Ocean Color - Simultaneous Marine and Aerosol Retrieval Tool (OC-SMART)

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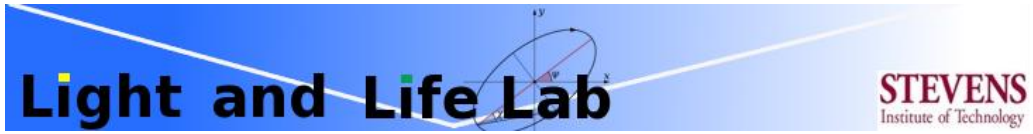
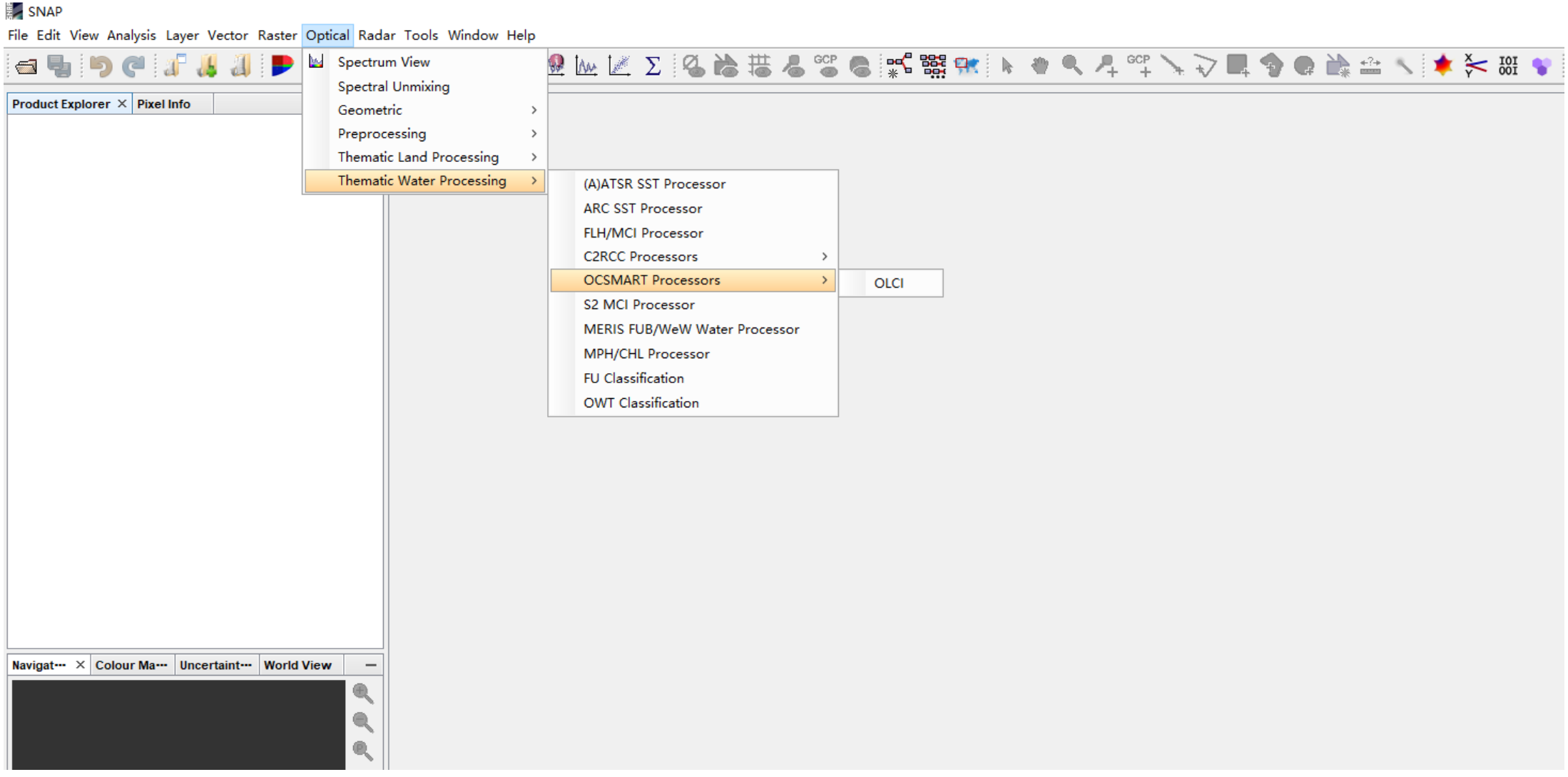
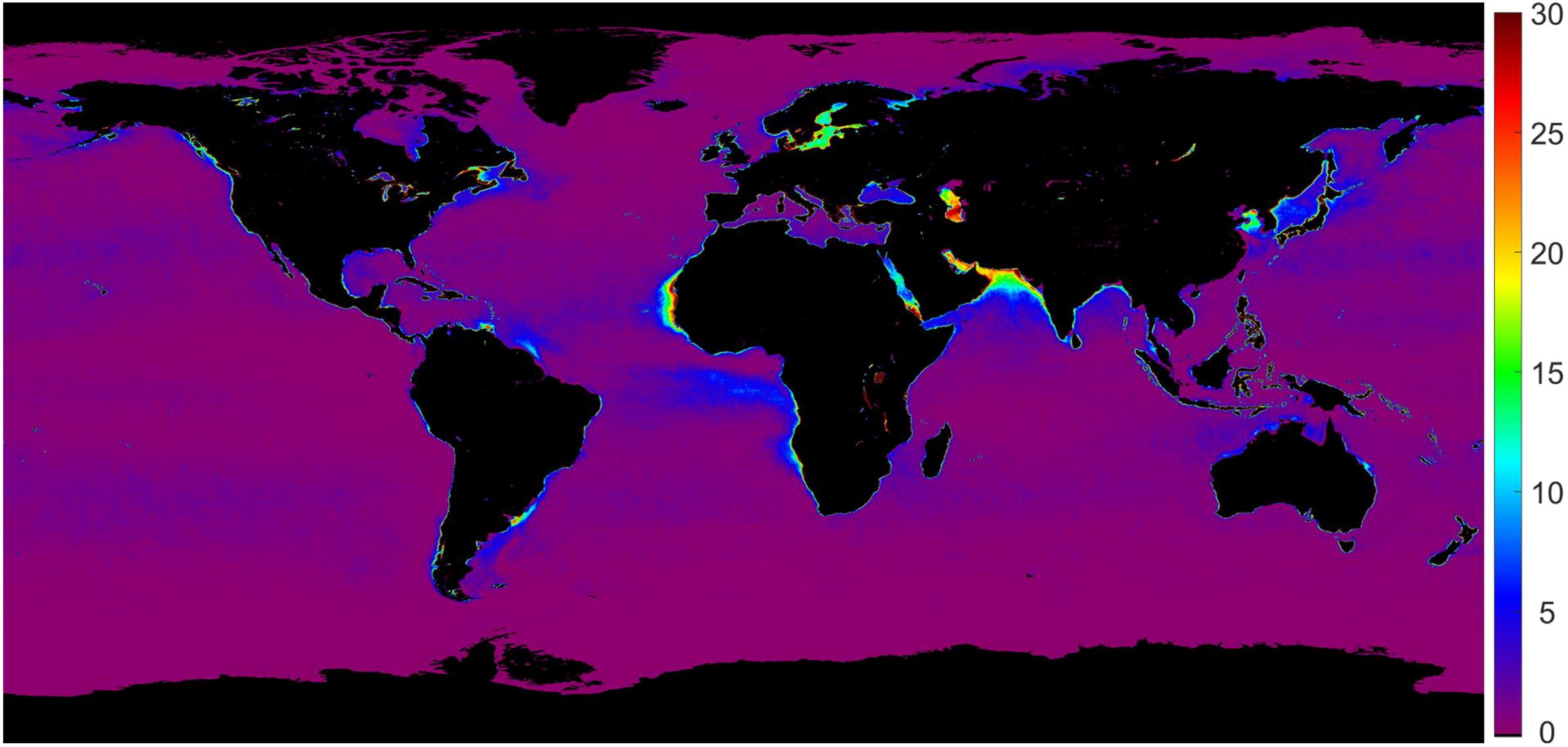


OC-SMART Introduction

The Ocean Color - Simultaneous Marine and Aerosol Retrieval Tool (**OC-SMART**) is a toolbox designed to retrieve aerosol and ocean color products from satellite remote sensing images. It utilizes **multilayer neural networks** (MLNNs) driven by **extensive radiative transfer simulations** using our **coupled atmosphere-ocean RT model**, AccuRT, to perform atmospheric correction (AC).



