IOVWST, Scripps Institution of Oceanography, May 2-4, 2017

Dynamics of wind stress response to ocean mesoscale surface temperatures

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Akira Kuwano-Yoshida[3] and Hisashi Nakamura[2]
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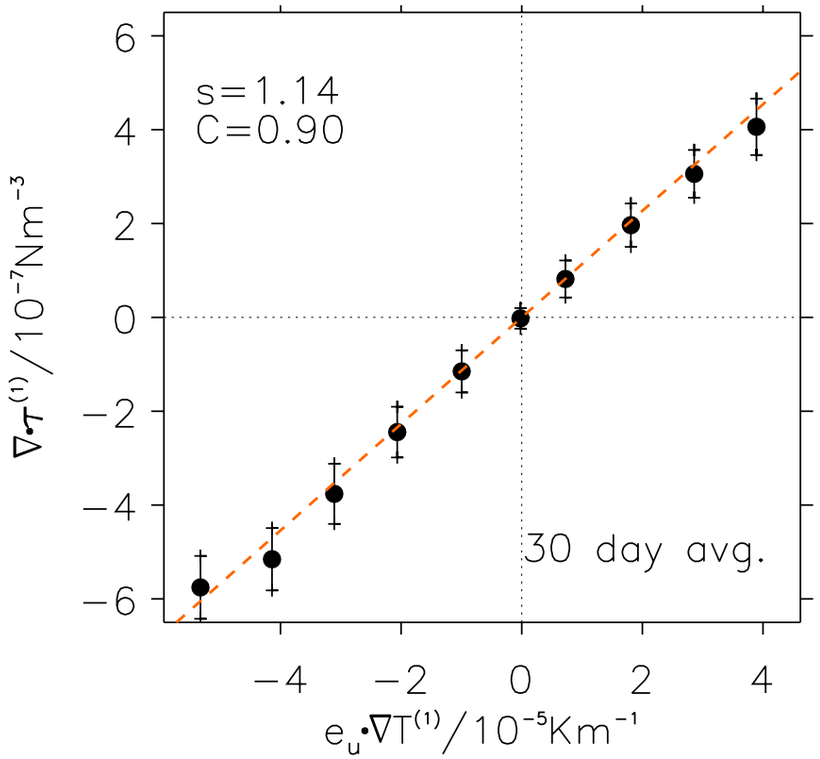
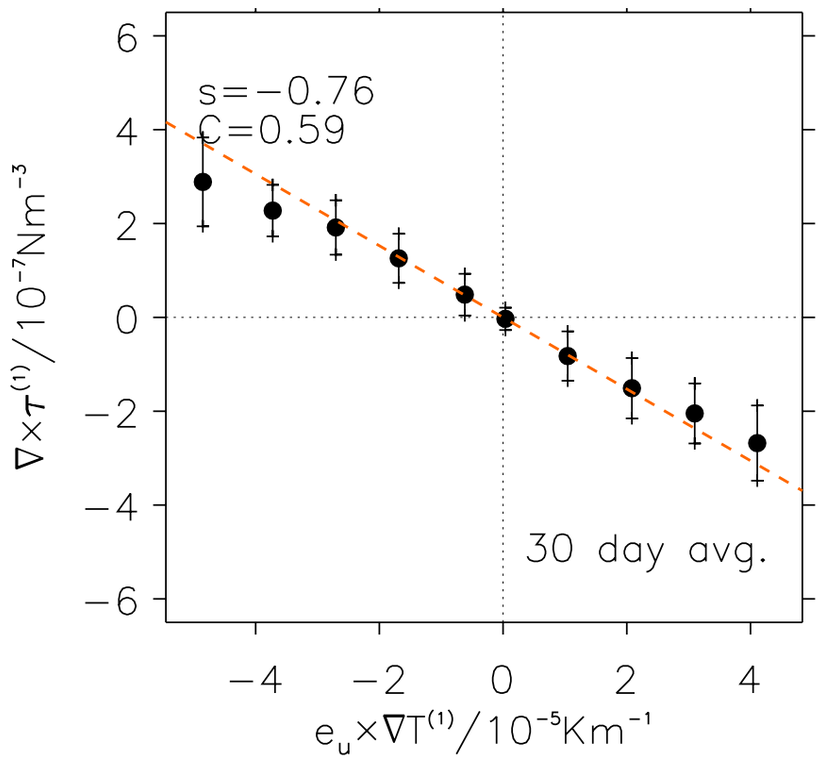
wind stress divergence



AFES 1.14·10^{-2} Nm^{-2}K^{-1}
Obs. 1.24 · 10^{-2} Nm^{-2}K^{-1}

wind stress curl



AFES -0.76·10^{-2} Nm^{-2}K^{-1}
Obs. -0.68 · 10^{-2} Nm^{-2}K^{-1}

AFES: Agulhas Retroflection, 5°E -85°E,50°S-34°S, daily averages, JFM, 1982-2000

Observations: Southern Ocean, Aug 1999-July 2001 (o'Neill et al. 2003)

Surface layer dynamics

wind speed

$$\vec{\tau} = \rho C U^2 \hat{e}$$

stability dependent
drag coefficient

wind direction

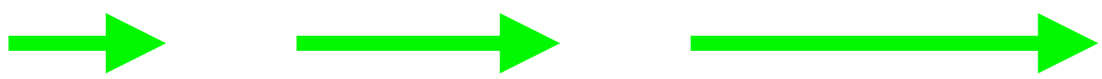
$$\vec{\tau} = \rho\, C\, U^2\, \hat{e}$$

Wind stress divergence

downwind change of stability

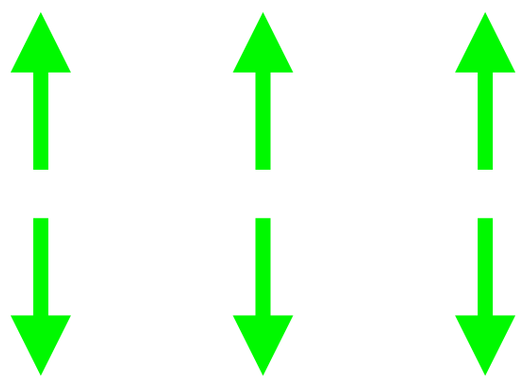
Liu et al. 2007
Liu and Xie 2008

acceleration of winds



o'Neill et al. 2010

divergent crosswinds



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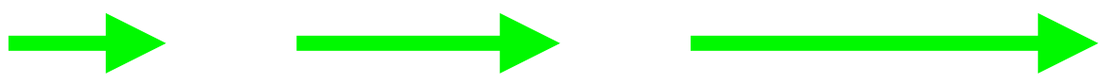

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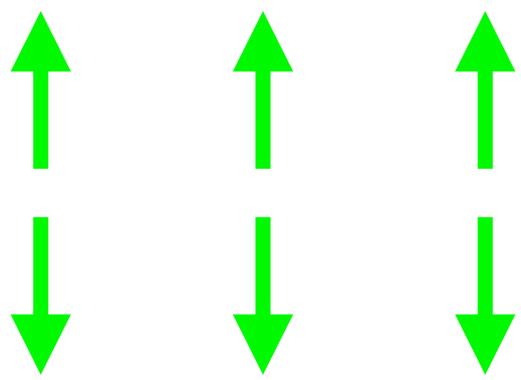
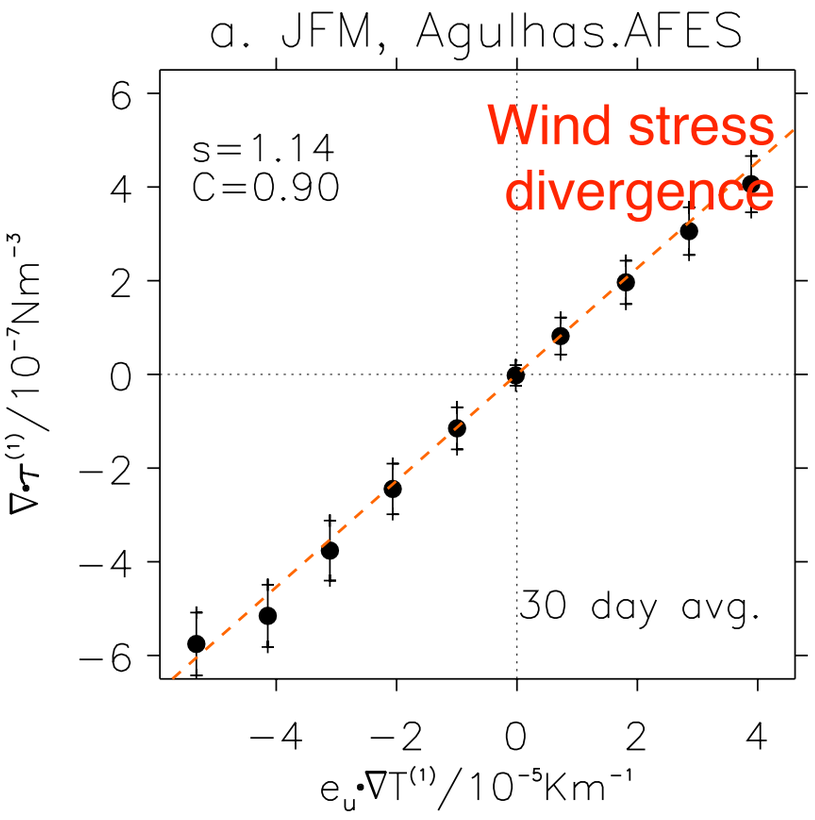


