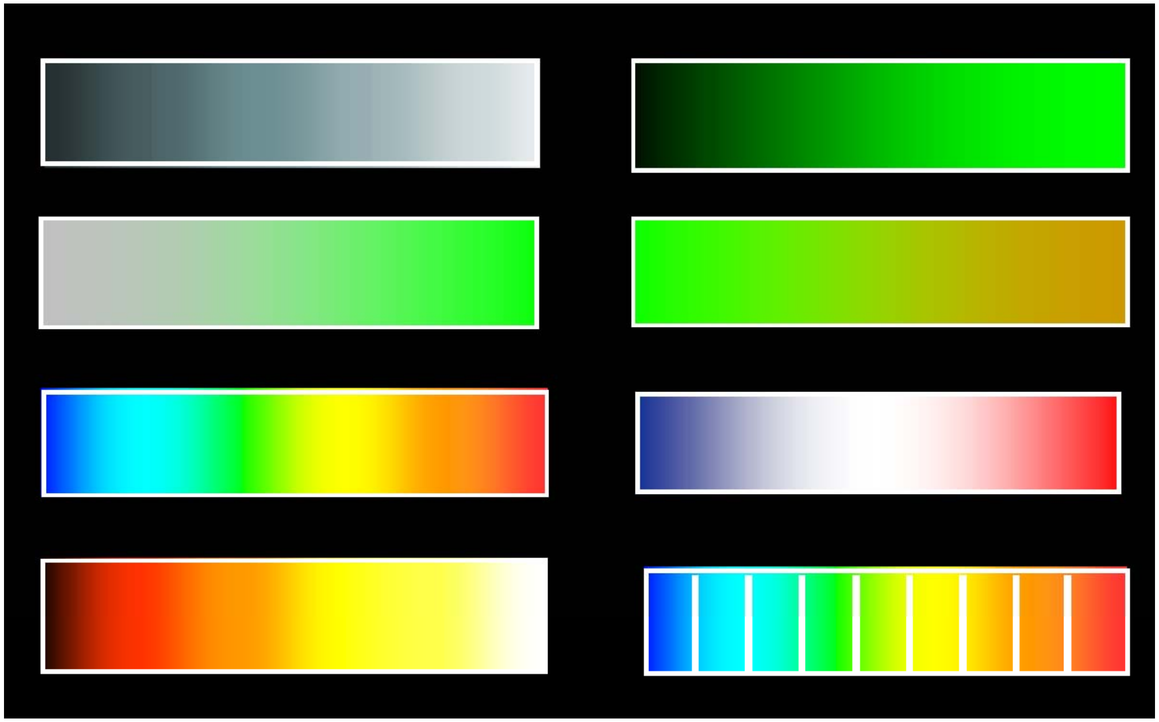
Terrain Visualization

Mike Bailey

mjb@cs.oregonstate.edu

Oregon State University

Reminder: Color Scale Transfer Functions

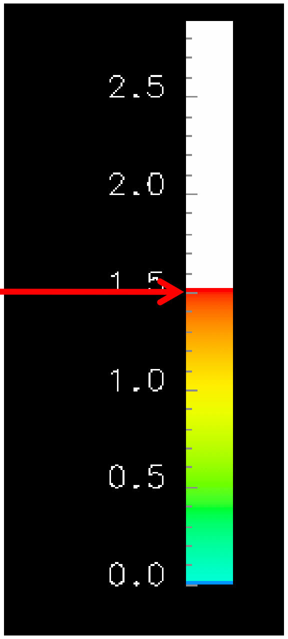


The biggest rule here is to design something that is ***intuitive***. The “snapshot rule” definitely applies!

Sometimes elevation is represented by a color transfer function, like one of these. Sometimes elevation is represented by the color of what exists at that elevation (sand, dirt, grass, trees, snow, etc.) Remember Tufte’s *Do No Harm* admonition.

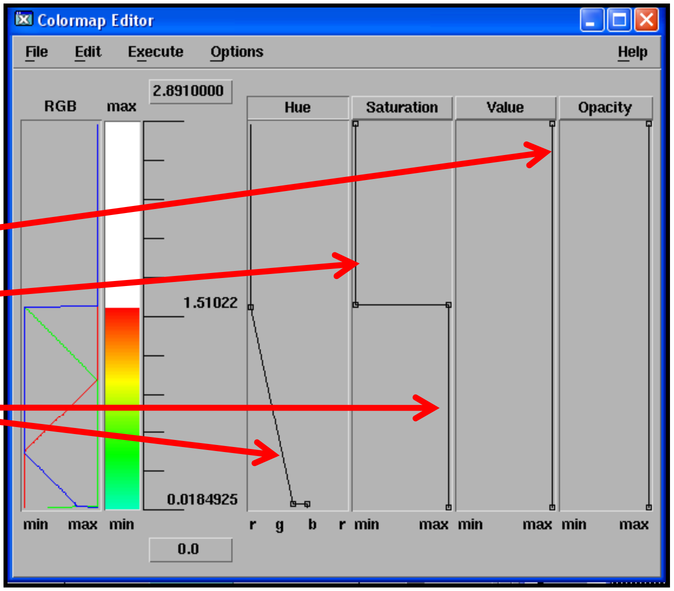
A Possible Color Scale Transfer Function for Oregon

Assume snow level is at 1.5 miles



Sculpting the transfer function in HSV.

Full value, no saturation above 1.5 miles, full-saturation hue change below 1.5 miles.

