Madagascar Open-Source Software Package: Interface to Reproducible Research

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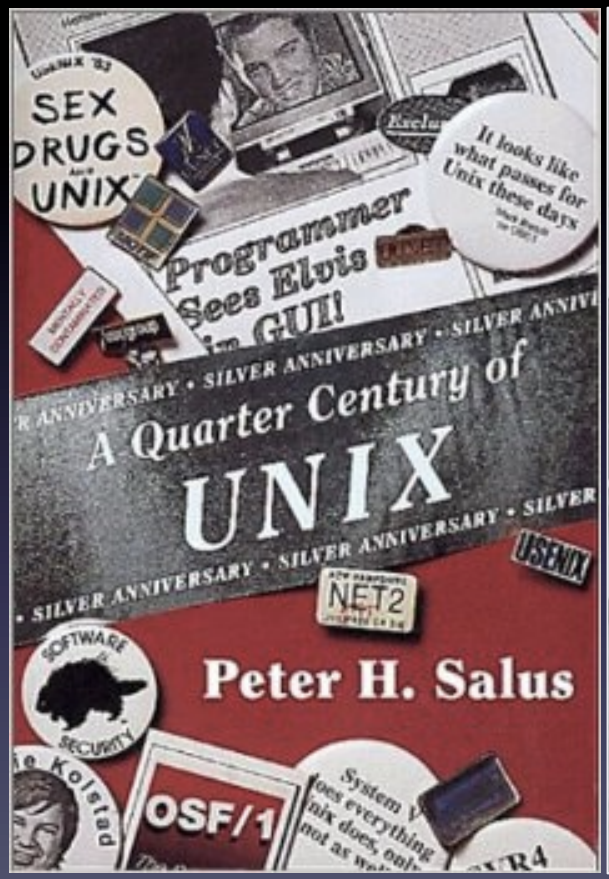
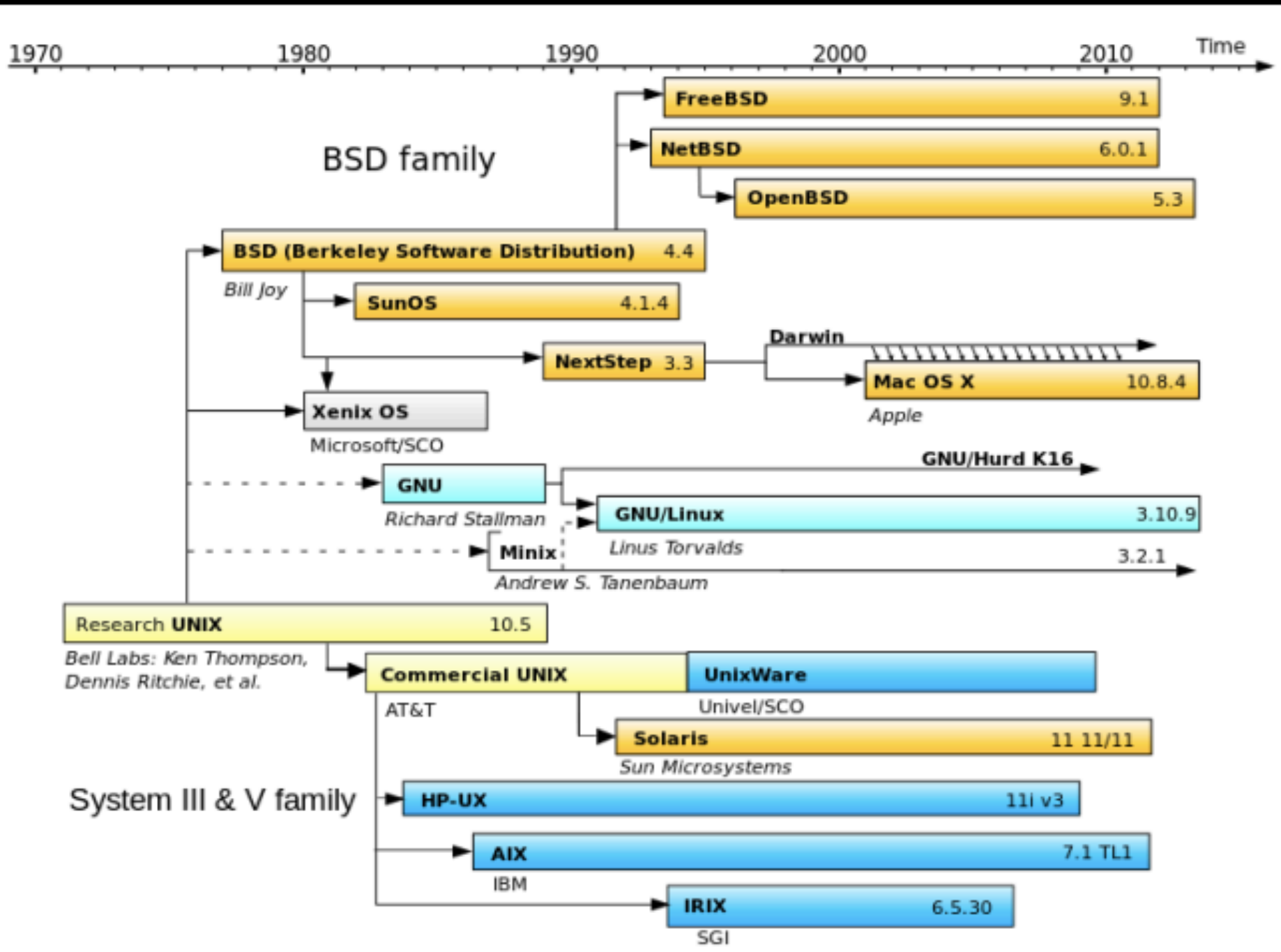
45 Years of Unix

