Ice Sheet System Model

Application of Operation Ice Bridge Data

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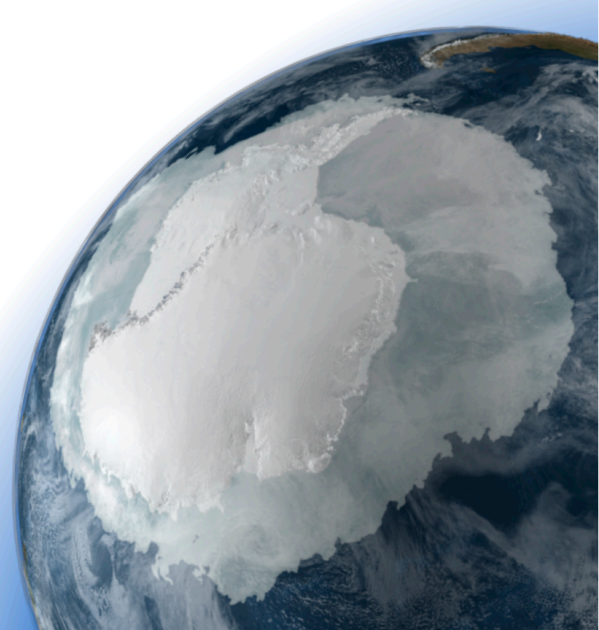


Overview

1. Introduction
2. Mesh
3. Parameterization
4. Control Method Solution
5. Transient Solution
6. Plot Results

Goals

Use your new ISSM skills to adjust a coarse Greenland model by adding IceBridge data.
We refine the mesh in the Jakobshavn basin and add higher resolution bedrock and surface elevation data from IceBridge in this area.

Steps:

- Refine Greenland mesh using given Jakobshavn outline
- Parameterize, include the high-resolution IceBridge bedrock and surface data
- Plot ice base and surface data
- Stress Balance: run 2 inverse method runs to solve for control drag (20 steps recommended)
- Transient: run 20 year runs, with coarse and refined bedrock and surface elevation data
- Plot transient results

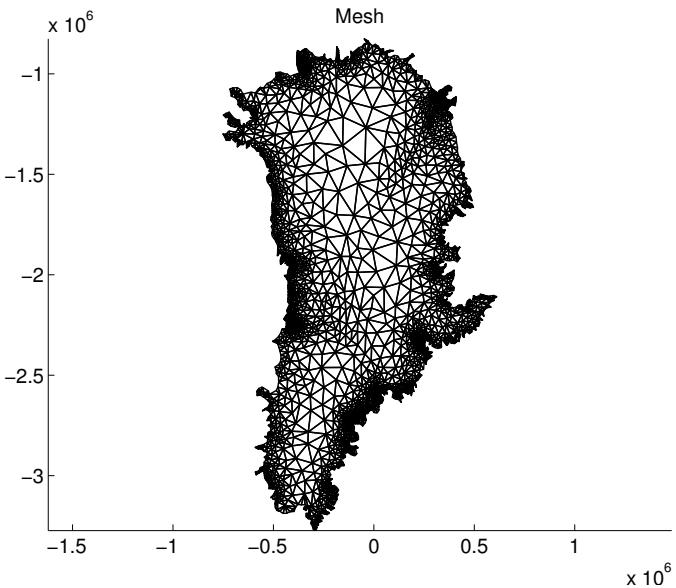
First Run Step: Mesh

We modify the experiment from the Greenland SeaRISE talk, and improve from there.

First, run the first step in runme.m in directory 10IceBridge to mesh the Greenland domain as done in the previous talk.

Step 1 is interrupted after making the default mesh. Plot the result.

It should look like this:



Mesh, 2/5

Adapt

We want to refine the mesh in the Jakobshavn area. An outline of this area Jak_outline.exp can be found in directory Exp_Par.

Try using exptool to view this outline:

```
1  >> exptool('Exp_Par/Jak_outline.exp');
```

Mesh, 3/5

Adapt

Next, we modify the bamg command by imposing a 3 km resolution within the Jakobshavn area: using hmaxVertices.

