Airborne imaging spectroscopy for mapping urban green pools

David R. Thompson[1,4]
Manuel de la Torre Juárez[1]
Christopher M. Barker[2]
Jodi Holeman[3]
Sarah Lundeen[1]
Steve Mulligan[3]
Thomas H Painter[1]
Erika Podest[1]
Felix Seidel[1]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA
[2]Center for Vectorborne Diseases, University of California, Davis, CA
[3]Consolidated Mosquito Abatement District, Selma, CA
[4]david.r.thompson@jpl.nasa.gov

(Google Earth)

Research described in this presentation was carried out at the Jet Propulsion Laboratory under a Research and Technology Development Grant, under contract with the National Aeronautics and Space Administration.

Images courtesy NASA / Caltech JPL / Consolidated Mosquito Abatement District, CA. Copyright 2012. All Rights Reserved.

Green pools are a significant challenge for vector control

Neglected pools are common *culex* microhabitats

Current control efforts rely heavily on street-level control campaigns

Image: Santa Clara County Vector Control District,
http://www.sccgov.org/sites/vector/Pages/Vector-Control-District-Site-Home-Page.aspx

Remote sensing can help

Pool detection in pan-sharpened satellite images (Kim et al. 2011)

- Can build GIS pool databases
- Does not detect colonization

This study uses *imaging spectroscopy* to:

