CHARACTERISATION OF CHLOROPHYLL PLUMES IN THE FIJI WATERS USING OCEAN COLOUR REMOTE SENSING

RESEARCHER

Timoci Koliyavu

ADVISORS

Dr. Awnesh Singh

Dr. Cecile Dupouy

Dr. Robert Frouin

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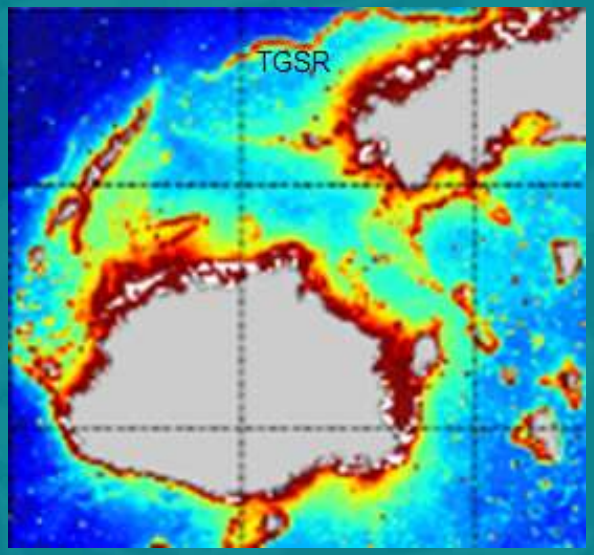

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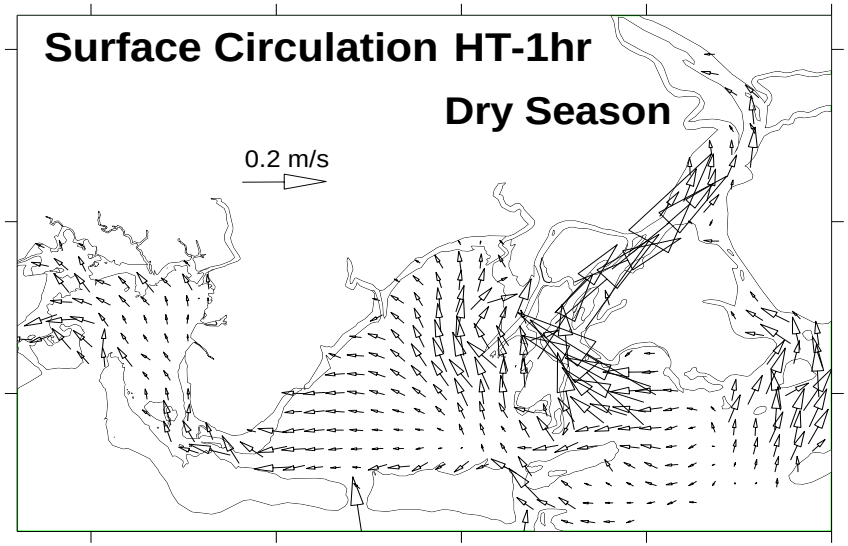
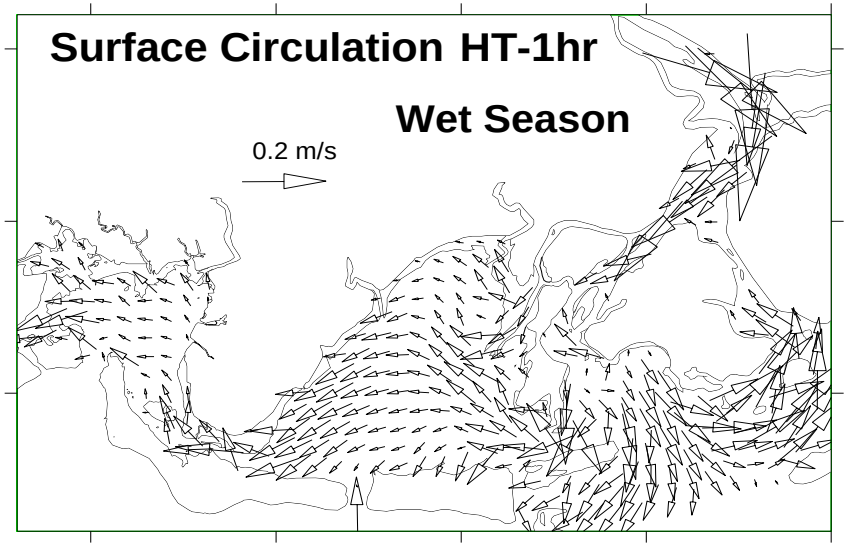
Surface Circulation – Rewa River

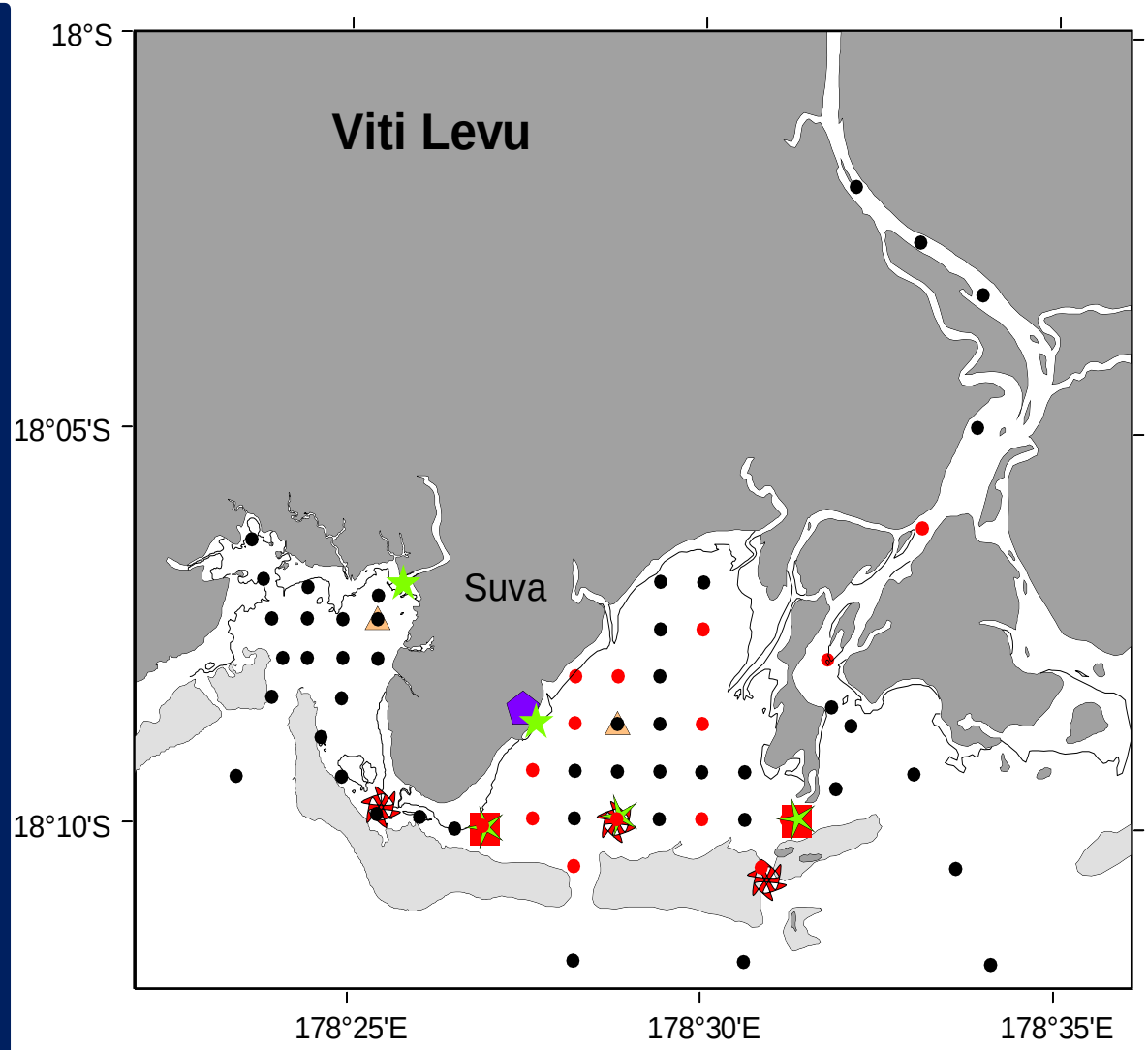




Hydrodynamic modelling of Suva lagoon for the dry(left) and wet(right) season
DROPS – IRD/USP

STUDY STATION(S) Examples in the Suva Sampling Site

- Bula stations
- PhD stations
- Current meters
- Doppler current meter
- Tidegauge
- Weather stations
- Sediment core
- Sediment traps



15 STATIONS from DROPS PROJECT, IRD-USP

What are phytoplankton?

