# Forecast of Economic Gas production in the Marcellus

## Supporting Online Materials-1:
## Details of GEV Fits for Each of Dynamic Well Cohorts

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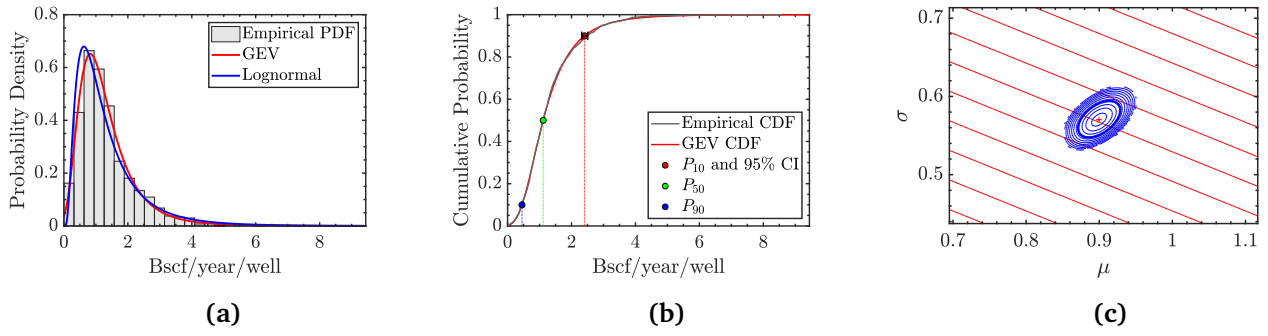Emails: wardana.saputra@kaust.edu.sa; tadeusz.patzek@kaust.edu.sa

**Figure 1.** Distribution of gas production rates for 1685 horizontal wells with one year on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.14$, $\mu = 0.90$, $\sigma = 0.57$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
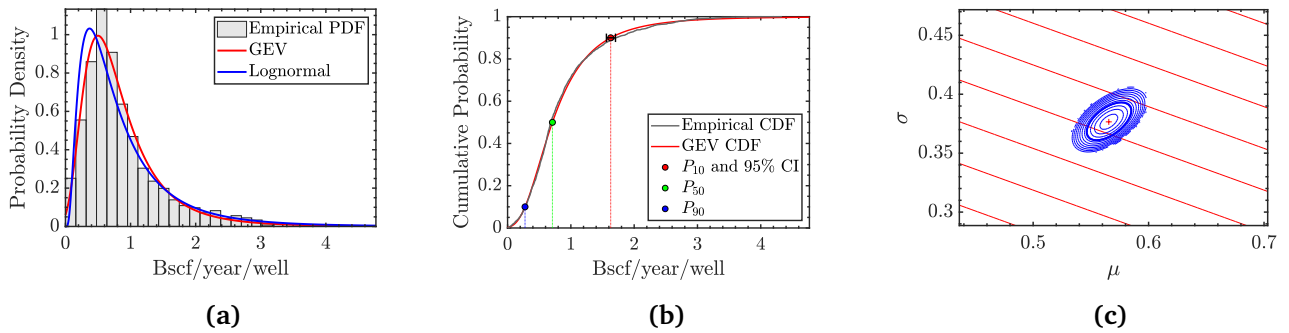


**Figure 2.** Distribution of gas production rates for 1677 horizontal wells with two years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.19$, $\mu = 0.57$, $\sigma = 0.38$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
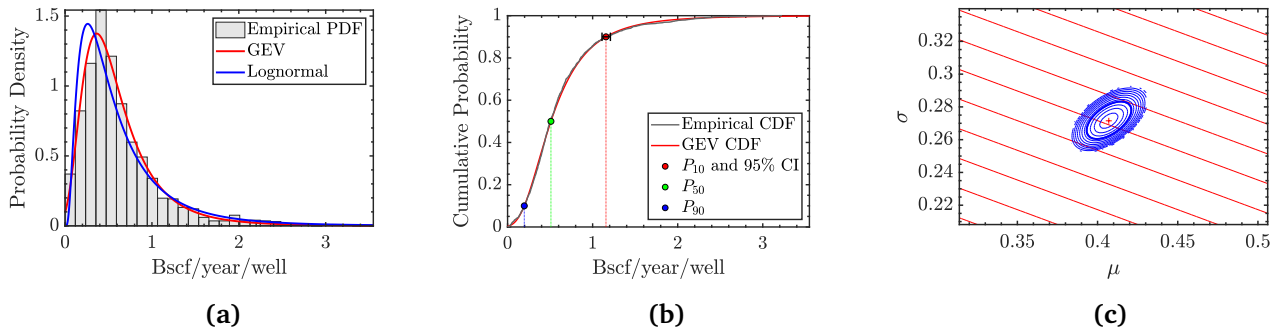


**Figure 3.** Distribution of gas production rates for 1666 horizontal wells with three years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.18$, $\mu = 0.41$, $\sigma = 0.27$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
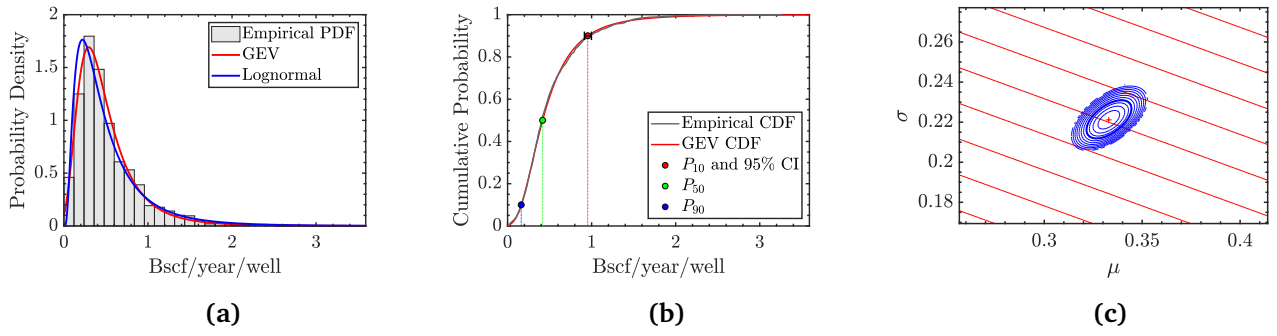
**Figure 4.** Distribution of gas production rates for 1651 horizontal wells with four years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.19$, $\mu = 0.33$, $\sigma = 0.22$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
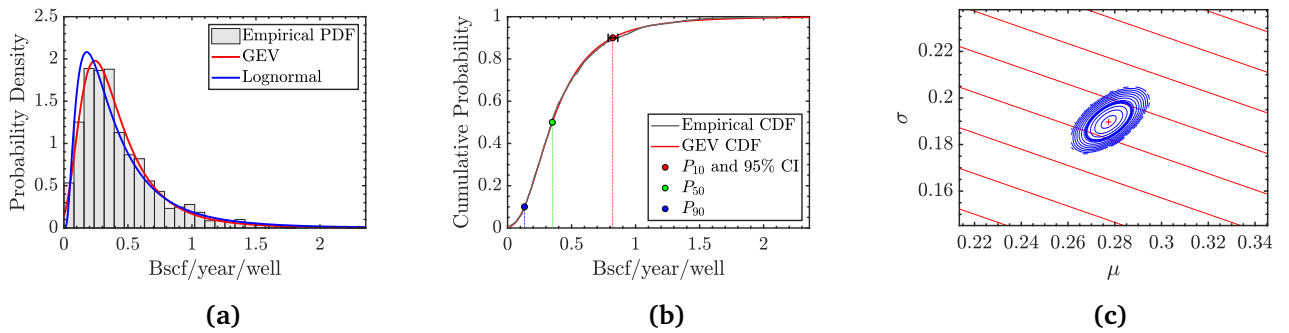


**Figure 5.** Distribution of gas production rates for 1646 horizontal wells with five years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.21$, $\mu = 0.28$, $\sigma = 0.19$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
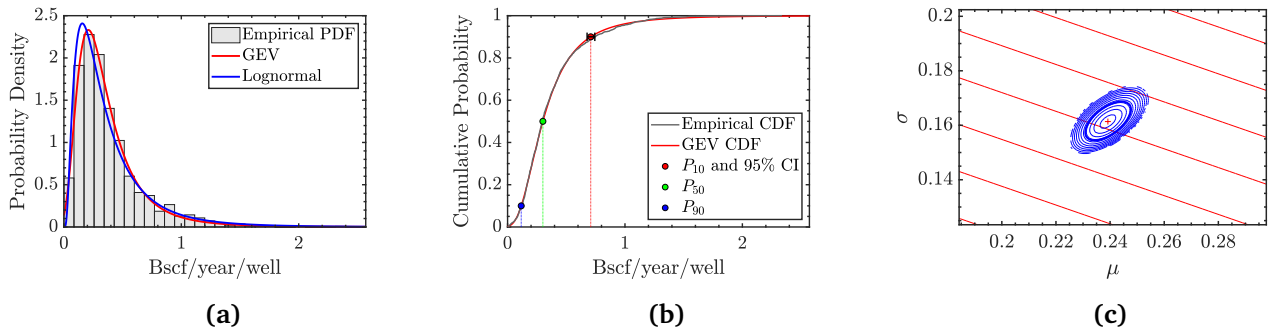


**Figure 6.** Distribution of gas production rates for 1630 horizontal wells with six years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.22$, $\mu = 0.24$, $\sigma = 0.16$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
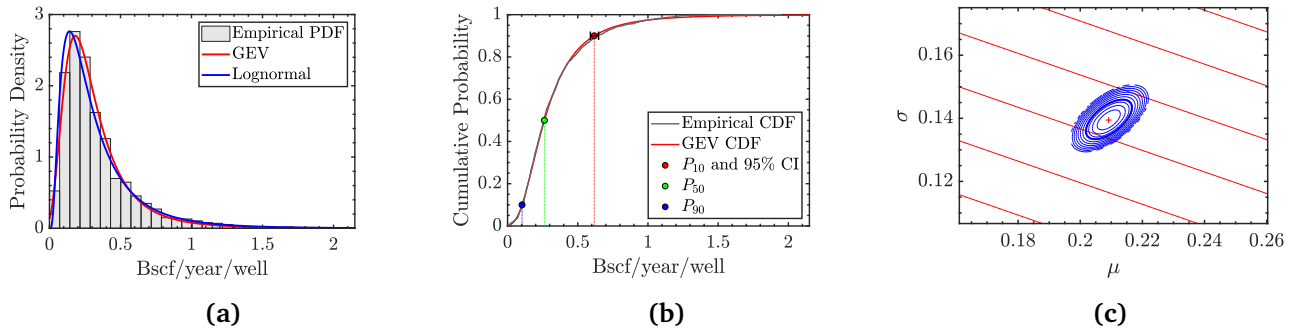
**Figure 7.** Distribution of gas production rates for 1597 horizontal wells with seven years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.22$, $\mu = 0.21$, $\sigma = 0.14$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
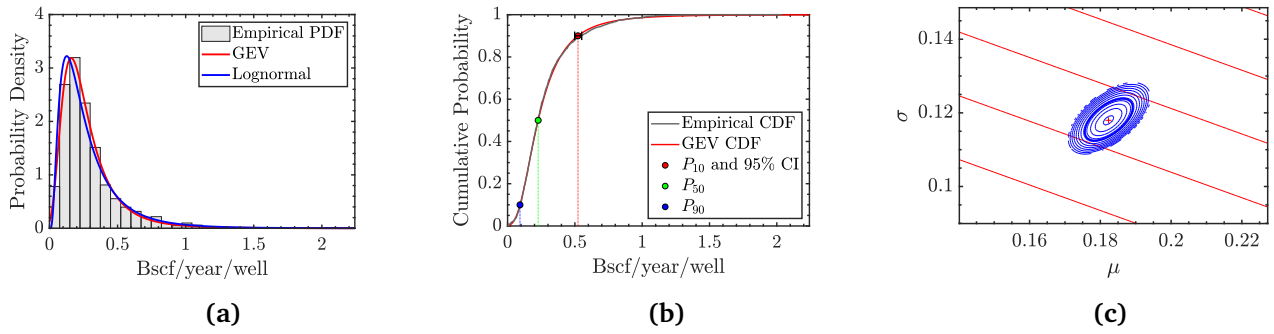


