Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy

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FEMSA: A Finite Element Simulation Tool for Quasi-static Seismic Deformation

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INTRODUCTION

Modeling stress and displacement fields resulting from seismic faulting is an increasingly valuable tool in earthquake physics. In the last two decades, many different approaches have been proposed to study the static and quasi-static deformations associated with a seismic event.

On one hand, analytical and semi-analytical models, although often very accurate and simple to implement, suffer from a limited flexibility, as they give very little opportunity to account for geometrical and/or rheological complexities. On the other hand, purely numerical models have been developed to overcome restrictions and improve performances with respect to analytical techniques, but in some cases they also result unable to model all the significant features or geometric complexities of interest. Among numerical methods, however, Finite Element (FE) modeling in three dimensions allows accurate modeling of complex faulting geometry, inhomogeneous materials and realistic viscous flow, appearing an excellent tool to investigate a lot of specific phenomena related with earthquakes. Unfortunately, at present FE analyses are mostly based on commercial or in-house codes, which in fact involve other practical disadvantages since they both result hardly accessible to the whole scientific community for different reasons. Commercial codes have often prohibitive prices and are typically affected by the absence of any user-code interaction. Moreover, most commercial codes are aimed to industrial design problems and their adaptation to geophysical problems is not straightforward. In-house codes, in most of the cases, turn out to be easily understandable and usable just by their developers and are often designed to specific problems, resulting hardly extendable to more general cases. Furthermore, they are not particularly robust with respect to errors or inaccuracies, as they are mostly based on ad hoc made FEM solvers that are actually not widely used and tested.

We developed a flexible, versatile, robust and reliable computational tool to model quasi-static deformation generated by faulting sources

FEMSA

Finite Element Modeling for Seismic Applications

- Freely distributed (with user manual): e-mail us!
- User friendly
- Automatic procedure implemented
- Based on widely used (i.e. well tested) packages