- Micro-plants(microalgae), just like terrestrial plants they contain chlorophyll and require the sunlight to make their own food(photosynthesis), live & grow.
- Also means synthesis of organic compounds from CO_2 dissolved in water;
- Base of the ocean food web providing food for wide range of sea creatures , hence passing organic matter up the food chain;
- Buoyant and float in upper surface of waters where sunlight penetrates(euphotic zone);
- Organic matter return to the waters and dissolve(DOM) through decomposition(runoff) of dead tissues & fecal discharge.

<u>Photosynthesis</u>

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

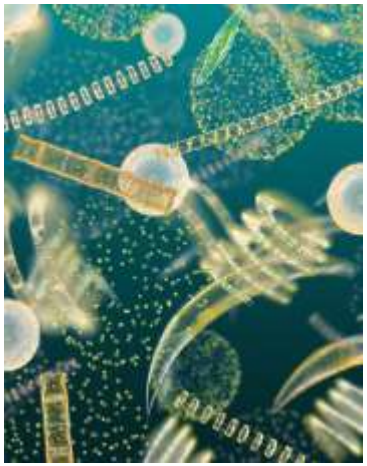
Carbon Dioxide Water Sugars Oxygen

Phytoplankton, CDOM & FDOM

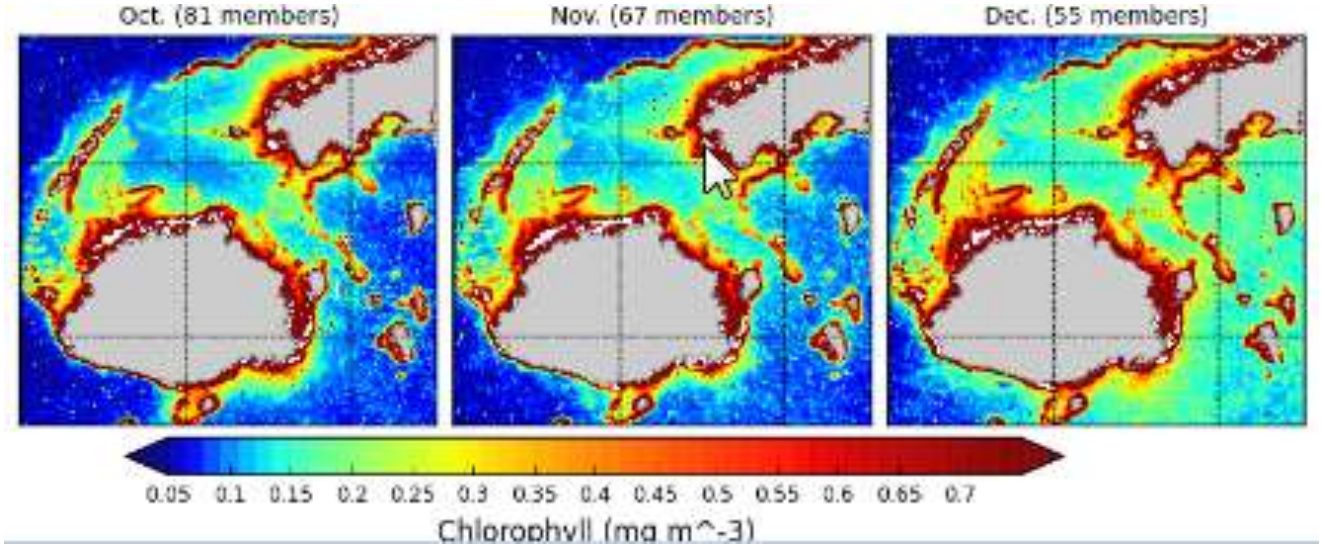
- Colored(chromophoric) dissolved organic matter (CDOM) refers to the optically measurable portion of DOM;
- CDOM absorbs light of short wavelengths ranging from blue to ultraviolet – Absorbance(Liquid Waveguide Capillary flow Cell) LWCC;
- A portion of CDOM re-emit light and fluoresce, fluorescence dissolved organic matter (FDOM) –Fluorescence measured in Spectrofluorometer – proxies for dissolved organic carbon(DOC);
- Non-turbid waters with little or no CDOM appears blue;
- Distinguishes anthropogenic or natural forcing;
- CDOM diminishes light penetration for photosynthesis;
- More CDOM will affect water clarity & phytoplankton photosynthetic capability

Phytoplankton & Ocean Color Remote Sensing(OCRS) – Ba & Suva Lagoons

- 20 – 200 µm



PHYTOPLANKTONS



Natural forcing –

- Other RS Data
- Sea surface winds, SSW
- Sea surface height, SSH
- Sea surface temperature, SST

RS Ocean Data Maps - IRD

Overall, ---------- "CC & Land degradation"

Ho: Phytoplankton density and distribution are not affected by CC

Science Questions

1. What are the seasonal patterns observed of chlor-a ,CDOM (& turbidity)?
2. Are these patterns affected by natural /anthropogenic forces of the environment?
3. How do shifts in these patterns correspond to changes in SSW, SST and SSH?

liyavu

Concerns the watersheds to lagoon transfers of dissolved organic matter, in particular for CDOM, FDOM, DOC.

Tools & Methods in RS

Satellite Data(NASA Ocean Color webpage):

- Aqua MODIS archived data(IRD) for chlorophyll : 2002 – 2010

- 2010 – 2016

- SSW: 2002 -2016-Quicscat vector winds
- SST: 2002 – 2016 – Aqua MODIS
- SSH: 2002 – 2016 – AVISO altimetry data

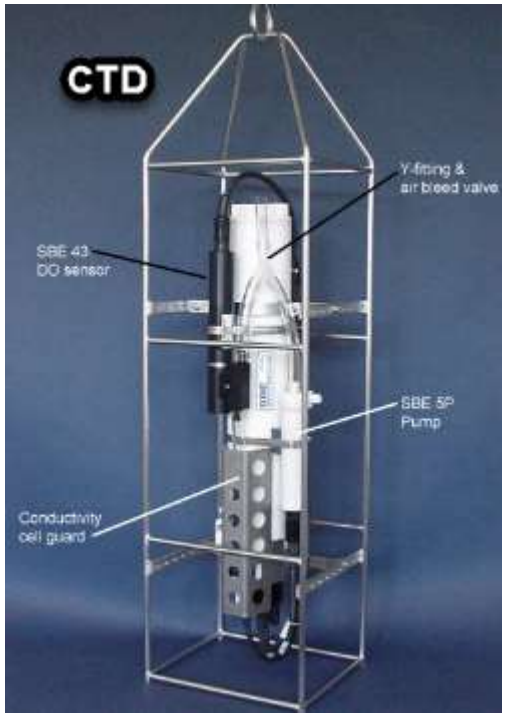
<u>Numerical Tests</u>

- Classification Statistical Tests
- Association and cluster Tests (Singh,2012 & Hisaki, 2015)
- Other line analyses

- SOM(unsupervised machine intelligence test);

Tools & Methods

- In situ water sample

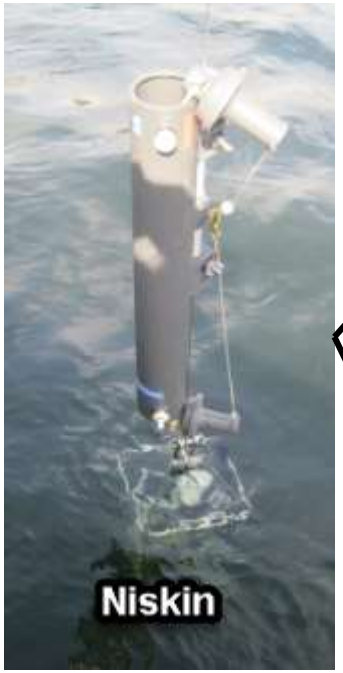


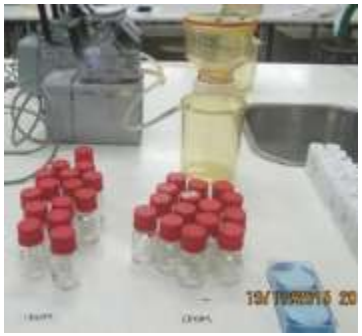
Physical tests:

- Conductivity(salinity)
- Temperature
- Depth(Pressure)
- Dissolved Oxygen
- Chlorophyll(Fluorescence)

Tools & Methods - adopt Cecile et al., 2014.

