



Impact of climate change on sea surface  
wind in South East Asia, from  
climatological average to extreme events  
Results from a RegCM dynamical downscaling  
of CNRM-CM5 CMIP5 simulations

Marine Herrmann<sup>1,2</sup>, Ngo Duc Thanh<sup>2</sup>, Trinh Tuan Long<sup>2</sup>

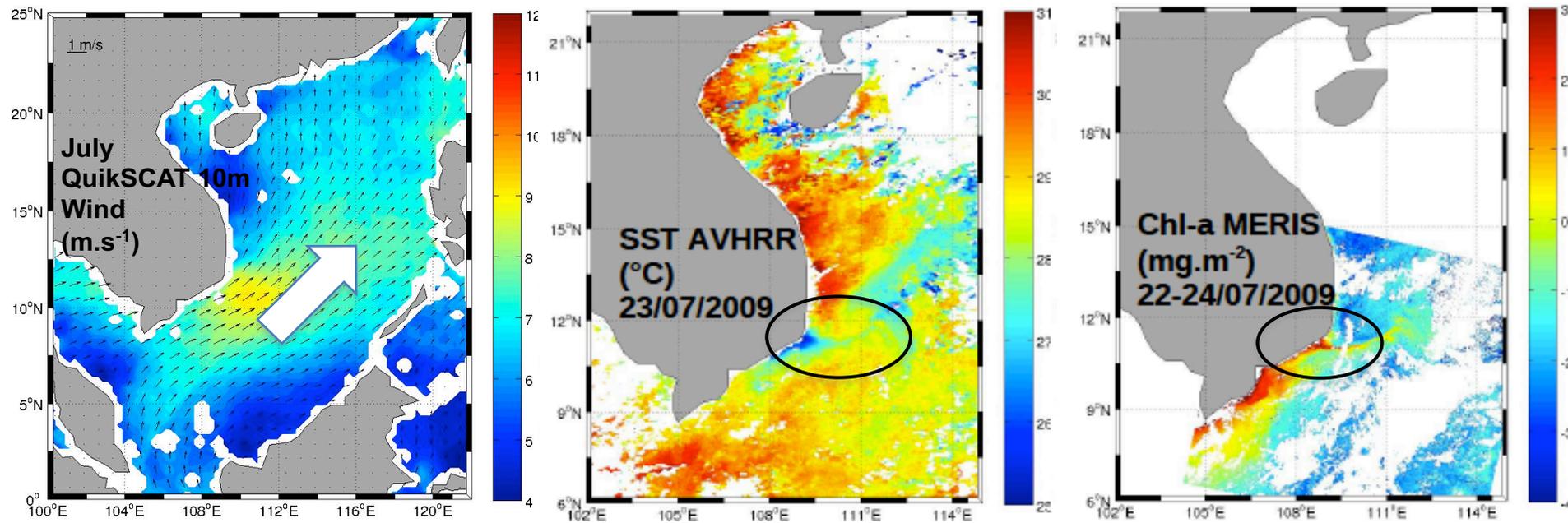
1 : LEGOS, IRD, Toulouse, France    2 : LOTUS, USTH, Hanoi, Vietnam

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# Objective : answer of sea surface wind to climate change in SEA

- Impact of climate change on atmospheric circulation in South East Asia (SEA) :
- Most studies focus on **temperatures and precipitations**.
- **Impact on surface winds** barely studied.
- Surface wind triggers **ocean circulation and dynamics**.
- Ocean dynamics impacts **ocean ecosystems** through nutrients advection and mixing.

*Example of the South Vietnam Upwelling (South China Sea), Da et al., 2019, JGR-Oceans*



# Objective : answer of sea surface wind to climate change

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→ Our goal =  
assess the impact of climate change on sea surface wind speed  
in SEA using a dynamical downscaling of CMIP5 simulations

# Methodology : regional dynamical downscaling

## CMIP5 GGM : CNRM-CM5

*Voldoire et al. (2015)*

- Atmospheric resolution :  $\sim 1.4^\circ \sim 110\text{km}$
- Global simulations:
  - HIST : 1850-2006, [GHG]=historical obs.
  - RCP4.5 and RCP8.55 : 2006-2100, [GHG] follows IPCC scenarios

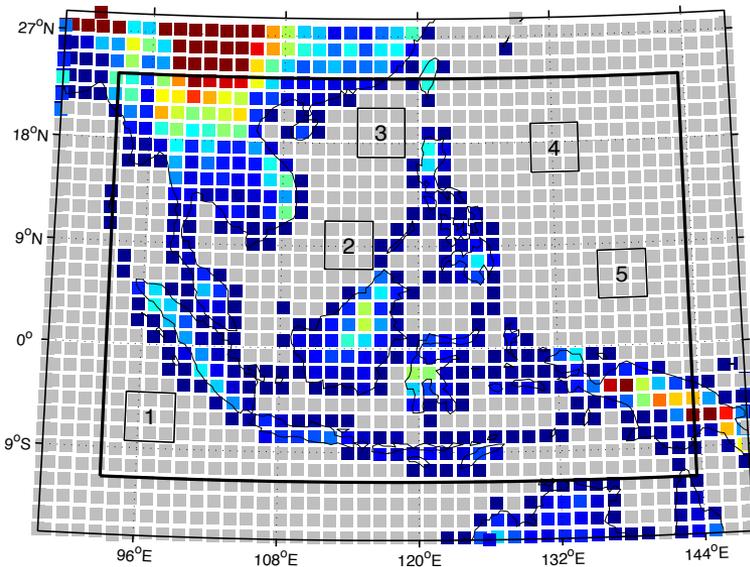
## RCM : RegCM4

*Giorgi et al. (2012)*

- Resolution : 25km
- No Spectral nudging
- Downscaled simulations of CNRM-CM5
- CORDEX-SEA framework

### CNRM-CM5

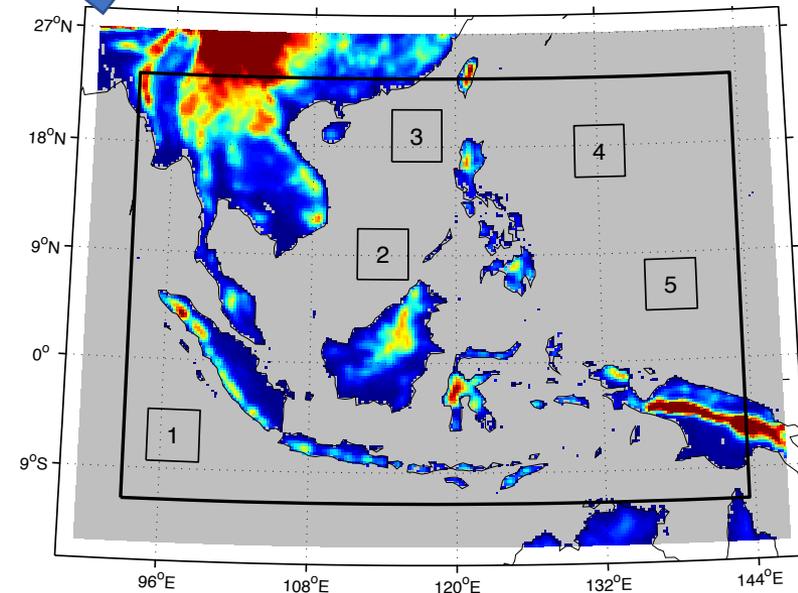
mask and orography over SEA



Orography (m)

