Projection of potential Vegetation change over Europe for the end of the 21st century

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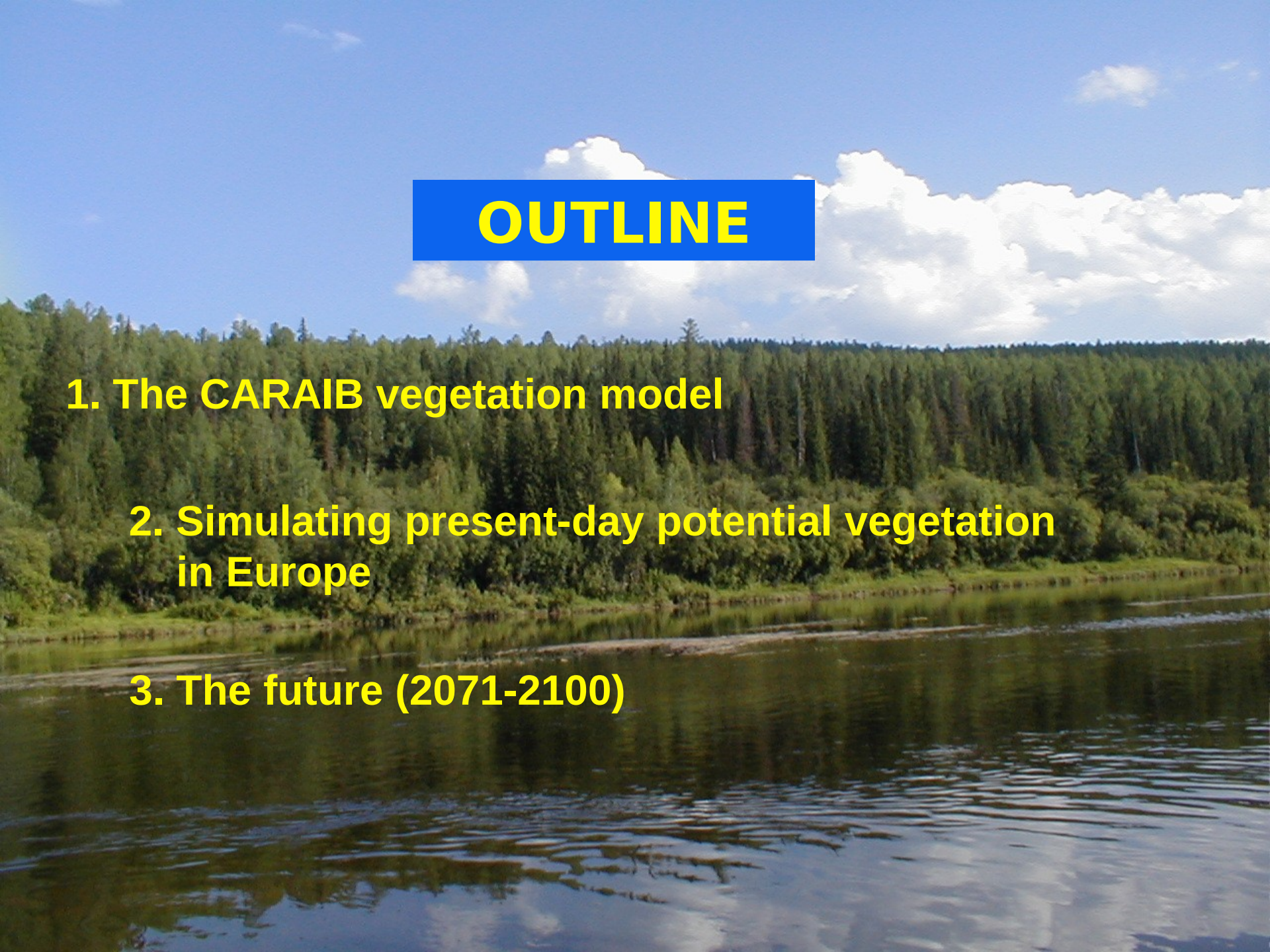
Belgian Biodiversity Platform Conference 2007
« Biodiversity and Climate Change », Brussels, May 21-22, 200



OUTLINE

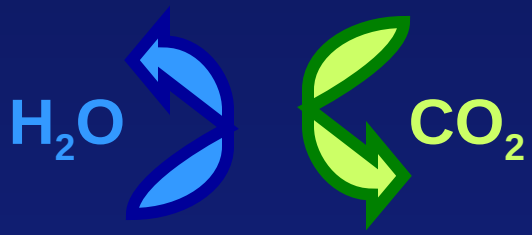
1. The CARAIB vegetation model

2. Simulating present-day potential vegetation in Europe

3. The future (2071-2100)


THE CARAIB
VEGETATION MODEL
www.DesktopCollector.com

THE CARAIB MODEL



Hydrological Budget

Precipitation

Runoff

AET

SOIL WATER

Deep drainage

IBM

Stomatal Regulation

$c_i = c_a - A_n/g$

$g = g_0 + g_1 A_n h_s/(c_a - \Gamma)$

Photosynthesis

$A_n = A - R_d$

$A = \min(A_j, A_v)$

Allocation-Growth-Respiration

Metabolic
fine roots *leaves*

Structural
wood

Decomposition

Litter
structural *metabolic*

Soil Carbon

Bio-geography

competition for light between storeys

competition of plant types within storeys

assemblage of plant types

Biomes

COMPETITION OF BIOCLIMATIC AFFINITY GROUPS (BAGs)

Overstorey Competition: $f_i = NPP_i/\Sigma NPP$

Trees:

- Cedrus, Pinus halepensis, Pinus pinaster
- Abies alba, Taxus
- Pinus cembra
- Cupressaceae, Juniperus, Juniperus communis
- Abies
- Picea abies, Pinus, Pinus sylvestris
- Laris decidua
- Olea eur., Pistacia, Phillyrea, Q. ilex, Q suber
- Castanea, Juglans, Ostrya, Q. pubescens
- Acer campestre, Carpinus, Fagus syl., Tilia pla.
- Acer, Fraxinus, F. excel., Tilia cordata, Ulmus
- Alnus, Al. gl., Corylus, Q. robur, Populus, Tilia
- Betula, Salix

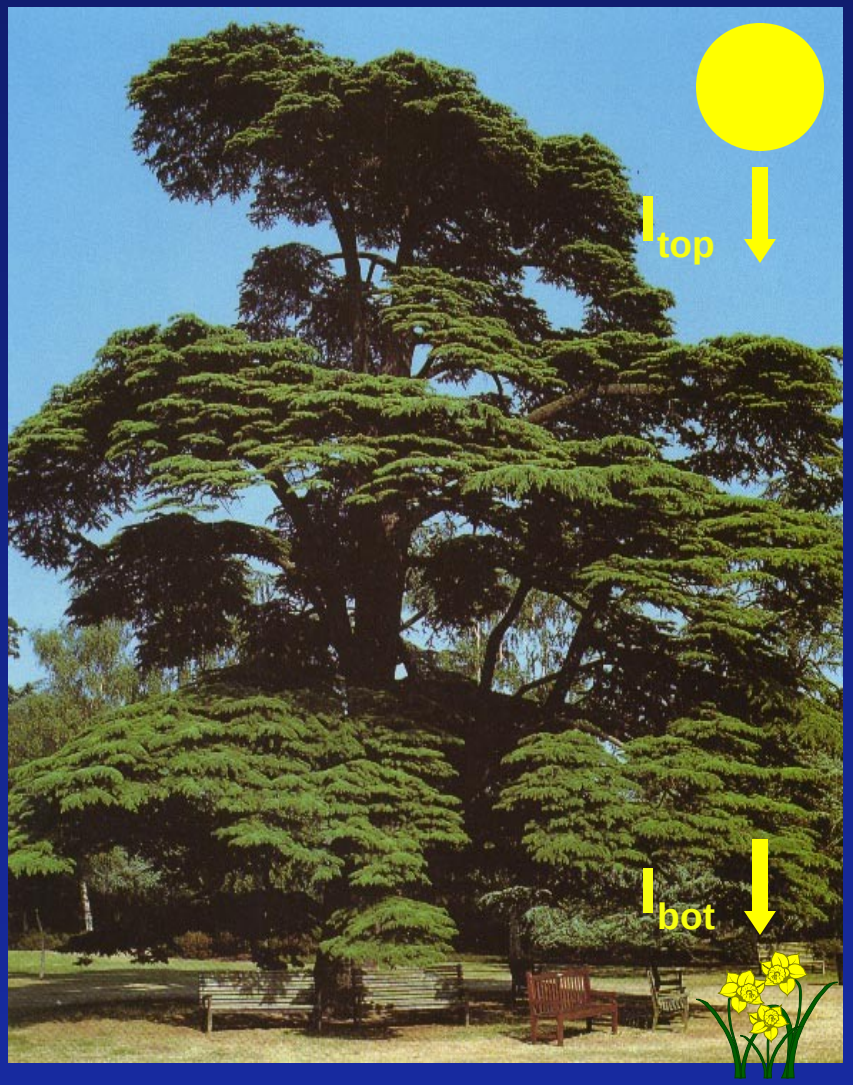
Understorey Competition: $f_i = NPP_i/\Sigma NPP$

Shrubs:

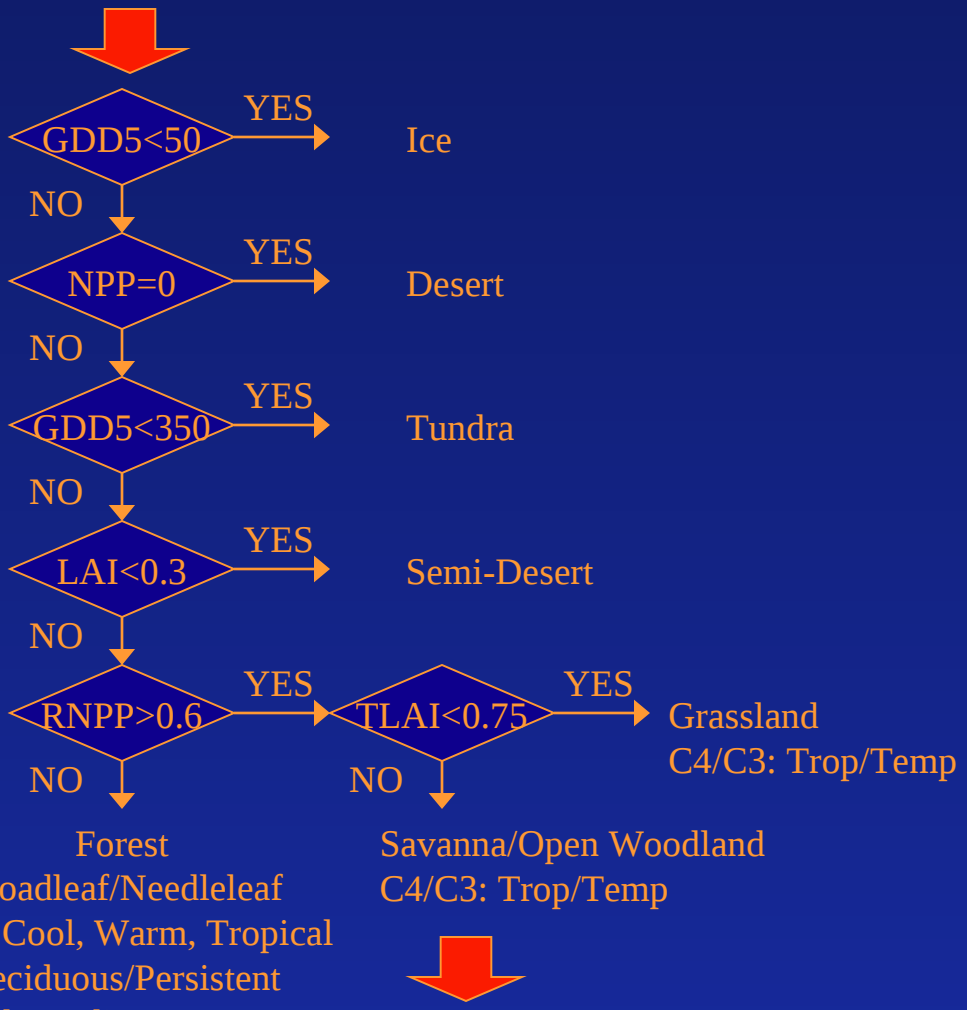
- Cistus, Myrtus
- Buxus sempervirens, Hedera h., Ilex acquif.
- Artostaphylos uva-ursi, Calluna vul., Daphne
- Berberis vul., Crataegus, Genista, Rhamnus
- Sambucus, Frangula a, Prunus, Sorbus, Vaccinium
- Alnus vir, Arctostap., A.alpinus, B. nana
- Ephedra, Ulex

Herbs:

- Anemone, Gypsophila, Helleborus, etc
- Asteraceae asteroideae, Poaceae, etc
- Anthemis, Artemisia, Bidens, Calystegia, etc
- Brassicaceae, Caltha, Cardamine, etc
- Achillea, Alchemilla, Angelica, Campanula, etc
- C_4 grass



Assemblage of BAGs predicted by CARAIB for each grid cell on the basis of NPP percentages



Biome type predicted for each grid cell

BIOME PREDICTION

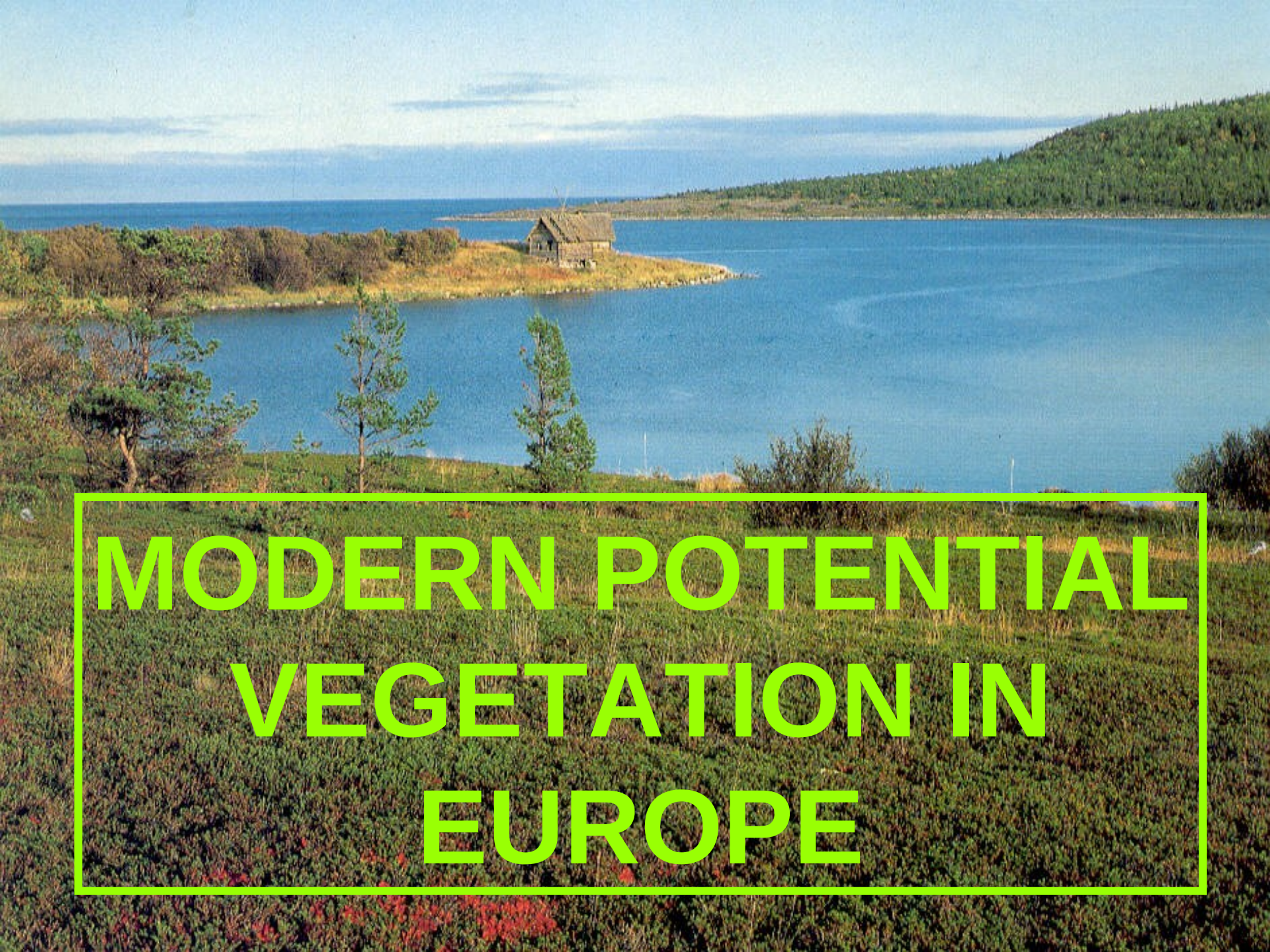
- Boreal/montane forest
- Cool temperate mixed forest
- Cool temperate conifer forest
- Temperate broadleaved deciduous forest
- Warm temperate mixed forest
- Warm temperate conifer forest
- Warm temperate broadleaved evergreen forest
- Sub-tropical forest
- Tropical seasonal forest
- Tropical rainforest
- Cold temperate/boreal open woodland
- Warm temperate open woodland (Mediterranean)
- Tropical savanna
- Temperate grassland
- Tropical grassland
- Tundra
- Semi-desert
- Desert
- Ice

GDD5 = Growing Degree Days above 5°C
TLAI = Tree LAI
RNPP = Grass NPP/Tree NPP

SIMULATING PLANT SPECIES

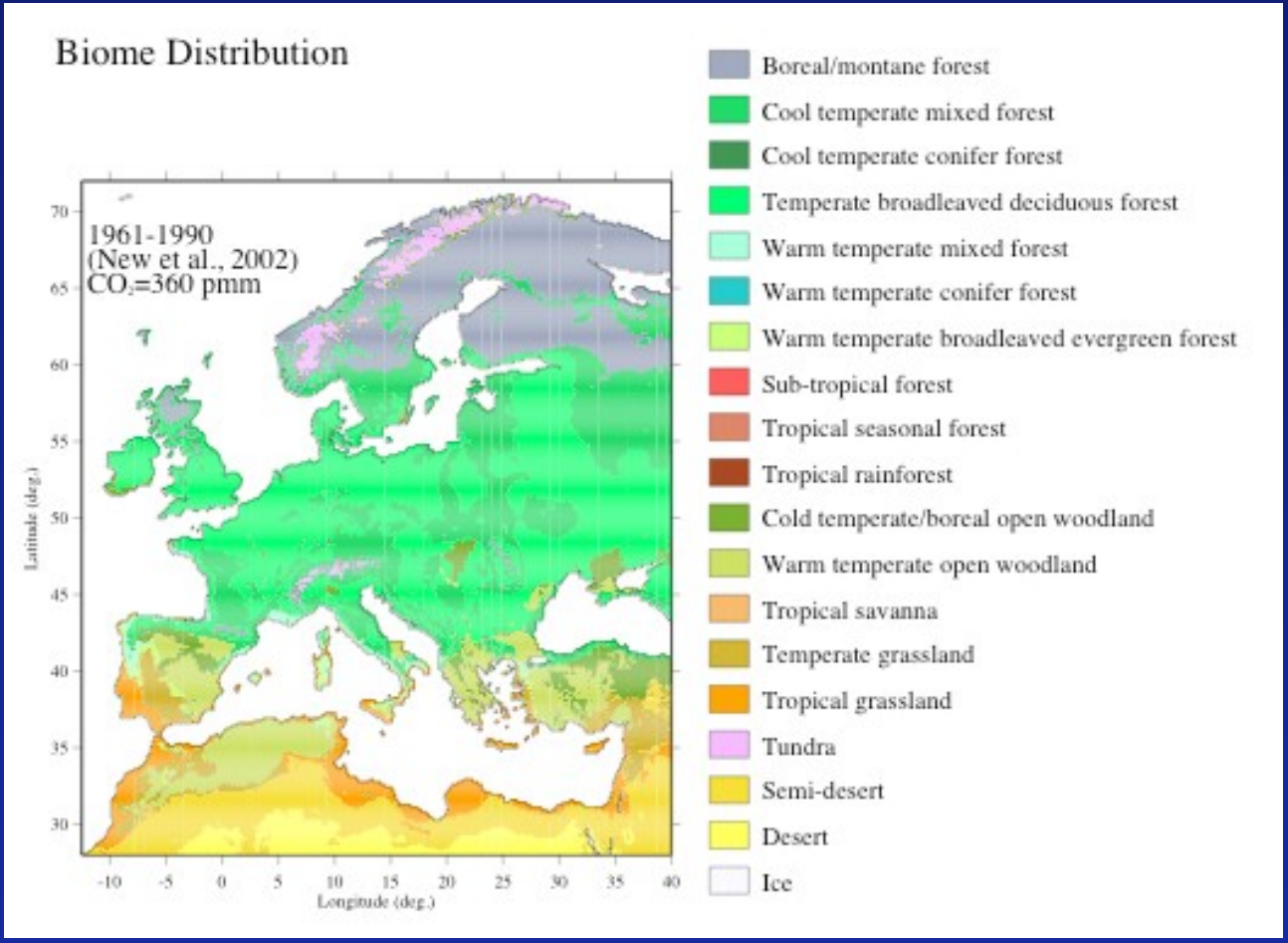
- The model can also simulate **plant species distributions**
- A species will be considered as present when **NPP > 50 g m^{-2} yr**
- As for plant types, parameters describing **stress conditions** (temperature, soil water) and **requirements for establishment** (length of vegetation season, cold or drought requirements) are defined.

