Centro de Estudios e Investigación para la Gestión de Riesgos Agrarios y Medioambientales

POLITÉCNICA "Ingeniamos el futuro"

Escuela Técnica Superior de Ingenieros Agrónomos

8th International Conference of EWRA

Porto, Portugal, 26th-29th June 2013

Managing drought economic effects through insurance schemes based on local water availability

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1. INTRODUCTION

There are countries offering drought insurance only for **rainfed crops**, based on:

- Meteorological indices: rainfall, temperature…
- Actual losses verified on field
- Examples: Spain, Portugal(SIPAC), Nicaragua, Mexico, Austria, Morocco, Canada, USA…

For **irrigated agriculture**, some attempts to calculate insurance premiums have been done.

1. INTRODUCTION

Pérez Blanco and **Gómez Gómez,** (2012): Indemnity based on net income loss and related to an observable drought index

Quiroga et al., (2011): Have computed the willingness to pay of farmers for hypothetical hydrological insurance

Leiva and Skees, (2008): Irrigation insurance based on a river flow index

Zeuli and Skees, (2005): Proposed a rainfall index financial contract as a tool to improve drought management

Brown and Carriquiry, (2007): Proposed a combination of two tools: bulk water option contracts and index insurance based on reservoir inflows

1. INTRODUCTION

Objectives of the study:

- Evaluate hydrological drought risk in arable crops
- Design drought insurance for irrigated arable crops
- Determine the most suitable insurance scheme for irrigated agriculture

2. METHODOLOGY

To estimate losses due to water scarcity, the FAO's Yield estimation model based on water availability, Aquacrop, is used

Aquacrop allows to calculate in a dynamic way:

- Crop water needs or potential ET (Steduto et al. 2012).
- Soil water balance
- Biomass formation
- Harvest index
- FINAL CROP YIELD

2. METHODOLOGY

Aquacrop needs to be adjusted with parameters defining local conditions:

- Geographic location and historical weather
- Soil characteristics: type, depth, etc
- Crop varieties
- Agricultural practices
- Irrigation type and water allocation

A final yield is obtained and it is a function of actual weather and irrigation water allocations

2. METHODOLOGY

Since farmers manage water shortages by adjusting the surface of more or less water demanding crops, insurance will be also calculated for a whole ID (*Whole-farm insurance*)

Premium rates:

Premium = E(Eligible losses)=E(Guaranteed value – Actual value)

Thus:

$$\text{Premium} = \frac{1}{n}\sum_{t=1}^{n} p_g \times max\left(\bar{y}_g - y_t, 0\right)$$

2. METHODOLOGY

Insurance net of variable irrigation costs (VIC)

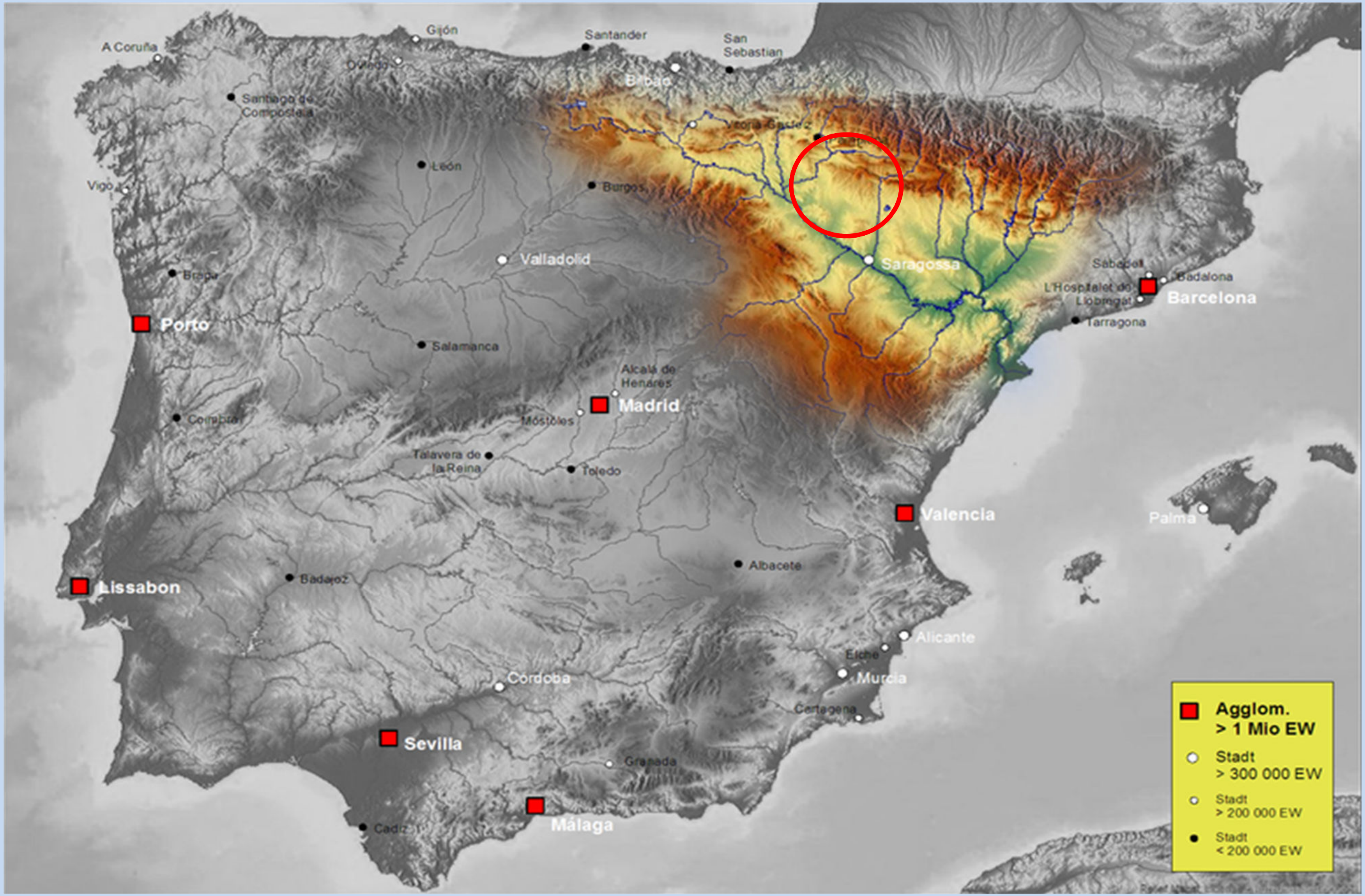
Premium net of VIC= $$\frac{1}{n}\sum_{t=1}^{n}\left[p_g \times max\left(y_g - y_t, 0\right) - max(\overline{VIC} - VIC_t, 0)\right]$$

