Overview

EuroPICS

Drilled ice cores

Planned ice cores

Drill liquids

Rapid Access Drills

Drilled ice cores

EuroPICS

Berkner Island

James Ross Island

Fletcher Promontory

Roosevelt Island

Aurora Bassin

Drilled ice cores – Weddel Sea Ice Cores

EuroPICS

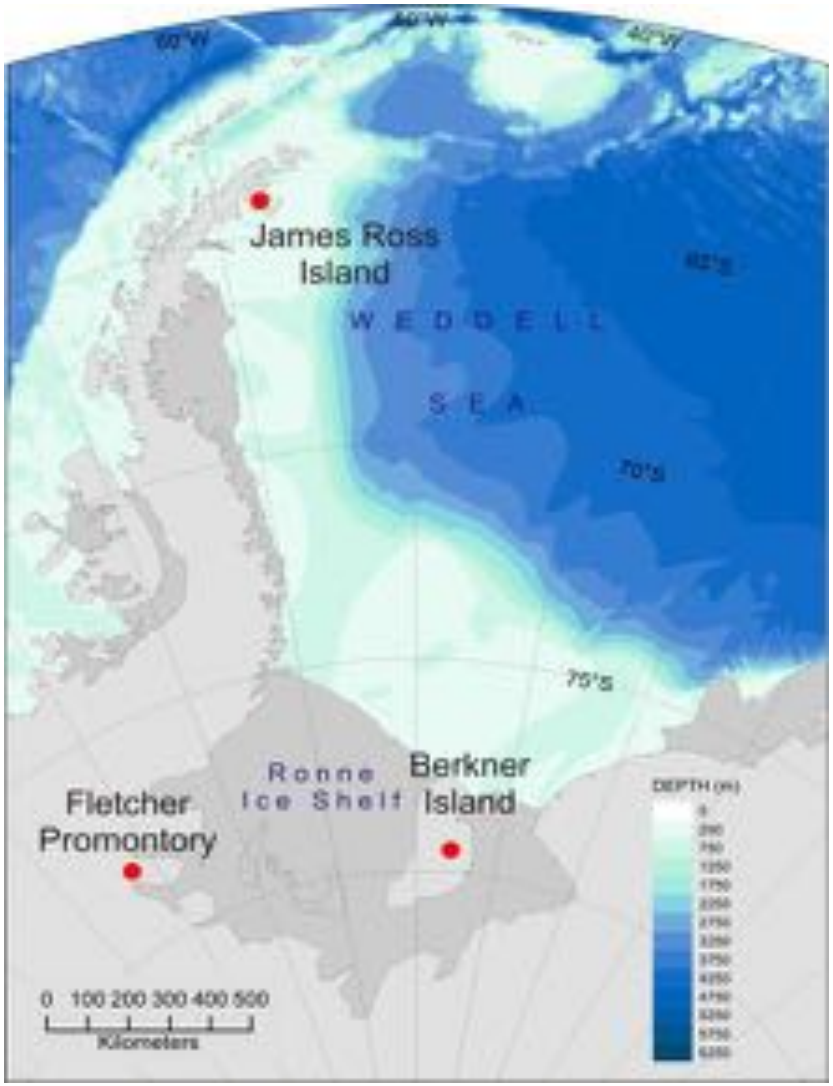
UK – ice cores

(reported at EuroPICS meeting at
EGU April 13th 2015 by Rob Mulvaney)

Berkner Island

James Ross Island

Fletcher Promontory



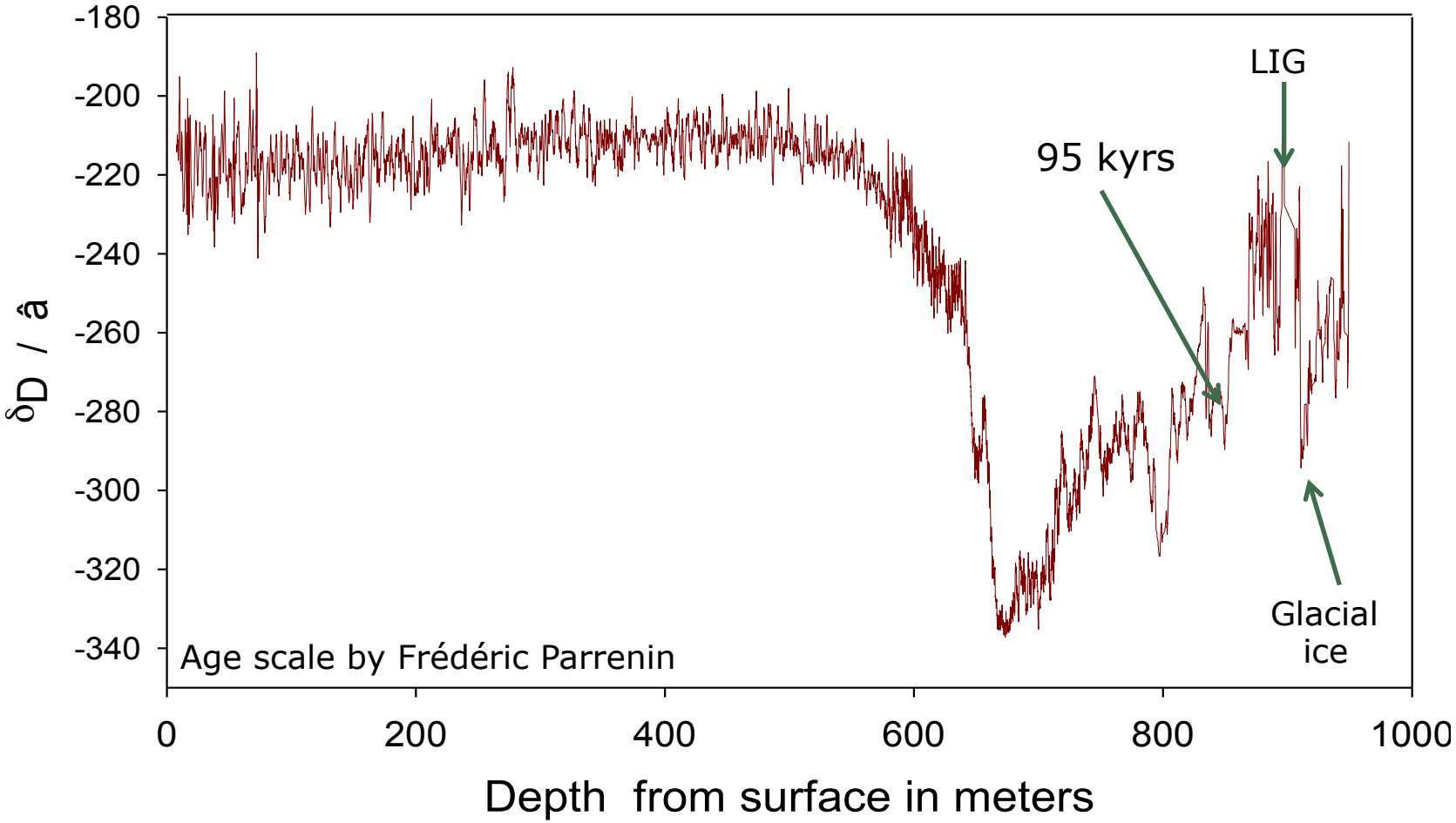
Drilled ice cores – Weddel Sea Ice Cores

EuroPICS

Drill setup

Drilled ice cores – Berkner Island

EuroPICS

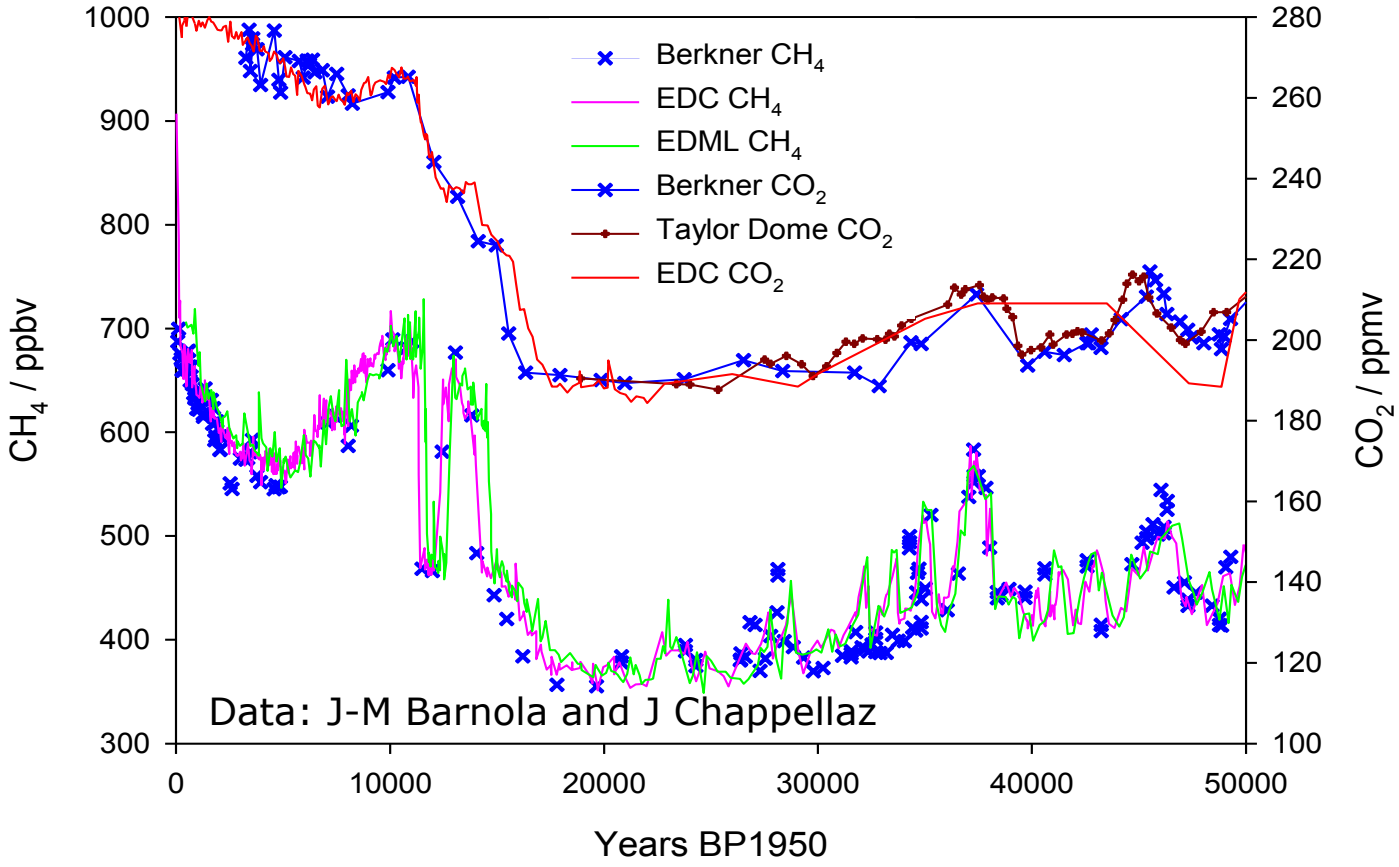


Climate record through the Berkner Island core

- reliable dating to 95kyrs – AICC12 with matching to CH_4

Drilled ice cores – Berkner Island

EuroPICS

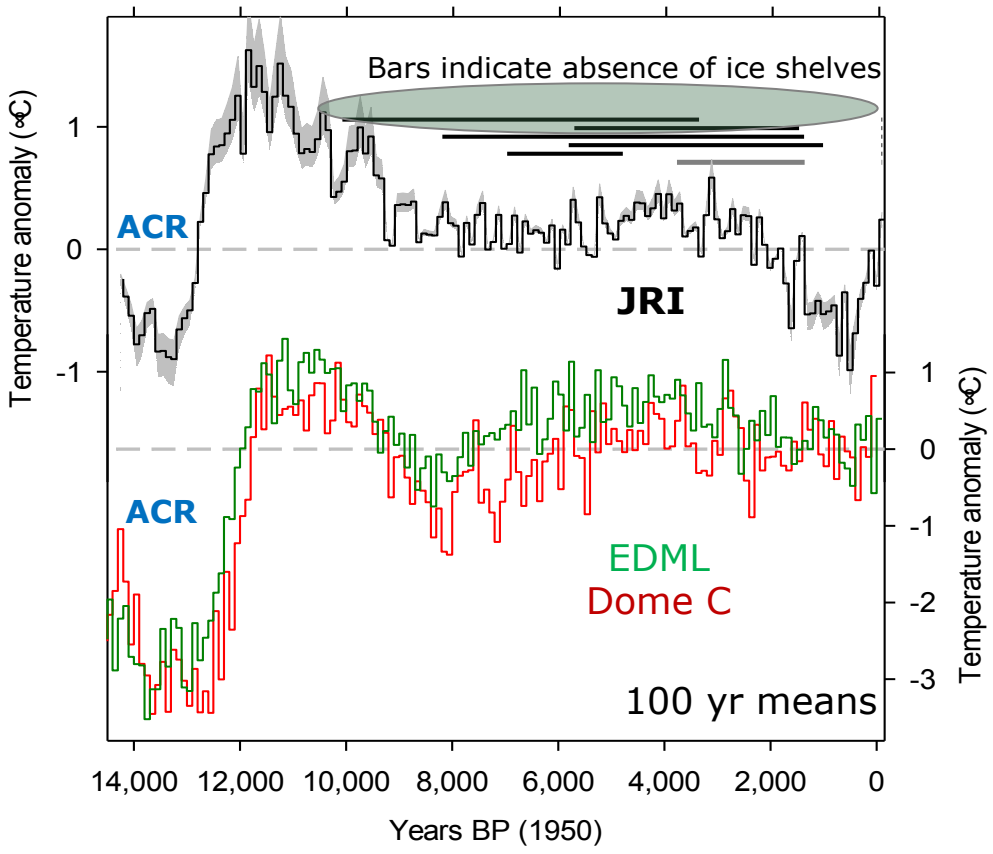


Berkner CH_4 and CO_2 on an older age scale

Drilled ice cores – James Ross Island

EuroPICS

15,000 years climate record
James Ross Island
with Dome C and EDML cores



Mulvaney et al, Nature 2012

Progress

- Although includes glacial ice, focus so far on Holocene
- Three major publications

Intentions

- Currently working on chemistry of Holocene ice

Drilled ice cores – James Ross Island

EuroPICS

LETTER

doi:10.1038/nature11391

Recent Antarctic Peninsula warming relative to Holocene climate and ice-shelf history

Robert Mulvaney[1], Nerilie J. Abram[1,2], Richard C. A. Hindmarsh[1], Carol Arrowsmith[3], Louise Fleet[1], Jack Triest[1], Louise C. Sime[1], Olivier Alemany[4] & Susan Foord[1]‡

nature geoscience

ARTICLES

PUBLISHED ONLINE: 14 APRIL 2013 | DOI: 10.1038/NGEO1787

Acceleration of snow melt in an Antarctic Peninsula ice core during the twentieth century

Nerilie J. Abram[1,2]*, Robert Mulvaney[1]*, Eric W. Wolff[1], Jack Triest[1,3], Sepp Kipfstuhl[4], Luke D. Trusel[5], Françoise Vimeux[6], Louise Fleet[1] and Carol Arrowsmith[7]

