Comparison of Endmember Extraction Algorithms for Hyperspectral Unmixing

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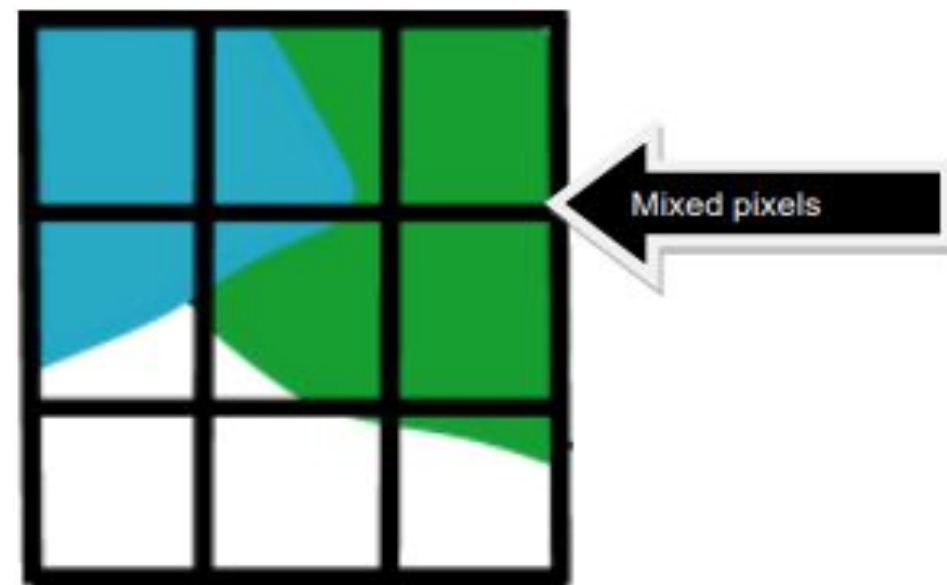[2]*Summer Bridge Scholar,*

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Advisor: [1,3]*Miguel Velez-Reyes*

Abstract:

- Different materials in mixed pixels affect accurate classification

- Mathematics to solve mixed pixel problem

- Characterization by spectral signature and fraction area

Mixed pixels

Courtesy of Reference 1

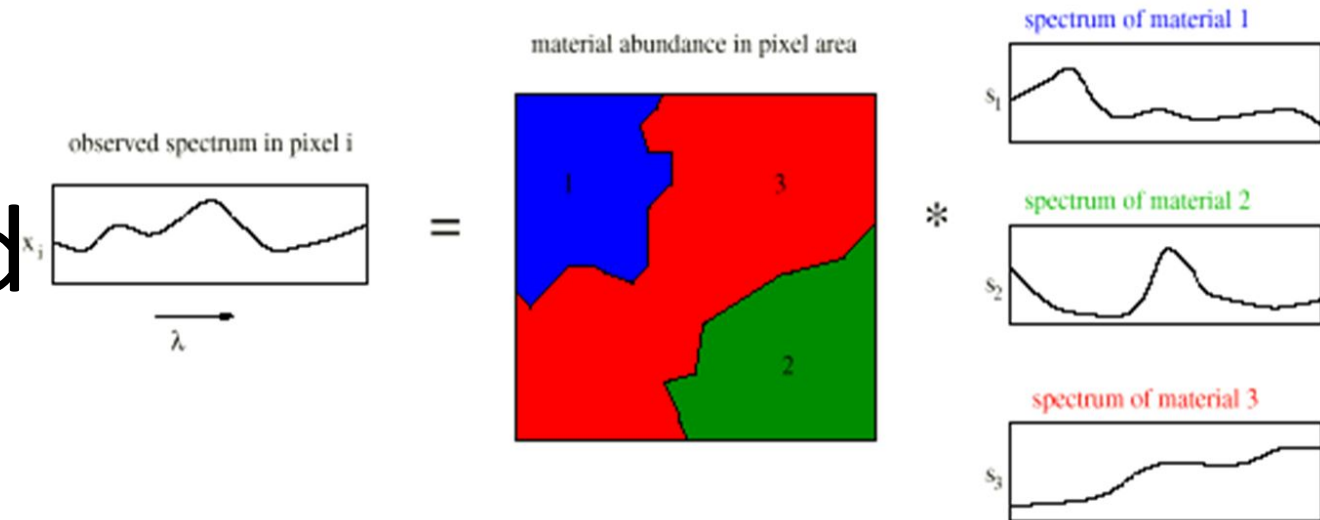# *Background: Hyperspectral unmixing*

- Total spectrum of mixed pixel is sum of individual endmembers identified spectra and fractional abundance

