

# Swell direction impact to satellite derived sea surface winds

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**National Environmental  
Satellite, Data, and Information  
Service**

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# Motivation

- It has been shown that the presence of swell can impact L-band radiometer and GNSS-R signals (e.g. SMAP, CyGNSS)
- Above observation mostly focused on significant waveheight impact (from full spectrum)
- This time, interested in swell directional impact, including its significant waveheight and peak period properties, to selected radiometer and scatterometer retrieved wind speed



# Dataset general information

Dataset	Grid size	Time period
SMAP JPL v5.0	25 km	2017 Jan-2020 Dec
SMAP JPL v5.3.4	25 km	2019 Jan-2020 Dec
SMAP RSS	.25 deg	2017 Jan-2020 Dec
AMSR 2 NOAA	10 km	2017 Jan-2019 Dec
AMSR2 RSS	.25 deg	2017 Jan-2020 Dec
ASCAT NOAA	25 km	2017 Jan-2020 Dec

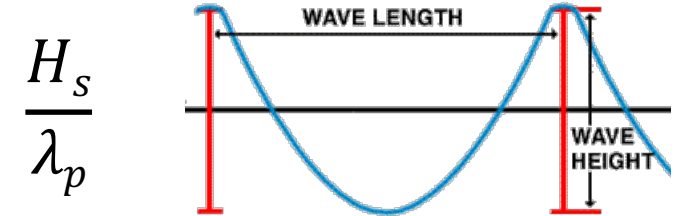
- 0.5°/3 hourly IFREMER implementation of Wavewatch III model bilinearly interpolated to each dataset
  - *'first swell'* direction
  - *'first swell'* significant waveheight
  - *'first swell'* peak period
- 0.25°/6 hourly ECMWF forecast\* u/v components bilinearly interpolated to each dataset

\*used as input wind forcing to IFREMER WW3

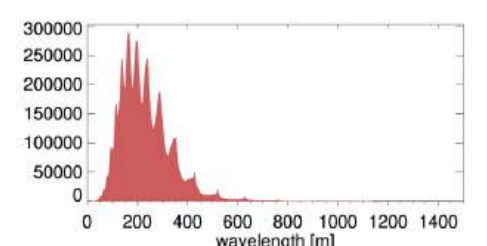
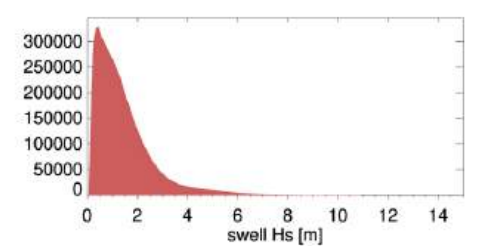
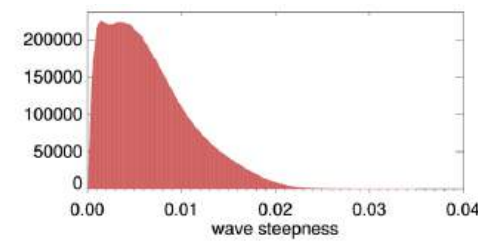
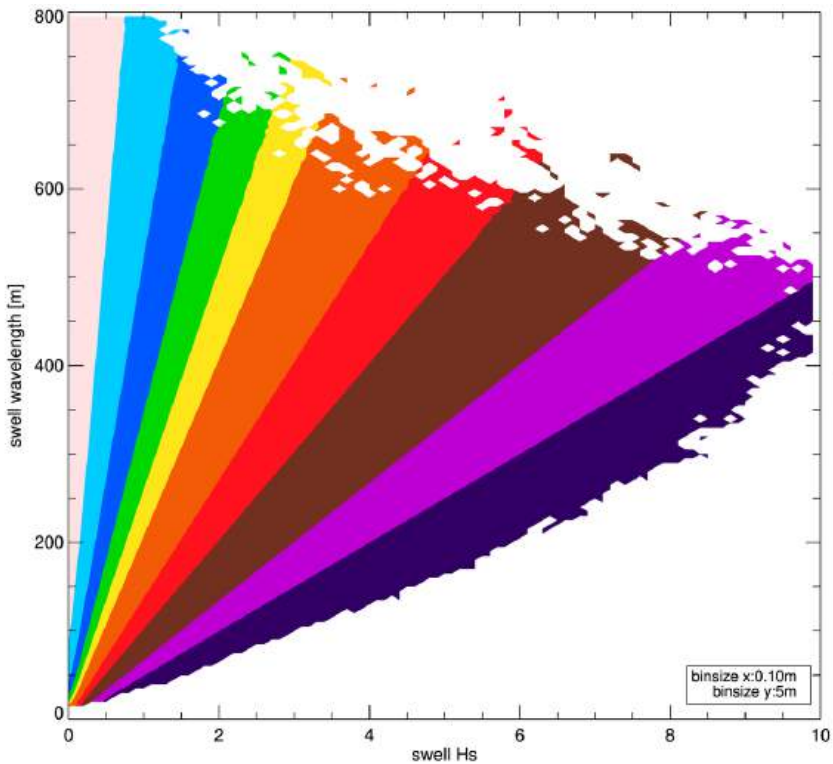


# The use of spectral wave steepness

Instead of generating hundreds of plots for different  $H_s$ , and peak period, wave steepness parameter can be used as it encompasses these.



Source: <https://www.ndbc.noaa.gov/education/waves.shtml>



IFREMER product does not provide peak wavelength, only peak period.

Used dispersion relation of deep ocean waves to derive peak wavelength

$$\lambda = \frac{g}{2\pi} T^2 \tanh\left(2\pi \frac{h}{\lambda}\right) \sim \frac{g}{2\pi} T^2 \sim 1.5T^2$$

