Land Data Reanalyses

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With contributions from

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Overview

- Land Data Assimilation
  - Conventional Observations (station data)
  - Remotely sensed data
- Land Reanalyses
  - Offline Land Data Assimilation Systems
    - NLDAS, GLDAS, ELDAS, GSWP2
    - Land Reanalysis for MERRA
  - Coupled Land/Atmosphere DA
  - 20th Century Reanalysis
- Discussion

Land DA: Conventional Obs

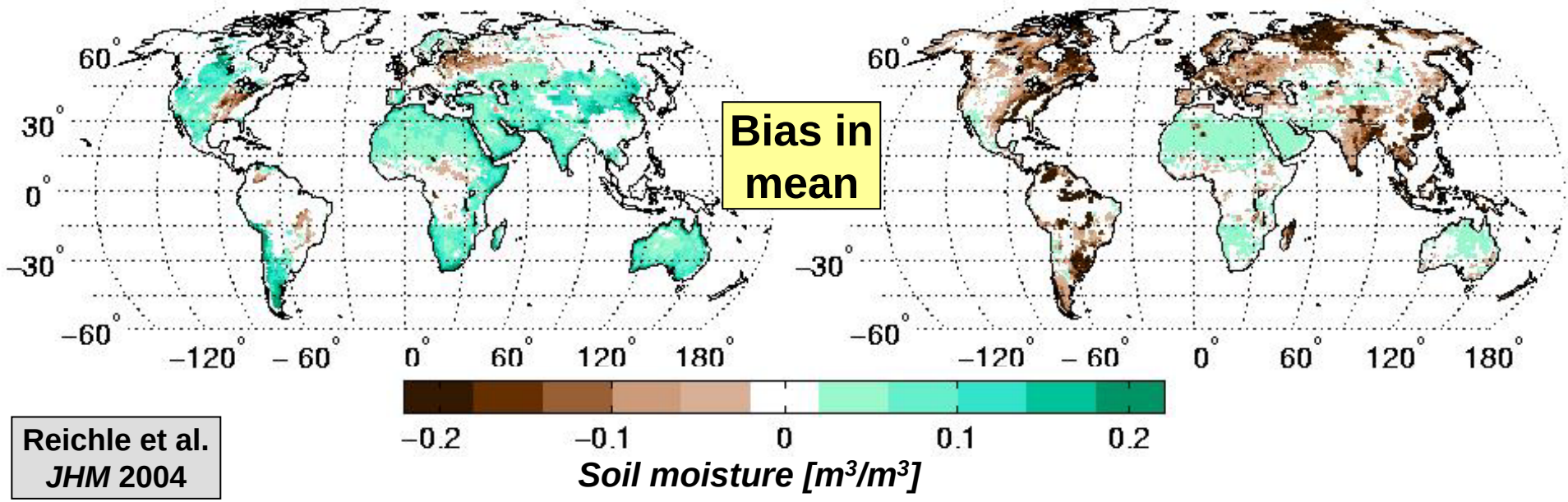
- Mahfouf (1991, JAM)
  - Tested the feasibility of using surface meteorology (T and q) to adjust the soil moisture
  - Presently, many operational centers have some variant of this idea in analysis
  - Needs care: Budgets, especially soil water, can react strongly to this kind of nudging (Betts et al.)
  - What to do in data sparse regions?
  - Recent activity includes sfc met and remotely sensed skin temperature Seuffert et al. (2004)

Land DA: Remote Sensed Data

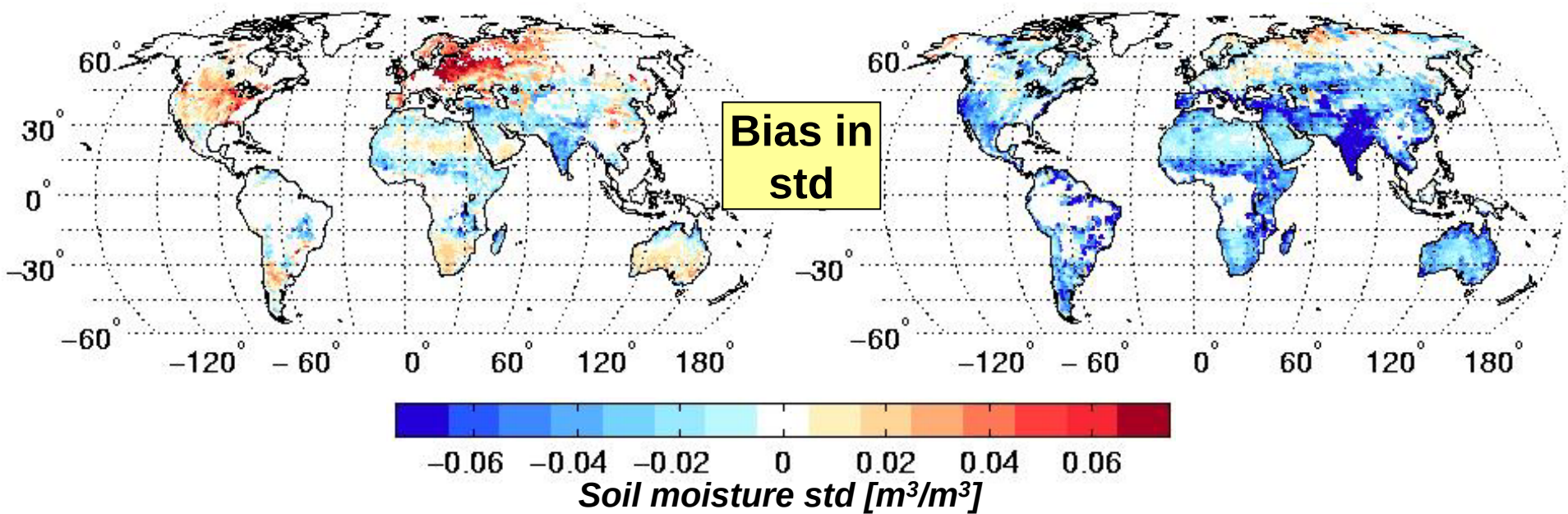
- Global coverage is the advantage of remotely sensed data
- Temporal coverage is usually the limiting factor (uncertainty is another)
- Need to link the observable, with the prognostic variable
  - Soil wetness; depth
  - “Skin” temperature
  - Snow water equivalent