$$x = \sum_{n=1}^{P} f_n e_n$$

where

e_n endmember spectra
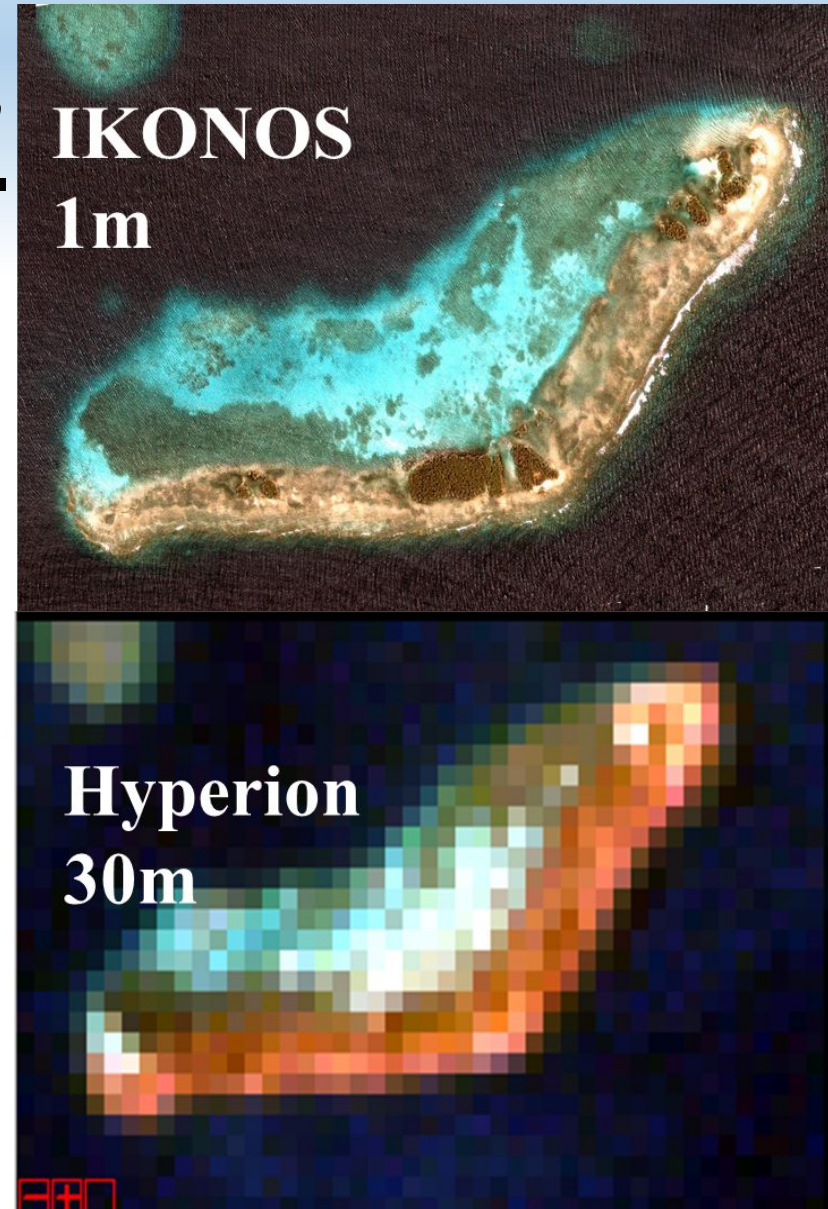f_n fractional abundance

observed spectrum in pixel i

x_i

λ

= material abundance in pixel area

*

spectrum of material 1

s_1

spectrum of material 2

s_2

spectrum of material 3

s_3

Motivation for the study:

- Accurate classification of satellite images important $\Longrightarrow$

- Numerous endmember extraction algorithms proposed – Which is more accurate?

- Understand similarities and differences
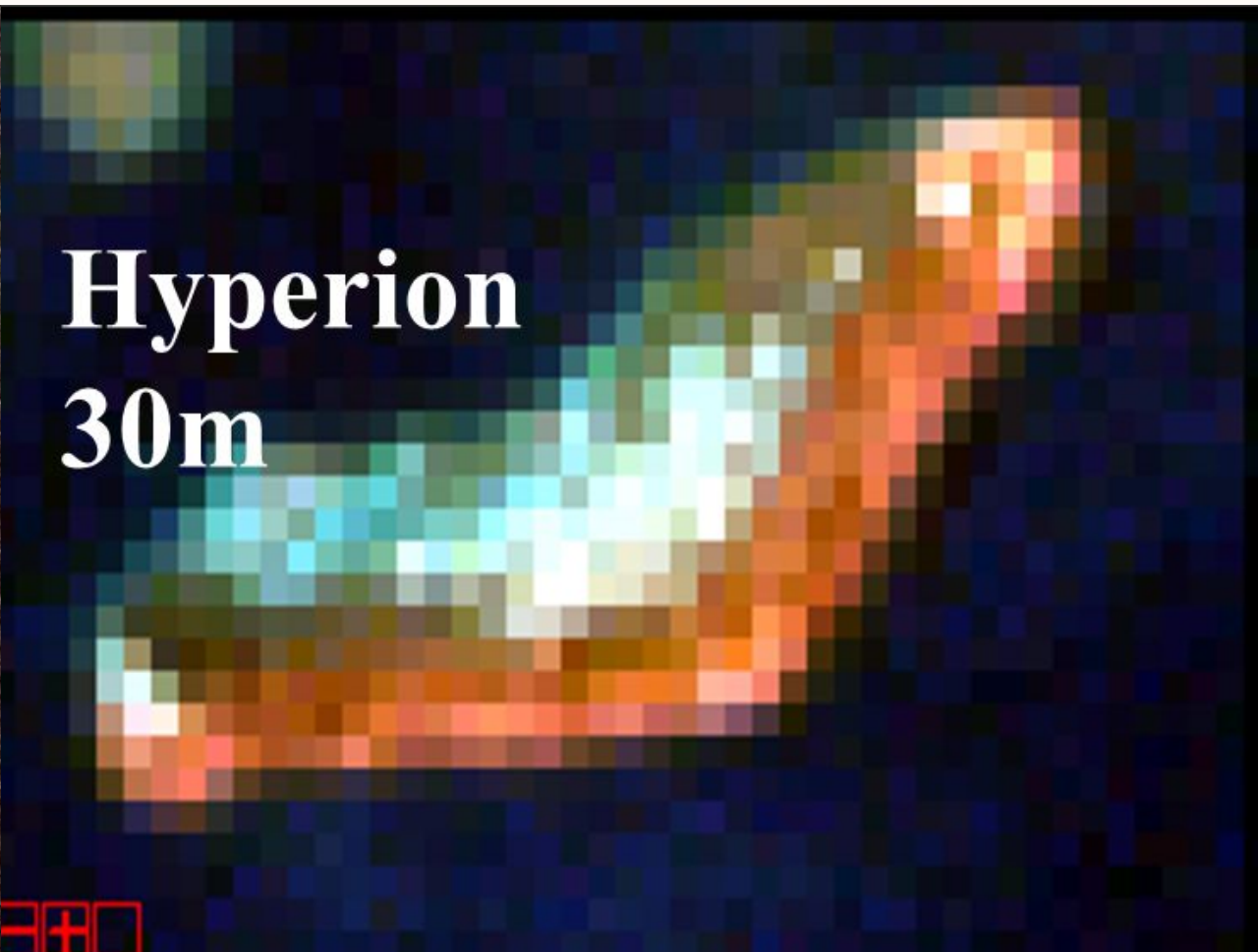
Courtesy of Reference 2

Research questions:

- Will different extraction algorithms identify the same endmembers for a given number of endmembers?

