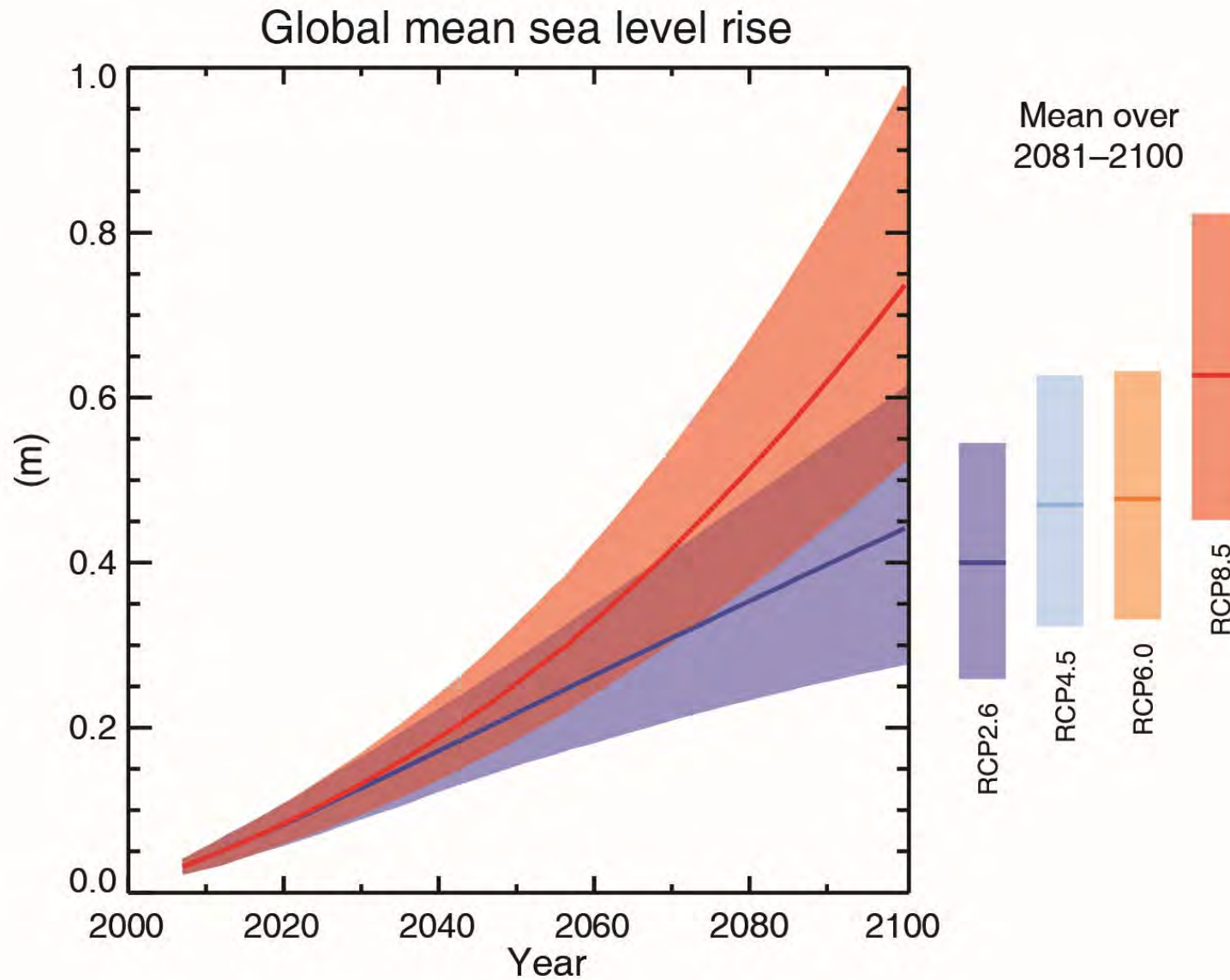
Satellite altimetry era (since 1993)
Rate: 3.3 ± 0.4 mm/a



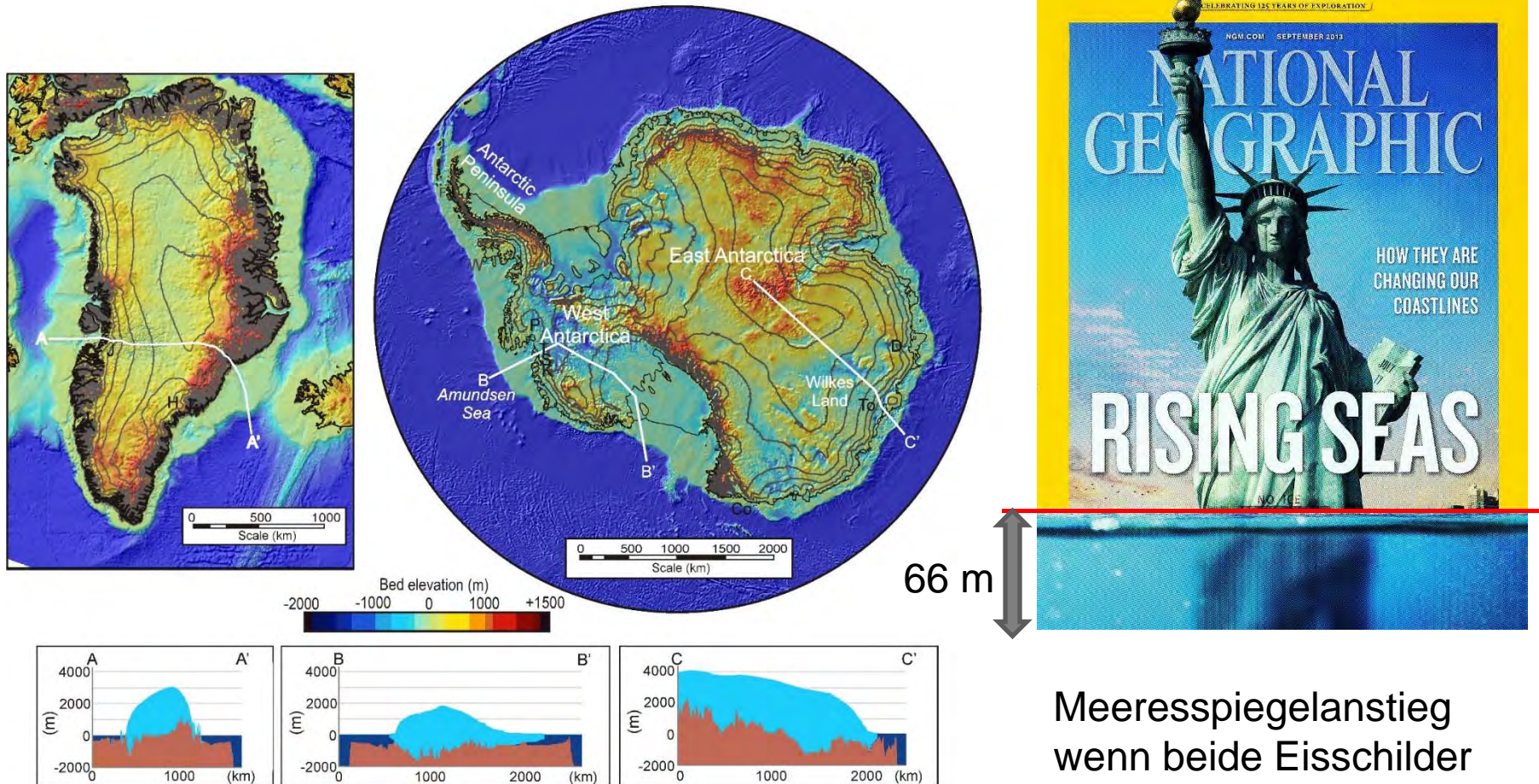
Historical data (Church & White, 2006)
Rate: 1.7 ± 0.3 mm/a

