

Predictability of Western Australia Marine Heatwaves Using a Linear Inverse Model

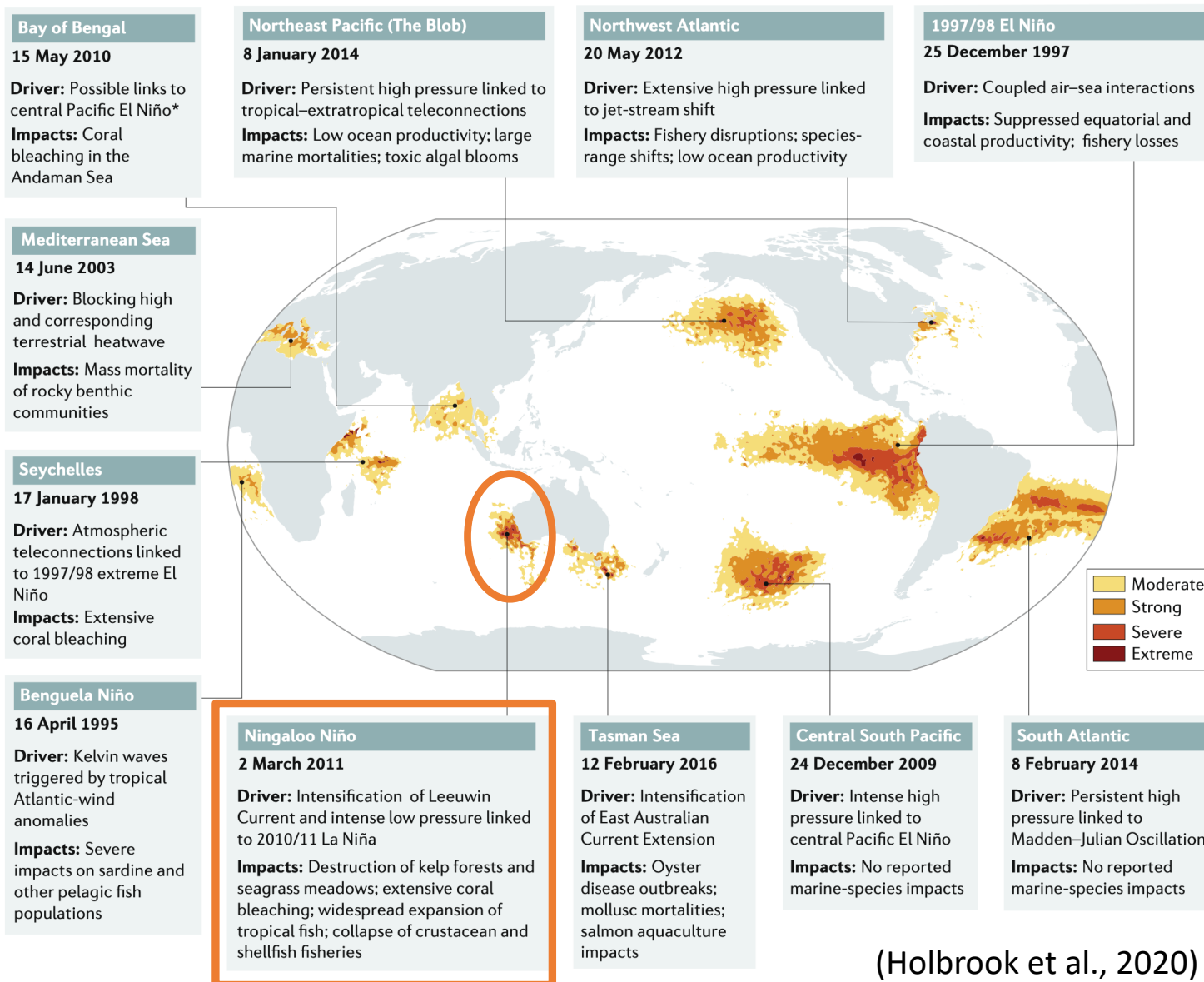
PhD student: Yuxin Wang^{1,2}

Supervisors: Prof. Neil Holbrook^{1,2}, Dr. Jules Kajtar^{1,2}

¹Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Australia

²ARC Centre of Excellence for Climate Extremes

Western Australia marine heatwaves (WA MHWs)



(Holbrook et al., 2020)

Drivers of WA MHWs:

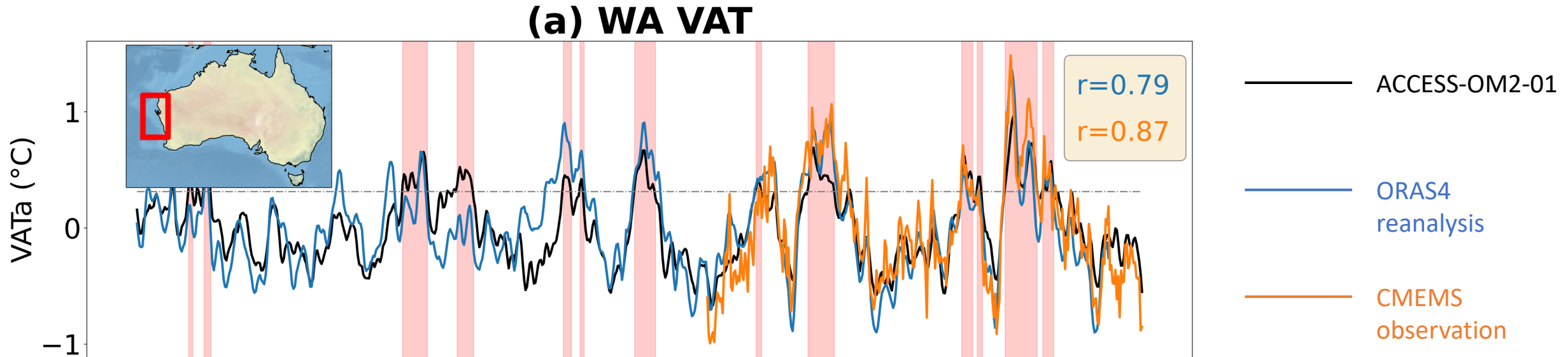
- La Niña → enhance Leeuwin Current → enhance bringing warm water to Western Australia (WA) Coast
- Positive Indian Ocean Dipole (IOD) events → northerly wind anomalies along the WA coast → enhance the Leeuwin Current and weaken the coastal upwelling → warm ocean temperature anomaly over WA coast (Zhang et al. 2018)

Research question:

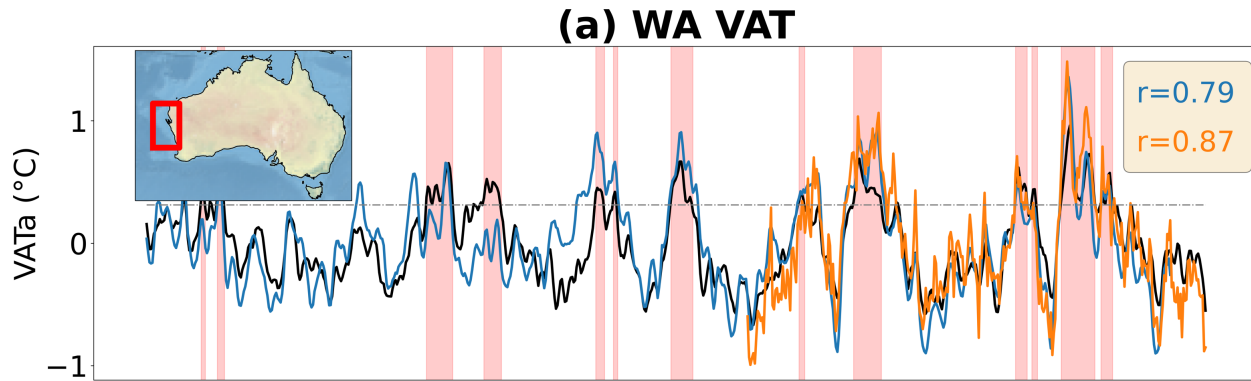
To what extent do La Niña and positive IOD provide WA MHW predictability?

Western Australia (WA) marine heatwaves (MHWs)

