# Characterization of frontal air-sea interaction by spectral transfer functions

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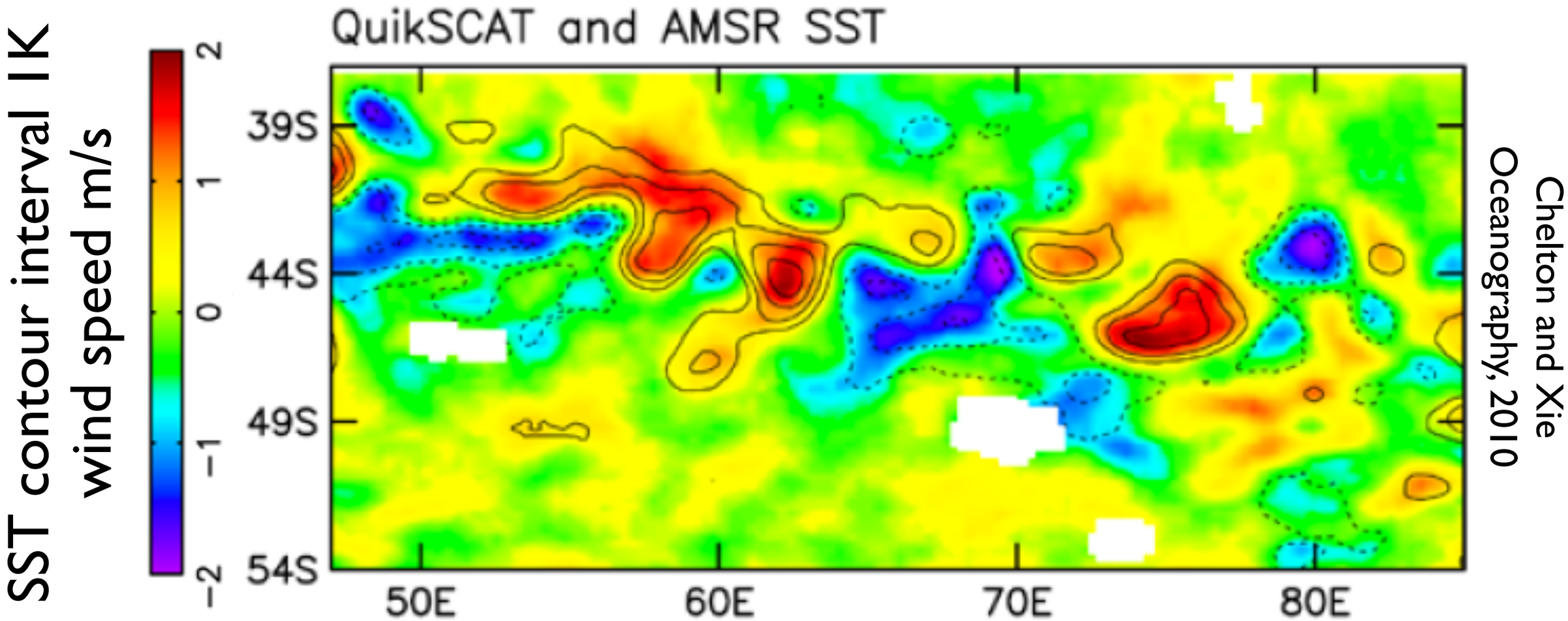



July 2002, monthly average, spatially high pass filtered

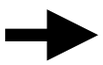
Imprint of ocean mesoscale on extratropical atmosphere
**warm SST** associated with **high wind speed**

International Ocean Vector Winds Science Team Meeting, Hokkaido University, Sapporo, Japan, May 17-19, 2016

# Air-sea interaction at **weak** SST fronts

Schneider and Qiu, JAS, 2015

inversion



Background
Ekman spiral

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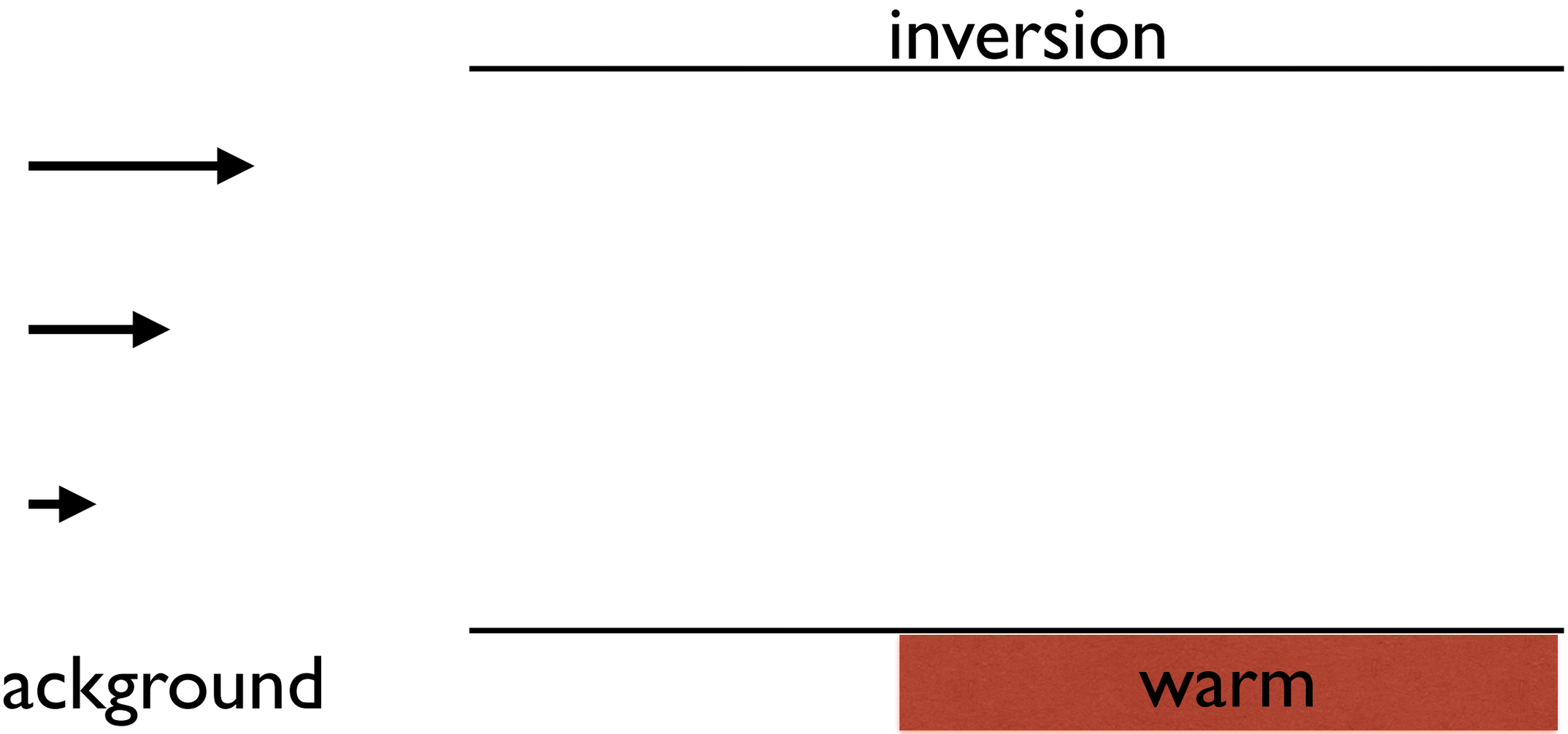

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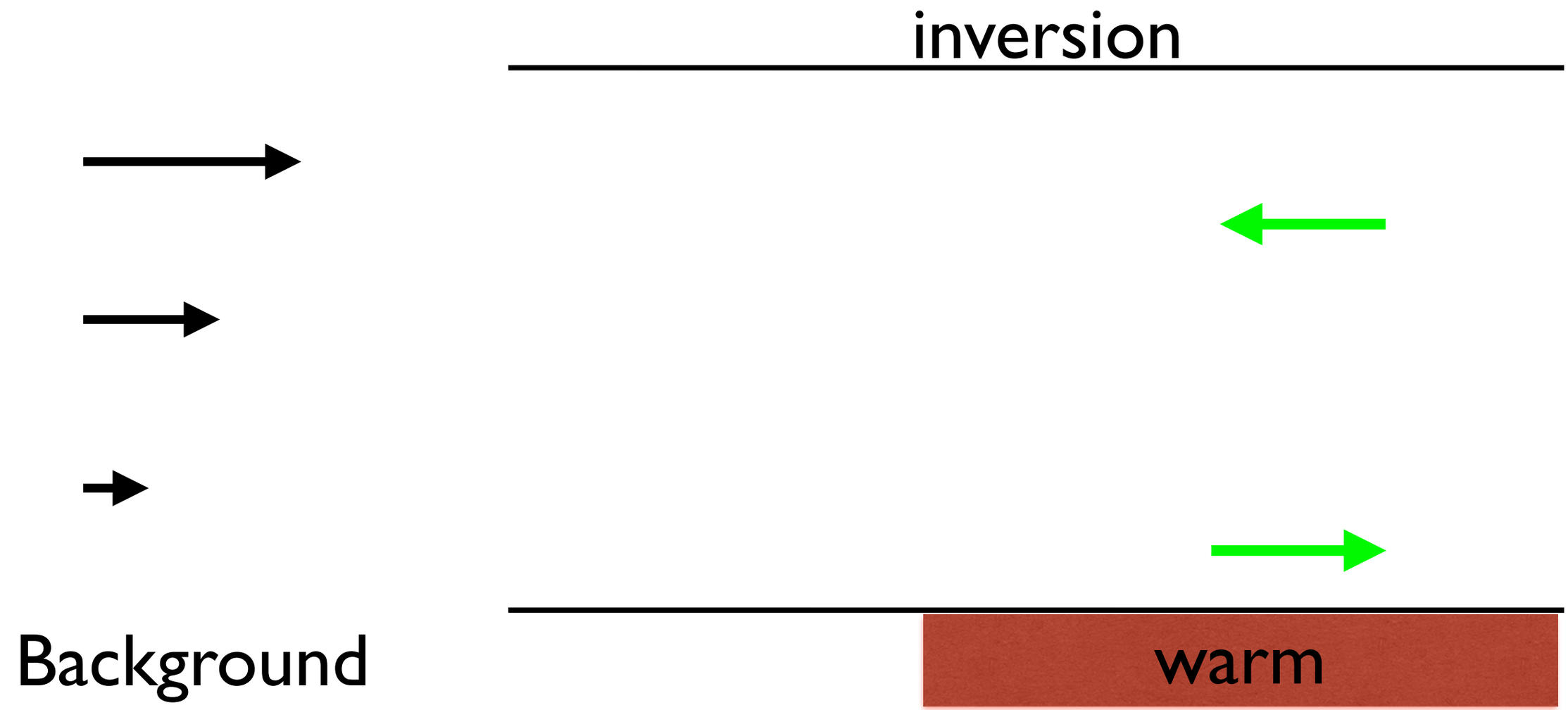
**Vertical mixing mechanism** (Wallace et al. 1989, Hayes et al. 1989, Samelson et al. 2006)