Frequency of negative Rrs from SeaDAS standard AC



Percentage of negative remote sensing reflectance (Rrs) in 8 day averaged 4 km Aqua MODIS L3 data from 2003-2016

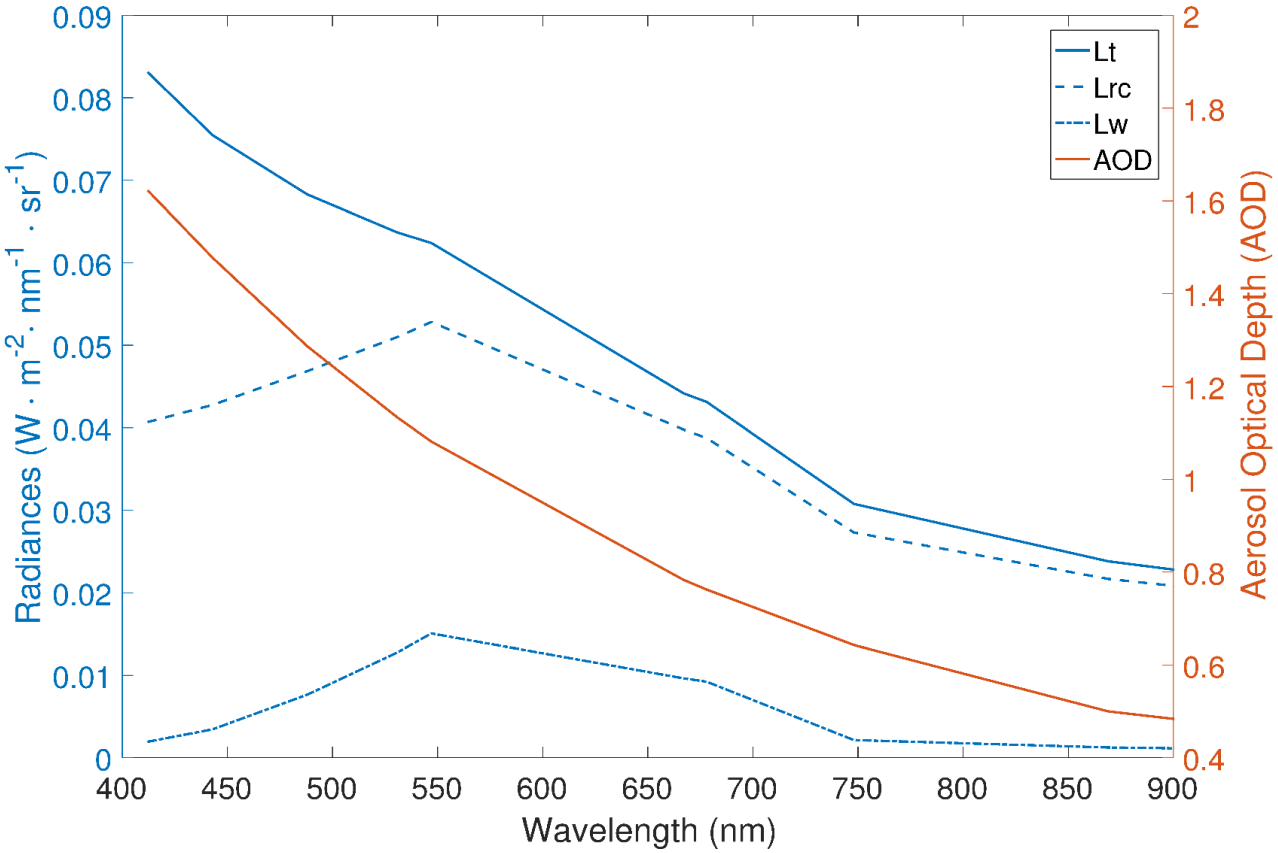
The Multilayer Neural Network (MLNN) based AC Algorithm

The **MLNN AC** algorithm is a spectral matching algorithm based on the **spectral similarity between Rayleigh corrected TOA radiances (L_{rc}) and the water-leaving radiances (L_w)**. Therefore it **does not require the aerosol radiances to be retrieved**. Keys to success of the algorithm include:

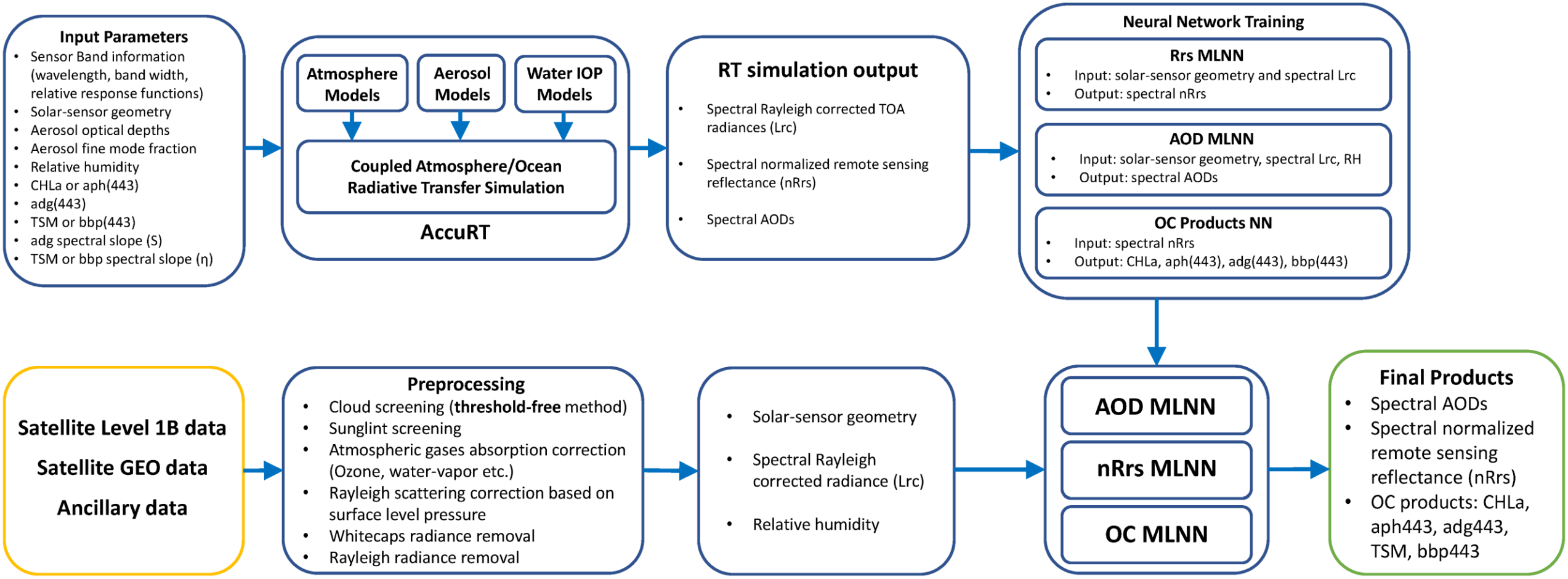
- The MLNN AC rely on **extensive and accurate RT simulations** from a **coupled atmosphere-ocean RT model**, AccuRT, that accurately computes multiple scattering and BRDF effects between the atmosphere and ocean.

- **Multiple flexible water IOP models (modified GSM, CCRR, Morel 2002) and aerosol models (Ahmad 2010, OPAC 4.0b)** are used in the RT simulations to create a comprehensive global dataset that is **representative of most marine and aerosol conditions**.

- **Realistic input parameter distributions** for the aerosol and water IOP models are obtained **by analyzing level-3 global ocean color products** from current ocean color sensors.