1. Detect pools remotely
2. Determine probability of *culex* larvae colonization.

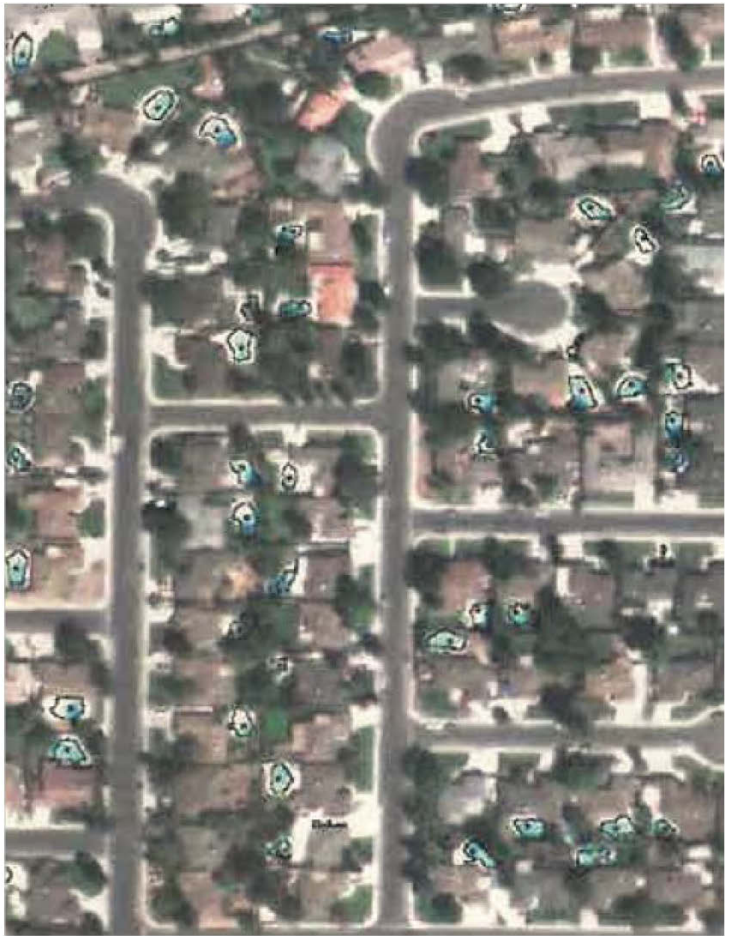
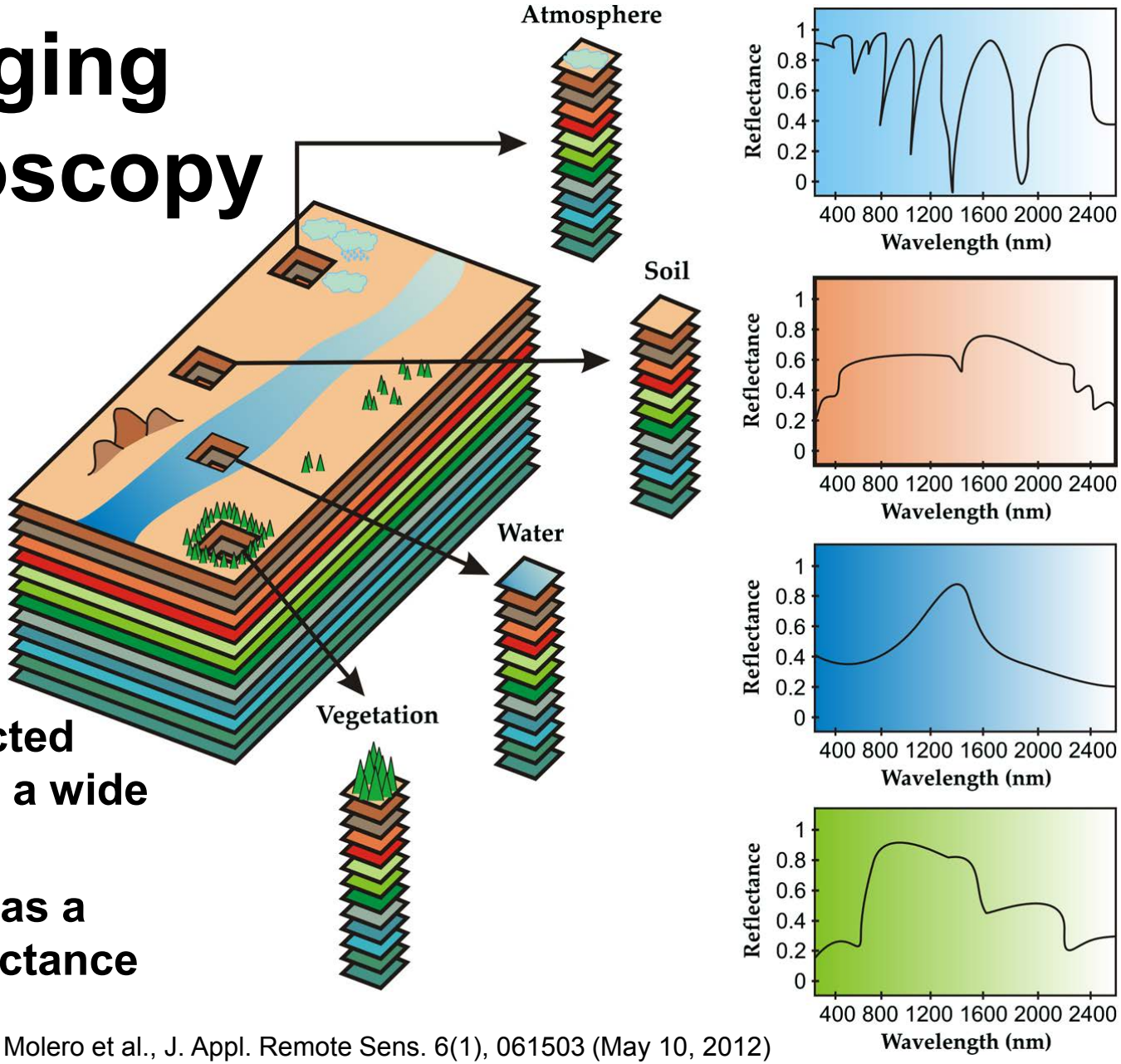


Image: Detected pools. Kim et al., *PERS* 77(11), 2011.

An imaging spectroscopy primer

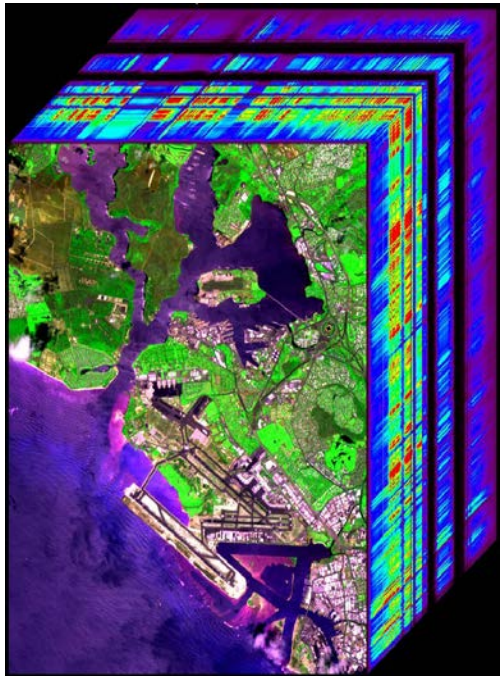


Measures reflected sunlight across a wide spectral range

Each material has a distinctive reflectance "fingerprint"

