Reproducible Research: Experience of the MADAGASCAR Open-Source Project

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ON SEISMIC COMPUTATIONS, WITH APPLICATIONS, I

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INTRODUCTION

The problem of depth determinations from data obtained by the method commonly called “reflection shooting” is an interesting one and one which, very often, assumes an importance that justifies a good deal of study. It is the purpose of this paper to indicate a method

1 Published by permission of the Board of Directors, Humble Oil and Refining Company.

2 Mathematician, Geophysics Department, Humble Oil and Refining Company.
Editor's Note: The term "doodle-bug" is coming more and more to mean proposed methods of geophysical prospecting that are neither based upon scientific fact nor upon known or proven properties of oil, minerals and geologic formations. The geophysicist is often consulted concerning the reliability of such a proposed method, and his task then is to explain scientifically just why the proposed method fails and is unsuitable for the intended purpose.
What is Science?
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Science is the systematic enterprise of gathering knowledge about the universe and organizing and condensing that knowledge into testable laws and theories. The success and credibility of science are anchored in the willingness of scientists to independent testing and replication by other scientists. This requires the complete and open exchange of data, procedures and materials. American Physical Society, What is Science?
Abandoning the habit of secrecy in favor of process transparency and peer review was the crucial step by which alchemy became chemistry. In the same way, it is beginning to appear that open-source development may signal the long-awaited maturation of software development as a discipline.

Eric Raymond, TAUP, 2004
What is Reproducible Research?

- Attaching software code and data to publications
- Communicating computational results to a skeptic

*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.*  
*J. Buckheit and D. Donoho, WaveLab*
Reproducible Research Discussions

ICASSP 2007
Berlin-6 2008
CiSE 2009

► Donoho et al.
► LeVeque
► Ping & Eckel
► Stodden

IEEE Signal Processing Magazine 2009
► Vandewalle et al.

Yale Roundtable 2009
NSF Archive Workshop 2010

► http://www.reproducibleresearch.net
Reproducible Research Discussions

AAAS 2011
- The Digitization of Science: Reproducibility and Interdisciplinary Knowledge Transfer

SIAM CS&E 2011
- Verifiable, Reproducible Research and Computational Science

SIAM GS 2011
- This minisymposium

AMP 2011
- Reproducible Research: Tools and Strategies for Scientific Computing

ICIAM 2011
- Reproducible Research in Computational Science: What, Why and How
Reproducible Research

History of Madagascar

Outline

Reproducible Research

History of Madagascar
Jon Claerbout’s Story

1987 Sunview experience
▶ Interactive programs are slavery

1992 \textsf{LATEX} + cake
▶ Building books by a single command

1990s Ph.D. students
▶ cake to make, CD-Rom to WWW

2001 Reproducible research paper in \textit{CiSE}
▶ The principal beneficiary is the author
The principal beneficiary is the author.
http://reproducibility.org/
http://ahay.org/
Lesson 2

▶ http://www.ahay.org/wiki/Reproducible_Documents

Each computation is a test.
Thanks

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School and Workshop: Houston 2010
Lessons 3 and 4

Reproducibility requires maintenance.
Maintenance requires an open community.
MADAGASCAR Design

- Multidimensional arrays as files

  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, Unix
#include <rsf.h>

int main(int argc, char* argv[])
{
    int n1, n2, i1, i2;
    float clip, *trace;
    sf_file in, out;

    sf_init(argc,argv);
    in  = sf_input("in");
    out = sf_output("out");

    sf_histint(in,"n1",&n1); /* trace length */
    n2 = sf_leftsize(in,1); /* number of traces */
    if (!sf_getfloat("clip",&clip)) sf_error("Need clip=");

    trace = sf_floatalloc(n1);
    for (i2=0; i2 < n2; i2++) {
        sf_floatread(trace,n1,in);
        for (i1=0; i1 < n1; i1++) {
            if (trace[i1] > clip) trace[i1]= clip;
            else if (trace[i1] < -clip) trace[i1]=-clip;
        }
        sf_floatwrite(trace,n1,out);
    }

    exit(0);
}
MADAGASCAR filter in Python

```python
#!/usr/bin/env python

import numpy
import m8r

par = m8r.Par()
input = m8r.Input()
output = m8r.Output()

n1 = input.int("n1")  # trace length
n2 = input.size(1)    # number of traces

clip = par.float("clip")

trace = numpy.zeros(n1, 'f')
for i2 in xrange(n2):  # loop over traces
    input.read(trace)
    trace = numpy.clip(trace, -clip, clip)
    output.write(trace)
```

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SIAM Geosciences 2011
MADAGASCAR SConstruct script

```python
from rsf.proj import Flow

Flow('spike',None,'spike n1=1000 n2=100 | bandpass fhi=10')
Flow('cliped','spike','clip clip=0.5')
```

bash$ scons
scons: Building targets ...
/usr/bin/sfspike n1=1000 n2=100 | /usr/bin/sfbandpass fhi=10 > spike.rsf
< spike.rsf /usr/bin/sfclip clip=0.5 > cliped.rsf
scons: Done building targets.
bash$ sed -i'' -e's /0.5/0.25/ ' SConstruct
bash$ scons -Q
< spike.rsf /usr/bin/sfclip clip=0.25 > cliped.rsf

▶ http://www.scons.org/

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Reproducible research

- Attaching software and data to publications
- Computational experiments communicated to a skeptic

**MADAGASCAR Lessons**

1. The principal beneficiary is the author.
2. Each computation is a test.
3. Reproducibility requires maintenance.
4. Maintenance requires an open community.