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CLIMATE CHANGE SCENARIOS EFFECTS ANALYSES OVER THE RIPARIAN VEGETATION DYNAMICS IN A MEDITERRANEAN REACH (MIJARES RIVER, SPAIN)

Instituto de Ingeniería del Agua y Medio Ambiente

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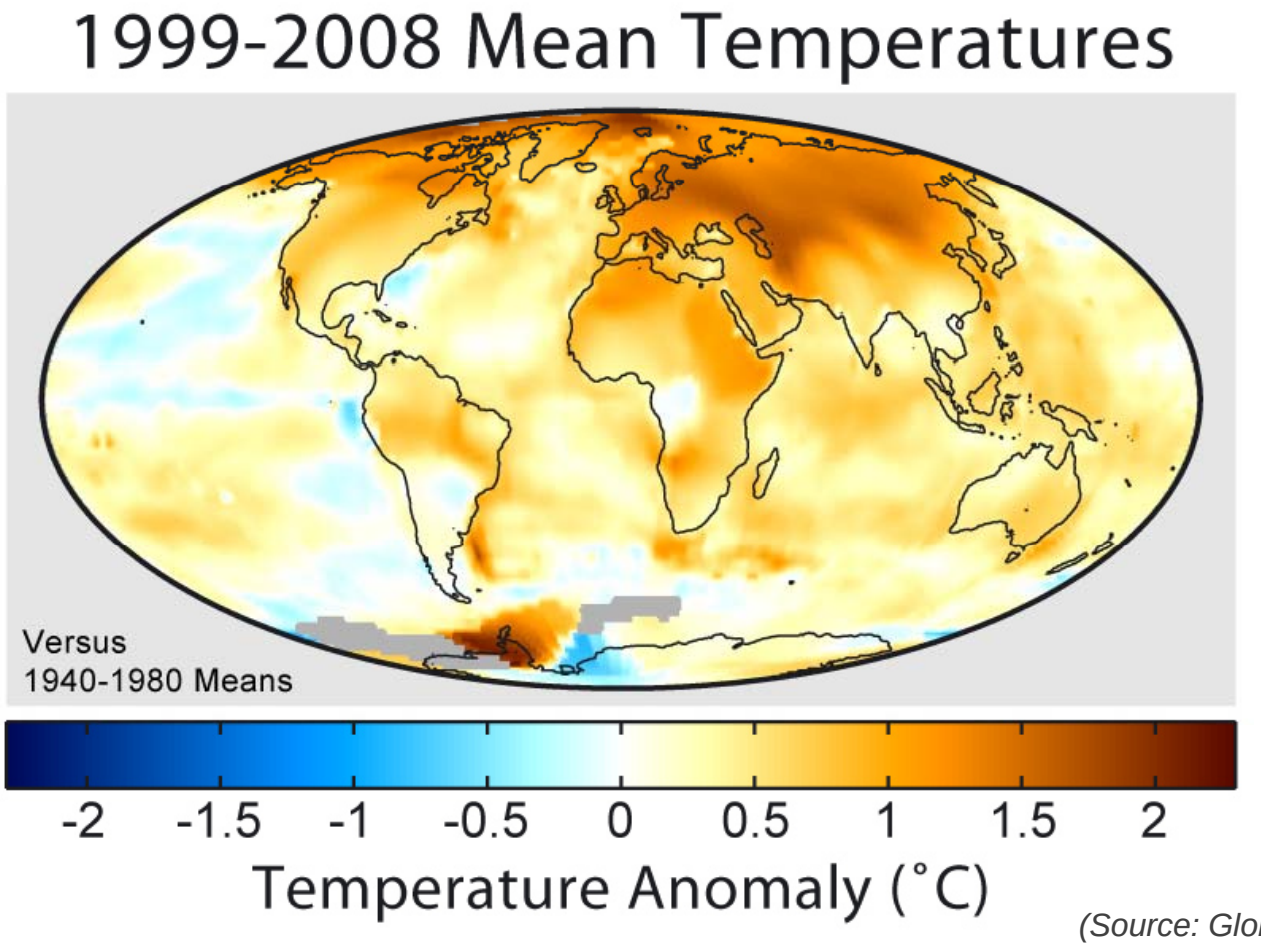
iwrm-net Regional and national research programmes network on Integrated Water Resource Management

scarce

CONSOLIDER Ingenio 2010

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

The climate change threat



(Source: Global Warming Art)