IPCC AR5 Globaler Meerspiegelanstieg

IPCC: Intergovernmental Panel for Climate Change -Weltklimarat



Eisschilder in Grönland und der Antarktis

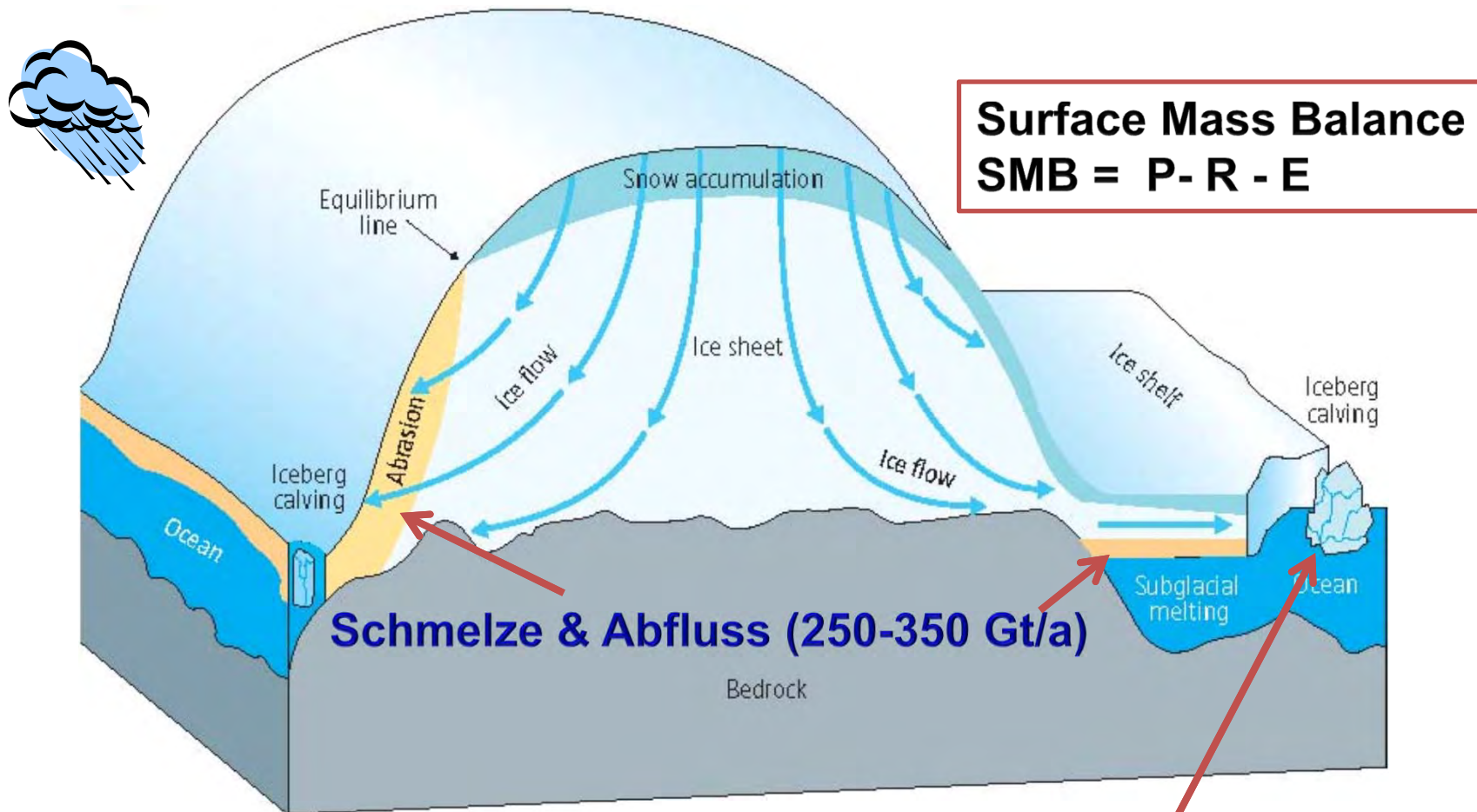


Meeresspiegelanstieg
wenn beide Eisschilder
schmelzen: 66 m

Grönlands Massenbilanz

Niederschlag (550-640 Gt/a)

Verdunstung (5-63 Gt/a)



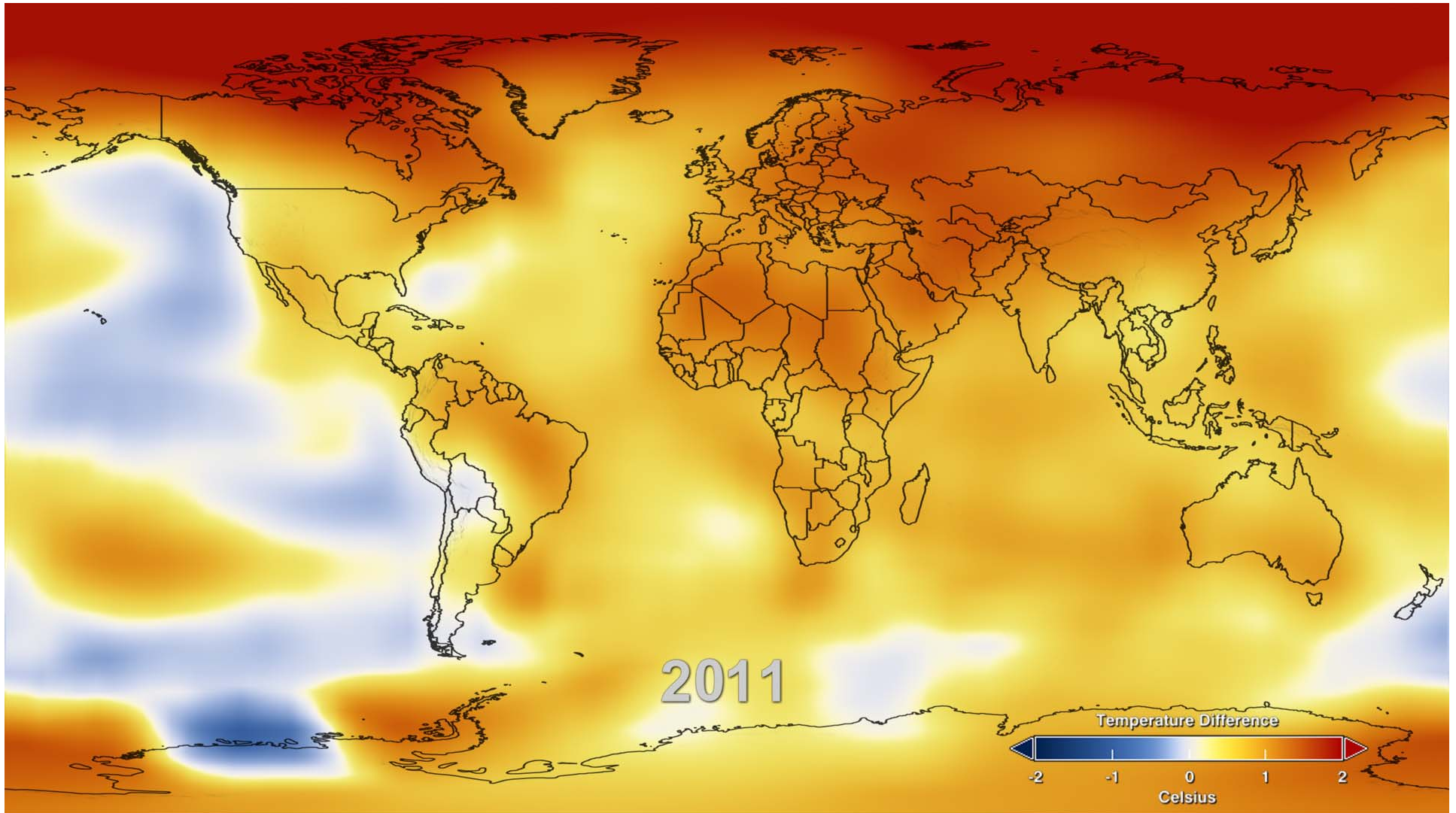
Surface Mass Balance
SMB = P - R - E

Schmelze & Abfluss (250-350 Gt/a)

Bilanz (-50 bis -200 Gt/a)

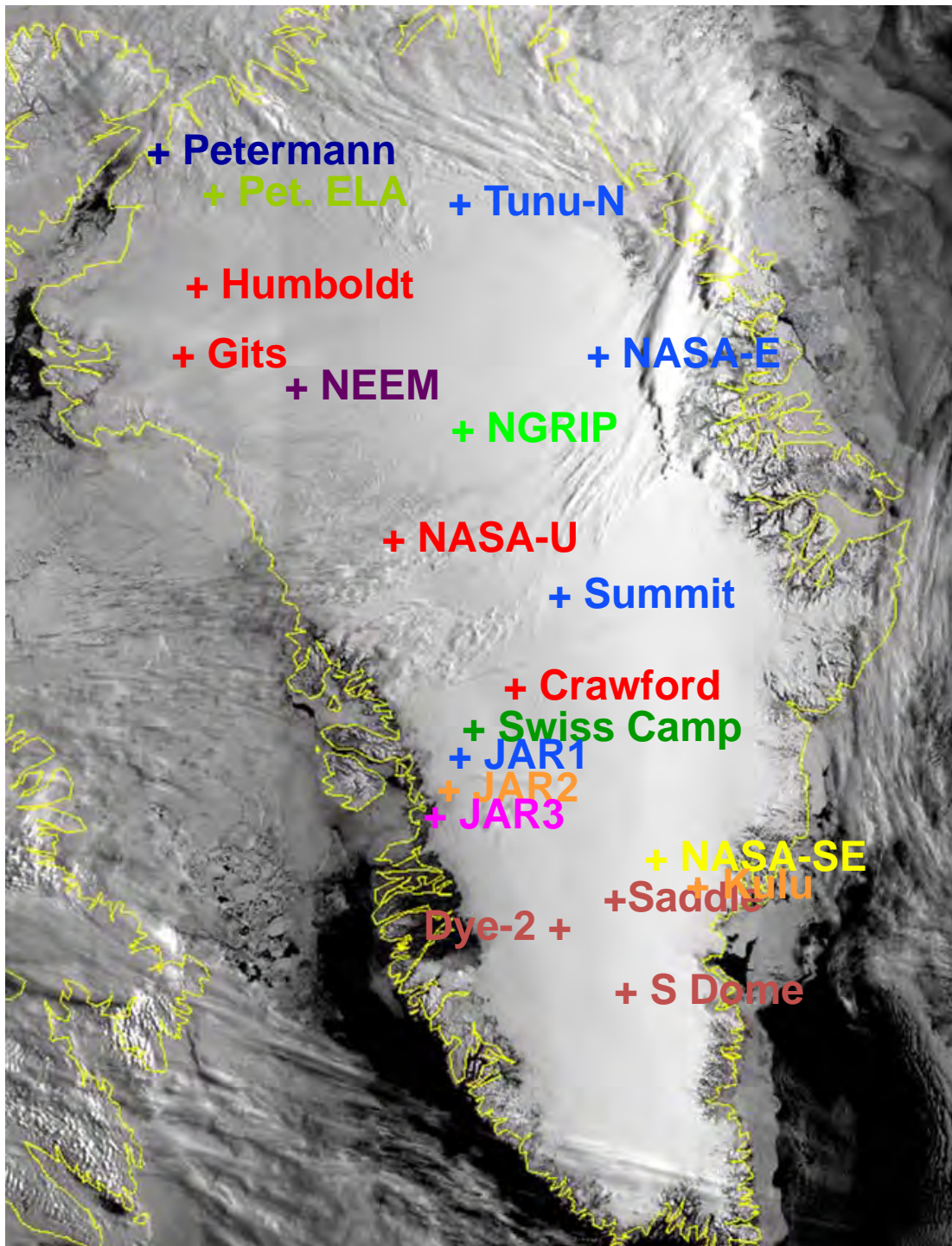
Eisberge (320-420 Gt/a)

Global Temperature Anomaly in 2011



Compared against 30-year mean (1980-2010)

James Hansen (NASA/GSFC GISS)

