Basics of Digital Image Analysis

[using Windows Image Manager = WIM]

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WimSoft, https://Wimsoft.com

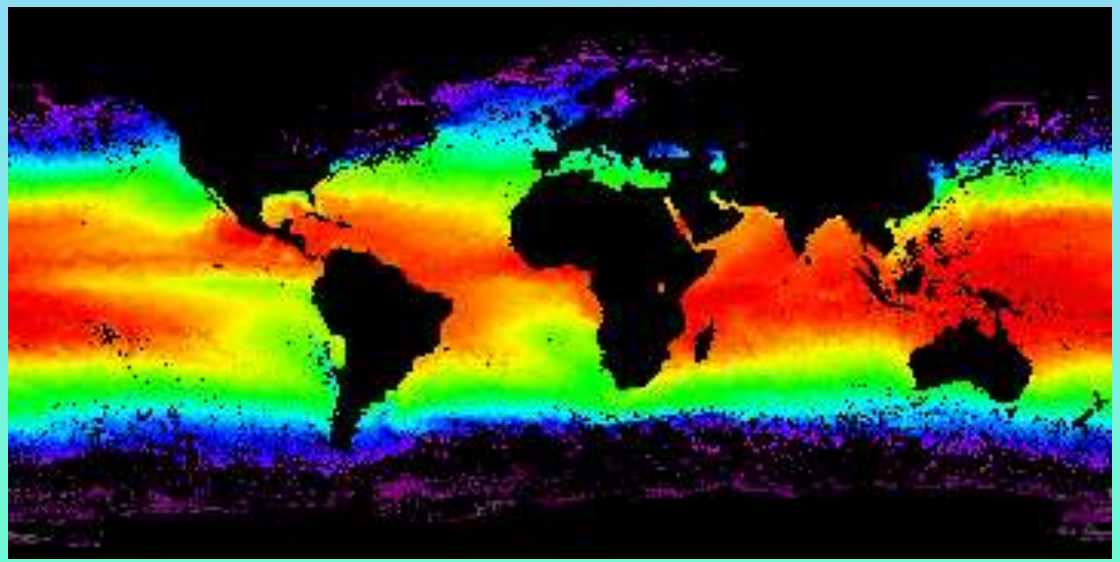
1/10/2019

The basics of image analysis

Raster image

EO raster image

(EO = Earth Observation)

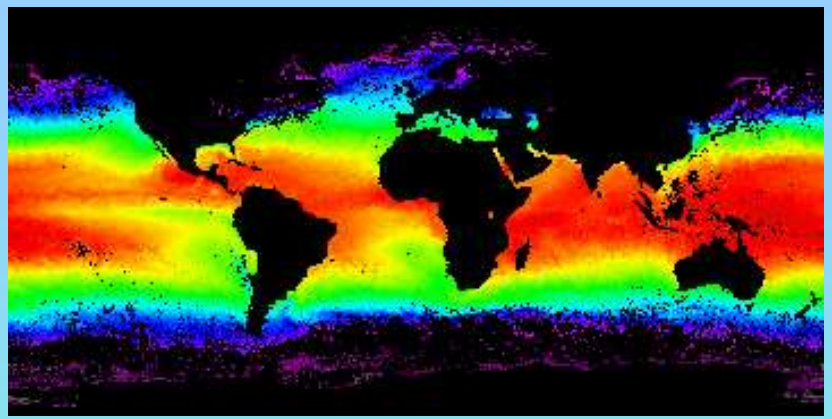


- 2 types of images, convertible

What is common and what is different?

Raster image

EO raster image



•Emphasis on **color**

•Different color systems, e.g. RGB (red-green-blue), CMYK (cyan-magenta-yellow-black), numerical values irrelevant

•Hundreds of file formats: JPEG, PNG, BMP, DIB,TIFF, PICT, Photoshop, X11 bitmap, Sun raster, IRIS RGB, Targa

•Compression important, "lossy" compression: JPEG, GIF, etc.

•Emphasis on the **numerical value** (e.g. SST)

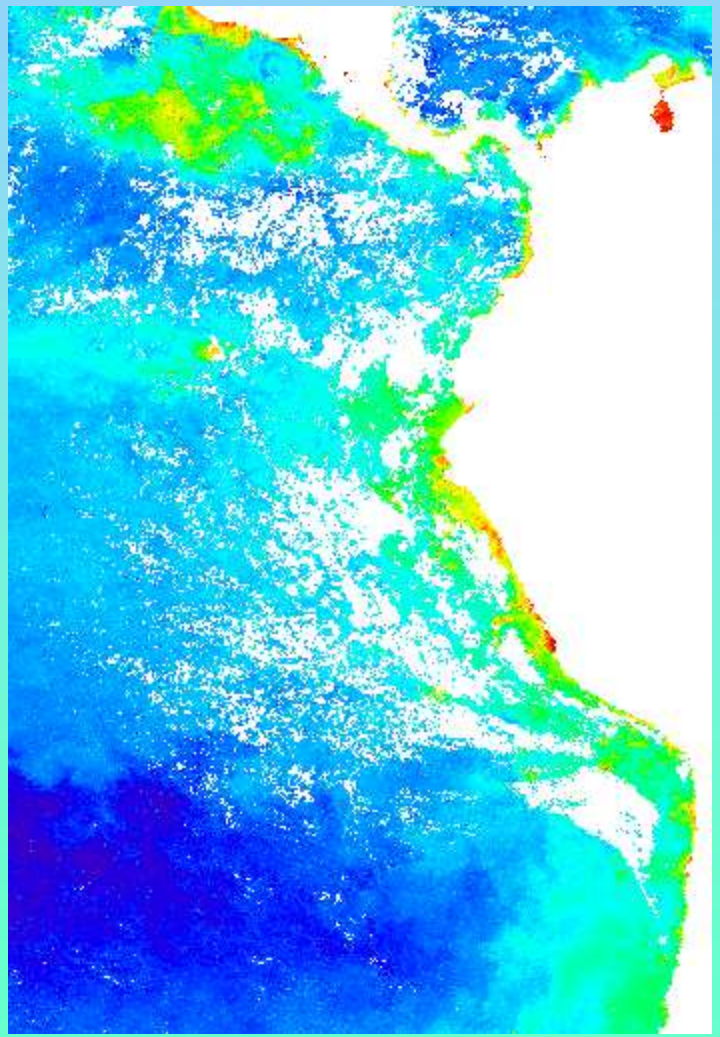
•Each pixel (picture element) is defined by its x,y & Lat, Lon coordinates and a numerical value

•**Numerical values do not have color, color is added for visualization but can be changed without changing the essence of the image**

•Many file formats (e.g. **HDF, netCDF**), can use "lossless" compression, "lossy" compression not allowed!

Difference between bitmap and quantitative image data

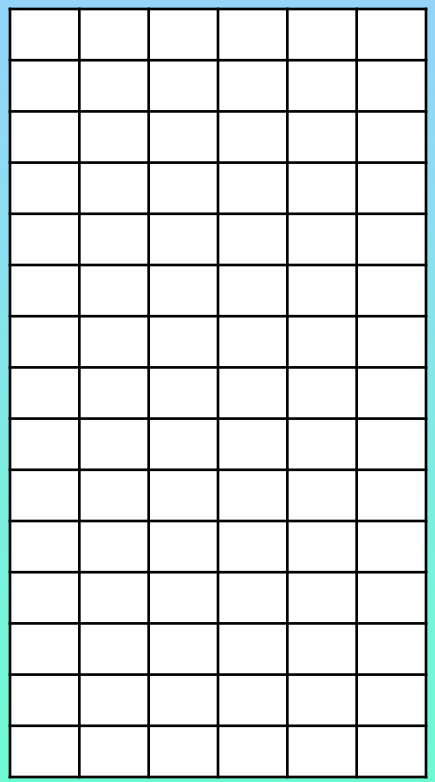
- Bitmap-type images (GIF, JPEG, PNG) available on the web
- The usage of Bitmap-type data is very limited!



Quantitative imagery, such as HDF, netCDF allows to perform operations not possible with bitmaps:

- Look-up coordinates, pixel values, geo-physical values
- Overlay coastlines, lat-lon grids, stations, etc.
- Do mathematical operations, e.g. compositing, averaging, differencing
- Use images to calculate complex new images (e.g. NPP calculated from Chl-a, PAR, SST)
- Change color palettes and stretch color look-up tables
- Create RGB images from 3 composites
- And much more!
- Don’t be fooled with bitmaps!

What is a *Digital raster image* ?



- **A rectangular matrix of numbers where cells are called pixels (=picture elements)**
- **Pixels can be of different type (bpp = bytes per pixel):**
  - 1 bpp, **BYTE**, values 0:255 (unsigned), -127:127 (signed)

    What is a byte?
  - 2 bpp, **SHORT INTEGER** 0:65535 (unsigned), -32767:32767 (signed short)
  - 4 bpp, **LONG INTEGER**: 0:~4 billion (unsigned), -2 billion : 2 billion (signed)
  - 4/8 bpp **FLOAT (Float32, Float64)**: almost unlimited
- **Remember: Numbers have no color!**
- **Colors can be assigned to pixels depending on their value in the color palette (LUT = look-up table)**
- **Geo-referencing (projection) is an algorithm that maps each pixel to a location on earth**

Example of a *digital raster image* :

199	200	201	202
200	200	201	202
200	200	201	201
198	199	200	200
197	198	199	199
196	197	198	198

4 x 6 pixel image (it's a very small "image"!)

