How do we measure the ocean from space?

Key outcomes: If you get nothing else out of this brief session i hope you will understand that:

- Clouds are the enemy and the reason we have patchy coverage.
- We use mathematical models of the real world to interpret raw satellite observations and as our understanding of the real world grows so does our models ability to represent that world.

Introduction

The current eReefs system uses two types of remote sensing science: ocean colour and sea surface temperature (SST).

Ocean colour uses visible radiation to estimate the constitutents of the surface ocean and SST uses thermal radiation to estimate the temperature of the ocean's surface.

Ocean Colour

Ocean colour has traditionally been used to measure the biomass and distribution of marine microbes in the open ocean. In recent years there has been significant advances in the use of ocean colour for water quality assesment - which is mainly how we use it here.

More information about the science of ocean colour can be found at the International Ocean Colour Coordinating Group or at the NASA Ocean Biology Processing Group Web Page

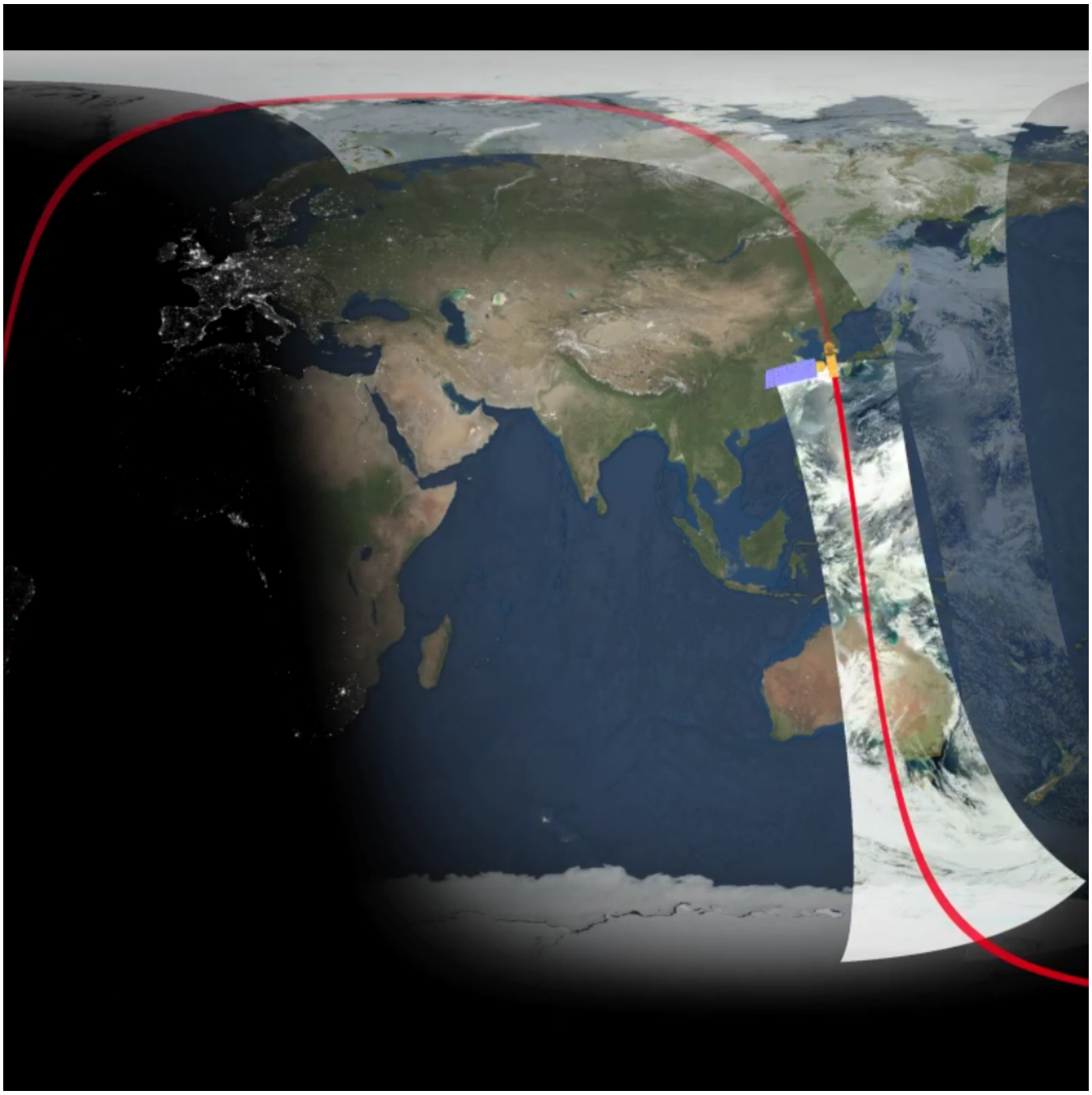
Sea Surface Temperature

Sea Surface Temperature (SST) is a measure of the surface ocean's energy due to the motion of molecules at the top layer of the ocean. Temperatures are measured from about 1mm or less below the surface of the ocean.

Good source of information is the NASA podaac and the Group for High-Resolution Sea Surface Temperature (GHRSST).

How does it work?

All of the data provided through the ereefs mwq and reeftemp systems start as light measured from satelite wizzing around the just outside the top of the atmosphere.



Start of video

This video is of the modis aqua satellite - the main sat we use for ereefs at the moment. It passes over the GBR twice a day - once in the day and once at night. We measure mwq during the day and rt at night (we can do it in the day too...). as we see the video go on you'll notice that we can see the land, oceans, and cloud in the visible images collected by the satellite. Clouds are the enemy! we can't see through them and neither can the satellite - this results in the patchy nature of the dialy data presented by eReefs mwq and rt.

End of video

Now I want to give you a brief overview of how we get from light measured at the top of the atmosphere to reliably knowing anything about the contents or properties of the ocean.