Trigger insurance

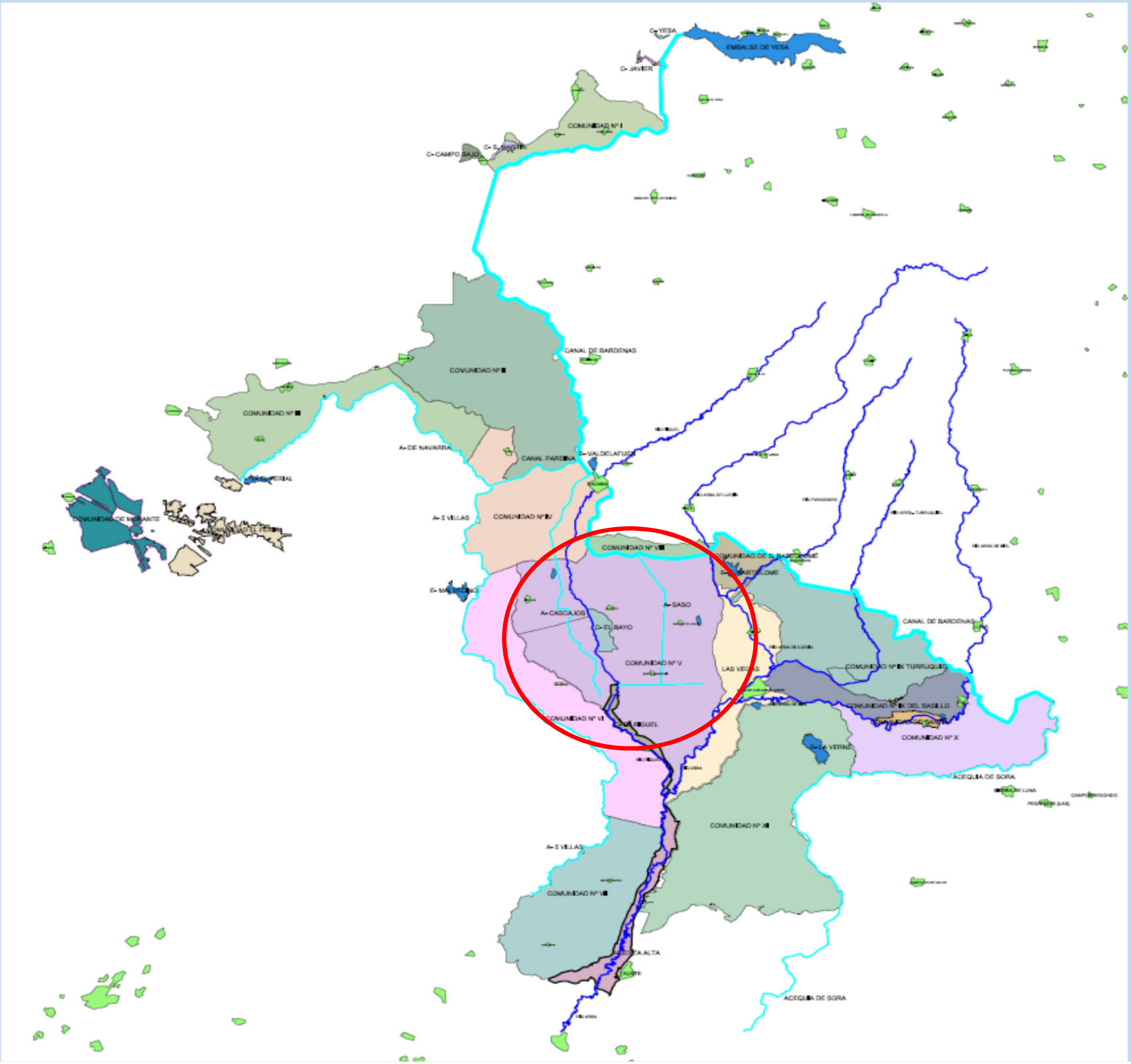
$$\text{Premium} = \frac{1}{n}\sum_{t=0}^{n} p_g \times max\left(\bar{y}_g - y_t, 0\right) \times \alpha_t \quad \alpha_t = \begin{cases} 1, & i_t < i_{tr} \\ 0, & i_t \geq i_{tr} \end{cases}$$