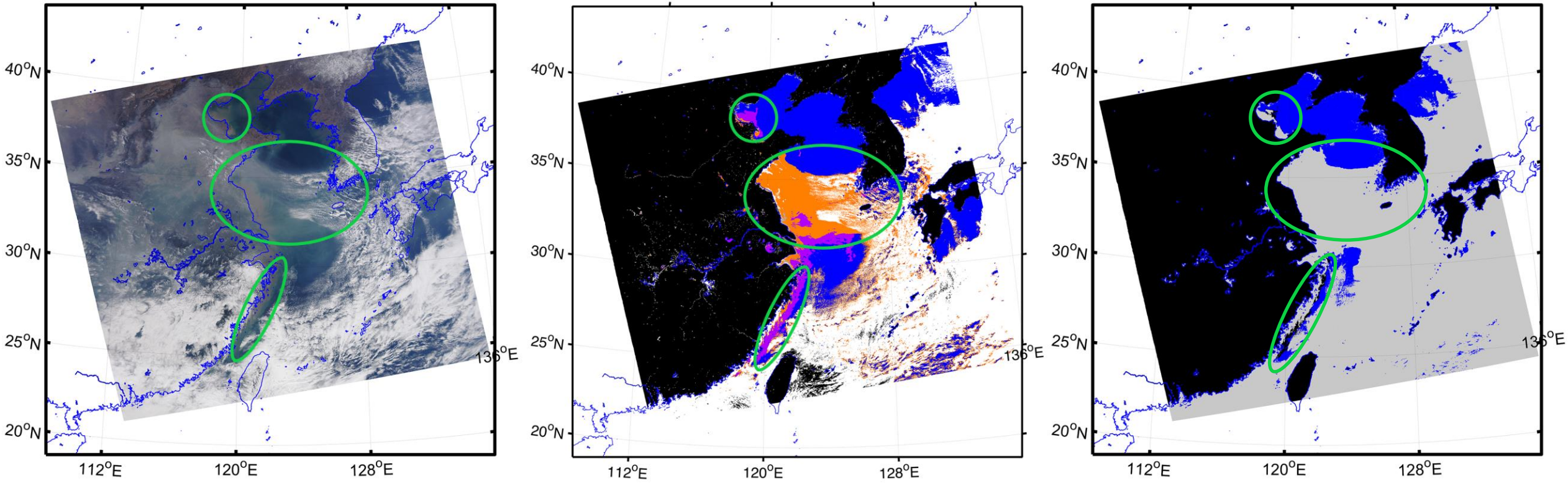


OC-SMART Flowchart



The Neural Network based Cloud Mask

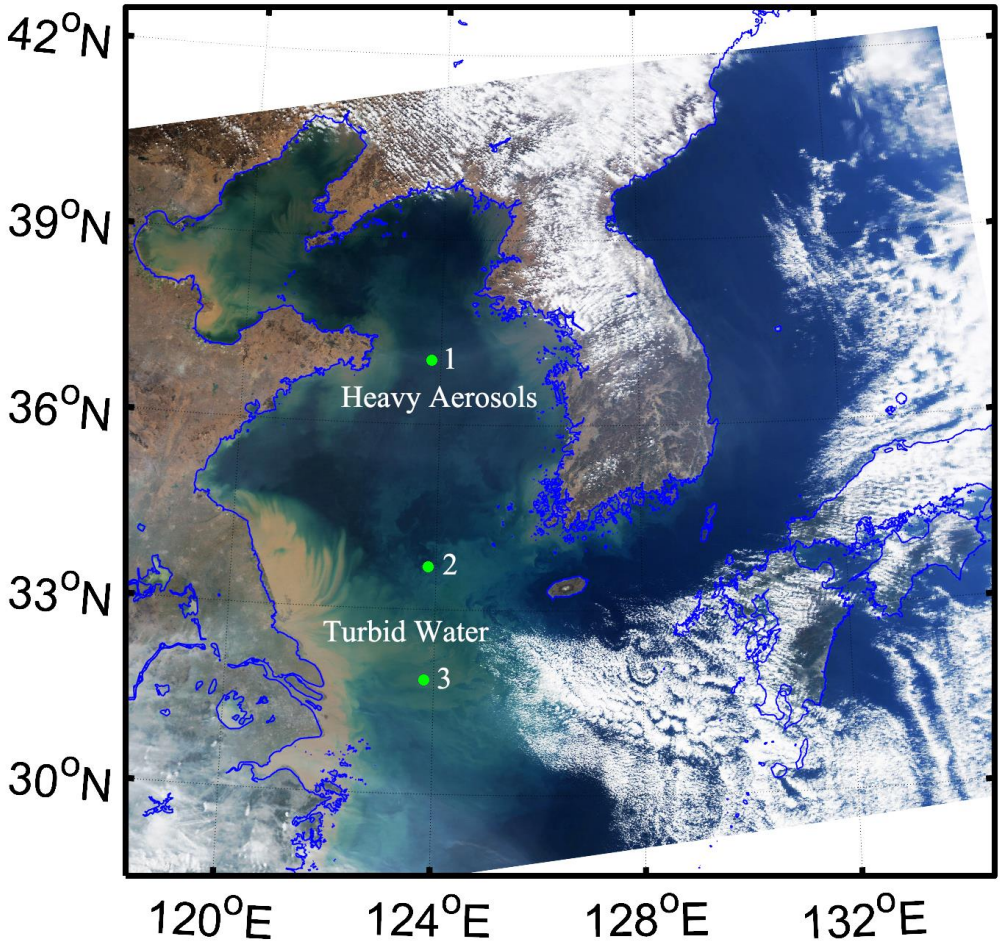
The cloud mask (CM) algorithm in OC-SMART is **threshold-free** and **based on a neural network classifier** driven by extensive radiative transfer simulations. Example below shows the cloud screening results from our CM applied to MODIS by **using ONLY 4 bands** (469, 555, 645, and 859 nm).

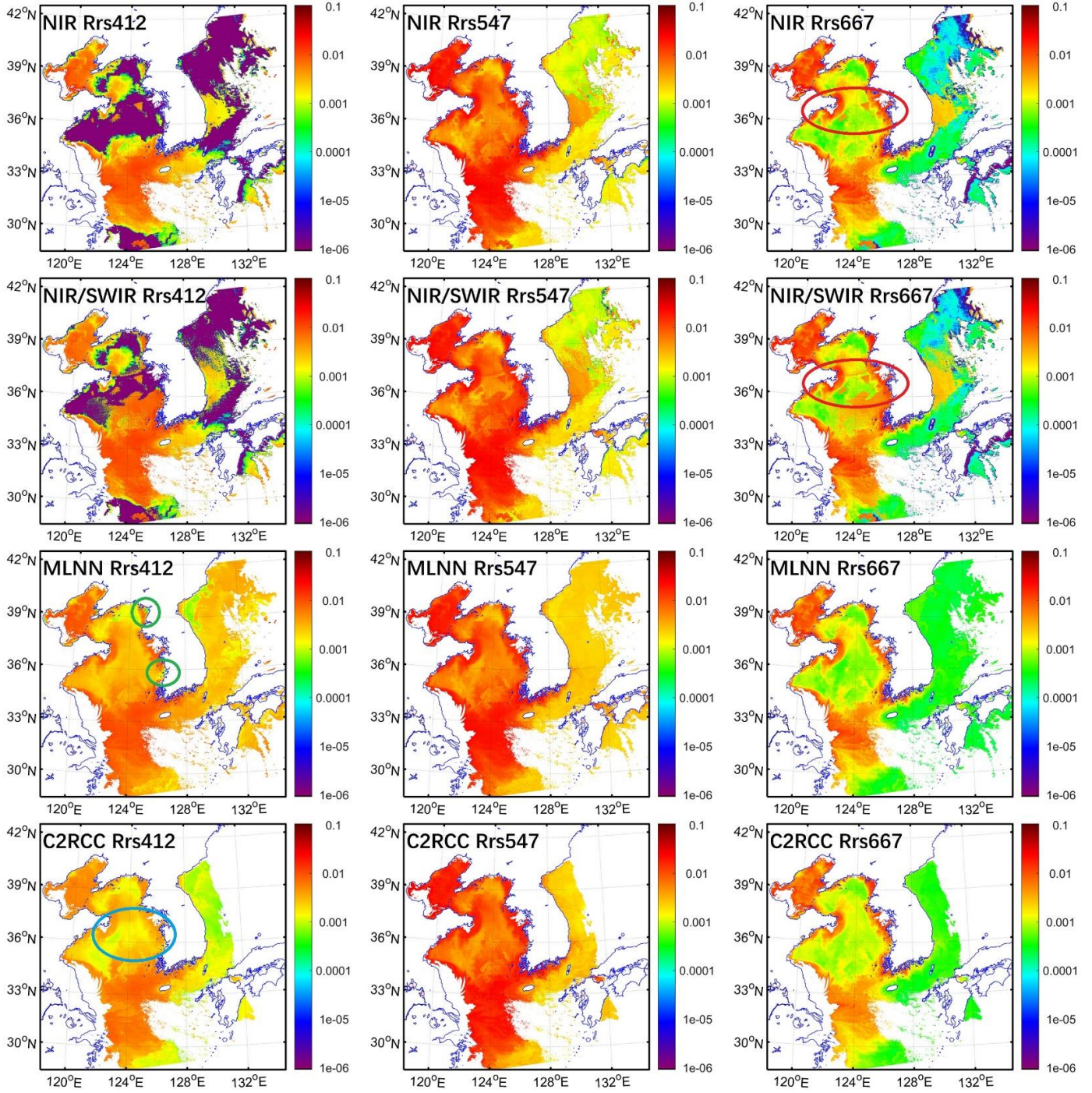


Left: Aqua MODIS RGB image on 03/09/2014.
Middle: Cloud mask results from **neural network cloud mask** algorithm using only 4 MODIS bands (469, 555, 645, and 859 nm).
Right: Cloud mask results from **threshold-based method** used in SeaDAS.

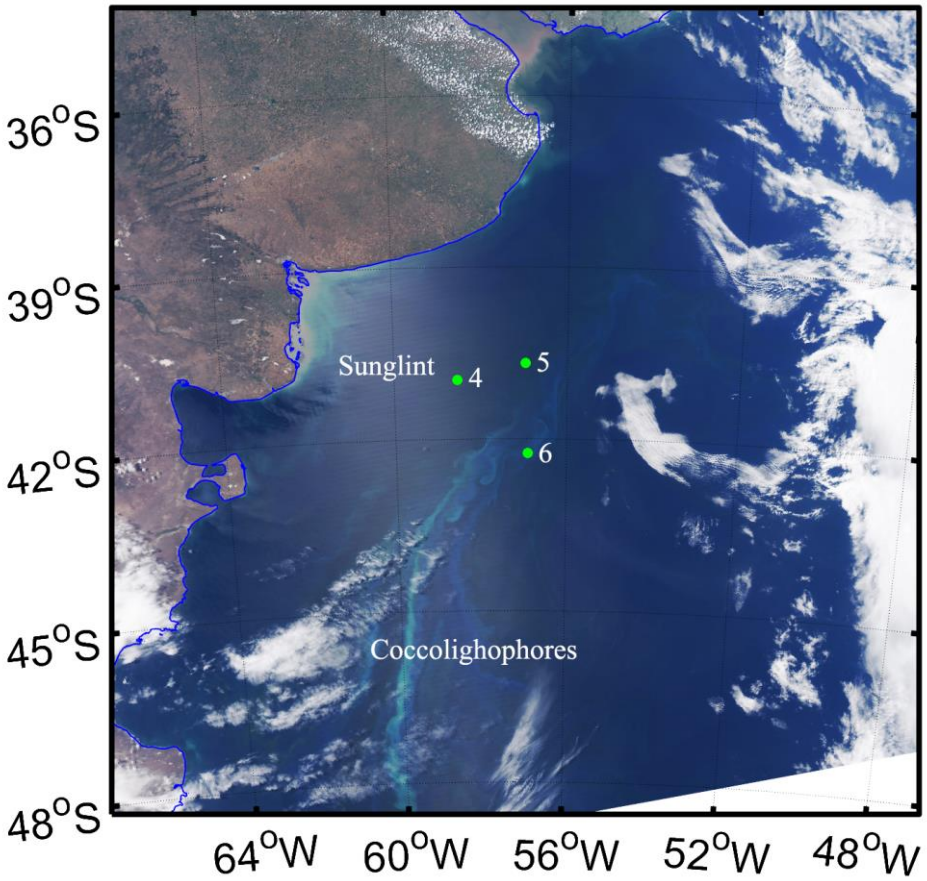
Blue: deep clean water, magenta: coastal/turbid water, orange: heavy aerosol loading over water, white/grey: clouds.