### RegCM4

mask and orography  
and SEA domain

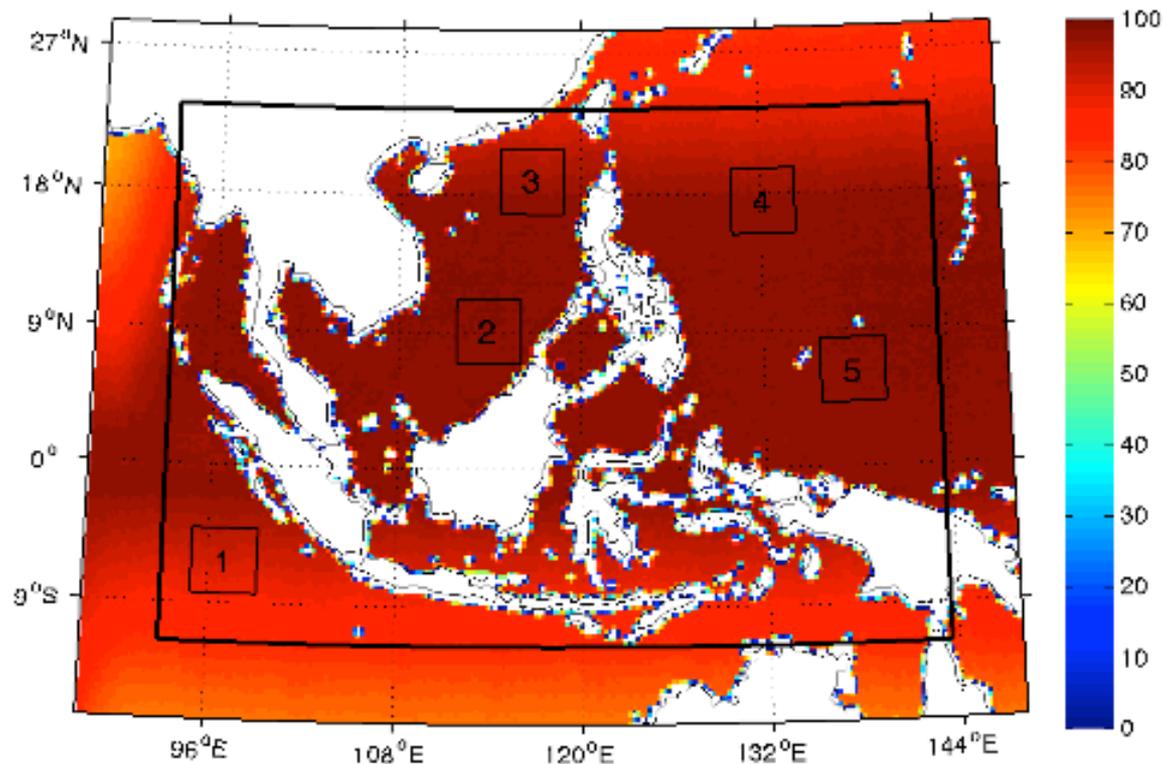


# Methodology : satellite observation data

## QuikSCAT LEVEL 3

- 19/07/1999-21/11/2009
- Daily data
- Resolution :  $0.25^{\circ}$ ~20km
- Data used : availability  $> 80\%$

QuikSCAT data availability over 2000-08, %

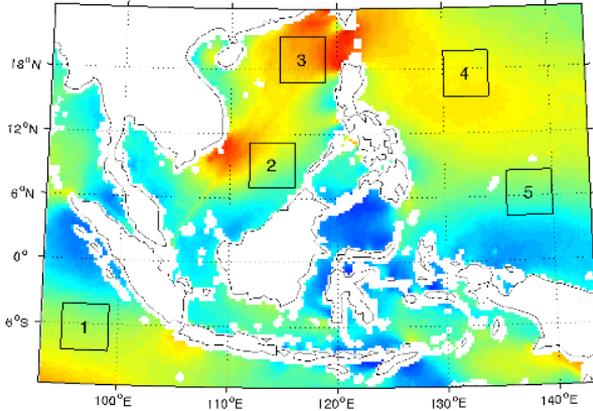


# Added value of the dynamical downscaling

## QuikSCAT

SEA average : 6.46 m.s<sup>-1</sup>

mean : QuikSCAT, 6.46



## For the climatological average

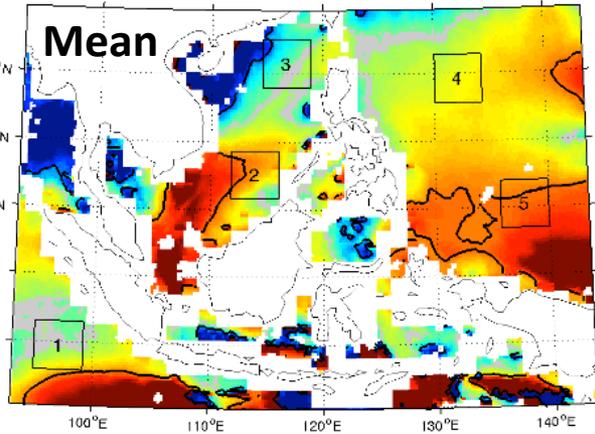
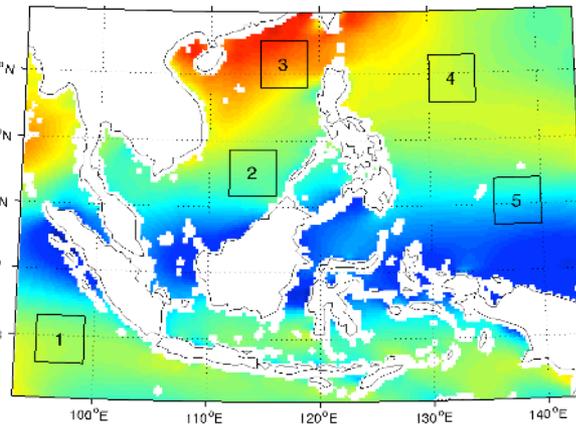
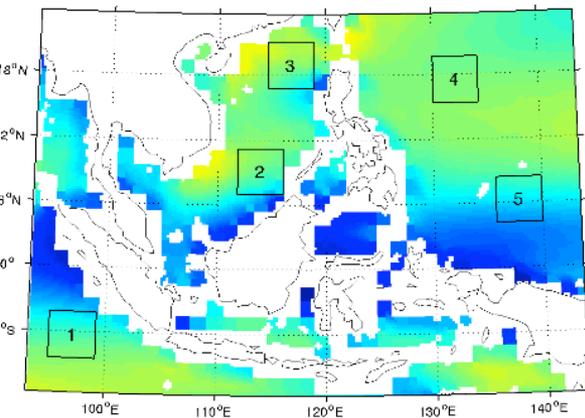
- Both models underestimate wind speed over SEA
- RegCM corrects this underestimation
- Over 66% of SEA

## CNRM-CM5

SEA average : 5.00 m.s<sup>-1</sup>, bias -23%

## RegCM4

SEA average : 6.19 m.s<sup>-1</sup>, bias -4%



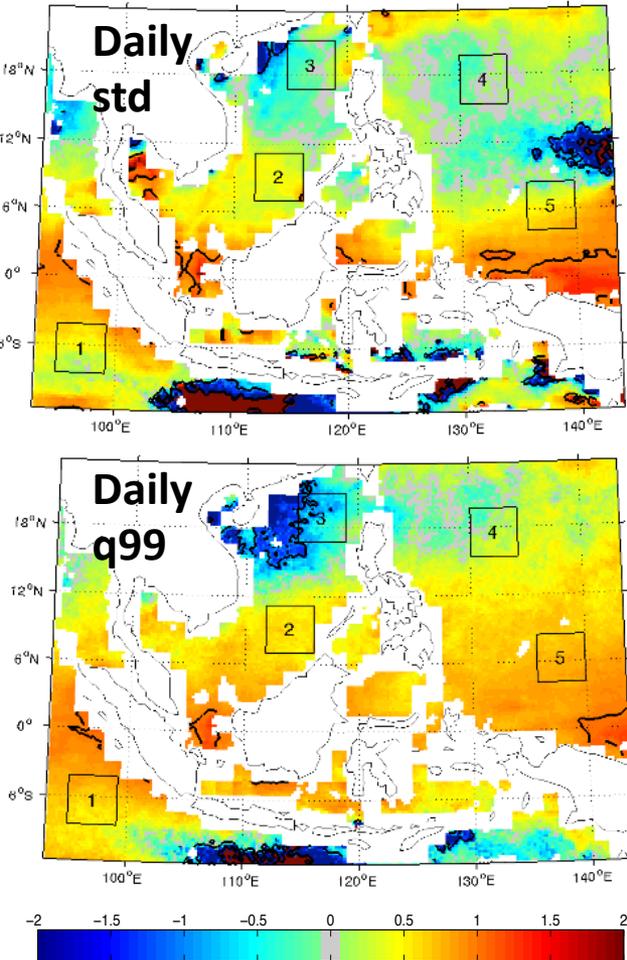
*Ratio bias RegCM / bias CNRM  
for mean  
(black lines : +/-1 isocontours)*

*Average wind speed over  
2000-08 (m.s<sup>-1</sup>)*



# Added value of the dynamical downscaling

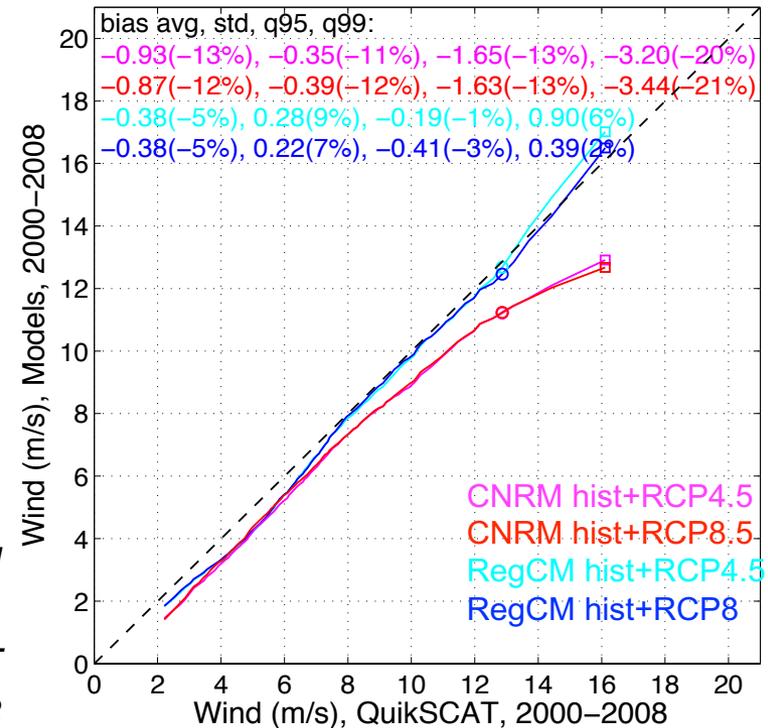
Ratio bias RegCM / bias CNRM  
(black lines : +/-1 isocontours)



