

Surf Zone Characterization From UAV Imagery

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Giuliana Pennucci
with Raven-A

Operational METOC Requirements for Littoral Domain include

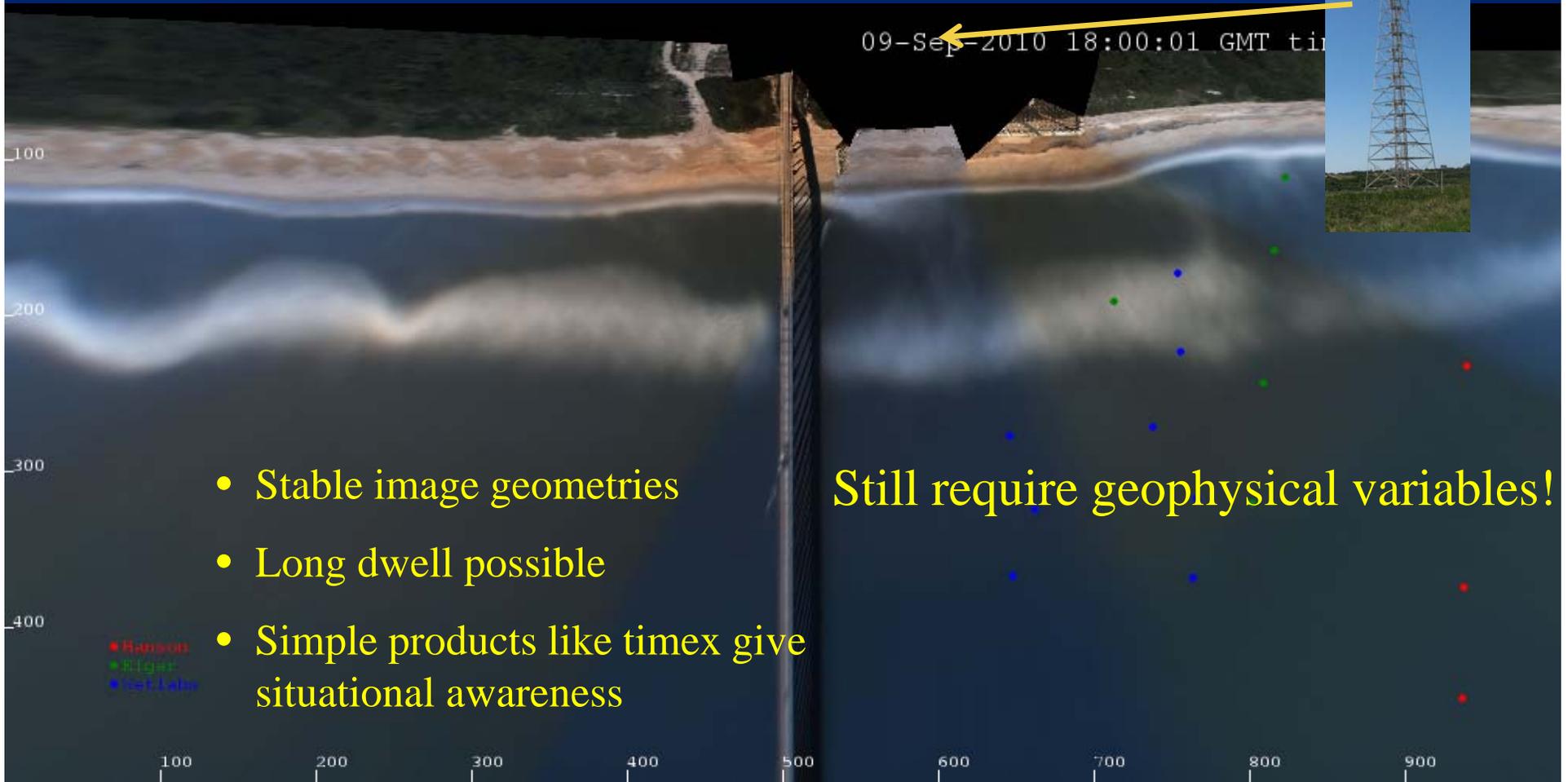
- Bathymetry
- Wave height
- Currents



Raven A image from
Piscinas di Ingurtosu

- Region is often denied or dangerous for sampling
- Satellite sampling has limited resolution or dwell
- An ideal task for sampling by UAVs (UASs)

