Validation of IVINE crop growth model using MACSUR2 project measurements in a few European vineyards

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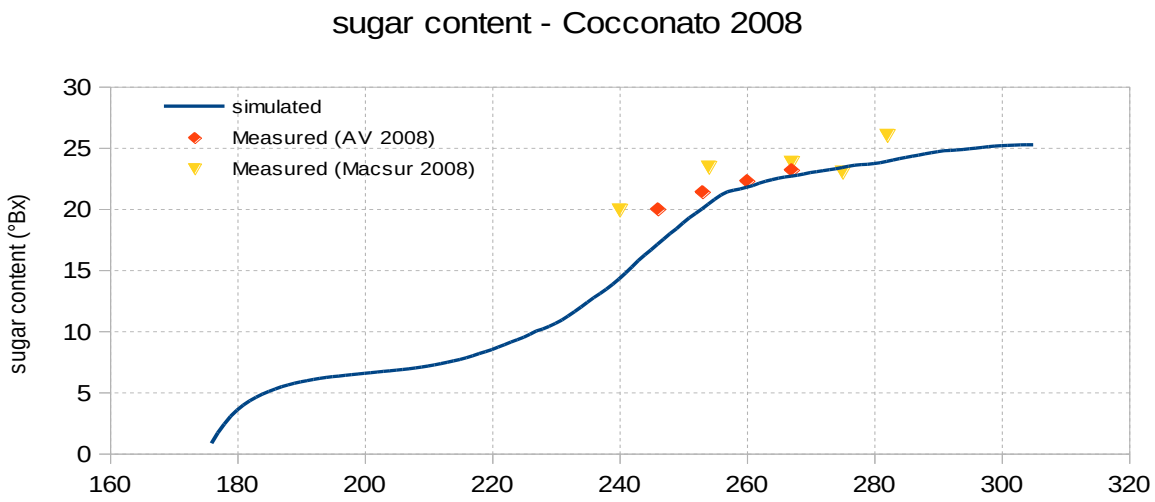
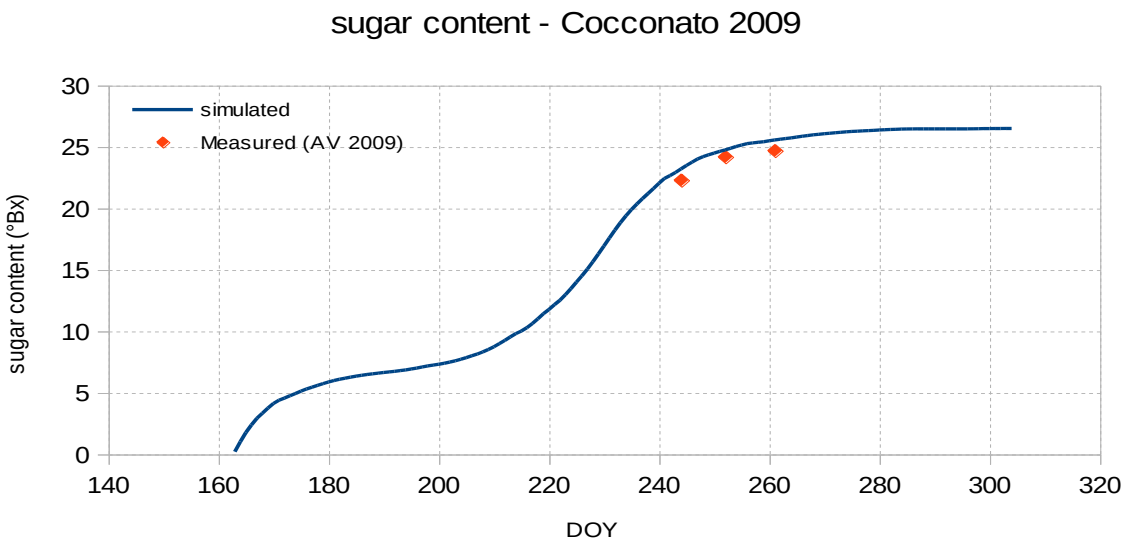
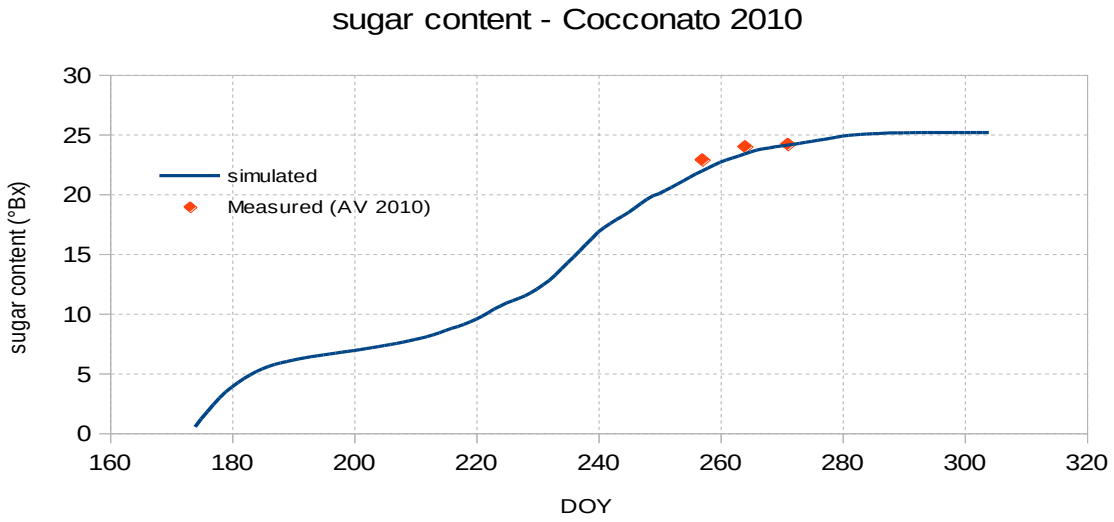
Summary

- The crop growth model IVINE (Italian Vineyard Integrated Numerical model for Estimating physiological values) was developed to simulate grapevine phenological and physiological processes and it was originally optimized only for cv. Nebbiolo.
- The main IVINE model outputs are: the timing of phenological stages, the leaf development, the yield, the berry sugar concentration and the predawn leaf water potential.
- Recently IVINE model has been calibrated and validated also on different grapevine varieties (cv. Barbera, cv. Merlot, cv. Cannonau, cv. Vermentino).
- We are presenting here the results of these preliminary simulations of grapevine growth processes executed using datasets assembled in the frame of MACSUR2 project.

