26 NOVEMBRO

IMPACTO DAS ALTERAÇÕES CLIMÁTICAS NOS RECURSOS HÍDRICOS

IPBeja
Instituto Politécnico de Beja

IV JORNADAS DOS RECURSOS HÍDRICOS

11h10 **Sessão 2. O Ciclo Hidrológico**

Alterações nas características climatológicas e hidrológicas | João Corte Real (UÉ)

João Corte Real[1,2] (apresentação)

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DEPARTAMENTO DE AERONÁUTICA E TRANSPORTES

organização: ASSOCIAÇÃO PORTUGUESA DOS RECURSOS HÍDRICOS - NÚCLEO REGIONAL DO SUL; IPBeja

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u évora UNIVERSIDADE DE ÉVORA

COMPETE; QREN Quadro de Referência Estratégico Nacional; União Europeia Fundo Europeu de Desenvolvimento Regional

Governo da República Portuguesa FCT Fundação para a Ciência e a Tecnologia

icaam Instituto de Ciências Agrárias e Ambientais Mediterrânicas Knowledge connecting land, food and people

Alterações nas Características Climatológicas e Hidrológicas

Rong Zhang, João Corte-Real, Madalena Moreira

Overview

- Motivation
- General downscaling methods
- Data and methodology
- Downscaling of CTL and FUT climates
- Conclusions

Motivation

Future hydrological impacts' assessment

- To get **hourly** synthetic **rainfall** series;
- To get **daily** synthetic FAO PM **PET** series.

Remember:

(1) They are **not available** in RCM ouputs;

(2) RCM data need to be **bias-corrected**;

General downscaling methods

- Dynamical downscaling:

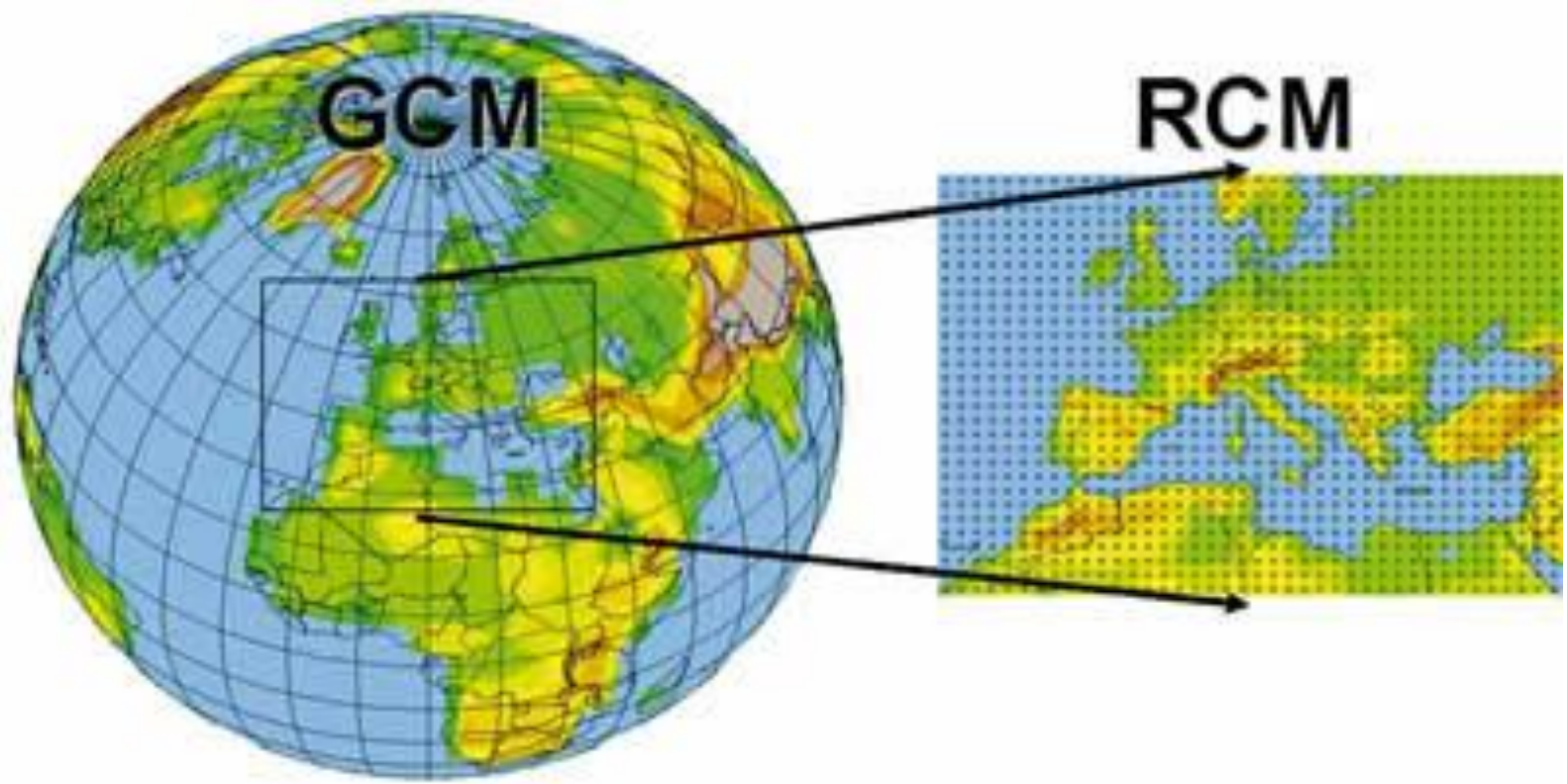
  Regional climate models (RCMs) or

  Limited-area models (LAMs).

- Statistical-stochastic downscaling:
  - ✓Regression models;
  - ✓Weather typing schemes;
  - ✓Weather generators.

Fowler *et al*. (2007)

Schematic depiction of RCM nesting approach



Giorgi 2008

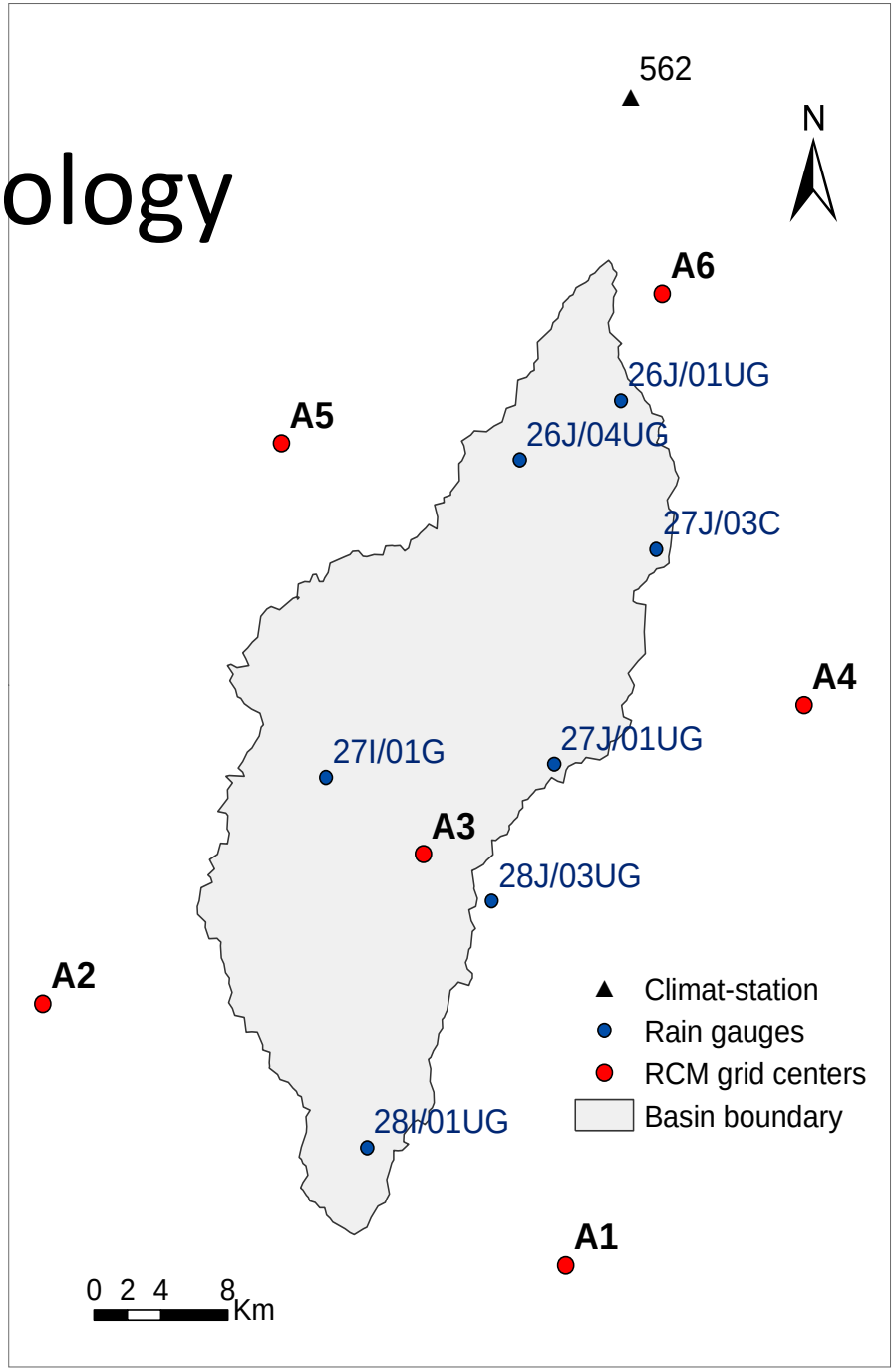
Data and methodology

Observed data:

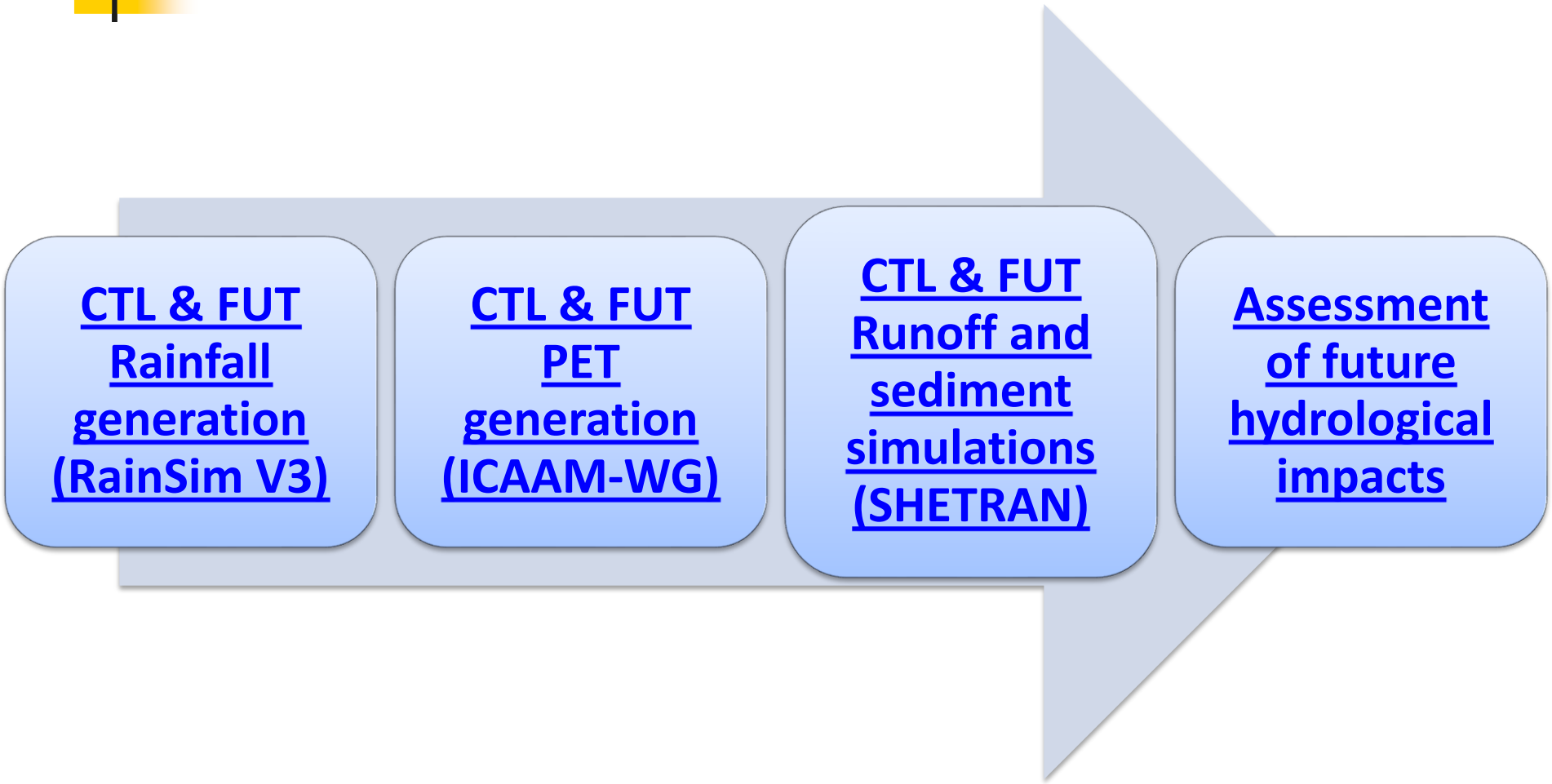
1. DP, **1981–2010**, at 7 rain gauges (SNIRH), 1 climat-station (IPMA);
2. HP, **2001–2010**, at 62 Guadiana rain gauges (SNIRH) ;
3. DT_{max}, DT_{min}, VP, WS, SS, **1981–2004** at 1 climat-station (IPMA) .

