Programming and Modelling (week 36)

C. Thieulot

Institute of Earth Sciences

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1997 Bachelor in mathematics

2000 Masters in theoretical physics

2004 PhD in non-equilibrium hydrodynamics and numerical modelling

2005 Various post-docs in Computational Geodynamics

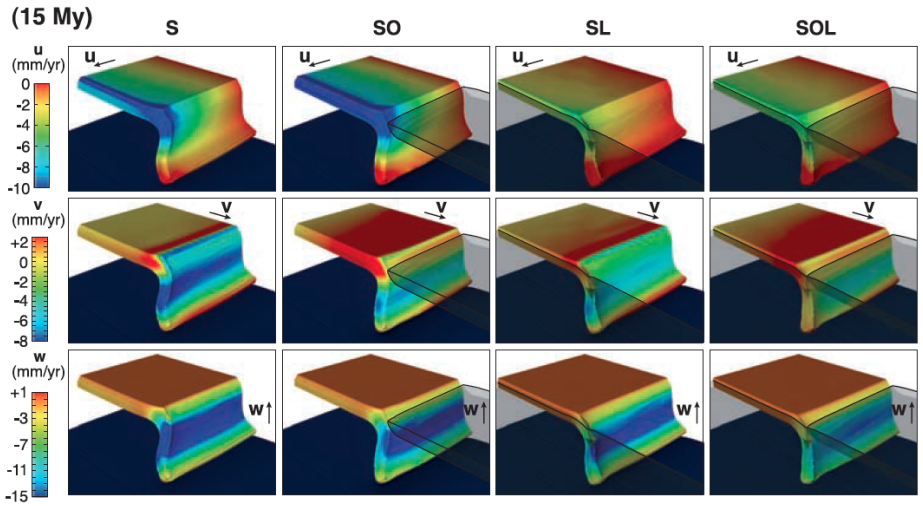
2012 Post-Doc at University of Utrecht

2015 Assistant Prof. at University of Utrecht

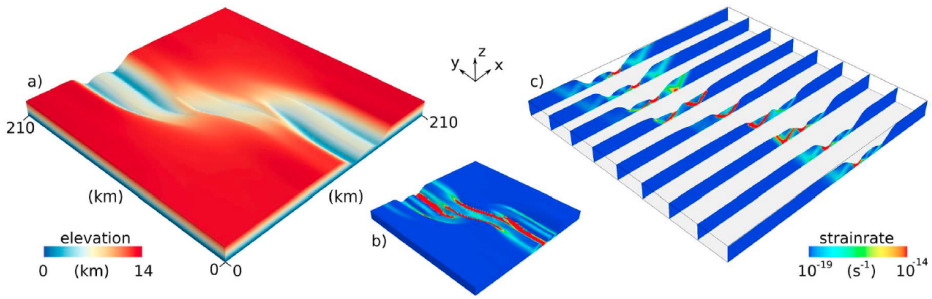
motivation (1)

- getting acquainted with the art of programming
- develop a systematic reasoning
- learn the basics of a programming language (transferable skill)
- understanding more internet jokes such as:
  "There are 10 types of people in this world. Those who understand binary, and those who don't."

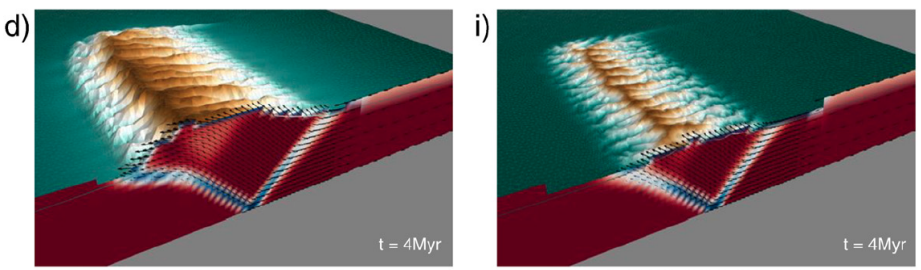
motivation (2)



(3D subduction)

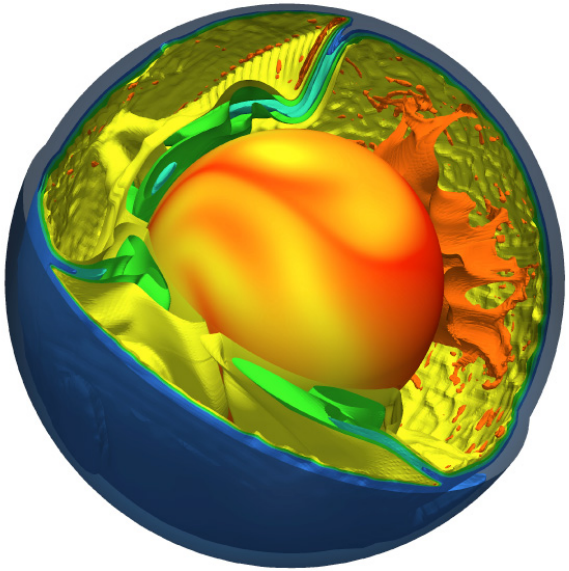


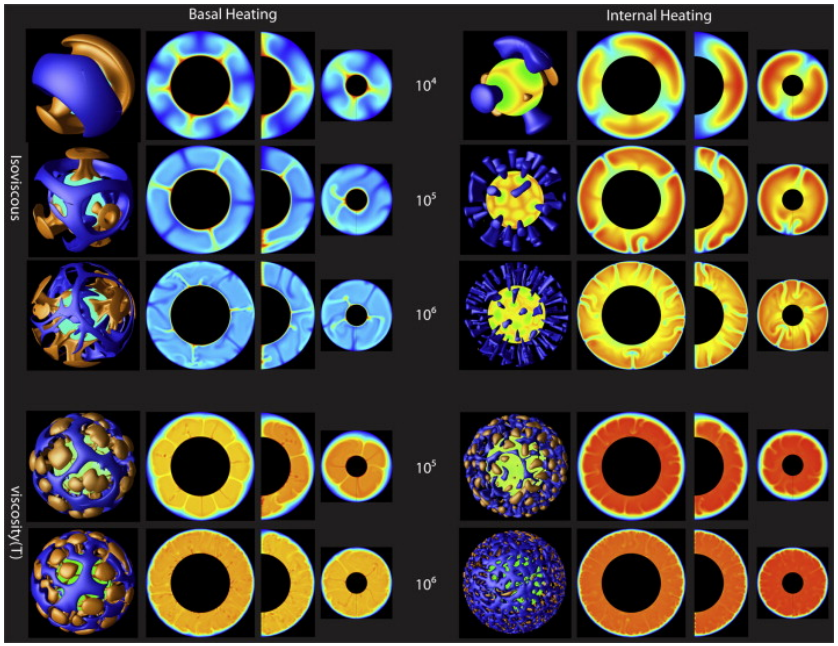
(rift interaction)

