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Scale dependence of observed wind stress response to ocean mesoscale surface temperatures

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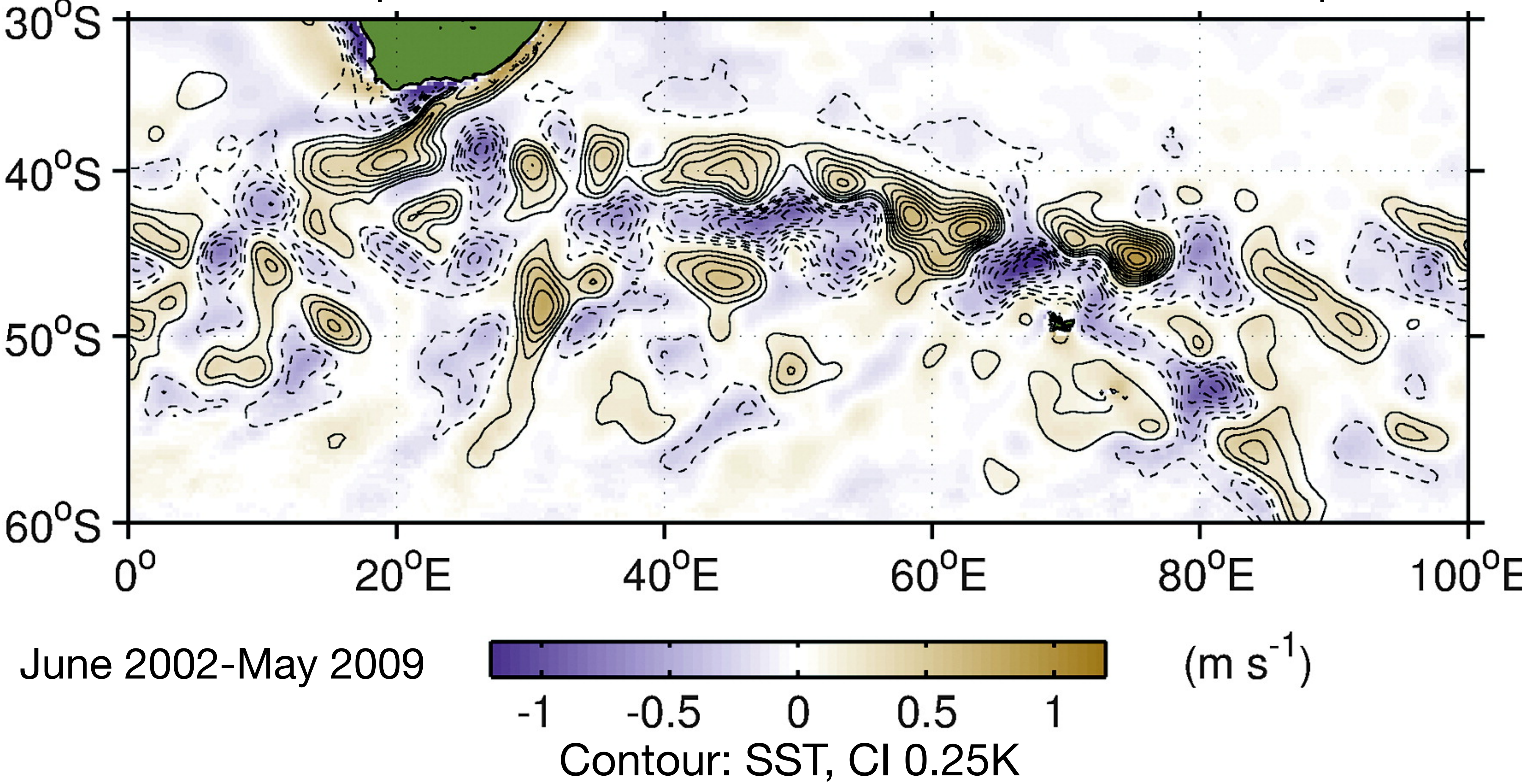
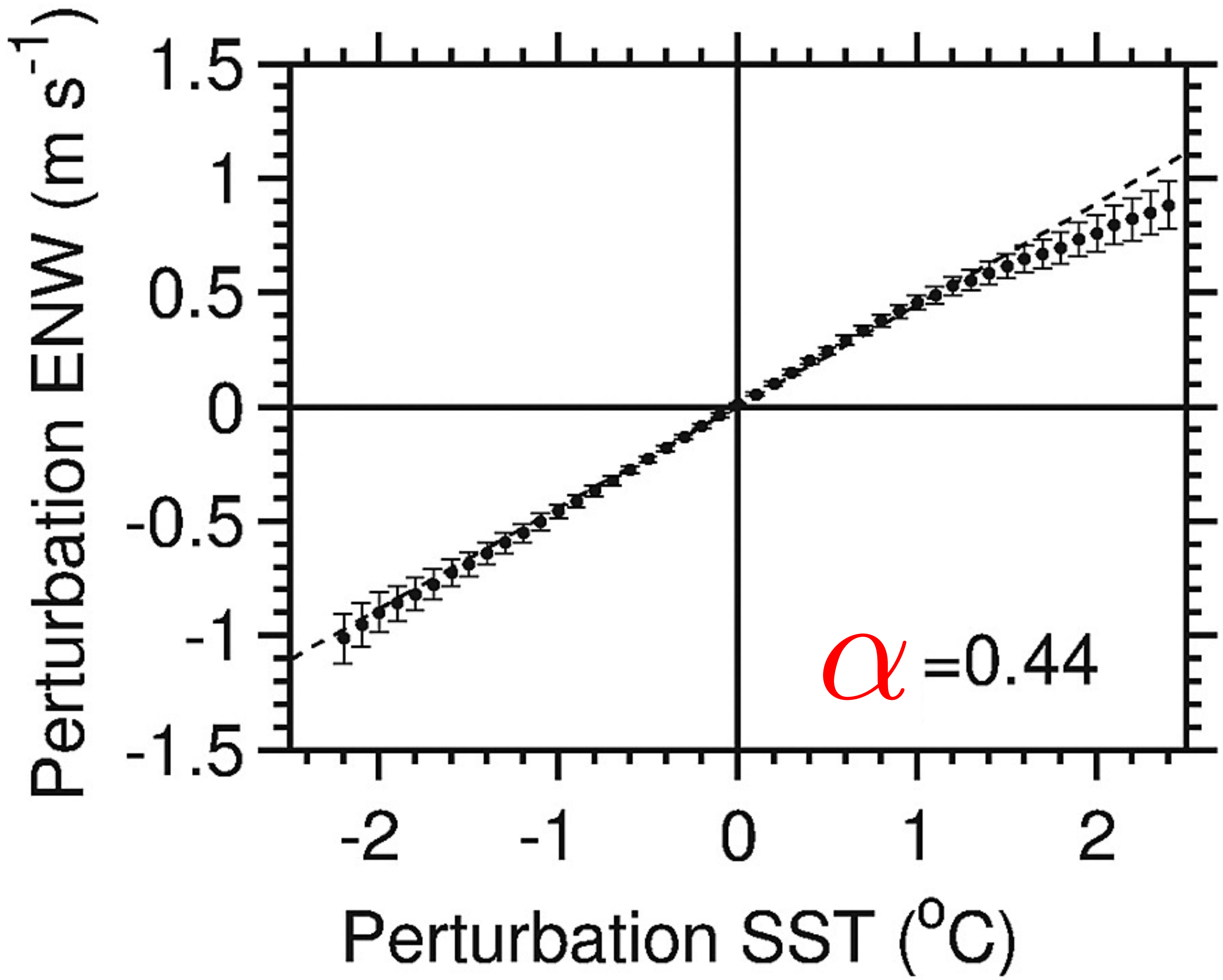
QuikSCAT Equivalent Neutral Wind, AMSR-E Sea Surface Temperature