LETTERS

PUBLISHED ONLINE: 11 MAY 2014 | DOI: 10.1038/NCLIMATE2235

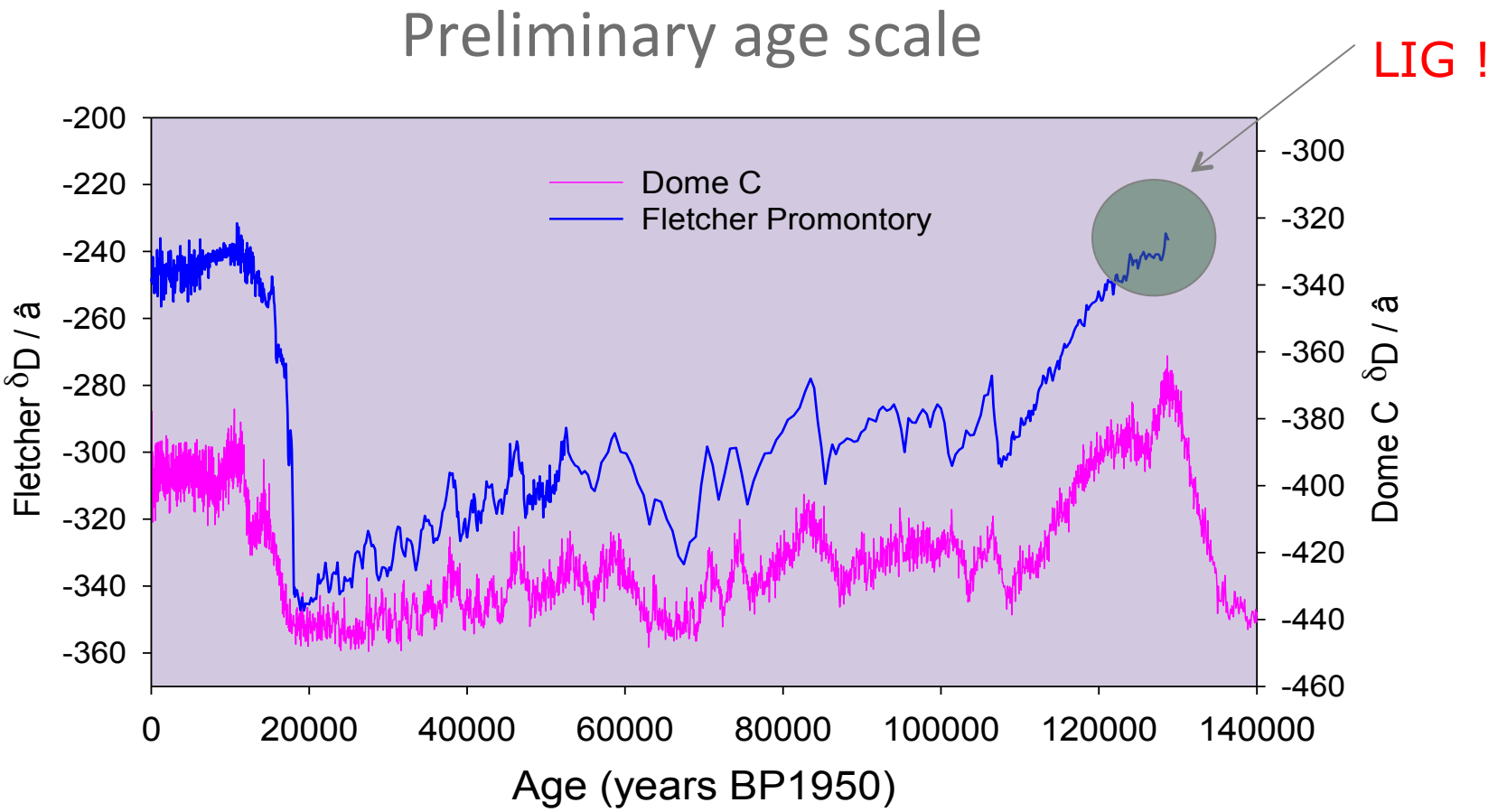
nature climate change

Evolution of the Southern Annular Mode during the past millennium

Nerilie J. Abram[1,2]*, Robert Mulvaney[1], Françoise Vimeux[3], Steven J. Phipps[4], John Turner[1] and Matthew H. England[4]

Drilled ice cores – Fletcher Promontory

EuroPICS

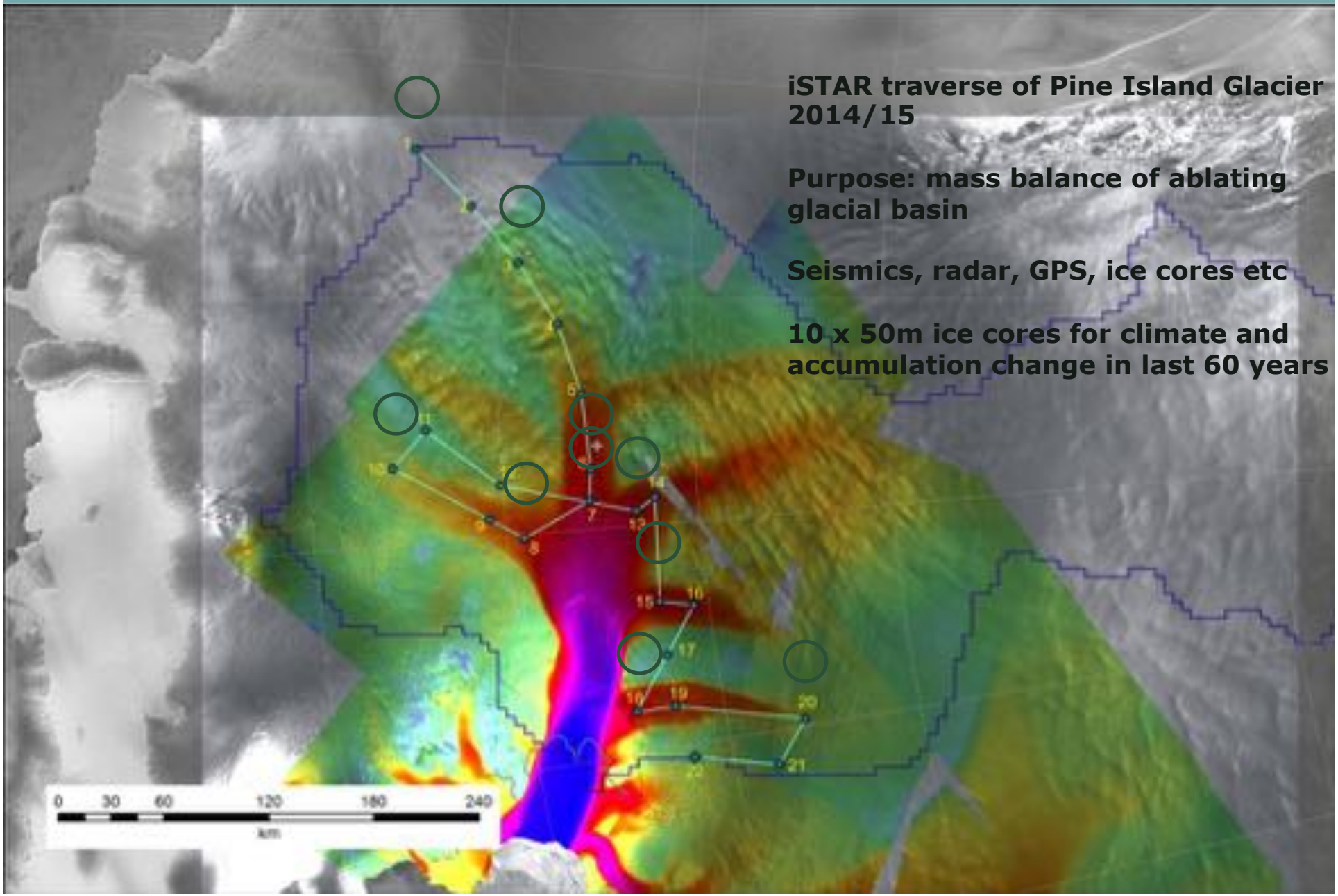


Progress: Isotope profile almost complete – indicates some ice from previous deglaciation (not shown), but with perhaps flow disturbance in bottom meters

Currently working on robust age scale

Drilled ice cores – Pine Island

EuroPICS



iSTAR traverse of Pine Island Glacier 2014/15

Purpose: mass balance of ablating glacial basin

Seismics, radar, GPS, ice cores etc

10 x 50m ice cores for climate and accumulation change in last 60 years

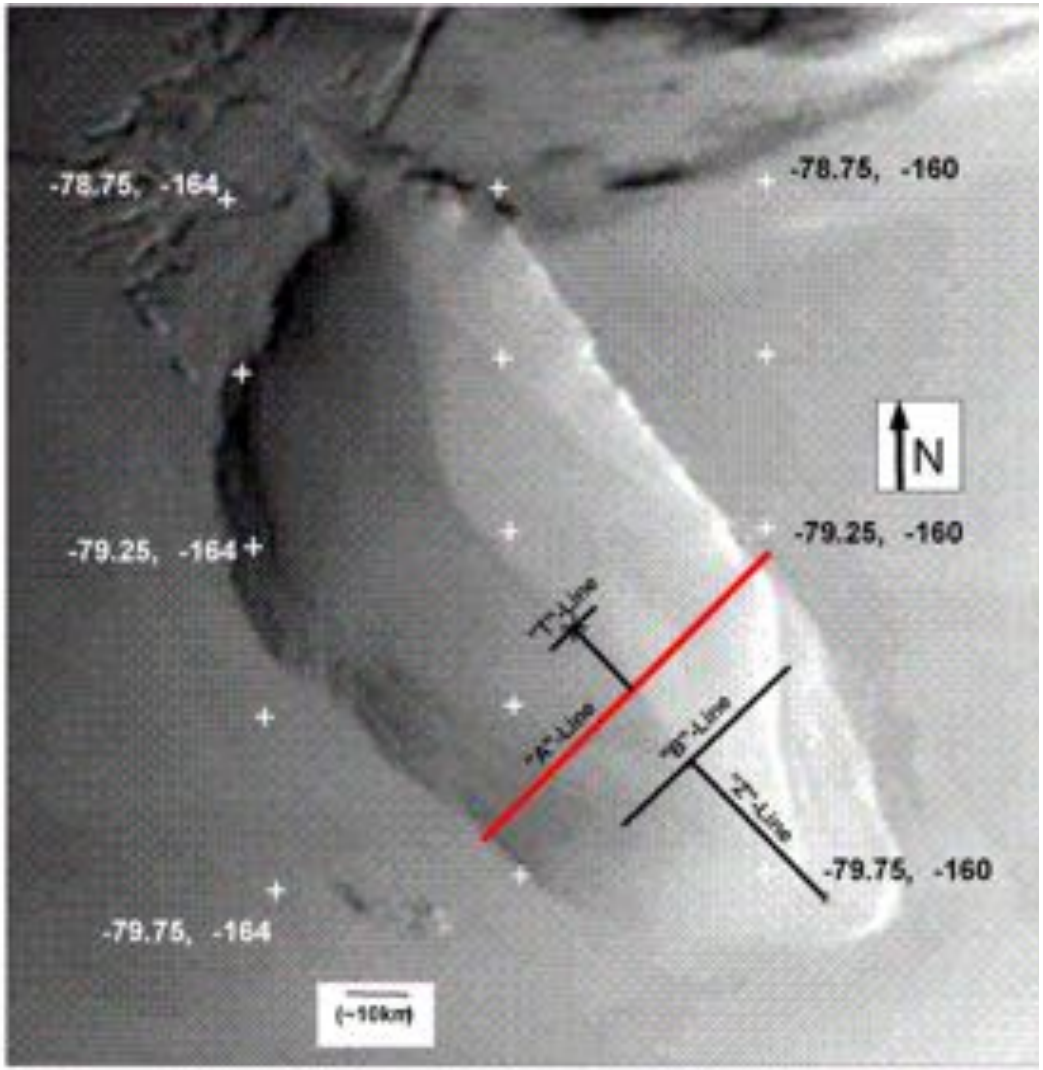
Drilled ice cores – Roosevelt Island

EuroPICS

Wellington drill from NEEM

Drilled ice cores – Roosevelt Island

EuroPICS



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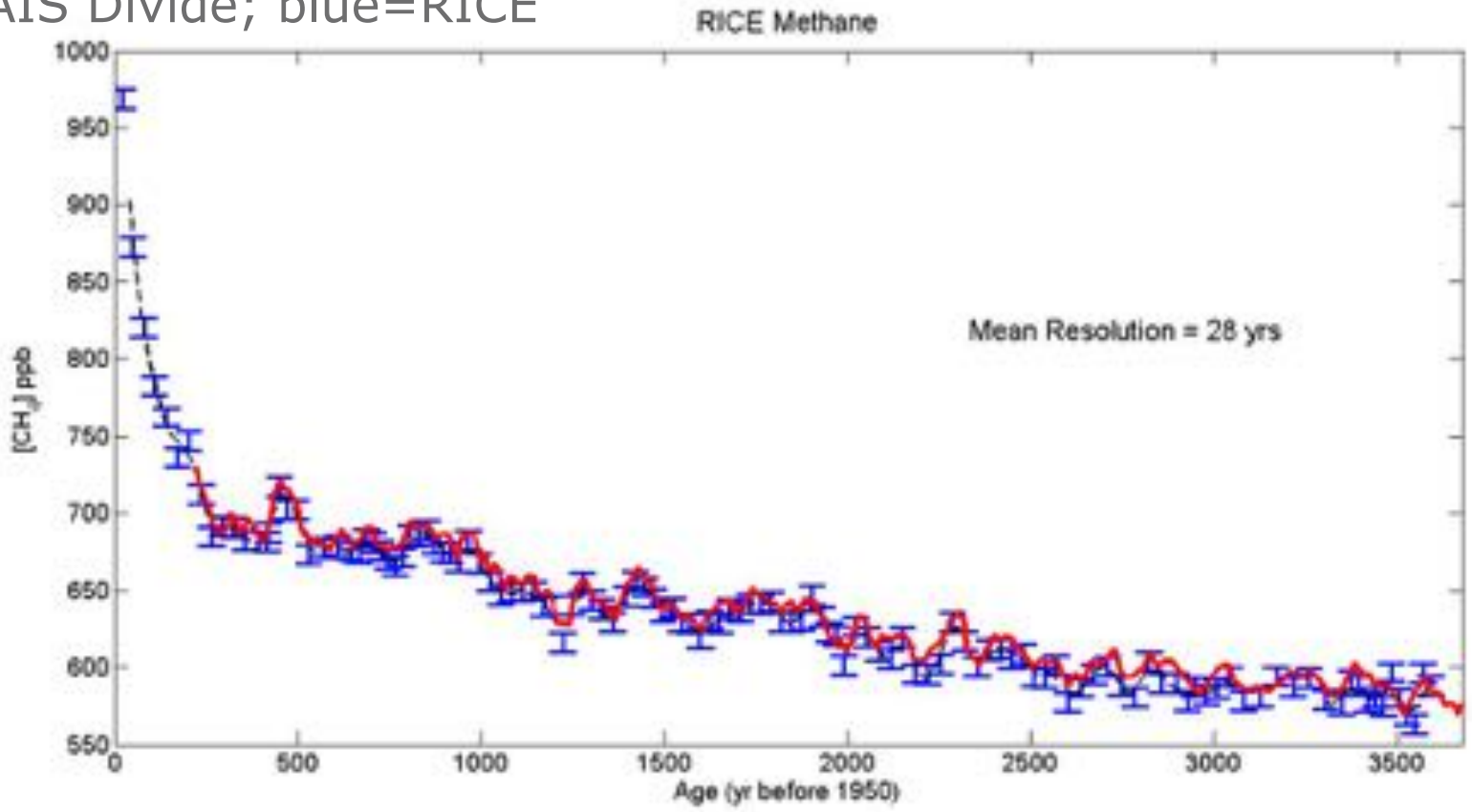
RICE CH4 on age scale w/ WDC06A