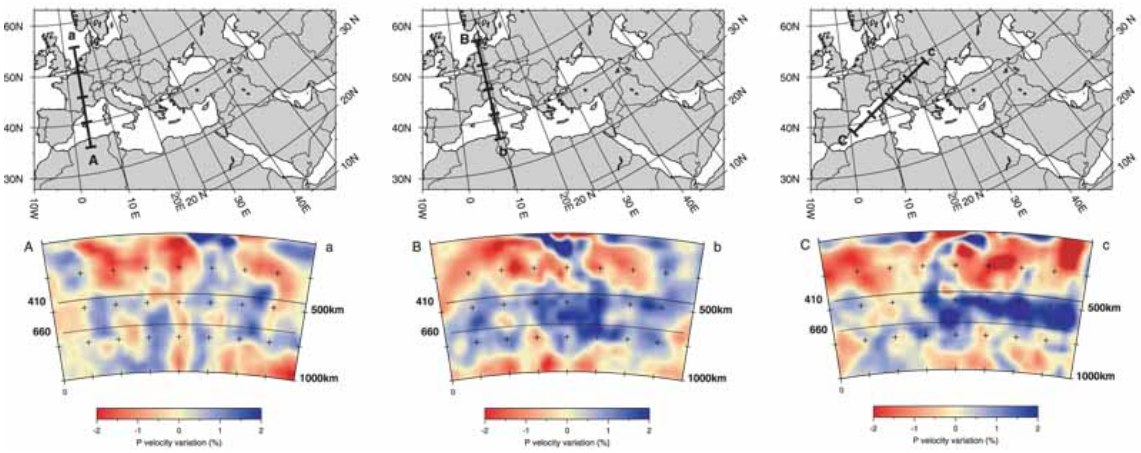


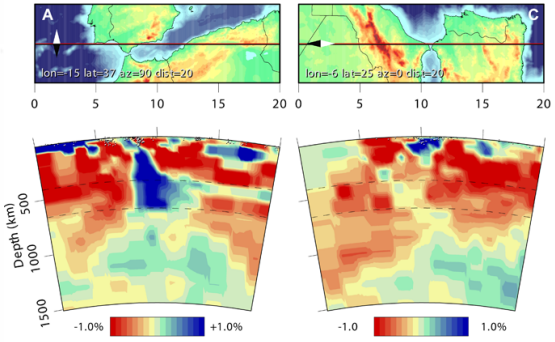
(erosion+orogenesis)

motivation (3)



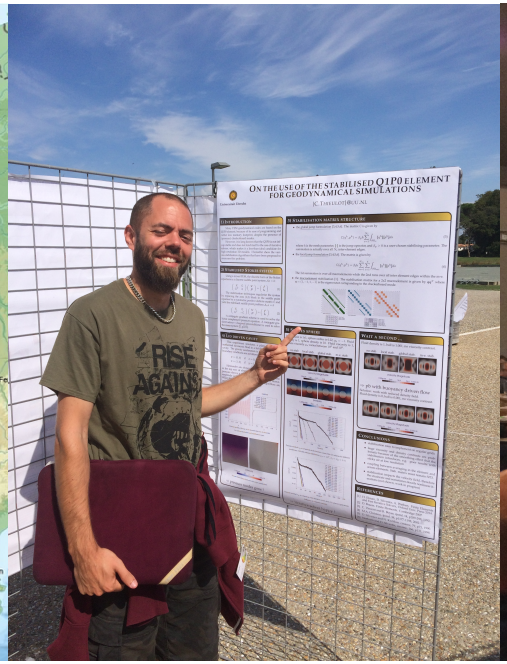






(mantle modelling and tomography)

motivation(4)



XIV International Workshop on Modelling of Mantle and Lithosphere Dynamics, Aug 31st, Sept. 5th 2015, Oleron, France.

motivation(5)

motivation (6)

Q: Why do we have to use computers ?

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A: Because the equations used to describe the physical phenomena most often do not have an analytical solution.

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Let us look at the Stokes equation:

$$\boldsymbol{\nabla} \cdot (\mu \boldsymbol{\nabla} \boldsymbol{v}^s) - \boldsymbol{\nabla} p = \rho \boldsymbol{g}$$

μ is the dynamic viscosity ($Pa.s$), which can depend on:

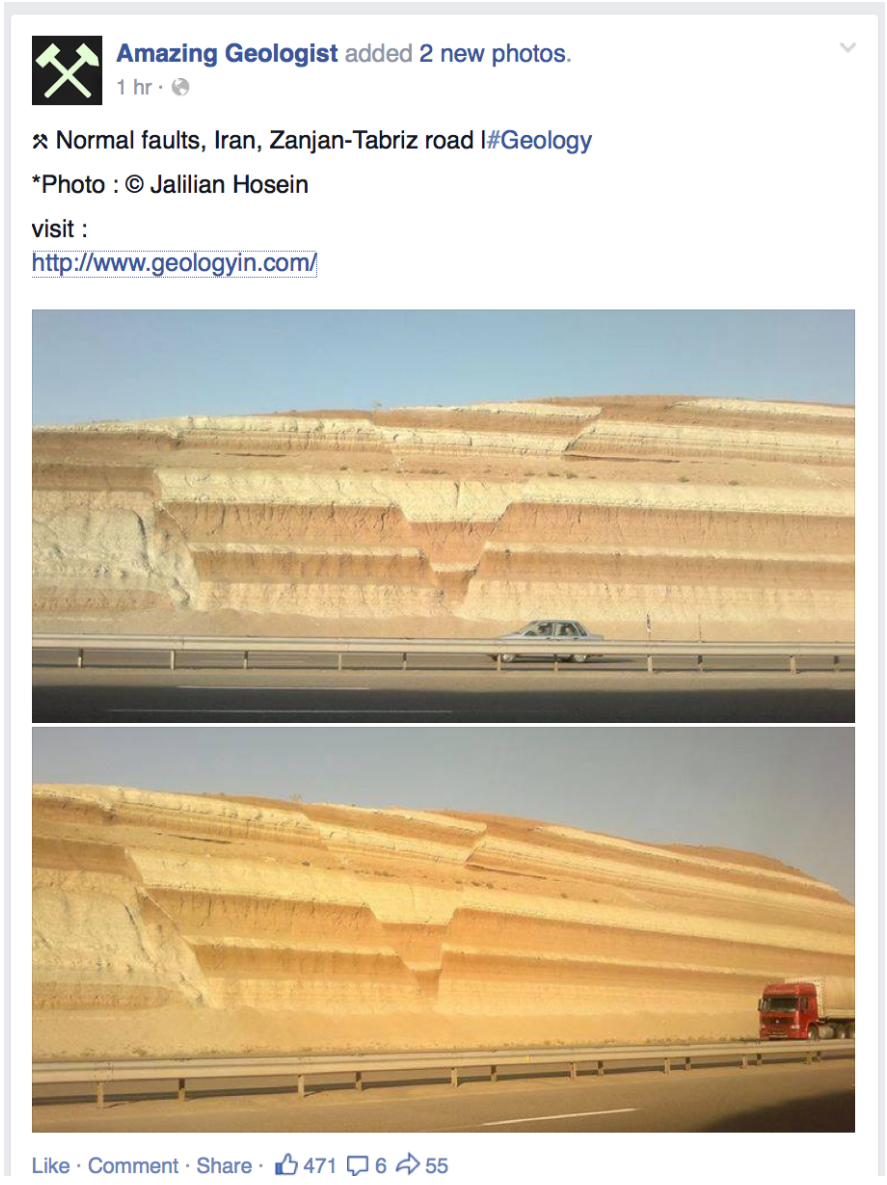
- local velocity gradient (strainrate)
- temperature
- composition
- history of deformation
- depth/pressure

