Limitations and biases of wind reanalysis products for ocean model forcing

Wind forcing in simulation experiments

- Air-sea fluxes of momentum and heat
- Gas exchange

Biases in different reanalysis products

- Land contamination of measurements
- Atmospheric grid coarser than ocean
- Interpolation (winds over land?)

Consequences (coastal processes)

- SST biases
- Biogeochemistry

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Assessment of different wind reanalysis products

Analysis focusing on ocean model forcing

- Three reanalysis products and equivalent versions including corrections
- Included an interpolation step (0.25° grid)
  - all locations *vs* only ocean locations
- Use QuikSCAT data as reference
- Focus on wind stress and spatial derivatives in coastal regions

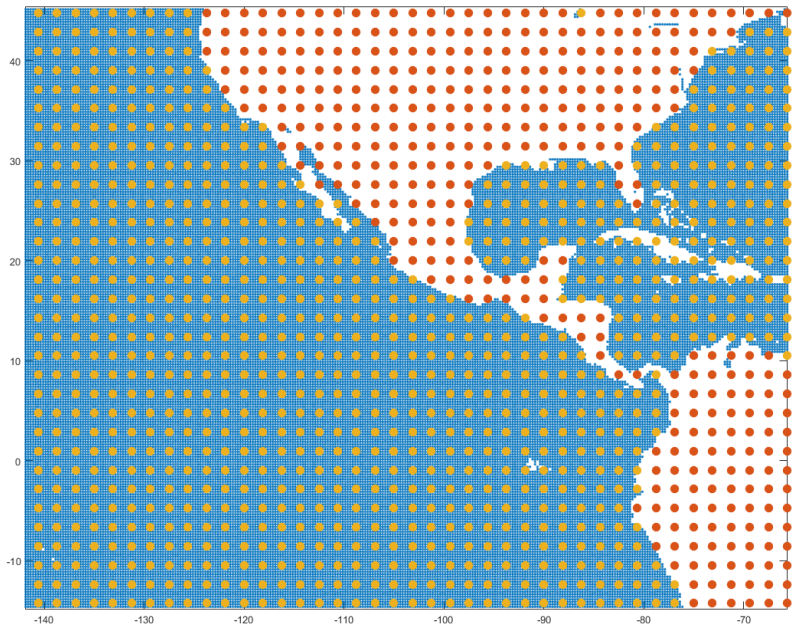
Reanalysis product	Corrected version	Resolution	
ERA-Interim	DRAKKAR	0.70° x 0.70°	3h
NCEP	CORE v2.1	1.85° x 1.90°	6h
JRA-55	JRA-55corr	0.56° x 0.56°	3h

Interpolation

Gaussian covariance function:

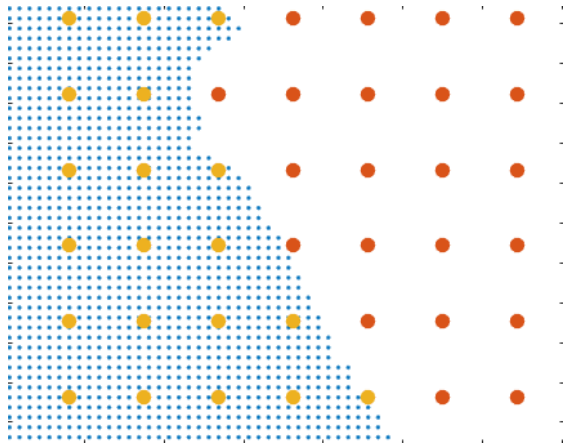
$$C(d_x, d_y) = \exp(-\phi_x^2 d_x^2 - \phi_y^2 d_y^2)$$

d is zonal or meridional distance
ϕ is a decay parameter (2 x intercell distance, latitude)
Only 50 nearest neighbours



Two different schemes:

- Interpolate between ocean and land pixel locations
- Inter/Extrapolate from ocean pixels locations alone



QuikSCAT (Sep 1999 – Nov 2009)

Improvements on last reprocessing JPL L2B v3 12.5 km (Fore et al. 2014 *IEEE*):

- New geophysical model avoids previous overestimation of wind speed (Ku-2011, Ricciardulli and Wentz 2015 *J Atmos Oceanic Technol*)
- New binning algorithm: improved accuracy and reduced noise, wind retrievals as close as 25 km from the coast
- Improved rain flags and corrections
- Overall RMSE: 1.01 m/s and 17.4° with respect to buoy data (Fore et al. 2014 *IEEE*)

Problems that remain; rainy conditions, sea ice and limited coverage (93% of the ocean surface daily); these are neutral winds

Put QuikSCAT winds on the same 0.25° grid

Wind speed, wind stress and its curl, Ekman pumping and coastal divergence

- Wind stress assuming constant air density, drag coefficient (C_D) from Large et al. 1994 *Rev Geophys*

$$\vec{\tau} = \rho_{air} C_D \vec{u} |\vec{u}|$$

- Ekman pumping following Risien and Chelton 2008 *J Phys Oceanogr*

$$w_{curl} = \frac{1}{\rho_{sw}} \nabla \times \left(\frac{\vec{\tau}}{f} \right) = \frac{1}{\rho_{sw} f} \left(\nabla \times \vec{\tau} + \frac{\beta}{f} \tau_x \right)$$