RCM data: DP, DT_{max}, DT_{min} at grids A_1–A_6 (RCM: HadRM3Q0; AOGCM: HadCM3Q0; SRES A1B) for

1. **CTL: 1981–2010**;
2. **FUT: 2041–2070**.



Data and **methodology**



Rainfall simulation (CTL/FUT)

Preparation of rainfall statistics

Calibration of RainSim V3

Data generation and analysis

Validation of RainSim V3

Preparation of rainfall statistics

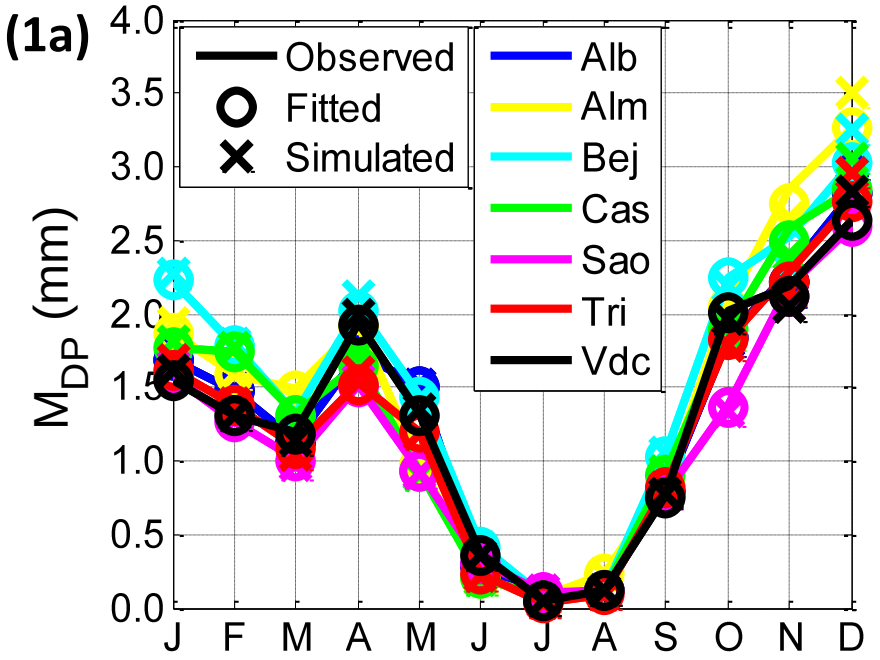
Rainfall statistics:

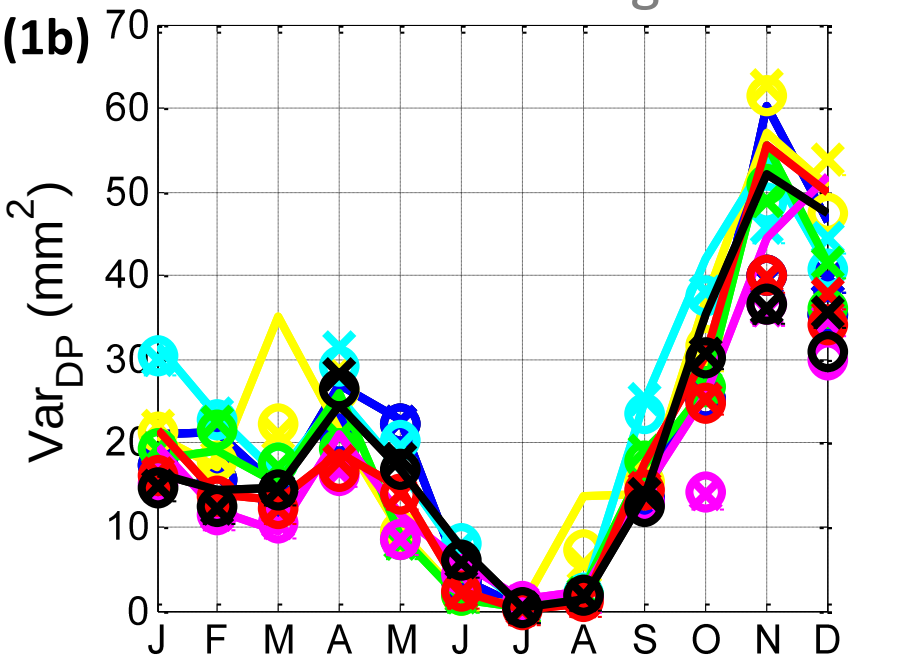
Monthly M_{DP}, Var_{DP}, $Skew_{DP}$, $Pdry_{DP1.0}$, $L1AC_{DP}$, XC_{DP}, Var_{HP}, $Skew_{HP}$, $Pdry_{HP0.1}$;

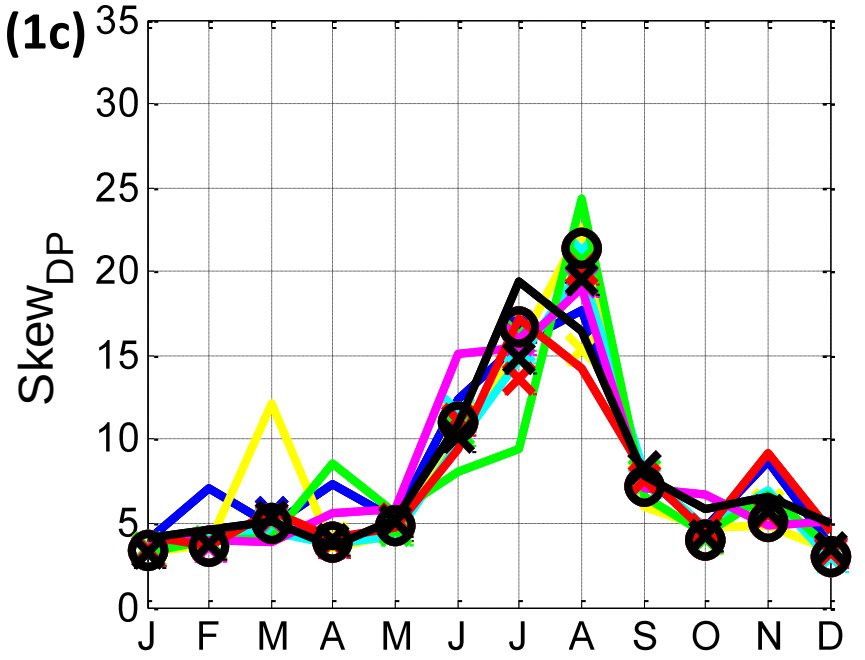
- CTL period: 1981–2010, OBS statistics;
- FUT period: 2041 – 2070,

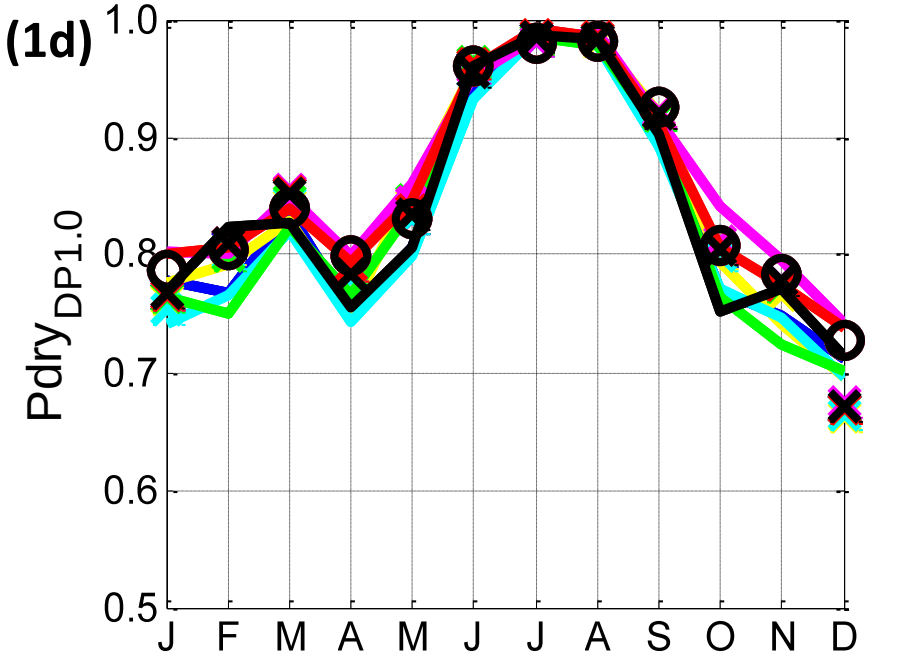
  CF statistic = FUT_{RCM} statistic / CTL_{RCM} statistic,

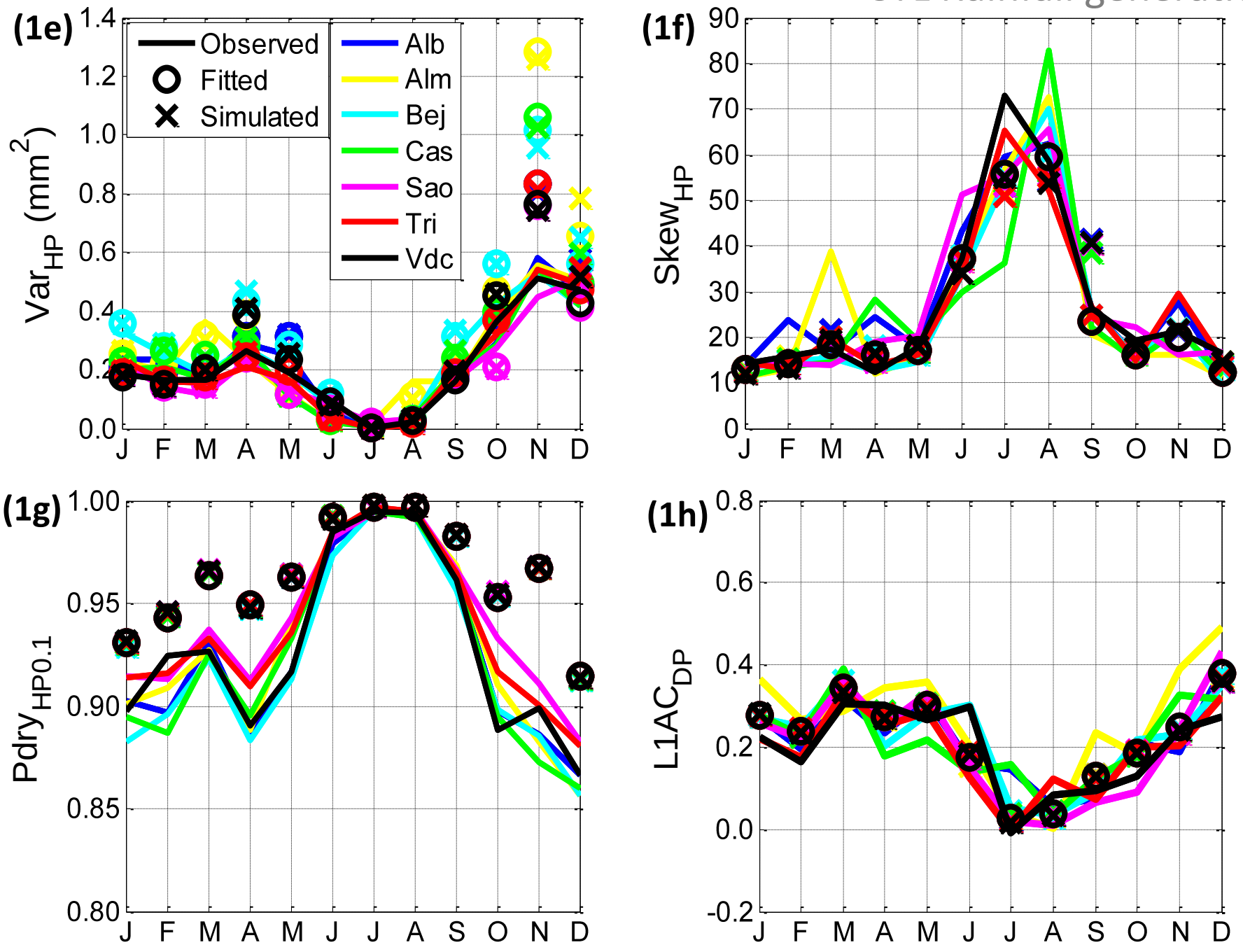
  Proj statistic = CF × OBS statistic.

