

# Encoding of Swath Data in CF

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**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

# Resources

- 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>

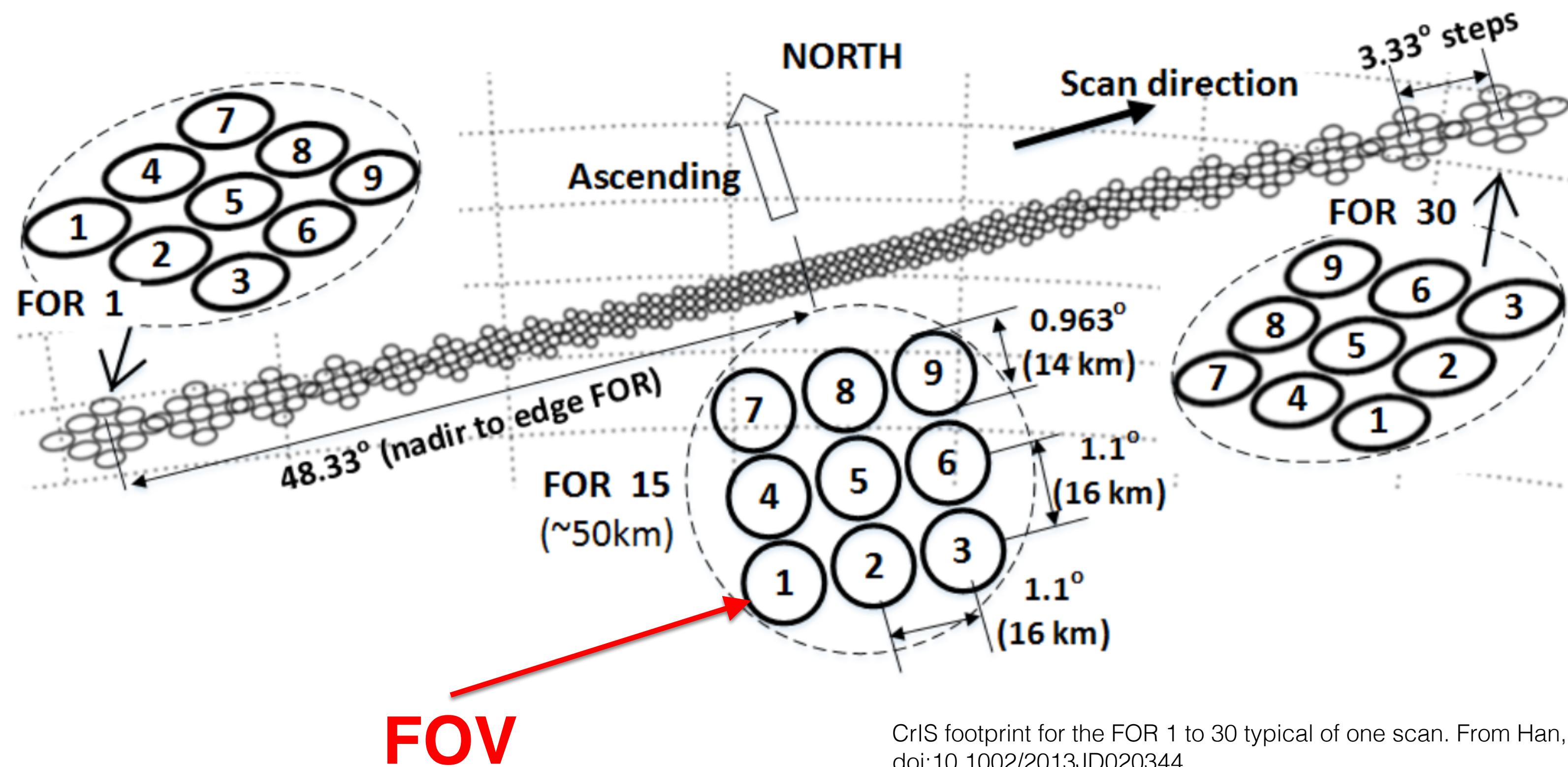
Real swath examples:

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

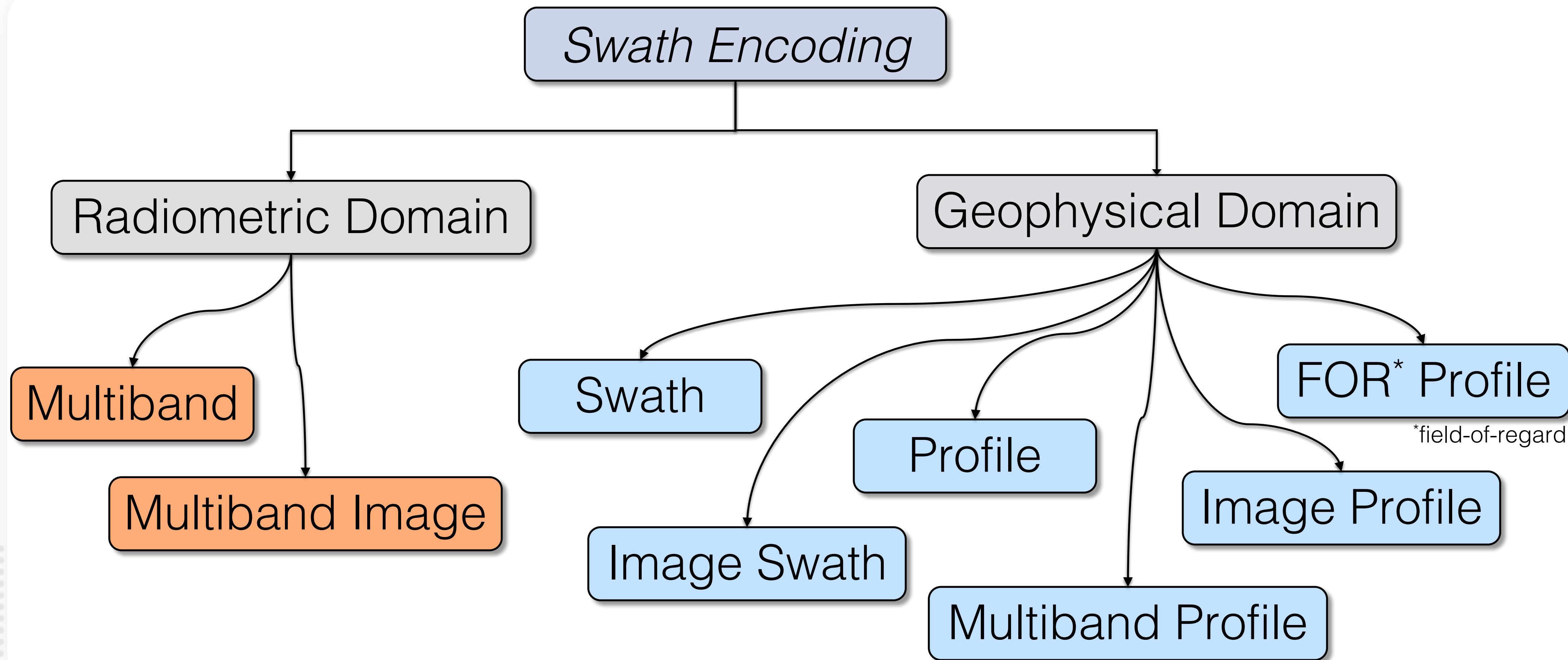
<https://eosdap.hdfgroup.org:8888/thredds/catalog/testAll/cf2/swath-real/catalog.html>

# Swath Data Encodings

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



# Proposed Encodings



# Time Coordinate

- 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\_center\_radiation\_wavelength, sensor\_band\_center\_radiation\_wavenumber,  
sensor\_band\_center\_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" ;
```

# Geospatial Coordinates

- 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" ;
```

