USE OF SOIL MOISTURE OBSERVATIONS TO REDUCE CALIBRATION UNCERTAINTIES OF A RAINFALL-RUNOFF MODEL

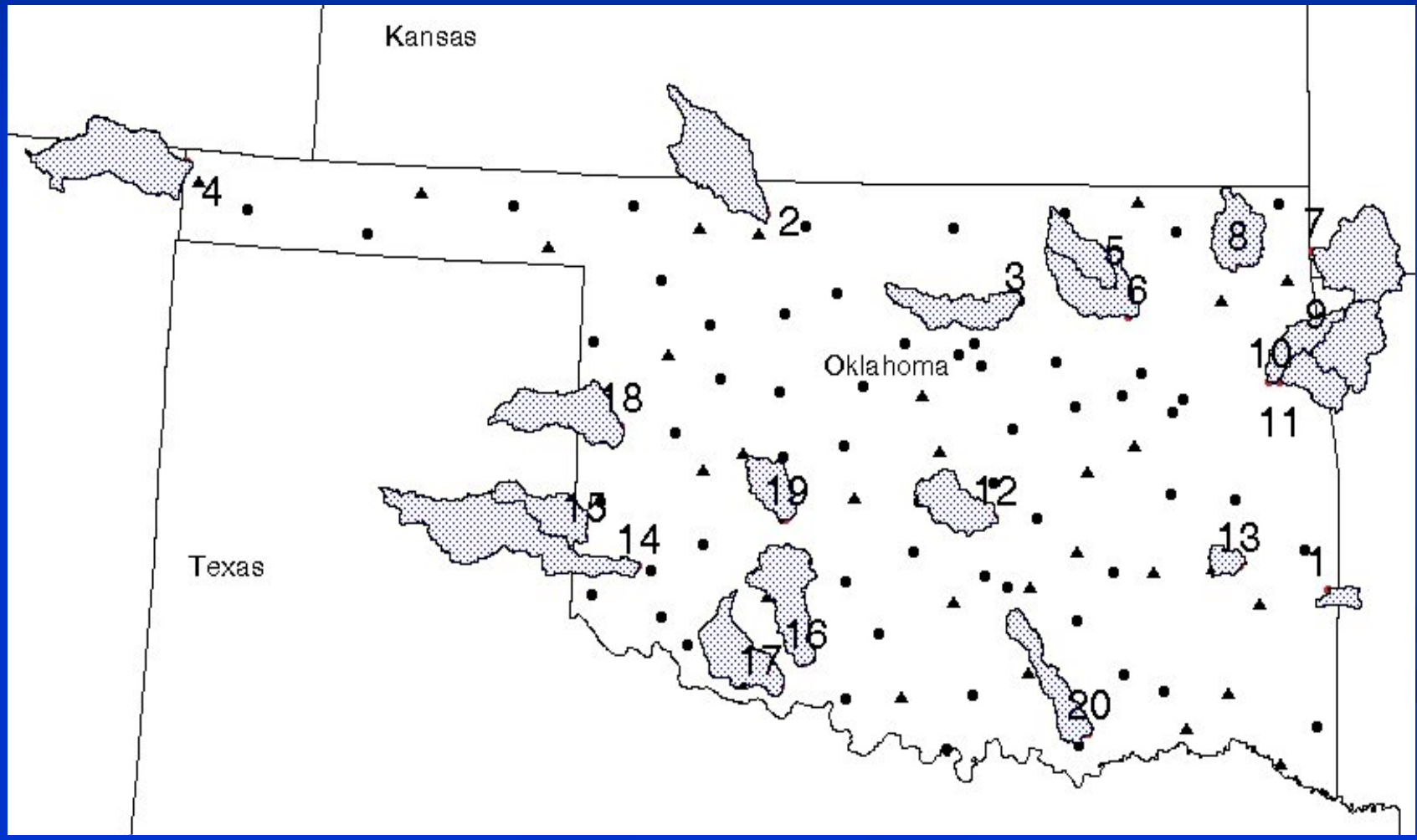
DOH Science Conference
July 17, 2008

Victor Koren, Fekadu Moreda, Michael Smith

Motivation

- Investigate model and parametric uncertainties using Oklahoma Mesonet soil moisture data
- Improve parameter calibration consistency

Oklahoma Mesonet Gauge Network and Test Basins



$$F_q = \sqrt{\left[\sum_{i}^{4}\left(\frac{\sigma_{q,1}}{\sigma_{q,i}} RMSE_{q,i}\right)^2\right]}$$

