Retrieving chlorophyll concentration from GOES-R advanced baseline imager using deep learning

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Motivation

- Ocean color

  Higher spectral, spatial, temporal resolutions

- Geostationary ocean color

  GOCI, launched 2010; GOCI-II, launched 2020 South Korea

  GEOCAPE, launch date TBD USA

- Geostationary weather satellites
  - Advanced Himawari Imager (AHI) / Himawari-8 Japan [*Murakami*, 2016]

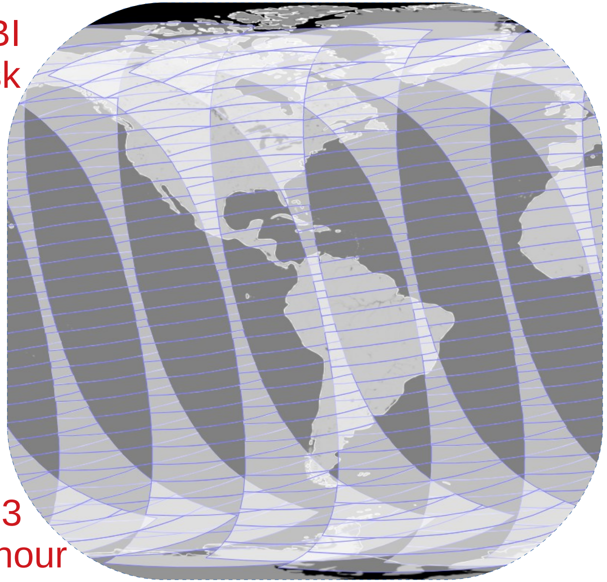
    470 nm 510 nm 640 nm
  - Advanced Baseline Imager (ABI) / GOES-R USA

    470 nm 640 nm

Matchup ABI with VIIRS

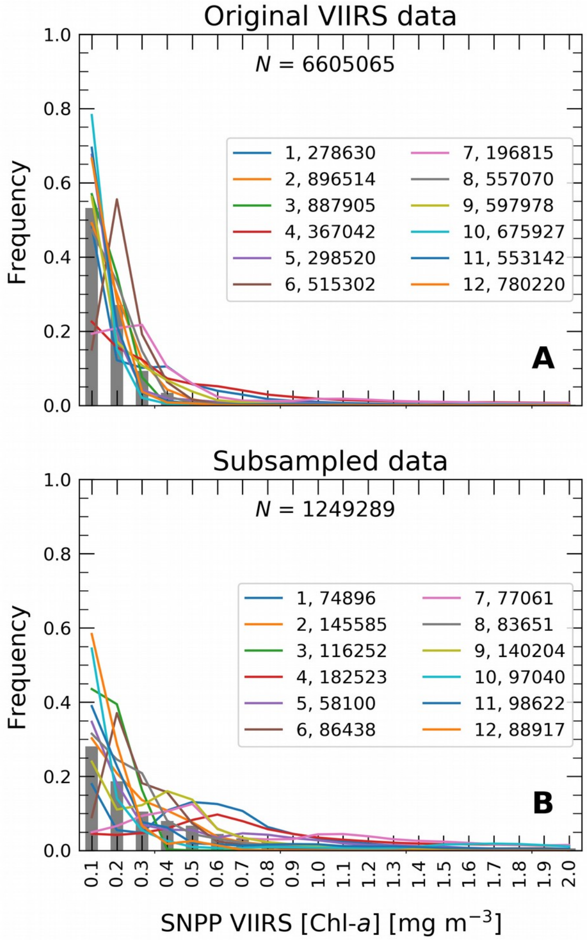
- Selected Jan 21 – Dec 21, 12 days in 2018
- ±2 hours, cloud masked
- Subsampled to have more balanced [Chl-*a*] distribution