O'Neill et al. 2012

Coupling coefficients

$$|\vec{u}| = \alpha \; T$$



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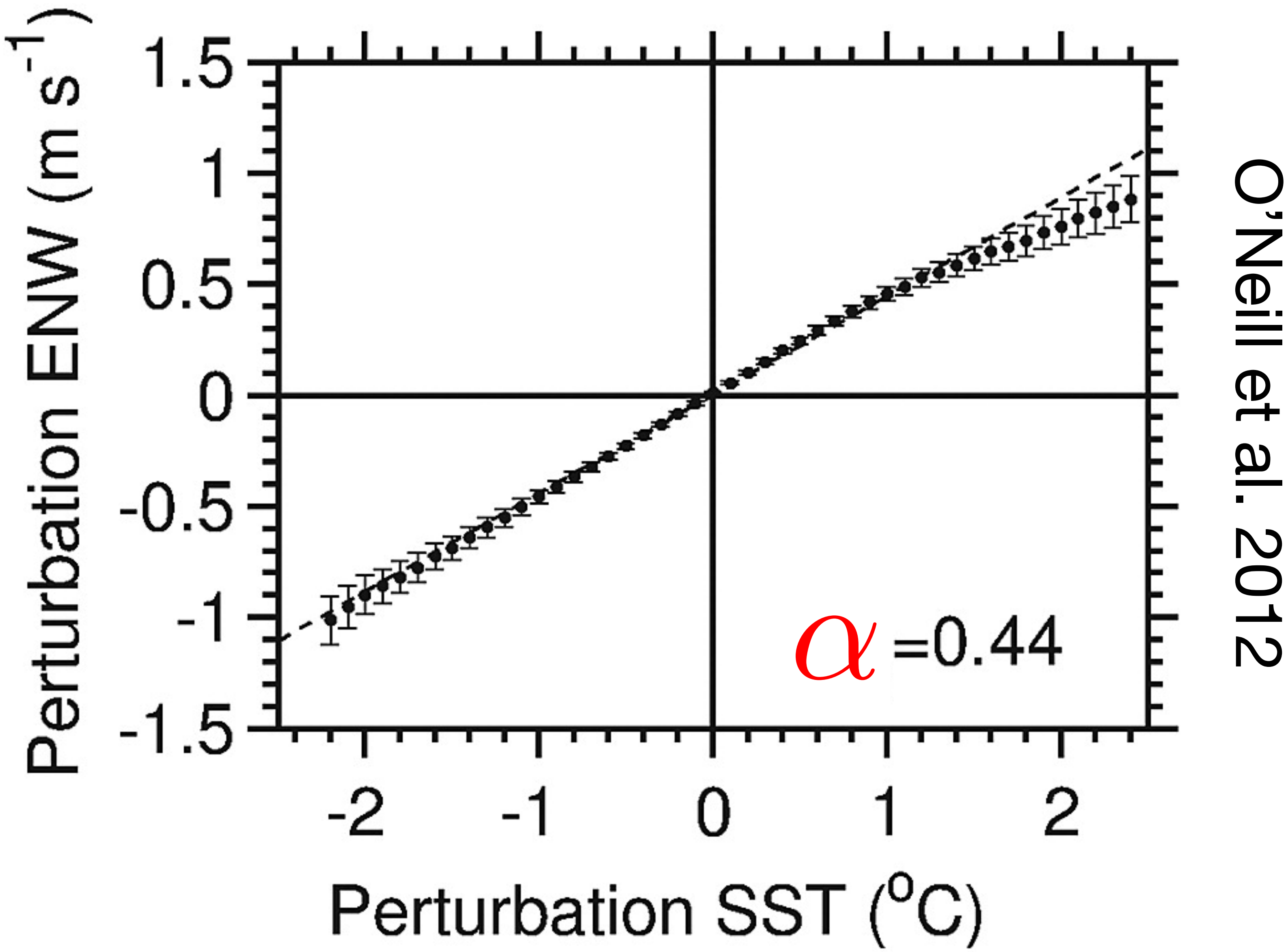


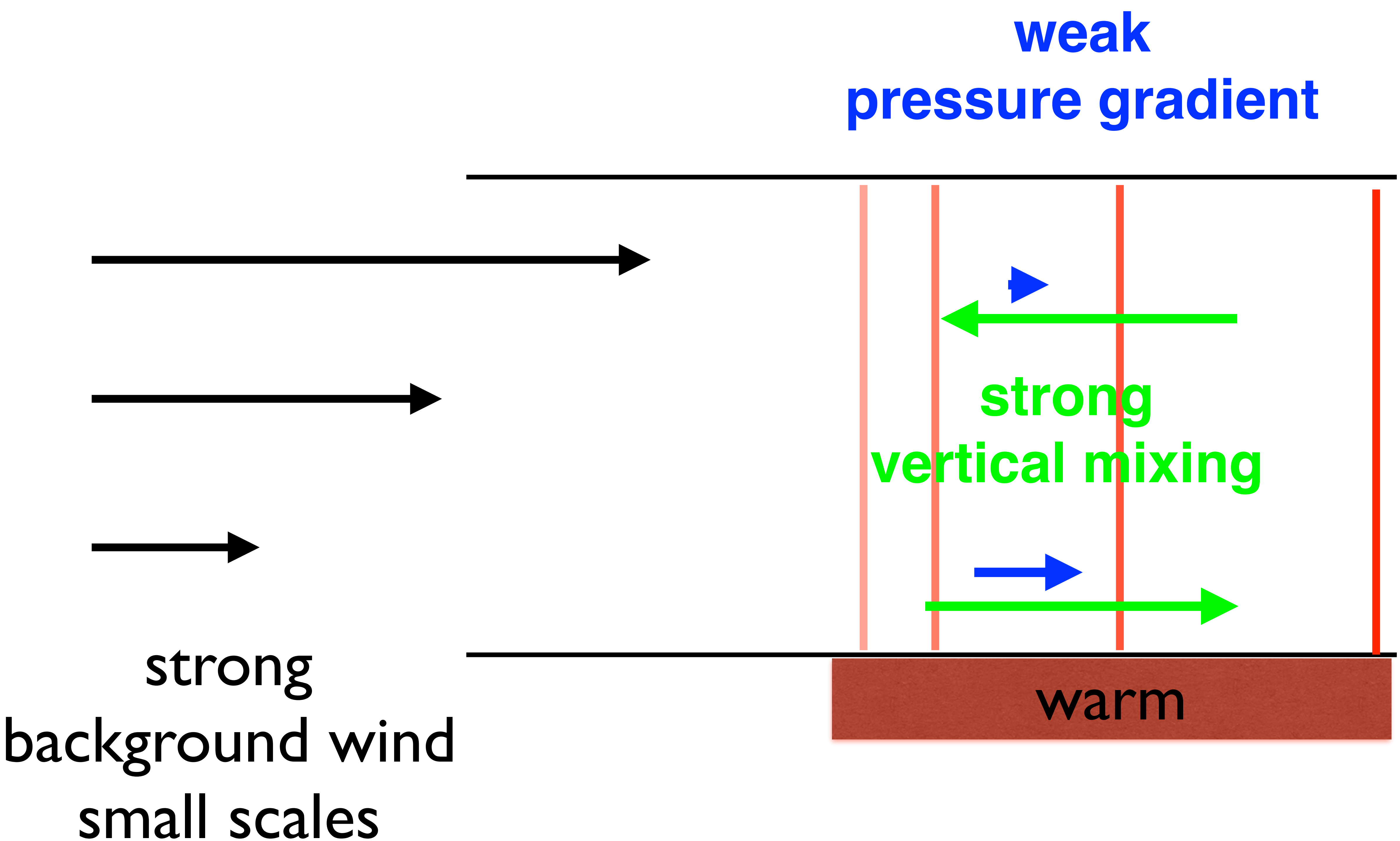
wind divergence related to down-wind SST gradients

wind curl related to cross-wind SST gradients

Scale Dependence

Pressure effect Lindzen and Nigam 1987

Vertical mixing mechanism Wallace et al. 1989, Hayes et al. 1989, Samelson et al. 2006



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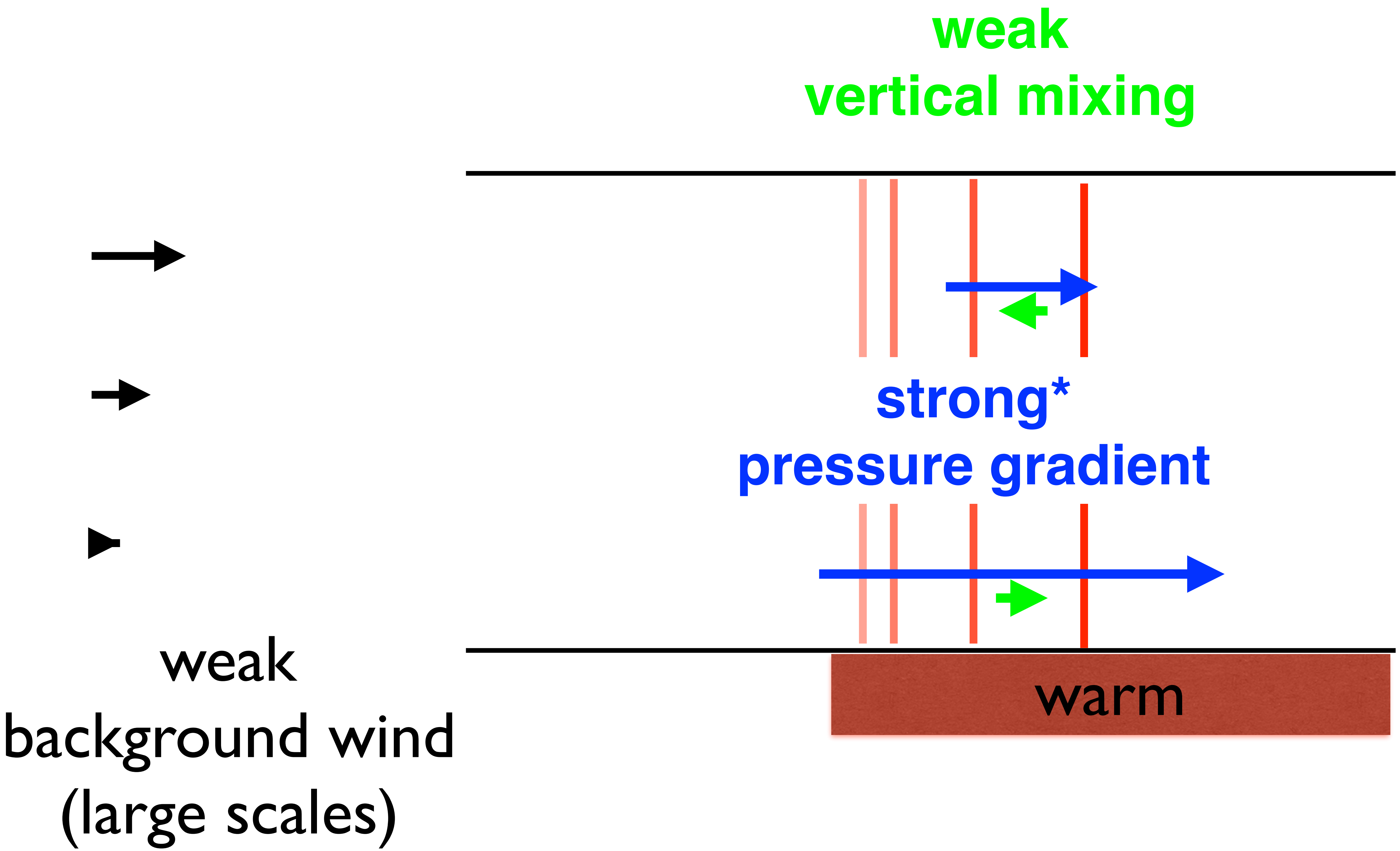

