

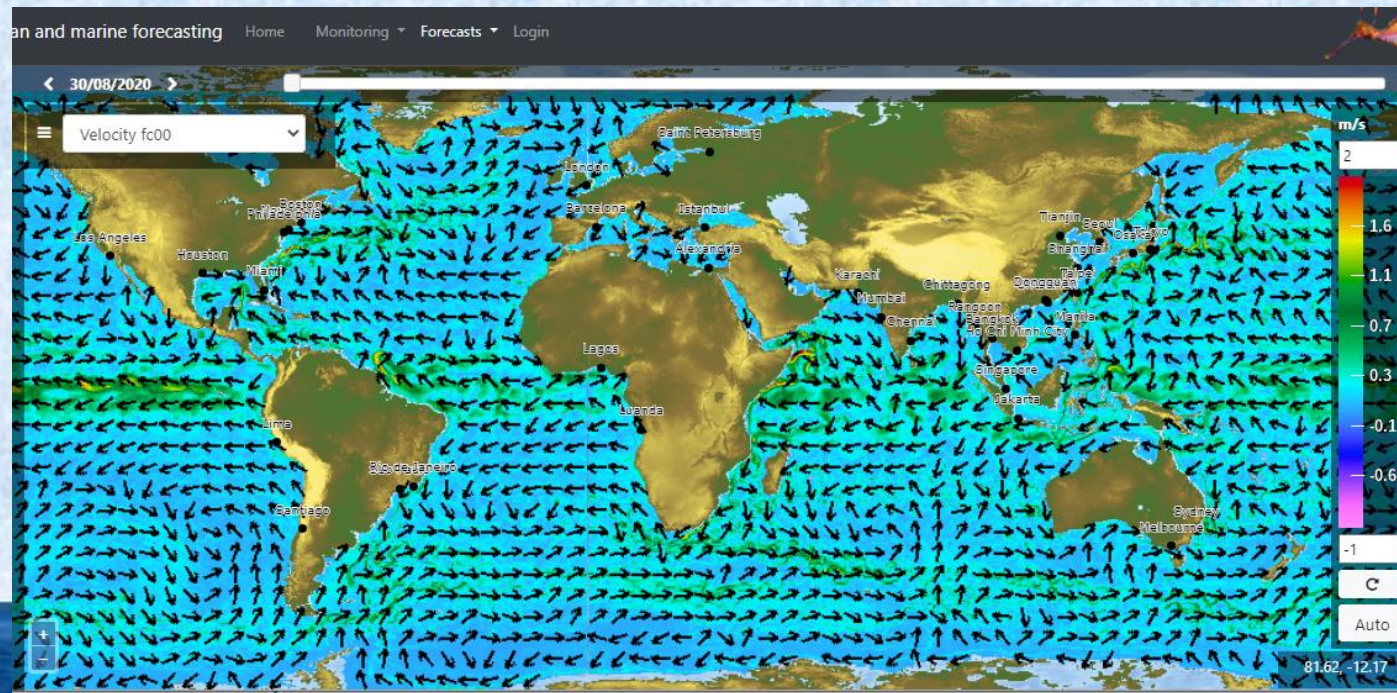


Verification and inter-comparison of near-surface ocean currents in global ocean forecasting systems

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¹Bureau of Meteorology

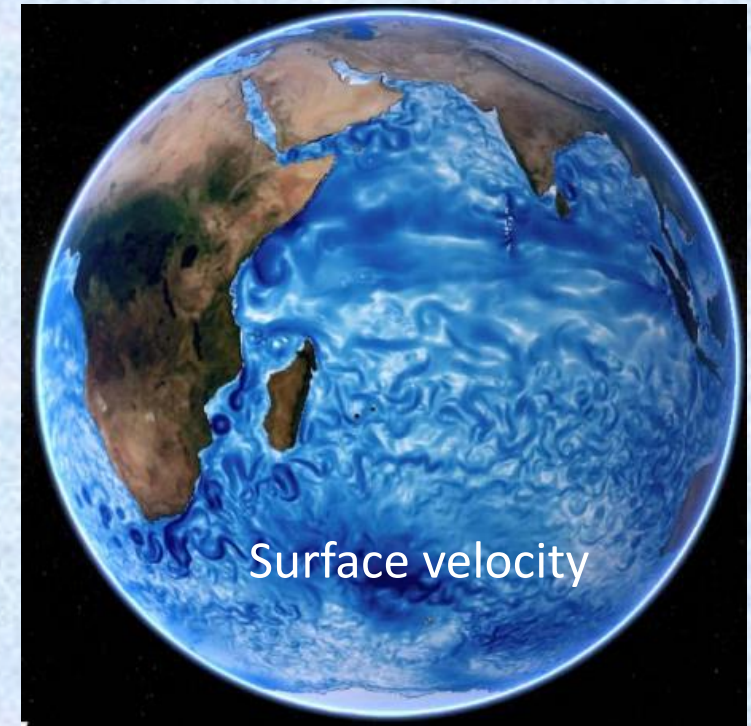
²Mercator Océan, France





Outline

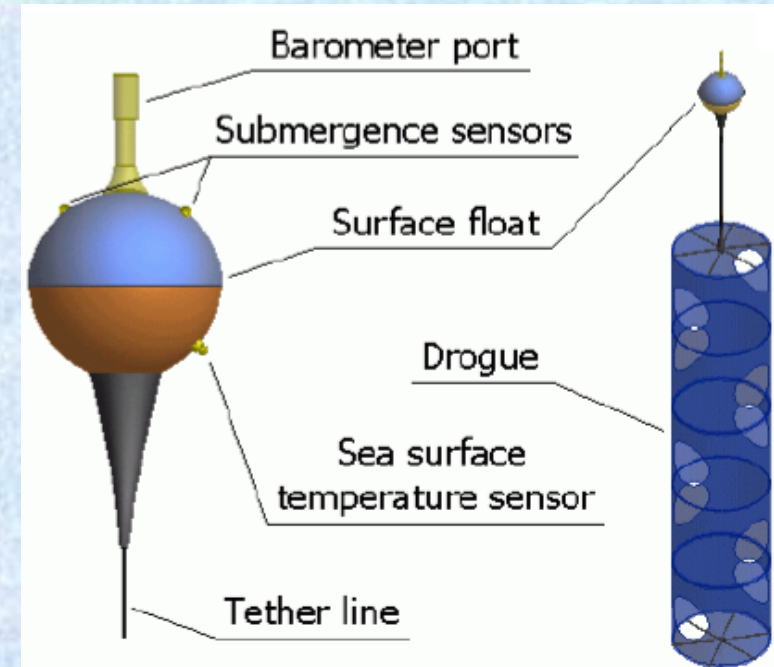
- What is the Surface Velocity Drifter Program (SVP)
- Models used for Inter-comparison
- Verification methods under the GODAE OceanView Inter-comparison and Verification (IV-TT) CLASS4 data standard.
- Impacts of Stokes drift and tides on verification.
- Comparison of performance of OceanMAPS, multi-cycle ensemble (ENS-OMAPS), and CMEMS.
- Verification time period: 2018, **2019** & 2020.
- Results - metrics: Bias, MAE, RMSE, Correlations, CDF, Q-Q plots.





