Research Towards the Next Generation of NOAA Climate Reanalyses

A joint effort between NCEP, ESRL & NCDC
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Outline

• Shortcomings of the current generation of NOAA climate reanalyses

• Proposed research and assimilation infrastructure

• Connecting with a unified NOAA reanalyses approach
• What is analysis?
  – An objective method for analysis using data assimilation to estimate the state of various components of the Earth System by forming weighted average of observations and guess generated by short-term (~ 6 hours) forecast based from a model

• What is climate reanalysis?
  – Regenerating the analyses over several decades using quality-controlled observations and a fixed data assimilation system to make a climate record. Climate reanalysis
    • can utilize delayed observations (that may have been missing in real-time)
    • can also use of symmetric time-windows for ingesting observations
• NCEP/NCAR (R1): 1948-present; *initiated* ~ 1995
• NCEP/DoE (R2): 1979-present; *initiated* ~ 1998
• North American Regional Reanalysis (NARR): 1979-present; *initiated* ~ 2004

• 20th Century Reanalysis (20CR): 1871-2011; *initiated* ~ 2009
• Climate Forecast System Reanalysis (CFSR): 1979-present; *initiated* ~ 2007
• 20CR and CFSR, although both NOAA efforts, used different models and data assimilation systems

• CFSR has various discontinuities in the climate record. Some are due to
  – running the system in six different streams
  – ingest of latest observational platforms leading to changing observing system

• CFSR is not well suited for climate monitoring and a replacement for NCEP/NCAR R1
Hydrological Cycle

CFSR - Issues with trends

Tropical 200mb Z

R1 vs. 20CR
Soil Moisture

Stratospheric Temperature

CFSR - Issues because of multiple streams
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• Connecting with a unified NOAA reanalyses approach
• Research towards the next generation of climate reanalysis for the atmosphere
  – Focus on developing methods to identify spurious climate trends due to changes in observational data (e.g., changes in observational platforms; data density etc.), and
  – Develop methods to reduce the influence of changes in observational data on climate trends
• Will follow a hierarchical approach with increase in the complexity for the reanalysis system

• Will utilize a common data assimilation infrastructure – Hybrid Ensemble Kalman Filter (EnKF)
• Hierarchal (tiered) data assimilation approach
  – Boundary forced (equivalent to AMIP); 1850-present
  – Surface pressure; 1850-present
  – Surface and conventional data; 1946-present
  – Satellite date; 1973-present

• Reanalysis with higher level of complexity will be informed by the previous tier reanalysis
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• Connecting with a unified NOAA reanalyses approach
• Uses of climate reanalysis
  – Climate monitoring
  – Providing initial conditions for hindcasts (reforecasts)

• Tension between analysis for the purpose for climate monitoring and for forecast initialization

• Hindcasts, and bias correction methods, are also susceptible to climate trends if the influence of initial conditions persists during the forecasts, or if the real-time analysis system differs from one for the historical analysis
A Distinct Change in Forecast Bias for SST in Equatorial Pacific Before and After 1999
• Hindcasts, therefore, also impose additional constraints on the quality, and strategies, for historical reanalysis

• With judicious design of a hierarchical reanalysis system and an integration with offline analysis of other components of the Earth system – ocean; land; cryosphere – it may be possible to come up with a climate reanalysis infrastructure that can address needs of various communities