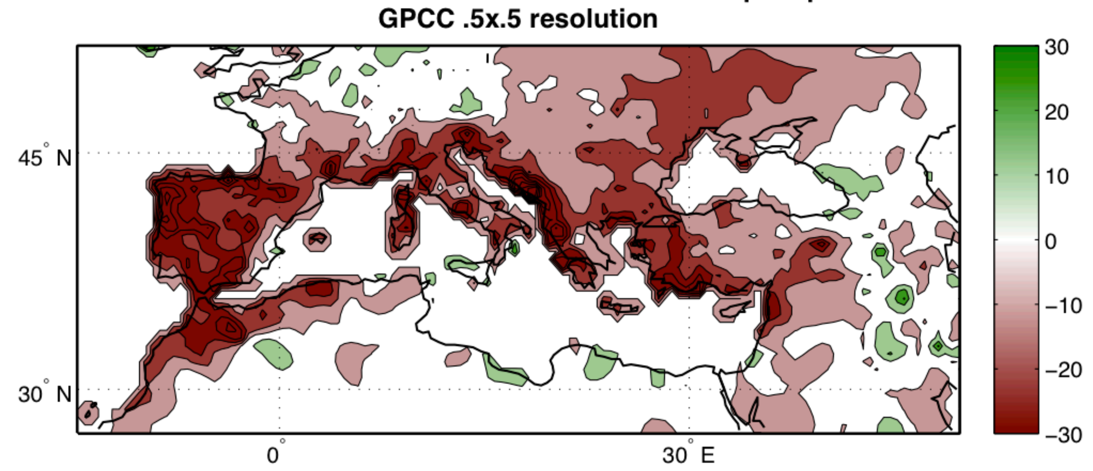
The relative contributions of radiative forcing and natural variability to the late 20th century winter drying of the Mediterranean region

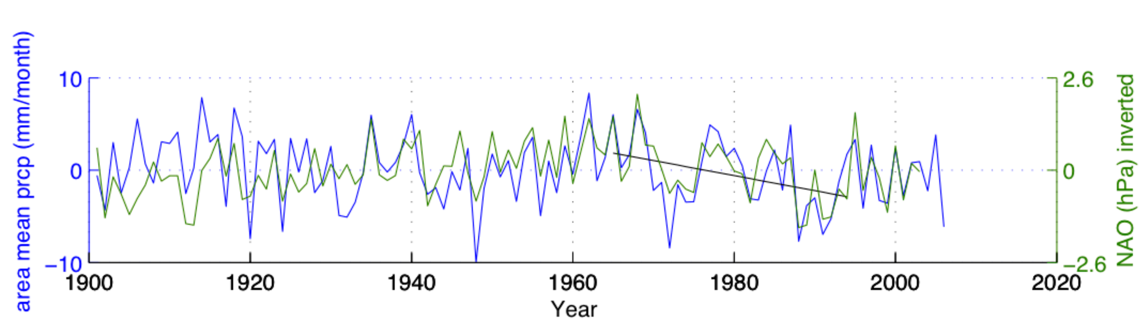
Colin Kelley, Mingfang Ting, Richard Seager, Yochanan Kushnir, Lamont-Doherty Earth Observatory, Columbia University, New York - ckelley@ldeo.columbia.edu

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

Abstract

The Mediterranean region as a whole has seen a reduction in precipitation over the last sixty years, with an especially large drying trend from the 1960s to the 1990s that corresponded with a sharply positive trend in the NAO, the dominant mechanism controlling extended winter precipitation (~35% of total var. explained, Nov-Apr mean). The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) predicted that recent drying of the region will continue through the 21st century, stating that **it is "very likely" that annual precipitation will decrease** in most of the region (IPCC 2007). Five recently released CMIP5 models agree that extended winter (Nov-Apr) drying will persist through the 21st century according to the Representative Concentration Pathway (RCP) 8.5 core experiment with increasing greenhouse gas concentrations. Evolutionary thirty-year trend analysis of observed and modeled SLP and precipitation reveals that the strong observed trends (1965-1995) were within the total distribution of CMIP3 model simulations, as rare events. Signal-to-noise maximization provides a modeled best estimate of the radiatively forced "signals" of SLP and precipitation onto which observed fields could then be regressed, and the forced and residual portions of the total trends calculated. The resulting patterns imply that observed drying over the last half century was dominated by low frequency natural variability, with a smaller but not insignificant contribution from radiative forcing that could steadily increase through the 21st Century.