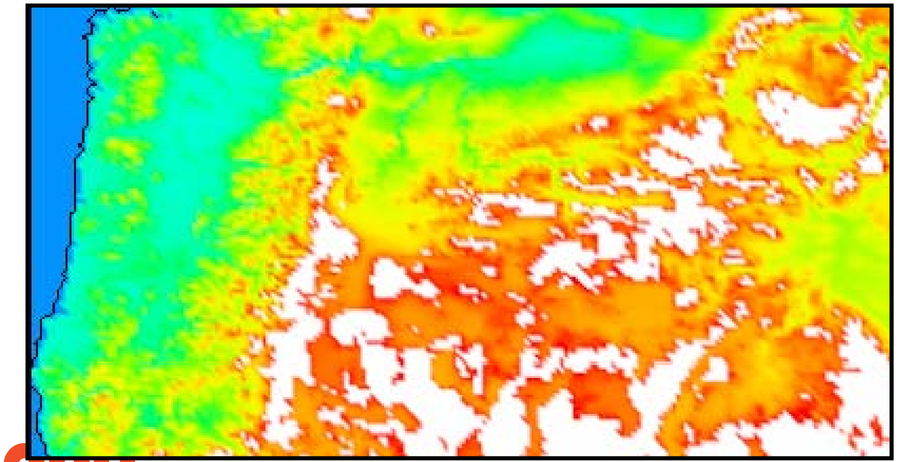


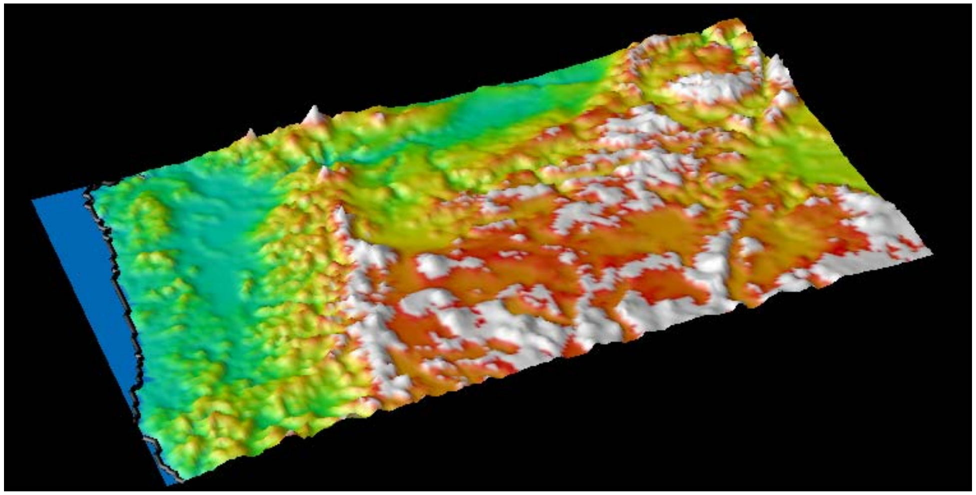
2.8910000

1.51022

0.0184925

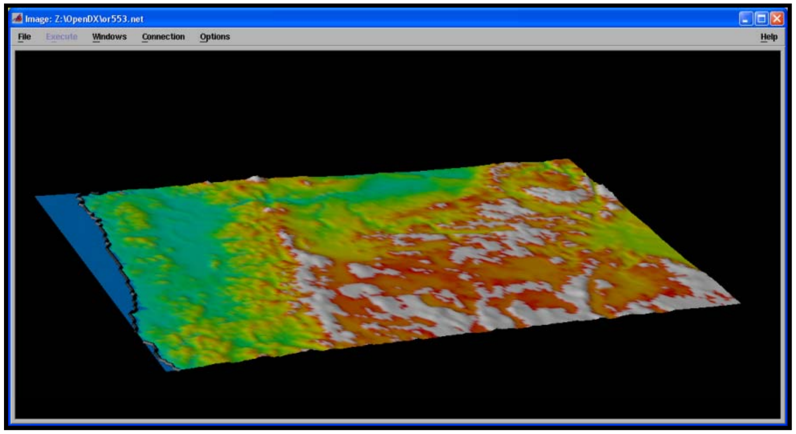
0.0



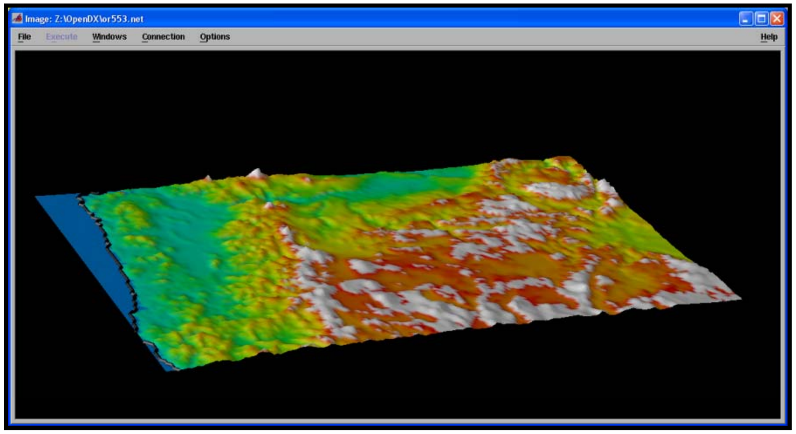


Height Exaggeration

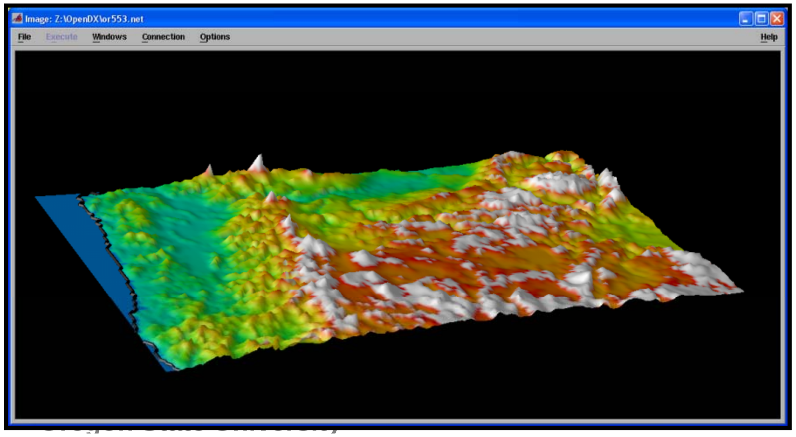
Most terrain visualization applications require height exaggeration to see any elevation changes. Why? Consider Oregon for example. Oregon is about 360 x 260 miles horizontally, and has an elevation range of about 2.5 miles vertically. This makes the elevation range less than 1% of the horizontal dimensions – hardly noticeable. However, be careful of going overboard.



