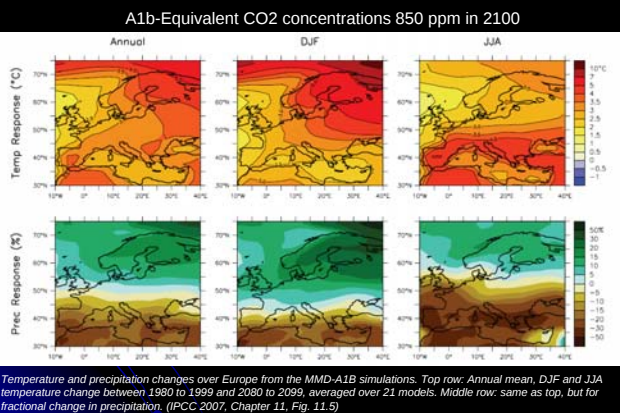
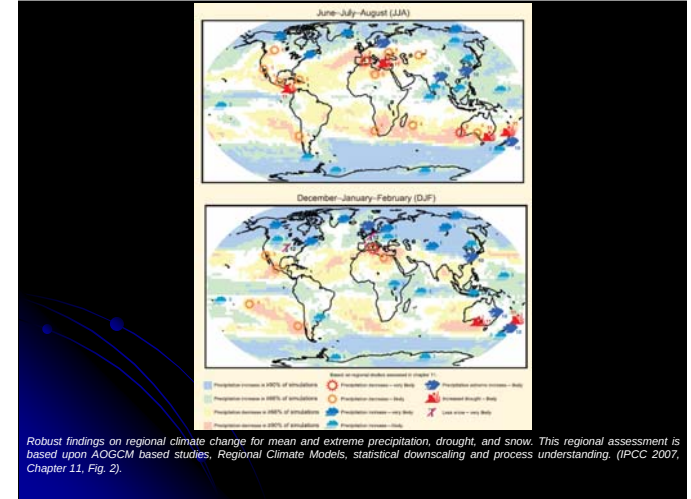
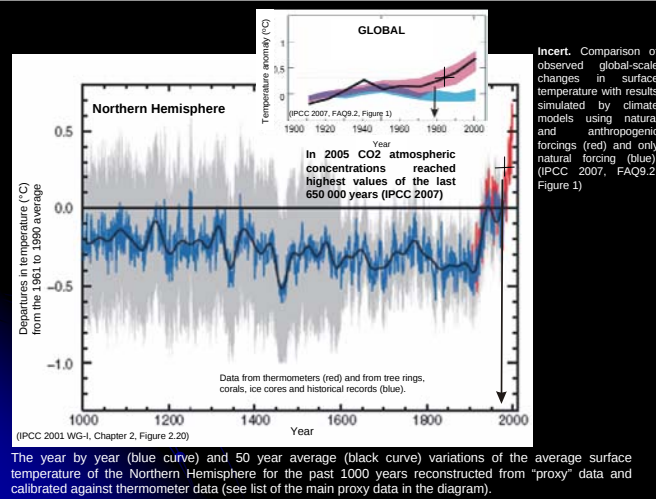


Precipitation decline in the eastern Mediterranean and its impacts on trees' growth and ground water utilization

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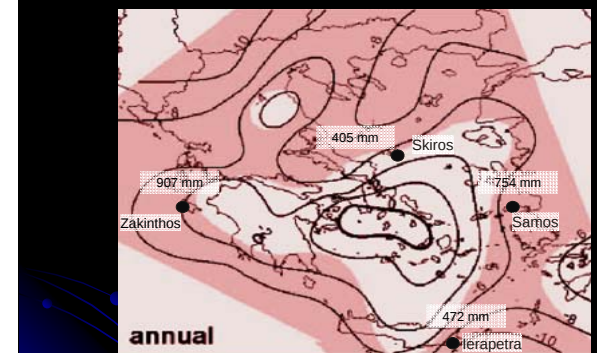
Funded by the Research Comity of the University of Patras
under the project "Karatheodori" for basic research
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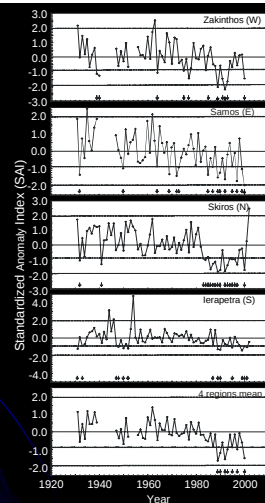
•We present evidence of a recent drying in the eastern Mediterranean, based on weather and tree-ring data for four Greek regions: Samos, Zakinthos, Skiros and Ierapetra



