Unit 2 - Ocean Colour Data Validation with SNAP

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Phytoplankton from space: intro to ocean color – 29 & 30 June 2019
Ocean Optics & Ocean Color Remote Sensing

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Contents

- Practical (short) course on ocean colour (OC) remote sensing using **Sentinel Application Platform** (SNAP).

- Lectures:
  - **Unit 1 :**
    - Ocean colour data (sensors and data archives)
    - Exploring OC data using SNAP

  - **Unit 2:**
    - Validation Tools

  - **Unit 3:**
    - Batch Processing

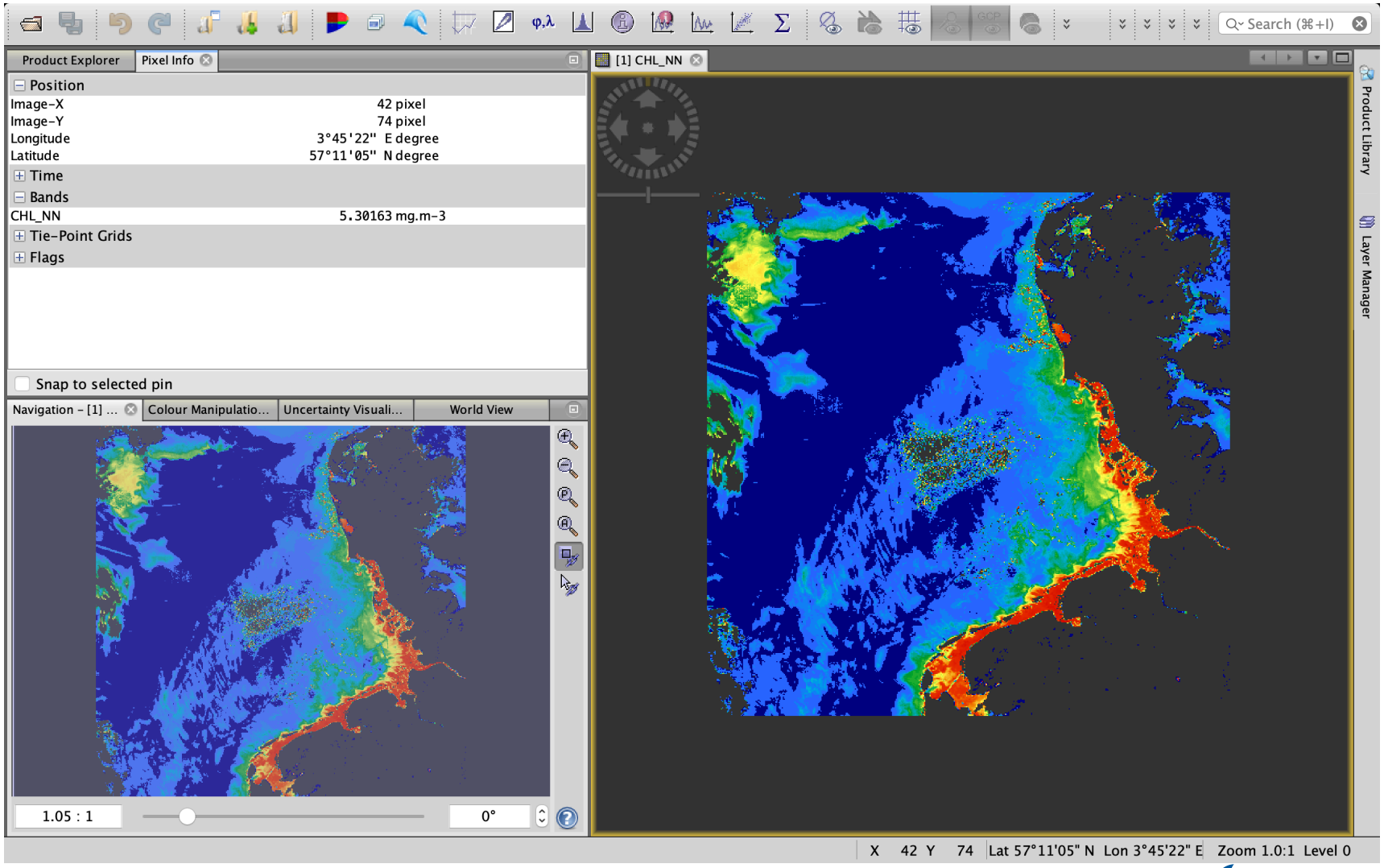
SNAP: Desktop Basic Functions

- Open products and display bands
  - Open OLCI Level 2 data (*.xml file)

    S3A_OL_2_WRR____20190622T095648_20190622T104112_20190622T124053_2664_046_122_____MAR_O_NR_002.SEN3

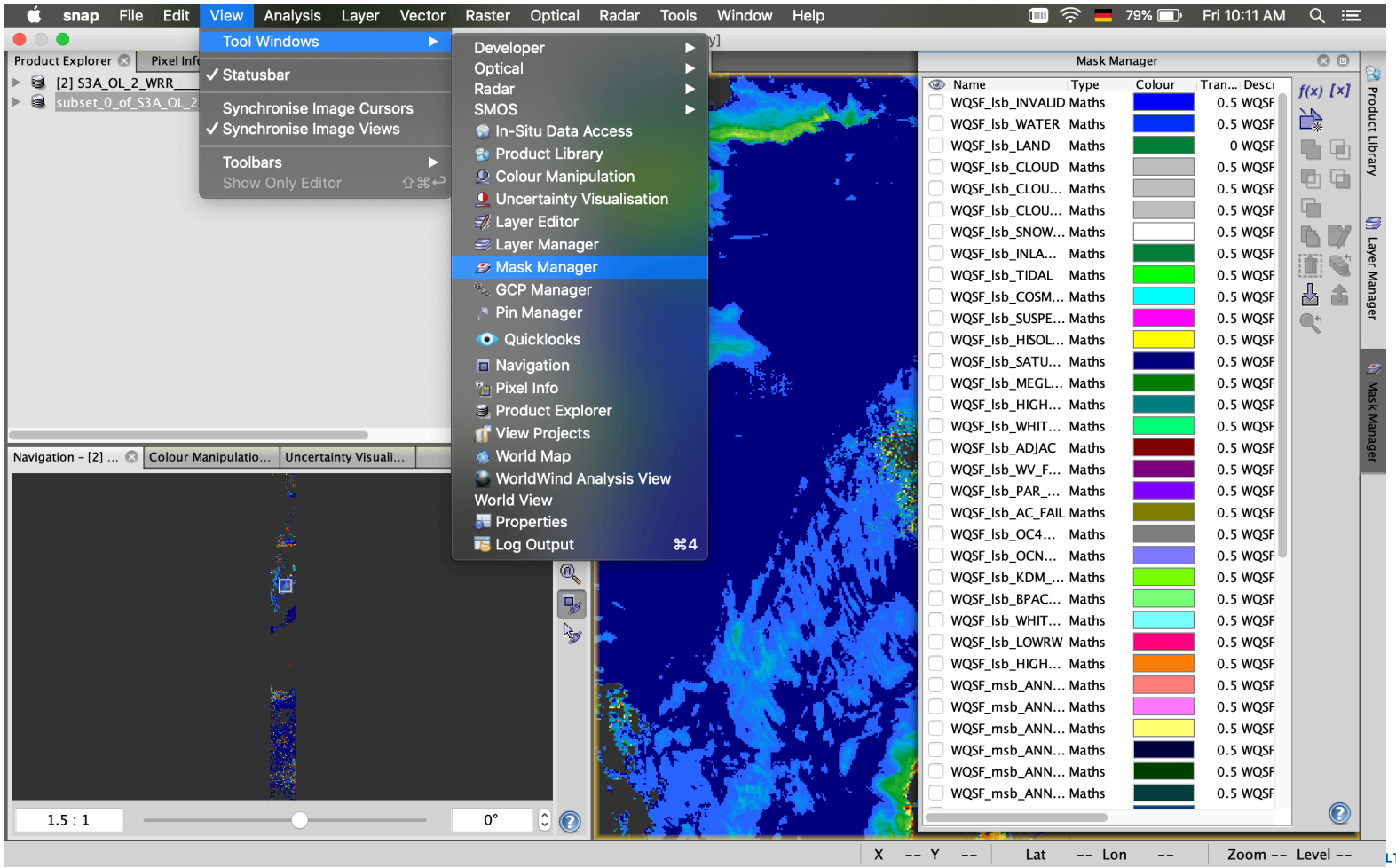
  1) Display CHL product
  2) Apply existing masks
  3) Create new masks

SNAP: Display CHL



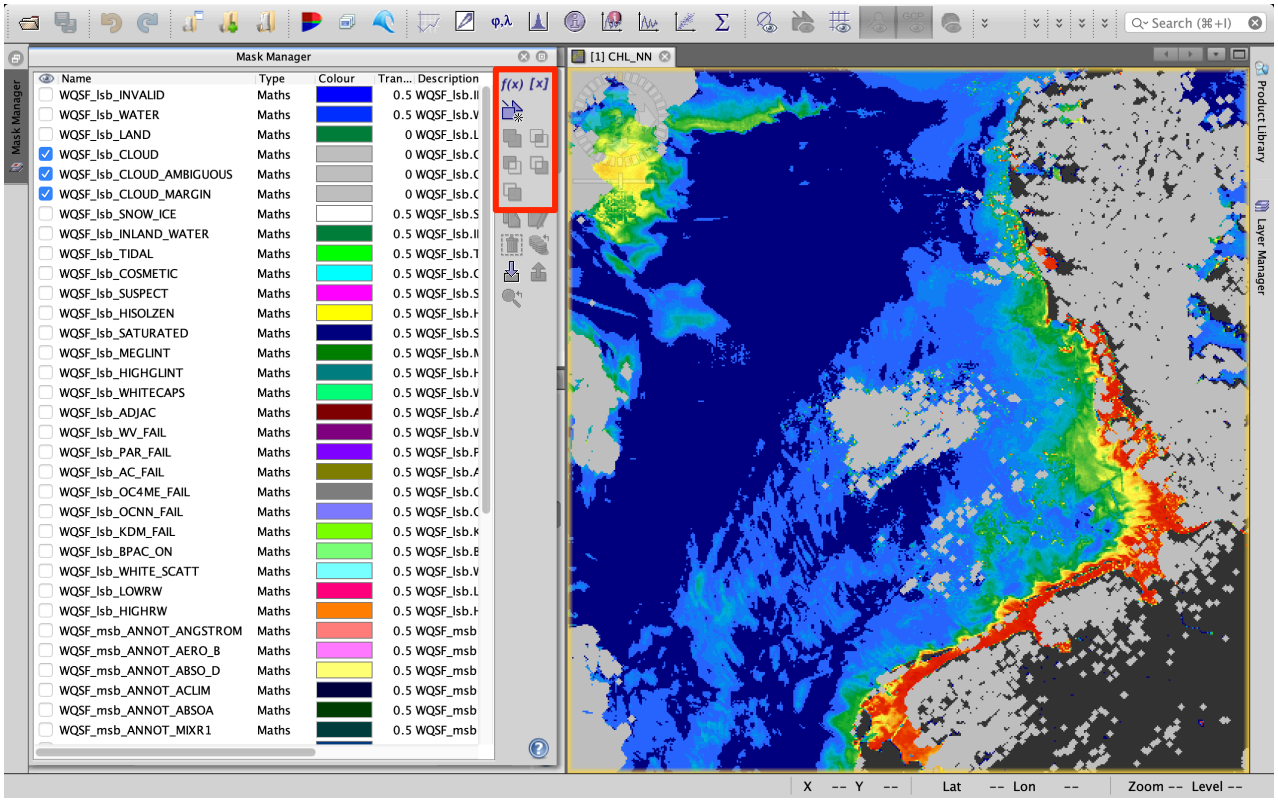
SNAP: Apply existing masks

- View -> Tool Windows -> Mask Manager
- Or 



SNAP: Apply existing masks

- Flags of OLCI standard products are automatically included as masks.
- All geometries, pins and imported vector data are included as masks.
- Own masks can be generated:
  - from flags, geometries, band math expression;
  - by combination of flags.