## And for the daily scales

- Both models underestimate daily wind speed variability over SEA
- RegCM corrects this underestimation
- Over 88% of SEA for daily std, 89% for q95 and 93% for q99

BOX 4. QS: avg 7.32, std 3.11, q95 12.87, q99 16.11



Qqplot of daily wind  
averaged over box 4,  
models vs. QuikSCAT  
2000-08

# Impact of climate change

## **Periods of references for climate change impact : 30 years**

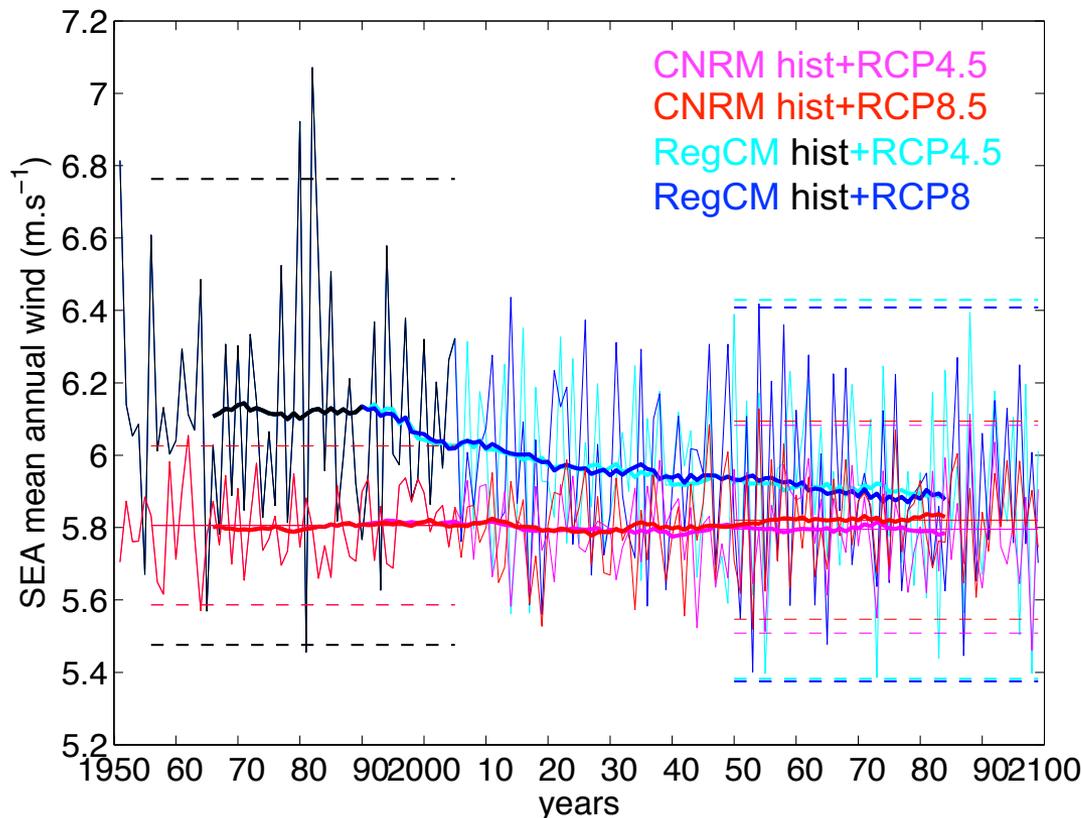
- 1961-1990 = XX
- 2070-2099 = XXI

# Impact of climate change

## Periods of references for climate change impact : 30 years

- 1961-1990 = XX
- 2070-2099 = XXI

## Impact of climate change stronger in RegCM than in CNRM-CM5



For both scenarios :

- CNRM : 0% over SEA
- RegCM : -4% over SEA ( $p < 0.01$ )

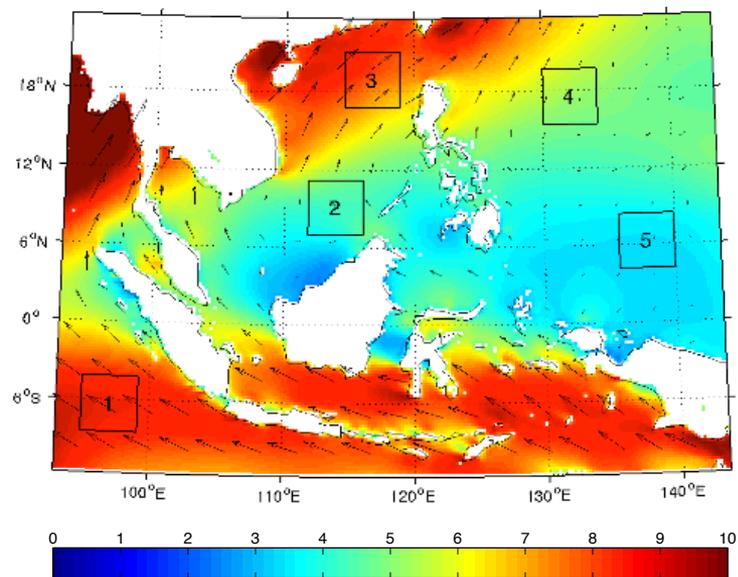
*Time series of yearly sea surface wind speed averaged over SEA*

# Impact of climate change

## RegCM : decrease of summer monsoon

- RCP4.5 : -5% over SEA (p=0.04) for JJA
- RCP8.5 : -7% over SEA (p=0.01) for JJA
- Especially in SCS and northwestern PAC

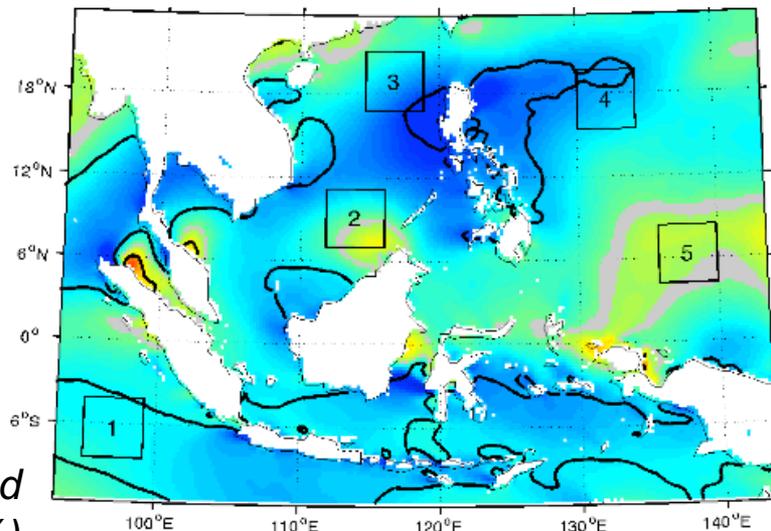
*HIST* : JJA average over XX  
( $m \cdot s^{-1}$ )



