Alternative Precipitation Data for CBW Model:
NEXRAD-Based and NLDAS

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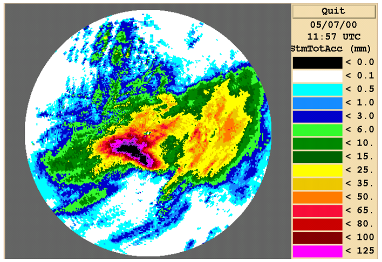
  - Gauge- vs. NEXRAD-based precipitation in CBW modeling
- D.-J. Seo, Dept. of Civil Eng., The University of Texas at Arlington (formerly with NWS Office of Hydrologic Development)
  - Multisensor Precipitation Estimator (MPE) vs. North American Land Data Assimilation System (NLDAS) data

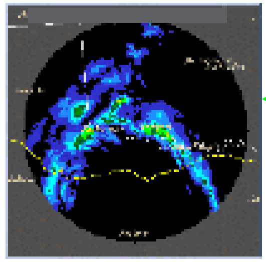
In this presentation

- CBW modeling using gauge- vs. NEXRAD-based precipitation
  - Multisensor Precipitation Estimator (MPE)
  - Comparison of data
  - CBW model calibration and performance
  - Summary of findings
- MPE vs. NLDAS precipitation data
  - Description of data
  - Technical considerations for use in CBW modeling
  - Closing remarks
- Q/A

From Seo et al. (2011)



Digital Hybrid-Scan Reflectivity

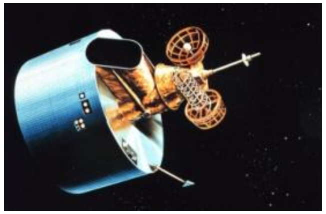


Digital Precipitation Array

Open Radar Product Generator / Precipitation Processing Subsystem

WSR-88D

Rain Gauges

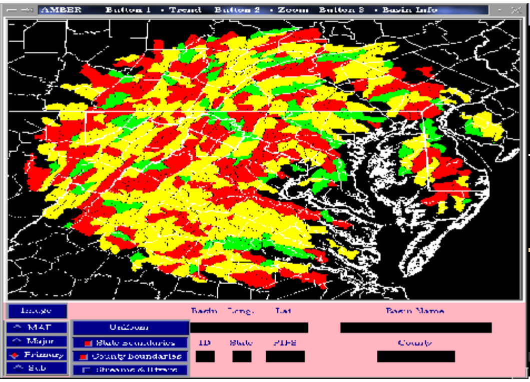


Hydro-Estimator

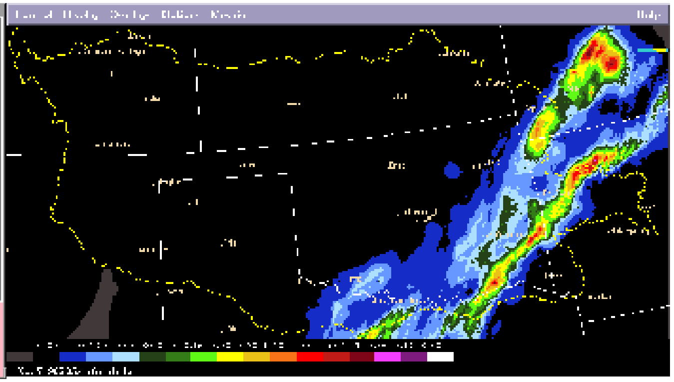
Flash Flood Monitoring & Prediction System

Multi-Sensor Precipitation Estimator (MPE)

