INTRODUCTION TO NETCDF-4

HDF Workshop XII

Denver, Oct 15, 2008

Ed
Hartnett
Unidata

Show of Hands...

- How many traveled to be here?
- University/Gov't/Industry
- How many use netCDF?
- Primary programming language for netCDF?
- Other data formats of interest?

NetCDF-4 as a Four-part Mini-series

Introduction to NetCDF

What is netCDF?

NetCDF Data Models

How we think of data.

NetCDF Software Libraries

Using netCDF APIs.

Secrets of NetCDF

Stuff known only to the netCDF insiders!

Introduction to NetCDF

- History of NetCDF: Classical and NetCDF-4 Eras
- The Four NetCDF Disk Formats
- The Classic and Enhanced Data Models
- Backward Compatibility
- Conventions
- HDF5 Interoperability
- Tools for NetCDF
- NetCDF Documentation and Support

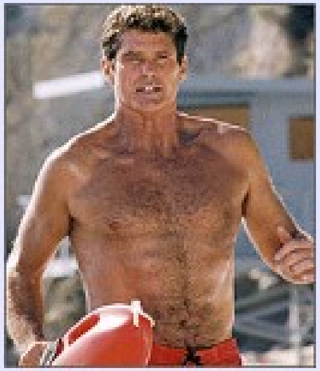
What is NetCDF?

- NetCDF (network Common Data Form) is a set of software libraries and machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data.
- NetCDF now supports four binary formats and APIs in many programming languages.
- There is a large body of existing netCDF software, many netCDF programmers, and lots and lots of netCDF data.

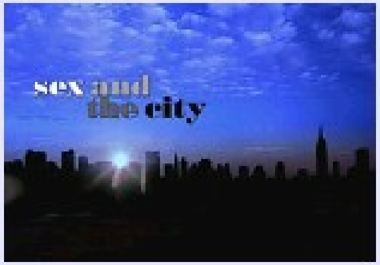
Important Events in NetCDF/Television

1988: NetCDF is developed at Unidata

1991: NetCDF 2.0 released



1996: NetCDF 3.0 released



1998: NetCDF Java 1.0 released

2004: NetCDF 3.6.0 released

2008: NetCDF 4.0 released

NetCDF Disk Formats

NetCDF version
1.0, 1988

classic format

NetCDF version
3.6.0, 2004

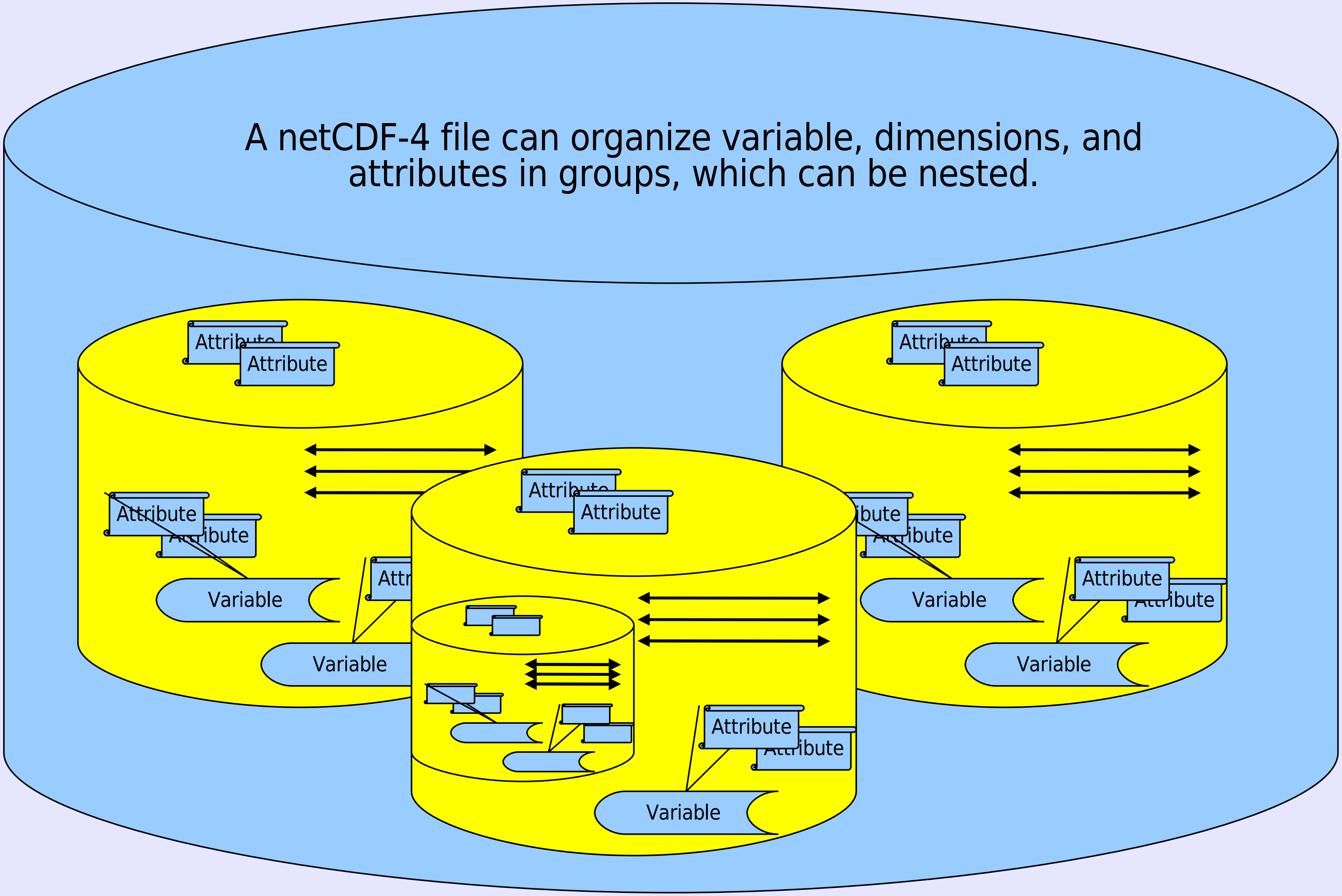
64-bit offset format

NetCDF version
4.0, 2008

netcdf4/hdf5 format

netcdf4/hdf5 classic model format

Data Models



A netCDF-4 file can organize variable, dimensions, and attributes in groups, which can be nested.

Commitment to Backward Compatibility

Because preserving access to archived data for future generations is sacrosanct:

- NetCDF-4 provides both read and write access to all earlier forms of netCDF data.
- Existing C, Fortran, and Java netCDF programs will continue to work after recompiling and relinking.
- Future versions of netCDF will continue to support both data access compatibility and API compatibility.

Conventions

- The NetCDF User's Guide recommends some conventions (ex. "units" and "Conventions" attributes).
- Conventions are published agreements about how data of a particular type should be represented to foster interoperability.
- Most conventions use attributes.
- Use of an existing convention is highly recommended. Use the CF Conventions, if applicable.
- A netCDF file should use the global "Conventions" attribute to identify which conventions it uses.

The Climate and Forecast Conventions

The CF Conventions are becoming a widely used standard for atmospheric, ocean, and climate data.

The NetCDF Climate and Forecast (CF) Metadata Conventions, Version 1.3, describes consensus representations for climate and forecast data using the netCDF-3 data model.

http://cf-pcmdi.llnl.gov/documents/cf-conventions/1.3/cf-conventions.html

HDF5/NetCDF-4 Interoperability

- NetCDF-4 can interoperate with HDF5 with a SUBSET of HDF5 features.
- Will not work with HDF5 files that have looping groups, references, and types not found in netCDF-4.
- HDF5 file must use new dimension scale API to store shared dimension info.
- If a HDF5 follows the Common Data Model, NetCDF-4 can interoperate on the same files.
- HDF5 files created with netCDF-4 look like normal HDF5 files, and use dimension scales.

Tools for NetCDF: ncdump and ncgen

- These two tools come with the netCDF distribution, and are supported by the netCDF programming team.
- ncdump converts a netCDF data file to human-readable text form.
- ncgen takes the text form (CDL) and creates a netCDF data file.
- Both support netCDF-4 for classic model files, but ncgen does not support enhanced model (but this is under development.)

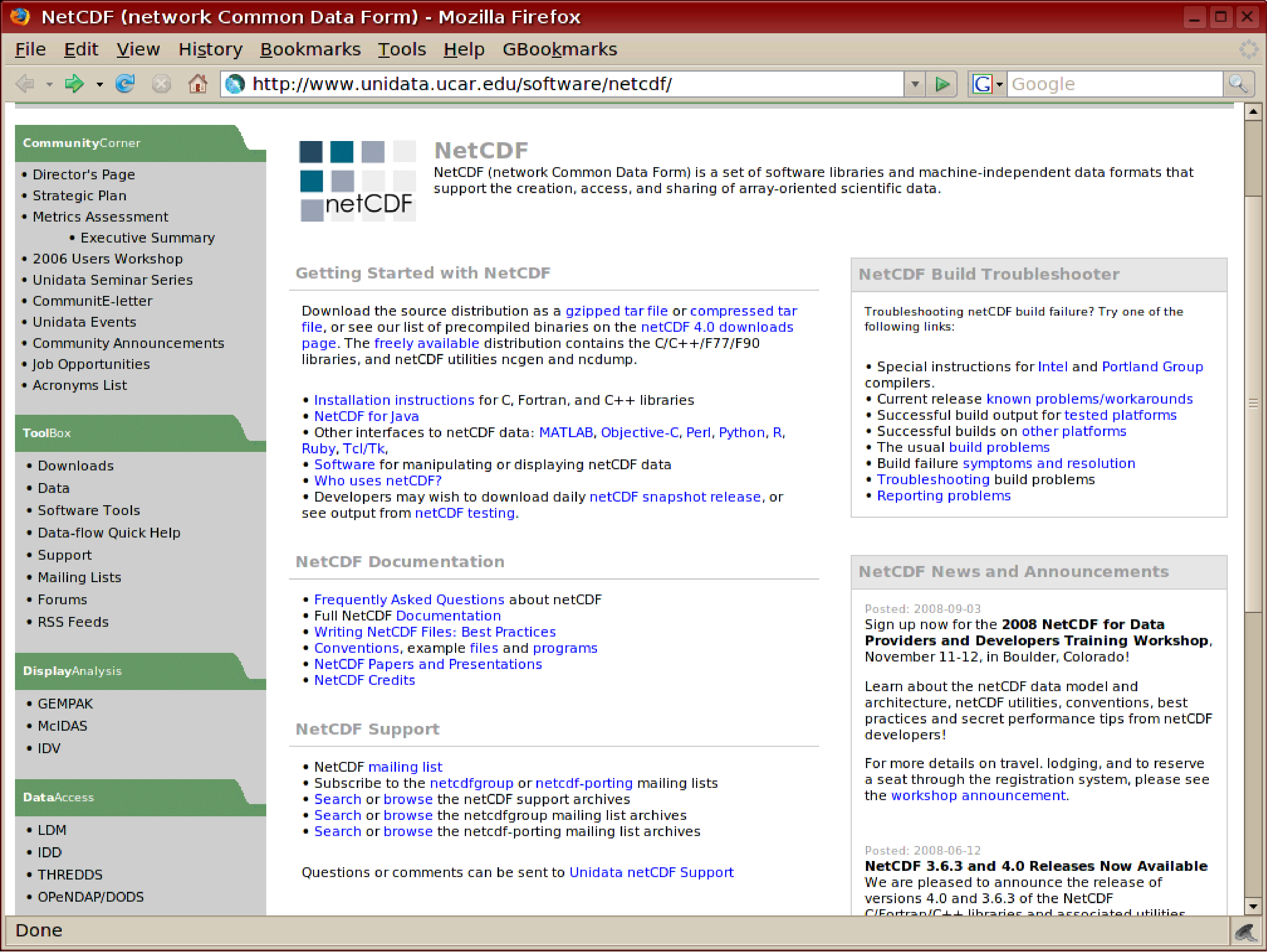
Additional NetCDF Tools

- Many graphics tools support netCDF, including grads, IDV, NCL.
- Command line tools include the NetCDF Command Operators (NCO.)
- Tools can quite easily upgrade to handle netCDF-4/HDF5 classic model files.
- Tools have to be substantially enhanced to handle the enhanced model.
- A partial list of tool can be found on the netCDF web page.

