

CF and Netcdf

CF
Standard

CF
Standard

Why?

- Customers want it
- Open standard
- Transparent path to improvement
- Prepares us for future innovations

CF
Standard

Use case

- Customer finds a output file and wants to understand it?

What should he know?

- What? (Quantity)
- Where? (Location, cell centered, sigma, coordinate system?, projection?)
- When? (Time, calendar, interval, timezone?)
- How much? (Value, unit, , cell method)

CF
Standard

Open standard

- Climate & Forecasting Metadata convention
 - Last version 17 januari 2008
 - Main contributors: NOAA, MetOffice, UCAR, NCAR, USGS, PCMDI
- Formalized yet open
- Well designed

CF
Standard

Open standard

- What is standardized?
 - Variable names
 - Units
 - Locations (lat, lon)
 - Levels (z, sigma, bar)
 - Cells (boundaries, measures)

Variable names

- **runoff_amount**: "Amount" means mass per unit area. Runoff is the liquid water which drains from land. If not specified,
- **runoff_flux**: Runoff is the liquid water which drains from land. If not specified, "runoff" refers to the sum of surface runoff and subsurface drainage. In accordance with common ...

Variable names

- **sea_water_potential_temperature:**
Potential temperature is the temperature a parcel of air or sea water would have if moved adiabatically to sea level pressure.
- **normalized_difference_vegetation_index:**
"Normalized_difference_vegetation_index", usually abbreviated to NDVI, is an index calculated from reflectances

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Variable names

- <http://cf-pcmdi.llnl.gov/documents/cf-standard-names> (v7 21 nov 2007)

CF
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Units

udunits

```
## BASE UNITS. These must be first and are identified by a nil definition.  
#count          P          # dimensionless decimal number  
kelvin          P          # thermodynamic temperature  
kilogram        P          # mass  
meter           P          # length  
mole            P          # amount of substance
```

```
d              S day  
min            P minute  
hr             P hour  
h              S hour  
fortnight     P 14 day    # exact  
week          P 7 day     # exact  
jiffy         S 0.01 second # believe it or not!  
jiffies       S jiffy     # assumed plural spelling
```

```
# International foot stuff:  
international_inch S 2.54 cm          # exact  
international_inches S international_inch # alias  
international_foot S 12 international_inches # exact  
# Alias unspecified units to the international units:  
inch          S international_inch # alias  
foot          S international_foot # alias
```

```
STATUS = UTDEC('2 jiffies since 1990-1-1', TIMECENTERS_UNIT)  
IF (STATUS .NE. 0) *THEN  
  PRINT *, 'UTDEC() =', STATUS  
ELSE
```

```
$udunits  
You have: days since 2000-1-1  
You want: minutes since 1930-1-1  
  <minutes since 1930-1-1> = <days since 2000-1-1>*1440 + 3.68165e+07  
  <minutes since 1930-1-1> = <days since 2000-1-1>/0.000694444 + 3.68165e+07
```

Fortran 90 interface

Command line utility

CF
Standard

Locations

- Latitude, Longitude or x, y
 - unit usually degrees north and east
- Height defined in known units or as function of a physical or both. Axis positive or negative.
- Trajectories, stations

CF
Standard

Time

- Calendars (gregorian, julian, no leap)
- Start point (days since 2005)
- Units(days, seconds, jiffies)

NetCDF

The logo for NetCDF, consisting of the text "NetCDF" in a white, sans-serif font centered within a rounded square button that has a vertical gradient from light to dark grey.

NetCDF

Use case

- Customer has output file and wants to use it from it's favorite tools:
 - Matlab
 - Arcgis
 - Excel
 - His favorite text editor (emacs of course)

The logo for NetCDF, consisting of a rounded square with a vertical gradient from light to dark, containing the text "NetCDF" in white.

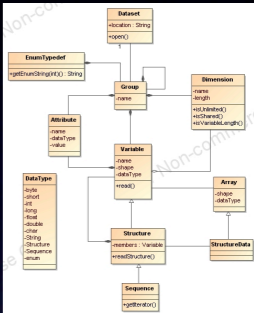
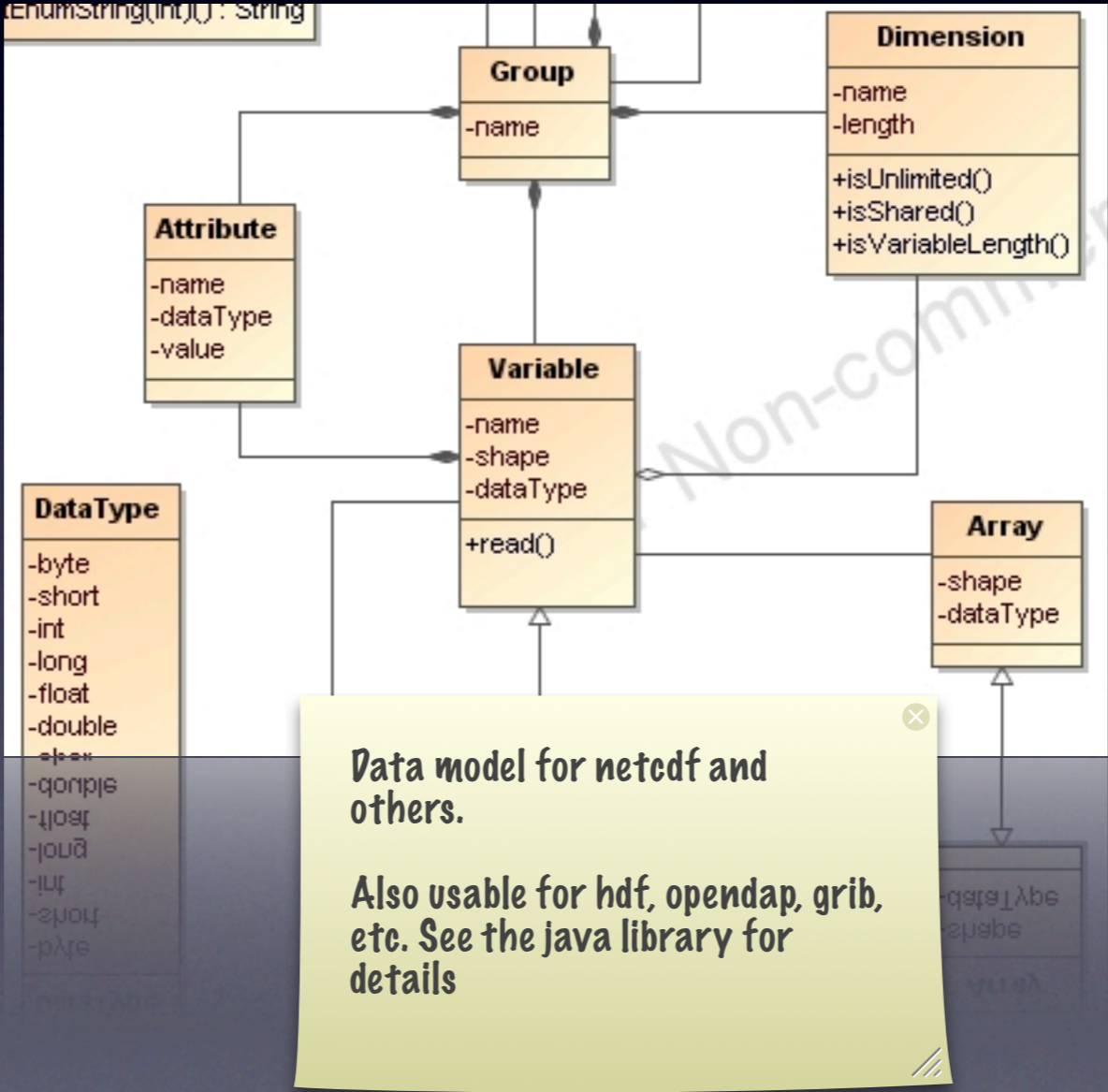
NetCDF