(numerical) modelling

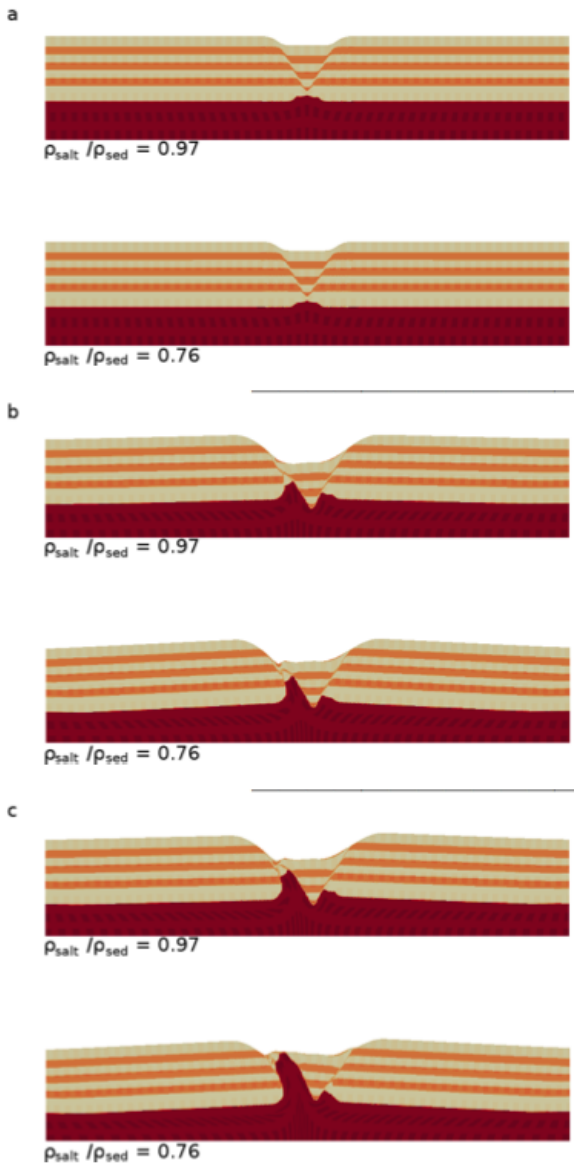
How do we build a model of the observed reality ?

- observe and quantify the observed reality
- find a mathematical description which takes the physical processes at hand in account
- find the appropriate numerical methods for this type of equation(s)
- code design, platform, language, ...
- coding/programming
- testing parts individually, then the whole code
- build experience by using the code on progressively more and more complex systems
- produce awesome results, publish in Nature, get rich and famous