When α_t = 1, Trigger value indicates a hydrological drought and so the indemnity is due

3. APPLICATION TO BARDENAS IRRIGATION DISTRICT



3. APPLICATION TO BARDENAS IRRIGATION DISTRICT



3. APPLICATION TO BARDENAS IRRIGATION DISTRICT

Dynamic simulation model of yield response to water

- Time Series: 2000-2011
- Climate:
  - Agroclimatic Information System for Irrigation (SIAR)
  - National Meteorological Agency (AEMET)
- Soil: According to Isidoro et al. (2002)
  1. Soils in the high terraces (Sasos): Gross items and petrocalcic horizon
  2. Soils in the floodplains: Deeper may have drainage problems
  3. Soils with salinity problems: Used for rice

3. APPLICATION TO BARDENAS IRRIGATION DISTRICT

Dynamic simulation model of yield response to water

- Crop:
  - Reference local dates for the different stages in the crop life cycle
  - Reference dates for planting and cuttings of alfalfa
  - Weight of 1000 seeds of the most common crop varieties in Riegos de Bardenas: Wheat, barley, maize, alfalfa and rice

*Aquacrop doesn't simulate fodder crops yet:

- Production function was used for alfalfa (based on Uku, 2011)

$$y_t = 3.646 + (2.3 \times 10^{-3})x_t + (4.42)x_{t^2}$$

3. APPLICATION TO BARDENAS IRRIGATION DISTRICT

Dynamic simulation model of yield response to water

- Irrigation:
  - Annual water allocations supplied by ID-V (2000-2011)
  - Periodic irrigation events simulated
  - Amount of each one: Annual allocation divided by number of irrigations
  - Simulated Yields weighted according to irrigation system
  - For Whole-farm we take into account ID crops surface distribution