	Stress		Establishment		
	T (°C)	SW (rel.)	GDD5 (°C day)	T_g (°C)	SW_g (rel.)
Abies alba	-14.3	0.23	1421	0.3	-
Carpinus betulus	-14.9	0.23	1500	1.8	-
Fagus sylvatica	-14.3	0.24	1417	1.6	-
Quercus robur	-21.8	0.22	1020	2.3	-
Quercus pubescens	-12.7	0.17	1804	2.6	-
Olea europaea	-4.9	0.07	3244	6.4	0.27
Quercus ilex	-9.9	0.09	2127	5.3	0.60
Cedrus atlantica	-9.5	0.05	2300	2.6	-

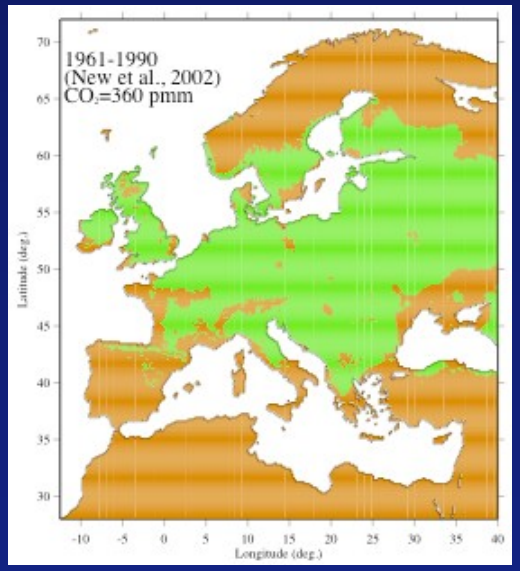

MODERN POTENTIAL VEGETATION IN EUROPE

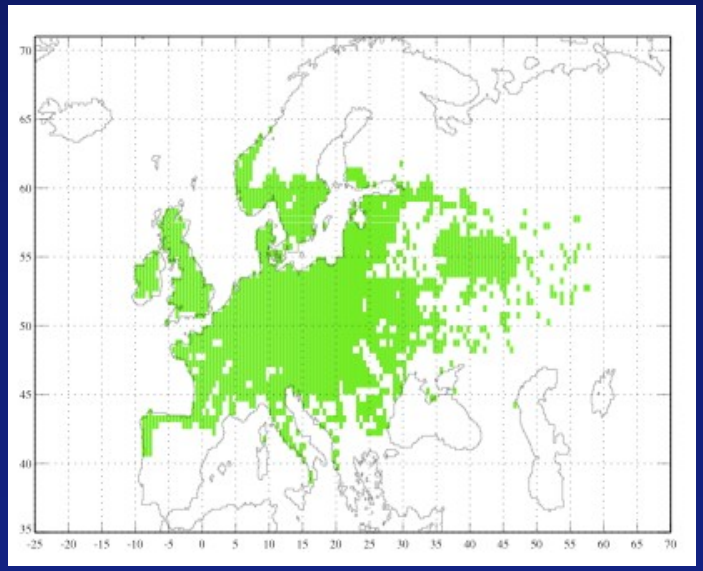
MODEL POTENTIAL VEGETATION (PRESENT-DAY)

