Networking Friday with Milton Kampel

May 15th, 2020

Question and Answers Report

Anonymous Attendee:

Q: Will the remote sensing symposium be held in Portuguese or English?

A: The Brazilian Remote Sensing Symposium usually invites international speakers in all its editions. The symposium has sessions in Portuguese and English. Many sessions have simultaneous translation. Submitted papers are accepted in Portuguese, English and Spanish.

Miguel Belló Mora:

Q: What is the optimum temporal resolution for coral reef analysis with HS sensor?

A: It will depend on the interest of your study. I think that, in the case of a mapping, the temporal resolution may not be as important, as the spectral and spatial resolutions, for example. However, in the case of monitoring due to water heating or other coral stressors, the temporal resolution may be more relevant.

In general, we must keep in mind that there is a compromise between spatial, temporal, and spectral resolutions. This means that when prioritizing a very high spectral resolution, as in the case of a hyperspectral sensor, the other resolutions may be slightly impaired. Usually we also seek to have a high (or medium) spatial resolution. Thus, temporal resolution ends up being less favored in this type of conceptual analysis.

I am considering sensors here on orbital platforms. However, once the sensor is installed on an aircraft or drone, there would be no limitation for temporal resolution, from the point of view of the system itself. Of course, in these cases, the limitations must be more related to questions of financing survey campaigns, weather conditions and system autonomy.

Anonymous Attendee:

Q: Is there any current application to fisheries?

A: The use of remote sensing has been used to manage fisheries at sustainable levels and to guide the fishing fleet in locating schools of fish more efficiently. Fish tend to aggregate in oceanic regions that have favorable environmental conditions for certain species. Several environmental or meteoceanographic variables of interest can be estimated by remote sensing, such as sea surface temperature, ocean color (productivity) and location of ocean fronts, meanders, eddies, and gradients. The spatial and temporal variability of environmental conditions strongly influences the natural fluctuations in fish stocks. The historical analysis of remotely-sensed data (acquired by satellites or even by aircrafts), can be especially useful in this type of analysis. In addition, data obtained by remote sensors can be transmitted to fishermen in quasi-real time (or Near-Real Time), to optimize fishing activity, with fuel savings and search time. These data can also be used by modelers/specialists to prepare fishing forecast charts. And for scientists who help develop strategies for sustainable fisheries management.

Yaya Soro:

Q: Is there a notable difference between the data measured in situ and those obtained by remote sensing for the 50 m surface of marine waters?

A: To properly answer your question, we should define first in which part of the electromagnetic spectrum we are talking about. Let´s assume that is the optical spectrum in the visible and near-infra-red (from 380 to 800 nm), as beyond these borders, water is strongly absorbing, and remote sensing instruments receive no signal anymore. In this sense, most of the instruments measure in a passive way by receiving reflected and back-scattered light from the water.

As I've mentioned in my presentation, although remote sensing has a great potential in studies of the sea bottom, extracting the reflectance spectrum from the data of orbital optical sensors is complex. Several processes affect the satellite signals.

A significant part of these interferences comes from the atmosphere itself (and from the ocean-atmosphere interface). Other parts come from the water column. So, there is a need for atmospheric correction and for water column correction.

in situ and field measurements directly offer properties of the observed matter (e.g., algae content, temperature, etc.). In situ instruments do not suffer from the problem of atmospheric interference, which already represents a good difference in relation to the data collected by satellite.

Before continuing to develop these ideas, without knowing if this was your doubt, I prefer to stop here and remain available if you need further clarification.

Anonymous Attendee:

Q: Does Brazil plan to launch a satellite with hyperspectral sensor?

A: According to the national space sector demands report (published in 2019 by the Brazilian Space Agency - AEB)[1], the need for the development of a national satellite with an optical sensor with high spectral or hyperspectral resolution was identified. This demand has also been manifested by different sectors of the Brazilian community of users of remote sensing data, both from the government and from academia, the private sector and the third sector.

