



Understanding uncertainties in future evapotranspiration projections to study the impact of climate change on hydrology over France

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Understanding uncertainties in future evapotranspiration projections to study the impact of climate change on hydrology over France.

Session 6 : Understanding the human footprint on the hydrological cycle/processes in a changing world

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➤ Context

Potential evapotranspiration (PE) is an important input for hydrological model.

How will future climate impact potential evapotranspiration?

Understanding the uncertainty sources:

How future climate uncertainty, coming from RCPs, GCMs and RCMs, are transferred to PE projections?

How much the uncertainty in PE formulation contributes to overall climate impact uncertainty?

-> PART 1

Adapting PE formulations to account for surface–atmosphere interactions in a simplified way:

What are the differences between several existing schemes to account for elevated atmospheric CO₂ concentrations in PE estimations ?

What are the consequences on runoff projections ?

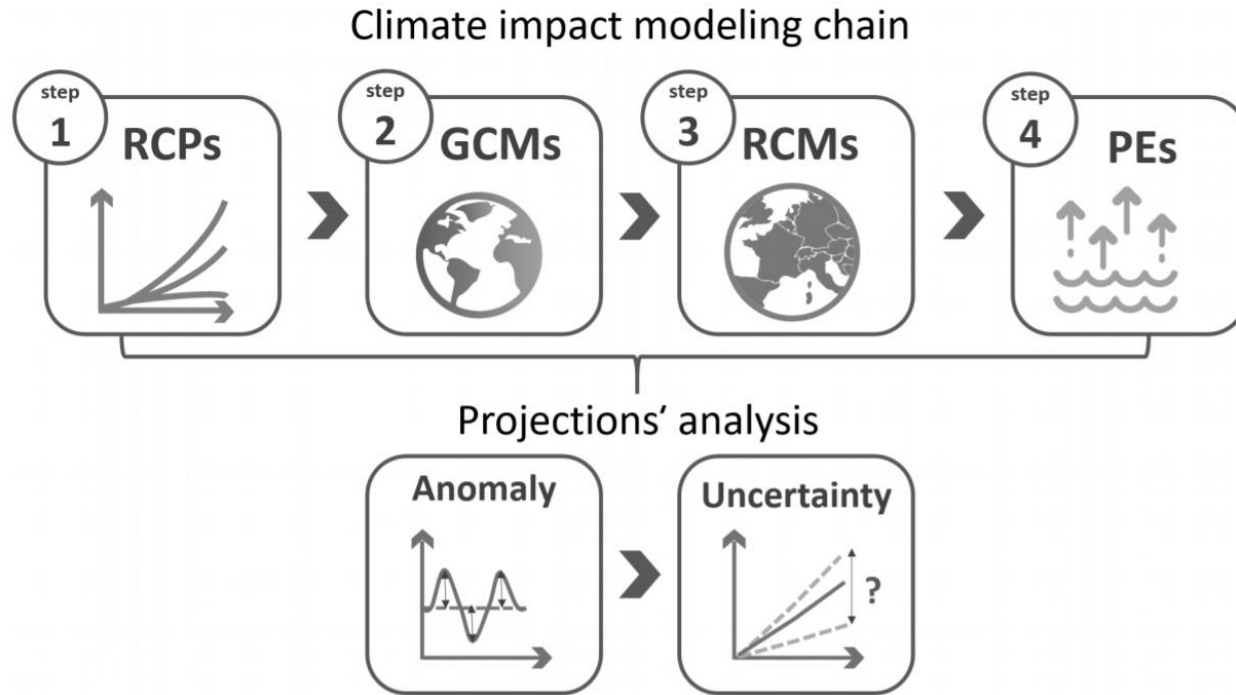
-> PART 2

PART 1: The contribution of potential evaporation formulation to uncertainty

➤ Approach to quantify uncertainty

An ensemble of 30 GCM– RCM couples, from CMIP5 under 3 different RCPs (EURO-CORDEX)

7 PE formulations selected including physically and empirically based method.



1) Complete the available ensemble of climate projections with a *bayesian process*

2) An *analysis of the variance* is performed to quantify the contribution of models