File format

- library for fortran, c, c++, java, etc...
- text, xml and binary format
- From netcdf4 HDF storage



Data model



NetCDF

F90 interface

File

Open
Create
Inquire
Define
Close

Dimension

Define
Inquire

Variables

Put
Get
Inquire

Attributes

Put
Get
Inquire

- [NF90_STRERROR](#)
- [NF90_INQ_LIBVERS](#)
- [NF90_CREATE](#)
- [NF90_OPEN](#)
- [NF90_REDEF](#)
- [NF90_ENDDEF](#)
- [NF90_CLOSE](#)
- [NF90_INQUIRE](#) Family
- [NF90_SYNC](#)
- [NF90_ABORT](#)
- [NF90_SET_FILL](#)

- [NF90_DEF_DIM](#)
- [NF90_INQ_DIMID](#)
- [NF90_INQUIRE_DIMENSION](#)
- [NF90_RENAME_DIM](#)

- [NF90_DEF_VAR](#)
- [NF90_INQ_VARID](#)
- [NF90_INQUIRE_VARIABLE](#)
- [NF90_PUT_VAR](#)
- [NF90_GET_VAR](#)
- [NF90_RENAME_VAR](#)

- [NF90_PUT_ATT](#)
- [NF90_INQUIRE_ATTRIBUTE](#)
- [NF90_GET_ATT](#)
- [NF90_COPY_ATT](#)
- [NF90_RENAME_ATT](#)
- [NF90_DEL_ATT](#)

Matlab

```
>> url = 'http://tashtego.marine.rutgers.edu:8080/thredds/dodsC/roms/nena/  
SRTM/w100w20s10n90.nc';  
>> lon = nc_varget ( url, 'lon' );  
>> size(lon)
```

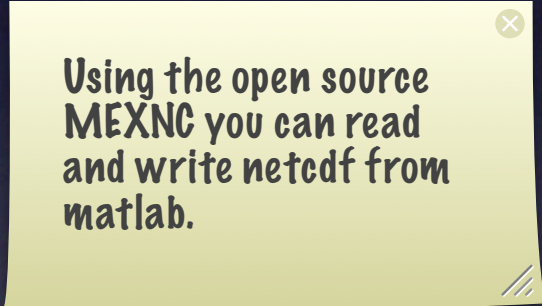
ans =

```
9600    1
```

```
>> lon(1:5)
```

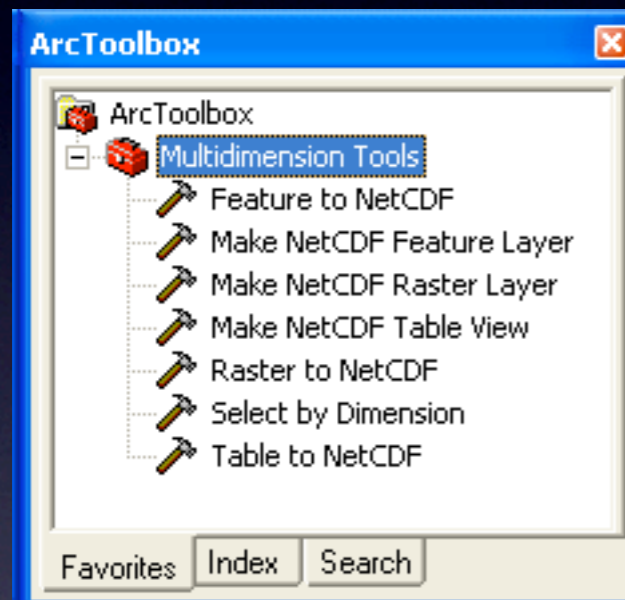
ans =

```
-99.9958  
-99.9875  
-99.9792  
-99.9708  
-99.9625
```

