VIIRS ocean color validation in the Gulf Stream : Nancy Foster Cruise

Robert Arnone[1], R. Vandermeulen[1], Sherwin Ladner[2], Wesley Goode[2], Michael Ondrusek[3], Joaquin Goes[4]

[1] University of Southern Mississippi, [2] Naval Research Laboratory, [3] NOAA STAR [4] Lamont Doherty

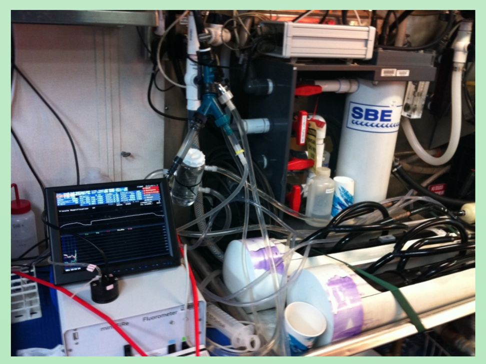
Abstract

The NOAA cal/val cruise for VIIRS in the Gulf Stream provided a unique data set for evaluation of the VIIRS ocean color products. The spatial and temporal variability of different waters masses were identified, demonstrating a unique potential to improve cal/val procedures and protocols for ocean color satellite. The in situ ocean color (nLw) and the inherent optical properties were collected to provide an integrated ocean optical data set to define the components and processes that impact the VIIRS ocean color signatures. The data set will enhance the capability of VIIRS ocean products to optically define the ocean ecological system, thereby enhancing the understanding of the response of ocean color to physical oceanographic process. The cruise results demonstrated the differences derived from various in situ ocean color radiometers and how it influences the calibration and validation procedures for ocean color satellites. Additionally, the cruise demonstrated how VIIRS ocean products can be used in dynamic regions for characterizing ocean processes such as front and eddies. New methods and procedures to improve the cal/val methods were identified by the cruise participants.

Objectives

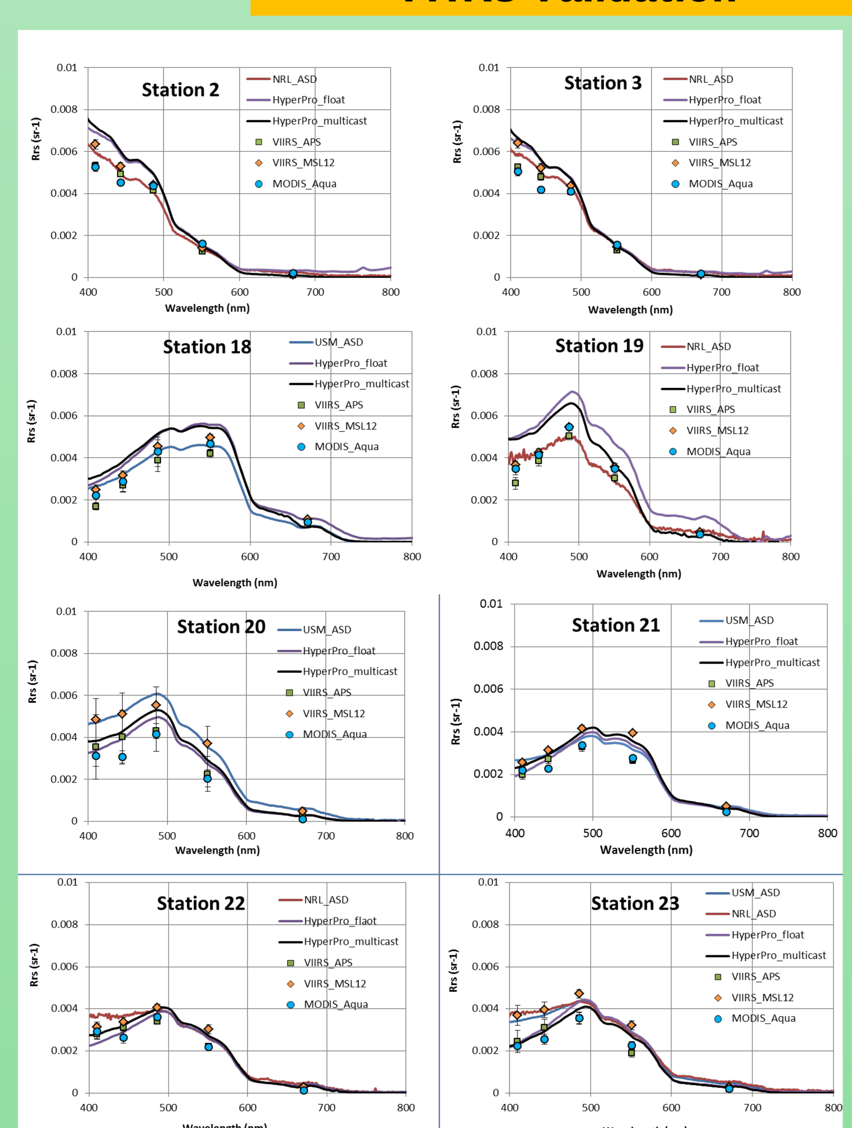
1. Determine the ocean color response across the Gulf Stream fronts.
2. Define the ocean color spatial variability during the cruise and how this impacts satellite calibration and validation.
3. Compare multiple water radiometry instruments and measurements protocols used by the ocean color community.
4. Define the optical properties of water masses in Gulf Stream fronts, shelf and coastal waters using in situ measurements for improving VIIRS product validation.
5. Validate VIIRS products to define Gulf Stream processes (eddies, shingles, fronts).

