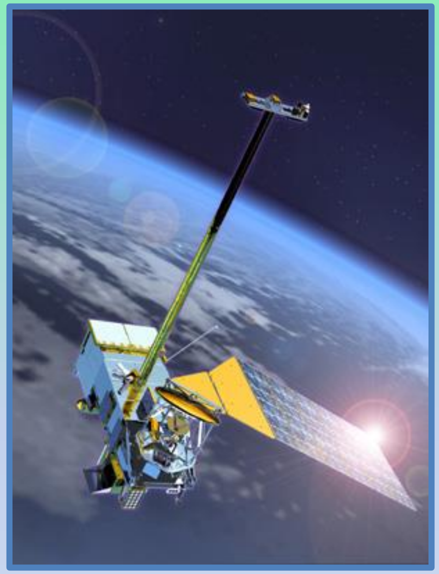
Thinking Outside of the Blue Marble:

Novel Ocean Applications Using the VIIRS Sensor



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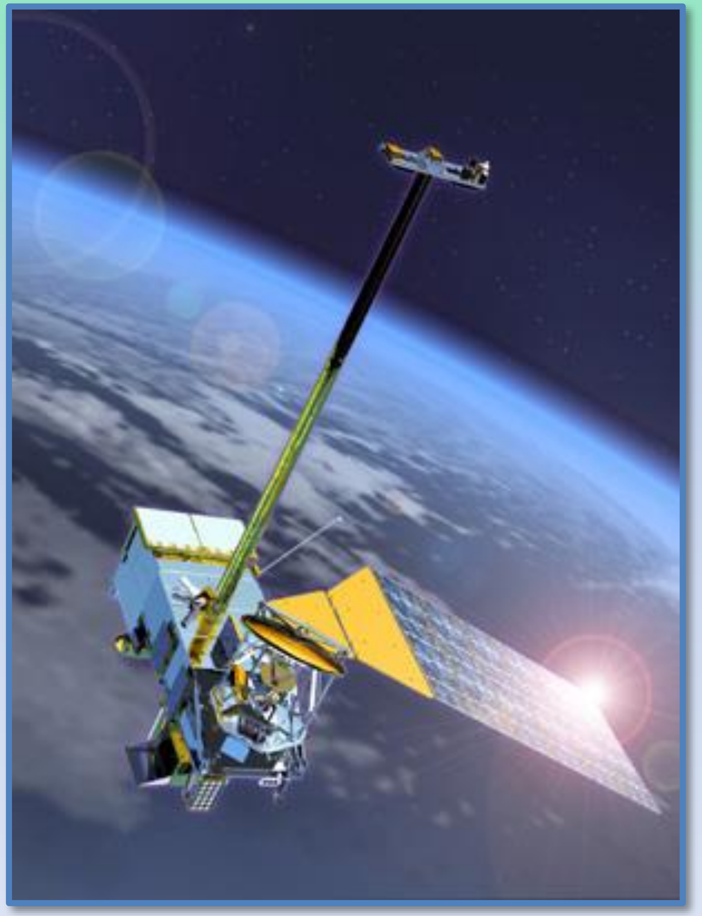
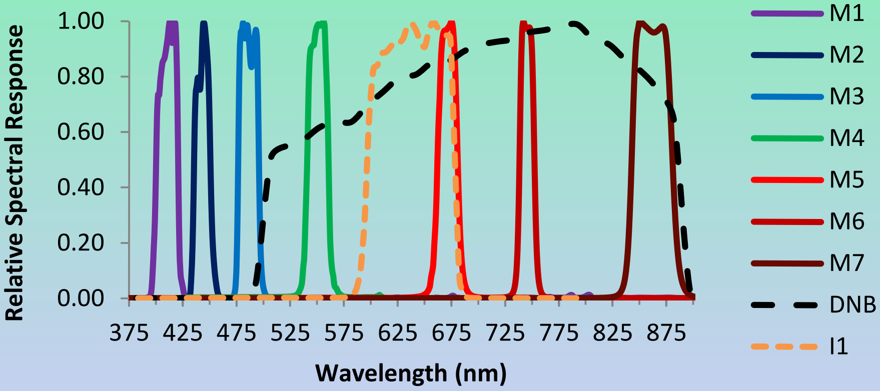
2016 OCEAN SCIENCES MEETING

Visual Infrared Imaging Radiometer Suite (VIIRS)

