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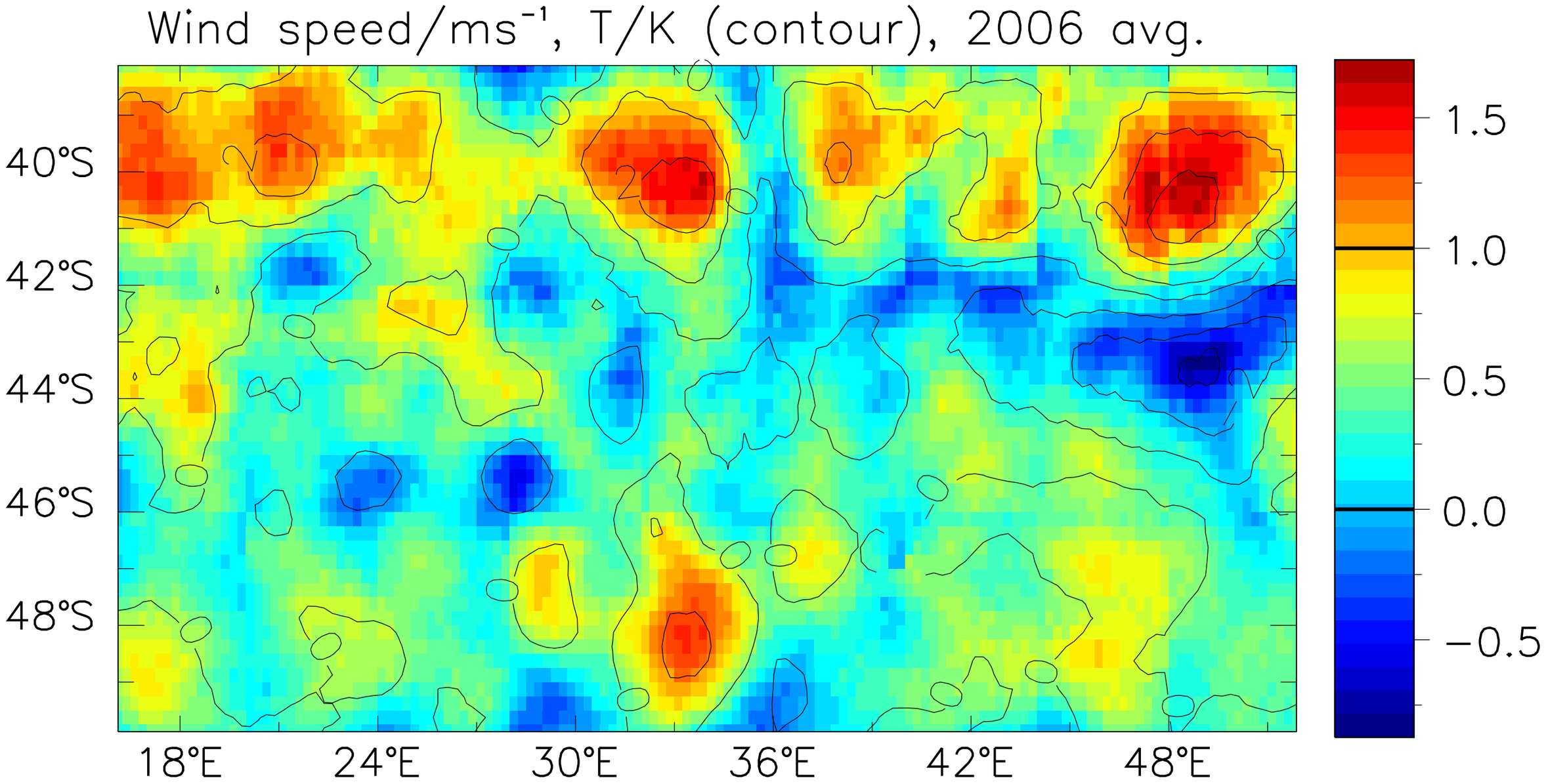
Fundamental response patterns of the observed wind response to ocean-mesoscale sea surface temperatures

Niklas Schneider
International Pacific Research Center & Department of Oceanography
University of Hawai'i at Mānoa



QuikSCAT Equivalent Neutral Wind, AMSR-E Sea Surface Temperature

Hypothesis

QuikSCAT scatterometer winds

Coupling coefficient

AMSR-E sea surface temperatures

$u(\vec{x}) = \alpha T(\vec{x})$

Hypothesis

Scale dependence

QuikSCAT scatterometer winds

Transfer function

AMSR-E sea surface temperatures

$$u(\vec{x}) = \int d\vec{k}\ \tilde{A}\left(\ \vec{k}\ \right)\ \tilde{T}(\vec{k})\ e^{-\imath\,\vec{k}\cdot\vec{x}}$$

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Transfer function

large scale winds

AMSR-E sea surface temperatures

$$u(\vec{x}) = \int d\vec{k}\ \tilde{A}\left(\hat{e}_U \cdot \vec{k}, (\hat{e}_3 \times \hat{e}_U) \cdot \vec{k}, U\right)\ \tilde{T}(\vec{k})\ e^{-\imath \vec{k} \cdot \vec{x}}$$

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$$\textit{Rossby number} = \frac{(U\ \hat{e}_U) \cdot \vec{k}}{f}$$

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Agulhas Return Current 12°E-52°E, 52°S-36°S