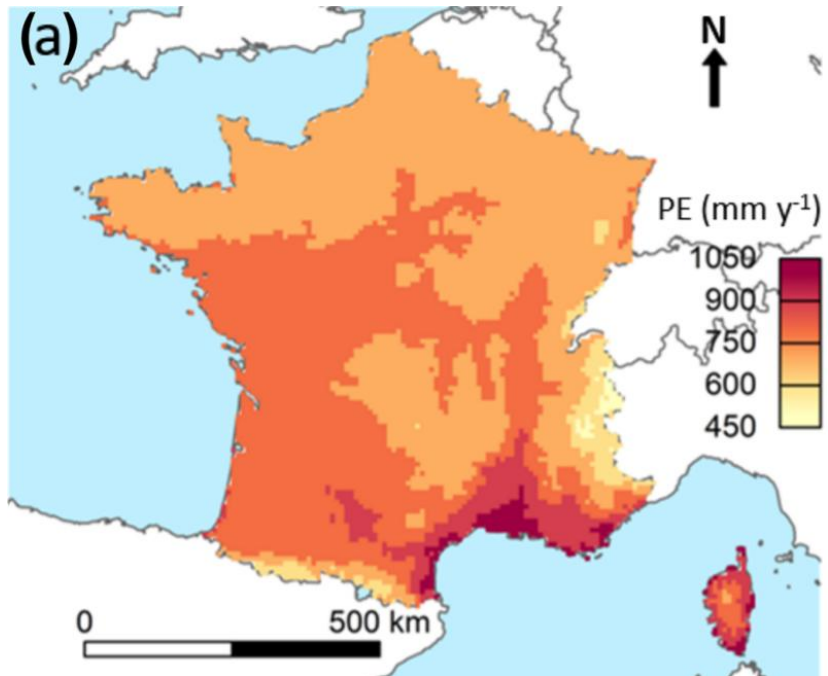
QUALYPSO method is available on R CRAN (G. Evin et al., 2019)

QE-ANOVA approach for climate change analyses established by Hingray et Saïd (2014)

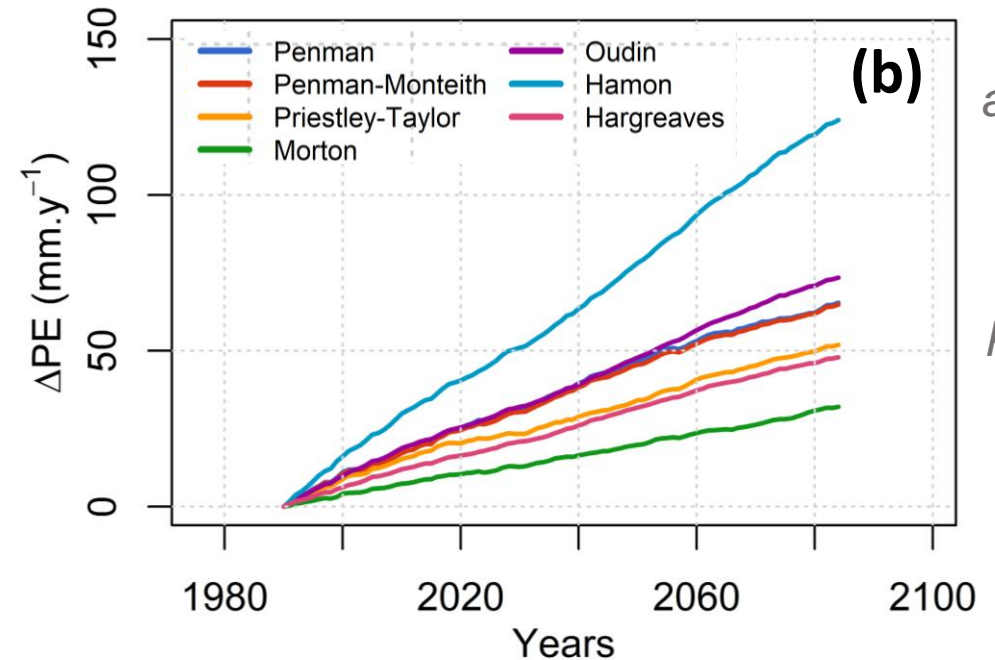
Formulation	Variable
Penman	SR, T, RH, u
Penman-Monteith	SR, T, RH, u
Priestley-Taylor	SR, T
Morton	SR, T, RH
Oudin	T
Hamon	T
Hargreaves	T