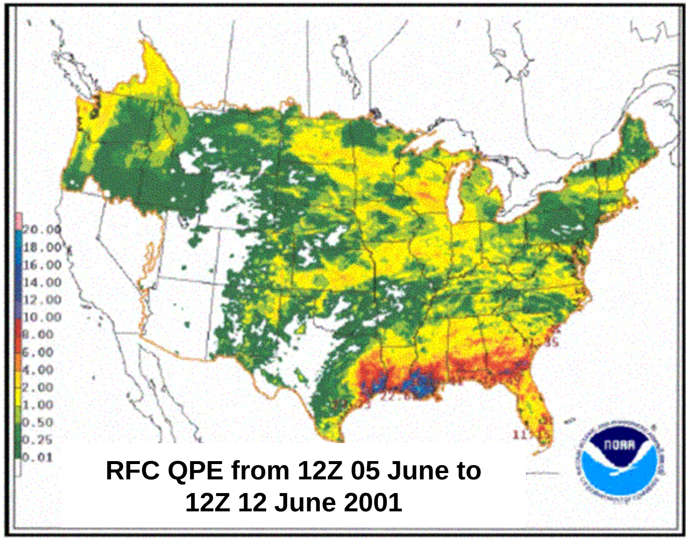
Stage IV



WFO



RFC, WFO



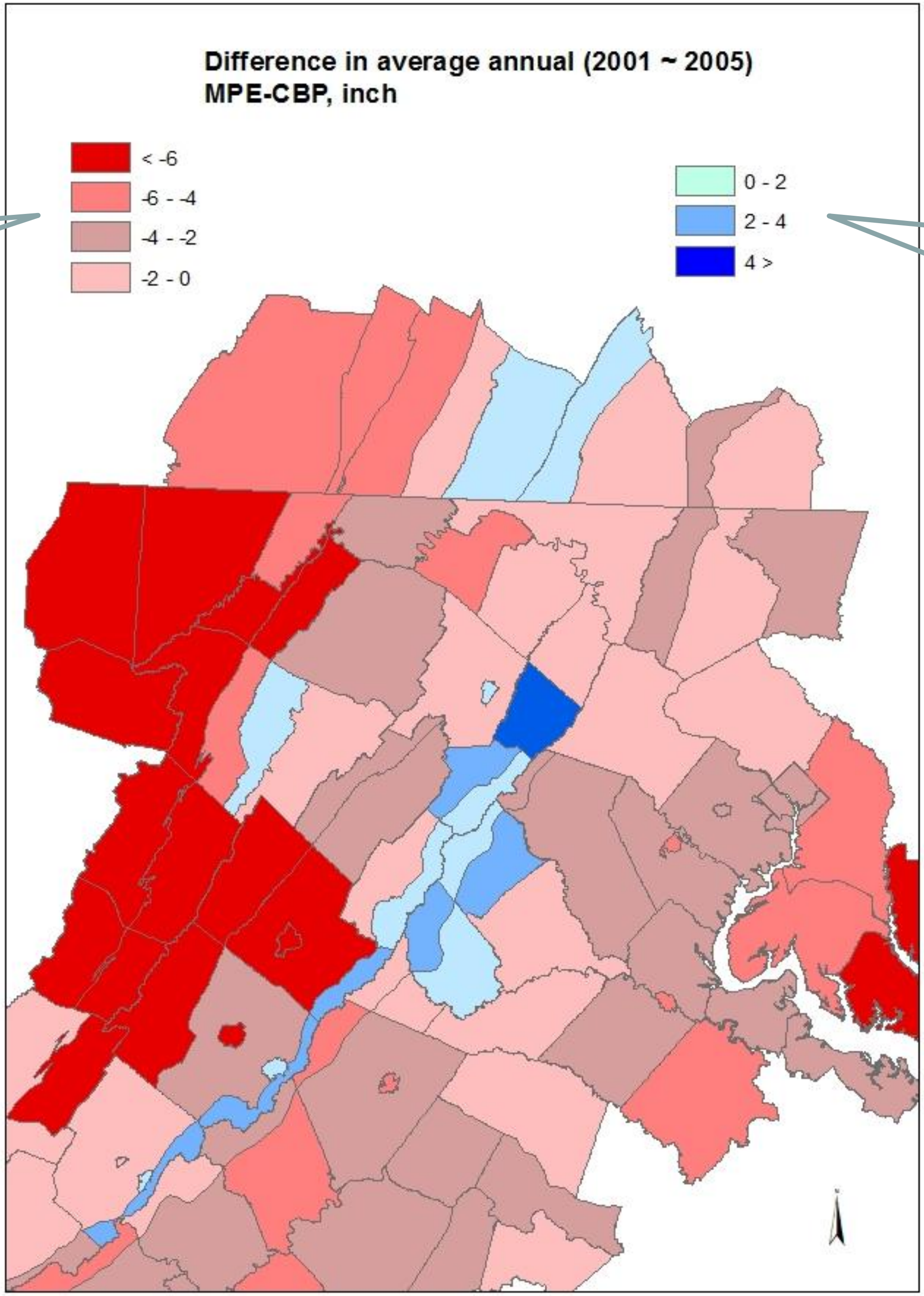
NCEP

Gauge- vs. MPE-based mean areal precipitation (MAP) for model calibration

- Study period: 2001 ~ 2005
- Area: Potomac River Basin

CBP (USEPA, 2010)	MPE
Gauge-based	NEXRAD-based (radar & gauges)
Spatially interpolated on 5 km x 5 km grid	~4 km x 4 km grid
Aggregated to CBW Model unit (county)	

