Lack of Change in Atmospheric Blocking Duration in a Warming Climate

Ebrahim Nabizadeh, Sandro W. Lubis, and Pedram Hassanzadeh
Rice University

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Blocking events & associated weather extremes in a warming climate

Improving understanding & *regional* projections

Blocking characteristics:

- Frequency
- Duration
- Size
- Intensity

fully coupled GCMs

large-ensembles
(random noise added to initial conditions)

idealized moist GCMs

idealized dry GCMs

Simple ODEs/PDEs

Hierarchical modeling

No change in the average blocking duration under climate change

Robust w.r.t. region, season, land vs ocean, index, other studies, model hierarchy

	Sector	Average duration of long blocks (days) 2075-2100 vs 1980-2005	
		LENS2-LE	CM3-LE
Summer	North Atlantic	11.4 vs 11.3	12.1 vs 12.2
Summer	North Pacific	11.6 vs 11.4	12.0 vs 12.2
Summer	Russia	11.9 vs 11.4	11.9 vs 12.5
Winter	North Atlantic	11.8 vs 12.0	12.1 vs 12.1
Winter	North Pacific	12.5 vs 12.3	13.4 vs 14.0
Winter	Russia	12.1 vs 12.1	12.5 vs 12.7

Same conclusion:

- for short blocks (+5 days)

- another index

- other studies using CMIP3 & 5

  (Barnes et al. 2012 Clim. Dyn.; Sigouin & Son 2013 JGR; Huguenin et al. 2020 GRL)

Hierarchical modeling

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full-physics atmospheric GCMs

MiMA:
Jucker & Gerber (2017 J. Climate)

idealized moist GCMs

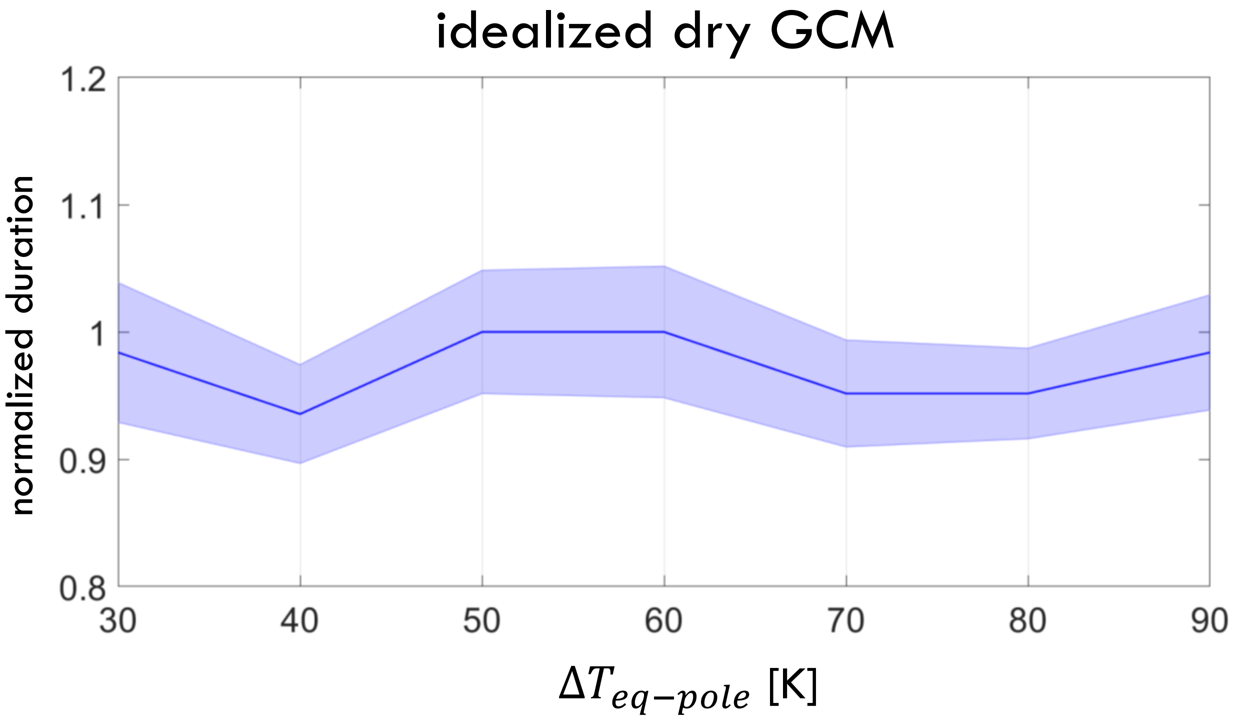
Dry dynamical core:
Held & Suarez (1994 BAMS)