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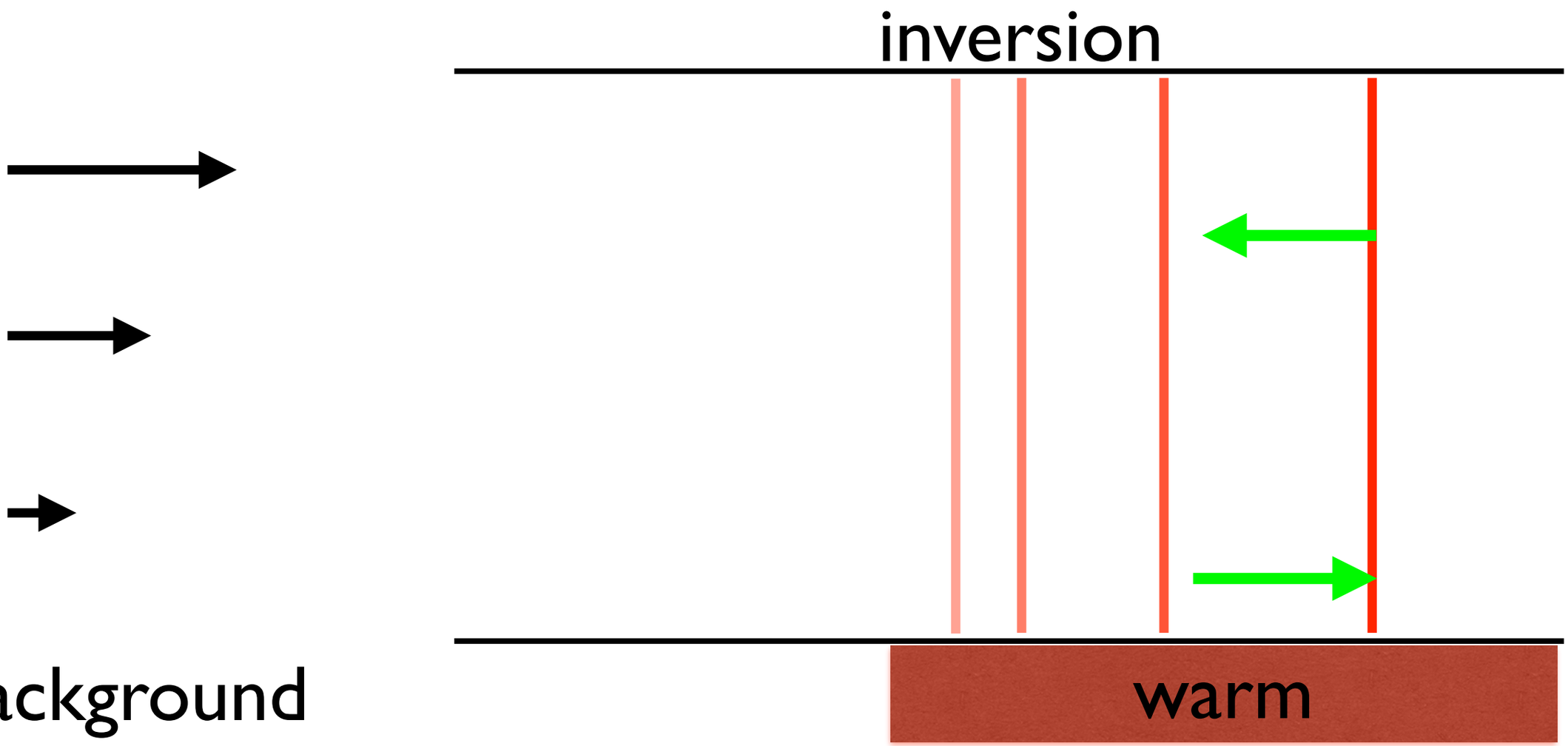


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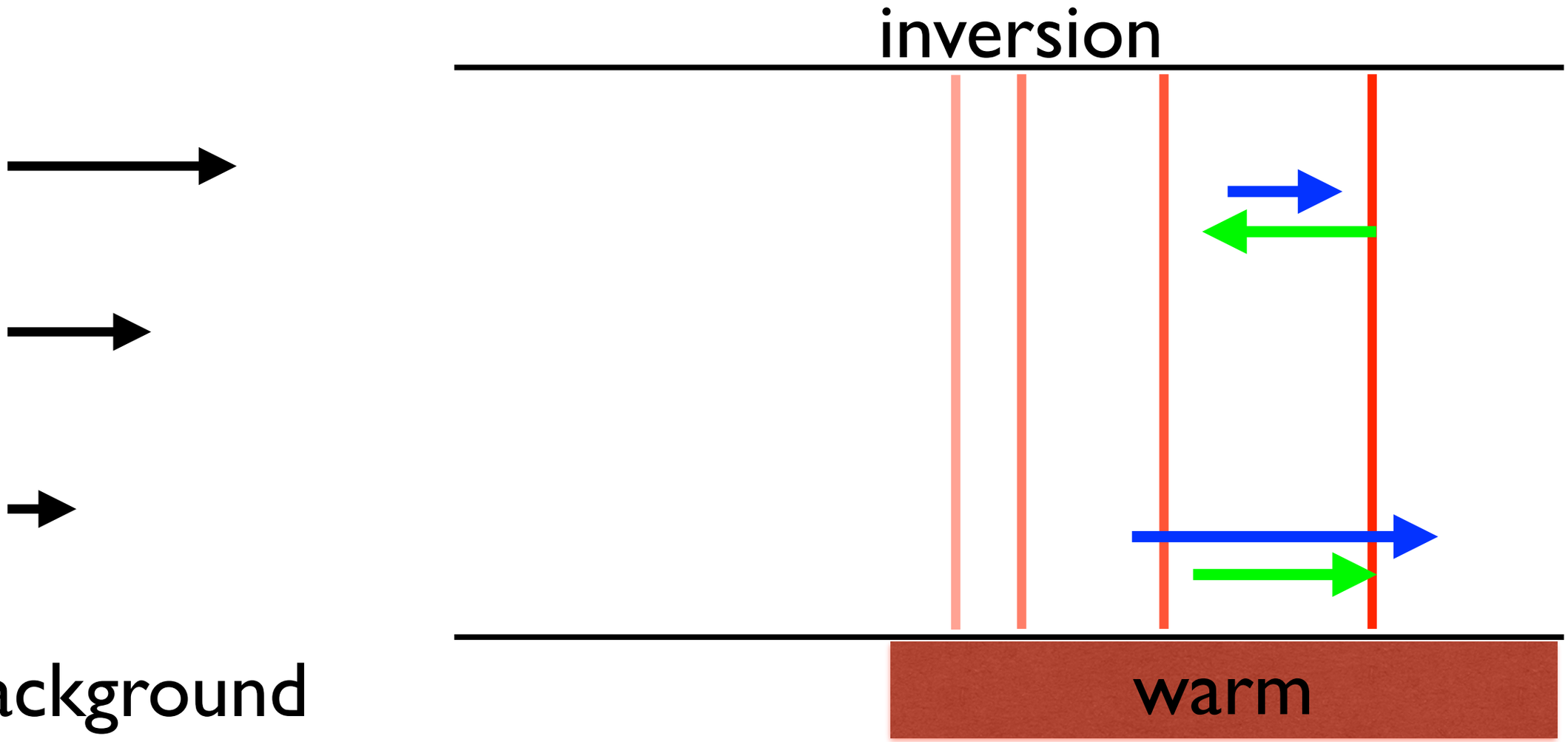


