Understanding the observed global and regional monsoon precipitation changes since 1850

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Introduction

- Monsoons are an integral part of the Earth's climate system.
- The rainfall during the monsoon season is essential for the livelihoods of approximately two-thirds of the world's population.
- the GM domain is defined as the region where the annual precipitation range exceeds 2.5 mm day^{-1}

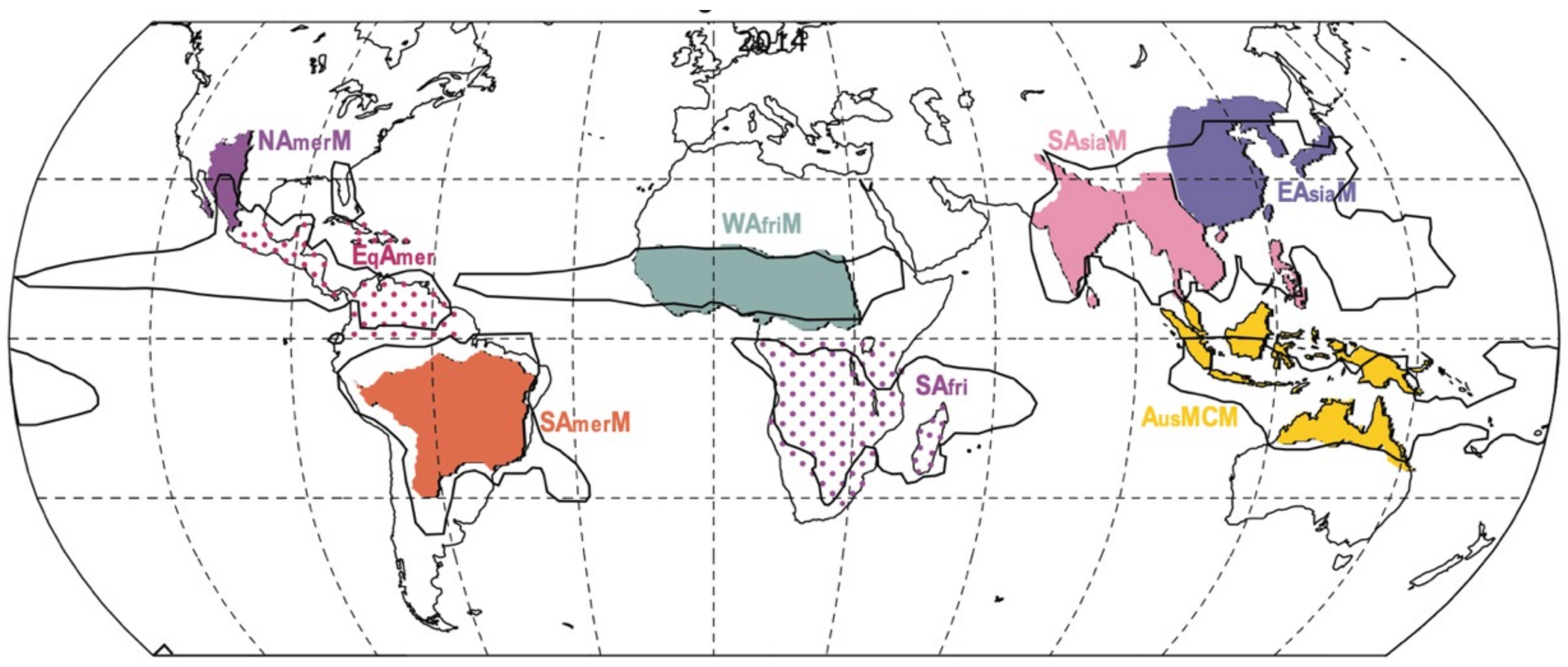

Figure1: The regional monsoons: The global monsoon (GM) shown by the black contour is defined as the area with local summer minus winter precipitation rate exceeding 2.5 mm day $^{-1}$ (Adapted from IPCC, 2021: Annex V).

