0   Prerequisites

We assume that WIM has been installed on the computer that you are using and that you are familiar with the basics of using WIM, e.g. loading files, file associations. If not then please check out *0_computer_tips.pps* and section 3.1 in *Wim_Exercises.pdf*.

1.1 Problems of scale

The aim of this exercise is to show the effect of different pixel sizes of satellite sensors.

Load *California\tm_a_1_2_3_rgb.hdf* by clicking on it. Click *Cancel* in response to "*Select geolocation file*" (there is currently no geo-location for this image). Scroll the image up and down, locating an interesting area, e.g. the bright narrow lines of *Noctiluca* accumulations. Select *View-Zoom* from the menu, then press down the left mouse button and move the mouse pointer to an area of interest. Currently the zoom window has is zooming with the zoom factor of 2x. This is a Landsat TM image with pixel size (ground resolution) of 25 m. Other typical pixel sizes are 250 m for MODIS bands 1-2, 500 m for MODIS bands 3-7 and ~1 km for most ocean color sensors (CZCS, SeaWiFS, MODIS, etc). By clicking on the + sign of the Zoom window you will increase the zoom factor to 4x, 8x, 16x…) up to 64x. With the zoom factor 64x there are 12 x 12 pixels in the Zoom window.

Show the size of a 250-m pixel. How many of 25-m pixels does it average over?

Imagine the size of a 1-km pixel.

Examine which features may be visible at 250-m and at 1 km resolution.

Close the Zoom window, cut out a rectangular area of interest (select with left button, then use the *Scissors* tool). Use *Transf-Zoom-Bilinear* to zoom down 10x (zoom factor 0.1), then zoom up 10x. In effect, we blurred the image by reducing the inherent resolution by 10x. An image with a 250-m pixel size would take 10 x 10 pixel averages out of this image. See which features are still detectable and which are not. Now reduce the original Cut-off image down 40 times (*Transf-Zoom-Bilinear*, 0.025) and up 40 times (*Transf-Zoom-Bilinear*, 40) to get an idea what a 1-km sensor would see.

1.2 Simple thresholding

Load *California\S2003090200439.L2_HMBR.sub.hdf*, pick the *chlor_a dataset* (SDS). Upwelling blooms in the California Current have typical Chl-a concentrations < 20 mg m^{-3}. Therefore the simplest method detecting red tides is to look for high Chl-a areas.

Convert the SDS to 1-byte per pixel image with Log-scaling (use the €$ icon on the toolbar, *Log-Chl, mg/m3*). Pick the Color Definition icon, stretch the colors between arbitrary Chl-a concentrations. Pick the *Rainbow* palette (in *Current-Settings*, i.e. the Hammer icon). Observe that all pixels below the lower threshold value become black and all pixels above the upper threshold value become white. This is the simplest red tide detection method!

1.3 Using SeaWiFS Level-2 flags

Load Level-2 flags (*l2_flags*) from *California\S2003090200439.L2_HMBR.sub.hdf*. Move the mouse pointer with the Right button down, observe the flags that are set.

SeaWiFS Level-2 flag bit numbers, along with their associated masking keywords are:

1. atmospheric correction algorithm failure, ATMFAIL
2. land, LAND
3. missing ancillary data, BADANC
4. Sun glint, HIGLINT
5. total radiance greater than the knee value, HILT
6. large sensor zenith angle, HISATZEN
7. shallow water, COASTZ
8. negative water-leaving radiance, NEGLW
9. stray light, STRAYLIGHT
10. cloud or ice, CLDICE
11. Coccolithophores, COCCOLITH
12. Case 2 (turbid) water, TURBIDW
13. large solar zenith angle, HISOLZEN
14. high aerosol concentration, HITAU
15. low water-leaving radiance at band 5, LOWLW
16. chlorophyll algorithm failure, CHLFAIL
17. questionable navigation, NAVWARN
18. absorbing aerosol, ABSAER
19. Tricodesmium, TRICHO
20. NIR algorithm exceeded maximum iteration, MAXAERITER
21. moderate sun glint, MODGLINT
22. chlorophyll < 0.01 or > 64, CHLWARN
23. epsilon out of range, ATMWARN
24. dark pixel, DARKPIXEL
26. spare, SPARE
27. spare, SPARE
28. spare, SPARE
29. spare, SPARE
30. spare, SPARE
31. spare, SPARE
32. ocean, OCEAN

The task now is to find pixels that are classified as turbid (i.e. potentially caused by a HAB) but not coastal (i.e. eliminating typical sediments suspension near the coast). Use *Transf-Bitmask* to find areas (pixels) that have the *Turbid water* (TURBIDW) flag set but that are NOT in the coastal zone (flag COASTZ is off). Coastal zone is operationally defined here as areas with depths less than 30 m. To see where the detected pixels are create a coastlines image (*Geo-Get Map Overlay*, pick *coast_inter.b* as the file with

coastlines data). Overlay the coastlines image on your detected high-turbidity-no-coastal image (click on the base image, then on the Overlay icon (or *Multi-Overlay Image* from the menu.

1.4 Nodularia blooms in the Baltic, other blooms in the Baltic and North Seas area

Nodularia spumigena is filamentous, toxic cyanobacterium that forms dense surface accumulations in the Baltic Sea and some Australian estuaries. Like many other HABs it can be detected by strong reflectance caused by strong back-scattering (due to air vacuoles in *Nodularia* cells). Load dataset *nLw_555* (normalized water-leaving radiance at 555 nm) from SeaWiFS Level-2 file *Baltic\sw\S2002211113448.L2_HNOR.sub.hdf.*

Convert the Int16 dataset to Byte (per pixel) dataset by *Transf-Convert-Byte-Log-Chl,* stretch colors with the color definition, find the surface accumulations.