**Figure 8.** Distribution of gas production rates for 1353 horizontal wells with eight years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.21$, $\mu = 0.18$, $\sigma = 0.12$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
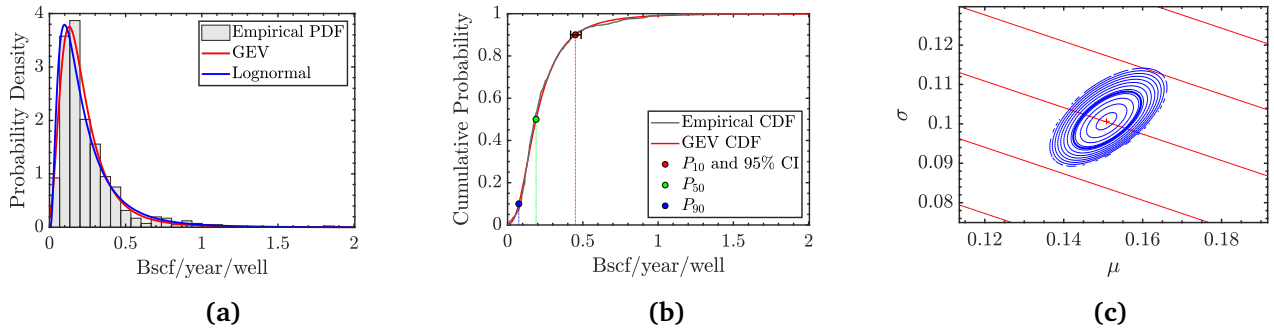


**Figure 9.** Distribution of gas production rates for 615 horizontal wells with nine years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.24$, $\mu = 0.15$, $\sigma = 0.10$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
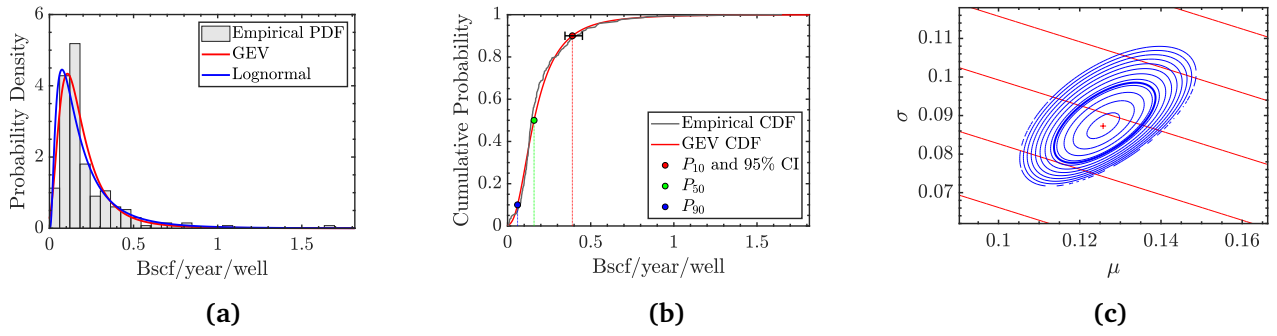
**Figure 10.** Distribution of gas production rates for 220 horizontal wells with ten years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.25$, $\mu = 0.13$, $\sigma = 0.09$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
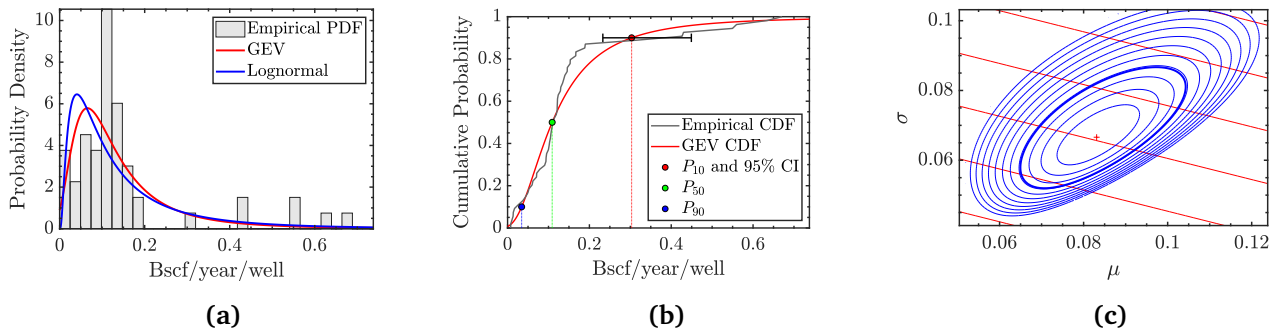


**Figure 11.** Distribution of gas production rates for 54 horizontal wells with eleven years on production, completed between the year 2009 and 2012 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.32$, $\mu = 0.08$, $\sigma = 0.07$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
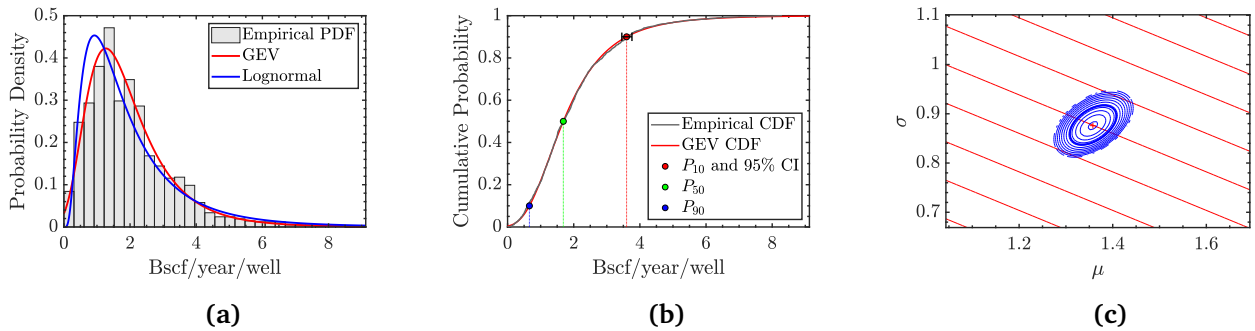


**Figure 12.** Distribution of gas production rates for 1367 horizontal wells with one year on production, completed between the year 2013 and 2014 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.11$, $\mu = 1.36$, $\sigma = 0.88$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
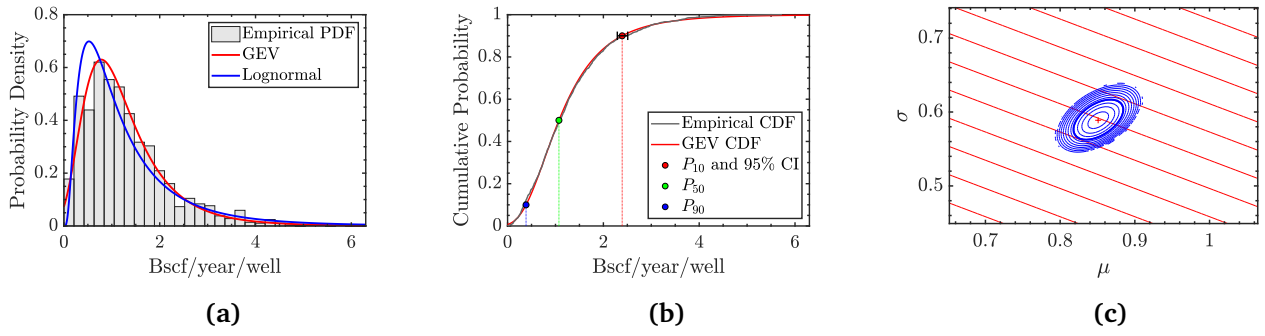
**Figure 13.** Distribution of gas production rates for 1366 horizontal wells with two years on production, completed between the year 2013 and 2014 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.13$, $\mu = 0.85$, $\sigma = 0.59$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
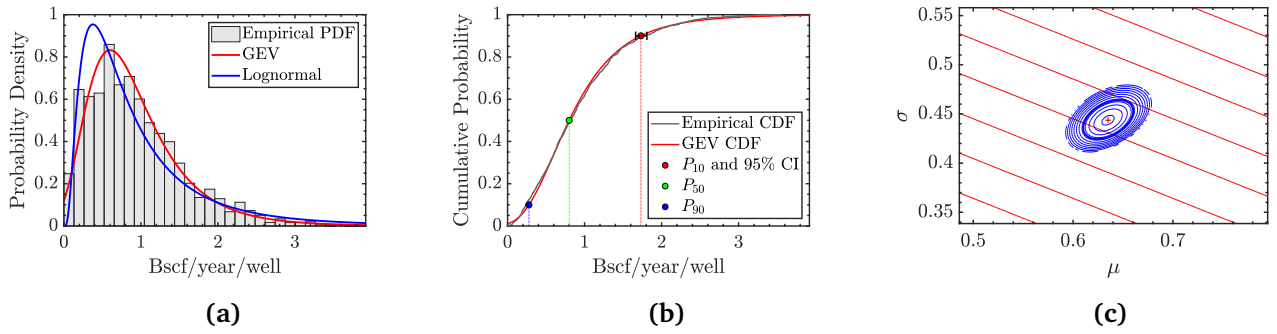


**Figure 14.** Distribution of gas production rates for 1363 horizontal wells with three years on production, completed between the year 2013 and 2014 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.08$, $\mu = 0.64$, $\sigma = 0.44$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
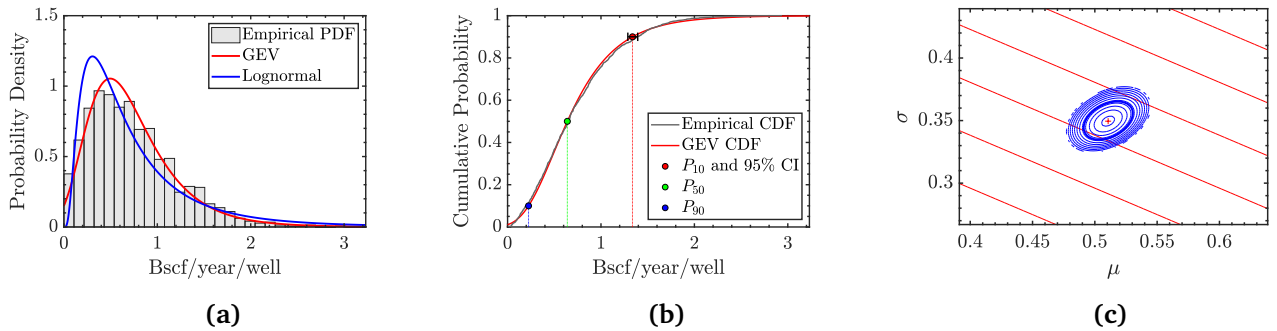