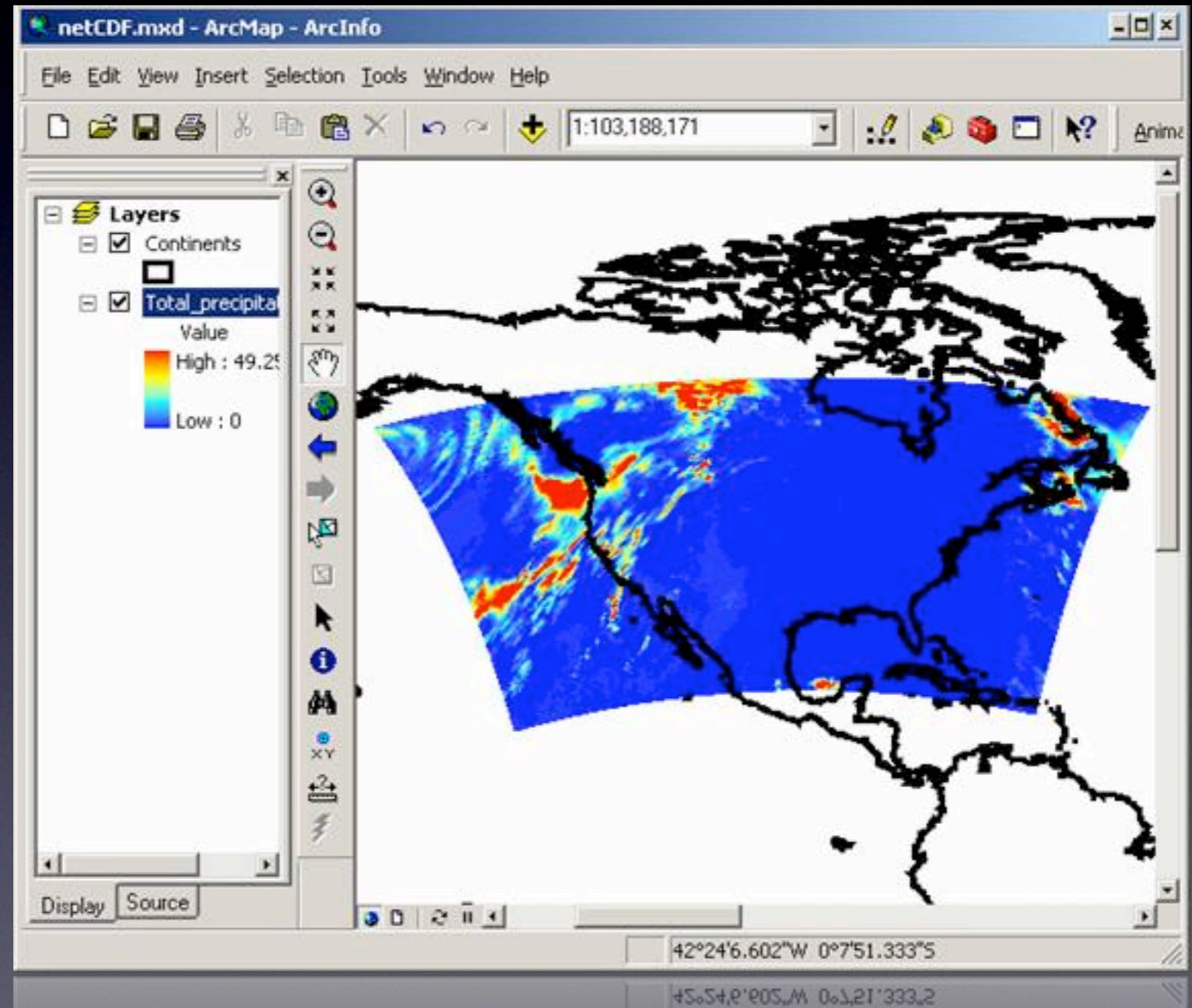


Using the open source
MEXNC you can read
and write netcdf from
matlab.

ArcGis



ArcGis also reads and writes netcdf files.



Excel

'VBA interface to netcdf

```
ReDim myVar(0 To dimLen - 1)
```

```
'Open File
```

```
status = nc_open(fileName, NC_NOWRITE, ncid)
```

```
status = nc_inq_varid(ncid, varName, varid)
```

```
status = nc_get_var_int(ncid, varid, myVar(0))
```



Excel is limited to 32768 rows. Be careful!
Excel only understands 1D & 2D.

NetCDF

```
$ ncdump vec.nc
netcdf vec {
dimensions:
    n = UNLIMITED ; // (5 currently)
variables:
    float v(n) ;
data:
    v = 10 , 20.3 , 30.2 , 40.9 , 50 ;
}
```

Create text
representation of a
netcdf file

NetCDF

```
$ nc2text vec.nc v  
10 20.3 30.2 40.9 50
```

Simple nice.