2003-2008, daily

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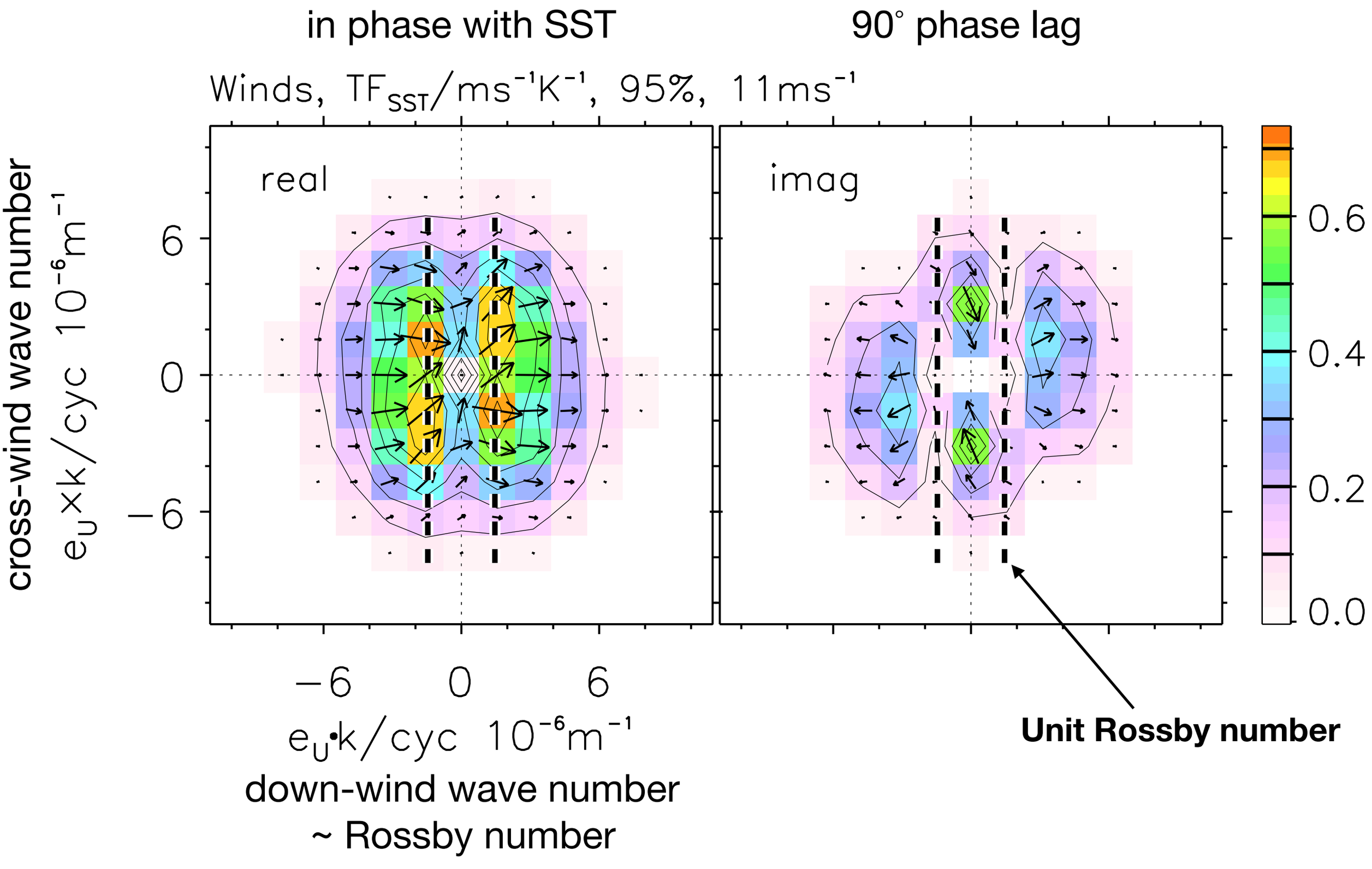
Agulhas Return Current 12°E-52°E, 52°S-36°S

2003-2008, daily

fit captures 80% of rms of annual averages of mesoscale wind speed and 70% of wind direction (cross-validated)

Transfer Function

$$\tilde{A}\left(\hat{e}_U \cdot \overrightarrow{k}, (\hat{e}_3 \times \hat{e}_U) \cdot \overrightarrow{k}, U = 11ms^{-1}\right)$$