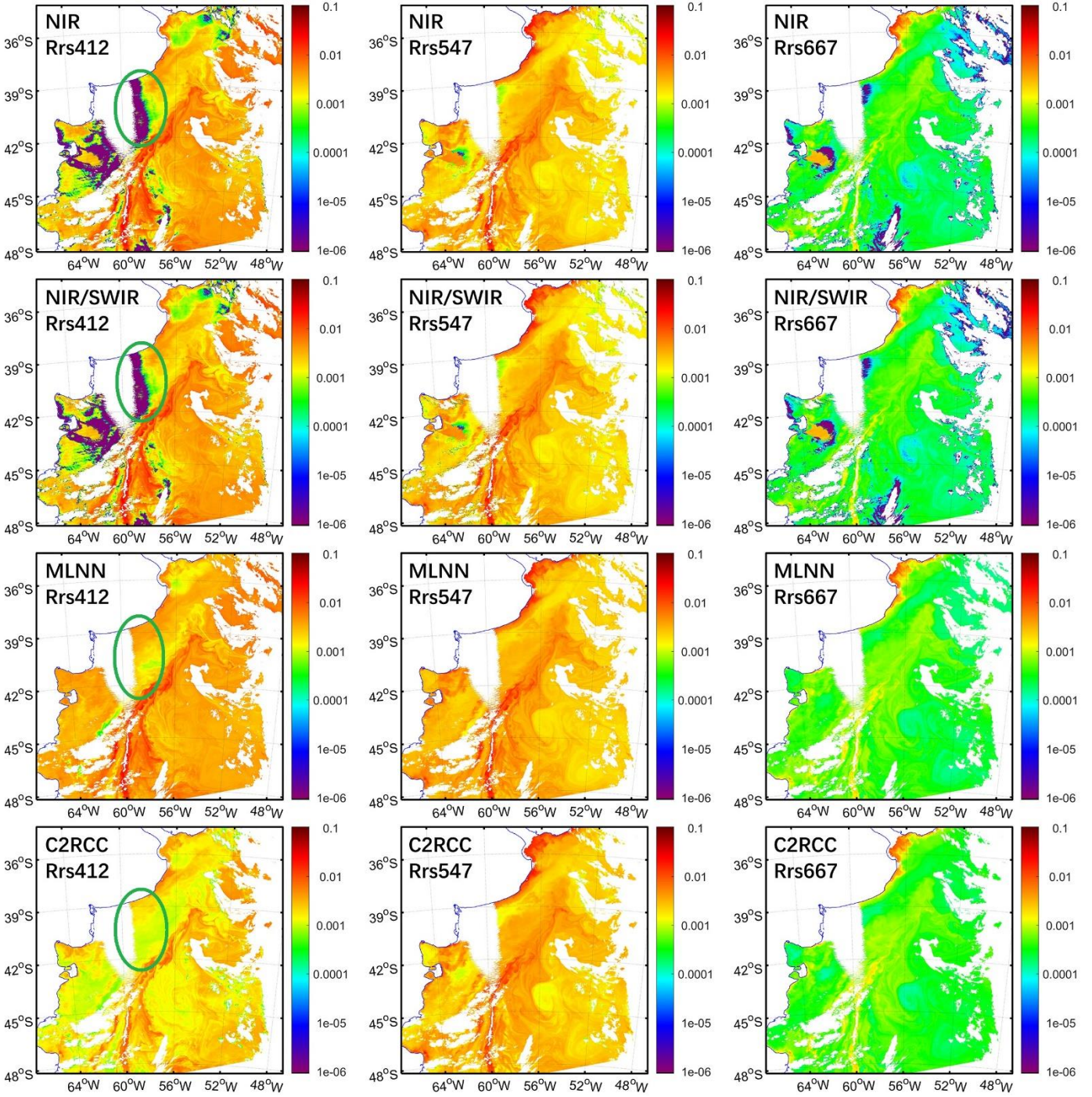
OC-SMART – MODIS image retrieval





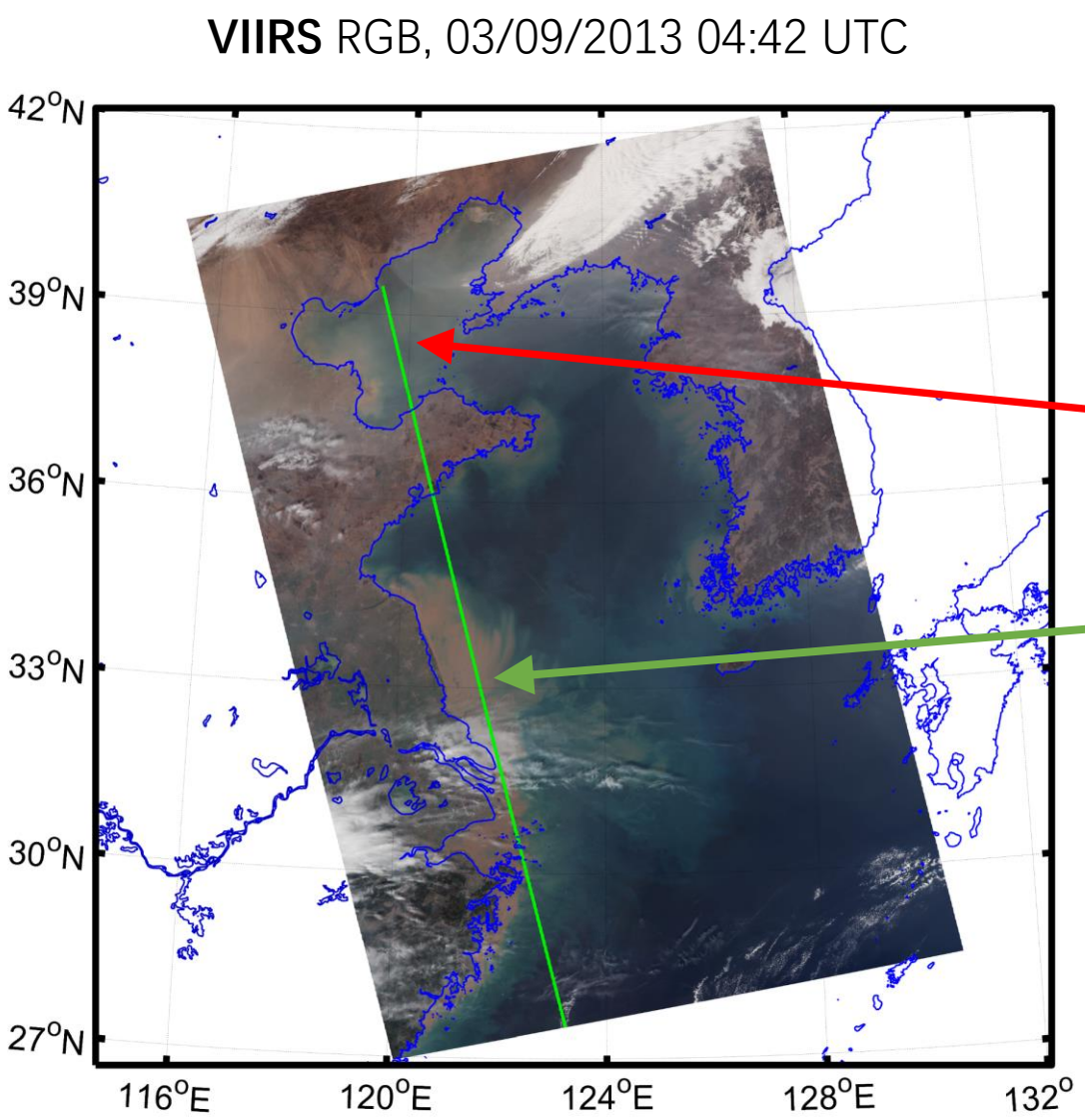
OC-SMART – MODIS image retrieval

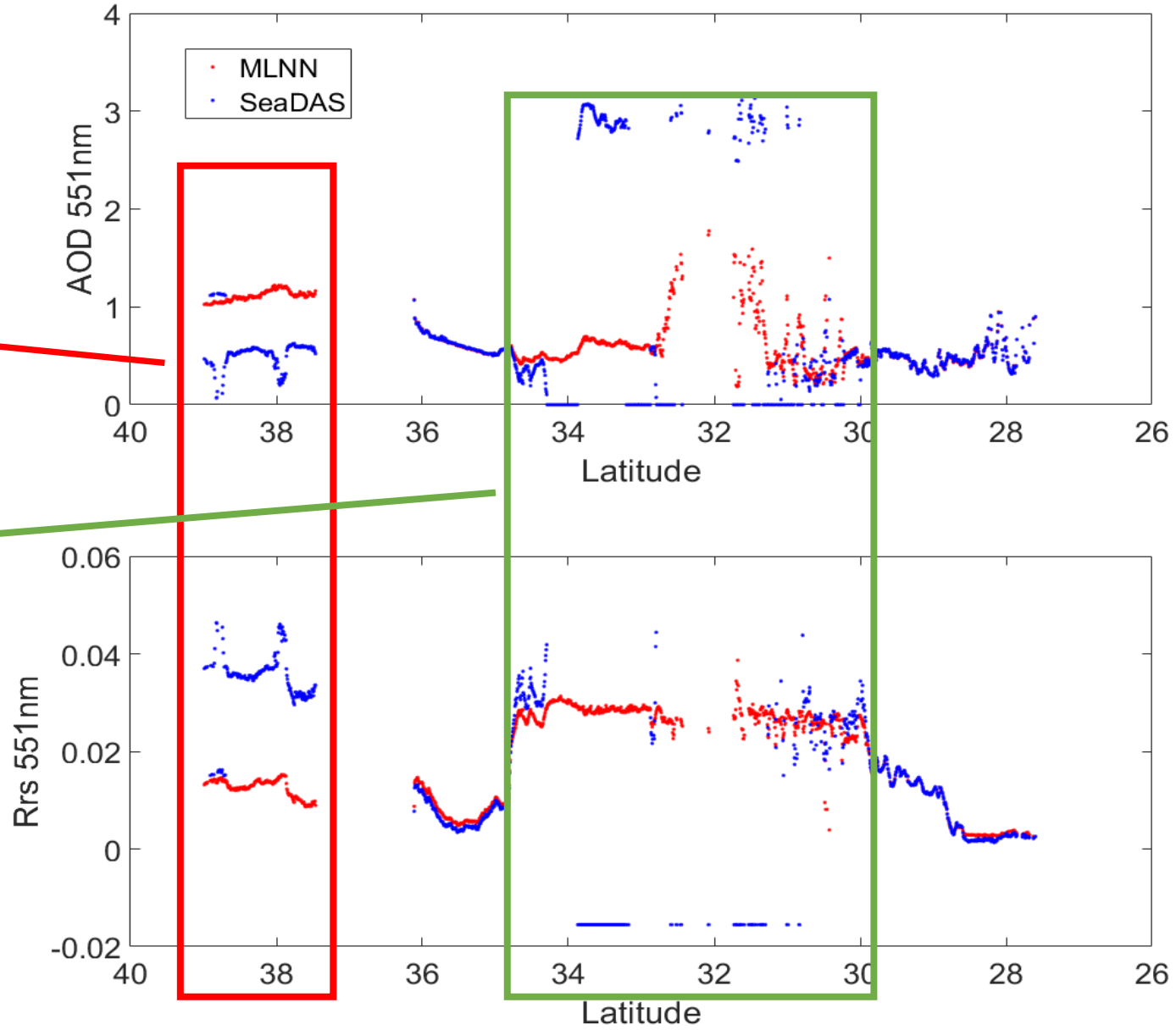




OC-SMART – VIIRS image retrieval (heavy aerosol and extremely turbid water)

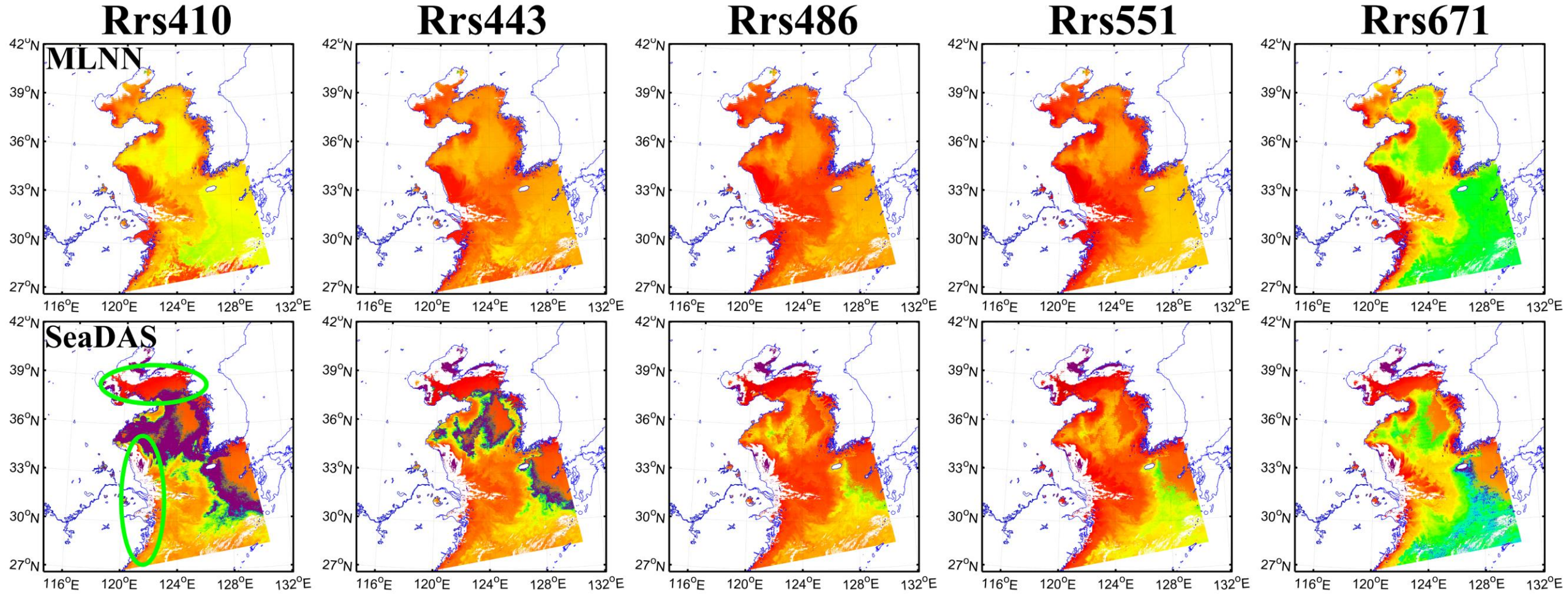
- OC-SMART is applicable to heavily polluted continental aerosols and extremely turbid water conditions.