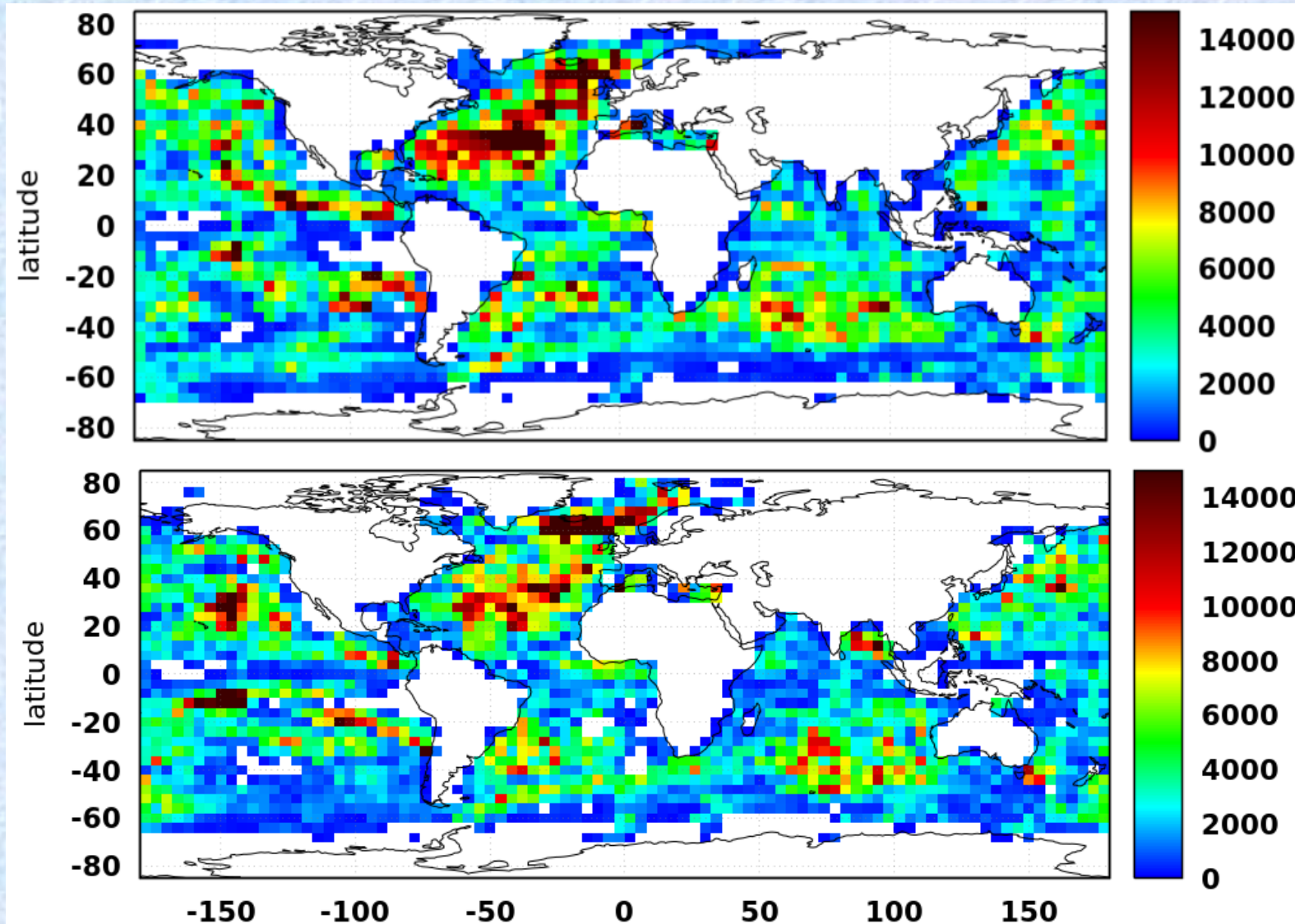
Surface Velocity Program (SVP) Drifters

- Buoys track surface currents (Lagrangian drifters) at the depth corresponding to the depth of their drogue. The drogue is centred at 15 m depth.
- **Only drifters with drogues are included.**
- Drifters obtain their absolute positions via satellite, and transmit near-real-time information globally to the GTS.
- The Coriolis data Centre (Ifremer and Météo-France) delivers the SVP drifter data as part of the Global Drifter Program.
- Product name:
INSITU_GLO_UV_NRT_OBSERVATIONS_013_048
- Lanczos filter applied prior to analysis.





Number of OBS per 4 degree bin



2018
N=7,092,015

2019
N=7,261,296



Models for Inter-comparison

Ocean Model, Analysis and Prediction System

OceanMAPS 3.2 (OMAPS)

- Modular ocean model OFAM3 (MOM 5)
- $0.1^\circ \times 0.1^\circ$ horizontal resolution, 51 vertical levels
- ACCESS-G2 forcing, no tides, no sea-ice

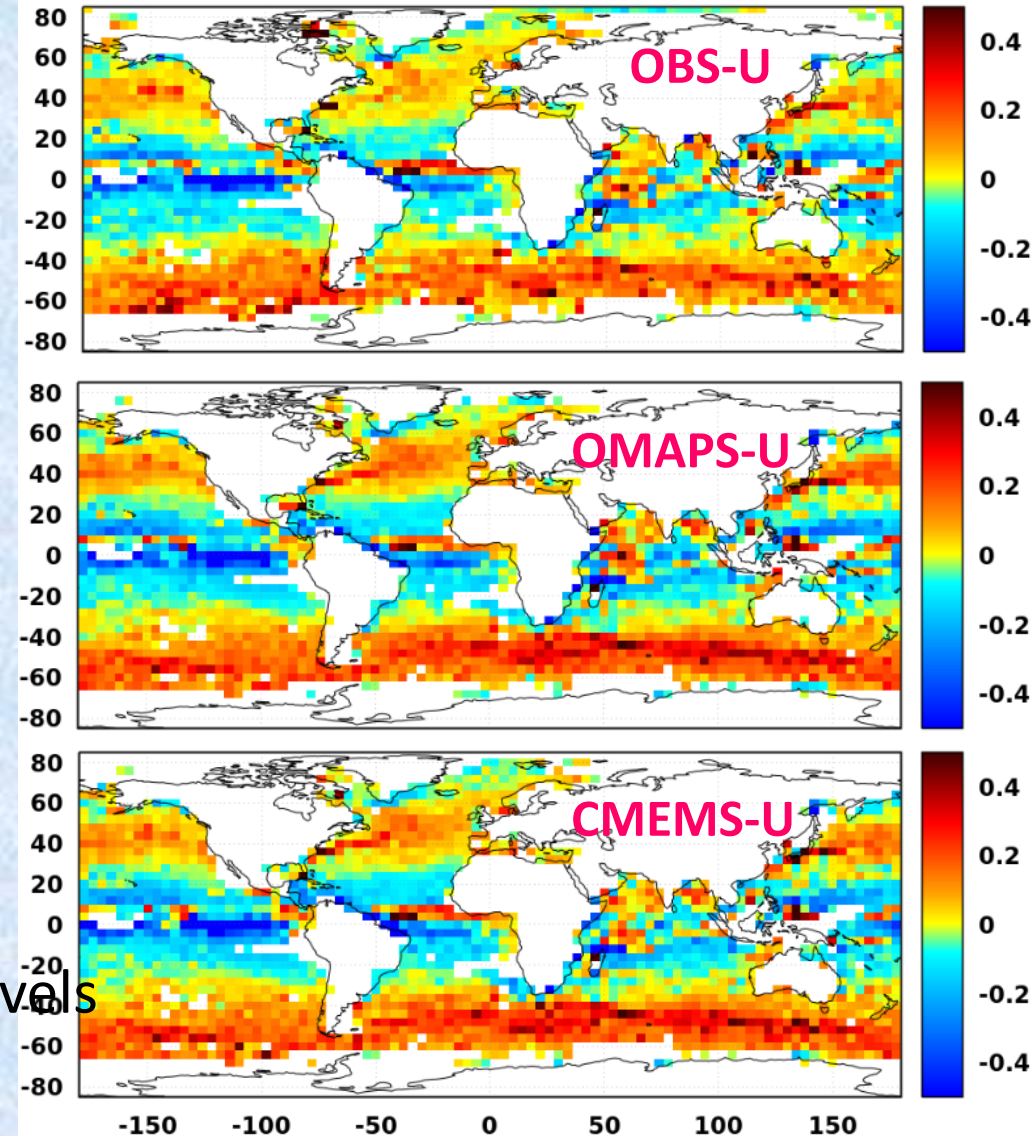
Ensemble OceanMAPS (ENS-OMAPS)