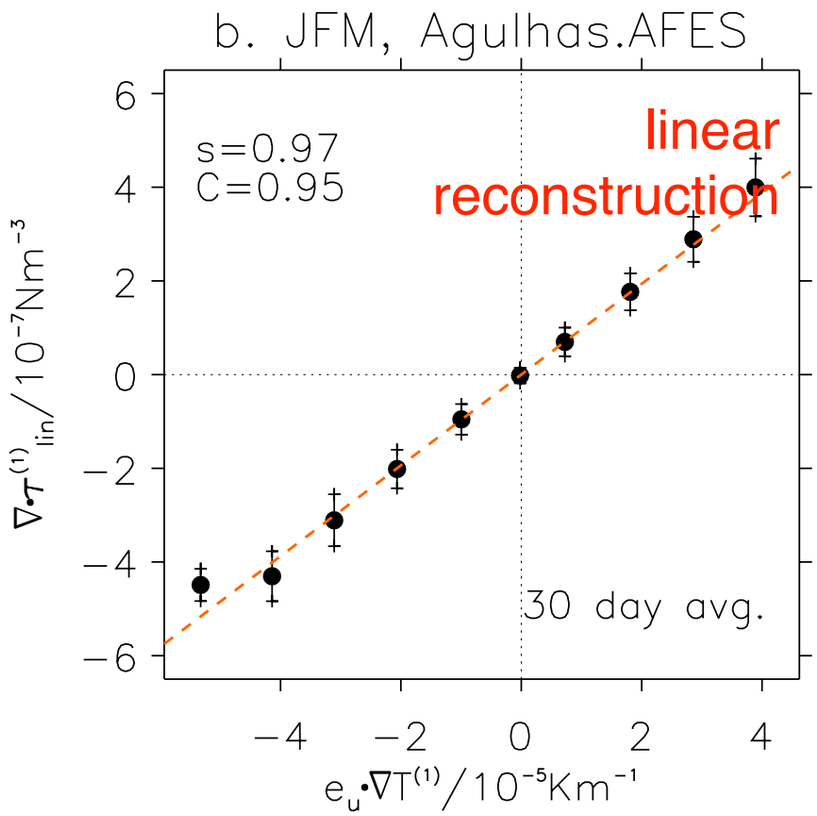
separate components by linearization of wind stress around background winds
assume ocean mesoscale SST as stability proxy

Deconstruction of coupling coefficients

wind stress divergence

linear reconstruction:
correlation 0.87
skill score 0.74





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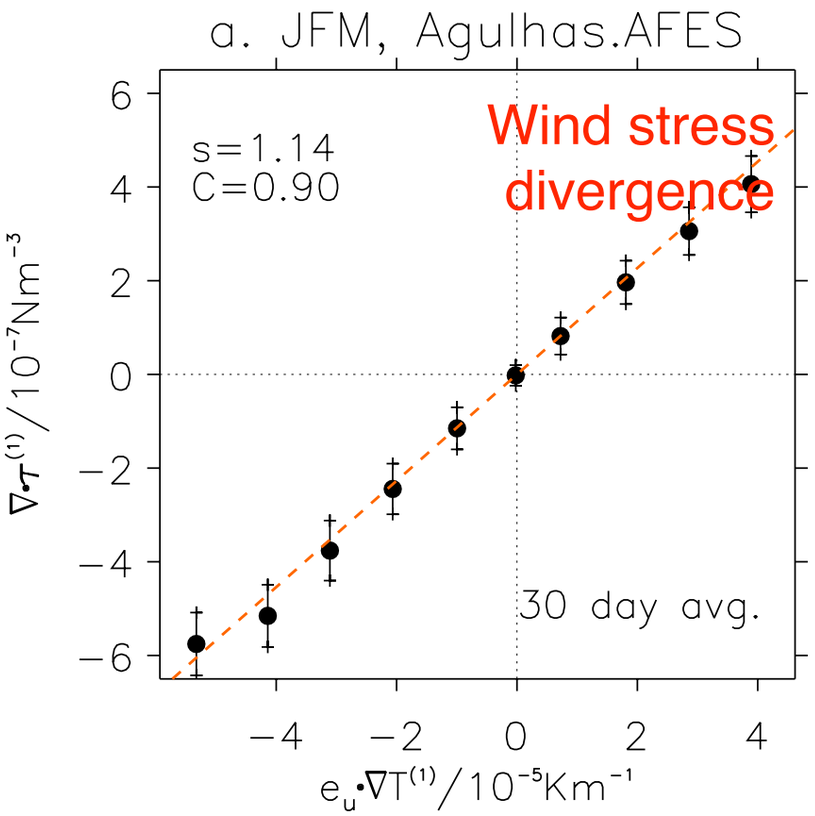