- How would differences in extracted endmember affect abundance estimates?
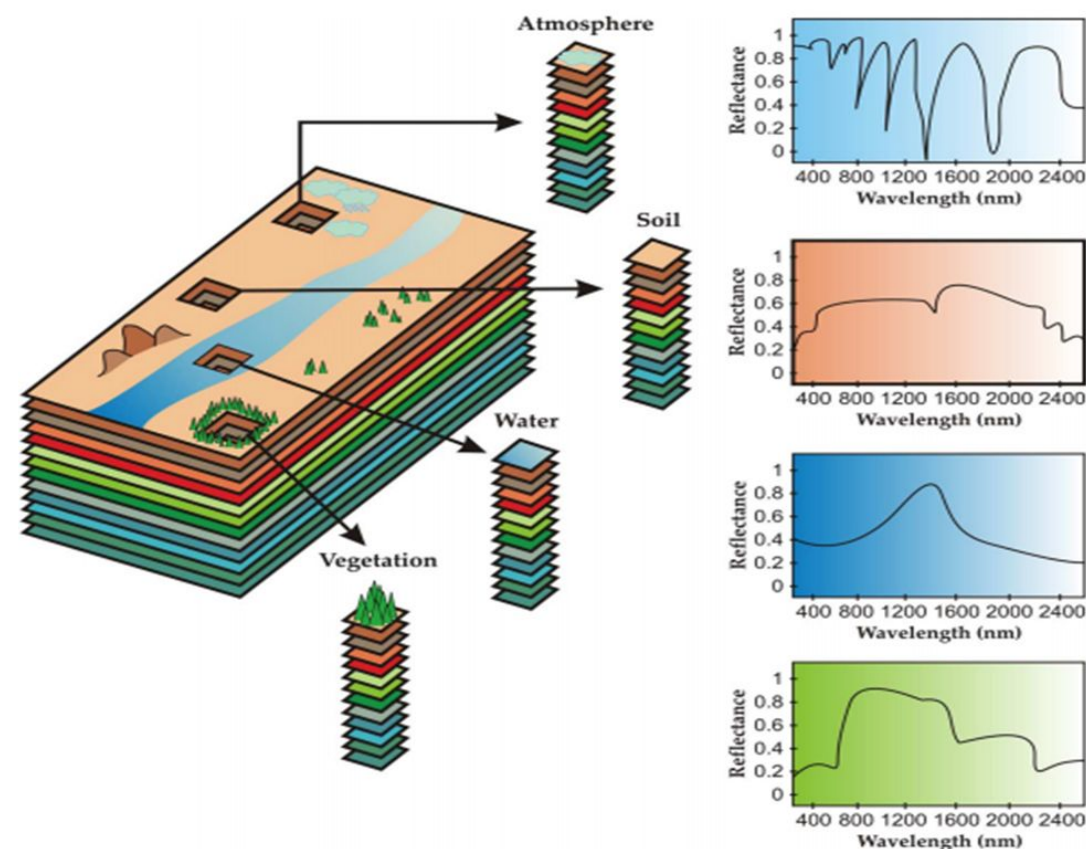
Courtesy of Reference 3

Enrique Reef in La Parguera southwestern Puerto Rico:

Courtesy of Reference 2

Methods:

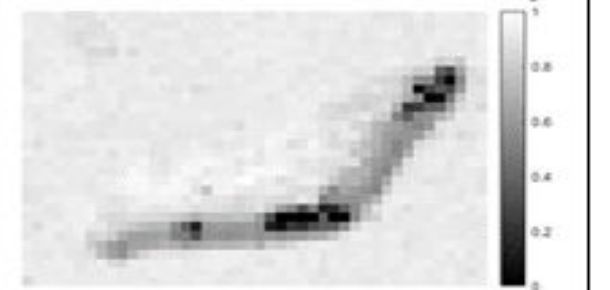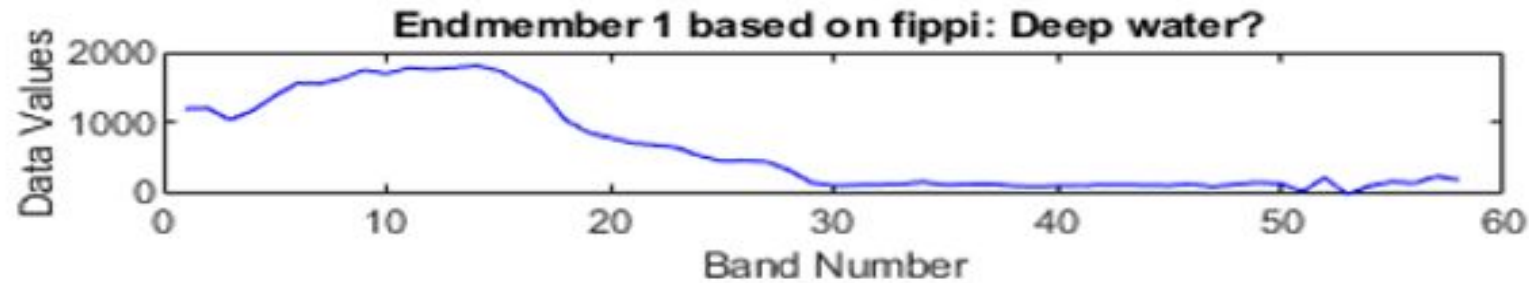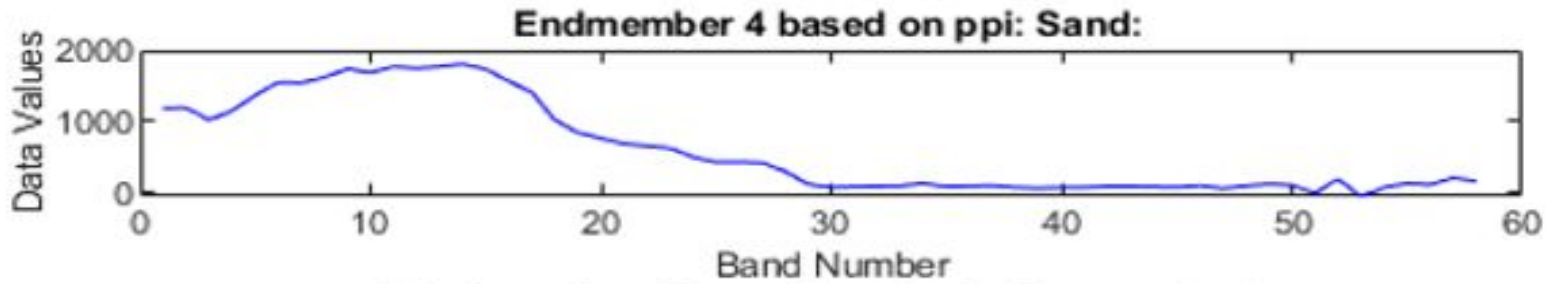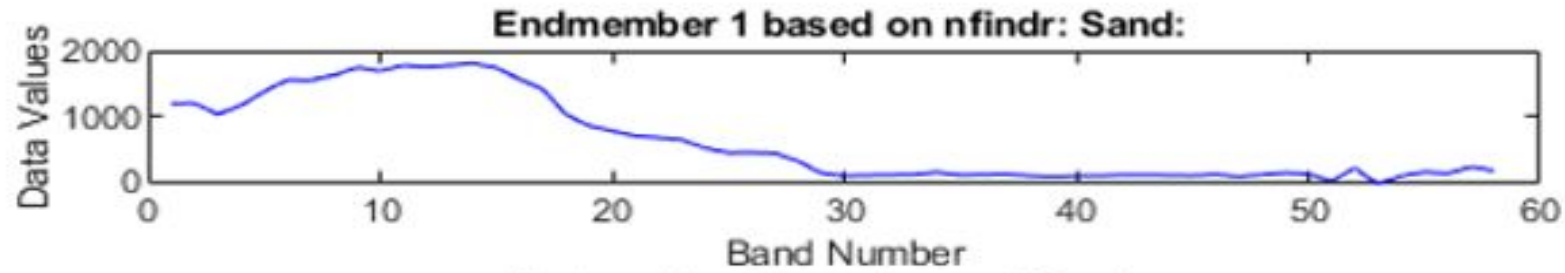|	Unmixing algorithms from Hyperspectral Imaging Processing Toolbox on MATLAB
_1_	**countEndmembersHFC:** Computes the number of endmembers in the data set
_2_	**nfindr** [4]: Nearest finder
_3_	**ppi** [2]: Pixel purity index
_4_	**fippi:** Fast iterative pixel purity index
_5_	**estimateAbundanceLS:** Estimates individual fractional abundances per endmember

Pixels at the extremes are incremented in the candidate pixels' index
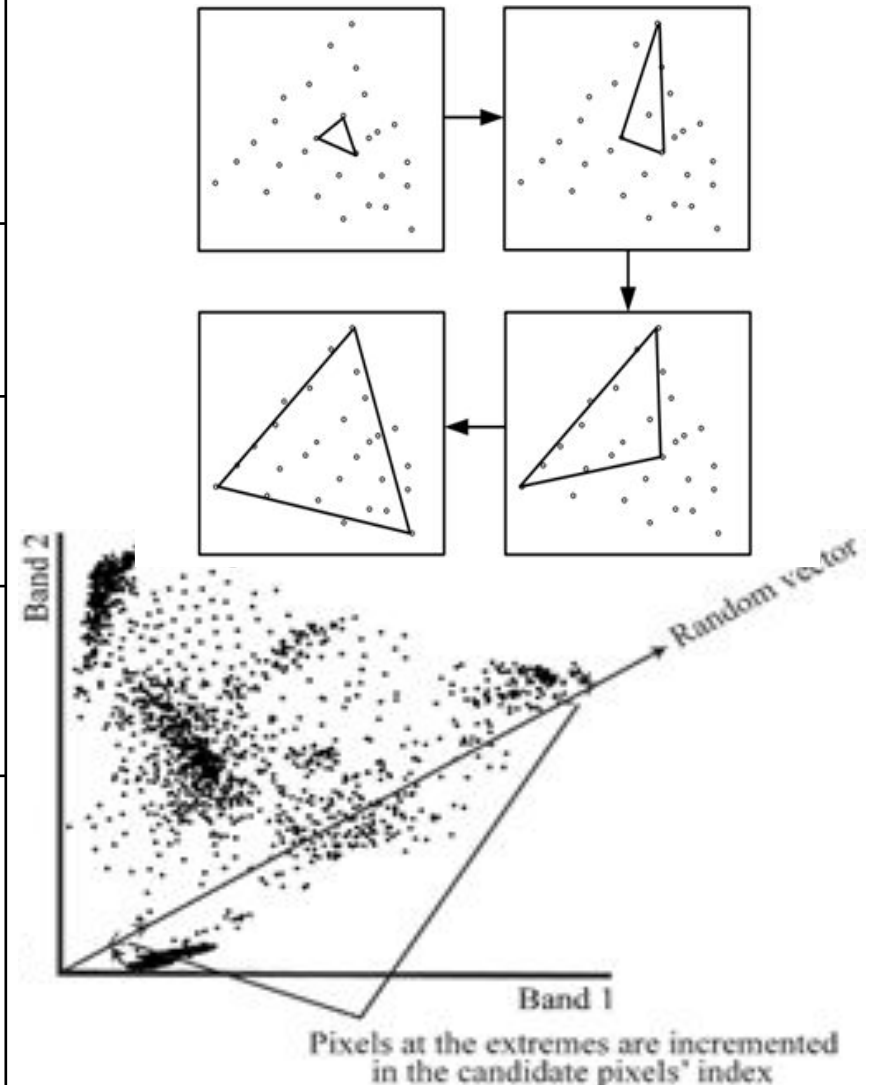
Qualitative results:

		nfindr:		*ppi*		*fippi:*
E	1	sand	1	unknown	1	deep water?
n	2	reef flat	2	mangrove	2	mangrove
d	3	mangrove	3	reef flat	3	mangrove?
m	4	reef flat?	4	sand	4	unknown
e	5	sea grass	5	sand?	5	reef flat
m						
b						
e						

Discussion:

Sand or water?