ABI
Full Disk

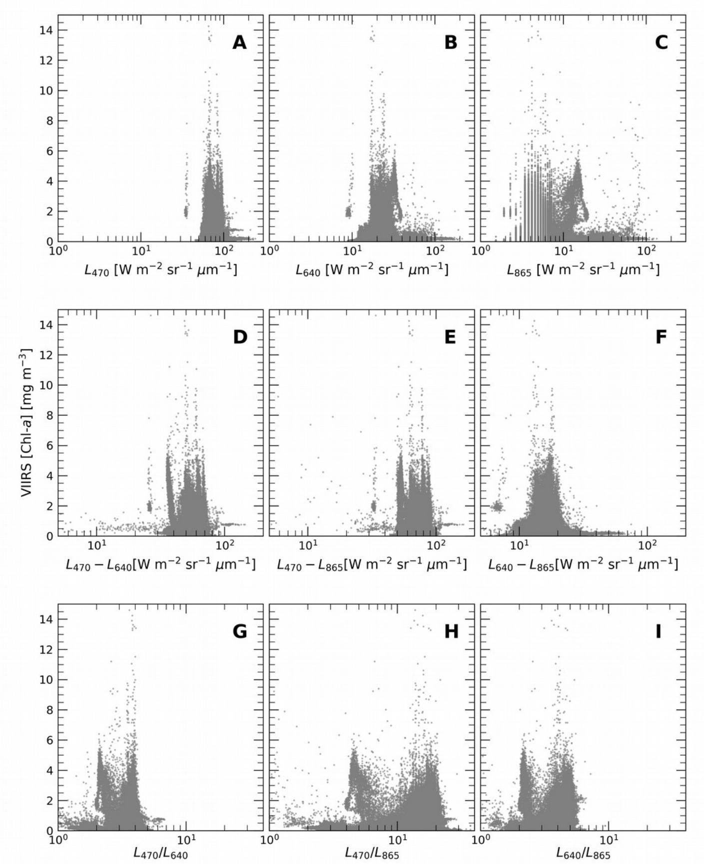


VIIRS
~1:30 pm
equator
crossing

Mode 3
4 scans/hour

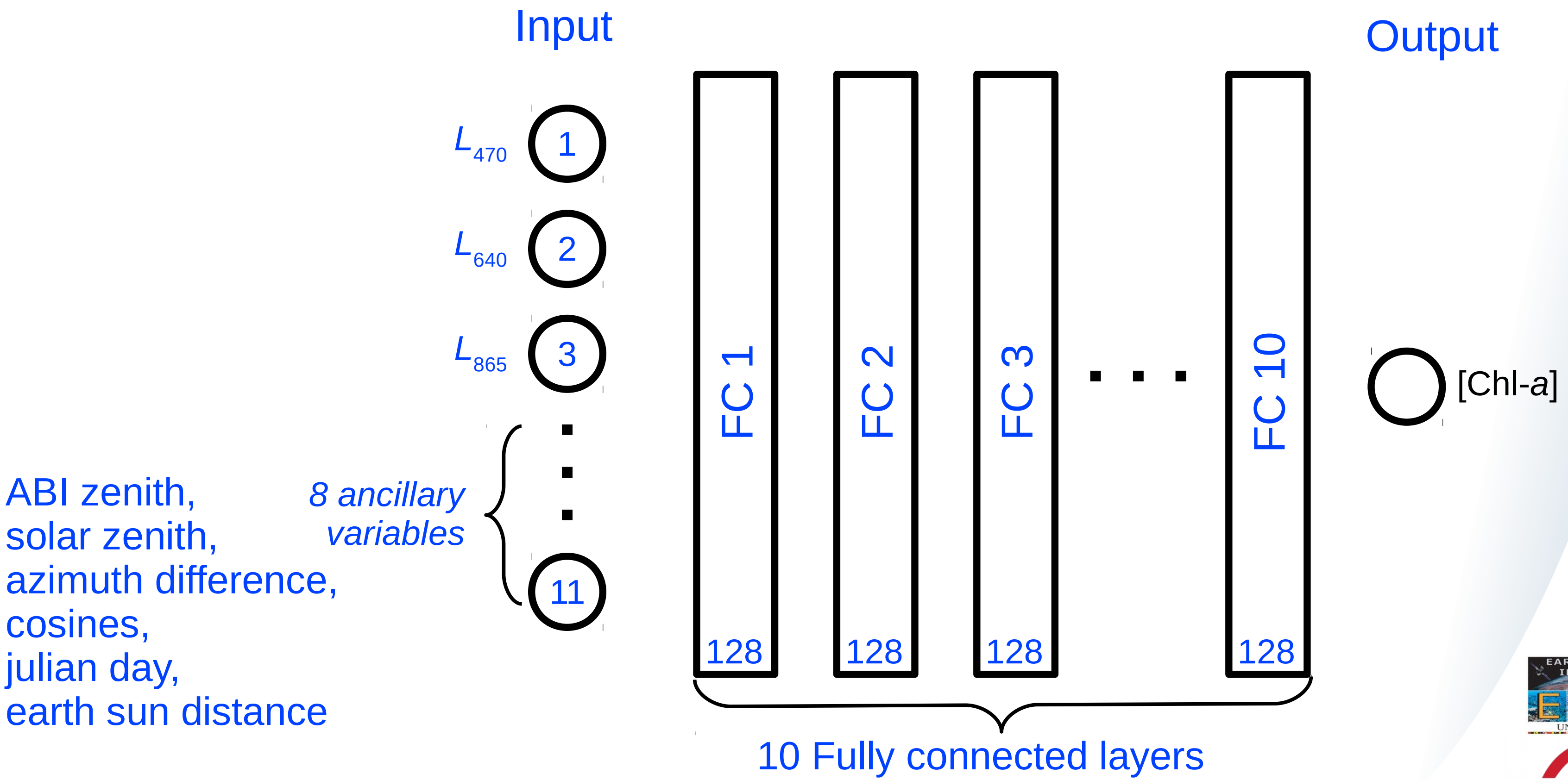


Raw ABI Data vs. VIIRS-derived [Chl-*a*]