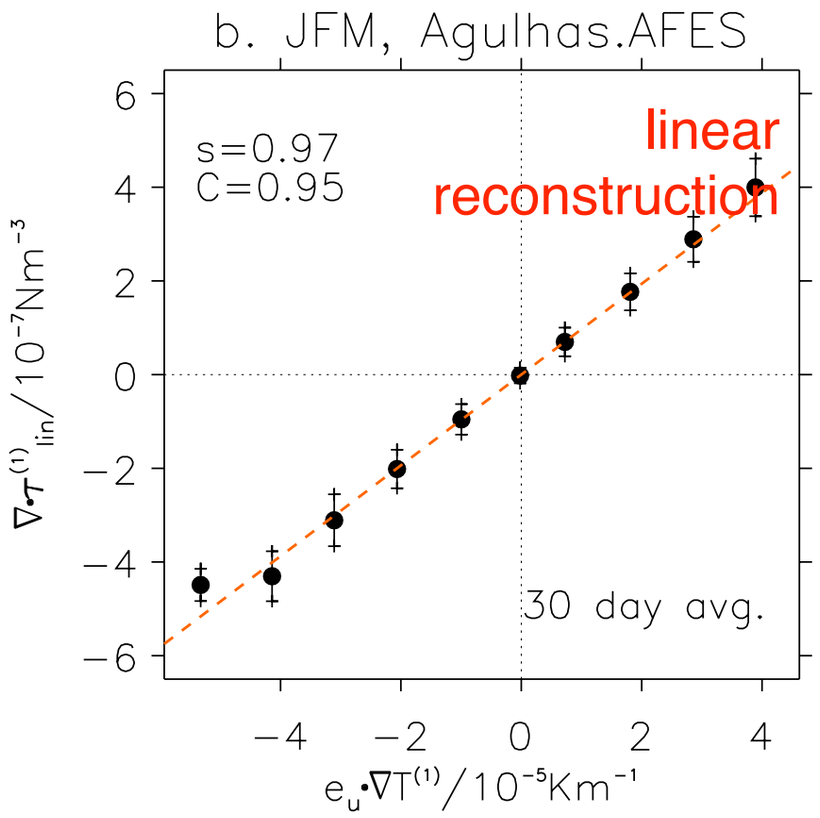

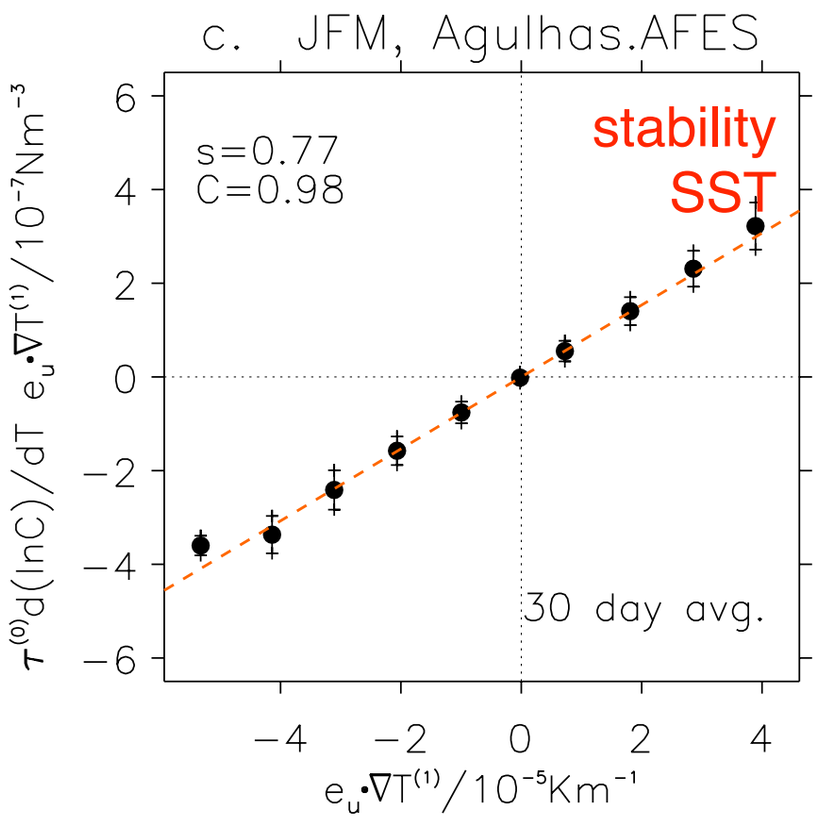

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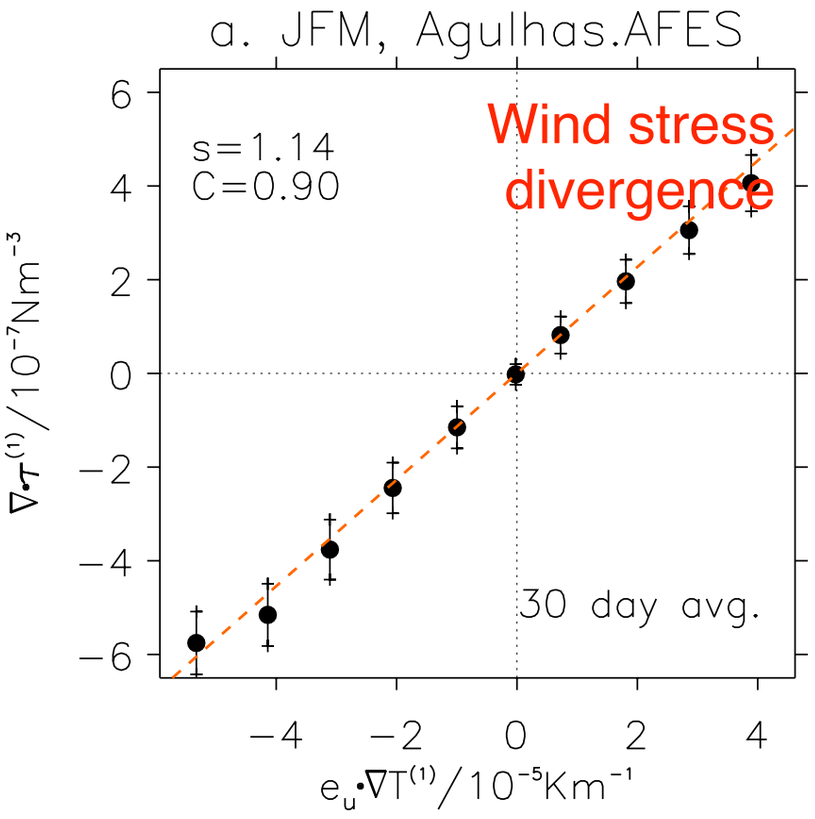