- In situ water sample





Spectrofluorometry

CDOM/FDOM

Water filtration in the lab

- 4 set ups; 2 displayed here

Other Tests:

- Suspended matter(MES)
- DOC

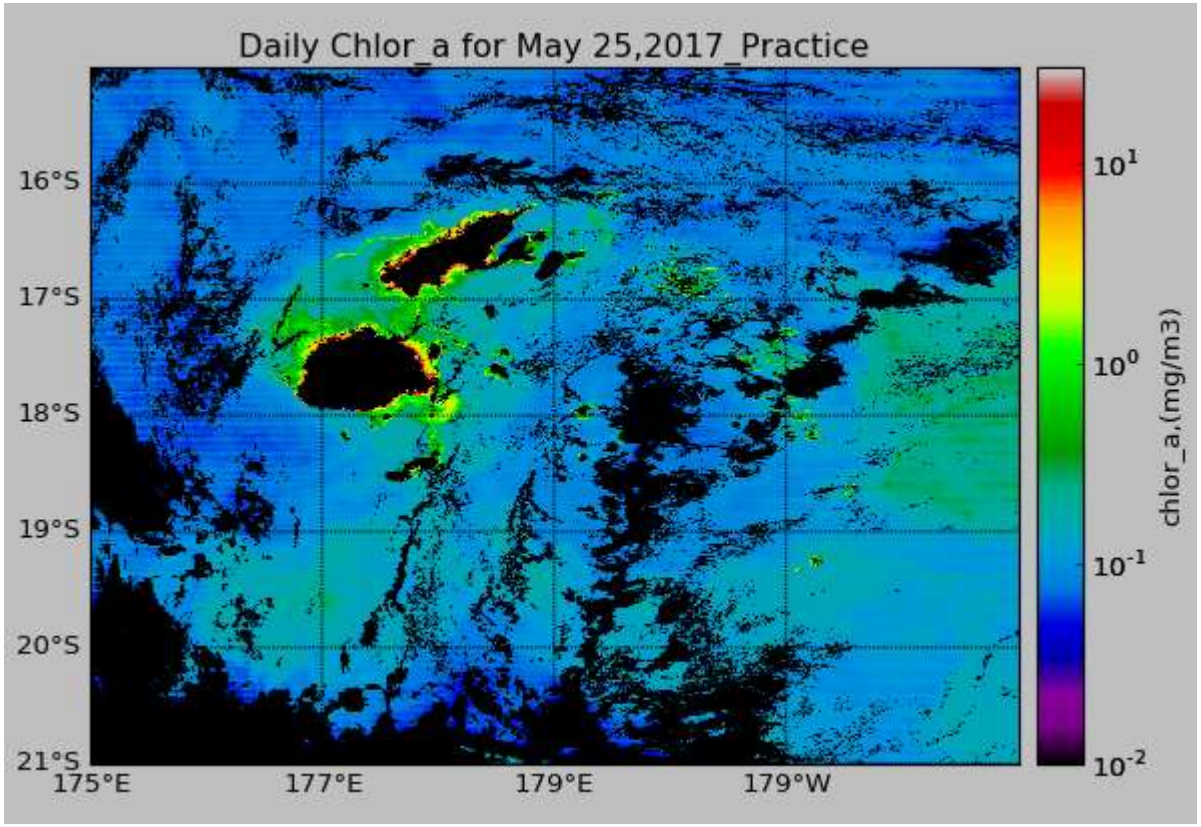
Particular abs./chlor-a

Tools & Methods - HPLC

- In situ water sample – NASA Validation Program

- Collection of high resolution in-situ data as inputs
- Calibration of OC satellite sensors
- Validate algorithms for satellite

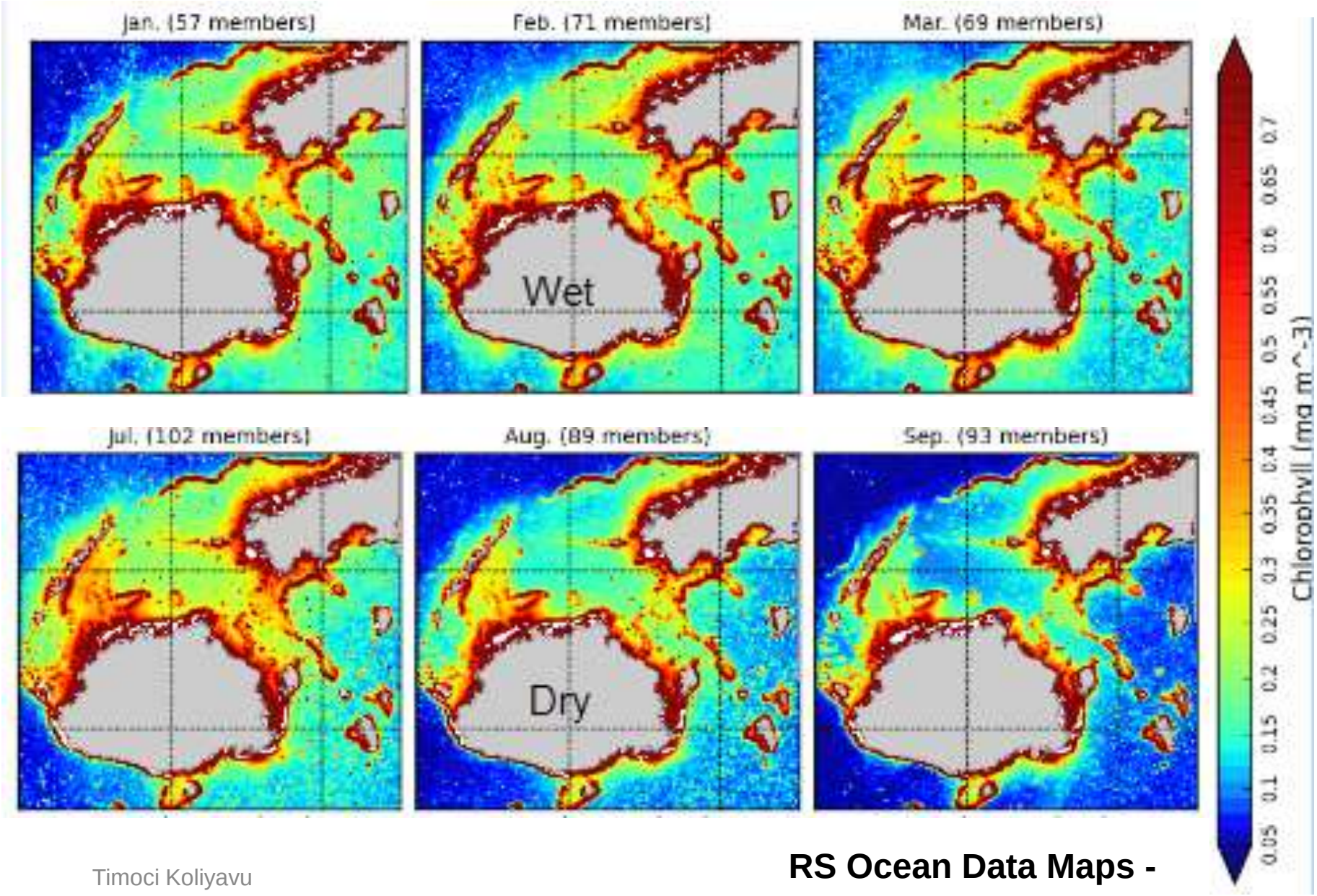
RESULTS PROGRESS



Association
-Mean Daily
-Mean Monthly
-Mean Annually

Datasets- MODIS 2002 - 2017
SSW,SLA,SST
Cluster: EOF/SOM

RESULTS PROGRESS – IRD



RS Ocean Data Maps - IRD

So, what will the project achieve…

- Proxies: Water Quality and Clarity ------ Ocean health

- Demarcation of productive/polluted areas and this has national policy implications in terms of licensing, choice of marine protected sites, etc.