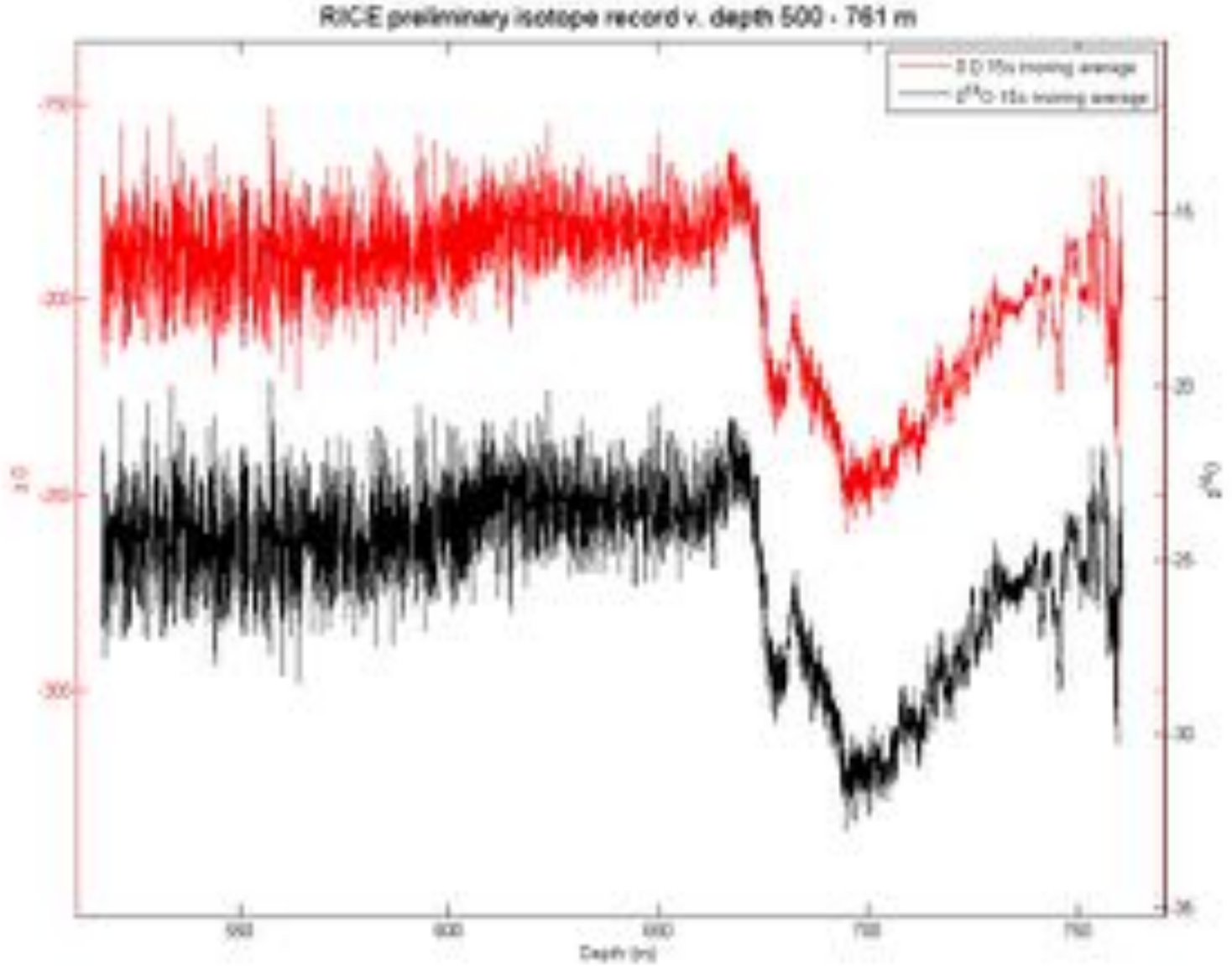
coherence = 0.981 RICE matched to WDC06-8 using XCM (Huybers)
red=WAIS Divide; blue=RICE



Drilled ice cores – Roosevelt Island

Drilled ice cores – Roosevelt Island

EuroPICS



Drilled ice cores – Roosevelt Island

EuroPICS

Drilled ice cores – Roosevelt Island

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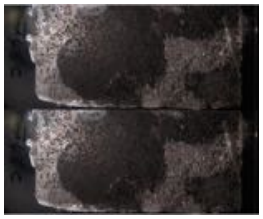
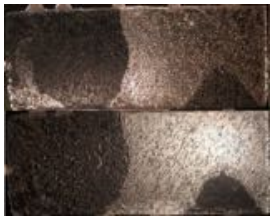
Depth 696.9 m
D = -245 o/oo

Depth 745.9 m
D = -220 o/oo



Depth 744.7 m
D = -210 o/oo



Depth = 747.1 m
D = -185 o/oo

Depth 757.1 m
D = -215 o/oo

Drilled ice cores – Roosevelt Island

EuroPICS

Depth 744.7 m
D = -210 o/oo

Drilled ice cores – Aurora Bassin

EuroPICS

Ice core drilled 2013/2014 – ECM done
Processing Reno 2015

Planned ice cores

EuroPICS

Renland

EGRIP

Korff Ice Rise

Halfvarryggen

Amundsen / Bellingshausen Seas Coastal Dome

Beyond EPICA oldest ice

Illimani, Colle Gnifetti (CG), Svalbard, Belukha and Tsambagarav (Mongolia).

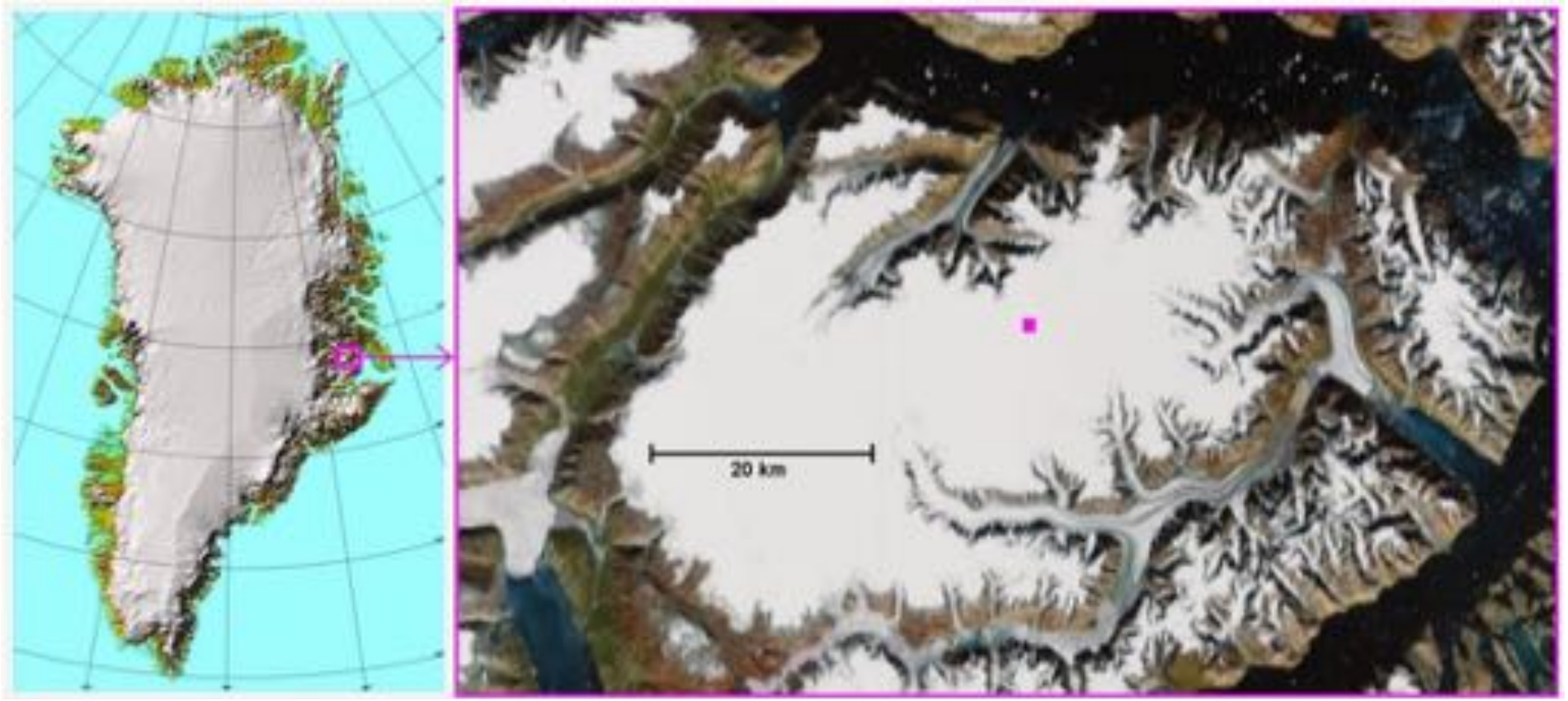
180 m at the Eurocore site in Greenland

2 cores near Dome C

120 m at Derwael ice rise

Planned ice cores - Renland

EuroPICS



Nations: Denmark, the U.S., Germany and Italy
Goal: Unbrittle Holocene ice – reaches back to the LIG

Planned ice cores - Renland

EuroPICS

H**igh-priority science questions:**

1) How did the East Greenland and thus **Arctic sea-ice** conditions evolve during the Holocene and the Glacial and how did conditions and variability compare to the present downturn in sea ice?

2) How did the **atmospheric composition**, including pole-to-pole gradients in trace gas contents, change **during the entire Holocene**?

3) What is the **East Greenland signature of the abrupt climate shifts** seen during the last Glacial?

4) Has the **Renland ice cap always had the same shape and size**, so the climate record from a Renland ice core can be assumed to stem from snow deposition on a site with unchanged elevation, yielding a Greenland climate record at fixed elevation?

Planned ice cores - Renland

EuroPICS

Scientific plan for RECAP 2015

Late April to early May: Radar measurements with CRESIS surface radar, establish skiway (4 crew).

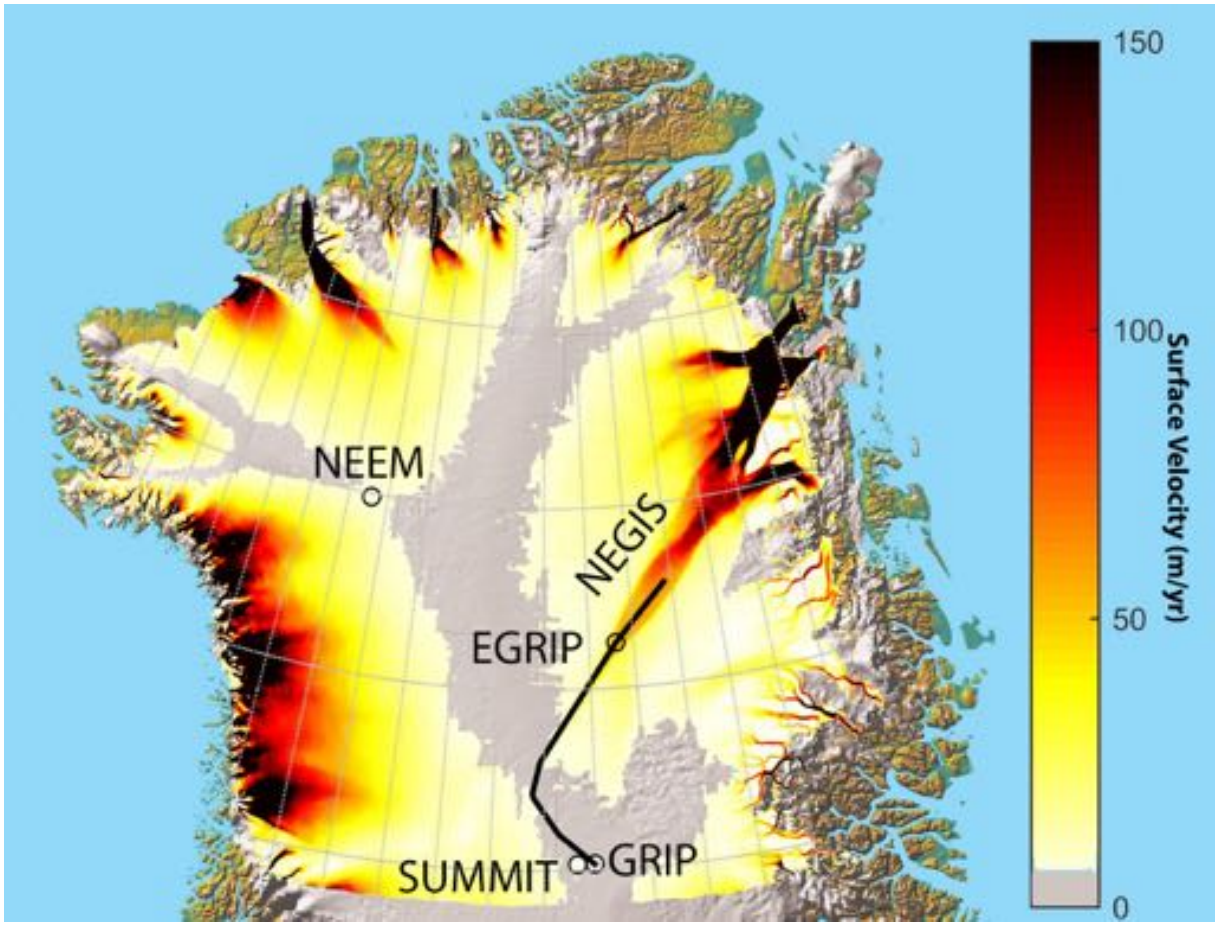
Early May to end of May: Establish main camp, deep drilling, firn gas project (11 crew).

Beginning of June to late June: Deep drilling, rapid access test, take down camp (11 crew).