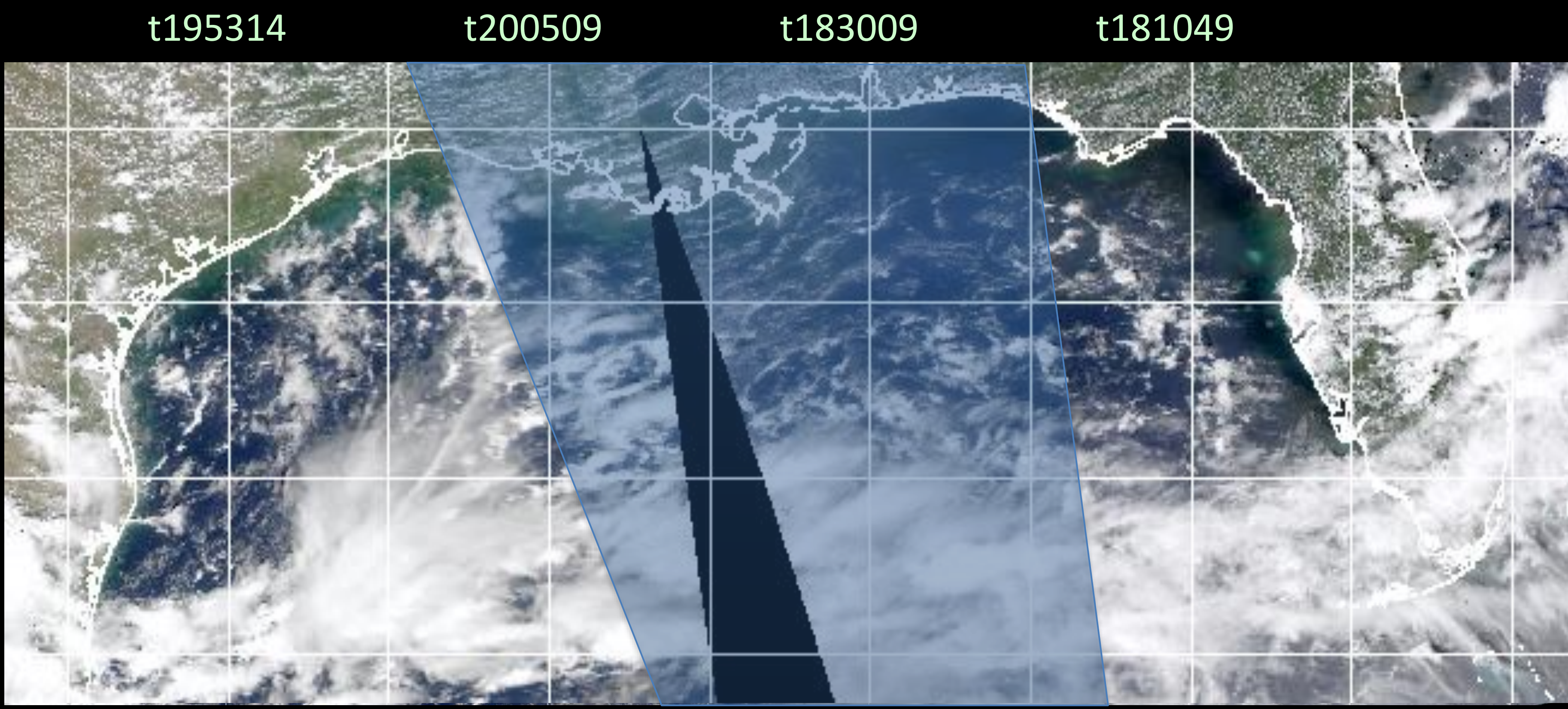




- 16 moderate resolution (750-m) spectral bands
- 5 higher resolution (375-m) Imaging bands
- 1 Day-Night-Band
- On-board aggregation enabling increased resolution at high zenith angles

How can we maximize what we learn for future missions with the tools we have?

