

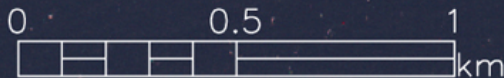


Spectral Imaging of Coral Reefs: Inversion, Classification, & Modeling Ecosystem Function

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Bermuda Institute of Ocean Sciences

**2013 HyspIRI Science and Application Workshop
Pasadena, California
16 October 2013**



Traditional Culture & Food



ARC Centre of Excellence for Coral Reef Studies/Marine Photobank

\$Multibillion Recreation Industry

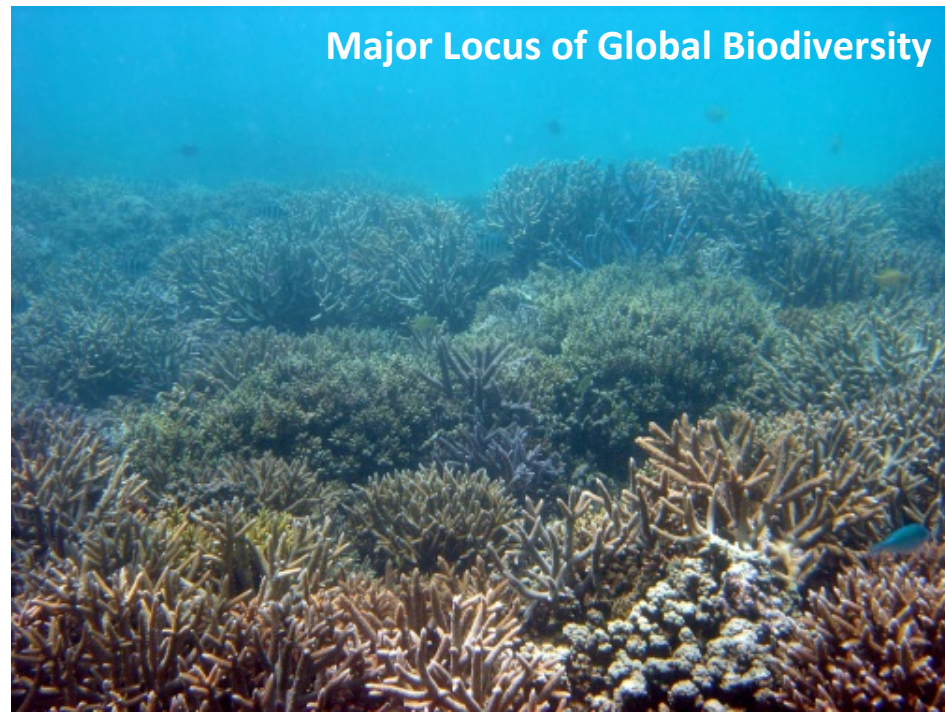


Unattributed

**Shoreline
Protection**



Major Locus of Global Biodiversity



The (Modern) Coral Reef Problem



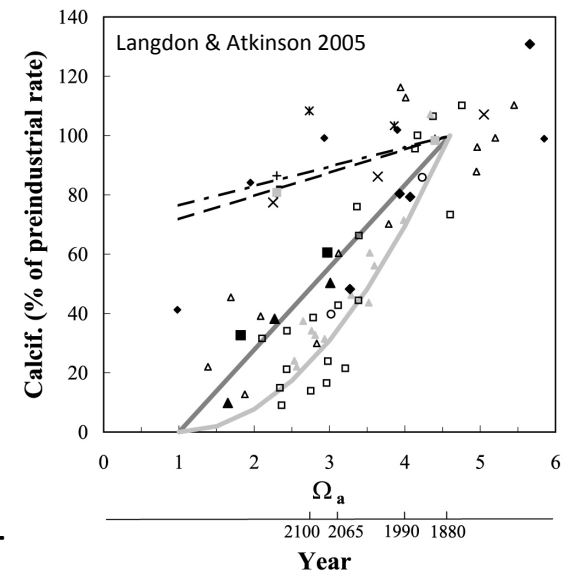
Acanthaster planci
GBR 1960s–1970s
Elsewhere 1980s–

