Helping the maize food chain make better choices

The value of seasonal climate forecasts

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The cost-loss model

- A **decision-maker** has to decide whether to take a **protective action**, considering the uncertainty about the possibility of weather-adverse conditions (e.g. a drought).
- If no protective measures are taken and a drought takes place, **a loss L** will be incurred.
- Instead, the agent may choose to reduce the risk by taking protective action **at a cost C**.

The decision-maker aims at **minimizing the average long-term expense**.

Farmer		Event occurs	
		Yes	No
Action taken	Yes	$C+L-L_1$	C
	No	L	0
Buyer		Event occurs	
		Yes	No
Action taken	Yes	C	C
	No	L	0
Insurer		Event occurs	
		Yes	No
Action taken	Yes	C	0
	No	L	$-C_1$

Expense matrix

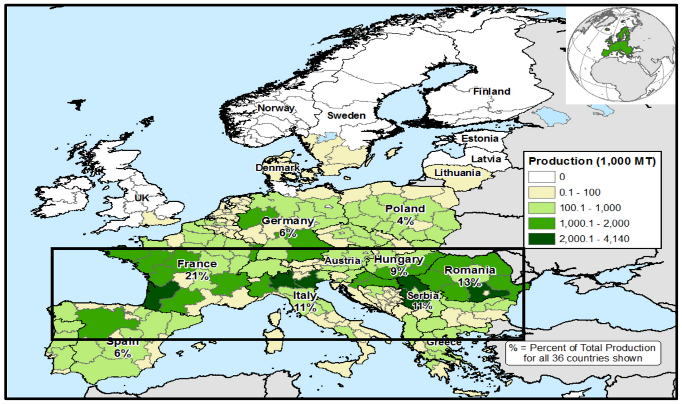
	Buyer	Farmer	Insurer
Protective action	Buy the product in advance	Irrigation, early sowing, water saving, etc..	Increase the premium
Cost C	Additional cost of buying in advance	Cost of setting a mitigation strategy	Paying back the farmer, after premium increase
Negative Cost C_1	x	x	A profit is made
Cost $C+L-L_1$	x	Cost of partial crop failure	x
Loss L	Paying a high price after the drought	Total crop failure	Paying back the farmer, without increasing the premium

Precautionary actions, costs and losses for the different decision-makers

- We enriched the traditional version (Richardson, 2000)
- Set $L_1 = ½ L$
  - Some damage occurs despite protection
- Set $C_1 = 5/6\ C$, depending on
  - Premium increase
  - Payback
  - Lost clients
- $V = \frac{E_{climate} - E_{forecast}}{E_{climate} - E_{perfect}}$

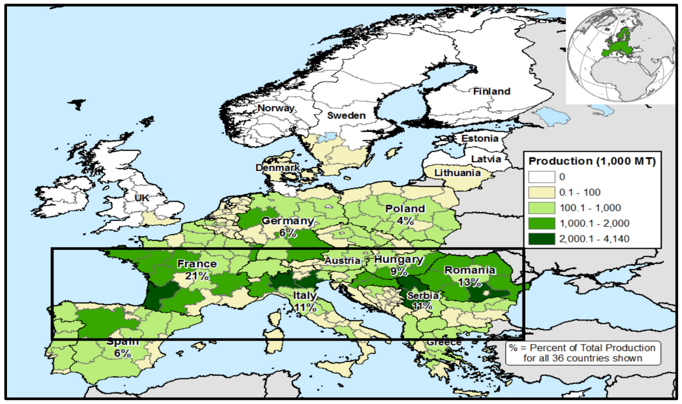
		Meaning
Expenses	$E_{climate}$	Optimal strategy in the absence of climate information (e.g. the user always/never takes precautionary actions).
	$E_{perfect}$	Perfect knwoledge of future weather conditions (e.g. the user intervenes only in case of drought)
	$E_{forecast}$	The user follows the forecast. The expense is computed by by multiplying the corresponding cells of the expense matrix and the contingency table.
Value		If it is greater than 0, it means that the the use of the forecast is economically beneficial.

Seasonal forecast system



- Copernicus C3S seasonal forecast multimodel, **100 members**, hcast **1993-2016**, **March** start date, monthly target on **May, June, July** (flowering phase, very sensitive to water stress)
- We aim at predicting a drought severity index, detected if **SPI-3 < 10th pct** over **> 20% domain**
- **DSI = DMG x DEX**
  DEX = fraction of the hit domain
  DMG = mean SPI-3 in this portion
- Reference: **EOBSv20** precip