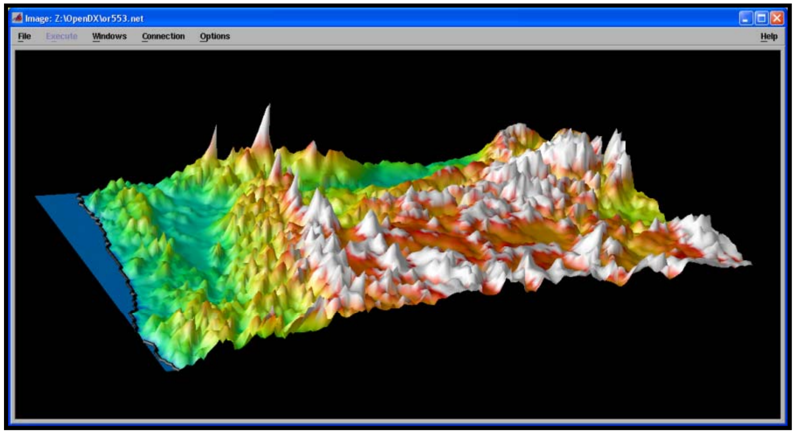
Height Exaggeration = 1.0



Height Exaggeration = 2.0

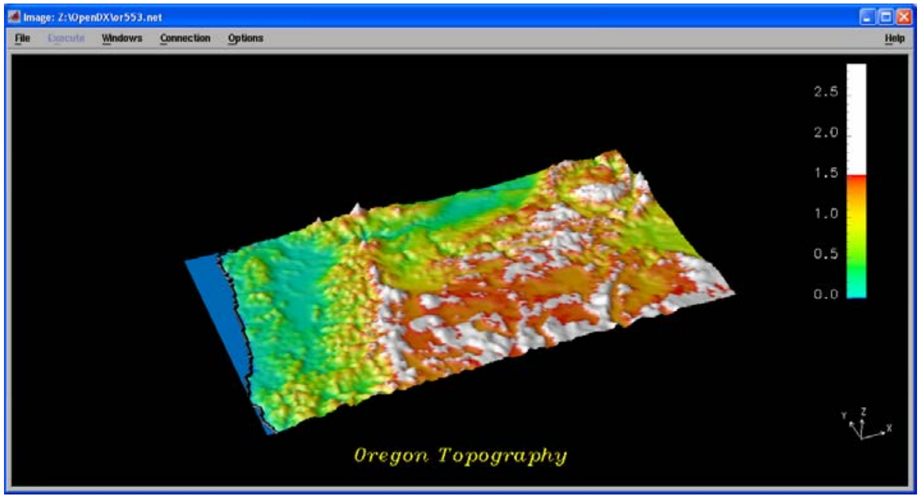


Height Exaggeration = 3.0

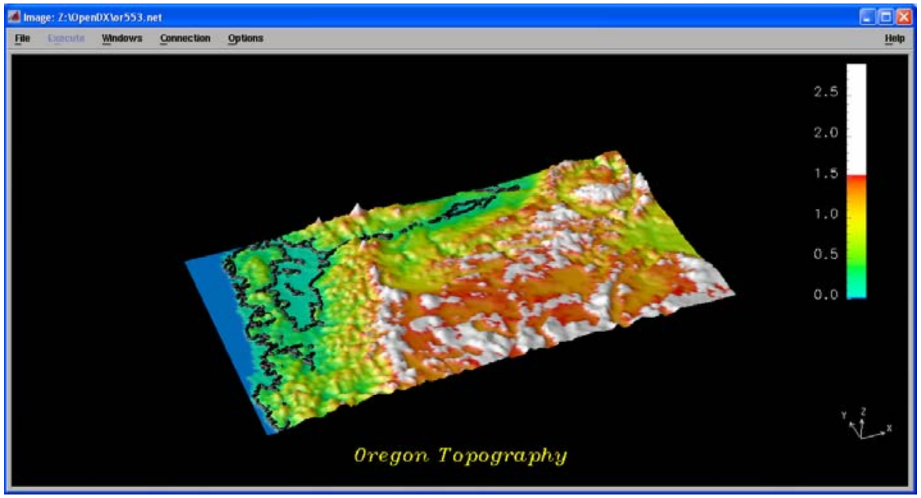


Height Exaggeration = 10.0

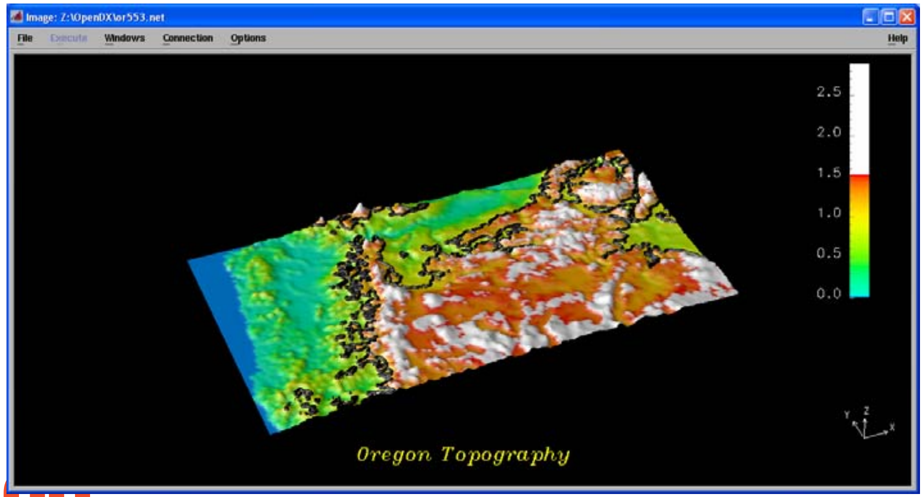
Different Contour Lines



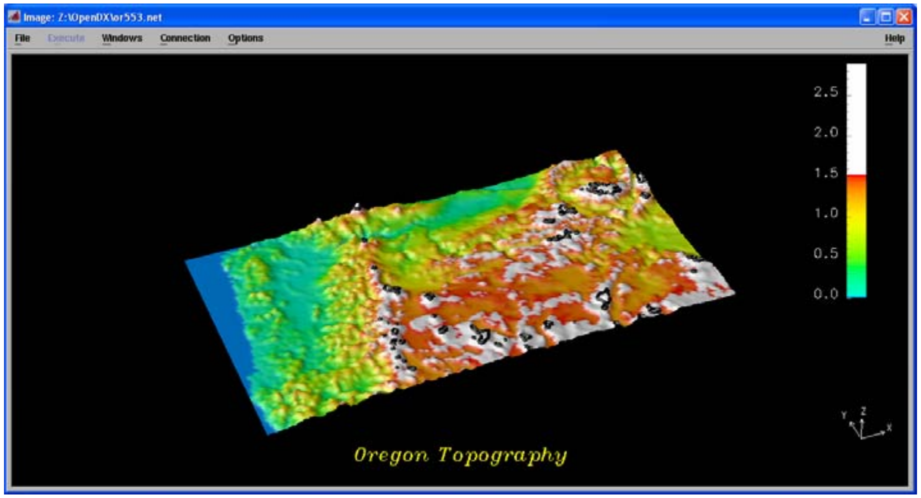
S* = 0 miles



S* = 0.17 miles

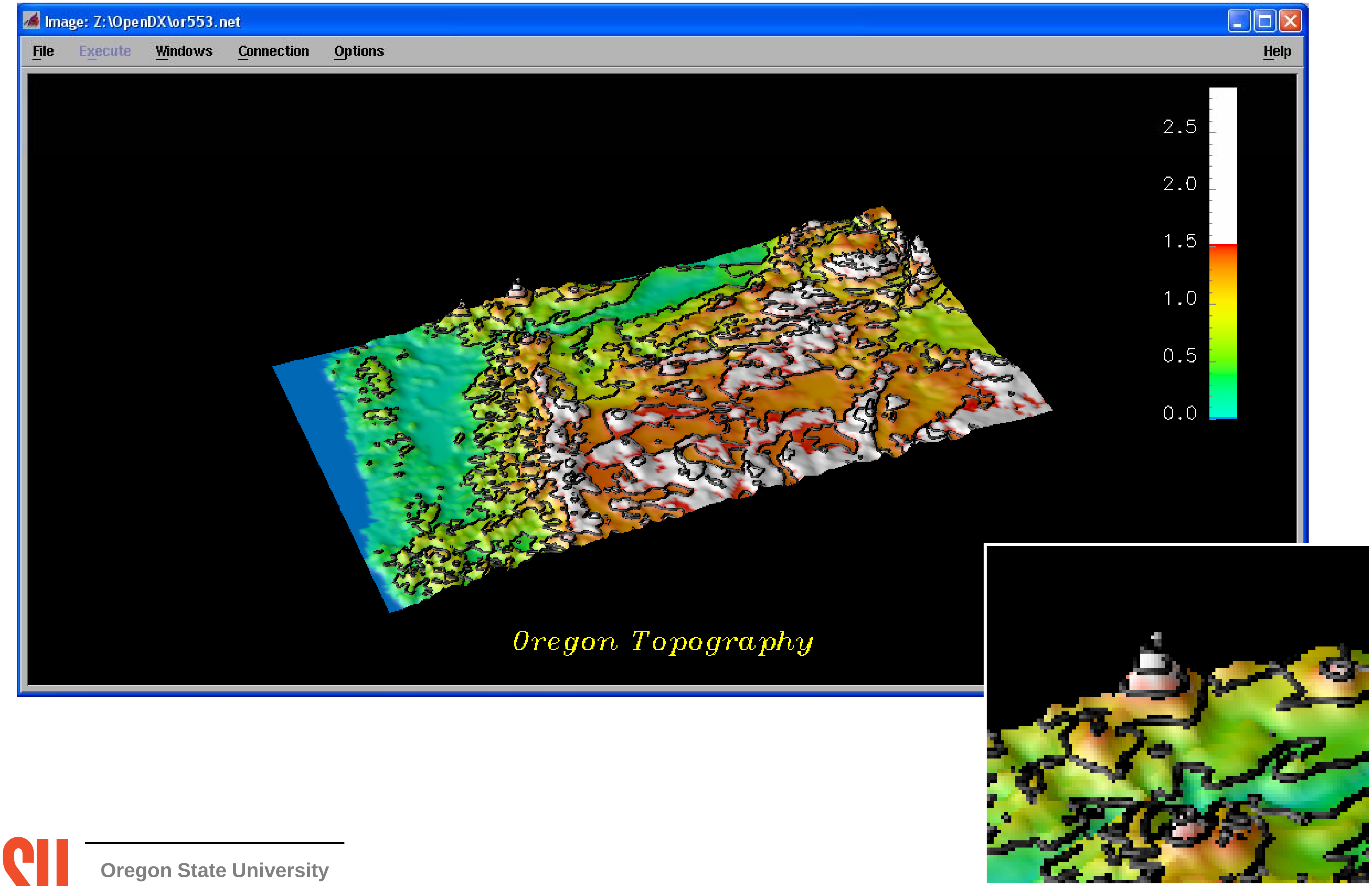


S* = 1.00 miles

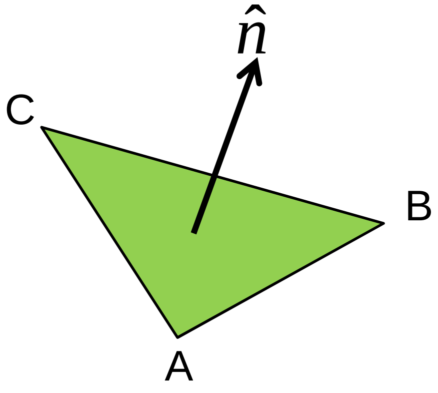


S* = 2.00 miles

Multiple Contour Lines

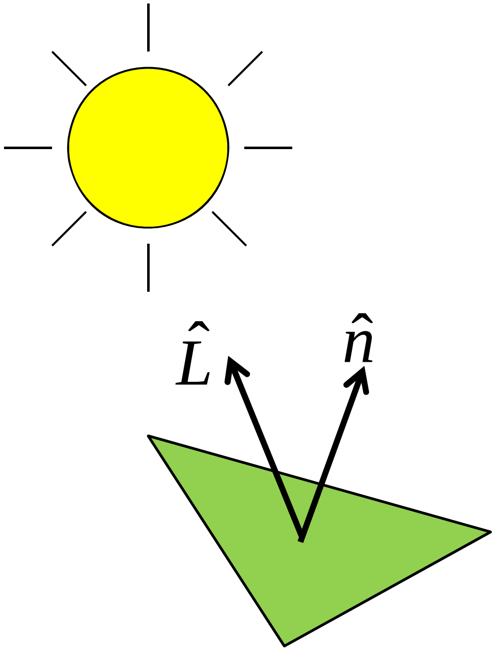


Lighting



To do effective lighting of terrain surfaces, you need a surface normal for each triangle. You can get this with the cross product and unitizing:

$$\hat{n} = \frac{AB \times AC}{\left\| AB \times AC \right\|}$$



You can use this unitized normal directly in the OpenGL glNormal3f( ) call to do dynamic OpenGL lighting.

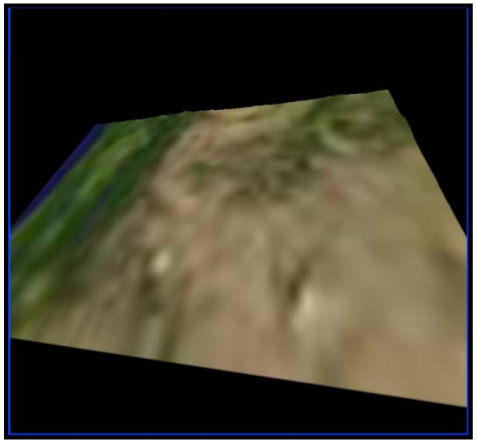
You can also do pseudo-lighting, where you assume that the sun is in a fixed direction from the scene. The diffuse portion of the lighting model is then:

$$I_d = \hat{n} \bullet \hat{L}$$

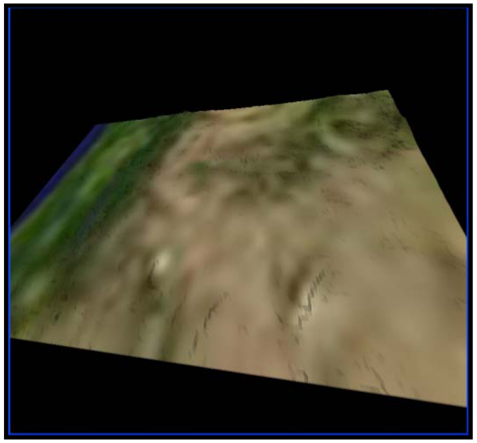
If you assume that the sun is directly overhead, then this reduces to just the vertical component of the unit surface normal.

Lighting Height Exaggeration

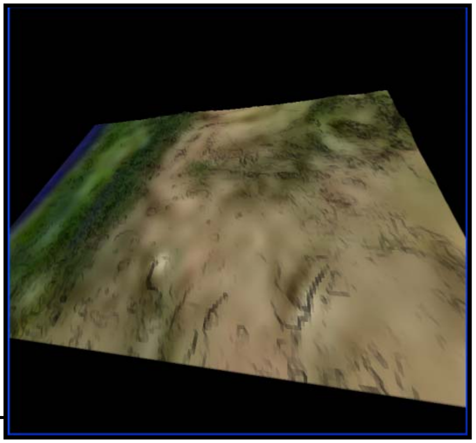
At times it is helpful to exaggerate the height for the lighting computations, but not for the height display.



