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Ozone risk for vegetation in Europe under different climate change scenarios based on ozone uptake calculations

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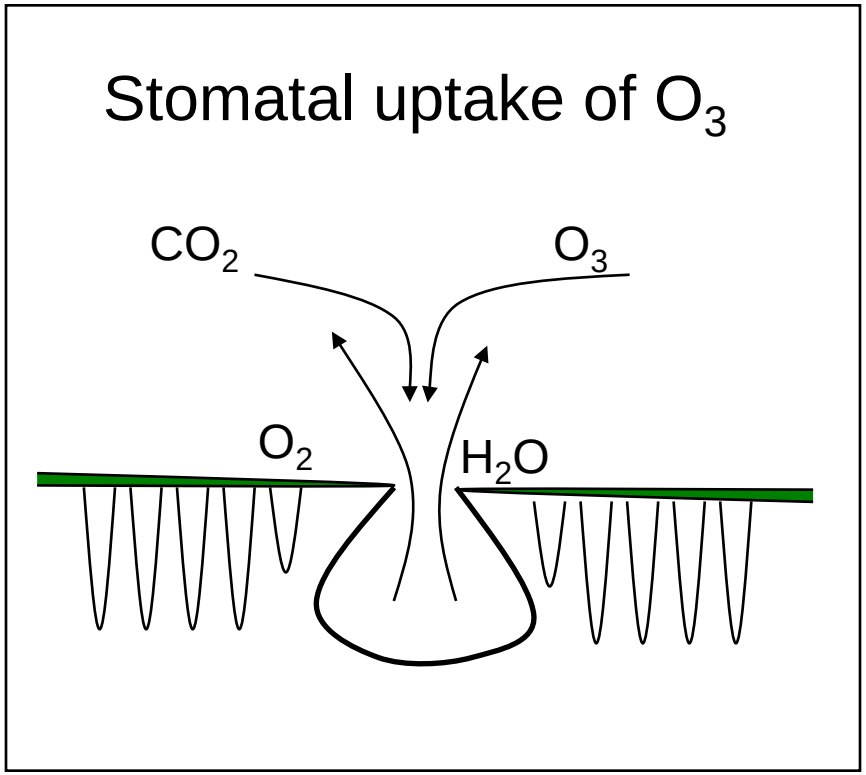
Ozone risk for vegetation

- Exposure
- Leaf uptake
- Defence capacity

O_3 flux more relevant than AOT40 exposure in risk assessment



Climatic conditions important!

Flux-based risk for wheat

- Variations in risk for O_3 damage from north to south in Europe
- Differences between current climate, the IPCC A2 and B2 scenario
- Influence of increasing [CO_2] on stomatal uptake
- Influence of timing of the growing season
- Influence of potentially increasing background [O_3]

Multiplicative model for stomatal conductance

$$g_{sto} = g_{\max} \times \{\min(f_{phen}, f_{O_3})\} \times f_{light} \times \max\{f_{\min}, (f_{temp} \times f_{VPD} \times f_{SWP})\}$$

Species dependent maximum stomatal conductance

Mapping Manual

UNECE CLRTAP, 2004. Manual on methodologies and criteria for Modelling and Mapping Critical Loads & Levels and Air Pollution Effects, Risks and Trends. www.icpmapping.org

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Phenology decides the accumulation period

O_3 accelerates senescence

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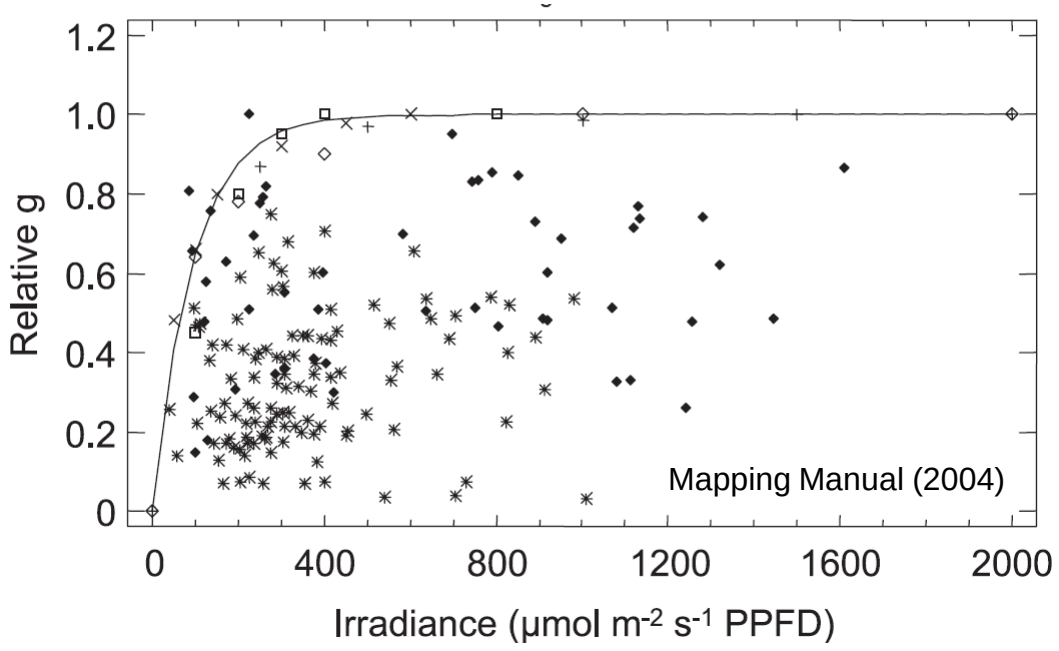

