CfRadial-1 to CfRadial-2
CF NetCDF for RADAR and LIDAR Data in Polar Coordinates

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See: https://github.com/NCAR/CfRadial/tree/master/docs

Goals for CfRadial Data Format

- Represent data from pulsed instruments – RADARs and LIDARs – in their native polar coordinates
- Be as simple as possible
- Be self-describing
- Be accurate and complete – including all relevant metadata
- Incorporate lessons learned from earlier radar data formats
- Meet the needs of the research, scientific and operational user community

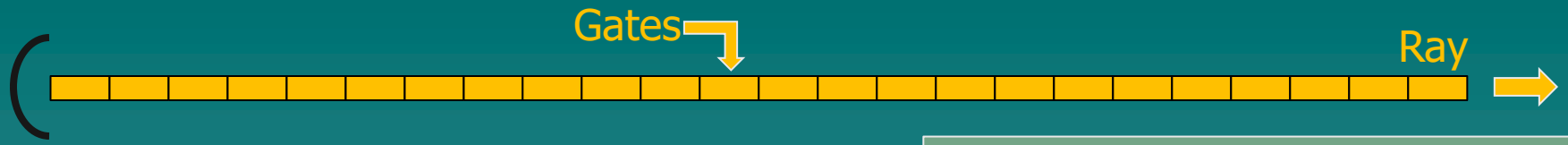
CfRadial-1:

- NetCDF3 classic design, using a flat structure

CfRadial-2:

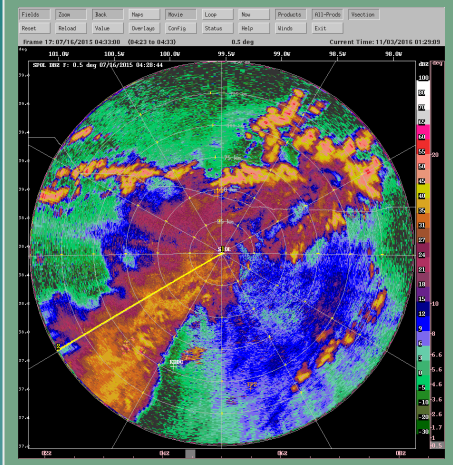
- NetCDF4, utilizing groups to represent the logical structure of the data

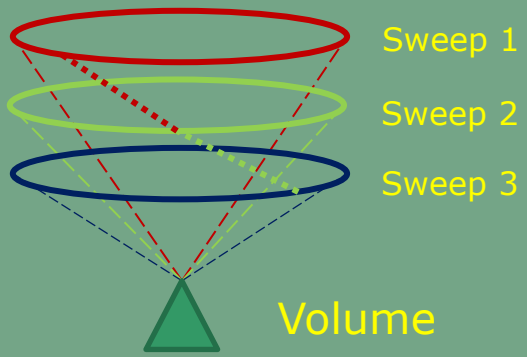
DATA MODEL – radars and lidars are pulsed instruments that produce data at GATES with constant distances from the antenna.



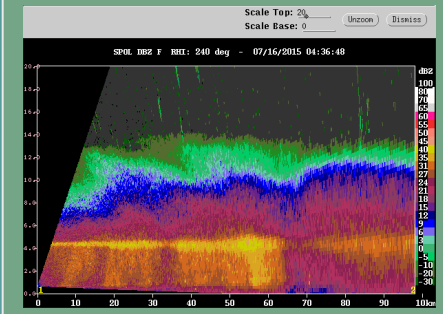
A collection of GATES forms a RAY.
A collection of RAYS forms a SWEEP.
A collection of SWEEPS forms a VOLUME.

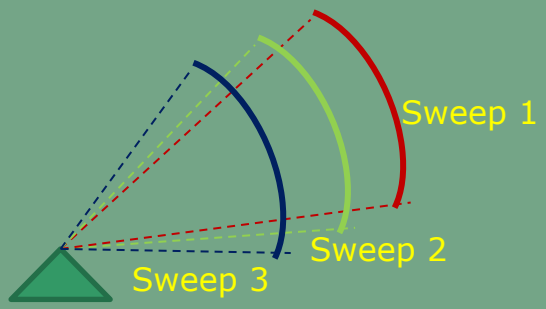
PPI mode – surveillance / sector – constant elevation sweeps