Planned ice cores - EGRIP

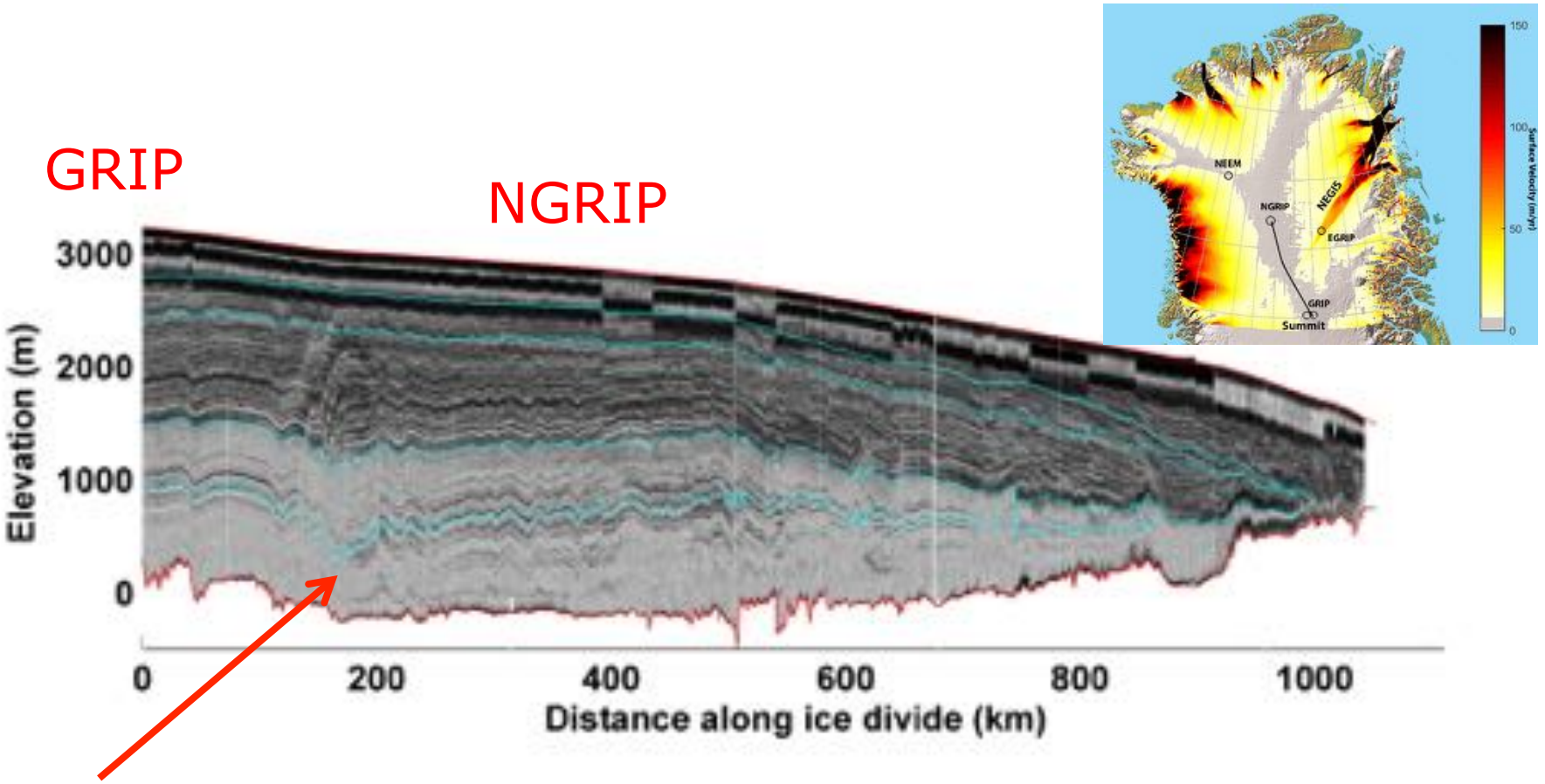
EuroPICS

The North Greenland Ice Stream (NEGIS) is the largest ice stream in Greenland



Planned ice cores - EGRIP

EuroPICS

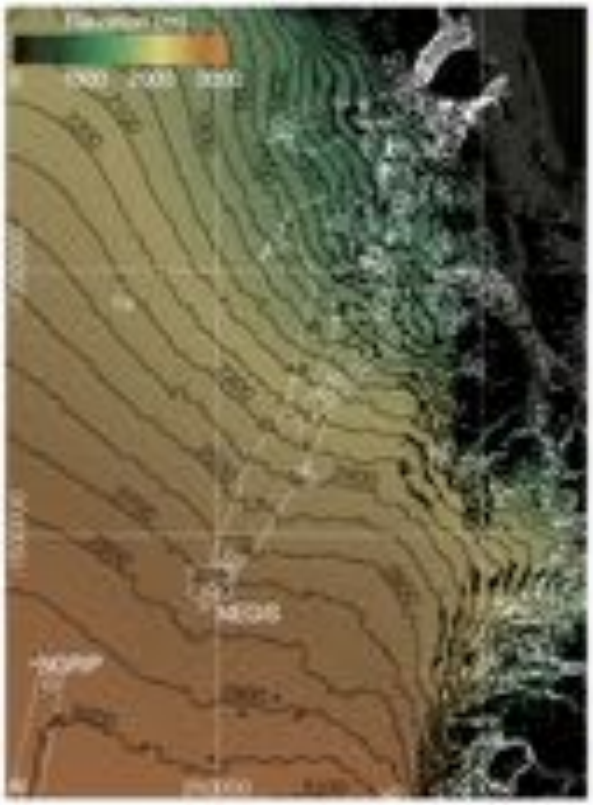


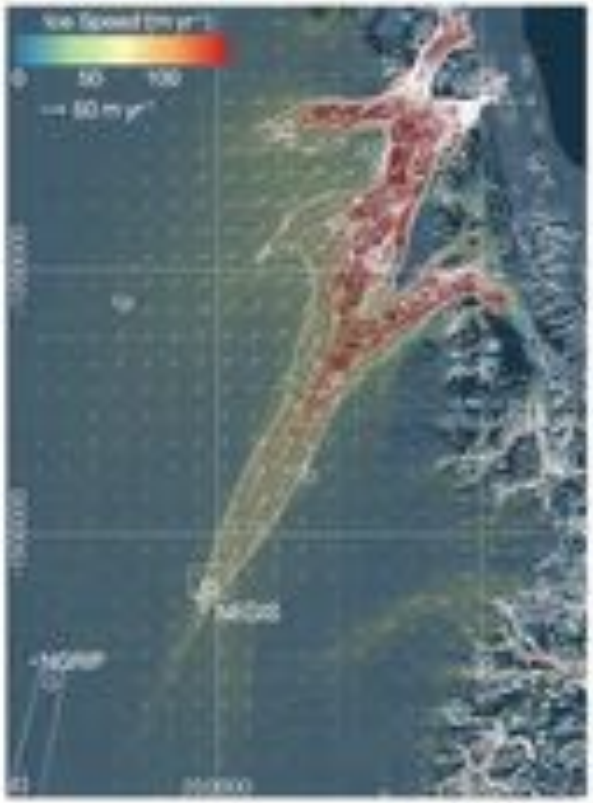
The ice stream originates at the ice ridge where the RES layers are pulled down. (Basal melt 2-3 cm per year)

Planned ice cores - EGRIP

EuroPICS

NEGIS surface, bed and surface velocity





Planned ice cores - EGRIP

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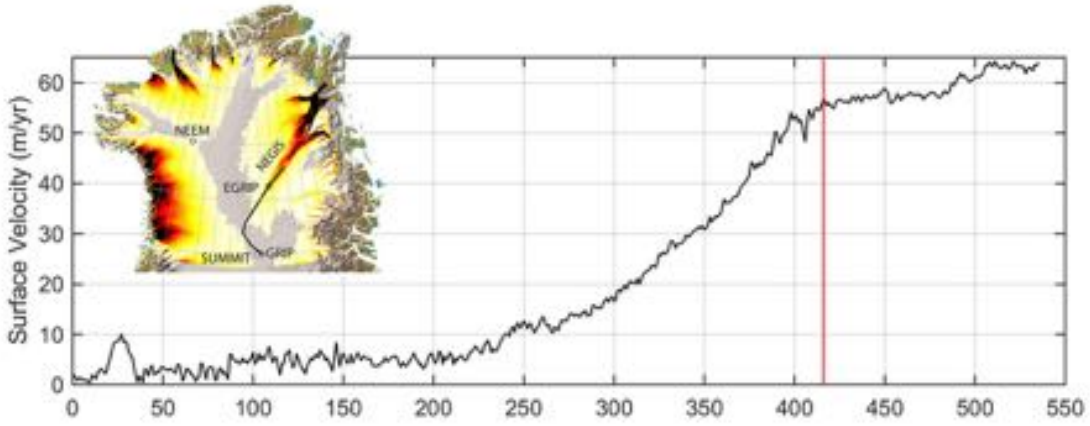
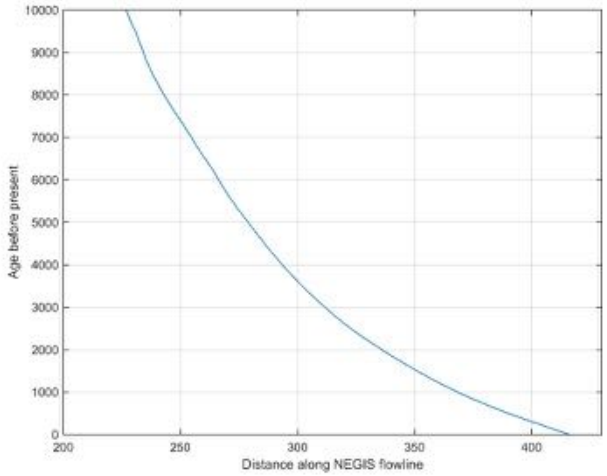
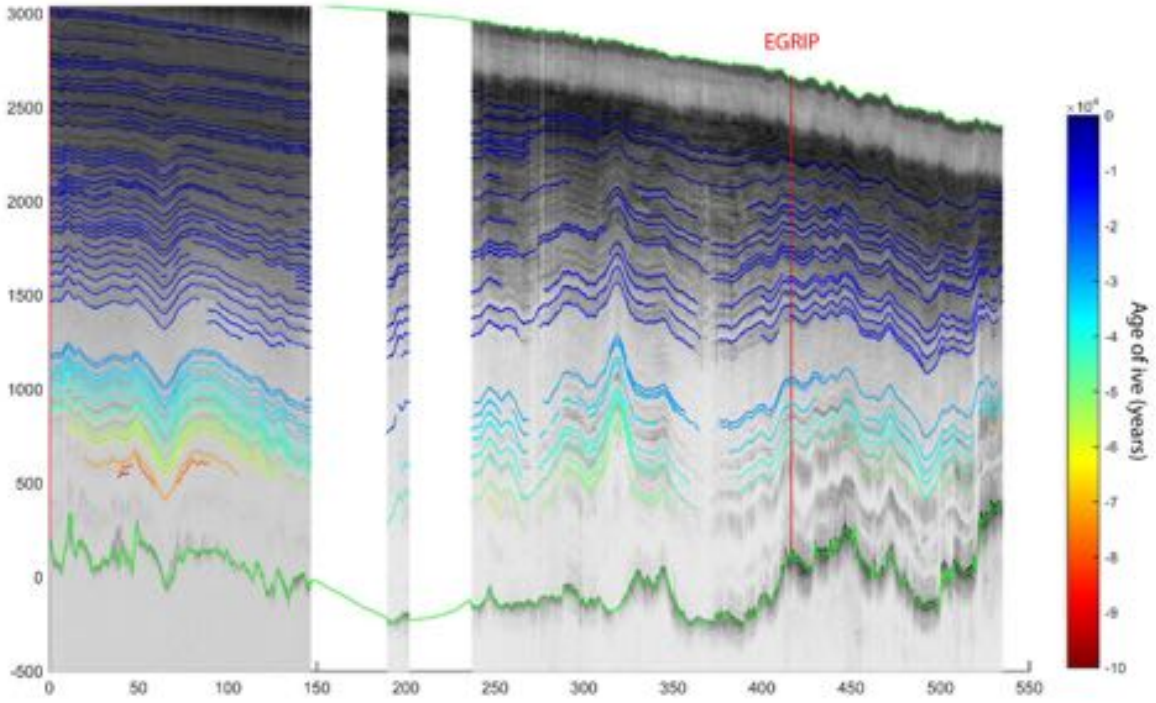






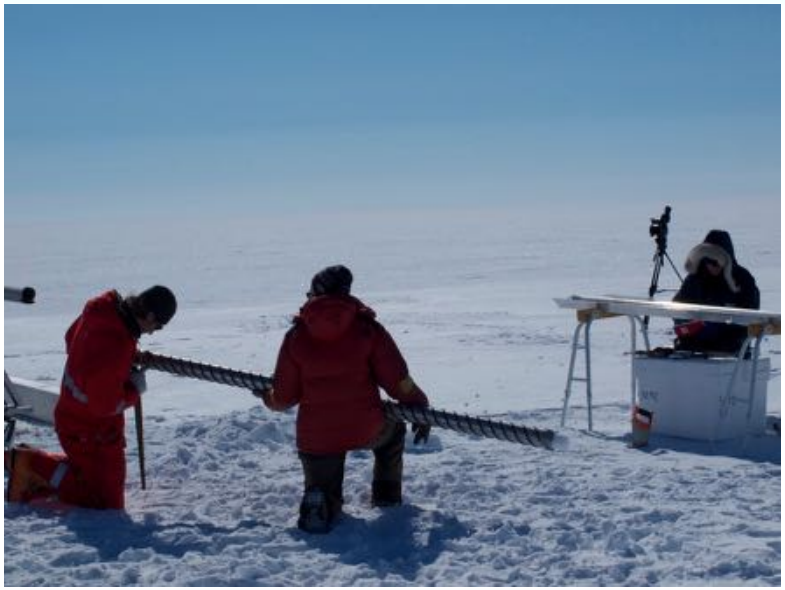
The ice originates upstream:

1000 yrs: 50 km
3000 yrs: 100 km
5000 yrs: 140 km
10000 yrs: 180 km

RES over NEGIS

Planned ice cores - EGRIP

EuroPICS



NEGIS drilling June 2012

Planned ice cores - EGRIP

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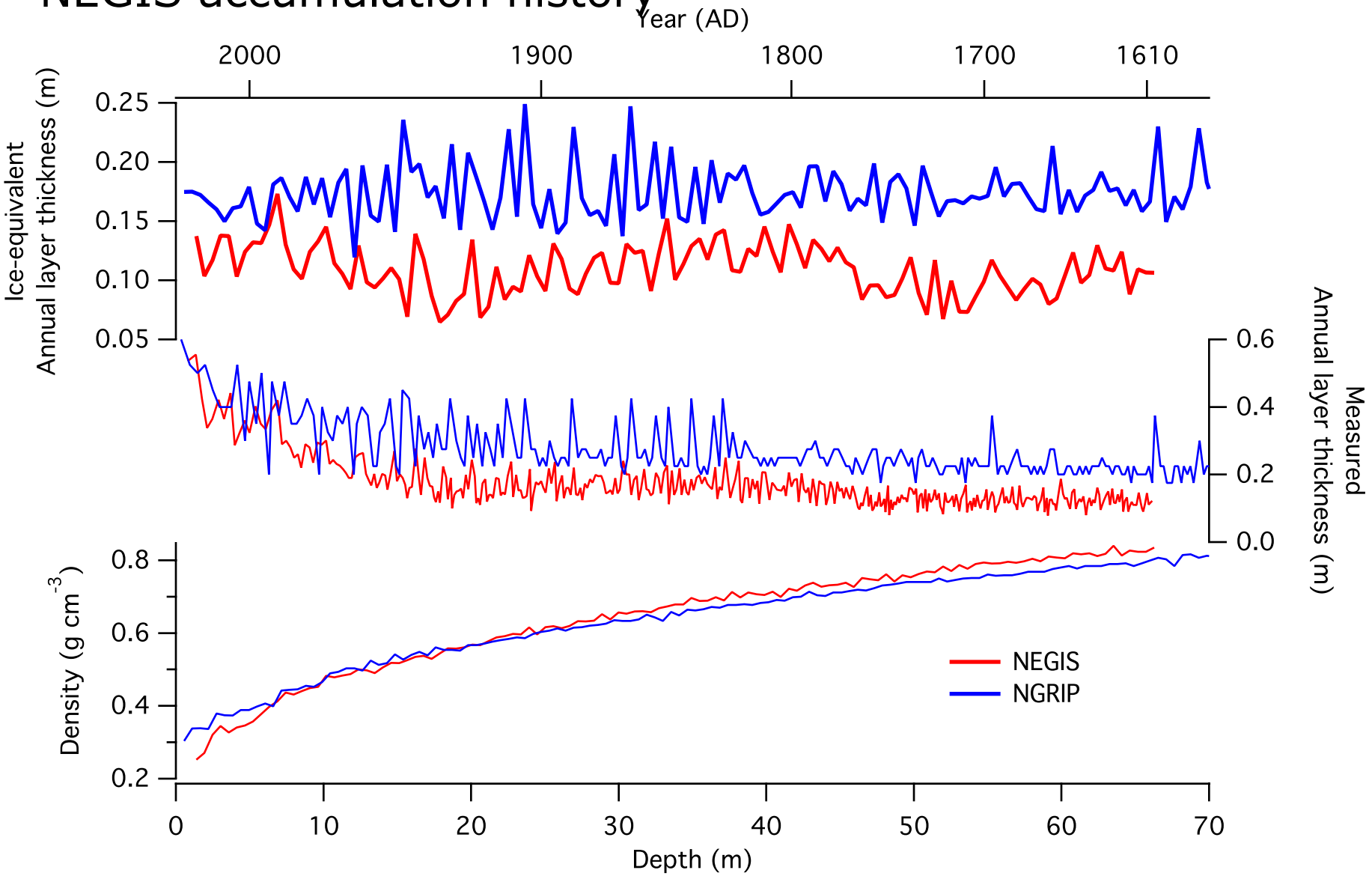
NEGIS accumulation history