To do this i'm going to do a couple of drawings on the board:

- here we have the earth and a satellite whizzing about above it.
- And here we have the sun shining down onto the ocean.
- as the light of the sun reaches the ocean it reflects back off the surface and this can sometimes be seen by the sat - this is sun glint and we try to mask this out as best as we can.
- The suns light can also reflect off the tops of clouds and this causes noise in the sensor - there's not a lot we can do about this -but NASA does calibrate the sensor to try to deal with this as much as possible.
- Once some light finally makes it into the water it might hit some cells of algae, or a particle or sediment, or the sea floor. If this happens, some of the light is relfected back up out of the waters surface and through the atmosphere into the satellites sensor. This is the light we want.
- Unfortunately, there is an atmosphere and a bunch of clouds in the way that often tend to intercept this light as it passes back out of the ocean. How do we deal with this atmosphere? well this is best described by looking at our data processing workflow at the same time.

I will now draw a new drawing of the workflow of MWQ (ReeftTemp is similar but not the same. It doesn't use visible light but rather measures heat which is somewhat less difficult and so we won't delve into that much here):

- L0: "raw" data are aquired from the sat.
- L1B: L0 data are calibrated and geolocated.
- L2: Compute basic environmental properties and get TOA.
- Rrs: Use a specifically designed atmospheric correction to get from toa to just above the surface of the water. This uses an ANN which has a bunch of knowledge about typical conditions on the GBR.
- MWQ: The Rrs is taken and converted into MWQ indices based on the typical condition of the GBR - if lots of green then lots of algae, if lots of brown then lots of sediment, just more mathematically than that.

The last two steps are models of the real world and as such they require a lot of *in situ* measurments of both light and in water constituants to train them about how the real world works. As such, these models are only as good as the data used to make them and so both CSIRO and us are always trying to improve the models design and to collect more *in situ* measurments.