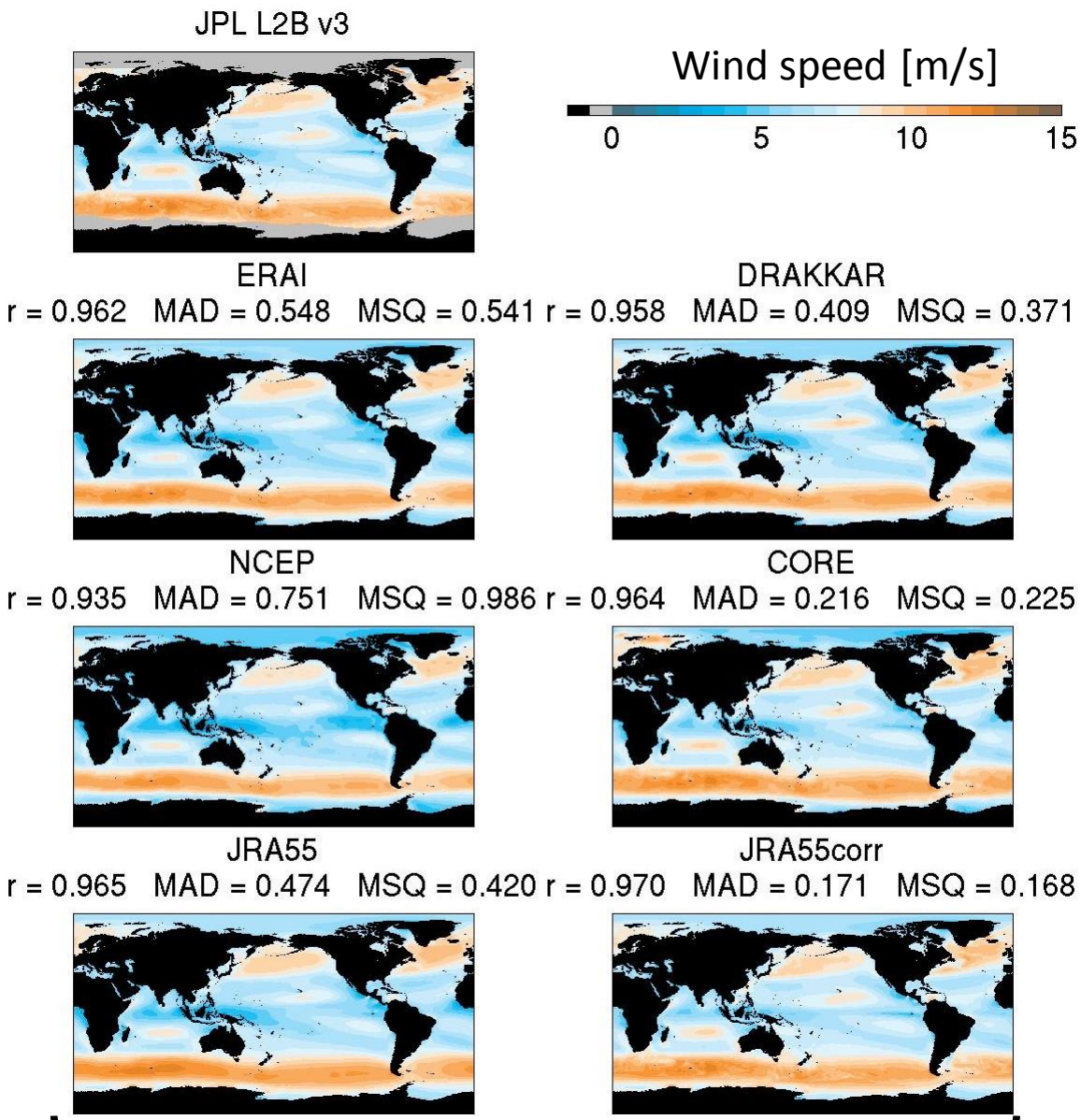
- Coastal divergence from alongshore stress (Bakun 1973 *NOAA Tech Rep*)

$$Q_{upw} = TL = \frac{\tau_a L}{\rho_{sw} f} \longrightarrow w_{coast} = \frac{T}{R_d}$$