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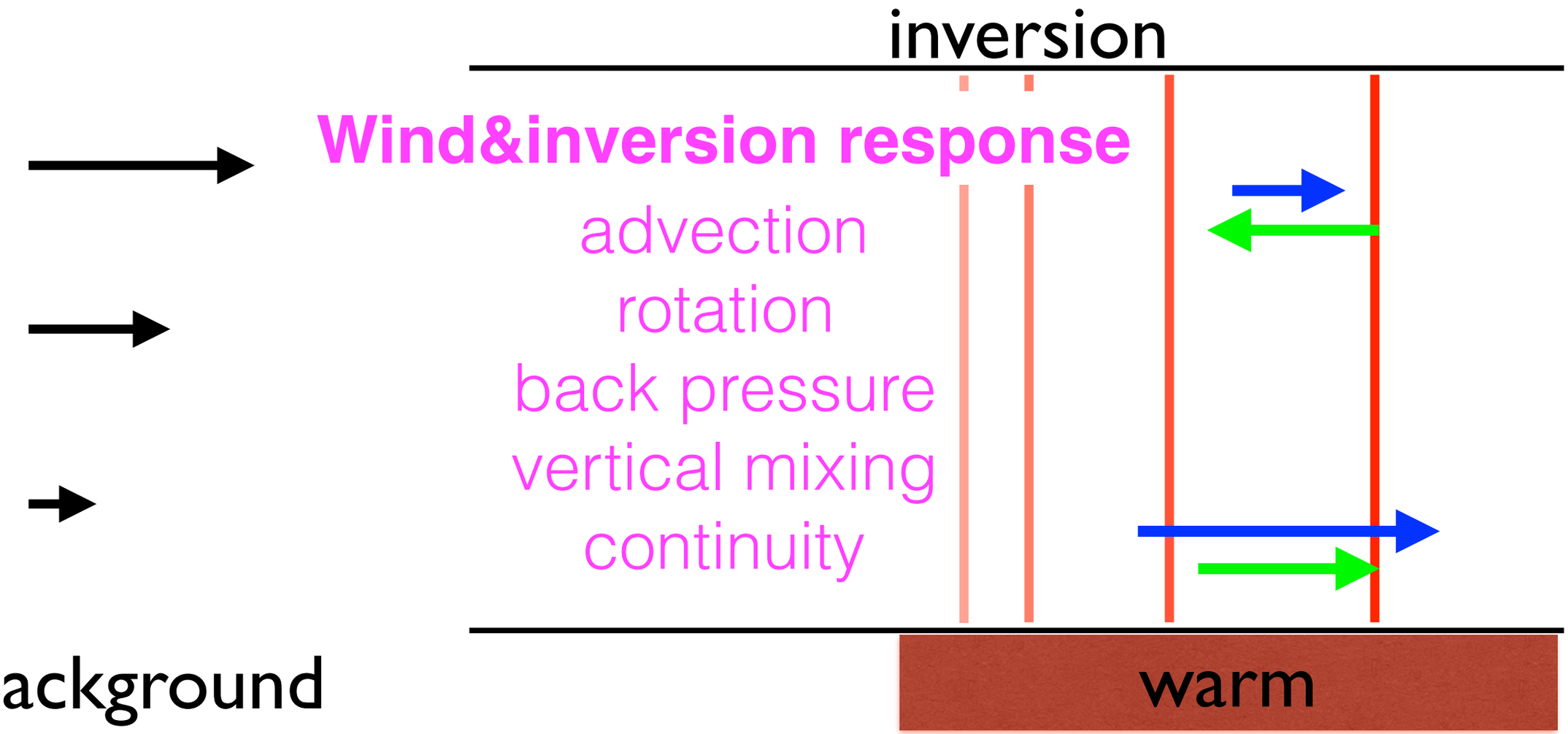

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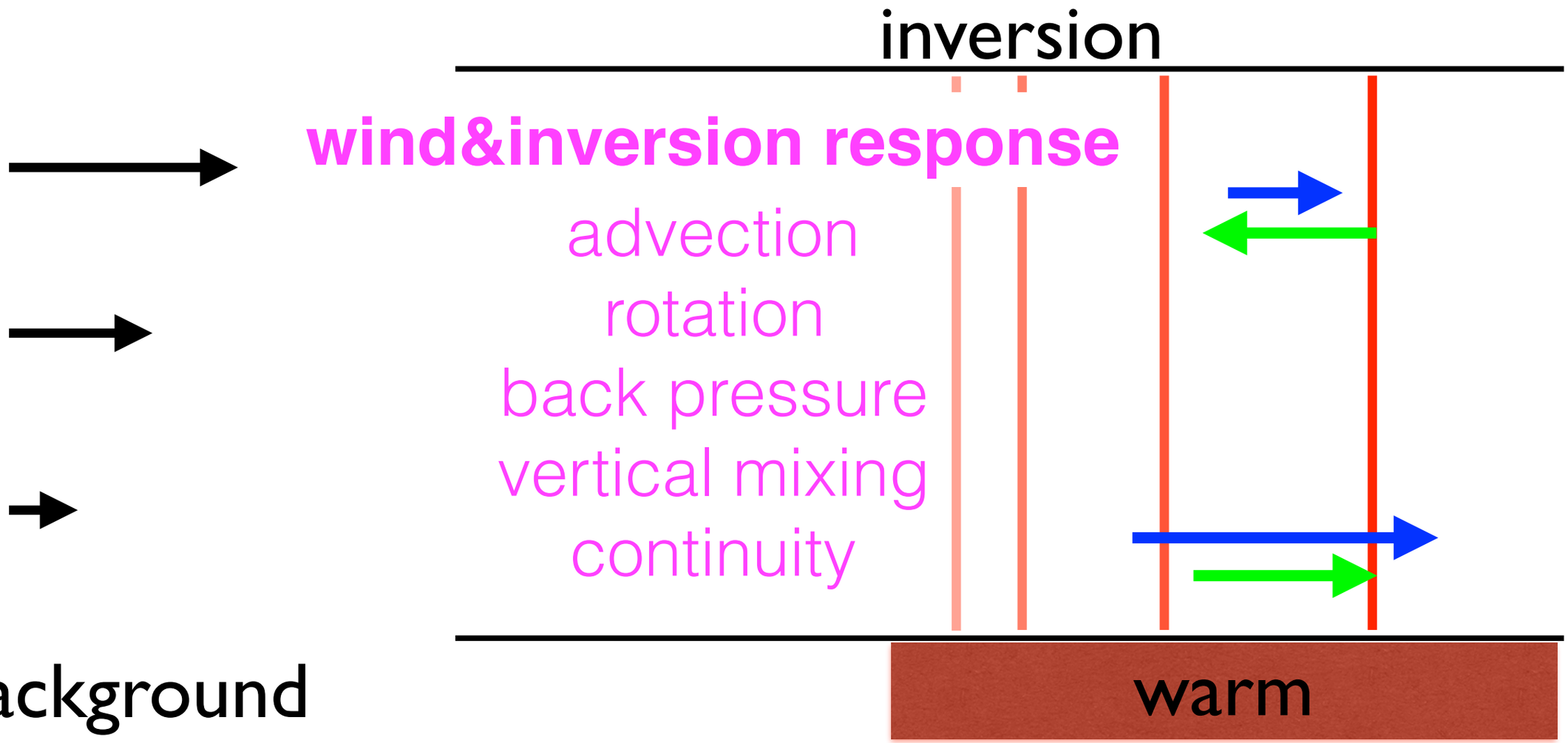


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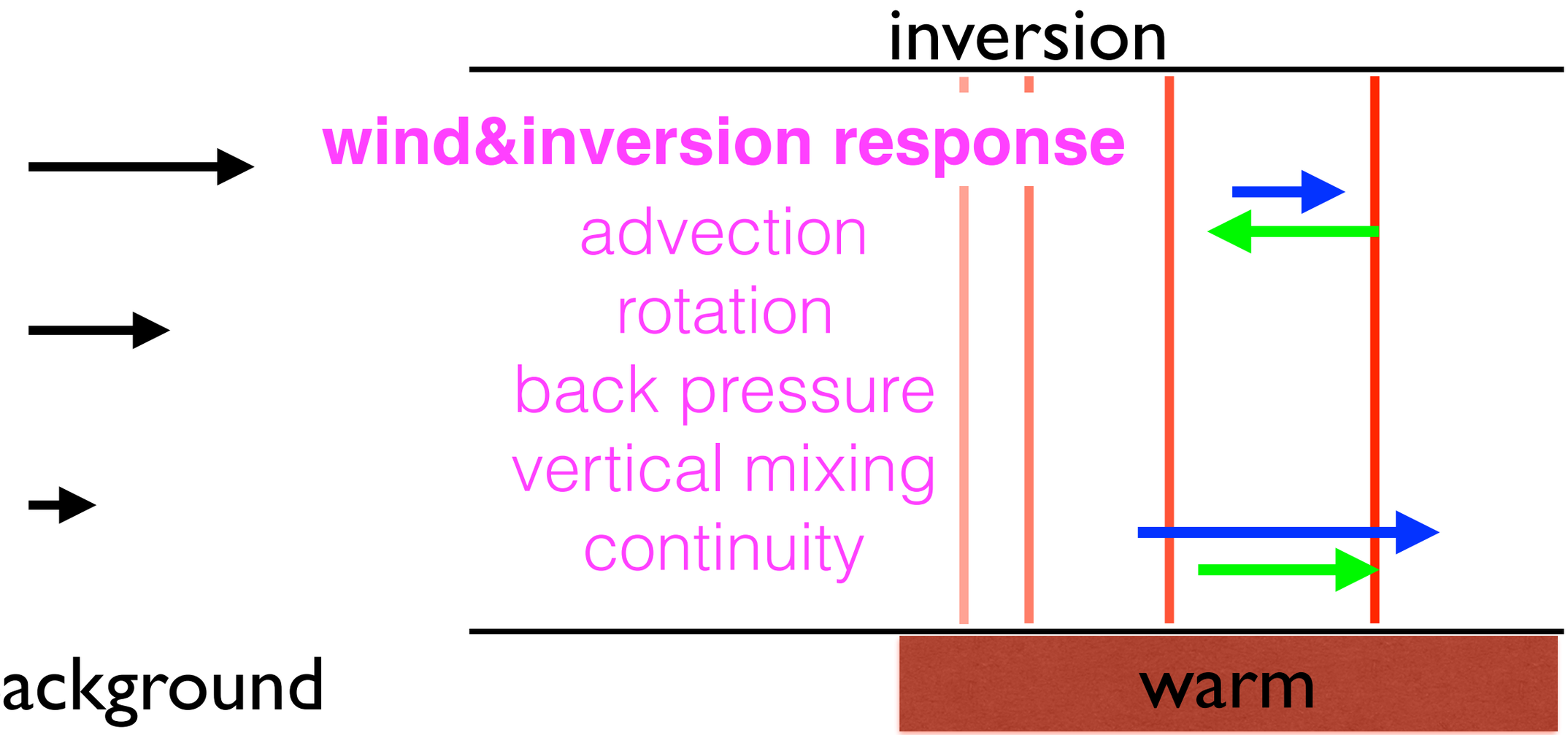
advection by background winds only