Calibration Tests

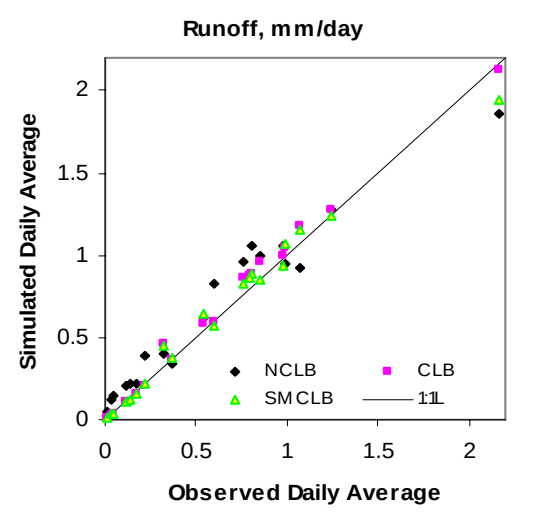
- 20 basins not affected significantly by regulation were selected for calibration tests
- Local pattern search technique was used in parameter estimation
- Two sets of calibration results were analyzed:
  - Calibration criteria (F_q) was based only on outlet hydrograph multi-scale goodness-of-fit ($RMSE_q$)

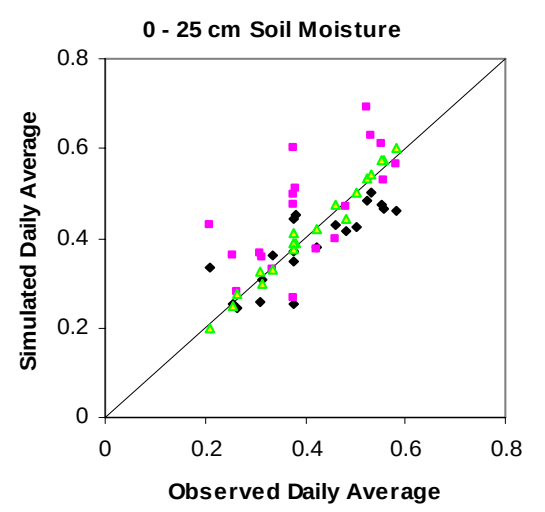
$$F_q = \sqrt{\left[\sum_{i=1}^{4}\left(\frac{\sigma_{q,1}}{\sigma_{q,i}} RMSE_{q,i}\right)^2\right]}$$

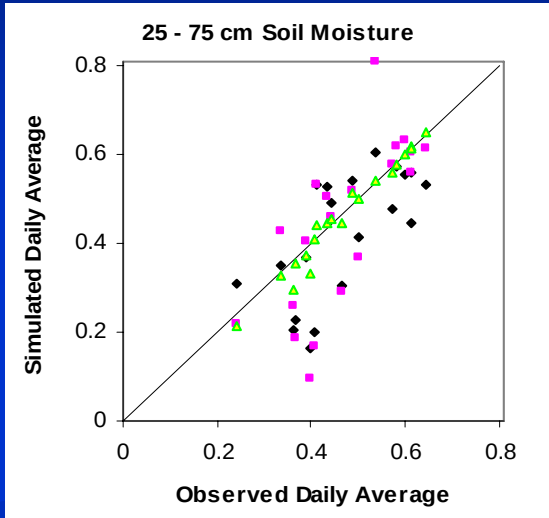
  - Soil moisture simulation errors ($RMSE_{sm}$) at two soil layers were accounted for in addition to discharges. Soil moisture errors were weighted by a ratio of outlet discharge variability to soil moisture variability

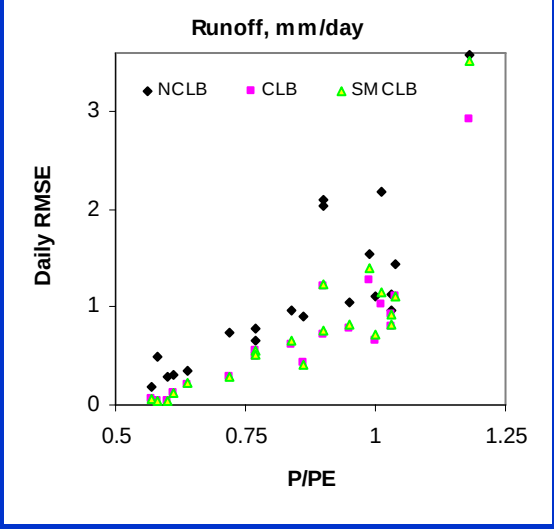
$$F_{q\&sm} = \sqrt{\left[F_q^2 + \sum_{i=1}^{2}\left(\frac{\sigma_{q,1}}{\sigma_{sm,i}} RMSE_{sm,i}\right)^2\right]}$$

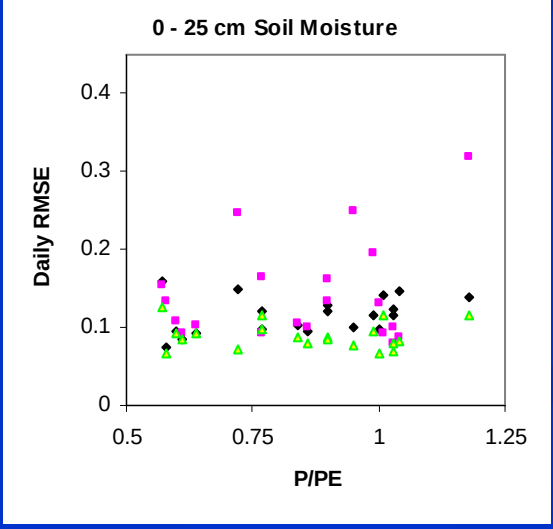
Calibration Results: Statistics of daily runoff and soil moisture simulated using 1) a priori parameters (black), 2) calibrated using runoff only (magenta), and 3) calibrated using runoff and soil moisture (green)

