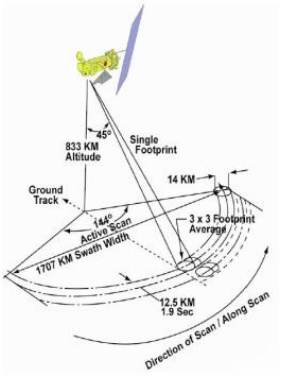
Title:	Mapping Sea Ice using a Microwave Imager/Sounder (SSMIS)
	Part I: Download and import SSMIS data
	Part II: Calculate and Map Sea Ice Concentration
	Part III: Make corrections to sea ice map and compare to NASA product
Product Type:	Curriculum
Developer:	Helen Cox (Professor, Geography, California State University, Northridge): helen.m.cox@csun.edu Laura Yetter (Research Asst., Institute for Sustainability, California State University, Northridge)
Target audience:	Level 4 Graduate or undergraduate with some experience in remote sensing
Format:	Tutorial (pdf document)
Software requirements*:	ArcMap 9 or higher (ArcGIS Desktop) (Parts I, II, III), ArcGIS Spatial Analyst (Parts II, III), ERDAS Imagine 2010 or higher (Part I), Microsoft Excel 2003 or higher (Part II)
Data:	All data required are obtained within the exercise.
Estimated time to complete:	All parts: 7 hrs
	Part I: 2.5 - 3 hrs.
	Part II: 2.5 - 3 hrs.
	Part III: 1 hr.
Alternative Implementations:	• Parts I and II together provide a standalone exercise producing a sea ice concentration map • Parts I, II and Part III (starting at #4) together provide a standalone exercise producing a sea ice concentration map and comparing it to one produced by NASA • Completing all parts (I through III) produce a sea ice concentration map with corrections that is compared to one produced by NASA
Learning objectives:	Part I: • Understand relationship between sea ice and climate • Understand concept of brightness temperature • Learn about the SSMIS instrument and use of microwave data in remote sensing • Download, import and map SSMIS data in ERDAS Imagine and ArcGIS
	Part II: • Understand concepts of first year and multiyear ice • Understand and employ tie points for calibration • Build a model to calculate first year and multiyear ice concentration • Generate a map of total sea ice concentration
	Part III: • Apply quality control procedures to correct for spurious ice misclassification • Compare derived sea ice concentration map with NASA product

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



Mapping Sea Ice using a Microwave Imager/Sounder (SSMIS) Part III: Make corrections to sea ice map and compare to NASA product

Objective:

- Apply quality control procedures to correct for spurious ice misclassification
- Compare derived sea ice concentration map with NASA product

1. Weather effects over the open water

Weather effects like clouds, rain, and large waves can increase the brightness temperature values of areas of open water and cause them to be misclassified as sea ice. To correct for this a Weather Filter is applied as follows:

If GR(37/19) is greater than 0.05 or GR(22/19) is greater than 0.045, the sea ice concentration is set to zero, except for satellite F-17 in the southern hemisphere (if GR(37/19) is greater than 0.053 reset the cell to 0 (NOAA, 2012). These GR thresholds effectively eliminate most of the weather contamination. (National Oceanic and Atmospheric Administration [NOAA], 2012) (http://nsidc.org/data/docs/daac/nasateam/index.html)