OC-SMART – VIIRS image retrieval (heavy aerosol and extremely turbid water)

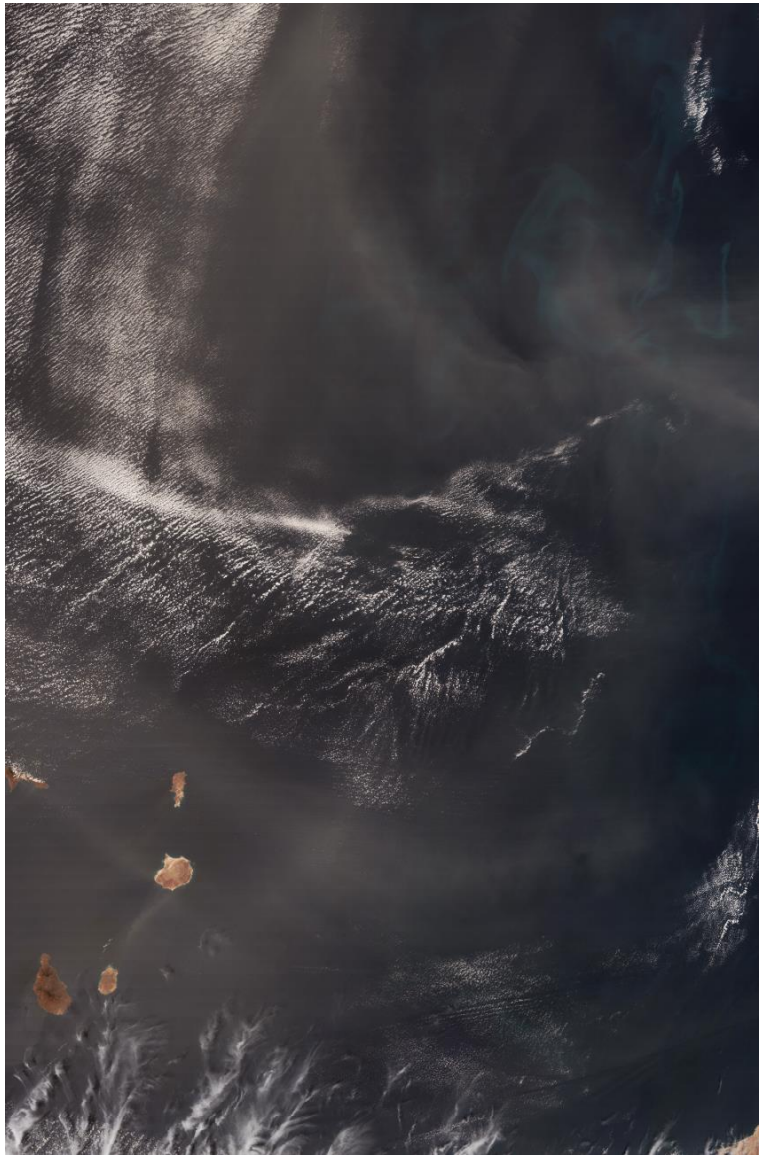
- OC-SMART significantly improves R_{rs} retrievals in areas with heavily polluted aerosols and turbid water. The standard SeaDAS algorithm produces a large number of **negative R_{rs} (purple color)** and **large areas with no retrievals**.