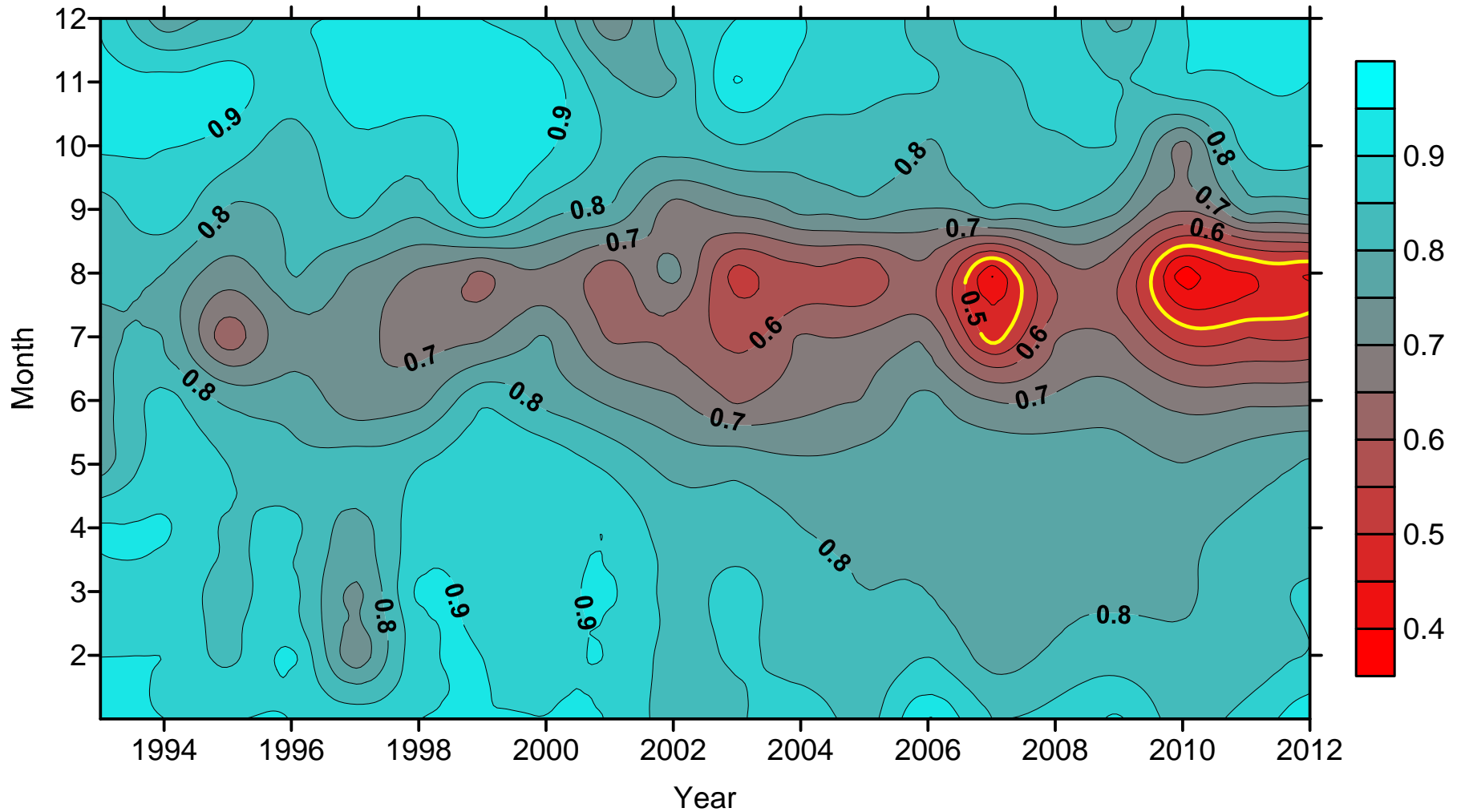


GC-Net Greenland Climate Network



Albedo Variabilität

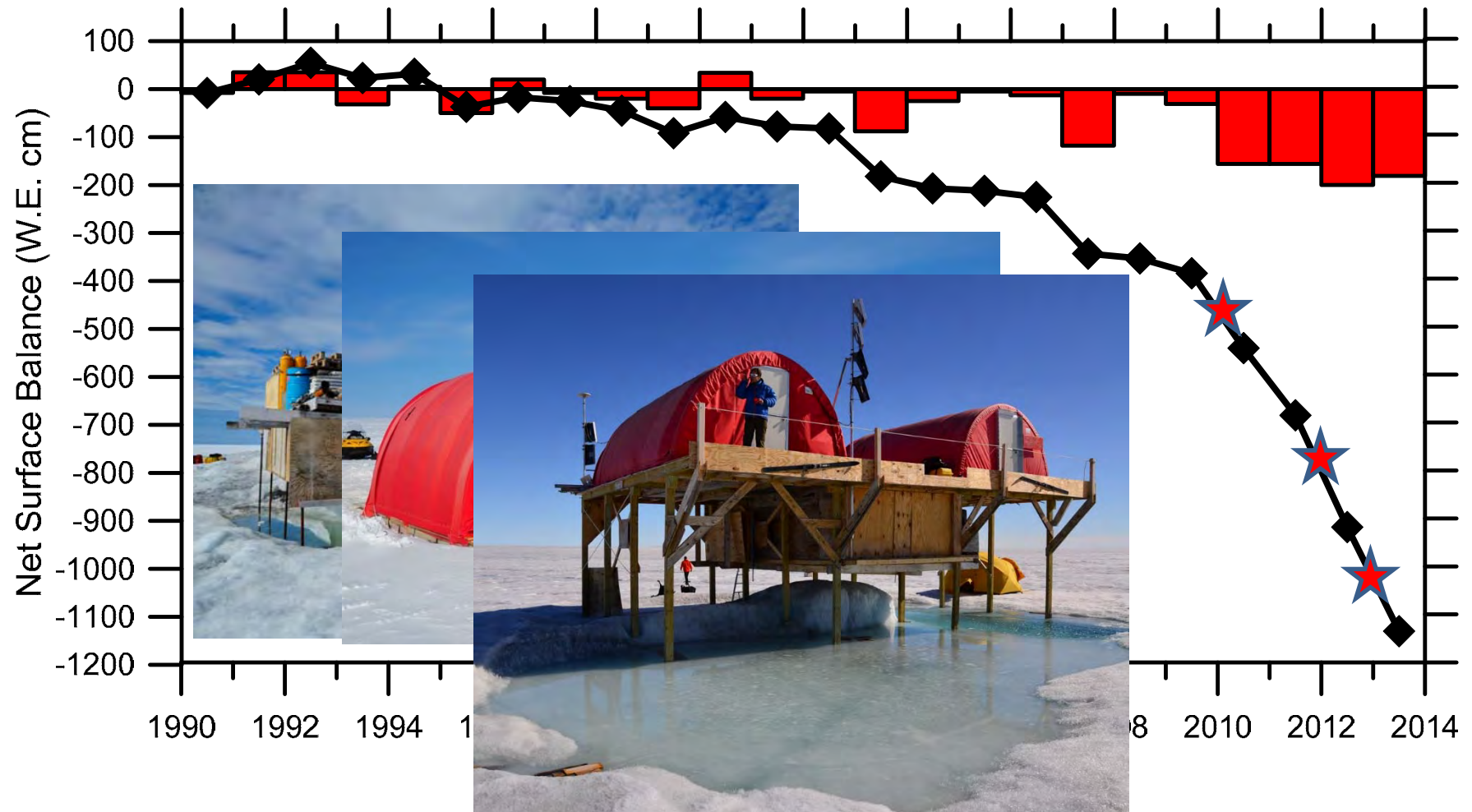
Swiss Camp 1993-2012



Massen Bilanz ist negative seit 2000

Variabilität der Massenbilanz

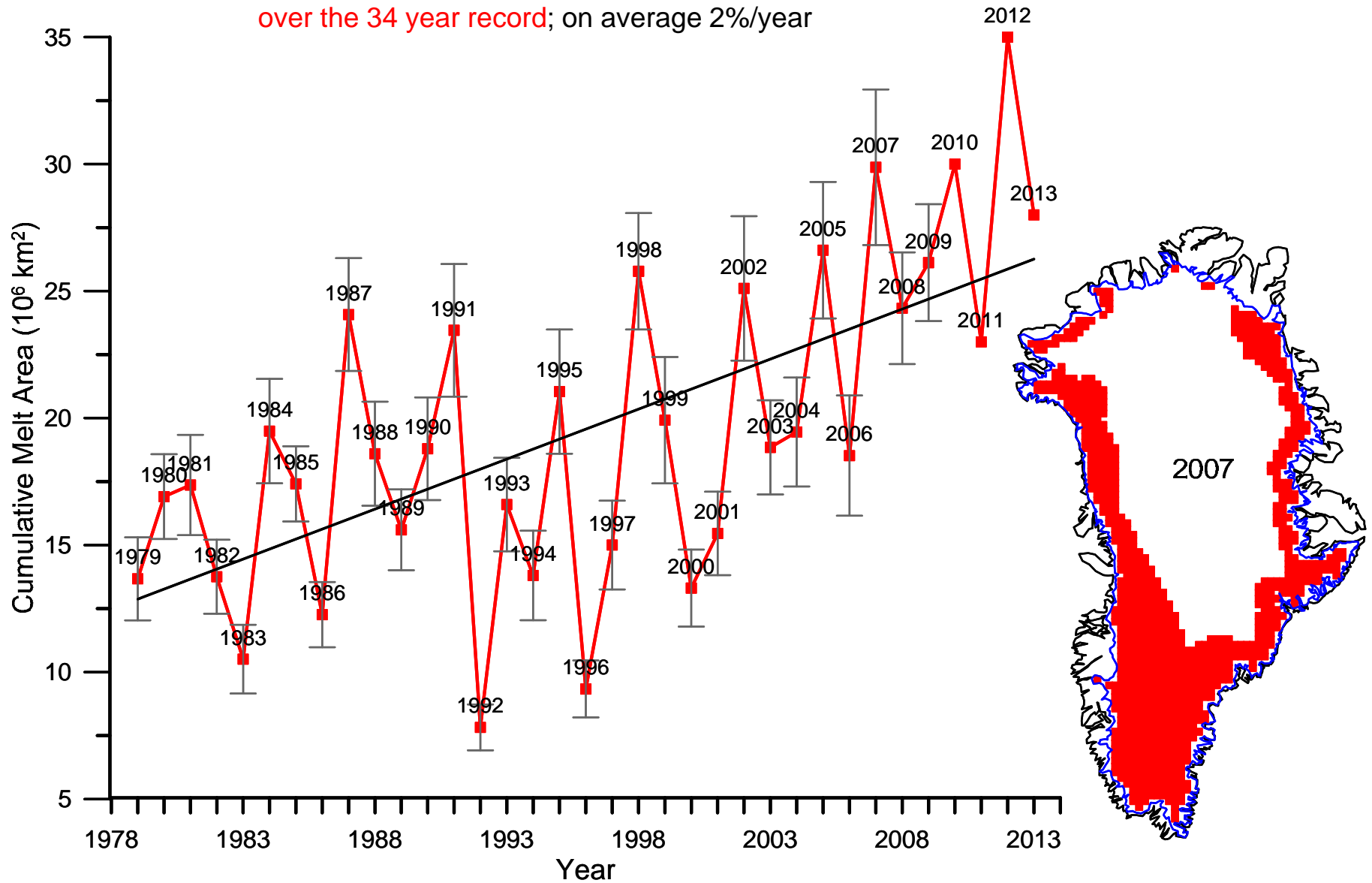
Swiss Camp 1990 bis 2013



Die Gleichgewichtslinie war in den 90'ziger Jahren bei 1100 m, inzwischen hat ist 11.5 m Eis beim Swiss Camp geschmolzen, vor allem in den letzten 10 Jahren.

Grönlands Schmelze: 1979-2013

Total Greenland ice sheet melt area increased 65% since 1979 over the 34 year record; on average 2%/year



Greenland Climate Network (GC-Net)

Automatic Weather Stations (AWS)

6-Day Data for