Datasets

- DAMIP output from CMIP6
- CRU rainfall datasets
- GPCC rainfall datasets

Observed Precipitation Changes

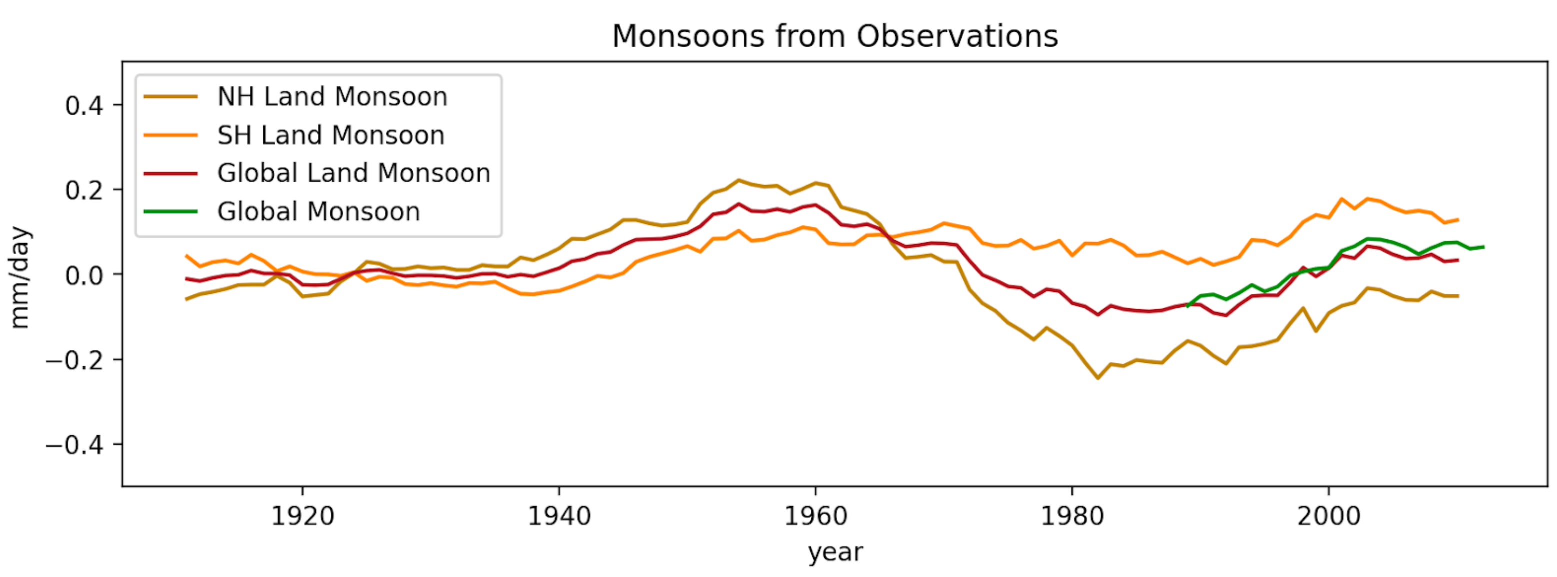

***Figure 2:** Time-series of observed precipitation anomaly (mm day^{-1}) for the global land monsoon (reddish brown); northern hemisphere (NH) land monsoon (golden) and southern hemisphere (SH) land monsoon (orange), based on the CRU dataset for the period 1901-2020.*