Documentation for NetCDF

Extensive documentation can be found on-line:

- NetCDF Users Guide
- NetCDF Installation and Porting Guide
- NetCDF Tutorial
- API References for Java, C, F77, F90, and CXX
- FAQ
- One or Two Day NetCDF Workshop
- Example programs in C, F77, F90, C++, Java, Python, MATLAB, Perl, IDL
- Example datasets illustrating CF conventions
- Find all documentation on the web


NetCDF (network Common Data Form) - Mozilla Firefox
File Edit View History Bookmarks Tools Help GBookmarks
http://www.unidata.ucar.edu/software/netcdf/
Google
netCDF
Done

CommunityCorner

- Director's Page
- Strategic Plan
- Metrics Assessment
  - Executive Summary
- 2006 Users Workshop
- Unidata Seminar Series
- CommunitE-letter
- Unidata Events
- Community Announcements
- Job Opportunities
- Acronyms List

ToolBox

- Downloads
- Data
- Software Tools
- Data-flow Quick Help
- Support
- Mailing Lists
- Forums
- RSS Feeds

DisplayAnalysis

- GEMPAK
- McIDAS
- IDV

DataAccess

- LDM
- IDD
- THREDDS
- OPeNDAP/DODS

NetCDF

NetCDF (network Common Data Form) is a set of software libraries and machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data.

Getting Started with NetCDF

Download the source distribution as a gzipped tar file or compressed tar file, or see our list of precompiled binaries on the netCDF 4.0 downloads page. The freely available distribution contains the C/C++/F77/F90 libraries, and netCDF utilities ncgen and ncdump.

- Installation instructions for C, Fortran, and C++ libraries
- NetCDF for Java
- Other interfaces to netCDF data: MATLAB, Objective-C, Perl, Python, R, Ruby, Tcl/Tk,
- Software for manipulating or displaying netCDF data
- Who uses netCDF?
- Developers may wish to download daily netCDF snapshot release, or see output from netCDF testing.

NetCDF Documentation

- Frequently Asked Questions about netCDF
- Full NetCDF Documentation
- Writing NetCDF Files: Best Practices
- Conventions, example files and programs
- NetCDF Papers and Presentations
- NetCDF Credits

NetCDF Support

- NetCDF mailing list
- Subscribe to the netcdfgroup or netcdf-porting mailing lists
- Search or browse the netCDF support archives
- Search or browse the netcdfgroup mailing list archives
- Search or browse the netcdf-porting mailing list archives

Questions or comments can be sent to Unidata netCDF Support

NetCDF Build Troubleshooter

Troubleshooting netCDF build failure? Try one of the following links:

- Special instructions for Intel and Portland Group compilers.
- Current release known problems/workarounds
- Successful build output for tested platforms
- Successful builds on other platforms
- The usual build problems
- Build failure symptoms and resolution
- Troubleshooting build problems
- Reporting problems

NetCDF News and Announcements

Posted: 2008-09-03

Sign up now for the **2008 NetCDF for Data Providers and Developers Training Workshop**, November 11-12, in Boulder, Colorado!

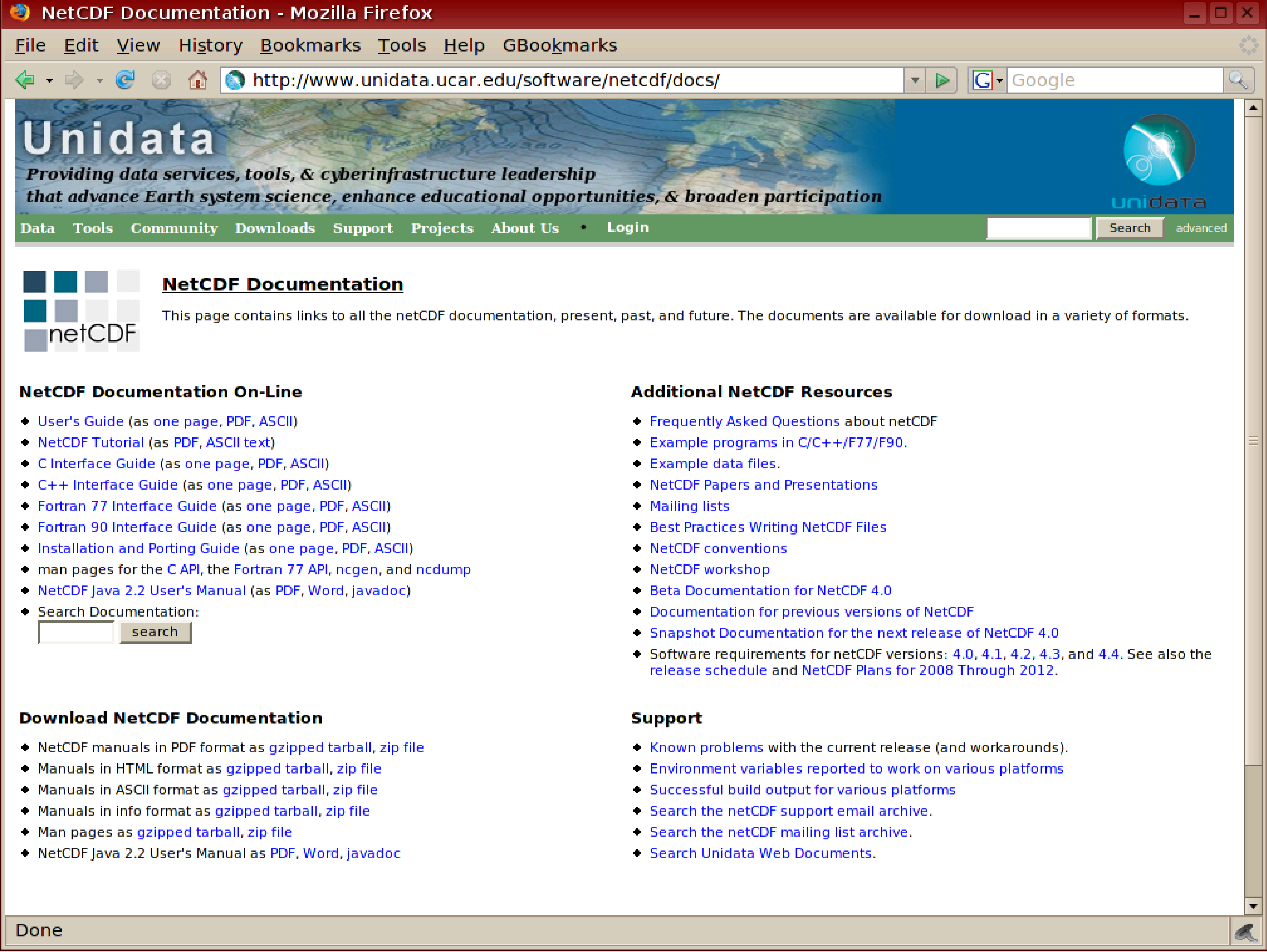
Learn about the netCDF data model and architecture, netCDF utilities, conventions, best practices and secret performance tips from netCDF developers!

For more details on travel. lodging, and to reserve a seat through the registration system, please see the workshop announcement.

Posted: 2008-06-12

NetCDF 3.6.3 and 4.0 Releases Now Available

We are pleased to announce the release of versions 4.0 and 3.6.3 of the NetCDF C/Fortran/C++ libraries and associated utilities


NetCDF Documentation - Mozilla Firefox
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Providing data services, tools, & cyberinfrastructure leadership that advance Earth system science, enhance educational opportunities, & broaden participation

NetCDF Documentation

This page contains links to all the netCDF documentation, present, past, and future. The documents are available for download in a variety of formats.

NetCDF Documentation On-Line

- User's Guide (as one page, PDF, ASCII)
- NetCDF Tutorial (as PDF, ASCII text)
- C Interface Guide (as one page, PDF, ASCII)
- C++ Interface Guide (as one page, PDF, ASCII)
- Fortran 77 Interface Guide (as one page, PDF, ASCII)
- Fortran 90 Interface Guide (as one page, PDF, ASCII)
- Installation and Porting Guide (as one page, PDF, ASCII)
- man pages for the C API, the Fortran 77 API, ncgen, and ncdump
- NetCDF Java 2.2 User's Manual (as PDF, Word, javadoc)
- Search Documentation:

Download NetCDF Documentation

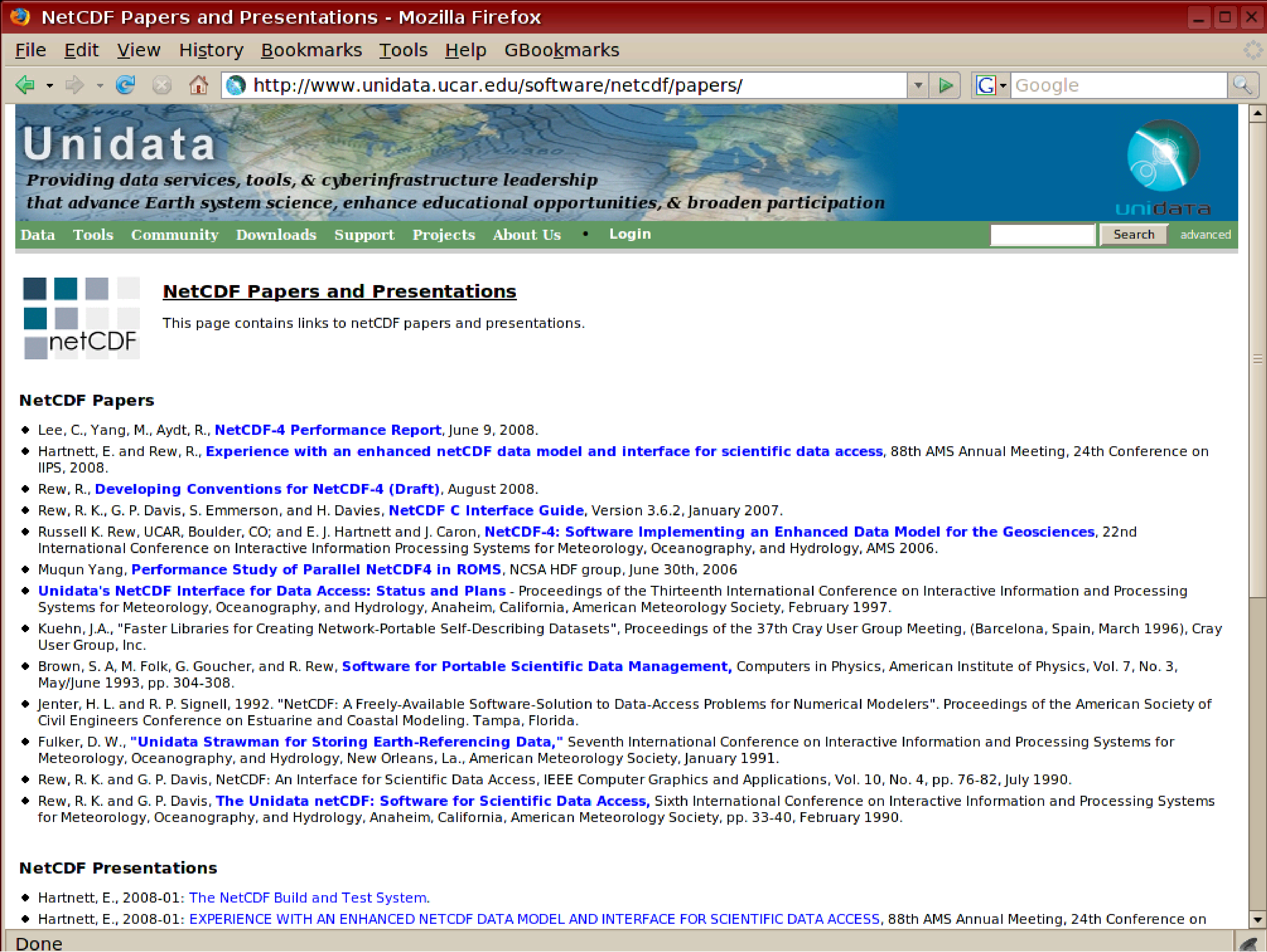
- NetCDF manuals in PDF format as gzipped tarball, zip file
- Manuals in HTML format as gzipped tarball, zip file
- Manuals in ASCII format as gzipped tarball, zip file
- Manuals in info format as gzipped tarball, zip file
- Man pages as gzipped tarball, zip file
- NetCDF Java 2.2 User's Manual as PDF, Word, javadoc