- Climatology (New et al., 2002) : 1961-1990
- Atmospheric CO_2 : 360 ppmv

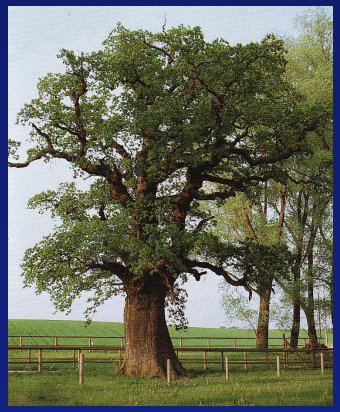


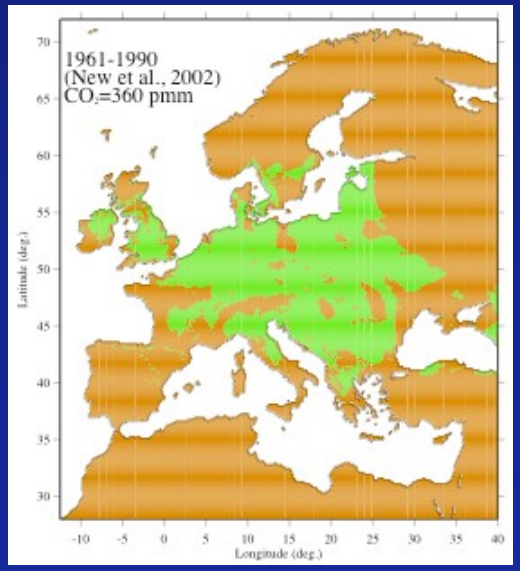
PRESENT RANGES OF SOME DECIDUOUS SPECIES

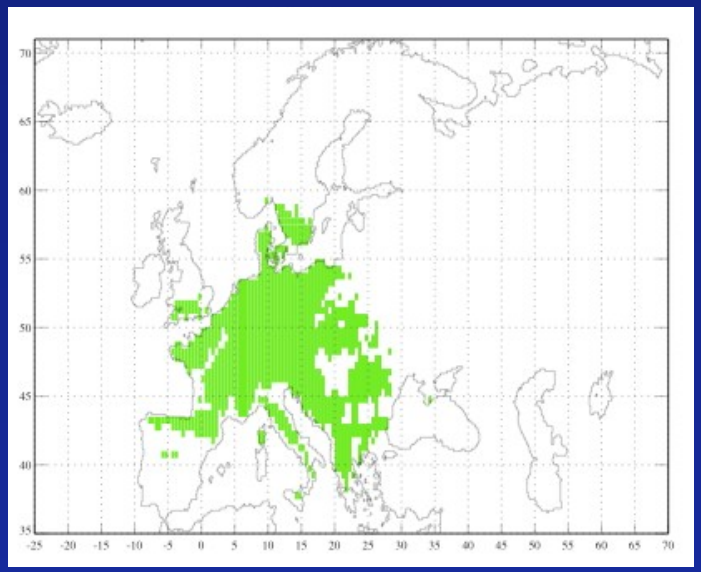




Quercus robur



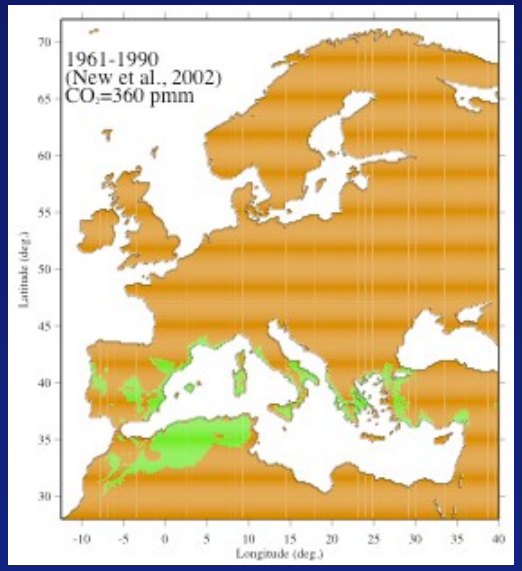


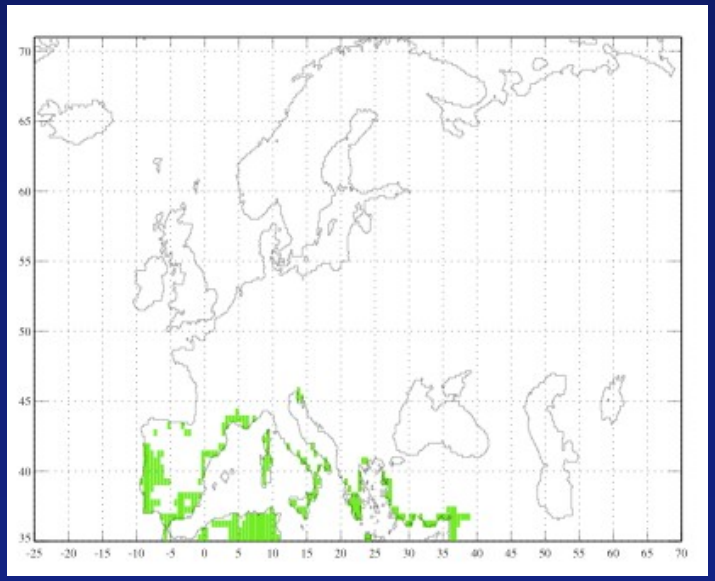


Fagus sylvatica

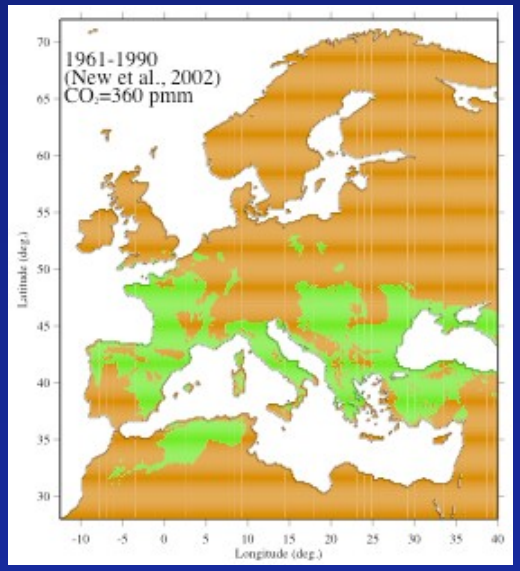
MODEL **OBSERVED**

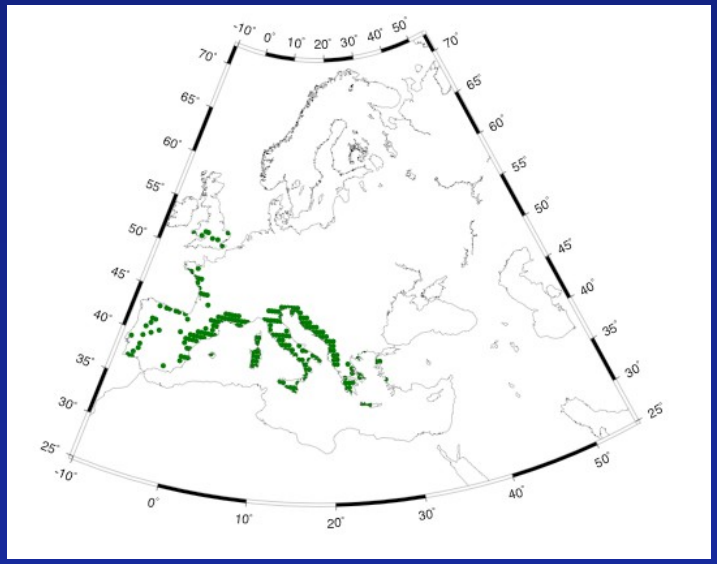
PRESENT RANGES OF SOME MEDITERRANEAN SPECIES





Olea europaea





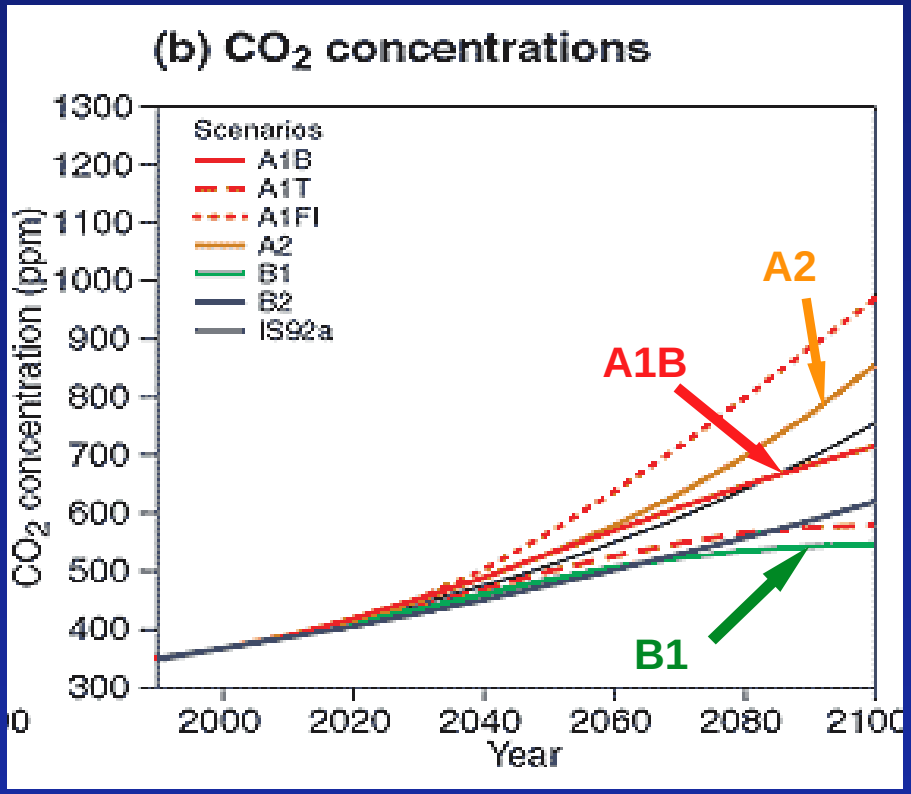
Quercus ilex

MODEL **OBSERVED**

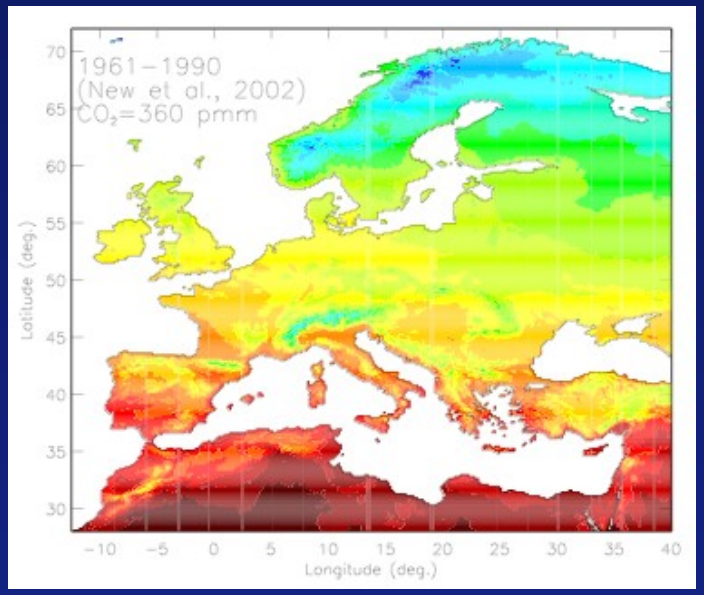

THE FUTURE
(2071-2100)

FUTURE SCENARIOS

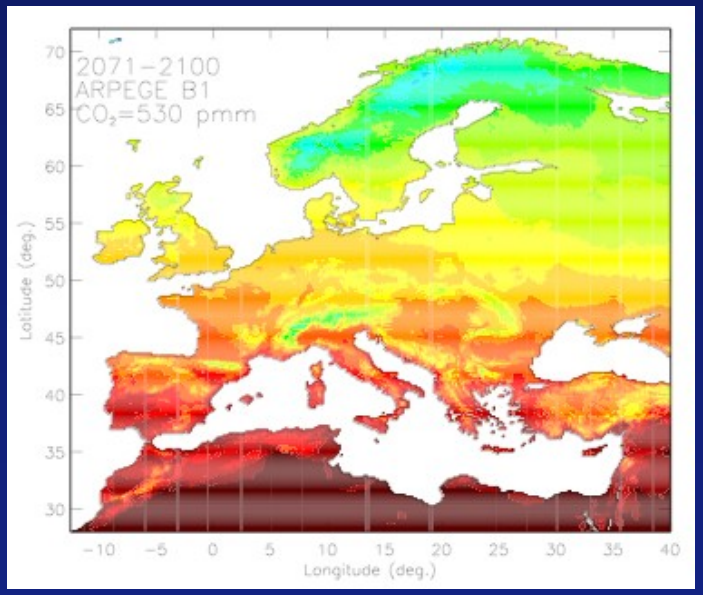
- ARPEGE-CLIMAT model simulations (IPCC 4th AR)
  → non regular grid with zoom
  over Mediterranean region
- Scenarios: IPCC SRES scenarios B1, A1B, A2
- Inputs to vegetation model for 2071-2100
  - average climate from ARPEGE-CLIMAT interpolated at 10'x10'
  - atmospheric CO_2:
    530 ppmv (B1)
    660 ppmv (A1B)
    750 ppmv (A2)



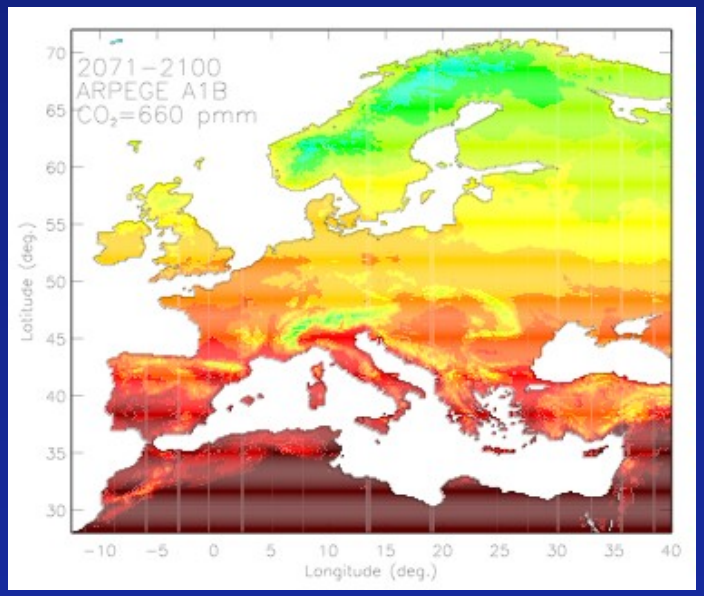
Reference (1961-1990)



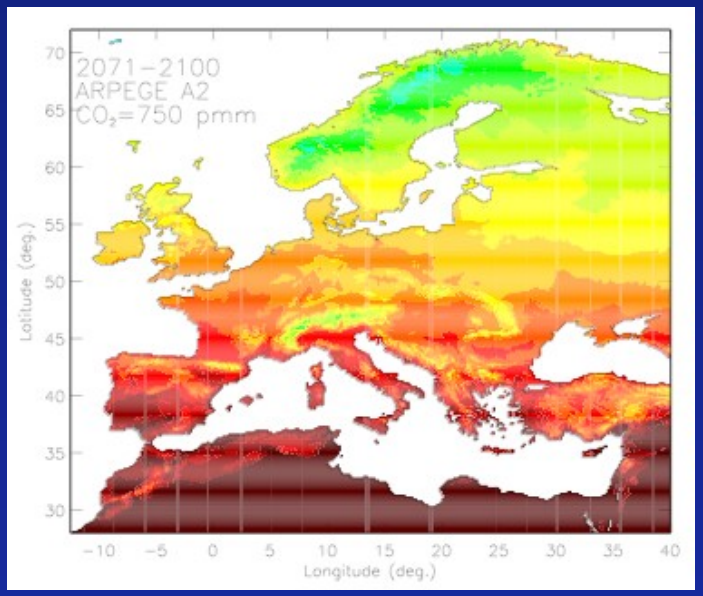
2071-2100 B1



Annual Mean Air Temperature (°C)

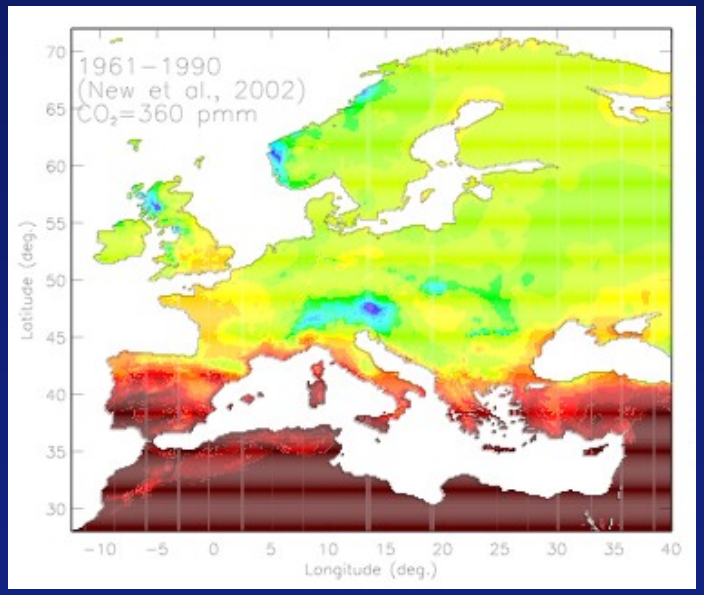


2071-2100 A1B



2071-2100 A2

Reference (1961-1990)



