



# Working with command-line systems and GAMIT/GLOBK

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[http://geoweb.mit.edu/~floyd/courses/gg/201711\\_AAU/](http://geoweb.mit.edu/~floyd/courses/gg/201711_AAU/)

Material from R. W. King, T. A. Herring, M. A. Floyd (MIT) and S. C. McClusky (now at ANU)

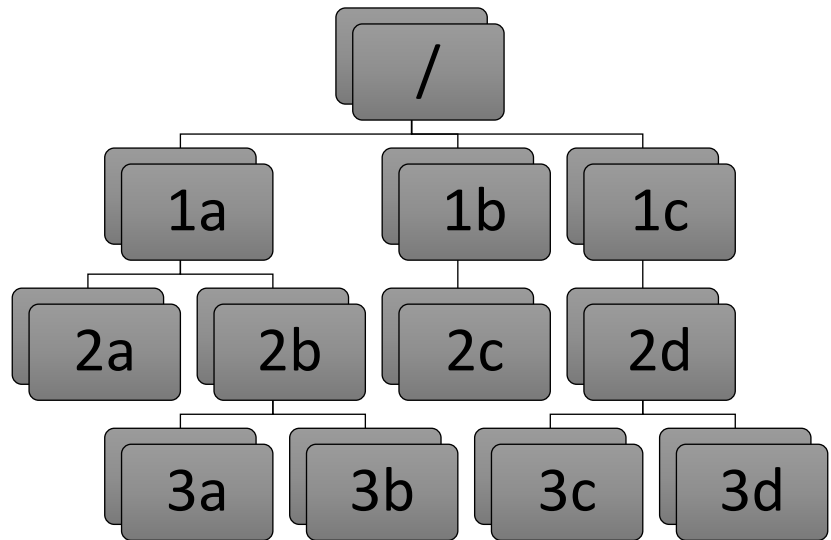
# Introduction to command-line computing

- Directory structure and navigation
- Using a command line
- Commands to know
- Introduction to shell scripts

# Directory structure and navigation

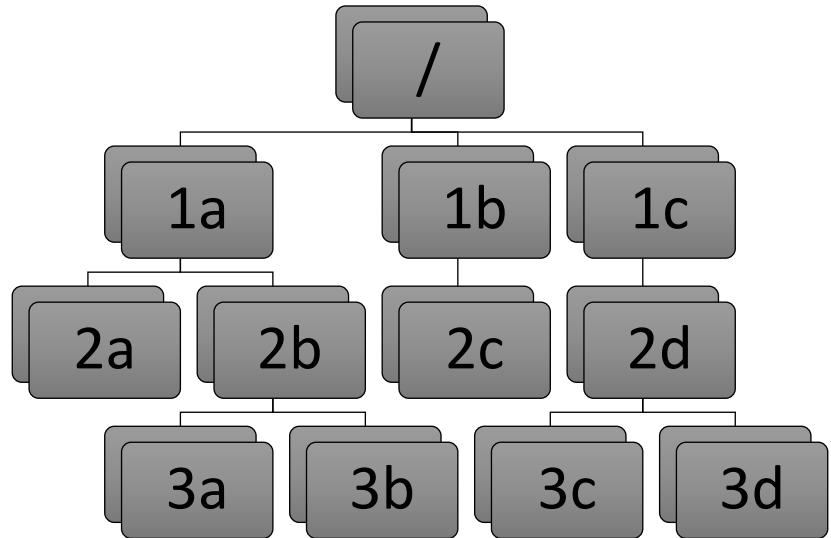
# Directory structures

- One must be familiar with the layout of files and directories (or “folders”)
- Once one has a mental “map” of the directory structure, navigating between directories and finding files is easier
- Think of it as a filing cabinet or family tree



