Mapping and modeling Earth Science Data

Segment I: More UNIX and shell scripts

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UNIX tools: compression and dealing with big files

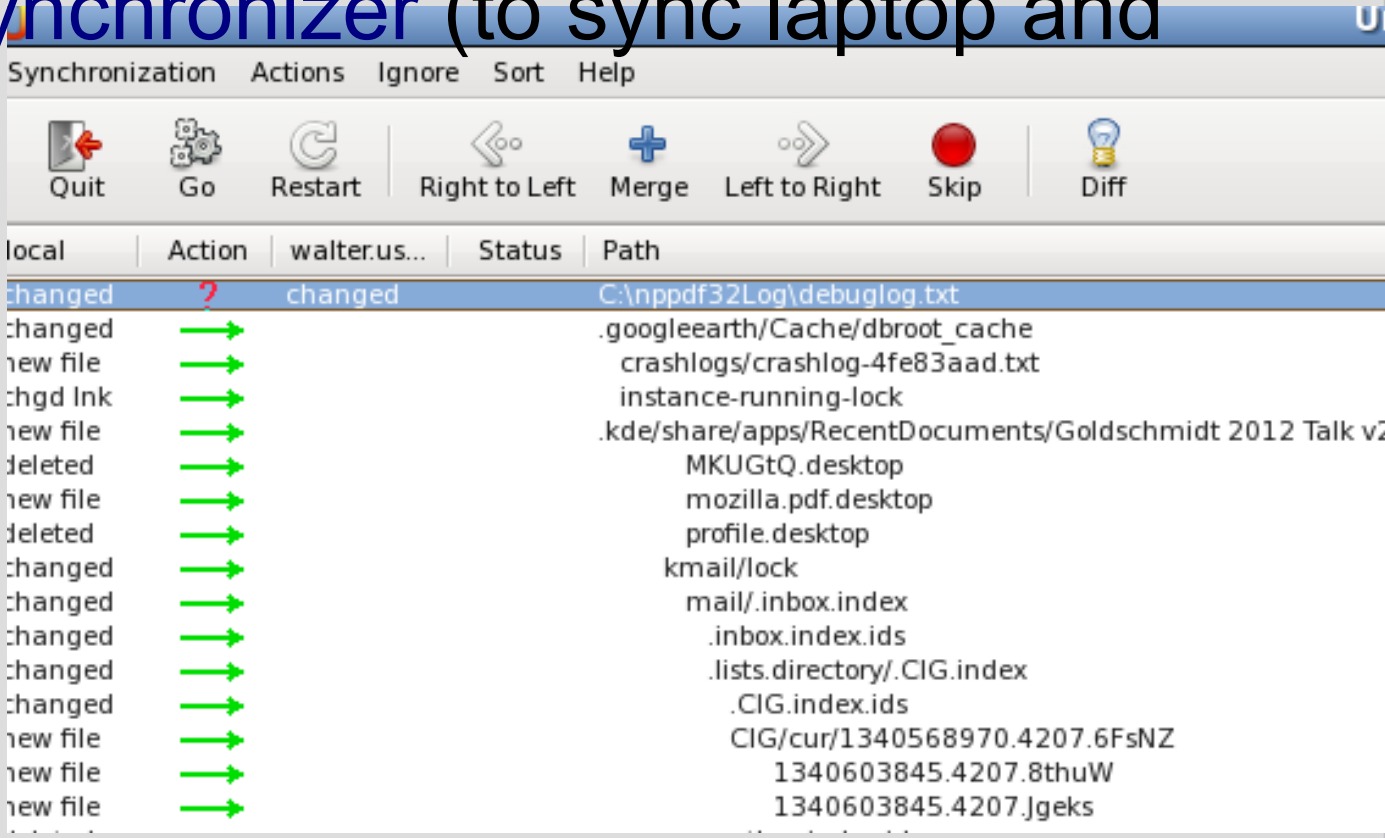
- **gzip**: compress ASCII files, *which can be huge*, to binary
  - compress: gzip file
  - uncompress: gunzip file.gz
- can write gzipped from within C, can use gunzip on the fly (**zcat**): this allows using nice ASCII tools such as awk while storing things compactly
- **bzip2**: smaller files, takes longer

UNIX tools: dealing with big and lots of files

- **tar**: combine lots of files into an archive
- ```
  tar --create --verbose --compress --file my_dir_cfiles.tgz \
  dir/*.c
  ```
- ```
  gunzip my_dir_cfiles.tgz
  tar tf my_dir_cfiles.tar
  tar xf my_dir_cfiles.tar
  ```
- **wget**: download large files
- **rsync**: copy file systems (for backup)