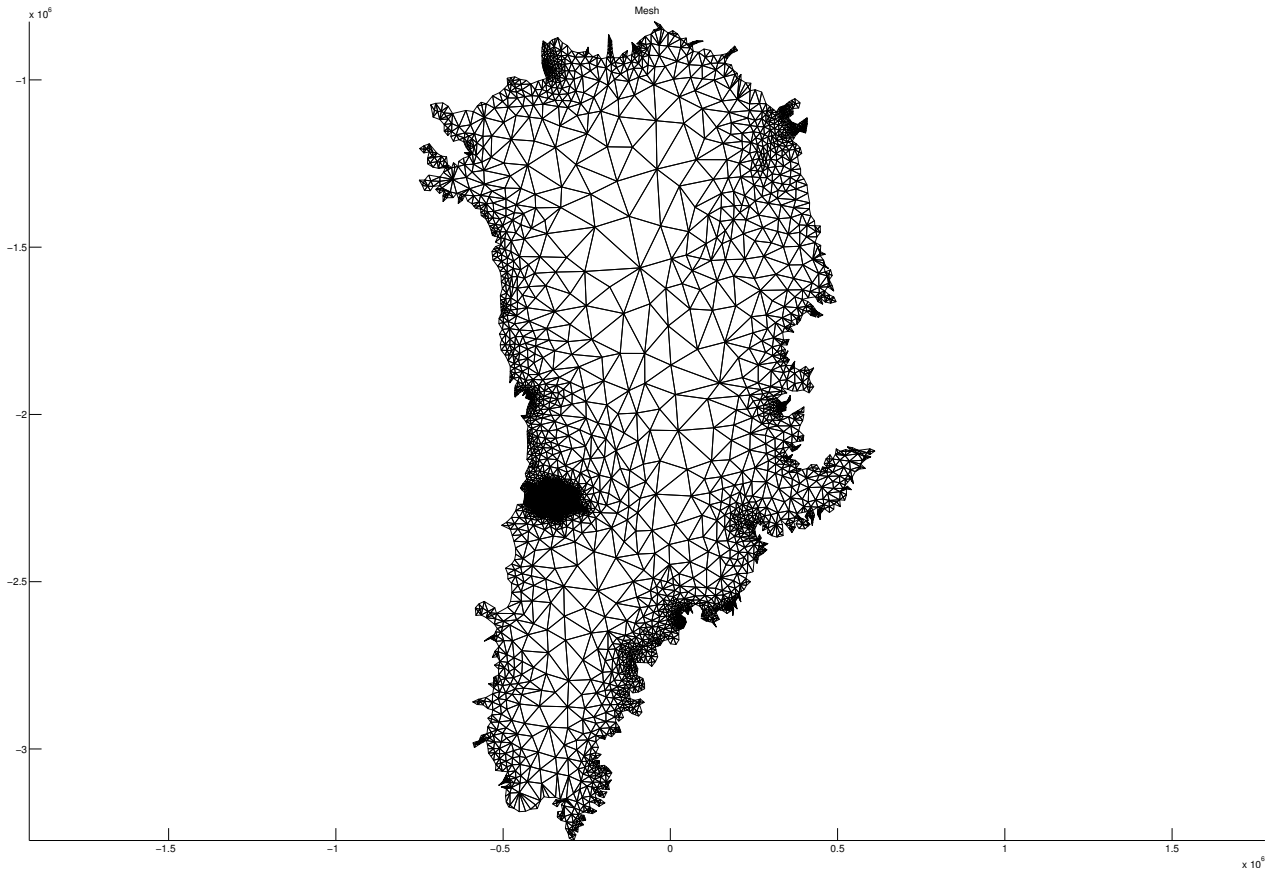
Note that you need to deactivate the previous bamg command.

```
26  %Refine mesh in the region of Jakobshavn (resolution = 3000 m)
27  hmaxVertices=NaN*ones(md.mesh.numberofvertices,1);
28  in=ContourToMesh(md.mesh.elements,md.mesh.x,md.mesh.y,...
29   './Exp_Par/Jak_outline.exp','node',1);
30  hmaxVertices(find(in))=3000;
31  md=bamg(md,'hmax',400000,'hmin',5000,'gradation',1.7,'field',vel,...
32   'err',8,'hmaxVertices',hmaxVertices);
```

Check your results using plotmodel.