Con (gr37/19 < 0.05, CT, 0) **output name: CTweatherFilter1.tif**

Con (gr22/19 < 0.045, CTweatherFilter1, 0) **output name: CTweatherFilter2.tif**

2. Ocean Climatology Masks

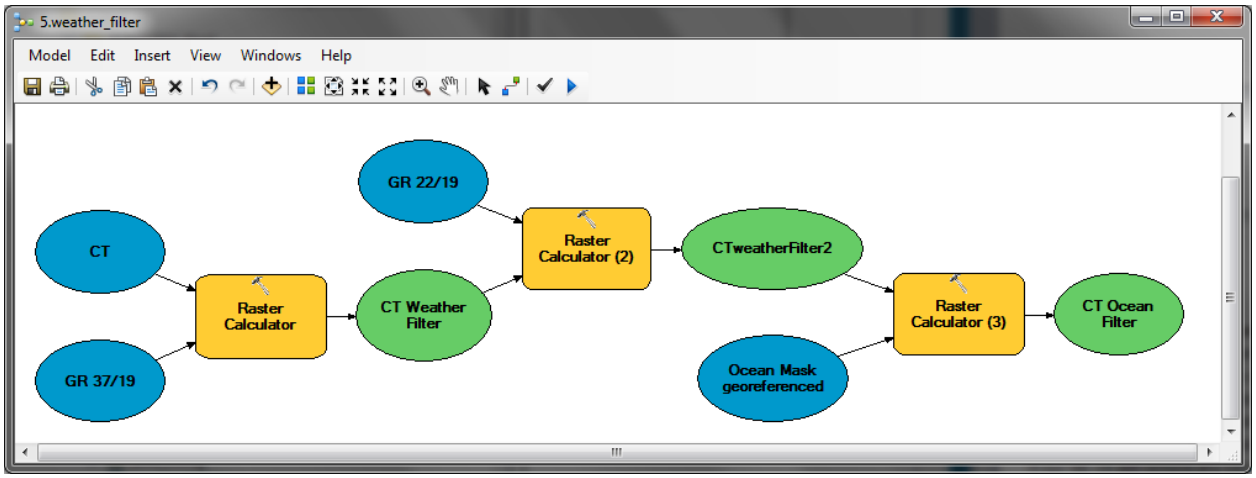
The Ocean Climatology Mask is another filter that is applied to eliminate areas that may be misclassified as sea ice due to extreme weather (NOAA, 2012). These masks classify areas as water, ice, coast, land and lakes and are used to designate the maximum sea ice extent and eliminate ice misclassified along the coastlines. In the northern hemisphere the ocean masks are created monthly based on observations of the maximum sea ice extent for that month for all prior years to 1979. Any pixels that are classified as sea ice outside the maximum sea ice extent have their ice concentrations reset to zero. In the southern hemisphere a value of 275 K in the sea surface temperature (SST) (Levitus and Boyer 1994) is used to determine the sea ice extent.

The ocean mask is a thematic raster with classes as shown below:

	Ocean Mask Values
0	Water
1	Ice
2	Coast
3	Land
4	Lake

Create a Conditional Statement in your model: “if sea ice is beyond the <month> (in this example month is August) average maximum mask delete it”

Con (ocean mask = = 1, CTweatherFilter2,0) **output name: CT_OceanFilter.tif** (must add .tif)



3. Land-spillover effect

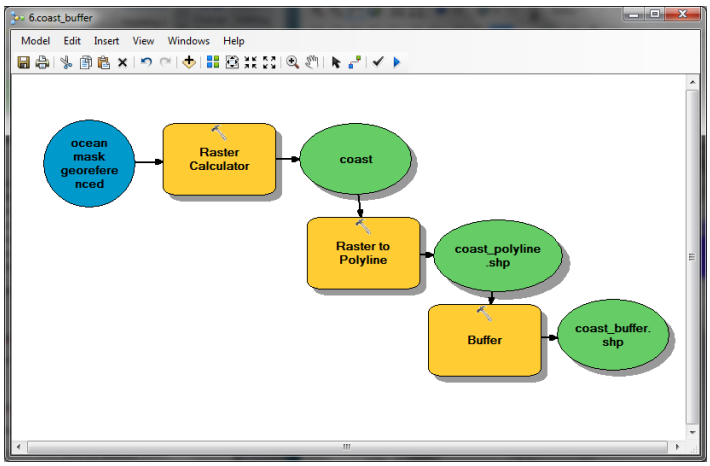
The results of a sea ice concentration map will often show sea ice along the coast of areas that do not contain ice. This happens because the spatial resolution of the satellite is 25 km and land and ocean are sometimes observed in the same cell. Land emits a brightness temperature value similar to sea ice and the ocean emits a lower brightness temperature. Therefore land/ocean mixed cells can give a brightness temperature value that is misclassified as sea ice. This is called the Land-spillover effect. Technical procedures such as ocean climatology masks can be used to correct for this, but can be quite complex. In our lab we will remove any ice with 50 km (2 cells) of the coast (Maslanik et al 1996).

Create Conditional Statement: From the ocean mask create a new raster of just the Coast (value 2)

Con(ocean mask == 2, 1, 0) **output name: coast**

Create a polyline from the coast raster **output name: coast polyline**.

Create a buffer for the polyline by 50 km and dissolve all **output name: coast buffer**.