The climate change threat

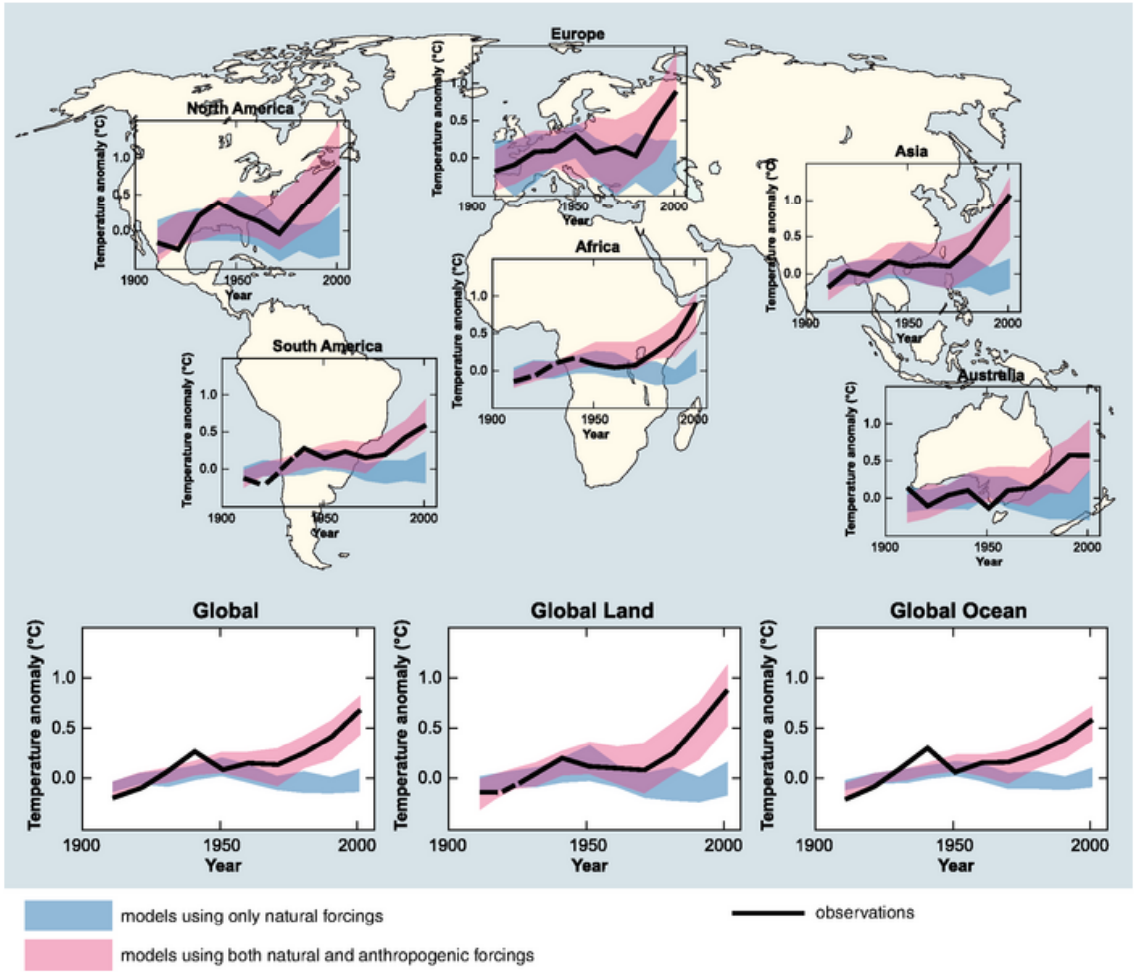
Temperature Increase

Observed during last 100 years

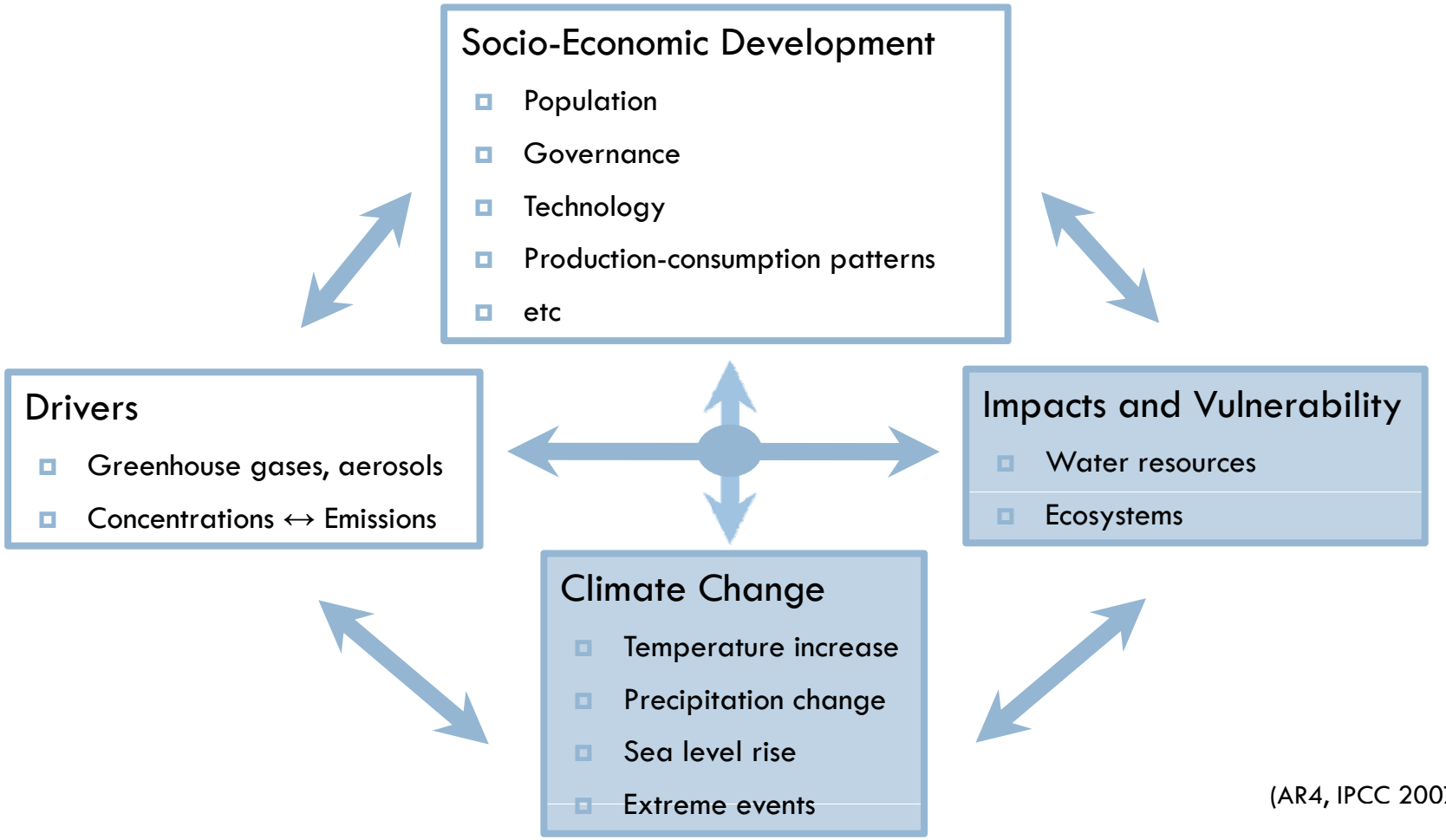
- Greater at northern latitudes
- Land regions have warmed faster than the oceans

Expected during next 100 years

(AR4, IPCC 2007)

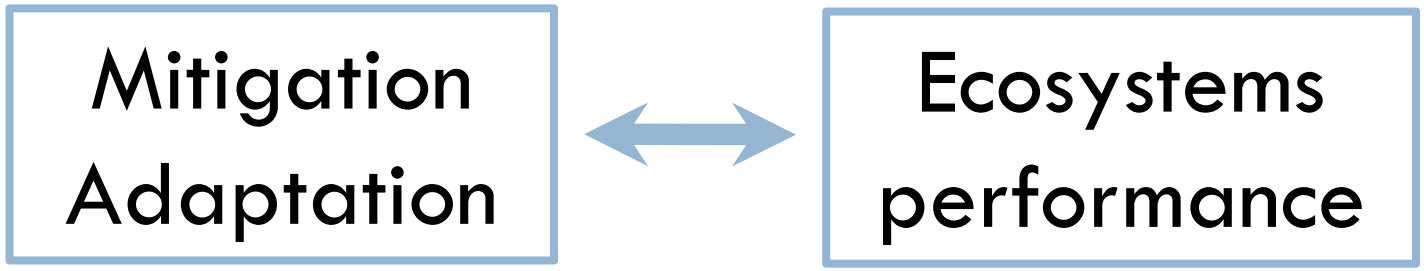


The climate change threat



(AR4, IPCC 2007)

The climate change threat



We need tools to know what may happen if…

Models

The riparian vegetation importance

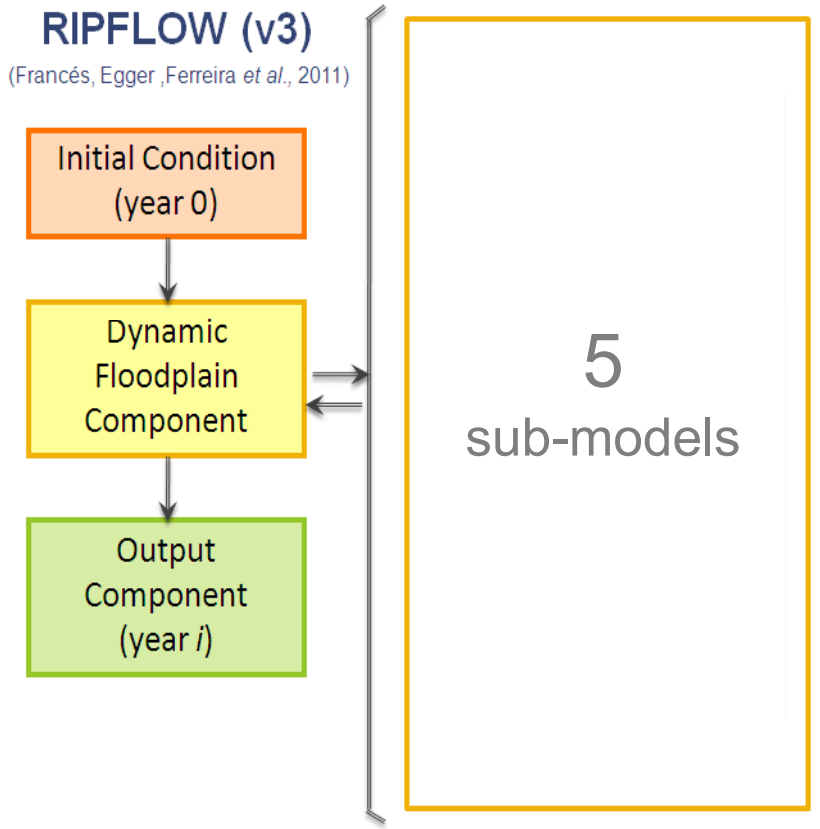
- Riparian ecosystems main elements
  - Water, soil and vegetation
- Riparian vegetation
  - Diversity of Habitats
  - Soil and nutrients retention
  - Temperature regulation (Shadow effect)

River ecological status (WFD)