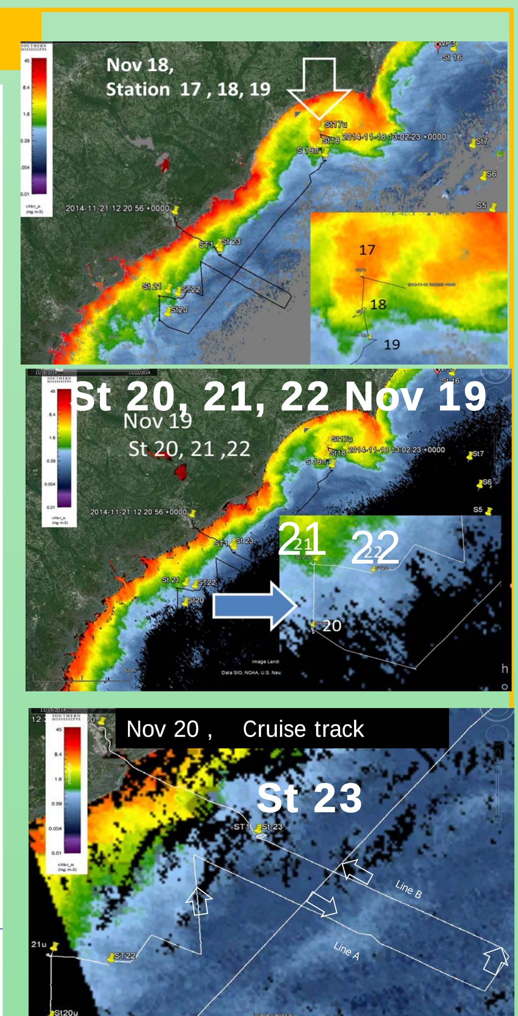
Measurements and Analysis



- IOPs
  - AC9 (beam attenuation and absorption at 9 λ)
    - Total AC9 and 0.2 micron filtered AC9
    - Intake at 3 meters
    - Operating from Nov 11 – 20
    - 1200 km at 1 minute average
    - Level 1 processing (conversion to engineering units and merging of ships data, e.g., GPS/CTD)
    - Calibration pre-cruise, mid-cruise and post-cruise
    - Level 2 processing (temperature, salinity & scattering corrections and calibration applied)
- AOPs
  - ASD (Remote sensing reflectance)
    - 106 ASD measurements made from 5 groups (USM, NRL, NOAA, USF, CUNY)
    - 11 simultaneous comparisons with other ASDs and HyperPro/SBA
    - Inter-comparisons using different and uniform protocols
    - A total of 9 VIIRS matchups from 23 processed and QC stations
- Plans
  - Compiling inter-comparisons from other groups (Station 17)
  - Improving sensor protocols for above water radiometry with comparison with other sensors

