CEOP Global Models

Presented by Michael Bosilovich

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And of course

Sam Benedict and Petra Koudelova

Background and Objectives

- Providing global analyses and forecasts supporting CEOP science goals including MOLTS for local process studies
- Evaluating the uncertainty of models and analyses
- Ideally, the science activities then feedback into understanding the global NWP systems

Recent Accomplishments

- Adding cloud data and process studies in the global model frameworks (Kohler and Pinker) Progressing
- Defining new global MOLTS and Converting to NetCDF (much thanks B. Geyer)
- 8 global analyses archived at MPI (??? TB)
- Uncertainty in Analyses: Multi-model Analysis for CEOP

A Multi-model Analysis for CEOP

Michael Bosilovich, David Mocko
John Roads and Alex Ruane

Data contributions from
BMRC, CPTEC, ECPC, JMA, MSC, NCEP and UKMO

(Submitted to JHM)

ftp://gmaoftp.gsfc.nasa.gov/pub/papers/mikeb/
MAC_Manuscript_submitJHM.pdf

Coordinated Enhanced Observing Period (CEOP) Global Analyses

- NWP Centers contributed analysis and forecast data
  - BMRC, CPTEC, ECPC, JMA, MSC, NCEP and UKMO (Oct 2002-Dec 2004)
- Uncertainty of Analyses and to support the science activities (Bosilovich and Lawford, 2002)
- Initial studies focused on point-wise comparison of the stations and analyses surface energy budgets

Multi-model Analysis for CEOP (MAC) Objective

- To homogenize the differences in the data products, facilitating comparisons and evaluations with independent data
- Focus on the global to large-scale water and energy cycles
- To produce an ensemble mean and variance data set that may support CEOP science activities
- Hypothesis: Since the input observations are closely related, an ensemble mean should minimize uncorrelated model background error and bias

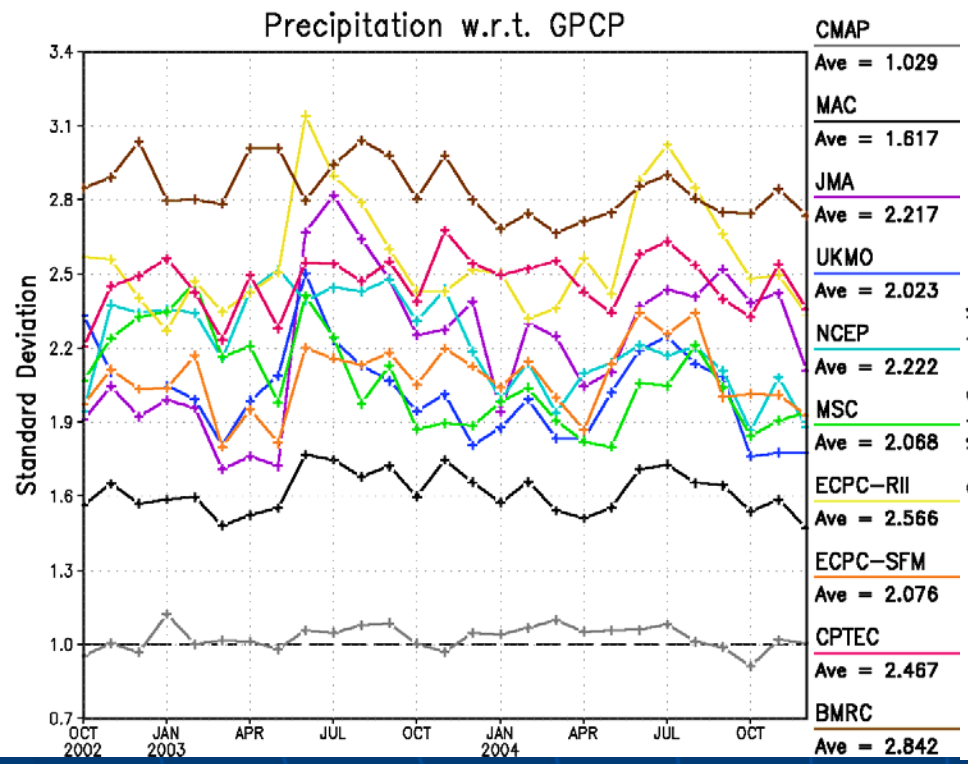
Multi-model Analysis for CEOP (MAC)