- 3-cycle time-lagged ensemble

Copernicus Marine Environment Monitoring Service

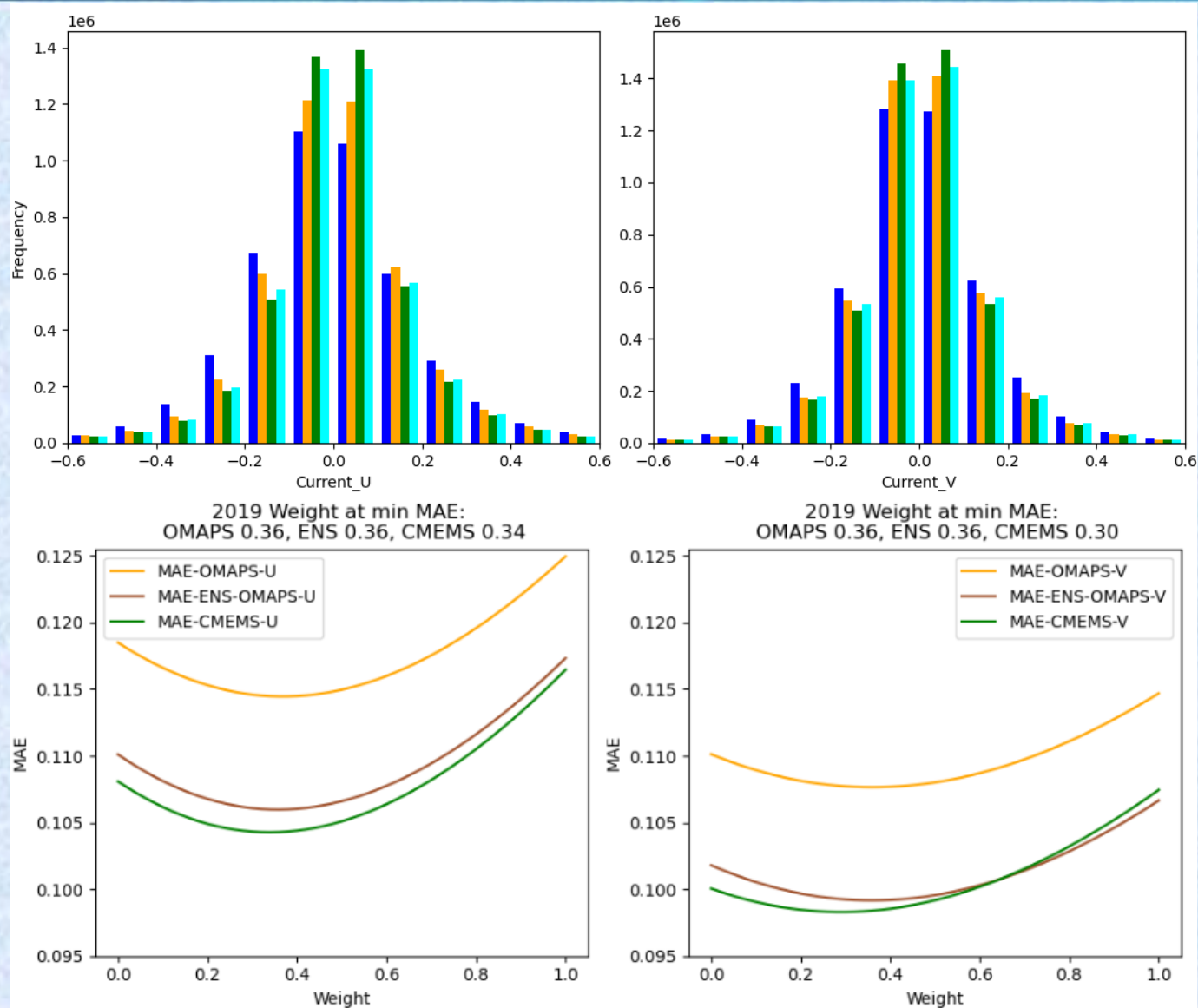
CMEMS 3.1 - CMEMS System PSY4V3R1

- NEMO ocean model version 3.1
- Horizontal resolution: 9 km ($1/12^\circ$) at equator, 7 km at mid-latitudes, 2 km at Ross/Weddel seas, 50 vertical levels
- ECMWF atmospheric forcing, no tides, sea-ice





Impact of tides & stokes drift 2019 Global



- OBS
- OMAPS+stokes drift
- OMAPS+tide
- OMAPS

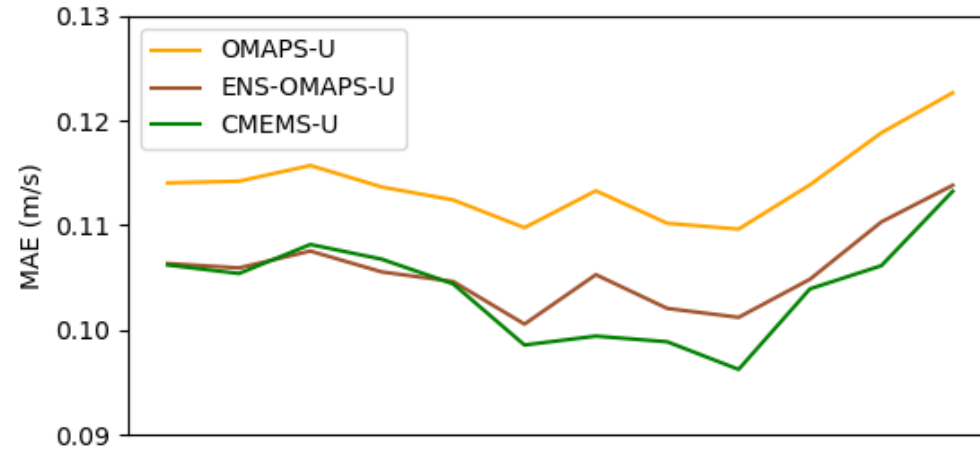
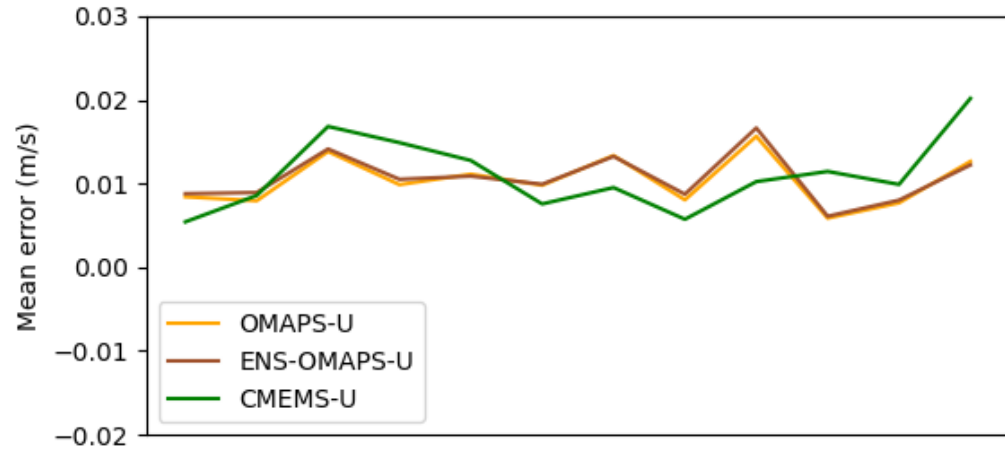
**MAE vs
weighted
Stokes drift**



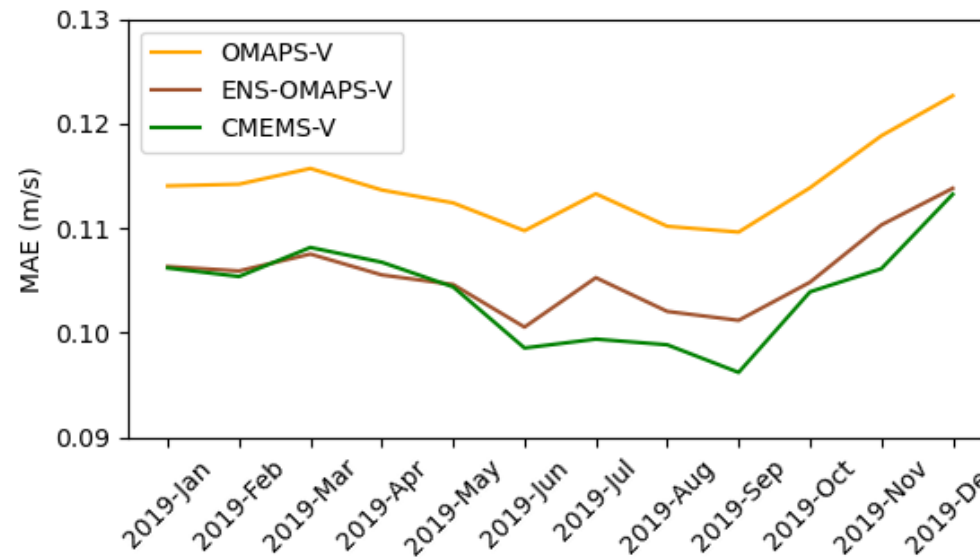
Monthly mean errors 2019 - Global Analysis

Model - OBS

| Model - OBS |



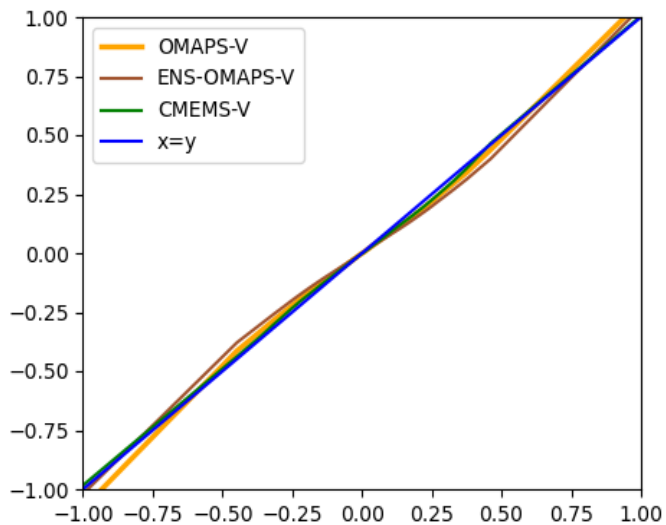
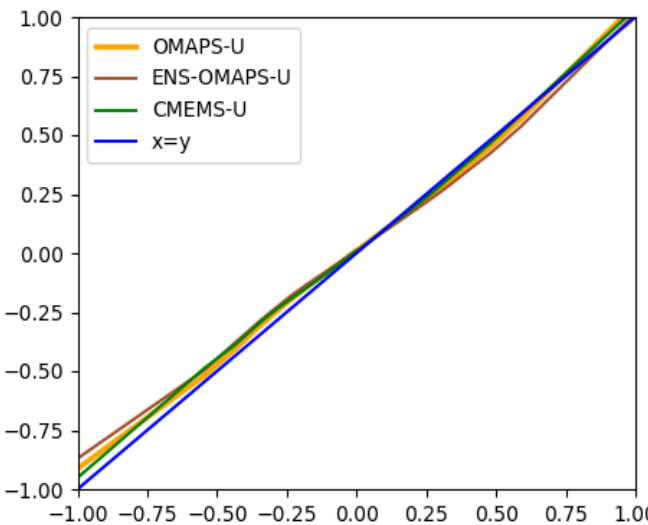
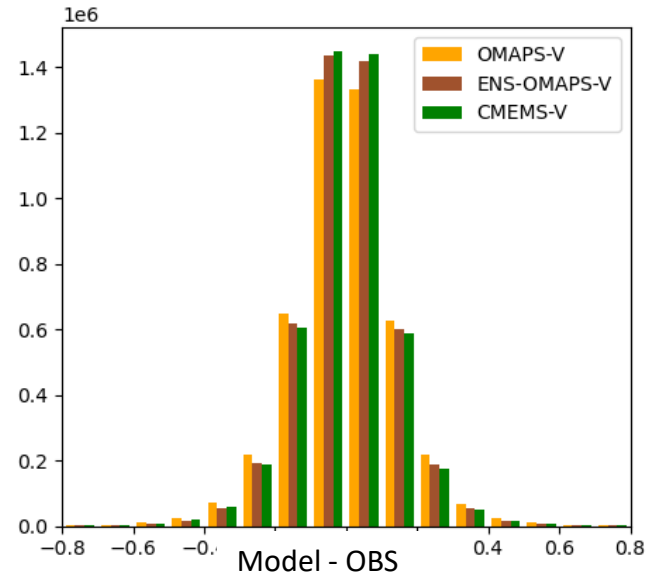
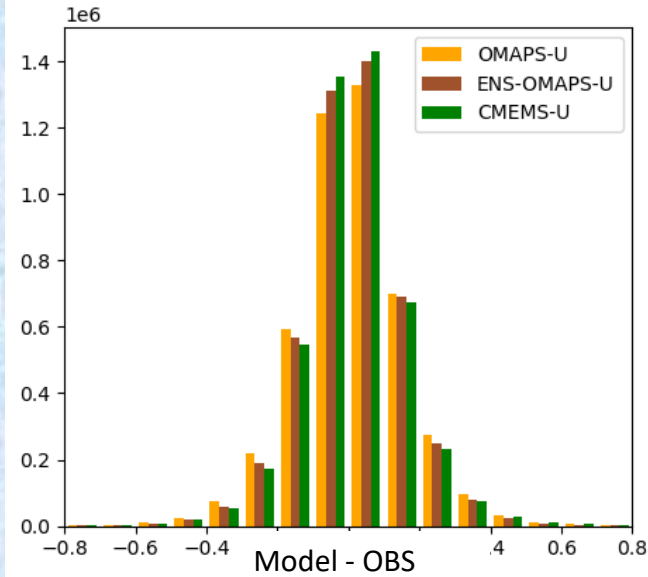
Zonal



