# **Galapagos Islands**

## Overview

The Galapagos Islands are composed of thirteen primary islands located in the equatorial Pacific (between approximately 2°S to 1°N and 88° to 92° W). The islands are volcanic in origin and are scattered over an area of approximately 72000 sq. km about 965 km west of Ecuador (Figure 1).



Figure 1: Bathymetry map of the Galapagos Islands [Smith and Sandwell, 1997]

#### **Observations**

There has been very little scientific research on the internal waves around the Galapagos Islands. Satellite imagery shows a complex distribution of internal wave signatures both between islands and propagating away from the archipelago. The complex wave signatures around the islands result from the large number of internal wave sources that include the sills between islands and seamounts. Similar patterns have been observed around other island groups (e.g. The Azores). Table 1 shows the months of the year during when internal wave imagery has been acquired.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	1	3	3						2	3	

 Table 1 - Months when internal waves have been observed around the Galapagos Islands.

 (Numbers indicate unique dates in that month when waves have been noted)

The internal waves around the Galapagos fall into two categories; those propagating in close proximity among and between the islands, and those fields in the open ocean surrounding the archipelago.

Figures 2, 4, 10 and 12 show the waves among the Islands. Figure 2 is an Astronaut photograph showing internal wave signatures in the Isabela Channel. The image shows waves generated at the sill between the islands of Isabela and San Salvador propagating away in opposite directions. Figures 4 and 12 are synthetic aperture radar images of the areas around Santa Maria Island and Santa Cruz Island. The images show internal waves propagating in most every direction, testifying to the number of source locations around the islands. An interpacket separation, for packets from the same generation point are on the order of 30 km.

Figure 10 is Astronaut photograph that shows an internal wave packet, with an along crest length of approximately 60 km, propagating north (toward San Christobel Island). The wavelength of the lead soliton is approximately 1 km. The wave appears to be a combination of two waves that formed at different locations near the 500 isobath (Figure 9). This is type of combination is common and often seen in continental shelf internal waves.

Figures 3, 5-8 show internal wave signatures in the open ocean surrounding the Galapagos. Figures 3, 5 and 6 are ERS-1 SAR images acquired in November 1992. The images show a spatially expansive internal wave field radiating away from the archipelago to the east-northeast (3) and north-northeast (5-6) and. These patterns, which extend beyond 200 km from the islands, indicate the seamounts and small islands northwest of Isla Isabela are the generation sources.

Figures 7 and 8 show two Astronaut photographs acquired 7 March 1985. The figures, like Figure 3, 5-6 show an internal wave field over a large area propagating to the north-northeast away from the islands.

### References

Smith, W. H. F., and D. T. Sandwell, Global seafloor topography from satellite altimetry and ship depth soundings, Science, v. 277, p. 1957-1962, 26 Sept., 1997. http://topex.ucsd.edu/marine\_topo/mar\_topo.html



Figure 2. Astronaut photograph (ISS006-E-38827) acquired on 16 March 2003 at 1501 UTC. The sunglint photograph shows the signature of internal waves in the Isabela Canal propagating in several directions. Imaged area is approximately 25 km x 30 km. [Image Courtesy of the Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center (http://eol.jsc.nasa.gov)]





Figure 3. ERS-1 (C-Band, VV) SAR image of the Galapagos Islands acquired on 18 November 1992 at 1619 UTC (orbit 7027, frames 3573, 3591). The image shows the signature of a large internal wave field radiating away from the Galapagos archipelago to the eastnortheast. Imaged area is 100 km x ©ESA 1992 200 km. [Image courtesy of Werner Alpers, University of Hamburg, Hamburg, Germany]



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An Atlas of Oceanic Internal Solitary Waves (February 2004) by Global Ocean Associates Prepared for Office of Naval Research – Code 322 PO



Figure 4 (Left). ERS-1 (C-Band, VV) SAR image of the Galapagos Islands acquired on 18 November 1992 at 1620 UTC (orbit 7027, Frames 3609, 3627). The image shows the signature of internal waves around Santa Cruz Island (center) and Santa Maria Island (bottom) in the Galapagos. Imaged area is 100 km x 200 km. ©ESA 1992 [Image courtesy of Werner Alpers, University of Hamburg, Hamburg, Germany]





Figure 5. ERS-1 (C-Band, VV) SAR image of the Galapagos Islands acquired on 15 November 1992 at 1614 (orbit 6984, Frames 3591, 3609). The image shows the signature of a large internal wave field radiating away from the archipelago to the north-northeast. Imaged area is 100 km x 200 km ©ESA 1992 [Image courtesy of Werner Alpers, University of Hamburg, Hamburg Germany]





Figure 6. ERS-1 (C-Band, VV) SAR image of the Galapagos Islands acquired on 15 November 1992 at 1615 UTC (orbit 6984, Frames 3627, 3645). The image shows the signature of internal waves around San Christobal Island (top left) in the Galapagos. Imaged area is 200 km x 100 km ©ESA 1992 [Image courtesy of Werner Alpers, University of Hamburg, Hamburg, Germany]



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Figure 7. Astronaut photograph (STS067-730A-30) acquired on 7 March 1985 at 2153 UTC. The low oblique sunglint photograph shows a large internal wave field propagating to the north-northeast beyond the edge of Isla San Christobal. (North is in the upper right corner). Imaged area is approximately 100 km x 100 km. [Image Courtesy of the Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center (http://eol.jsc.nasa.gov)]





Figure 8. Astronaut photograph (STS067-730A-31) acquired on 7 March 1985 at 2154 UTC. The low oblique sunglint photograph shows a large internal wave field propagating to the north-northeast away from the Galapagos Islands (North is in the upper right corner). Imaged area is approximately 200 km x 200 km. Image Courtesy of the Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center (http://eol.jsc.nasa.gov).





Figure 9. Astronaut photograph (STS41b-031-1100) shown with the local bathymetry. [Smith and Sandwell, 1997]



Figure 10. Astronaut photograph (STS41b-031-1100) acquired on 3 February 1984 showing fine scale internal wave propagating toward San Christobel Island (Galapagos). [Imaged area is approximately 100 km x 100 km. Image Courtesy of the Earth Sciences and Image Analysis Laboratory, NASA Johnson Space Center (http://eol.jsc.nasa.gov)]





Figure 11. SIR-C survey acquired on 11 April 1994 shown with the local bathymetry. [Smith and Sandwell, 1997]



Figure 12. SIR-C (L-band) SAR image acquired on 11 April 1994 at 2131 UTC (Data Take 40.5). The image shows the signature of internal wave around Santa Maria Island in the Galapagos. Imaged area is approximately 100 km x 51 km.



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