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| Title: | Mapping snow cover using MODIS |
| | Part I: The MODIS Instrument |
| | Part II: Normalized Difference Snow Index |
| | Part III: Quality Control Procedures and Masks |
| | Part IV: Apply masks to create a corrected snow map |
| Product Type: | Curriculum |
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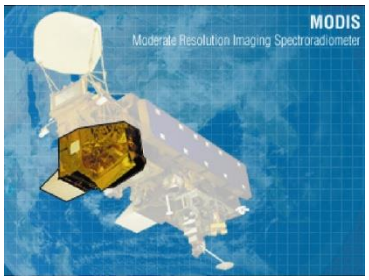
| Target audience: | Undergraduate |
| Format: | Tutorial (pdf document) |
| Software requirements*: | ArcMap 9 or higher (ArcGIS Desktop) (Parts II, IV),<br>ERDAS Imagine 2010 or higher (Parts I, II, III, IV) |
| Data: | All data required are obtained within the exercise. |
| Estimated time to complete: | All parts: 7 hrs. |
| | Part I: 2 hrs. |
| | Part II: 2 hrs. |
| | Part III: 2 hrs. |
| | Part IV: 1 hr. |
| Alternative Implementations: | • Parts I and II together provide a standalone exercise producing a snow map<br>• Parts I, II and Part IV (starting at #2) together provide a standalone exercise producing a snow map and comparing it to one produced by NASA<br>• Completing all parts (I through IV) produce a snow map with corrections that is compared to one produced by NASA |
| Learning objectives: | Part I:<br>• Learn about the MODIS instrument and MODIS data<br>• Download MODIS data |
| | Part II:<br>• Learn about the Normalized Difference Snow Index (NDSI)<br>• Create a Model in ERDAS Imagine to calculate the NDSI<br>• Create a snow map |
| | Part III:<br>• Learn how to identify water and forests where snow could be misidentified<br>• Create a Normalized Difference Vegetation Index (NDVI) image<br>• Create masks that will be used to eliminate water and dark forests from the NDSI |
| | Part IV:<br>• Apply the water, forest, and NDVI masks to eliminate water and forest from the snow map<br>• Re-project the snow map and compare to a MODIS snow product map |

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




# Mapping snow cover using MODIS
# Part III: Quality Control Procedures and Masks

**Objective**

- **Learn how to identify water and forests where snow could be misidentified**
- **Create a Normalized Difference Vegetation Index (NDVI) image**
- **Create masks that will be used to eliminate water and dark forests from the NDSI**

**Identifying Water and Forests**

Sometimes water and dense forests are confused with snow, because they have a similar NDSI reading to snow. In order to avoid this problem we need to remove all pixels that are water and dark forest from the snow map. Water can be identified by examining band 2 (0.841-0.876 µm NIR). All snow-mapped pixels with a reflectance of less than 11% in band 2 can be considered water and will be eliminated. Forest can be identified by examining band 4 (0.545- 0.565 µm green). Pixels classified as snow but with a reflectance of less than 10% in band 4 can be considered non-snow forest and will be eliminated. However, some forests will be snow covered. To identify those areas the NDVI (Normalized Difference Vegetation Index) is examined. If the NDVI is about 0.1 a pixel should be mapped as snow even if the NDSI is less than 0.4.

The following masks will be created in this exercise and used in Exercise 4 to make the appropriate corrections to the snow map.