Drivers of Observed precipitation changes

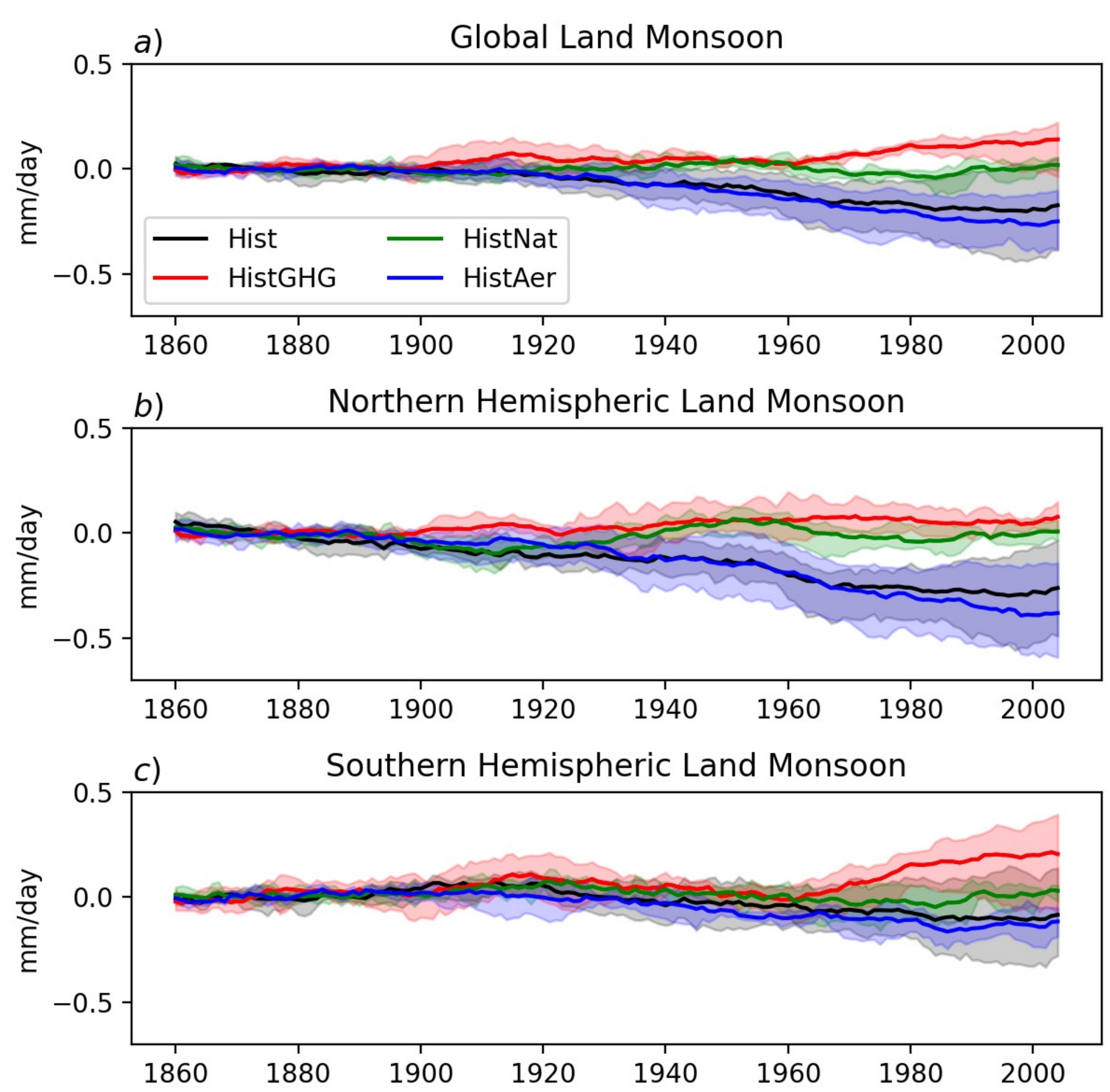

***Figure 3:** Time series of precipitation anomalies (mm day^{-1}) from DAMIP models a) Northern hemispheric land monsoon (NHM) b) Southern hemispheric land monsoon (SHM) c) Global land monsoon (GLM).*

Summary

- The decrease of the global land monsoon (GLM) and NH land monsoon (NHM) precipitation since the mid-20th century was primarily driven by anthropogenic aerosol emissions from the NH.
- The decrease of GLM and NHM precipitation is mainly linked to weakening of the South Asian, East Asian and West African monsoon circulations and associated precipitation reductions of the regional monsoons.