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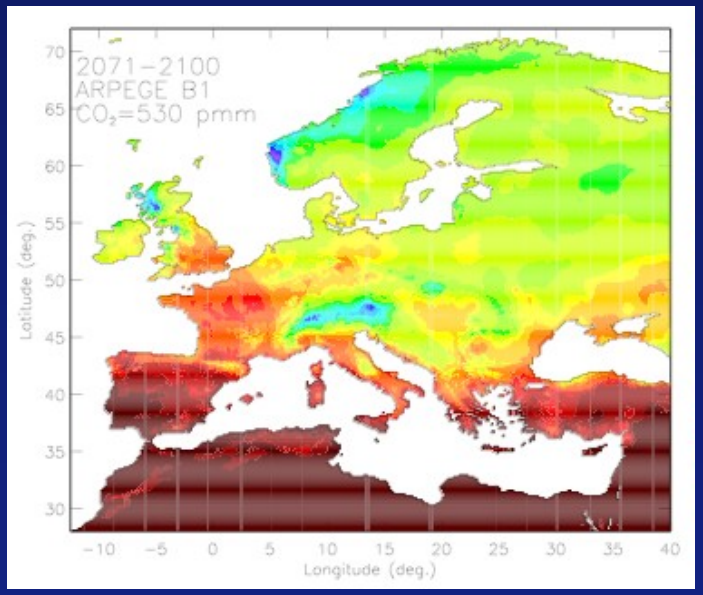
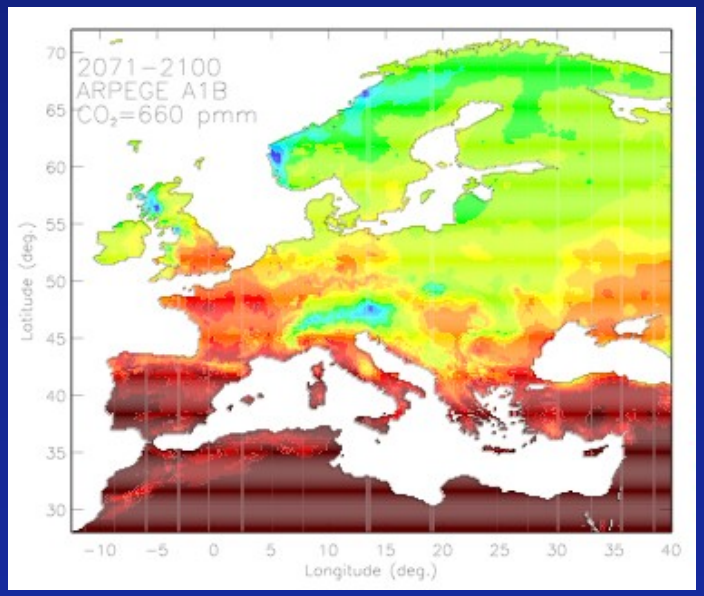
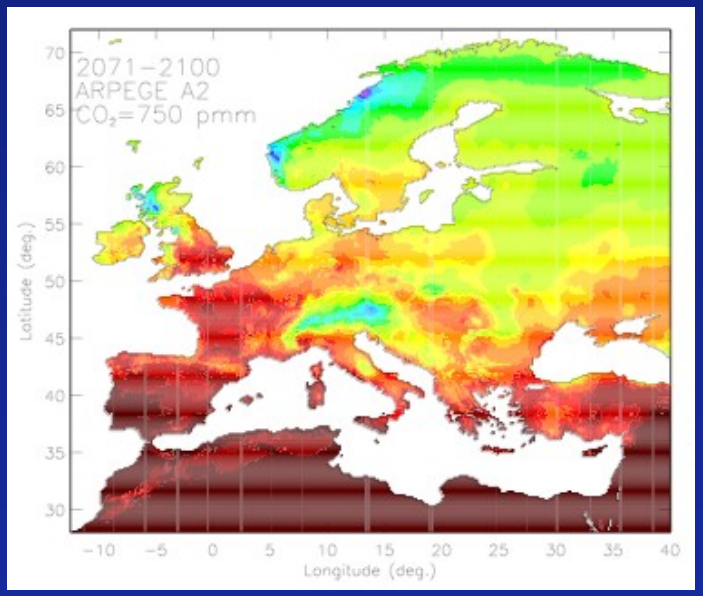


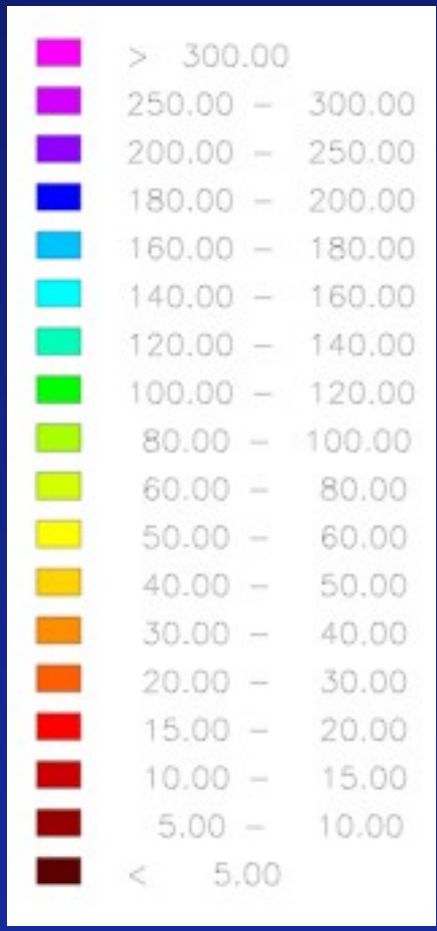


2071-2100 A1B



2071-2100 A2

July Precipitation (mm/month)



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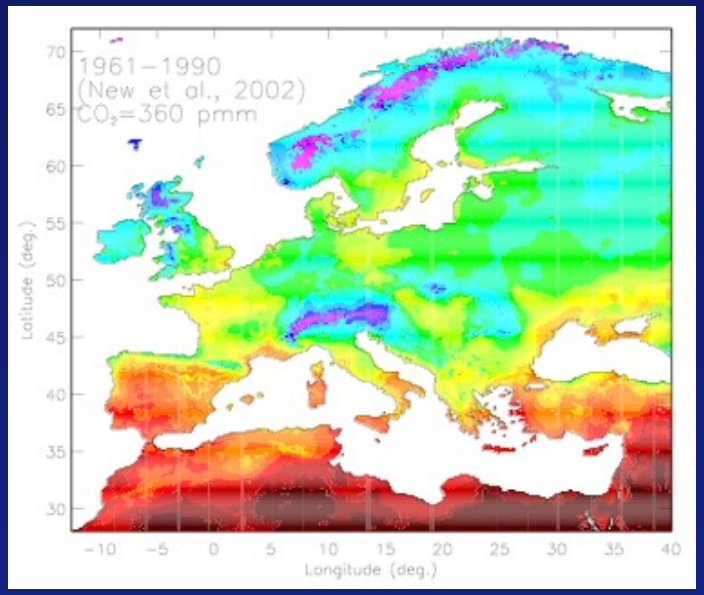

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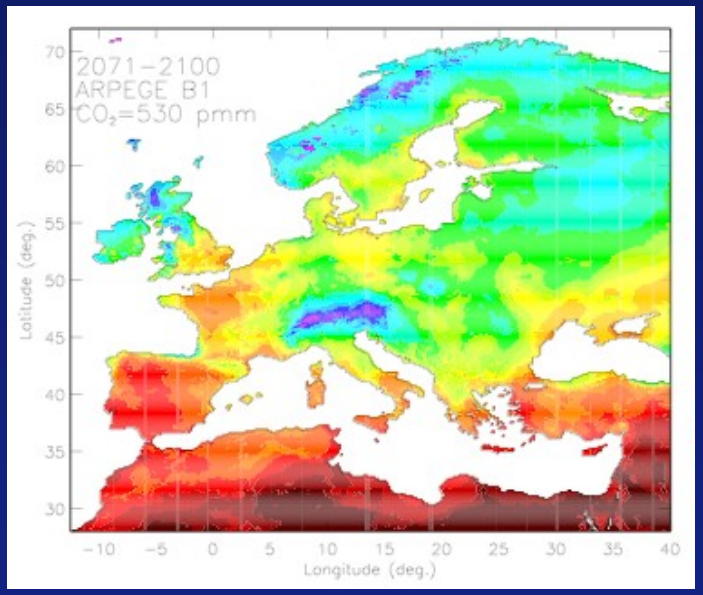
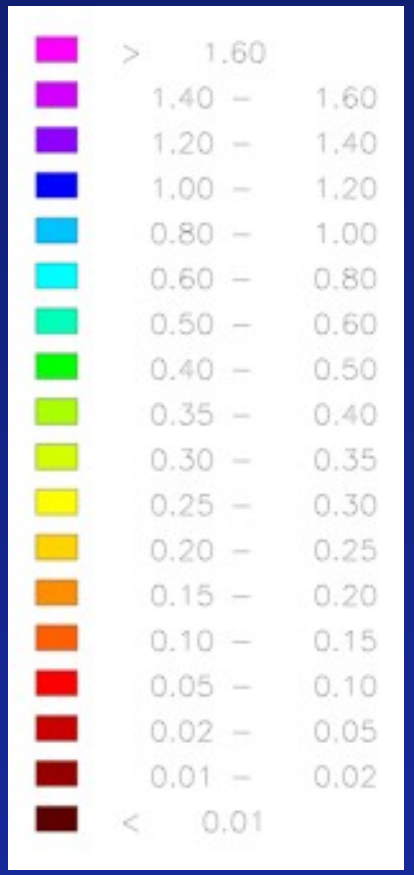
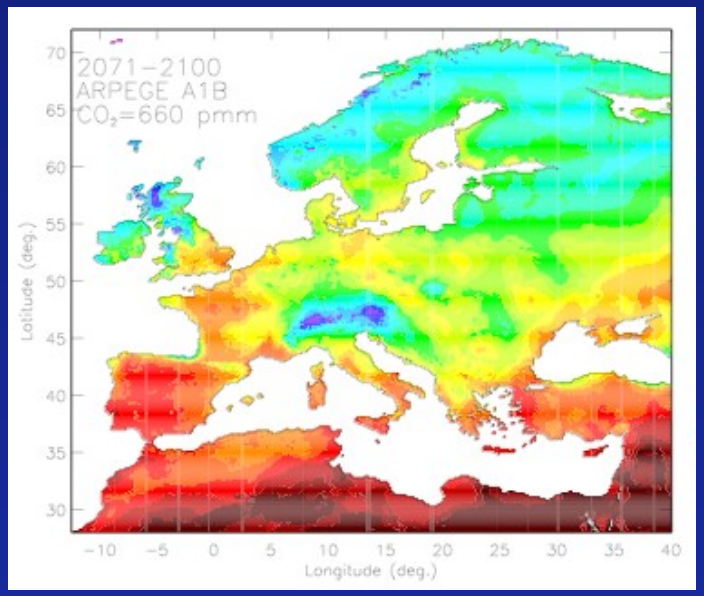
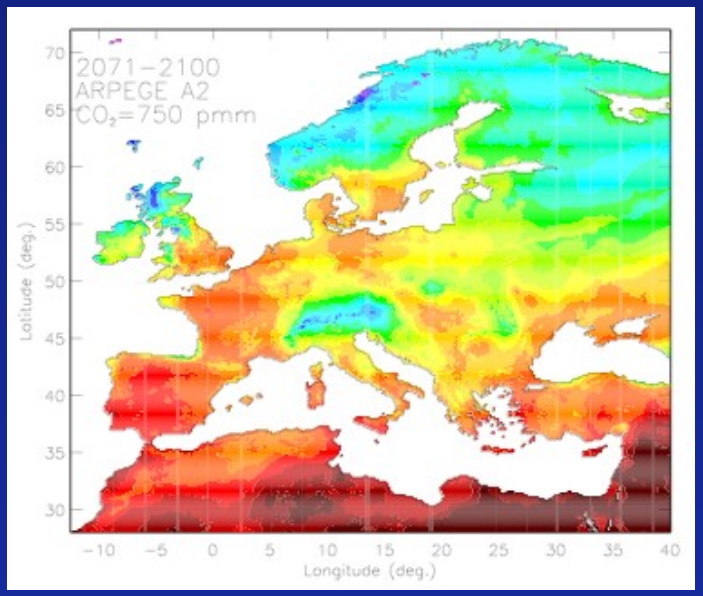


