Exploring the dynamics and past climate of the coastal ice shelves and ice rises of Antarctica

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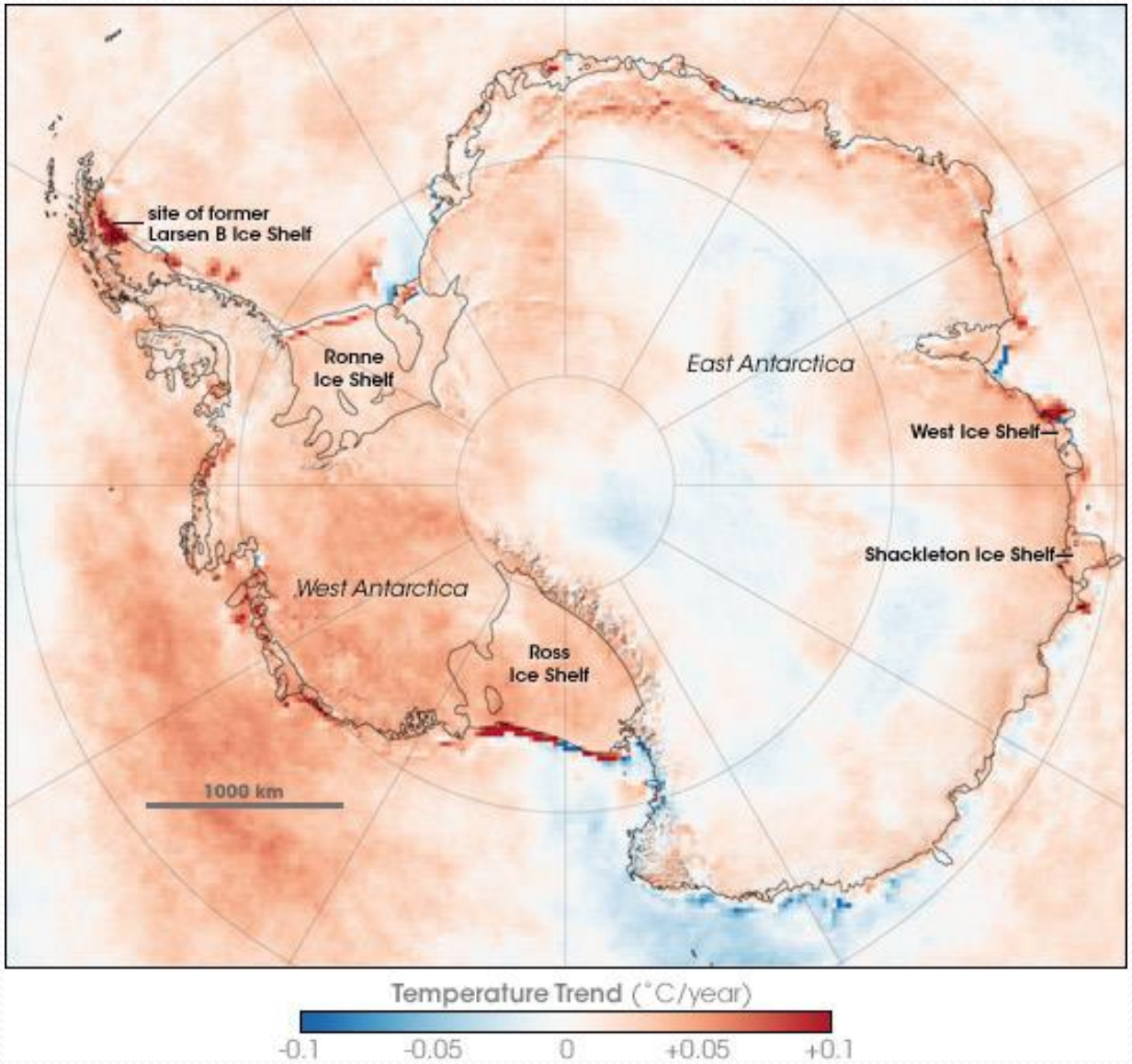
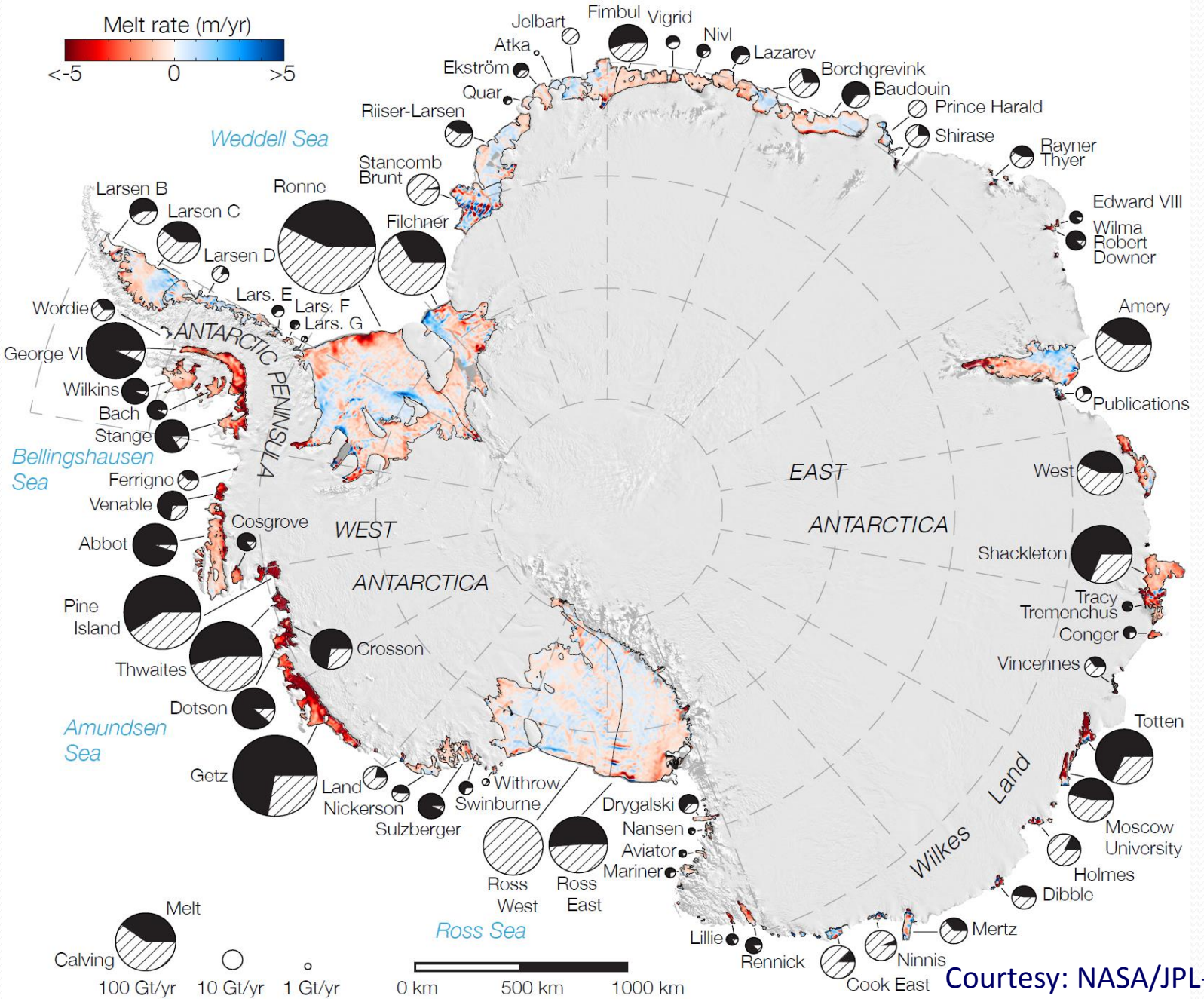
Antarctic is warming