Littoral Imaging from Fixed Platforms: – The Argus Program

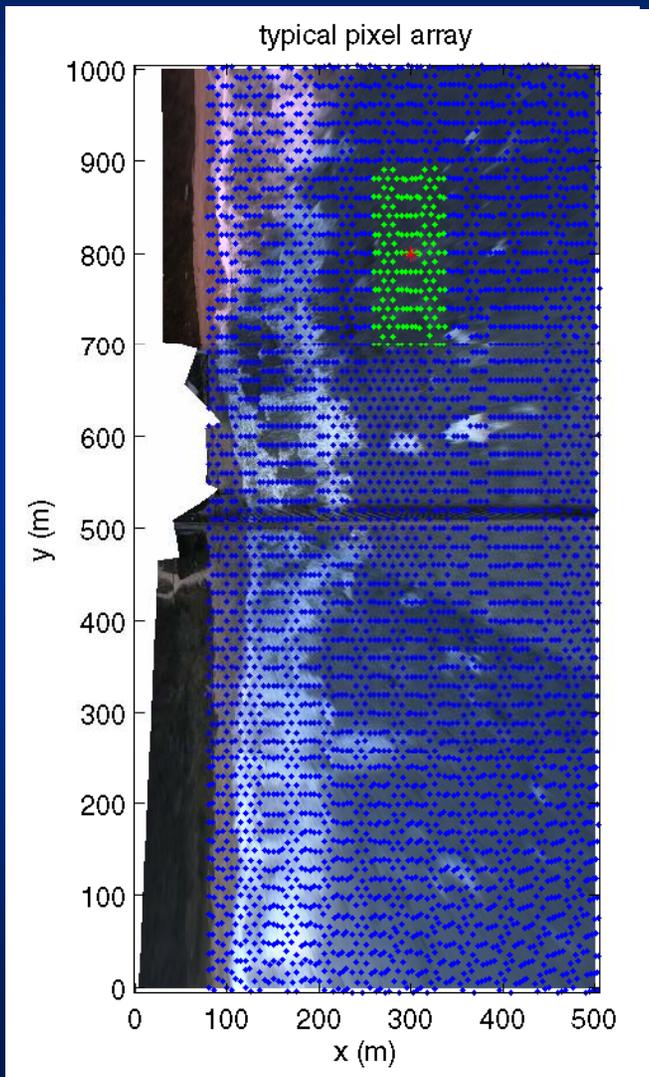


- Stable image geometries
- Long dwell possible
- Simple products like timex give situational awareness