1) Need to know the number of columns, rows:

4 x 6 or 6 x 4?

199	200	201	202	200	200	201	202	200	200	201	201 …

Storage in computer memory is just a sequence of bytes with no additional information, such as:

- **What is the *number of columns*? *Number of rows*?**

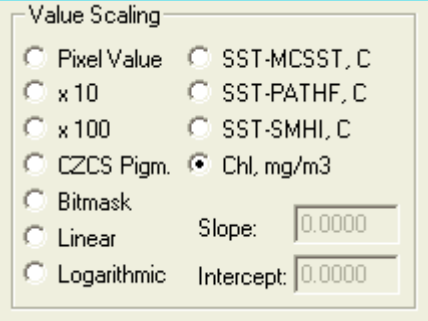
(If we have 24 pixels, the image could be 4 x 6 or 6 x 4 pixels)

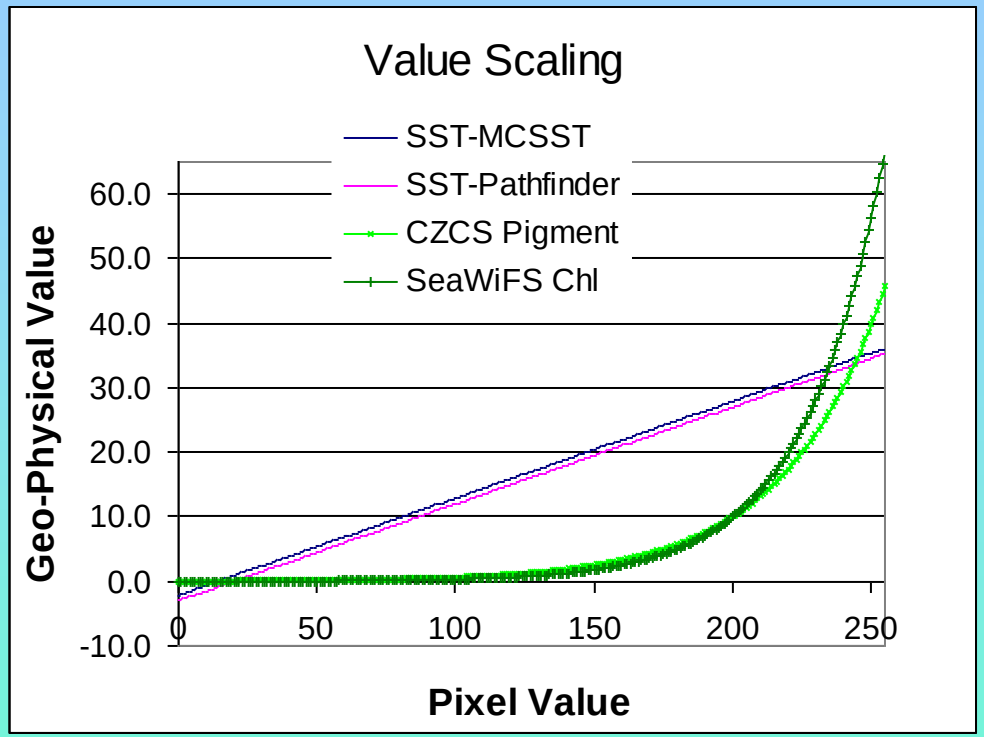
- **What is the pixel type? Byte: values from 0 to 255; Uint16, Int16, Uint32, Int32, Float32, Float64**
- **What is the scaling? Geo-location?**
- **Other attributes? HDF and netCDF include all that!**

Value Scaling

We need it because a **Byte** can have values 0:255 but real life values (e.g. Chl-a conc) are real numbers

- Value scaling, used for 1 bpp (**Byte**) and 2 bpp (**Int16**) images; not needed for *Float32* or *Float64*. Why?





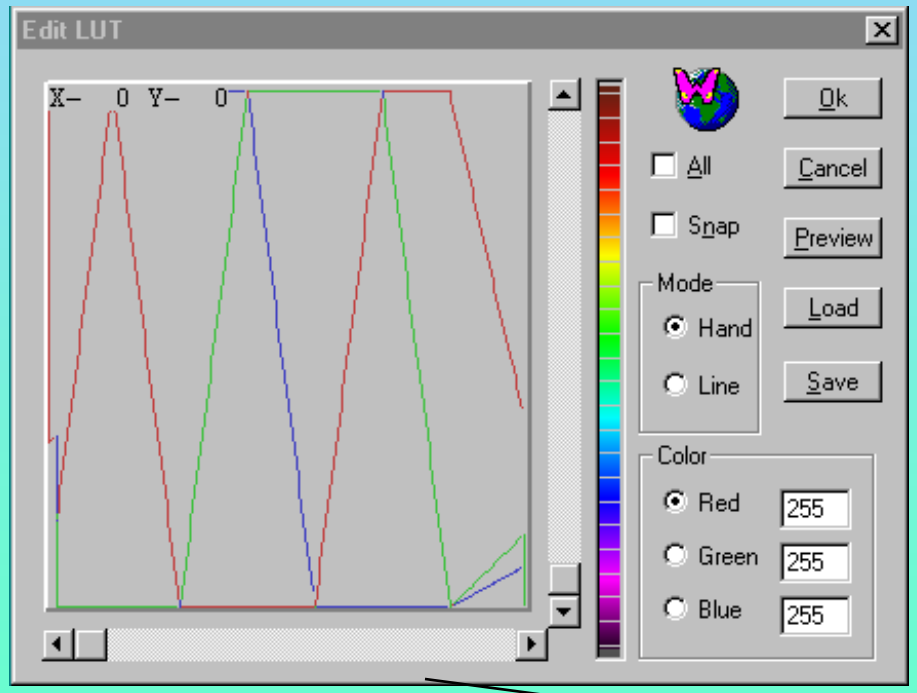
	Slope	Intercept	Range
•Linear			
•Pathfinder SST, C	0.15	-3.0	-3.0:35.25
•Logarithmic Base=10.0	**Slope**	**Intercept**	**Range**
SeaWiFS Chl-a, mg m^{-3}	0.015	-2.0	0.01:66.83

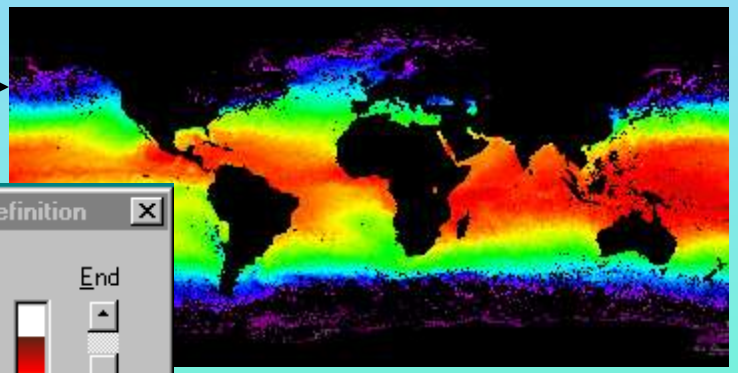
Color Scaling

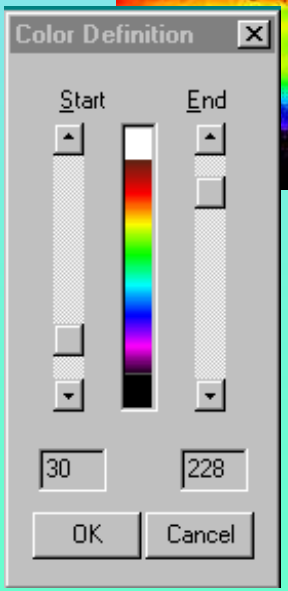
(needed because numbers don't have color!)

SST: 24.9 25.05 25.05 24.9 25.05 25.5 25.8 25.65 26.1 25.95 25.95 25.95 25.8 25.65 25.35 24.45 24.15 24.45...

PV: 249 250 250 249 250 255 258 256 255 259 259 259 258 256 253 244 241 244….