No photosynthesis in the absence of light – stomata close

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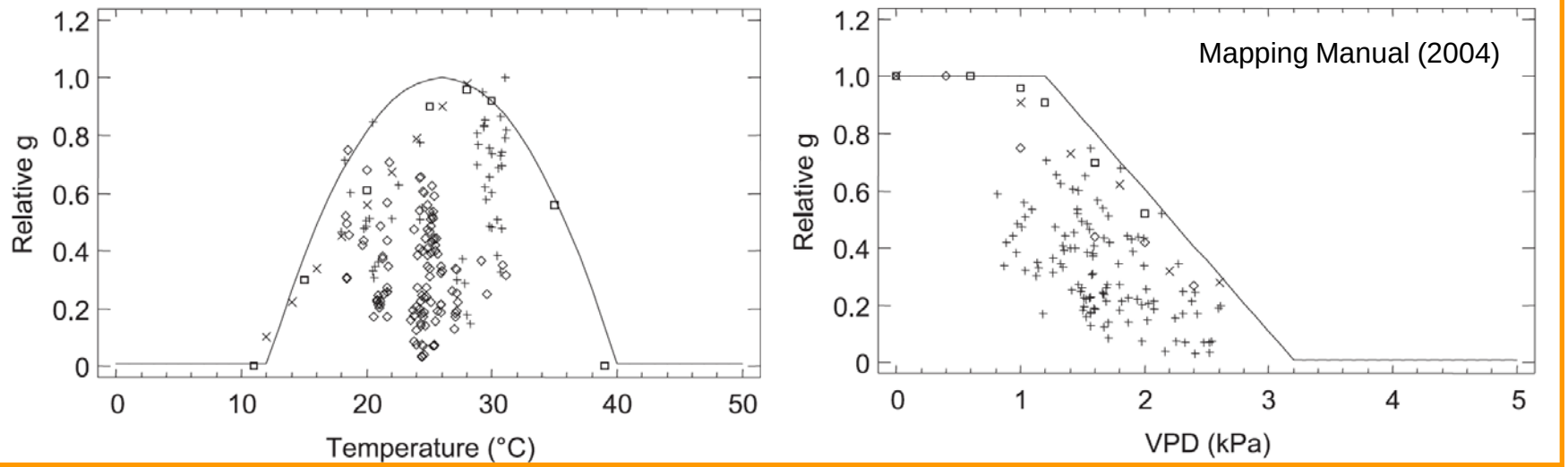
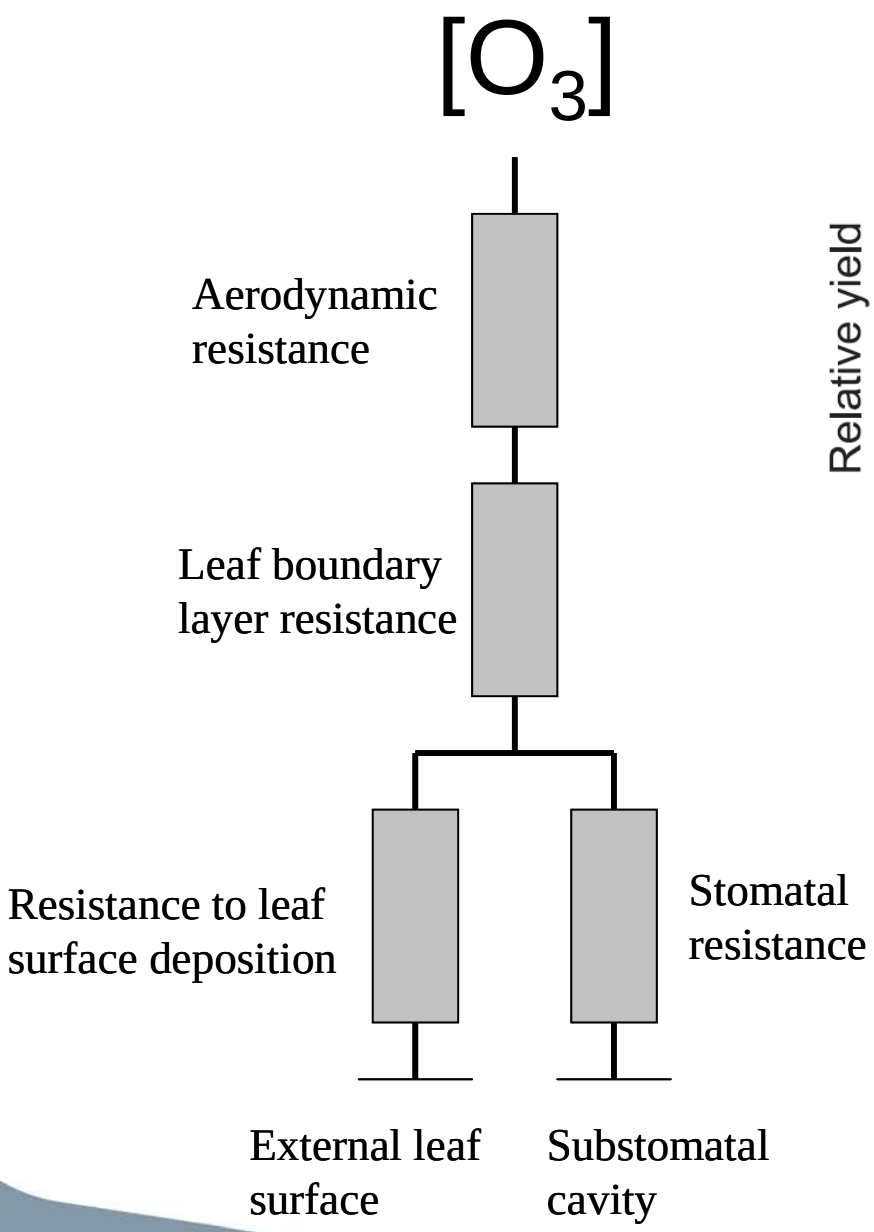
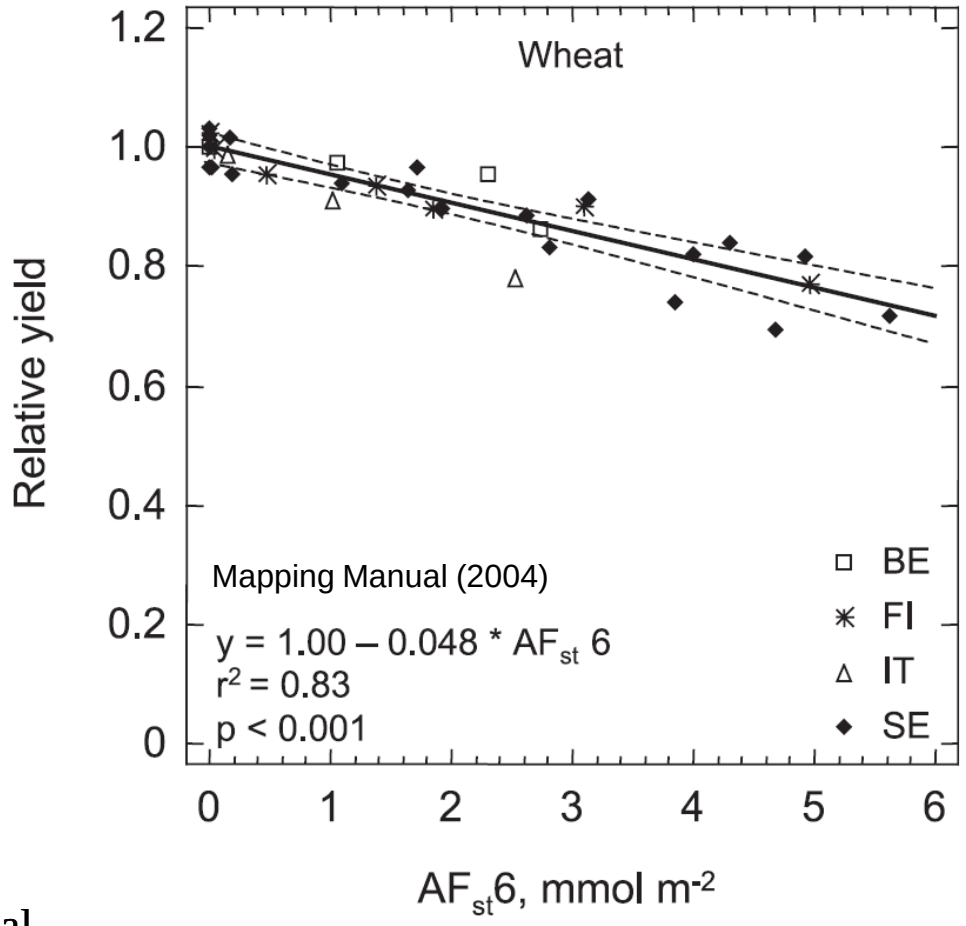