**Figure 15.** Distribution of gas production rates for 1354 horizontal wells with four years on production, completed between the year 2013 and 2014 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.04$, $\mu = 0.51$, $\sigma = 0.35$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
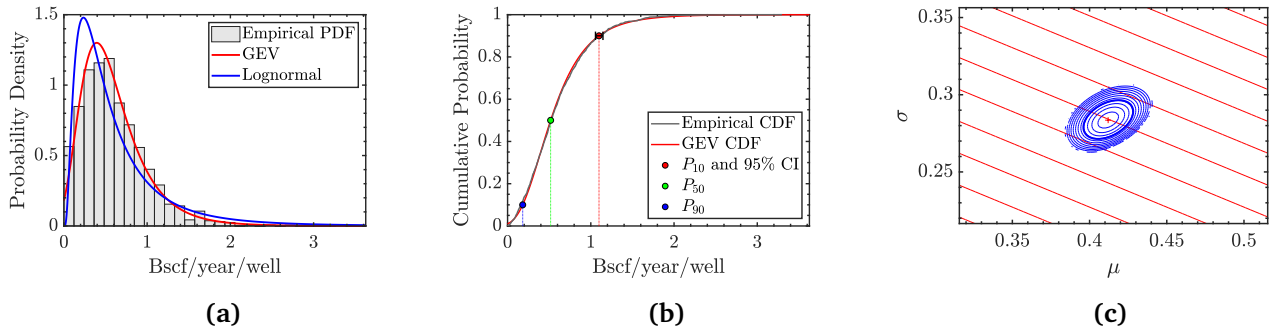
**Figure 16.** Distribution of gas production rates for 1336 horizontal wells with five years on production, completed between the year 2013 and 2014 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.06$, $\mu = 0.41$, $\sigma = 0.28$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
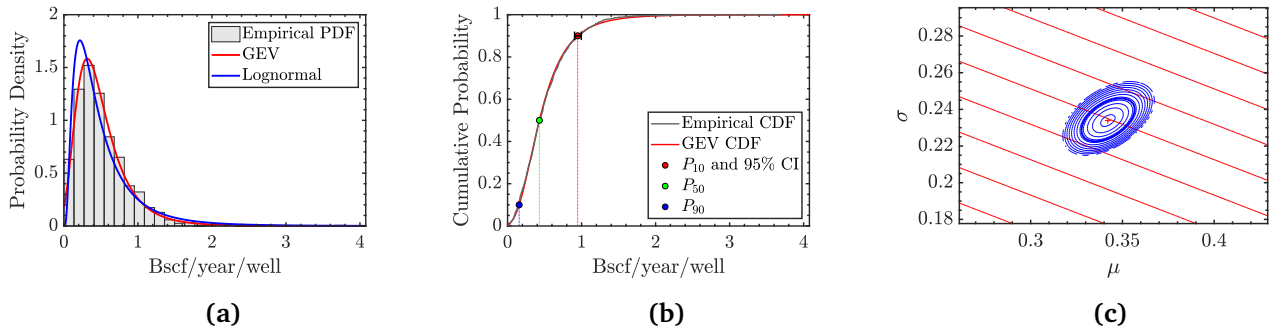


**Figure 17.** Distribution of gas production rates for 1142 horizontal wells with six years on production, completed between the year 2013 and 2014 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.12$, $\mu = 0.34$, $\sigma = 0.23$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
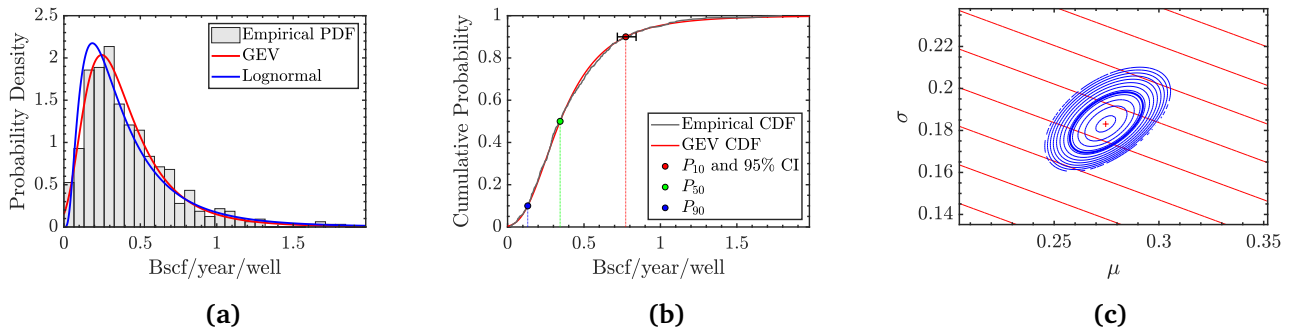


**Figure 18.** Distribution of gas production rates for 491 horizontal wells with seven years on production, completed between the year 2013 and 2014 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.16$, $\mu = 0.27$, $\sigma = 0.18$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
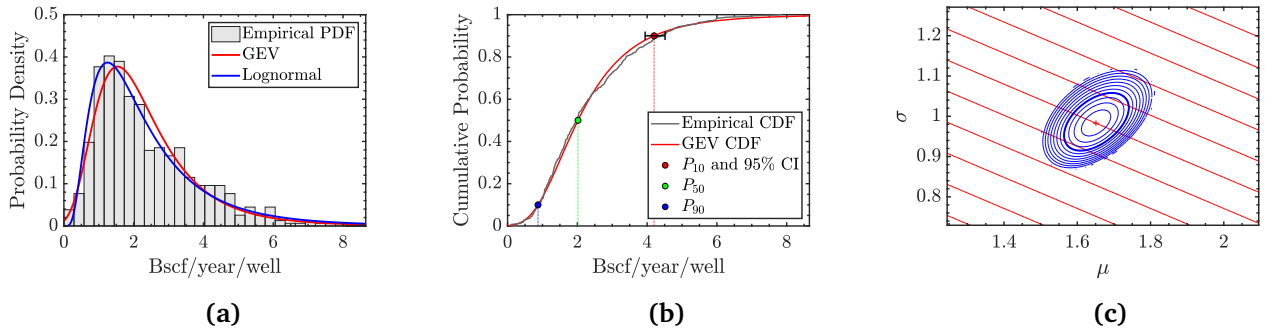
**Figure 19.** Distribution of gas production rates for 543 horizontal wells with one year on production, completed between the year 2015 and 2016 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.12$, $\mu = 1.65$, $\sigma = 0.98$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
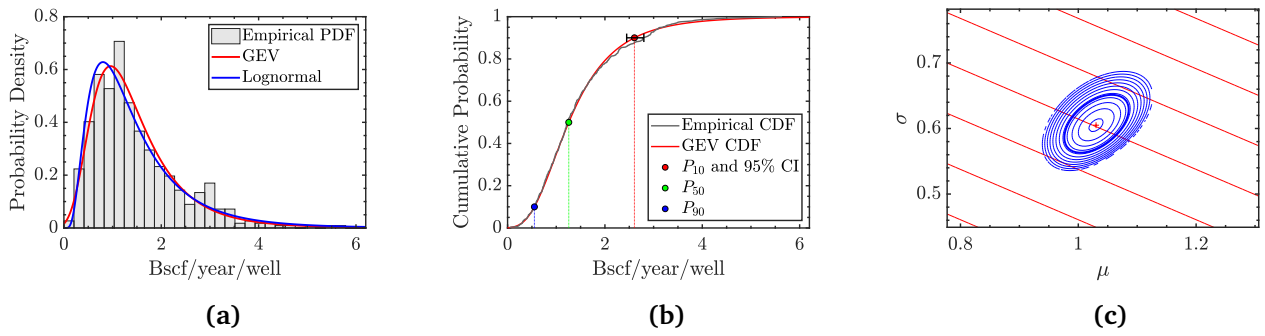


**Figure 20.** Distribution of gas production rates for 541 horizontal wells with two years on production, completed between the year 2015 and 2016 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.13$, $\mu = 1.03$, $\sigma = 0.61$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
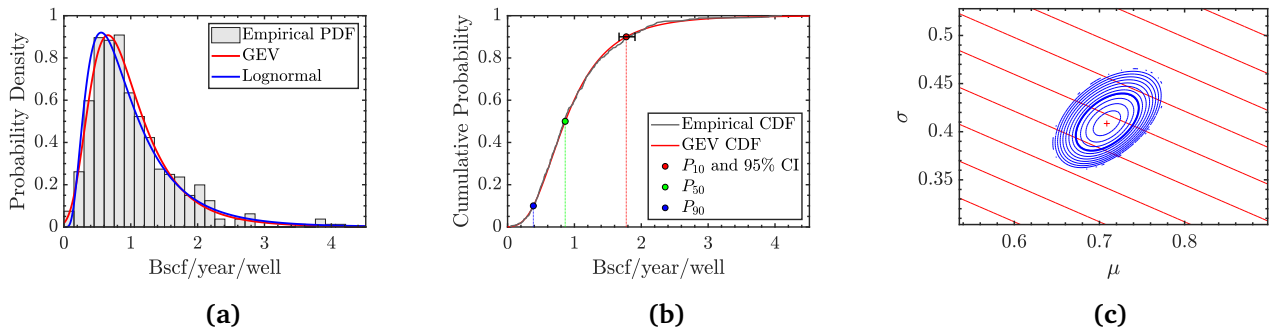


**Figure 21.** Distribution of gas production rates for 534 horizontal wells with three years on production, completed between the year 2015 and 2016 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.13$, $\mu = 0.71$, $\sigma = 0.41$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
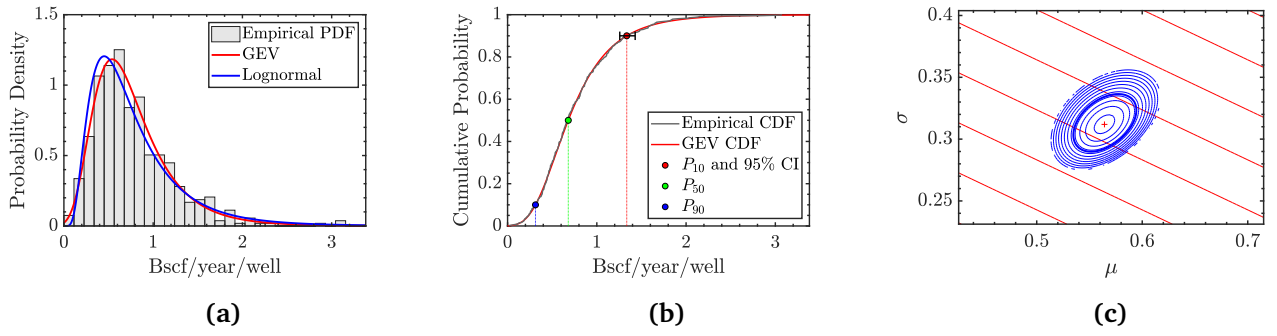
**Figure 22.** Distribution of gas production rates for 475 horizontal wells with four years on production, completed between the year 2015 and 2016 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.08$, $\mu = 0.56$, $\sigma = 0.31$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
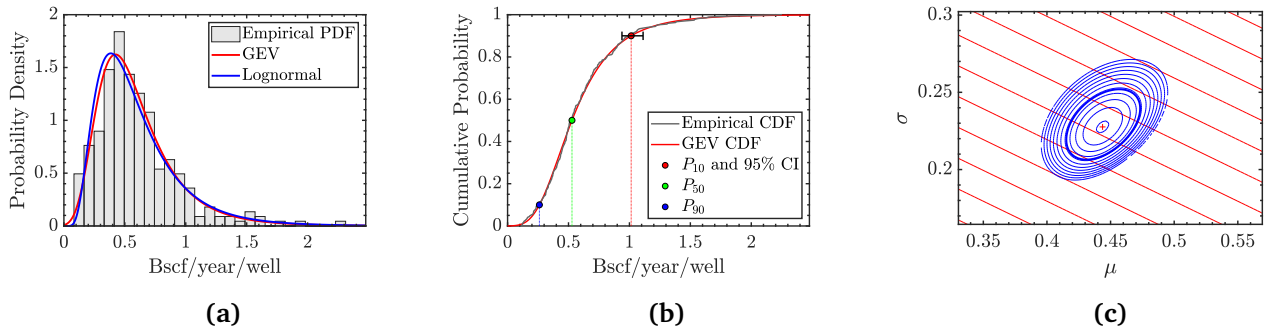