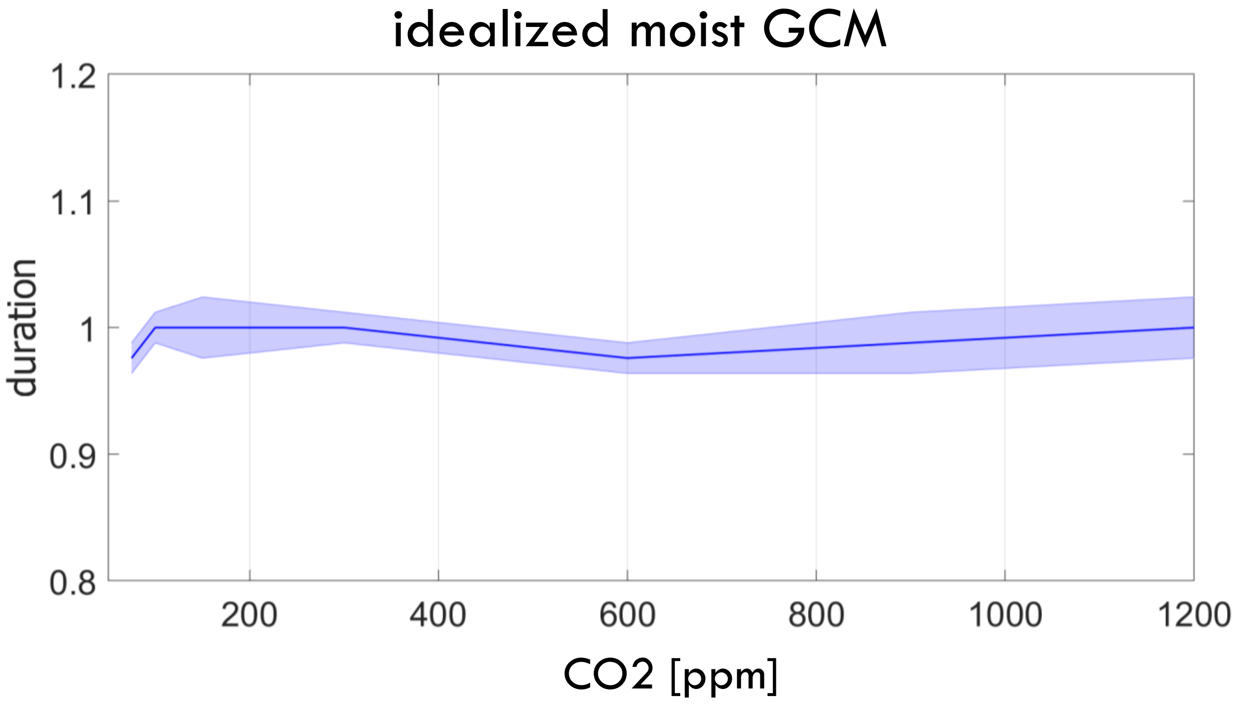
idealized dry GCMs

Traffic jam model

No change in the average blocking duration under climate change

Idealized dry & moist GCMs isolate the role of large-scale atmospheric circulation





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traffic jam model

Nakamura & Huang (2018 Science)