Molero et al., J. Appl. Remote Sens. 6(1), 061503 (May 10, 2012)

AVIRIS instrument (JPL)



Spectral Characteristics

Range	380 to 2500
Sampling	9.8 nm
Accuracy	0.5 nm

Radiometric

Range	0 to Max Lambertian
Sampling	16 bits
Accuracy	>96 percent
Precision*	>1000 VNIR, >500 SWIR

Spatial (ER2 / WB57 / Proteus / Twin Otter aircraft)

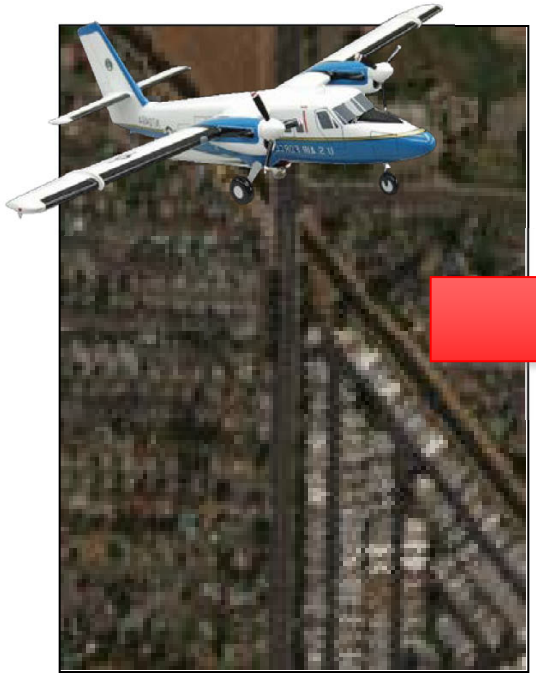
Swath	11 / 8 / 5 / 2.5 km
Sampling	20 / 15 / 8 / 4 m
Accuracy	20 / 15 / 8 / 4 m

Full INU/GPS geo rectification

*for AVIRIS reference radiance

Step 1

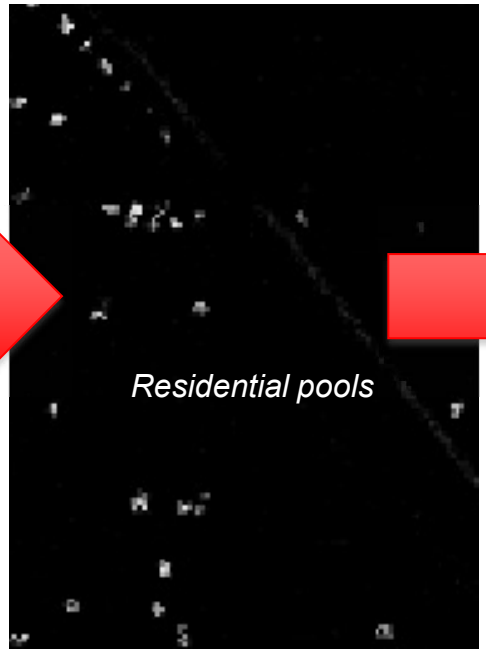
AVIRIS overflight, preprocessing



(Twin Otter aircraft via warplanes.com

Step 2

Find pools using subpixel target detection



Step 3

Estimate probability of mosquito colonization

(Google Earth)

Evaluation procedure

Overflew Fresno, CA by Airborne Visible Infrared Imaging Spectrometer (AVIRIS) on Sept. 30, 2011

Coincident ground survey by mosquito abatement teams records factors including:

- Pool GPS locations
- Breeding / non-breeding status

We matched survey logs with 50 pools

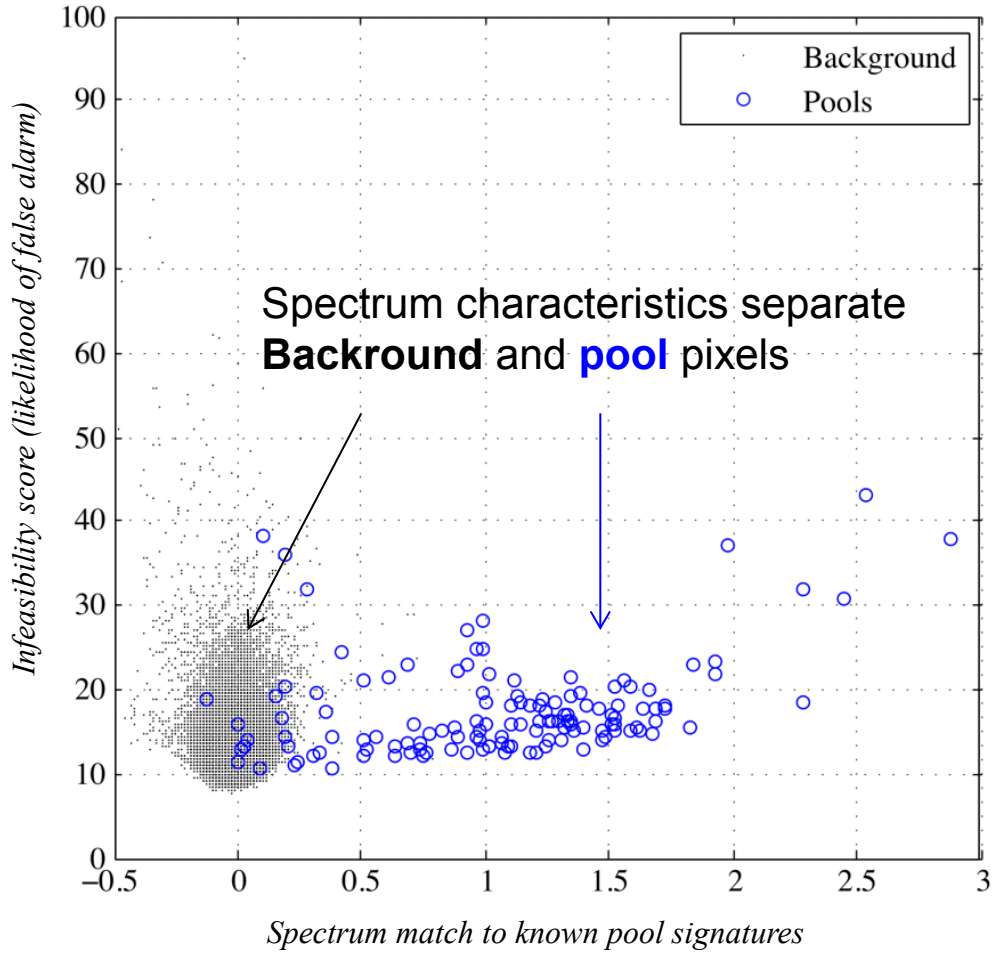
- Developed our model with the first 25 pools
- Evaluated it on the remainder.

Pool detection performance

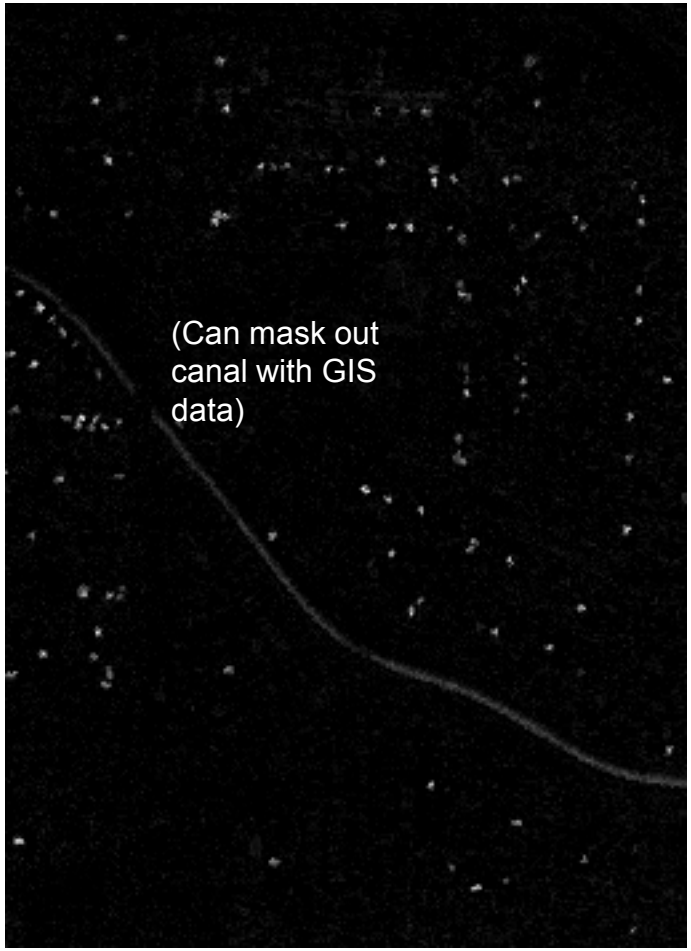
In advance, collect a pool "spectral library"