**Figure 23.** Distribution of gas production rates for 270 horizontal wells with five years on production, completed between the year 2015 and 2016 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.09$, $\mu = 0.44$, $\sigma = 0.23$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
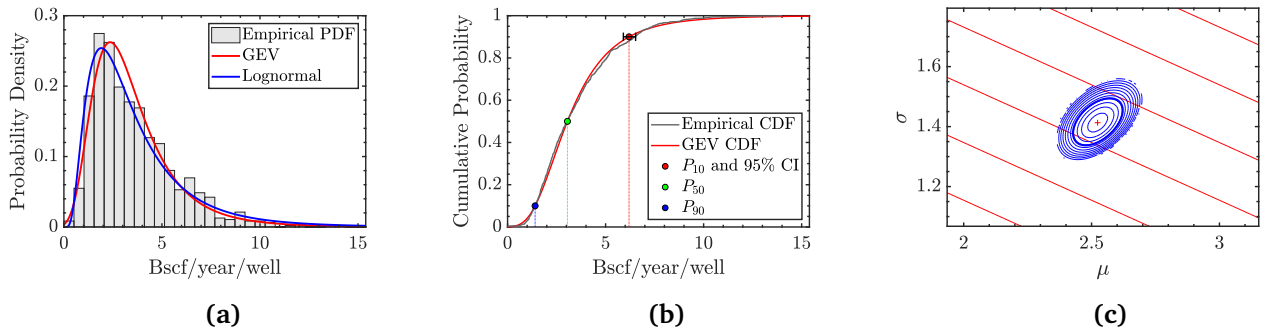


**Figure 24.** Distribution of gas production rates for 922 horizontal wells with one year on production, completed between the year 2017 and 2020 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.13$, $\mu = 2.52$, $\sigma = 1.41$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
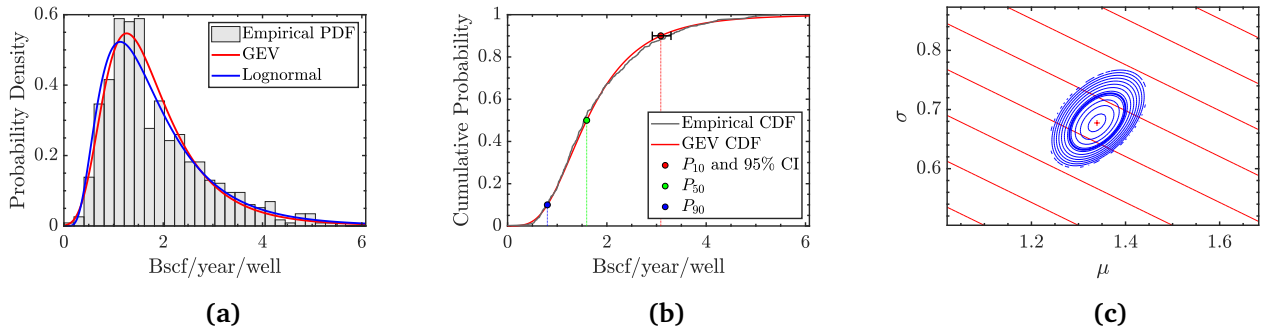
**Figure 25.** Distribution of gas production rates for 570 horizontal wells with two years on production, completed between the year 2017 and 2020 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.12$, $\mu = 1.34$, $\sigma = 0.68$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
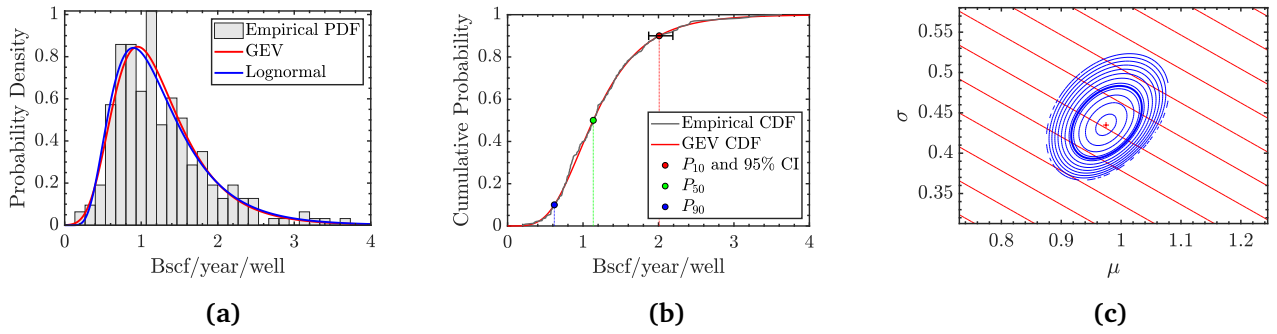


**Figure 26.** Distribution of gas production rates for 236 horizontal wells with three years on production, completed between the year 2017 and 2020 in the Northeast Core area. (**a**) GEV PDF: $\xi = 0.05$, $\mu = 0.97$, $\sigma = 0.43$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
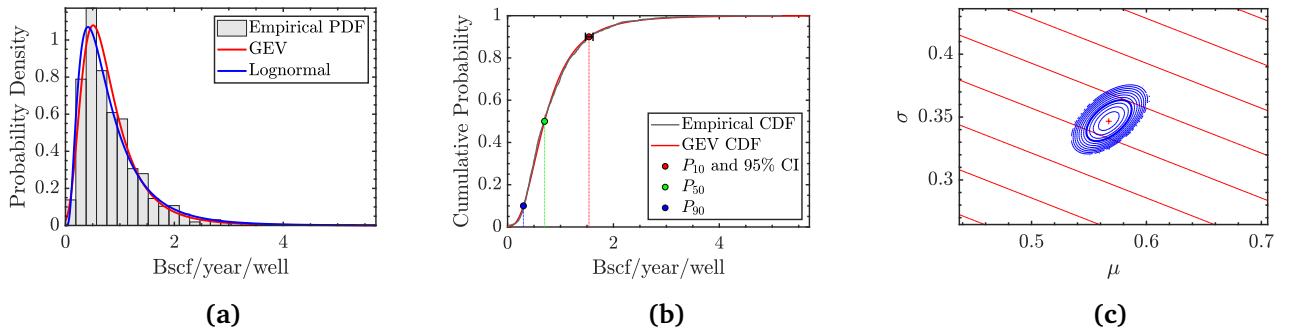


**Figure 27.** Distribution of gas production rates for 1374 horizontal wells with one year on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.19$, $\mu = 0.57$, $\sigma = 0.35$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
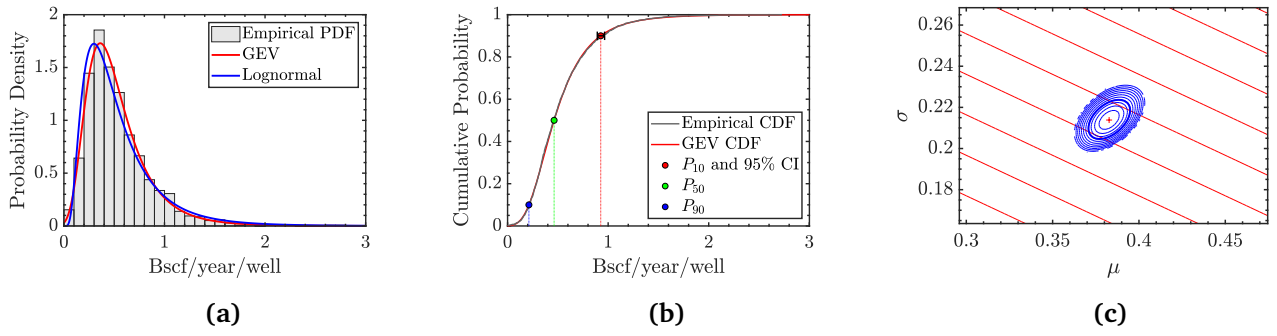
**Figure 28.** Distribution of gas production rates for 1369 horizontal wells with two years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.11$, $\mu = 0.38$, $\sigma = 0.21$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
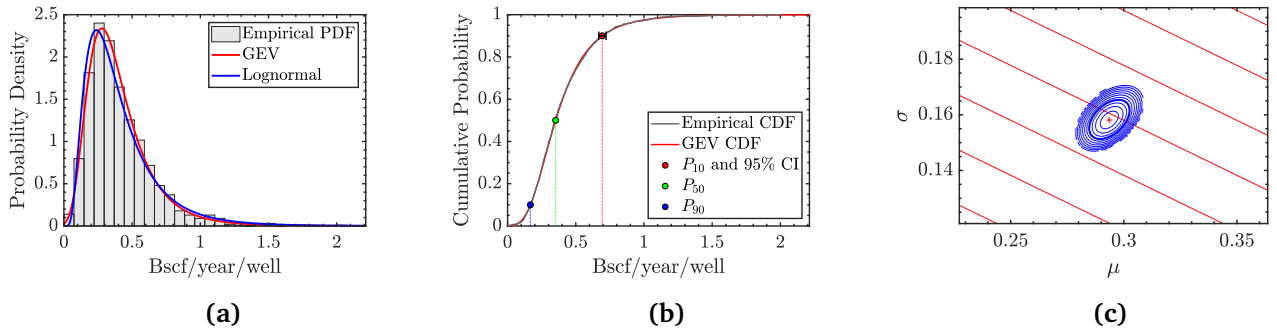


**Figure 29.** Distribution of gas production rates for 1361 horizontal wells with three years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.10$, $\mu = 0.29$, $\sigma = 0.16$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
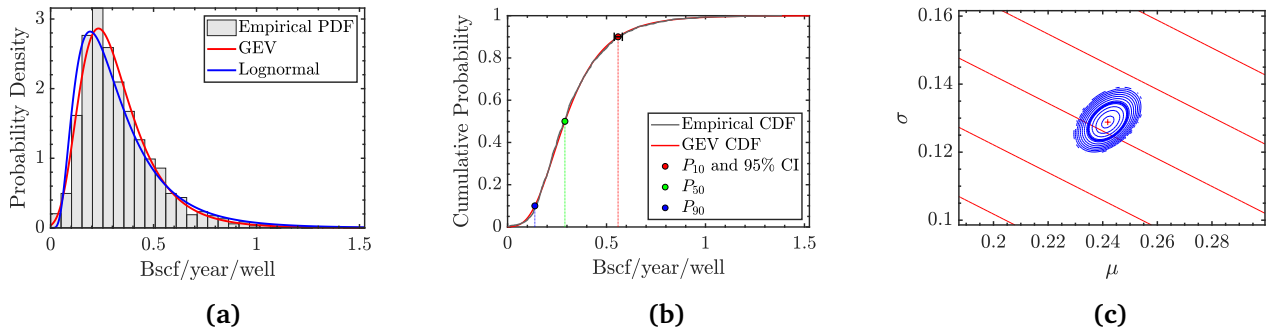


**Figure 30.** Distribution of gas production rates for 1352 horizontal wells with four years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.08$, $\mu = 0.24$, $\sigma = 0.13$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
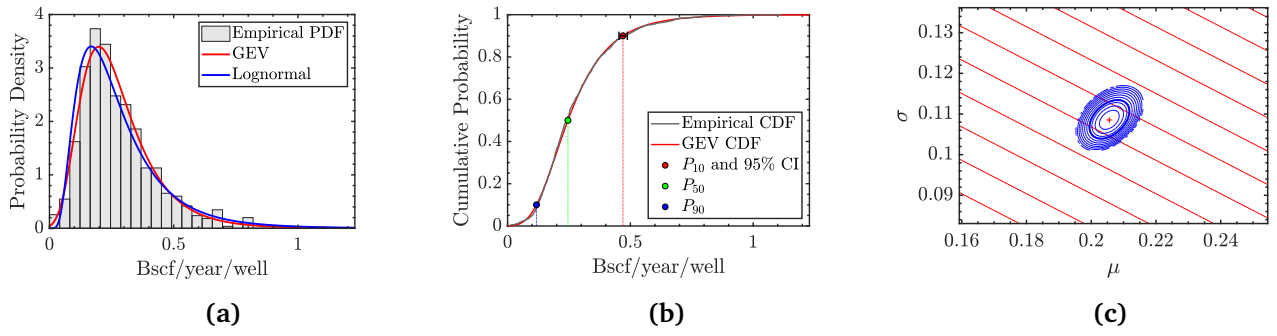
**Figure 31.** Distribution of gas production rates for 1340 horizontal wells with five years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.07$, $\mu = 0.21$, $\sigma = 0.11$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
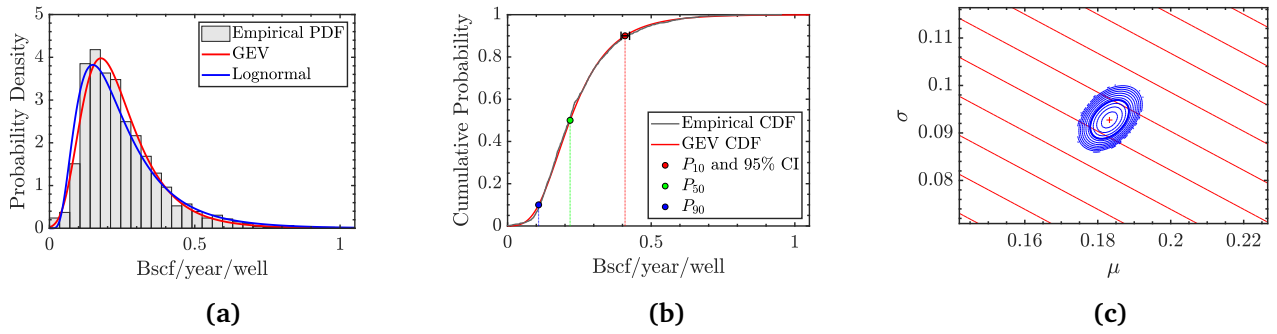