Average blocking duration in the 1D traffic jam model

Provides a quantitative framework for the eddy-blocking feedback

$$\frac{\partial A}{\partial t} = -\frac{\partial}{\partial x}\left(U_{ref}(x)\ A\right) + \left[\frac{\partial}{\partial x}A^2 + S(x,t)\right] + \text{damping} + \cdots$$

zonal advection

nonlinear feedback

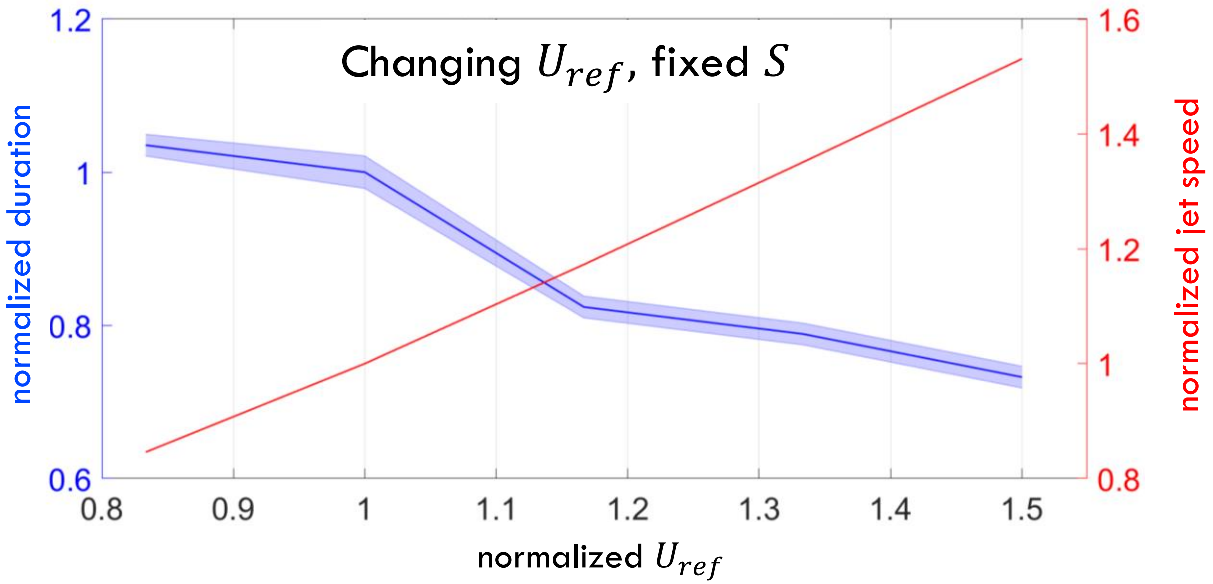
transient eddies

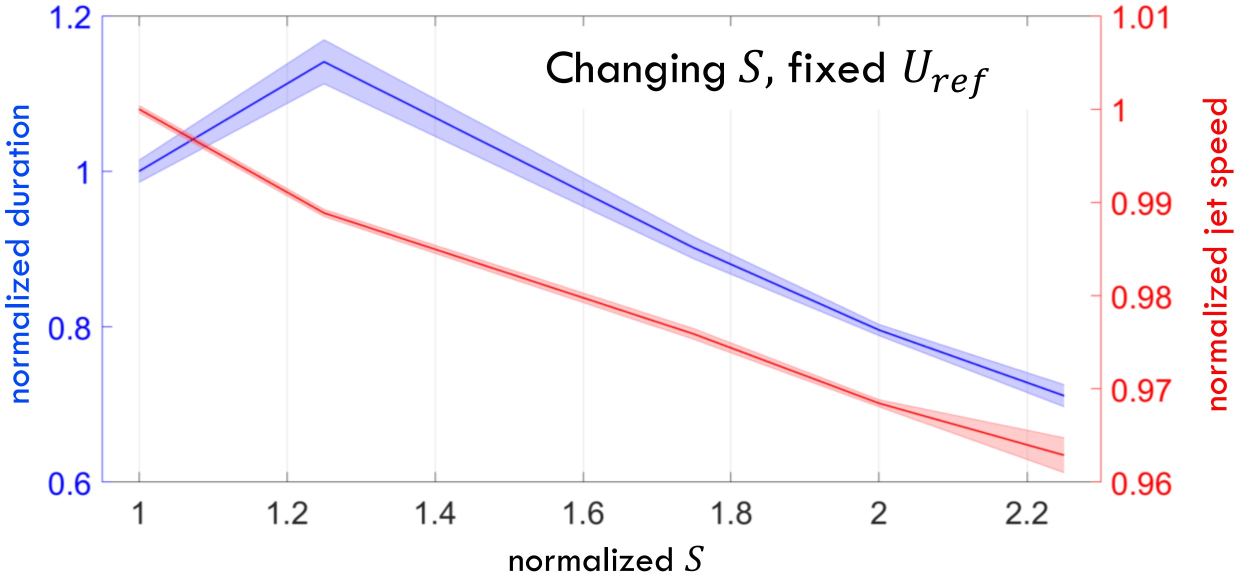
$A(x,t)$: finite-amplitude wave activity $(\sim\overline{\omega})$