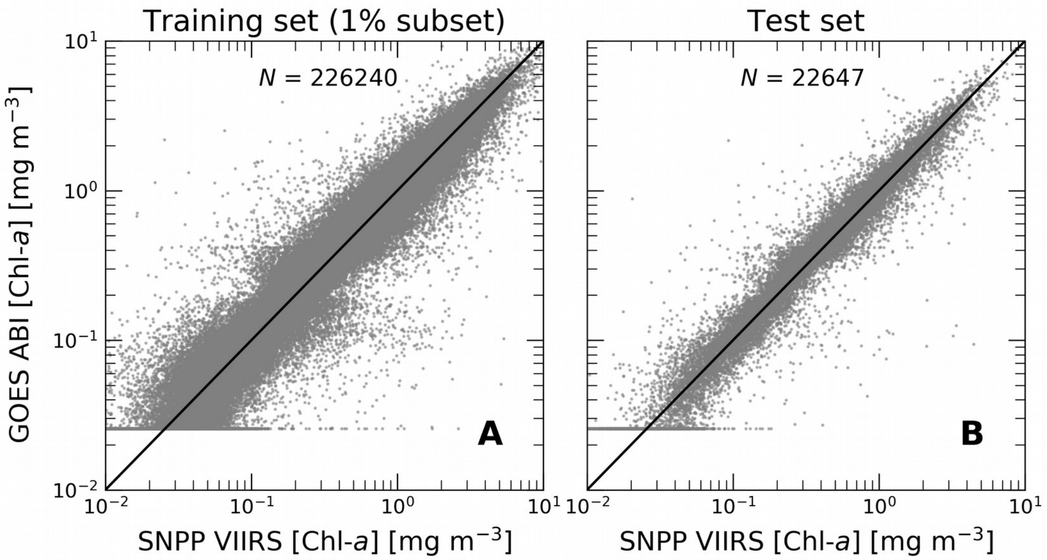


- No atmospheric correction applied on ABI radiance data
- No visible correlation between ABI bands and VIIRS [Chl-*a*] values

Model Architecture



ABI- vs. VIIRS-derived [Chl-*a*]