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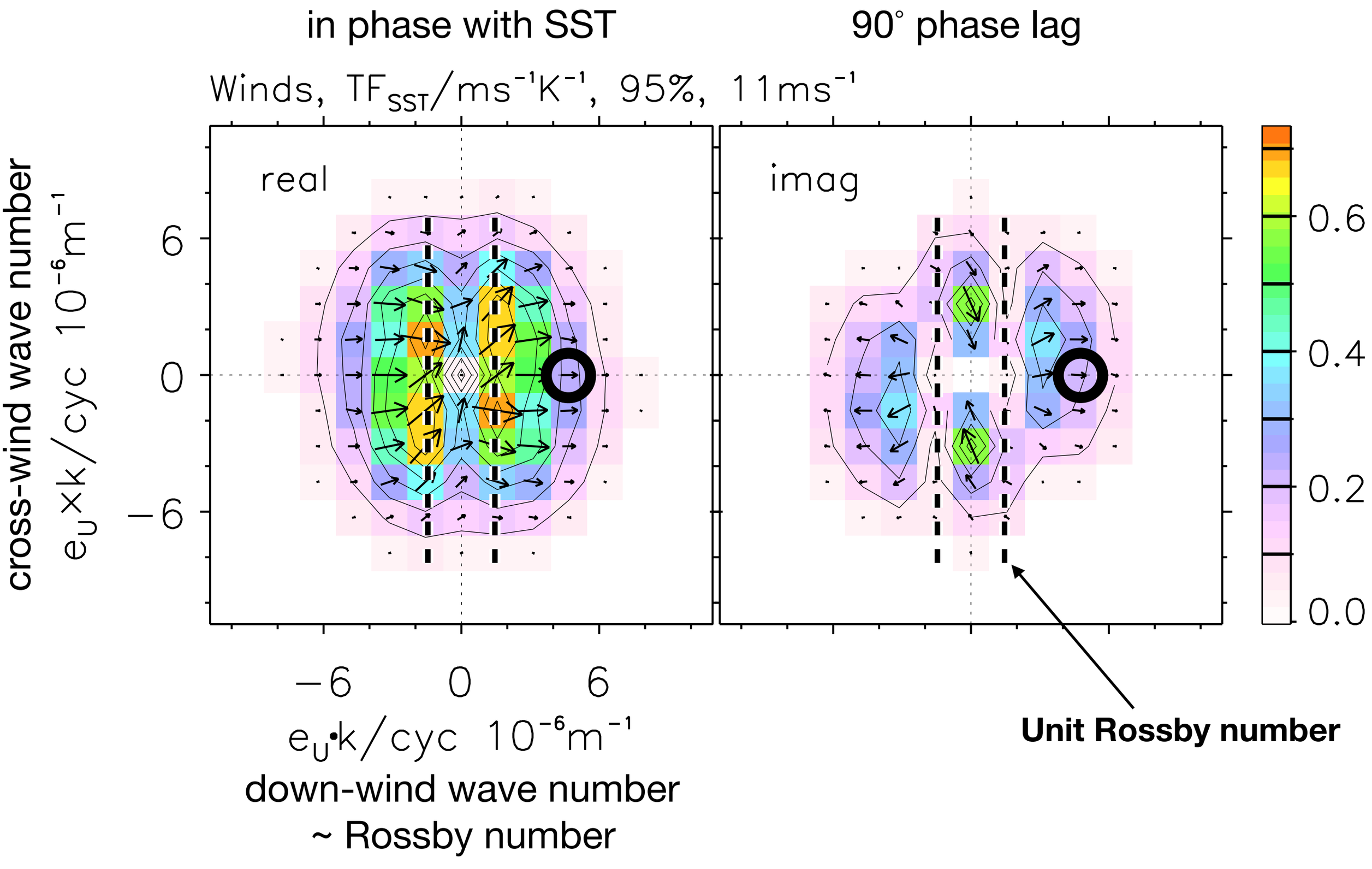