Regional monsoon precipitation changes

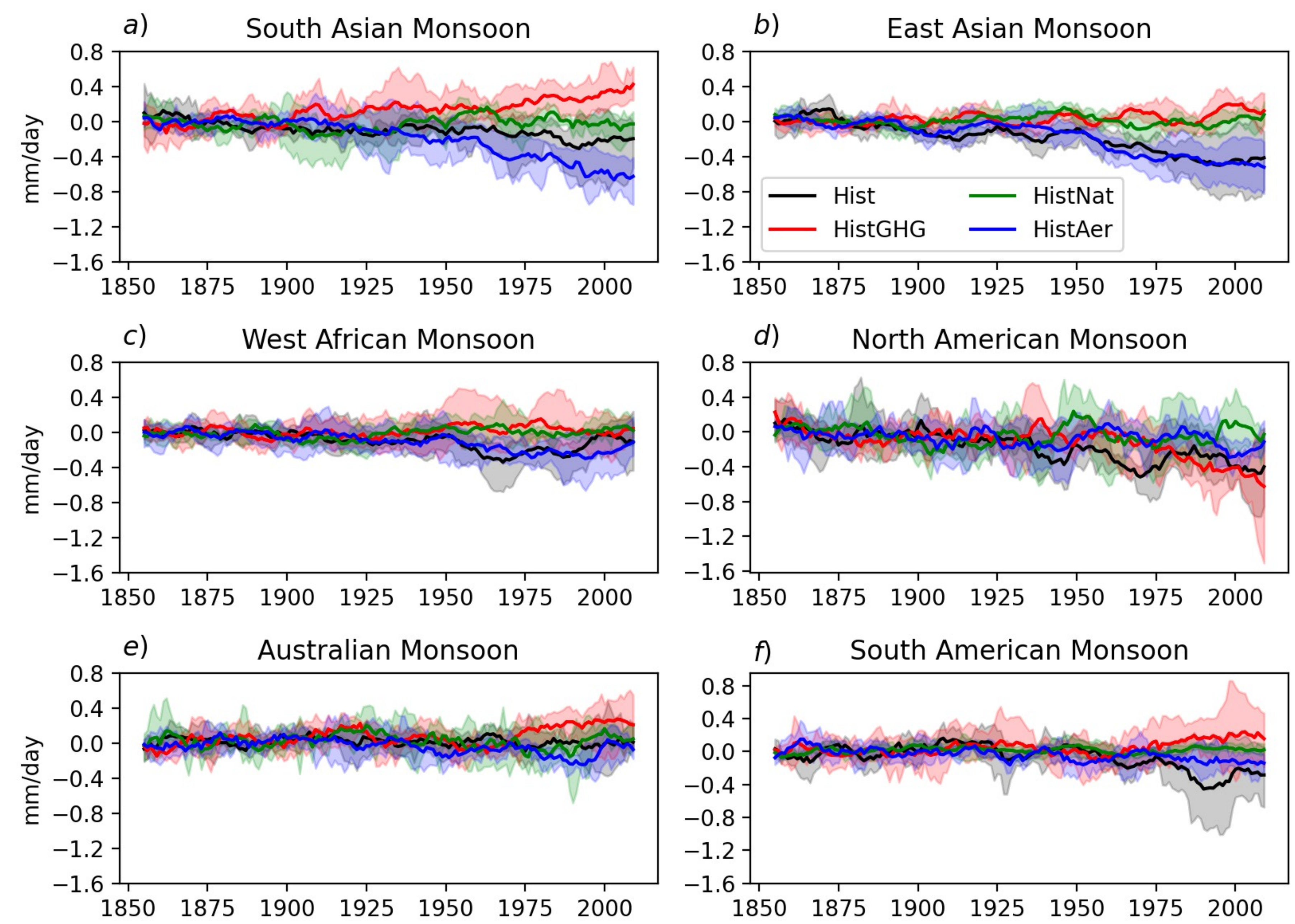

***Figure 4:** Multimodel mean precipitation anomalies (mm day^{-1}) for HIST (black), HIST-NAT (green), HIST-GHG (red) and HIST-AER (blue) Shading is used to represent the multi-model spread, indicated by the minimum and maximum values among the individual models for the different regional monsoons.*

	Time period	Observation	HIST	HIST-GHG	HIST-AER	HIST-NAT
GLM	1901-2014	0.0012	**-0.019**	**0.01**	**-0.027**	0.0067
	1951-2015	-0.02	-0.15	**0.024**	**-0.026**	0.0013
NHM	1901-2014	-0.009	**-0.022**	0.005	**-0.037**	0.007
	1951-2014	**-0.056**	-0.01	0.004	**-0.044**	-0.005
SHM	1901-2014	**0.013**	**-0.016**	**0.017**	**-0.017**	-0.006
	1951-2014	0.009	-0.012	**0.049**	-0.0075	0.008

***Table 1:** Linear trend of global land monsoon precipitation (GLM), northern hemispheric land monsoon (NHM), and southern hemispheric land monsoon (SHM) (mm day^{-1} decade^{-1}) for two time-periods a) 1901-2014 and 1951-2014.*