Example

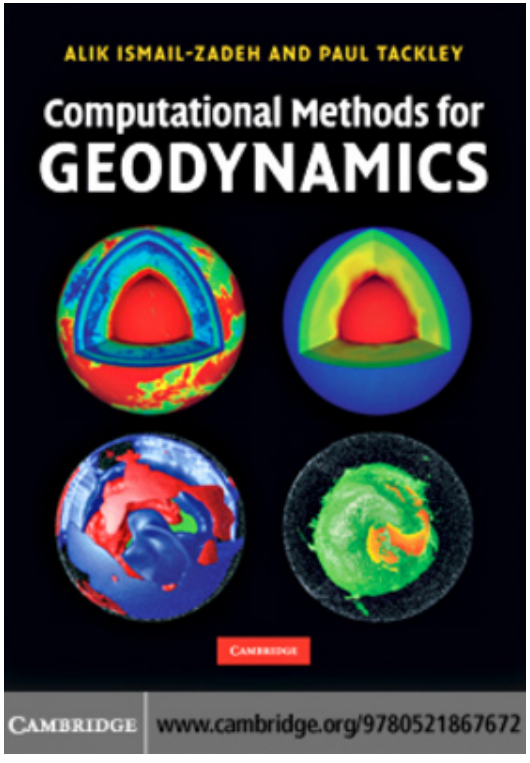


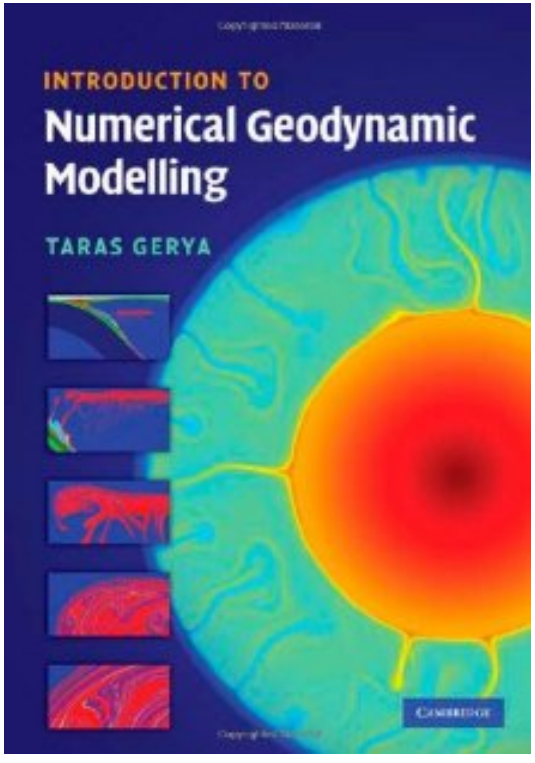
Facebook

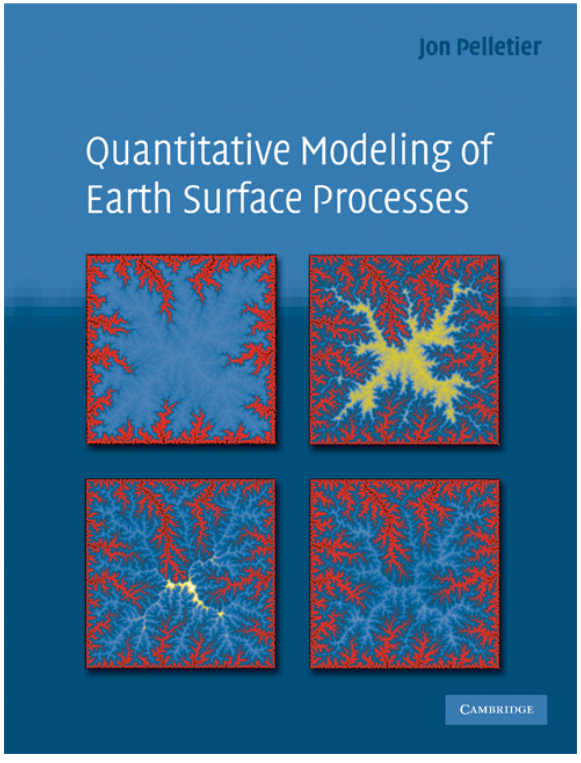


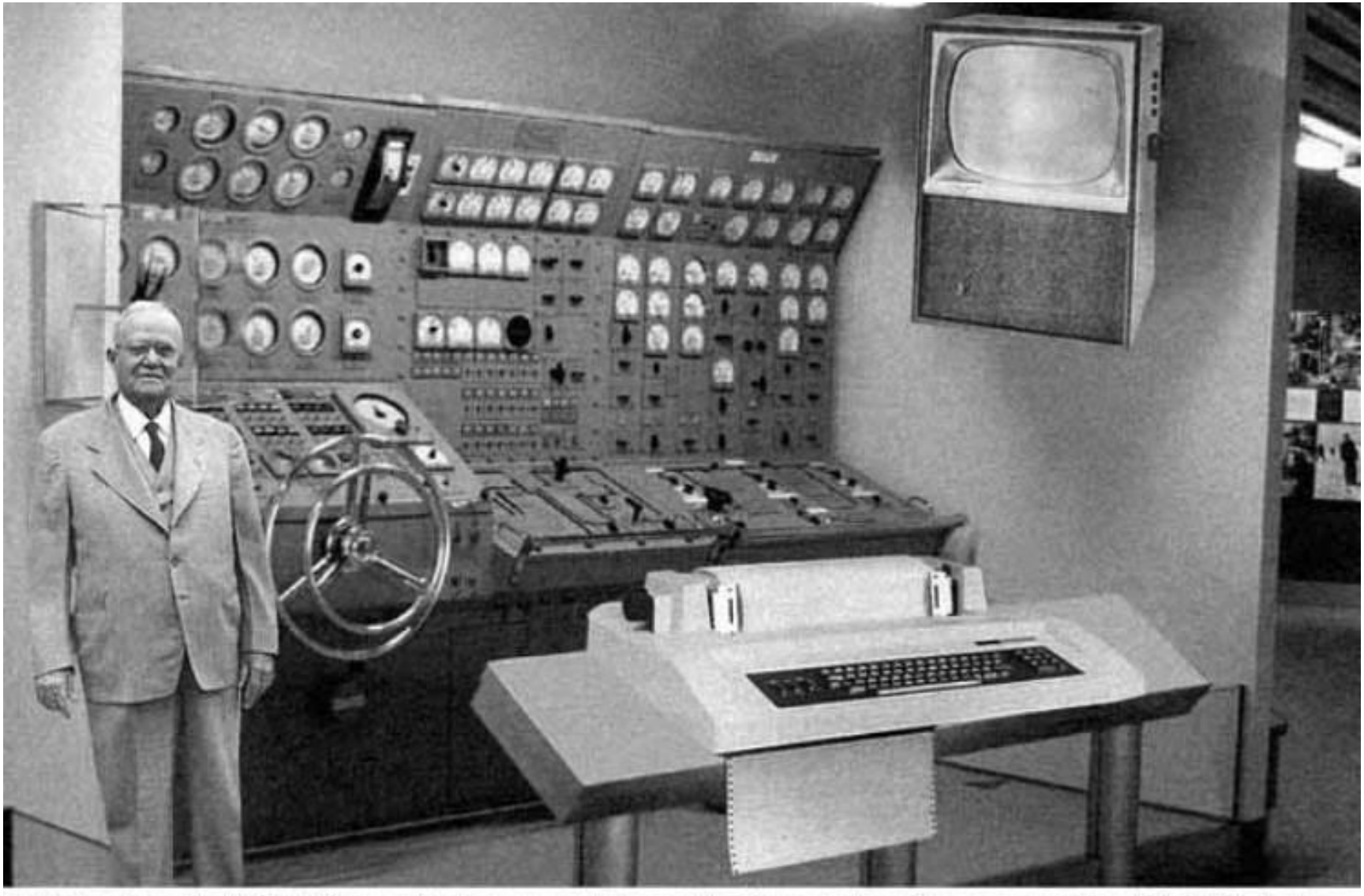
G. Harms, Masterscriptie, 2015

Some help

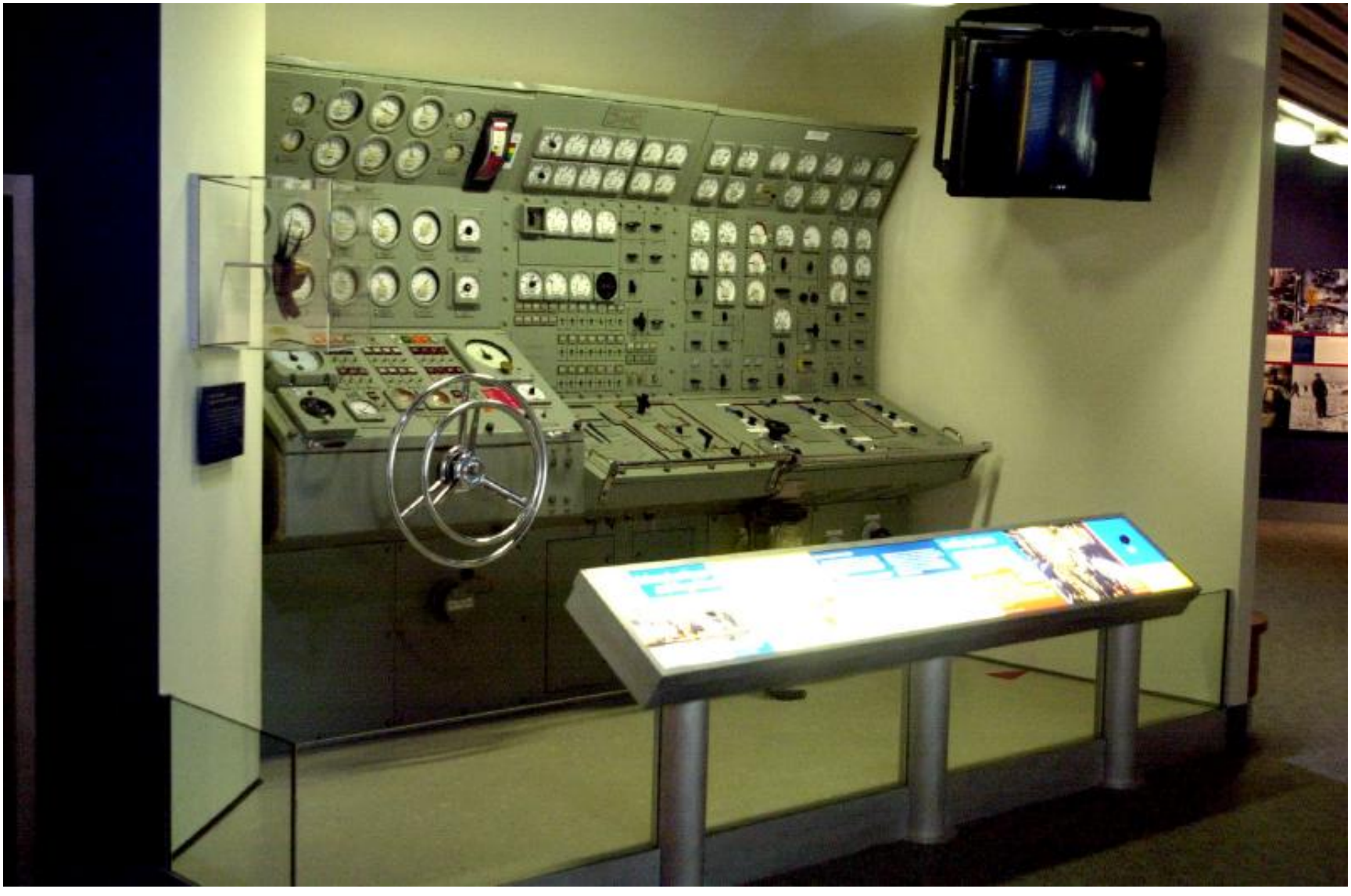

ALIK ISMAIL-ZADEH AND PAUL TACKLEY
Computational Methods for
GEODYNAMICS
CAMBRIDGE
www.cambridge.org/9780521867672