Emacs

```
Terminal — emacs-i386 — 96x28
<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2" location="./bhbok4g4.ncxml"
  <dimension name="time" length="18" />
  <dimension name="pressure_difference_layer" length="6" />
  <dimension name="y" length="303" />
  <dimension name="x" length="491" />
  <attribute name="Conventions" type="String" value="CF-1.0" />
  <attribute name="Originating_center" type="String" value="US National Weather Service (NCEP) $
  <attribute name="Generating_Process_or_Model" type="String" value="Forecast" />
  <attribute name="Product_Status" type="String" value="Operational productsService (NCE" />
  <attribute name="Product_Type" type="String" value="Forecast productsctsService (NCE" />
  <attribute name="cdm_data_type" type="String" value="Grid" />
  <attribute name="creator_name" type="String" value="US National Weather Service (NCEP) subcen$
  <attribute name="file_format" type="String" value="GRIB-2" />
  <attribute name="location" type="String" value="/data/ldm/pub/native/grid/NCEP/DGEX/CONUS_12k$
  <attribute name="history" type="String" value="Direct read of GRIB into NetCDF-Java 2.2 API; $
  <attribute name="_CoordinateModelRunDate" type="String" value="2008-03-04T06:00:00Z" />
  <attribute name="_CoordinateModelBaseDate" type="String" value="2008-02-15T06:00:00Z" />
  <attribute name="History" type="String" value="Translated to CF-1.0 Conventions by Netcdf-Jav$
  Original Dataset = NCEP-DGEX-CONUS_12km_RUN_2008-03-04T06:00:00Z; Translation Date = Tue Mar 04$
  <variable name="U-component_of_wind" shape="time pressure_difference_layer y x" type="float">
    <attribute name="units" type="String" value="m s-1" />
    <attribute name="long_name" type="String" value="U-component of wind @ pressure_difference_$
    <attribute name="missing_value" type="float" value="-9999." />
    <attribute name="grid_mapping" type="String" value="Lambert_Conformalby Netcdf-Java " />
    <attribute name="GRIB_param_discipline" type="String" value="Meteorological productscdf-Jav$
-uuu:**-F1  bhbok4g4.ncxml  Top L5  (XML)-----
<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2" location="./bhbok4g4.ncxml"
  <dimension name="time" length="18" />
  <dimension name="pressure_difference_layer" length="6" />
  <dimension name="y" length="303" />
  <dimension name="x" length="491" />
  <attribute name="Conventions" type="String" value="CF-1.0" />
  <attribute name="Originating_center" type="String" value="US National Weather Service (NCEP) $
  <attribute name="Generating_Process_or_Model" type="String" value="Forecast" />
  <attribute name="Product_Status" type="String" value="Operational productsService (NCE" />
  <attribute name="Product_Type" type="String" value="Forecast productsctsService (NCE" />
  <attribute name="cdm_data_type" type="String" value="Grid" />
  <attribute name="creator_name" type="String" value="US National Weather Service (NCEP) subcen$
  <attribute name="file_format" type="String" value="GRIB-2" />
  <attribute name="location" type="String" value="/data/ldm/pub/native/grid/NCEP/DGEX/CONUS_12k$
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    <attribute name="long_name" type="String" value="U-component of wind @ pressure_difference_$
    <attribute name="missing_value" type="float" value="-9999." />
    <attribute name="grid_mapping" type="String" value="Lambert_Conformalby Netcdf-Java " />
    <attribute name="GRIB_param_discipline" type="String" value="Meteorological productscdf-Jav$
```

xml representation of a netcdf file

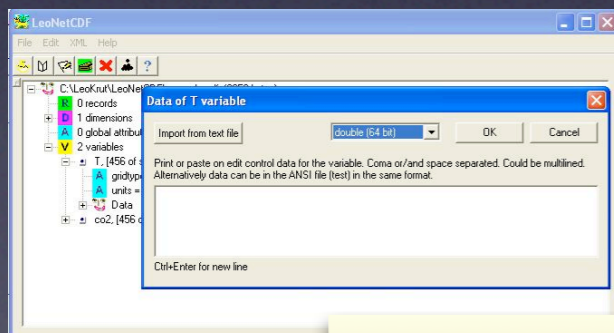
Other Tools

NCO

```
#diff
ncdiff -v time file1.nc file2.nc
#compression & packing
ncpdq -4 -L 9 in.nc out.nc # Deflated packing (~80% lossy compression)
#selecting variables by regex
ncks -v '^Q..' in.nc # Q01--Q99, QAA--QZZ, etc.
```

Very useful

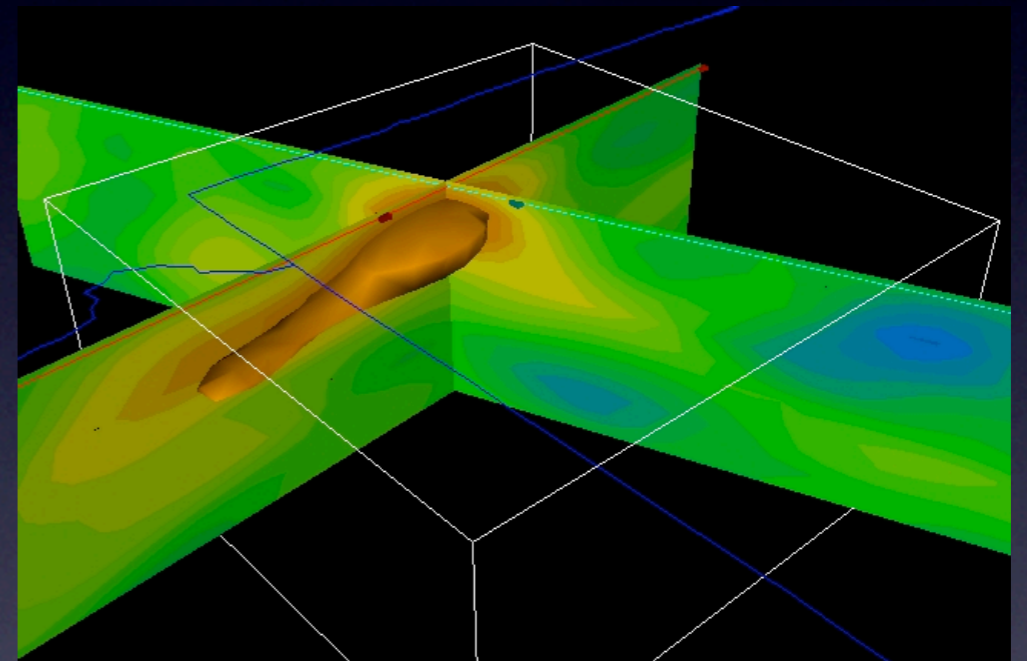
LeoNetCDF



Leo will like this.

IDV

Not so stable.



Web hyperslabs, cool!

The logo for OPeNDAP, featuring a stylized blue star above the text 'OPeNDAP' in a blue, serif font.