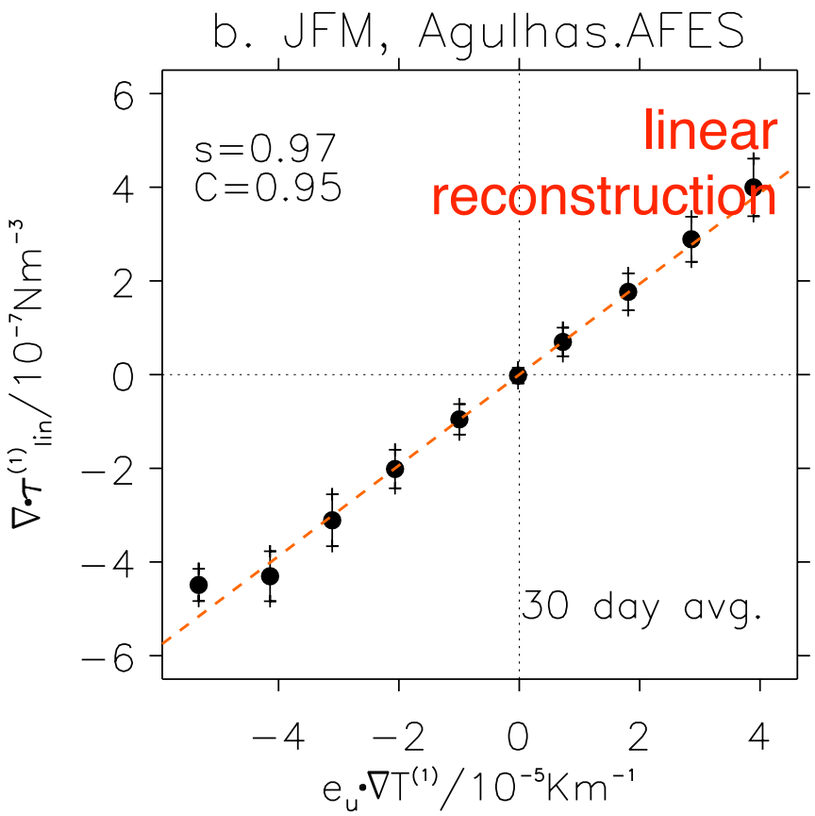
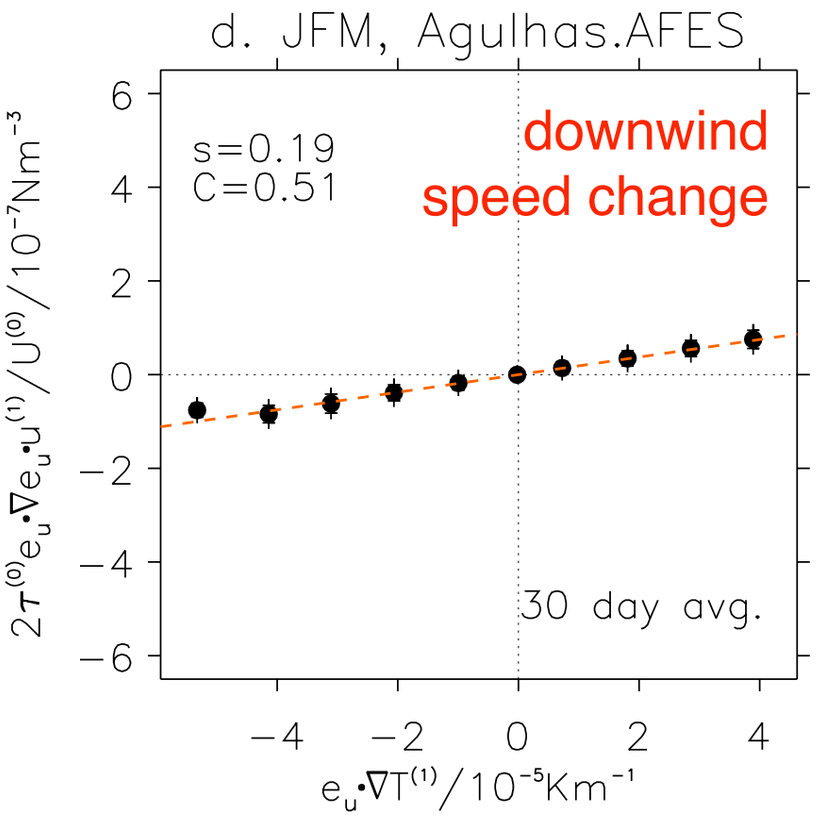
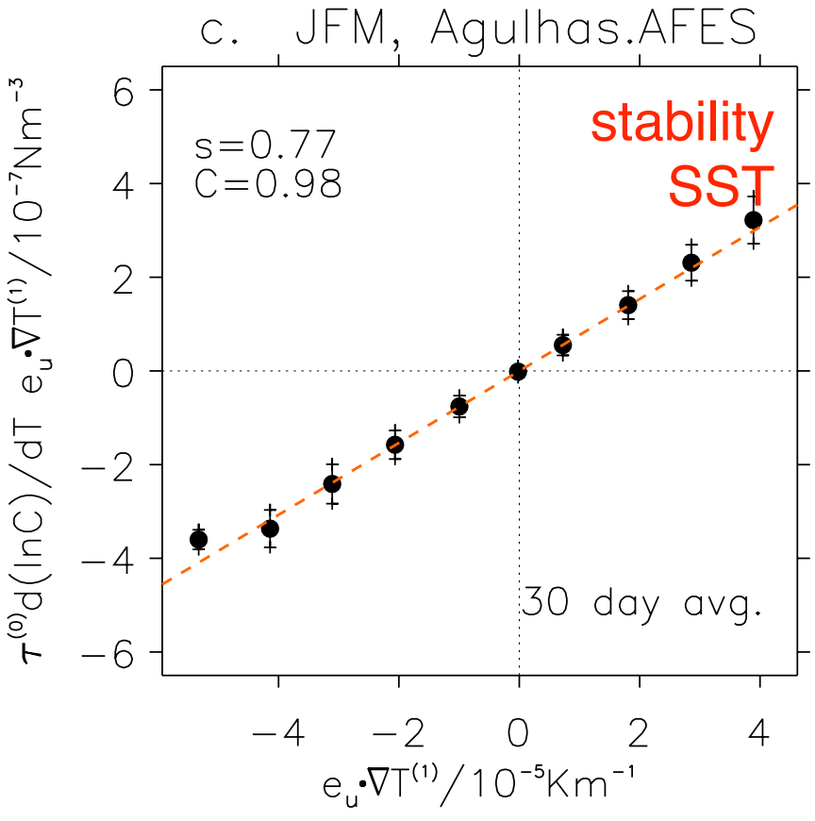
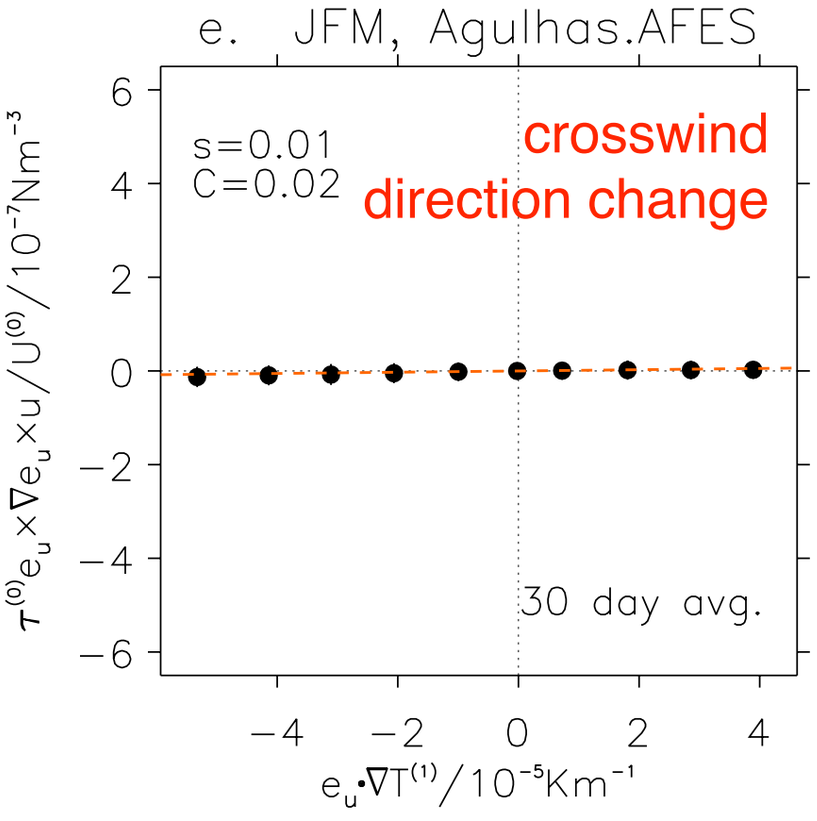