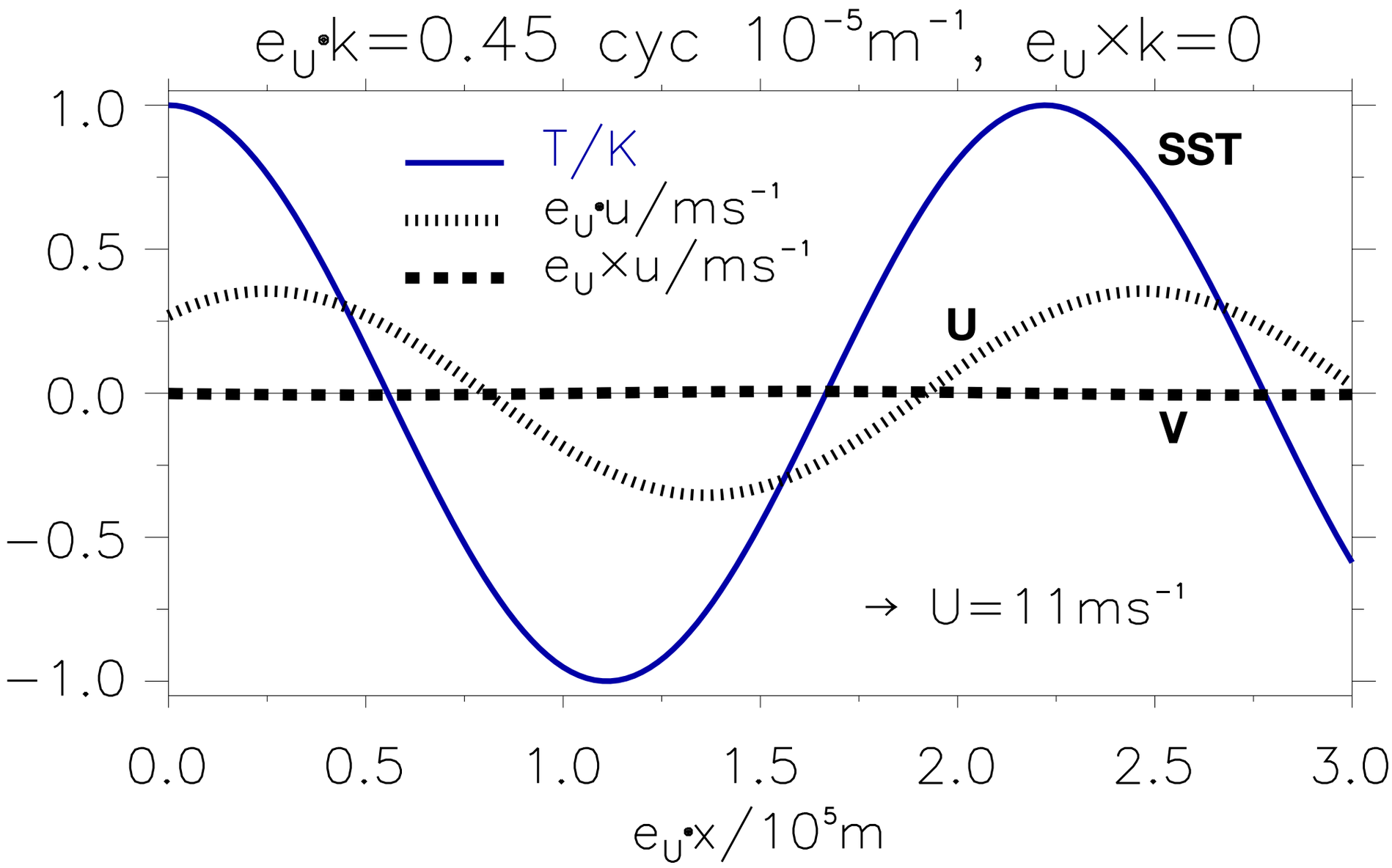
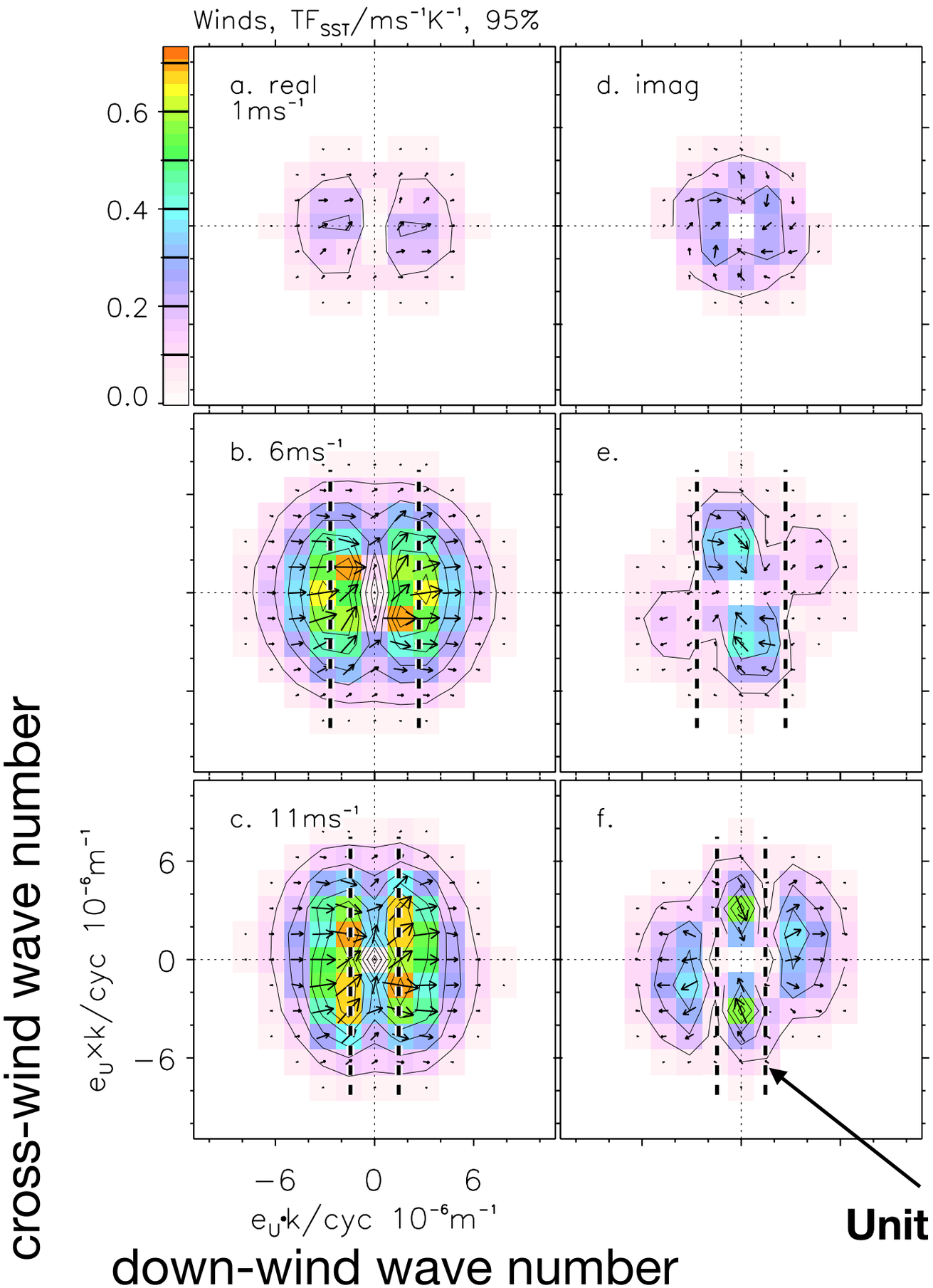


