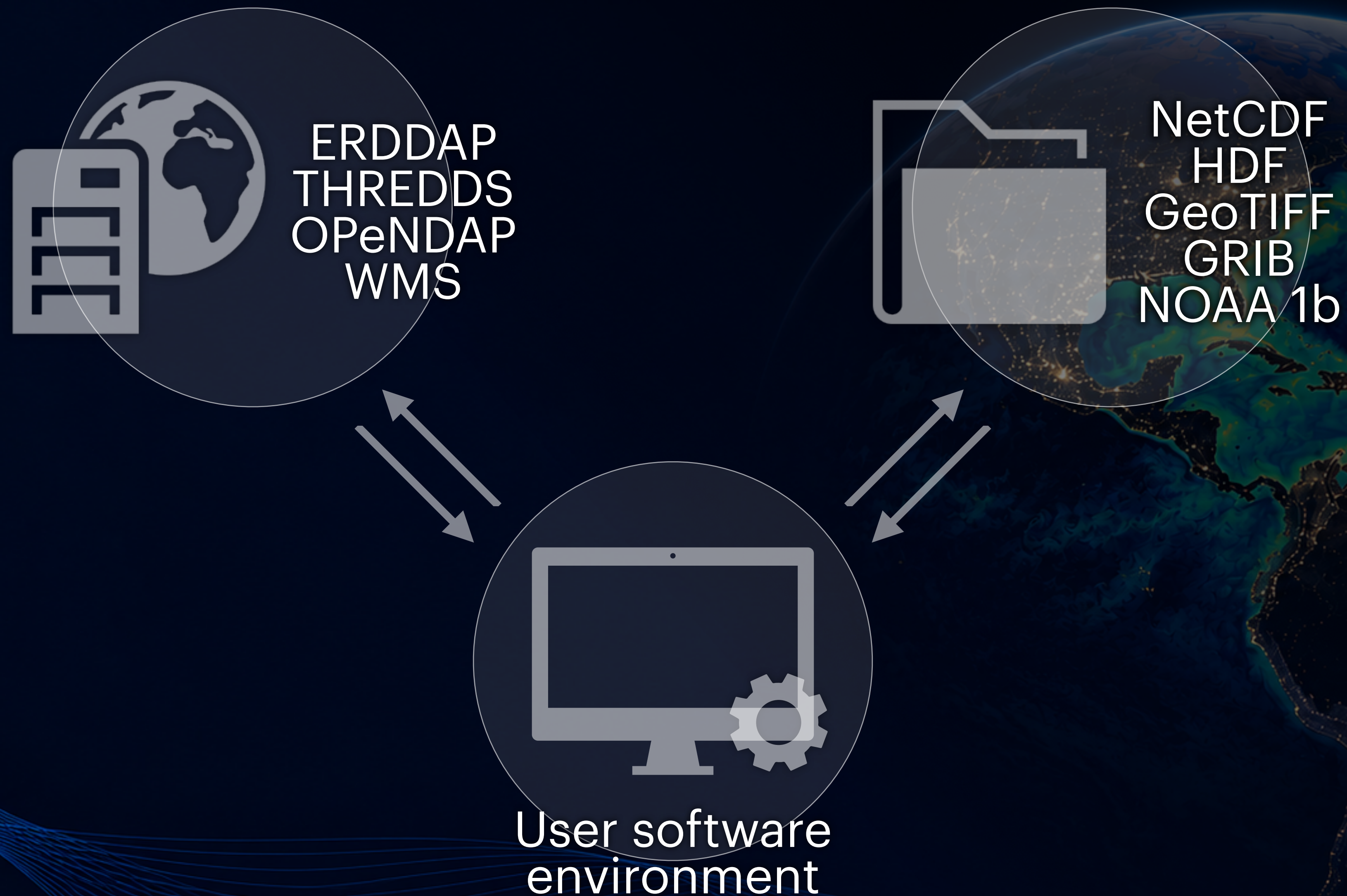


The background of the slide features a satellite in orbit above the Earth. The satellite, located in the upper right, has a yellow body and blue solar panels, with a beam of light directed towards the planet. The Earth is shown from space, with a glowing blue horizon. Overlaid on the Earth's surface is a map of the coastal waters of Central and South America, with colors ranging from dark blue to yellow and red, indicating different data values. The title text is centered over this map. In the bottom left corner, there are decorative blue wavy lines.

A Practical Tour of the CoastWatch Utilities

Peter Hollemans, CoastWatch Central Operations
Satellite 201 Summer Lecture Series, July 2026

Scientific data work generally happens through a server or through local files



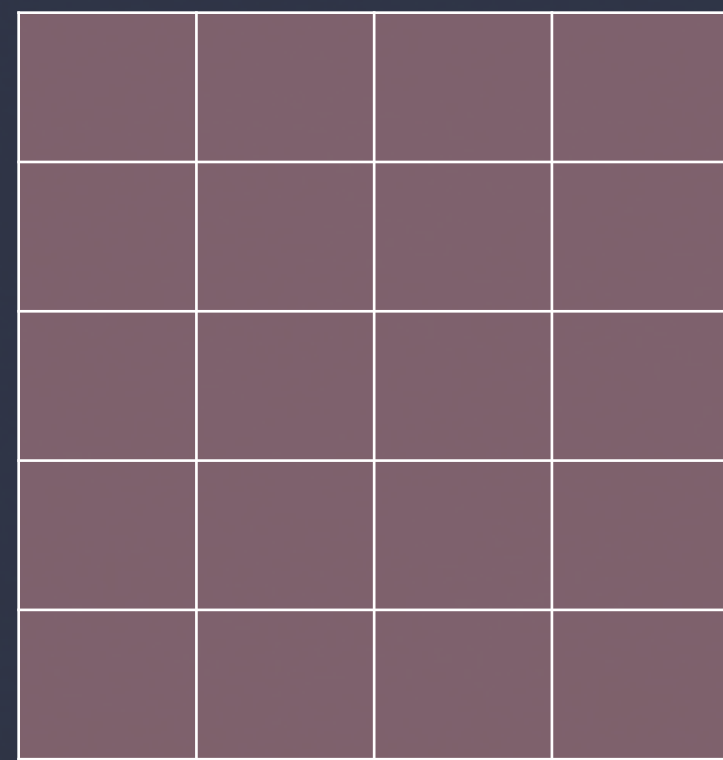
A scientific data file combines descriptive metadata with numerical arrays

Attributes

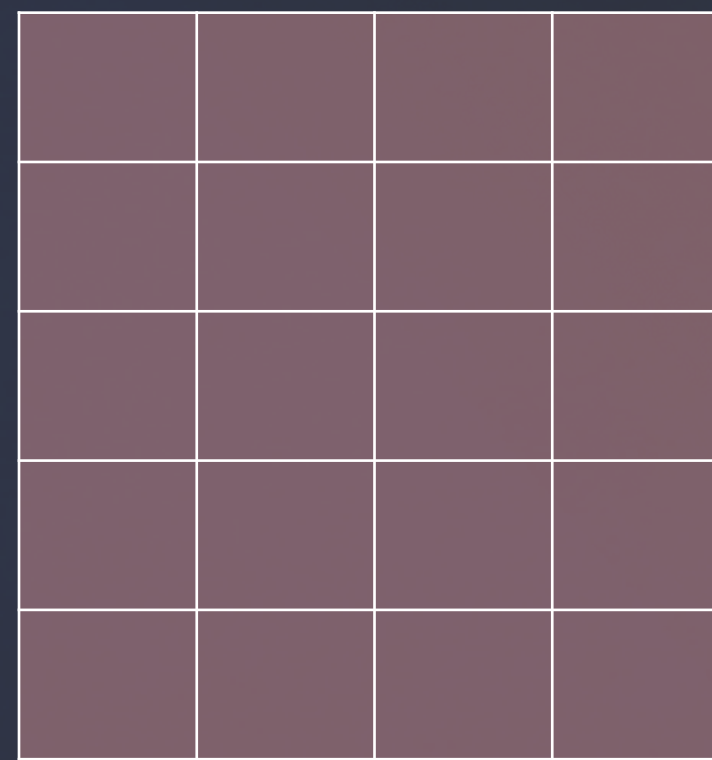
Key/value pairs: satellite='metop-3', sensor='avhrr',
calibration=[0.5,0.6,0.7]