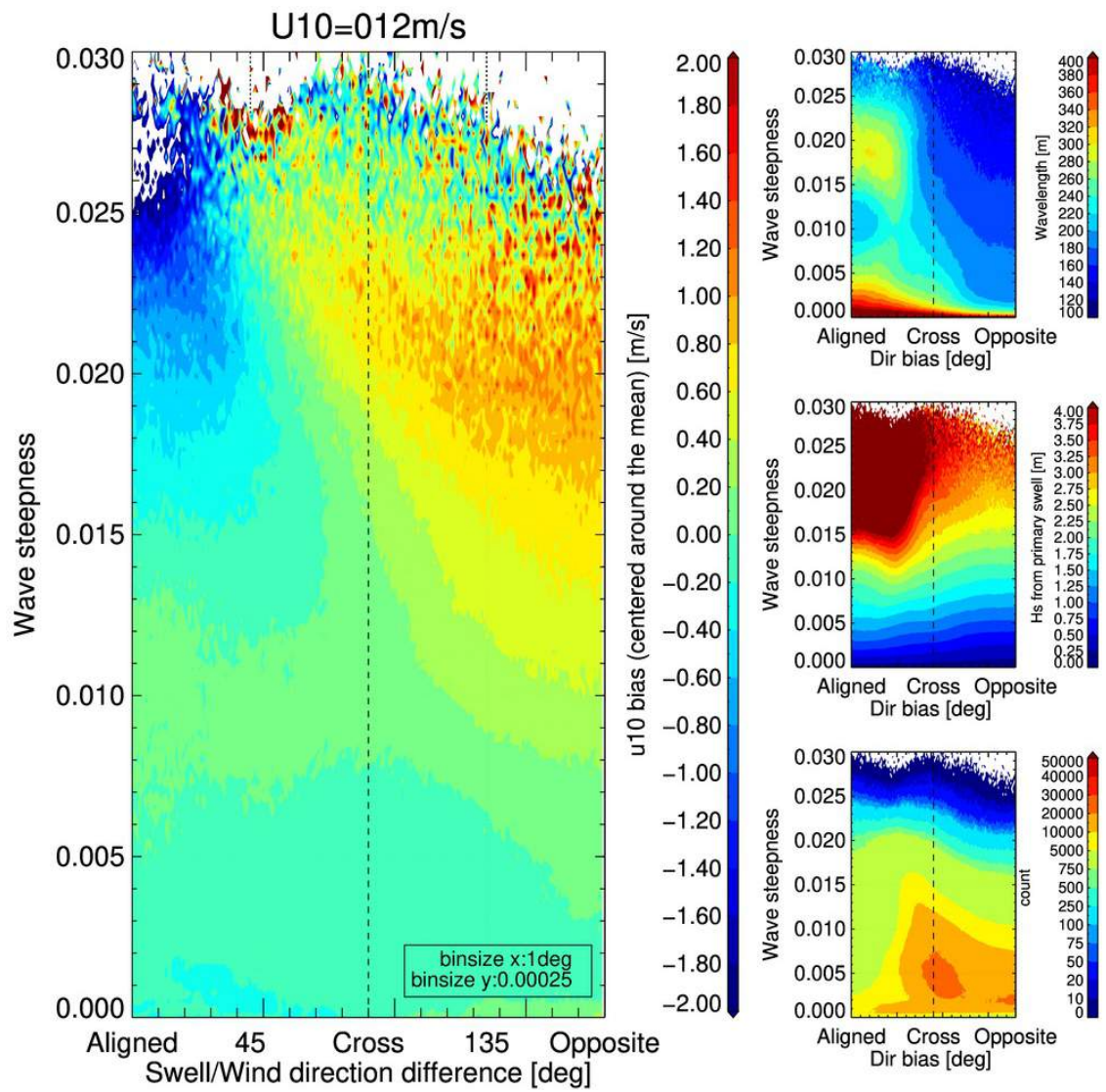
~1 in deep ocean



# Wind speed bias as a function of wave steepness and swell/wind direction difference

Time period: 20170101-20201231 | collocated model wind speed fixed at 12 m/s +/- 1m/s

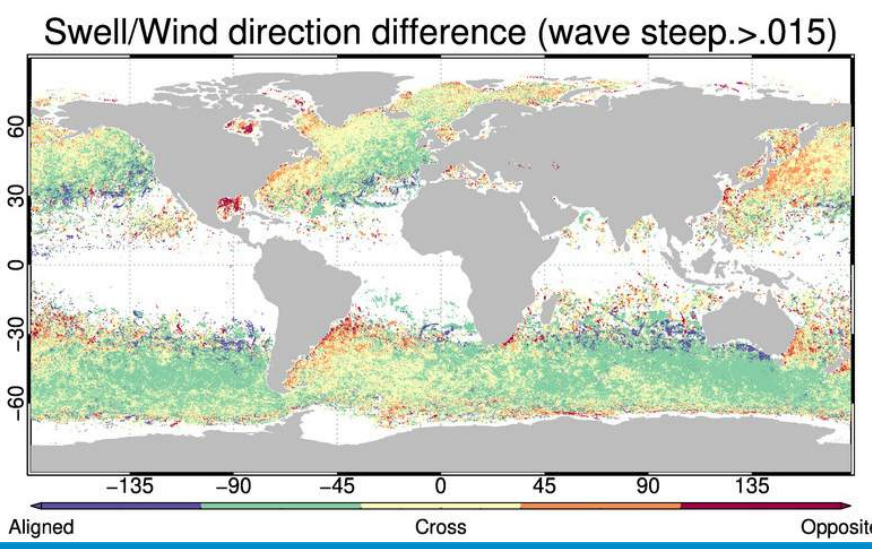
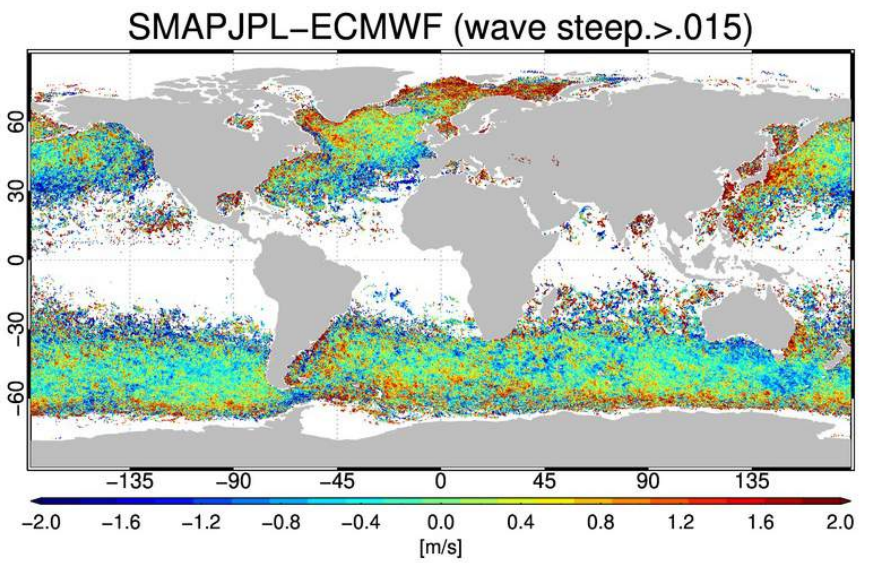
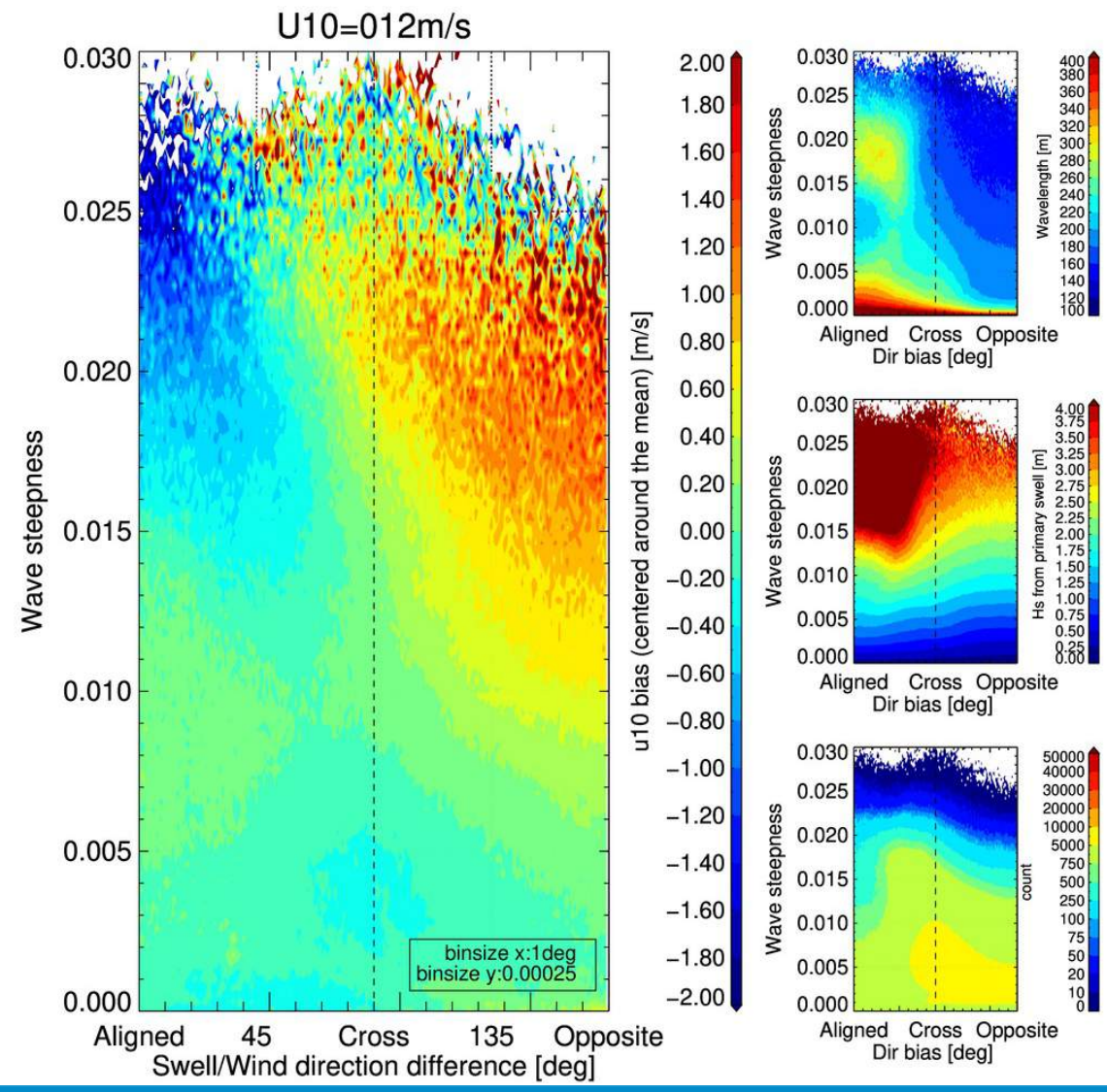
ASCAT25NOAA