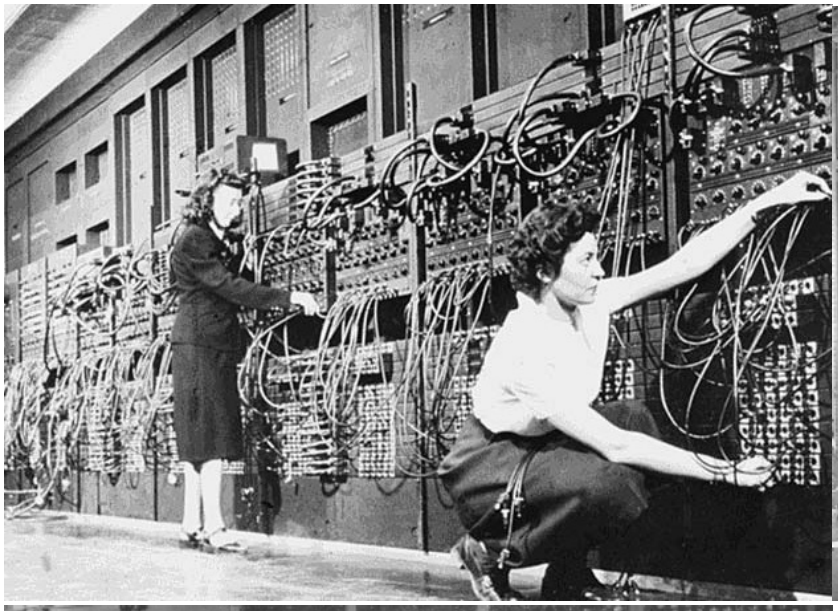

INTRODUCTION TO
Numerical Geodynamic
Modelling
TARAS GERYA
CAMBRIDGE

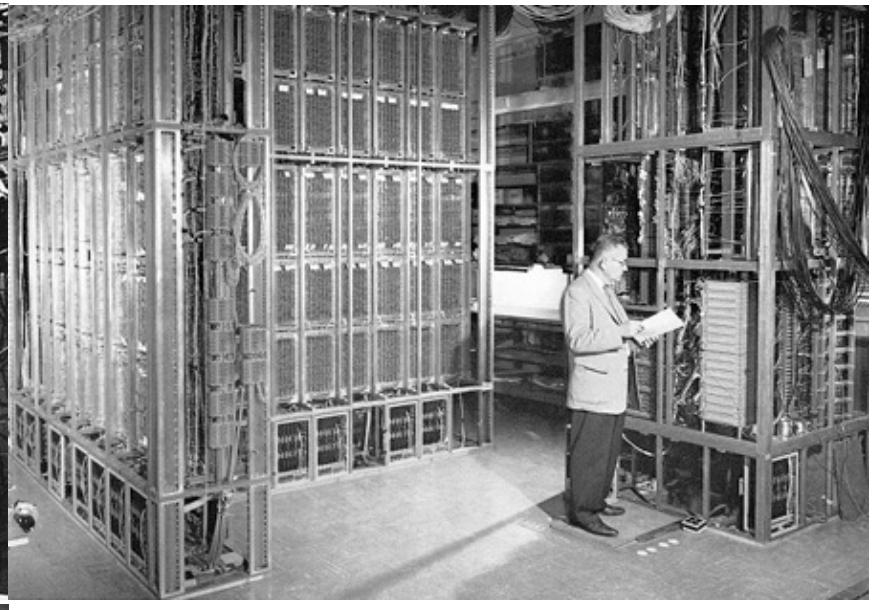

Jon Pelletier
Quantitative Modeling of
Earth Surface Processes
CAMBRIDGE

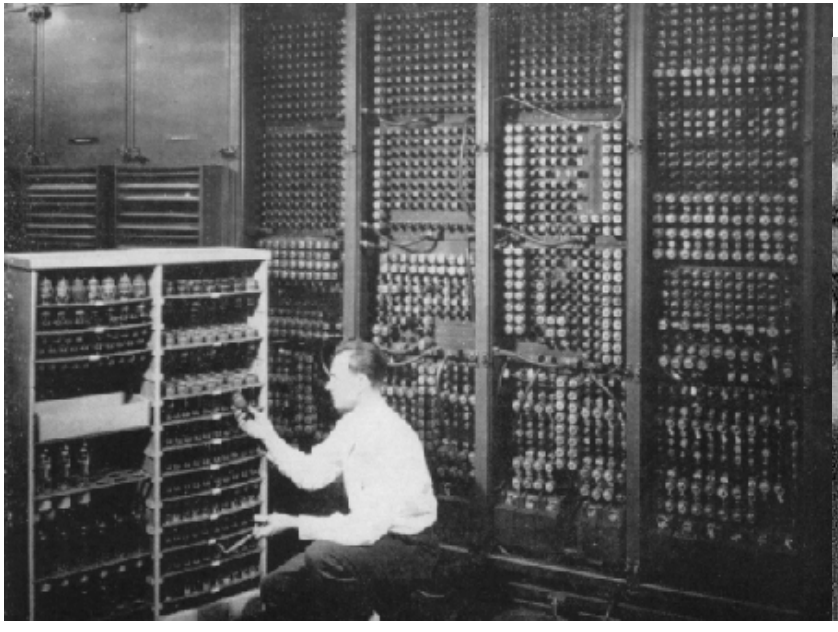


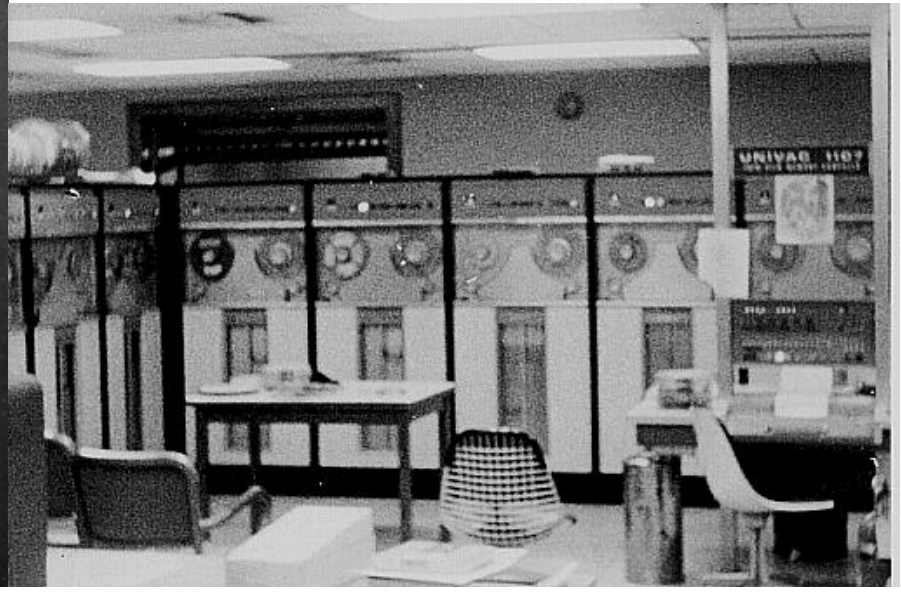
Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.