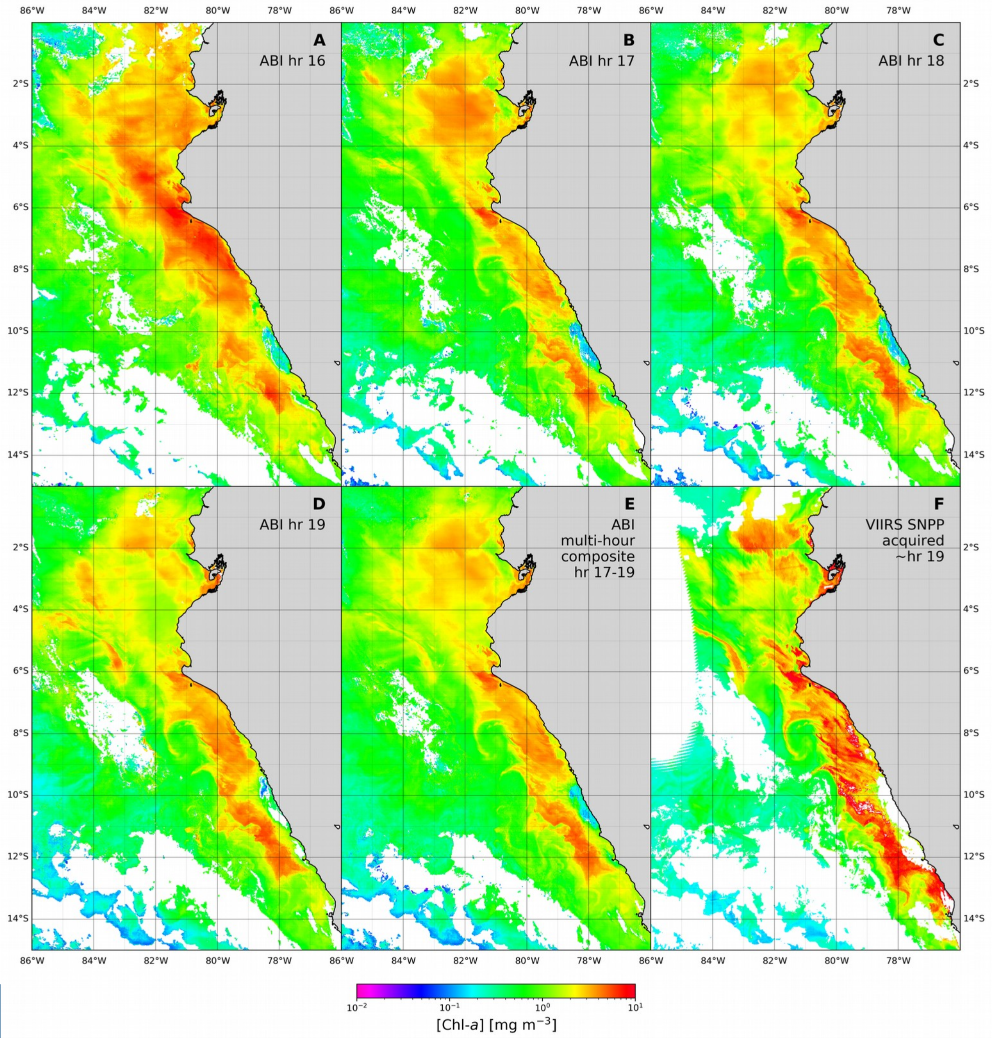


- Good agreement
- Artifact at very low [Chl-*a*] values (<0.03 mg m^{-3})

Dataset	*RMSE* mg m^{-3}	R^2	Slope	*MAE* mg m^{-3}	*MAPE*	Bias mg m^{-3}	Log-*MAE*	Log-Bias	*N*
Training	0.249	0.890	0.917	0.0987	22.90	0.0118	1.218	1.038	22624044
Test	0.247	0.891	0.933	0.101	23.14	0.0131	1.220	1.036	22647

ABI Hourly composite

Chilean coastal upwelling



- Hours around local noon agree better with VIIRS
- Magnitude is underestimated but spatial features are well preserved
- Improved data coverage than VIIRS

