Analysis of possible rainfall and temperature change in the greater Mekong sub-region

1. How to detect climate changes in climate model outputs ?
2. Statistical analysis of PRECIS output data
3. Trends in temperature and rainfall time series

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1 How to detect CC in climate model outputs ?

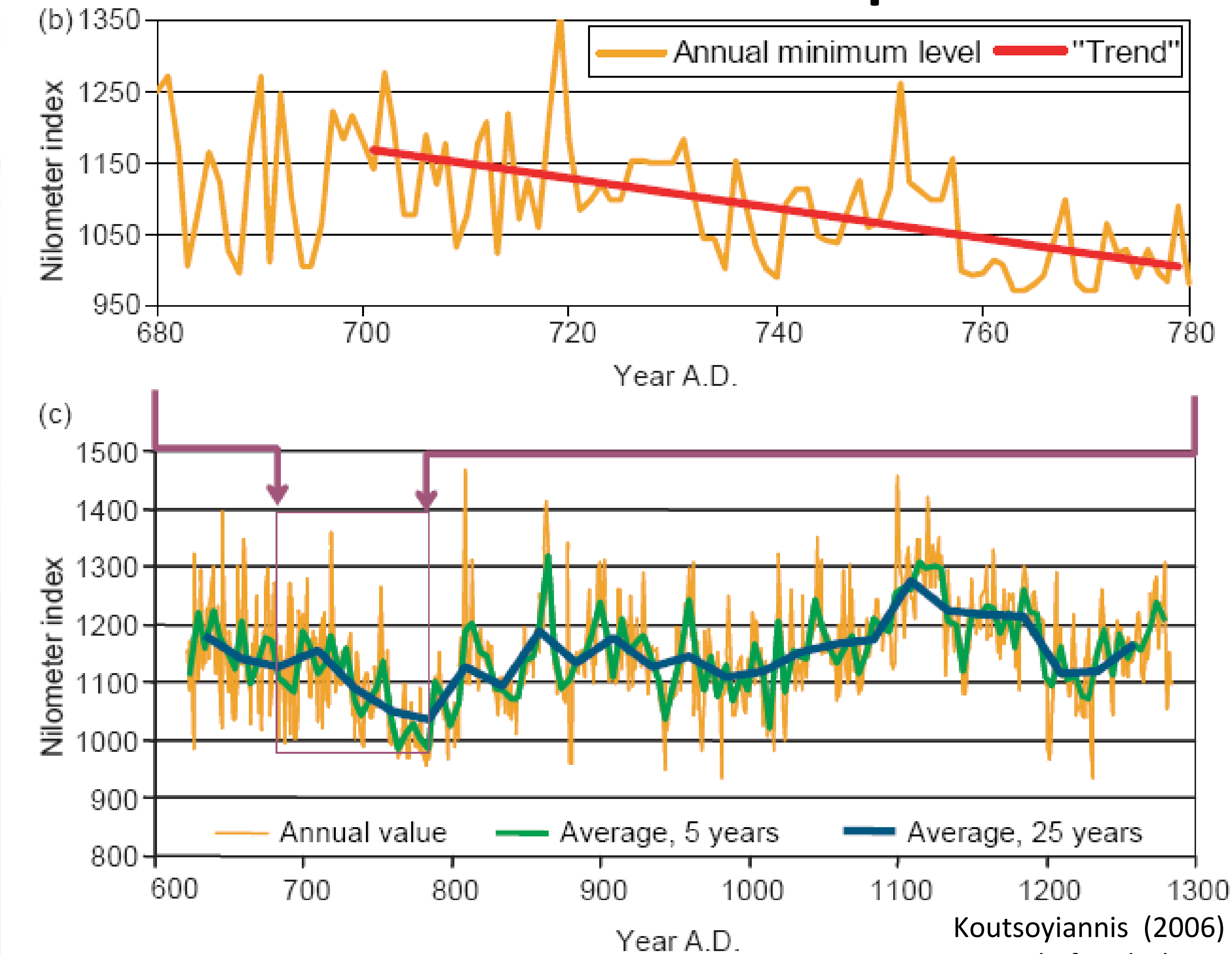
- Uncertainties in climate model output
  - 1/ Uncertainties in future emissions (population growth and socio-eco. dvlp)
- Uncertainties in change detection methodology
  - 2/ Uncertainties in future atmospheric gases concentrations (imperfect understanding of Carbon cycle and conversion of GHG emission into concentration)
  - 3/ Uncertainty in the response of climate (climate mechanisms not fully understood and high complexity → incorrect representation : discrepancies between models output at same location)

1 How to detect CC in climate model outputs ?

- Uncertainties in change detection methodology
  - 1/ Detection of CC requires demonstration that observed change is larger than would be expected to occur by natural causes alone
  - 2/ Detecting monotonous trends over which period length ? Problem of the Hurst phenomenon (Hurst, 1951) and natural multi-decadal variability (El Nino)

Hurst phenomenon: long term hydrological persistence : tendency of wet (dry) years to cluster into multi-year wet (dry) periods

1 How to detect CC in climate model outputs ?



Koutsoyiannis (2006)
Journal of Hydrology

The longest hydro-meteorological time-series ever measured: Annual minimum water level of Nile River for years 622 to 1284 A.D. (663 observations), measured at the Roda Nilometer near Cairo

A 80-year period with a **natural** downward trend…

1 How to detect CC in climate model outputs ?

- Uncertainties in change detection methodology
  - 3/ Statistical versus practical significance…
    - a trend is inferred by *induction* and not by *deduction* (**a posteriori**)
    - This trend is NOT a deterministic function = we don't know its cause (complexity of climate models, stochastic behavior)