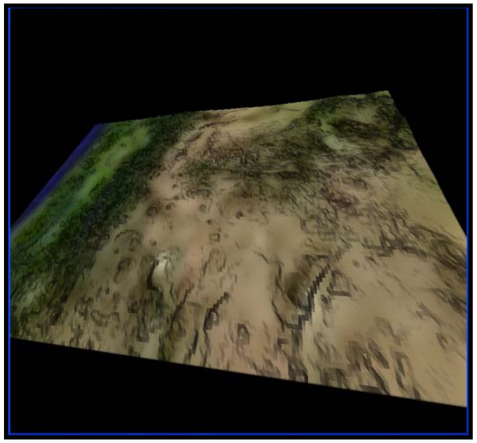
Lighting Height Exaggeration = 1.0



Lighting Height Exaggeration = 5.0

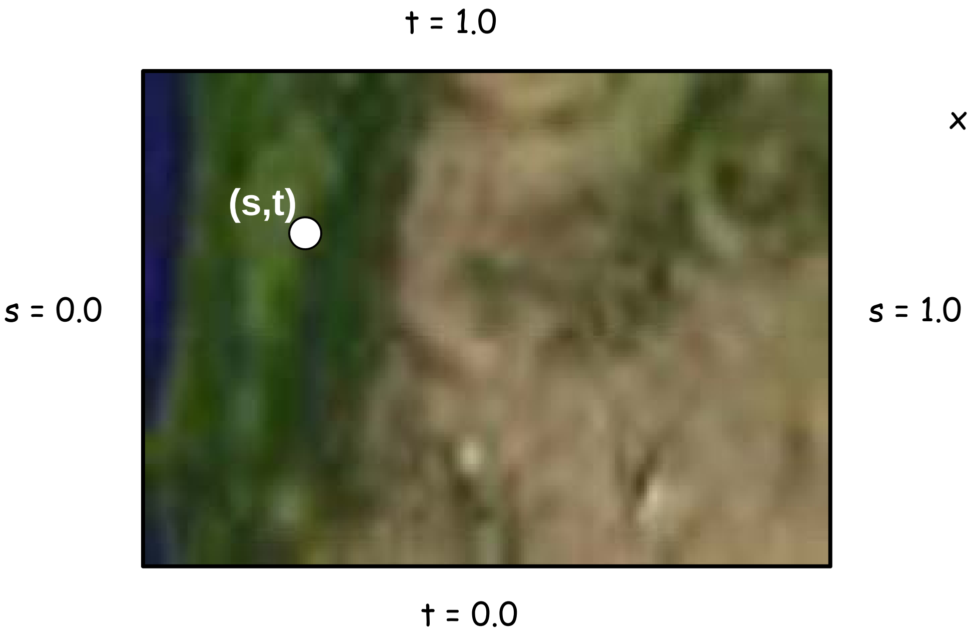


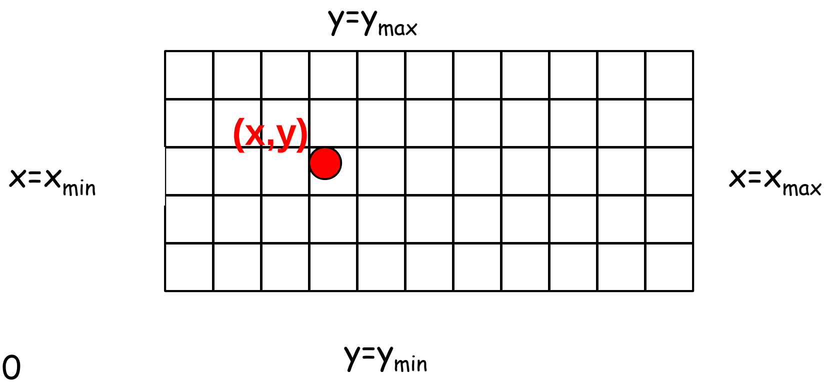
Lighting Height Exaggeration = 10.0



Lighting Height Exaggeration = 20.0

Computing (s,t) Texture Coordinates

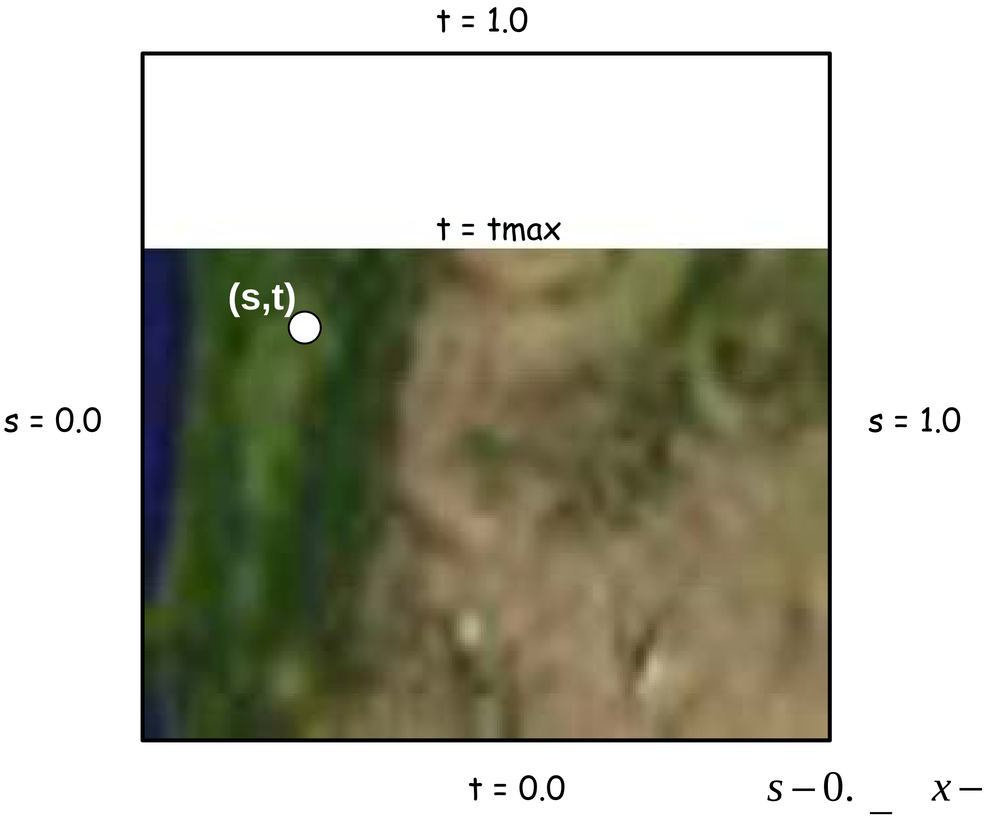


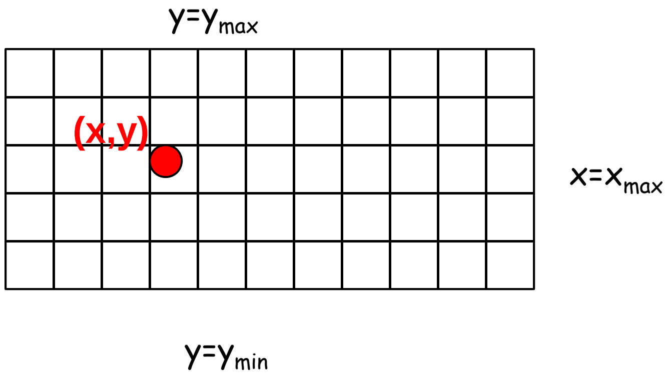


$$\frac{s-0.}{1.-0.}=\frac{x-x_{\min}}{x_{\max}-x_{\min}} \qquad \frac{t-0.}{1.-0.}=\frac{y-y_{\min}}{y_{\max}-y_{\min}}$$

$$s=\frac{x-x_{\min}}{x_{\max}-x_{\min}} \qquad t=\frac{y-y_{\min}}{y_{\max}-y_{\min}}$$

Computing (s,t) Texture Coordinates:
What if the Texture doesn't occupy the entire Image?

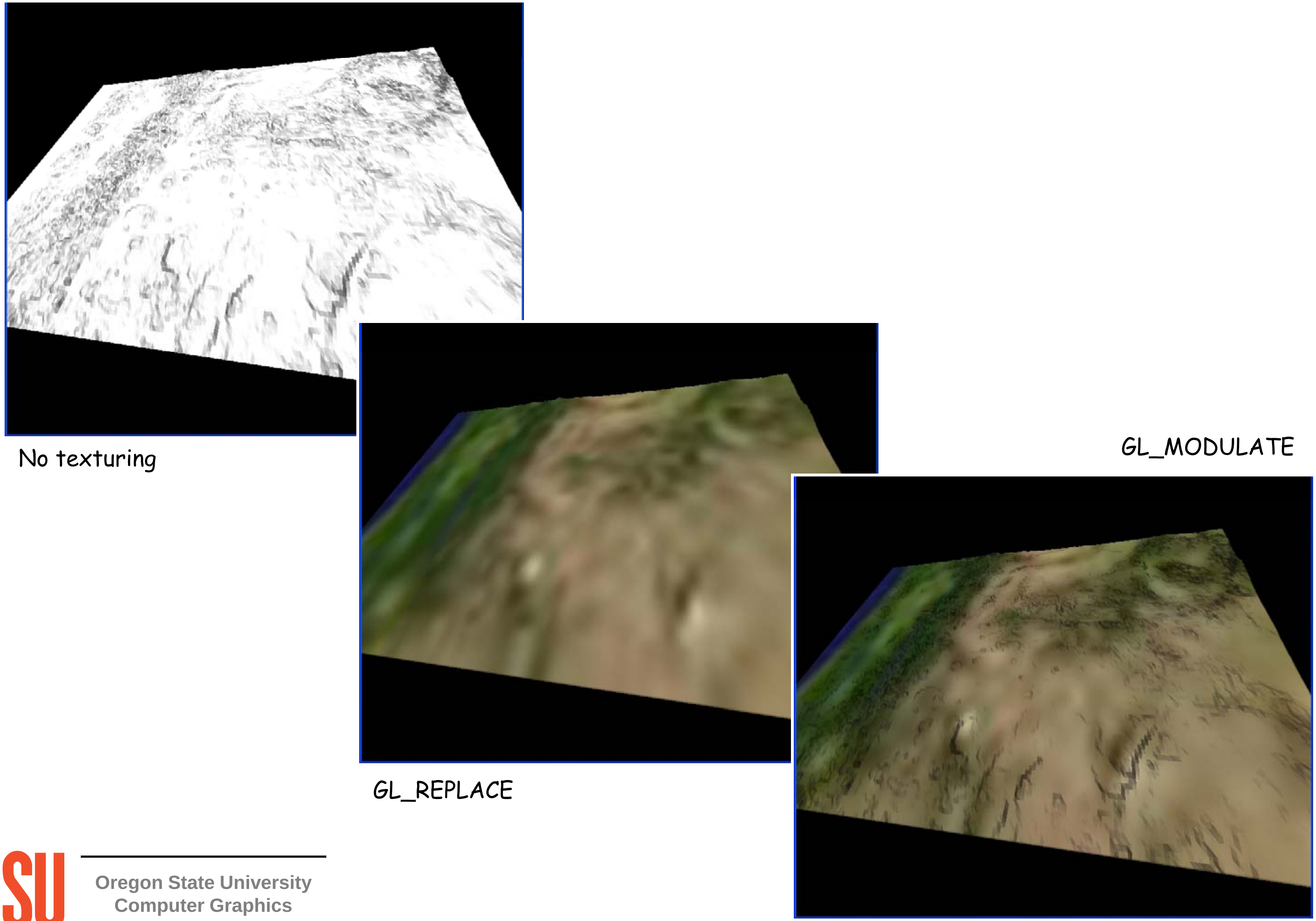




$$\frac{s-0.}{1.-0.}=\frac{x-x_{\min}}{x_{\max}-x_{\min}} \qquad \frac{t-0.}{t_{\max}-0.}=\frac{y-y_{\min}}{y_{\max}-y_{\min}}$$

$$s=\frac{x-x_{\min}}{x_{\max}-x_{\min}} \qquad t=\frac{t_{\max}(y-y_{\min})}{y_{\max}-y_{\min}}$$