# Directory structures

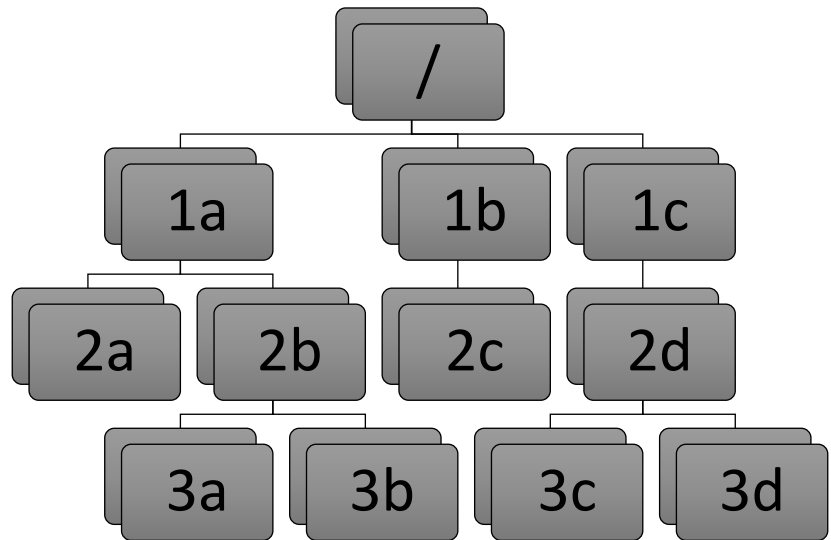
- Top-level (“root”) directory (e.g. “/” on Unix, “C:\” on Windows, etc.)
- User’s current working directory is referred to by the shorthand “.” [dot]
- The “parent” directory is one level above the current working directory in the hierarchy
- Parent directory is referred to by the shorthand “..” [double dot]



# Changing directory

Once user knows where they are with “mental map” of directory structure, move around. We can move up or down the hierarchy but not sideways.

- `cd /`
  - Takes user to top-level (“root”) directory
- `cd 1b`
  - Takes user to “1b” directory in first level (move down hierarchy)
- `cd 2c`
  - Takes user to “2c” directory in second level, below “1b” (move down hierarchy)
- `cd 2d`
  - Unknown directory. Why?
  - User attempting to move sideways but “2c” not connected directly to “2d”.



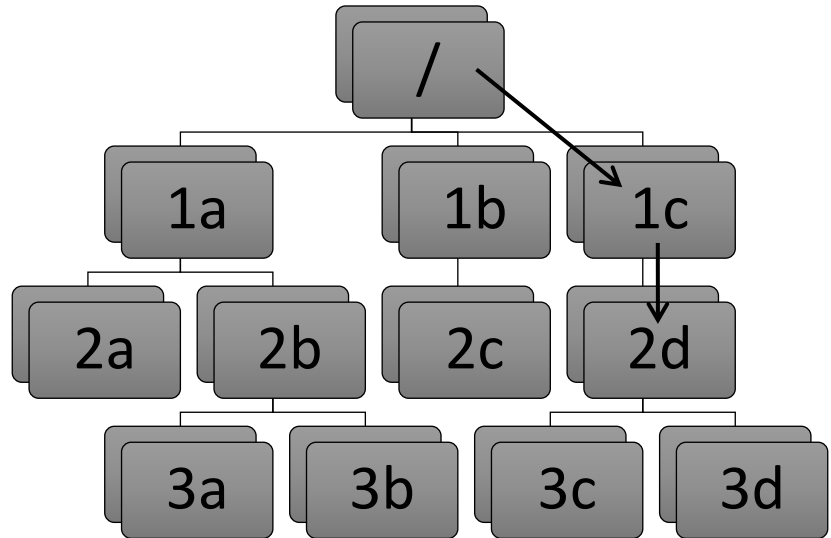
# Absolute paths

To move back up the hierarchy to “2d”, one may explicitly start from the top level, e.g.