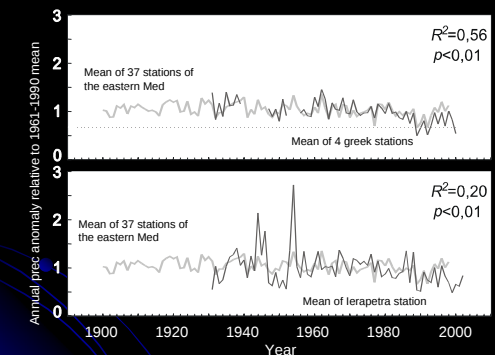
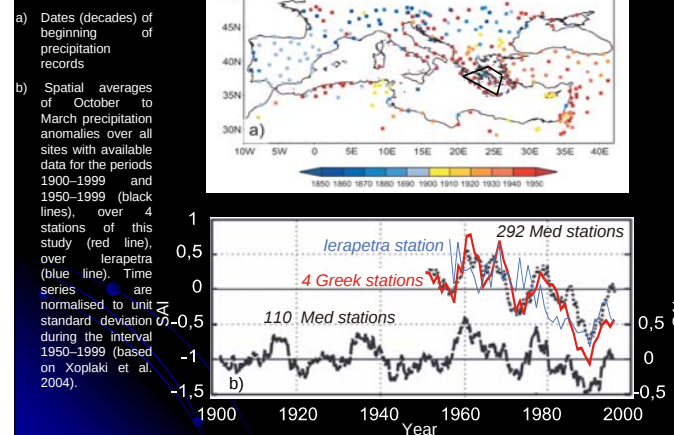
•These regions were selected to represent regions where precipitation declined significantly during the last 40 years and simulate conditions that resemble if not verify IPCC model predictions for reduced precipitation over the Mediterranean

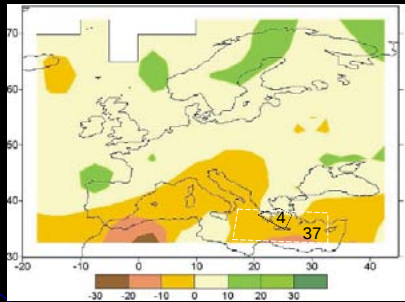


Spatial distribution of the slope b (percentage contribution per decade) and significance levels (pink levels indicate a significance level greater than 95%) of the regression analysis for the annual and seasonal totals (1955–2001), (Feidas et al. 2007).



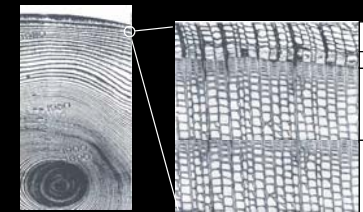
Annual precipitation variations





Deviation % of 1990-98 mean annual precipitation from 1900-90 average (CRU 2004, Hulme et al. 1998).

Basic dendroclimatological principle in our analysis

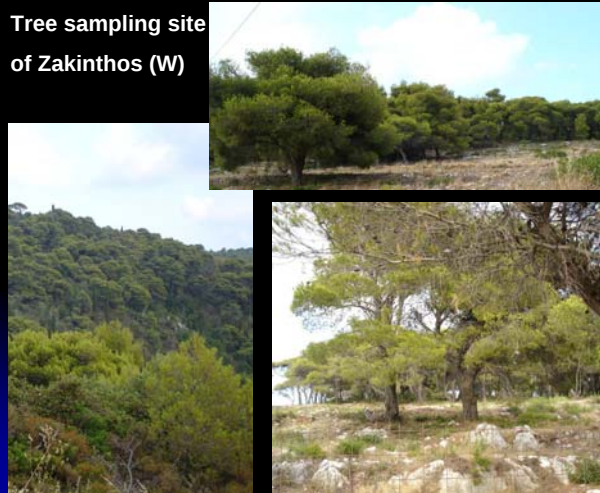


Phloem
Zone of cambial cells
Tree-ring of 1986
Tree-ring of 1985

Cambium tissue cells found in the stem of perennial plants are responsible for constructing new plant vessels each year. These vessels are formed through lignification and serve to transport water, nutrients and to provide mechanical support. Environmental factors influence this process. As a result distinct rings on wood cross sections are created called tree-rings.