Planned ice cores - EGRIP

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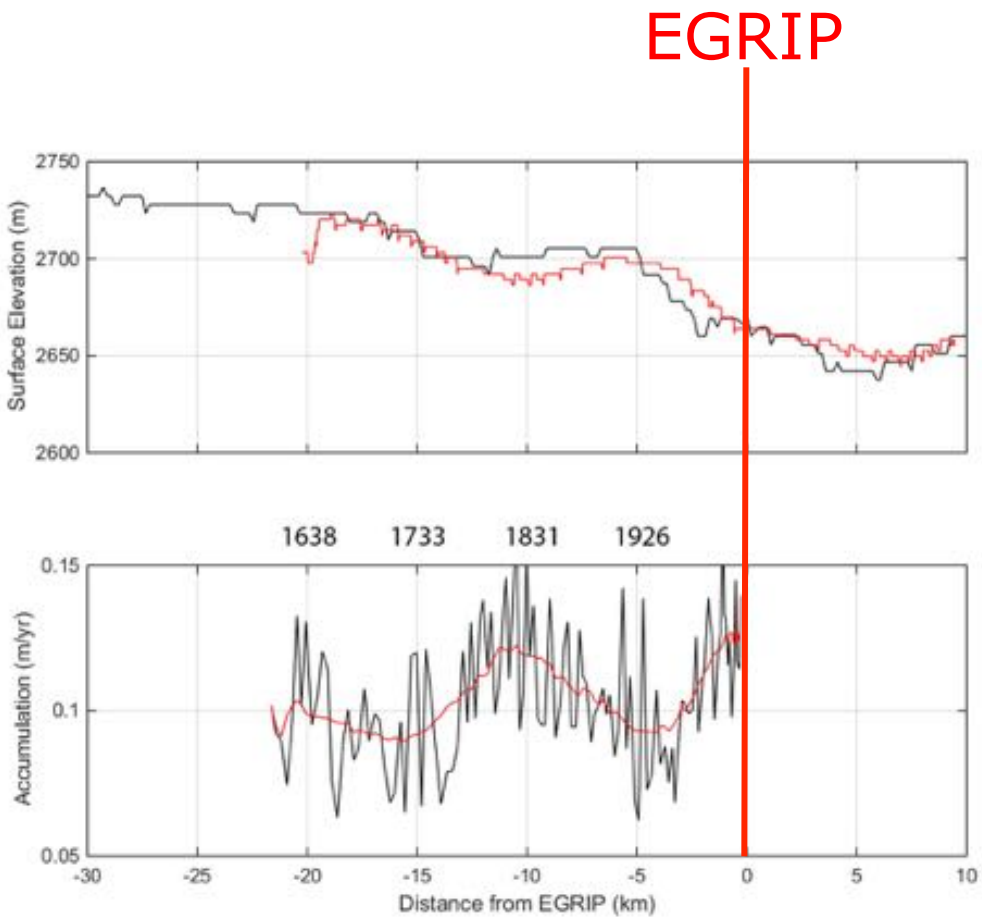
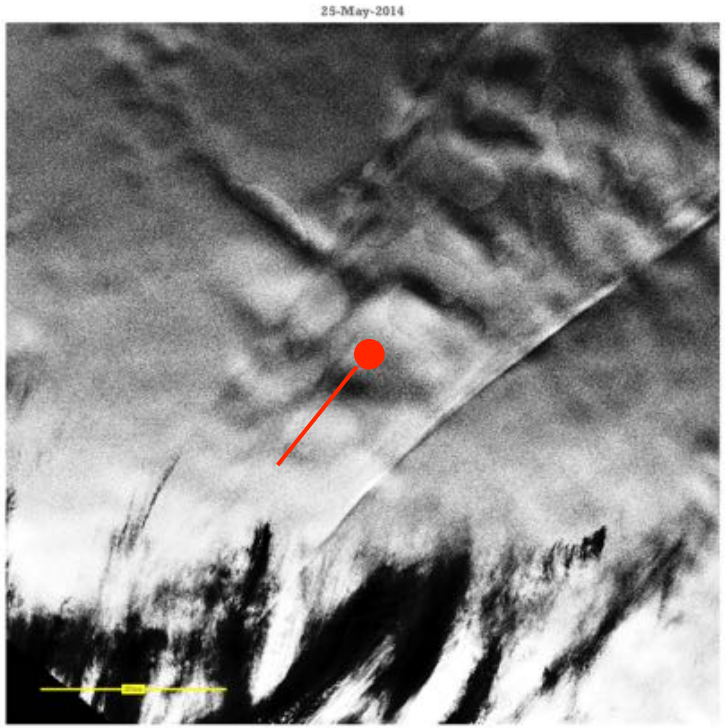
NEGIS accumulation – surface undulations



MODIS image



Planned ice cores - EGRIP

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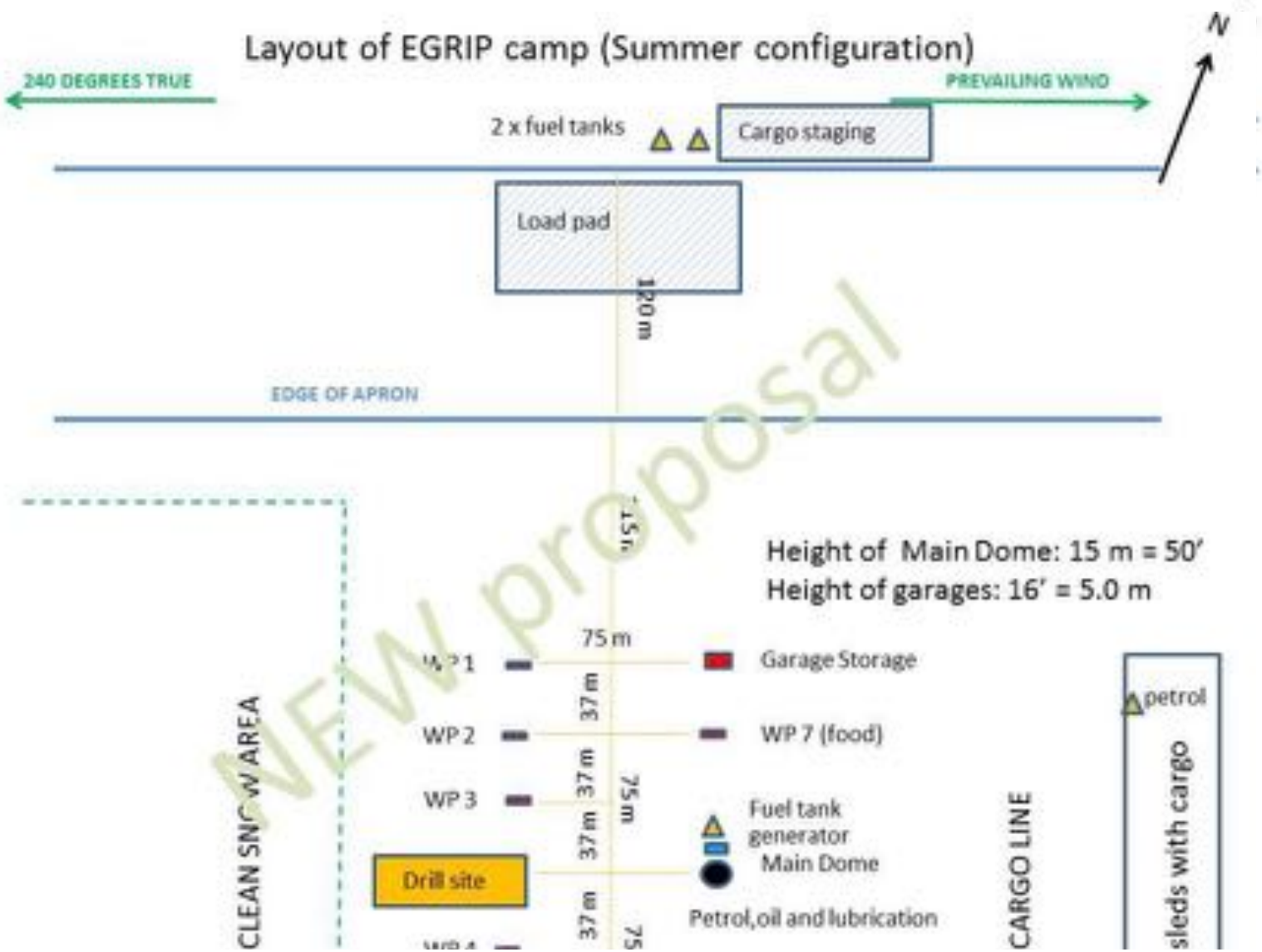

Planned ice cores - EGRIP

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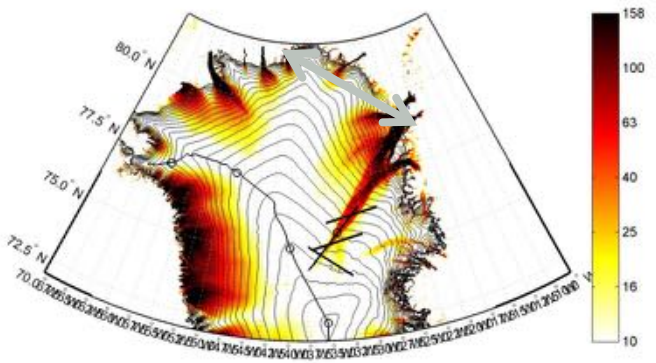
NEGIS tentative time line

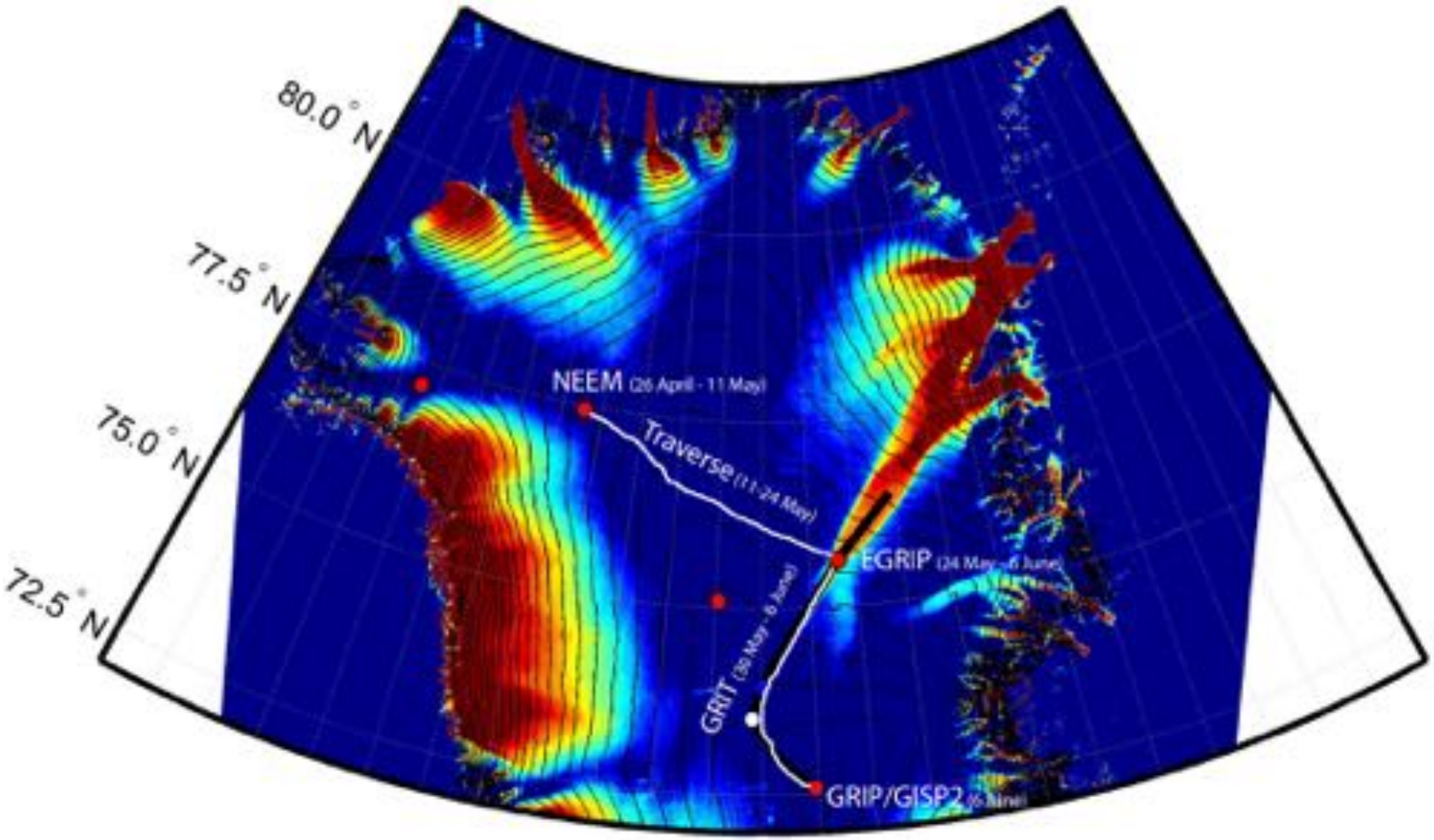


TIME LINE

2015: Move equipment, skiway
2016: Drill to 500 m
2017: Continue drilling
2018: Bedrock and water studies
2019: Last year

Planned ice cores - EGRIP

EuroPICS



Planned ice cores - EGRIP

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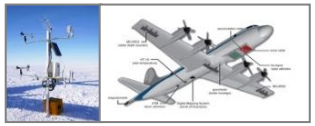
Planning

Planning of the project. Preparation of proposals

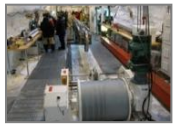


Pre-investigations

Greenland Climate Network has placed an Automatic Weather Station at EGRIP and NASA Operation IceBridge has made radar lines over the camp . A NSF track vehicle has been positioned at EGRIP.

Camp Establishment

Dome and sledges with equipment from NEEM is moved to EGRIP and a skiway is established.



Drilling starts

Snow trenches for drilling and ice core processing are made and the first 600 m ice core is drilled. Surface programs start.

Ice core processing

Drilling continues while the ice core processing starts. The surface program continues.

Bedrock reached

Drilling reaches bedrock and the monitoring of the bedrock begins. The surface program continues.

Logging

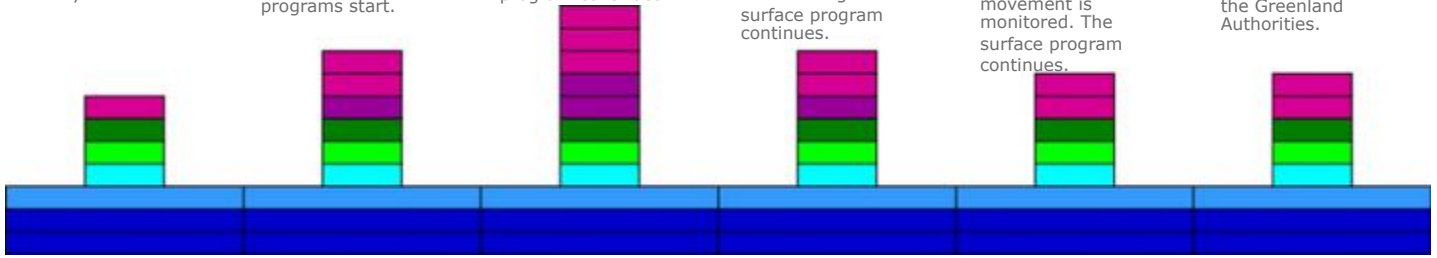
Focus is on the deformation and sliding of the ice. The hydrolic pressure at the bed and the water movement is monitored. The surface program continues.

EGRIP closes

All eqipment is packed and moved to the coast or stored on sledges depending on the agreemtns with the Greenland Authorities.