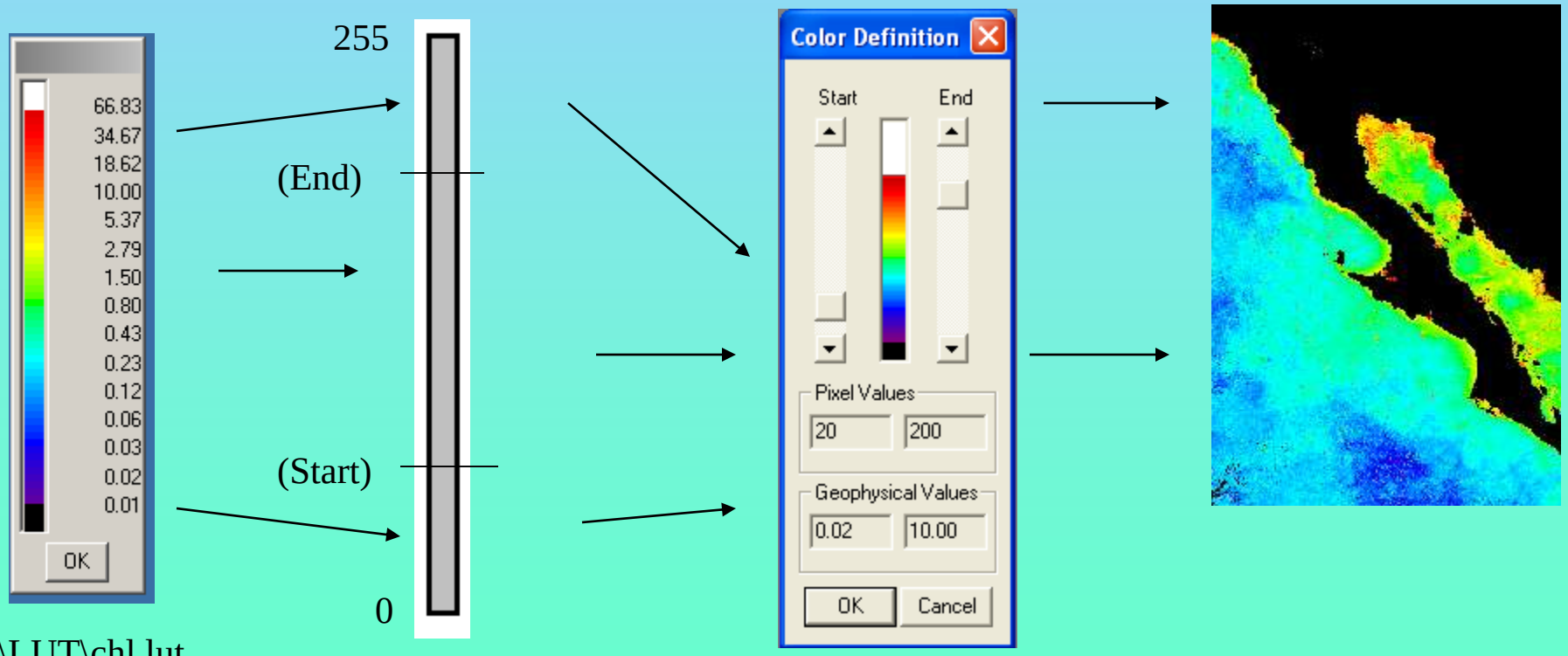




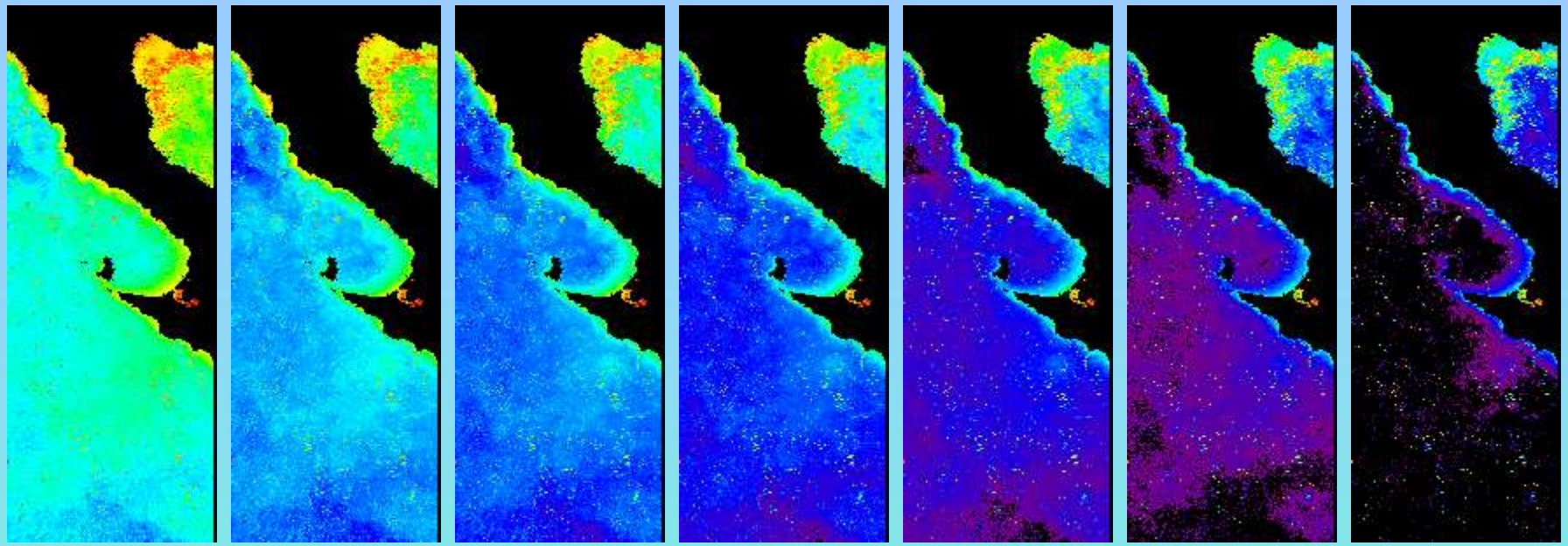
Color Scaling for Byte images

- 256 pixel values (PV or DN, from 0 to 255) vs. Palette (LUT) of N colors
  - Palette usually of N = 256 colors