Additional NetCDF Resources

- Frequently Asked Questions about netCDF
- Example programs in C/C++/F77/F90.
- Example data files.
- NetCDF Papers and Presentations
- Mailing lists
- Best Practices Writing NetCDF Files
- NetCDF conventions
- NetCDF workshop
- Beta Documentation for NetCDF 4.0
- Documentation for previous versions of NetCDF
- Snapshot Documentation for the next release of NetCDF 4.0
- Software requirements for netCDF versions: 4.0, 4.1, 4.2, 4.3, and 4.4. See also the release schedule and NetCDF Plans for 2008 Through 2012.

Support

- Known problems with the current release (and workarounds).
- Environment variables reported to work on various platforms
- Successful build output for various platforms
- Search the netCDF support email archive.
- Search the netCDF mailing list archive.
- Search Unidata Web Documents.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http://www.unidata.ucar.edu/software/netcdf/papers/
Google
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Providing data services, tools, & cyberinfrastructure leadership
that advance Earth system science, enhance educational opportunities, & broaden participation
unidata
Data Tools Community Downloads Support Projects About Us • Login
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NetCDF Papers and Presentations

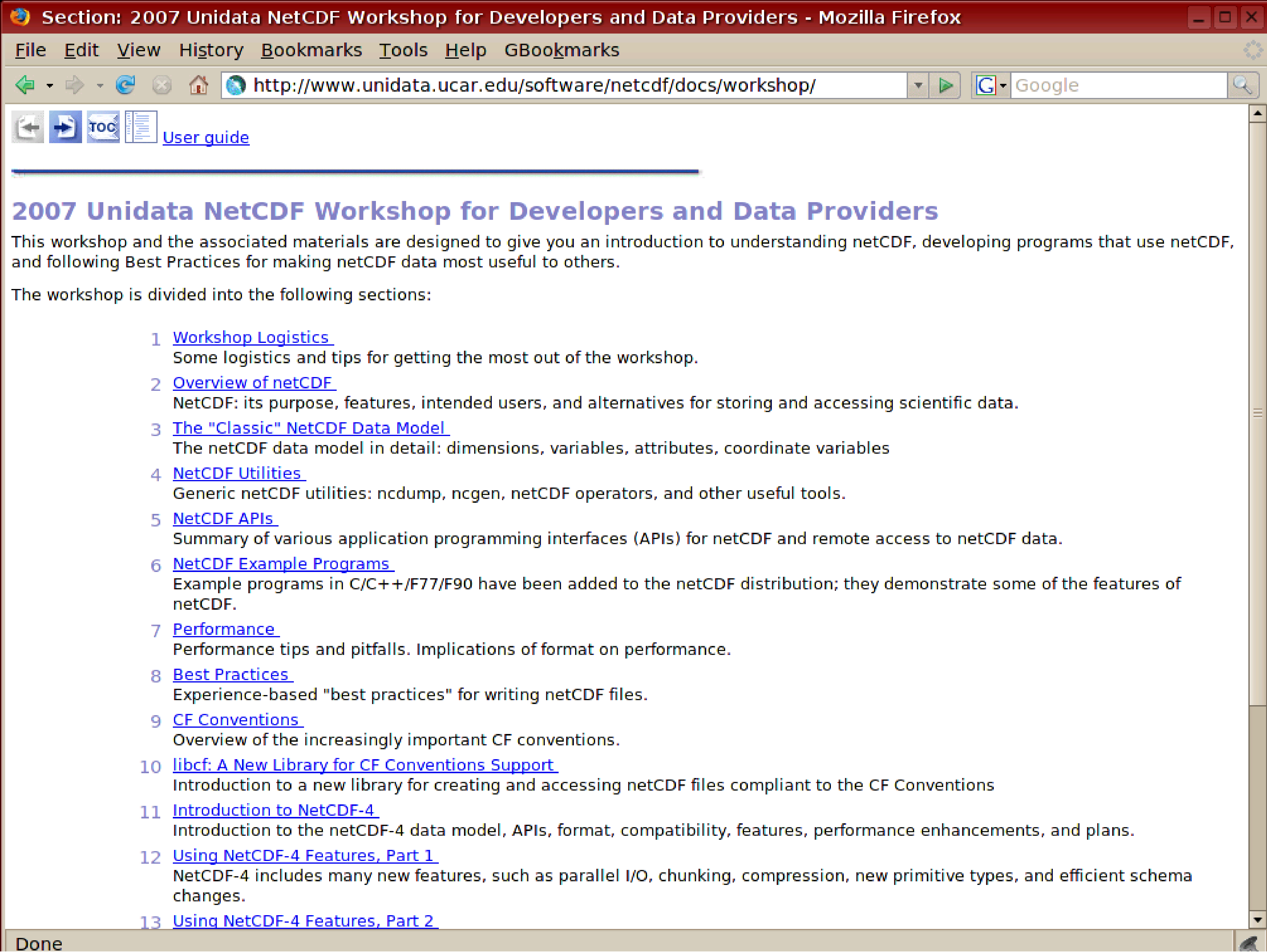
This page contains links to netCDF papers and presentations.

NetCDF Papers

- Lee, C., Yang, M., Aydt, R., **NetCDF-4 Performance Report**, June 9, 2008.
- Hartnett, E. and Rew, R., **Experience with an enhanced netCDF data model and interface for scientific data access**, 88th AMS Annual Meeting, 24th Conference on IIPS, 2008.
- Rew, R., **Developing Conventions for NetCDF-4 (Draft)**, August 2008.
- Rew, R. K., G. P. Davis, S. Emmerson, and H. Davies, **NetCDF C Interface Guide**, Version 3.6.2, January 2007.
- Russell K. Rew, UCAR, Boulder, CO; and E. J. Hartnett and J. Caron, **NetCDF-4: Software Implementing an Enhanced Data Model for the Geosciences**, 22nd International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology, AMS 2006.
- Muqun Yang, **Performance Study of Parallel NetCDF4 in ROMS**, NCSA HDF group, June 30th, 2006
- **Unidata's NetCDF Interface for Data Access: Status and Plans** - Proceedings of the Thirteenth International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, Anaheim, California, American Meteorology Society, February 1997.
- Kuehn, J.A., "Faster Libraries for Creating Network-Portable Self-Describing Datasets", Proceedings of the 37th Cray User Group Meeting, (Barcelona, Spain, March 1996), Cray User Group, Inc.
- Brown, S. A, M. Folk, G. Goucher, and R. Rew, **Software for Portable Scientific Data Management,** Computers in Physics, American Institute of Physics, Vol. 7, No. 3, May/June 1993, pp. 304-308.
- Jenter, H. L. and R. P. Signell, 1992. "NetCDF: A Freely-Available Software-Solution to Data-Access Problems for Numerical Modelers". Proceedings of the American Society of Civil Engineers Conference on Estuarine and Coastal Modeling. Tampa, Florida.
- Fulker, D. W., **"Unidata Strawman for Storing Earth-Referencing Data,"** Seventh International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, New Orleans, La., American Meteorology Society, January 1991.
- Rew, R. K. and G. P. Davis, NetCDF: An Interface for Scientific Data Access, IEEE Computer Graphics and Applications, Vol. 10, No. 4, pp. 76-82, July 1990.
- Rew, R. K. and G. P. Davis, **The Unidata netCDF: Software for Scientific Data Access,** Sixth International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, Anaheim, California, American Meteorology Society, pp. 33-40, February 1990.

NetCDF Presentations

- Hartnett, E., 2008-01: The NetCDF Build and Test System.
- Hartnett, E., 2008-01: EXPERIENCE WITH AN ENHANCED NETCDF DATA MODEL AND INTERFACE FOR SCIENTIFIC DATA ACCESS, 88th AMS Annual Meeting, 24th Conference on


Section: 2007 Unidata NetCDF Workshop for Developers and Data Providers - Mozilla Firefox
File Edit View History Bookmarks Tools Help GBookmarks
http://www.unidata.ucar.edu/software/netcdf/docs/workshop/
Google
TOC
User guide
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2007 Unidata NetCDF Workshop for Developers and Data Providers

This workshop and the associated materials are designed to give you an introduction to understanding netCDF, developing programs that use netCDF, and following Best Practices for making netCDF data most useful to others.