Scale dependence

$\dfrac{\vec{k}\cdot\vec{U}}{\gamma}$	pressure effect	vertical mixing mechanism
	$\ll 1$	$\gg 1$

Scale dependence

$$\frac{\vec{k}\cdot\vec{U}}{\gamma}$$	pressure effect	vertical mixing mechanism
	$\ll 1$	$\gg 1$
$$\frac{\vec{k}\cdot\vec{U}}{f}$$	rotation Ekman spiral	advection
down-wind background Rossby number		

Hypothesis & observations

Scale dependence of coupling coefficients indicates forcing mechanism for the atmospheric wind response to ocean mesoscale temperatures

Agulhas Retroflection, 45°E-75°E, 50°S-35°S
2000-2008

QuikSCAT (RSS V4) equivalent neutral wind, daily
Reynolds SST, daily

Scale dependent coupling coefficients

Fourier amplitudes

$$\vec{u}_{\vec{k}} = \vec{A}_{\vec{k},\vec{U}} \, T_{\vec{k}}$$

Transfer function

dependent on wavenumber relative to background wind & on background wind speed

Scale dependent coupling coefficients

Fourier amplitudes

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Transfer function

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4 day averages, 8°x8° squares

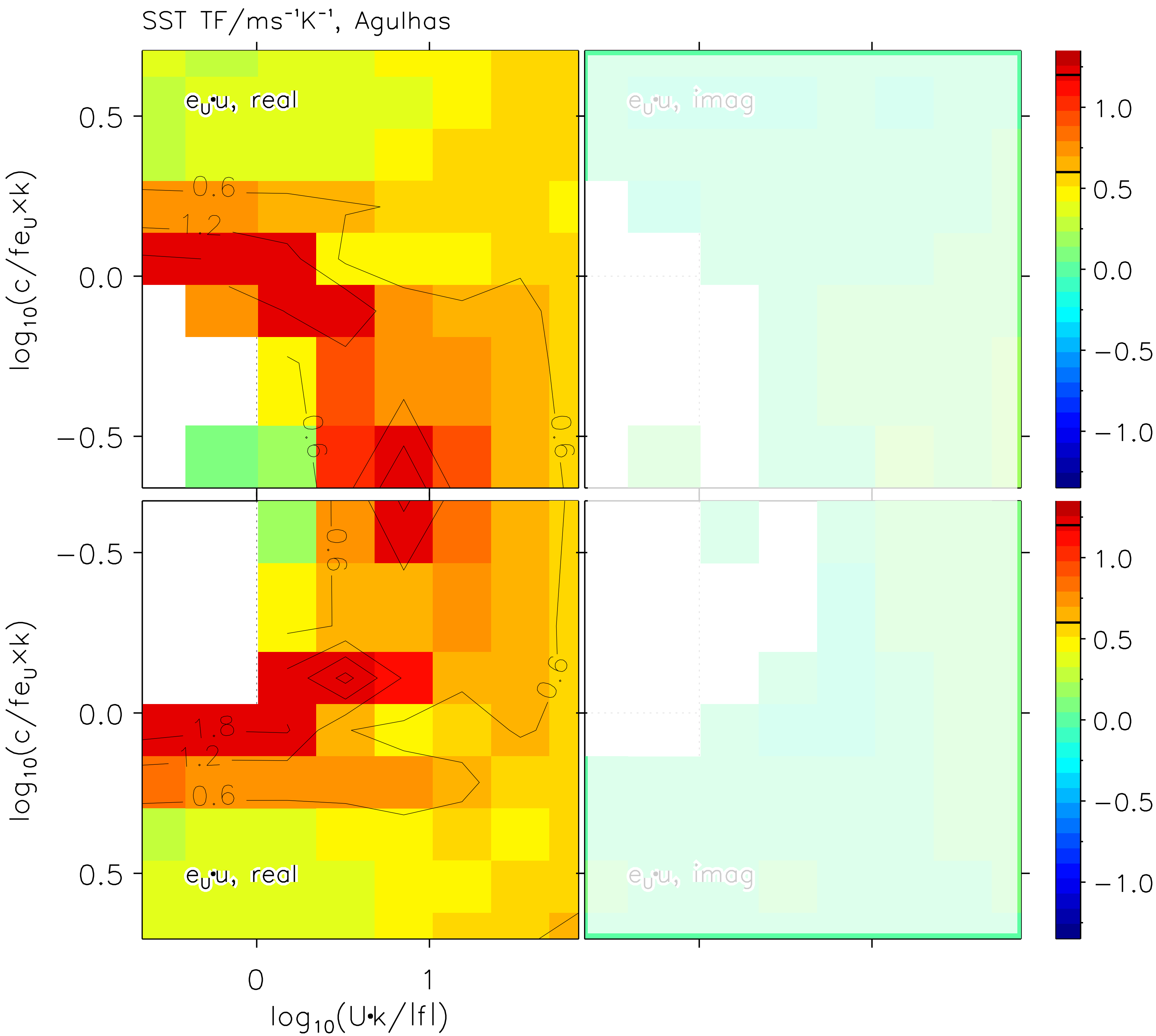
background winds: area average

mesoscale perturbations: wave-number Fourier amplitudes

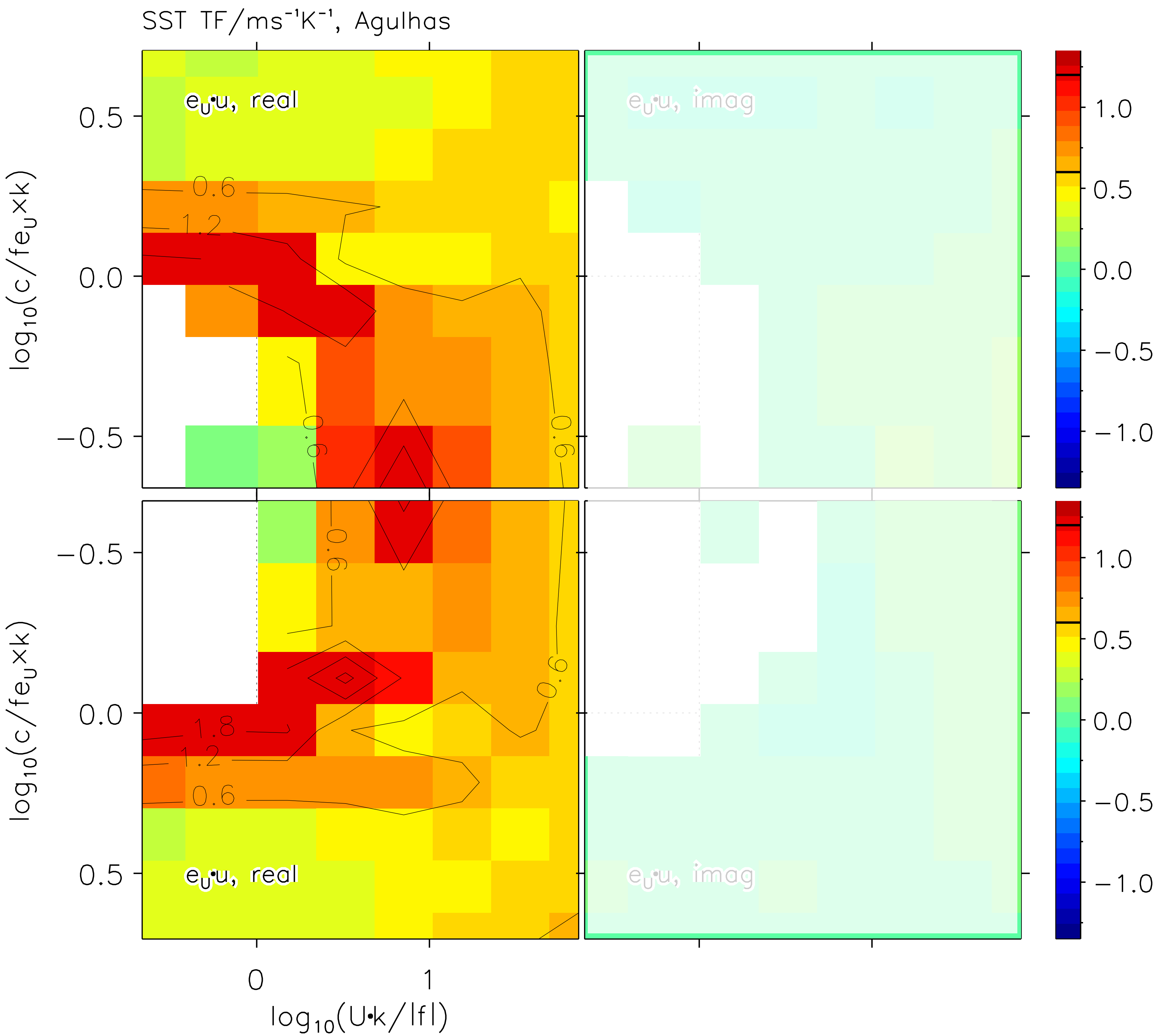
estimated via a least square fit

Transfer function: complex regression between Fourier amplitudes of ocean mesoscale SST and winds