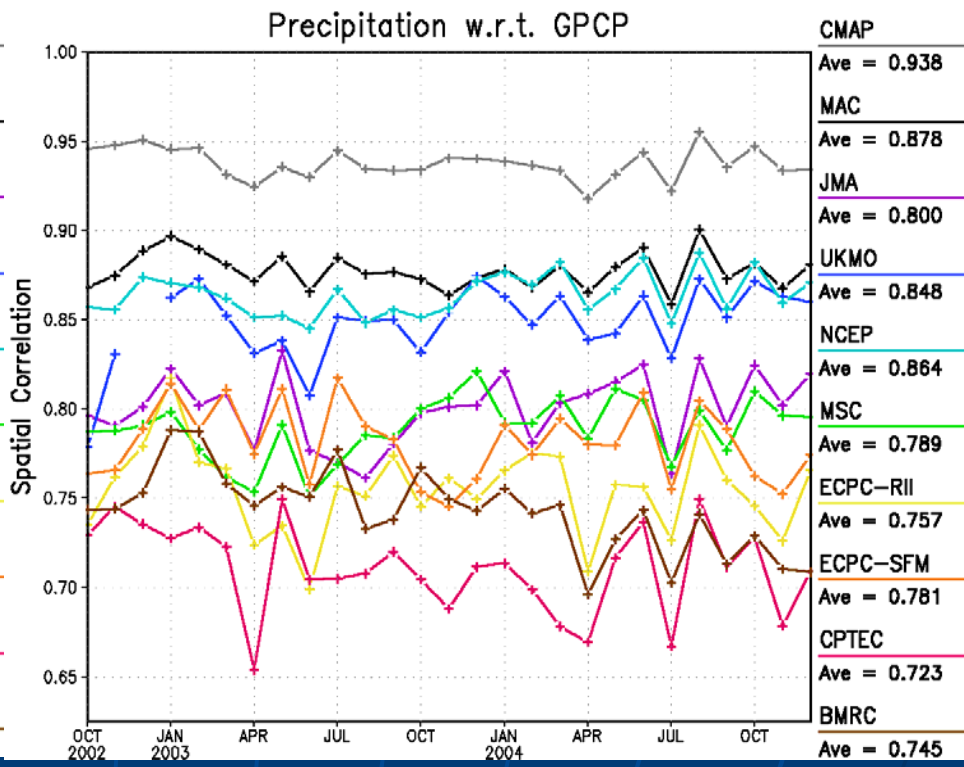
- Each of 8 systems provides 6 hourly analyses, largely the same input observations with different
  - Some important differences among members
- Output: Ensemble mean and variance
  - 1.25 degree global spatial resolution
  - Monthly, daily, and 6 hourly time series – For all 8 members, ensemble mean and std. dev.
  - NetCDF and Grib online, Binary in archive
- Issues in developing the Ensemble
  - Missing data, spatial resolution, temporal averaging, analysis vs. forecast, occasional bugs, P Surface intersecting the topography, variable names

Variable Timing

		Centers							
Description	**Units**	**BMRC**	**CPTEC**	**ECPCRII**	**ECPCSFM**	**JMA**	**MSC**	**NCEP**	**UKMO**
Surface Pressure	Pa	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Mean Sea Level Pressure	Pa	analysis		analysis	analysis				analysis
Surface Air Temperature	K	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Surface Skin Temperature	K	analysis	12hr fcst+	6hr fcst	6hr fcst		anl/6hr fcst+	6hr fcst	analysis
Surface Air Moisture	kg kg^{-1}	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Surface Eastward Wind	m s^{-1}	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Surface Northward Wind	m s^{-1}	analysis	12hr fcst+	6hr fcst	6hr fcst	analysis	anl/6hr fcst+	6hr fcst	analysis
Precipitation	kg m^{-2} s^{-1}	analysis	12hr fcst+	0-6hr ave	0-6hr ave	6hr fcst	3hr fcst+	0-6hr ave	0-6hr acc
Convective Precipitation	kg m^{-2} s^{-1}			0-6hr ave	0-6hr ave				0-6hr acc
Surface Runoff	kg m^{-2}		12hr fcst+	0-6hr ave	0-6hr ave		3hr fcst+	0-6hr acc	0-6hr acc
Liquid equivalent snow depth	kg m^{-2}	analysis		6hr fcst	6hr fcst		anl/6hr fcst+	6hr fcst	
Latent Heat Flux	W m^{-2}	analysis	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Sensible Heat Flux	W m^{-2}	analysis	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Surface Incoming Shortwave	W m^{-2}	analysis	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Surface Incoming Longwave	W m^{-2}	analysis	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Surface Reflected Shortwave	W m^{-2}	analysis	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Surface Outgoing Longwave	W m^{-2}	analysis	12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
TOA Longwave Outgoing	W m^{-2}		12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
TOA Shortwave Incoming	W m^{-2}			0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+		0-6hr ave
TOA Shortwave Outgoing	W m^{-2}		12hr fcst+	0-6hr ave	0-6hr ave	0-6hr ave	3hr fcst+	0-6hr ave	0-6hr ave
Total Cloud Cover	(0-1)		12hr fcst+	0-1hr ave	0-1hr ave	analysis	anl/6hr fcst+	0-6hr ave	analysis
Total Column Water Vapor	kg m^{-2}	analysis	12hr fcst+	6hr fcst	6hr fcst		anl/6hr fcst+	6hr fcst	
Total Column Condensed Water	kg m^{-2}					analysis	anl/6hr fcst+	6hr fcst	
Q850	kg kg^{-1}	analysis	12hr fcst+	analysis	analysis		anl/12hr fcst	6hr fcst	analysis
T850	K	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	6hr fcst	analysis
U850	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	6hr fcst	analysis
V850	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	6hr fcst	analysis
H850	m	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	6hr fcst	analysis
Q700	kg kg^{-1}	analysis	12hr fcst+	analysis	analysis		anl/12hr fcst	6hr fcst	analysis
T700	K	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	6hr fcst	analysis
U700	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	6hr fcst	analysis
V700	m s^{-1}	analysis	12hr fcst+	analysis	analysis	analysis	anl/12hr fcst	6hr fcst	analysis

