

Encoding of Swath Data in CF

2017 EarthCube netCDF-CF Workshop



EARTH CUBE
TRANSFORMING GEOSCIENCES RESEARCH



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What We Call Swath Data?

- **Electromagnetic radiation collected from a specific direction into a solid angle and then measured at a number of intervals of the electromagnetic spectrum**
- **Data collected by instruments on satellites, airplanes, and unmanned aerial systems**
- **Original instrument viewing geometry**

Current Status

- **Second draft finished last month**
- **Undergoing community review**
- **Community:**
 - **NASA ESDS Dataset Interoperability Working Group**
 - **CF Satellite**
 - **Personal contacts**

Next Steps

- **Complete community review of the second draft**
- **Announce on the CF mailing list**
- **Engage the CF governing body on the best approach to make this proposal part of the official convention**

- Document's home: <https://github.com/Unidata/EC-netCDF-CF/blob/master/swath/swath.adoc>
- Pretty print version: <https://goo.gl/8QPJUB>
- Comments/suggestions/corrections:
<https://github.com/Unidata/EC-netCDF-CF/issues> (Label issues with *Ext-Swath*)

Resources: Sample Files

“Skinny” examples:

<https://eosdap.hdfgroup.org:8888/thredds/catalog/testAll/cf2/swath/catalog.html>

<https://eosdap.hdfgroup.org:8080/opendap/data/earth-cube-cf2/swath/contents.html>

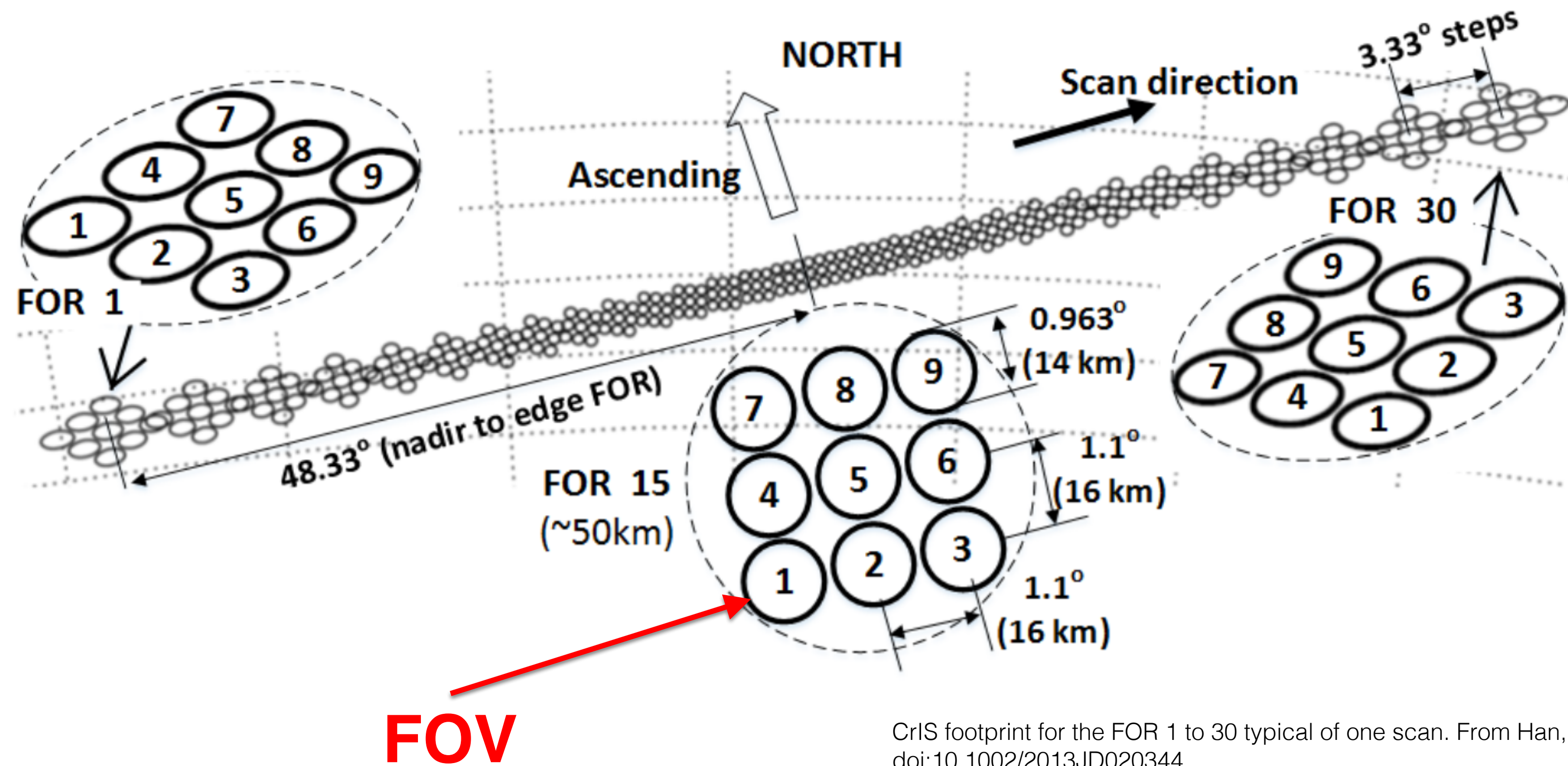
Real swath examples:

<https://eosdap.hdfgroup.org:8080/opendap/data/earth-cube-cf2/swath-real/contents.html>

<https://eosdap.hdfgroup.org:8888/thredds/catalog/testAll/cf2/swath-real/catalog.html>

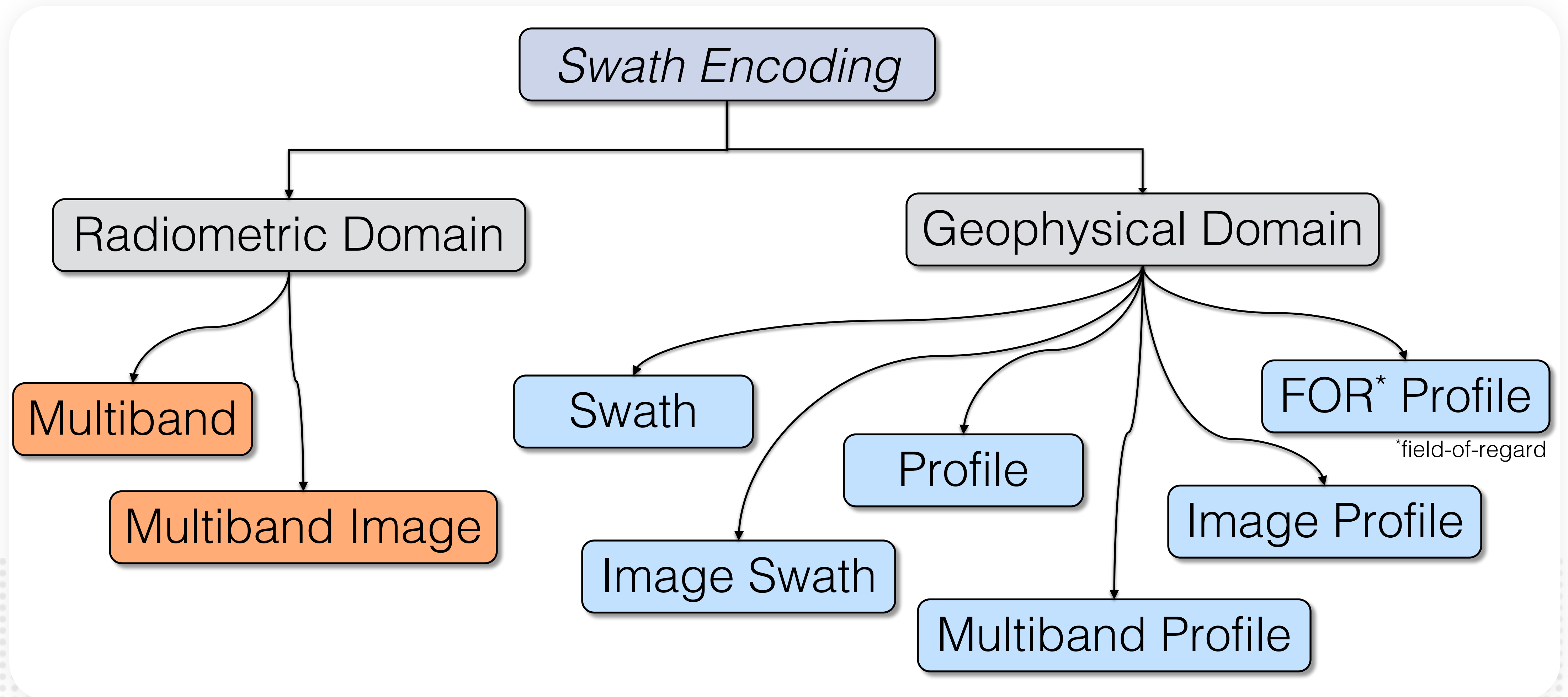
Swath Data Encodings

Disambiguation: Field-of-View (FOV) vs. Field-of-Regard (FOR)