UNIX tools: storage and backup

- Unison file synchronizer (to sync laptop and workstation)



- *backup all the time* (it's easy to screw up big time), or have your admin backup for you

UNIX tools: awk and sed

- **awk**: (or gawk) powerful language for ASCII data and text manipulations
  - like C, interpreted at run time
  - the best thing since sliced bread
    - **cat** file.dat | gawk '{print($2,cos($5))}' *or*
    - gawk '{print($2,cos($5))}' file.dat
- **sed**: streaming text editor
  - **sed** 's/Bush/Kerry/g' file.dat > new_file.dat
- **perl**: more powerful, more complex

UNIX tools:
Getting smart: a few tricks

- unpacking on the fly:
  - **gunzip** -c newsoftware.tgz | tar xv
- interpreting commands on the fly:
  - **echo** $variable_a `cat file.dat | gawk -f mean.awk`
- tcsh interactive functionality:
  - **foreach** f (*.ps)
    - **convert** $f $f:r.gif
  - **end**

Shells: Job control

- **ps**: list currently running processes
- **jobs**: list current jobs (processes started from shell in background)
- running commands in background
  - **emacs** & (or: **emacs**; CTRL-Z; bg)
  - **echo** mybigjob.exe | nohup (don't quit with shell)
  - **kill** %2 (kill the second job running, % are job IDs)
  - **kill** -KILL 12344 (kill process with PID 12344)
- **top**: show machine load

Shells: Job control example

```
becker@jackie:~ > ps
  PID TTY          TIME CMD
 1758 pts/5    00:00:00 tcsh
 2500 pts/5    00:00:00 ps

becker@jackie:~ > ps aux | tail

becker    1413  0.0  0.0  4348 1004 ?        S    15:10   0:00 /bin/sh /usr/bin/realplay /tmp/youfm_cms.ram
becker    1418  3.2  1.1 79664 12000 ?       Sl   15:10   3:24 /usr/local/RealPlayer/realplay.bin /tmp/youfm_cms.ram
becker    1420  0.0  0.5 25720 5260 ?        S    15:10   0:00 /usr/local/RealPlayer/realplay.bin /tmp/youfm_cms.ram
becker    1421  0.0  0.5 25720 5260 ?        S    15:10   0:00 /usr/local/RealPlayer/realplay.bin /tmp/youfm_cms.ram
becker    1642  0.0  0.1  5200 1776 pts/3    Ss+  16:03   0:00 -csh
becker    1703  0.0  0.1  6624 1764 pts/4    Ss+  16:08   0:00 -csh
becker    1758  0.0  0.1  5328 1984 pts/5    Ss   16:14   0:00 -csh
becker    1888  0.0  1.6 27332 17228 ?       S    16:26   0:01 /usr/lib/acroread/Reader/intellinux/bin/acroread -display :
0.0 -name main -visual default +useFrontEndProgram -xrm *useNullDoc:false -progressPipe 3 -xrm *noPrivateColormap:true
-xrm *exitPipe:4
becker    2501  0.0  0.0  3032  772 pts/5    R+   16:54   0:00 ps aux
becker    2502  0.0  0.0  4212  532 pts/5    R+   16:54   0:00 tail


becker@jackie:~ > kill 1413
...
```

Shells: Parallel processing

```
#!/bin/bash


...

process file1 &
process file2 &
process file3 &

wait

...
```

Shells: Job automation

- **at**

```
echo "echo It\'s 1 a clock and time for lunch" |\
    at 1pm
```

- **cron** crontab file, crontab -l, crontab -r

```
#               field          allowed values
#               -----          --------------
#               minute         0-59
#               hour           0-23
#               day of month   0-31
#               month          1-12 (or names, see below)
#               day of week    0-7 (0 or 7 is Sun, or use names)
# every day at 5am, check my calendar
4 5 *  * * $HOME/progs/batch/check_calendar
# every Sun night at 4am, clean the tmp directory (WARNING!)
17 4 *  * Sun rm -rf $HOME/tmp/* 2> /dev/null
# every week, 6pm Sa backup the home directories
15 18 * * Sat $HOME/progs/batch/backup_home_rsync 0
```

Experimentation time

```
1.echo a b > file1.txt
2.echo c b > file2.txt
3.cat file1.txt
4.cat file?.txt
5.grep b file*.txt
6.ln -s file1.txt file3.txt
7.diff file1.txt file3.txt
8.rm file3.txt
9.diff file1.txt file2.txt
10.paste file1.txt file2.txt
11.ls -la
```

1. `sleep 5`
2. Run the command in the background using &.
3. Run sleep 15 in the foreground, suspend it with Ctrl-z and then put it into the background with bg.
   Type `jobs`. Type `ps`.
   Bring the job back into the foreground with fg.
4. Run `sleep 15` in the background
5. using &, and then use `kill` to terminate the process by its job number.
6. Repeat, except this time kill the process by specifying its PID.