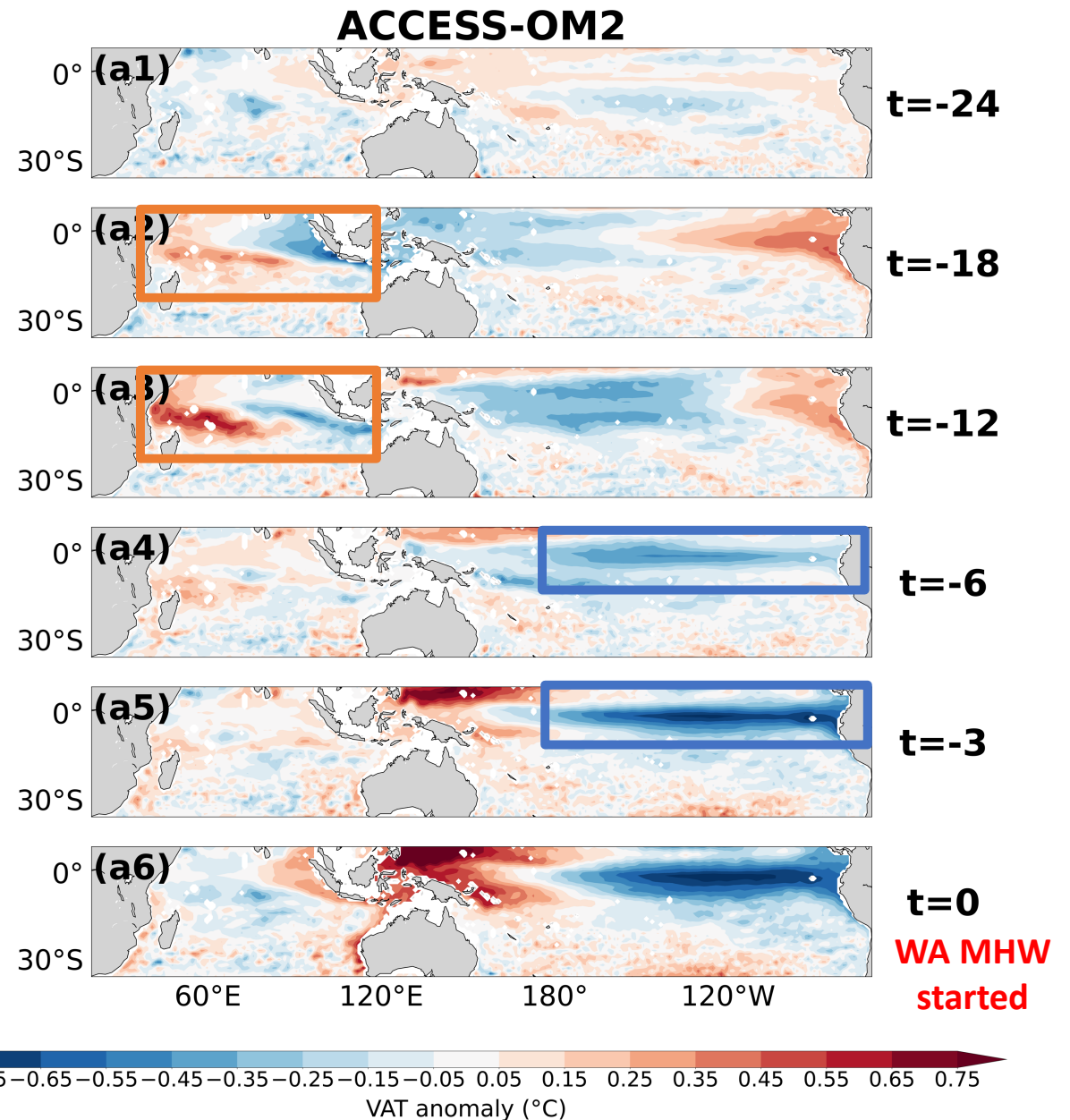
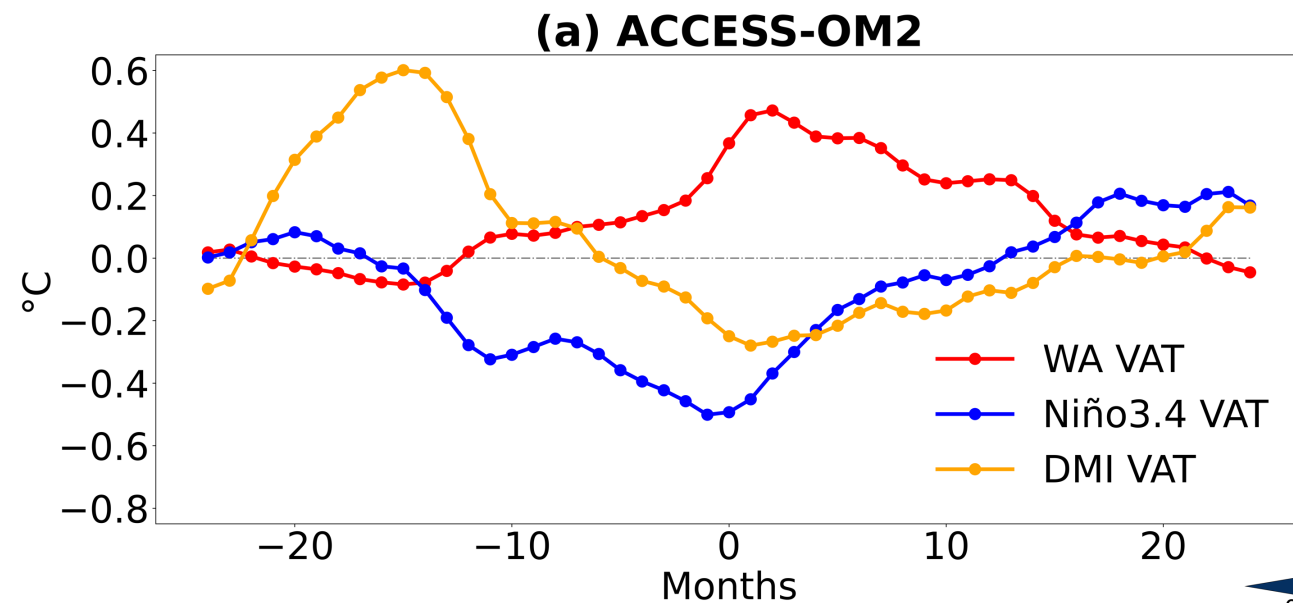
- **MHW definition:** Monthly vertically averaged temperature (VAT) anomaly from 0-282m depth staying above the MHW threshold: 1 standard deviation (1σ) of monthly VAT anomaly at least 3 months
- **Temperature Data:** Monthly 3-dimensional ocean model temperature data - ACCESS-OM2-01 (Kiss et al. 2020) during period 1959–2018
- **Western Australia (WA) index:** spatially averaged VATa within the red box (110°E–116°E, 22°S–32°S)