Cocconato (barbera): sugar content







We present here an example of intercomparison between model and observation for one variety in one site

In Cocconato site the simulated berry sugar content resulted close to the in-field measured values in the final part of the season while in the central part it was underestimated.

Conclusions and perspectives

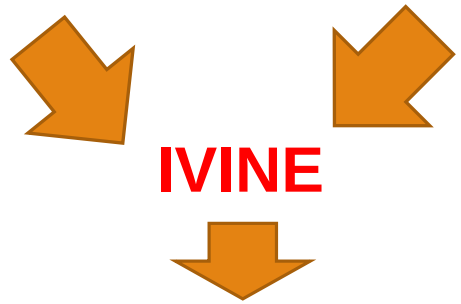
- The crop growth model IVINE, originally calibrated for Nebbiolo variety only, has been adapted also for other cultivars, such as red varieties Barbera, Cannonau and Merlot, and white, such as Vermentino
- The results of the simulations, compared between each other in different years, and of few intercomparisons between simulated and measured data have been here presented
- The former allowed to estimate the interannual variability of some variables, while the latter allowed the validation of the model for such new varieties; however, available data were too few
- The IVINE model seems able to correctly represent the evolution of growth processes in these varieties. Eventual other available measured data collected in different vegetative season or in different sites could improve the calibration of the model and allow an higher accuracy on model outputs

Supplementary slides

The crop growth model IVINE: structure
(Italian Vineyard Integrated Numerical model for Estimating physiological values)

Input data (meteorological)

- Air temperature
- Air relative humidity
- Solar global radiation
- Photosynthetically active radiation
- Soil temperature
- Soil water content
- Wind speed and direction
- Rainfall
- Leaf wetness



Input data (others)

- Geography (latitude, longitude, slope, height)
- Soil hydrology
- Plant density (plants/ha)
- Variety characteristics
  - ✓ clusters/plants, berries/cluster,
  - ✓ °Brix maximum value, thermal thresholds
- Vineyard management (trimming, severity of trimming)

Output data

- Predawn leaf water potential
- Timing of the main phenological phases
  - dormancy break, budburst, flowering, fruit-set,
  - beginning of ripening, veraison, harvest
- Leaf development
- Yield
- Sugar concentration

Model reference
Andreoli, V.; Cassardo, C.; La Iacona, T.; Spanna, F., 2019: Description and Preliminary Simulations with the Italian Vineyard Integrated Numerical Model for Estimating Physiological Values (IVINE), Agronomy, 9, 94; doi:10.3390/agronomy9020094

Experimental locations and varieties

- Cocconato (Piedmont, Italy) (45° 05' 20" N, 8° 02' 26" E, 311 m a.s.l.), soil type: silty clay loam
  - Barbera (red wine)
- Fubine (Piedmont, Italy) (44° 57' 49" N, 8° 25' 52" E, 210 m a.s.l.), soil type: clay loam
  - Barbera (red wine)
- Oristano (Sardinia, Italy) (39° 54’ N, 8° 37’ E, 13 m a.s.l.), soil type: NN
  - Vermentino and Cannonau (white and red wines)
- Couhins (France) (44.754406° N, 0.559028° W, 23 m a.s.l.), soil type: loam
  - Merlot (red wine)

Meteorological inputs

- Cocconato
  - Data available from in-situ measurements (within vineyards) during MACSUR observation phase (2008-2010 growing season)
- Fubine
  - Data available from in-situ measurements (within vineyards) during MACSUR observation phase (2008-2010 growing season)
- Oristano
  - Data evaluated using UTOPIA land surface model, driven by meteorological data extracted by GLDAS 2.1 project during XXXX growing season)
- Couhins
  - Data evaluated using UTOPIA land surface model, driven by meteorological data extracted by GLDAS 2.1 project during 2004-2005 growing season)

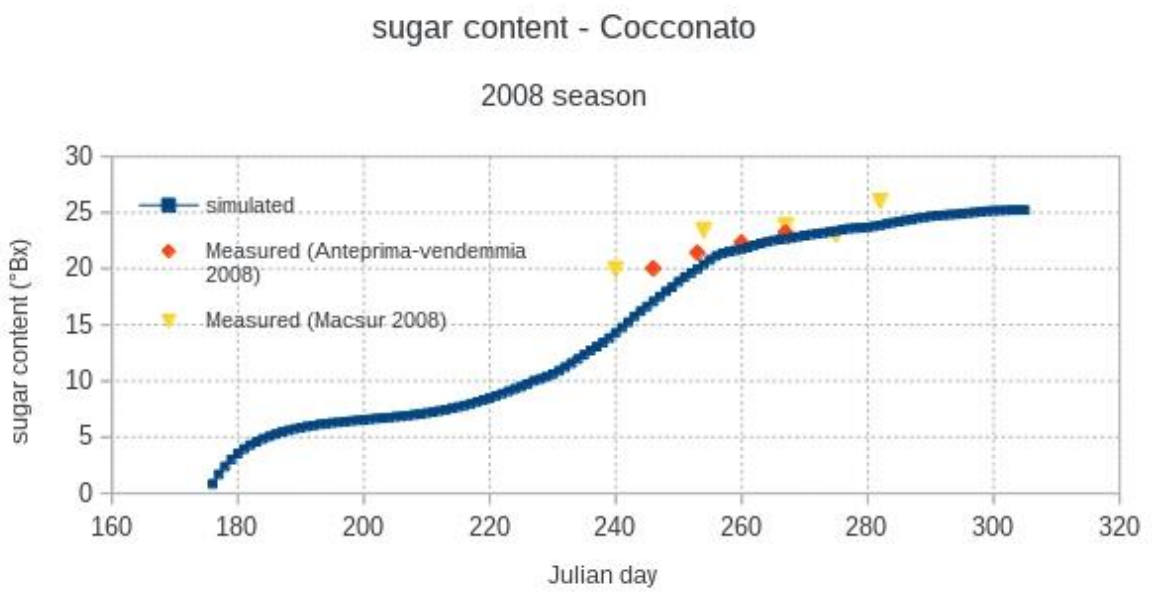
Land surface model UTOPIA (University of TOrino model of land Process Interaction with Atmosphere) references:

