On The Influence of Bed Topography On Results from Dynamic Ice Sheet Models

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(7) Center for Remote Sensing of Ice Sheets, U of Kansas

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- NASA Cryospheric Sciences
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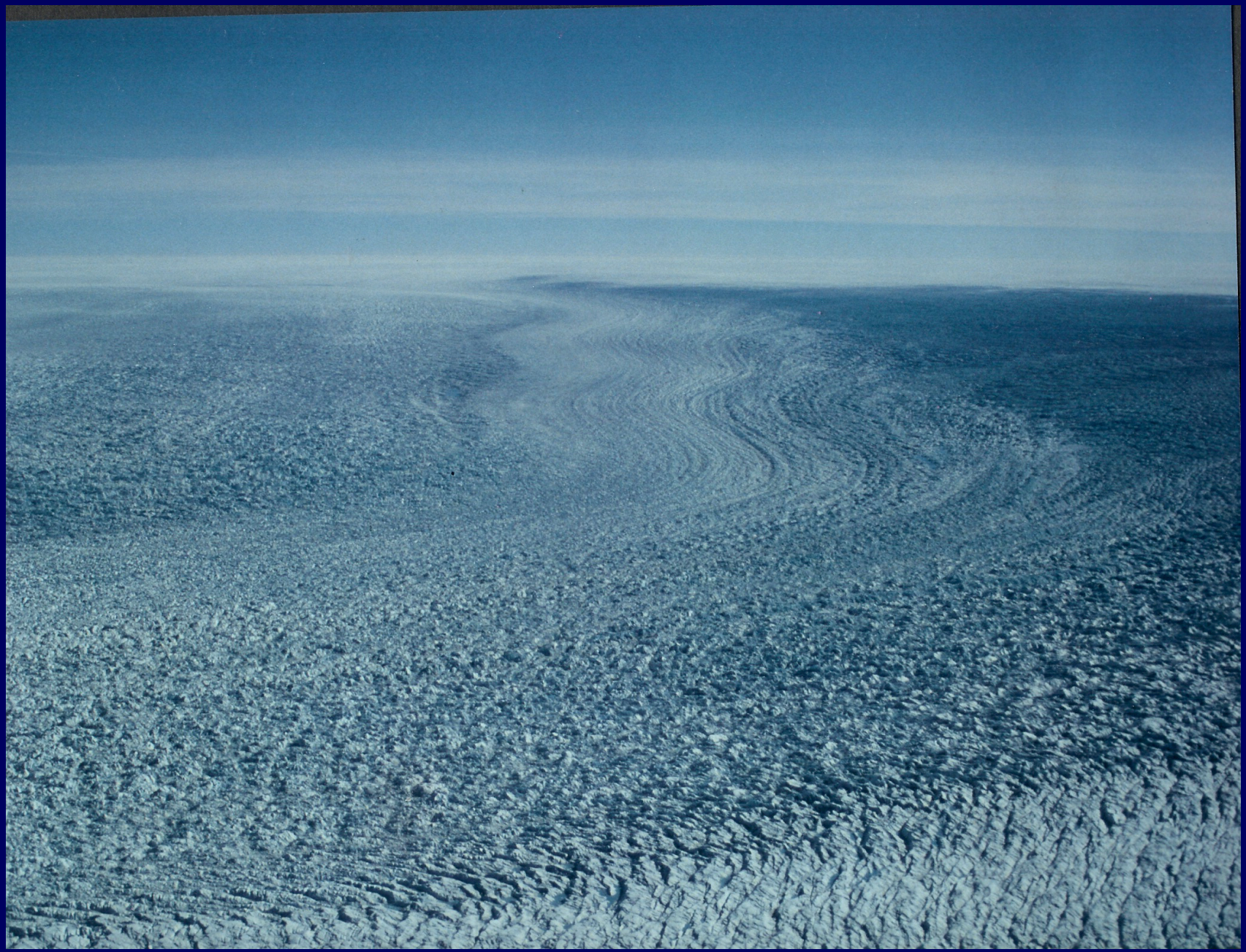
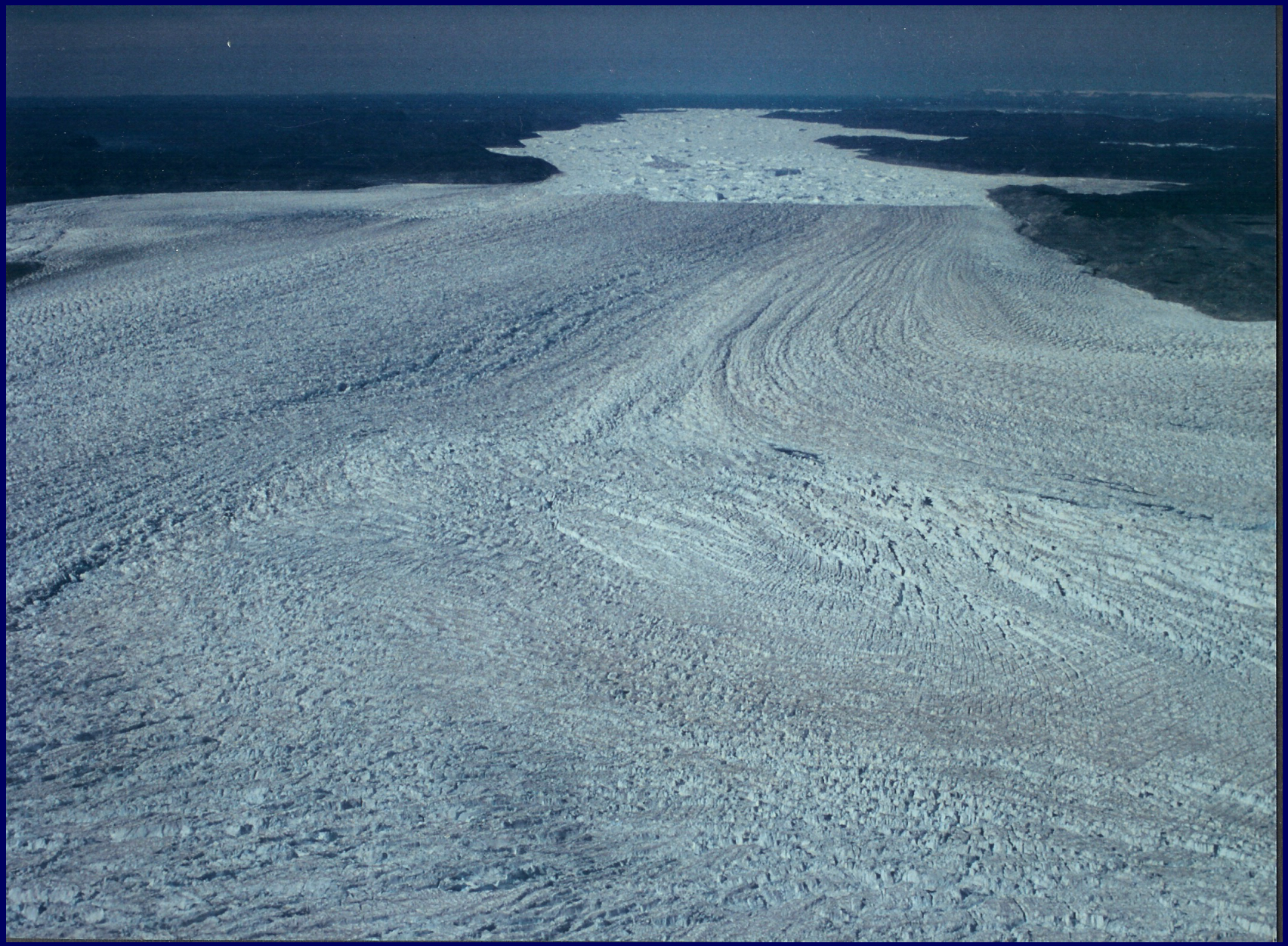
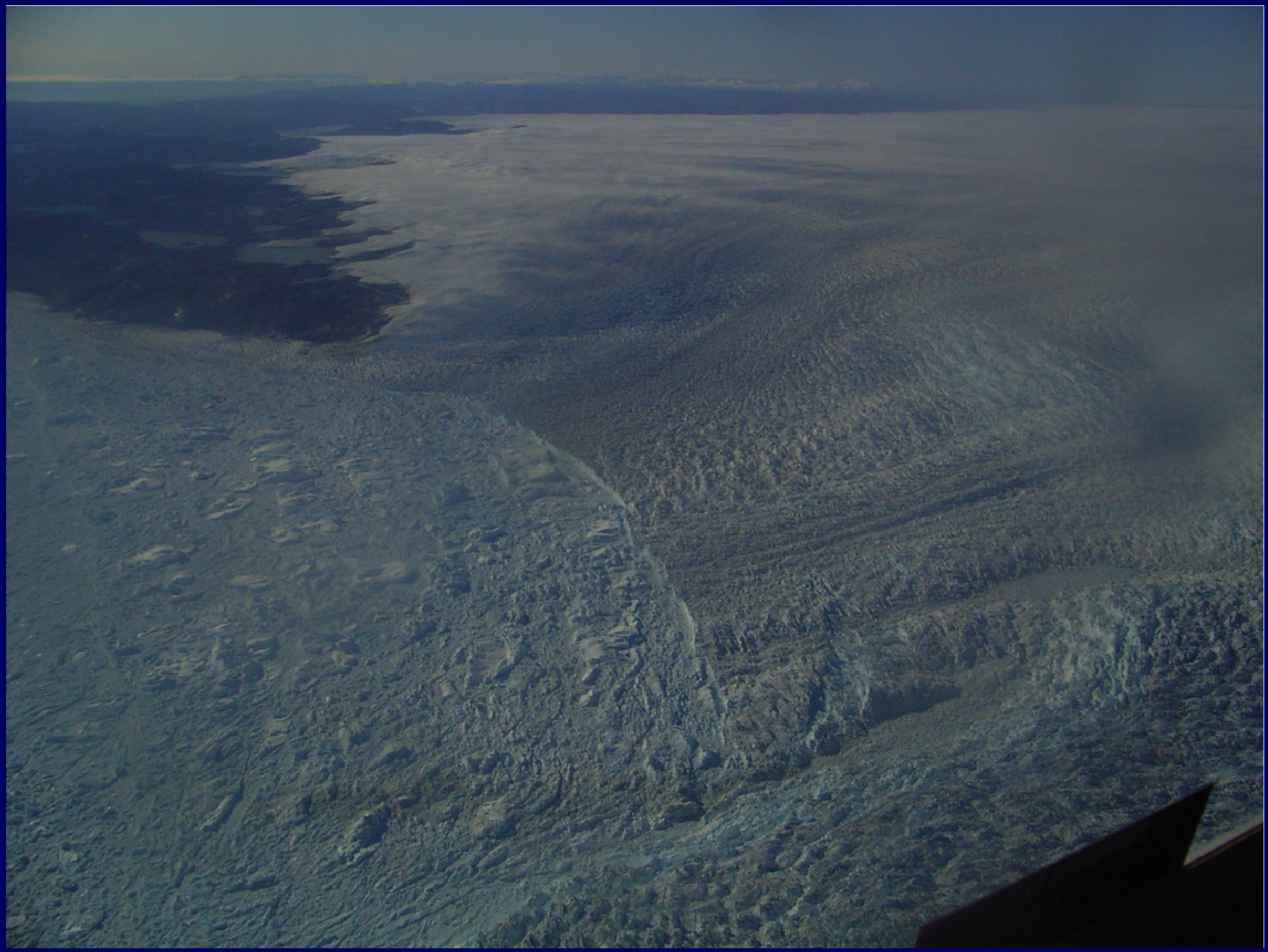
- University of Colorado UROP Program