The workshop is divided into the following sections:

1. Workshop Logistics
   Some logistics and tips for getting the most out of the workshop.
2. Overview of netCDF
   NetCDF: its purpose, features, intended users, and alternatives for storing and accessing scientific data.
3. The "Classic" NetCDF Data Model
   The netCDF data model in detail: dimensions, variables, attributes, coordinate variables
4. NetCDF Utilities
   Generic netCDF utilities: ncdump, ncgen, netCDF operators, and other useful tools.
5. NetCDF APIs
   Summary of various application programming interfaces (APIs) for netCDF and remote access to netCDF data.
6. NetCDF Example Programs
   Example programs in C/C++/F77/F90 have been added to the netCDF distribution; they demonstrate some of the features of netCDF.
7. Performance
   Performance tips and pitfalls. Implications of format on performance.
8. Best Practices
   Experience-based "best practices" for writing netCDF files.
9. CF Conventions
   Overview of the increasingly important CF conventions.
10. libcf: A New Library for CF Conventions Support
    Introduction to a new library for creating and accessing netCDF files compliant to the CF Conventions
11. Introduction to NetCDF-4
    Introduction to the netCDF-4 data model, APIs, format, compatibility, features, performance enhancements, and plans.
12. Using NetCDF-4 Features, Part 1
    NetCDF-4 includes many new features, such as parallel I/O, chunking, compression, new primitive types, and efficient schema changes.
13. Using NetCDF-4 Features, Part 2

Support for NetCDF

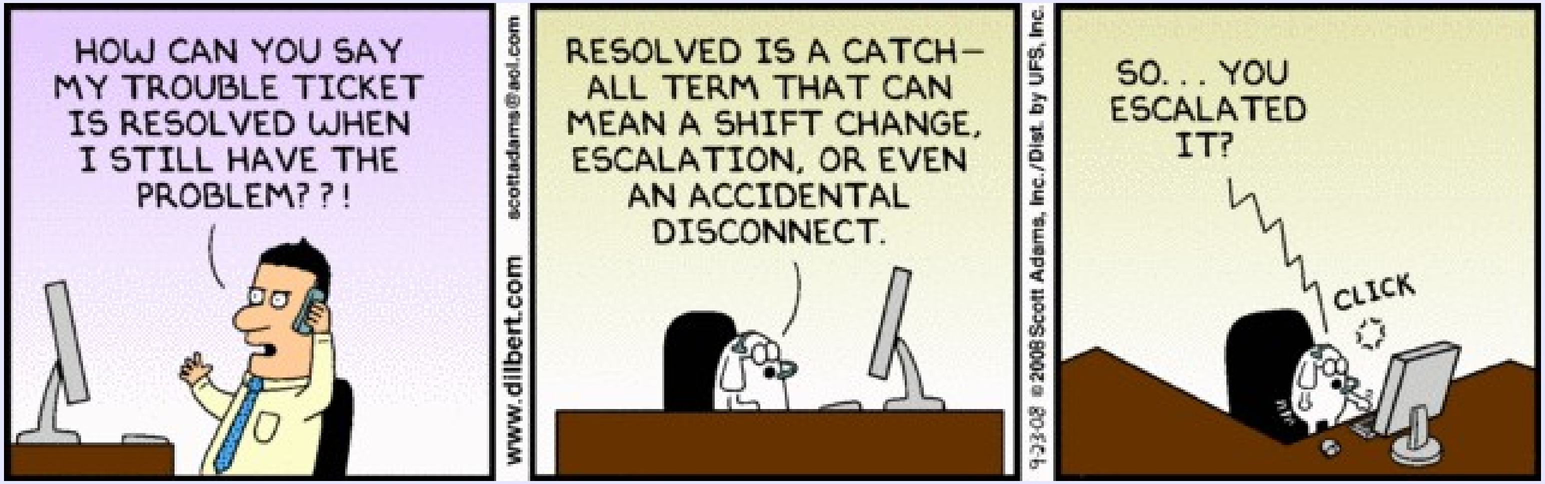
- There is no dedicated support team for netCDF. All netCDF support is handled by netCDF programmers.
- There are many support resources on-line, including a database of all support questions and responses.
- Most support questions are related to building netCDF. Before sending a support request, see the “Build Troubleshooter” section of the home page.

Email Support

Send bug reports and support requests to:
support-netcdf@unidata.ucar.edu

Your support email will enter a support tracking system which will ensure that it does not get lost.

But it may take us a while to solve your problem...


HOW CAN YOU SAY MY TROUBLE TICKET IS RESOLVED WHEN I STILL HAVE THE PROBLEM??!
scottadams@aol.com
www.dilbert.com
RESOLVED IS A CATCH-ALL TERM THAT CAN MEAN A SHIFT CHANGE, ESCALATION, OR EVEN AN ACCIDENTAL DISCONNECT.
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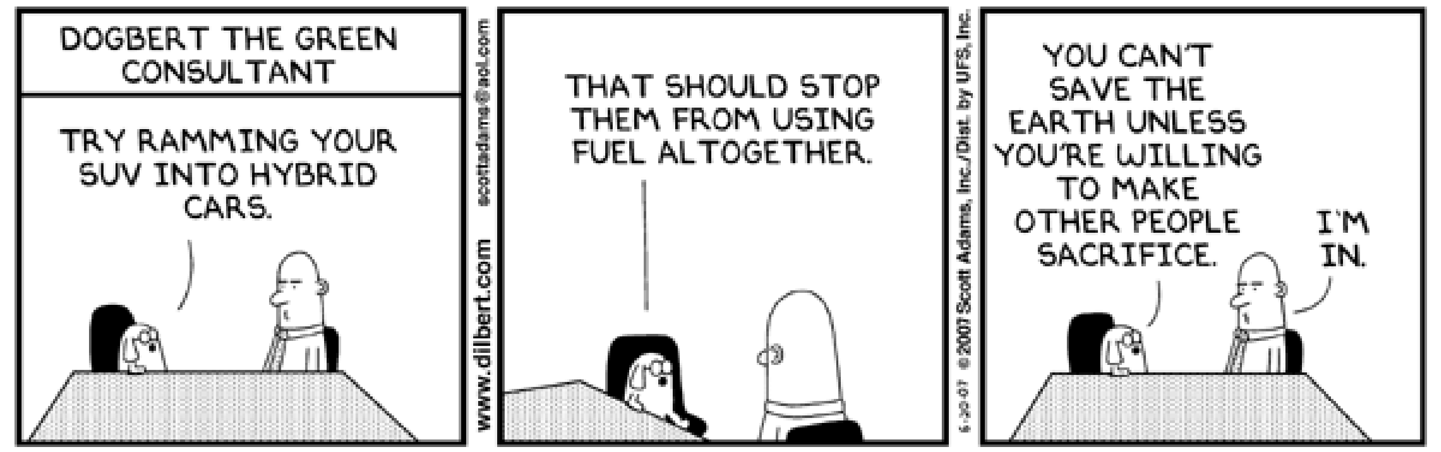
SO... YOU ESCALATED IT?
CLICK

Questions So Far?


DOGBERT THE GREEN CONSULTANT
TRY RAMMING YOUR SUV INTO HYBRID CARS.
scottadams@aol.com
www.dilbert.com
THAT SHOULD STOP THEM FROM USING FUEL ALTOGETHER.
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YOU CAN'T SAVE THE EARTH UNLESS YOU'RE WILLING TO MAKE OTHER PEOPLE SACRIFICE.
I'M IN.

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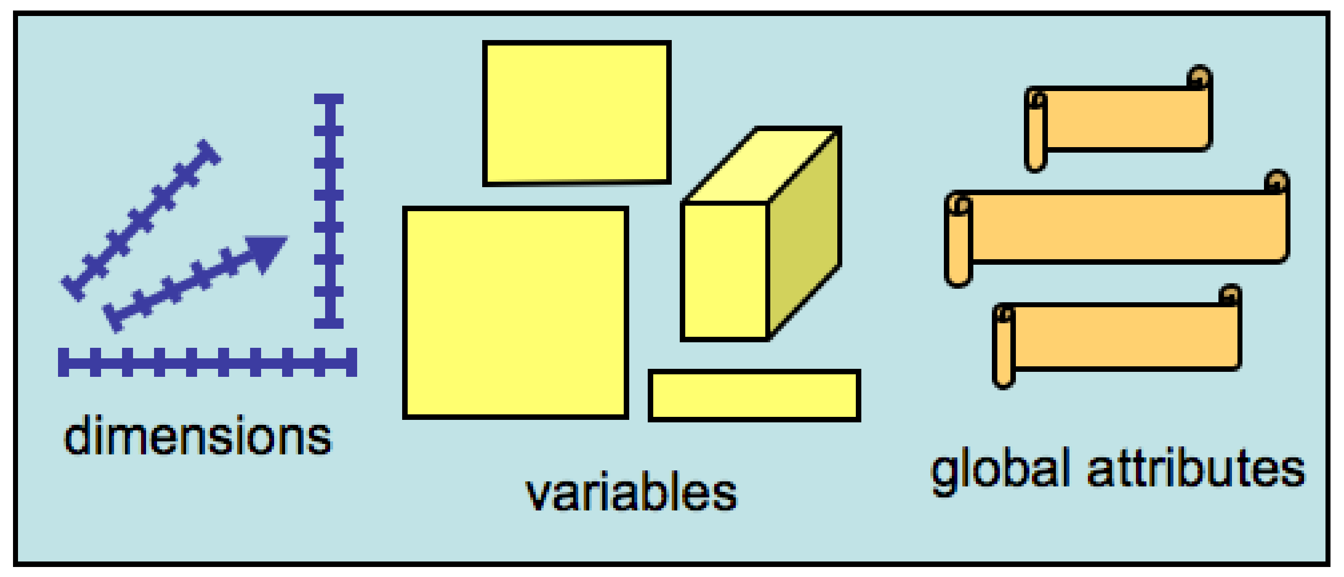
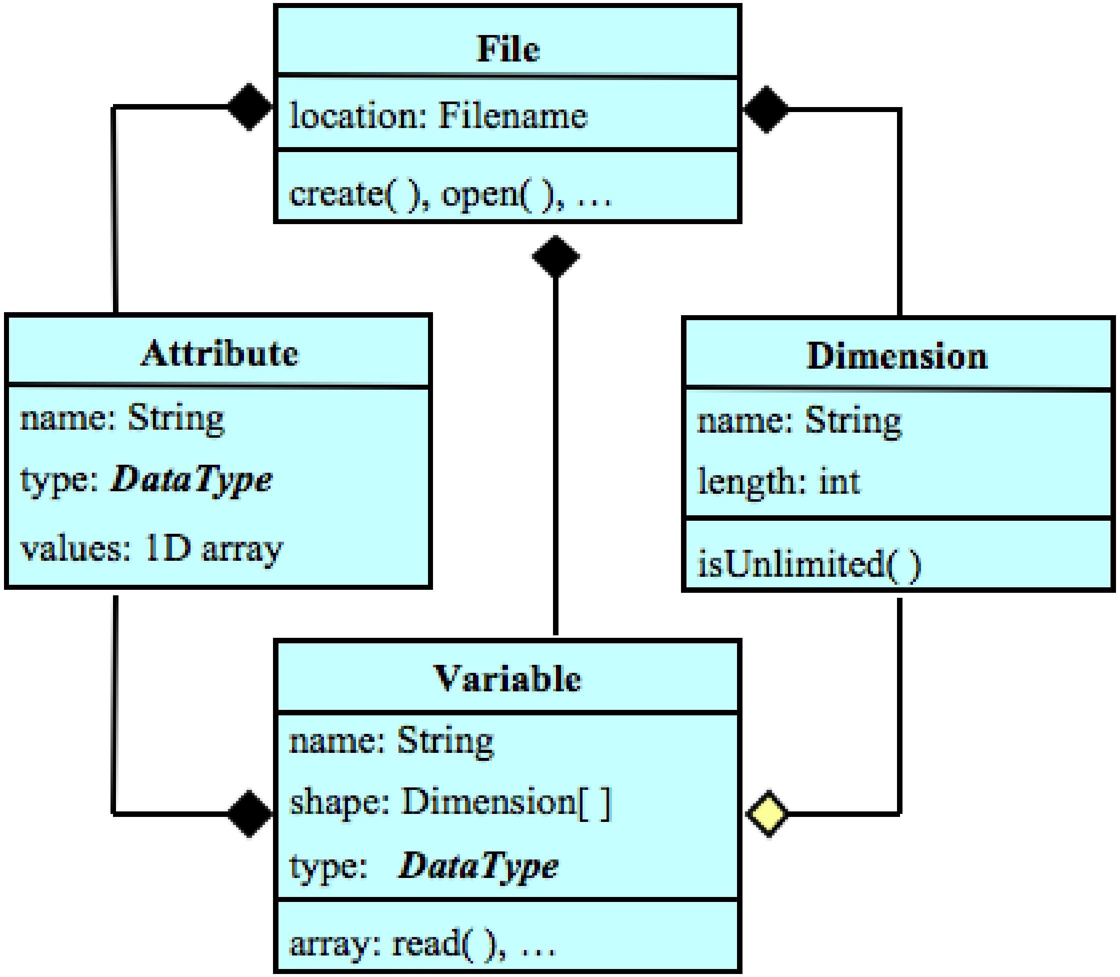
NetCDF Data Models

- The Classic Data Model
  - UML and Text Descriptions
  - Introducing the Common Data Language (CDL)
  - Dimensions
  - Variables
    - Coordinate Variables
  - Attributes
- NetCDF-4 Features That Don't Use Enhanced Model
- The Enhanced Data Model
  - UML and Text Descriptions
  - HDF5 Features Now Available in NetCDF

The Classic NetCDF Data Model



UML Classic NetCDF Data Model



File

location: Filename

create( ), open( ), …

Attribute

name: String

type: ***DataType***

values: 1D array

Dimension

name: String

length: int

isUnlimited( )

Variable

name: String

shape: Dimension[ ]

type: ***DataType***

array: read( ), …

Variables and attributes have one of six primitive data types.