CrIS footprint for the FOR 1 to 30 typical of one scan. From Han, Y. et al. (2013), doi:10.1002/2013JD020344

Proposed Encodings



- **The rank of time coordinate can range from one to the rank of its swath variable**
- **The slowest varying dimension must represent along-track platform movement**
- **International Atomic Time (TAI) not supported by CF but used in some swath data files**

Spectral Coordinate

- **Describes the spectrum intervals at which electromagnetic radiation is measured**
- ***Must* be present in radiometric swath data**
- **Type: radiometric physical property or alphanumeric**
- **The data can be either monotonic or non-monotonic**

Spectral Coordinate

Monotonic values

`dimensions:`

```
band = 5 ;
```

`variables:`

```
float band(band) ;  
band:standard_name = "sensor_band_..." ;  
band:units = "μm" ;
```

Non-monotonic values

`dimensions:`

```
num_band = 5 ;
```

`variables:`

```
float band(num_band) ;  
band:standard_name = "sensor_band_..." ;  
band:units = "cm-1" ;
```

Standard names to use:

sensor_band_central_radiation_wavelength, sensor_band_central_radiation_wavenumber, sensor_band_central_radiation_frequency, radiation_frequency, radiation_wavelength.

Alphanumeric Spectral Coordinate

netCDF Enhanced Model

dimensions:

```
num_band = 5 ;
```

variables:

```
string band(num_band) ;
```

```
band:standard_name = "sensor_band_identifier" ;
```

netCDF Classic Model

dimensions:

```
num_band = 5 ;
```

```
band_strlen = 10 ;
```

variables:

```
char band(num_band, band_strlen) ;
```

```
band:standard_name = "sensor_band_identifier" ;
```

- **Horizontal component required, vertical component optional**
- **Vertical component: Any CF-supported type**
- **Horizontal component: latitude-longitude, map projection**
- **Latitude and longitude coordinates:**
 - **Rank at least two**
 - **The slowest varying dimension represents along-track platform movement**

Radiometric Encoding: Multiband

dimensions:

```
time = 120 ;  
scan = 512 ;  
band = 8 ;
```

variables:

```
float band(band) ;  
  
float lat(time, scan) ;  
  
float lon(time, scan) ;  
  
double time(time) ;  
  
float swath_data(time, scan, band) ;  
    swath_data:coordinates = "lon lat" ;
```

Radiometric Encoding: Multiband Image

dimensions:

```
time = 1 ;  
nrows = 2048 ;  
ncols = 2048 ;  
band = 10 ;
```

variables:

```
float band(band) ;  
  
float lat(time, nrows, ncols) ;  
  
float lon(time, nrows, ncols) ;  
  
double time(time) ;  
  
float swath_data(time, nrows, ncols, band) ;  
swath_data:coordinates = "lon lat" ;
```


Geophysical Encoding: Swath

dimensions:

```
time = 512 ;  
scan = 1024 ;
```

variables:

```
double time(time) ;  
  
float lat(time, scan) ;  
  
float lon(time, scan) ;  
  
float swath_data(time, scan) ;  
    swath_data:coordinates = "lon lat" ;
```

Geophysical Encoding: Image Swath

dimensions:

```
time = 1 ;  
nrows = 1024 ;  
ncols = 3600 ;
```

variables:

```
float lat(time, nrows, ncols) ;  
  
float lon(time, nrows, ncols) ;  
  
double time(time) ;  
  
float swath_data(time, nrows, ncols) ;  
    swath_data:coordinates = "lon lat" ;
```

Geophysical Encoding: Profile

dimensions:

```
time = UNLIMITED ;  
scan = 512 ;  
press = 15 ;
```

variables:

```
float press(press) ;  
  
float lat(time, scan) ;  
  
float lon(time, scan) ;  
  
double time(time) ;  
  
float swath_data(time, scan, press) ;  
    swath_data:coordinates = "lon lat" ;
```