MPE lower

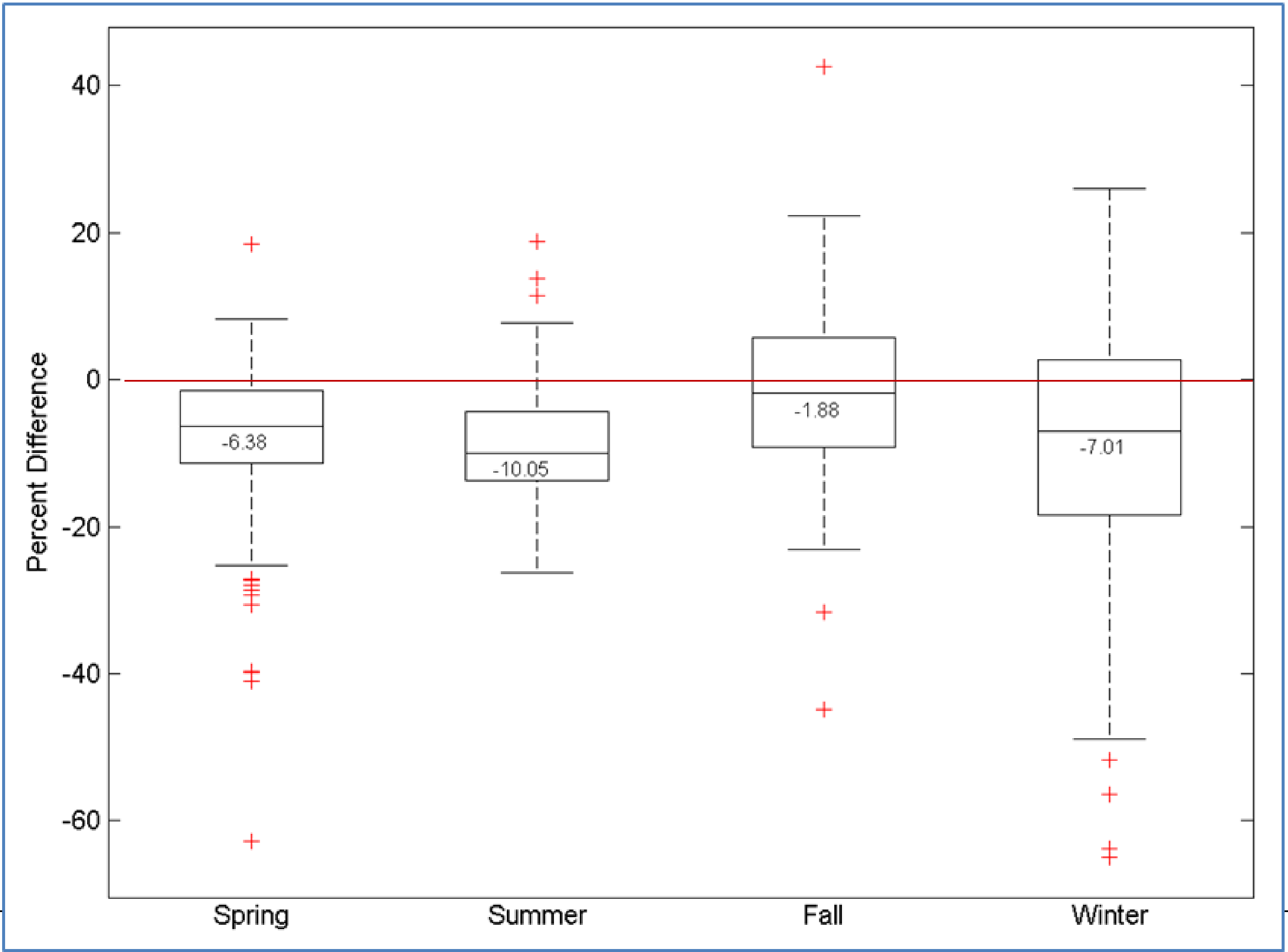


MPE higher

Average seasonal percent difference in MAP

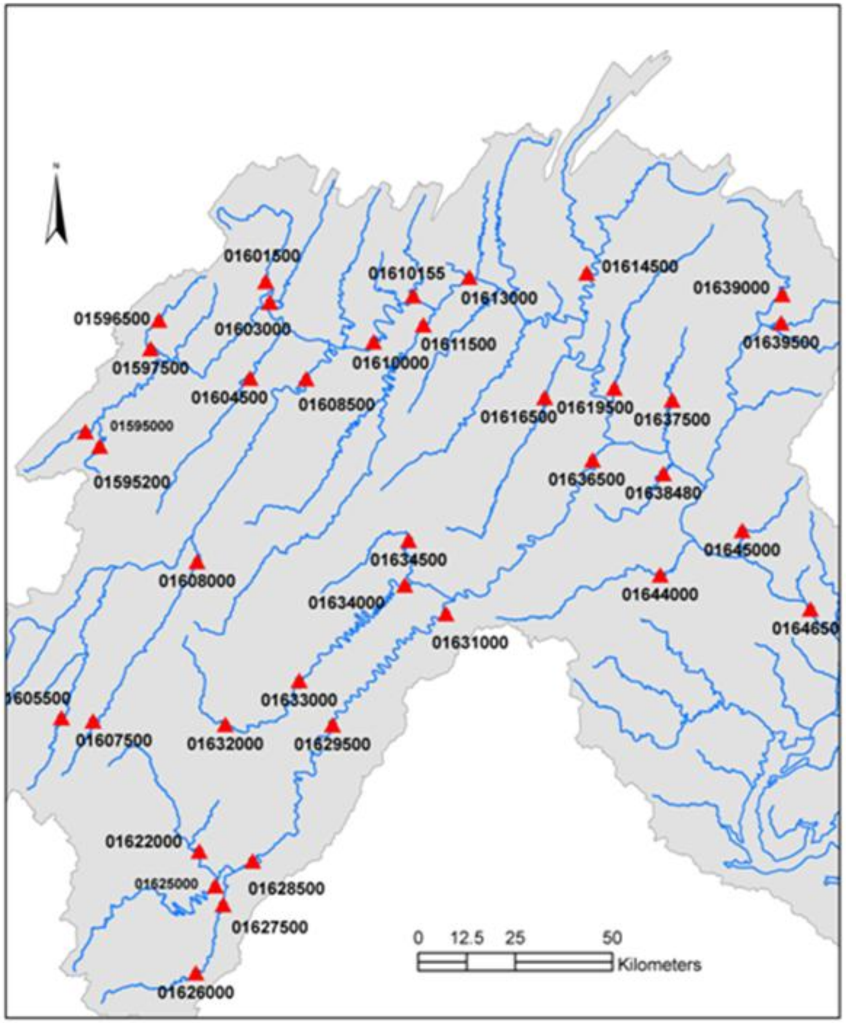
MPE > CBP

MPE < CBP



Calibration of CBW model

- Model: Phase 5.2
- 37 USGS stations
- Calibration period:
  CY 2002~2004



Bias in streamflow simulation

Criteria	Statistics for 37 stream gauge stations	CBP-forced calibration	MPE-forced calibration
Total Bias (0 if perfect)	Min	-0.143	-0.294
	Q_{25}	-0.009	-0.025
	Median	0.002	0.002
	Q	0.071	0.045
	Max	0.288	0.209
Summer Bias/ Winter Bias (1 if perfect)	Min	0.534	0.556
	Q1	0.999	0.924
	Median	0.998	1.040
	Q3	0.992	1.110
	Max	1.278	2.068

Model response

- As expected, the CBW model responds differently to different precipitation forcing
- MPE-forced calibration performed better than the CBP-forced, but with different bounds on LZSN

Precipitation	Bounds on LZSN
CBP	8~12
MPE	2~12

Comparison of hydrologic fluxes

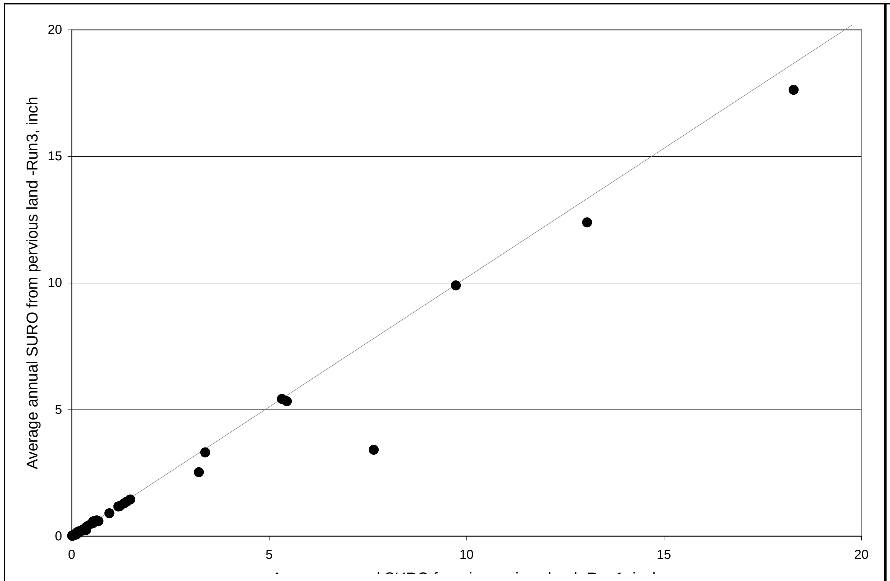
	Flux	Hydrograph component
Impervious	SURO	Surface runoff
Pervious	SURO	Surface runoff
	IFWO	Interflow
	AGWO	Groundwater flow