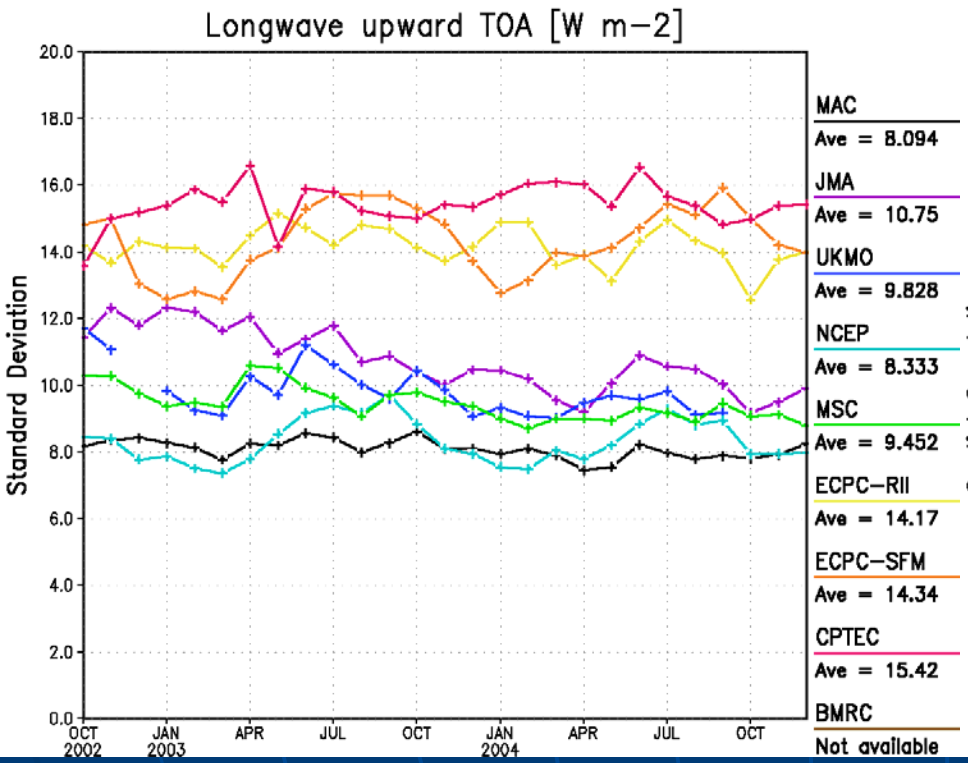
Full EOP 3-4 time series (Monthly)