Still require geophysical variables!

Duck, NC, Surf Zone Optics Expt.

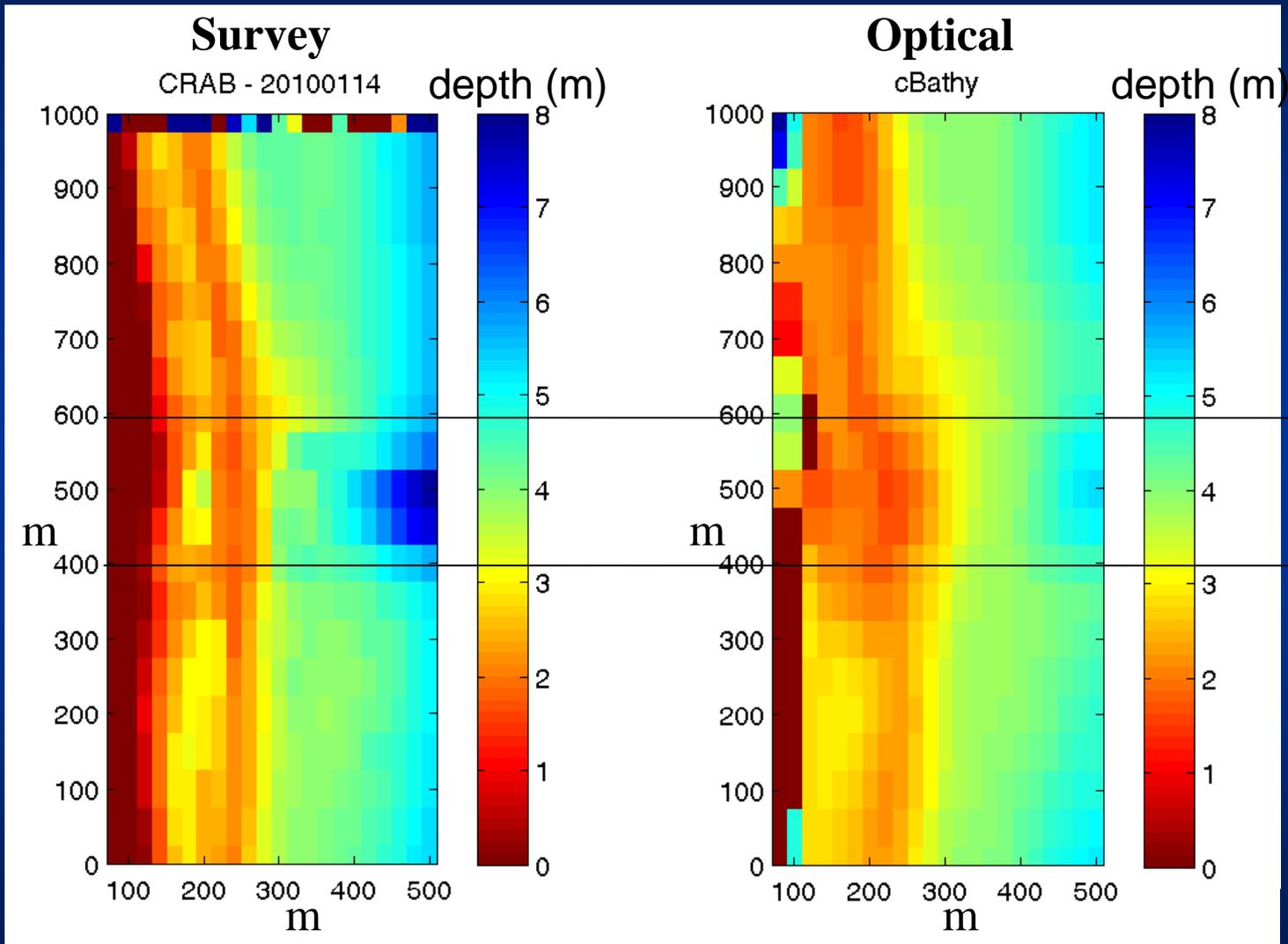
Exploitation of the Time Domain: *cBathy*