**Figure 32.** Distribution of gas production rates for 1305 horizontal wells with six years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.07$, $\mu = 0.18$, $\sigma = 0.09$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
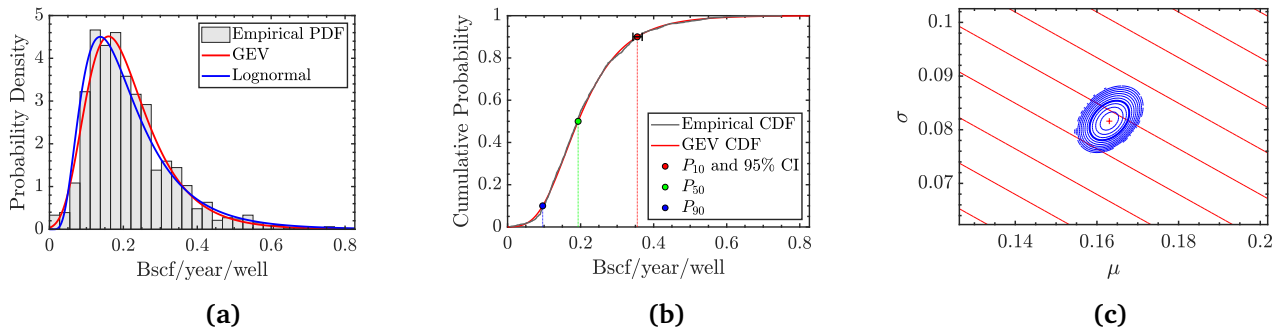


**Figure 33.** Distribution of gas production rates for 1207 horizontal wells with seven years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.04$, $\mu = 0.16$, $\sigma = 0.08$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
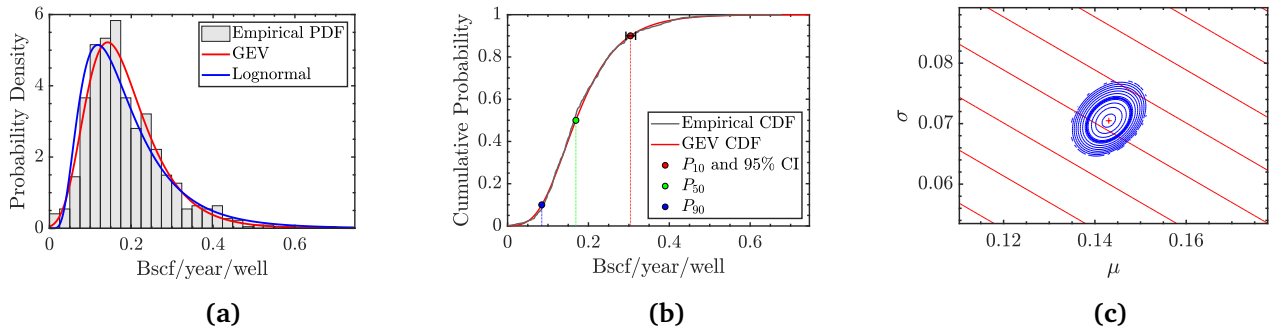
**Figure 34.** Distribution of gas production rates for 889 horizontal wells with eight years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.01$, $\mu = 0.14$, $\sigma = 0.07$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
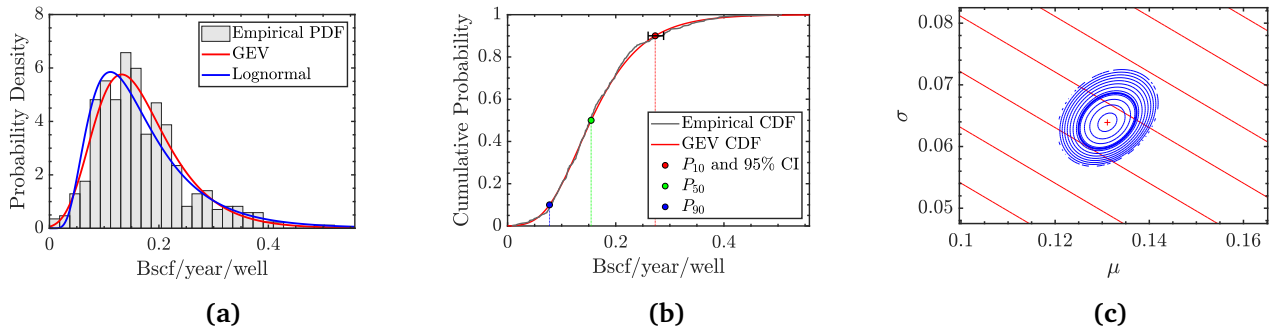


**Figure 35.** Distribution of gas production rates for 458 horizontal wells with nine years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.01$, $\mu = 0.13$, $\sigma = 0.06$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
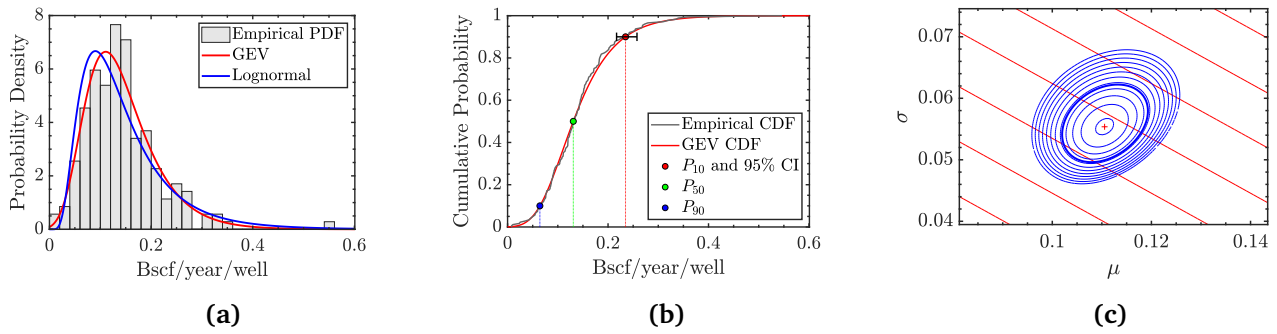


**Figure 36.** Distribution of gas production rates for 176 horizontal wells with ten years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.00$, $\mu = 0.11$, $\sigma = 0.06$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
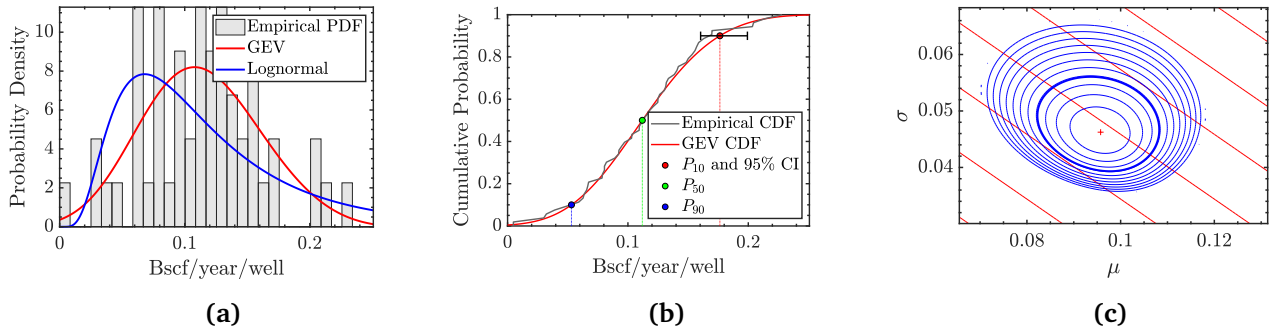
**Figure 37.** Distribution of gas production rates for 53 horizontal wells with eleven years on production, completed between the year 2009 and 2012 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.24$, $\mu = 0.10$, $\sigma = 0.05$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
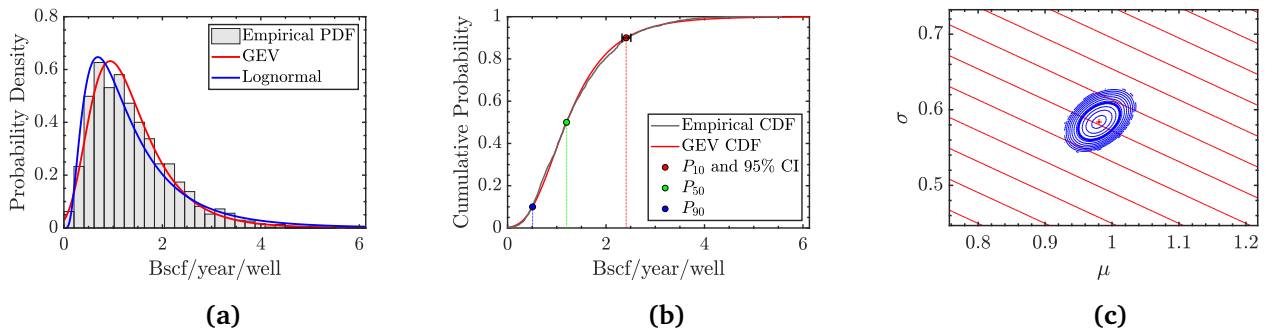


**Figure 38.** Distribution of gas production rates for 1492 horizontal wells with one year on production, completed between the year 2013 and 2014 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.07$, $\mu = 0.98$, $\sigma = 0.58$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
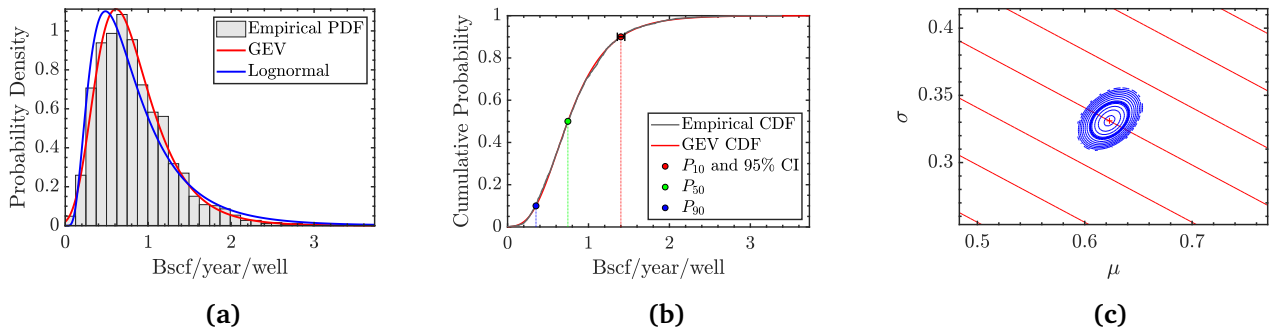