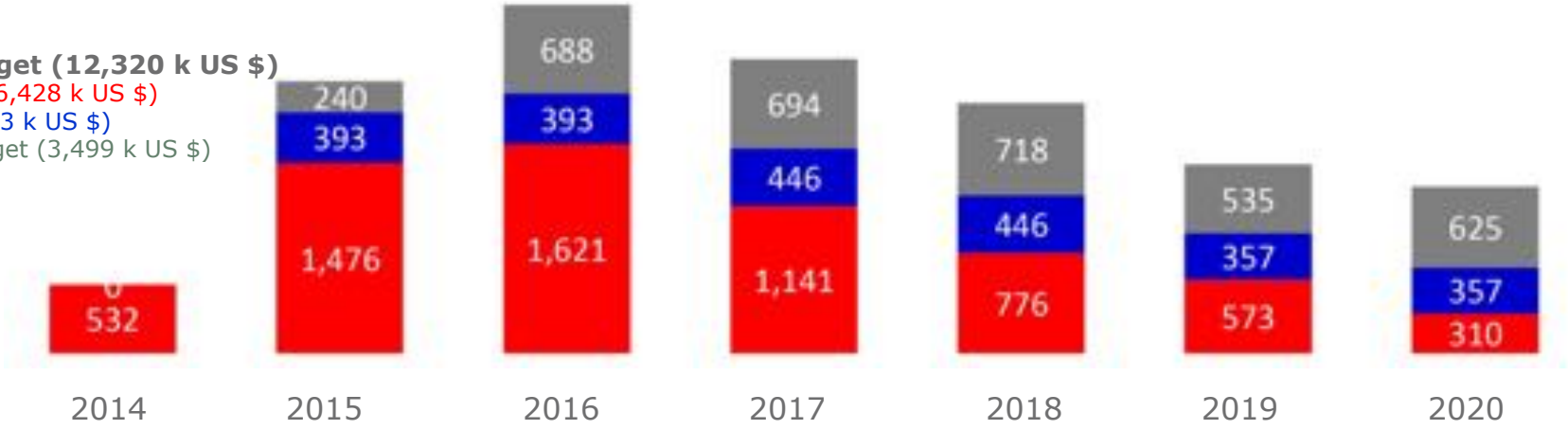
Logistisc Personal

Camp help
Carpenter
Diesel mechanic
Cook
Doctor
Drill Engineer
Logistisc Coordinator



Logistisc Budget (12,320 k US $)

Danish Budget (6,428 k US $)
US Budget (2,393 k US $)
CH+J+F+D Budget (3,499 k US $)



Planned ice cores - EGRIP

EuroPICS

Innovation:

Ballon trenches

Dome on skies

Drill liquids

Unbrittle the brittle ice

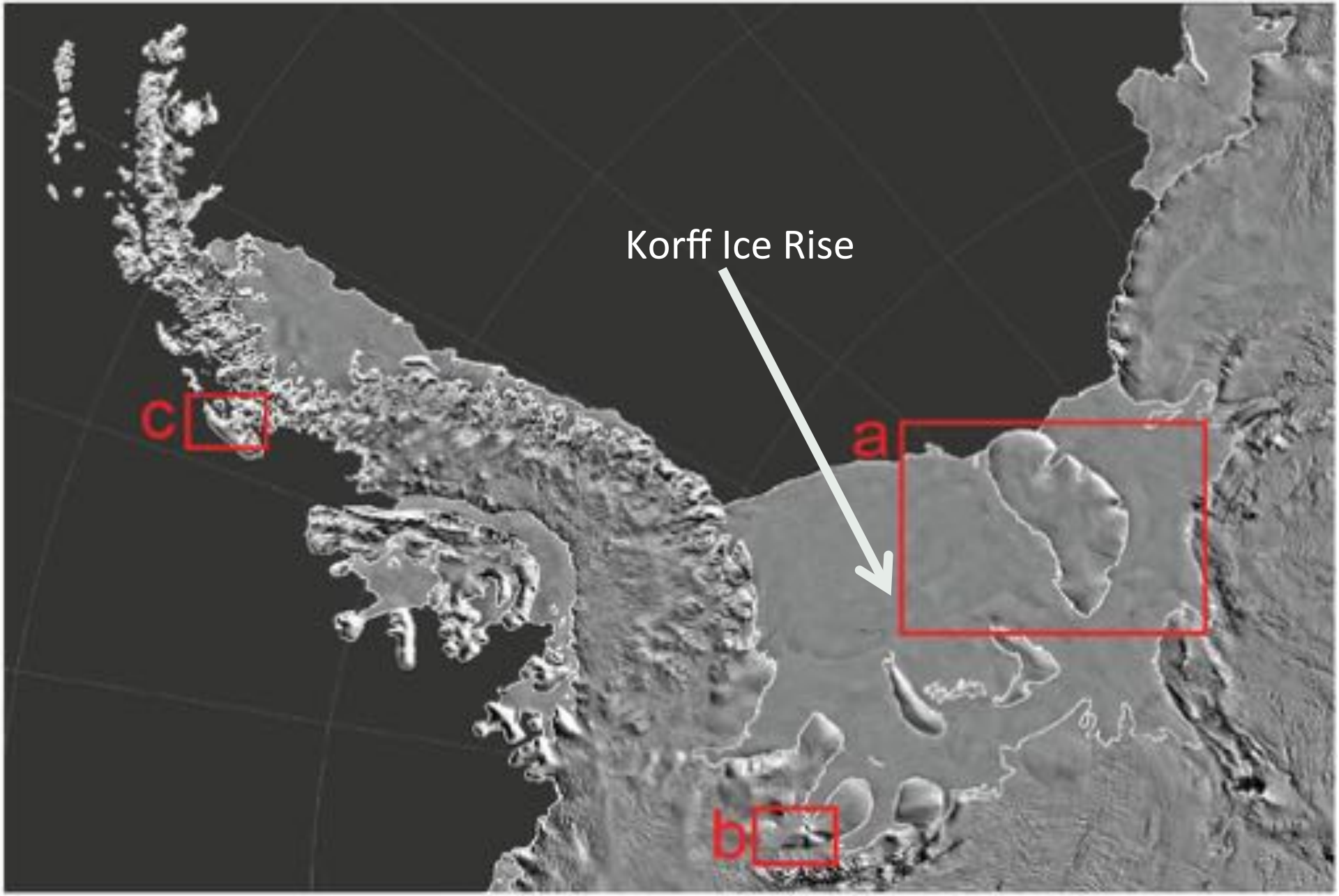
Logging tools – to be developed

International

School for young researchers

Planned ice cores – Korff Ice Rise

EuroPICS



Planned ice cores – Korff Ice Rise

EuroPICS

Hypotheses

1. Korff formed very recently (last few thousand years)
   - did WAIS retreat farther back than present at start of present interglacial?

2. Korff formed during last glacial
   - implications for grounding line position of SW Ronne area, and possible WAIS collapse during last interglacial

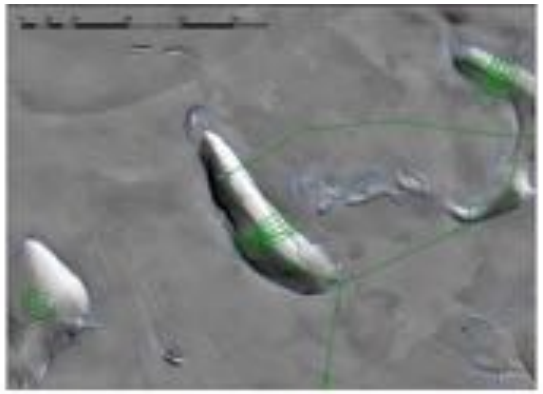
3. Korff formed several glacial cycles ago
   - does this mean no collapse since then?

We have reason to believe 1 is the most likely scenario.

Test with drill to basal material: marine origin? age of sediment? age of bottom ice? evidence of marine ice at bottom?

Planned ice cores – Korff Ice Rise

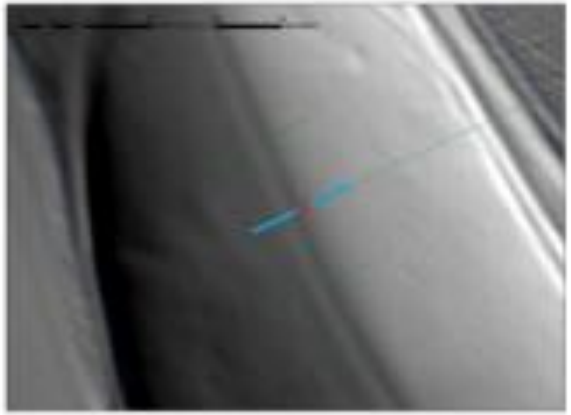
EuroPICS

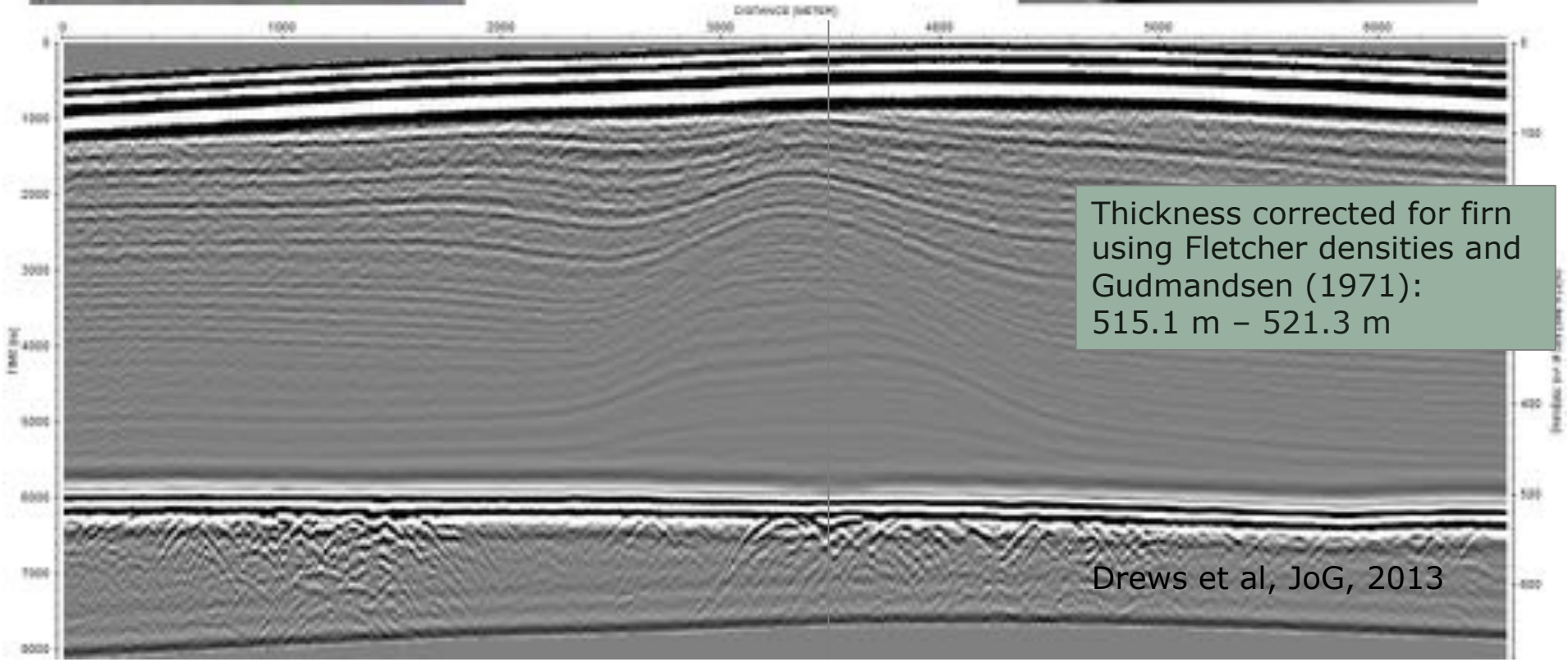


Left – radar lines over Korff

Right – drill site (red dot)

Below – radar across ridge at drill site (blue line in upper right figure) with drill site as black line



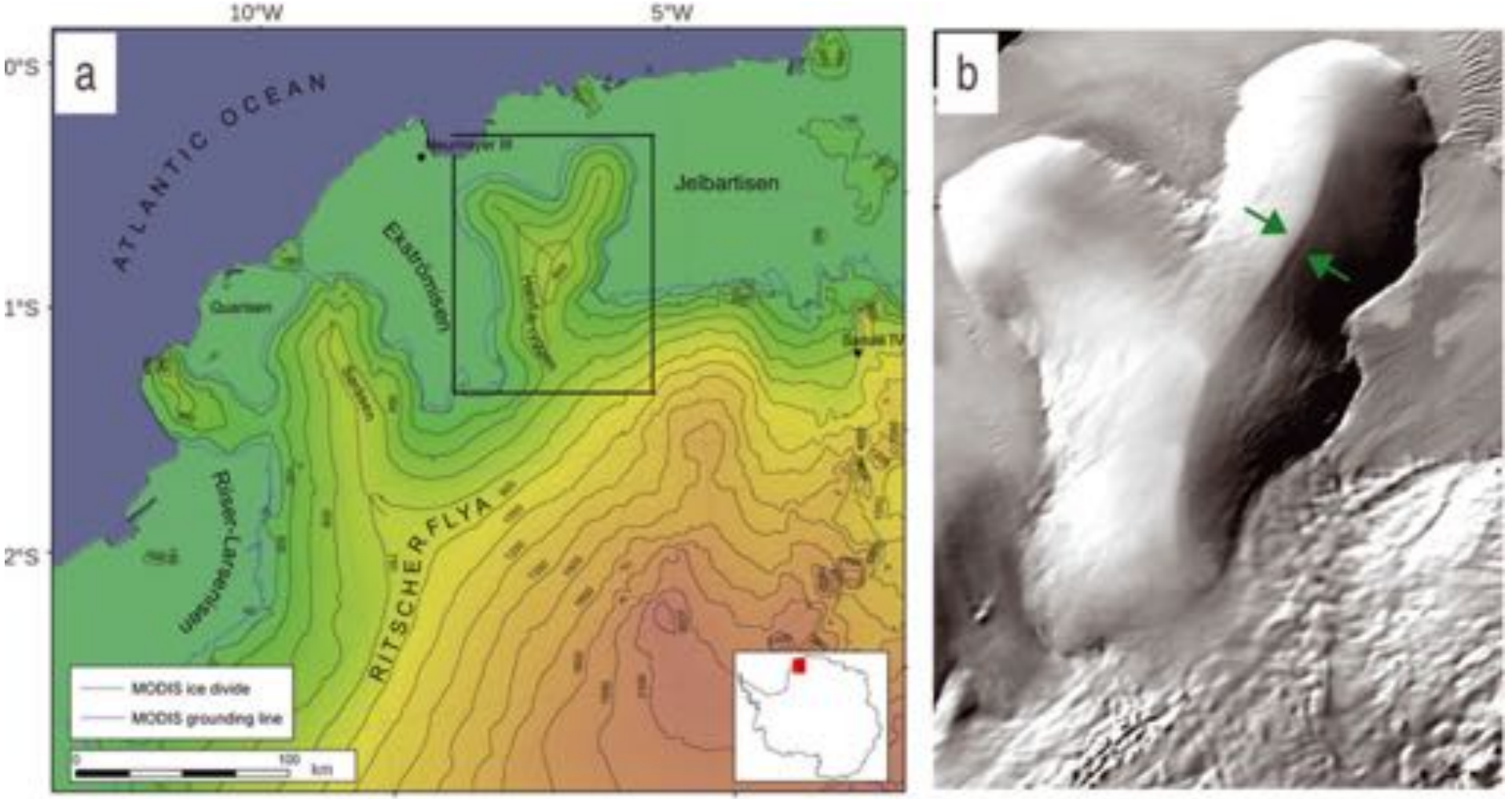


Thickness corrected for firn using Fletcher densities and Gudmandsen (1971):
515.1 m – 521.3 m