Wind speed transfer function

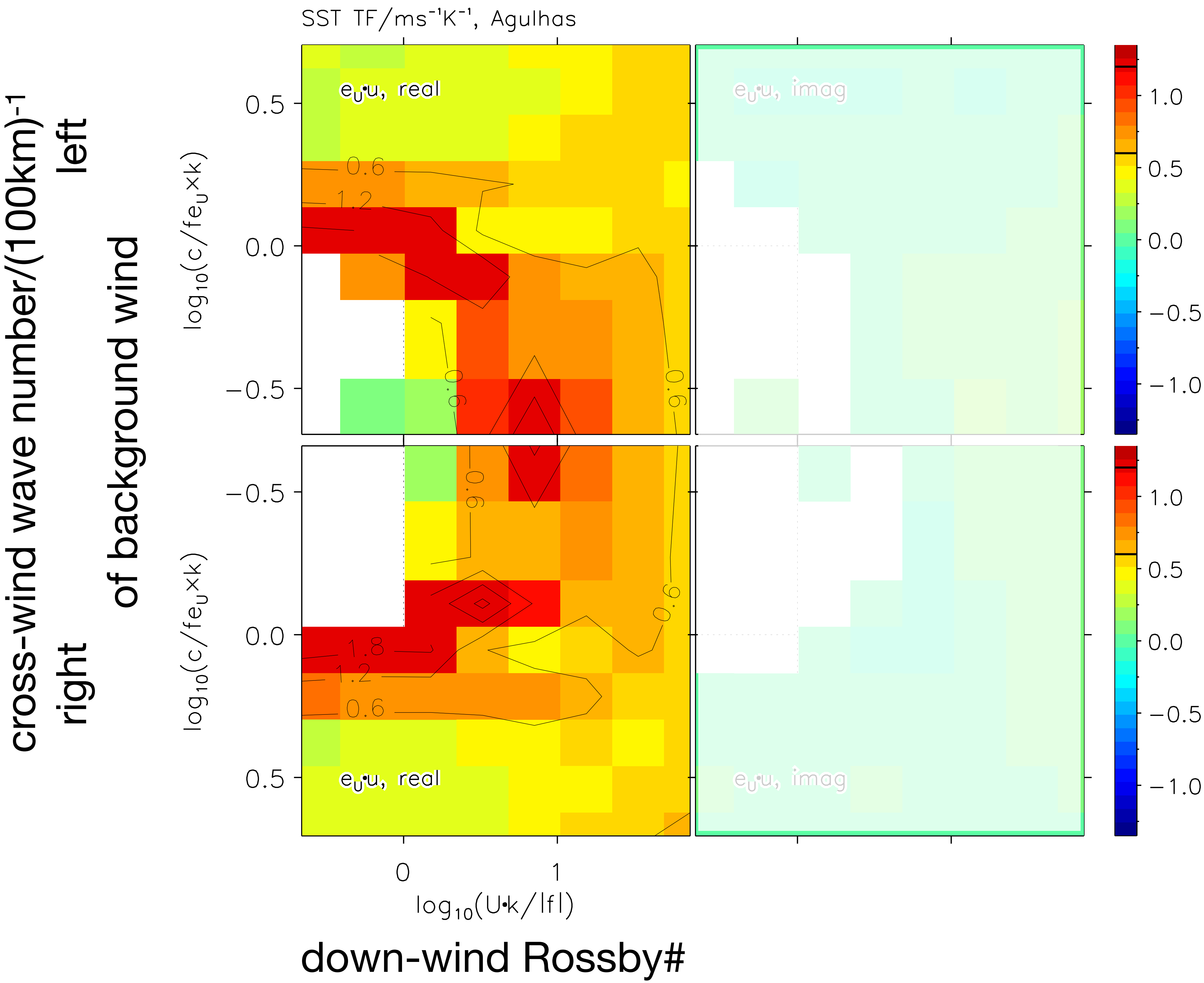


Wind speed transfer function



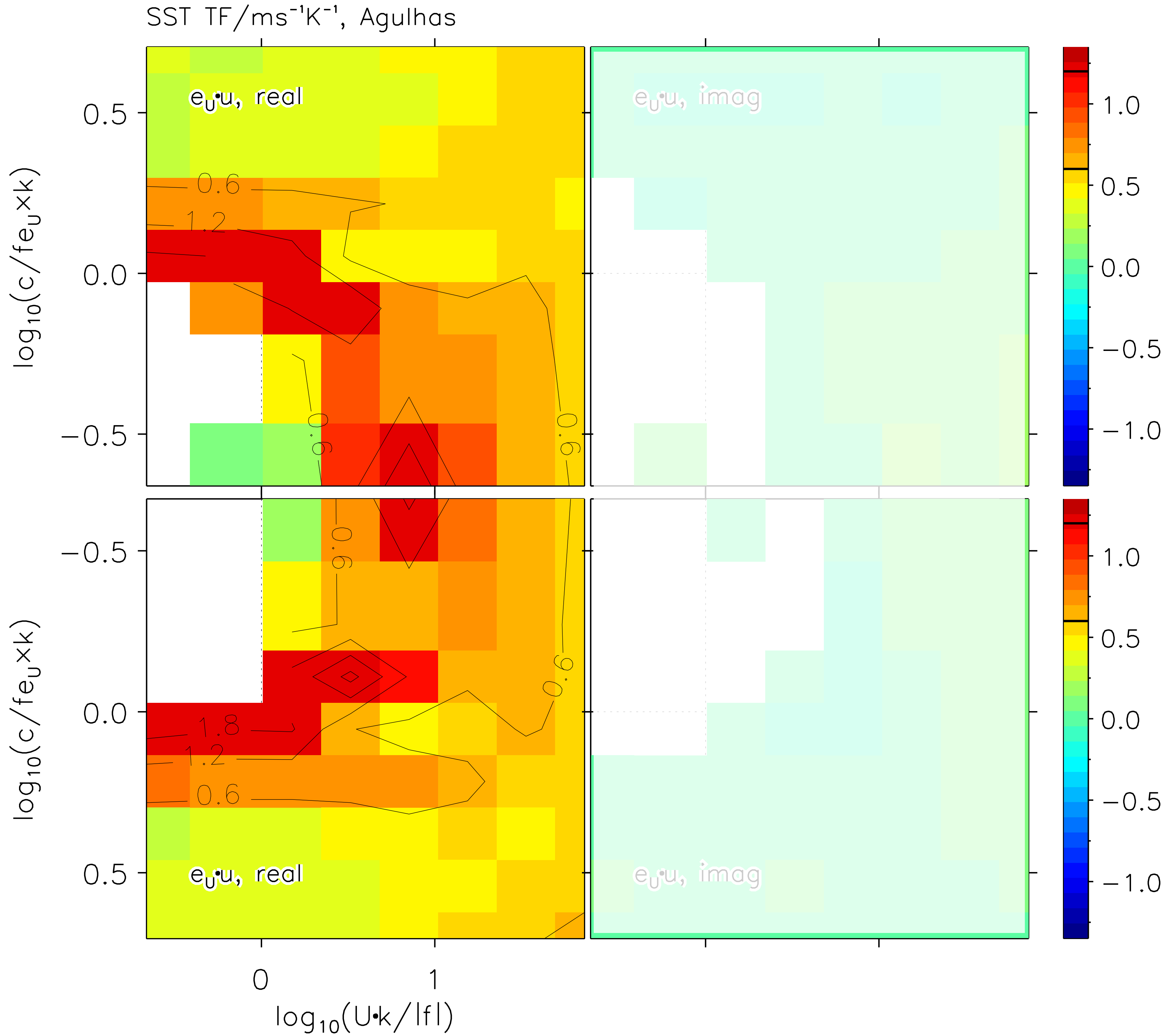
down-wind Rossby#

Wind speed transfer function



Wind speed transfer function

in phase with SST



cross-wind wave number/(100km)-1