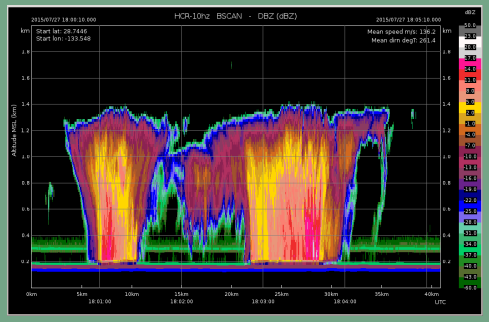


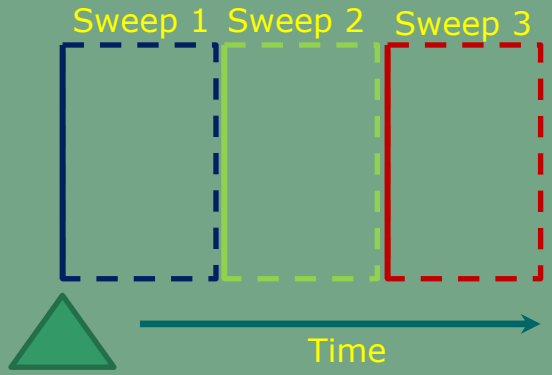
RHI mode – constant azimuth sweeps



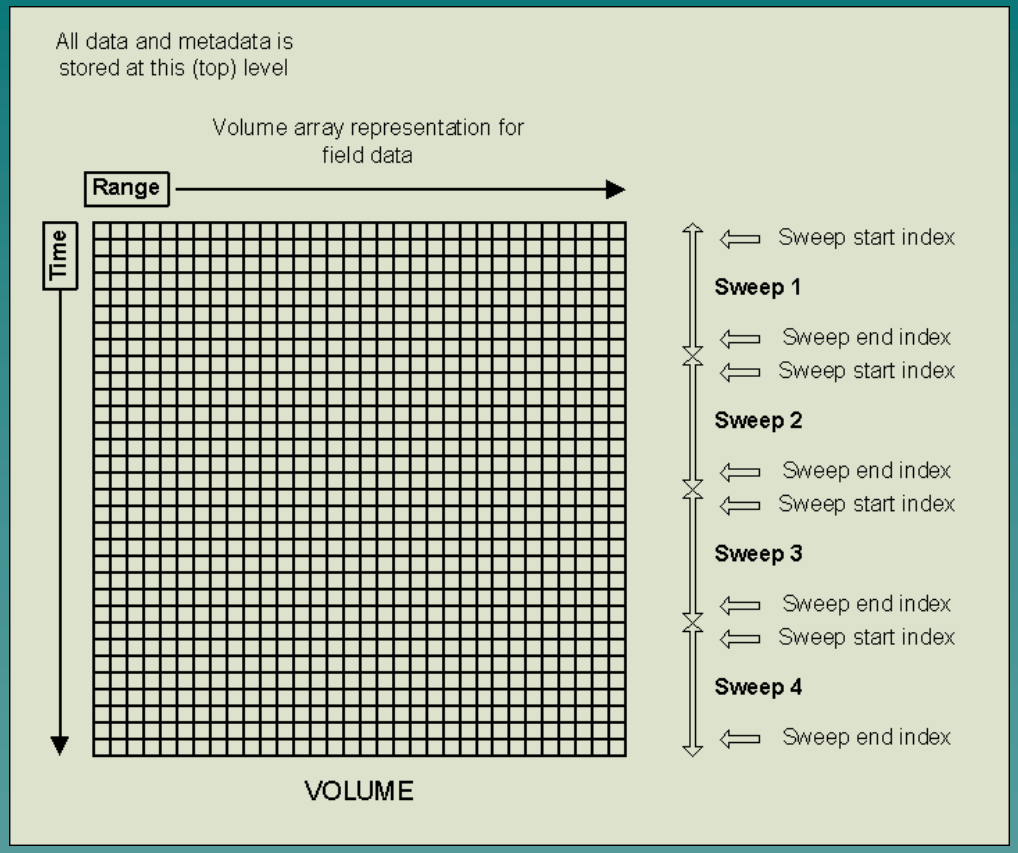


Vertical pointing mode
Sweeps are time-delimited





CfRadial-1 is based on NetCDF3 – a FLAT structure



Data fields are stored contiguously for the whole volume.