Mass bleaching
Global 1980s–1990s



Coral diseases
Global 1990s–

Ocean acidification
Global 2000s–

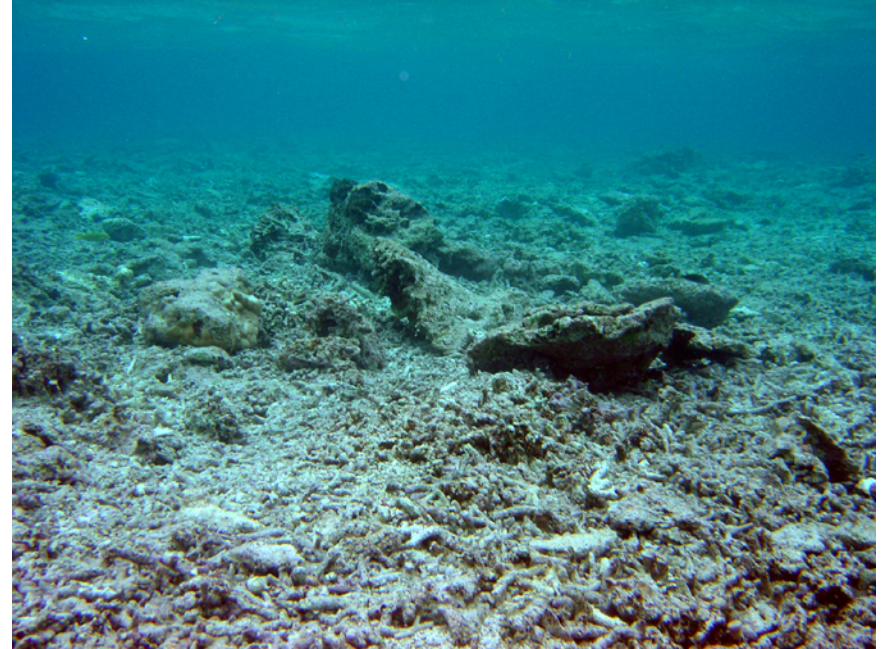


The (Modern) Coral Reef Problem

Phase shift

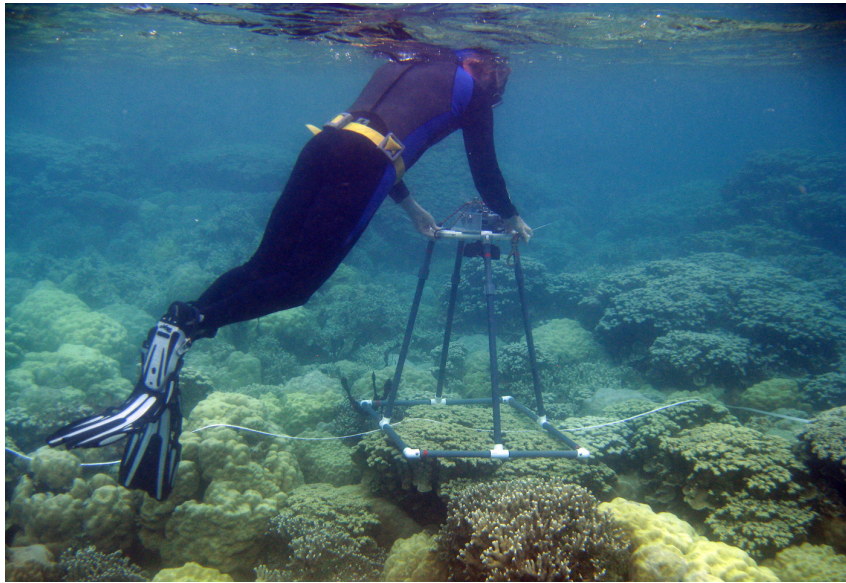


- High coral cover
- High productivity/calcification
- “Healthy”

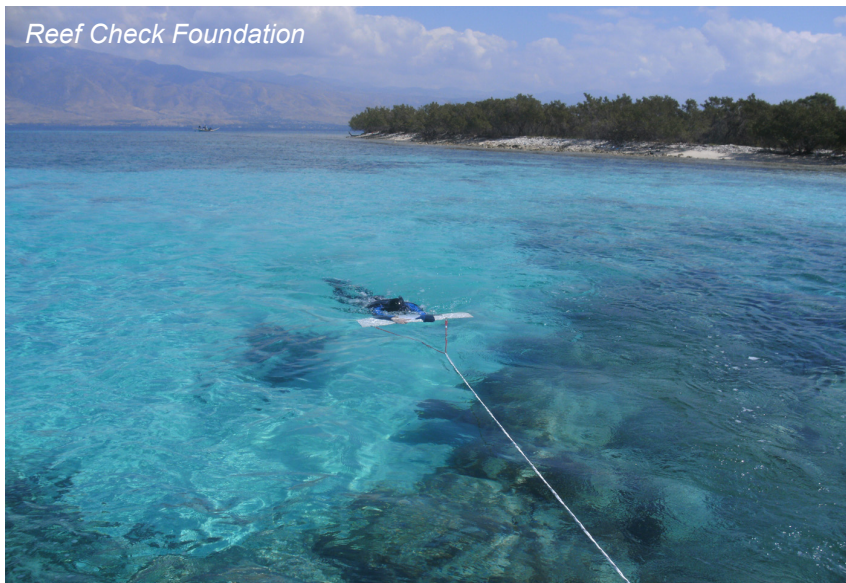


- Low coral cover
- Low productivity/calcification
- Not “healthy”

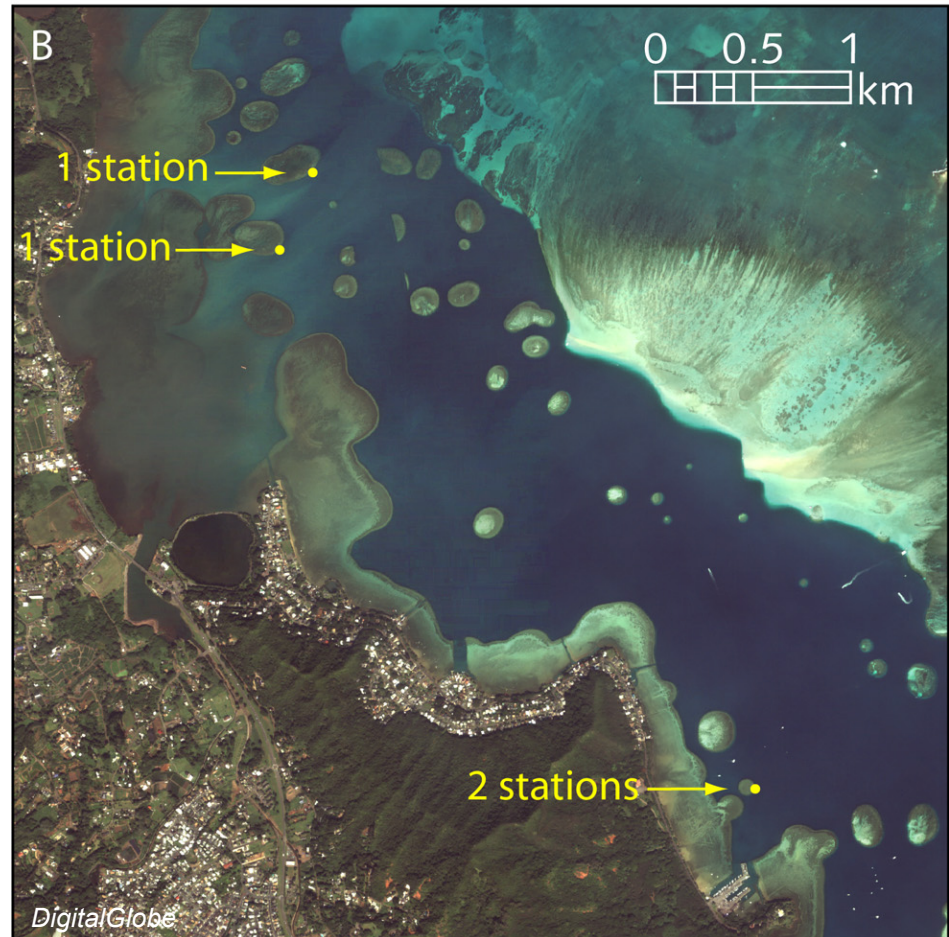
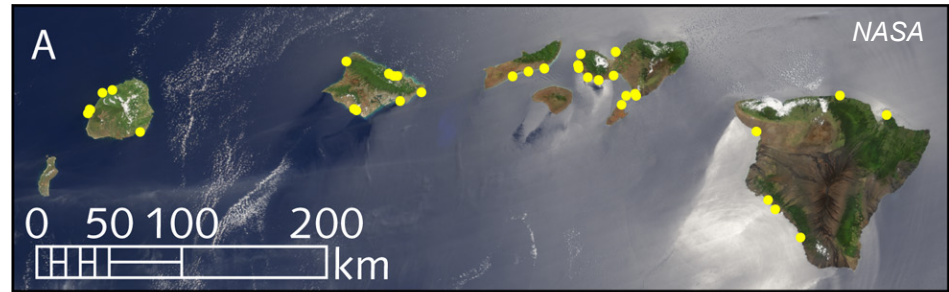
State of the Art in Assessment of Coral Reef Structure