07/24/2012 - 07/30/2012

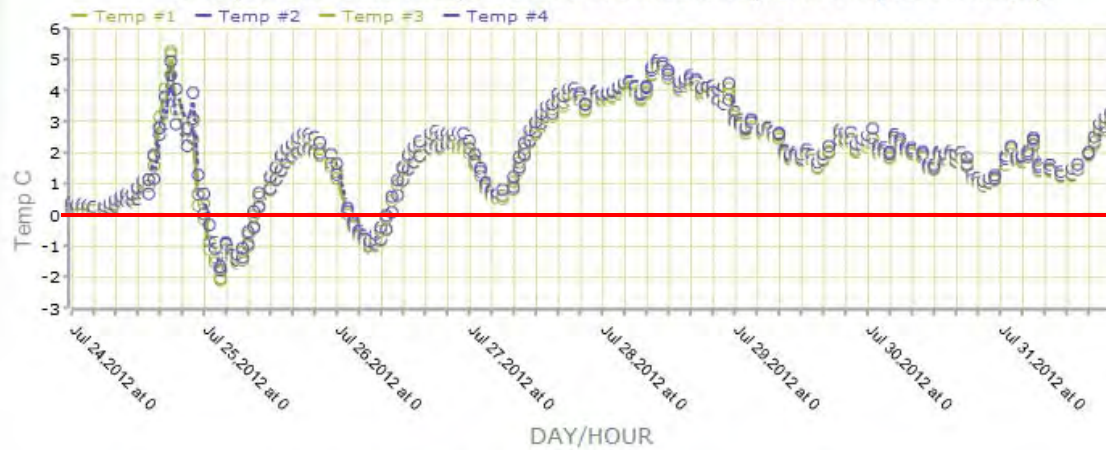
Name: Swiss Camp

Latitude: 69°35'53"N Longitude: 49°19'51"W Elevation: 1176

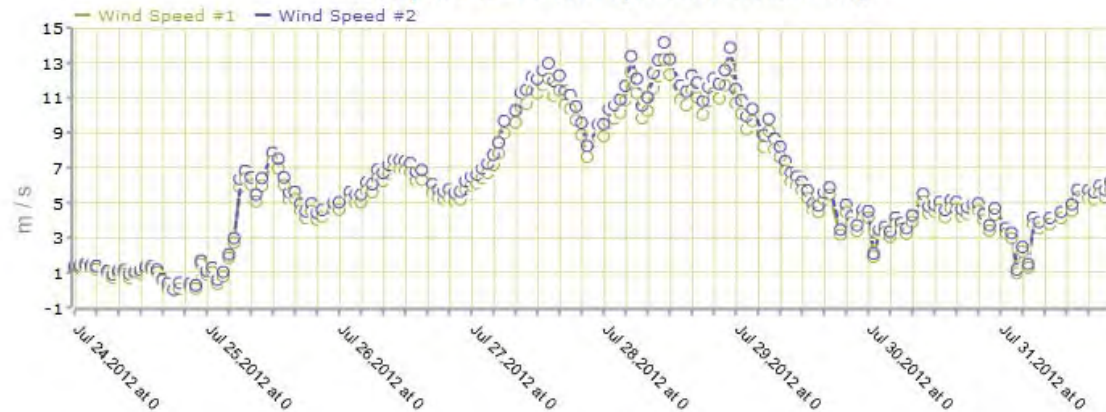
Start Date: 1990.30

Swiss Camp Air Temperatures

6-Day GC-NET Air Temperatures at Swiss Camp Plot on (Jul 30 2012)



6-Day GC-NET Wind Speed at Swiss Camp



Greenland Climate Network (GC-Net)

Automatic Weather Stations (AWS)

6-Day Data for

07/24/2012 - 07/30/2012

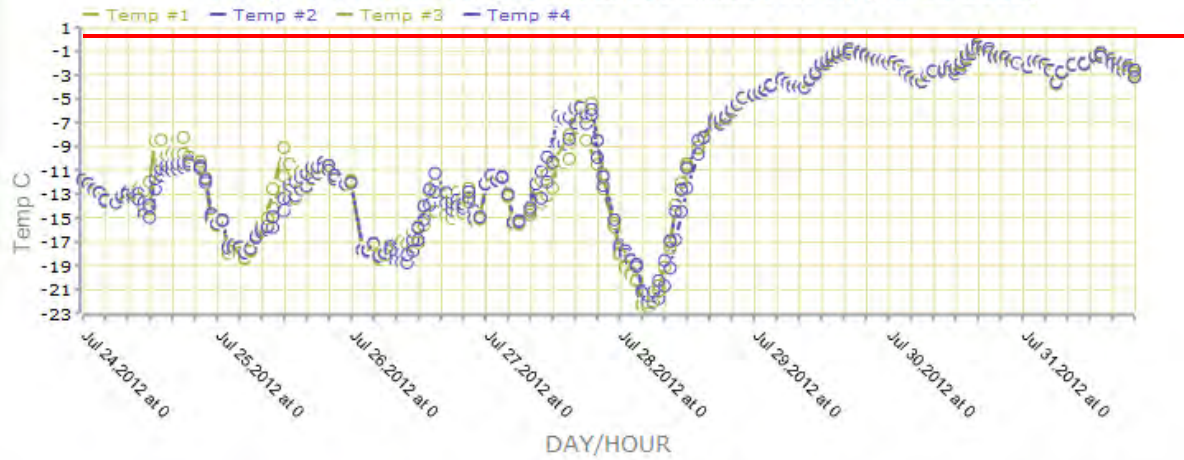
Name: Summit

Latitude: 72°34'46"N Longitude: 38°30'19"W Elevation: 3199

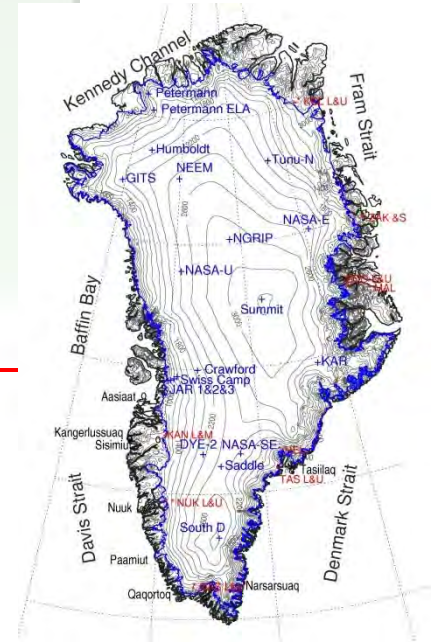
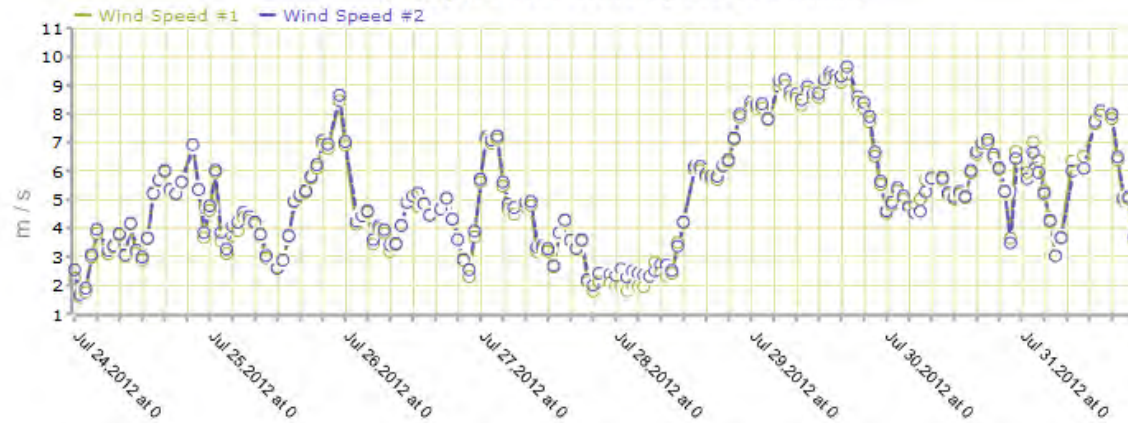
Start Date: 1996.37