Temperature trends in Antarctica between 1981 and 2007, based on thermal infrared observations made by a series of NOAA satellite sensors (Courtesy: Robert Simmon)

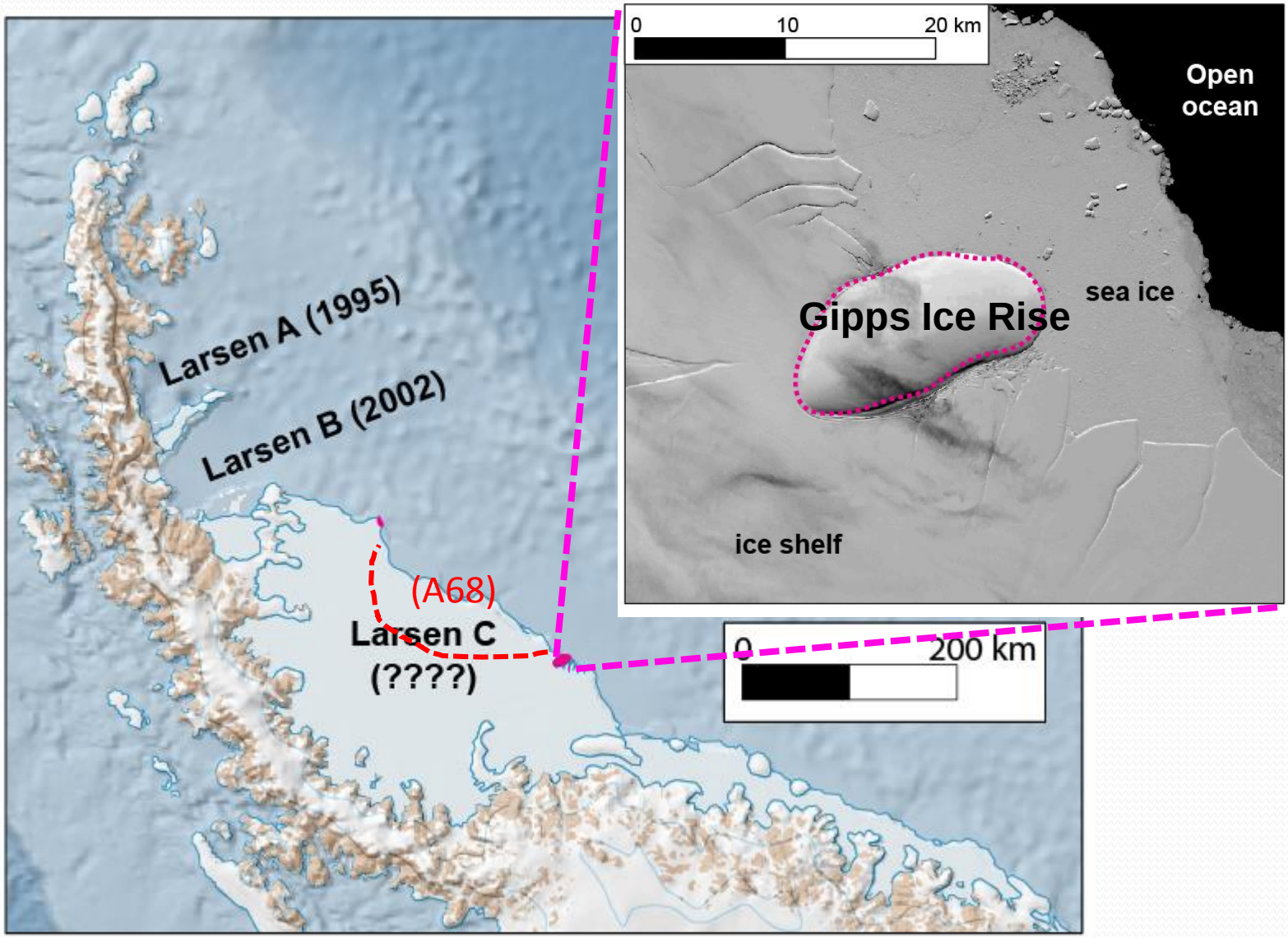
Effect of warming on ice shelves – basal melt & calving



Courtesy: NASA/JPL-Caltech

A trillion-ton iceberg has detached from Antarctica
(nearly twice the area of Goa!)

Loss of ice shelves & role of ice rises



ANTARCTIC ICE SHELVES & ICE RISES:

“bottle cork” for Antarctic ice sheets?

Image: Peter Leopold (NPI)

Illustration: Reinhard Drews (ULB)

How will DML ice shelves behave in future?