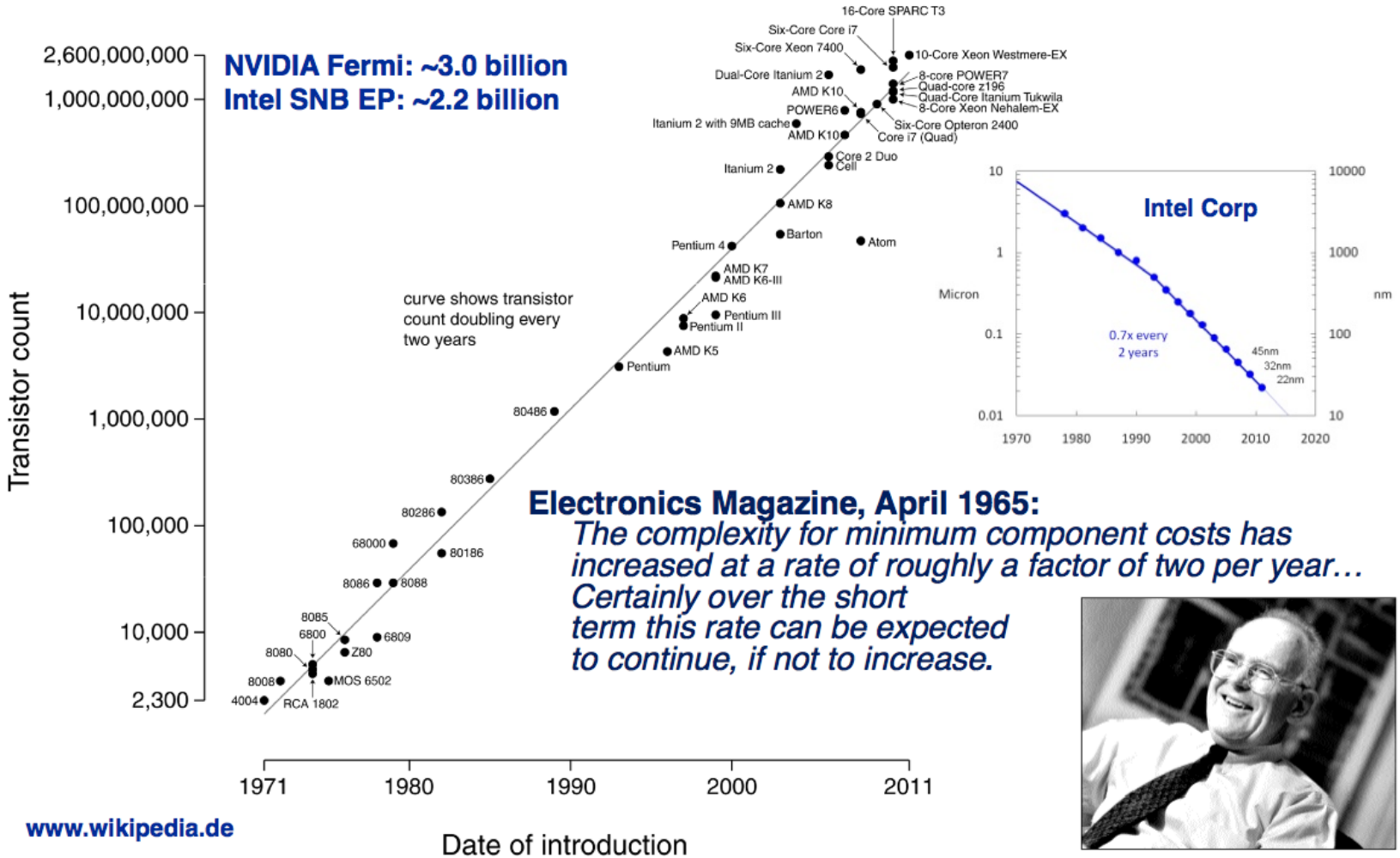






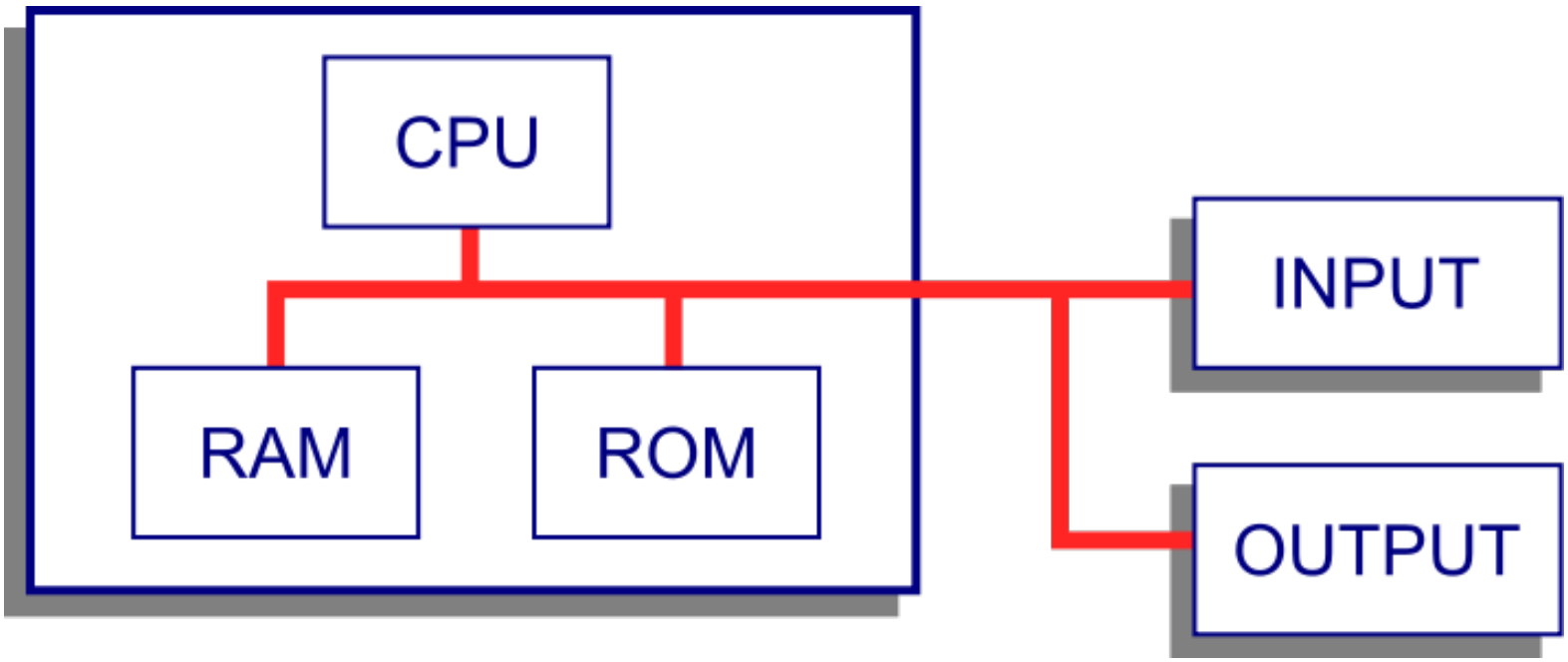

UNIVAC 1107

Moore's law continues…



Electronics Magazine, April 1965:

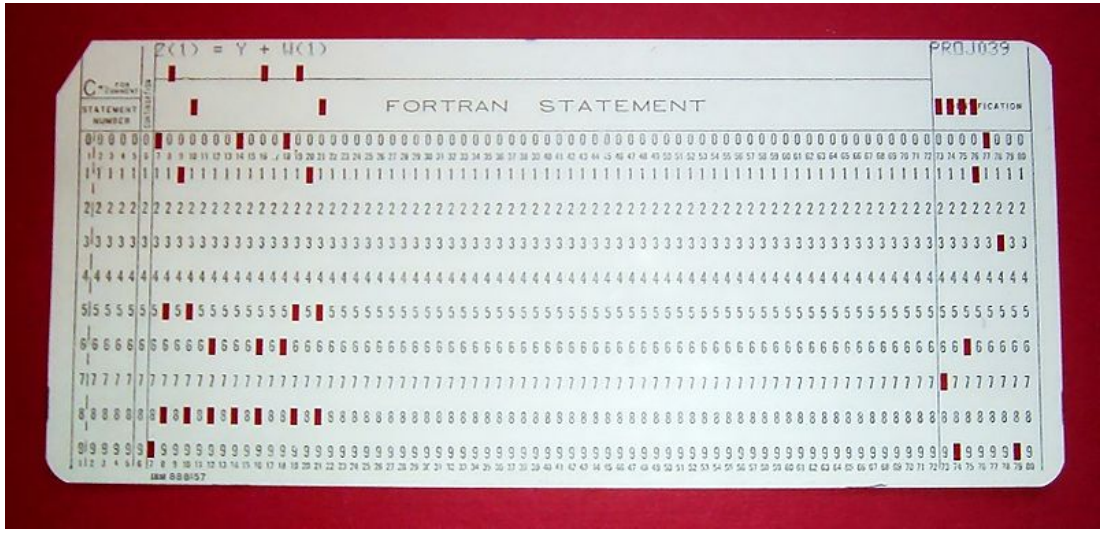
The complexity for minimum component costs has increased at a rate of roughly a factor of two per year… Certainly over the short term this rate can be expected to continue, if not to increase.



- CPU: Central processing unit (2-3Ghz)