Jakobshavns Isbræ, view upglacier: August 1996

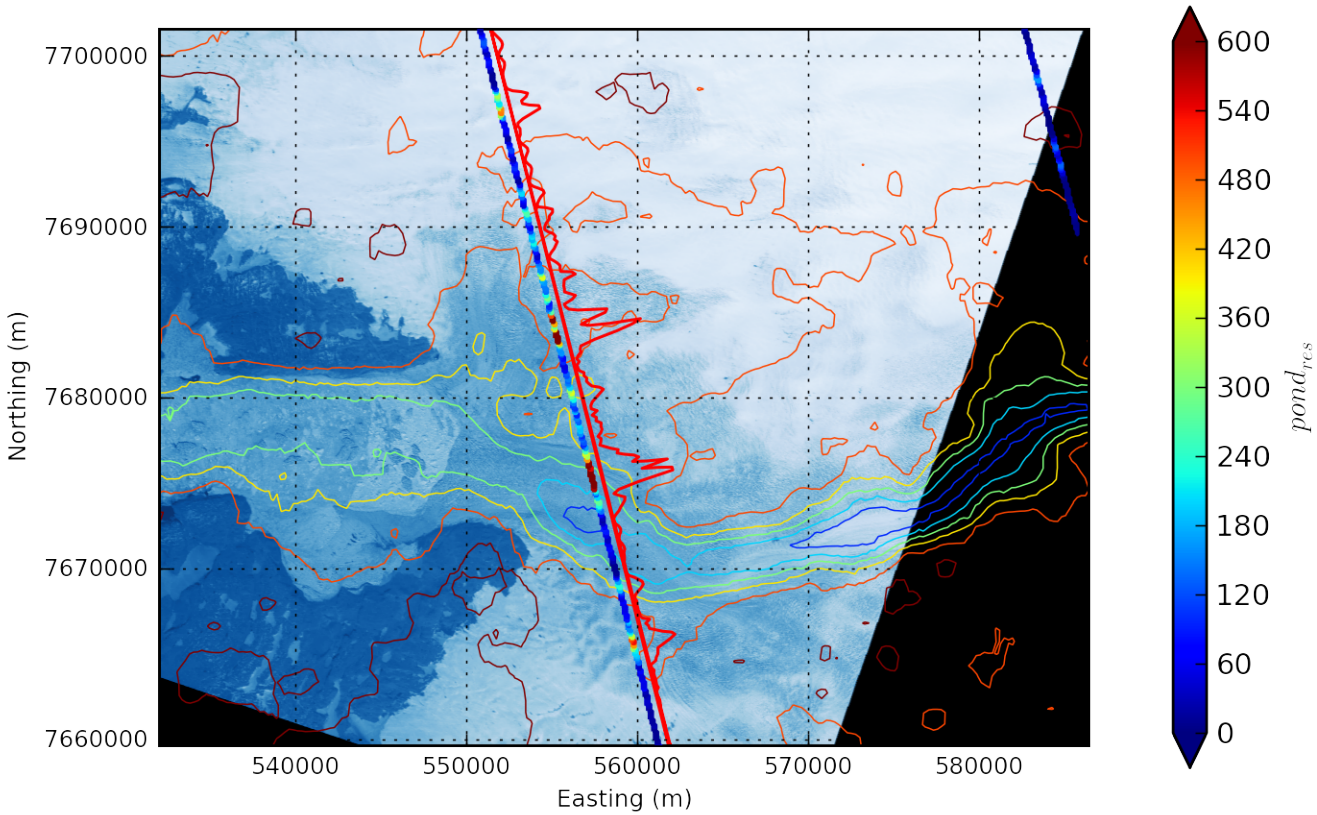


Jakobshavns Isbræ, view downglacier over Jakobshavns Isfjord: August 1996



Jakobshavns Isbræ, retreat of calving front: July 2005

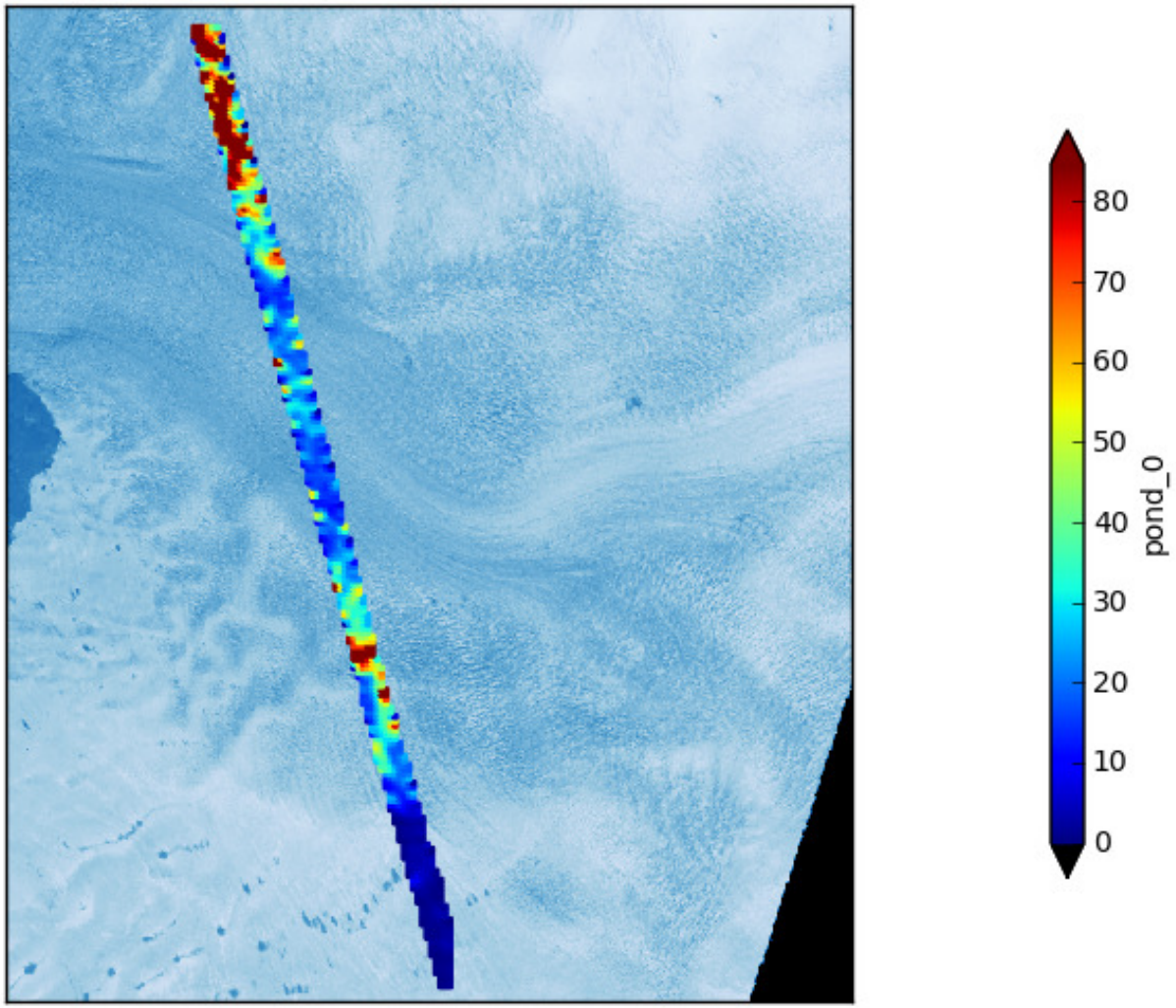
Dynamic Provinces in Jakobshavns Isbræ from ICESat (GLAS, 2003-2009) and IceBridge (ATM, 2009) Data



\AS L3I 11/2007 left to right: $pond_{res}$, $ppond$ \ASTER 3B 05-2003 Background with CRESIS Bed contours

/home/chenpa/documents/brucescripts/test/jakGLASL3I_pondppondres_zoom2_b.png 2010-12-6

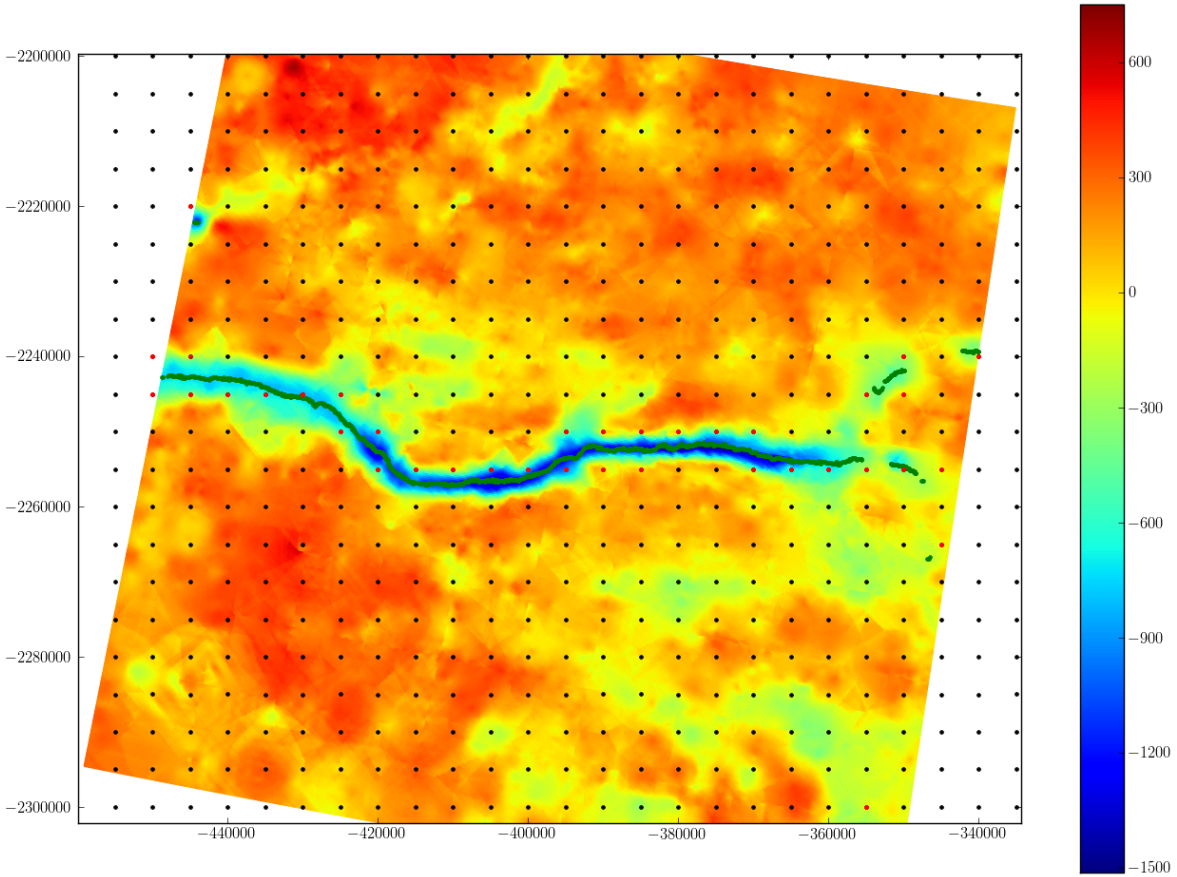
Jakobshavn Isbrae - Roughness measures



ATM full pond_0 parameter
ASTER 3B 05-2003 Background

Building a Greenland Bed for Modeling (at 5 km)