OpenGL Texture Environments



No texturing

GL_REPLACE

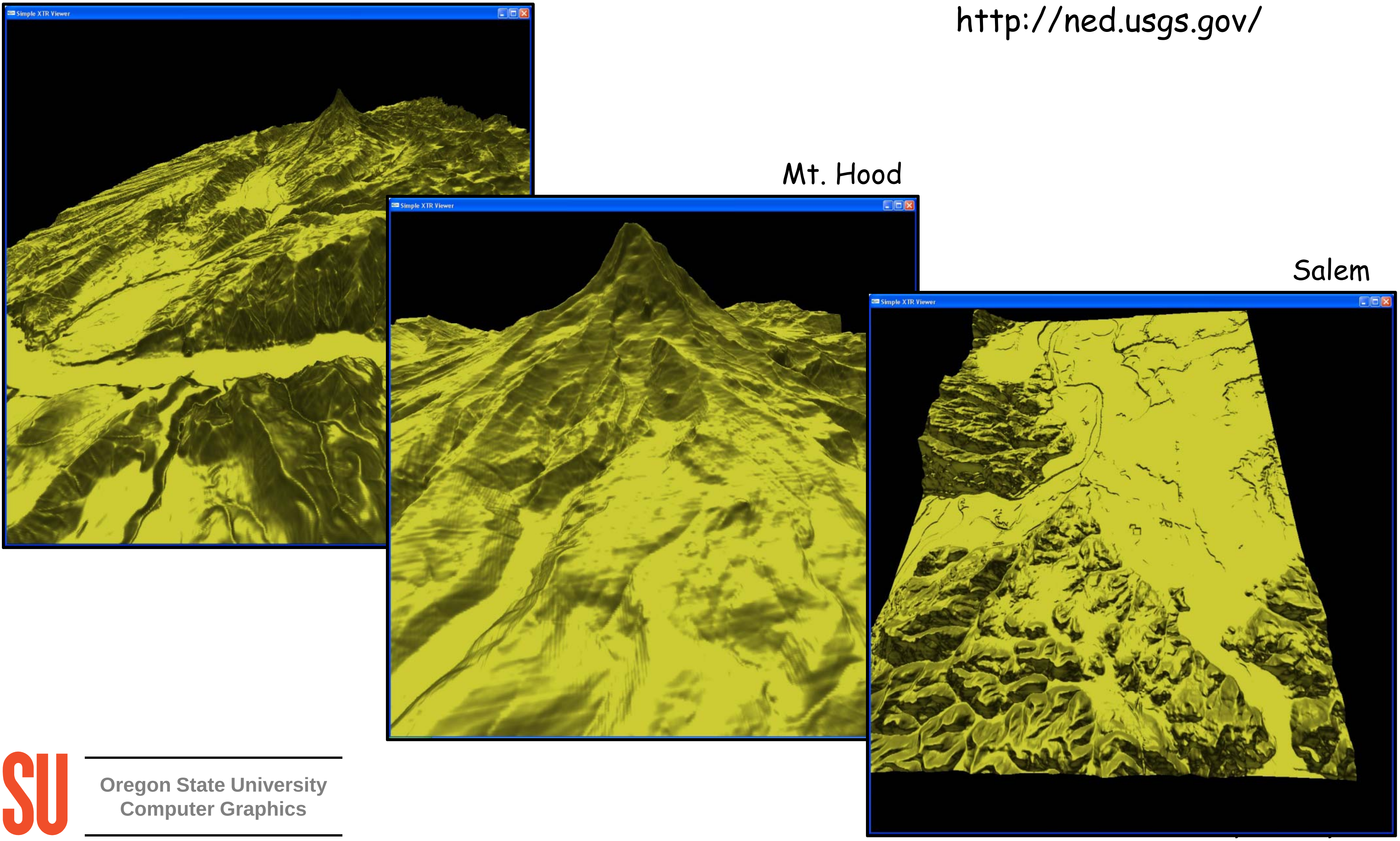
GL_MODULATE

USGS National Elevation Database Program

Continental US Data available free at 10m resolution.

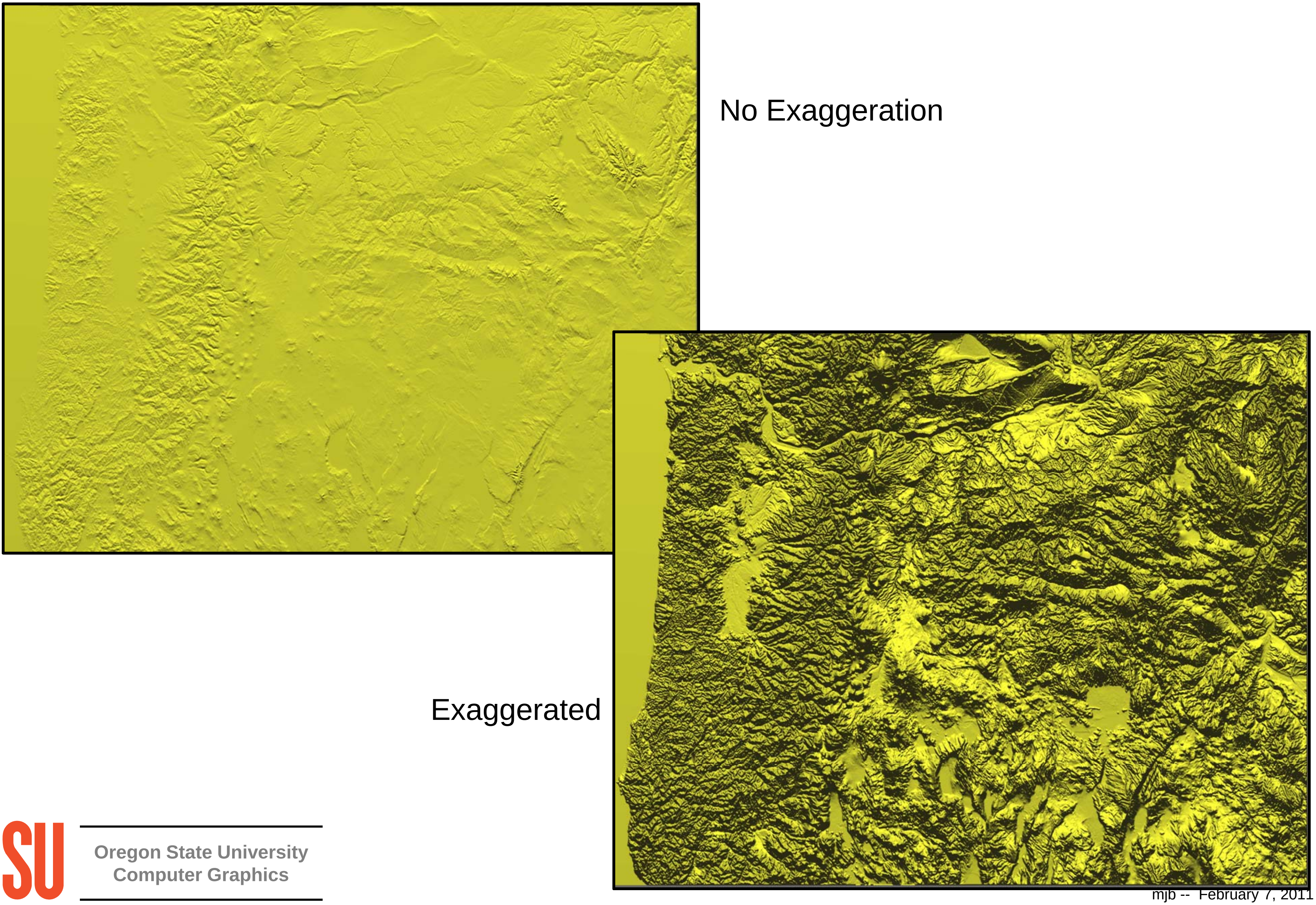
http://ned.usgs.gov/

Mt. Hood



Oregon State University
Computer Graphics

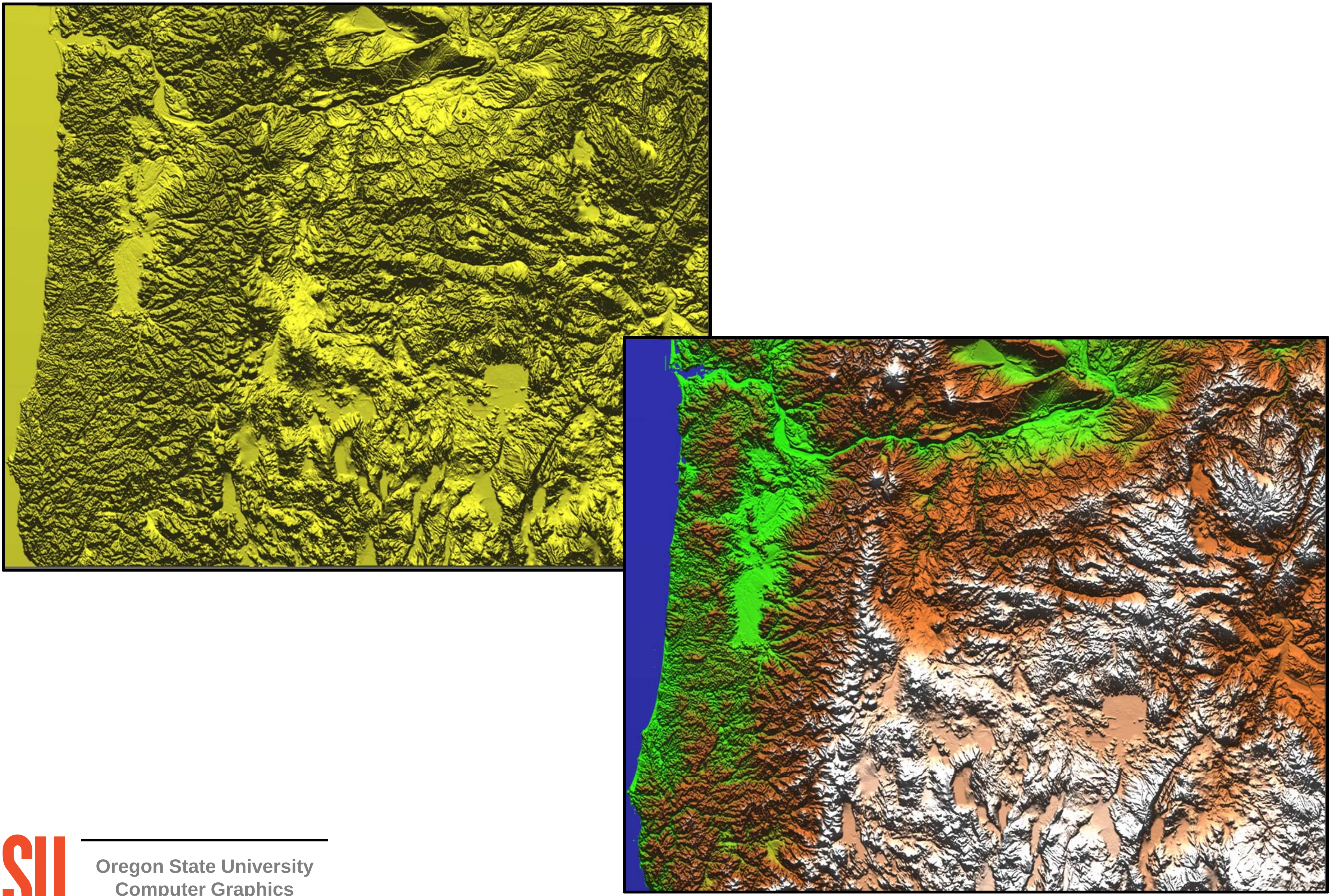
Terrain Height Bump-mapping: Exaggerating the Height