NetCDF

netcdf & deltares

- 2D/3D data structures
- 1D data structures
- Current libraries

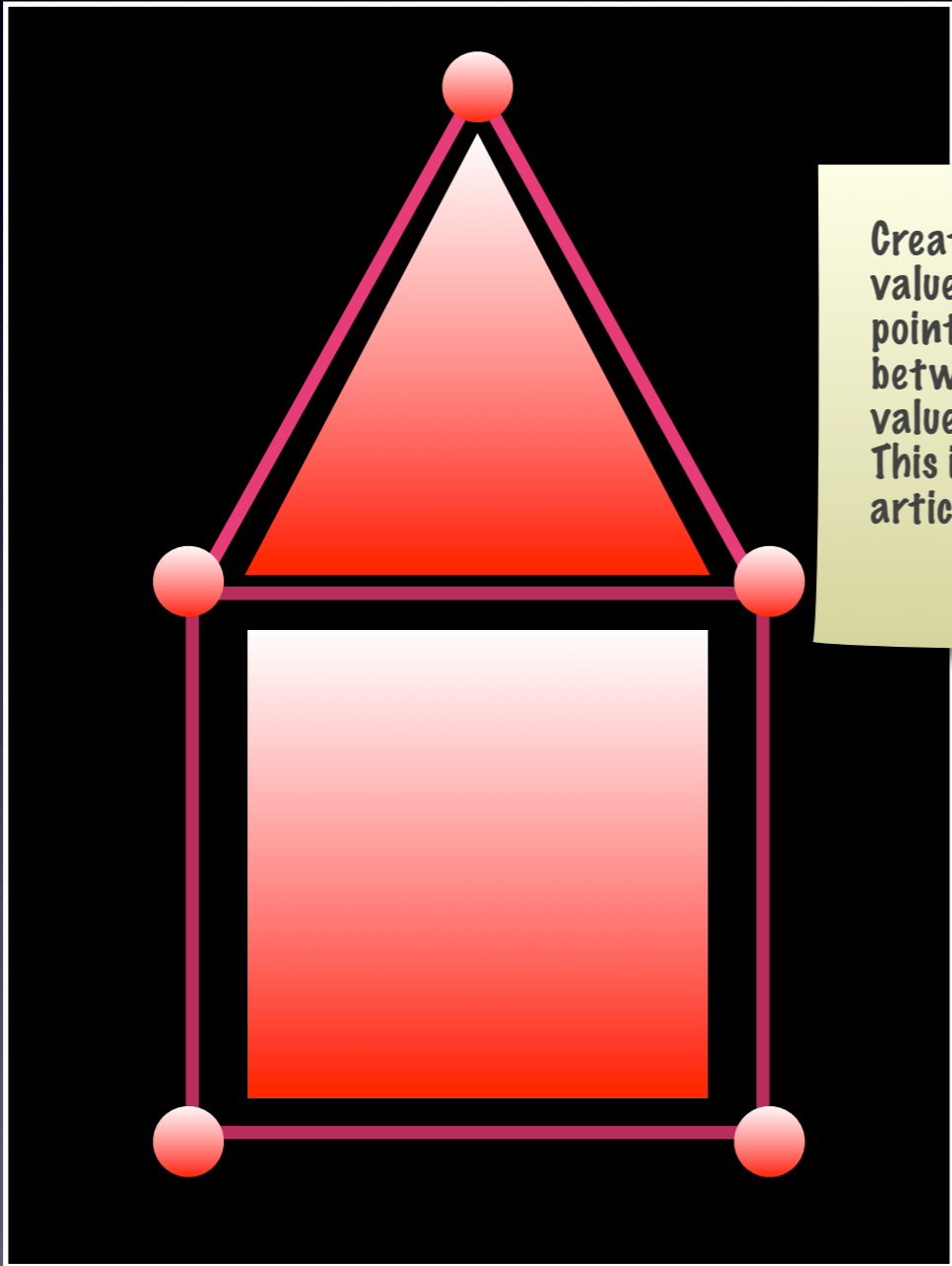
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NetCDF