**Figure 39.** Distribution of gas production rates for 1491 horizontal wells with two years on production, completed between the year 2013 and 2014 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.04$, $\mu = 0.62$, $\sigma = 0.33$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
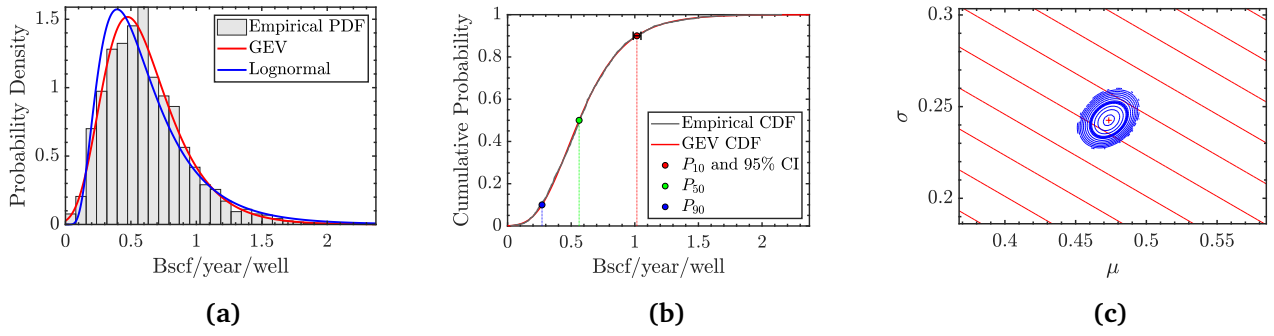
**Figure 40.** Distribution of gas production rates for 1481 horizontal wells with three years on production, completed between the year 2013 and 2014 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.00$, $\mu = 0.47$, $\sigma = 0.24$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
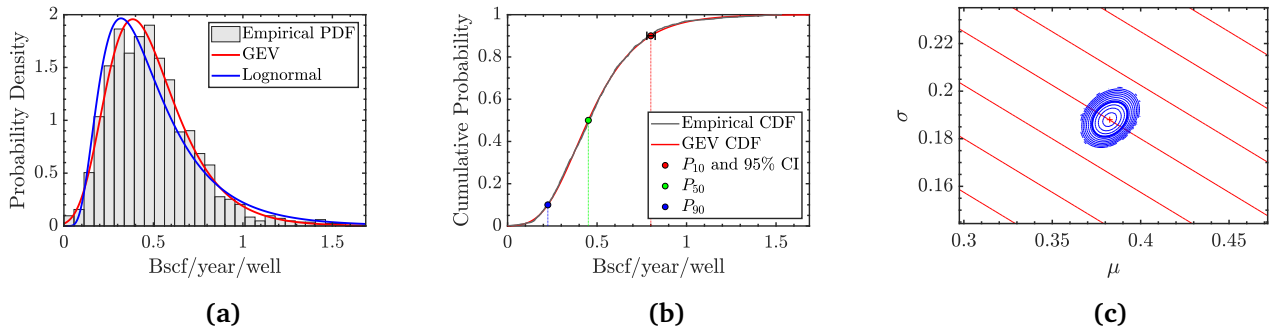


**Figure 41.** Distribution of gas production rates for 1479 horizontal wells with four years on production, completed between the year 2013 and 2014 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.01$, $\mu = 0.38$, $\sigma = 0.19$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
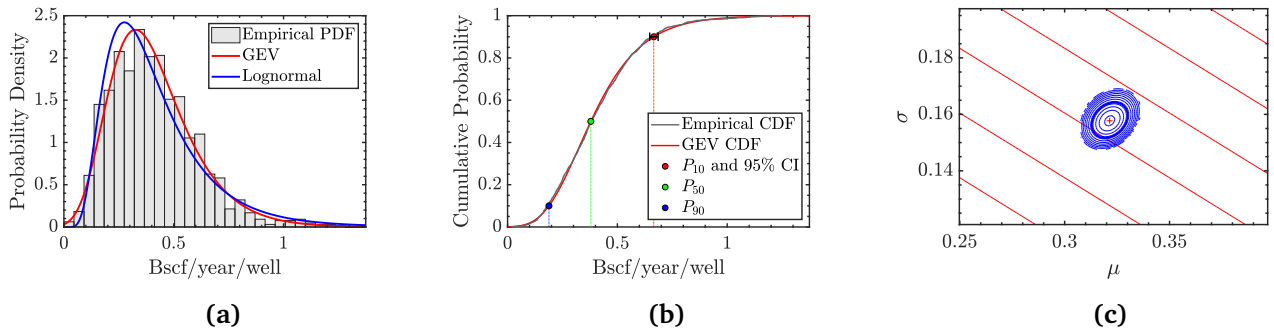


**Figure 42.** Distribution of gas production rates for 1430 horizontal wells with five years on production, completed between the year 2013 and 2014 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.03$, $\mu = 0.32$, $\sigma = 0.16$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
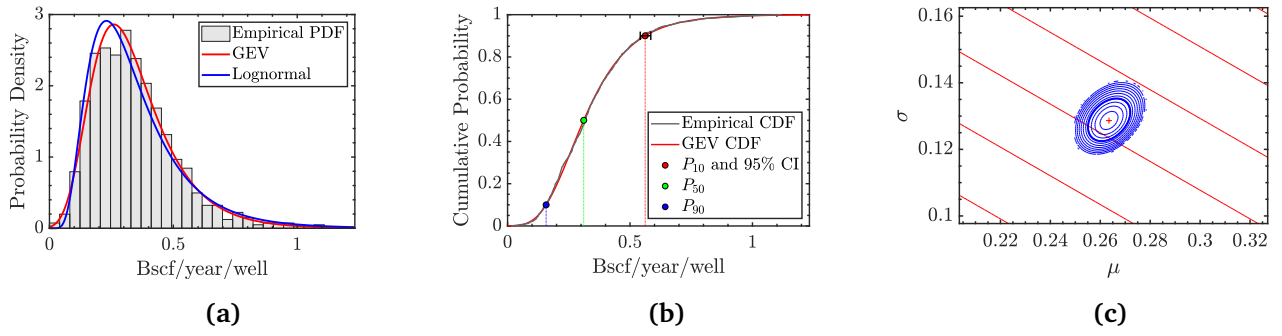
**Figure 43.** Distribution of gas production rates for 981 horizontal wells with six years on production, completed between the year 2013 and 2014 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.03$, $\mu = 0.26$, $\sigma = 0.13$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
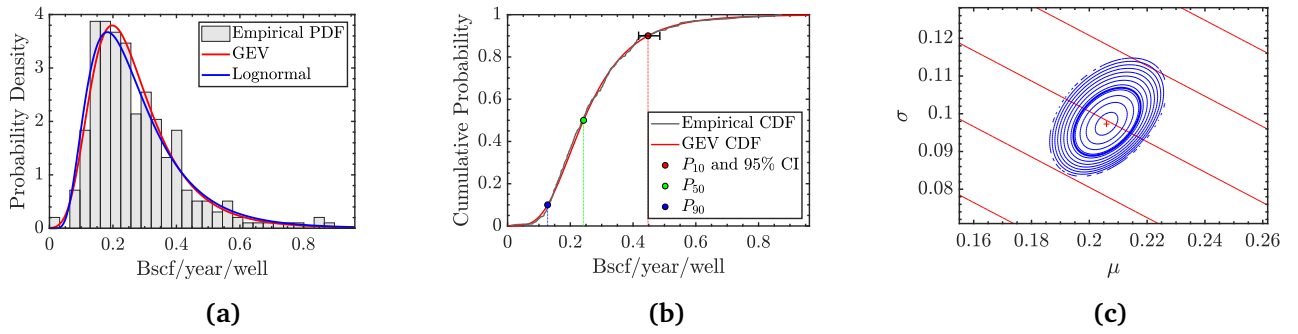


**Figure 44.** Distribution of gas production rates for 306 horizontal wells with seven years on production, completed between the year 2013 and 2014 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.09$, $\mu = 0.21$, $\sigma = 0.10$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
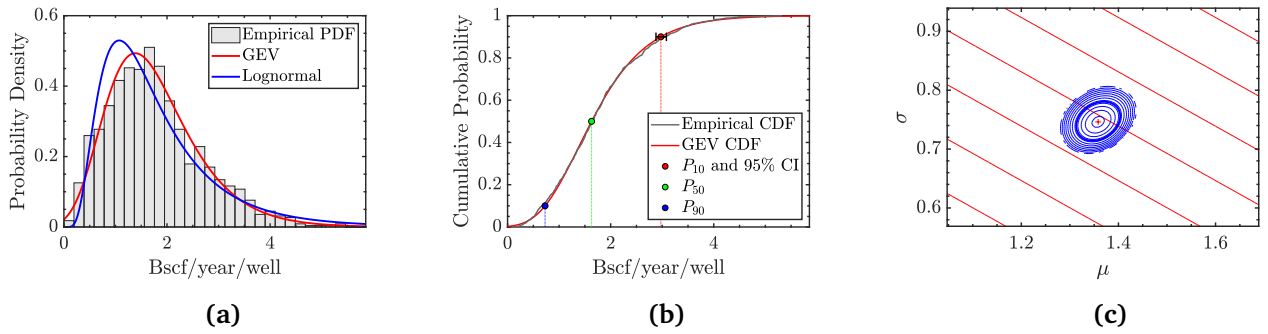


**Figure 45.** Distribution of gas production rates for 1145 horizontal wells with one year on production, completed between the year 2015 and 2016 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.03$, $\mu = 1.36$, $\sigma = 0.75$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
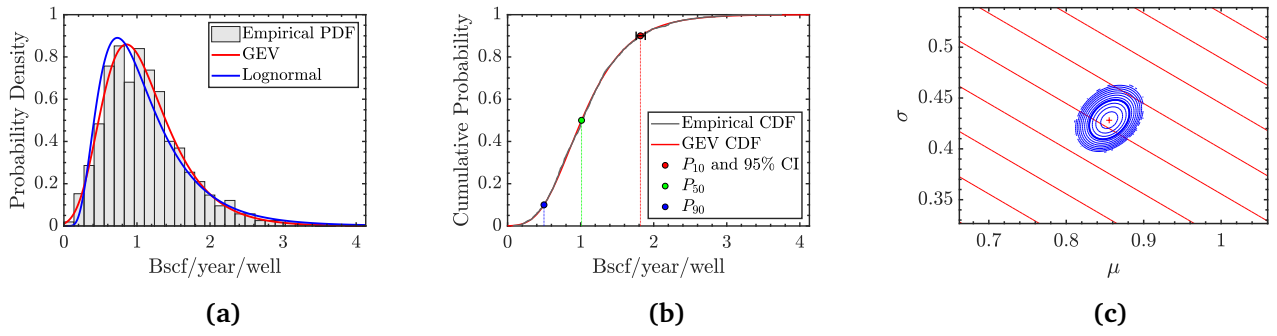
**Figure 46.** Distribution of gas production rates for 1142 horizontal wells with two years on production, completed between the year 2015 and 2016 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.00$, $\mu = 0.86$, $\sigma = 0.43$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
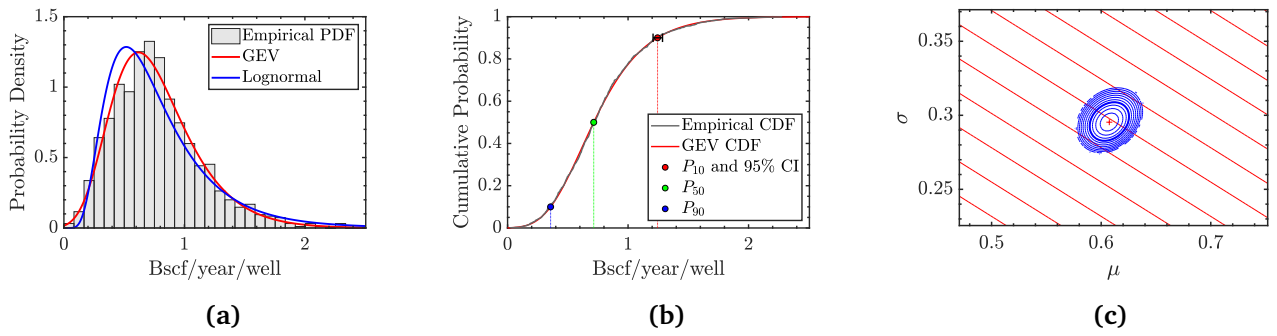


