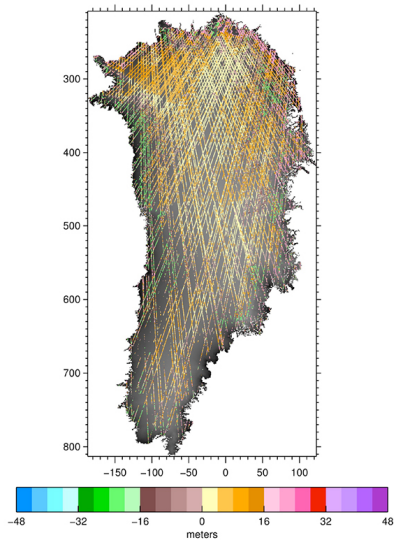# The Cryosphere model Comparison tool (CmCt): The Ice Sheet Model Comparison Tool for Greenland and Antarctica using various Altimetry, and GRACE Satellite Data

Erika Simon[1], Sophie Nowicki[2], Lori Tyahla[3], Jack Saba[4], John Dimarzio[3], Steven Price[5], Jenni Bonin[6], Craig Johnson[1], Bryant Loomis[2], Michael Croteau[7]

GRACE Mascon Total Mass Change

GRACE Delta cm water equiv., 2004.0-2016.0

meters

cm/yr water
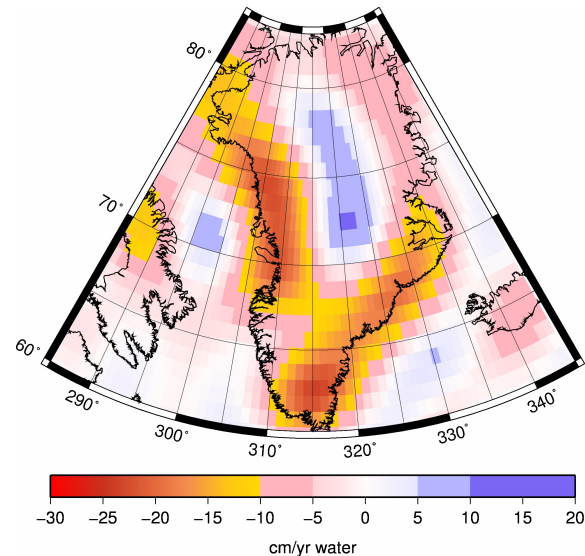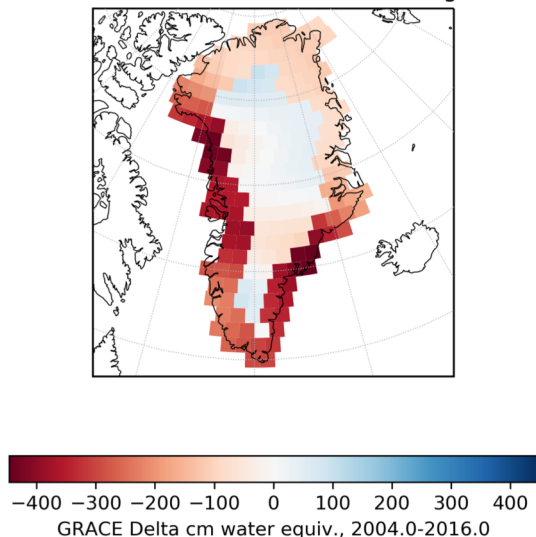
[1] Innovim LLC. Greenbelt MD, [2]NASA GSFC Greenbelt MD,
[3] SGT, Inc. Greenbelt MD, [4]SSAI, Inc. Greenbelt MD , [5]LANL, [6]University of Southern Florida, [7]University of Colorado

Outline

- *Motivation*

- *Concept*

- *CmCt Website*

- *Submission and Output*

- *Moving Forward*
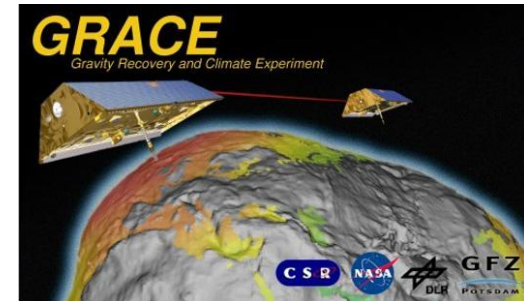
Motivation

- There are currently over 2 decades of large-scale satellite observations over Greenland and Antarctica:

- ERS1/2:   1991 - 2003
- ICESat: 2003 - 2009
- GRACE: 2003 - 2016
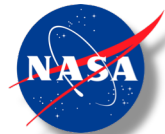- Envisat: 2002 - 2012

- Future missions will extend these observational time series:

- ICESat-2:   2018 – 20??
- GRACE Follow-On: 2018 – 20??
- GRACE2   2020's - ?

Concept

- Run ice sheet model over some specified time period for which remote sensing (e.g. ICESat and / or GRACE) observations exist

- Process model output for comparison to these observations

- Process observations for comparison to model output

- Evaluate model performance relative to observations (e.g):

  - ICESat, ERS-1, ERS-2, Envisat : ice sheet surface elevation
  - GRACE : mass trends

- Calculate various qualitative and quantitative metrics to evaluate model performance

CmCt Website

- The Cryosphere model Comparison tool (CmCt) is a web-based data validation tool that has been developed in order to facilitate ice sheet model analysis.

- Available at https://ggsghpcc.sgt-inc.com/cmct/

- **ICESat** laser altimetry data and **ERS-1, ERS-2, Envisat** radar altimetry for ice sheet *surface elevation*

- **GRACE SH and Mascon solution** for *mass trend estimation*
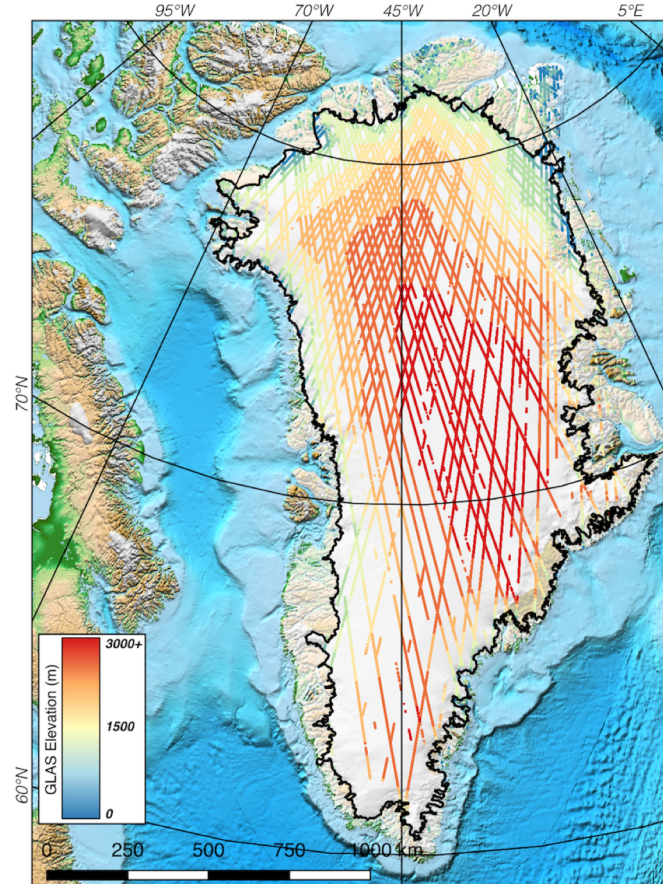
- Evaluate model performance