Each of these rings corresponds to a plant growing season. Their width is relative to moisture available for tree-growth in warm climate zones, which also stands for Mediterranean climate. Moisture availability in turn is linked to precipitation, especially in dry limestone substrate biotopes. Tree-ring width from such habitats is most sensitive to precipitation variability and can be used for past rainfall reconstruction.

Tree sampling site of Zakynthos (W)



Tree sampling site of Limionas, Samos (E)

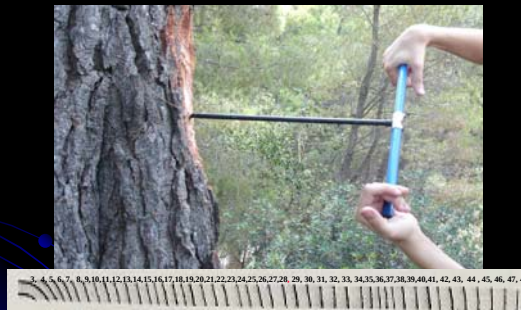
Tree sampling site of Skiros (N)



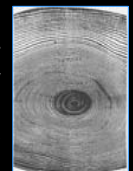
Tree sampling site of Ierapetra (S)

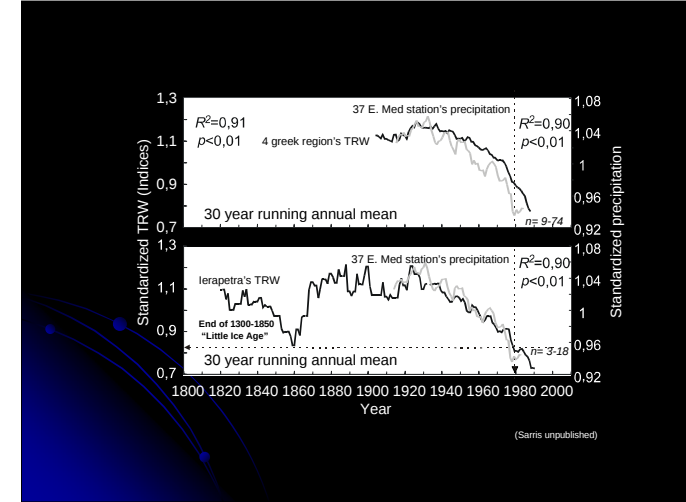
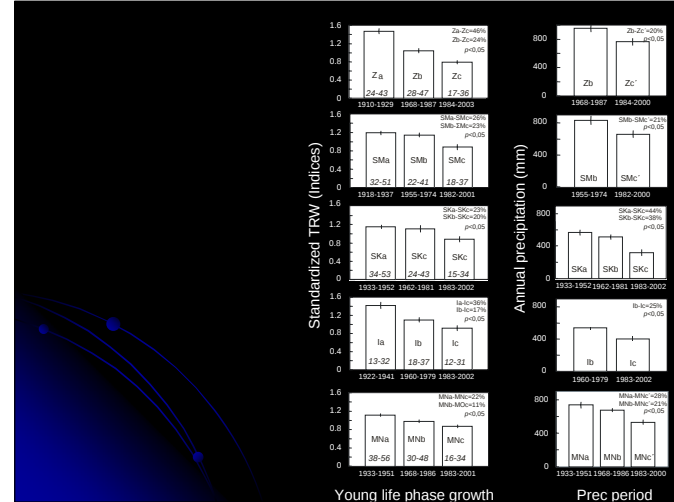
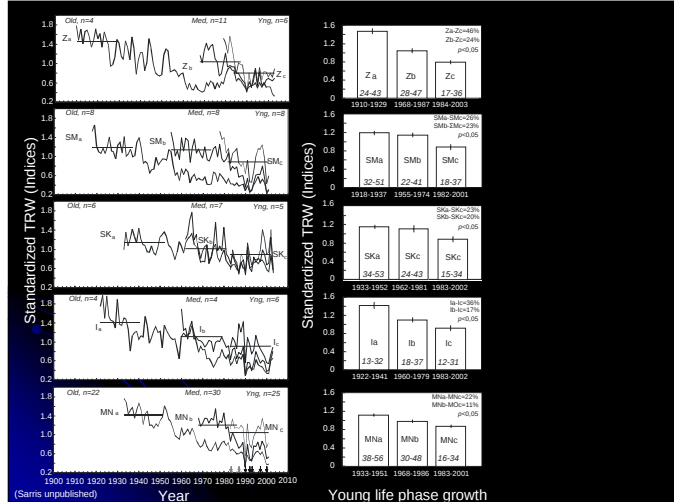