SR: Solar Radiation, T: Temperature, RH: Relative Humidity, u: wind speed

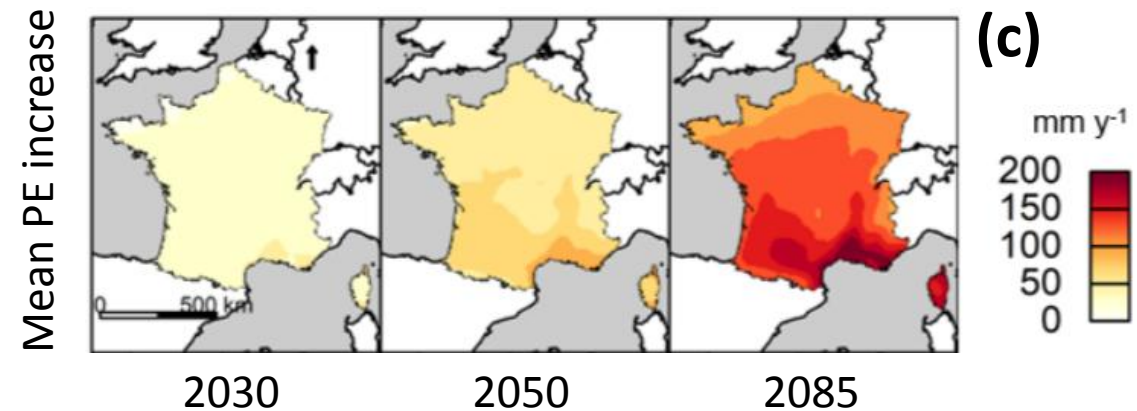
➤ Results: potential evapotranspiration projections



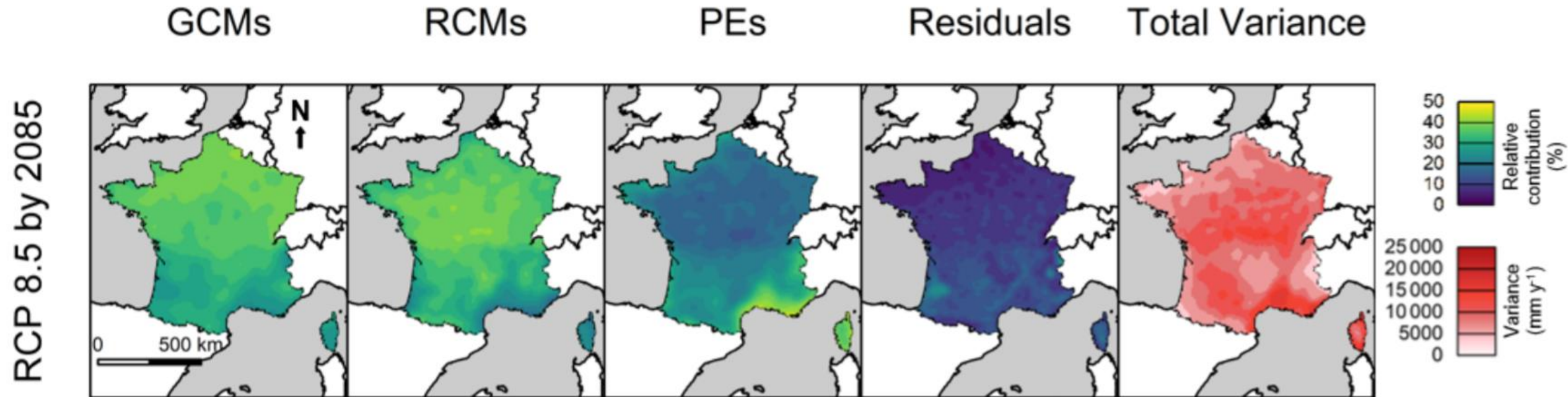
Mean annual PE (mm y⁻¹) computed with climate projections from 1976 to 2005 over France



Anomalies are computed with a 30-years reference period, and a 30-years rolling mean is applied.