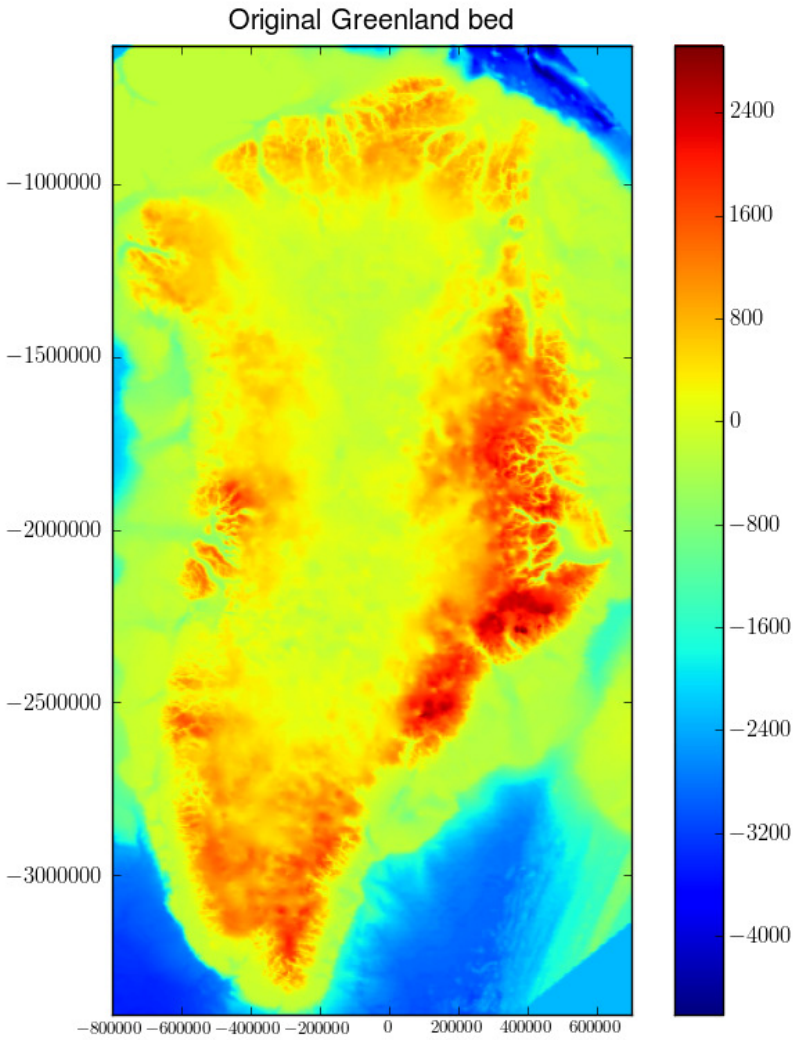
Jakobshavn region subglacial topography (CReSIS, prelim)
With AlgoA trough set (red)



radar data: Center for Remote Sensing of Ice Sheets (CReSIS), University of Kansas

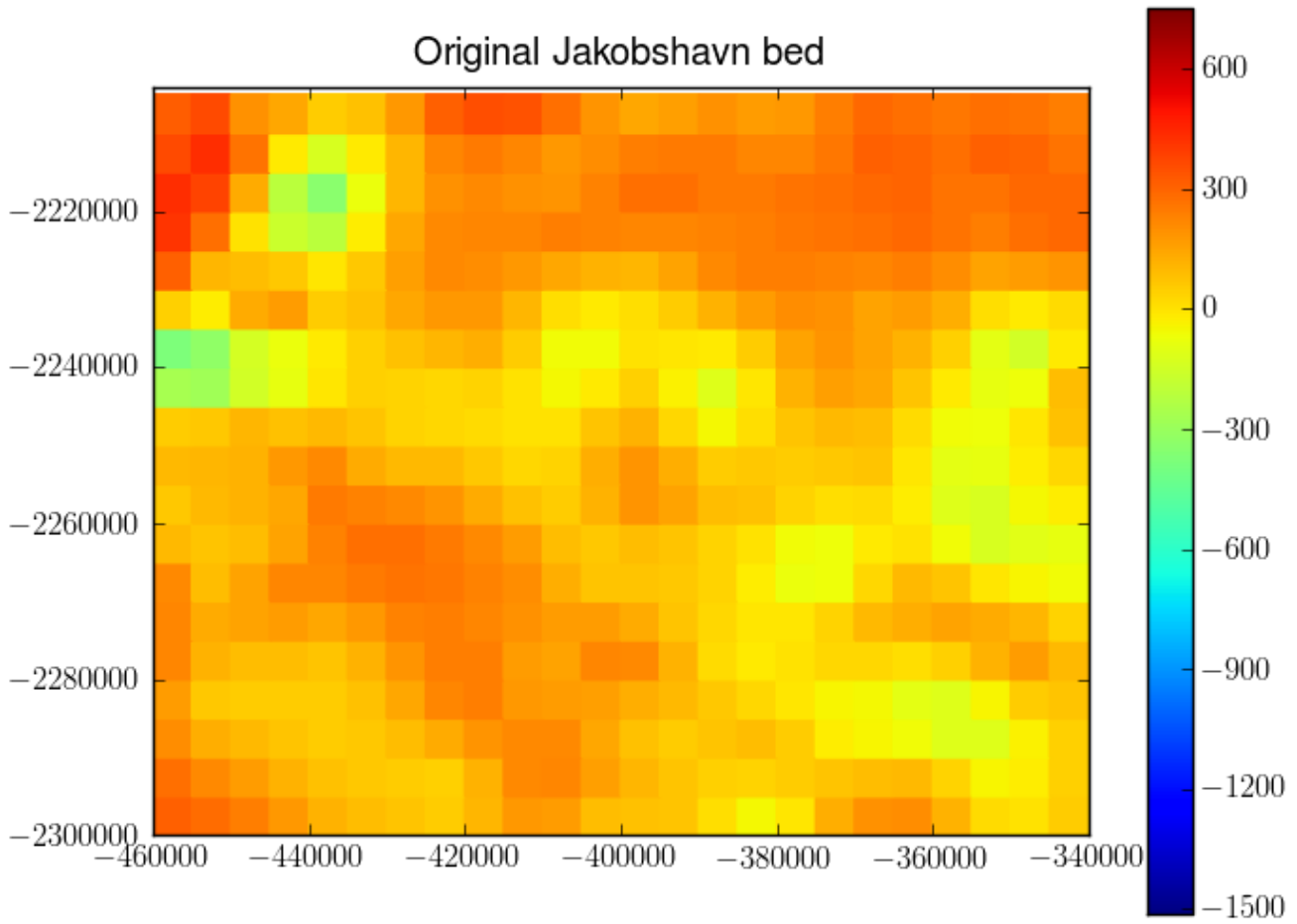
cartography and coloring of CReSIS data by Bruce Wallin

Greenland subglacial topography - without Jak trough



based on Bamber, Layberry and Gogineni 2001

Jakobshavn region subglacial topography - without Jak trough



based on Bamber, Layberry and Gogineni 2001

Jakbed Algo

(1) identification of trough location

(2) establish edge-connectedness of trough bottom

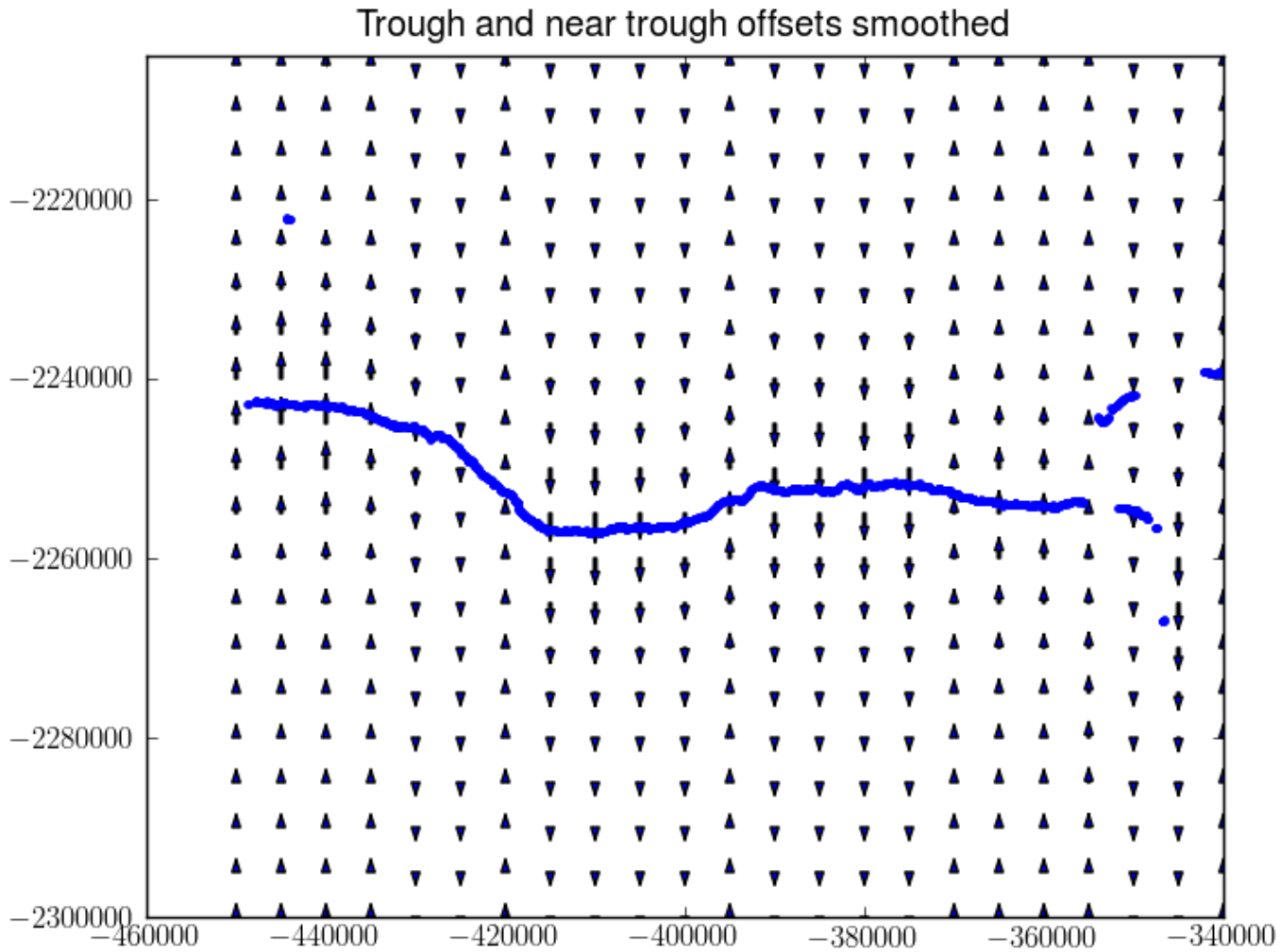
(3) adjustment of high-resolution grid to trough-location (morph-stretch algorithm for entire Jak region), preserves morphology

