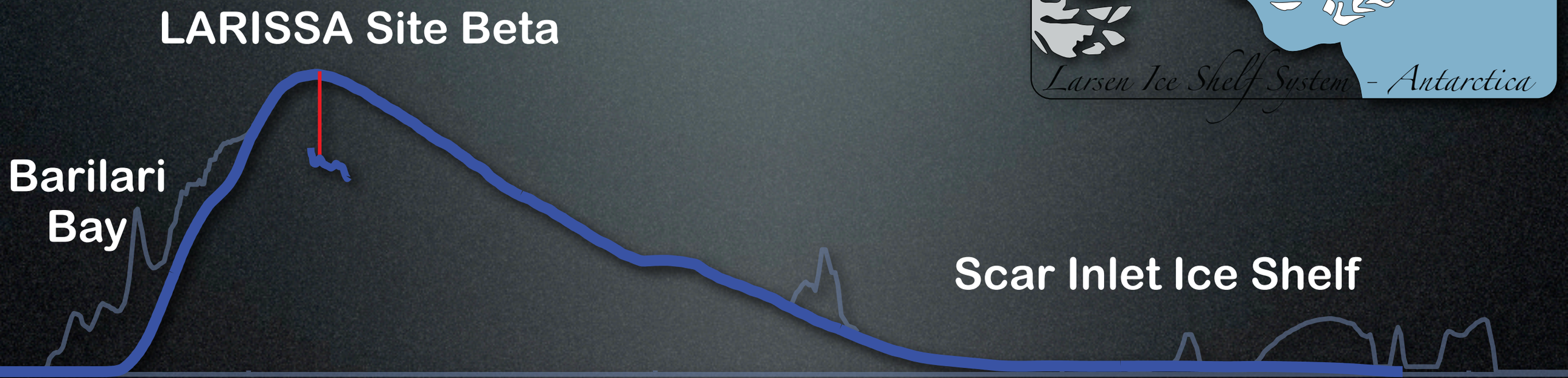
The Bruce Plateau Ice Cap: Ice Dynamics across the Antarctic Peninsula

LARISSA



Erin Pettit (UAF)
Ted Scambos (NSIDC)
Martin Truffer (UAF)
Robert Bauer (NSIDC)
Ellen Mosley-Thompson (OSU)
Victor Zagorodnov (OSU)
Terry Haran (NSIDC)

Ronald Ross
(Avega Systems/NSIDC)
Bryan Blaire (NASA)
Ian Joughin (UW)
and LARISSA TEAM

Cryosphere and Oceans

Global change:

Atmospheric warming

Ocean warming

Precipitation

Surface melting

Ice flux

Crevassing - calving

Possible meltwater feedbacks

Ice-shelf buttressing

Basal melting and heat exchange

Sub-ice-shelf circulation

Ice core record

of atmospheric chemistry and paleoclimate

Ice extent today

Ice extent at LGM?

Stranded glacial deposits on nunataks - record of ice extent and elevation

2000

1000

masl

0

Marine and Quaternary Geoscience

Former ice shelf

0

mbsl

1000

Seafloor geomorphology - record of ice extent and subglacial processe s

Sedimentary records of ice extent and paleoceanography

0

100

200

kilometers

Photosynthetic flux

Basal melting and heat exchange

Sub-ice-shelf circulation

Meltwater and sediment flux

Benthic ecosystem

Geochemical and geothermal fluxes

Antarctica

AMIGOS stations (6 proposed)
Ice Core Sites (1 proposed)
Instrumented mooring and sediment traps (in place)
Automated Weather Stations (in place)
GPS flow and rebound sta. (6 proposed; 2 w/ Seismic:)
Exposure age sites (14 proposed)

Marambio
Weddell Sea
Larsen A Embayment
Matienzo
Robertson Is.
Marine and Biology Operational Area "A"
Larsen B Embayment
Cape Framnes
Bawden Ice Rise
Palmer
Larsen C Ice Shelf
Marine + Bio Operational Area "B" (contingency, for heavy 2009 sea ice conditions)
Bellingshausen Sea
0 km 100

CTD Mooring
Crane Gl.
AMIGOS
CTD Mooring
Scar Inlet Ice Shelf
(Larsen B remnant)
Jason
Peninsula
AMIGOS
GPS
AMIGOS
AMIGOS
CTD Mooring
Flask Gl.
AMIGOS
GPS
Leppard Gl.
Larsen C Ice Shelf
61°W
62°W
64°W
Bruce Plateau
25 km
65.5°S
66°S
66.5°S
AMIGOS Ice Core

Characteristics of the Bruce Platuau and the Larissa Site Beta Ice Core Site

Is the divide migrating?
How does that affect the ice core analysis?