Drews et al, JoG, 2013

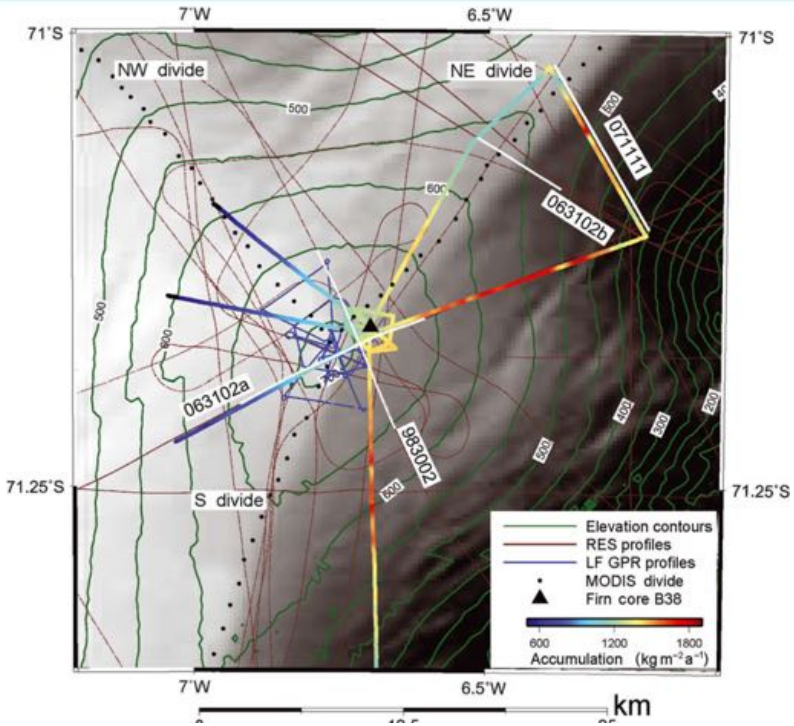
Planned ice cores - Halfvarryggen

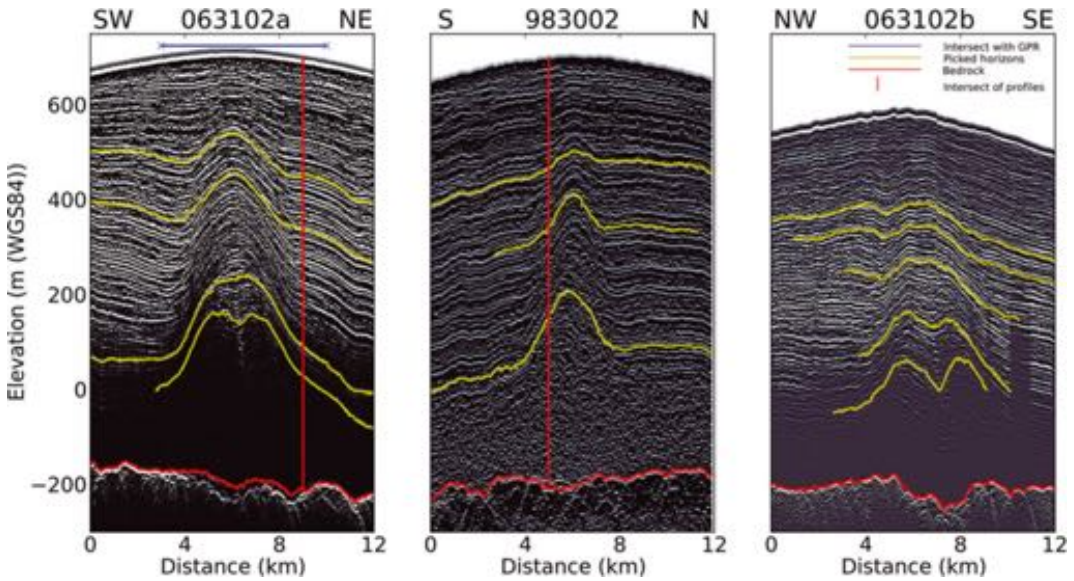
EuroPICS



Planned ice cores - Halfvarryggen

EuroPICS

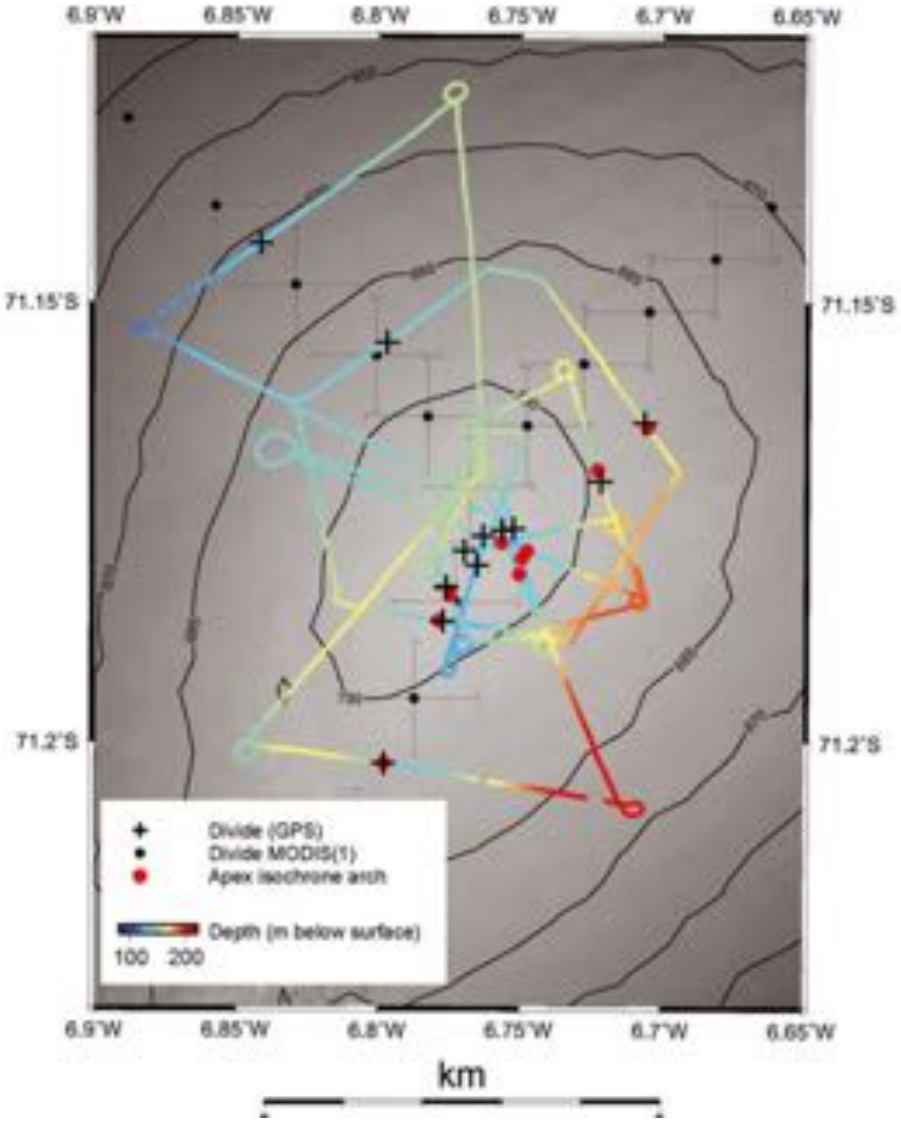




Drews et al, JoG, 2013

Planned ice cores - Halfvarryggen

EuroPICS



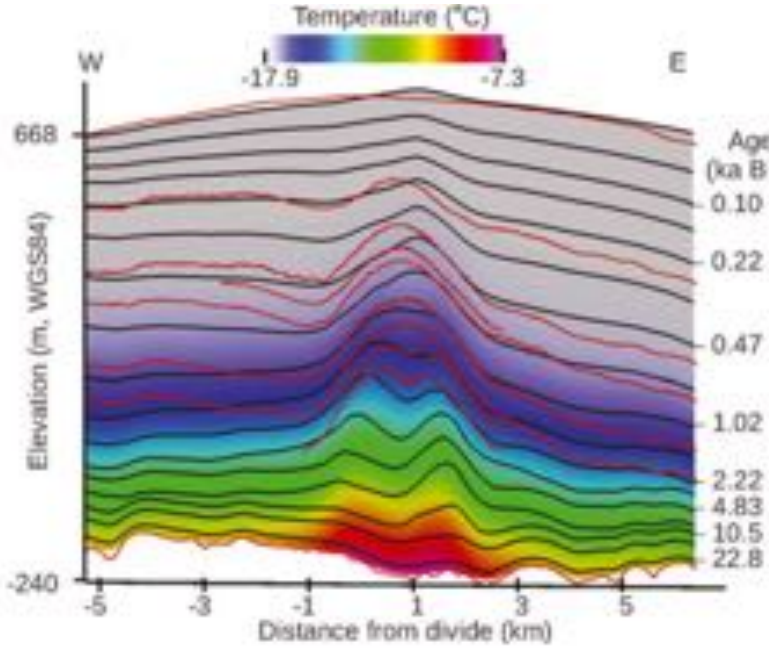


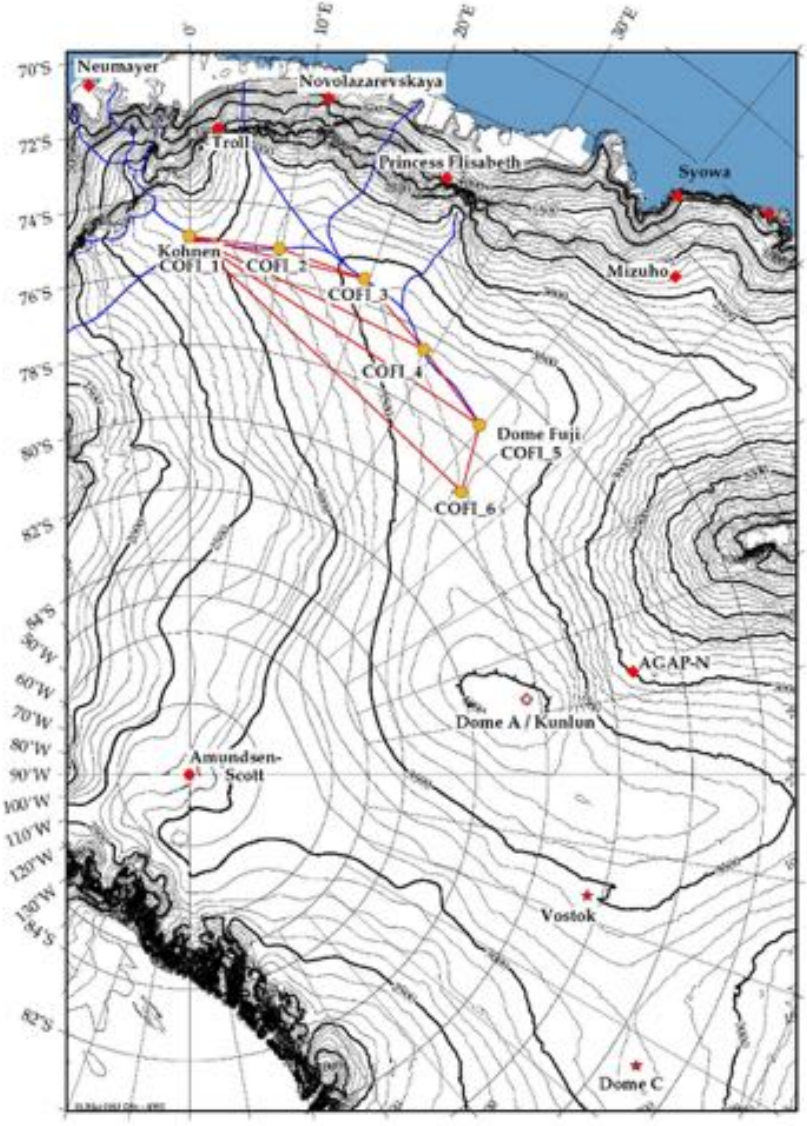
Fig. 7. Model output ($G = 50\,\mathrm{mW\,m^{-2}}$, $n = 3$) along RES 063102a close to the dome (see Fig. 3 for location). The mo isochrones (black lines) are shown in comparison to the mea RES layers (red lines). The temperature field is displayed background and predicts –7.3°C at the ice/bed interface under the divide.

interpolation (Fig. 10, further below) illustrates tha isochrone arches beneath the southern and the northea

Drews et al, JoG, 2013

Planned ice cores - COFI

EuroPICS



Coldest Firn cores from Kohnen towards Dome Fuji.

The idea is to use synergies by coordination with radar survey work in the area for oldest ice pre-site survey.

Planned ice cores

EuroPICS

Renland

EGRIP

Korff Ice Rise

Halfvarryggen

Amundsen / Bellingshausen Seas Coastal Dome

Beyond EPICA oldest ice

2a cores at 5 sites: Illimani, Colle Gnifetti (CG), Svalbard, Belukha and Tsambagarav (Mongolia).

180 m at the Eurocore site in Greenland

350 m + 100 m cores near Dome C

120 m at Derwael ice rise

Drill liquids

EuroPICS

Several overview papers are published now in Annals of Glaciology

Estisol 140

Pros: cloth+core can dry

Cons: smelly

Estisol 240

Pros: not smelly, lubricates chips well

Cons: cloth+core do not dry, increase borehole diameter

Rapid Access Drills

EuroPICS

SUBGLACIOR

RADIX

BAS Rapid Drill

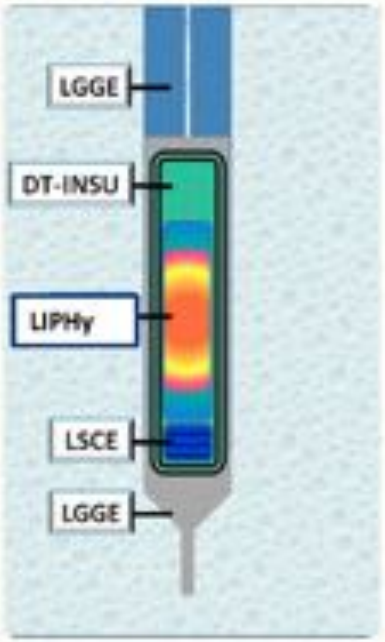
Rapid Access Drills - GLACIOR

EuroPICS

ERC ICE&LASERS – ANR SUBGLACIOR

SUBGLACIOR probe objectives

- Drill down to bedrock through a single run and in a single summer Antarctic season (December-January)
- Embarked OF-CEAS laser spectrometer for in-situ measurements of δD of H_2O and of methane concentration, with continuous data transfer to surface