# Wind speed bias as a function of wave steepness and swell/wind direction difference

Time period: 20170101-20201219 | collocated model wind speed fixed at 12 m/s +/- 1m/s

SMAPJPL

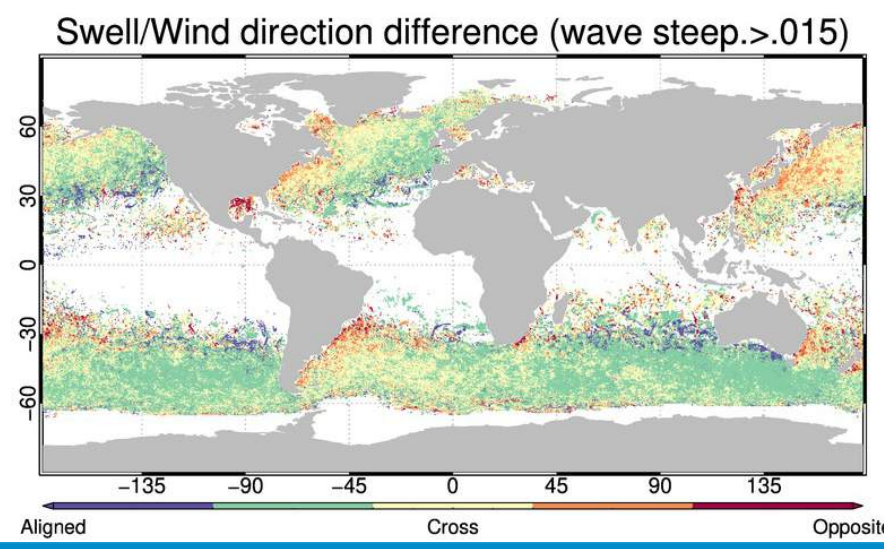
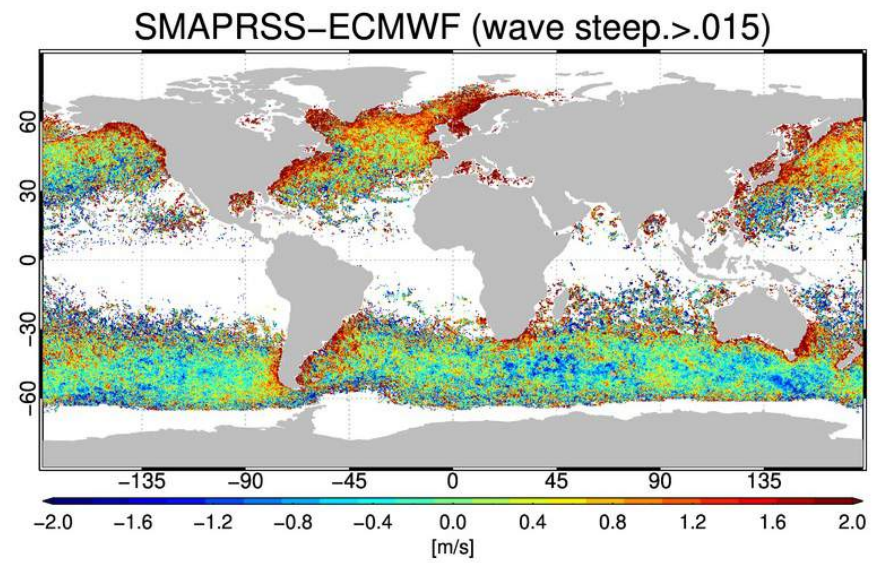
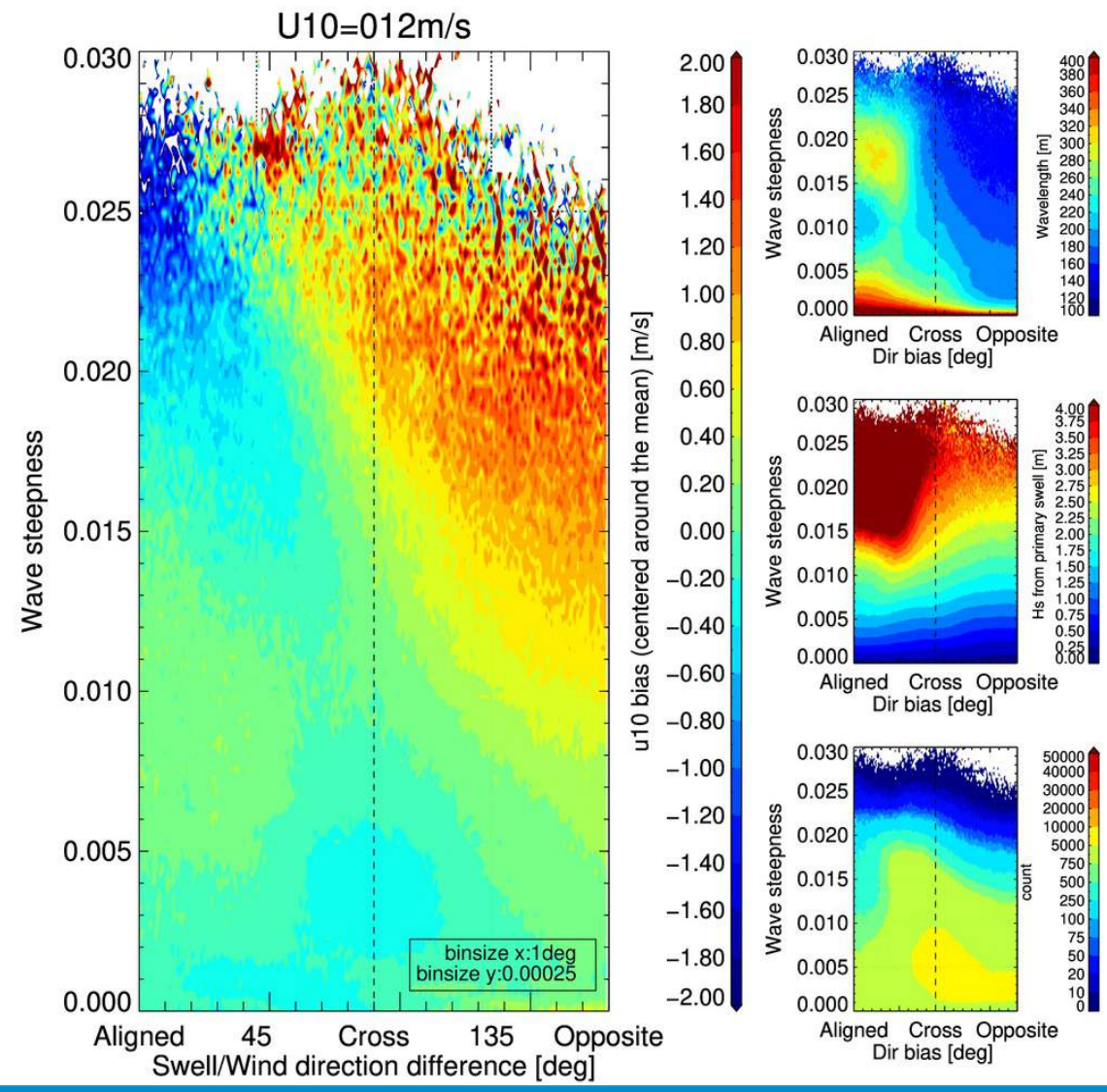