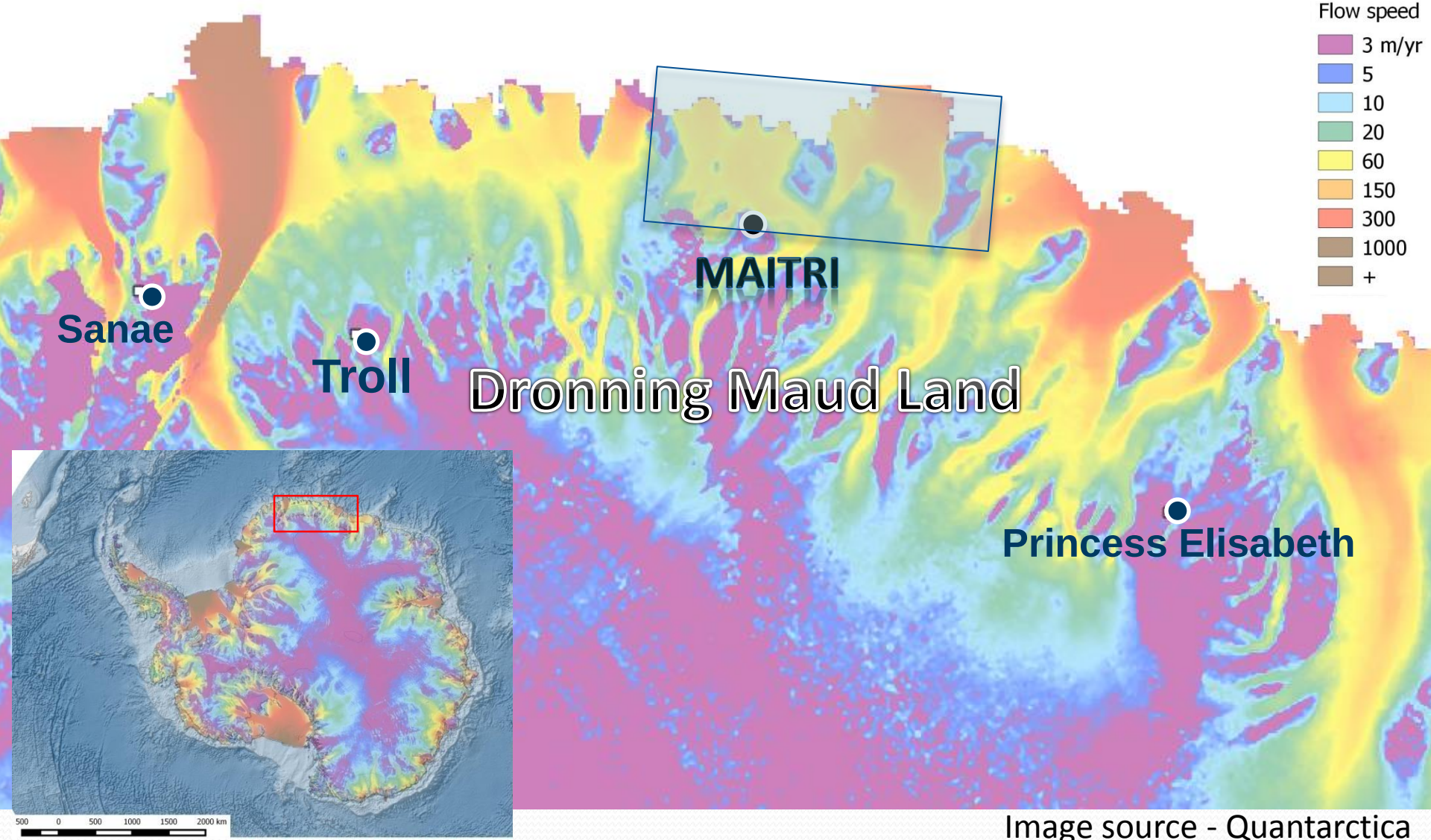
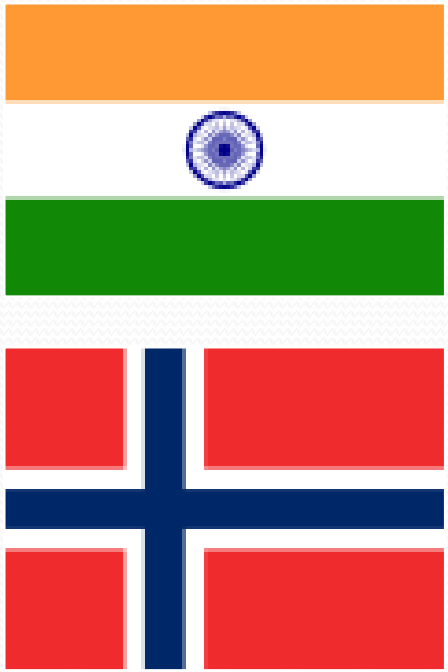


Image source - Quantarctica

An Indo-Norwegian project funded by the Ministry of Earth Sciences (MoES) Research Council Norway (2016-2020)

Mass balance, dynamics, and climate of the central Dronning Maud Land coast, East Antarctica (MADICE)



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MADICE Project objectives:

1: To understand the current status and dynamics of ice shelves in DML to decipher their sensitivities for the future climate change;

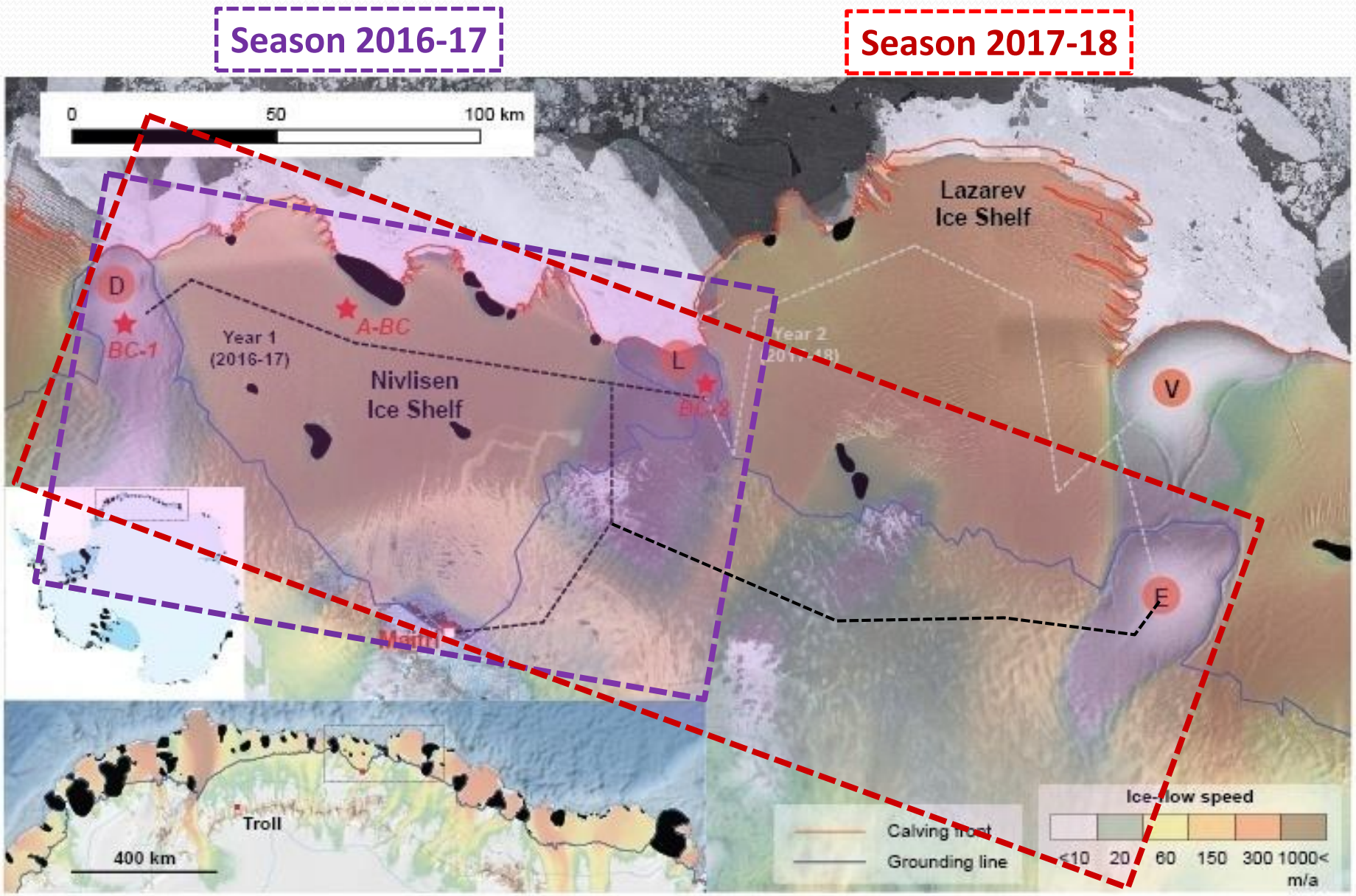
2: To study long-term evolution of the coastal Antarctic ice rises to assess the role of ice rises on stability of ice shelf and ice sheet;

3: To understand the long-term climate variability and its relation to the ice sheet dynamics in coastal Antarctica;