Introduction and objectives

Does the observed drying in recent decades signify an emergence of an anthropogenic forced trend? Precipitation in the Mediterranean region is strongly influenced by the North Atlantic Oscillation (NAO), the leading pattern of climate variability in the North Atlantic, and the winter drying trend could be a consequence of the **strongly positive NAO trend from the 1960s to the 1990s**, which itself **could be the result of natural multidecadal variability**. However, due to the simultaneous increase in global anthropogenic forcing and decrease in regional observed drying we are led to consider whether there is a relationship between the two, and then to quantify the amount of this late 20th century drying trend for which the radiative forcing may be responsible.

There are several mechanisms whereby anthropogenic warming could potentially cause drying of the region. The first is via **changes in the location or strength of the NAO**. It is reasoned that increasing concentrations of greenhouse gases (GHG) will induce shifts towards the positive states of the annular modes and the NAO. However, model-projected changes in the NAO cannot fully explain projected drying of the Mediterranean. Other possibilities include **future increases in specific humidity** leading to **intensified water vapor transport** patterns in regions of existing **mean moisture divergence**, such as the subtropics in general and the Mediterranean in particular, and **poleward expansion of the Hadley Cell** and migration of the northern hemisphere storm track.

Identifying and understanding the patterns, characteristics, and mechanisms of the precipitation changes associated with each of these natural and anthropogenic processes are important tasks for climate scientists. An overall reduction in precipitation minus evaporation (P-E) in this region, and in the subtropics in general will **increase stress on water resources in an already semi-arid area.** The objective of this research is to **attribute observed precipitation change over the Mediterranean to both natural variability and anthropogenic causes.**