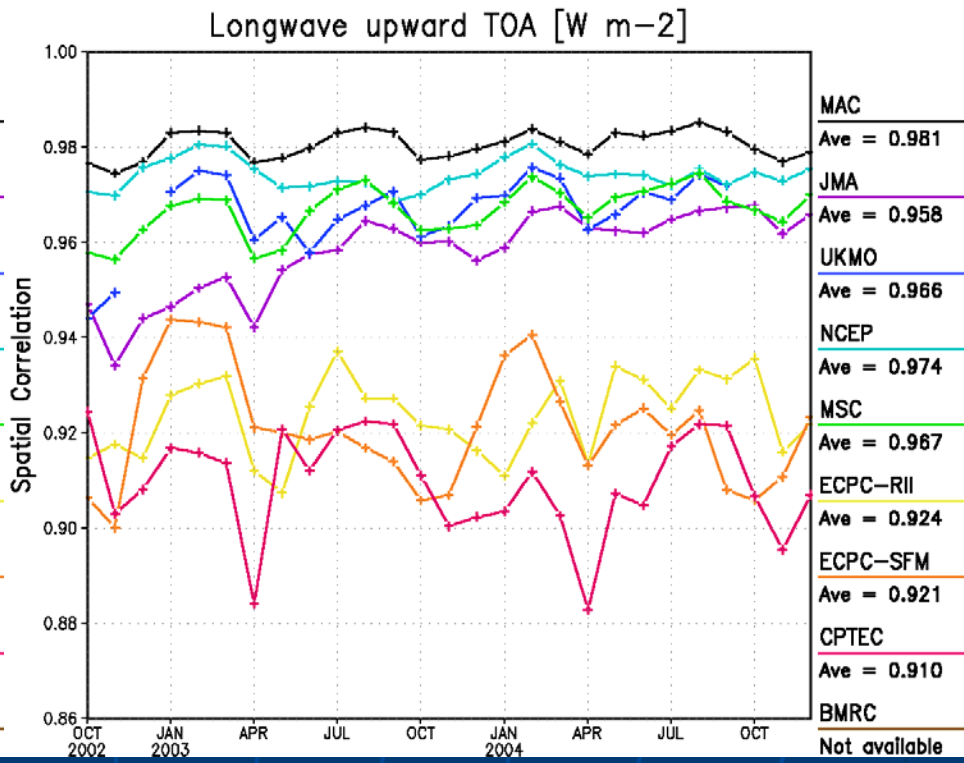




- Global spatial statistics of MAC precipitaiton compared to GPCP

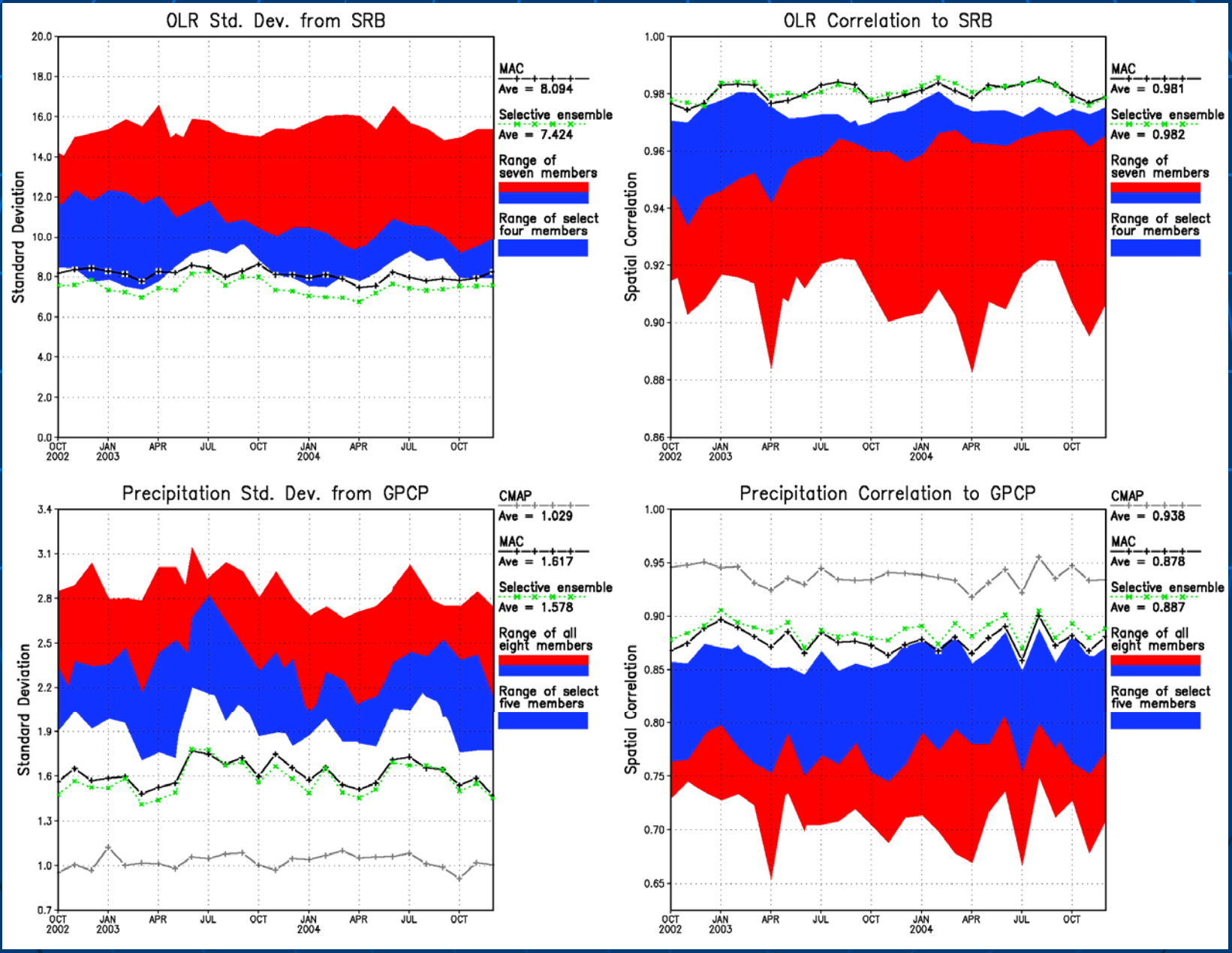
Full EOP 3-4 time series (Monthly)