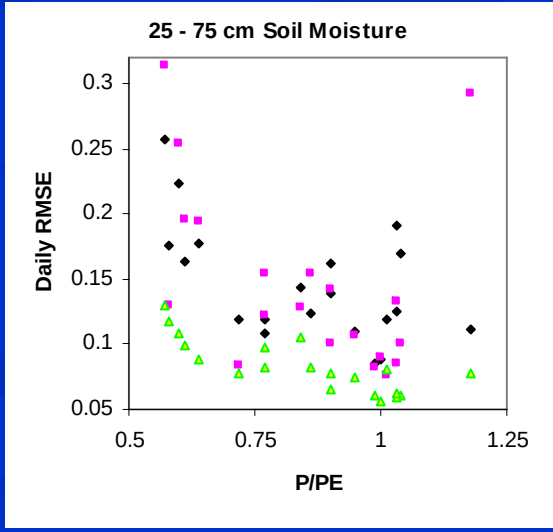




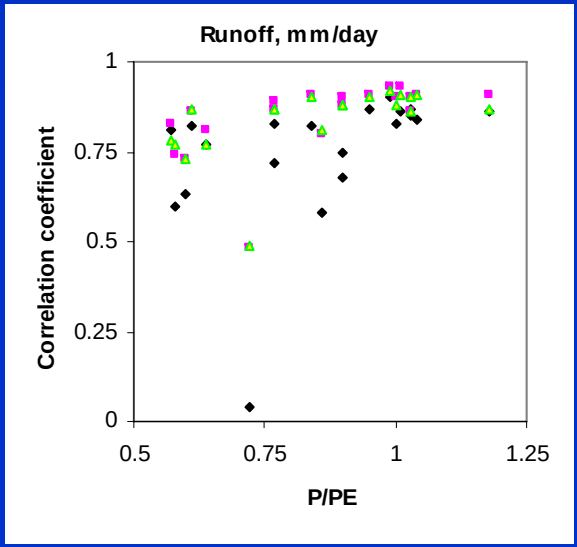


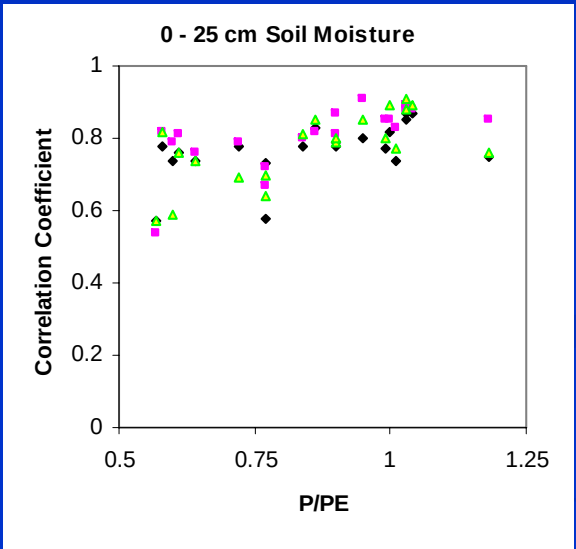


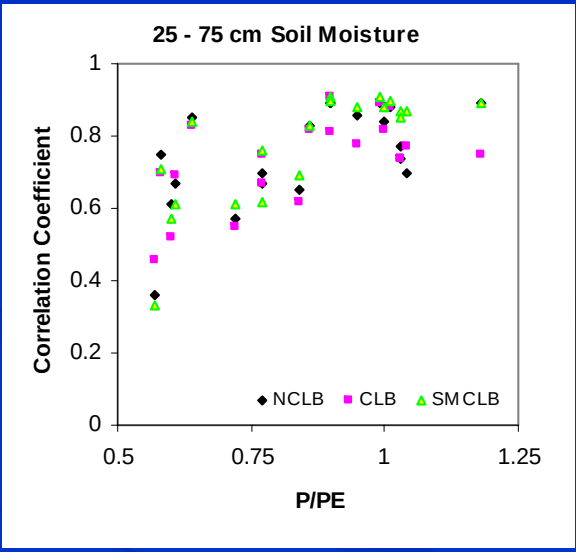




Calibration Results: Correlation coefficient of daily runoff and soil moisture simulated using 1) a priori parameters (black), 2) calibrated using runoff only (magenta), and 3) calibrated using runoff and soil moisture (green)





