High-resolution regional climate simulations of the long-term decrease in September rainfall over Indochina

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Long-term decrease in September precipitation

Kanae et al.(2001) found that the decrease in September precipitation over the inland of Indochina Peninsula.

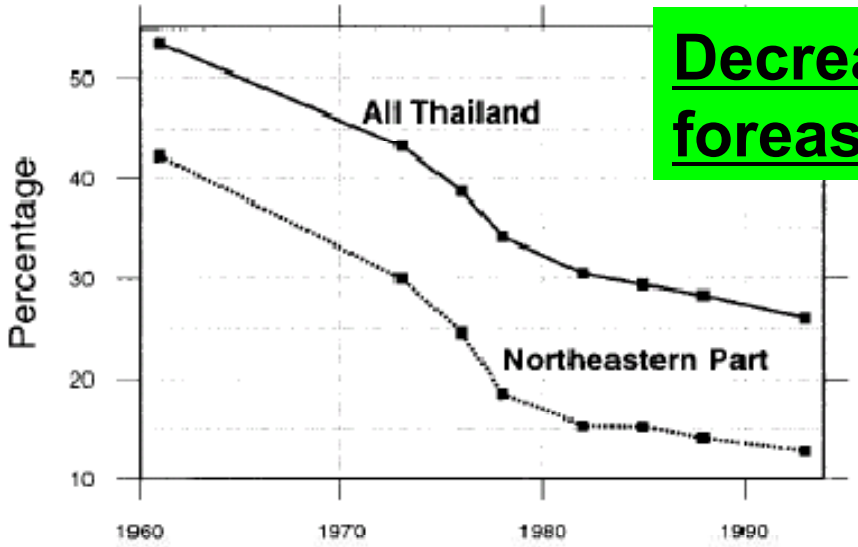
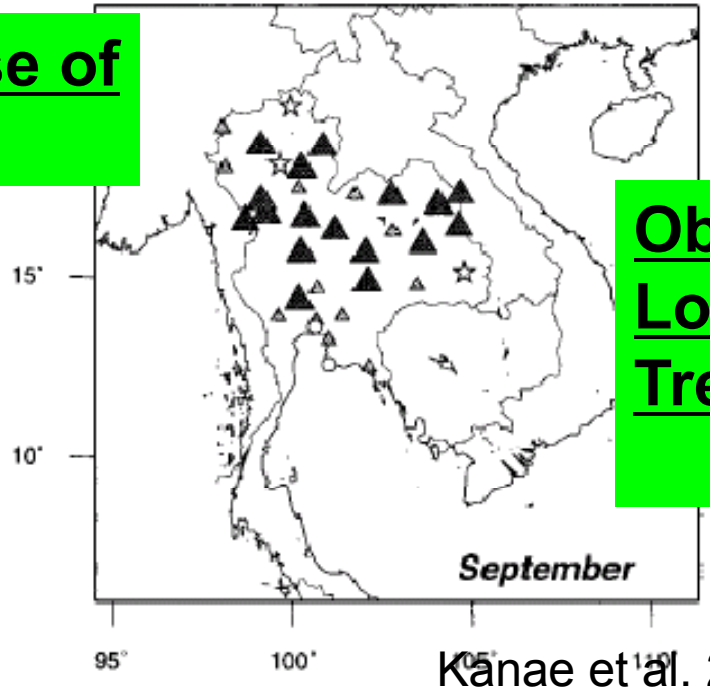


FIG. 1. Time series of forested area in Thailand. Data source: Forestry Statistics of Thailand (Royal Forestry Department of Thailand).