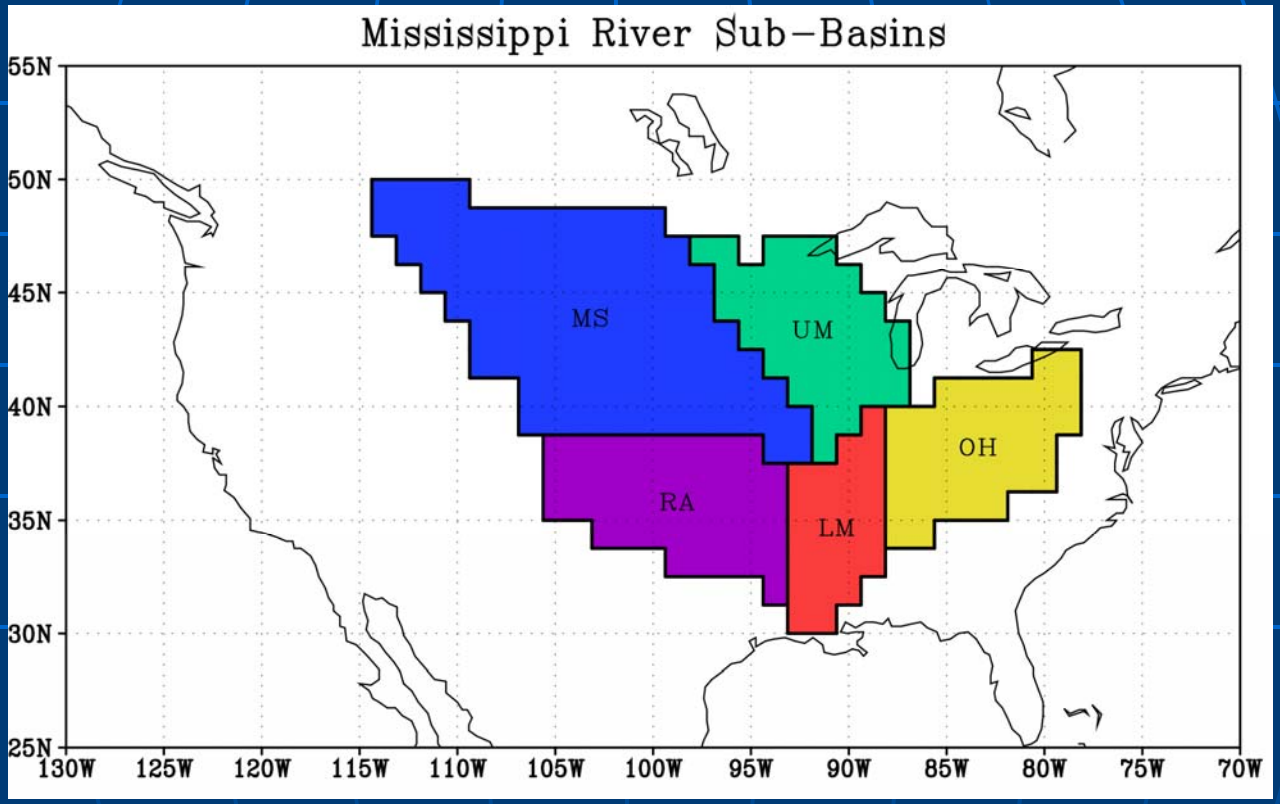


- Global spatial statistics of MAC TOA OLR compared to SRB

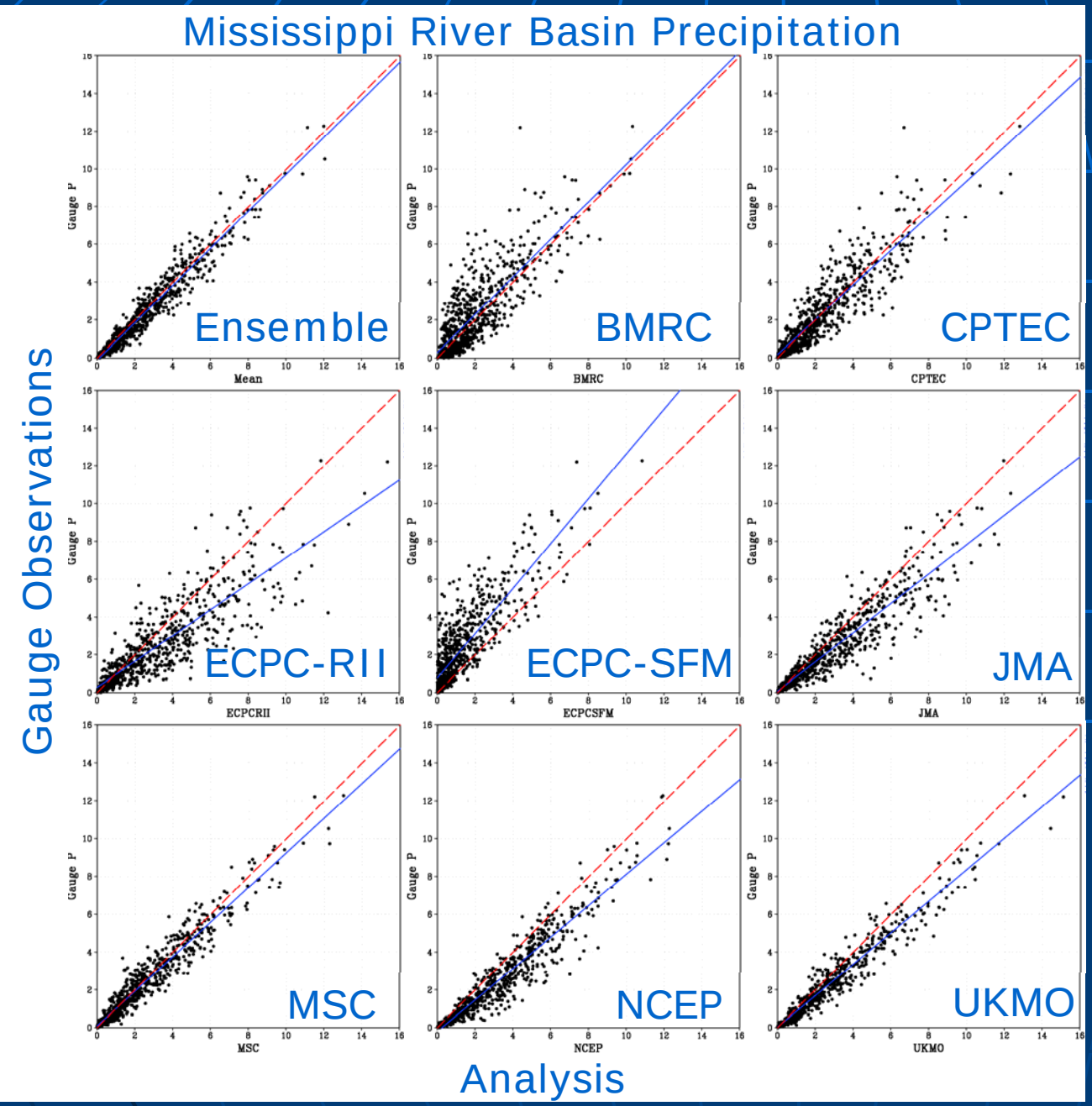
Selective Ensembles