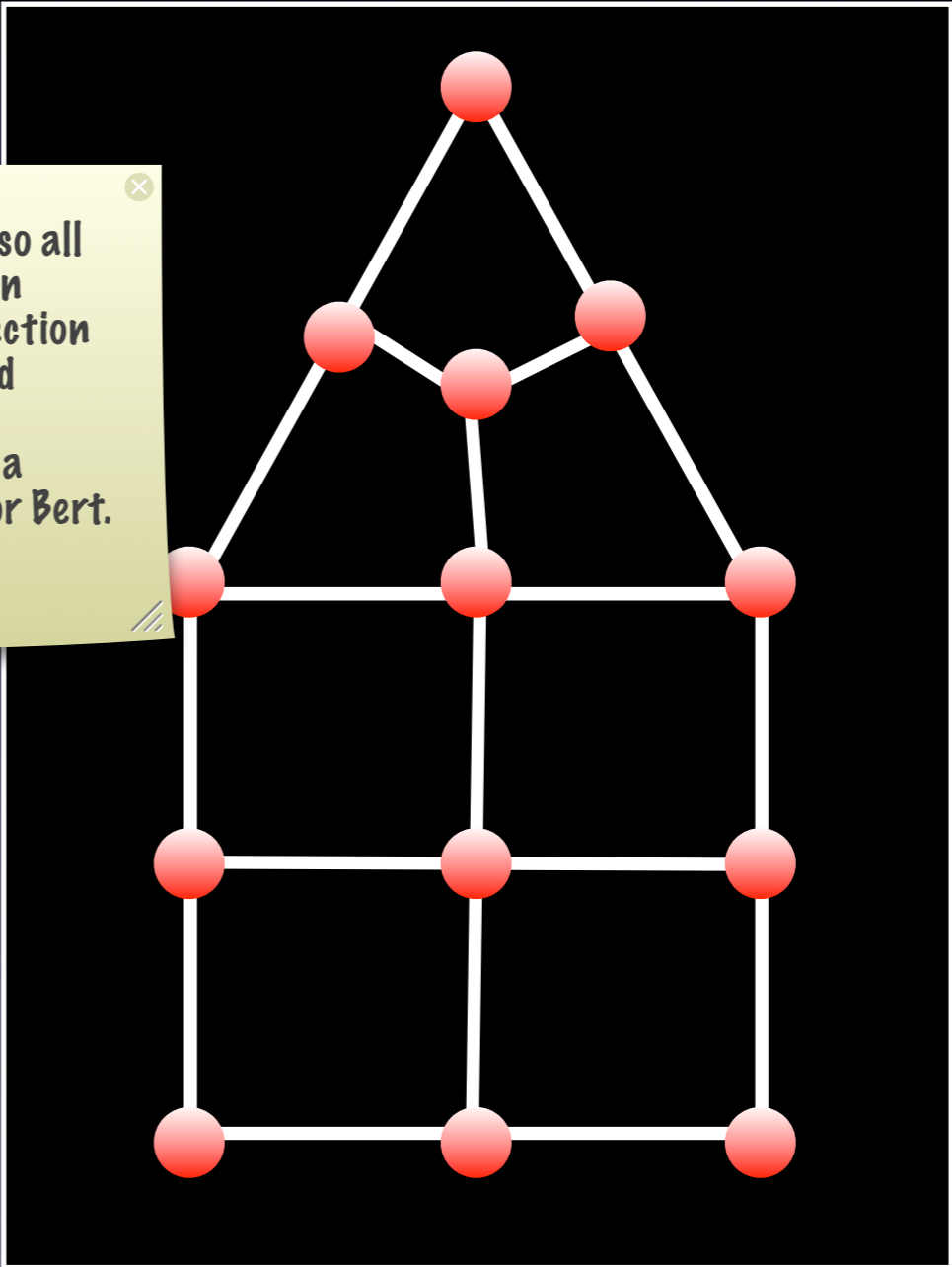
unstruc

- Unstructured data definition
- Windows build
- F77, F90 interfaces
- cfortran header file

Polygon grids

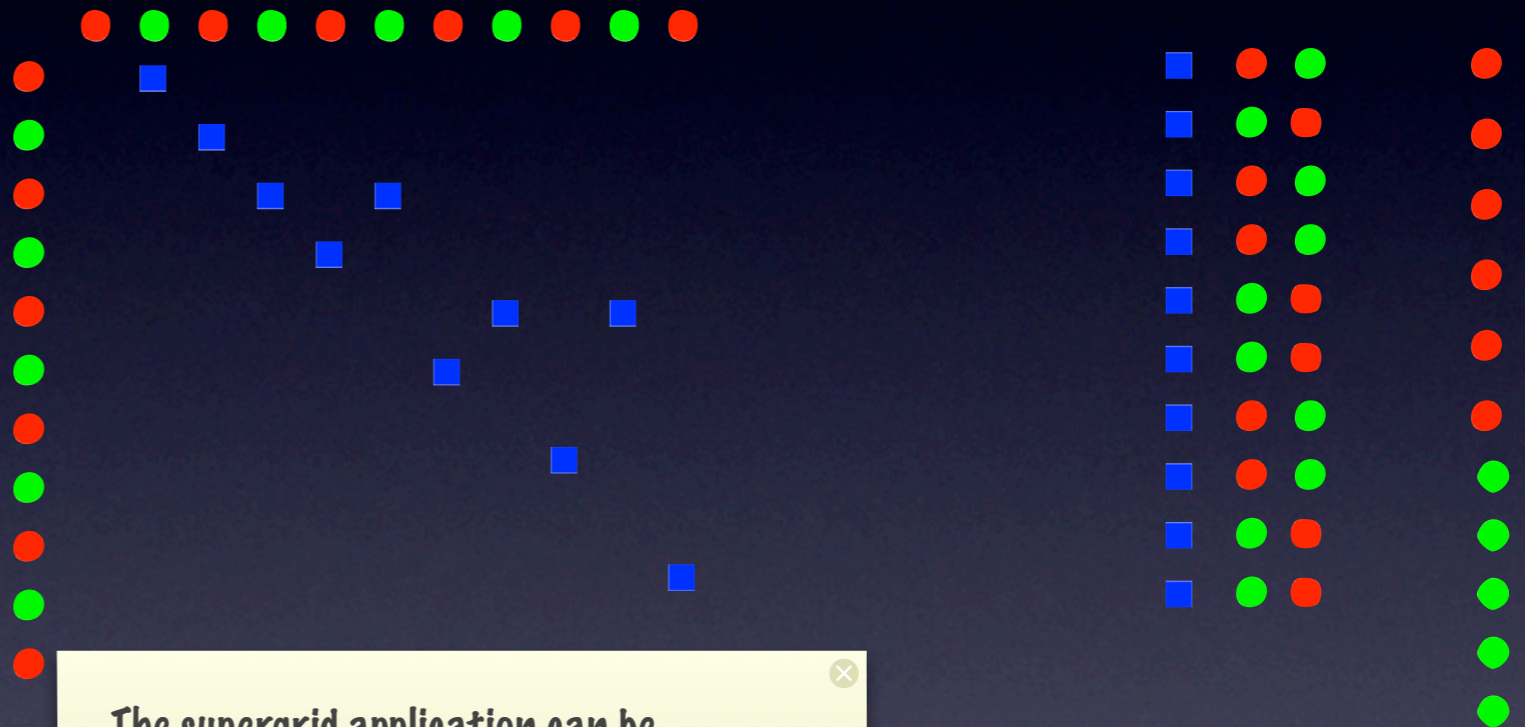
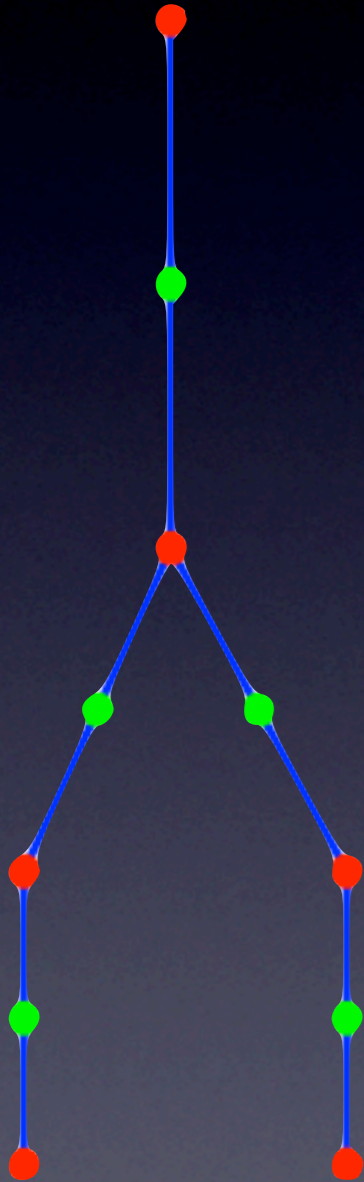


Create a supergrid so all values are defined on points. Store connection between points and values on points. This is described in a article. Ask Fedor or Bert.





