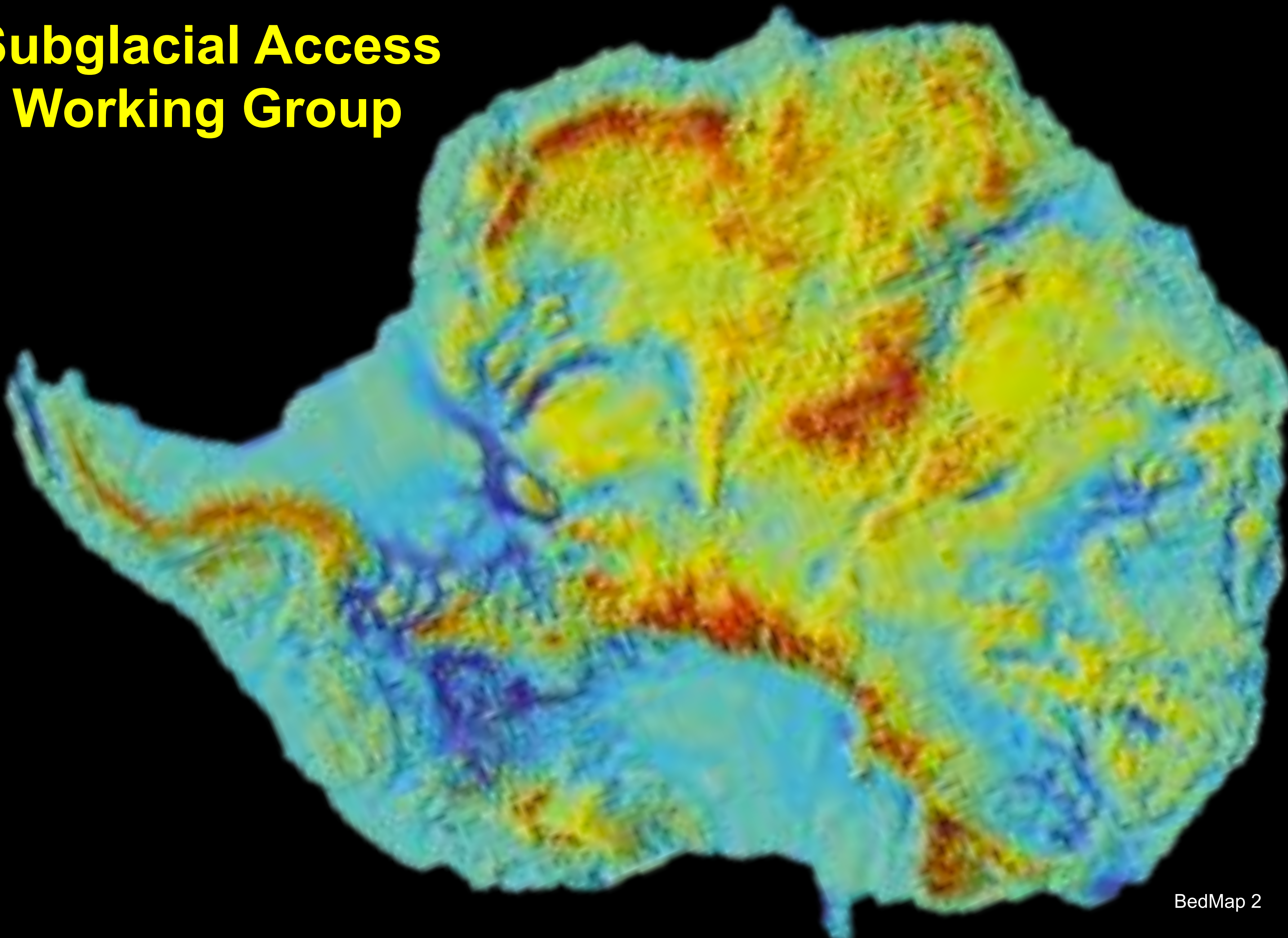
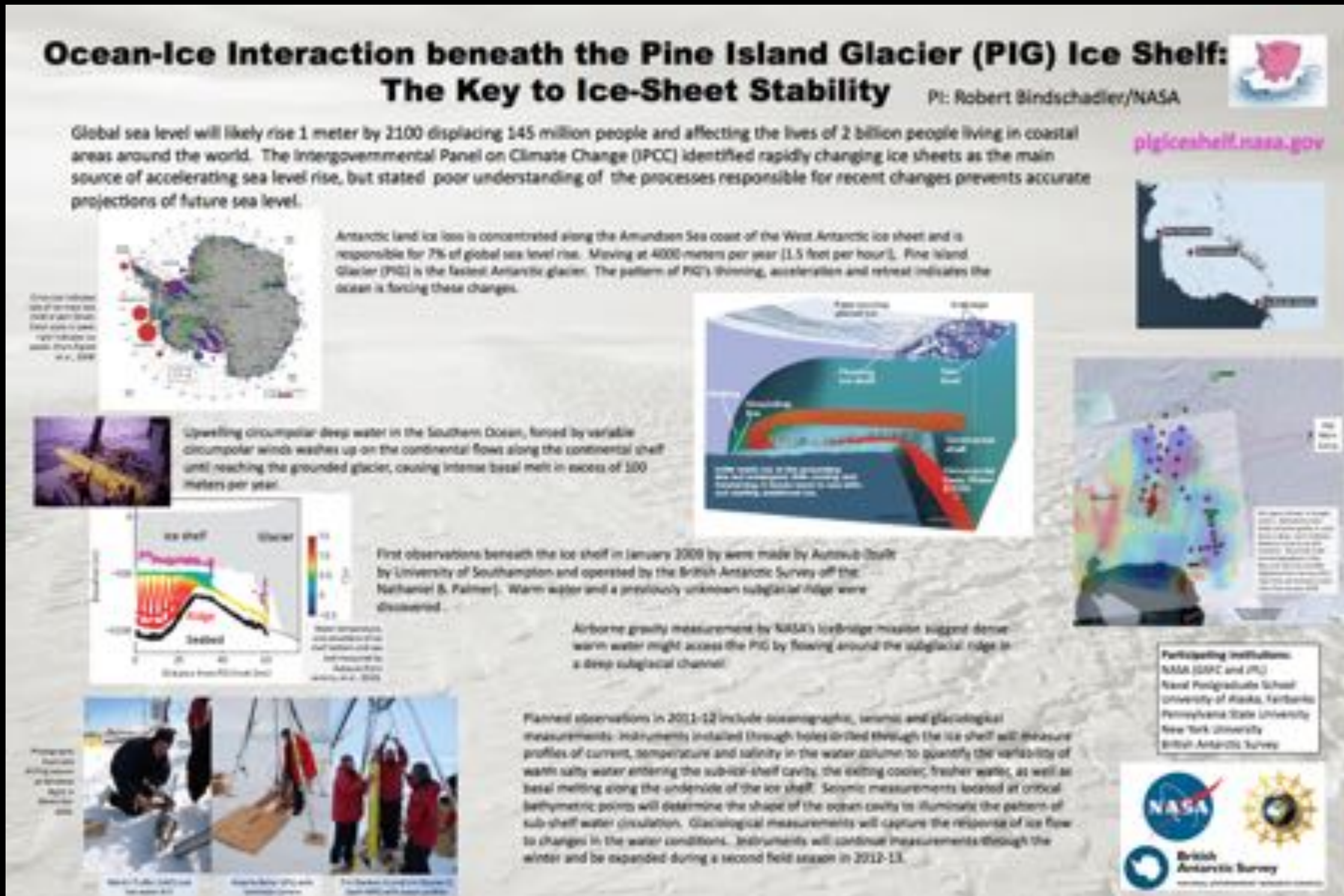
Subglacial Access Working Group



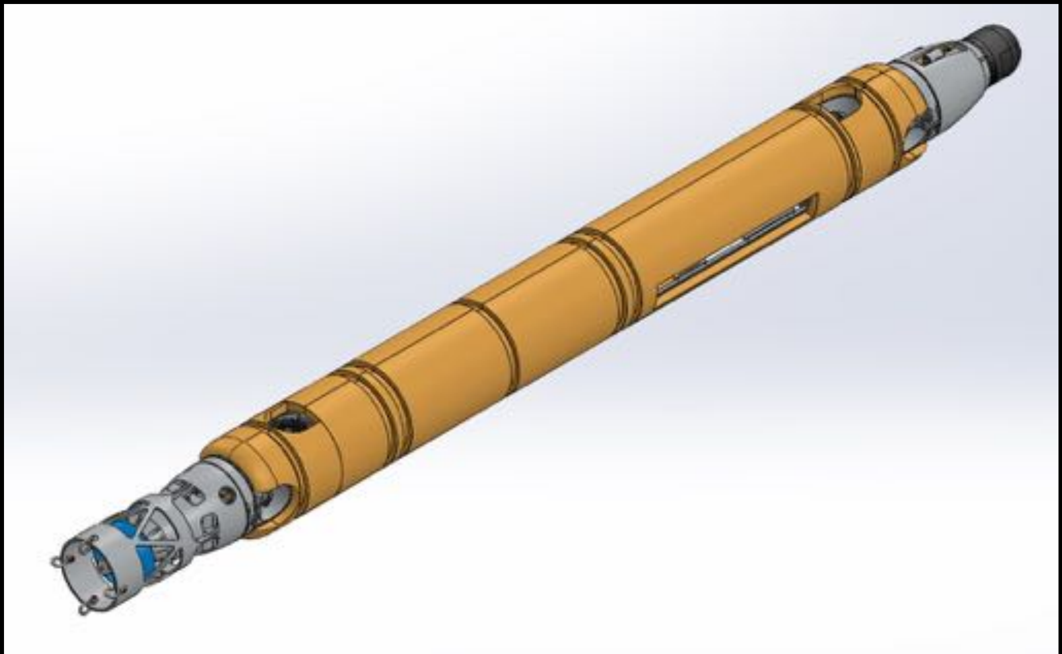
Anadakrishnan, Bay, Blankenship, Foreman, Goodge, Gulley,
Holland, Jacobel, Mikucki, Powell, Rack, Stone, Truffer, Tulaczyk

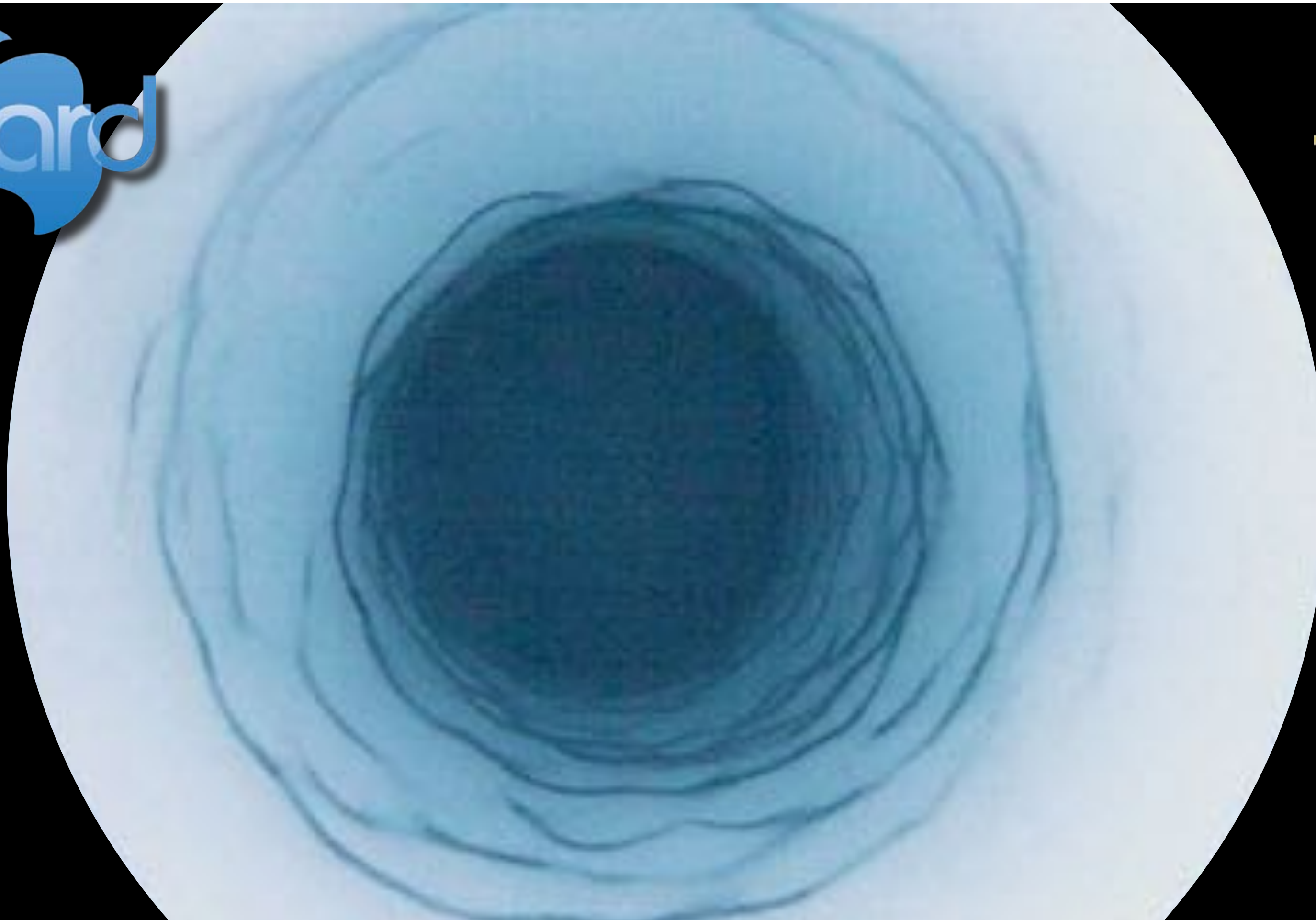
Pine Island (PIG Project)