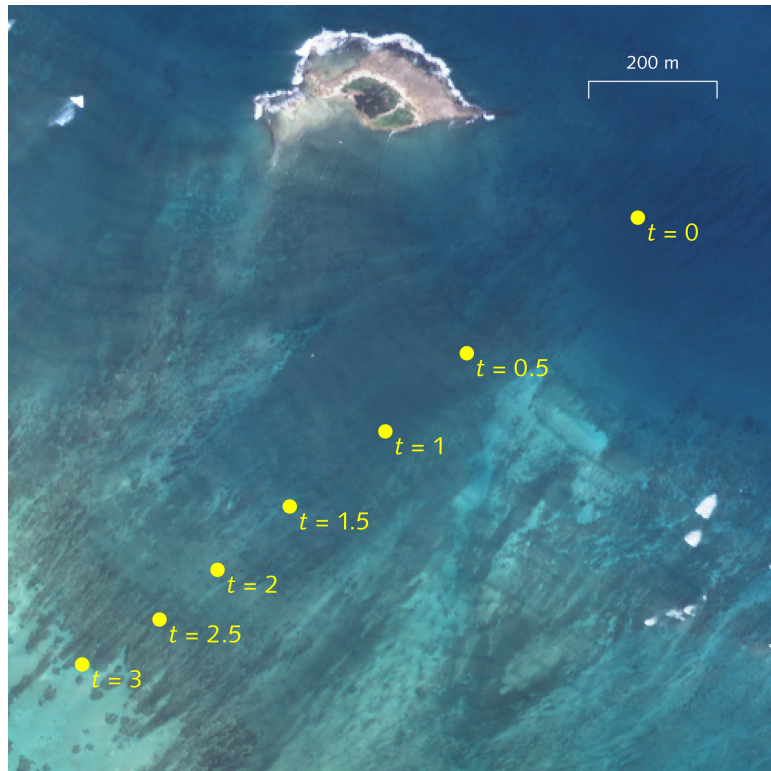
Photoquadrat Transects: detailed, laborious, small footprint