Meridional



2019 Analysis - Global



OMAPS

Annual mean bias-U = 0.010

Annual mean bias-V = -0.001

ENS-OMAPS

Annual mean bias-U = 0.011

Annual mean Bias-V = -0.002

CMEMS

Annual mean bias-U = 0.011

Annual mean bias-V = -0.001

N = 4,618,510

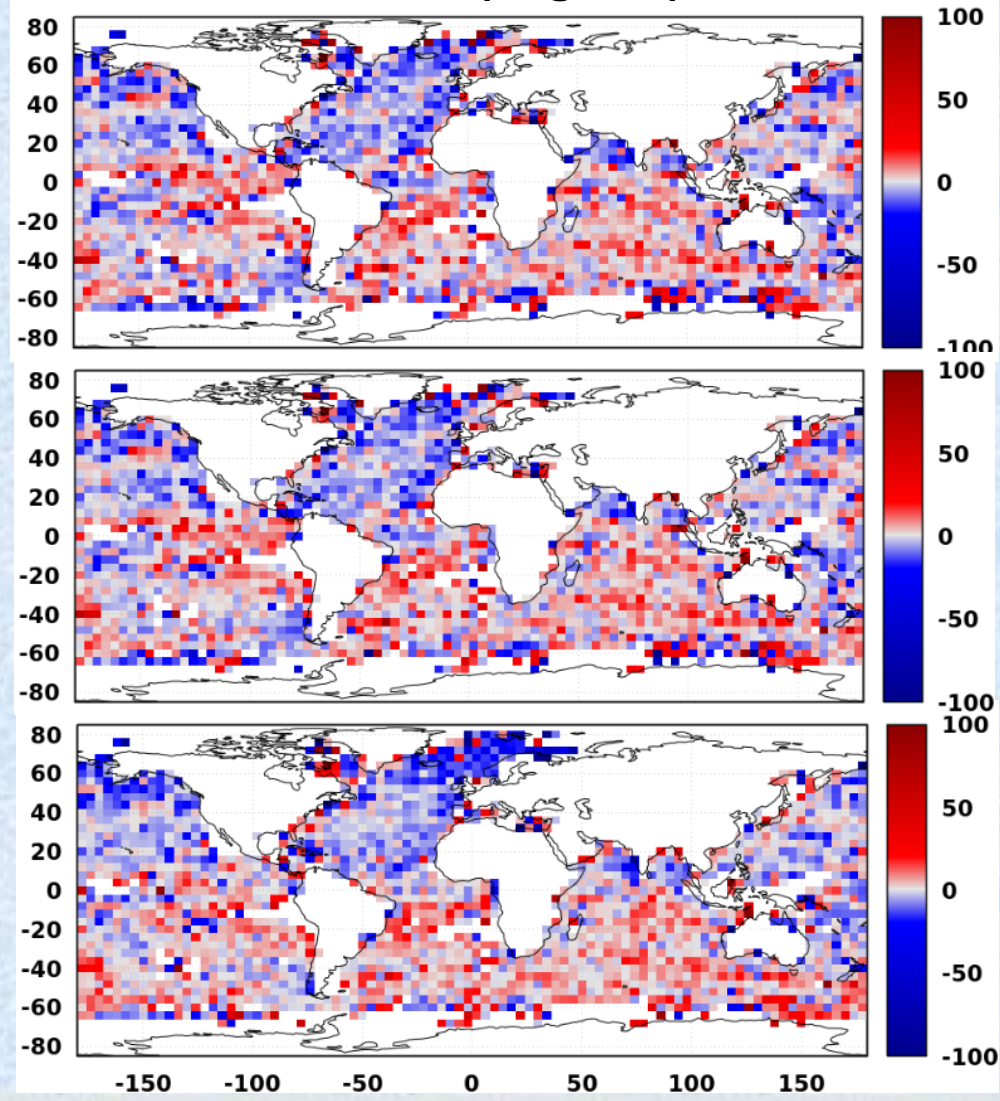
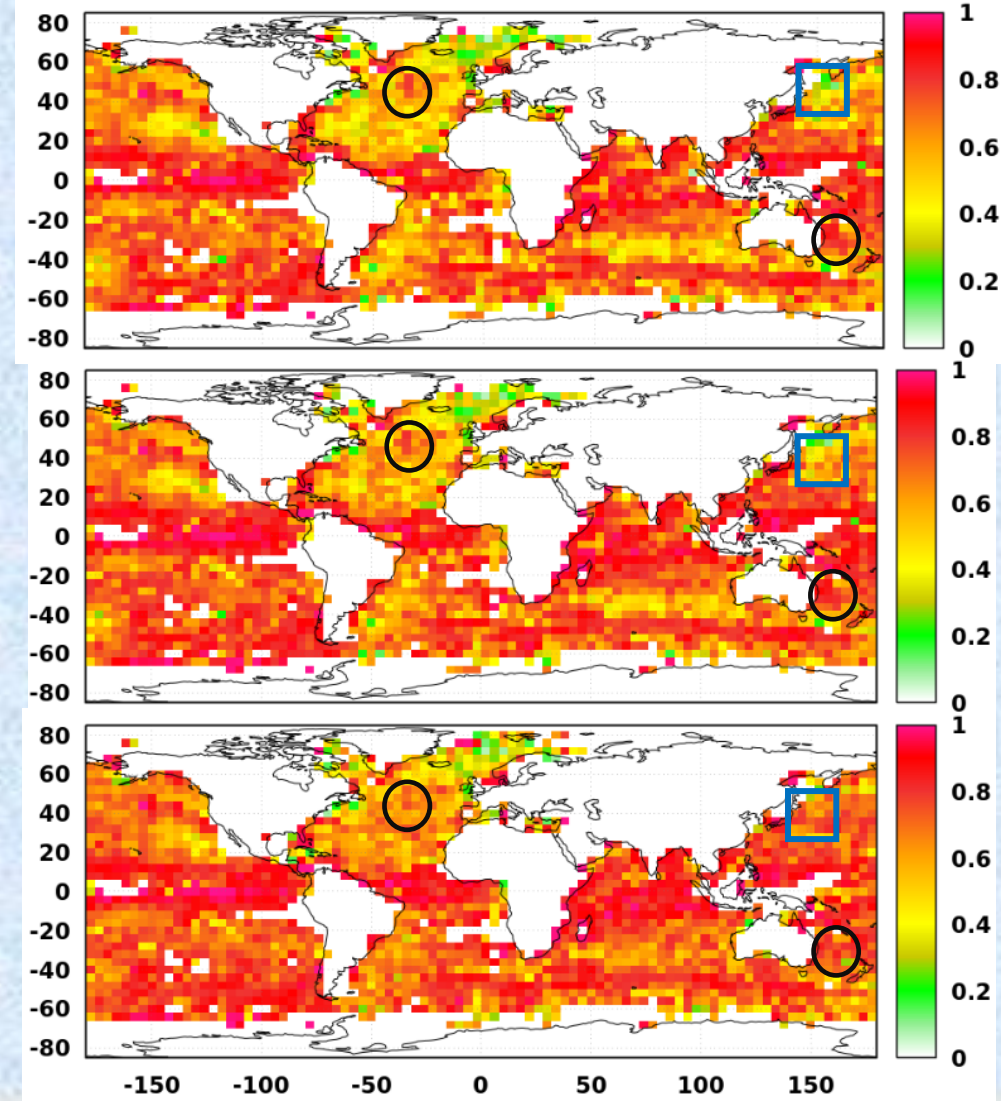
Q-Q plots



| Complex Correlation | & Rotation 2019 Analysis

| Complex Correlation |

Rotation (degrees)