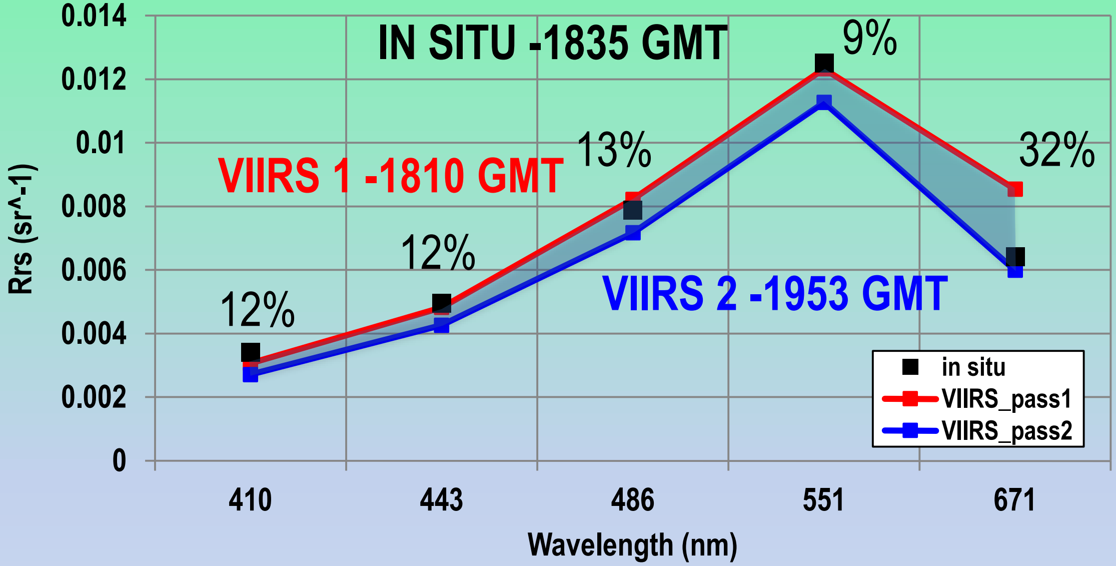
VIIRS ORBITAL OVERLAP

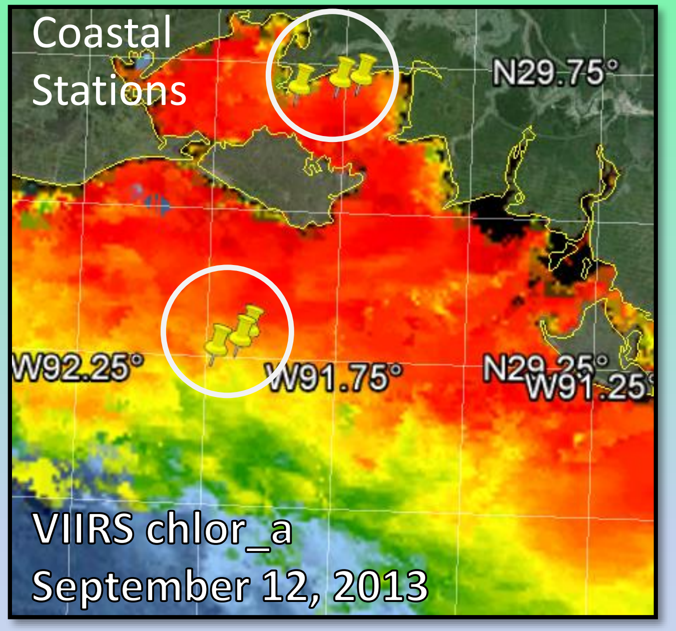


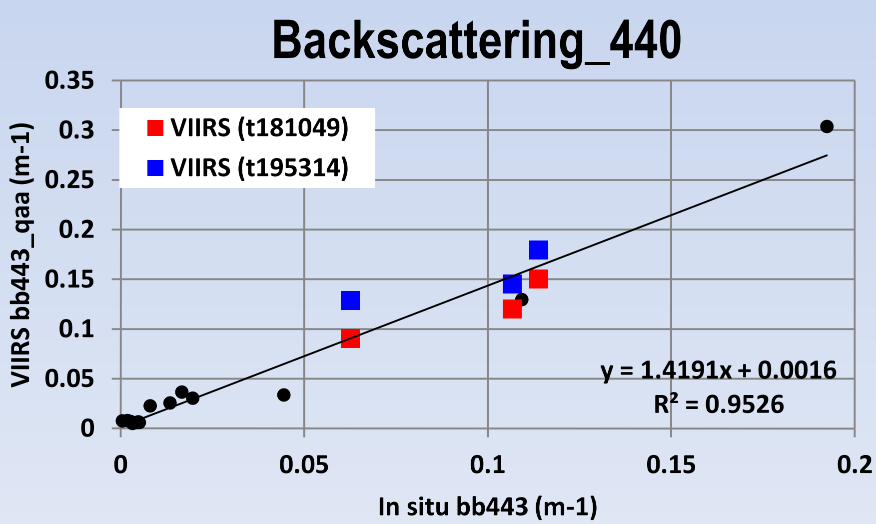
100 minutes of separation between VIIRS overpasses

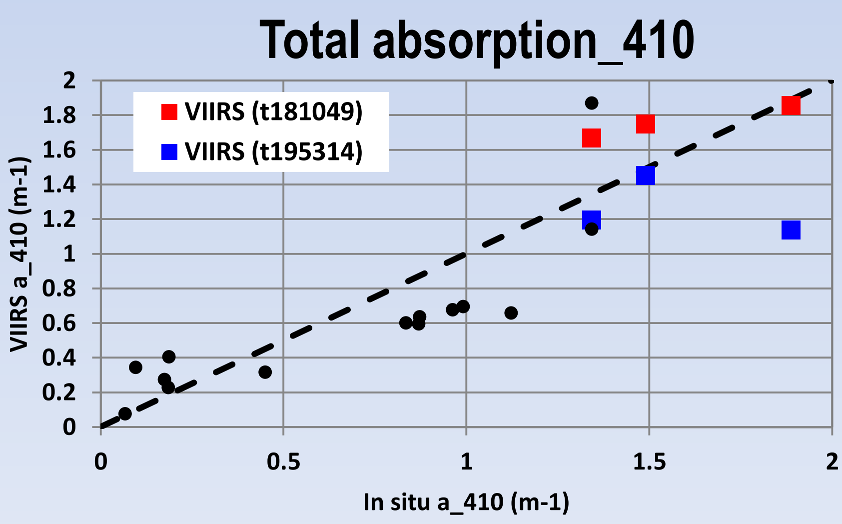
What are the differences between the passes? Are they real?
Can polar-orbiting sensors detect diurnal changes in ocean color?