Tree-ring sampling

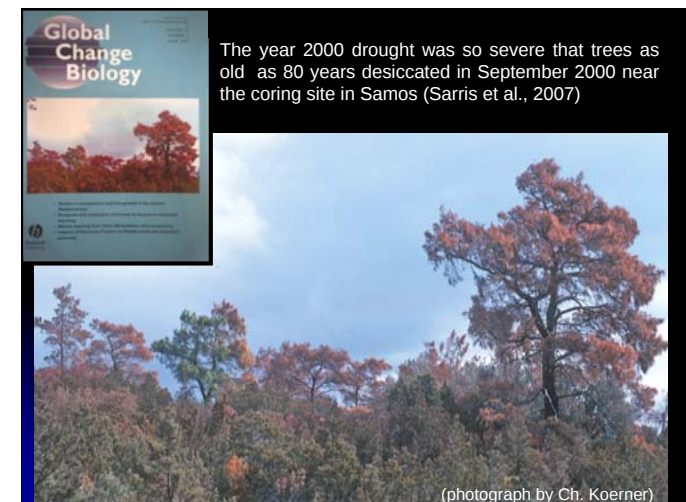
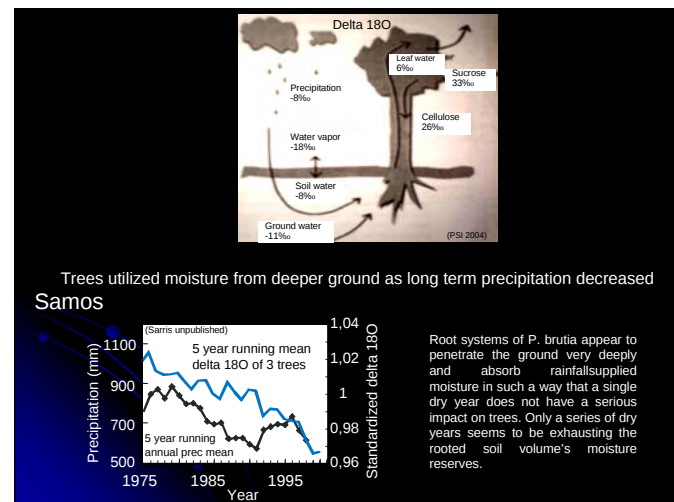
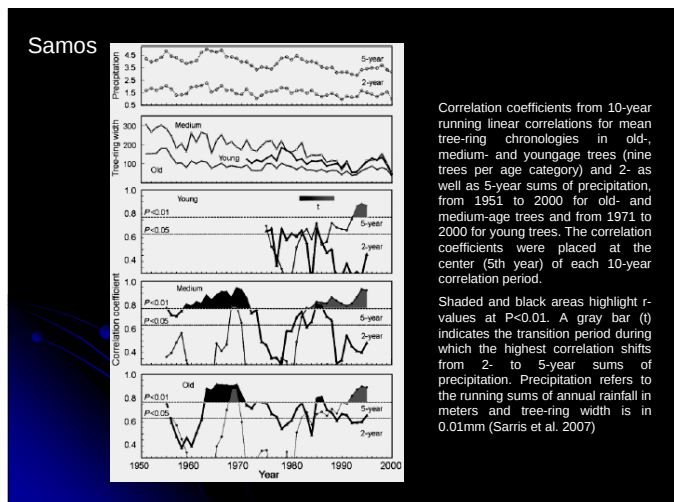
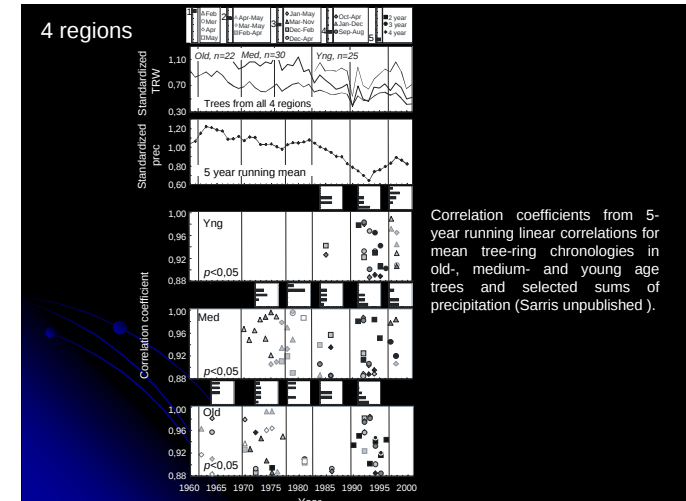
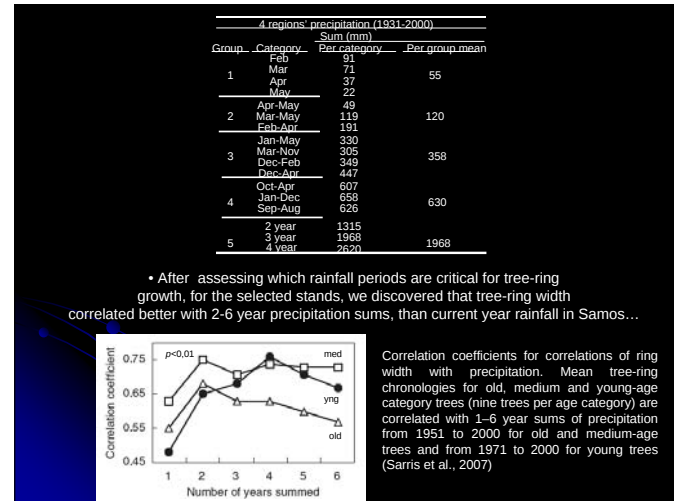