This provides target signatures to evaluate every new pixel

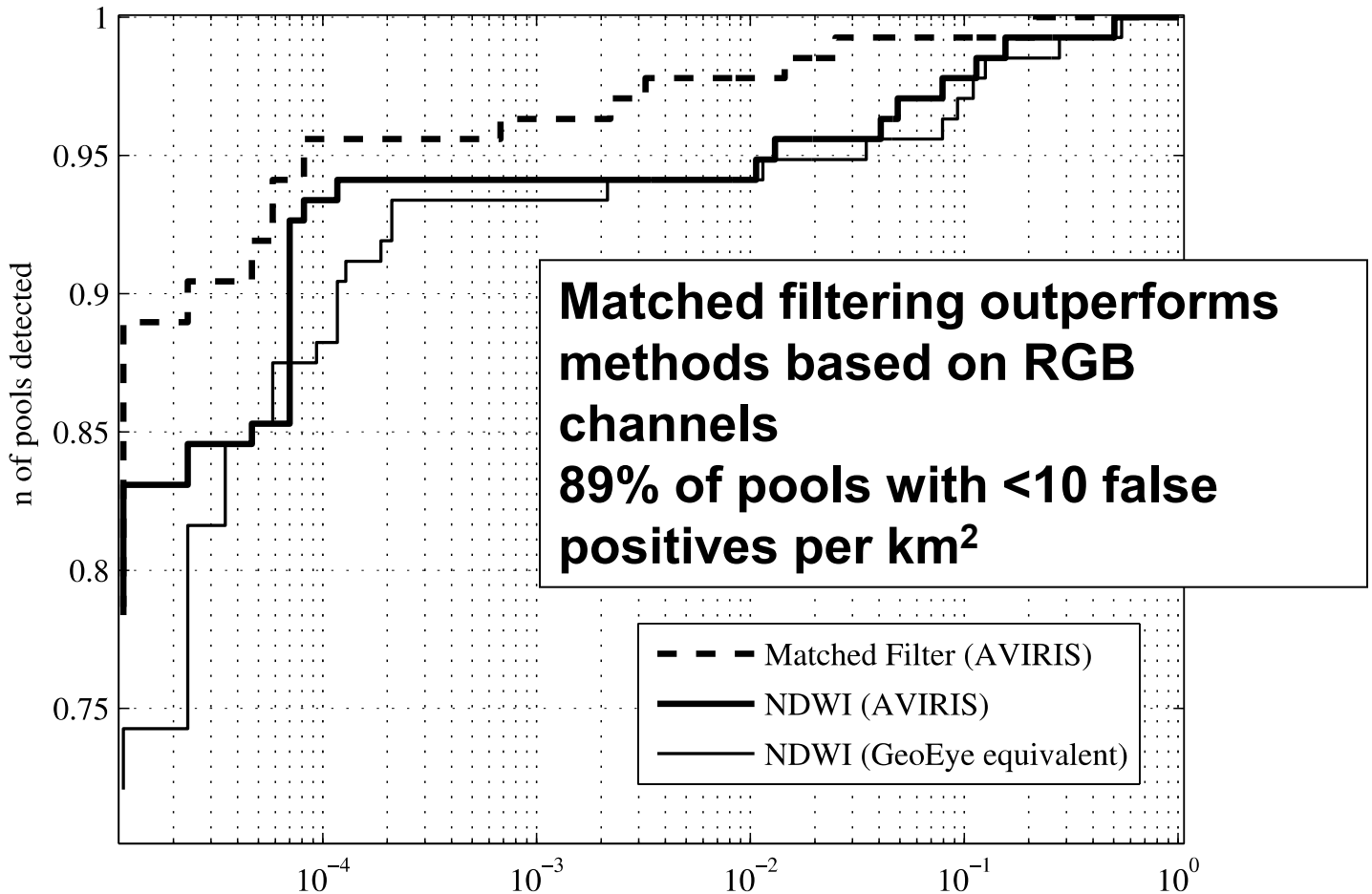
We combine classical Matched Filter techniques with False Alarm Mitigation (DiPietro 2010)