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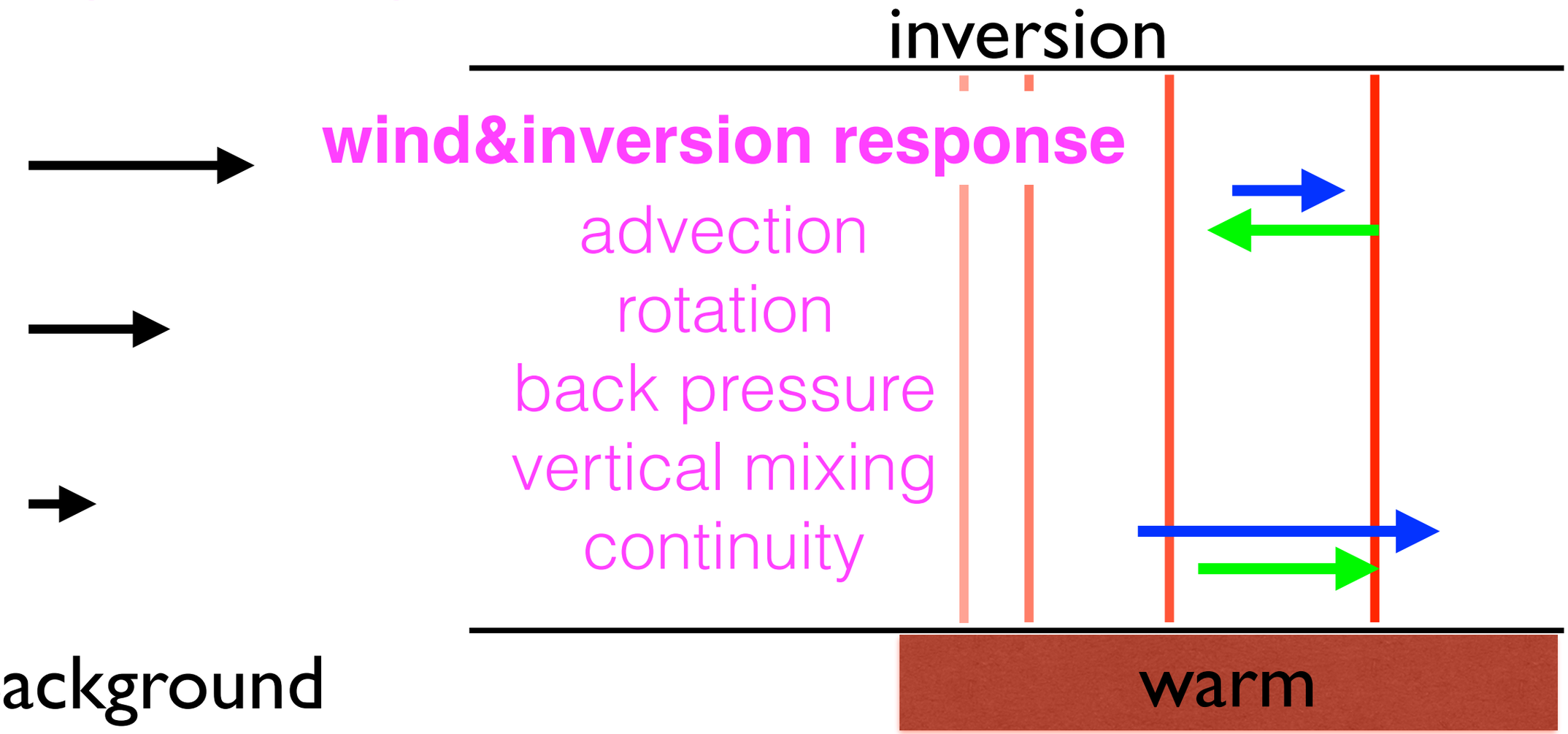

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linear Rossby adjustment problem with coefficients constant in x, y

$$\widetilde{\mathbf{A}}_{\vec{k}} \quad \widetilde{\mathbf{\Phi}}_{\vec{k}} = \widetilde{\mathbf{D}}_{\vec{k}} \quad \widetilde{\mathbf{T}}_{\vec{k}}$$

dynamics u, v, w, h, Θ SST forcing

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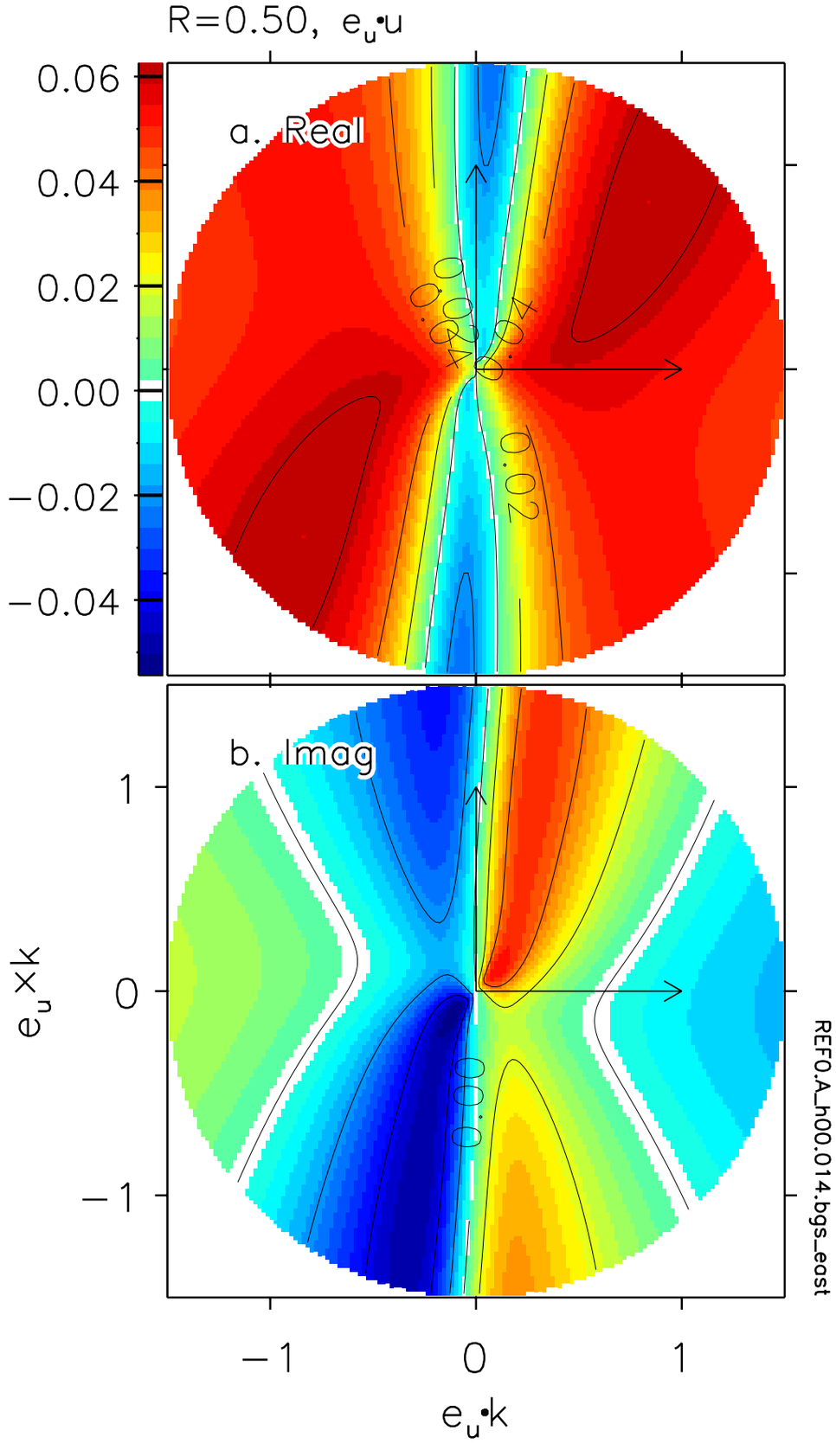
$$\widetilde{\mathbf{\Phi}}_{\vec{k}} = \boxed{\widetilde{\mathbf{A}}_{\vec{k}}^{-1} \widetilde{\mathbf{D}}_{\vec{k}}} \widetilde{\mathbf{T}}_{\vec{k}}$$

**Transfer function**

dependent on **background wind speed**, **direction**

**mixing formulation**

# Transfer function for surface wind speed



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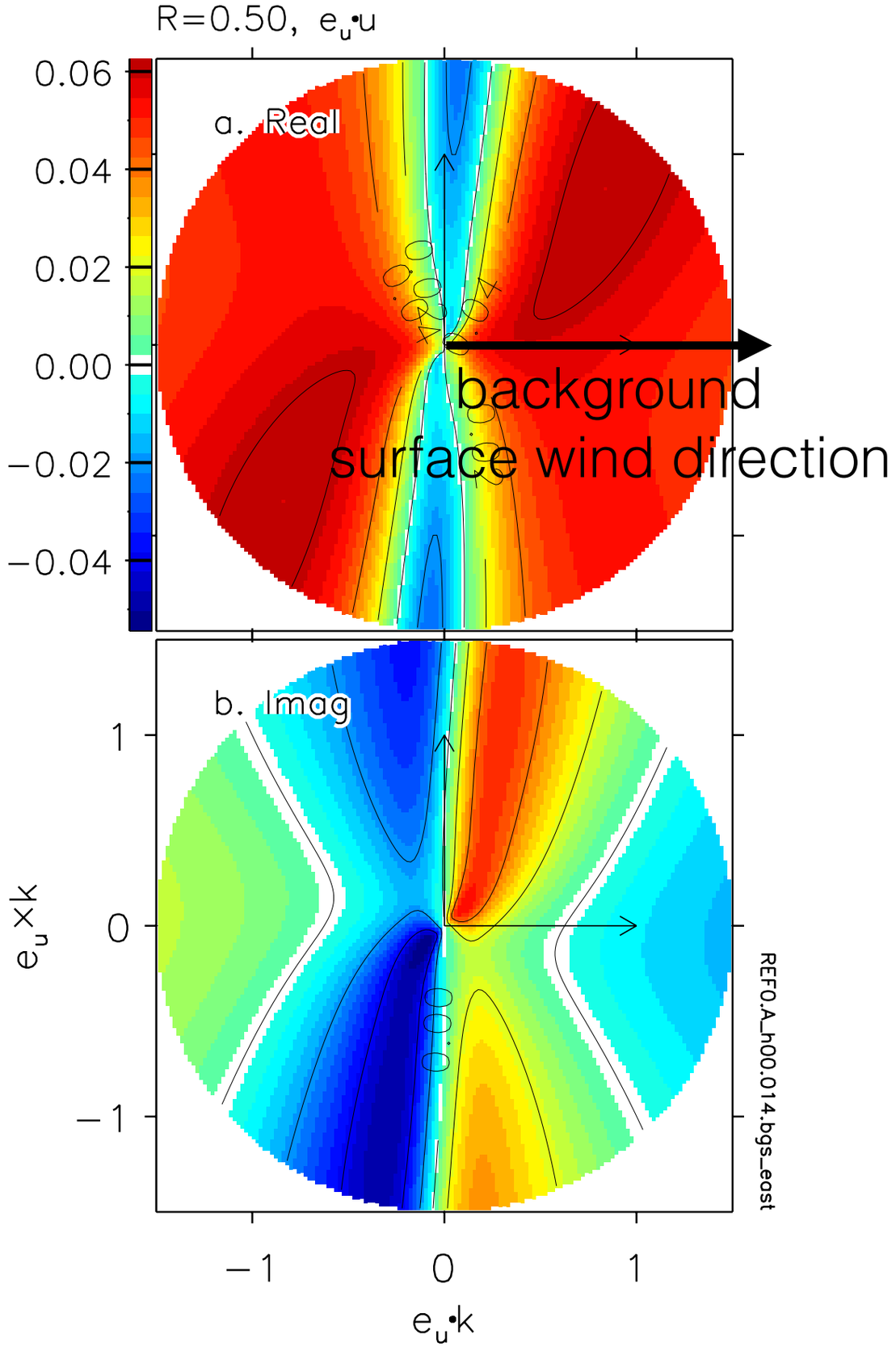

