CISM development updates

"Imminent" public release of CISM 2.0 includes significant improvements:

1) links to Trilinos library

2) parallel linear solve for elliptic, 1st-order momentum balance (using 1)

3) JFNK solver for nonlinear iteration on momentum balance

4) new "parallel-ready" heat-balance solver (beta!)

5) directory restructuring and modified build system

6) stable build scripts for several standard CESM platforms

(e.g. Bluefire, Jaguar)

CISM development updates

Significant advances in solver and problem size capability through distributed parallelism of momentum balance (through ISICLES - SEACISM)

Progress on development of interfaces to external dycores (e.g. LBNL L1L1/ CHOMBO dycore; UT FS dycore)

Progress on CISM adjoint development efforts (MIT / ANL / UMT)

Progress on initial efforts at applying UQ / model calibration tools to CISM (ISICLES – LANL / UT)

Excellent progress on the development of L1L2, 1st-order, and Stokes FEM-based dycores (ultimately to be coupled to MPAS version of CISM)

Progress on more robust treatment of initial and boundary conditions

CISM ongoing / future development

Existing 1st-order dycore is parallel and showing good scaling. Now needs to be made more robust.

Improvements in model physics – New LANL postdoc starting in August to focus on improvement of hydrology models; informal collaboration w/ Canadian colleagues at implementing new, realistic process-scale hydrology models into CISM

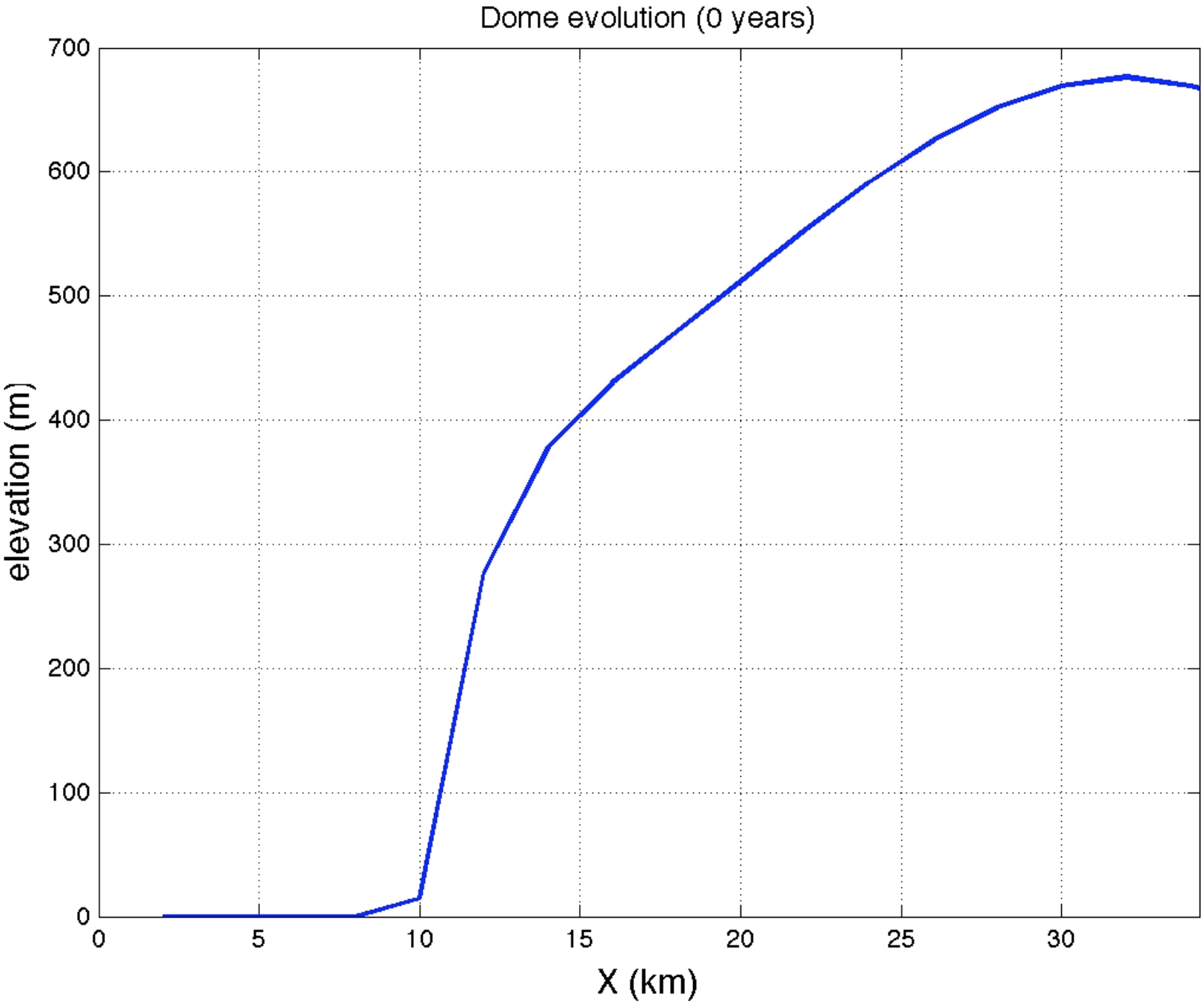
Lots of other work on model physics still needed, e.g., calving, ice ocean coupling at coarse resolution, basal sliding, etc.

Continued work on development of realistic initial conditions.

Continued work on parameter estimation / calibration techniques and UQ

CISM: boundary and initial condition improvements

Evolution of simple “dome” test case for ~500 yrs showing realistic margin advance …