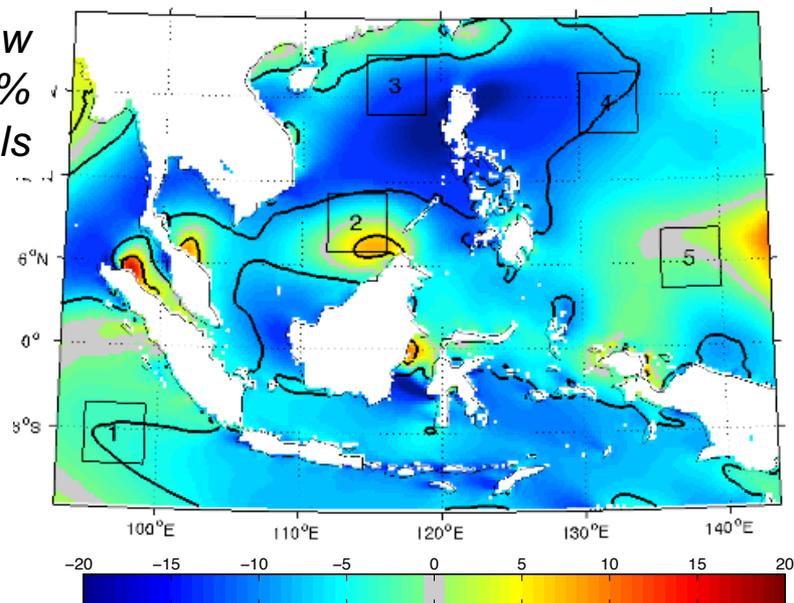
Average JJA wind  
XXI – XX (%)

black lines show  
contour of 95%  
significant levels

**RCP4.5** : -5% over SEA (p=0.04)



**RCP8.5** : -7% over SEA (p=0.01)

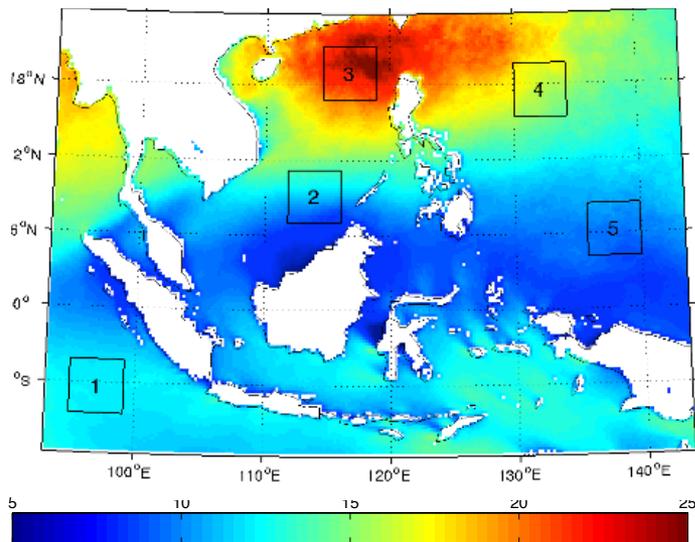


# Impact of climate change

**RegCM : decrease of daily variability and extreme events of sea surface wind speed in summer**

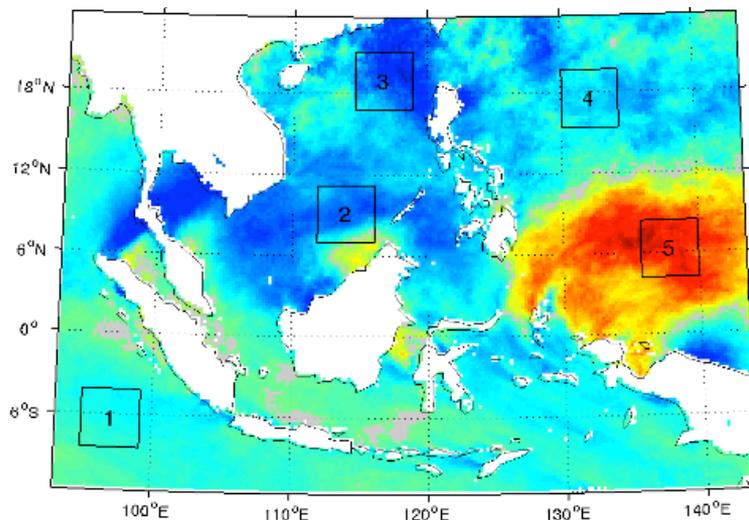
- RCP4.5 : -7% over SEA for daily q99 for JJA
- RCP8.5 : -8% over SEA for daily q99 for JJA
- Especially in SCS and northwestern PAC

**HIST** : daily q99 for JJA  
over XX (m.s<sup>-1</sup>)

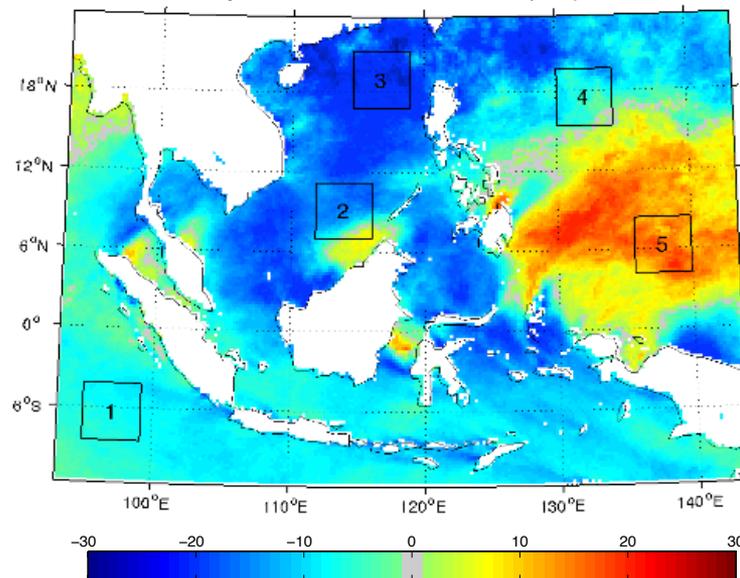


Daily q99 for JJA  
XXI – XX (%)