- `cd /`
- `cd 1c`
- `cd 2d`

or, combined, simply

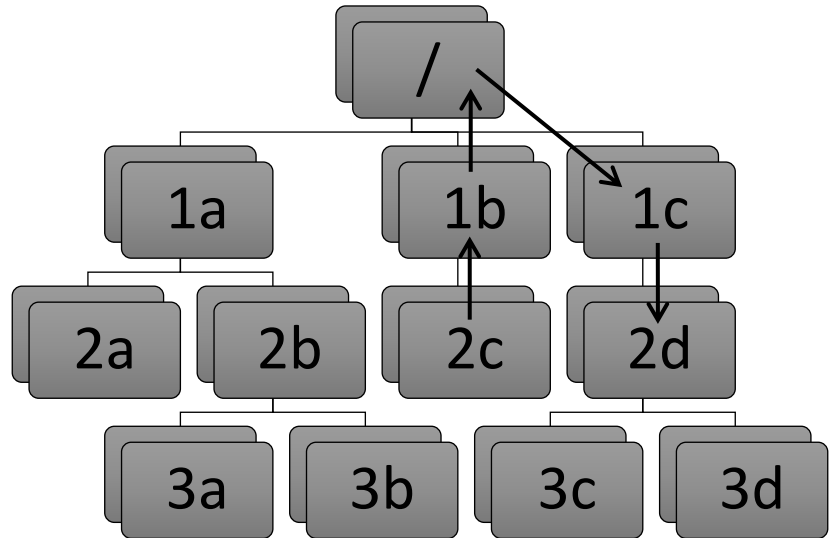
- `cd /1c/2d`
  - Directories are separated by forward slashes



# Relative paths

Or:

- Move back up to “1b”
  - `cd ..`
- Move back up to “/”
  - `cd ..`
- Move down to “1c”
  - `cd 1c`
- Move down to “2d”
  - `cd 2d`
- Or, combined, simply:
  - `cd ../../1c/2d`





Using a command line

# Using a command line

- Basic syntax is:  
`<command> <options> <argument(s)>`
- `<command>` is the program to run, including directory if not included in PATH environment variable (more in a couple of slides...)
- `<options>` are usually prepended by a dash (e.g. `-a`)
- `<argument(s)>` are usually input or output files to work on
- Commands may or may not have options or expect arguments

# Basic commands

- `cd`
  - Change directory, for navigating the directory structure
- `pwd`
  - Print working directory, to know where you are
- `ls`
  - List directories and files in current working directory (“.”) or directory given after command
- Use the “tab” key to auto-complete options

# Environment variables

- A computer must be told information in order to work the way you expect
- Many important settings are kept in “environment variables”
  - \$HOME = user’s home directory
  - \$PATH = list of directories containing programs
  - \$SHELL = user’s command shell
- `printenv`
  - Prints information on environment variables

# Local variables

- To make life easier, one may also set local variables, which may be referred back to at any time
- Useful if one finds the need to write the same thing many times
- sh/bash:
  - `var='Hello'`
  - Instead of writing “Hello”, any reference to `$var` will be equivalent to “Hello”
  - `var=( Hello Goodbye )`
  - Any reference to `${var[0]}` will be equivalent to “Hello” and `${var[1]}` to “Goodbye”
- csh/tcsh:
  - `set var = 'Hello'`
  - Instead of writing “Hello”, any reference to `$var` will be equivalent to “Hello”
  - `set var = ( Hello Goodbye )`
  - Any reference to `$var[1]` will be equivalent to “Hello” and `$var[2]` to “Goodbye”

Commands to know

# Everyday commands

- `awk`
- `grep`
- `sed`
- `sort`
- `paste/join`
- `tr`
- `echo/cat`

# awk

Powerful formatted read/write utility, e.g.

- `awk '{print $1,$2,$3}' <file>`
  - Prints first, second and third white-spaced columns (“fields”) from each line of <file>
- `awk -v n=3 -v FS=',' '{print $NF/n}' <csv-file>`
  - Prints the last comma-separated field divided by 3 from each line of <csv-file>
- `awk 'BEGIN {sum=0}; {sum=sum+$1}; END {printf "%.1f\n",sum/NR}' <file>`
  - Calculate mean of first field: sums first field on each line then divides by number of lines (“records”)



# grep

Pattern-matching command (“**general regular expression**”)

