Remote influences on the Indian monsoon low-level jet intraseasonal variations

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Reference: ***Swathi, M. S., Izumo, T., Lengaigne, M., Vialard, J., & Kumar, M. R. (2020). Remote influences on the Indian monsoon low-level jet intraseasonal variations. Climate Dynamics*, *54*(3), 2221-2236.**
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(and at https://takeshi-izumo.locean-ipsl.upmc.fr/publications.html)

Abstract

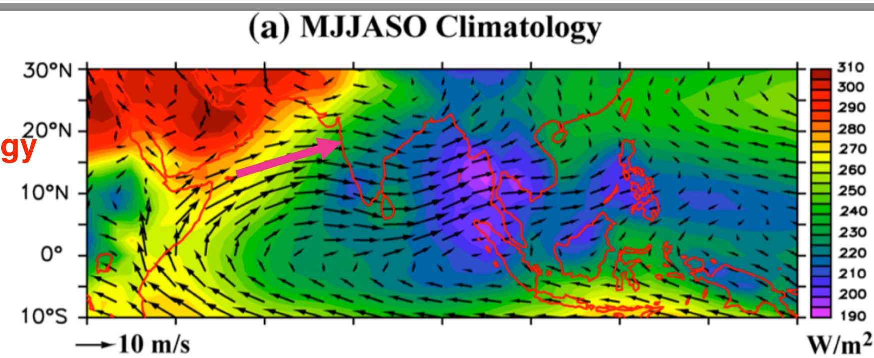
A strong Low-Level Jet (LLJ), also known as the Findlater jet, develops over the Arabian Sea during the Indian summer monsoon (**Fig. 1a**). This jet is an essential source of moisture for monsoonal rainfall over the densely-populated Indian subcontinent and is a key contributor to the Indian Ocean oceanic productivity by sustaining the western Arabian Sea upwelling systems. The LLJ intensity fluctuates intraseasonally within the ~20-90 days band, in relation with the northward-propagating active and break phases of the Indian summer monsoon (**Fig. 1bcd**). Our observational analyses reveal that these large-scale regional convective perturbations only explain about half of the intraseasonal LLJ variance (**Fig. 2**), the other half not being related to convective perturbations over the Indian Ocean. We show that convective fluctuations in two regions outside the Indian Ocean remotely force a LLJ intensification, four days later (**Fig. 3**). Enhanced atmospheric deep convection over the northwestern tropical Pacific yields westerly wind anomalies that propagate westward to the Arabian Sea as baroclinic atmospheric Rossby Waves (**Fig. 4bd**). Suppressed convection over the eastern Pacific / North American monsoon region yields westerly wind anomalies that propagate eastward to the Indian Ocean as dry baroclinic equatorial Kelvin waves (**Fig. 4ac**). Those largely independent remote influences jointly explain ~40% of the intraseasonal LLJ variance that is not related to convective perturbations over the Indian Ocean (i.e. ~20% of the total), with the northwestern Pacific contributing twice as much as the eastern Pacific (**Fig. 3**). Taking into account these two remote influences should thus enhance the ability to predict the LLJ.

Fig.1 Introduction: Active, Break and Transition phases of Summer Monsoon

OLR (color) and wind(vector)

Strong low-level jet (LLJ), i.e. the Findlater jet, over the Arabian Sea during the Indian summer monsoon.

MJJASO climatology



Past work have shown a clear modulation of the LLJ in response to monsoon active and break phases, the main mode of 20-90 day atmospheric convection variability over the Indian Ocean (here depicted through a regression to the Goswami 2005 index)