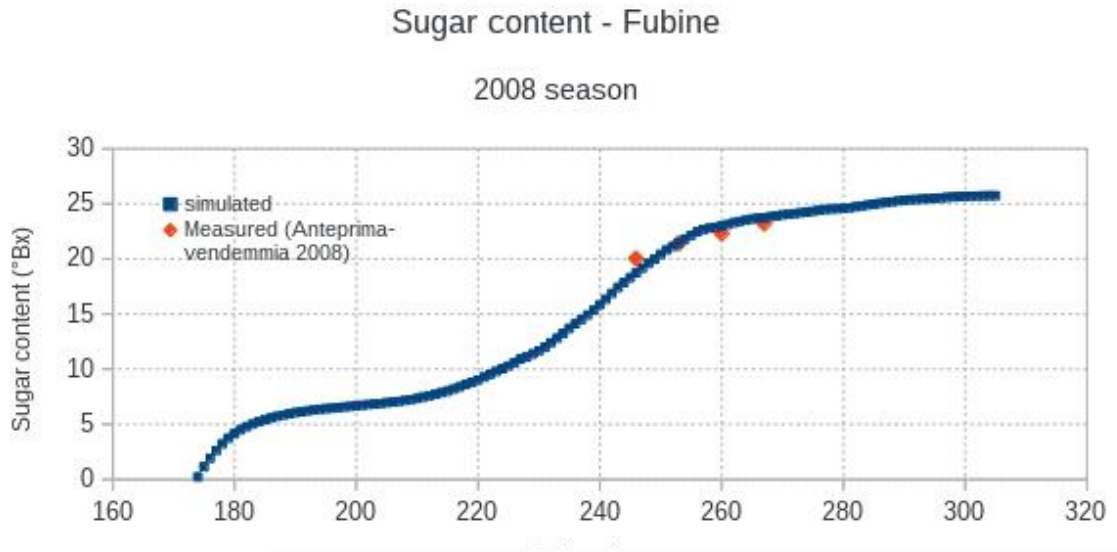
- Cassardo, C.; Andreoli, V., 2019. On the Representativeness of UTOPIA Land Surface Model for Creating a Database of Surface Layer, Vegetation and Soil Variables in Piedmont Vineyards, Italy. Appl. Sci., 9, 3880; doi:10.3390/app9183880
- Cassardo, C. The University of Torino Model of Land Process Interaction with Atmosphere (UTOPIA) Version 2015; Technical Report No. SSRC/CCCPR-TR-2015-1; Ewha Womans University: Seoul, Korea, 2015; p. 80.

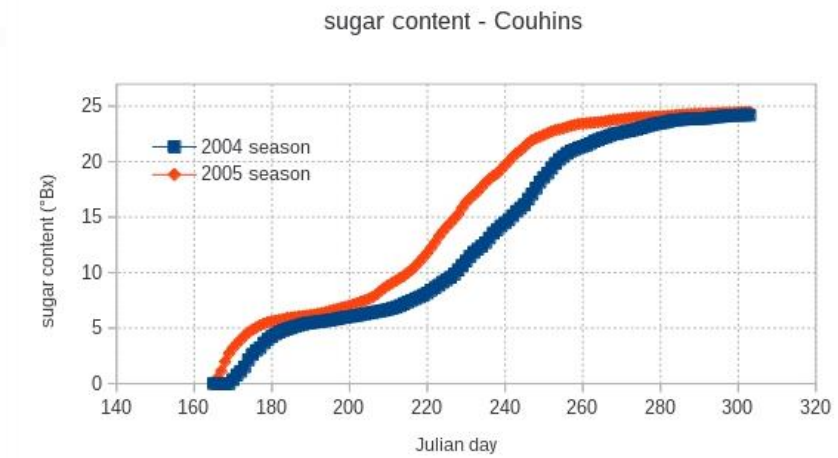
Datasets for IVINE output validation

- The input datasets used for simulations on Barbera and Merlot have been assembled in the frame of the MACSUR project (phase 2).
- Meteorological data for the two Italian Piemonte region sites (Cocconato and Fubine) have been taken in two vineyards located in Piedmont region and integrated with simulations carried out using the land surface model UTOPIA
- Meteorological data for the locations in France (Couhins) and Sardinia have been extracted by the GLDAS 2.1 database in the nearest grid point and integrated with simulations carried out using the land surface model UTOPIA (University of TOrino model of land Process Interaction with Atmosphere)
- An intercomparison between simulated data and in-field measured data (if available) has been done with the specific aim of calibrate and validate the model on grapevine different varieties