- `grep 'hello' <file>`
  - Prints all lines from <file> with occurrence of “hello” in them
- `grep -ci '^POS S' <file>`
  - Prints the number (“-c”) of lines that begin (“^”) with “POS S” in either upper- or lower-case letters (“-i”) in <file>
- `grep '^ .* P$' <file>`
  - Print all lines in <file> that begin (“^”) with a space, followed by any number of any characters (“.\*”), and end (“\$”) with a space followed by P

# sed

## Basic text editor

- `sed 's/ //g' <file>`
  - Substitute (“s”) all (“g”) instances of a single whitespace with nothing (i.e. delete all whitespace)
- `sed '/^ */d; s/hello/goodbye/1' <file>`
  - Delete (“d”) all empty lines and substitute the first instance of “hello” with “goodbye” on each line of <file>

# sort

## Sorts records

- `sort <file>`
  - Outputs basic alpha-numerically ordered <file>
- `sort -u <file>`
  - Same as above but uniquely sorted (i.e. removes duplicate records)
- `sort -g -k 3 <file>`
  - General numeric ordering based on third field of <file>
- `sort -u -k 2.1,2.4 <file>`
  - Sort based on first character of second field to fourth character of second field and use this as the basis for the uniqueness test

# tr

## Basic translation

- `tr '[:upper:]' '[:lower:]'`
  - Transposes all upper-case letters to lower-case
- `tr -d '\r'`
  - Deletes all carriage return (“CR”) characters (useful for changing a file’s line ending from DOS to UNIX format)

# echo/cat

Echoes the argument

- `echo 'Help!'`
  - Prints "Help!"
- `cat <file>`
  - Reads out entirety of <file>
- `cat << END`

Help!

END

- Same as "echo 'Help!'"

# Redirection

- The output from one command may be written to a file...
  - “>” to *overwrite* an existing file
  - “>>” to *append* to an existing file
  - `sort [file] > [sorted file]`
- ...or “piped” to another command, effectively forming the second command’s input
  - “|”
  - `grep '^ .* P$' [file] | sort > [grep'd and sorted file]`

# Shorthands

- Top-level (“root”) directory = “/”, e.g.
  - `cd /`
- Your home directory = “~” or “\$HOME”, e.g.
  - `ls ~`
- “Links” or “shortcuts” may be created, e.g.
  - `ln -s /home/user/gg/10.61 ~/gg`
- This creates a link in the user’s home directory called “gg” that points to the directory `/home/user/gg/10.61`
  - Rather than “`cd /home/user/gg/10.61`”, one can get to the same place simply with “`cd ~/gg`”
  - (This is used in GAMIT/GLOBK scripts and *must* remain in place!)

# Useful commands

- **du**
  - Disk usage: useful if you want to know how much space your (or others'!) directories are taking up
- **df**
  - Disk free space: useful if you want to know how much disk space is used and free
- **top**
  - Table Of Processes: useful if you want a real-time overview of processes that are running
- **ps**
  - List processes: useful if you want to see what processes are running and their process numbers, commands, etc.



# Introduction to shell scripts

# What is a script?

- Scripts contain a series of commands written in one file and prepended by a “hash-bang”
  - `#!/bin/sh` for original Bourne Shell (usually the same as bash on modern systems)
  - `#!/bin/bash` for Bourne Again Shell
  - `#!/bin/csh` for C Shell (usually the same as tcsh on modern systems)
  - `#!/bin/tcsh` for TENEX C Shell
- The script may then be executed to run all of the commands in sequence as written
- Most scripts in GAMIT/GLOBK are written in csh or tcsh; many newer scripts are written in bash
  - Must have both csh and tcsh installed to run GAMIT/GLOBK scripts
  - bash usually installed by default on current Linux distributions

# Script example

```
#!/bin/bash
echo -n 'The ISO date is: '
date '+%Y-%m-%dT%H:%M:%S%Z'
echo -n 'The mean of all numbers between 1 and
10 is: '
echo 1 10 | awk 'BEGIN {sum=0; n=0}; {for (i=$1;
i<=$2; i++) {sum=sum+i; n++}}; END {print
sum/n}'
echo 'Goodbye!'
```