East versus West :
how are they thermally and dynamically different?

Rough Drawing from Radar Images
(not perfectly to scale!)

Divide
0km

Flank
~10km

WEST

EAST

Kansas Hill

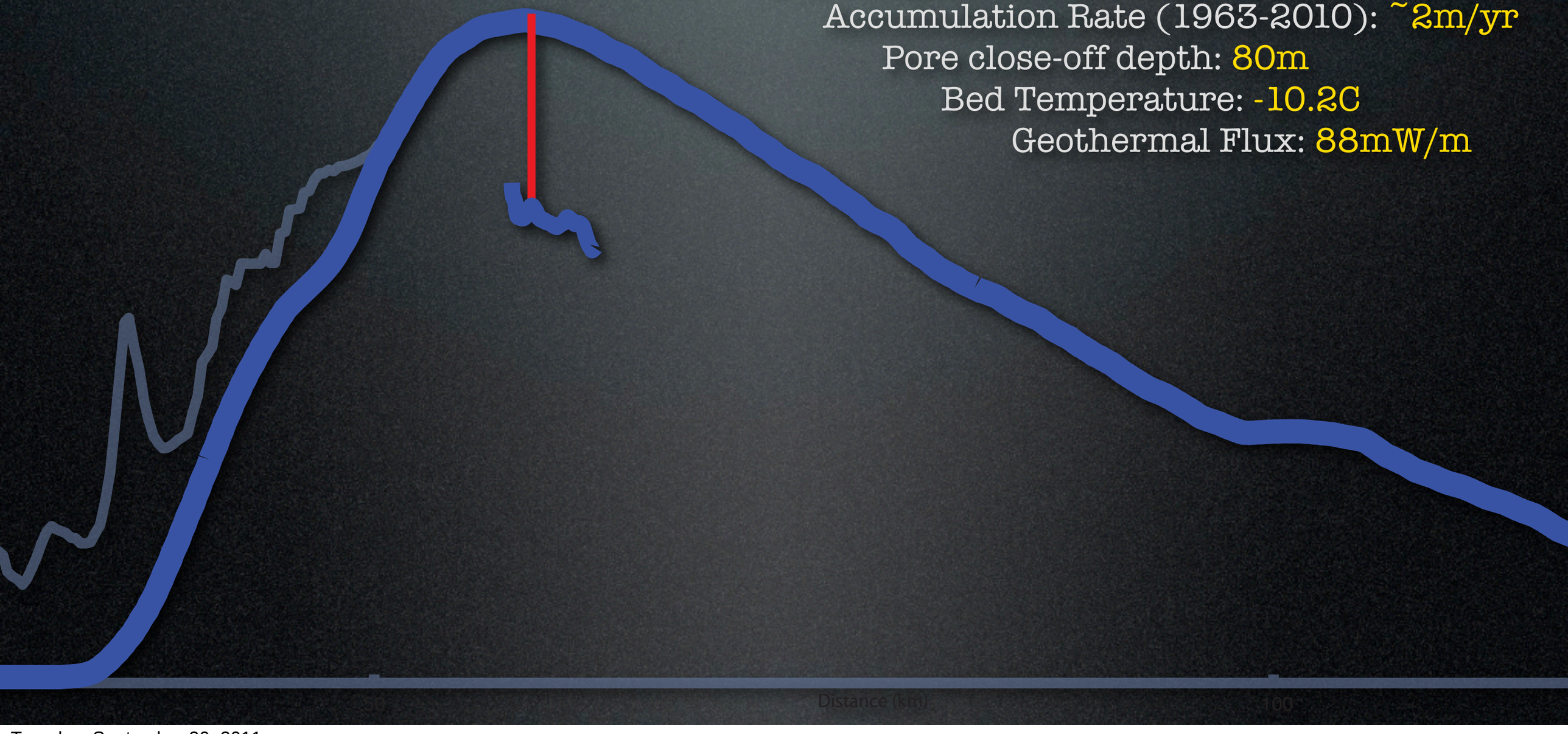
Divide and Ice Core Site Characteristics based on preliminary data:

LARISSA

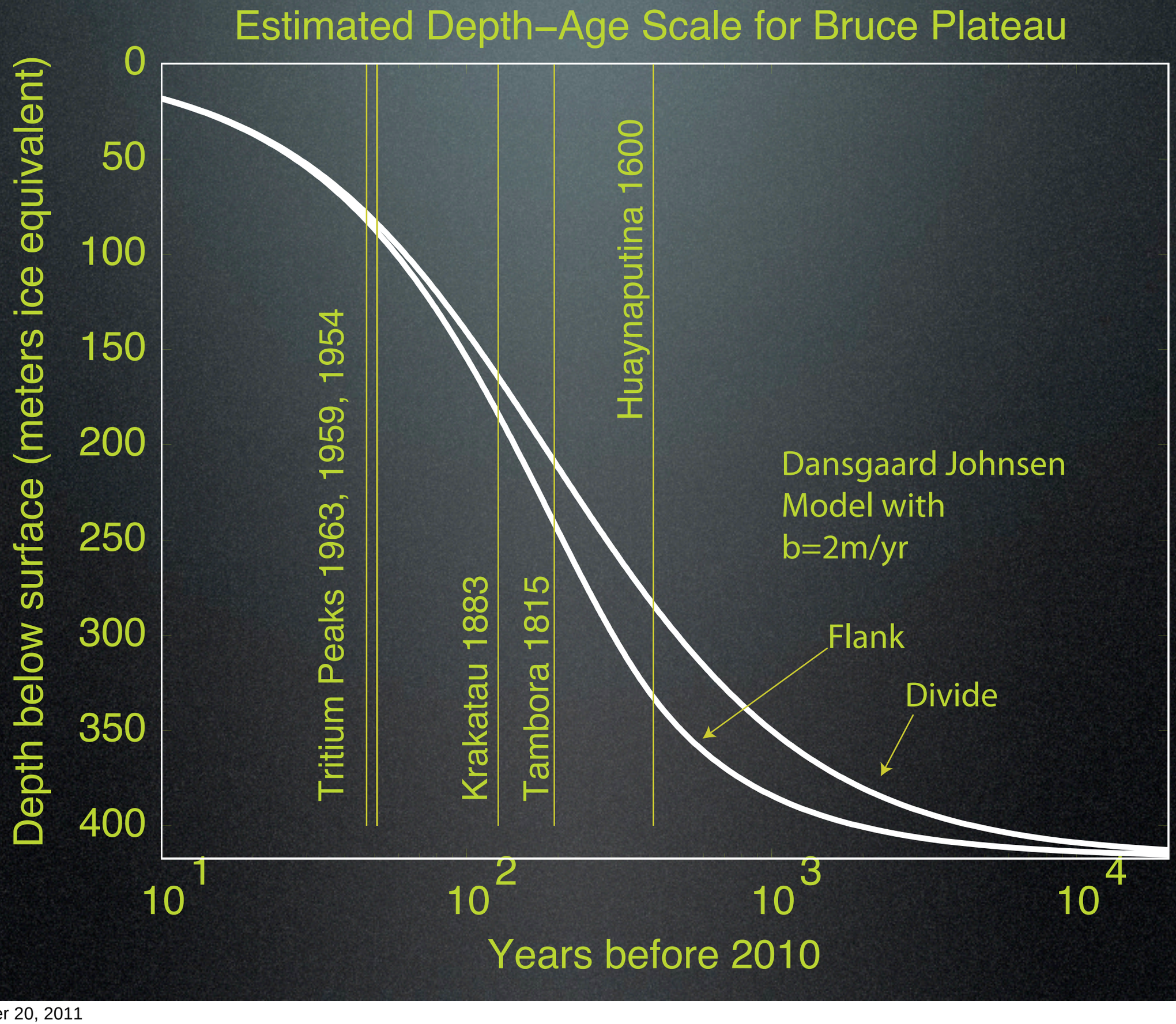
Larsen Ice Shelf System - Antarctica

Surface Elevation: divide: 2012m; ice core site: 1976m
Thickness: divide: 460m; ice core site: 447m