In 2011-2012, a collaborative study was carried out between INPE (Brazilian National Space Research Institute) and JPL / NASA, for the joint development of a hyperspectral mission. The

[1] http://mtc-m21c.sid.inpe.br/col/sid.inpe.br/mtc-m21c/2019/09.18.19.23/doc/Demandas%20Nacionais%20ao%20Setor%20Espacial%202019.pdf

mission then called GTEO (Global Terrestrial Ecosystem Observatory) would rely on the use of the multi-mission platform (PMM) developed by INPE and a 256 bands instrument developed by JPL.

More recently, we have approved a project for the analysis of a coastal hyperspectral mission, within the scope of the Academic Cooperation Program in National Defense (PROCAD-Defense) (Announcement 15/2019). PROCAD-Defense is an initiative generated by a demand submitted by the Ministry of Defense of Brazil (MD) to the Coordination for the Improvement of Higher Education Personnel (CAPES). The Program complies with CAPES guidelines for the temporary induction of strategic areas, considers the priorities of the Brazilian science and technology policy and consists of providing incentives for the training of human resources and financial support for research projects according to the criteria defined in the Announcement. This project will last up to 4 years (until 2023).

Another initiative was the proposal to develop a hyperspectral CubeSat. The use of CubeSats is becoming a space technology trend that is attracting new users in many countries. The number of CubeSats developed by Brazil can still be considered modest, but it is growing every year. For example, we had the joint launch of the China-Brazil remote sensing satellite CBERS-04A with CubeSat FloripaSat-1 in December 2019. But it is still necessary to invest in a strategy of development of small satellites to meet some needs of interest to the national space sector, such as continuous staff training, constant access to space applications, consistent industry development and mastery of critical technologies.

Janice Trotte-Duha:

Q: Satellites are essential infrastructures for some specific monitoring activities, like oil spills etc. In your view, what would be the best design of a satellite monitoring program for the Blue Amazon, bearing in mind the occurrence of a major oil spill that hit the Brazilian coast some months ago and also considering an immense increase in maritime traffic in the South Atlantic region? By the way, we have failed to identify the origin of the oil spill and also have faced several "false positive" spills via satellite imagery only.

A: Considering the satellite monitoring of the Blue Amazon region, we should consider a constellation of satellites operating in different regions of the electromagnetic spectrum. This way, we would have optical and thermal radiometers, and radars. With these types of sensors, it would be possible to obtain information related to sea surface temperature, surface circulation, surface winds, ocean color, ship and oil slick detection, among other variables of interest. We could rely on a Brazilian constellation of satellites, although this would take some time to be developed and implemented. So, acquiring data from international orbital missions would be feasible in a shorter time.

Regarding oil slick detection, it is necessary to have an operational system, with daily coverage of the area of interest, provided by orbital synthetic aperture radar (SAR) systems. We still do not have such a Brazilian sensor, neither a short-term program envisioning this type off application. But there are some commercial and even freely available alternatives. For this, a ground segment system must be organized in terms of satellite data acquisition, processing, analysis, archiving and distribution, integrating with other relevant in situ data and oil dispersion modelling.

Now, regarding the last year oil slick event into Brazilian waters, looks like the potential source was in international waters, in the "middle or somewhere in the Atlantic" where routine surveillance by SAR satellites is not quite common. This way, imagery availability was somehow limited, as SAR data is only acquired on demand, and not "on the fly" as for e.g. visible and/or thermal radiometers.

The matter of international waters monitoring should be more discussed to evolve into a feasible approach. However, in case of having an operational system running for the Brazilian margin, or even for the most active oil & gas E&P regions, this would probably increase our ability to issue early warnings related to these events, also assisting decision-making in relation to follow-up and mitigation actions.

Specifically, on the issue of false positives, there is still a research and development effort that must be done in this area. However, the experience of the professionals involved, integrating different types of satellite data and other sources of information, can largely minimize these events. It so happens that in the last accident, there was effectively no ready and operational team performing this type of monitoring (this is as far as I know, not considering institutions with this institutional mission here - maybe to verify with IBAMA or even Brazilian Navy). What was done was to bring together, somehow, responsive institutions based on the best effort.

