



Supplement of

Flow pathways and nutrient transport mechanisms drive hydrochemical sensitivity to climate change across catchments with different geology and topography

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SI1: Illustration of mechanisms of data flow through the INCA model (adapted from Crossman et al., 2012)



SI2: Conceptual diagram of the nutrient flow pathways within the INCA-P model (adapted from Crossman et al., 2012). P: Phosphorus; TDP: Total Dissolved Phosphorus; PP: Particulate Phosphorus;



SI3: Detailed site schematic of each study area, including location of sewage treatment work (STW) inputs



SI 4: Monthly delta change (temperature) of each perturbed physics ensemble member (Q0-Q15) within A) Holland B) Pefferlaw C) Beaver D) Whites.



SI 5: Monthly delta change (precipitation) of each perturbed physics ensemble member (Q0-Q15) within A) Holland B) Pefferlaw C) Beaver D) Whites



SI 6: Average seasonal TDP concentrations within soil water of the Holland River catchment (monthly averages over the calibration period).

| Date | Catchment | change in temperature (°C) | | | Uncertainty (°C) | | | Change in precipitation (%) | | | Uncertainty (%) | | |
|------|-----------|-------------------------------|-------|-------|------------------|-------|-------|--------------------------------|-------|-------|-----------------|-------|-------|
| | | 10 % | 50 % | 90 % | 10% | 50 % | 90 % | 10 % | 50 % | 90 % | 10% | 50 % | 90 % |
| | | level | level | level | level | level | level | level | level | level | level | level | level |
| 2030 | Holland | 1.7 | 2.6 | 3.2 | 0.6 | 1.1 | 0.9 | -16.0 | 4.2 | 25.4 | 14.7 | 12.8 | 25.5 |
| | Pefferlaw | 1.7 | 2.5 | 3.2 | 0.6 | 1.1 | 1.0 | -18.9 | 1.8 | 22.3 | 9.9 | 14.1 | 19.6 |
| | Beaver | 1.6 | 2.6 | 3.1 | 0.6 | 1.2 | 1.0 | -20.6 | 2.7 | 28.1 | 12.0 | 10.8 | 22.5 |
| | Whites | 1.6 | 2.6 | 3.1 | 0.6 | 1.1 | 1.1 | -20.1 | 4.0 | 27.4 | 16.4 | 18.3 | 24.8 |
| 2070 | Holland | 3.6 | 5.0 | 6.7 | 1.8 | 1.9 | 1.8 | -23.7 | 7.6 | 39.3 | 31.7 | 13.9 | 24.3 |
| | Pefferlaw | 3.6 | 5.1 | 6.8 | 1.8 | 2.0 | 1.7 | -28.1 | 4.2 | 31.5 | 34.8 | 14.0 | 25.4 |
| | Beaver | 3.6 | 5.1 | 6.7 | 1.8 | 2.0 | 1.8 | -27.9 | 4.3 | 37.3 | 33.2 | 16.8 | 21.3 |
| | Whites | 3.6 | 5.1 | 6.8 | 1.8 | 2.0 | 1.8 | -27.0 | 3.5 | 35.6 | 26.0 | 19.1 | 29.1 |

SI7: PPE ensemble average model projections and associated uncertainty of temperature change (°C) and precipitation change (%) at the 10%, 50% and 90% probability levels (1 d.p).



SI 8: Boxplot of seasonal changes in temperature across all PPE members in A) Holland B) Pefferlaw C) Beaver and D) Whites



SI 9: Boxplot of seasonal changes in precipitation across all PPE members in A) Holland B) Pefferlaw C) Beaver and D) Whites

| | | Chan | ge in flov | v (%) | Uncertainty (%) | | | | |
|------|-----------|-------|------------|-------|-----------------|-------|-------|--|--|
| Date | Catchment | 10 % | 50 % | 90 % | 10% | 50 % | 90 % | | |
| | | level | level | level | level | level | level | | |
| 2020 | Holland | -24.4 | -0.7 | 59.1 | 18.1 | 31.2 | 44.6 | | |
| | Pefferlaw | -23.2 | -2.1 | 36.7 | 23.0 | 34.3 | 45.7 | | |
| 2050 | Beaver | -37.2 | -2.8 | 30.2 | 20.6 | 42.1 | 50.9 | | |
| | Whites | -42.9 | -2.1 | 51.3 | 13.8 | 18.8 | 25.3 | | |
| | Holland | -37.1 | -5.8 | 91.6 | 11.4 | 33.6 | 41.7 | | |
| 2070 | Pefferlaw | -41.5 | -8.2 | 49.1 | 27.5 | 30.6 | 39.1 | | |
| 2070 | Beaver | -57.8 | -20.4 | 43.9 | 44.1 | 33.6 | 37.5 | | |
| | Whites | -67.3 | -29.2 | 69.5 | 34.2 | 33.2 | 43.8 | | |

SI 10: Ensemble model projections and associated uncertainty of change in monthly discharge at the 10%, 50% and 90% probability levels (1.d.p).



SI 11: Boxplot of seasonal changes in HER across all PPE members in A) Holland B) Pefferlaw C) Beaver and D) Whites



SI 12: Boxplot of seasonal changes in flow across all PPE members in A) Holland B) Pefferlaw C) Beaver and D) Whites

| Date | Catchment - | Change in TP concentration (%) | | | Uncertainty (%) | | | Change in TP loads (%) | | | Uncertainty (%) | | |
|------|-------------|-----------------------------------|-------|-------|-----------------|-------|-------|------------------------|-------|-------|-----------------|-------|-------|
| | | 10 % | 50 % | 90 % | 10% | 50 % | 90 % | 10 % | 50 % | 90 % | 10% | 50 % | 90 % |
| | | level | level | level | level | level | level | level | level | level | level | level | level |
| 2030 | Holland | -6.8 | -0.8 | 5.3 | 8.0 | 5.3 | 6.8 | -27.3 | 3.5 | 67.9 | 7.8 | 30.4 | 42.6 |
| | Pefferlaw | -10.0 | -1.1 | 10.5 | 5.1 | 9.0 | 4.8 | -27.9 | -2.4 | 34.4 | 4.3 | 28.1 | 23.4 |
| | Beaver | -18.4 | -3.5 | 6.0 | 22.6 | 4.7 | 11.3 | -41.4 | -10.3 | 27.5 | 4.4 | 30.6 | 41.4 |
| | Whites | -20.8 | -2.2 | 12.3 | 30.1 | 21.2 | 13.5 | -53.1 | -2.6 | 66.0 | 11.9 | 50.4 | 48.0 |
| 2070 | Holland | -10.3 | -0.8 | 8.4 | 11.9 | 5.7 | 3.8 | -47.2 | -7.00 | 110.8 | 6.4 | 51.8 | 45.8 |
| | Pefferlaw | -15.9 | -5.7 | 9.6 | 10.5 | 12.4 | 8.4 | -40.0 | -11.2 | 54.6 | 4.7 | 40.5 | 26.5 |
| | Beaver | -30.6 | -6.7 | 4.9 | 21.0 | 8.7 | 5.1 | -70.4 | -25.3 | 49.4 | 8.0 | 35.3 | 47.1 |
| | Whites | -36.3 | -9.7 | 10.2 | 36.8 | 18.3 | 10.3 | -78.0 | -39.7 | 86.4 | 9.3 | 51.3 | 61.9 |

SI 13: Ensemble model projections and associated uncertainty of change in monthly TP concentrations and loads at the 10%, 50% and 90% probability levels (1.d.p).