Encoding of Swath Data in CF

2017 EarthCube netCDF-CF Workshop

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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

- Pretty print version: https://goo.gl/8QPJUB
- Comments/suggestions/corrections: https://github.com/Unidata/EC-netCDF-CF/issues (Label issues with Ext-Swath)
“Skinny” examples:
https://eosdap.hdfgroup.org:8888/thredds/catalog/testAll/cf2/swath/catalog.html


Real swath examples:

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

Swath Encoding

Radiometric Domain
- Multiband
  - Multiband Image

Geophysical Domain
- Swath
- Image Swath
- Profile
- Image Profile
- FOR* Profile
  *field-of-regard
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 alphanumerical
- 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" ;
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";
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" ;

Radiometric Encoding: Multiband Image
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";
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" ;
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" ;
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" ;
      :ancillary_variables = "ancillary/quality" ;

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

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" ;
THANK YOU!

Questions or Comments?