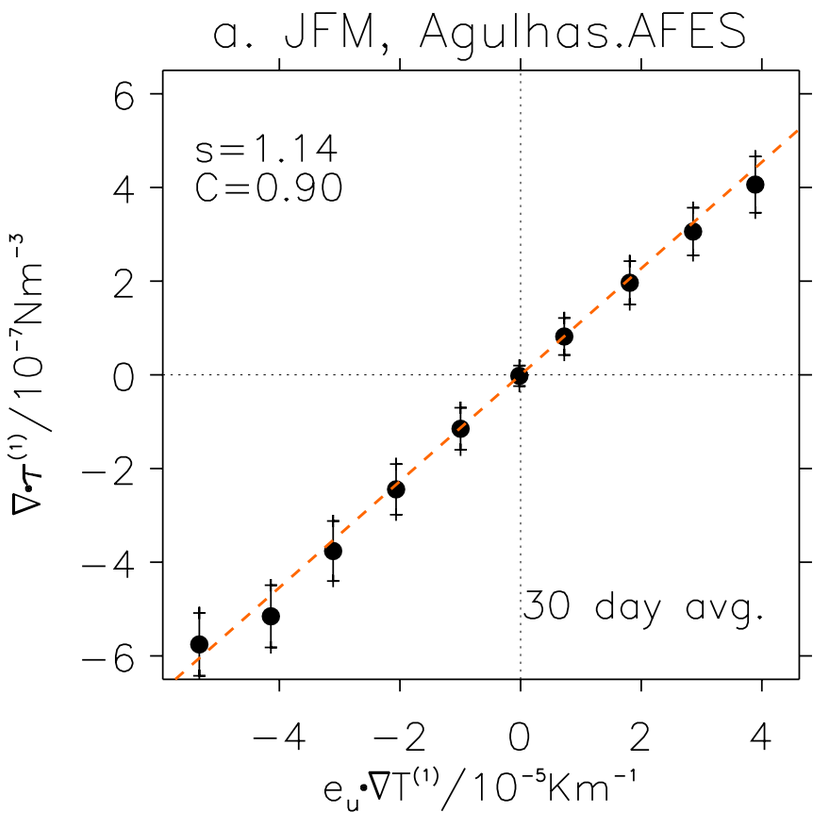
s: lsf fit slope
C: skill score

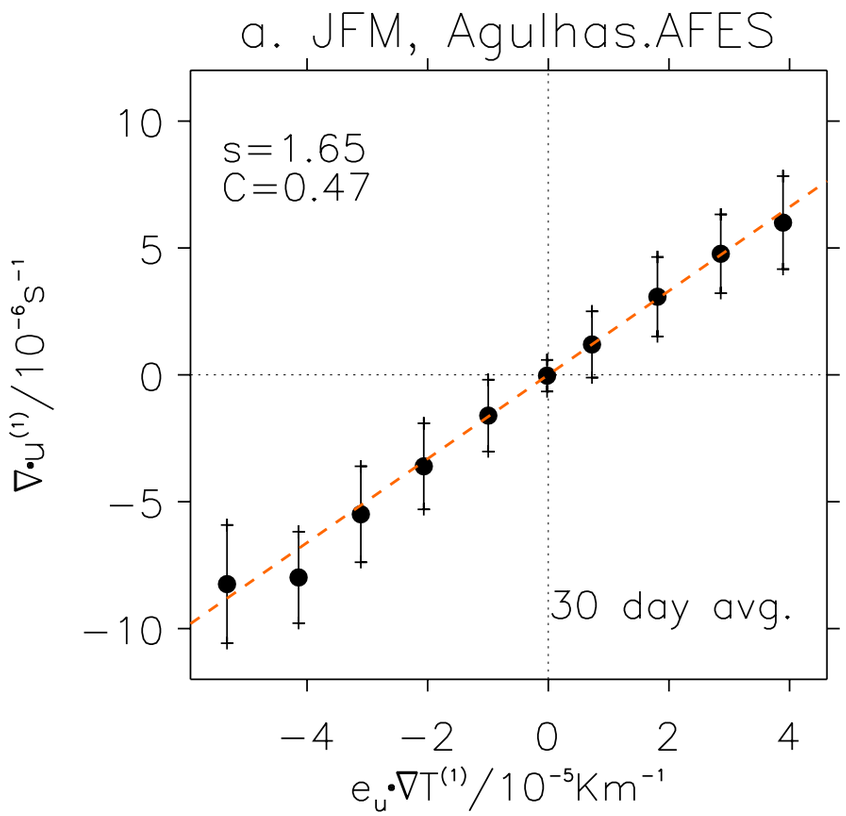
AFES: Coupling coefficients

wind stress

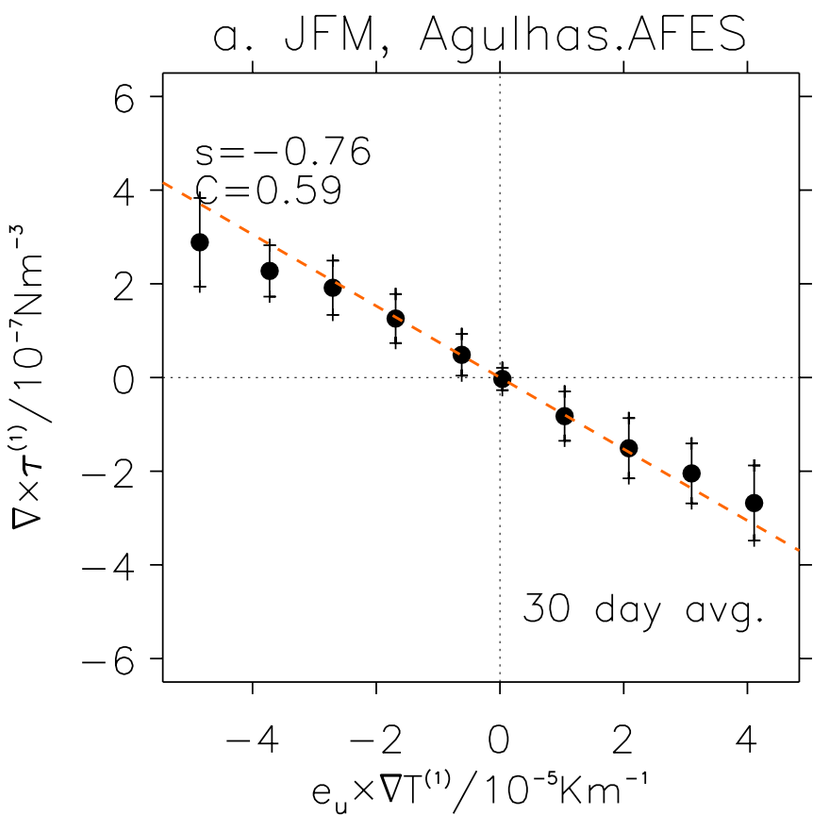
wind

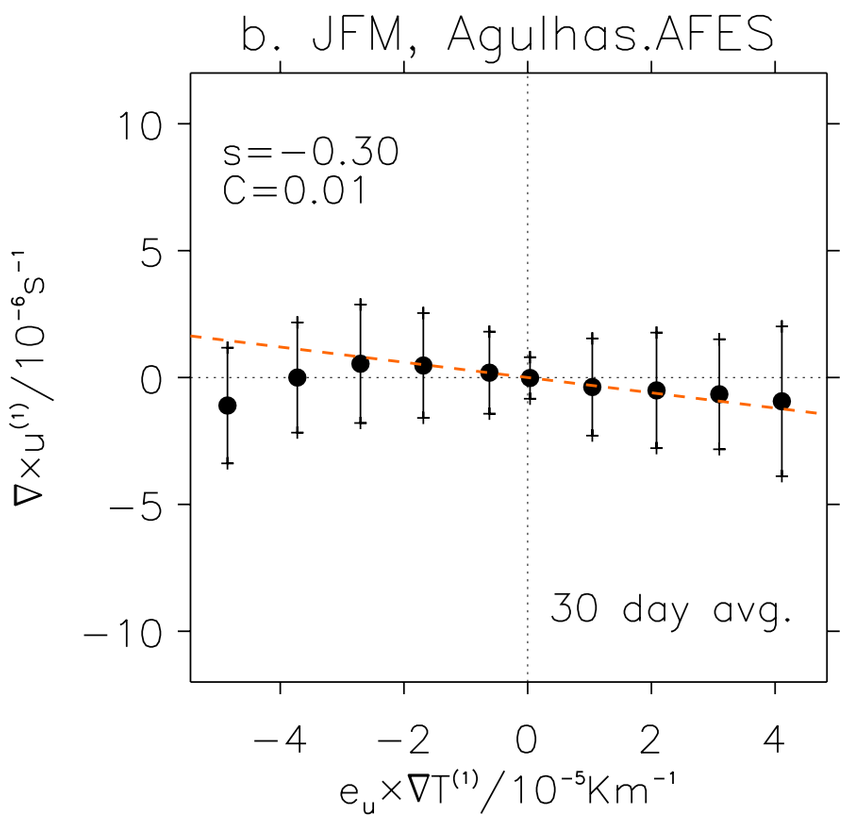
divergence





curl





Boundary layer dynamics

Schneider and Qiu, JAS, 2015

Linear Rossby adjustment problem with background advection and mixing in response to vertical mixing mechanism and pressure effect

