Potential contributions of “Staring Images” to geodynamics research

Bruce G. Bills

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA
what is geodynamics?

broad definition:
  long-term dynamics of Earth deformation

narrow definition:
  viscosity structure of Earth’s interior
basic problem

• on time-scales shorter than a day
  – Earth behaves like an elastic solid
  – from the surface to the core-mantle boundary

• on plate tectonic time-scales (millions of years)
  – Earth behaves like a viscous fluid
  – from the lithosphere on down

• how does that transition occur?
### methods of probing Earth structure

<table>
<thead>
<tr>
<th>type</th>
<th>input</th>
<th>output</th>
<th>time scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>earthquakes</td>
<td>impulsive displacement</td>
<td>displacement</td>
<td>seconds-days</td>
</tr>
<tr>
<td>tides</td>
<td>periodic gravitational potential</td>
<td>displacement, gravity anomaly</td>
<td>hours-weeks</td>
</tr>
<tr>
<td>ice sheets</td>
<td>complex vertical load</td>
<td>displacement</td>
<td>$10^2$-$10^4$ years</td>
</tr>
<tr>
<td>large lakes</td>
<td>complex vertical load</td>
<td>displacement</td>
<td>$10^2$-$10^4$ years</td>
</tr>
</tbody>
</table>
advantages of large lakes

• significant vertical deflection
  – produced via loading
  – recorded in shoreline elevations

• complex load
  – spatial complexity
  – temporal complexity

• temporal record
  – sedimentary layers
  – less destructive than glaciers
A simple model of the Earth....

Crust

Mantle
basin subsides

Crust

Mantle flow
coastal geomorphic systems in a pluvial lake basin
loop barrier in Pyramid Lake, western Nevada

formed within 6 months, when lake level rose 2.8 m in 1997
case study: Lake Bonneville

large lake
- 300 km E-W extent
- 600 km N-S extend
- 300 m maximum depth
- ~10,000 km³ maximum volume

well studied
- 100's of radio-carbon dates
- 100's of surveyed shoreline elevations
Lake Bonneville shorelines on Antelope Island
Lake Bonneville shorelines: Stansbury island
data and models for Bonneville and Provo shorelines

data:

Currey, D.R. (1982),
Lake Bonneville: Selected features of relevance to neotectonic analysis,

models:

Viscosity estimates for the crust and upper mantle from patterns of lacustrine shoreline deformation,
lake Bonneville load and rebound pattern

10 m contours

100 km
Bonneville: Observed vs Computed

- Observed deflection (m)
- Computed deflection (m)
what role for Gazing Imaging?

Bonneville basin needs much more topographic data

current sampling
  averages 1 survey point every 20 km along shoreline
  only has samples on 2 prominent shorelines
  elevation accuracy ±2 m

future sampling
  1 point per km, or better
  dozens of intermediate shorelines

other lake basins,
  (Nevada, Bolivia, Mongolia, ....)
  some in quite remote locations
what role for Staring Images?

other characteristics of shorelines

shoreline ridges often have larger grain-sizes than the surrounding area

this leads to contrast in thermal inertia BRDF

this could help to map shorelines, basin wide
what role for Staring Images?

The most conspicuous shorelines, as seen in LandSat data, in Utah and Nevada, are those at the north end of Spring Valley.

In satellite images, there are pronounced light and dark ridges.

Topographically, they are very subtle, with only ~1 m of relief.

The dark features are gravel, with little vegetation.
The light features are sand, with some grass.

**Staring Images** would likely see very significant differences in these features, and could aid in mapping them.
shorelines at north end of Spring Valley, Nevada