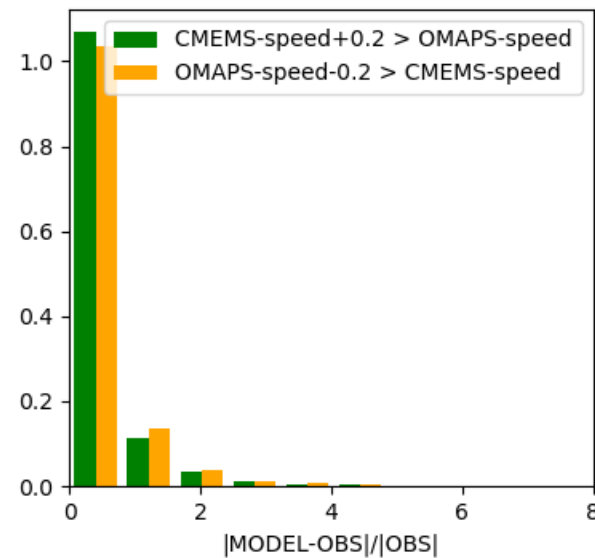
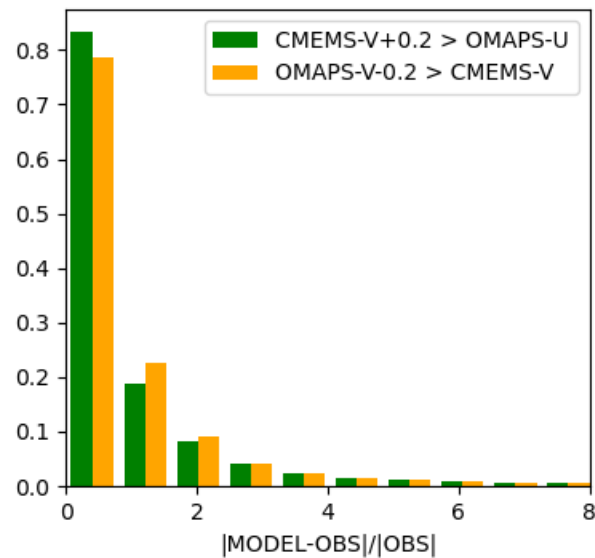
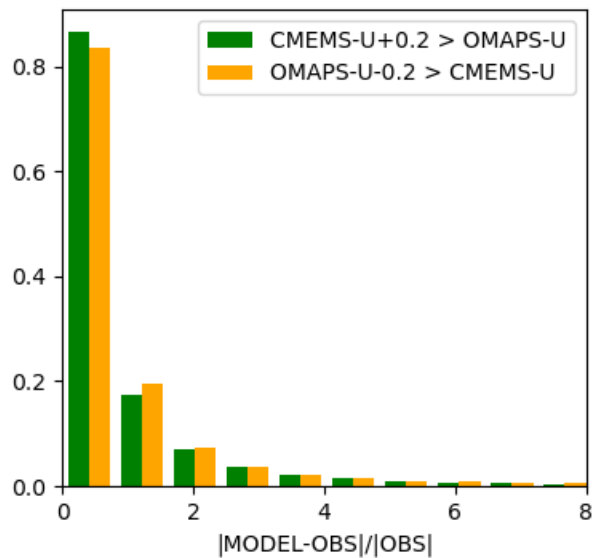
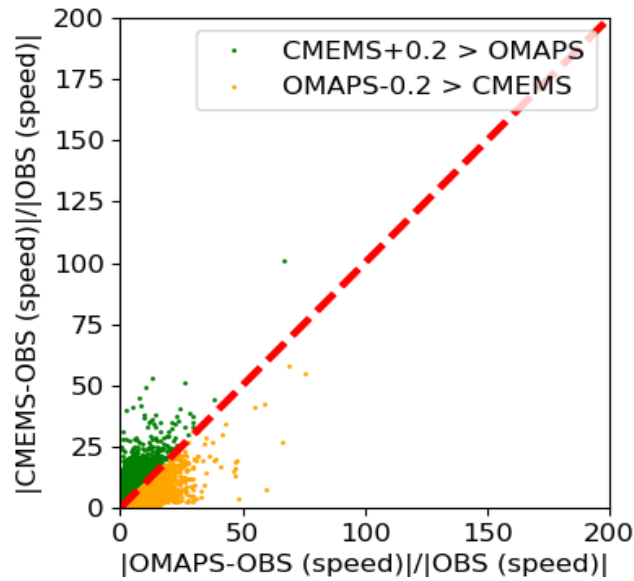
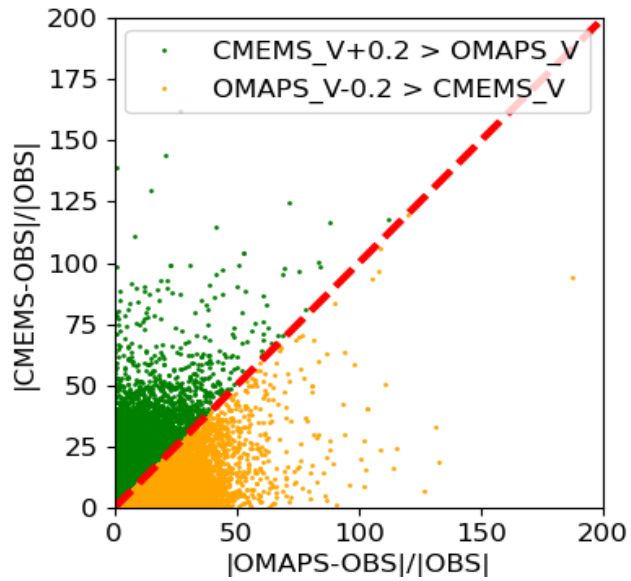
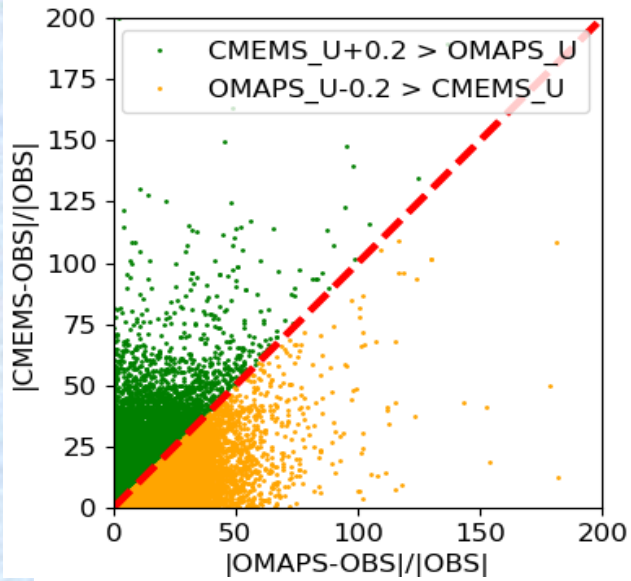
(OMAPS, OBS)

(ENS-OMAPS, OBS)

(CMEMS, OBS)