Ice-ocean interaction and ice dynamics
Light weight
Great science payoffs
Issues of operational access and support

- WISSARD (main, roving)
- MSLED
- MIDGE (IceMole)
- Valkyrie
- SIMPLE (Icefin)
- SCINI
- Deep SCINI
- RAID





Exploring below the Whillans Ice Stream

http://wissard.org

LOGISTICS:

Subglacial Lake Whillans Drilling Camp

First use of ‘deep field’ laboratories

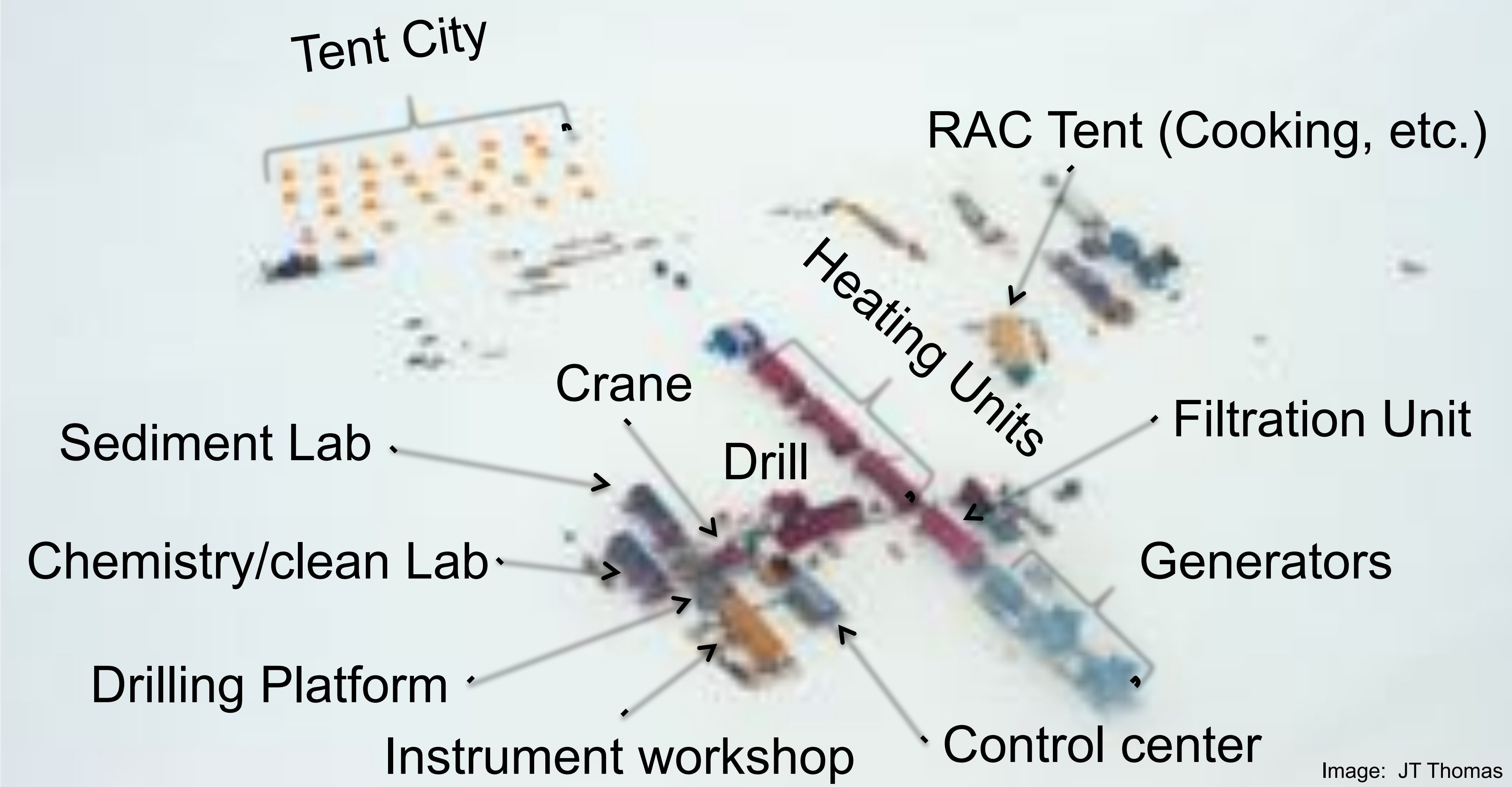
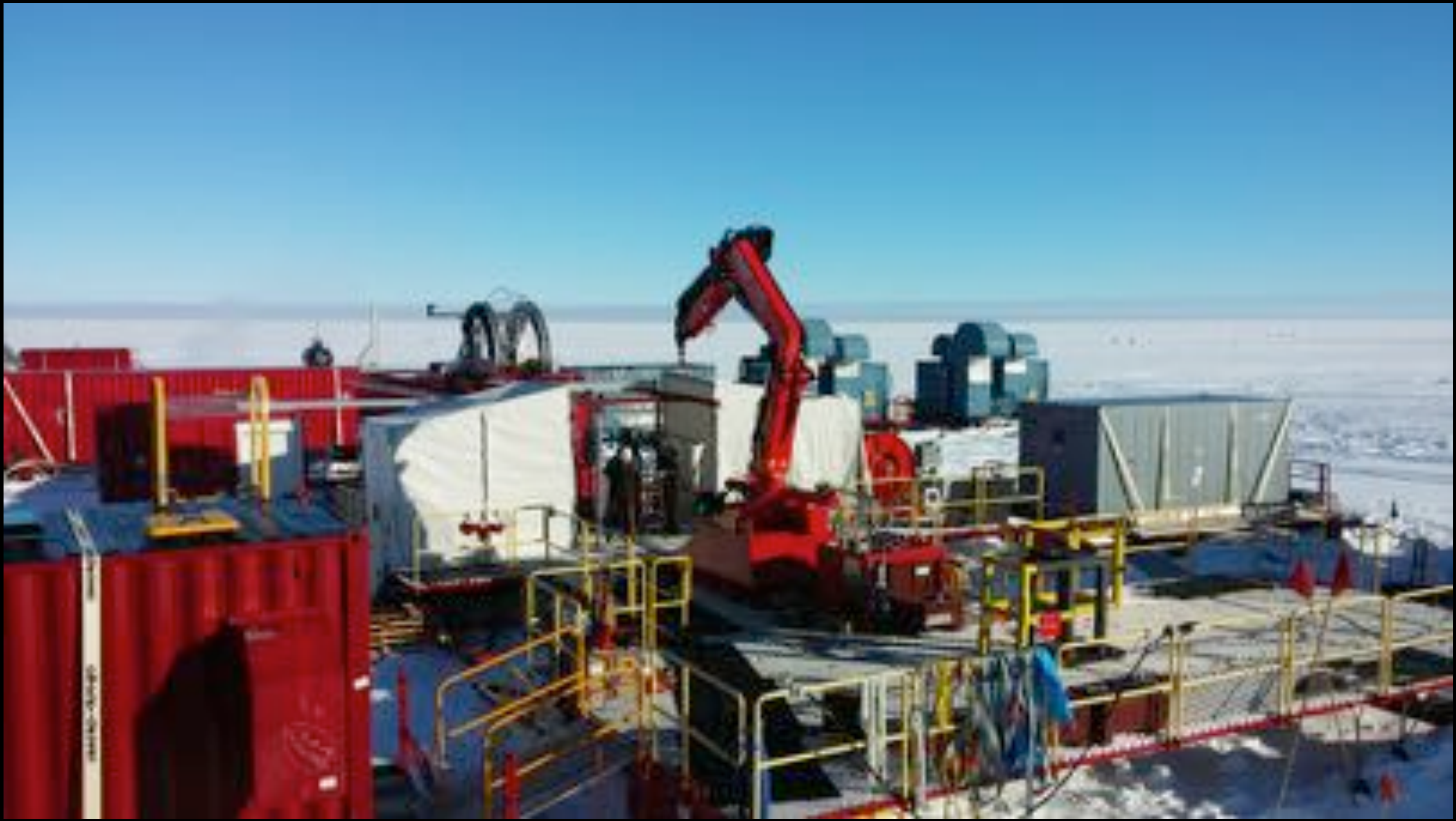


Image: JT Thomas

Moonpool operations for WISSARD

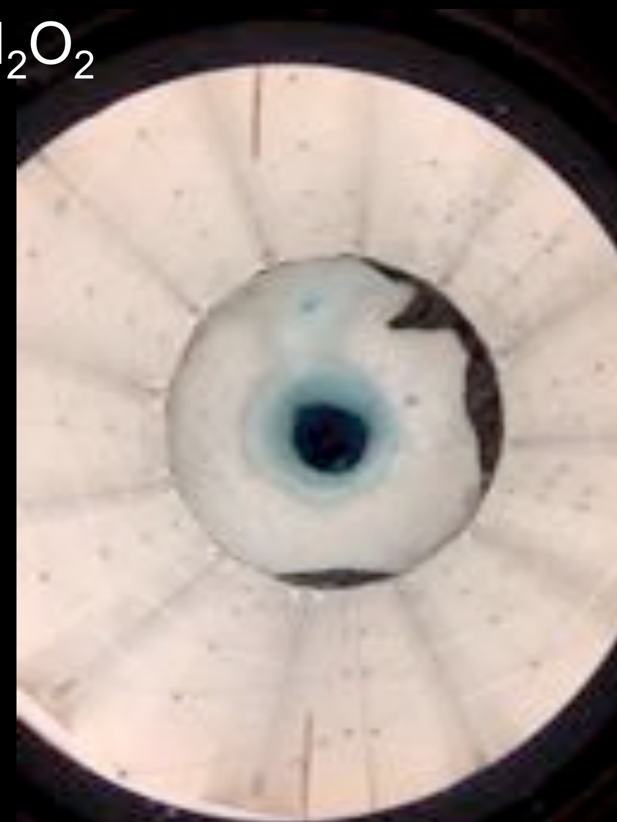


Deck, HWD (x2 - melters, heaters, pumps, hoses, reels), labs (x2), clean access, crane, winches, sleds, containers, generators

The WISSARD ‘Clean Access’ Approach

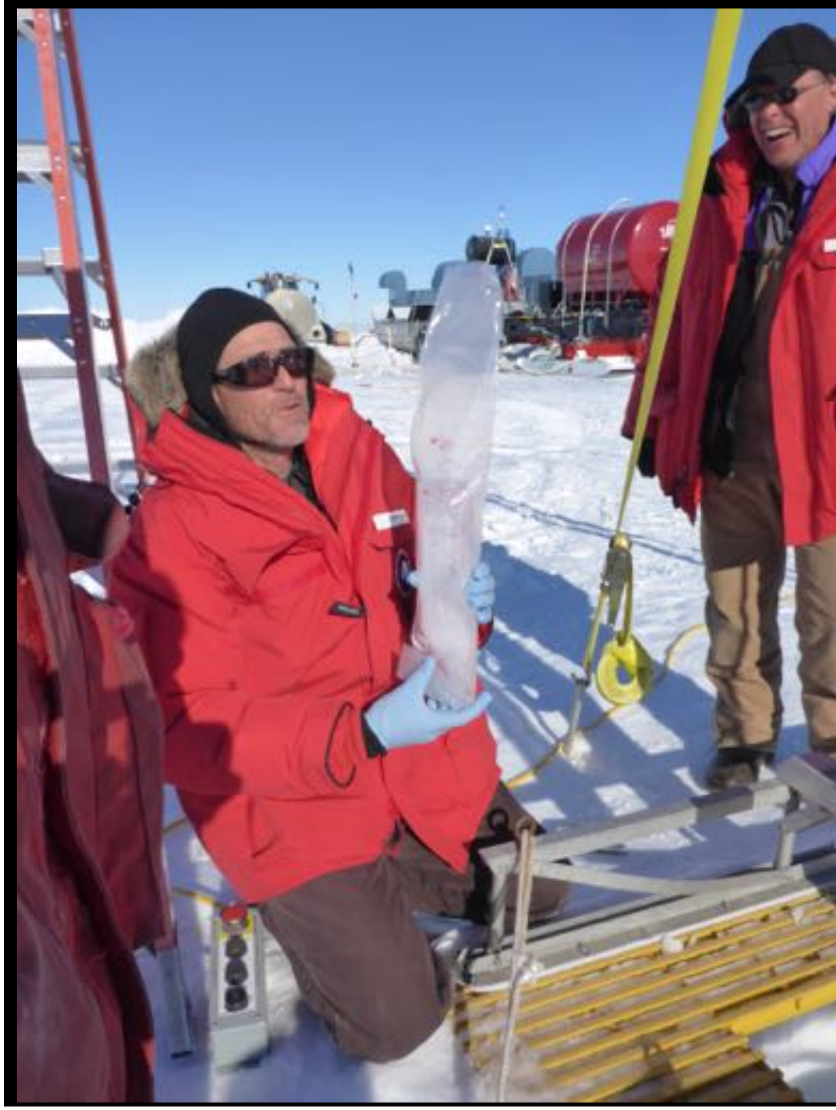
- Physical removal of cells and particles (2µm and 0.2µm filters)
- UV lamps (185nm and 254nm)
- Flash pasteurization Alcoda heaters ($90^{o}C$ and 600psi)
- Disinfection with 3% H_2O_2

