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Supplement of

**A parallel workflow implementation for PEST version 13.6 in
high-performance computing for WRF-Hydro version 5.0:
a case study over the midwestern United States**

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This supplementary file includes two figures and three tables:

Figure S1. Spatio-temporal patterns of daily averaged precipitation (mm) during April 8-19 2013.

Figure S2. Observed and modeled discharge (m³/sec) using default and calibrated parameters during a 3-day calibration period (April 19–21, 2013) over four local stations.

Table S1. Parameters calculated using the 3-day calibration, based on calibration of Stations 1, 2, 3, and 4 shown in Figure 1. The calibration considers 48 parameters using estimation mode; does not consider weights for different stations.

Table S2: Calibrated 22 parameters and the optimum parameters found after five iterations, based on four local USGS stations. The station numbers are: 05568500, 05474000, 05465500, and 05558300.

Table S3: Statistics of model performance using optimum and default (in parentheses) parameters for local stations during the calibration period.

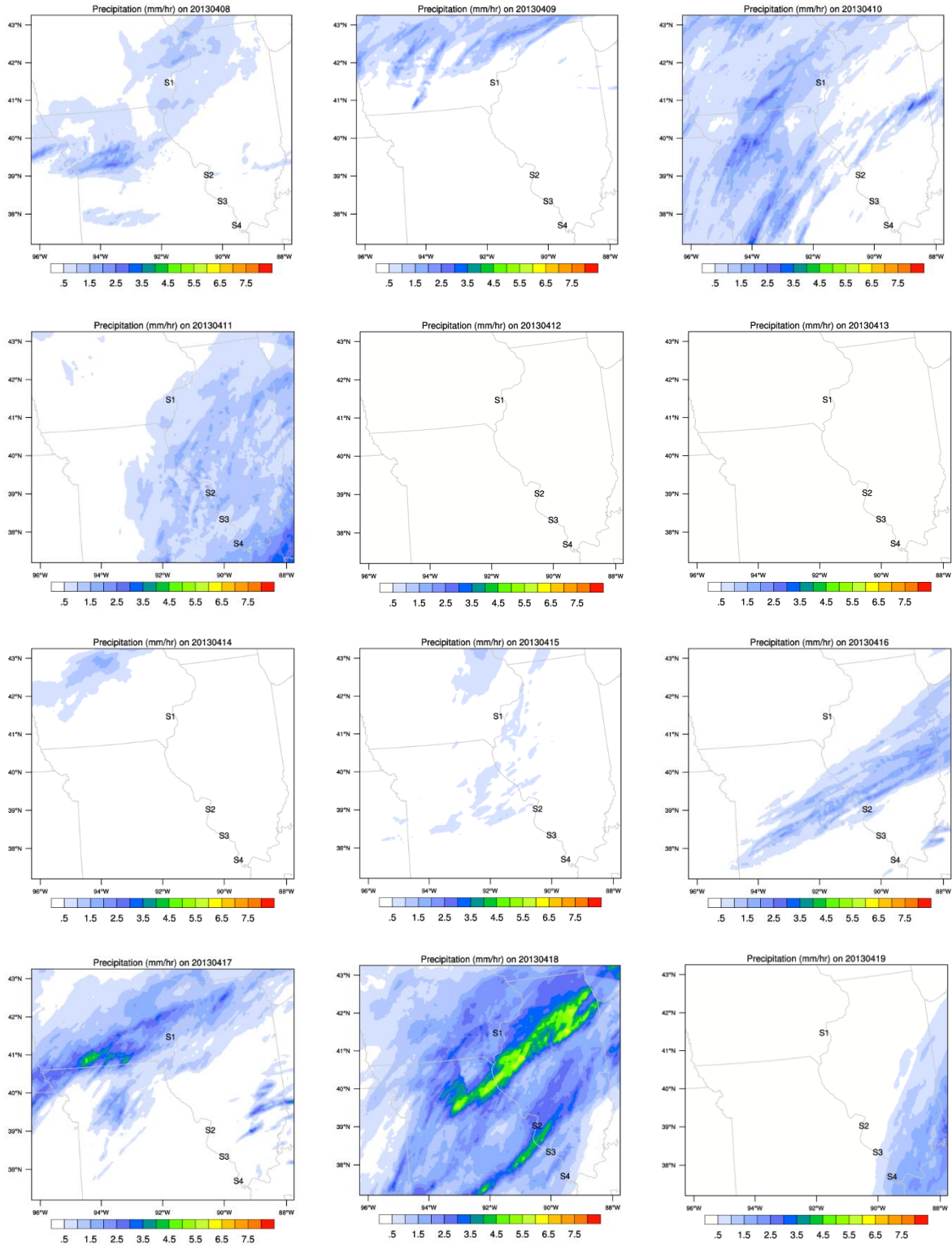


Figure S1. Spatio-temporal patterns of daily averaged precipitation (mm) during April 8-19 2013.