Basin-scale Precipitation



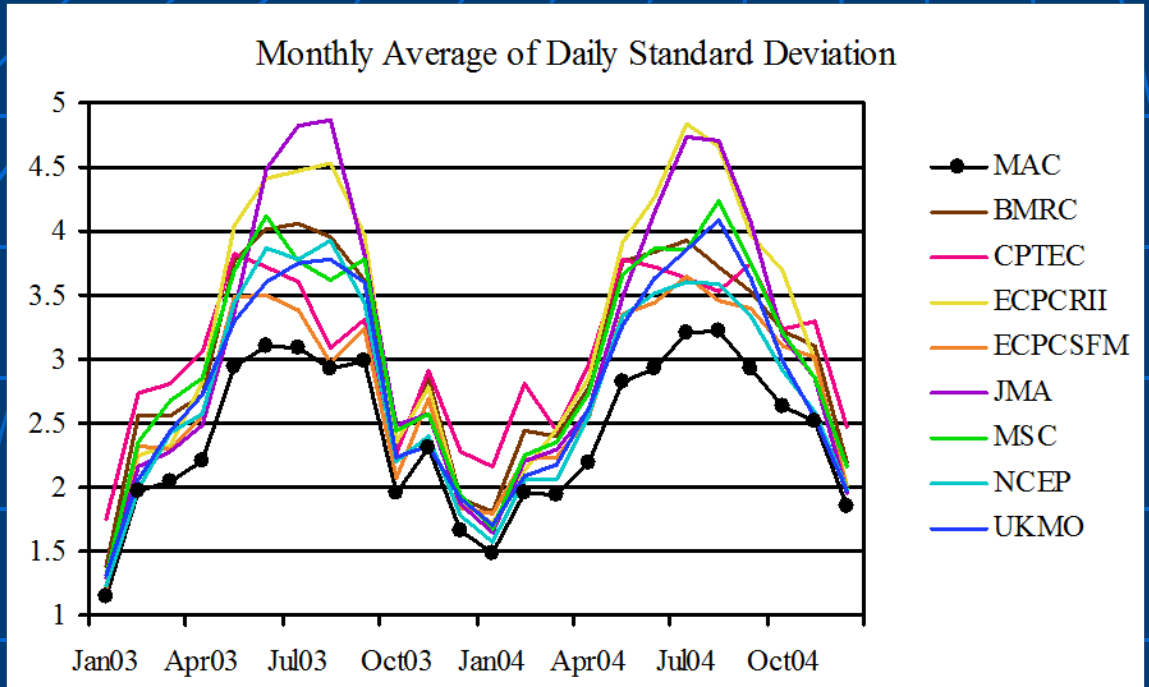
- CPC US ¼ gridded gauge data
- Daily, EOP 3-4 (Oct 2002 – Dec 2004)
- Consider all of the Mississippi River Basin domain