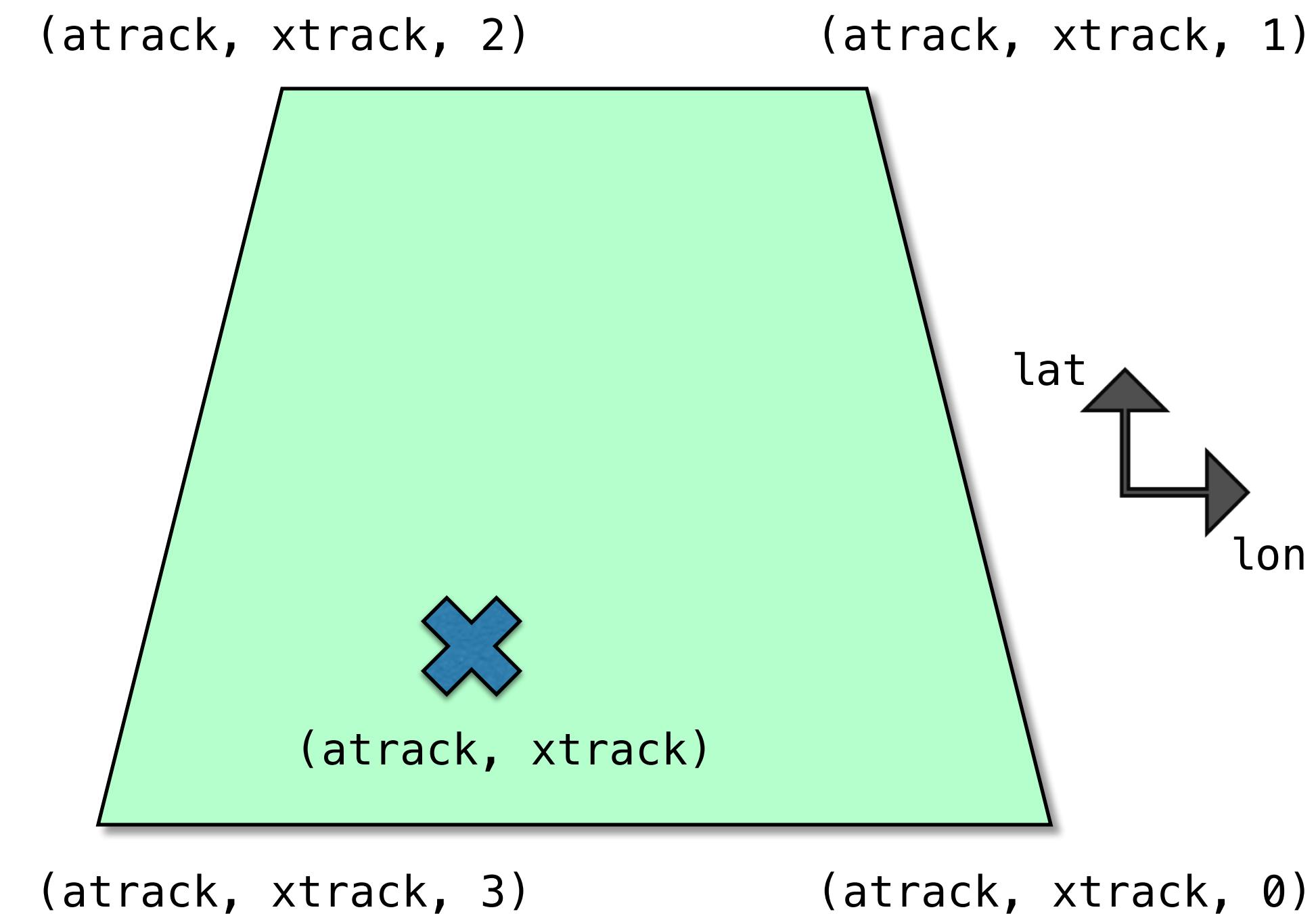
# Encoding Field-of-View Geospatial Extent

# 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:  
attrack = 512 ;  
xtrack = 1024 ;  
vertices = 4 ;  
  
variables:  
double time(attrack) ;  
  
float lat(attrack, xtrack) ;  
lat:bounds = "lat_vertex" ;  
  
float lon(attrack, xtrack) ;  
lon:bounds = "lon_vertex" ;  
  
float lat_vertex(attrack, xtrack, vertices) ;  
float lon_vertex(attrack, xtrack, vertices) ;  
  
float swath_data(attrack, 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?