CmCt Website

CmCt ICESat Comparison

Input 5km model of elevations
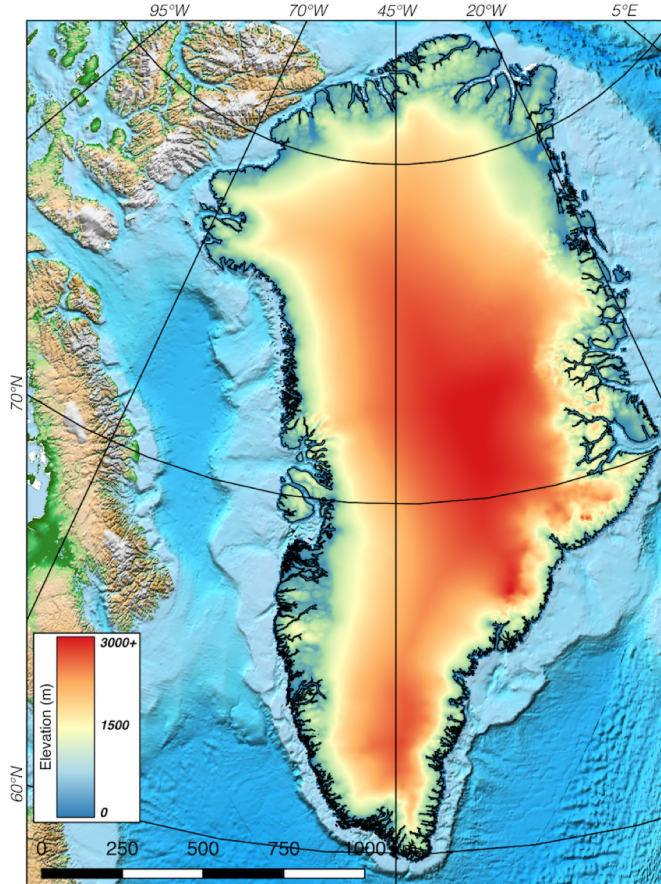
ICESat elevations from L2D campaign

CmCt ICESat Comparison

After submission, user will receive an email with a link to download the data as a zipped tar file. It will contain:

- Log file.

- Record list file.

- Netcdf grid.

- Histogram file.

CmCt ICESat Comparison
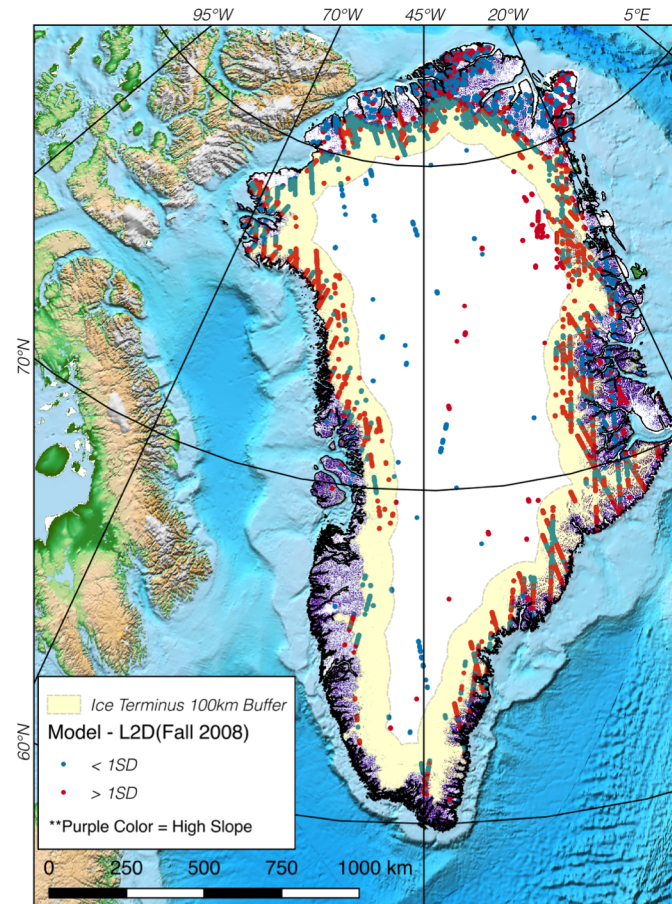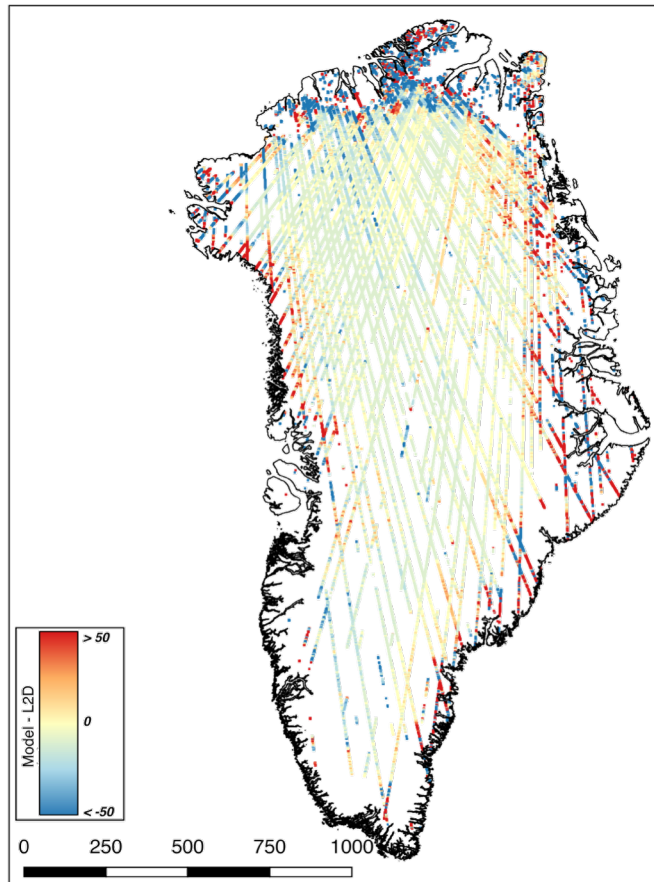
- Log file.

