9.13 GrADS 1.9 and the GrADS-DODS Server

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This paper describes the new features in the latest releases of GrADS (version 1.9) and the GrADS-DODS Server (GDS, version 1.2.7). The new features were implemented to give the user community access to a much larger pool of data. GrADS can read a variety of data formats: GRIB, NetCDF, HDF-SDS, binary (both gridded and station data formatted), and now BUFR, the WMO standard for point data. All of these data formats can be distributed over the internet with the GDS, which makes the varying formats transparent to the users. Using GrADS (or other DODS-enabled tools) as a client, these distributed data sets are easily accessed and intercompared without having to copy large volumes to local disk.

I. GrADS (the client) and the GDS (the server) provide DODS/OPeNDAP access to station data

A significant new feature in GrADS 1.9 is the capability to serve and access station data (a.k.a. in situ or sequence data) over the internet via DODS/OPeNDAP. GrADS has long been one of the few (freely available) tools for the display and analysis of station data (Doty and Kinter, 1995). As new conventions for distributed station data are emerging, GrADS is once again at the vanguard.

Any station data file readable by GrADS can now be served on the GDS (Wielgosz et al., 2001) and accessed with GrADS 1.9. No special descriptor file is required for GDS station data sets. Simply use the "open" command followed by the DODS URL. This allows easy intercomparison of station and gridded data sets, local or remote.

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The server-side analysis capability of the GDS also applies to expressions involving station data. Complex or even simple analysis expressions may be performed at the server and the result (which is usually a much smaller data set than the data components that were required to generate it) is served as a GDS data set and may be used for further analysis.

GrADS 1.9 also has an option to write out a station data subset to local disk (using the 'set gxout fwrite command') so that users may save a small portion of a larger station data set that is of interest.

GrADS 1.9 is also client for a prototype EPIC DODS server. Accessing station data from other varieties of DODS servers will likely require a simple descriptor file that provides the names for the coordinate variables (latitude, longitude, level, and time).

II. A new interface for BUFR station data

To complement and enhance the new station data capabilities of GrADS 1.9, a new interface was added to read data files from NCEP formatted in BUFR (Binary Universal Form for the Representation of Meteorological data). BUFR is the new WMO standard for point data. NCEP uses BUFR format for observational data and forecast model output at station locations.

Every piece of information in a BUFR file is uniquely identified by a trio of integers. For data, the first member of the trio is always zero: 0-x-y. The second and third members of the trio will hereafter be referred to as the x,y pair. The contents of the BUFR file and the x,y pairs that correspond to each data variable may be retrieved using the external GrADS utility *bufrscan*. The GrADS BUFR interface entails writing a special descriptor file that is similar to a GrADS station data descriptor file,

but with a few additional entries which provide the x,y pairs for all data values to be retrieved from the file. Descriptor file entries specifically for BUFR data are as follows:

DTYPE bufr

XVAR x,y
YVAR x,y
ZVAR x,y
STID x,y
These four entries provide the x,y pairs for the world coordinates latitude, longitude, and vertical level, plus the station ID.

TVAR yr x,y mo x,y dy x,y hr x,y mn x,y sc x,y
This entry provides the x,y pairs for all the base time coordinate variables. Each time unit (year, month, day, hour, minute, second) is presented as a 2-letter code followed by the x,y pair that goes with that unit (coordinate variable). The two letter codes are:

yr	year
mo	month
dy	day
hr	hour
mn	minute
sc	second

TOFFVAR has the same syntax as **TVAR**, but represents the x,y pairs for the offset time coordinate variables. The time for any individual station report is the base time plus the offset time. All six (twelve, actually) time units are not required to appear in the TVAR/TOFFVAR records, only those that are in the data file.

If any time coordinate data in units of seconds are present in the BUFR file, they will be converted to minutes – GrADS does not handle seconds in the time dimension.

VARIABLE DECLARATIONS: The *units* fields of the variable declaration contains the x,y pair for that variable. The *varname* entry can be anything, but must meet the criteria for GrADS variable names: less than 15 characters, starting with an alphabetic character, and not containing any upper case letters or non-alpha-numeric characters. The *levs* entry is 0 for surface variables, 1 for z-varying variables.