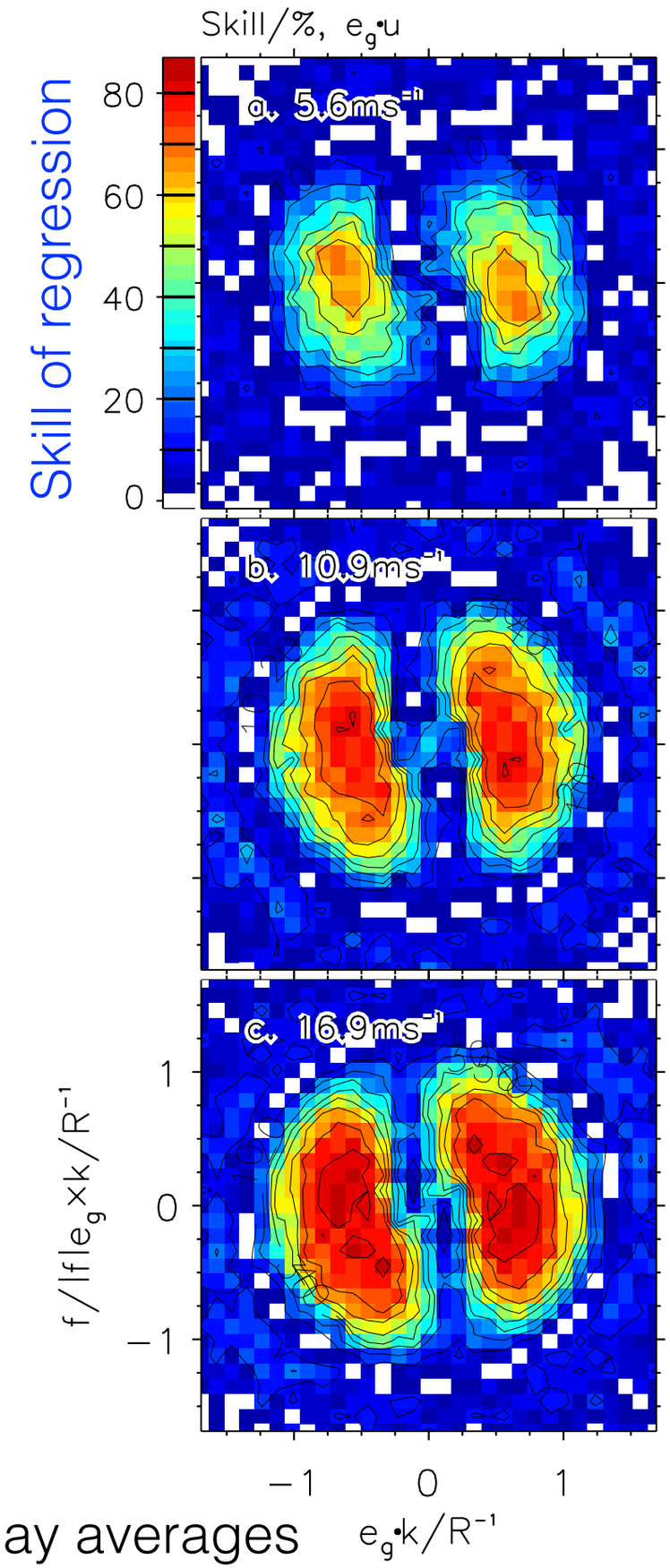
Fourier amplitudes

$$\vec{u}_k = \vec{A}_k \; T_k$$

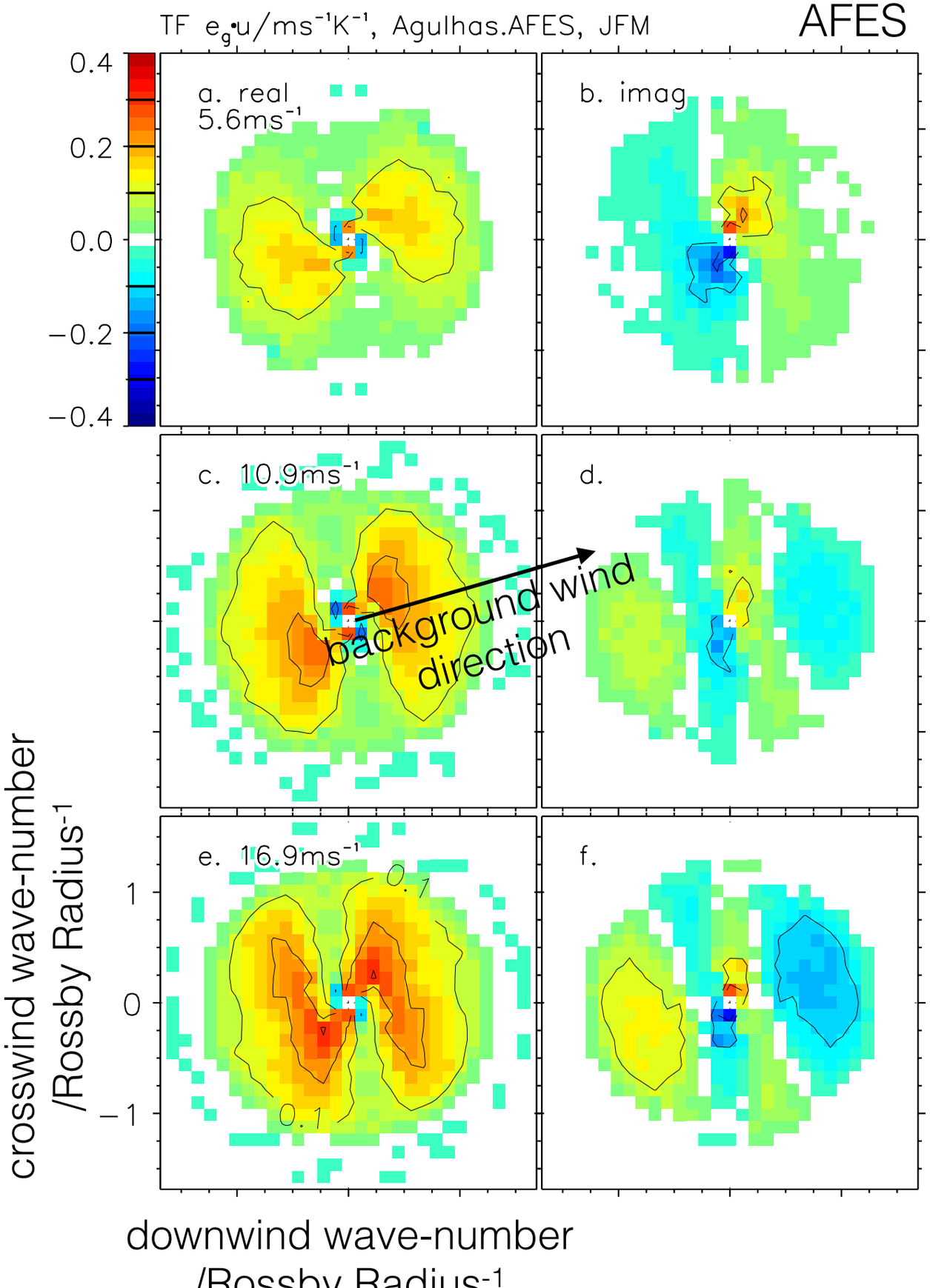
Transfer function

dependent on wavenumber relative to background wind, on background wind speed, and on mixing formulations

Frontally induced surface **winds in direction** of **background** winds



30 day averages



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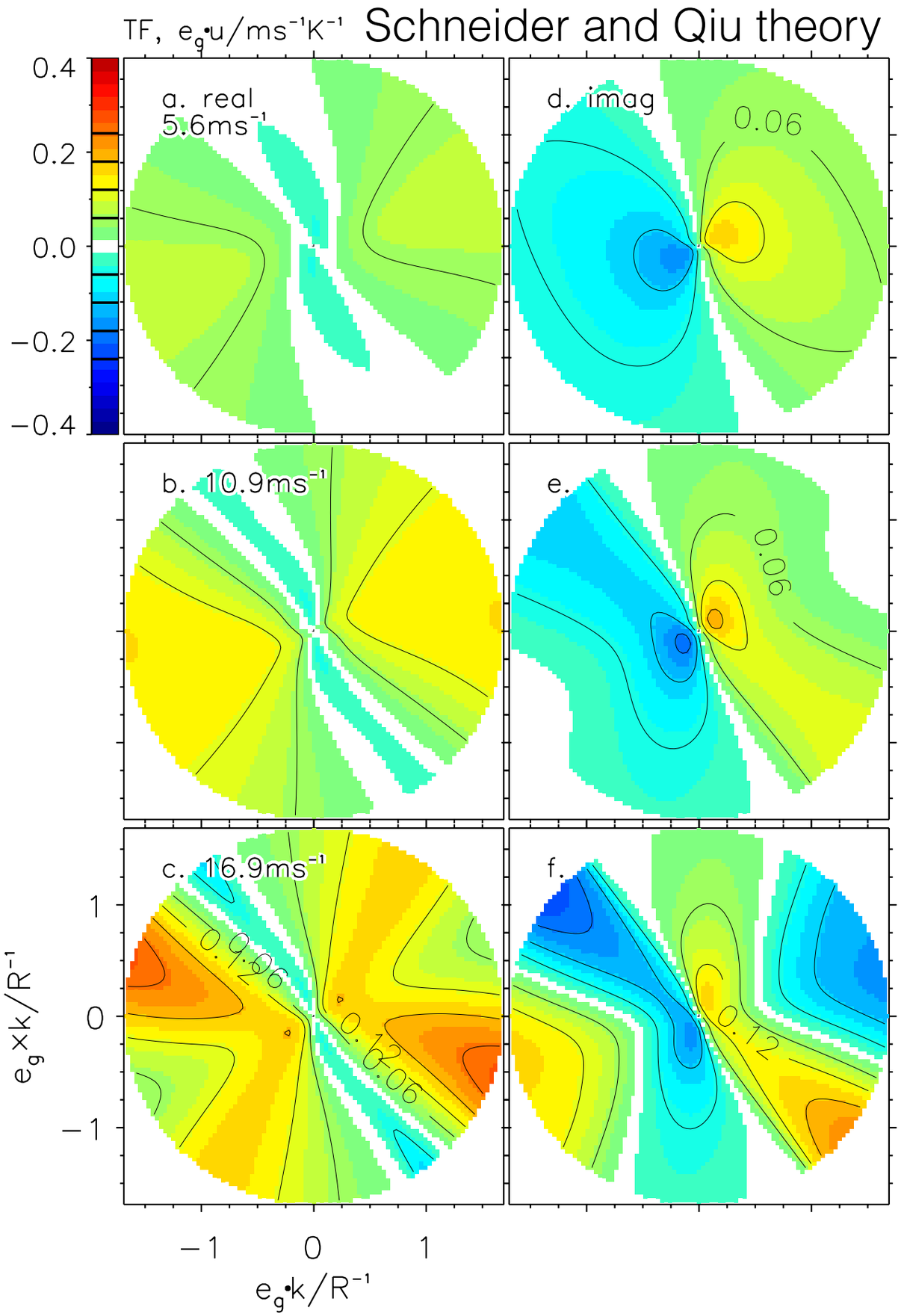
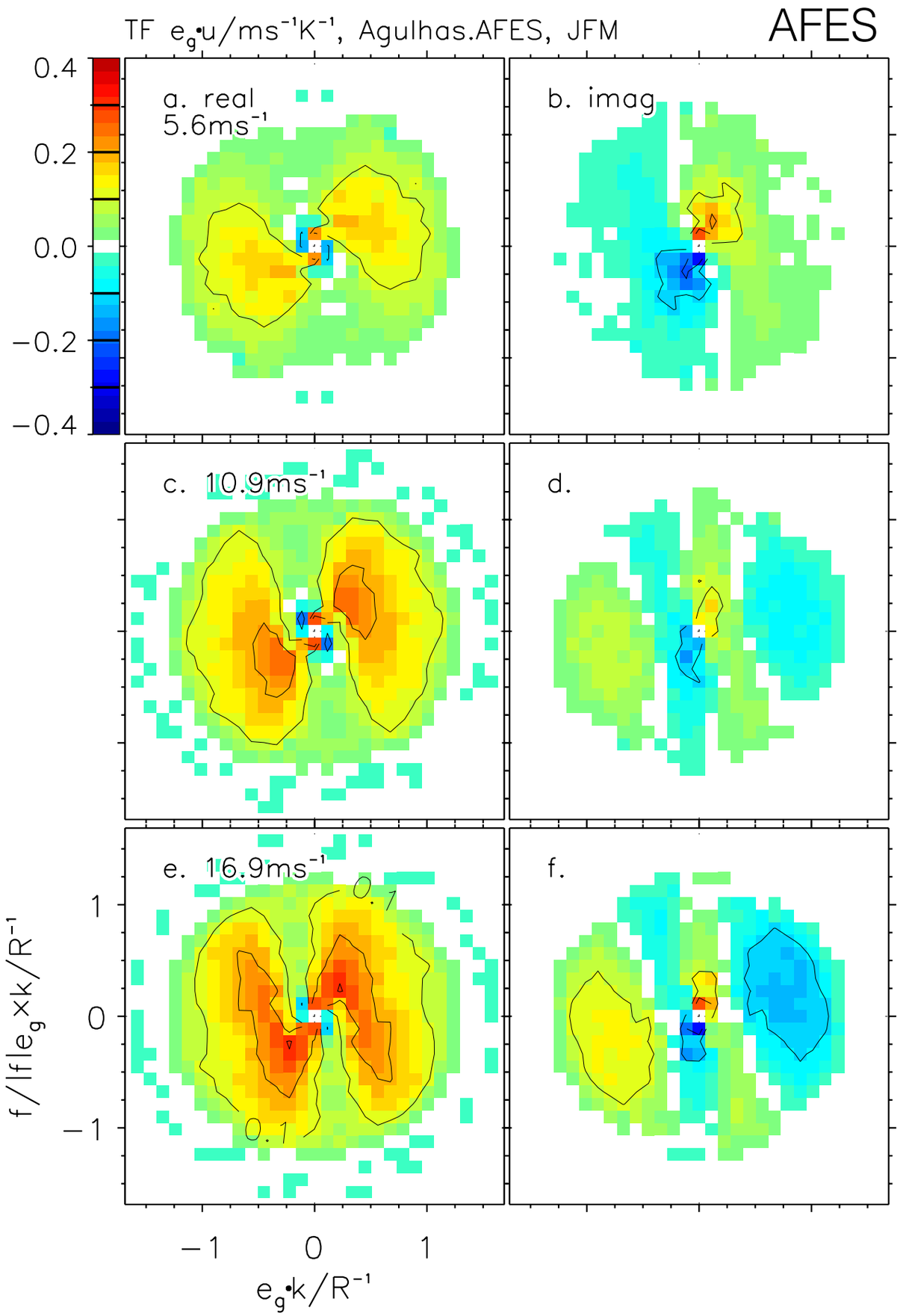