Decrease of foreast

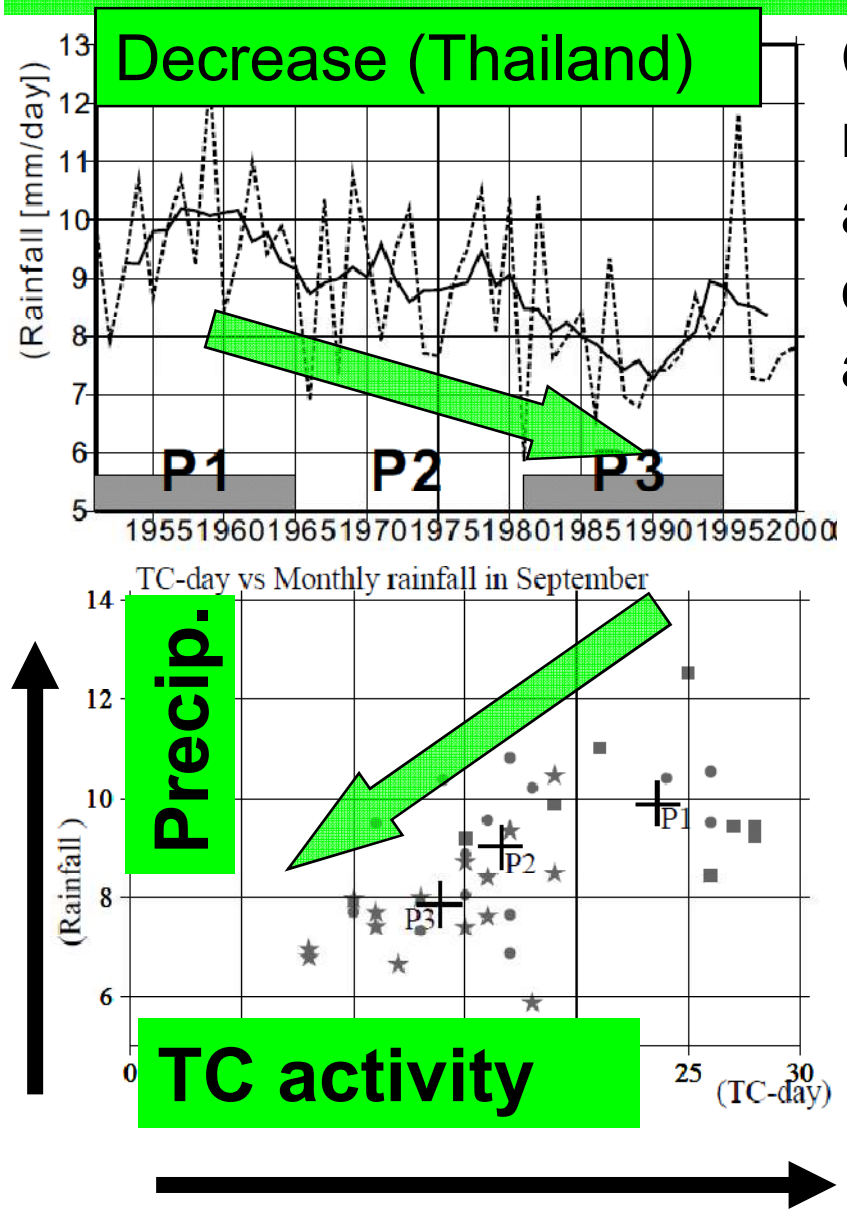


Observed Long-term Trend.

