Web Tool Deconstructs Variability in Twentieth-Century Climate

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Climate, as experienced over time in a particular locality or region, exhibits a wide spectrum of variability, ranging from daily weather to century-scale trends and beyond. As a result, climate-related risks will tend to vary as well, with slower variations modulating the likelihood of adverse or beneficial events that play out on shorter time scales. For example, the risk of crop loss due to insufficient seasonal rainfall will generally be increased during decades that themselves are drier than normal, and vice versa. Short-term planning for such risk might involve securing adequate supplies of a drought-resistant cultivar, while on longer time scales such infrastructure decisions as the design of irrigation systems or reservoirs may be at issue. An understanding of how variations on different time scales have combined to produce observed climate histories can inform adaptation or risk mitigation strategies in light of such multi-time-scale risk variability.

A new Web-based tool developed by the International Research Institute for Climate and Society, the “Time Scales Map Room,” can shed light on the characteristics of historical temperature and precipitation variability, in the process clarifying the potential utility of different types of climate information (predictions, projections, uncertainty estimates) in the context of anticipated risks. With this tool the user can examine global or regional maps showing relative contributions to the observed climate of century-scale trends, as well as variability on decadal and interannual time scales. The displayed maps may be enlarged for convenient examination of detail, while an option allows for area averaging, in which case a decomposition into trend, decadal, and interannual components of the time series representing the selected area is shown. For further analysis, the user may download the data shown in any of the maps or plots.

The utility of these displays lies in the expectation that, at least for the next few decades, the decomposition by time scale, as inferred by the map room from records spanning the twentieth century, will continue to apply—that, for instance, a region where precipitation has been dominated by strong interannual variability will not suddenly become quiescent on the interannual time scale. The user is encouraged to examine the displayed records in detail to confirm the degree to which this expectation has been realized during the period covered by the map room data.

The Map Room

Available at http://iridl.ldeo.columbia.edu/maproom/Global/Time_Scales/, the map room initially presents the user with brief descriptive text and two links, to the precipitation and temperature pages. The default display, once one of these variables has been selected, is a global map, showing at each point the percentage of June–August (i.e., seasonal) variance associated with the decadal time scale (Figure 1). The user can define a “season” anywhere between 1 and 12 months in length (seasons may cross the year boundary), choose the component (trend, decadal, interannual) for which information is displayed, and zoom in for closer inspection of the map. The user may choose to have the displayed data area averaged or may click on a specific point. Either of these actions will bring up plots showing a decomposition of the resulting time series and giving the fractional variance attributable to trend, decadal, and interannual components (Figure 1, inset). For example, a user who displays a global map of the June–August precipitation variance fraction attributable to trend and then decides to examine the interannual contribution will discover a dramatic contrast, with the map room revealing in just a few clicks that twentieth-century trends have been relatively weak almost everywhere, while interannual variability has been dominant, accounting for 65% or more of the total variance in most locations. Such information is expected to be useful in the development of climate adaptation and risk mitigation strategies.

Data Analysis Method

The map room decomposition currently utilizes the TS2.1 data product from the Climatic Research Unit, University of East Anglia, a monthly, quality-controlled, gridded data set covering land areas and spanning the years 1901–2002. It is complete (i.e., there are no missing values) but includes data that have been filled in with climatological values where sufficient weather station data, on which the product is based, are lacking. The map room provides a link to the complete documentation for this data set, which the user is encouraged to consult.

Once the user has selected precipitation or temperature and a geographic region, the map room code screens the selected data for filled values. At the user’s discretion, this screening may be strict, lenient, or a compromise between these end members. Strict screening, denoted in the map room as “high temporal coverage,” rejects grid points having any filled values; this choice yields the most reliable time scale decomposition but results in maps having fewer qualifying grid points. At the other extreme, denoted “high spatial coverage,” data are not screened for filled values. In this case, the time scale decomposition is likely to be less reliable, but spatial coverage is greater. The “intermediate coverage” option offers a compromise between these extremes. In implementing these screening criteria, the map room considers both the number and distribution over time of filled values. Because of the map room’s focus on time series behavior, the user is encouraged in the on-site documentation to prefer high temporal coverage or, as a second choice, the intermediate option.

For precipitation, the map room also screens out those grid points where climatological seasonal rainfall falls below 30 millimeters, because very dry basic conditions render estimation uncertain and interest is more likely to center on wet seasons. All screening is performed grid point by grid point. When the map room computes an area average, only those grid points that qualify individually are included; grid points lacking sufficient data are blank on the map, so the user can see clearly which points are contributing to the area average.
Once the data have been screened, the map room algorithm fits a nonlinear trend at each grid point, or to the area-averaged data if that option has been selected. One aim in this step is to reduce fluctuations due to natural internal climate variability, so that the trend represents, to the extent possible, climatic changes due to external forcing. This is accomplished by regressing the series on a smoothed, globally averaged, multimodel mean temperature record derived from a 23-member ensemble of the general circulation models (GCMs) contributing to the fourth assessment report of the Intergovernmental Panel on Climate Change. These models are forced by realistic twentieth-century boundary conditions, including greenhouse gases and aerosols; their outputs include both the response to these forcings and unforced variability intrinsic to the climate system itself. Because the latter is essentially incoherent across models, it is reduced by averaging, while the climate change signal that the models have in common is enhanced. (Although the observed global mean temperature record could be used for this step, recent work has suggested that the observed long-term trend may be affected to some extent by internally generated variability.)

Residuals from this regression, representing the natural, unforced component of climate variability, are then filtered to separate variations on decadal time scales from those on interannual scales. The filter effectively classifies variability due to El Niño–Southern Oscillation (ENSO) as interannual. Variability on longer time scales, which may be associated with low-frequency modes such as the Pacific Decadal Oscillation or Atlantic Multidecadal Oscillation, or with low-frequency random variability, is partitioned into the decadal band. The filtering step completes the time scale decomposition process and yields the data displayed in the map room plots.

**Caveats for Interpretation**

The map room’s apparent simplicity poses interpretive risks, so the online documentation provides appropriate guidance. For instance, it is noted that detrending via regression on the multimodel temperature record represents only an approximate separation of forced and natural variability (the trend and residuals, respectively); rigorously performed, such separation is often a more complex exercise. Depending on timing and period, natural fluctuations in the data could project onto the multimodel mean temperature signal and be incorrectly identified with the forced response.

In addition, although it may provide some sense of future expectations, the map room is primarily a means of deconstructing the past rather than a predictive tool. In particular, it cannot tell the user how the character of variability may change in response to global warming and thus how the decomposition of variance by time scale might eventually evolve.

Caveats notwithstanding, it is hoped that the Time Scales Map Room will further the dissemination of climate information in a format that is intuitively comprehensible, in the process contributing to a better understanding of the climate histories that have actually been experienced in the diverse settings of users around the world.

**Acknowledgment**

This work was funded by cooperative agreement NA10OAR4310210 and grant NA08OAR4320912 from the National Oceanic and Atmospheric Administration (NOAA). The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its subagencies.

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*Fig. 1. Snapshot of the International Research Institute for Climate and Society (IRI) Time Scales Map Room precipitation start page. The global map shows the percent of total precipitation variance attributable to decadal-scale variability, based on June–August seasonal data for 1901–2002. The high-temporal-coverage option is selected, reducing to some degree the number of available grid points. The inset shows a decomposition into trend and the decadal and interannual components of variability for data averaged over the user-selected region indicated on the map by the red box.*