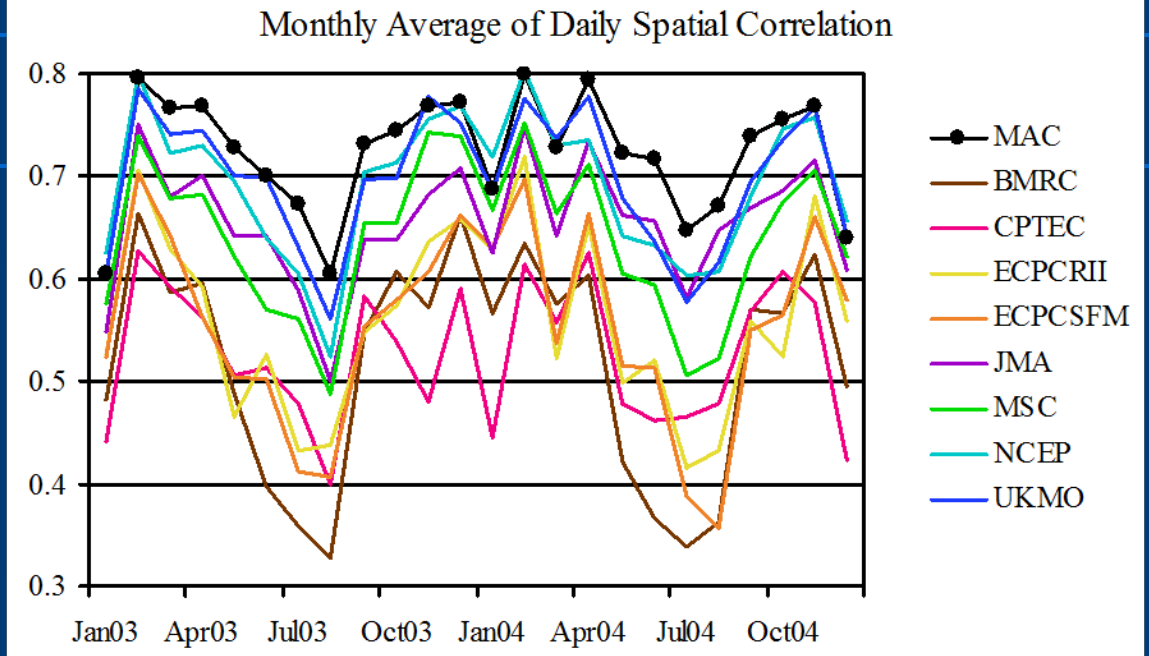


CEOP EOP 3-4 Daily MRB Precipitation

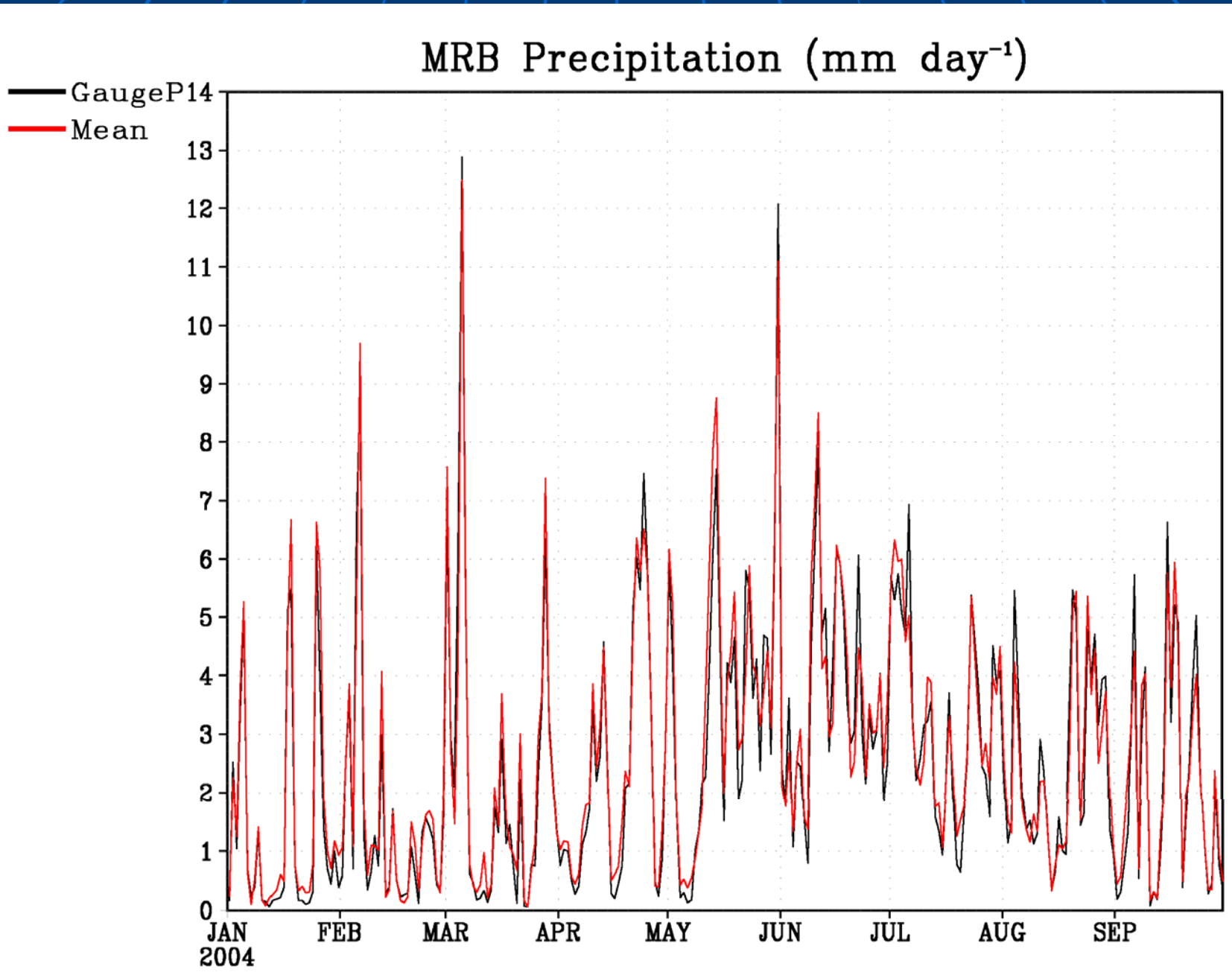
- MRB is in the heart of a data rich region for analyses
- Precipitation is independent (not assimilated)
- In general, Models have different characters
- Most overestimate high rain events
- BMRC excessively dry summer
- Ensemble fits well