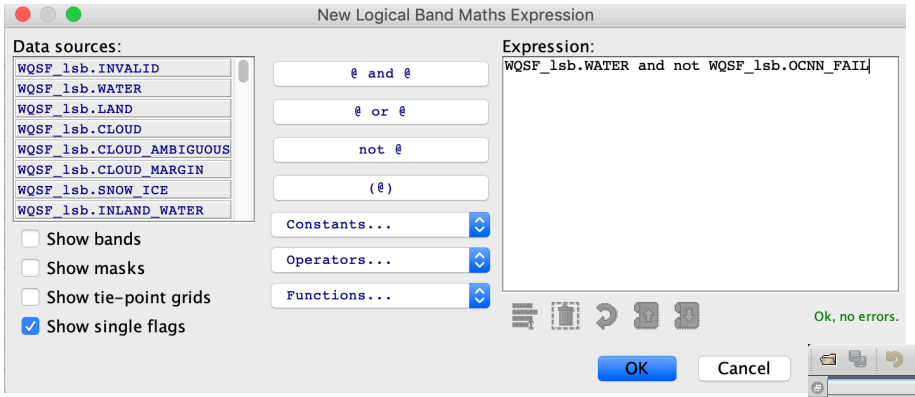
SNAP: Generation of new masks

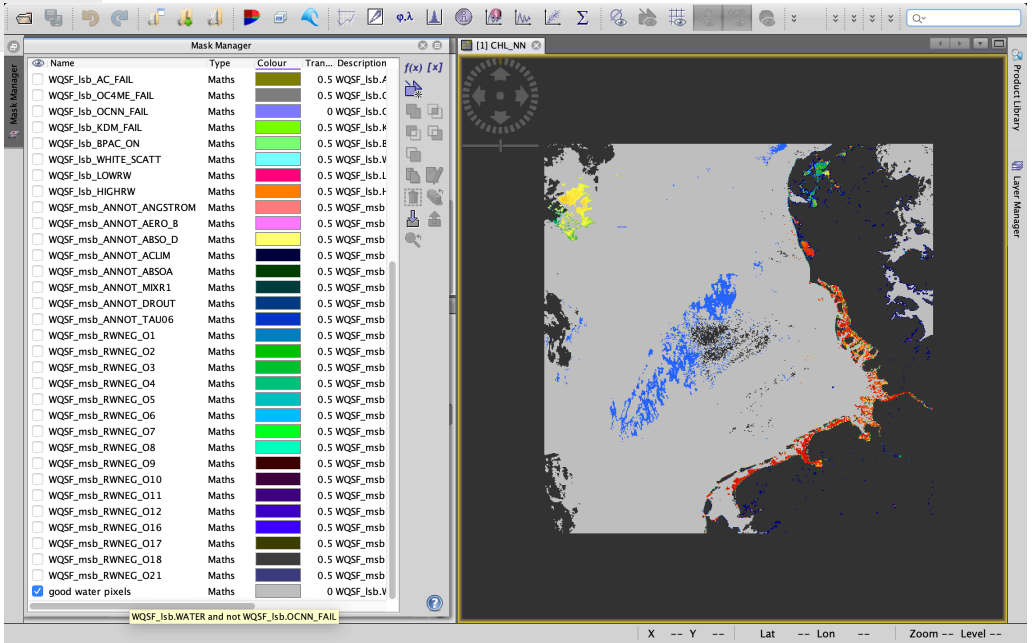
- Masks defined by a band maths expression *f(x)*
- Masks defined by a value range *[x]*
- Masks defined by a geometry such as lines and polygons 
- Combination of Masks:
  - Union
  - Intersection
  - Differences (top down or bottom up order)
  - Complement of a mask

SNAP: Generation of new masks

- Masks defined by a band maths expression $f(x)$

WQSF_lsb.WATER and not WQSF_lsb.OCNN_FAIL





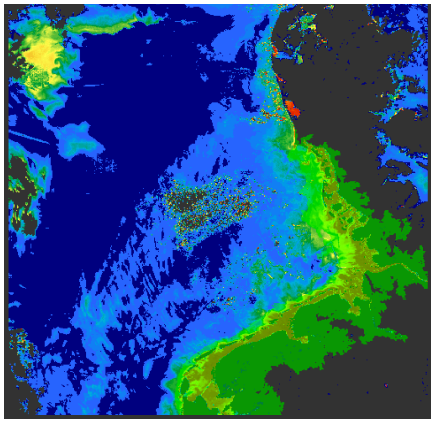
SNAP: Generation of new masks

- Combination of masks

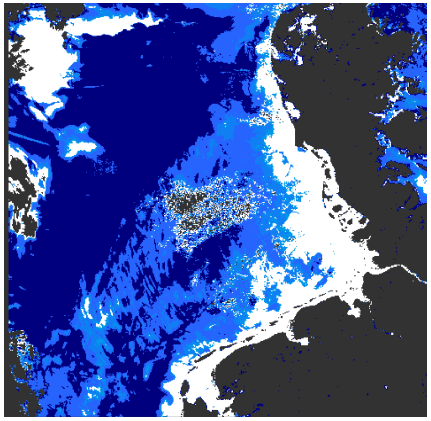
High chlorophyll area not in tidal area

1) Create a high CHL mask using range e.g. 1 < CHL_NN < 30
2) Select WQSF_lsb_TIDAL and high CHL (but do not check the boxes) →

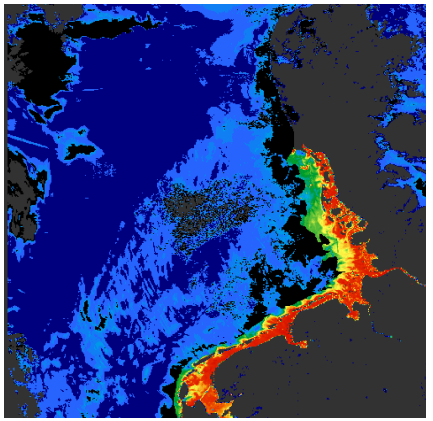
tidal regions (green)



high CHL (white)

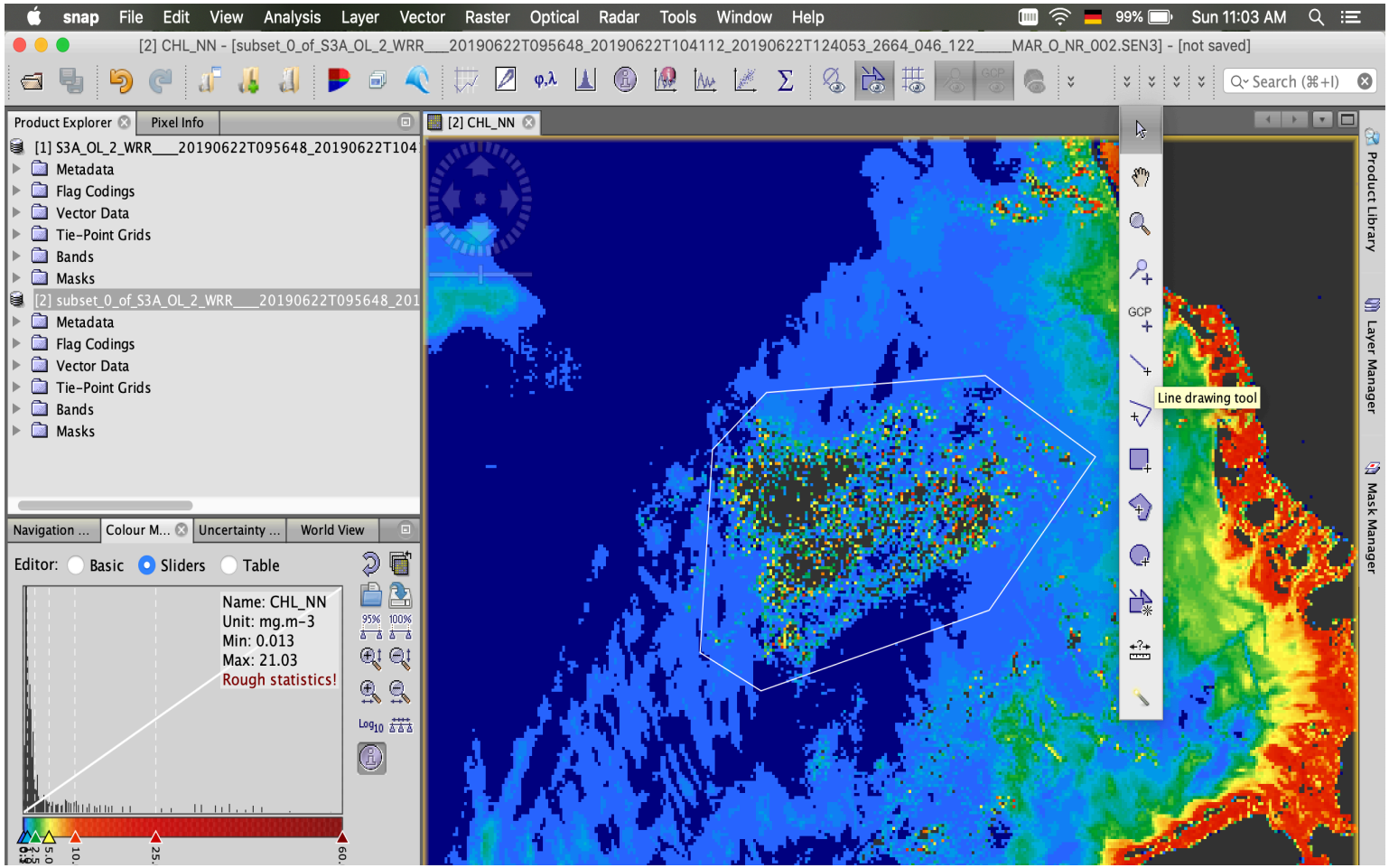


high CHL not in tidal area



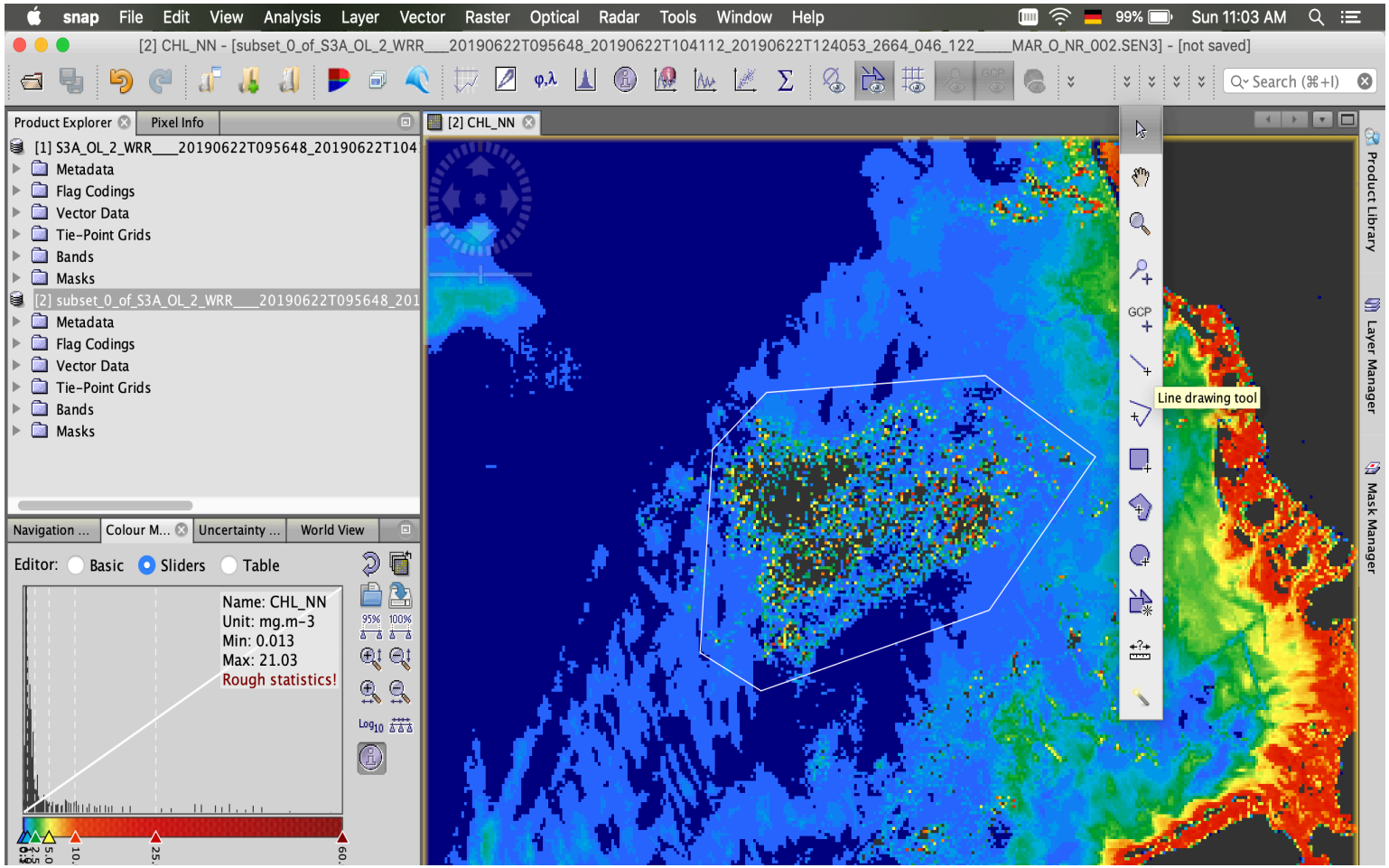
SNAP: Geometry

- Masks can be created as geometries. Geometries can be drawn on a product view or imported from external files