Geophysical Encoding: Multiband Profile

dimensions:

```
time = UNLIMITED ;  
scan = 512 ;  
band = 5 ;  
press = 15 ;
```

variables:

```
float band(band) ;  
  
float press(press) ;  
  
float lat(time, scan) ;  
float lon(time, scan) ;  
  
double time(time) ;  
  
float swath_data(time, scan, press, band) ;  
swath_data:coordinates = "lon lat" ;
```

Geophysical Encoding: Image Profile

dimensions:

```
time = 1 ;  
FOR = 1024 ;  
FOV = 3600 ;  
press = 100 ;
```

variables:

```
float press(press) ;  
  
float lat(time, FOR, FOV) ;  
  
float lon(time, FOR, FOV) ;  
  
double time(time) ;  
  
float swath_data(time, FOR, FOV, press) ;  
    swath_data:coordinates = "lon lat" ;
```

Geophysical Encoding: Field-of-Regard Profile 1

dimensions:

```
time = 10 ;  
FOR = 30 ;  
press = 15 ;  
FOV_atrack = 3 ;  
FOV_xtrack = 3 ;
```

variables:

```
float press(press) ;  
  
float lat(time, FOR, FOV_atrack, FOV_xtrack) ;  
  
float lon(time, FOR, FOV_atrack, FOV_xtrack) ;  
  
double time(time) ;  
  
float swath_data(time, FOR, FOV_atrack, FOV_xtrack, press) ;  
swath_data:coordinates = "lon lat" ;
```

Geophysical Encoding: Field-of-Regard Profile 2

dimensions:

```
time = 10 ;  
FOR = 30 ;  
press = 15 ;  
FOV_atrack = 3 ;  
FOV_xtrack = 3 ;
```

variables:

```
short FOV_atrack(FOV_atrack) ;  
  
short FOV_xtrack(FOV_xtrack) ;  
  
float press(press) ;  
  
float lat(time, FOR) ;  
  
float lon(time, FOR) ;  
  
double time(time) ;  
  
float swath_data(time, FOR, FOV_atrack, FOV_xtrack, press) ;  
swath_data:coordinates = "lon lat" ;
```

Encoding Field-of-View Geospatial Extent

Field-of-View Geospatial Extent

- **Field-of-View (FOV) is typically represented as a point**
- **Points have no geospatial extent but real FOVs do**
- **Current CF supports describing FOV geospatial extent if:**
 - **One geopolygon without any holes**
 - **Same number of vertices for all FOVs**