Mesh, 4/5

Solution



Try zoom to make a close-up of the Jakobshavn domain.

Mesh, 5/5

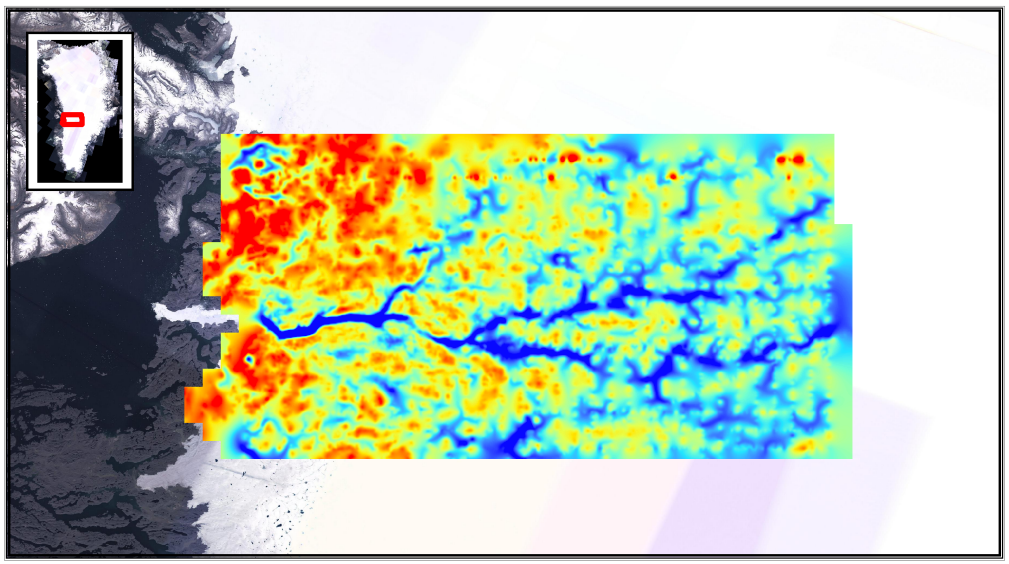
Full Solution

```
22  %Mesh greenland without refinement in Jak basin
23  md=bamg(md,'hmax',400000,'hmin',5000,'gradation',1.7,'field',vel,'err',8);
24  return;
25
26  %Refine mesh in the region of Jakobshavn (resolution = 3000 m)
27  hmaxVertices=NaN*ones(md.mesh.numberofvertices,1);
28  in=ContourToMesh(md.mesh.elements,md.mesh.x,md.mesh.y,...
29   './Exp_Par/Jak_outline.exp','node',1);
30  hmaxVertices(find(in))=3000;
31  md=bamg(md,'hmax',400000,'hmin',5000,'gradation',1.7,'field',vel,...
32   'err',8,'hmaxVertices',hmaxVertices);
33
34  %convert x,y coordinates (Polar stereo) to lat/lon
35  [md.mesh.lat,md.mesh.long]=xy2ll(md.mesh.x,md.mesh.y,+1,39,71);
36
37  save ./Models/Greenland.Mesh_generation md;
```

Parameterization

We want to include high-resolution bedrock and surface elevation data acquired in the IceBridge mission. Accessible on:

https://data.cresis.ku.edu/data/grids/
Jakobshavn_2008_2011_Composite_XYZGrid.txt