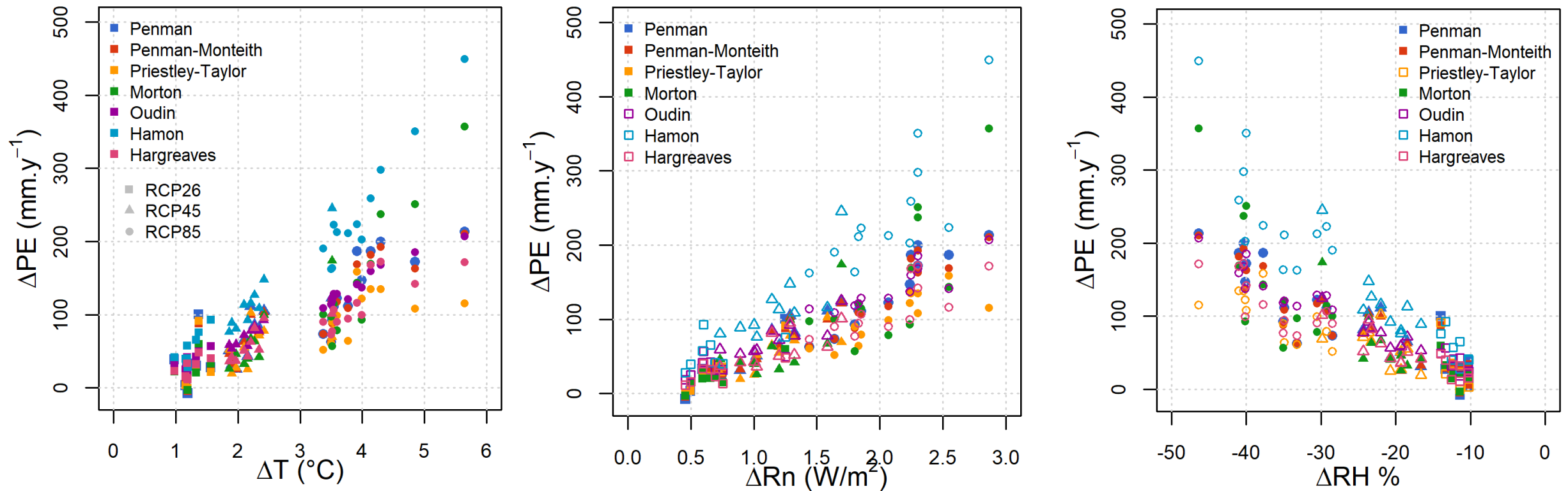
➤ Results: Uncertainty analysis



PE formulation is a minor source of uncertainty in PE future anomaly on most of the country.
However, it is the major sources of uncertainty over the mediterranean region.

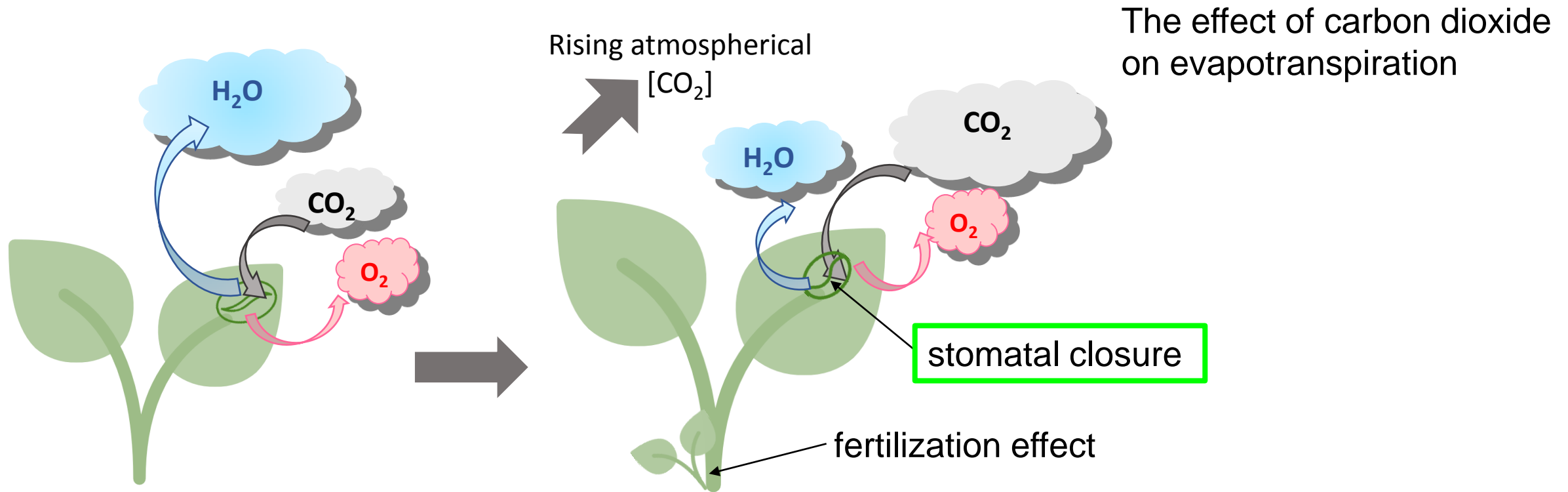
➤ Results: Role of climate variables

- Correlation between PE anomalies and temperature (T), net radiation (Rn), and relative humidity (RH).
- Even formulations that do not use Rn and RH, the associated PE estimation is still consistent.