- Good indicators for primary productivity, regions for high biological activity such as photosynthetic activity, atmospheric carbon fixation and sequestration, upwelling of nutrient rich waters,water clarity(CDOM), & ocean acidification.

- Baseline for future studies and ongoing long term monitoring.
- R2R National Priorities – Land Degradation, CC, Biodiversity

References

Dupouy, C., Röttgers, R., Tedetti, M., Martias, C., Murakami, H., Doxaran, D., Lantoine, F., Rodier, M., Favareto, L., Kampel, M., Goutx, M., Frouin, R. (2014). Influence of CDOM and Particle Composition on Ocean Color of the Eastern New Caledonia Lagoon during the CALIOPE Cruises, Proceedings of SPIE, 9261, 932 – 1102.

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VINAKA VAKALEVU! ???

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Work Done in Fiji on Chlorophyll

- Very little in Fiji (3 cited);
- A number in the Pacific(7 cited);

Cited Works	Topic & Coverage
Charpy et al.,1999	Pycophytoplankton biomass & community structure in the Great Astrolabe Reef, Kadavu - Fiji
Radenae et al., 1999	Sea surface chlorophyll signature in tropical Pacific Ocean during eastern & central Pacific ENSO events
Cecile et al., 2014	DROPS Project (same as the above)
Cecile et. Al., 2014	CDOM and Particle composition in Eastern New Caledonia ; Spatial and temporal analysis of SeaWiFS chlorophyll in the South Tropical Pacific Ocean
Martias,2014	Dynamic of CDOM in the South Pacific, Suva Lagoon. (ongoing PhD study)

MAP OF THE STUDY AREA

16 S

18 S

176 E

177W

Work Done in Fiji on Chlorophyll

- Mostly CDOM – focus is on the assessment of global transfers of CDOM from land to ocean

Cited Works	Topic & Coverage
Cecile et al., 2016	Dynamics of CDOM in the Pacific, an application of ocean color remote sensing
Tedetti et al., 2016	Spectorflouresce data analysis to characterize CDOM distribution with dedicated algorithms from Senteniel 3, New Caledonia.

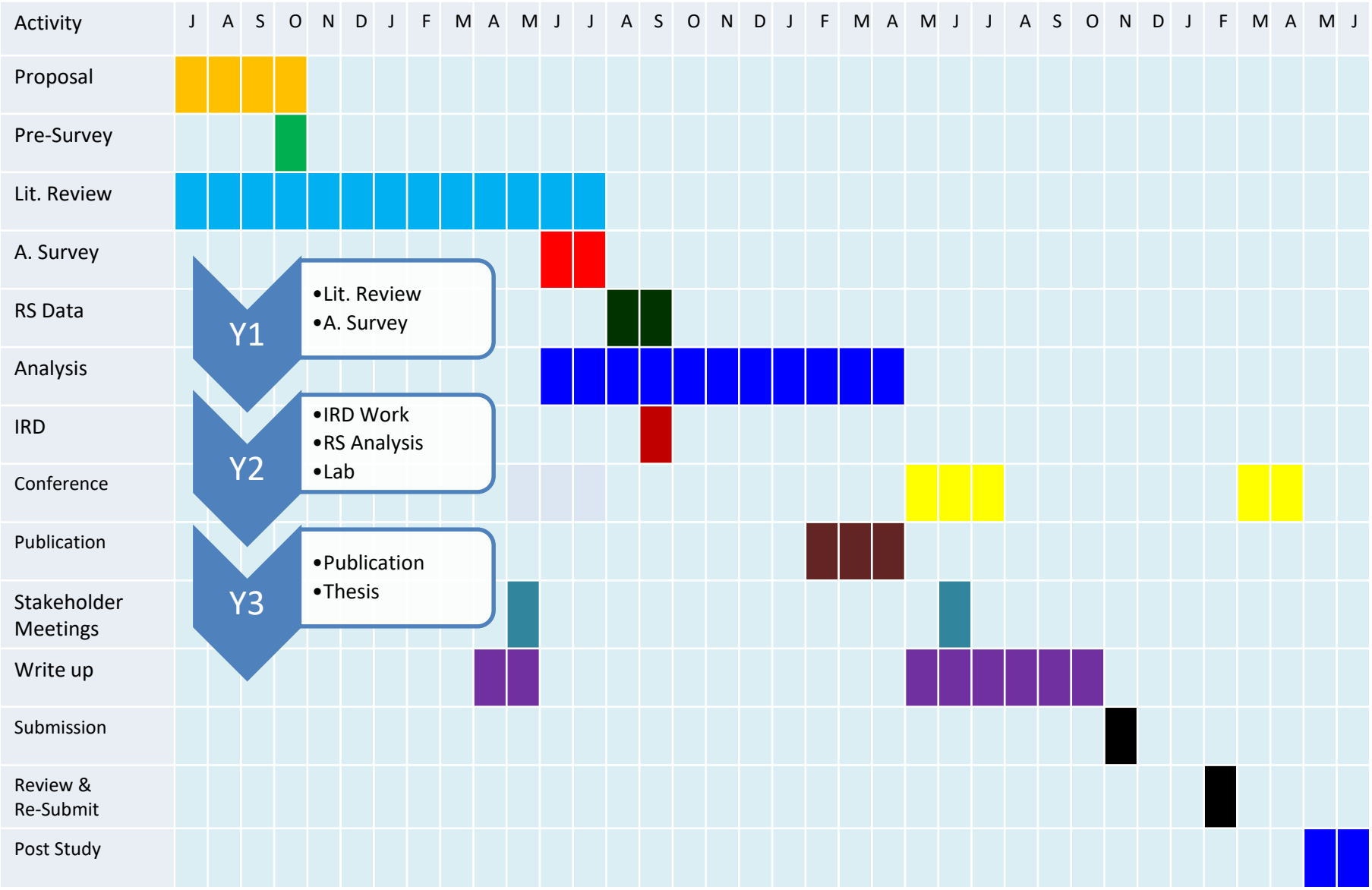
Tools & Methods in RS

Satellite Data(NASA Ocean Color webpage):

- Aqua MODIS archived data for chlorophyll : 2002 – 2010
- Download : 2010 – 2016
- SSW: 2002 -2016-Quicscat vector winds
- SST: 2002 – 2016 – Aqua MODIS
- SSH: 2002 – 2016 – AVISO altimetry data

- Using python for various computational analysis
- Classification and cluster analyses(Singh,2012 & Hisaki, 2015)
- Error analyses