Rossby number 3
Advective response to vertical mixing mechanism



Wind transfer function

in phase … 90° phase lag … with SST



background wind 1 ms^{-1}

6 ms^{-1}

11 ms^{-1}

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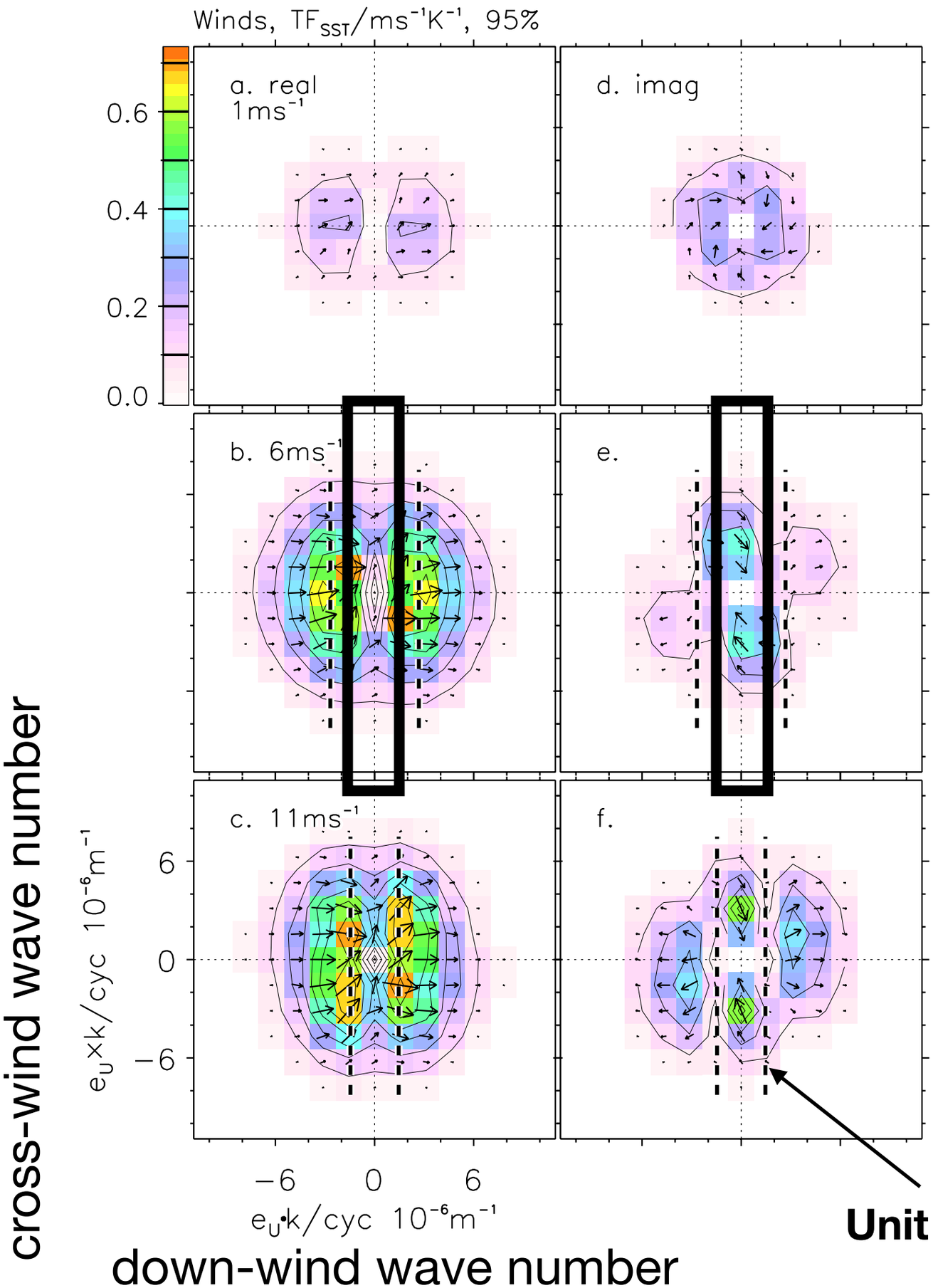

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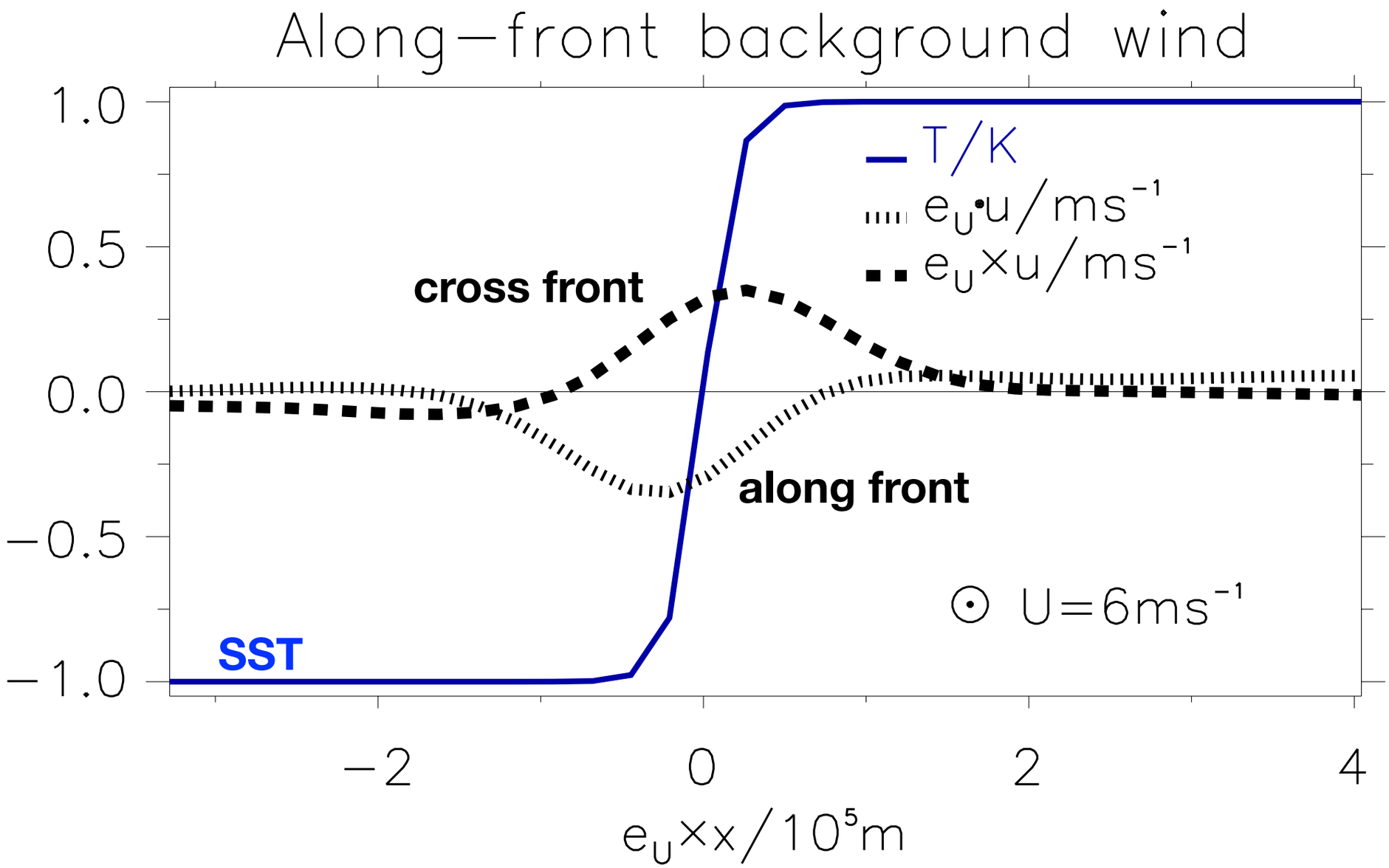
Unit Rossby number