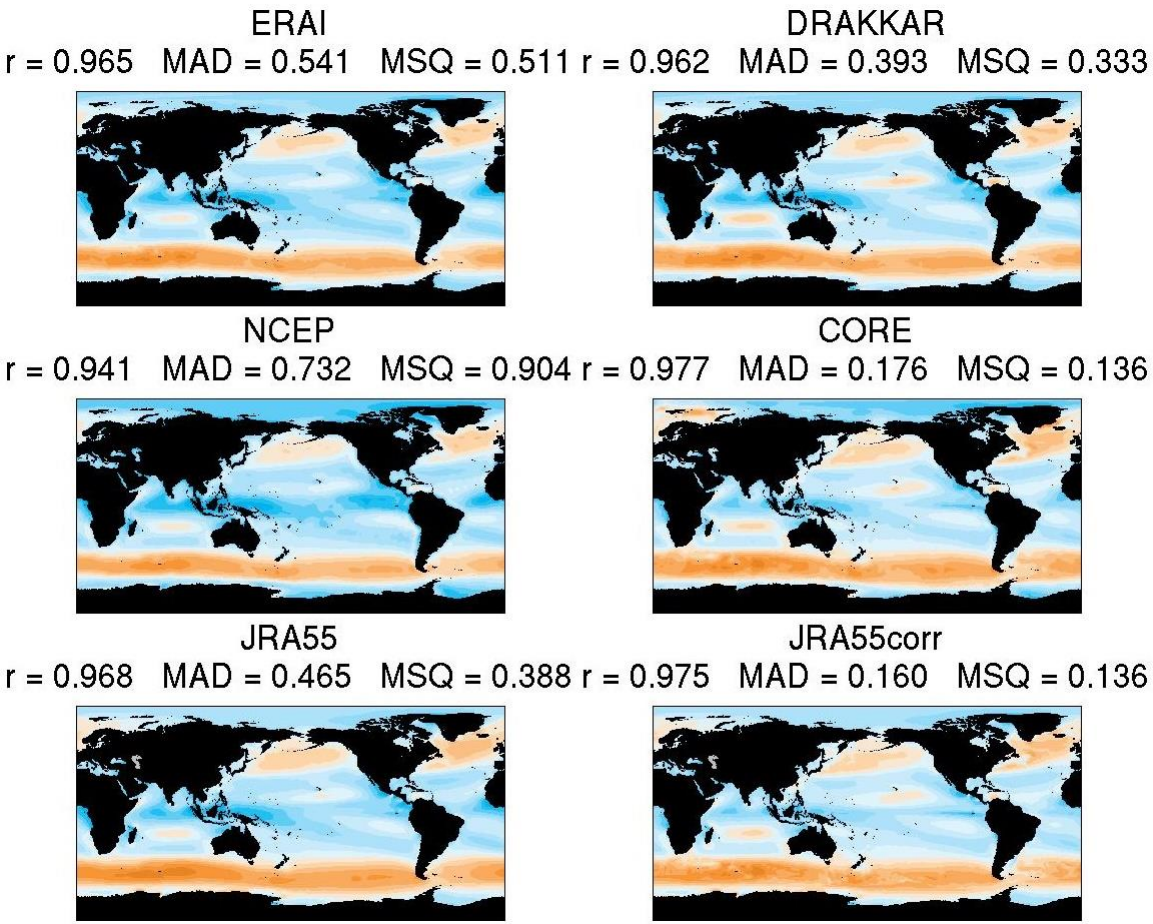
where the Rossby radius of deformation (R_d) was taken from Chelton et al. 1998 *J Phys Oceanogr*