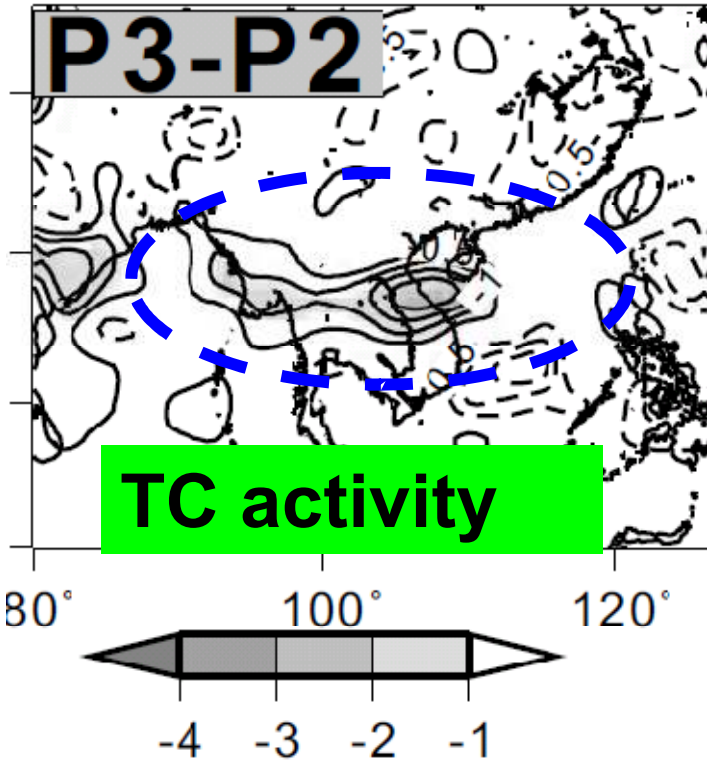
Kanae et al. 2001

They conducted low-resolution climate simulation, and suggested that the decrease in evapotransipiration due to the deforestation caused the decrease in precipitation there.

Long-term change in tropical cyclone activities around the Indochina Peninsula



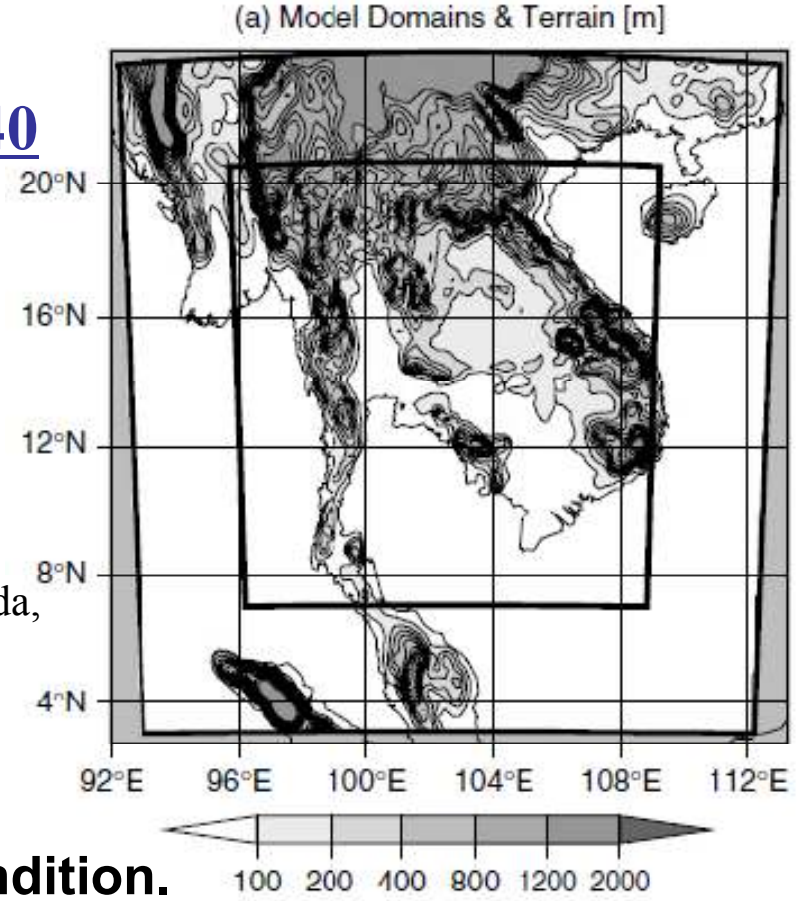
Concurrent with the decrease in rainfall, the Tropical cyclone (TC) activities also changed, which can explain the decrease.（Takahashi and Yasunari 2008, JMSJ)