# Wind speed bias as a function of wave steepness and swell/wind direction difference

Time period: 20170101-20201219 | collocated model wind speed fixed at 12 m/s +/- 1m/s

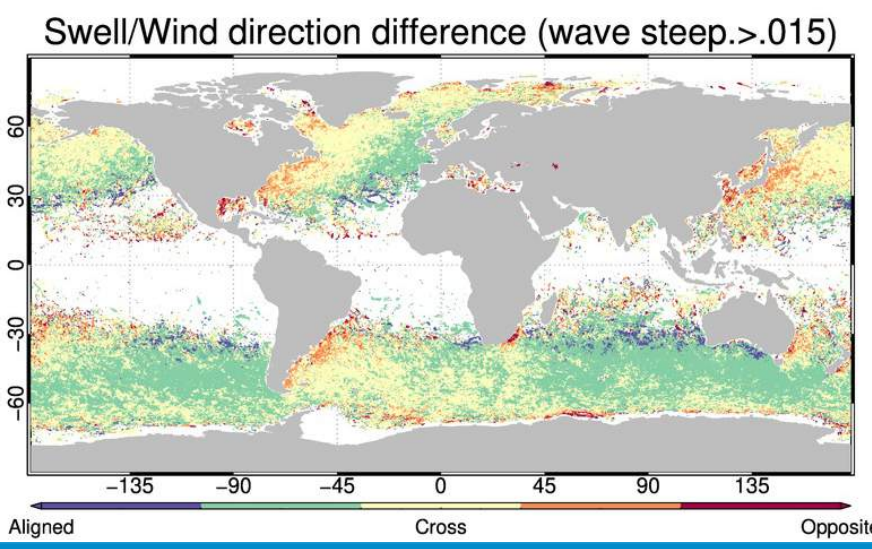
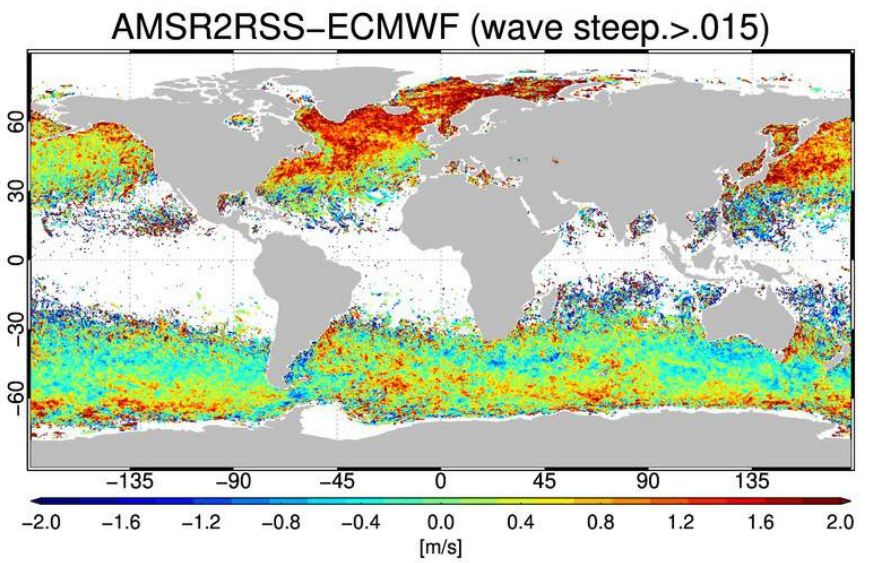
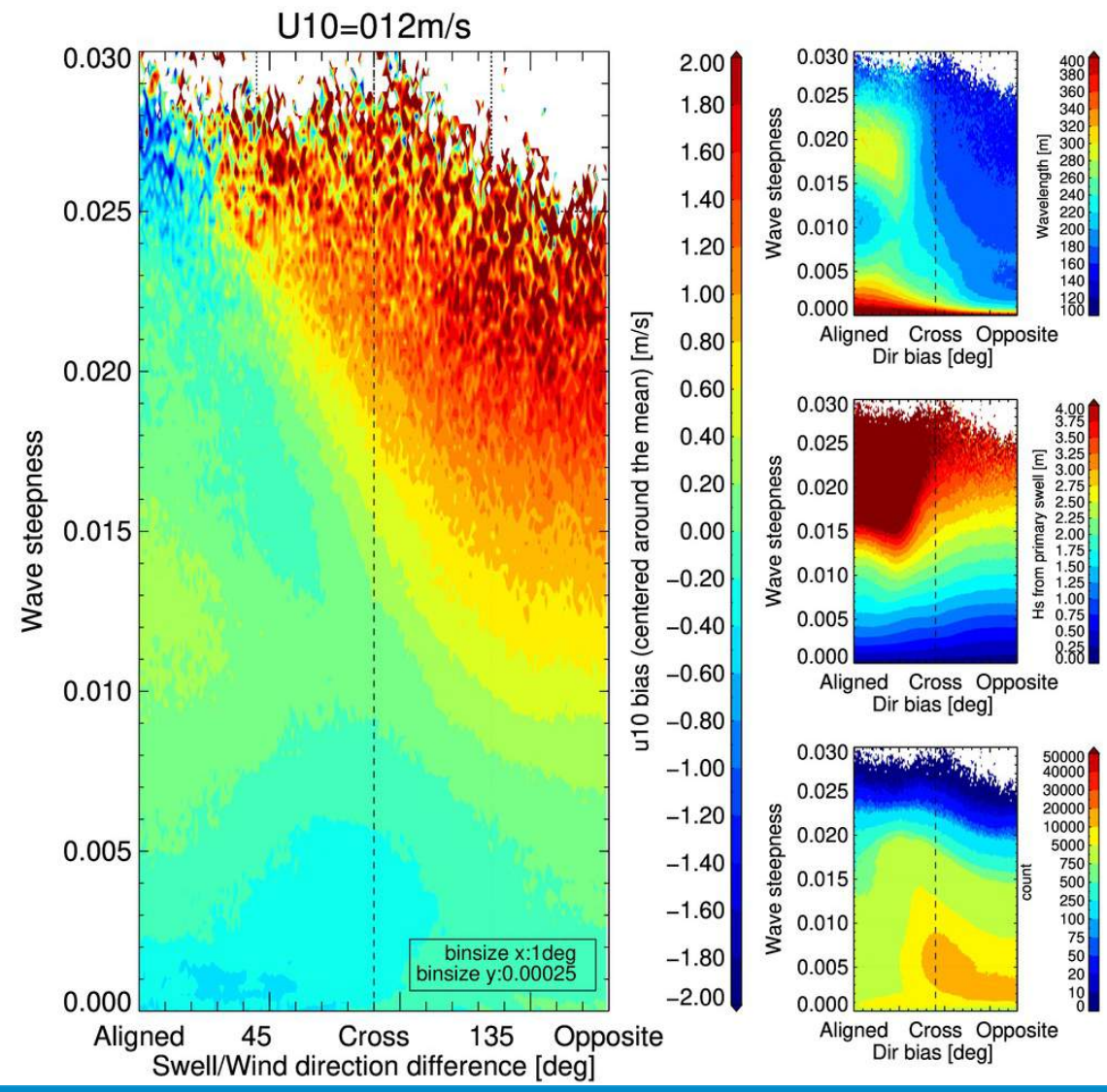
SMAPRSS