# Installing GAMIT/GLOBK

# Sources of prerequisite information

<http://web.mit.edu/mfloyd/www/computing/gg/pre/>

[ftp://guest@chandler.mit.edu/updates/documentation/GAMIT\\_prerequisites.pdf](ftp://guest@chandler.mit.edu/updates/documentation/GAMIT_prerequisites.pdf)

<http://web.mit.edu/mfloyd/www/computing/mac/gfortran/>

<http://web.mit.edu/mfloyd/www/computing/mac/gv/>

# Separation of tasks

- Source code directory
- Installation directory
- Processing directory

Source code directory  
(optional)

# Source code directory

- Users may wish to keep a local copy of source code
  - As backup in case of problems during installation
  - If unable to reconnect to the source code repository (<ftp://chandler.mit.edu>)
- If you wish to do this, keep it separate from where you intend to *install* GAMIT/GLOBK, e.g.
  - `~/src/gg/10.61`
  - `~/Programs/src/gg/10.61`



Master installation directory

# Master installation directory

- Choose a suitable directory for installing the software
  - Suggested place in home directory, e.g. `~/src/gg`, `~/Programs/gg`, etc. (for example, I install GG version 10.61 in `/Users/Mike/Programs/gg/10.61`)
  - Alternative may be your `/usr/local` directory, e.g. `/usr/local/gg/10.61` but you must have administrator permissions
  - Take great care not to mix source versions, e.g. 10.6 versus 10.61
- Change to this directory to download (or copy) the source code
- This will be the directory that is ultimately linked from your home directory (`~/gg`)

Downloading source via FTP

# FTP server

- `chandler.mit.edu`
  - username: `guest`
  - password: [changeable]
- Use FTP client, such as `ftp` or `ncftp`
- Alternatively, use internet browser
  - `ftp://guest@chandler.mit.edu`

# Source code

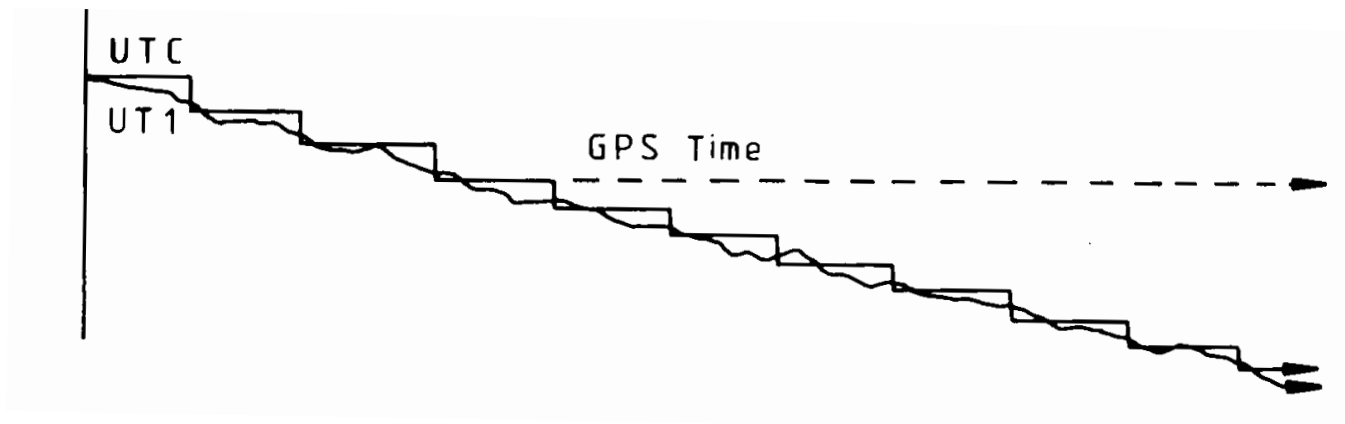
- Change directory to `updates/source/`
- Need *at least*:
  - `com`
  - `gamit`
  - `help`
  - `kf`
  - `libraries`
  - `tables`
  - `incremental_updates` (if any)
- Also download `install_software`
- Depending on your processing strategy, may also need to download grids (e.g. ocean-tide loading, atmospheric loading grids, etc.) from `ftp://everest.mit.edu/pub/GRIDS/`