Successful at removing ~99% of microbial cells in the drilling water

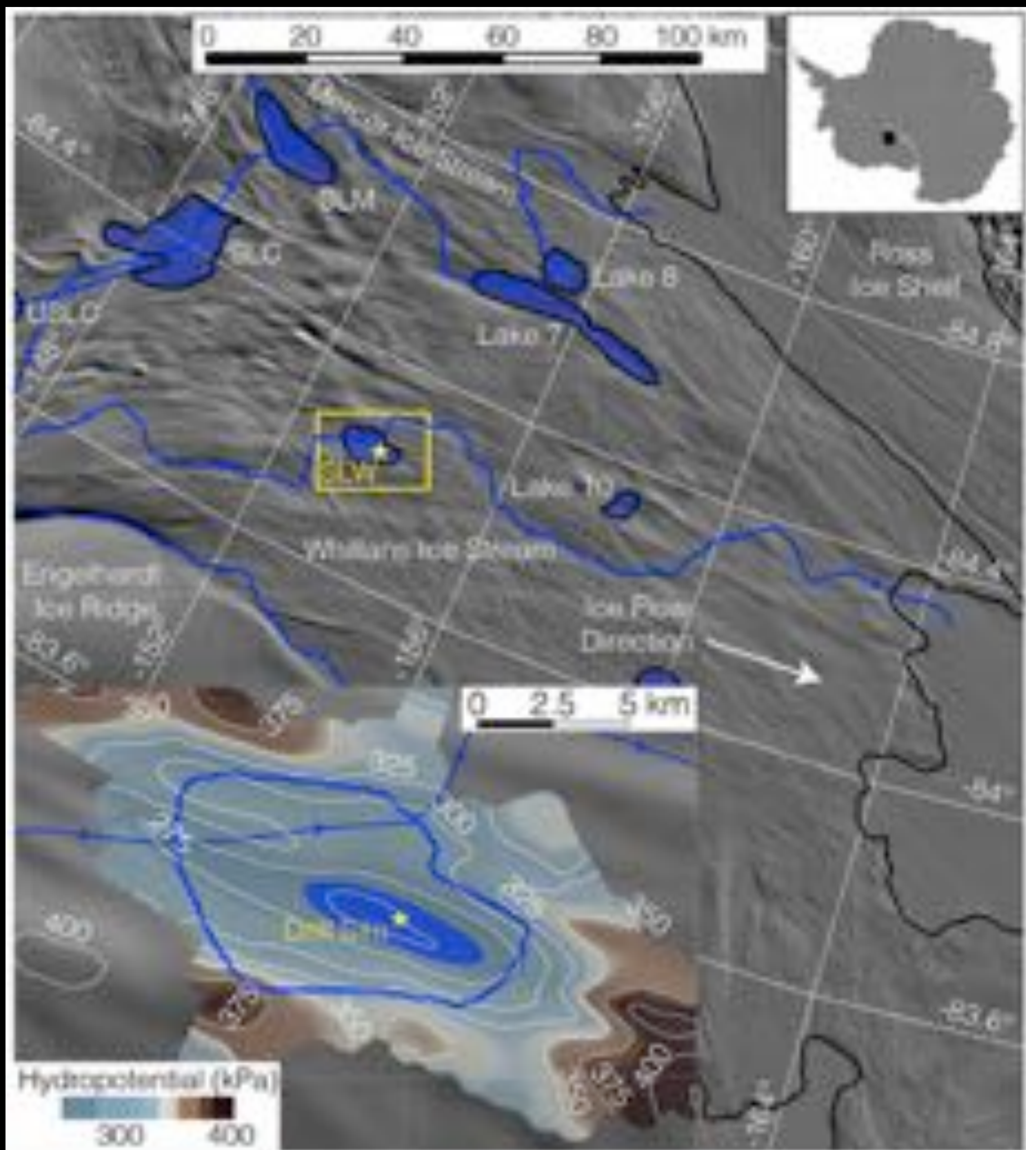


Priscu et al. (2013), *Antarctic Science*, Tulaczyk et al., (2014) *Annals of Glaciology*

Hot water ice corer at WGZ

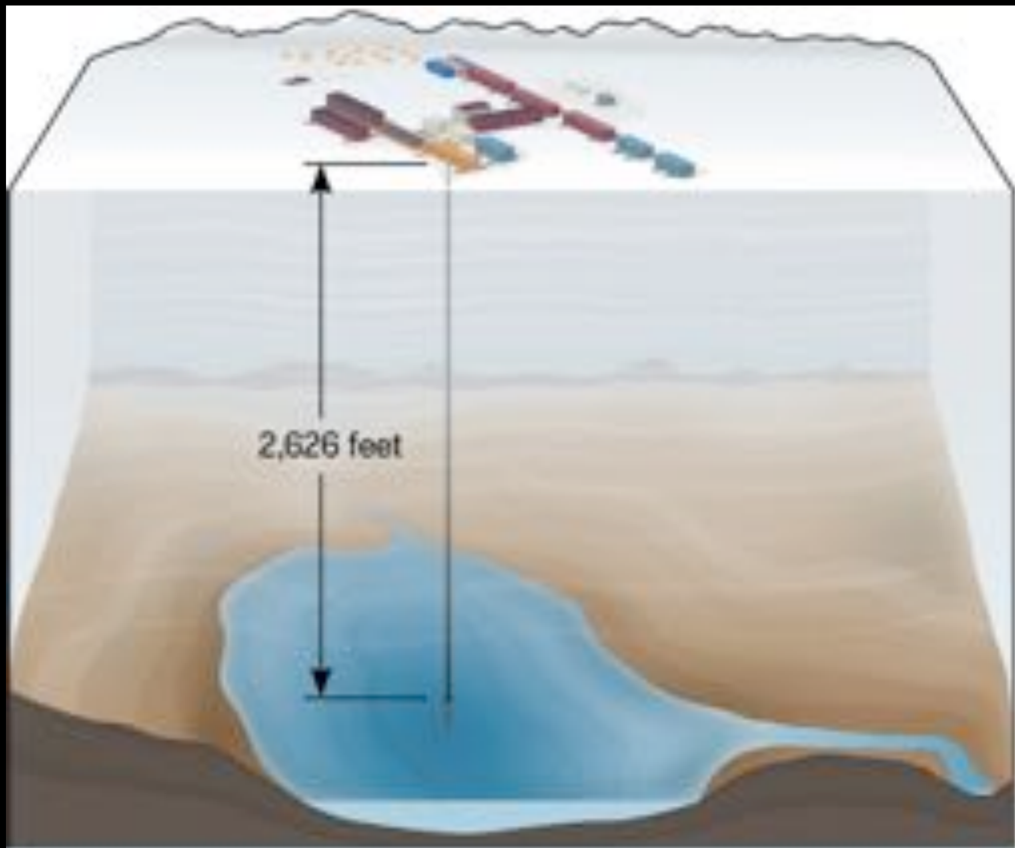


Whillans Ice Stream Subglacial Access Research Drilling Project



Subglacial Lake Whillans is a hydrologically active lake along the Whillans Ice Stream

Christner et al. 2014



WISSARD Hot Water Drill

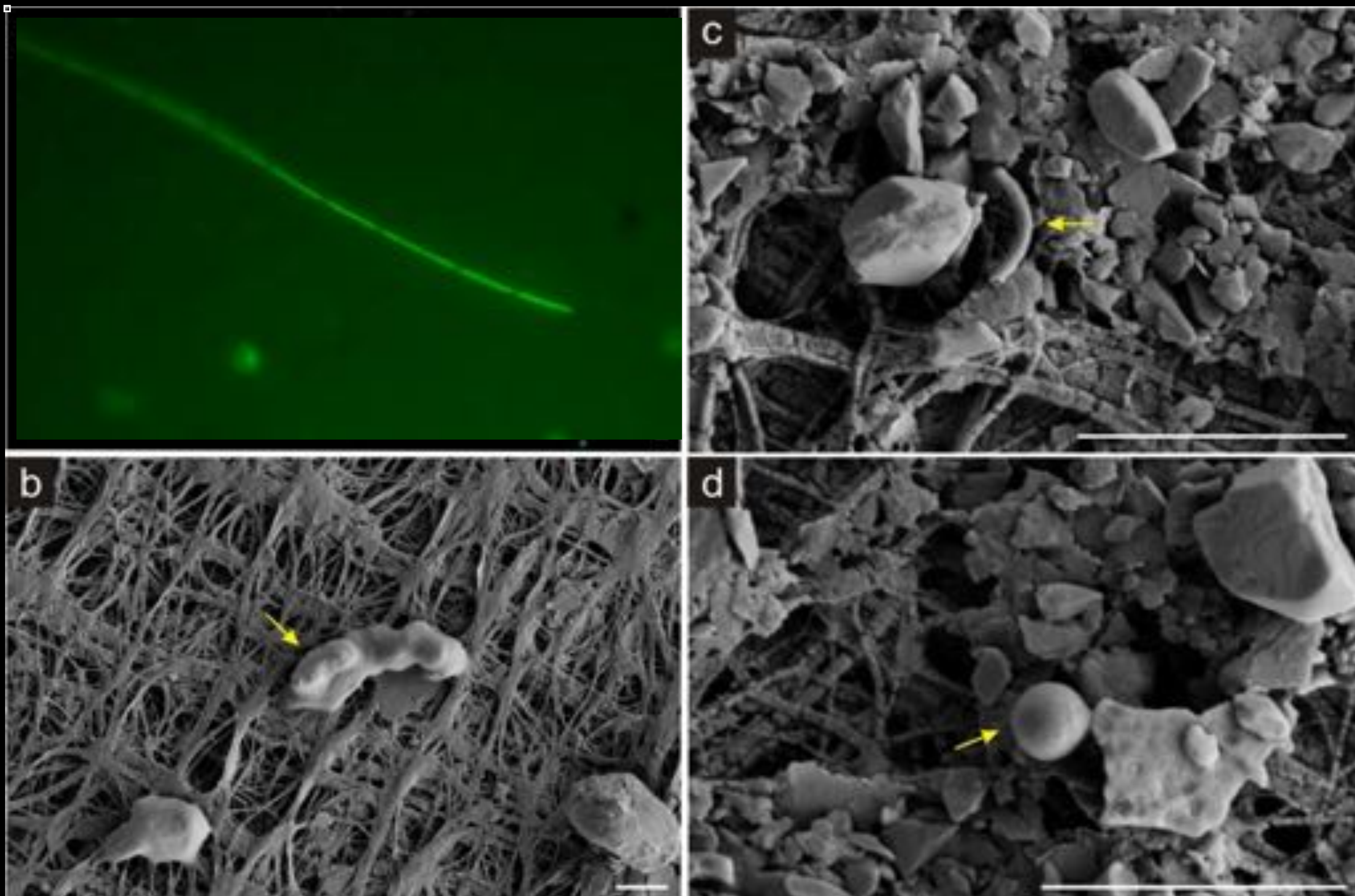
801m glacier ice

Lake lowstand
~2.2 m water column

15 ~20-80 cm of sediment core collected
(with a multi-, piston and percussion corer)