Distance east of the divide: ~2km
Surface slope: ~0.025 at the core site
Surface velocity: 10(+/- 4) m/yr
15m Temperature (average annual): -14.8C
Accumulation Rate (1963-2010): ~2m/yr
Pore close-off depth: 80m
Bed Temperature: -10.2C
Geothermal Flux: 88mW/m



Preliminary Dansgaard Johnsen Model

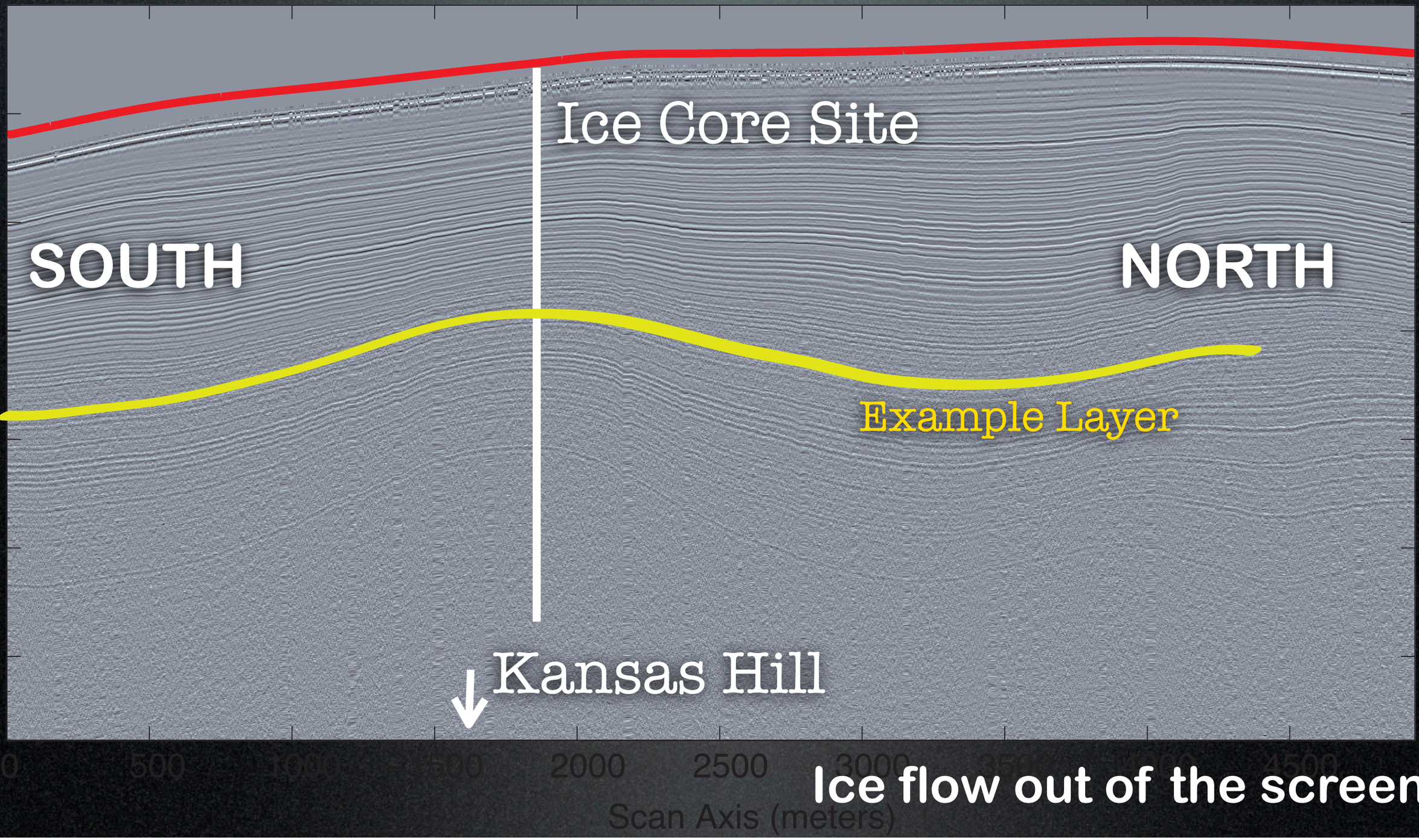


Slightly Divergent Flow due to Kansas Hill

suggests additional thinning of layers

LARISSA

Larsen Ice Shelf System - Antarctica



Thermal Model

Estimated Accumulation Pattern

6m/yr

2m/yr

LARISSA

Larsen Ice Shelf System - Antarctica

-14.8C

high precip
high advection

low precip
low advection

-10.2C

colder ice
colder bed

warmer ice
warmer bed
Initiaion of sliding?