256 pixel values | 256 colors | (Linear Stretch) | Color Image



\LUT\chl.lut



Start: 16 32 48 64 80 96 112

Palette: \Wimsoft\LUT\chl1_white_end.lut

0 132 0 124

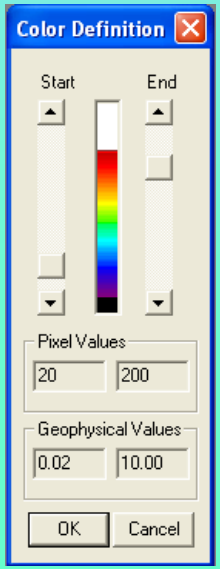
1 132 0 124

2 132 0 124

3 132 0 124

4 122 0 134

5 122 0 134 ……

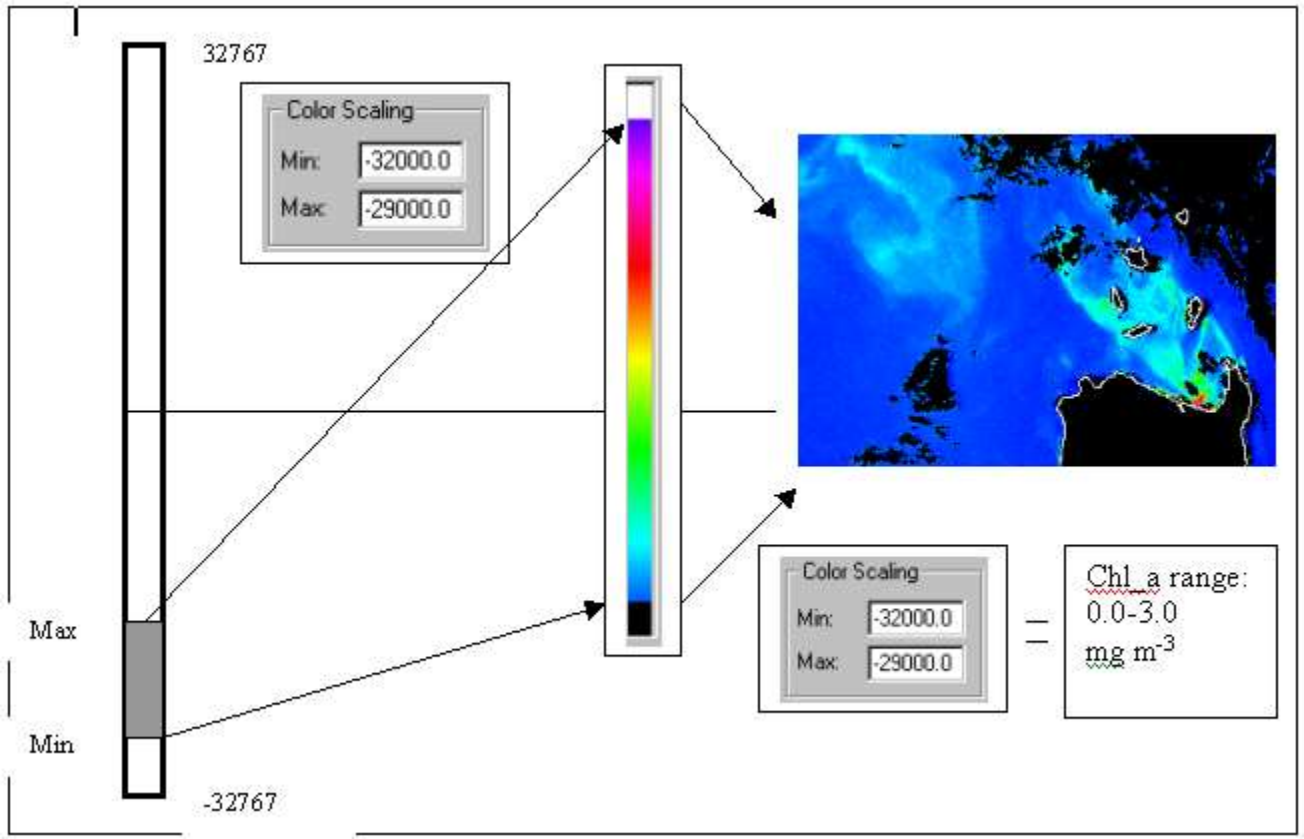


Color Scaling for multi-Byte images

•Int16: 64K (~65 thousand) values vs. Palette (LUT) of 256 colors

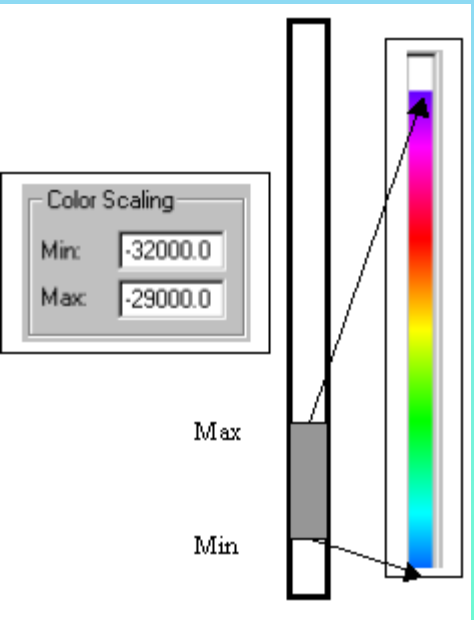
•Float: unlimited number of values vs. Palette (LUT) of 256 colors

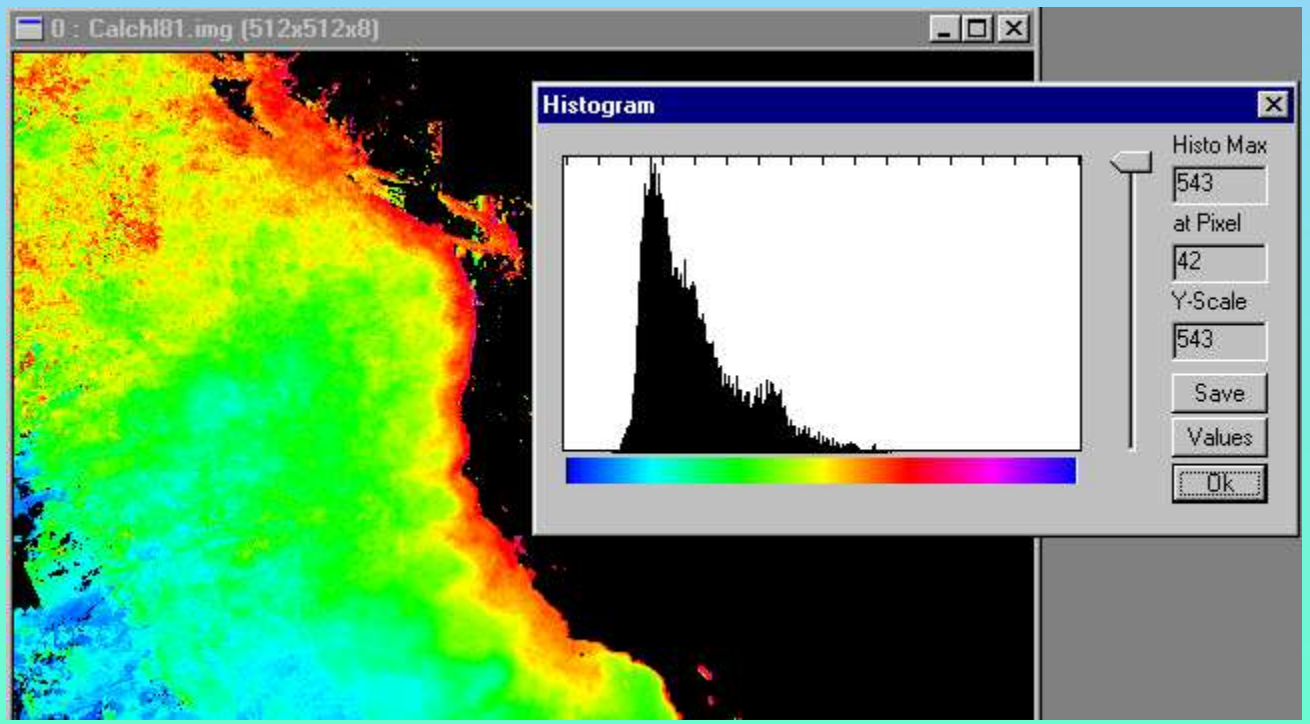
•Using *Color Scaling Min* and *Max* to "map" these ranges of values to 0:255 and then use the same method as with Byte images.



Basic operations on images

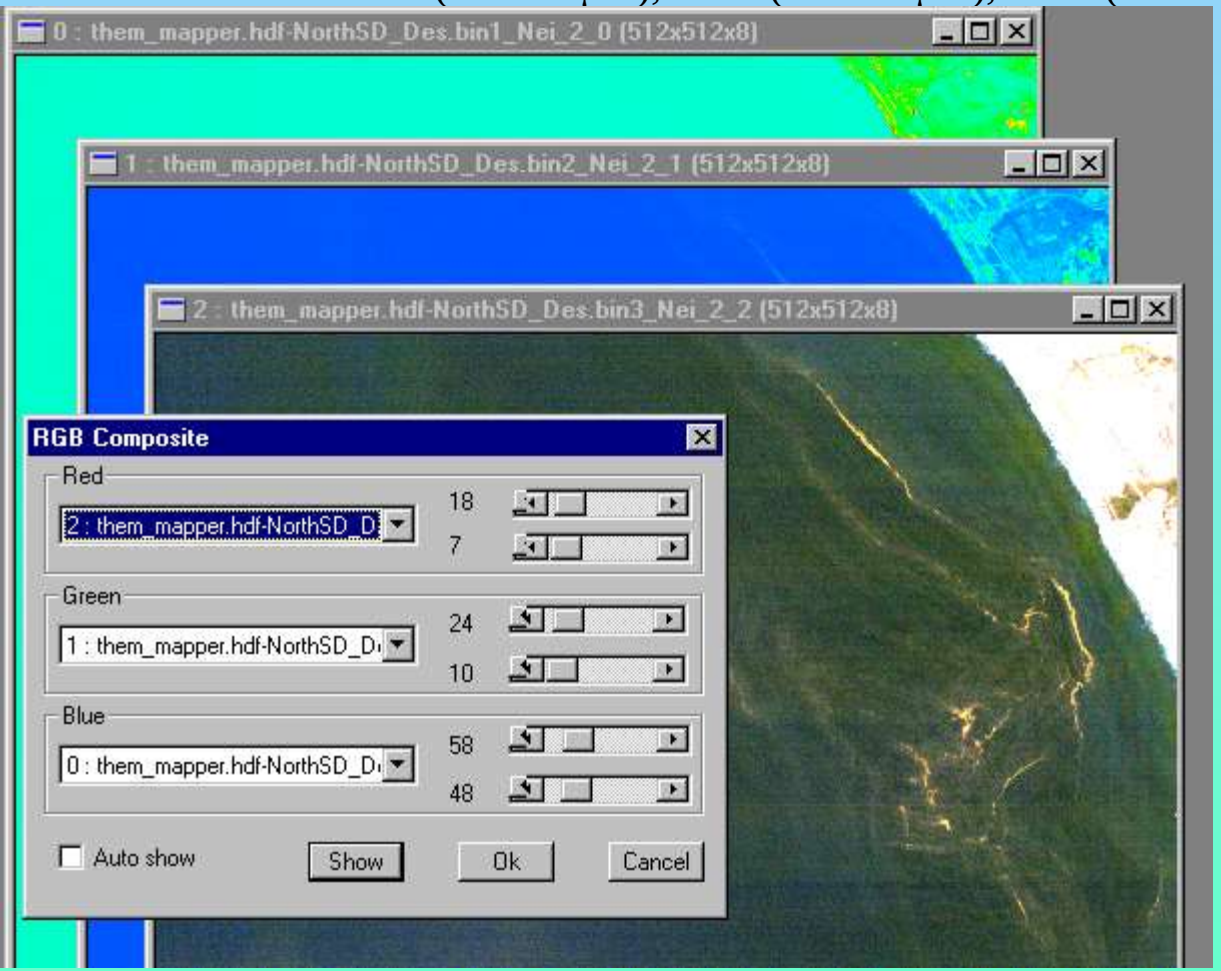
- Histogram
  - 1 bpp: 256 possible values
  - 2 bpp: 65 thousand possible values
  - 4 bpp: ~unlimited number of different values