- **Record list file**

- Netcdf grid.

- Histogram file.

CmCt ICESat Comparison
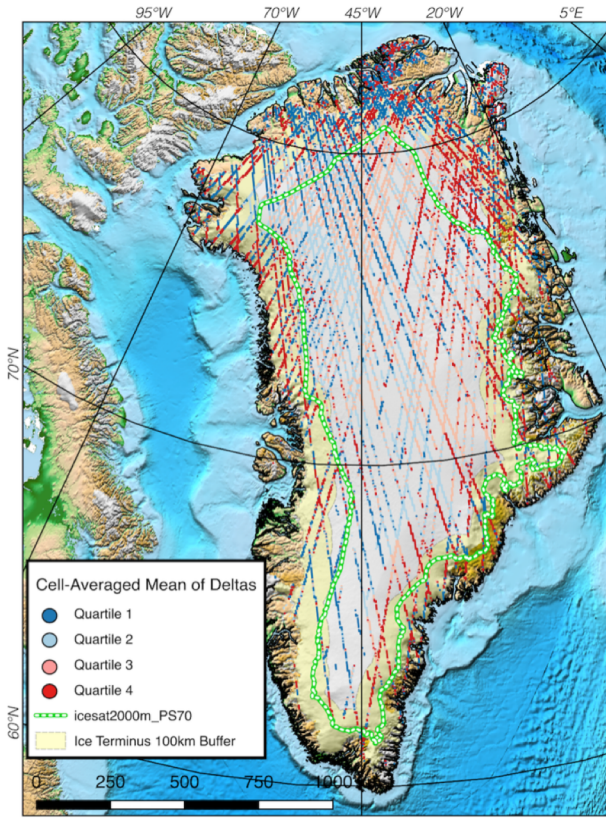
Mean of the model/observation deltas
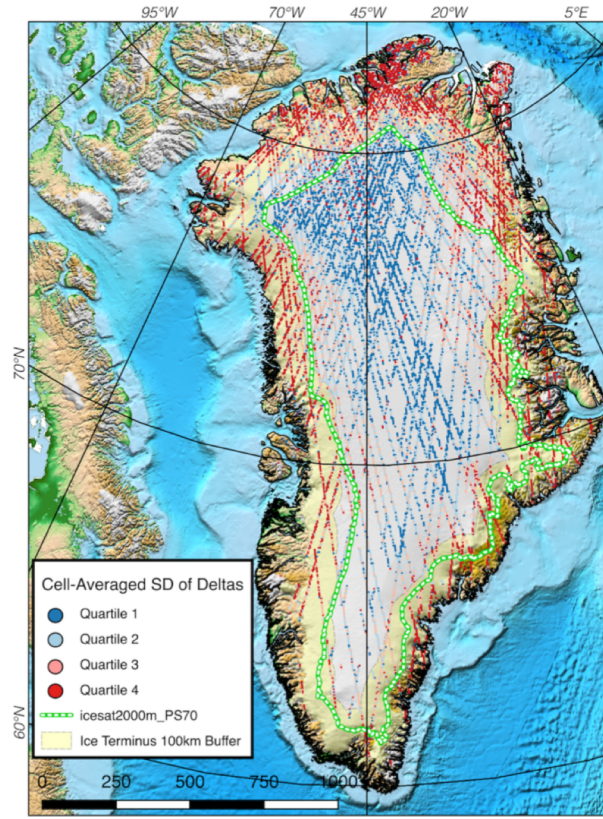
Standard deviation of the model/observation deltas.