# Wind speed bias as a function of wave steepness and swell/wind direction difference

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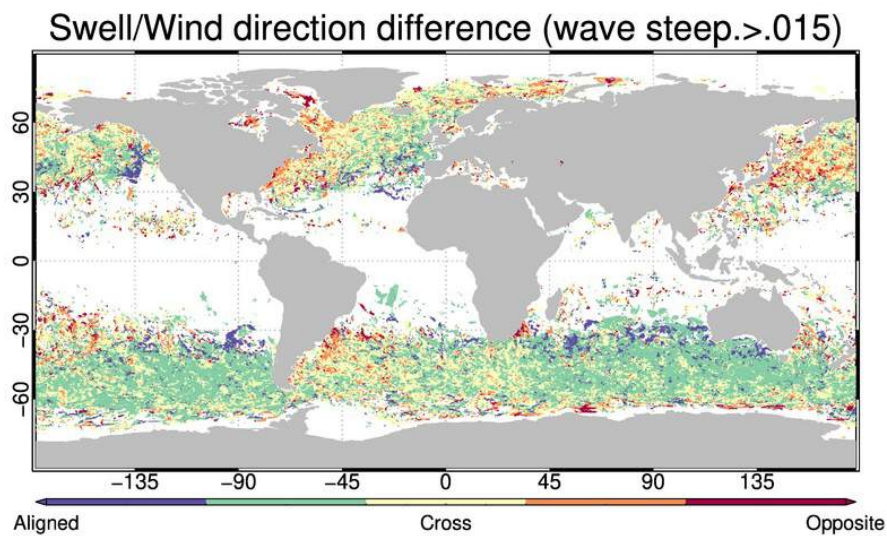
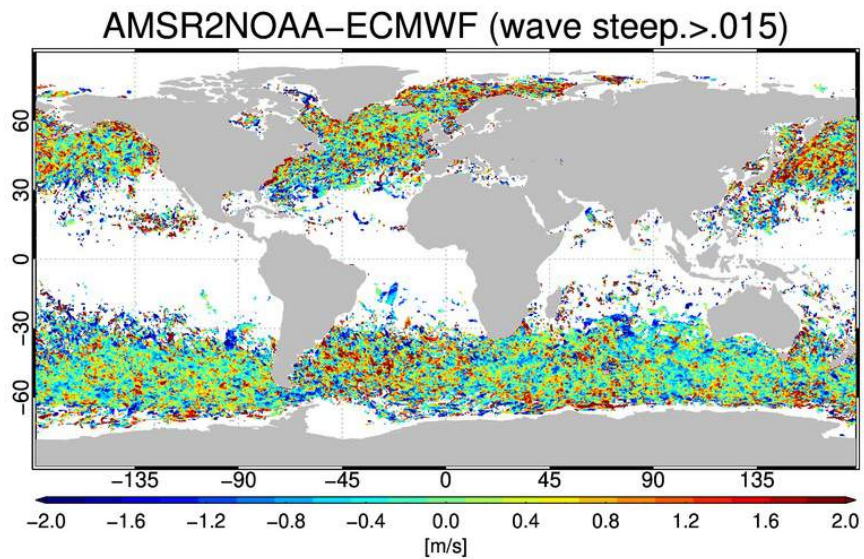
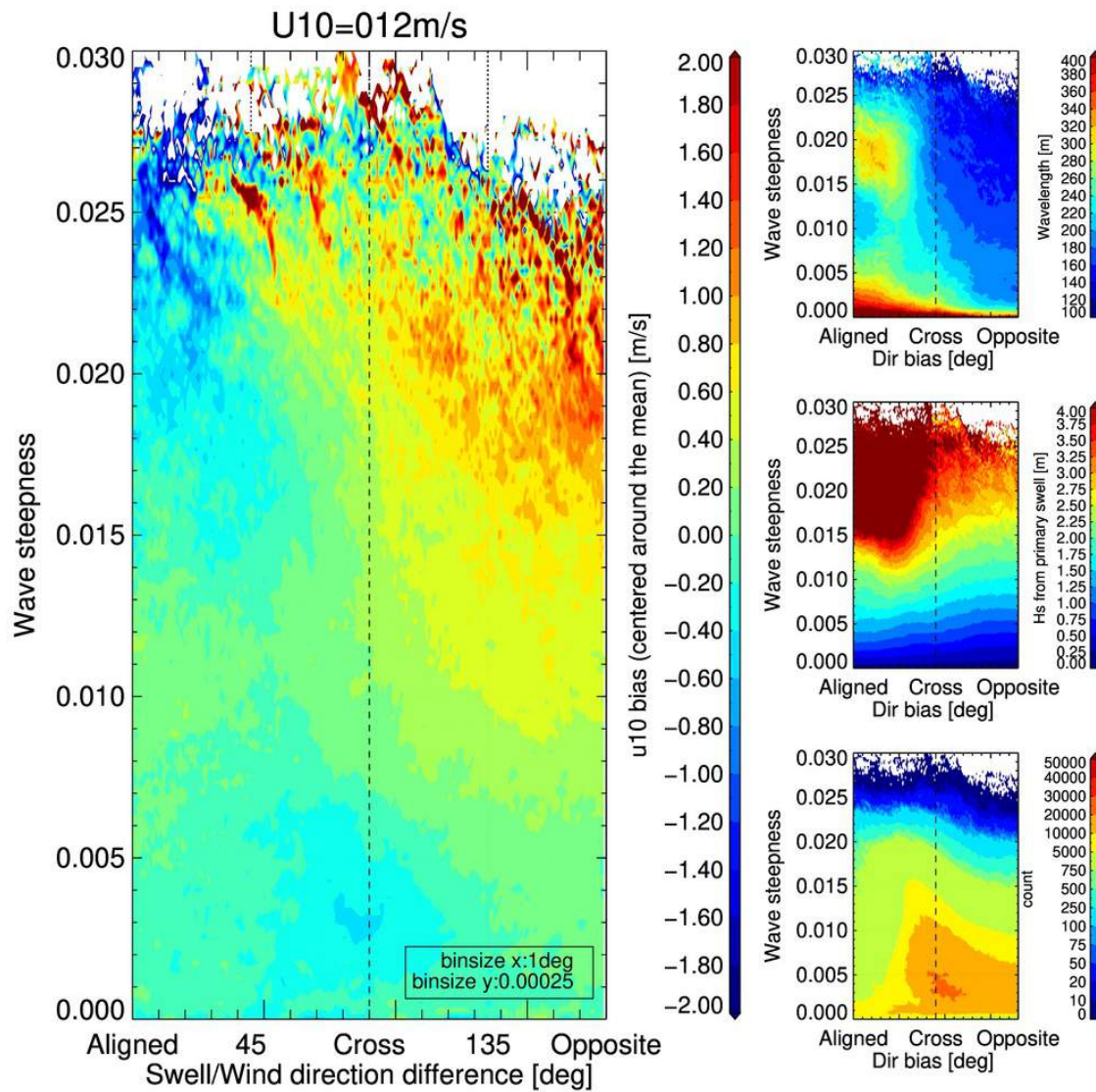
AMSR2RSS