- Pixel arrays provide good sampling even using 0.2% of available pixels
- Map bathymetry from frequency-wavenumber measurements using dispersion relationship
- Exploit robust signal processing and *many* degrees of freedom (17 min. runs)

Work with Plant, Holland

Example Bathymetry Estimate



Jan 14, 2010
Duck, NC, USA

$\mu, \sigma = -0.18, 0.27\text{m}$, excluding $400 < y < 600$.
7 run average $\mu, \sigma = 0.09, 0.46\text{m}$

Application of Argus Methods to UAVs



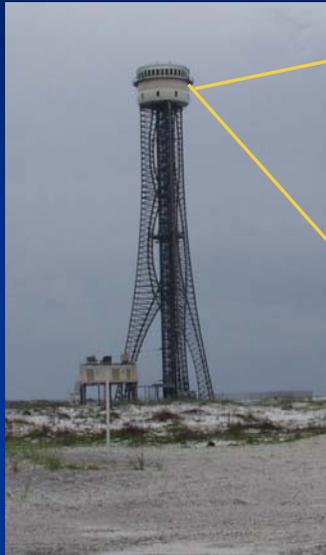
Limitations Compared to Fixed Platforms

- Image resolution
- Limited dwell
- Gappy records
- Image geolocation

Fixed Platform Proxy Tests Eglin Air Force Base



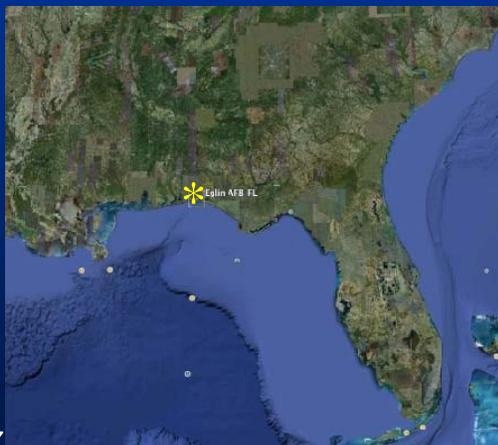
100 m



Eglin tower



Southwest-looking camera

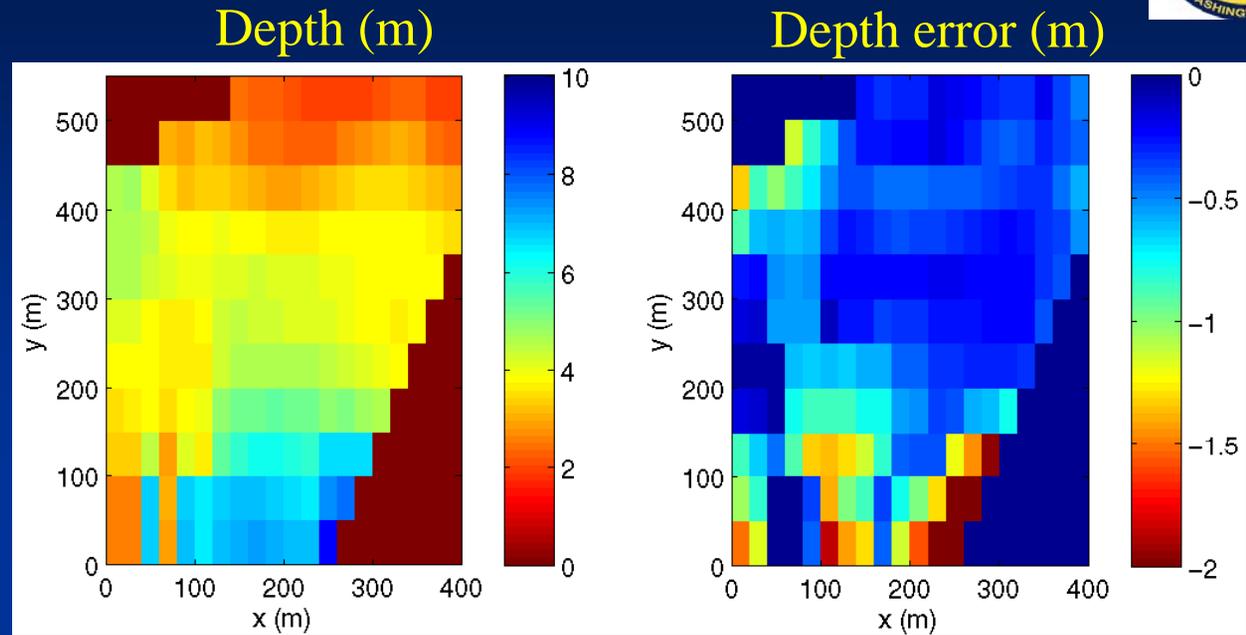


- 100m high tower with multiple Argus cameras
- Use southwest view as test proxy for UAV imagery
- Test dwell limitation and sensitivity to gaps

Short Record Lengths?