Demonstration of overlap "uncertainty" from 2013 GEO-CAPE cruise

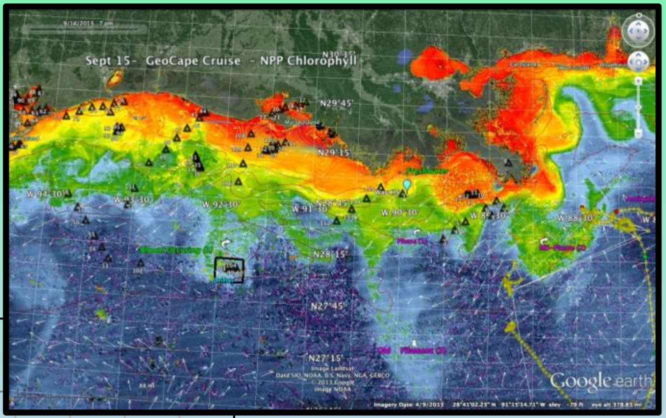




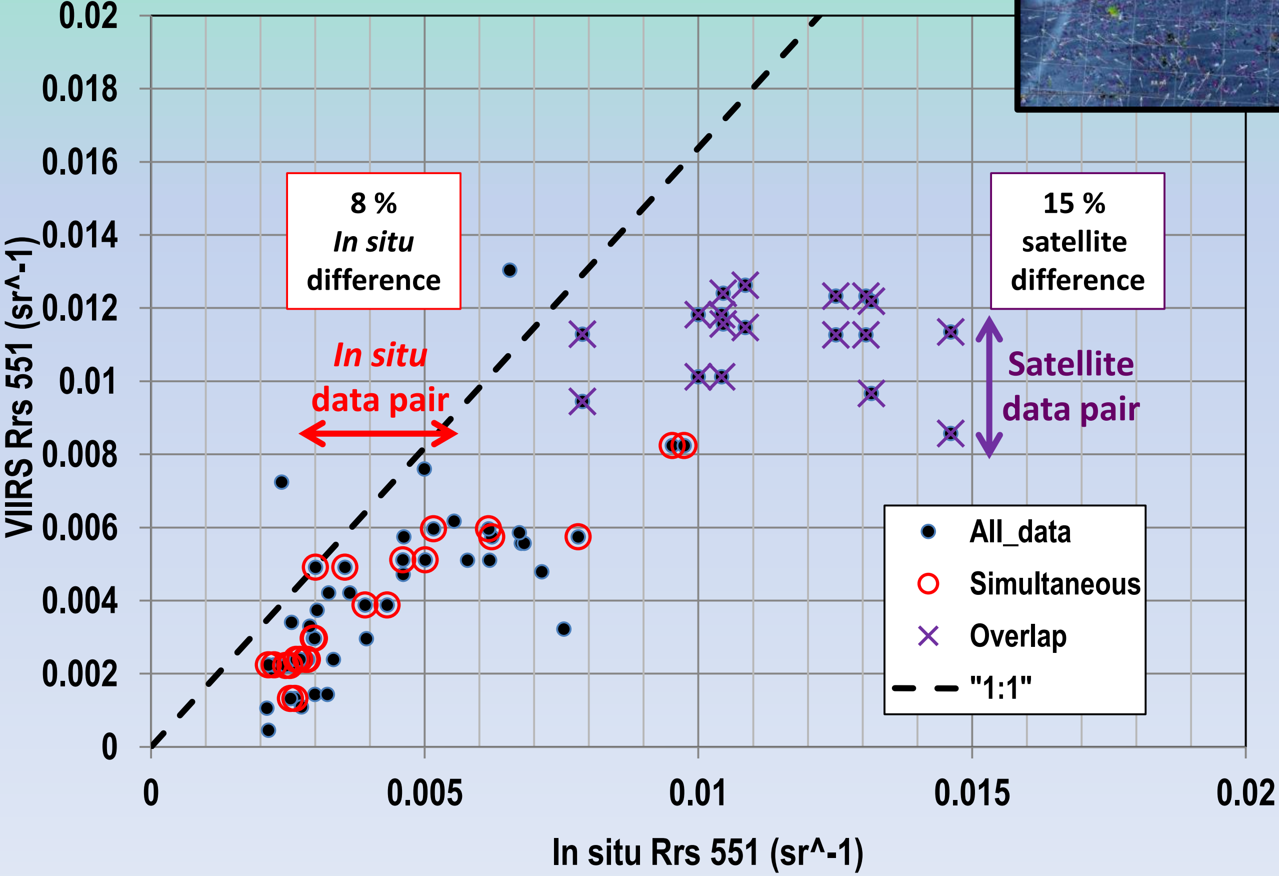




Demonstration of overlap "uncertainty" from 2013 GEO-CAPE cruise



Do differences in simultaneous in situ measurements exceed differences in satellite?



What causes these changes from sequential orbits?

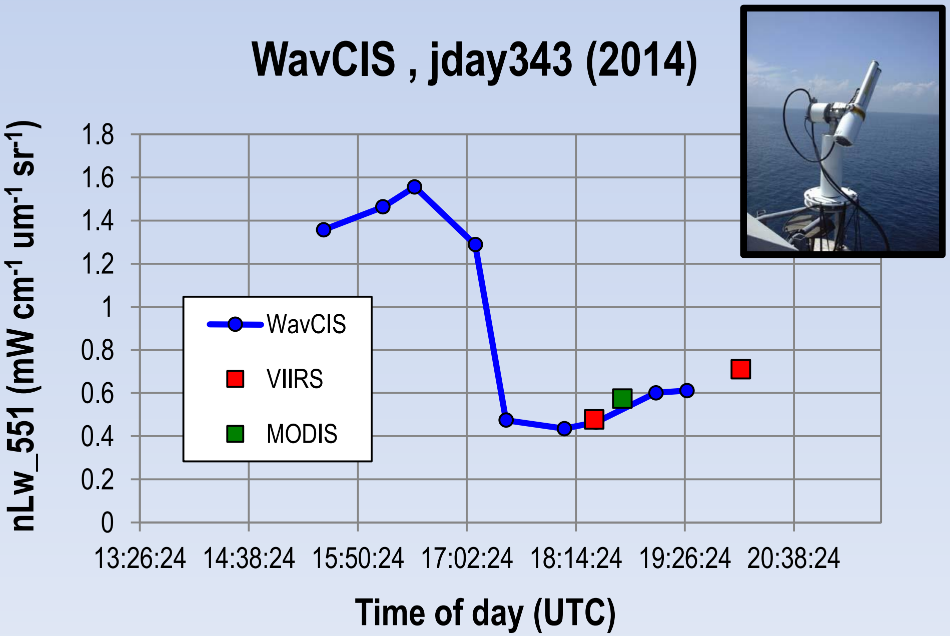
- *Real bio-optical changes?*
- *Solar/sensor angles (BRDF)?*
- *Advection?*
- *Vertical Migration?*
- *Sensor calibration (striping)?*
- *Coastal aerosols?*

