

Requirements, Issues, and Research towards NOAA's Next Generation of Climate Reanalyses

Arun Kumar

Climate Prediction Center

arun.kumar@noaa.gov

Requirements

Needs for Climate Reanalysis

- Monitoring
 - ▶ Monitoring real-time climate anomalies requires placing them in a historical context, and hence, the need for a **climate reanalysis**
 - ▶ Attribution, and an increasing demand to provide explanations for extreme climate events requires access to physically consistent **climate reanalysis** data sets
 - ▶ **Climate reanalysis** data sets are used in a wide array of societal applications, e.g., decision making in the context of infrastructure development

Needs for Climate Reanalysis

- Forecasting
 - ▶ **Climate reanalysis** data sets provide base climatology relative to which climate forecasts are issued
 - ▶ **Climate reanalysis** data sets are needed to verify hindcasts and real-time forecasts and provide skill information to the users
 - ▶ **Climate reanalysis** data sets are needed to bias correct and calibrate real-time forecasts
 - ▶ **Climate reanalysis** could provide initial conditions for hindcasts and real-time climate forecasts – ocean, land, sea ice

Needs for Climate Reanalysis

- Therefore, reliance on climate reanalysis is an essential component of CPC's mission to deliver "...real-time products and information that predict and describe climate variations on timescales from weeks to years thereby promoting effective management of climate risk and a climate-resilient society"
- NOAA's climate reanalysis products are extensively used, and have a global user base

Tools for Climate Reanalysis

- Model based data assimilation systems for 3-D analysis for various component of the Earth System
 - Atmosphere: R1, NARR,
 - Ocean: GODAS
 - ...
- Objective analysis systems for univariate quantities (precipitation; surface temperature)

NCEP/NCAR Reanalysis (R1)

- Circa 1995 model and data assimilation system
- Atmospheric model – T62/L28
- 1948-present; maintained in real-time by CPC
- Still widely used for the analysis of climate variability

WEB OF SCIENCE™

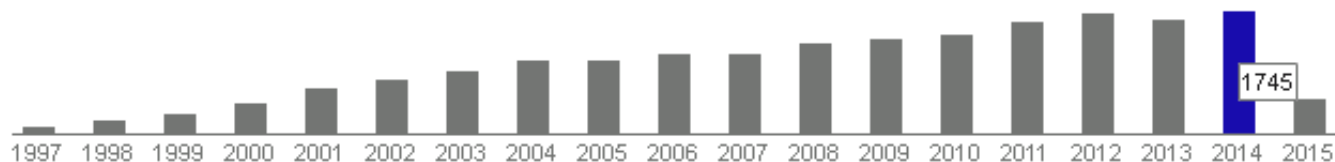
All Times Cited Counts

13,192 in All Databases

12,297 in Web of Science Core
Collection

Google

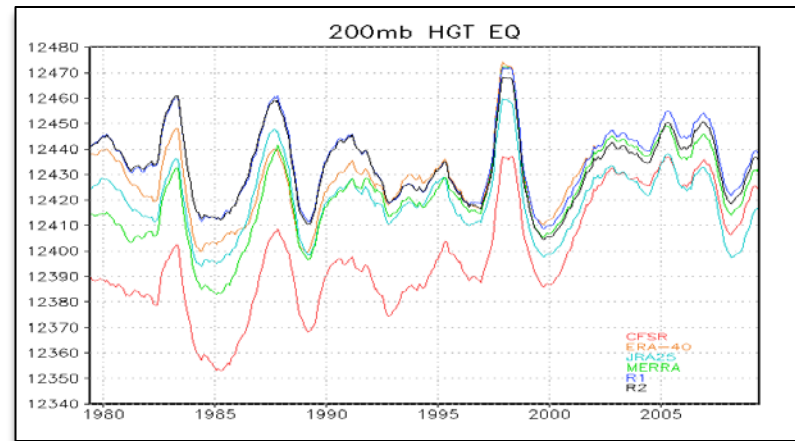
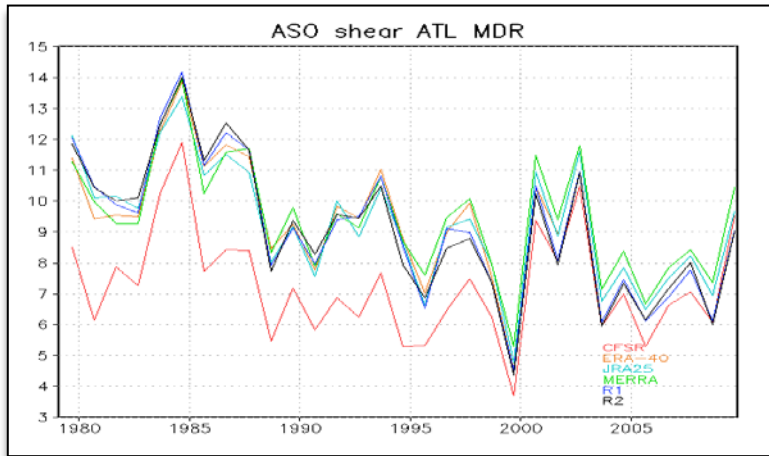
Total citations Cited by 19164