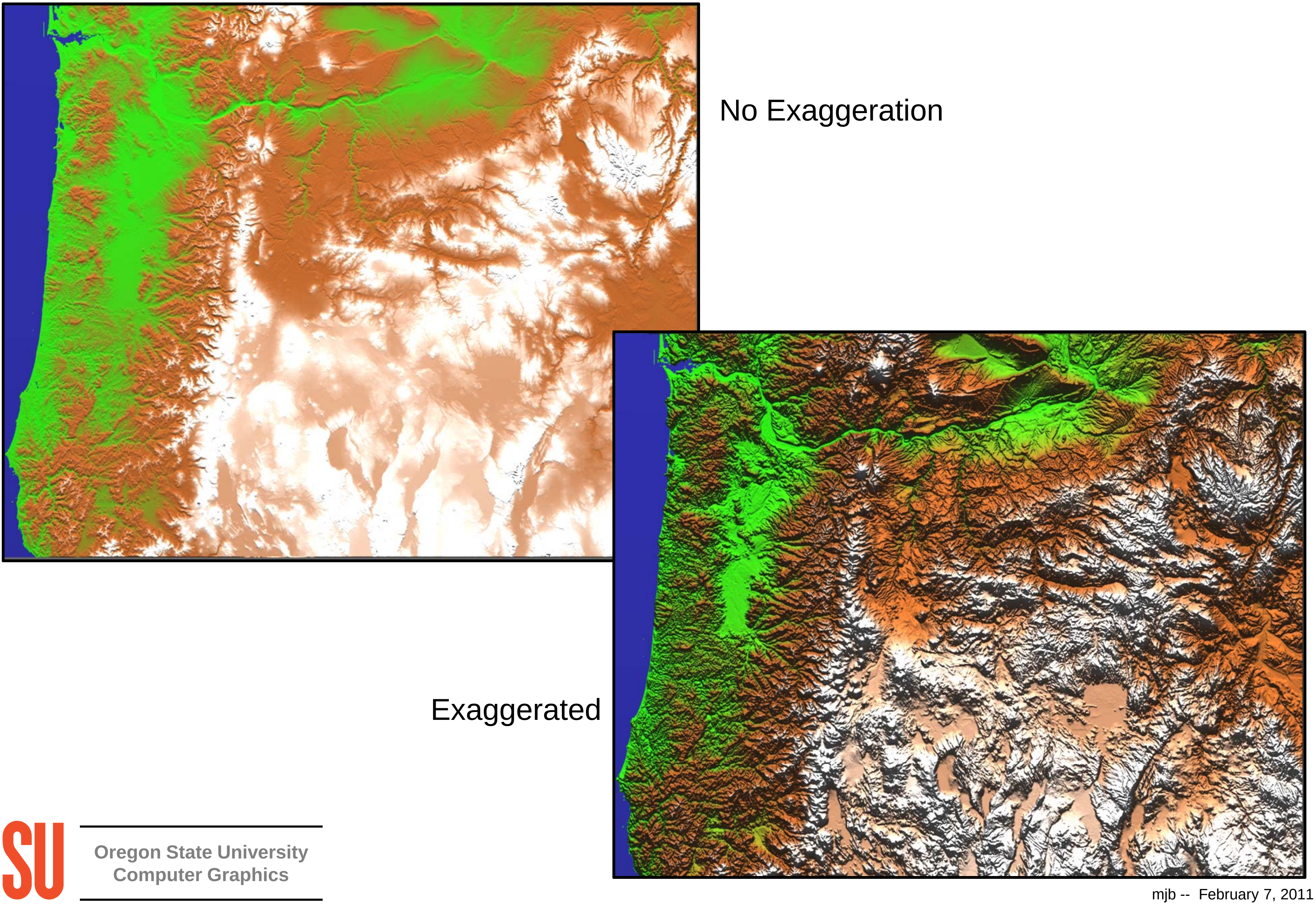
No Exaggeration

Exaggerated

Terrain Height Bump-mapping: Coloring by Height



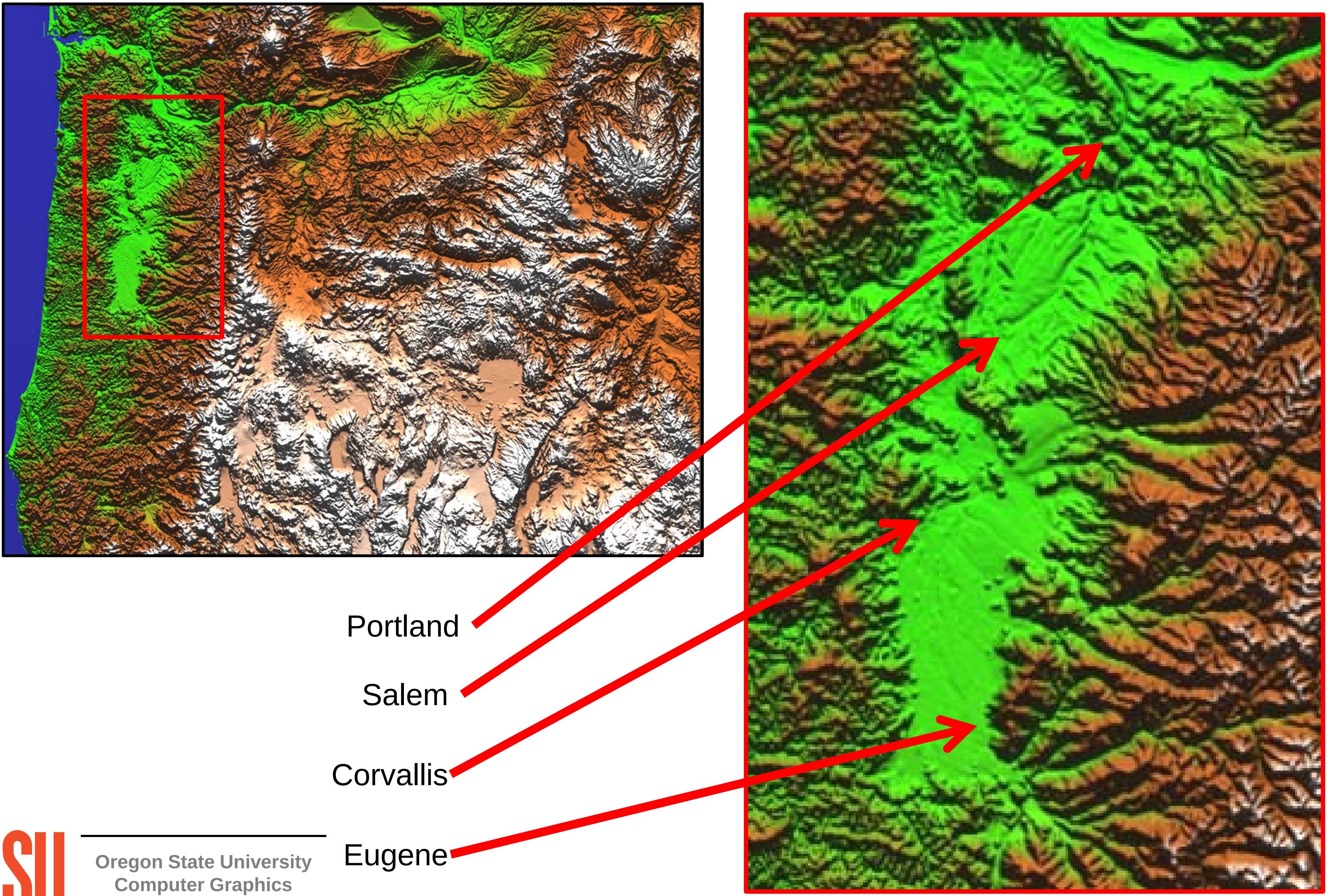
Terrain Height Bump-mapping: Coloring by Height