Good match with large scale climatological patterns

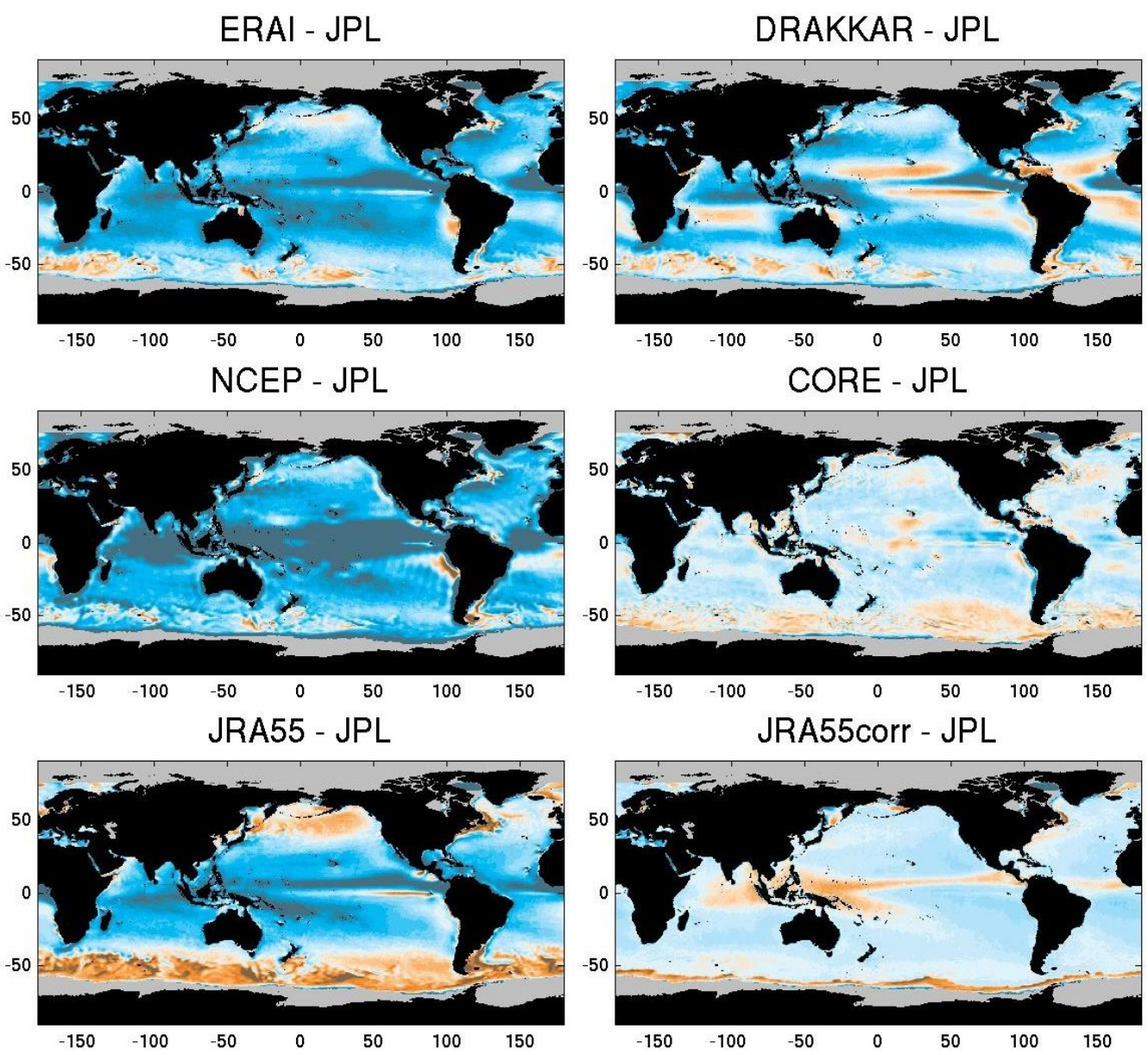
Corrected JRA-55 performs best

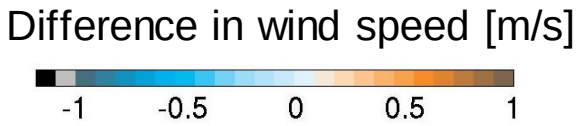


Interpolation using both land and ocean pixels



Interpolation using only ocean pixel locations





Interpolation using only ocean pixel locations

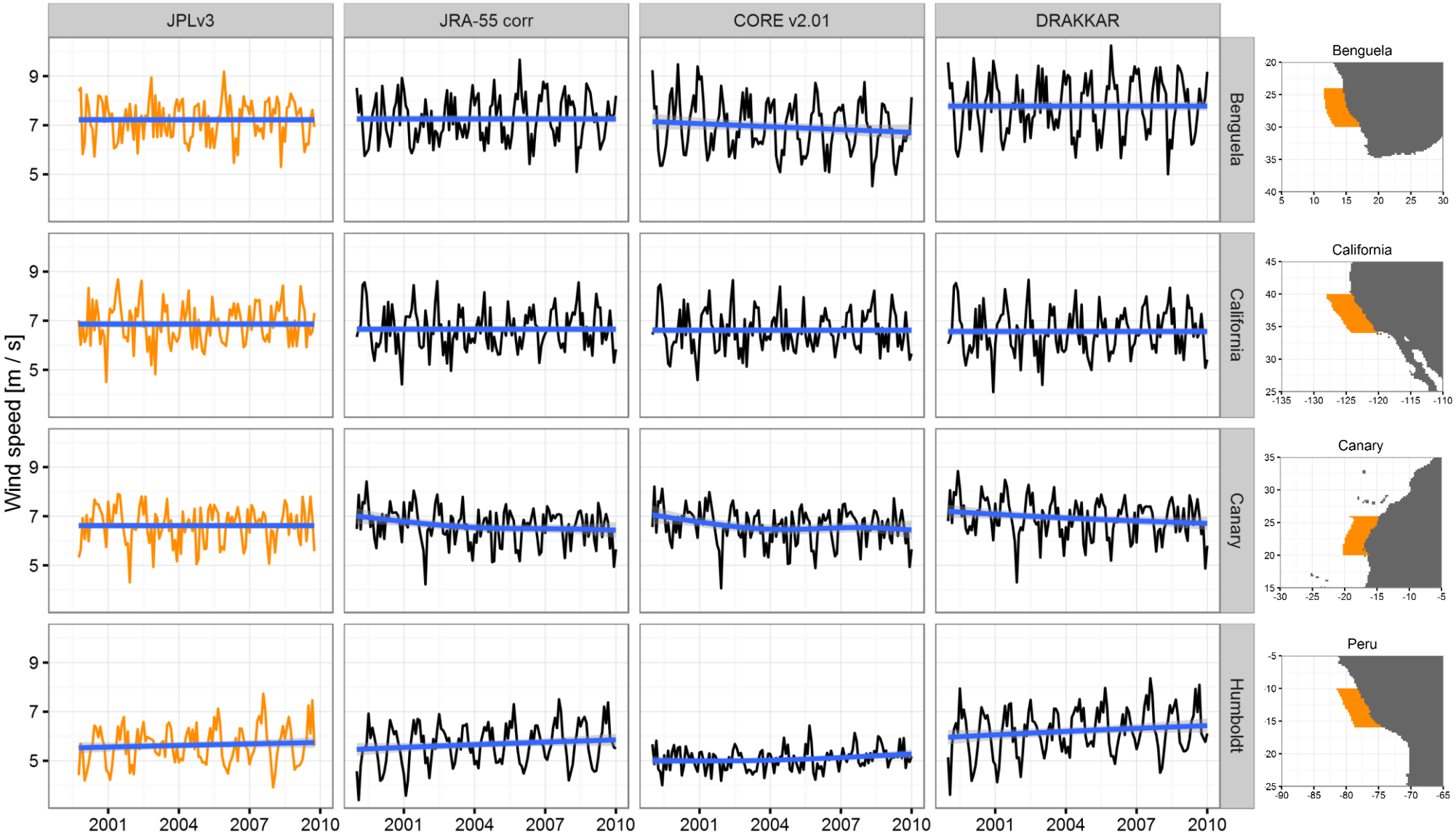
Difference in winds *before* and *after* applying corrections

