IN23B-1079: NetCDF-4 and the Weather Research and Forecasting (WRF) Model

Edward J. Hartnett, Unidata/UCAR
ed@unidata.ucar.edu

Background

- NetCDF-4 is the latest version of the popular netCDF C/Fortran libraries.
- NetCDF-4 is fully backward compatible, with transparent read of all existing netCDF data; it is a drop-in replacement for netCDF-3.x.
- Existing code can be used with netCDF-4 without modification, for results identical to use of the 3.x libraries. But with some code modifications, additional features of netCDF-4 can be used.
- The available features include use of HDF5 as a storage layer, increased sized variables and files, compression, parallel I/O, user defined types, and more.
- The WRF model is undergoing conversion to *optionally* use netCDF-4 now. In this poster it will be used as an example of conversion of existing code to netCDF-4.
- Users are advised to convert to netCDF-4 only when needed.
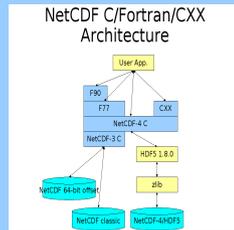
The architecture of the netCDF C/Fortran/C++ libraries.

Getting and Using NetCDF-4

- Get the netCDF-4 release from the netCDF home page: www.unidata.ucar.edu/software/netcdf
- Unpack the tarball and build with configure and make, as with most Unix distributions.
- If the –enable-netcdf-4 option is not used with configure, the netCDF distribution will build without netCDF-4 features. This builds the 3.6.x library, without requiring HDF5 or zlib.
- If –enable-netcdf-4 is used with configure, HDF5-1.8.2 and zlib-1.2.3 are required, and must be installed first.
- Windows need to build the DLL from source code in Visual Studio, or get the pre-built binaries from the netCDF web site.
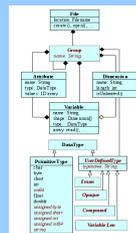
The netCDF data model, with the classic data model in black, and the netCDF-4 enhancements in red.

Converting the WRF to NetCDF-4

- The WRF team decided to allow users to optionally use netCDF-4/HDF5 output format. The code below (from WRFV3/external/io_netcdf/wrf_io.F90 shows one way to convert the output of WRF to netCDF-4. (Code by Dave Gill.)

```
#ifdef WRFIO_NCD_V4
  stat = NF_CREATE(FileName,
IOR(IOR(NF_CLOBBER,NF_NETCDF4),NF_CLASSIC_MODEL), DH%NCID)
#else
# ifdef WRFIO_NCD_LARGE_FILE_SUPPORT
  stat = NF_CREATE(FileName, IOR(NF_CLOBBER,NF_64BIT_OFFSET), DH%NCID)
# else
  stat = NF_CREATE(FileName, NF_CLOBBER, DH%NCID)
# endif
#endif
```

Converting Existing C or Fortran Programs to use NetCDF-4

- The WRF team decided to allow users to optionally use netCDF-4/HDF5 output format. This will help users who want to save very large (> 4GB) variables.
- The first step in converting to netCDF-4 is simply to link to the new library. This requires that the following libraries be linked: -lnetcdf -lhdf5_hl -lhdf5 -lz
- To create files in the new format, the nf_create call is changed to include the NF_NETCDF4 and NF_CLASSIC_MODEL flags.
- Now the WRF code will create files in netCDF-4/HDF5 format.
- Any netCDF software will transparently read the netCDF-4/HDF5 files, once it too has been upgraded to netCDF-4, and relinked.

To convert F77 code:
- **Build netCDF-4 with --enable-netcdf-4**
- **Change your create call to include NF_NETCDF4 and NF_CLASSIC_MODEL.**
- **Link with -lnetcdf -lhdf5_hl -lhdf5 -lz**
- **Rerun your app: now netCDF-4/HDF5 files are produced.**

Parallel I/O and NetCDF

- For netCDF classic and 64-bit offset files, files can be read in parallel with the netCDF library.
- To write netCDF classic and 64-bit offset files in parallel, the pnetcdf library from Argonne National Lab and Northwestern University must be used. This requires that code be rewritten in the pnetcdf C or Fortran API. This is currently supported in the WRF model.
- NetCDF-4 supports parallel I/O for netCDF-4/HDF5 format files (not classic and 64-bit offset format files).
- To use parallel I/O, create or open the files with the new create_par and open_par functions. A new module must be written for WRF to support netCDF-4 parallel I/O.
- Metadata operations are collective, data reads and writes are independent.

To convert sequential netCDF code to parallel I/O:
- **Create and open files with nc_create_par() with mode flag NF_NETCDF4| NF_CLASSIC_MODEL.**
- **Metadata creation must be done collectively on all processors.**
- **nc_put_vara_int (and related functions) can be called from any processor.**

Future Plans for NetCDF C/Fortran Libraries

- Upcoming C/F77/F90/C++ 4.0.1 maintenance release in beta now.
- First quarter 2009: 4.1 release of C libraries including built-in OpenDAP enhanced model.
- Development of libcf C/Fortran library to assist with CF client, ncgen support for netCDF-4 enhanced model.
- NetCDF 4.2 and beyond: development of DAP client to fully support netCDF-4 conventions.
- For more information about netCDF, or to obtain the daily snapshot release, visit the netCDF website: www.unidata.ucar.edu/software/netcdf