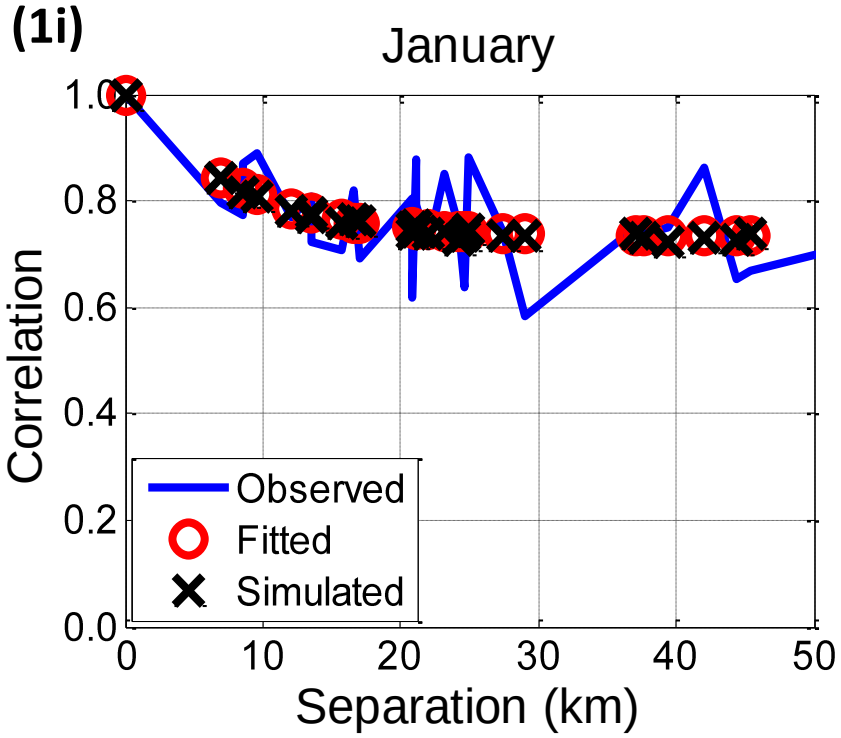

(1a)
Observed
Fitted
Simulated
Alb
Alm
Bej
Cas
Sao
Tri
Vdc
M_{DP} (mm)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
J F M A M J J A S O N D