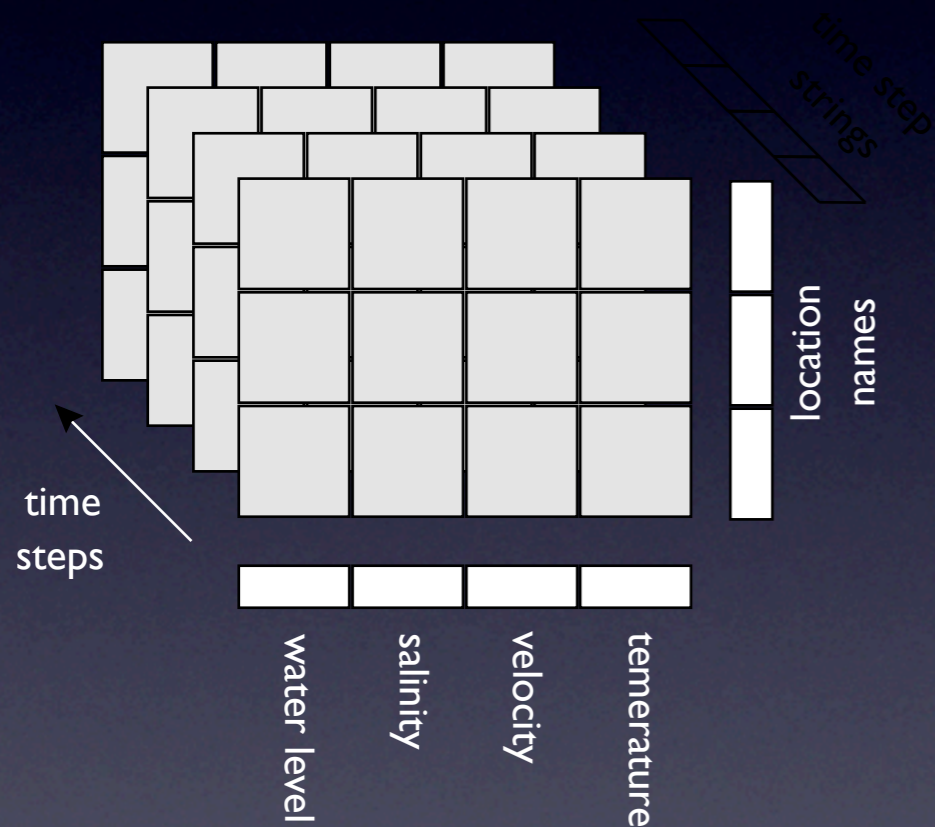
1D networks



The supergrid application can be generalized to 1D networks. It's best to store the connection matrix as a sparse connection table for storage considerations. The 1D representation is less common in the climate world.