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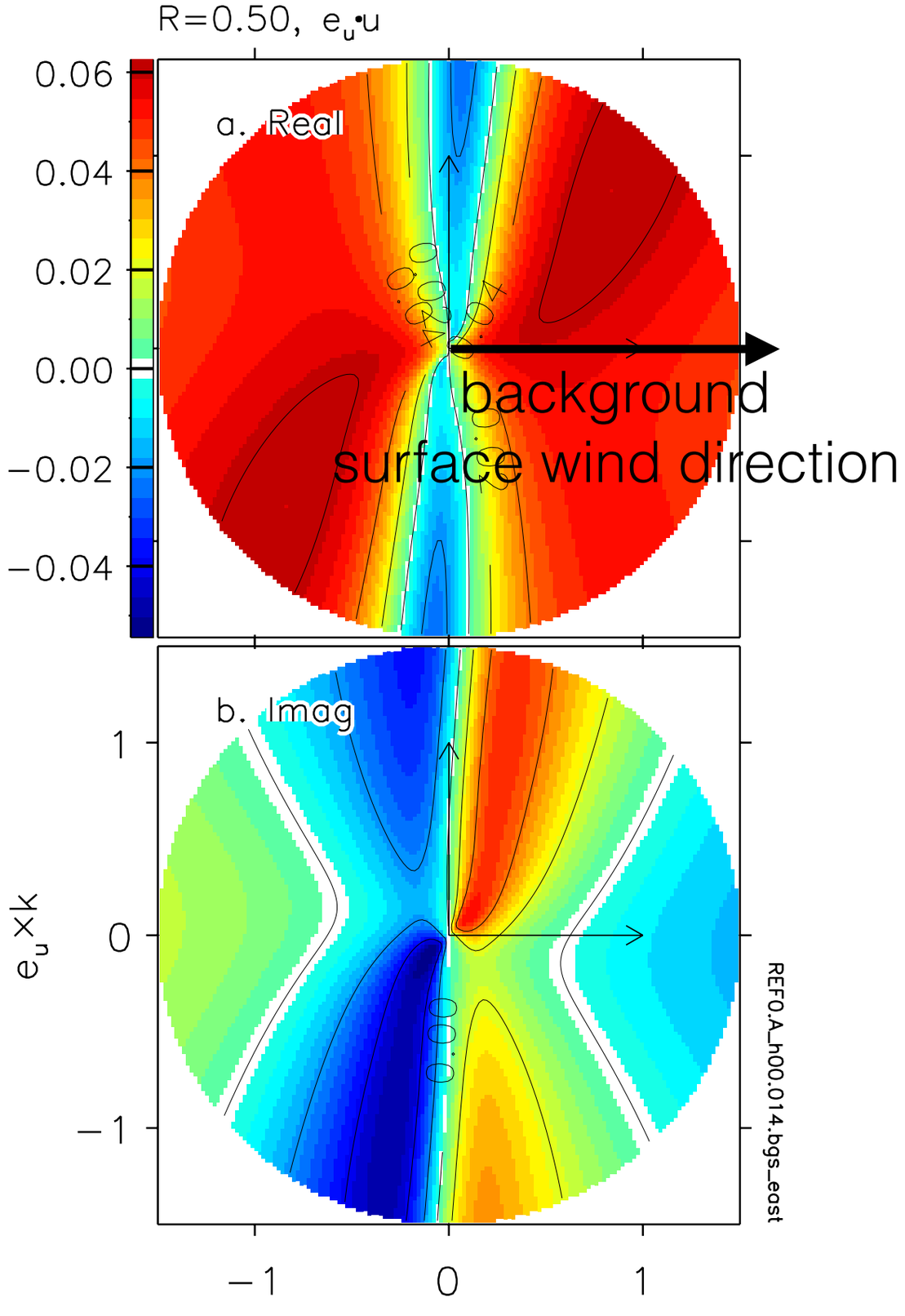

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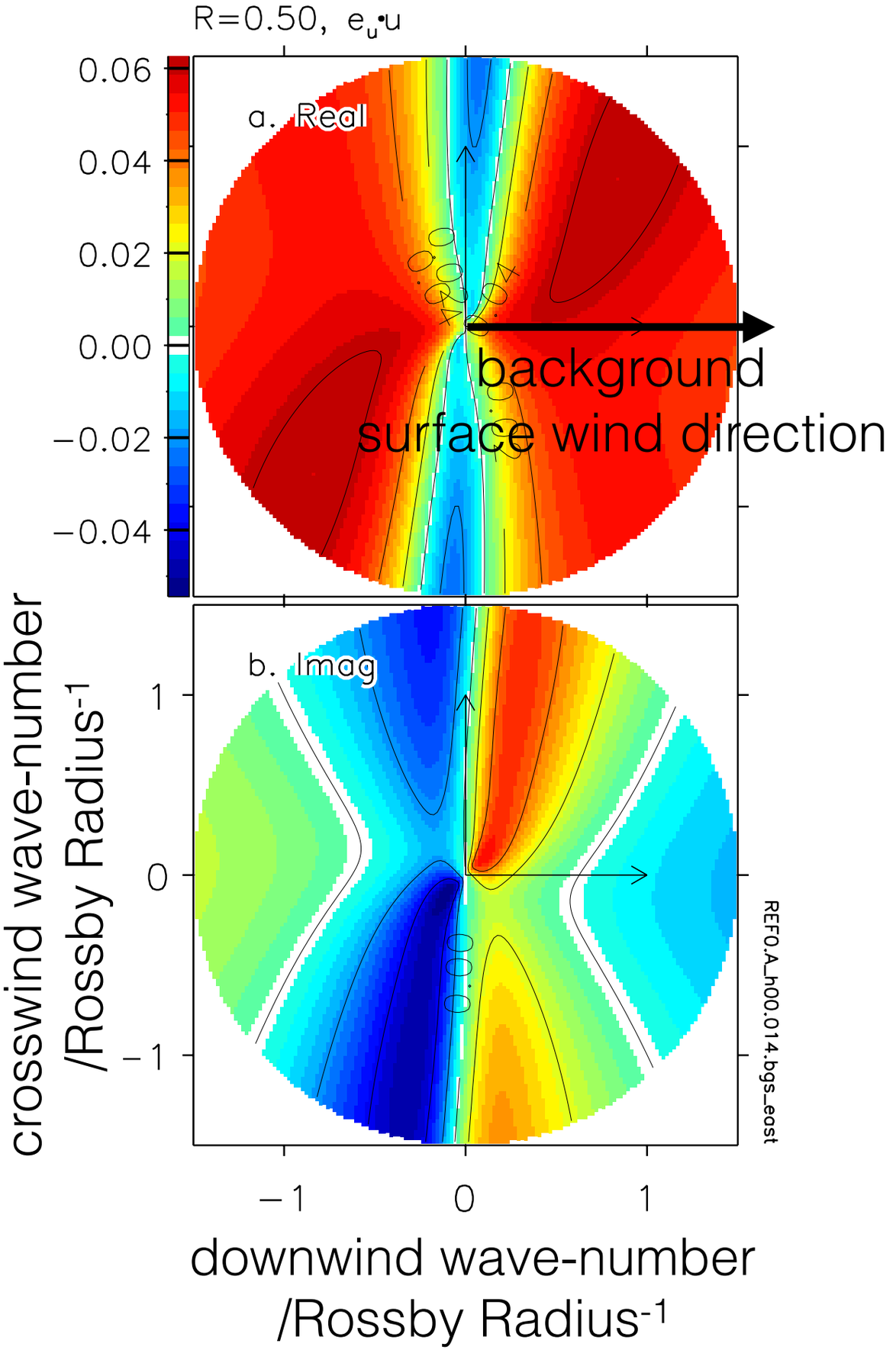