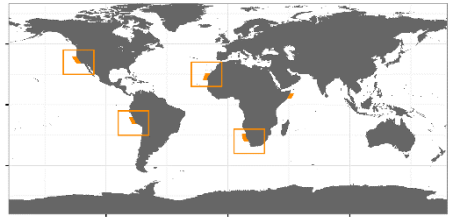
With respect to QuikSCAT, corrections lead to;

- weaker winds on subpolar latitudes (including the Southern Ocean)
- strengthened winds on the tropics

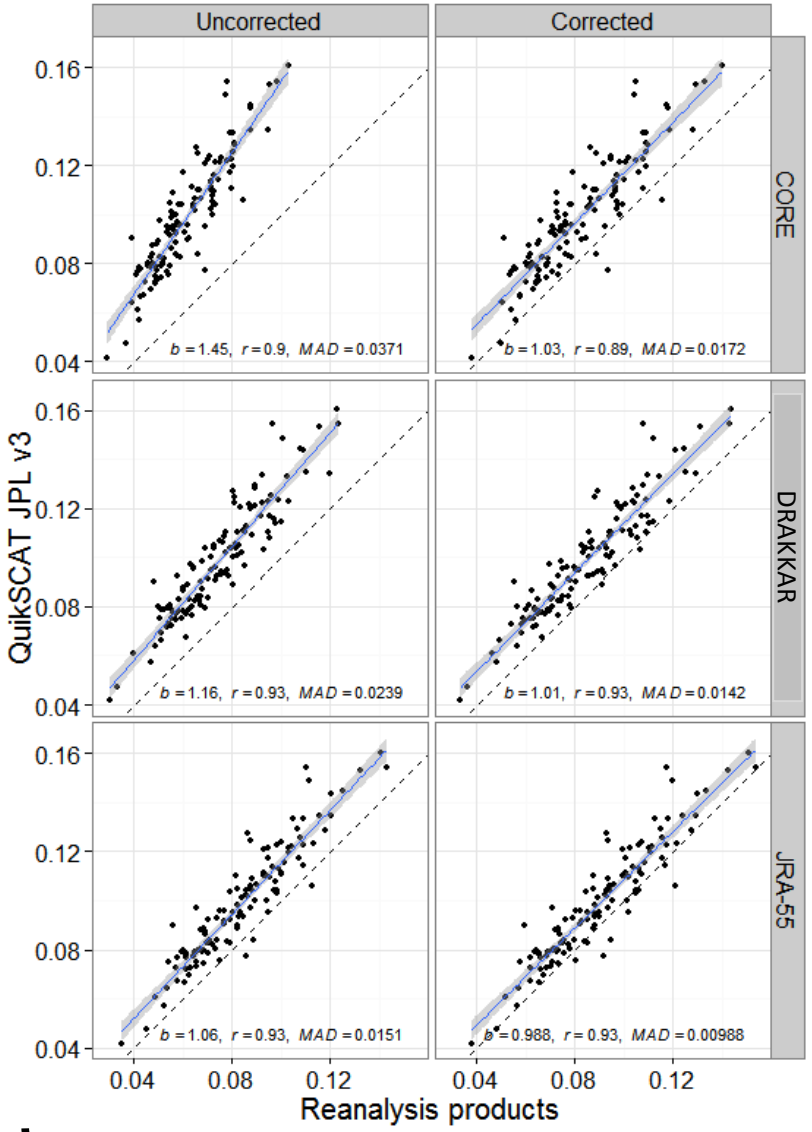
Bias remain, especially in the tropics; in JRA-55, tropical bias clearly associated with regions of high precipitation