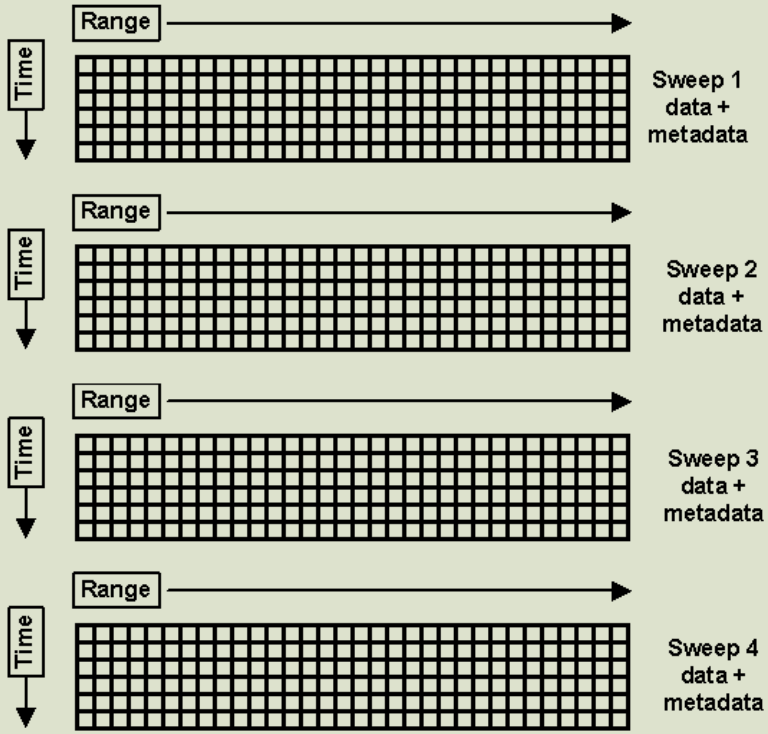
Sweeps are defined by index arrays that delineate the start and end of the sweep.

All metadata is stored at the top level.
The file organization does not capture the logical structure of the data set.

CfRadial-2 is based on NetCDF4 – supports groups and a TREE structure

Root group: top level metadata

Sweep groups:



Other groups for metadata:

- radar parameters
- lidar parameters
- calibration data
- moving platform georeference data

Sweeps comprise rays with some properties in common.

Data fields are stored individually for each sweep.

Sweeps are defined by the contents of a single group.

Metadata is distributed throughout various levels (groups) in the file.

The groups in the file represent the structure of the data sets.

Uses strings rather than char variables.

Group structure in CfRadial2

```
dimensions:
                sweep = 14 ;
                frequency = 1 ;

group: radar_parameters  {
  ..............
}

group: radar_calibration  {
                dimensions: r_calib = 1 ;
  ..............
}

string sweep_group_name(sweep) ;

float sweep_fixed_angle(sweep) ;

group: sweep_0001 {
  dimensions:
                time = 720 ;
                range = 1832 ;
                group: monitoring {
                }
  ..............
}
```

```
group: sweep_0002 {
  dimensions:
                time = 720 ;
                range = 1648 ;
                group: monitoring {
                }
  ..............
}
.....................
.....................
group: sweep_0013 {
  dimensions:
                time = 540 ;
                range = 276 ;
                group: monitoring {
                }
  ..............
}
group: sweep_0014 {
  dimensions:
                time = 360 ;
                range = 224 ;
                group: monitoring {
                }
  ..............
}
```

Standard Names

- The CfRadial2 team has compiled an initial list of standard names, for which approval will be requested.
- There are total of about 120 standard names in the proposal, as follows:
  - 50 radar 'moments' variables
  - 56 radar 'covariance' variables, many of which comprise complex numbers represented as power and phase as separate fields
  - 6 radar spectra variables
  - 7 lidar variables
- These will be submitted soon after the workshop.

Geometry

- Radars and lidars operate in radial (polar) coordinates. These are effectively 'line of sight' instruments, complicated by atmospheric refraction.
- We chose the 'radial' name rather than 'polar' to avoid confusion with projections such as 'Polar Stereographic'.
- To be consistent with CF, we need to have the native radar projection type added to CF. Our proposed name is 'radar_lidar_radial_scan'.
- Until this is added, we have to leave out the grid mapping information in order to pass the CF compliance checker.

Strictness in CfRadial

- CfRadial is a much stricter convention than simple CF.
- CfRadial requires many of the metadata variable names to match exactly.
- For example, 'elevation' refers to the scan angle above the horizontal plane, and 'azimuth' refers to the scan angle clockwise from True North.
- These variables must be named elevation and azimuth.
- To use the CF practice of inferring the existence of these coordinate variables from the units would be impractical.
- This strictness applies to many variables in CfRadial.

WMO Standards

- Currently WMO supports BUFR as the standard for radial radar data exchange. BUFR is not well suited to this task.
- WMO has formed the Inter-Programme Expert Team on Operational Weather Radars (IPET OWR).
- This team is evaluating CfRadial2 as a probable candidate to replace the BUFR standard.
- The CfRadial2 design aims to merge the strengths of CfRadial1 and the EU ODIM HDF5 format.
- One big advantage of CfRadial2 would be to encourage data exchange between the operational agencies and the research community.

THANK YOU