WA MHWs in ACCESS-OM2



13 WA MHW events are detected in total over the period 1959-2018 (60 years) ACCESS-OM2 VAT



Linear Inverse Model (LIM)

Linear inverse model equation:

$$\frac{d\mathbf{x}}{dt} = \mathbf{L}\mathbf{x} + \xi$$



integrate

2000-member 60-year-long Indo-Pacific Ocean VATa

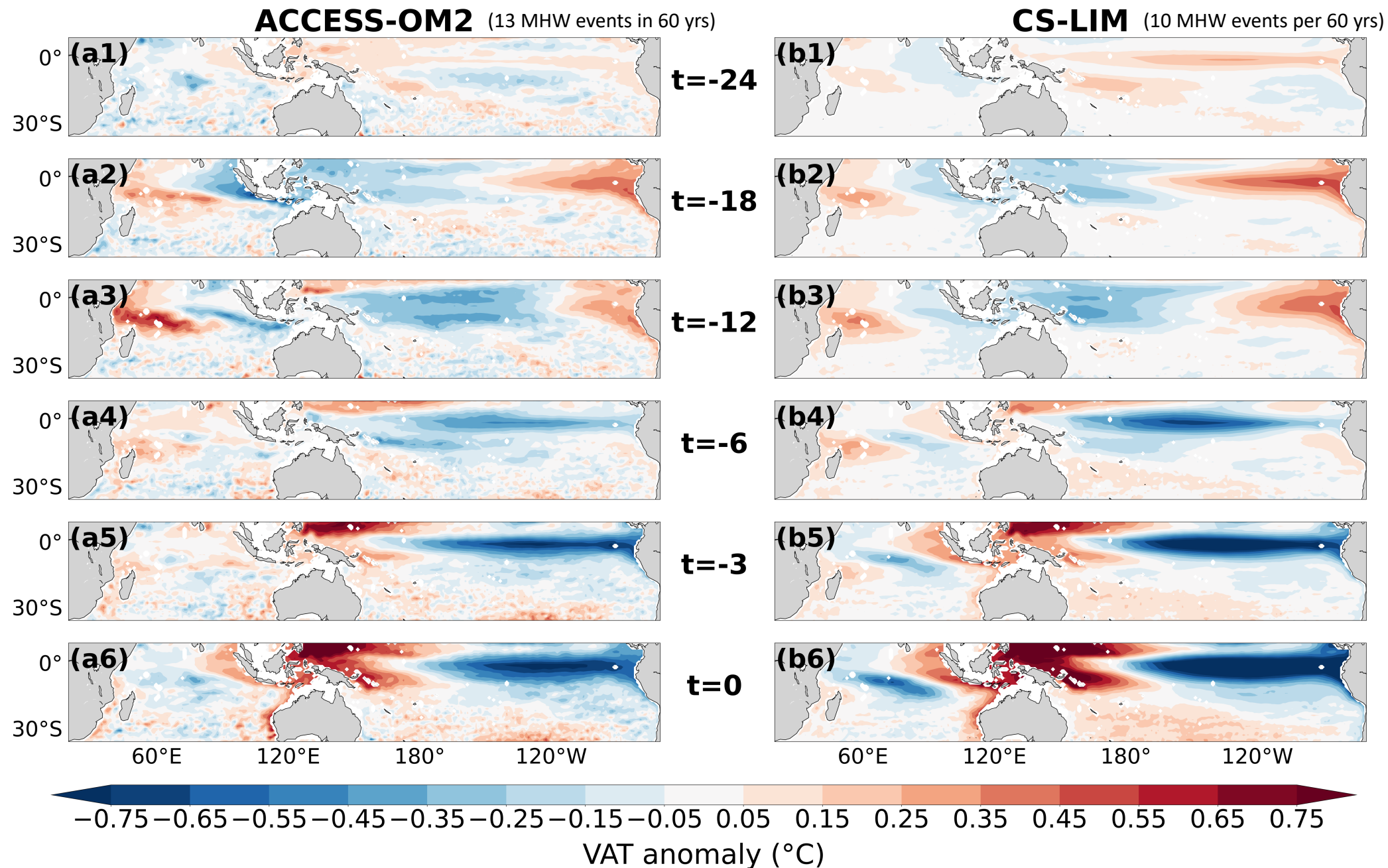
\mathbf{x} : state of the system, which is VATa in our study

\mathbf{L} : dynamical operator describing the dynamical features of the evolution of \mathbf{x}