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UNIX Reference Card

Warnings!!

When a file has been **DELETED** it can only be restored from a backup. The original is gone!

When a file is **OVERWRITTEN** it has been changed forever! It can only be restored from a backup.

Directory Abbreviations

~	home directory (tilde)
~*username*	another user's home directory
.	current working directory
..	parent of current working directory

Communication

ssh [*options*] hostname
Ssh (Secure Shell) a program for logging into a remote host. Replaces telnet, rlogin, and rsh
options:
-l *login_name* specifies the user to log in on the remote machine

scp [*options*] user@host1:file1 user@host2:file2
Secure copy files between hosts on a network; uses ssh for data transfer.
options:
-p preserve modification times
-r recursively copy entire directories

Comparison

diff [*options*] *file1 file2*
Compare two text files.
options:
-a treat all files as text files
-b ignore repeating blanks and end-of-line blanks; treat successive blanks as one
-i ignore case in text comparison
-q output only whether files differ

File Management

cat [*options*] [*files*]
Read one or more *files* and print them on standard output. Use the > operator to combine several files into a new file; use >> to append files to an existing file.
options:
-n print the number of the output line to the line's left
-s squeeze out extra blank lines

cd [*dir*]
Change working directory to dir; default is the users home directory.

chgrp *newgroup files*
Change the group of one or more *files* to *newgroup*. *newgroup* is either a group ID number of a group name. Only the owner can change the group
options:
-c print information about those files that are affected
-R recursively apply changes to subdirectories

chmod [*options*] *mode files*
Change the access *mode* (permissions) of one or more *files*. Only the owner of a file or a privileged user may change its mode.
options:
-c print information about affected files
-R recursively apply changes to subdirectories
mode:
can be numeric
4 read
2 write
1 execute
or an expression of the form *who opcode permission*. *who* is optional (if missing, default is **a**)
who
u user
g group
o other
a all (default)
opcode
+ add permission
– remove permission
= assign permission
permission
r read
w write
x execute
X set execution permission only if executable by user

cp [*options*] *file1 file2*
cp [*options*] *files directory*
Copy *file1* to *file2*, or copy one or more *files* to the same names under *directory*.
options:
-a preserves attributes of original files
-f remove existing files in the destination
-i prompt before overwriting destination files
-r recursively copy directories
-s make symbolic links instead of copying

file [*options*] *files*
Classify the named *files* according to the type of data they contain.

less [*options*] [*filename*]
A program for browsing or paging through files or other output. Can use arrow keys for scrolling forward or backward.
options:
see **man** pages for options (type: **man less**)

ln [*options*] *sourcename* [*destname*]
ln [*options*] *sourcenames destdirectory*
Create links for files, allowing them to be accessed by different names.
options:
-b backup files before removing originals
-i prompt for permission before removing files
-s create a symbolic link. This lets you see the name of the link when you run **ls -l** (otherwise there is now way to know the name that a file is linked to).

ls [*options*] [*names*]
List the contents of a directory. If no *names* are given, the files in the current directory are listed.
options:
-a list all files, including hidden files
-c list files by status change time
-l long format listing (permissions, owner, size, modification time)

mkdir [*options*] *directories*
Create one or more directories.
options:
-m *mode* set the access *mode* for new directories. See **chmod** for *mode* formats.
-p create intervening parent directories if they don't exist

more [*options*] [*files*]
Display the content of the named *files* one screen at a time. See less for an alternative.
options:
see **man** pages for options (type: **man more**)

pwd
Print the full pathname of the current working directory.

scp [*options*] user@host1:file1 user@host2:file2
Secure copy files between hosts on a network; uses ssh for data transfer.
options:
-p preserve modification times
-r recursively copy entire directories

mv [*options*] *sources target*
Move or rename files and directories. The *source* and *target* determine the result.

source	*target*	*result*
file	*name*	rename file as *name*
file	existing file	overwrite existing file with source file
directory	*name*	rename directory as *name*
directory	existing subdirectory of existing directory	move directory to be a

options:
-b back up files before moving
-f force the move
-i query user before removing files

rm [*options*] *files*
Delete one or more *files*. *Once a file or directory has been removed it can only be retrieved from a backup!*
options:
-d remove directories, even if they are not empty
-f remove files without prompting
-i prompt for file removal
-r recursively remove an entire directory and its contents, including subdirectories. *Be very careful with this option.*

Miscellaneous

! Repeat the last command

!*string* Repeat the last command beginning with *string*.