Key borehole results beyond geophysical surveys

Active microbes in lake water and sediments



Christner et al. Nature, 2014

Scale bars = 2 μm

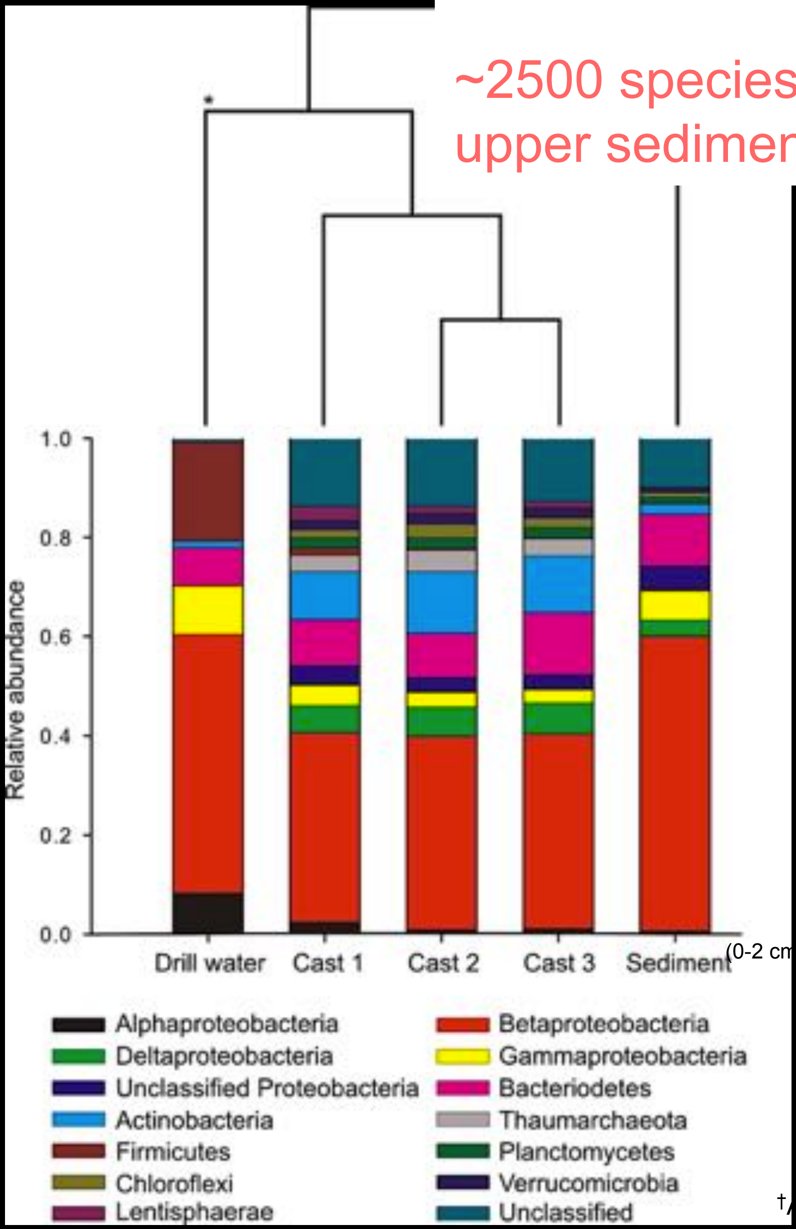
In situ filtration

Microbial diversity based on DNA sequence data

Christner et al. Nature, 2014

~4000 species in water column

~2500 species in upper sediments



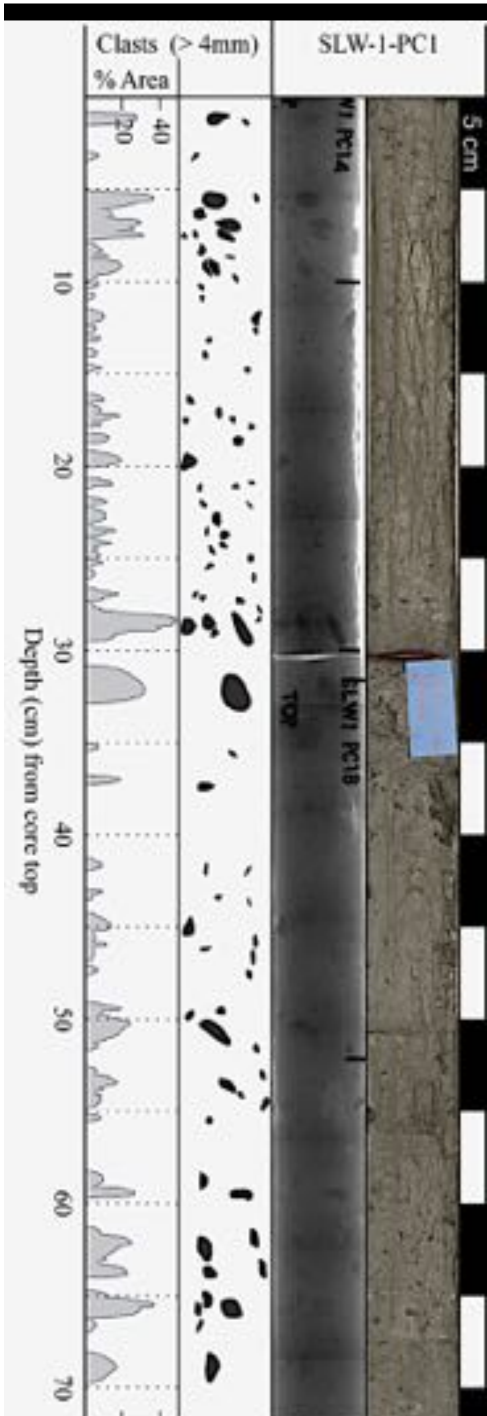
Geothermal gradient

High heat flow

285±80 mW/m^2

Significantly higher than continental and regional averages

Fischer Tulcaczk et al. submit



Sediment Cores

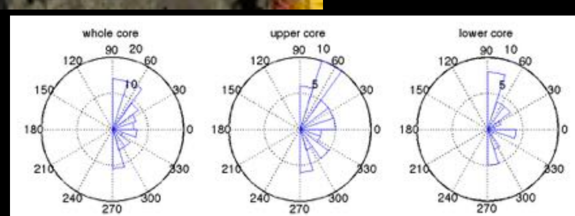
Structurally weak, uniform, degassed till

Slow transport by shear

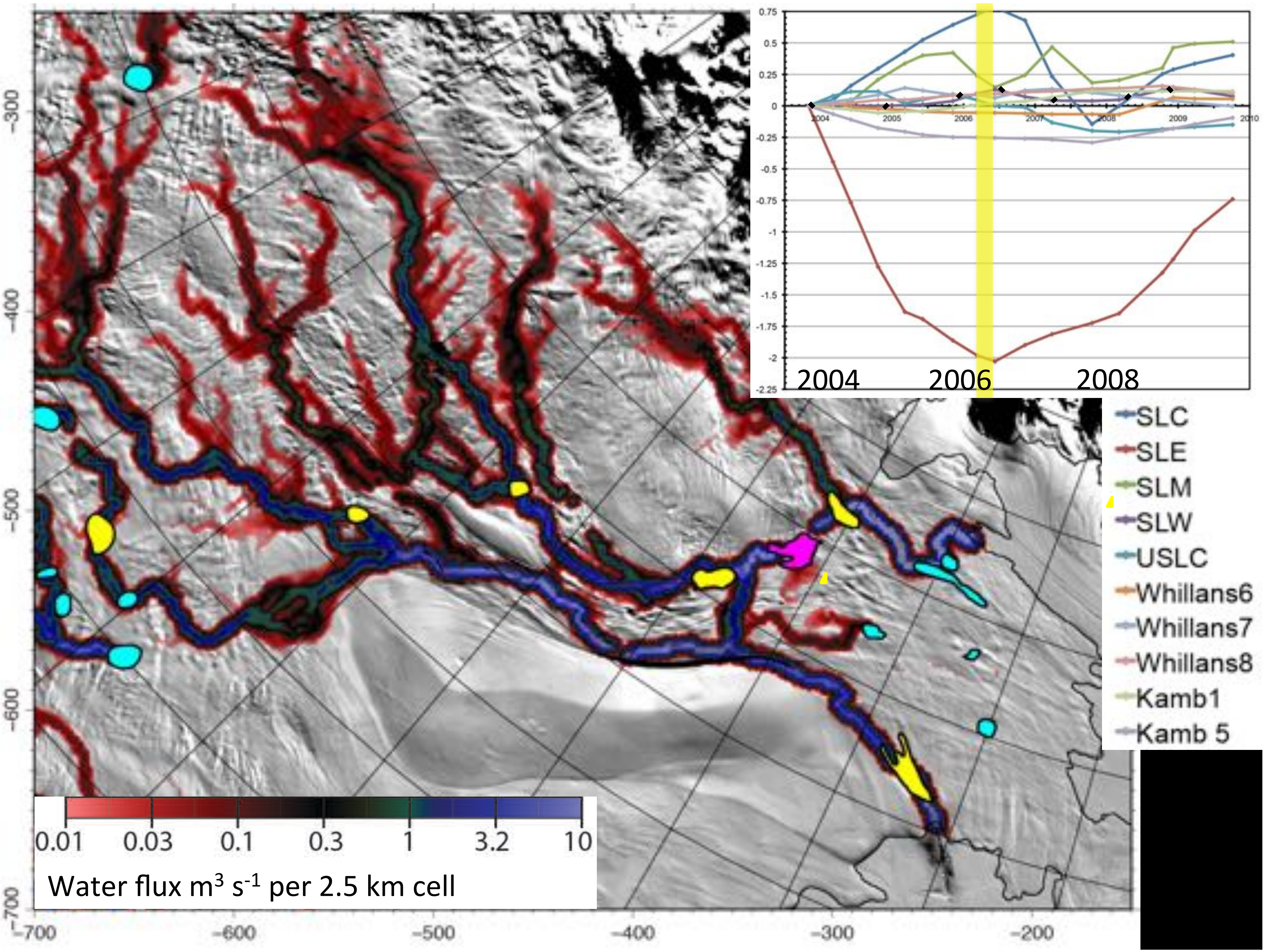
Low water recharge/discharge velocities

All show low sediment fluxes

Sources similar to UpB



Hodson, Powell et al. submit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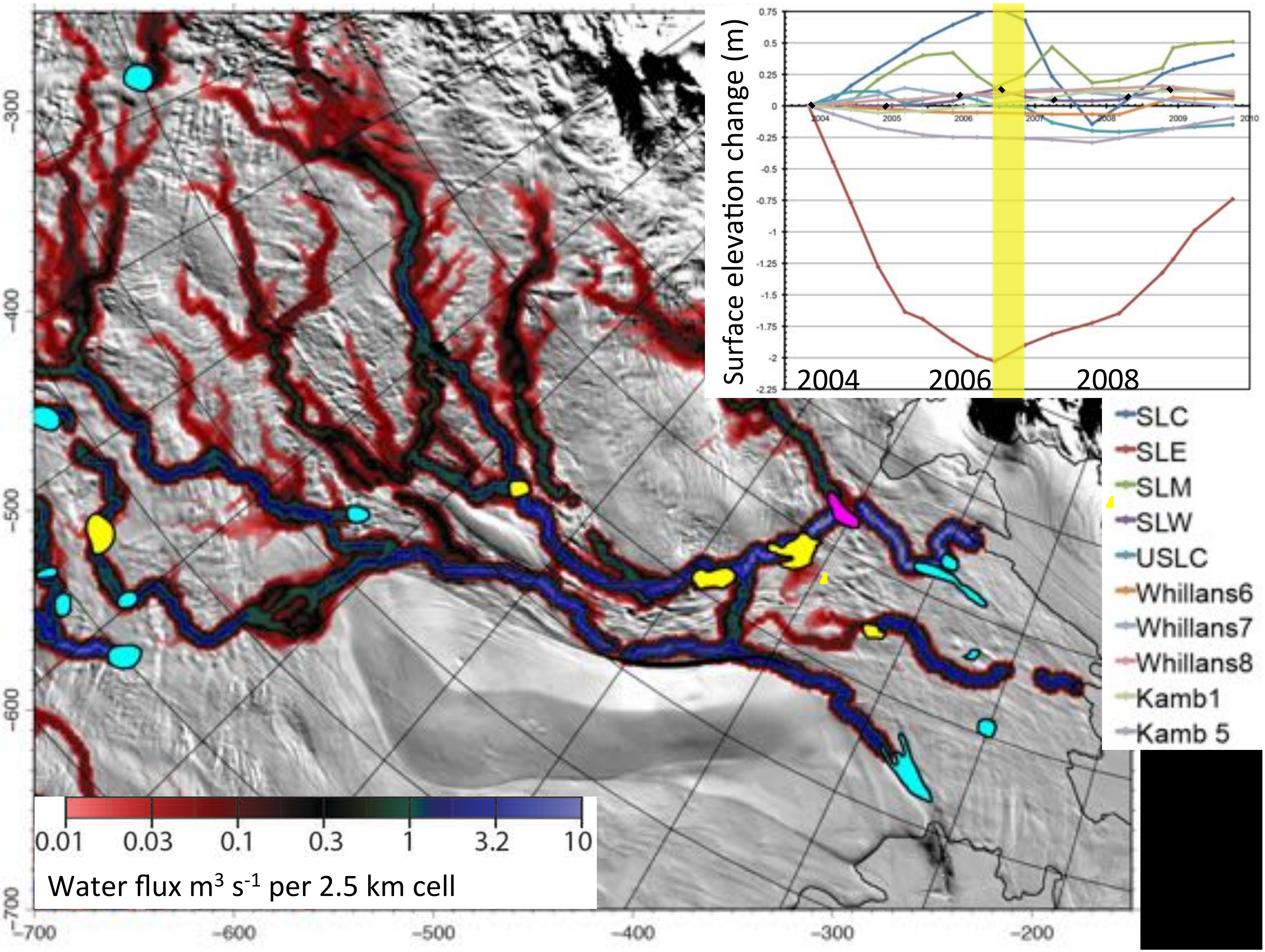
Water flux m³ s⁻¹ per 2.5 km cell