$AF_{st}6$: accumulated flux over a threshold

Modelled data used

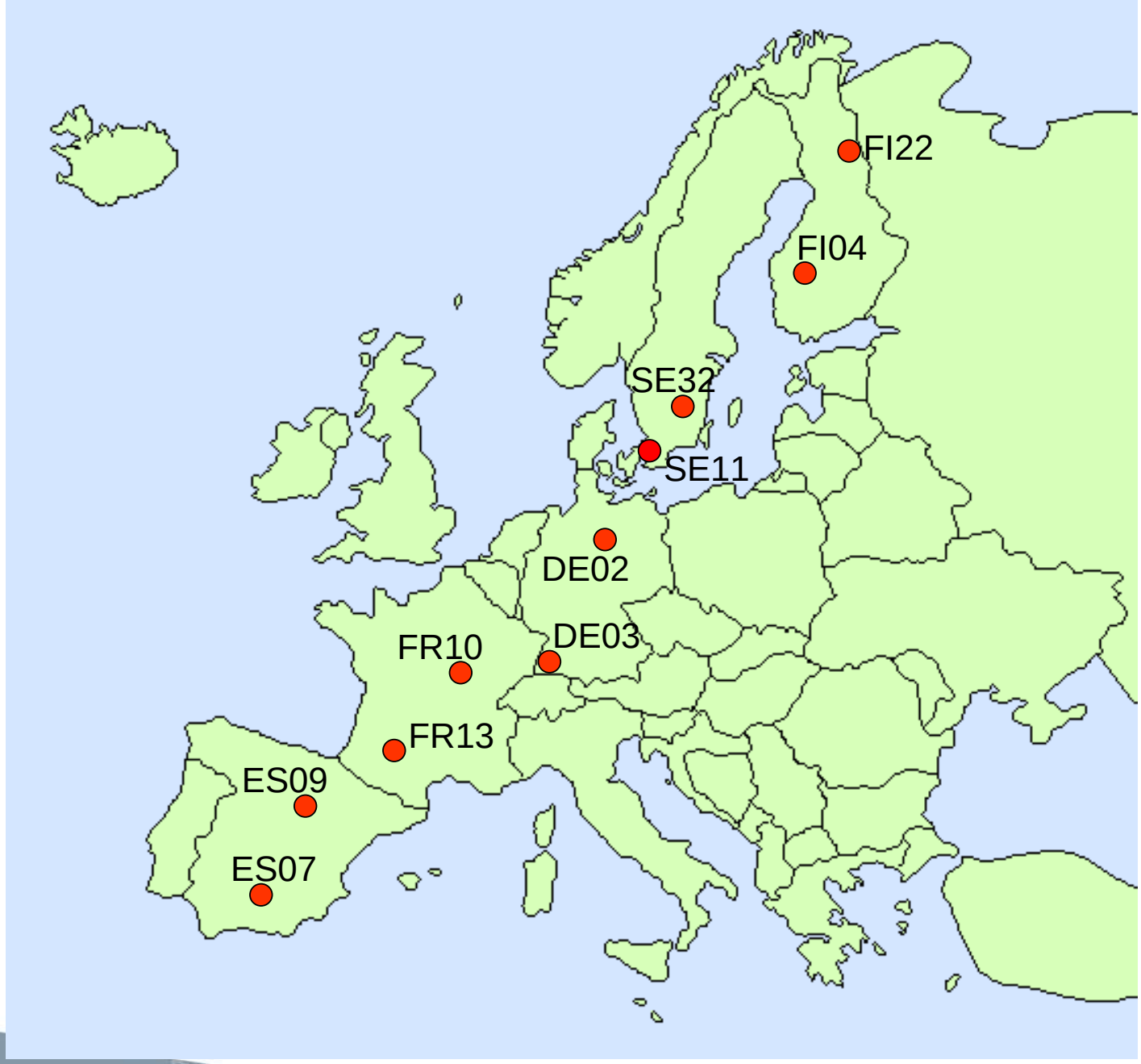
MATCH
- Ozone concentration

RCA3
- Air temperature
- Air humidity
- Soil moisture
- Radiation
- Wind speed

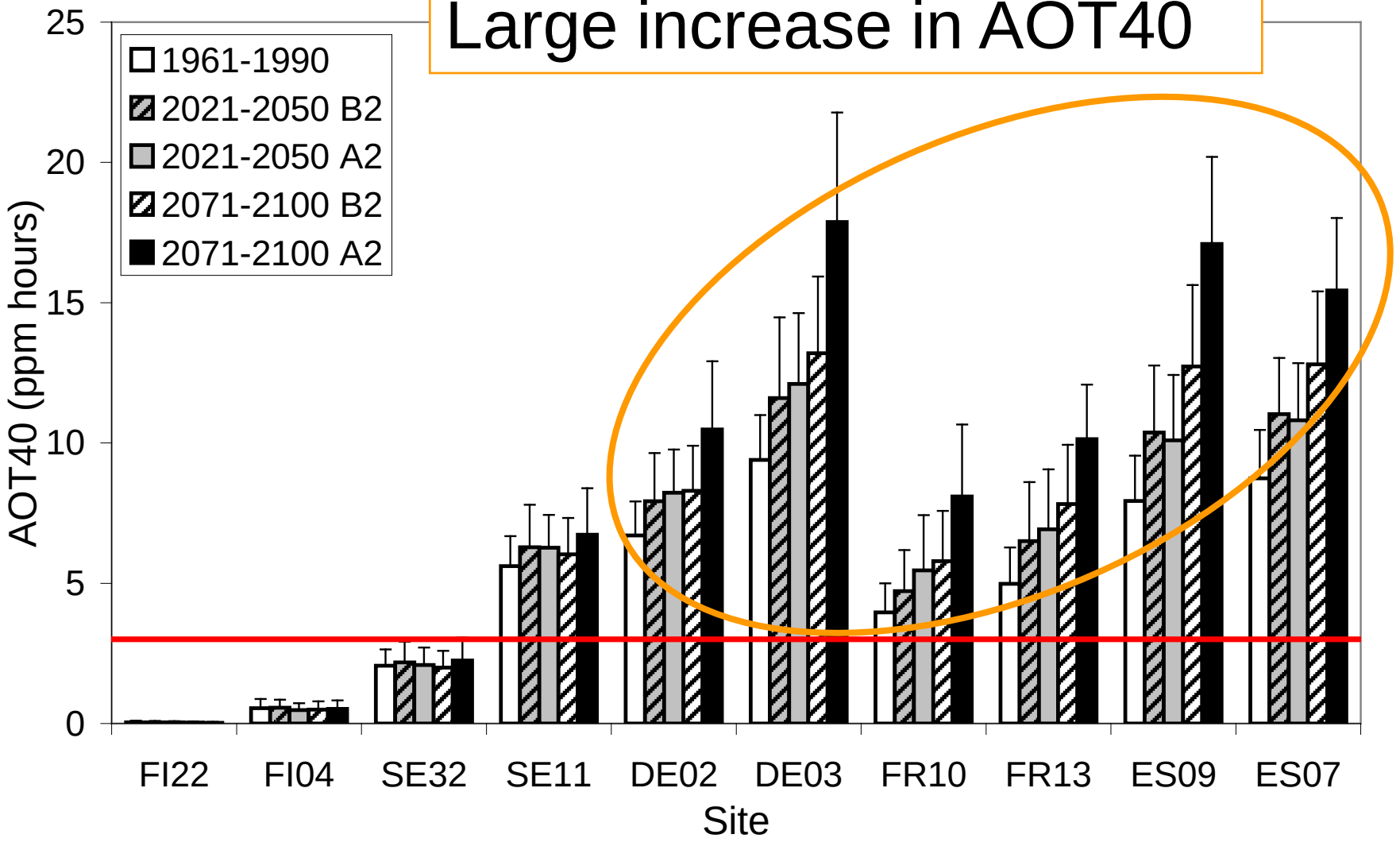
Emissions constant - represent year 2000