PART 2: The effect of CO₂ on stomatal resistance in Penman–Monteith PE formulation

➤ Investigate the role of other variables



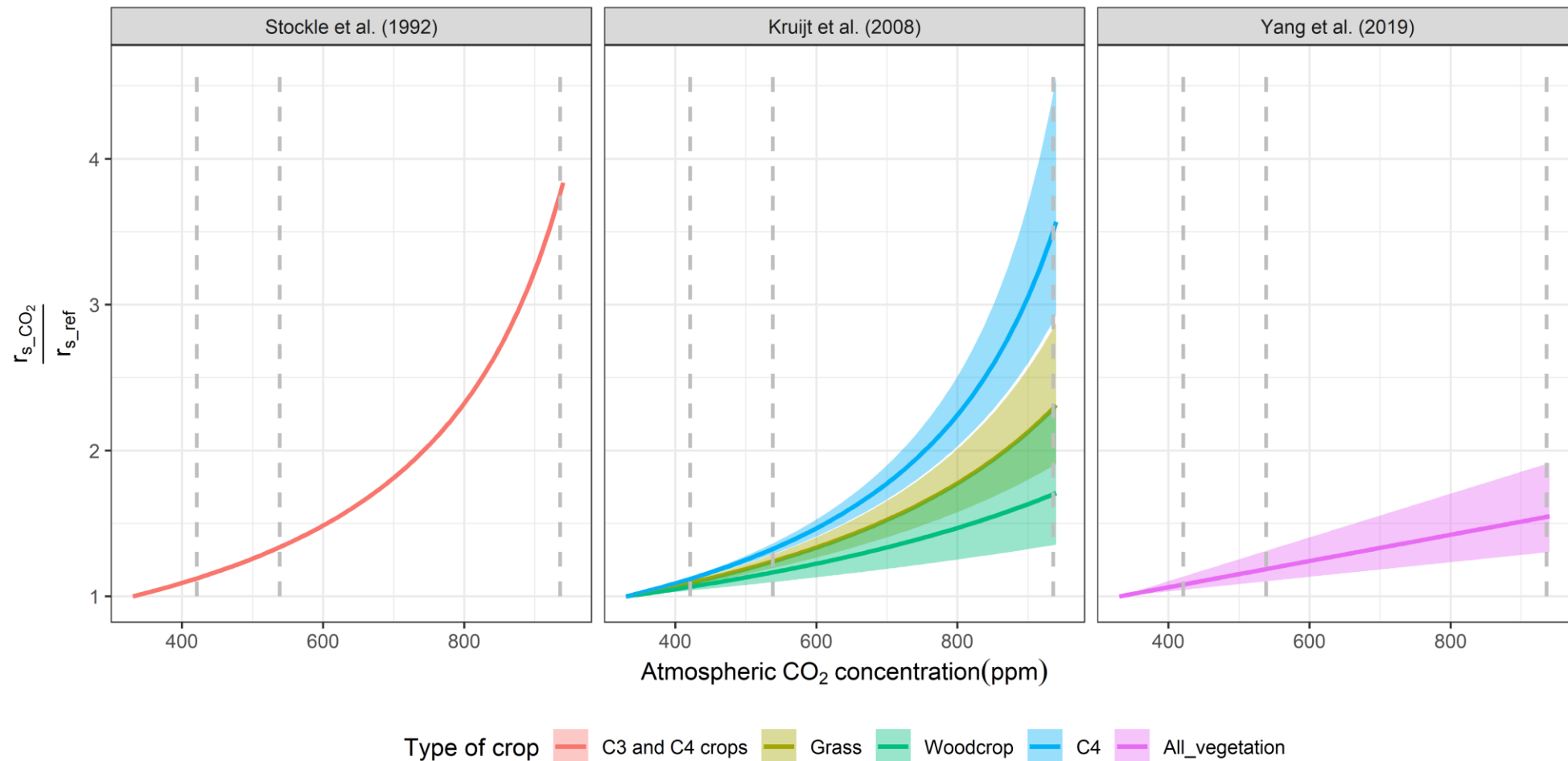
Penman–Monteith (FA056)
formulation :

$$\lambda \cdot PE = \frac{\Delta R_n + (\rho_a \cdot \frac{C_p}{r_a})(e_s - e_a)}{\Delta + \gamma(1 + \frac{r_s}{r_a})}$$