→ The existence of trends implies even **greater uncertainty**

- **Objective** of the present study:
  - To detect impacts of CC on rainfall and temperature in the Greater Mekong Sub-region, using output from the PRECIS regional climate model data (scenarios A2 and B2) produced by Southeast Asia START IHDP · IGBP · WCRP Regional Center

- **Two assumptions**:
  - 1/ We trust the model *(uncertainties !!)*
  - 2/ Climate change = long-term monotonous trend *(natural climate variability, Hurst phenomenon !!)*

2 Statistical analysis of PRECIS output data (A2, B2 : 1960-2049)

- **Method**

- 1/ Data quality control: Lower Mekong Basin (LMB): 32 rainfall values >1000 mm/day and 1037 rainfall values >500 mm/day replaced by max realistic values
- 2/ Merging cells into 2×2 square degrees (96 time series covering the Greater Mekong Sub-region)
- 3/ 14 annual variables derived from daily values: annual and seasonal cumulative rainfall depths per year, timing of seasons, min, average and max temperature
- 4/ Trend detection test: Kendall and Stuart, Mann-Kendall to detect monotonous trend in annual time series

2 Statistical analysis of PRECIS output data (A2, B2 : 1960-2049)

Advantage of rank-based trend detection tests

(Kendall and Stuart, Mann-Kendall)

- Function of the ranks of observations rather than their actual values (low-sensitive to outlier, distribution-free test)

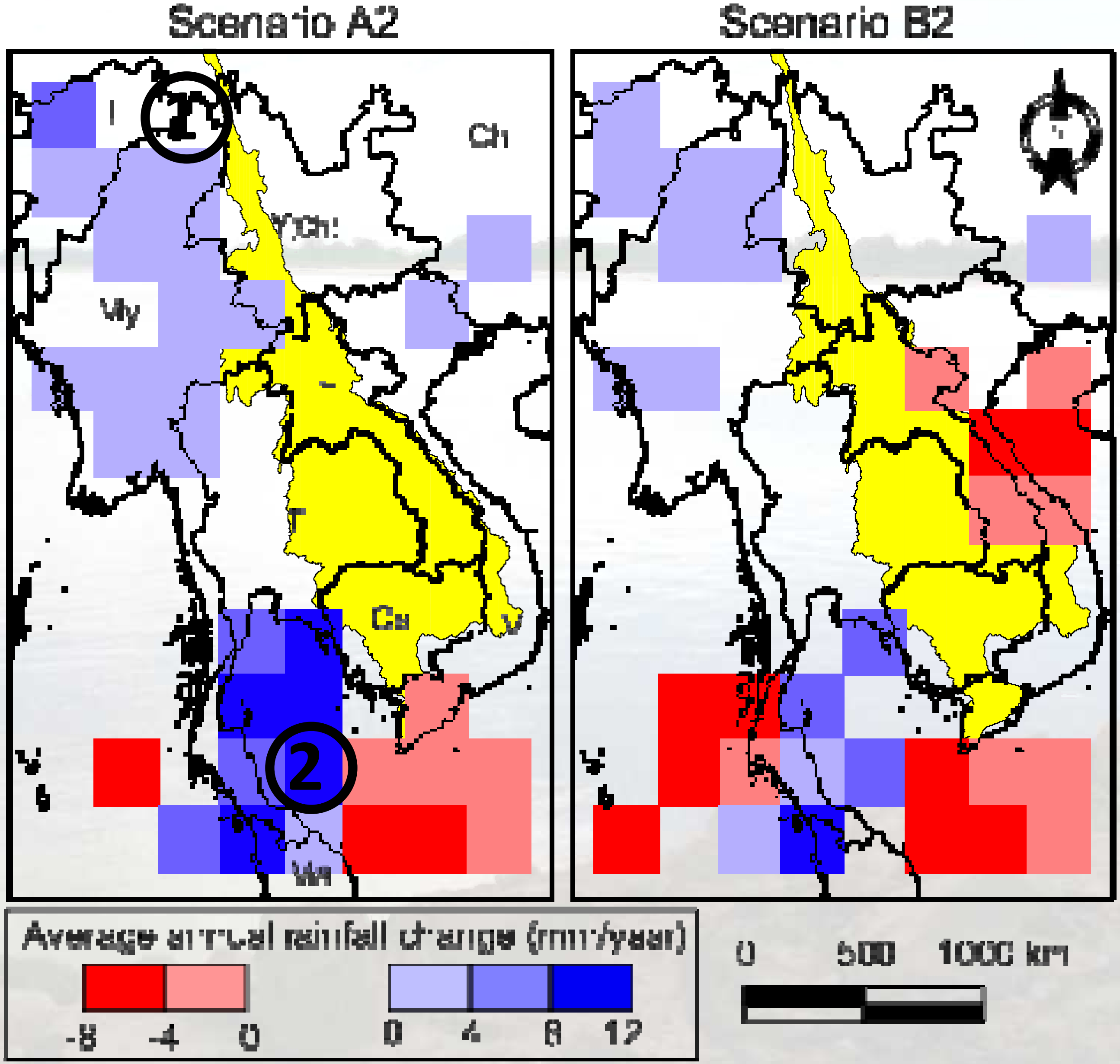
- Based on the calculation of a statistic S