Summit Air Temperatures

6-Day GC-NET Air Temperatures at Summit Plot on (Jul 30 2012)



6-Day GC-NET Wind Speed at Summit



NEEM Air Temperatures

Greenland Climate Network (GC-Net)

Automatic Weather Stations (AWS)

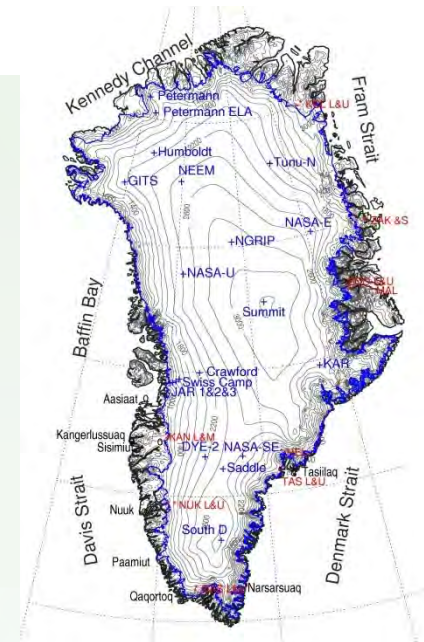
6-Day Data for

07/24/2012 - 07/30/2012

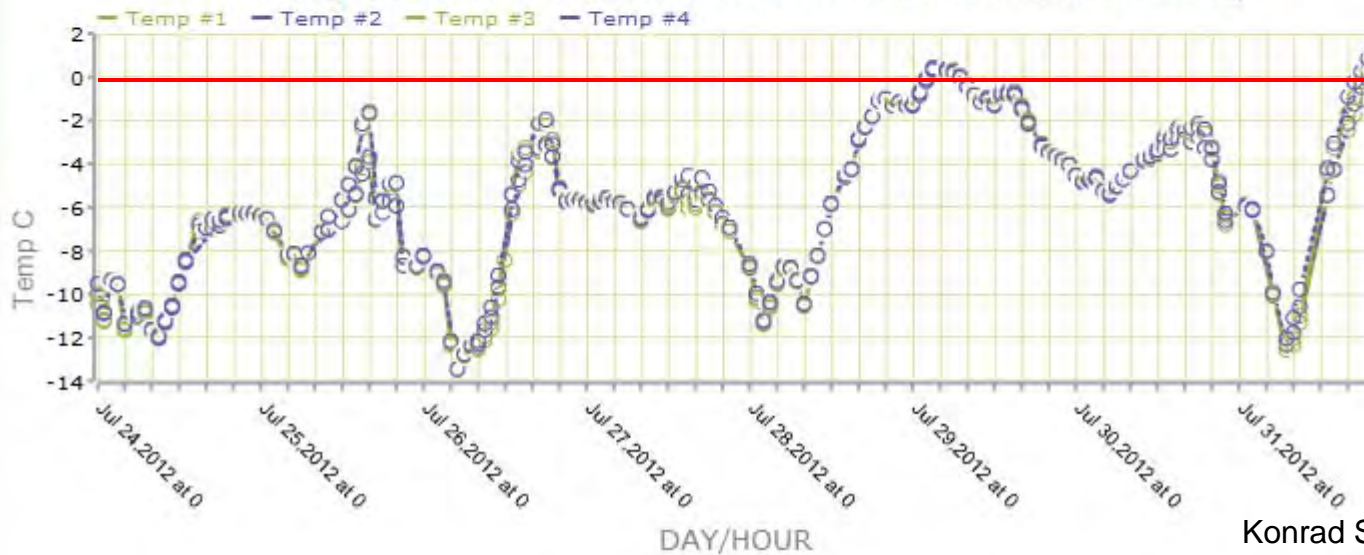
Name: NEEM

Latitude: 77°30'08"N Longitude: 58°04'22"W Elevation: 2454

Start Date: 2006.00



6-Day GC-NET Air Temperatures at NEEM Plot on (Jul 30 2012)



Konrad Steffen WSL/ETH/EPFL)

Grönlands Schmelze im Juli 2012

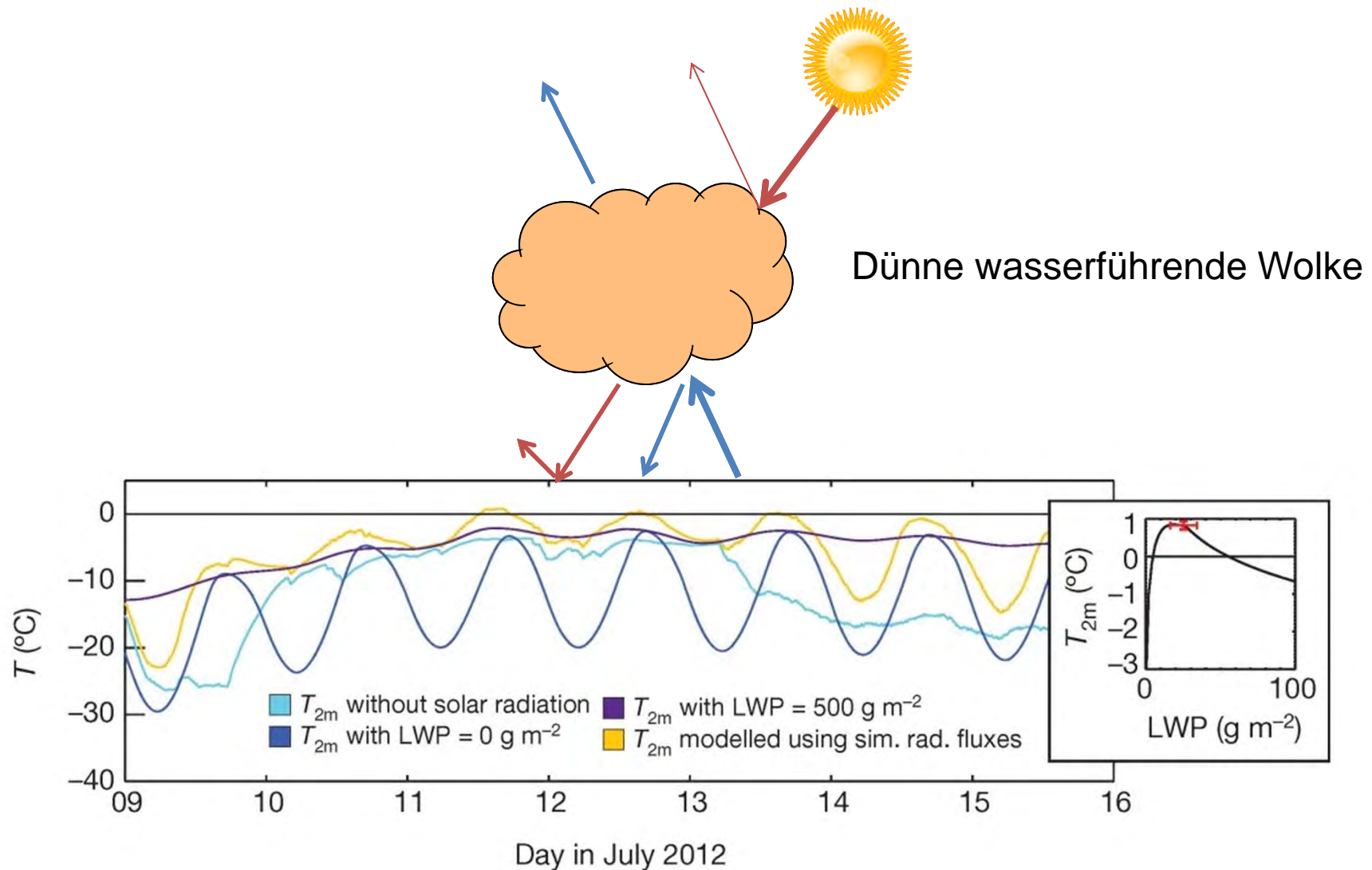


Surface Baseline Radiation Network (BSRN)

ETH Radiation monitoring at Summit Greenla since 1991

R. Bennartz, M. D. Shupe, D. D. Turner, V. P. Walden, K. Steffen, C. J. Cox, M. S. Kulie, N. B. Miller & C. Pettersen
July 2012 Greenland melt extent enhanced by low-level liquid clouds, Nature, doi:10.1038/nature12002.

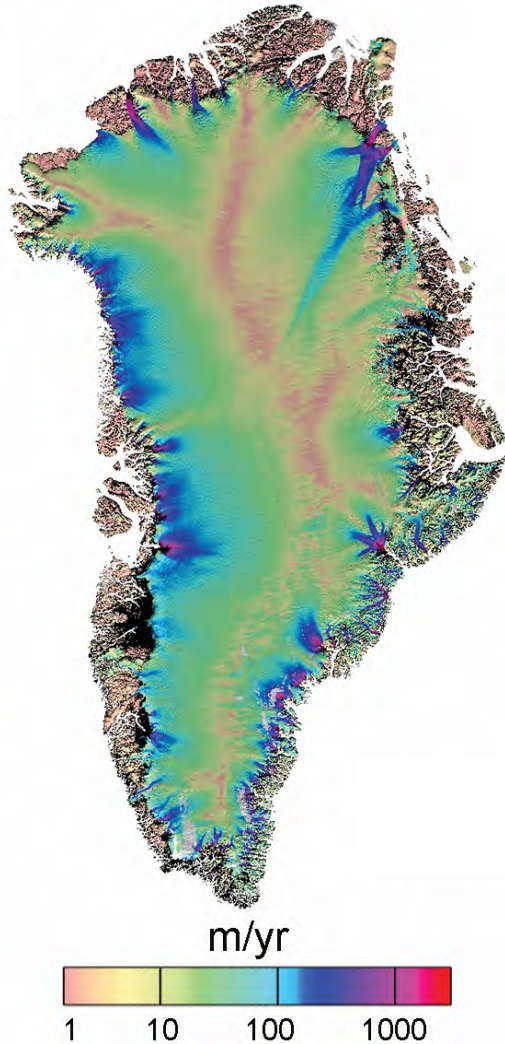
Grönlands Schmelze im Juli 2012



R. Bennartz, M. D. Shupe, D. D. Turner, V. P. Walden, K. Steffen, C. J. Cox, M. S. Kulie, N. B. Miller & C. Pettersen
July 2012 Greenland melt extent enhanced by low-level liquid clouds, Nature, doi:10.1038/nature12002.