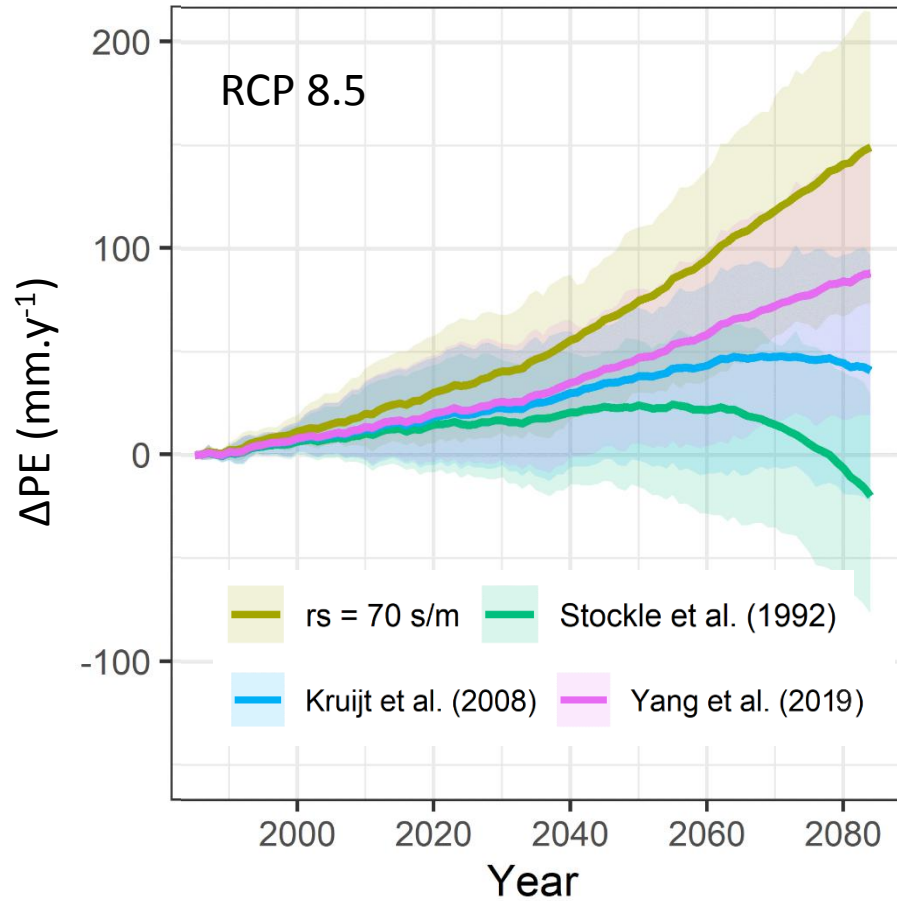
$r_s = 70 \text{ s.m}^{-1}$

➤ Investigate the role of CO₂ on evapotranspiration

We compare 3 options from the literature to compute the effect of CO₂ on stomatal resistance