Table S1: Parameters calculated using the 3-day calibration, based on calibration of Stations 1, 2, 3, and 4 shown in Figure 1 in the main paper. The calibration considers 48 parameters using estimation mode; does not consider weights for different stations.

| Calibrated parameters | Default | Lower Bound | Upper Bound | Optimum Parameters |
|-----------------------|----------|-------------|-------------|--------------------|
| mannn1 | 0.55 | 0.05 | 0.6 | 0.199596 |
| mannn2 | 0.35 | 0.05 | 0.6 | 0.218347 |
| mannn3 | 0.15 | 0.05 | 0.5 | 8.84E-02 |
| mannn4 | 0.1 | 0.05 | 0.5 | 5.00E-02 |
| mannn5 | 7.00E-02 | 0.01 | 0.3 | 4.10E-02 |
| mannn6 | 5.00E-02 | 0.01 | 0.3 | 2.03E-02 |
| mannn7 | 4.00E-02 | 0.01 | 0.2 | 1.26E-02 |
| mannn8 | 3.00E-02 | 0.001 | 0.1 | 2.45E-03 |
| mannn9 | 2.00E-02 | 0.001 | 0.05 | 4.87E-02 |
| mannn10 | 1.00E-02 | 0.001 | 0.05 | 1.00E-03 |
| xslope1 | 0.1 | 1.00E-04 | 1 | 0.412796 |
| xslope2 | 0.6 | 1.00E-04 | 1 | 0.6 |
| xslope3 | 1 | 1.00E-04 | 1 | 1 |
| xslope4 | 0.35 | 1.00E-04 | 1 | 0.351282 |
| xslope5 | 0.55 | 1.00E-04 | 1 | 0.547404 |
| xslope6 | 0.8 | 1.00E-04 | 1 | 0.801104 |
| xslope7 | 0.63 | 1.00E-04 | 1 | 0.63 |
| xslope8 | 1.00E-06 | 1.00E-08 | 1 | 1.00E-06 |
| xslope9 | 1.00E-06 | 1.00E-08 | 1 | 1.00E-06 |
| refdk | 2.00E-06 | 1.00E-09 | 1.00E+02 | 2.10E-07 |
| refkdt | 1 | 0.01 | 10 | 1.72369 |
| ovn1 | 2.50E-02 | 0.005 | 0.35 | 5.07E-03 |
| ovn2 | 3.50E-02 | 0.005 | 0.35 | 0.103207 |
| ovn3 | 3.50E-02 | 0.005 | 0.35 | 9.19E-02 |
| ovn4 | 5.50E-02 | 0.005 | 0.35 | 5.50E-02 |
| ovn5 | 3.50E-02 | 0.005 | 0.35 | 1.63E-02 |
| ovn6 | 6.80E-02 | 0.005 | 0.35 | 4.60E-02 |
| ovn7 | 5.50E-02 | 0.005 | 0.35 | 5.00E-03 |
| ovn8 | 5.50E-02 | 0.005 | 0.35 | 5.50E-02 |
| ovn9 | 5.50E-02 | 0.005 | 0.35 | 5.50E-02 |
| ovn10 | 5.50E-02 | 0.005 | 0.35 | 0.299628 |
| ovn11 | 0.2 | 0.005 | 0.35 | 0.314094 |
| ovn12 | 0.2 | 0.005 | 0.35 | 0.199799 |
| ovn13 | 0.2 | 0.005 | 0.35 | 0.199799 |
| ovn14 | 0.2 | 0.005 | 0.35 | 4.27E-02 |
| ovn15 | 0.2 | 0.005 | 0.35 | 2.29E-02 |

| | | | | |
|-------|----------|----------|------|----------|
| ovn16 | 5.00E-03 | 0.005 | 0.35 | 5.00E-03 |
| ovn17 | 7.00E-02 | 0.005 | 0.35 | 4.92E-02 |
| ovn18 | 7.00E-02 | 0.005 | 0.35 | 4.92E-02 |
| ovn19 | 3.50E-02 | 0.005 | 0.35 | 2.06E-02 |
| ovn20 | 5.50E-02 | 0.005 | 0.35 | 5.50E-02 |
| ovn21 | 5.50E-02 | 0.005 | 0.35 | 5.50E-02 |
| ovn22 | 5.50E-02 | 0.005 | 0.35 | 5.50E-02 |
| ovn23 | 5.50E-02 | 0.005 | 0.35 | 5.50E-02 |
| ovn24 | 1.00E-02 | 0.005 | 0.35 | 2.00E-02 |
| ovn25 | 1.00E-02 | 0.005 | 0.35 | 2.00E-02 |
| ovn26 | 0.1 | 0.005 | 0.35 | 9.94E-02 |
| ovn27 | 1.00E-02 | 0.005 | 0.35 | 2.00E-02 |
| ovn28 | 5.00E-03 | 5.00E-04 | 0.35 | 5.00E-04 |