# GNSS test code

- Test code for processing GNSS is also available on the FTP server
  - Currently “gnss\_test.170619.tar.gz”
- If you wish to install this code, the gnss\_test tar-file must be un-tar’d *after* all other tar-files, including incremental\_updates
  - We do not recommend installing this code unless you intend actively to process data from GNSS systems other than GPS
- If you wish to uninstall this code, one needs to reinstall all necessary components (com, gamit, help, kf, libraries and tables) plus incremental\_updates again *without* gnss\_test

# Updates!

- Incremental updates are made available approximately every month, so please check at least
  - Earth orientation parameters (pole.\* and ut1.\*; or sh\_update\_eop)
  - SVN-PRN translation tables (svnav.dat)
  - Differential code biases (dcb.dat)
  - Leap seconds (leap.sec)
  - Loading grids (ftp://everest.mit.edu/pub/GRIDS/)
- Example: 2016-12-31T23:59:60Z leap second



# Documentation

- Top-level “README” file at  
<ftp://guest@chandler.mit.edu/updates/README>
- Change directory to `updates/documentation/`
  - GAMIT/GLOBK prerequisites in **GAMIT\_prerequisites.pdf**  
<http://web.mit.edu/mfloyd/www/computing/gg/pre/>  
[ftp://guest@chandler.mit.edu/updates/documentation/GAMIT\\_prerequisites.pdf](ftp://guest@chandler.mit.edu/updates/documentation/GAMIT_prerequisites.pdf)
  - Introductory GPS material in **Intro\_GG.pdf**  
[http://geoweb.mit.edu/~simon/gtgk/Intro\\_GG.pdf](http://geoweb.mit.edu/~simon/gtgk/Intro_GG.pdf)  
[ftp://guest@chandler.mit.edu/updates/documentation/Intro\\_GG.pdf](ftp://guest@chandler.mit.edu/updates/documentation/Intro_GG.pdf)
  - GAMIT reference manual in **GAMIT\_Ref.pdf**  
[http://geoweb.mit.edu/~simon/gtgk/GAMIT\\_Ref.pdf](http://geoweb.mit.edu/~simon/gtgk/GAMIT_Ref.pdf)  
[ftp://guest@chandler.mit.edu/updates/documentation/GAMIT\\_Ref.pdf](ftp://guest@chandler.mit.edu/updates/documentation/GAMIT_Ref.pdf)
  - GLOBK reference manual in **GLOBK\_Ref.pdf**  
[http://geoweb.mit.edu/~simon/gtgk/GLOBK\\_Ref.pdf](http://geoweb.mit.edu/~simon/gtgk/GLOBK_Ref.pdf)  
[ftp://guest@chandler.mit.edu/updates/documentation/GLOBK\\_Ref.pdf](ftp://guest@chandler.mit.edu/updates/documentation/GLOBK_Ref.pdf)



# Compiling GAMIT/GLOBK

# Required tools

Depending on your system, a number of programs may need to be added. One needs:

- A Fortran code compiler (e.g. gfortran)
- A C code compiler (e.g. gcc)
- X11 libraries and headers, specifically:
  - libX11.a, libX11.so, libX11.dylib, libX11.la or libX11.dll.a (depending on your system)
  - Xlib.h
- Linux
  - Be sure a C-shell (csh and tcsh) is installed (this is not the case by default with Ubuntu, for instance)
  - X11 libraries and headers may also need to be installed
- Mac
  - Have an Apple ID and download the latest “Command Line Tools for Xcode” (Mac OS X 10.7.3 or later) or “Xcode” (prior to Mac OS X 10.7.3) appropriate to your system from <https://developer.apple.com/download/more/>
  - X11 was replaced by XQuartz (<https://www.xquartz.org/>) for Mac OS X 10.8 (Mountain Lion) and later
- Windows
  - Ubuntu on VirtualBox or VMWare virtual machine (or Bash on Ubuntu on Windows on recent versions of Windows 10):  
`sudo apt install gfortran make libx11-devel csh tcsh bc`
  - Cygwin: Devel/make; Math/bc; Shells/tcsh; X11/libX11 (or X11/xinit)