Satellite vs. model bias

SMMR minus model (1979-87) **AMSR-E minus model (2002-05)**



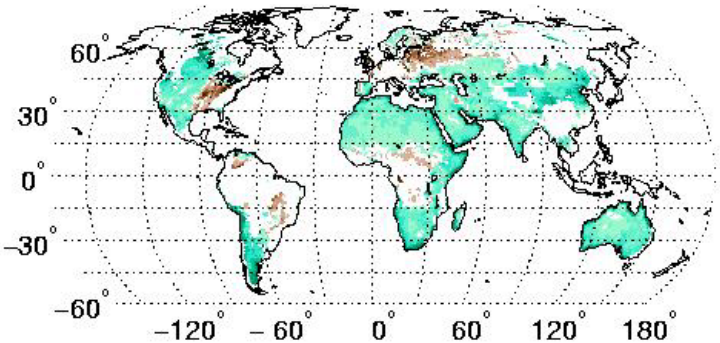
Reichle et al. *JHM* 2004



Soil moisture scaling for data assimilation (mean)

ORIGINAL multi-year data sets
(Satellite minus model)

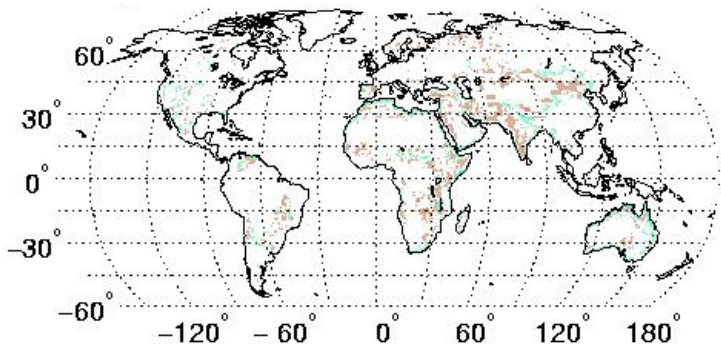
SMMR



Reichle et al. *JHM* 2004

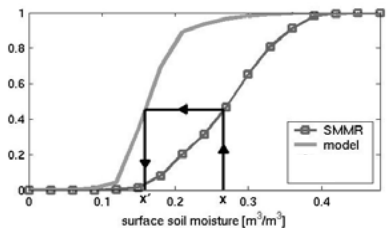
SCALED multi-year data sets
(Satellite minus model)

SMMR

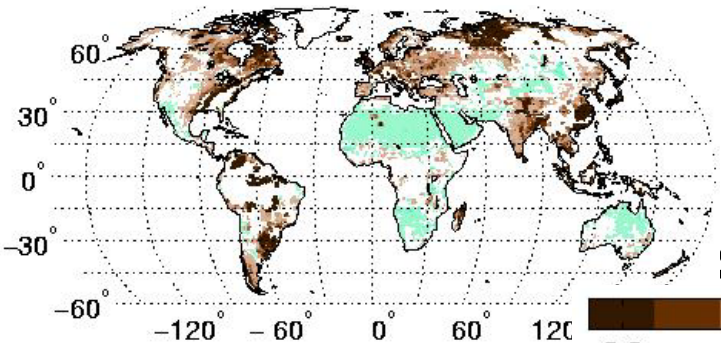


Reichle & Koster *GRL* 2004

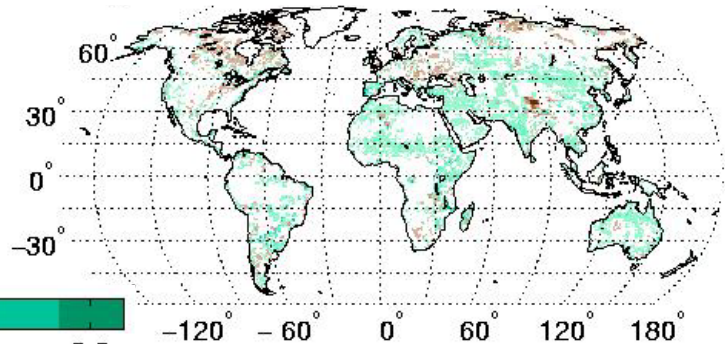
CDF scaling based on **1 year** of satellite data