Daily Spatial Statistics of MRB Precip





- Each day calculate the spatial correl. and Std. Dev for the MRB
- Time average the daily statistics for presentation
- The daily spatial distribution of the MAC Ensemble Precip has more skill than any single member


MRB Precipitation (mm day⁻¹)
GaugeP14
Mean
0
1
2
3
4
5
6
7
8
9
10
11
12
13
JAN
2004
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

Multi-model Analysis for CEOP (MAC) Global Energy

Center	LH	SH	RLd_{sfc}	RLu_{sfc}	RSd_{sfc}	RSu_{sfc}	RLu_{toa}	RSd_{toa}	RSu_{toa}	NET_{Sfc}	Precip
BMRC	92	18	350	400	167	25				-19.3	3.32
CPTEC	99	22	347	401	206	24	244		100	7.4	3.40
ECPC-RII	96	7	337	400	202	24	247	341.4	92	11.9	3.21
ECPC-SFM	84	17	333	400	207	27	249	341.4	91	13.0	2.47
JMA	90	17	320	398	204	25	257	341.4	88	-6.2	3.15
MSC	91	20	334	397	201	28	249	342.0	94	-0.6	2.61
NCEP	95	9	332	398	208	29	248		87	8.5	3.26
UKMO	95	16	345	399	180	22	235	341.5	105	-7.2	3.58
MAC	92	16	337	399	197	26	247	341.5	93	1.1	3.12
Sdev	4.6	5.3	9.8	1.3	15.2	2.4	6.6	0.2	6.5	11.3	0.38
TFK	80	17	333	396	184	23	238.5	341.3	101.9	1.2	2.73
SRB/GPCP			343	398	182	22	241	341.4			2.63

- **Model data are for Jan 2003-Dec 2004**
- **MAC is an ensemble average based on 6 hourly means (not the average of the global values)**
- **Sdev is the standard deviation of the models global values**
- **TFK = Trenberth, Fasullo and Keihl (2008, BAMS)**
- **P in mm/day, others W/m2**
- **SRB/GPCP for 2003-2004, as in the models, TFK for Mar2000-May2004**

Summary

- So far, MAC Ensemble data comparing well to Global P (GPCP), Global OLR and Basin scale precip
- GMAO has used this data to evaluate a Reanalysis system
- GMAO and ECMWF (Interim) contributions to be added in early 2009 (version 2)
  - Willing to make adjustments, based on reviews of the docs and data

Implications of this Work

- GEWEX Objectives 1 & 2: A data set that can be used to better understand W&E cycles and contributes to the RHPs and focus studies
- GMAO initiated a reprocessing of the EOP 3-4 period as a contribution
- Stephane Belair (MSC) is taking the results to argue for continued effort in CEOP
- Ken Mitchell (NCEP) has copied the data and is using it in their system evaluations
- Paul Houser has acquired a copy for NASA Energy and Water Cycle Studies (NEWS)
- MAC Copies provided to Paul Earnshaw (UKMO), Kun Yang (WEBS) and W. Guo (S-A)

Implications for Climate Data Records

- Reanalyses were initiated to compensate for the variability of the data assimilation systems
- Existing Reanalyses have or will stop forward processing, so that the number of long reanalyses in present time will be smaller than pre-2002
- A collection of operational analyses could supplement the recent period, in an ensemble approach

CEOP Modeling Evolution

- Provides impetus to continue or expand the efforts tested in the CEOP Global modeling group
- Further scientific testing, not just from CEOP but also GMPP (plus CLIVAR and the community)
- Breakouts: Is the global data useful?
- Going forward in time: Need commitments from NWP centers, not just data, but formatting, and documentation
- Can we enhance the archive site to handle the reformatting of the model analyses and forecasts? Probably with input from the contributing center