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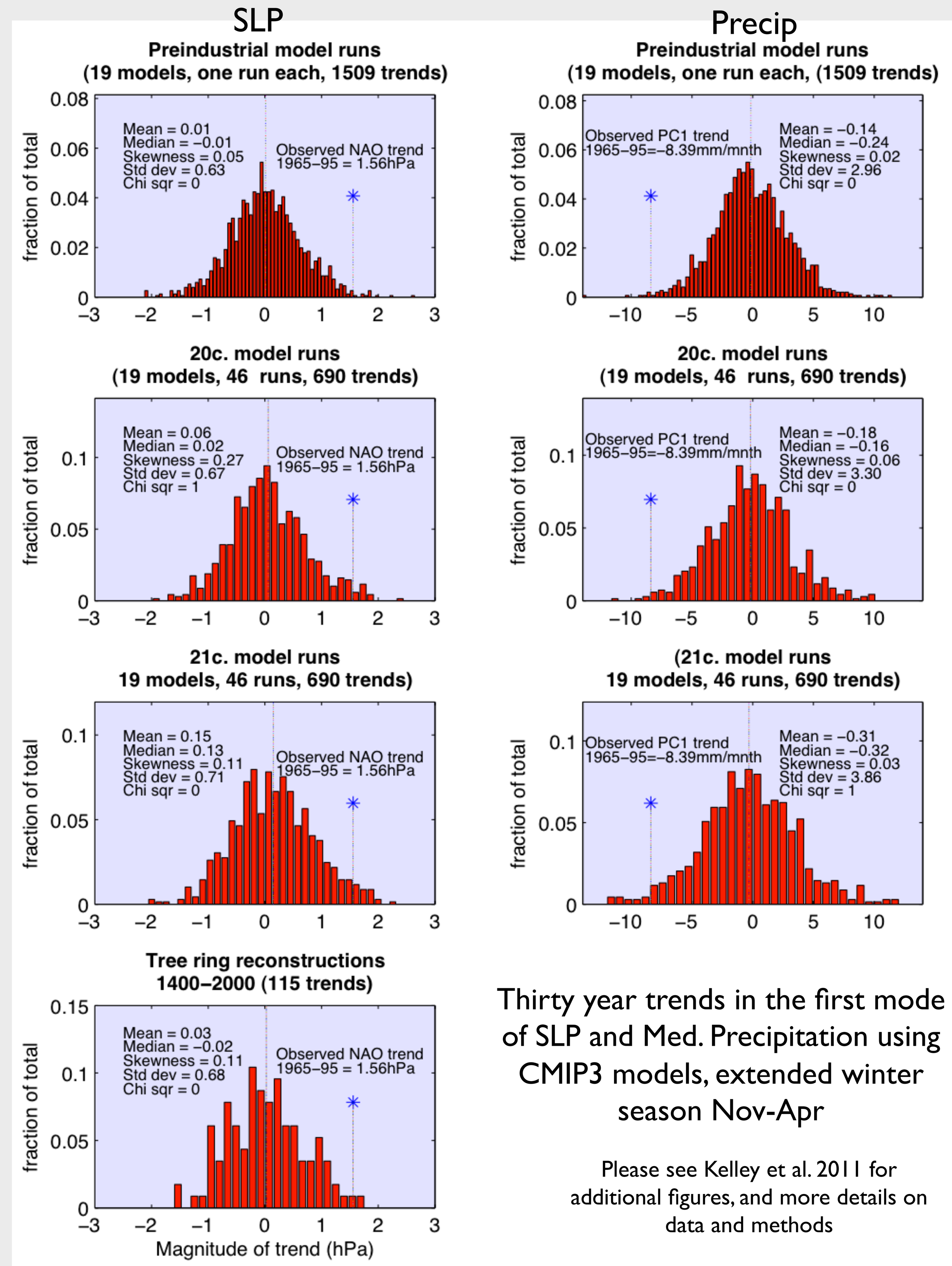
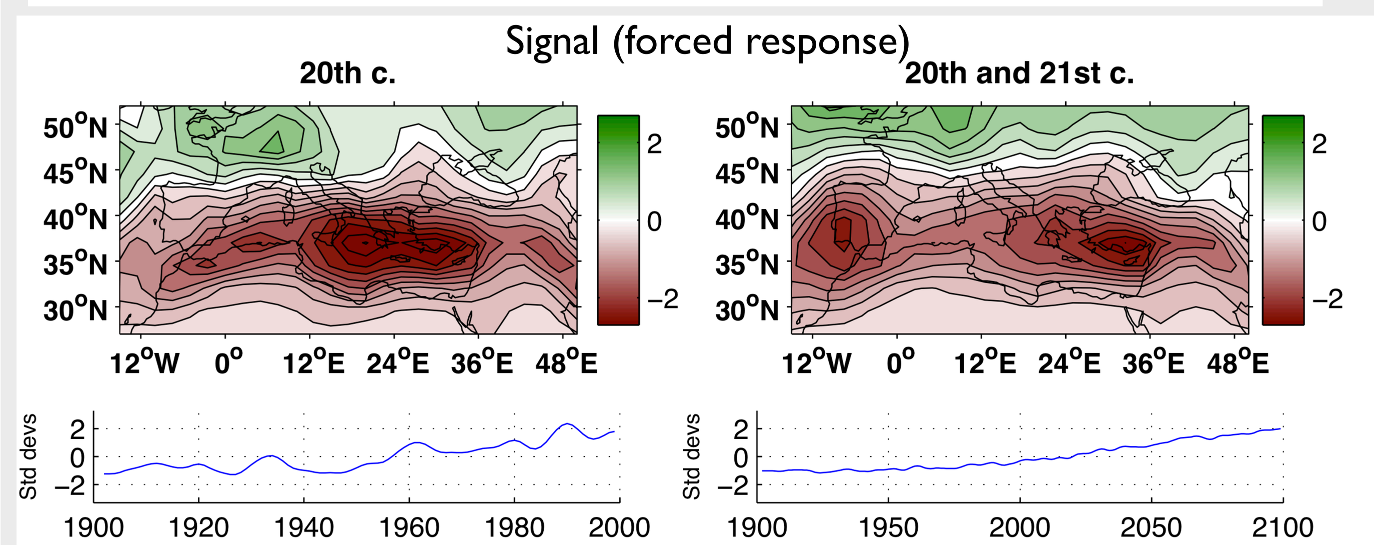
Results