Timeline



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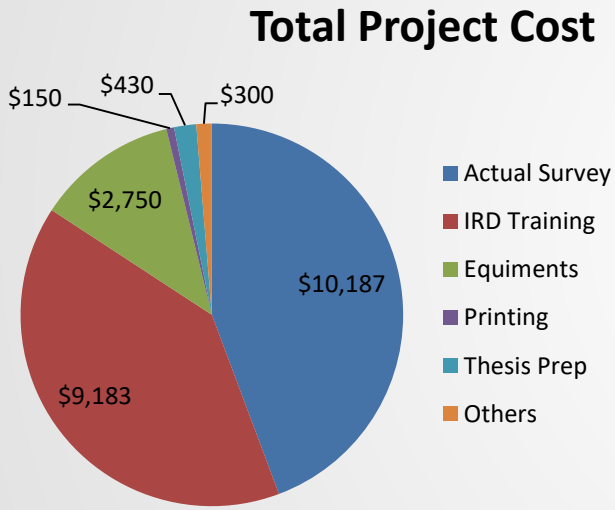
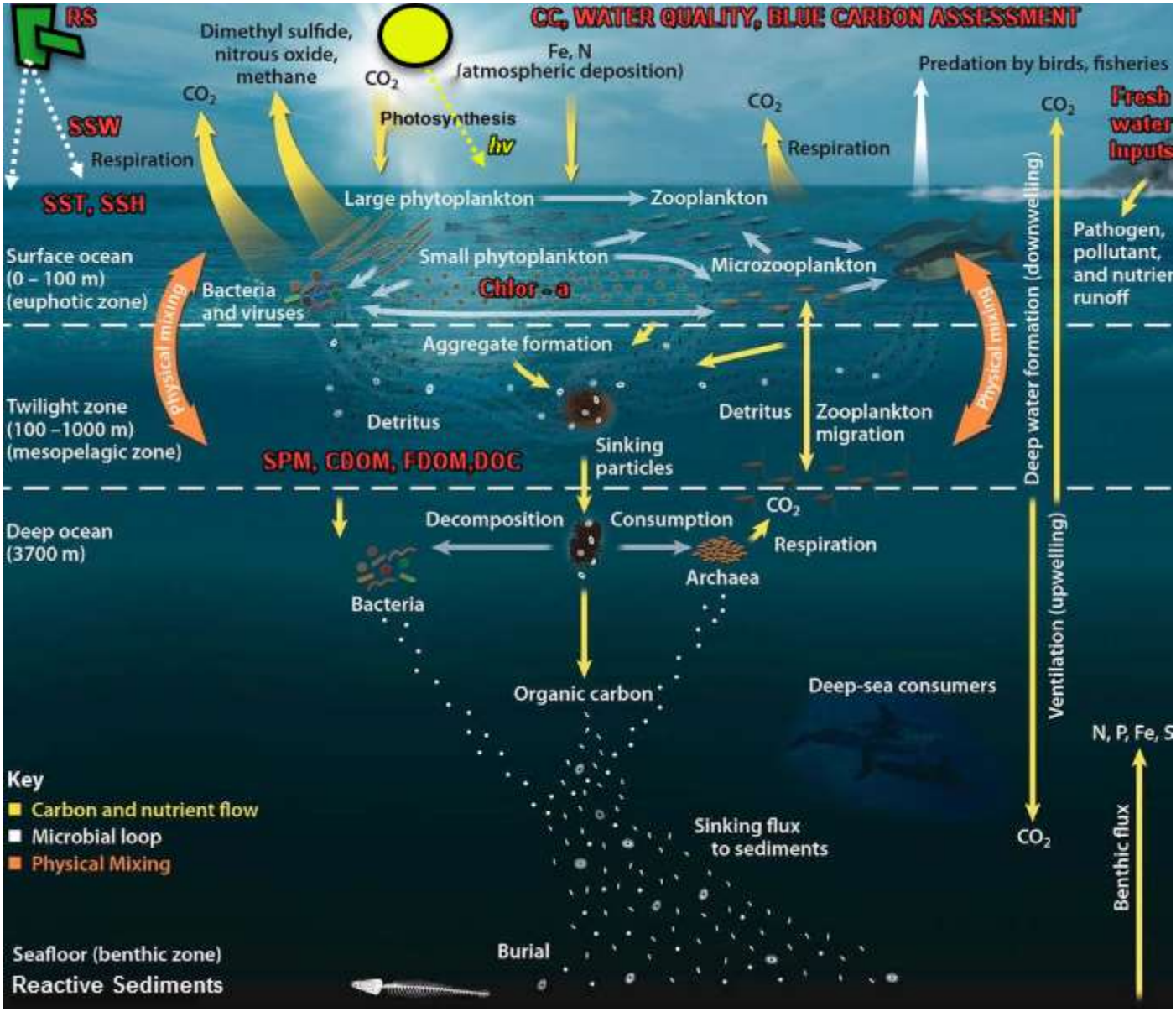
BUDGET SUMMURY



Justification		
Item	**Justification**	**Amount (FJD)**
Travel cost		
Actual field survey for Ba and Suva (16 days sampling, 2 days stakeholder communication & engagement).	Costs of MSP Halimeda boat hire @$750 for 7 days sampling, 1 Field assistant @$50 for 7days; Local boat hire@$300 for 7 days USP Per Diem for 2 persons in Ba for 9 days @$190 and field assistant for 7 days@$50; plus cost of sampling equipment and other costs.	**10,190**
Return Air Ticket Suva-Noumea	Costs of Return Air Fare	**2,900**
IRD Training in CDOM, SEM, Chlor- a and Satellite analysis from external supervisor	Costs of USP Per Diem@$209 75% UN rate) facilitation for 12 days laboratory and 18 days satellite data works.	**6,280**
Equipment & Consumables		
Labelling and Packaging	Costs of packaging, labelling and storage of samples before sending overseas for tests	**50**
Survey Equipment's and Other costs	Cost of sampling gallons, bottles, laboratory materials, dry bags, wet containers storages, wet lab books, other costs	**200**
Laptop PC and Accessories	Cost of 1 laptop@$2,000 and accessories	**2,000**
Miscellaneous		
Thesis Photocopying	Costs as per USP Research Student Standard	**75**
Thesis Printing		**75**
Thesis Binding		**180**
CD-ROMs		**100**
Miscellaneous Printing & photocopying		**100**
Inter Library loans		**150**
Miscellaneous		**700**
Total		**23,000****