**RCP4.5** : -7% over SEA



**RCP8.5** : -8% over SEA

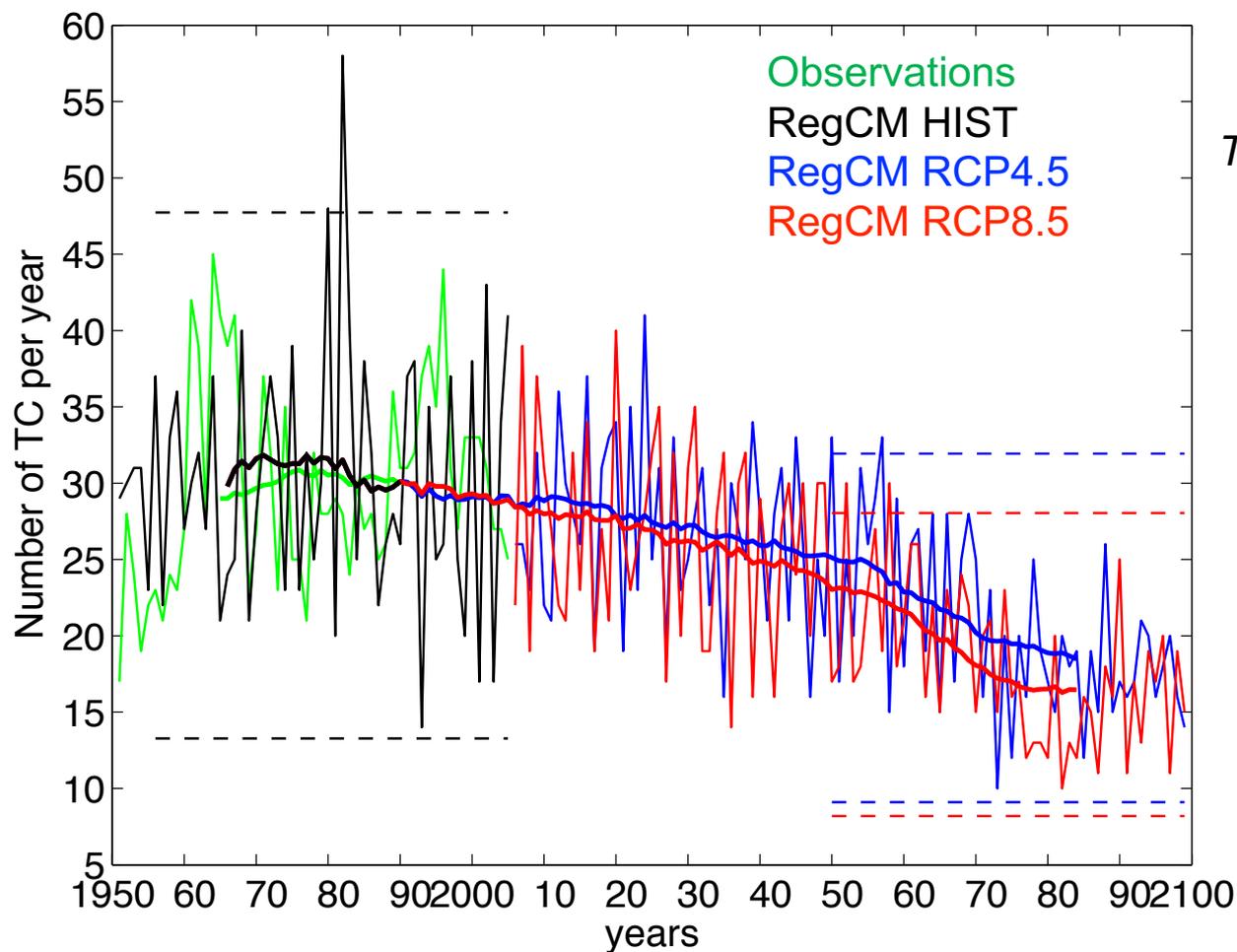


# Impact of climate change

**RegCM : decrease of extreme events of sea surface wind speed**

**Together with typhoon frequency decrease :**

- RCP4.5 : -41%
- RCP8.5 : -49%



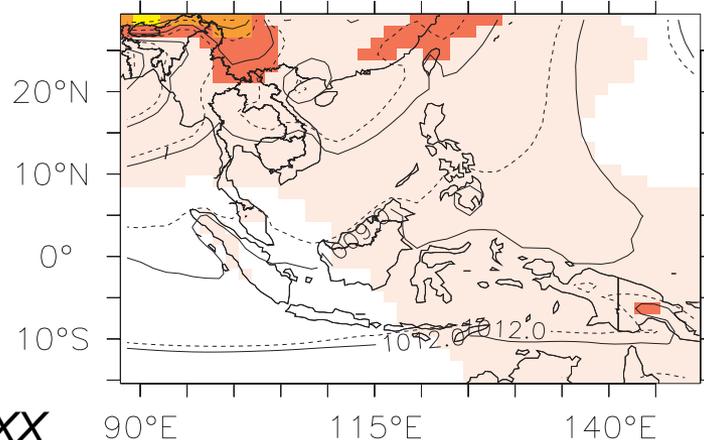
*Time series of yearly number of tropical cyclones over SEA in RegCM simulations*

# Physical explanation : increase of the South-North SLP gradient

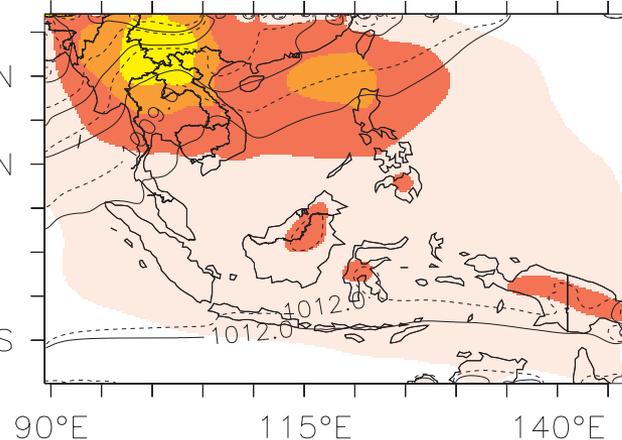
## Increase of the meridional SLP gradient

- Increase of SLP in both models (stronger in RegCM)
- Stronger in the North

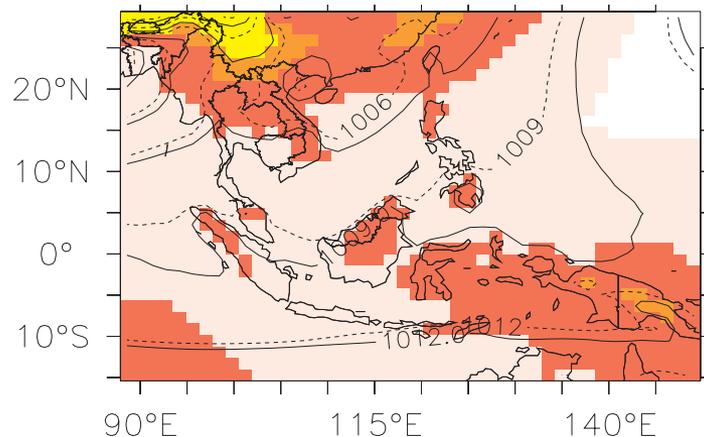
CNRM RCP4.5, JJA, XXI-XX



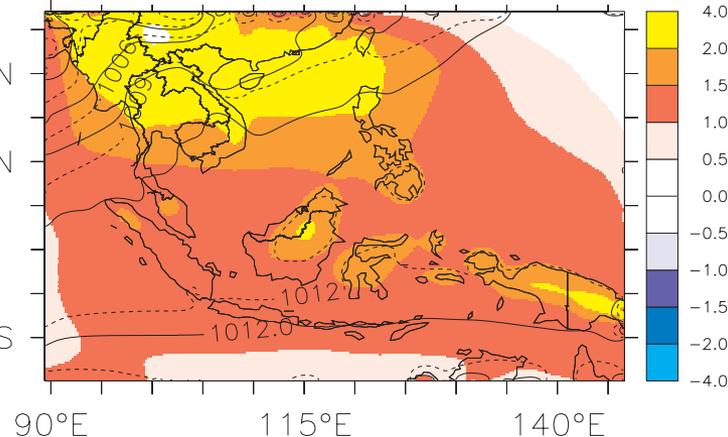
RegCM RCP4.5, JJA, XXI-XX



CNRM RCP8.5, JJA, XXI-XX



RegCM RCP8.5, JJA, XXI-XX



*Difference of average SLP between XXI and XX (hPa)*

# Physical explanation : increase of the South-North SLP gradient

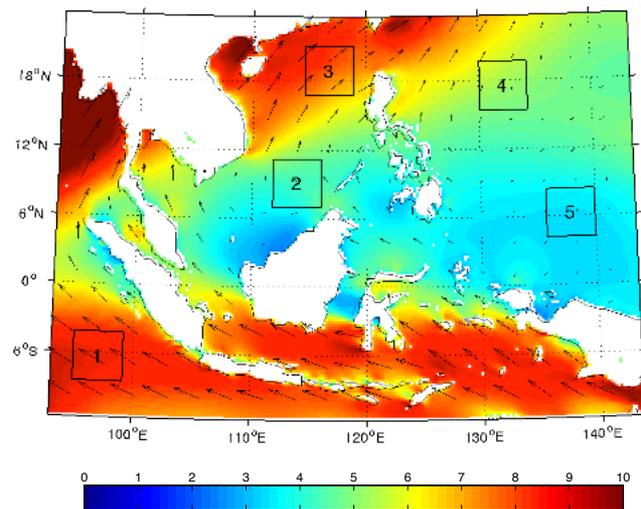
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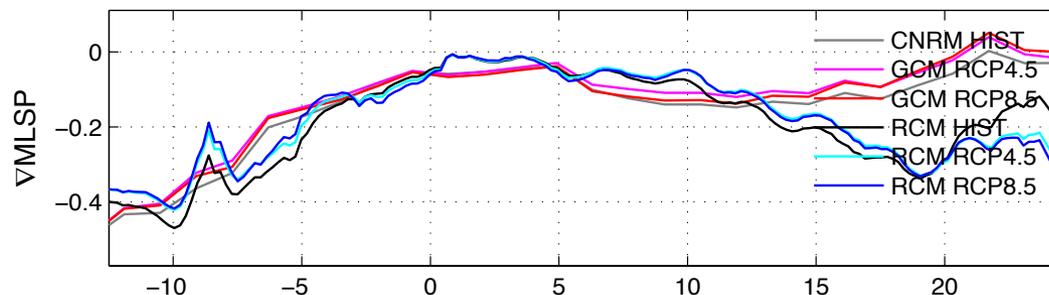
→ increase of South-North SLP gradient : +0.01 hPa/deg for both scenarios

→ Weakens the Northward summer monsoon, associated with negative gradient

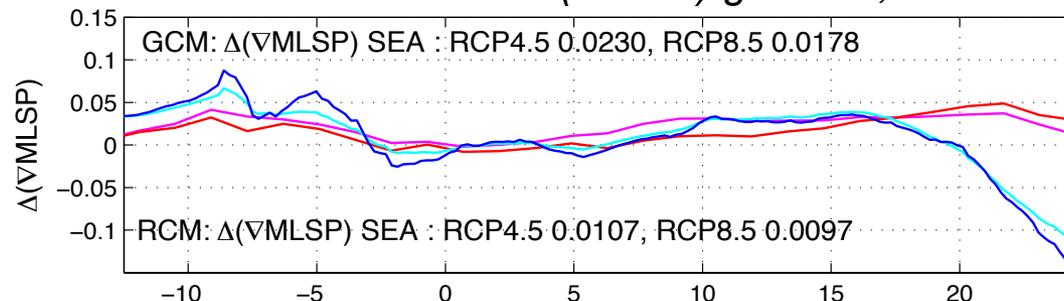
HIST : JJA average over XX  
( $m \cdot s^{-1}$ )