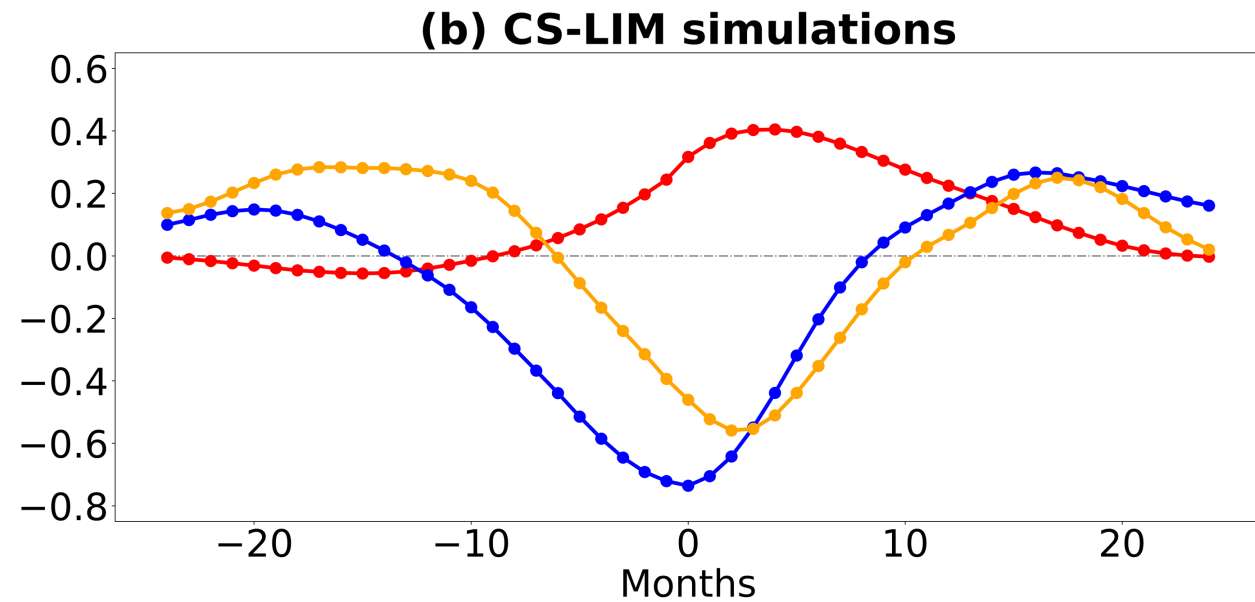
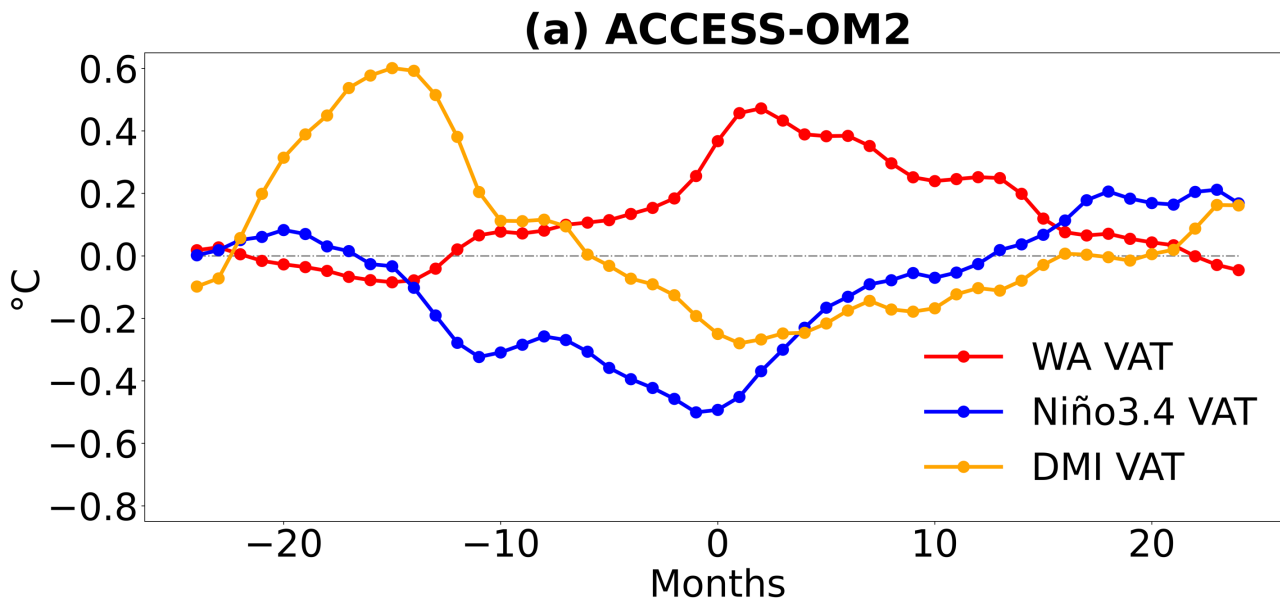
ξ : stochastic forcing

