Brief Overview: GRIB, HDF, WRF.nc

- NCL supports via **addfile** function
  - GRIB1 and GRIB2
  - HDF-SDS [**S**cientific-**D**ata-**S**et subset of HDF]
  - HDF-EOS [**E**arth **O**bserving **S**ystem]
  - netCDF [netCDF-4 with version 5.0.1]

- variables imported (read) from grib, hdf, hdf-eos
  - will have the **same [consistent] structure**
  - will 'look/feel' like variables read from netCDF
  - **powerful programming concept**

GRIB1, GRIB2: Gridded Binary

World **M**eteorological **O**rg. (**WMO**) standard

- bit-oriented data format: very efficient for transmission/archival
  - netCDF (float) 2-4 times larger than corresponding GRIB
- two dimensional horizontal grids only
  - each grid has scale/offset for optimal precision
- **requires** external parameter table (s)
- **no** official read/write API for GRIB; makes GRIB 'problematic'
  - http://www.wmo.ch/web/www/reports/Guide-binary2.html
  - ftp://ftp.ncep.noaa.gov/pub/nws/nmc/docs/gribed1/

Reanalysis/operational datasets [NCEP/ECMWF] use GRIB

NCL: GRIB

NCL presents GRIB files/variables as netCDF variables

- unpacks 2D grids; sorts; creates multi-dimensional arrays
  - creates a variable data object [structure]
- NCL **built-in** NCEP/ECMWF parameter tables
- user defined GRIB tables allowed
- (generally) ignore warning messages from NCL for GRIB
- http://www.ncl.ucar.edu/Document/Manuals/Ref_Manual/NclFormatSupport.shtml

GRIB is really a record format and not a file format

- records can be placed in **any order**!!
- NCL must **scan entire file**
- **sort all records** to logical grouping by variable
- use information from **built-in parameter tables**
- creates attributes and corrdinates
- creates “values-added” variables like 2-dim coord arrays

NCL: GRIB1

```
ncl 0 > f = addfile ("monthly_1979_1151.grb" , "r")
ncl 1 > print (f)          ; like “ncdump –h” [I always do this]
```

```
Variable: f (file variable)
  filename:       monthly_1979_1151.tar
  path:   monthly_1979_1151.tar                    [note: no global atts]
    file global attributes:                        [grib files have none]
    dimensions:
      initial_time0 = 12
      lv_ISBL1      = 17
      g0_lat_2      = 73
      g0_lon_3      = 144
        [BIG SNIP]
```

```
ncl 2 > T = f->TMP_GDS0_ISBL    ;   printVarSummary(T)
```

```
float TMP_GDS0_ISBL ( initial_time0, lv_ISBL1, g0_lat_2, g0_lon_3 )
        center :       European Center for Medium-Range Weather Forecasts
long_name :    Temperature
        units :        K
        _FillValue :   -999
        level_indicator :      100
        grid_number :  255
        parameter_number :     130
        forecast_time :        0
        [BIG SNIP]
```

```
; can create netCDF if desired
g = addfile (“foo.nc”,”c”)
g@title = “Grib-to-netCDF”
g->T     = TMP_GDS0_ISBL
```

HDF (Hierarchical Data Format)

HDF4 [H4]: **basic features similar to netCDF**

- more flexible/features than netCDF but more complicated

NCL supports H4 Scientific Data Set (SDS) interface only

- can **not** access raster, palette, Vgroup, Vdata, annotations

HDF-EOS (EOS: Earth Observing System) HE4

- standard HDF with additional conventions, metadata
- three **geolocation** data types
  - **grid**: regular grid, based upon map projections
  - **point**: network of irregularly spaced locations
  - **swath**: time-sequences of scan-lines, profiles, array data
- special interfaces needed to get geolocation/temporal info
- http://hdfeos.gsfc.nasa.gov/hdfeos/index.cfm

HDF (Hierarchical Data Format)

HDF5 [H5]: new format (NCL support being developed)

- parallel I/O, no 2GB limit, data compression
- chunking access, multiple unlimited dimensions

NASA requires H5 in 2004 with launch of Aura sat.

- only occasional exceptions granted

Unidata/NCSA collaborating to merge netCDF/H5

– will be called **netCDF-4 [Oct 2006]**

– H5 will be used as its storage layer

HDF4 (Scientific Data Set)

```
ncl 0> f = addfile ("S3096284.hdf" , "r")
ncl 1> print (f)

Variable: f (file variable)

filename:       S3096284
path:   S3096284.hdf
  file global attributes:
    Producer_Agency : NASA
    Producer_Institution : JPL
    Sensor_Name : NSCAT
          [... snip...]
    Data_Format_Type : HDF
 dimensions:
    row       = 300
    column = 720
 variables
     float row ( row )
       long_name :    Latitude
       units :        degrees_north

    float column ( column )
       long_name :    Longitude
       units :        degrees_east
            [... snip ...]
```

```
short Avg_Wind_Vel_U ( row, column )
        valid_range :  <ARRAY>
        long_name :    average east-west comp
                       of the wind velocity vector
                       Positive is eastward
        units :          m/s
        coordsys :     Lat/Lon
        scale_factor : 0.01
                  [... snip...]

ncl 2 > u = f->Avg_Wind_Vel_U
ncl 3 > printVarSummary (u)

 Variable: u
 Type: short
 Total Size: 432000 bytes
          216000 values
 Number of Dimensions: 2
 Dimensions and sizes:
                    [row | 300] x [column | 720]
 Coordinates:
          row: [-75..74.5]
          column: [ 0..359.5]
 Number Of Attributes: 9
                    [... snip ...]
```