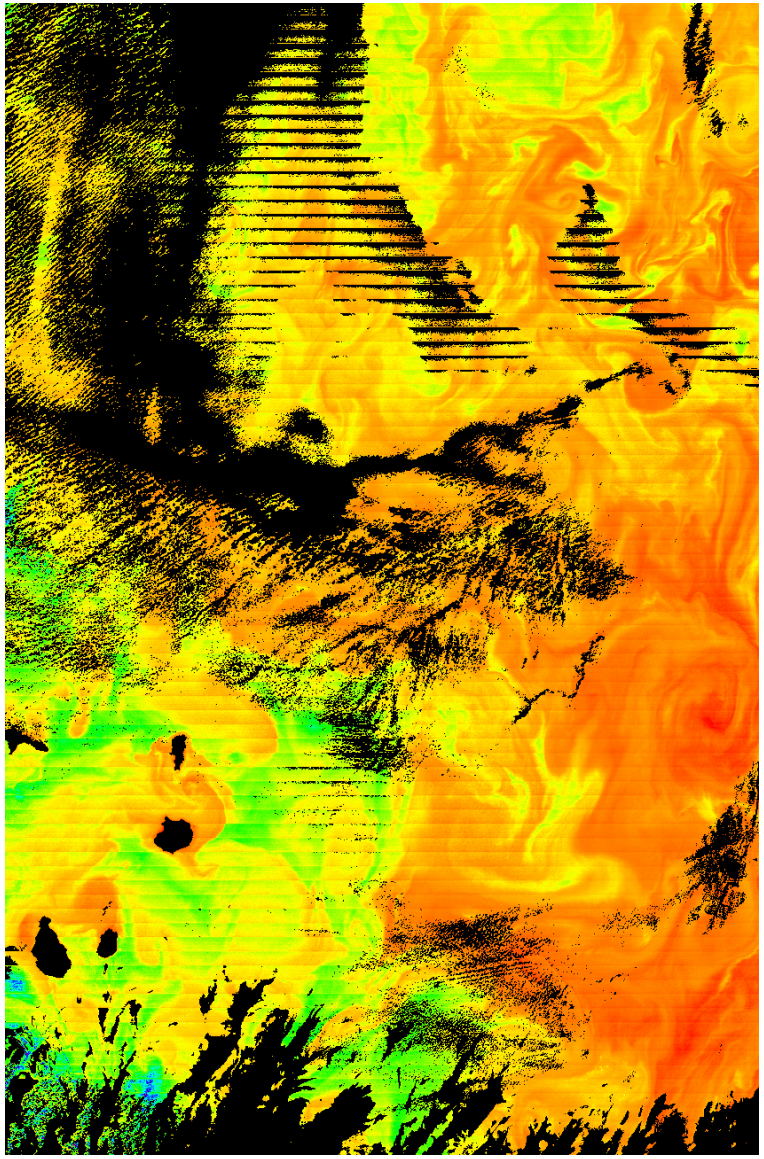
OC-SMART – VIIRS image retrieval (dust storm)

- OC-SMART better (than SeaDAS) reveals algal bloom patterns in the water under dust storm conditions.