Parameterization, 2/6

Bedrock data is read, transformed into a usable grid, and interpolated to the mesh in the parameter file Exp_Par/Greenland.par:

```
30  %Reading IceBridge data for Jakobshavn
31  disp('      reading IceBridge Jakobshavn bedrock');
32  fid  = fopen('Data/Jakobshavn_2008_2011_Composite_XYZGrid.txt');
33  titles = fgets(fid); data = fscanf(fid,'%g,%g,%g,%g,%g',[5 266400])';
34  fclose(fid);
35
36  [xi,yi]= ll2xy(md.mesh.lat,md.mesh.long,+1,45,70);
37  bed  = flipud(reshape(data(:,5),[360 740])); bed(find(bed==-9999))=NaN;
38  bedy = flipud(reshape(data(:,1),[360 740]));
39  bedx = flipud(reshape(data(:,2),[360 740]));
40
41  %Insert Icebridge bed and recalculate thickness
42  bed_jks=InterpFromGridToMesh(bedx(1,:)',bedy(:,1),bed,xi,yi,NaN);
43  in=ContourToMesh(md.mesh.elements,md.mesh.x,md.mesh.y,...
44   './Exp_Par/Jak_grounded.exp','node',1);
45  bed_jks(¬in)=NaN;
46  pos=find(¬isnan(bed_jks));
47  md.geometry.base(pos)=bed_jks(pos);
48  md.geometry.thickness=md.geometry.surface-md.geometry.base;
```

Modify Greenland.par such that the surface elevation data is also included for the Jakobshavn area.

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Parameterization, 3/6

Solution

```
30  %Reading IceBridge data for Jakobshavn
31  disp('      reading IceBridge Jakobshavn bedrock');
32  fid  = fopen('Data/Jakobshavn_2008_2011_Composite_XYZGrid.txt');
33  titles = fgets(fid); data = fscanf(fid,'%g,%g,%g,%g,%g',[5 266400])';
34  fclose(fid);
35
36  [xi,yi]= ll2xy(md.mesh.lat,md.mesh.long,+1,45,70);
37  bed  = flipud(reshape(data(:,5),[360 740])); bed(find(bed==-9999))=NaN;
38  surf  = flipud(reshape(data(:,4),[360 740])); surf(find(surf==-9999))=NaN;
39  bedy = flipud(reshape(data(:,1),[360 740]));
40  bedx = flipud(reshape(data(:,2),[360 740]));
41
42  %Insert Icebridge bed and recalculate thickness
43  bed_jks=InterpFromGridToMesh(bedx(1,:)',bedy(:,1),bed,xi,yi,NaN);
44  surf_jks=InterpFromGridToMesh(bedx(1,:)',bedy(:,1),surf,xi,yi,NaN);
45  in=ContourToMesh(md.mesh.elements,md.mesh.x,md.mesh.y,...
46   './Exp_Par/Jak_grounded.exp','node',1);
47  bed_jks(¬in)=NaN;
48  surf_jks(¬in)=NaN;
49  pos=find(¬isnan(bed_jks));
50  md.geometry.base(pos)=bed_jks(pos);
51  md.geometry.surface(pos)=surf_jks(pos);
52  md.geometry.thickness=md.geometry.surface-md.geometry.base;
```

Plot surface elevation, thickness, and base.