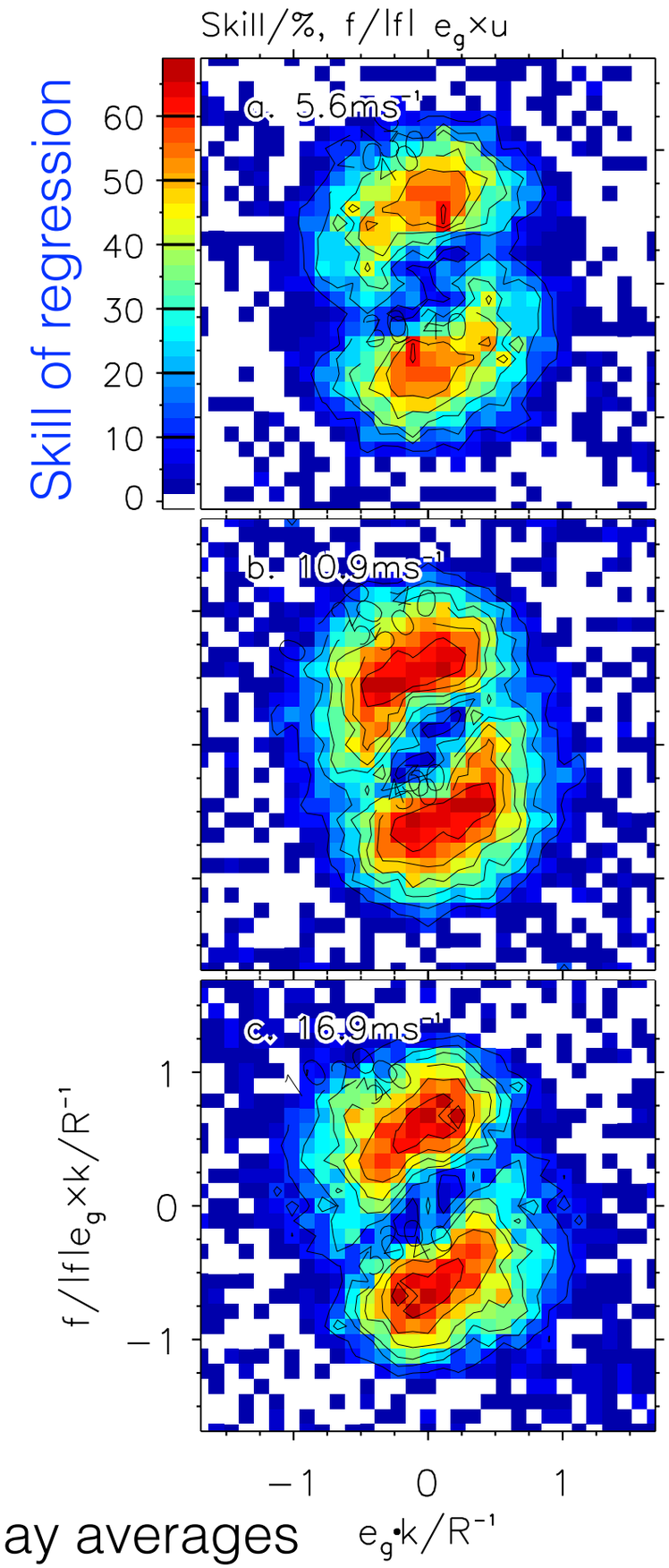


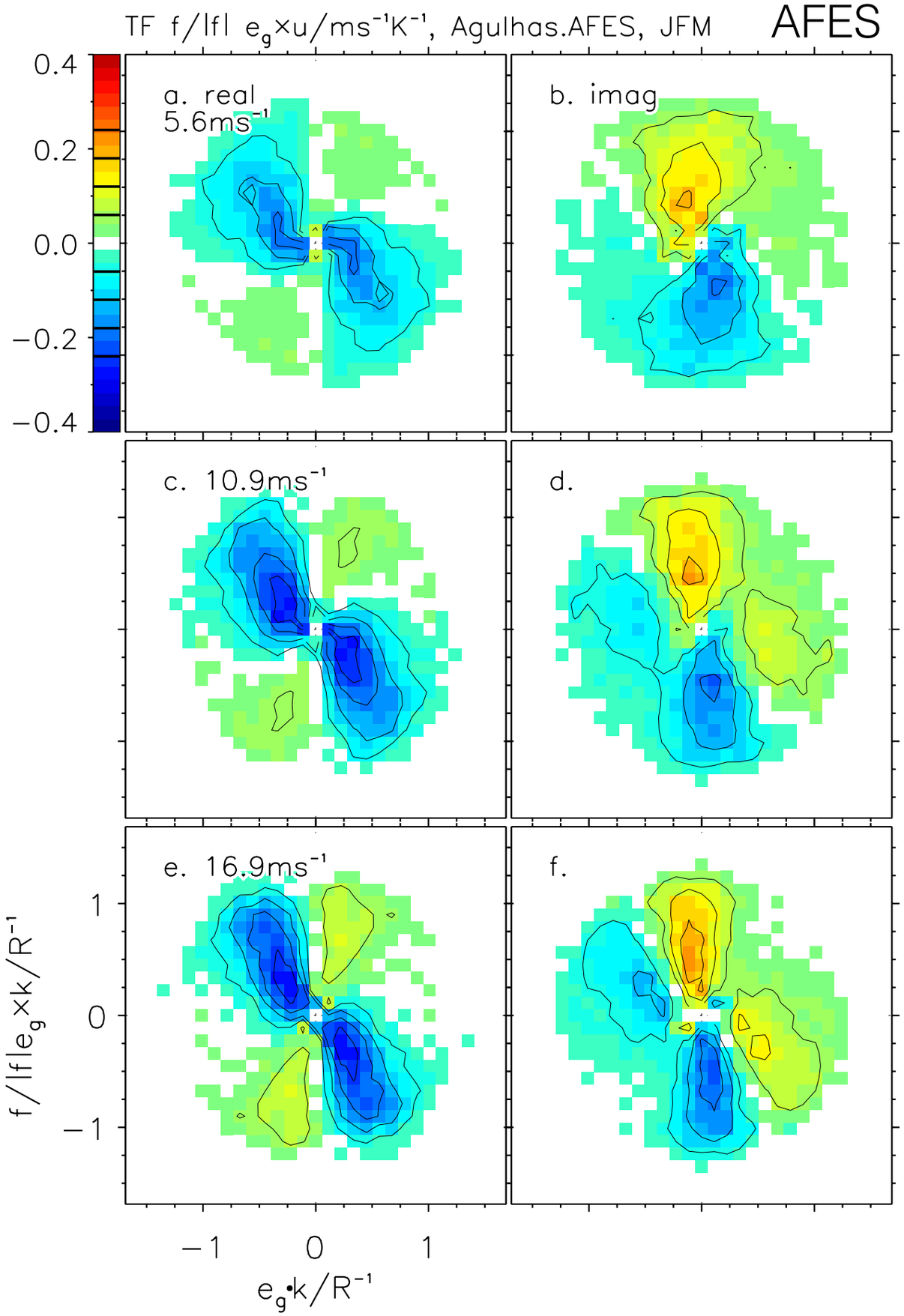
Conclusions

- Coupling coefficients of ocean mesoscale SST induced wind stress divergence and curl reflect in large part surface layer stability.
- Surface wind divergence and surface wind curl are weakly related to gradients of SST.
- Surface winds divergence and, to a lesser extent, curl, are described by scale-dependent transfer functions.
- The transfer functions are captured by linearized dynamics of the Schneider and Qiu (2015) theory.

