Image source: https://oceancolor.gsfc.nasa.gov/

Analysis of Remote Sensing Reflectance from VIIRS and MODIS Satellite Measurements Over Coastal Waters

Brandon Flores[1,2], Eder Herrera Estrella[1,3], Alex Gilerson[1,4]

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[1]NOAA CESSRST,
[2]Summer Bridge Scholar,
[3]Graduate Center, The City University of New York
[4]Department of Electrical Engineering, The City College of New York, The City University of New York

Intro / (Overview & objectives)

- Remote sensing is the “process of detecting and monitoring the physical characteristics of an area by measuring its reflectance and emitted radiation at a distance from a satellite” (U.S. Geological Survey).
- Remote sensing of water areas is known as Ocean Color (OC)
  - Regular monitoring of different ocean water characteristics such as water quality, biomass in the ocean and the sea surface temperature around the Earth
- Why Ocean Color is important?
  - Deriving chlorophyll-a concentration
  - Measure water quality (biological characteristics)
  - Forecasting of Harmful Algal Bloom (HAB)
  - Quantifying phytoplankton biomass
  - Biological and physical oceanography (Ocean system modeling)
  - Fisheries oceanography
- Research will focus on 3 satellite sensors: MODIS, VIIRS on NOAA 20, and SNPP
- The Aerosol Robotic Network - Ocean Color (AERONET-OC)
  - Network consists of globally distributed radiometer systems maintained at fixed offshore sites (lighthouses or oil platforms)
  - Monitor water parameters such as chlorophyll and sediment concentrations in different coastal waters
  - Used to validate satellite sensor measurements of remote sensing reflectance (Rrs)
  - Research will focus on 3 station sensors: LISCO, Venise, WaveCIS site
  - The comparison made between OC and AERONET-OC has the purpose of validating and assessing the satellite sensor performance in retrieving remote sensing reflectance (Rrs) from dynamic coastal water environments

Methodology

- All level 2 satellite data files available in NASA Ocean Color for the period 2017 – July 2021 were collected for all 3 remote sensors.
- Satellite observations were made in a period of ±2hrs over AERONET-OC stations
- Code will select the pixels closest to each station in every available level 2 satellite file for the time period and different wavelengths
  - The pixel will be valid if it passes trough the following flags: Land, high and moderate sun glint, high sensor viewing or solar zenith angle, straylight, cloud or ice, and bad navigation
- Code will select a 3x3 grid box centered at the chosen pixels from the previous step
  - Average Rrs is recorded if at least half of the pixels passes through the flags
  - Pixels that record a negative Rrs at any wavelength are excluded when calculating average Rrs for that wavelength
- Rrs for all AERONET-OC files was calculated with the following equation: $R_{Rs} = \frac{(10 * nLw)}{F_0}$, where F_0 is the solar flux and nLw is the normalized leaving water radiance (which is retrieved from the level 2 satellite files).
  - A factor of 10 was added such that the satellite data units match up with the station data units
- For the correlation between sensors and stations we used the coefficient of determination (R^2). It shows the variance between the data, was well as minizine the effect of outliers in the regression line.