Sugar content



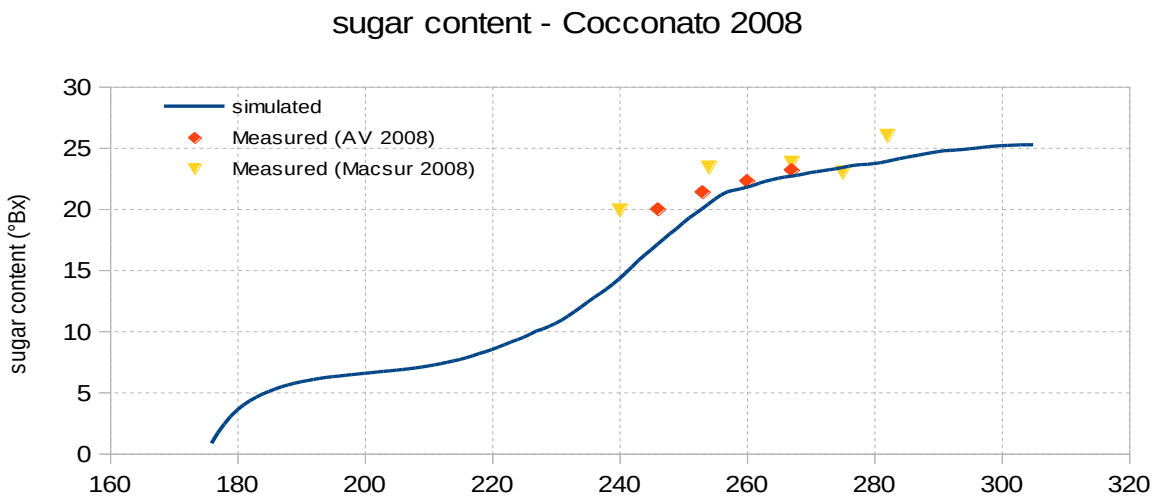


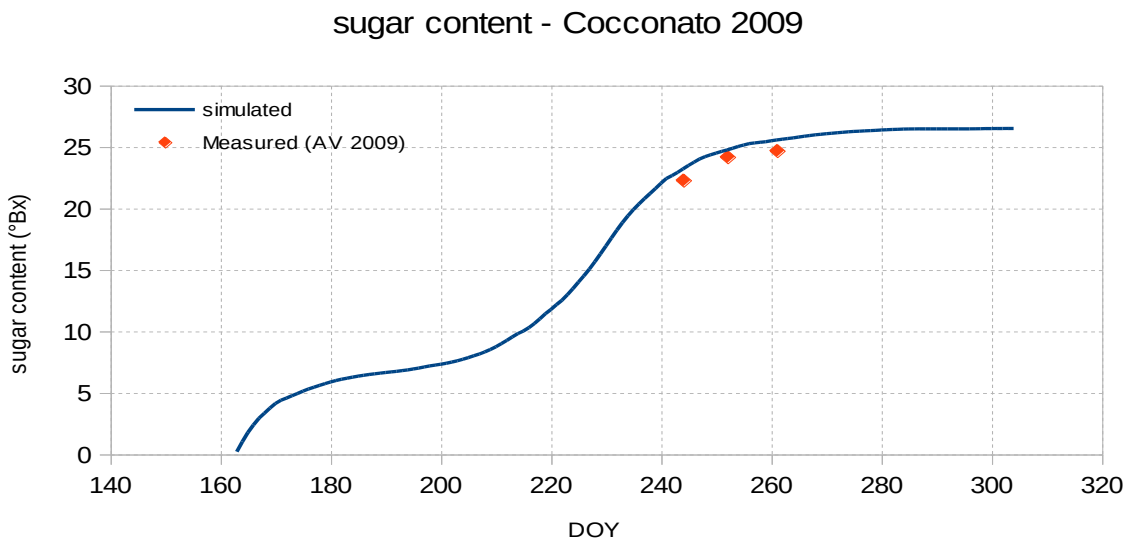


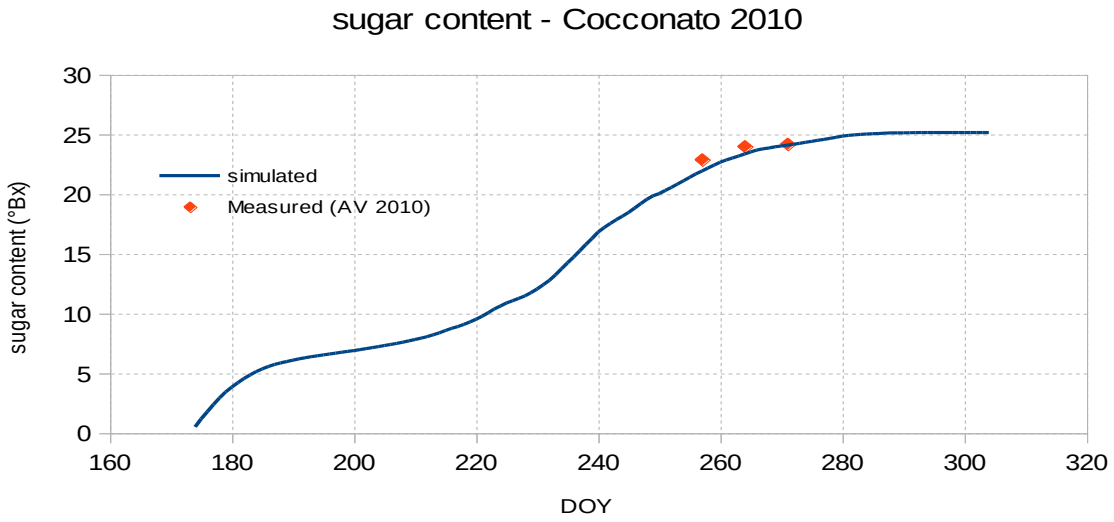
In Cocconato site the simulated berry sugar content resulted close to the in-field measured values in the final part of the season while in the central part it was underestimated.

In Fubine site, simulated and measured values resulted to be close and the trend was well reproduced.

Cocconato (barbera): sugar content







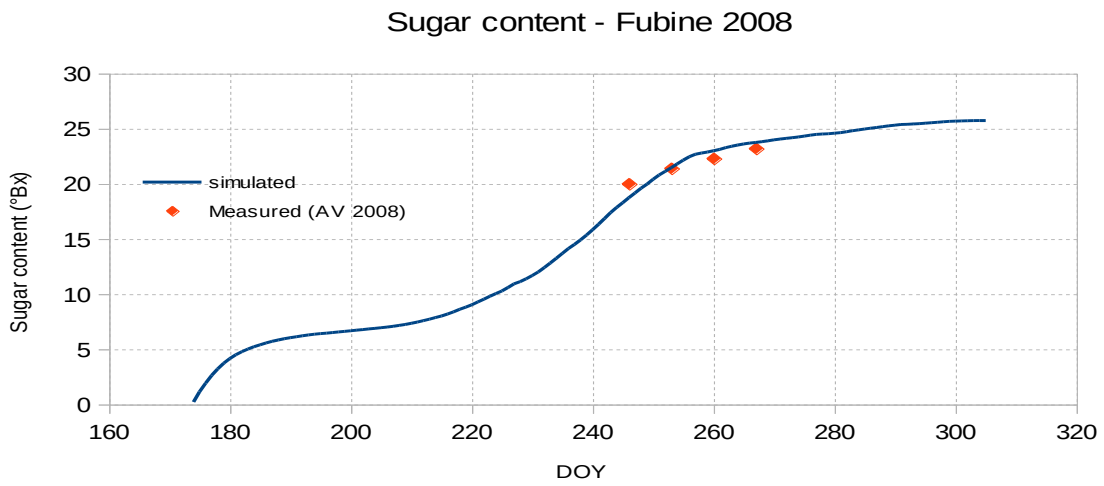
In Cocconato site the simulated berry sugar content resulted close to the in-field measured values in the final part of the season while in the central part it was underestimated.