DataType

char

byte

short

int

float

double

A file has named variables, dimensions, and attributes. Variables also have attributes. Variables may share dimensions, indicating a common grid. One dimension may be of unlimited length.

Common Data Language of Simple Classic Model File

```
netcdf example {   // example of CDL notation
  dimensions:
    x = 3 ;
    y = 8 ;
  variables:
    float rh(x, y) ;
         rh:units = "percent" ;
         rh:long_name = "relative humidity" ;
  // global attributes
    :title = "simple example, lacks some conventions" ;
  data:
   rh =
    2, 3, 5, 7, 11, 13, 17, 19,
    23, 29, 31, 37, 41, 43, 47, 53,
    59, 61, 67, 71, 73, 79, 83, 89 ;
  }
```

CDL Details

- This example has only one variable, but multiple variables of may be included in a netCDF file.
- You can use the ncdump utility to get the CDL form of a binary netCDF file (more on this later).
- You can use the ncgen utility to generate a binary netCDF file from CDL (more on this later).
- This simple example neglects recommended best practices for netCDF data.
- NcML is an XML-based notation similar to CDL for netCDF data

Dimensions

- Dimensions may be shared among variables, indicating a common grid.
- Dimensions may be associated with coordinate variables to identify coordinate axes.
- In the classic netCDF data model, at most one dimension can have the unlimited length, which means variables can grow along that dimension.
- In the enhanced data model, multiple dimensions can have the unlimited length.

Variables in the Classic Model

- In the classic data model, the type of a variable is the external type of its data as represented on disk, one of: char, byte, short, int, float, double.
- The shape of a non-scalar variable is specified with a list of dimensions.
- A variable may have attributes to specify properties such as units.
- A variable is equivalent to a HDF5 dataset.

A Strong Convention: Coordinate Variables

- A variable with the same name as a dimension is called a coordinate variable.
- Examples: lat, lon, level, and time.
- The notion of coordinate variables has been generalized to multidimensional coordinate axes in the netCDF Java library and the Common Data Model it supports.
- Closest HDF5 equivalent: dimension scales.

Coordinate Variable CDL Example

```
netcdf elev1 {
dimensions:
  lat = 180 ;
  lon = 360 ;
variables:
  float lat(lat) ;
      lat:standard_name = "latitude" ;
      lat:units = "degrees_north" ;
  float lon(lon) ;
      lon:standard_name = "longitude" ;
      lon:units = "degrees_east" ;
  short elev(lat, lon) ;
      elev:standard_name = "height" ;
      elev:missing_value = 32767s ;
      elev:units = "meter" ;
```

Attributes in the Classic Model

- Like variables, the type of an attribute may be one of char, byte, short, int, float, or double.
- Attributes are scalar or 1D.
- Global attributes apply to a whole file. Variable attributes apply to a specific variable.
- NetCDF conventions are defined primarily in terms of attributes.
- Attributes cannot have attributes.

More Realistic Example

```
netcdf co2 {
dimensions:
  T = 456 ;
variables:
  float T(T) ;
      T:units = "months since 1960-01-01" ;
  float co2(T) ;
      co2:long_name = "CO2 concentration by volume" ;
      co2:units = "1.0e-6" ;
      co2:_FillValue = -99.99f ;

// global attributes:
      :references = "Keeling_etal1996 Keeling_etal1989
  Keeling_etal1995" ;
```

Advantages of the Classic Model

- Files that follow the classic model will be compatible with existing netCDF software.
- Classic model is simple but powerful.
- We advise that you use the classic model wherever possible, for maximum interoperability.

Not All NetCDF-4 Features Require the Enhanced Model!

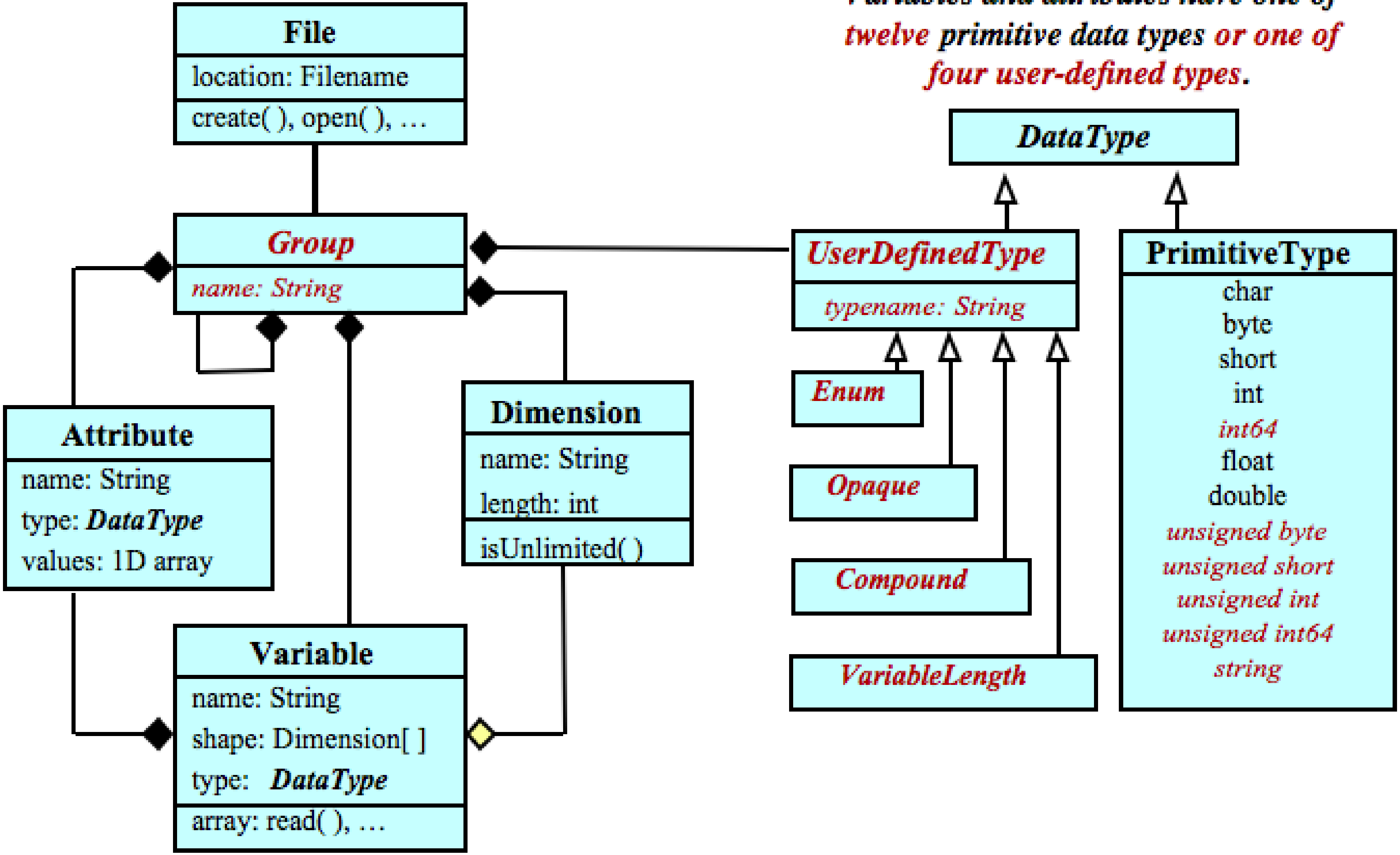
Many features of the HDF5 layer can be used without using the enhanced data model:

- parallel I/O
- zlib compression/decompression
- endianness control
- chunking
- expanded size limits

NetCDF-4 Enhanced Model

- The classic model is expanded to include groups, new types (including user-defined types), multiple unlimited dimensions.
- Using the enhanced model requires rewriting the reading programs.

Variables and attributes have one of twelve primitive data types or one of four user-defined types.



File

location: Filename

create( ), open( ), …

Group

name: String

Attribute

name: String

type: ***DataType***

values: 1D array

Dimension

name: String

length: int

isUnlimited( )

Variable

name: String

shape: Dimension[ ]

type: ***DataType***

array: read( ), …

DataType

UserDefinedType

typename: String

Enum

Opaque

Compound

VariableLength

PrimitiveType

char

byte

short

int

int64

float

double

unsigned byte

unsigned short

unsigned int

unsigned int64

string

A file has a top-level unnamed group. Each group may contain one or more named subgroups, user-defined types, variables, dimensions, and attributes. Variables also have attributes. Variables may share dimensions, indicating a common grid. One or more dimensions may be of unlimited length.

NetCDF-4 Features from HDF5

- The enhanced netCDF-4 data model includes new types:
  - String type
  - Unsigned ints and 64-bit ints
  - Compound type
  - VLEN type
  - Enum type
  - Opaque type

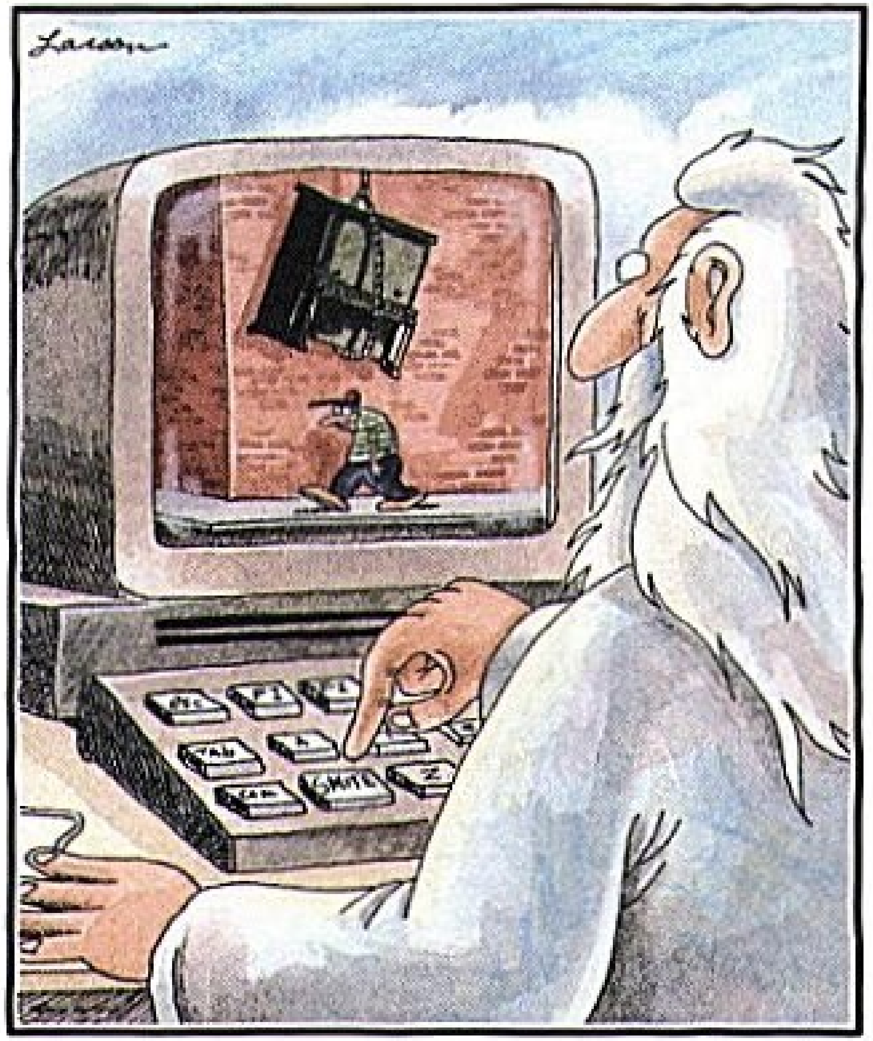
More NetCDF-4 Enhanced Model Features

- Multiple unlimited dimensions are allowed (and in any order.)
- Groups are supported.
- Dimensions are visible to any sub-groups.