I believe that the National Contingency Plan must be implemented in an operational manner, including all the preparatory measures that are necessary, with resources for that.

A federal institution dedicated to oceanography could effectively contribute to these coordinated actions with other institutions with capacity in this area.

Foster Mensah:

Q: Does your team have a GEE workflow for mapping mangrove forests you can share?

A: Although we use GEE for different applications, we did not map any mangrove forest using this approach yet, and consequently, we do not have a GEE workflow for mapping mangrove forests to share with you on this opportunity. However, I can share (or recommend) the following publication where you can find useful information related to your question: Diniz, C.; Cortinhas, L.; Nerino, G.; Rodrigues, J.; Sadeck, L.; Adami, M.; Souza-Filho, P.W.M. Brazilian Mangrove Status: Three Decades of Satellite Data Analysis. Remote Sens. 2019, 11, 808. https://doi.org/10.3390/rs11070808.

Isa Elegbede:

Q: How has your studies been effective to community dwellers?

A: I have doubts if I can provide a unique and direct answer to your question, but I would like to share some information or considerations. Firstly, as a teacher and academic advisor, I dedicate a good part of my professional time to capacity building, training and qualification of personnel. I believe that by better educating and training to community dwellers, we are helping them to effectively improve their quality of life.

Second, we seek to develop quality science and technology in a developing country like Brazil, which despite having great natural wealth, still lacks greater social, economic, political and environmental justice. But we believe that by setting a good example, we show that it is possible to do a good job with international recognition and thus, inspire and motivate future generations or young people.

In our work agenda, we develop studies in coastal regions on indices of sustainable development, mapping of natural resources, fundamental ecosystem services that can support actions of ecosystem-based management. We hope that the results generated in our work would be well used by decision makers, as well as by the various stakeholders present in these regions.

It can be difficult to present effective and clear metrics answering your question. But we believe that the public recognition of our society is an important milestone that if is not 100% proven, at least it indicates that we are moving in a right direction.

Suleiman Sadiku:

Q: What is the relationship between TSM, CDOM, Chlorophyll-a and aquatic productivity, and subsequently a probable boom and bust of coral reefs?

A: I am not sure about what you wanted to say about “boom and bust of the coral reefs”, but let me try to briefly explain or clarify on what I have said about the “annual phytoplankton bloom in the Abrolhos Coral Reef Bank (ACRB) region, in Eastern Brazil” (although I did not had enough time to better comment about this, sorry for that).

We´ve analyzed time series of ocean data products to describe the average pattern and time variability in the ACRB region. Sea surface temperature, chlorophyll-a concentration and euphotic depth fields were estimated using decadal MODIS data, and integrated with mixed layer depth data and surface wind intensity contributing to the understanding of meteoceanographic processes that influence the distribution of bio physicochemical properties of coastal and oceanic waters in the study region. The seasonal phytoplankton cycle is the dominant mode of temporal variability. The use of a Gaussian function to fit the temporal variability of satellite-derived surface chlorophyll-a concentration allowed the characterization of the timing and magnitude of the annual phytoplankton bloom in the region. Chlorophyll data (used as an index of phytoplankton biomass) showed that the maximum surface bloom occurs in austral winter (dry season, July), having initiated in the autumn (May).

Air-sea interactions promote the evaporative cooling of the surface layer driving mixed layer cooling and deepening that reaches its maximum in winter. The blooming of phytoplankton in the ACRB waters appears to be regulated by changes in the mixed layer depth and wind missing processes. It is expected that the results are useful for the environmental management and monitoring required to ensure adequate and sustainable use of natural resources in this region.

Ana Maria Martins:

Q: We work at the University of the Azores using Satellite Oceanography basically for mesoscale variability studies, but we are very interested to go for higher resolution and even hyperspectral particularly for coastal regions.