(4) apply distance-weighted average in morph-stretched topology

(5) assign local trough minimum to grid nodes in trough set

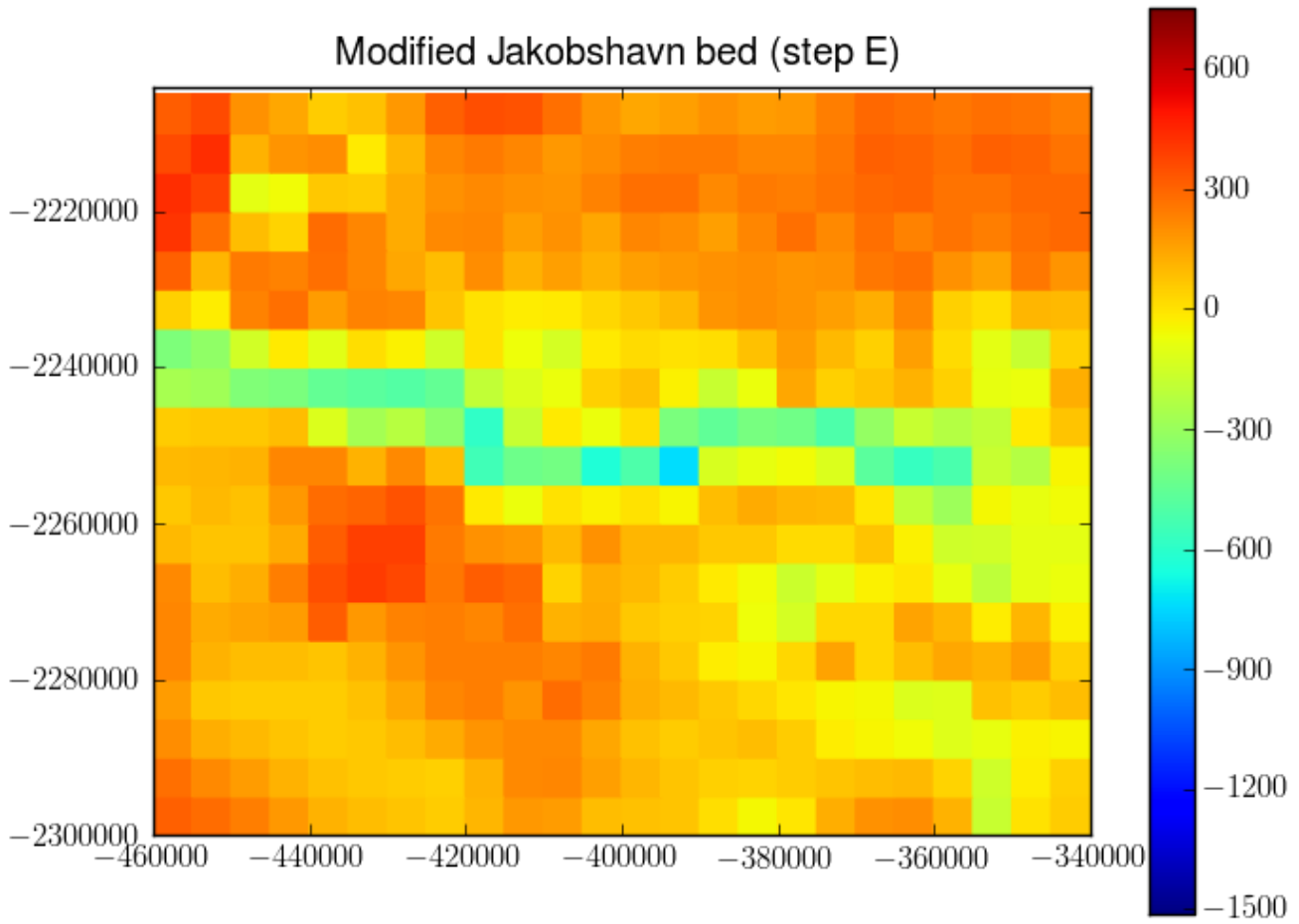
Herzfeld, U.C., B.F. Wallin, C.J. Leuschen and J. Plummer, An Algorithm for Adjusting Topography to Grids while Preserving Sub-Scale Morphologic Characteristics — Creating A Glacier Bed DEM for Jakobshavns Trough as Low-Resolution Input for Dynamic Ice Sheet Models, Computers&Geosciences (2011)

Trough detection and morphological stretch, v6



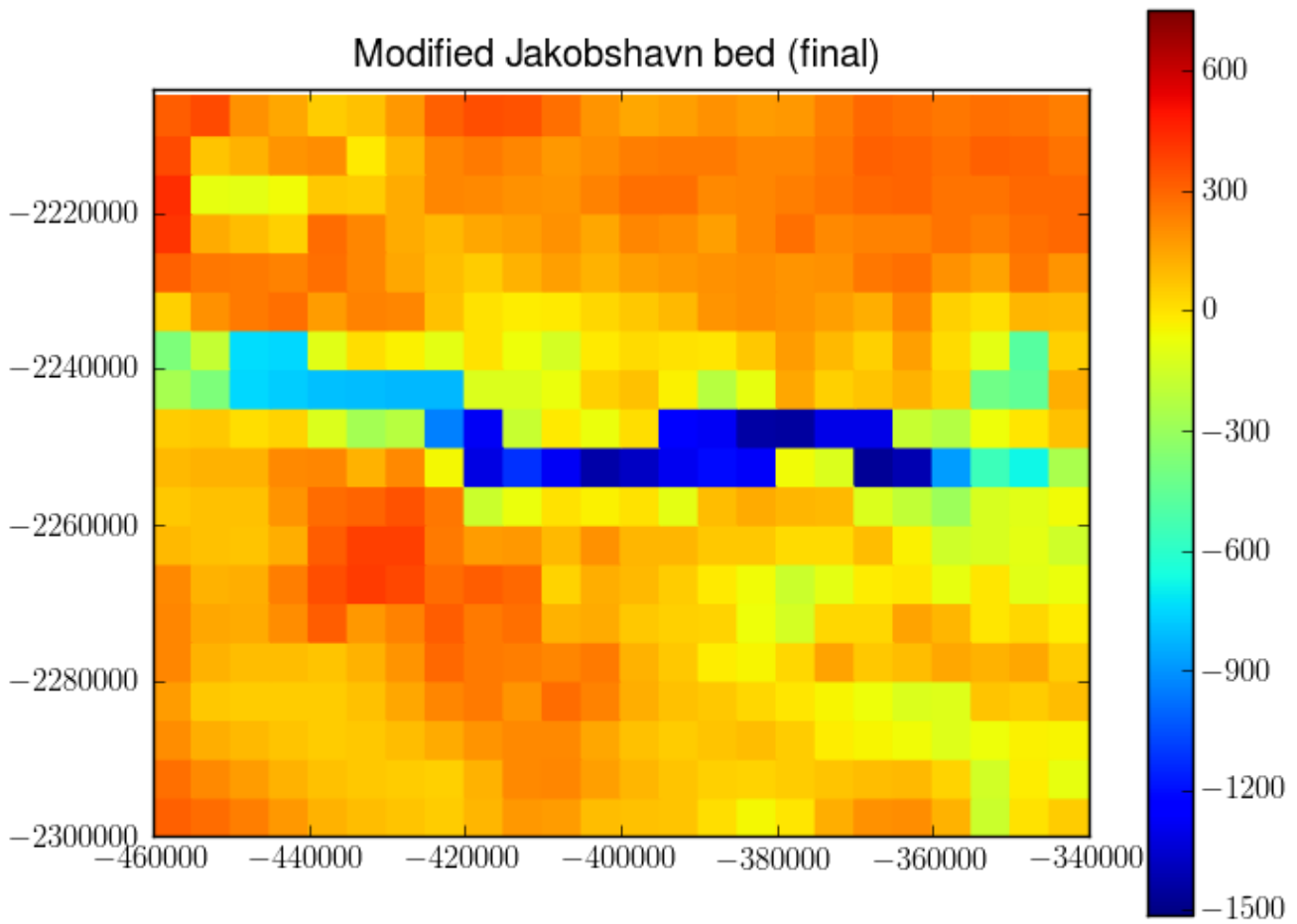
(from Herzfeld, Wallin, Leuschen and Plummer 2011)

Intermediate step
after morph-stretch and distance-weighted averaging, v6



(from Herzfeld, Wallin, Leuschen and Plummer 2011)

Jakobshavn region subglacial topography
AlgoA (edge-connected), morph-stretched, v5



(from Herzfeld, Wallin, Leuschen and Plummer, Computers&Geosciences, 2011)

Integration of Jakbed into Greenland modeling DEMs

(1) trafo CRESIS data onto same coordinate system as used by modeling groups

(2) utilize netCDF format preferred by modeling groups

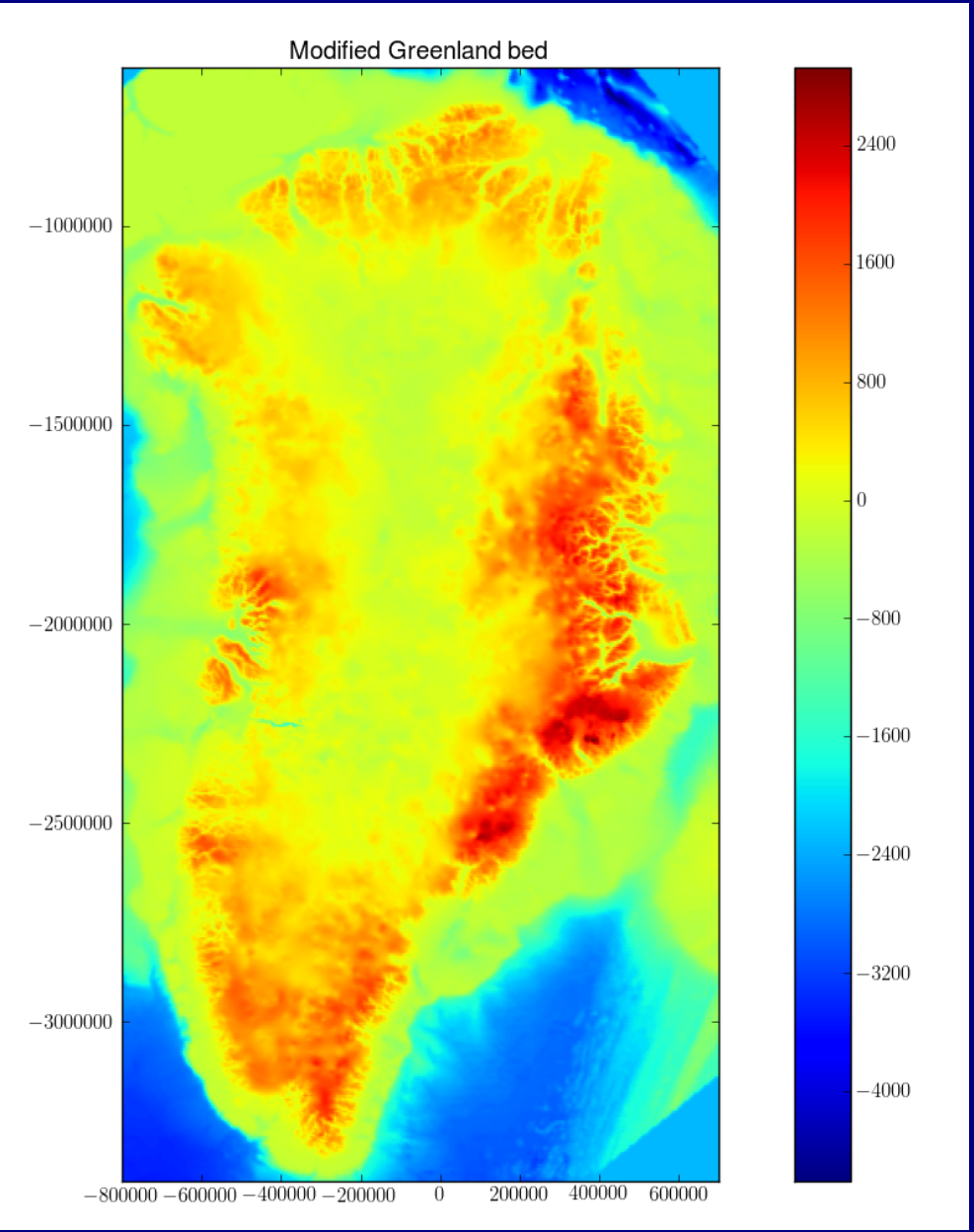
(3) morph-stretch algo facilitates seamless integration