Numerical data arrays

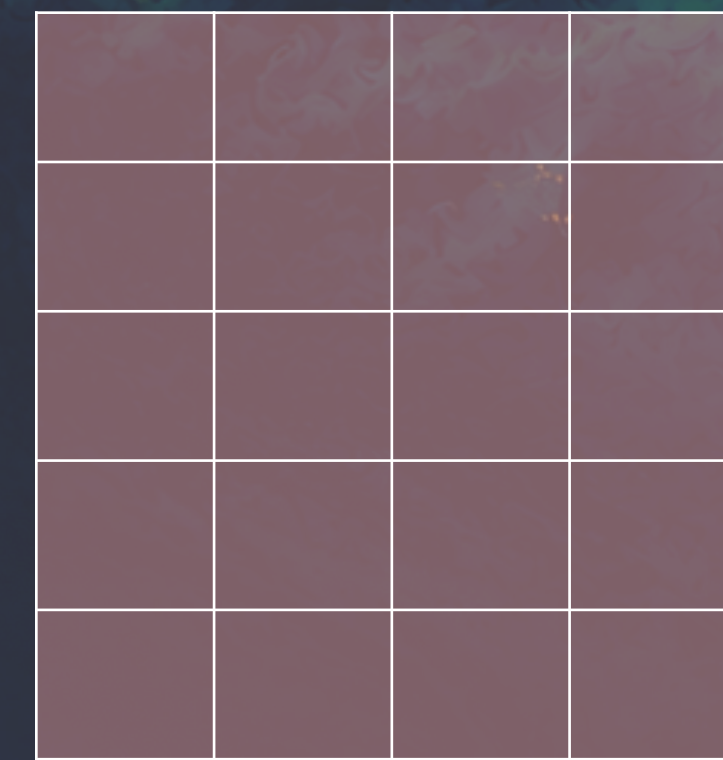
avhrr_ch2



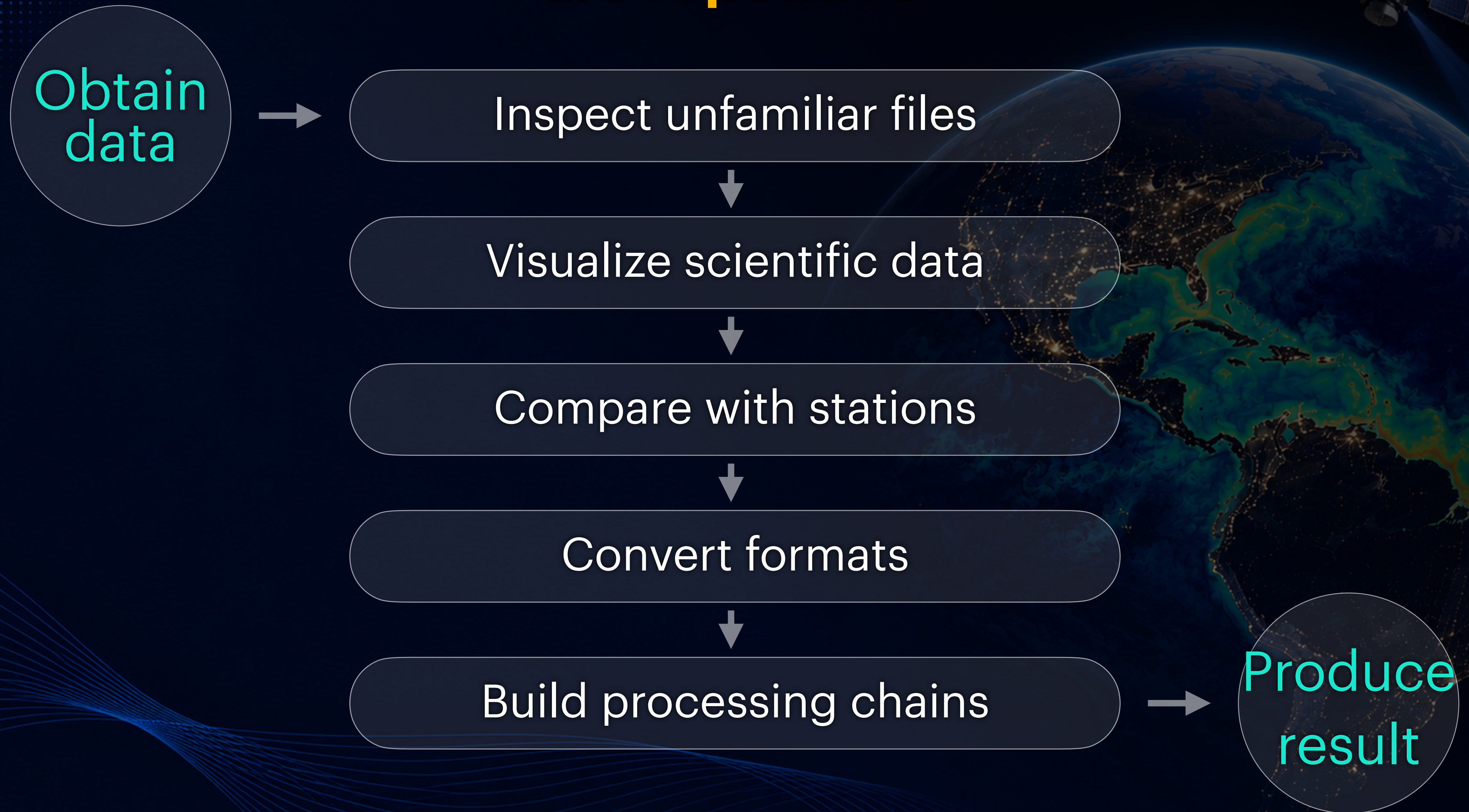
sst



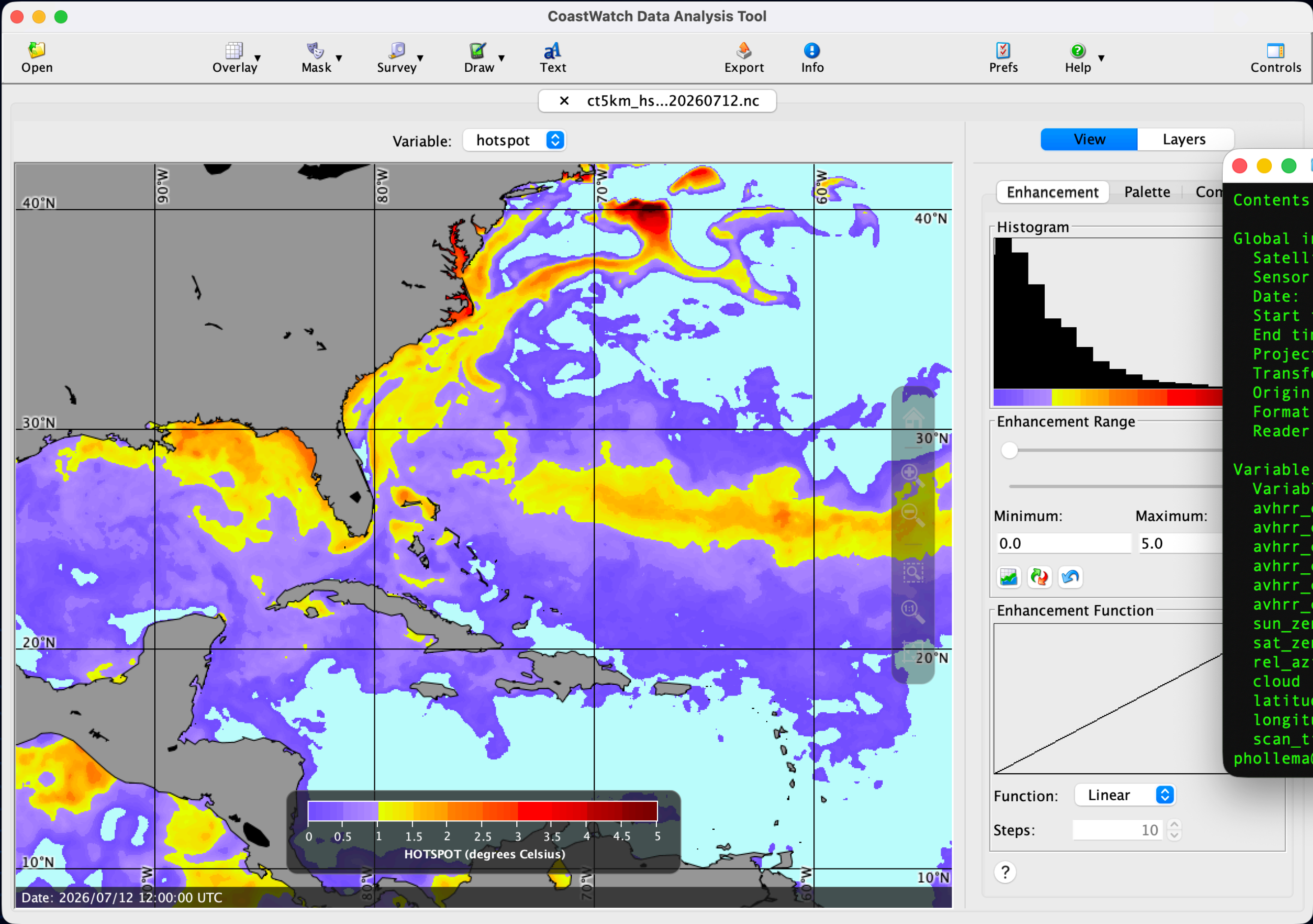
solar_zenith



The tools exist because satellite data workflows are repetitive



Interactive exploration and command-line automation support different parts of the same workflow



```
graphics — -zsh — 108x30
Contents of NSS.FRAC.M3.D25091.S0108.E0252.B3320203.SV

Global information:
Satellite:      metop-3
Sensor:         avhrr
Date:           2025/04/01 JD 091
Start time:     01:08:05 UTC
End time:       02:52:15 UTC
Projection type: swath
Transform id:   noaa.coastwatch.util.trans.SwathProjection
Origin:         USDOC/NOAA/NESDIS
Format:         NOAA 1b version 5
Reader id:      noaa.coastwatch.io.NOAA1bV5Reader

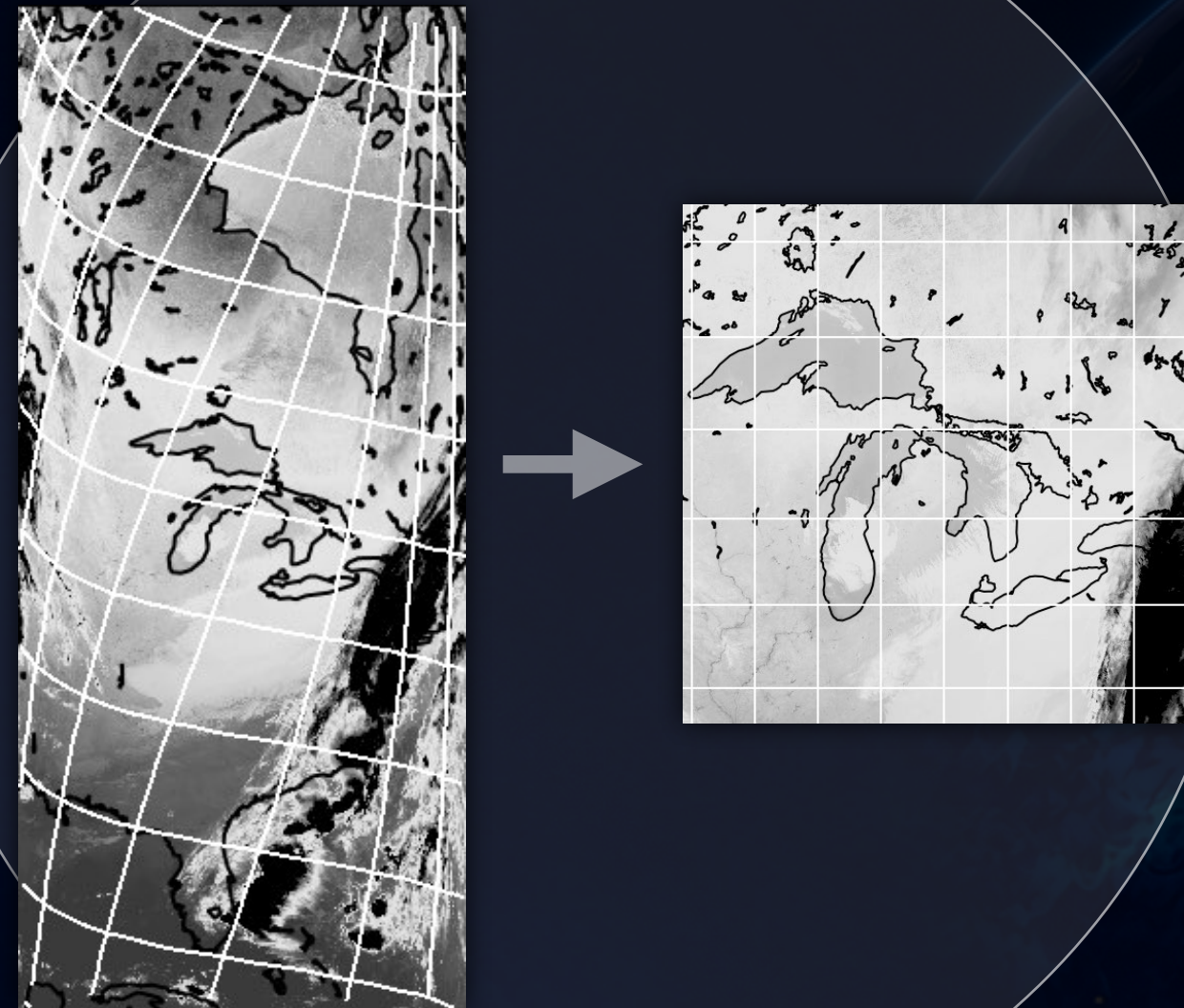
Variable information:
Variable      Type      Dimensions  Units      Scale  Offset
avhrr_ch1     short    4586x2048   percent    0.01   0
avhrr_ch2     short    4586x2048   percent    0.01   0
avhrr_ch3a    short    4586x2048   percent    0.01   0
avhrr_ch3     short    4586x2048   celsius    0.01   0
avhrr_ch4     short    4586x2048   celsius    0.01   0
avhrr_ch5     short    4586x2048   celsius    0.01   0
sun_zenith    short    4586x2048   degrees    0.01   0
sat_zenith    short    4586x2048   degrees    0.01   0
rel_azimuth   short    4586x2048   degrees    0.01   0
cloud         byte     4586x2048   -          1      0
latitude      float    4586x2048   degrees    1      0
longitude     float    4586x2048   degrees    1      0
scan_time     long     4586x2048   milliseconds 1      0
phollem@Peters-MacBook-Air-15 graphics %