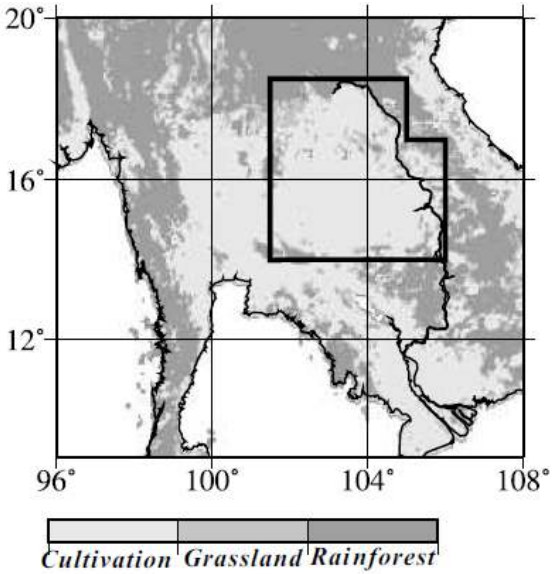


Design of Numerical Experiment

WRF V2.2.1
Initial and Boundary conditions:ERA40
No Cumulus Parameterization
Period: 1966-1995 for September

Microphysics: Hong and Lim (2006)
LSM: Noah LSM (Chen and Dudhia 2000)
Radiation: Long wave: Rapid Radiative Transfer Model (Mlawer et al. 1997), Short wave MM5 shortwave (Dudhia 1989)
PBL : Mellor-Yamada-Janjic TKE scheme (Mellor and Yamada, 1982; Janjic 1996, 2002)