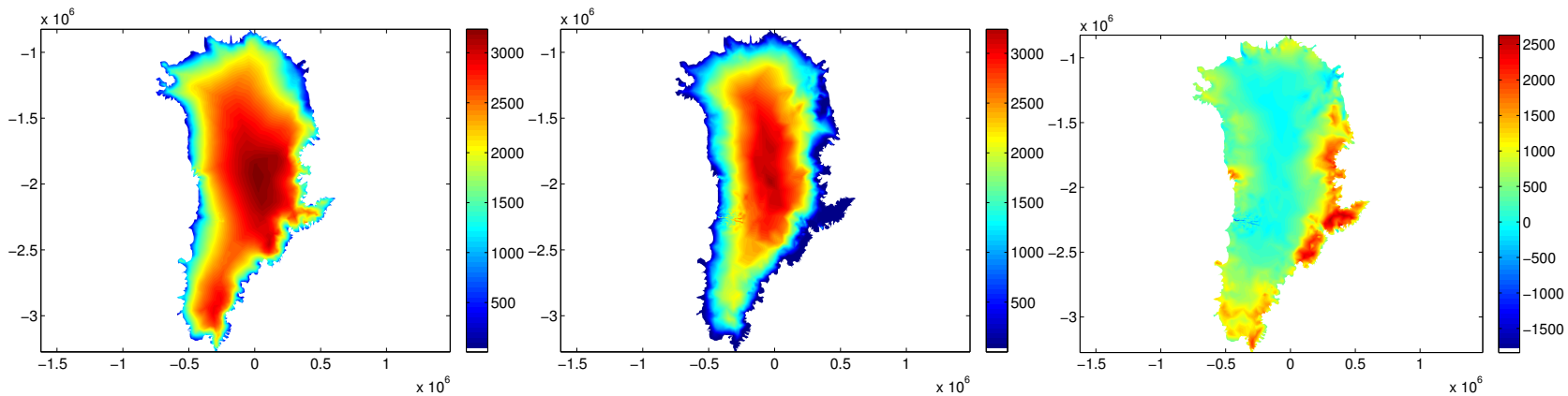
JPL

Parameterization, 4/6

Solution

```
1   >> plotmodel(md,'data',md.geometry.surface);
2   >> plotmodel(md,'data',md.geometry.thickness);
3   >> plotmodel(md,'data',md.geometry.base);
```

They should look like:



Parameterization, 5/6

Solution

To plot the difference in ice base topography between the SeaRISE and IceBridge datasets:

Modify the parameterization step in your runme and save the model under a different name.

A difference in fields can be plotted using:

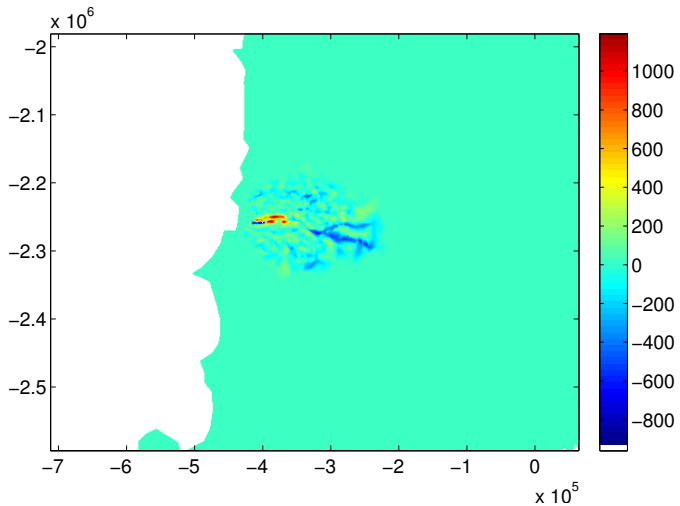
```
>> md2=loadmodel('Models/Greenland.Parameterization2');
>> md=loadmodel('Models/Greenland.Parameterization');
>> plotmodel(md,'data',md2.geometry.base-md.geometry.base);
```

Parameterization, 6/6

Solution

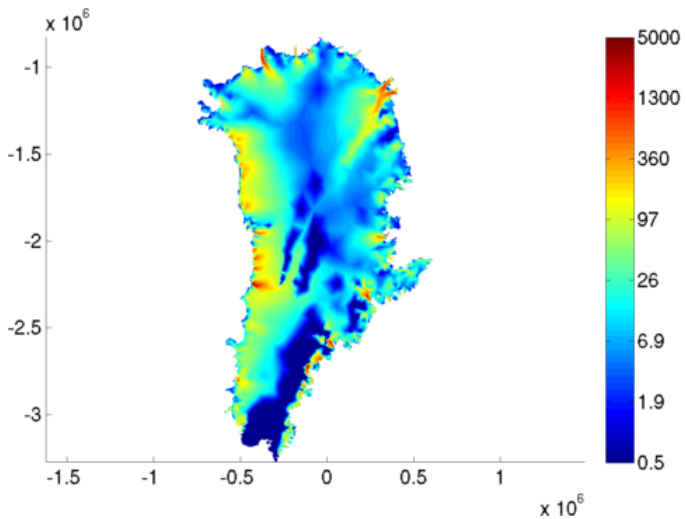
A difference in fields can be plotted using:

```
1   >> md2=loadmodel('Models/Greenland.Parameterization2');
2   >> md=loadmodel('Models/Greenland.Parameterization');
3   >> plotmodel(md,'data',md2.geometry.base-md.geometry.base);
```