Figure 1: LISCO station SNPP-VIIRS view

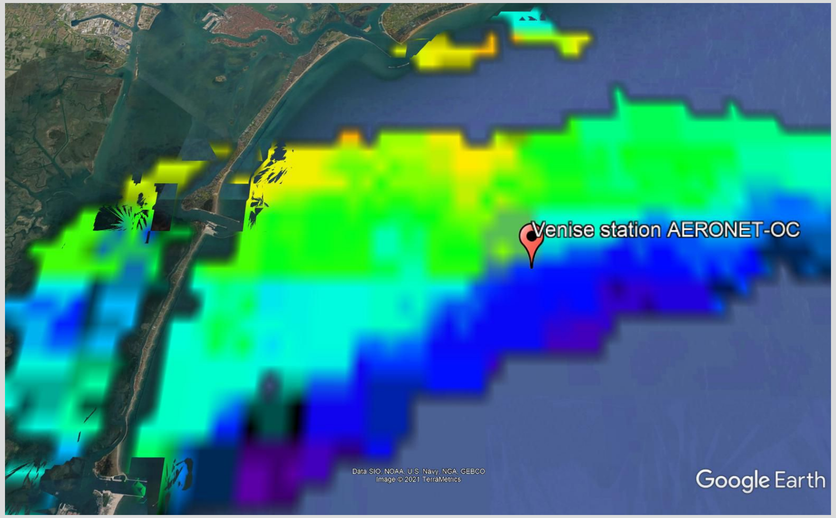


Figure 2: Venise station SNPP-VIIRS view

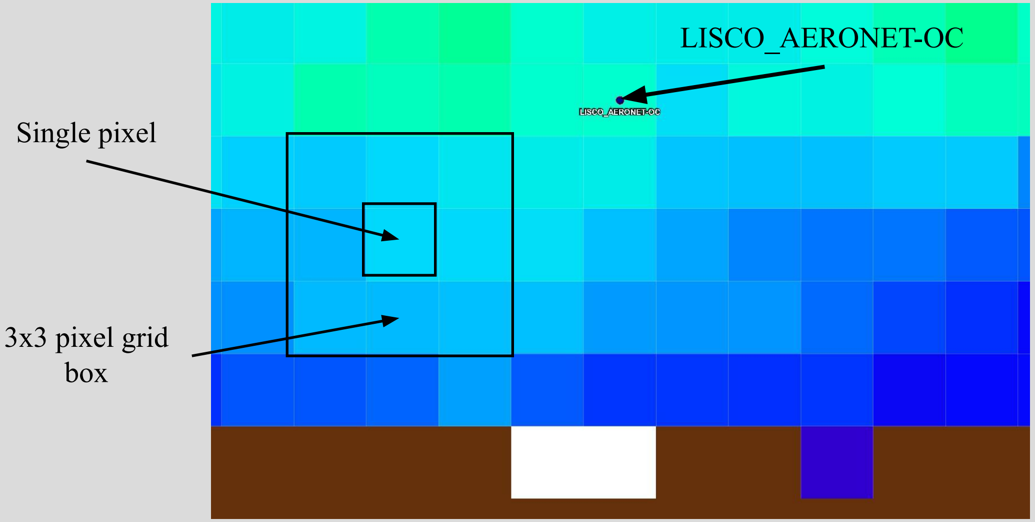


Figure 3: Pixel samples for 486nm wavelength (SNPP-VIIRS)