(4) variable package provided for easy use of data in model runs (bed topography, precipitation and other data fields)

This is Greenland bed dev1.2 (v5)

see http://websrv.cs.umt.edu/isis/index.php/SeaRISE_Assessment (maintained by Jesse Johnson's group at University of Montana)

Greenland subglacial topography with Jak trough [data set dev1.2]



Uploaded to SeaRISE web site (http://websrv.cs.umt.edu/isis/ index.php/SeaRISE_Assessment)

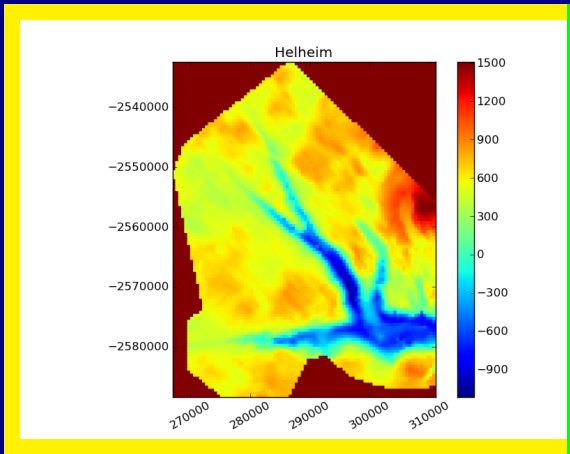
The new JakHelKanPet Bed

Improvement of trough system topography for major Greenland glaciers:

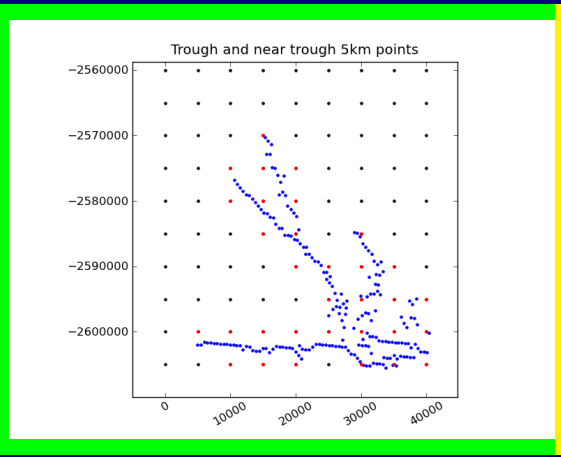
(1) Jakobshavn Isbræ Western Greenland
(2) Helheim Glacier, Eastern Greenland
(3) Kangerdlussuaq Glacier, Eastern Greenland
(4) Petermann Gletscher, Northern Greenland

Data: MCORDS Radar data collected by CReSIS as part of NASA's Operation IceBridge and NSF-funded campaigns

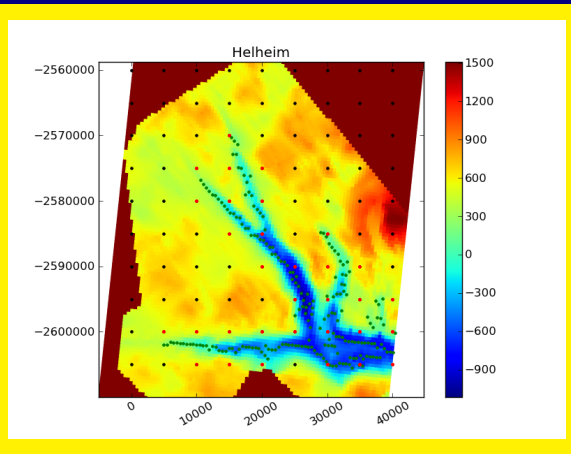
Helheim Glacier



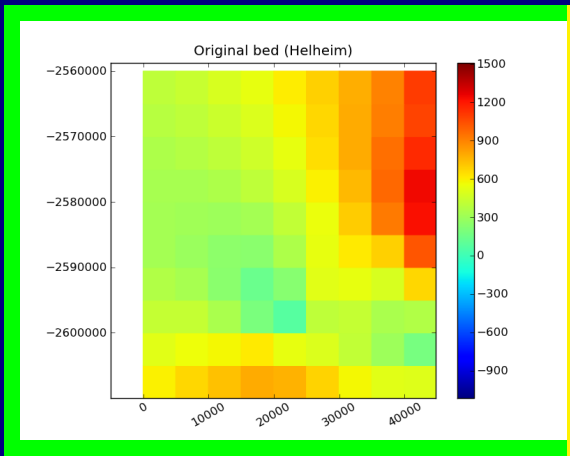
(a) CReSIS data, gridded



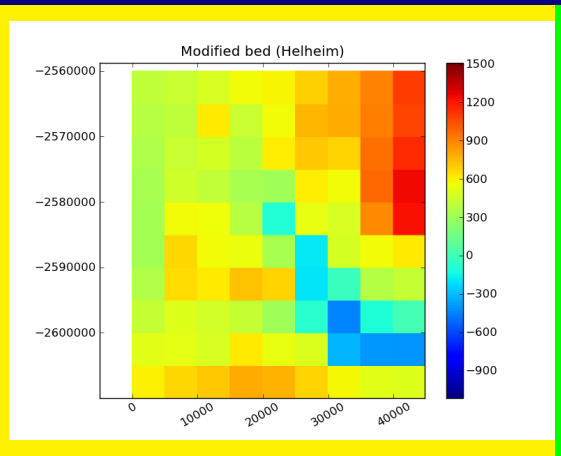
(b) trough detection



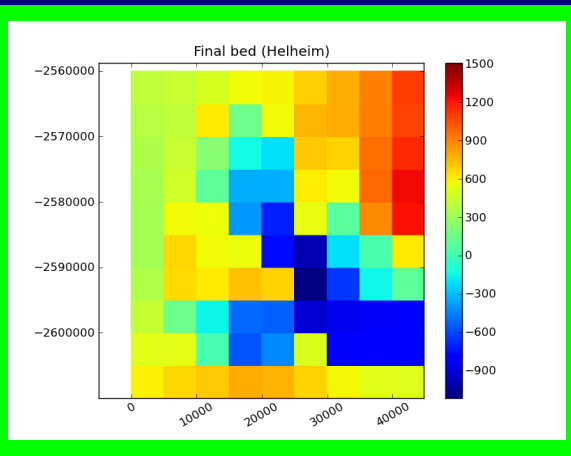
(c) trough over hi-res grid



(d) orig bed (Bamber et al. 2001)



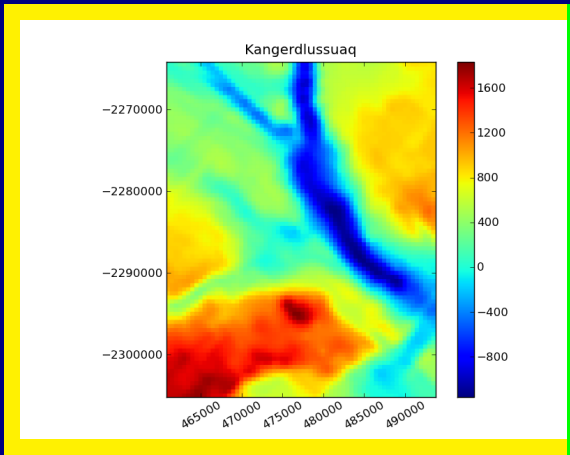
(e) interpolated w new data



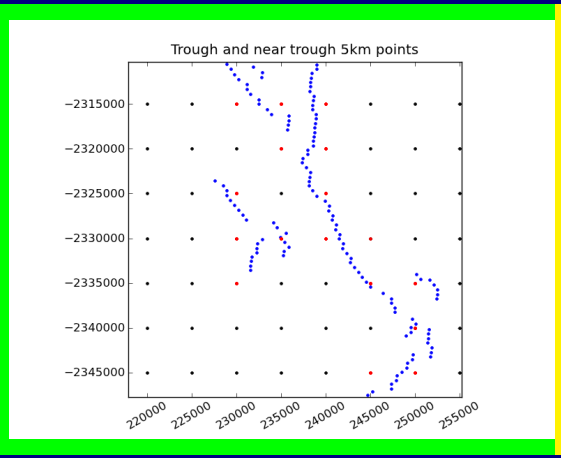
(f) final bed w trough integration

(from Herzfeld et al., Annals Glaciol., 2011, ms)