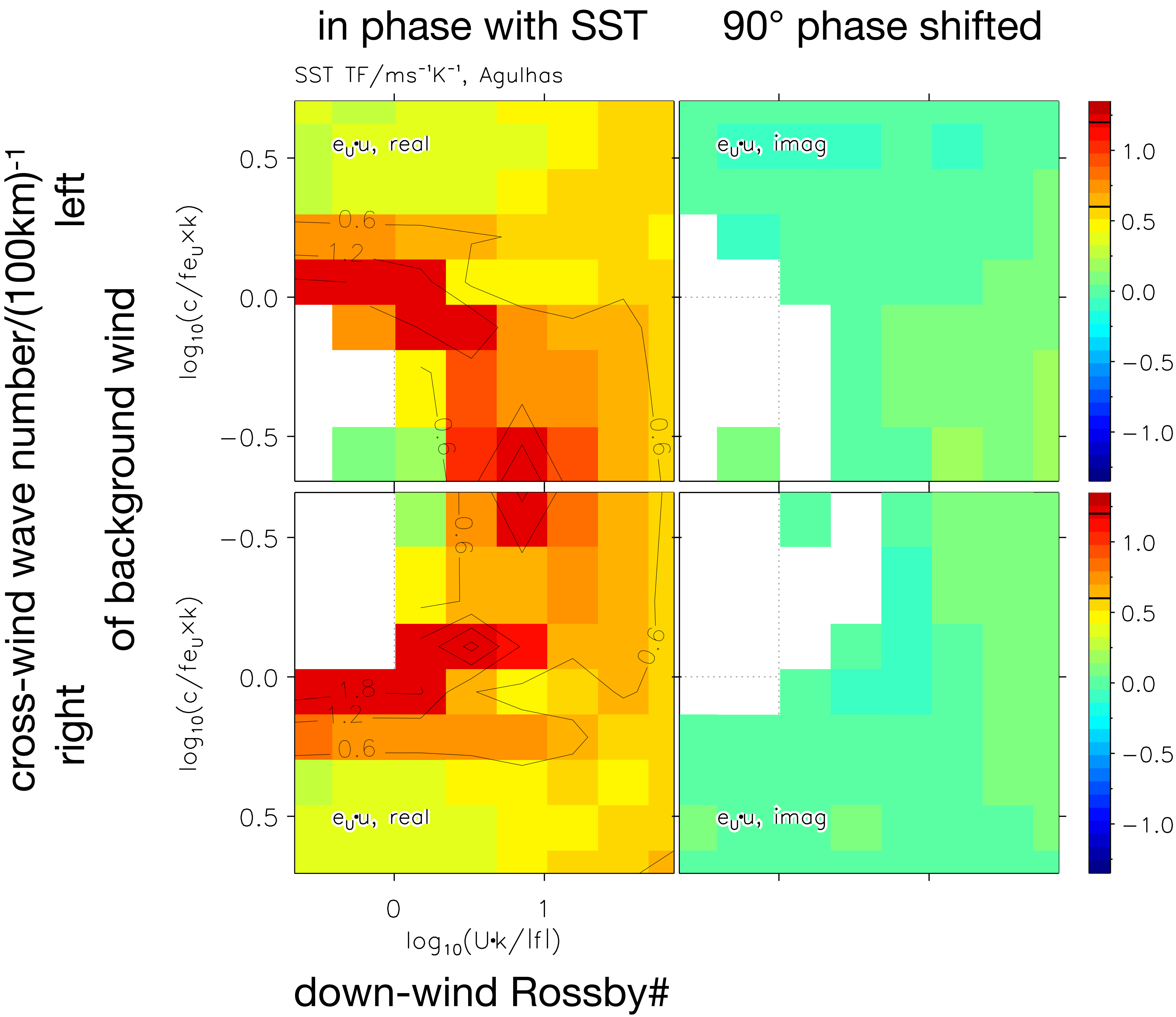
left

right

of background wind

down-wind Rossby#

Wind speed transfer function



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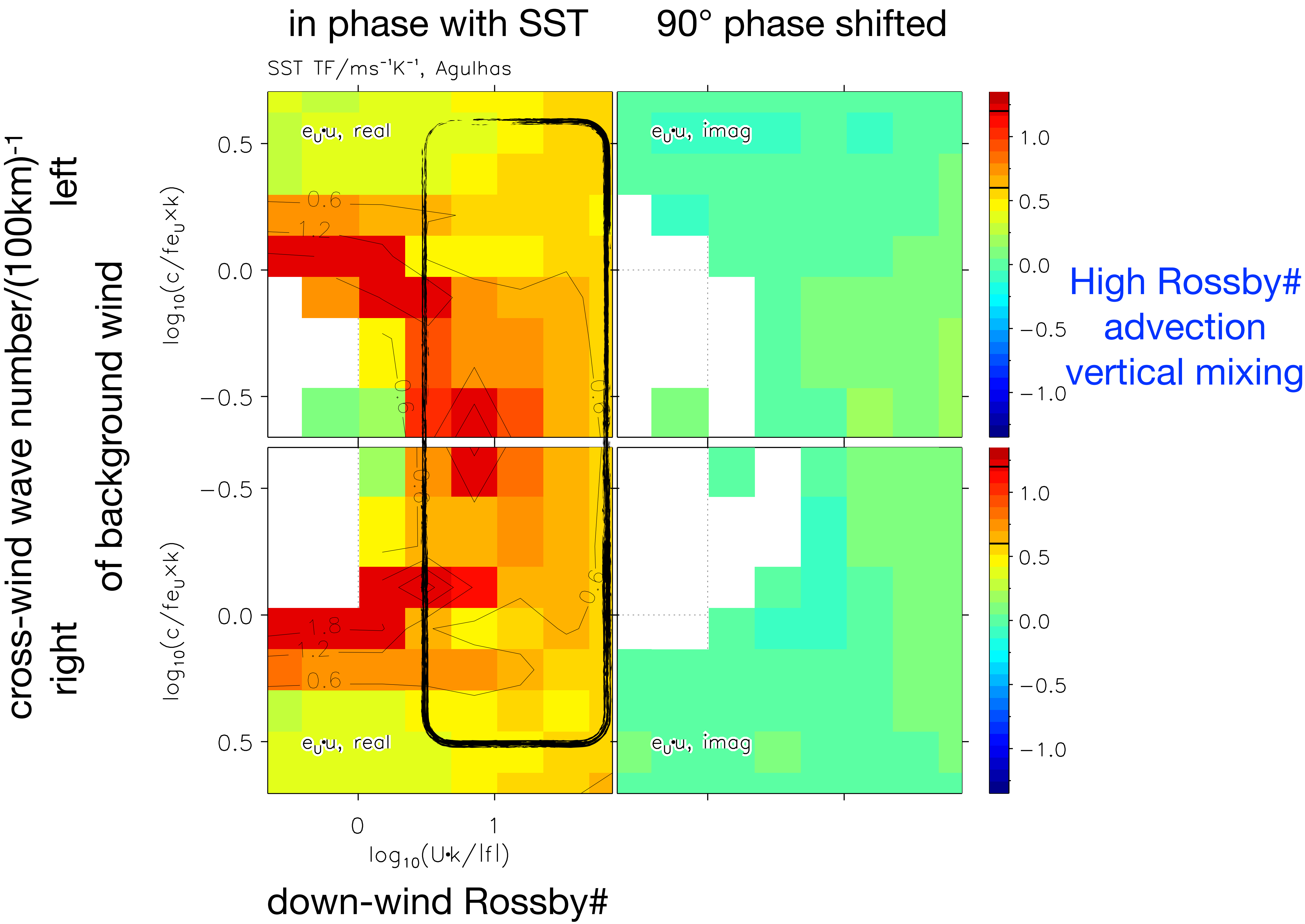

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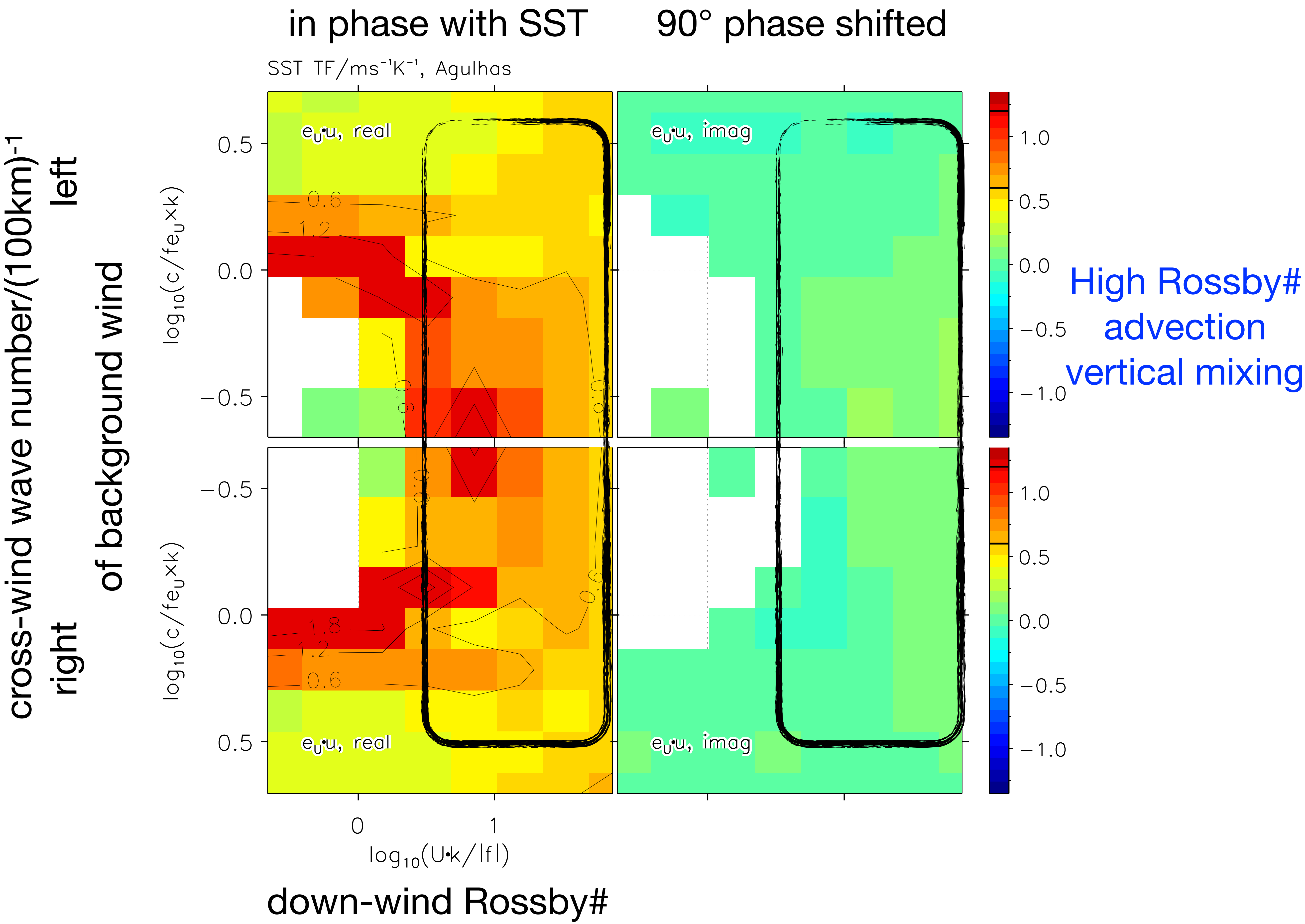