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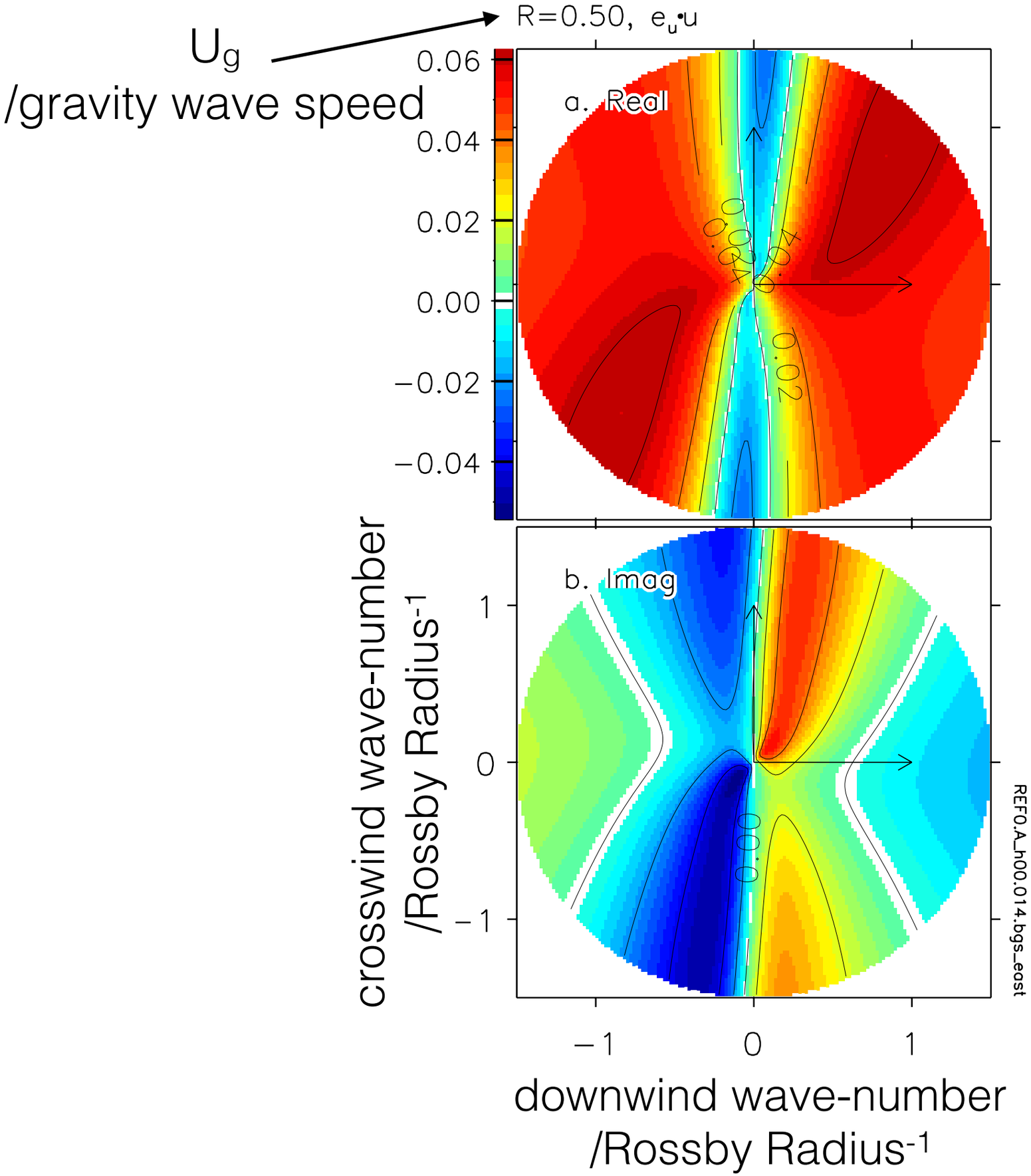
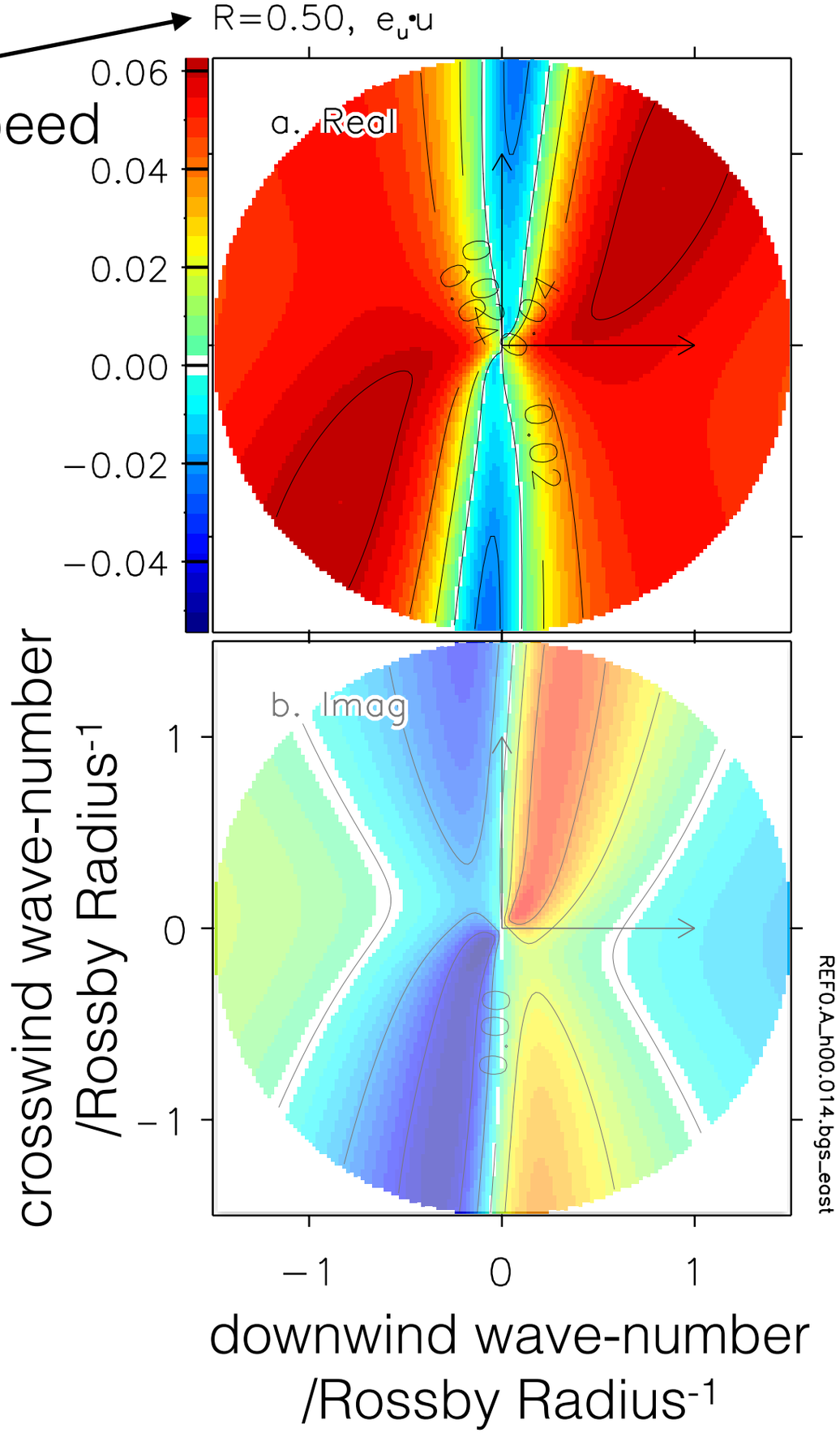