SNAP: Geometry

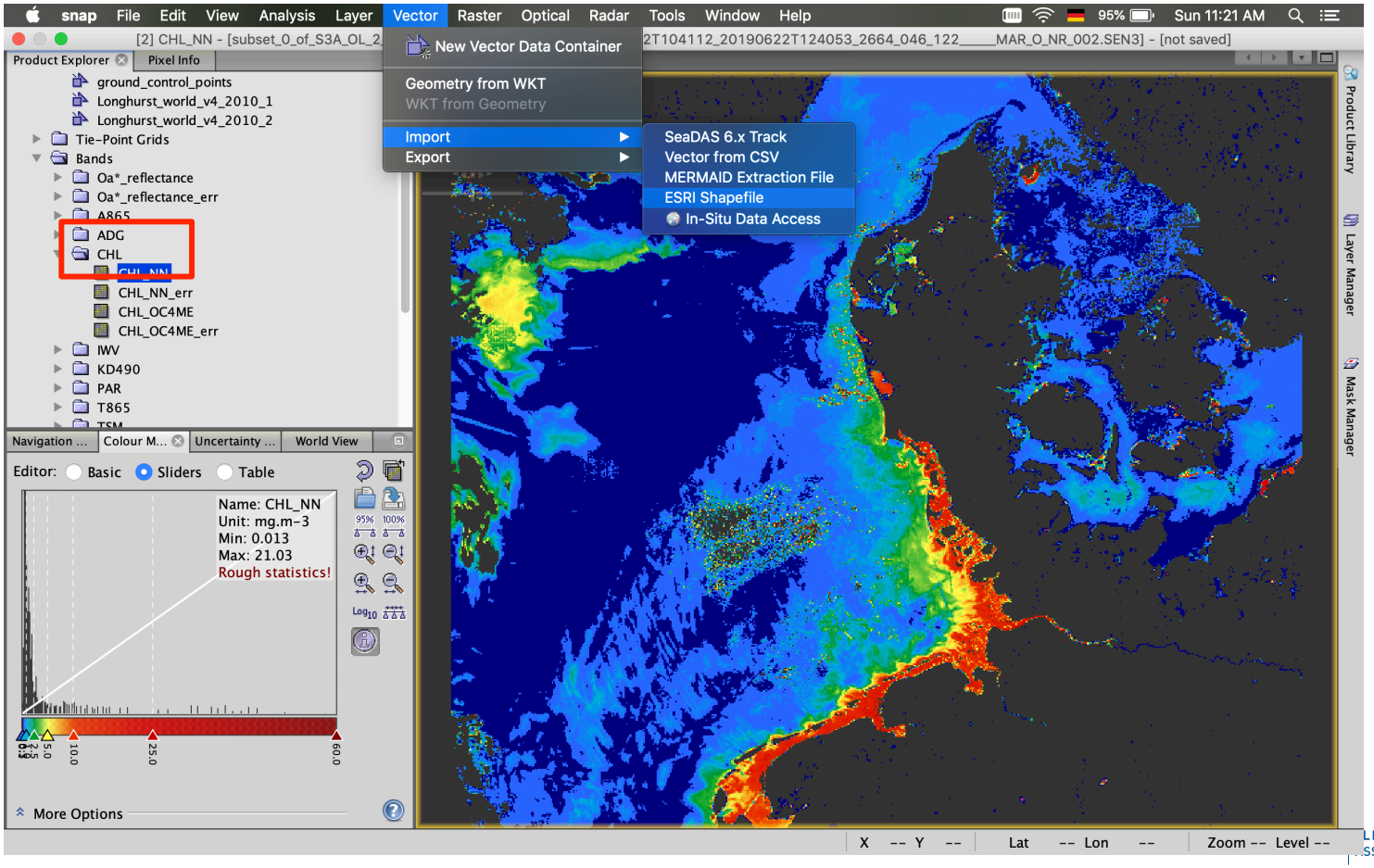
1) Create a shapefile. The shapefile is saved in the folder Vector Data and as Masks
2) Save the geometry as shapefile (.shp)



SNAP: Importing shapefile

1) Vector → Import → ESRI as shapefile: Longhurst biogeochemical provinces (Longhurst_world_v4_2010.shp, choose ok → yes)

- Select the band before importing the shapefile!

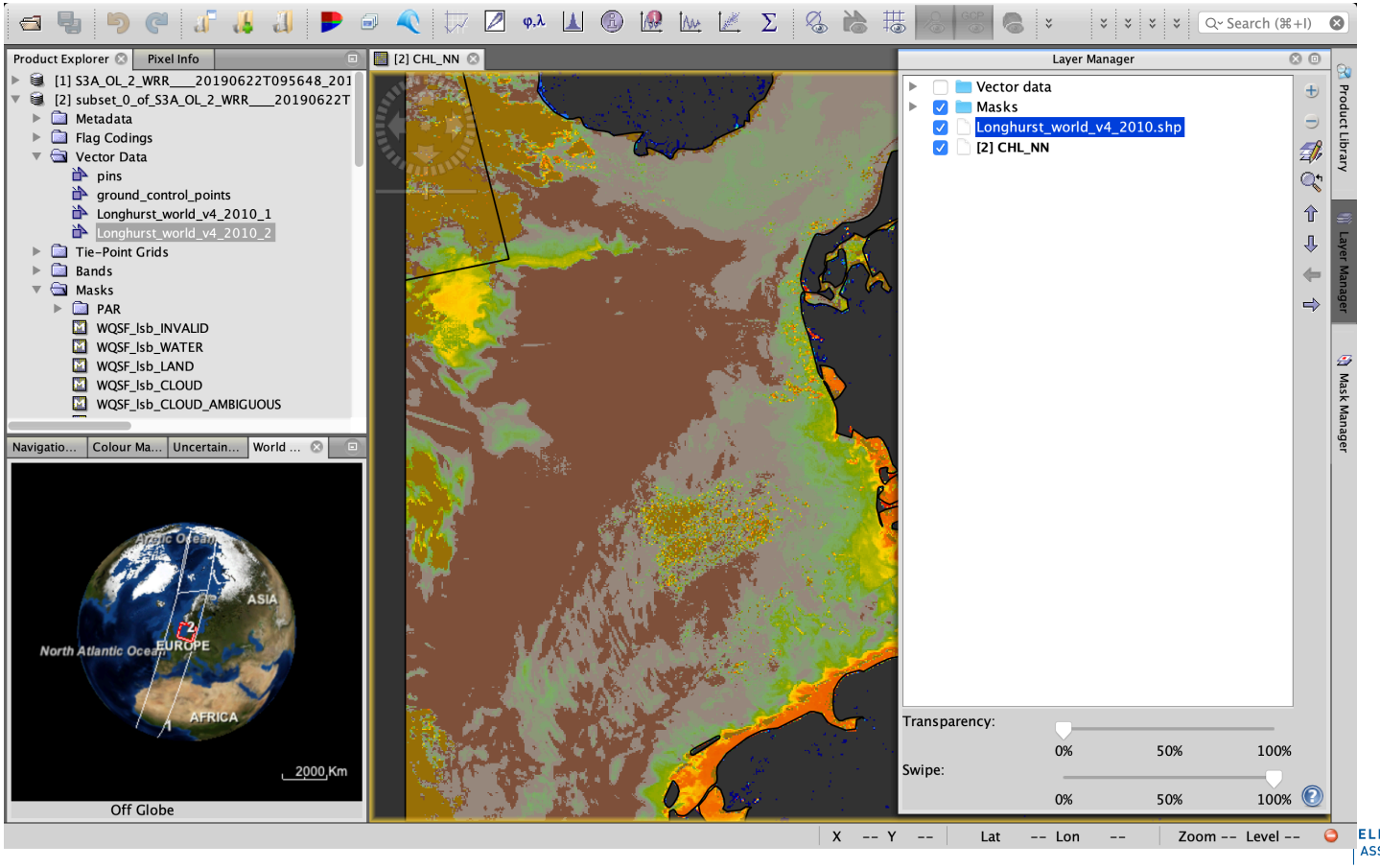


SNAP: Importing shapefile

1) Vector → Import → ESRI as shapefile: Longhurst biogeochemical provinces (Longhurst_world_v4_2010.shp, choose ok → yes)

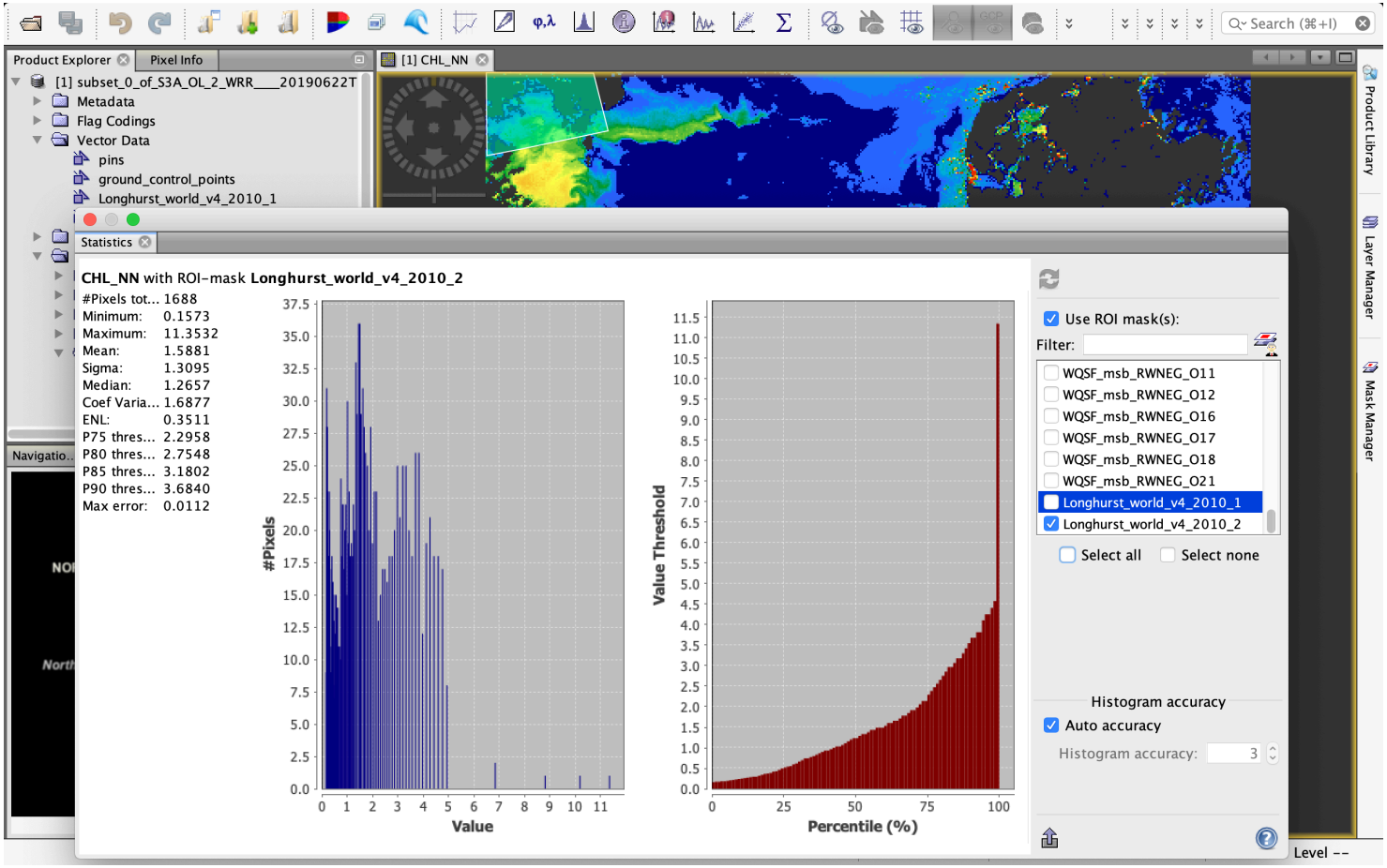
- Select the band before importing the shapefile!

2) To display check the Layer Manager and Mask windows



SNAP: Shapefile as Regio of Interest (ROI)

- Statistics for ROIs: Analysis → Statistics → check the box “Use ROI masks”



SNAP: Masks

- Mask
  - Masks regions of raster dataset.
  - Masks can be derived from an expression, a value range, a geometry or from combinations of different masks.
- Layer
  - Views are composed of multiple, configurable layers
  - A layer is used to visualise a certain data source
  - Vector data, raster data and masks and represented by special layer types
- Geometry
  - A geometric shape (point, line, polyline or polygon).
  - Geometries can be drawn on a product view or imported from external files.
- Region of Interest (ROI)
  - Statistical computation and Analysis Tools can be performed on ROIs.
  - Masks are always and automatically applicable ROIs (→ ROIs are a role of Masks).