No enddefs and redefs Needed

- In classic netCDF model, enddef is needed to end define mode, redef to re-enter define mode.
- With netCDF-4 files, this is not necessary. These functions will be called automatically, as needed.
- If you use the NC_CLASSIC_MODEL flag when creating the file, you must explicitly call enddef and redef.

Questions About Data Models?



God at His computer

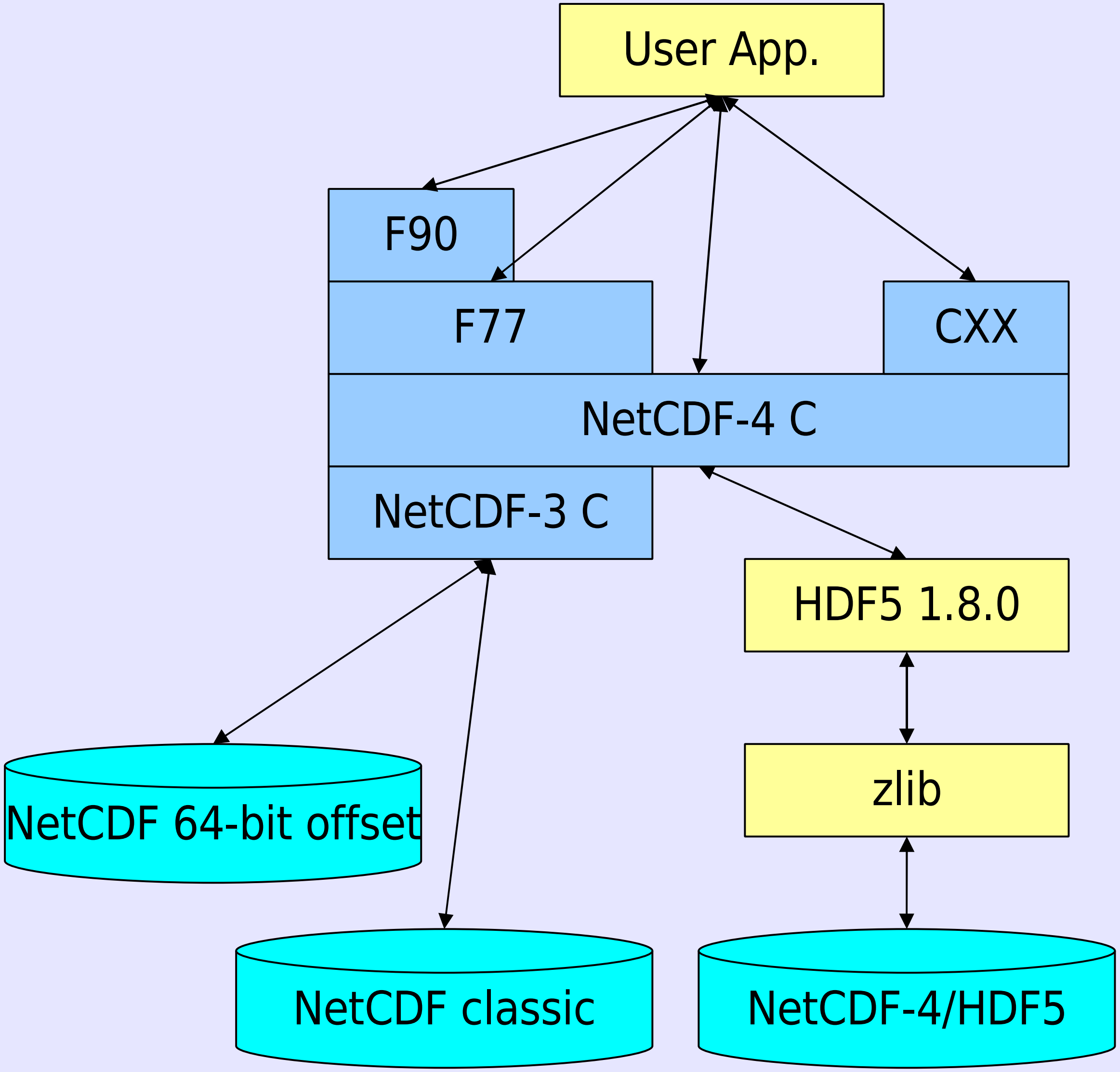
NetCDF Software Libraries

- The NetCDF APIs.
- Architecture of C-based Libraries
- Simple C Example
- Simple Fortran90 example

NetCDF APIs

- The netCDF core library is written in C and Java.
- Fortran 77 is “faked” when netCDF is built – actually C functions are called by Fortran 77 API.
- A C++ API also calls the C API, a new C++ API us under development to support netCDF-4 more fully.

NetCDF C/Fortran/CXX Architecture



C API: Simple Example

```
nc_create(FILE_NAME, NC_CLOBBER, &ncid);
nc_def_dim(ncid, "x", NX, &x_dimid);
nc_def_dim(ncid, "y", NY, &y_dimid);
dimids[0] = x_dimid;
dimids[1] = y_dimid;
nc_def_var(ncid, "data", NC_INT, NDIMS,
           dimids, &varid);
nc_enddef(ncid);
nc_put_var_int(ncid, varid, &data_out[0][0]);
nc_close(ncid);
```

F90 API: Simple Example

```
call check( nf90_create(FILE_NAME, NF90_CLOBBER,
  ncid) )
call check( nf90_def_dim(ncid, "x", NX, x_dimid) )
call check( nf90_def_dim(ncid, "y", NY, y_dimid) )

dimids =  (/ y_dimid, x_dimid /)

call check( nf90_def_var(ncid, "data", NF90_INT, dimids,
  varid) )

call check( nf90_enddef(ncid) )
call check( nf90_put_var(ncid, varid, data_out) )
call check( nf90_close(ncid) )
```

Parallel I/O Example

```
nc_create_par(FILE, NC_NETCDF4|NC_MPIIO, comm, info, &ncid);

nc_def_dim(ncid, "d1", DIMSIZE, dimids);
nc_def_dim(ncid, "d2", DIMSIZE, &dimids[1]);
nc_def_var(ncid, "v1", NC_INT, NDIMS, dimids, &v1id);

/* Set up slab for this process. */
start[0] = mpi_rank * DIMSIZE/mpi_size;
start[1] = 0;
count[0] = DIMSIZE/mpi_size;
count[1] = DIMSIZE;
nc_var_par_access(ncid, v1id, NC_INDEPENDENT);
nc_put_vara_int(ncid, v1id, start, count,
                          &data[mpi_rank*QTR_DATA]);
```

Compound Type Example

```
nc_create(FILE_NAME, NC_NETCDF4, &ncid);
nc_def_compound(ncid, sizeof(struct sf_med_rec), "SFMedRec",
                &typeid);
nc_insert_compound(ncid, typeid, "num_heads",
                   NC_COMPOUND_OFFSET(struct sf_med_rec,
                   num_heads), NC_UBYTE);

nc_insert_compound(ncid, typeid, "num_hairs",
                   NC_COMPOUND_OFFSET(struct sf_med_rec,
                   num_hairs), NC_UINT64);
nc_def_dim(ncid, STARDATE, DIM_LEN, &dimid);
nc_def_var(ncid, "starbase_13", typeid, 1, dimids, &varid);
nc_put_var(ncid, varid, med_data_out);
nc_close(ncid);
```

Group Example

```
 /* Create a file with one group, a group to contain data about
    Henry VII. */
if (nc_create(FILE_NAME, NC_NETCDF4, &ncid)) ERR;
if (nc_def_grp(ncid, HENRY_VII, &henry_vii_id)) ERR;
if (nc_inq_grp_parent(henry_vii_id, &parent_ncid)) ERR;
if (parent_ncid != ncid) ERR;
if (nc_close(ncid)) ERR;
```

F90 NetCDF-4 Example

```
call check(nf90_create(FILE_NAME, nf90_netcdf4, ncid))
call check(nf90_def_opaque(ncid, OPAQUE_SIZE, &
           OPAQUE_TYPE_NAME, opaque_typeid))
call check(nf90_put_att_any(ncid, NF90_GLOBAL, &
           att_name, opaque_typeid, 1, opaque_data))
call check(nf90_def_var(ncid, var_name, nf90_int64, varid))
call check(nf90_put_var(ncid, varid, BIG_NUMBER))
call check(nf90_close(ncid))
```

C++ and NetCDF-4

- Existing C++ API works with netCDF-4 classic model files.
- The existing API was written before many features of C++ became standard, and thus needed updating.
- A new C++ API has been partially developed by Shanna-Shaye Forbes, a Unidata student employee.
- You can build the new API (which is not complete!) with --enable-cxx4.

Questions About Software Libraries?

TED, I KNOW YOU SAID YOUR HEAD WOULD EXPLODE IF I ASK YOU TO DO ONE MORE THING, BUT...
scottadams@aol.com
www.dilbert.com
POW!
7-18-08
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CLEANUP ON AISLE THREE.

Secrets of NetCDF

- Converting to netCDF-4
- Using Compression
- NetCDF Development Process
- NetCDF Testing
- NetCDF Development Process
- Future Plans

Converting Existing NetCDF Code to NetCDF-4

- NetCDF-4.0 is a drop-in replacement for netCDF-3.x. By default all created files are in classic format.
- To create netcdf4/hdf5 files, change the mode parameter in nc_create() calls.
- Existing write code will work the same way, but a netcdf4/hdf5 file will be produced.
- NetCDF reading software must be upgraded (i.e. relinked) with the netCDF-4.0 release.
- No modifications needed in reading code.