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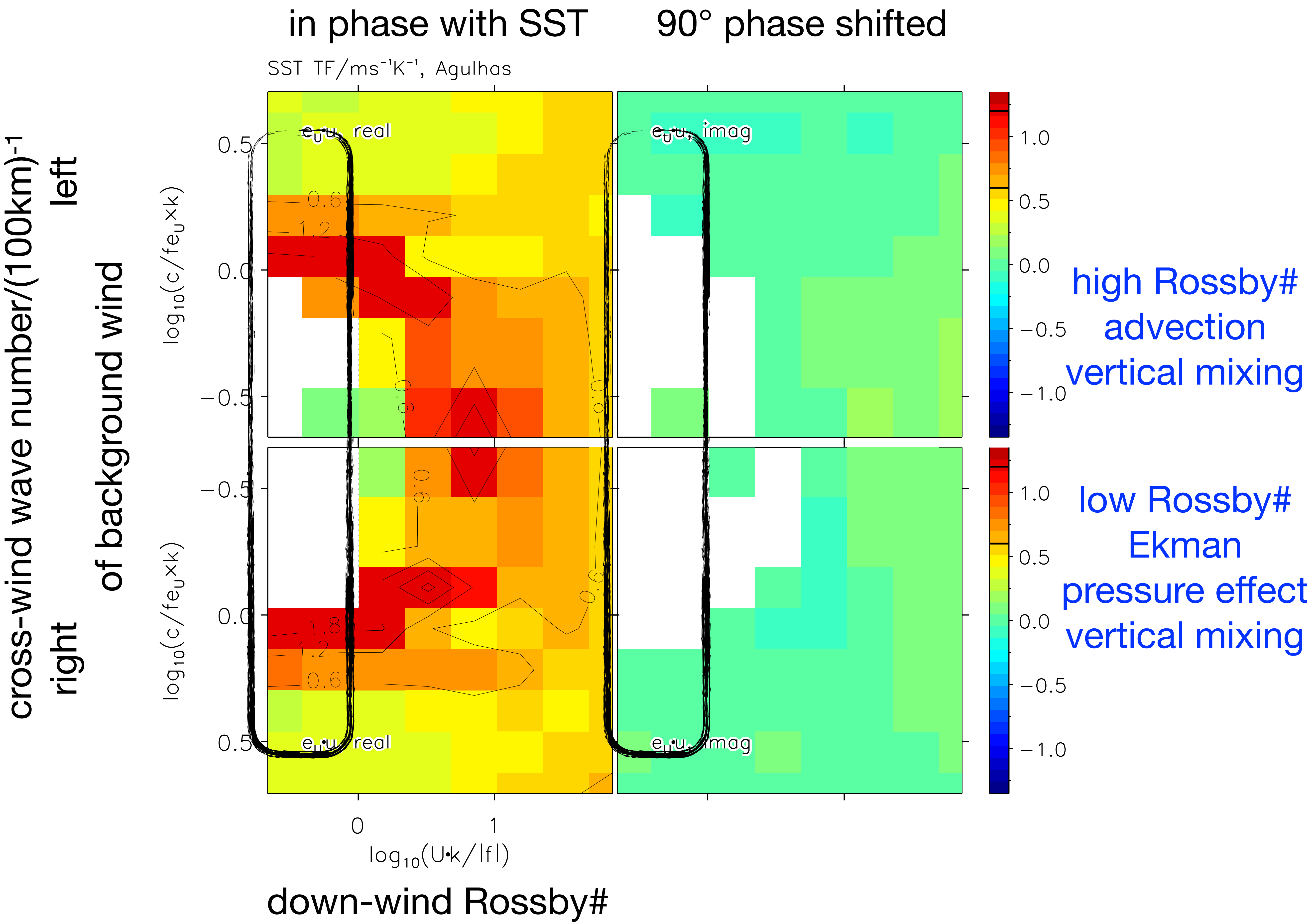
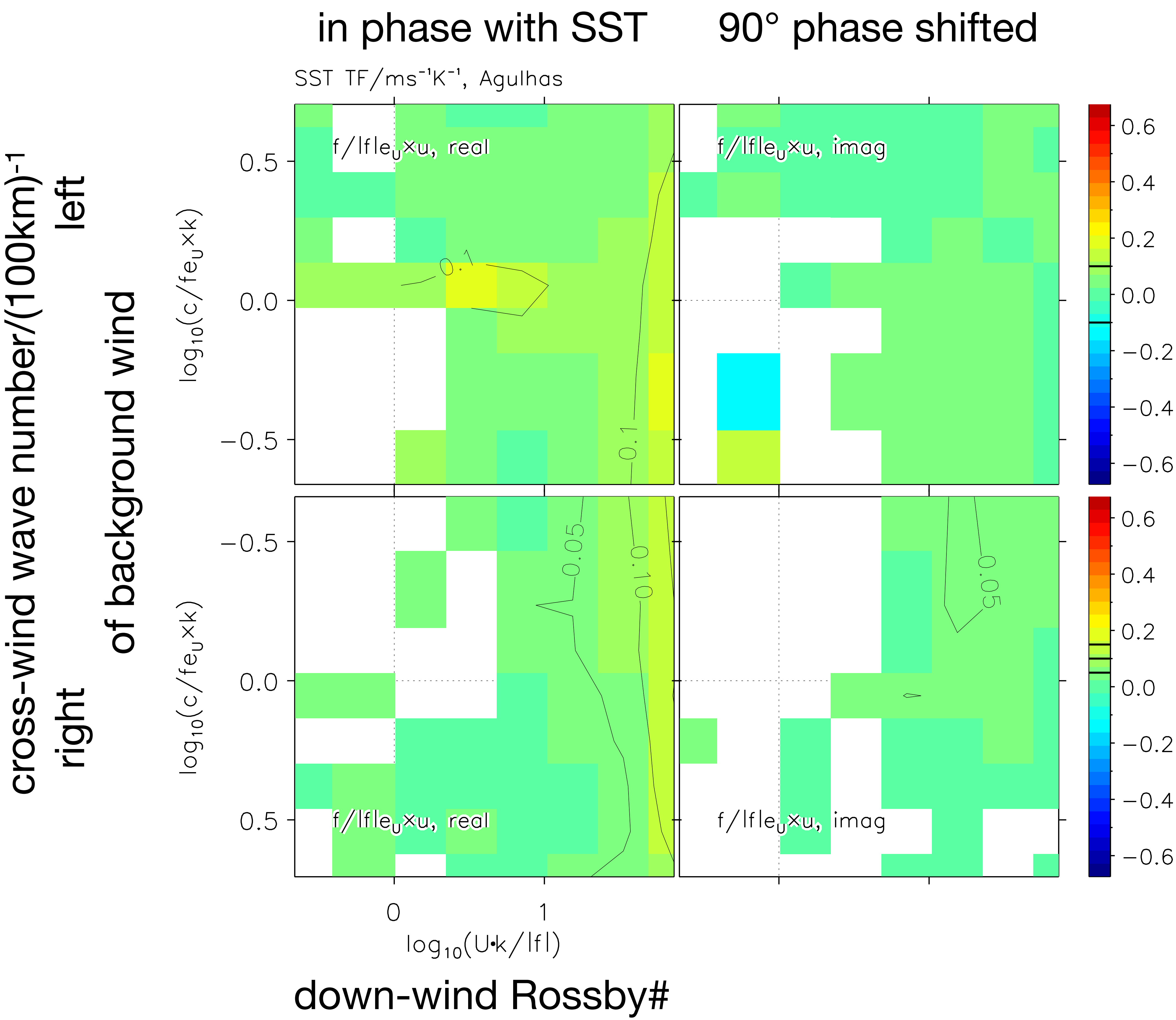