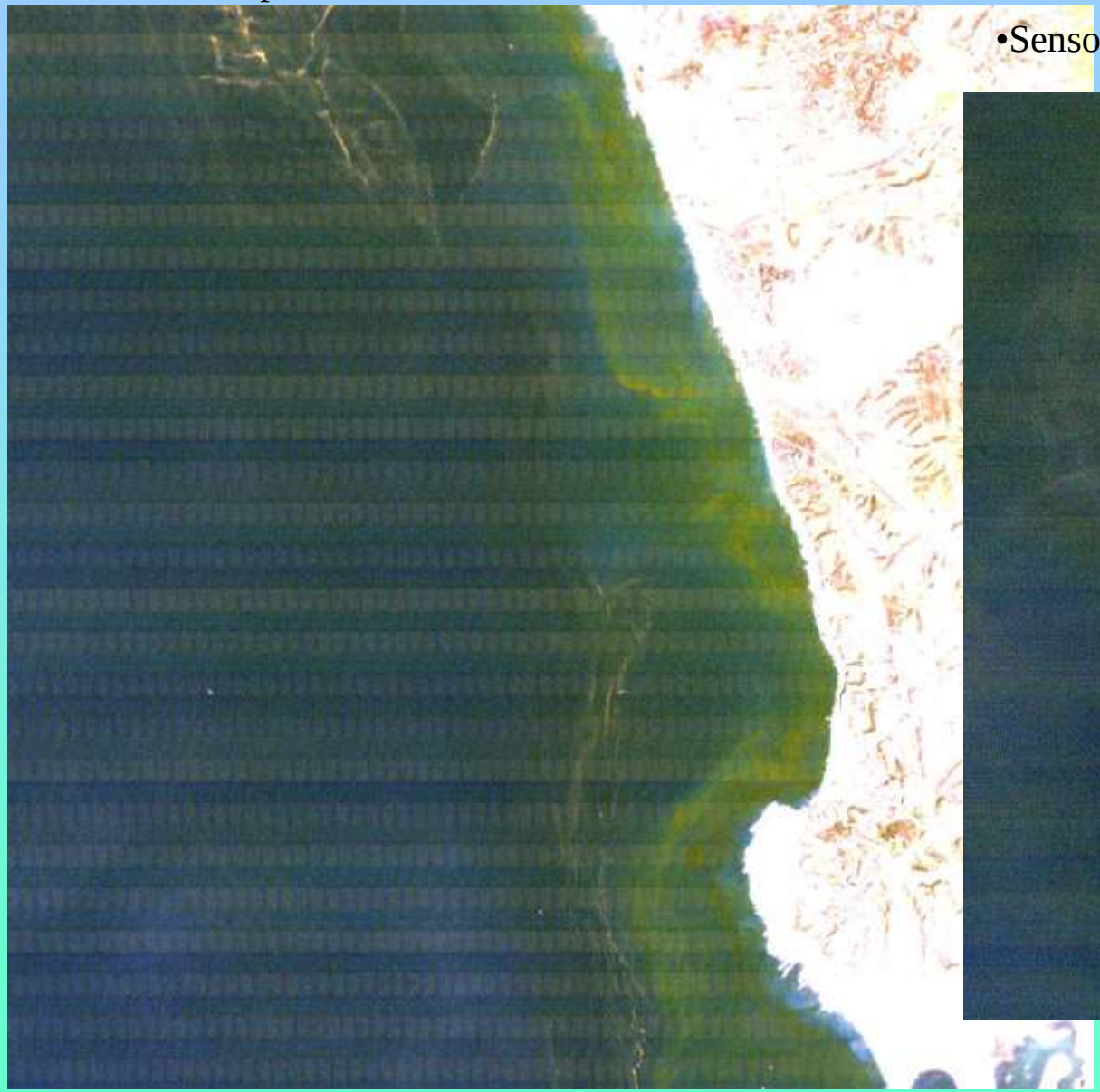


Basic operations on images

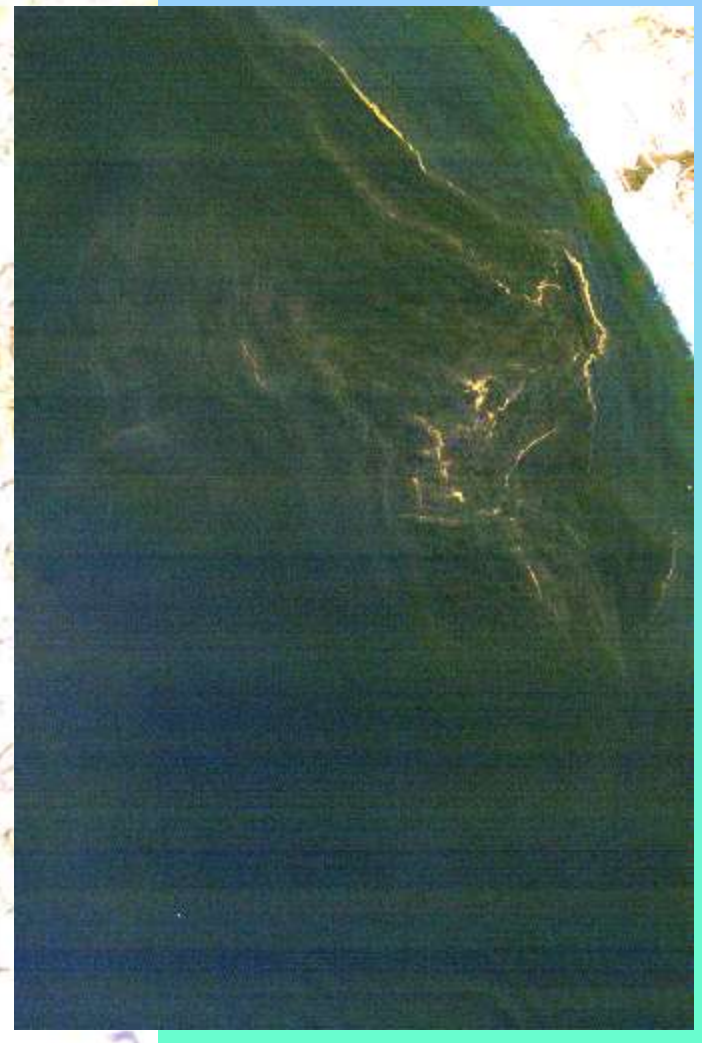
- **Band Compositing**
  - RGB color composite from 3 bands
  - e.g. Thematic Mapper on Landsat 5 bands 1-3 correspond ~ to Blue, Green, Red
    - TM1 (.45-.54 μm), TM2 (.52-.60 μm), TM3 (.63-.69 μm)



•TM RGB composite, 1995/04/03



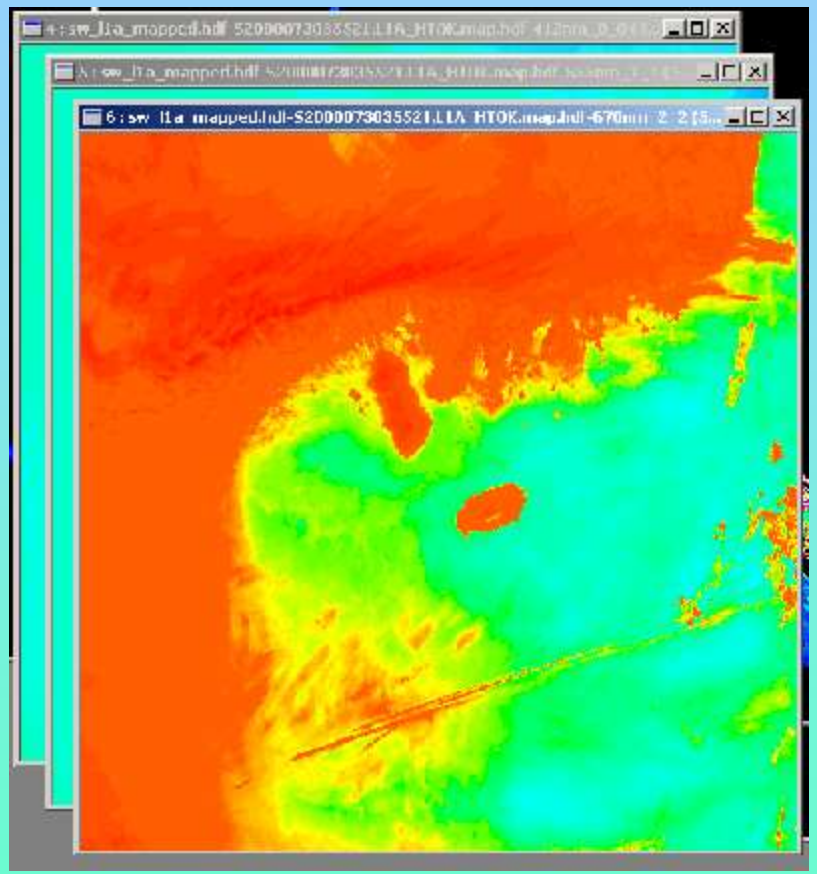
•Sensor striping - destriping algorithms