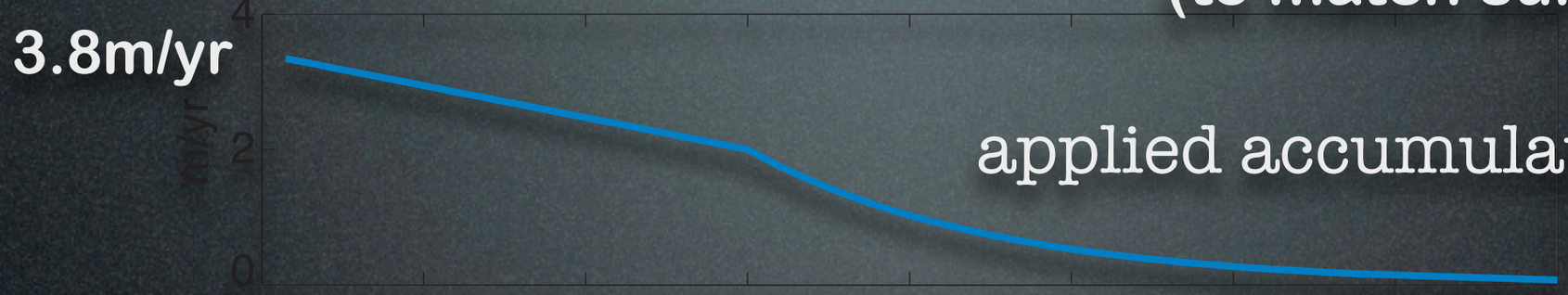
-15km

0km

30km

divide migration experiments
1. steady state

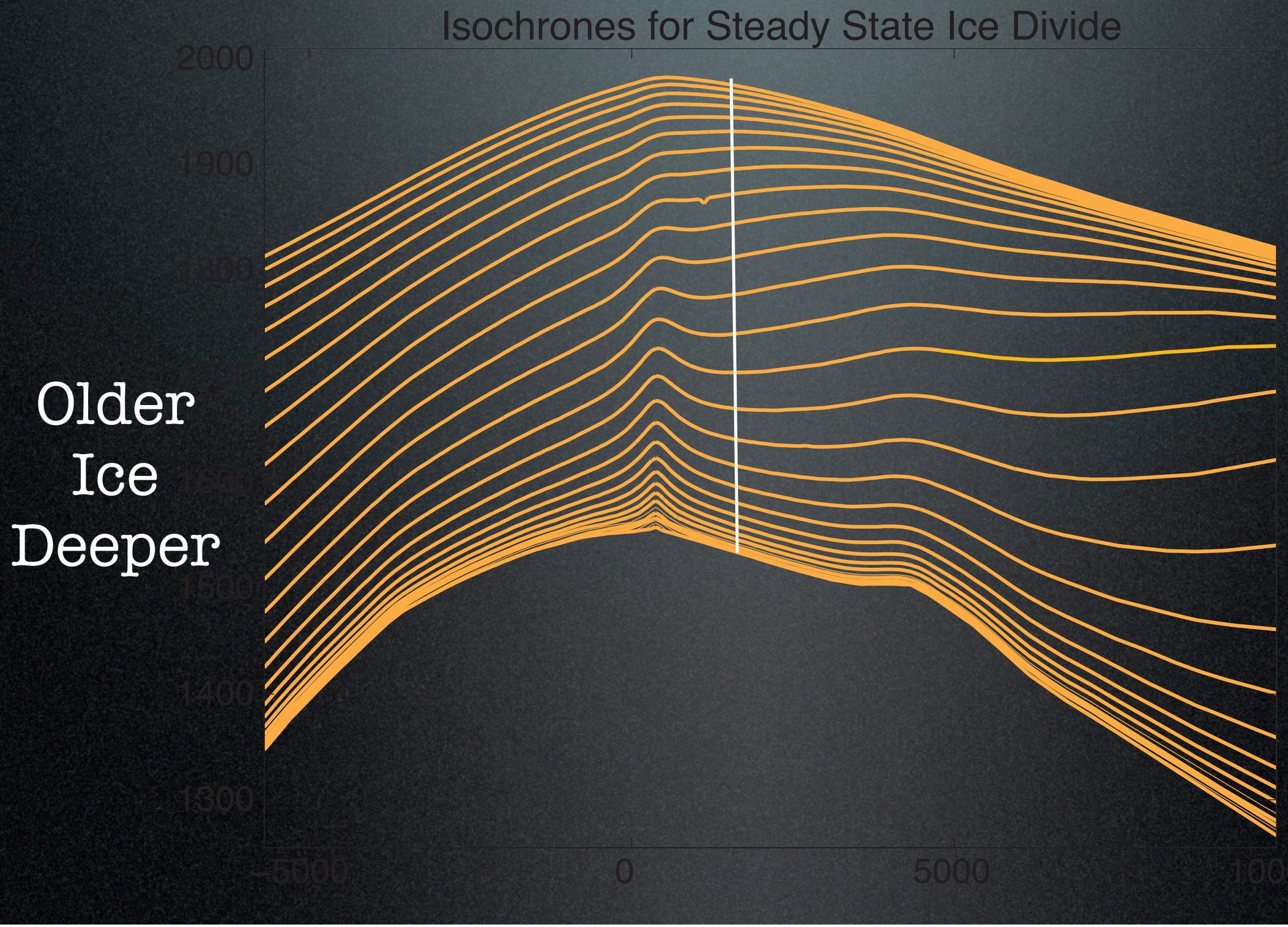
enhancement =5
(to match surface data)



horizontal velocity

vertical velocity

Isochrones


Isochrones for Steady State Ice Divide
2000
1900
1800
1700
1600
1500
1400
1300
−5000
0
5000
10000
Older Ice Deeper
Older Ice Near Surface