"Manta-Tows": quick, semi-quantitative, larger footprint



State of the Art in Assessment of Coral Reef Structure

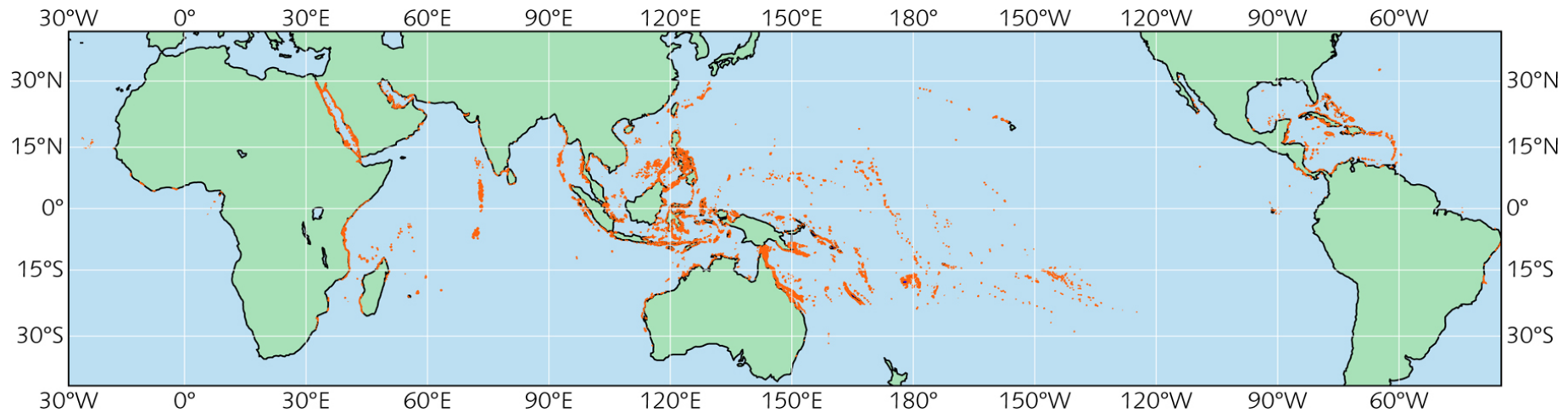


Lagrangian or Eulerian
measurements



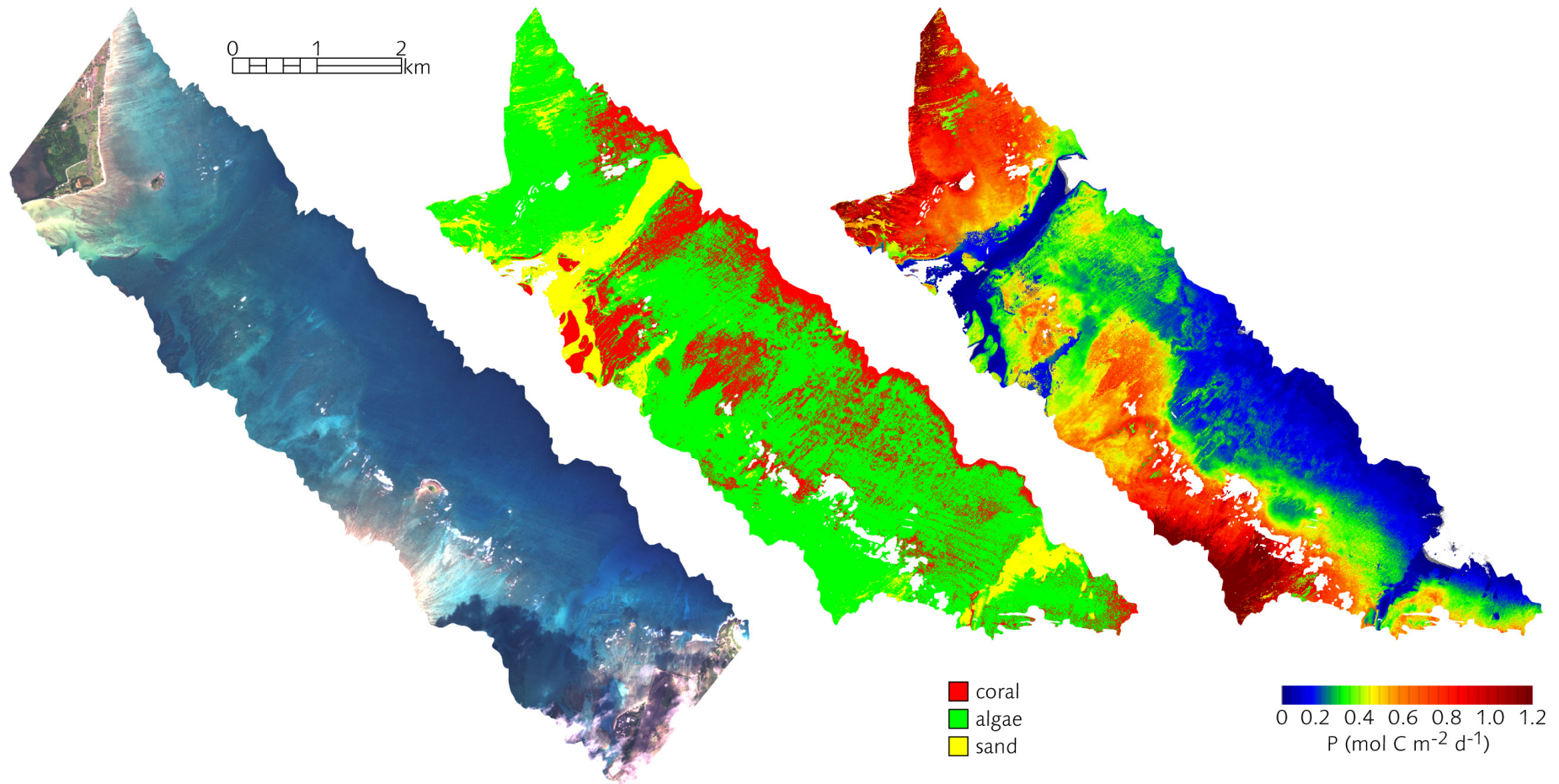
Benthic chamber

Coral Reefs: Sampling Problem



- ~9,000 reefs in the world, covering ~500,000 km²
- Spread across 200,000,000 km² of ocean
- Quantitative in situ surveys cover only 10s to 100s of km² worldwide
- Measurements of productivity and calcification are insignificant
- *Current estimates of reef degradation are based on direct observation of only 0.01–0.1% of the world's reef area*
- **Only satellite remote sensing can provide the uniform data set required for assessment of the global status of coral reefs**

**Case study after case study:
The information does exist in the spectral imagery**

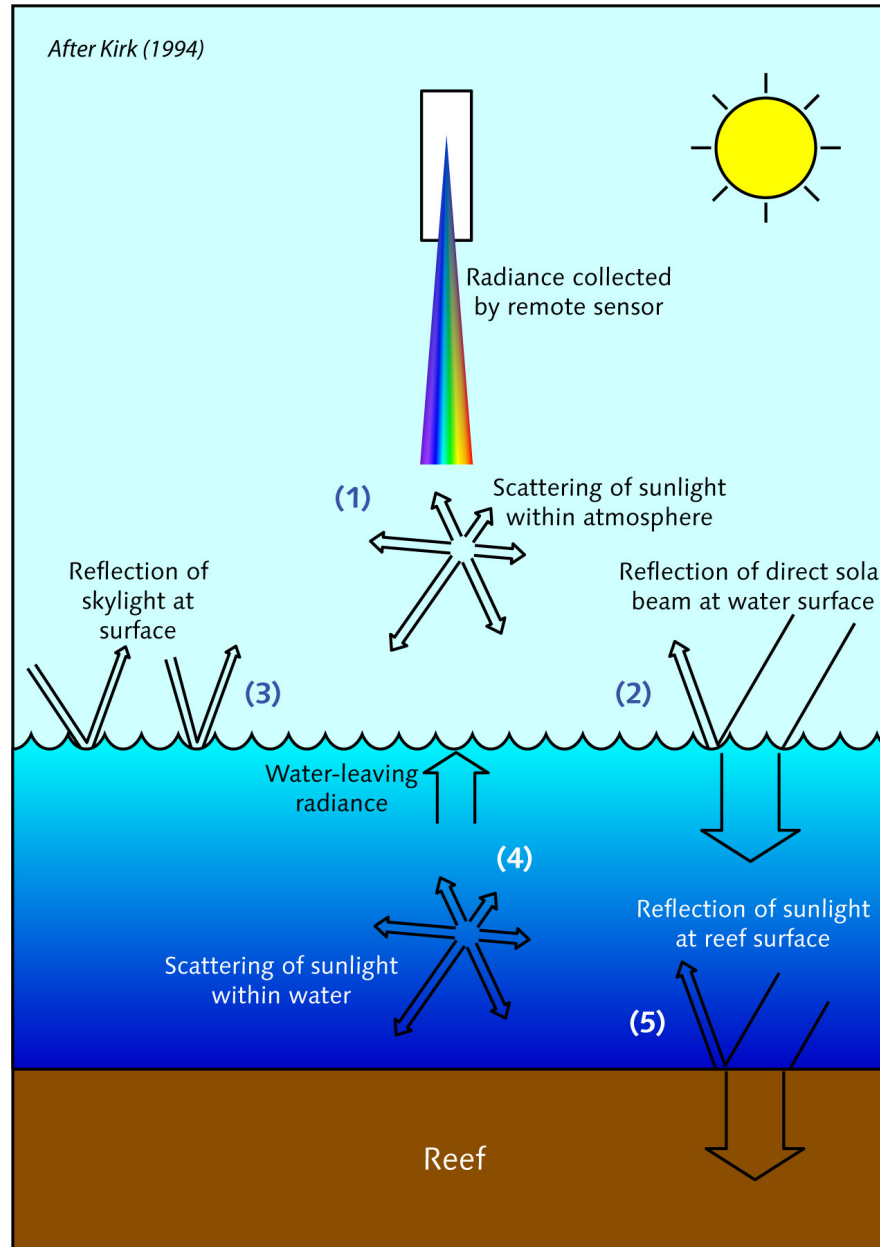


AVIRIS 2005 — Kaneohe Bay, Hawaii

Coral Reef Remote Sensing Problem

Five sources of light received by a remote sensor pointed at a reef

Only light reflected from the reef surface can provide information about the reef



Spectral Discrimination

Hochberg & Atkinson (2003)