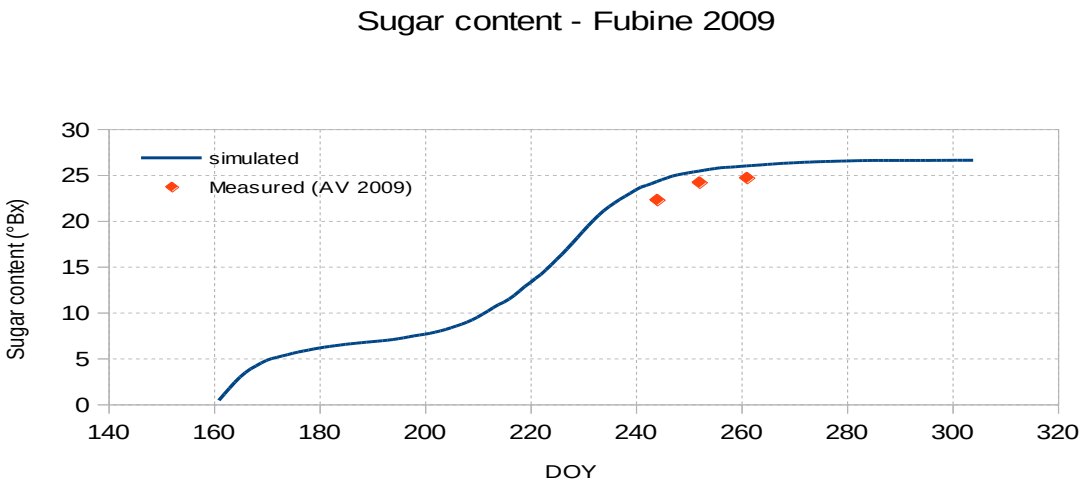
Cocconato (barbera): phases

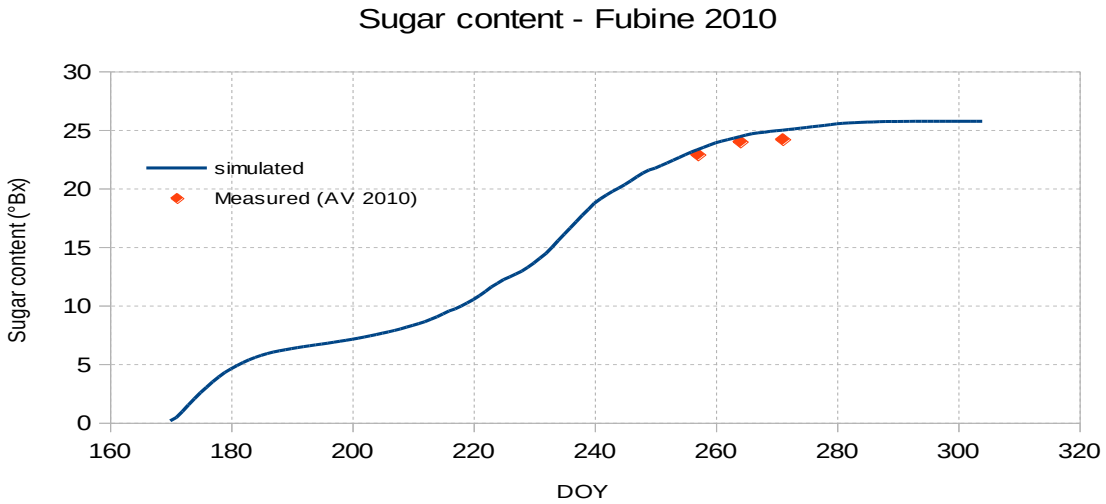
Phenological Stage	Year	Simulated Julian day	Simulated BBCH	Measured Julian day	Measured BBCH
Bud-break	2008	92	7	122	15
	2009	98		92	7
	2010	110		138	15
Flowering	2008	162	65	150	61
	2009	149		145	63
	2010	159		154	60
Fruit-set	2008	167	71	202	77
	2009	154		191	75
	2010	163		176	75
Beginning of ripening	2008	230	81	223	79
	2009	217		202	77
	2010	225		209	79
Veraison	2008	236	83	244	83
	2009	222			
	2010	232			

Simulated and observed phases, when characterized by the same BBCH stages, differ by about 7 days
The largest difference is the underestimation of the Veraison (8 days)
2009 season seems anticipated with respect to others

Fubine (barbera): sugar content







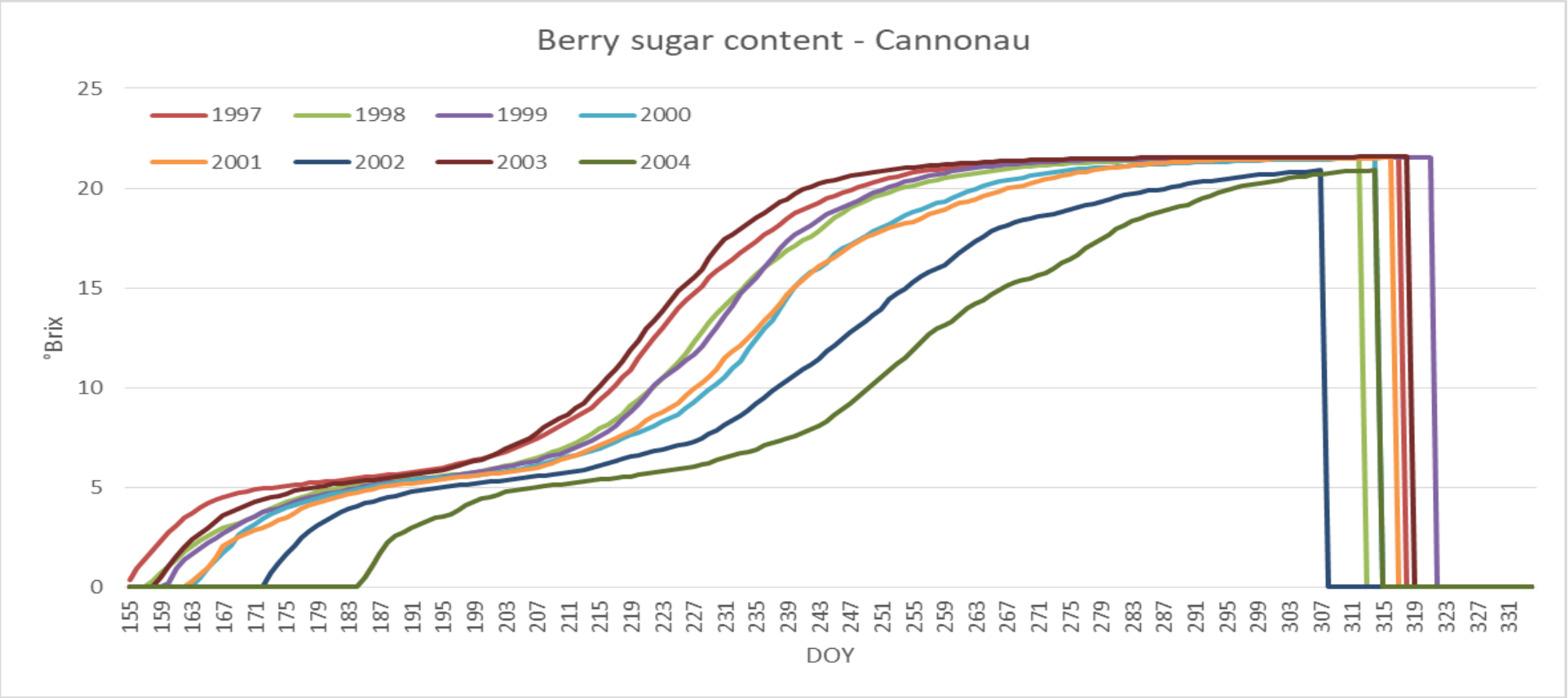
In Fubine site, the simulated berry sugar content resulted to be close and the trend was well reproduced.

