

Impacts of Climate Change on Durum Wheat Production in Sardinia (Italy)

Valentina Mereu^{1,2}, Carla Cesaraccio^{2,3}, Martin Dubrovsky⁴, Donatella Spano^{1,2}, Gianluca Carboni⁵, Pierpaolo Duce^{2,3}

¹ Department of Economics and Woody Plant Ecosystems - DESA, University of Sassari, Italy, vmereu@uniss.it; ² EuroMediterranean Center for Climate Change - CMCC, Sassari, Italy; ³ Institute of Biometeorology, CNR-IBIMET Sassari, Italy; ⁴ Institute of Atmospheric Physics, Prague - Academy of Sciences of the Czech Republic; ⁵ Agricultural Research Agency of Sardinia - AGRIS - Cagliari, Italy.

The high sensitivity of agriculture to climate conditions and the large uncertainty on the combined effects of increasing CO₂ concentration and projected changes in temperature and especially in rainfall patterns on crops, reveals the necessity to better understand the impacts of future climate for implement appropriate adaptation and mitigation strategies in agriculture, to increase production and food security.

This study aimed to assess impacts of potential climate change in ambient carbon dioxide (CO₂) level on production and phenology for two of the most important varieties of durum wheat at four experimental sites in Sardinia, Italy, assuming different soils, climate conditions and management practices, and to provide guidelines for realistic adaptation strategies in a typical Mediterranean area.

Methodology

The CERES-Wheat (Ritchie et al., 1985) model in combination with a stochastic Weather Generator (WG), recently developed (M&Rfi, Dubrovsky, 2009), was used to quantify the climate change impacts on wheat development and production (Fig.1) for 4 experimental sites in Sardinia (Fig.2). Synthetic weather series representing possible future climates were generated by modifying the WG parameters according to a set of GCM based climate change scenarios. To take into account the uncertainties in future climate development, a set of 9 climate change scenarios derived by the pattern scaling technique (Santer et al., 1990, Dubrovsky et al., 2005) were developed. Three GCM-based (HadCM3, NCAR and ECHAM) standardised scenarios were multiplied by three values (low, middle, high) of changes in global mean temperature (ΔT_G) obtained by MAGICC climate model assuming various combinations of climate sensitivity (1.5, 3 and 4.5 °C) and four emission scenarios (SRES B1, B2, A1B, A2), for 3 future periods: 2025, 2050, 2075. In the climate change impact assessment, we explored separately direct CO₂ effect (known as a fertilization effect) and indirect CO₂ effect (related only to changed weather conditions) for the three future periods.