IPCC A2 & B2 scenario

Three 30-year periods
- 1961-1990
- 2021-2050
- 2071-2100

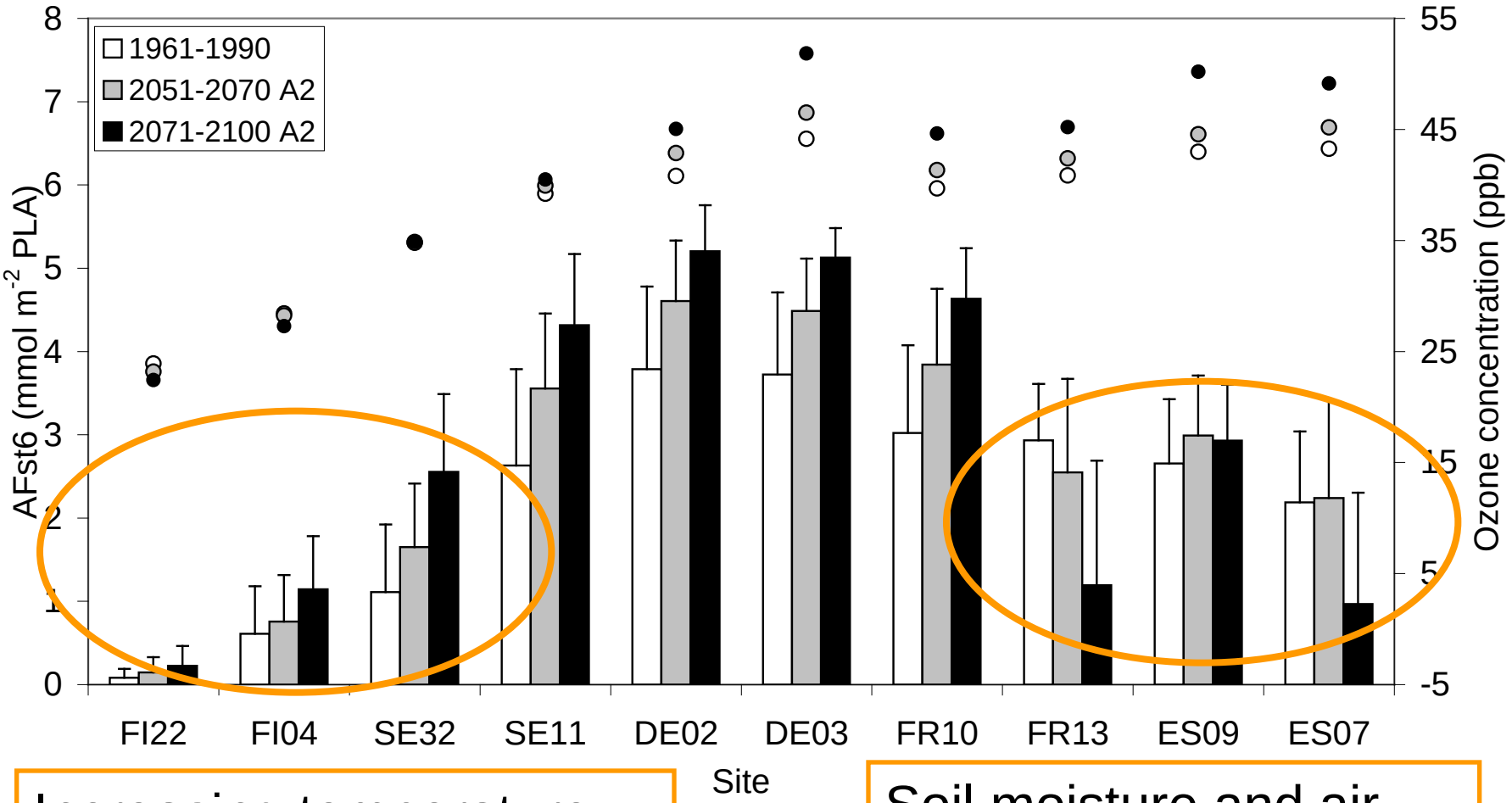

FI22
FI04
SE32
SE11
DE02
DE03
FR10
FR13
ES09
ES07

Large increase in AOT40



north → south