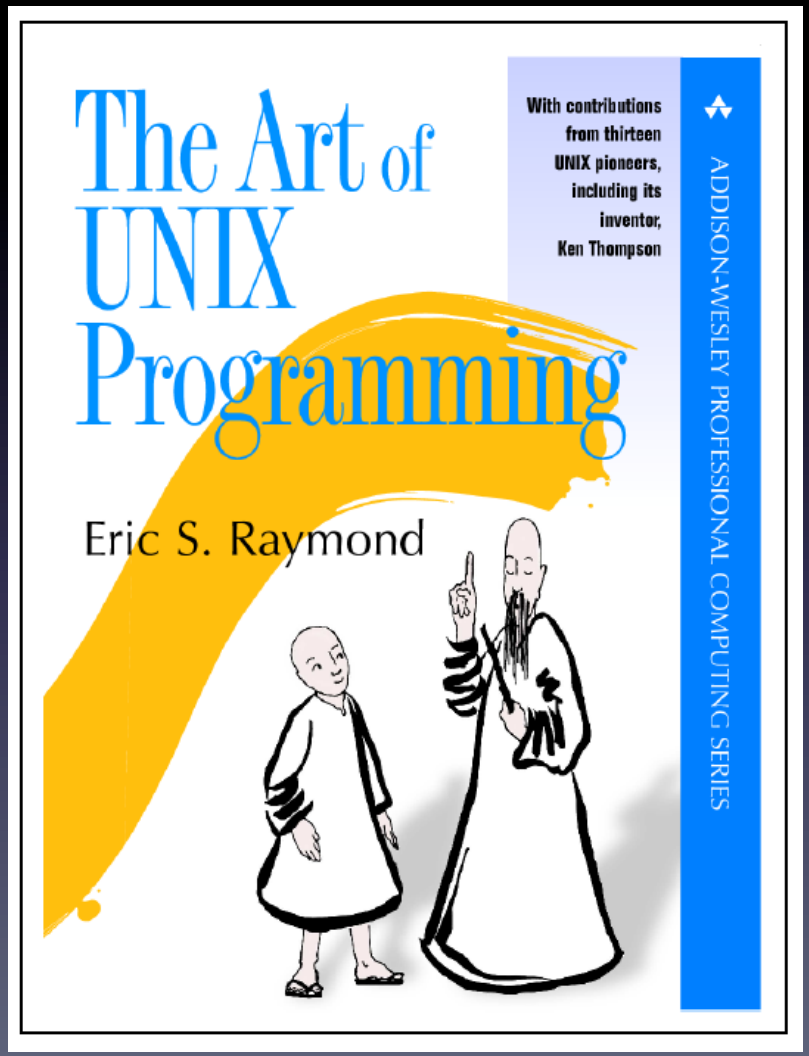



1970
1980
1990
2000
2010
Time
BSD family
FreeBSD 9.1
NetBSD 6.0.1
OpenBSD 5.3
BSD (Berkeley Software Distribution) 4.4
Bill Joy
SunOS 4.1.4
NextStep 3.3
Darwin
Mac OS X 10.8.4
Apple
Xenix OS
Microsoft/SCO
GNU/Hurd K16
GNU
Richard Stallman
GNU/Linux 3.10.9
Linus Torvalds
Minix 3.2.1
Andrew S. Tanenbaum
Research UNIX 10.5
Bell Labs: Ken Thompson, Dennis Ritchie, et al.
Commercial UNIX
UnixWare
AT&T
Univel/SCO
Solaris 11 11/11
Sun Microsystems
System III & V family
HP-UX 11i v3
AIX 7.1 TL1
IBM
IRIX 6.5.30
SGI

Unix Philosophy

"Write programs that do one thing and do it well. Write programs to work together. Write programs to handle text streams, because that is a universal interface."

Doug McIlroy



Outline

- The tao of Unix
- **Madagascar history and status**
- Unix-style abstraction in Madagascar
  - sfdottest/sfconjgrad
  - sfomp/sfmpi
  - pscons/sfbatch
- Reproducible research

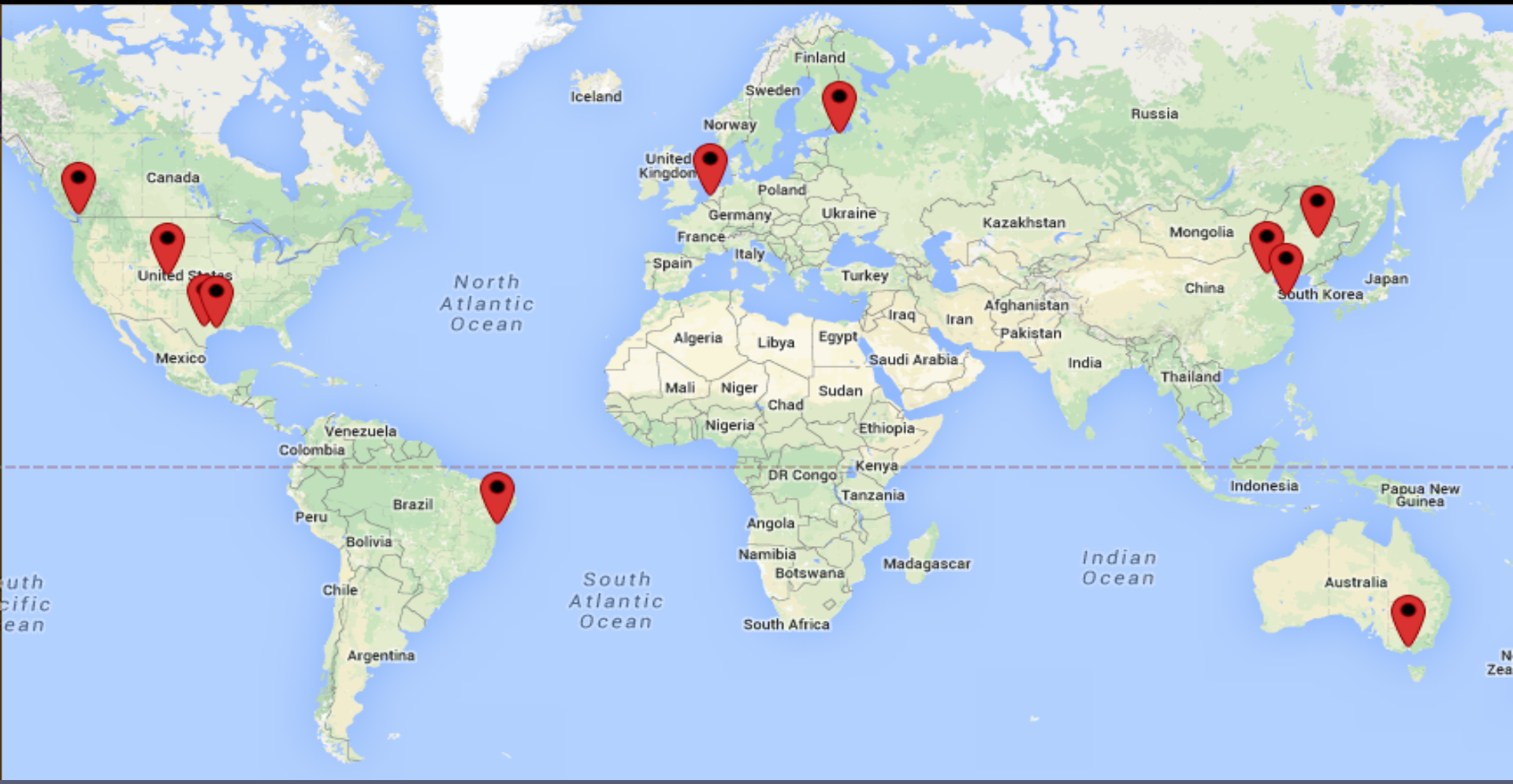
Madagascar Facts

In a Nutshell, Madagascar…

…has had 12,445 commits made by 85 contributors
Representing 1,098,245 lines of code
…is mostly written in C
with an average number of source code comments
…has a well established, mature codebase
maintained by a large development team
with stable Y-O-Y commits
…took an estimated 302 years of effort
starting with its first commit in May, 2003