# Wind speed bias as a function of wave steepness and swell/wind direction difference

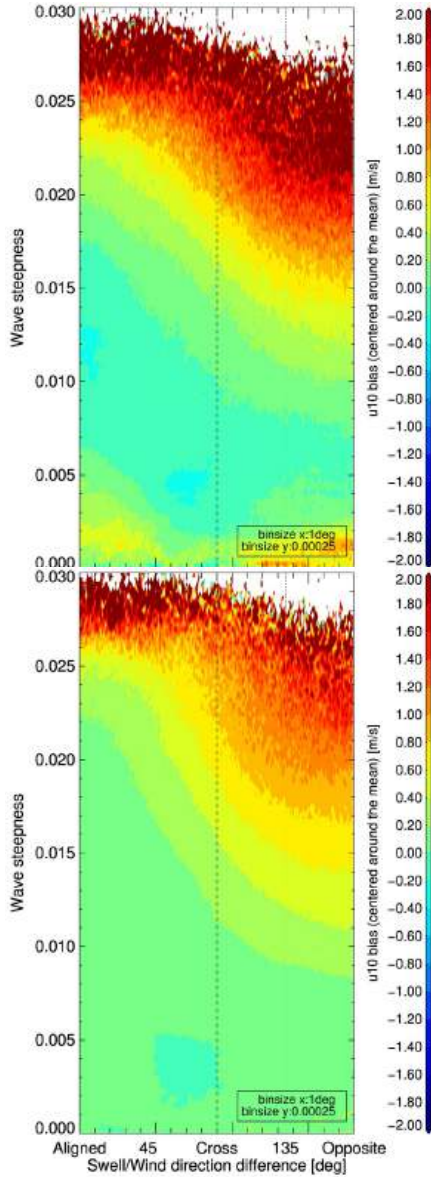
Time period: 20170202-20191225 | collocated model wind speed fixed at 12 m/s +/- 1m/s

AMSR2NOAA



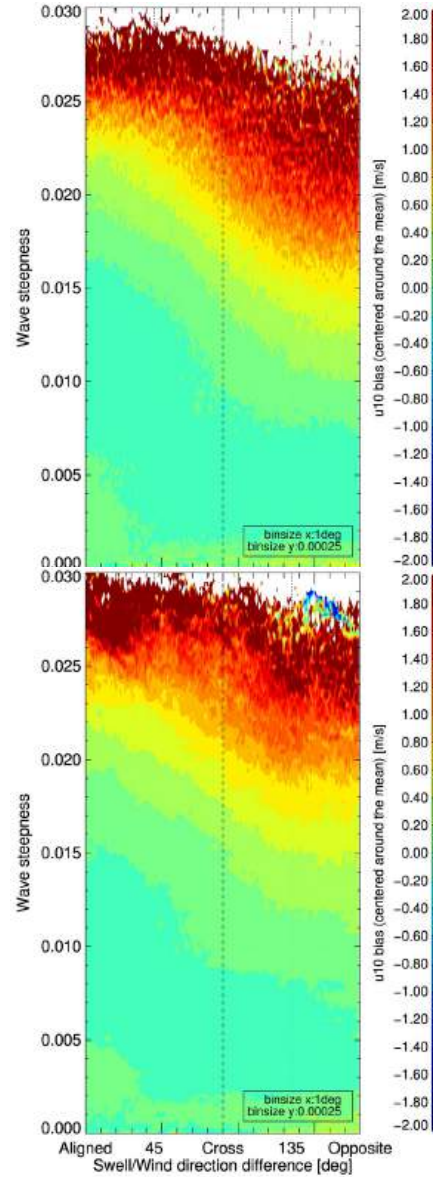
# Model wind speed fixed at 6 m/s +/- 1 m/s