•The significant rainfall decline reduced water availability and was clearly captured by tree-rings of *P. halepensis* and *P. brutia* trees from all 4 regions

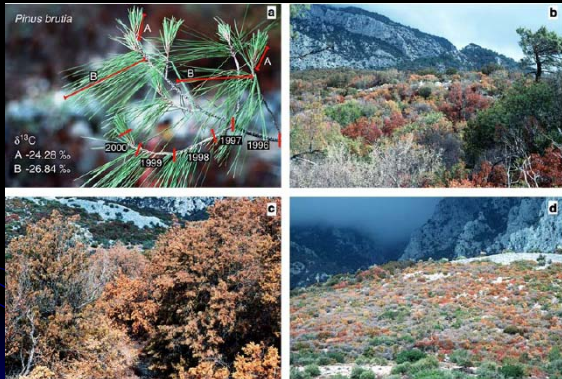




The decline in rainfall not only affected tree growth... but also influenced trees' ground water utilization.



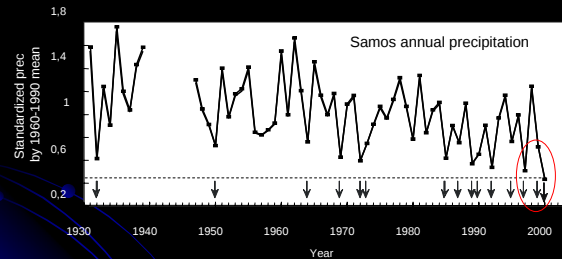
Exceptional damage was also recorded for the Macchia shrub vegetation of this area



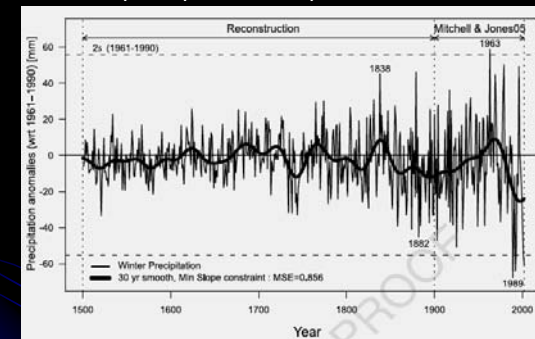
a Shoots and needles remained short and the stable carbon isotope discrimination in needle dry matter in 2000 was close to the minimum known for C3 species. A year 2000, B year 1999. b-d On many ridges and S-exposed slopes sclerophyllous shrubs died from drought in the year 2000 in the SW of Samos (Limnionas-Kalitheia).