Surface runoff

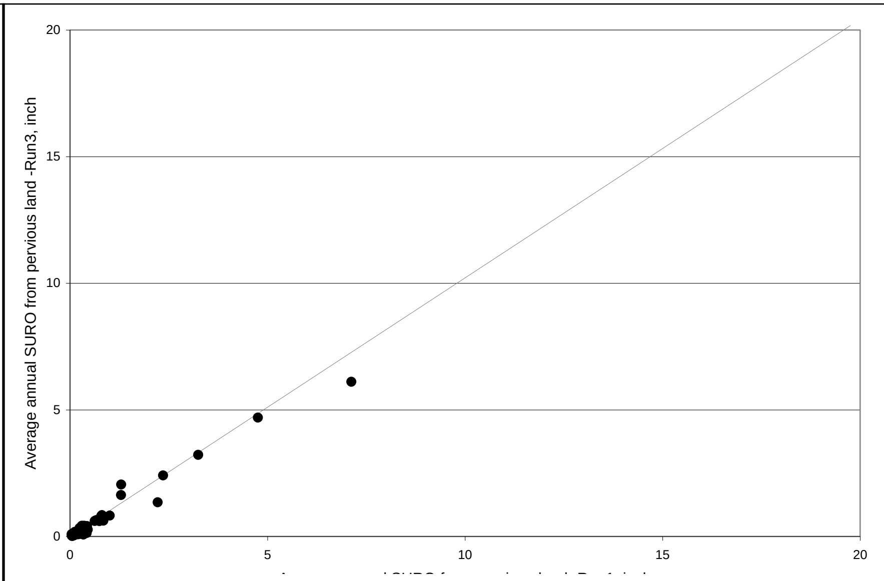
Mean annual SURO-impervious

Mean annual SURO-pervious

SURO from MPE-forced calibration



SURO from CBP-forced calibration



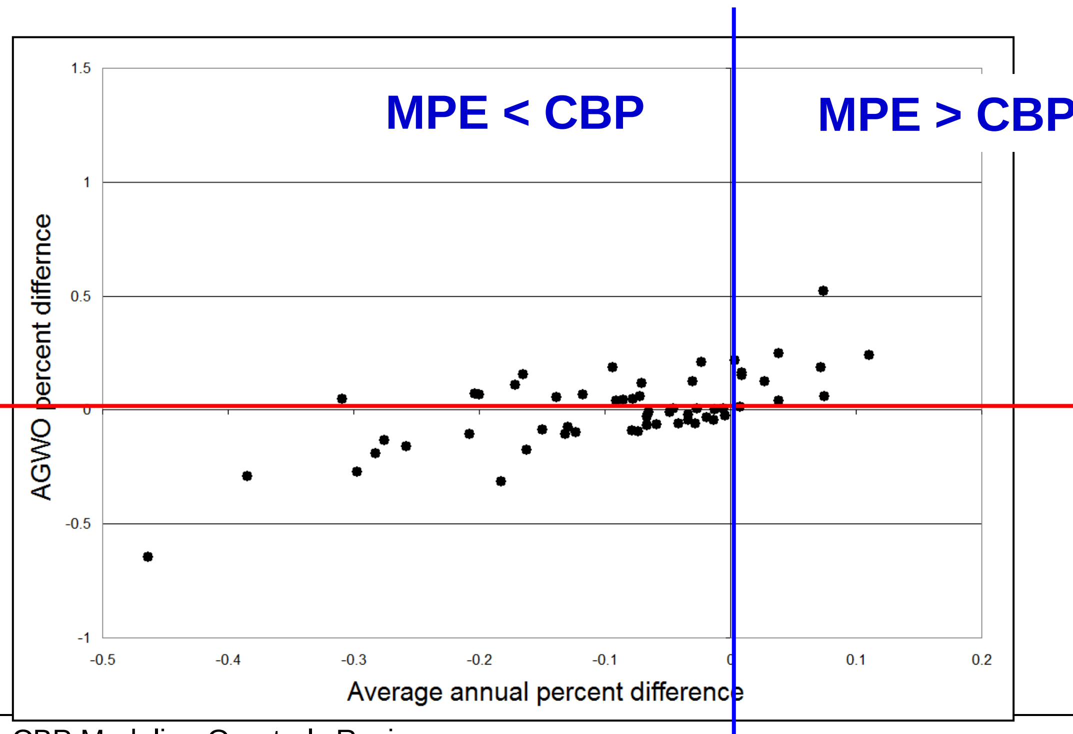
SURO from CBP-forced calibration

IFWO, AGWO

- Subsurface flows are impacted by LZSN, and hence by the choice of precipitation data.
- (Given that SURO is comparable) Less precipitation, expectedly, results in smaller subsurface storage and flow.

