**Lab—Evaluating Rainfall, Landslides, and Weather: Big Sur, California**

Department of Earth Sciences, Monterey Peninsula College

**Background Information/Data-**

**Book class** How Does Earth Work? Smith and Pun, 2nd ed. Chapters 15, 21.

***USGS*** (U.S. Geological Survey, Landslide Hazards Program; <http://landslides.usgs.gov/>).

***CGS*** (California Geological Survey). Since the 1960’s, the California Geological Survey (CGS) has produced numerous maps that show landslide features and delineate potential slope-stability problem areas (<http://www.conservation.ca.gov/cgs/geologic_hazards/landslides/Pages/Index.aspx>). Following the 1982 El Nino storms in the San Francisco Bay area, the Landslide Hazard Mapping Act mandated new maps to show landslides and landslide hazards. Landslide Hazard Identification Maps were prepared by CGS for use by local government planners from 1986 to 1995. A set of three to four maps was prepared for each map study area, usually encompassing a USGS 7.5-minute topographic quadrangle map. The set of maps typically consisted of a geologic map, a landslide inventory map - showing the location and distribution of existing landslides – and one or two landslide relative susceptibility maps. Also beginning in the early 1980’s, concerns about the long-term ecologic impacts of timber harvesting lead to the mapping of landslide features in forested lands.

***California Department of Water Resources*** (<http://www.water.ca.gov/>).

***NOAA*** (National Oceanic and Atmospheric Administration; <http://www.elnino.noaa.gov/index.html>).

**Goals-**

* To test the hypothesis that there is a relationship between precipitation and frequency of mass wasting events
* To analyze real local data to investigate and understand landslide potential

* To research records from data repositories.
* To understand the link between weather patterns (El Niño) and mass wasting events

**Big Sur Case Study**

Big Sur is located south of the Monterey Peninsula, in the Central Coast of California. It is a very popular destination where tourists experience the breathtaking views of the Pacific Ocean driving along Highway 1 between San Simeon and Carmel (see location figure on the right).

This section of Highway 1 is also known by common and sometimes catastrophic mass wasting events. Steep topography, active faulting, and seasonal storms make this rugged area one of the most landslide-prone stretches of the California coast (for more information read the UGSG 2004 report, CGS 2001 report, several news links in the References). Rock and debris slides, as well as widespread erosion, are the most typical hazards in the area and there are times when Highway 1 is closed for weeks/months in order to repair the damage and attempt to stabilize the slope after a rock slide occurs. One such closure in 1983 (Sycamore Draw Slide) cost over $7 million to remove the debris that moved down slope and to dig out the highway itself.

Three areas along the Big Sur coastline have been studied intensively by the USGS due to the occurrence of numerous mass wasting events:

* Hurricane Point (initial failure 1999, continued creep)
* Big Slide (historically active, “catastrophic failure” in 1998, continued creep)
* Pitkins Curve (2000 slide, continued creep)
* Landslide (March 2011, landslide)

**Assignments-**

**PART 1-RAINFALL**

Table 1 below contains data collected by the California Department of Water Resources (<http://www.water.ca.gov/>) and shows the monthly precipitation totals for the Big Sur collection station. Use this information to answer the following questions.

**Table 1**: Big Sur Monthly Precipitation Totals (1997-2005, 2007)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | Total  |
| 1997 | 2.83 | 11.48 | 22.94 | 19.45 | 0.39 | 0.22 | 0.5 | 0.02 | 0.2 | 0 | 1.38 | 0 | 59.41 |
| 1998 | 0.4 | 9.29 | 8.09 | 17.01 | 24.3 | 6.72 | 4.54 | 4.93 | 0.06 | 0 | 0 | 0 | 75.34 |
| 1999 | 0.4 | 1.95 | 0.99 | 2.89 | 1.77 | 2.62 | 2.71 | 0.02 | 0 | 0 | 0 | 0.32 | 13.67 |
| 2000 | 0.18 | 4.26 | 0.38 | 17.59 | 20.18 | 3.01 | 2.66 | 1.96 | 0.01 | 0 | 0 | 1.25 | 51.48 |
| 2001 | 7.12 | 0.77 | 0.55 | 9.03 | 8.83 | 4.24 | 3.79 | 0 | 0 | 0 | 0 | 0.15 | 34.48 |
| 2002 | 1.24 | 8.28 | 10.06 | 4.61 | 3.99 | 4.62 | 0.74 | 0.57 | 0 | 0 | 0.03 | 0.13 | 34.27 |
| 2003 | 0.05 | 6.73 | 13.96 | 3.63 | 3.65 | 0.4 | 4.7 | 1.28 | 0 | 0.07 | 0 | 0 | 34.47 |
| 2004 | 1.91 | 4.45 | 7.72 | 8.66 | 7.57 | 5.7 | 3.25 | 0.84 | 0.26 | 0.04 | 0.08 | 0  | 40.48 |
| 2005 | 7.3 | 2.87 | 13.71 | 10.45 | 11.28 | 8.52 | 3.32 |  0 |  0 | 0  |  0 | 0  | 57.45 |
| 2007 | 0.14 | 2.81 | 6.58 | 1.07 | 9.28 | 0.89 | 1.55 | 0.32 | 0 | 0 |  0 | 0  | 22.64 |

1. What three months of the year typically receive the most rainfall in the Big Sur area?
2. The Hurricane Point rock slide occurred in a year that had very low annual rainfall. What do you think might account for this discrepancy?
3. Is it possible that the *pattern* of rainfall could affect the number of landslides? That is, would it matter if all the rain falling in a heavy rainfall year fell mostly in a few months or whether it was spread out over many months (for example, 1997 vs. 2005). Think about how that might affect the saturation of the ground in terms of the relationship between runoff and infiltration.
4. Considering the location of Big Sur (rocky coastline), what other weathering and erosional processes are attacking the area that may be responsible for causing landslides?
5. Go to the California Department of Water Resources link I gave you and find this year’s rain fall data. How do the correlate to historical data?