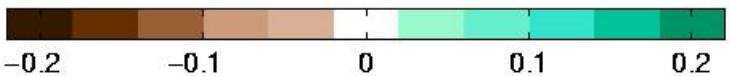
AMSR-E



AMSR-E

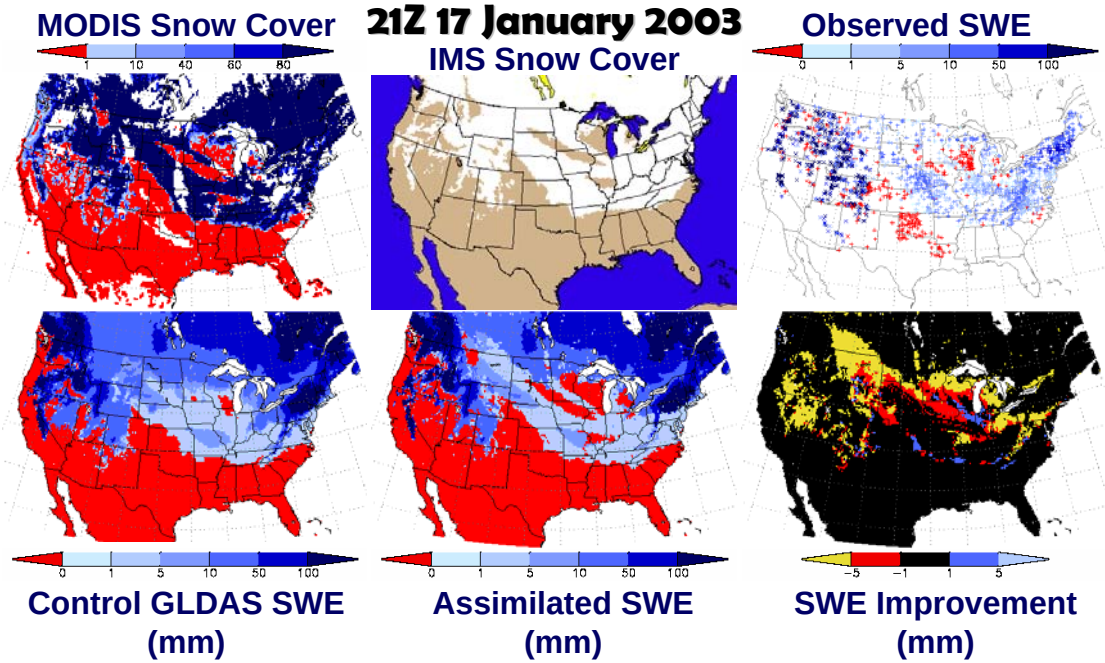


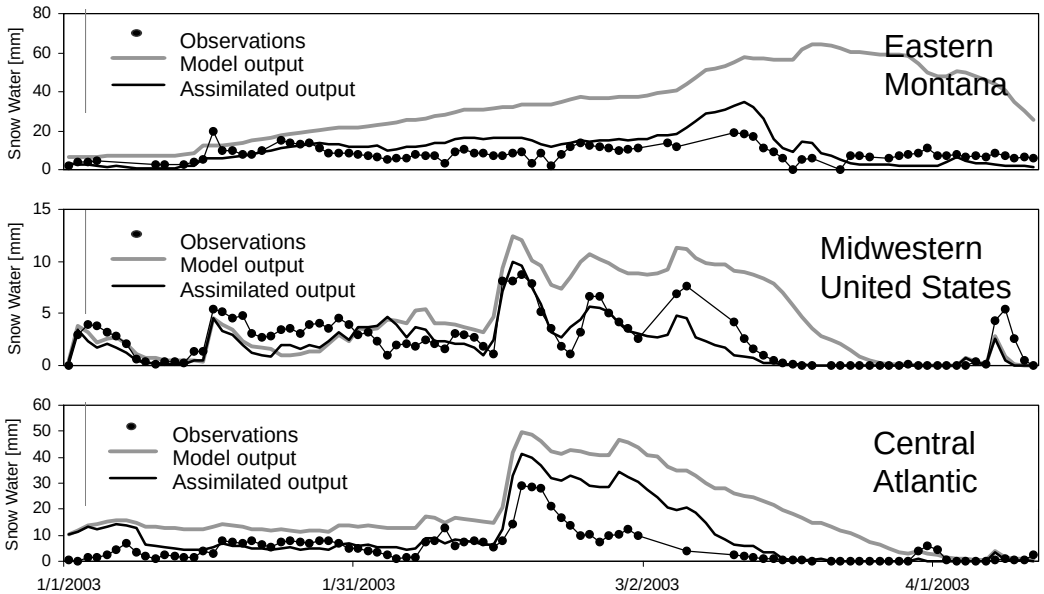
Soil moisture [m³/m³]



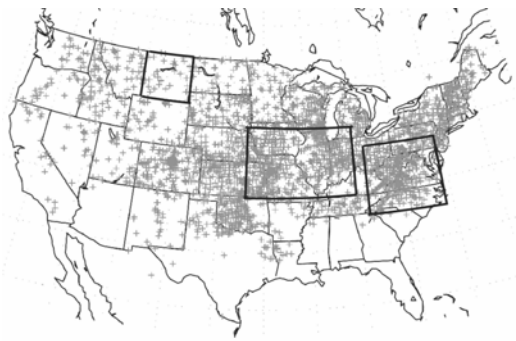
1 year of satellite data sufficient for considerable reduction in long-term bias.

MODIS Snow Cover Assimilation





- Errors in precipitation and temperature forcing cause inaccuracies in modeled snow water equivalent (SWE)
- GLDAS/Mosaic simulations improved by assimilating MODIS snow cover
- Models fill spatial and temporal gaps in data and provide SWE output, which is more valuable than snow cover
- Output agrees more closely with IMS snow cover fields (top left) and ground observations (bottom left)



Locations of averaging regions and Cooperative Network snow observation sites

Rodell, M., and P. R. Houser, Updating a land surface model with MODIS derived snow cover, J. Hydromet., 5 (6), 1064-1075, 2004.

