

Title:	Using GRACE to evaluate change in Greenland's ice sheet
	Part I: Download, import and map GRACE data
	Part II: View and animate seasonal ice sheet mass changes
	Part III: Calculate and visualize annual ice sheet mass changes
	Part IV: Calculate annual mass loss rate
Product Type:	Curriculum
Developer:	Helen Cox (Professor, Geography, California State University, Northridge): helen.m.cox@csun.edu Laura Yetter (Research Asst., Institute for Sustainability, California State University, Northridge)
Target audience:	Undergraduate/Graduate
Format:	Tutorial (pdf document)
Software requirements* :	ArcMap 9 or higher (ArcGIS Desktop) (Parts I, II, III, IV), ArcGIS Spatial Analyst (Parts III, IV)
Data:	All data required are obtained within the exercise.
Estimated time to complete:	All parts: 5.5 hrs
	Part I: 2 hrs.
	Part II: 0.5 hrs.
	Part III: 1.5 hrs. - 2 hrs.
	Part IV: 1 hr.
Alternative Implementations:	<ul style="list-style-type: none"> • Part I provides a standalone exercise producing a map of ice sheet mass • Parts I and II together provide a standalone exercise producing an animation of seasonal change in ice sheet volume • Parts I, II and III together provide a standalone exercise to produce animations of seasonal and annual ice sheet volume changes • Completing all parts (I through IV) include calculations of the total decadal mass change and corresponding sea level rise
Learning objectives:	Part I: <ul style="list-style-type: none"> • Understand the GRACE satellites and how they measure gravity • Understand the application of GRACE to measure ice sheet volume • Download, import and map GRACE data
	Part II: <ul style="list-style-type: none"> • View GRACE data in ArcGIS • Create an animation of seasonal ice sheet changes
	Part III: <ul style="list-style-type: none"> • Create an animation of annual ice sheet volume • Generate images to show annual changes in ice sheet mass • Calculate change in ice sheet mass over past decade
	Part IV: <ul style="list-style-type: none"> • Compute annual and decadal ice sheet mass change • Compute sea level rise

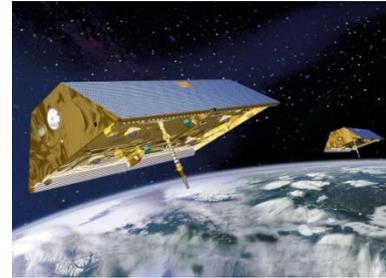
*Tutorials may work with earlier versions of software but have not been tested on them

Using GRACE to evaluate change in Greenland's ice sheet

Part II: View and animate seasonal ice sheet mass changes

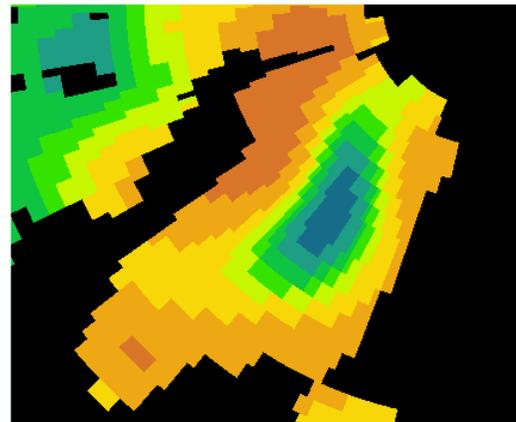
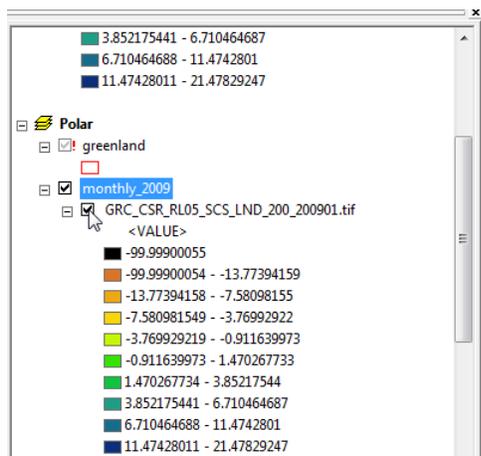
Objectives:

- View GRACE data in ArcGIS
- Create an animation of seasonal ice sheet changes



In this exercise we will create an animation of the month by month changes in Greenland's ice sheet allowing us to view the seasonal changes that occur.

1. Open the GRACE .mxd file that you created in Pt I. Make sure all the links are resolved so that the data is projected and displayed correctly.



2. Now add all the other months of 2009 to this data frame and set the symbology to be the same. (Do this by right clicking -> Properties -> Symbology -> Classified -> Import -> navigate to the first image. OK. OK.) This will take the color scheme from the first month and use it for the other months. (If you receive a message that a histogram could not be generated due to too many unique values you should select Unique Values > yes first and then switch back to classified.)