NetCDF with mean and standard deviations of Deltas per cell.

- Log file.

- Record list file.

• Netcdf grid.

- Histogram file.

CmCt ICESat Comparison
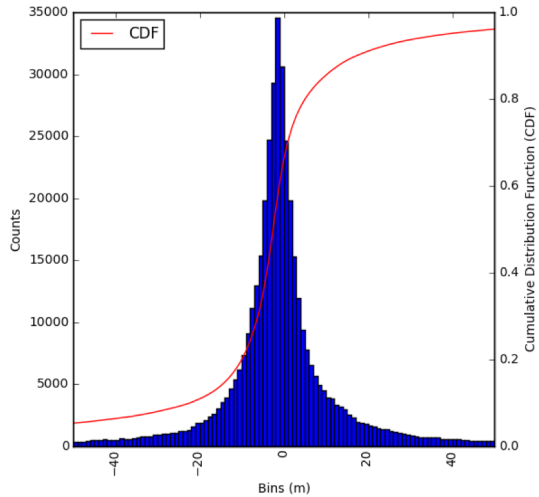
Histogram text file with 1 meter bins.

- Log file.

- Record list file.

- Netcdf grid.

• Histogram file.

GRACE Spherical Harmonics Comparison

- Convert the model data to a more "GRACE-like" resolution.
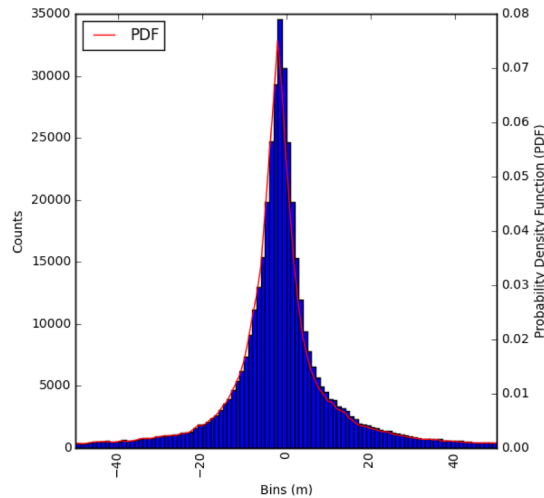
- GRACE sees only mass anomalies.

- Calculate the mass change in each individual year and change trend over the 2003-2012 period.

- The resolution of the processed model output is further reduced. The uniform grid is being converted to spatial harmonics at degree-and-order 60.

- Calculate various qualitative and quantitative metrics to evaluate model performance

GRACE SH Comparison Total Mass Change

GRACE

RACMO
SMB-only

SMB-only

SMB+FF

GRACE–thk.2003–2012.Total_Mass_Change.slopes

cism–thk.2003–2012.AlbFF.60x60.slopes

cism–thk.2003–2012.AlbSMB.60x60.slopes

cism–thk.2003–2012.RACMO.60x60.slopes

cm/yr water
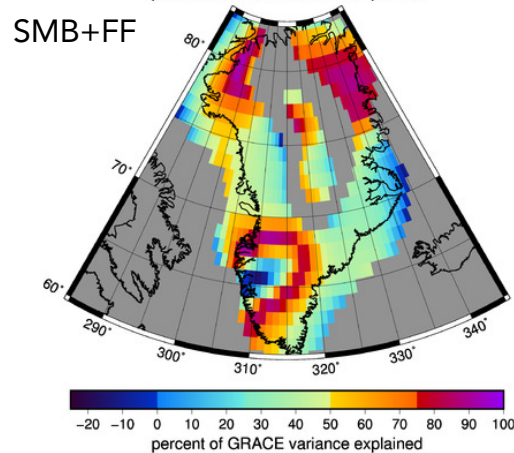
Total mass change trend over the 2003-2012 period