Dome evolution (0 years)
elevation (m)
X (km)
0
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500
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0
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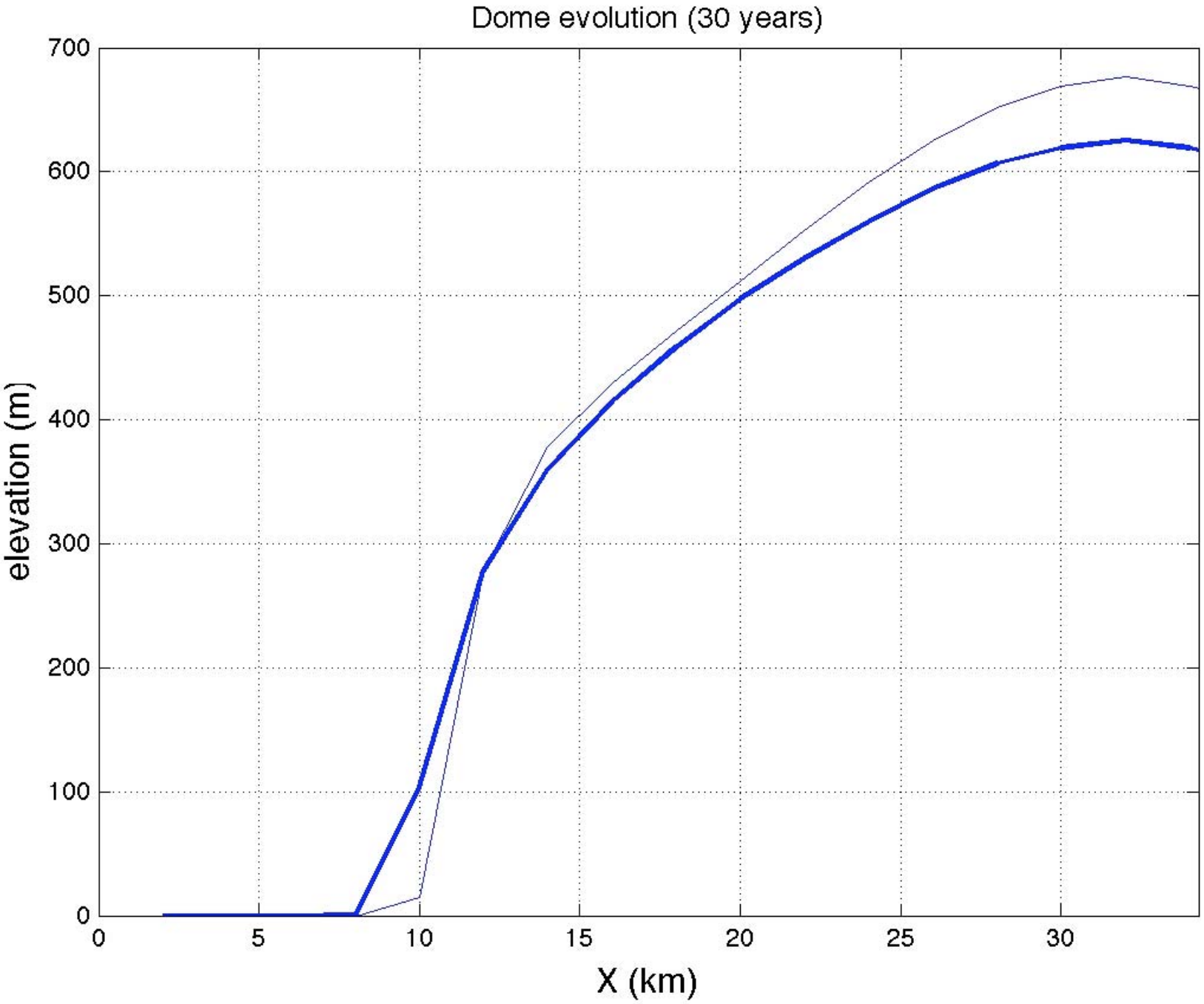
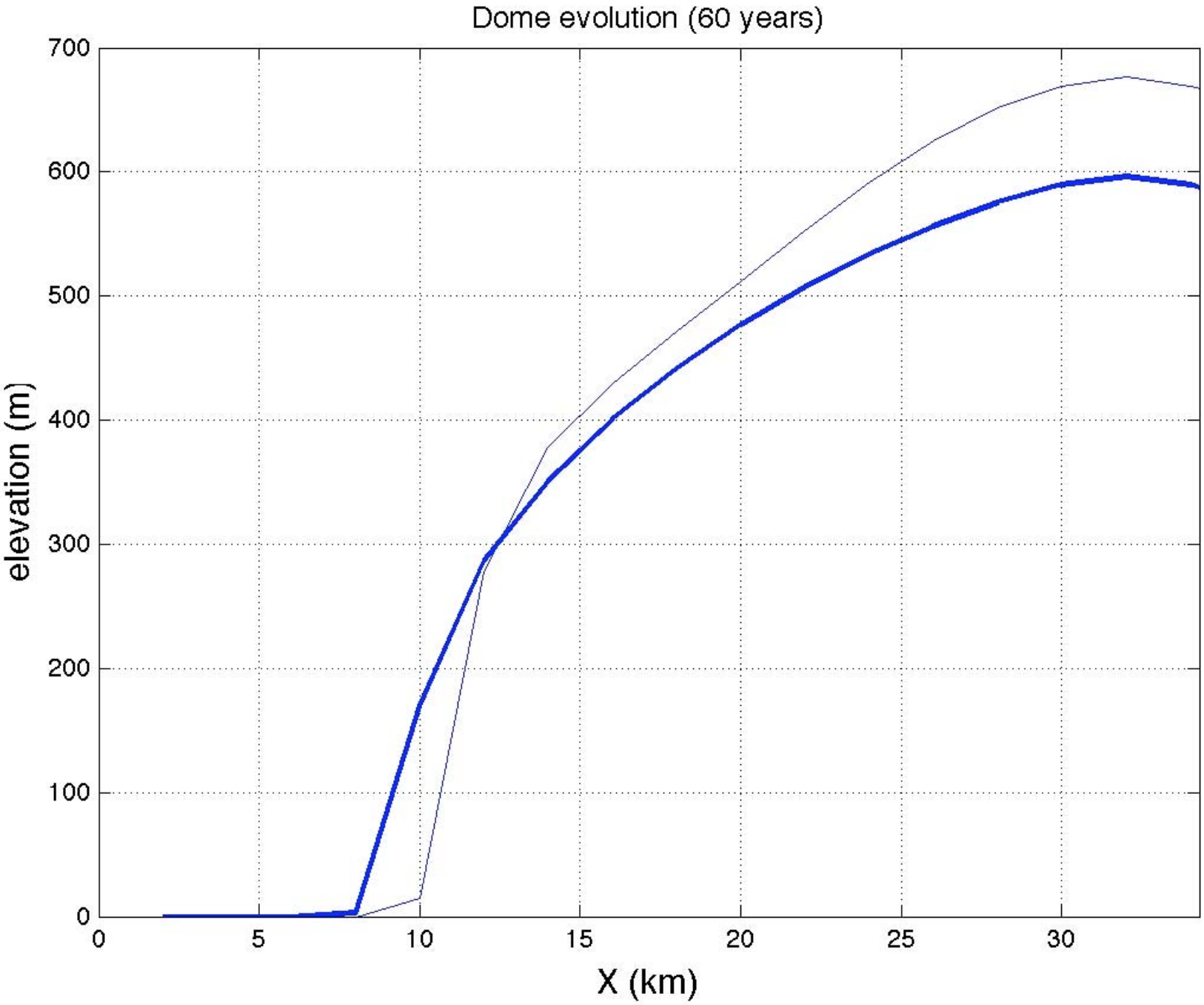
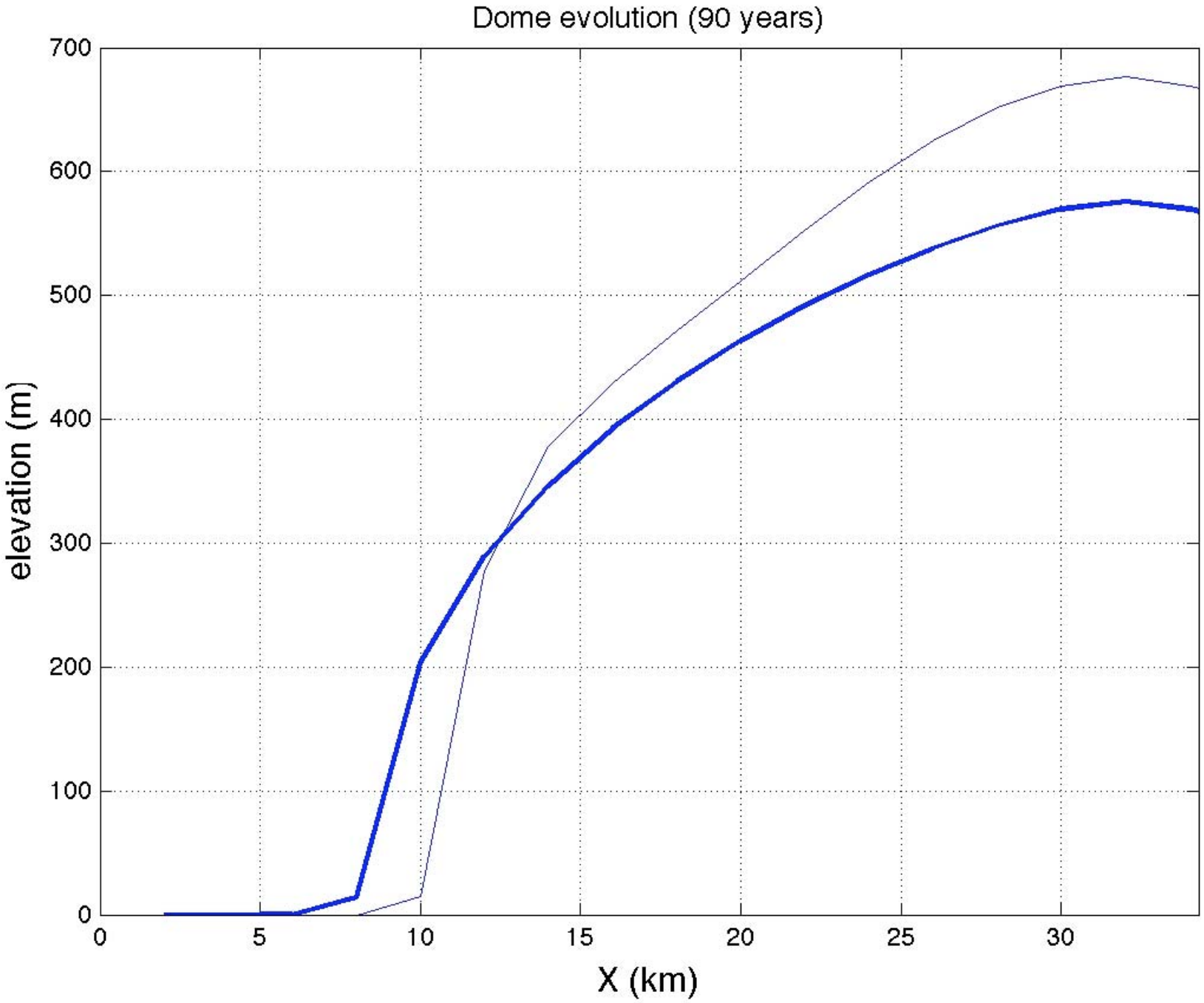
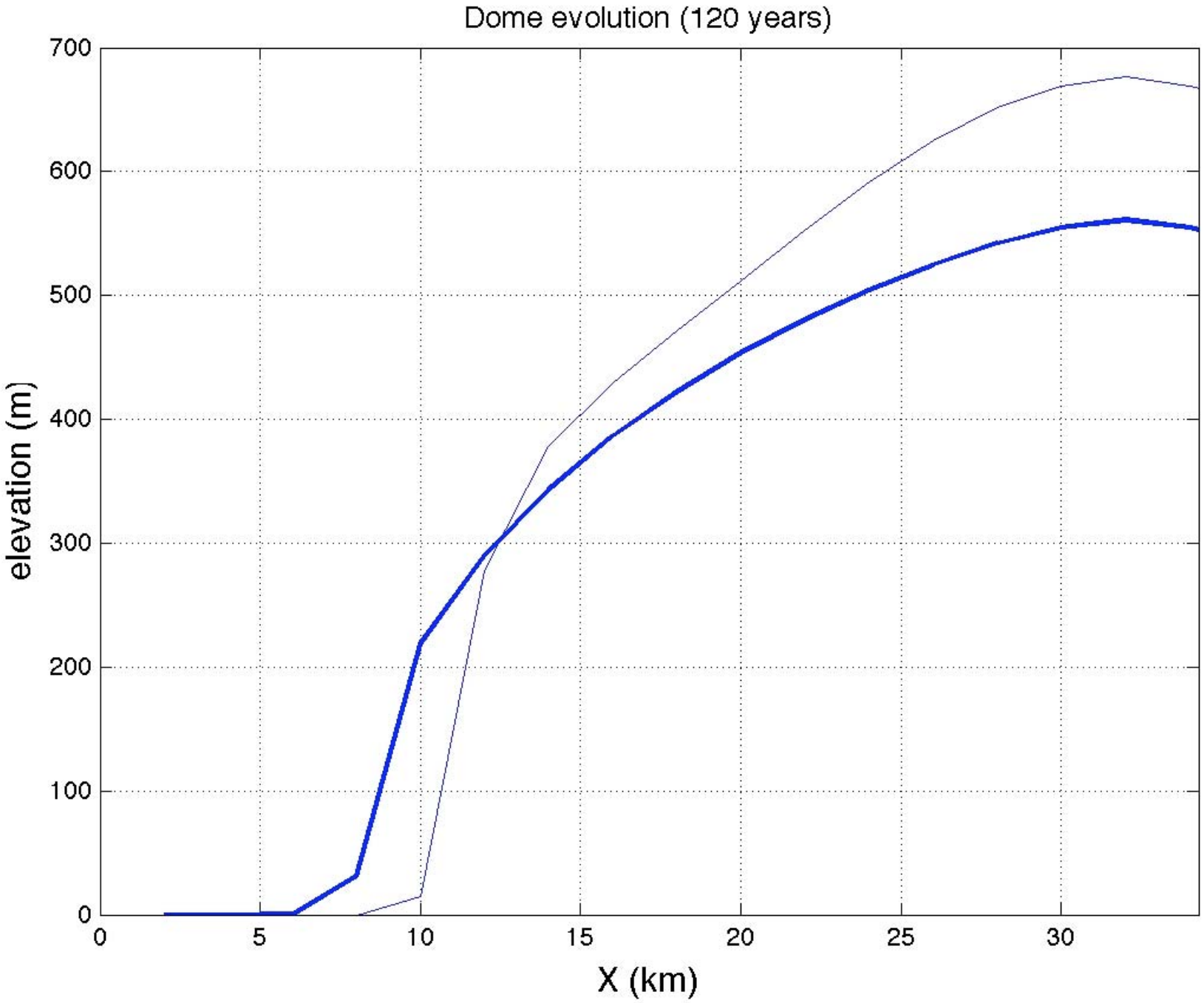
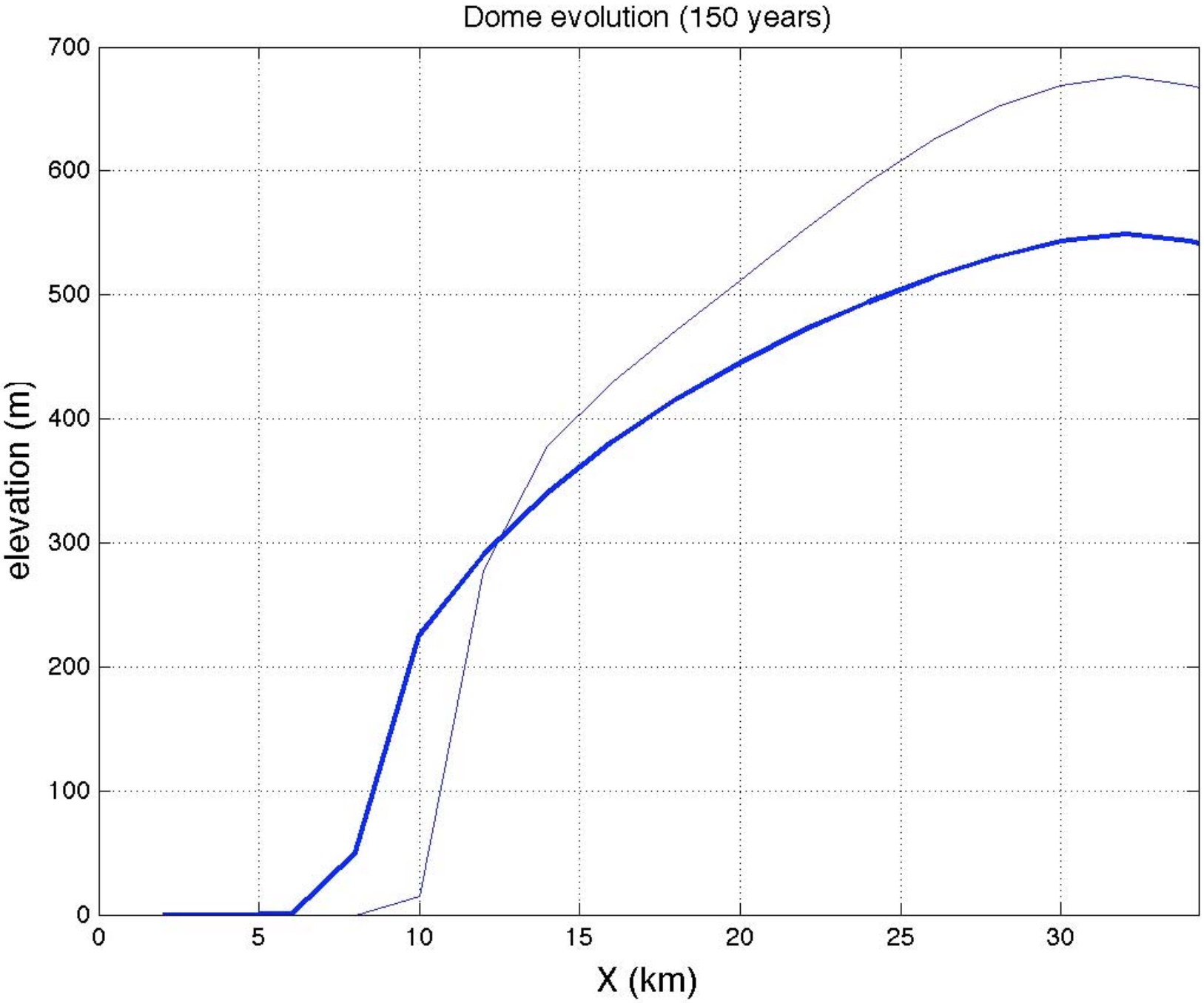
20
25
30