# Transfer function for surface wind speed

$U_g$ /gravity wave speed




Frontally induced surface wind speed …

… in phase with SST

# Transfer function for surface wind speed

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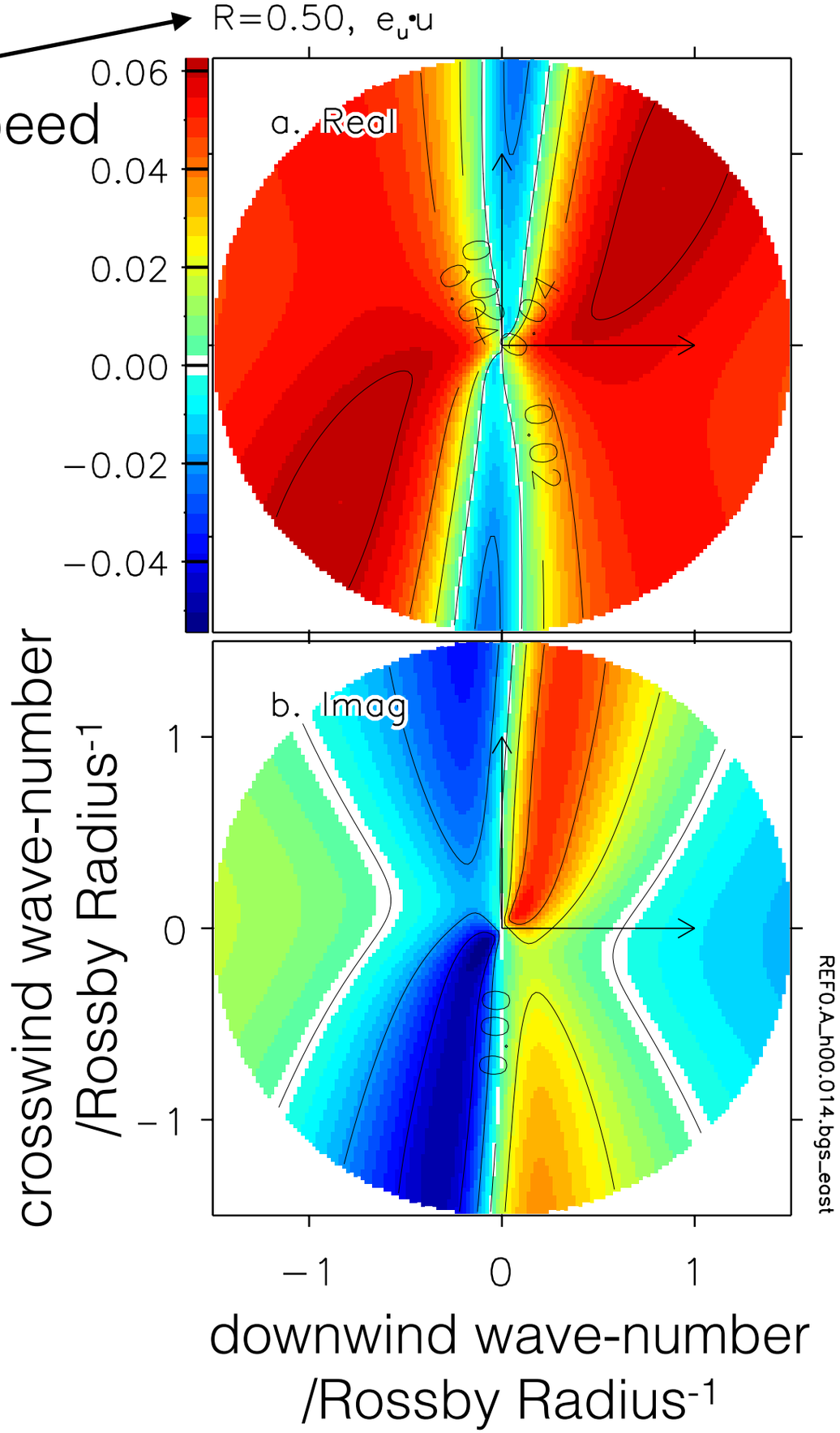
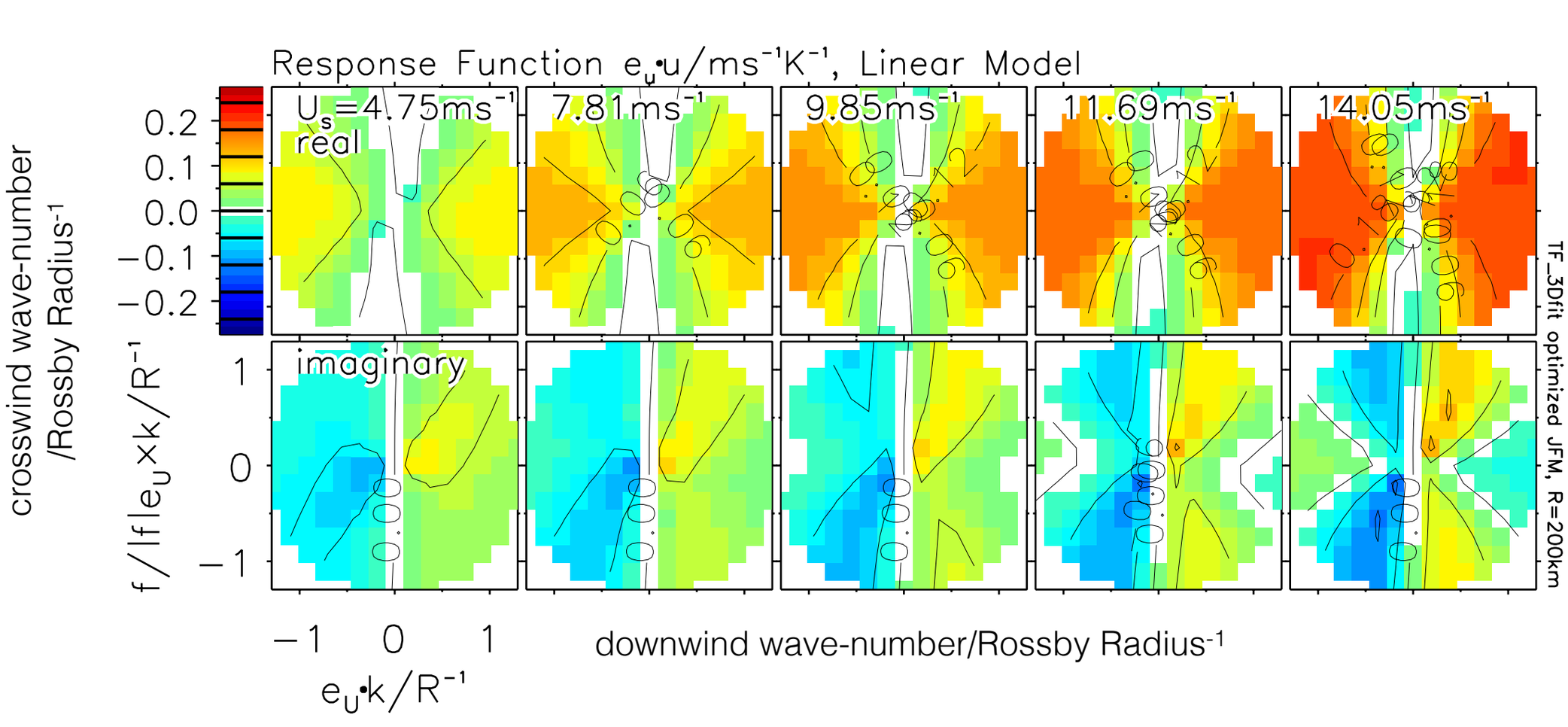



Frontally induced surface wind speed …

… in phase with SST

… 90° phase-shifted with SST

# Surface wind speed, best fit linear model



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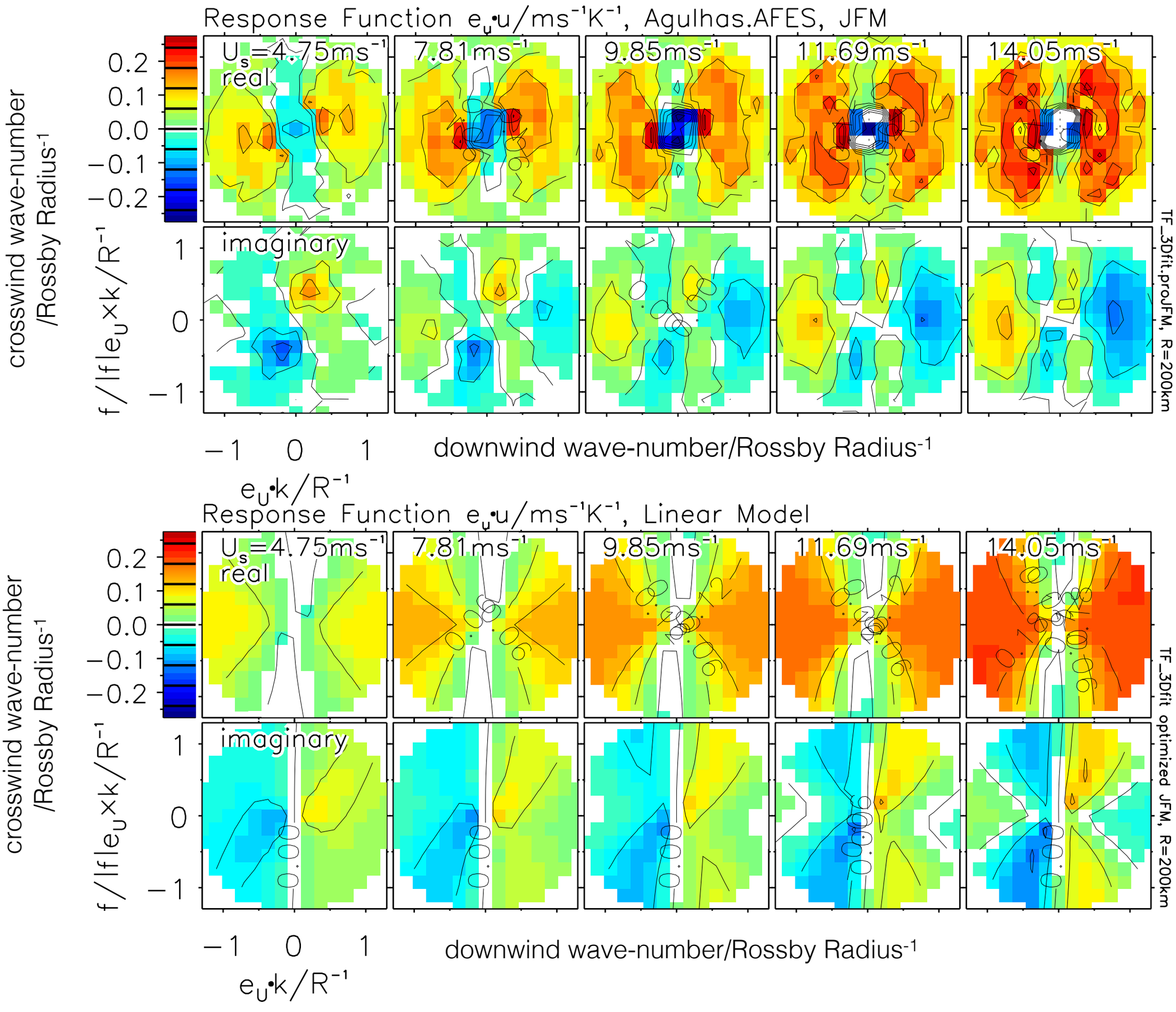
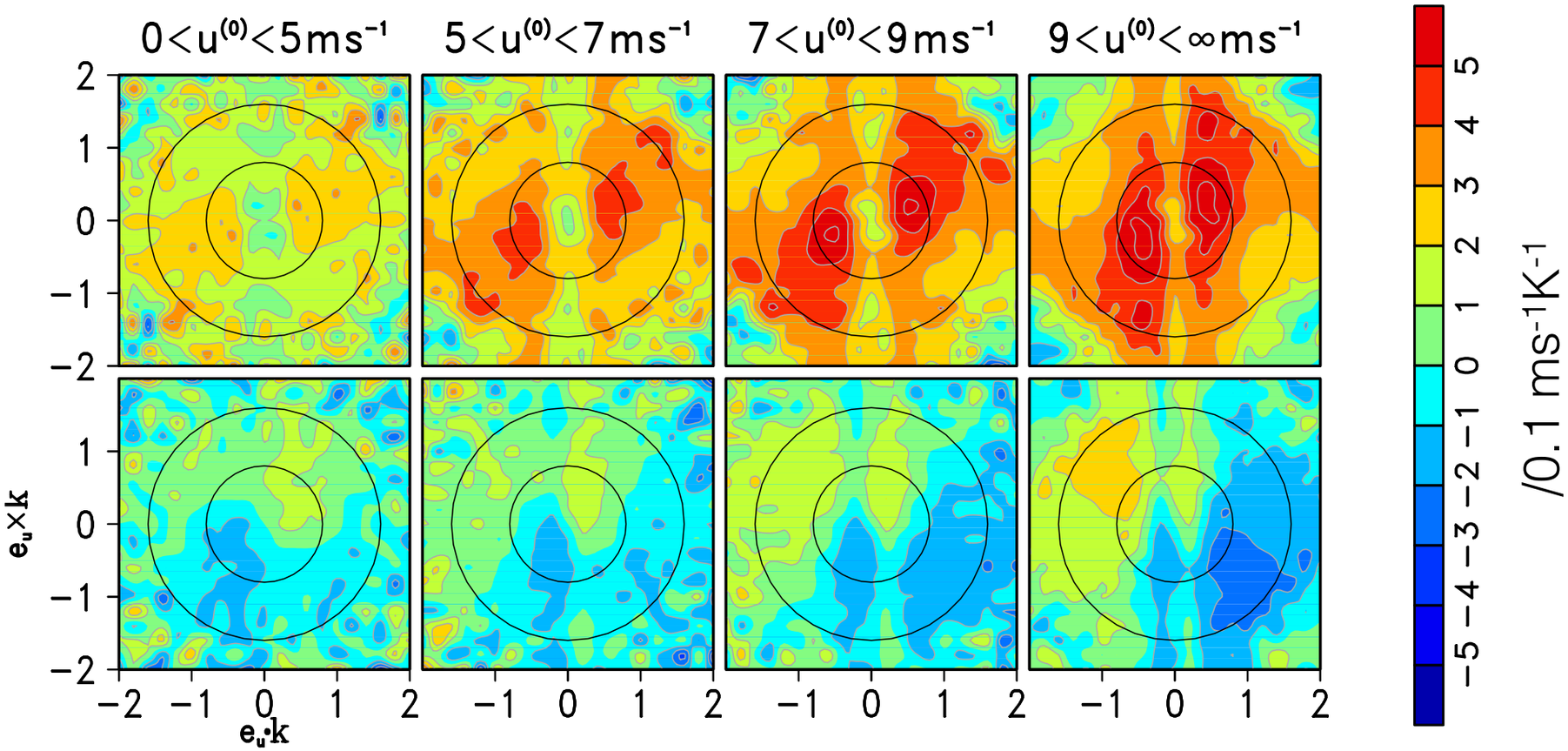
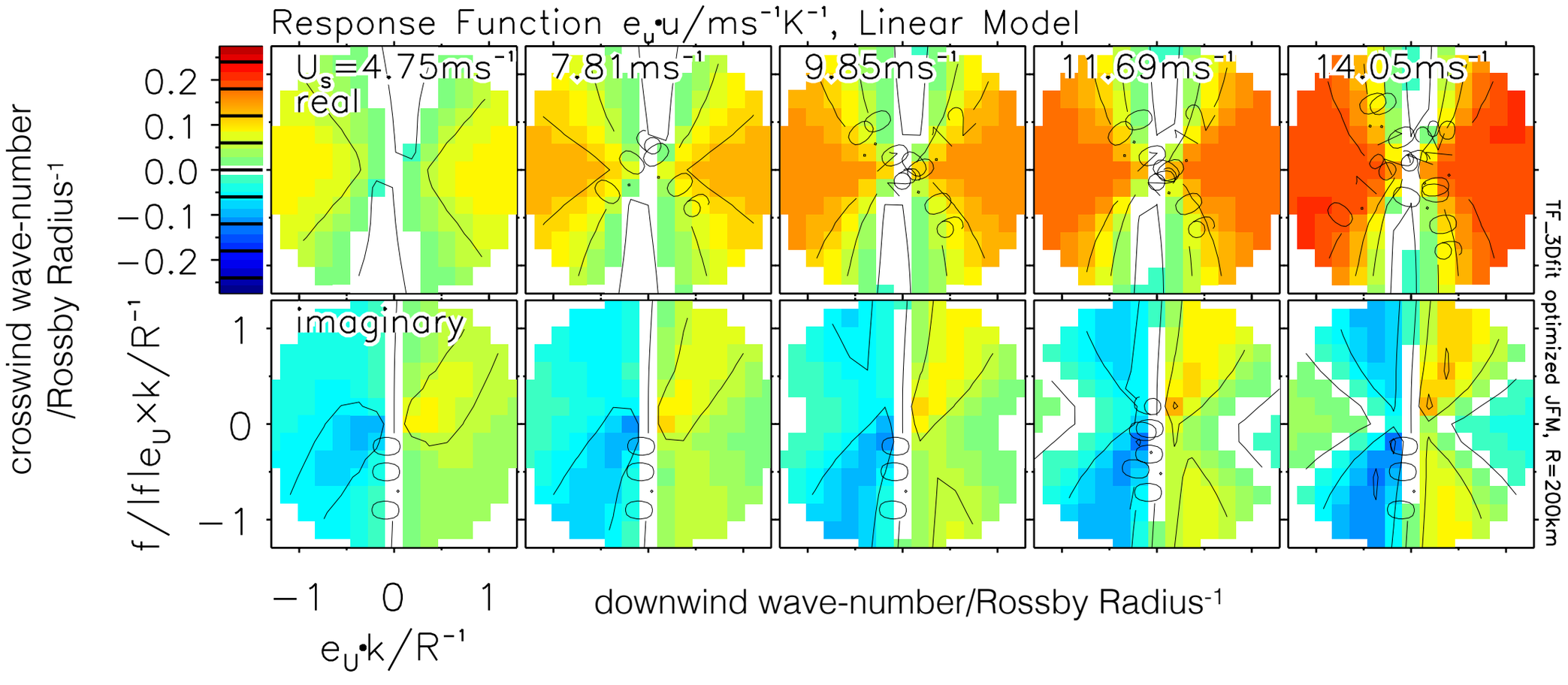