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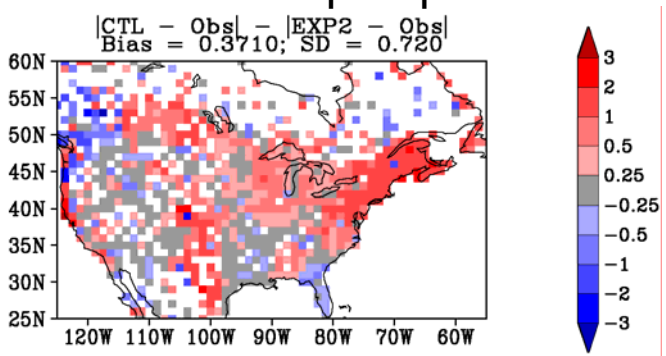
Surface Temperature Assimilation

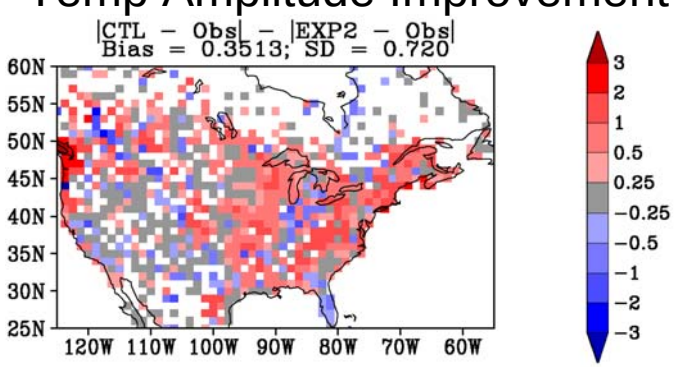
- ISCCP 3 hourly Ts Assimilated with a diurnal bias correction (July 2001)

$$C\frac{\partial T_S}{\partial t} = R_S^{\downarrow} - R_S^{\uparrow} + R_L^{\downarrow} - R_L^{\uparrow}(T_S) - H_S(T_S) - LE(T_S) + G - B$$

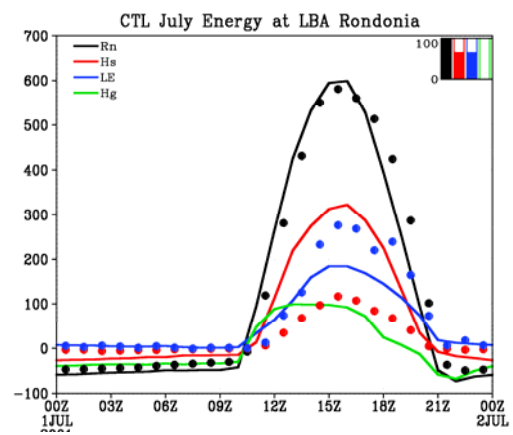
Mean Air Temp Improvement



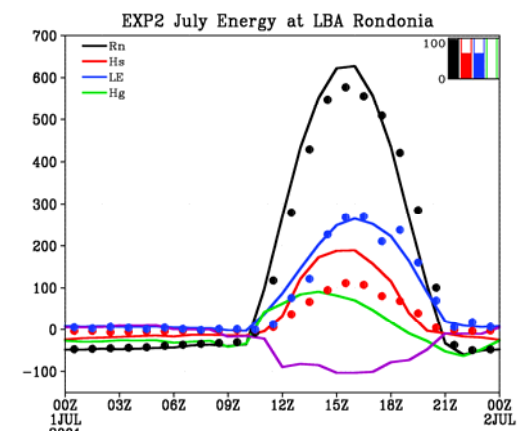
Temp Amplitude Improvement



Control



Ts DBC



Bosilovich et al., 2007: Skin Temperature Analysis and Bias Correction in a Coupled Land-Atmosphere Data Assimilation System. Submitted to JMSJ

Offline Land Data Assimilation

- Offline = Land model only, no Atmos.
- Requires prescribed forcing fields
  - Near sfc air T, q and wind, Ps, Rad, Precip
  - Use available Obs, fallback to a reanalysis
- Uses
  - Land DA development (long runs, less cost than coupled systems)
  - Observational forcing to produce land data product - fluxes, soil states etc (Maurer et al. 2002)
  - Could feed back to a coupled system

GSWP-2 Multi-model Analysis

Name	Institute	Nation	Time step	Vertical Structure[1]
CLM2-TOP	U. Texas	USA	1hE 5mS[2]	10W 10T 5S
HY-SSiB ★	GSFC	USA	30m	3W 2T 2S
ISBA	Météo France / CNRM	France	5m	3W 2T 1S
Mosaic ★	NASA / GSFC / HSB	USA	30m	3W 2T 1S
MOSES2	Met Office	UK	30m	4W 4T 1S
NOAH ☆	NOAA / NCEP / EMC	USA	15m	4W 4T 1S
NSIPP-Catchment	NASA / GSFC / GMAO	USA	20m	3W 6T 3S
SiBUC	Kyoto U.	Japan	1h	3W 2T 1S
SSiBCOLA	IGES / COLA	USA	30m	6W 6T 1S
SWAP	Russian Academy of Sciences / IWP	Russia	3h	2W 1T 1S
VISA	U. Texas	USA	3hE 5mS[2]	10W 10T 5S
LaD	NOAA / GFDL	USA	30m	1W 18T 1S
ORCHIDEE	IPSL	France	1h	4W 7T 1S
Sland	U. Maryland	USA	20m	1W 2T 0S
BucketIIS	U. Tokyo	Japan	3h	1W 1T 1S

- 1986-1995 ISLSCP II Period
- 1 degree global land
- Land fluxes and states from 10 Models

Contribute fully to the multi-model analysis in as far as each reports all mandatory variables

Do not contribute to the multi-model estimate of normalized soil wetness because of problems in defining a relevant soil wetness index within those schemes, but they do contribute to other variables

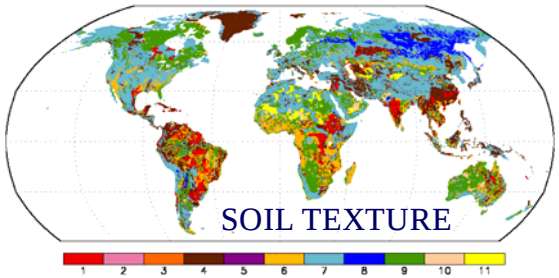
Simple and intermediate models that do not report all mandatory fields, so are excluded from the multi-model analysis