Start of monsoon Active Phase

Monsoon Active Phase

Onset of monsoon break Phase

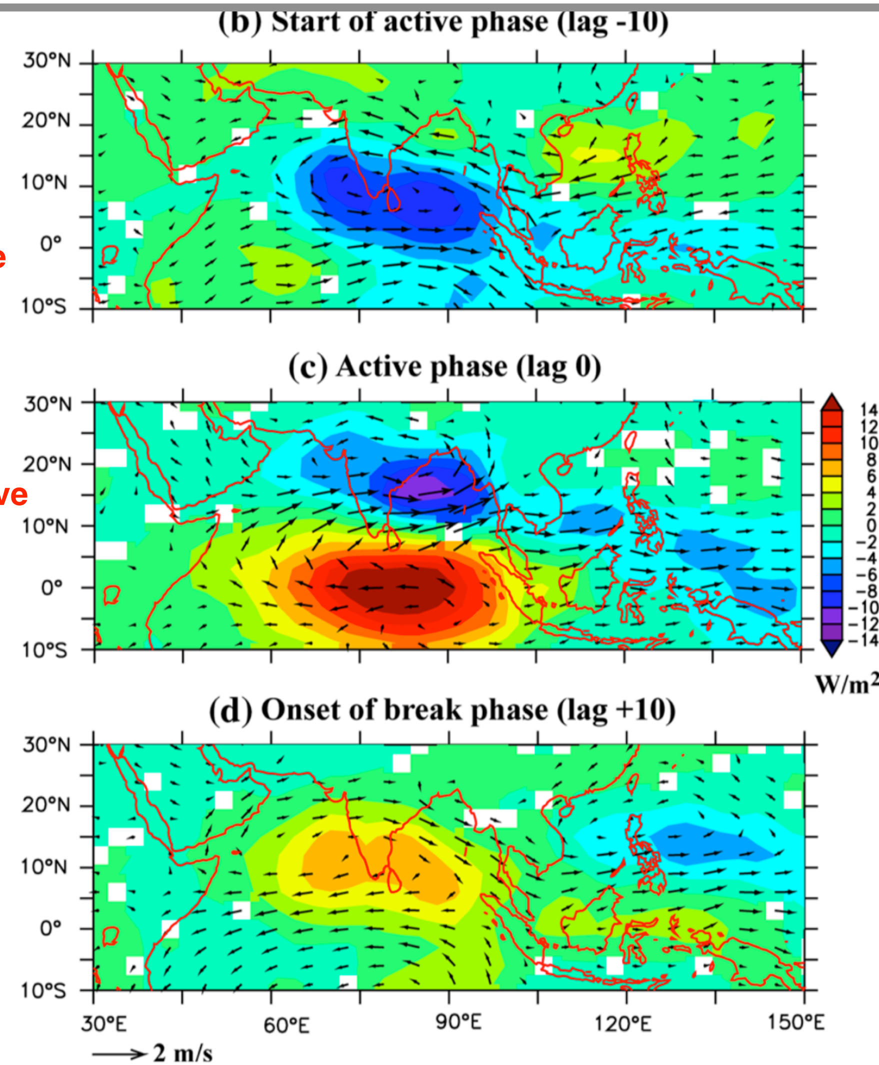
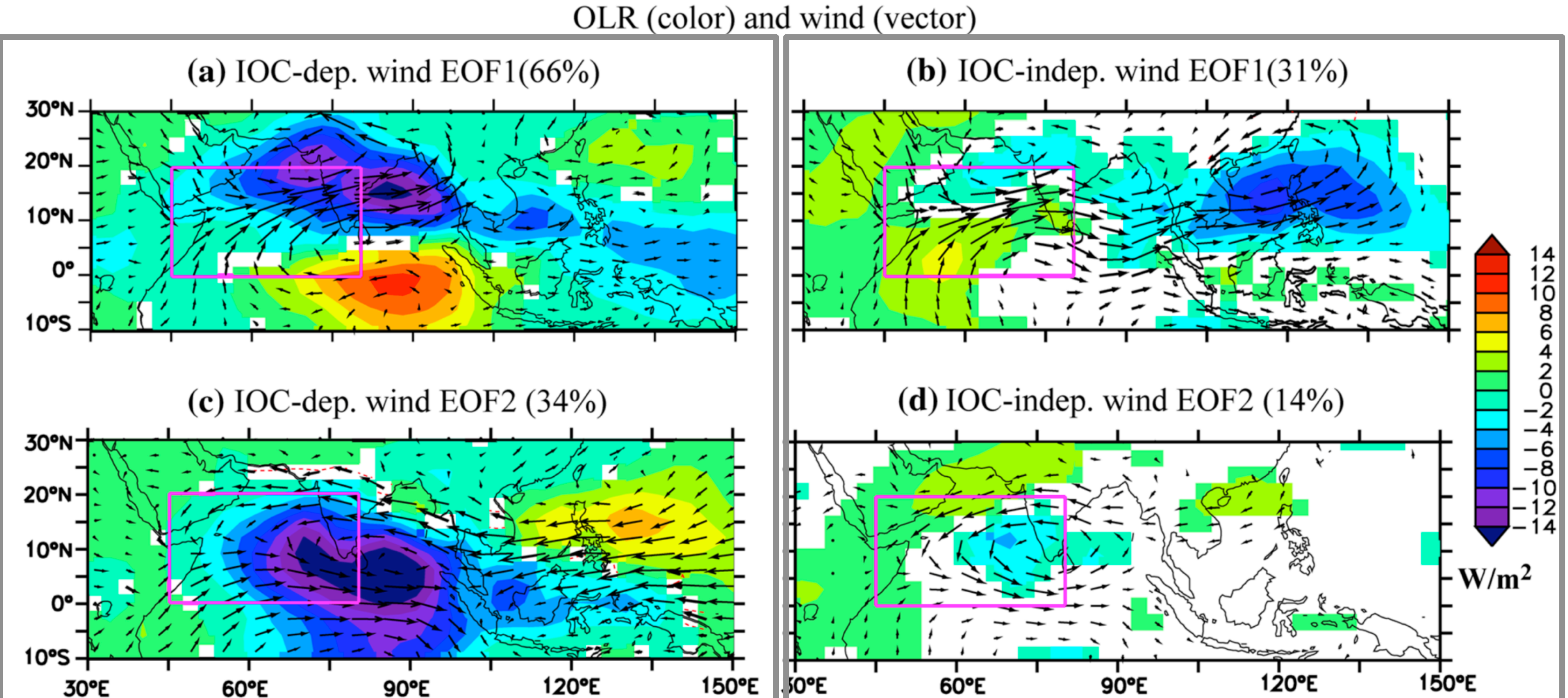