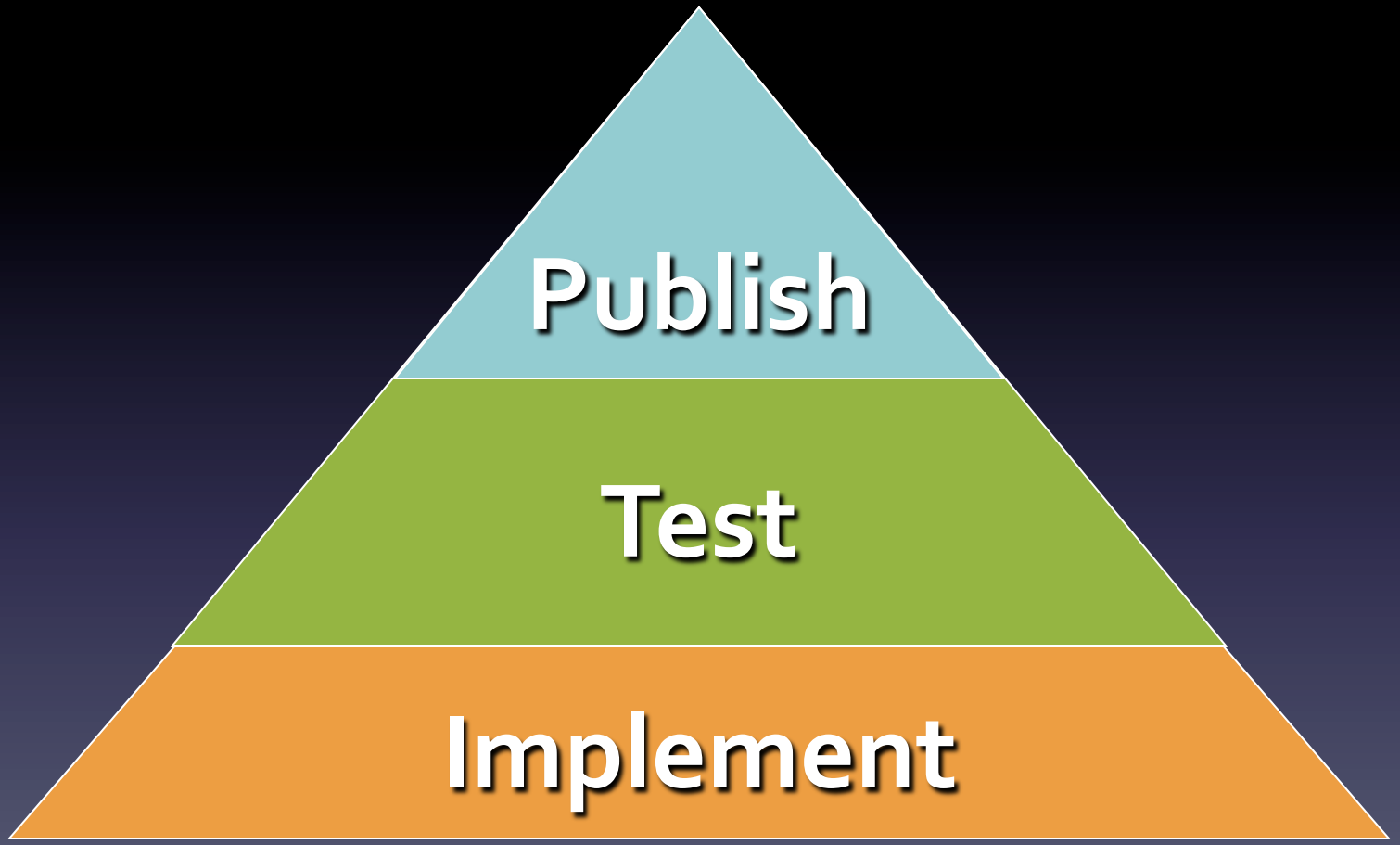
Madagascar Contributors

Madagascar Schools

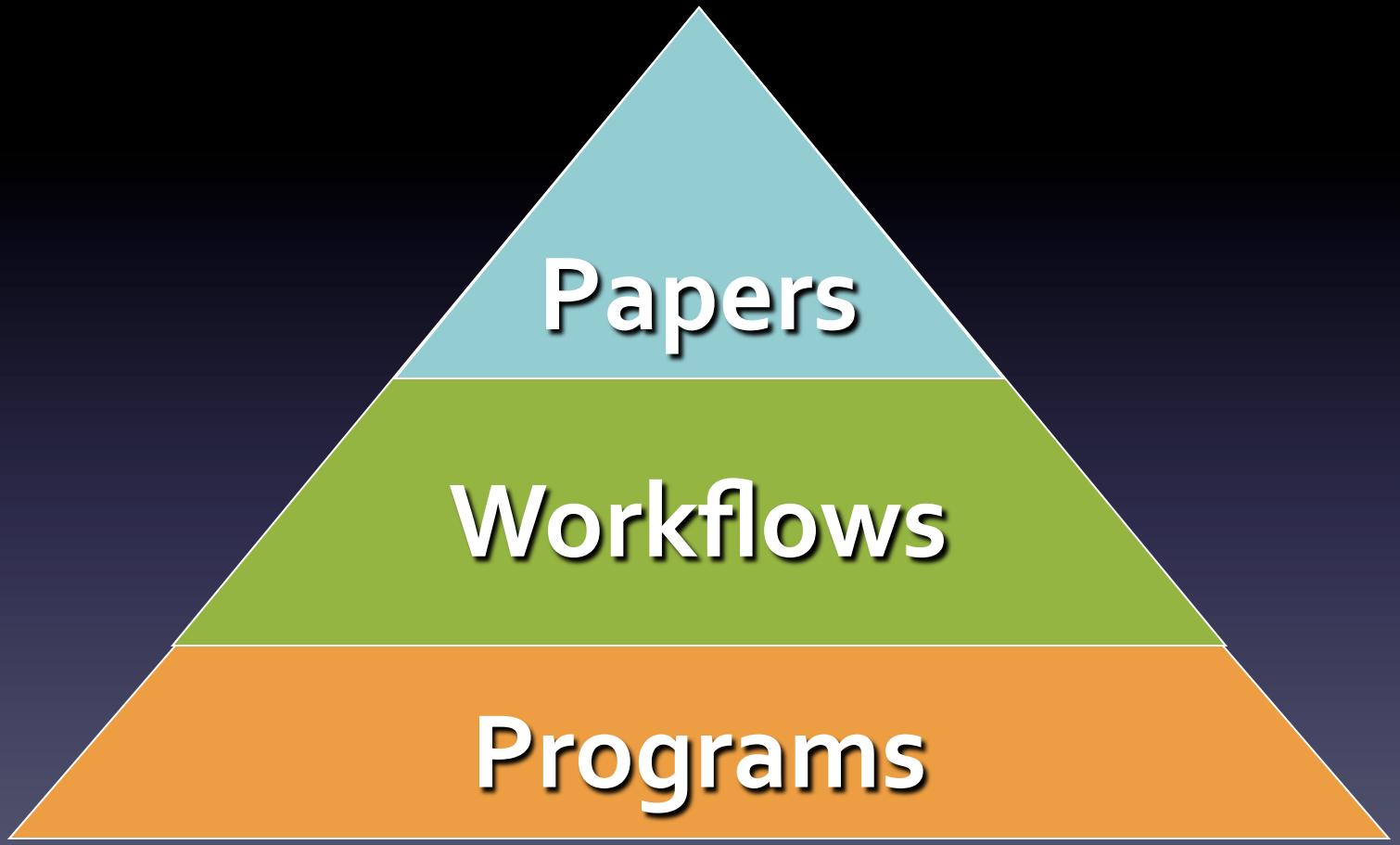



2011年Madagascar计算地球物理暑期学校
2011 Madagascar School on Reproducible Computational Geophysics

