Detection of Key Atmospheric Features in Reanalysis Data

Phillip Arkin[1], Randy Dole[2], Siegfried Schubert[3], James Carton[4], Eugenia Kalnay[4], Randy Koster[3]

[1]Earth System Science Interdisciplinary Center, University of Maryland, USA

[2]Earth System Research Lab, NOAA, USA

[3]Global Modeling and Assimilation Office, GSFC/NASA, USA

[4]Department of Atmospheric and Oceanic Science, University of Maryland, USA

Correspondence: parkin@essic.umd.edu

INTRODUCTION

Beginning in the late 1980s, several reanalysis projects were initiated to develop long time records of analyses better suited for climate purposes (Table 1). The products of these first reanalyses have proven to be among the most valuable and widely used in the history of climate science, as indicated both by the number of scholarly publications that rely upon them and by their widespread use in current climate services. They have produced detailed atmospheric climate records that have enabled successful climate monitoring and research to be conducted. They have provided a vitally needed test bed for improving prediction models on all time scales (see next section), especially for seasonal-to-interannual forecasts, as well as greatly improved basic observations and data sets prepared for their production. Reanalysis, when extended to the present as an ongoing climate analysis, provides decision-makers with information about current climate events in relation to past events, and contributes directly to climate change assessments.

The US Climate Change Science Program has undertaken a comprehensive set of Synthesis and Analysis Projects (SAP) to assess the current state of understanding of variability and change in the global climate system. Since reanalysis data sets have become crucial to the description and understanding of atmospheric behavior, their ability to identify and characterize important features of atmospheric variability and change is crucial. SAP 1.3 is aimed at evaluating and assessing that capability and is the source for the material in this presentation. Since the report is still undergoing review, specific details must be limited.

KEY FINDINGS

The report is organized into 4 chapters, the second of which is the source for this presentation. Chapter takes the form of sections addressing a series of questions, with a set of specific conclusions, referred to as findings, leading the material. Here we summarize those key findings as found in the draft report.

- Reanalysis plays a crucial integrating role within a global climate observing system by producing comprehensive long-term, objective, and consistent records of climate system components, including the atmosphere, oceans, and land surface..
- Reanalysis data play a fundamental and unique role in studies that address the nature, causes and impacts of global-scale and regional-scale climate phenomena.
- Reanalysis data sets are of particular value in studies of the physical mechanisms that produce high-impact climate anomalies such as droughts and floods, as well as other key atmospheric features that affect the U.S., including climate variations associated with **El Niño-Southern Oscillation** and other major modes of **climate variability**.
- Observed global and regional surface temperature trends are captured to first order in reanalysis data sets, particularly since the late 1970s, although some regions continue to show major differences with observations

(e.g., Australia). Reanalysis precipitation trends are much less consistent with those calculated from observational datasets, likely due principally to deficiencies in current global **reanalysis models**.

- The overall quality of reanalysis products varies with latitude, height, time period, spatial and temporal scale, and quantity or variable of interest.
- Current global reanalysis data are most reliable in Northern Hemisphere middle latitudes, in the middle to upper **troposphere**, and on synoptic (weather) and larger spatial scales. They are least reliable near the surface, in the **stratosphere**, tropics, and polar regions.
- Current global reanalysis data are most reliable on daily to interannual time scales. They are least reliable in the representation of the diurnal cycle, and in the representation of decadal and longer time scales where they are most impacted by deficiencies in the coverage and quality of observational data and changes in observing systems over time.
- Current global reanalysis data are most reliable in quantities that are most strongly constrained by the observations (e.g., temperature and winds), and least reliable for quantities that are highly model dependent, such as evaporation, precipitation, and cloud-related quantities.
- Substantial biases exist in various components of the atmospheric water cycle (e.g., precipitation, evaporation and clouds), that limit the value of current reanalysis data for assessing the veracity of these quantities in **climate models**, as well as for practical applications. There are also significant biases in other surface and near-surface quantities related to deficiencies in representing interactions across the land-atmosphere and ocean-atmosphere interfaces.
- The comprehensive and multi-variate nature of reanalysis data provide value for understanding the causes of surface temperature and precipitation trends beyond what can be obtained from relatively incomplete observational datasets alone, even in the face of the noted biases in reanalysis-based trends.
- Reanalysis data play a critical role in assessing the ability of climate models to simulate the statistics of climate – the means and variances (at various time scales) of basic variables such as the horizontal winds, temperature and pressure. In addition, the adjustments or analysis increments (i.e., the "corrections" imposed on model states by the observations) produced during the course of a reanalysis provide a means to identify fundamental errors in the physical processes and/or missing physics that create climate model biases
- Reanalyses have had enormous benefits for climate research and prediction, as well as for a wide range of societal applications. Nevertheless, significant future improvements are possible by developing new methods to address observing system inhomogeneities, by developing estimates of the reanalysis uncertainties, by improving our observational database, and by developing integrated Earth system models and analysis systems that incorporate key climate elements not included in atmospheric reanalyses to date.