No Exaggeration

Exaggerated

Terrain Height Bump-mapping: Zooming In



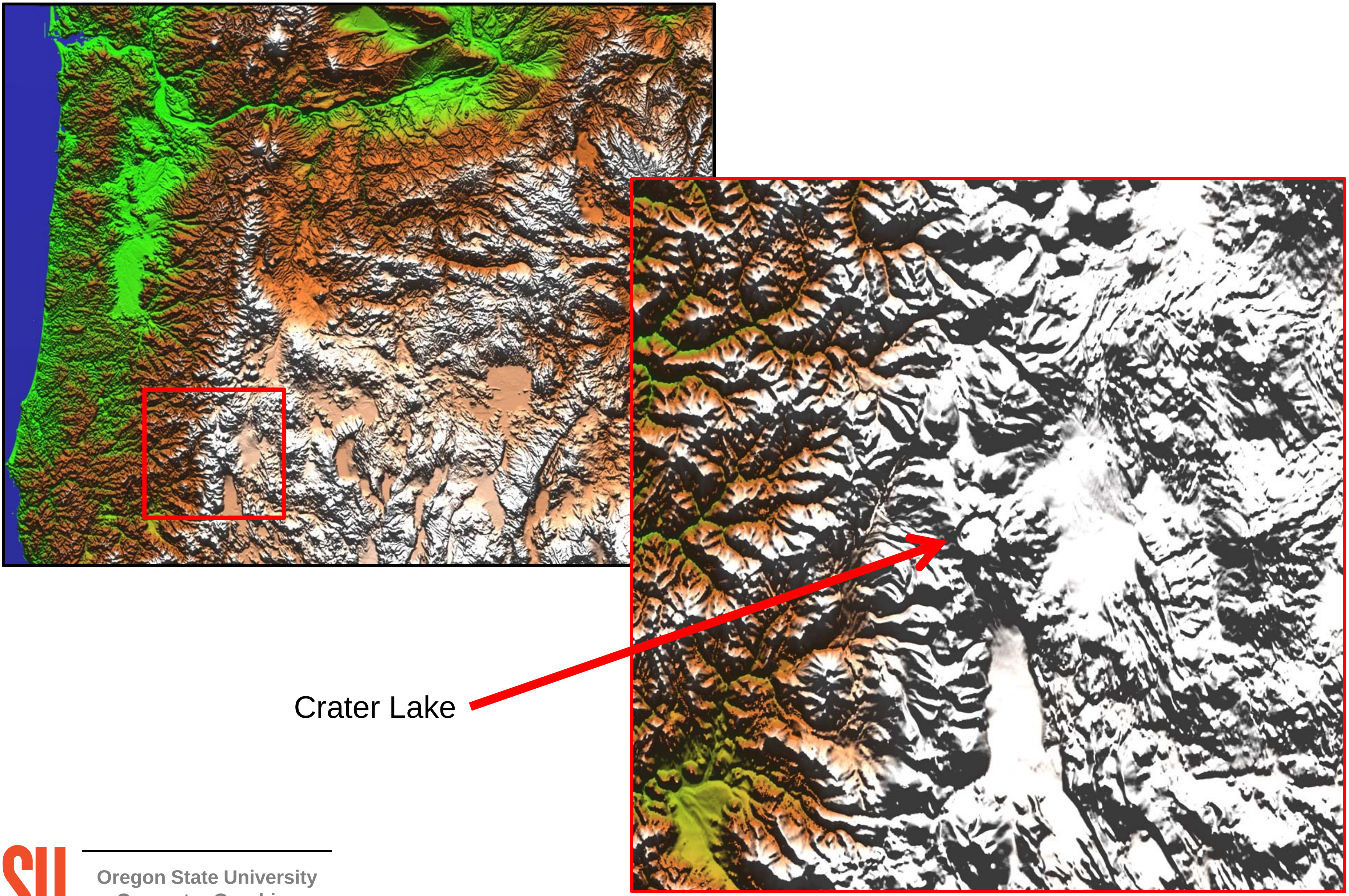
Portland

Salem

Corvallis

Eugene

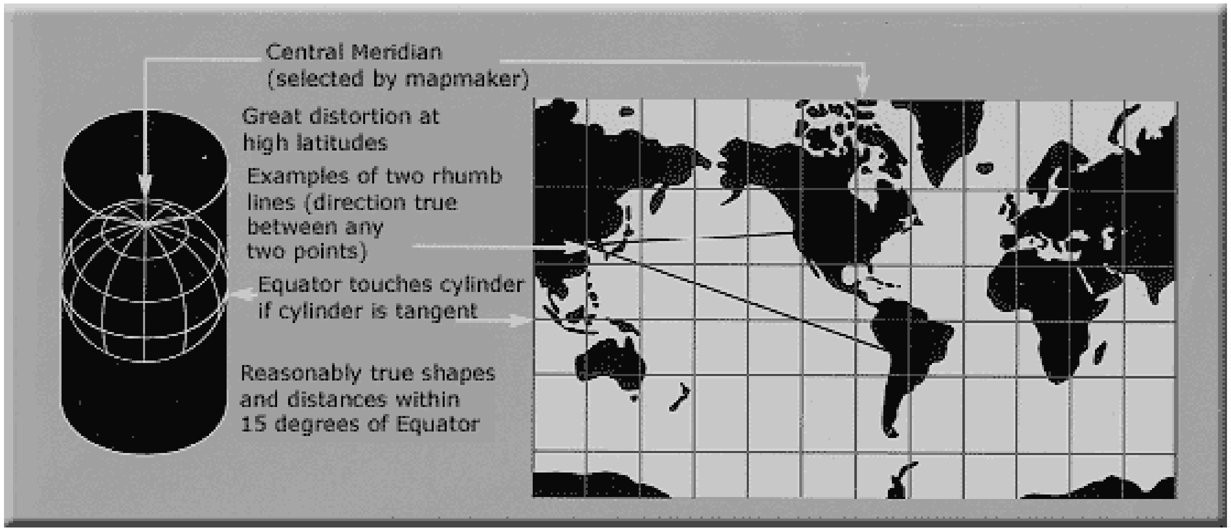
Terrain Height Bump-mapping: Zooming In



Crater Lake

Map Projections

Mercator



Central Meridian (selected by mapmaker)

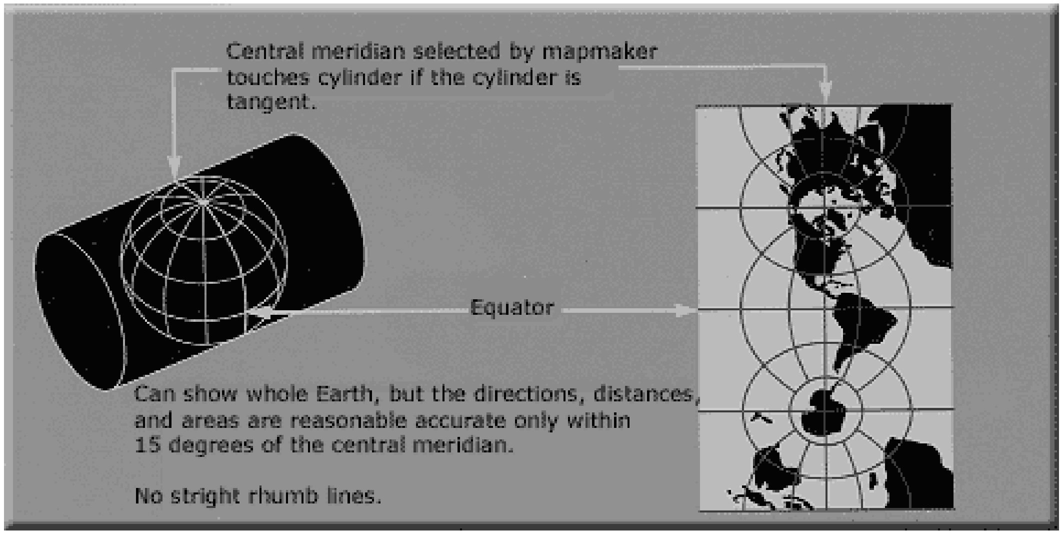
Great distortion at high latitudes

Examples of two rhumb lines (direction true between any two points)

Equator touches cylinder if cylinder is tangent

Reasonably true shapes and distances within 15 degrees of Equator

Transverse Mercator



Central meridian selected by mapmaker touches cylinder if the cylinder is tangent.

Equator

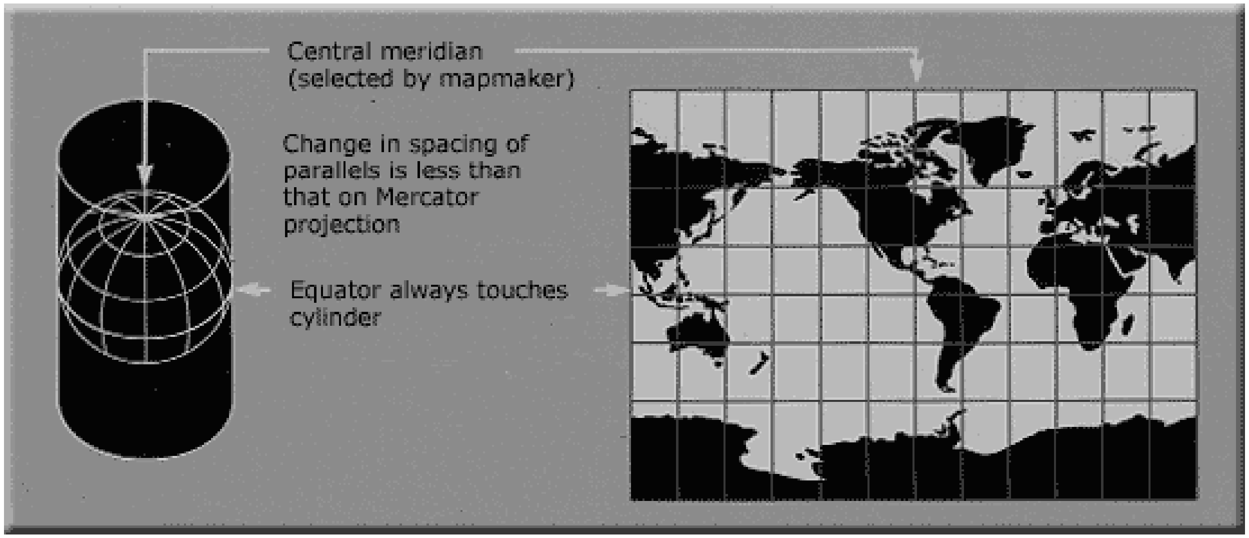
Can show whole Earth, but the directions, distances, and areas are reasonable accurate only within 15 degrees of the central meridian.