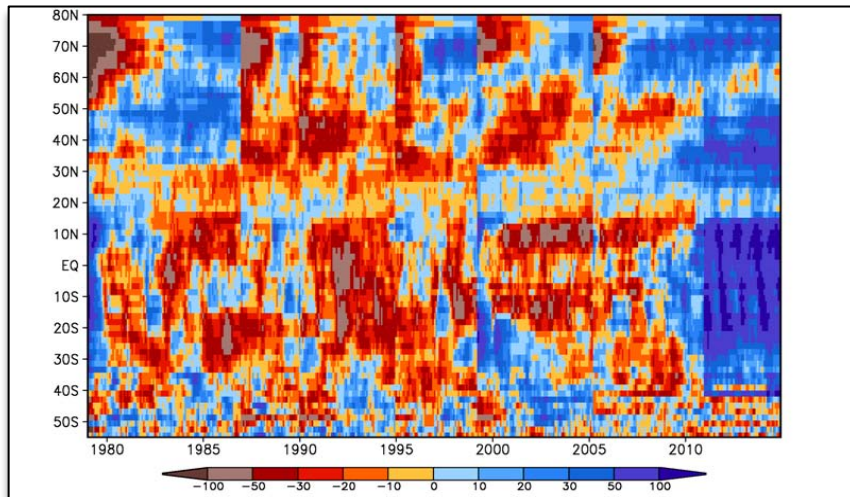
→ Issues

- Issues with R1
 - Relies on data assimilation system that is 20 years old
 - Portability and maintenance
 - Uses satellite retrievals (that are under constant threat to be discontinued)
- Replacement for R1 preferably should
 - Extend over the same period
 - Not have climate trends & discontinuities worse than R1

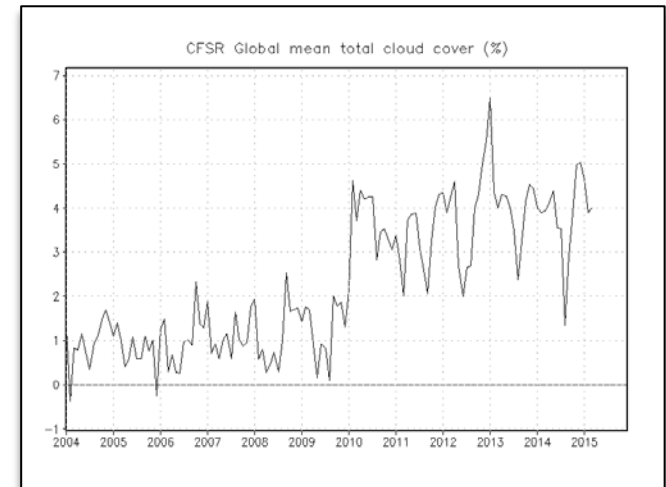
Climate Forecast System Reanalysis (CFSR)



Analysis during earlier period is an outlier



Multiple Streams – Zonal Avg. SM



Change in Resolution – NH SM

As a consequence...