**** Please note that the overhang costs per itemised activity will be sourced from DROPS and Research Office.**

Background - In a Nutshell



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MAP OF THE STUDY AREA

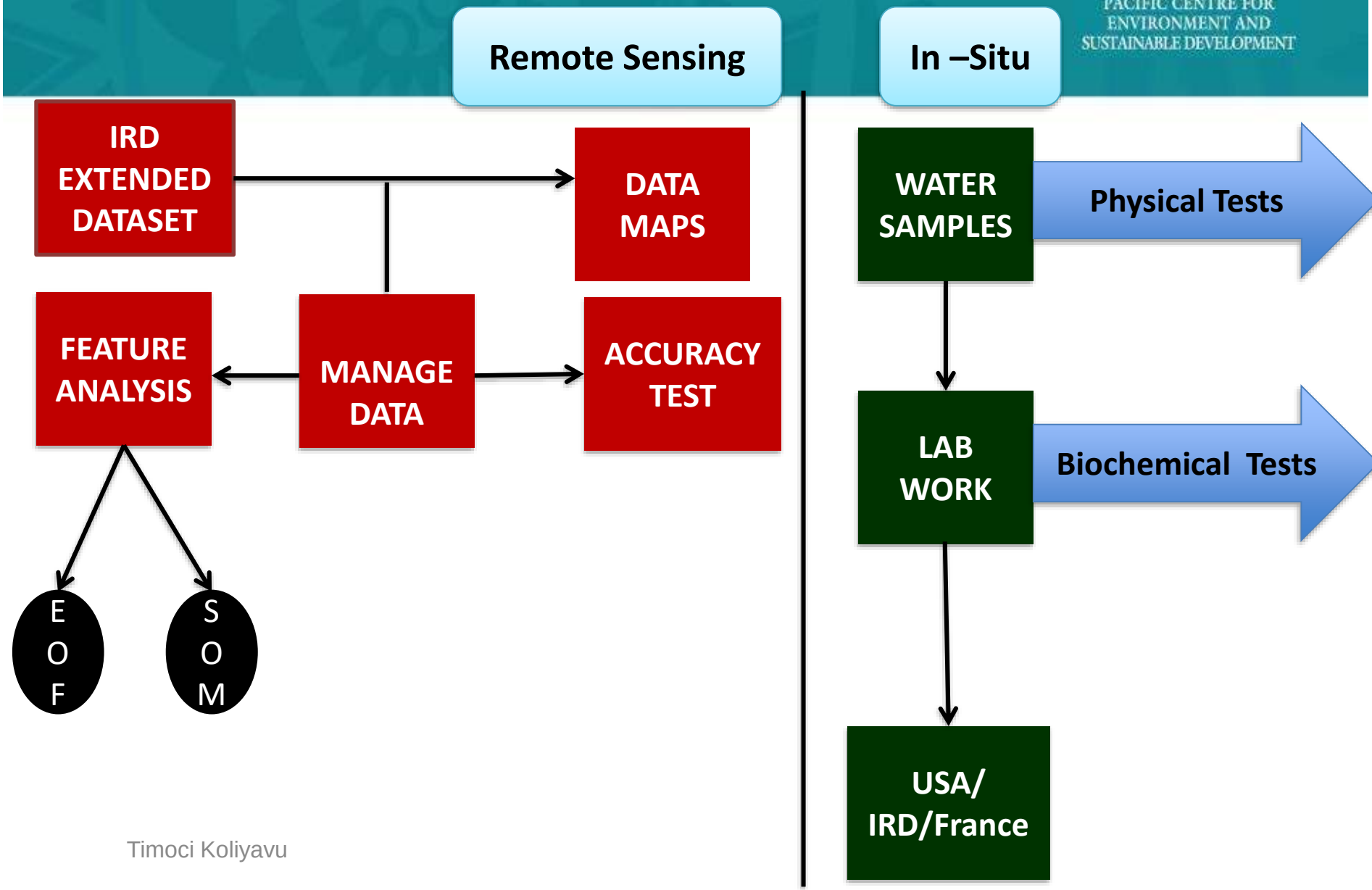
16 S

18 S

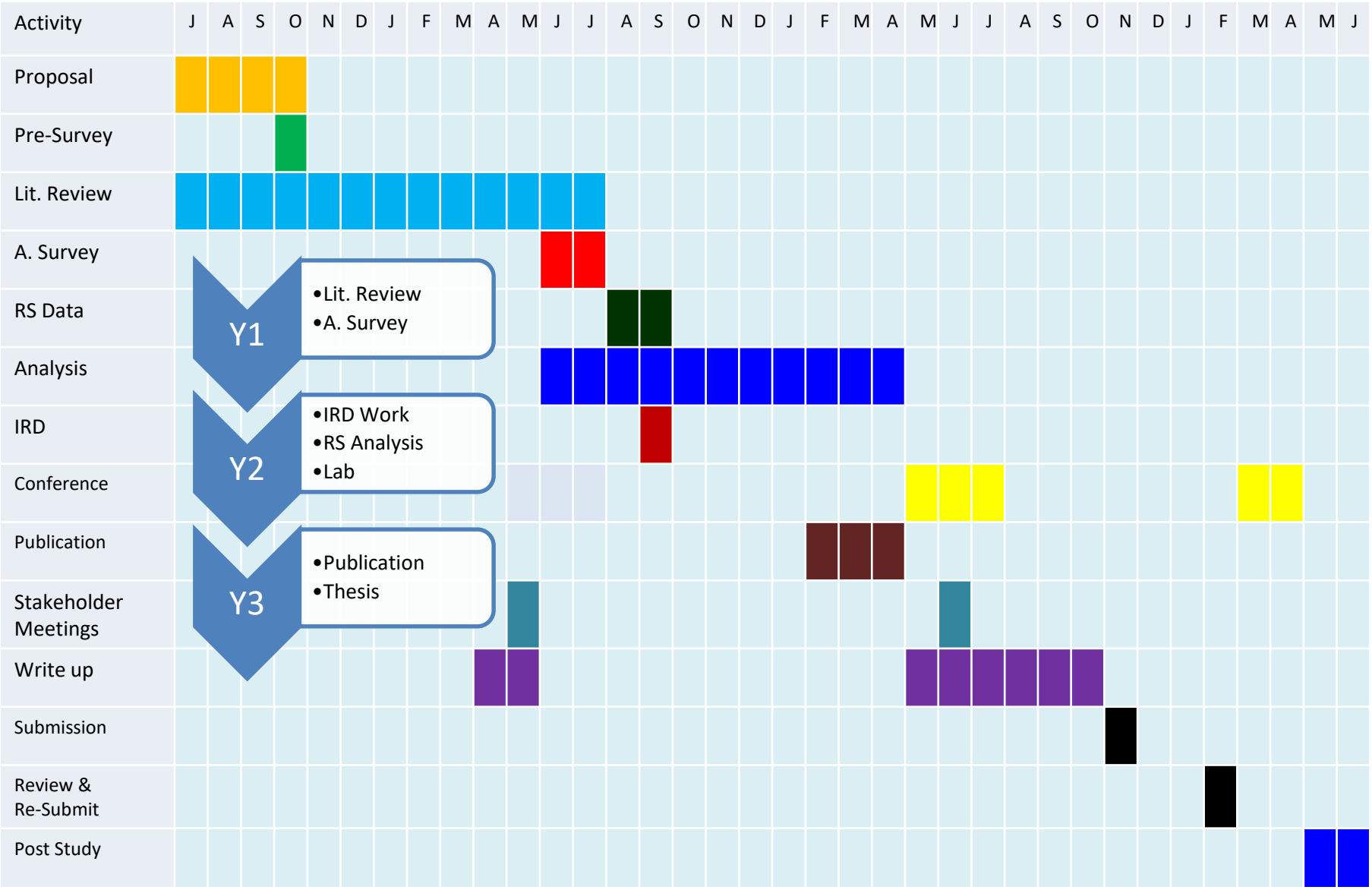
176 E

177W

Methodology/Approach



Timeline



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➢ Many cruises and *in situ* data

Laucala Bay cruise

Sampling in Fiji

Physical Parameter

- Temperature
- Salinity
- Turbidity
- Fluorescence

Biogeochemical parameter

Analysis in Noumea

- Chlorophyll a
- Suspended matter
- Particular absorption
- Nutrients
- CDOM absorption

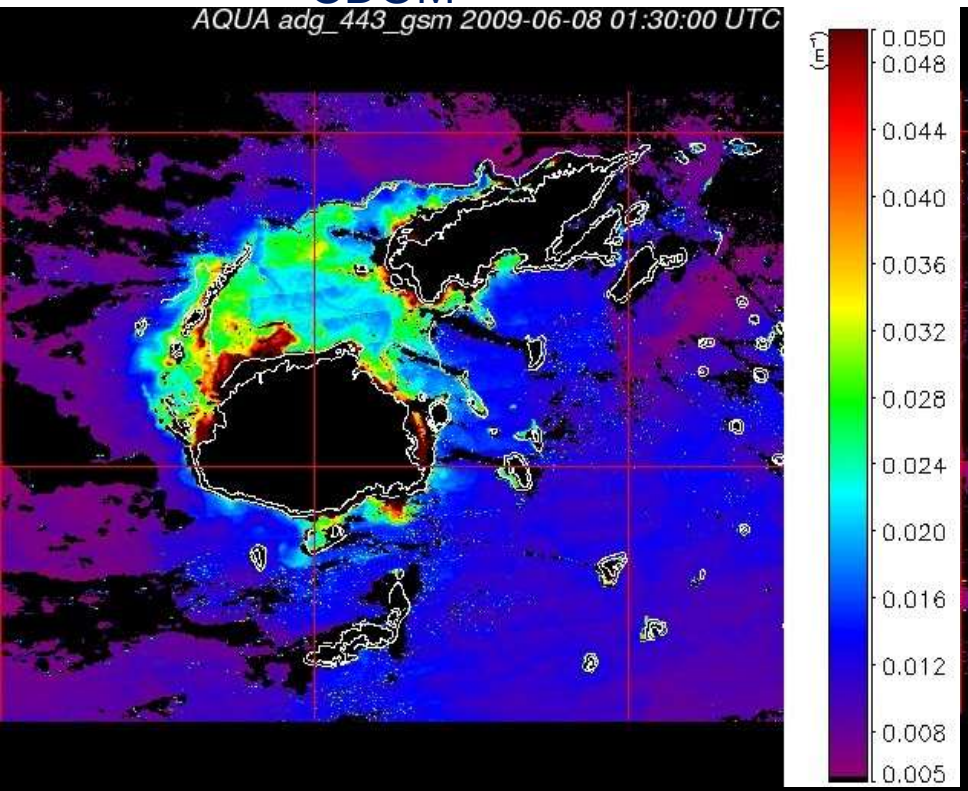
Analysis in Marseille

- DOC (Dissolved Organic Carbon)
- Bacterial counts (cytometry)
- FDOM (Fluorescent Dissolved Organic Carbon)