* \mathbf{L} is taking seasonality into account

WA MHWs in ACCESS-OM2 and LIM

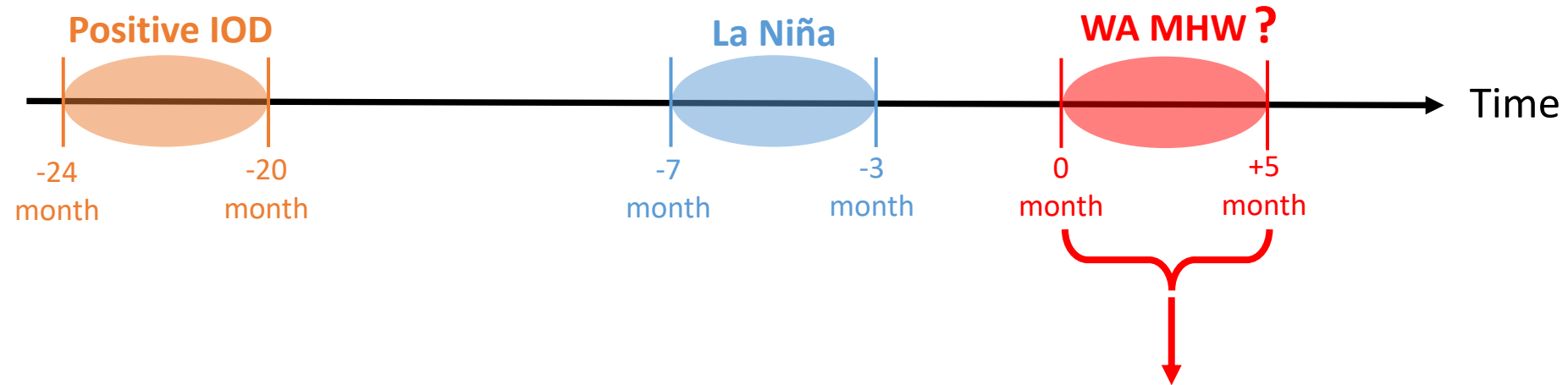


WA MHWs in ACCESS-OM2 and LIM



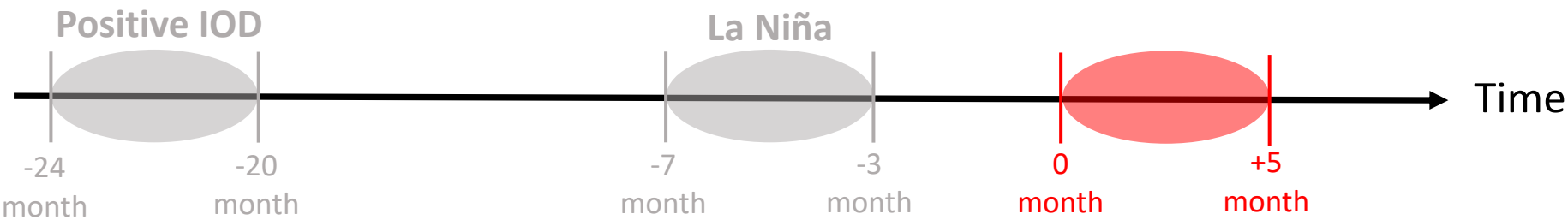
Likelihood of WA MHWs being preceded by La Niña and/or positive IOD

From WA MHWs detected by 2000 LIM simulations:



In these 6 months, how will the proportion of WA MHW months changes with La Niña, positive IOD, or a combination of the two?

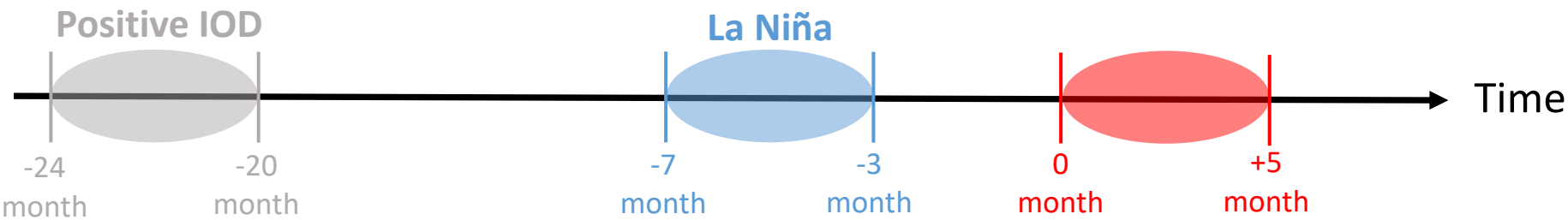
Likelihood of WA MHWs being preceded by La Niña and/or positive IOD