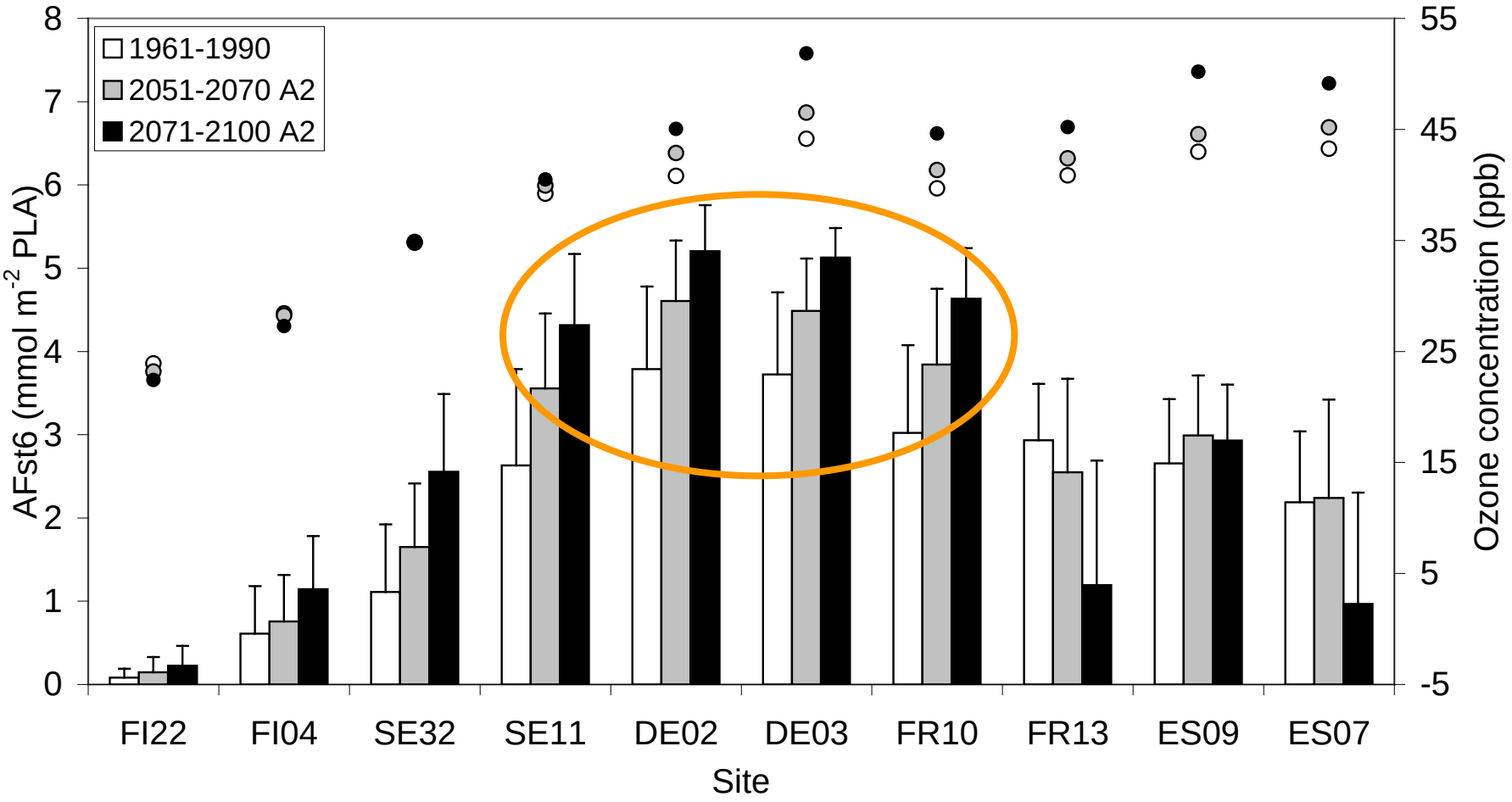
O_3 risk from north to south



Increasing temperature most important

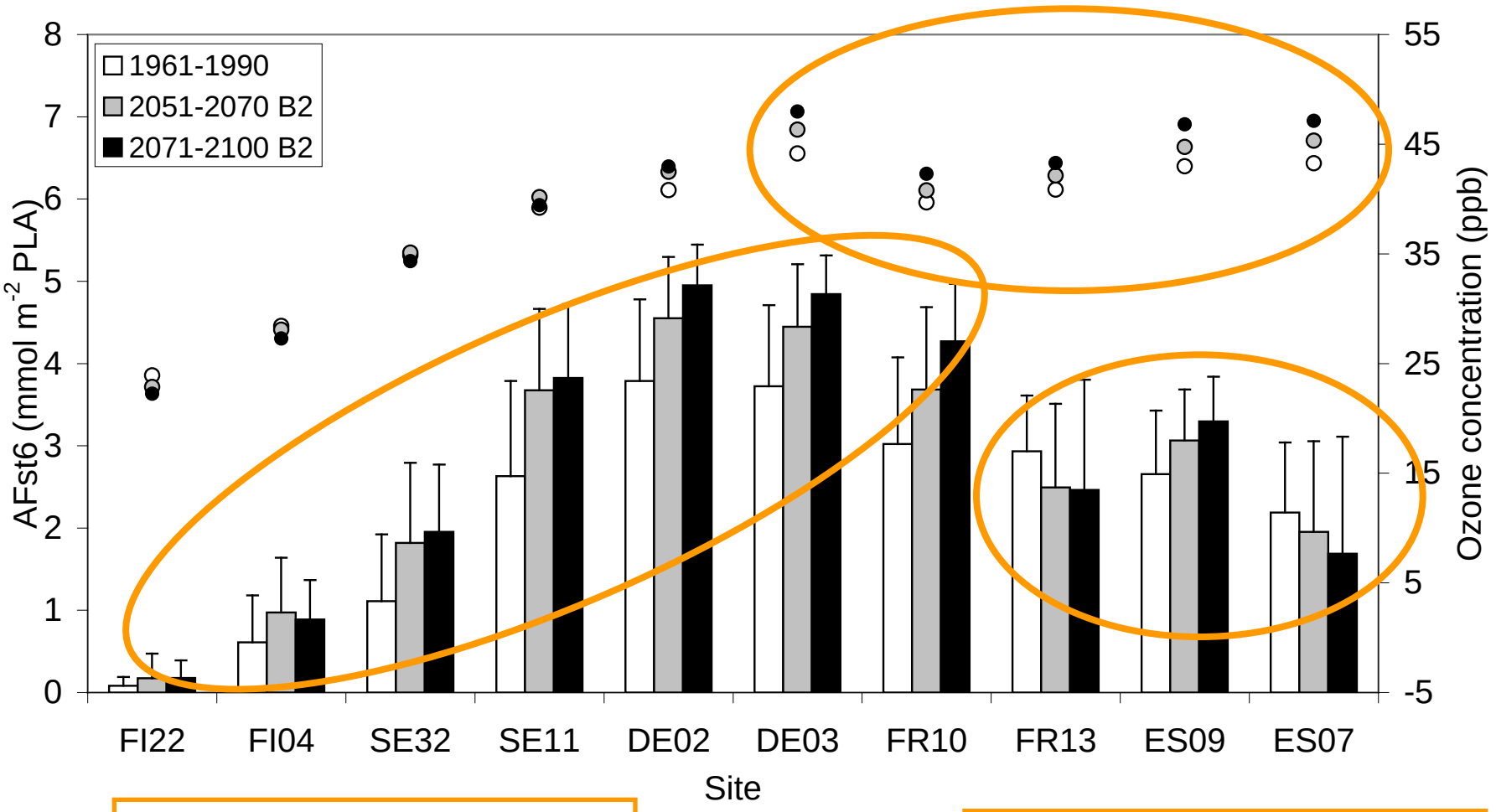
Soil moisture and air humidity limiting

O_3 risk from north to south