SMAPJPL



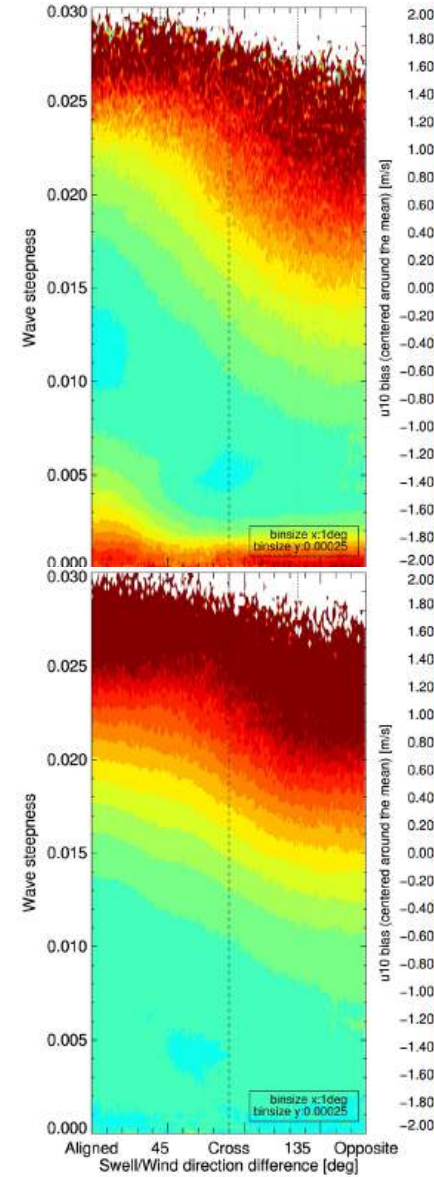
ASCAT25NOAA

SMAPJPLnew



AMSR2NOAA

SMAPRSS



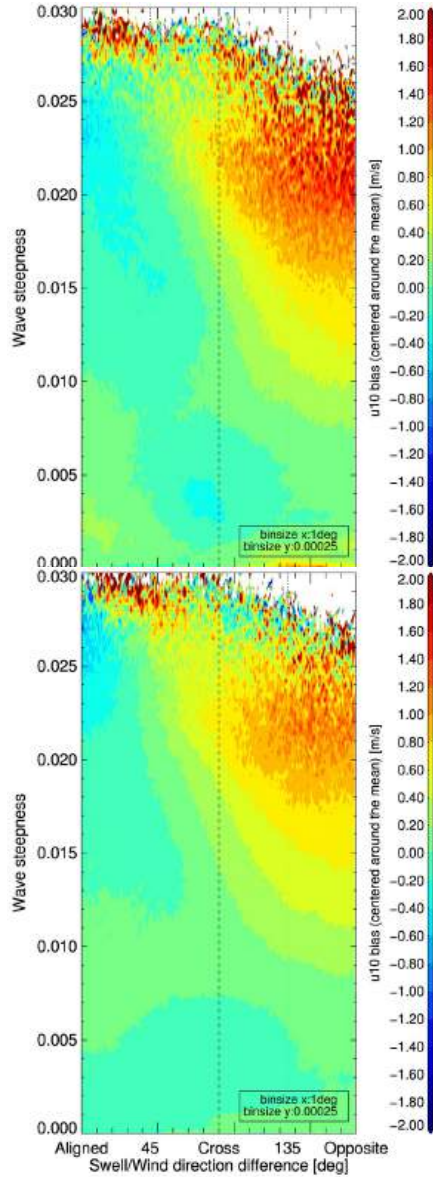
AMSR2RSS

Similar wind speed trend for all listed wind speed products



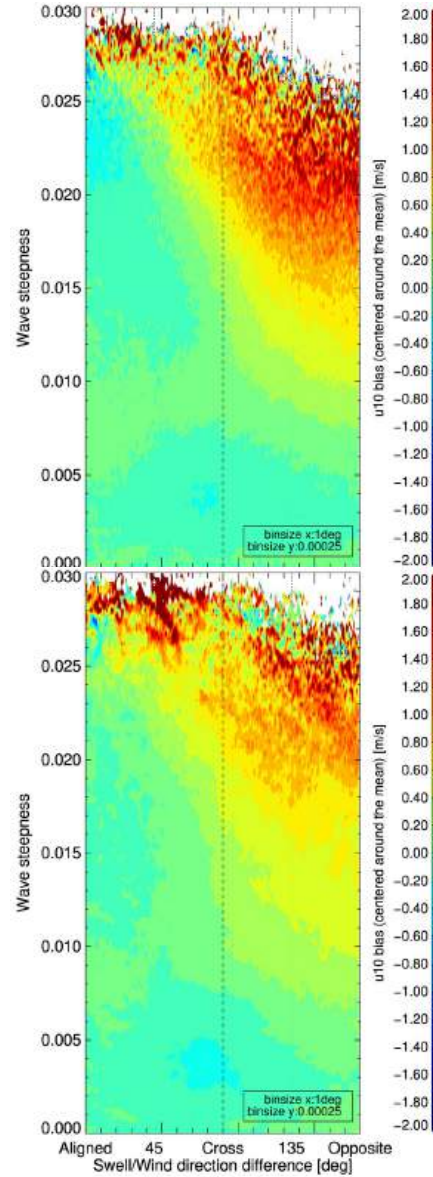
# Model wind speed fixed at 9 m/s +/-1 m/s

SMAPJPL



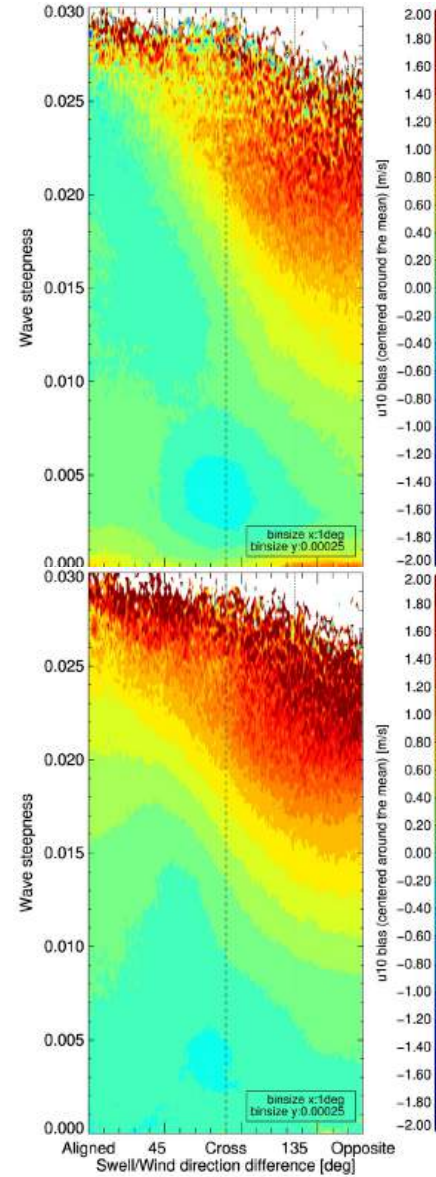
ASCAT25NOAA

SMAPJPLnew



AMSR2NOAA

SMAPRSS

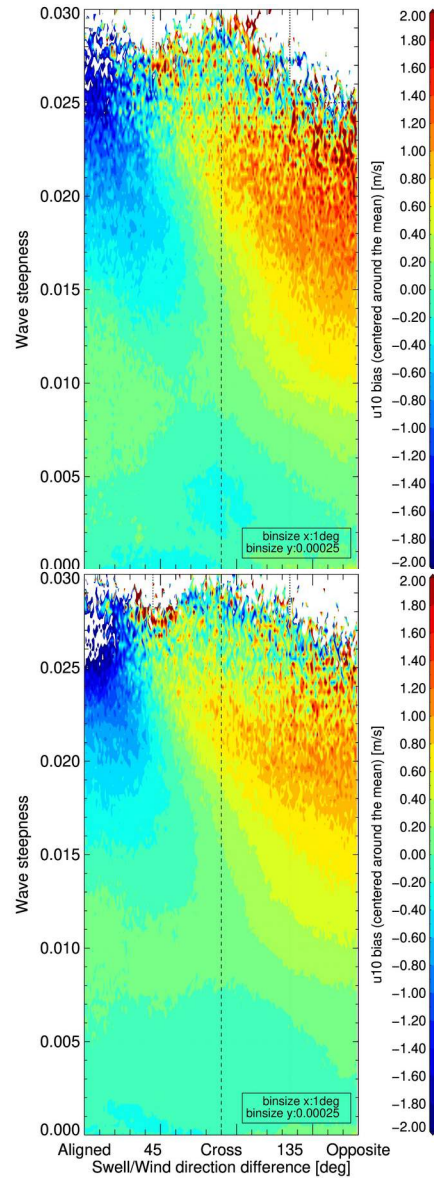


AMSR2RSS



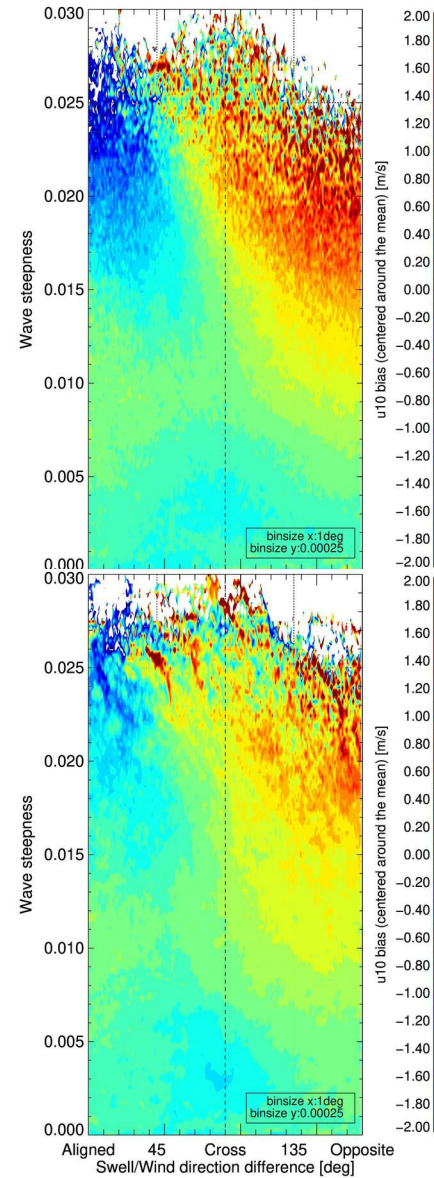
# Model wind speed fixed at 12 m/s +/- 1 m/s