Analysis comparing monthly time series on major coastal upwelling areas

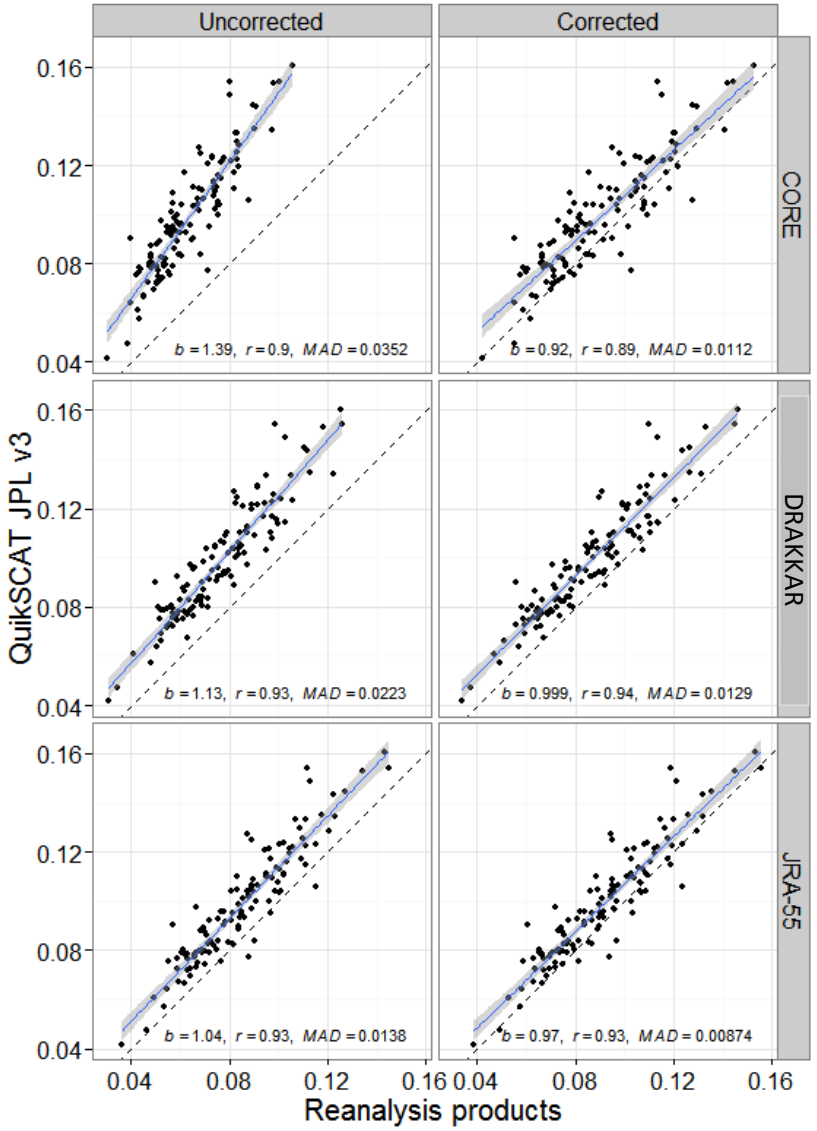




Wind stress [N / m^2], California Current region



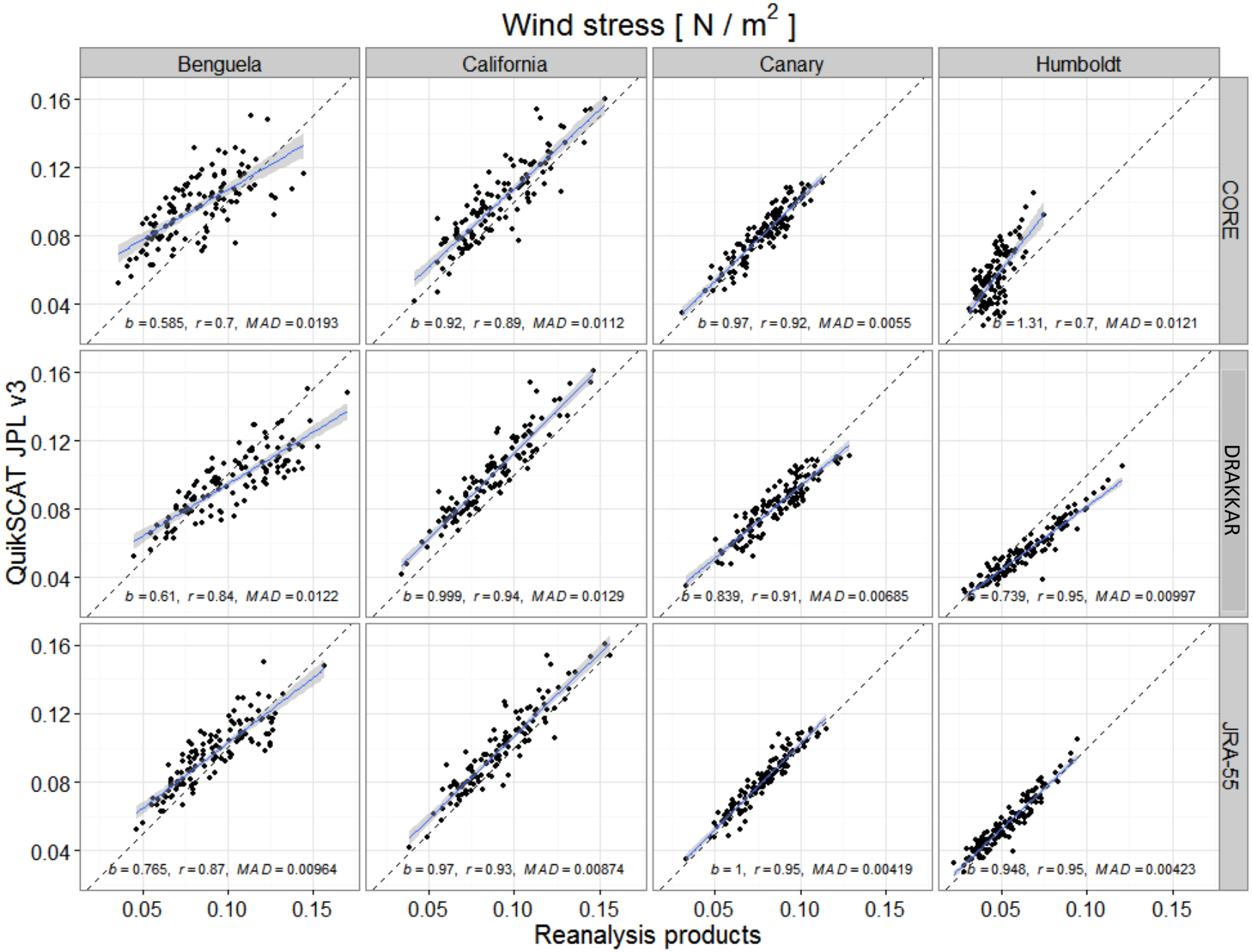
Interpolation using both land and ocean pixels