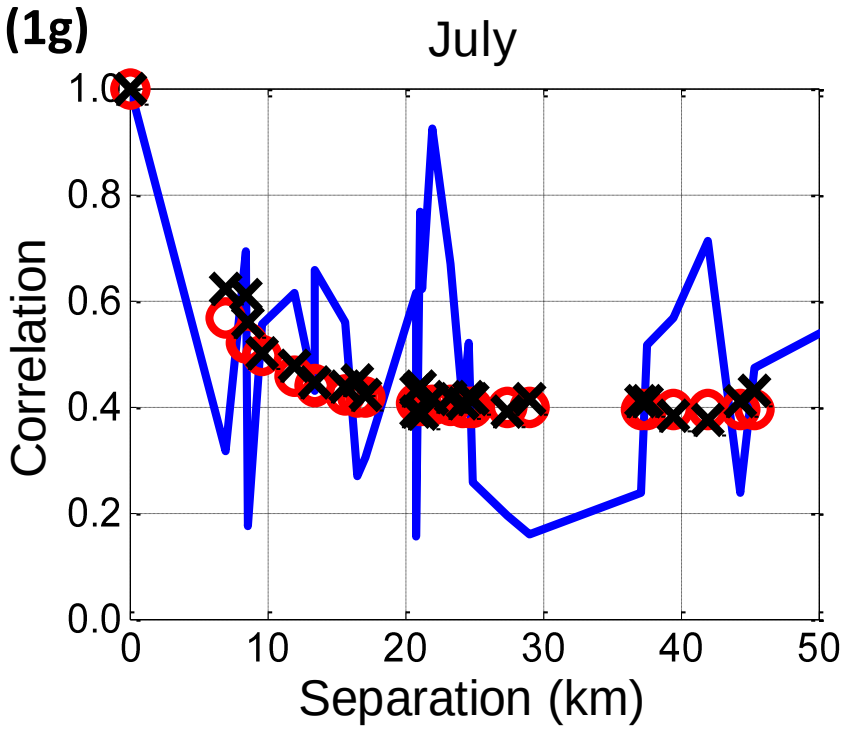

(1b)
Var_{DP} (mm^2)
70
60
50
40
30
20
10
0
J F M A M J J A S O N D

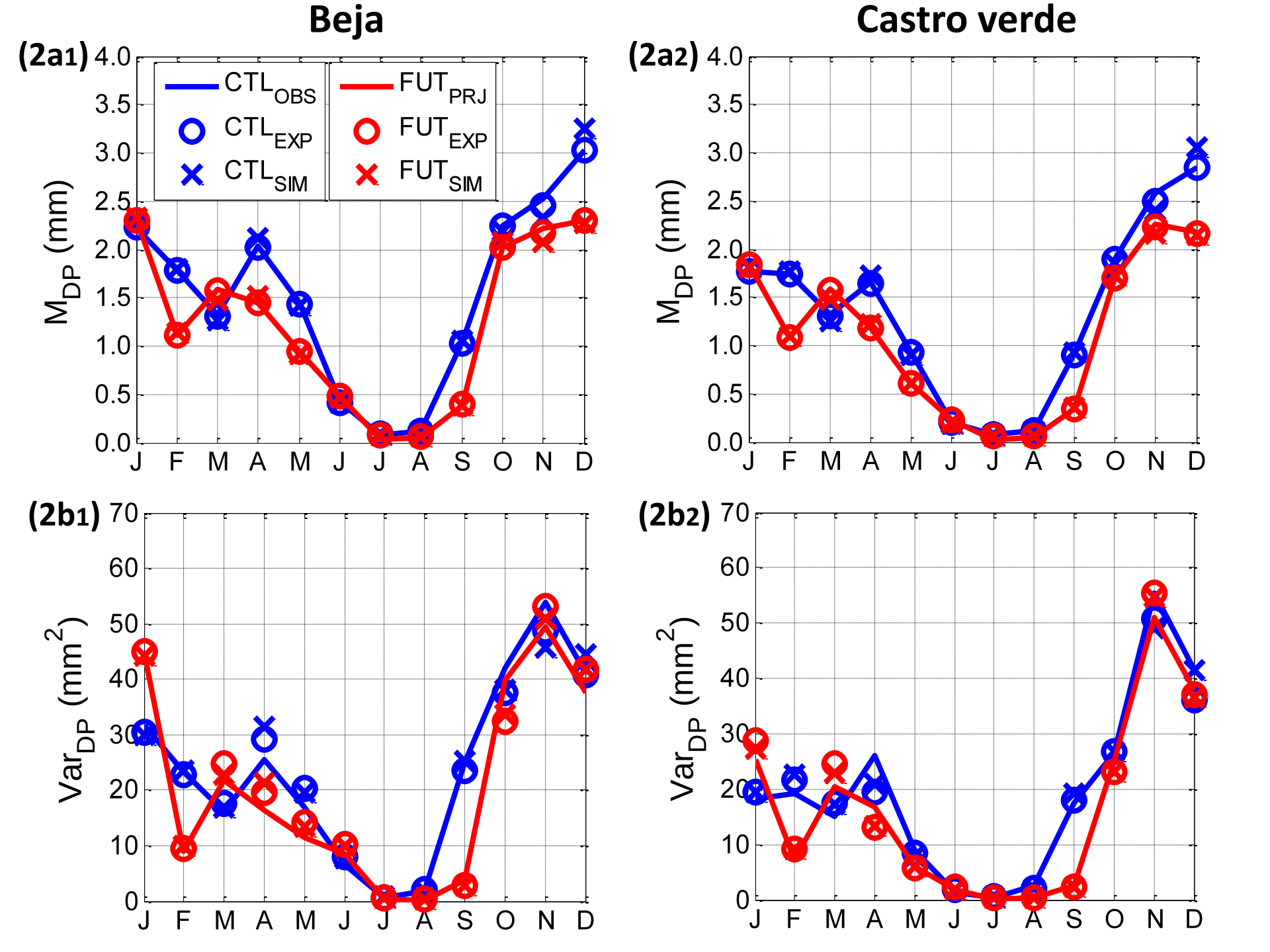

(1c)
$Skew_{DP}$
35
30
25
20
15
10
5
0
J F M A M J J A S O N D

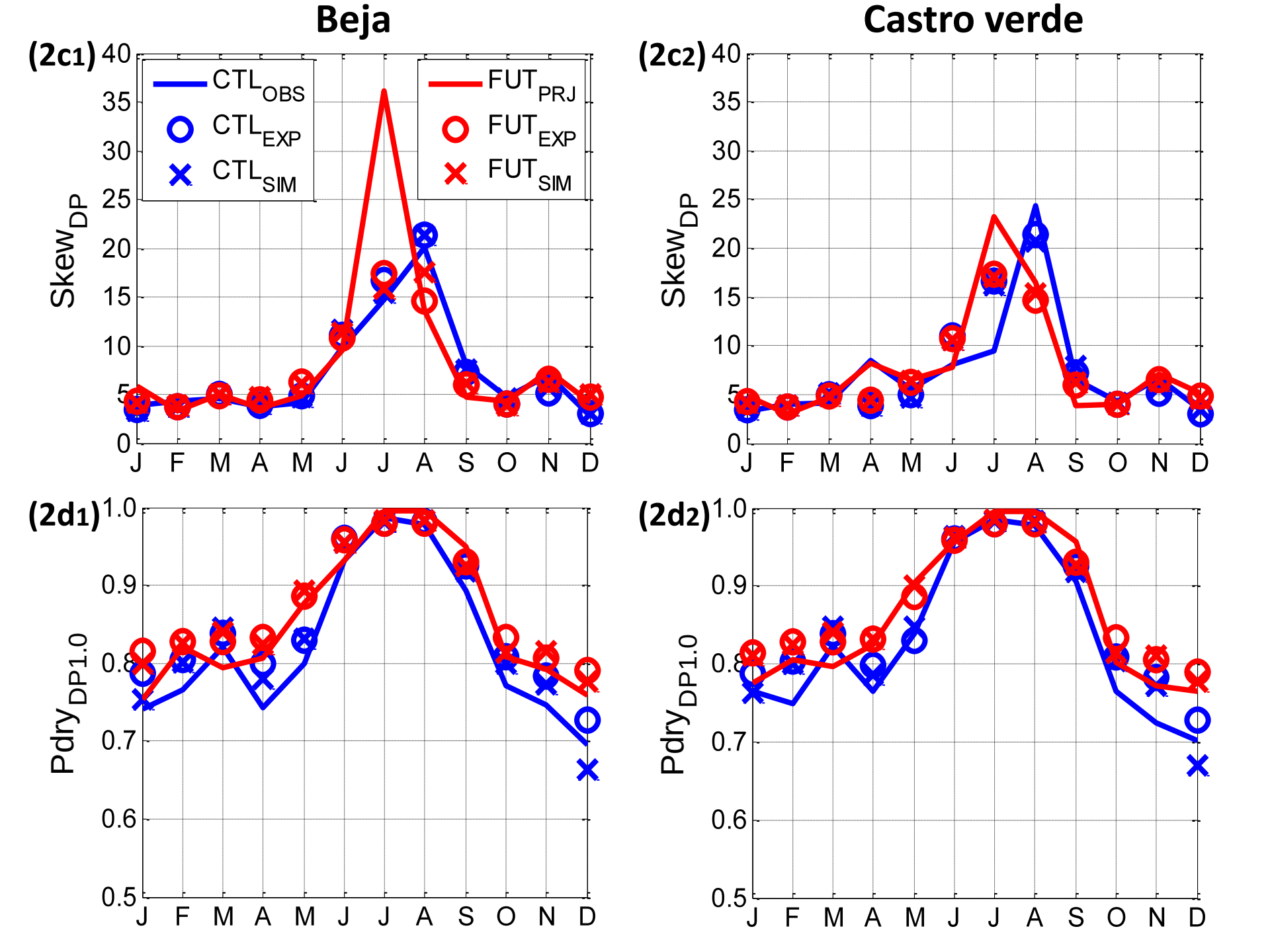

(1d)
$Pdry_{DP1.0}$
1.0
0.9
0.8
0.7
0.6
0.5
J F M A M J J A S O N D

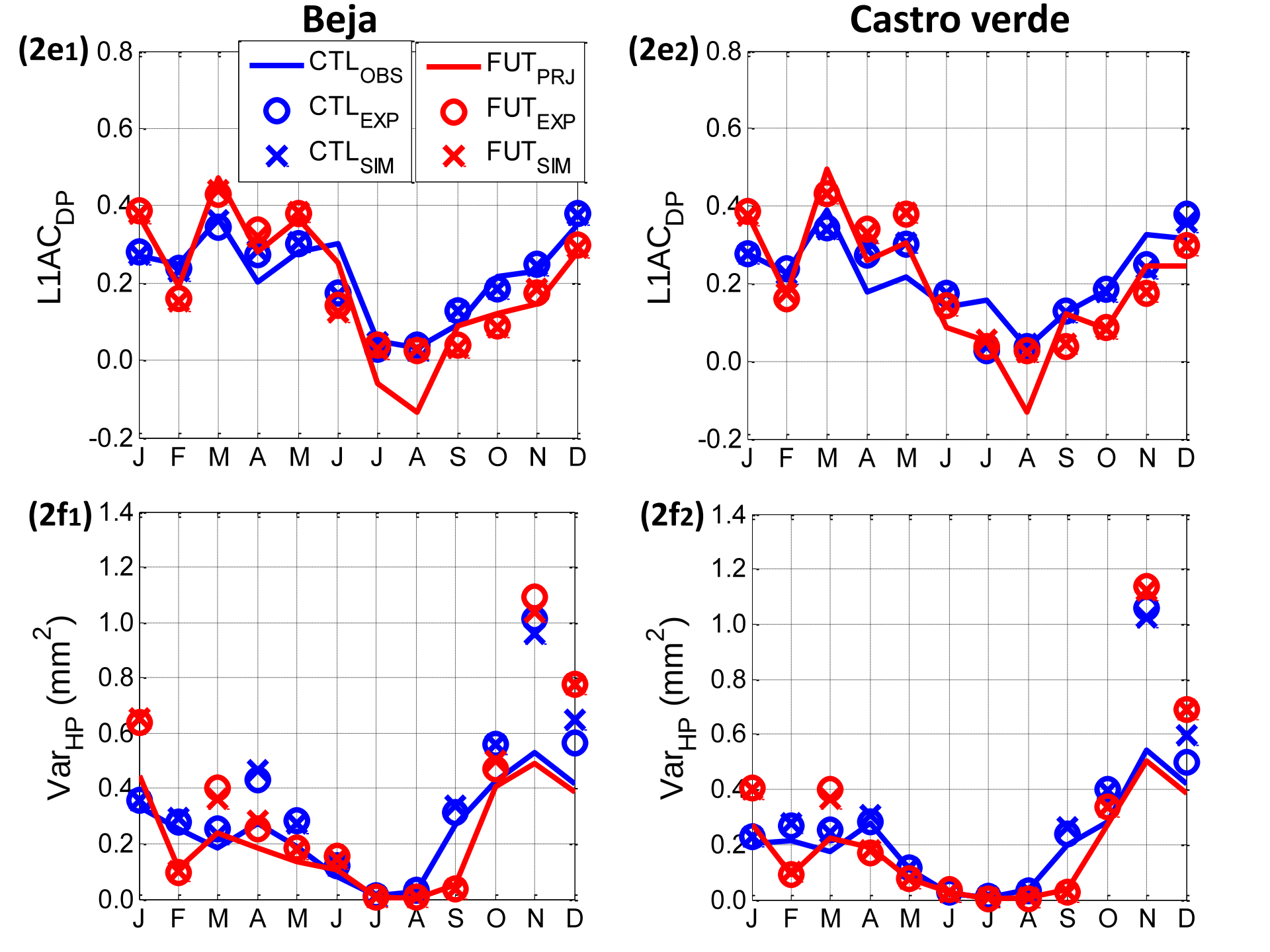

(1e)
Observed
Fitted
Simulated
Alb
Alm
Bej
Cas
Sao
Tri
Vdc
Var_HP (mm^2)
(1f)
Skew_HP
(1g)
Pdry_HP0.1
(1h)
L1AC_DP
J F M A M J J A S O N D

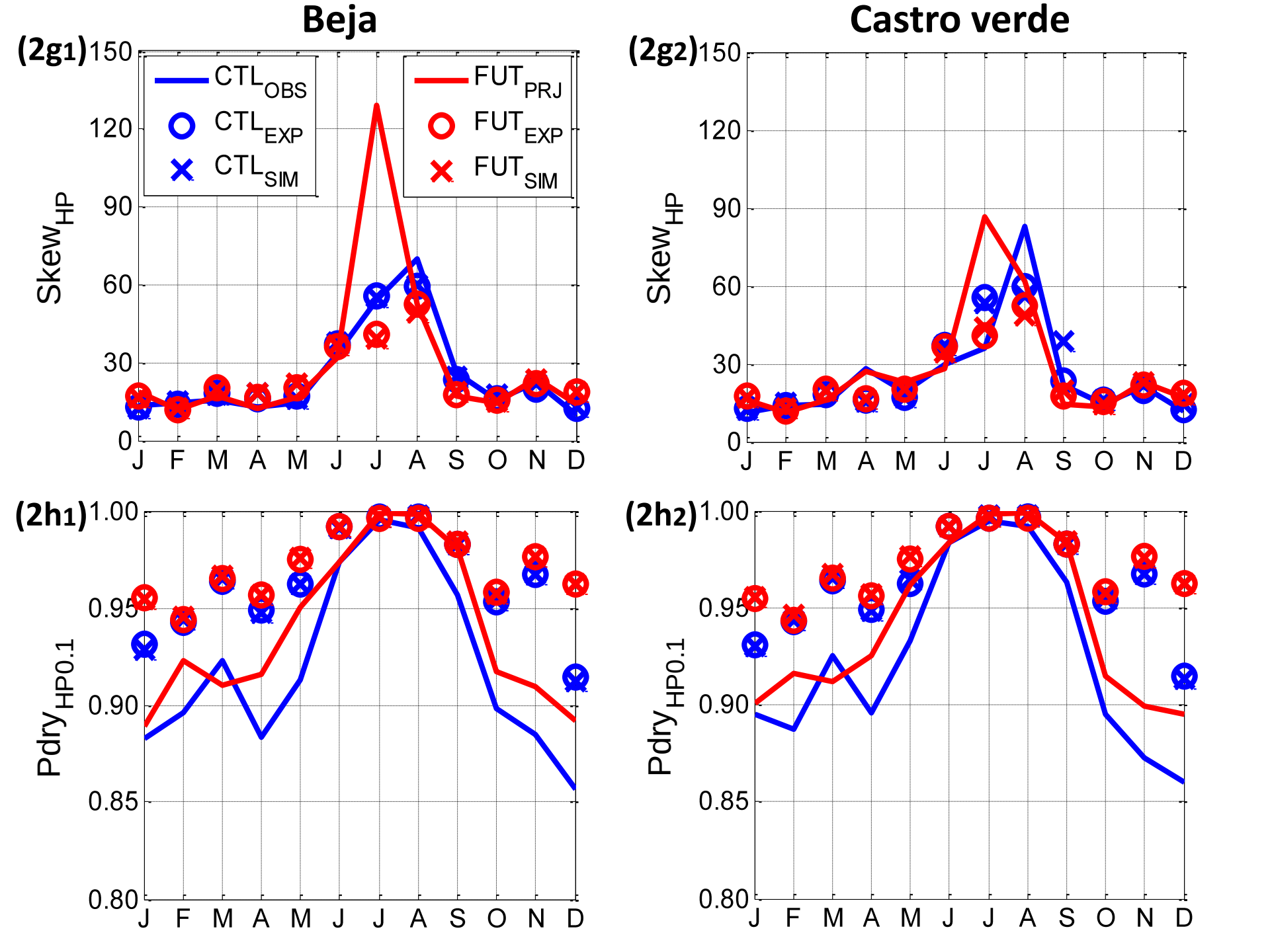

(1i)
January
Correlation
Separation (km)
Observed
Fitted
Simulated
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50


(1g)
July
Correlation
Separation (km)
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50

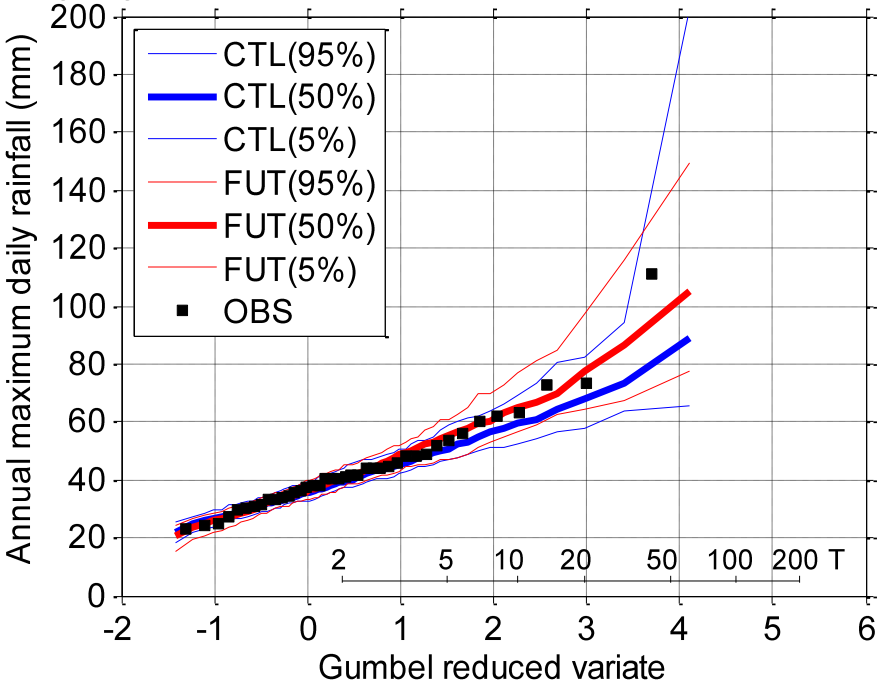

Beja
Castro verde
(2a1)
(2a2)
(2b1)
(2b2)
CTL_OBS
CTL_EXP
CTL_SIM
FUT_PRJ
FUT_EXP
FUT_SIM
M_DP (mm)
Var_DP (mm^2)
J F M A M J J A S O N D


Beja
Castro verde
(2c1)
(2c2)
(2d1)
(2d2)
CTL_OBS
CTL_EXP
CTL_SIM
FUT_PRJ
FUT_EXP
FUT_SIM
Skew_DP
Pdry_DP1.0
J F M A M J J A S O N D

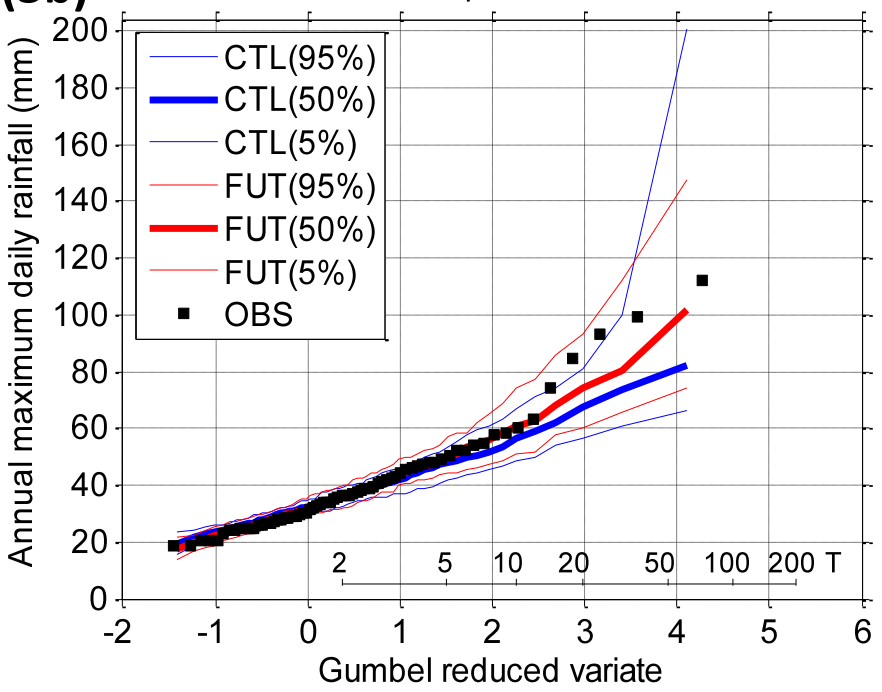

Beja
Castro verde
(2e1)
(2e2)
(2f1)
(2f2)
CTL_OBS
CTL_EXP
CTL_SIM
FUT_PRJ
FUT_EXP
FUT_SIM
L1AC_DP
Var_HP (mm^2)
J F M A M J J A S O N D


Beja
Castro verde
(2g1)
(2g2)
(2h1)
(2h2)
CTL_OBS
CTL_EXP
CTL_SIM
FUT_PRJ
FUT_EXP
FUT_SIM
Skew_HP
Pdry_HP0.1
0
30
60
90
120
150
0.80
0.85
0.90
0.95
1.00
J F M A M J J A S O N D

(3a)



(3b)



Conclusions from Figs 3a–3b:

1. OBS annual maxima are well reproduced for the CTL period;
2. For extremes with return periods between 20 and 50 years, FUT annual maxima are around 15% higher than the CTL values.