Annual Basin Averages over Greenland

- □ SMB-only Sim
- ● SMB+FF Sim
- ▼ RACMO SMB-only Sim
- ◆ GRACE

Gigatons of total mass change

Observed and modelled, cumulative, whole-ice-sheet mass trends
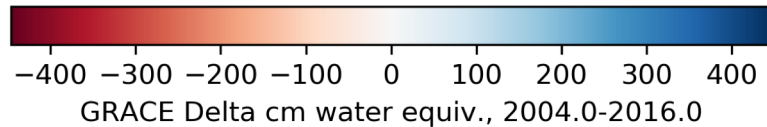
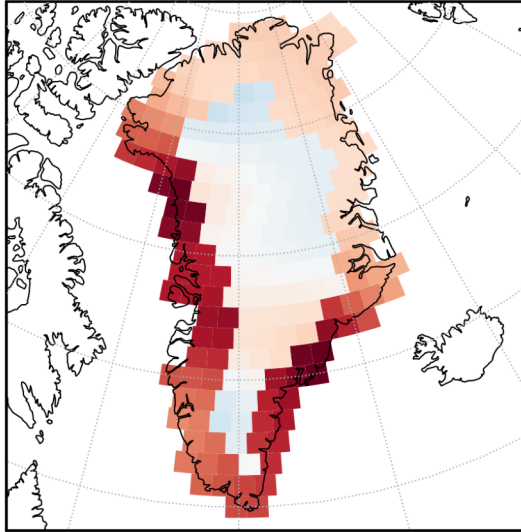# GRACE SH Comparison Percent Variance
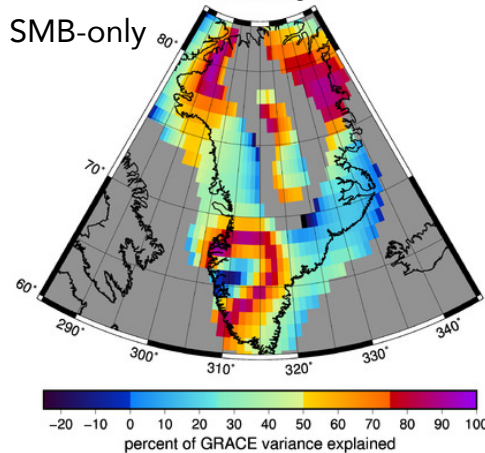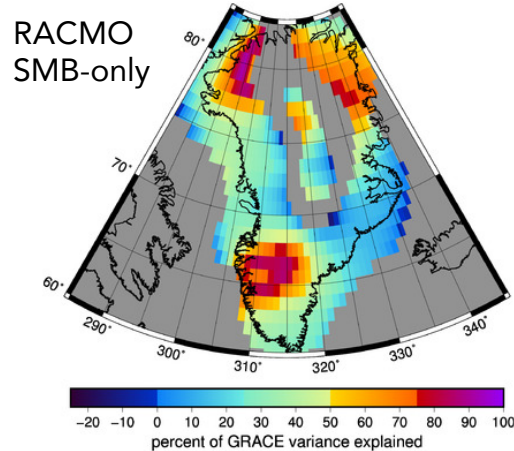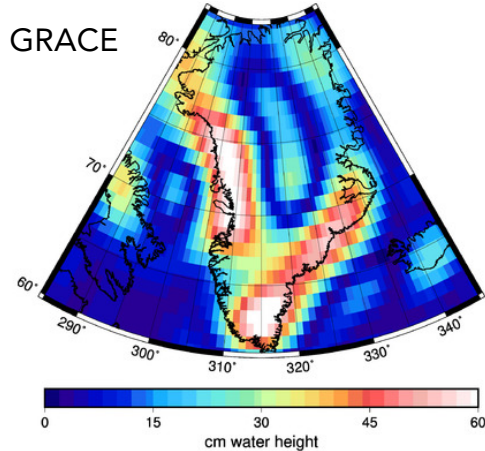
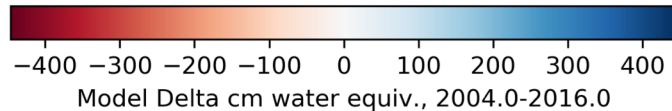Grace percent variance plot and percent variance explained by the various models.
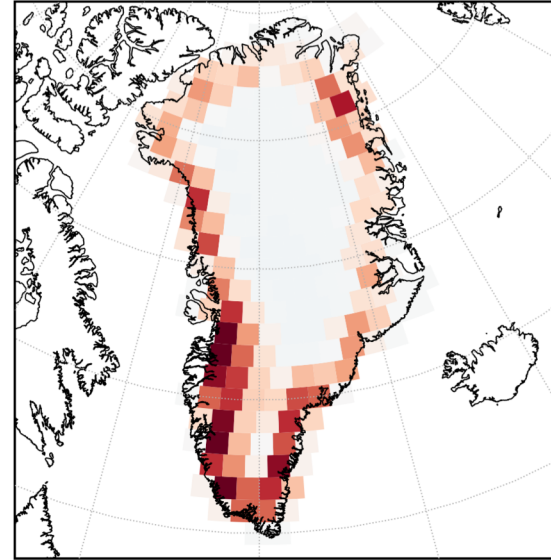
GRACE MASCON Comparison