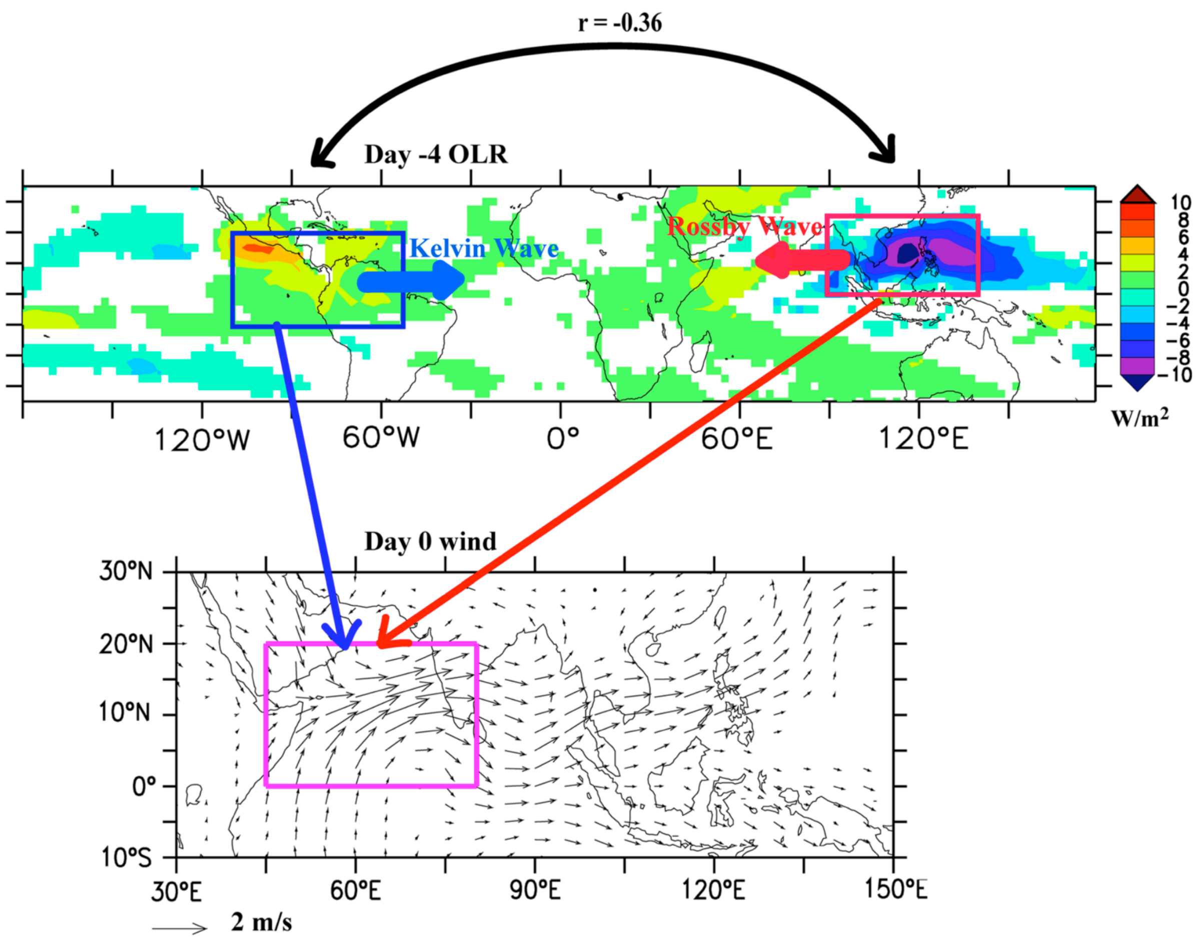
Fig.2 Wind variability dependent and independent of the Intraseasonal Indian Ocean Convective activity (IOC)