$AGWO_{MPE} > AGWO_{CBP}$

$AGWO_{MPE} < AGWO_{CBP}$



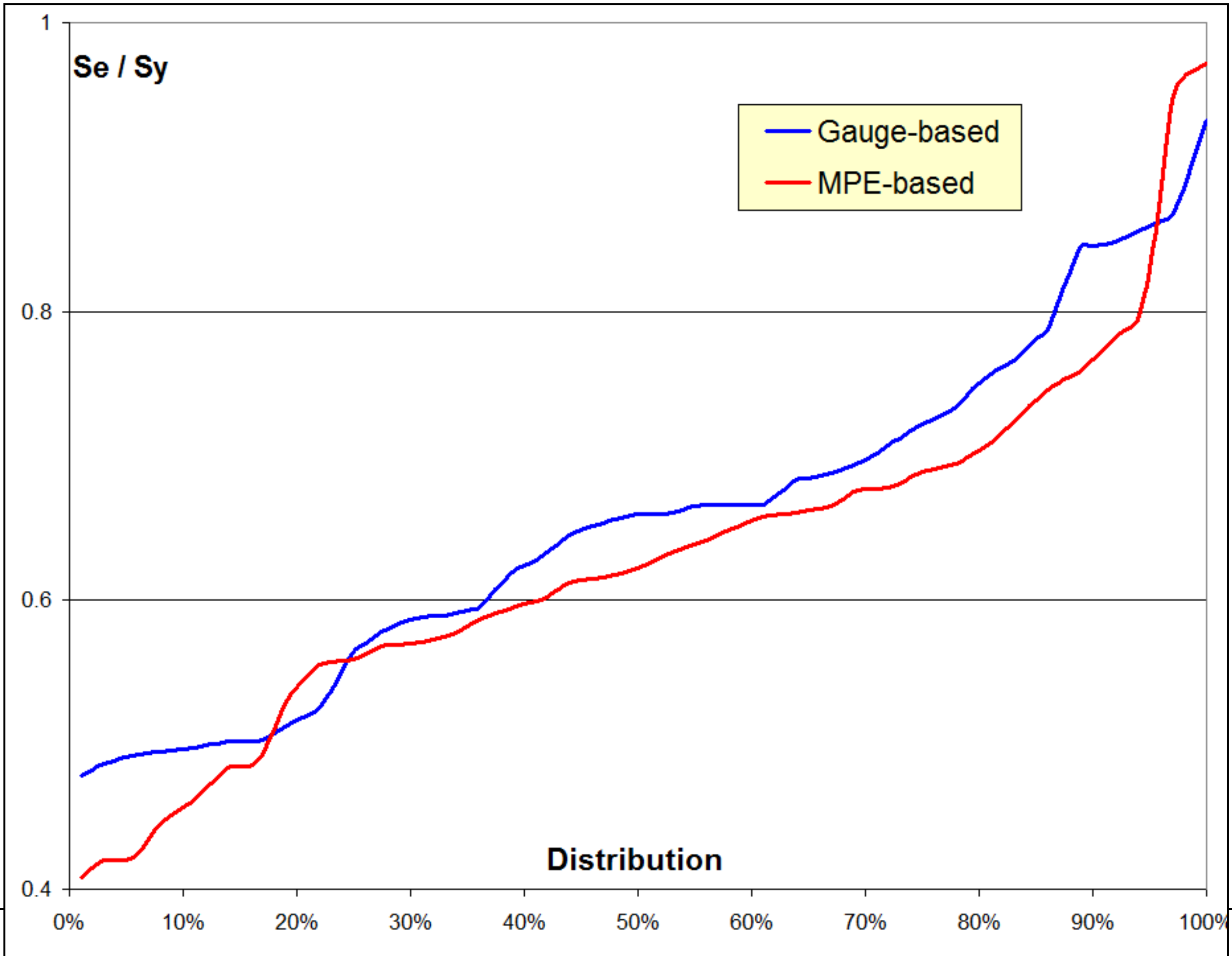
Goodness of streamflow simulation: Nash-Sutcliffe Efficiency (NSE)

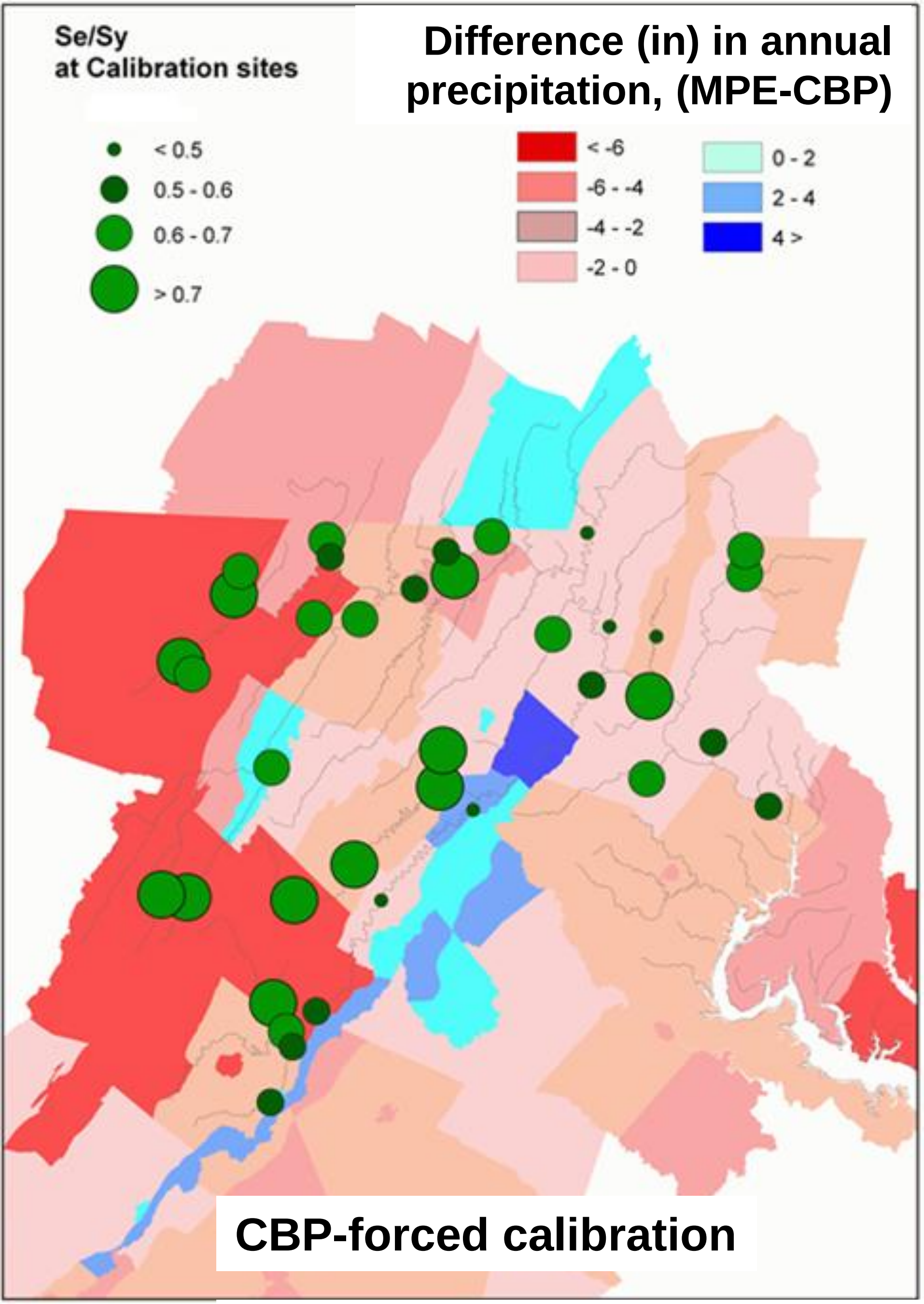
- The higher, the better (1 if perfect)