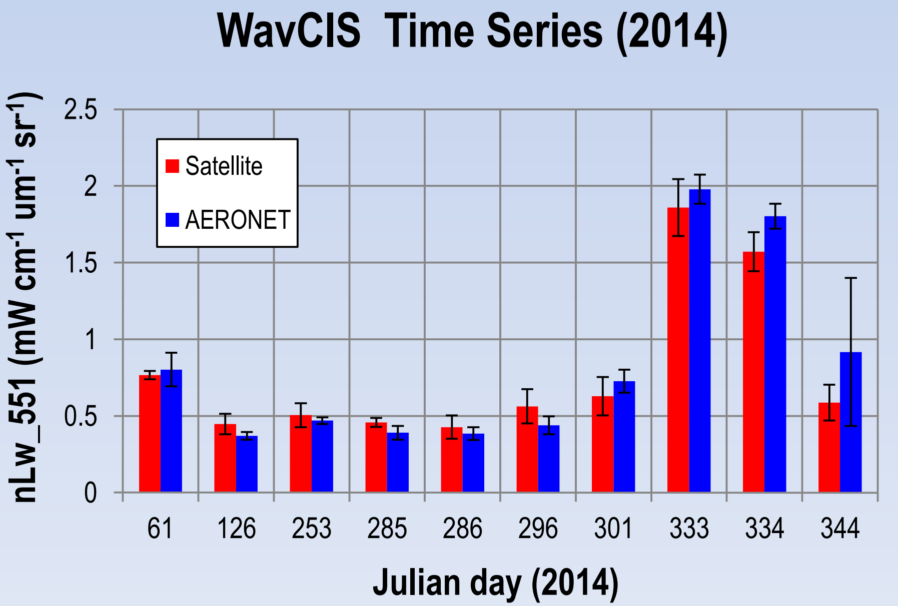
Acknowledgements
M. Ondrusek / Z.P. Lee

WavCIS overlap analysis

- Analyzed orbital overlap images at WavCIS site (VIIRS orbit 1 & 2, MODIS)
  - 8 – 11 in situ returns (lvl 1.5) from AERONET per day, cutoff around 19:30 UTC
  - 3 satellite returns within 100 minutes

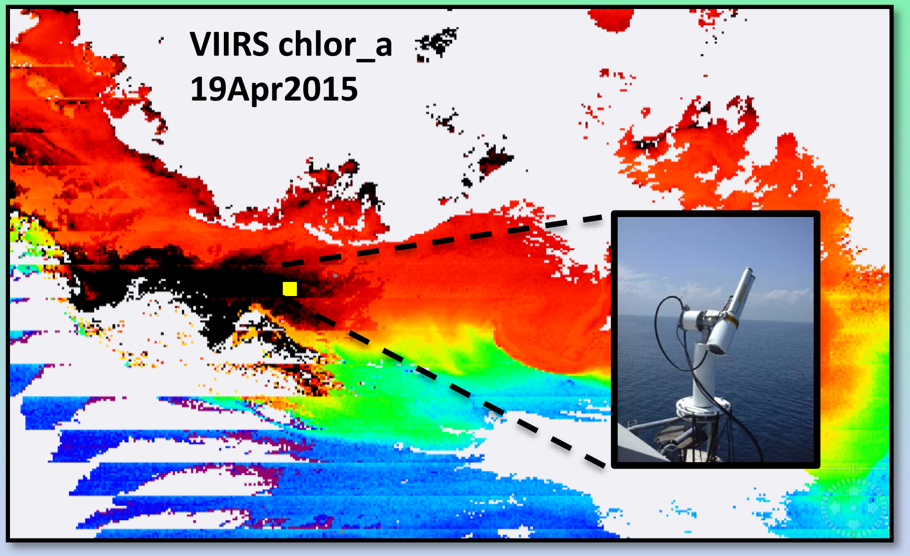
- There are LARGE bio-optical changes on short temporal scales (hours)
- Satellite returns appear to follow diurnal changes pretty well
- Throughout the year, the variability between three satellite images in one day is often times less than variability of AERONET.