Stress Balance

Use control methods to inversely solve for Greenland friction coefficient
Comparable to the 10SeaRISE_GrIS experiment



The observed velocity map contains some gaps; exclude these from the inversion by creating a new exp file that outlines the gaps in the velocity data, using exptool:

```
1   >> exptool('Exp_Par/data_gaps.exp');
```

Stress Balance, 2/3

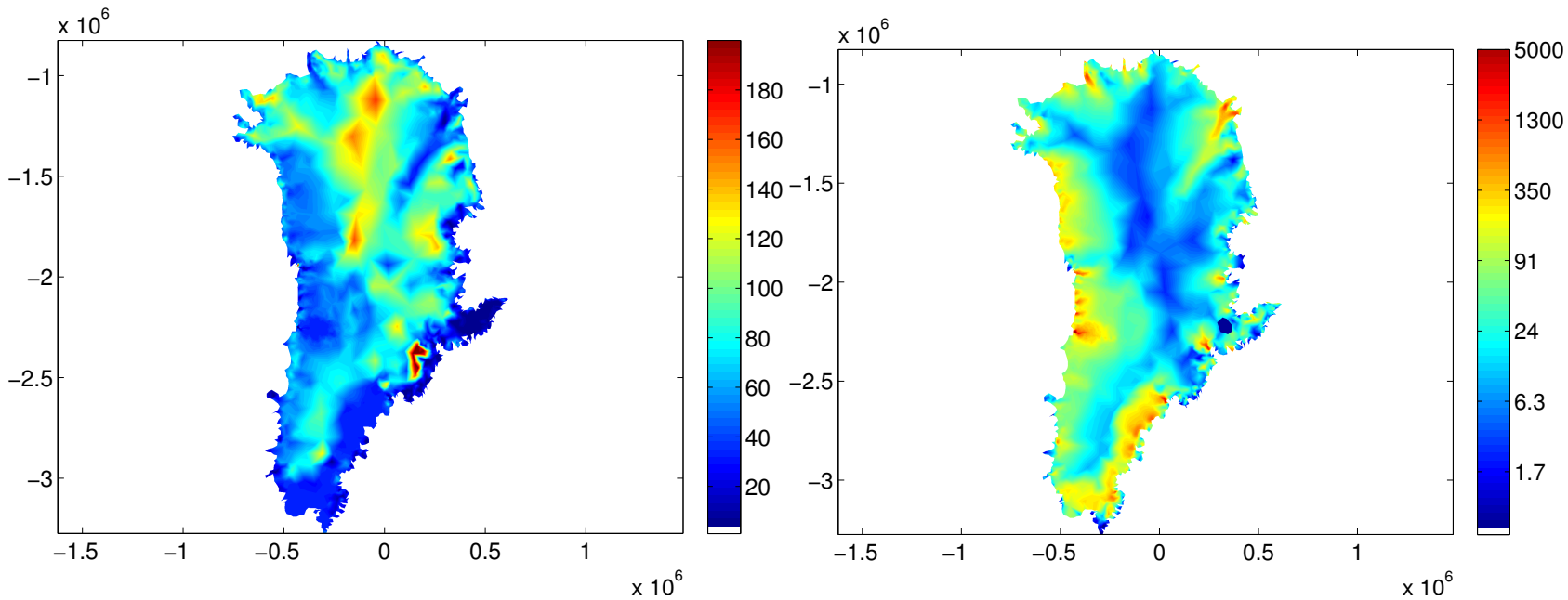
```
74   in=ContourToMesh(md.mesh.elements,md.mesh.x,md.mesh.y,...
75    './Exp_Par/data_gaps.exp','node',1);
76   md.inversion.cost_functions_coefficients(find(in),1)=0.0;
77   md.inversion.cost_functions_coefficients(find(in),2)=0.0;
```