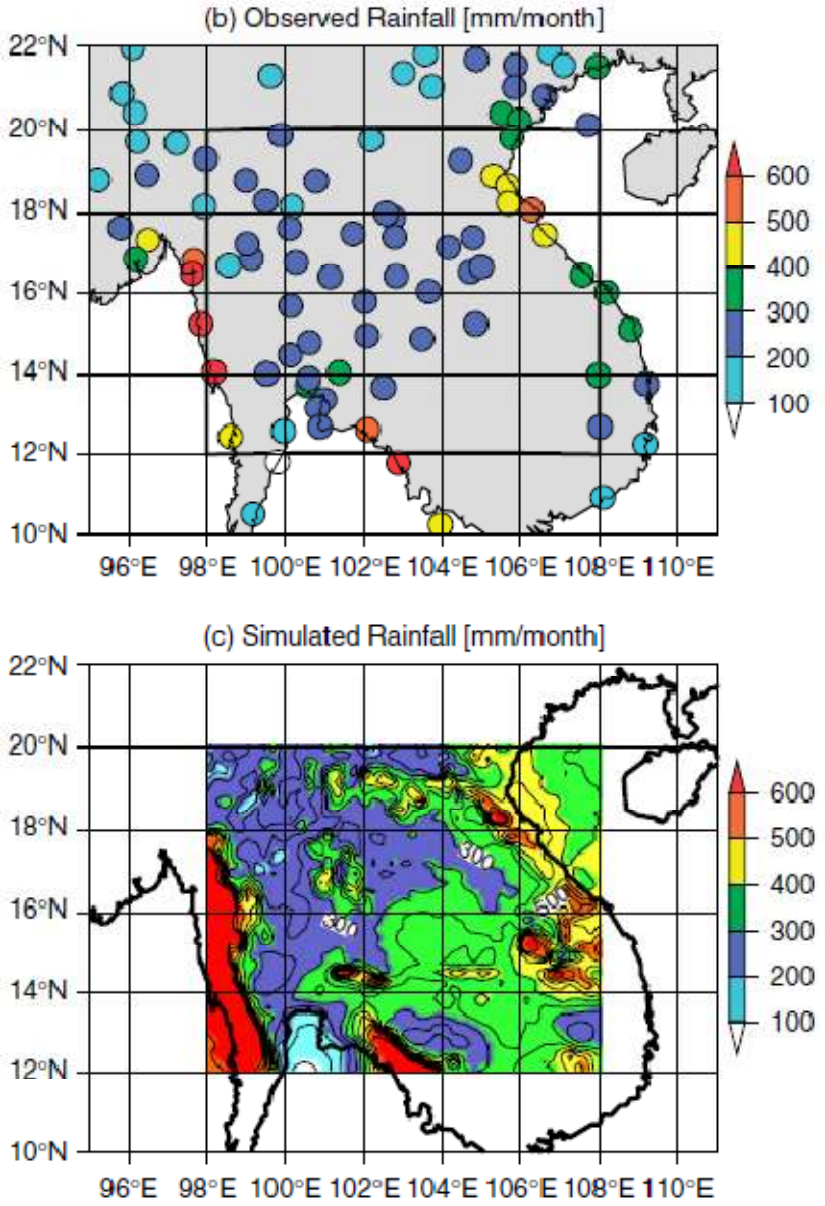




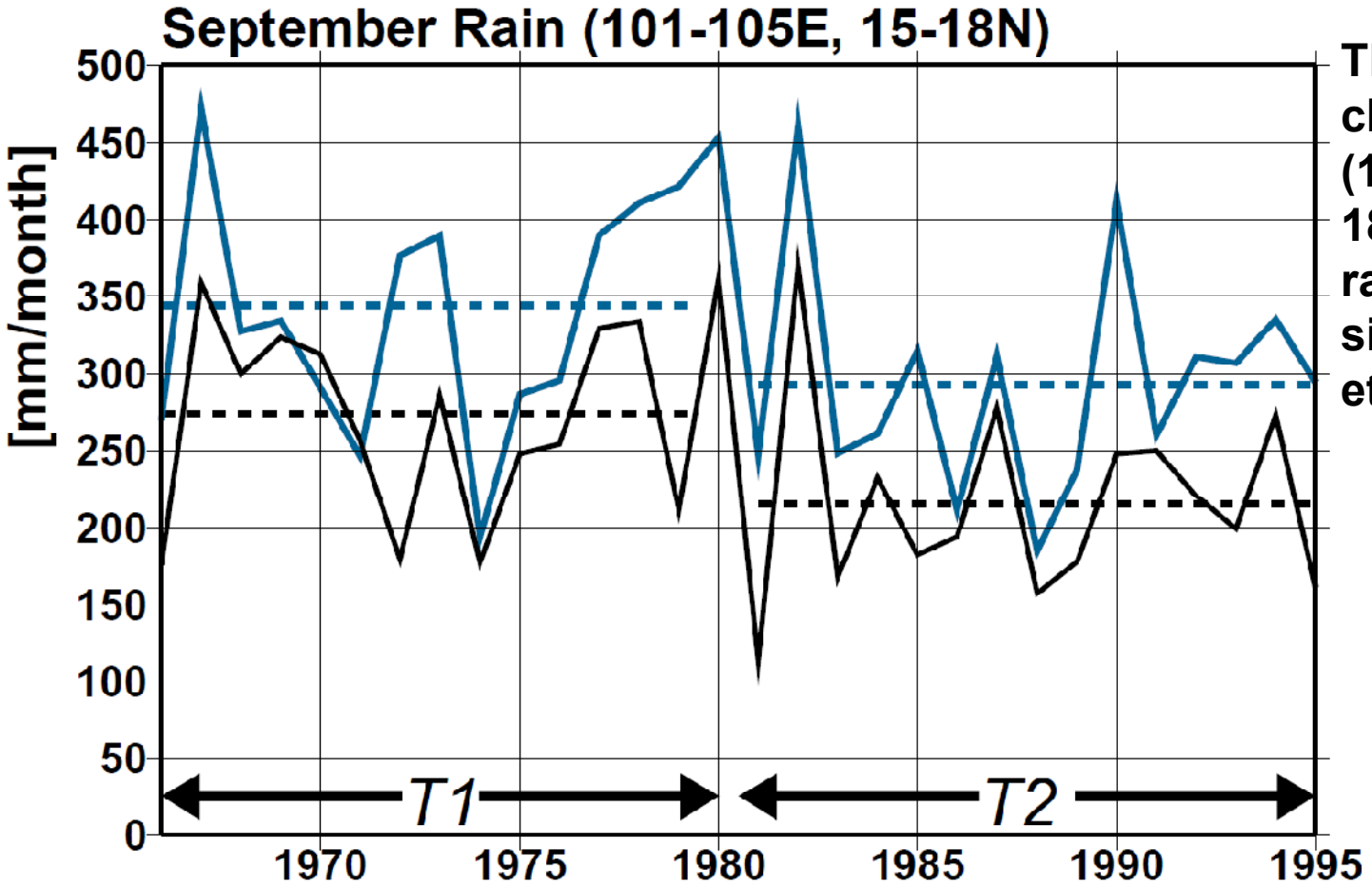
Current land-use condition.
In the past, Thailand was highly forested, whereas the 1992 data categorised the majority of Thailand as under cultivation. Thus, if the effect of deforestation was the most significant factor, a long-term decrease in rainfall would not be apparent in the model.