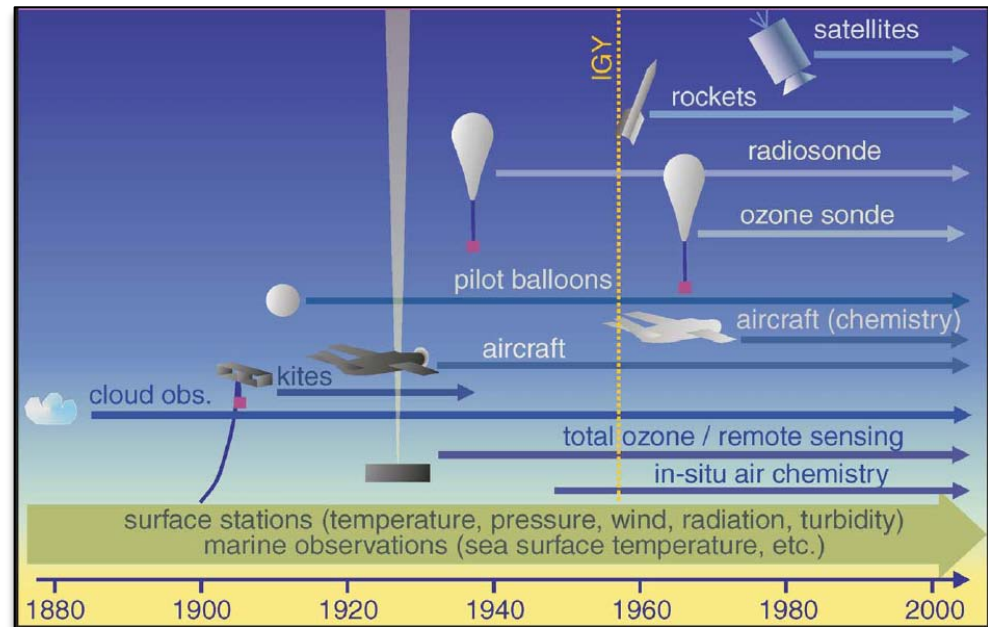
- Continued our reliance for climate monitoring products on R1
- Developed a research effort to understand some of the issues with climate reanalysis efforts, result of which is...
- The NOAA Climate Reanalysis (NCR) effort
 - Develop a hierarchical approach for climate reanalysis
 - Investigate the impact to the time-varying quality and density of the observing system and determine ways to reduce this impact
 - Deliverable: develop a prototype climate reanalysis as a potential candidate for replacing R1

