Changing ice mass balance within the Himalayas using GRACE

Christopher Pearson 2011

Introduction

The Himalayas stretch over 1500 miles across Asia, containing the largest mountain in the world Mt Everest. It is home to 15000 glaciers which store approximately 12000km^3 of water and supplies approximately 1.3 billion people with water across southern Asia. These glaciers are of constantly changing size and potentially effecting the life of the surrounding population in the years to come.

The NASA/GFZ GRACE satellite mission launched in 2002 is a tandem pair of satellites in a near polar orbit some 220 km apart. These satellites measure differential changes in gravitation pull by very accurately monitoring the range rate between the two satellites as they orbit the Earth using a microwave device. Changes in gravitation pull can be linked to changes in surface mass.

Aim

To determine if the ice mass balance over the Himalayas is changing in size and where the changes are occurring.

Objectives

- To create a suitable outline to define the region covered by the Himalayas
- Use 9 years of GRACE data to look for trends within the data sets
- Split the Himalayas up into smaller regions to investigate spatial variability
- Remove the effects of hydrology from outside the region that could be effecting results

Method 1

1. Use a kernel function (values of 1inside the area and 0 outside) expanded in spherical harmonics up to degree and order 60
2. Calculate estimates of hydrololgy outside the area to eliminate their effects
3. Calculate the mass level for each month of the data set
4. Plot the mass levels on a graph and identify any linear trends