Rossby number 0
Ekman spiral with pressure effect

and cross-frontal advection by sheared background wind



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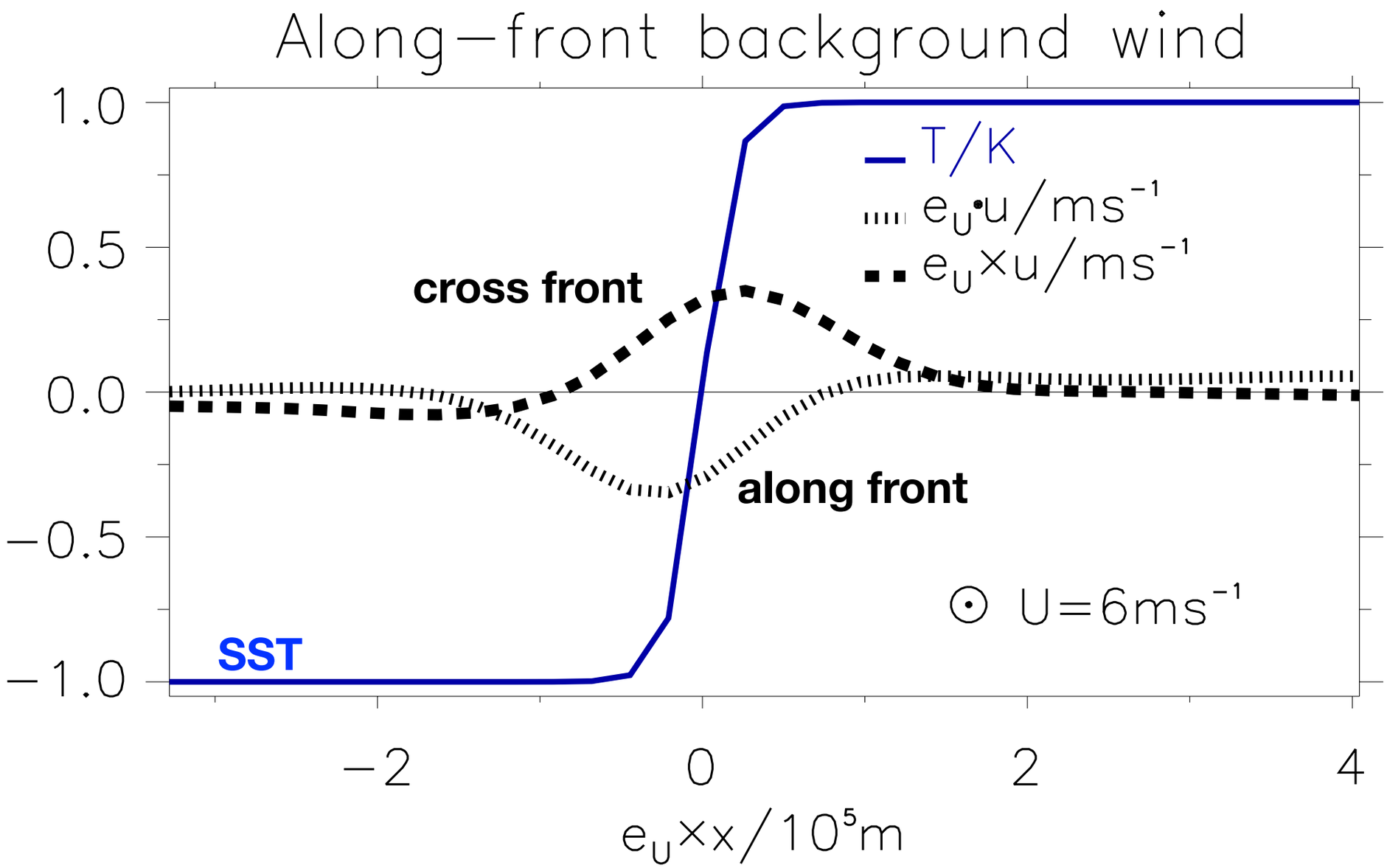
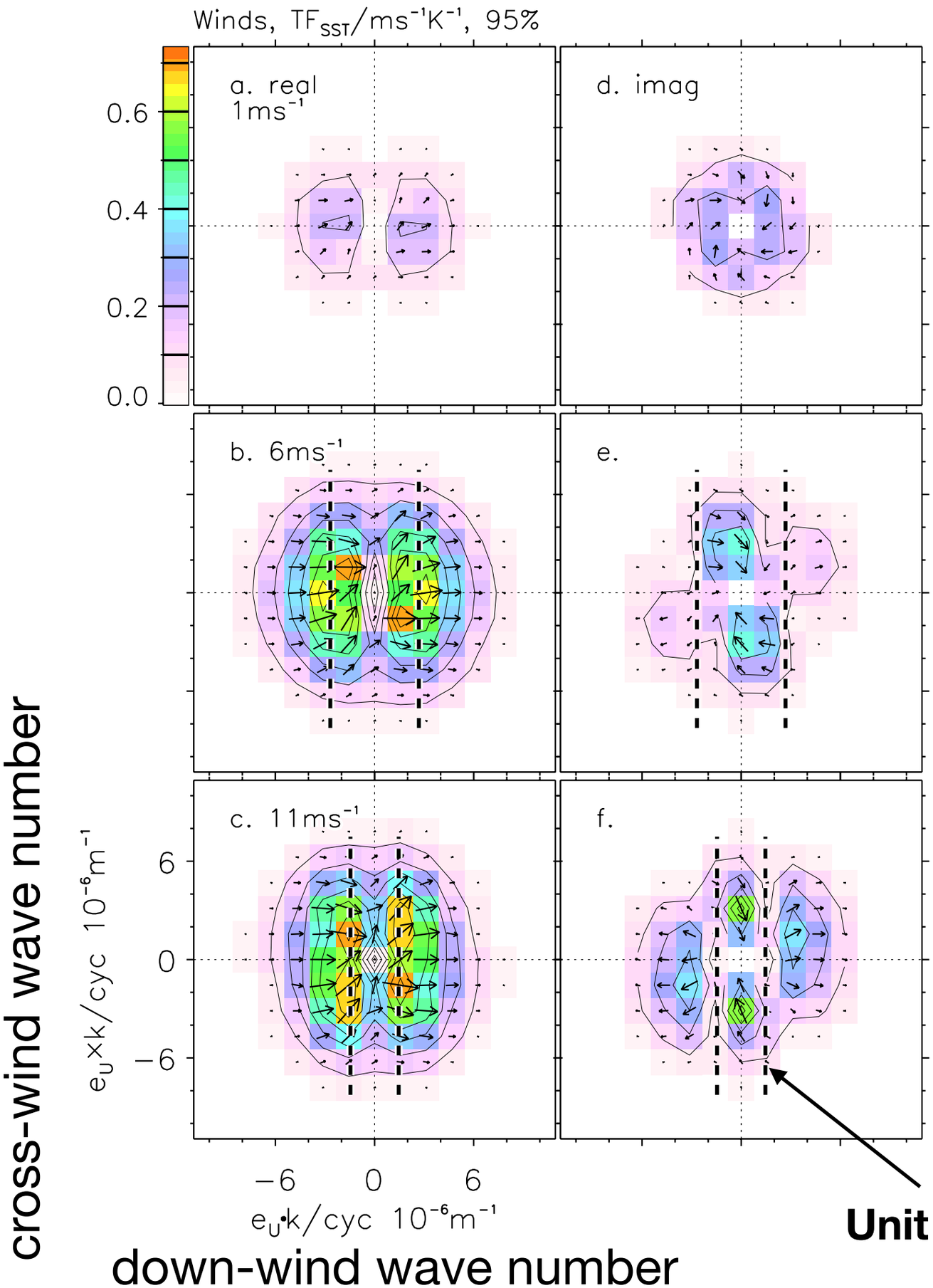