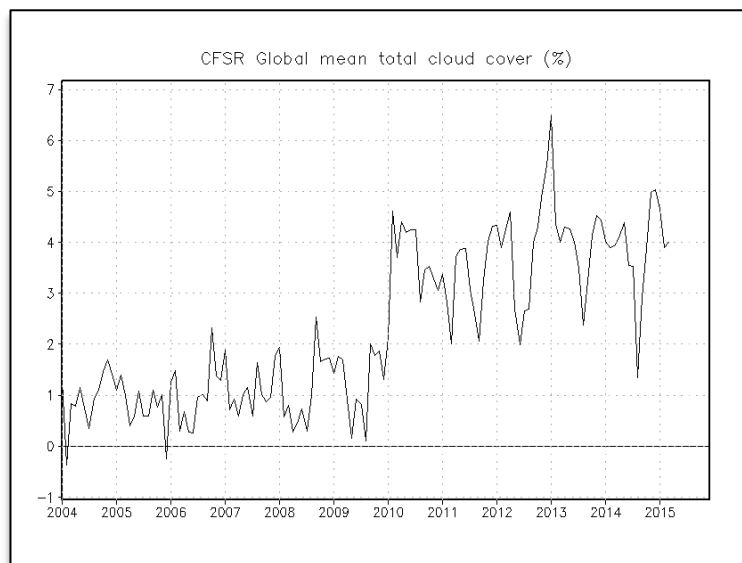
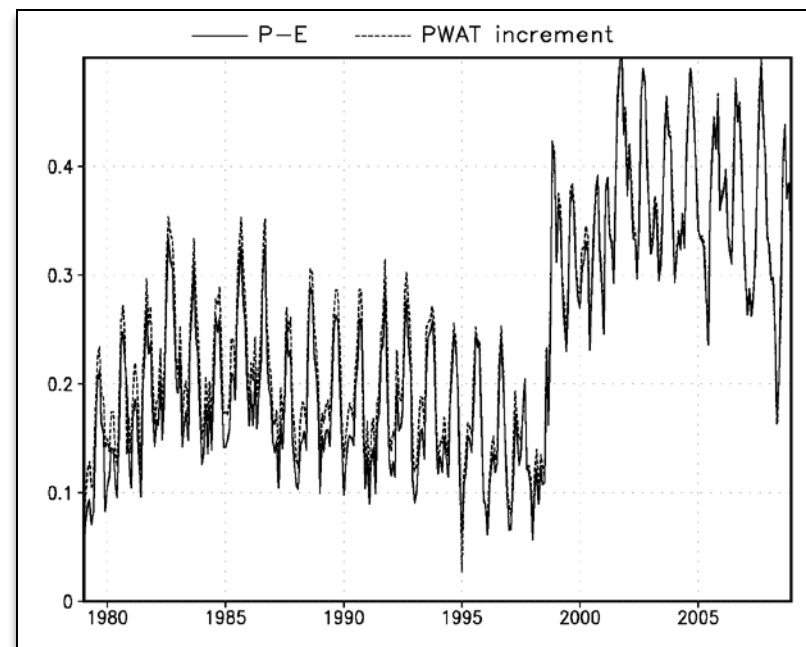
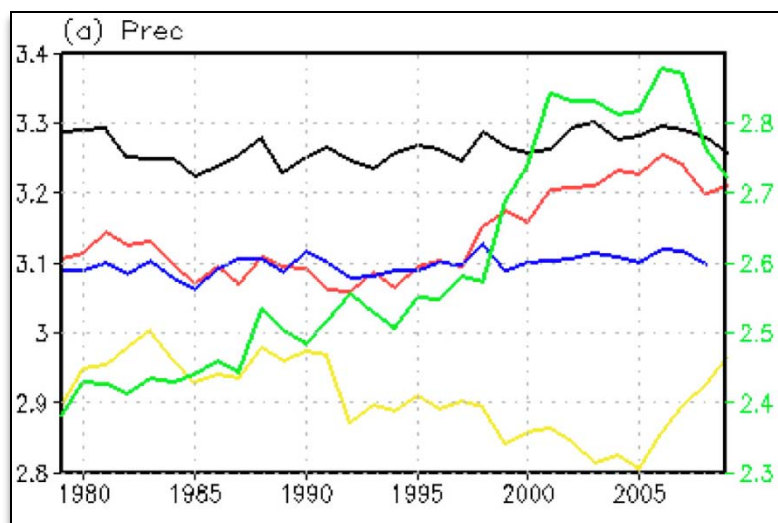
NOAA Climate Reanalysis (NCR)

- Hierarchical climate reanalysis approach
 - Stream 0 : Boundary-forced, 1850-present ensemble of “AMIP” simulation
 - Stream 1: Historical, 1850-present using only surface data (20CR)
 - Stream 2: Modern, 1946-present using only surface and conventional upper air data
 - Stream 3: Satellite era
- Use a common data assimilation infrastructure (EnkF) shared across NOAA

Some Outstanding Research Issues

- Two overarching issues of climate reanalysis efforts
 - Understanding reasons for discontinuities when new observational platforms come in
 - Connecting climate reanalysis efforts and analysis efforts for initializing forecasting