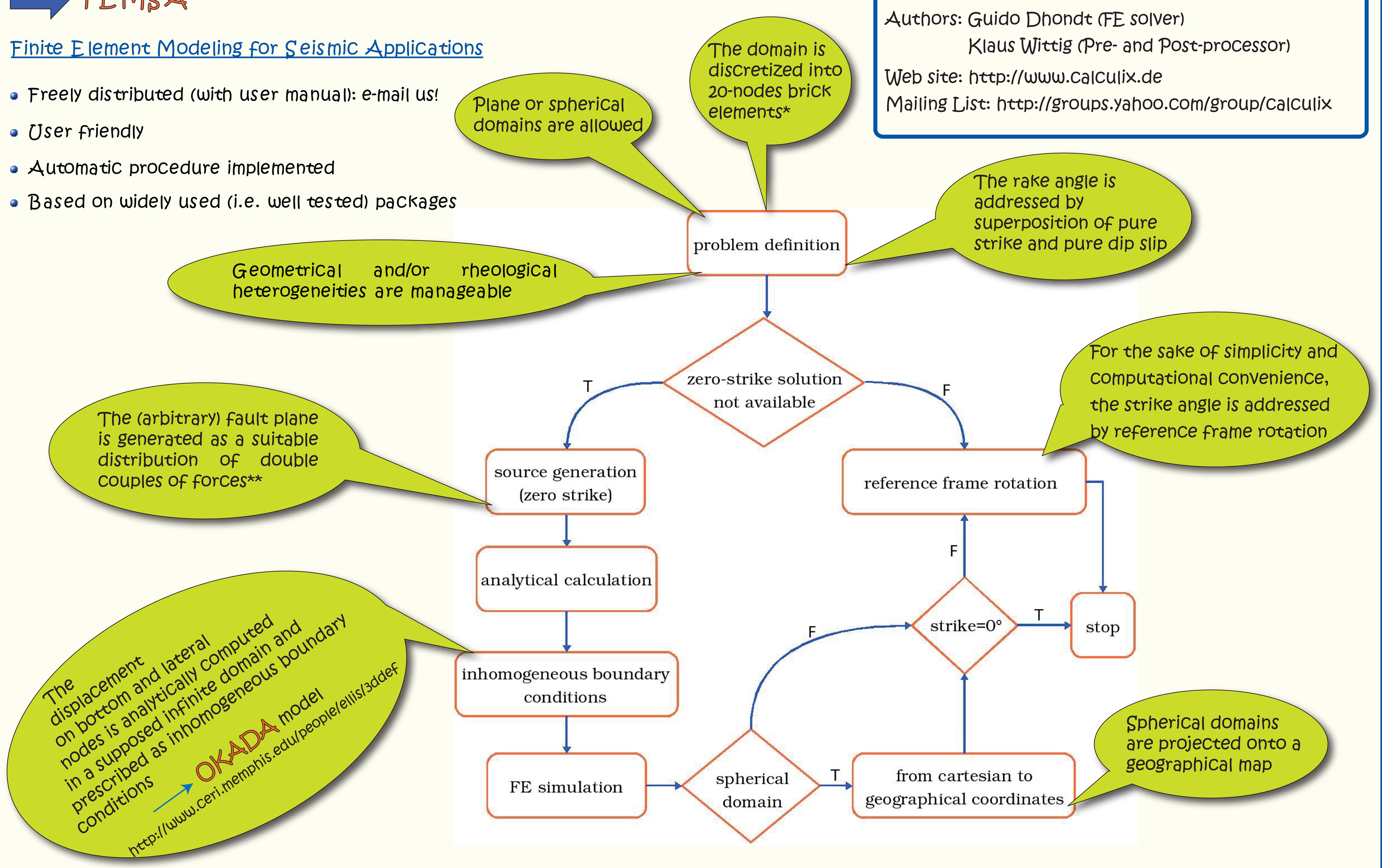
CalculiX

A free 3D structural Finite Element software

Authors: Guido Dhondt (FE solver)
Klaus Wittig (Pre- and Post-processor)

Web site: http://www.calculix.de

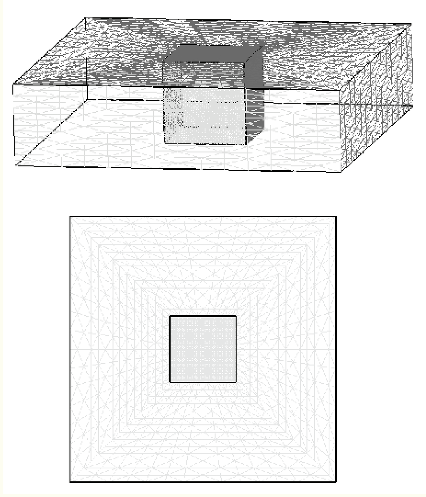
Mailing List: http://groups.yahoo.com/group/calculix



* this choice is not mandatory: other element types can be implemented

** in the next future contact elements will be available

BENCHMARK SIMULATIONS

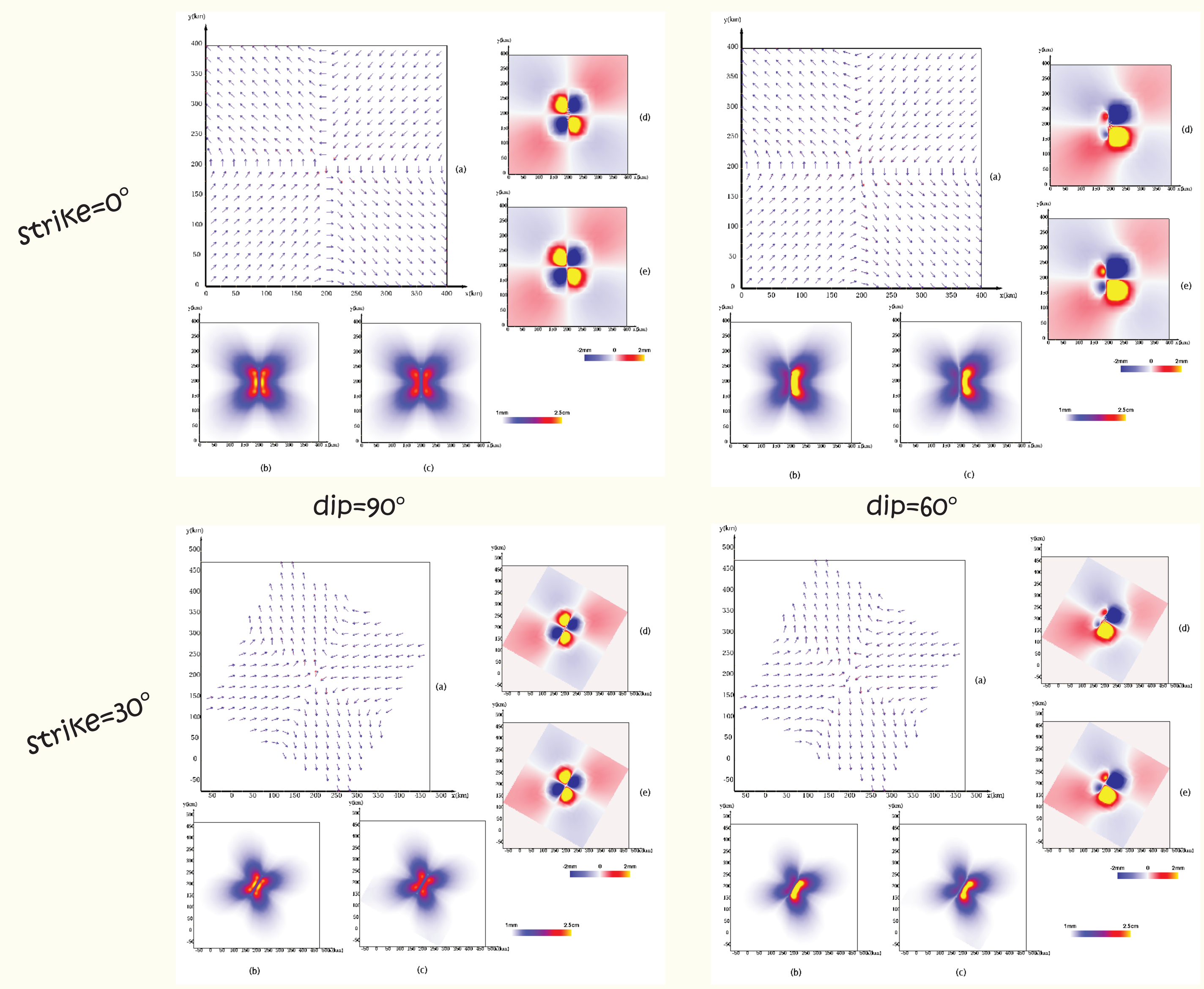


Test plane domain (400 x 400 x 100 km)
Homogeneous domain with elastic rheology
"Okada" boundary conditions