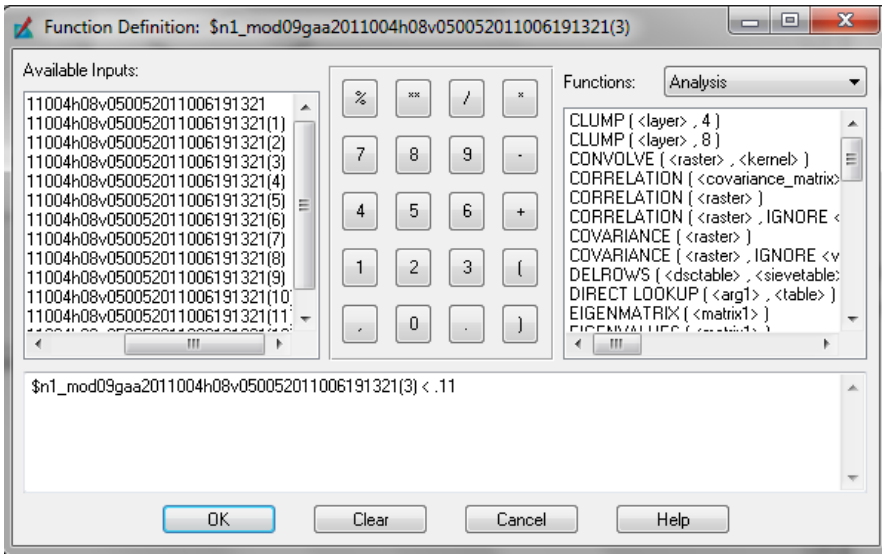
- snow if the NDSI is >= 0.4 (snow mask already created in Exercise 2)
- water if band 2 is < 0 .11
- forest if band 4 is < 0 .10
- snow-forest if the NDVI = ~0.10

**Model Maker Tips:**

If you will be running the model more than once, check the box “delete if exists” for the output raster. If you do not need to keep the output raster and it is just an intermediate result consider making it a temporary raster only.

**1. Water Mask**

Create a new model in Model Maker. Use the stacked MODIS raster as an input and write a function to generate a raster with values of 1 (“TRUE”) if band 2 < .11 and 0 (“FALSE”) otherwise. This is your water mask. **Be careful not to confuse bands and layers**. Your output mask will only have values of 0 or 1 so make the data type unsigned 8-bit.



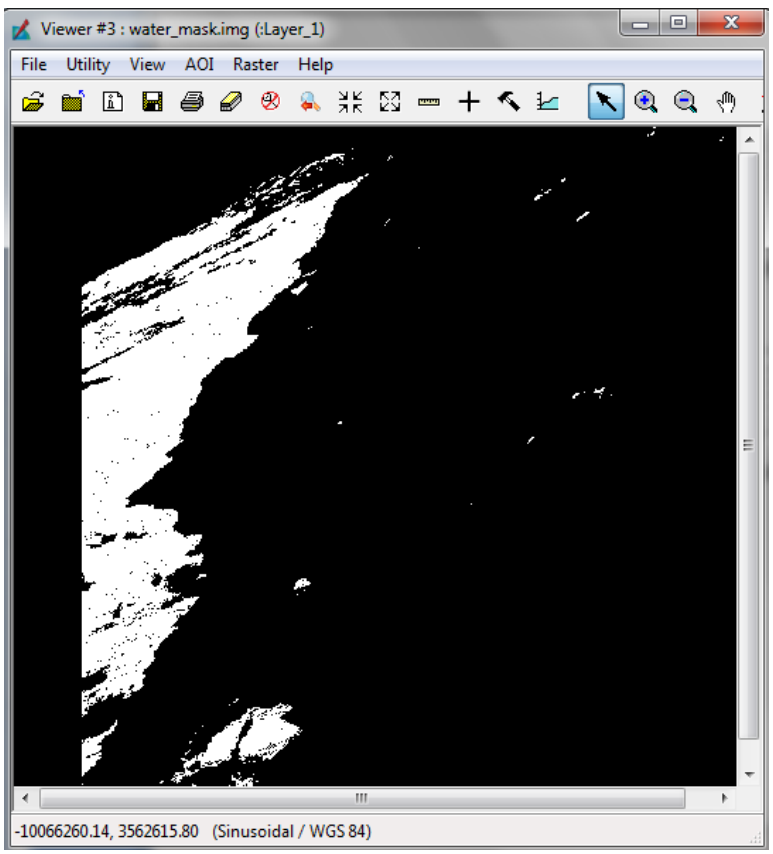




**Figure 1. Water mask for January 4, 2011. White areas indicate water.**

## 2. Create a Forest Mask

The forest mask can be added to the same model as the water mask.

Use the stacked MODIS raster as an input and write a function to generate a raster with values of 1 ("TRUE") if band 4 < .10 and 0 ("FALSE") otherwise. This is your forest mask. Run the model and examine the results.