- Modelling the riparian vegetation distribution
  - RIPFLOW and RibAV models

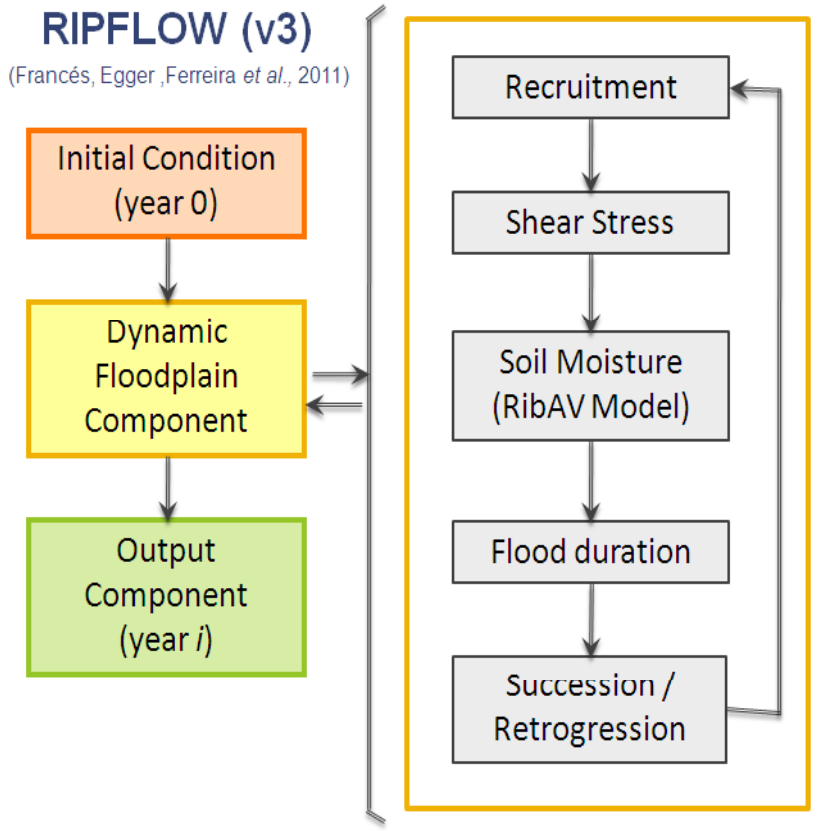
RIPFLOW model

- Distributed model (cell resolution 1m)
- Annual temporal scale (soil moisture daily)
- Main state variable
  - vegetation succession phase
- Dynamic riparian vegetation distribution
  - Physical parameters → Succession or retrogression



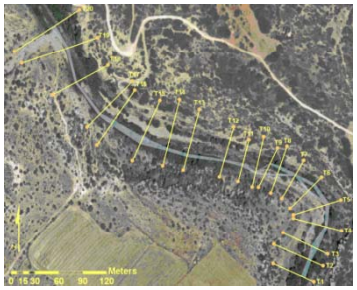
RIPFLOW model definition

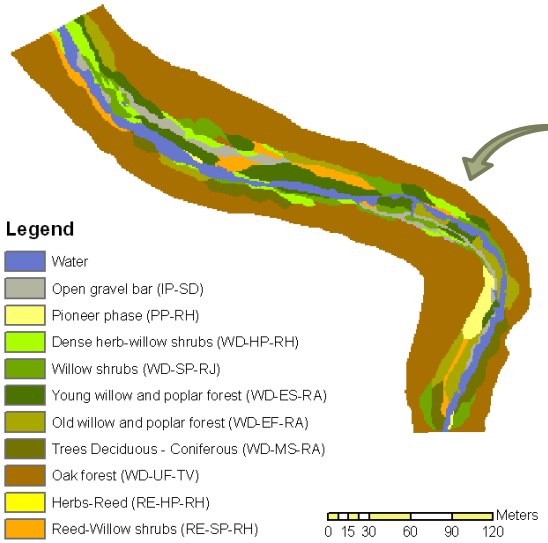
- Five successive sub-models:
  - Recruitment → morphology, scour disturbances & WTE
  - Shear stress → vegetation remotion (SSlim)
  - Flood duration → physiological stress, root asphyxia
  - Soil moisture → water stress (ETidx)
  - Succession progression → different succession series
- Parameters → thresholds



Terde reach at the Mijares River

- 539 m long, 850 masl
- Basin area: 665 km^2
- **Permanent** flow regime
- Bankfull Q = 5 m^3/s
- **No flow regulation** upstream
- Riparian vegetation:
  - *Salix eleagnos*
  - *Salix purpurea*
  - *Populus nigra*
- Upland forest:
  - *Pinus* and *Quercus*





Source: The RIPFLOW Project

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Performance evaluation

- Confusion matrix

Table 1. Confusion matrix. Observed vegetation in rows; simulated vegetation in columns.

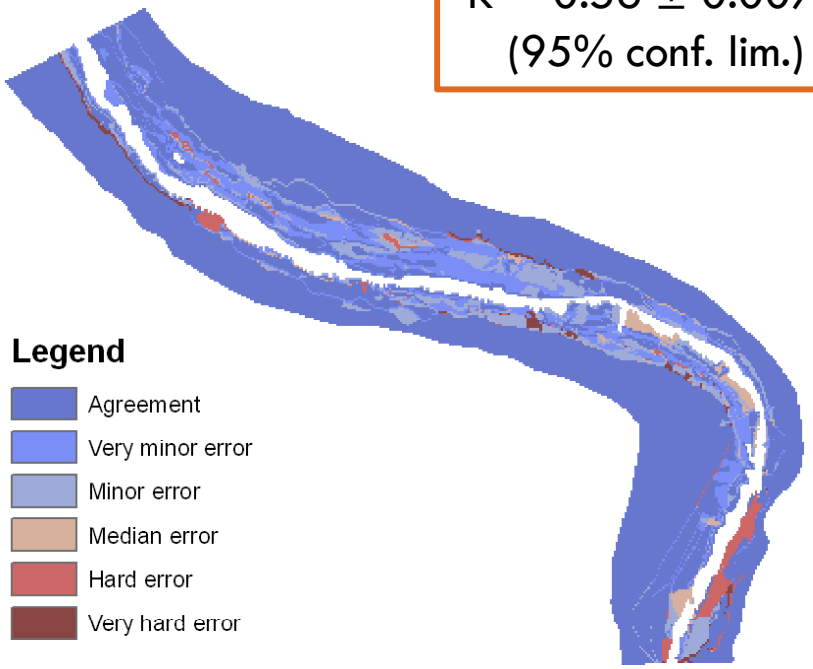
Phases	IP	PP	HP	HP*	SP	SP*	ES	EF	MS	UF
IP	**145**	19	611	29	153	3	131	55	105	0
PP	196	**181**	36	13	38	5	36	1	4	17
HP	243	14	**551**	13	163	3	128	36	98	29
HP*	0	0	0	**0**	0	0	0	0	0	0
SP	335	30	197	19	**931**	12	130	34	164	45
SP*	179	23	75	17	349	**25**	66	81	455	7
ES	313	47	23	16	84	13	**1255**	156	757	59
EF	389	28	22	45	97	22	5	**1112**	229	62
MS	496	12	12	4	78	12	27	13	**750**	4
UF	304	76	41	32	637	46	37	60	205	**17678**

* Reed succession series

main diagonal → 71.86 %
terrestrial vegetation → 93.64 %
riparian vegetation → 98.80 %

- Cohen's kappa → coefficient of agreement, chance effect

K = 0.56 ± 0.0079
(95% conf. lim.)