Relative errors - OMAPS vs CMEMS 2019 Analysis - Global

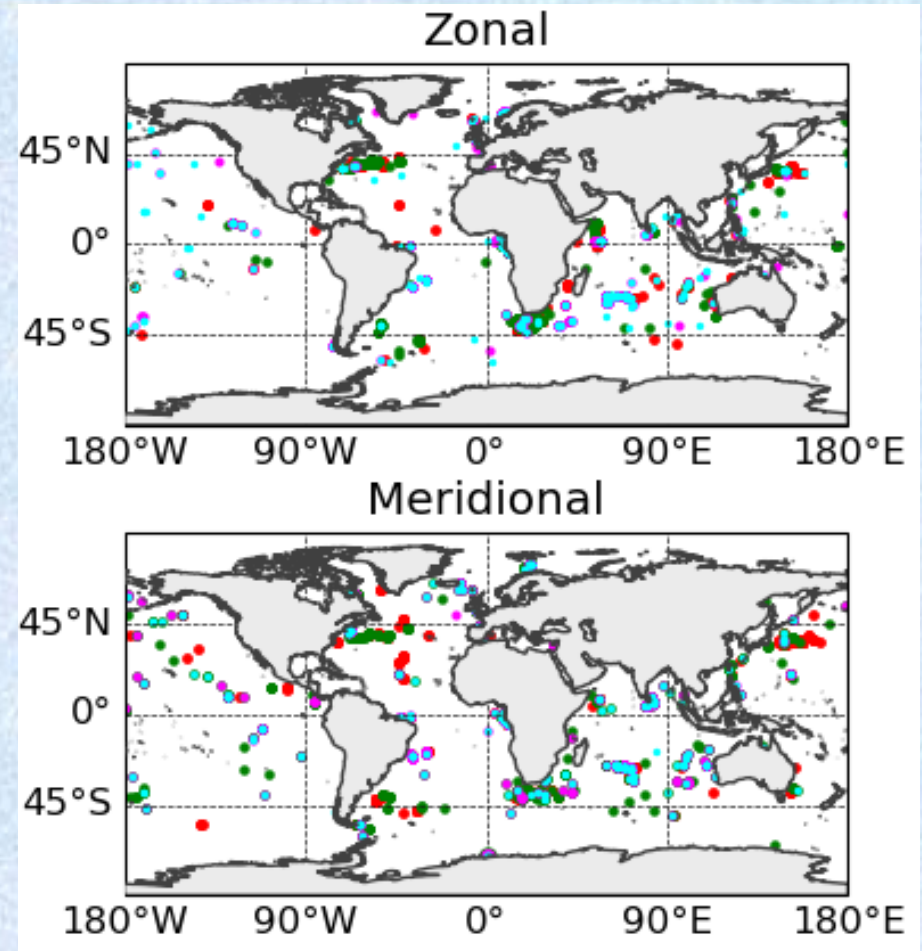
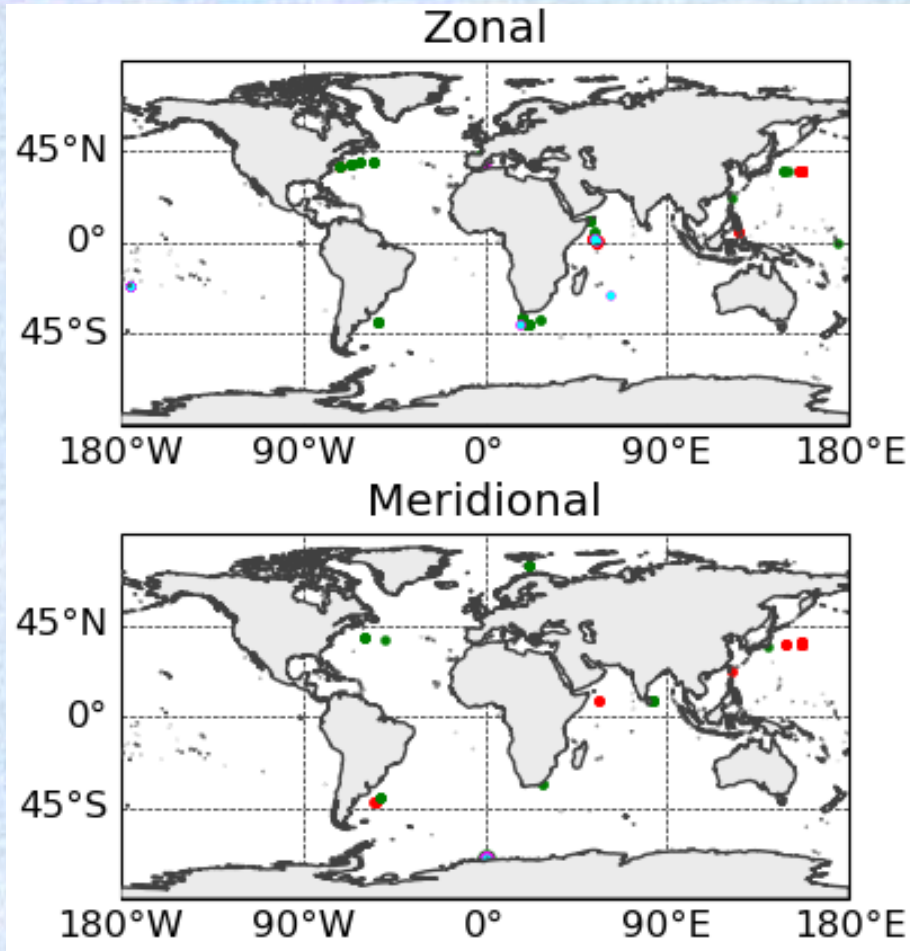


Relative Error:

$$\frac{|\text{Model} - \text{OBS}|}{|\text{OBS}|}$$



Outliers $|\text{Model} - \text{OBS}| > 1.5$



FILTERED

- $|\text{OMAPS-OBS}| > 1.5$ & $|\text{CMEMS-OBS}| < 1.5$
- $|\text{CMEMS-OBS}| > 1.5$ & $|\text{OMAPS-OBS}| < 1.5$
- $|\text{OMAPS-OBS}| > 1.5$ & $|\text{CMEMS-OBS}| > |\text{OMAPS-OBS}|$
- $|\text{CMEMS-OBS}| > 1.5$ & $|\text{OMAPS-OBS}| > |\text{CMEMS-OBS}|$

RAW/UNFILTERED



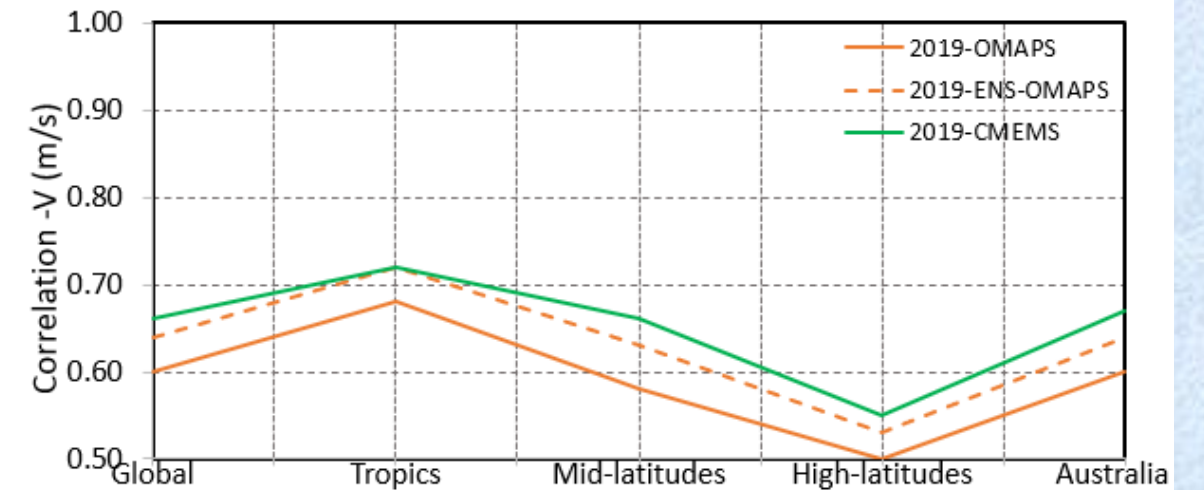
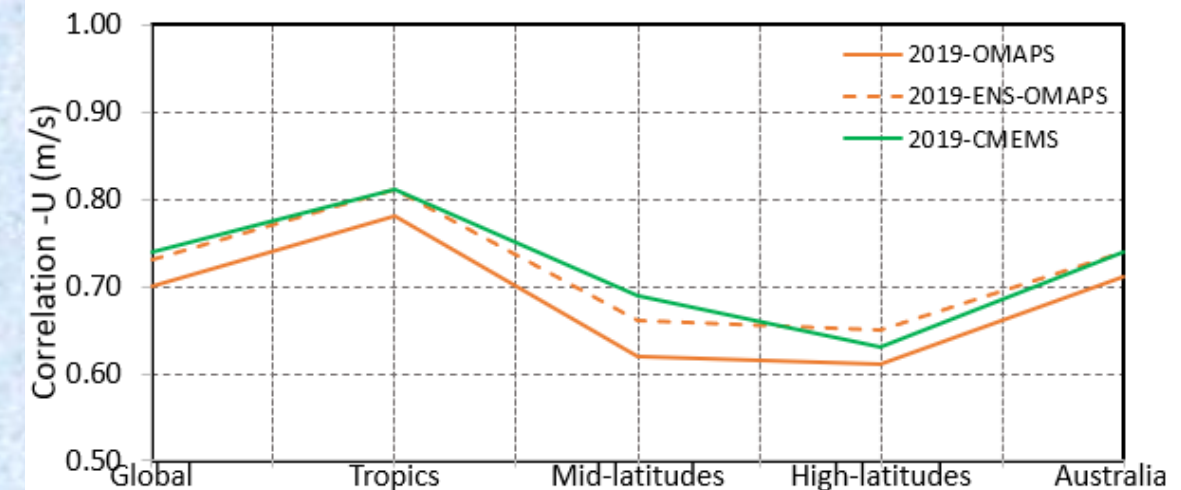
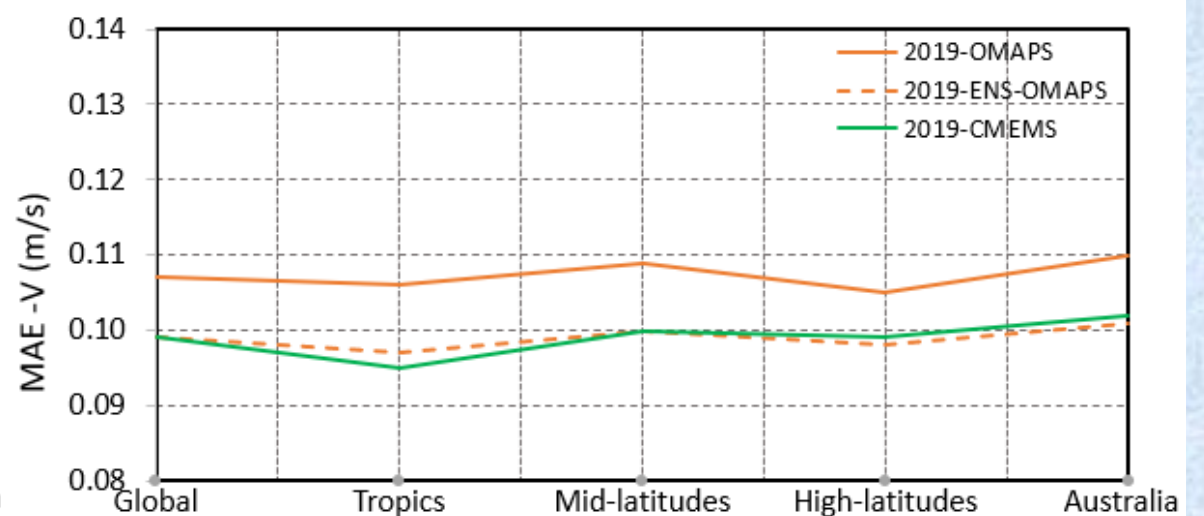
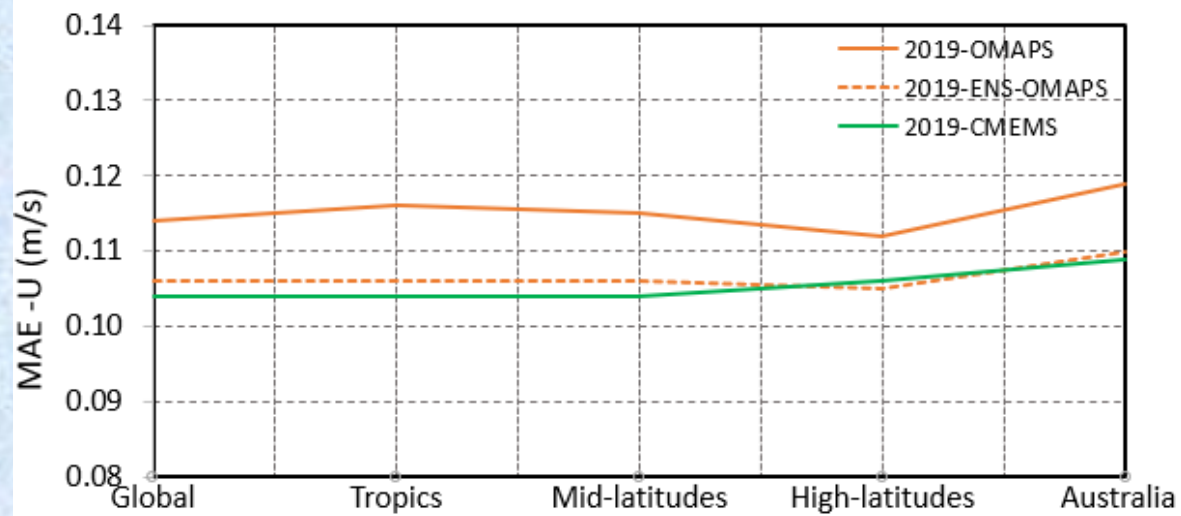
Annual MAE & Correlation in global, tropics, mid & high latitudes

