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New 3D seismicity maps using chromo-stereoscopy with two alternative freewares

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Preface

Seismicity maps play a key role in an introduction of geosciences studies or outreach events. Various techniques are used in order to show earthquakes in three dimensions. To use "chromo-stereoscopy" is our simple and easier-making solution. The GMT version was already presented at the IGC33rd (Oslo 2008). Here we present new POV-Ray version.

Methods

Chroma Depth 3D Glasses:
Two thin films of "blazed gratings" are covered with a paper holder and cost only 1 US$. A colored chart with a black background turns into a three dimensional space looks like a laser-holographic image due to diffraction.

Try the hanging glasses !

Softwares:
GMT (The Generic Mapping Tools, Wessel and Smith.1988) Ver.3.4: employed for our previous version (Okamoto, 2008).
POV-Ray(The Persistence of Vision Raytracer; Persistence of Vision Pty. Ltd., 2004) Ver.3.5: New version presented here.

Data:
Seismicity: JMA seismicity catalogue (at the Bosai Kagiken Web server) and USGS (ANSS) catalogue.
Coastlines and political borders: Coastline Extractor (NGDC) web site.
Plate boundaries and some related data: http://www.mri-jma.go.jp/Dep/sv/2ken/fhirose/index.html

Map samples:
・2011 Tohoku earthquake and aftershocks; Before and after 2011 Tohoku EQ. maps are shown as follows; The Tohoku region is a typical subducting zone, so "the Wadati-Beniof zone" is clearly fringed by deeper earthquakes colored yellow, green to blue. Also the maps show the huge ruptured area and the seismicity changes before and after the Tohoku earthquake.
・San Andreas Faults, active fault region: The San Andreas fault system is clearly seen as linear branches.
・Hawaii islands, active volcanic region: Surface volcanoes and beneath the complicated seismic swarms are displayed.
These figures also show plate boundaries or volcanoes (magenta colored cones) with coastlines and political borders.

Principle of 3D

After "Chromo-stereoscopy"(Ucke,1998)

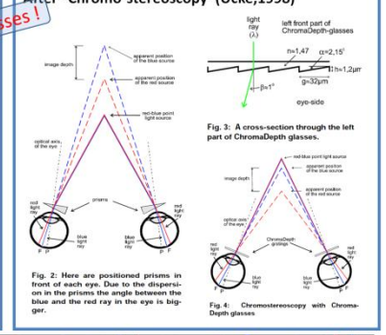

Fig. 2: Here are positioned prisms in front of each eye. Due to the dispersion in the prisms the angle between the blue and the red ray in the eye is bigger.

Fig. 3: A cross-section through the left part of ChromaDepth glasses.

Fig. 4: Chromostereoscopy with Chroma-Depth glasses

Discussion

Comparison of two mapping softwares
POV-Ray has no function to draw lines in a 3D space, so we use shere_sweep command to draw lines such as coastlines, political borders or plate boundaries(trenches).
The two softwares have their own advantages; GMT is specialized for various map making with simple scripts, while POV-Ray produces realistic 3D rendering images with more complicated scripts. Also csv data are necessary for POV-Ray coding.
GMT has no function to draw 3D images as a plotting symbol although it has various commands to draw three dimensional or contoured surface maps.

Back draws
Instead of plate boundaries, for active faults or active volcanoes, the amazing 3D effect is somewhat spoiled because of their shallow complicated seismic structures .

Improvements
Transparent spheres model is tried to avoid problems above using POV-Ray (Lower figures). Transparent effect is not sufficient enough though the deeper earthquakes are visible beneath shallower ones.

Conclusions & Further study

Conclusions
3D Seismicity maps with CD3D glasses are developed and used as teaching tools.
The two alternative softwares GMT and POV-Ray are tested as both printed and on PC.
These 3D seismicity maps help students easily to recognize plate boundary structures.
This 3D effect is so amazing that the students wearing these glasses are strongly moved and fascinated with this simple mechanism. They also try to study their optics.
The efficiency of our maps depends on the target regions.
New transparent spheres version is developed and tested. However the effect is not so sufficient as I expected. Further improvement is necessary.
In spite of some back draws, their simple and easier-making process is quite suitable for study in class rooms and outreach purpose, not only for geosciences study itself but also for optics study at the secondary levels or more.

Further study
The future task is to evaluate the three dimensional effect quantitatively, particularly 1) color coding 2) color pixel separation 3) background color effect.
The targets should be extended to the other related regions around plate boundaries.

Acknowledgement & References

Christian Ucke kindly permits me to quote figures with captions of his article and also provides me some useful suggestion. This work was supported by KAKENHI 23916002 (MEXT Japan). The maps described here are now available in my website (http://www.osaka-kyoiku.ac.jp/~yossi/).

References

Christian Ucke(1998):"3-D Vision with ChromaDepth Glasses" Proceedings of the ICPE/GIREP-conference 'Hands-On Experiments in Physics Education' August 23 - 28, 371-374.
Yoshio Okamoto (2008): Seismicity Maps for "Chroma Depth 3D Glasses"using "The Generic Mapping Tools" 33rd IGC Oslo 2008, abstract CDROM
Kita et al. (2010, EPSL), Nakajima and Hasegawa (2006, GRL), Nakajima et al. (2009, JGR) for Plate boundary data.