Pool detection performance



Pool detection performance

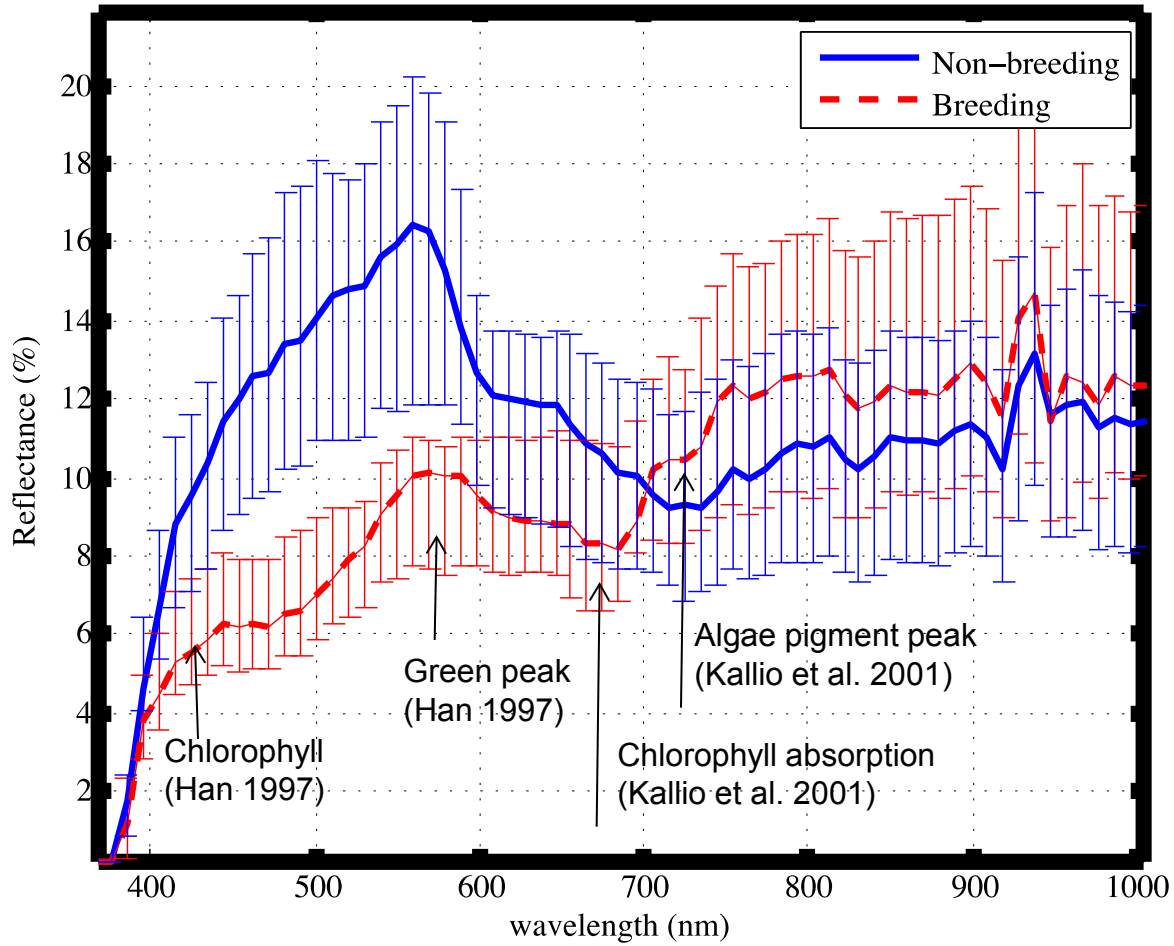


Matched filtering outperforms methods based on RGB channels
89% of pools with <10 false positives per km^2

Predicting colonization

Unmaintained pools show distinctive spectral features associated with algae

These data are consistent with typical algae signatures used in water quality studies.