A: Most of last year's developments have focused on improving remote sensing of water-color in coastal, and other optically-complex, bodies of water (such as inland waters). The complexity of coastal waters is multifaceted and includes both optical and biological complexity as well as an overlay of temporal and spatial dynamics.

In terms of requirements for optically shallow remote sensing, hyperspectral sensors are generally required to differentiate bottom types. In terms of the required spatial resolution, I think that it depends on science question. In any case, digital image processing should consider removal of sun glint, atmospheric correction and water column correction.

Extensive studies using in-itu measurements and remote sensing imaging have shown that visible hyperspectral imaging is one of the best available tools to resolve the complexity of the coastal ocean from space. There is a need for high spatial (and temporal) resolution in the near costal ocean. As I've mentioned in my presentation, for Case 2 waters we admit that at least 3 relevant quantities (phytoplankton, suspended material and yellow substances, and perhaps bottom reflectance) can vary independently of each other. The development of algorithms for Case 2 augments the technical requirements of ocean (or water-) color sensors, with respect to their spectral resolution and radiometric accuracy. Algorithms should unravel non-linear, spectrally varying interactions among at least 3 variables and remotely-sensed signals. The changes in signal with changes in the concentrations of the constituents are often small. At some wavelengths, two or more substances may influence the optical signal in a similar manner, making it difficult to distinguish one type of material from another.

As you know, remote sensing reflectance at sea surface is a function of properties of the water column and the bottom. To solve this problem, we need a stable, well-calibrated sensor with high signal-to-noise ratio (SNR), good characterization and calibration, atmospheric correction, in-water algorithms to solve for water column optical properties (and bottom type and bathymetry).

Open question: How to approach the optimal spatial, temporal and spectral resolution requirements for applications in optically complex waters (coastal and inland)?

Carlos Loureiro:

Q: Can you please comment on the feasibility of reliable bathymetry estimations in complex coastal environments like reefs, where the variation in bottom characteristics is quite significant?

A: Although remote technologies have a great potential in studies of the sea bottom, extracting the reflectance spectrum from the data of orbital optical sensors is complex. More traditional empirical algorithms used to estimate bathymetry may have limitations to consider different bottom reflectance (or bottom types) and, therefore, produce biased estimates for certain benthic environments, such as in reefs areas.

Another group of physics-based inversion algorithms is based on radiative transfer models to estimate bathymetry without the need for in situ calibration data. An important advantage is that these algorithms can derive the depth and reflectance of the sea bottom simultaneously, making them robust to variations in bottom type. Nevertheless, these algorithms are also very sensitive to atmospheric correction, since they require radiometric accuracy of the input orbital data.

More recently, approaches have been proposed integrating the two types of algorithm. There are also approaches that use more complex methods such as artificial neural networks and non-linear machine learning techniques. Anyway, there are still issues that deserve additional research effort. For example, how to properly consider 3D coral morphology and structure, shading issues, and last but not the least, on the impact of bottom albedo on surface reflectance. Also, in which environmental conditions the reflectance may be affected by it (depending on depth, nature of the bottom, and inherent optical properties).

Claire Jolly:

Q: Do you think there might be major innovations to come in the horizon (next 5 years) to better track the health of coral reefs or just progressive scientific/technical progress?

A: Coral reefs are submitted to different regional and global pressures, which have been reported as responsible of biodiversity losses worldwide. Models predict a significant reduction in reef spatial extension together with a decline in biodiversity in the relatively near future. Global and regional pressures demand efficient monitoring and management programs with the purpose of protecting and preserving coral reefs. Remote sensing approaches to acquiring data in coral reef ecosystems are cost-effective and allow for synoptic monitoring of large areas, including places with difficult access. In recent years, studies on coral ecosystems by remote sensing have increased considerably because of a greater availability of orbital sensors with better spatial and spectral resolutions and the development of different methodologies in digital classification processes and data analysis. More recently, there are also approaches that use more complex methods such as artificial neural networks and machine learning techniques. New types of sensors and platforms have been developed more and more quickly and with an increasing reach of users, even though capacity building is still a fundamental need, mainly in certain countries or regions.