Mean soil water of the driest month (SW-WP)/(FC-WP)



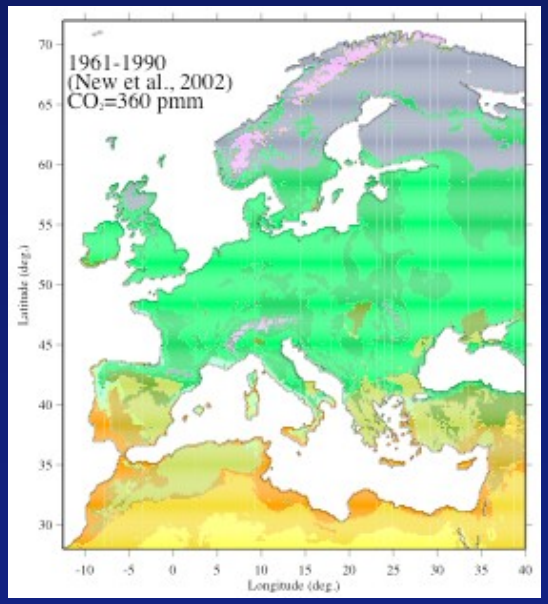


2071-2100 A1B



2071-2100 A2

Reference (1961-1990)



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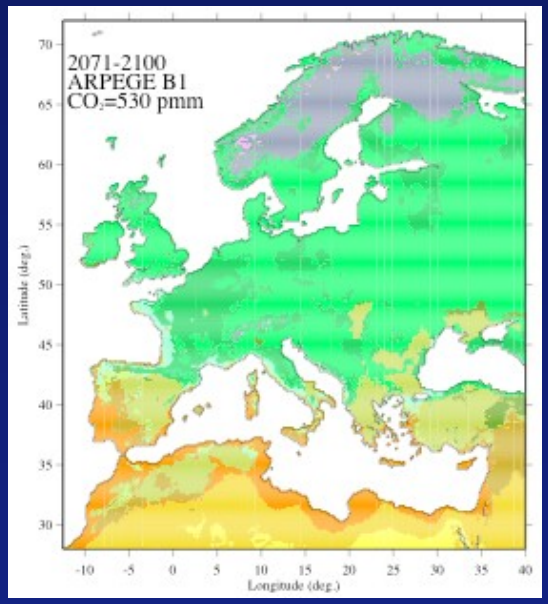
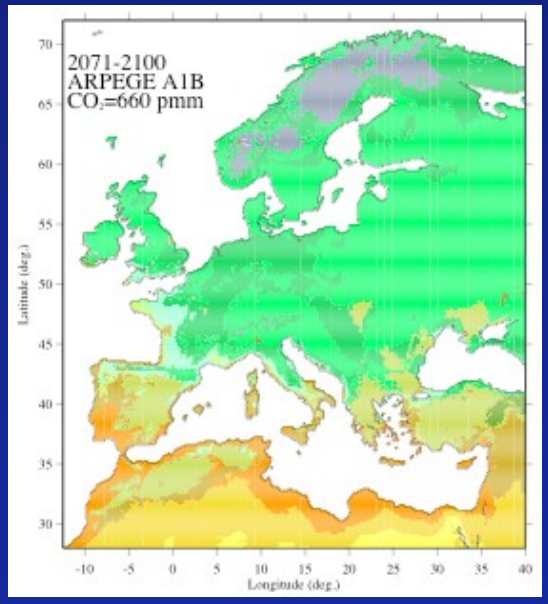
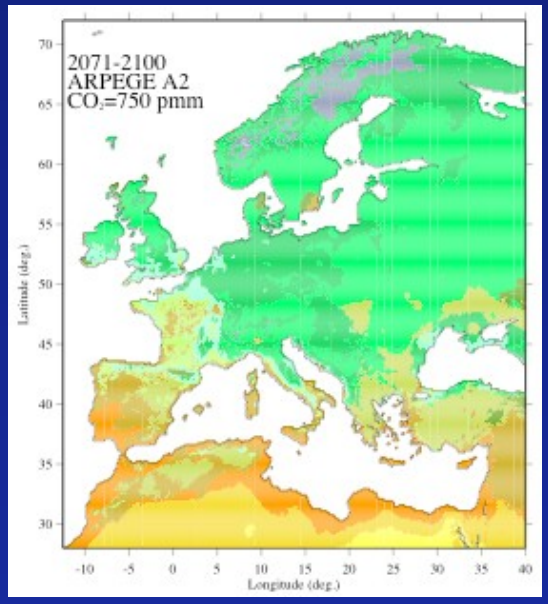




2071-2100 A1B



2071-2100 A2

Potential vegetation (Biomes)

- Boreal/montane forest
- Cool temperate mixed forest
- Cool temperate conifer forest
- Temperate broadleaved deciduous forest
- Warm temperate mixed forest
- Warm temperate conifer forest
- Warm temperate broadleaved evergreen forest
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- Temperate grassland
- Tropical grassland
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- Semi-desert
- Desert
- Ice

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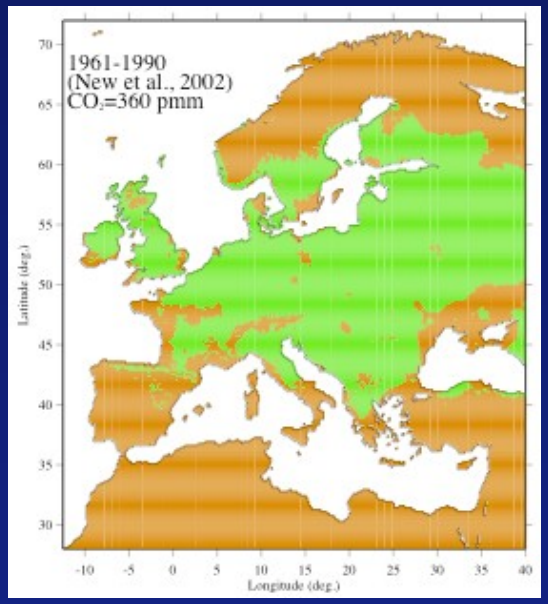

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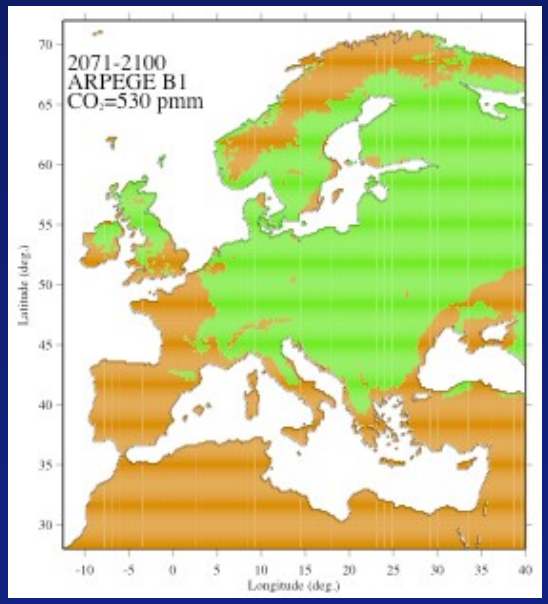

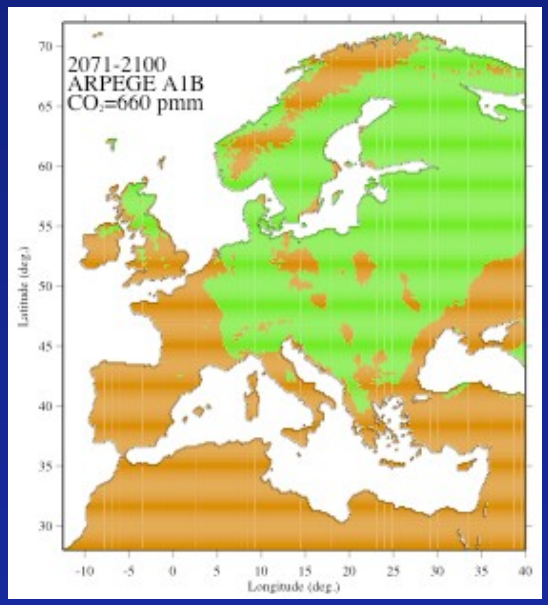

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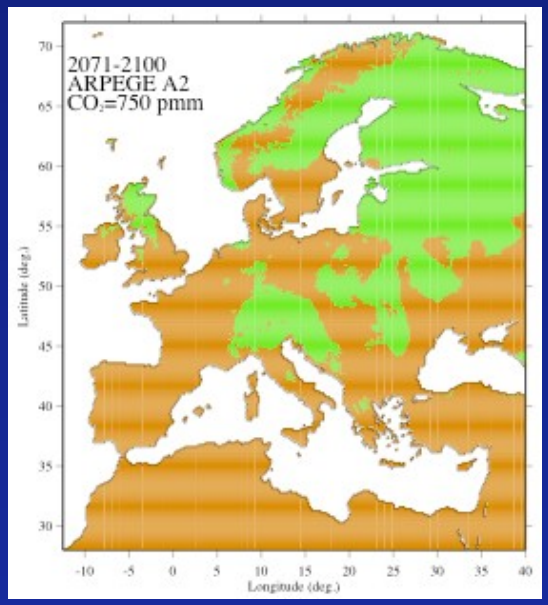
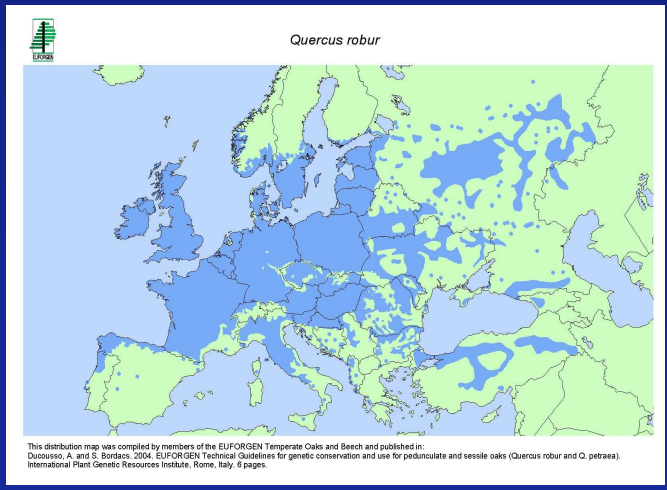


