```
md = loadmodel('/Users/rishi/Desktop/ISSM-macOS-Silicon-MATLAB/examples/Pig/
Models/Stange_Inverted.mat');
```

Read the Paolo netcdf data

```
paolo ='/Users/rishi/Desktop/ISSM-macOS-Silicon-MATLAB/examples/Data/
Paolo_Ice_thickness_1996_2017.nc';

% read the parameters from the paolo datasets
x = double(ncread(paolo,'x'));
y = double(ncread(paolo,'y'));
bmb = ncread(paolo,'melt'); % basal mass balance
smb = ncread(paolo,'smb'); % surface mass balance

% mean of the mass balance from Paolo
smb_mean   = ncread(paolo,'smb_mean')'; % mean surface mass balance
bmb_mean = double(ncread(paolo,'melt_mean')); % mean basal melt rate

% transpose the basal mass balance and surface mass balance matrices
bmb = permute(bmb, [2 1 3]);
smb = permute(smb, [2 1 3]);

% flip the y and the data matrices to read in ISSM
y = flipud(y);
bmb = flip(bmb, 1);
smb = flip(smb, 1);

% convert the data into a yearly data for the convenience
smb_yearly = squeeze(mean(reshape(smb,length(x),length(y),4,104/4),3));
bmb_yearly = squeeze(mean(reshape(bmb,length(x),length(y),4,104/4),3));

% read the time parameters
TIME = ncread(paolo,'time');
converted_time = datetime(1950, 1, 1) + days(TIME); % Convert to datetime
YEARS = unique(year(converted_time));
```

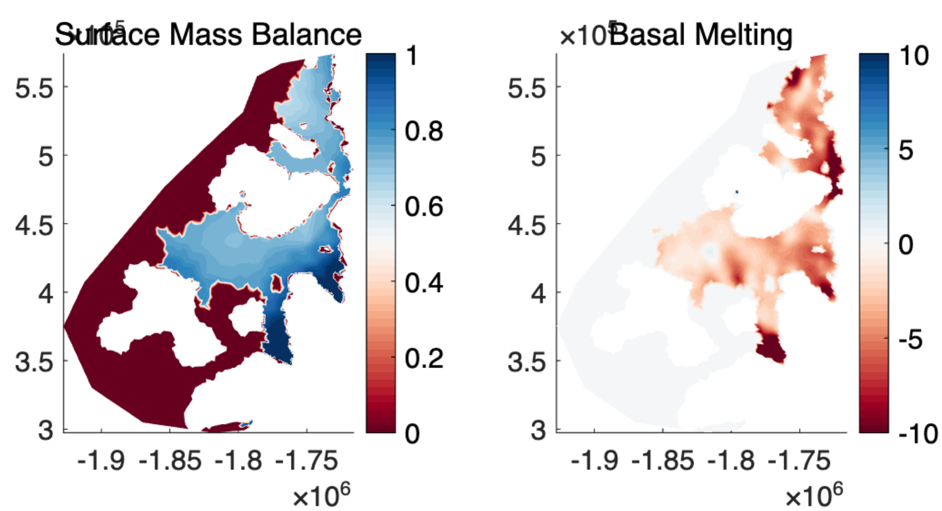
Allocate basal melt and surface mass balance forcing array

```
md.basalforcings.floatingice_melting_rate = zeros(md.mesh.numberofvertices
+ 1, numel(YEARS));
md.basalforcings.floatingice_melting_rate(end, :) = YEARS;

md.smb.mass_balance = zeros(md.mesh.numberofvertices + 1, numel(YEARS));
md.smb.mass_balance(end, :) = YEARS;

% Loop over time steps
for i = 1:numel(YEARS)
    md.basalforcings.floatingice_melting_rate (1:end-1, i) = ...
```

```
        InterpFromGridToMesh(x, y, bmb_yearly(:,:,i), md.mesh.x, md.mesh.y,
0);

    md.smb.mass_balance (1:end-1, i) = ...
        InterpFromGridToMesh(x, y, smb_yearly(:,:,i), md.mesh.x, md.mesh.y,
0);
end

% set the grounded ice melting rate
md.basalforcings.groundedice_melting_rate =
zeros(md.mesh.numberofvertices,1);

% change the nan values to zero for the sake of model run
md.basalforcings.floatingice_melting_rate
(isnan(md.basalforcings.floatingice_melting_rate)) = 0;
md.smb.mass_balance (isnan(md.smb.mass_balance)) = 0;
```