```


Most CoastWatch Utilities work can be characterized as inspect, transform, or visualize

```
graphics --zsh --108x30
avhrr_ch1 short 4586x2048 percent 0.01 0
avhrr_ch2 short 4586x2048 percent 0.01 0
avhrr_ch3a short 4586x2048 percent 0.01 0
avhrr_ch3 short 4586x2048 celsius 0.01 0
avhrr_ch4 short 4586x2048 celsius 0.01 0
avhrr_ch5 short 4586x2048 celsius 0.01 0
sun_zenith short 4586x2048 degrees 0.01 0
sat_zenith short 4586x2048 degrees 0.01 0
rel_azimuth short 4586x2048 degrees 0.01 0
cloud byte 4586x2048 - 1 0
latitude float 4586x2048 degrees 1 0
longitude float 4586x2048 degrees 1 0
scan_time long 4586x2048 milliseconds 1 0
iphollema@Peters-MacBook-Air-15 graphics % cwstats --sample 1% NSS.FRAC.M3.D25091.S0108.E0252.B3320203.SV
Variable Count Valid Min Max Mean Stdev Median
avhrr_ch1 94095 94095 -0.02 1.39 0.032656 0.031546 0.04
avhrr_ch2 94095 94095 -0.06 4.45 0.003032 0.046493 0
avhrr_ch3a 94095 0 NaN NaN NaN NaN
avhrr_ch3 94095 94095 -73.79 39.22 -10.830061 18.959024 -13.5
avhrr_ch4 94095 94095 -73.21 24.19 -11.931617 18.952844 -14.25
avhrr_ch5 94095 94095 -73.62 22.21 -13.03461 18.629931 -15
sun_zenith 94095 94095 90.06 139.64 114.655013 10.350157 114.82
sat_zenith 94095 94095 0.29 68.62 32.30691 19.271062 31.62
rel_azimuth 94095 94095 -107.19 168.12 36.374429 92.835664 -44.61
cloud 94095 45026 1 3 2.697175 0.685958 3
latitude 94095 94095 19.4676 68.9288 44.767226 12.734933 44.855
longitude 94095 94095 -122.0355 -64.3535 -86.083881 10.066759 -85.198463
scan_time 94095 94095 1743474681100 1743475444434 1743475062766.6052 220837.271991 174347506276
7
iphollema@Peters-MacBook-Air-15 graphics %
```