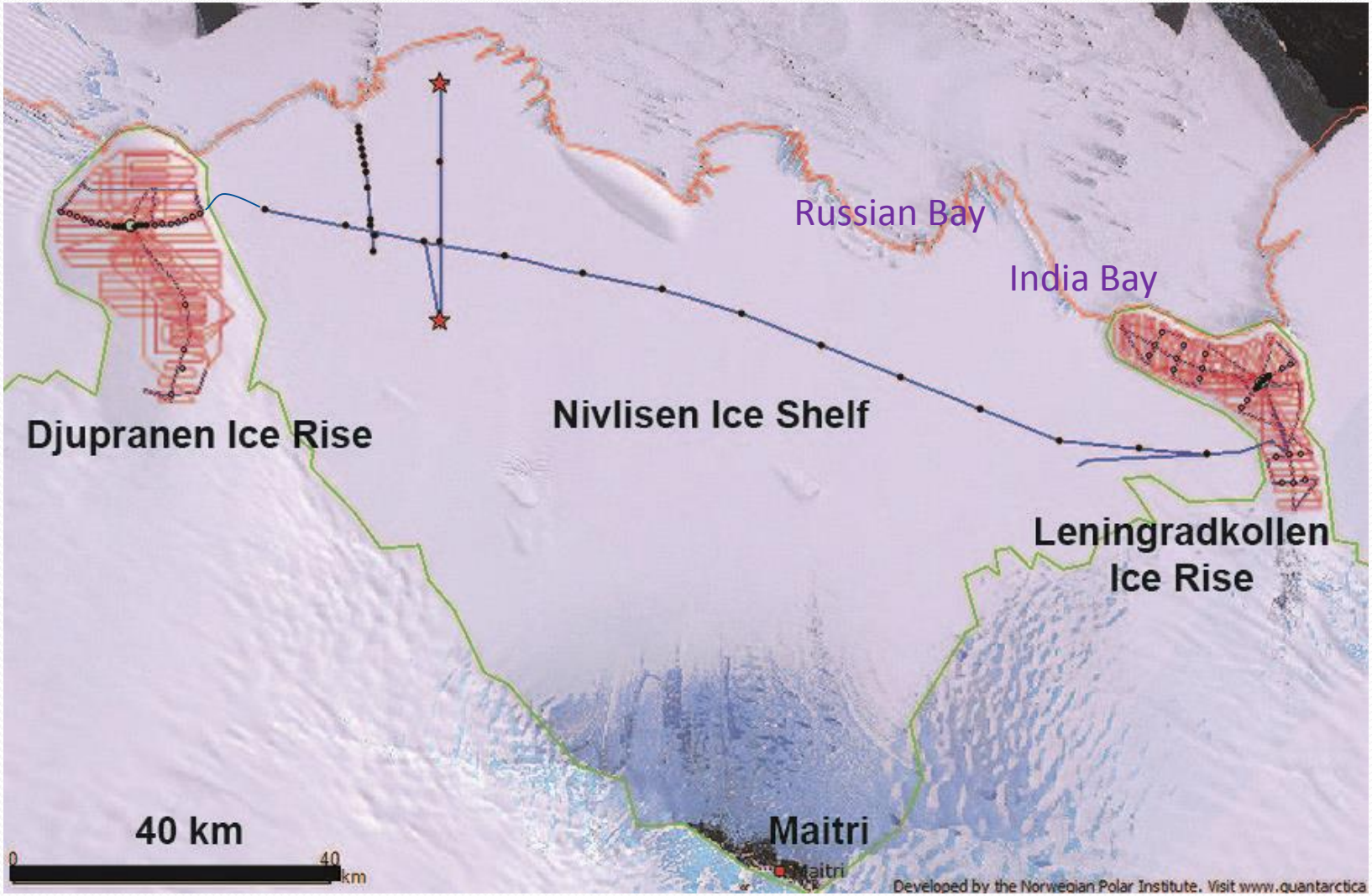
4: Synthesis of regional instability & identify sites for deep ice-cores

We integrated the complimentary interest, expertise and strengths of NCAOR (Ice core studies, geochemistry) and NPI (Glaciology, geophysics)

MADICE field campaigns

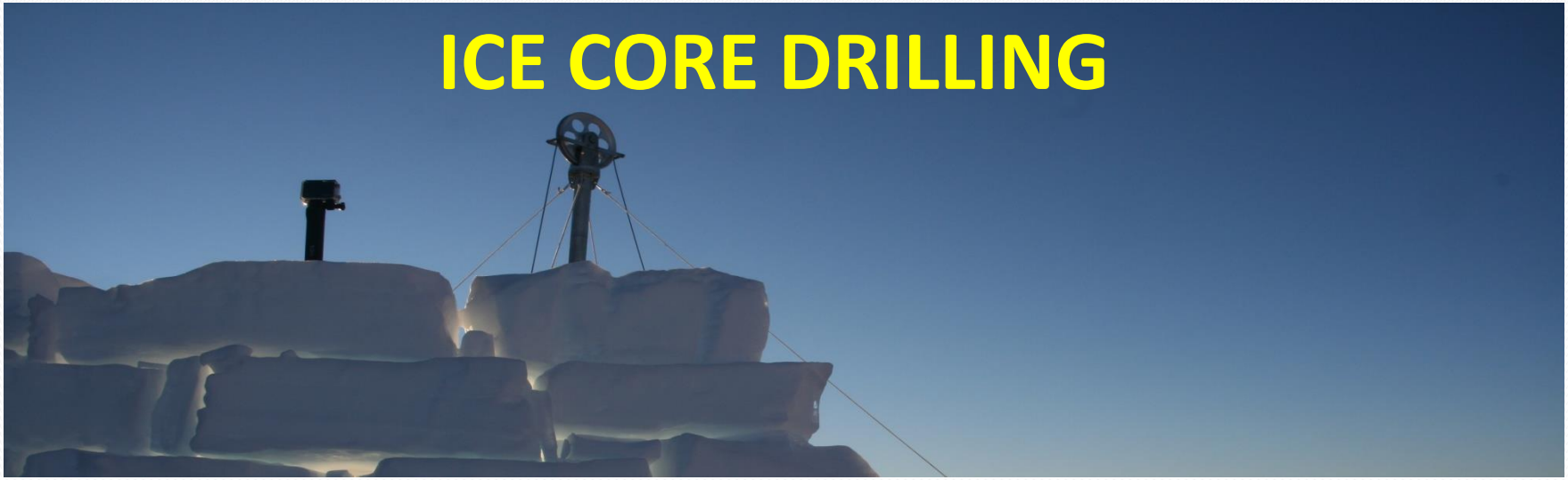


MADICE field campaign 2016-17



Summary of MADICE 2016 field study. Blue and red curves show radar and GPS profile locations, respectively. **Black dot**s show 90 GPS markers and 52 ApRES (autonomous phase-sensitive radar) study sites. Two red stars show the wintering ApRES stations. The green curve shows the grounding line (ice-sheet/ice-shelf transition), while the orange curve shows the calving line (background - LIMA satellite image). Two white circles at the summit of ice rises are the ice core drilling sites.