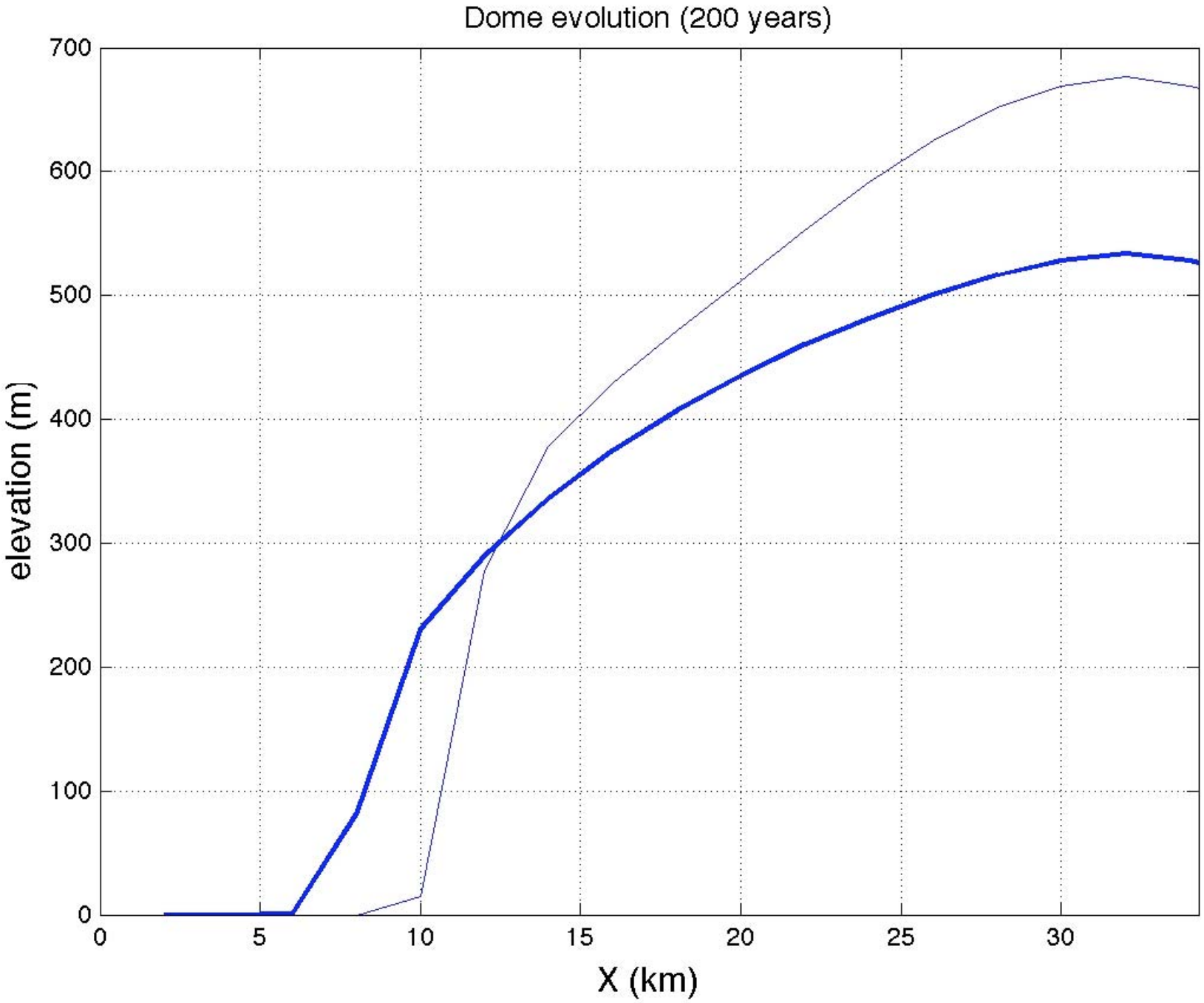

Dome evolution (30 years)
elevation (m)
X (km)
0
100
200
300
400
500
600
700
0
5
10
15
20
25
30

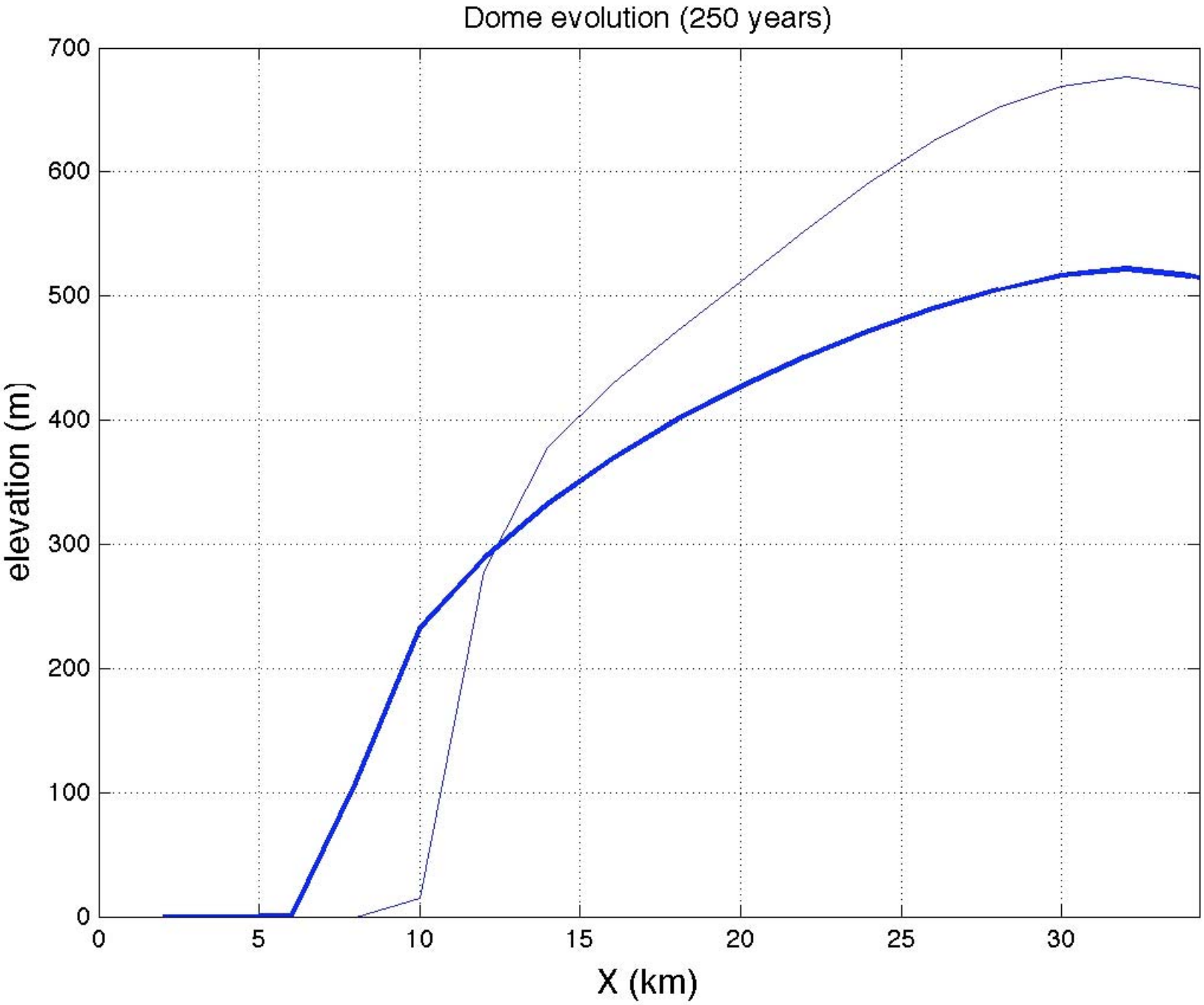

Dome evolution (60 years)
700
600
500
400
300
200
100
0
elevation (m)
0
5
10
15
20
25
30
X (km)

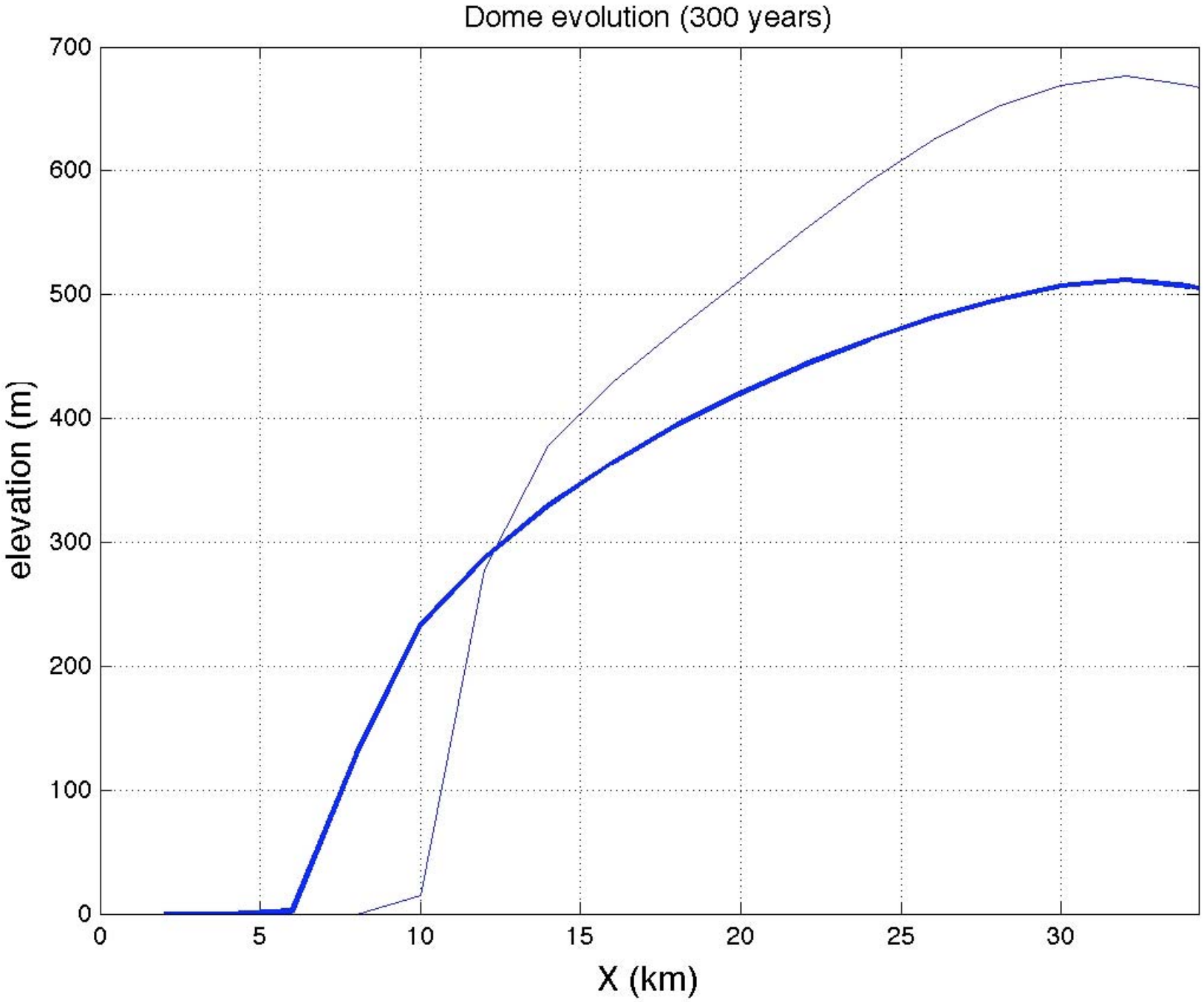

Dome evolution (90 years)
700
600
500
400
300
200
100
0
elevation (m)
0
5
10
15
20
25
30
X (km)