**Figure 47.** Distribution of gas production rates for 1139 horizontal wells with three years on production, completed between the year 2015 and 2016 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.04$, $\mu = 0.61$, $\sigma = 0.30$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
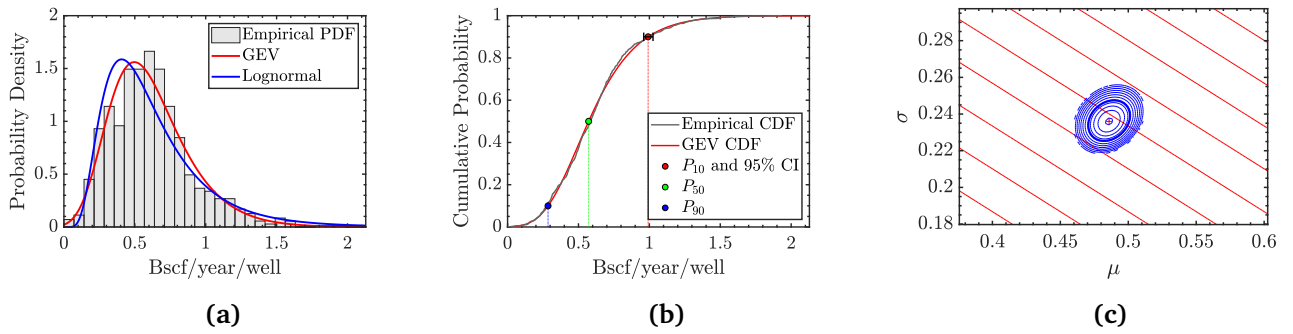


**Figure 48.** Distribution of gas production rates for 1000 horizontal wells with four years on production, completed between the year 2015 and 2016 in the Southwest Core area. (**a**) GEV PDF: $\xi = -0.04$, $\mu = 0.49$, $\sigma = 0.24$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
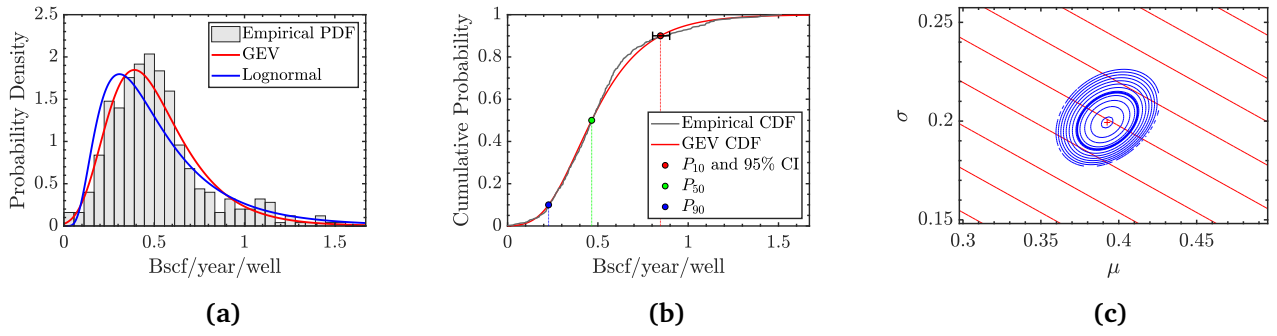
**Figure 49.** Distribution of gas production rates for 450 horizontal wells with five years on production, completed between the year 2015 and 2016 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.01$, $\mu = 0.39$, $\sigma = 0.20$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
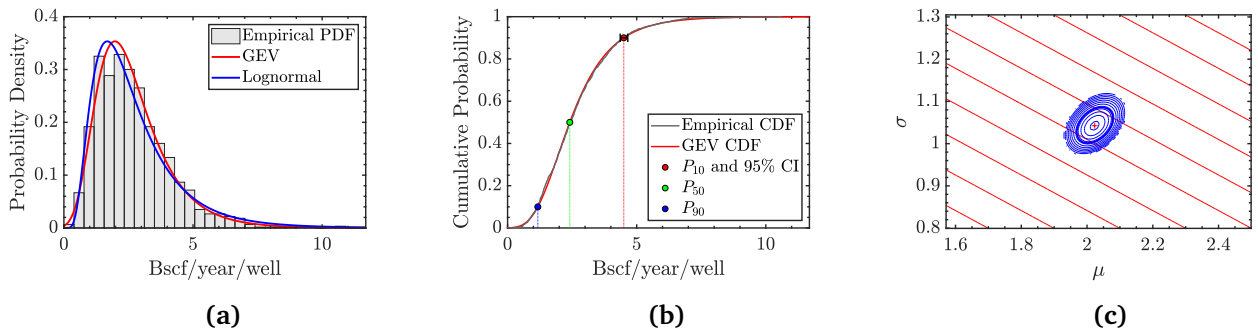


**Figure 50.** Distribution of gas production rates for 1539 horizontal wells with one year on production, completed between the year 2017 and 2020 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.05$, $\mu = 2.02$, $\sigma = 1.04$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
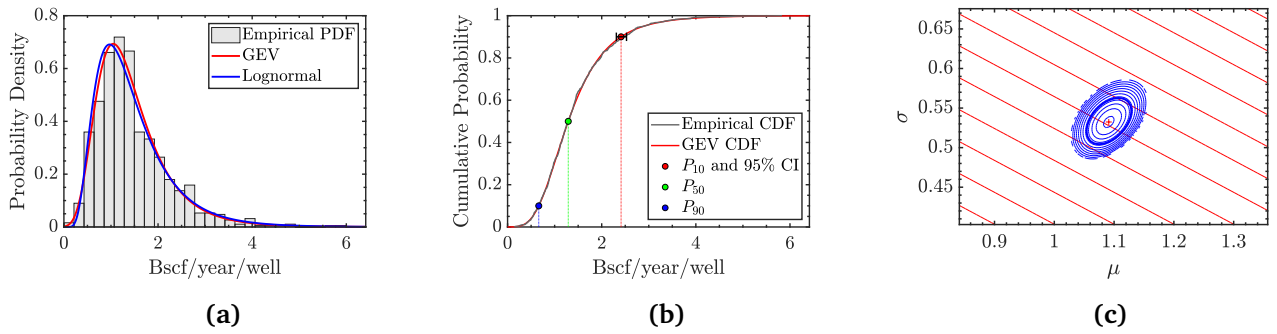


**Figure 51.** Distribution of gas production rates for 885 horizontal wells with two years on production, completed between the year 2017 and 2020 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.09$, $\mu = 1.09$, $\sigma = 0.53$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
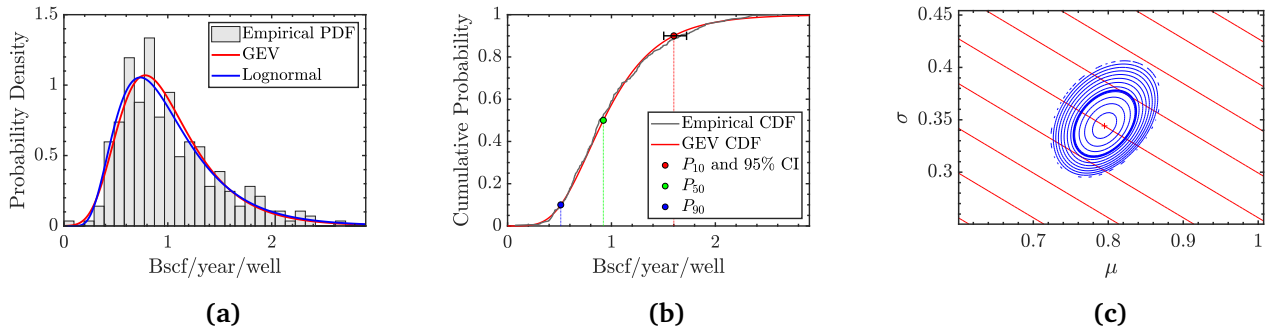
**Figure 52.** Distribution of gas production rates for 294 horizontal wells with three years on production, completed between the year 2017 and 2020 in the Southwest Core area. (**a**) GEV PDF: $\xi = 0.03$, $\mu = 0.79$, $\sigma = 0.34$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
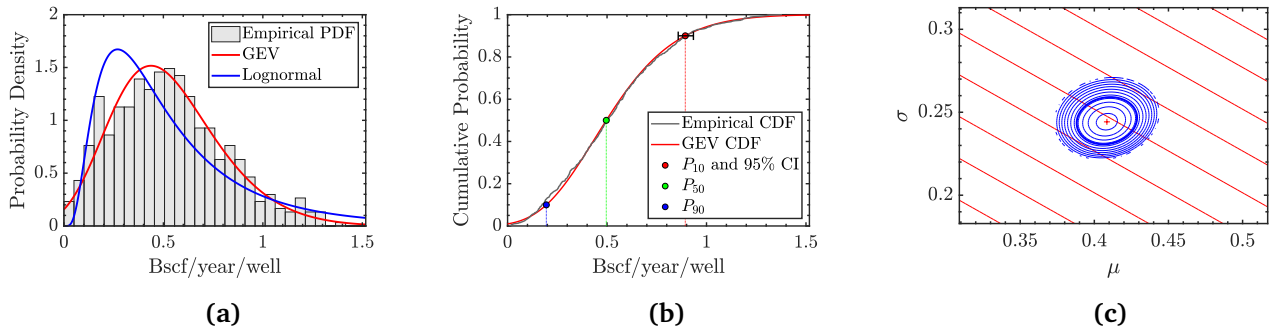


**Figure 53.** Distribution of gas production rates for 597 horizontal wells with one year on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.11$, $\mu = 0.41$, $\sigma = 0.24$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
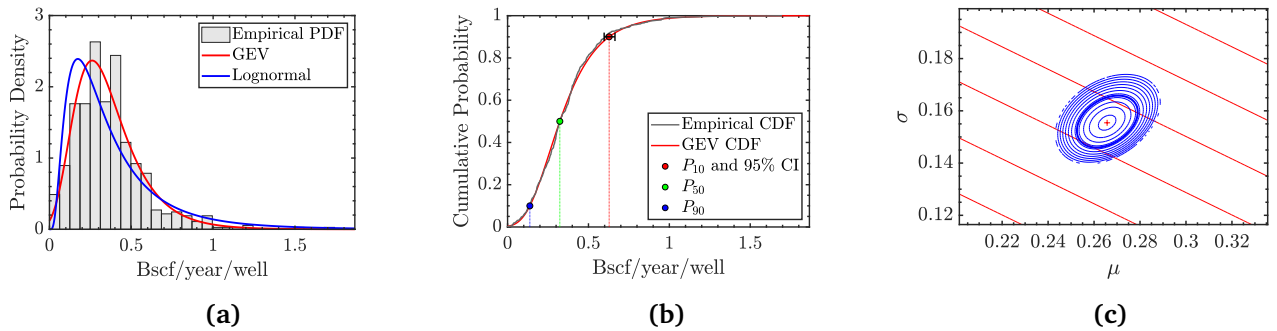