check whether the surface mass baalance is properly implemented

```
plotmodel(md,'data',md.smb.mass_balance(1:end-1, 5),'title','Surface Mass
Balance','caxis#1',([0 1]),...
    'data',md.basalforcings.floatingice_melting_rate(1:end-1,
5),'title','Basal Melting','caxis#2',([-10 10]))

colormap(brewermap(50,'RdBu'))
```



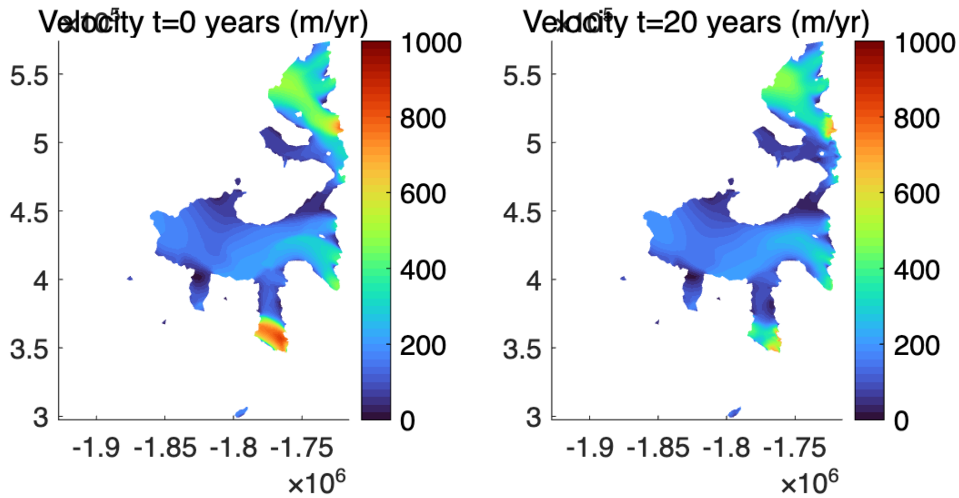
Set Up The Transient run for the simulation of 20 years

```
%Indicate the components of transient to activate
md.transient.ismasstransport = 1;
md.transient.isstressbalance = 1;
md.transient.isgroundingline = 1;
md.transient.ismovingfront = 0;
md.transient.isthermal = 0;

%Specify time steps and length of simulation (years)
md.timestepping.start_time = 0;
md.timestepping.time_step = 0.1;
md.timestepping.final_time = 20;

%Disable inverse method
md.inversion.iscontrol = 0;

%Initialize fields for transient and add boundary conditions
md.initialization.vx = md.results.StressbalanceSolution.Vx;
md.initialization.vy = md.results.StressbalanceSolution.Vy;
md.initialization.vel = md.results.StressbalanceSolution.Vel;
md.masstransport.spcthickness = NaN * ones(md.mesh.numberofvertices,1);

%Request additional outputs
md.transient.requested_outputs =
{'default','IceVolume','IceVolumeAboveFloatation','TotalSmb','TotalFloatingB
mb'};

% Solve transient
md.cluster = generic('name',oshostname,'np',4);
md.verbose = verbose('solution',false);
md = solve(md,'Transient');
```

```
launching solution sequence

Ice-sheet and Sea-level System Model (ISSM) version  4.24
(website: http://issm.jpl.nasa.gov forum: https://issm.ess.uci.edu/forum/)

call computational core:
write lock file:

   FemModel initialization elapsed time:   0.02904
   Total Core solution elapsed time:       50.3309
   Linear solver elapsed time:             40.191  (80%)

   Total elapsed time: 0 hrs 0 min 50 sec
```