Fubine (barbera): phases

Phenological Stage	Year	Simulated Julian day	Simulated BBCH	Measured Julian day	Measured BBCH
Bud-break	2008	91	7	120	16
	2009	97		105	12 – 13
	2010	109			
Flowering	2008	160	65	142	57
	2009	147		138	113 – 55
	2010	157			
Fruit-set	2008	165	71	171	71-73
	2009	152		159	73-75
	2010	161			
Beginning of ripening	2008	227	81	214	79
	2009	214		208	81
	2010	221			
Veraison	2008	233	83		
	2009	219		225	83
	2010	227			

Simulated and observed phases, when characterized by the same BBCH stages, differ by about 7-10 days
The largest difference is the underestimation of the Veraison (8 days)
Also at Fubine 2009 season seems anticipated with respect to others

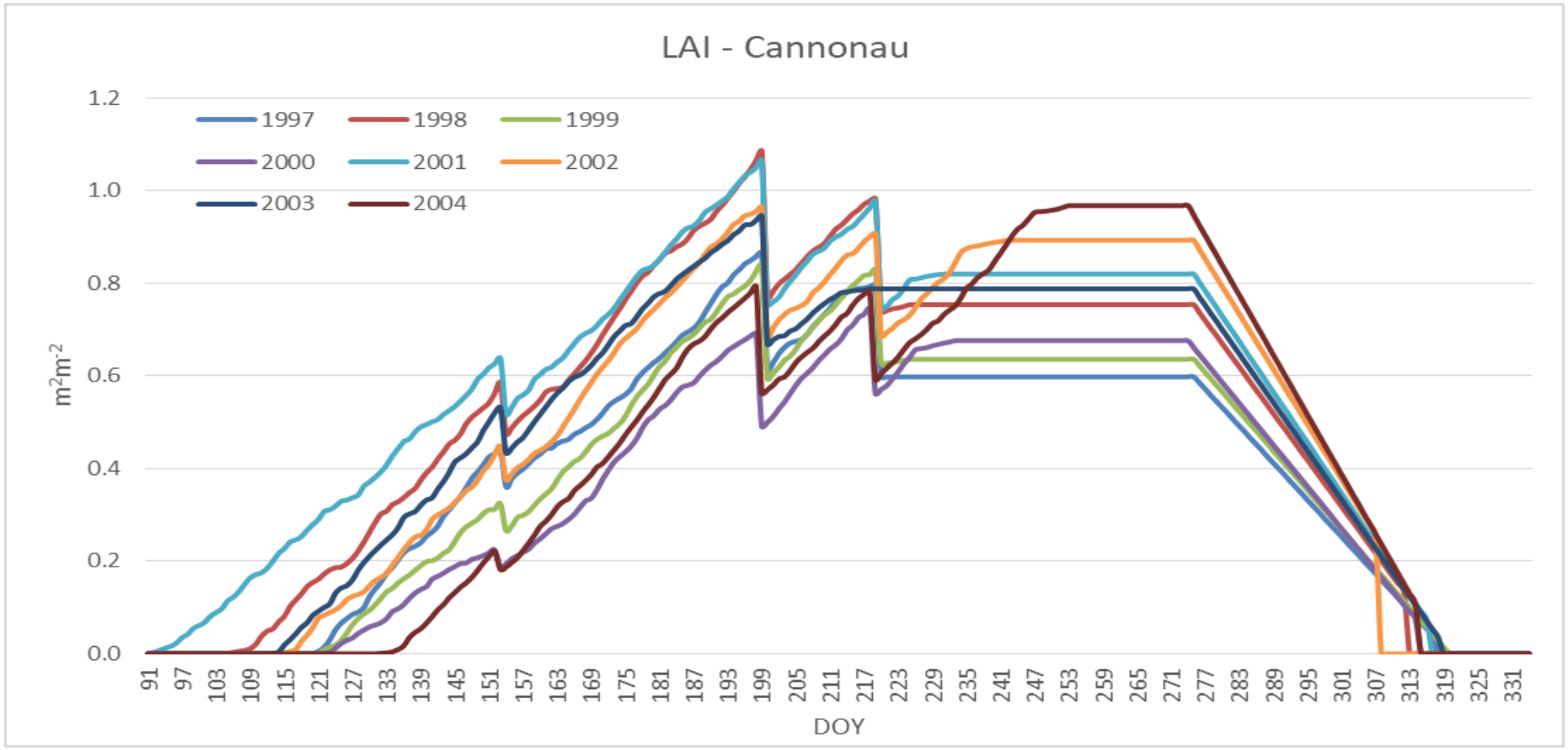
Oristano (cannonau): sugar content



In absence of experimental measurements, we show the interannual variability among different years for berry sugar content

During the extremely hot 2003 season, sugar exceeds 20 °Bx already at DOY 240, while in the late 2001 the same value was exceeded only at DOY=300

Oristano (cannonau): LAI



LAI behavior shows a large interannual variability and evidences the three seasonal topping of vineyards imposed by IVINE