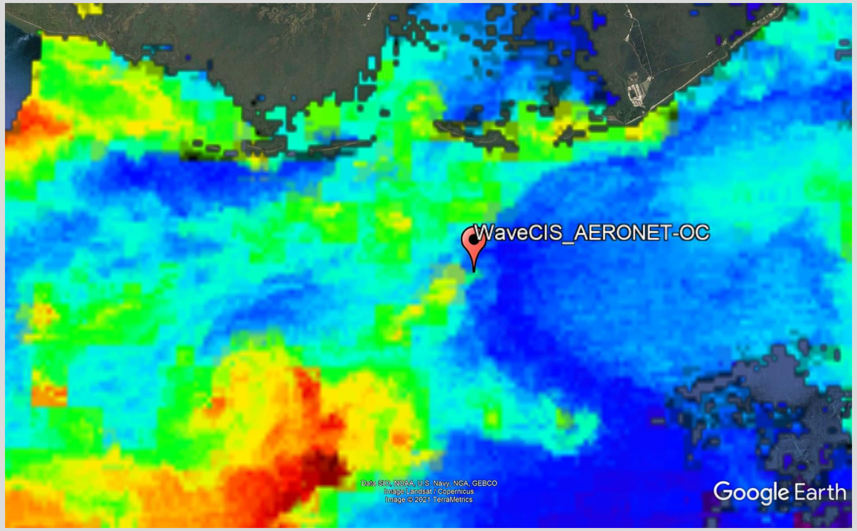
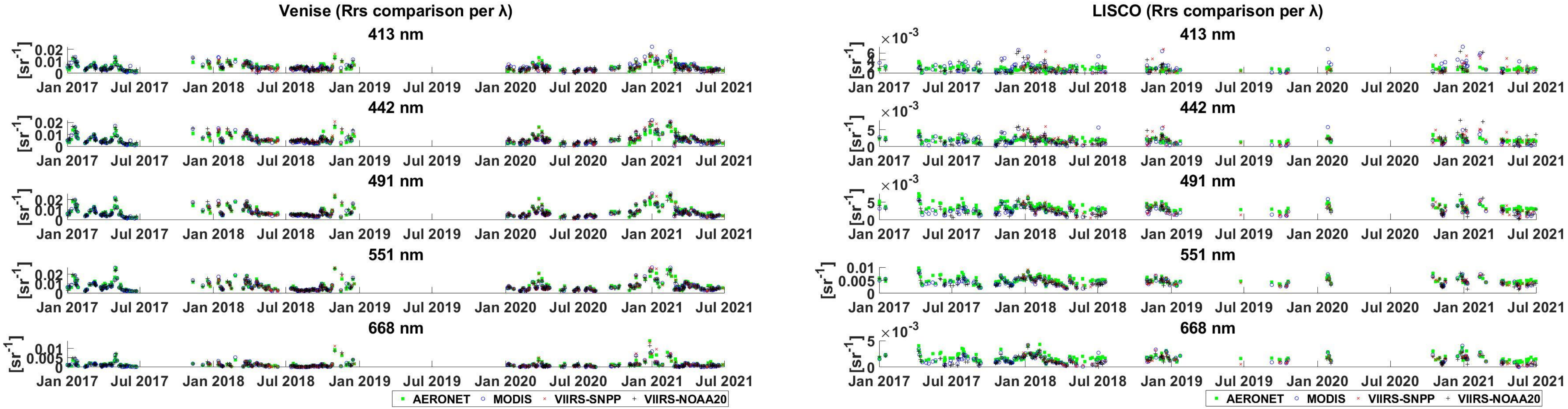
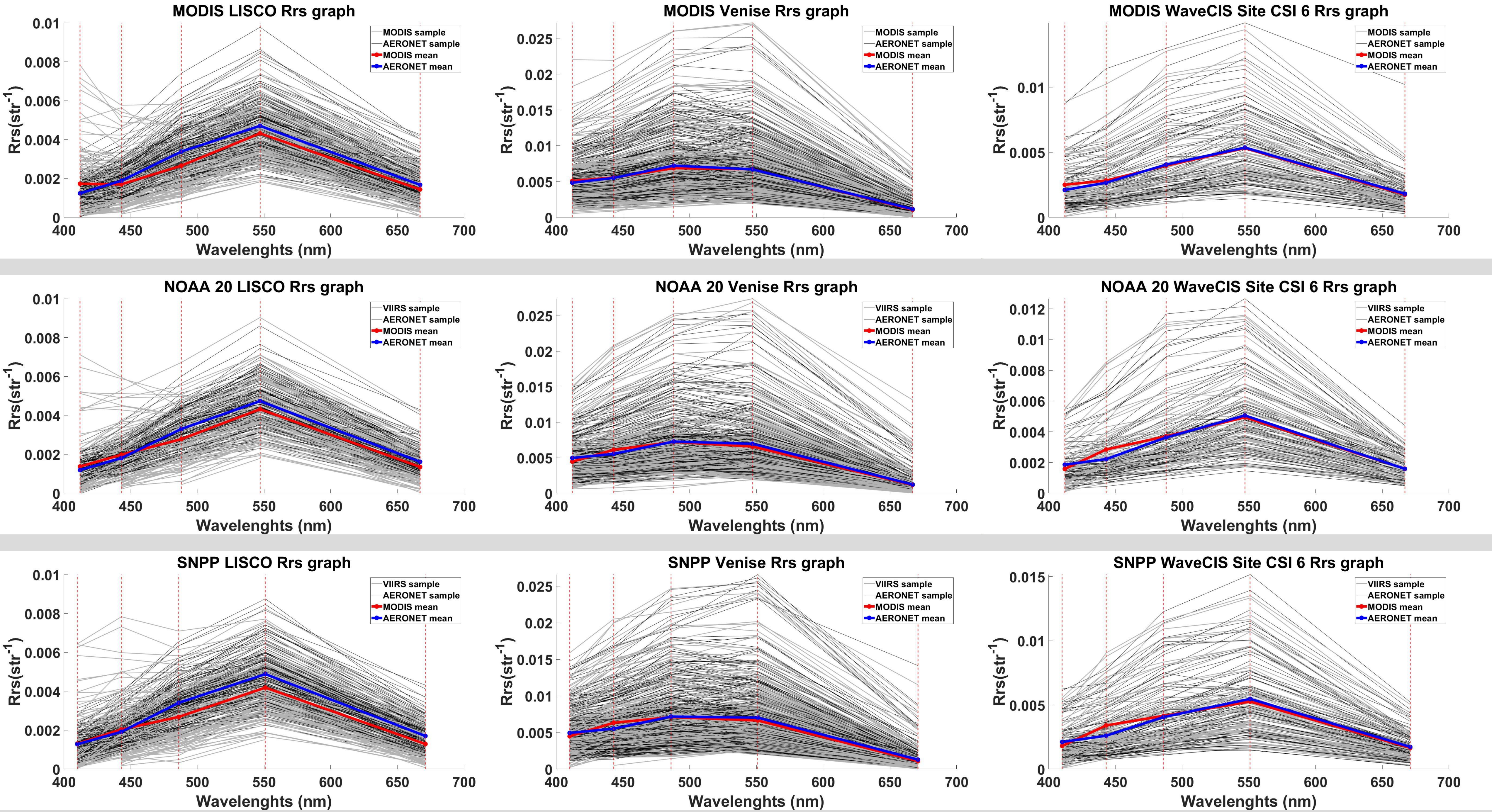