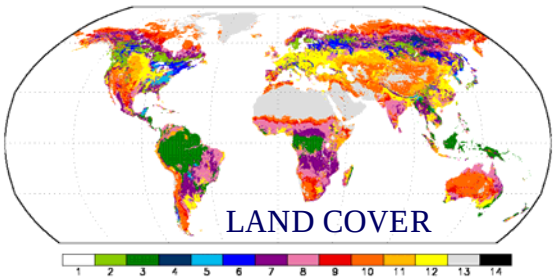
Courtesy P. Dirmeyer, T. Oki
http://www.iges.org/gswp2/

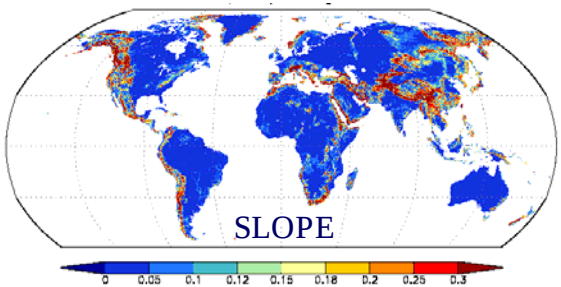
Global Land Data Assimilation System (GLDAS) and Land Information System (LIS)

GOAL: Produce high resolution (1/4°-1 km), optimal output fields of land surface states and fluxes.

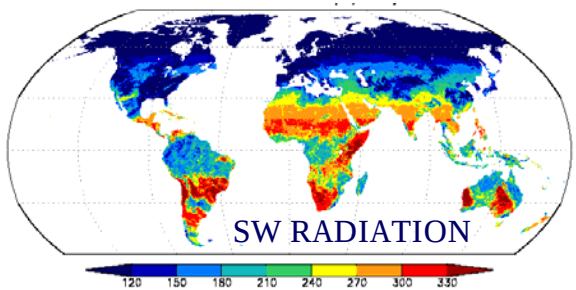
Parameter Inputs

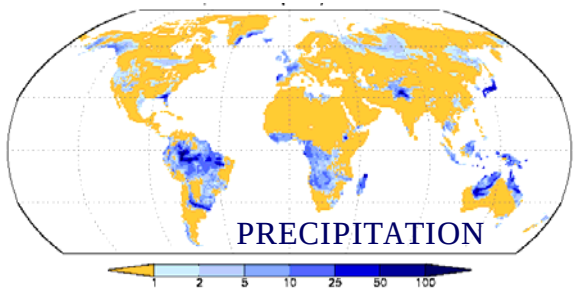






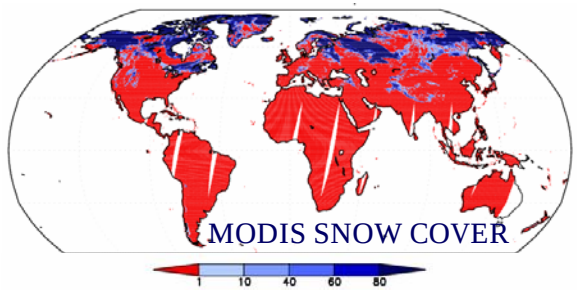
Satellite Based Forcing





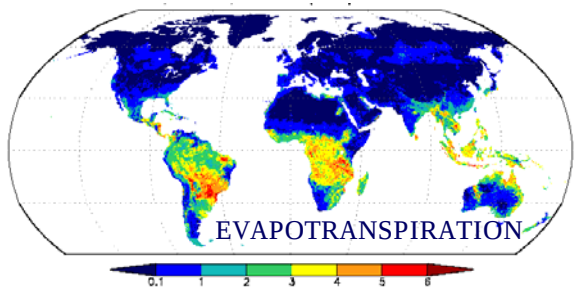
APPROACH: Parameterize, force, and constrain sophisticated land surface models with observation based data.

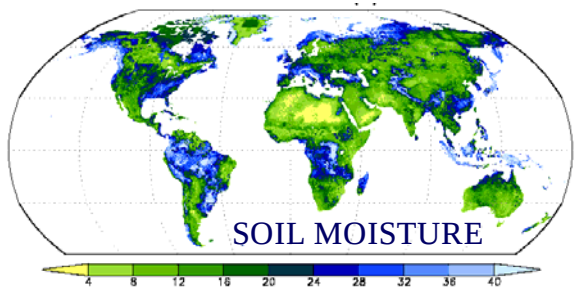
Assimilated Observations



SIGNIFICANCE: Results are used for initialization of weather and climate forecast models, water resources applications, and hydrometeorological investigations.

Integrated Output





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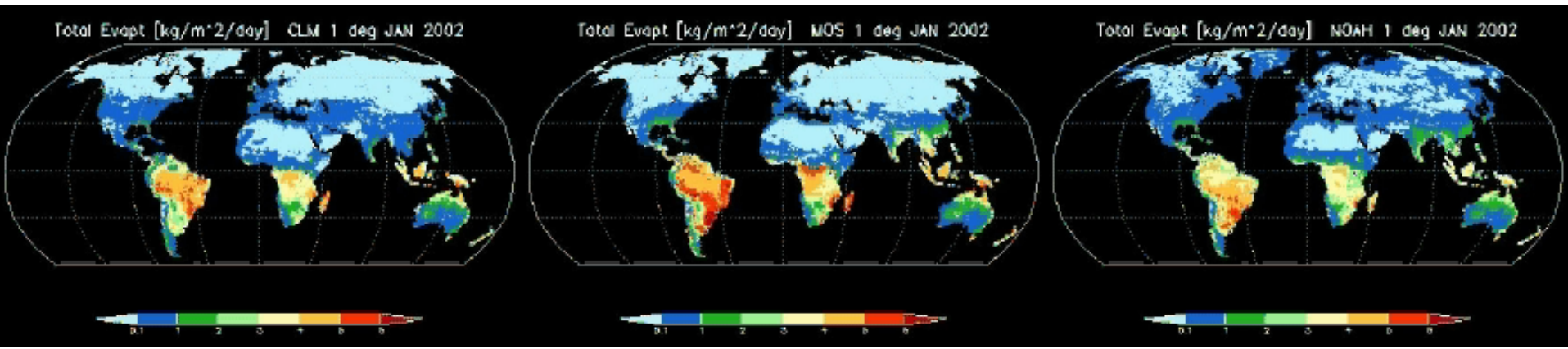
GLDAS Overview