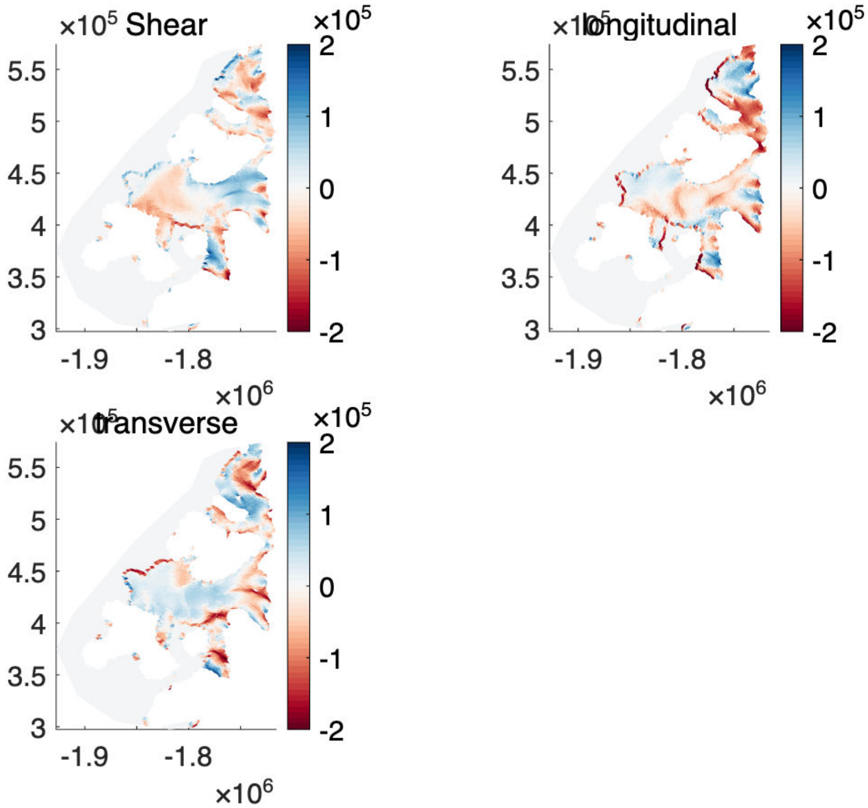
```
md.results.TransientSolution(1).Vel (md.results.TransientSolution(1).Vel ==
0) = nan;
md.results.TransientSolution(end).Vel
(md.results.TransientSolution(end).Vel == 0) = nan;
```

```
%Plot results
plotmodel(md, 'data', md.results.TransientSolution(1).Vel,'title#1',
'Velocity t=0 years (m/yr)',...
  'data', md.results.TransientSolution(end).Vel,'title#2', 'Velocity t=20
years (m/yr)',...
  'caxis#1',([0 1000]),'caxis#2',([0 1000]));
```



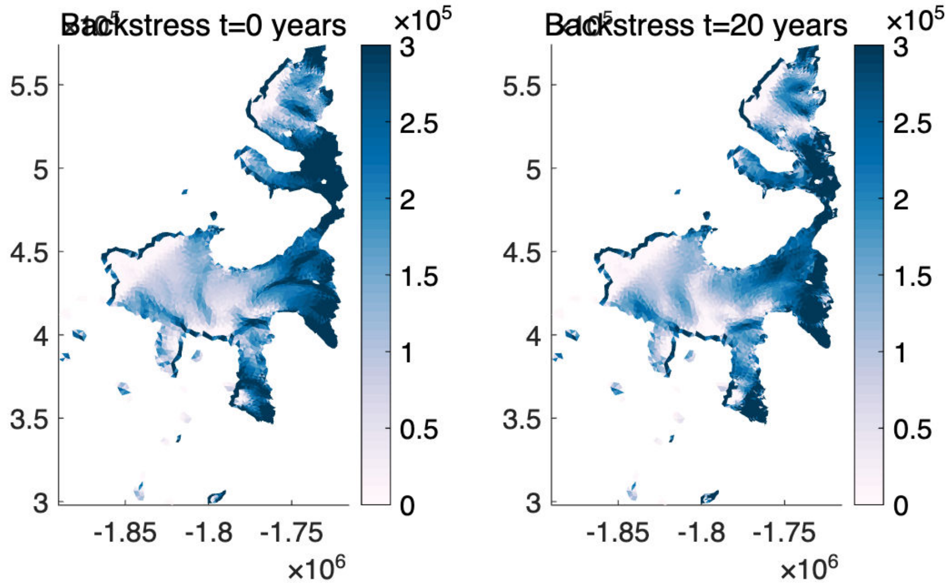

```
% try to produce the mechanical properties of an ice shelf from the
% transient run

% This is the stress and strain output of the first year before run
vx1 = md.results.TransientSolution(1).Vx;
vy1 = md.results.TransientSolution(1).Vy;
md = mechanicalproperties(md, vx1, vy1);
md.results.deviatoricstress_start = md.results.deviatoricstress;

% This is the stress and strain output of the end year after run
vxt = md.results.TransientSolution(end).Vx;
vyt = md.results.TransientSolution(end).Vy;
md = mechanicalproperties(md, vxt, vyt);
md.results.deviatoricstress_end = md.results.deviatoricstress;


%% plotting the Deviatoric Stresses for the last year
plotmodel(md,'data',md.results.deviatoricstress_start.xy,'title','Shear',...
'data',md.results.deviatoricstress_start.xx,'title','longitudinal',...
```

```
'data',md.results.deviatoricstress_start.yy,'title','transverse','caxis#all'
,[-2e5 2e5]);
colormap(brewermap(50, 'RdBu'));
```