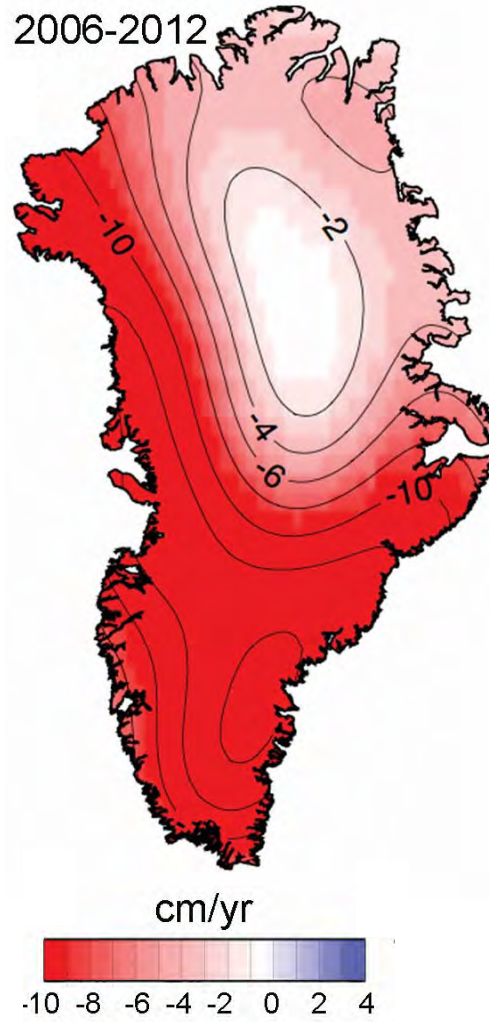
Grönländisches Eisschild

Eisfliessgeschwindigkeit



Eisverlust

2006-2012



Eisverlust 1992-2001:
 $34 \pm 40 \text{ Gt yr}^{-1}$

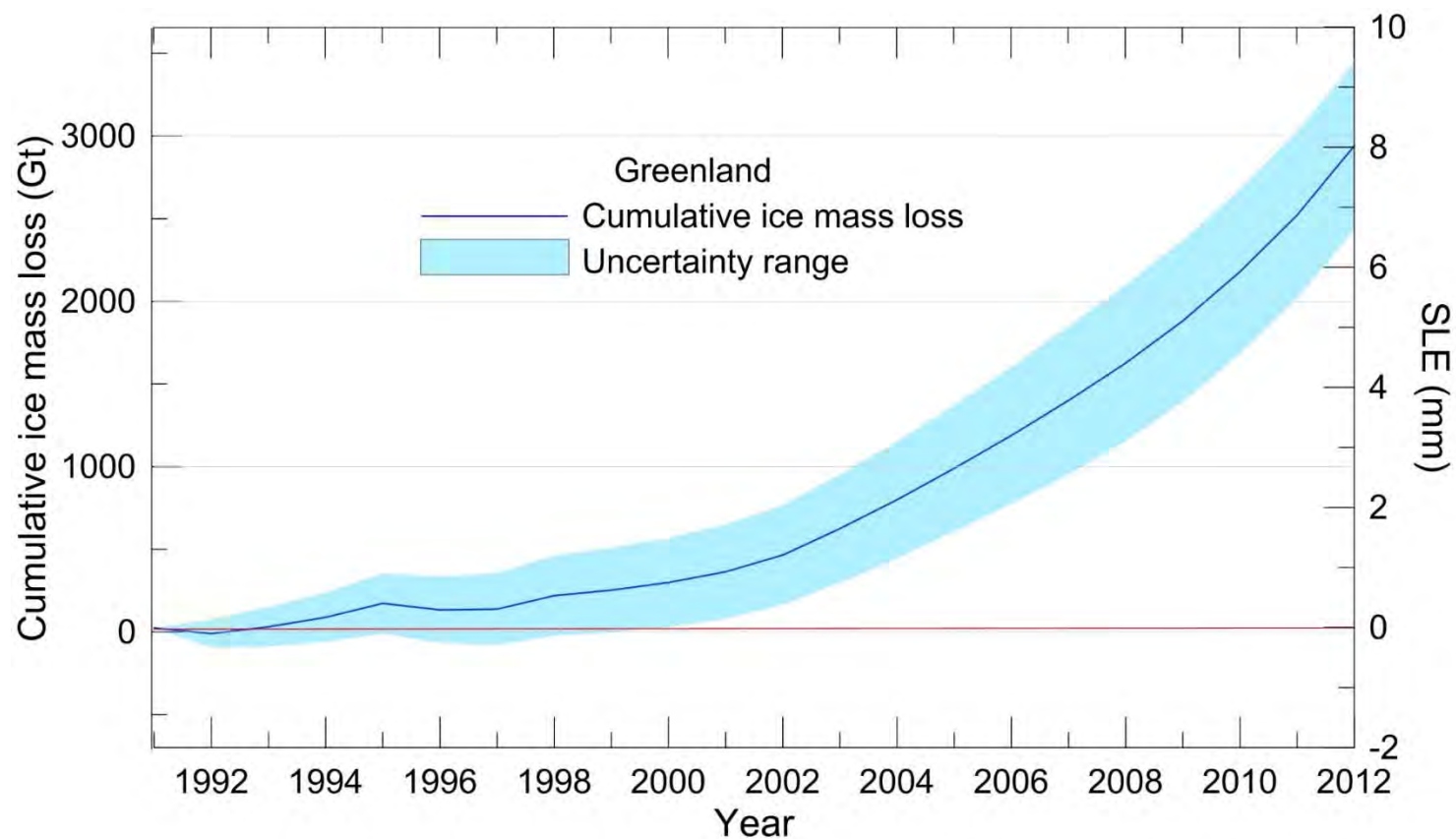
Eisverlust 2002-2011:
 $215 \pm 58 \text{ Gt yr}^{-1}$

Eisschmelze und
Eisdynamik sind zu je a
50% für den Eisverlust
verantwortlich

Die meisten Ausfluss-
gletscher haben ihre
Fliessgeschwindigkeit
verdoppelt

Die Erwärmung der Meere
um Grönland spielt auch
eine wichtige Rolle im
Eisverlust

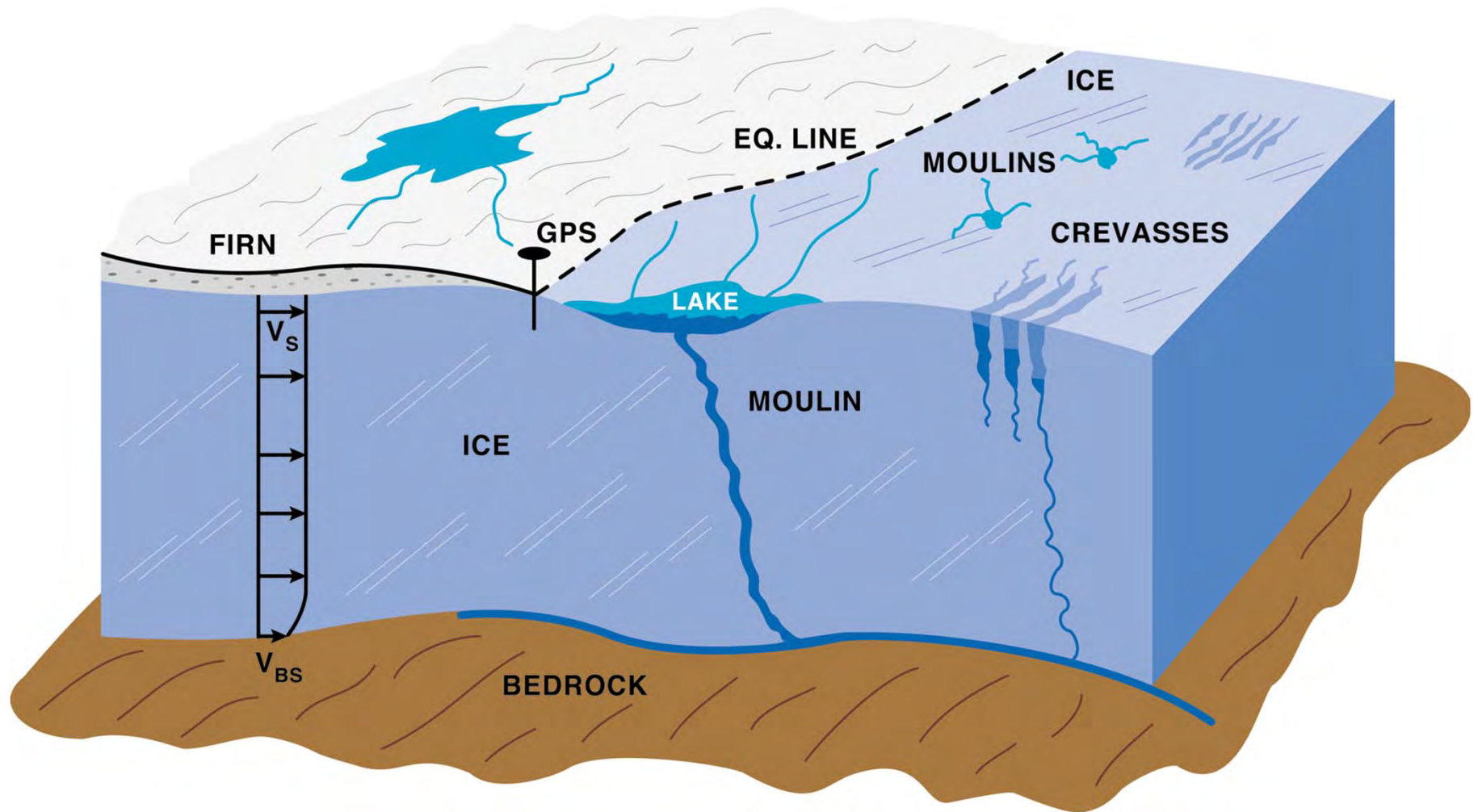
Grönländisches Eisschild



- Eisverlust von Grönland verursacht einen global Meeresspiegelanstieg von 8 mm seit 1992
- Der Eisverlust zeigt eine Beschleunigung seit 2002