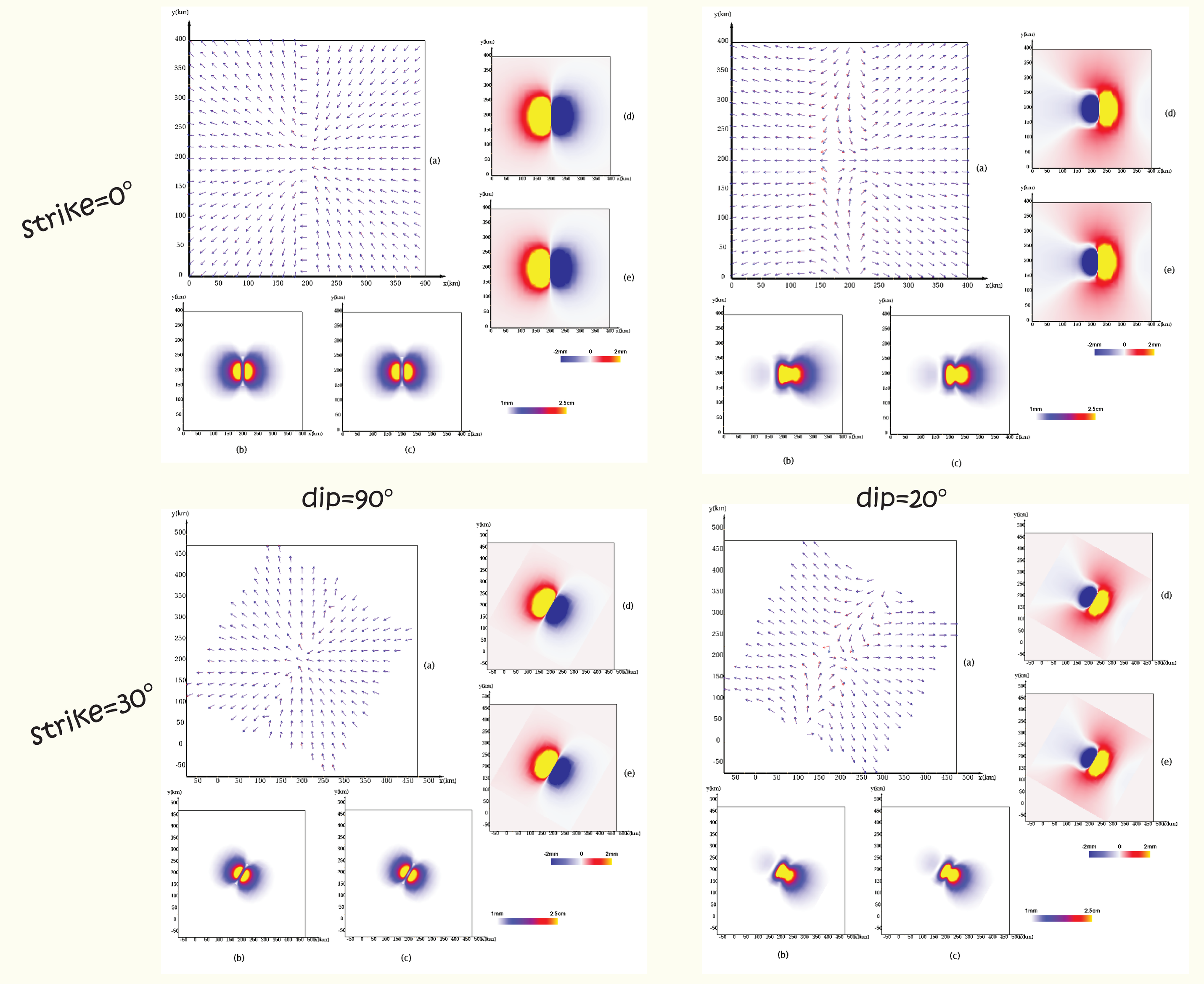
Picture guidelines:

(a) Vector plot for the ground horizontal displacement field: numerical (blue arrows) vs analytical (red arrows) solution
(b)-(c) Color plot for the ground horizontal displacement field: numerical (b) vs analytical (c) solution
(d)-(e) Color plot for the ground vertical displacement field: numerical (d) vs analytical (e) solution

right-lateral strike slip



normal dip slip



What about different boundary conditions?

Example: bottom and lateral nodes kept fixed

Example: bottom and lateral nodes kept fixed in the direction perpendicular to the surface