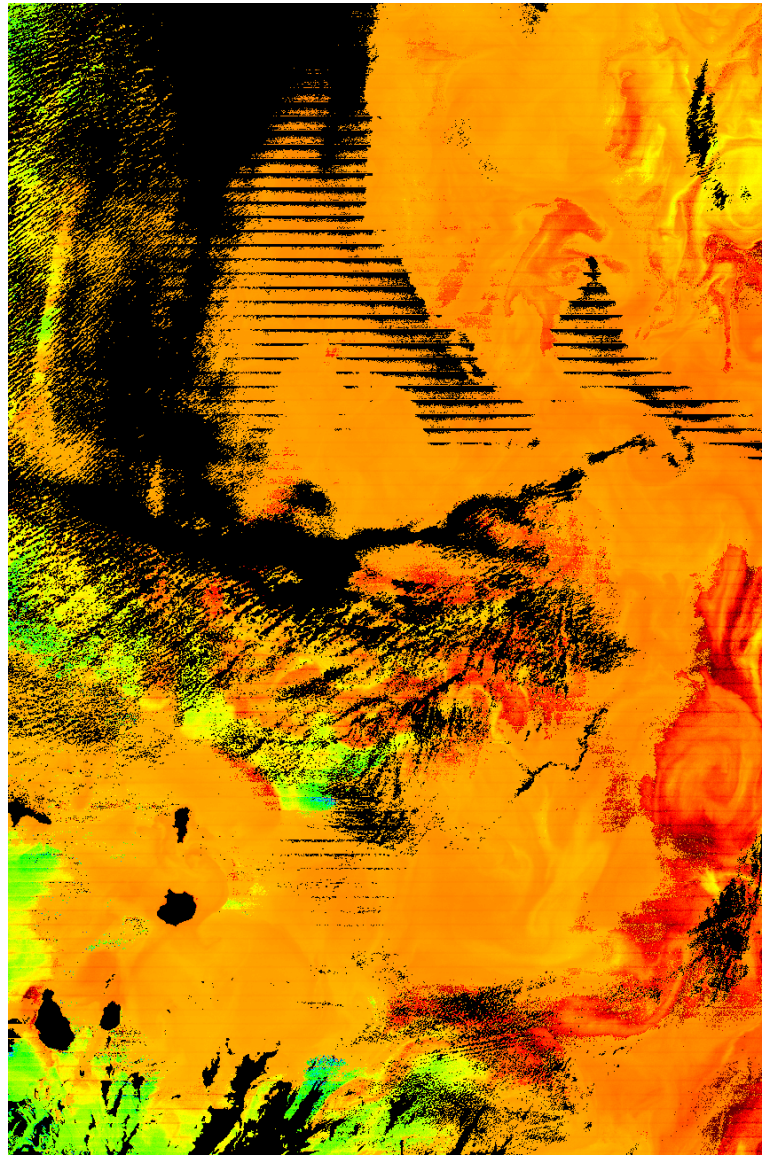
VIIRS RGB, 03/10/2015 14:48 UTC



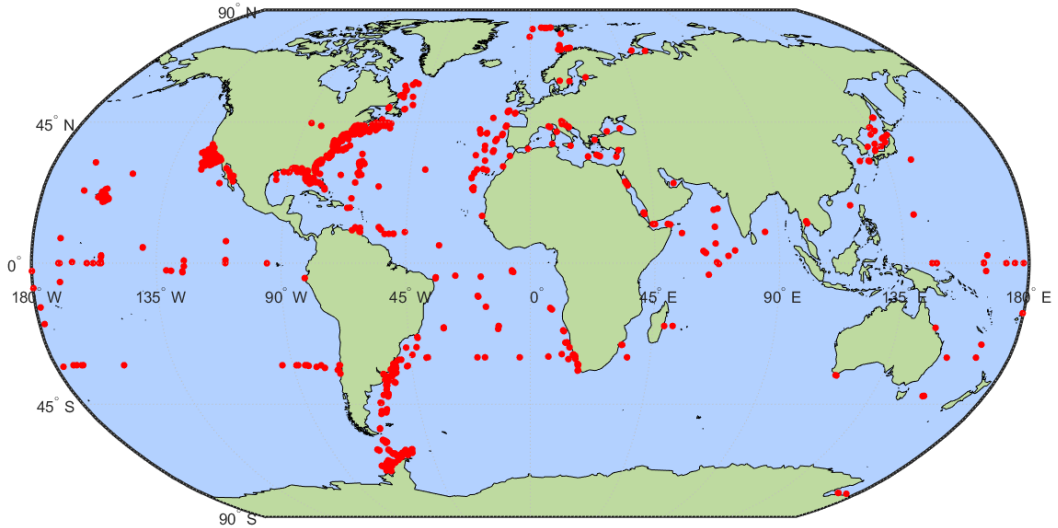
OCSMART CHLa

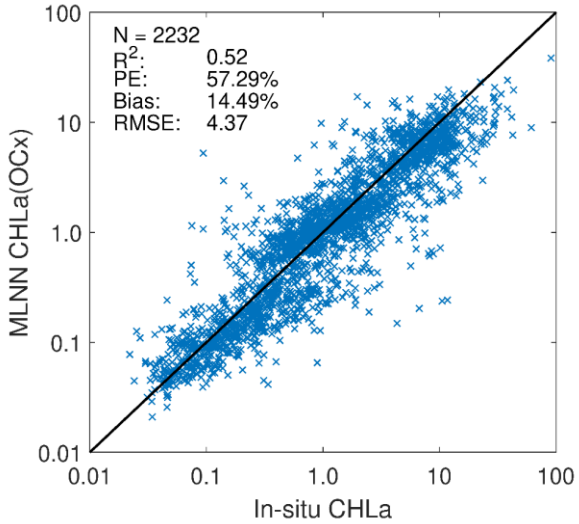


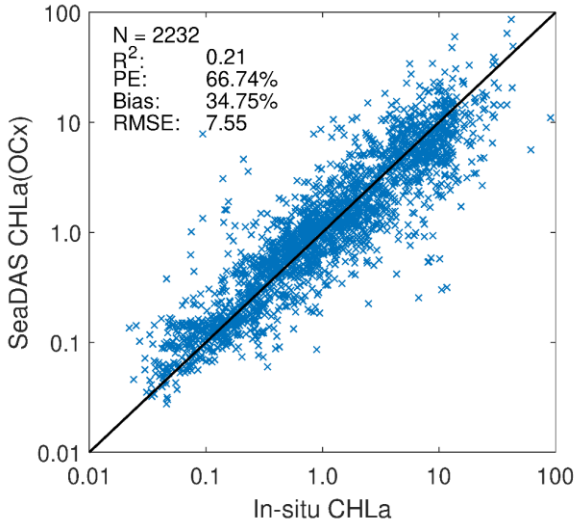
SeaDAS CHLa

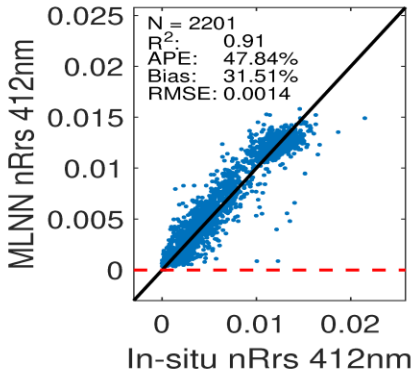


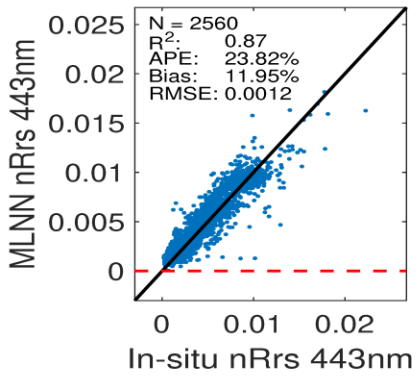
OC-SMART – Validation on SeaWiFS (1997-2010)