cool SST
high pressure

warm SST
low pressure

Wind transfer function

in phase … 90° phase lag … with SST



background wind 1 ms^{-1}

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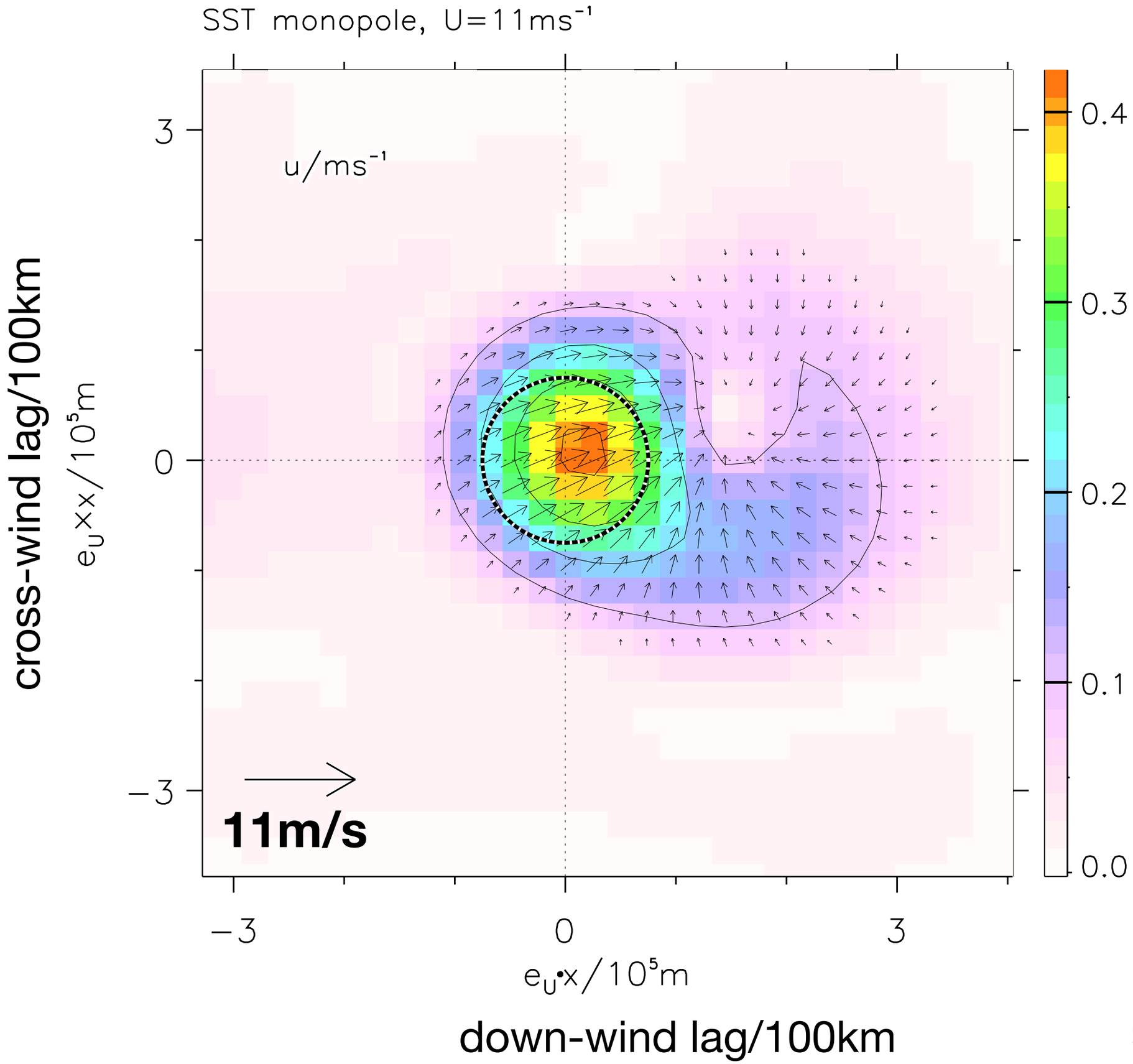
Wind response to SST monopole