Interpolation using only ocean pixel locations

Monthly means averaged within 300 km of the coast

Impact of interpolation scheme less important than bias correction

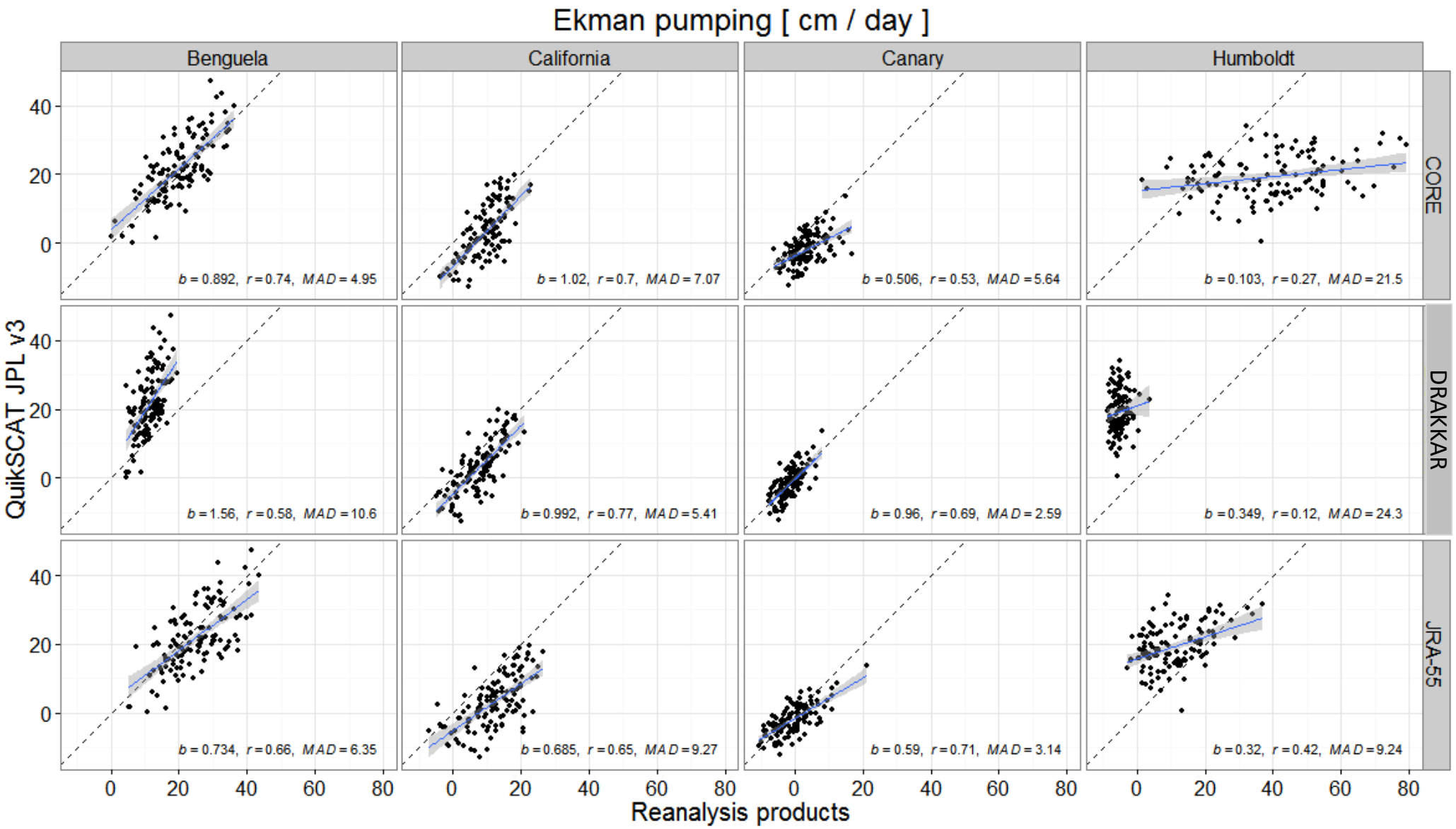


Geographical patterns based on corrected datasets, interpolated using only with ocean pixel locations