Inside the function you should have an expression like:
$n4_mod09gaa2011004h08v050052011006191321(5) <.10

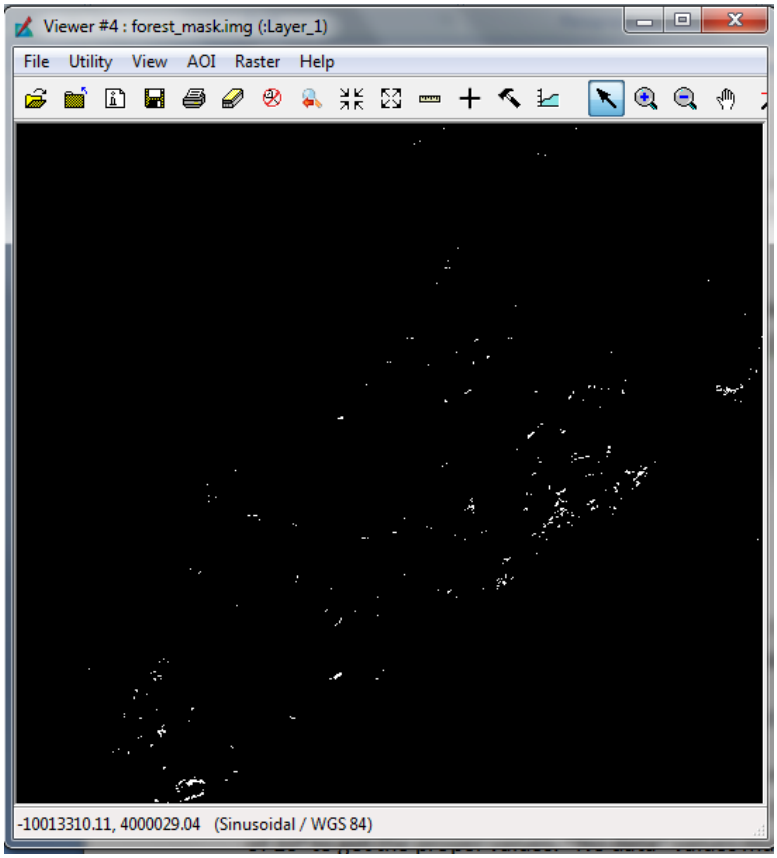



**Figure 2. Forest mask for January 4, 2011.**

Save the water and forest masks model and results.

### 3. Calculate the NDVI

Use Model Maker in Imagine to calculate the NDVI. Use the MODIS stacked layer as the raster input, and calculate the NDVI using bands 2 (0.841- 0.876 µm NIR) and band 1 (0.620- 0.670 µm red) as follows:

NDVI = (MODIS band 2 - MODIS band 1) / (MODIS band 2 + MODIS band 1)

(Remember that the pixel values in the reflectance image are whole numbers with a range from -100 to 16000 and pixels of no data have a value of -28672. Data must be shifted by 100 and scaled by a factor of $10^4$ to get the proper values. "No data" values must also be left out of the equation so they do not skew the results.)

For the numerator create the equation:

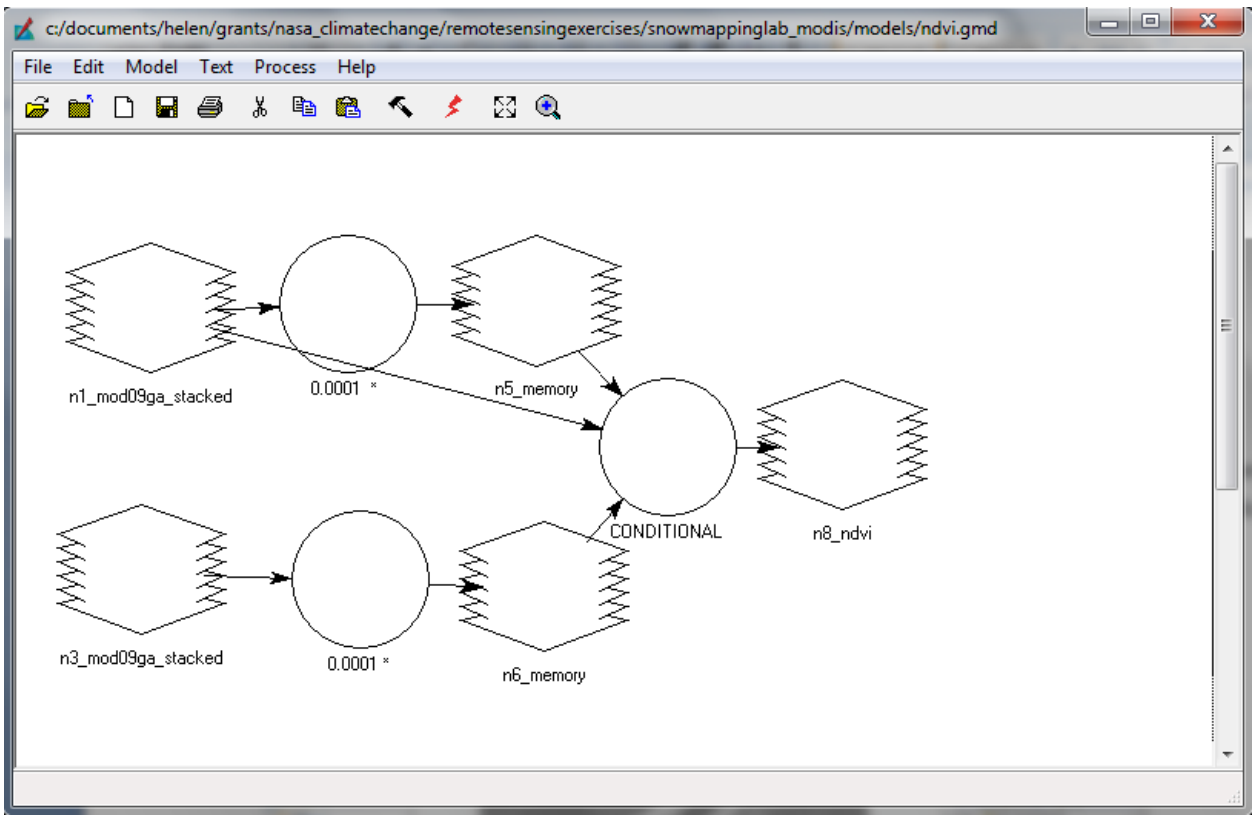
(0.0001 * (band 2 + 100) - 0.0001* (band 1 + 100))

denominator:

(0.0001 * (band 2 + 100) + 0.0001 *(band 1 + 100))

Save the output rasters for the numerator and denominator as temporary rasters.

Now input the numerator and denominator rasters, together with the MODIS stacked layers into a function and create an NDVI output raster. Be careful to check for “No Data” values and do not divide by zero). Your model should look like the one below and be very similar to your NDSI model except that you are using different bands in this calculation.




Save your Model and your NDVI raster image.