Endmember 1 based on nfindr: Sand:

Endmember 4 based on ppi: Sand:

Endmember 1 based on fippi: Deep water?

Discussion:

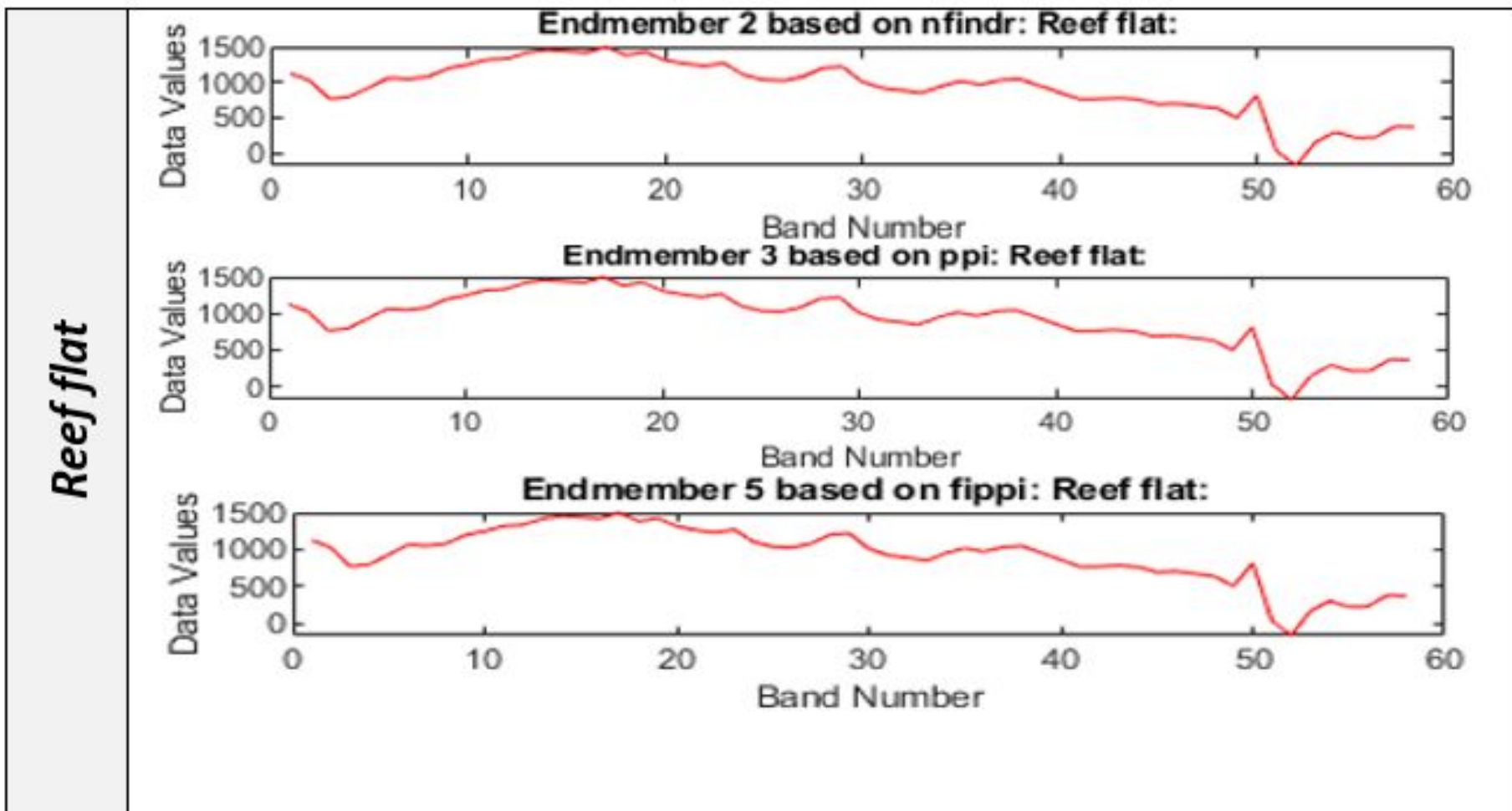Reef flat

| Endmember 2 based on nfindr: Reef flat: | |

Discussion:

Mangrove

Endmember 3 based on nfindr: Mangrove:

Endmember 2 based on ppi: Mangrove:

Endmember 2 based on fippi: Mangrove:
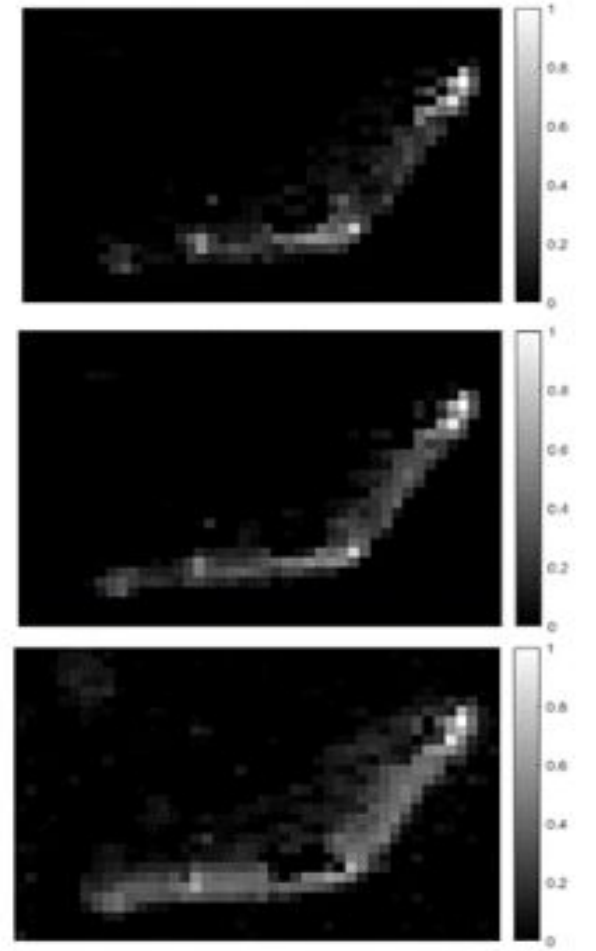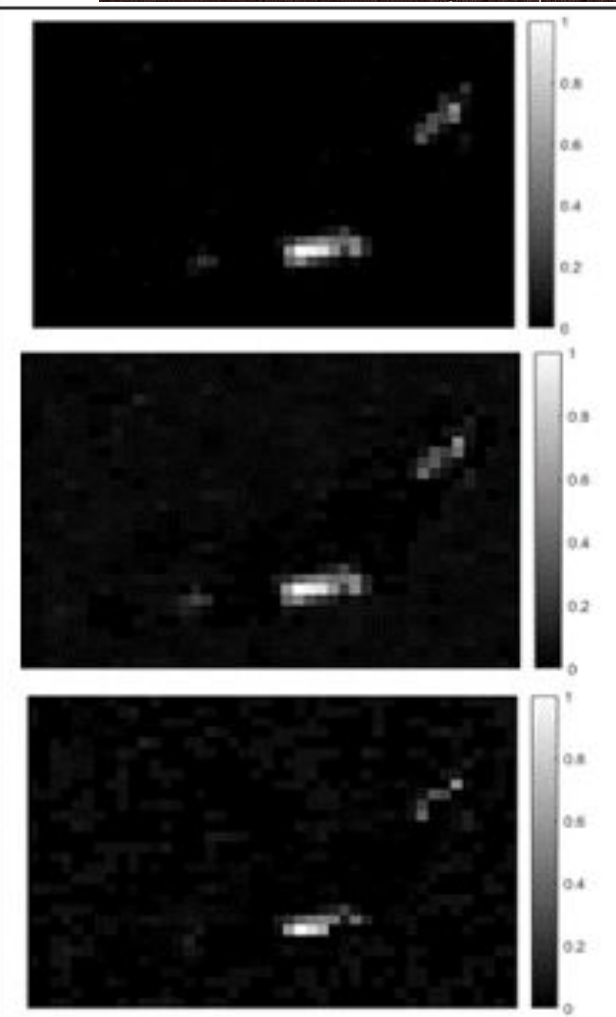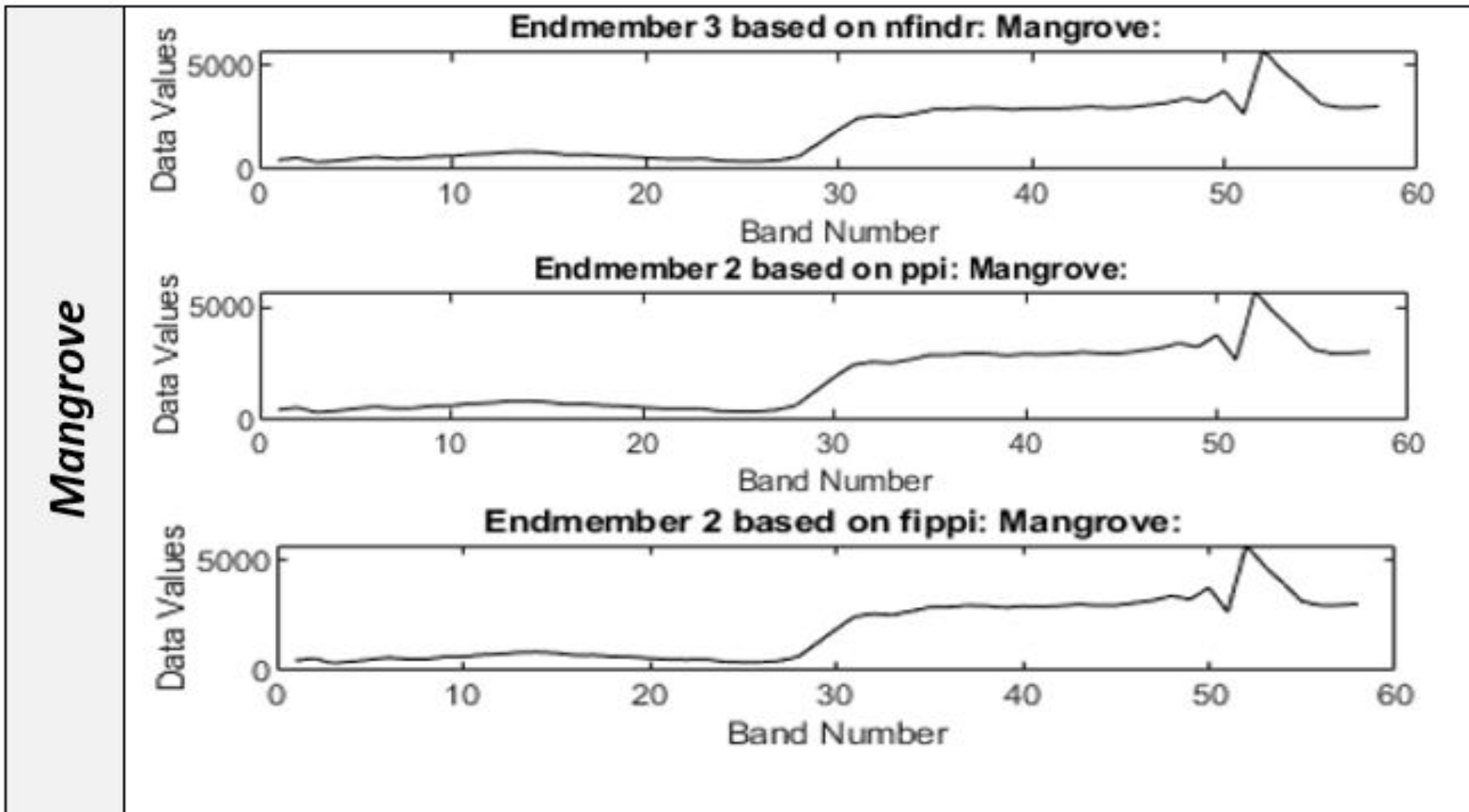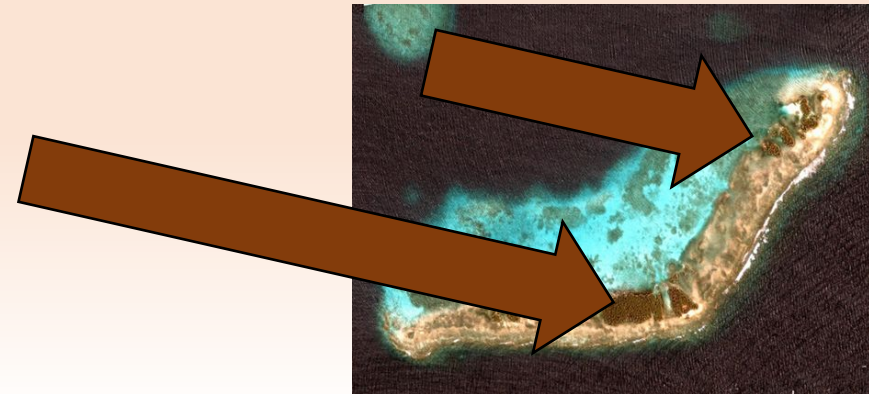
Discussion:

Sea grass or sand?

Endmember 5 based on nfindr: Sea grass:

Endmember 5 based on ppi: Sand?

Discussion:

Unmatched endmembers:

nfindr

Endmember 4 based on nfindr: Reef flat?

Endmember 6 based on nfindr: Deep water:

ppi

Endmember 1 based on ppi: Unknown:

Endmember 6 based on ppi: Deep water:

fippi

Endmember 3 based on fippi: Mangrove?:
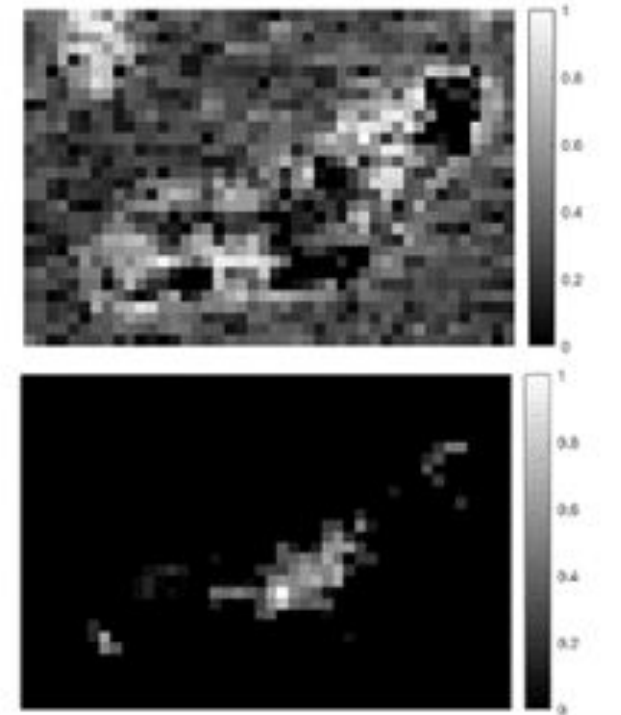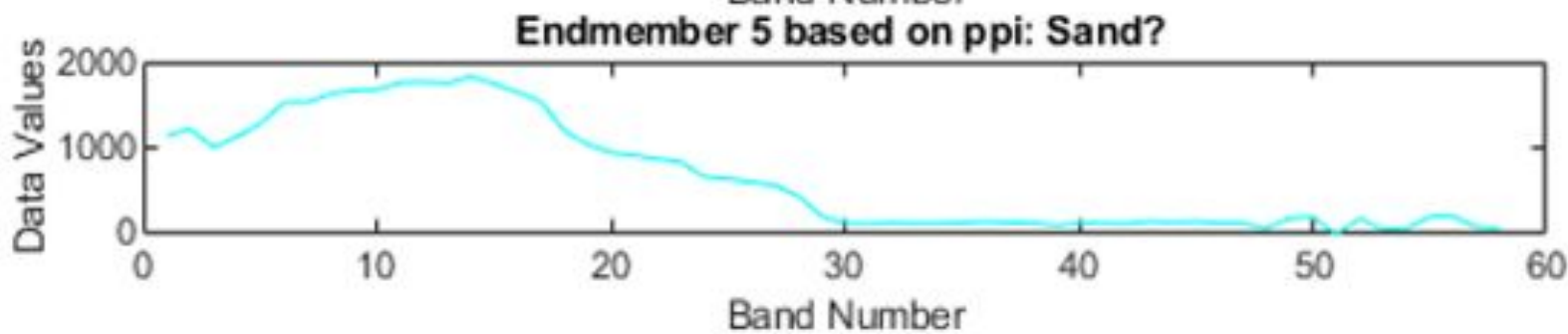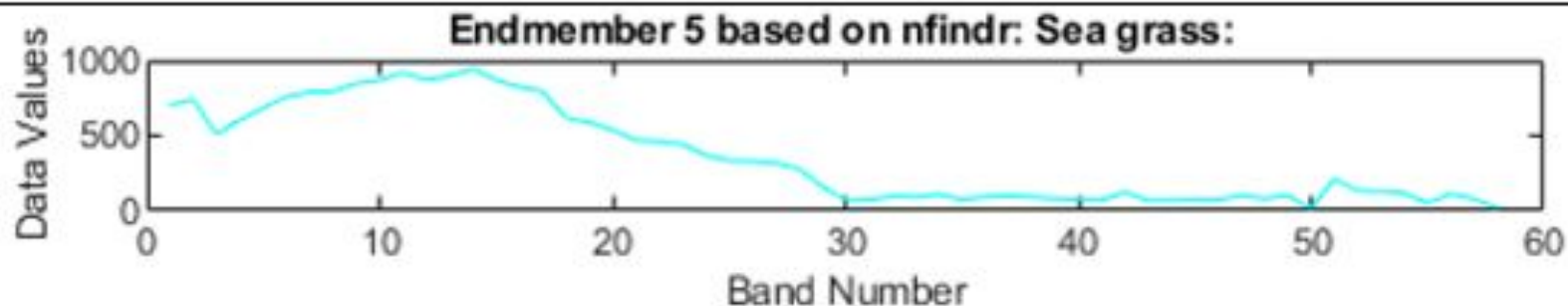
Endmember 4 based on fippi: Unknown:
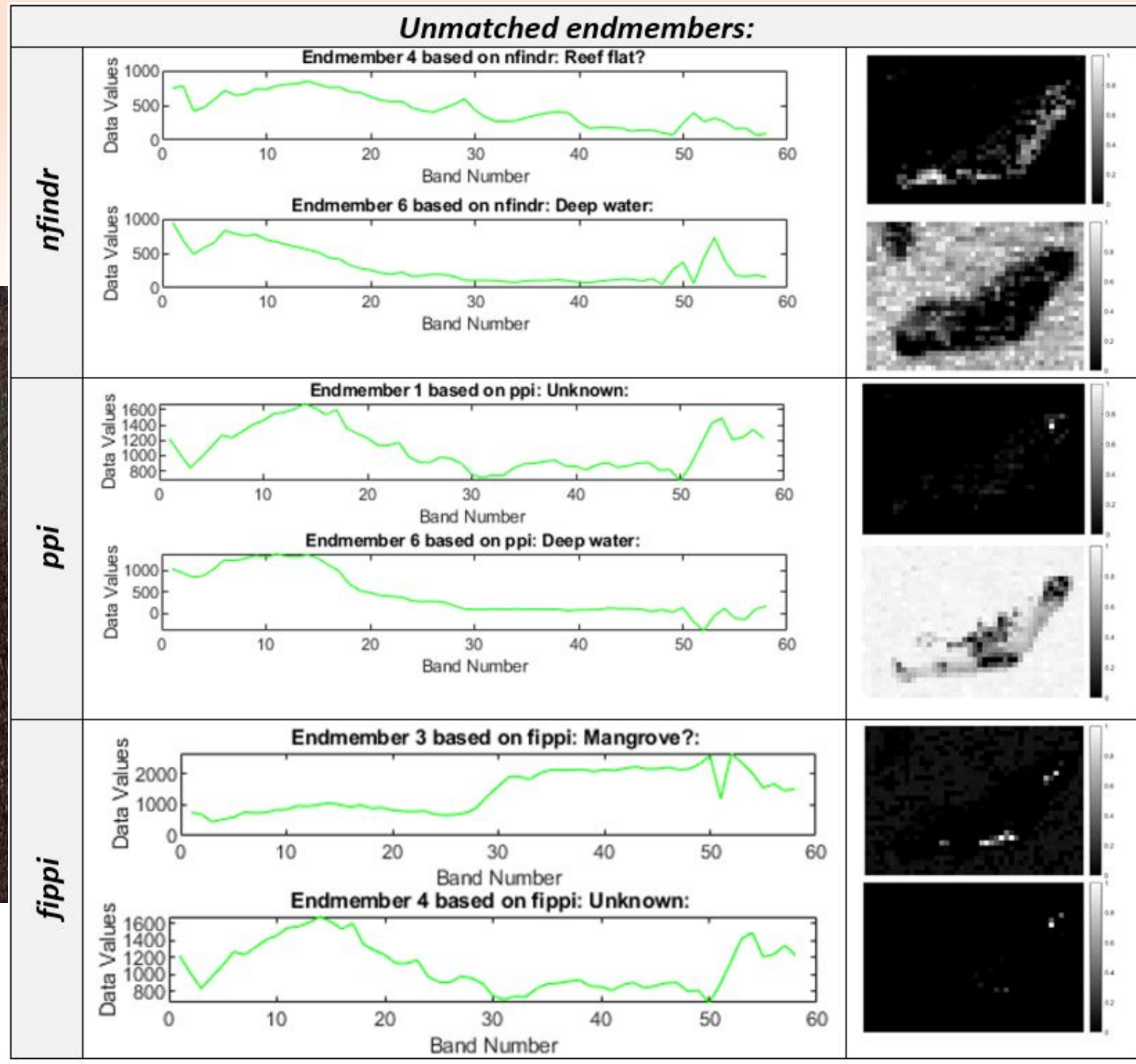
Summary/Conclusions:

- fippi identified 5 endmembers

- Extractions had similar signatures for sand, water, and sea grass

- nfindr show more accuracy based on available reference data for Enrique Reef

Summary/Conclusions:

- Reef flat and mangrove identifiable
- Inaccurate abundances between sand, water, sea grass
- Remaining endmembers from extractions could not be comparable
- Unprecise extractions lead to inaccurate abundances

Future work:

- Perform quantitative comparisons to reference data or other images for endmember signatures and abundances

- Evaluate similarities, differences, and limitations

- Use results to determine which extraction algorithm performs best

References:

[1] Kaur, G., and Mittal, M. (2013). Mixed pixel resolution by evolutionary algorithm: A survey. Global journal of computer science and technology graphics and vision, vol. 12(5).

[2] Velez-Reyes, M., "Intro to hyperspectral unmixing," presented to Class, University of Texas at El Paso, El Paso, Texas, United States. [PowerPoint slides]. Accessed on: August 03, 2021.

[3] Bioucas-Dias, J.M., Plaza, A., Dobigeon, N., Parente, M., Du, Q., Gader, P., and Chanussot, J. (2012). Hyperspectral unmixing overview: Geometrical statistical and sparse regression-based approaches. IEEE Journal of selected topics in applied Earth observations and remote sensing, vol 5(2).

[4] Xu, J. and Xu, F. (2014). The endmembers selection and spectral unmixing based on the optimal combination of the endmembers extracted by N-FINDR algorithm and SSWA algorithm. International conference on mechatronics, electronic, industrial and control engineering.

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