Table 1

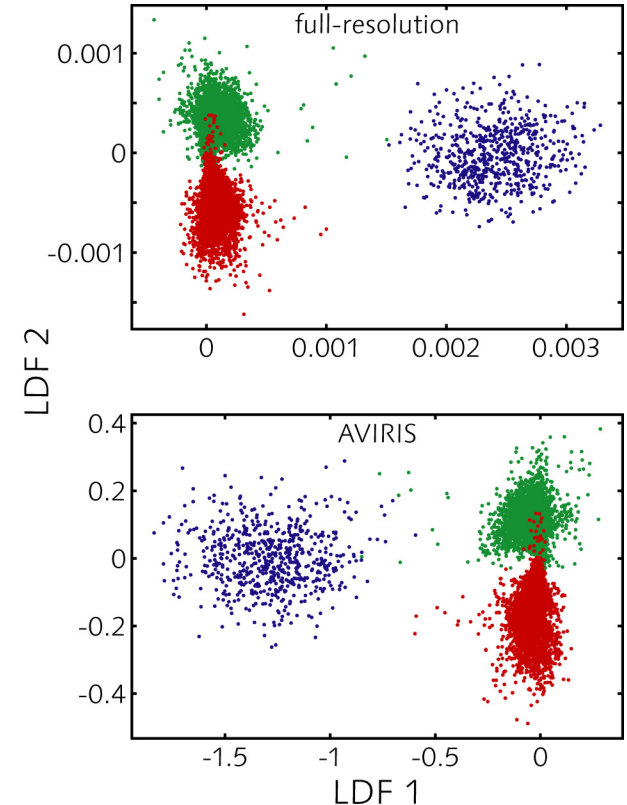
Classification error matrices for in situ spectral reflectances of three coral reef classes: coral, algae, and carbonate sand

(A) Full-resolution: overall accuracy = 98%

		Actual class		
		Algae	Coral	Sand
Predicted class	Algae	2726 (99.2)	75 (3.3)	1 (0.3)
	Coral	23 (0.8)	2168 (96.6)	0 (0.0)
	Sand	0 (0.0)	1 (0.0)	320 (99.7)

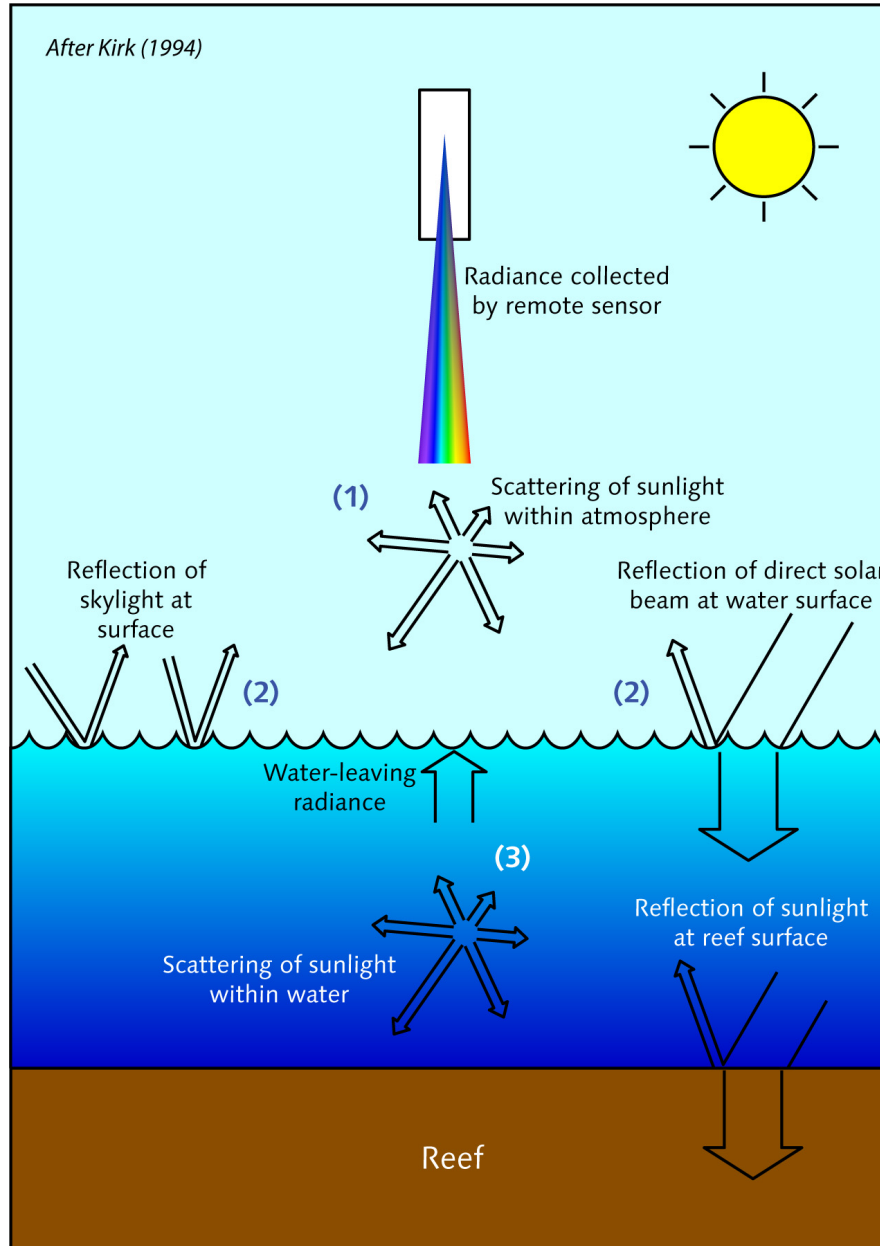
(C) AVIRIS: overall accuracy = 98%

		Actual class		
		Algae	Coral	Sand
Predicted class	Algae	2725 (99.1)	74 (3.3)	1 (0.3)
	Coral	24 (0.9)	2170 (96.7)	0 (0.0)
	Sand	0 (0.0)	0 (0.0)	320 (99.7)



Conclusion: Contiguous, 10-nm-wide wavebands over range 400–700 nm provide excellent spectral discrimination between coral, algae, sand