HDF-EOS: HE4

```
ncl 0> f = addfile ("BOG99_L2.hdfeos" , "r")
ncl 1> print (f)
filename:  BOG99_L2
file global attributes"
      HDFEOSVersion: HDFEOS_V2.4
      StructMetadata.0 : Group=SwathStructure
        Group=SWATH_1
          SwathName="bog99"
           GROUP=Dimension
             OBJECT=Dimension_1
               DimensionName="Cell_along_Swath"
                Size=203
              END_OBJECT=Dimension_1
                   [... SNIP other objects ...]
            END_GROUP=Dimension
        END_GROUP=SWATH_1
      END_GROUP=SwathStructure


 dimensions:
      Cell_along_Swath:BOG99 = 203
          [... snip ...]
      detectors per 250m band = 240   // unlimited
      number of 500m bands   = 5      // unlimited
      detectors per 500m band = 20    // unlimited
   variables: [... snip...]
      byte gflags (Cell_along_Swath:BOG99 ,
                   1KM_geo_dim: [...snip...] )
         _FillValue : 377
        Bit 7 (MSB)  :   1 = invalid input dataset
              Bit 6  :   1  = no ellipsoid intersection
                 [... snip...]

byte Cloud_Mask
(byte_segment,cell_Along,cell_Across)
          valid_range :  <ARRAY>
          _FillValue   : 0
          long_name  : MODIS Cloud Mask
          units :   none
          Geolocation_Pointer :
                External product   description:
bit fields within byte ordered left to right
bit field    description          key
------       ---------            --------------
   0         cloud mask flag      0 = unknown
  2,1        quality              00= cloudy
                                  01=uncertain
                                  10=probably clear
                                  11=confidently clr
                  [... SNIP...]
---------End byte 1 \----------------------
```

```
 ncl 2 > cm = f->Cloud_Mask
                  ; unpack bits
 ncl 3 > flags = dim_gbits( ....)
```

WRF: Weather Research and Forecast Model

Does not fully conform to common netCDF standards

- variable "**Time**" is of type ***character***
  - + not coordinate variable [not numeric; monotonic +/-]
- XLAT / XLONG variables
  - + does not use "degrees_north" or "degrees_east"
  - + 3-dimensional [function of time]
    - not "coordinate variable" [multi-dim; not monotonic]

global attribute "MAP_PROJ" tells map projection

- all required mapping information is provided
  - f@MAP_PROJ

WRF: netCDF

```
ncl 0 > f = addfile ("netcdf wrfout_d01_000000.nc" , "r")
ncl 1 > print (f)          ; like "ncdump –h" [I always do this]
```

```
dimensions:
        Time = UNLIMITED ; // (25 currently)
        DateStrLen = 19 ;
        west_east_stag = 91 ;
        south_north = 81 ;
        bottom_top = 27 ;
        west_east = 90 ;
        south_north_stag = 82 ;
        bottom_top_stag = 28 ;
        soil_layers_stag = 4 ;

variables:
        char Times(Time, DateStrLen) ;
        float U(Time, bottom_top, south_north, west_east_stag) ;
                U:FieldType = 104 ;
                U:MemoryOrder = "XYZ" ;
                U:description = "x-wind component" ;
                U:units = "m s{-1}" ;

[BIG SNIP]
```

WRF: netCDF

```
 float XLAT(Time, south_north, west_east) ;
            XLAT:FieldType = 104 ;
            XLAT:MemoryOrder = "XY " ;
            XLAT:description = "LATITUDE, SOUTH IS NEGATIVE" ;
            XLAT:units = "degree"          ; not udunits conformant
            XLAT:stagger = "" ;
 float XLONG(Time, south_north, west_east) ;
            XLONG:FieldType = 104 ;
            XLONG:MemoryOrder = "XY " ;
            XLONG:description = "LONGITUDE, WEST IS NEGATIVE" ;
            XLONG:units = "degree“        ; not udunits conformant
            XLONG:stagger = "" ;
[BIG SNIP]
// global attributes:
            :TITLE = " OUTPUT FROM WRF V1.3 MODEL" ;
            :START_DATE = "2001-06-11_12:00:00" ;
            :WEST-EAST_GRID_DIMENSION = 91 ;
            :SOUTH-NORTH_GRID_DIMENSION = 82 ;
            :BOTTOM-TOP_GRID_DIMENSION = 27 ;
[snip]
 :CEN_LAT = 43.99802f ;              :CEN_LON = -98.f ;
 :TRUELAT1 = 30.f ;                  :TRUELAT2 = 60.f ;
 :GMT = 12.f ;
 :JULYR = 2001 ;                     :  JULDAY = 162 ;
 :MAP_PROJ = 1 ;
```