cal [*-jy*] [[*month*] *year*]
Print a 12-month calendar for the given *year* or a one-month calendar of the given *month* and year. No arguments, print a calendar for the current month.
options:
-j display Julian dates
-y display entire current year

clear
Clear the terminal display

history
Display list of most recently executed commands

kill [*option*] *IDs*
Send a signal to terminate one or more process *IDs*.
options:
-l list all signals
-signal the signal number (from **ps -f**) or name (from **kill -l**). You can kill just about any process with a signal number of 9.

man *command*
Display information from the online reference manuals.

jobs [*options*] *job_id*
Display status of jobs in the current session. Simply specifying jobs returns the status of all stopped jobs, running background jobs, and all suspended jobs.
options:
-l provide more information about each job listed
-p display only the process IDs for the process group leaders of the selected jobs

whereis *command*
Locate a *command*; display the full pathname for the *command*.

which [*commands*]
List which files would be executed if the named *commands* had been run.

Searching

egrep [*options*] [*regexp*] [*files*]
grep [*options*] [*regexp*] [*files*]
Search one or more *files* for lines that match a regular expression *regexp*. To include characters such as +, ?, |, ( ), blank spaces, etc. enclose these expressions in quotes. See **man** pages for the differences between **egrep**, **fgrep**, and **grep**.
options:
-c print only a count of matched lines
-i ignore case
-l list filenames but not matched lines
-n print lines and their line numbers
-v print all lines that do not match *regexp*

find [*pathnames*] [*conditions*]
Useful for finding particular files. **find** descends the directory tree beginning at each *pathname* and locates files that meet the specified *conditions*.
options:
-name *pattern* find files whose name matches *pattern*
-print print the matching files and directories using their full pathnames
see **man** pages for options (type: **man find**)

Storage

compress [*options*] [*files*] – compress file
uncompress [*options*] [*files*] – uncompress compressed file
compress reduces the size of the named *files*. When possible the resulting compressed file will have the file extension **.Z**. Compressed files can be restored using **uncompress**.
options:
-d uncompress file, same as **uncompress**
-v prints the percentage reduction
-V prints the version of compress

gzip [*options*] [*files*] – compress file
gunzip [*options*] [*files*] – uncompress gzipped file
GNU compression utility. Renames compressed files *filename.gz*. Uncompress with **gunzip**.
options:
-d uncompress file, same as **gunzip**
-r recursively compress or decompress files within a directory
-v print name and percent size reduction for each file

tar [*options*] [*tarfile*] [*other-files*]
Copy *files* to or restore *files* from an archive. If any files are directories, **tar** acts on the entire subtree.
options:
-c create a new archive
-d compare the files stored in tarfile with other-files
-r append other-files to the end of an existing archive
-t print the names of files in archive
-v verbose, print filenames as they are added or extracted
-x extract *other-files* from archive, or extract all files if *other-files* not specified

System Status

Control-C
Stop (interrupt) job running in the foreground

Control-Z
Suspend job running in the foreground

date [*options*] [*+format*] [*date*]
Print the current date and time. You may specify a display *format*.
options:
see **man** pages for options (type: **man date**)

df [*options*] [*name*]
Report the amount of free disk space available on all mounted file systems or on a given *name*.
options:
-k print sizes in kilobytes

du [*options*] [*directories*]
Print disk used by each named directory and its subdirectories.
options:
-k print sizes in kilobytes
-s print only the grand total for each directory

env [*option*] [*variable=value ...*] [*command*]
Display the current environment or, if an environment *variable* is specified, set it to a new *value* and display the modified environment.
option:
-u unset the specified *variable*

ps [*options*]
Report on active processes.
options:
-a list all processes except processes not associated with the terminal
-e list all processes
-l produce long format listing
-u *list* list for usernames in *list*

quota [*option*]
Display disk usage and limits
option:
-v report quotas even if they haven't been exceeded

Contact Information

Phone: 612-626-0802

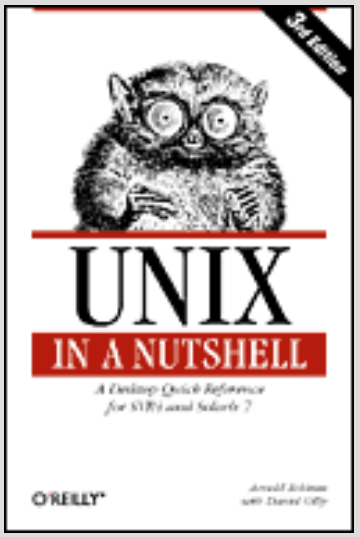
Email: help@msi.umn.edu

WWW: http://www.msi.umn.edu

http://www.msi.umn.edu/user_support

UNIX: UNIX/LINUX references

- UNIX reference card
- Robbins: UNIX in a nutshell
- Siever at al: LINUX in a nutshell
- Online list of UNIX commands
- Local computing center documentation and lecture notes
- google on UNIX: commands, shell scripts, EMACS, awk, ...



