Plotting and Analyzing Data Trends in Ternary Diagrams Made Easy

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Ternary plots are used in many fields of science to characterize a system based on three components. Triangular plotting is thus useful to a broad audience in the Earth sciences and beyond. Unfortunately, it is typically the most expensive commercial software packages that offer the option to plot data in ternary diagrams. However, they lack features that are paramount to the geosciences, such as the ability to plot data directly into a standardized diagram and the possibility to analyze temporal and stratigraphic trends within this diagram.

To address these issues, ΔPlot was developed with a strong emphasis on ease of use, community orientation, and availability free of charge. This "freeware" supports a fully graphical user interface where data can be imported as text files, or by copying and pasting. A plot is automatically generated, and any standard diagram can be selected for plotting in the background using a simple pull-down menu. Standard diagrams are stored in an external database of PDF files that currently holds some 30 diagrams that deal with different fields of the Earth sciences. Using any drawing software supporting PDF, one can easily produce new standard diagrams to be used with ΔPlot by simply adding them to the library folder. An independent column of values, commonly stratigraphic depths or ages, can be used to sort the data sets.

Two options exist for graphically exploring the relationships between these variables and spatial distribution of the data in the diagram. Data points can either be linked by a line with an arrowhead pointing toward the direction of sorting (either ascending or descending), or the fill color of each data point can be calculated between two end-member colors to represent its position in the data set. Hence, possible trends in the data set can be graphically examined in large as well as small data sets. The combined standard diagram and data set can then be exported as a single PDF file to be used in publications or for future work. Additionally, the graph and the data can be saved together as a ΔPlot file. ΔPlot runs on any Macintosh computer equipped with Mac OS X version 10.2 or newer, and is available free of charge at http://www.crog.org/dplot.

More detailed information about ΔPlot is available on the *Eos* Electronic Supplement at http://www.agu.org/eos_elec/000562e.html.

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MEETINGS

Progress in Understanding the Arctic Climate System

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The Arctic region is where numerical climate models generally predict the largest warming under the influence of increased greenhouse gas concentrations. It is also the area where discrepancies between predictions are greatest. Arctic processes seem to be crucial for maintaining the oceanic meridional overturning circulation (MOC), and some models suggest that global warming might freshen the Arctic Ocean and peripheral seas to the extent that this circulation collapses. Should that happen, parts of the North Atlantic region might cool rather than warm over the next 100 years.

So, what are the global consequences of natural or human-induced changes in the Arctic climate system? Is the Arctic climate system really as sensitive to enhanced greenhouse gas concentrations as climate models suggest?

For the past 10 years, the World Climate Research Programme (WCRP) Arctic Climate System Study (ACSYS) has been working to answer these questions through the development and coordination of national and international research activities on Arctic climate.

ACSYS consisted of five related programs. Four covered the main elements of the Arctic climate system: sea ice, ocean circulation, the atmosphere, and the hydrological cycle. The fifth program, numerical modeling, was aimed at simulating these components and their interactions to improve understanding of the Arctic influence on, and response to, changing climate.

With the decade-long project drawing to a close at the end of 2003, nearly 250 scientists met at the Arctic and Antarctic Research Institute (AARI) of the Russian Federal Service for Hydrometeorology and Monitoring of the Environment (Roshydromet) last November to assess progress in understanding the Arctic climate system.

Aims and Themes

The conference aim was to summarize improvements in knowledge of the Arctic climate system during the ACSYS decade, drawing together advances in understanding each of the elements of the Arctic climate system, and more particularly, of the interactions among them. The conference also sought to examine future research challenges for the Arctic climate system. To do this, it brought together observational scientists and modelers to provide a common forum for presenting results.

The conference was divided into four sessions that addressed the following:

- The state of the Arctic climate system: Improvements in knowledge of the Arctic climate system and its variability through historical data, ongoing measurements, and process studies.
- Observing the Arctic climate system: Improvements in our ability to measure and observe aspects of the Arctic climate system and its processes across a range of spatial and temporal scales.
- Process studies and modeling: Improvements in representation of atmospheric, cryospheric, oceanic, and terrestrial processes in models, including assimilation of observations into models.
- Interactions with the global climate system: Improvements in understanding of the Arctic's role in the global climate system, its response to large-scale climate variations, and the processes involved.

Each of these sessions included keynote lectures and selected presentations from submitted abstracts.

In a final session, presentations were made by the chairmen of the four ACSYS panels on numerical modeling, observation products, data management and information, and polar products from re-analysis. This was followed by a panel discussion that examined the question, What are the important gaps in our knowledge and what opportunities and initiatives exist to fill them?

Over 160 posters, displayed throughout the 4-day meeting, complemented about 40 oral presentations.

Scientific Highlights

Talks and posters provided many scientific highlights, both in the presentation of new results and in synthesizing improved knowledge during the ACSYS decade. Examples included:

- The Arctic experienced very strong warming during the last 3 decades, in concert with the global trend. However, examining the entire period of the last century, variations in Arctic climate do not simply match global variations, suggesting a more complex relationship to global climate. This relationship remains the focus of ongoing study and debate.
- No convincing evidence of significant slowdown of the Atlantic MOC has yet been found, but some evidence suggests that recent freshening of the sub-Arctic seas might not be a localized Atlantic event, but the strong local expression of a change in the global water cycle. Freshening has been observed in high latitudes of both the Atlantic and Pacific Oceans, while low latitude oceans seem to become more saline.