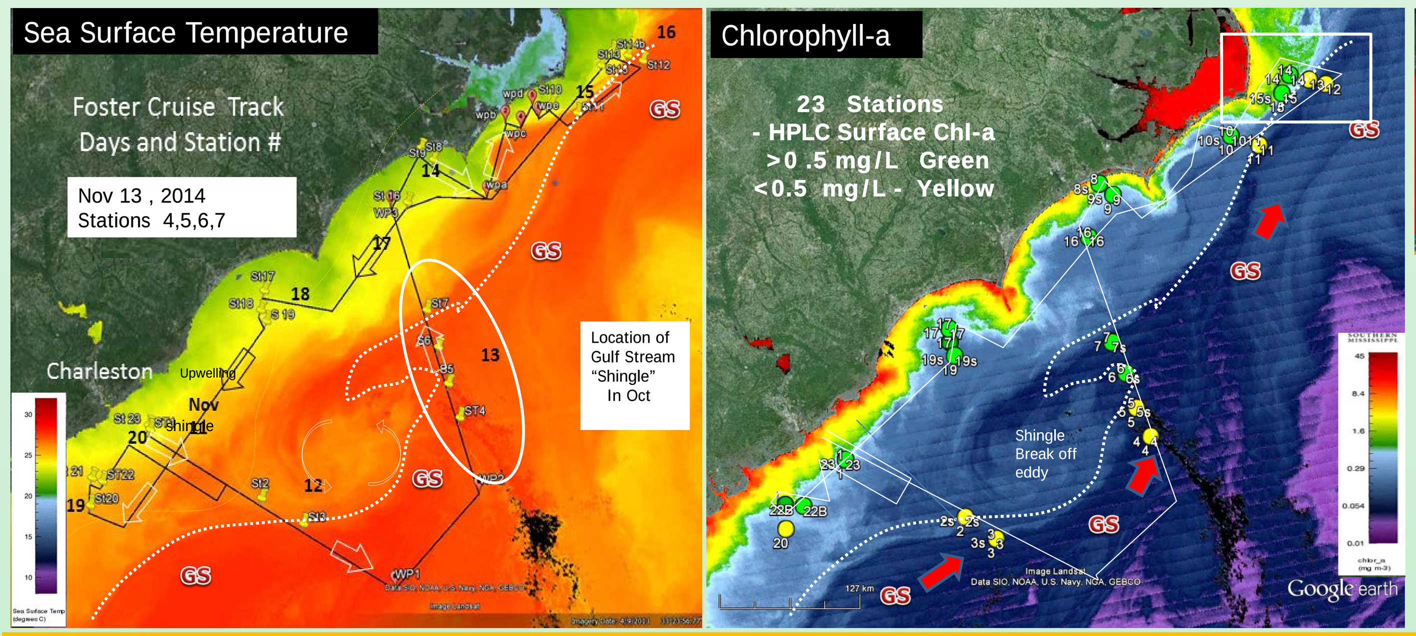
VIIRS Validation

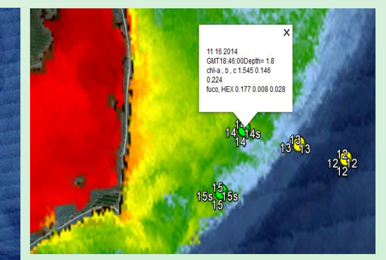




Good Comparisons between Instruments and satellite

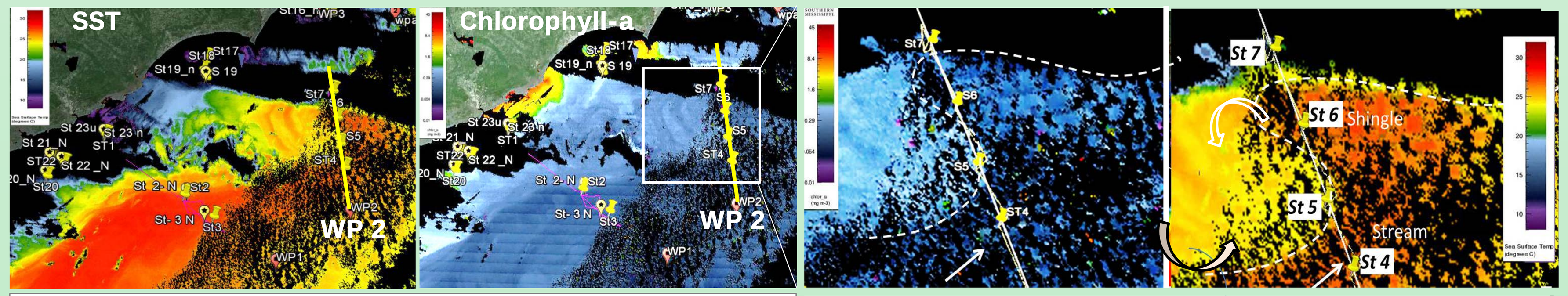
Cruise Track Stations