Tropics: 20°S - 20°N

Mid latitudes: 20°S/N - 50°N/S

High latitudes: 50°S/N - 90°N/S

Australia: 0-50°S, 100°S-180°S





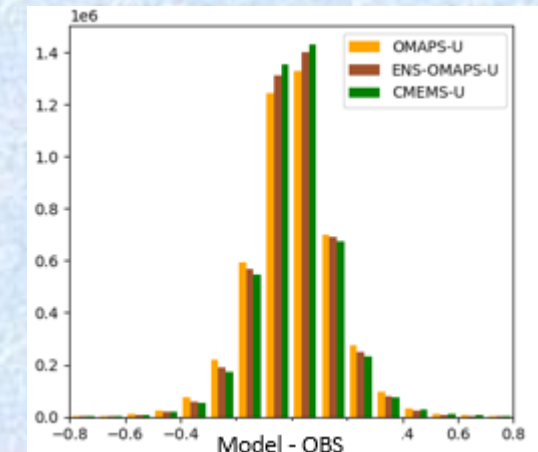
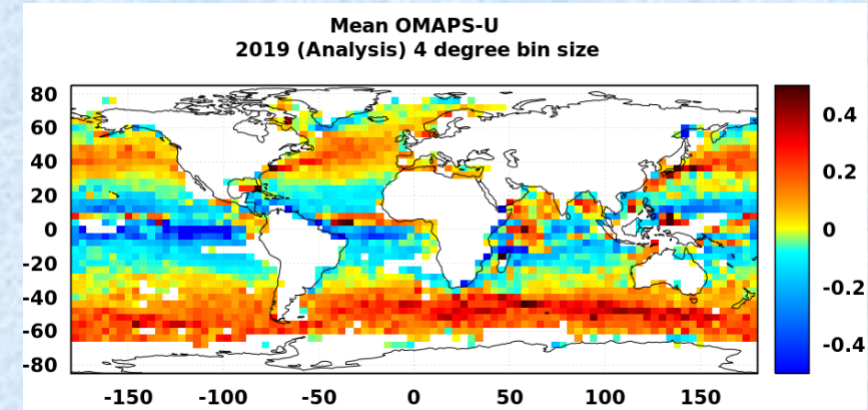
Statistics for OMAPS, CMEMS & ENS-OMAPS 2019 Analysis

	OMAPS			CMEMS			ENS-OMAPS		
Variable	MAE (m/s)	RMSE (m/s)	R	MAE (m/s)	RMSE (m/s)	R	MAE (m/s)	RMSE (m/s)	R
U-velocity-Global	0.11	0.16	0.70	0.10	0.14	0.74	0.11	0.14	0.73
V-velocity	0.11	0.15	0.60	0.10	0.14	0.66	0.10	0.13	0.64
Current speed	0.10	0.14	0.62	0.10	0.14	0.65	0.10	0.14	0.64
U-velocity-Tropics	0.12	0.16	0.78	0.10	0.14	0.81	0.11	0.15	0.81
V-velocity	0.11	0.14	0.68	0.10	0.13	0.72	0.10	0.13	0.72
Current speed	0.11	0.15	0.72	0.09	0.13	0.75	0.10	0.14	0.75
U-velocity-Australia	0.12	0.16	0.71	0.11	0.15	0.74	0.11	0.15	0.74
V-velocity	0.11	0.15	0.60	0.10	0.14	0.67	0.10	0.13	0.64
Current speed	0.11	0.14	0.55	0.10	0.14	0.60	0.10	0.14	0.58



Summary

- Verification
 - Produced CLASS4 format drifter data files
 - Model analysis verified against SVP drifter data
- OMAPS and CMEMS differences
 - Horizontal resolution CMEMS ($1/12^\circ$) vs OMAPS ($1/10^\circ$)
 - Vertical resolution CMEMS (1m) vs OMAPS (5m)
 - ECMWF forcing vs ACCESS-G2
- CMEMS and ENS-OMAPS appear to be remarkably statistically equivalent
 - CMEMS has the slightly lower errors than ENS-OMAPS & OMAPS
 - OMAPS/ENS-OMAPS performs best in mid-latitudes and majority of boundary currents
 - CMEMS shows a small improvement in the high latitudes and Kuroshio Current
 - Errors appear to be independently sampling the random error
 - Useful benchmark to compare future systems
- Next steps
 - Evaluate relative errors between OBS and models
 - Include more ocean models (FOAM, ROAM...) in inter-comparison