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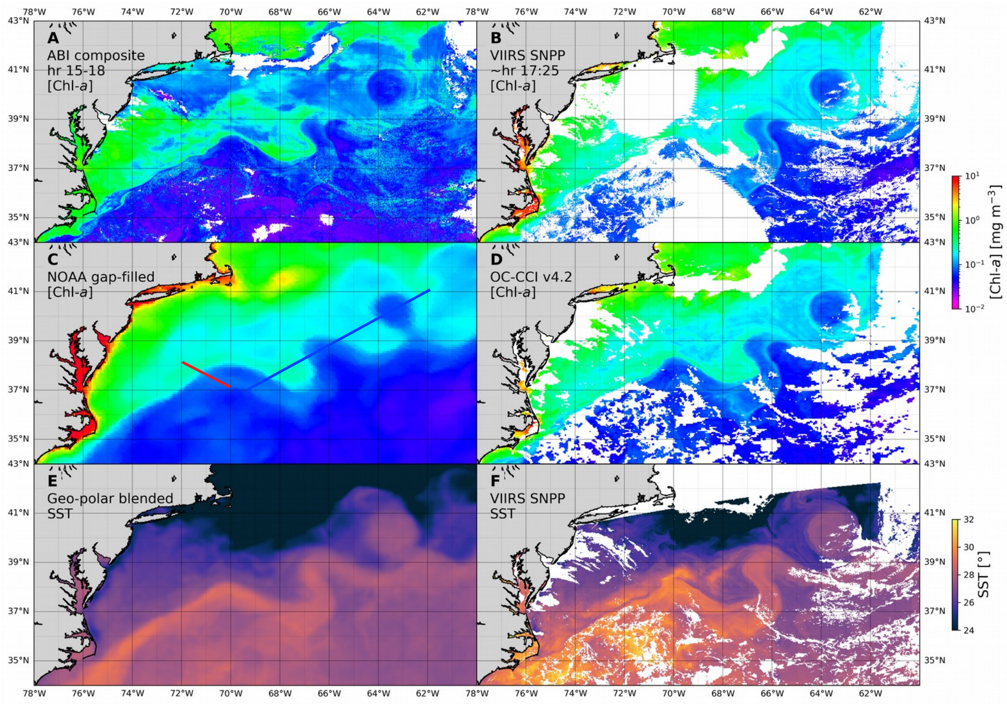
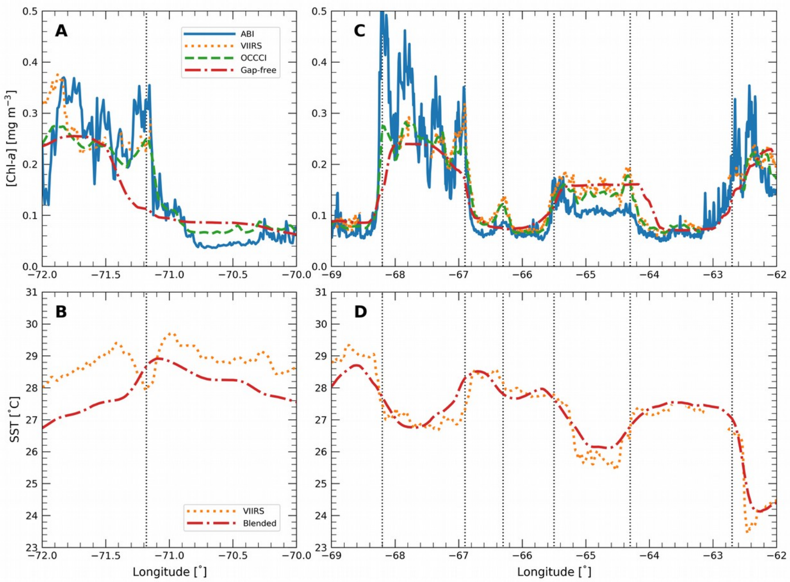
Comparison with [Chl-*a*] and SST products