Wind ‘direction’ transfer function



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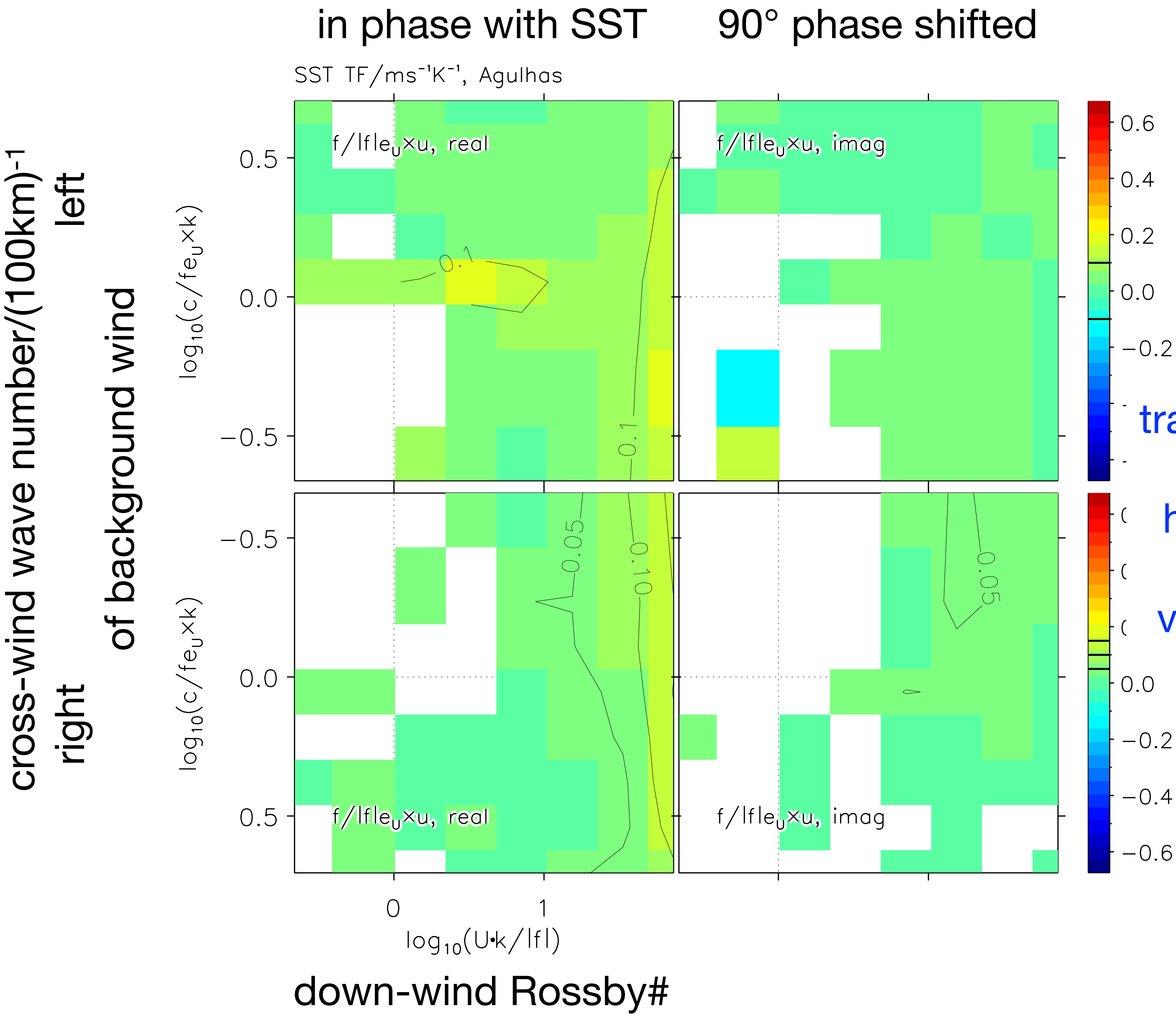