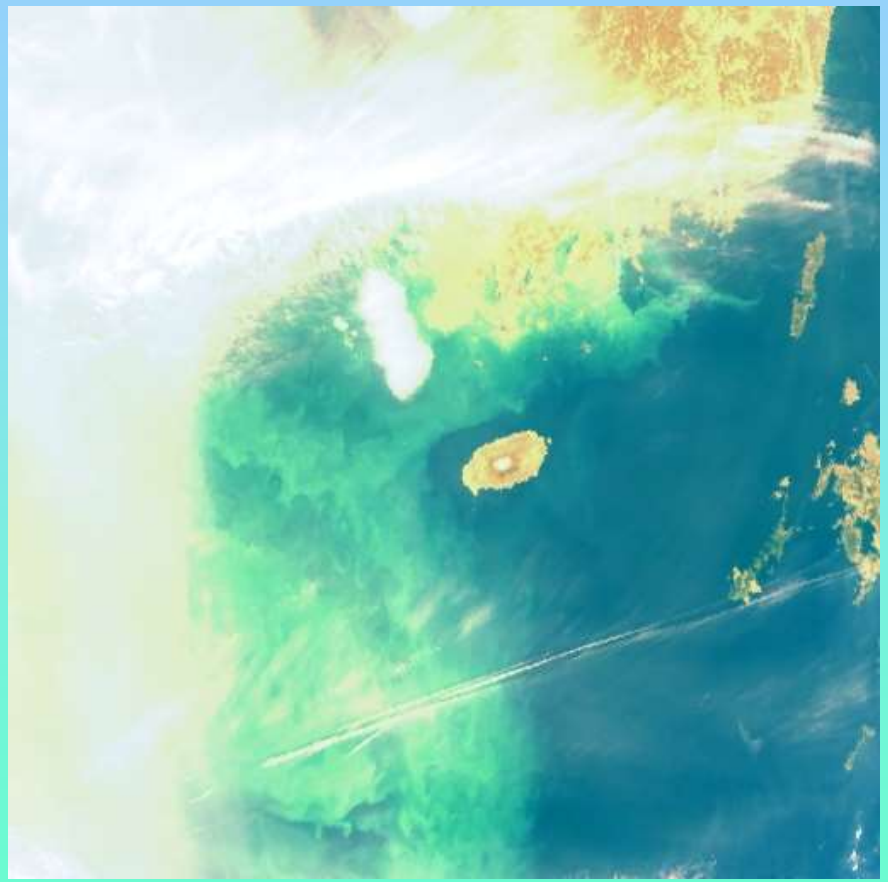


SeaWiFS Level1a mapped, 2000/03/13,

Lt670-Red, Lt555=Green, Lt412=Blue

Land, turbid water, aircraft contrails, fog, clouds

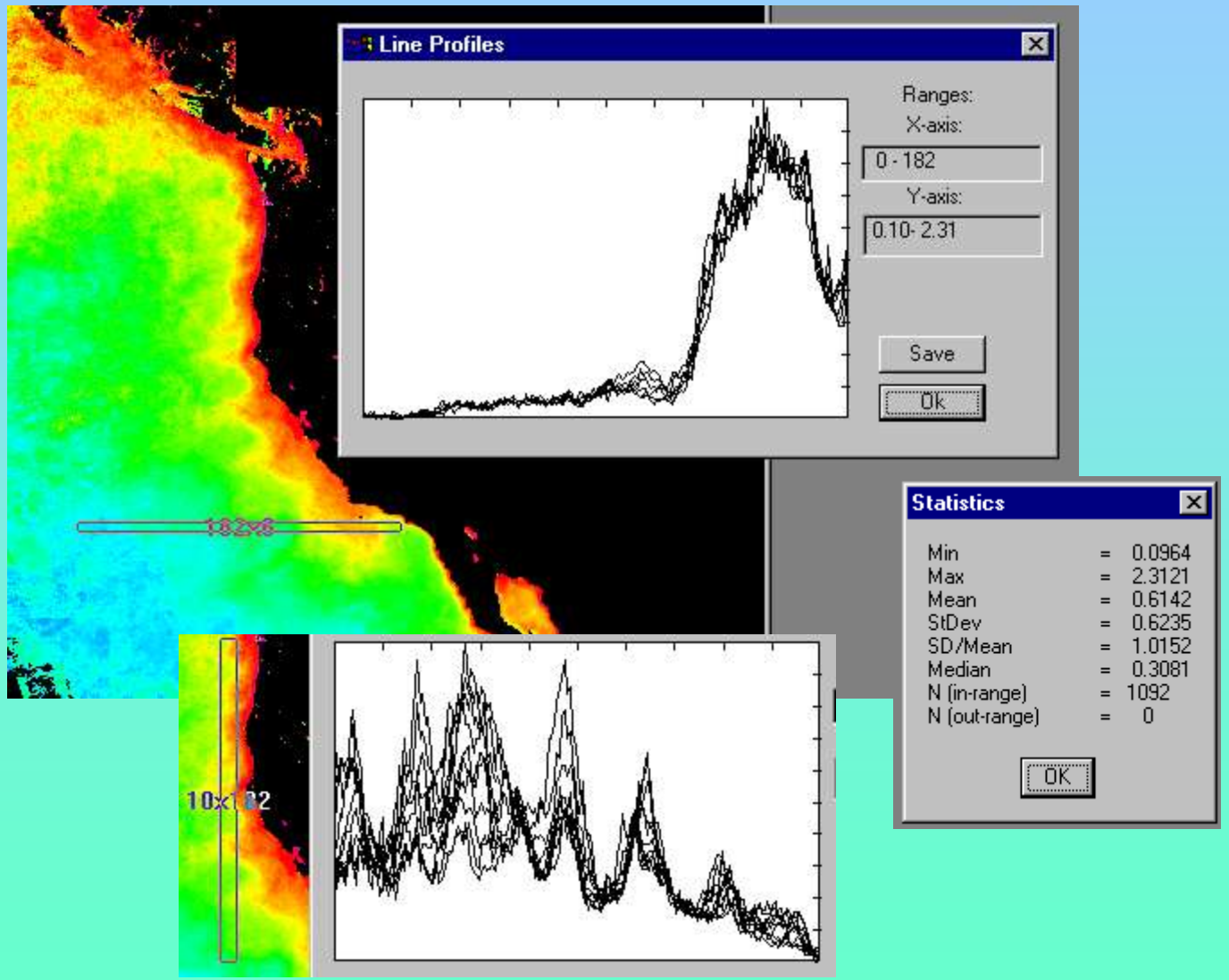




Red : 40-45, Green: 20-51, Blue: 24-65

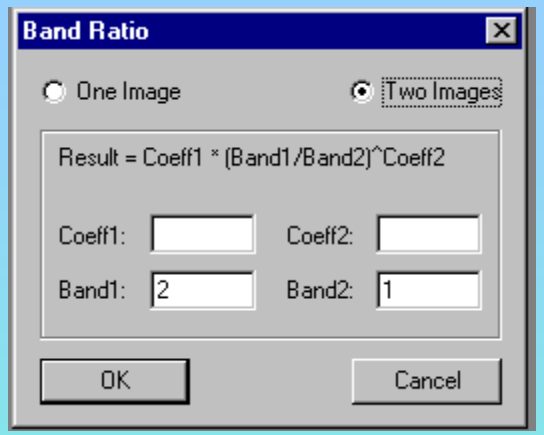
Basic operations on images

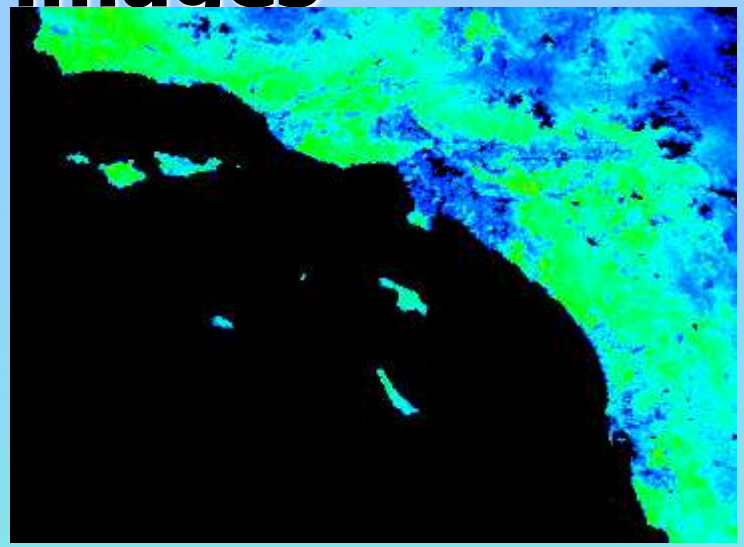
•Profiles, Statistics, Pixel Value and Geo-Physical Value, Coordinates