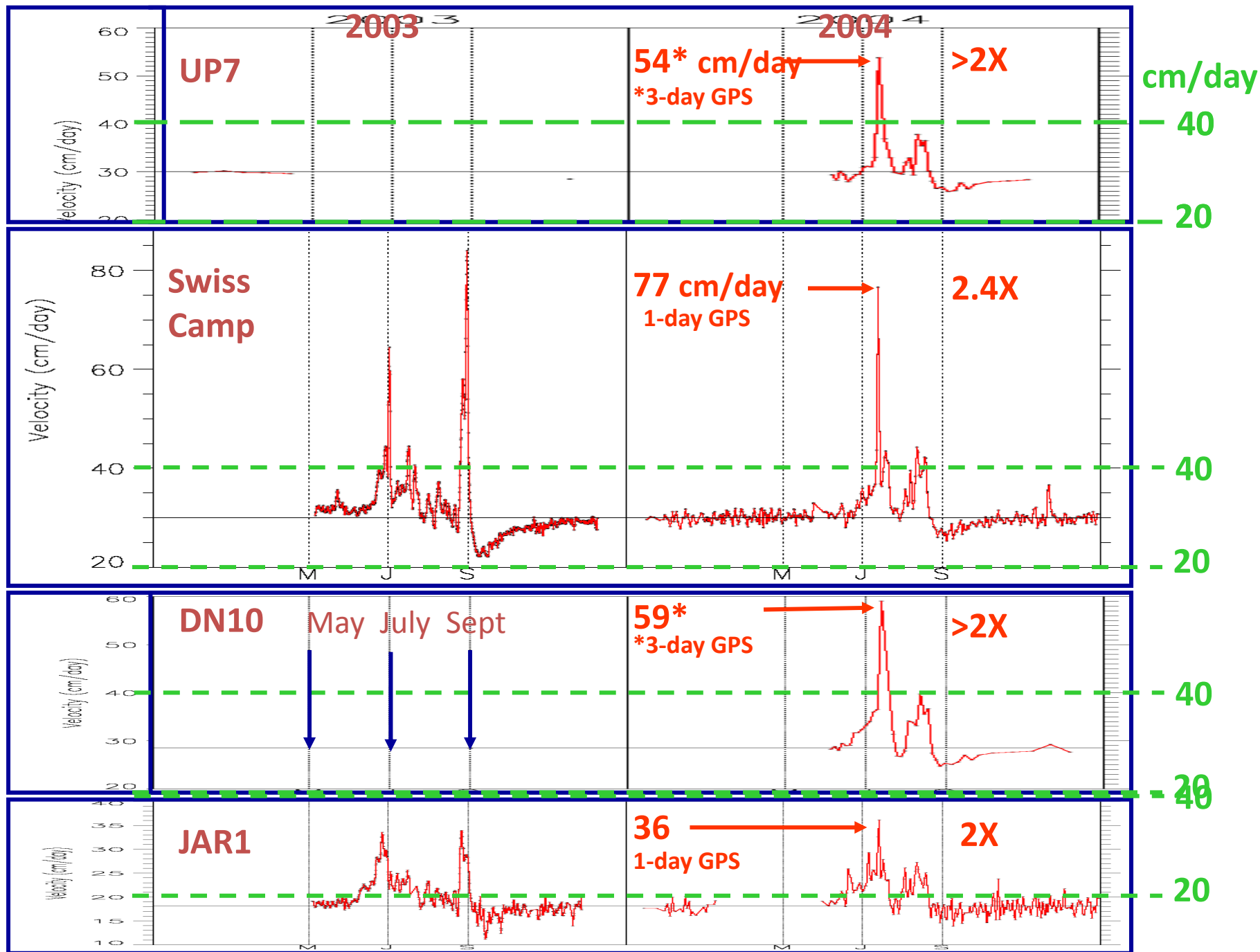


Beschleunigung des Eisstroms durch Oberflächen-induzierte Schmelze

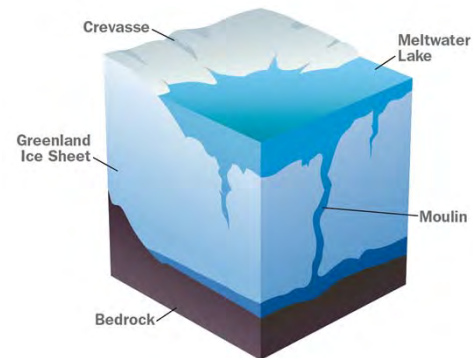
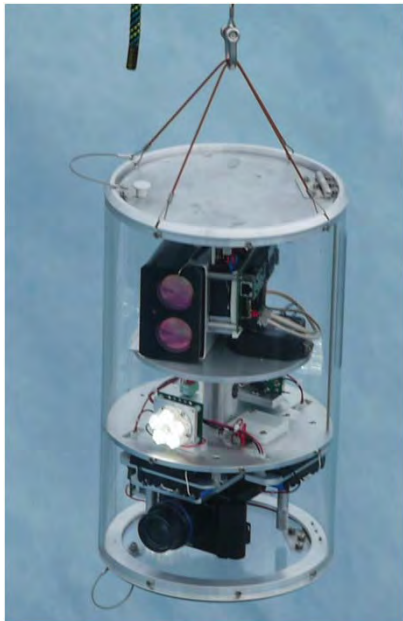
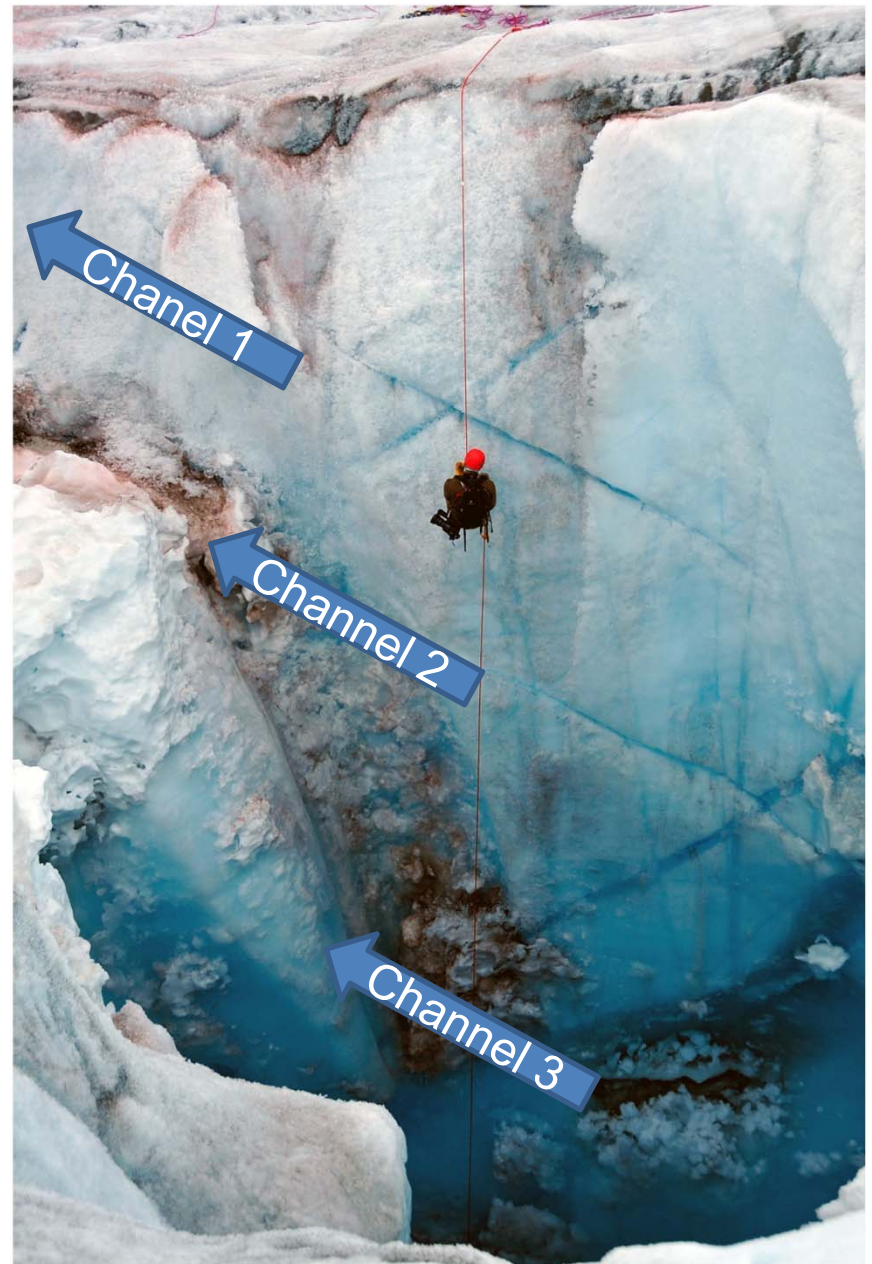
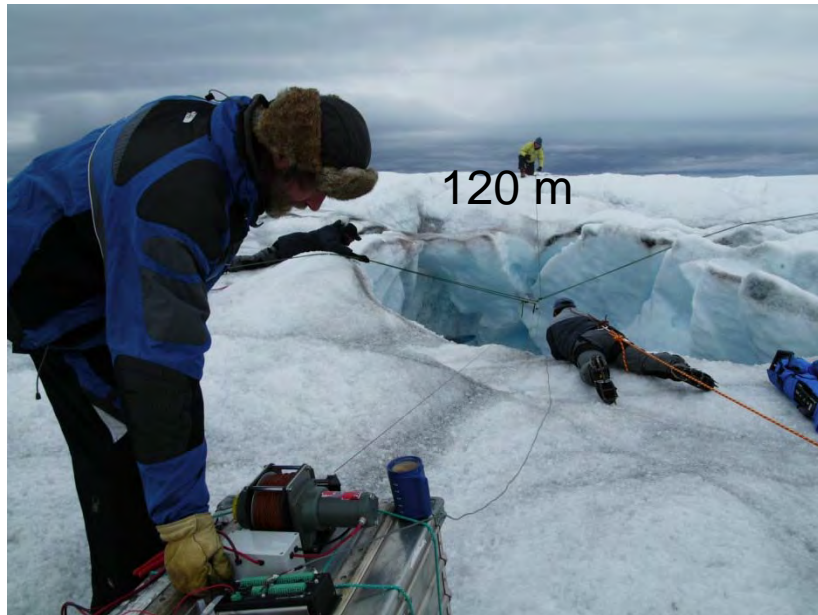