Seasonal forecast system and performance



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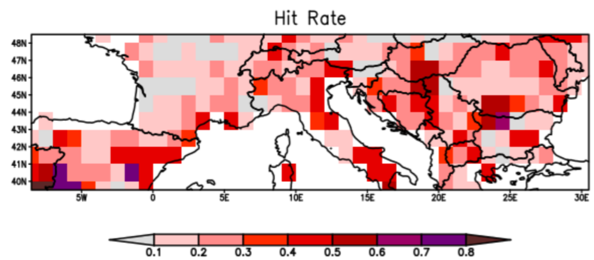
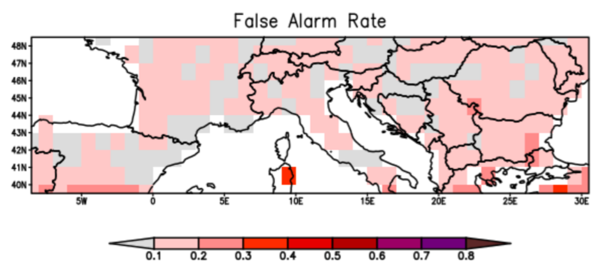
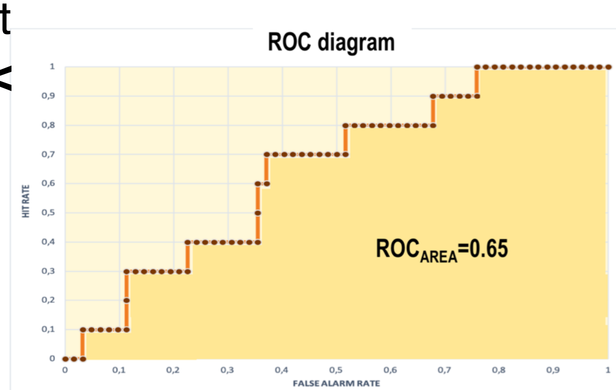
	OBS YES	OBS NO
FCS YES	HE = 7	FA = 23
FCS NO	ME = 3	CR = 39
LPL = 0.163	HR = 0.7	FAR = 0.37







Being the forecast probabilistic, we need to set a **LPL** to make it "deterministic", and allow the DSI to be identified.

Forecast hit rate (HR) = 0.7
False alarm rate (FAR) = 0.37

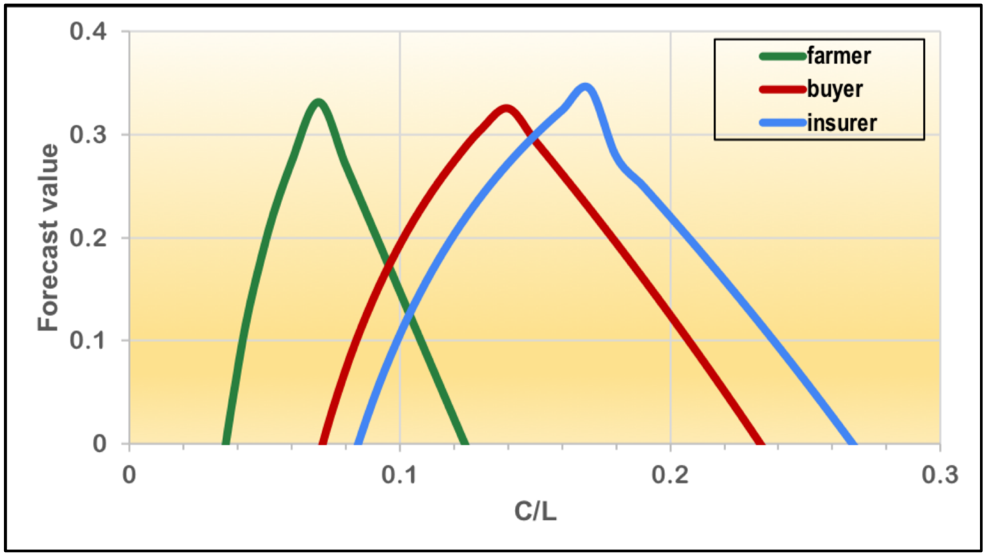
- The forecast probability of having a drought -> higher when droughts occur: the prediction changes depending on the outcome -> **discrimination**.

- A measure of discrimination: **ROC** -> the ability of a probability forecast to discriminate a dichotomous event.

- Area under ROC curve $\boldsymbol{A_{ROC}} = \boldsymbol{0.65}$, meaning the ROC skill score is largely above the 0.5 climatological threshold. Therefore, the forecast contains potentially useful information

Seasonal forecast value for the users

$$V = \frac{E_{climate} - E_{forecast}}{E_{climate} - E_{perfect}}$$



		Event occurs	
Farmer		Yes	No
Action taken	Yes	C+L-L_1	C
	No	L	0
Buyer		**Event occurs**	
		Yes	No
Action taken	Yes	C	C
	No	L	0
Insurer		**Event occurs**	
		Yes	No
Action taken	Yes	C	0
	No	L	-C_1

- The use of the forecast can be beneficial to the three agents, to a different extent depending on their **C/L ratio**.
- The prediction is most valuable for the **insurer**, who can reach a maximum reduction in mean expense that is approximately 35% of what would be obtained through a perfect knowledge of future weather conditions.
- The insurer and the buyer also have the largest C/L ratio range over which the value is greater than zero, meaning that they have larger room of manoeuvre on the decision about the precautionary actions to be taken.