2071-2100 A2

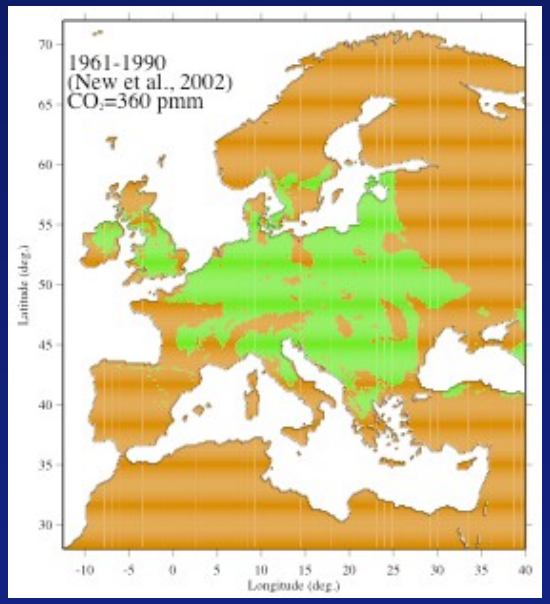
Quercus robur

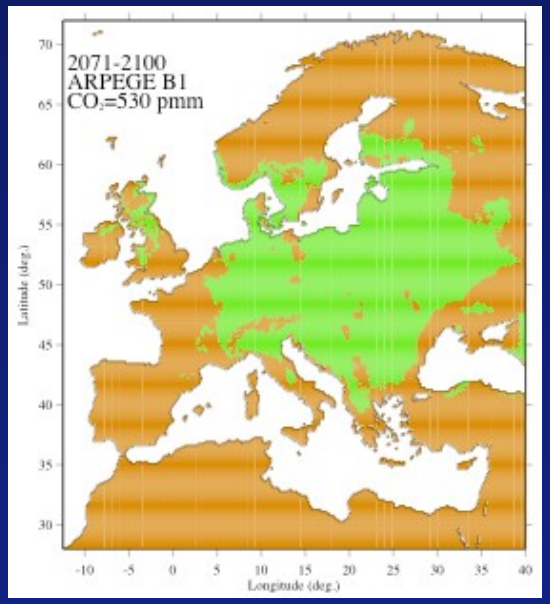


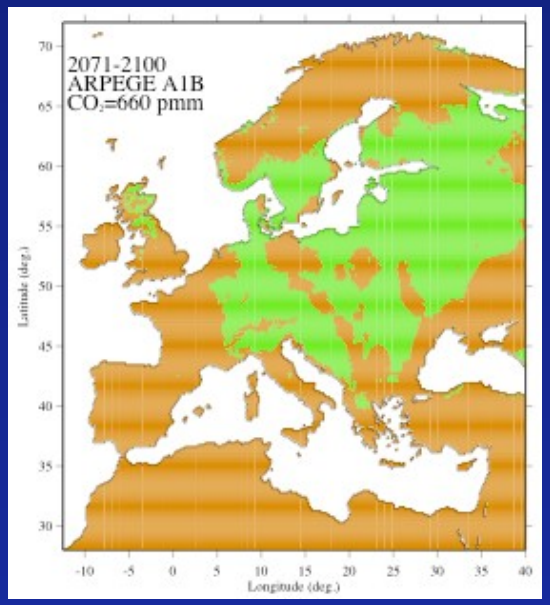
Observed

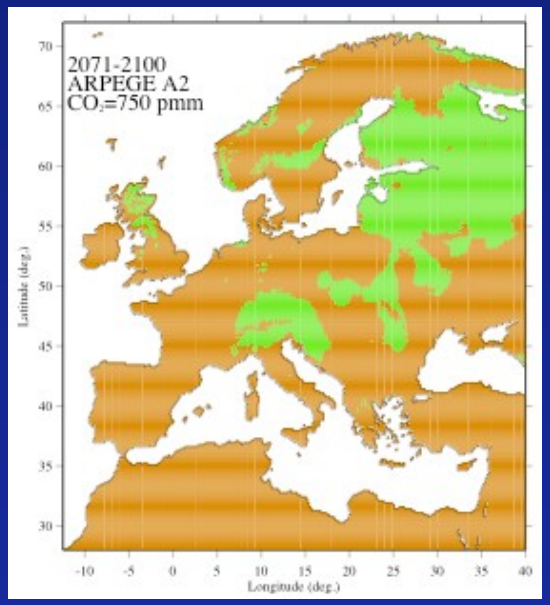
Reference (1961-1990)

2071-2100 B1





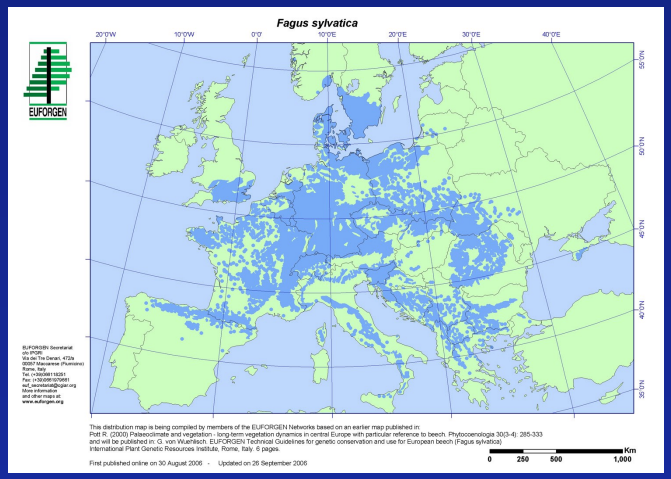




2071-2100 A1B

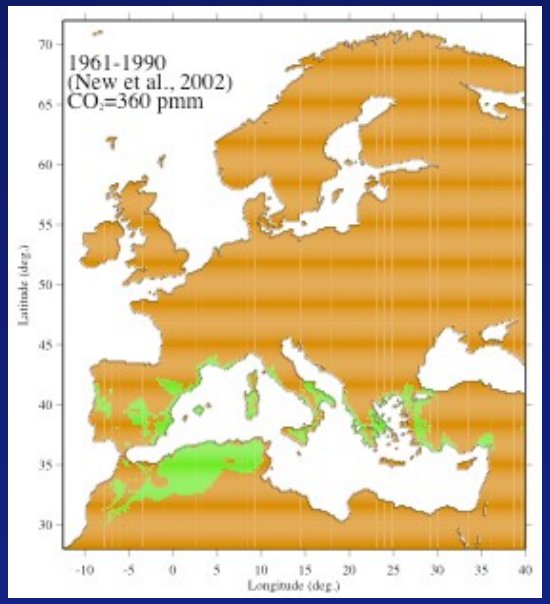
2071-2100 A2

Fagus sylvatica

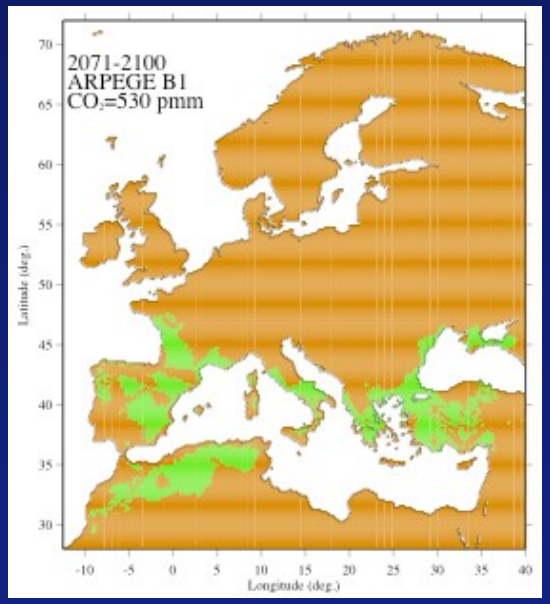


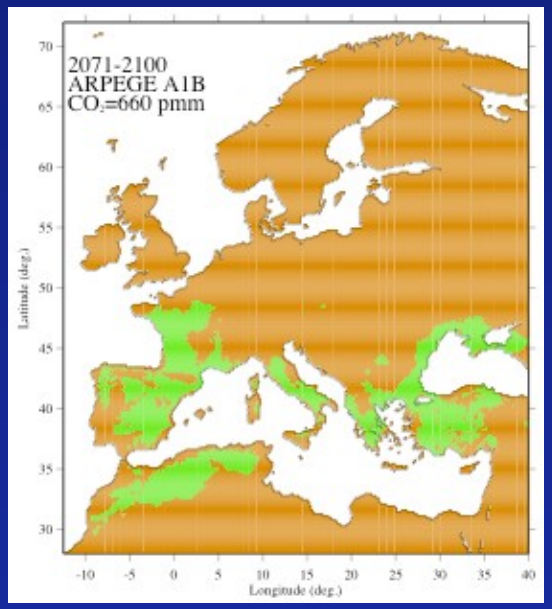
Observed

Reference (1961-1990)