Basic operations on images

•Band ratios, other arithmetic operations





•NDVI

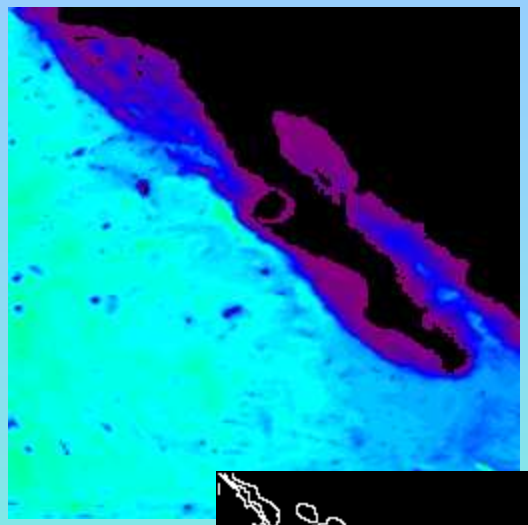
•**<u>Veget. Index</u>** - finds the Normalized Difference Vegetation Index (*NDVI*) from two imges. It is assumed that the current image is from AVHRR channel 1 (0.58-0.68 µm) and another image is channel 2 (0.725-1.10 µm). *NDVI* is calculated according to the formula *NDVI = (Ch2 - Ch1) / (Ch1 + Ch2)* and ranges from -1 to 1. A new image buffer is allocated with the corresponding pixel values equaling *100 * NDVI + 100*.

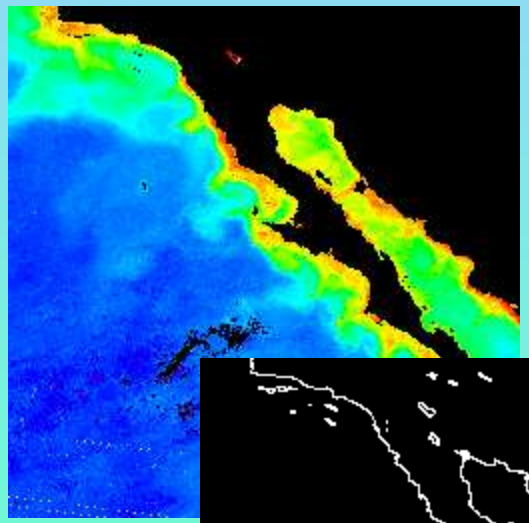
NDVI is a rough index of the amount of green plant biomass. *NDVI* is negative for water, near zero for clouds and bare soil, and changes between 0.05 and 0.6 for vegetative surfaces. *NDVI* can been used to detect thick surface phytoplankton blooms. As *NDVI* for water surface is normally negative since water is nearly a black body at near-infrared (channel 2), positive values indicate dense accumulations of surface floating algae. Even small negative numbers indicate surface floating algae.

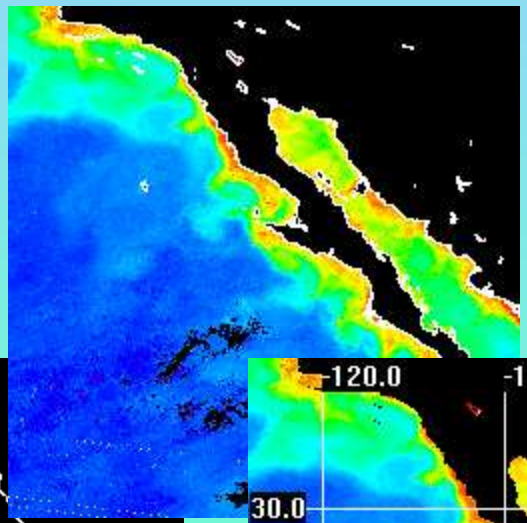
Example: reduced vegetation density in the Los Angeles and San-Diego/Tijuana urban areas.

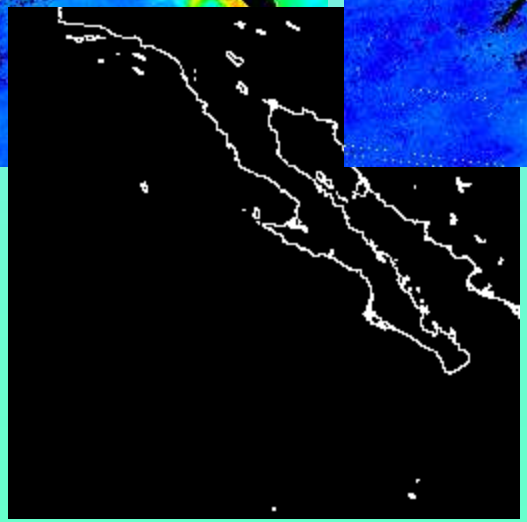
(Map) Projections, i.e. geo-referencing

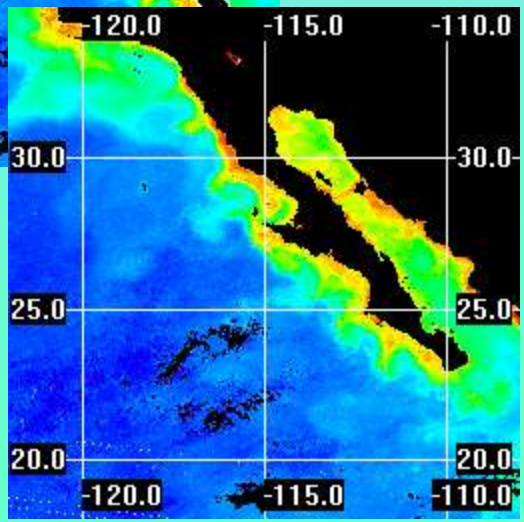
- Coastlines (different resolutions)
- Bathymetry
- Political Boundaries
- Rivers

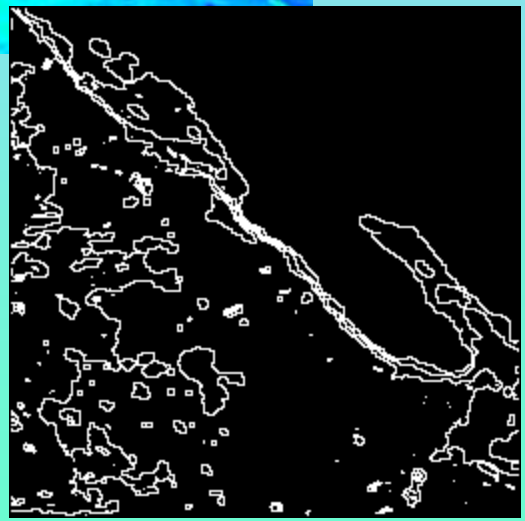












Basic operations

- **Image compositing**
  - Most images are mostly cloudy; large cloud-free areas seldom found => compositing cloud-free areas from many (N) images into a single image
  - Drawbacks: reduces and smears gradients, may introduce artificial boundaries if N is small