SMAPJPL



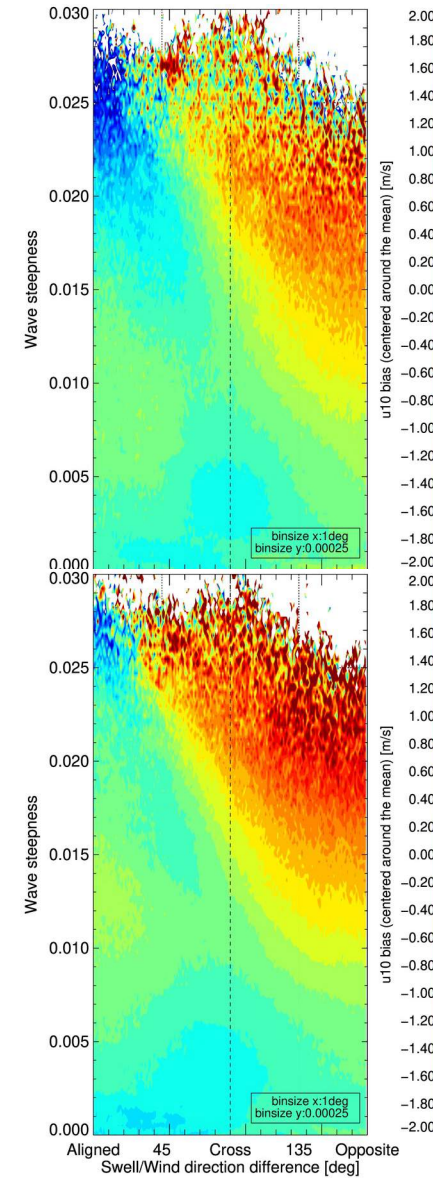
ASCAT25NOAA

SMAPJPLnew



AMSR2NOAA

SMAPRSS

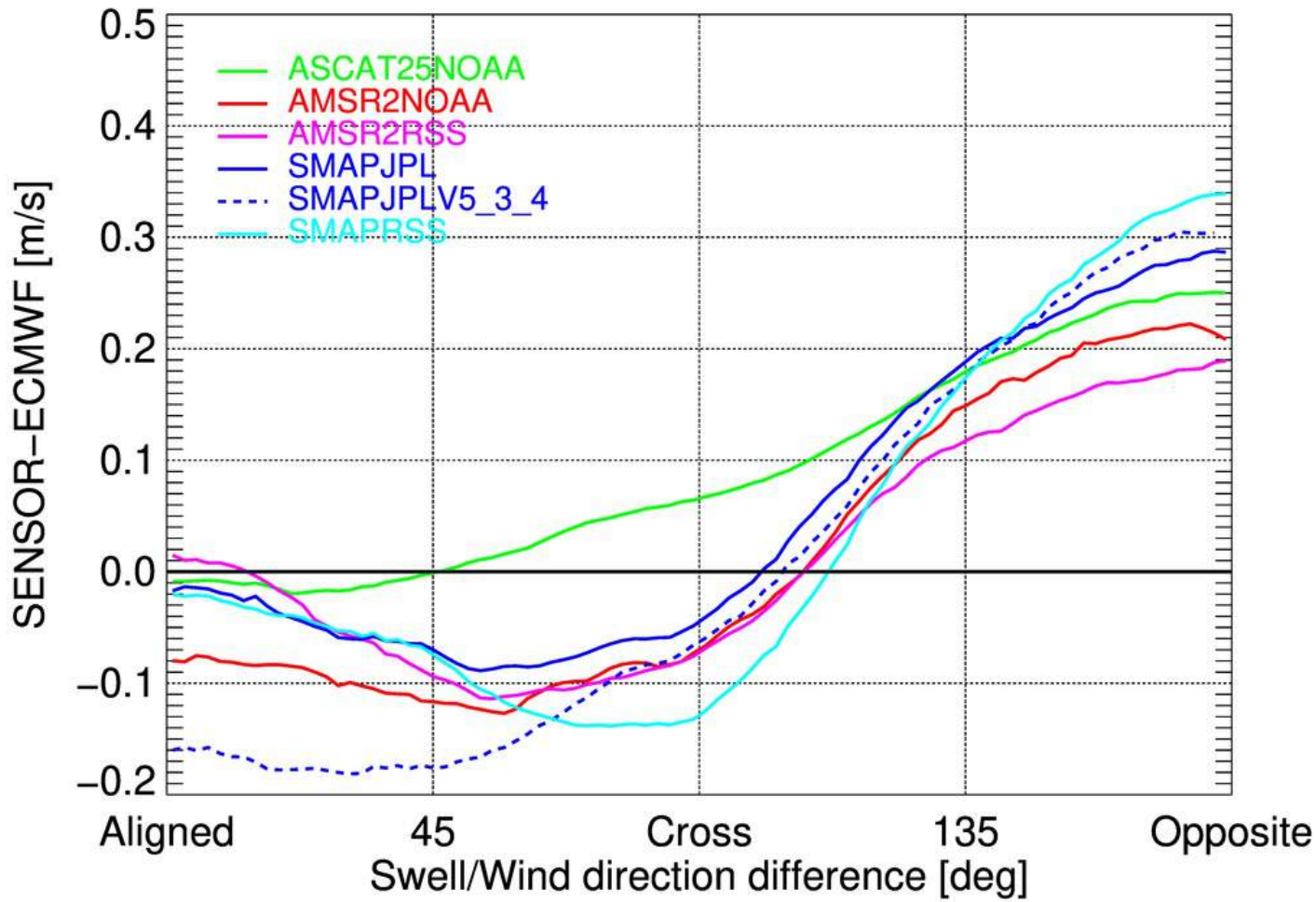


AMSR2RSS

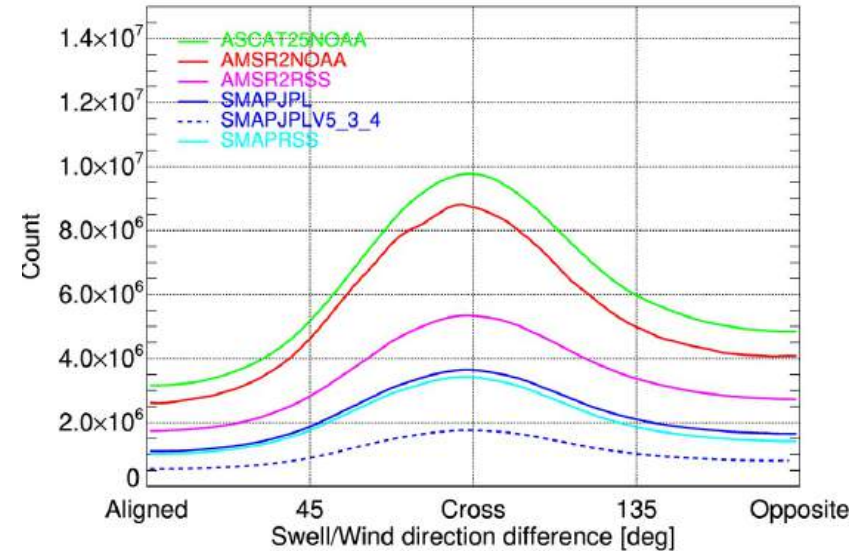
As the fixed model wind speed bin increases, the wind speed bias trend becomes more dynamic (as a function of the swell/wind direction difference)



# Sensor wind speed bias\* as a function of the primary swell/model wind direction difference (given model wind > 8 m/s)



- ASCAT showing least dynamic range
- SMAP RSS shows largest dynamic range between cross and opposition directions
- SMAP JPL V5.3.4 most dynamic range between aligned and opposite directions



\*centered around the mean

# Summary

- Wind speed error (sensor-model) from SMAP, AMSR2, ASCAT increases when the swell direction becomes opposite to the wind direction
- This error becomes prevalent as the swell spectral wave steepness parameter increases
- Most likely roughness and wave breaking slightly altered (tilt/hydrodynamic modulations perhaps?) with ‘steeper’ swell passing in opposite/cross directions. However, did neglect potential impact of ocean surface current
- Respective GMF may need to be revisited to take into account above effect

## Possible future work

- Use SWIM data and identify measured swell Hs/direction and verify wind speed bias trend using ASCAT data (don’t think AMSR2/SMAP can be used due to very low matchup)
- Check potential impact on level 1 data (e.g. ASCAT sigma0, SMAP excess emissivity)
- Repeat exercise with CyGNSS data
- Include time component
- Repeat exercise within tropical cyclone condition

Free advert 😊: upcoming IGARSS talk on “EXPLORING SWELL IMPACT TO RADIOMETER DERIVED FOAM FRACTION AND WIND SPEED” *Faozi Said, Zorana Jelenak, Paul S. Chang, Magdalena D. Anguelova, Michael H. Bettenhausen*