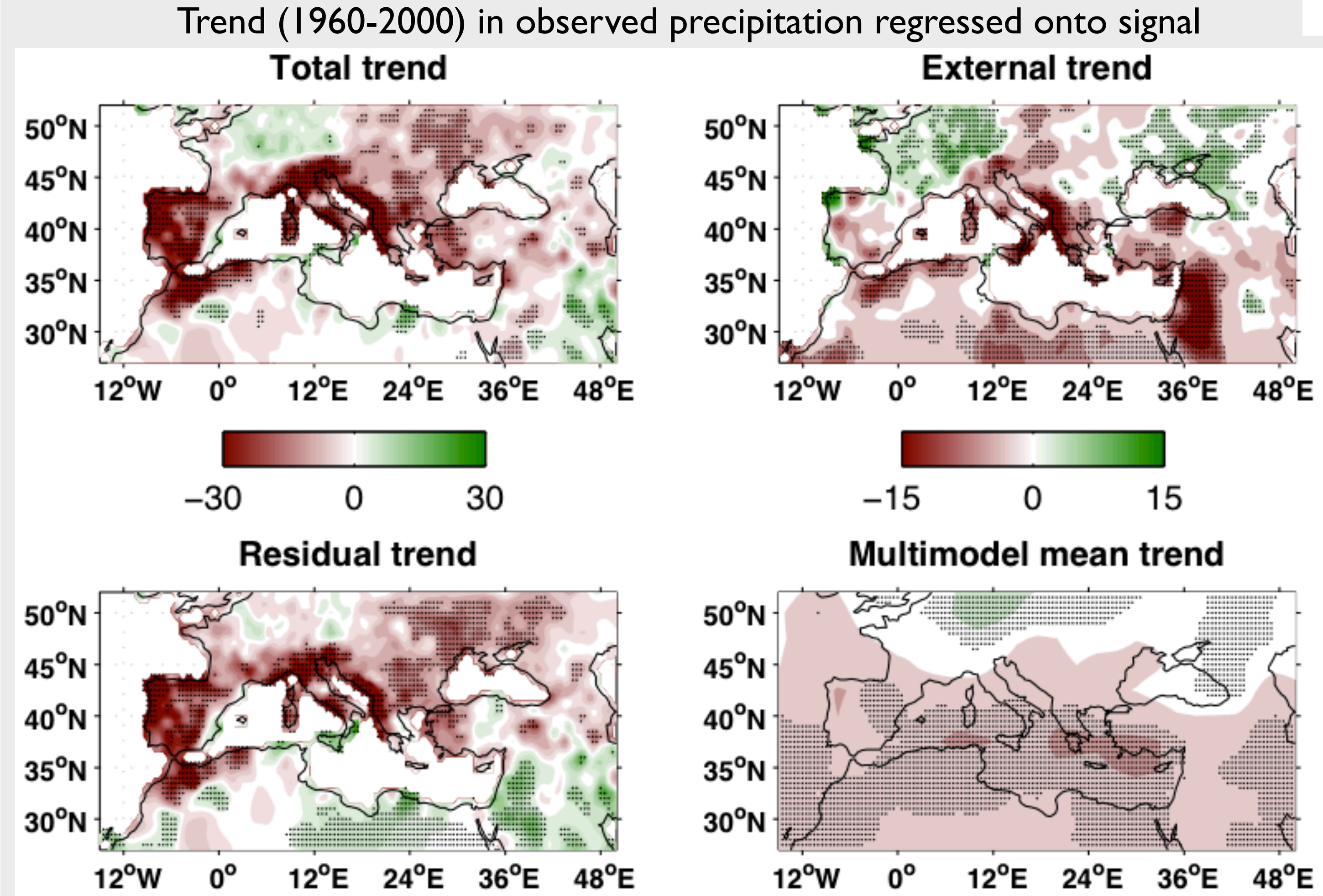


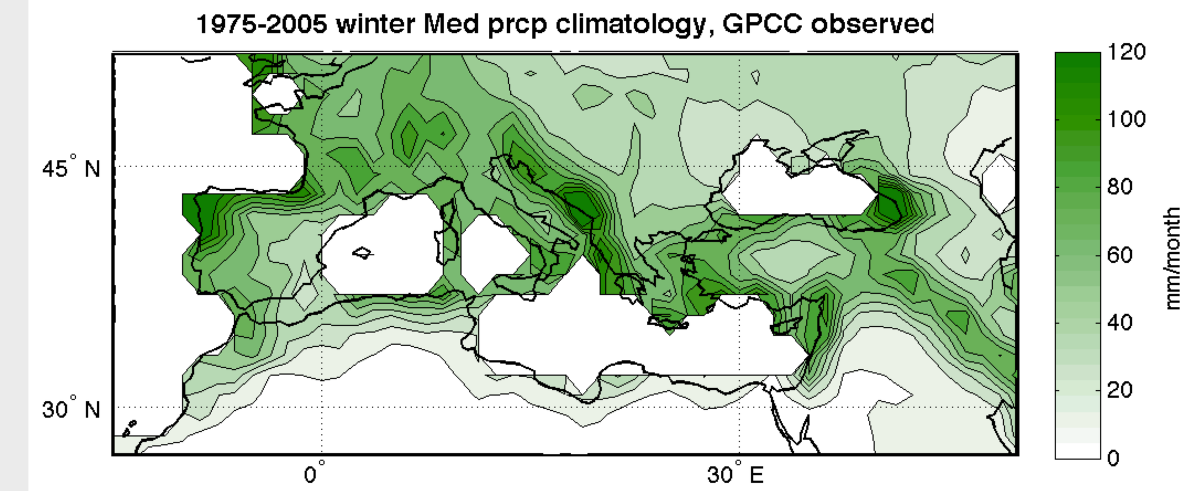
Thirty year trends in the first mode of SLP and Med. Precipitation using CMIP3 models, extended winter season Nov-Apr