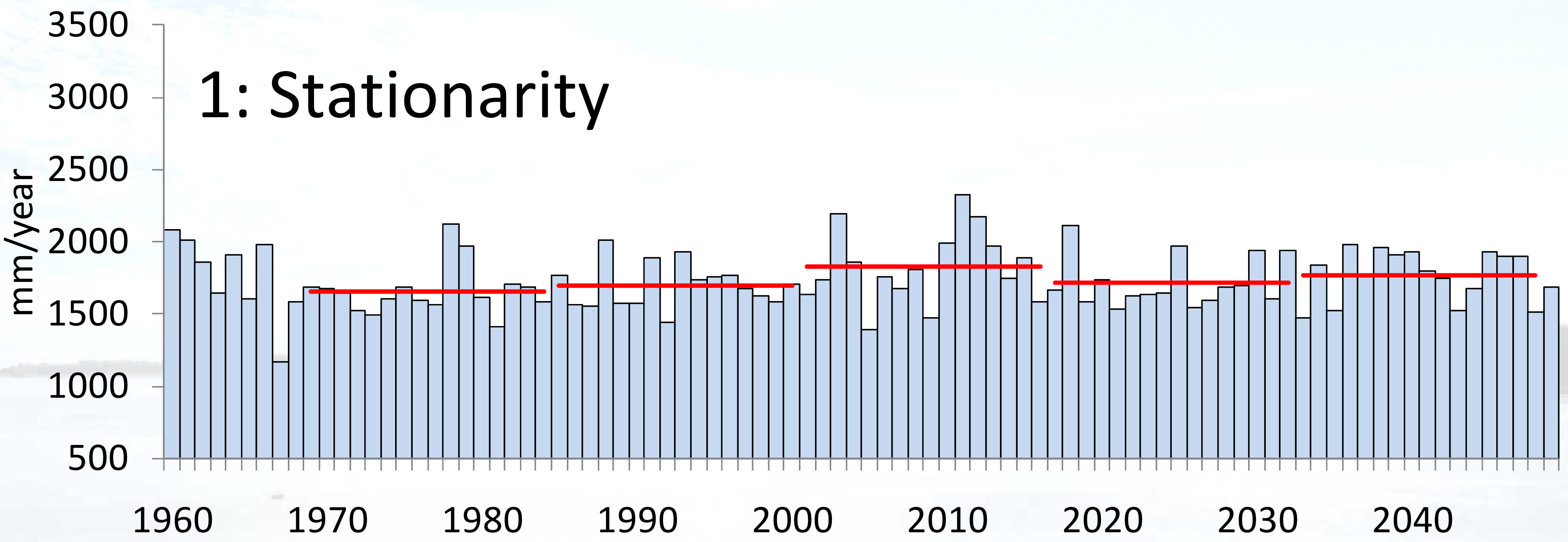
$$X = x_1, x_2, \dots, x_n \qquad S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn(X_j - X_i) \qquad sgn(\theta) = \begin{cases} 1 \; if \; \theta > 0 \\ 0 \; if \; \theta = 0 \\ -1 \; if \; \theta < 0 \end{cases}$$

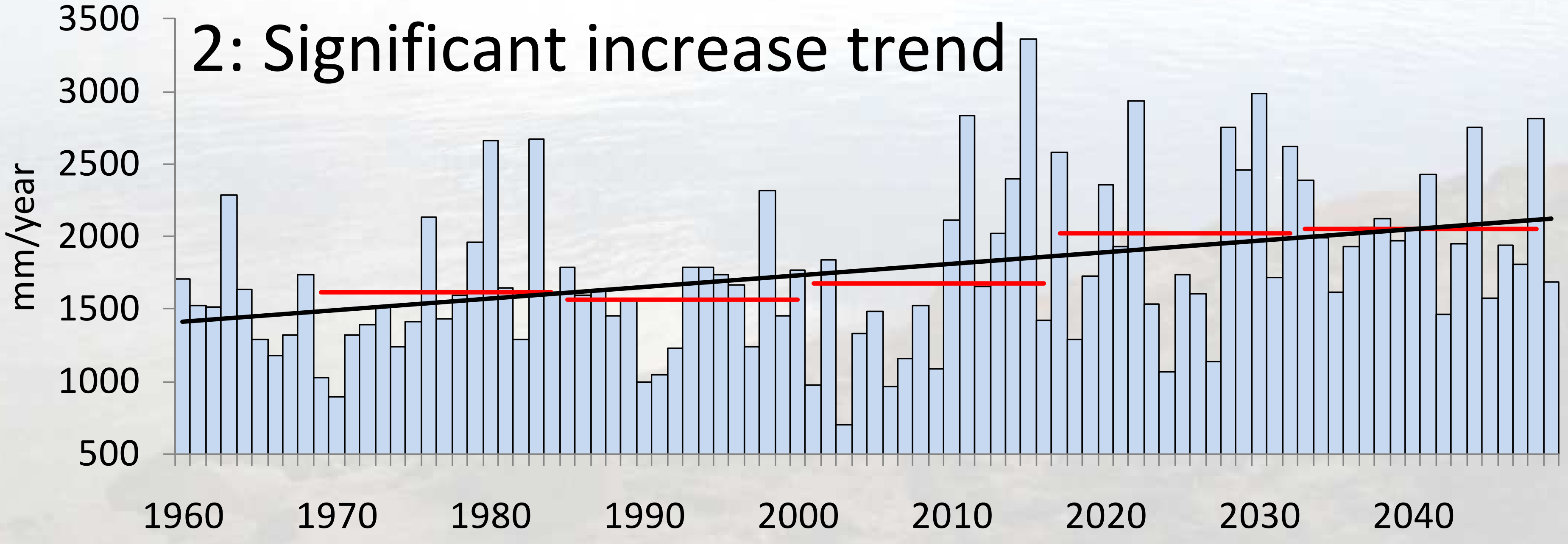
$$V(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{n} t_i i(i-1)(2i+5)}{18} \qquad Z = \begin{cases} \frac{S-1}{\sqrt{Var(S)}} & if \; S > 0 \\ 0 & if \; S = 0 \\ \frac{S+1}{\sqrt{Var(S)}} & if \; S < 0 \end{cases}$$

$$p = 0.5 - \Phi(|Z|) \qquad \Phi(|Z|) = \frac{1}{\sqrt{2\pi}} \int_0^{|Z|} e^{-\frac{t^2}{2}} dt$$