*slide prepared by Ana Ruescas from Brockmann Consultancy

SNAP: Validation - Formats for data import

- CSV-vector data:
  - Tab-separated (not only blanks, use Notepad++ (Win))
  - A CSV file must have a *header line* with (at least) the following column names:
    - ✓ Name: 'name'
    - ✓ Latitude: 'lat' or 'latitude'
    - ✓ Longitude: 'lon', 'long' or 'longitude'
    - ✓ optional: Date and Time as 'DateTime‘ (format *yyyy-mm-dd*T*HH:MM:SS*)
    - ✓ optional: column(s) with in-situ values
  - Can be imported as points, lines, or polygons

*slide prepared by Ana Ruescas from Brockmann Consultancy

SNAP: Example of an in-situ table

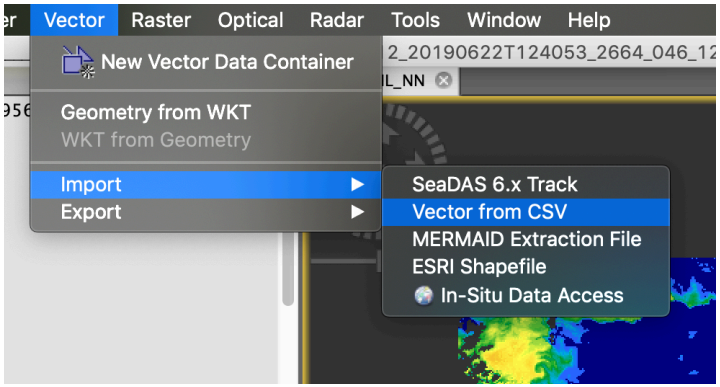
header line

	Name	Longitude	Latitude	Label	DateTime	CHL	TSM
2	Station_1	8.433142	54.063217	Station_1	2012-04-04T08:05:00	20	40
3	Station_2	8.248533	54.270275	Station_2	2012-04-05T08:05:00	10	20
4	Station_3	8.100735	54.493687	Station_3	2012-04-06T08:05:00	8	25
5	Station_4	7.9993324	54.66786	Station_4	2012-04-07T09:05:00	12	20
6	Station_5	8.017196	54.945965	Station_5	2012-04-07T12:05:00	13	18
7	Station_6	8.073449	55.284126	Station_6	2012-04-08T09:05:00	14	1
8	Station_7	7.724219	55.33581	Station_7	2012-04-08T10:05:00	16	4
9	Station_8	7.6007733	55.081173	Station_8	2012-04-08T10:50:00	14	2
10	Station_9	7.526144	54.820965	Station_9	2012-04-09T07:05:00	20	3
11	Station_10	7.4434566	54.583225	Station_10	2012-04-09T09:05:00	1	5
12	Station_11	7.329495	54.252396	Station_11	2012-04-09T14:05:00	1	6
13	Station_12	7.2102094	53.997543	Station_12	2012-04-09T17:05:00	4	2
14	Station_13	7.622393	53.926735	Station_13	2012-04-10T11:05:00	6	5
15	Station_14	8.139690	53.970703	Station_14	2012-04-10T14:05:00	3	15

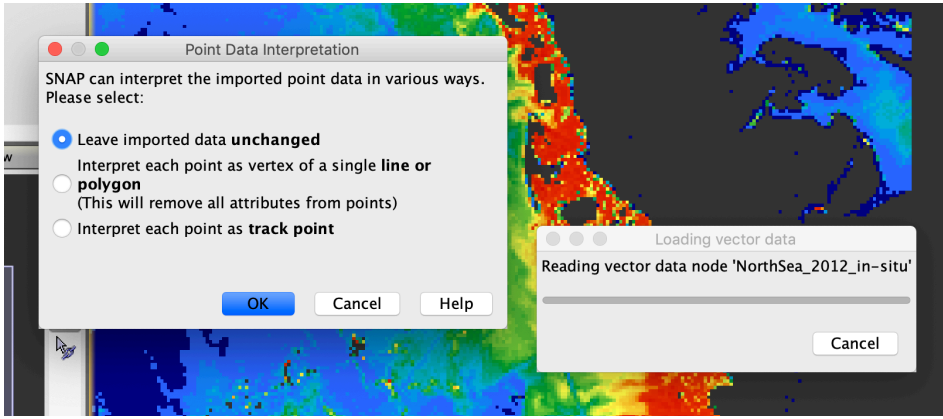
*slide prepared by Ana Ruescas from Brockmann Consultancy

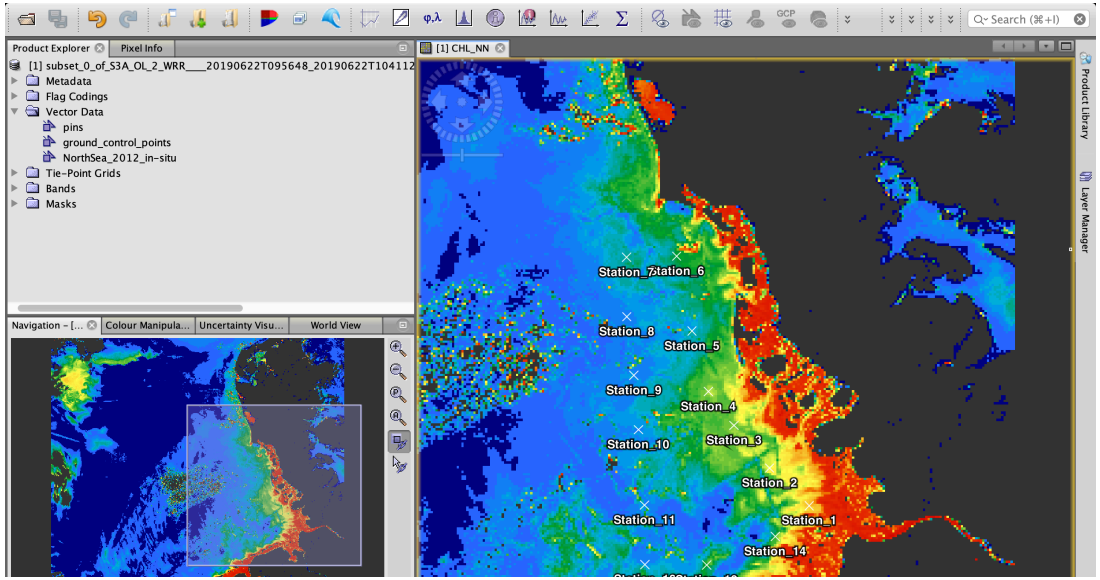
SNAP: Import station info

- Vector → Vector from CSV → select file NorthSea.txt → ok → leave imported data unchanged



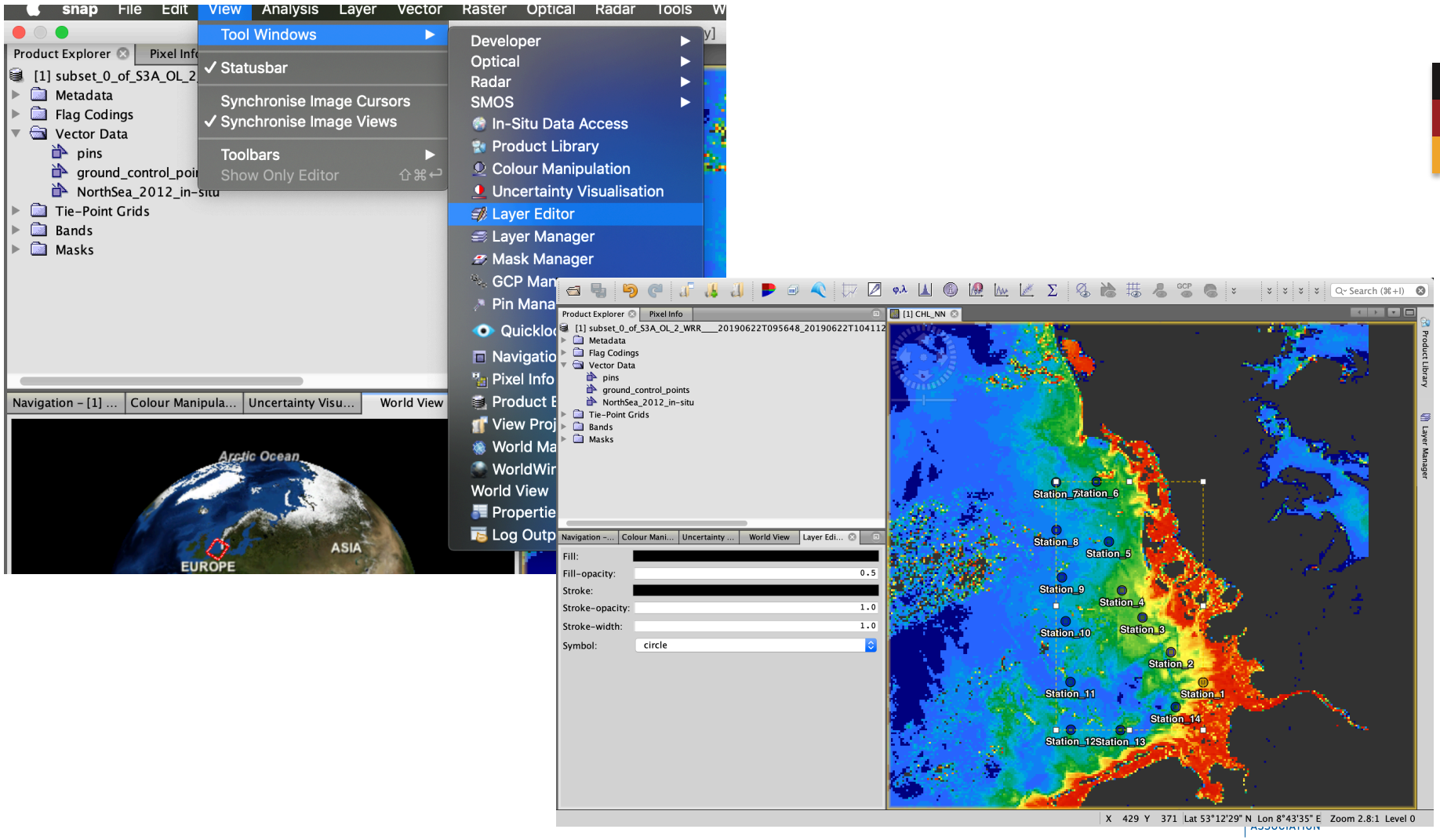
→





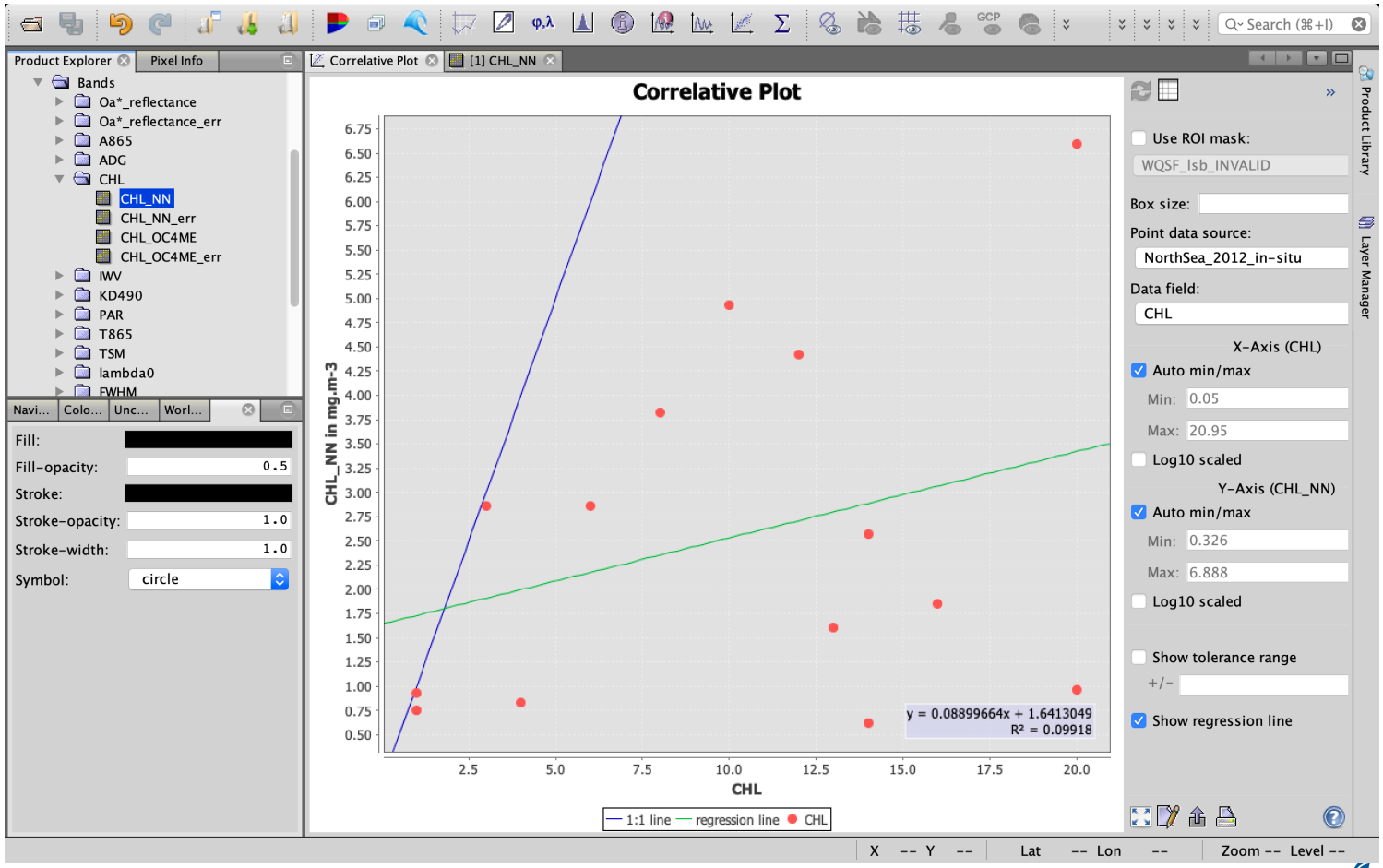
SNAP: Layer editor

- View → Layer Editor → change color, symbol...