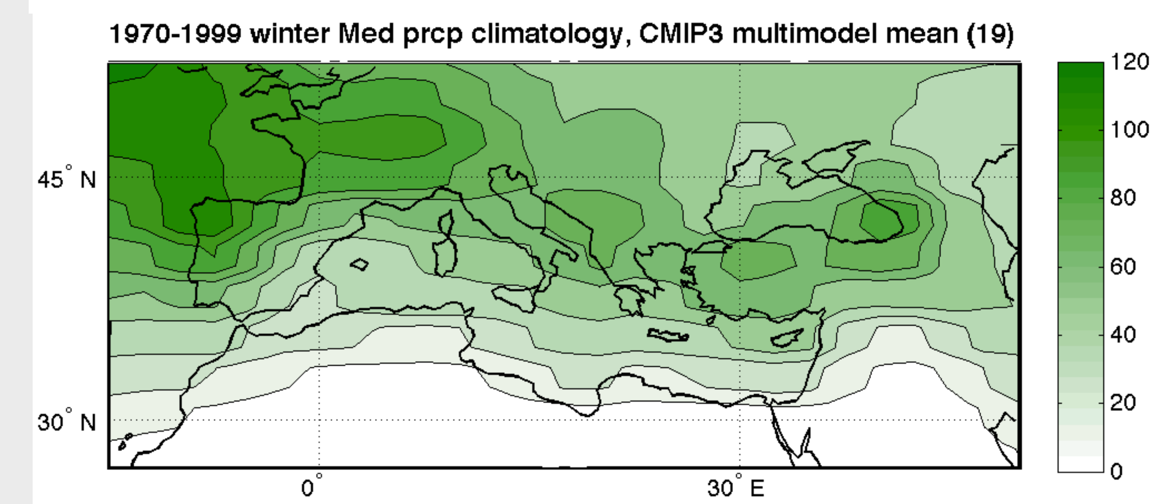
Please see Kelley et al. 2011 for additional figures, and more details on data and methods