**PART 2-EL NIÑO**

El Niño is a disturbance in the ocean-atmosphere system that occurs when surface water temperatures are higher than normal in the Pacific Ocean. These temperature changes alter the normal circulation of the atmosphere bringing warm, wet weather to the East Pacific (where we are) and drought conditions to the Western Pacific (It also blocks the cool, nutrient-rich waters that are usually found in our area, making fish populations hungry!). For more information about the basics you can go to the NOAA website: <http://www.elnino.noaa.gov/index.html>.

Table 2 lists the years between 1981 and 2010 in which El Niño conditions existed. It also rates the El Niños as moderate or strong. Table 3 gives the total rainfall in Big Sur, by year, for the same time period. See both in the next page.

Note that the rainfall totals listed in Table 3 are for **water years.** Water years run from October to October, to take into account the fact that we have rainy seasons that span two calendar years. The water year tells you whether it was a wet winter or dry winter better than annual rainfall totals.

Answer the following:

1. In which water year did Big Sur receive the most precipitation?
2. Does this year correspond with a known El Niño event?
3. Considering all of the data provided, do all years with high annual rainfall correspond to El Niño events? What can you conclude about the correlation between the timing of high rainfall and El Niño events? Does it matter whether we consider whether it was a strong or moderate El Niño?

|  |  |
| --- | --- |
| Water Year  | Annual Rainfall |
| 1980 | 28.05 |
| 1981 | 64.22 |
| 1982 | 86.5 |
| 1983 | 31.73 |
| 1984 | 28.81 |
| 1985 | 54.37 |
| 1986 | 31.59 |
| 1987 | 29.3 |
| 1988 | 29.94 |
| 1989 | 21.95 |
| 1990 | 32.22 |
| 1991 | 35.53 |
| 1992 | 56.47 |
| 1993 | 28.87 |
| 1994 | 67.94 |
| 1995 | 51.75 |
| 1996 | 54.18 |
| 1997 | 75.32 |
| 1998 | 38.43 |
| 1999 | 51.98 |
| 2000 | 31.07 |
| 2001 | 37.45 |
| 2002 | 37.42 |
| 2003 | 36.25 |
| 2004 | 58.99 |
| 2005 | 53.42 |
| 2006 | 23.12 |
| 2007 | 30.33 |
| 2008 | 35.84 |
| 2009 | 49.42 |
|  |  |

|  |  |
| --- | --- |
| Water Year | Event |
| 1981-82 | El Niño (strong) |
| 1982-83 | El Niño (strong) |
| 1983-84 |  |
| 1984-85 |  |
| 1985-86 |  |
| 1986-87 | El Niño (moderate) |
| 1987-88 | El Niño (moderate) |
| 1988-89 |   |
| 1989-90 |   |
| 1990-91 |   |
| 1991-92 | El Niño (strong) |
| 1992-93 | El Niño (moderate) |
| 1993-94 |   |
| 1994-95 | El Niño (moderate) |
| 1995-96 |   |
| 1996-97 |   |
| 1997-98 | El Niño (strong) |
| 1998-99 |   |
| 1999-00 |   |
| 2000-01 |   |
| 2001-02 |   |
| 2002-03 | El Niño (moderate) |
| 2003-04 |   |
| 2004-05 | El Niño (moderate) |
| 2005-06 |  |
| 2006-07 |  |
| 2007-08 |  |
| 2008-09 |  |
| 2009-10 | El Niño (moderate) |

**Table 2**: Years that California Experienced an El Niño.

**Table 3**: Big Sur Water Year Precipitation Totals (1987-2009).

**References-**

*Reports Big Sur Landslides:*

C.J. Wills, M.W. Manson, K.D. Brown, C.W. Davenport and C.J. Domrose, 2001, Special Report 185 - Landslides in the Highway 1 Corridor: Geology and Slope Stability along the Big Sur Coast between Point Lobos and San Carpoforo Creek, Monterey and San Luis Obispo Counties, California. California Geological Survey, 40 pp. <http://www.conservation.ca.gov/cgs/rghm/landslides/SR_185/Documents/CT001mon%20Report.pdf>

[http://sanctuarysimon.org/projects/100243/estimated-sediment-yield-from-coastal-landslides-and-active-slope-distribution-along-the-big-sur-coast,-monterey-and-san-luis-obispo-counties,-california--](http://sanctuarysimon.org/projects/100243/estimated-sediment-yield-from-coastal-landslides-and-active-slope-distribution-along-the-big-sur-coast%2C-monterey-and-san-luis-obispo-counties%2C-california--)

*El Niño:*

NOAA El Niño/ENSO Discussion at <http://www.ncdc.noaa.gov/teleconnections/enso/enso-tech.php>

NOAA’s El Niño page at <http://www.elnino.noaa.gov/index.html>

*Landslides Local News:*

<http://www.noozhawk.com/article/032611_big_sur_landslides/>

<http://www.mercurynews.com/ci_17638872>