- ROM: Read-only memory
- RAM: Random-access memory (1-32Gb)

operating systems (1)

- punchcard

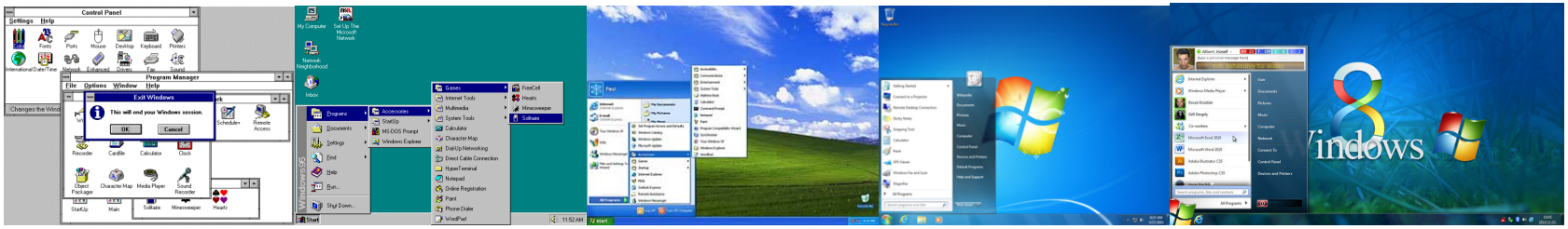


- screen prompt

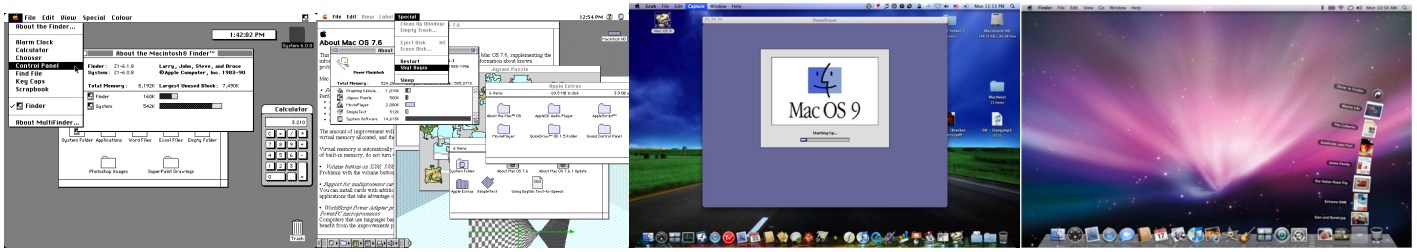
```
DOS/4GW Professional Protected Mode Run-time  Version 1.96
Copyright (c) Rational Systems, Inc. 1990-1994

Silent Hunter
installed.

Type `SH; IF YOU EXPERIENCE VIDEO PROBLEMS, USE SH /V' to start.

C:\GAMES\SILENT>_
```

operating systems (2)