SNAP: Correlative Plot

- Investigate how the satellite data and in situ data match
- Analysis → Correlative Plot



SNAP: Correlative Plot

- Investigate how the satellite data and in situ data match
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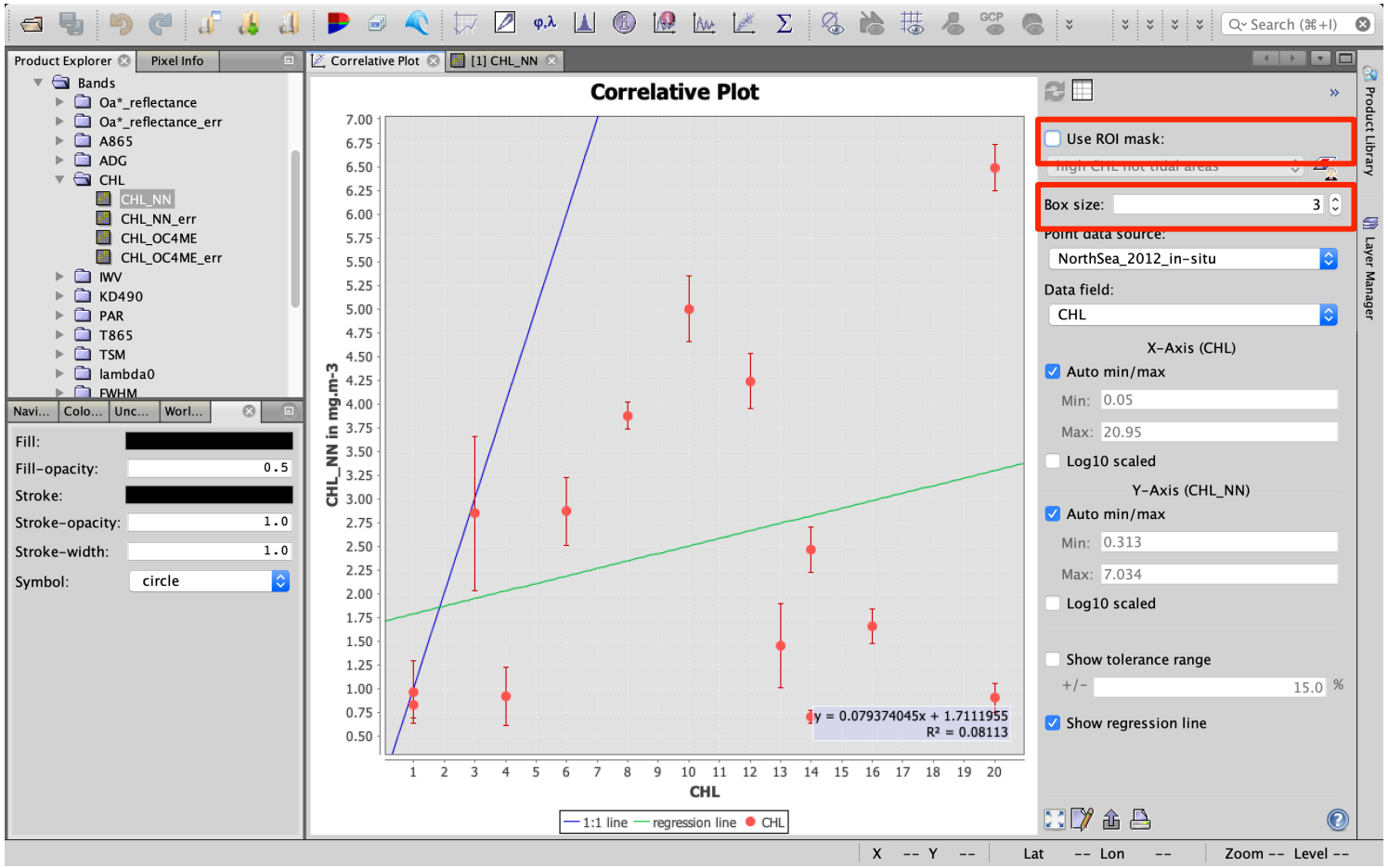
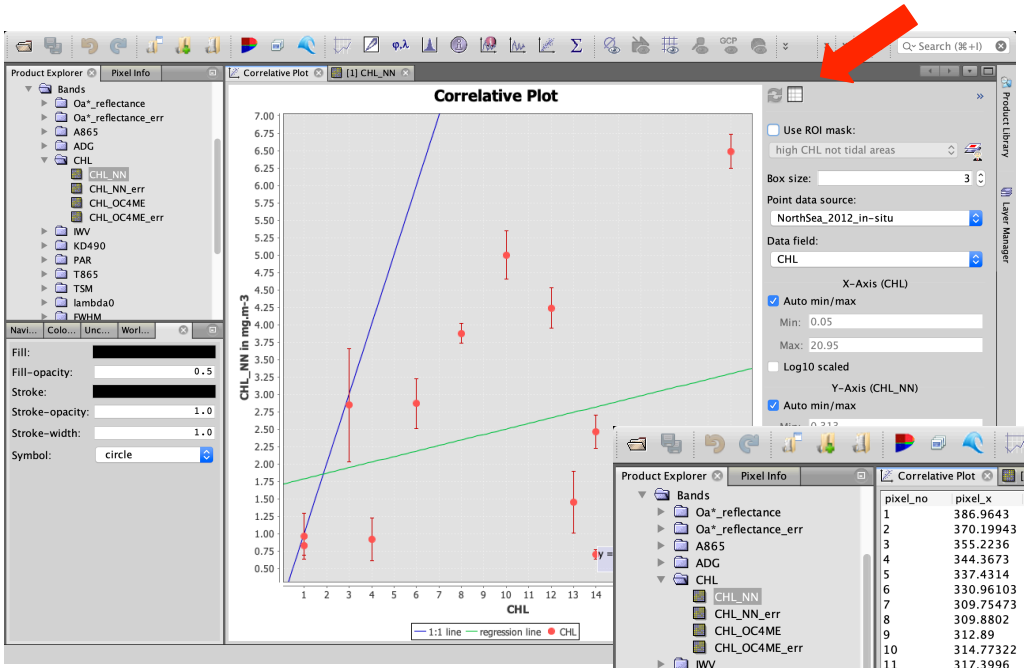
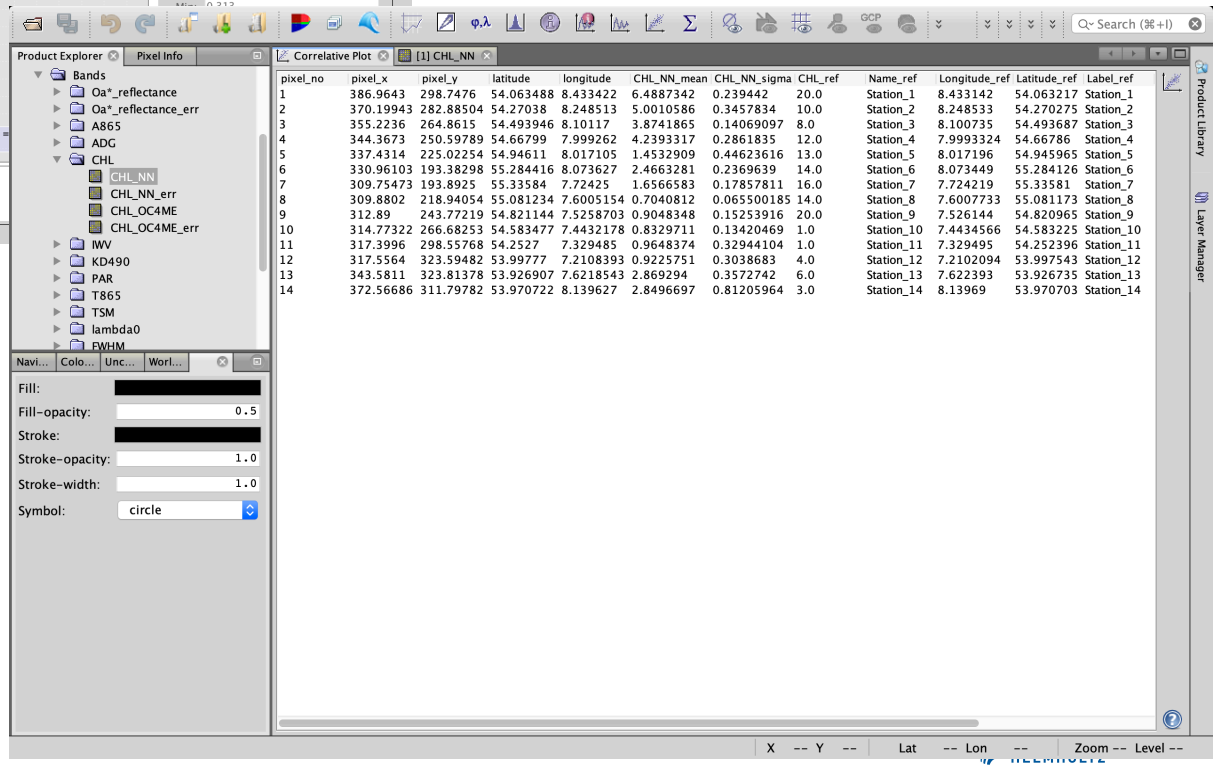