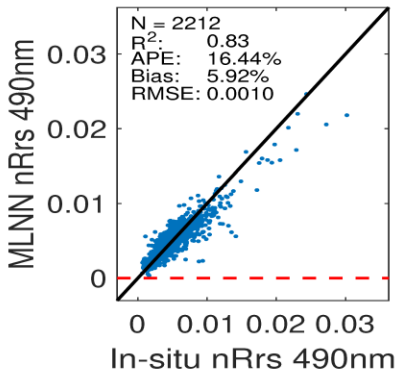


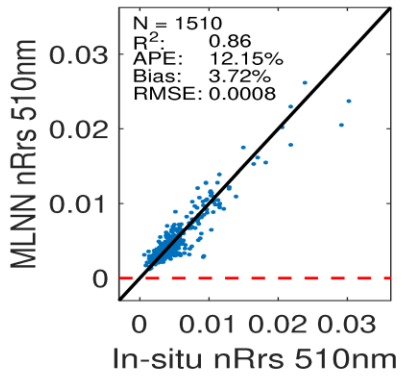


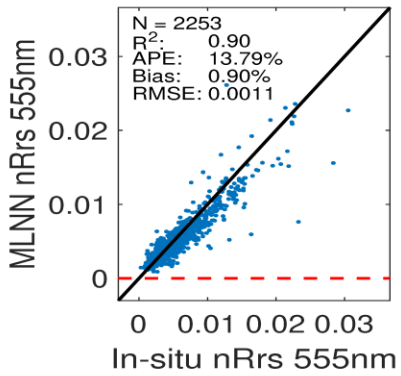


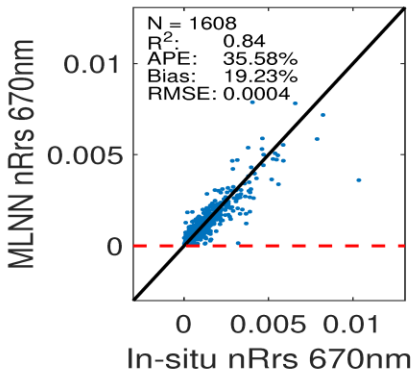


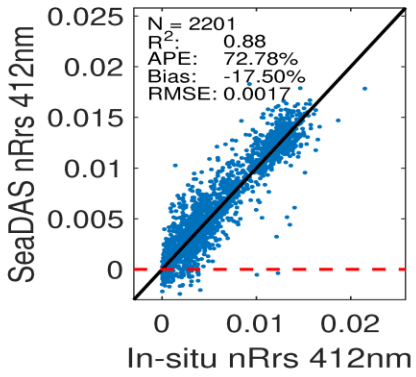


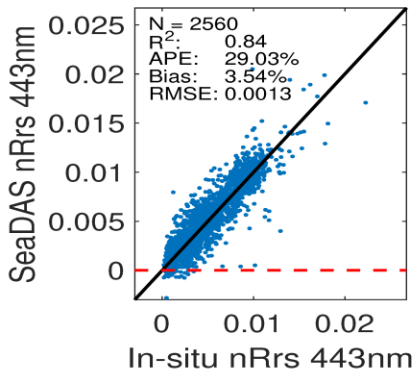


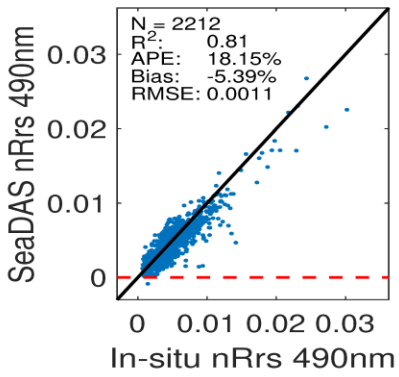


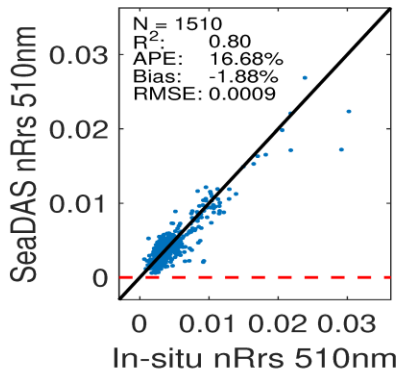


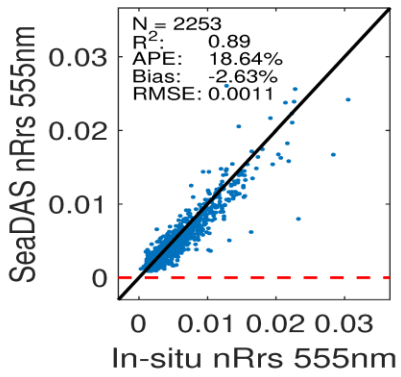


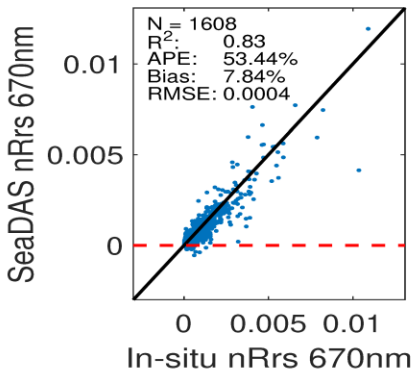




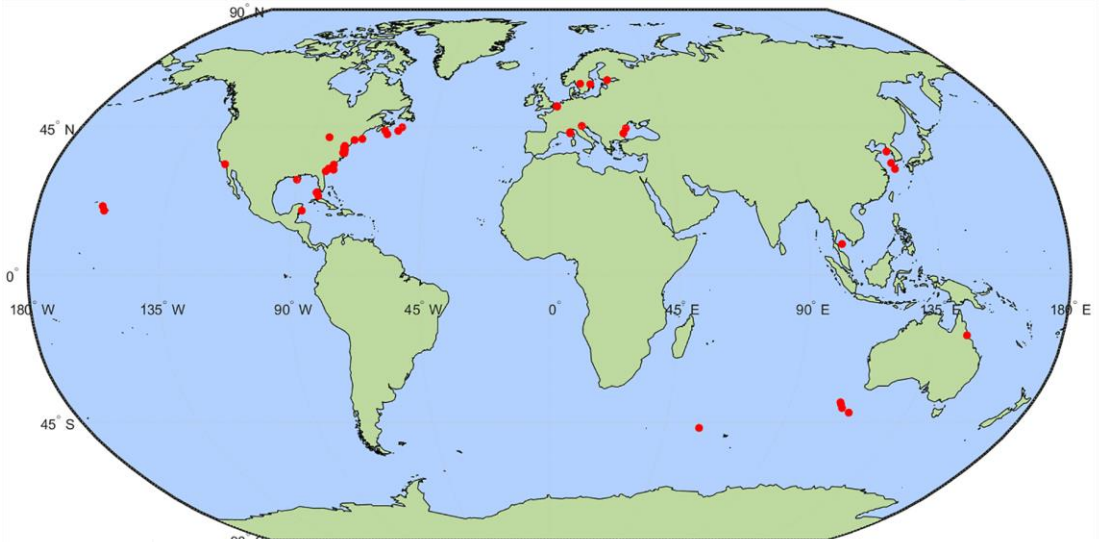


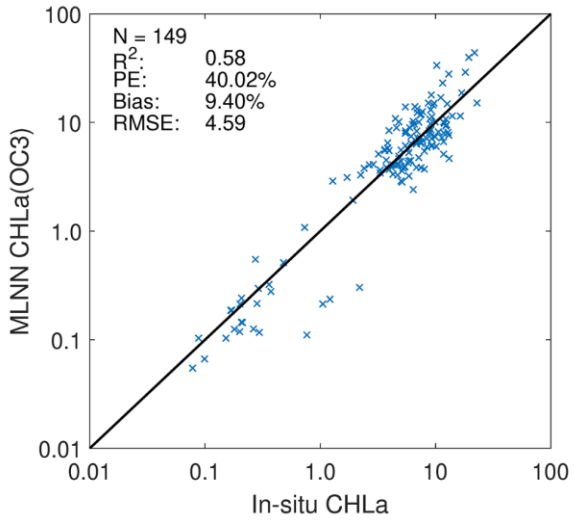


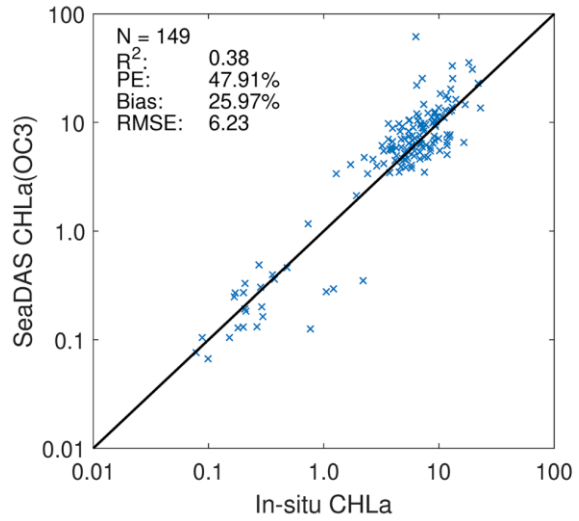


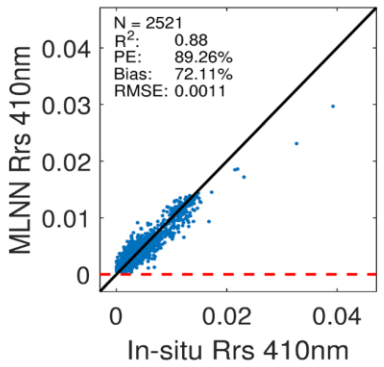


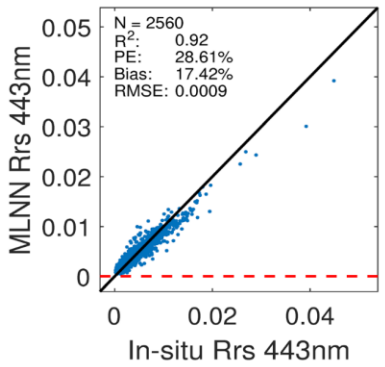
OC-SMART – Validation on VIIRS (2012-2017)

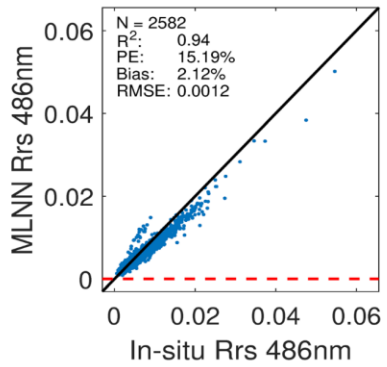


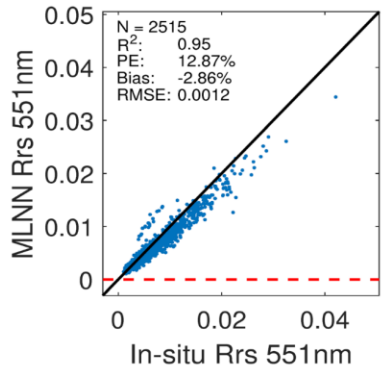


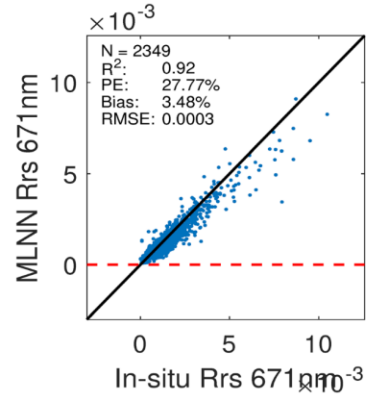


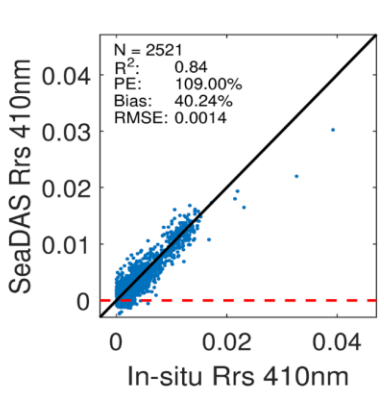


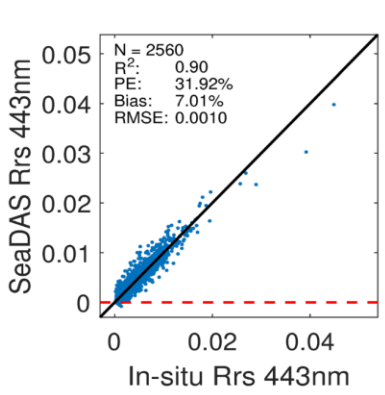


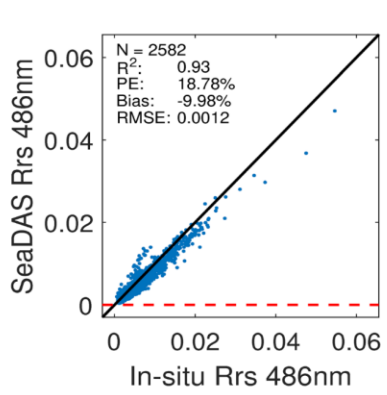


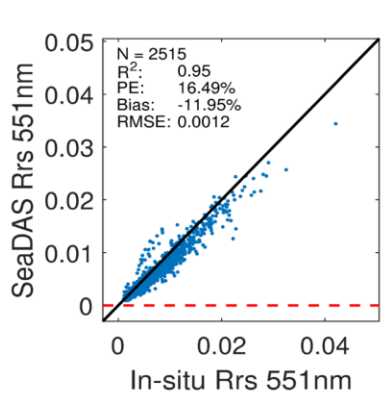


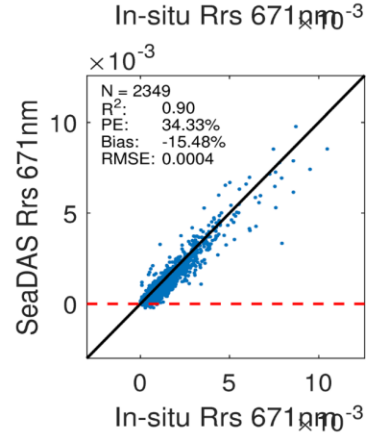












Summary

- OC-SMART, a new satellite remote sensing image analysis tool, based on **coupled atmosphere-ocean radiative transfer simulations** and **multilayer neural network** (MLNN) techniques has been developed and validated for several OC sensors based on global field measurements.
- OC-SMART is **applicable in both open ocean and coastal/inland water** areas.
- OC-SMART has **superior cloud screening over water** areas based on machine learning method.
- OC-SMART **completely eliminates the negative remote sensing reflectance issue** which plagues many other AC algorithms.
- OC-SMART **improves retrievals of normalized remote sensing reflectances (nR_{rs})** compared to the SeaDAS NIR algorithm.
- OC-SMART **improves data quality of derived products**, such as CHLa, because of the improved nR_{rs} retrievals.
- OC-SMART is **applicable to heavy aerosol and extremely turbid water conditions** and is **resilient to sunglint and adjacency effects** from bright targets.
- OC-SMART **does not require data from SWIR bands**, and is therefore applicable to all ocean color sensors. In fact, we have already developed algorithms for **MODIS, VIIRS, SeaWiFS, Sentinel-3 OLCI, and GOCI**. OC-SMART algorithms for **Sentinel-2 MSI, Landsat-8 OLI, DSCOVR EPIC** and **JAXA GCOM-C SGLI** sensor are under development.
- OC-SMART is **very fast (7 times faster than SeaDAS) and suitable for operational use**. We are developing plugins of OC-SMART for the ESA SNAP platform.

Reference:

- Y. Fan, W. Li, C. K. Gatebe, C. Jamet, G. Zibordi, T. Schroeder and K. Stamnes, "Atmospheric correction over coastal waters using multilayer neural networks", Remote Sensing of Environment, Vol. 199, p218-240, (2017). DOI: 10.1016/j.rse.2017.07.016.
- N. Chen, W. Li, C. Gatebe, T. Tanikawa, M. Hori, R. Shimada, T. Aoki, & K. Stamnes, "New cloud mask algorithm based on machine learning methods and radiative transfer simulations", Remote Sensing of Environment, Vol. 219, p62-71, (2018).

Thank you!

Questions?