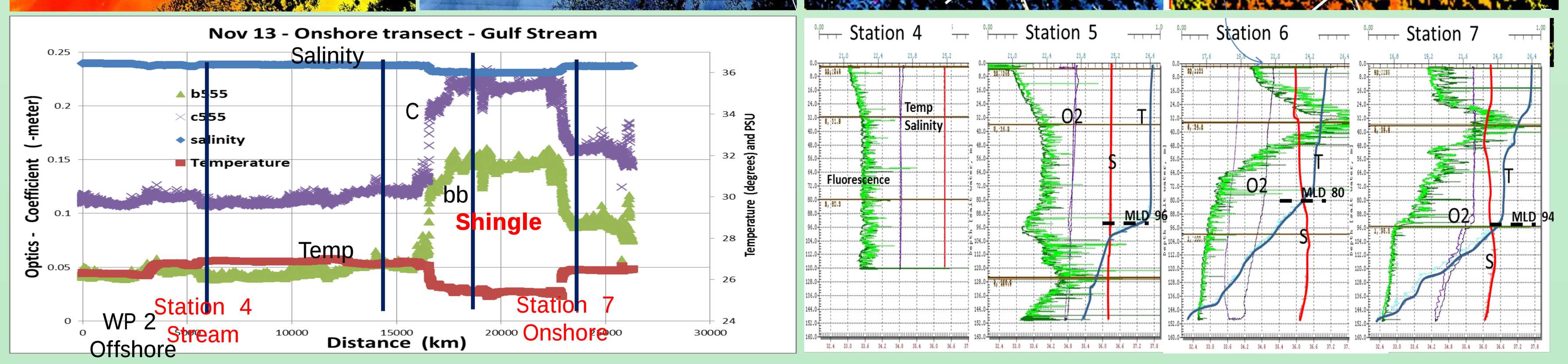




Hatteras Crossing

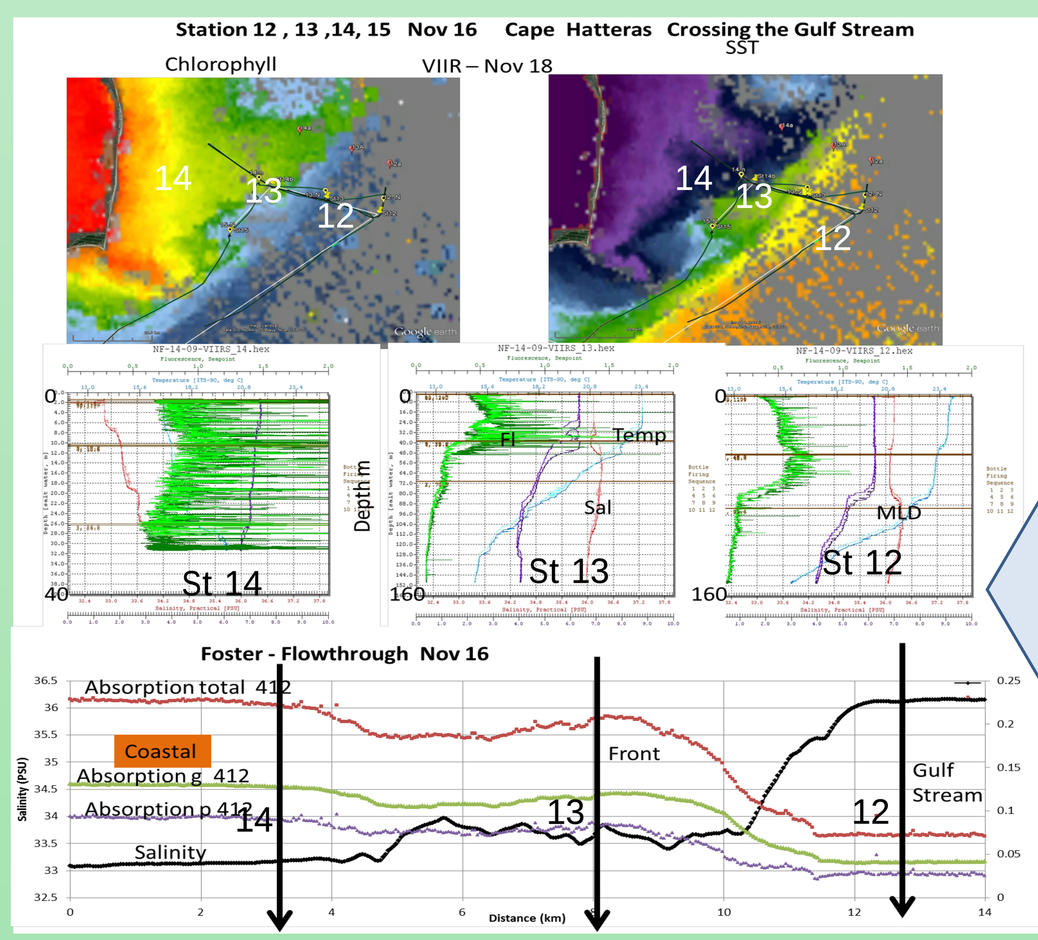
1. Gulf Stream "Shingle" Crossing





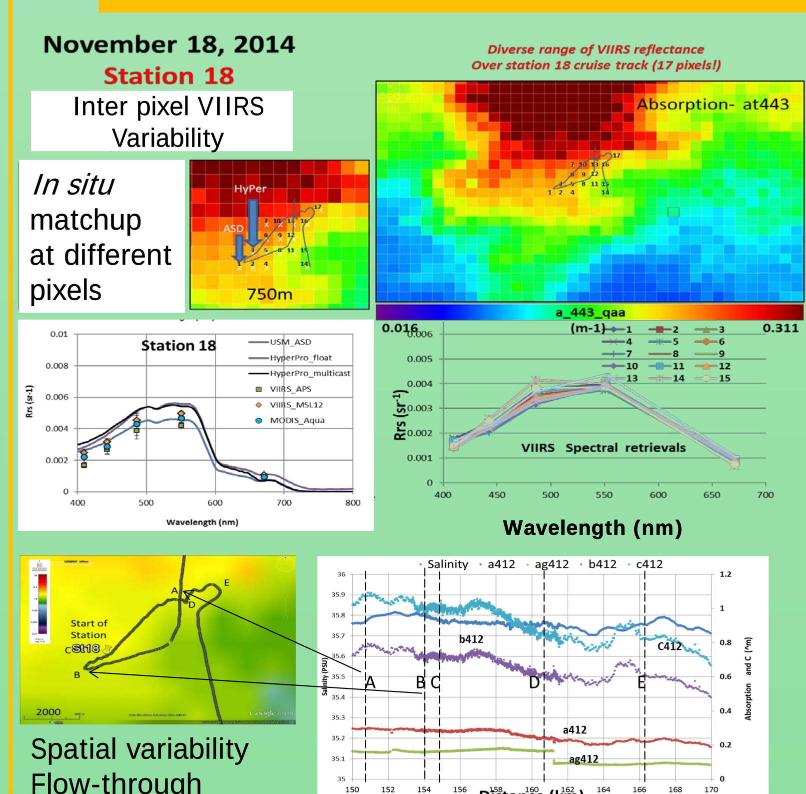
Shingle Crossing – Cruise track crosses a frontal eddy (shingle). VIIRS SST and Color identified the surface features through the clouds. The surface bio-optics (flowthrough) showed the upwelling vertical structure across the front.