SNAP: Correlative Plot - table view

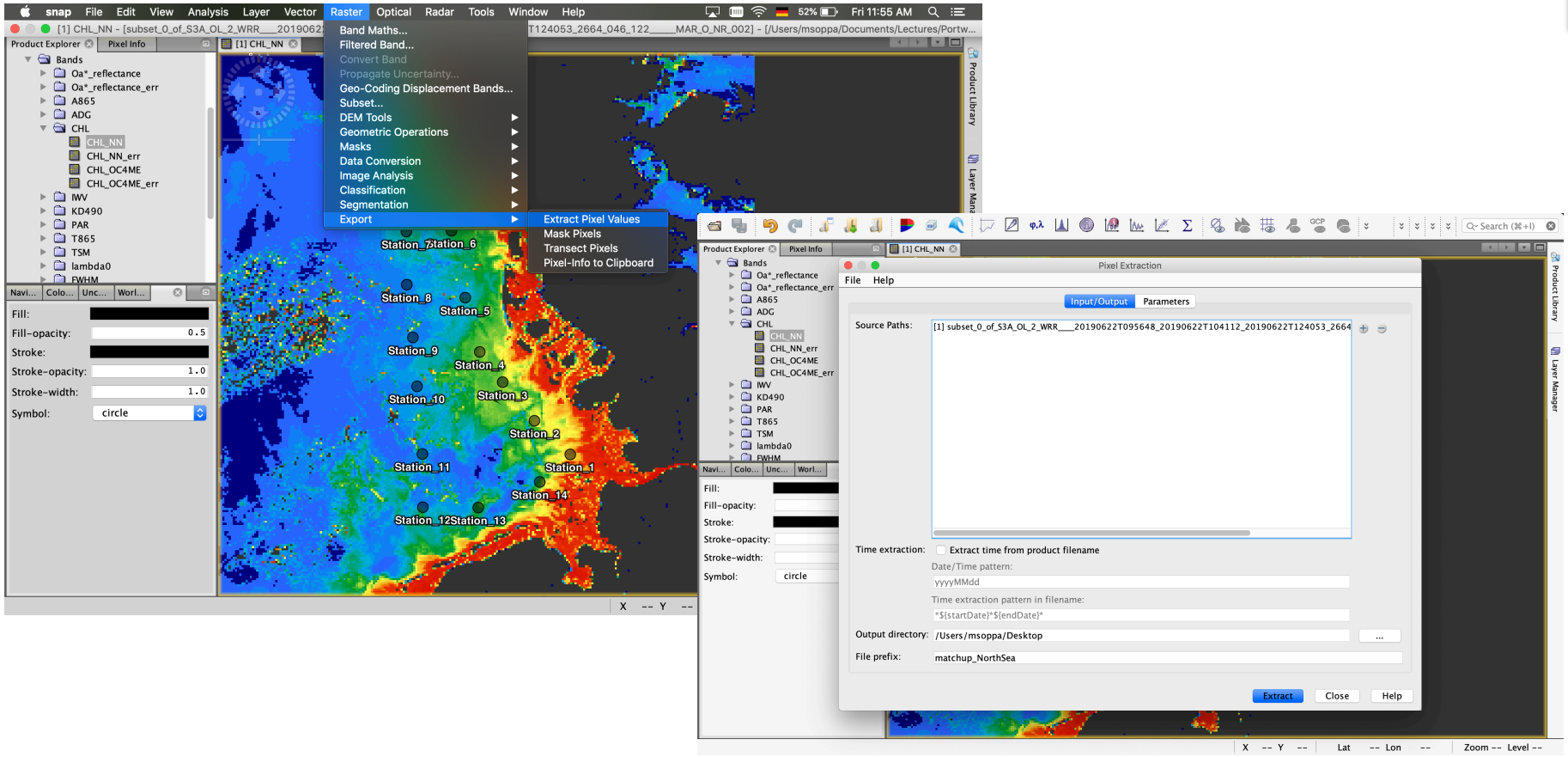




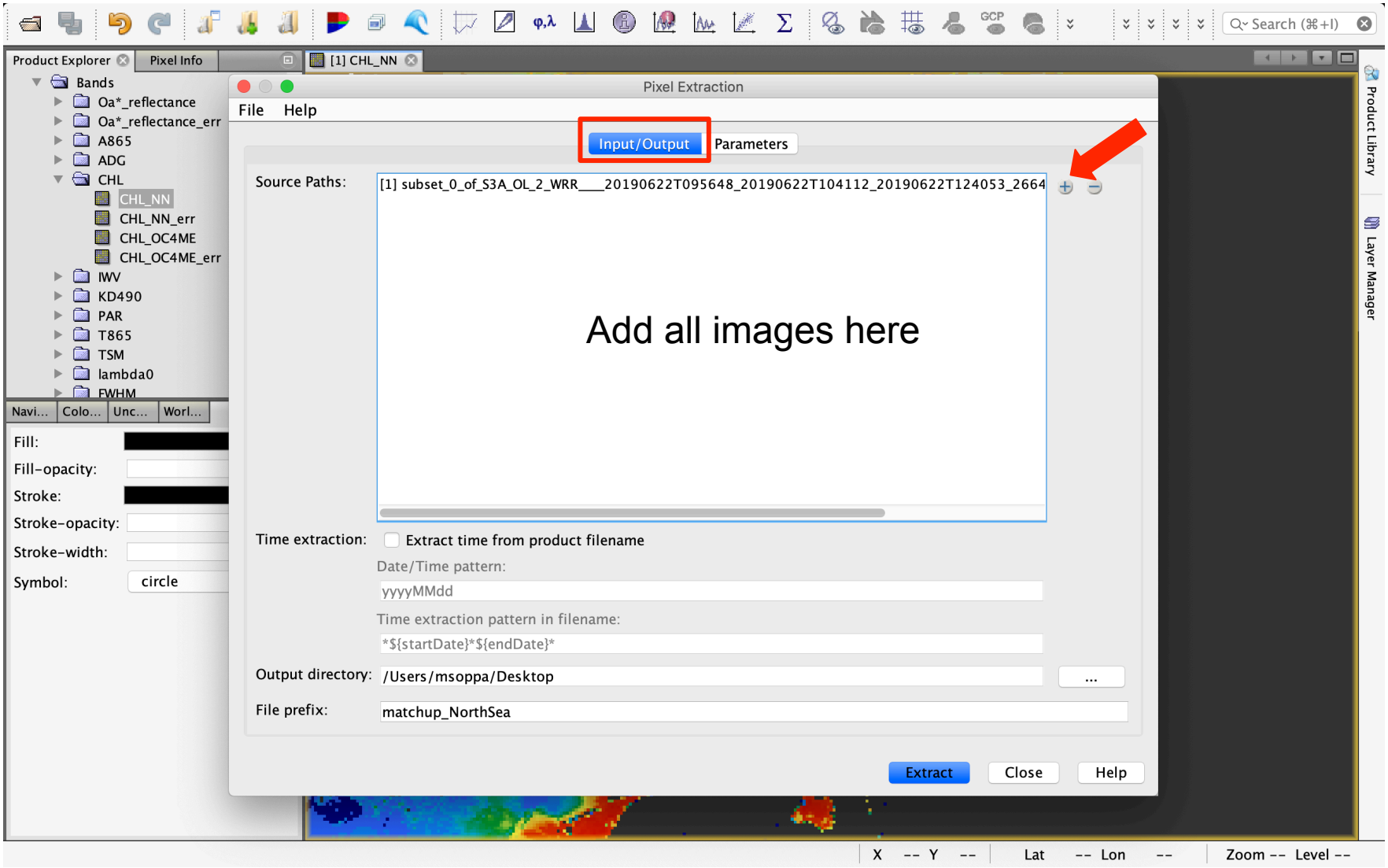
pixel_no	pixel_x	pixel_y	latitude	longitude	CHL_NN_mean	CHL_NN_sigma	CHL_ref	Name_ref	Longitude_ref	Latitude_ref	Label_ref
1	386.9643	298.7476	54.063488	8.433422	6.4887342	0.239442	20.0	Station_1	8.433142	54.063217	Station_1
2	370.19943	282.88504	54.27038	8.248513	5.0010586	0.3457834	10.0	Station_2	8.248533	54.270275	Station_2
3	355.2236	264.8615	54.493946	8.10117	3.8741865	0.14069097	8.0	Station_3	8.100735	54.493687	Station_3
4	344.3673	250.59789	54.66799	7.999262	4.2393317	0.2861835	12.0	Station_4	7.9993324	54.66786	Station_4
5	337.4314	225.02254	54.94611	8.017105	1.4532909	0.44623616	13.0	Station_5	8.017196	54.945965	Station_5
6	330.96103	193.38298	55.284416	8.073627	2.4663281	0.2369639	14.0	Station_6	8.073449	55.284126	Station_6
7	309.75473	193.8925	55.33584	7.72425	1.6566583	0.17857811	16.0	Station_7	7.724219	55.33581	Station_7
8	309.8802	218.94054	55.081234	7.6005154	0.7040812	0.065500185	14.0	Station_8	7.6007733	55.081173	Station_8
9	312.89	243.77219	54.821144	7.5258703	0.9048348	0.15253916	20.0	Station_9	7.526144	54.820965	Station_9
10	314.77322	266.68253	54.583477	7.4432178	0.8329711	0.13420469	1.0	Station_10	7.4434566	54.583225	Station_10
11	317.3996	298.55768	54.2527	7.329485	0.9648374	0.32944104	1.0	Station_11	7.329495	54.252396	Station_11
12	317.5564	323.59482	53.99777	7.2108393	0.9225751	0.3038683	4.0	Station_12	7.2102094	53.997543	Station_12
13	343.5811	323.81378	53.926907	7.6218543	2.869294	0.3572742	6.0	Station_13	7.622393	53.926735	Station_13
14	372.56686	311.79782	53.970722	8.139627	2.8496697	0.81205964	3.0	Station_14	8.13969	53.970703	Station_14

SNAP: Pin extraction tool

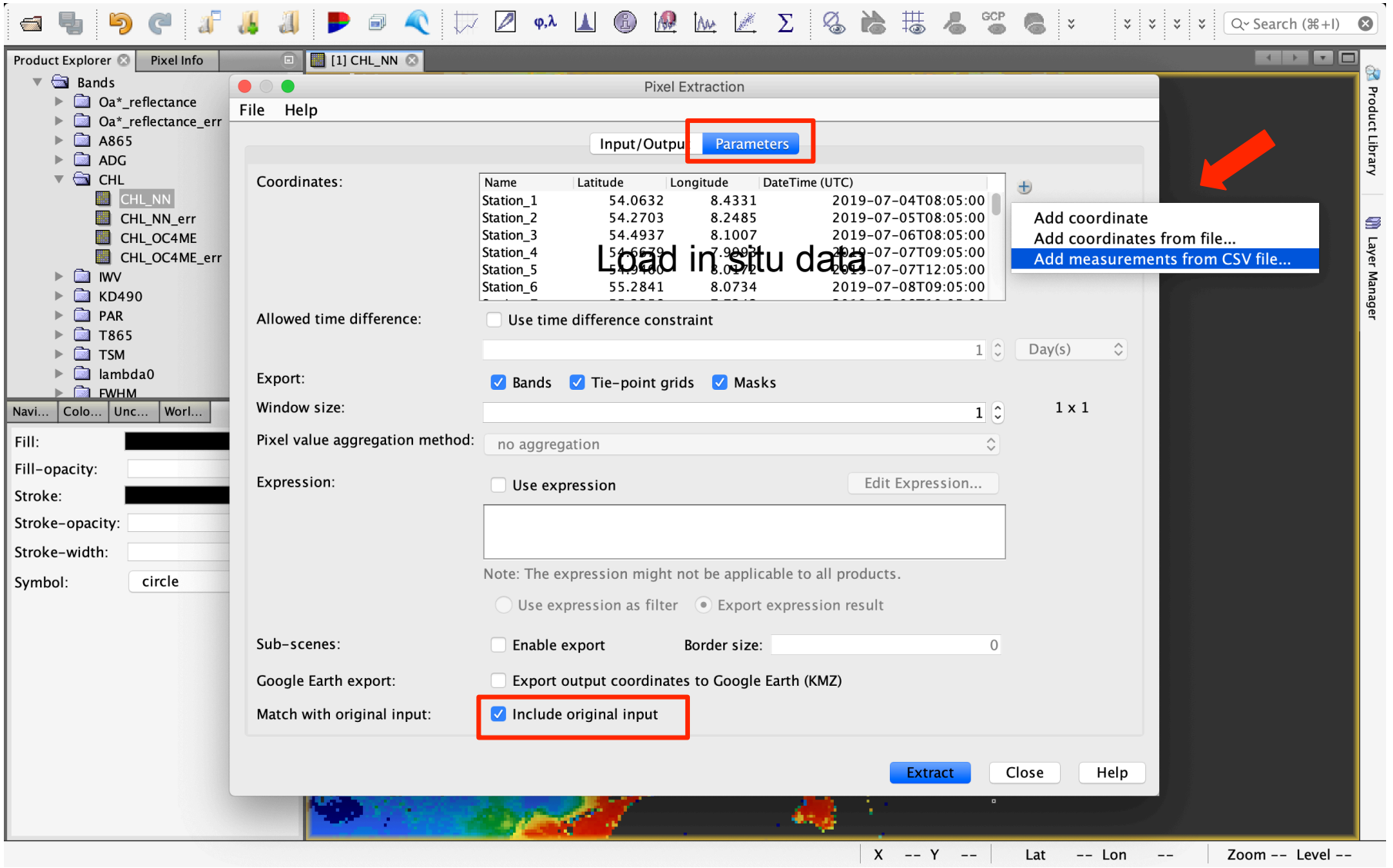
- Using the pins location, extract information from the image and export in a .csv or text file.
- For extraction of match-ups and time series analysis
- Usefull when working with large in-situ/satellite datasets (several days of sampling)



SNAP: Pin extraction tool

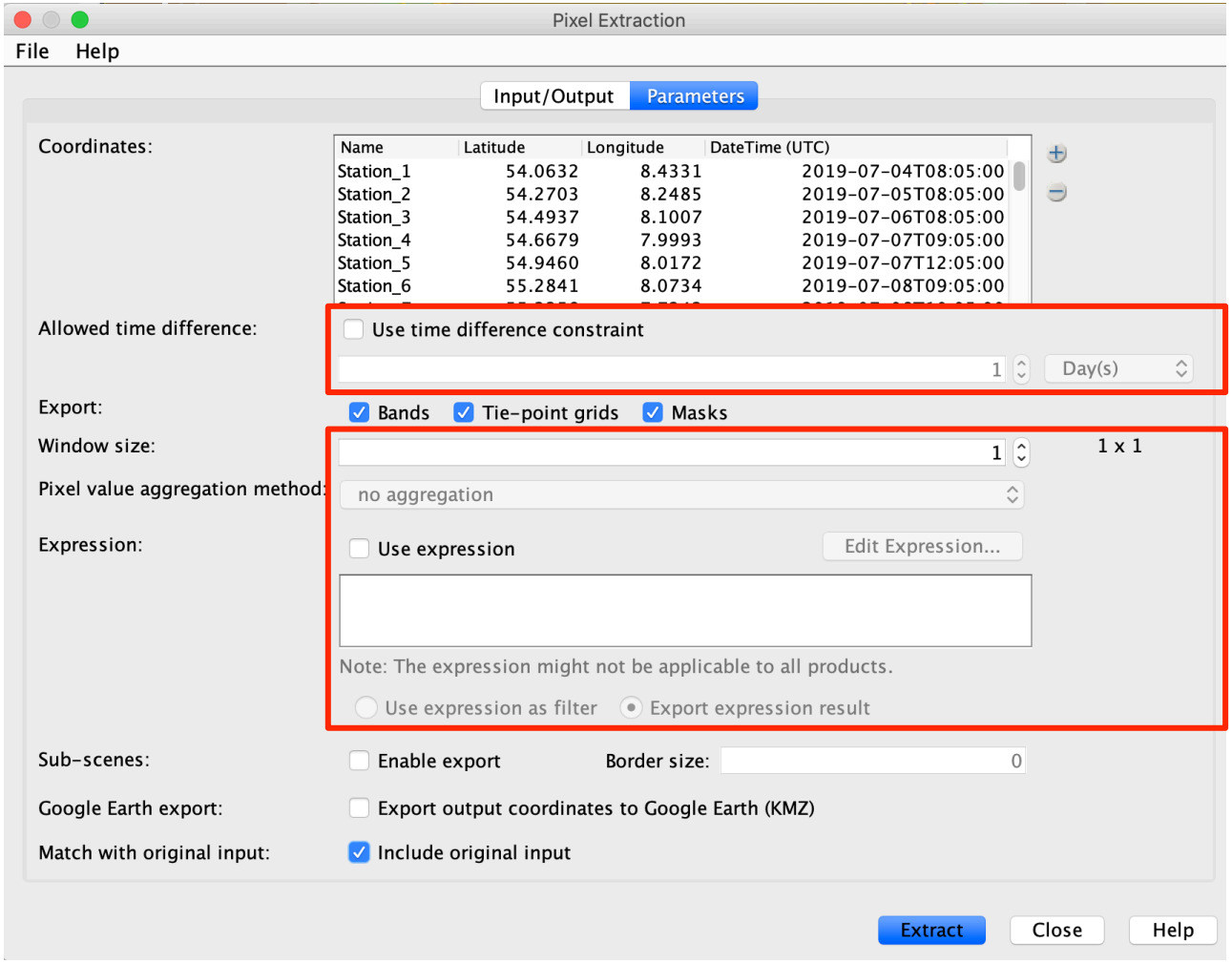


SNAP: Pin extraction tool



HELMHOLTZ ASSOCIATION

SNAP: Pin extraction tool



- Default: only spatial match
- Optional: time match in a selected range
- Optional: conditional check (e.g. pixel should be in *water = not (land or cloud)*)