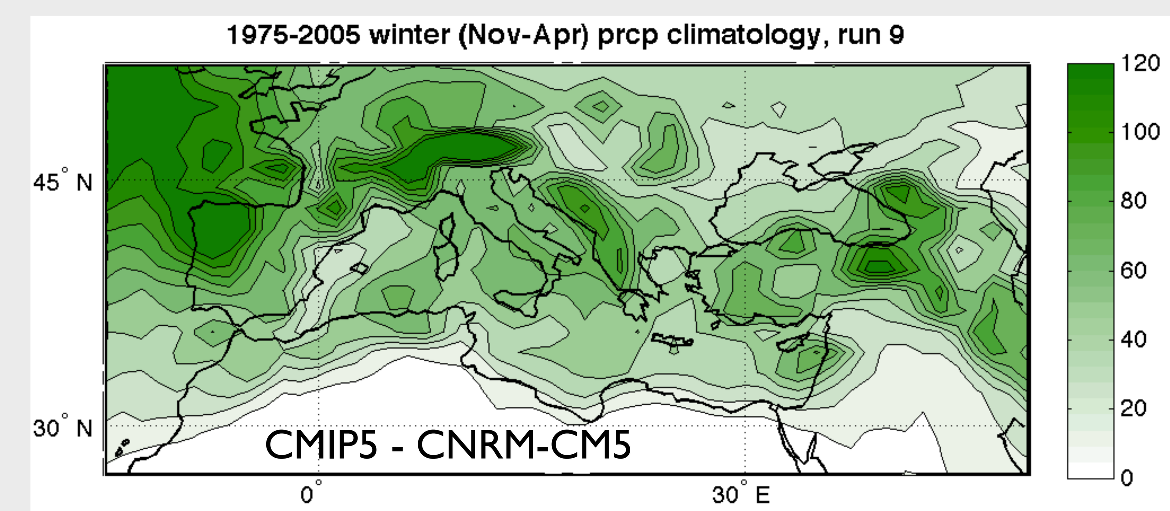


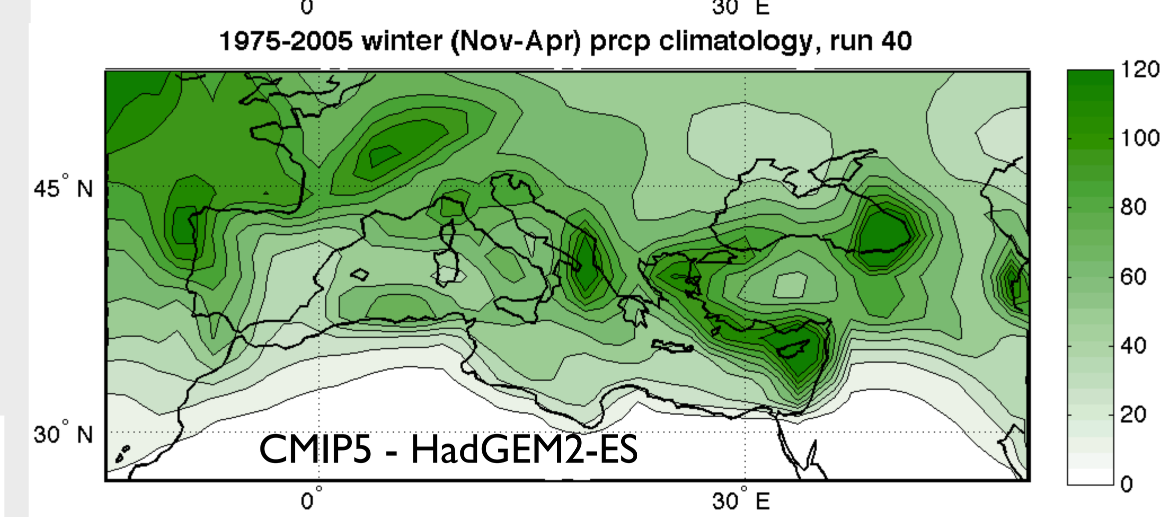
Trend (1960-2000) in observed precipitation regressed onto signal