Shells: The environment

- shells: interpret your commands when logged in and using a terminal session
- **csh**, **tcsh**: nice for interactive stuff, syntax close to C, command completion, auto correction
- **bash**, **ksh**: nice for programming
- shells use mostly same commands, but there are differences in the script languages, *e.g.*
  - **export** var=100 (bash)
  - **setenv** var 100 (csh)

Shells: Command history and other feature that save typing

- use up, down, left, right arrows to navigate and edit commands on the command line
- use a bunch of tricks to access and modify last commands, *e.g.*
  - !n: execute last command that starts with “n”
- *auto-completion* (TAB key)
- *auto-correction*
- many more tricks

Shells: Can use variables, and many are predefined (csh example)

```
becker@jackie:~ > setenv region 0/360/-90/90

becker@jackie:~ > echo $region
0/360/-90/90

becker@jackie:~ > echo $HOME
/home/becker

becker@jackie:~ > echo $USER
becker

becker@jackie:~ > env
BIBINPUTS=.:/home/becker/TEX//:
CFLAGS_DEBUG=-g -DDEBUG -DDEBUG -DLINUX_SUBROUTINE_CONVENTION
LDFLAGS=-posixlib -nofor_main  -Vaxlib  -L/usr/lib/gcc/i386-redhat-linux/3.4.3/ -lg2c -lm
MANPATH=/home/becker/progs/man/:/home/becker/progs/man/:
DVIPSHEADERS=/home/becker/TEX//:
SUPPORTED=en_US.UTF-8:en_US:en
SSH_AGENT_PID=31881
HOSTNAME=jackie.usc.edu
DXROOT=
DXMEMORY=128
CONFC=ifort
HOST=jackie.usc.edu
SHELL=/usr/bin/tcsh
FFLAGS_DEBUG=-g -DDEBUG -fpp    -nofor_main  -DDEBUG

....
```

Shells: Startup/configuration

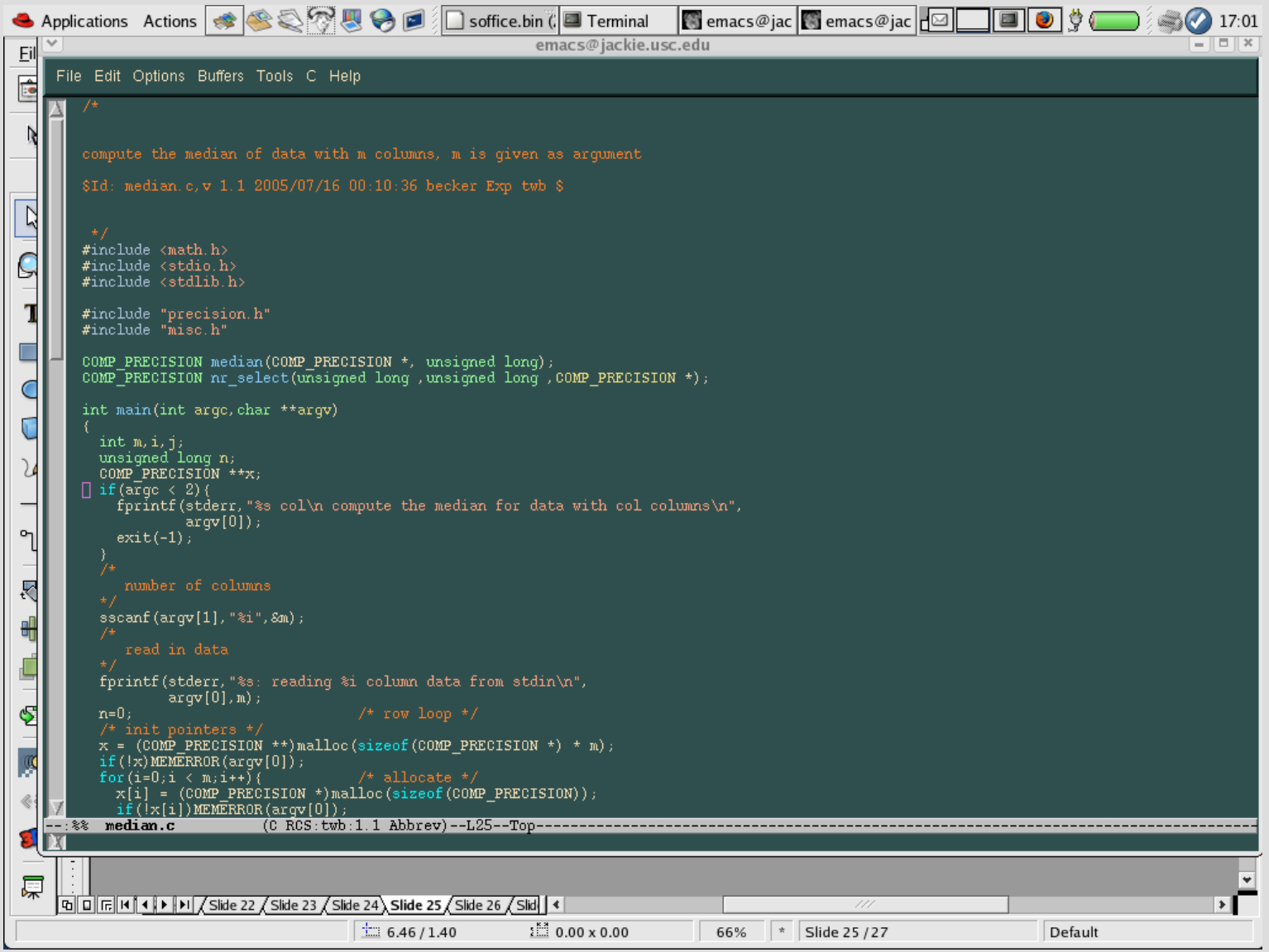
- ~/.login (= $HOME/.login) at startup
- ~/.cshrc every time you start a shell
- those scripts are where you define environment variables and aliases you want to use in all sessions
  - **alias** rm 'rm -i'
  - **setenv** F77 ifort; **setenv** FFLAGS “-O3 -ipo”
- ~/.login is an example of a hidden file
- see references on UNIX and dotfiles.com