Next, run the model and plot the resulting friction coefficient and velocity pattern

```
1   >> plotmodel(md,'data',md.results.StressbalanceSolution.FrictionCoefficient);
2   >> plotmodel(md,'data',md.results.StressbalanceSolution.Vel,...
3      'log',10,'caxis',[0.5 5000]);
```

Stress Balance, 3/3

```
>> plotmodel(md,'data',md.results.StressbalanceSolution.FrictionCoefficient);
>> plotmodel(md,'data',md.results.StressbalanceSolution.Vel,...
   'log',10,'caxis',[0.5 5000]);
```



Transient

Forcing

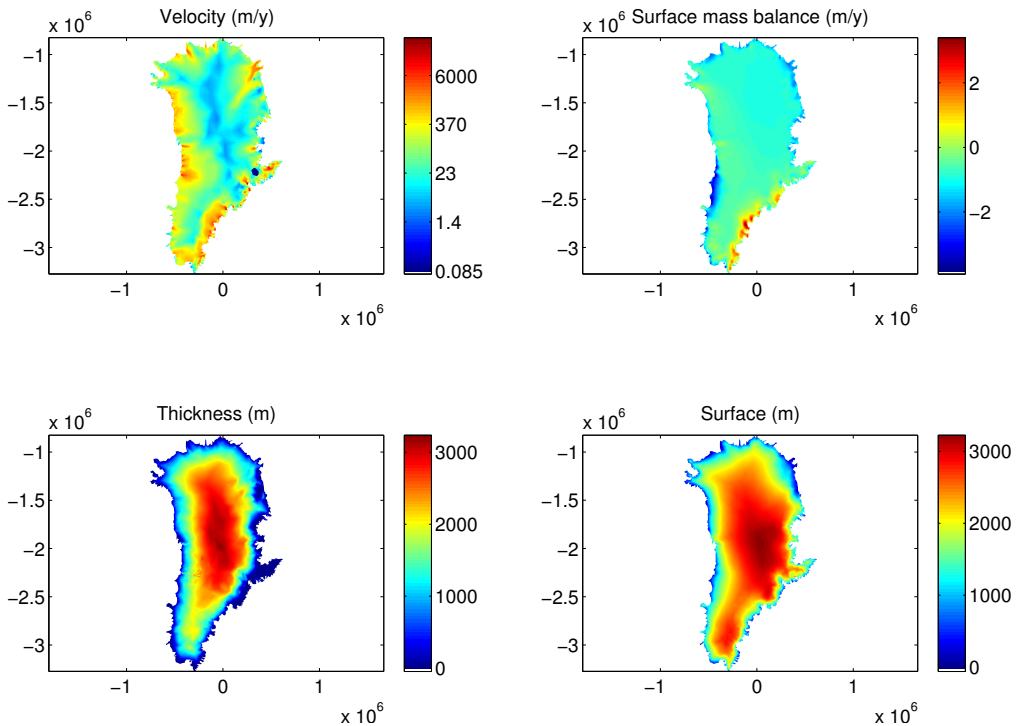
Do a transient run..

Transient Results

Plot Plan

Your results are located in md.results.TransientSolution. Plot your results.