Seasonal forecast value for the users

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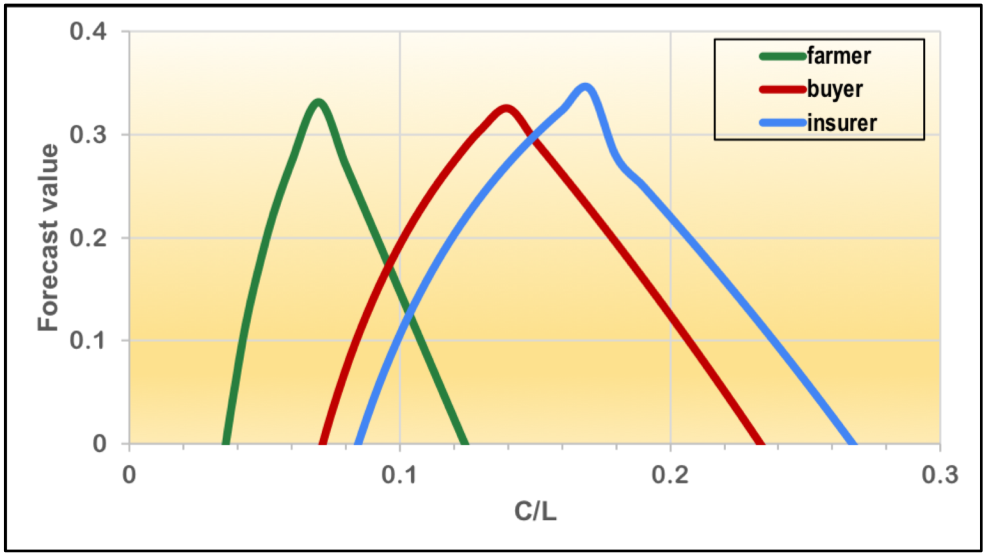

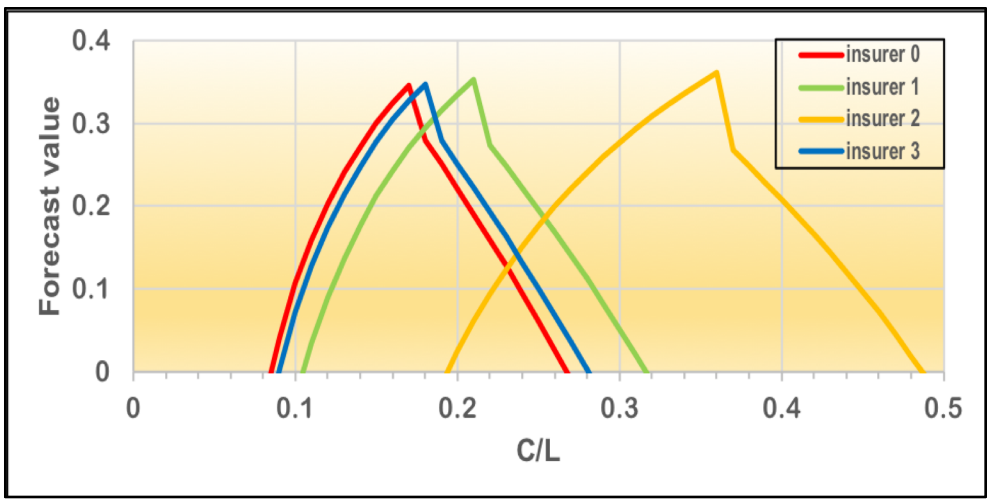

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With regard to the insurer, much depends on C_1/C ratio, determined by the boundary conditions.

We make different assumptions to calculate the forecast benefit to different insurers, three additional scenarios have been included

- **Insurer 0**. *i*) premium raised by 100%, *ii*) 60% of clients lost, and *iii*) the insurer pays back 5 times the original premium if the drought takes place;
- **Insurer 1**. *i*) premium raised by 10%, *ii*) 20% of clients lost, and *iii*) the insurer pays back 3 times;
- **Insurer 2**. *i*) premium raised by 10%, *ii*) 20% of clients lost, and *iii*) the insurer pays back 5 times;
- **Insurer 3**. *i*) premium raised by 80%, *ii*) 60% of clients lost, and *iii*) the insurer pays back 5 times.

Conclusions

- Despite the low seasonal precipitation skill of dynamical predictions in Europe, forecasts of drought can be of sure benefit for a number of users in the maize sector;
- Depending on the C/L ratio, users can reach a 30% reduction in expenses by using the forecast;
- The range of C/L associated with positive forecast value is larger for buyers and insurers;
- A larger assessment, that includes a dialogue between seasonal forecast providers and stakeholders, is needed to provide a realistic score to each forecast outcome, in order to calculate LPL, and monetize the forecast value by means of C and L estimations.

Thanks

Materia S., Ceccacci A., (in prep.). Helping the maize food chain make better choices: the value of seasonal climate forecasts

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