Multi-model subseasonal forecasts of spring cold spells: potential value for the hazelnut agribusiness

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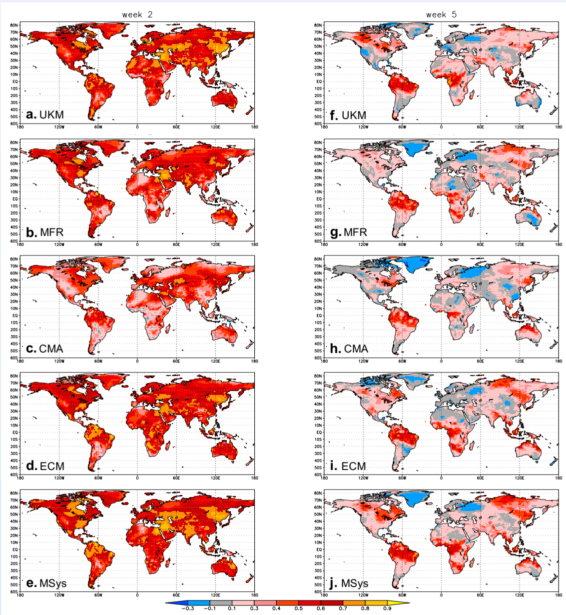
Producing sub-seasonal forecasts with two-to-six weeks target, is crucial for agribusiness, to allow mitigation strategies to be adopted for counteracting weather hazards. For example, spring frosts may result in dramatic losses at the harvest time. Here we present a multi-model ensemble that includes four climate prediction systems involved in the Subseasonal-to-Seasonal (S2S) Prediction project, in an effort to test the quality of spring cold spell forecasts in the Turkish region facing the Black Sea, which is global leader in the production of hazelnuts. In a warming world where climate variability is projected to increase, forecast may be seen as an adaptation tool, useful to mitigate extreme event damages and to plan more profitable crop strategies of less environmental impact.

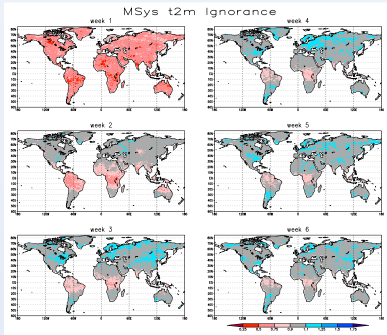
Model	Institution	Country	Ensemble size	Start dates
BCC-CPS-S2Sv1	CMA	China	9	27-28 Feb, 1 Mar 13-14-15 March 30-31 Mar, 1 Apr
GloSea5	UKMO	UK	7	1 March 17 March 1 Apr
IFS Cy43r3	ECMWF	Europe	10	28 February 14 March 28 March
CNRM-CM 6.0	Météo France	France	14	1 March 15 March 1 April
Multi-System MSys			**40**	**1 March** **15 March** **1 April**

- Multiple forecast initializations (Mar 01, Mar 15, Apr 01) concatenated to increase sample size when assessing skill.
- Forecast skill decreases with time, but it remains much above 0.5 in a few areas at week 5.
- Regions of high and low skill are rather consistent throughout models.
- The Multi-System forecast quality is close to that of ECMWF and UKMO models at week 2, and the system is by far more skillful than each of the single models at week 5.

Global temp 2m correlation (weeks 2-5)



MSys Ignorance Skill Score

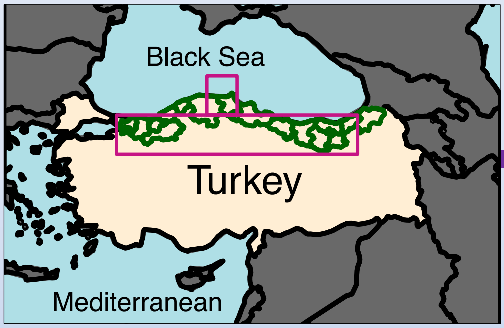


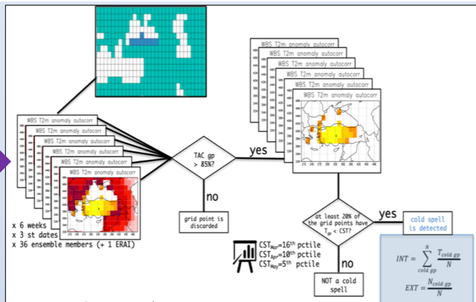
- **Correlation** between models ensemble mean and reanalysis gives a measure of the **forecast deterministic skill**
- **Ignorance** represents the amount of information gain expected from a forecast.