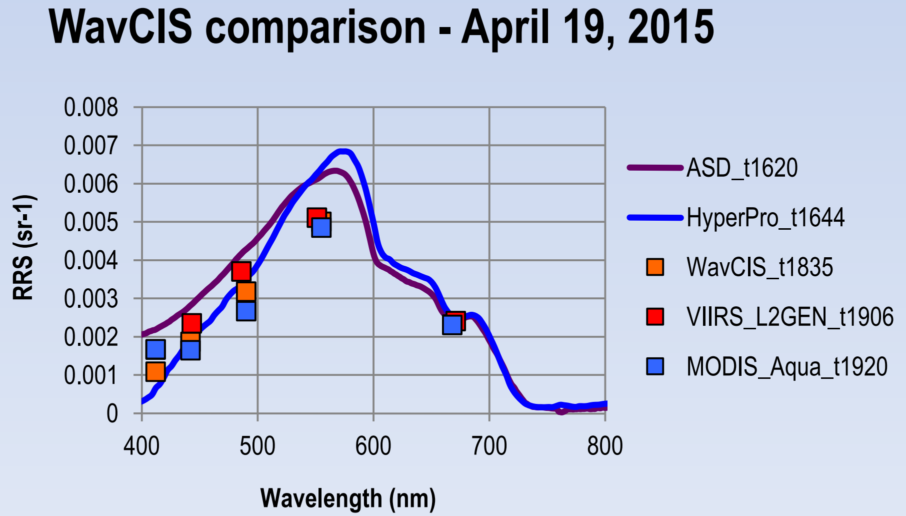


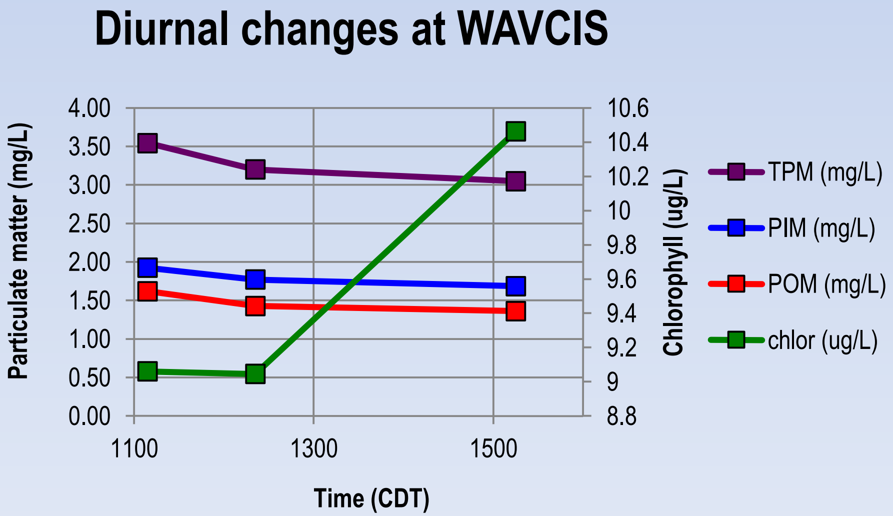


What changes are due to bio-optics at WavCIS?

- UMB/USM/NRL ground truth cruise to AERONET WavCIS platform on April 19, 2015.
- Collected: Radiometry, IOPs, chlor-a, Particulate matter (total, PIM/POM), CDOM, Particle absorption at **ONE location**
- Only 1 WavCIS return
- High GLINT in satellite image







Could sensor viewing angles be responsible for differences in overlap nLw?

SUN GLINT ANGLE

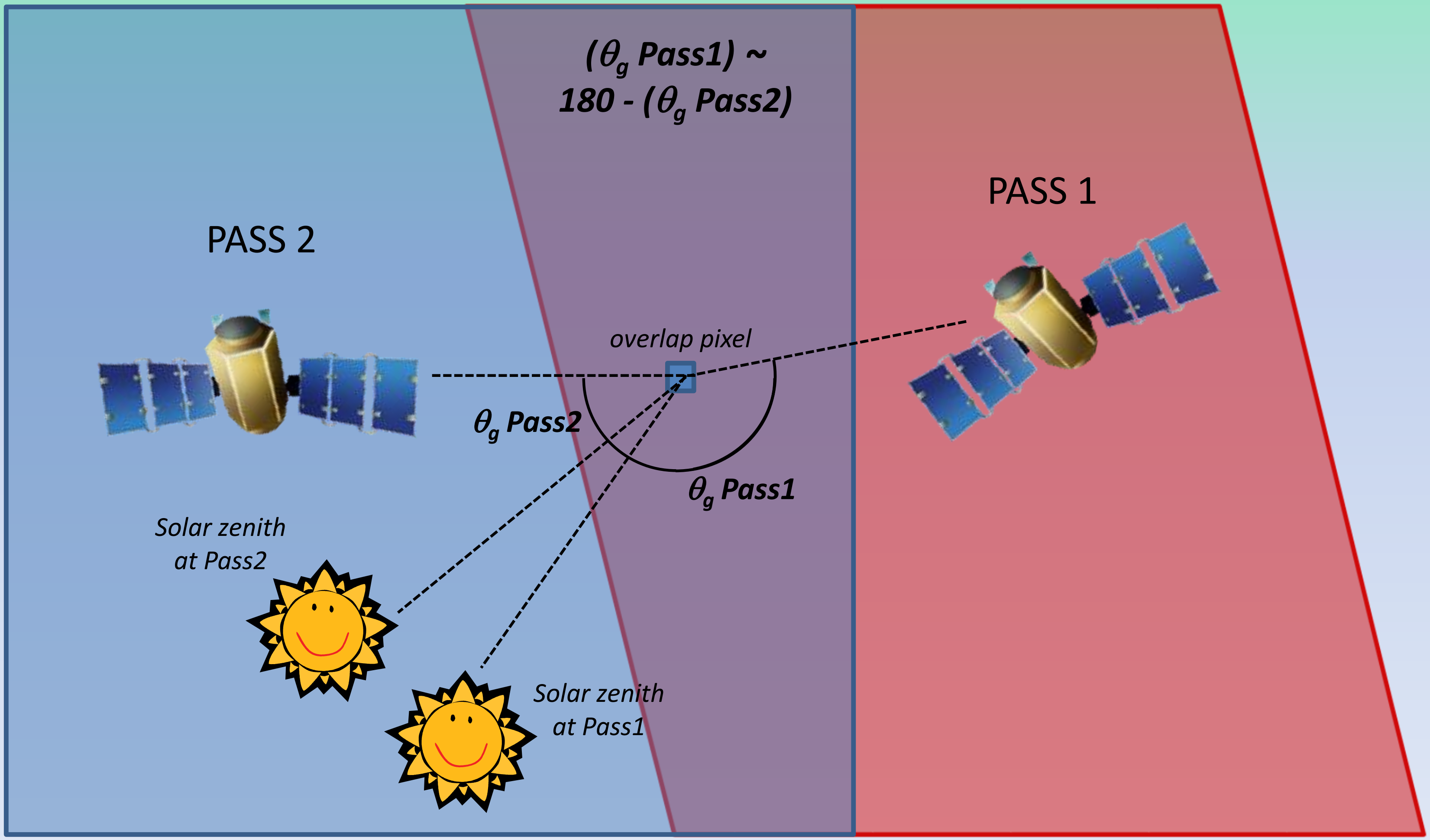
$$\cos(\theta_g) = \cos(\theta_s)\cos(\theta_r) - \sin(\theta_s)\sin(\theta_r)\cos(u_s - u_r)$$