Surface elevation change (m)
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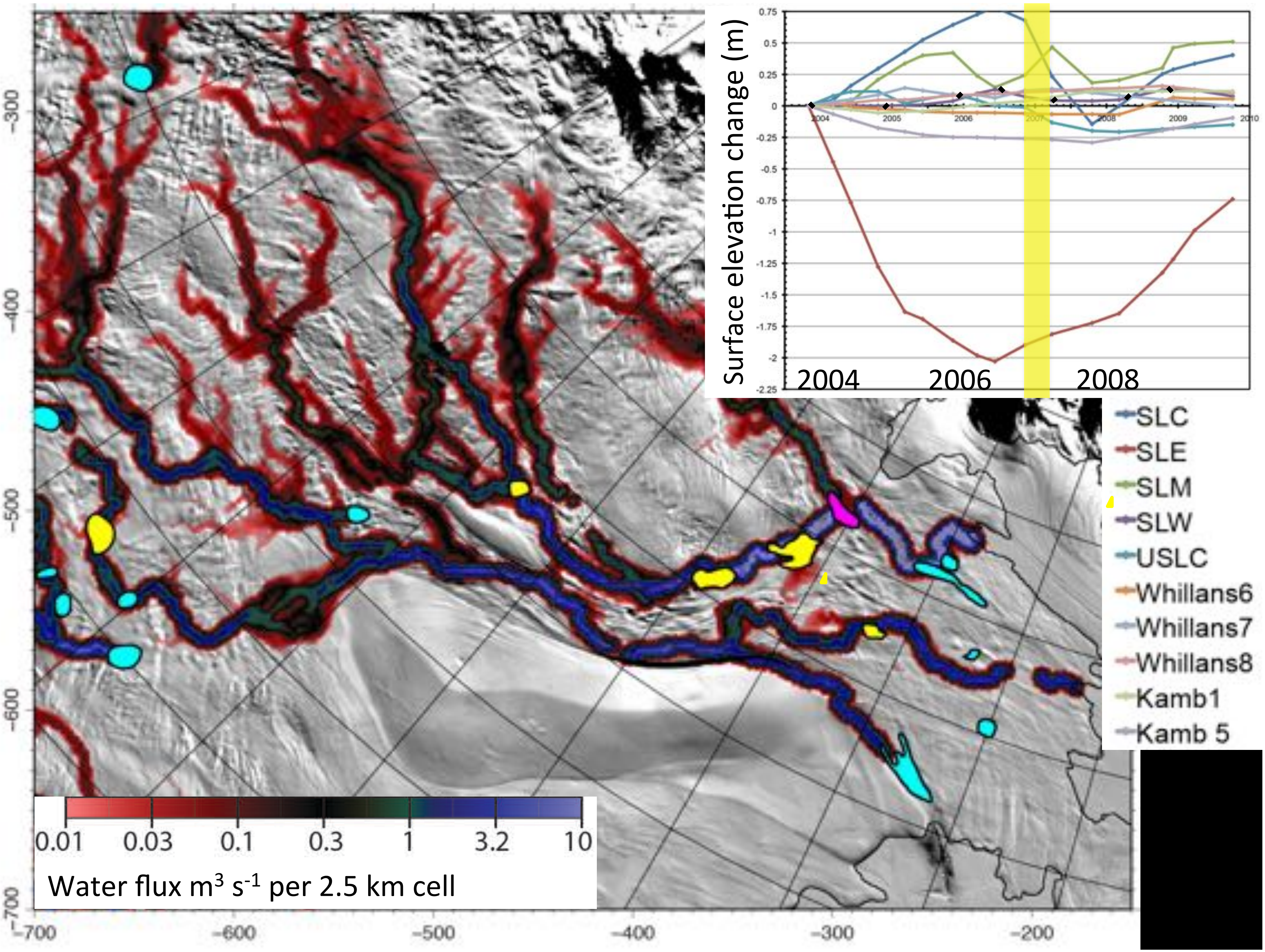

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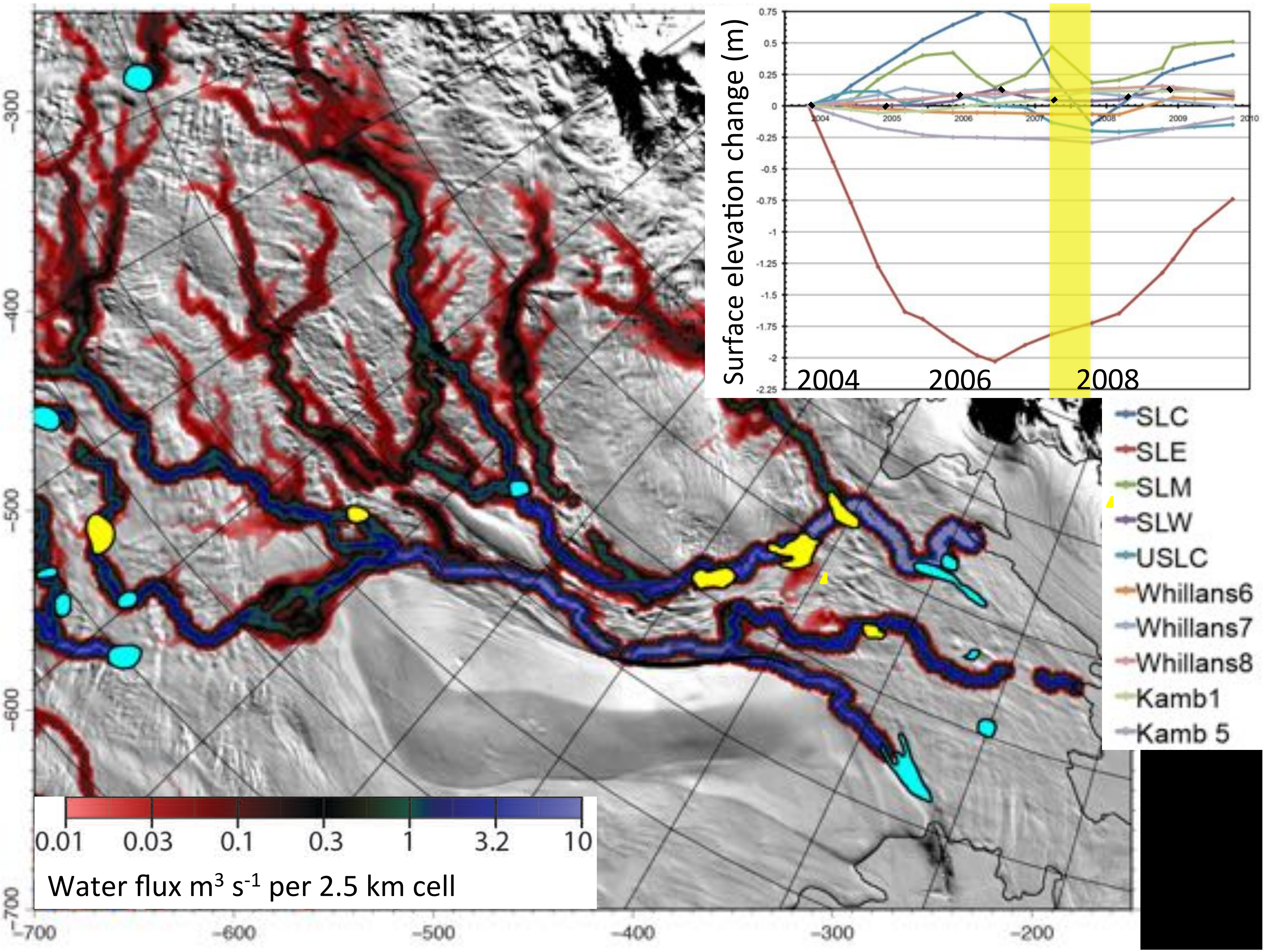
Water flux m^3 s^{-1} per 2.5 km cell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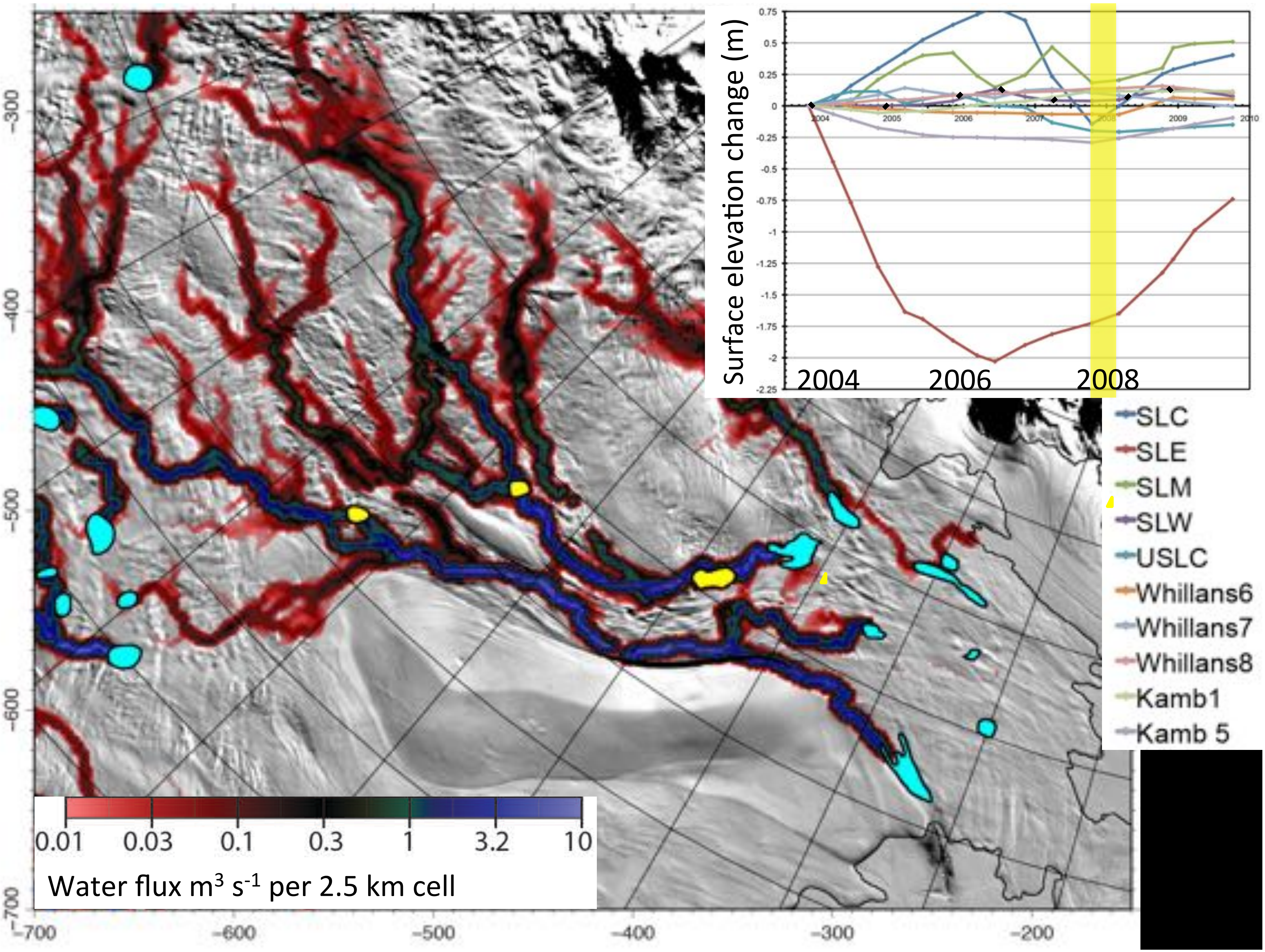
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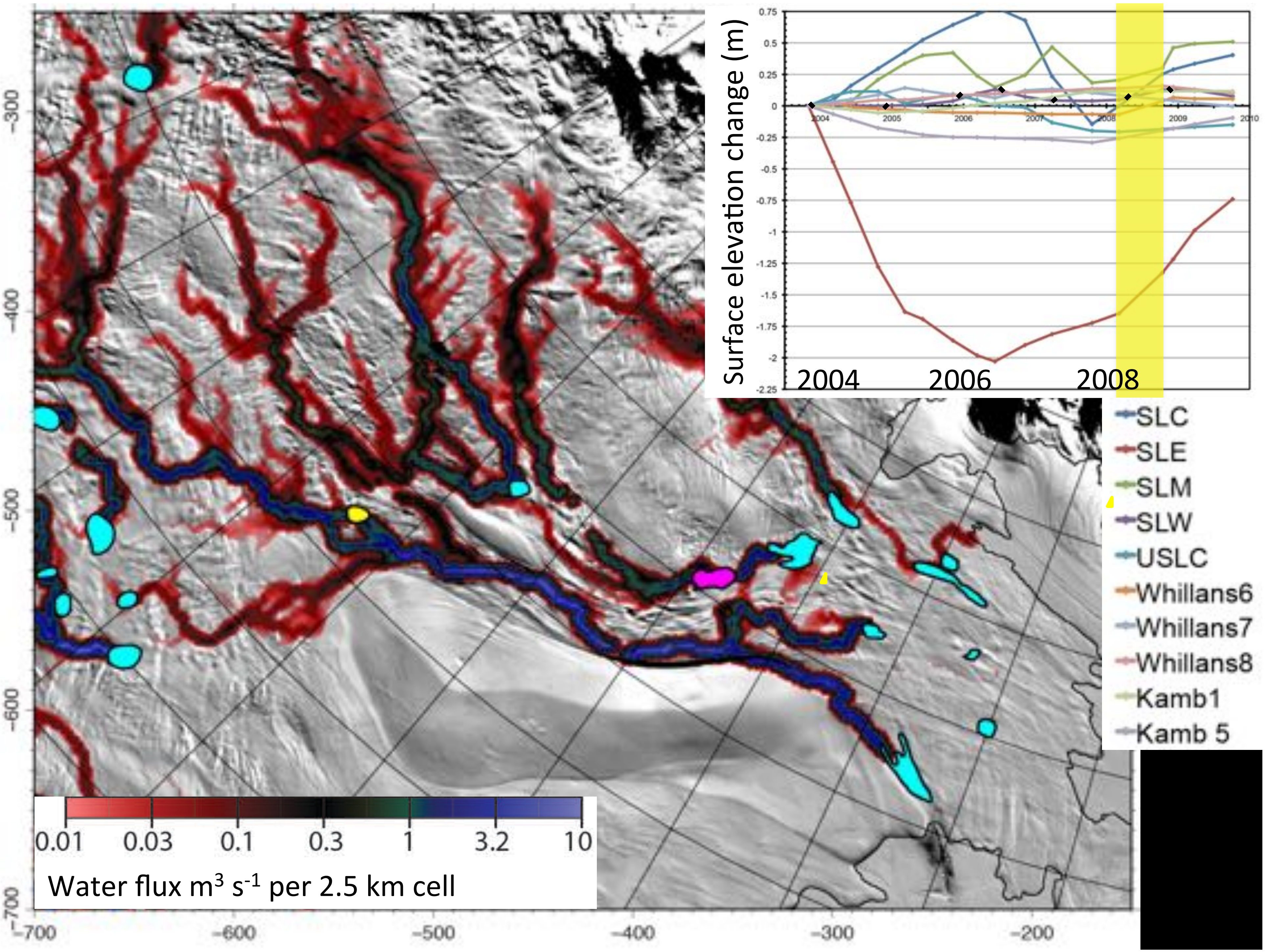