Use the Furst_buttressing function to calculate the changes in the backstress

```
% buttressing and backstress for the initial time
vx = md.results.TransientSolution(1).Vx;
vy = md.results.TransientSolution(1).Vy;
[Kn_start, Backstress_Furst_start] = Furst_buttressing(md, vx, vy, false);
% Max buttressing

% buttressing and backstress for the end time
vx = md.results.TransientSolution(end).Vx;
vy = md.results.TransientSolution(end).Vy;
[Kn_end, Backstress_Furst_end] = Furst_buttressing(md, vx, vy, false);

% Plot them and show the difference between them
plotmodel(md,'data',Backstress_Furst_start,'title', 'Backstress t=0
years','caxis#1',[0 3e5], ...
              'data',Backstress_Furst_end,'title', 'Backstress t=20
years','caxis#2',[0 3e5])

colormap(brewermap(50,'PuBu'))
```




```
% FURST Buttressing functions

function [Kn, Backstress_Furst] = Furst_buttressing(md, vx, vy,
use_flow_direction)
%------------------------------------------------------------------------------
% FURST_BUTTRESSING:  Calculate Furst Buttressing Number and Backstress
% from given velocities (steady or transient)
%
% Inputs:
%   md                 - ISSM model structure
%   vx, vy             - Velocity fields (nodal)
%   use_flow_direction - true = flow-aligned, false = principal stress
%
% Outputs:
%   Kn                 - Furst buttressing number (0 = no buttressing)
%   Backstress_Furst   - Estimated backstress in Pa
%------------------------------------------------------------------------------

% Update stress from provided velocities
md = mechanicalproperties(md, vx, vy);
dev = md.results.deviatoricstress;

% Constants
g = md.constants.g;
rho_i = md.materials.rho_ice;
```

```
rho_w = md.materials.rho_water;

% Mesh info
n_el = md.mesh.numberofelements;
H = mean(md.geometry.thickness(md.mesh.elements), 2);
vx_el = mean(vx(md.mesh.elements), 2);
vy_el = mean(vy(md.mesh.elements), 2);

% Allocate
Kn = NaN(n_el, 1);
Backstress_Furst = NaN(n_el, 1);

% Loop through elements
for el = 1:n_el
    tau_xx = dev.xx(el);
    tau_yy = dev.yy(el);
    tau_xy = dev.xy(el);
    R = [2*tau_xx + tau_yy, tau_xy; tau_xy, 2*tau_yy + tau_xx];

    if use_flow_direction
        vec = [vx_el(el); vy_el(el)];
    else
        vec = dev.principalaxis2(el, :)';
    end

    if norm(vec) == 0
        continue;
    end
    n = vec / norm(vec);

    N = n' * R * n;
    N0 = 0.5 * g * rho_i * (1 - rho_i / rho_w) * H(el);
    Kn(el) = 1 - N / N0;
    Backstress_Furst(el) = N0 - N;
end

Backstress_Furst(Backstress_Furst == 0) = NaN;
end
```