Drives multiple LSMs with obs-based forcing & parameters

- Land Information System software http://lis.gsfc.nasa.gov
- Includes archive of land surface and met datasets
- **Available Land Reanalyses** includes 0.25° and 1° global, 1979-present simulations with 3 LSMs: CLM, Mosaic, and Noah
- Rodell et al.,BAMS 2004; Matthew.Rodell@nasa.gov



Monthly mean evapotranspiration, 2002-04, from simulations with CLM2, Mosaic, and Noah 2.7.1 LSMs. [Color bars range from 0.1 to 8 mm/day]

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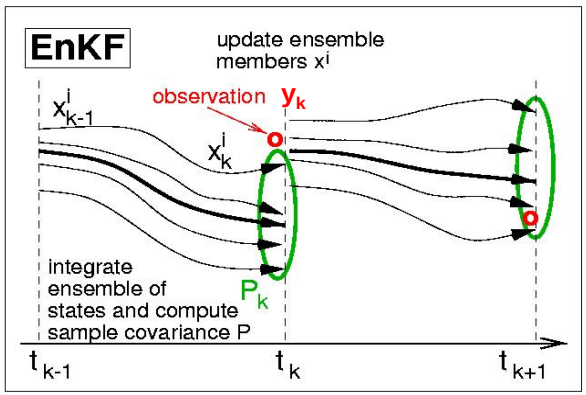
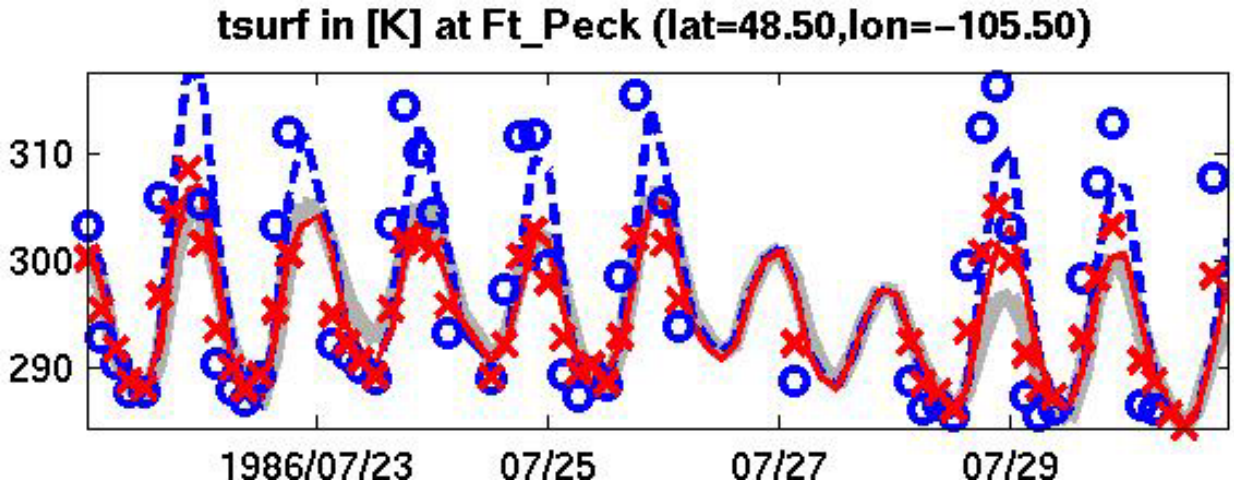
MERRA Land Reanalysis