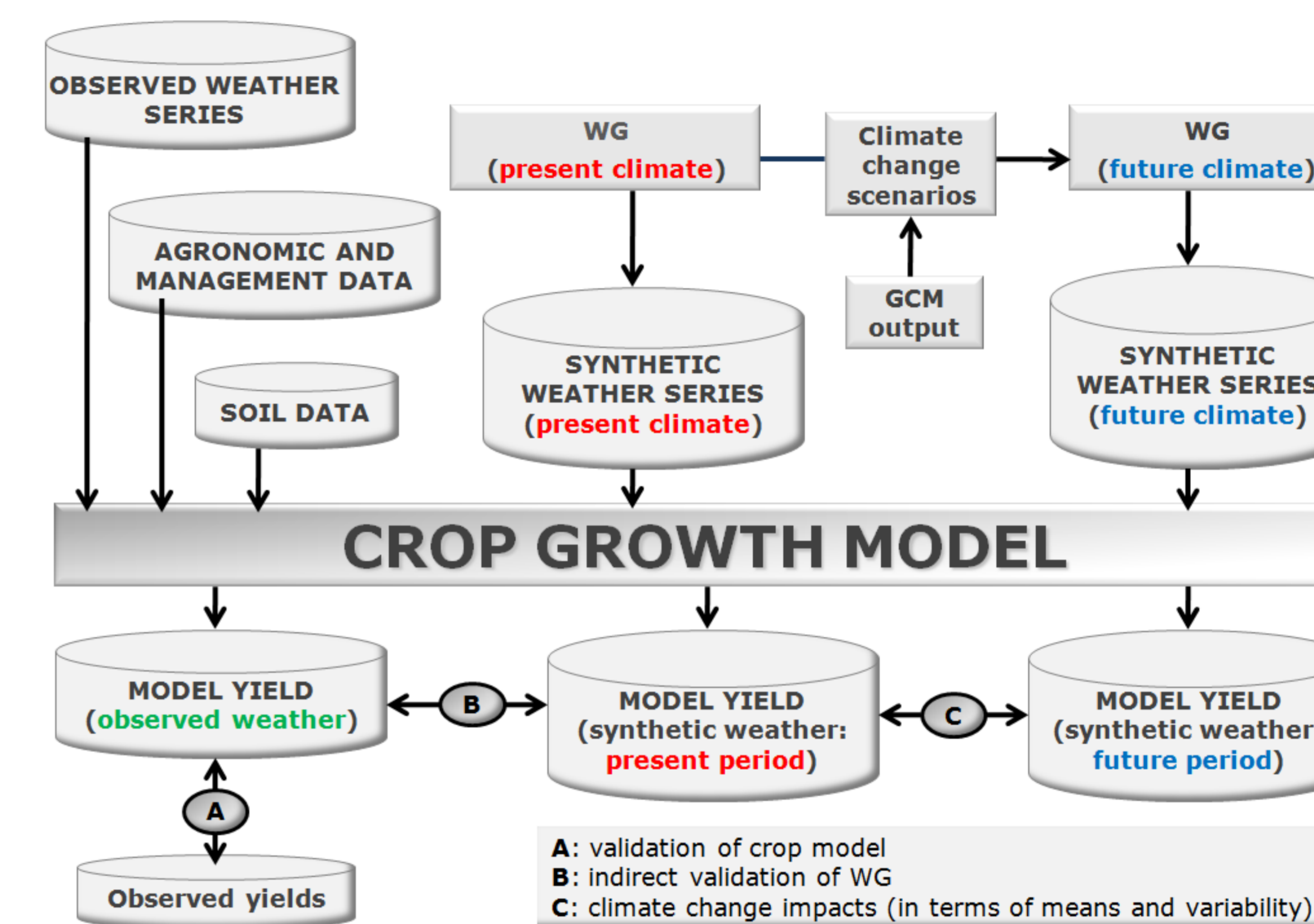


Fig.1. General scheme of methodology (from Dubrovsky, 2009).

Results

The results obtained for climate change impact on anthesis date, show an advancement of anthesis phase occurrence: from the lower value of 2 days projected for 2025 to 15 days projected for 2075, for both cultivars studied (Fig.3). The indirect effect of CO₂ concentration on crop yield is negative: crop yield will decrease by 2-6% for 2025, and by 10-18% for 2075. On the other hand, considering both direct and indirect effects of CO₂ concentration, the yield will increase by 5-7% for 2025 and by 16-21% for 2075 (Fig.4).

The shift of the ordinary sowing date (1 month earlier or later) shows that an earlier planting date would produce an additional increase in yield, reducing the negative effect on yield due to changed climate change conditions (Fig. 5).