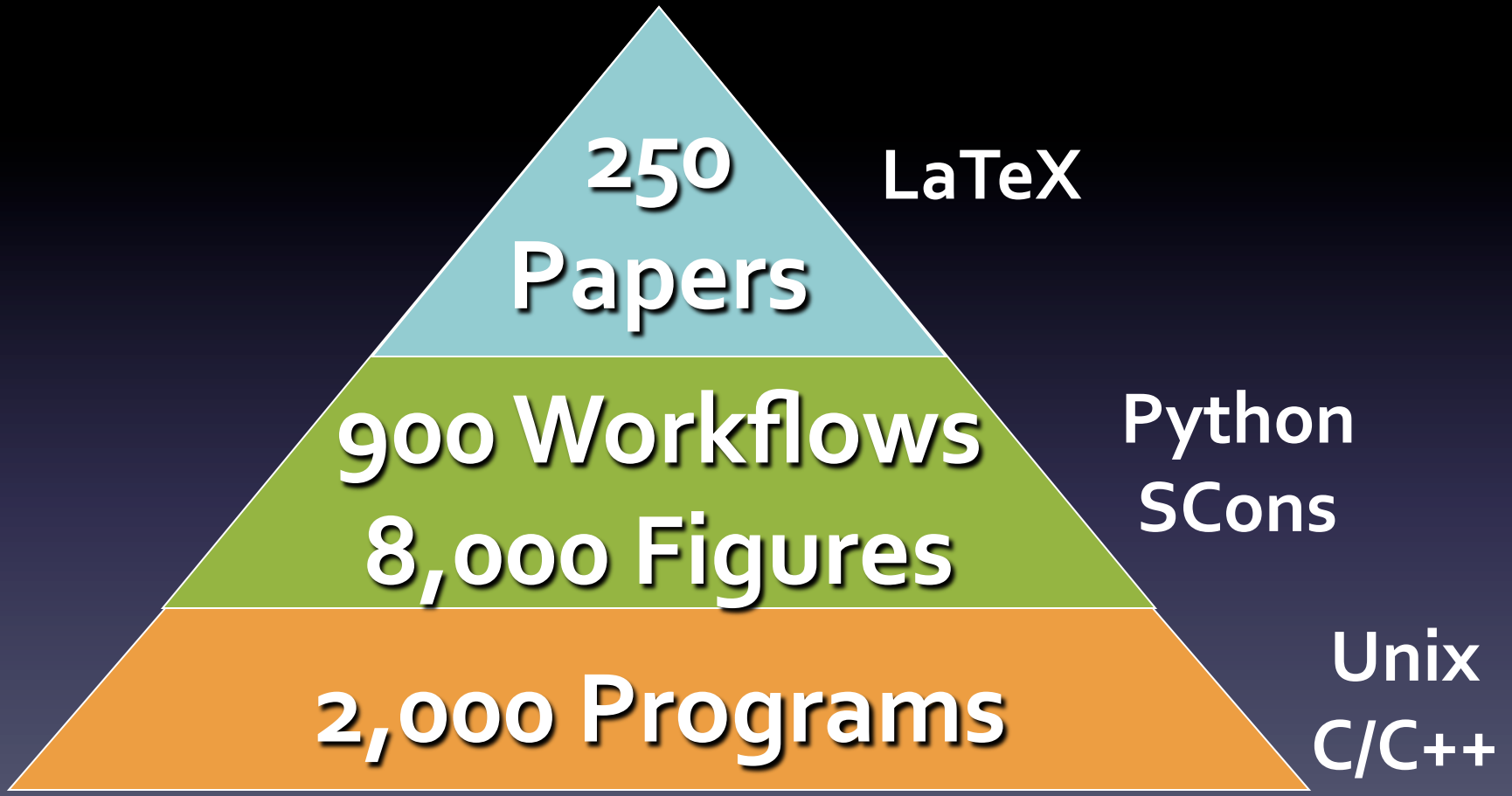
Research Pyramid



Research Pyramid



Research Pyramid



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sfdottest/sfconjgrad

mathematics geophysics

- sfconjgrad sfmodeling velocity=vel.rsf \

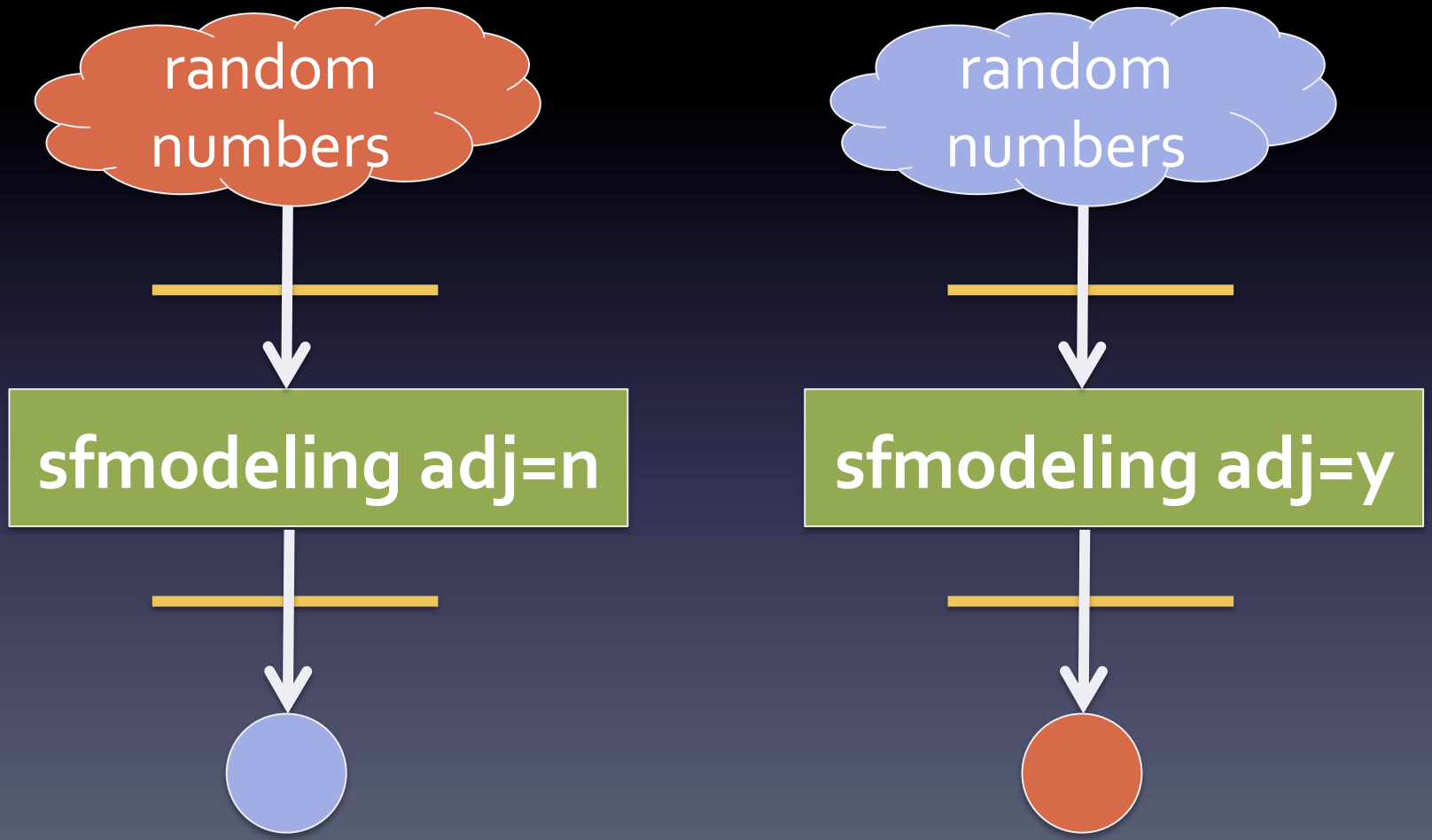
  niter=100 x0=m0.rsf < data.rsf > model.rsf