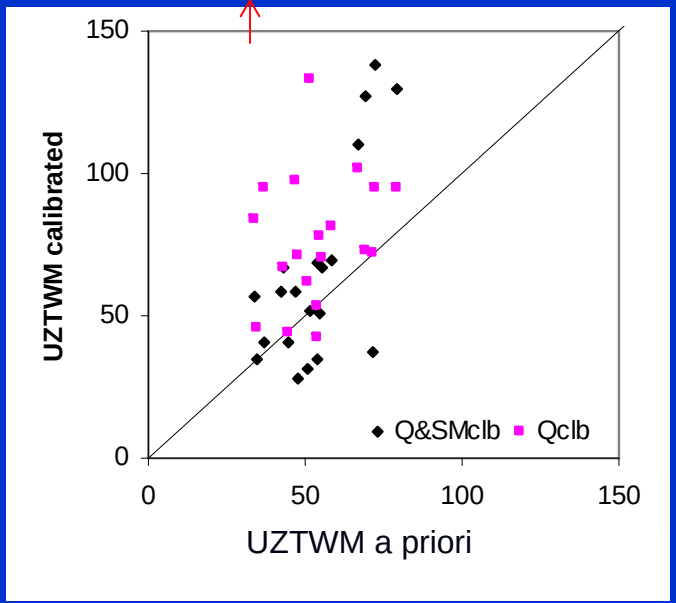


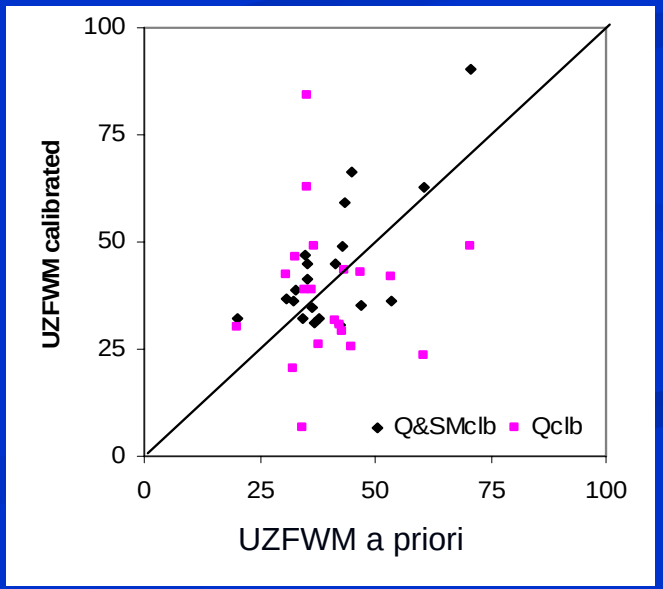
Calibration Results: Comparing model parameters calibrated with and without use of soil moisture measurements

Correlation coefficients between calibrated (with/without soil moisture data) and a priori parameters (higher correlation values are in green)

Parameter ---------- Calibration option	UZTWM	UZFWM	ZPERC	REXP	LZTWM	LZFSM	LZFPM	LZSK	LZPK
With soil m. data	0.70	0.73	0.03	0.73	0.80	0.47	0.25	0.21	0.51
Without soil m. data	-0.06	0.01	-0.21	0.52	-0.05	0.10	0.87	-0.10	0.68

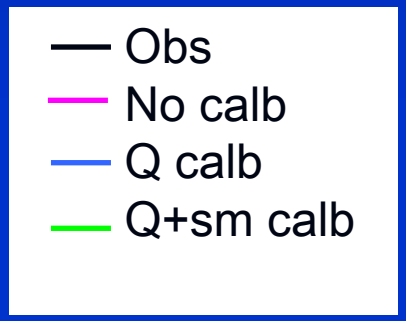
One Qclb point (270mm) is excluded because of scale