(Koerner et al., 2005)

As the limit for the distribution of *P. brutia* is around 400mm annual rainfall (Nahal, 1983; Que'zel, 2000) the 353mm precipitation of 2000, combined with very low rainfall during the years before, truly mark an extreme situation that seems to have pushed these trees very close to their survival limits.



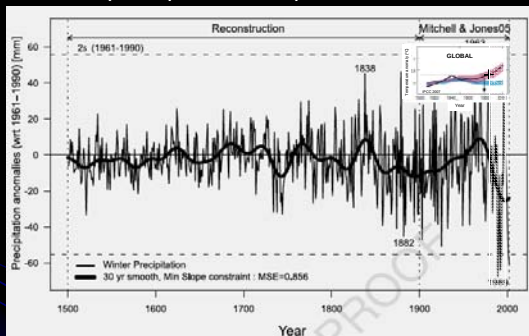
Winter (DJF) averaged-mean Mediterranean precipitation anomalies (with respect to 1961-1990) from 1500 to 2002



The values for the period 1500-1800 are reconstructions (Pauling et al., 2005), data from 1801 to 2002 are derived from Mitchell et al. (2004) and Mitchell and Jones (2005). The thick black line is a 30-year smooth "minimum slope" constraint calculated according to Mann (2004). The dashed horizontal lines are the ± 2 standard deviations of the period 1961-1990. The driest and the wettest Mediterranean winters for the reconstruction and the full period are denoted.

From: Luterbacher J, Xoplaki E, Casty C et al. (2006) Mediterranean climate variability over the last centuries: A review. In: *The Mediterranean Climate: an overview of the main characteristics and issues* (eds Lionello P, Malanotte-Rizzoli P, Boscolo R), pp. 27-148. Elsevier, Amsterdam.