2. Hatteras Gulf Stream Crossing



Hatteras – Cruise track across front shown in VIIRS SST and Color. Stations in Gulf Stream, front and Coastal waters. Upwelling at front at Station 13 shown in the vertical and surface flowthrough bio-optics.

Characterizing spatial variability used in VIIRS validation

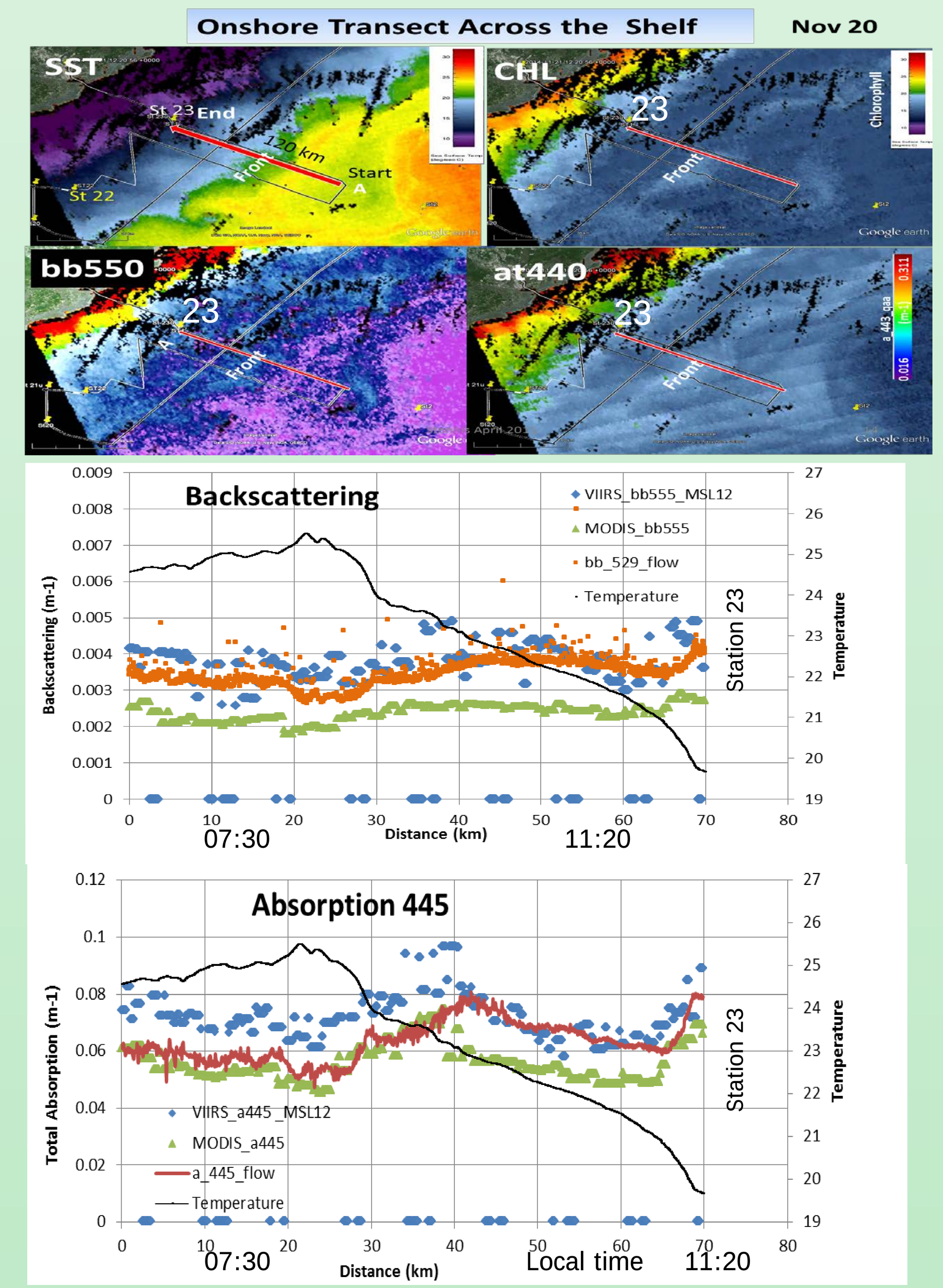


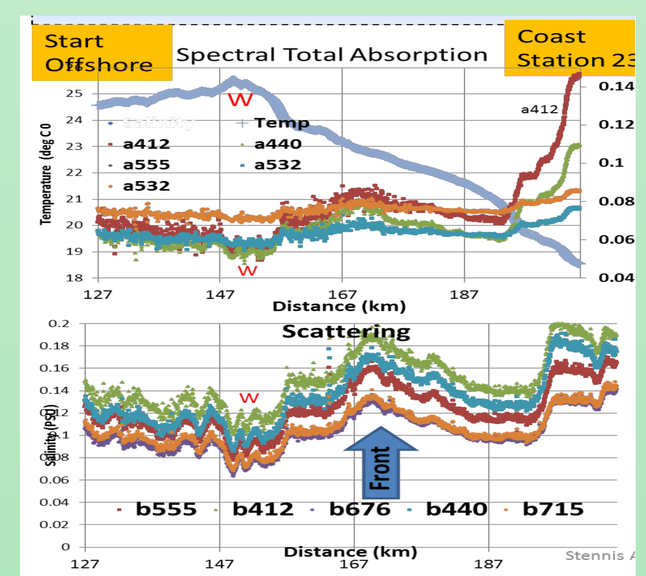
Drift at station impacts the pixel boundaries used for matchup. Example: St. 18 shows the 15 VIIRS pixels the station crossed and the pixel variability. The flow-through shows the changes across the pixels.

The location of the instrument deployment changes for different pixel.

Comparison of instruments and pixel required maintaining pixel location !!