# Surface wind speed, best fit linear model

**QuikSCAT**



# Conclusions

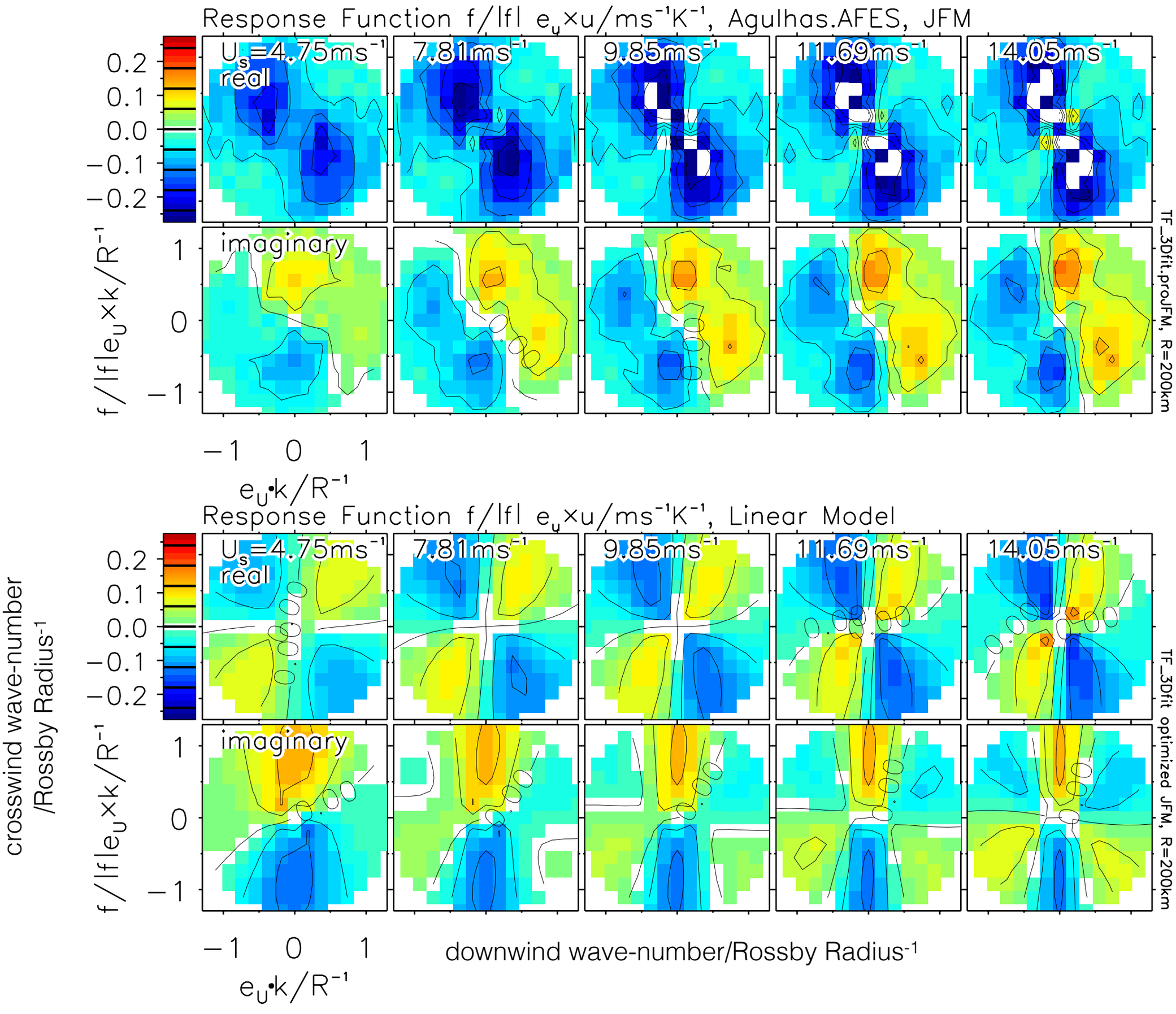
- A linearized model for the atmospheric boundary layer response to ocean mesoscale sea surface temperatures is tested.

- Spectral transfer functions of the linear model and based on an AGCM (AFES) and QuikSCAT observations compare favorably in the Southern Ocean, and suggest that the linear model captures the underlying physics.

- Additional physics can be tested to improve fit between linear model, AGCMs and observations.

Schneider, N. and B. Qiu, 2015: The atmospheric response to weak sea surface temperature fronts. *J. Atmos. Sci.*, **72,** 3356-3377.

# Cross-wind


Response Function f/|f| e_u×u/ms⁻¹K⁻¹, Agulhas.AFES, JFM
U_s=4.75ms⁻¹
7.81ms⁻¹
9.85ms⁻¹
11.69ms⁻¹
14.05ms⁻¹
real
imaginary
0.2
0.1
0.0
−0.1
−0.2
f/|f|e_u×k/R⁻¹
1
0
−1
−1 0 1
e_u•k/R⁻¹
TF_3Dfit.projFM, R=200km
Response Function f/|f| e_u×u/ms⁻¹K⁻¹, Linear Model
crosswind wave-number /Rossby Radius⁻¹
downwind wave-number/Rossby Radius⁻¹
TF_3Dfit optimized JFM, R=200km

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**QuikSCAT**