- sfdottest sfmodeling velocity=vel.rsf \

  mod=model.rsf dat=data.rsf

```
sfdottest:  L[m]*d=1165.87
sfdottest: L'[d]*m=1165.87
```

sfdottest: fork/exec



sfomp/sfmpi

- sfomp sfmodeling split=1 join=2 \

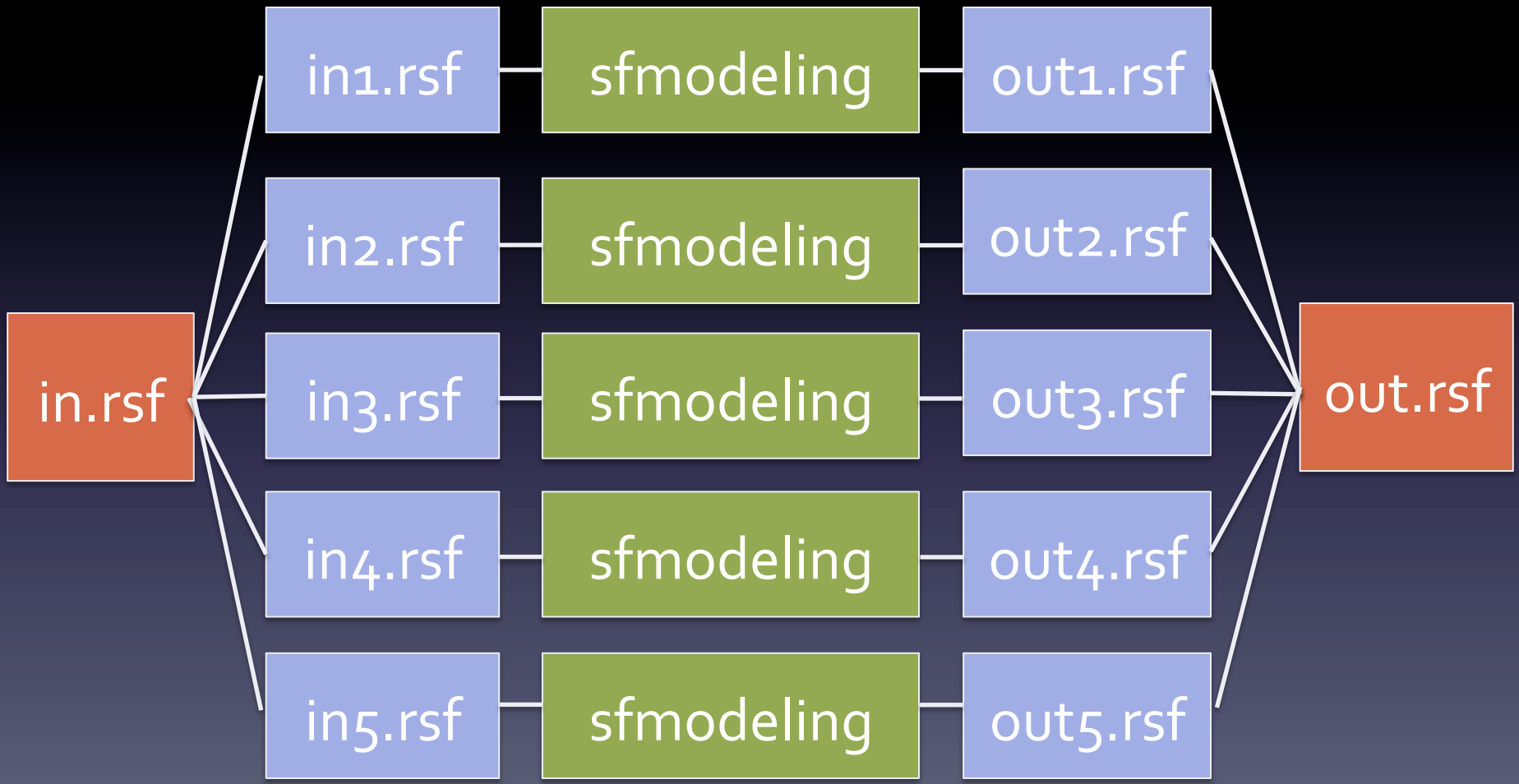
  velocity=vel.rsf < shots.rsf > data.rsf

- mpirun –np 100 sfmpi sfmodeling \

  split=1 join=2 velocity=vel.rsf \

  --input=shots.rsf --output=data.rsf

sfomp/sfmpi


in.rsf
in1.rsf
in2.rsf
in3.rsf
in4.rsf
in5.rsf
sfmodeling
sfmodeling
sfmodeling
sfmodeling
sfmodeling
out1.rsf
out2.rsf
out3.rsf
out4.rsf
out5.rsf
out.rsf

sfbatch/pscons

- sfbatch: submit a job to a shared cluster

```
sfbatch exe='scons NP=100 data.rsf'
```

```
scons BATCH=1 data.rsf
```

- pscons: parallel scons (wrapper for scons –j)

```
Flow('data','shots','modeling',split=[3,'omp'])
```

```
Flow('data','shots','modeling',split=[3,'mpi'])
```

```
Flow('data','shots','modeling',split=[3,1000])
```