SNAP: Pin extraction tool

- Two output files: table of extracted pixels (all bands) and list of input products (product ID)

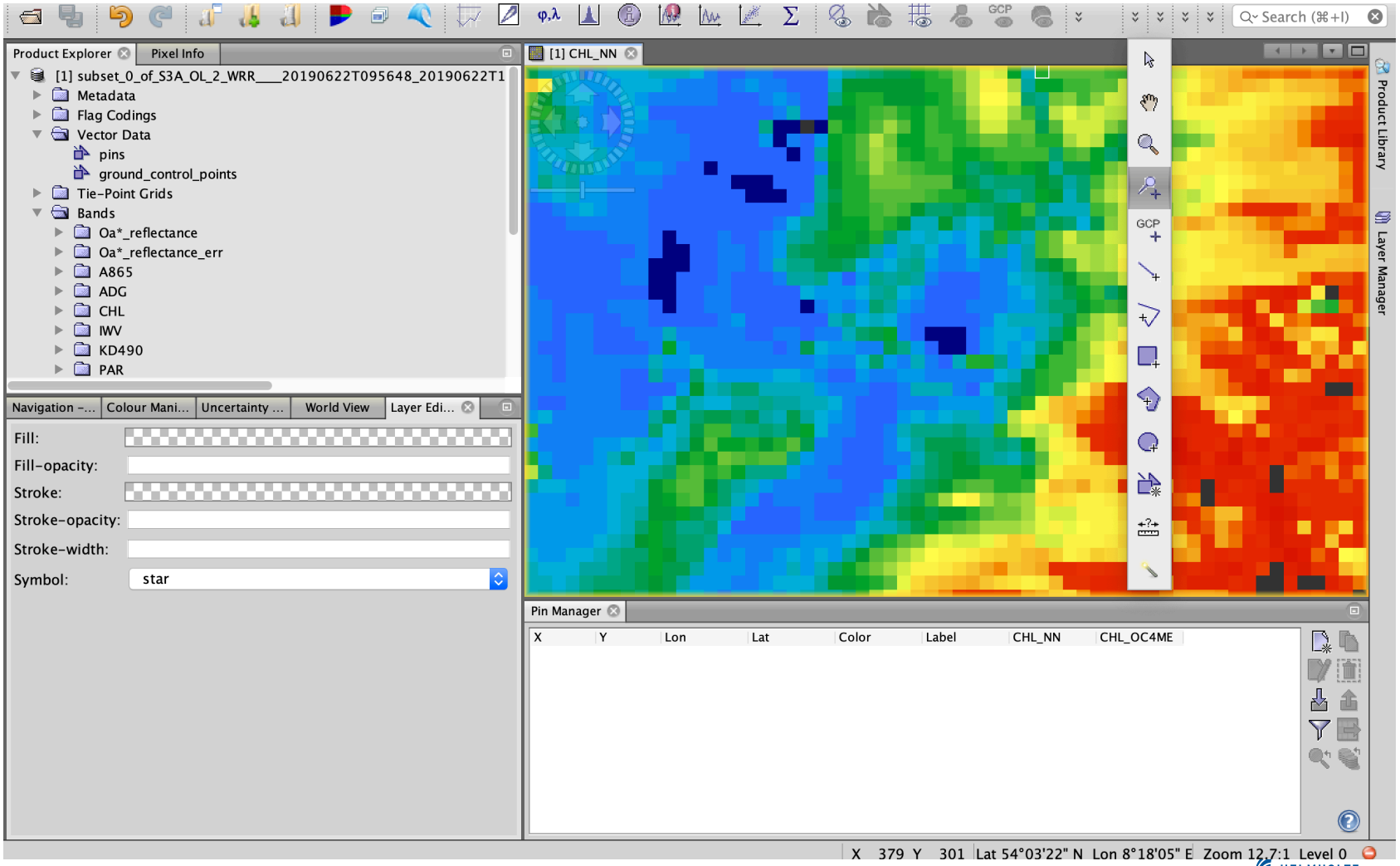
```
# SNAP pixel extraction export table
#
# Window size: 1
# Created on:   2019-06-28 10:23:05

# Wavelength:                                                                                                                   400.0   400.0   412.5   412.5   442.5
        442.5   490.0   490.0   510.0   510.0   560.0   560.0   620.0   620.0   665.0   665.0   673.75  673.75  681.25  681.25  708.75  708.75  753.75  753.75  778.75  778.75  865.0
        865.0   885.0   885.0   1020.0  1020.0  0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
        0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
        0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
        0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
        0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
        0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
        0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
        0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
Name    Longitude       Latitude        Label   DateTime        CHL     TSM     geometry        ProdID  CoordID Name    Latitude        Longitude       PixelX  PixelY  Date(yyyy-MM-
dd)     Time(HH_mm_ss)  Oa01_reflectance        Oa01_reflectance_err    Oa02_reflectance        Oa02_reflectance_err    Oa03_reflectance        Oa03_reflectance_err
Oa04_reflectance        Oa04_reflectance_err    Oa05_reflectance        Oa05_reflectance_err    Oa06_reflectance        Oa06_reflectance_err    Oa07_reflectance
Oa07_reflectance_err    Oa08_reflectance        Oa08_reflectance_err    Oa09_reflectance        Oa09_reflectance_err    Oa10_reflectance        Oa10_reflectance_err
Oa11_reflectance        Oa11_reflectance_err    Oa12_reflectance        Oa12_reflectance_err    Oa16_reflectance        Oa16_reflectance_err    Oa17_reflectance
Oa17_reflectance_err    Oa18_reflectance        Oa18_reflectance_err    Oa21_reflectance        Oa21_reflectance_err    CHL_NN  CHL_NN_err      CHL_OC4ME       CHL_OC4ME_err
altitude        latitude        longitude       detector_index  FWHM_band_1     FWHM_band_2     FWHM_band_3     FWHM_band_4     FWHM_band_5     FWHM_band_6     FWHM_band_7
FWHM_band_8     FWHM_band_9     FWHM_band_10    FWHM_band_11    FWHM_band_12    FWHM_band_13    FWHM_band_14    FWHM_band_15    FWHM_band_16    FWHM_band_17    FWHM_band_18
FWHM_band_19    FWHM_band_20    FWHM_band_21    frame_offset    lambda0_band_1  lambda0_band_2  lambda0_band_3  lambda0_band_4  lambda0_band_5  lambda0_band_6  lambda0_band_7
lambda0_band_8  lambda0_band_9  lambda0_band_10 lambda0_band_11 lambda0_band_12 lambda0_band_13 lambda0_band_14 lambda0_band_15 lambda0_band_16 lambda0_band_17 lambda0_band_18
lambda0_band_19 lambda0_band_20 lambda0_band_21 solar_flux_band_1       solar_flux_band_2       solar_flux_band_3       solar_flux_band_4       solar_flux_band_5
solar_flux_band_6       solar_flux_band_7       solar_flux_band_8       solar_flux_band_9       solar_flux_band_10      solar_flux_band_11      solar_flux_band_12
solar_flux_band_13      solar_flux_band_14      solar_flux_band_15      solar_flux_band_16      solar_flux_band_17      solar_flux_band_18      solar_flux_band_19
solar_flux_band_20      solar_flux_band_21      ADG443_NN       ADG443_NN_err   IWV     IWV_err PAR     PAR_err KD490_M07       KD490_M07_err   TSM_NN  TSM_NN_err      A865
A865_err        T865    T865_err        WQSF_lsb        WQSF_msb        TP_latitude     TP_longitude    OAA     OZA     SAA     SZA
atmospheric_temperature_profile_pressure_level_1        atmospheric_temperature_profile_pressure_level_2        atmospheric_temperature_profile_pressure_level_3
atmospheric_temperature_profile_pressure_level_4        atmospheric_temperature_profile_pressure_level_5        atmospheric_temperature_profile_pressure_level_6
atmospheric_temperature_profile_pressure_level_7        atmospheric_temperature_profile_pressure_level_8        atmospheric_temperature_profile_pressure_level_9
atmospheric_temperature_profile_pressure_level_10       atmospheric_temperature_profile_pressure_level_11       atmospheric_temperature_profile_pressure_level_12
atmospheric_temperature_profile_pressure_level_13       atmospheric_temperature_profile_pressure_level_14       atmospheric_temperature_profile_pressure_level_15
atmospheric_temperature_profile_pressure_level_16       atmospheric_temperature_profile_pressure_level_17       atmospheric_temperature_profile_pressure_level_18
atmospheric_temperature_profile_pressure_level_19       atmospheric_temperature_profile_pressure_level_20       atmospheric_temperature_profile_pressure_level_21
atmospheric_temperature_profile_pressure_level_22       atmospheric_temperature_profile_pressure_level_23       atmospheric_temperature_profile_pressure_level_24
atmospheric_temperature_profile_pressure_level_25       horizontal_wind_vector_1        horizontal_wind_vector_2        humidity        sea_level_pressure
total_columnar_water_vapour     total_ozone     WQSF_lsb_INVALID        WQSF_lsb_WATER  WQSF_lsb_LAND   WQSF_lsb_CLOUD  WQSF_lsb_CLOUD_AMBIGUOUS        WQSF_lsb_CLOUD_MARGIN
WQSF_lsb_SNOW_ICE       WQSF_lsb_INLAND_WATER   WQSF_lsb_TIDAL  WQSF_lsb_COSMETIC       WQSF_lsb_SUSPECT        WQSF_lsb_HISOLZEN       WQSF_lsb_SATURATED      WQSF_lsb_MEGLINT
        WQSF_lsb_HIGHGLINT      WQSF_lsb_WHITECAPS      WQSF_lsb_ADJAC  WQSF_lsb_WV_FAIL        WQSF_lsb_PAR_FAIL       WQSF_lsb_AC_FAIL        WQSF_l
WQSF_lsb_OCNN_FAIL      WQSF_lsb_KDM_FAIL       WQSF_lsb_BPAC_ON        WQSF_lsb_WHITE_SCATT    WQSF_lsb_LOWRW  WQSF_lsb_HIGHRW WQSF_msb_ANNOT_ANGSTR
WQSF_msb_ANNOT_ABSO_D   WQSF_msb_ANNOT_ACLIM    WQSF_msb_ANNOT_ABSOA    WQSF_msb_ANNOT_MIXR1    WQSF_msb_ANNOT_DROUT    WQSF_msb_ANNOT_TAU06    WQSF_m
WQSF_msb_RWNEG_O2       WQSF_msb_RWNEG_O3       WQSF_msb_RWNEG_O4       WQSF_msb_RWNEG_O5       WQSF_msb_RWNEG_O6       WQSF_msb_RWNEG_O7       WQSF_m
WQSF_msb_RWNEG_O9       WQSF_msb_RWNEG_O10      WQSF_msb_RWNEG_O11      WQSF_msb_RWNEG_O12      WQSF_msb_RWNEG_O16      WQSF_msb_RWNEG_O17      WQSF_m
WQSF_msb_RWNEG_O21      good water pixels       high CHL        high CHL not tidal areas        NorthSea_2012_in-situ
                                                0       1       Station_1       54.067281       8.427350        386.500 298.500 2019-0
0.008728294633328915    9.460746077820659E-4    0.007995850406587124    7.446524687111378E-4    0.011767938733100891    4.699858545791358E-4    0.0205
2.502526040188968E-4    0.02368846908211708     2.136303810402751E-4    0.03353984281420708     1.5869706112425774E-4   0.019678335636854172    1.4038
0.013287760317325592    1.0376374120824039E-4   0.012628559954464436    1.0376374120824039E-4   0.012866605073213577    1.2207485269755125E-4   0.0081
8.545263699488714E-5    0.002191229723393917    6.71415327815339E-5     0.002282785251736641    -6.10289498581551E-6    0.0012939856387674809   -6.102
0.0010925634996965528   -6.10289498581551E-6    0.001403852249495685    4.333636607043445E-4    6.590185165405273       1.0369266271591187      10.558
0.324945867061615       40      54.07382583618164       8.422183990478516       2398    13.775712013244629      9.788885116577148       9.92278385162
        9.940460205078125       9.998224258422852       9.950459480285645       9.955803871154785       7.530254364013672       7.543585300445557
7.530660629272461       2.7805793285369873      3.717043161392212       2.7266080379486084      14.996623992919922      19.965267181396484      9.9781
9.964242935180664       19.82373046875  27.54508399963379       -1      400.76165771484375      412.18035888671875      443.27996826171875      490.79
510.7190856933594       560.66259765625 620.6968383789062       665.4459838867188       674.1793212890625       681.7462768554688       709.2862548828
761.90771484375 764.9830932617188       768.0437622070312       779.3812866210938       865.5684814453125       884.4321899414062       899.4279785156
        1015.905029296875       1485.8558349609375      1655.69775390625        1838.9586181640625      1879.785400390625       1853.4844970703125
1596.667724609375       1480.85888671875        1446.5155029296875      1421.4749755859375      1357.2747802734375      1225.9781494140625      1208.
```

```
# Product ID Map
ProductID       ProductType     ProductLocation
0       OL_2_WRR        /Users/msoppa/Documents/Lectures/Portwimns_Summerschool/Unit1/
subset_0_of_S3A_OL_2_WRR____20190622T095648_20190622T104112_20190622T124053_2664_046_122___
```