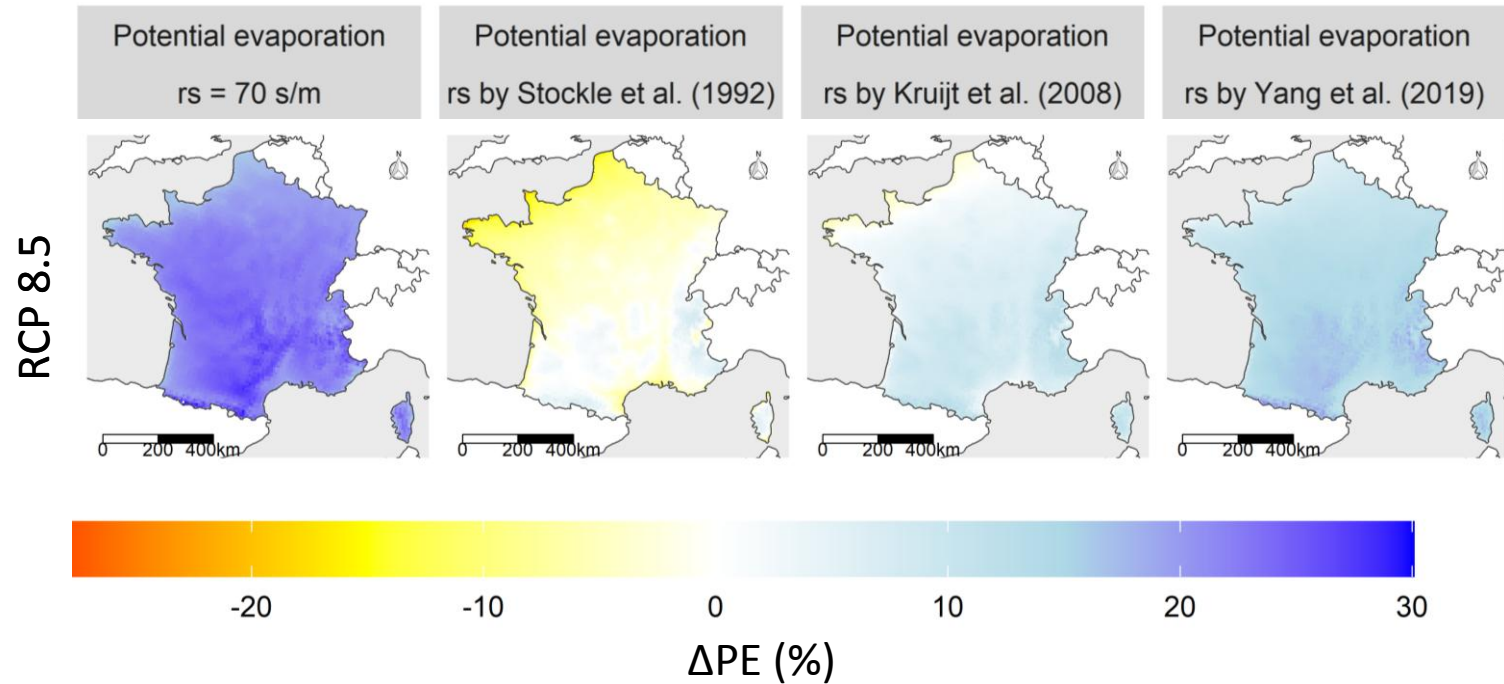
➤ Results: potential evapotranspiration projections with r_s changes



the evolutions in PE anomalies diverge and the trends depend greatly on the formulation of r_s .