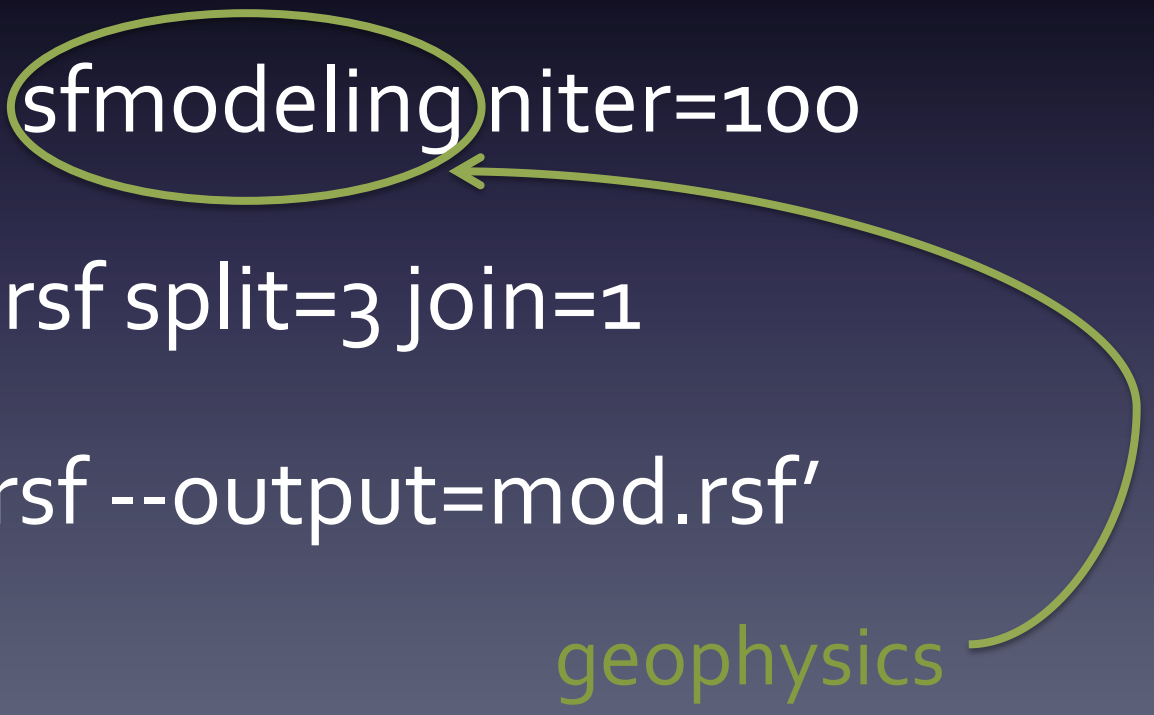
What Does This Command Do?

- sfbatch exe='sfconjgrad mpirun -np 1000

  sfmpi sfomp sfmodeling niter=100

  vel=velocity.rsf split=3 join=1

  --input=dat.rsf --output=mod.rsf'



Python interface

```
def conjgrad(oper,dat,x0,niter):
    'Conjugate-gradient algorithm for minimizing |A x - dat|^2'
    x = x0
    R = oper(adj=0)[x]-dat
    for iter in range(niter):
        g = oper(adj=1)[R]
        G = oper(adj=0)[g]
        gn = g.dot(g)
        print "iter %d: %g" % (iter+1,gn)
        if 0==iter:
            s = g
            S = G
        else:
            beta = gn/gnp
            s = g+s*beta
            S = G+S*beta
        gnp = gn
        alpha = -gn/S.dot(S)
        x = x+s*alpha
        R = R+S*alpha
    return x
```

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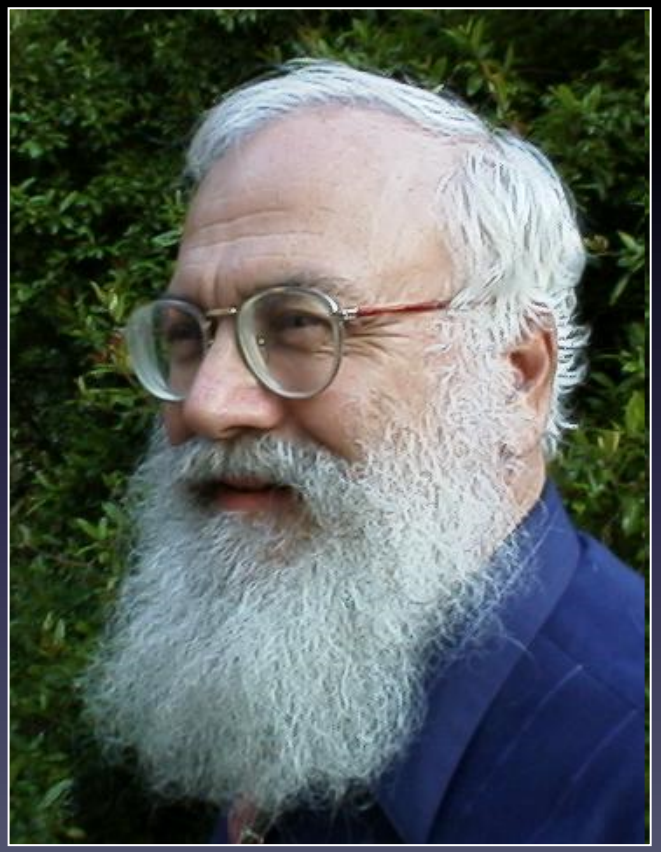
Claerbout's Principle

"An article about computational science in a scientific publication is not the scholarship itself, it is merely advertising of the scholarship. The actual scholarship is the **complete software development environment and the complete set of instructions which generated the figures**."

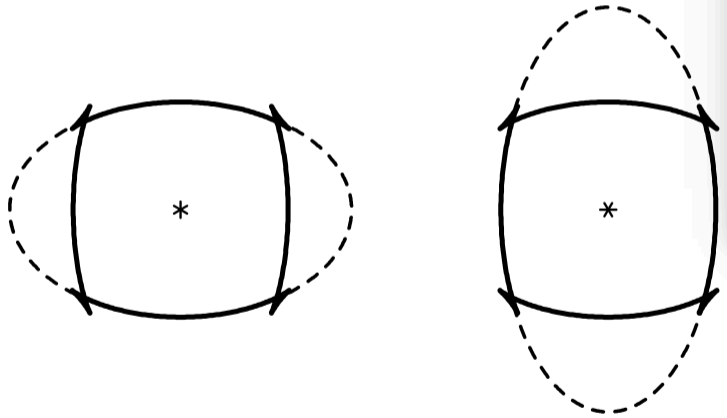
(Buckheit and Donoho, 1995)



Reproducible Research

"It is a big chore for one researcher to reproduce the analysis and computational results of another [...] I discovered that this problem has a simple technological solution: illustrations (figures) in a technical document are made by **programs and command scripts that along with required data should be linked to the document itself** [...] This is hardly any extra work for the author, but it makes the document much more valuable to readers who possess the document in electronic form because they are able to track down the computations that lead to the illustrations." (Claerbout, 1991)