Coral reefs provide shelter and habitat for fish nurseries and unique genetic resources, as well as providing recreational value to maritime tourism. Previous work already provided global estimates of several ecosystem services, including coral reefs. But the development of new methodologies to better integrate natural, social, and economic sciences can support advances in this sector. More widely recognized quantifications on perception, wish to pay for preservation, conservation and environmental quality are expected to advance in the coming years.

It is worth mentioning that marine biodiversity is a great pharmacy under water. Substances present in coral reefs can be a great source of new antivirals, antithrombotics and antimicrobials to treat diseases, endemics, epidemics and pandemics, such as the one face today. However, in many countries such as Brazil, marine research is taking slow steps. Although there are groups of excellence involved in the area, evolution comes up against one factor: funding ($). Or rather, the lack of it. So, having new forms of sustainable, continued and committed financing, such as environmental bonds, environmental funds, crowdfunding, among others, should appear and evolve in the coming years.

The involvement of ordinary citizens in these matters also grows every day. In addition, it is necessary to attract young talents to work (or continue to work) in the area. It is necessary to have trained and qualified people. However, several researchers are leaving the country, because here, more and more, investment in science is decreasing.

Suleiman Sadiku:

Q: Any comparison of satellite data and empirical and analytical ground data?

A: Efforts at modelling ocean color for applications in remote sensing revolve around two major issues: (i) Development of theoretical models for representation of ocean color as a function of inherent optical properties; (ii) Cataloguing the inherent optical properties of substances encountered in water bodies, and their variations with the concentrations of the substances. This later step is essential for the representation of the bulk inherent optical properties as functions of the optical properties of individual components and their concentrations.

There are essentially two approaches by which spectral data from remote sensing (in situ or orbital), acquired over the ocean, can be used to estimate the concentrations of optically active constituents (OACs): (i) Empirical: which is based on the development of bi or multivariate statistical regressions between concomitant measures of remote sensing reflectance and concentrations of OACs. When diagnostic spectral features of OACs are known and included in regression analysis, some authors call the approach semiempirical; (ii) Semi-analytical: based on direct and inverse relationships between OACs and optical properties, through solutions of the Radiative Transfer Equation.

While empirical models are more common due to their simplicity, these bio-optical algorithms have no temporal scope and do not allow the characterization of the spectral composition of the underwater light field (often 1 parameter). Thus, semi-analytical algorithms have become of great importance, as they provide not only the temporal range, but also allow the determination of the underwater light field, the depth of the euphotic zone and the diffuse attenuation coefficients (a suite of parameters). There are other types of algorithms, based on inversion methods, such as, neural network, principal components, non-linear optimization, Look-Up-Tables, spectral matching / optimization.

Anyway, remote sensing data and products must be validated globally and regionally. In certain cases, calibration of algorithms is recommended. Generally, the validation of remote sensing algorithms is done through direct comparison with field (ground) measurements (or in the laboratory).

Adekunle Oresegun:

Q: After the array of methods to monitor the Ocean characteristics, could it be adapted to identify the availability of fish species in the water?

A: Although direct detection of fish stocks would appear to be the most obvious goal for remote sensing, it is in fact the most difficult to achieve. Visual fish spotting from aircraft has been used for locating some pelagic species such as anchovy, swordfish, menhaden and tuna (although I do not have any experience with this type of application). In this case, a trained observer is the "sensor" and direct radio communication is maintained with vessels in the area. If a camera is also carried onboard the aircraft, photographs can be taken for subsequent stock assessment (nowadays, drones can be used similarly for this application). Different species can be distinguished on the basis of their colour, behaviour and schooling patterns. Table 1.1 lists a number of species which were directly observable from low-level aircraft. Fish spotting is limited by the range of the aircraft and is only feasible when the probability of fish detection is reasonably high, and the economic return derived from the catch **justifies** the expense of aerial surveillance.