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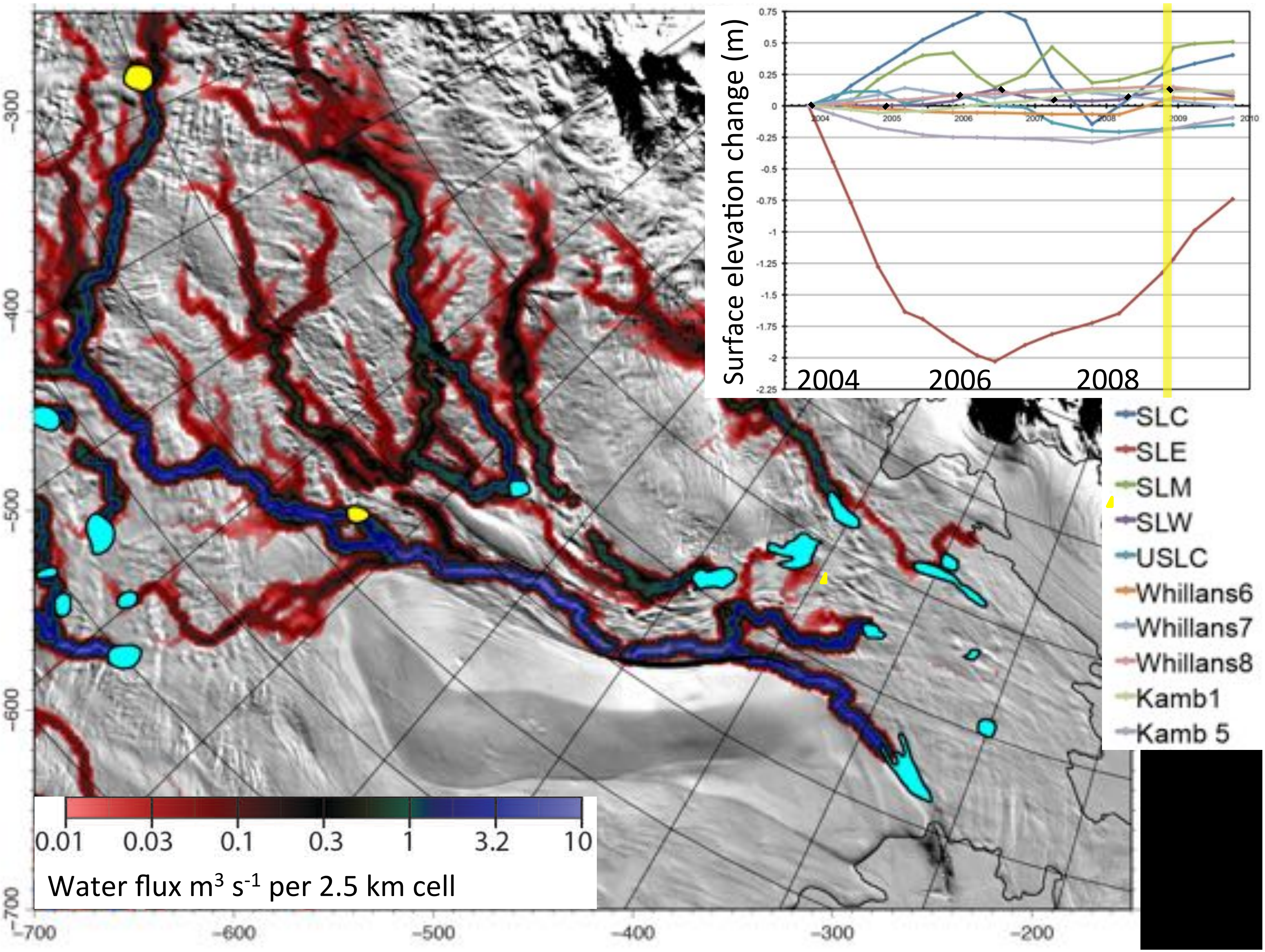

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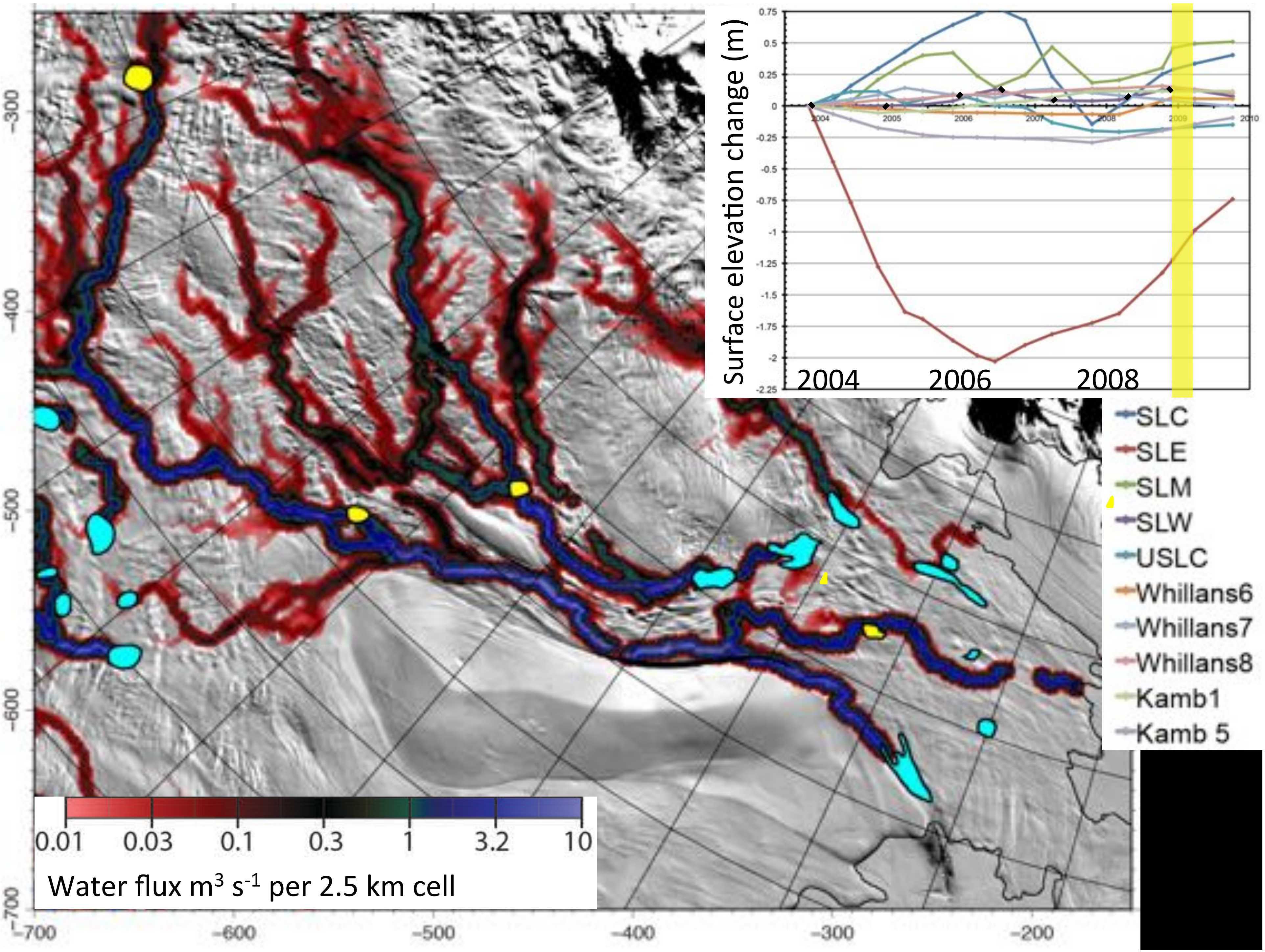

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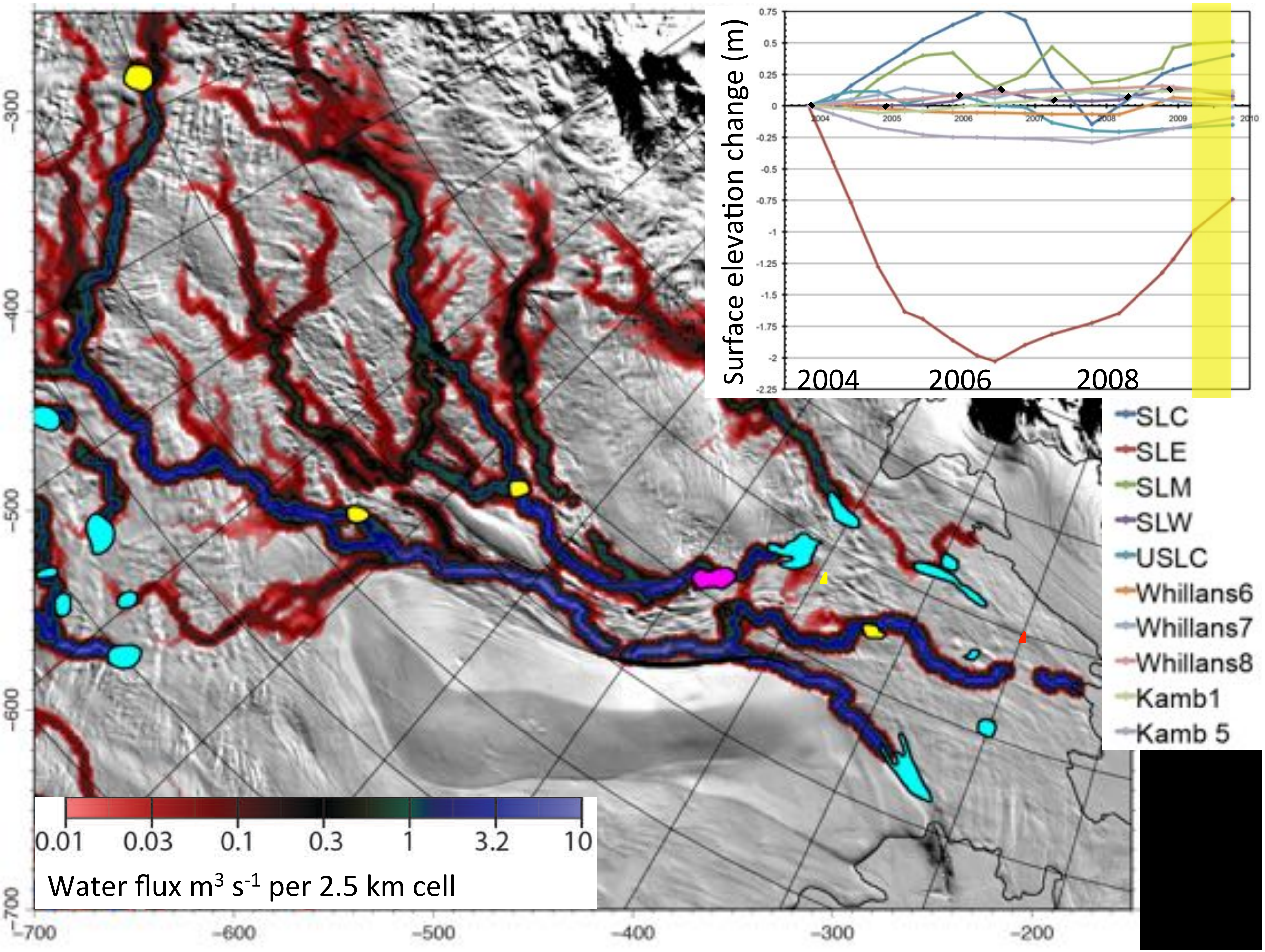