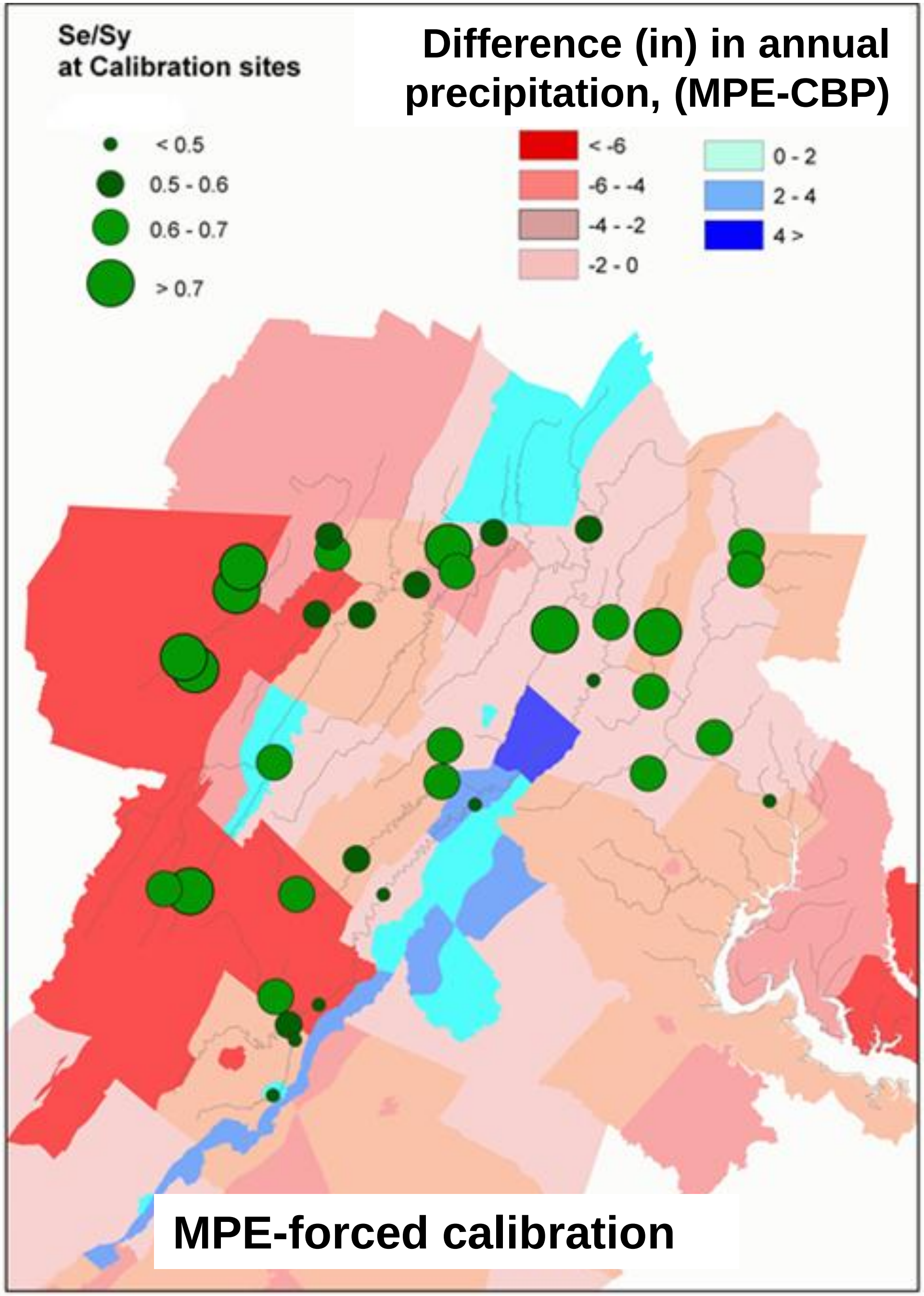
NSE	CBP	MPE
Minimum	0.109	0.054
Q_{25}	0.477	0.525
Median	0.566	0.614
Q_{75}	0.681	0.688
Maximum	0.775	0.839

Goodness of streamflow simulation: Relative standard error of estimate (Se/Sy)

- The smaller, the better (0 if perfect).







Goodness of calibration vs. difference in annual precipitation

Mountainous region

- MPE issues
  - Underestimation and reduced accuracy due to
    - beam blockage
    - vertical profile of reflectivity (VPR)
- CBP issues
  - May not capture spatial variability due to orography
  - Missing data

Summary of findings

- MPE-forced calibration of the CBW model yielded more skillful streamflow simulation than the CBP-forced.
  - It was necessary, however, to adjust the parameter bounds for LZSN.

- Simulated surface flows are similar.
  - The differences in precipitation hence manifest as differences in subsurface storage and flow.
  - Choice of precipitation input hence has significant implications for WQ simulations.