Mean SLP gradient for JJA(hPa/deg) XX period



Variation of mean SLP (hPa/m) gradient, XXI—XX

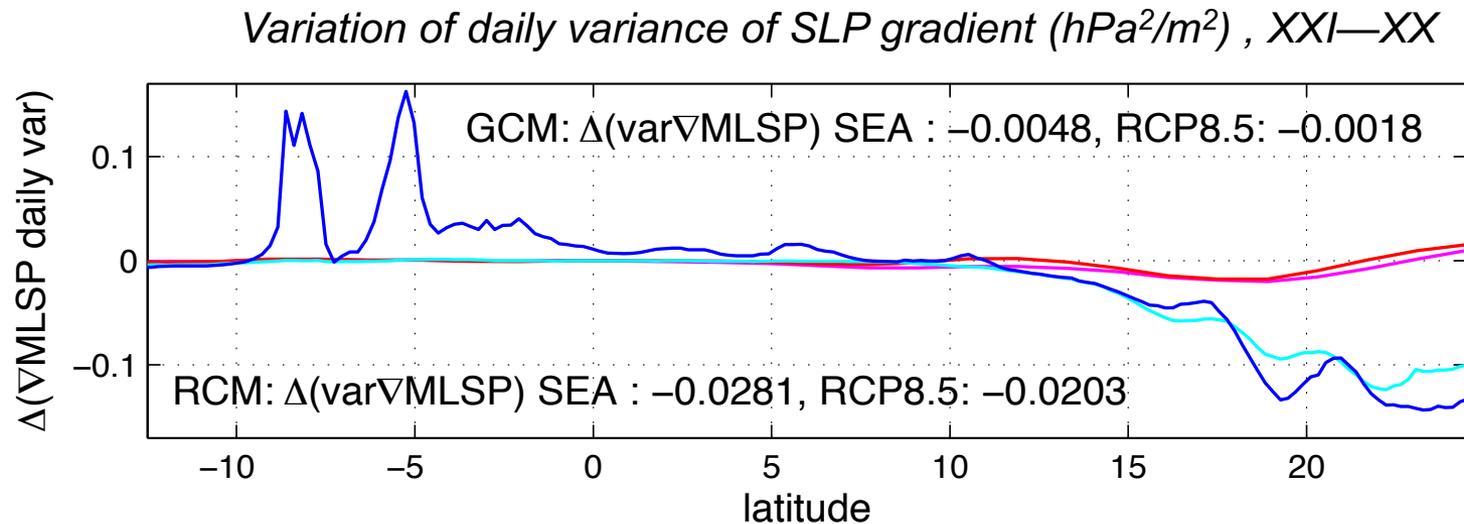


# Physical explanation : weakening of the south to north SLP gradient

## Weakening of the meridional SLP gradient variability

- Decrease of SLP gradient daily variance :  
RCP4.5 :  $-0.03 \text{ hPa}^2/\text{deg}^2$  ; RCP8.5 :  $-0.02 \text{ hPa}^2/\text{deg}^2$

→ Weakens the sea surface wind daily variability (std, q95, q99)



# Conclusions

- **Added value** of RegCM4 downscaling of CNRM-CM5 CMIP5 simulations for sea surface wind speed : **correction of underestimation at all time scales**
- Climate change mainly induce a **decrease of summer wind, from average to extreme event scales**
- Associated with a **decrease of typhoons**
- **Weakening of the average and variability of SLP gradient** explains those results
- Next steps :
  - **ensemble** simulations (CORDEX-SEA)
  - **coupled** simulations

# Climate Change in the Asia-Pacific region

## from Environmental Aspects to Socio-Economic Impacts



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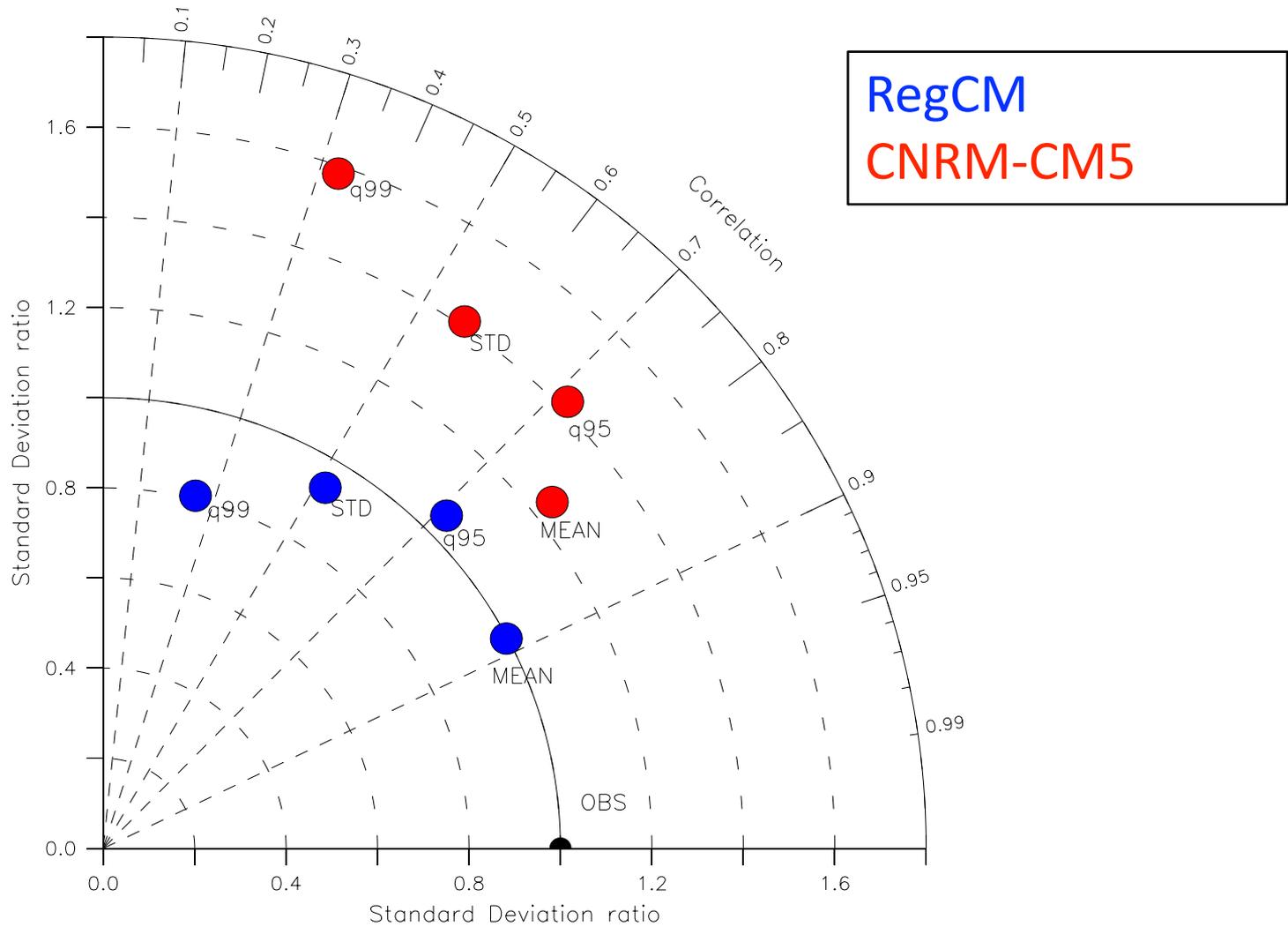
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# Added value of the dynamical downscaling

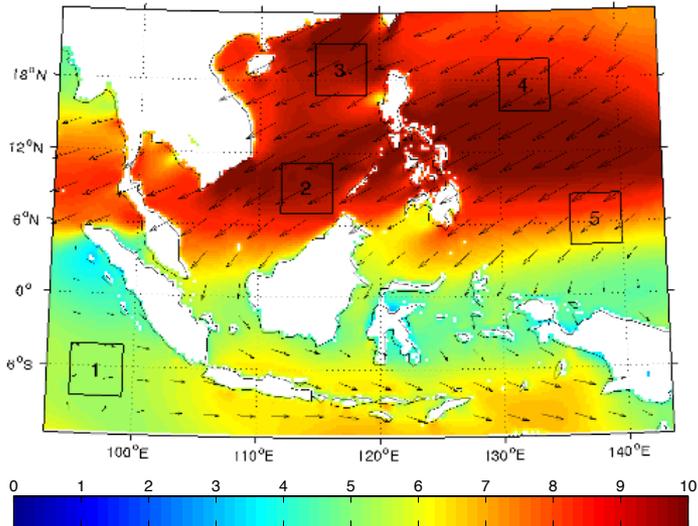


# Impact of climate change

## RegCM : slight increase of winter monsoon

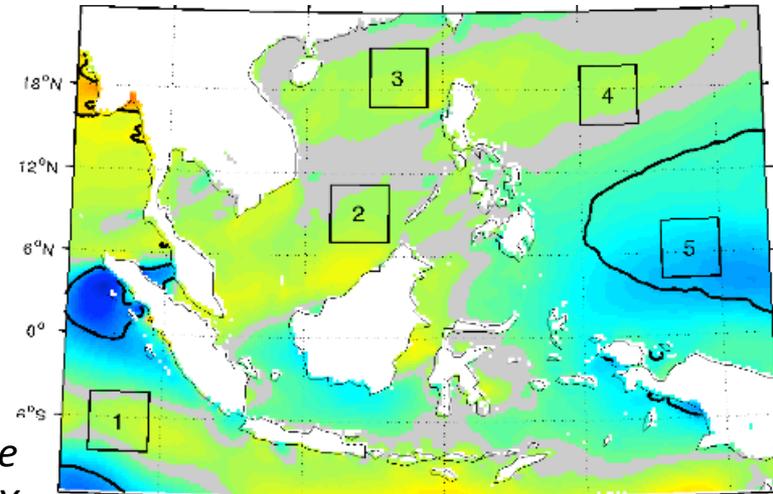
- +1% over SEA for both scenario ( $p > 0.10$ ) for DJF
- But locally significant for RCP8.5