Fundamental response patterns

The transfer function formulation

$$u(\vec{x}) \;=\; \int d\vec{k}\;\; \tilde{A}\left(\hat{e}_U \cdot \vec{k}, (\hat{e}_3 \times \hat{e}_U) \cdot \vec{k}, U\right)\;\; \tilde{T}(\vec{k})\;\; e^{-\imath\, \vec{k} \cdot \vec{x}}$$

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… of the **impulse response function** with sea surface temperature

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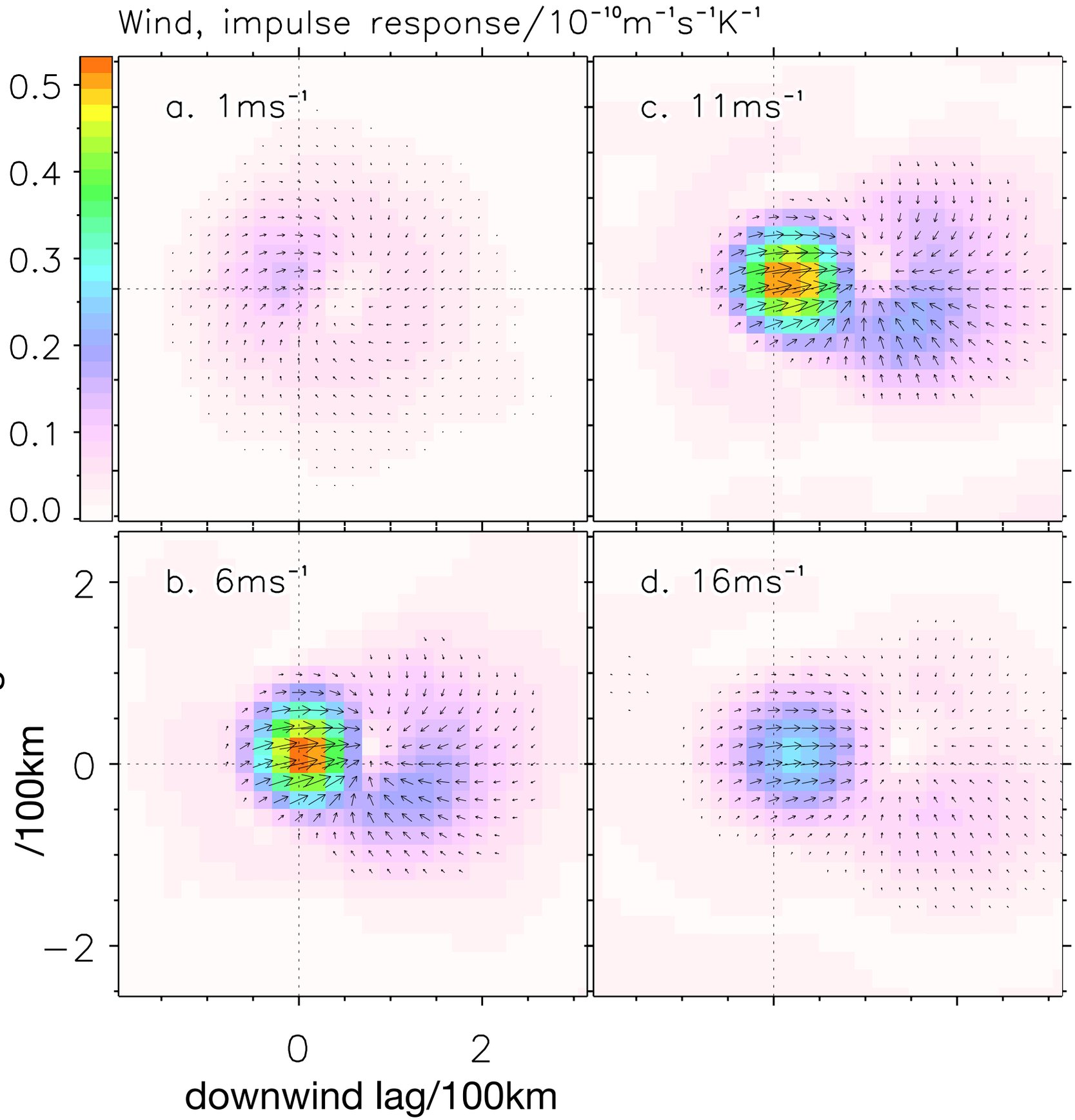
… of the **impulse response function** with sea surface temperature

The wind response to any distribution of SST can be reconstructed from the impulse response function

Impulse response functions



1 ms⁻¹

background wind 11 ms⁻¹

6 ms⁻¹

16 ms⁻¹

S. Hemisphere

Conclusions

- Observed imprints of ocean mesoscale SST on surface winds are strong functions of spatial scale
- In wave-number space physical regimes separate by Rossby number:
  - large to one: vertical mixing effect and advection
  - small to one: and Ekman solution to pressure effect
- In physical space impulse response functions are the fundamental wind response patterns
  - collocated with warm SST: speed increase and anticyclonic turning (vertical mixing)
  - wake: near-inertial lee wave, on right side of background winds resonance with pressure gradient force (Southern Hemisphere)