Example drawing:

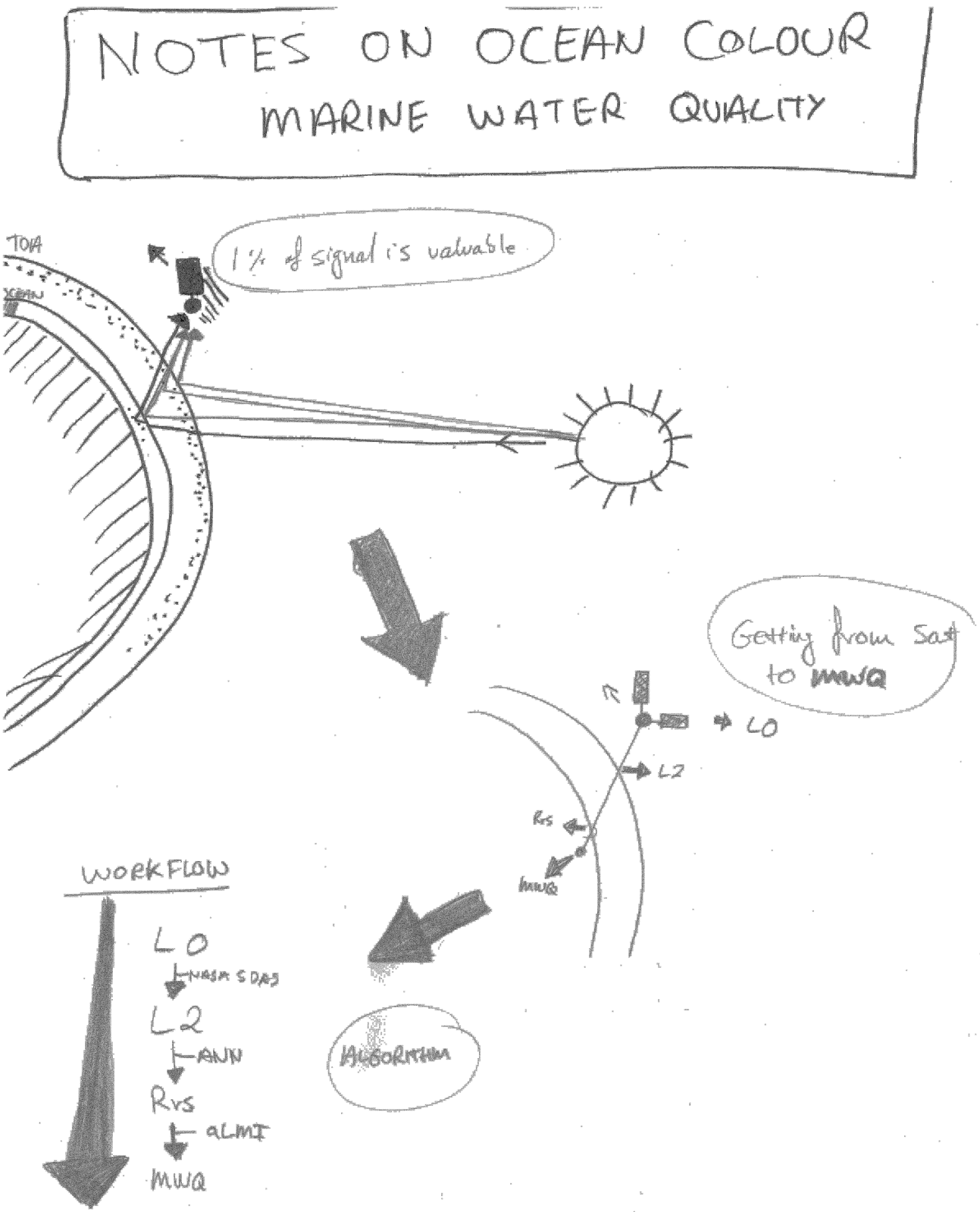


Figure 1: Drawing of ocean colour scientce