Part of the LLJ intraseasonal variations associated with Indian Ocean convective perturbations (was known before)

Part of the LLJ intraseasonal variations **NOT** associated with Indian Ocean convective perturbations (50% of LLJ variance, topic of this study)

Fig.3 Two remote drivers of IOC-independent LLJ variability: the eastern tropical Pacific and Northwestern tropical Pacific



$$\text{LLJ}(t+4) \sim (0.24 \pm 0.05) \times \text{OLR}_{\text{EPac}}(t) - (0.49 \pm 0.05) \times \text{OLR}_{\text{NWPac}}(t)$$

r = 0.62

Indian Ocean-independent LLJ intensifications are preceded by OLR anomalies in two remote regions 4 days before:

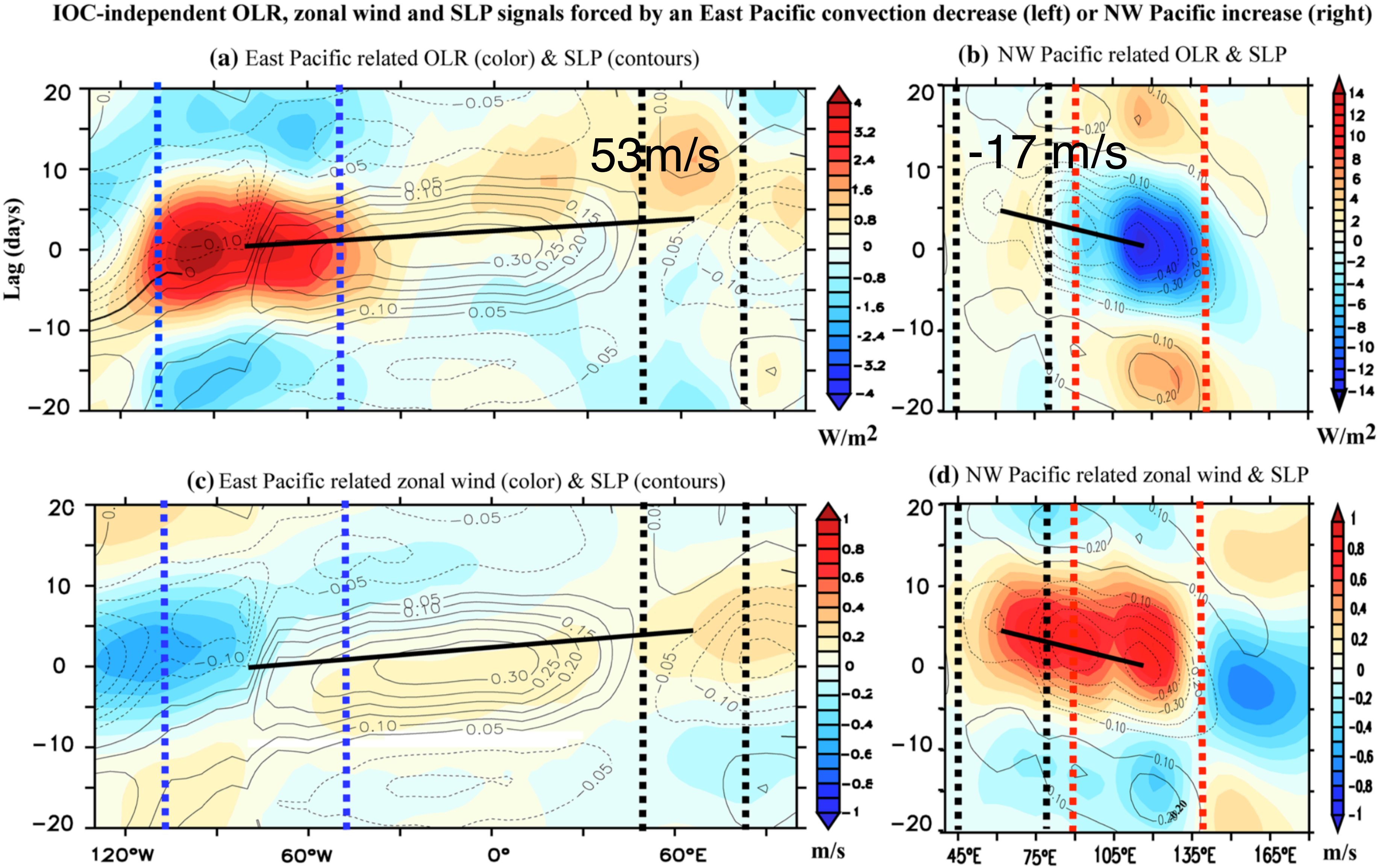
- Northwestern tropical Pacific
- eastern tropical Pacific

Fluctuations in these two regions are relatively independent (r=-0.36)

The northwestern tropical Pacific has a twice larger influence than the eastern Pacific

Together, they explain 40% of the Indian-Ocean independent LLJ fluctuations (20% of the total intraseasonal fluctuations)

Fig.4 Mechanisms of remotely-driven LLJ variability: Kelvin and Rossby waves



- Influences from the northwestern tropical Pacific propagate westward as baroclinic Rossby waves
- Influences from the eastern tropical Pacific propagate eastward as dry baroclinic equatorial Kelvin waves

Summary

Large-scale regional Intraseasonal Indian Ocean Convective activity (IOC) only explains about half of the intraseasonal Low-Level Jet (LLJ) variance, the other half being unrelated to large-scale convective perturbations over the Indian Ocean.

Convective fluctuations in two regions outside the Indian Ocean can remotely force a LLJ intensification, four days later:

1) Enhanced atmospheric deep convection over the northwestern tropical Pacific yields westerly wind anomalies that propagate westward to the Arabian Sea as baroclinic atmospheric Rossby Waves.

2) Suppressed convection over the eastern Pacific/North American monsoon region yields westerly wind anomalies that propagate eastward to the Indian Ocean as dry baroclinic equatorial Kelvin waves.

Those largely-independent remote influences jointly explain ~ 40% of the IOC-independent intraseasonal LLJ variance (i.e. ~ 20% of the total), with the northwestern Pacific contributing twice as much as the eastern Pacific.

Taking into account these two remote influences should thus enhance the ability to predict the LLJ.

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