PET generation

- ✓ Fundamentals of the ICAAM-WG model;
- ✓ Daily CTL PET simulation;
- ✓ Daily FUT PET simulation;
- ✓ Evaluation of future PET climate.

Fundamentals of ICAAM-WG

Structure of **ICAAM-WG**:

- Rainfall model (RainSim V3): generated DP series;
- Weather model (autoregressive processes): generates T_{max}, T_{min}, VP, WS and SS.

$$T = (T_{max} + T_{min})/2; \; R = T_{max} - T_{min}$$

ICAAM-WG **weather model**

Development procedure:

1. Getting standard anomalies of T, R, VP, WS and SS for 24 (12×2) half-month periods;
2. Getting autoregressive models of T and R for 6 transition states of weather;
3. Getting autoregressive models of VP, WS and SS.

Preparation of weather statistics

Weather statistics:
24 half-monthly mean & var of T, R, VP, WS and SS;

- CTL period: 1981–2010, OBS statistics;
- FUT period: 2041 – 2070,

For T, R: CF mean = FUT_{RCM} mean – CTL_{RCM} mean,
Proj mean = CF mean + OBS mean.
CF var = FUT_{RCM} var / CTL_{RCM} var,
Proj var = CF var × OBS var.

For VP, WS and SS:
Proj statistics = OBS statistics (assumption).

CTL PET simulation

Get autoregressive eqs of daily **T** and **R**

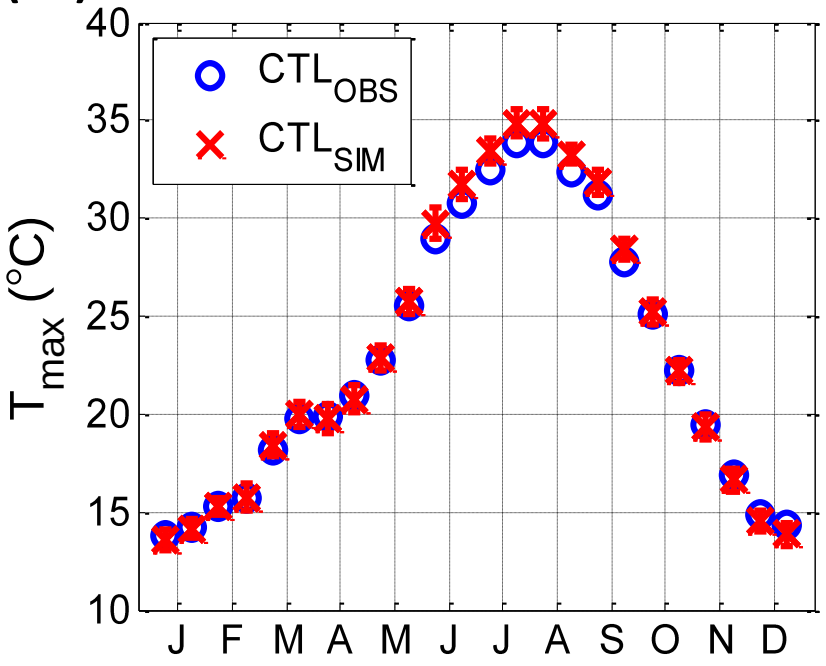
Generate syn CTL daily **Tmax, Tmin**

Get autoregressive eqs of daily **VP, WS, SS**

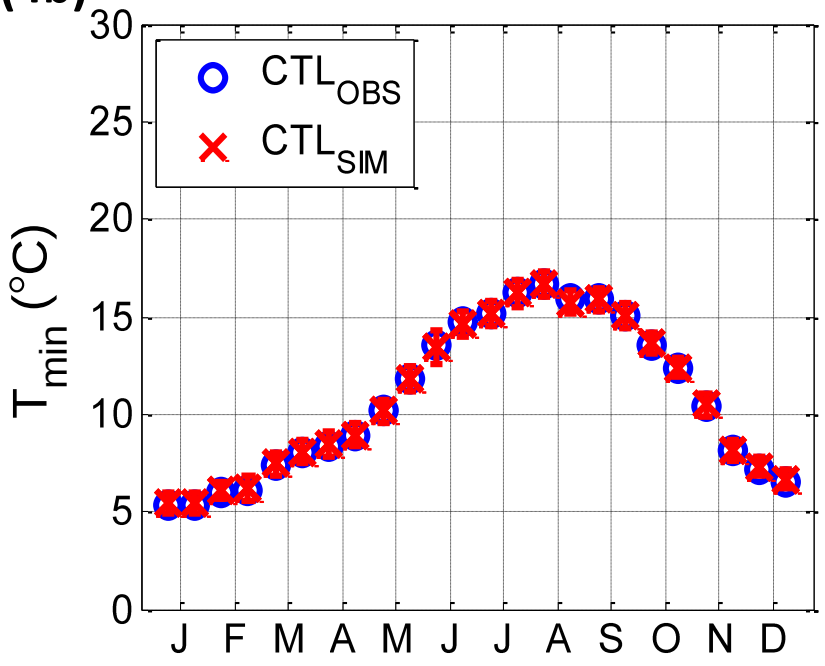
Generate syn CTL daily **VP, WS, SS**

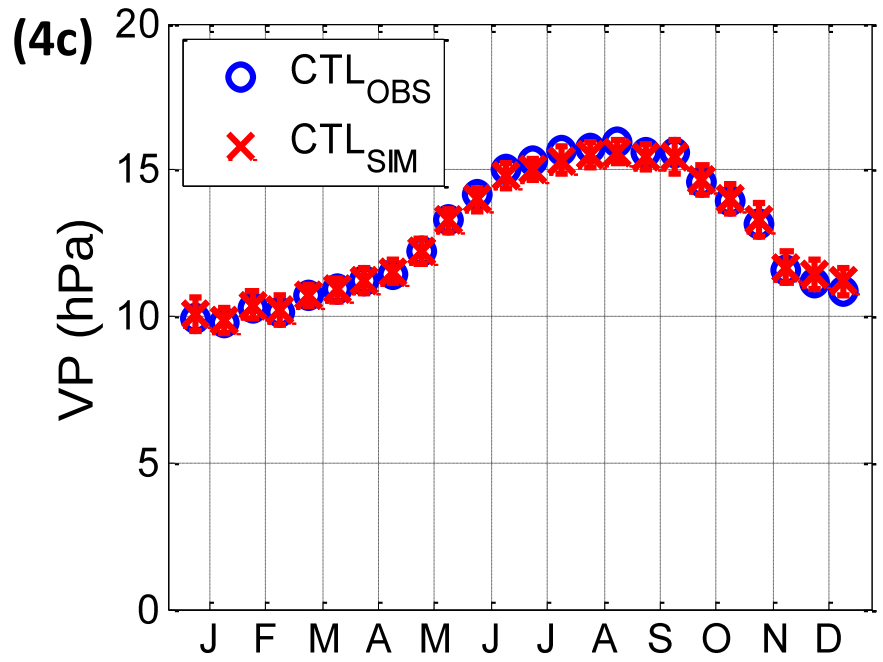
Get syn CTL PET series

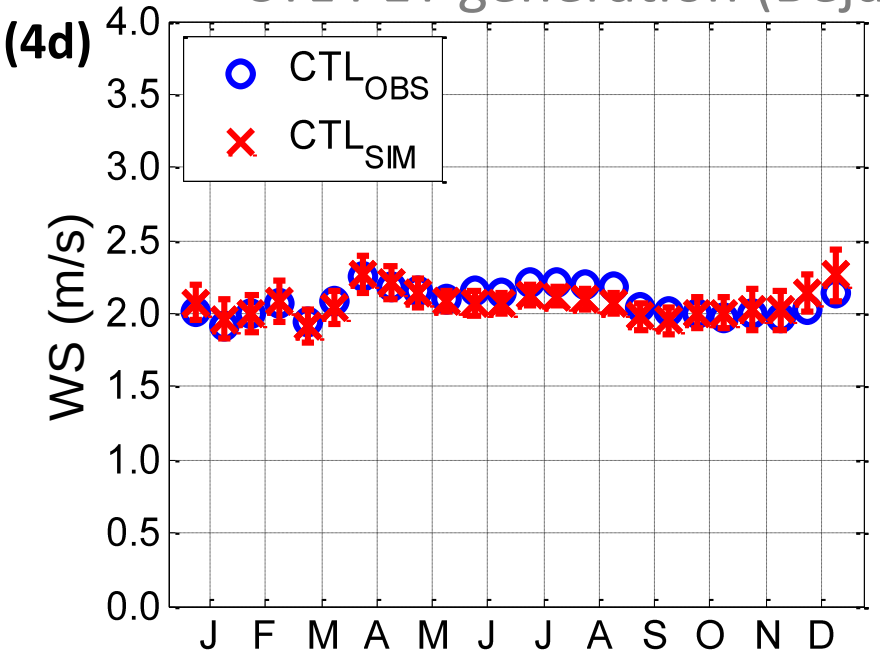
(4a)

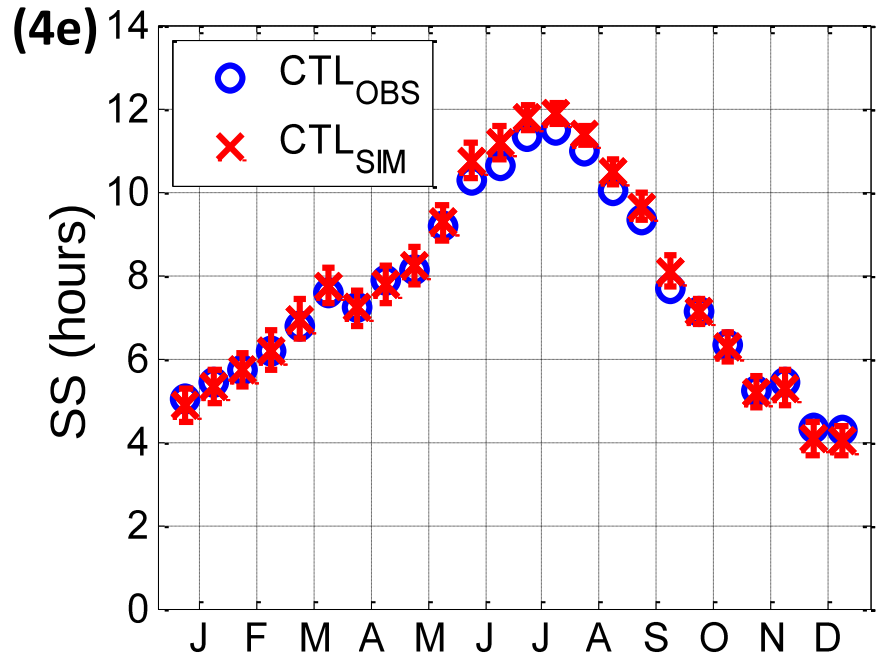

CTL_OBS
CTL_SIM
T_max (°C)
40
35
30
25
20
15
10
J F M A M J J A S O N D

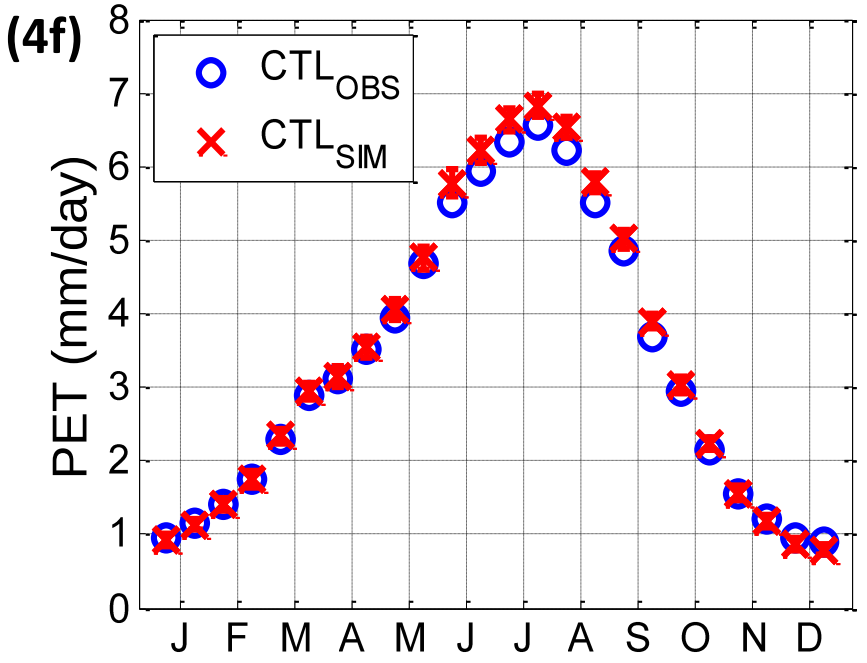
(4b)


