Impact of drought stress and climate change on yield and forage quality of grassland

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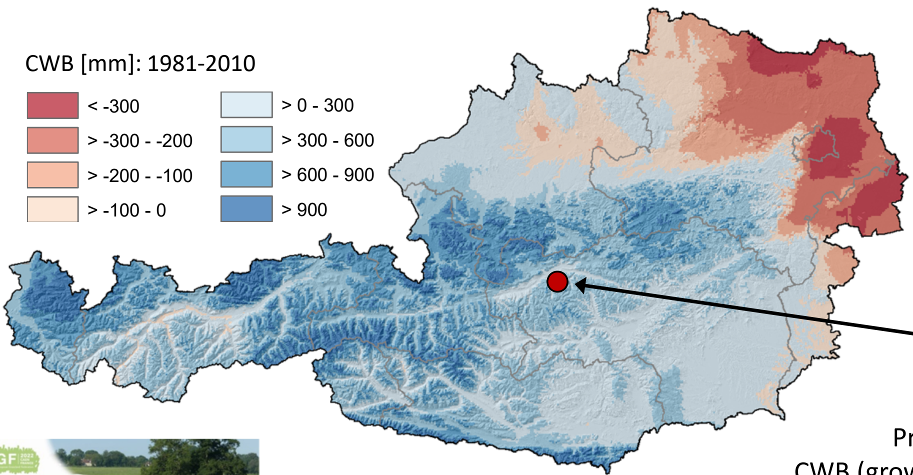
Climatic water balance in the growing season



Climatic Water Balance (CWB):

Precipitation - ET
(Penman-Monteith)

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Temperatur: **8.5 °C**
Precipitation: **1077 mm**
CWB (growing season): **260 mm**

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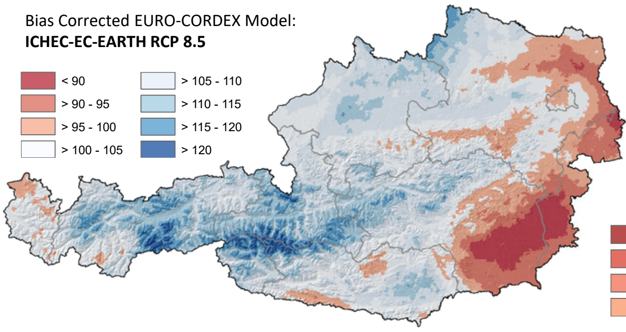
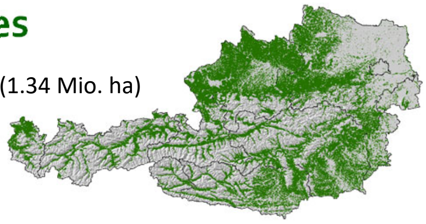
Climatic water balance: projected changes

Changes in %: 1981-2010 to 2071-2100

Bias Corrected EURO-CORDEX Model:
ICHEC-EC-EARTH RCP 8.5

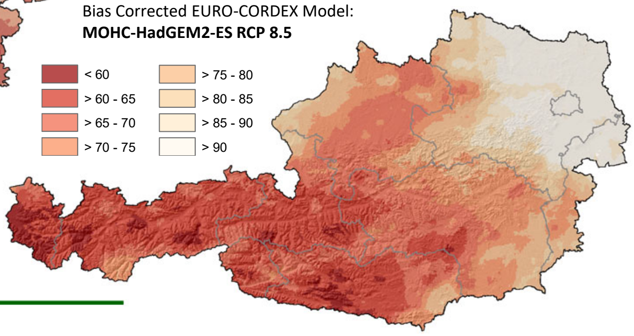


Grassland (1.34 Mio. ha)



Changes in %: 1981-2010 to 2071-2100

Bias Corrected EURO-CORDEX Model:
MOHC-HadGEM2-ES RCP 8.5



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ClimGrass: Research for climate impact on grassland

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ClimGrass: Multifactoral field experiment

Temperature - 3 Levels:

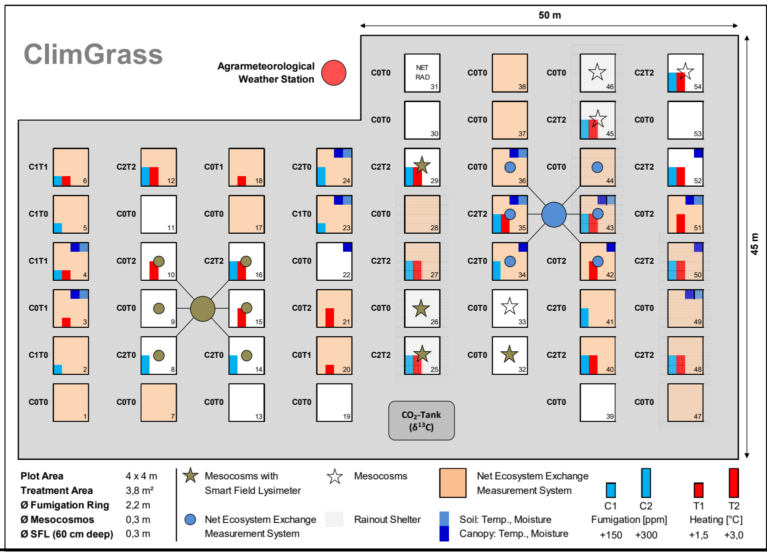
- **ambient (T0)**
- + 1,5 °C (T1)
- **+ 3,0 °C (T2)**

CO_2-Concentration - 3 Levels:

- **ambient (C0)**
- + 150 ppm (C1)
- **+ 300 ppm (C2)**

Drought - Rainout shelters:

- **12 Plots (C0T0 and C2T2)**



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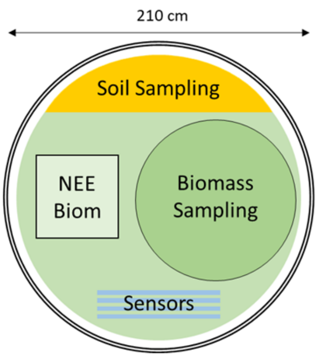
ClimGrass: Plot design and technical equipment

Treatment area on 4 x 4 m plots



- **Temperature increase**: Infrared heater (6 per plot)
- **CO_2-Enrichment:** Gastank, blower and perforated rings
- **Drought stress:** Sensor controlled rainout shelter for 12 plots
- **Lysimeter:** Montoring soil water balance on 10 plots
- **Net Ecosystems Exchange (NEE) measurement system:** Frames for plant and soil respiration (4 different soil depths)
- **3 Weather stations**
- **Controlling:** Highly dynamic adjustments with NI LabView
- **Central database:** Collecting of about 50.000 data per day

Material and Methods: Drought simulation with rainout shelters

- **Management:** 3-Cut-System, mineral fertilizer (NPK: 90 kg / 65 kg / 170 kg ha^{-1})
- **Sward** (established 2012): 85 % grasses, 10 % herbs, 5 % legumes
- **Drought experiments:** Second growth (June/July) in 2017, 2020, 2021
- **Non-destructive measurements (weekly):** Spectral signatures, crop height, LAI
- **Destructive measurements:** Yield, wet chemical analysis
- **Rewetting:** Irrigation of 40 mm after the second cut

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Material and Methods: Data collection and analysis

- **Observation years:** 2017, 2020, 2021
- **Climate treatments:** C0T0 and C2T2 (ambient water supply), C0T0R and C2T2R (drought stress)
- **Observations and replicates:** n = 45, C0T0, C0T0R and C2T2R with 4 replicates, C2T2 with 3
- **Statistical analysis with SAS:** Proc GLIMMIX (generalised linear mixed model), fixed effects of year, climate treatment and their interaction on DM, CP, ADL, LAI and crop height



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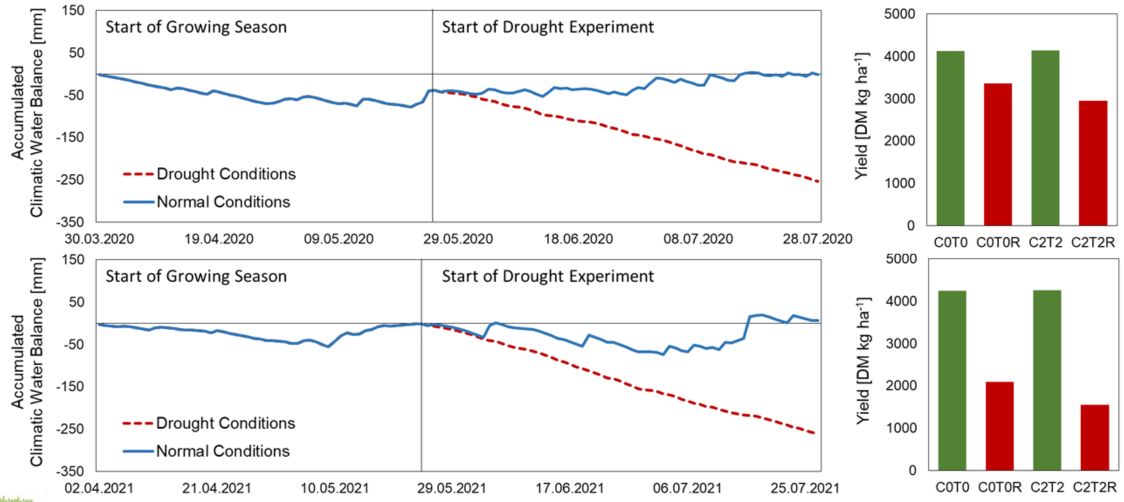
Results: Climatic water balance and yield