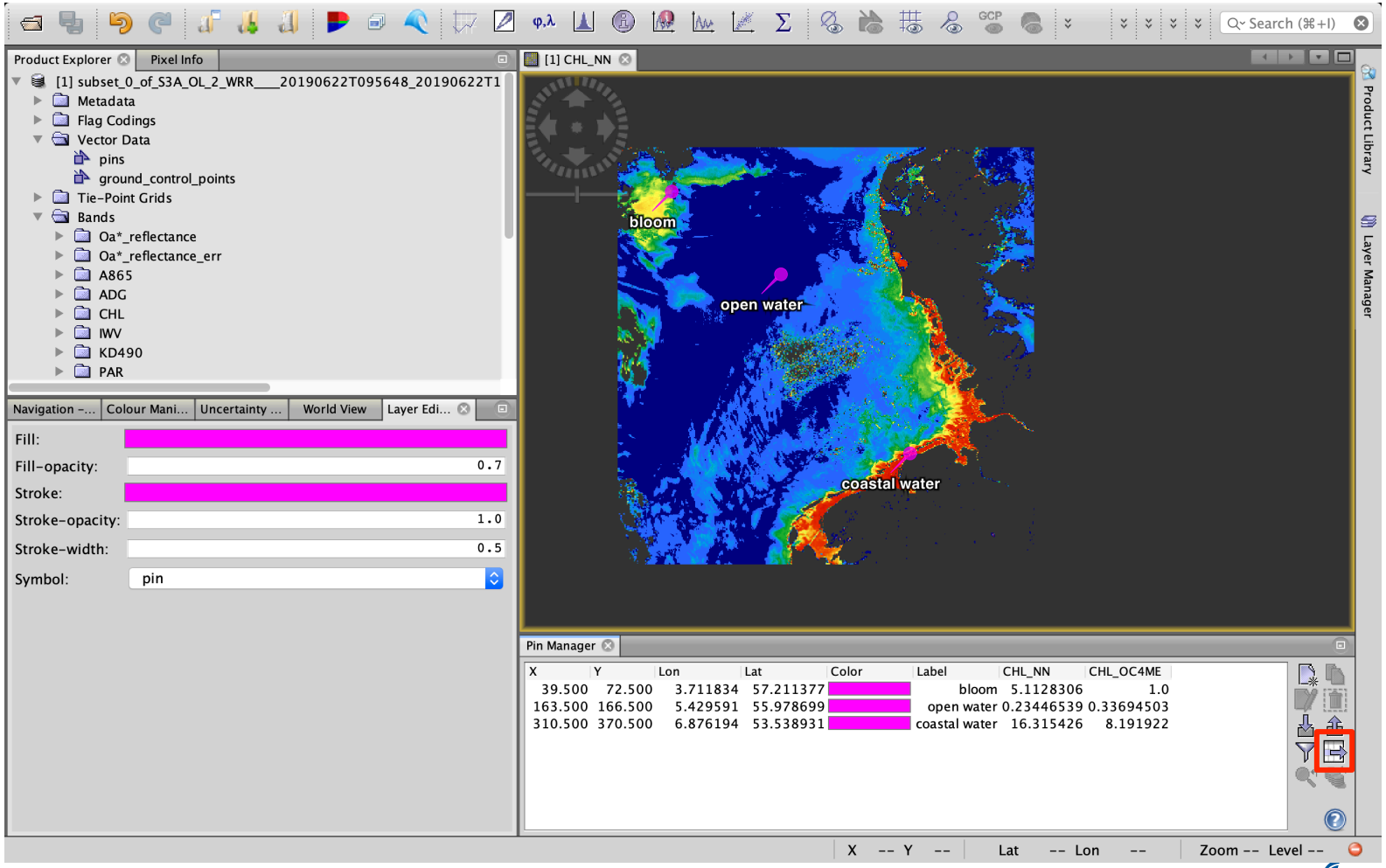
SNAP: Pin manager

- View → Tool Windows → Pin Manager or  or



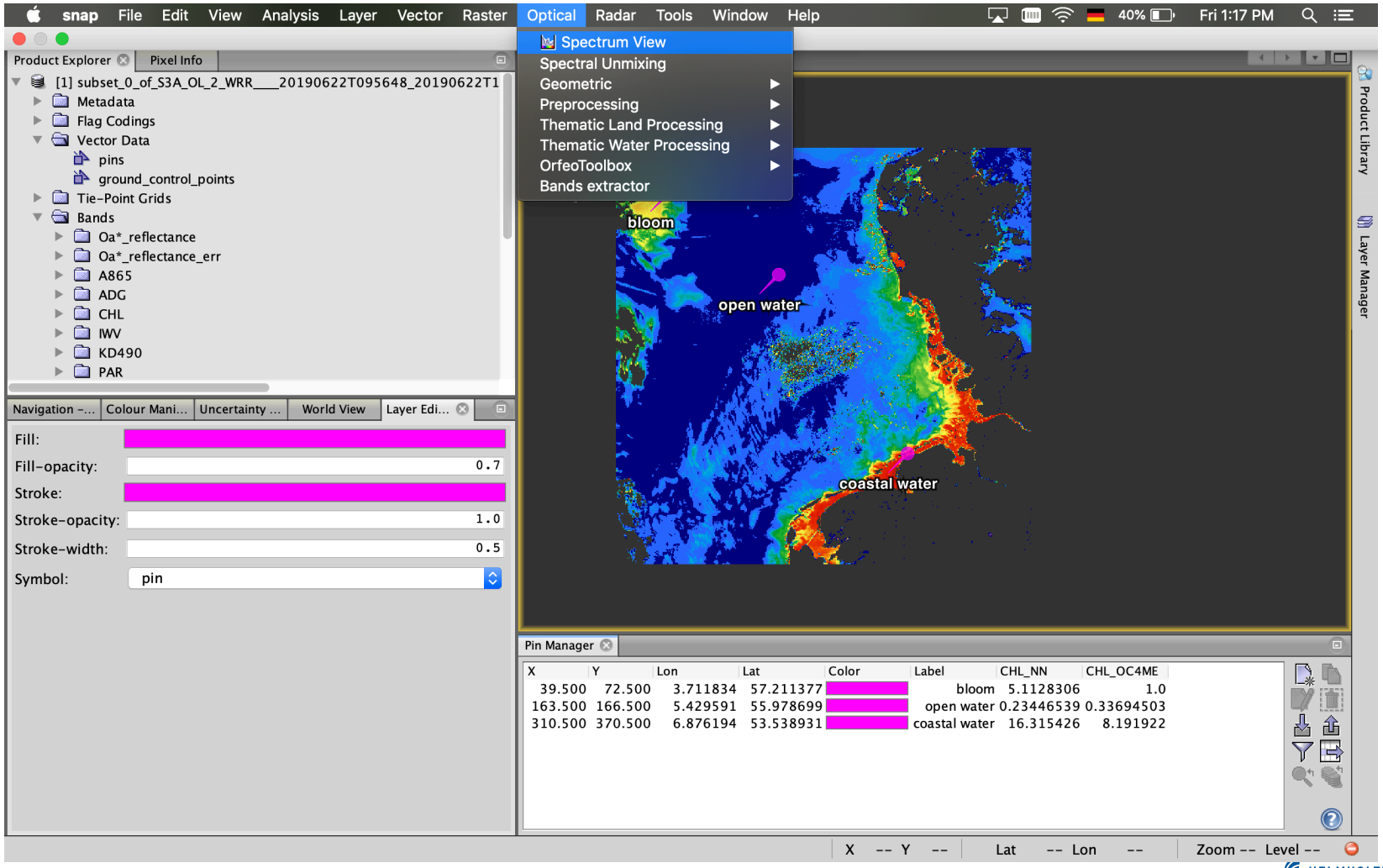
SNAP: Pin manager

- Create 3 pins: bloom, open ocean and coastal water



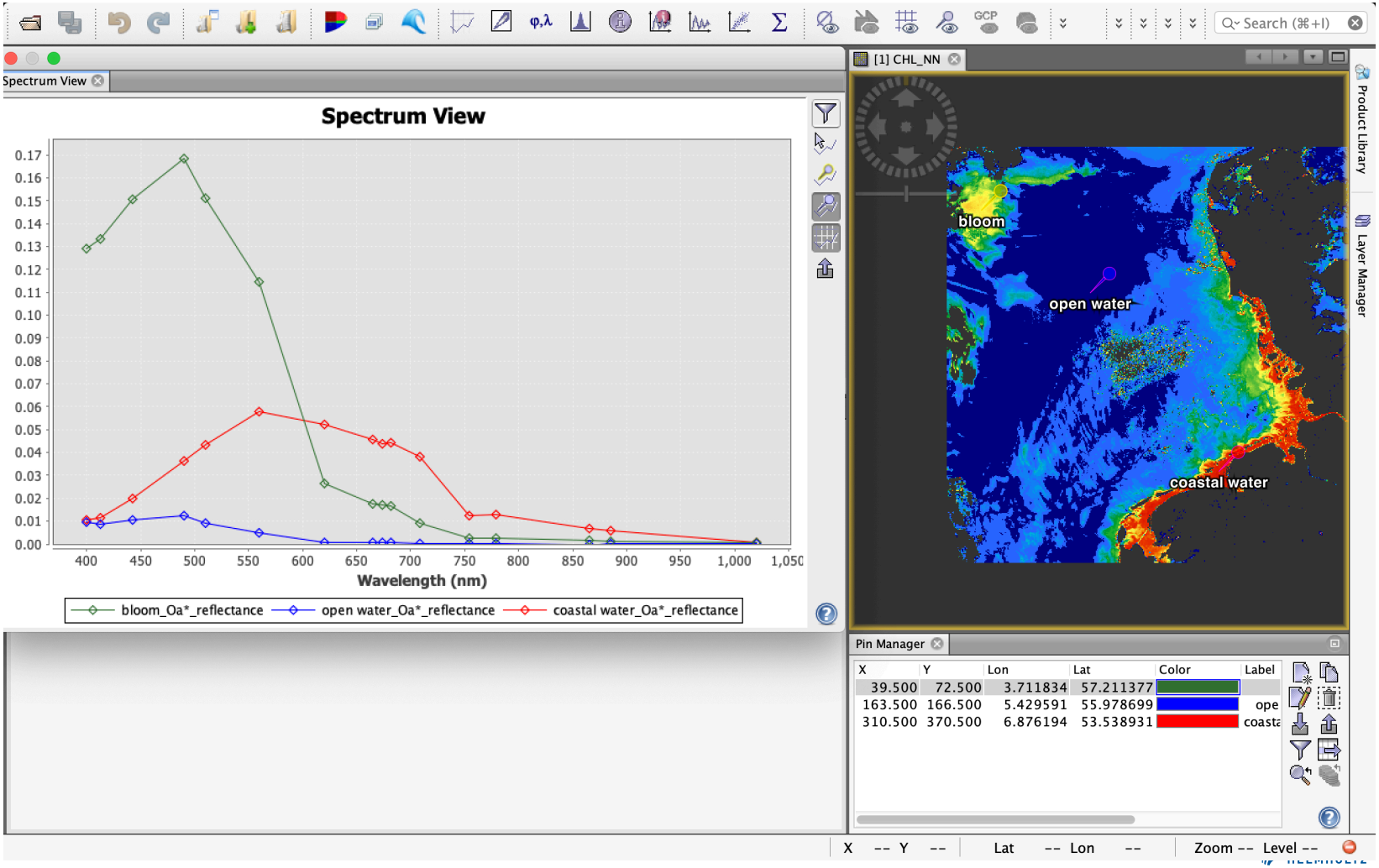
SNAP: Spectrum view

- Optical → spectrum view



SNAP: Spectrum view

- Display reflectance spectra of different surface types using the spectrum view



End of Unit 2

Thanks to Ana Ruescas (Brockmann Consult) for originally developing material for the SNAP course. Some of her slides and ideas we could use here too.