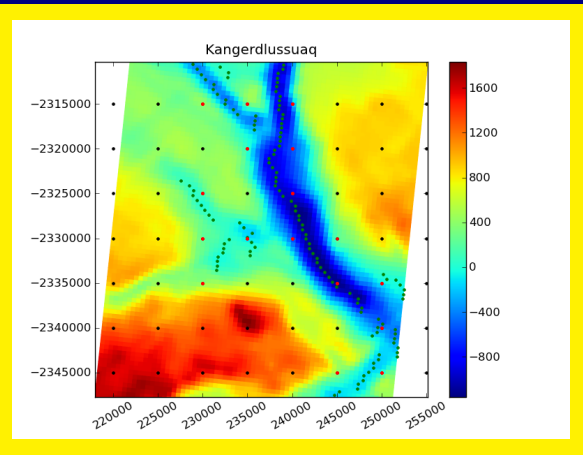
Kangerdlussuaq Glacier



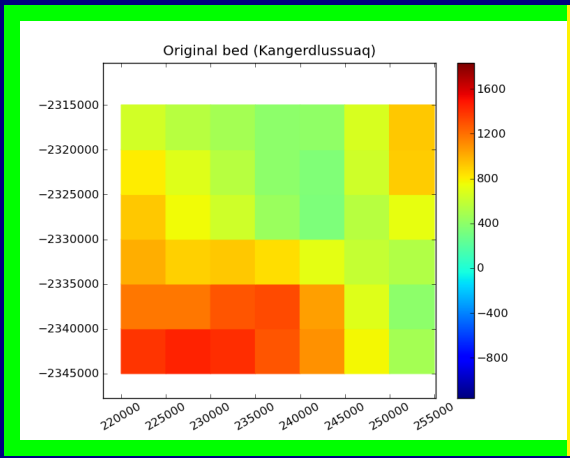
(a) CReSIS data, gridded



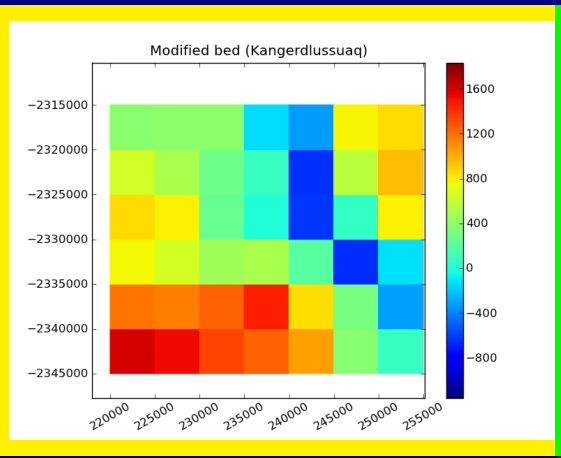
(b) trough detection



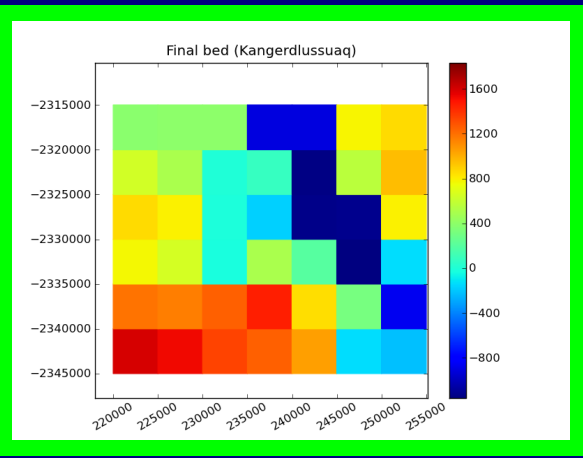
(c) trough over hi-res grid



(d) orig bed (Bamber et al. 2001)



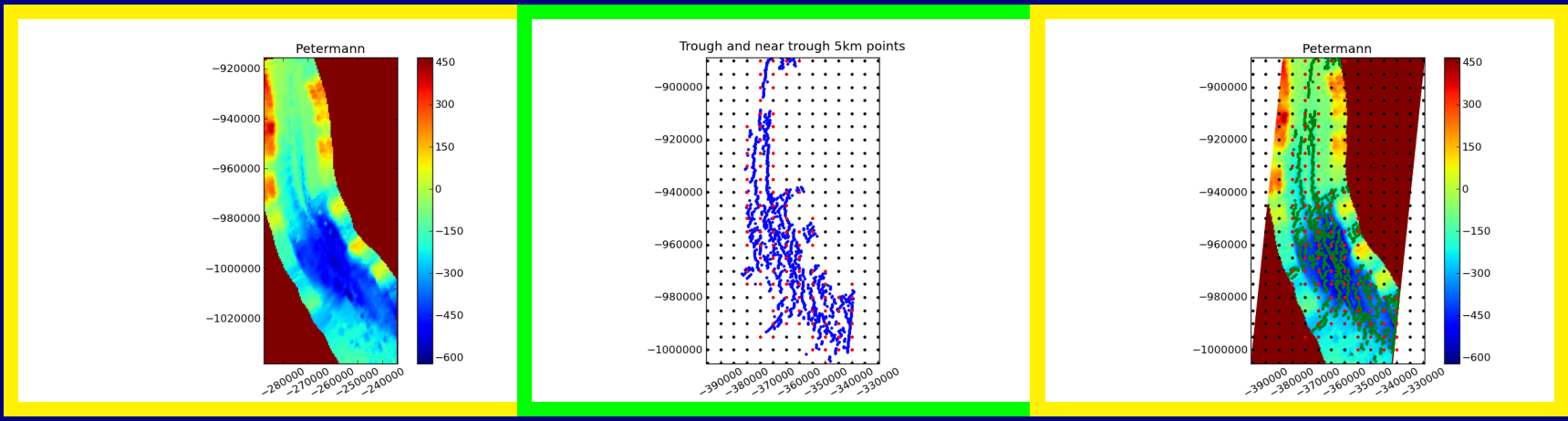
(e) interpolated w new data



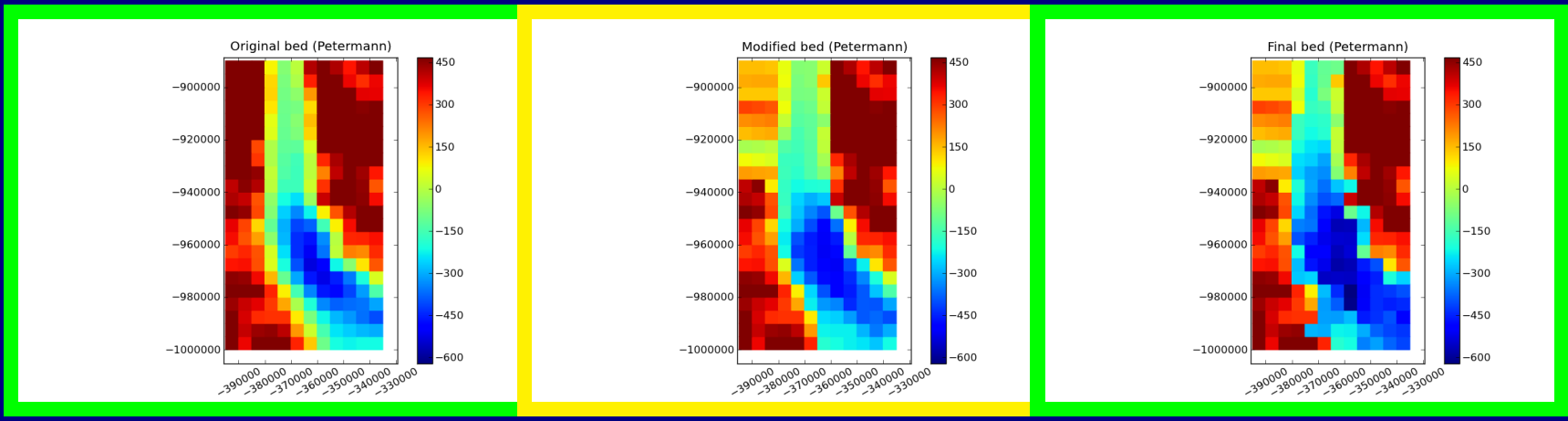
(f) final bed w trough integration

(from Herzfeld et al., Annals Glaciol., 2011, ms)

Petermann Gletscher



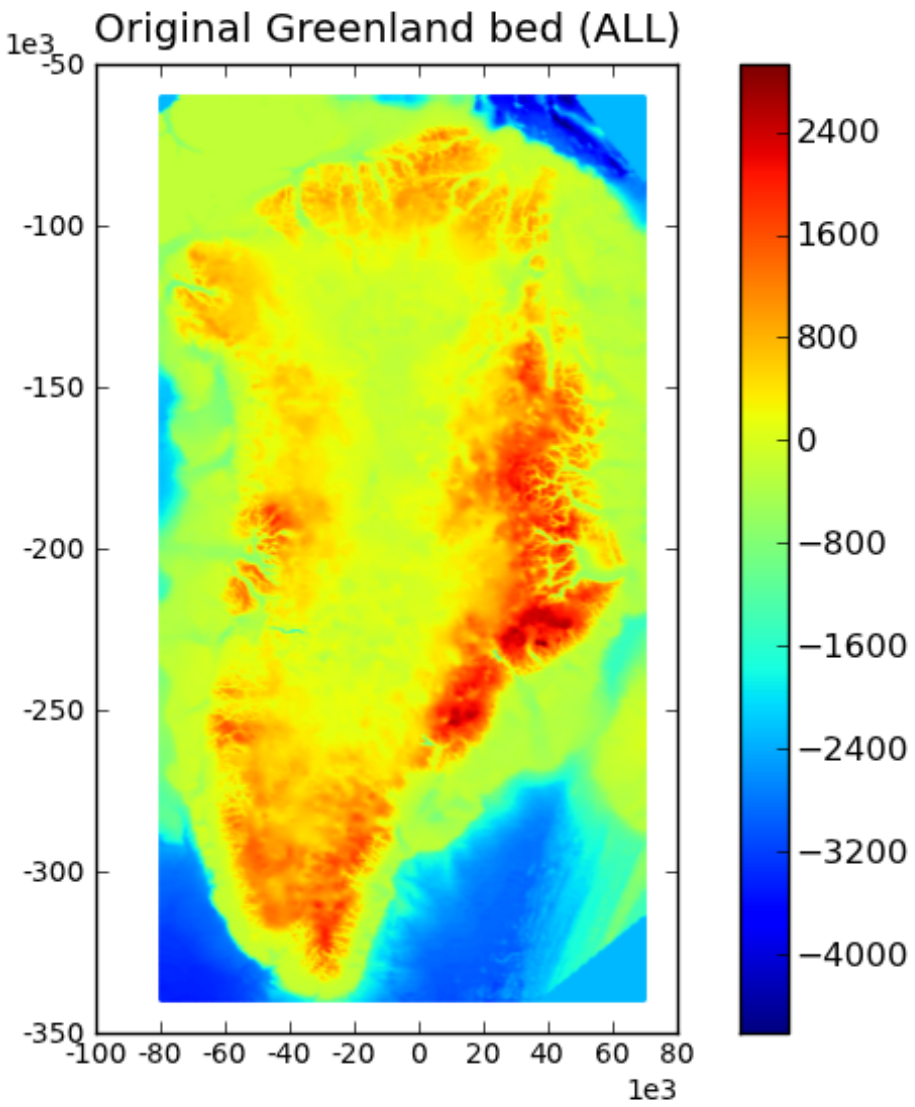
(a) CReSIS data, kriging (CU, AOK) (b) trough detection (c) trough over hi-res grid



(d) orig bed (Bamber et al. 2001) (e) interpolated w new data (f) final bed w trough integration

(from Herzfeld et al., Annals Glaciol., 2011, ms)

Greenland subglacial topography with JakHelKanPet troughs



[UPDATE FILE TO JHKP BED, this is JHK Bed]

Results of Sensitivity Studies:

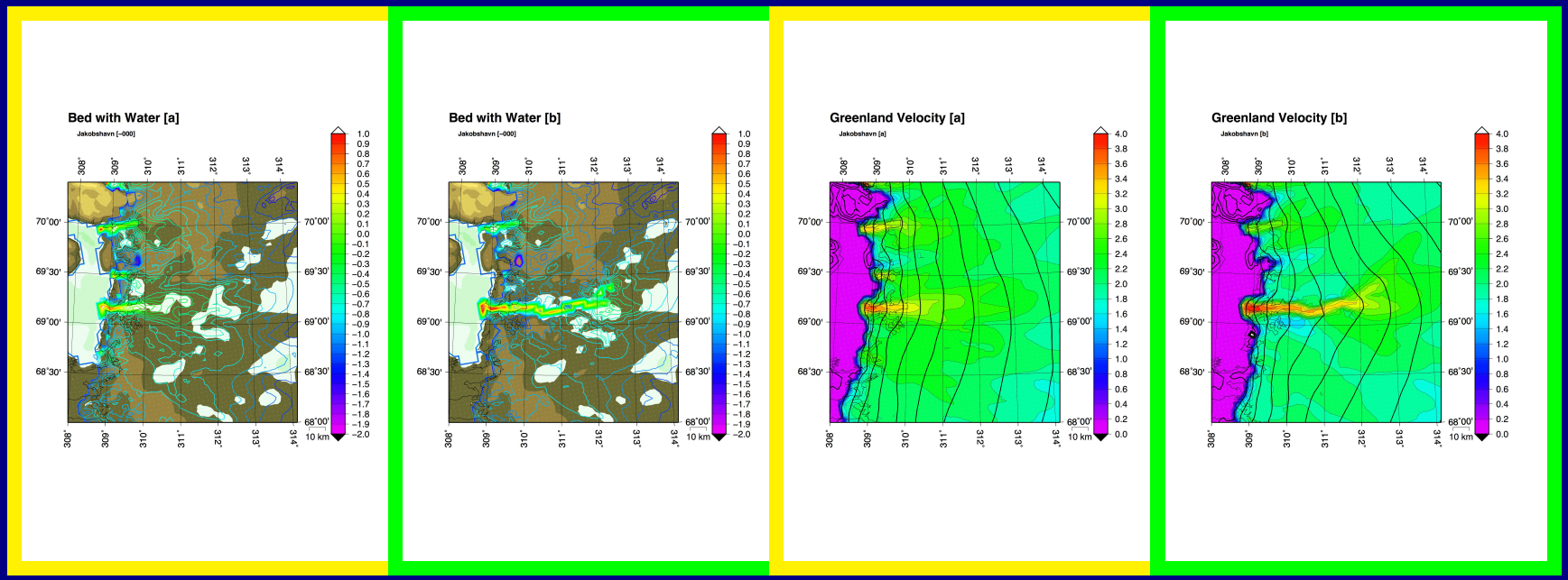
(1) University of Maine Ice Sheet Model (UMIS) [James Fastook]

(2) SICOPOLIS [Ralf Greve]

(3) Parallel Ice Sheet Model (PISM) [Ed Bueler, Andy Aschwanden]

Full spin-up, Bed Topography: v093 vs JHKP, Precipitation and Air Temperature Ettema

UMIS [James Fastook]: Jakobshavn

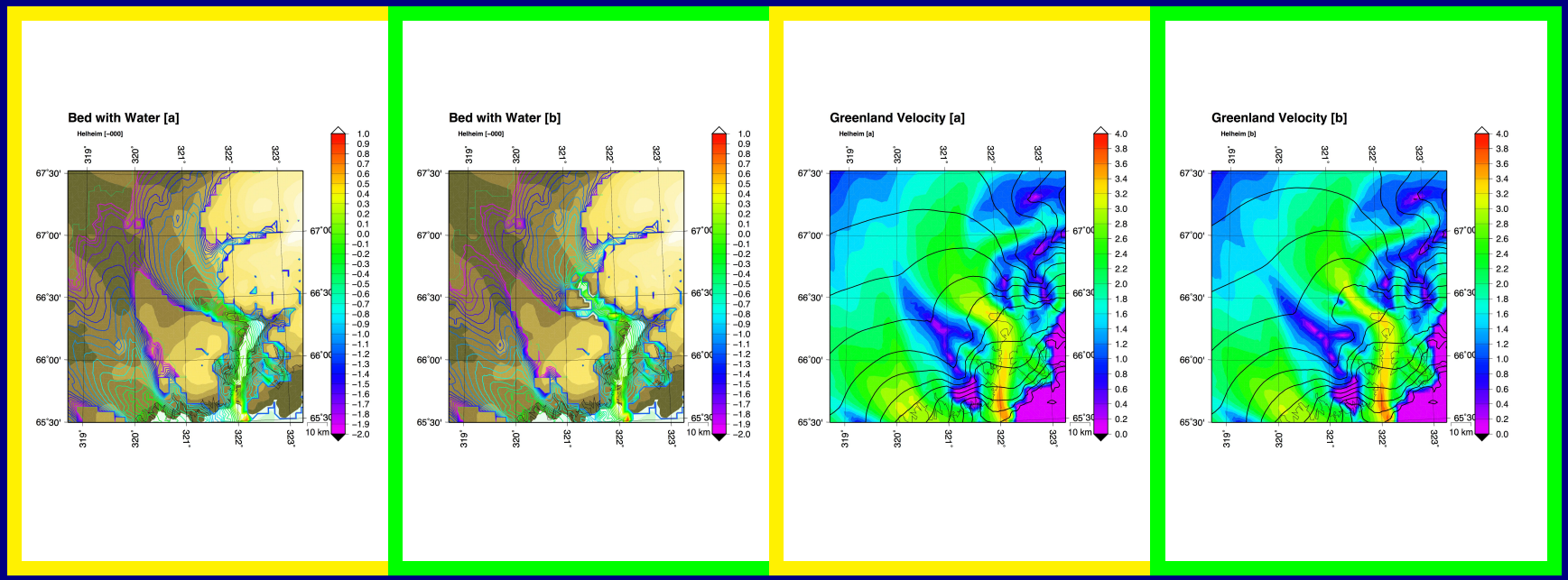


(a) Bed w Water [a] (b) Bed w Water [b] (c) Ice Velocity [a] (d) Ice Velocity [b]

1000 year spin up, Air temperature and Precipitation Ettema; Results from 30,000-year full spin up are similar.

[a] = Old Bed v093 (Bamber et al. 2001), [b] = New Bed JHKP (Herzfeld et al. 2011, ms)

UMIS [James Fastook]: Helheim



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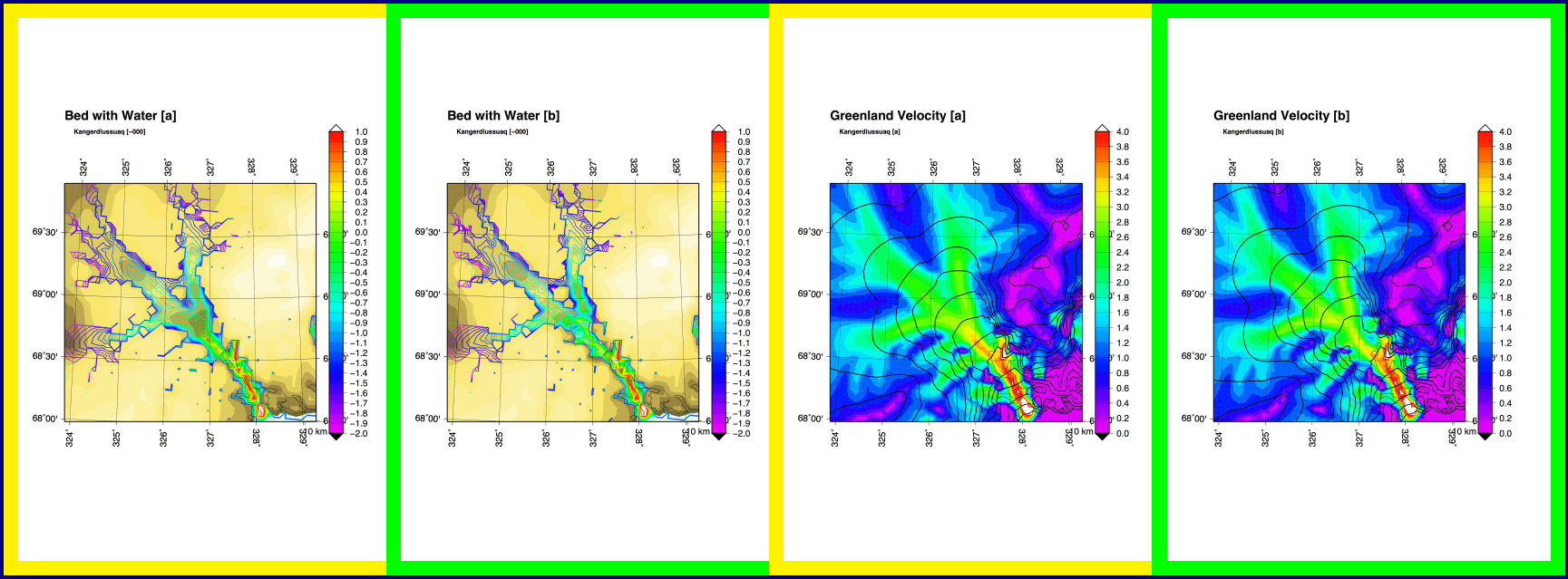
1000 year spin up, Air temperature and Precipitation Ettema; Results from 30,000-year full spin up are similar.

[a] = Old Bed v093 (Bamber et al. 2001), [b] = New Bed JHKP (Herzfeld et al. 2011, ms)

UMIS [James Fastook]: Kangerdlussuaq



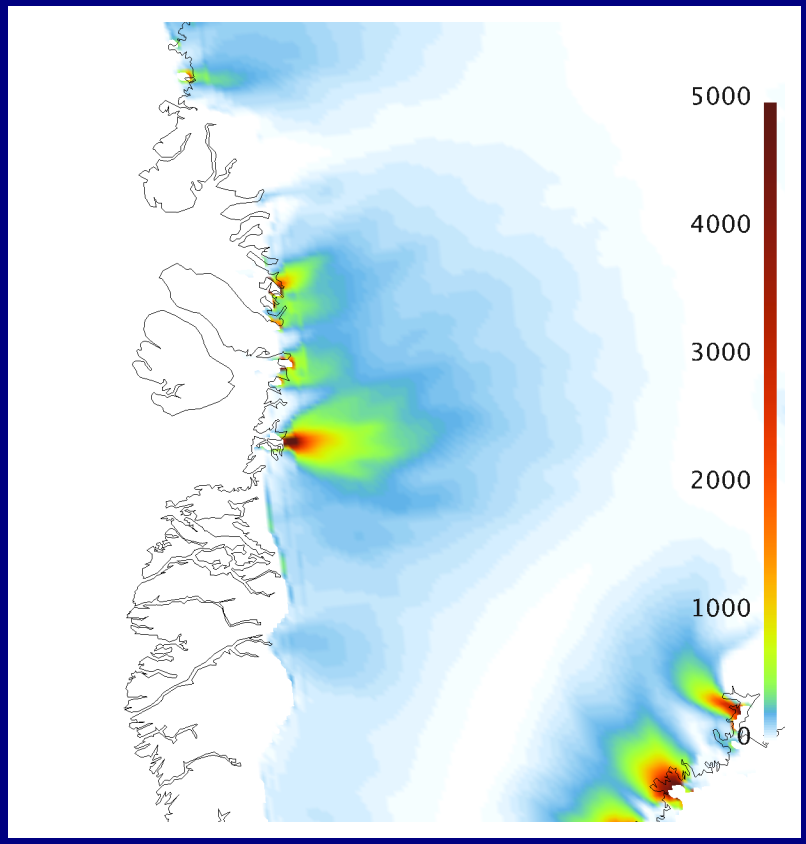
(a) Bed w Water [a] (b) Bed w Water [b] (c) Ice Velocity [a] (d) Ice Velocity [b]

1000 year spin up; results from 30,000-year full spin up are similar.