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

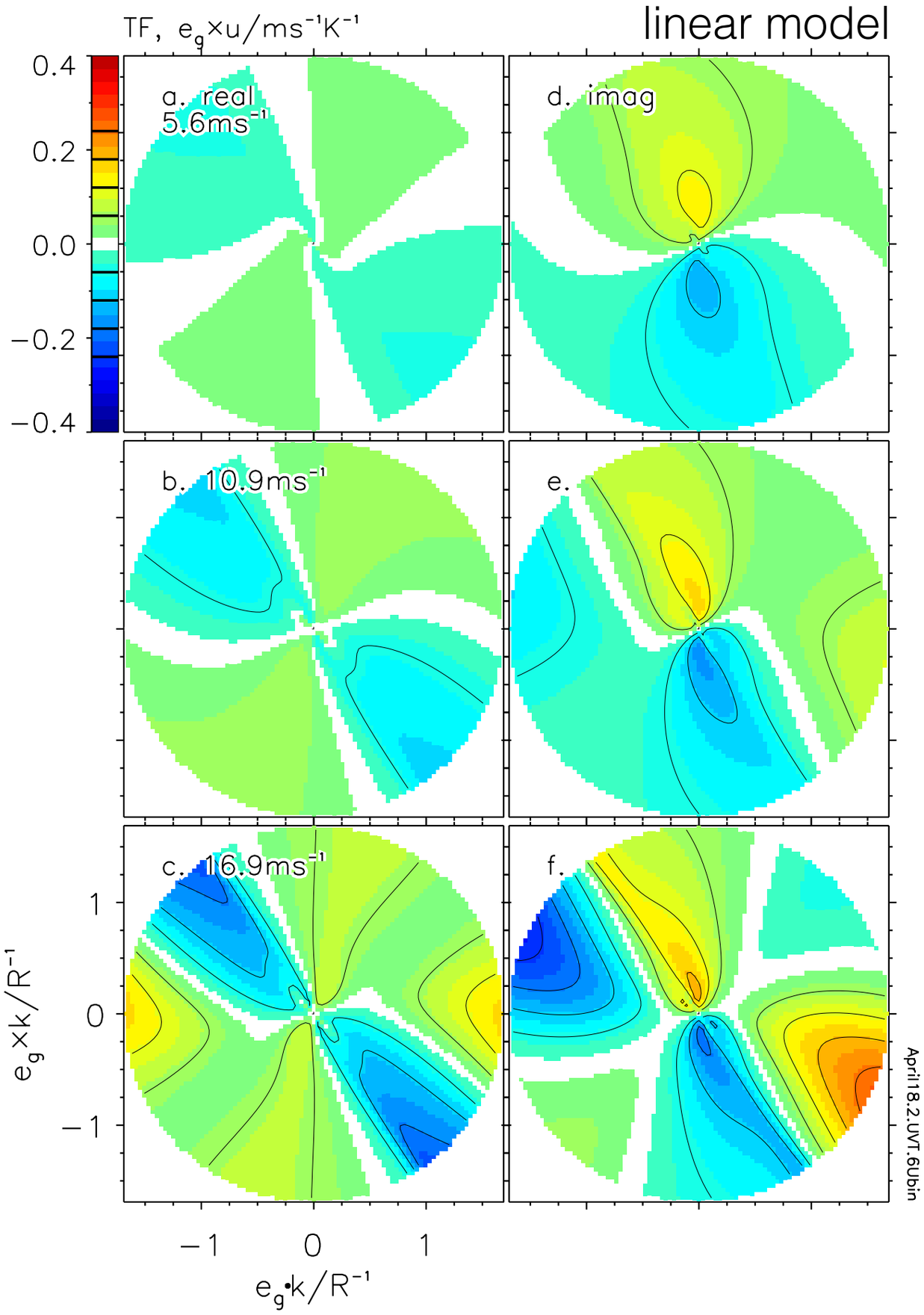
Frontally induced surface **winds perpendicular** to **background** winds

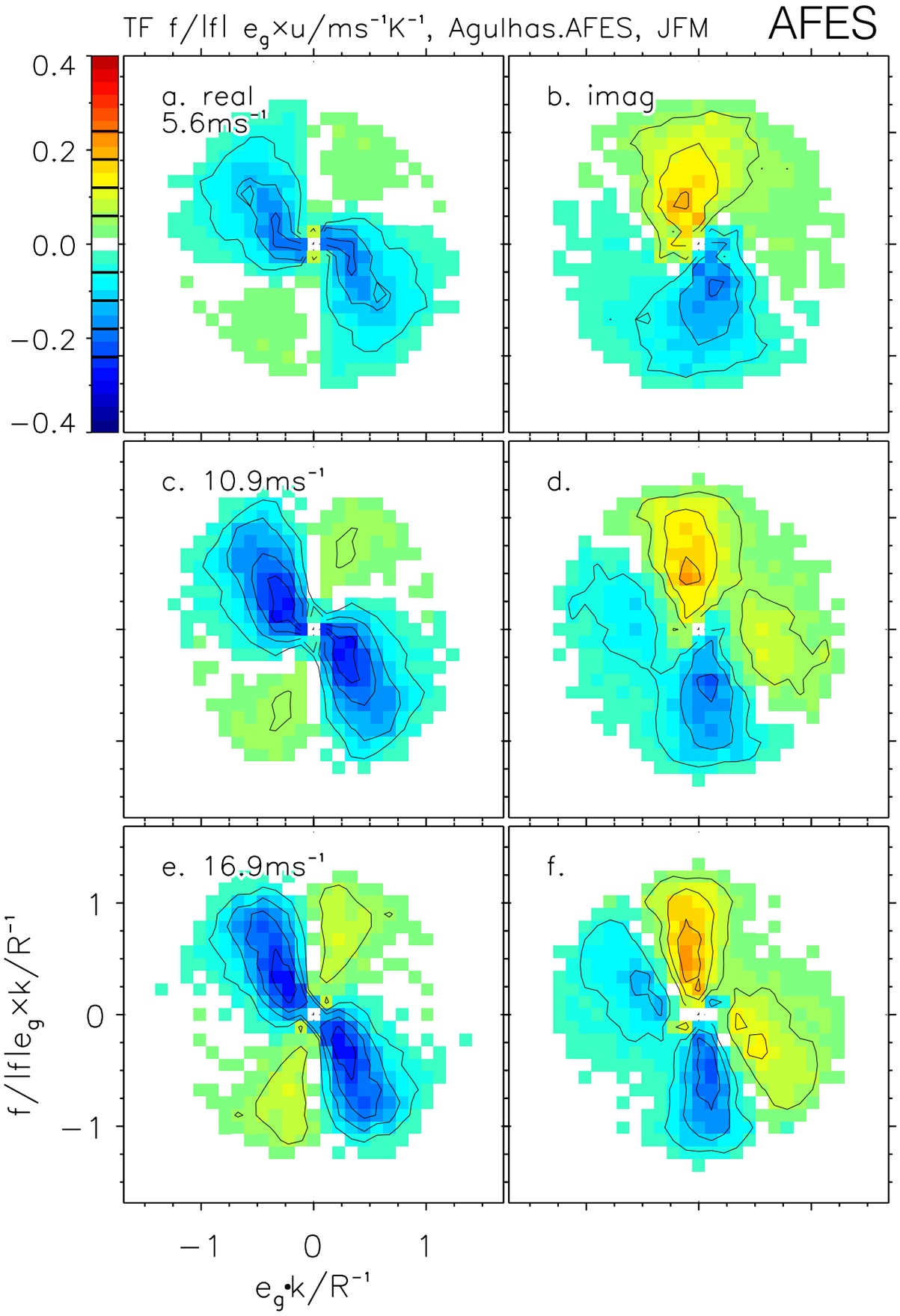




30 day averages

Frontally induced surface **winds perpendicular** to **background** winds





Momentum mixing in AFES

Akira Kuwano-Yoshida

Momentum flux by vertical diffusion

$$Fu = K_M \frac{\partial u}{\partial \sigma} \ , \qquad \text{(III.12.1)}$$

$$Fv = K_M \frac{\partial v}{\partial \sigma} \ , \qquad \text{(III.12.2)}$$

- Based on Meller and Yamada (1974, 1982) level 2 with Nakanishi and Niino (2004) parameters
- Fu, Fv: momentum fluxes for u, v
- KM: momentum vertical diffusion coefficient

Reconstruction skill

correlations of 30 day averages

	coupling coefficients	transfer functions
wind divergence	**0.6**	**0.7**
wind curl	**0.15**	**0.33**