Figure 4: WaveCIS station SNPP-VIIRS view

Results



Sample size			
	SNPP	MODIS	NOAA
LISCO	142	145	116
Venise	294	272	242


MODIS LISCO Rrs graph
MODIS sample
AERONET sample
MODIS mean
AERONET mean
Rrs(str-1)
Wavelenghts (nm)
MODIS Venise Rrs graph
MODIS sample
AERONET sample
MODIS mean
AERONET mean
Rrs(str-1)
Wavelenghts (nm)
MODIS WaveCIS Site CSI 6 Rrs graph
MODIS sample
AERONET sample
MODIS mean
AERONET mean
Rrs(str-1)
Wavelenghts (nm)
NOAA 20 LISCO Rrs graph
VIIRS sample
AERONET sample
MODIS mean
AERONET mean
Rrs(str-1)
Wavelenghts (nm)
NOAA 20 Venise Rrs graph
VIIRS sample
AERONET sample
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Rrs(str-1)
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NOAA 20 WaveCIS Site CSI 6 Rrs graph
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SNPP LISCO Rrs graph
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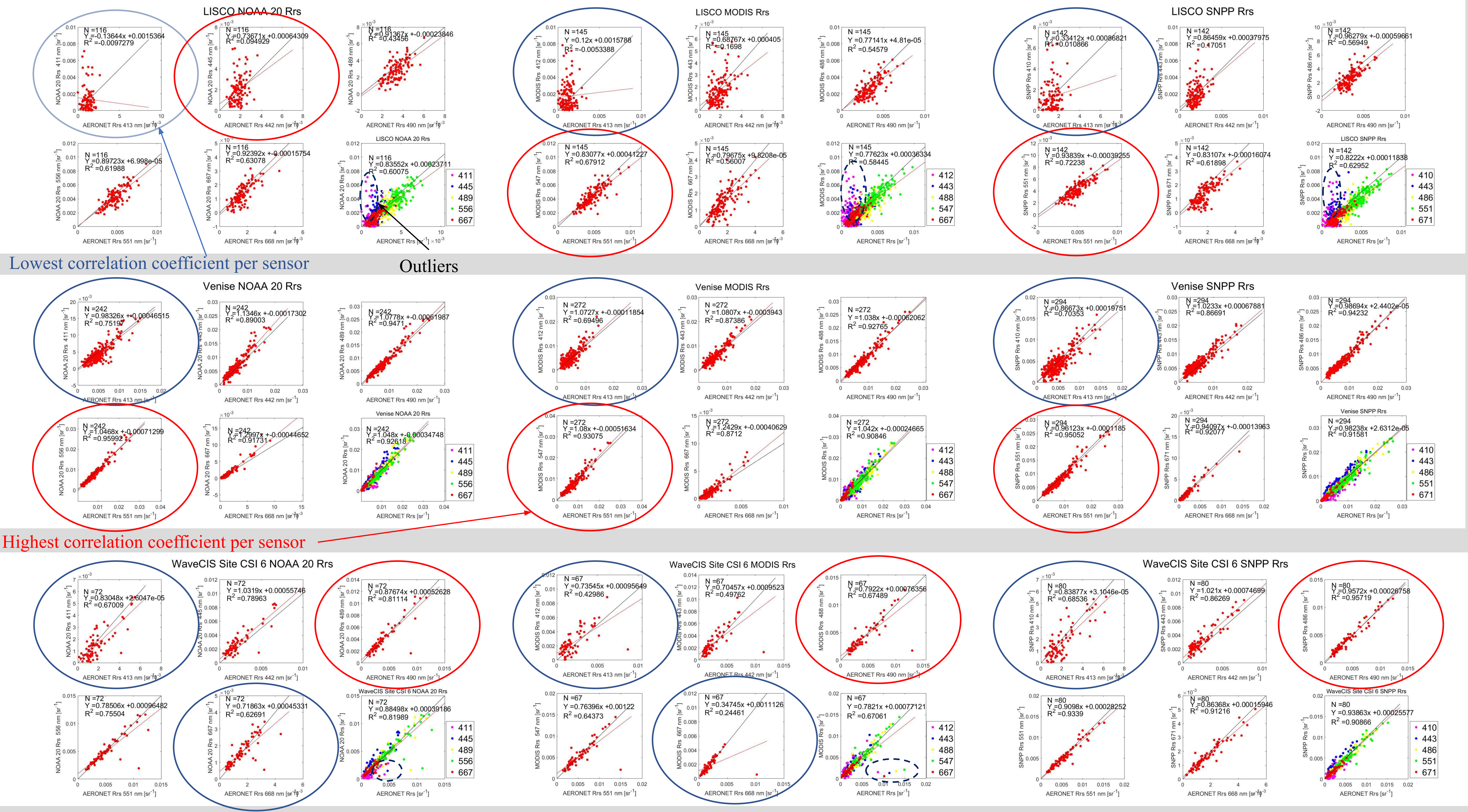
Rrs(str-1)
Wavelenghts (nm)
SNPP Venise Rrs graph
VIIRS sample
AERONET sample
MODIS mean
AERONET mean
Rrs(str-1)
Wavelenghts (nm)
SNPP WaveCIS Site CSI 6 Rrs graph
VIIRS sample
AERONET sample
MODIS mean
AERONET mean
Rrs(str-1)
Wavelenghts (nm)