No stright rhumb lines.

http://egsc.usgs.gov/isb/pubs/MapProjections/projections.html

Map Projections

Miller Cylindrical

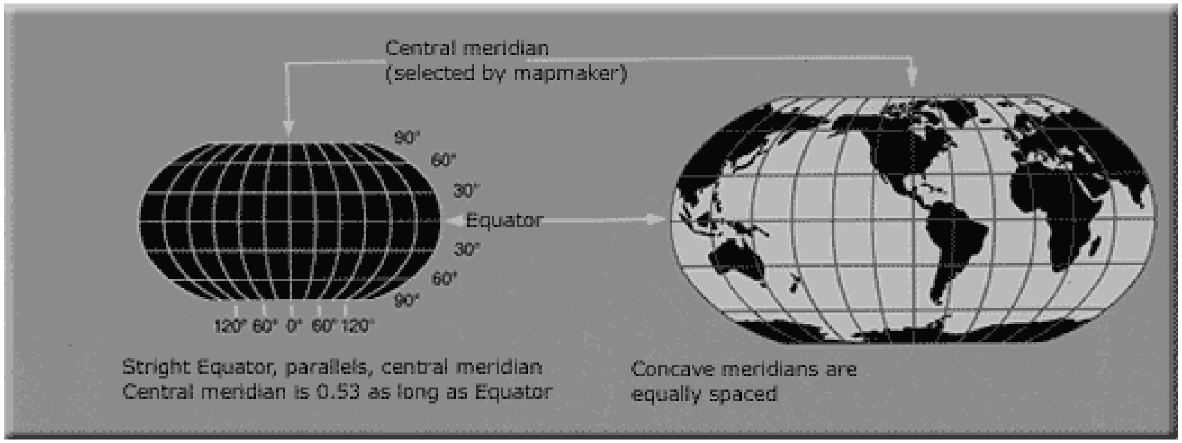


Central meridian (selected by mapmaker)

Change in spacing of parallels is less than that on Mercator projection

Equator always touches cylinder

Robinson



Central meridian (selected by mapmaker)

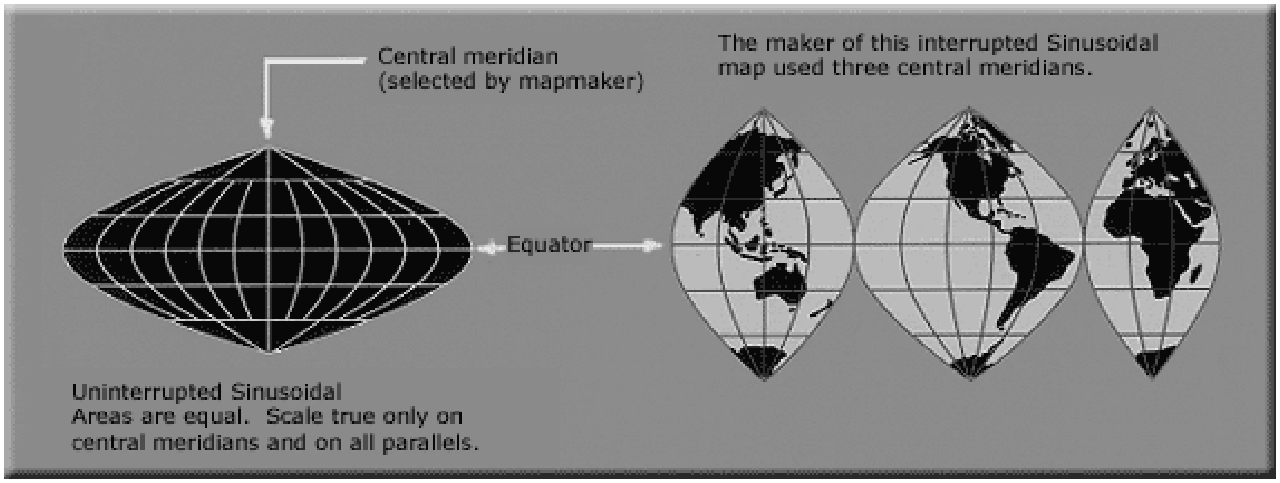
Stright Equator, parallels, central meridian
Central meridian is 0.53 as long as Equator

Concave meridians are equally spaced

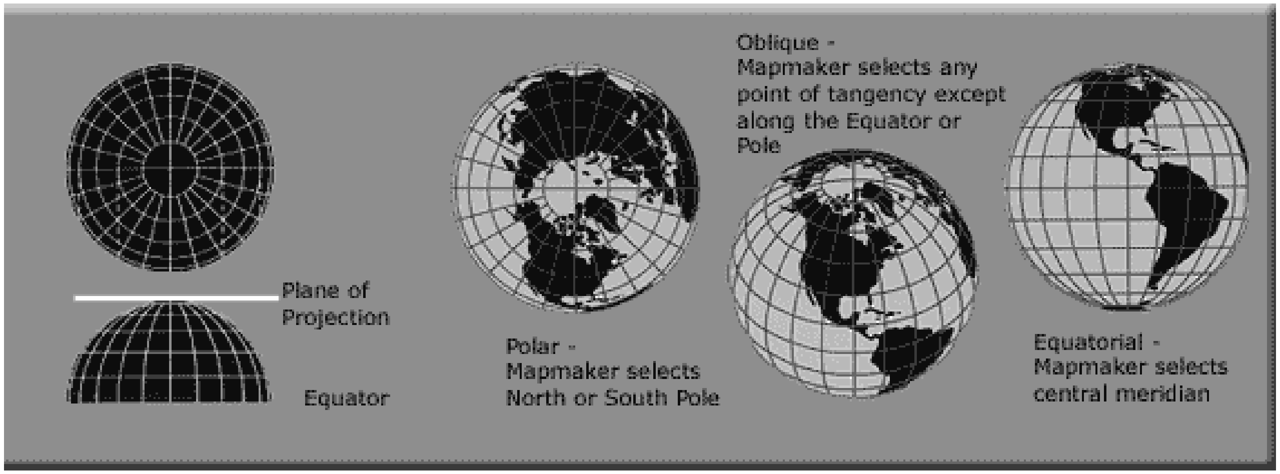
http://egsc.usgs.gov/isb/pubs/MapProjections/projections.html

Map Projections

Sinusoidal Equal Area


Central meridian
(selected by mapmaker)
The maker of this interrupted Sinusoidal
map used three central meridians.
Equator
Uninterrupted Sinusoidal
Areas are equal. Scale true only on
central meridians and on all parallels.

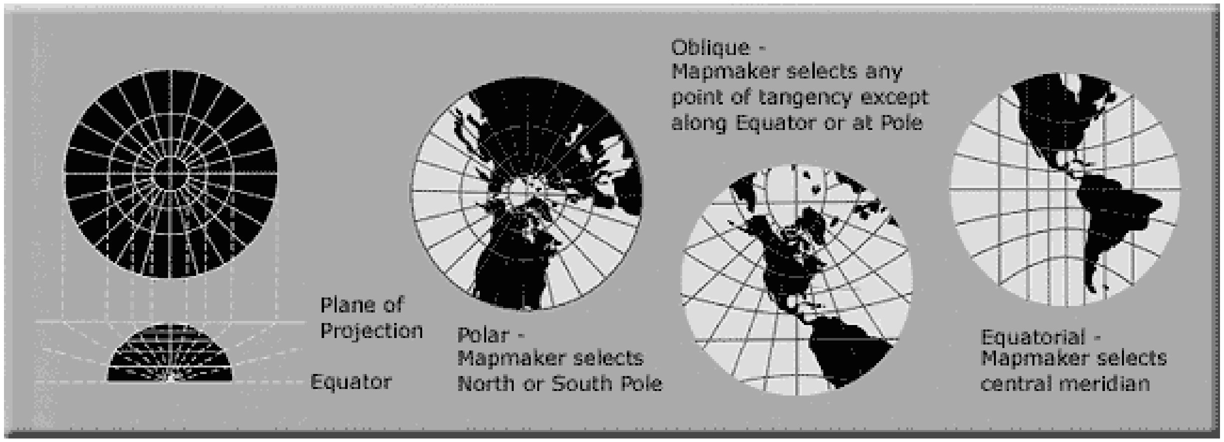
Orthographic



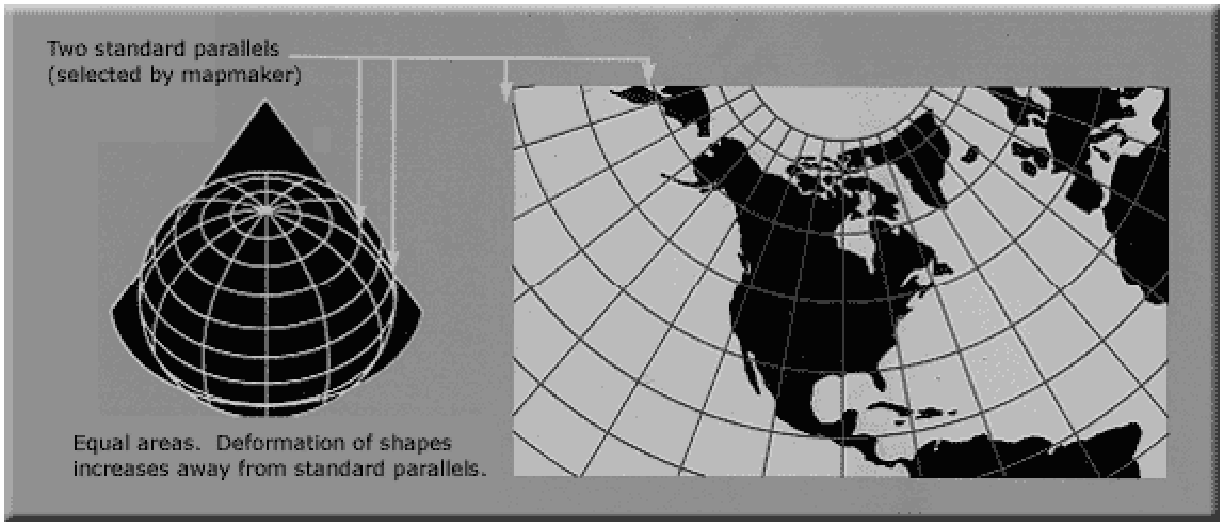
http://egsc.usgs.gov/isb/pubs/MapProjections/projections.html

Map Projections

Gnomonic



Albers Equal Area Conic


Two standard parallels
(selected by mapmaker)
Equal areas. Deformation of shapes
increases away from standard parallels.

http://egsc.usgs.gov/isb/pubs/MapProjections/projections.html