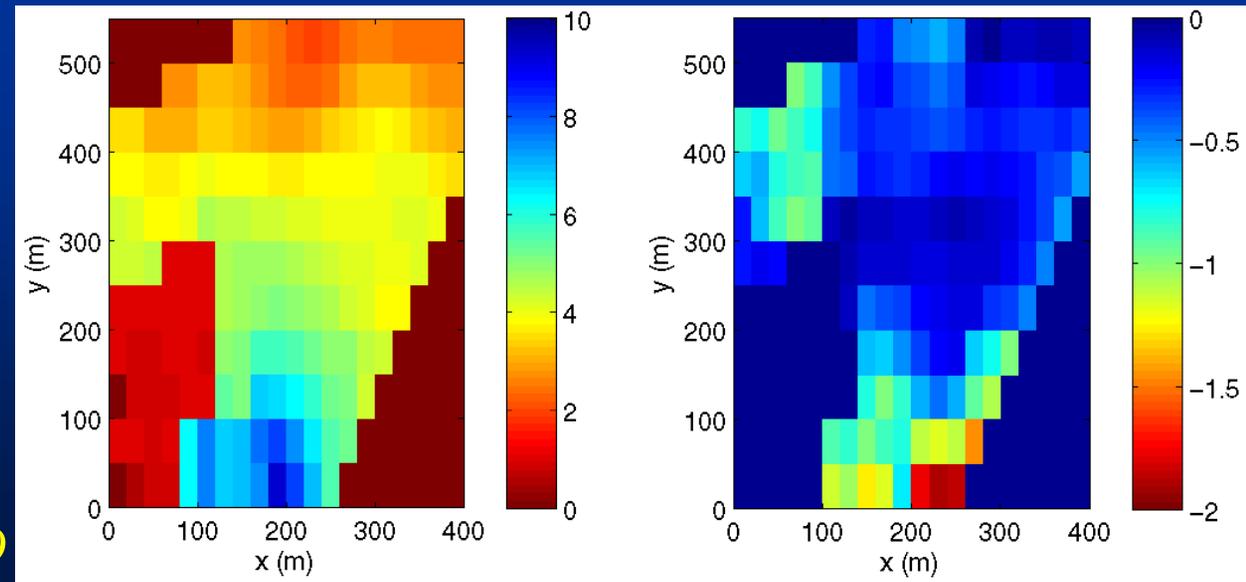


512 s. full record



offshore
↓

First 50 s. only

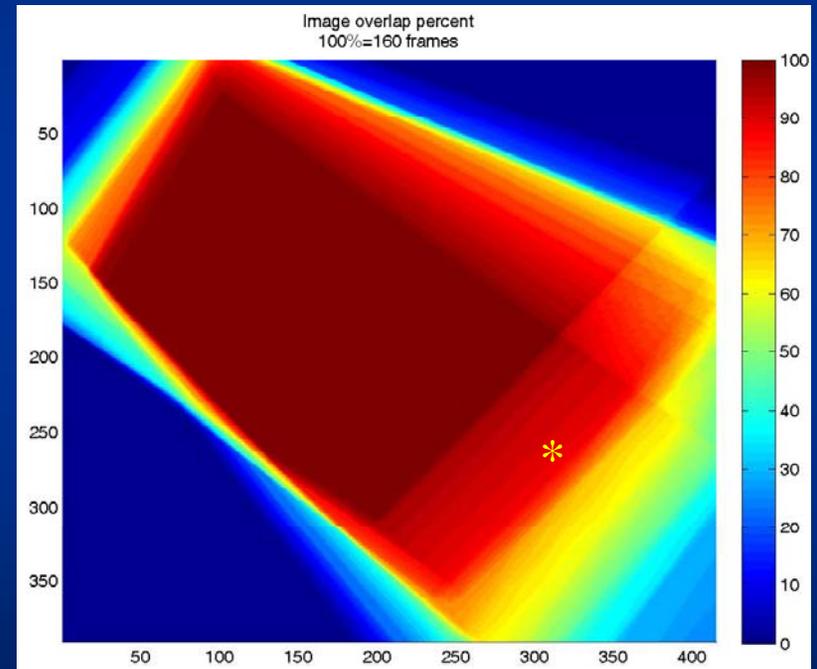


Gappy Records?

Geo-mapped 50s time exposure for
Eglin Raven-B run with pixel time
series locations for the Bahy.
Percentage sampling map.