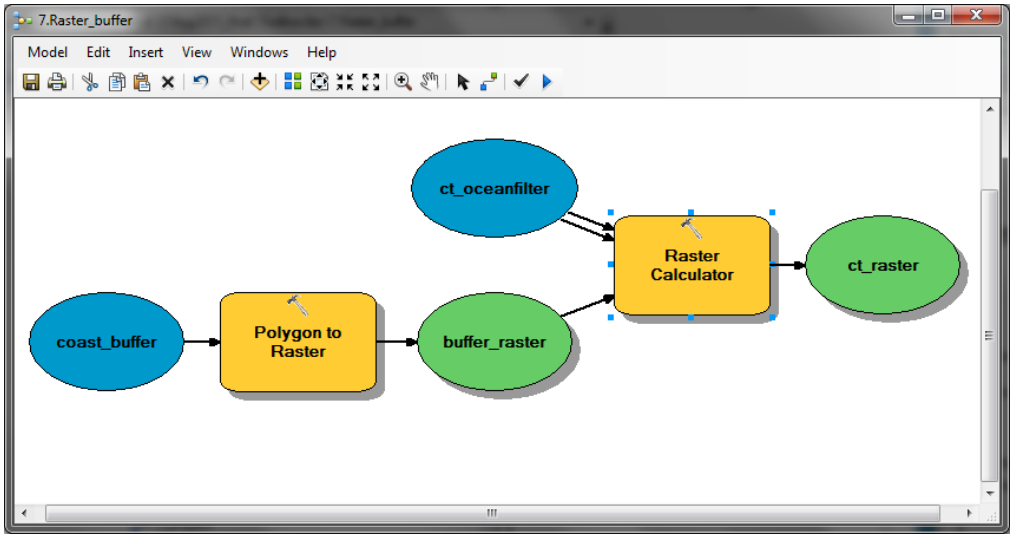


Convert coast buffer polygon to raster layer with the cell size the same as CT ocean filter **output name: buffer raster**

Create conditional statement: to remove all ice within the buffer

Con (IsNull(buffer_raster), ct ocean filter,0) **output name: ct_raster**

(This says if the ice concentration pixel is outside the buffer, use the ct ocean filter value otherwise change the values to 0.)



Run the model and open your results in ArcMap. With your results, change the symbology to classified, give 0 values a no fill color, and examine the results. Add a base map to for reference.