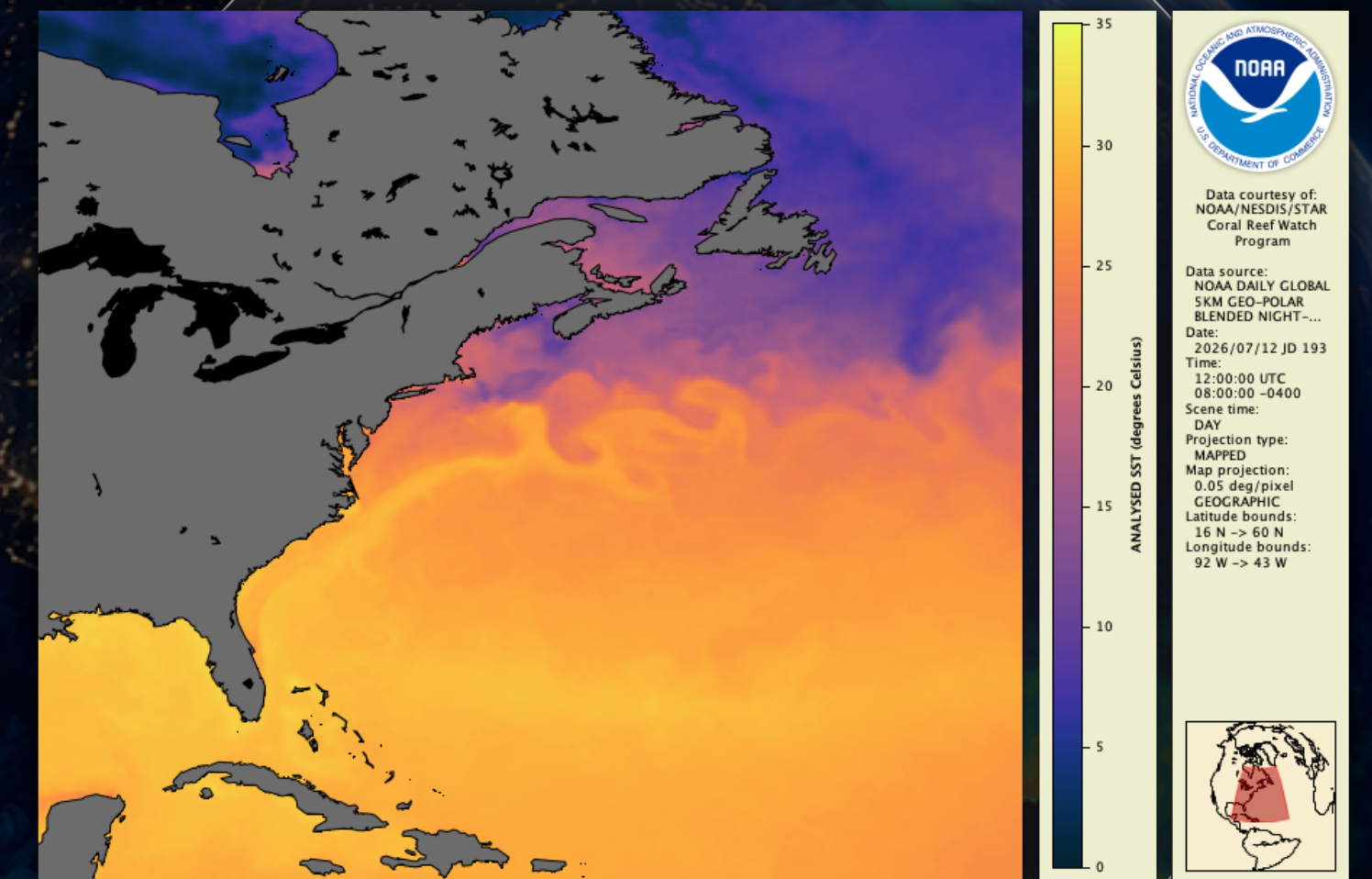
Inspect

Information, statistics,
sampling



Transform

Compute, aggregate,
rearrange



Visualize

Render, interact,
animate

The utilities support file inspection, generating statistics, and data sampling

Dataset level



Source



Temporal



Spatial

Variable level



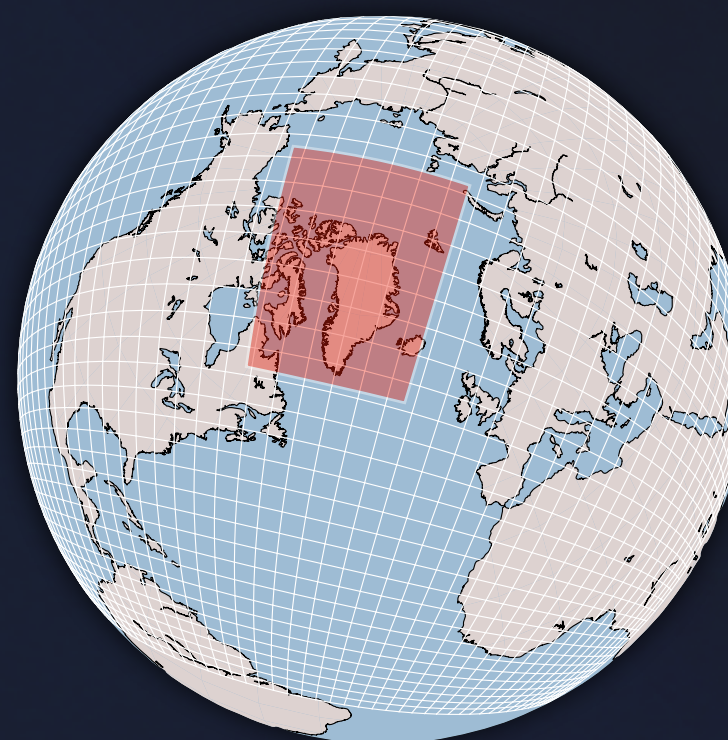
Storage

cwinfo

Basic statistics

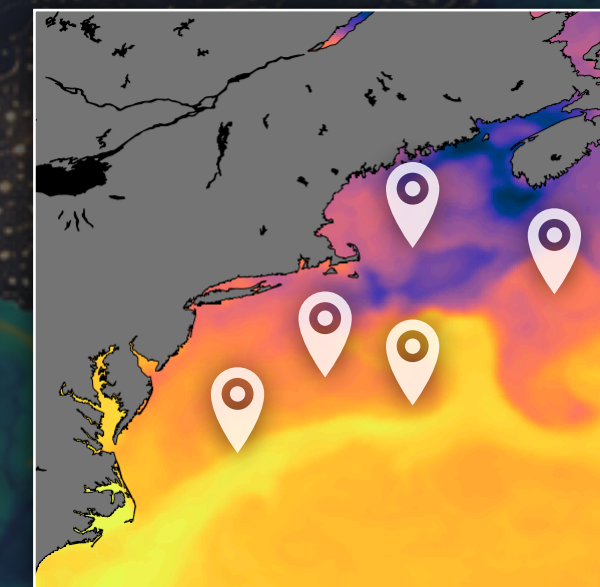
$$\bar{x} = \frac{\sum x_n}{N}$$

Region limits