GRACE Mascon Total Mass Change

Ice Sheet Model Mascon Total Mass Change

GRACE Delta cm water equiv., 2004.0-2016.0

Model Delta cm water equiv., 2004.0-2016.0

Other Available Datasets

- Datasets from the ERS-1, ERS-2, and ENVISAT are also available for comparison.

- ERS and ENVISAT had a lower pulse rate and shorter repeat period, so data is sparser than ICESAT.

- However, they operated continuously to get monthly repeats over a long time span.
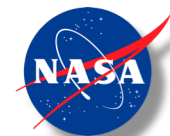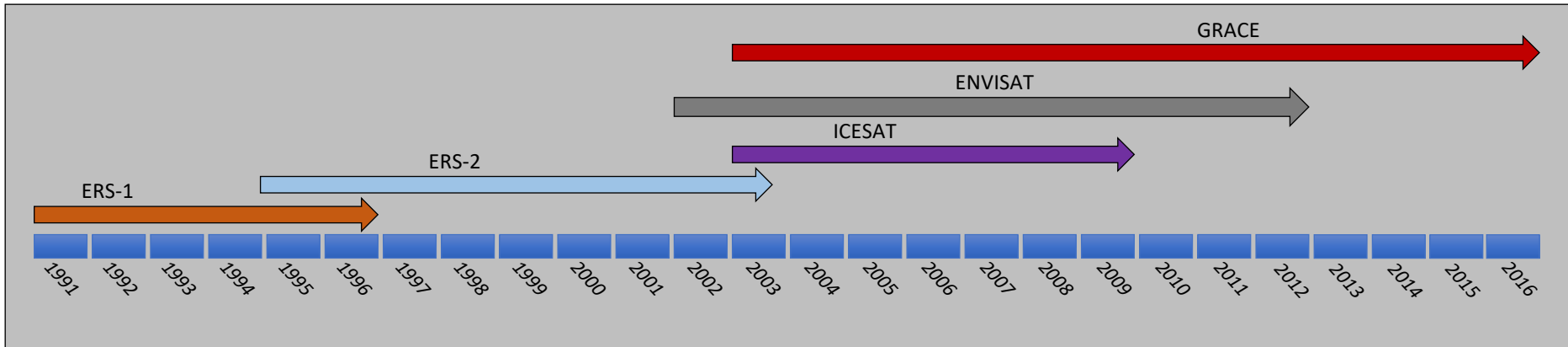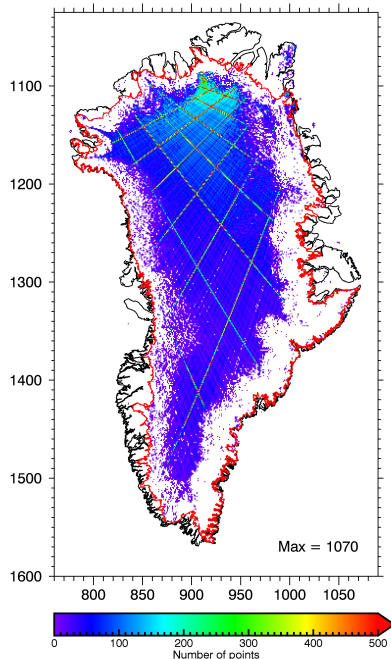
Available Radar Altimetry Datasets