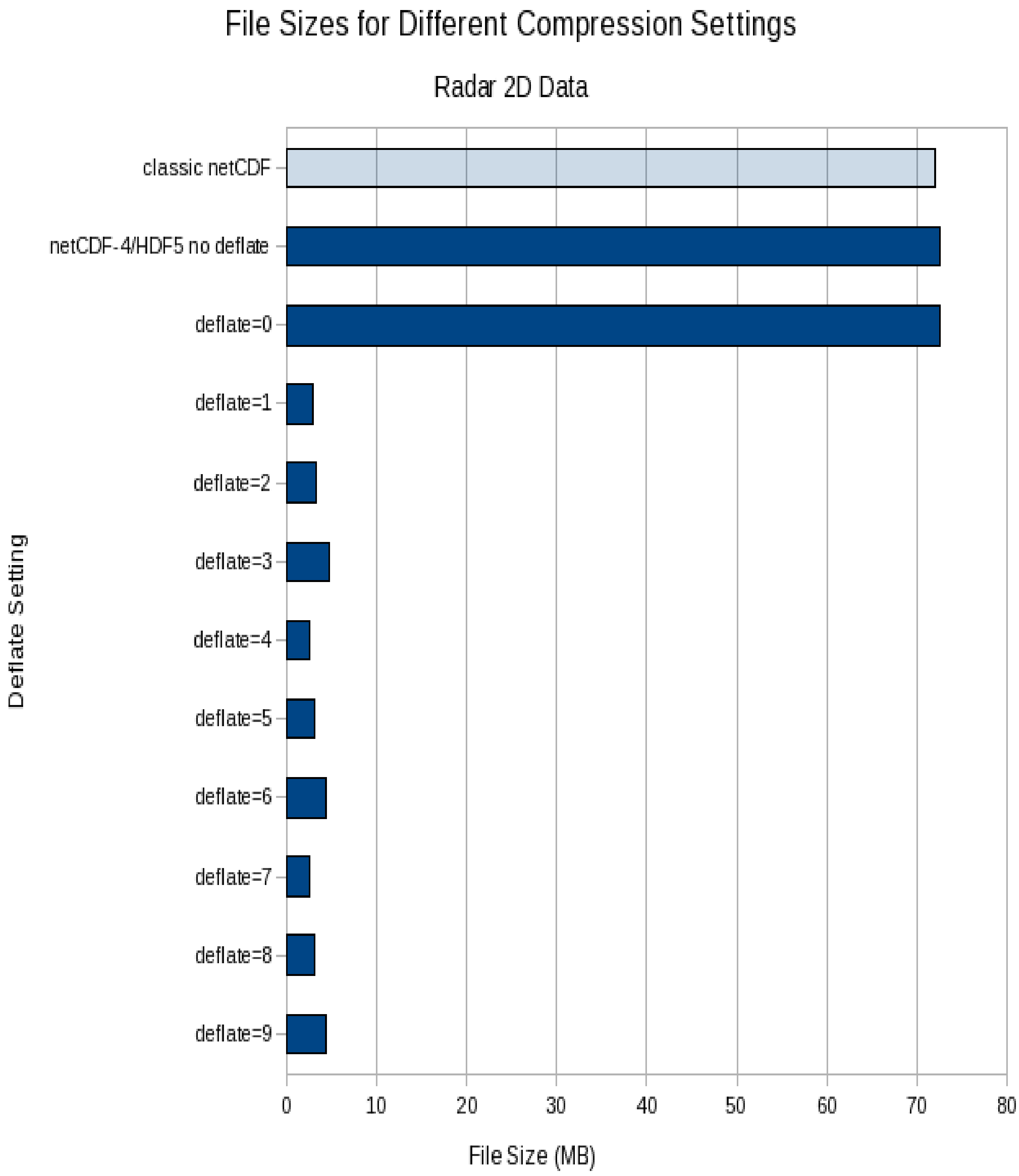
More on Converting to NetCDF-4

- When using the classic model, use the NC_CLASSIC_MODEL flag when creating the file.
- To use enhanced model, but writing and reading software must be modified.
- Some advanced structures are problematic in Fortran. We don't know how to handle compound types in a machine independent way, for example.
- Makefiles must be changed to include:
  -lnetcdf -lhdf5_hl -lhdf5 -lz

Using Compression

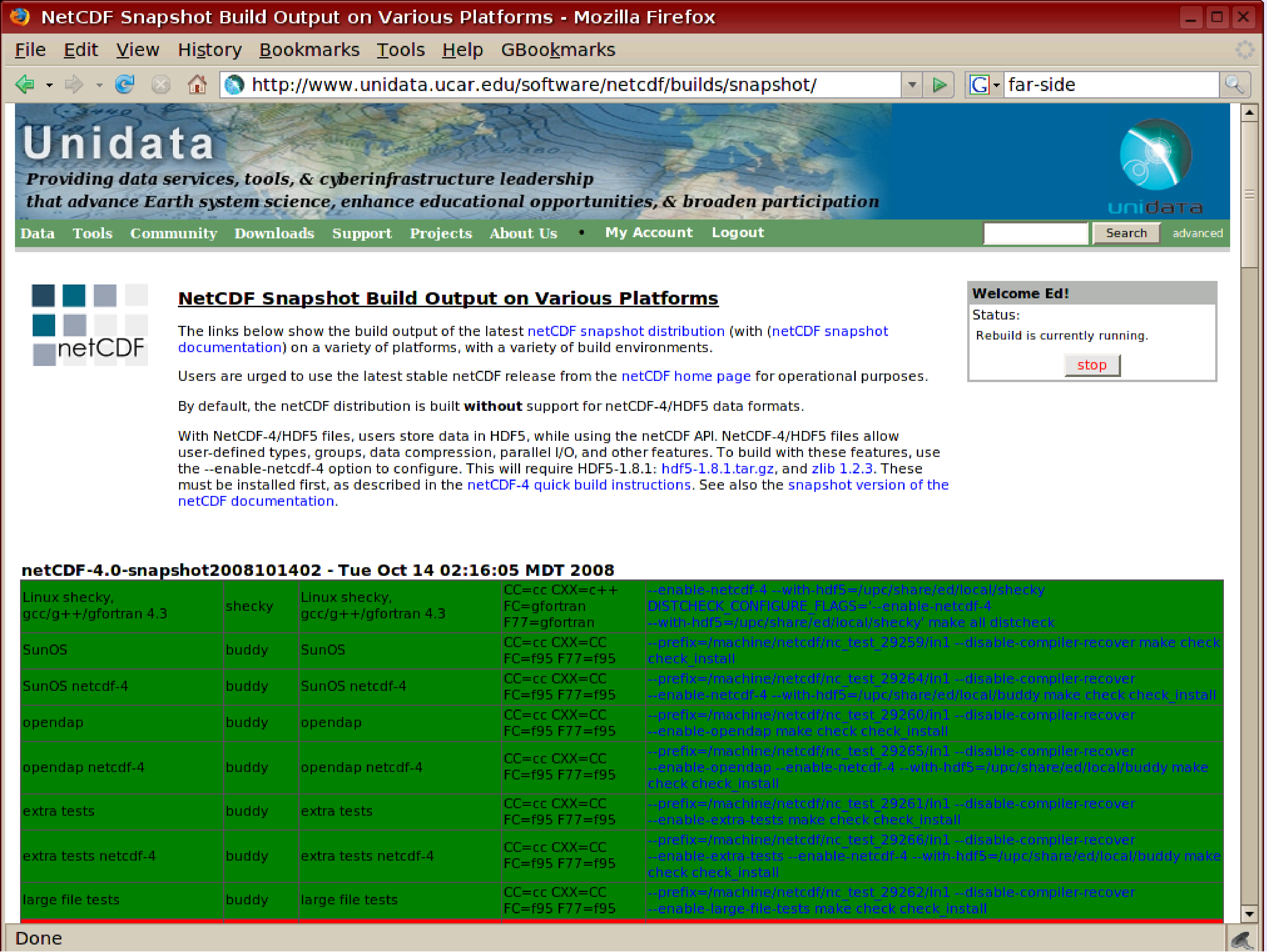
- NetCDF-4 supports zlib deflation.
- szlib data may be read through netCDF-4, but not written. Is there interest in this?
- You can't deflate while writing with parallel I/O.
- Set deflate with the nc_def_var_deflate after the variable is defined, but before the first endef.

Deflate of 2D Radar Data



Testing of C/F77/F90/C++ Libraries

- Cross-platform testing takes place nightly at Unidata.
- The daily snapshot release is a complete netCDF release, version “netcdf-4.0-snapshot2008101402”
- Snapshot passes “make distcheck” on Linux platform before its release.
- Get the daily snapshot for the latest updates to the code and documentation.
- Snapshot documentation us on-line: http://www.unidata.ucar.edu/software/netcdf/docs_snapshot/



NetCDF Snapshot Build Output on Various Platforms - Mozilla Firefox
File Edit View History Bookmarks Tools Help GBookmarks
http://www.unidata.ucar.edu/software/netcdf/builds/snapshot/
far-side
Unidata
Providing data services, tools, & cyberinfrastructure leadership
that advance Earth system science, enhance educational opportunities, & broaden participation
unidata
Data Tools Community Downloads Support Projects About Us • My Account Logout
Search
advanced
netCDF
Done

NetCDF Snapshot Build Output on Various Platforms

Welcome Ed!

Status:

Rebuild is currently running.

stop

The links below show the build output of the latest netCDF snapshot distribution (with (netCDF snapshot documentation) on a variety of platforms, with a variety of build environments.

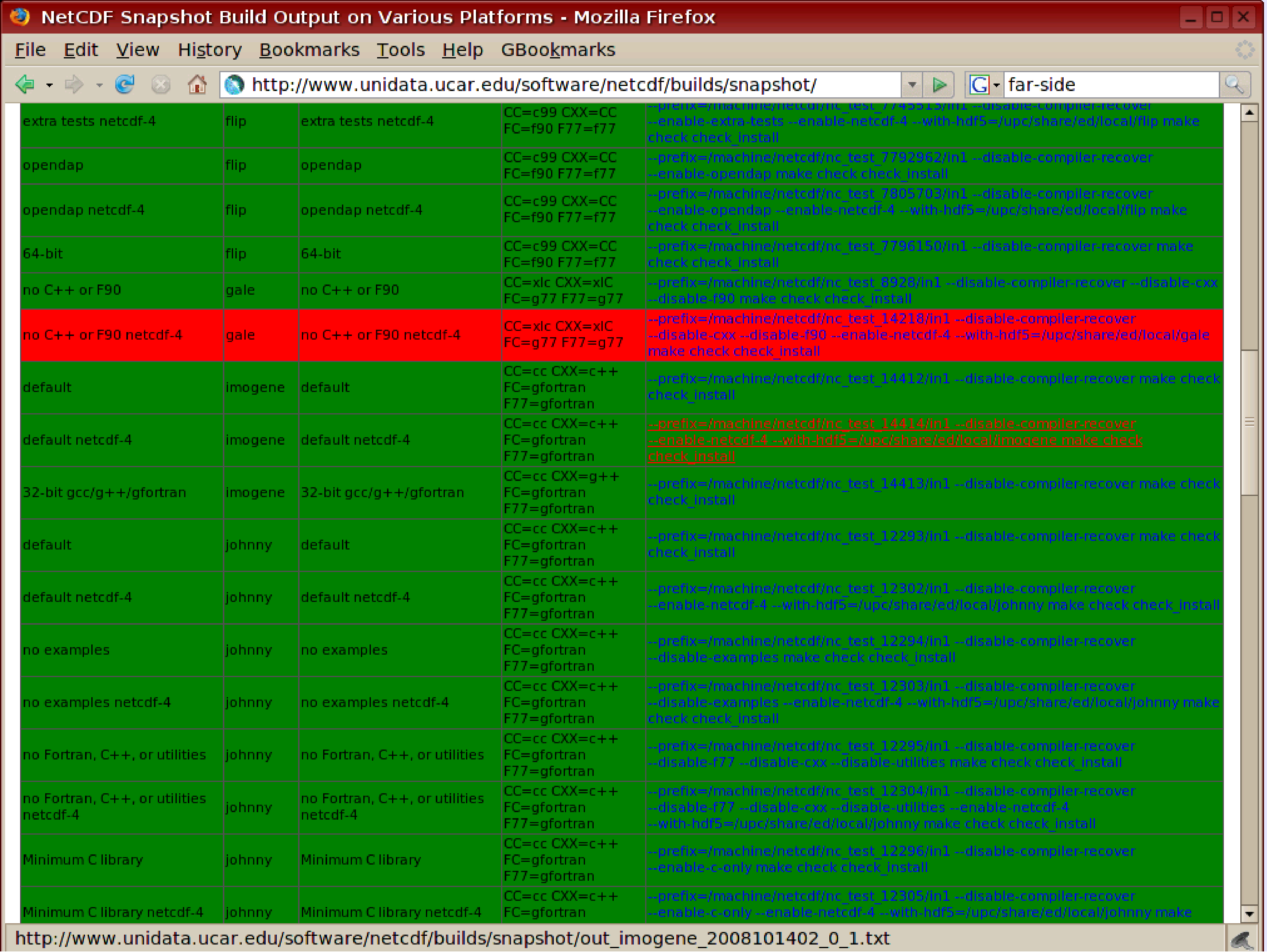
Users are urged to use the latest stable netCDF release from the netCDF home page for operational purposes.