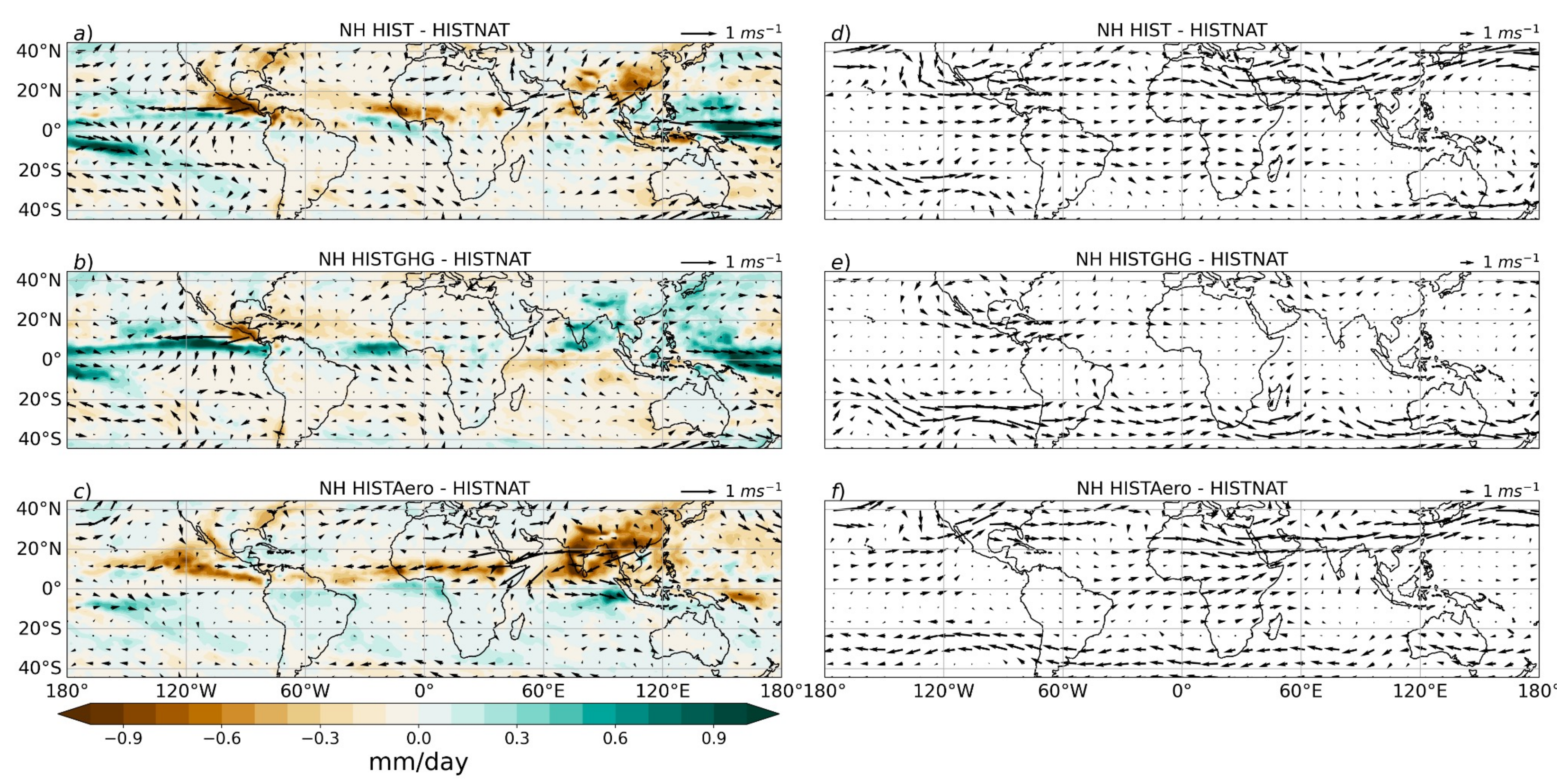

***Figure 5:** Difference maps of northern hemispheric (JJAS) precipitation (mm day^{-1}) and 850 hPa winds (ms^{-1}) in left column; and 200 hPa winds (ms^{-1}) in right column. The differences are relative to the HISTNAT experiment for the period 1951-2014.*