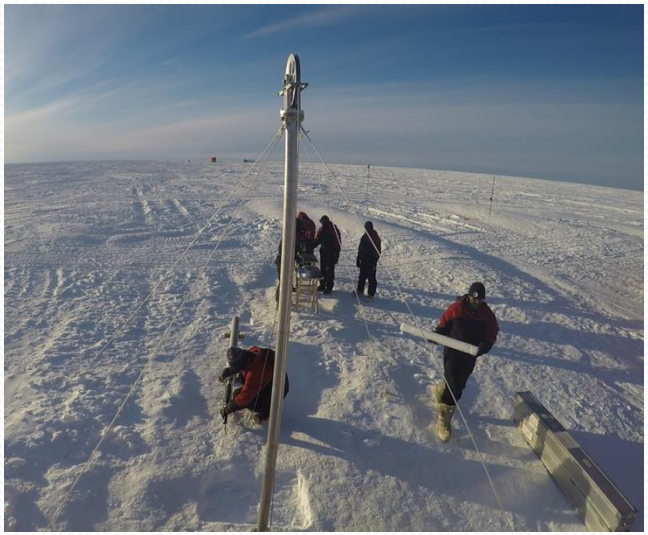
ICE CORE DRILLING

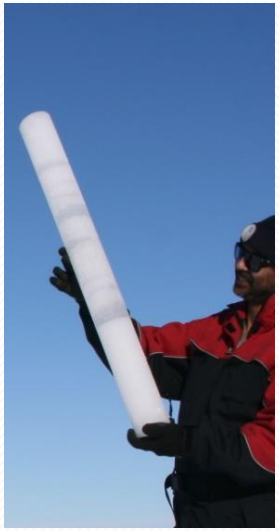


Two ice cores from Djupranen ice rise (122 m) and Leningrad ice rise (51 m)

Djupranen ice core is the longest ice core by Indian scientists so far!

Ice cores are arrived NCAOR in June and study underway





Geophysical surveys

1. Elevation measurements with DGPS
2. Stakes for ice flow measurements
3. Ice thickness measurements with low-frequency radar
4. Englacial features with high-frequency radar
5. Strain rates, basal melting and crystalline texture with phase sensitive radar
6. Weather station

GEOPHYSICAL SURVEYS - DGPS

Kinematic DGPS surveys (topography) along pre-designed grids using skidoos;
90 Static DGPS markers (ice flow velocity) installed & to be reoccupied in 2017

Total kinematic GPS survey = 1900 line kilometers over 2 ice rises

GEOPHYSICAL SURVEYS - RADAR

High Frequency (250 MHz) Radar surveys for ice layering and englacial features; layers can be dated by ice core data

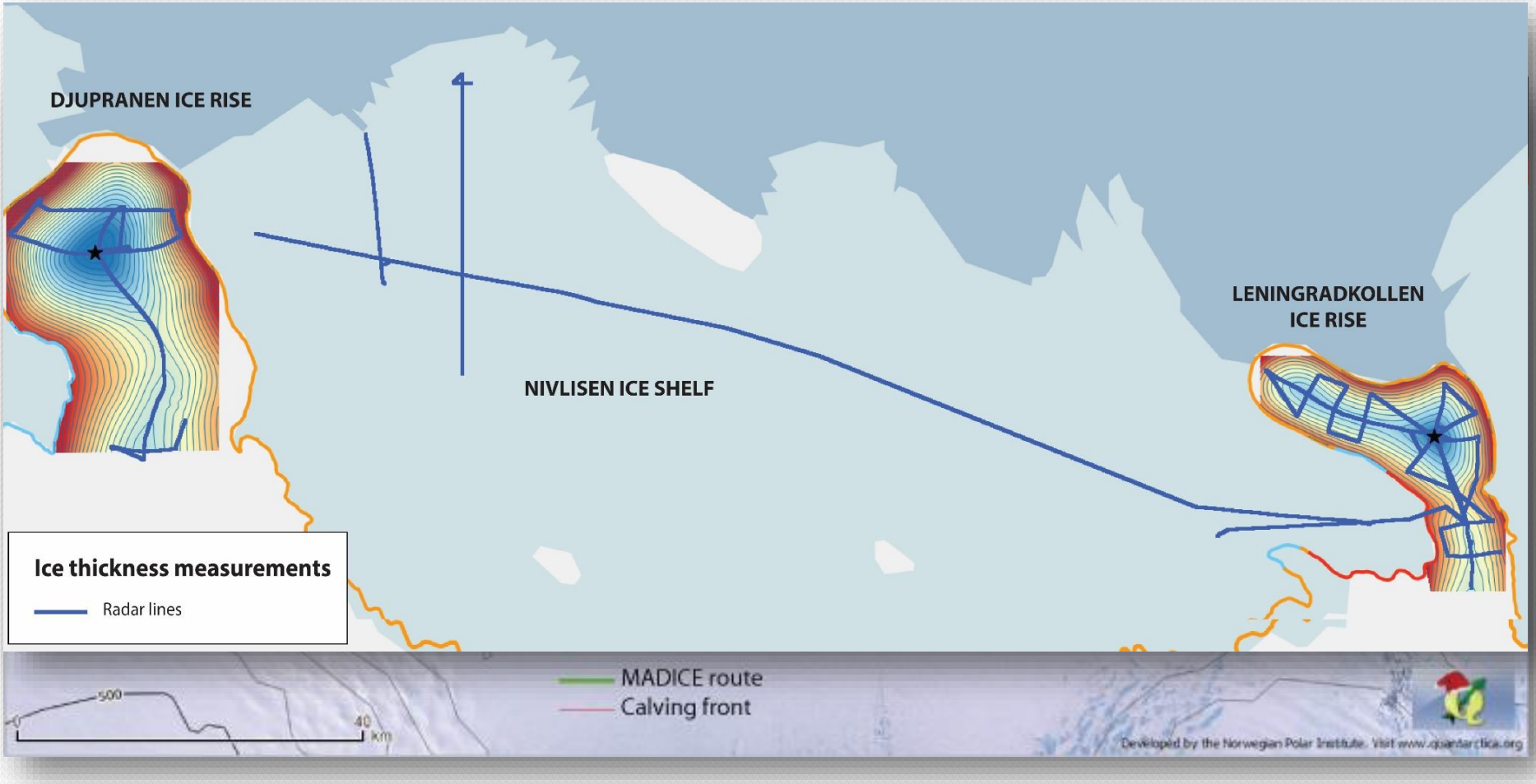
Total surveyed = 270 line kilometres

Low Frequency (2.5 & 5 MHz) Radar surveys for ice thickness and bed topography for ice-flow modeling