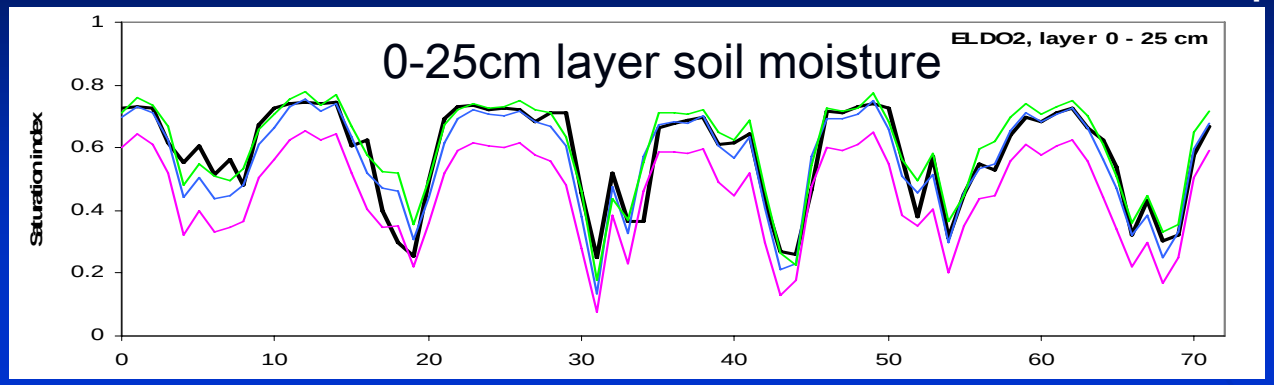


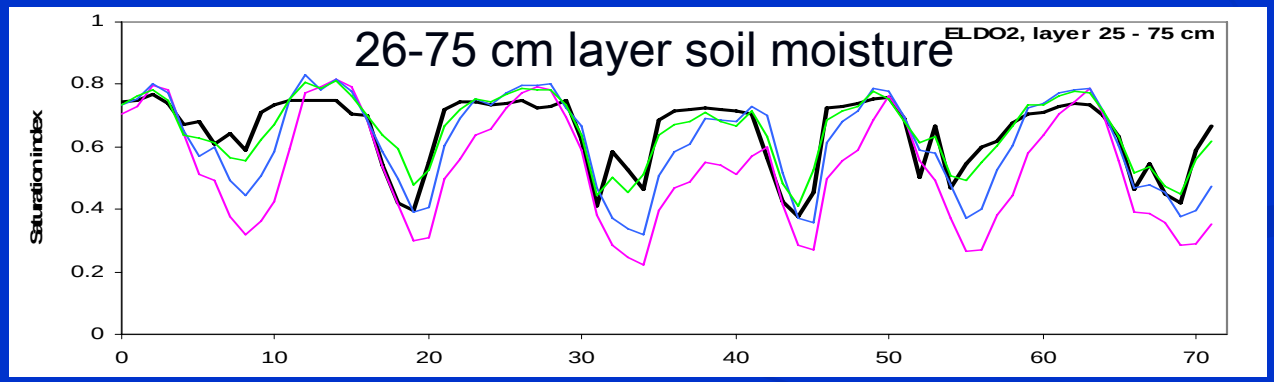


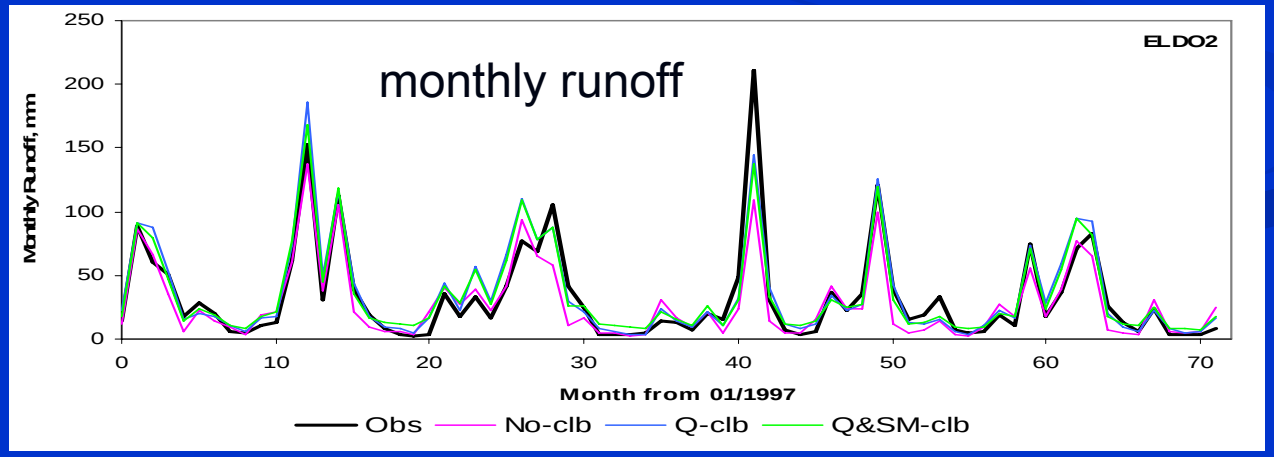
Calibration Results: Monthly soil moisture and runoff estimated from a priori and calibrated parameters with/without use of soil moisture measurements

Case 1. Not much difference in simulated soil moisture between two calibration approaches