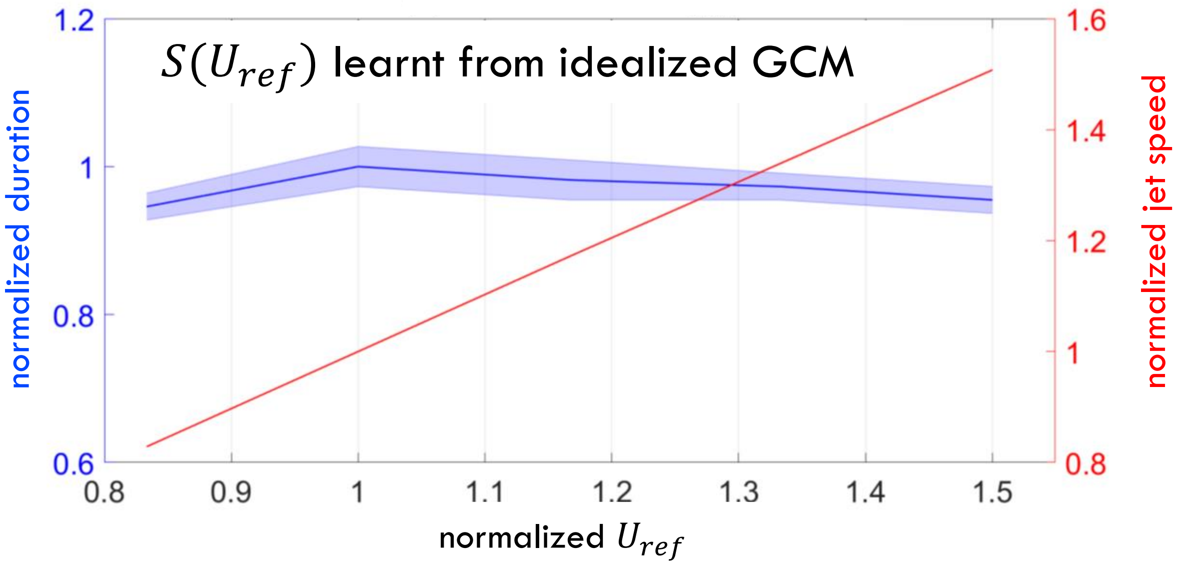
x: longitude

Average blocking duration in the 1D traffic jam model

No change IF the relationship between mean flow & eddies are accounted for

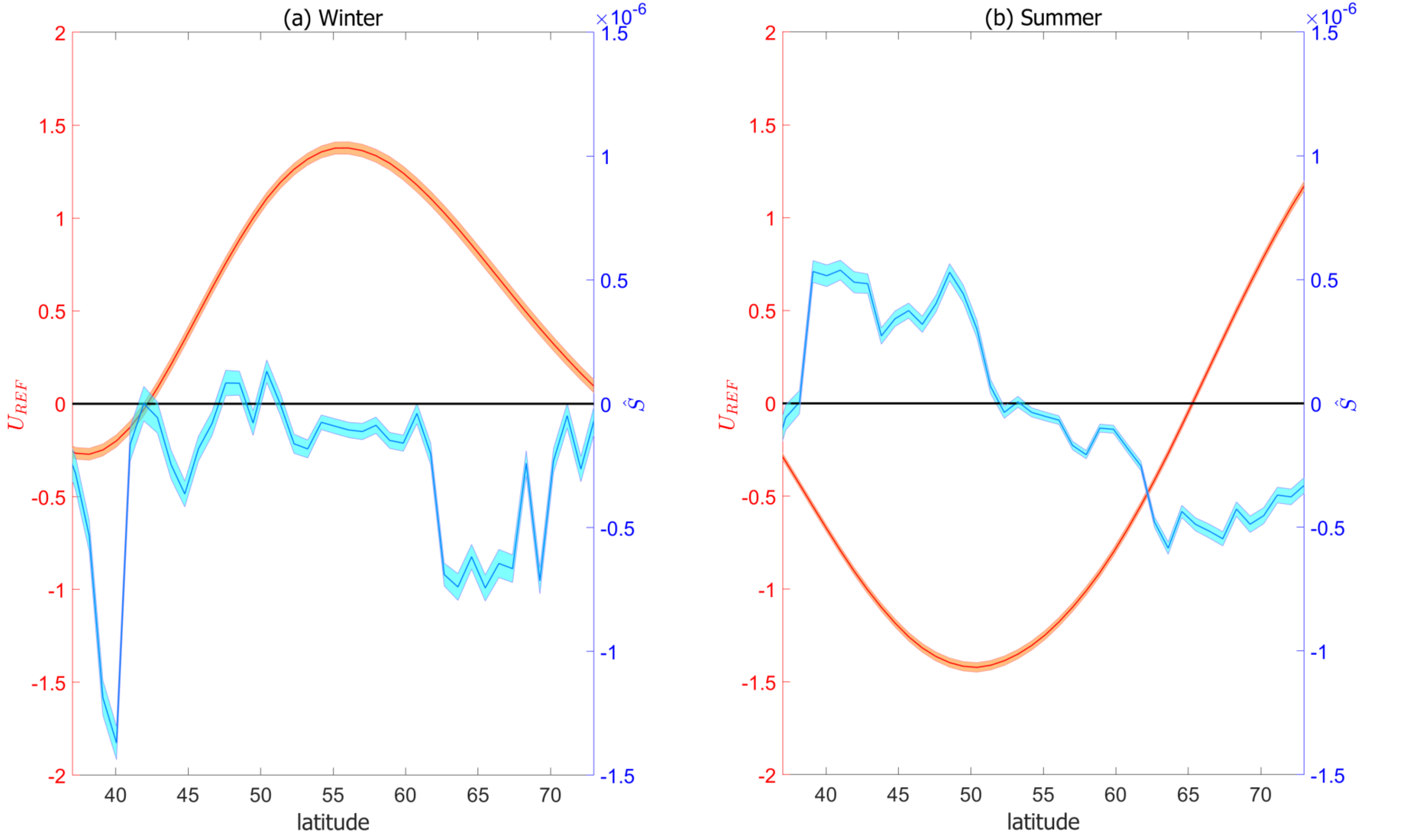






Responses of S and U_{REF} under climate change

Future responses compensate the impact on the duration



No change in the average blocking duration under climate change

Due to proportional change of the mean jet speed and eddy feedback

Major implication:

Increase in duration of future heat waves is not due to dynamics (thus, due to thermodynamics)

Nabizadeh, Lubis & Hassanzadeh, *Lack of change in atmospheric blocking duration in a warming climate*.
In preparation

Consistent with Li & Thompson (2021 Nature):

Increase in duration of future heat waves can be explained by thermodynamics alone

Important to understand the driver(s) of increased duration of future heat waves

- Better constrain the regional projections
- Identify sources of GCMs' biases and discrepancies
- Build simple models for risk analysis