<div>MHW criteria</div> <div>Conditions</div>	1-sigma-intensity 3-month-duration
Standard condition	15.2%
La Niña only	39.2%
Positive IOD only	21.3%
La Niña and Positive IOD	43.1%
Positive IOD and El Niño	3.5%

“Control condition”

Likelihood of WA MHWs being preceded by La Niña and/or positive IOD

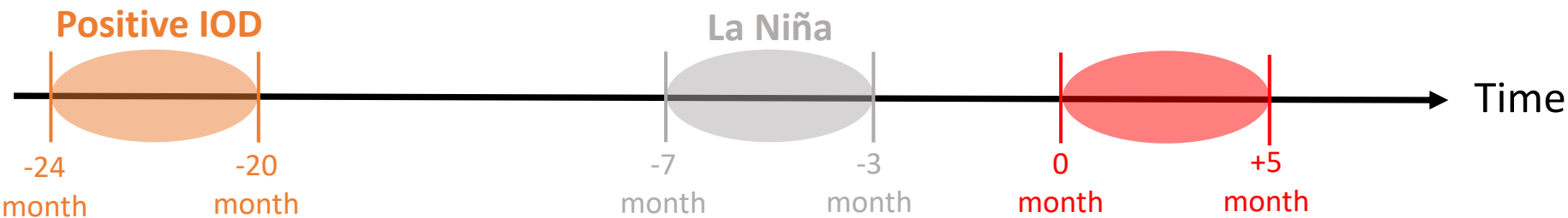


<div>MHW criteria</div> <div>Conditions</div>	1-sigma-intensity 3-month-duration
Standard condition	15.2%
La Niña only	39.2%
Positive IOD only	21.3%
La Niña and Positive IOD	43.1%
Positive IOD and El Niño	3.5%

“Control condition”

Likelihood × 2.5

Likelihood of WA MHWs being preceded by La Niña and/or positive IOD



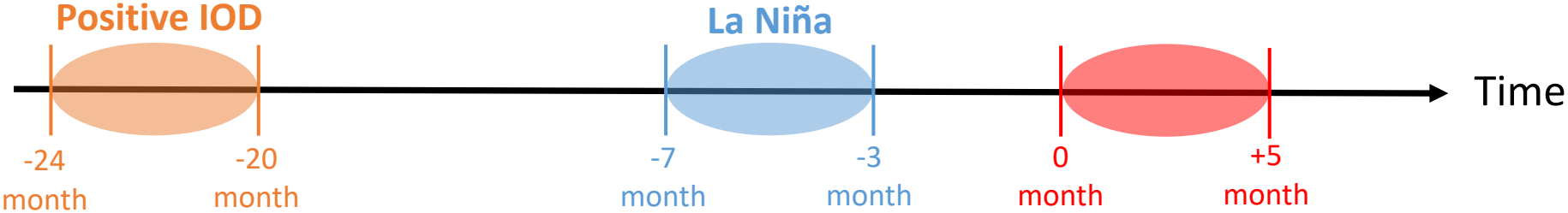
<div>MHW criteria</div> <div>Conditions</div>	1-sigma-intensity 3-month-duration
Standard condition	15.2%
La Niña only	39.2%
Positive IOD only	21.3%
La Niña and Positive IOD	43.1%
Positive IOD and El Niño	3.5%

“Control condition”

Likelihood × 2.5

Likelihood × 1.5

Likelihood of WA MHWs being preceded by La Niña and/or positive IOD



<div>MHW criteria</div> <div>Conditions</div>	1-sigma-intensity 3-month-duration
Standard condition	15.2%
La Niña only	39.2%
Positive IOD only	21.3%
La Niña and Positive IOD	43.1%
Positive IOD and El Niño	3.5%

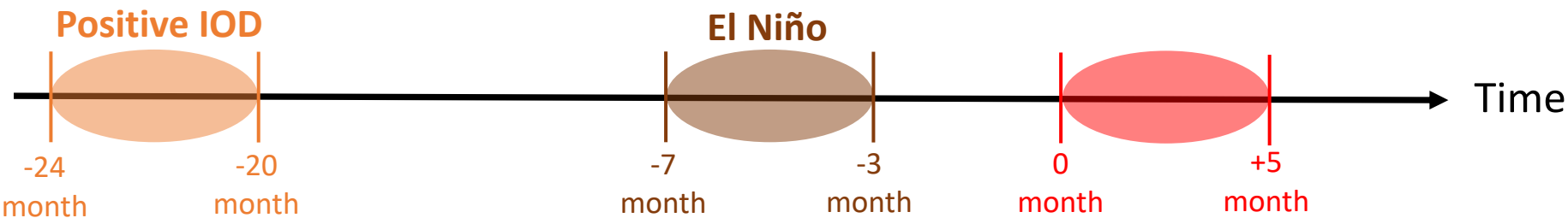
“Control condition”