CTL_OBS
CTL_SIM
T_min (°C)
30
25
20
15
10
5
0
J F M A M J J A S O N D


(4c)
VP (hPa)
CTL_OBS
CTL_SIM
0
5
10
15
20
J F M A M J J A S O N D


(4d)
WS (m/s)
CTL_OBS
CTL_SIM
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
J F M A M J J A S O N D


(4e)
SS (hours)
CTL_OBS
CTL_SIM
0
2
4
6
8
10
12
14
J F M A M J J A S O N D


(4f)
PET (mm/day)
CTL_OBS
CTL_SIM
0
1
2
3
4
5
6
7
8
J F M A M J J A S O N D

FUT PET simulation

Prepare FUT **T, R** statistics

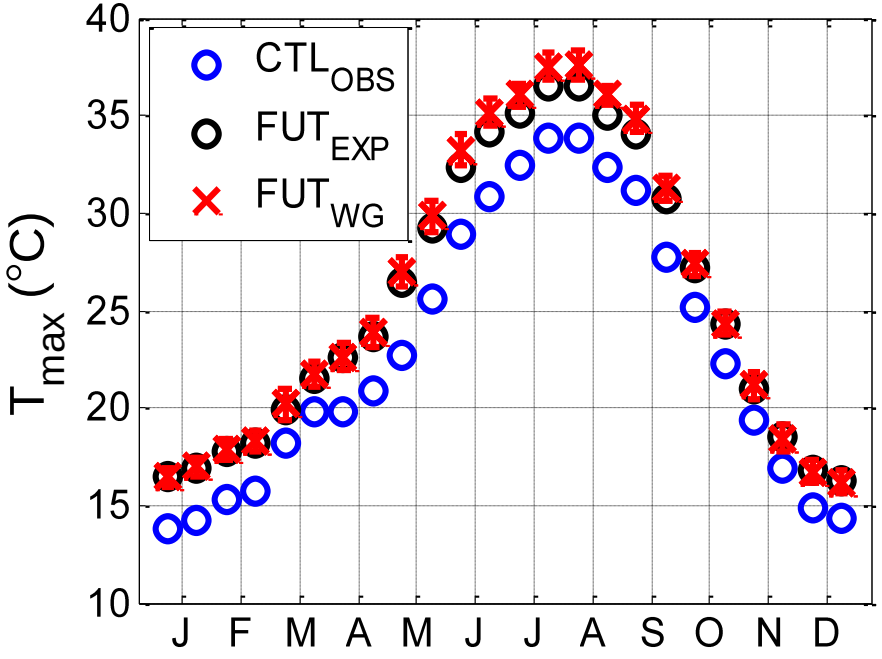
Generate syn FUT daily **T_{max}, T_{min}**

Prepare FUT **VP, WS, SS** statistics

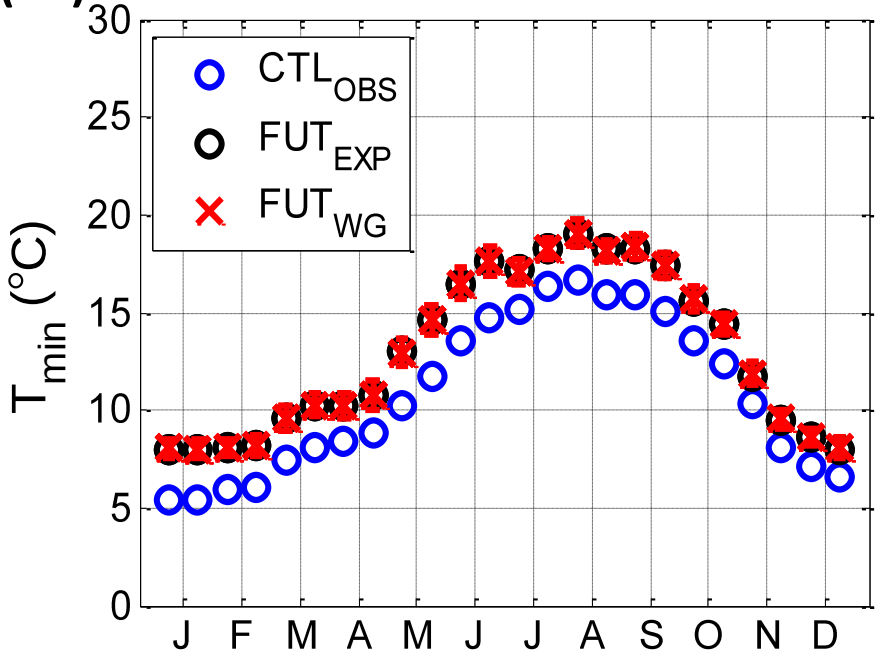
Generate syn FUT daily **VP, WS, SS**

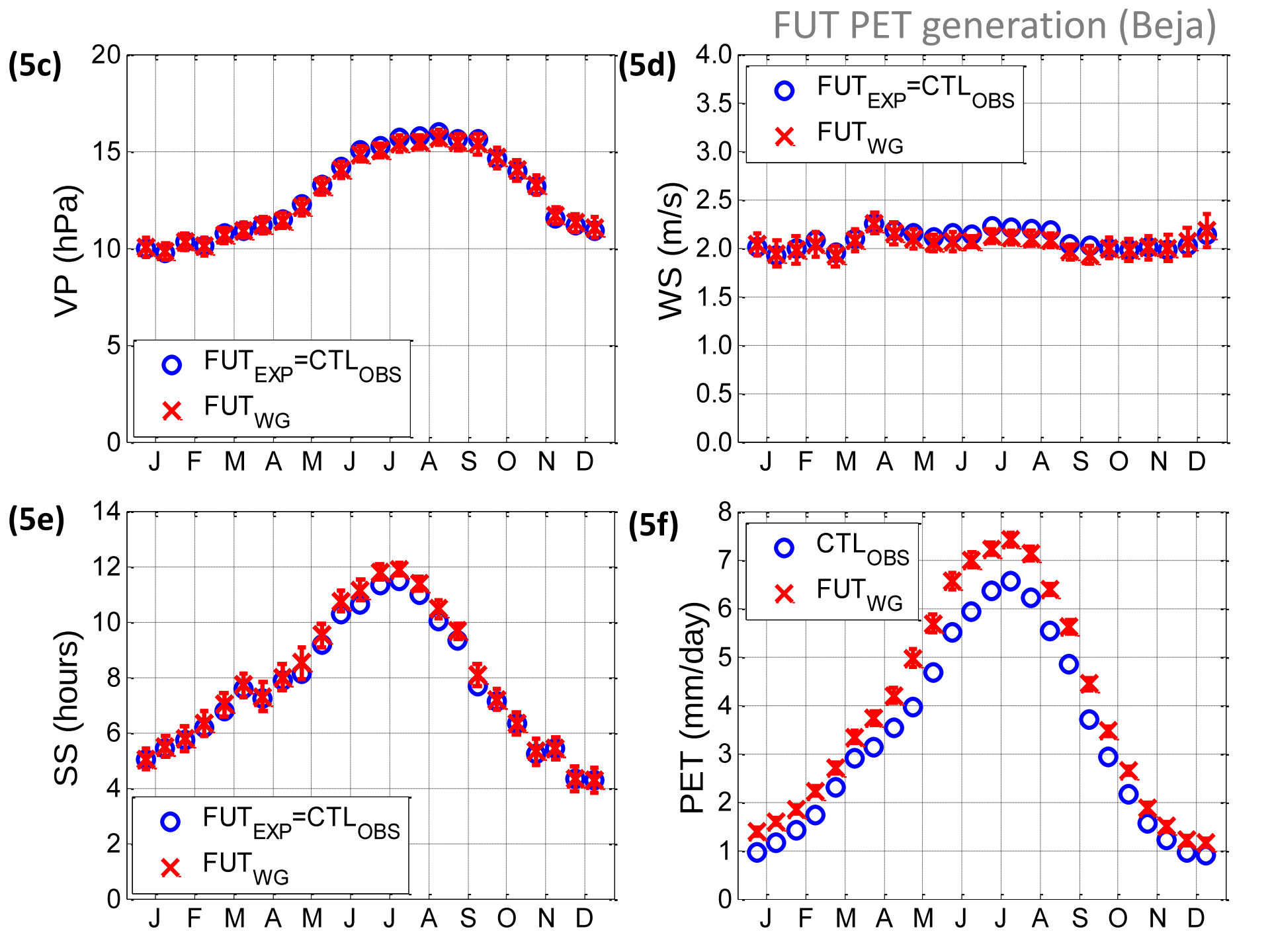
Get syn FUT PET series

(5a)


CTL_OBS
FUT_EXP
FUT_WG
T_max (°C)
40
35
30
25
20
15
10
J F M A M J J A S O N D

(5b)


CTL_OBS
FUT_EXP
FUT_WG
T_min (°C)
30
25
20
15
10
5
0
J F M A M J J A S O N D


(5c)
VP (hPa)
FUT_EXP=CTL_OBS
FUT_WG
(5d)
WS (m/s)
FUT_EXP=CTL_OBS
FUT_WG
(5e)
SS (hours)
FUT_EXP=CTL_OBS
FUT_WG
(5f)
PET (mm/day)
CTL_OBS
FUT_WG
J F M A M J J A S O N D