Increasing [O_3] and temperature most important

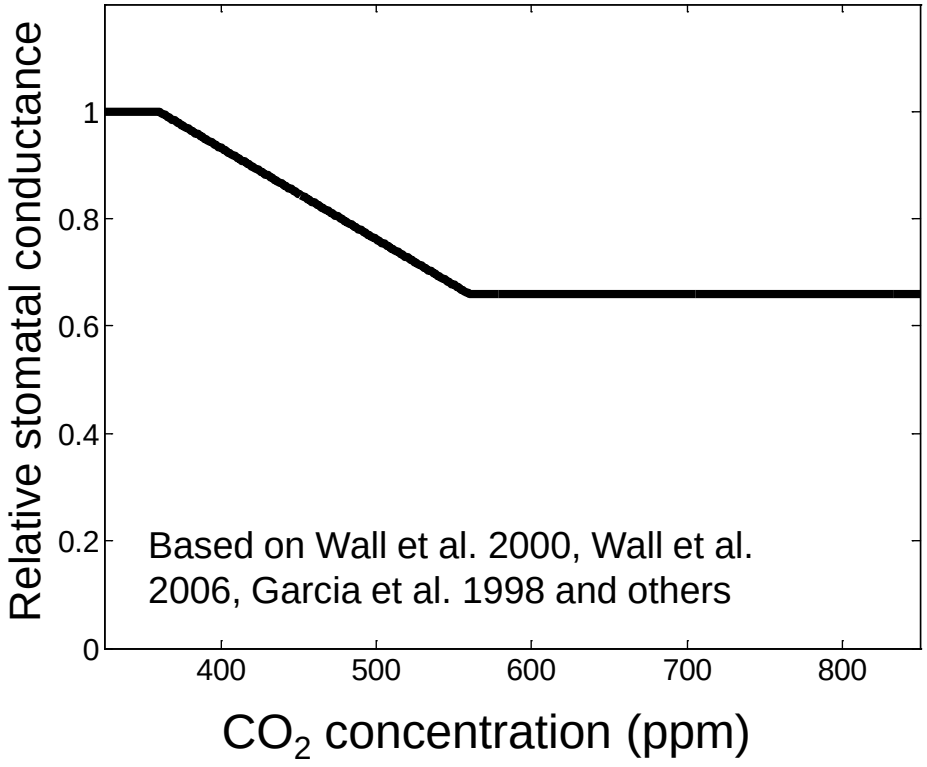
Differences between A2 and B2



Smaller increase in $[O_3]$ and AFst6 2071-2100

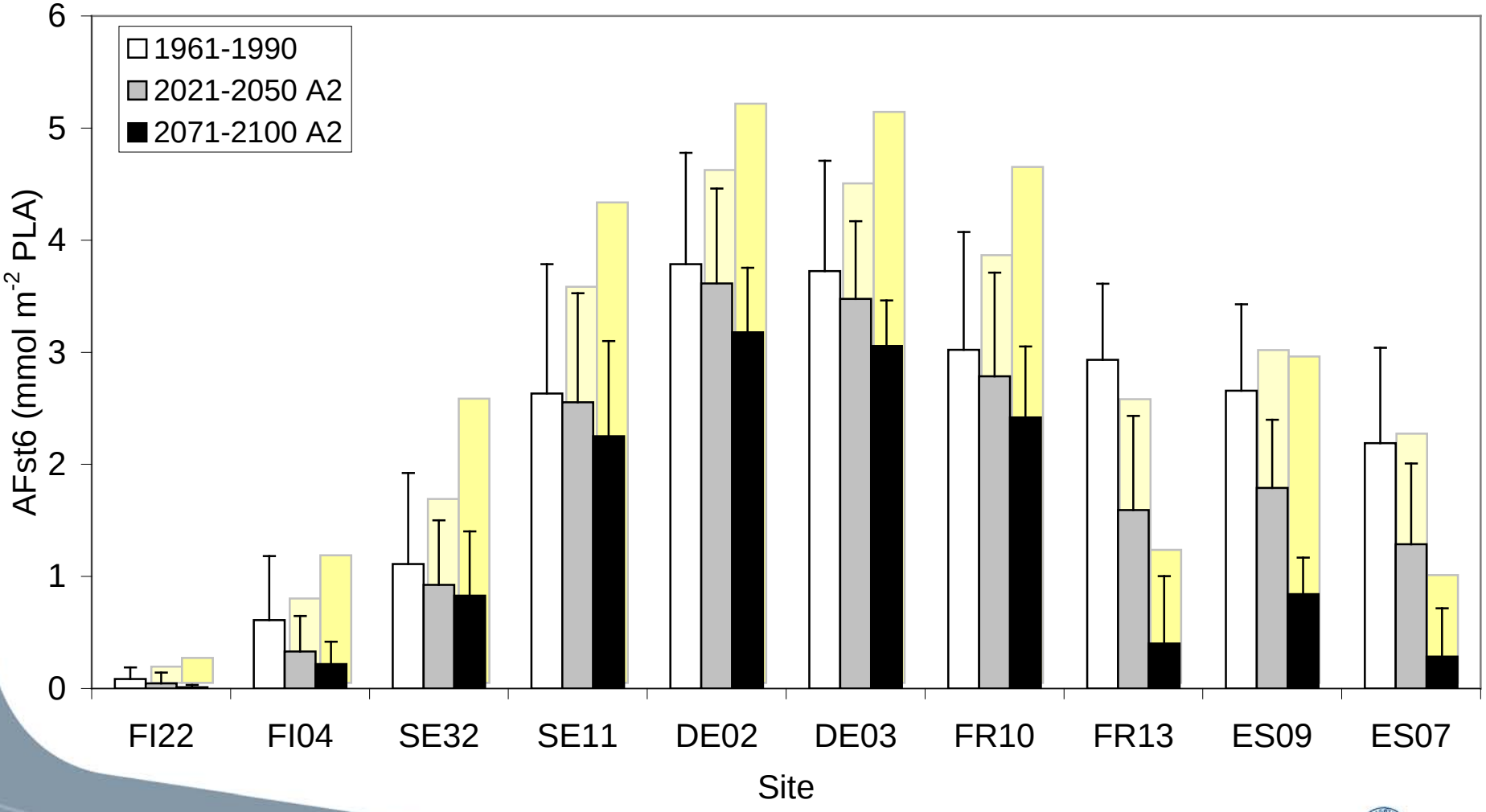
Not as dry in the south 2071-2100