Here's an Example of a BUFR descriptor file:

```
DSET   adpsfc.20021124200
DTYPE  bufr
UNDEF  –9.99e33
XVAR  6,2
YVAR  5,2
ZVAR  7,2
STID  1,2
TVAR  yr 4,1 mo 4,2 dy 4,3 hr 4,4 mn 4,5
TDEF 24 linear 24nov2002 1hr
VARS 6
spd    0   11,2     Surface Wind Speed
dir    0   11,1     Surface Wind Direction
t      0   12,101   Temperature
dpt    0   12,103   Dew Point Temperature
ps     0   10,4     Surface Pressure
dps    0   10,61    Surface Pressure Change
ENDVARS
```

III. A new GrADS interface for Gridded NetCDF and HDF Scientific Data Sets

GrADS 1.9 has added another interface for NetCDF and HDF Scientific Data Sets. Although NetCDF and HDF-SDS files are self-describing and may be read automatically using the sdfopen/xdfopen commands, this new interface gives users the option to override the file's own metadata by creating a descriptor file for some or all of the variables in the file. This interface may also be used if the metadata in the NetCDF or HDF-SDS file is insufficient or is not COARDS-compliant. This new interface enables GrADS to handle self-describing files in a more general and fully-featured way. Using the new NetCDF/HDF-SDS interface entails writing a GrADS descriptor file similar to those that describe gridded binary data sets, with only a few modifications:

DTYPE: netcdf or hdfsds

UNDEF: The UNDEF entry may also include the name of the attribute that contains the undef value, in case that value is different for individual variables in the file. After data I/O, the missing values in the grid are converted from the individual undef to the file-wide undef (the numerical value in the first argument of the UNDEF record). Then it appears to GrADS that all variables have the same undef, even if they don't in the original data file. For example:

```
UNDEF -9.9e33  _FillValue
```

UNPACK: For non-floating point data variables that need to be unpacked with a scale factor and offset, this is a new entry that contains the names of the required attributes. For example:

```
UNPACK   Scale_Factor   Add_Offset
```

VARIABLE DECLARATIONS: The syntax of the *varname* and *units* fields of the variable declaration may be slightly different.

The *varname* field of the variable declaration may contain the following "aliasing" syntax:

File_Varname=>grads_varname

where *File_Varname* is the name the data variable was given when the NetCDF/HDF-SDS file was originally created, and *grads_varname* must meet the criteria for GrADS variable names: less than 15 characters, starting with an alphabetic character, and not containing any upper case letters or non-alpha-numeric characters. For NetCDF files, the variable name appears in the output from *ncdump*. It is important that *File_Varname* exactly matches the variable name in the data file. *File_Varname* may contain uppercase letters and non-alpha-numeric characters. The classic "non-aliasing" syntax (i.e., when "*File_Varname*=>" is omitted) may be used if *File_Varname* meets the above-mentioned criteria for GrADS variable names.

The *units* fields of the variable declaration also has a different syntax: it is a comma-delimited list of the varying dimensions of the variable. Dimensions expressed as x, y, z, or t correspond to the four axes defined by XDEF, YDEF, ZDEF and TDEF. The order of the dimensions listed in the *units* field does matter. They must describe the shape of the variable as it was written to the data file. For NetCDF files, this information appears in the output from *ncdump* next to the variable name.

For example, a surface variable such as sea level pressure might look like this:

```
presSFC=>psfc  0  y,x  Surface Pressure
```

A time-varying atmospheric variable such as geopotential height might look like this:

```
Height=>z  17  t,z,y,x  Geopotential Hght (m)
```

If your data file contains a variable that also varies in a non-world-coordinate dimension (e.g. histogram interval, spectral band, ensemble number) then you can put a non-negative integer in the list of varying dimensions that will become the array index of the extra dimension. For example:

```
VAR=>hist0   0   0,y,x   First VAR historgram interval
VAR=>hist1   0   1,y,x   Second VAR  historgram interval
VAR=>hist2   0   2,y,x   Third VAR histogram interval
```

IV. Query File Attributes

Once a self-describing data file (NetCDF, HDF-SDS, or a DODS/OPeNDAP URL) has been opened with GrADS, the file's global and variable attributes may be retrieved using the new command: 'query attr'. This command prints out all global attributes, plus a list of all attributes associated with each variable in the data file. The 'query attr' command gives the user access to *all* the metadata associated with a particular data set, not just the required metadata that is contained in the descriptor file (which is retrieved with the 'query ctlinfo' command).

The complete set of metadata is also automatically passed through to the user if the file is being served on a GrADS-DODS Server. The GDS uses 'query attr' to extract the metadata information from the data files it is serving.

V. Summary

The substantial new capabilities in GrADS and the GrADS-DODS Server are sure to greatly benefit the geosciences community. The enhancements allow the user community to distribute and access a variety of new data sets previously unavailable via DODS.

Information about obtaining GrADS:
http://www.iges.org/grads/downloads.html

Information about obtaining/using the GDS:
http://www.iges.org/grads/gds/

Acknowledgements: The original development of GrADS was funded by the NASA Advanced Information Systems Research Program. The original development of the GDS was funded by the SIESIP grant from NASA's Earth Science Information Partnerships. Funding for development of new features for GrADS and the GDS has been provided by LIS, a NASA

Computational Technologies Round-3 Grand Challenge Investigation. Ongoing support for GrADS and the GDS is also provided by an omnibus grant jointly funded by the NSF, NOAA, and NASA that forms the core support for all research at COLA.

VI. References

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