GLAS (L3C, 2005-05-20 to 2005-06-23)
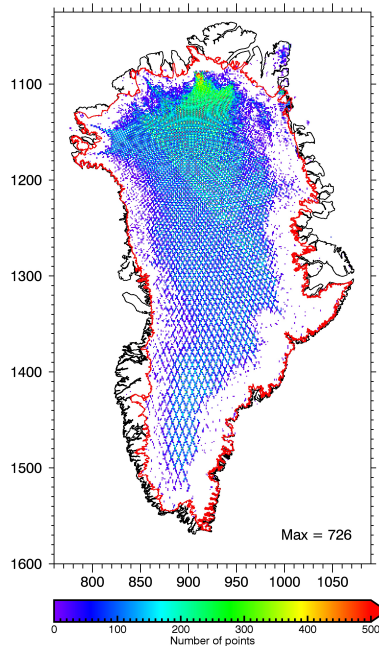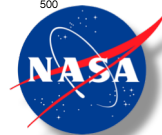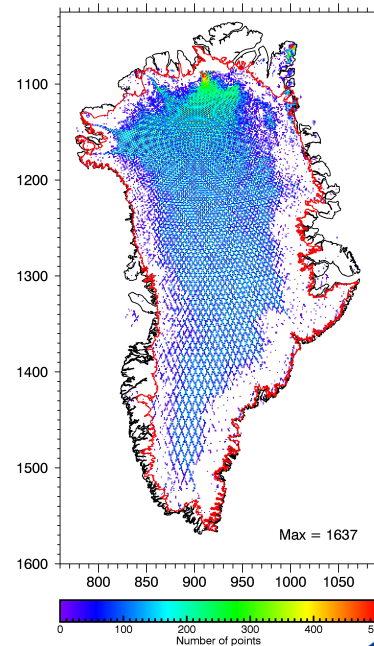Number of points per tile, 5 km grid
Max = 156
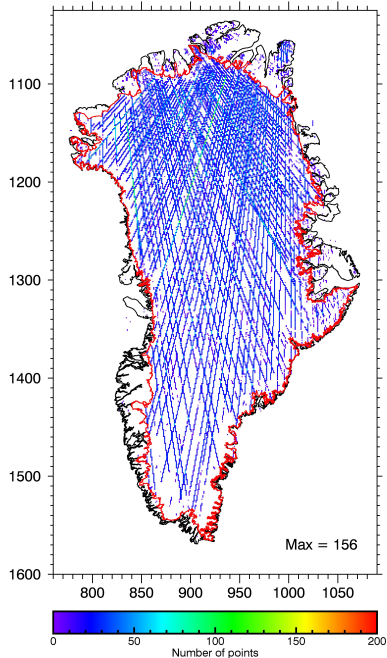
ERS1 , 1994
Number of points per tile, 5 km grid
Max = 1070

ERS2, 1998
Number of points per tile, 5 km grid
Max = 726

Envisat, 2007
Number of points per tile, 5 km grid
Max = 1637

Moving Forward

- Adding other datasets (Ice velocity, Hi-Res Airborne Altimetry from IceBridge, Follow-on missions, SMB and Velocity comparisons)
- Quality Control capabilities:
    - Quick QC of data before submission
    - Check for ISMIP6 requirements (names, units, etc.)
    - Regridding to ISMIP6 requirements

- Multiple model submission and model to model comparison tools (Taylor diagram, etc.)
- Batch upload
- Plotting and interactive plotting capabilities
- Regional Comparisons
- More flexibility in the space and time intercomparing
- What is of interest to the community?