Plants do not maximize CO_2 uptake but optimize water use efficiency.

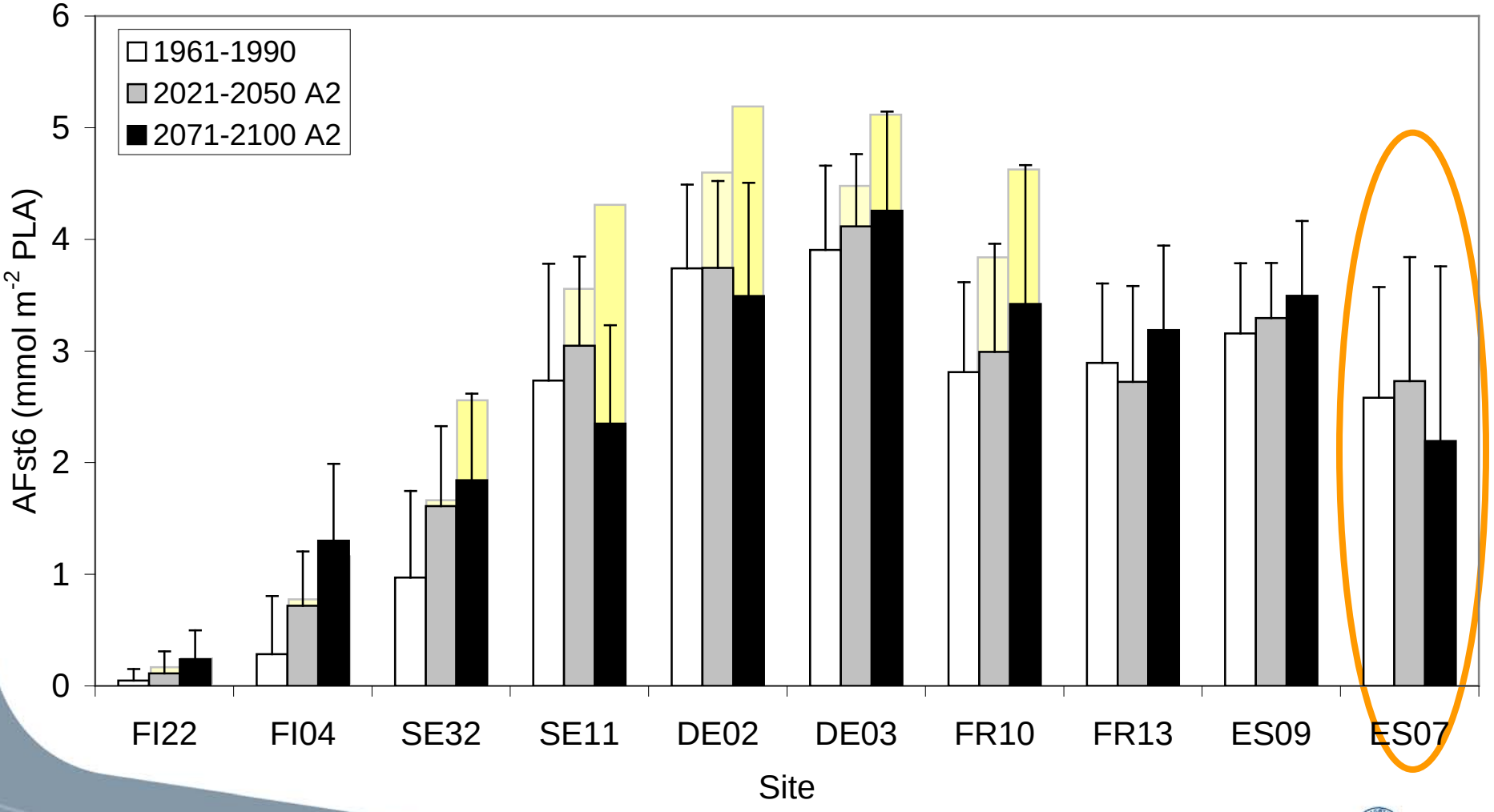


In higher [CO_2] the optimum water use efficiency is achieved with smaller stomatal opening.