Likelihood × 2.5

Likelihood × 1.5

Likelihood × 2.8

Likelihood of WA MHWs being preceded by La Niña and/or positive IOD



<div>MHW criteria</div> <div>Conditions</div>	1-sigma-intensity 3-month-duration
Standard condition	15.2%
La Niña only	39.2%
Positive IOD only	21.3%
La Niña and Positive IOD	43.1%
Positive IOD and El Niño	3.5%

“Control condition”

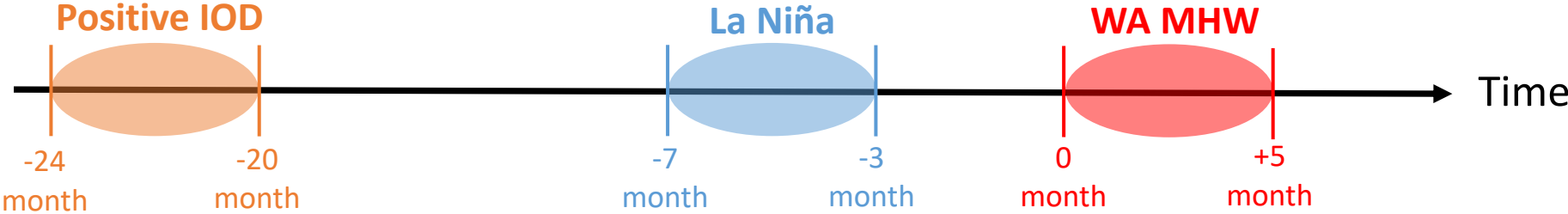
Likelihood × 2.5

Likelihood × 1.5

Likelihood × 2.8

Likelihood × 0.2

Likelihood of WA MHWs being preceded by La Niña and/or positive IOD



MHW criteria Conditions	1-sigma-intensity 3-month-duration
Standard condition	15.2%
La Niña only	39.2%
Positive IOD only	21.3%
La Niña and Positive IOD	43.1%
Positive IOD and El Niño	3.5%

“Control condition”

Likelihood × 2.5

Likelihood × 1.5

Likelihood × 2.8

Likelihood × 0.2

Changes of WA MHW likelihood following different climate conditions

Indian Ocean

Pacific Ocean

Warmer
west pole

Positive
IOD

Cooler
east pole

ENSO contribution

La Niña / El Niño

Positive IOD + La Niña

× 2.8

Positive IOD + El Niño
× 0.2

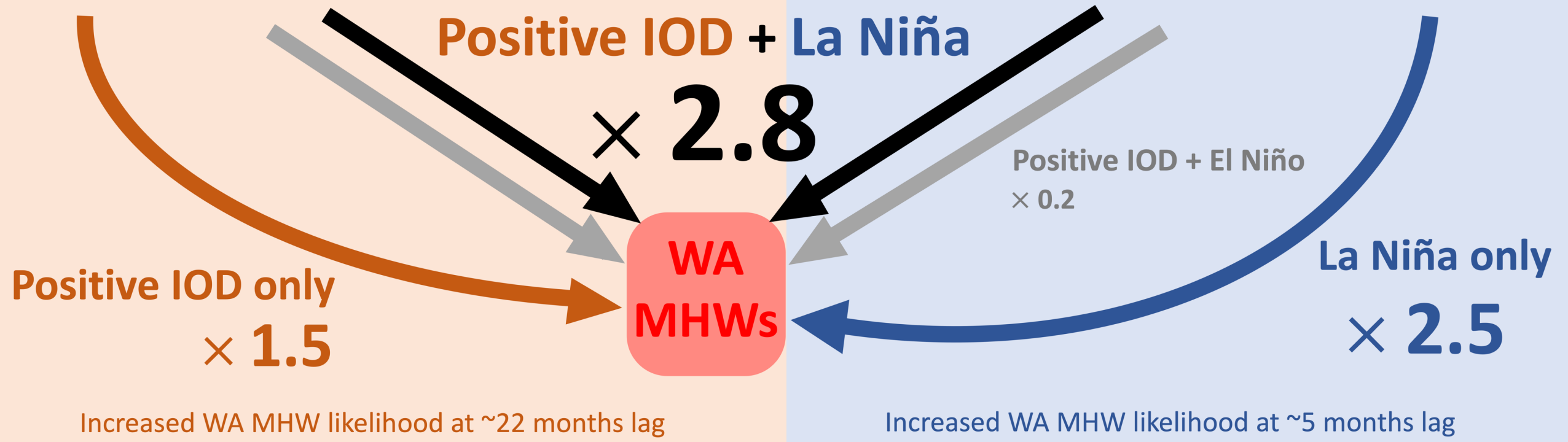
Positive IOD only
× 1.5

La Niña only
× 2.5

WA
MHWs

Increased WA MHW likelihood at ~22 months lag

Increased WA MHW likelihood at ~5 months lag



Thank you!

yuxin.wang@utas.edu.au