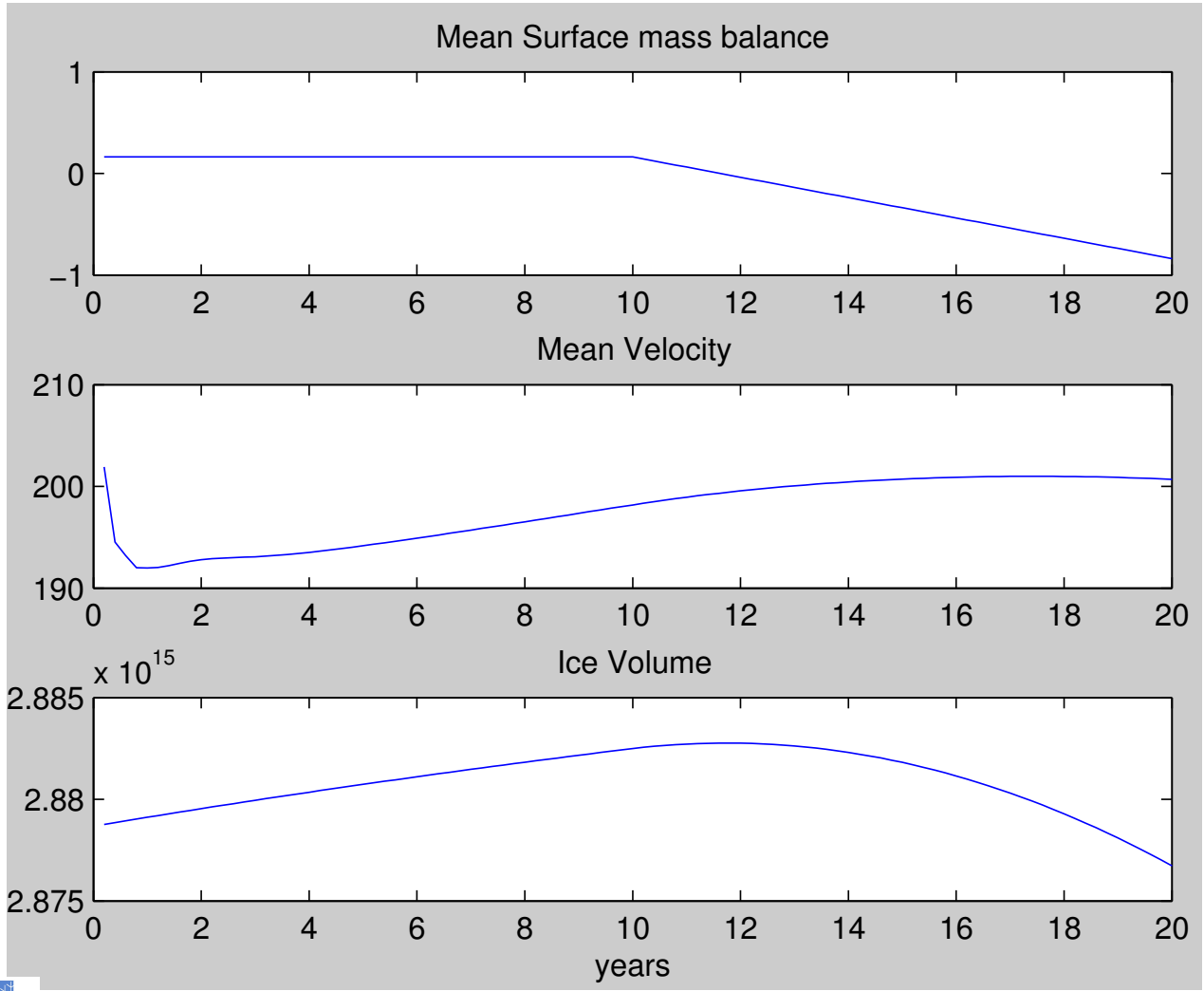
First, plot the initial plan view of velocity, surface mass balance, thickness, and surface.
They should look like:



Transient Results

Plot time series

They should look like:



Transient Results

Some suggestions what to explore further:

- How would you make a plot of time series of results from the SeaRISE and IceBridge experiments?
- How would you make a plot of the difference between final and initial ice thickness?
- ...

We can help you to implement your own ideas in the code.


Thanks!