Climate change scenarios

Projections, estimates and socio-economic models

Socio-economic scenarios

Emissions estimates

Emissions scenarios

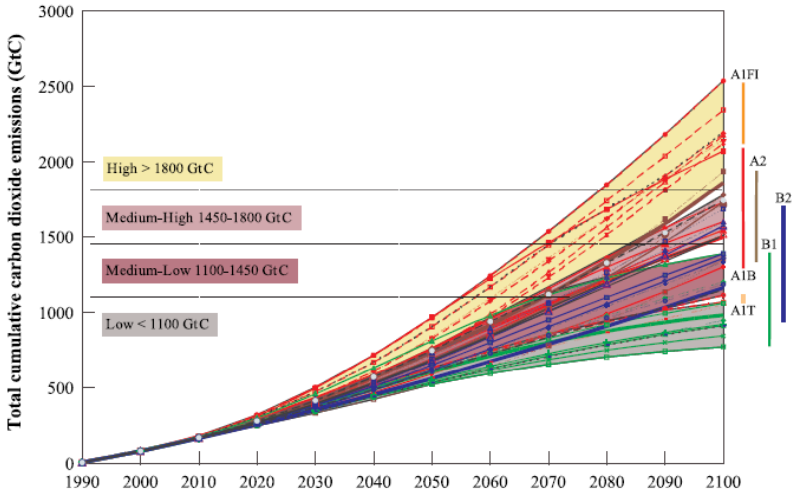
GCM and RCM

Climate scenarios

Hydrologic models

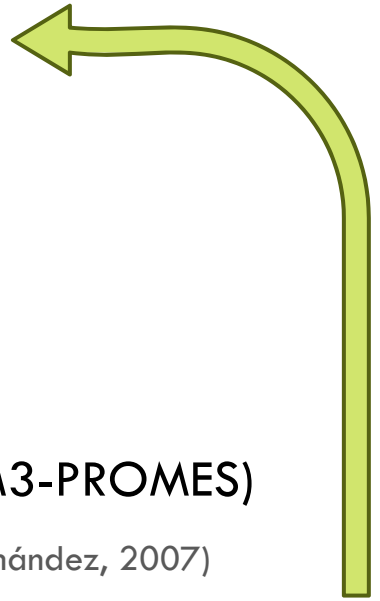
Hydrologic scenarios

IMPACTS ANALYSES



Climate change scenarios

- **Reference period: 1960-1990**
  - T and P → meteorological stations (AEMET)
  - Flow → gauging stations (CEDEX)
- **CC Scenarios period: 2070-2100**
  - Emissions scenarios:
    - Optimistic → SRES **B2**
    - Pessimistic → SRES **A2**
  - T and P → regional climate scenarios (HadCM3-PROMES)
  - Flow → Hydrologic scenarios (PATRICAL) (Hernández, 2007)

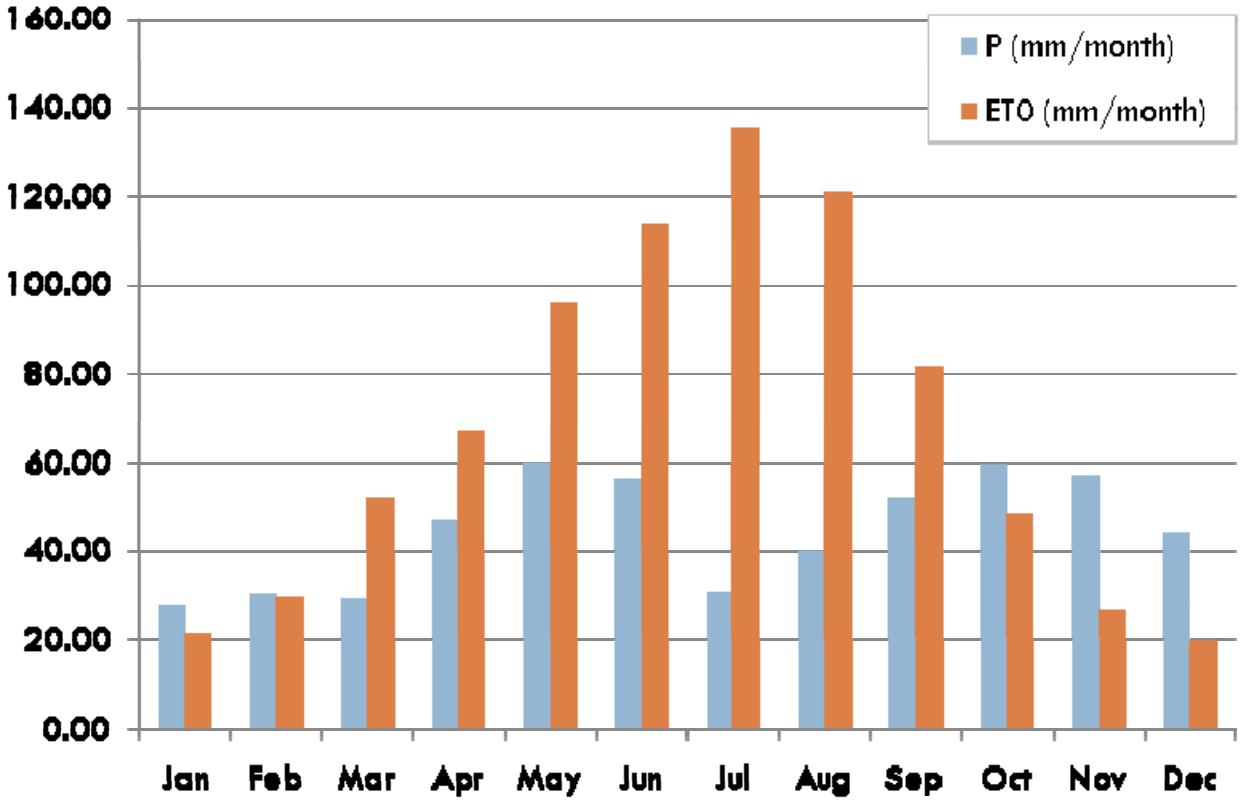


Optimistic CC scenario→ HadCM3-PROMES (2070-2100) SRES **B2**

Pessimistic CC scenario → HadCM3-PROMES (2070-2100) SRES **A2**

Climate change scenarios

- Reference period 1960 – 1990



- P= 530 mm/year
- ET_0 = 808 mm/year

$ET_0 > P$

SEMIARID ENVIRONMENT

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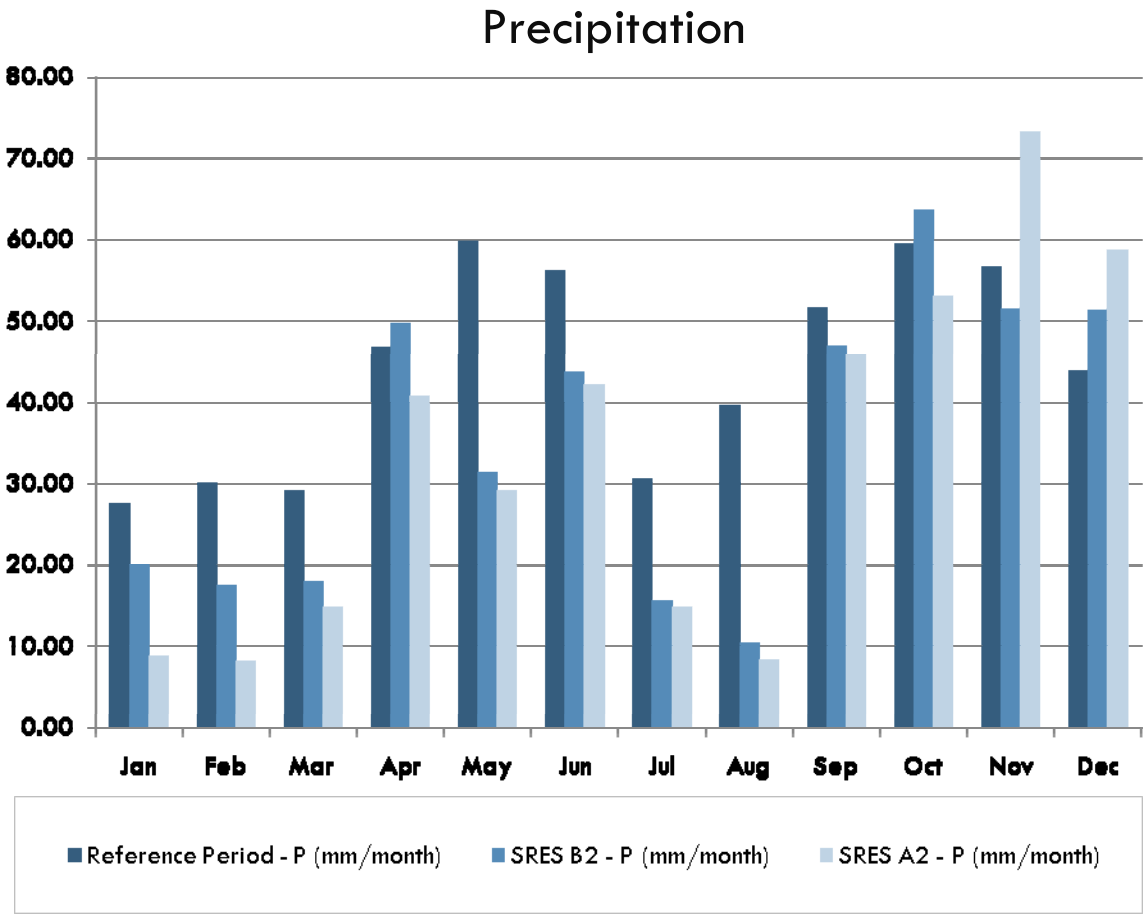
Climate change scenarios