- The Windows OS:



- The Mac OS (Unix)



- the Linux OS

Platforms/hardware (1)

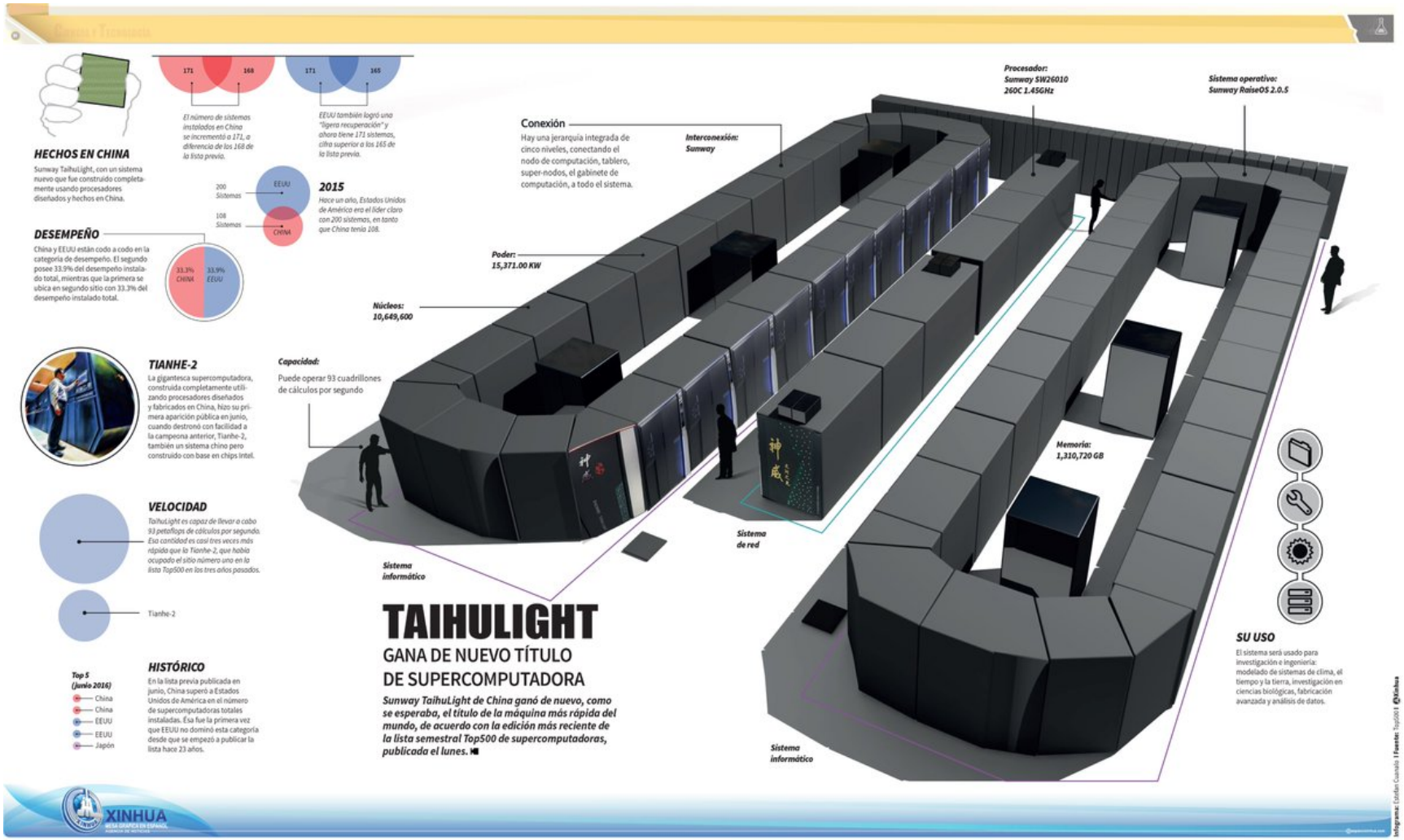
Platforms/hardware (2)

Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway

Site:	National Supercomputing Center in Wuxi
Manufacturer:	NRCPC
Cores:	10,649,600
Memory:	1,310,720 GB
Processor:	Sunway SW26010 260C 1.45GHz
Interconnect:	Sunway
Performace	
Linpack Performance (Rmax)	93,014.6 TFlop/s
Theoretical Peak (Rpeak)	125,436 TFlop/s
Nmax	12,288,000
HPCG [TFlop/s]	480.8
Power Consumption	
Power:	15,371.00 kW (Submitted)
Power Measurement Level:	2
Software	
Operating System:	Sunway RaiseOS 2.0.5

www.top500.org

Platforms/hardware (2)



Programming languages (1)

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'human friendly computer language' 

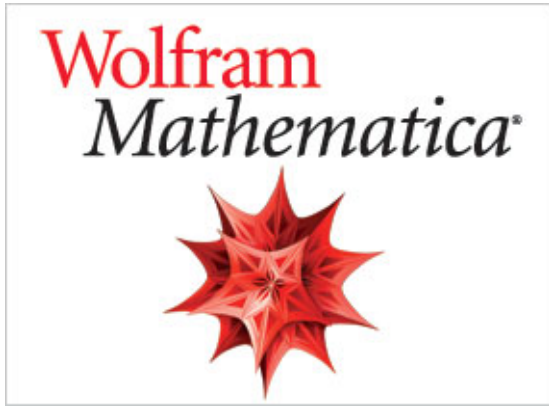
A **compiler** is a computer program that transforms source code written in a programming language into another computer language (the target language, often having a binary form). The most common reason for wanting to transform source code is to create an executable program.

Programming languages (2)

different languages $\rightarrow$ different compilers

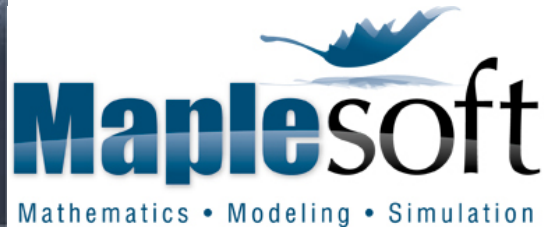
Software


MATLAB


Wolfram
Mathematica


ABAQUS


COMSOL
MULTIPHYSICS
COMSOL


Maplesoft
Mathematics • Modeling • Simulation


Scilab