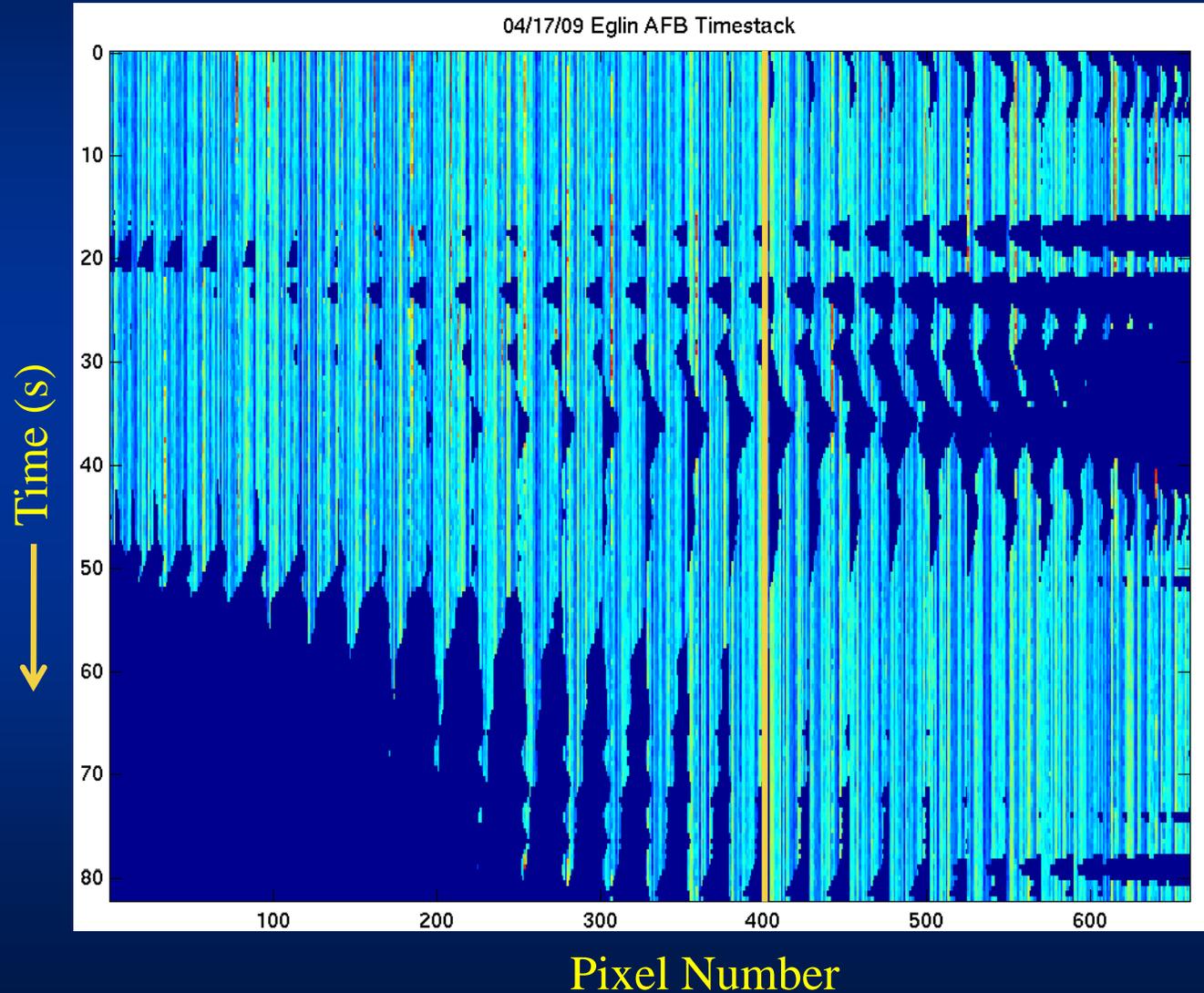
Eglin AFB Raven-B



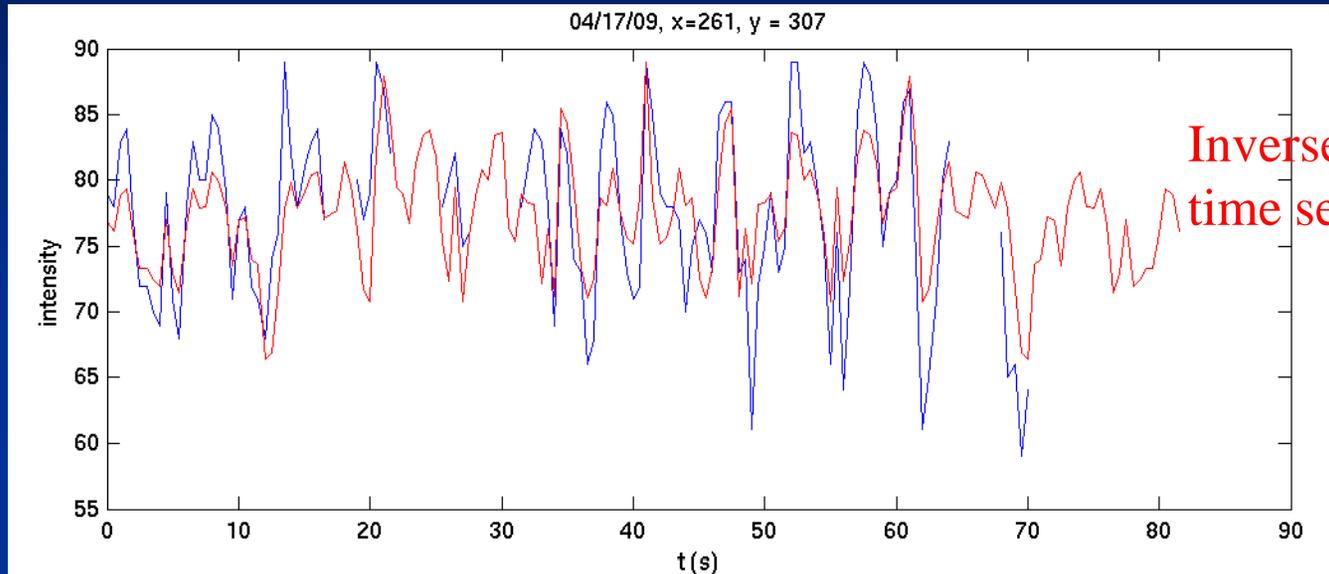
Gappy Records?



Example gappy timestack



Gappy Records?