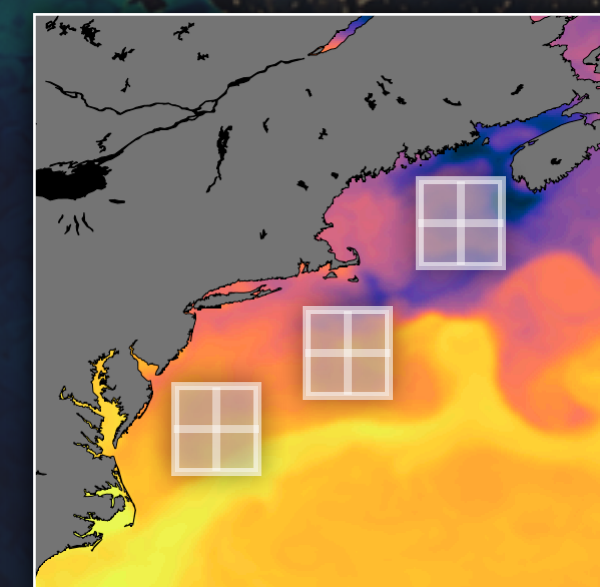


cwstats

Station sampling

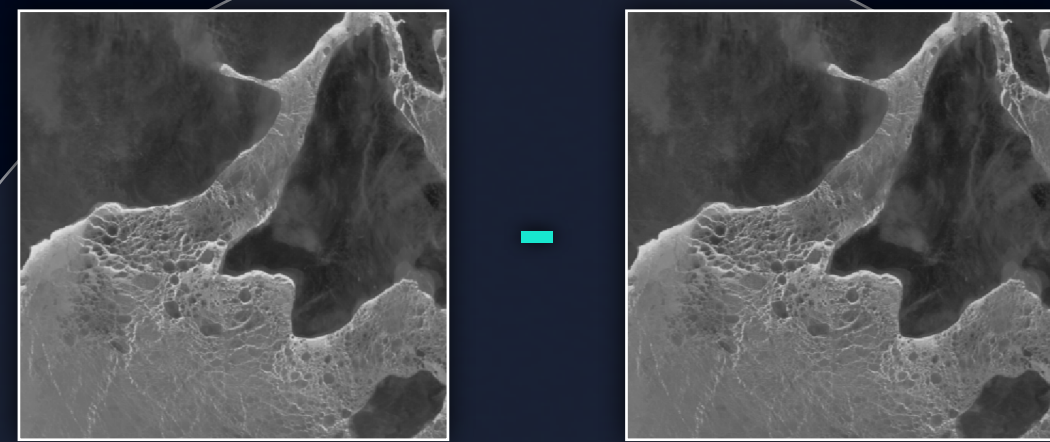


Window sampling

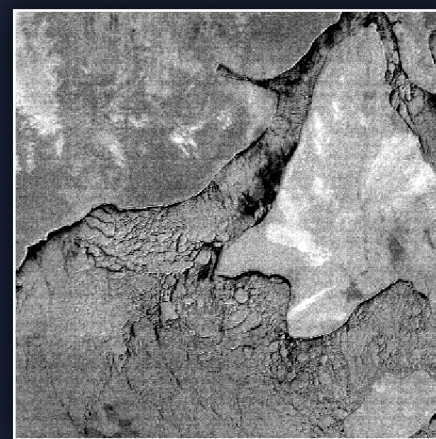


cwsample

Data transformation tools include generic math, resampling, and temporal/spatial compositing

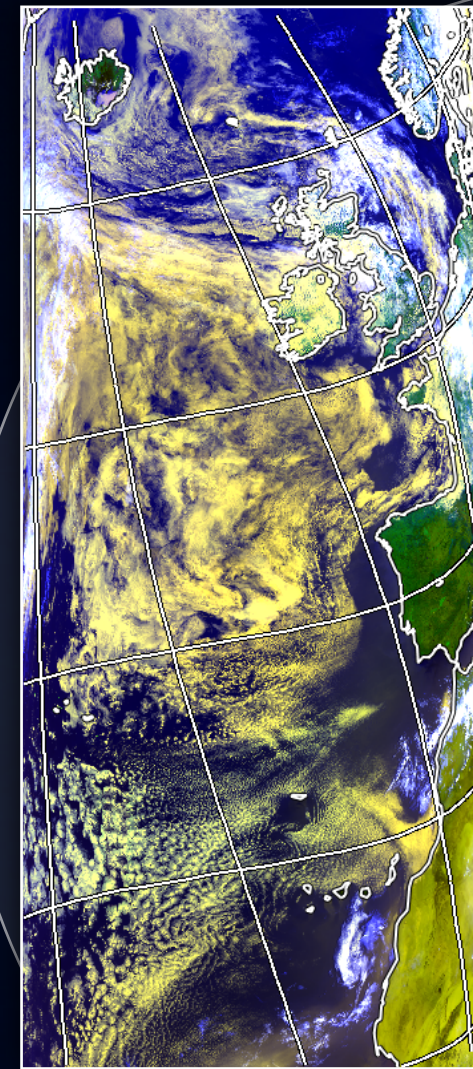


=

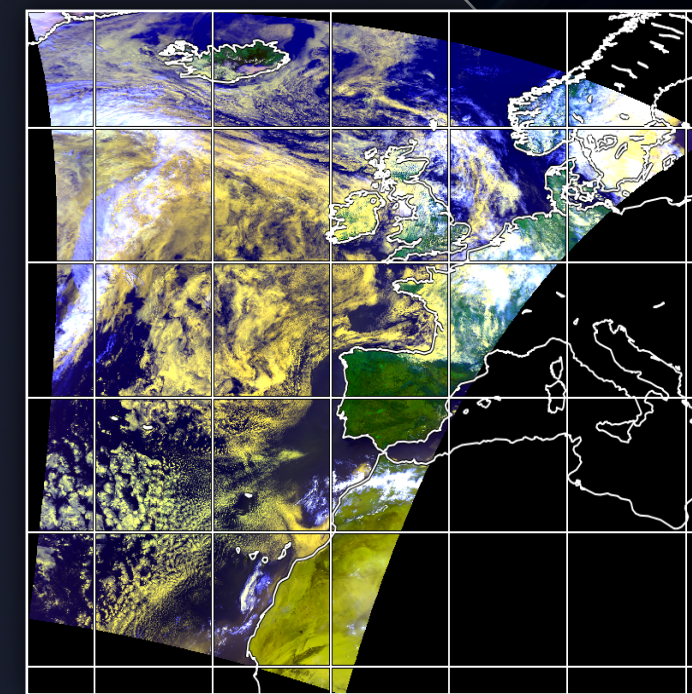


diff45 = ch4 - ch5

cwmath

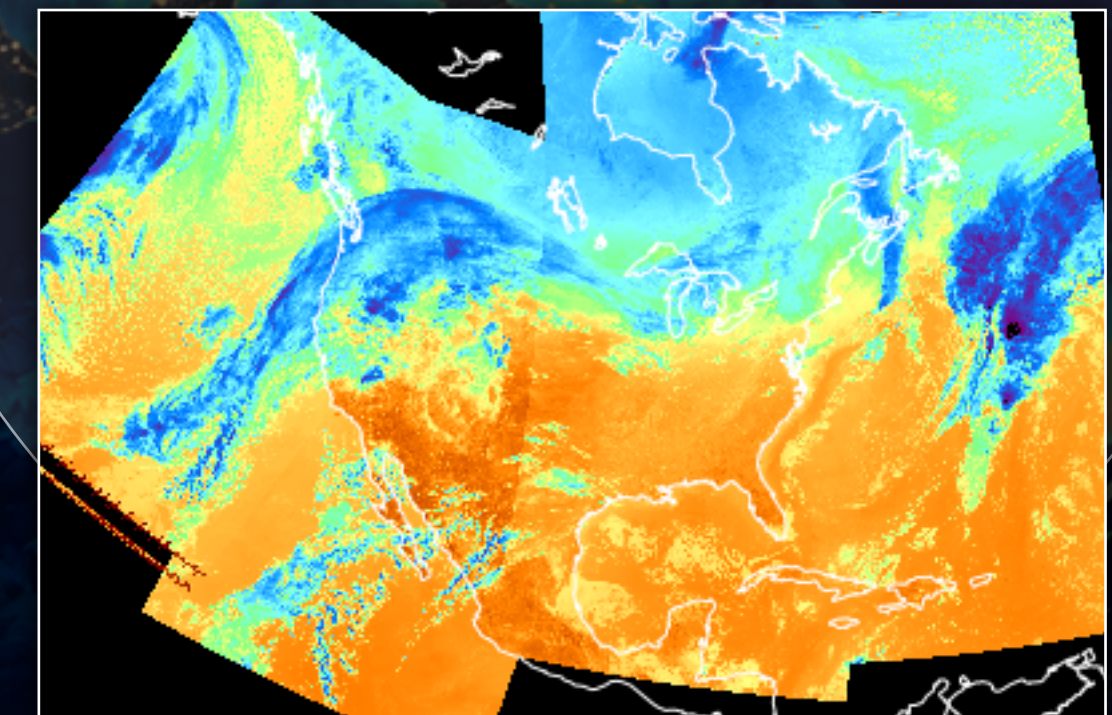
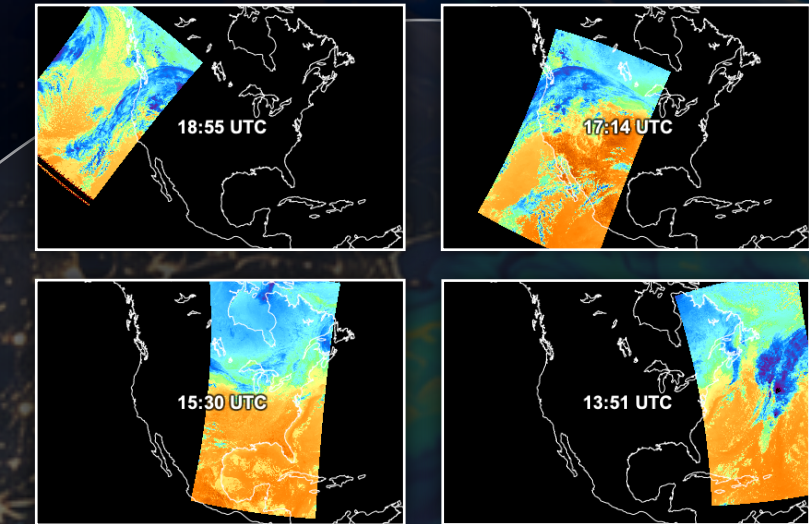