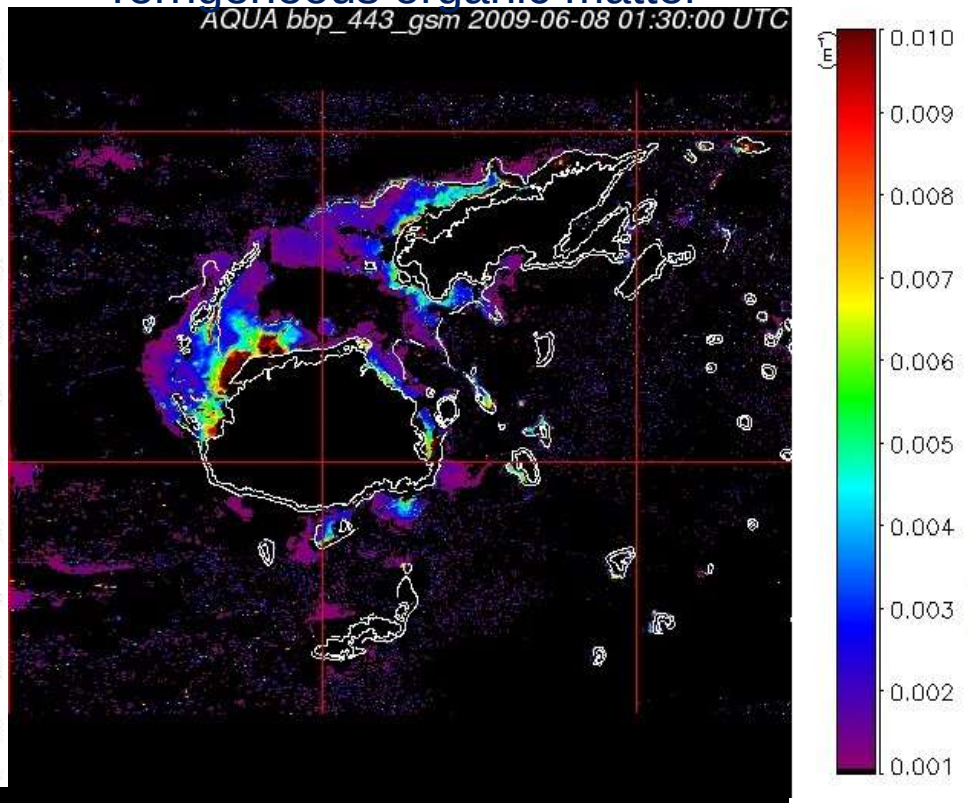
➢ AQUA MODIS observations

CDOM= Chromophoric Dissolved Organic Matter
DOM= Dissolved Organic Matter
FDOM= Fluorescent Dissolved Organic Matter

CDOM



Terrigeneous organic matter

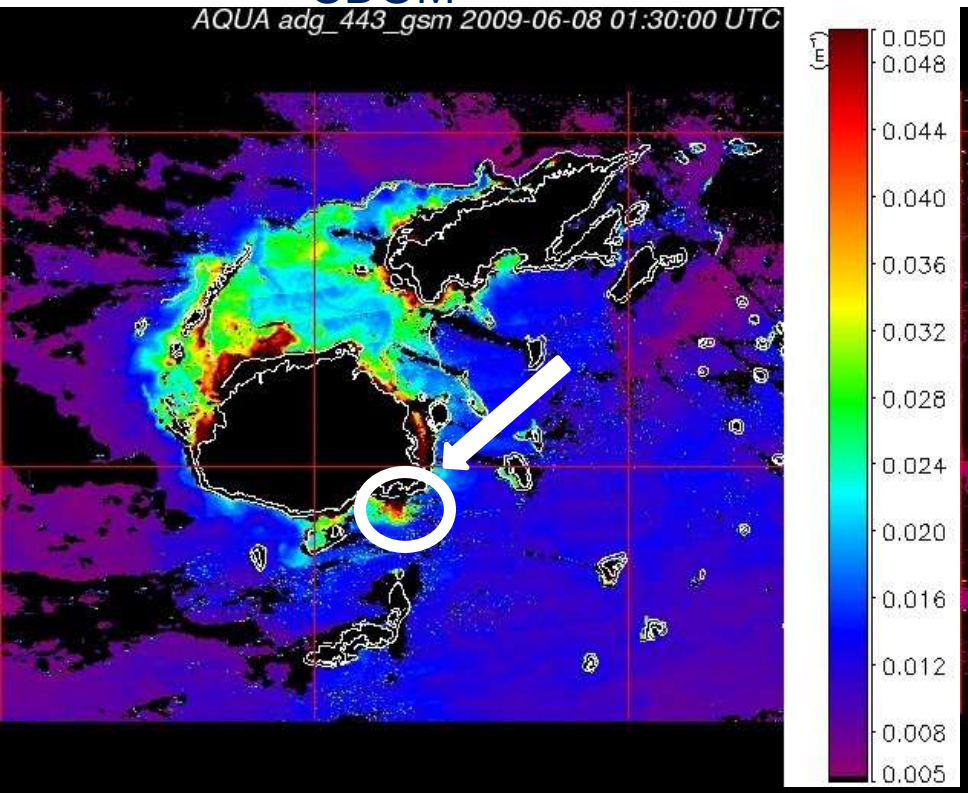


http://www.ird.nc/UR65/Lefevre/oc.modis.fiji/pix/daily/0702/fiji_0702z.html

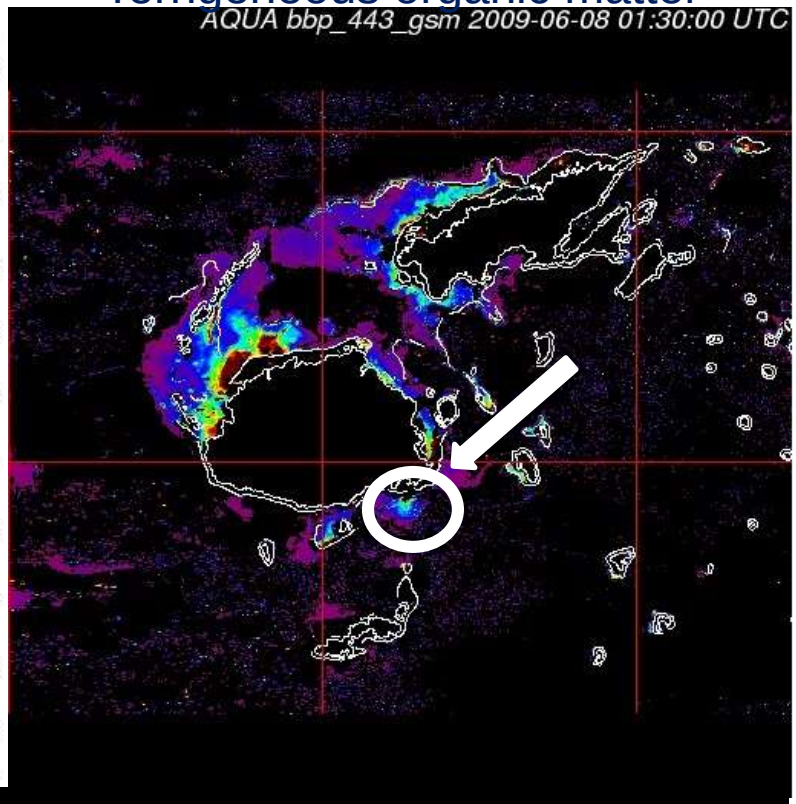
➢ AQUA MODIS observations

CDOM= Chromophoric Dissolved Organic Matter
DOM= Dissolved Organic Matter
FDOM= Fluorescent Dissolved Organic Matter

CDOM



Terrigeneous organic matter



http://www.ird.nc/UR65/Lefevre/oc.modis.fiji/pix/daily/0702/fiji_0702z.html

SWOT

STRENGTH

- Emerging Brand –OCSR /chlor-a &HPLC
- Renowned Agencies: NASA, IRD,UC
- Strong Team
- State of the Art Tools - HPLC,SOM
- Pilot studies
- Baseline study
- Missing Link

WEAKNESS

- High Project Cost
- Financial Support
- Institutional Capacities
- Infrastructural inadequacies
- Stakeholder Update

OPPORTUNITIES

- Multilateral
- Collaboration
- Stakeholder engagement
- Policy Update Frame
- Ongoing Monitoring
- Marketing

THREATS

- Bureaucracies
- Natural Events
- Clouds for RS
- Policies

➢ IRD Pacific Fund 2016

Objective:

Understand physical and biogeochemical dynamics of Laucala Bay for a better sustainable management of this area.