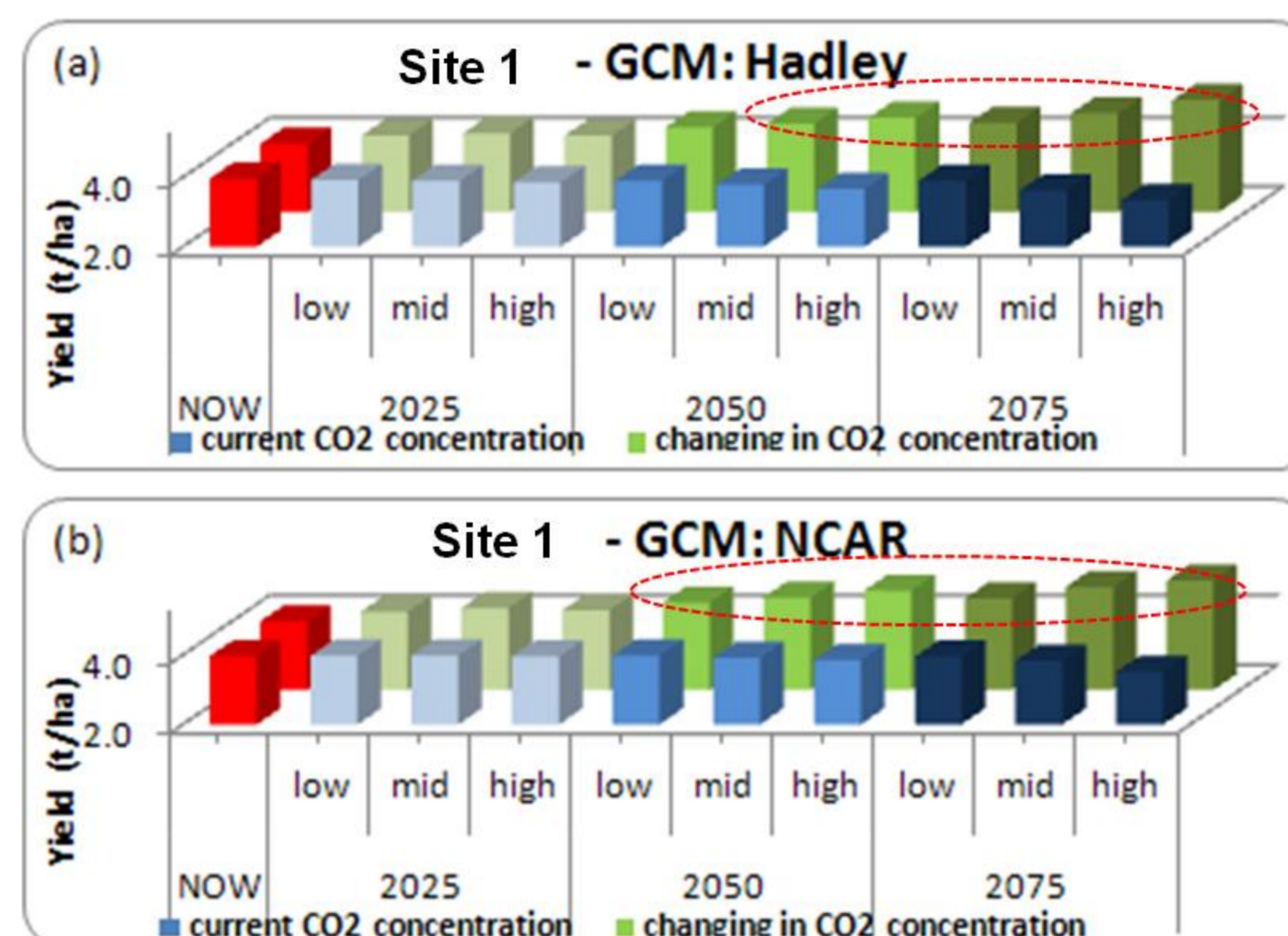


Fig.4. Changes in wheat yield (t ha⁻¹) considering direct and indirect effects of CO₂ concentration for Simeto cultivar at Ussana site.