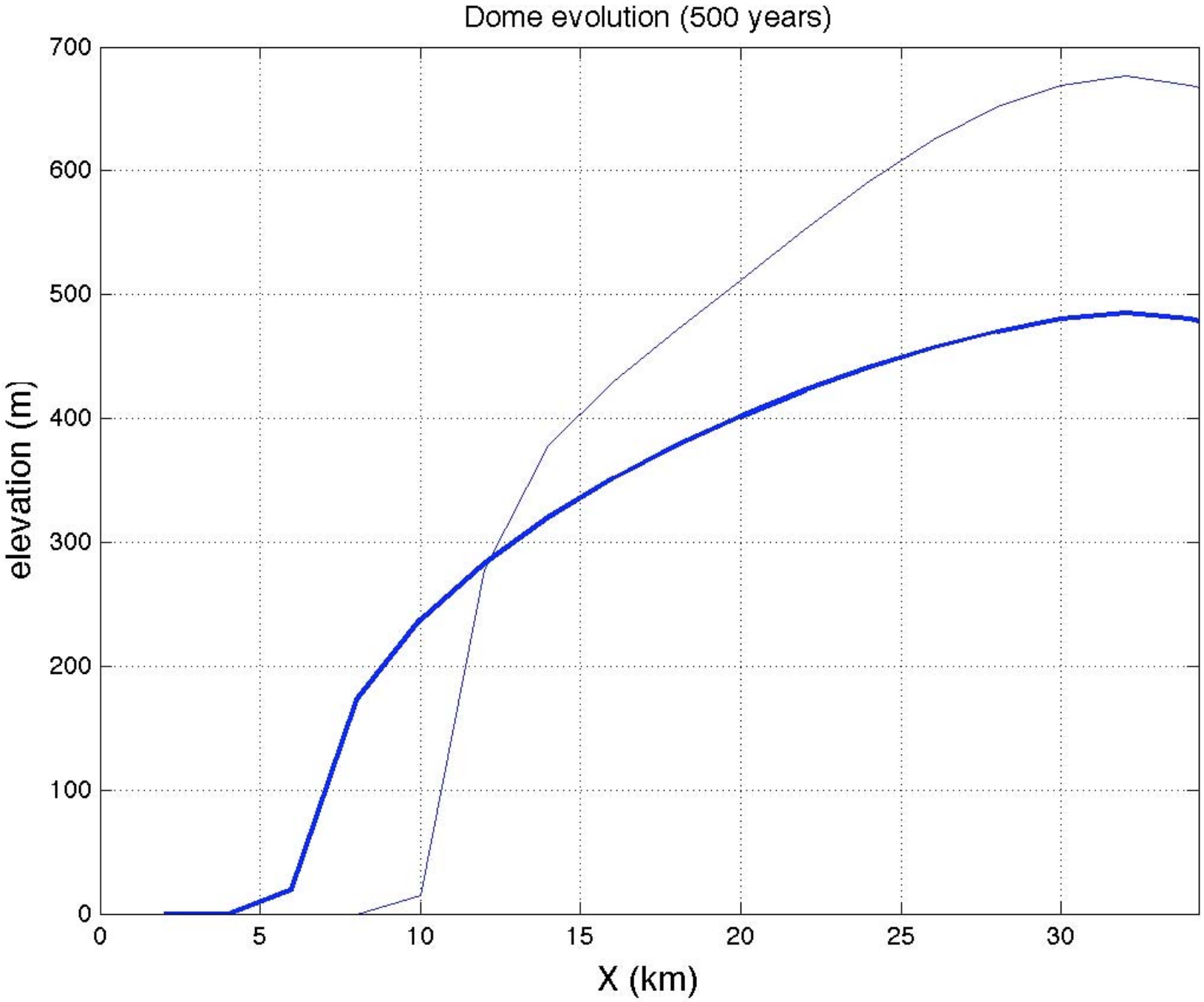

Dome evolution (120 years)
elevation (m)
X (km)
0
100
200
300
400
500
600
700
0
5
10
15
20
25
30


Dome evolution (150 years)
elevation (m)
X (km)
0
100
200
300
400
500
600
700
0
5
10
15
20
25
30


Dome evolution (200 years)
elevation (m)
X (km)
0
100
200
300
400
500
600
700
0
5
10
15
20
25
30

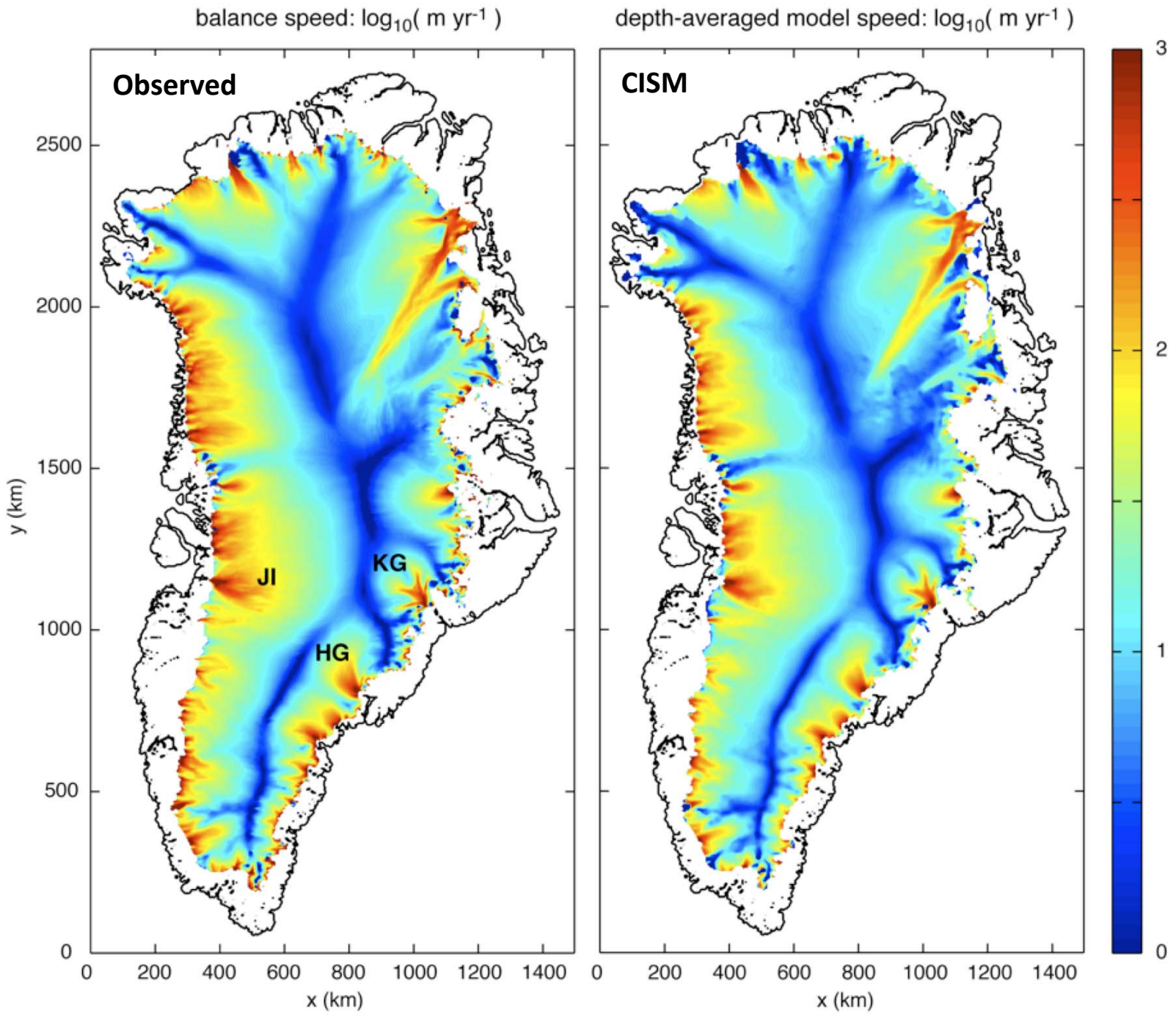

Dome evolution (250 years)
elevation (m)
X (km)
0
100
200
300
400
500
600
700
0
5
10
15
20
25
30


Dome evolution (300 years)
elevation (m)
X (km)
0
100
200
300
400
500
600
700
0
5
10
15
20
25
30


Dome evolution (500 years)
elevation (m)
X (km)
0
100
200
300
400
500
600
700
0
5
10
15
20
25
30

CISM: boundary and initial condition improvements

Existing *ad hoc* method of tuning basal sliding boundary condition to match a target velocity field works well …



[1]Price et al. (*PNAS*, **108**(22), 2011)

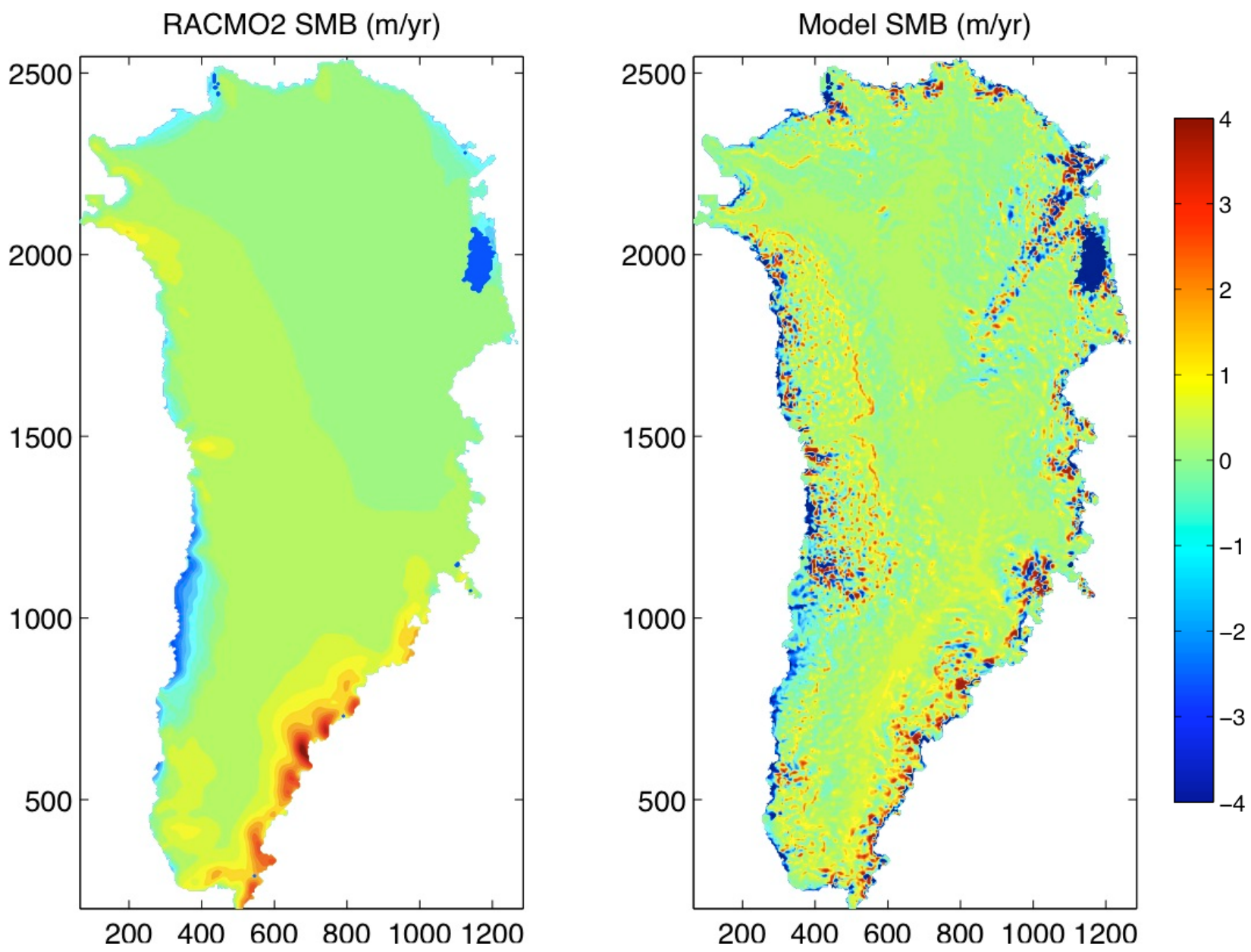
CISM: boundary and initial condition improvements

Without data assimilation techniques for ice sheet models (and enough of the right kind of data) a steady-state initial condition is the only immediately viable option for a pre-industrial ice sheet initial condition.