- Team of 21 persons from 4 French laboratories : LGGE, LIPhy, DT-INSU and LSCE
- Project started in 2012 (ends in 2018)
- Budget of 3.2 million €

http://www.iceandlasers-subglacior.org

Rapid Access Drills - GLACIOR

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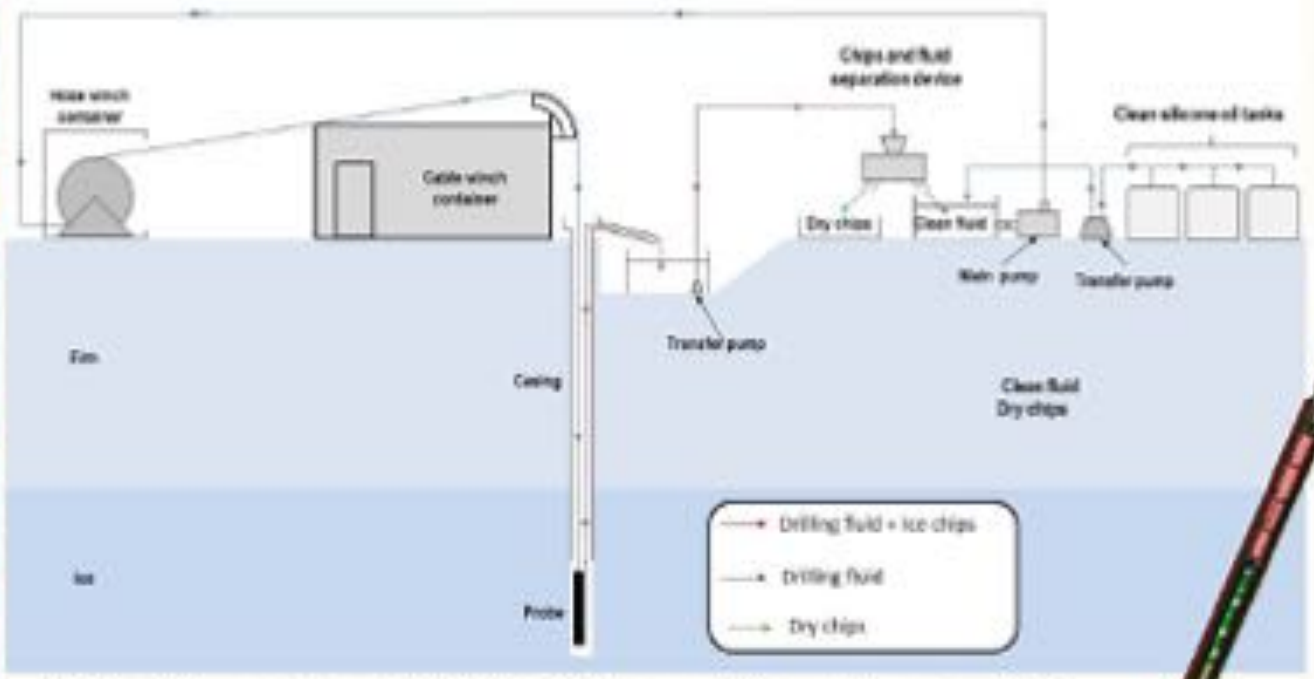
General concept



- 97% electromechanical drill + 3% thermal (sample production)
- Continuous evacuation of the chips through a drill fluid circulation
- Drill fluid : silicon oil BLUESIL FLD 47V3
- Sample handling at sub-atmospheric pressure
- Sample meltwater re-injected in the borehole
- Data transmission from spectrometer to surface through ADSL (up to 80 Kb/s)

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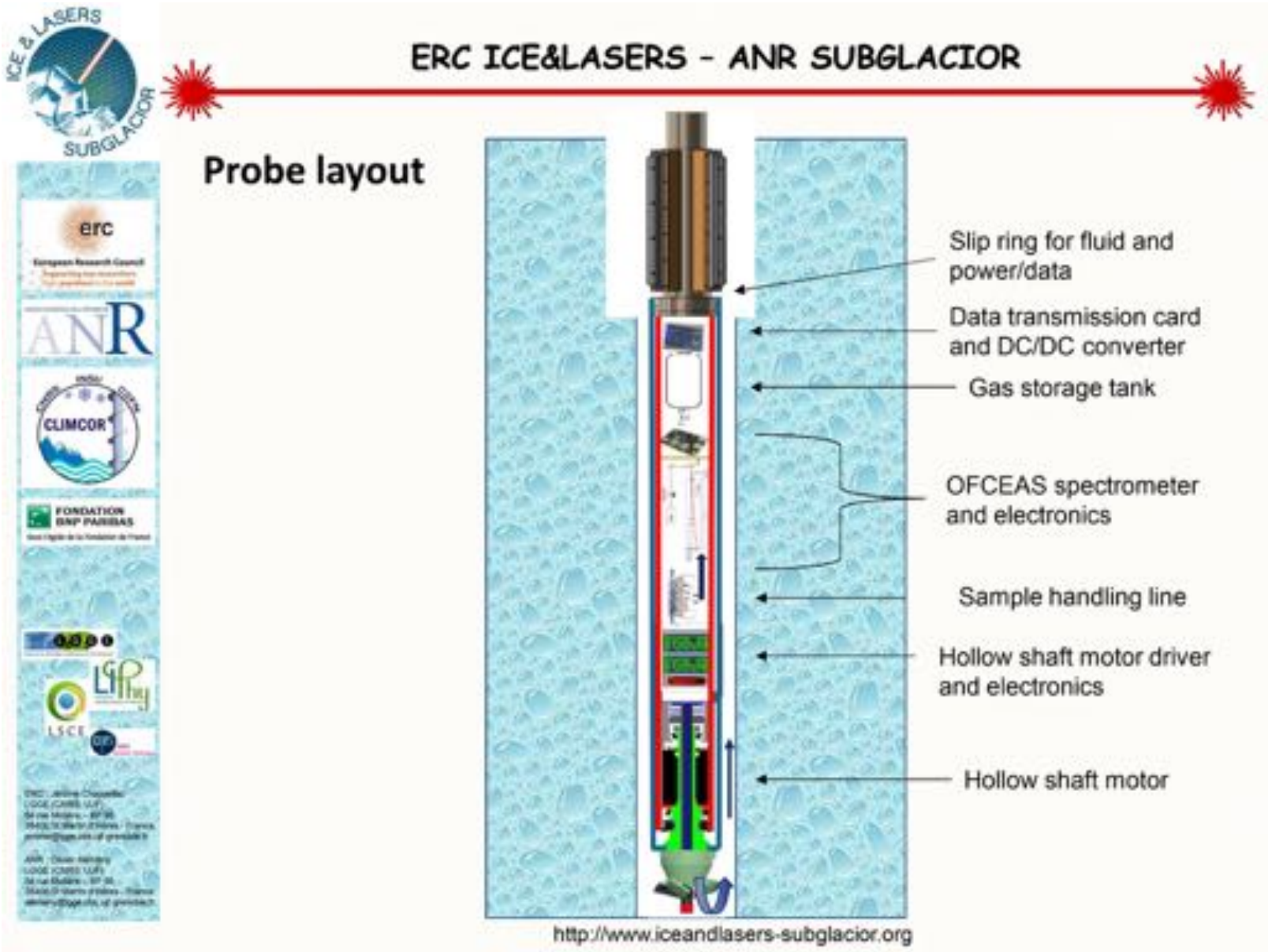

Rapid Access Drills - GLACIOR

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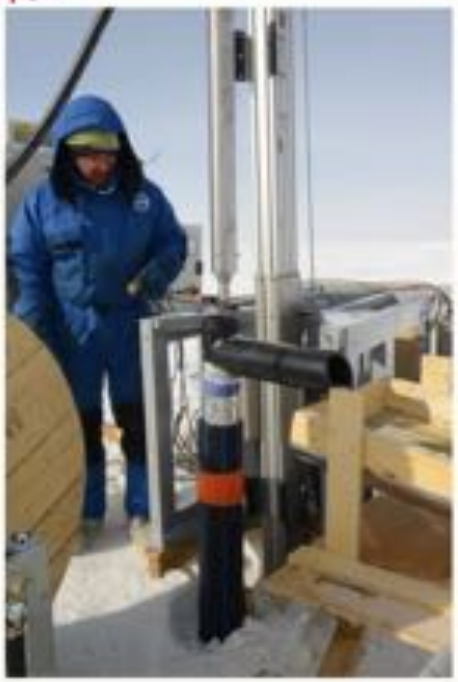
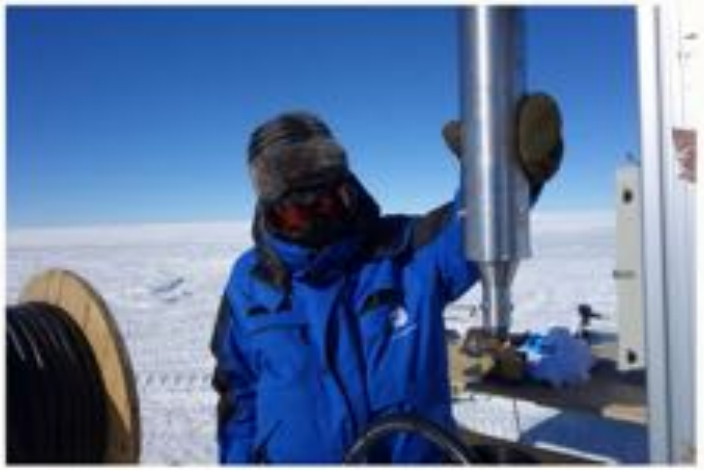
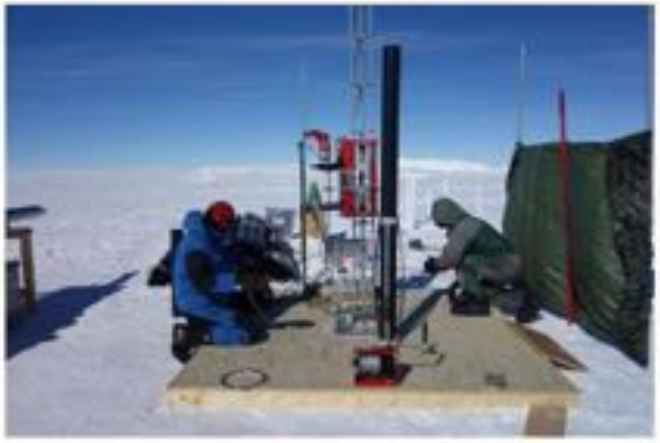


Field work 2013-2015 at Concordia





- Leak-tight tubing installed down to 120 m
- Successful test of fluid/chip circulation

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Rapid Access Drills - GLACIOR

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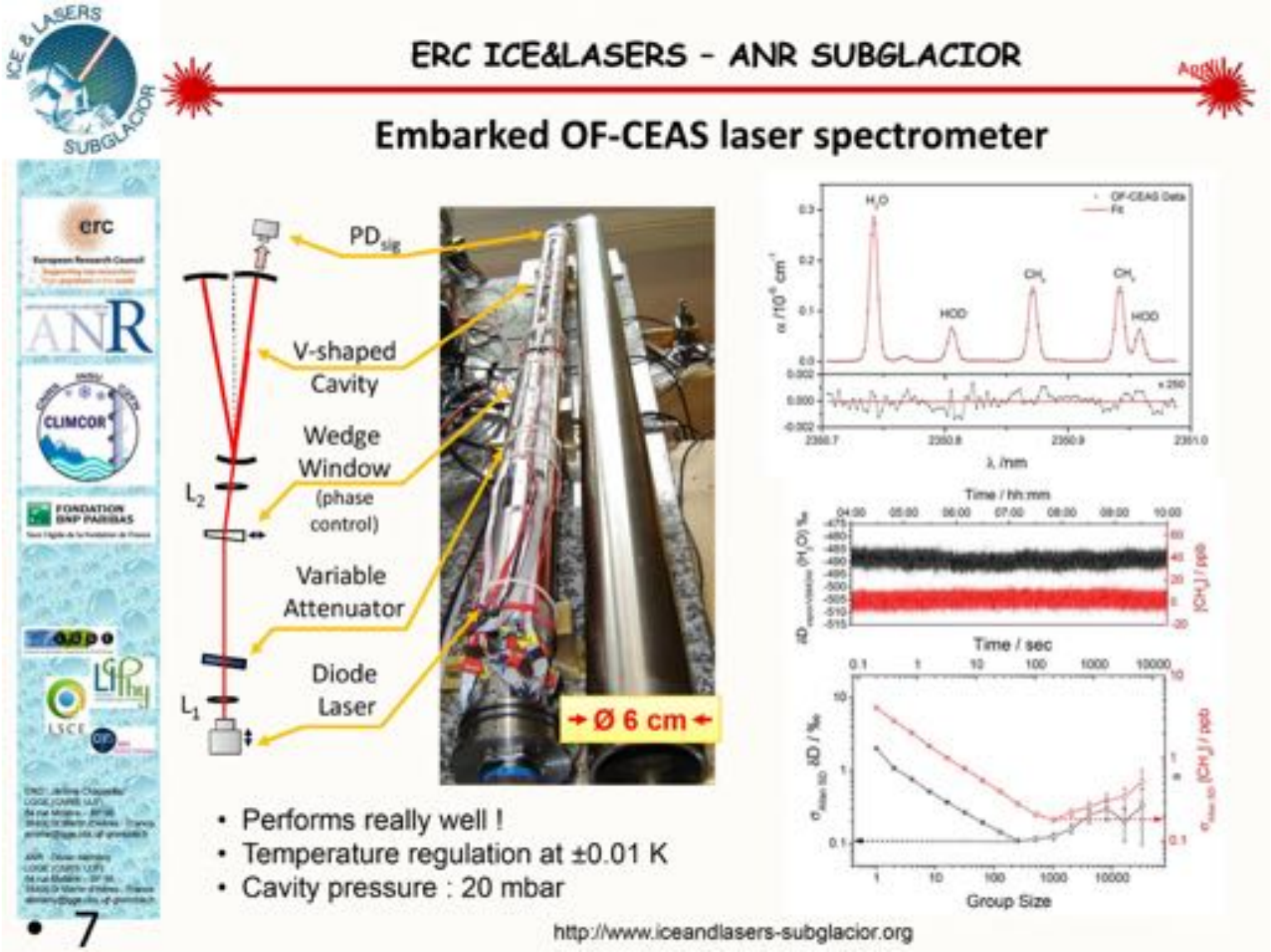

Rapid Access Drills - GLACIOR

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Conclusions and outlook

- SUBGLACIOR design nearly finished
- OF-CEAS spectrometer miniaturized and working very well
- Heavy surface equipment currently being built ; delivered to Antarctica on December 2015
- Full-scale test on December 2016-January 2017 at Concordia, next to EPICA/Dome C borehole → 1000 m of depth
- First deployment for the "oldest ice" challenge in 2017/18
- More sites afterwards (+ applications on internally dating fast ice stream glaciers)

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Rapid Access Drills - RADIX

EuroPICS

15-mm Ø Hydraulic-Motor

P > 50 Watt

Rapid Access Drills - RADIX

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RADIX: Pump und Drill

Rapid Access Drills - RADIX

EuroPICS

J	Flow rate	32 ml/s
η	Viscosity	$5*10^{-3}$ Pa s
d_h	Hole diameter	20 mm
d_i	Tubing inner diameter	8 mm
d_o	Tubing outer diameter	$d_o = d_i$ + 5.8 mm
x	Chips/fluid mixing ratio	1/10
H	Max. hole depth	2500 m
p_s	Fluid pressure at surface*	<30 MPa
p_m	Fluid pressure at motor*	<56 bar
p_o	Pressure at bottom*	1 MPa
e	Specific cutting energy	20 MJ/m^3
v	Drilling speed	0.01 m/s
P	Motor Power	max 63 W
γ	Motor efficiency	30%

* Pressure above hydrostratic pressure

Rapid Access Drills - RADIX

EuroPICS

The aim of the RADIX project is to **design and construct a fast-access ice drilling** equipment for prospecting a potential drilling site in Antarctica in the framework of the IPICS "Oldest Ice Project".

The aim is to develop a system **using minimal resources and logistics support**. The final goal will be to drill several holes at potential deep drilling sites to or near to bedrock.
The holes will be used for temperature and other downhole measurements.
The drilled ice chips and/or core samples from specific depths will be

Renland 2015: Drill performance and the fluid circulation and recycling.
We will install a casing into an access hole drilled beyond the firn-ice transition.
The casing is a 25 mm i.d. PE tube sealed at the bottom with frozen water.
We plan to drill a 20-mm hole to a depth of approx. 300 m.
The work should be completed in about 2 days.

Rapid Access Drills – BAS Rapid Drill

EuroPICS

To 500 m

Developed at BAS (Rob Mulvaney)

Has been tested

Ready to tested again 15/16

THANKS

EuroPICS