Results 1

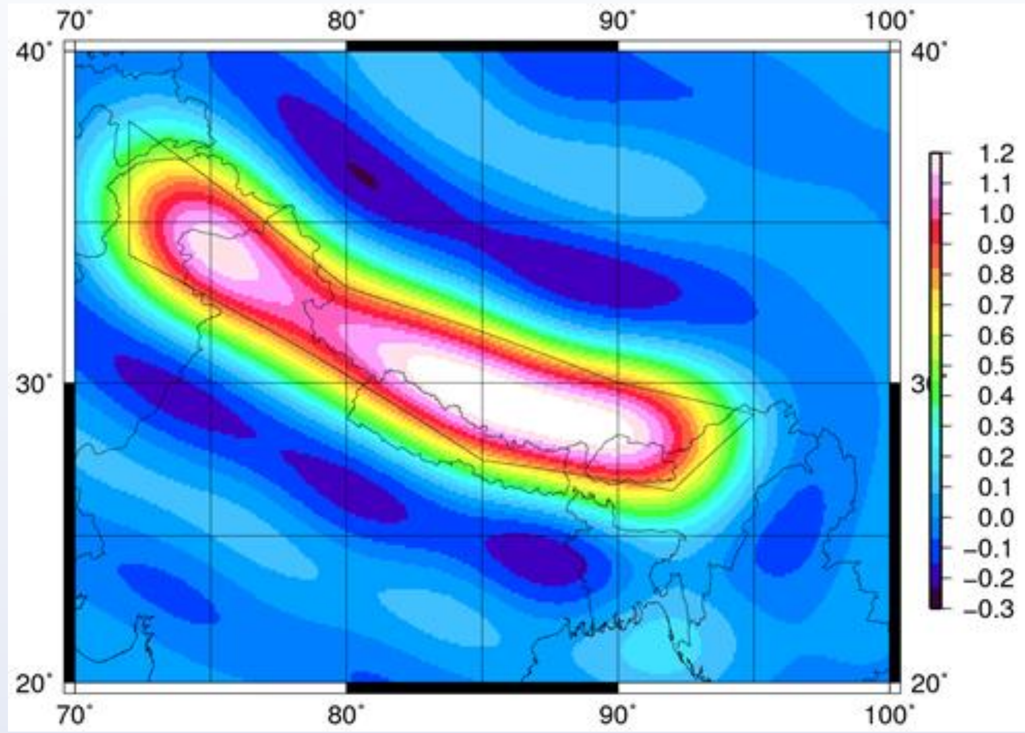

Figure 1 – Himalayas region

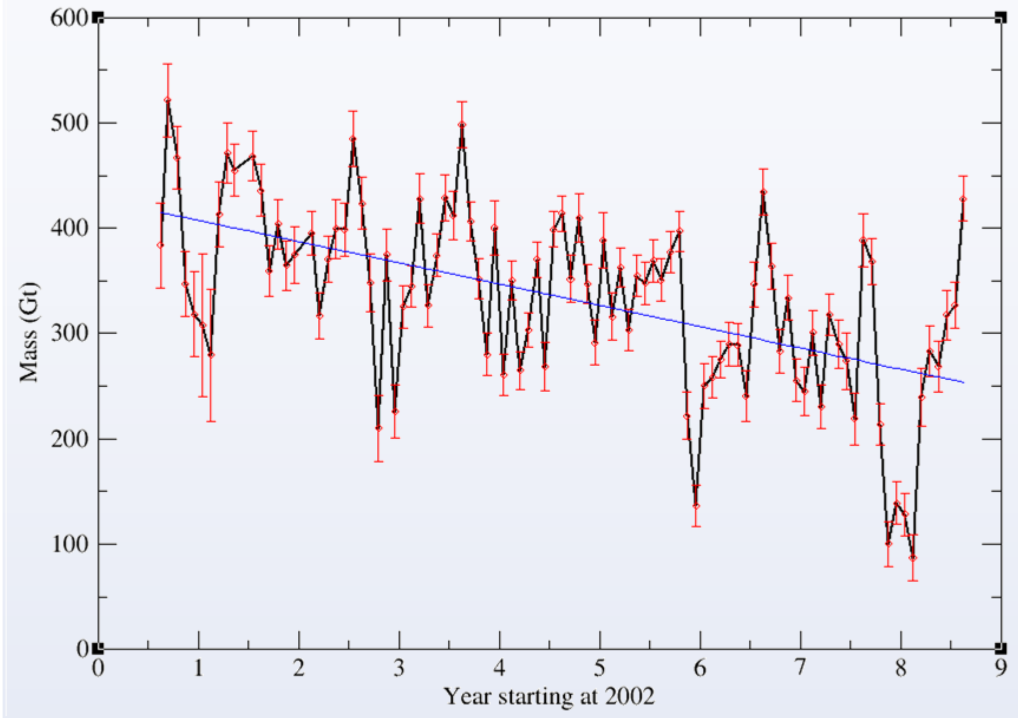

Figure 2 – Plot for whole region

Figure 2 clearly shows a significant loss in mass over the region identified in Figure 1. Over the 9 year period the region lost 20.2±3.2 Gt per year on average which is due to a loss in ice from the 15000 glaciers. This loss in ice mass is equivalent to 2.6±0.4cm in equivalent water height over the entire region per year. In order to identify more precisely where this loss was occurring from the region had to be split up into smaller sections.

Method 2

1. Split the area into half and re-run Method 1 in order investigate two separate regions (East and West Himalayas)
2. Split the area into three equally sized areas (East, central and West Himalayas) in order to also compare these regions