Swath



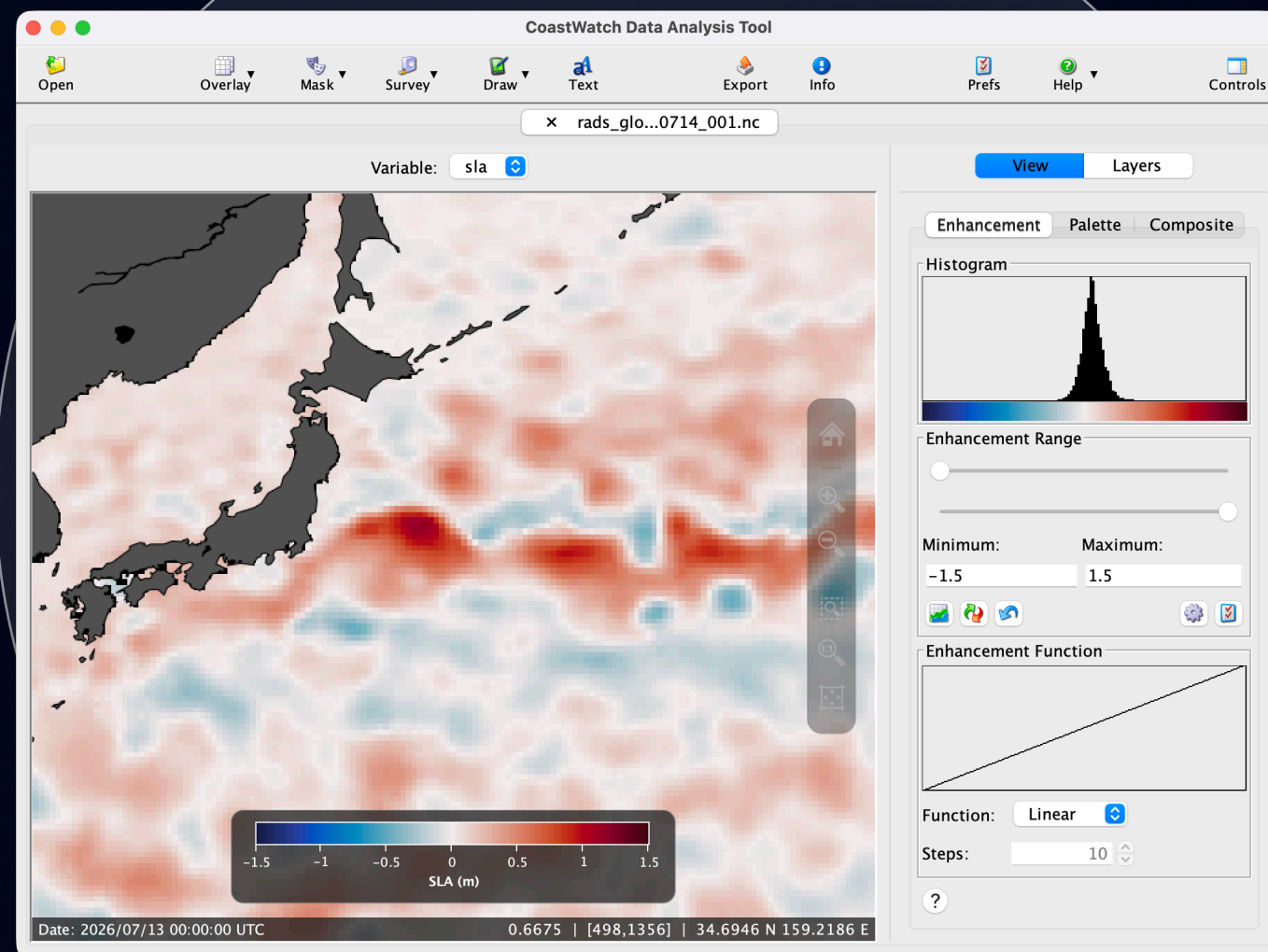
Mapped

cwregister2

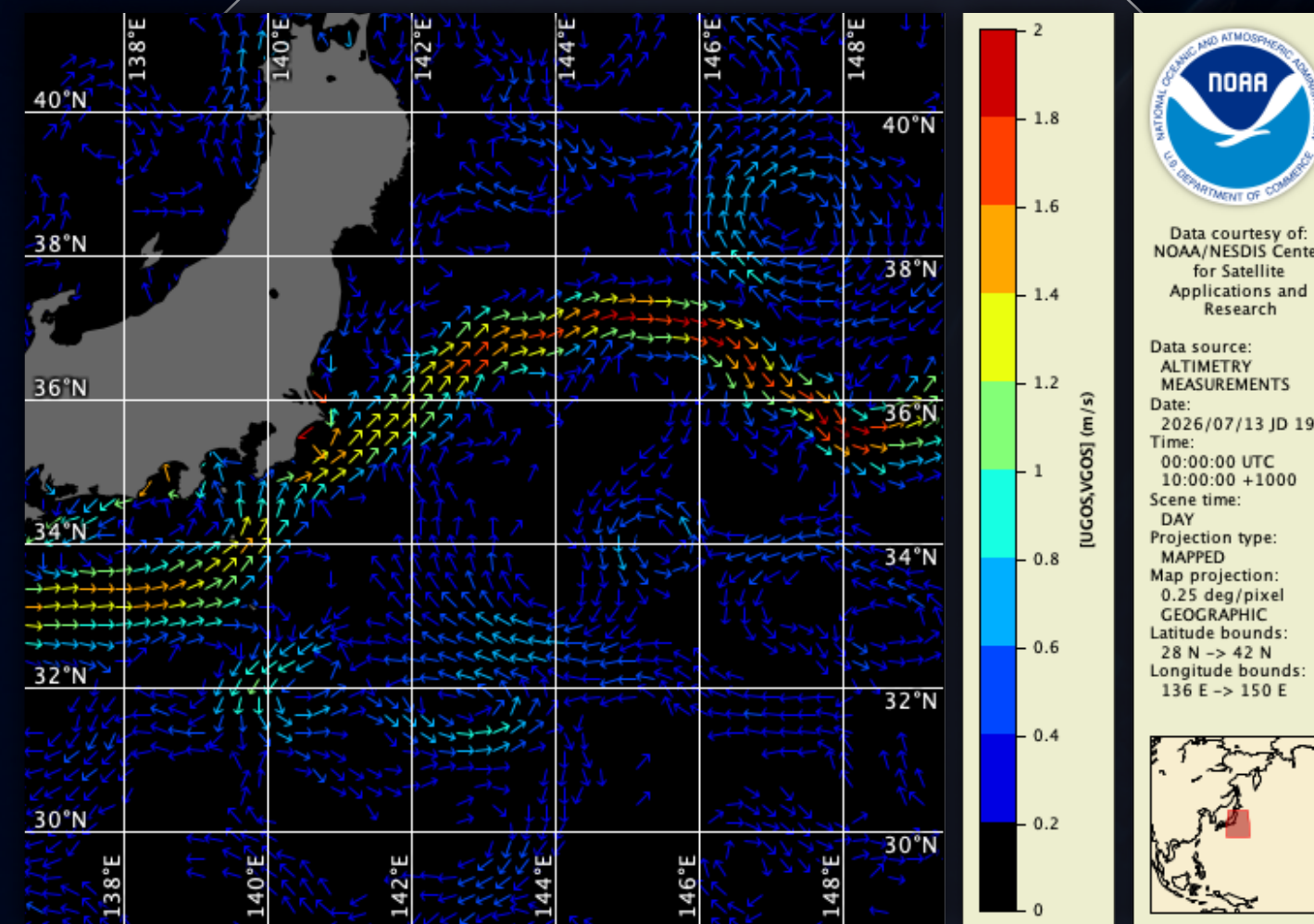


cwcomposite

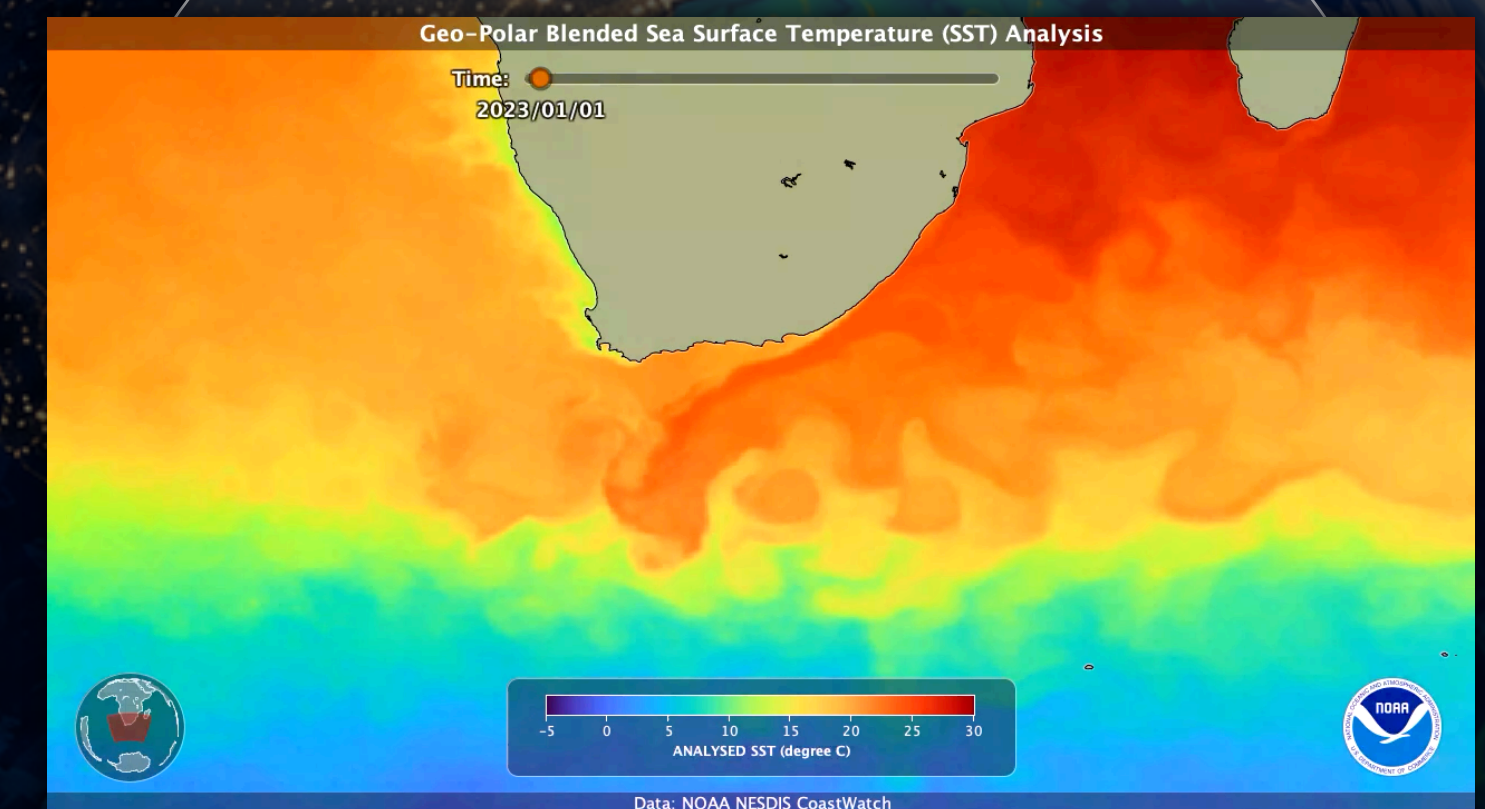
Visualization can be interactive, repeatable, or time-based



CoastWatch Data
Analysis Tool



cwrender



cwanimate

The online course provides guided, hands-on practice

<https://coastwatch-training.github.io/CoastWatch-Utilities>

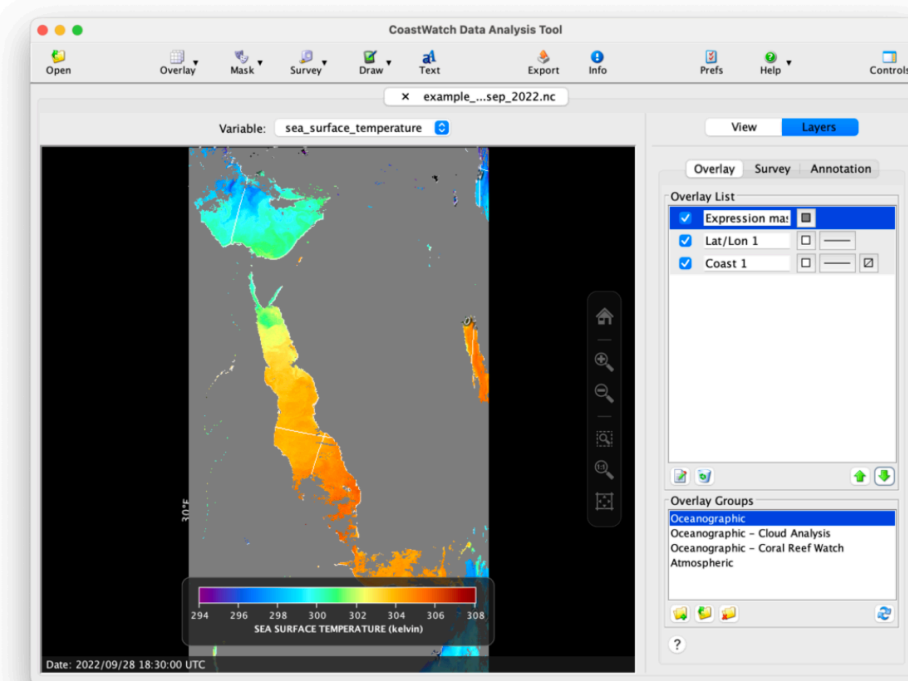
Data Overlays

CDAT shows graphics in the data view using overlays, which are layered on top of the data image. To show a latitude/longitude grid, coastlines, and to mask low quality SST data, do the following:

1. Click the **Overlay** button in the toolbar, then **Coastlines** to add a coastlines overlay.
2. Again using the **Overlay** button, click **Latitude / longitude grid** to add a grid overlay.
3. Click the **Mask** button in the toolbar, and then **Expression mask**. An overlay properties window will appear — type `quality_level < 5` in the mask expression text field, then click **OK**. The `quality_level` variable contains a rating value for the SST pixels on a scale from 1 (lowest quality) to 5 (highest quality). The expression masks out any pixels with a quality rating less than 5.

NOTE: Step 3 above will only work if you selected the `quality_level` variable when opening the file. If you get an error clicking **OK** on Step 3, close and reopen the file and select both the `sea_surface_temperature` and `quality_level` variables.

