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Water Vapor Budget in Atmospheric Rivers: A Multi-model Evaluation

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1. Introduction

Atmospheric rivers (ARs) are narrow, elongated, synoptic jets of water vapor that play important roles in the global water cycle and regional weather/hydrology. A recent study (Guan and Waliser 2017) revealed considerable challenges and inter-model differences in simulating the phenomenology of ARs (*e.g.*, geometry, frequency, intensity) with the state-of-the-art weather/climate models. The current work takes a step further to diagnose model errors at process levels, with a focus on quantifying the AR water vapor budget.

2. Data and methods

An AR detection algorithm (Guan and Waliser 2015; Guan *et al.* 2018) is applied to 20-year, 6-hourly simulations by 24 global weather/climate models from the GEWEX Atmosphere System Study - WCRP-WWRP/THORPEX Year of Tropical Convection (GASS-YoTC) Multi-model Experiment (Jiang *et al.*, 2015). Water vapor budget terms, including tendency of integrated water vapor (IWV), convergence of integrated water vapor transport (IVT), evaporation, and precipitation are calculated for four distinctive sectors (post-frontal, frontal, pre-frontal, and pre-AR) of ~6000 ARs in the northeastern Pacific during the winter months of 1991–2010, with the dominant terms identified in each sector. The simulated water vapor budget is evaluated against the ERA-Interim and MERRA-2 reanalyses, with the difference between the two reanalyses serving as a rough measure of observational uncertainty.

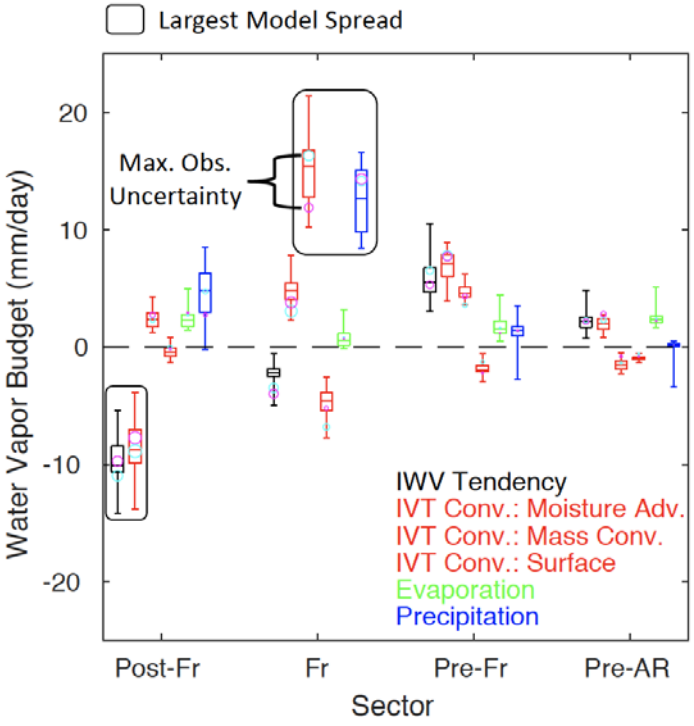

Fig. 1 Water vapor budget terms in four AR sectors based on ~6000 ARs in the northeastern Pacific during the winter months of 1991–2010 identified in ERA-Interim and MERRA-2 reanalyses (cyan and magenta circles) and 24 global weather/climate models from the GASS-YoTC Multi-model Experiment (box-whiskers).

3. Key results

The results reveal the dominant water balance is different across the four AR sectors, with overall good agreement between ERA-Interim and MERRA-2. The largest observational uncertainty is associated with IVT convergence due to mass convergence in the frontal sector (difference between cyan and magenta circles in Fig. 1). Model spread is notable compared to observational uncertainty. The largest model spread occurs in post-frontal and frontal sectors in their respective dominant budget terms (box-whiskers in Fig. 1). Model performance in terms

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of the correlation between each pair of the water vapor budget terms is also examined (not shown). The work contributes to the ongoing development of a suite of AR simulation diagnostics and model performance metrics and associated software packages, and can help guide dedicated observational efforts for better constraining AR processes in weather and climate models.

References

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