2. Change Accumulation

LARISSA

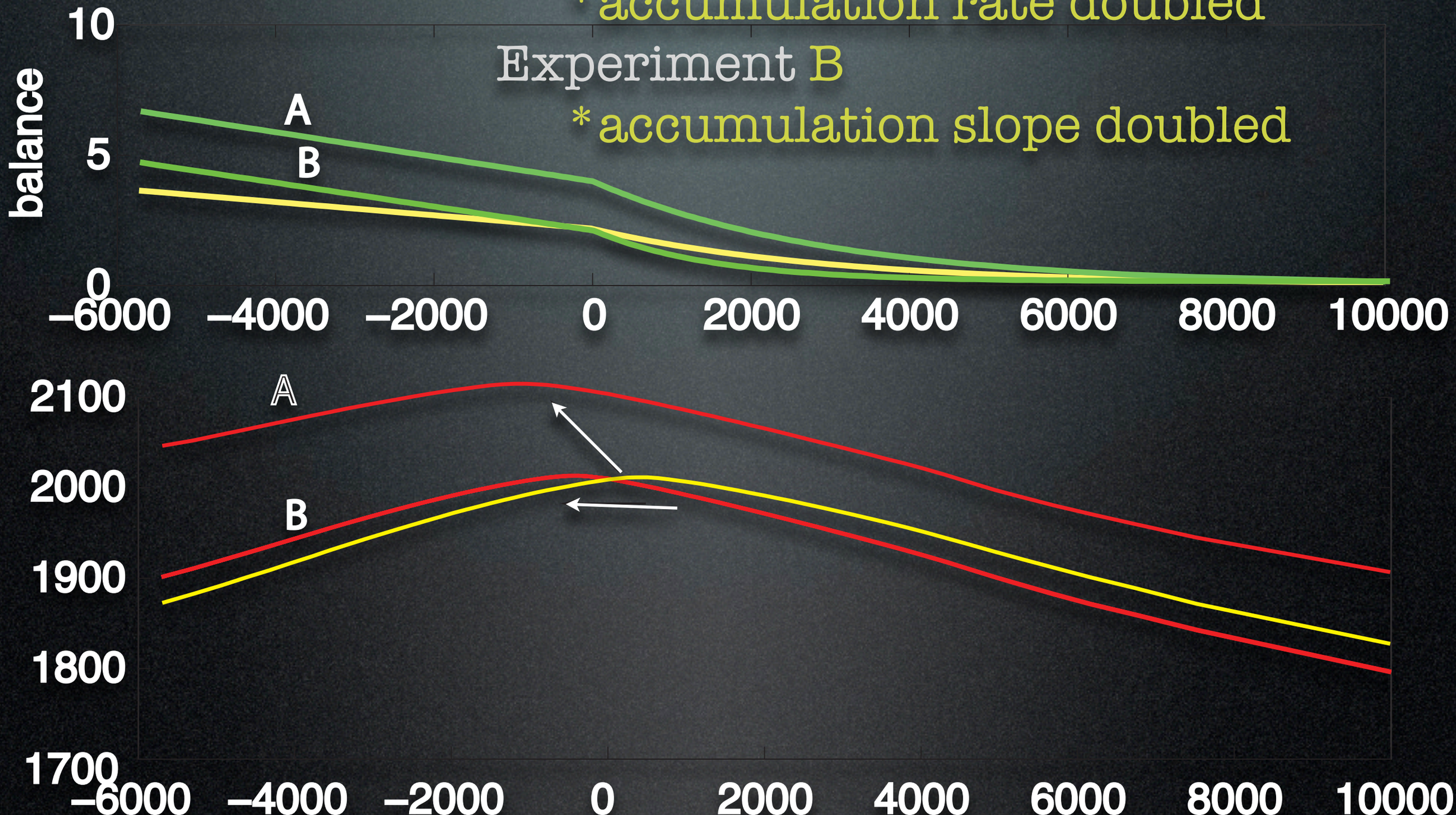
Larsen Ice Shelf System - Antarctica

Experiment A

* accumulation rate doubled

Experiment B

* accumulation slope doubled



2. Change Accumulation

Experiment A: accumulation rate doubled

* divide moved ~1500 m west to new s.s.
* divide increased elevation by ~120m
* timescale for response ~ 25years

Experiment B: accumulation slope doubled

* divide moved ~800 m west to new s.s.
* divide elevation did not change
* timescale for response ~25 years

What does this mean?

These response timescales are ~1/10th of the fundamental H/b timescale (which is ~250 years at this site).
Hindmarsh (1996) predicated a timescale 1/16 H/b for accumulation-driven divide migration.

Both accumulation changes result in a WESTWARD migration - away from our ice core site

* *Unlikely that our core site was on west side in past - good for interpretation

* *recent migration of the divide results in more catchment area for Larsen B - does this affect the overall Peninsula dynamics?

Characteristics of the Bruce Platuau and the Larissa Site Beta Ice Core Site

LARISSA

Larsen Ice Shelf System - Antarctica

Is the divide migrating? How does that affect the ice core analysis?

East versus West : how are they thermally and dynamically different?

Future

These preliminary experiments suggest further experiments:

1. Integrate the heat flow model (include viscous strain heating) to explore the onset of fast flow

2. Improve the orographic precipitation pattern

3. Apply stochastic or data-driven accumulation history to see how much the divide moves over centennial timescales and how much this change in catchment area would affect the downstream dynamics (if at all).

4. Incorporate a realistic width of the flow band and realistic rheological properties to more accurately capture the flow patterns.