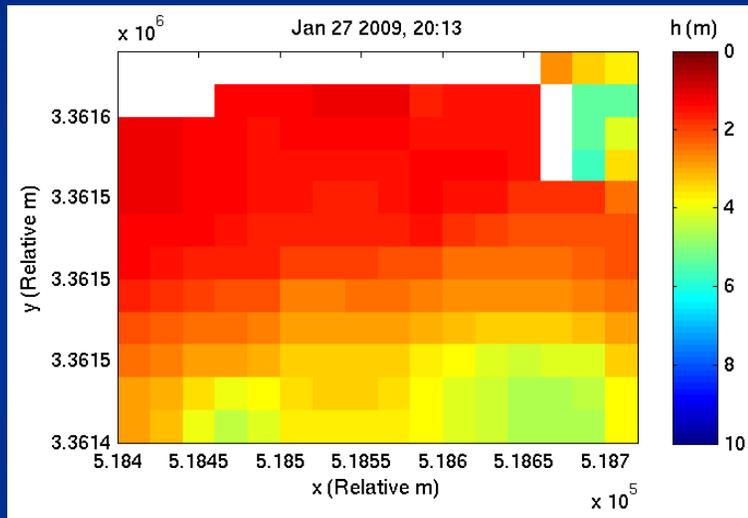
30% gaps in record

- Fourier transform still effectively captures wave phase with up to 50% gaps
SlowFT:
$$Y(f) = \sum_{n=1}^N y(n) \exp(-i2\pi f t_n)$$
- Also requires detrending and camera auto-gain compensation

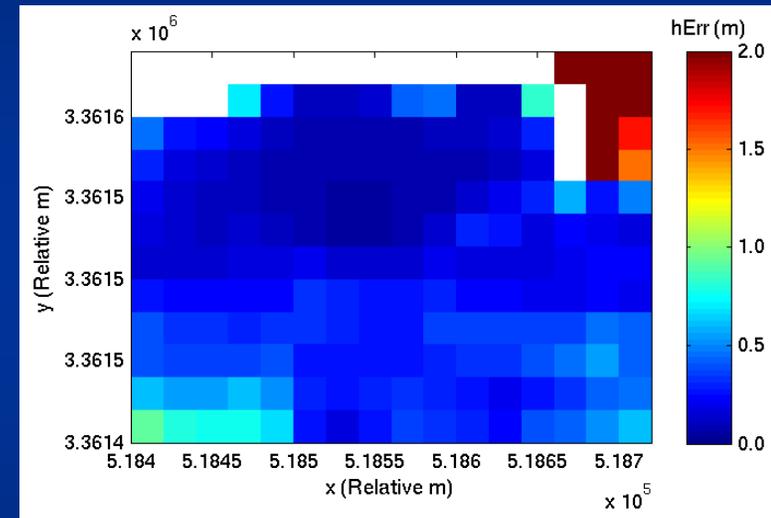
Example Bathymetry Product



Depth (m)



Error (m)



- 54 second record
- Raven-B nose camera descending stare (into wind)

Image Geolocation Issues



- Image geolocation can not be accurately extracted from UAV nav data.
- Images must be stabilized using ground control
- This requires shore views and tedious processing

Gimbaled, stabilized cameras will help

Can we develop a water-based stabilization algorithm?

Remove high frequency variance while exploiting long-term accuracy of nav data



Conclusions



- Littoral zone METOC can be quantified using small UAVs
- Dwell as short as 30-50 seconds is adequate for useful estimates
- Record gaps and image quality issues can be handled by proper signal processing
- Geolocation remains the primary obstacle and may be addressed using gimballed cameras or new wave-based stabilization

Questions?