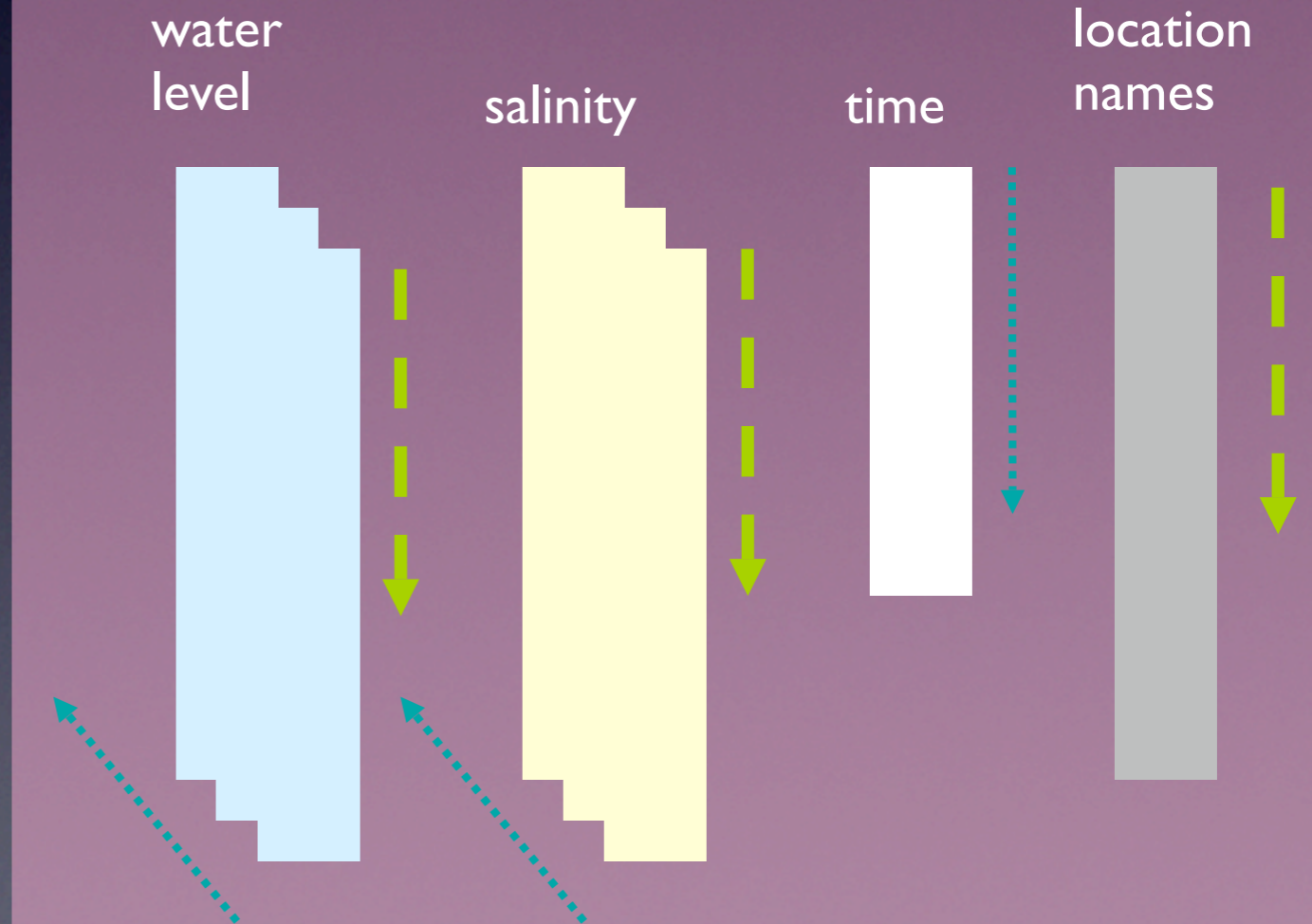
DelftIO → Netcdf

dimensions



Variables are saved separately, not as a dimension.

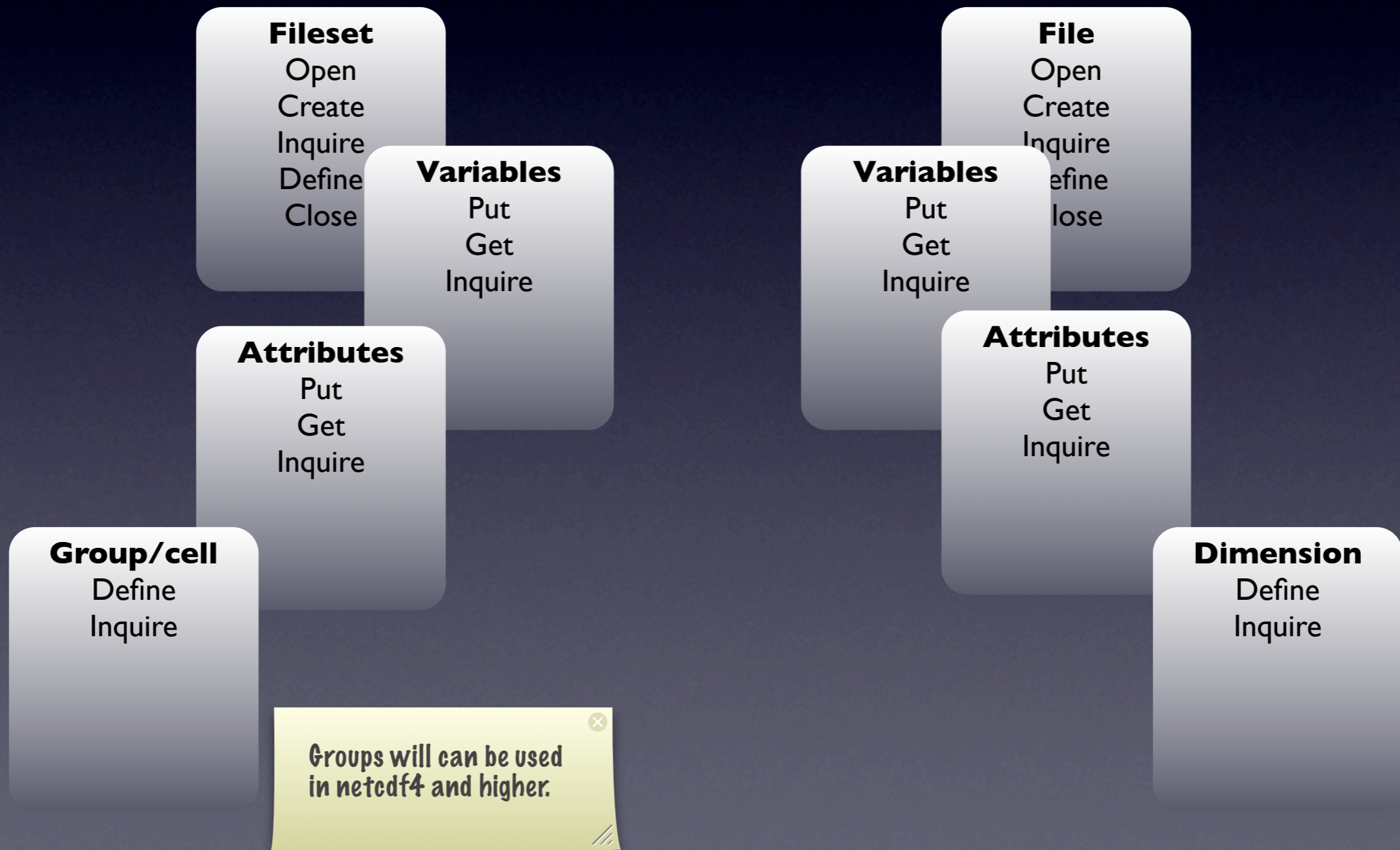
variables



Delft IO usage

- **Configuration:** data_3d, kernel_sobek, delft3d/coup203, delft3d/flow
- **ParLocTime Define:** data_3d, kernel_sobek, delft3d/coup203, delft3d/../flow_modsrc, d3d_wave, gw_sobek
- **2D Field Define:** data_3d, delft3d/flow, d3d_wave
- **DioPltCreate, 3D block Create, 2D Field Create, Dataset, Stream:** internal only

Nefis -> NetCDF



Next steps

- Write convertors (april - july)
 - Utilities
 - Suggestions to improve standard
- Change default output to CF/NetCDF (july - december), replace his and nefis