Editors:
Editing text or ASCII data files

- **vi**: old school: fast, efficient, bizarre
  - controlled by typing commands like !w, /text
  - good for minor editing tasks, required for admins
- **emacs**: best overall tool
  - GUI, menus
  - flexible, expandable
  - Bizarre
- **gedit**: people like it because it's close to Word
- tons of others, but don't use Word or such, since UNIX expects pure ASCII characters

Editors:

What EMACS looks like



Scripts: Scripts and GUIs

- scripts are the opposite of point-and-click
- need to work hard once to generate template
- benefit forever if you want to produce more products (*e.g.* plots) using different parameters, or if the data has changed
- automate research galore (needed to explore parameter space)
- scripts can serve as documentation of steps taking to analyse data and produce results

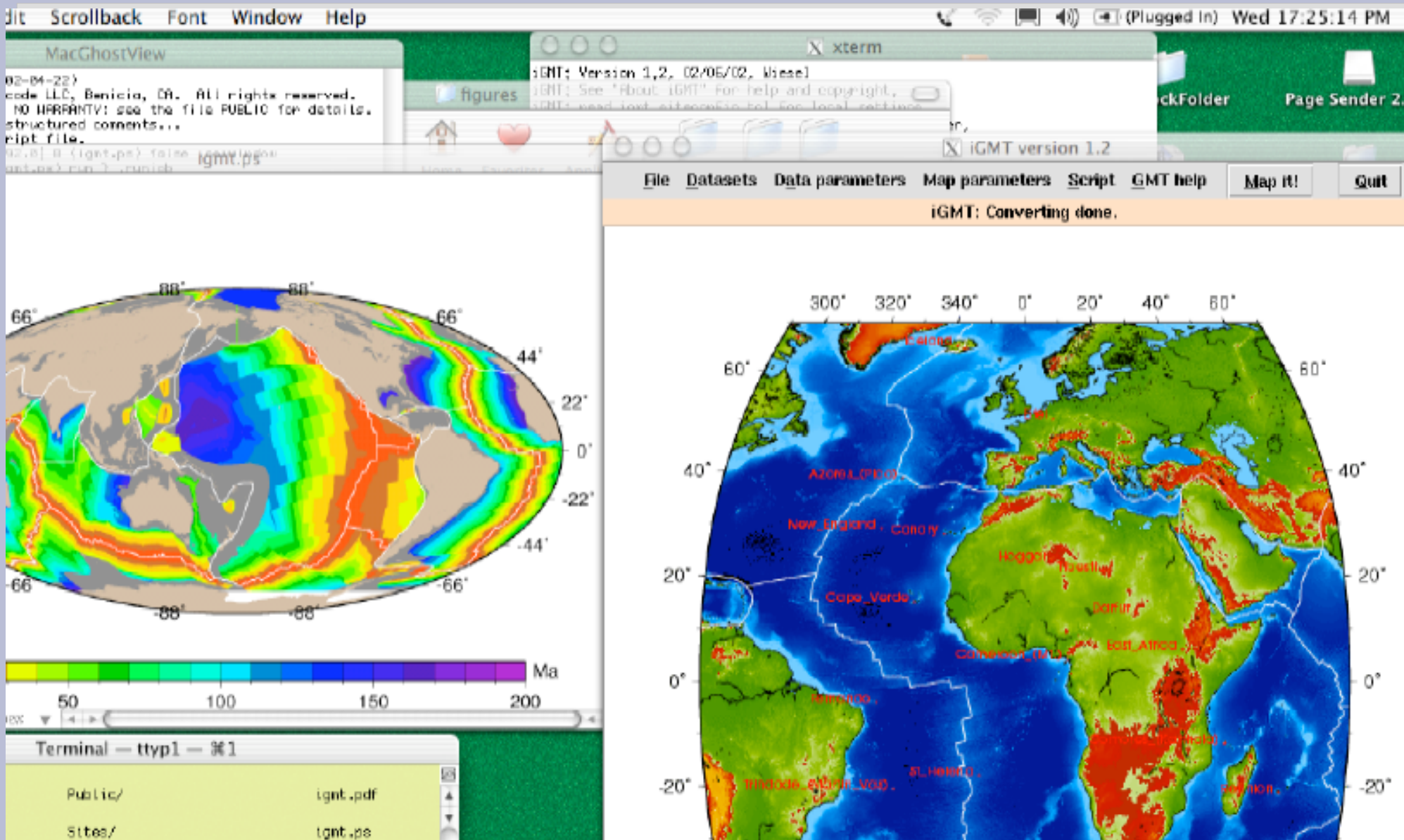
Scripts: An example script

```
#!/bin/bash
#
# run run_fstrack for different models
#
models=${1-"pmDsmean_nt pmDnngrand_nt saf1 saf2 saf3 "}
strains=${2-"2 1 0.5"}

# PBS queues to use
q1="becker64";q2="scec"

c=0
for m in $models;do
    cd $m
    for s in $strains ;do
        if [ $c -eq 1 ];then
            queue=$q1;c=0
        else
            queue=$q2;c=1
        fi
        # regional
        ../run_fstrack 1 0 0 0 $s 1 2 1 -14 0 60 "" 1 $queue
    done
    cd -
done
```