09/12/10, 1100 EST, darkest

People walking on pier



Max run-down



Person walking along max runup

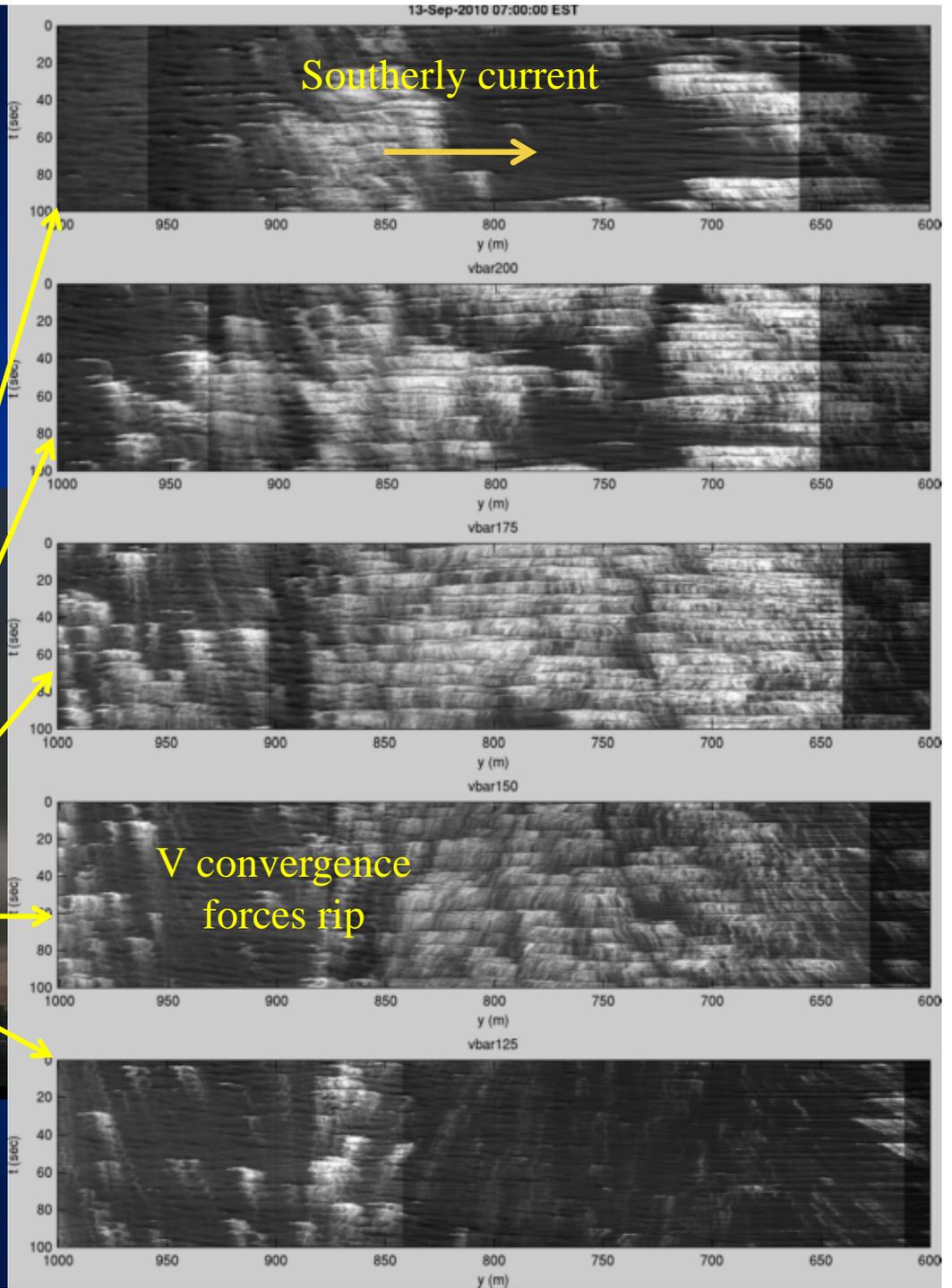
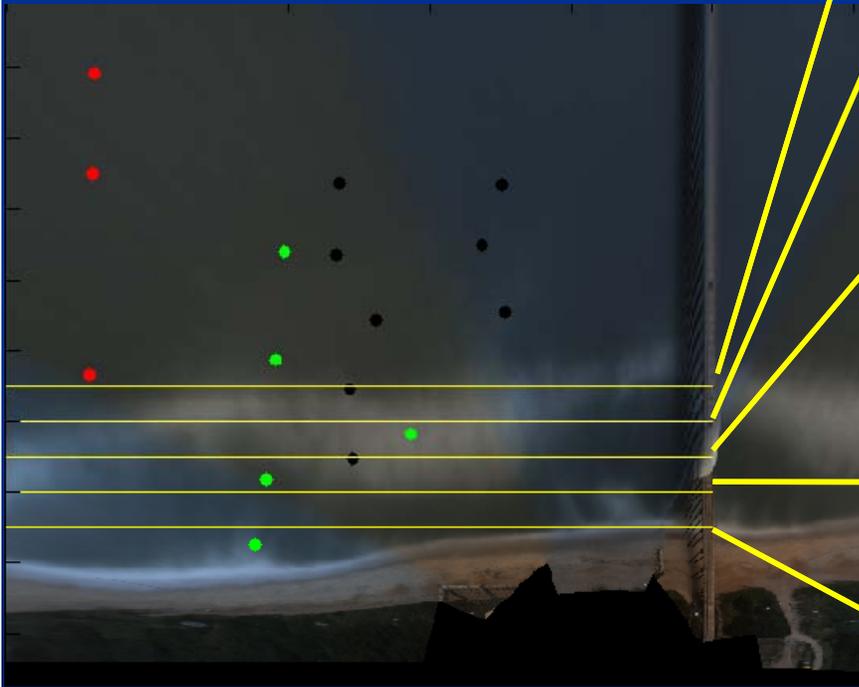


09/12/10, 1100 EST, brightest



Max runup

Longshore Currents From Imagery



Application of Argus Methods to UAVs



Eglin AFB – Raven-B

Limitations Compared to Fixed Platforms

- Image resolution **OK**
- Limited dwell **Minor limit**
- Gappy records **fixable**
- Image geolocation **difficult**