Reference Period (1960-1990)

- **P= 530 mm/year**

Optimistic scenario

HadCM3-PROMES(2070-2100) SRES B2

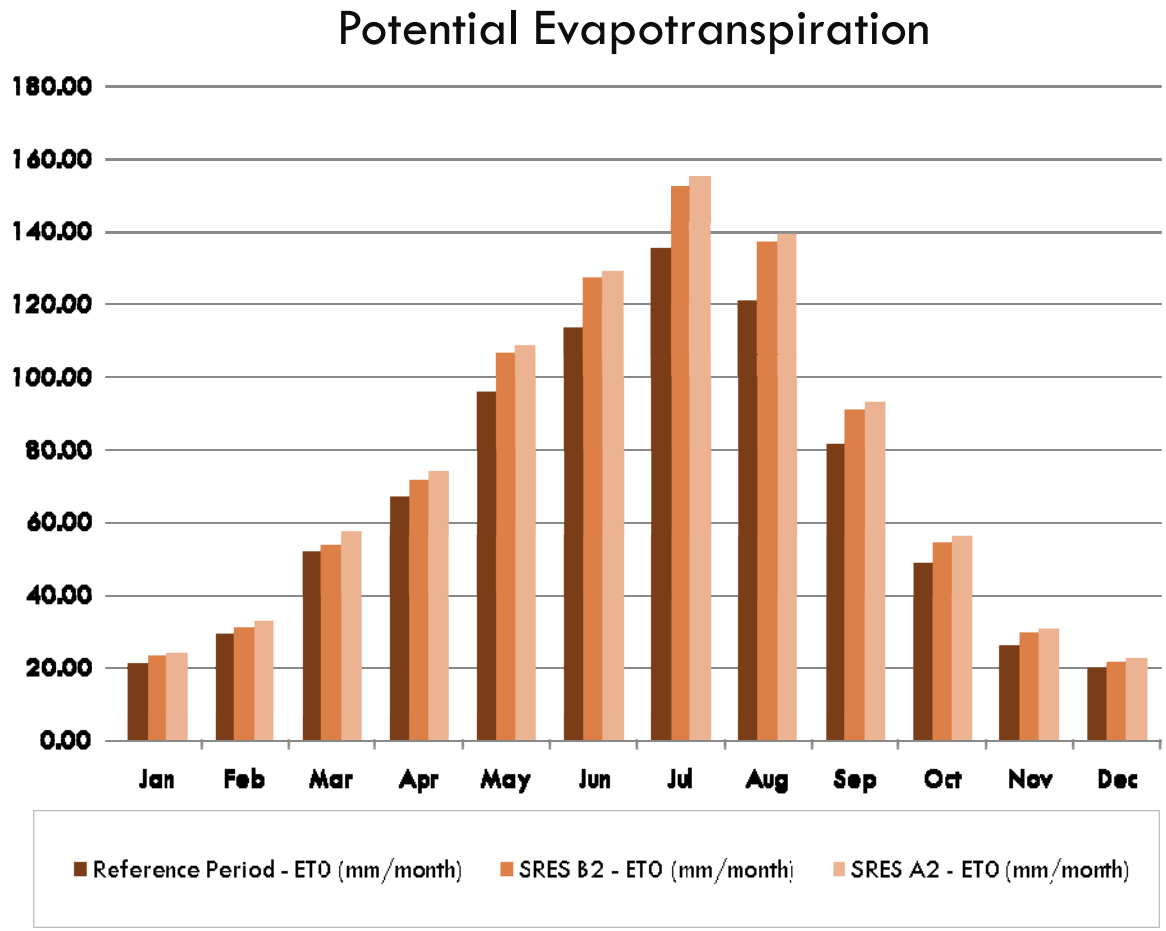
- **P= 418 mm/year**

Pessimistic scenario

HadCM3-PROMES(2070-2100) SRES A2

- **P= 397 mm/year**

Climate change scenarios



Reference Period (1960-1990)

- P= 530 mm/year
- ET_0 = 808 mm/year

Optimistic scenario

HadCM3-PROMES(2070-2100) SRES B2

- P= 418 mm/year
- ET_0 = 898 mm/year

Pessimistic scenario

HadCM3-PROMES(2070-2100) SRES A2

- P= 397 mm/year
- ET_0 = 920 mm/year

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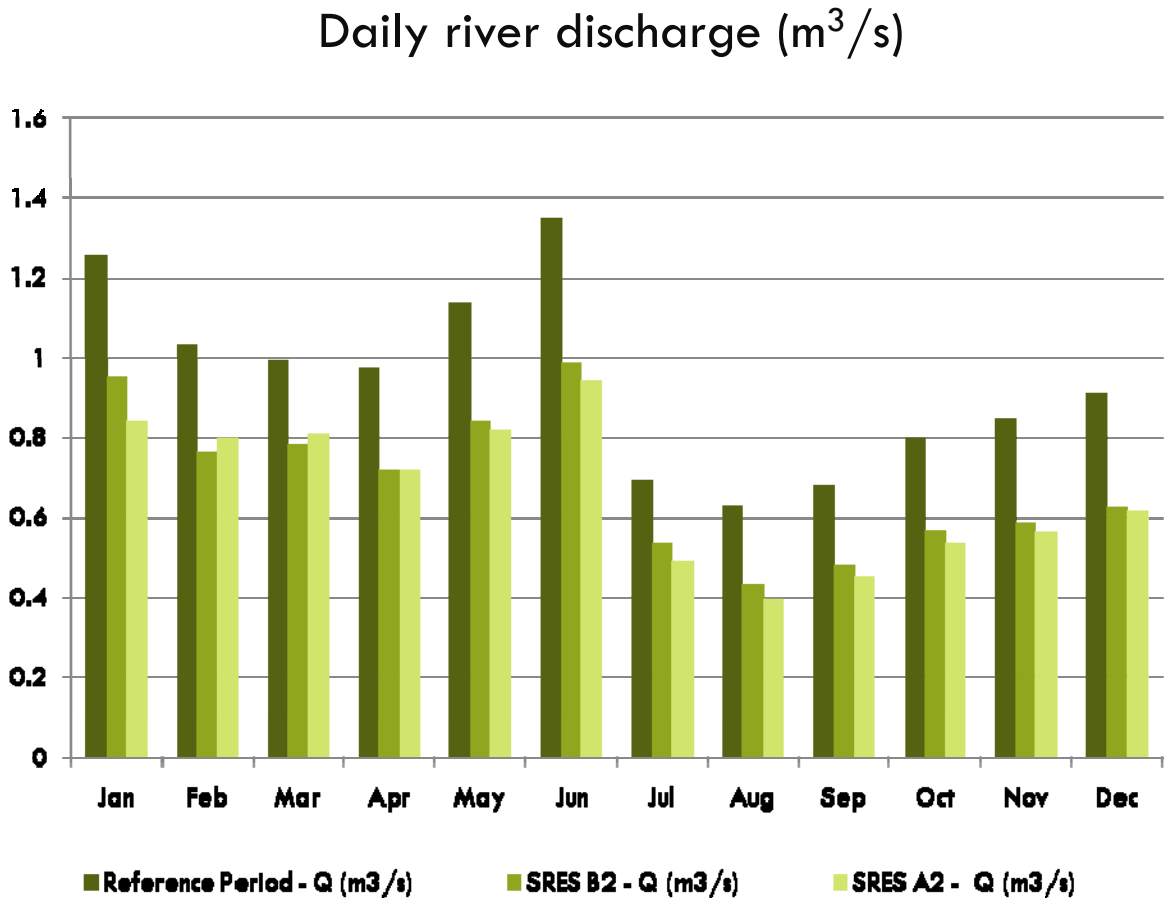
Climate change scenarios