H. Jay Zwally, Waleed Abdalati, Tom Herring, Kristine Larson, Jack Saba, and Konrad Steffen, *Science* 297, 2002.

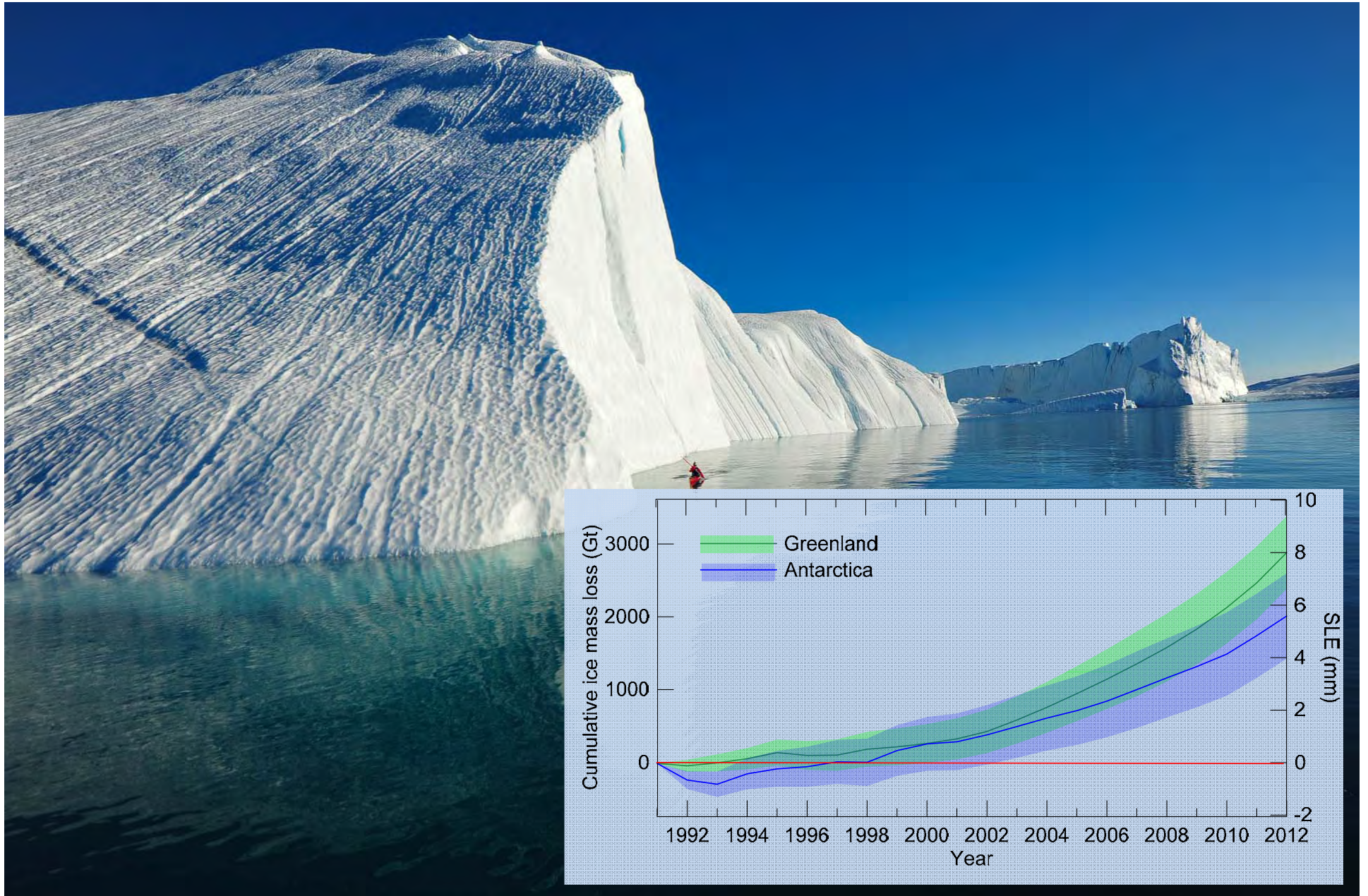
Spatial Gradient and Timing of Acceleration



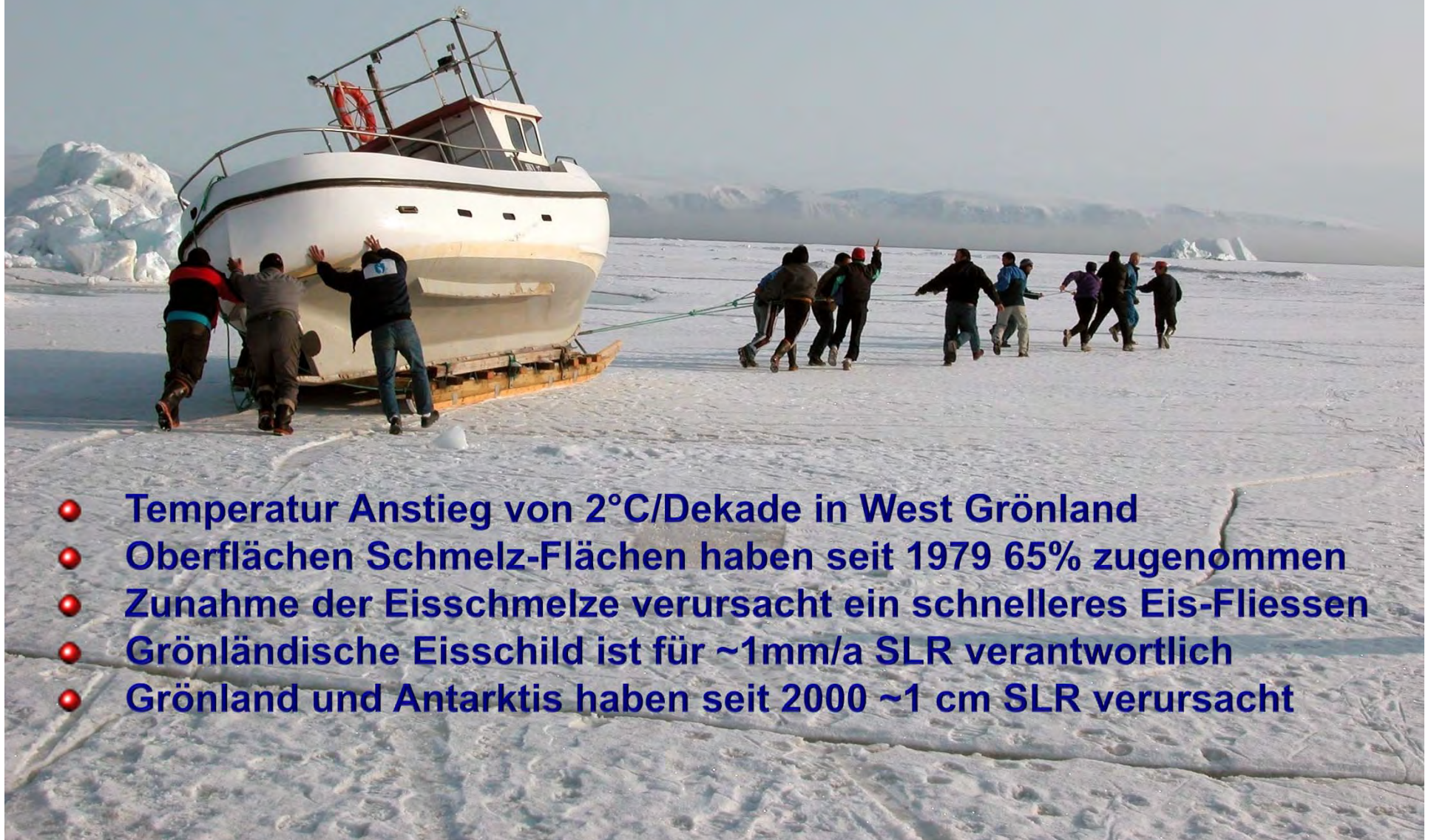
Moulin Experimente



Massenbilanz von Grönland und Antarktis



Zusammenfassung



- Temperatur Anstieg von $2^{\circ}\text{C}/\text{Dekade}$ in West Grönland
- Oberflächen Schmelz-Flächen haben seit 1979 65% zugenommen
- Zunahme der Eisschmelze verursacht ein schnelleres Eis-Fliessen
- Grönländische Eisschild ist für $\sim 1\text{mm}/\text{a}$ SLR verantwortlich
- Grönland und Antarktis haben seit 2000 ~ 1 cm SLR verursacht



Thank you