θ_s = solar viewing zenith angle (rad)

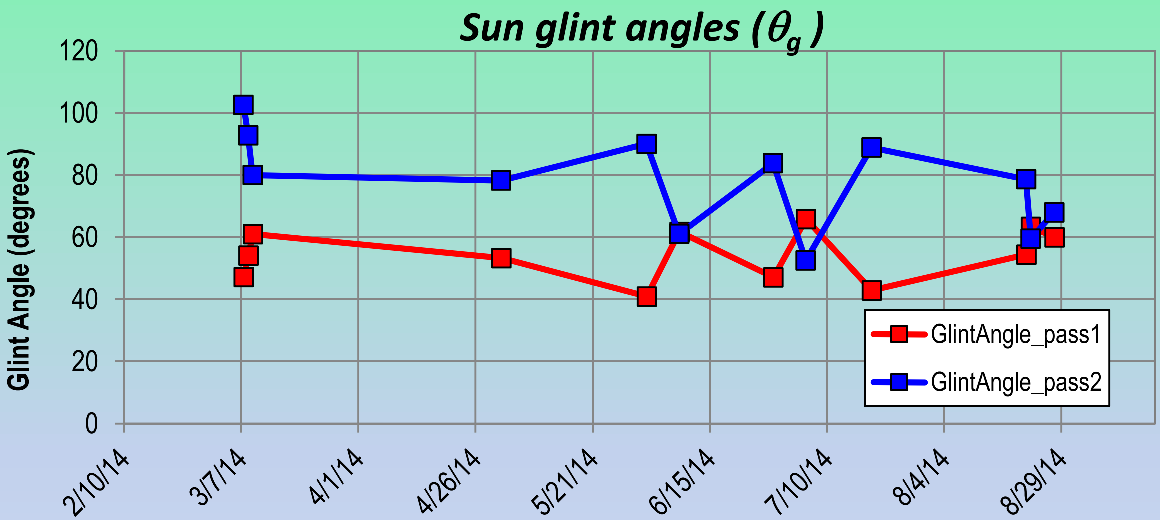
u_s = solar viewing azimuth angle (rad)

θ_r = sensor viewing zenith angle (rad)

u_r = sensor viewing azimuth angle (rad)

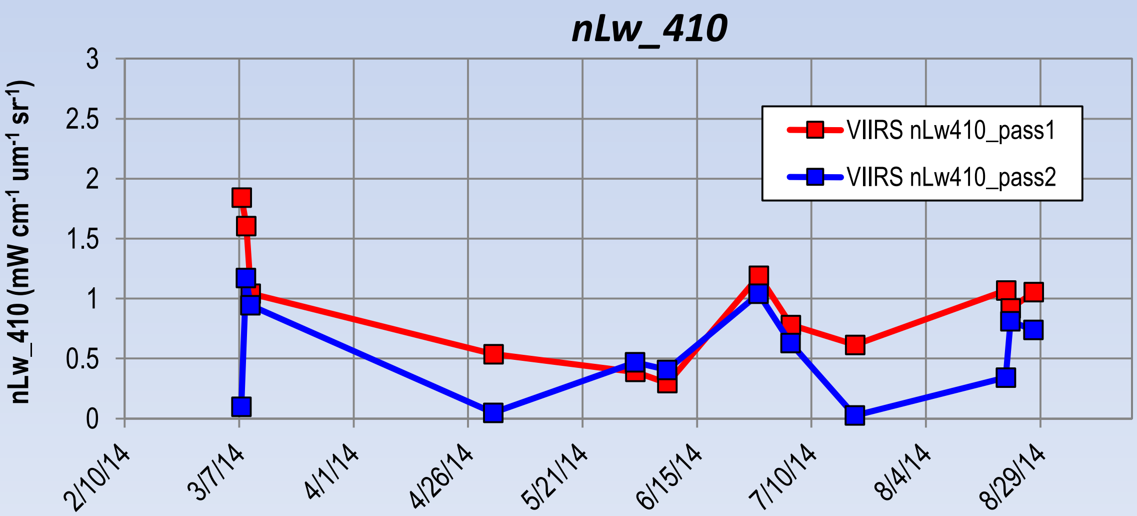


VIIRS @ AERONET – AAOT (Venice)