Reproducible Research in PDF



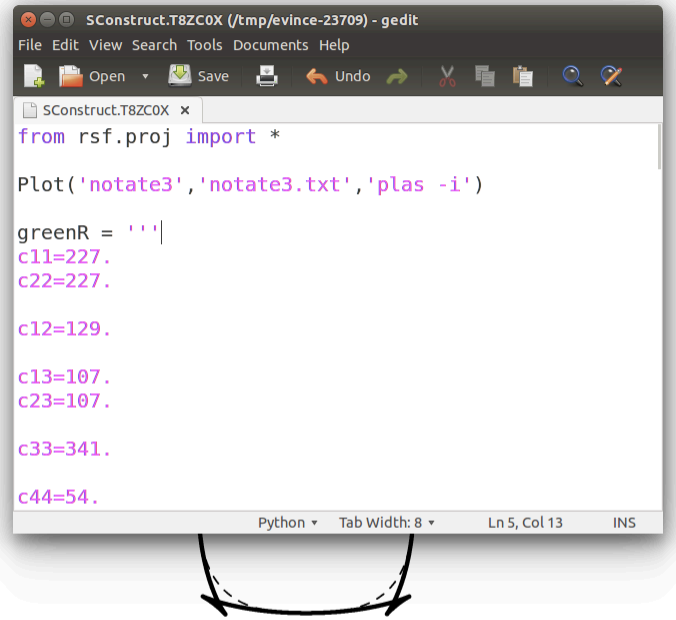
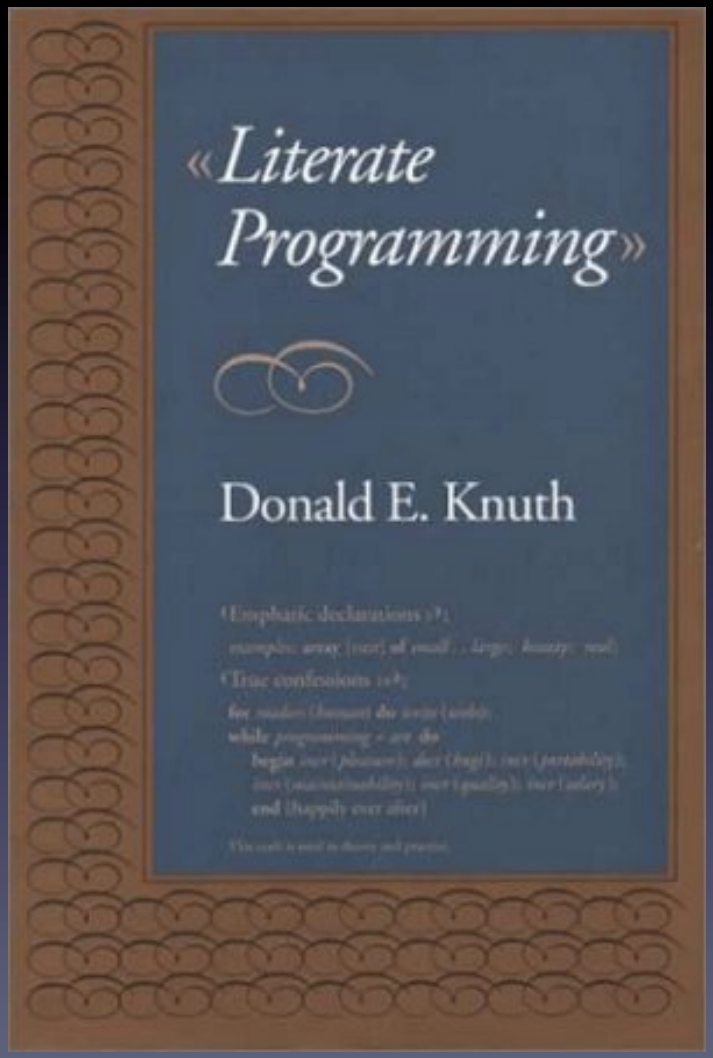
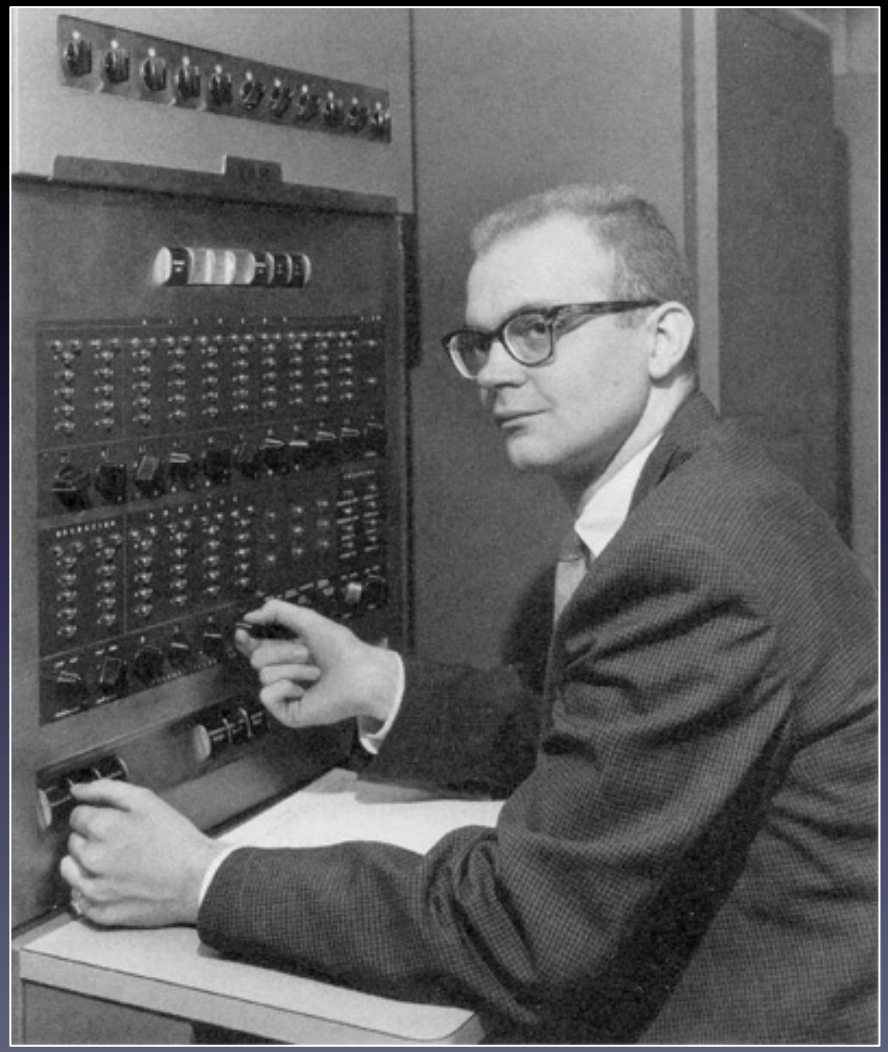


Figure 2: Three different approximations (dashed curves) to the *q*SV impulse-response surface of Greenhorn Shale (bold curves). On the left is the standard vertical paraxial elliptic approximation. In the center is the horizontal paraxial elliptic approximation. On the right is Muir's double-elliptic approximation. vels/ verthoriz