Load other nLw datasets from *Baltic\sw\S2002211113448.L2_HNOR.sub.hdf.* Observe the spectral differences between bands of nLw. Can you explain the differences?

Keep only *nLw412*, *nLw490*, *nLw555*, create RGB composite image with *Examine-RGB Image* (or the RGB icon on the toolbar). Pick *nLw555* as Red, *nLw490* as green, *nLw412* as blue (why these particular bands?). Tune the RGB colors by stretching the individual bands. Can you distinguish different features ? Some areas look more pink, others yellow, yet others green.

Compare SeaWiFS and MODIS, load *nLw_555* (SeaWiFS) and *nLw_551_mapped* (MODIS-Terra) from *Baltic\Modis\SW_and_MOD_2002211_lwn550.hdf*. Compare the differences of the same day passes from these two sensors. MODIS has more sensitivity but the calibration and atmospheric correction are more difficult.

Compare the previous 1-km imagery with the MODIS 250-m imagery by loading MODIS bands 1 and 2 from *Baltic\Modis\mod02qkm.a2002197_0945_0950.subset.1_2.scaled.hdf.* Find the location of the 250-m images on the large 1-km images.

Creative exercises:

Load the same type of dataset from the SeaWiFS files of the same day that we used in the in the first exercises on Nodularia:

Baltic\sw\S2002211113448.L2_HNOR.sub.hdf and

Baltic\sw\S2002211113448.L2_HNOR.sub.map.hdf.

What is the difference between these datasets? Hint: use *Geo-Grid* on both and see the difference? Convert these Int16 datasets to Byte using the *Log-Chl* scaling and use again the *Geo-Grid* function. Why is the color of the grid different on the different images (i.e. Int16 vs. Byte)? What do you need to do to convert the images in the **.sub.hdf* files to look like the corresponding images in the **.sub.map.hdf* images? Do that! (Hint: *Geo-Remap Projection*)

Load *nLw_555* and *l2_flags* from *Baltic\SW\ S1999190115603.L2_MLAC.x.hdf*. Observe 2 main areas of high reflectance: in the Baltic Sea, south of the Swedish island of Gotland (this is a *Nodularia* bloom), and in the Skagerrak (in the western part, between Denmark, Norway and Sweden. In 1988 the fish farming industry in the Skagerrak and Kattegat (south-east, between the Baltic and the Skagerrak) was devastated by a highly toxic bloom of a haptophyte *Chrysochromulina polylepis.* Its toxin is a real fish killer. Could this high-reflectance area be a toxic bloom? Can you guess what species or phytoplankton group? What evidence you can find in the satellite data? (Hint: the *Chrysochromulina* bloom was at the thermocline depth.)

Load *nLw_555* and *l2_flags* from *Baltic\SW\ S2003177115821.L2_MLAC.x.hdf*. Observe the high-reflectance areas in the Skagerrak, the North Sea and the Kattegat. Are they representing the same type of bloom or are they different blooms? What can you use to investigate this using SeaWiFS Level-2 data? (Hint: the Level-2 flags)

Load *nLw_555* and *l2_flags* from *Baltic\SW\S2002074115848.L2_HNOR.sub.hdf*. Observe 2 main areas of high reflectance: west of Denmark and off the eastern coast of the Baltic Sea. Are these toxic HABs?

1.5 Florida "black waters"

Detect areas of Florida "black waters", i.e. areas of low back-scattering (use *nLw555* as a proxy for back-scattering intensity) and high Chl-a. You can use two files:

Florida\ 2001265175156.L2_HUSF.sub.map.hdf or

Florida 2001276172746.L2_HUSF.sub.map.hdf . Load *nLw_555* and *chlor_a*. Convert chlor_a to Byte with the *Log-Chl* scaling. Then use *Transf-Binarize* to find areas (pixels) that have Chl-a between 4 and 64 mg m^{-3} and *nLwn_555* between 0 and 0.5. What is the unit of *nLw_555*? Check it out by looking at the attributes (the attribute icon looks like a printed page). If you got the "black waters" pixels, do you understand where they are? Create a coastlines image with a pixel value that is different from the marked pixels, overlay on top of the marked pixels.

1.6 MODIS-Aqua Level-2 1-km data

Freely downloadable from the http://oceancolor.gsfc.nasa.gov Level 1 and 2 Browser. Load datasets from *Paracas\MODIS_Aqua_subsets.A2004106.1845.004.hdf*. Ignore the warnings. Now load some datasets (e.g. *nLw551* or *chlor_a*) from Paracas\ A2004106184500.L2_LAC. Observe the practical problems with these images: clouds, cloud edges, speckle (bright outliers), striping, banding. Find the Paracas bay. It is not easy! Cut out a rectangular area about 10 times the size of the annotated RGB image of the Paracas bay (loaded previously). Now remap the rectangular cut to the projection and size of the RGB image with *Geo-Remap Projection*. Can you detect the Paracas bay red tide in the MODIS 1-km imagery? No way! That's why we need to use higher-resolution imagery, e.g. MODIS 250-m data for studying HABs that have smaller scales. This is the task of the set of exercises in *Exercises_modis_250m.pdf*.