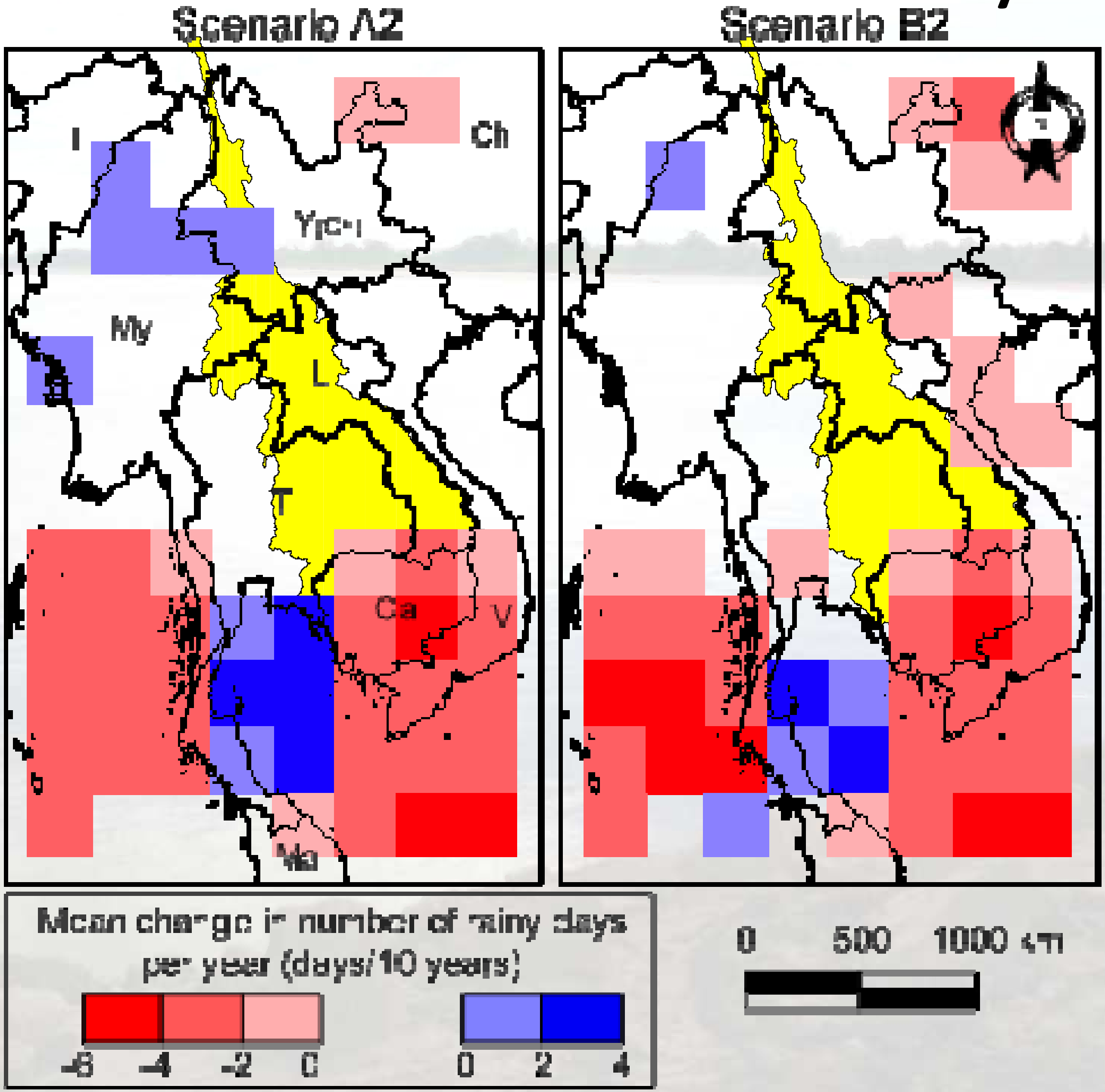
3 Results : annual rainfall



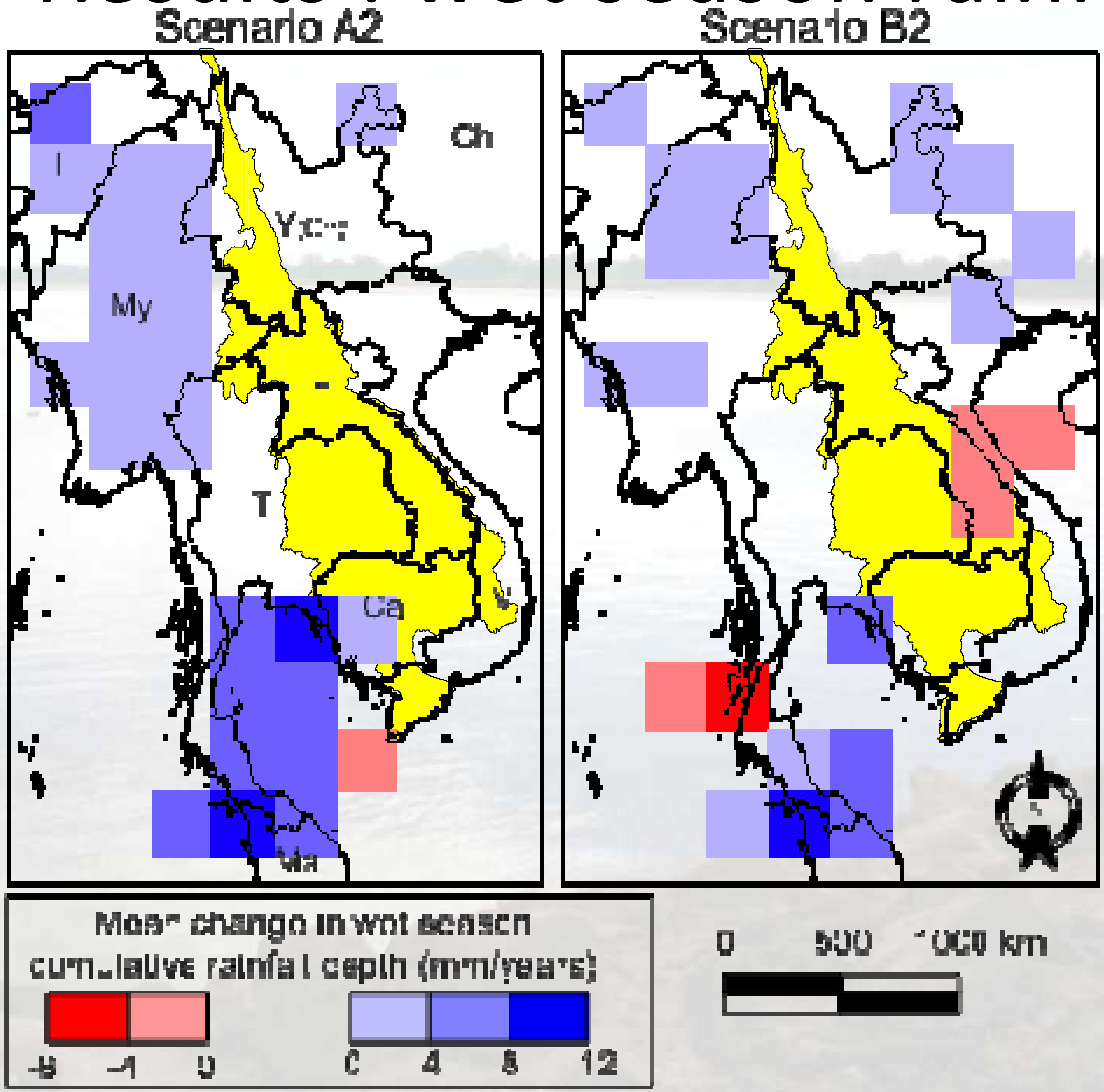

1: Stationarity
mm/year
3500
3000
2500
2000
1500
1000
500
1960
1970
1980
1990
2000
2010
2020
2030
2040


2: Significant increase trend
mm/year
3500
3000
2500
2000
1500
1000
500
1960
1970
1980
1990
2000
2010
2020
2030
2040