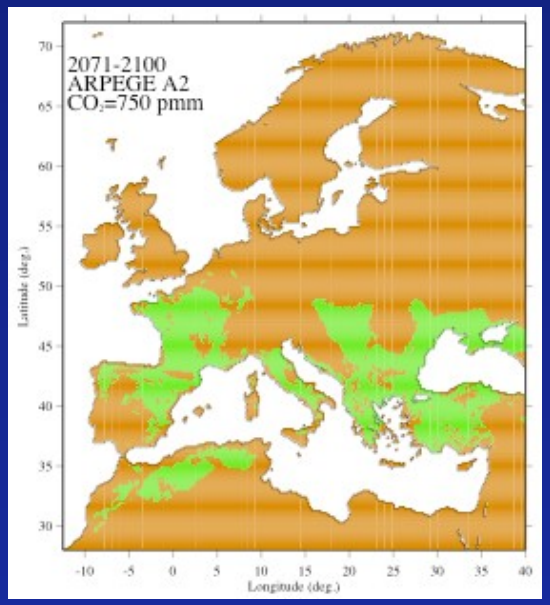


2071-2100 B1





2071-2100 A1B

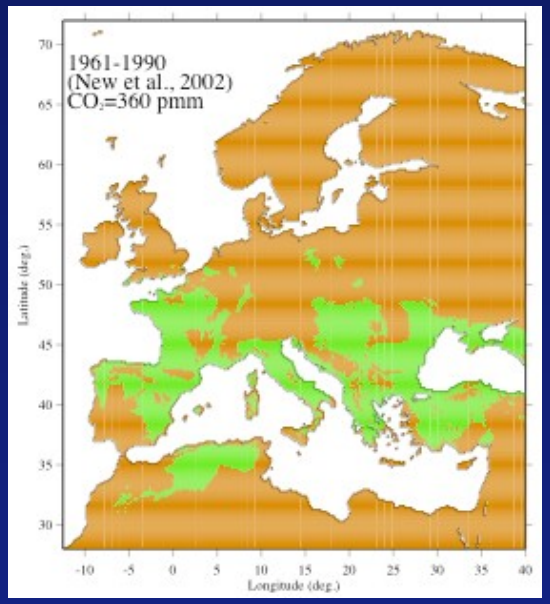


2071-2100 A2

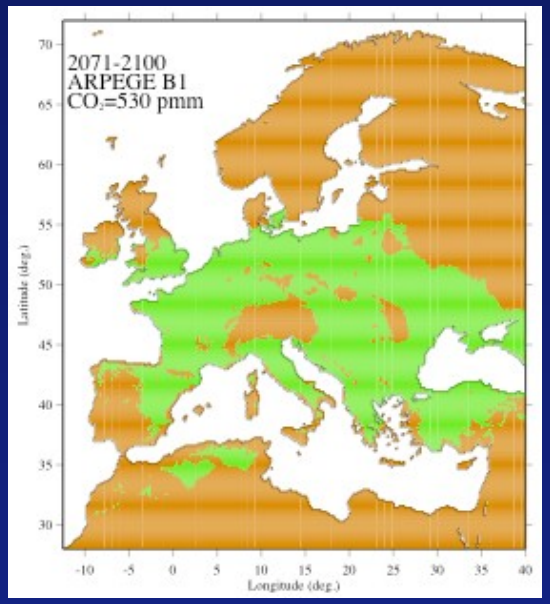
Olea europaea

Observed

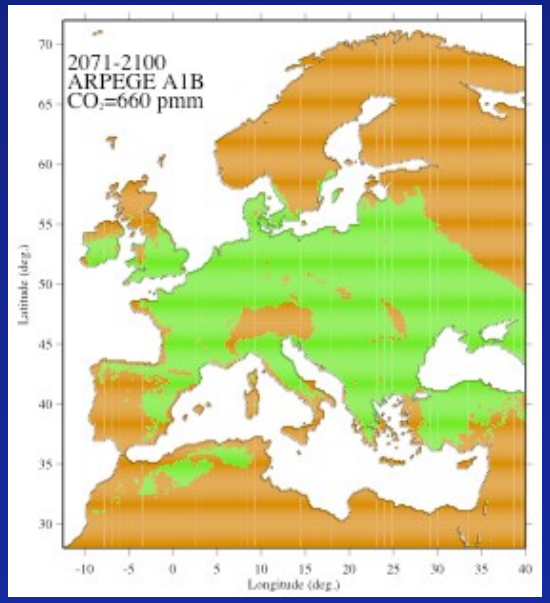
Reference (1961-1990)



2071-2100 B1



Quercus ilex



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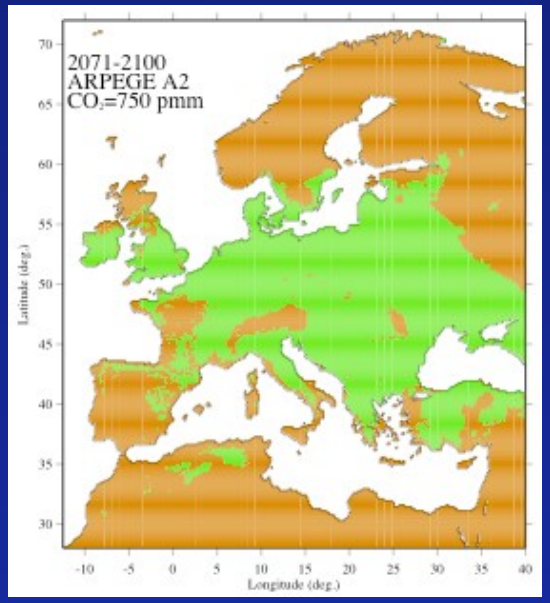
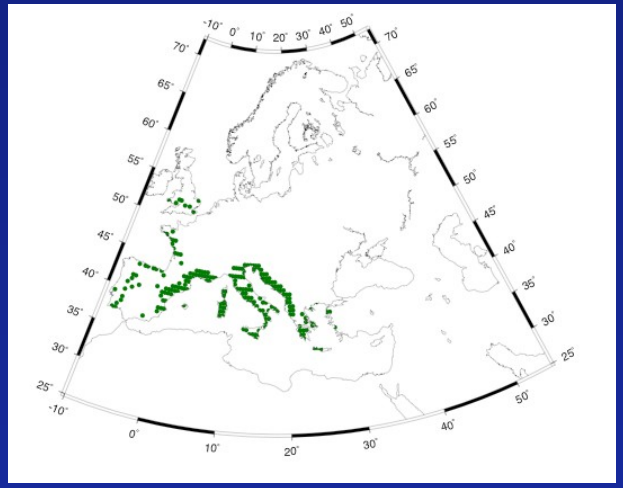
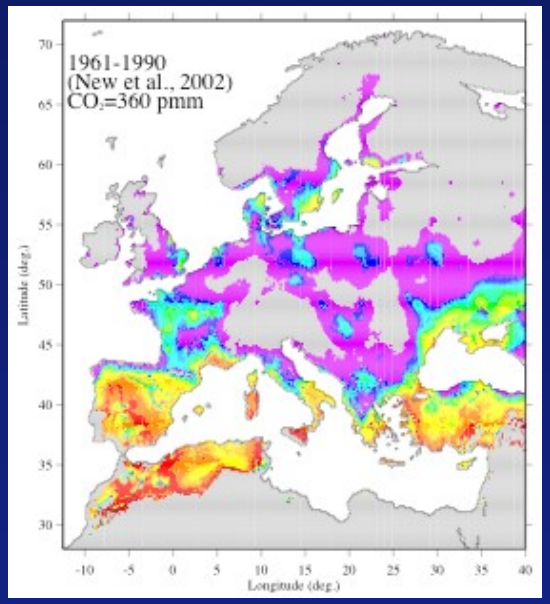


2071-2100 A2

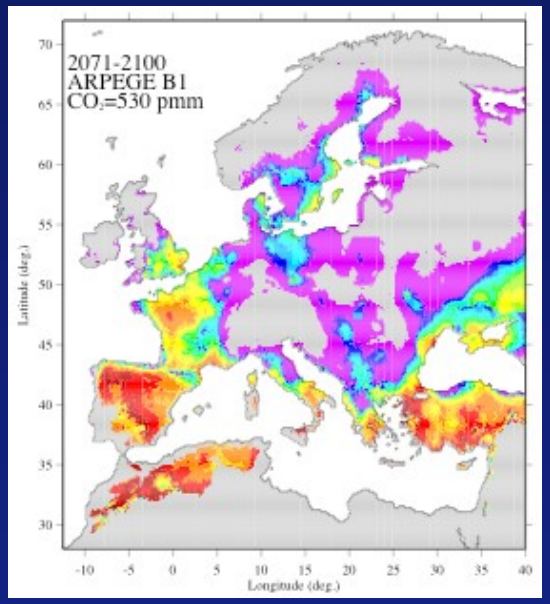


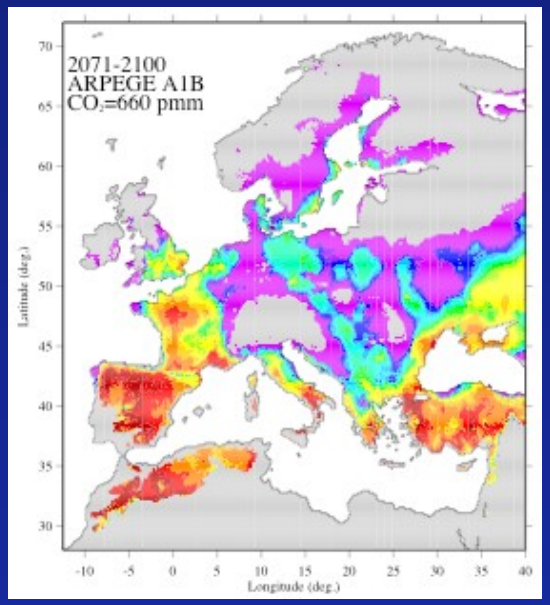
Observed

Reference (1961-1990)

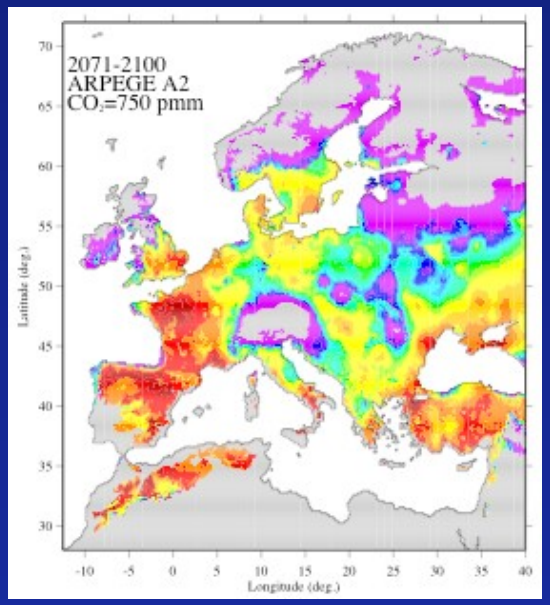


2071-2100 B1





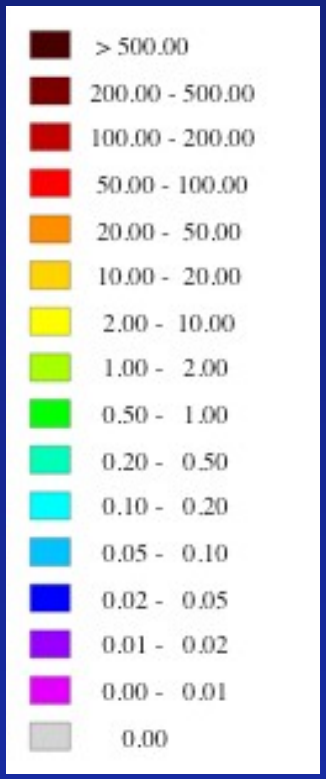
2071-2100 A1B



2071-2100 A2

Fires (with natural vegetation !)

Mean annual area burned per pixel (ha)



CONCLUSIONS

- The latest version of the CARAIB vegetation model provides a finer classification of plant types adapted to the regional scale and based on a detailed statistical analysis of present vegetation distribution in Europe: the *Bioclimatic Affinity Groups*

- Simulations at the species level are also possible within CARAIB

- CARAIB simulations for the future (2071-2100, B1, A1B, A2) suggest :
  - a more open vegetation in the Mediterranean basin
  - a substantial northward shift of Mediterranean vegetation (France, Danube basin, north of Black Sea)
  - a significant northward/eastward shift of deciduous forests
  - the almost complete disappearance of the tundra biome in Europe

- Very large changes are especially observed for scenario A2 :
  - some currently widespread deciduous trees (*Q. robur*, *Fagus syl.*) will tend to be restricted to mid-altitude mountains or northern Europe
  - by contrast, some Mediterranean species (*Q. ilex, Cedrus atl.*) will tend to have much wider potential distributions than today