Performance of long-term experiment

Abundant rainfall was observed along the coast of the Bay of Bengal, the Gulf of Thailand and the eastern coast of northern Vietnam. The peaks of the simulated rainfall were closely correlated with the peaks indicated by rain-gauge observations. In addition, the total simulated amount of rainfall was generally very close to that observed using rain gauges. Because the rainfall along the eastern coast of northern Vietnam was very likely associated with the westward-moving TCs, the peak in the simulated rainfall there suggests that the model can simulate both TCs and the rainfall pattern caused by TCs.



Interannual variations and long-term changes in rainfall (Comparison with the observation (10 stations))

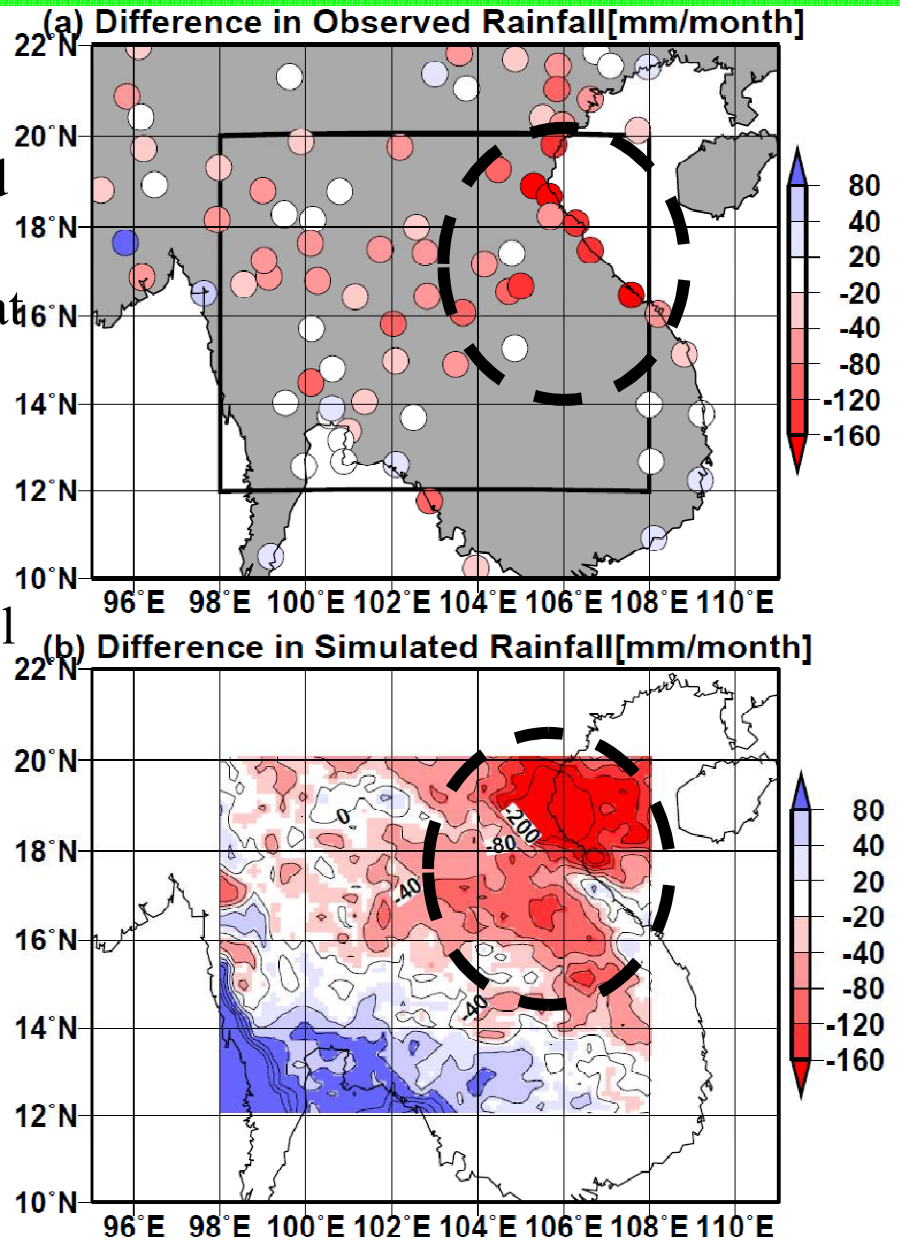


The reference area chosen was an area (101◦ –105 ◦E, 15◦–18◦N) in which rainfall decreased significantly (Kanae et al. 2001).

Both time series showed clear interannual variation, with close agreement. The 15% decrease in simulated rainfall was close to the 21% decrease in the observed rainfall. Thus, the model well simulated the long-term change in rainfall.

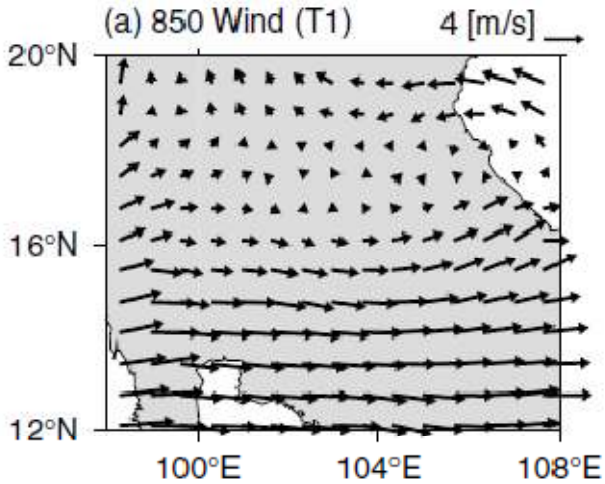
Spatial pattern of long-term changes in rainfall T2[1981-1995] - T1[1966-1980]