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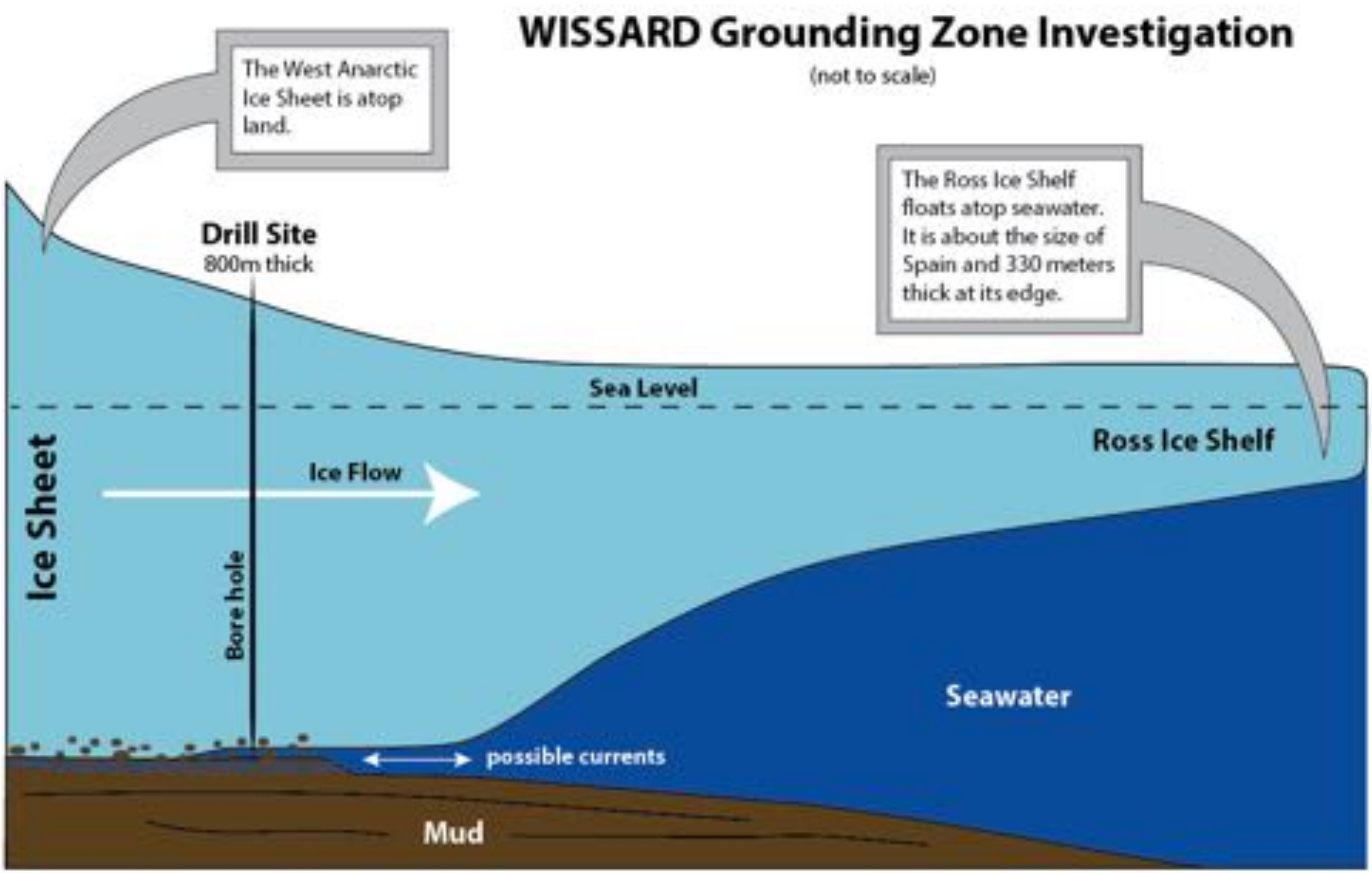
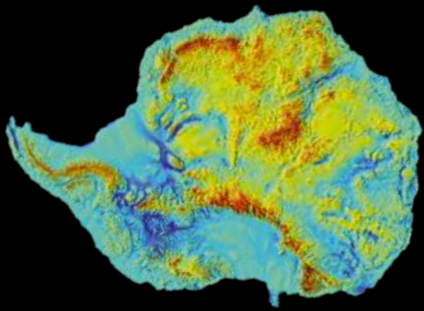
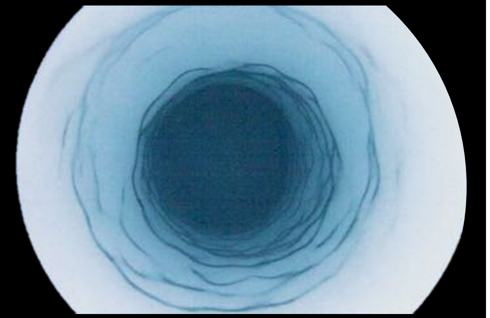
SLW:
Subglacial Lake Whillans (2013)

WGZ:
Whillans Grounding Zone (2015)





SUBGLACIAL ACCESS TOWNHALL MEETING



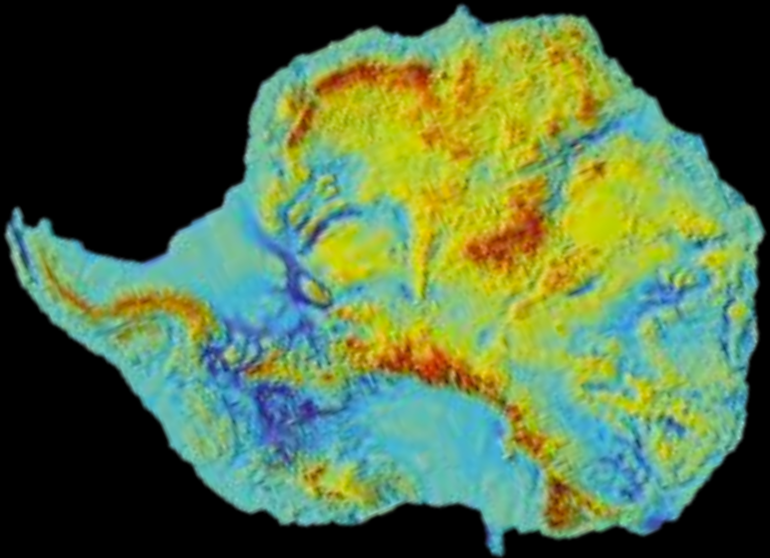
Since SCAR SALEGoS and SALE in 2000s
SCAR had interest in subglacial access for scientific exploration

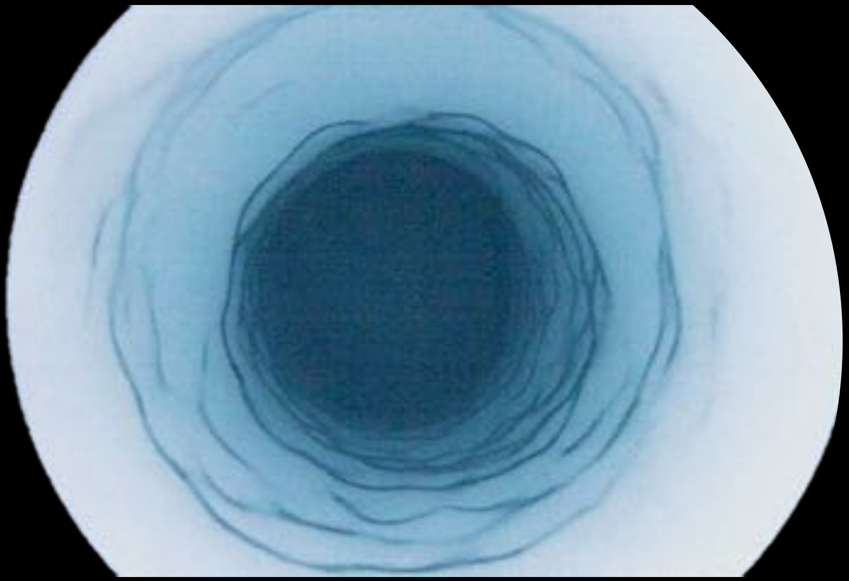
…exploration has started with
Ellsworth, Vostok, Whillans projects

…and subglacial resesrch interest has expanded

DISCUSSION

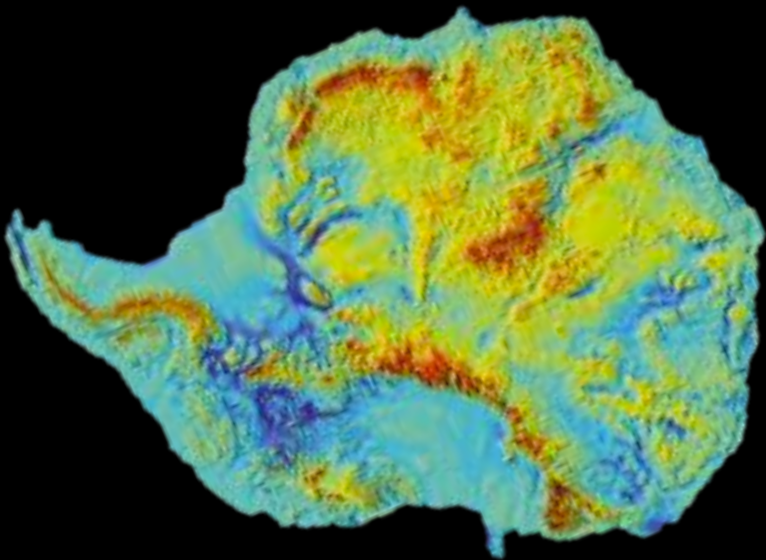
- Are there similar science objectives and targets
- Build international community similar to ice core community
- Share burden of logistics and costs

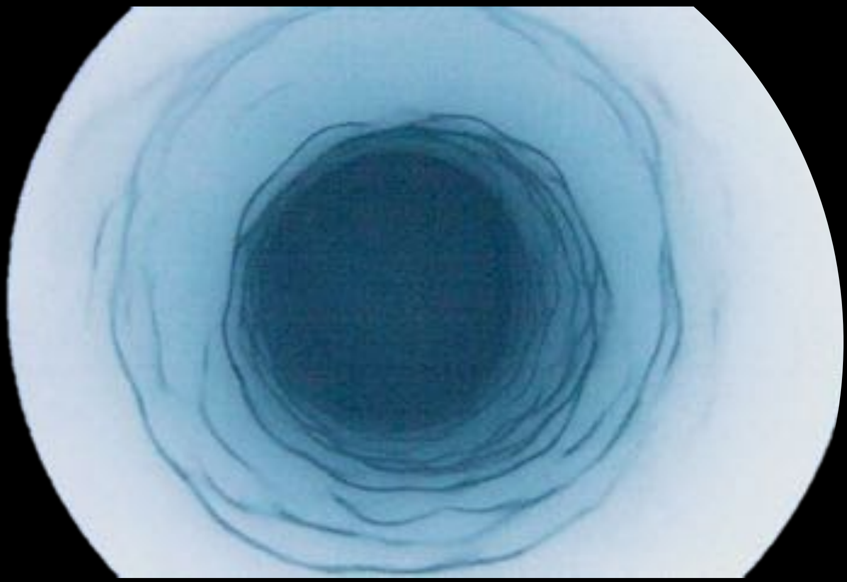




Countries represented

China
Italy
NZ
Russia
UK
USA





Discussion Points:

1. Synthesize current projects and identify near-term plans
2. Assess science goals that could be of collaborative interest
3. Discuss possible targets to address the goals
4. Clarify joint logistic possibilities

Moving Forward:

- Establish working groups for science targets?
- Develop a structure for future collaborations - Propose a SCAR SRP (Science Research Program)?