*HIST : DJF average over XX ( $m \cdot s^{-1}$ )*

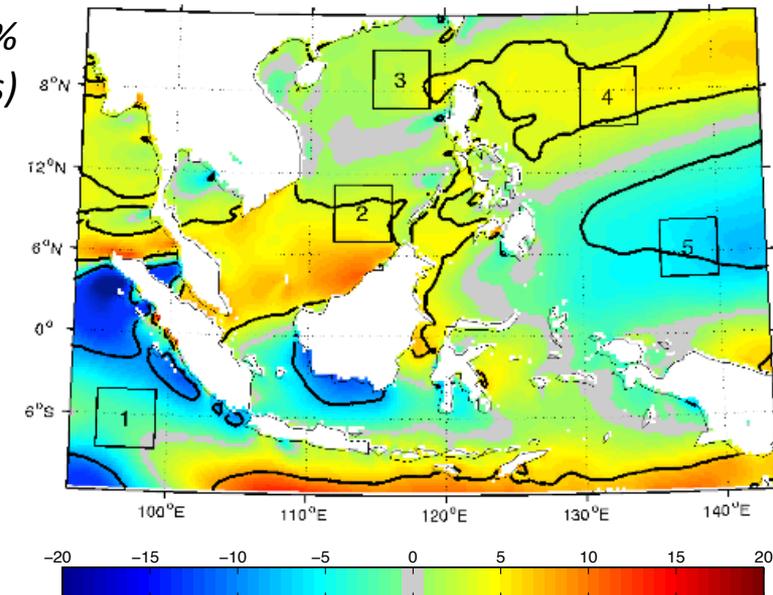


*Variation of average DJF wind between XX and XXI (black lines show contour of 95% significant levels)*

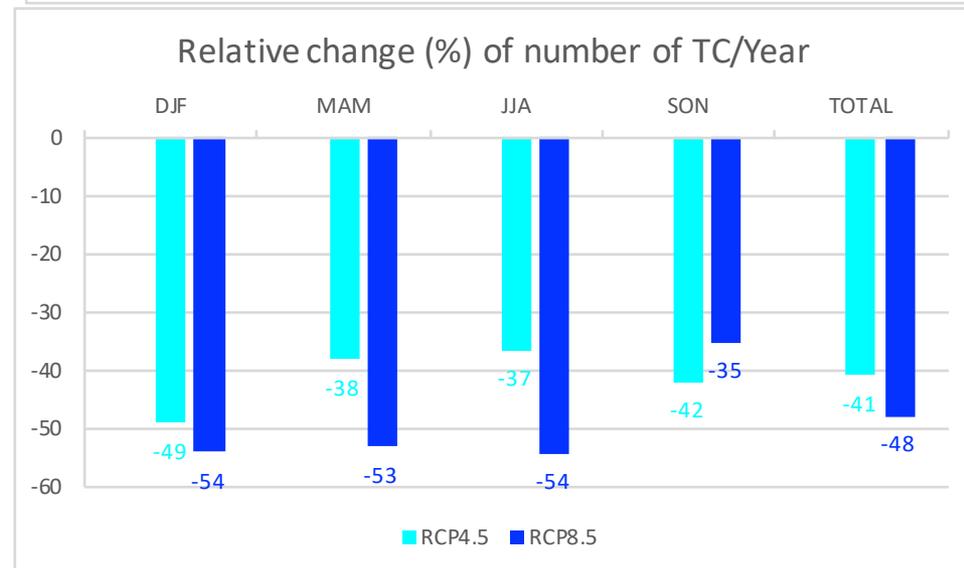
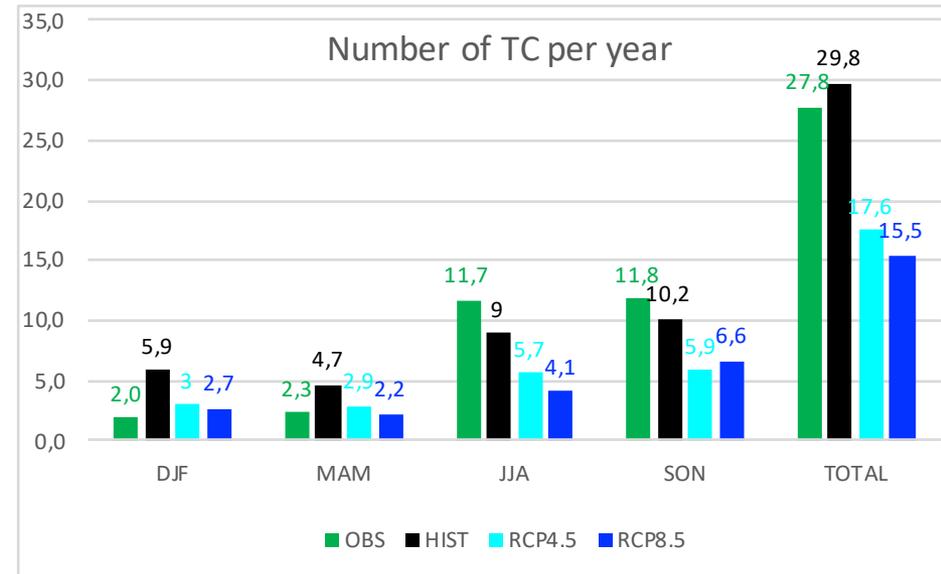
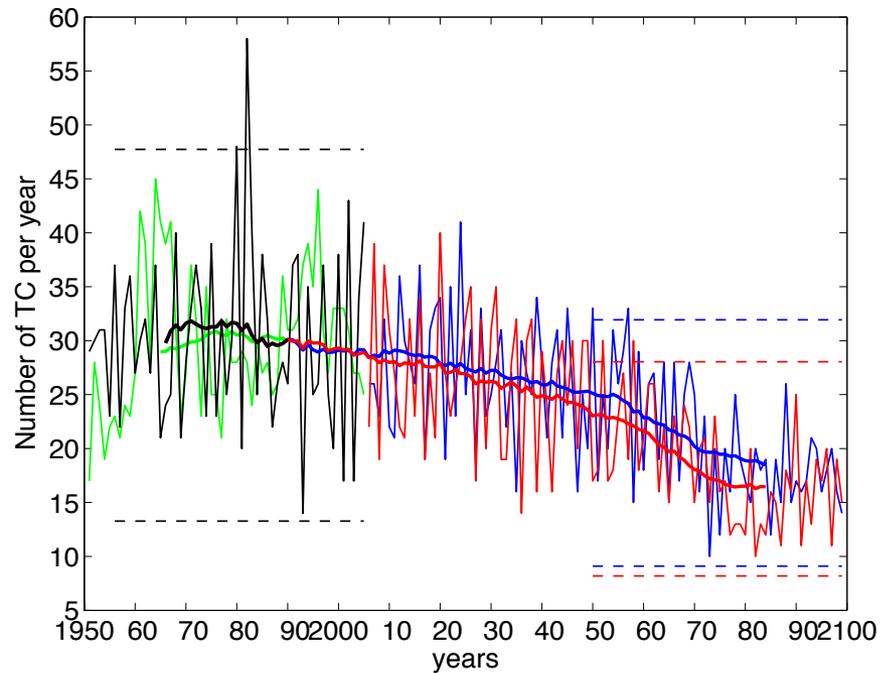
*RCP4.5 : XXI – XX (%)*