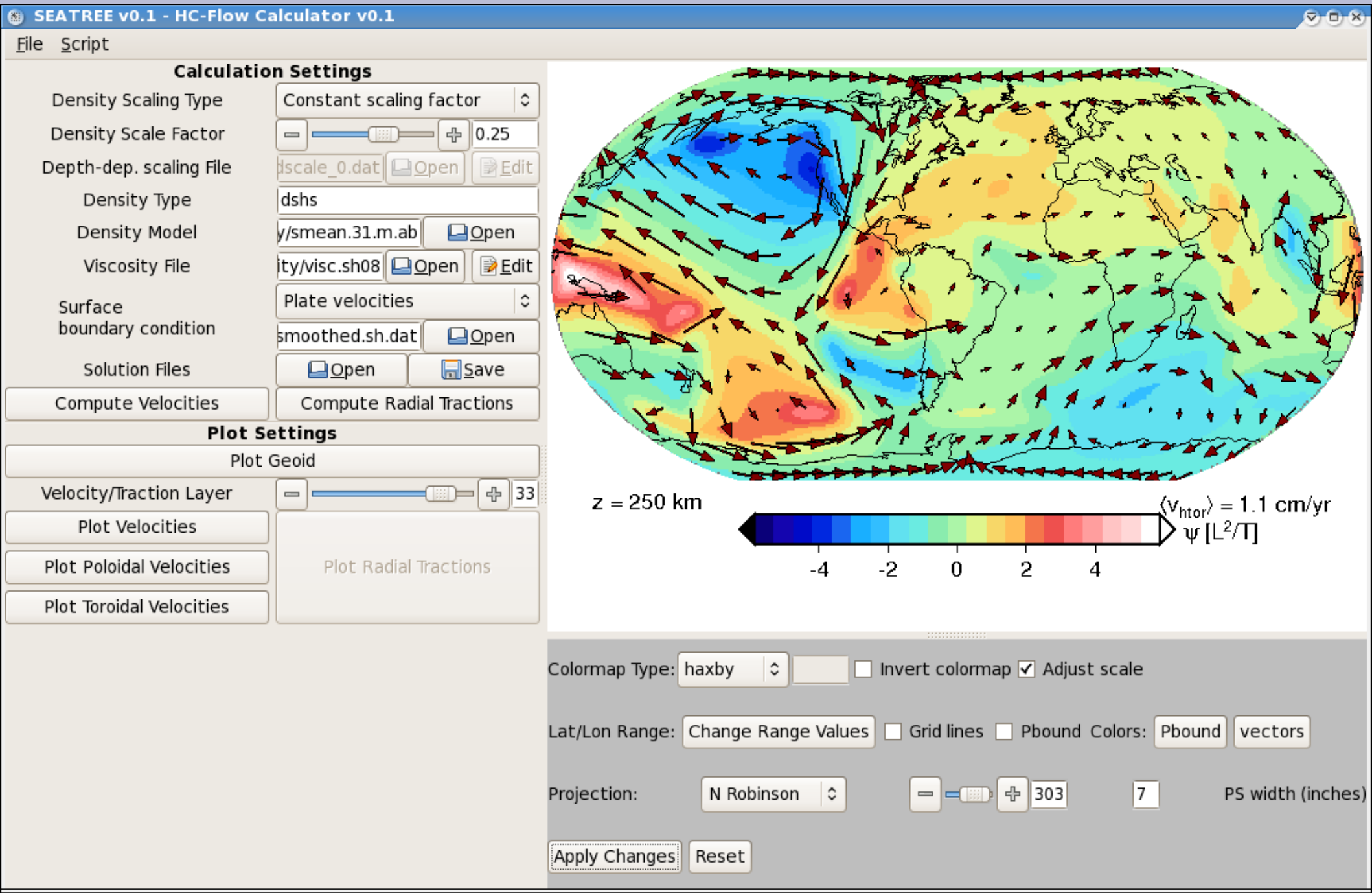
Scripts: scripting languages

- csh, tcsh
- bash
- perl
- *python*
- Scripted programs
  - gnuplot
  - Matlab
  - GMT
- Script whenever you can (because you'll want to reproduce things exactly)

Scripts: Visual scripting languages: Tcl/TK (*e.g. iGMT*), *GTK, Tkinter, Qt*



GUIs: Python and Gtk: SEATREE



Scripting

- Can be the way to go if individual processing steps are not time-sensitive
- If speed is an issue, need to compile from higher level language such as script
- For basic LINUX automatization tasks, bash and awk are very useful
- Python seems to be a nice middle ground for more advanced projects

Bash script programming

```
#!/bin/bash
#
# run run_fstrack for different models
#
models=${1-"pmDsmean_nt pmDnngrand_nt saf1 saf2 saf3 "}
strains=${2-"2 1 0.5"}

# PBS queues to use
q1="becker64";q2="scec"

c=0
for m in $models;do
    cd $m
    for s in $strains ;do
        if [ $c -eq 1 ];then
            queue=$q1;c=0
        else
            queue=$q2;c=1
        fi
        # regional
        ../run_fstrack 1 0 0 0 $s 1 2 1 -14 0 60 "" 1 $queue
    done
    cd -
done
```

Bash scripting

- Command line arguments

```
file=${1-”tmp.grd”}
```

- If, case statements

```