We want to see visually how the ice mass changes from month to month. Why is it important that the symbology is exactly the same for each?

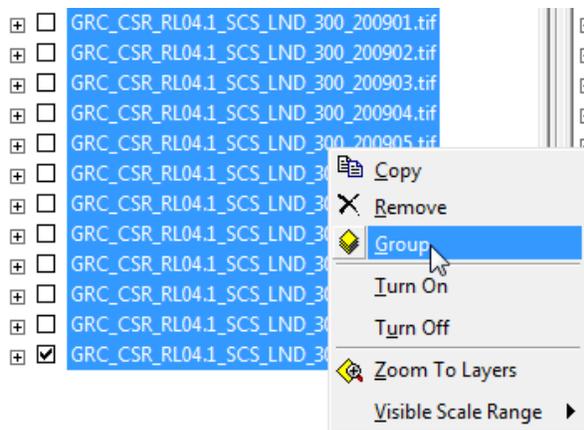
(To preserve the symbology so that it is the same the next time you open the images in ArcGIS, right click on the image name in the Table of Contents and then Save as Layer File->Check the file name (edit out the .tif and just use .lyr as the extension) and the file location and click Save. In future, open the lyr file in ArcGIS and it will automatically be linked to the .tif data.)

Arrange the images in order with the earliest (January) on top and have all images displayed (one under the next):

- ☐ **Polar projection**
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200901.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200902.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200903.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200904.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200905.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200906.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200907.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200908.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200909.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200910.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200911.tif
- ☑ GRC_CSR_RL04.1_SCS_LND_300_200912.tif

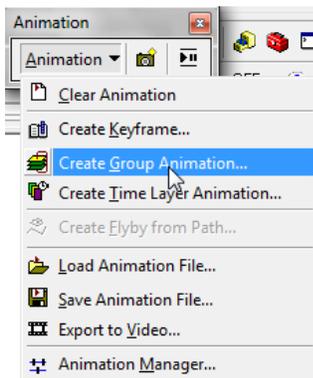
Unclick the images one by one starting at the top to see each month in turn. Comment on what you observe? How does the ice mass change throughout the year?

3. Group the months so that you can animate through them one at a time. To create the animation, first create a group layer of all the months by selecting all the layers, then right clicking and selecting “Group”.

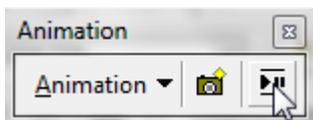
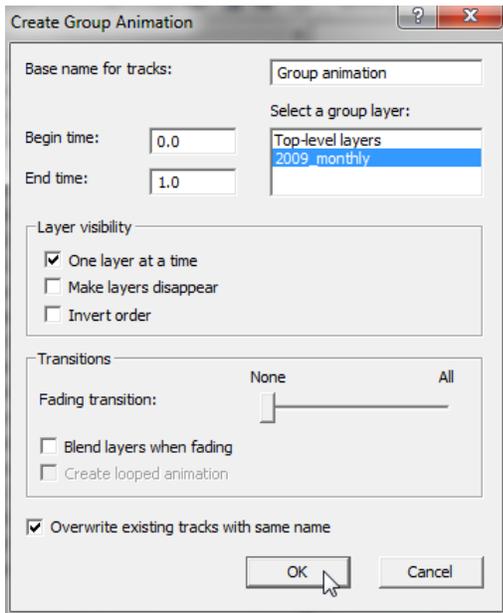


Give your group layer a name (like 2009_monthly).

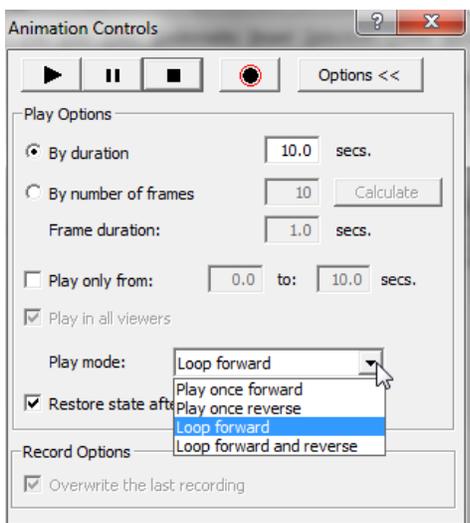
4. Create an animation through the months. Display the animation toolbar (Customize -> Toolbars -> animation). On the Animation toolbar, select “Create Group Animation”:



Select your group and press OK:



Brings up the play controls. Under “Options” you can choose to play once or loop:



Play through the animation.

Which month has least ice mass? Which has most?