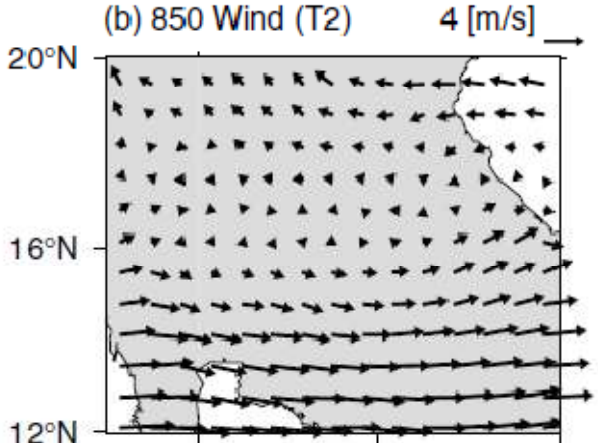
Over the Khorat Plateau, rainfall was decreased in T2, which was consistent with Kanae et al. (2001). Decreases were observed along the latitudinal band between 15◦ and 22◦N of the Indochina Peninsula, showing that a long-term decrease was observed not only over inland Thailand, but also across the Indochina Peninsula. This decrease was observed along the major route of the westward-moving TCs. The simulated rainfall was in close agreement with the observations in both spatial distribution and quantity. The regional long-term climate change was simulated without inclusion of the recorded deforestation.

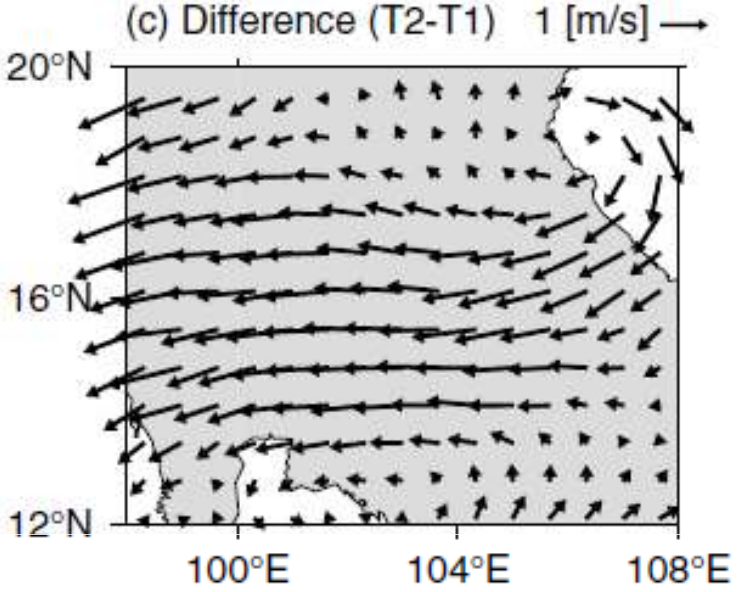


Spatial pattern of long-term changes in winds T2[1981-1995] - T1[1966-1980]

The difference clearly shows the anti-cyclonic circulation over northern Vietnam, which indicates a weakening of the monsoon trough







The frequency was defined from the 925-hPa wind speed offshore of northern Vietnam (106–109 ◦E, 17–20◦N). If any grid point in the region at 925 hPa had a wind speed greater than 12 m s−1, a TC was defined as occurring on that day

Category	Simulated TC appearance (days month^{-1})	Observed TC-day from TA08 (days month^{-1})
T1 (1966–1980)	13.7	16.6
T2 (1981–1995)	11.8	13.9

Conclusion

- The long-term high-resolution simulation accurately captured the climatological rainfall distribution and quantity.
- The spatial distribution of the long-term change in rainfall was also found to be in close agreement with observations. **A long-term decrease in rainfall was observed along the major route of the westward-moving TCs, including the eastern coast of northern Vietnam, rather than just over Thailand.**
- Finally, the simulated monsoon trough weakened from T1 to T2, which again was consistent with observations.

- **All of these long-term changes in rainfall were realistically simulated *without* including the effects of deforestation in the model.**

- The effects of deforestation over the Indochina Peninsula in September were likely spatially limited and hence are not likely to explain the observed decrease in rainfall. **The weakening of TC activity over and around the Indochina Peninsula could explain the spatial distribution of the observed decrease in rainfall.**
- Therefore, we conclude that the observed long-term decrease in September rainfall has been caused by the change in TC activity, rather than by the changes in the local surface conditions.