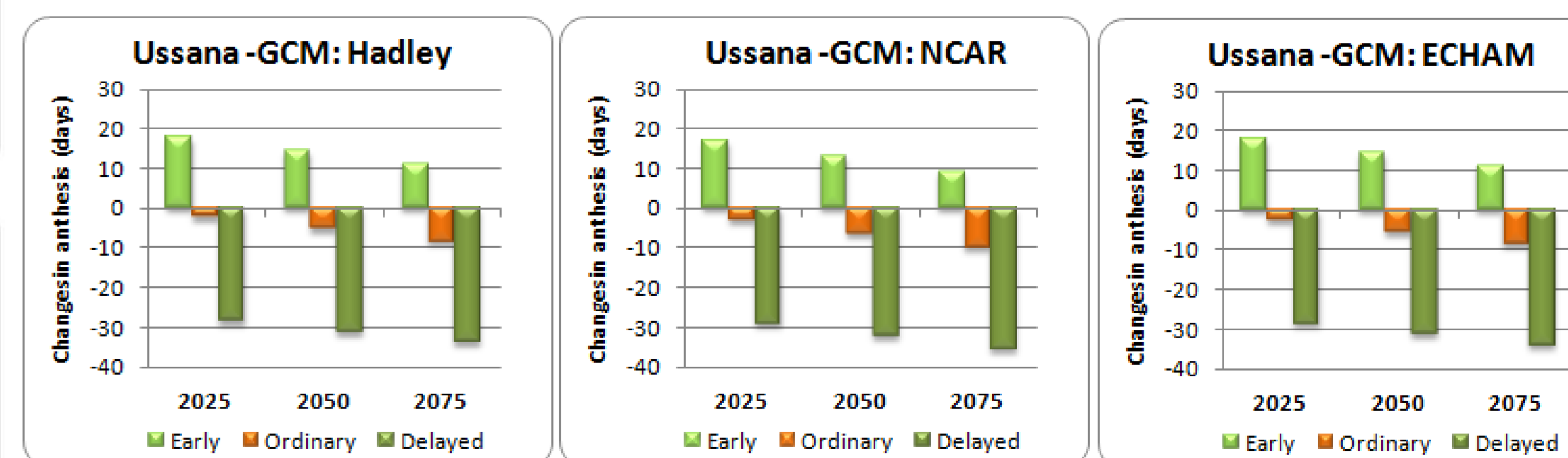


Fig.4. Changes in wheat yield (t ha⁻¹) considering an earlier and a later planting date for Simeto cultivar at Ussana site.



Fig.2. Sardinian experimental sites

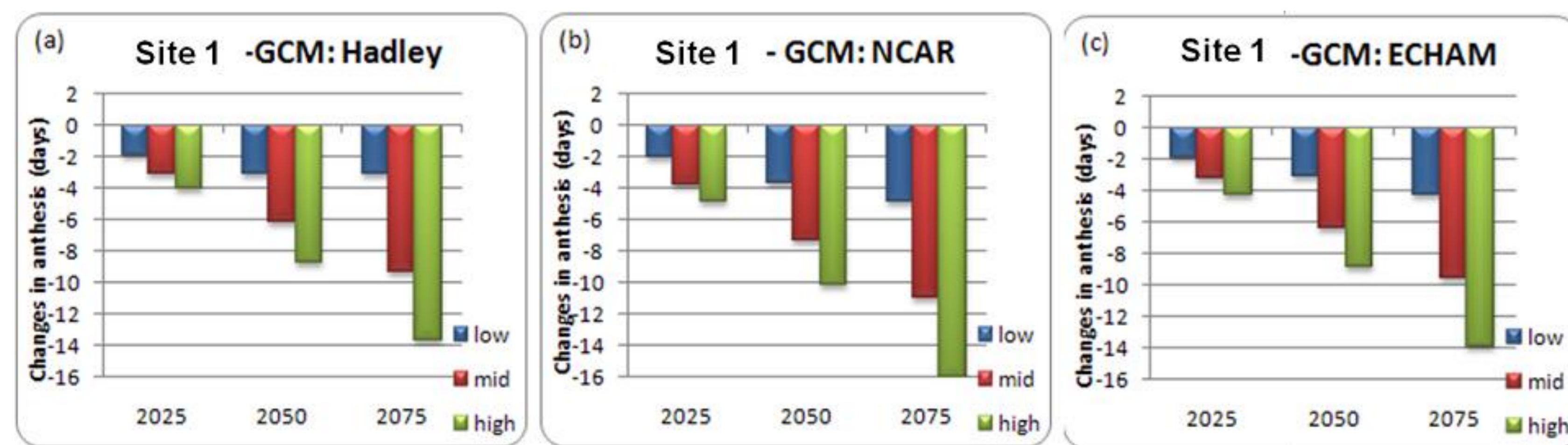


Fig.3. Changes in anthesis (days) for Simeto cv at Ussana site.

Conclusions

The methodology used allows to explore a wide range of possible future changes in climate and consequently, to give a more likely crop impact assessment. The climate change impacts assessment on yield show that the positive effects of increase in CO₂ concentration may off set the negative effect of changed weather conditions. It may be due to a synergic effect of two mechanisms related to increased CO₂ concentration: the intensified photosynthesis activity and greater Water Use Efficiency.

The analyses made for this region shows that the shift of the ordinary sowing date could be a reliable and efficient adaptation strategy for wheat cultivation in this Mediterranean area.

References

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