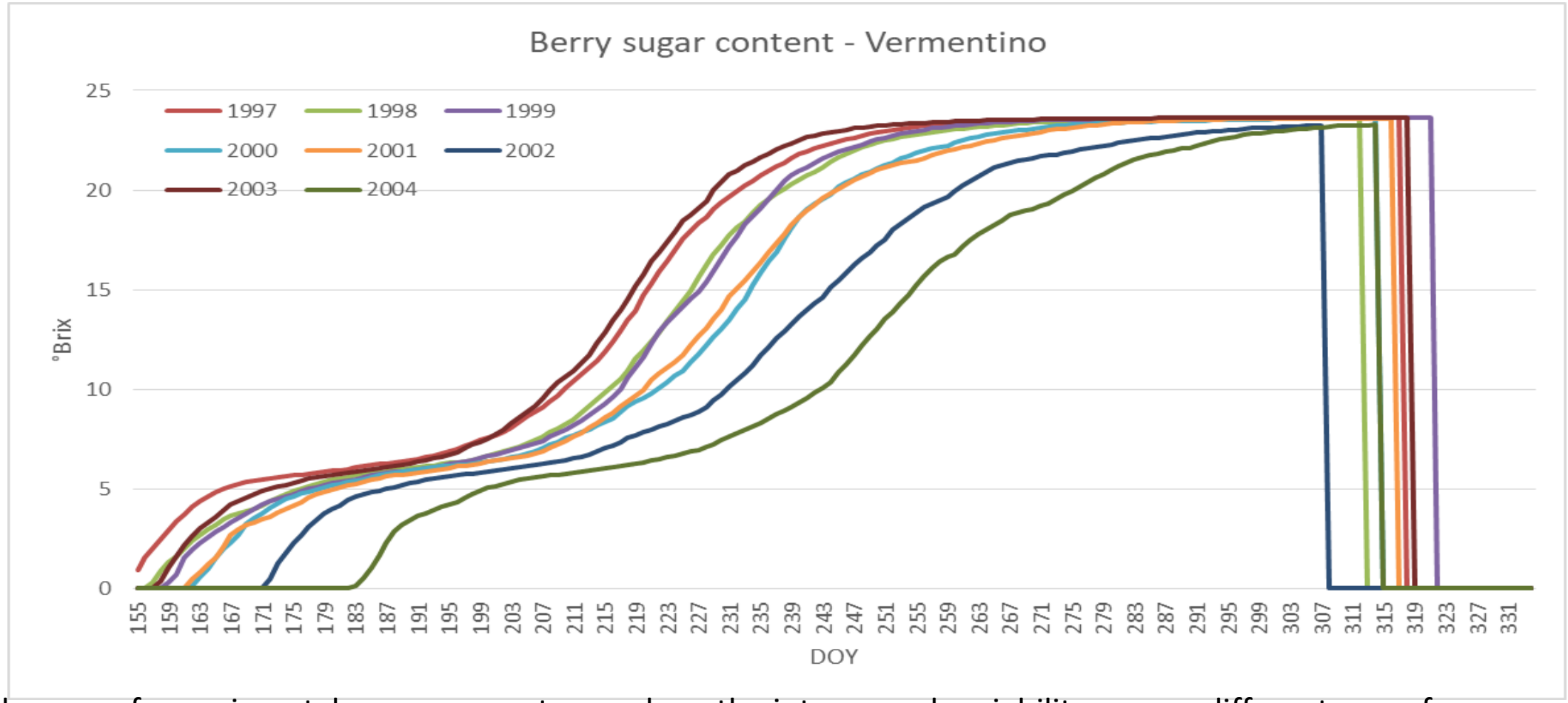
For LAI the hot 2003 (not extreme in Sardinia as in north Italy and France) did not produce a quite large decrease of LAI: so the combination of soil temperature and moisture influenced sugar content and yield, but not the LAI

Oristano (cannonau): phases

	Bud-break (BBCH 07) simulated	Bud-break measured	Flowering	Flowering measured	Veraison	Veraison measured
1997	119	101	145	147	220	209
1998	102		146	153	225	
1999	121		150		225	
2000	122		151		234	
2001	90		146		231	
2002	111		160		242	
2003	112	114	146	146	218	209

The few available measurements of phases reveal under/overestimations of 7-10 days for some phases in some years, and substantial good estimations in other situations.
Data are too few to allow more general considerations