3. APPLICATION TO BARDENAS IRRIGATION DISTRICT

The drought status index used as a trigger

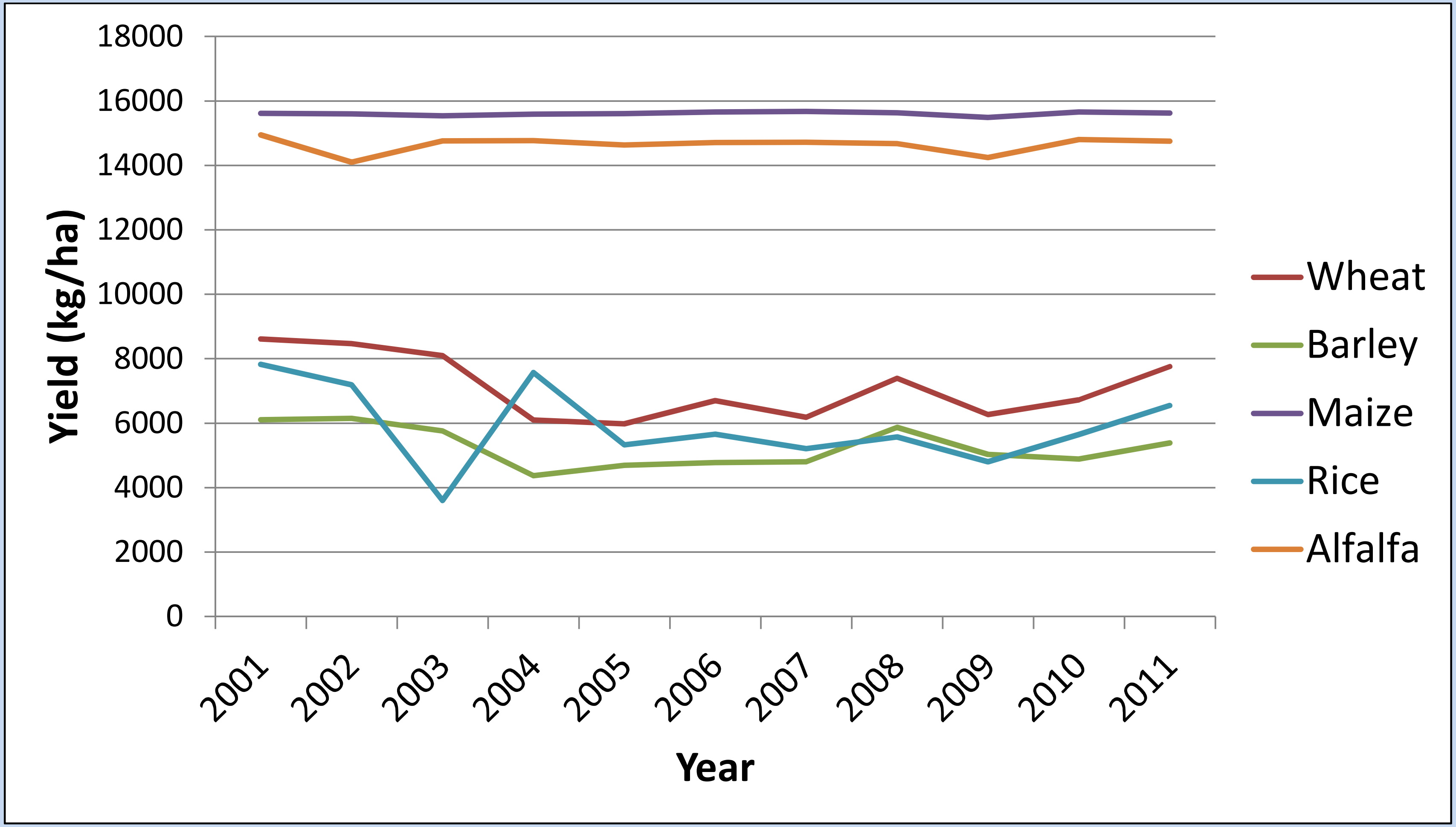
- Index for the irrigation system supplied by Yesa dam
- Published monthly by Confederation of the Ebro
- Value between 0 and 1
- Trigger value = 0.5 (threshold between normal and pre-alert status)

The index for each crop is the mean of the indexes for the two months of higher water demand

For the farm is the indexes' mean between April - September

4. RESULTS

Simulated Yield, Bardenas Irrigation District V



Maize and alfalfa are highly constant
Winter cereals and rice show irregular yields

} Reflection of the used amount of water

4. RESULTS

Simulated Guaranteed Yield and Insurance's Premium

	Guaranteed Yield	Premium (%)			
	(Kg/ha)	DI[1]	DI net of VIC[2]	Trigger DI	Trigger DI net of VIC
Wheat	7199	6.06	6.02	1.99	1.98
Barley	5349	5.50	5.47	1.91	1.90
Maize	15606	0.12	0.10	0.12	0.10
Rice	6019	8.73	8.67	6.49	6.44
Alfalfa	14667	0.58	0.51	0.58	0.51
Weighted average	-	1.99	1.95	1.05	1.01
ID / whole-farm ins.	-	1.04	1.00	0.43	0.42

(1) DI – Drought insurance
(2) VIC – Variable irrigation costs

Maize and alfalfa have smallest premiums
Winter cereals and rice have the highest
Weighted average higher than whole farm

Farmers manage water shortages

↓

Surfaces redistribution according to expected water allocations

5. CONCLUSIONS

- The use of **Aquacrop** implies:
  - **Advantages:** Simplicity, accurate representation of the water soil balance
  - **Disadvantages:** it's only available for arable crops
- Premiums rates are extremely variable between crops (0.1–8.73%)
  - Maize and Alfalfa: Extremely low
  - Rice and winter cereals: High premiums

  } Irrigators' behavior
  - Whole-farm/ID insurance more efficient (0.43-1.04%)

5. CONCLUSIONS

- Difference between DI and trigger-DI premiums:
  - Maize and Alfalfa have the same premium
    - Only suffer losses in years of severe drought
  - Winter cereals and rice: High difference
    - Suffer losses when the index does not show scarcity
  - Because of the low correlation: “status index”- supplied water allocations (corr = 0.38)
  - Further studies should analyze different indexes
    - Reservoir
    - Inflows

Thank you for your attention!