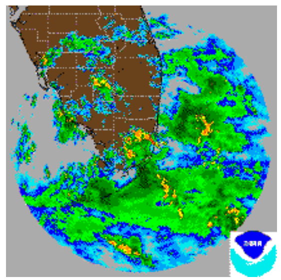
MPE vs. NLDAS precipitation

- Introduce NEXRAD-based and NLDAS precipitation processing system
  - Their ingredients are not independent
  - Understanding of the data sources and data processing will help data selection for planned/envisioned applications by CBP

NEXRAD-based precipitation processing: mid-1990's ~ early 2000's

Stage I

NEXRAD — DPA



HADS — Hourly

Stage II For a single radar domain

Mosaic

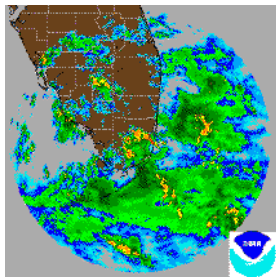
Stage III For each River Forecast Center domain

QC by human forecasters

Regional precipitation product in XMRG format

NEXRAD-based precipitation processing: early 2000's ~

NEXRAD → DPA →



HADS → Hourly →

Satellite Precipitation Estimates (in selected areas only) →

MPE
(MPE, P3, Mountain Mapper)

QC by human forecasters

For each River Forecast Center domain

↓

Regional precipitation products in XMRG format

↓ Mosaic over CONUS

Stage IV (6-hourly, daily)

NLDAS2 precipitation data

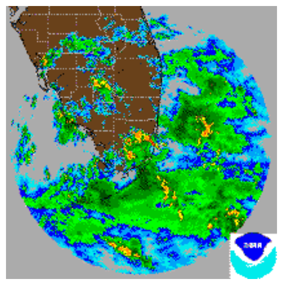
- 1979 ~ mid-1996
  - From North American Regional Reanalysis (NARR)
    - Data assimilation using NCEP Eta (and other models) to generate (re-)analysis of precipitation (and other variables) with spatial resolution of 32 km and 3-hour frequency
- Mid-1996 ~
  - A combination of national Stage 2 and daily gauge-only analysis

NLDAS precipitation processing (post mid-1996)

Stage I

NEXRAD

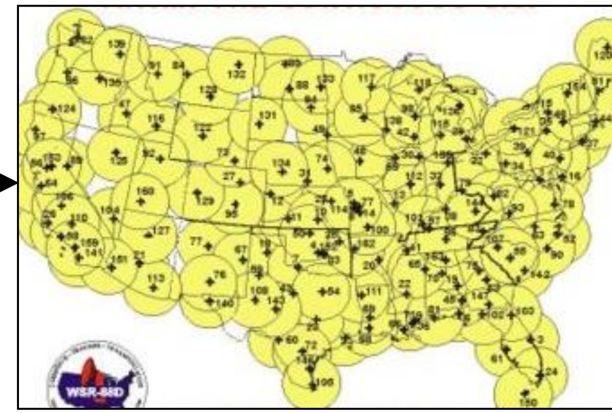
DPA



Hourly

HADS

Stage II algorithms



Automated gauge QC

Daily gauge-only analysis at NCEP/CPC

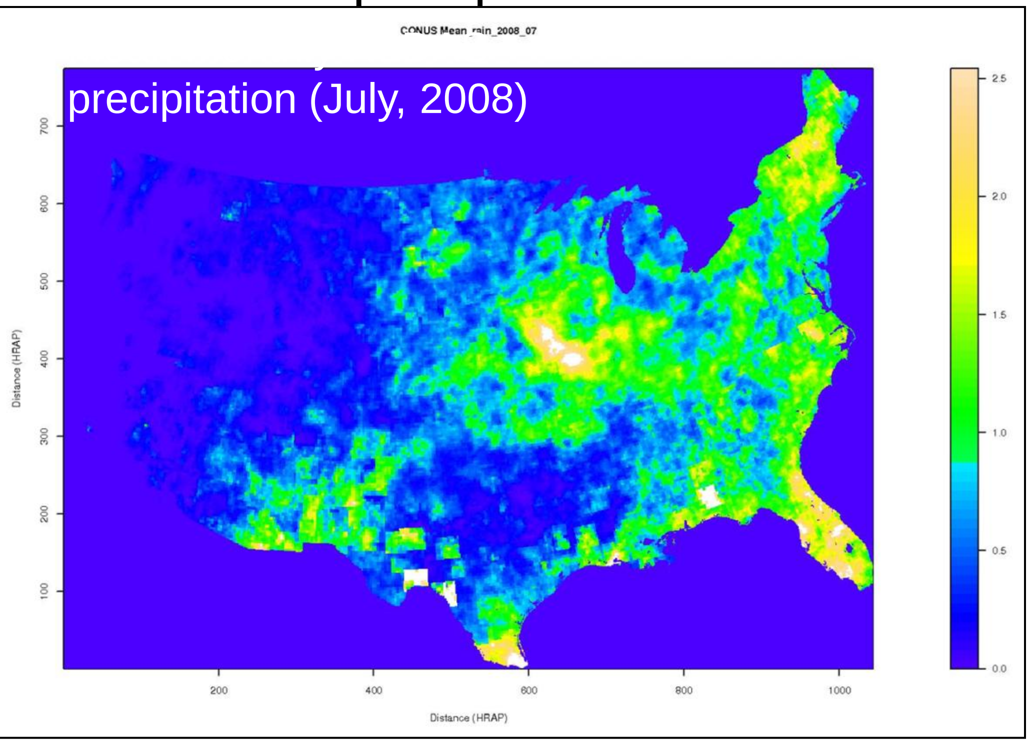
Disaggregation of daily analysis into hourly