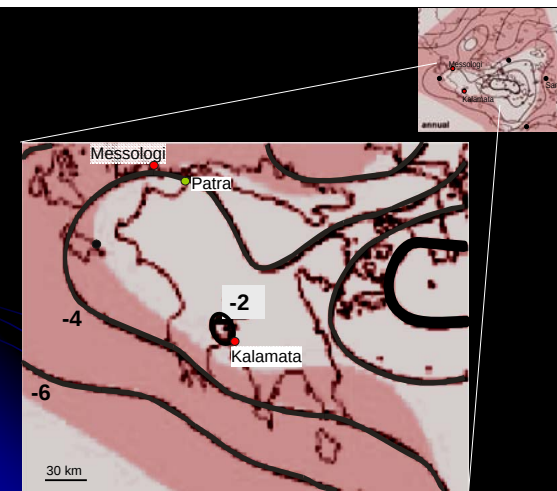
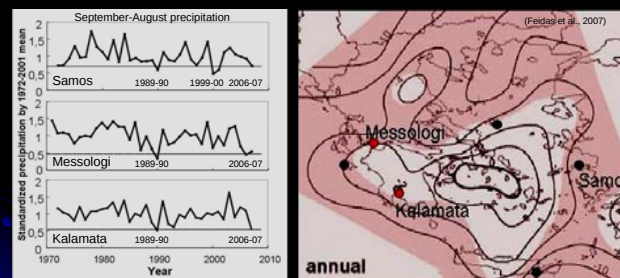
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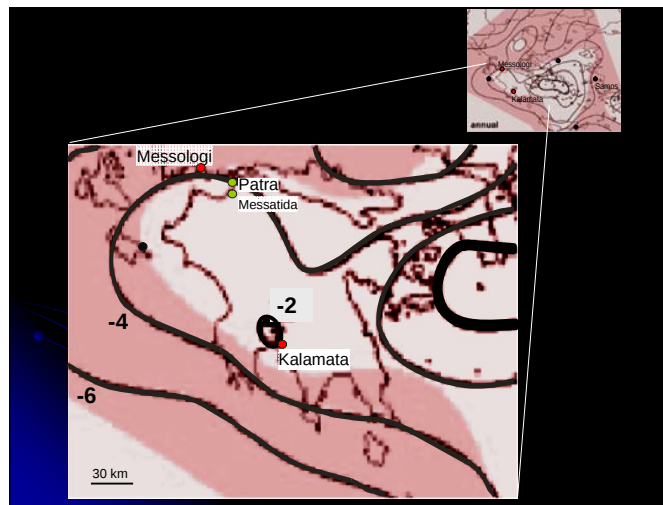
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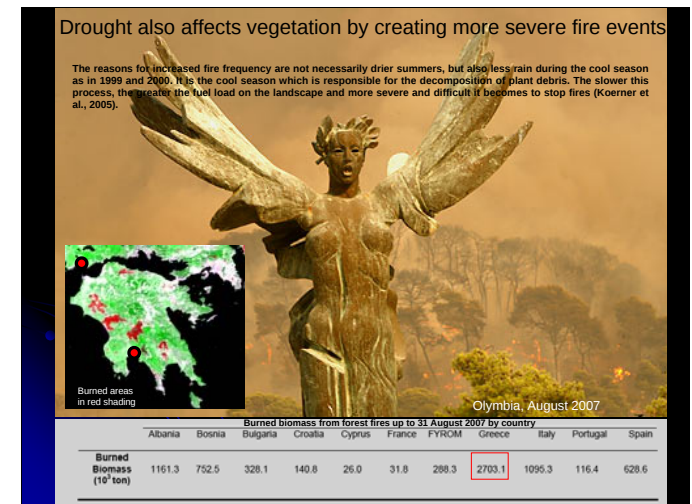
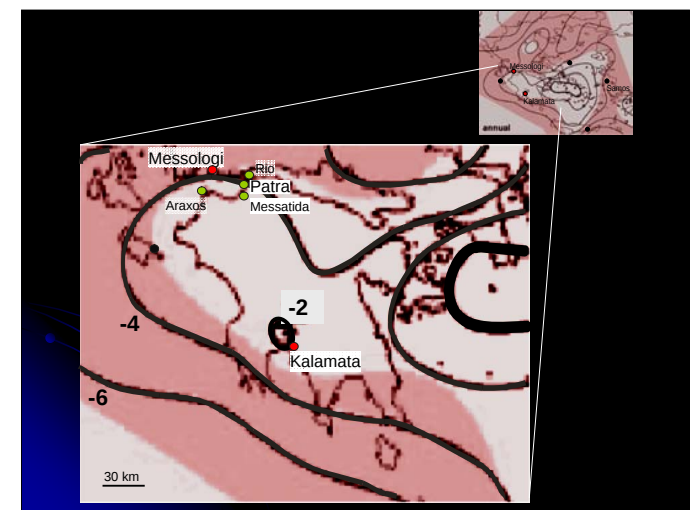
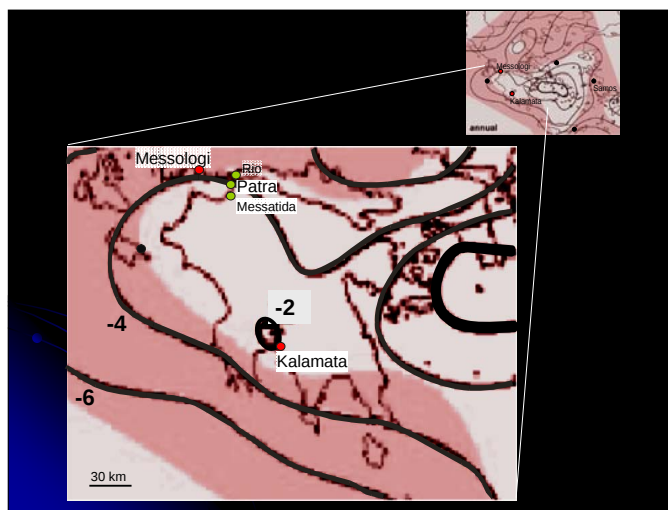
Are these trends continuing ?



Patra
August
2007
Photos by
D.Sarris



Messatida, August 2007
Photos by D.Sarris



Taken together:

- This analysis illustrates regional shifts in water relations, which is associated with global climatic change and has massive impact on vegetation.
- The data presented here represent conclusive evidence of a recent drying in the eastern Mediterranean, based on instrumental and tree-ring data, providing an early confirmation of IPCC model projections of an increase in drought conditions over the Mediterranean.
- The significant decline in rainfall in these 4 regions matches with trends across the entire Mediterranean.
- Tree-rings document that this decline was the most significant of the last two century and increased the dependency of tree growth on long-term (several years) precipitation signals pushing these trees very close to their limits of survival..
- This continuing declining trend could already have had a negative affect on establishment of germinating plants in moisture stressed sites and if continuing will could also have the same affect on the establishment of post-fire regenerating species in moisture stressed habitats

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