# Notes on known problems

- Very new gfortran releases, especially those with a version number ending in 0 (e.g. 4.9.0), often are buggy and produce compilation problems
  - If this is the case, try compiling a program using only the “-O3” flag or revert to an older, stable version of gfortran
- Currently running gfortran 6.3.0 on laptop with macOS 10.12 (Sierra) and 4.8.4 on MIT computers with Ubuntu Linux

# Running `install_software`

From the master installation directory, where the source tar-files and `install_software` should be copied

- Run `./install_software`
- As you pass through the installation process, *please read the questions*, e.g.
  - Searching directories set in `libraries/Makefile.config` for X11 installation  
Verified these paths to X11 libs and includes  
`X11LIBPATH:`  
`X11INCPATH:`  
Are these paths complete and correct for your system?  
(y/n)
- If they are not correct, say “n” then `install_software` will search or exit and one can then edit `libraries/Makefile.config` appropriately

# A note here on permissions

- A computer may read (“r”), write (“w”) and/or execute (“x”) a directory or file
- Each action may be allowed by a user (“u”), group (“g”) or others (“o”)
- A computer must follow instructions, called “permissions”, on if it allowed to do any or all of these for any
- Any file that you want to run as a program must be made “executable”
  - `chmod a+x <file>`
  - Change moderations (permissions) so executable (“x”) permissions are added to <file> for all (“ugo”)
- You may find you need to verify that directories and files are readable, writable and/or executable as necessary throughout your UNIX experience

# Potentially necessary edits

- `libraries/Makefile.config` is the main control file for the installation process
- Check:
  - `X11LIBPATH` (path to `libX11`)
  - `X11INCPATH` (path to `Xlib.h`)
  - `MAXSIT` (max. number of sites to process simultaneously)
  - `MAXSAT` (do not change)
  - `MAXATM` (max. atmospheric estimates per session)
  - `MAXEPC` (max. epochs per session, e.g. 24 hours at 30 s interval = 2880 measurement epochs)
  - `OS block` (usually no need to change)

# Setting environment variables

- sh/bash (e.g. in ~/.bash\_profile, ~/.bashrc or ~/.profile):

```
gg='/Users/Mike/Programs/gg/10.61'  
PATH="$gg/com:$gg/gamit/bin:$gg/kf/bin:$PATH" && export PATH  
HELP_DIR="$gg/help/" && export HELP_DIR  
INSTITUTE='MIT' && export INSTITUTE
```

- csh/tcsh (e.g. in ~/.cshrc):

```
set gg = '/Users/Mike/Programs/gg/10.61'  
setenv PATH "$gg/com:$gg/gamit/bin:$gg/kf/bin:$PATH"  
setenv HELP_DIR "$gg/help/"  
setenv INSTITUTE 'MIT'
```

# Additional environment variables

- Some locales (your computer's language and numbers setting) use a comma for the decimal separator rather than a point, e.g. "1000.00" versus "1000,00" for one thousand to two decimal places
- This is typical in most languages other than English
- Using this scheme breaks certain GAMIT/GLOBK scripts that perform basic numeric calculations while formatting data, as well as GMT
- To avoid this problem without having to change your language, set the "LC\_NUMERIC" environment variable to "C" or an appropriate language locale, e.g. "en\_GB.UTF-8" or "en\_US.UTF-8"
  - sh/bash (e.g. in ~/.bash\_profile, ~/.bashrc or ~/.profile):  
LC\_NUMERIC='C' && export LC\_NUMERIC
  - csh/tcsh (e.g. in ~/.cshrc):  
setenv LC\_NUMERIC 'C'