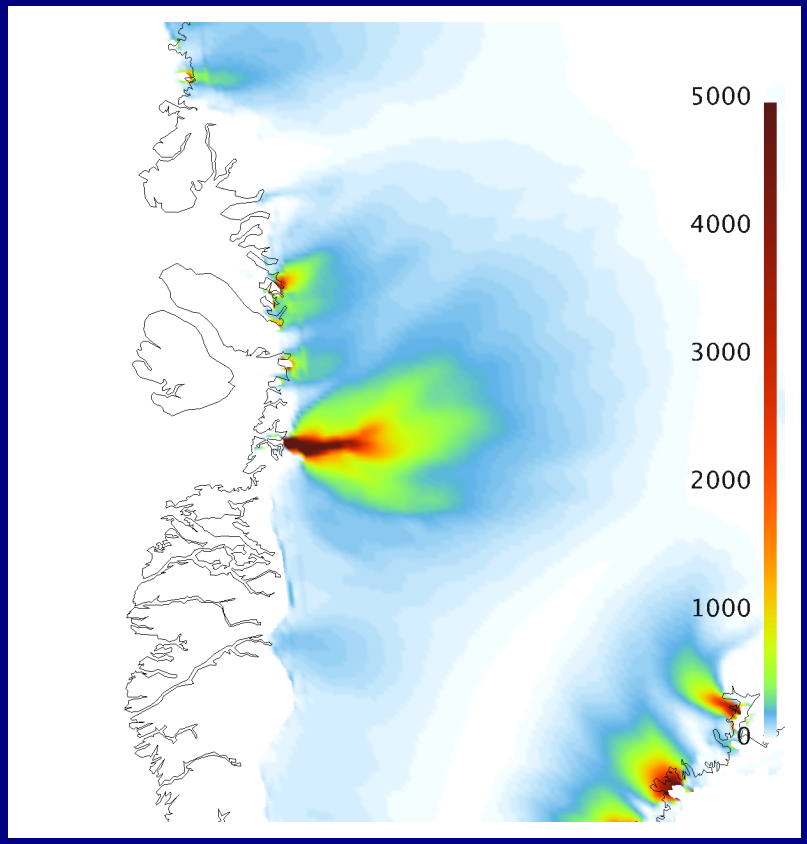
5 km model grid; air temperature and precipitation Ettema;

[a] = old bed v093 (Bamber et al. 2001), [b] = new bed JHKP (Herzfeld et al. 2011, ms)

PISM Jakobshavn



(A) old bed v0.93



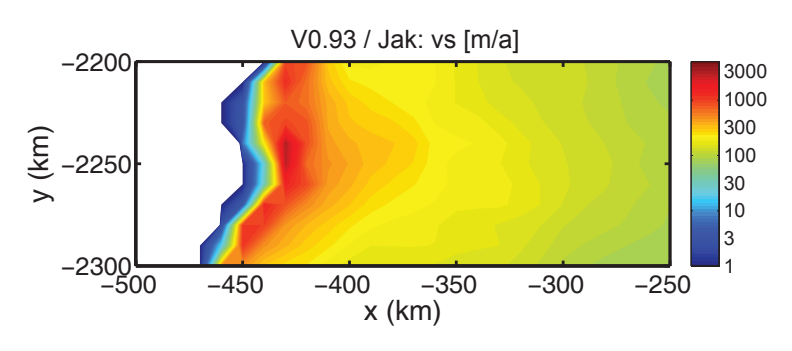
(B) bed topo JakHelKanPet

surface velocity [ma^{-1}]

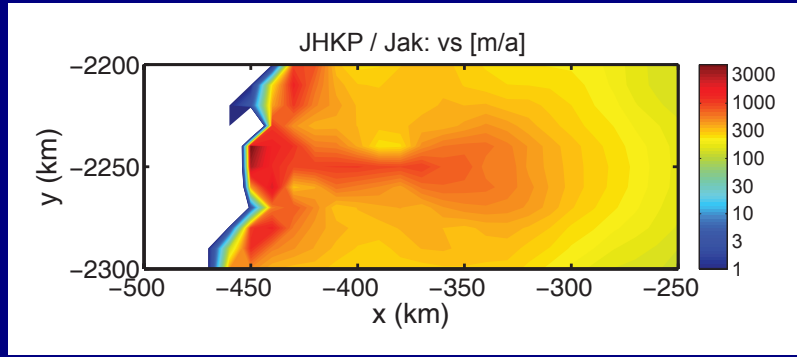
from Andy Aschwanden; model Ed Bueler

SICOPOLIS [Ralf Greve] Jakobshavn and Helheim

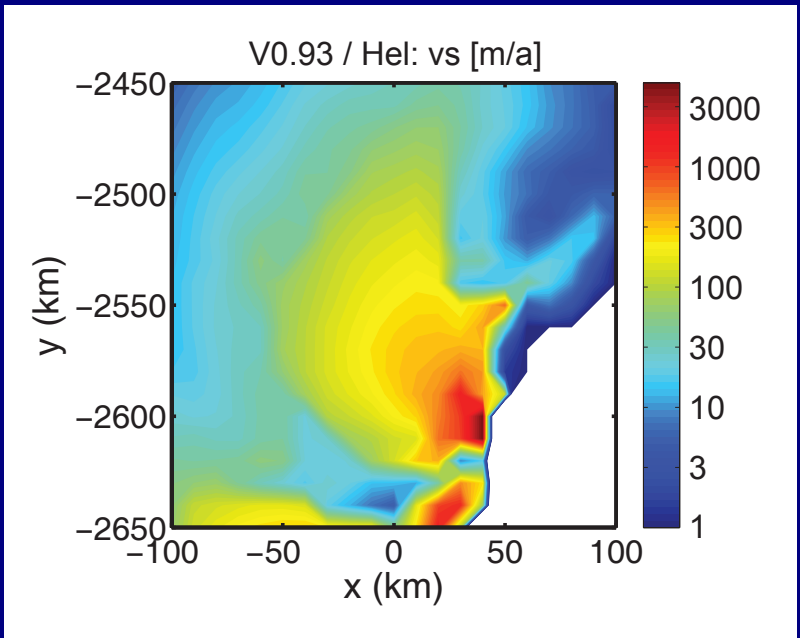
Present-day surface velocity (125000yr spin-up, 10km model grid)



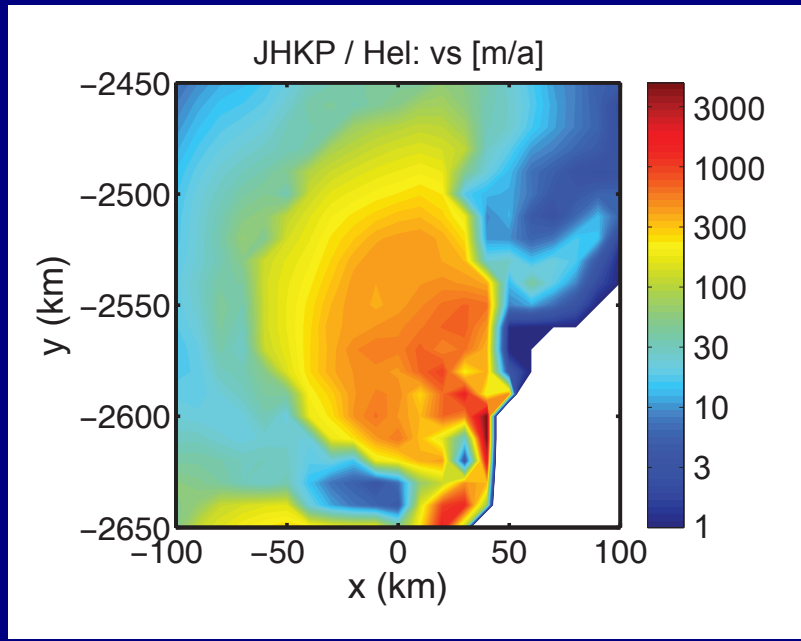
(A) bed topo v0.93



(B) bed topo JakHelKanPet

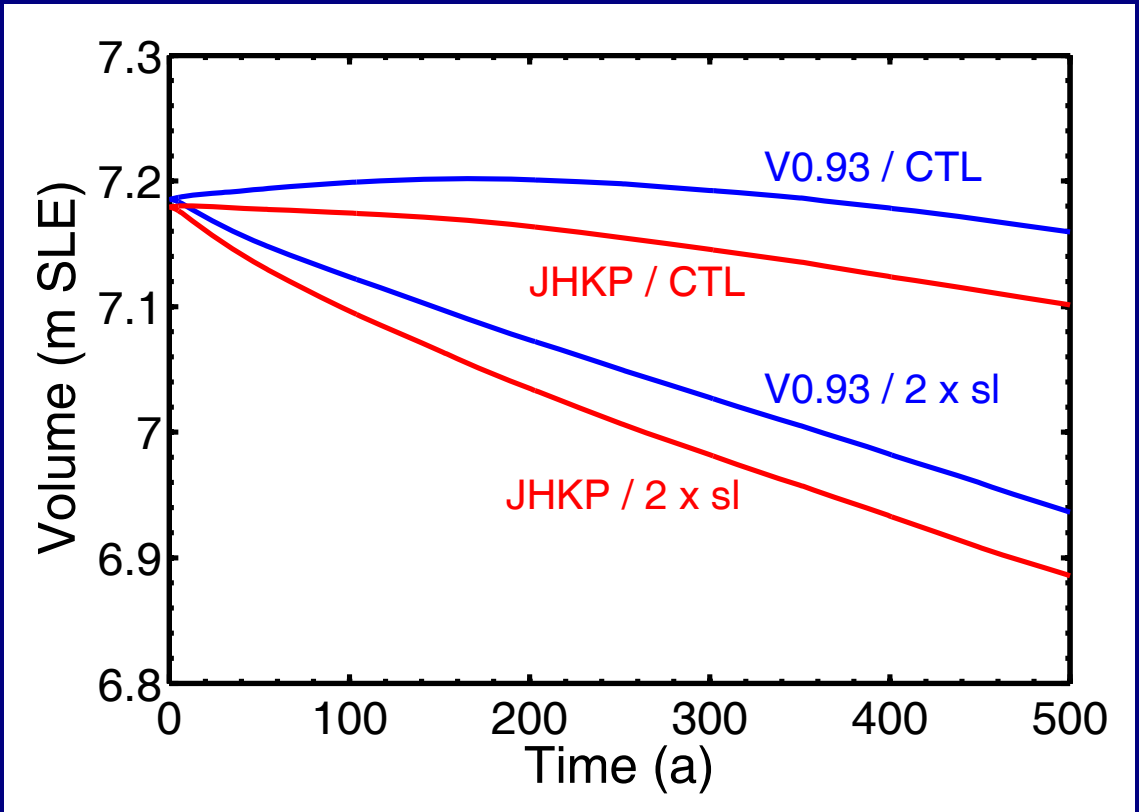


(A) bed topo v0.93



(B) bed topo JakHelKanPet

Predicted Mass Loss from the Greenland Ice Sheet



SICOPOLIS Results: Ice volumes (in sea-level equivalent) as functions of time for

(i) Constant climate control run 500 years into the future,
(ii) Constant climate forcing with doubled basal sliding (SeaRise experiment),

and both beds (V0.93, JHKP)

[Herzfeld, Greve, Fastook, Aschwanden et al., Annals Glaciol. 2011 (ms)]

Conclusions: Bed Topography and Mass Change/Sea-Level Rise

(1) Outlet glacier beds matter – need to be preserved in bed topography at proper generalization.

(2) The Jak-bed algorithm presented here allows integration of high-resolution morphologic features at a lower-resolution modeling scale.

(3) Significant changes in the modeled surface velocity, basal water levels, and hence in other modeled variables (surface mass balance, surface elevation) results.

(4) Modeled mass loss from the Greenland ice sheet and hence contribution to predicted sealevel rise changes.

There is a need for geomathematical data analysis specifically for modeling to more correctly assess future sea-level change!