*RCP8.5 : XXI – XX (%)*



# Impact of climate change

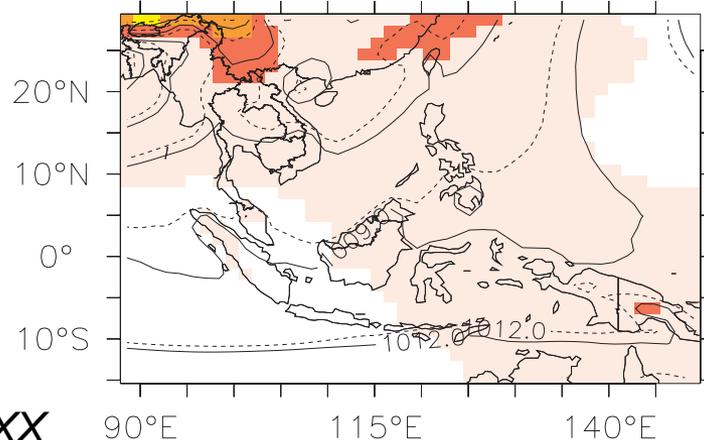


# Physical explanation : increase of the South-North SLP gradient

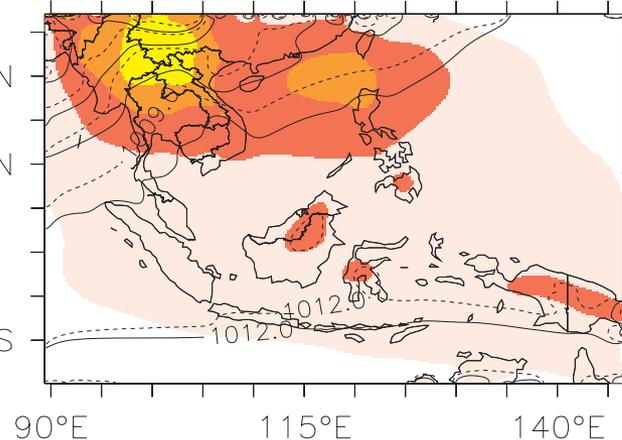
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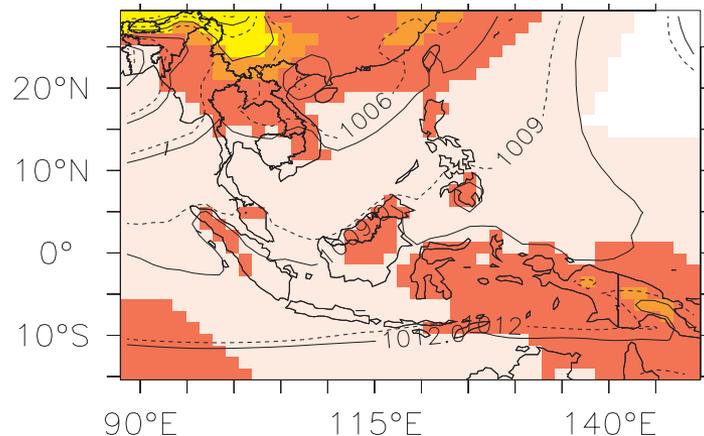
CNRM RCP4.5, JJA, XXI-XX



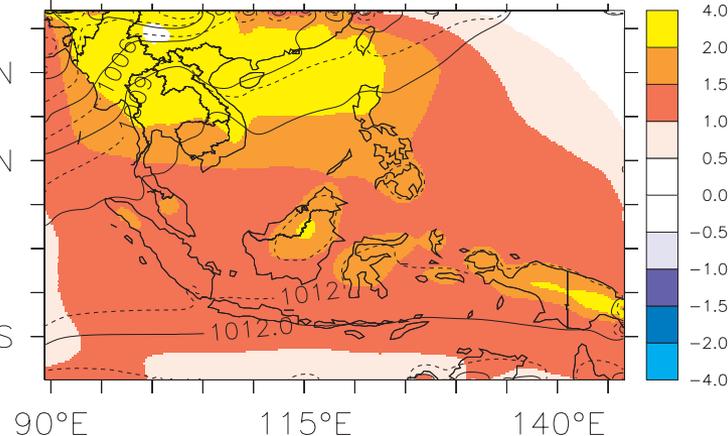
RegCM RCP4.5, JJA, XXI-XX



CNRM RCP8.5, JJA, XXI-XX



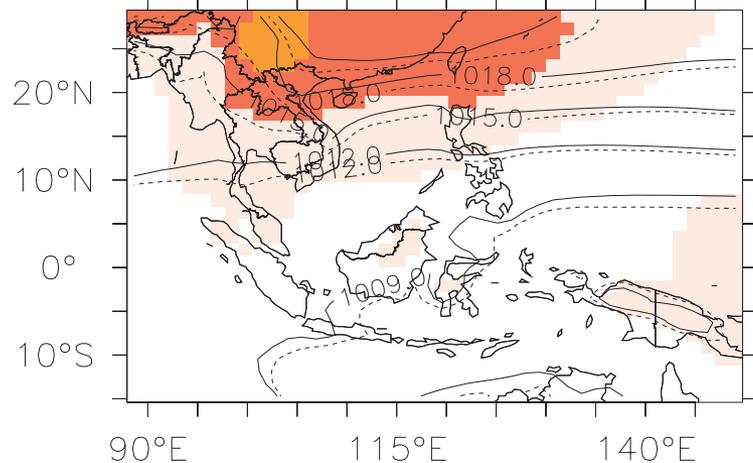
RegCM RCP8.5, JJA, XXI-XX



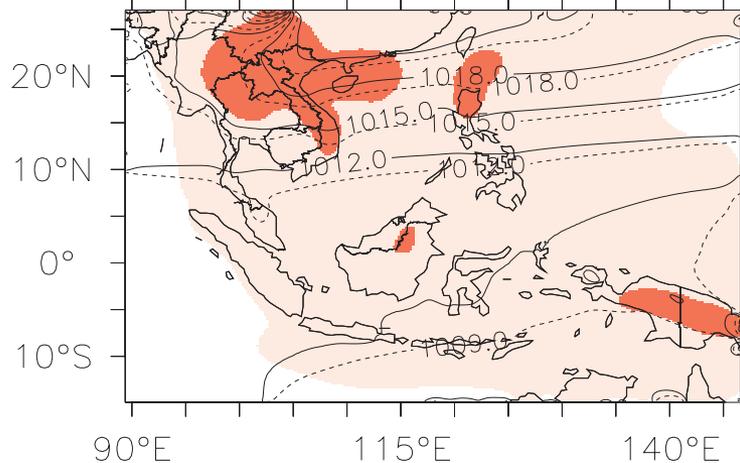
*Difference of average SLP between XXI and XX periods (hPa)*

# Physical explanation : weakening of the south to north SLP gradient

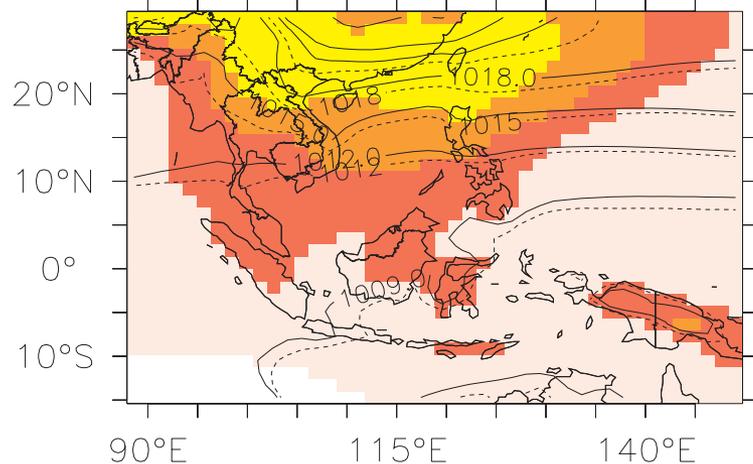
GCM: RCP4.5 – HIST, DJF



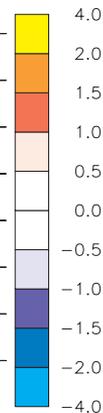
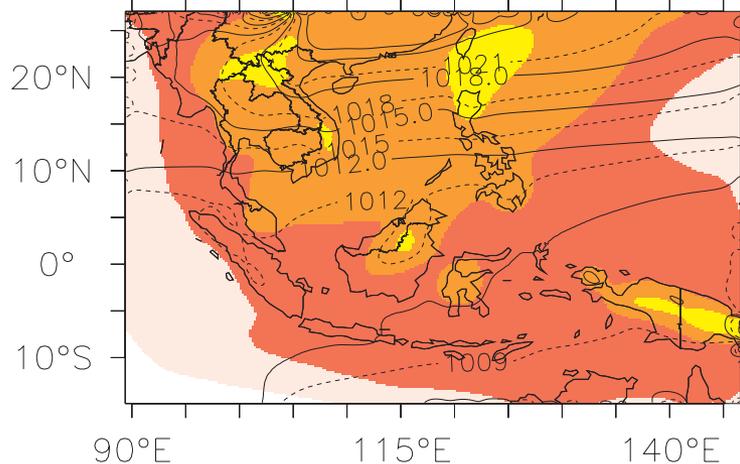
RCM: RCP4.5 – HIST, DJF



GCM: RCP8.5 – HIST, DJF



RCM: RCP8.5 – HIST, DJF



# Physical explanation : weakening of the south to north SLP gradient