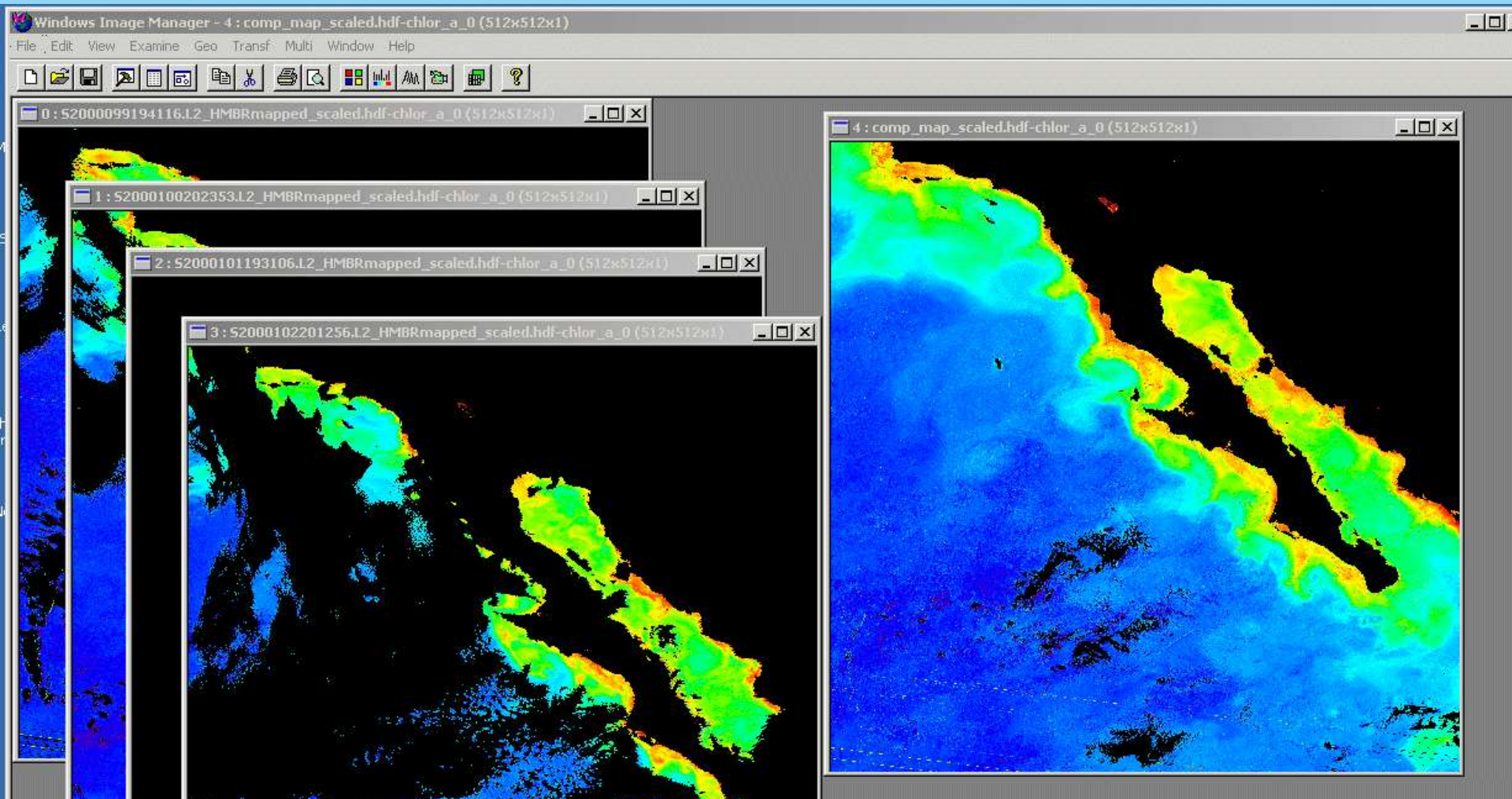


Image file formats

- Simple Binary Raster file
  - a sequence of bytes, no info about the size of image; need Width (DX), Height (DY), bpp. File size = DX * DY * bpp.
  - Historically common: 512 x 512 x 1 = 262144 bytes. Large satellite swaths into many small tiles.
  - Additional info: Signed/Unsigned, parameter info, value scaling, units, palette, projection, date, time, satellite, receiving station, algorithm and its version number,...
  - info can be embedded into a header (N bytes, e.g. 1024 bytes) or into a separate info-file. Used for years and in many formats, limited approach. Skip header option. Outdated.
  - ERDAS LAN (multi-band), CCAR (header embedded into image)
  - More than one band: Band sequential (BSQ), Band Interleaved by Line (BIL), Band Interleaved by Pixel (BIP)
- ASCII not practical due to size overhead (>3 x)

1('(*(*)*#&.""-,+-./'(')).0511-****1763++2*+)**+/7<?6&+&'(&&&)(&%%%+,-*/))%&'()*(-53/*.+,,63

Input image file formats (for WIM):

netCDF (*.nc) -netCDF3, netCDF4

HDF4 (*.hdf) -preferred for WIM

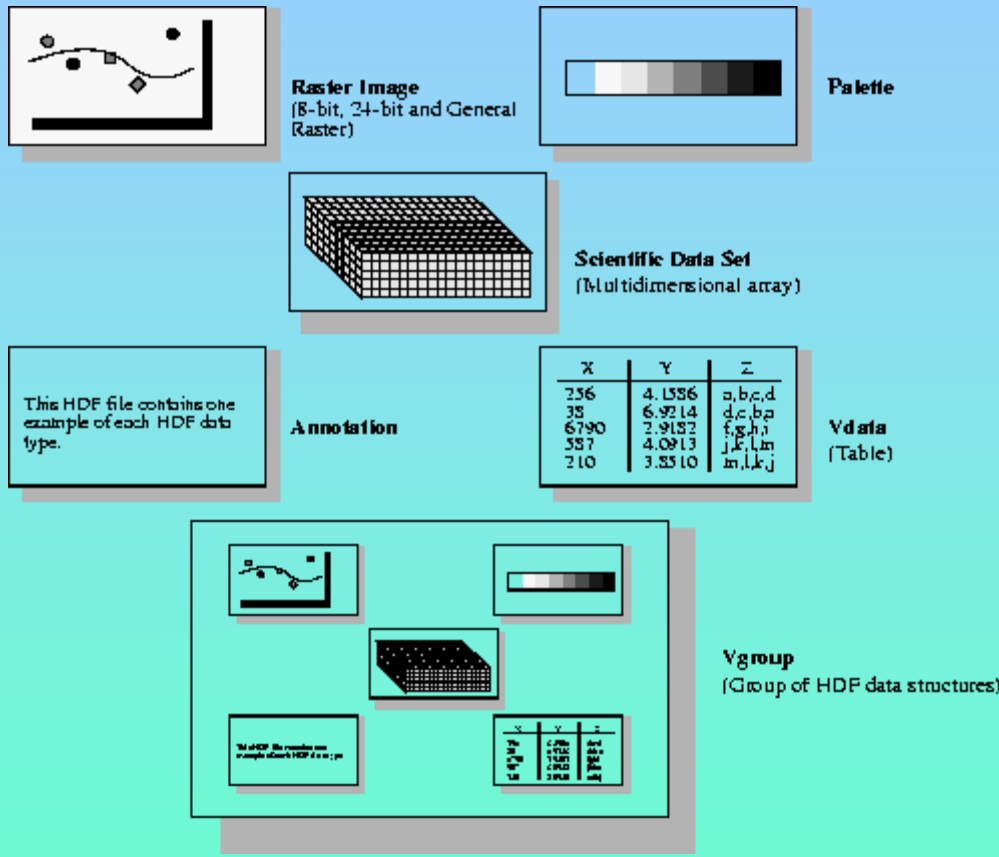
HDF5 (*.h5) -SGLI on JAXA's GCOM-C

- **Image (Plain Binary Raster file)**
- **ASCII**
- **ASCII Float**
- **Band Sequential**
- **Line Interleaved**
- **Pixel Interleaved**
- **CoastWatch**
- **Compressed**
- **ERDAS/LAN**
- **Float**
- **L1B (AVHRR)**
- **NAVOCEANO**
- **Unsigned 2-Byte Int**
- **Int->Byte**
- **Overlay (1 bit per pixel)**
- **GOES-SST**
- **TDF (Terascan)**
- **HDF4, HDF5**
- **netCDF3, netCDF4**

HDF (versions 4 and 5), and **netCDF** (versions 3 and 4)

The ***Hierarchical Data Format***, or ***HDF***, is a multiobject file format for sharing scientific data in a distributed environment. HDF was created at the National Center for Supercomputing Applications to serve the needs of diverse groups of scientists working on projects in various fields. Related NetCDF is developed and supported by Unidata.

- Support for the types of data and metadata commonly used by scientists.
- Efficient storage of and access to large data sets (HDF4: < 2 GB, HDF5: > 2 GB).
- Platform independence (exchange files between UNIX, Mac, Windows)
- Extensibility for future enhancements and compatibility with other standard formats.



Windows Image Manager - 0 : chlor_a (1354x2030x4)

Edit View Examine Geo Transf Multi Edge Segm Window Help

0 : chlor_a (1354x2030x4)

Select Images

Select buffers to read from A2006228205500.L2_LAC

Image Name	Width	Height	Type
longitude	170	2030	float32
latitude	170	2030	float32
chlor_a	1354	2030	float32
K_490	1354	2030	int16
tau_869	1354	2030	int16
eps_78	1354	2030	uint8
angstrom_531	1354	2030	int16
nLw_412	1354	2030	int16
nLw_443	1354	2030	int16

OK Cancel

Attributes of chlor_a

Attribute Name	Owner	Type	Data
Title	<GLOBAL>	char8	MODISA Level-2 Data
Sensor Name	<GLOBAL>	char8	MODISA
Product Name	<GLOBAL>	char8	A2006228205500.L2_LAC
Software Name	<GLOBAL>	char8	MSI12
Software Version	<GLOBAL>	char8	5.5.2
Replacement Flag	<GLOBAL>	char8	ORIGINAL
Orbit Node Longitude	<GLOBAL>	float32	0.000000
Orbit Number	<GLOBAL>	int32	0
Node Crossing Time	<GLOBAL>	char8	
Processing Time	<GLOBAL>	char8	2006228234415000

Add Edit Delete Copy To... Close

rent position: 810,660

Output from WIM

Save As…

- **HDF SDS (*.hdf)** ← with Projection
- **HDF with Lat-Lon Arrays** ← no Projection
- NetCDF **-not recommended**
- **PNG (*.png), JPEG (*.jpg)** - for bitmaps

Other, not recommended:

- TIFF (*.tif), GIF (*.gif)
- Image (1 byte/pixel, *.img), 2-byte Int per pixel (*.img), Overlay (1 bit / pixel, *.ovl)
- Compressed (RLE)(*.rle)
- Erdas/Lan (*.lan)
- Bitmap (*.bmp) : monochrome, 16-color, 256-color, 24 bit (*.bmp)
- ASCII (*.dat)
- Lon, Lat, Value ASCII (*.dat)