Total surveyed = 480 line kilometres

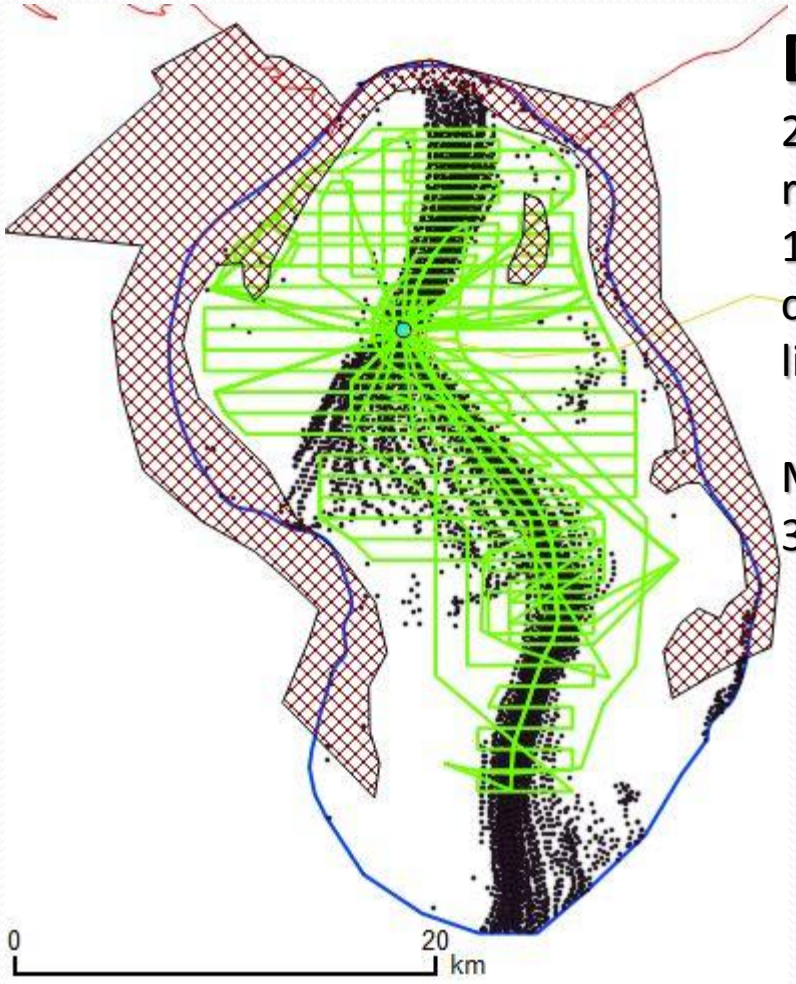
Preliminary Results

DGPS & GPR measurements



Data: Kenny Matsuoka & Katrin Lindback, NPI

Digital Elevation Model - Djupranen Ice Rise

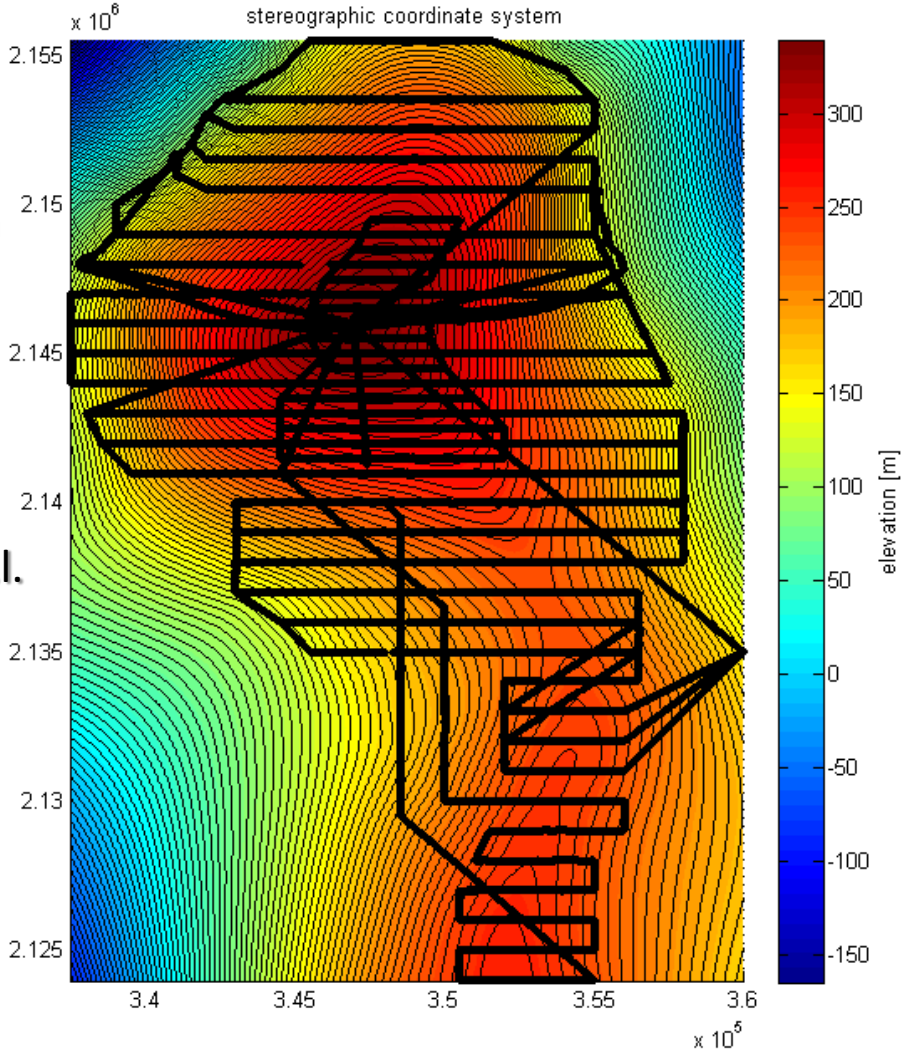


DEM

20 m resolution

10 m contour lines

Max elev: 306 m a.s.l.