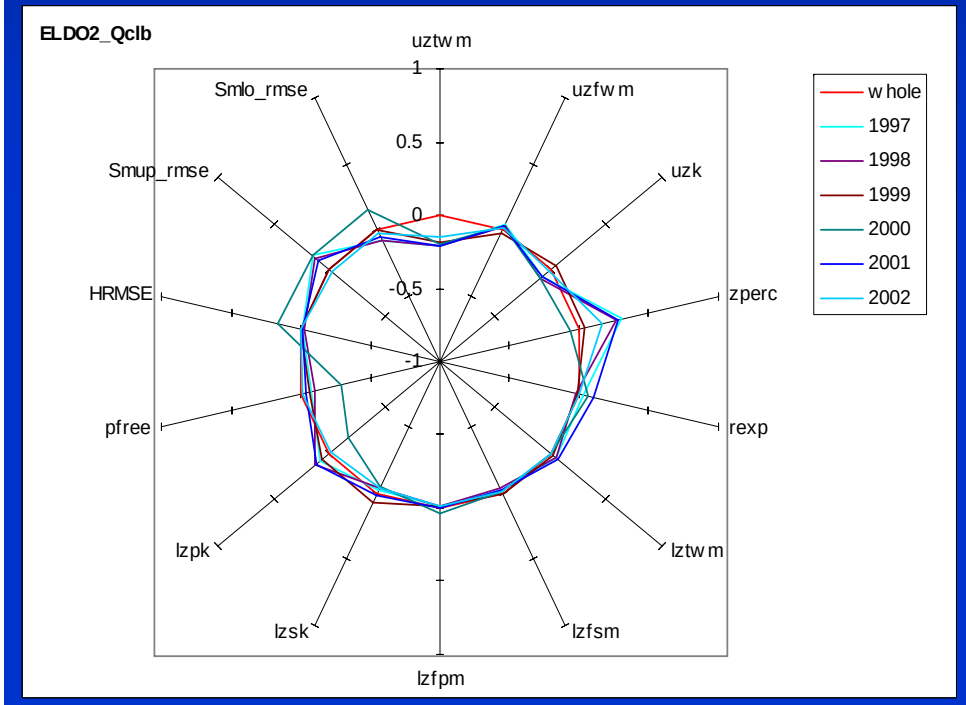


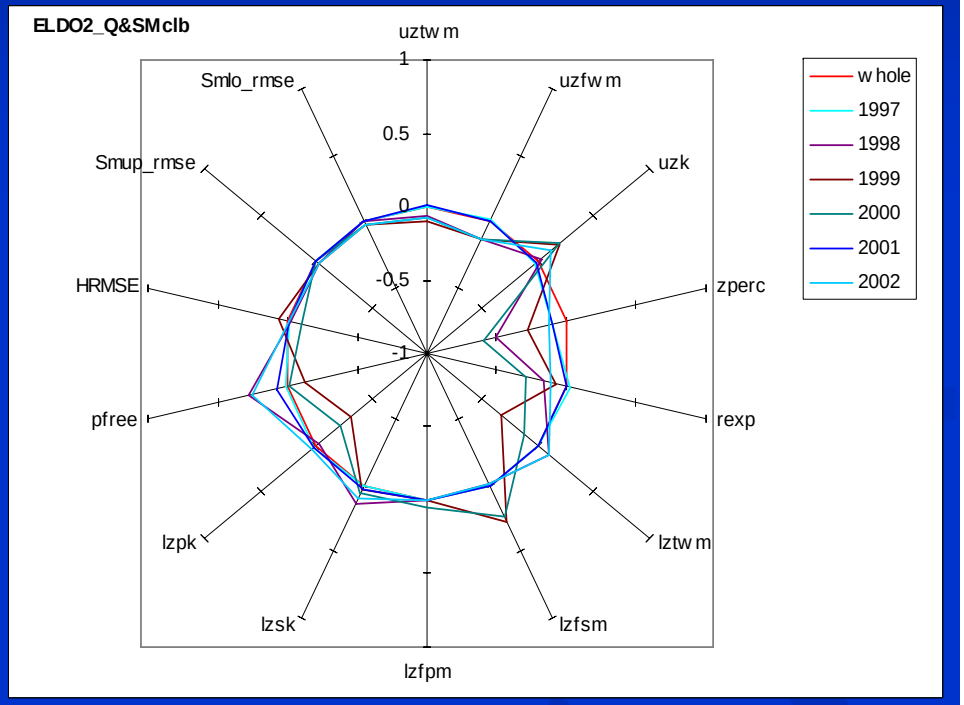




Calibration Results: Change in model parameters calibrated using different data sets and calibration criteria: only outlet hydrograph errors (left); outlet hydrograph and soil moisture errors (right)

Case 1. Not much difference in simulated soil moisture from two calibration approaches