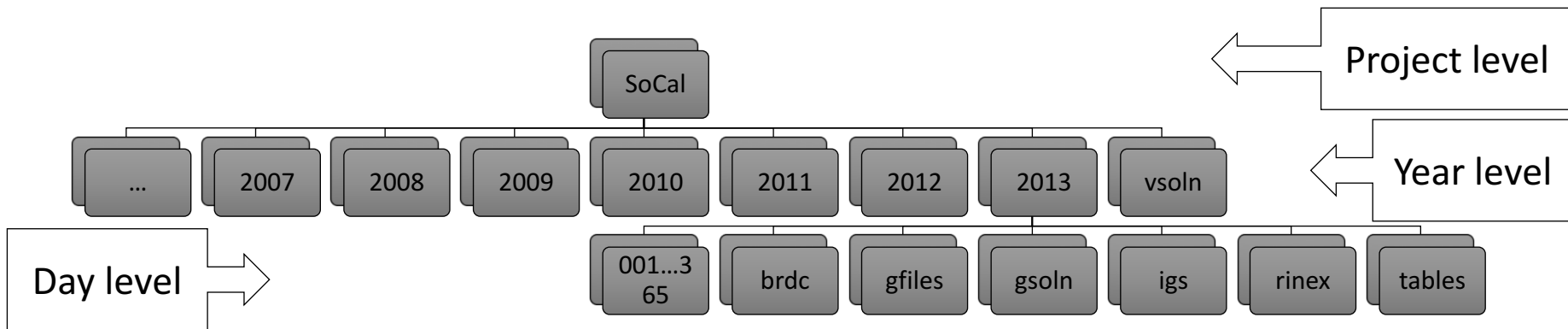


Processing directories

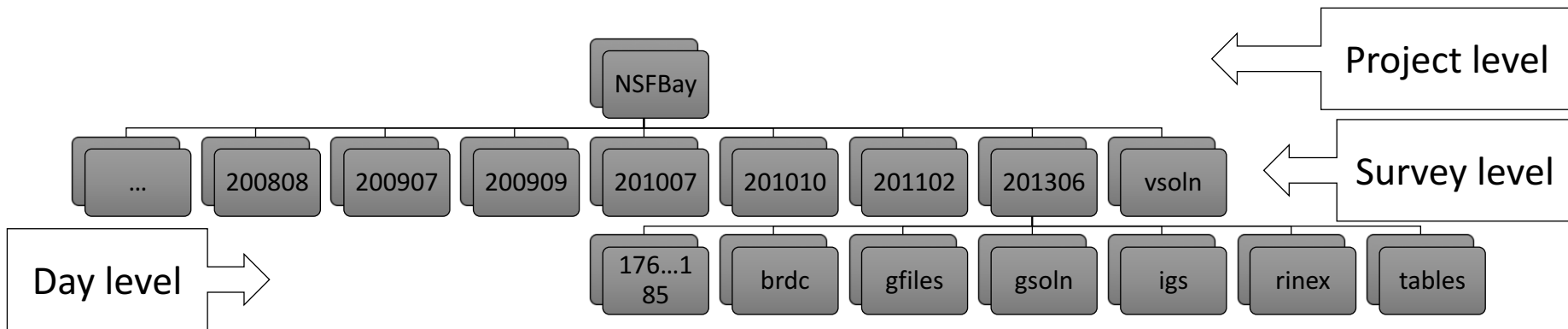
# Processing directory

- The *processing* directory will not have the same structure as the *master installation* directory
- Choose a different location, do not process in your master installation directory
- We will, however, be copying or linking to the master installation tables (via symbolic link or “shortcut” ~/gg/tables)

# Example continuous GPS structure



# Example survey GPS structure



# Additional software

- Generic Mapping Tools (GMT)  
(<http://gmt.soest.hawaii.edu/>)
  - Required for plotting scripts to work
  - Scripts in com/ use GMT 5
  - Prepend com\_preGMT5/ to \$PATH if using GMT 4
    - These scripts are no longer updated, so switch to GMT 5!
- Tom's GGMatlab tools  
(<http://www-gpsg.mit.edu/~tah/GGMatlab/>)
  - tsview
  - velview