By default, the netCDF distribution is built **without** support for netCDF-4/HDF5 data formats.

With NetCDF-4/HDF5 files, users store data in HDF5, while using the netCDF API. NetCDF-4/HDF5 files allow user-defined types, groups, data compression, parallel I/O, and other features. To build with these features, use the --enable-netcdf-4 option to configure. This will require HDF5-1.8.1: hdf5-1.8.1.tar.gz, and zlib 1.2.3. These must be installed first, as described in the netCDF-4 quick build instructions. See also the snapshot version of the netCDF documentation.

netCDF-4.0-snapshot2008101402 - Tue Oct 14 02:16:05 MDT 2008

Linux shecky, gcc/g++/gfortran 4.3	shecky	Linux shecky, gcc/g++/gfortran 4.3	CC=cc CXX=c++ FC=gfortran F77=gfortran	--enable-netcdf-4 --with-hdf5=/upc/share/ed/local/shecky DISTCHECK_CONFIGURE_FLAGS='--enable-netcdf-4 --with-hdf5=/upc/share/ed/local/shecky' make all distcheck
SunOS	buddy	SunOS	CC=cc CXX=CC FC=f95 F77=f95	--prefix=/machine/netcdf/nc_test_29259/in1 --disable-compiler-recover make check check_install
SunOS netcdf-4	buddy	SunOS netcdf-4	CC=cc CXX=CC FC=f95 F77=f95	--prefix=/machine/netcdf/nc_test_29264/in1 --disable-compiler-recover --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/buddy make check check_install
opendap	buddy	opendap	CC=cc CXX=CC FC=f95 F77=f95	--prefix=/machine/netcdf/nc_test_29260/in1 --disable-compiler-recover --enable-opendap make check check_install
opendap netcdf-4	buddy	opendap netcdf-4	CC=cc CXX=CC FC=f95 F77=f95	--prefix=/machine/netcdf/nc_test_29265/in1 --disable-compiler-recover --enable-opendap --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/buddy make check check_install
extra tests	buddy	extra tests	CC=cc CXX=CC FC=f95 F77=f95	--prefix=/machine/netcdf/nc_test_29261/in1 --disable-compiler-recover --enable-extra-tests make check check_install
extra tests netcdf-4	buddy	extra tests netcdf-4	CC=cc CXX=CC FC=f95 F77=f95	--prefix=/machine/netcdf/nc_test_29266/in1 --disable-compiler-recover --enable-extra-tests --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/buddy make check check_install
large file tests	buddy	large file tests	CC=cc CXX=CC FC=f95 F77=f95	--prefix=/machine/netcdf/nc_test_29262/in1 --disable-compiler-recover --enable-large-file-tests make check check_install



NetCDF Snapshot Build Output on Various Platforms - Mozilla Firefox
File Edit View History Bookmarks Tools Help GBookmarks
http://www.unidata.ucar.edu/software/netcdf/builds/snapshot/
far-side

extra tests netcdf-4	flip	extra tests netcdf-4	CC=c99 CXX=CC FC=f90 F77=f77	--prefix=/machine/netcdf/nc_test_7745513/in1 --disable-compiler-recover --enable-extra-tests --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/flip make check check_install
opendap	flip	opendap	CC=c99 CXX=CC FC=f90 F77=f77	--prefix=/machine/netcdf/nc_test_7792962/in1 --disable-compiler-recover --enable-opendap make check check_install
opendap netcdf-4	flip	opendap netcdf-4	CC=c99 CXX=CC FC=f90 F77=f77	--prefix=/machine/netcdf/nc_test_7805703/in1 --disable-compiler-recover --enable-opendap --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/flip make check check_install
64-bit	flip	64-bit	CC=c99 CXX=CC FC=f90 F77=f77	--prefix=/machine/netcdf/nc_test_7796150/in1 --disable-compiler-recover make check check_install
no C++ or F90	gale	no C++ or F90	CC=xlc CXX=xlC FC=g77 F77=g77	--prefix=/machine/netcdf/nc_test_8928/in1 --disable-compiler-recover --disable-cxx --disable-f90 make check check_install
no C++ or F90 netcdf-4	gale	no C++ or F90 netcdf-4	CC=xlc CXX=xlC FC=g77 F77=g77	--prefix=/machine/netcdf/nc_test_14218/in1 --disable-compiler-recover --disable-cxx --disable-f90 --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/gale make check check_install
default	imogene	default	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_14412/in1 --disable-compiler-recover make check check_install
default netcdf-4	imogene	default netcdf-4	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_14414/in1 --disable-compiler-recover --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/imogene make check check_install
32-bit gcc/g++/gfortran	imogene	32-bit gcc/g++/gfortran	CC=cc CXX=g++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_14413/in1 --disable-compiler-recover make check check_install
default	johnny	default	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_12293/in1 --disable-compiler-recover make check check_install
default netcdf-4	johnny	default netcdf-4	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_12302/in1 --disable-compiler-recover --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/johnny make check check_install
no examples	johnny	no examples	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_12294/in1 --disable-compiler-recover --disable-examples make check check_install
no examples netcdf-4	johnny	no examples netcdf-4	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_12303/in1 --disable-compiler-recover --disable-examples --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/johnny make check check_install
no Fortran, C++, or utilities	johnny	no Fortran, C++, or utilities	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_12295/in1 --disable-compiler-recover --disable-f77 --disable-cxx --disable-utilities make check check_install
no Fortran, C++, or utilities netcdf-4	johnny	no Fortran, C++, or utilities netcdf-4	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_12304/in1 --disable-compiler-recover --disable-f77 --disable-cxx --disable-utilities --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/johnny make check check_install
Minimum C library	johnny	Minimum C library	CC=cc CXX=c++ FC=gfortran F77=gfortran	--prefix=/machine/netcdf/nc_test_12296/in1 --disable-compiler-recover --enable-c-only make check check_install
Minimum C library netcdf-4	johnny	Minimum C library netcdf-4	CC=cc CXX=c++ FC=gfortran	--prefix=/machine/netcdf/nc_test_12305/in1 --disable-compiler-recover --enable-c-only --enable-netcdf-4 --with-hdf5=/upc/share/ed/local/johnny make

http://www.unidata.ucar.edu/software/netcdf/builds/snapshot/out_imogene_2008101402_0_1.txt

Test Platforms

- Each build includes a full run of the default netCDF tests.
- The automatic testing of the default build includes Linux, AIX, IRIX, Mac, SunOS, Cygwin, HP-UX (netcdf-3 only) and Visual Studio builds.
- Various C compilers are tested: gcc (several versions), Intel, PG, AIX, Sun, HPUX, and IRIX.
- Various Fortran compilers are tested: g95, gfortran (pre and post 4.2), ifort (9.1 and 10.1), PGI, AIX, IRIX, HPUX, and even g77.

More on Testing

- Additional, optional tests are also run on some platforms, including MPI I/O builds, and tests for very large files.
- Full output of configure and make, as well as the config.log, are available from the hyperlink on the test page.
- In case of problems, find your platforms and take a look.

NetCDF C/Fortran/C++ Development Process

- Agile programming, with aggressive refactoring, and heavy reliance on automatic testing.
- Daily snapshot allows bug fixes to be released immediately.
- Our highest priority is fixing bugs so that we do not have a bug-list to maintain and prioritize.

Russ Rew – core netcdf-3, ncdump, ncgen, C++

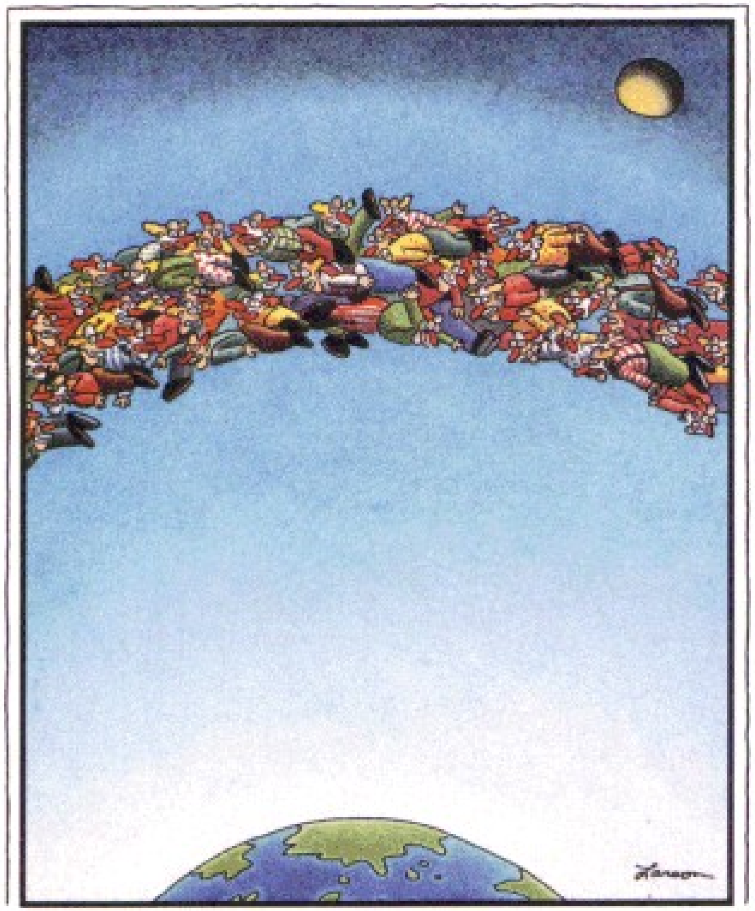
Dennis Heimbigner – OpenDAP client, ncgen enhanced

Ed Hartnett – core netcdf-4, tests, Fortran APIs and tests

Future Plans

- Upcoming C/F77/F90/C++ 4.0.1 maintenance release in beta this month.
- Java JNI to allow writing of netCDF-4 files from Java.
- First quarter 2009: 4.1 release of C libraries including built-in OpenDAP client, ncgen support for netCDF-4 enhanced model.
- NetCDF 4.2 and beyond: development of DAP client to fully support netCDF-4 enhanced model.
- Development of libcf C/Fortran library to assist with CF conventions.

Questions About Using NetCDF-4?



The bozone layer: shielding the rest of the solar system from the Earth's harmful effects.

Contact Information

NetCDF website:
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