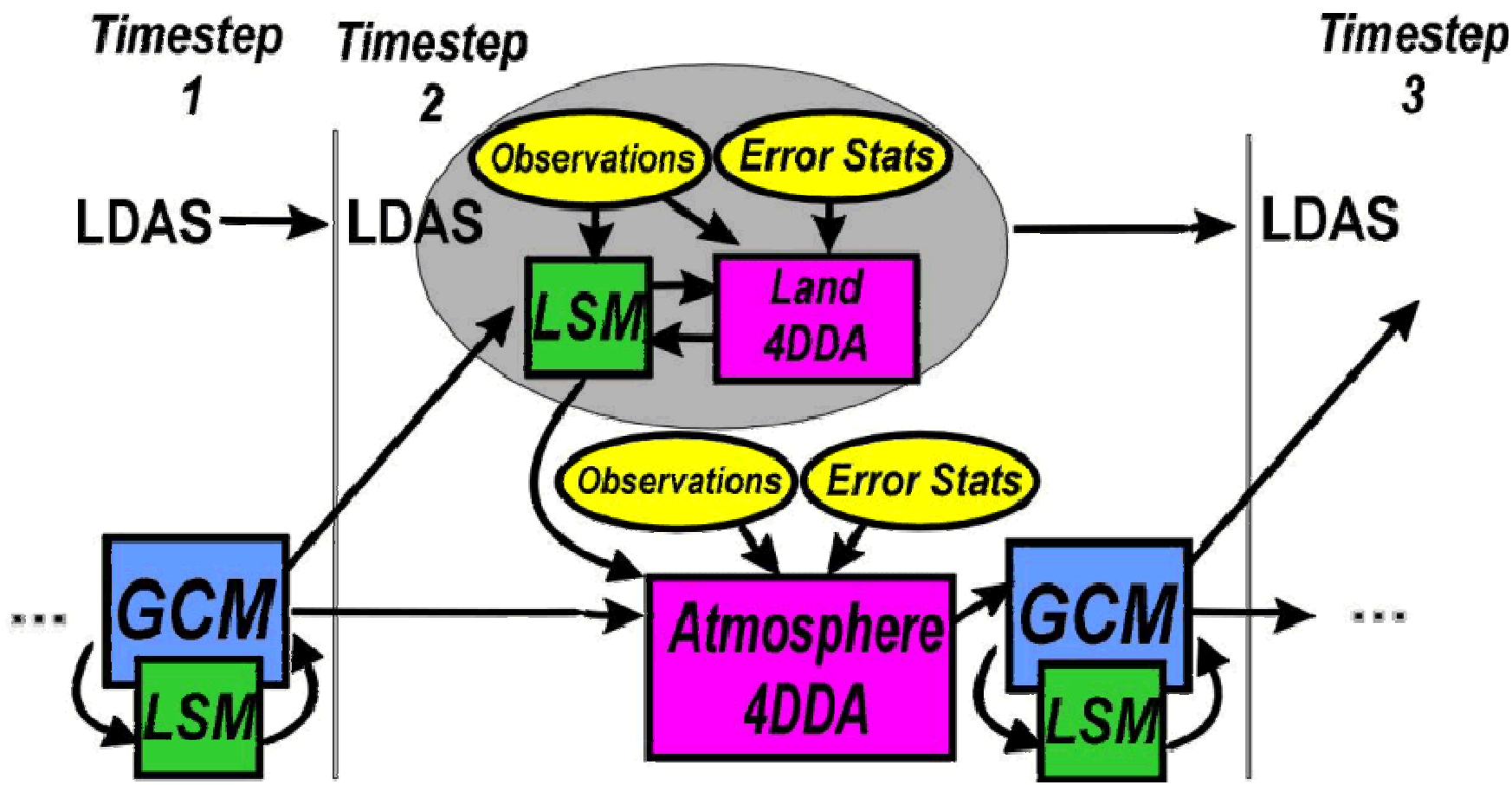
- Modern Era Retrospective-analysis for Research and Applications (MERRA)
  - ½ degree; 1979-present; 72L to Stratosphere
- Offline Land Data Assimilation
  - ISCCP DX 3hr; 30Km Clear sky Surface Temperature; 1983 – 2004
- Reichle, Koster, Bosilovich





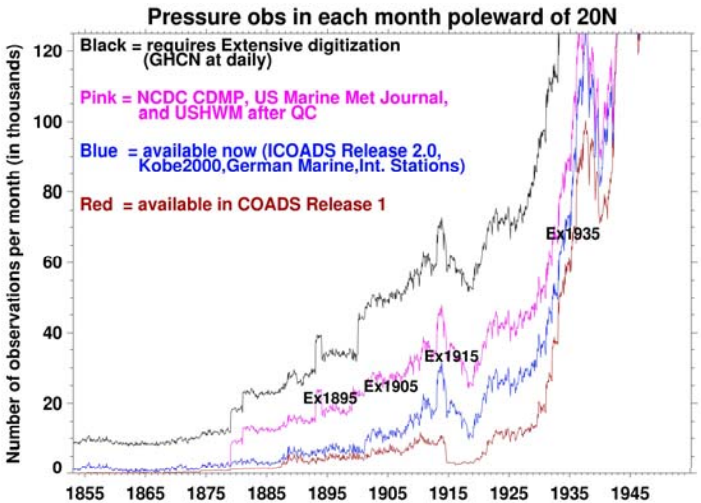
Coupled LDAS Concept

- Originally developed by Paul Houser et al. circa 1999
- Courtesy ldas.gsfc.nasa.gov