JRA-55 outperforms the other reanalysis products

Important improvement in Humboldt ecosystem

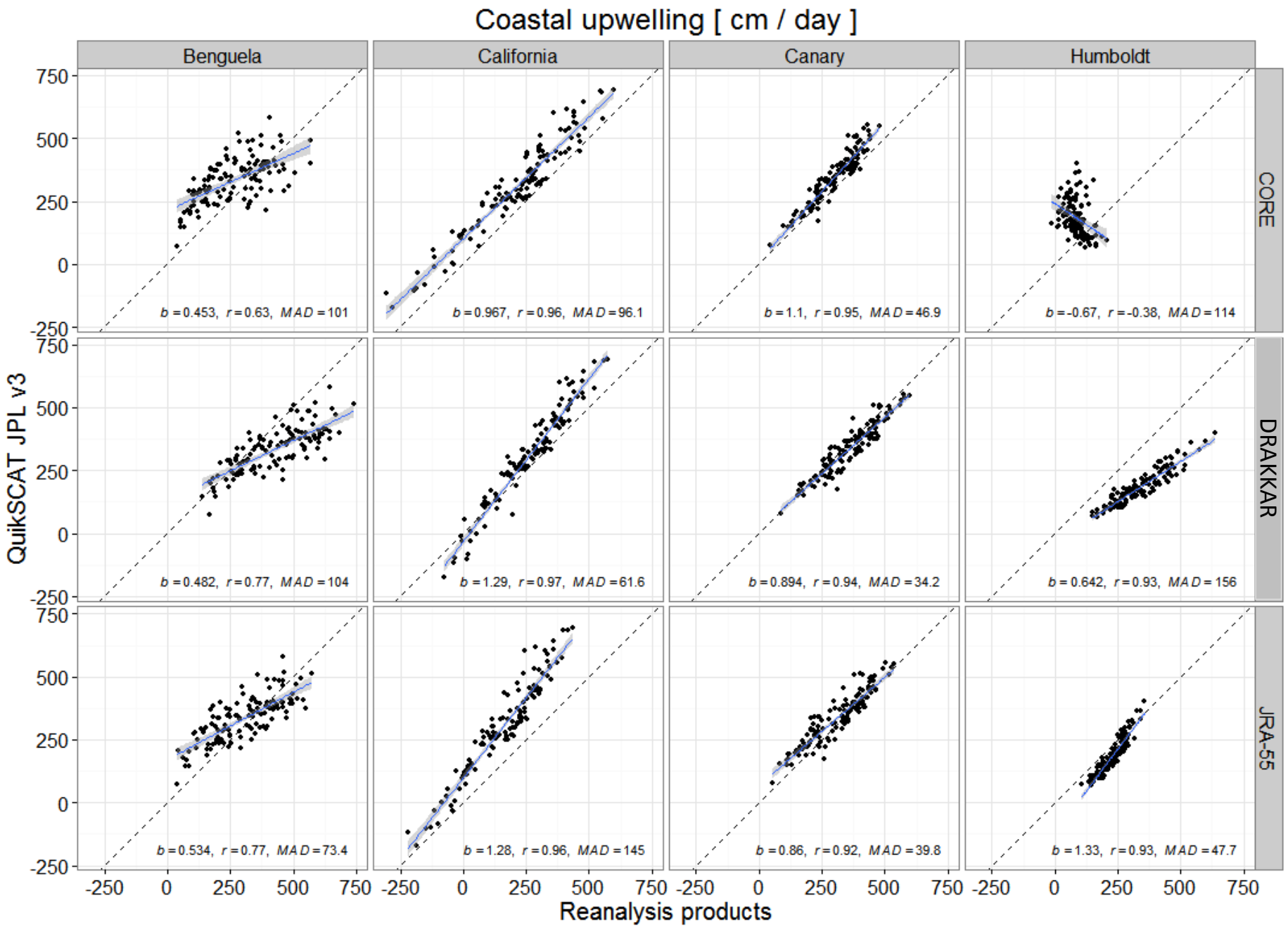
Some biases remain in Benguela (see Small et al. 2015 *J Clim*)



All reanalyses fail to reproduce wind stress curl patterns accurately near the coast, especially in the Humboldt current ecosystem

JRA-55 performed best again

Corrected datasets, interpolation based only with ocean pixel locations



The comparison for coastal upwelling is quite idiosyncratic;

- Benguela: difficult to reproduce
- California: upwelling remains weaker in reanalysis products
- Canary: catched!
- Humboldt: JRA-55 does the best work

Corrected datasets, interpolation based only with ocean pixel locations

Synthesis

High resolution reanalysis showed better performance; JRA-55 clear advance over CORE and DRAKKAR

Corrections necessary to avoid underestimation of wind strength

Interpolation ignoring land pixel locations can be important for low resolution products; but only provides a minor improvement in high resolution reanalysis

Biases remain in some regions; mainly California and Namibian upwelling regions

Wind stress curl patterns not captured and can lead to weaker upwelling

Recommendations

Update corrections of reanalysis products to latest version of QuikSCAT or to CCMPv02 (released last week by Remote Sensing Systems)

Test more elaborate correction methods and high resolution reanalysis products might be more rewarding than exploring complex interpolation schemes

References

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