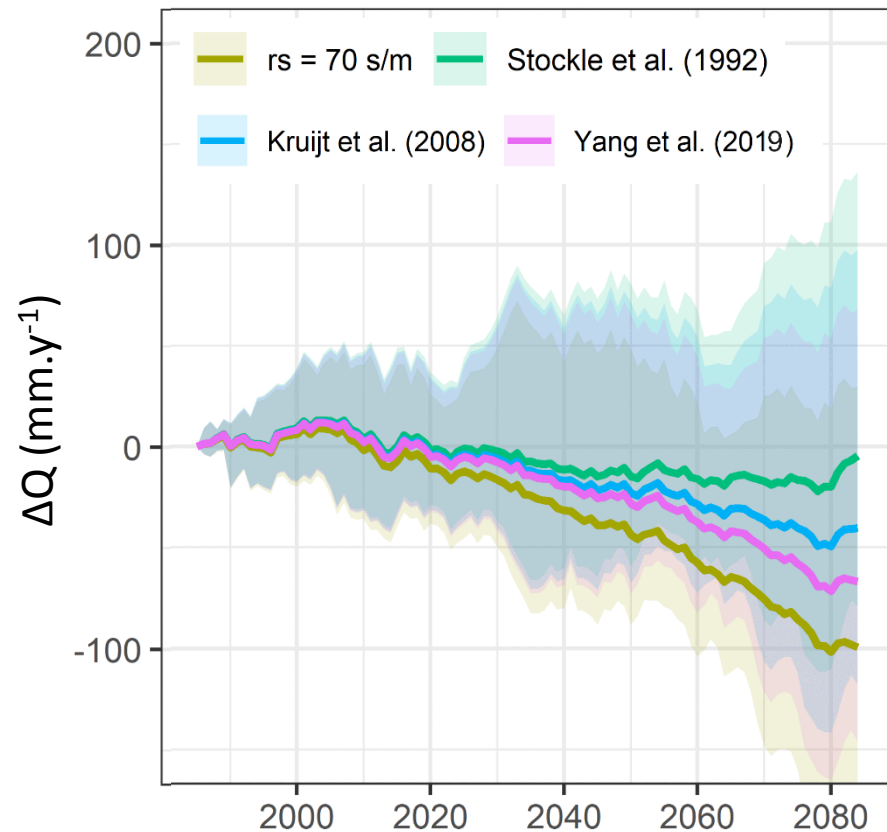
RCP 8.5 scenario: 935 ppm in 2100

Spatial patterns of changes

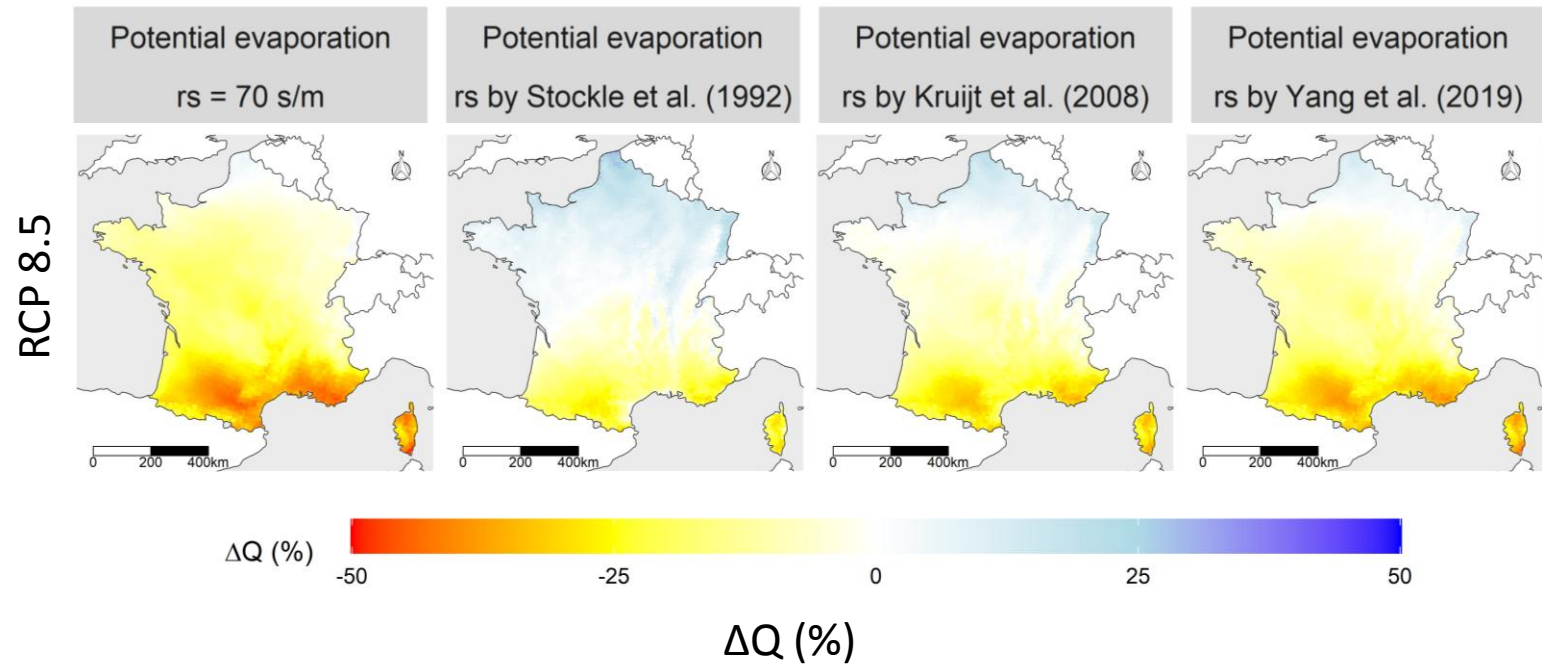


➤ Results: hydrological projections

We assess their impact on future runoff using the Budyko framework over France.



The implications of these different PE evolutions for simulated runoff are evident although dependent also on precipitation evolution



➤ Our findings

- PE formulations uncertainty is minor compared to other uncertainty sources (RCPs, GCMs, and RCMs) for PE anomaly, but not in the Mediterranean part.
- Consistency between the climate variables used in the EP calculations is maintained in the future.
- CO₂ effect in Penman-Monteith formulation leads to reduced PE amounts
- CO₂ limits the annual runoff reduction, and even increases annual runoff in some regions. Whereas the classic Penman–Monteith formulation leads to decreasing runoff projections over most of France.

➤ Perspectives

- Including the fertilization effect of CO₂ by adding the leaf area index (LAI) to our projections.