Reference Period (1960-1990)

- **Q= 0.94 m^3/s**

Optimistic scenario

HadCM3-PROMES(2070-2100) SRES B2

- **Q= 0.69 m^3/s**

Pessimistic scenario

HadCM3-PROMES(2070-2100) SRES A2

- **Q= 0.66 m^3/s**

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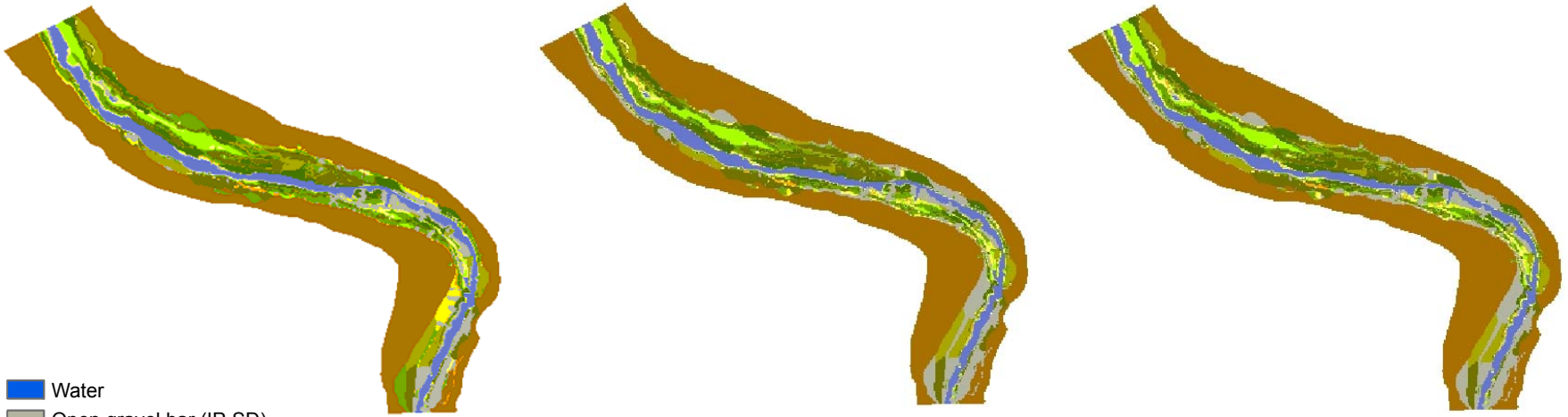
Results - Last year simulated vegetation

Reference Period (1960-1990)

HadCM3-PROMES SRES B2 (2070-2100)

HadCM3-PROMES SRES A2 (2070-2100)



- Water
- Open gravel bar (IP-SD)
- Pioneer phase (PP-RH)
- Dense herb-willow shrubs (WD-HP-RH)
- Willow shrubs (WD-SP-RJ)
- Young willow and poplar forest (WD-ES-RA)
- Old willow and poplar forest (WD-EF-RA)
- Trees Deciduous - Coniferous (WD-MS-RA)
- Oak forest (WD-UF-TV)
- Herbs-Reed (RE-HP-RH)
- Reed-Willow shrubs (RE-SP-RH)

Lower differences than expected

- Earlier succession phases are unfavoured
- Expansion of bare soil zones

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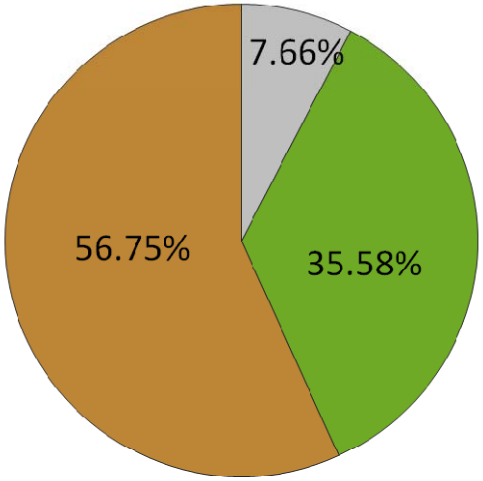
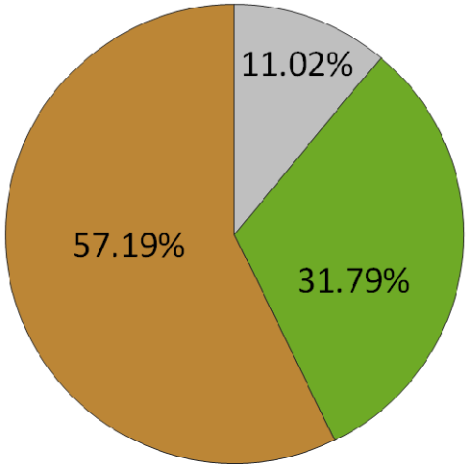
Results - Last year simulated vegetation

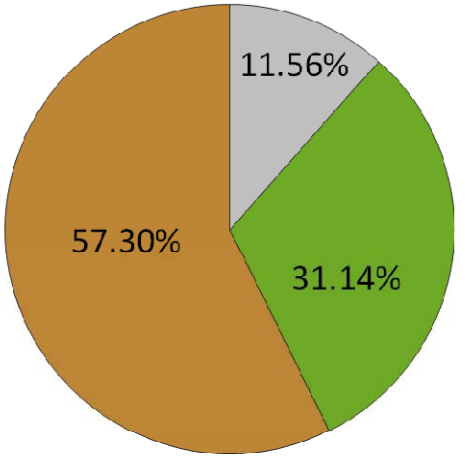
Reference Period (1990)



Optimistic scenario:
HadCM3-PROMES SRES B2 (2100)



Pessimistic scenario:
HadCM3-PROMES SRES A2 (2100)