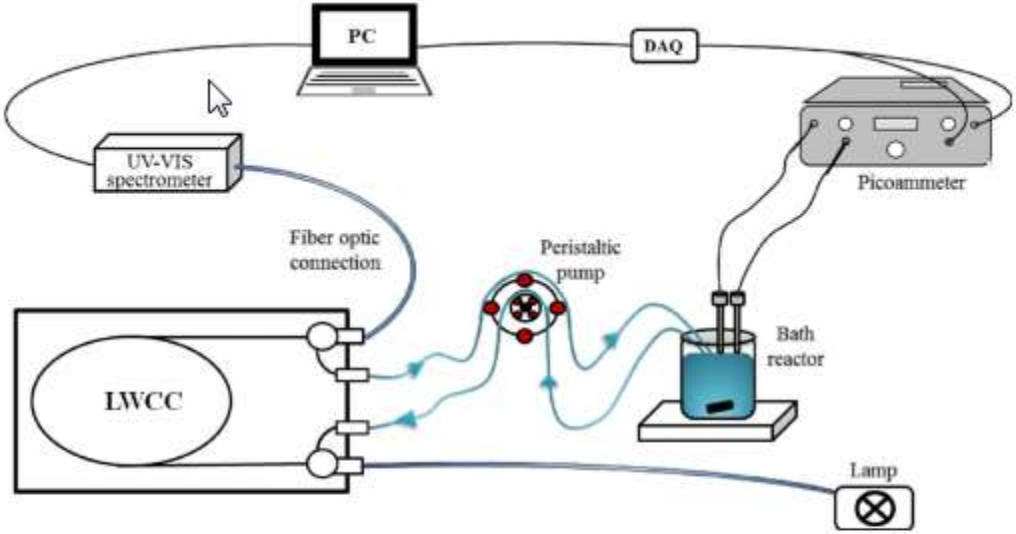
Scientific questions:

- What is the relationship between the residence time and the composition of CDOM ?
- What are the impacts of natural forcings (tides, winds, freshwater inputs, seasonal variability, ...) on the composition and distribution of CDOM ?
- How do anthropogenic impacts (agricultural and urban activities) modify the dynamics of CDOM?

Program:

- Exchange between 2 Fijian and New Caledonian students
- Training in New Caledonia and mornitoring in Fiji.

LWCC DIAGRAM



Figure

Caption

Figure 10: Experimental set-up using a liquid waveguide capillary flow cell (LWCC).

LWCC

Microliter sample volumes — exceptional sensitivity

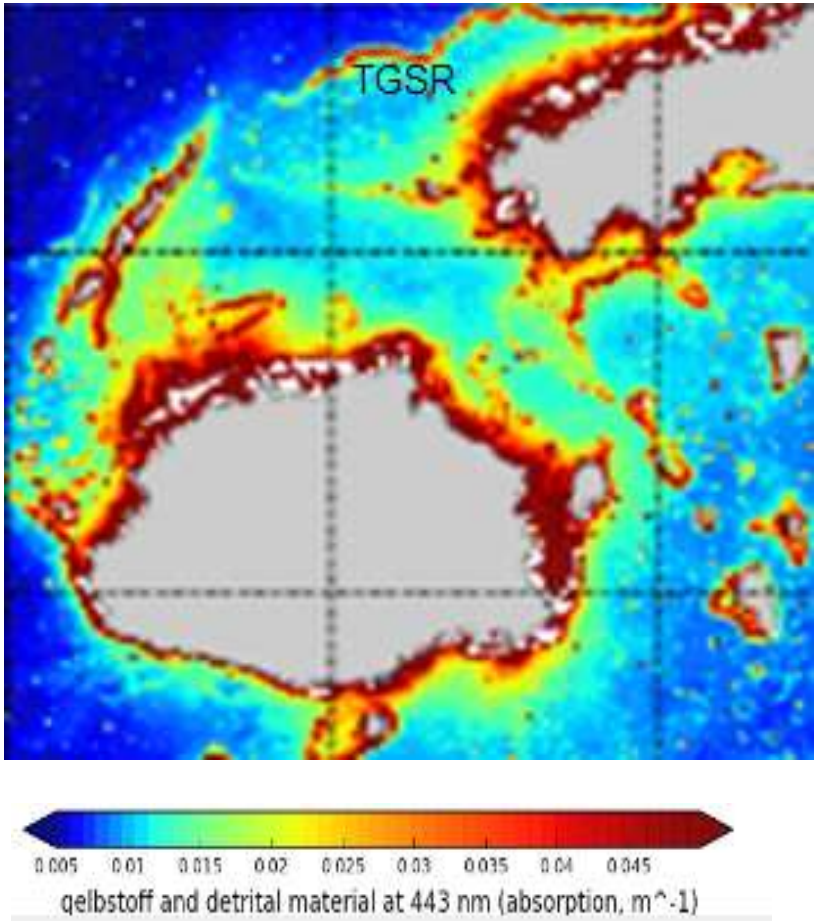
WPI's Liquid Waveguide Capillary Cell (LWCC) is a flow cell for absorbance measurements in the ultraviolet, visible and near infra-red ranges. Pathlengths range from 50–500cm, with increasing measuement sensitivity from 50 to 500-fold. The flow cells are fiber coupled and have a very small sample volume ranging from 125mL (50cm pathlength) to 1,250mL (500cm pathlength).

How does it work?

The sample solution is introduced into the LWCC at the liquid input. Light is coupled into the LWCC from a light source via a fiber optic cable. After passing through the LWCC, light is collected with an optical fiber and guided to a detector. The concentration of the sample is determined by measuring its absorbance in the LWCC, similar to a standard UV/VIS spectrometer.

PSICAM

The Great Sea Reef Story – Fishery Productive Areas Watch vs High Chlor-a Observed Area Pre-Survey



Timoci Koliyavu

NICE REVEIWER STORIES

M G M Khan 11:49 (26 minutes ago)

to me

Dear Timoci,

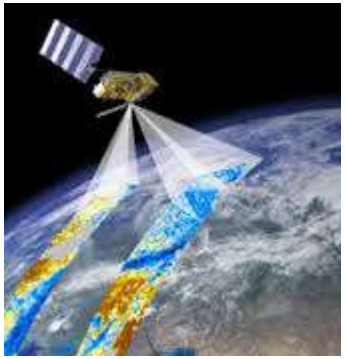
Thanks for your email. I got your research problem in PhD, which seems to me very interesting. But I couldn't get it why you are contacting me? Will I be in the supervisory team of your thesis?

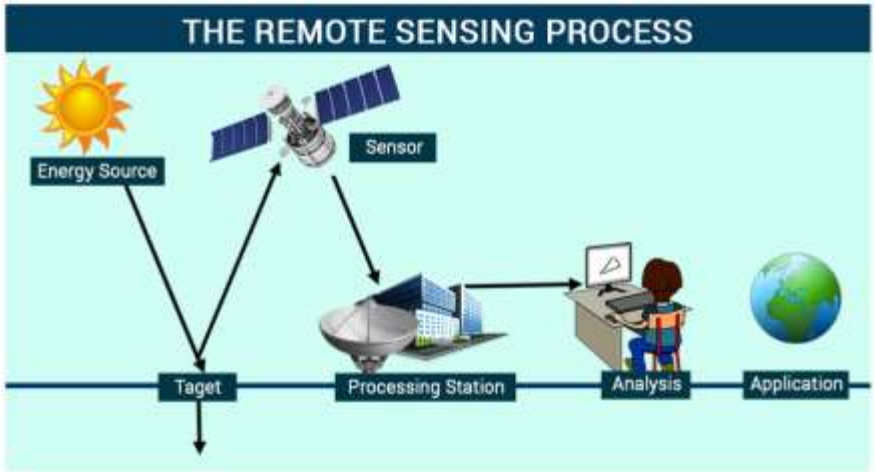
Regards
MGM

From: Timoci Koliavu [mailto:s95008286@student.usp.ac.fj]
Sent: Monday, April 24, 2017 11:26 AM
To: M G M Khan <khan_mg@usp.ac.fj>
Cc: Awnesh Singh <awnesh.singh@usp.ac.fj>; Elisabeth Holland <elisabeth.holland@usp.ac.fj>
Subject: SSW Research Intent at PaCE-SD Update

Ocean Colour and Remote Sensing

- Colour is determined by the intercations of the incident light with substances or particles present in the water
- When light hits the water surface, the diffrent colour are absorbed,transmitted, scattered or rflected in different wavelegnths and intrensities by the water molecules and other actively constituents suspended in the upper surface layer.
- RS is the science of obtaining information about objects or areas from a distance e.g satellite





➢ PhD results in progress

Hydrodynamic circulation in Laucala Bay, MARS 3D