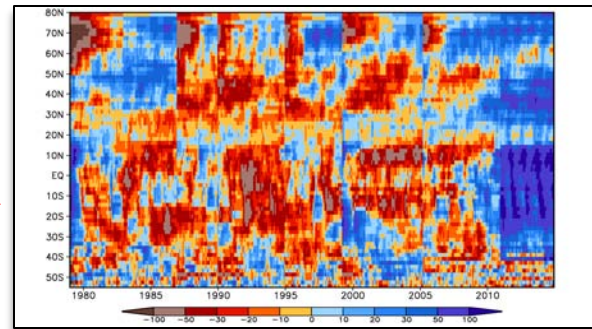




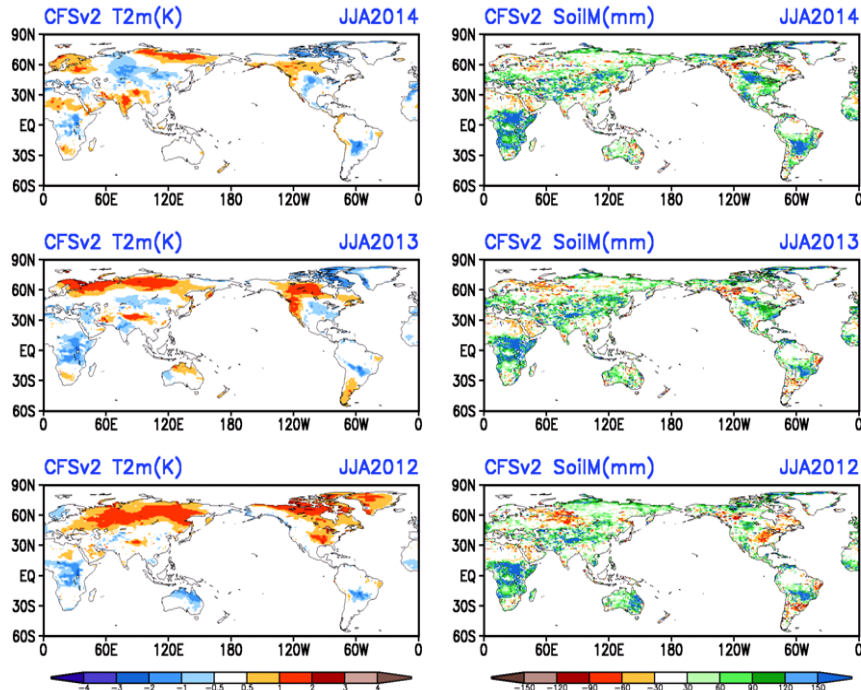
Discontinuities due to changes in observational platforms

Connecting Various Reanalysis Efforts

1. Reanalysis for the purposes of monitoring climate variability
 1. Minimizing discontinuities is important
 2. There is more leeway in system configuration (e.g., longer time window)
2. Reanalysis for initializing forecasts that are also accompanied by a set of hindcasts
 - i. Need best possible initial conditions; however,
 - ii. Need to maintain continuity in the analysis of some component of the Earth System across initializing hindcasts and real-time forecasts
 - iii. Need for hindcasts has a series of cascading implications and adds stipulations on the analysis that create hard barriers to overcome
3. Analysis for initializing forecasts (where a need for hindcasts is not perceived)

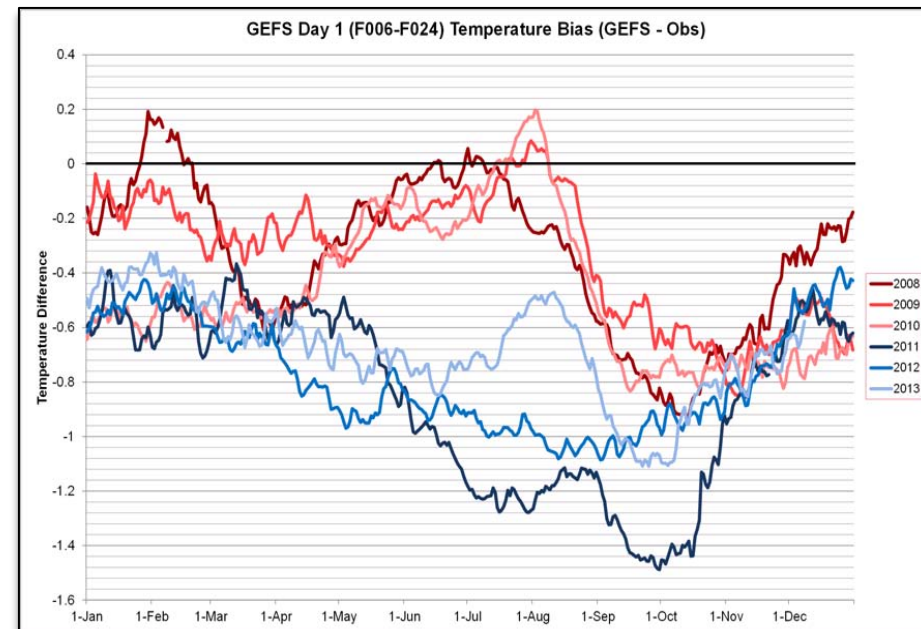


CFSv2 JJA 0-mon-Lead monthly



Seasonal Forecasts

Day 1 Forecast



Thanks!