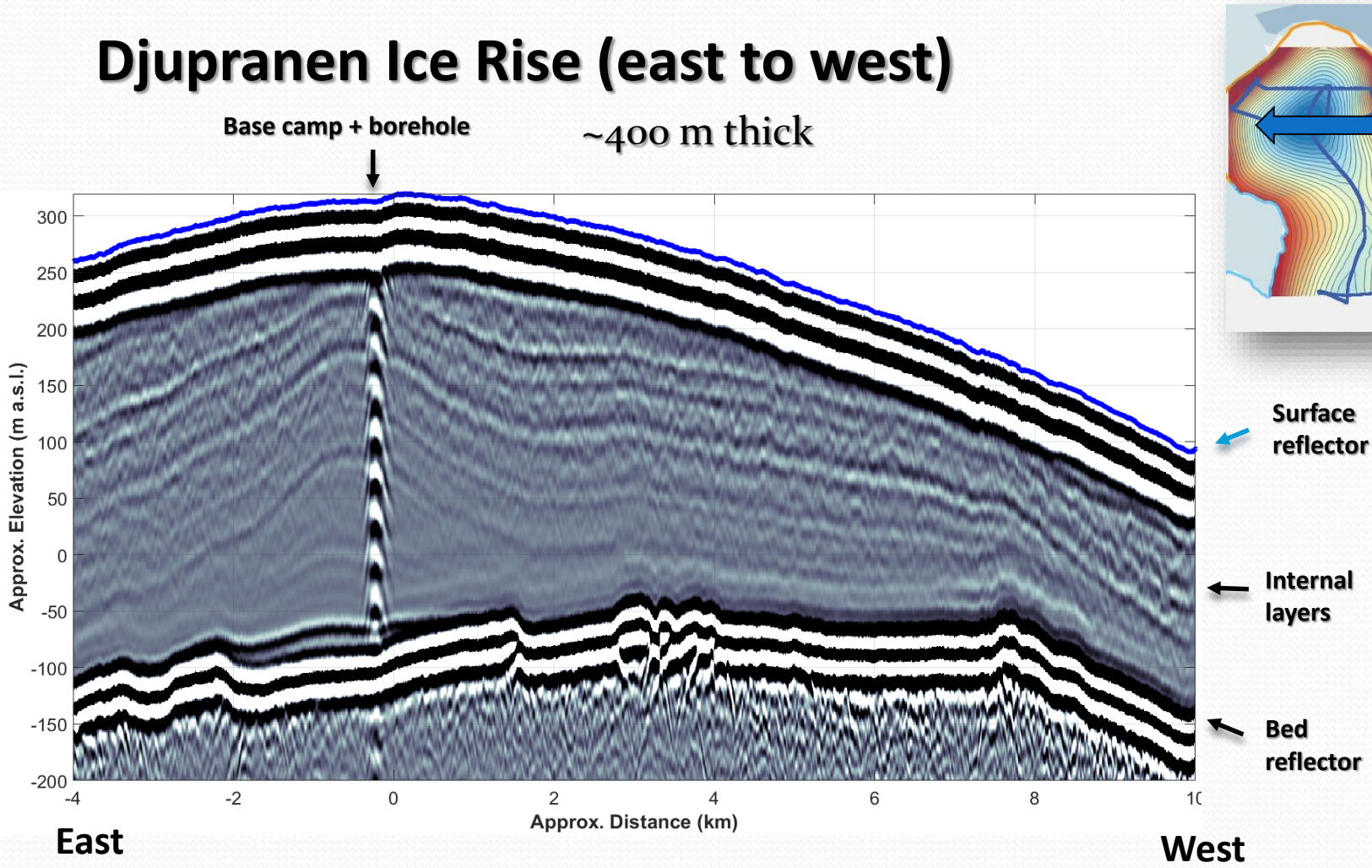


Survey lines, crevasse zones

Digital Elevation Model

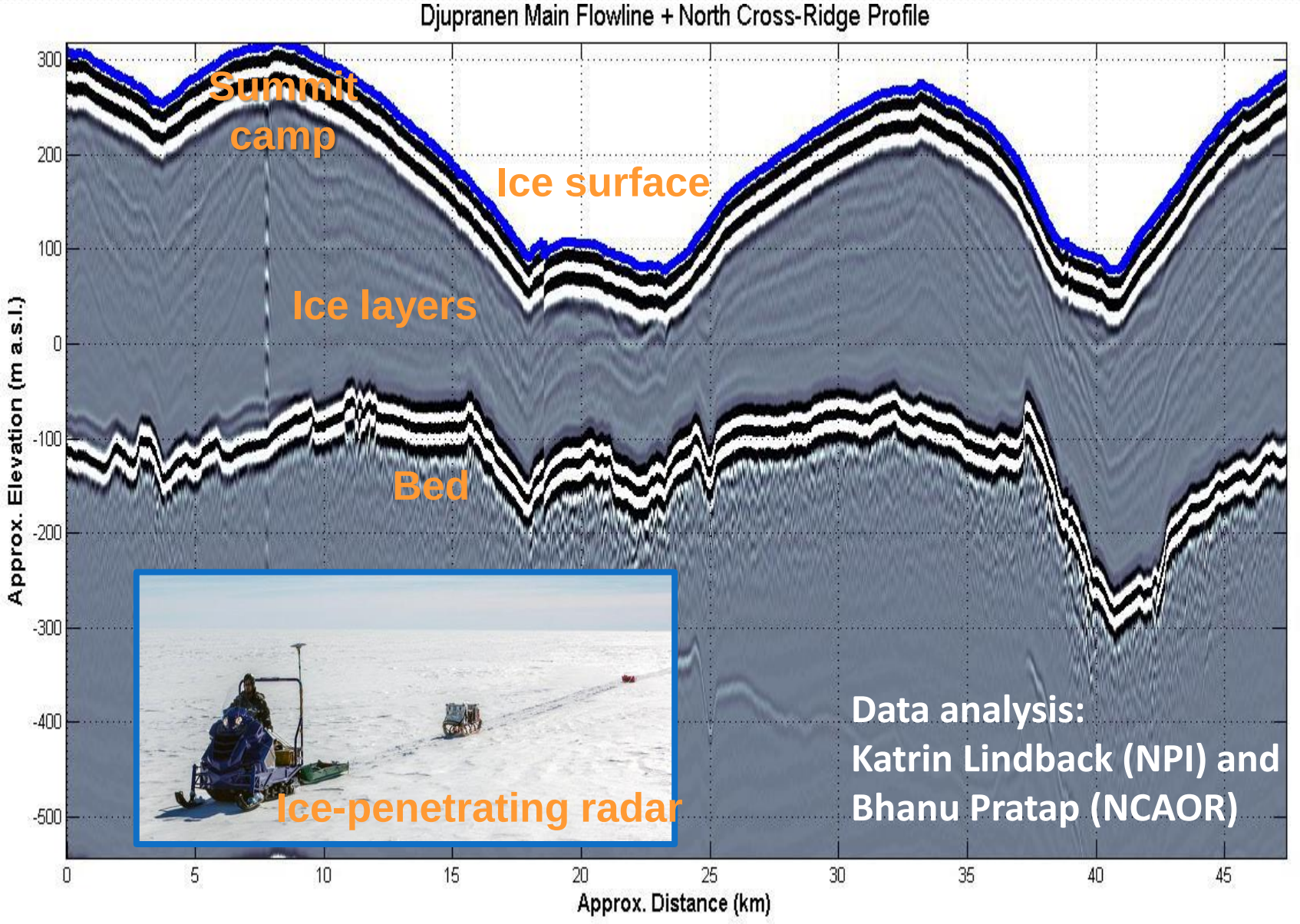
Ice Thickness

Djupranen Ice Rise (east to west)