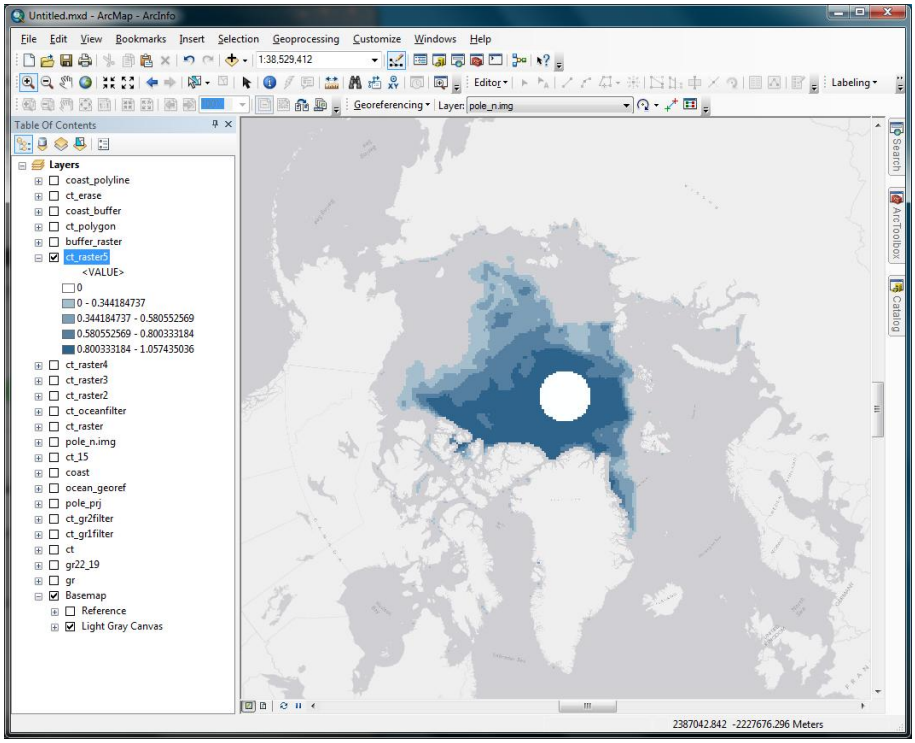


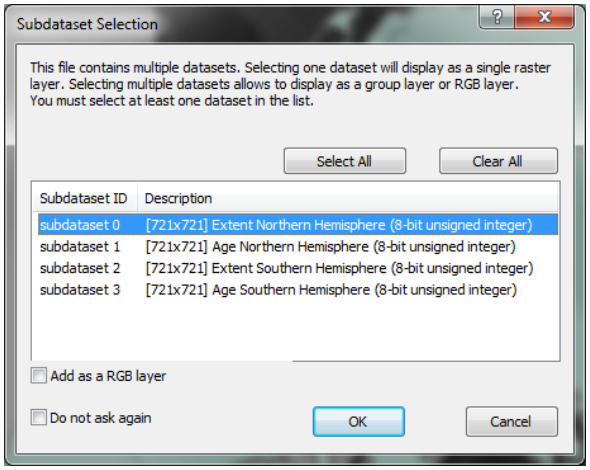
Figure 1. Final sea ice concentration map with quality control procedures applied.

4. Sea Ice Concentration Product Map

Open the Sea Ice Concentration Map that you downloaded earlier. If you have not already done so, change the file extension from .HDFEOS to .HDF (delete the EOS) because Imagine and ArcMap do not recognize EOS but otherwise the two formats are the same.

Add the .hdf layer into your ArcMap

A box will pop up asking you to select a dataset to display> Choose Extent Northern Hemisphere (or Extent for whichever hemisphere you are working with).



Say OK to the geographic coordinate system warning. The product map uses a different coordinate system but will project properly on the fly. **Compare with your results.**

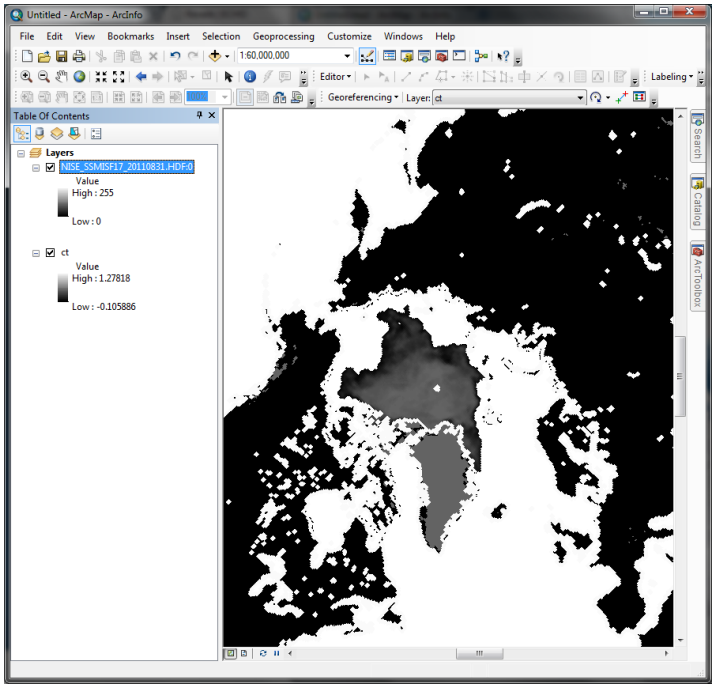


Figure 2. Sea ice concentration product map.

References

National Oceanic and Atmospheric Administration. (2012). Climate Algorithm Theoretical Basis Document C-ATBD Passive Microwave Sea Ice Concentration (CDR Program No. CDRP-TMP-0006). Retrieved from http://nsidc.org/data/docs/noaa/g02202_ice_conc_cdr/pdf/SeaIce_CDR_CATBD_final.pdf.

Levitus, S. and T.P. Boyer (1994). World Ocean Atlas 1994, Volumn 4: Temperature, NOAA NAtional Oceanographic Data Center, Ocean Climate Laboratory, U.S. Department of Commerce, Washington D.C.

Maslanik, J., Mark C. Serreze, and Roger G. Barry. (1996). Recent Decreases in Arctic Summer Ice Cover and Linkages to Atmospheric Circulation Anomalies. *Geophysical Research Letters* (23) 1677-1680.