Example with FOV Geospatial Extents

dimensions:

```
atrack = 512 ;  
xtrack = 1024 ;  
vertices = 4 ;
```

variables:

```
double time(atrack) ;
```

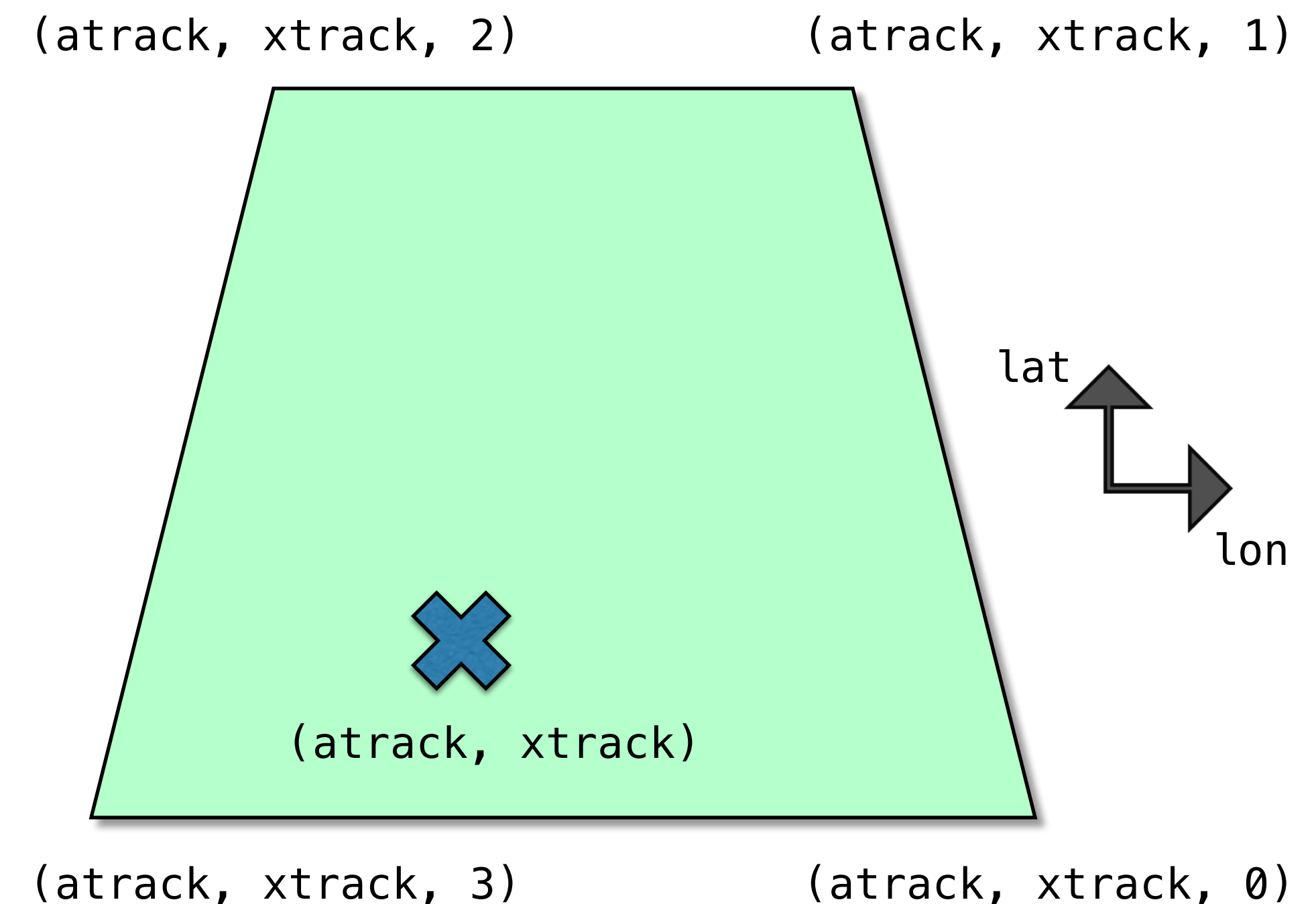
```
float lat(atrack, xtrack) ;  
lat:bounds = "lat_vertex" ;
```

```
float lon(atrack, xtrack) ;  
lon:bounds = "lon_vertex" ;
```

```
float lat_vertex(atrack, xtrack, vertices) ;
```

```
float lon_vertex(atrack, xtrack, vertices) ;
```

```
float swath_data(atrack, xtrack) ;  
swath_data:coordinates = "time lon lat" ;
```



Group Hierarchies

Swath Files and Groups

- **A feature of the NetCDF Enhanced Data Model**
- **Widely used in swath files**
- **Not supported by the current CF convention**

Simple Rules for Groups in Swath Files

- **Store swath data variables, their coordinates, or any other related variable in any group**
- **Keep variable attributes with their swath variables**
- **Use full variable names wherever they need to be referenced**

***Full variable name:* A name that represents the complete hierarchy of a variable starting from the top group**

Example with Groups

```
dimensions:
  vertex = 4 ;
  time = 392 ;
  band = 4 ;
  xtrack = 35 ;

variables:
  double time(time) ;

  float band(band) ;

group: ancillary {
  variables:
    float quality(time, xtrack, band) ;
      :coordinates = "/time /geolocation/lat /geolocation/lon /band" ;
}

group: geolocation {
  variables:
    float lat_vertex(time, xtrack, vertex) ;

    float lon_vertex(time, xtrack, vertex) ;

    float lat(time, xtrack) ;
      :bounds = "/geolocation/lat_vertex" ;

    float lon(time, xtrack) ;
      :bounds = "/geolocation/lon_vertex" ;
}

group: science {
  variables:
    float science_data(time, xtrack) ;
      :coordinates = "/time /geolocation/lat /geolocation/lon" ;
      :ancillary_variables = "/ancillary/quality" ;

    float radiance(time, xtrack, band) ;
      :coordinates = "/time /geolocation/lat /geolocation/lon /band" ;
      :ancillary_variables = "/ancillary/quality" ;
}
```

THANK YOU!

Questions or Comments?