TABLE 1.1

REPRESENTATIVE FISH TYPES OBSERVABLE FROM LOW-LEVEL AIRCRAFT (After W.H. Stevenson and E.J. Pastula, 1971)

ATLANTIC OCEAN AND MEDITERRANEAN SEA		*PACIFIC OCEAN AND INDIAN OCEAN*	
Eastern	*Northern (Continued)*	*Eastern*	*Eastern (Continued)*
Fish:	Fish:	Fish:	Fish:
Spanish sardine (*Sardinella aurita*)	ladyfish (*Elops saurus*)	basking shark (*Cetorhinus maximus*)	ocean sunfish (*Mola mola*)
herring (*Sardinella eba*)	blue runner (*Caranx crysos*)	white shark (*Carcharodon*) *carcharias*)	striped bass (*Morone saxatilis*)
Spanish mackerel (*Scomberomorus*) *maculatus*)	tarpon (*Megalops atlantica*)	northern anchovy (*Engraulis mordax*)	Pacific saury (*Cololabis saira*)
yellowfin tuna (*Thunnus albacares*)	herring (*Clupea harengus*)	Pacific sardine (*Sardinops sagax*)	swordfish (*Xiphias gladius*)
skipjack tuna (*Katsuwonus pelanis*)	Atlantic mackerel (*Scomber scombrus*)	Pacific bonito (*Sarda chiliensis*))	striped marlin (*Tetrapturus audax*)
pilchard (*Sardinops trachurus*)	butterfish (*Poronotus triacanthus*)	jack mackerel (*Trachurus symmetricus*)	Mammals:
	Atlantic menhaden (*brevoortia tyrannus*)	Pacific mackerel (*Scomber japonicus*)	gray whale
Northern			pilot whale
			Blackfish (killer whale)
		Pacific barracuda (*Sphyraena argentea*)	Porpoise and dolphin
Fish:	*Mediterranean Sea*		Seals and sea lions
thread herring (*Opisthonema oglinum*)		yellowtail (*Seriola dorsalis*)	
Spanish mackerel (*Scomberomorus*) *maculatus*)	Fish:	white seabass (*Cynoscion nobilis*)	Invertebrates:
	Spanish sardine (*Sardinella aurita*)		Squid
			Jellyfish
bluefish (*Pomatomus saltarix*)	Atlantic mackerel (*Scomber scombrus*)	bluefin tuna (*Thunnus thynnus*)	*Western and Indian Oceans*
gulf menhaden (*Brevoortia patronus*)		albacore tuna (*Thunnus alalunga*)	Fish:
		yellowfin tuna (*Thunnus albacares*)	pilchard (*Sardinops pilchardus*)
		skipjack tuna (*Katsuwonus pelamis*)	sardine (*Sardinella fimbriata*)
Butler et al. FAO ISBN 92-5-102694&-7		jacksmelt (*Atherinopsis*) (*californiensis*)	mackerel (*Rastrelliger kanagurta*)

Source: http://www.fao.org/3/t0355e/T0355E00.HTM

While the direct detection of fish is not always feasible, their indirect detection may be possible by observation of sea surface phenomena associated with species distribution. This may involve mapping the distribution of fishing activities within a given area. Changes in ocean colour serve as an indicator of increasing plankton abundance (in terms of chlorophyll concentration). While ocean colour has long been used locally by fishermen to locate fish species, aircraft and satellite imagery can record colour variations over a much wider area in a more precise manner.

Water temperature is another important factor in determining species distribution and thermal sensors can be used to produce maps of the sea surface temperature (SST). Such mapping can be used to identify cold water upwelling of nutrient-rich water and to locate boundary areas between warm and cold waters where certain species are known to congregate.

In addition to resource detection, remote sensing can be valuable in characterizing the marine and costal environments (as I have mentioned previously online).

It must be stressed, however, that remote sensing can seldom be used in isolation; it must be integrated with other sources of information.