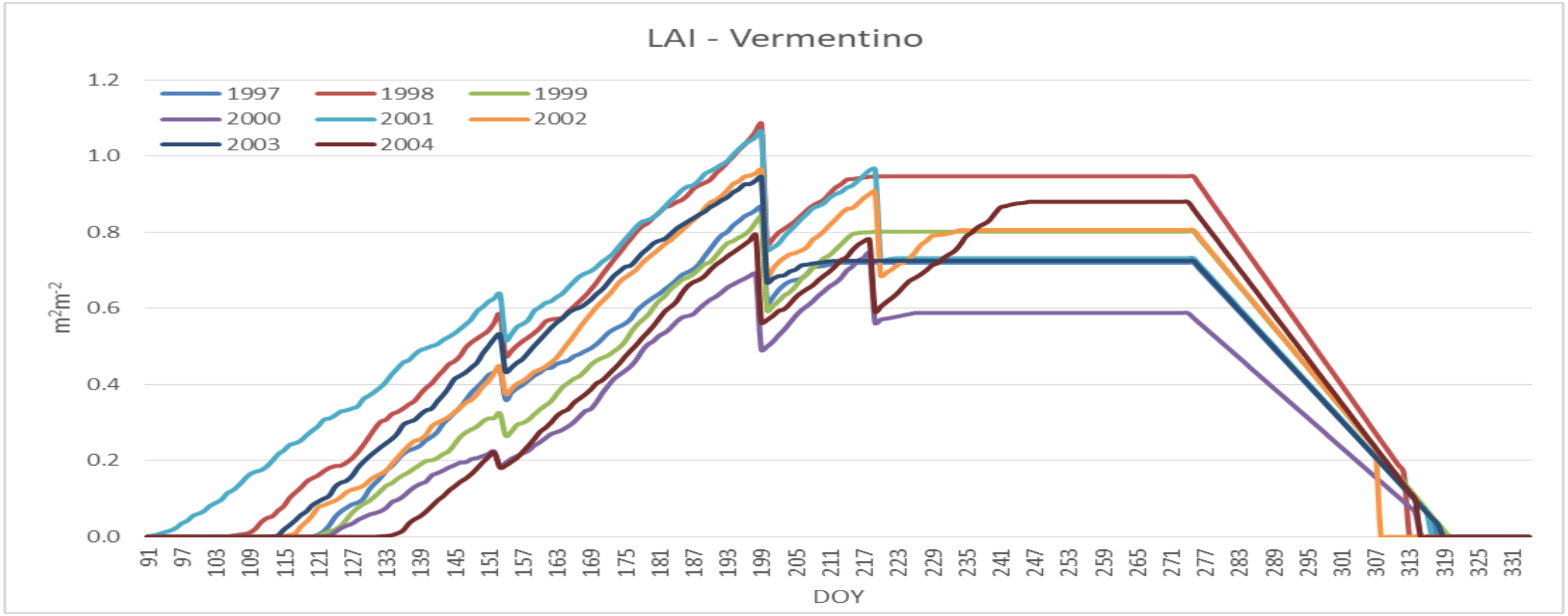
Oristano (vermentino): sugar content



In absence of experimental measurements, we show the interannual variability among different years for berry sugar content

During the extremely hot 2003 season, sugar exceeds 20 °Bx already at DOY 230, while in the late 2001 the same value was exceeded only at DOY=280

Oristano (vermentino): LAI



LAI behavior shows a large interannual variability and evidences the three seasonal topping of vineyards imposed by IVINE

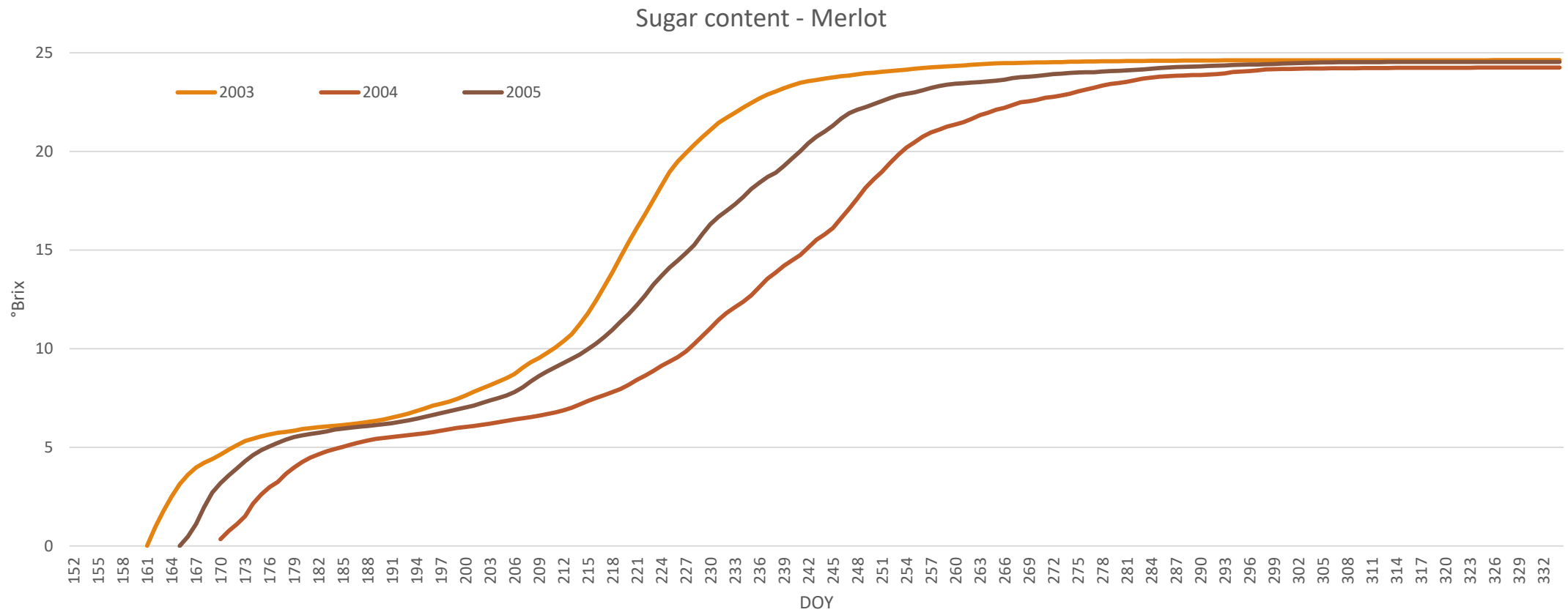
For LAI the hot 2003 (not extreme in Sardinia as in north Italy and France) kept low values of LAI, but not the lowest of the series: so the combination of soil temperature and moisture influenced sugar content and yield, but not the LAI

Oristano (vermentino): phases

	Bud-break (BBCH 07) simulated	Bud-break measured	Flowering (BBCH 65)	Flowering measured	Veraison (BBCH 83)	Veraison measured
1997	119	93	145	143	213	208
1998	102	112	146	155	219	210
1999	121		150		219	
2000	122		151		227	
2001	90		146		223	
2002	111	109	160	149	229	226
2003	112	112	146	145	212	212

The few available measurements of phases reveal under/overestimations of 5-20 days for some phases in some years, and substantial good estimations in other situations.
Data are too few to allow more general considerations

Couhins (merlot): sugar content



Only three years are available for this vineyards, but they include 2003 (the year with hottest summer) and the cooler 2004: the difference shows a remarkable interannual variability

During 2003 season, sugar exceeds 20 °Bx already at DOY 227, while in the 2004 the same value was exceeded only at DOY=254, e.g. about one month later

Main projects

- MASGRAPE (Multidisciplinary Approach to Study the GRAPEvine agroecosystem: analysis of biotic and abiotic factors able to influence yield and quality) – Regione Piemonte (2008-2010)
- MACSUR (Modelling European Agriculture with Climate Change on Food Security) phase 1 – Progetto Europeo JPI-FACCE (2013-2015)
- MACSUR (Modelling European Agriculture with Climate Change on Food Security) phase 2 – Progetto Europeo JPI-FACCE (2016-2018)
- Progetto LAGRANGE (Micro meteorological and vegetative assessments and advanced modelling for precision viticulture) (2015)
- Progetto LAGRANGE (Micro meteorological and vegetative assessments and advanced modelling for precision viticulture. Improvement and advances) (2016)
- Progetto CRT - DAMOVIP (DAti e MOdelli previsionali per la VIticoltura di Precisione) (2018-2019)
- Projects between privates and academy (2015-2019)