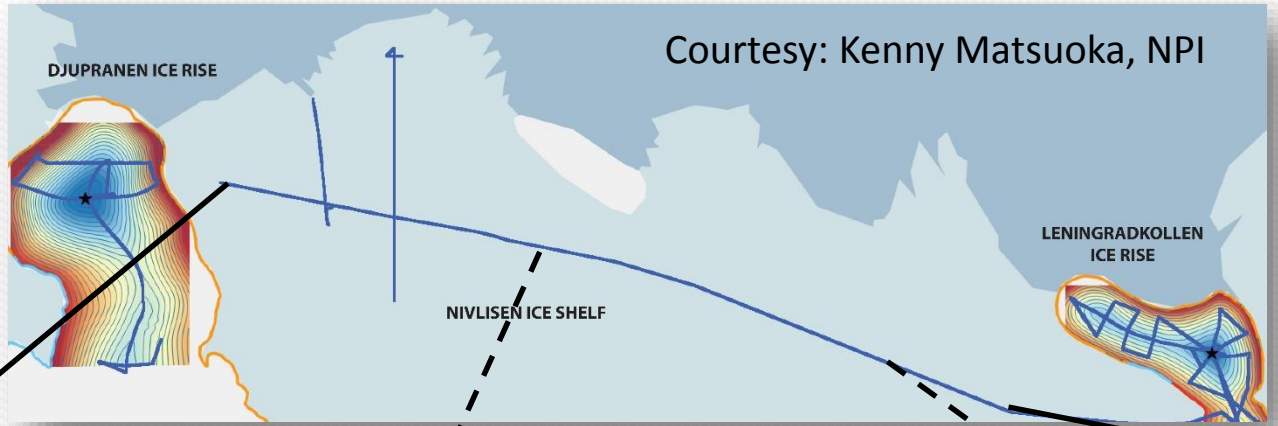
Courtesy: Kenny Matsuoka, NPI

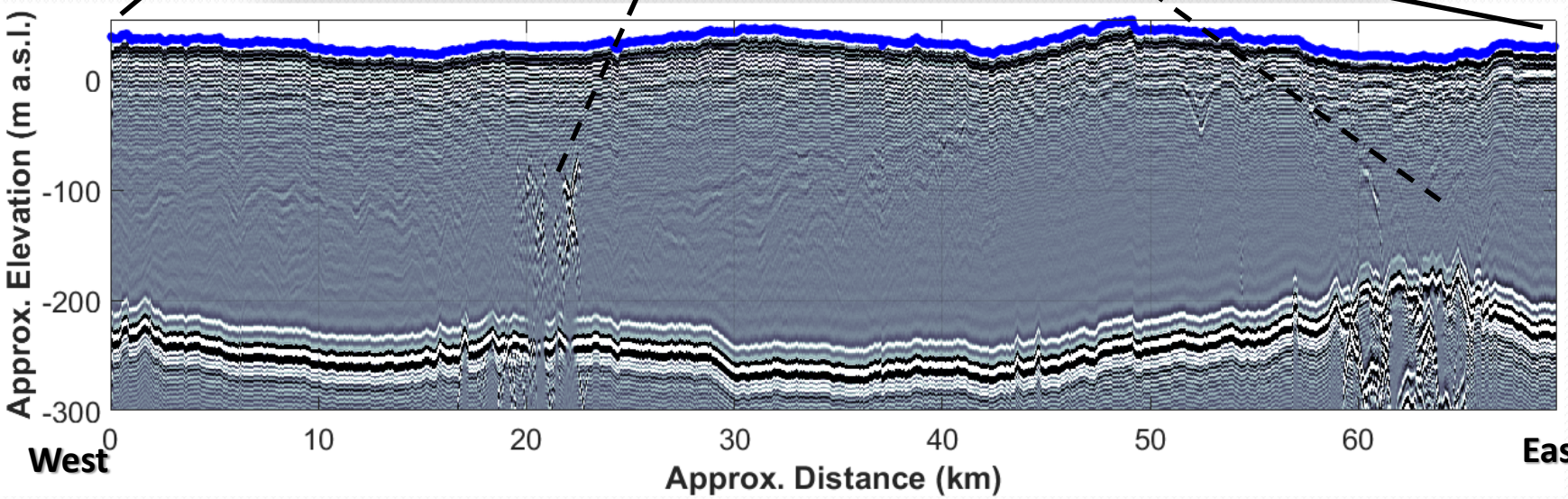
Deformation of ice layers with past evolution



Ice Thickness

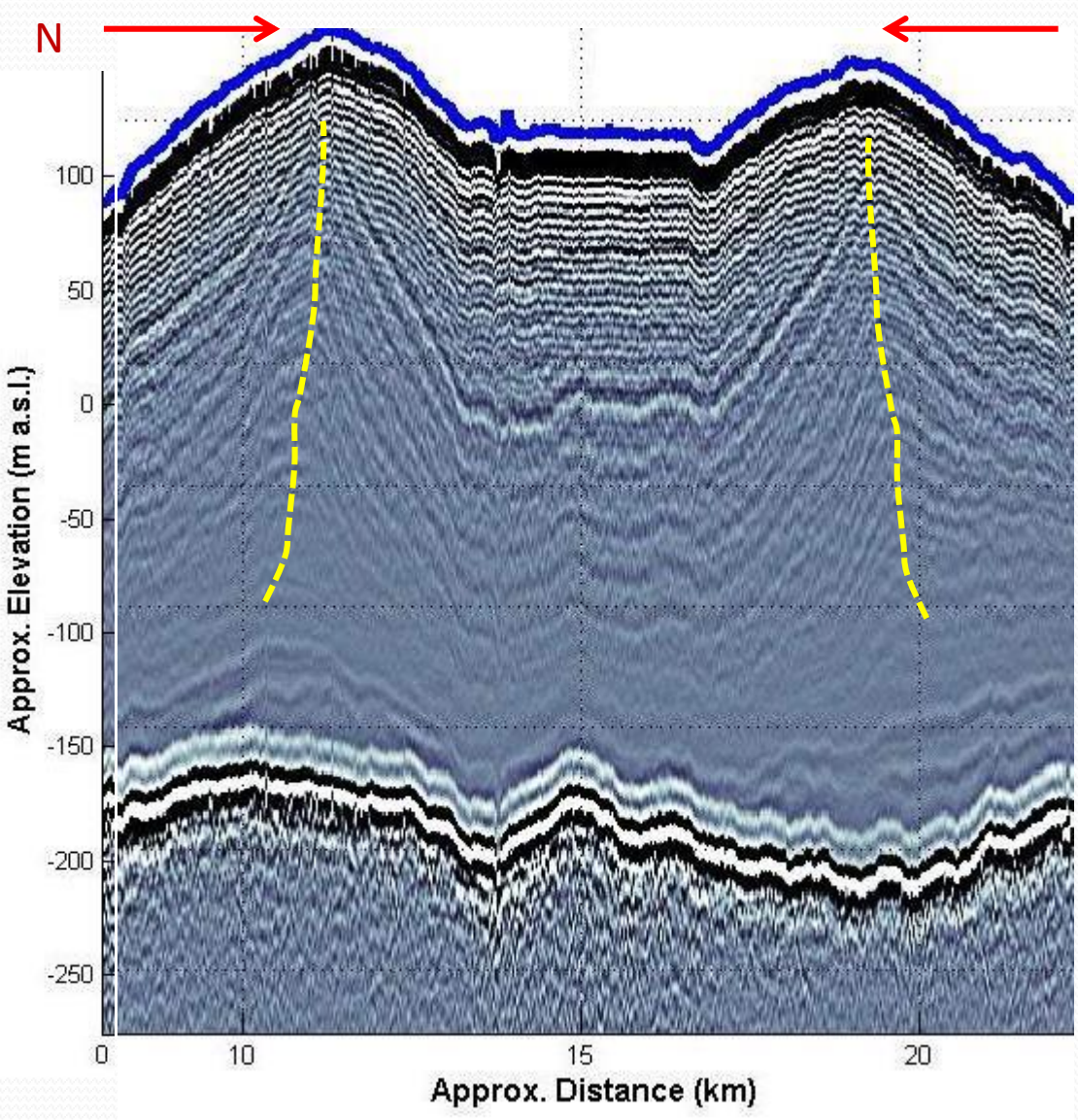
Nivlisen Ice Shelf (west to east)





Warming responses in ice rise radar profile and ice core

Leningradsky Ice Rise



Shallow ice core study - Context

- Coastal Antarctic ice sheets and ice shelves are more vulnerable to the changes; but we don't have many climate records from such places.
- IPICS (International Partnerships in Ice Core Sciences) has identified high resolution 2,000 year records (2k network) as a crucial requirement for quantitative study and modeling;
- Our study revealed that the signatures in coastal and inland ice cores are different and need more extensive study;
- Due to high snow accumulation and limited ice thickness, it is hard to get to recover longer climate records from coastal ice sheets
- Coastal ice rise sites provide the best possible opportunities for high resolution millennial climate reconstruction.

ACKNOWLEDGEMENTS

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