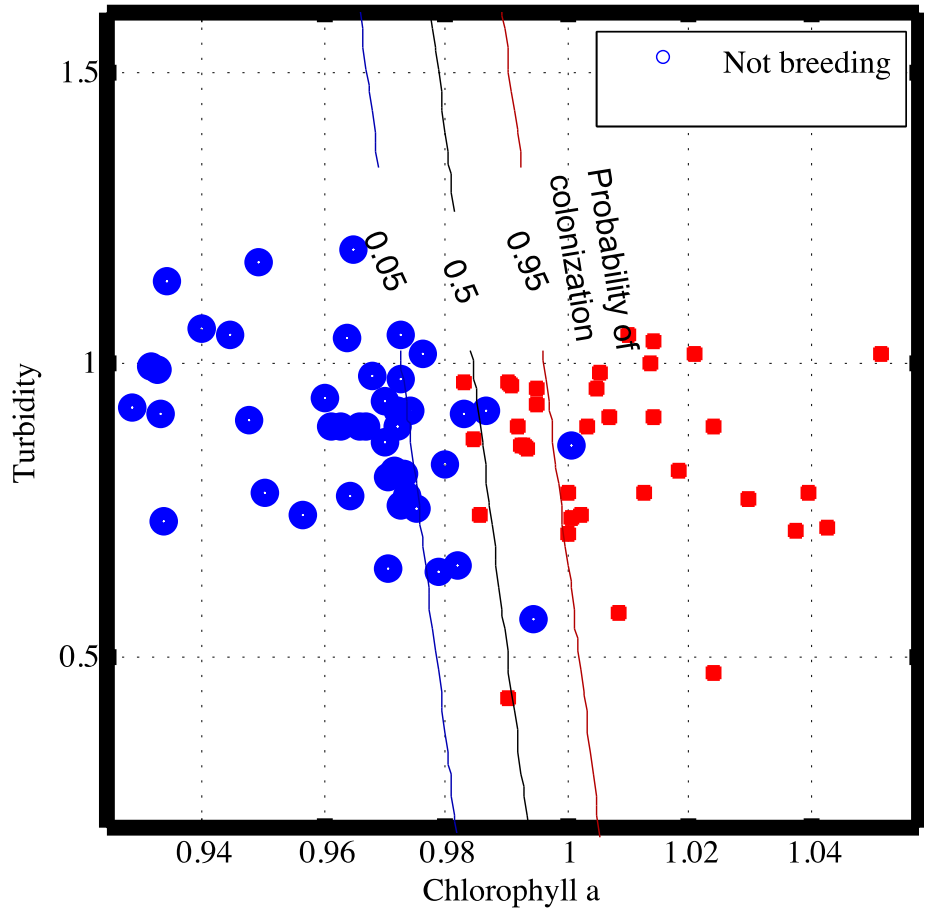
Predicting colonization

Chlorophyll a (688/674nm) is the best overall predictor

A logistic regression model based on chlorophyll detects 85% of colonized pools with <5% false alarms.