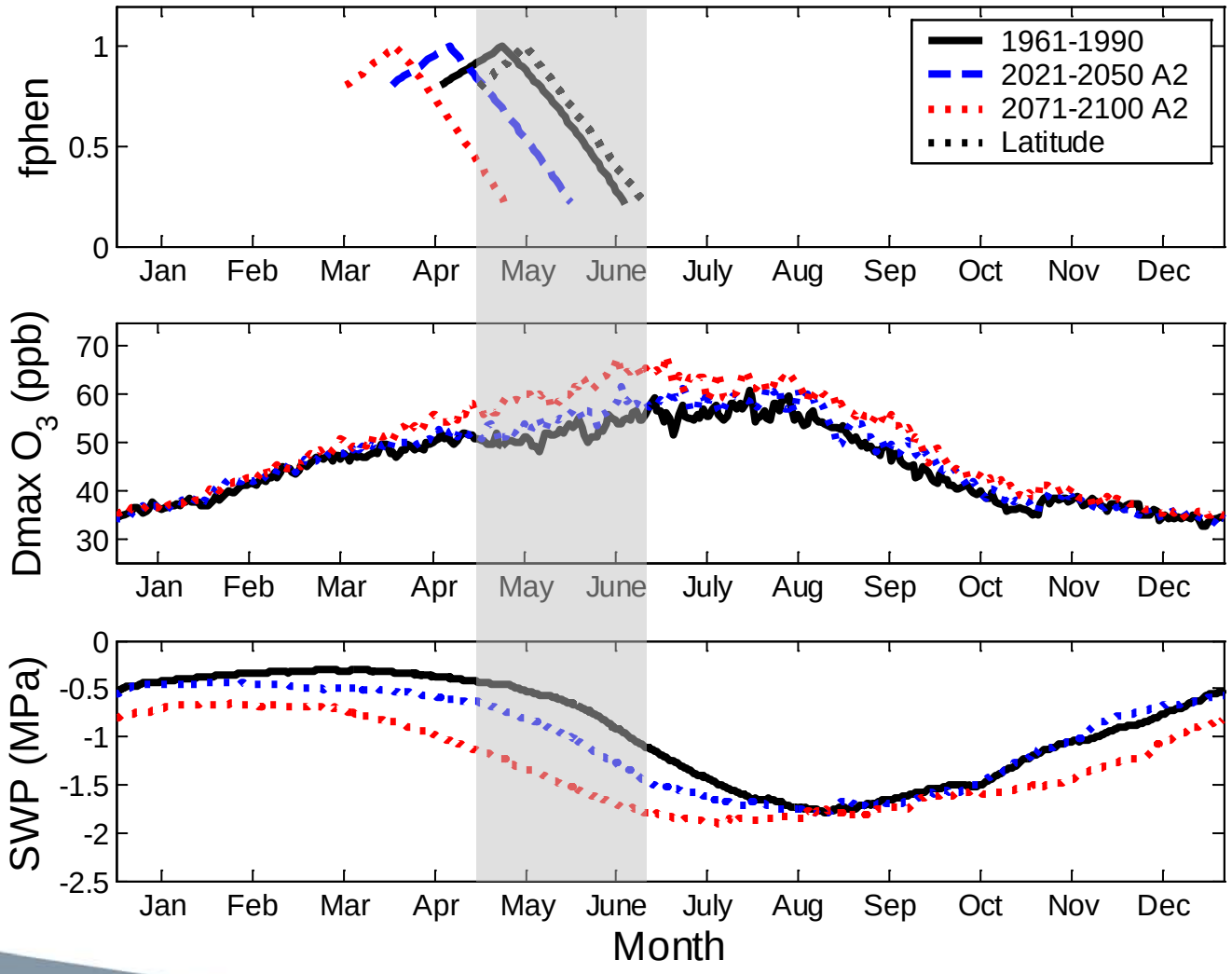
Influence of increasing [CO_2]



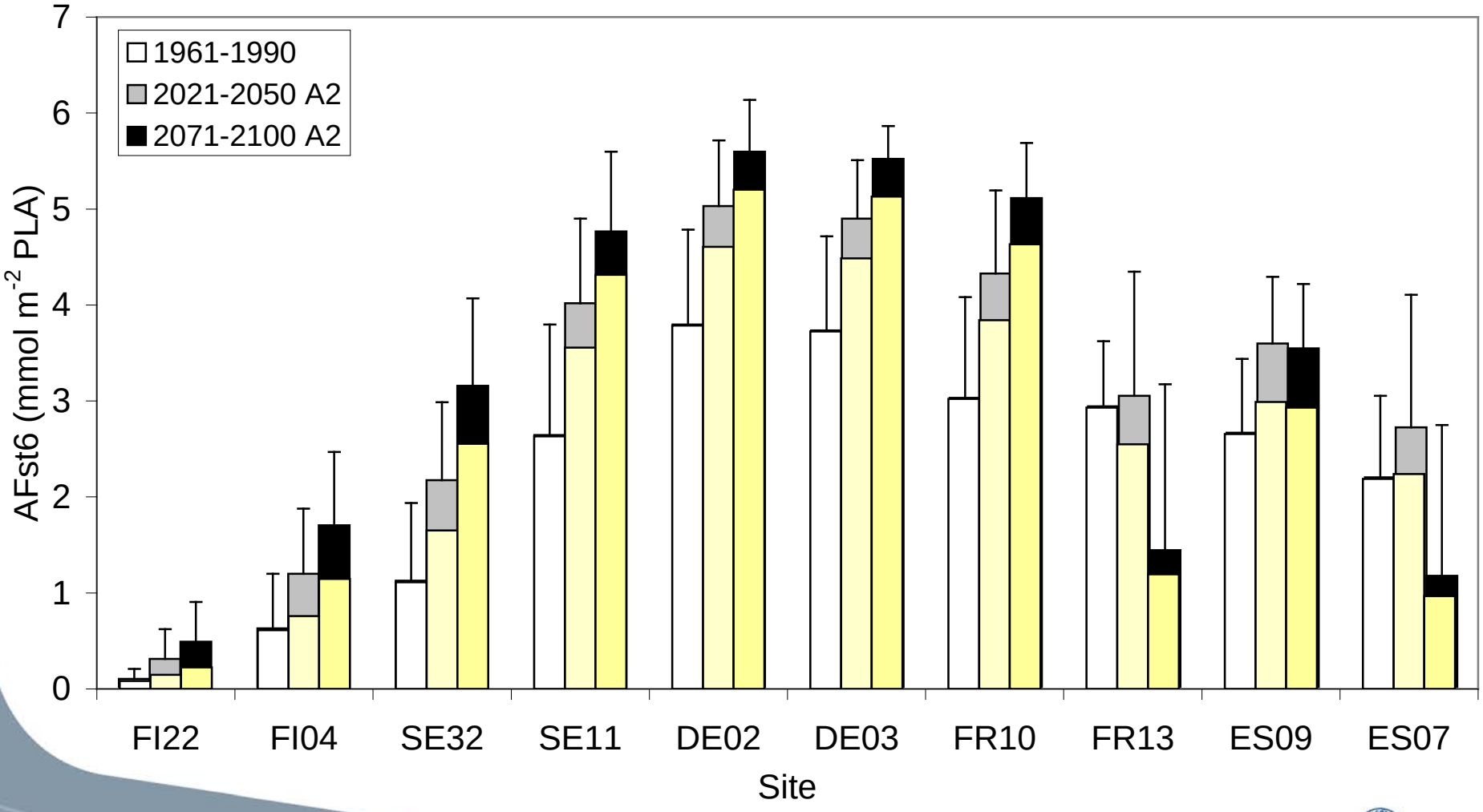
Influence of timing of growing season



Spain (ES07) as example



4 ppb increase in background [O_3]



Conclusions

- The risk for O_3 damage to plants increase in future climate (especially A2) except for southern Europe where drought restricts stomatal uptake of O_3.
- The plant response to increasing [CO_2] is uncertain but has the potential to change the conclusion above.
- An earlier sowing date could reduce the risk in central and increase the risk in southern Europe.
- Increasing background [O_3] could significantly increase the risk for negative effects on vegetation.

Ozone risk assessment for vegetation should include meteorological factors affecting stomatal conductance, timing of the growing season and plant response to elevated [CO_2], in addition to [O_3].

Thank you!