National Stage II analysis (hourly) at NCEP/EMC

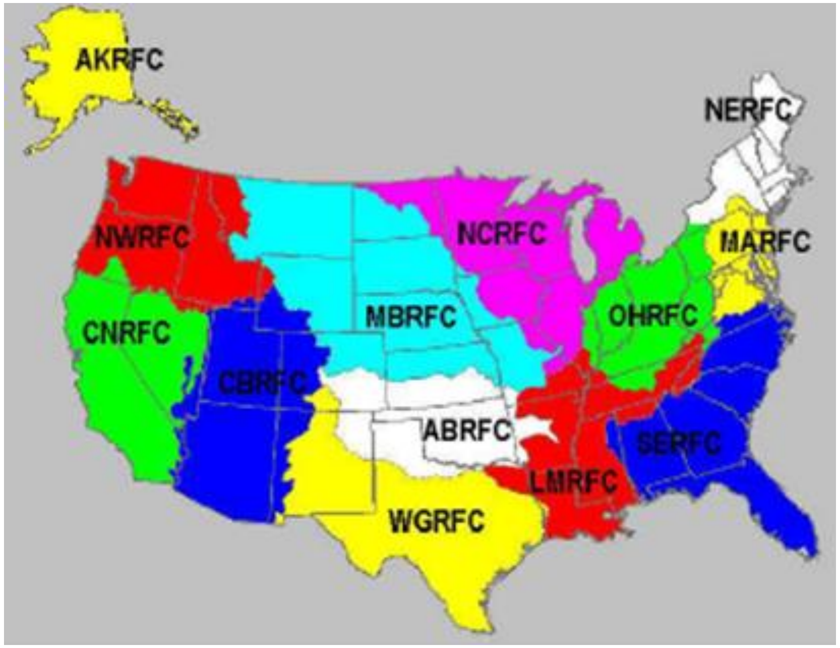
Hourly NLDAS precipitation data

Differences in the two processing systems

- NLDAS precipitation: automatic QC, older algorithms
- Uses daily gauge station data and modeled precipitation from NARR



- MPE: QC'ed by human forecasters at the RFC, newer algorithms
- Uses hourly gauge station data



Data attributes

Product		NLDAS2	MPE
Format		GRIB binary	XMRG binary
Decoder		wgrid	read_xmrg
Coordinate system		Geographic coordinate system	HRAP projection
Resolution	Temporal	1 hour	1 hour
	Spatial	1/8º x 1/8º (12 x 12 km^2) grid	4 x 4 km^2 grid
Period of record		1979~	2001~

Pre-processing for the CBW model

Download MPE XMRG

Download NLDAS GRIB

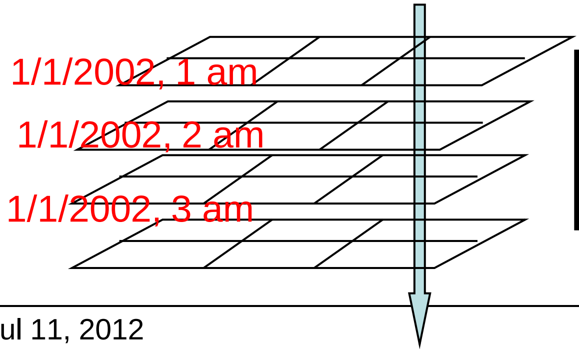
ASCII

Convert ASCII to GIS layer

GIS operations:

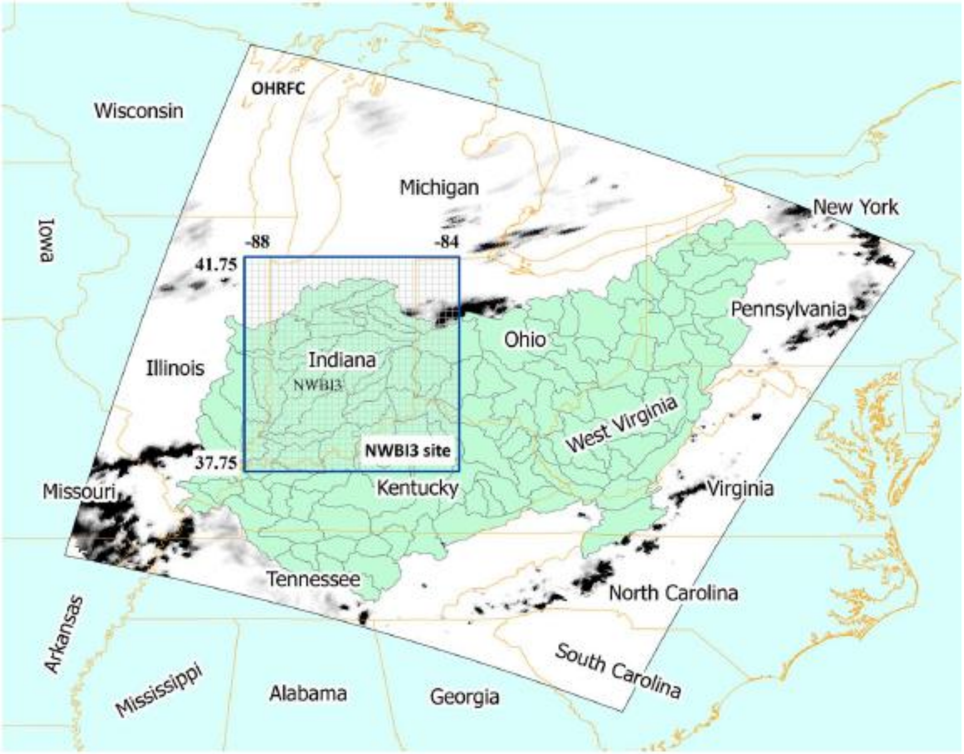
- Project precipitation grid layers over AOI
- Spatially-aggregate to model unit

Time series in wdm file format for a given location



Comparison of MPE and NLDAS precipitation (Nan et al. 2010)

- Analysis domain: 152,000km^2
- Reproject MPE to NLDAS
- Aggregate MPE to NLDAS
- 36,000 Pairs of data points covering 2002 ~ 2007



Comparison of MPE and NLDAS precipitation (Nan et al. 2010) (cont.)

- Results
  - Large differences in magnitude and spatial pattern
  - Temporal correlation is high (mean:0.73)

- Conclusion
  - Their findings support the fusion of the two products because both have their own strength

Concerns and suggestions

- Factors to consider for data selection
  - Spatial resolution (~16km^2 vs. ~144km^2)
  - Future applications of the model
    - For example, (near) real-time hourly data are needed for real time forecasting
- Pre-NEXRAD (before mid-1996) era
  - NLDAS2 precipitation data can be used.
  - Precipitation from NARR (1979 to mid-1996) should be evaluated before putting into the CBW model (ingredient data and information content are different)
- Low bias in MPE precipitation
  - Can be reduced by Post Analysis (PA) using daily gauge data

Reference

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Thank you

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