$$P_\Theta = \frac{1}{1 + exp(-240 + 243.3c)}$$

$$\text{for} \quad c = \frac{R_{685-691}}{R_{670-677}}$$



Fully automated pool maps

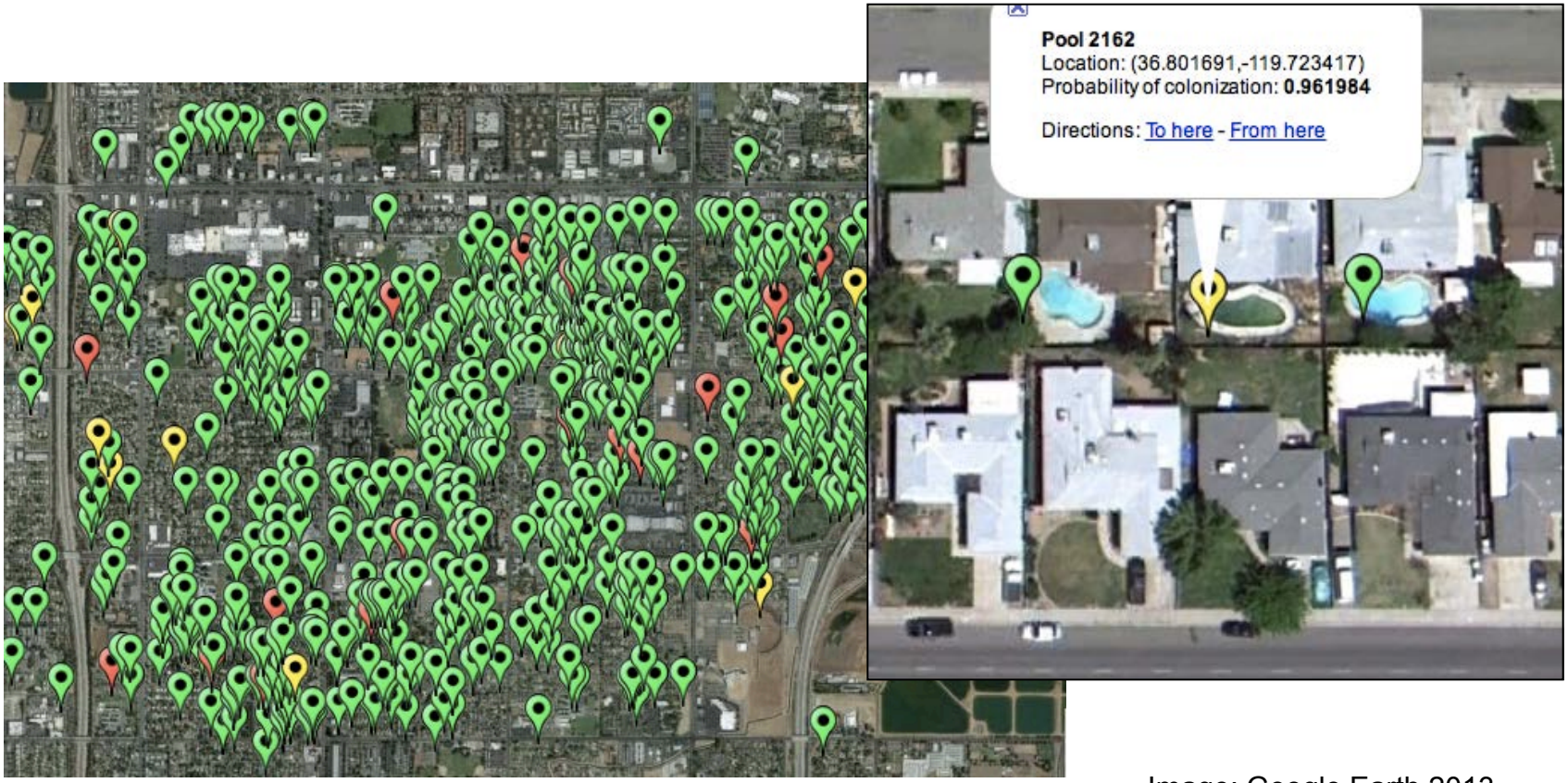


Image: Google Earth 2013

Concluding thoughts

- Imaging spectroscopy can automatically predict mosquito colonization with good accuracy
- Spectral signatures can disambiguate signatures from stagnant water vs. green paint (difficult for existing techniques)

Future work

- Validate model for different locales and seasons
- Account for volumetric effects and bottom reflectance
- Use new AVIRISng sensor (flights in 2013) for *order of magnitude* spatial resolution improvement

Thanks!

We thank Rob Staehle, Joao Teixeira, and Rob Green of JPL for counsel, advice and insight. This work was supported by a Jet Propulsion Laboratory Research and Technology Development Grant. AVIRIS data is available courtesy NASA, the AVIRIS team, and the Jet Propulsion Laboratory. The Consolidated Mosquito Abatement District provided spatial data on swimming pool conditions.

C. M. Barker is supported by grant U01 EH000418 from CDC, Climate Change: Environmental Impact on Human Health and a grant from NASA, Earth-Sun Science Applied Sciences Program, and by the Research and Policy for Infectious Disease Dynamics (RAPIDD) program of the Science and Technology Directorate, Department of Homeland Security and Fogarty International Center, National Institutes of Health.

Copyright 2012. All Rights Reserved.