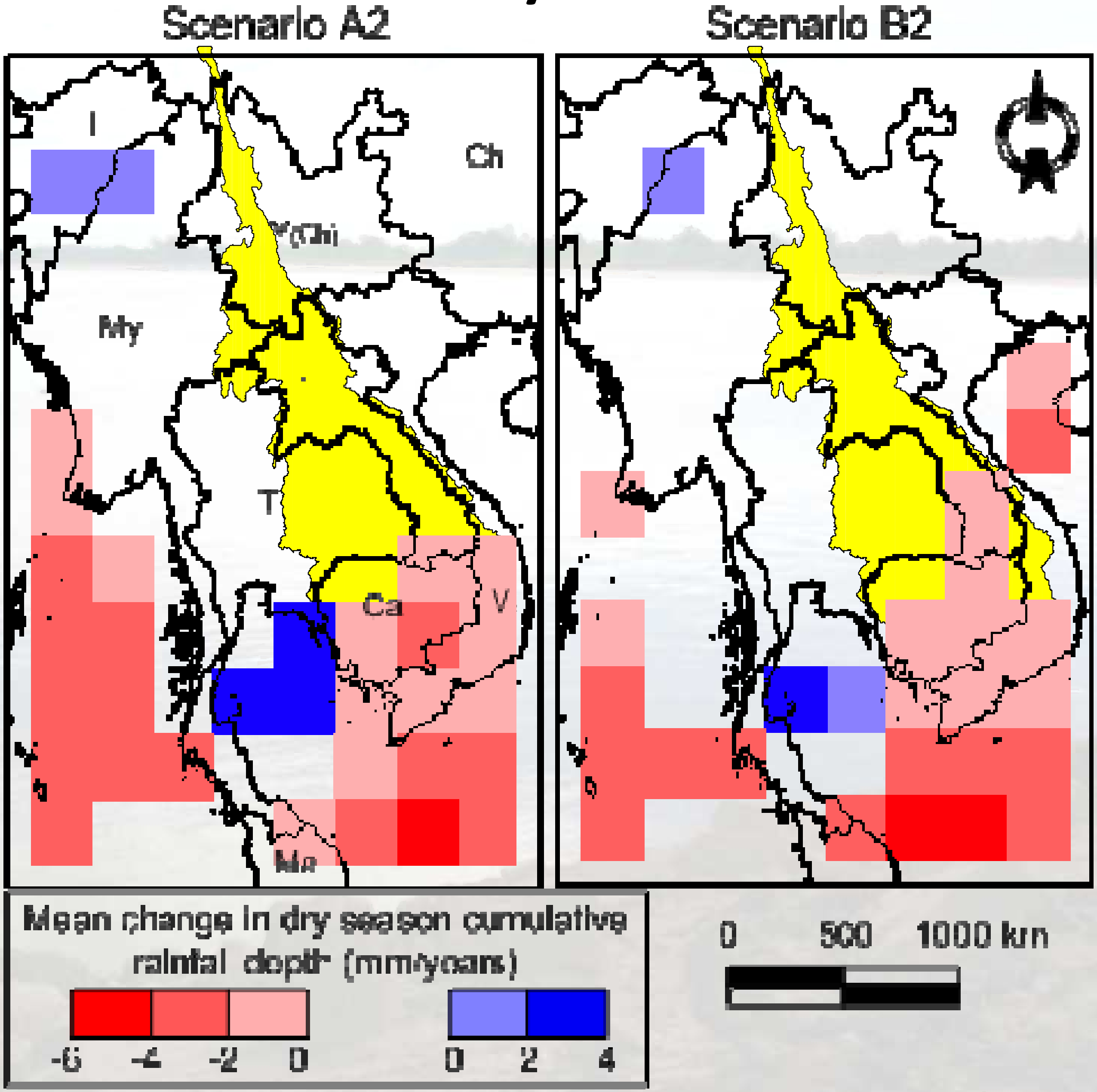
3 Results : number of rainy days



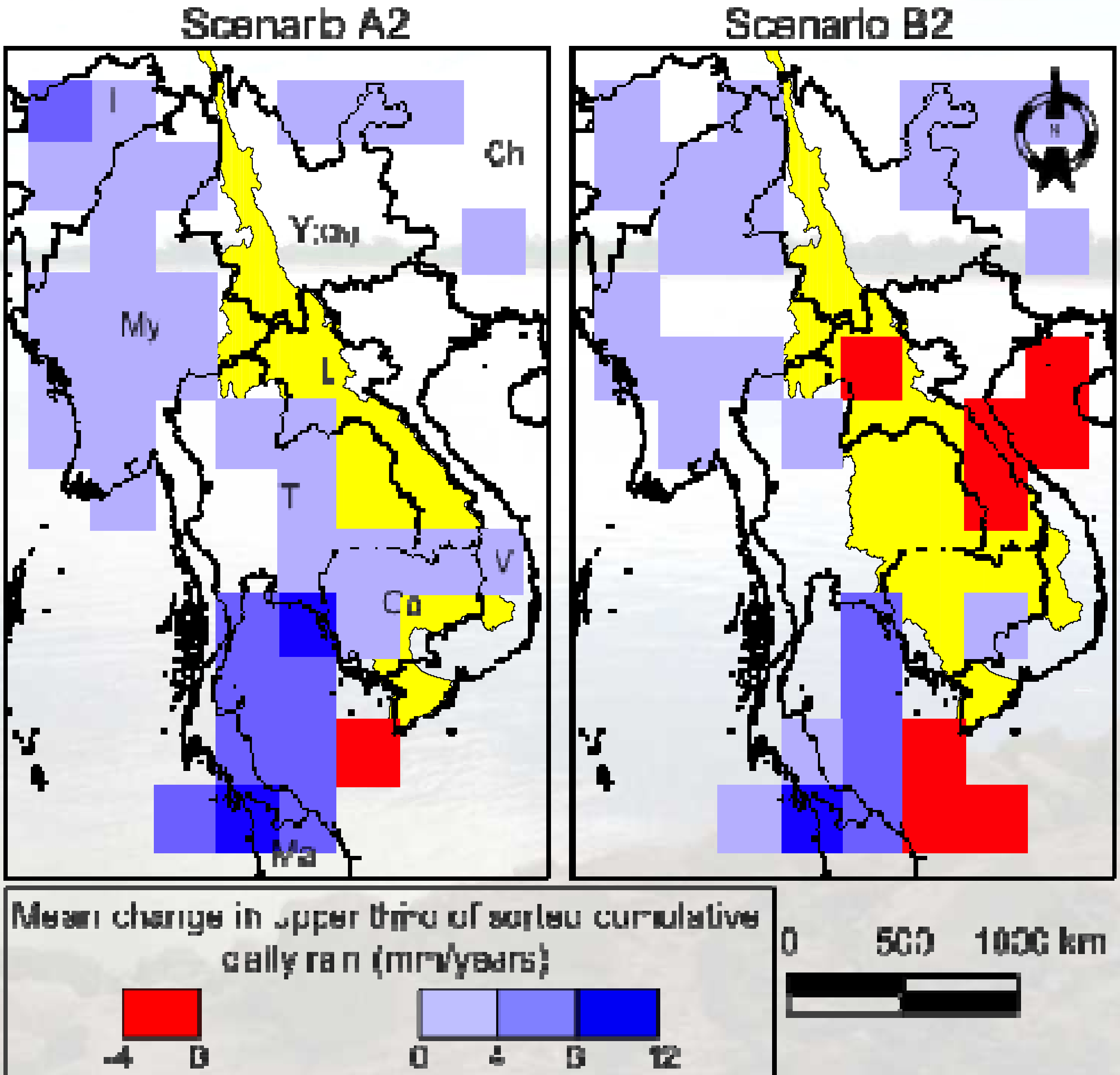
3 Results : wet season rainfall



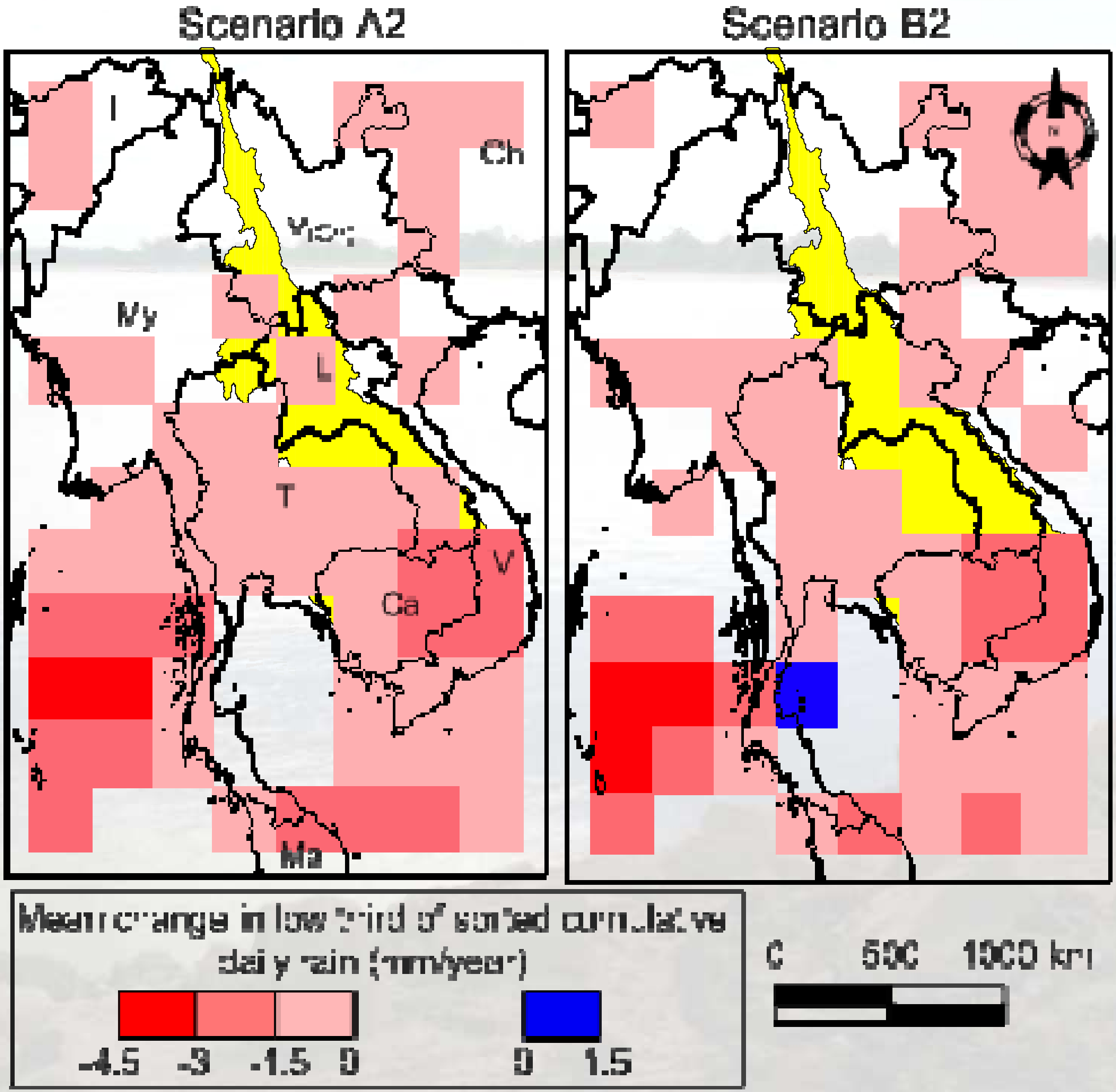
3 Results : dry season rainfall



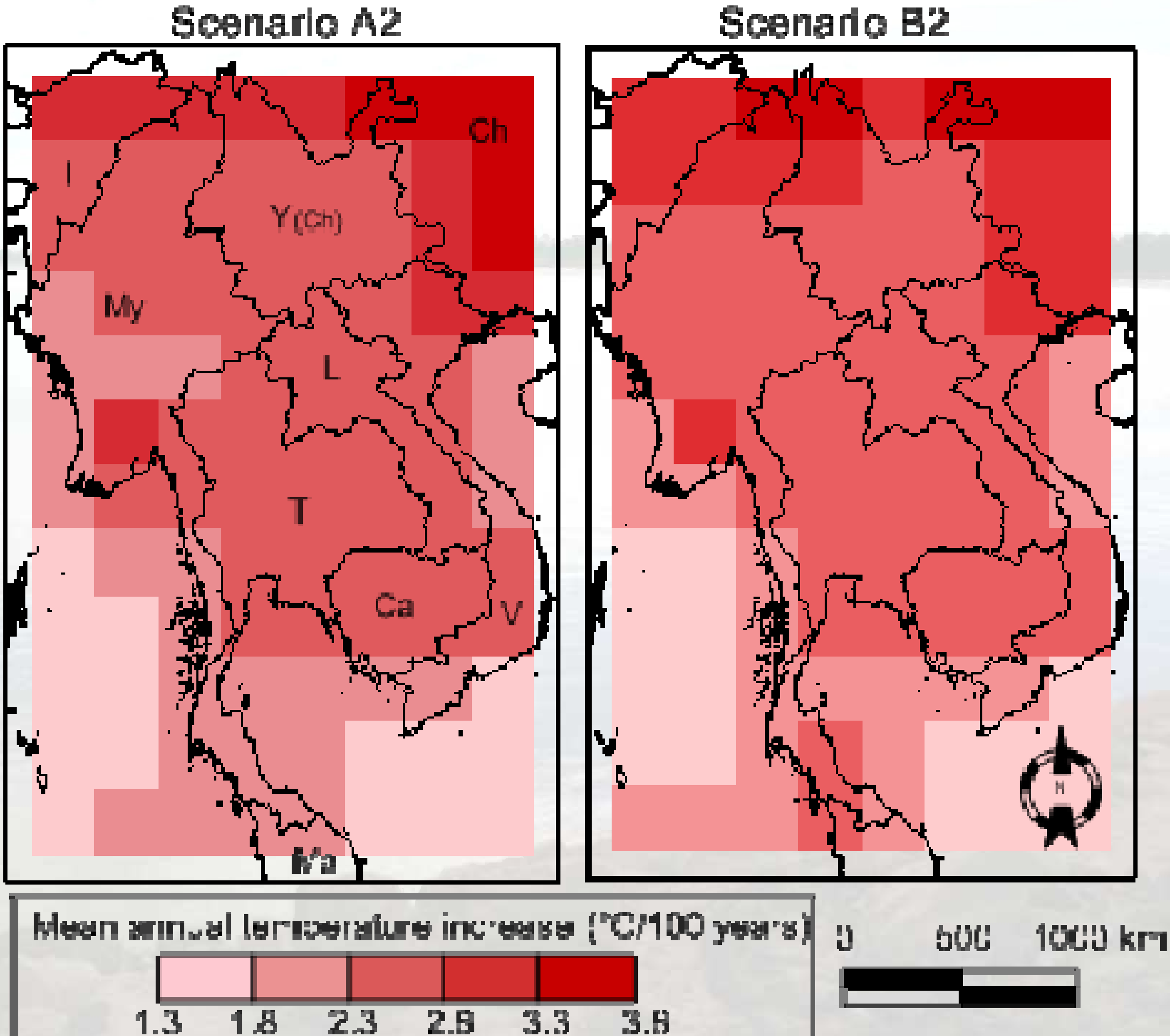
3 Results : Heavy rainfall



3 Results : Light rainfall



3 Results : Annual mean temperature



Discussion/conclusions

- Compared to temperature, rainfall changes in the Lower Mekong Basin over period 1960-2049 are minor
- Clearest tendency for the LMB : decrease of light rainfall and nb rain days during dry season in southern part of the catchment

Discussion/conclusions

- Comparison of our results with previous studies…

Authors	Location	Models	Scenarios	Period	Annual Rain change	Change in seasonal rainfall pattern	Temperature change