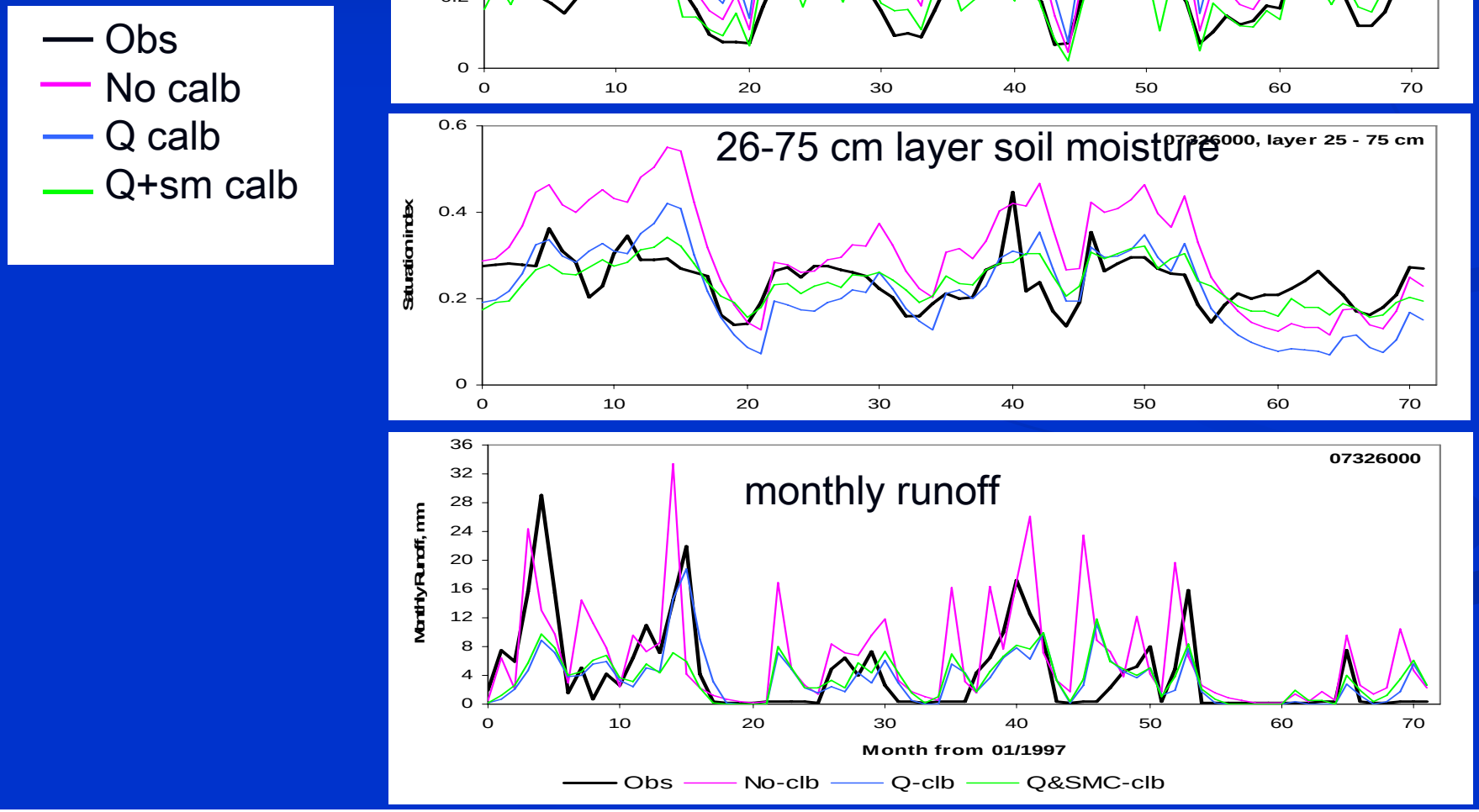
Average Discharge RMSE = 11.9 cms
Average Soil Moisture (upper layer) RMSE = 0.13
Average Soil Moisture (lower layer) RMSE = 0.13

Average Discharge RMSE = 12.1 cms
Average Soil Moisture (upper layer) RMSE = 0.08
Average Soil Moisture (lower layer) RMSE = 0.06

Parameters consistent from year to year in this case

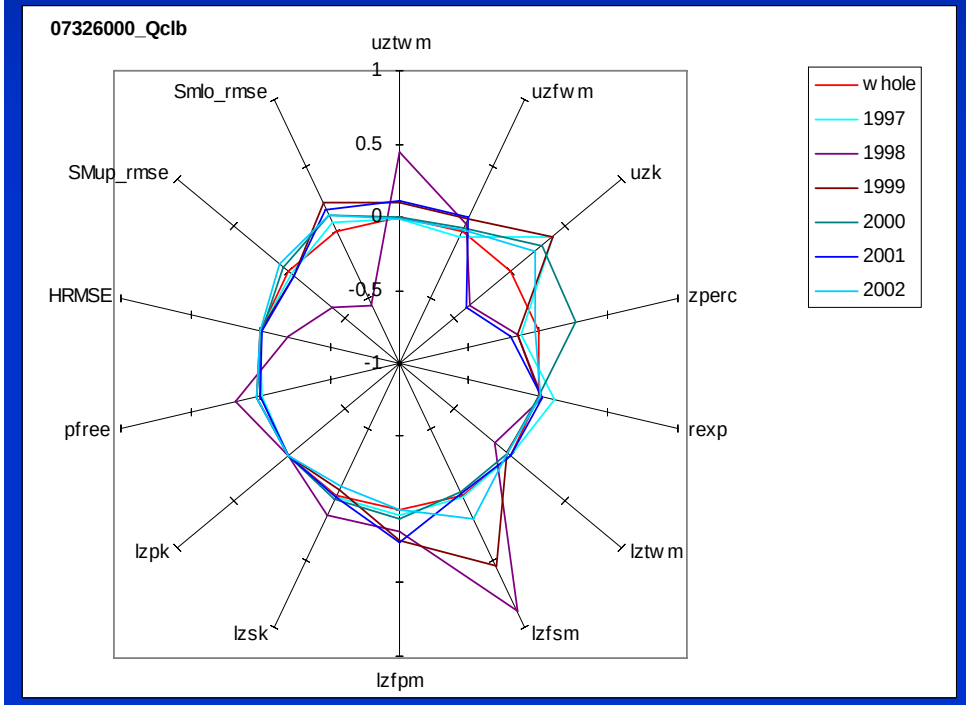
Calibration Results: Monthly soil moisture and runoff estimated from a priori and calibrated parameters with/without use of soil moisture measurements