Literate Programming

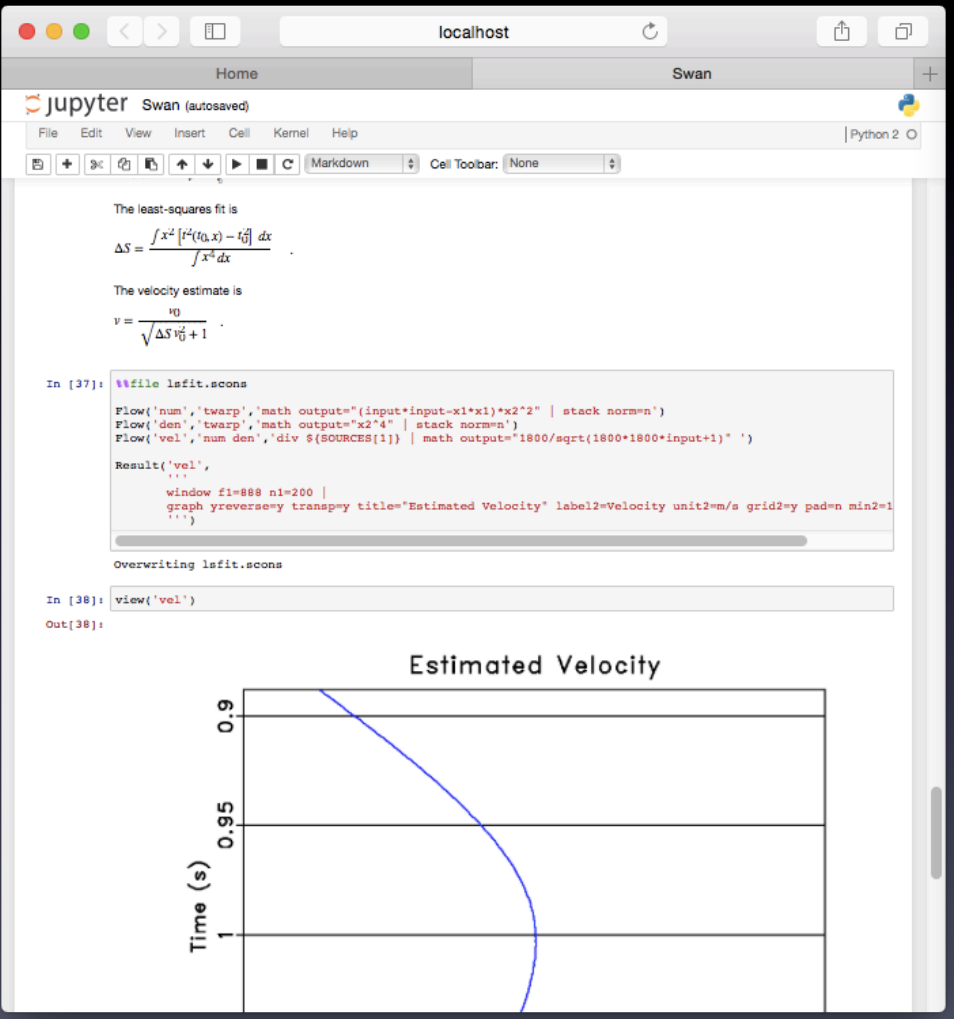


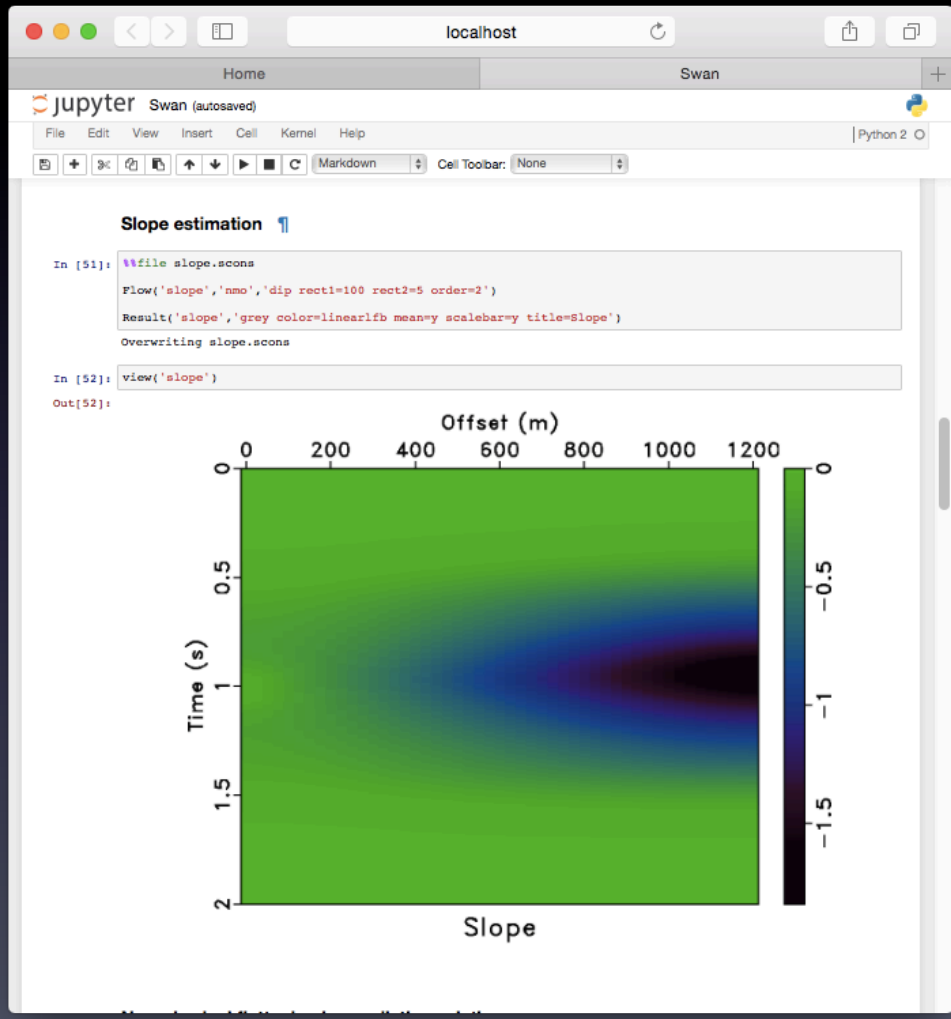


Literate Programming

"The basic idea of literate programming is to take a fundamentally different starting point for the presentation of programs to human readers, without any direct effect on the program as seen by the computer. Rather than to present the program in the form in which it will be compiled (or executed), and to intercalate comments to help humans understand what is going on (and which the compiler will kindly ignore), the presentation focuses on **explaining to humans the design and construction of the program, while pieces of actual program code are inserted to make the description precise and to tell the computer what it should do**." (van Leeuwen, 1990)

Literate Programming in IPython/Jupyter Notebooks





MADAGASCAR

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