CISM: boundary and initial condition improvements

Without data assimilation techniques for ice sheet models (and enough of the right kind of data) a steady-state initial condition is the only immediately viable option for a pre-industrial ice sheet initial condition.

However, the surface mass balance (SMB) from CESM will, in general, not agree with that required by the tuned model to maintain a steady state …


RACMO2 SMB (m/yr)
Model SMB (m/yr)
2500
2000
1500
1000
500
200
400
600
800
1000
1200
4
3
2
1
0
−1
−2
−3
−4

CISM: boundary and initial condition improvements

Problem: How do we reduce the “shock” when coupling between CESM and CISM is turned on?

Needed: A method for adjusting basal sliding coefficient in tuned model so that:

CISM: boundary and initial condition improvements

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$$\nabla \cdot \left(\mathbf{U} H \right) = SMB$$

$$r = \nabla \cdot \left(\mathbf{U} H \right) - SMB$$

CISM: boundary and initial condition improvements

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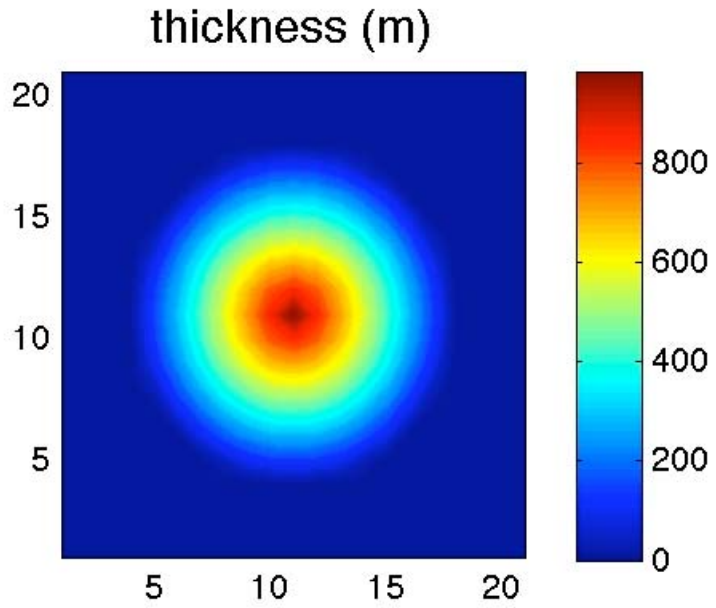
Needed: A method for adjusting basal sliding coefficient in tuned model so that:

$$\nabla \cdot \left(\mathbf{U} H \right) = SMB$$

$$r = \nabla \cdot \left(\mathbf{U} H \right) - SMB$$

Small $r(x,y)$ equals small shock; big $r(x,y)$ equals big shock


thickness (m)
20
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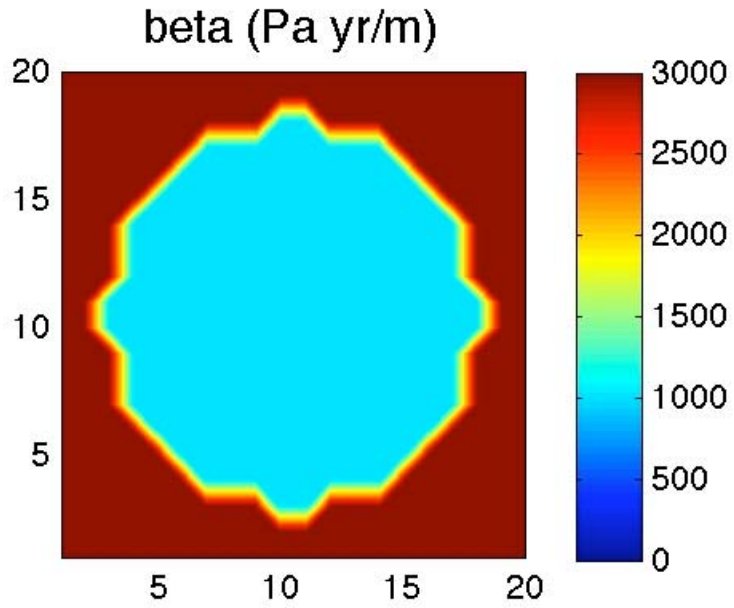
400
200
0


beta (Pa yr/m)
20
15
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10
15
20
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2000
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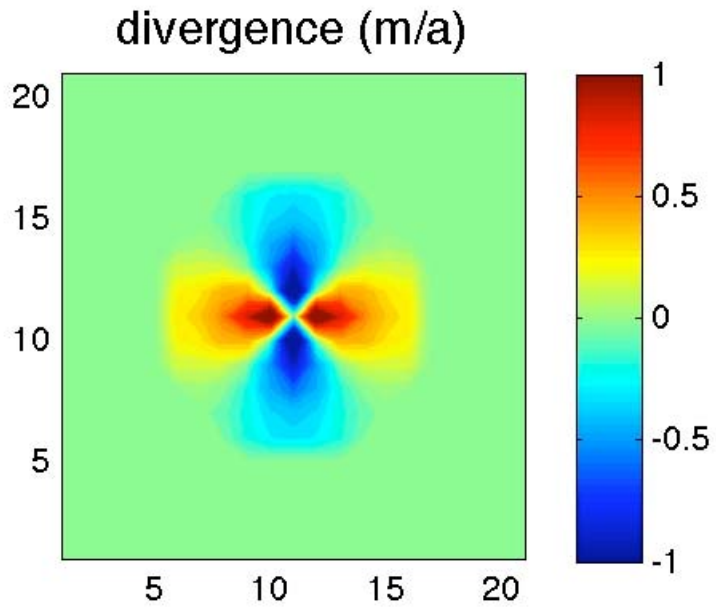
1000
500
0


divergence (m/a)
20
15
10
5
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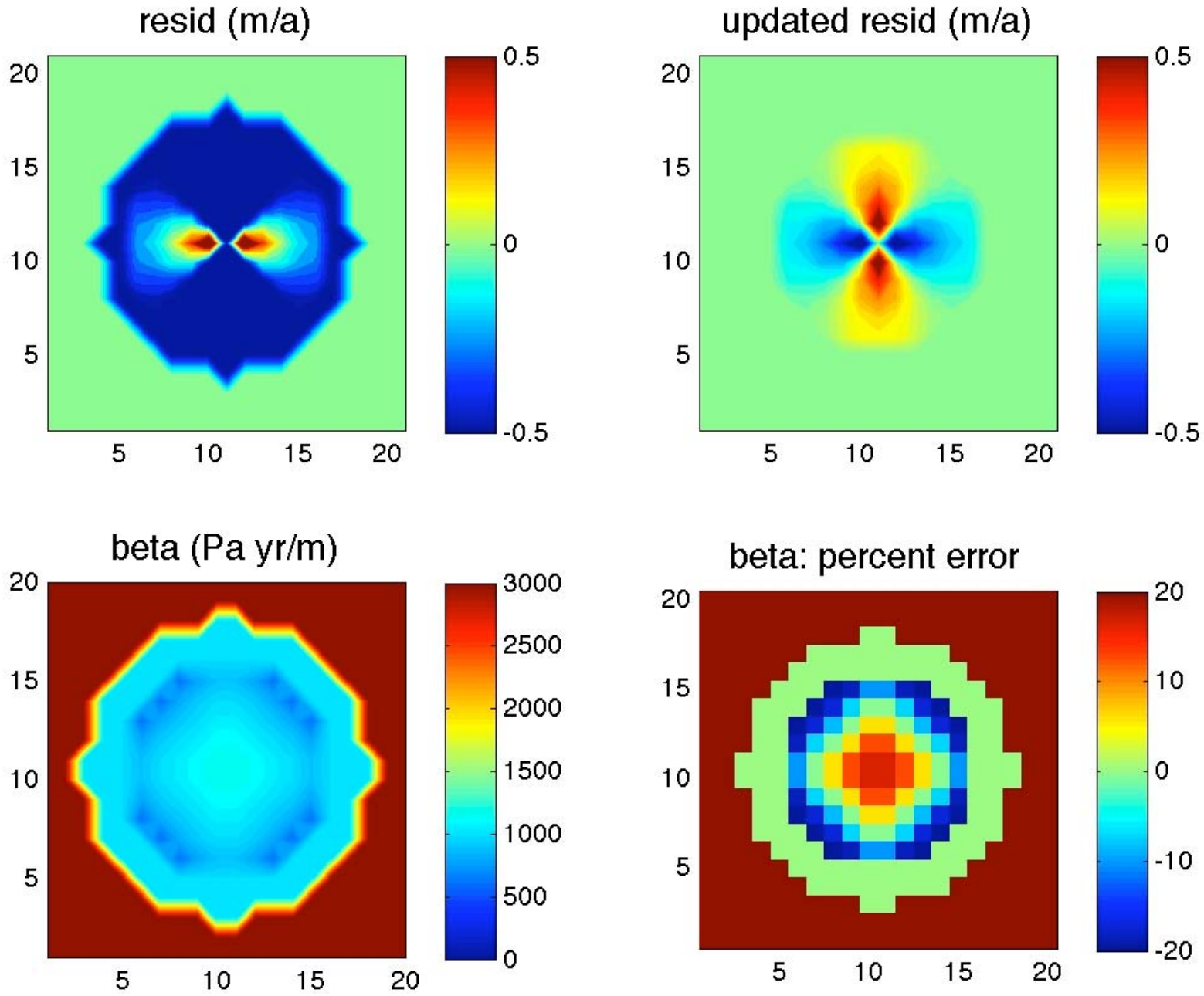
10
15
20
1
0.5
0
-0.5
-1


resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
20
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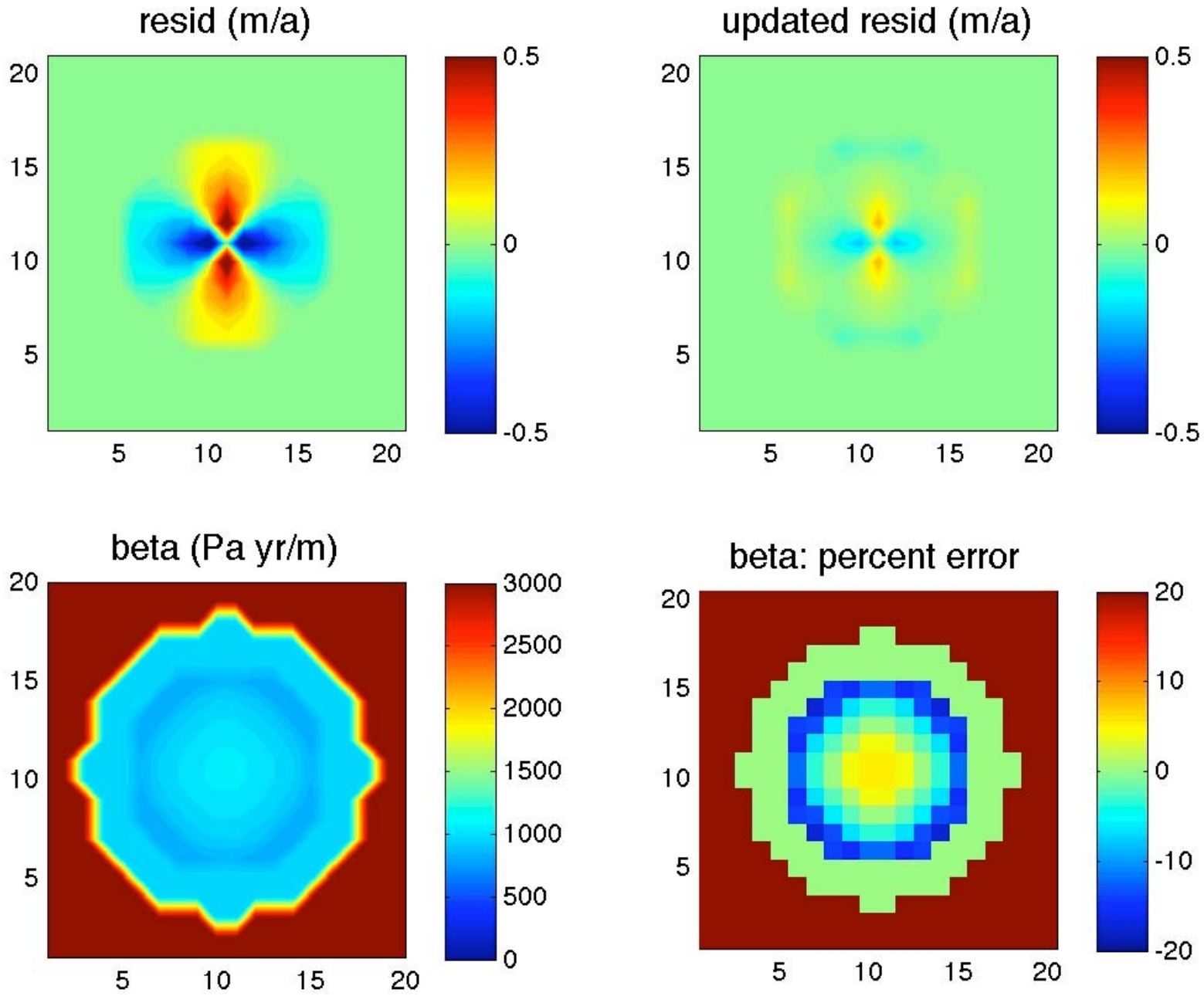
resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
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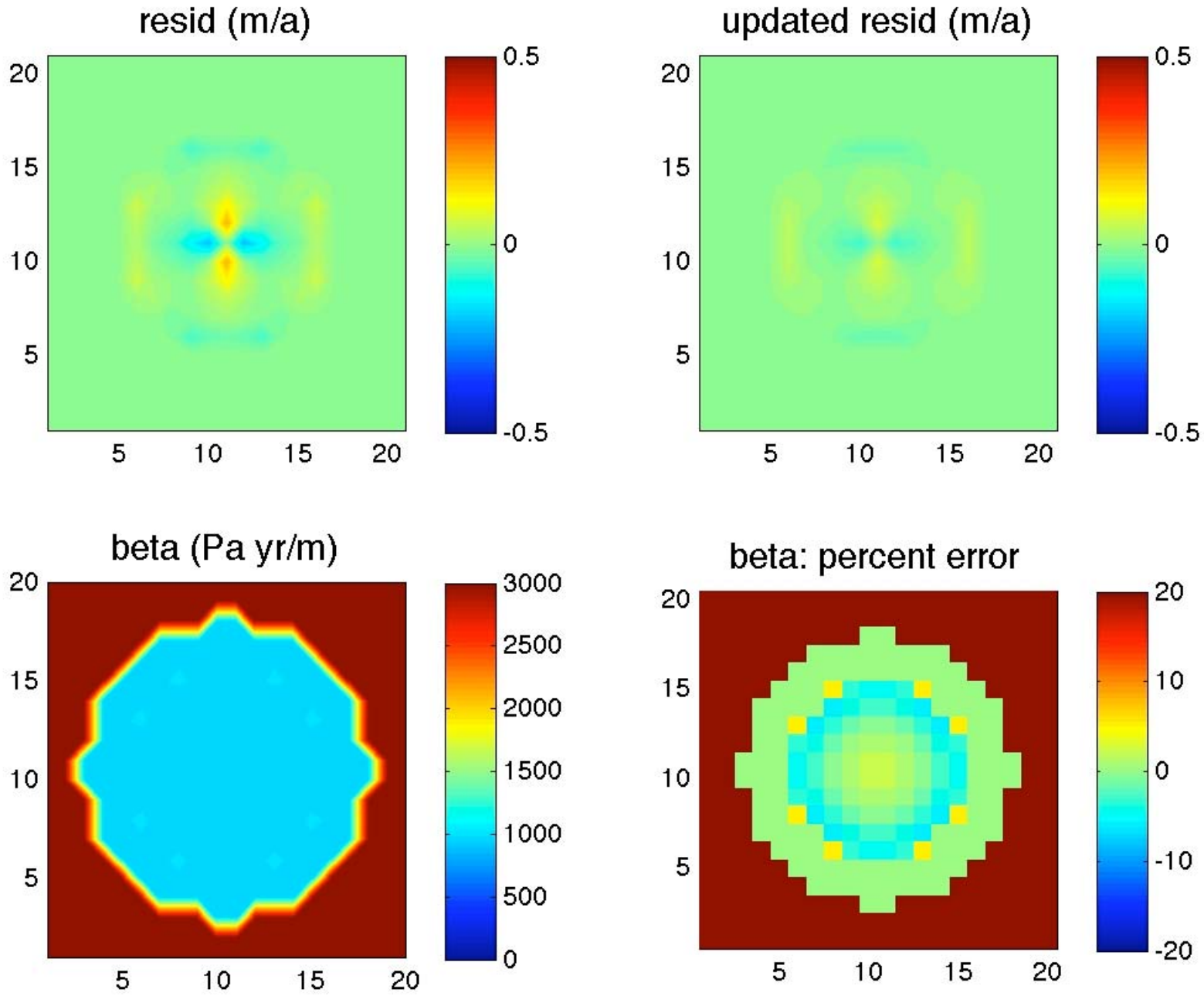
resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
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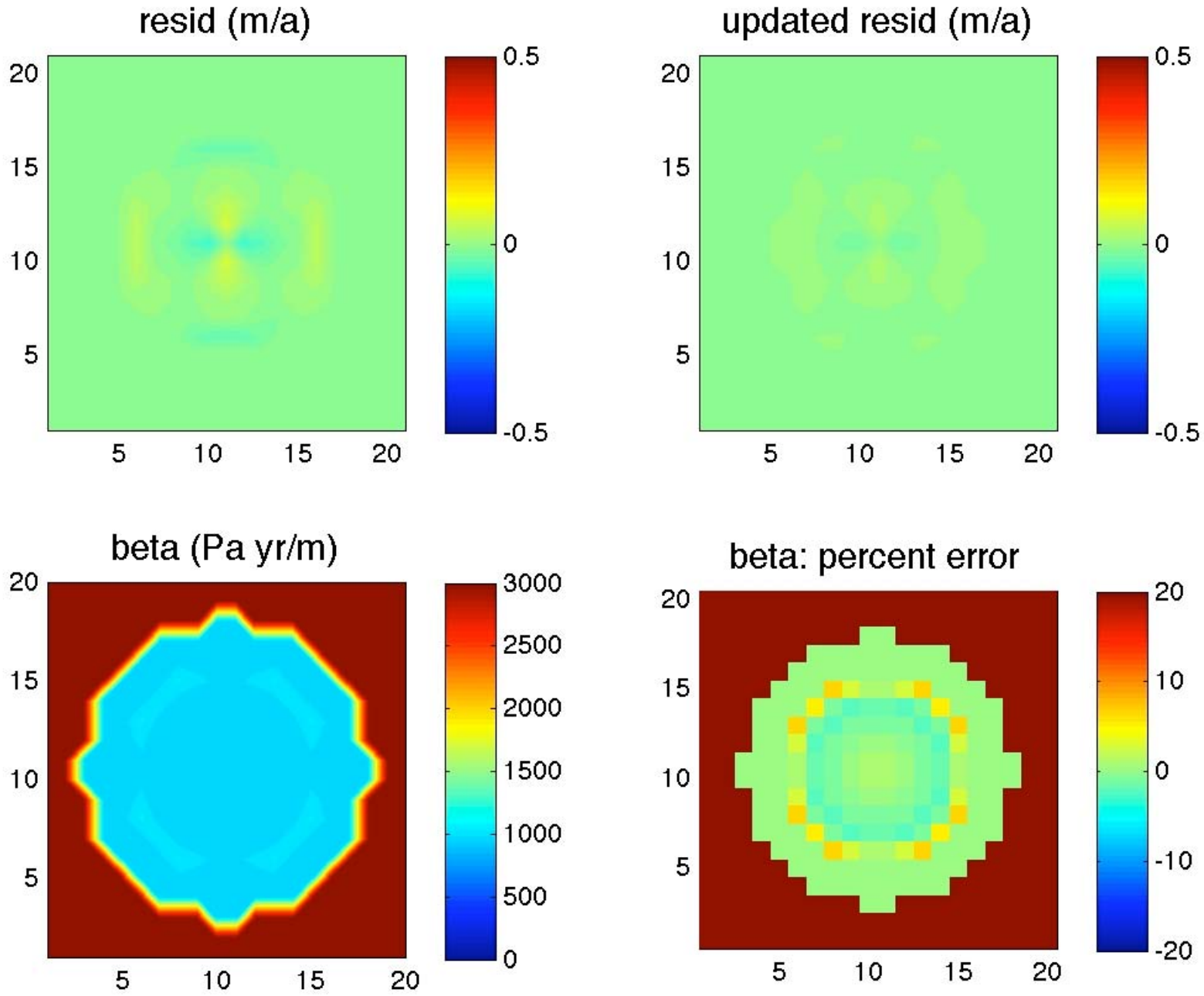
resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
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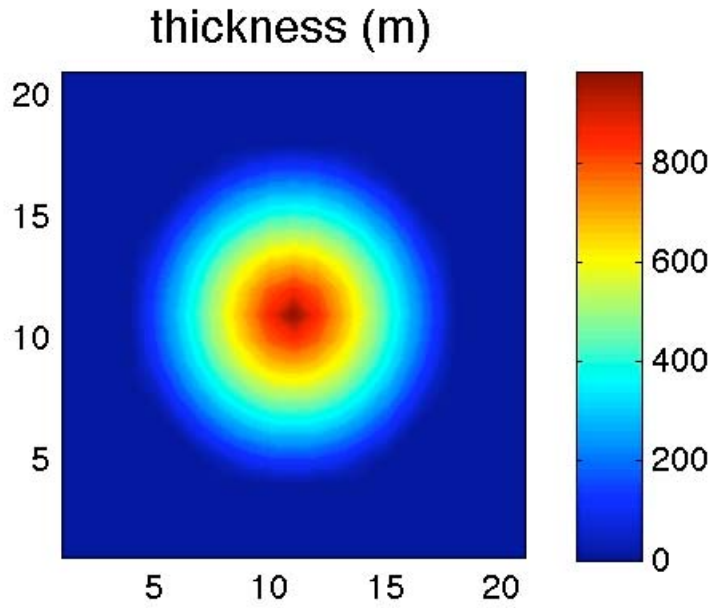
thickness (m)
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400
200
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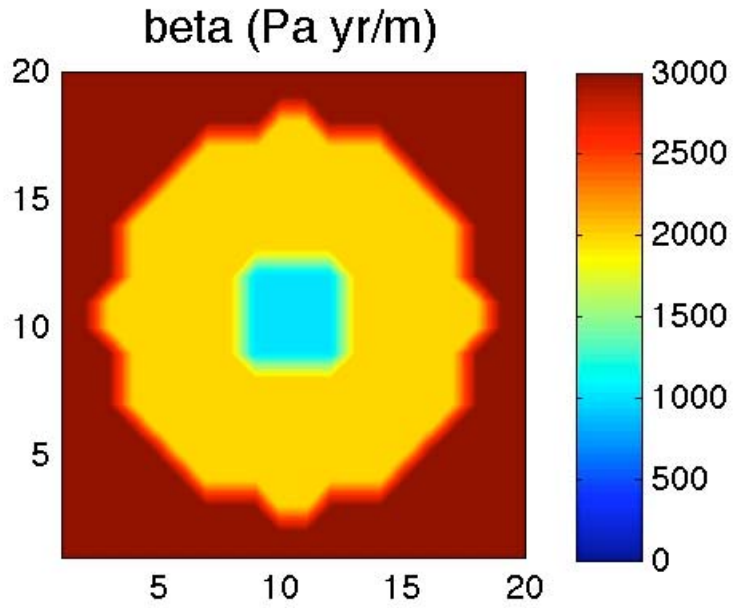
beta (Pa yr/m)
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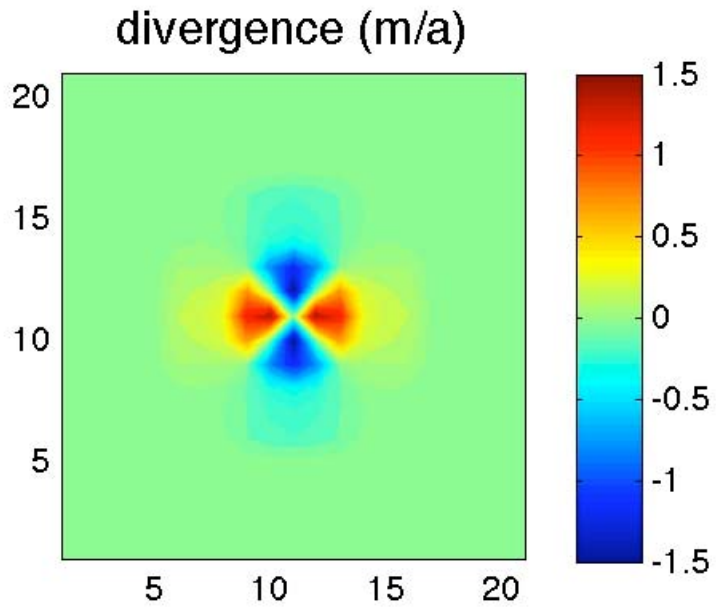
divergence (m/a)
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0.5
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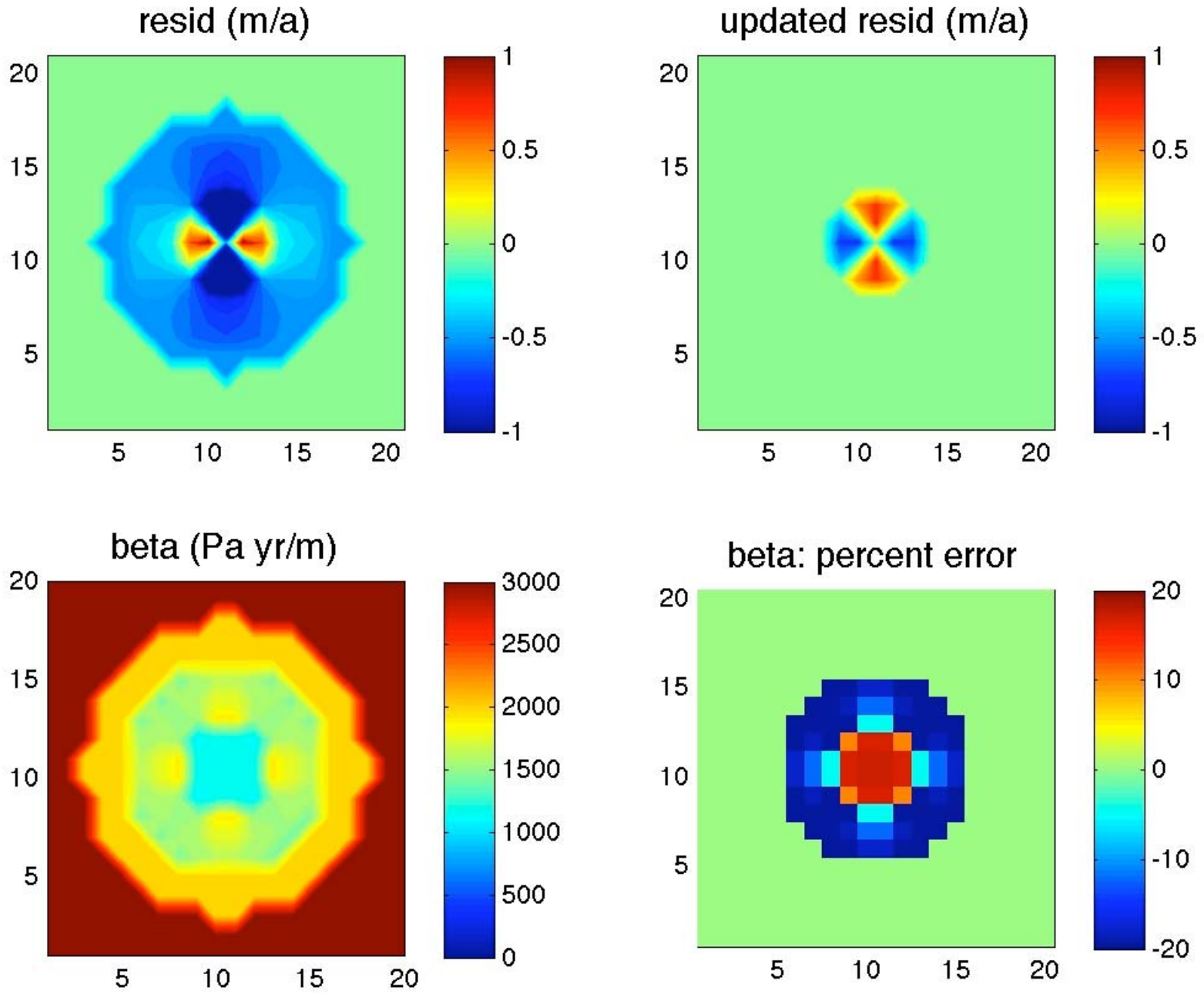
-1
-1.5


resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
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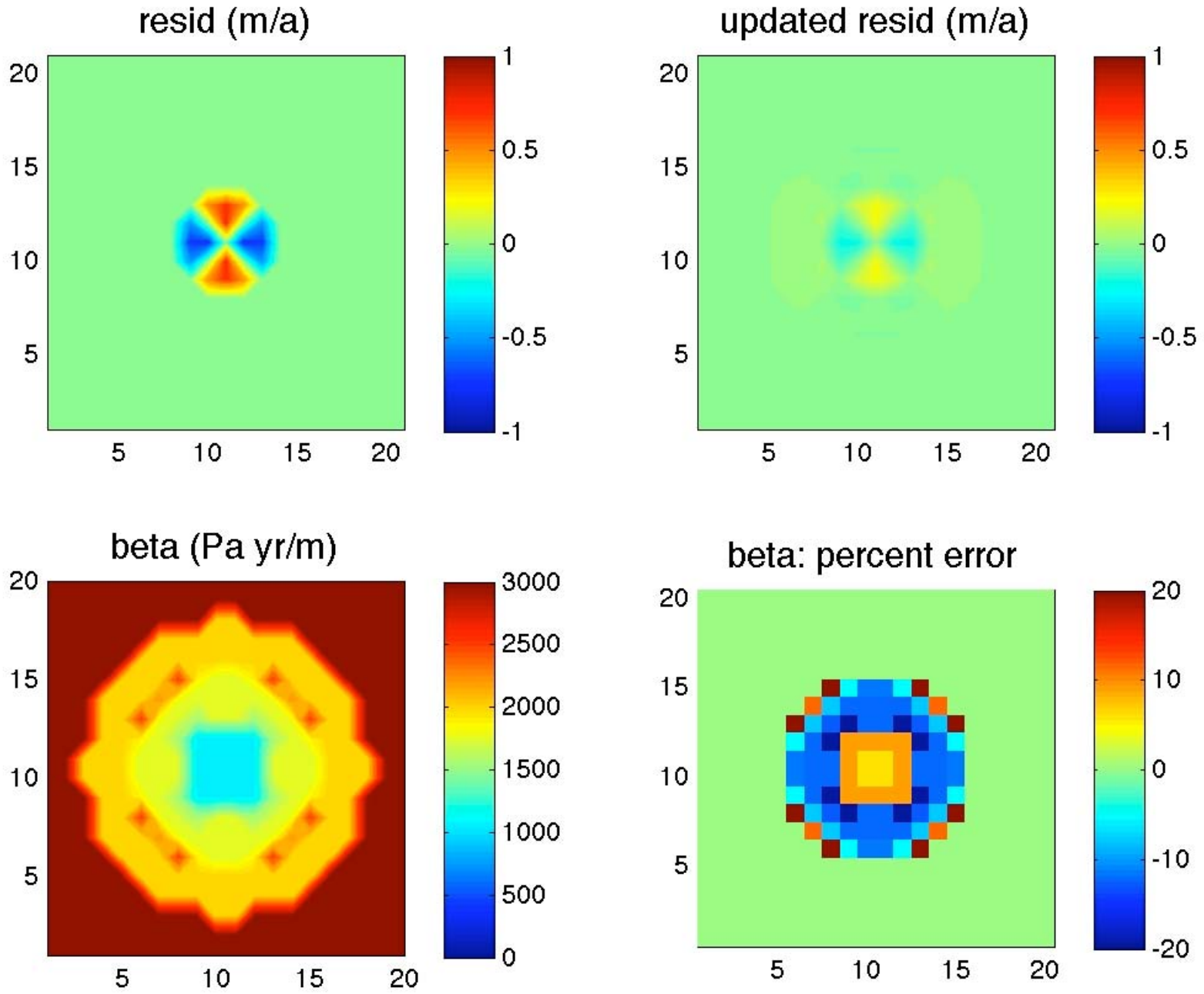
resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
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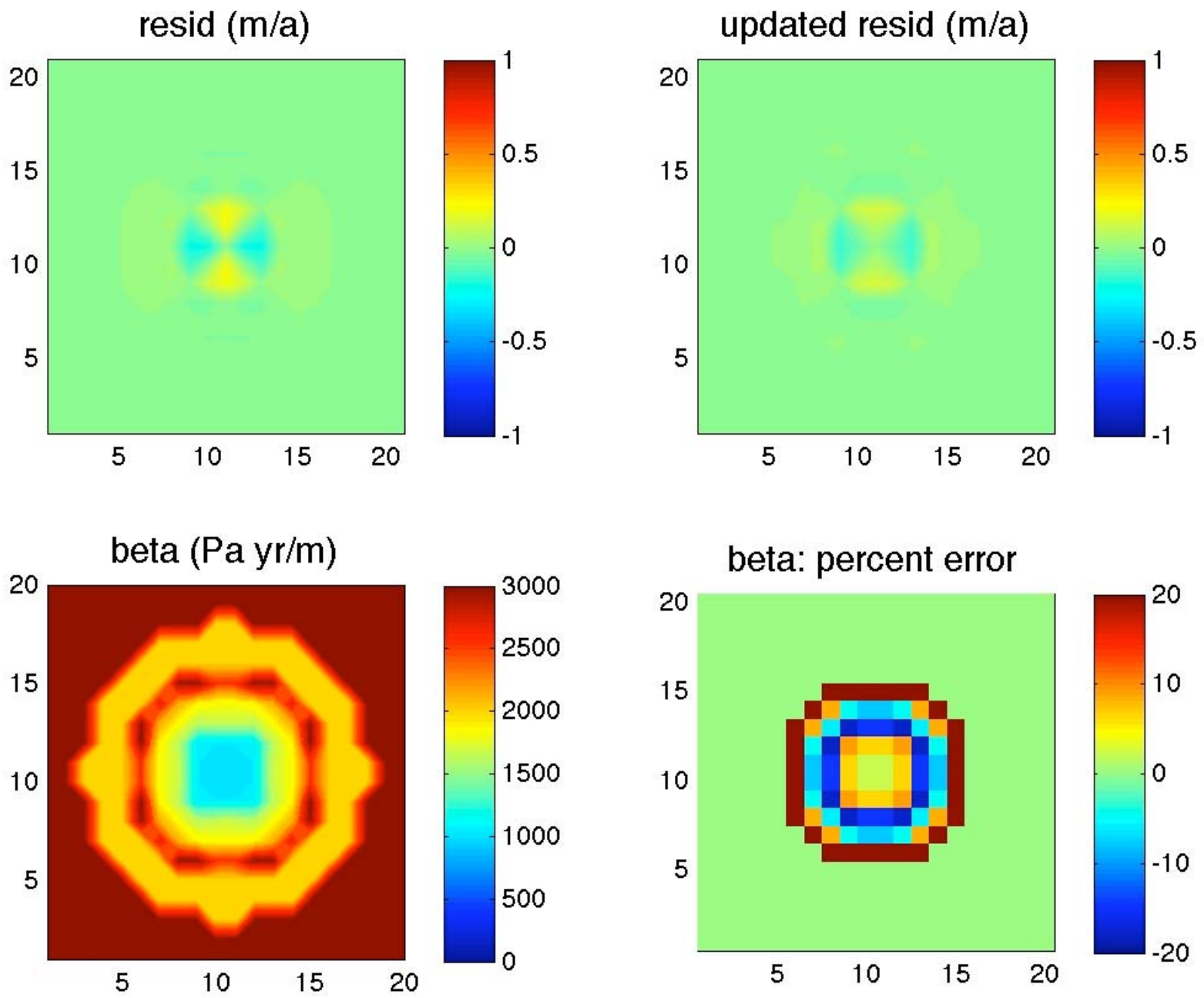
resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
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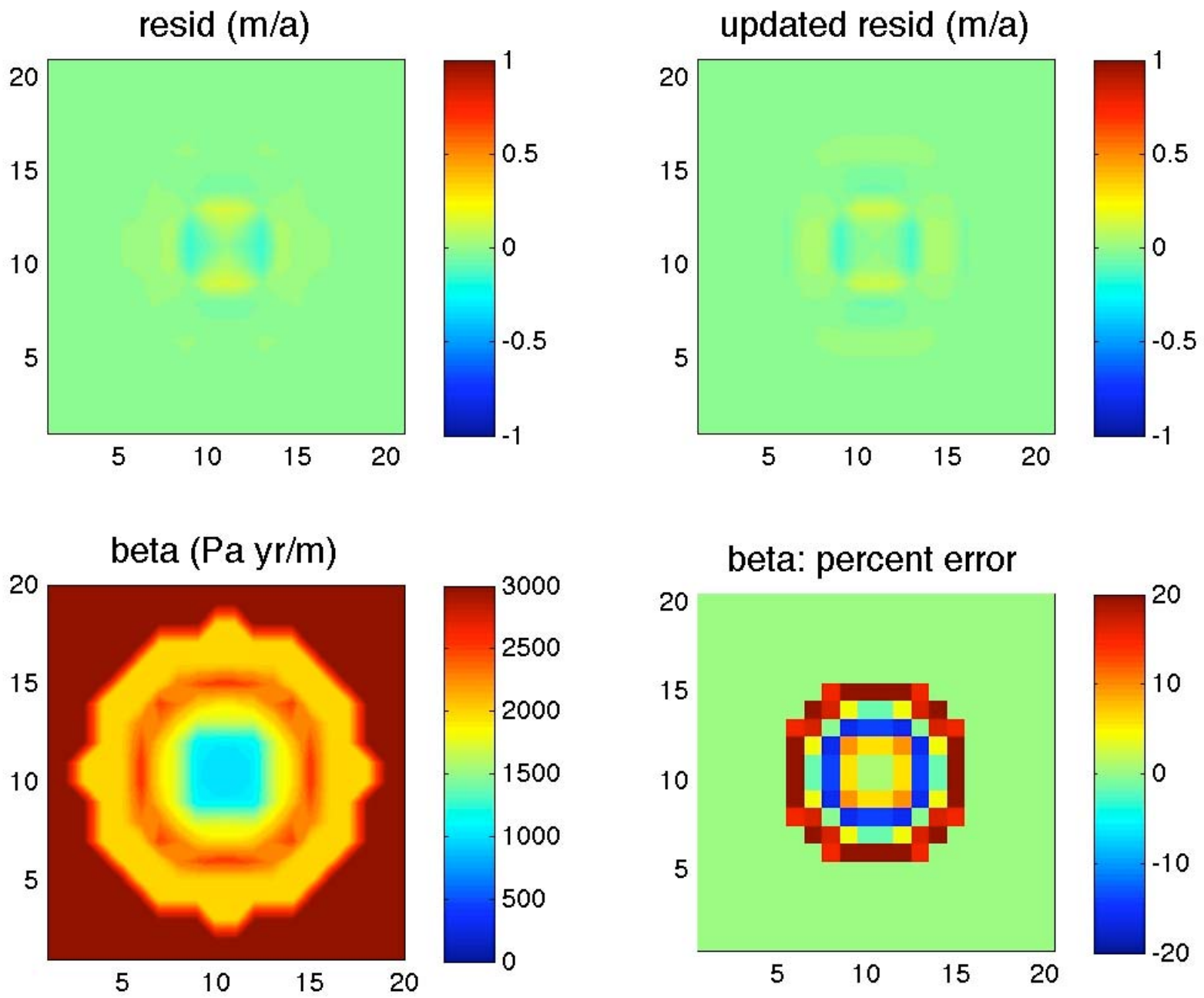
resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
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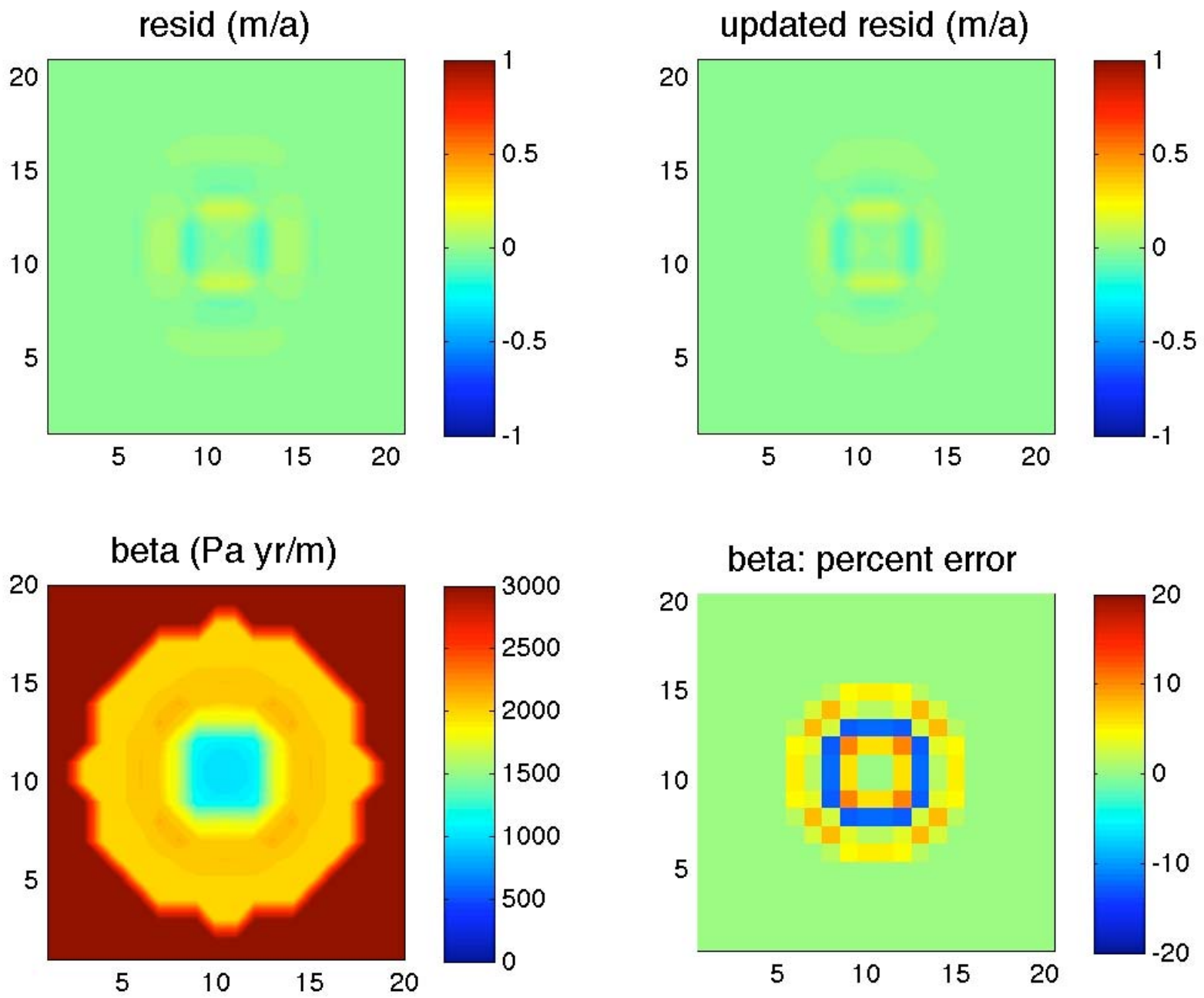
resid (m/a)
updated resid (m/a)
beta (Pa yr/m)
beta: percent error
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-0.5
-1
3000
2500
2000
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1000
500
0
20
10
0
-10
-20