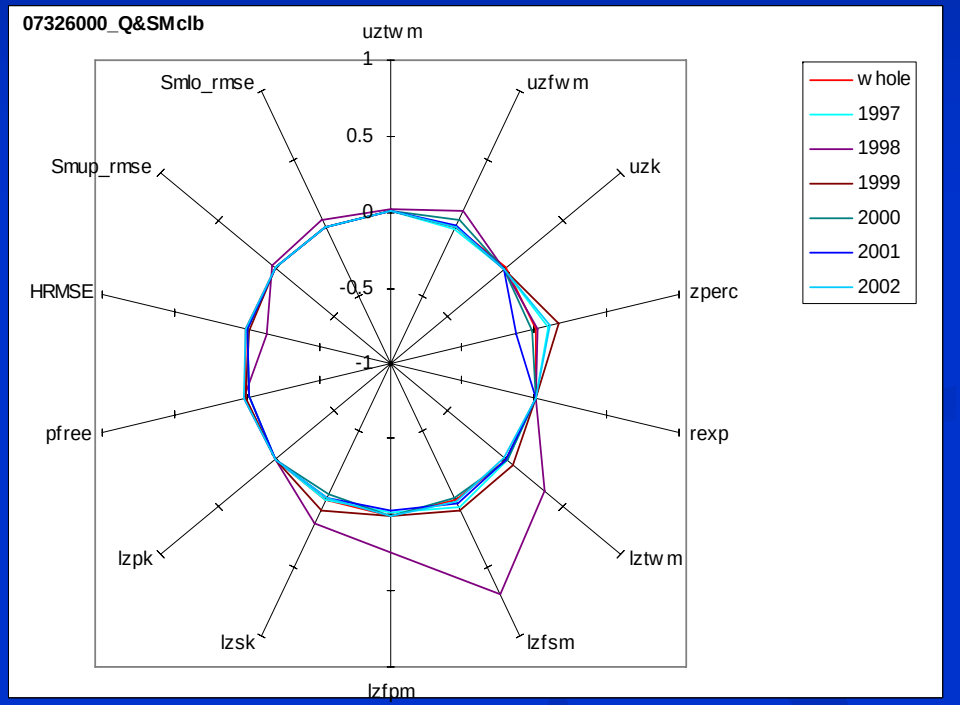
Case 2. Considerable difference in simulated soil moisture between two calibration approaches



Calibration Results: **Change in model parameters calibrated using different data sets and calibration criteria: only outlet hydrograph errors (left); outlet hydrograph and soil moisture errors (right)**

Case 2. Considerable difference in simulated soil moisture from two calibration approaches





Average Discharge RMSE = 2.37 cms
Average Soil Moisture (upper layer) RMSE = 0.34
Average Soil Moisture (lower layer) RMSE = 0.14

Average Discharge RMSE = 2.35 cms
Average Soil Moisture (upper layer) RMSE = 0.07
Average Soil Moisture (lower layer) RMSE = 0.07

Addition of soil moisture reduces uncertainty in this case

Statistics from discharge only (Qclb) & discharge and SM (Q&SMclb) calibration

Basin ID	RMSE		Bias		NS	
	Qclb	Q&SMclb	Qclb	Q&SMclb	Qclb	Q&SMclb
Hourly runoff, cms						
BLUO2	1.012	0.863	-0.026	0.051	0.750	0.820
ELDO2	1.125	1.424	-0.005	-0.133	0.880	0.810
TALO2	0.945	0.929	0.018	0.008	0.680	0.690
TIFM7	0.724	0.801	-0.032	-0.059	0.790	0.740
Average	0.951	1.004	-0.011	-0.033	0.802	0.780
Soil saturation index at 00-25 cm layer						
BLUO2	0.285	0.076	-0.260	0.003	-5.640	0.530
ELDO2	0.097	0.082	-0.021	-0.021	0.680	0.770
TALO2	0.125	0.069	0.085	-0.013	0.370	0.810
TIFM7	0.111	0.066	0.044	-0.008	0.370	0.780
Average	0.154	0.073	-0.038	-0.010	-0.135	0.744
Soil saturation index at 25-75 cm layer						
BLUO2	0.215	0.070	-0.189	-0.005	-2.360	0.650
ELDO2	0.125	0.061	-0.065	-0.004	-0.020	0.750
TALO2	0.092	0.062	-0.036	-0.007	0.400	0.730
TIFM7	0.141	0.057	-0.113	0.007	-0.460	0.760
Average	0.143	0.062	-0.100	-0.002	-0.447	0.725

SUMMARY

- Test results suggest that hydrograph-based calibration improves simulation results for all studied basins. However, significant soil moisture biases can be observed which can be larger than those generated from the a priori parameters
- Use of soil moisture data in calibration process reduces simulated soil moisture biases without considerable reduction in runoff accuracy. However, soil moisture measurement uncertainties should be accounted properly
- Calibration tests with different data sets suggest that the use of soil moisture observations reduces parametric uncertainty