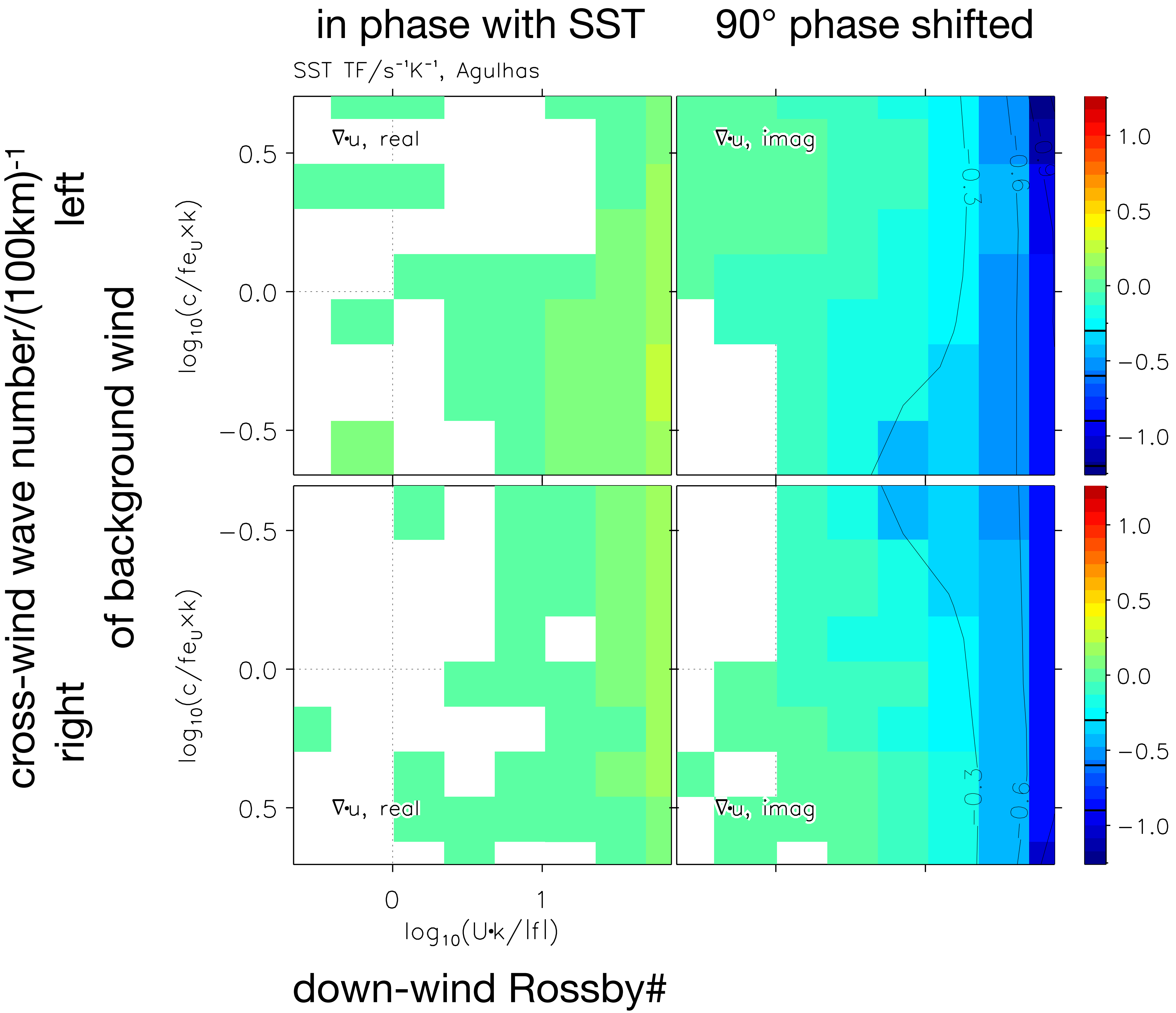
transfer function small

high Rossby#

advection

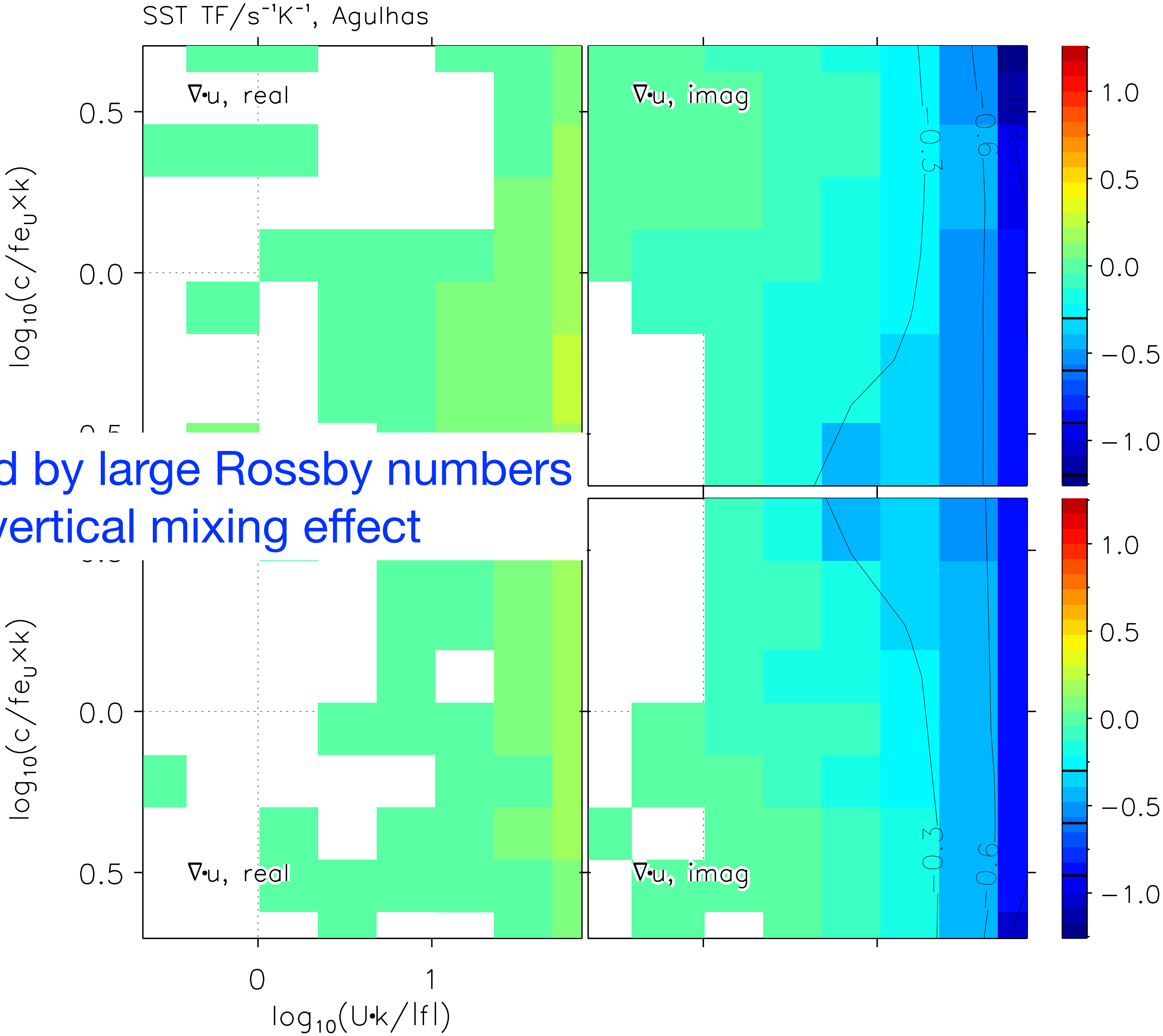
vertical mixing

Wind divergence transfer function



Wind divergence transfer function

in phase with SST　　90° phase shifted

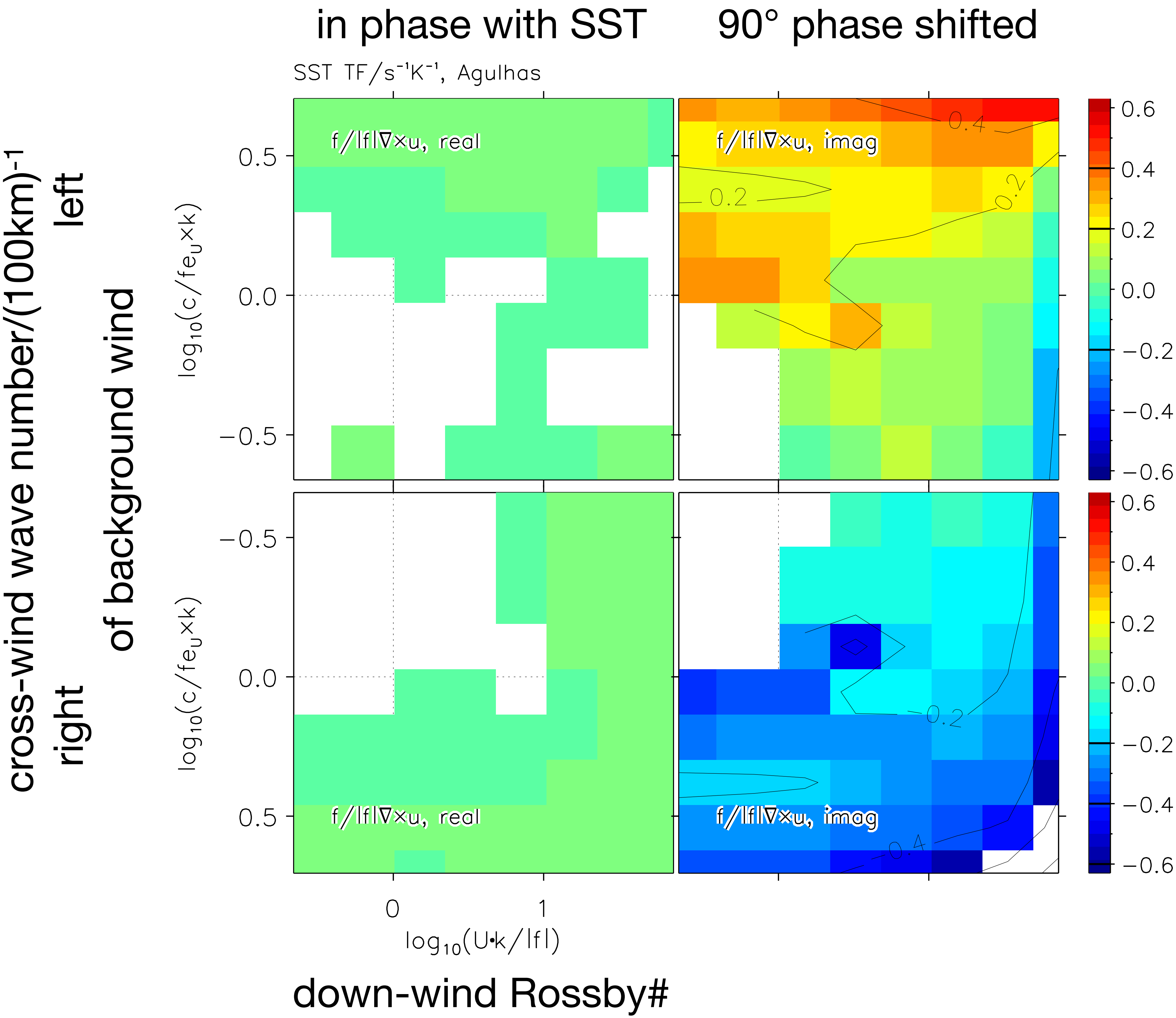


dominated by large Rossby numbers
& vertical mixing effect

cross-wind wa… umber/(100km)-1
of bac… nd wind
left
right

down-wind Rossby#

Wind curl transfer function



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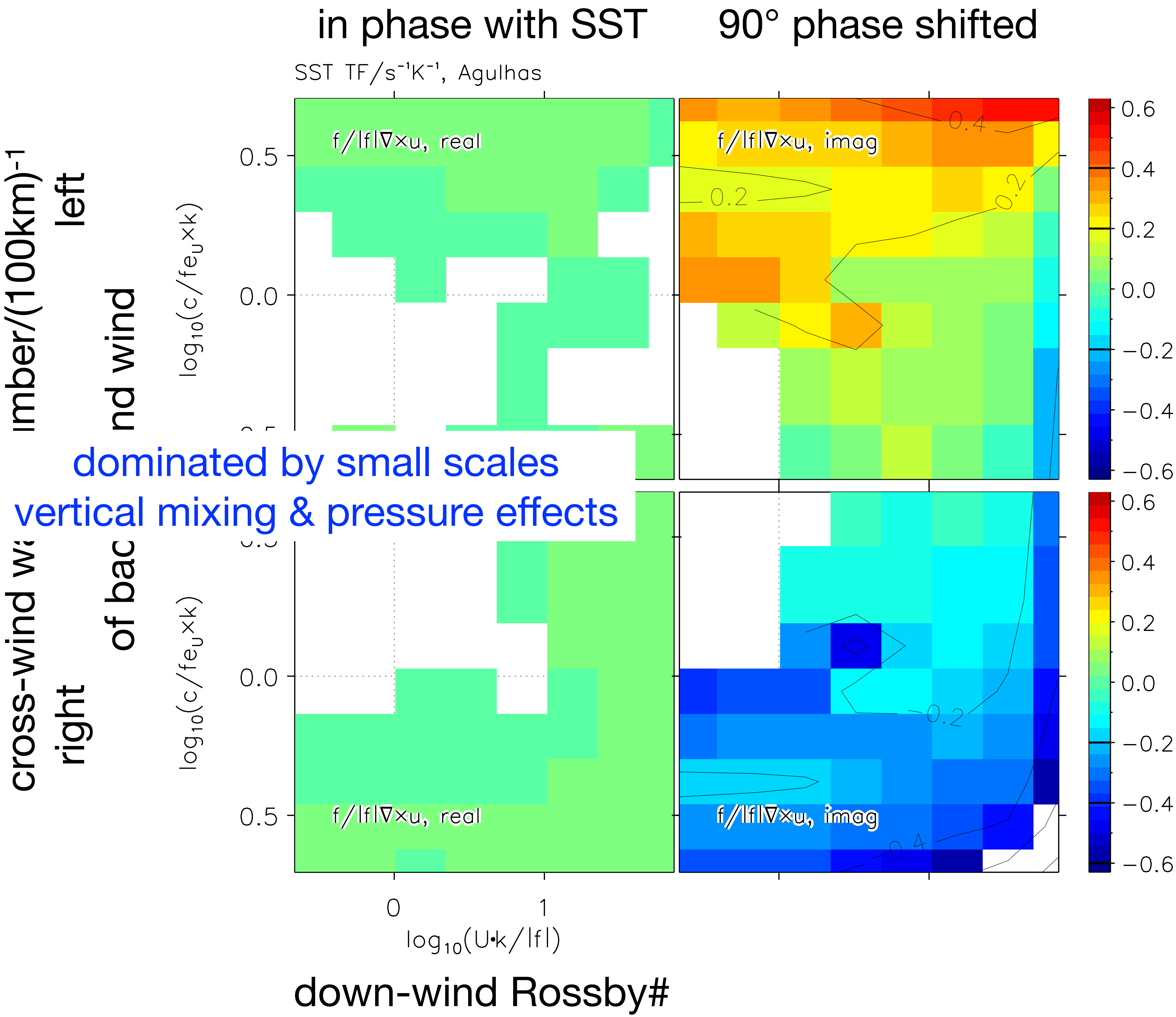

Conclusion

Observed imprints of ocean mesoscale SST on surface winds are strong functions of spatial scale

Transfer functions suggest:

- Wind speed modulations result from the vertical mixing mechanism at high background Rossby numbers
- Wind direction modulations are small & due to advection, vertical mixing and pressure effects
- Wind divergence is dominated by large background Rossby numbers, and results from the vertical mixing effect
- Wind curl is dominated by small scales, and results from a combination of pressure and vertical mixing effects and advection