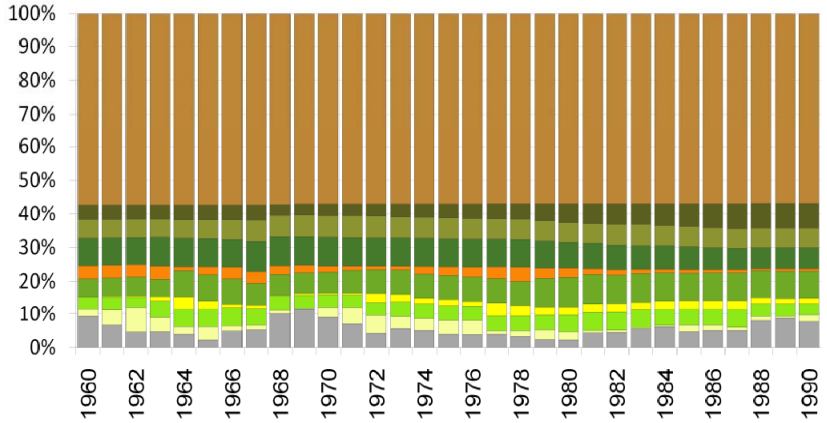


- Bare soil
- Riparian vegetation
- Terrestrial vegetation

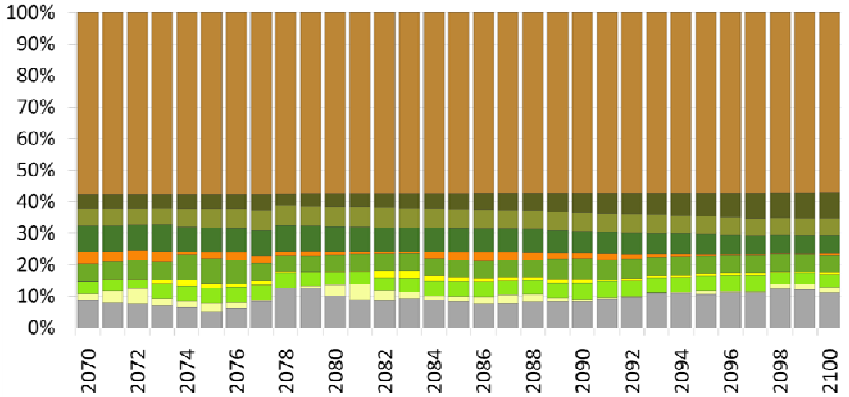
Reduction of riparian vegetation areas
- Small increase of terrestrial vegetation presence
- Small increase of bare soil

Results - Vegetation dynamics

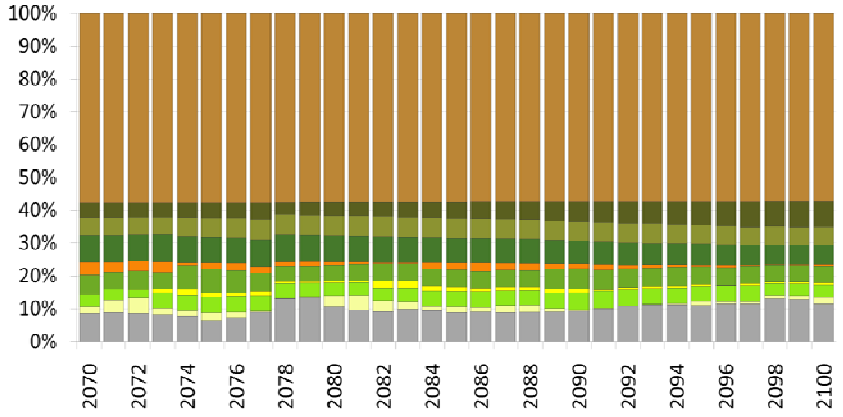
Reference Period (1960-1990)



Optimistic scenario: HadCM3-PROMES(2070-2100) SRES B2



Pessimistic scenario: HadCM3-PROMES(2070-2100) SRES A2



Similar patterns of temporal changes

- Open gravel bar
- Pioneer phase
- Dense herb - willow shrubs (Woodland)
- Herbs (Reed)
- Willow shrubs (Woodland)
- Willow shrubs (Reed)
- Young willow and poplar forest (Woodland)
- Old willow and poplar forest (Woodland)
- Deciduous - Coniferous trees (Woodland)
- Terrestrial Vegetation

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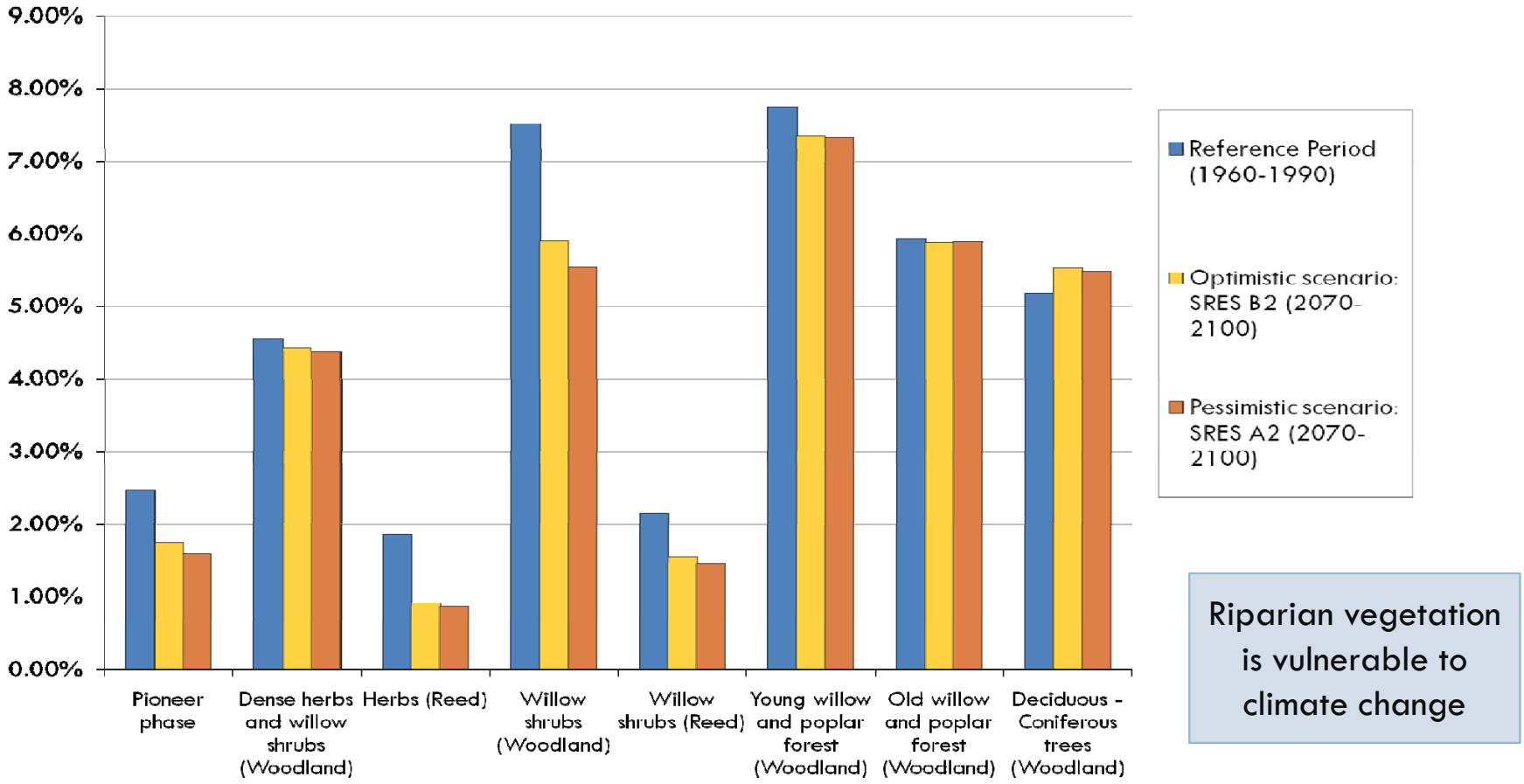
Results – Mean area balances