Mac Sweeney et al. (UNDP) (2008)	Cambodia, Vietnam	15 GCMs	A2, A1B, B1	1970-2090	From +0.3 to +0.6mm/year	Wetter wet season (+0.8 to +1.5mm/y (Ca) and +0.4 to +1.5mm/y (Vi))and drier dry season(-0.7 to -0.1mm/y (Ca) and -0.3 to -0.1mm/y (Vi))	From +0.00°C/y to +0.06°C/y (Ca and Vi)
Snidvongs et al. (2003)	Lower Mekong catchment	CCAM		From [1×CO_2] to [2×CO_2]		Dry Season drier and longer. 1-month delayed wet season	+ 1°c to +3°c (during about 100 years)
Ruosteenoja et al. (2003)	Southeast Asia	7 GCMs	A1F1, A2, B1, B2	1961-2095	Either >0 or <0, depend on models and scenarios. Almost always unsignificant		From +0.01°C/y to +0.05°C/y
Helsinki University and START (2008)	Lower Mekong catchment	ECHAM4-PRECIS	A2	1960-2099	Increase (not explicitly quantified)		Increase (not explicitly quantified)
Eastham et al. (2008)	Lower Mekong catchment	11 GCMs	A1B	1976-2030	From +0.14mm/y to 10.1mm/y	Wetter wet season (+1.7 to +6.1mm/y) and drier dry season (-0.3mm/y unsignificant)	From +0.012°C/y to +0.014°C/y
ADB (2009)	Thailand, Vietnam	MAGICC (GCM)	A1F1, B2	1990-2100	1990-2050: +1.26 to -1.62mm/y (B2) and - 0.66 to -1.14mm/y (A1F1) ; 1990-2100: +3.27 to +4.91mm/y (A1F1) and -1.63 to -2.45mm/y (B2)		From +0.03°C/y to +0.06°C/y
Hoanh et al. (2003)	Mekong catchment	HADCM3	A2, B2	1960-2099	From -1.64 mm/y to +4.36mm/y		From +0.026°C/y to +0.036°C/y
Present Study	Greater Mekong Sub-region	PRECIS/ ECHAM4	A2, B2	1960-2049	No significant change at the whole GMS scale	Wetter wet season in North Mynamar and Gulf of Thailand (From +0.2 to +0.6mm/y) Drier dry season on both sides of Gulf of Thailand (From -2.5 to -2.8mm/y)	From +0.023°C/y to +0.024°C/y

- In general, the different studies provide consistent results
- Some discrepancies for rainfall, due to natural variability and significance level of detected changes


Thank you for your attention…