if [[ $file = ”tmp.ps” && $i -eq 1 ]];then
 ...
fi
```

- Loops

```
while [ $i -le $n ];do
 ...
 ((i=i+1))
done
```

Bash scripting

- Command evaluation
  `variable = `grd2max $file.grd``
  where `grd2max` is another script:

```
#!/bin/bash
#
# program to find the maximum value of an Netcdf grd file using
# the GMT tool grdinfo
#
pname=`basename $0`
if [ $# -ne 1 ]; then           # need at least one argument
    echo $pname: usage: > /dev/stderr
    echo $pname file    > /dev/stderr
exit

if [ ! -s $1 ];then             # file does not exist
    echo $pname: error: file $1 is not there > /dev/stderr
    exit
fi
grdinfo -C $name | gawk '{print($7)}'
```

Bash scripting

- Functions
- Traps

```
tmpn=/tmp/$USER.$HOST.$$.`basename $0`
trap "rm -f $tmpn.* ; exit" 0 1 2 15
```

- Problems:
  - Sensitive to white space (`if [ $i -eq 5]` won't work)
  - Usually only deals with integers (`=` vs. `-eq` comparison)

Experimentation time

- Write a script that outputs:

```
1
2
3
4
5
OK
```

- Write a script that takes input *n* `myscript n` and writes

```
1
2
...
n
OK
```

- Write a script that works such that

```
>hello_user.sh
Hello lebowski!
Your home is: /nihilist/lebowski
Today's date is: Sun Jun 24 18:19:42
CDT 2012
```