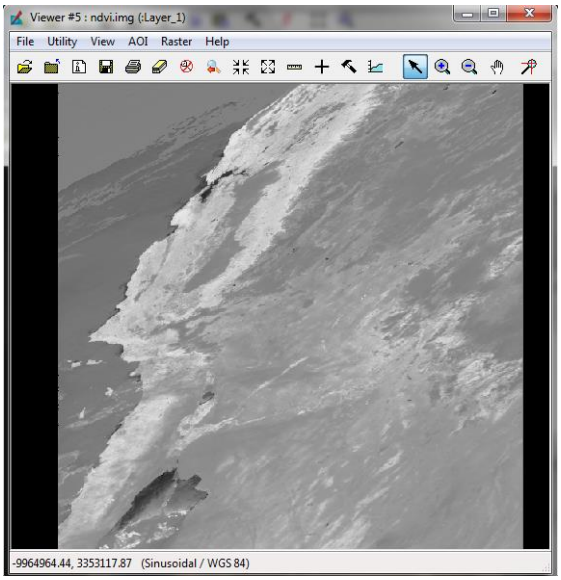


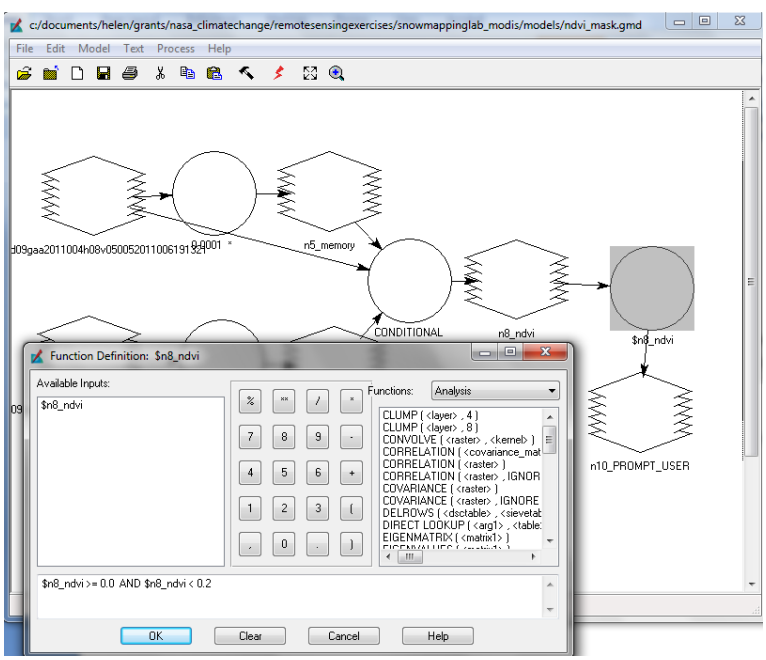

**Figure 3. NDVI for January 4, 2011.**

## 4. Create a snow-forest mask using the NDVI

Identify only those pixels that have an NDVI value of about 0.10 (let's say between 0 and 0.2) to identify snow covered forests. Add a function to the NDVI model and create a statement which checks for:

NDVI >= 0.0 AND NDVI < 0.2

If this is TRUE, then raster output should be 1, else output raster value is 0. This raster is the NDVI mask. Check the "Delete if exists" box on the ndvi and output rasters before running the model otherwise you will have to do this manually each time.



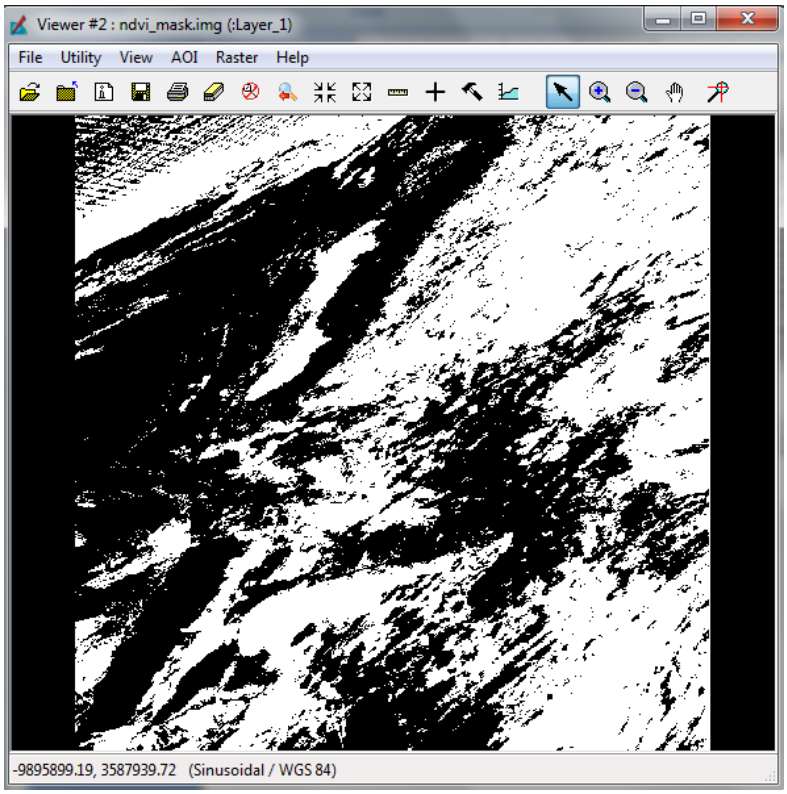



**Figure 4. NDVI mask for January 4, 2011.**

Save your models and results.