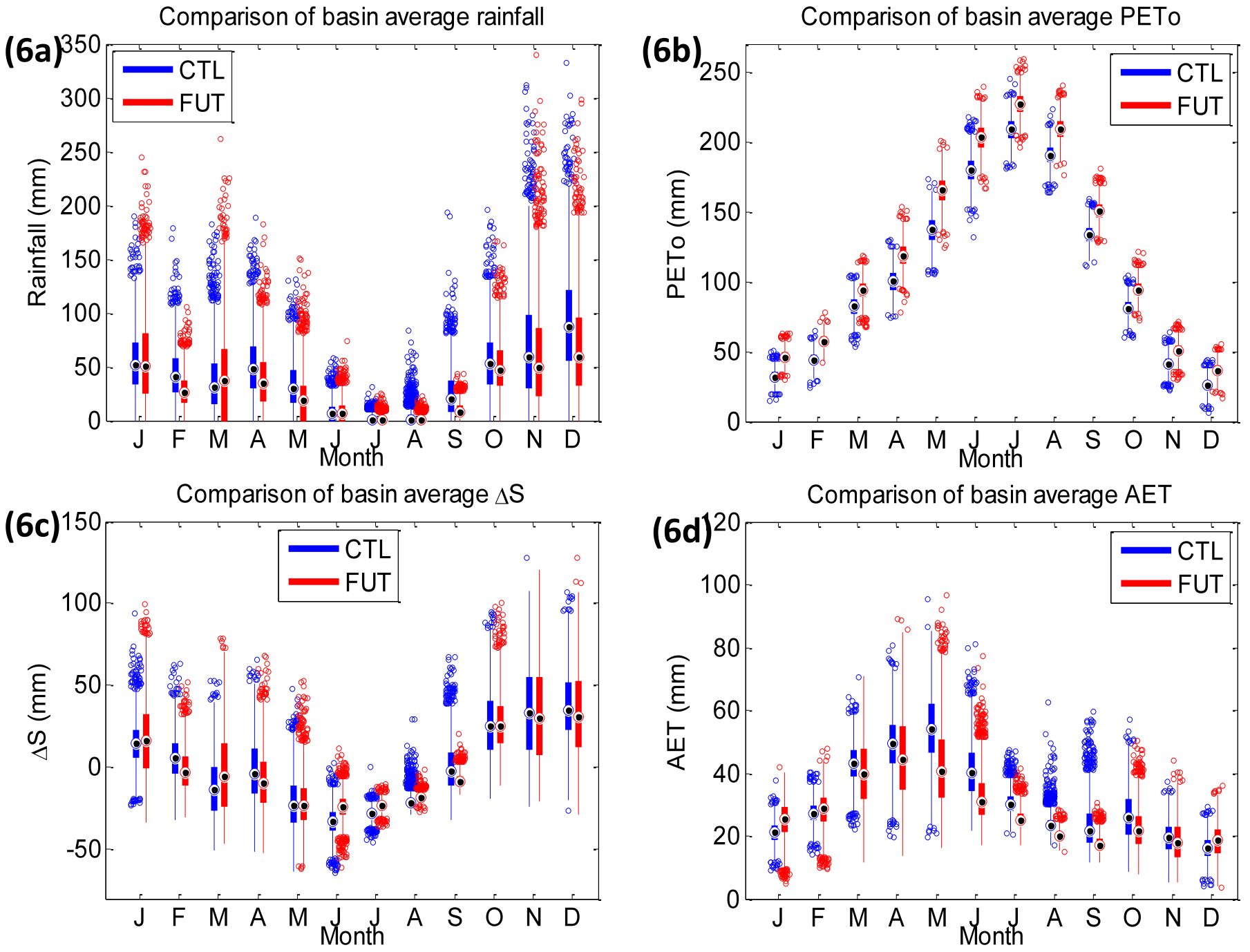
Runoff and sediment simulations

- ✓ Fundamentals of the SHETRAN model;
- ✓ CTL & FUT runoff and sediment simulation;
- ✓ Evaluation of climate change impacts on runoff and sediment simulations.

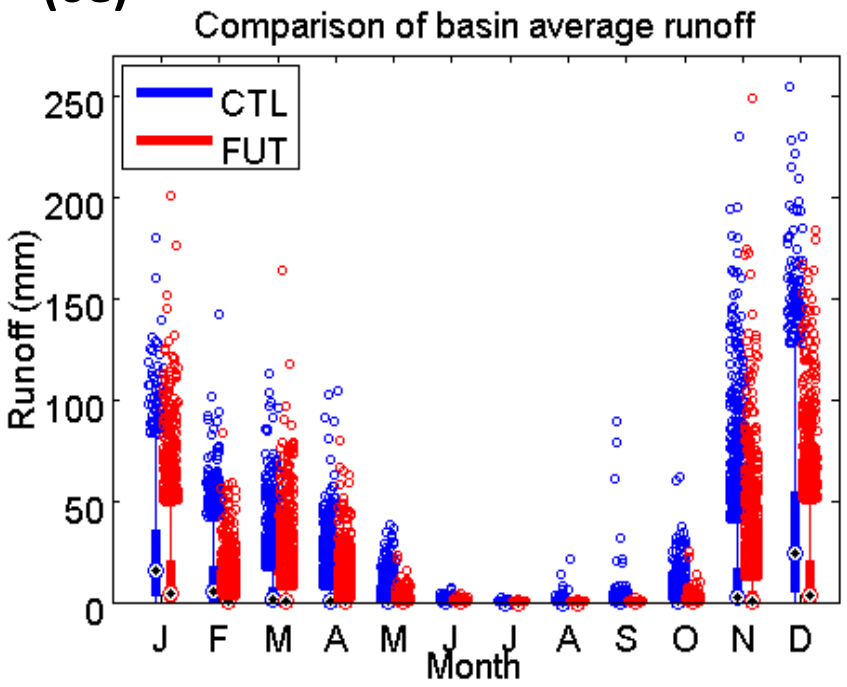
Fundamentals of SHETRAN model

1. Derived from ‘SHE’ (Système Hydrologique Européen) model (Abbott, M.B. et al., 1986a, 1986b);
2. A physically-based, fully distributed, deterministic, integrated surface and subsurface modeling system;
3. Be able to simulate water flow, sediment transport and contaminant transport at catchment scale (Ewen et al., 2000);

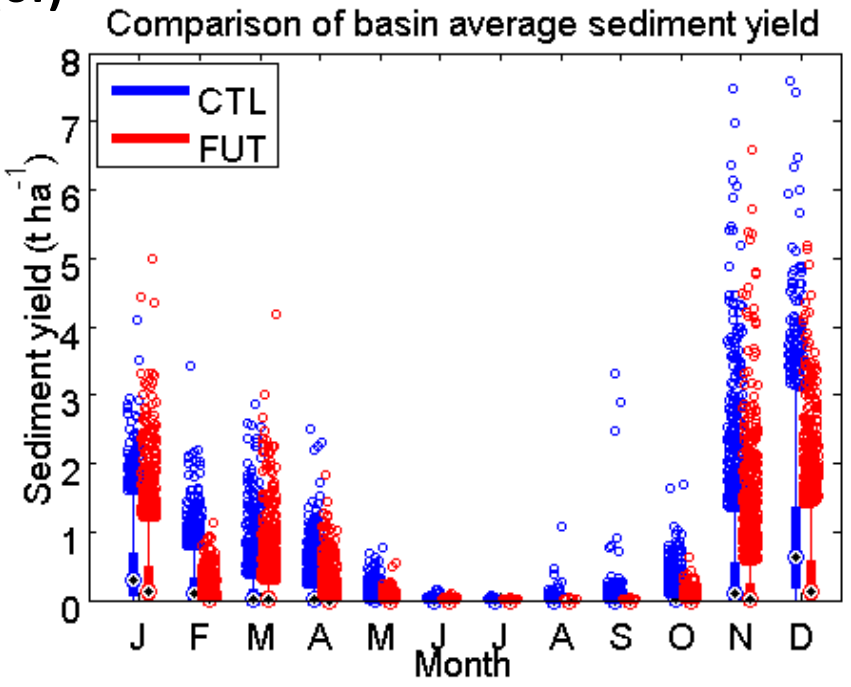
Statistics (Basin Average Annual)	CTL (FUT)					
	P (mm)	PET (mm)	AET (mm)	ΔS (mm)	R (mm)	SY (t/ha/yr^{-1})
Mean	**474** (**386**)	**1257** (**1453**)	**376** (**335**)	**2** (**2**)	**96** (**48**)	**2.35** (**1.29**)
STD	**104** (**102**)	**27** (**27**)	**40** (**50**)	**24** (**22**)	**68** (**49**)	**1.68** (**1.26**)
CV	**0.22** (**0.27**)	**0.02** (**0.02**)	**0.11** (**0.15**)	**13.00** (**9.82**)	**0.70** (**1.01**)	**0.71** (**0.98**)
$q_{0.05}$	**315** (**228**)	**1213** (**1408**)	**309** (**251**)	**-37** (**-36**)	**10** (**2**)	**0.30** (**0.04**)
$q_{0.50}$	**467** (**382**)	**1257** (**1452**)	**377** (**334**)	**2** (**2**)	**85** (**33**)	**2.04** (**0.91**)
$q_{0.95}$	**655** (**561**)	**1301** (**1497**)	**440** (**416**)	**42** (**38**)	**227** (**144**)	**5.57** (**3.72**)


(6a)
Comparison of basin average rainfall
Rainfall (mm)
CTL
FUT
J F M A M J J A S O N D
Month
(6b)
Comparison of basin average PETo
PETo (mm)
CTL
FUT
J F M A M J J A S O N D
Month
(6c)
Comparison of basin average ΔS
ΔS (mm)
CTL
FUT
J F M A M J J A S O N D
Month
(6d)
Comparison of basin average AET
AET (mm)
CTL
FUT
J F M A M J J A S O N D
Month

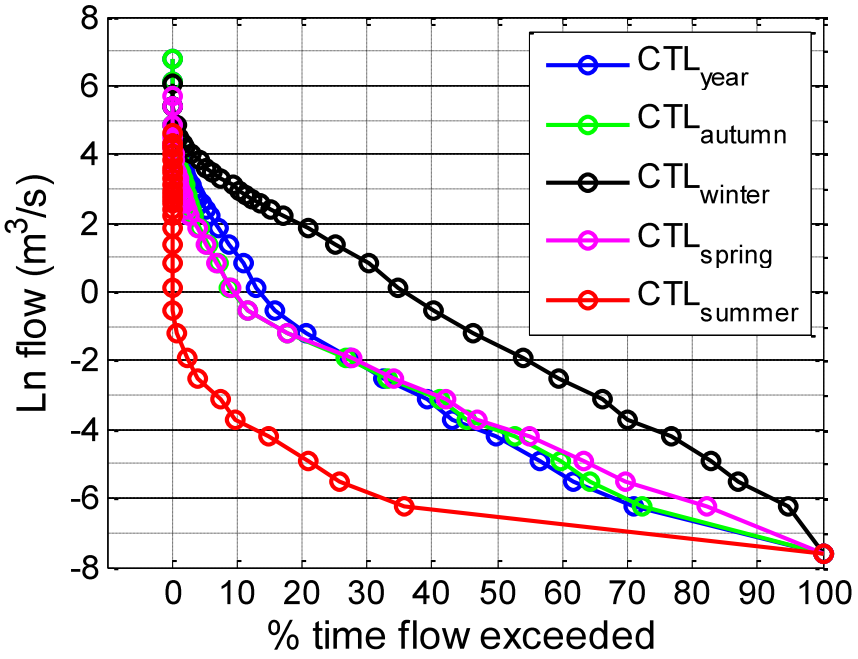
(6e)


Comparison of basin average runoff
CTL
FUT
Runoff (mm)
0
50
100
150
200
250
J F M A M J J A S O N D
Month

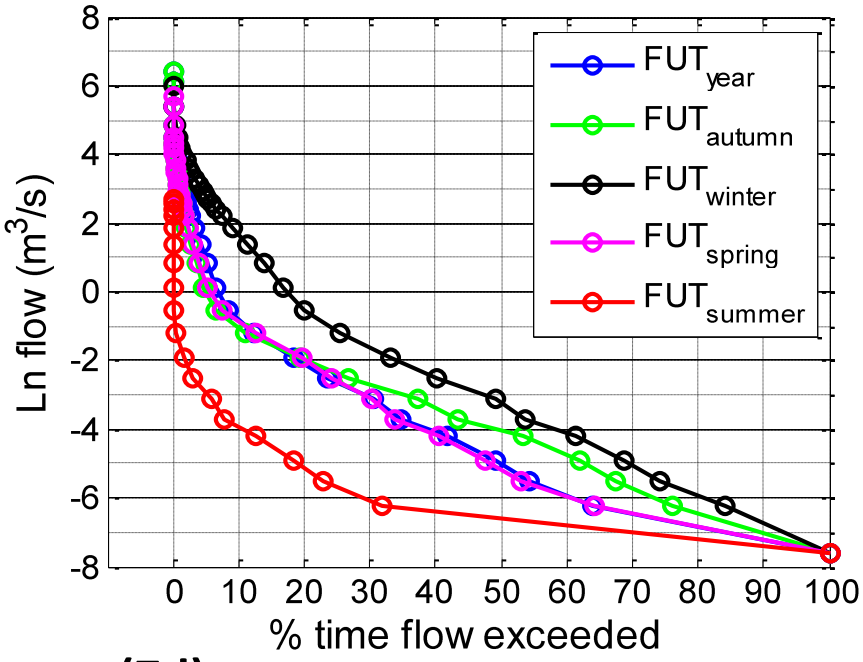
(6f)


Comparison of basin average sediment yield
CTL
FUT
Sediment yield (t ha-1)
0
1
2
3
4
5
6
7
8
J F M A M J J A S O N D
Month