Sun glint angles are mirror images on either side of swath…

High θ_g Pass1 = Low θ_g Pass2

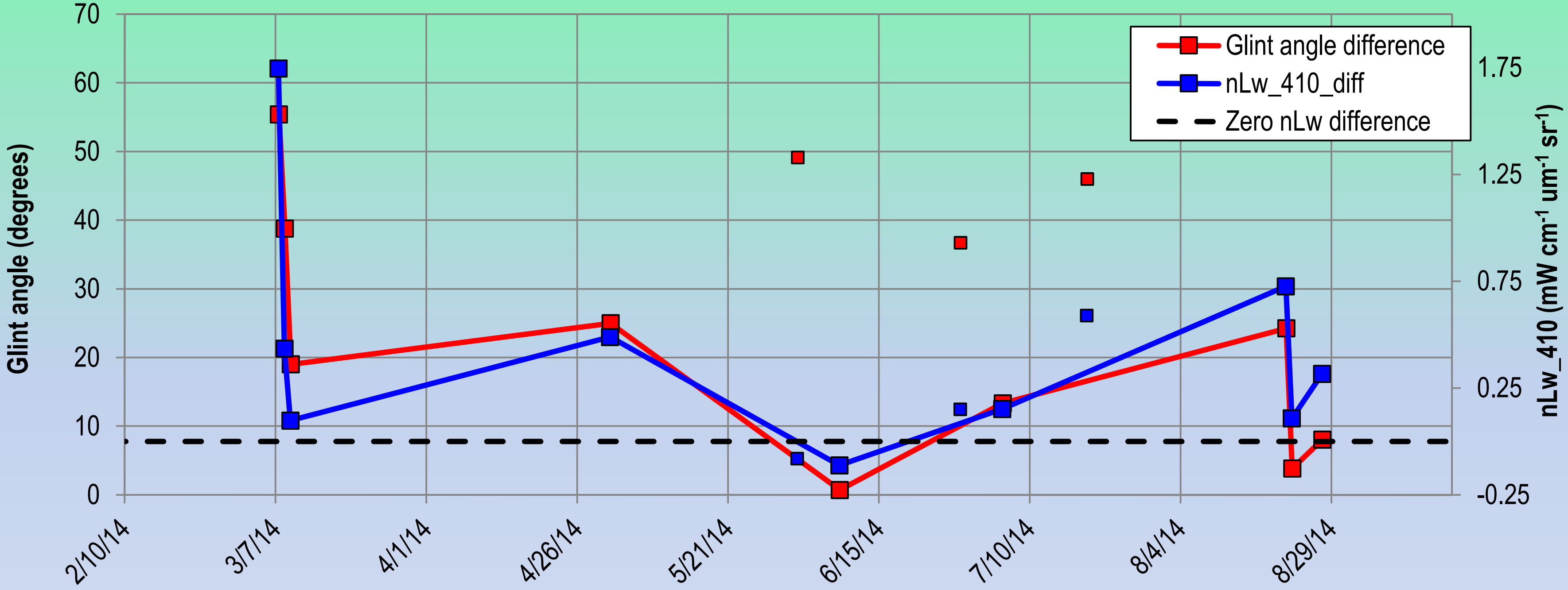


Time series of normalized water leaving radiance at 410 nm (highest uncertainty in green waters) shows differences from VIIRS pass 1 to VIIRS pass 2

Is there any correlation between sensor/solar viewing angles and nLw differences??

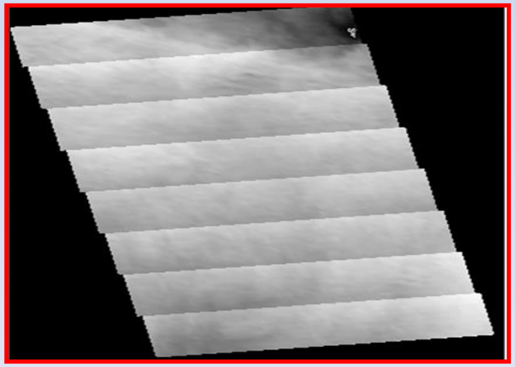
Acknowledgements - J. Bowers

Glint angle differences (θ_g pass2 – θ_g pass1) appear to have some correlation to nLw_410 differences



Differences are not solely function of angles…

Glint angles can affect striping in push-broom sensors. Scenes strongly affected by BRDF increase image striping (Liu et al. 2013)



Acknowledgments :

NOAA – JPSS Cal/Val program
NASA – GeoCAPE program

Conclusions:

VIIRS orbital overlap enables the characterization of temporal trends in bio-optics

- Track differences/uncertainties
- Diel changes in bio-optics
- Temperature changes - 4x per day! (Arnone et al. 2016)
- Optical flow (Yang et al. 2014)

Differences in multiple satellite returns per day are a result of multiple factors

- Real bio-optical changes (physiology, photo-oxidation, migration, advection)
- Atmospheric composition changes (absorbing aerosols)
- Bi-directional Reflectance Distribution Function (BRDF)
- Sensor Calibration (Striping)

VIIRS overlap characterization highlights the need to further distinguish between: **what changes are due to sensor artifacts, and what changes are resulting from actual *in situ* variations?**

Thank you

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Questions??

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