Coral Reef Remote Sensing Processing



(1) Atmosphere Correction

ATREM
FLAASH
Tafkaa
Glint-Aerosol Discrimination

(2) Glint Correction

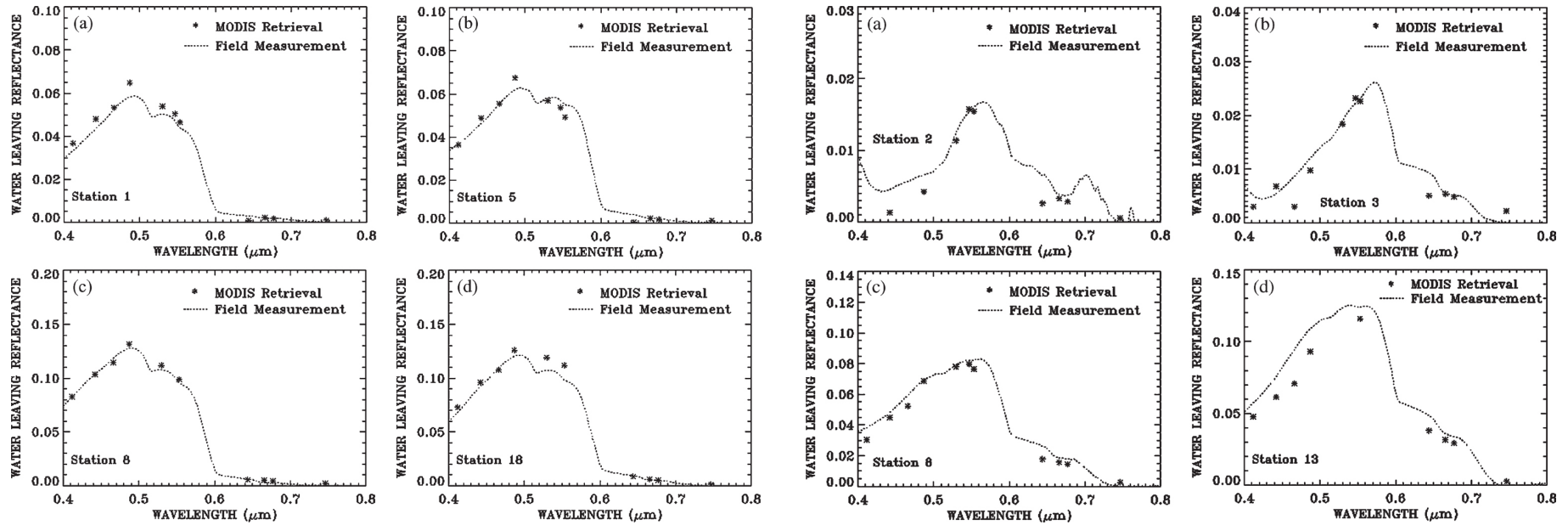
NIR-VIS Empirical Linear Relationship
Subtraction of NIR Reflectance
Uniform Spectral Offset Approach
Glint-Aerosol Discrimination

(3) Water Column Correction

Optimization
Look-Up Tables
Classification

(1) Atmosphere Correction

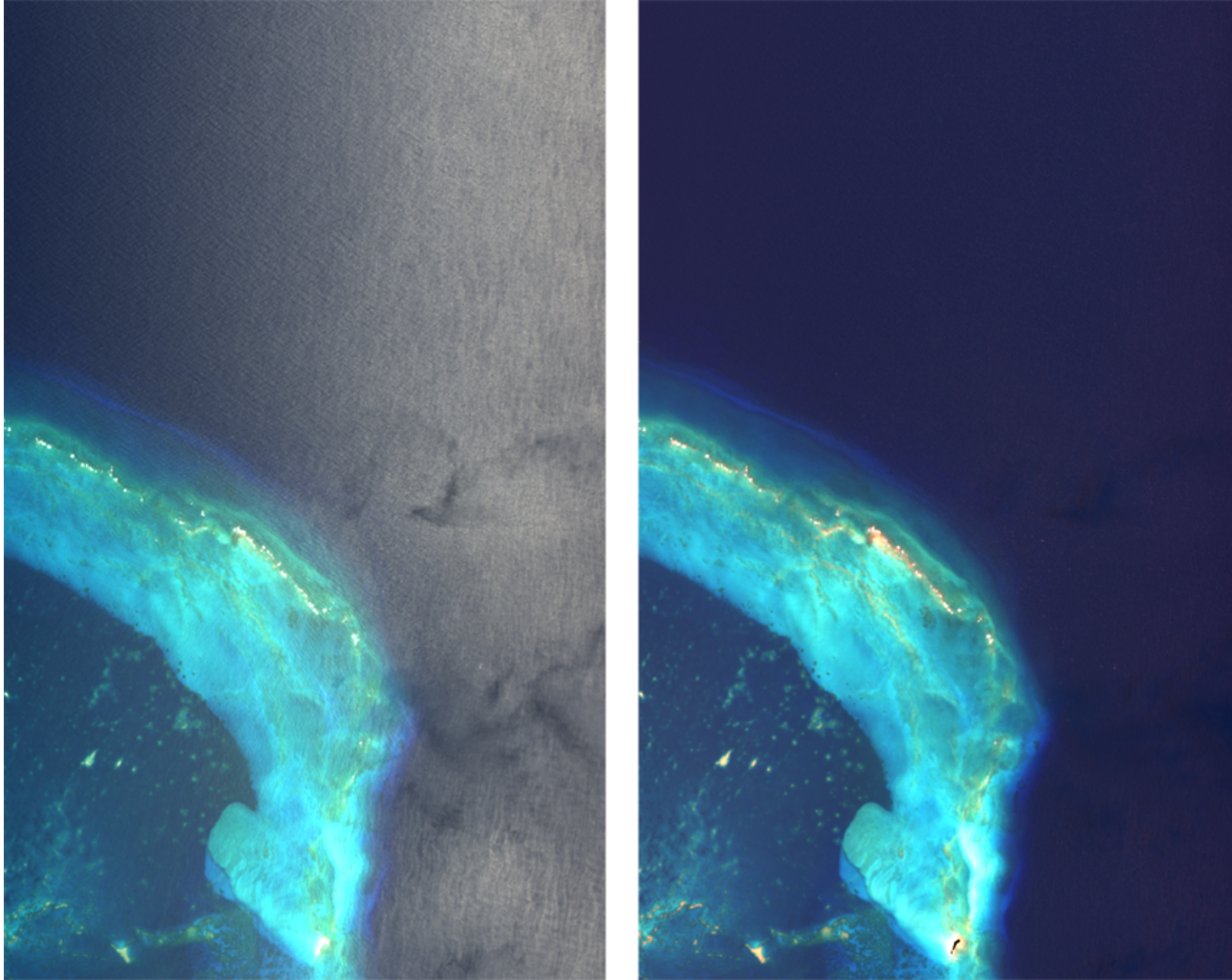
Gao et al. (2007)



Conclusion: Combined wavebands across NIR/SWIR (0.865, 1.04, 1.24, 1.64, and 2.25 μm) provide very good atmosphere correction

(2) Glint Correction

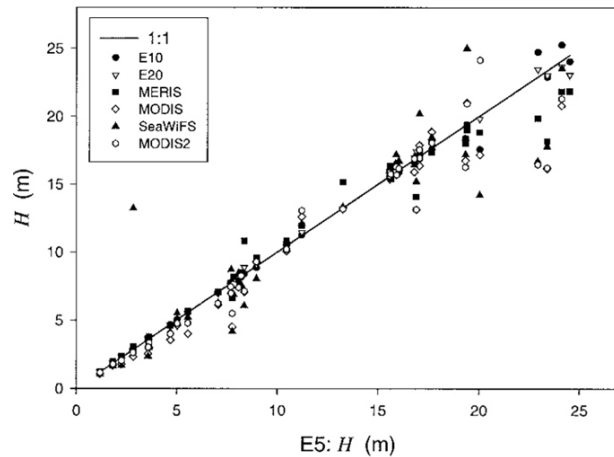
Various Workers & HyspIRI Sunlint Subgroup