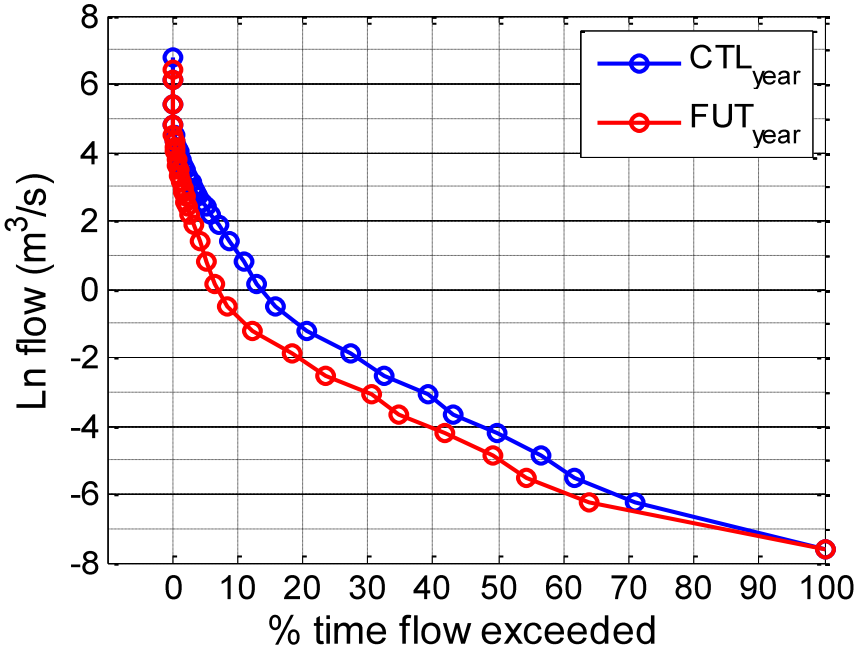
(7a)


CTL year
CTL autumn
CTL winter
CTL spring
CTL summer
Ln flow (m3/s)
% time flow exceeded

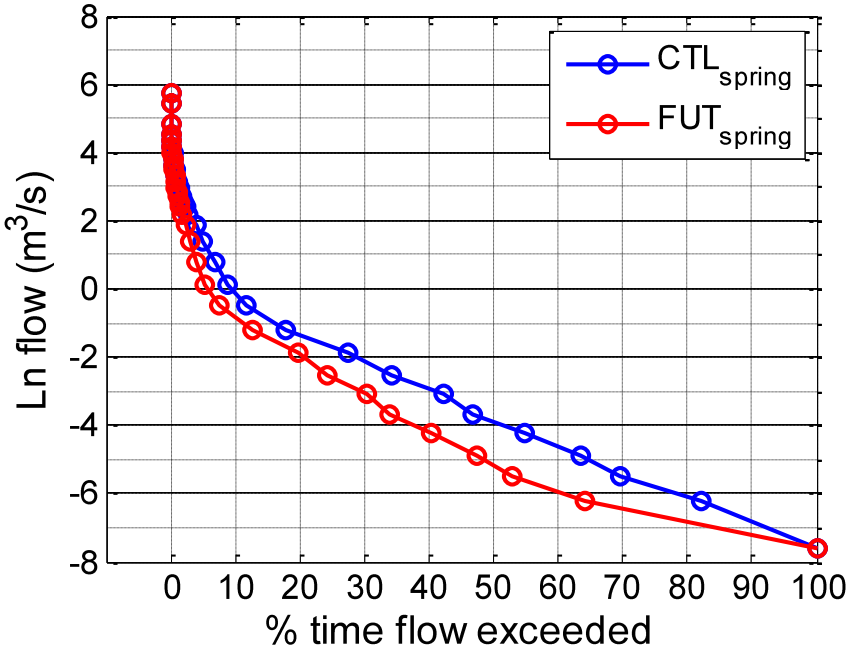
(7b)


FUT year
FUT autumn
FUT winter
FUT spring
FUT summer
Ln flow (m3/s)
% time flow exceeded

(7c)

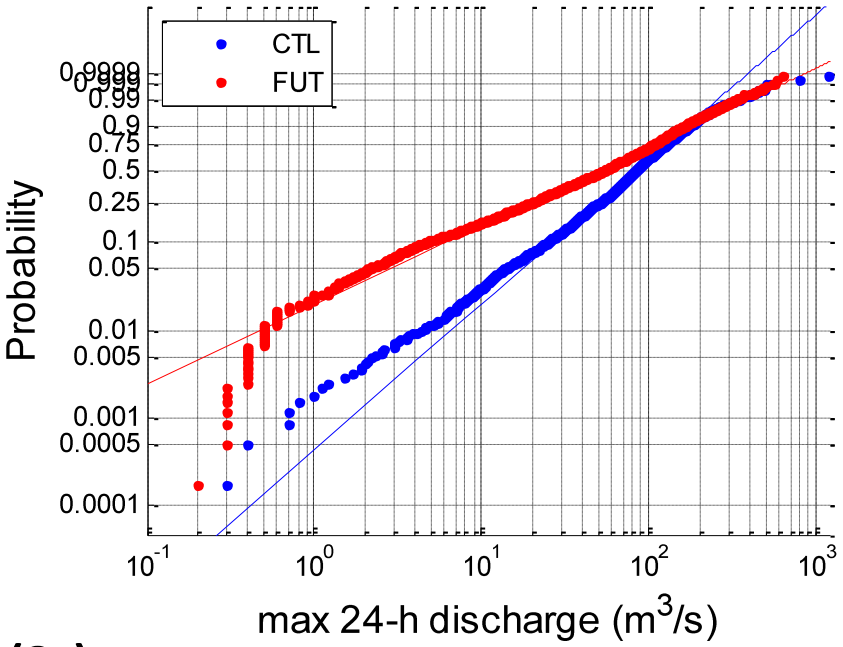

CTL year
FUT year
Ln flow (m3/s)
% time flow exceeded

(7d)

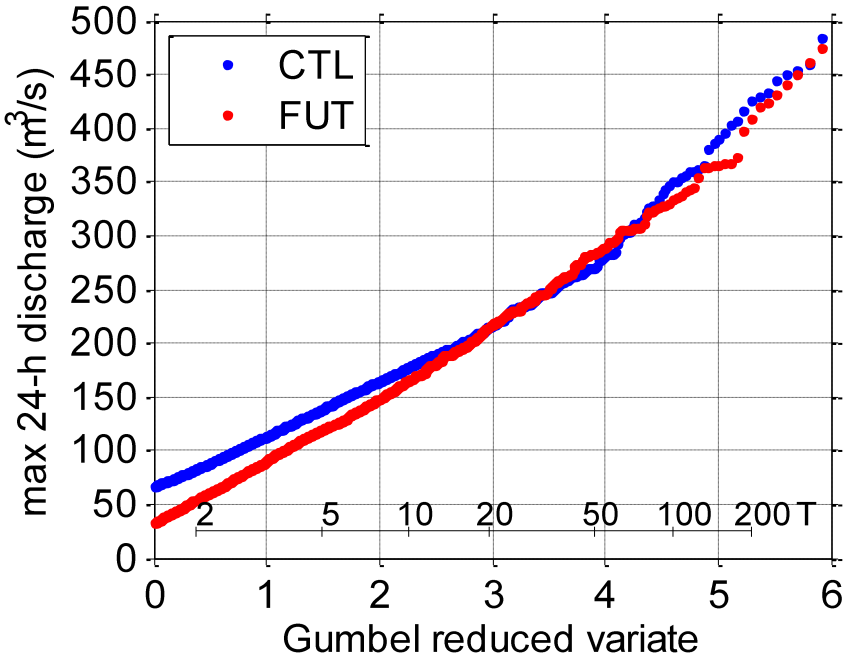

CTL spring
FUT spring
Ln flow (m3/s)
% time flow exceeded

q0.50	CTL: 1981–2010				FUT: 1981–2010			
	Bej	Cas	Alm	Tri	Bej	Cas	Alm	Tri
SDII (mm)	9.4	8.4	9.0	7.9	9.3	8.2	8.9	7.8
R5D (mm)	72.2	66.3	74.0	61.5	75.8	67.0	75.0	62.5
R30 (days)	2.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0
CDD (days)	74.0	75.0	75.0	80.0	78.0	79.0	78.0	84.0
FDD (freq.)	11.0	11.0	11.0	11.0	10.0	10.0	10.0	10.0
AII (mm)	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4

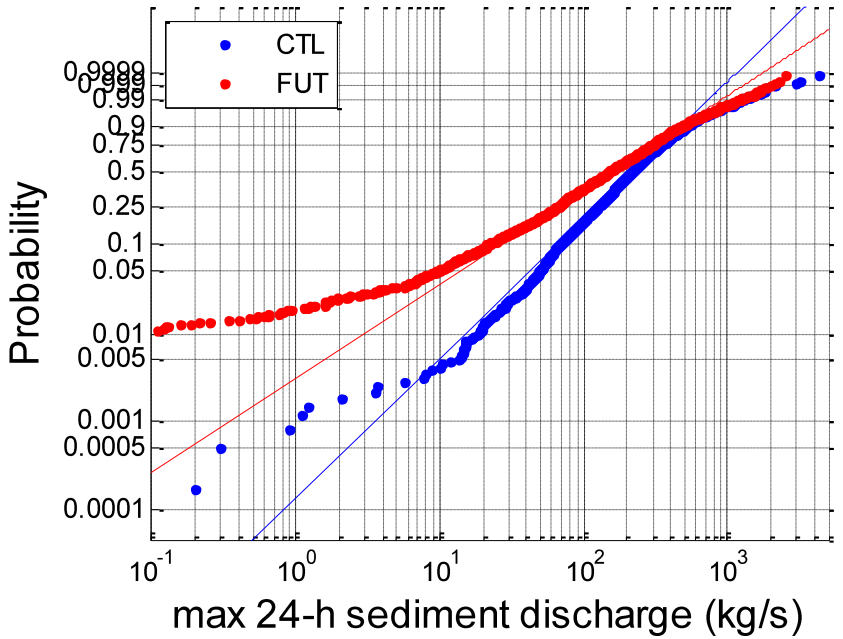
(8a)


Probability plot for Weibull distribution
CTL
FUT
Probability
0.9999
0.999
0.99
0.9
0.75
0.5
0.25
0.1
0.05
0.01
0.005
0.001
0.0005
0.0001
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
max 24-h discharge (m^3/s)

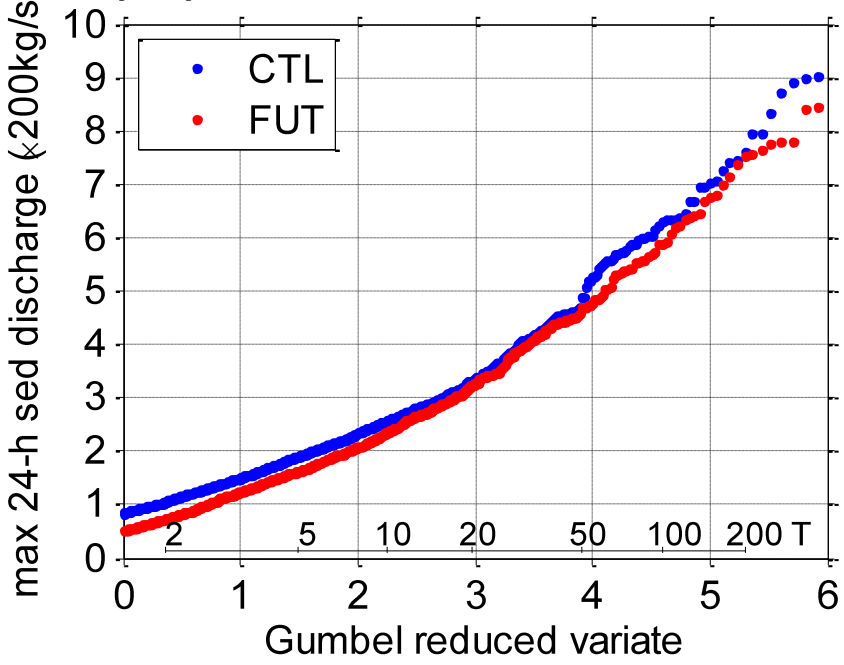
(8b)


CTL
FUT
max 24-h discharge (m^3/s)
0
50
100
150
200
250
300
350
400
450
500
2
5
10
20
50
100
200 T
0
1
2
3
4
5
6
Gumbel reduced variate

(8c)


Probability plot for Weibull distribution
CTL
FUT
Probability
0.9999
0.999
0.99
0.9
0.75
0.5
0.25
0.1
0.05
0.01
0.005
0.001
0.0005
0.0001
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
max 24-h sediment discharge (kg/s)

(8d)


CTL
FUT
max 24-h sed discharge (x200kg/s)
0
1
2
3
4
5
6
7
8
9
10
2
5
10
20
50
100
200 T
0
1
2
3
4
5
6
Gumbel reduced variate

Conclusions

- FUT **mean climate** is drier with decreased rainfall, increased PET and consequently decreased runoff and sediment yield;
- FUT **AET** is decreased all over the year except winter, indicating vegetation and crop growths are more water-limited than CTL climate;
- FUT wet extremes are more heavy tailed than CTL ones and slight increases are identified for extremes with return period of 20-60 years.

Thank you for your attention!