Subglacial Antarctic lake exploration: first results and future plans

Monday 30 - Tuesday 31 March, 2015

THE ROYAL SOCIETY

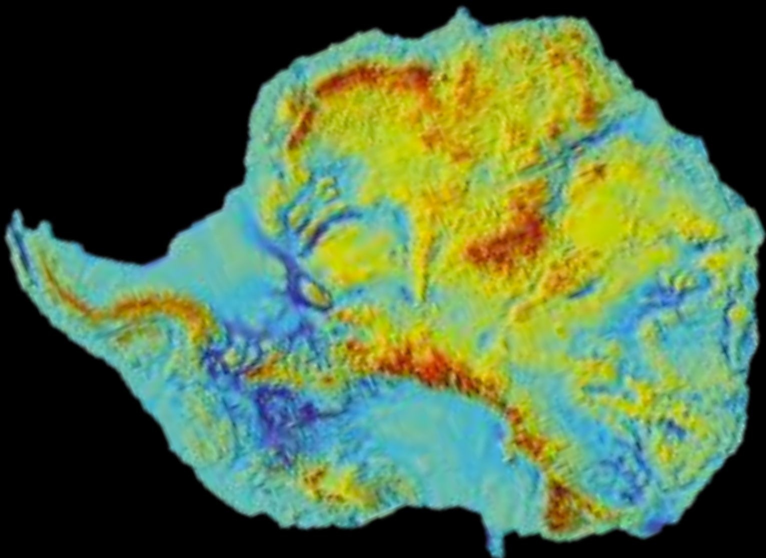
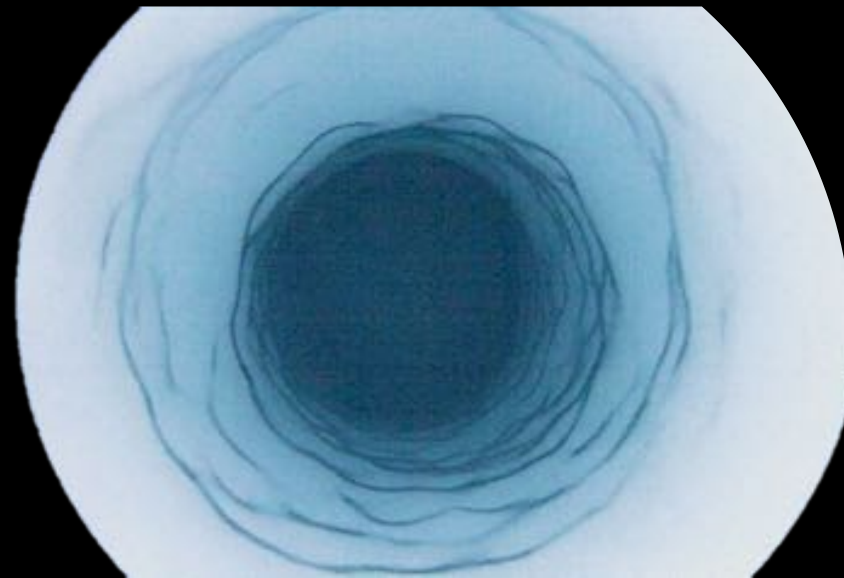
Royal Society Kavli Centre, Chicheley Hall, Buckinghamshire

Organized by
Martin Siegert, Irina Alekhina, Berry Lyons,
John Priscu, Jemma Wadham

Program

Time	DAY 1			Time	DAY 2		
	SESSION 1: **Subglacial environments and habitats for life** **Chair: Berry Lyons**		**SESSION 2:** **The role of subglacial lakes in basal hydrology and ice dynamics** **Chair: Irina Alekhina**		**SESSION 3:** **Sedimentary records in subglacial lakes** **Chair: Jemma Wadham**		**SESSION 4:** **Technological challenges in the exploration of subglacial lakes** **Chair: John Priscu**
09:00	Welcome by Peter Knight FRS & Martin Siegert						
09:05	**Dr Jill Mikucki** Geomicrobiology: Lake Whillans	**13:30**	**Helen Fricker** Satellite remote sensing	**09:00**	**Slawek Tulaczyk** Glacial geology and geophysics: Lake Whillans	**13:30**	**Vladimir Lipenkov** Lake Vostok access programme
09:30	Discussion	**14:00**	Discussion	**09:30**	Discussion	**14:00**	Discussion
09:45	**David Pearce** Microbiology: Lake Ellsworth	**14:15**	**Anne Le Brocq** Subglacial hydrology	**09:45**	**Dominic Hodgson** Technologies for retrieving sediment cores in Antarctic subglacial settings	**14:15**	**Keith Makinson** Lake Ellsworth access programme
10:15	Discussion	**14:45**	Discussion	**10:15**	Discussion	**14:45**	Discussion
10:30	Coffee	**15:00**	Tea	**10:30**	Coffee	**15:00**	Tea
11:00	**Sergey Bulat** Microbiology: Lake Vostok	**15:30**	**Frank Pattyn** Numerical modelling of ice sheets and subglacial lake interaction	**11:00**	**Robert Mckay** Sedimentary climate records: ANDRILL and beyond	**15:30**	**Frank Rack** Lake Whillans access programme
11:30	Discussion	**16:00**	Discussion	**11:30**	Discussion	**16:00**	Discussion
11:45	**John Parnell** Hydrochemistry of deep earth environments	**16:15**	**Duncan Young** Airborne glacier geophysics	**11:45**	**German Leychenkov** Sedimentary record of Lake Vostok	**16:15**	**Mahlon C Kennicutt** Summary of discussions and closing remarks
12:15	Discussion	**16:45**	Discussion	**12:15**	Discussion		
12:30	LUNCH	**17:00**	CLOSE	**12:30**	LUNCH	**17:00**	CLOSE

Wide variety of science objectives and targets

US Community meeting

- February just back form field
- March UK meeting
- April NSF deadline and SAB

- So next Fall

Community needs for on-going subglacial access research

Geophysical support

- Airborne surveys
  - IceBridge – NASA
  - Bassler – Blankenship
  - C130 – Bell (ICEPOD)
  - UAVs – CReSIS
  - Airborne Electromagnetics (SKYTEM)
- Ground
  - Shot-core seismics – Anandakrishnan
  - Vibroseis – Speece
  - Radar – Jacobel et al.
  - Phase-sensitive radar

Traverse equipment

- tractors, decking, sleds, containers, crane, winches, generators, labs, fixed wing support, etc.

Community needs for on-going subglacial access research

Hot water & access drills

- WISSARD – large clean access (hose, reel, heaters, pumps, clean access units)
  – roving drill ("dirty")
- RAID mobile mining rig hot water//geological drill
- ANDRILL hot water drill, then km-long geological cores
- Scalable hot water access drill, then short geological cores
- narrow borehole hot water drills, university owned
- agile sub-ice geological drill
- agile lake ice drill

Clean Access

- WISSARD
- more portable
- drilling fluid for deep ice
- protocols for new situations

Community needs for on-going subglacial access research

Instrumention Development

- various projects mentioned previously

Regular community meetings

- data exchange
- planning
- collaborating
- international group through SCAR?

On-going support

- drill/engineering facility
- program facilities/coordination office

HOT WATER Drills to meet our needs?

Scalable/Roving Drill capabilities
- up to ~1000-1500m
- up to 30-40 cm
- Mobile and clean capabilities

Medium drill (WISSARD) part I
- up to ~1000-1500m
- Diammeter less 50 cm
- Clean capabilities
- Stationary facilitates the drilling

Medium drill (WISSARD) part II
- up to ~1000-1500m
- Diameter up to 100 cm
- Clean capabilities
- Stationary facilitates the drilling

Deep Access Drill
- >3000m
- Engineering to sample (keep hole open)
- Targets like Ellsworth, Vostok, Deep sedimentary basins

SCAR Horizon Scan – Final List of 80 Questions

ANTARCTIC ICE SHEET AND SEA LEVEL

24. How does small-scale morphology in subglacial and continental shelf bathymetry affect Antarctic Ice Sheet response to changing environmental conditions?

25. What are the processes and properties that control the form and flow of the Antarctic Ice Sheet?

26. How does subglacial hydrology affect ice sheet dynamics, and how important is it?

27. How do the characteristics of the ice sheet bed, such as geothermal heat flux and sediment distribution, affect ice flow and ice sheet stability?

28. What are the thresholds that lead to irreversible loss of all or part of the Antarctic ice sheet?

29. How will changes in surface melt over the ice shelves and ice sheet evolve, and what will be the impact of these changes?

30. How do oceanic processes beneath ice shelves vary in space and time, how are they modified by sea ice, and do they affect ice loss and ice sheet mass balance?

31. How will large-scale processes in the Southern Ocean and atmosphere affect the Antarctic Ice Sheet, particularly the rapid disintegration of ice shelves and ice sheet margins?

32. How fast has the Antarctic Ice Sheet changed in the past and what does that tell us about the future?

33. How did marine-based Antarctic ice sheets change during previous inter-glacial periods?

34. How will the sedimentary record beneath the ice sheet inform our knowledge of the presence or absence of continental ice?

DYNAMIC EARTH PROBING BENEATH ANTARCTIC ICE

35. How does the bedrock geology under the Antarctic Ice Sheet inform our understanding of supercontinent assembly and break-up through Earth history?

36. Do variations in geothermal heat flux in Antarctica provide a diagnostic signature of sub-ice geology?

37. What is the crust and mantle structure of Antarctica and the Southern Ocean, and how do they affect surface motions due to glacial isostatic adjustment?

38. How does volcanism affect the evolution of the Antarctic lithosphere, ice sheet dynamics, and global climate?

39. What are and have been the rates of geomorphic change in different Antarctic regions, and what are the ages of preserved landscapes?

40. How do tectonics, dynamic topography, ice loading and isostatic adjustment affect the spatial pattern of sea level change on all time scales?

41. Will increased deformation and volcanism characterize Antarctica when ice mass is reduced in a warmer world, and if so, how will glacial- and ecosystems be affected?

42. How will permafrost, the active layer and water availability in Antarctic soils and marine sediments change in a warming climate, and what are the effects on ecosystems and biogeochemical cycles?

Appendix 3
Estimated Costs for Equipment Development and Upgrade Projects
PY 2014 - PY 2019

Development or Upgrade Project	PY 2014 (Current)	PY 2015	PY 2016	PY 2017	PY 2018	PY 2019	Total PY 2014-2019
Intermediate Depth Drill	1,137,000	220,000	128,000	64,000	64,000	64,000	1,677,000
Scalable Hot Water Access Drill	64,000	250,000	1,055,000	150,000			1,519,000
Agile Sub Ice Geologic Drill	328,000	300,000	225,000	70,000	70,000	50,000	1,043,000
Blue Ice Drill – Enhanced Capabilities	249,000	86,000	27,000	14,000	14,000	14,000	404,000
RAM Drill – Enhanced Capabilities		80,000	30,000	200,000	550,000	950,000	1,810,000
DISC Drill – East Antarctic Enhancements		125,000	50,000	970,000	850,000	500,000	2,495,000
Thermal Drill		20,000	5,000	5,000	5,000	5,000	40,000
New Agile Ice Coring Drill		40,000	20,000	100,000	330,000	300,000	790,000
Deep Logging Winch	18,000	40,000					58,000
4-inch Drill Upgrades	147,000	150,000	179,000	149,000	60,000	60,000	745,000
Badger-Eclipse Upgrades	61,000	100,000	102,000	53,000	53,000	53,000	422,000
Hand Auger Upgrades	3,000	70,000	50,000	40,000	30,000	30,000	223,000
Small Hot Water Drill Upgrades	1,000	150,000	46,000	20,000	10,000	10,000	237,000
Clean Sampling Methods Study			60,000	20,000			80,000
Shallow Lake Ice Drill		20,000					20,000
Koci Drill		50,000					50,000
Prairie Dog Drill		5,000	2,500	2,500	2,500	2,500	15,000
Logging Winches		25,000	10,000	10,000	10,000	10,000	65,000
Total Costs	2,008,000	1,731,000	1,989,500	1,867,500	2,048,500	2,048,500	11,693,000

(green)	Equipment Development
(orange)	Maintenance & Upgrade

HWD only 15% of budget projected out to 2019