Image Analysis and Spatial Statistics (IASS) - Spring 2016 ROBEX online course

Week 1 – Marine science

The marine environment is not the most ideal for photography:

- Light penetration is low after the first few 10s of meters depth
- Colour refraction is a problem
- Saltwater is a corrosive environment for many metals
- Pressure can mean lenses and / or pressure housings can be expensive when imaging the deep sea
- The environment is difficult to reach

Despite these problems, images are some of the most important data which can be acquired from an extreme environment. If you think about the trips of space probes to planetary bodies, or the recent trip to the extreme deep by James Cameron in his one man, single use submersible, it is not the sensor data from these vehicles which is most eagerly demanded by observers – it is the image data.

Image data can help place an ecosystem in context – images can show if a location is inhabited, how the seafloor looks like, whether strong currents are present etc. If an image of an area of seafloor shows curious bubbling from the seafloor, then curious readings in other marine sensors, such as methane sensors, may be explained… without images, it is a little more difficult to trust other sensor data.

There are many sorts of image data currently collected from the deep sea, and I will introduce some of those now, along with some historical context on their use:

Snorkel and Diver data

Since the invention of modern SCUBA equipment in the 1940s, the possibility to use lightly clad divers, with handheld photographic equipment, to explore and record shallow marine ecosystems has fed into many research publications. Scientific divers reqularly deploy oceanographic equipment an capture marine still and video images from the poles to the equator. Natural light penetration is negligible below 50 m depth, the effective scientific diving limit using standard equipment, and many uses focus on depths of 0 – 30m. Particularly common are photo-transects, carried out by divers swimming above the seafloor and photographing the bottom, making up image transects of ecosystems such as tropical coral reefs, or seagrass meadows within European waters.

Lander data

Since WWII, and progressively since the 1970s, a common way to get an understanding of an area of seafloor out of the depth range visitable by divers has been to deploy Lander systems. These lander systems are basically tripods or stands which can be mounted with instruments to measure marine conditions – whatever conditions are of interest for a particular research question – and also may mount camera systems. These landers can carry large battery packs to power the flashlight systems required for illuminating the depths for deep sea cameras to work. Commonly, landers can collect TIME SERIES images – basically photographs of the same region of seafloor taken again and again over time – to observe and record any visual change in the ecosystem during the deployment. These changes could include accumulation of material on the seafloor, the change in fish numbers, the timing of periods of high sediment transport.

Landers are in heavy, continuous use today, with many research institutes maintaining observatories in the deep sea, rotating landers every few years and publishing the results.

Submarine and Remote Operated Vehicle (ROV) surveys

Lander studies are fixed in position. They can remain on the seafloor for potentially years, but are constrained to sampling (and photographing) only in the area immediately around the Lander. Remote Operated Vehicles (ROVs) and research submarines, operate from research ships and can remain deployed for 10s of hours in an area, potentially taking measurements (including still image and video collection) in numerous areas around the vessel. These studies allow SPATIAL VARIABILITY in an ecosystem to be investigated. A good example of this might be the investigation of underwater 'black smokers' , volcanoes, and how the biology surrounding these volcanoes may alter with distance from the volcanic vents.

Though these methodologies add spatial analysis, they do not offer the temporal analysis over long periods offered by Landers. Keeping them in the water is expensive, and possibly difficult in winters. For temporal studies, the ships which carry the vehicles must revisit the sites. Such studies do occur, but are expensive.

Aside from varied ecosystems like underwater volcanoes, these investigation methods are also well suited to surveying areas before and after anthropogenic impact – such as areas before and after bottom trawling, before pollution plume deposition etc. Or to gauge recovery of an ecosystem over time (with repeat surveys over a few years).

Autonomous Underwater Vehicles (AUVs)

These are robot submarines capable of remaining underwater for weeks, or potentially months. The vehicles are programmed with courses, or with navigation algorithms, and then proceed to monitor as commanded. Seafloor imaging with these vehicles is in the early stages, but as we will learn later in this course (with a nice dataset from ongoing research), there is great potential here. At present, these vehicles tend to fly quite high in the water column, 5m + from the seafloor, to ensure safety. Because of this the energy cost required to illuminate the seafloor is high, limiting the number of images which may be collected.

Crawlers

A new sort of mobile underwater tracked vehicle, the Crawler, is starting to see action with various research groups. Jacobs University Bremen has been at the forefront of Crawler developments for more than a decade and has supplied vehicles of various types to various institutes.

Basically, crawlers use tracks or wheels to move across the seafloor, either under direct command via internet cable, or following navigational programs or algorithms. They are stable systems and allow spatial and temporal research and assessment of the seafloor.

Throughout this course you will get the chance to look at and assess data from all of the categories outlined above, and introduced to some techniques to analyse the images.

Marine science tasks this week:

1. Check the list of up-to-date tasks on this weeks page of the IASS website.
2. Particularly important, download, install and read the manual for the 'Papara(ZZ)I' software… we will use this heavily in the next week.
3. If you have time, use google scholar and try and find an image taken via each of the methods listed above. Post these on the course forum.