LISCO NOAA 20 Rrs
LISCO MODIS Rrs
LISCO SNPP Rrs
Lowest correlation coefficient per sensor
Outliers
Venise NOAA 20 Rrs
Venise MODIS Rrs
Venise SNPP Rrs
Highest correlation coefficient per sensor
WaveCIS Site CSI 6 NOAA 20 Rrs
WaveCIS Site CSI 6 MODIS Rrs
WaveCIS Site CSI 6 SNPP Rrs

Conclusion

- Remote sensing satellites sensors provide accurate Rrs data which match well in-situ AERONET-OC station measurements
- SNPP is the sensor that has a greater correlation values for all the 3 stations analyzed in this research: $R^2_{LISCO} = 0.6295$, $R^2_{Venise} = 0.9158$, $R^2_{WaveCIS} = 0.9086$
- Venise is the station that has a greater correlation with all the 3 sensors used: $R^2_{SNPP} = 0.9158$, $R^2_{MODIS} = 0.9084$, $R^2_{LISCO} = 0.9261$
- VIIRS-SNPP, VIIRS-NOAA_20 and MODIS show higher correlations at the longest wavelengths and lower correlations at the shortest wavelengths
- Venise is the station with the greatest average correlation, with 0.9168, while LISCO and WaveCIS have the lowest correlations with 0.6049 and 0.7997 respectively
- Outliers do affect the regression lines significantly
- Project was compared with a past research done for the time period of 2013 to 2015
    - MODIS Venise has a correlation of 0.927, which is close to the 0.908 correlation we estimated
    - MODIS WaveCIS has a correlation of 0.881, which is greater compared to the 0.6706 correlation we estimated
    - MODIS LISCO has a correlation of 0.717, which is greater compared to the 0.584 correlation we estimated
- The difference in correlation between satellite-station can be due to the change in version of AERONET data from version 2 to version 3, or the number of samples used in the previous research

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