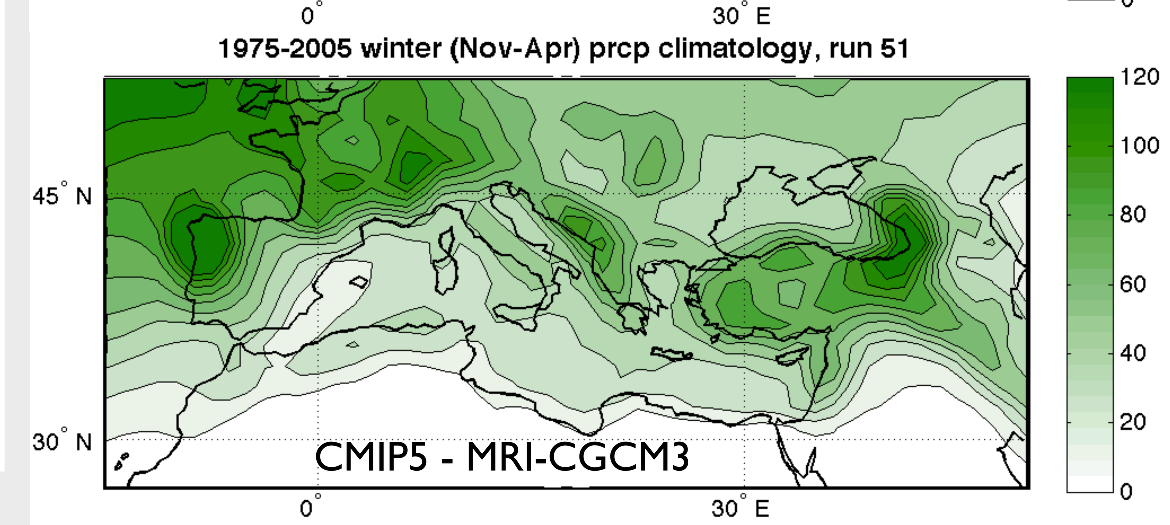


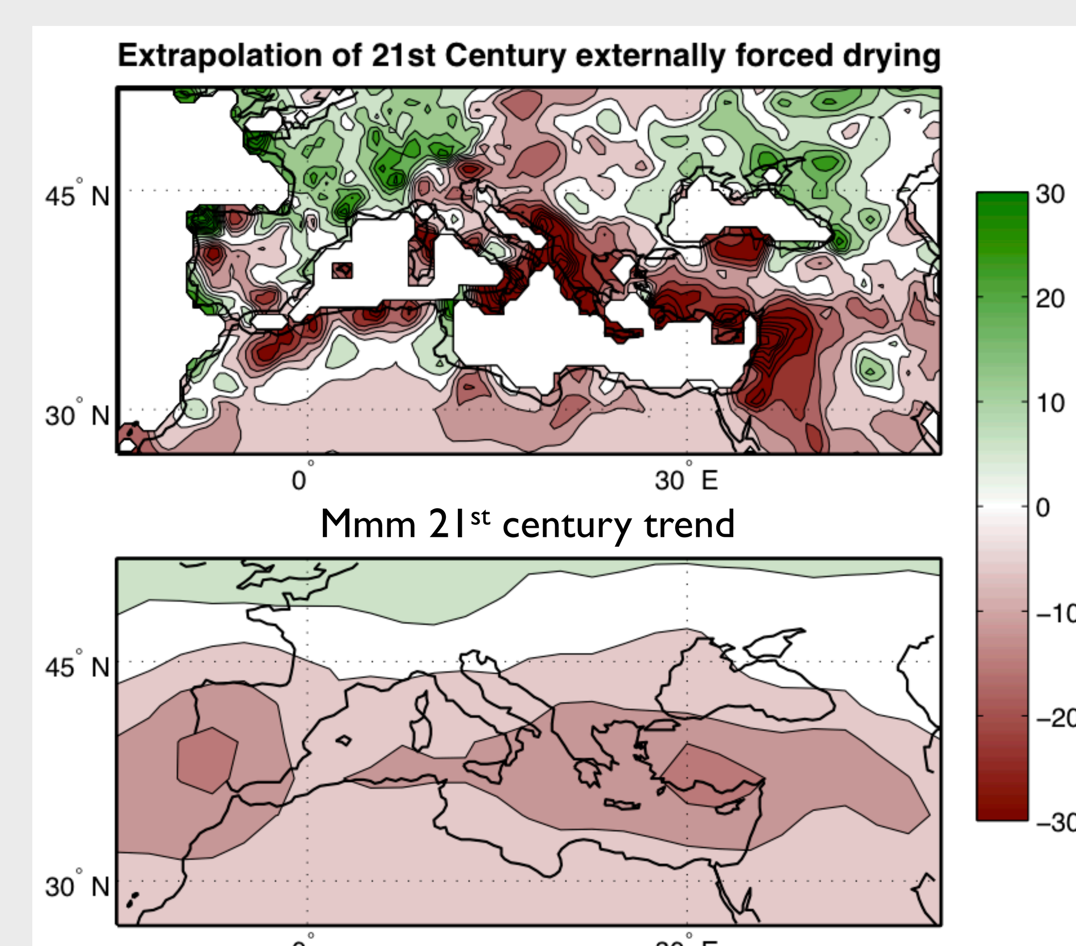


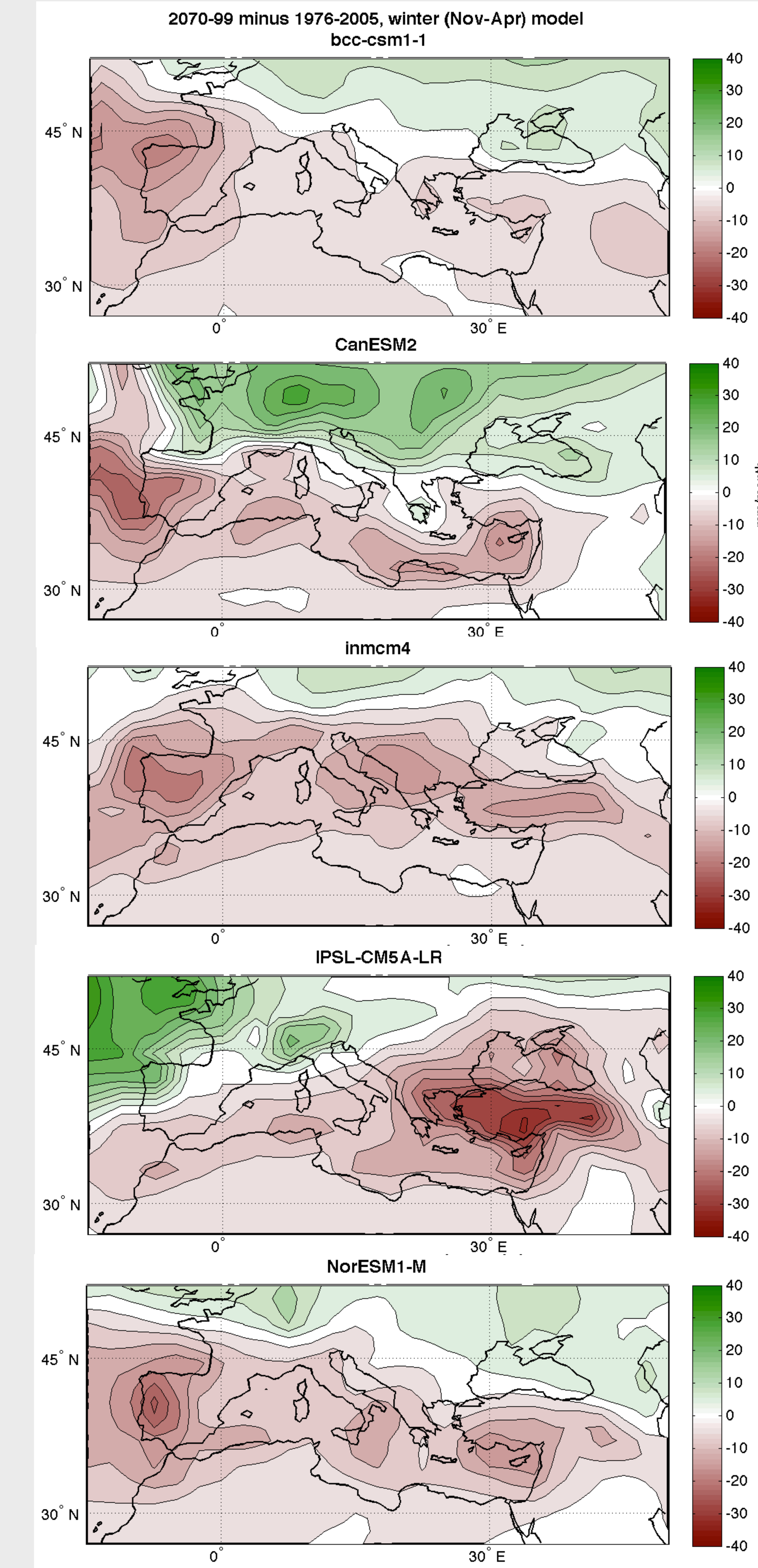












Summary

- The observed North Atlantic SLP and Mediterranean winter precipitation trends from 1965-95 are within the distributions of the CMIP3 models. This indicates that the models are capable of producing trends of comparable magnitude to those observed, although as rare events. The statistics of the modeled distributions appear to be changing as radiative forcing increases.
- The estimate of the radiatively forced signal in North Atlantic SLP indicates that a strong positive trend began several decades ago and will continue through the 21st century.
- The magnitude of the 1960-2000 radiatively forced trend is approximately twenty percent of the total precipitation trend during the same period. The difference in magnitude between a) the trend in SLP regressed onto the signal and b) the multi-model mean trend in SLP represents a range of forced drying. This leads us to presume that recent strong NAO trends are likely the result of low frequency natural variability.
- As the anthropogenically-forced trend amplifies in the 21st century, the future projected drying of the Mediterranean may increase and potentially approach the strength of the natural variability.
- These results suggest that only a small portion of the 1965-95 trend can be accounted for as a response to anthropogenic forcing and that instead, the Mediterranean winter drying trend was much more strongly influenced by natural multi-decadal variability.
- **Increased resolution in the CMIP5 models** reveals climatologies that are better able to resolve orographic features than CMIP3 models.