Results 2

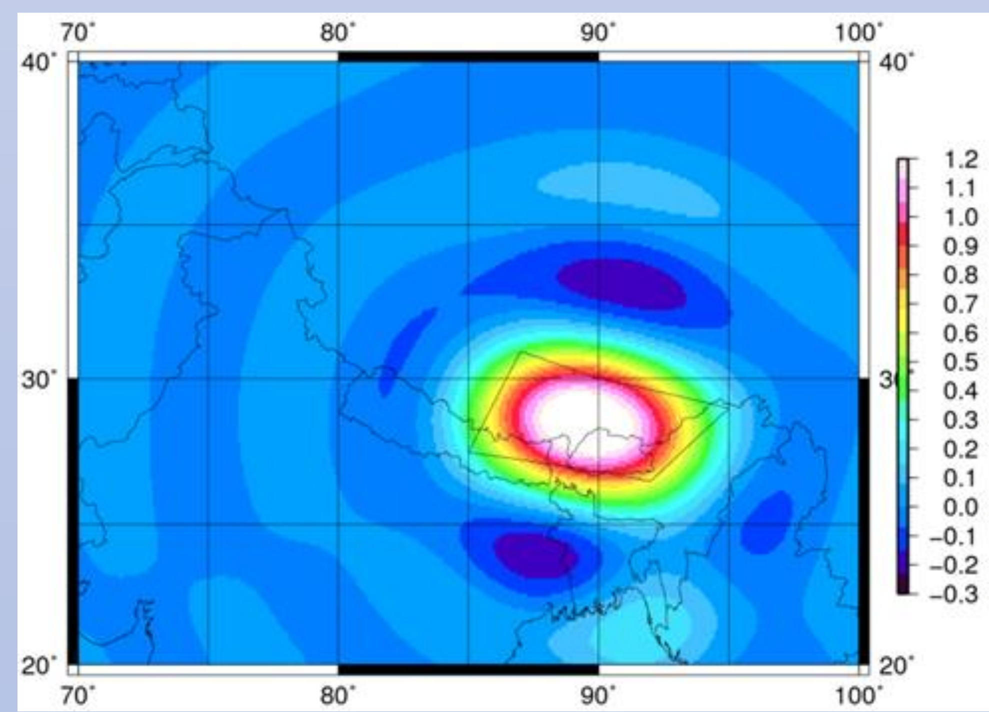

Figure 3 – Eastern third

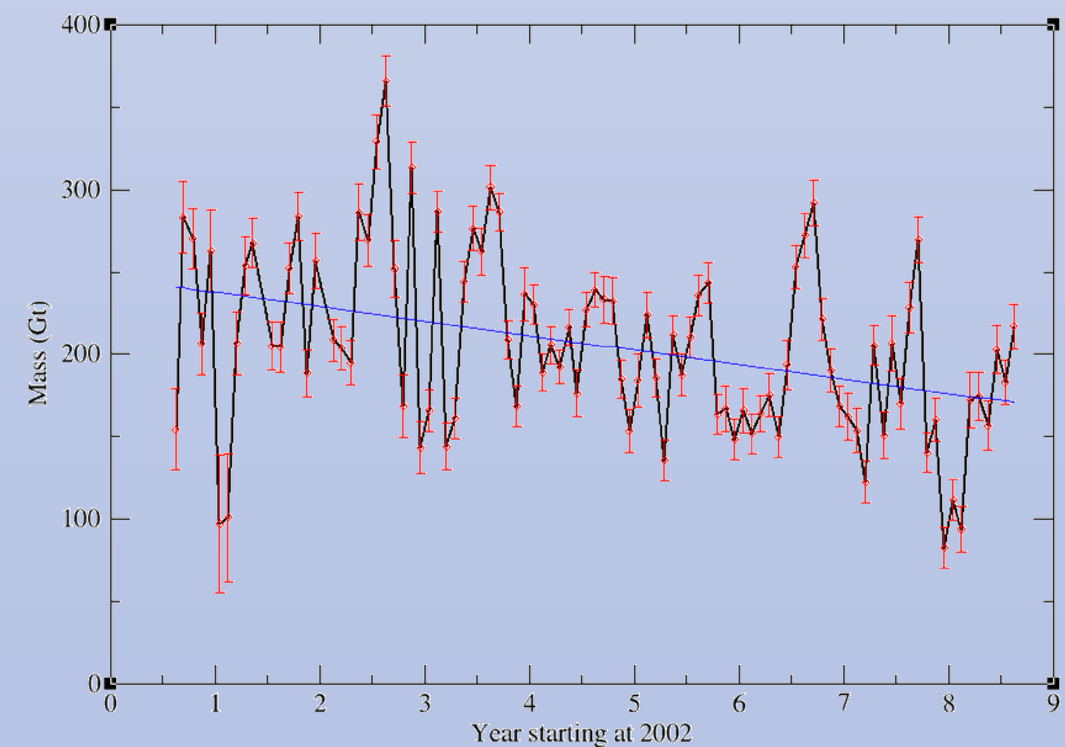

Figure 4 – Plot for eastern third

When the region was split into three sections the eastern section as shown in Figure 3 gave the largest response. Figure 4 shows that within this area 8.8±2.3 Gt per year of mass was lost. This corresponds to a 3.2±0.8cm loss in equivalent water height from the glaciers per year.

Despite the south east region appearing to have the largest amount of ice loss within the mountain range, the results are not statistically different from each other in order to prove this theory mathematically. All other attempts to divide the region up provided small variations in results which however failed to find any statistically different readings.

Conclusion

Using GRACE it has been possible to prove the glaciers within the Himalayas are losing mass at a significant rate. The loss of 2.5cm of equivalent water height per year from the glaciers may have a significant impact on the people dependent on waters within the area in years to come.

Despite attempts to identify smaller regions where the majority of the mass loss occurs the errors within the data were too large to be able to deduce a mathematically significant conclusion.

In order to improve these results more and ideally better data should be used. However, this is currently limited to the sensitivity of the GRACE mission at its altitude of about 450 km and to availability of data from 2002 onwards.

Acknowledgements

I would like to thank Prof Phil Moore and Stuart Andrews for their help and support throughout this project.

Civil Engineering and Geosciences • Cassie Building • Newcastle University • Newcastle upon Tyne • NE1 7RU • UK • www.ceg.ncl.ac.uk
further information: christopher.pearson@ncl.ac.uk