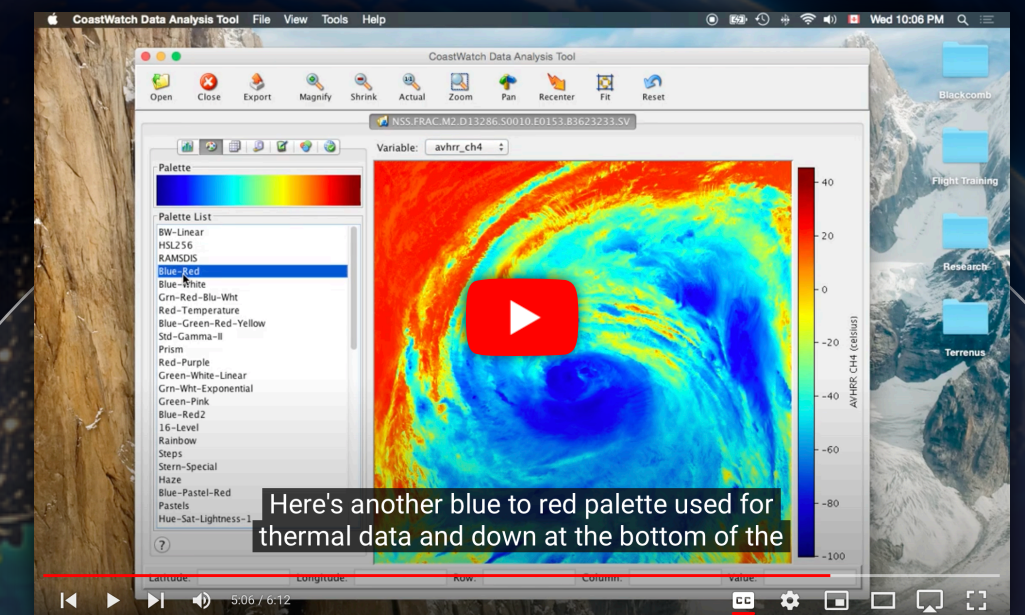
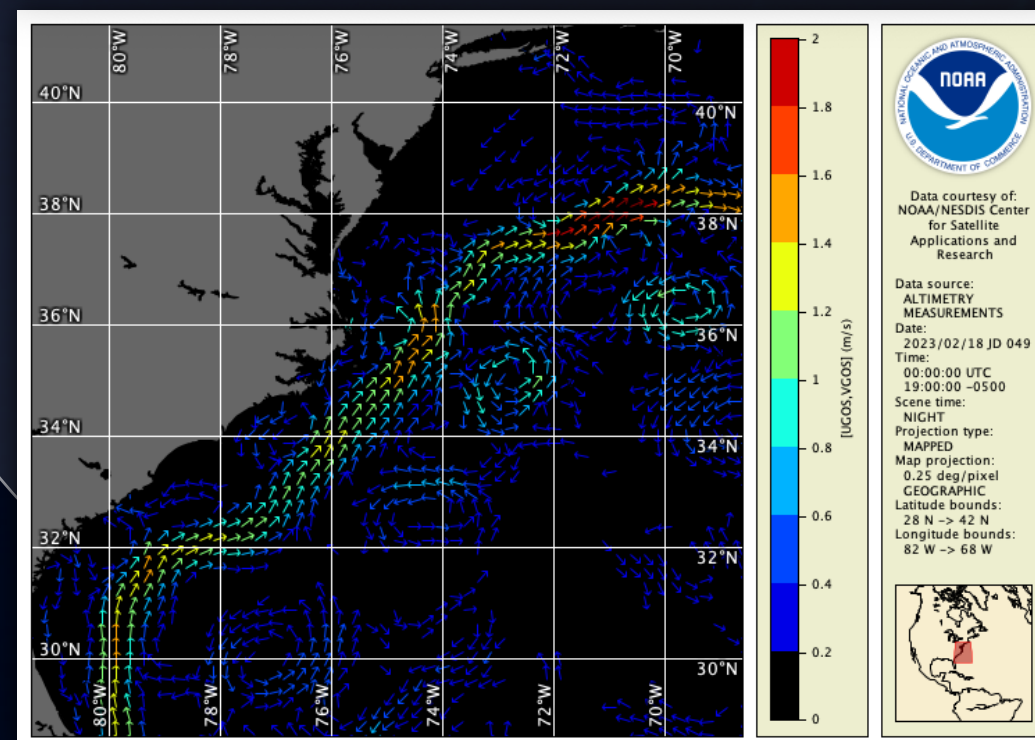
Your CDAT window will look similar to the following (notice that the control tabs were automatically updated to show the new overlay layers):



```
phollemas$ cwinfo example_altim_surface_curr_feb_2023.nc
Contents of example_altim_surface_curr_feb_2023.nc

Global information:
Data source: Altimetry measurements
Date: 2023/02/18 00 049
Time: 00:00:00 UTC
Scene time: day/night
Projection type: mapped
Transform ident: noaa.coastwatch.util.trans.GeographicProjection
Map projection: Geographic
Map affine: 0 0.25 0.25 0 -179.88 -89.88
Spheroid: WGS 84
Origin: NOAA/NESDIS Center for Satellite Applications and Research
Format: Java-NetCDF interface (NetCDF-4 ucar.nc2.dataset.conv.CF1Convention)
Reader ident: noaa.coastwatch.io.CommonDataModelNCReader

Variable information:
Variable Type Dimensions Units Scale Offset
sla short 720x1440 m 0.0001 -0
ugos int 720x1440 m/s 0.0001 -0
vgos int 720x1440 m/s 0.0001 -0
time double 1 days since 1950-01-01 00:00:00
latitude float 720 degrees_north
longitude float 1440 degrees_east
phollemas$
```



Question 3

1 pts

The `cwmaster` tool can read and write map projection master templates for:

- ☐ Polar Stereographic
- ☐ Albers Equal Area
- ☐ Mercator
- ☐ Icosahedral

Bonus exercises:

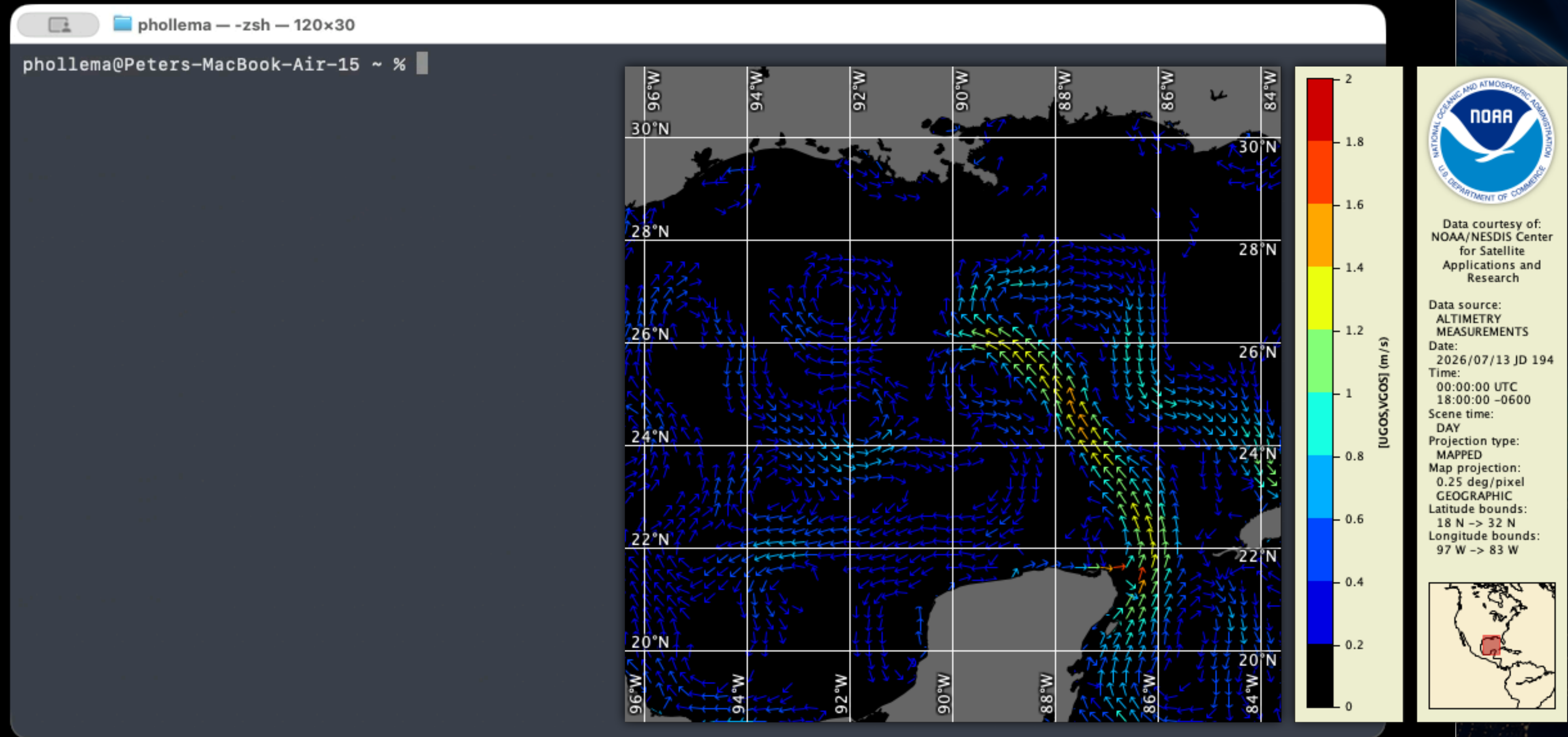
- Customize the SST processing script to produce a different output file format with your own preferred set of geographic overlays. The `cwrender` manual page will be useful.
- Use `cwmaster` to create your own master projection template and use that in the script instead of the one provided.
- Use your own ESRI shapefile data for the aquaculture enclosure polygons. You could create a custom shapefile visually using the [UCLA click2shp](#) web tool.
- Watch a [YouTube video](#) showing the use of a script that composites and renders a year of chlorophyll data.

Step by step use of
CDAT with screen captures

Example command
line calls and output

Assignments, quizzes, bonus
exercises, and videos

The help agent is being tested as a faster route from a question to a workable command



New versions are created twice a year and distributed from the CoastWatch central operations website



Dec 2025	4.1.5
TBD	4.2.0

~6-12 month release
as needed



Primary source of installation packages: coastwatch.noaa.gov (see Data Tools)
Source code and beta releases: github.com/phollemans/cwutils

Demo