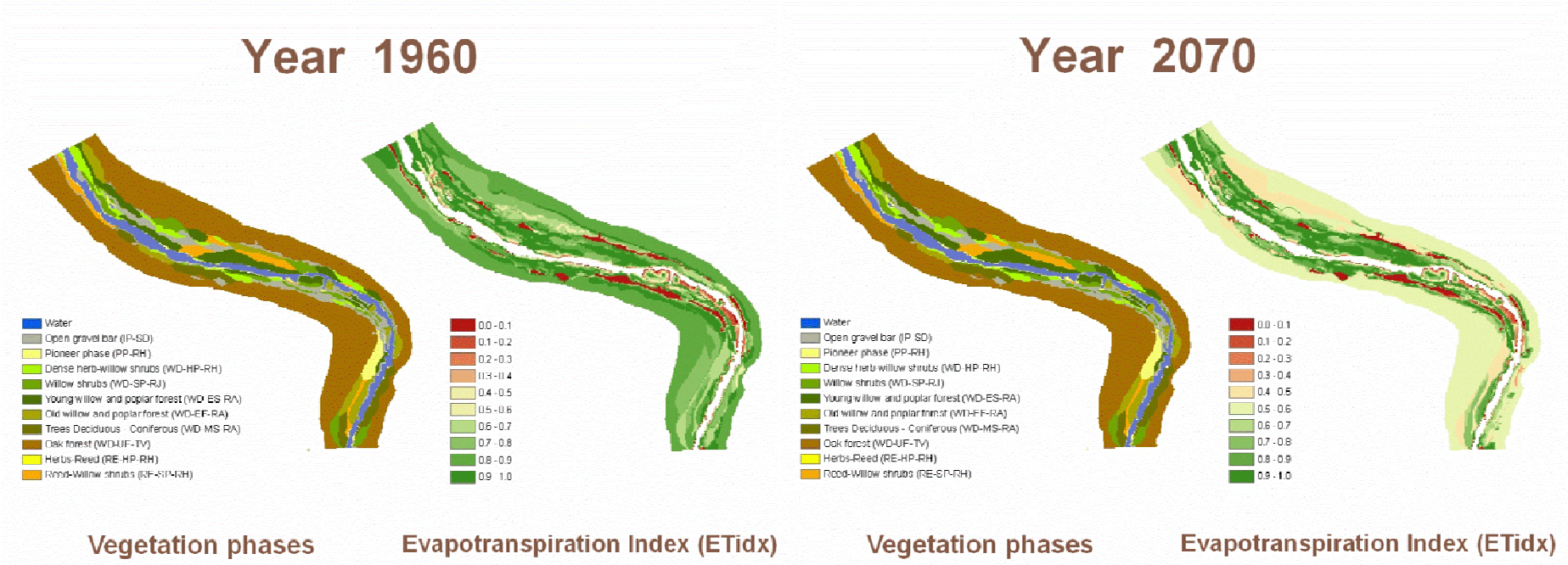


Riparian vegetation is vulnerable to climate change

Results – Vegetation distribution and ETidx maps

Reference Period (1960-1990)

Pessimistic scenario: HadCM3-PROMES(2070-2100) SRES A2



Vegetation phases | Evapotranspiration Index (ETidx) | Vegetation phases | Evapotranspiration Index (ETidx)

The RIPFLOW model simulates dynamic vegetation distribution and the RibAV 2D model simulates dynamic evapotranspiration indexes

RIPFLOW v3 = RIPFLOW + RibAV 2D

(Francés, Egger and Ferreira *et al.*, 2010)

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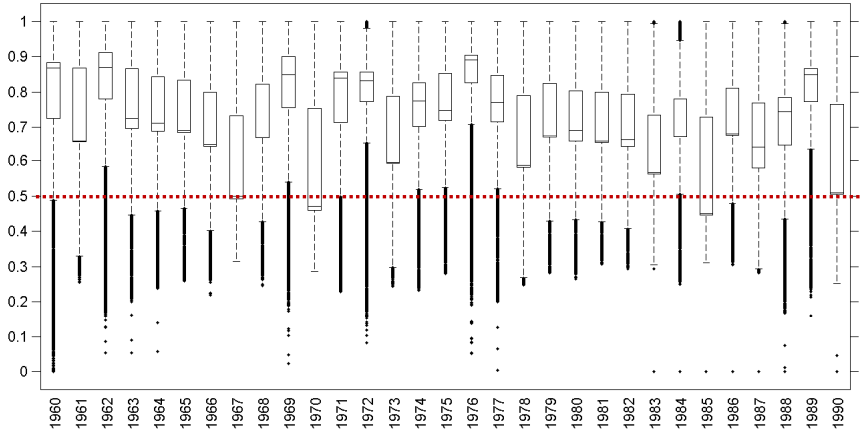
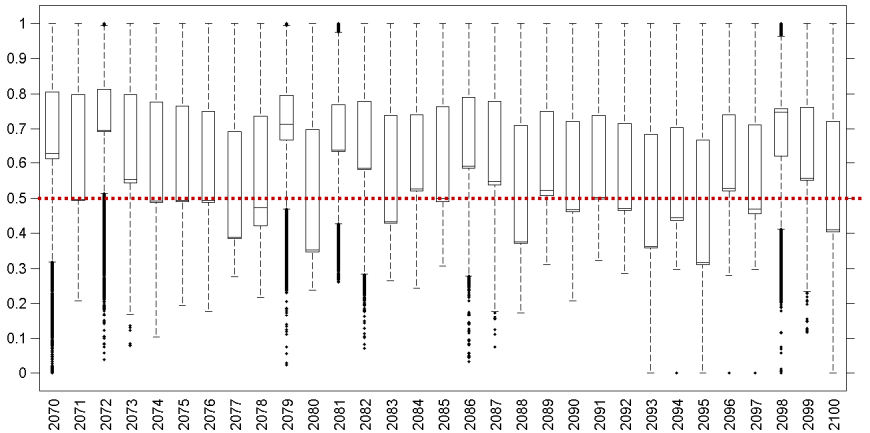
Results - Evapotranspiration capabilities

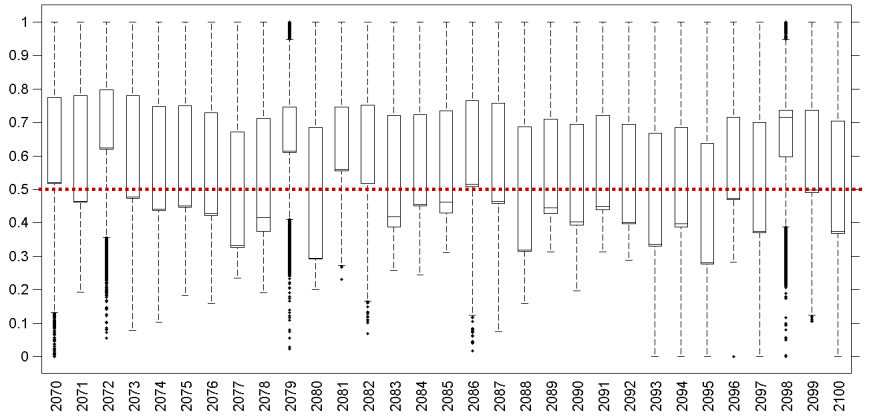
Reference Period (1960-1990)



Optimistic scenario: HadCM3-PROMES(2070-2100) SRES B2



Pessimistic scenario: HadCM3-PROMES(2070-2100) SRES A2



Generalized reduction of ET capabilities

- Harder during dry years
- Harder for the pessimistic scenario

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Results - Discussion

Riparian Vegetation under Climate Change

Drivers of change

- Temperature increase
- Precipitation regimes change
- Flow reduction
- Changes in extreme events ?

Impacts and Vulnerability

- Riparian areas reduction
- Increase of areas with bare soil
- Increase of terrestrial vegetation presence
- Earlier successional phases unfavoured
- Reduction on ET capabilities
- Gradual changes in riparian ecosystems

Acknowledgements

***RIPFLOW* project:** Riparian vegetation modelling for the assessment of environmental flow regimes and climate change impacts within the WFD. Era-net IWRM Funding Initiative, Acciones Complementarias del MEC (ref.: CGL2008-03076-E/BTE)
http://www.iiama.upv.es/RipFlow/index.htm

SCARCE project: Assessing and Predicting Effects on Water Quantity and Quality in Iberian Rivers caused by Global Change. CONSOLIDER Plan, Ministerio de Ciencia e Innovación (ref.: CSD2009-00065).
http://www.idaea.csic.es/scarceconsolider

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THANK YOU FOR YOUR ATTENTION

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