Table S2: Calibrated 22 parameters and the optimum parameters found after five iterations, based on four local USGS stations. The station numbers are: 05568500, 05474000, 05465500, and 05558300.

| Calibrated Parameter | Default | Lower Bound | Upper Bound | Optimum Parameter |
|--------------------------|----------|-------------|-------------|-------------------|
| mann1 | 0.55 | 0.35 | 0.6 | 0.6 |
| mann2 | 0.35 | 0.15 | 0.35 | 0.32004 |
| mann3 | 0.15 | 0.08 | 0.15 | 8.00E-02 |
| mann4 | 0.1 | 0.05 | 0.15 | 5.00E-02 |
| mann5 | 7.00E-02 | 0.02 | 0.1 | 6.24E-02 |
| mann6 | 5.00E-02 | 0.015 | 0.1 | 8.24E-02 |
| mann7 | 4.00E-02 | 0.01 | 0.08 | 2.33E-02 |
| mann8 | 3.00E-02 | 0.005 | 0.06 | 5.00E-03 |
| xslope1 | 0.1 | 1.00E-04 | 1 | 0.235462 |
| refdk | 2.00E-06 | 1.00E-08 | 1.00E-05 | 1.94E-07 |
| refkdt | 1 | 0.01 | 5 | 1.00E-02 |
| ovn1 (urban) | 2.50E-02 | 0.005 | 0.06 | 6.00E-02 |
| ovn2 (dry crop) | 3.50E-02 | 0.015 | 0.06 | 6.00E-02 |
| ovn3 (irrigated crop) | 3.50E-02 | 0.015 | 0.06 | 6.00E-02 |
| ovn5 (crop/grass) | 3.50E-02 | 0.015 | 0.06 | 1.50E-02 |
| ovn6 (crop/wood) | 6.80E-02 | 0.035 | 0.25 | 3.50E-02 |
| ovn7 (grass) | 5.50E-02 | 0.015 | 0.25 | 1.50E-02 |
| ovn10 (savanna) | 5.50E-02 | 0.015 | 0.3 | 1.50E-02 |
| ovn11 (deciduous forest) | 0.2 | 0.1 | 0.3 | 0.3 |
| ovn14 (evergreen forest) | 0.2 | 0.1 | 0.3 | 0.3 |
| ovn15 (mixed forest) | 0.2 | 0.1 | 0.3 | 0.197712 |
| ovn16 (water) | 5.00E-03 | 0.001 | 0.01 | 1.00E-03 |

Table S3: Statistics of model performance using optimum and default (in parentheses) parameters for local stations during the calibration period.

| Statistics | 0556855 | 05474000 | 05465500 | 05558300 |
|------------|------------------------|------------------------|-----------------------|------------------------|
| | Calibration | | | |
| NSE | 0.30 (-0.46) | -8.5 (-46.6) | 0.45 (-1.28) | -7.11 (-16.6) |
| RMSE | 431.88 (624.95) | 235.25 (526.44) | 351.18 (716.0) | 1579.9 (2329.9) |
| PCC | 0.96 (0.30) | 0.54 (-0.86) | 0.78 (0.33) | 0.70 (-0.23) |