Australian Government
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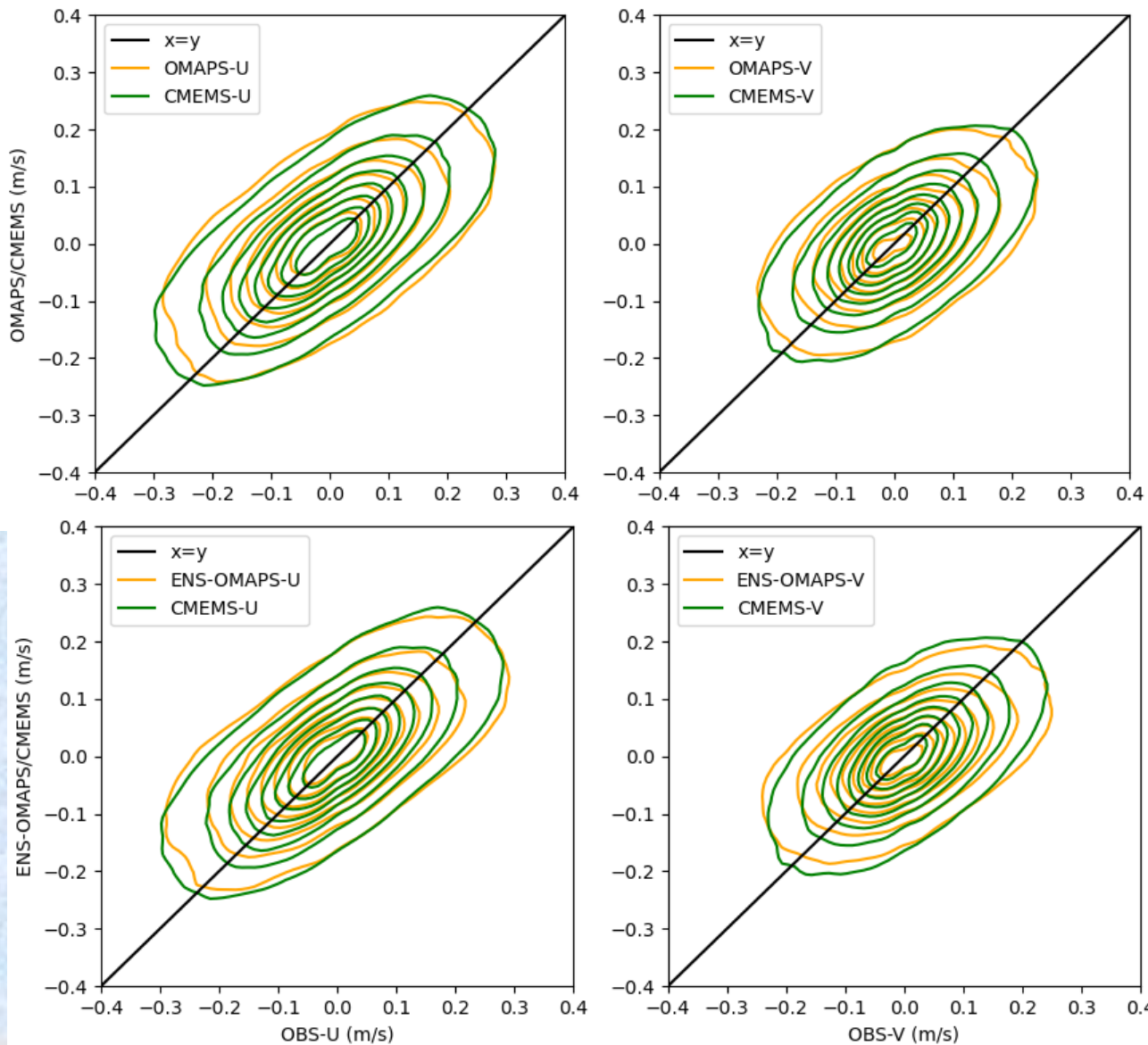
Thank you

Questions?

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Model vs OBS density 2019 Analysis - Global

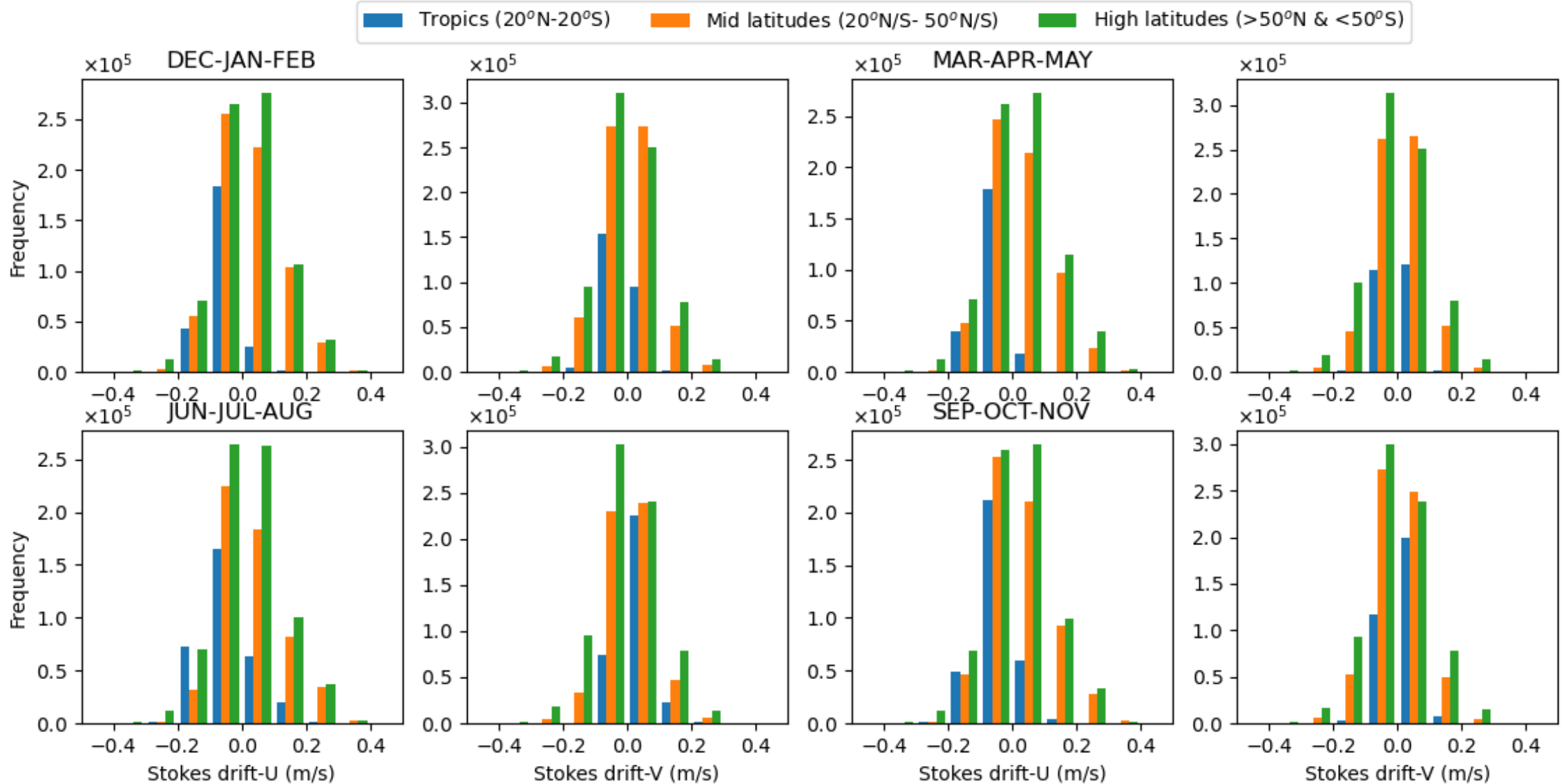


OMAPS, CMEMS

ENS-OMAPS, CMEMS

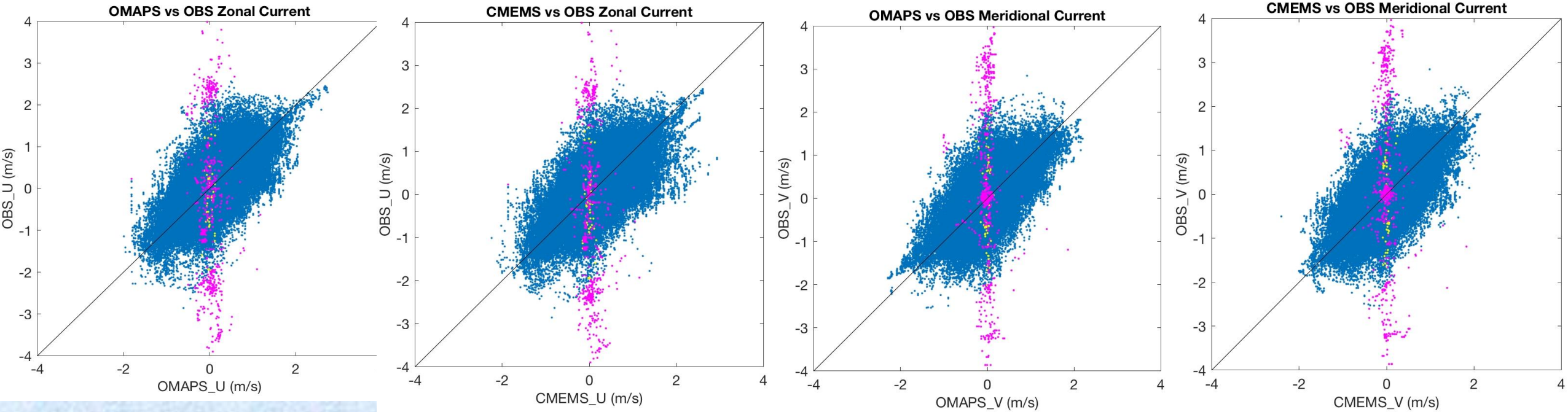


Seasonal & regional stokes drift





Outliers based (unfiltered data) 2019 Global



Relative Error:

$$\frac{|\text{Model} - \text{OBS}|}{|\text{OBS}|}$$

Magenta = Model error $|\text{Model} - \text{OBS}| > 2.0$

Yellow = Model relative error > 60