Flow-through Matchup: Shelf front

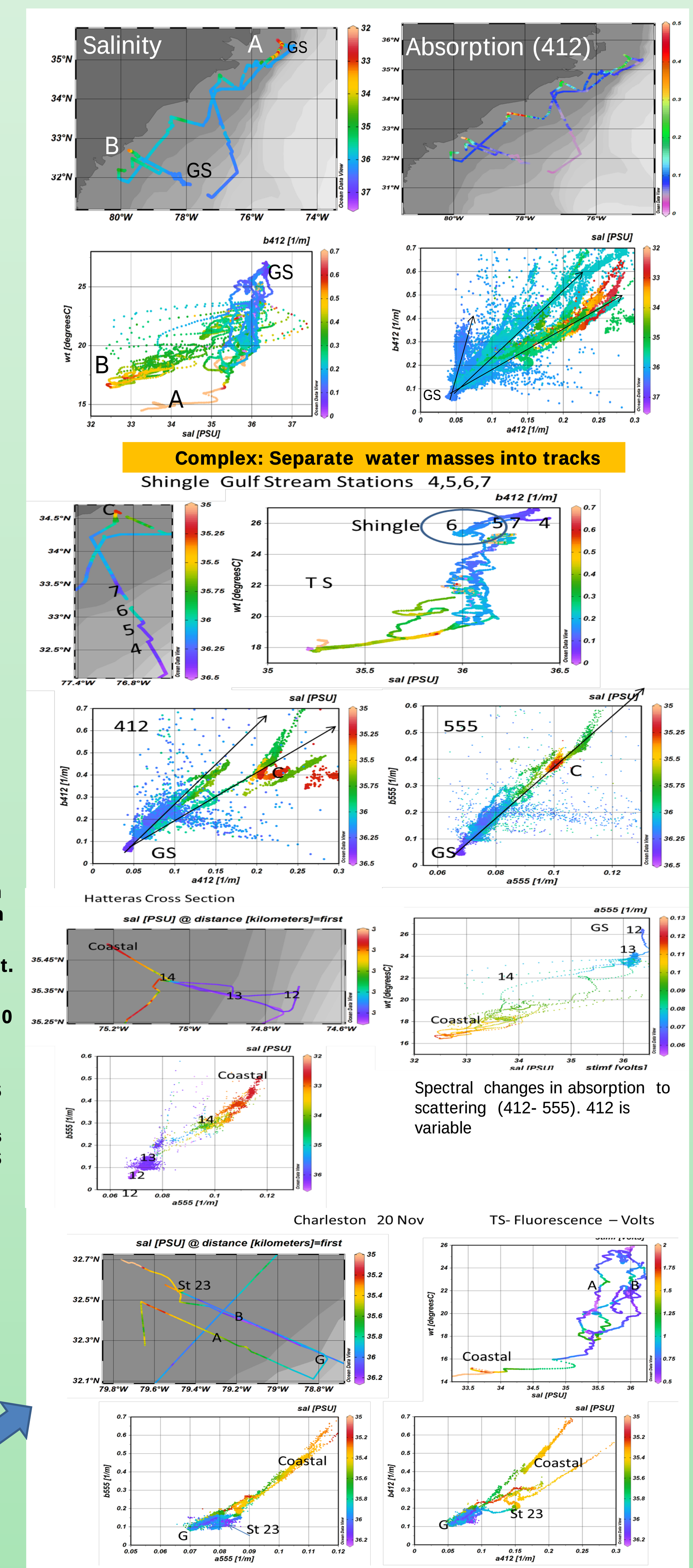




- VIIRS matchup with the ac9 flow-through
- Transect across the absorption front to St. 23
- On Nov 20 from 07:30 – 11:20 Local
- Matchup of bb550 and a443 with VIIRS MSL12 and MODIS (VIIRS overpass was at 11:45 and MODIS 12:30)

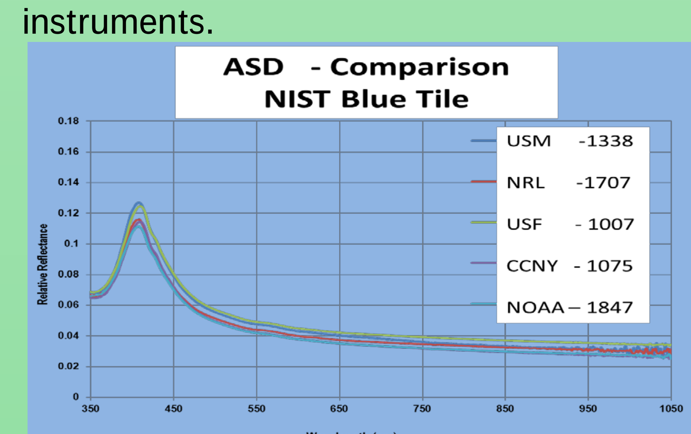
- High temporal resolution of in situ data gained from flow-through system enables an increased amount of matchups!
- The changes in bio-optical properties across the shelf front at different wavelengths can be used for water mass classification!

Bio-optical Water masses classification Flow-through cruise track



Comparisons of Remote Sensing Reflectance

- Evaluation of the Rrs from ASD - Above water reflectance was performed with 5 ASD instruments.
- The ASD protocols were evaluated and compared with Hyperpro (results of matchup).
- Comparison of ASD with a "standard" Blue tile shows good agreement between instruments.



With updated protocols , the ASD and Hyperpro can be used for VIIRS validation

Summary

- Cruise provided unique data set for calibration and validation of VIIRS through sampling a large variety of ocean waters and processes.
  New methods required for characterizing ocean spectroscopy for advancing VIIRS sensors .
  Ocean color (nLw) is dependent of optical properties and scattering and absorption processes.
  This optical processes define VIIRS products .
- VIIRS products has shown continuity of satellite ocean color .
- Cruise demonstrated
  1) Defining spatial variability of ocean color at stations is important to advance satellite cal val
  2) Need for protocols for individual cal val instruments
  3) Ocean processes can influence ocean color signatures →
  Frontal , upwelling, water masses characterization
  4) Water masses have high variability of absorption and scattering in open shelf and coastal waters .
- Applications of VIIRS ocean color products require better defining ocean process.
- The variability of ocean color is dependent on the processes that produce them.
  The spatial and temporal coherent scales of these processes will define cal val methods required
- New Questions:
  - How accurate is the nlw required from the satellite to determine changing ocean color across a front? This can define the cal val methods must account for these variability to define the accuracy of the satellite
  - nLw Satellite radiance averaged at a location may be more accurate than an individual station !
- Oceans color is shown to be support the vertical structure (Upwelling and frontal location.)