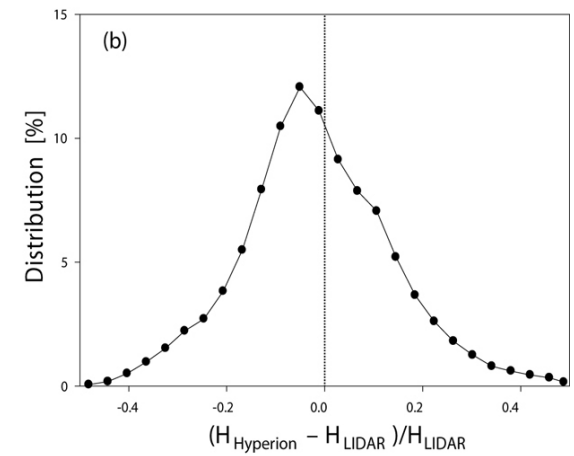
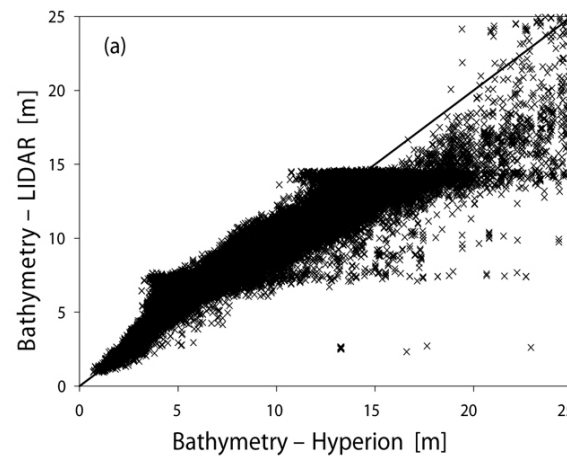
Conclusion: Glint is readily correctable, provided (a) suitable reference waveband(s) >900 nm and (b) good atmosphere correction

(3) Water Column Correction

Lee & Carder (2002)

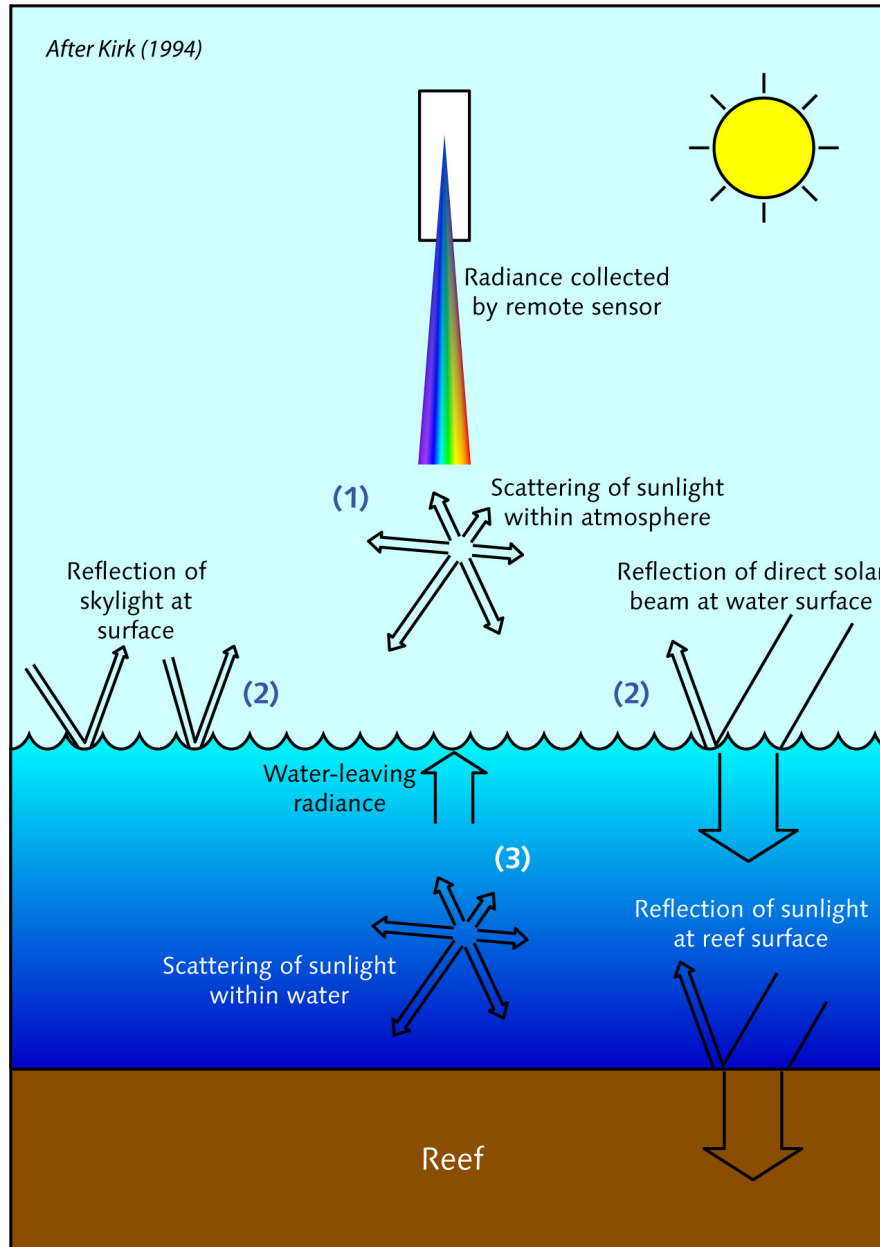


Lee et al. (2007)



Conclusion: Contiguous, 10-nm-wide wavebands over range 400–800 nm is excellent band set for retrieval of shallow water bathymetry