IGN = REL − RES + UNC

Ignorance Skill Score shows the probabilistic forecast skill evolution for Week 1 to 6. ISS=0 means perfect forecast. ISS=1 means as good as climatology.

Areas of hazelnut farming

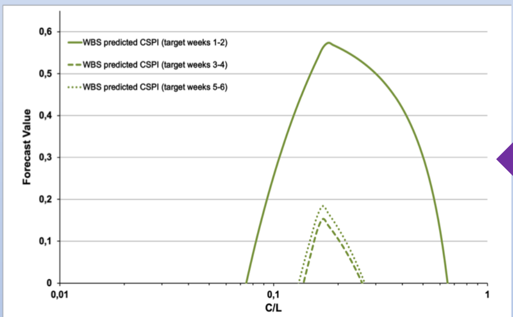




CSPI detection

	Mar 2-8	Mar 9-15	Mar 16-22	Mar 23-29	Mar 30-Apr 5	Apr 6-12
West Black Sea predicted CSPI (March 1st)						
	LPL=20.8%		LPL=15.2%		LPL=10.9%	
1996	82.5%	57.5%	25%	30%	30%	12.5%
1997	0%	10%	15%	17.5%	17.5%	12.5%
1998	2.5%	2.5%	5%	10%	5%	12.5%
1999	0%	5%	10%	10%	5%	10%
2000	5%	2.5%	2.5%	0%	15%	7.5%
2001	0%	0%	0%	5%	7.5%	10%
2002	2.5%	0%	7.5%	5%	10%	10%
2003	15%	2.5%	10%	10%	10%	10%
2004	0%	0%	17.5%	7.5%	15%	2.5%
2005	0%	22.5%	20%	12.5%	7.5%	12.5%
2006	0%	2.5%	2.5%	5%	2.5%	17.5%
2007	0%	0%	12.5%	5%	0%	5%
2008	0%	0%	0%	7.5%	0%	2.5%
2009	0%	0%	2.5%	5%	5%	7.5%
2010	0%	2.5%	0%	12.5%	5%	5%
2011	2.5%	57.5%	17.5%	17.5%	22.5%	15%
2012	80%	25%	30%	20%	20%	22.5%
2013	0%	0%	7.5%	2.5%	7.5%	10%
2014	0%	0%	5%	7.5%	5%	5%

Cost-Loss model



If CSPI occurs, a potential decision maker may lose part of the harvest (loss *L*). However, he may decide to take action against the cold spell: in this case, he will incur a cost *C* to take action, but he will avoid *L*. Having no info, the decision maker will guess about forthcoming cold spell. The forecast is meant to do better than a simple guess. The forecast value shows that there is, for some users more than 50% gain by using information from the forecast on lead weeks 1-2, and more than 10% even at weeks 3-4 and 5-6.

Contingency tables

Northern Coast of Turkey (all start dates)			
Weeks 1-2		ERAI YES	ERAI NO
	Model YES	**13**	*7*
	Model NO	7	87
Weeks 3-4		ERAI YES	ERAI NO
	Model YES	**7**	*20*
	Model NO	12	75
Weeks 5-6		ERAI YES	ERAI NO
	Model YES	**8**	*22*
	Model NO	11	73

The contingency tables show that the Msys has
DISCRIMINATION: The forecast is different depending on the outcome
RESOLUTION: The outcome differs depending on the forecast

MAIN CONCLUSION

Using a multi-system approach, low skill for 2-meter temperatures does not prevent the forecast from being potentially valuable to decision makers, if a different but related index (Cold Spell Power Index) is used instead.

How to obtain forecast outcomes?

Forecast is probabilistic: how high must the forecast probability be, to trigger off a cold spell alarm? Are we forecasting a cold spell when CSPI has, e.g., 16% chance of occurrence?

- Gerrity Skill Scores (GSS, Gerrity 1992) assign a value to each of the four possible combinations between the forecast and verification:

1. Hit events (HE)
2. Correct rejections (NN)
3. Missed events (ME)
4. False alarms (FA)

- Weeks 1-2, Weeks 3-4 and Weeks 5-6 treated separately.
- The sum of the 38 GSSs, relative to the nineteen outcomes (1996-2014) for each two-week chunk, is maximized by changing the threshold triggering a forecast of CSPI.
- For every start date a **LPL** is obtained for each two-week chunk, that maximizes the sum of the 38 GSSs.
- LPL sets the **minimum forecast probability required for a cold spell alert.** In other words, a CSPI forecast probability > LPL can be seen as a deterministic forecast of cold spell.

References:

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