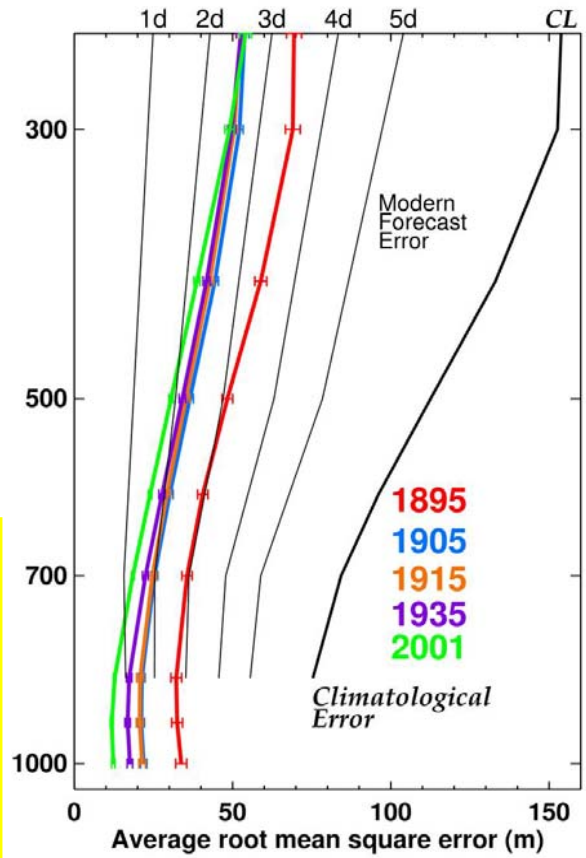


Feasibility of a 100-yr Reanalysis using only surface pressure observations

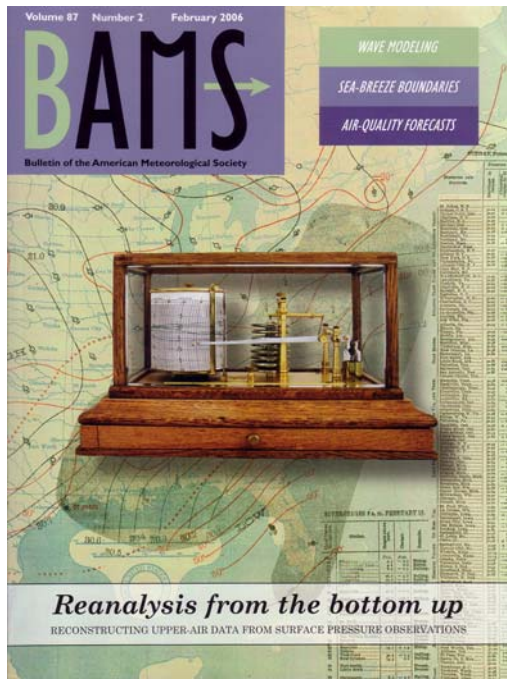
Available Surface Obs



"Reanalysis" results



RMS Skill of 6-hourly "reanalyses" of NH December 2001 geopotential heights with *Ensemble Filter* using only Surface Pressure obs at 1895, 1905, 1915, 1935, 2001 densities.



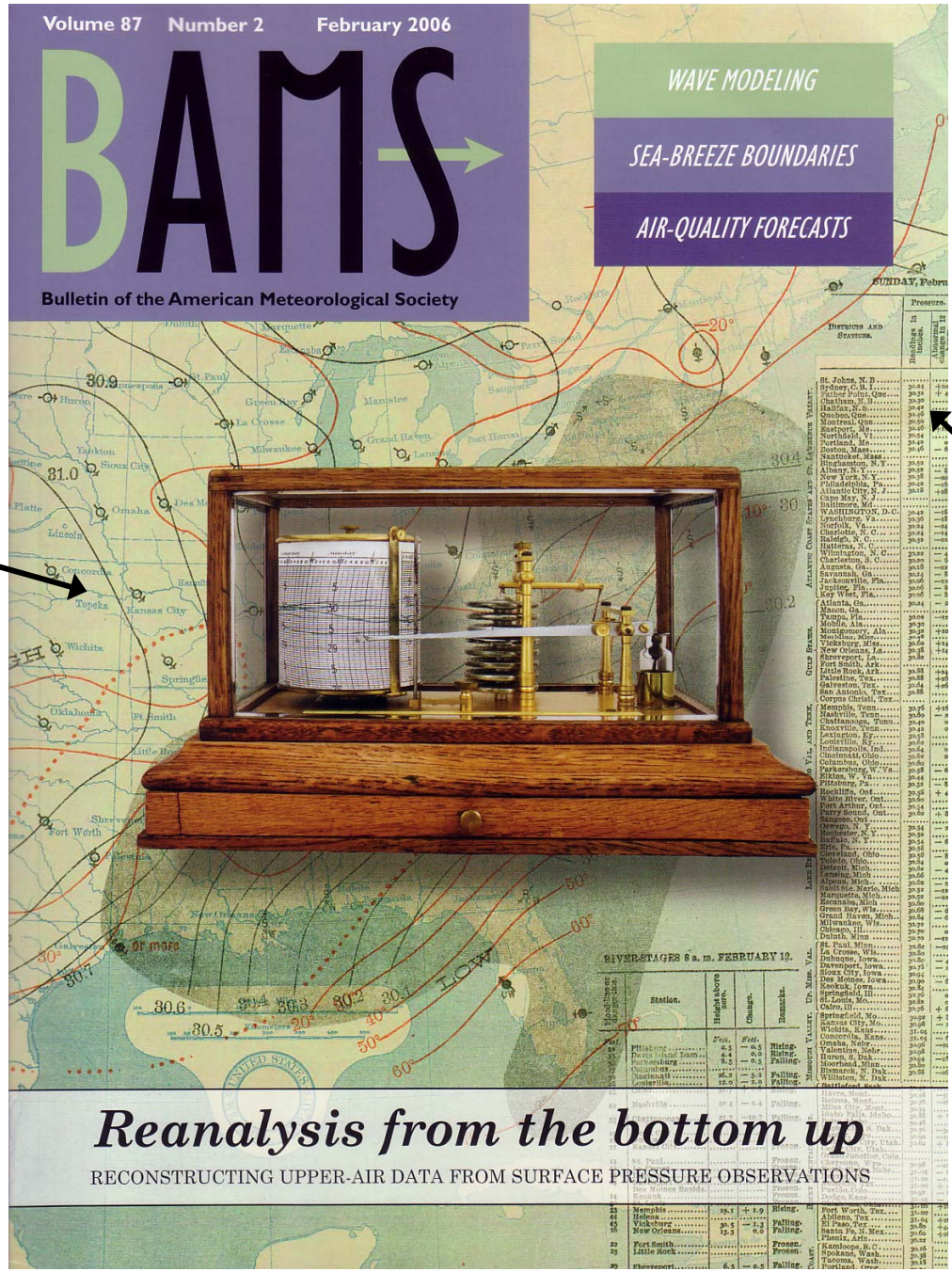
Conclusion:

100 year NH Reanalysis is feasible.

Even upper-tropospheric errors would be similar to current 2-3 day forecast errors.

Compo,G.P., J.S. Whitaker,and P.D. Sardeshmukh, 2006: Feasibility of a 100 year reanalysis using only surface pressure data. Bull. Amer. Met. Soc., 87, 175-190.

Historical Weather Map



River Stages

Contacts

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- Gilbert.P.Compo@noaa.gov
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- Paul Houser: houser@iges.org

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