Coral Reef Remote Sensing Processing



(1) Atmosphere Correction

ATREM
FLAASH
Tafkaa
Glint-Aerosol Discrimination

(2) Glint Correction

NIR-VIS Empirical Linear Relationship
Subtraction of NIR Reflectance
Uniform Spectral Offset Approach
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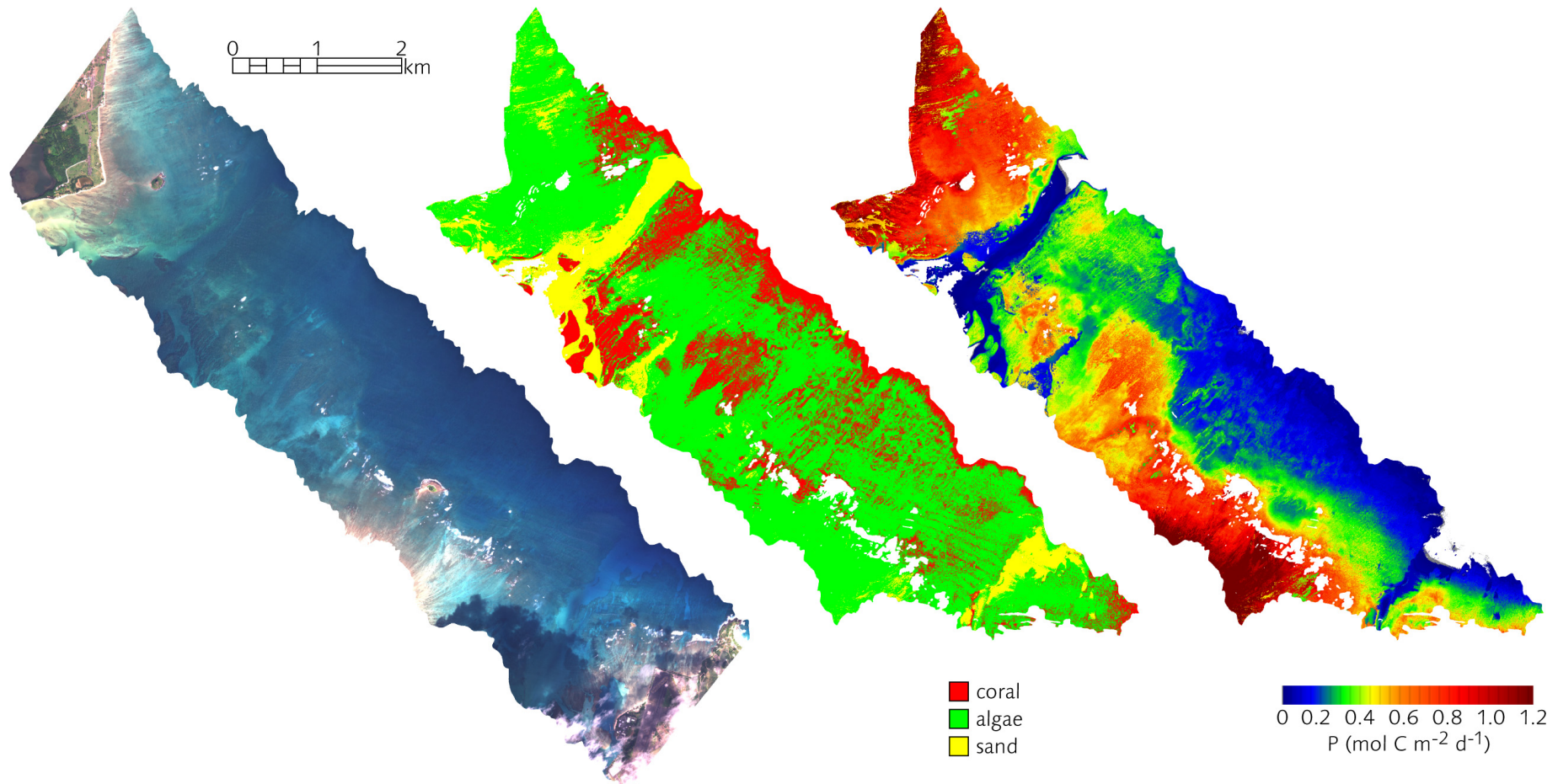
(3) Water Column Correction

Optimization
Look-Up Tables
Classification

(4) Successful Integration of (1) + (2) + (3) ??????

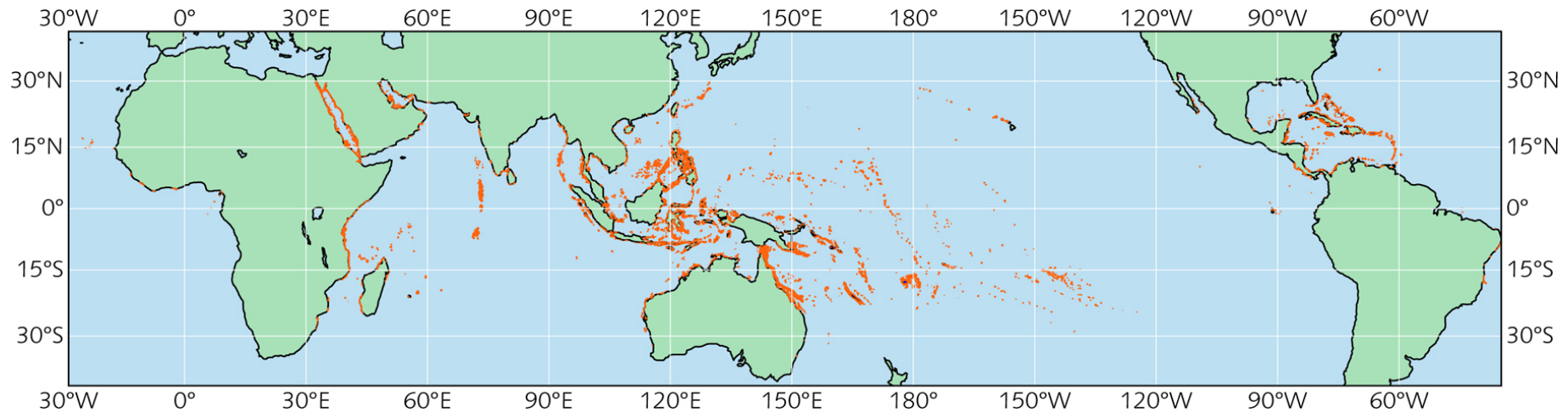
Case study after case study:

There are no complete data sets for validation of processing and products



AVIRIS 2005 — Kaneohe Bay, Hawaii

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- Only satellite remote sensing can provide the uniform data set required for assessment of the global status of coral reefs...
- **...But a concerted airborne effort to develop a quantitative inventory of merely 10% of the world's reefs would represent a 1,000-fold increase in surveyed reef area. (Hint, hint.)**

Potential HysplRI special issue in *Remote Sensing of Environment*

Organizers/Guest Editors

Phil Dennison

Eric Hochberg

Dar Roberts

????

Need 15+ accepted papers for a special issue

- Ecological aspects
- Open to other aspects

If we find “sufficient interest,” we can begin the process of handling papers

Interested? Please get in touch!