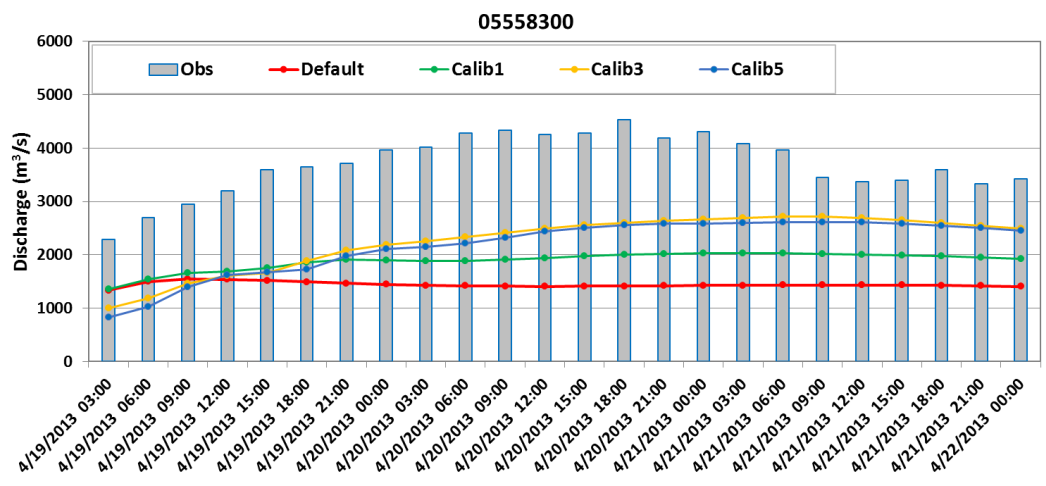
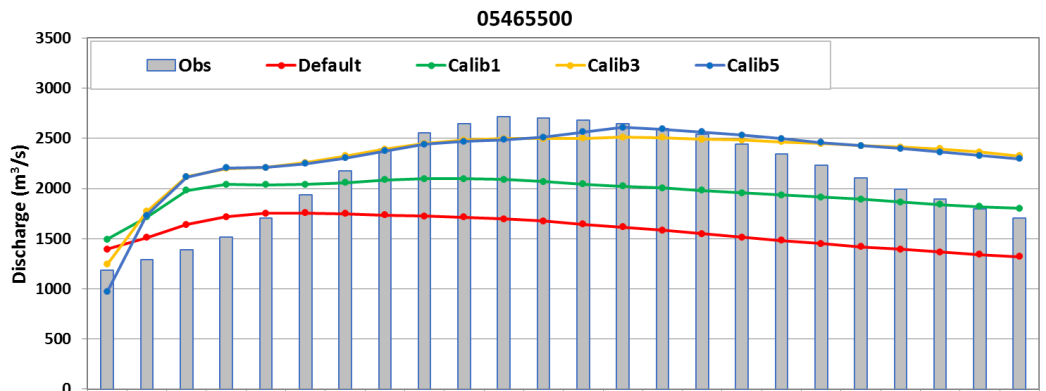
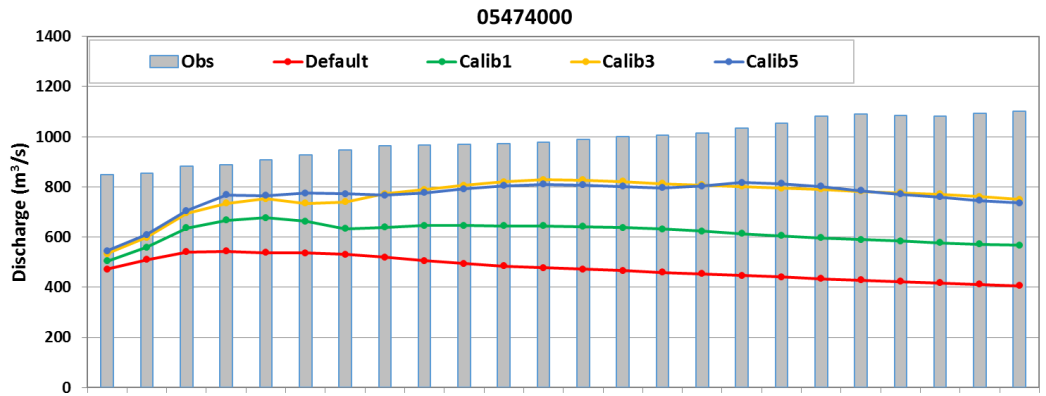
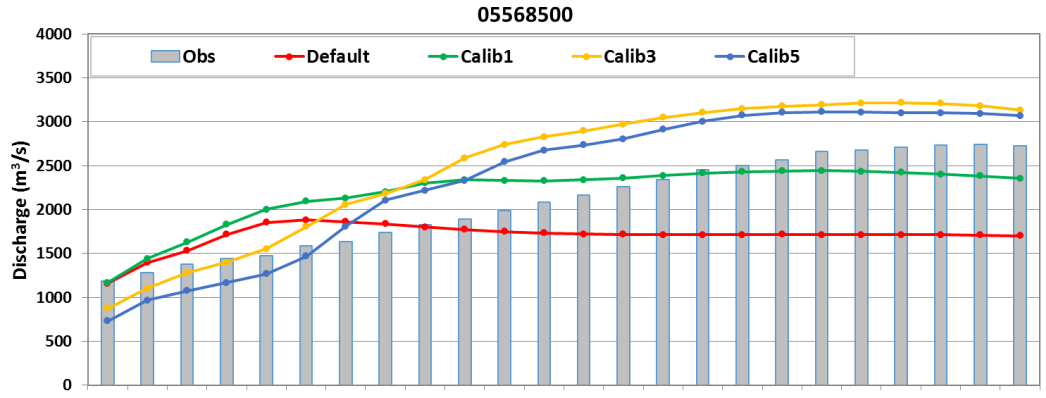


Figure S2: Observed and modeled discharge (m^3/sec) using default and calibrated parameters during a 3-day calibration period (April 19–21, 2013) over four local stations. Station numbers are indicated on top of each panel.