CISM-related publications, 2010-2011

Bougamont, M., S. F. Price, P. Christoffersen, and A. J. Payne. **Dynamic patterns of ice stream flow in a 3d higher-order ice sheet model with plastic bed and simplified hydrology.** *J. Geophys. Res.* (in review).

Carter, S. P., H. A. Fricker, D. D. Blankenship, J. V. Johnson, W. H. Lipscomb, S. F. Price, D. A. Young. **Modeling five years of subglacial lake activity in the MacAyeal Ice Stream catchment through assimilation of ICESat laser altimetry.** *J. Glaciol.* (in press).

Gladish, C. V., D. M. Holland, P. R. Holland, and S. F. Price. **Channelized basal topography in a coupled ice shelf and ocean model.** *J. Glac.* (in prep.)

Lemieux, J.F., S.F. Price, K.J. Evans, D. Knoll, A.G. Salinger, D. Holland, and A.J. Payne. 2011. **Implementation of the Jacobian-Free Newton-Krylov method for solving the first-order ice sheet momentum balance.** *J. Comput. Phys.*, doi:10.1016/j.jcp.2011.04.037.

Leng, W., L. Ju, M. Gunzburger, S. Price, and T. Ringler. **A Parallel High-Order Accurate Finite Element Nonlinear Stokes Ice-Sheet Model and Benchmark Experiments.** *J. Geophys. Res.* (in review).

Price, S.F., A.J. Payne, I.M. Howat, and B.E. Smith. 2011. **Committed sea-level rise for the next century from Greenland ice sheet dynamics during the past decade.** *PNAS*, doi:10.1073/pnas.1017313108.

Price, S.F., G. Flowers, and C. Schoof. **Improving hydrology in land ice models.** *EOS*, 92(19), 164.

Zhang H., L. Ju, M. Gunzburger, T. Ringler, and S. Price. 2011. **Coupled models and parallel simulations for three-dimensional full Stokes ice sheet modeling.** *Numer. Math. Theor. Meth. Appl.* (in press).