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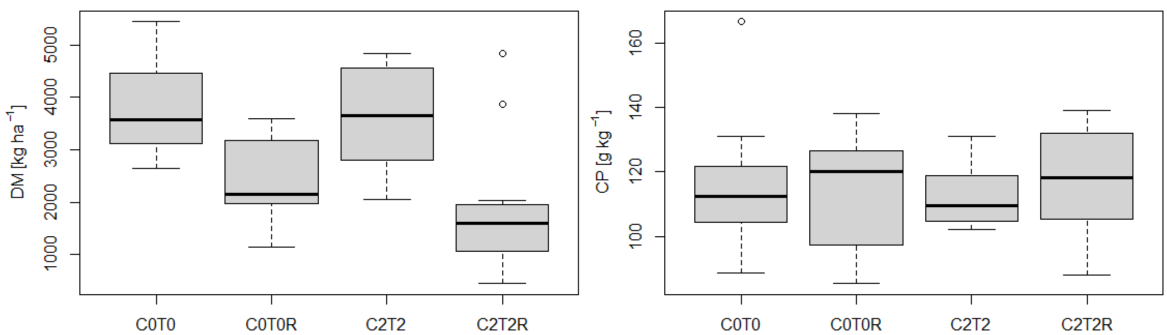
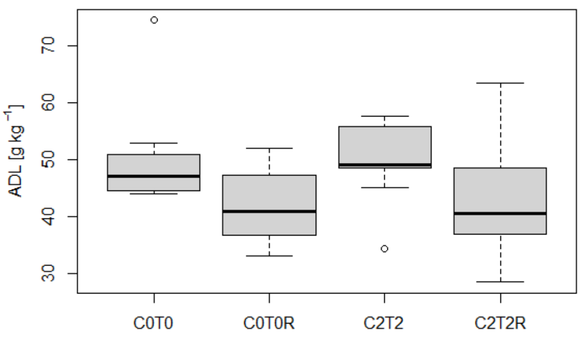
Results: Yield (dry matter) and quality (crude protein content)

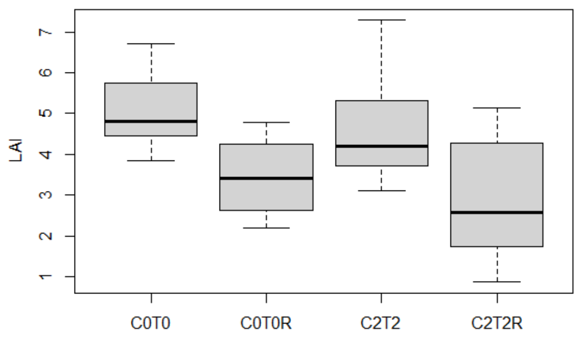


Drought stress

Drought stress

Results: Lignin content (ADL) and Leaf Area Index (LAI)





Drought stress

Drought stress

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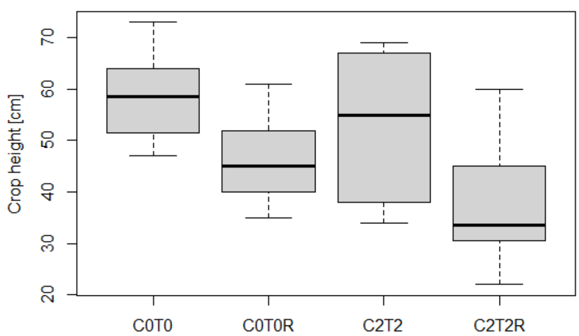
Results: Crop height (measured with ruler)



Drought stress

Photos from 21.07.2021

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Conclusions

- Soil moisture at the start of growth is crucial for the effect of drought on yield. Sufficient moisture supports the first phase before vegetative growth is constrained.
- Future climate with higher temperatures will increase drought stress and thus reduce yields.
- CP content does not differ much between drought-stressed and non-stressed plant stands.
- ADL is significantly lower under drought stress, because water shortage strongly reduces vegetative growth and thus leads to stocky stands with a smaller portion of stems.
- Impact of drought stress on growth concerning Leaf Area Index and crop height are comparable.

Drought results in lower yields, while forage quality remains more or less the same!

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Thank you for your attention

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ÖAW Österreichische Akademie der Wissenschaften

FWF Der Wissenschaftsfonds.

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