Gulf Stream



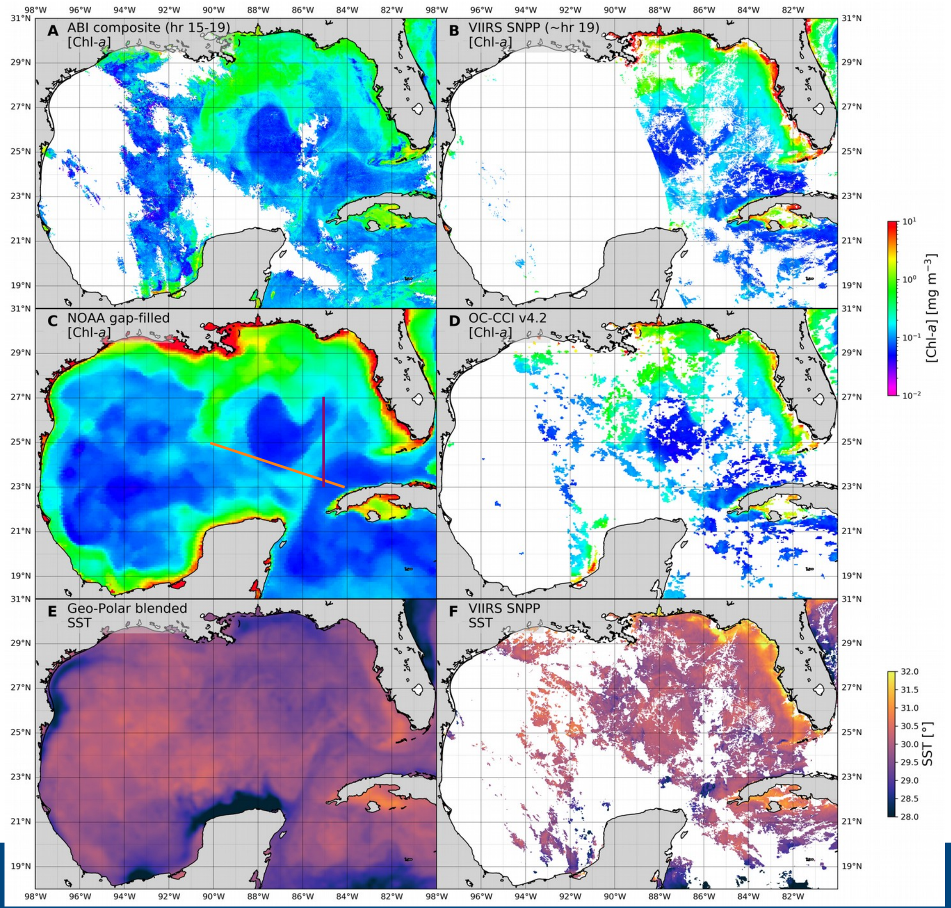
Transect Transect



- Front detection: ABI agrees with VIIRS and OC-CCI
- Gap-free [Chl-*a*] and SST data captures general but not detailed features

Comparison with [Chl-*a*] and SST products

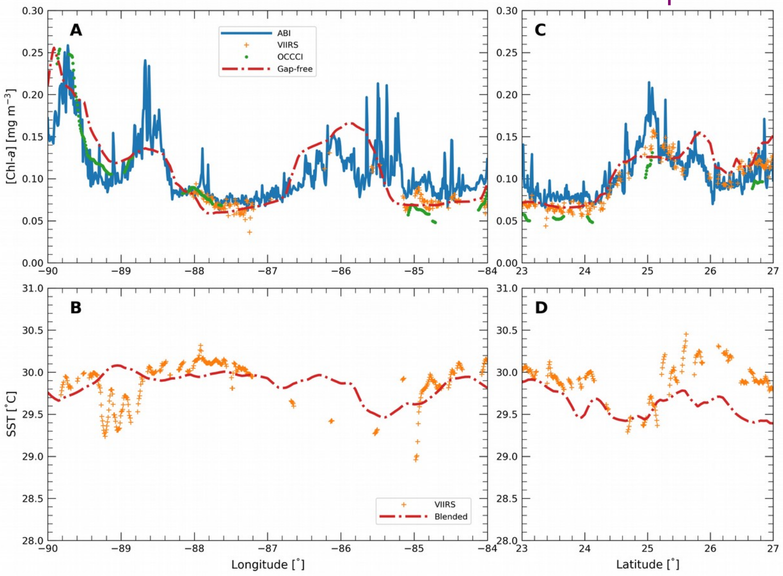
Gulf of Mexico



- Small SST but large [Chl-*a*] gradients
- Extended state of Loop Current

Transect

Transect



Summary

- We demonstrated the proof-of-concept to retrieve [Chl-*a*] for the open oceans using GOES-R ABI which was previously considered unfit for ocean color applications owing to the lack of a green band.

- The deep learning model is good at frontal feature detection although the input radiance data were not processed with any atmospheric correction. This suggests that deep learning can recognize subtle patterns barely perceptible to the human eye.

- Deep learning is a powerful tool to take into account a diverse set of input variables that are difficult for human to handle simultaneously. In this case, radiances, sun-sensor geometry, and julian day.

- Next steps: Add ancillary data being used for atmospheric correction. Detection of “bad” pixels.

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NOAA STAR Ocean Color Science Team

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