**Figure 54.** Distribution of gas production rates for 593 horizontal wells with two years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.03$, $\mu = 0.27$, $\sigma = 0.16$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
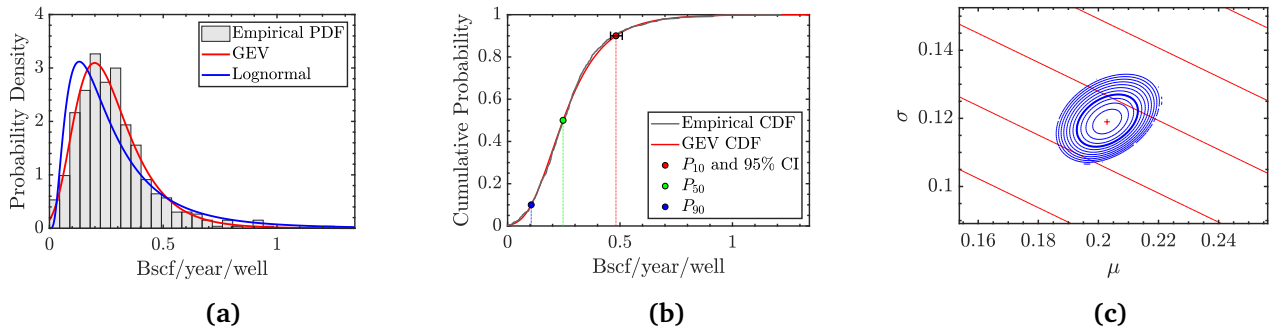
**Figure 55.** Distribution of gas production rates for 589 horizontal wells with three years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.04$, $\mu = 0.20$, $\sigma = 0.12$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
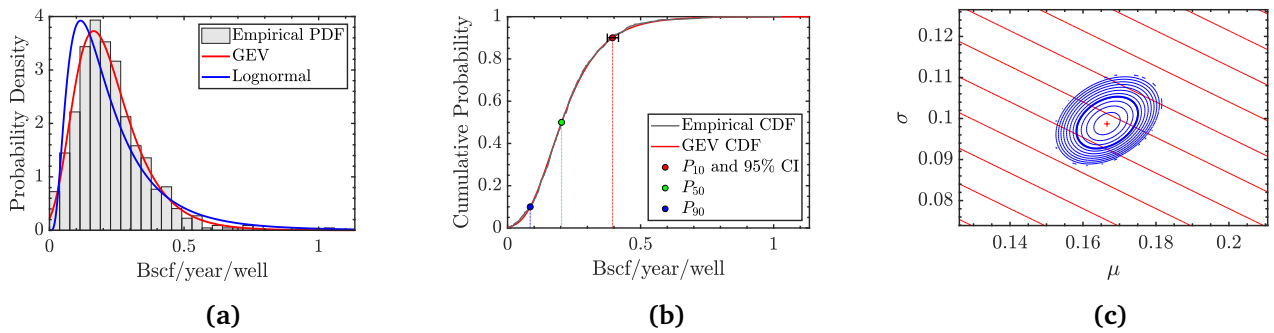


**Figure 56.** Distribution of gas production rates for 585 horizontal wells with four years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.02$, $\mu = 0.17$, $\sigma = 0.10$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
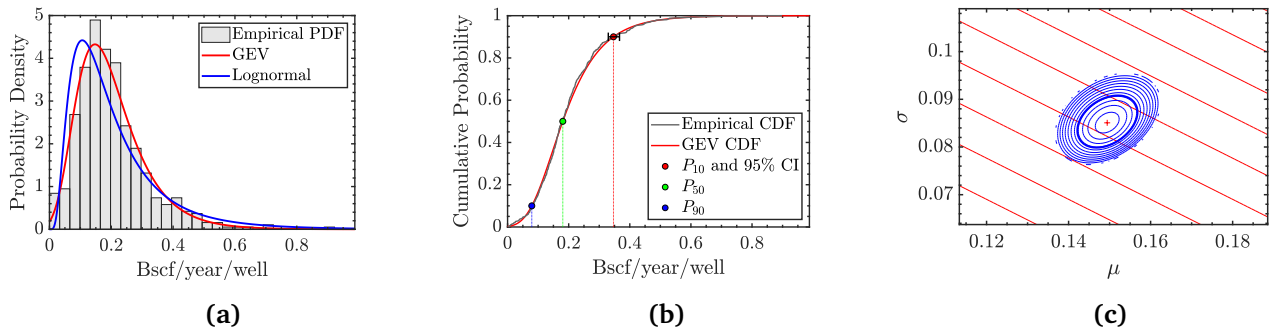


**Figure 57.** Distribution of gas production rates for 577 horizontal wells with five years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.03$, $\mu = 0.15$, $\sigma = 0.09$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
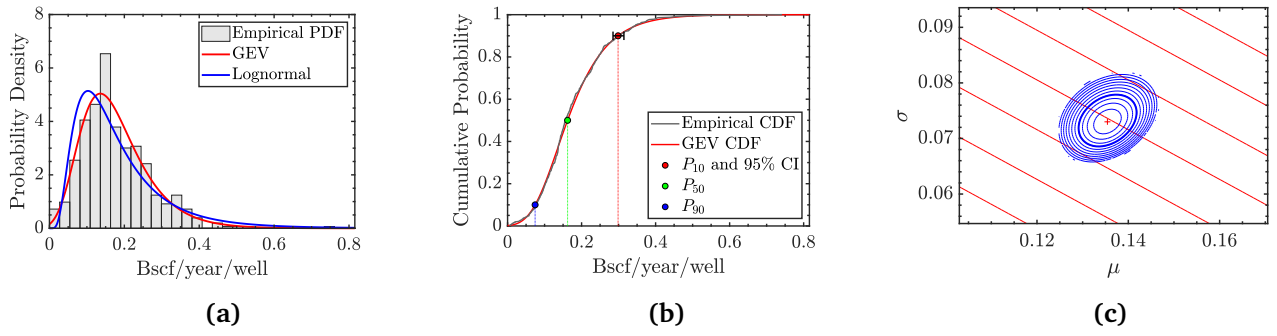
**Figure 58.** Distribution of gas production rates for 563 horizontal wells with six years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.01$, $\mu = 0.14$, $\sigma = 0.07$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
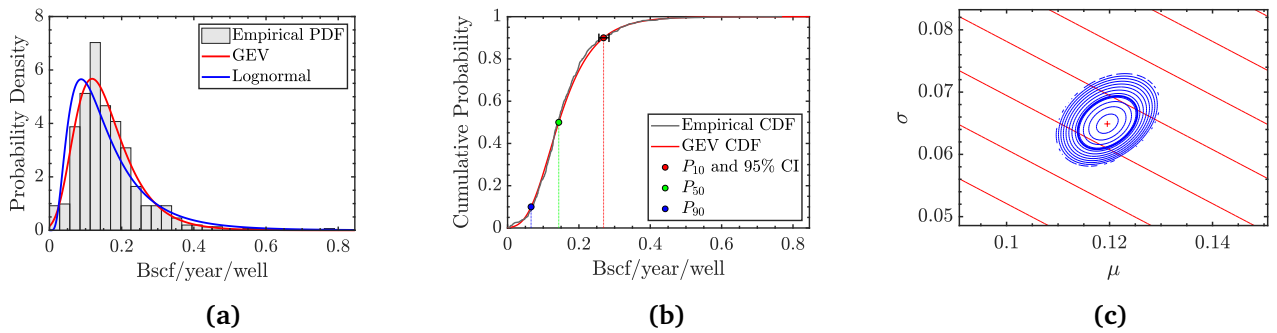


**Figure 59.** Distribution of gas production rates for 540 horizontal wells with seven years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.02$, $\mu = 0.12$, $\sigma = 0.06$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
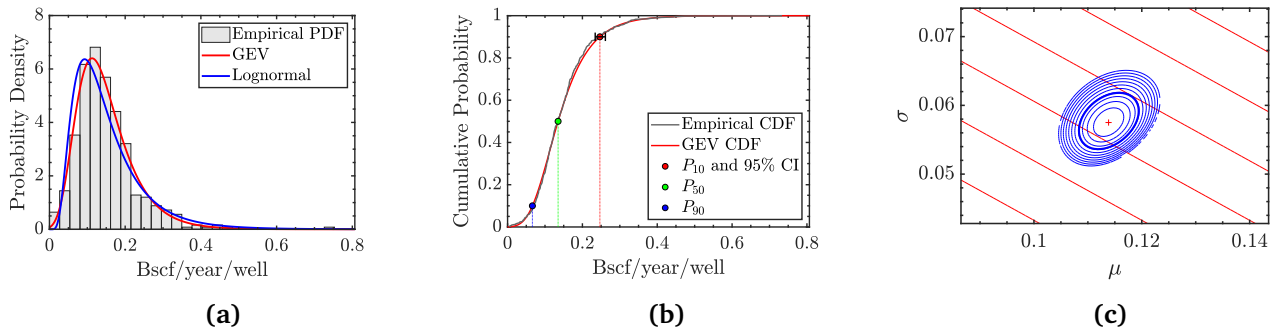


**Figure 60.** Distribution of gas production rates for 464 horizontal wells with eight years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.02$, $\mu = 0.11$, $\sigma = 0.06$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
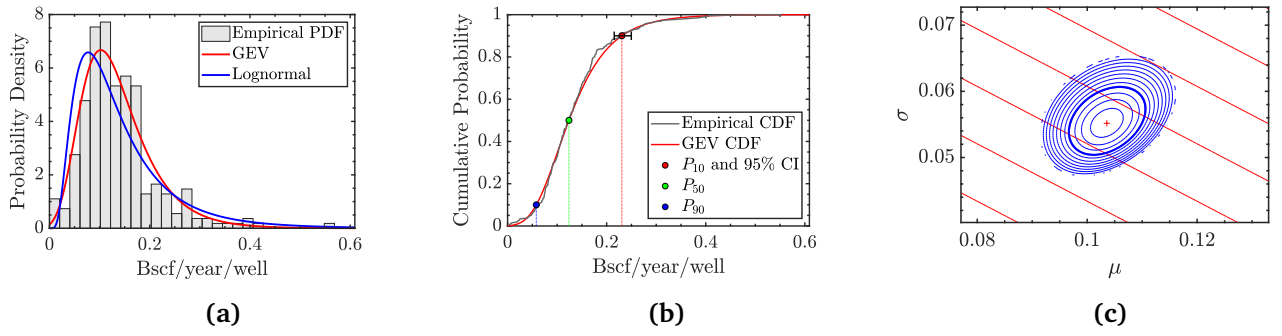
**Figure 61.** Distribution of gas production rates for 268 horizontal wells with nine years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.02$, $\mu = 0.10$, $\sigma = 0.06$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
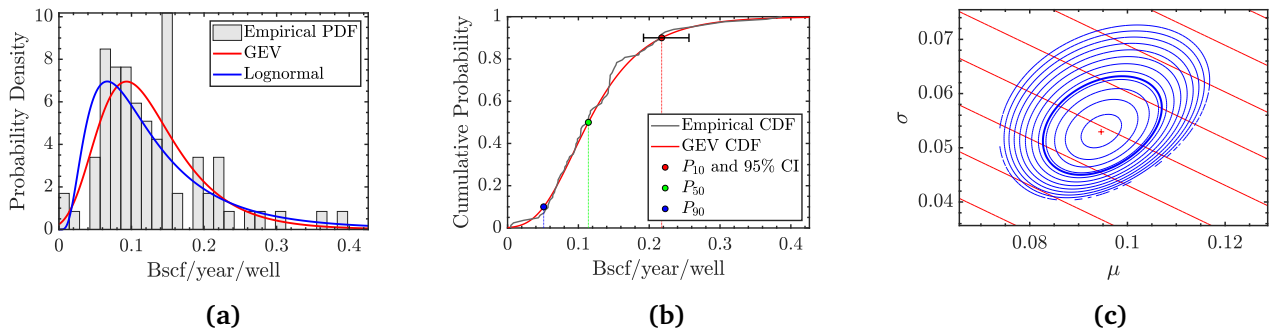


**Figure 62.** Distribution of gas production rates for 83 horizontal wells with ten years on production, completed between the year 2009 and 2012 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.03$, $\mu = 0.09$, $\sigma = 0.05$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
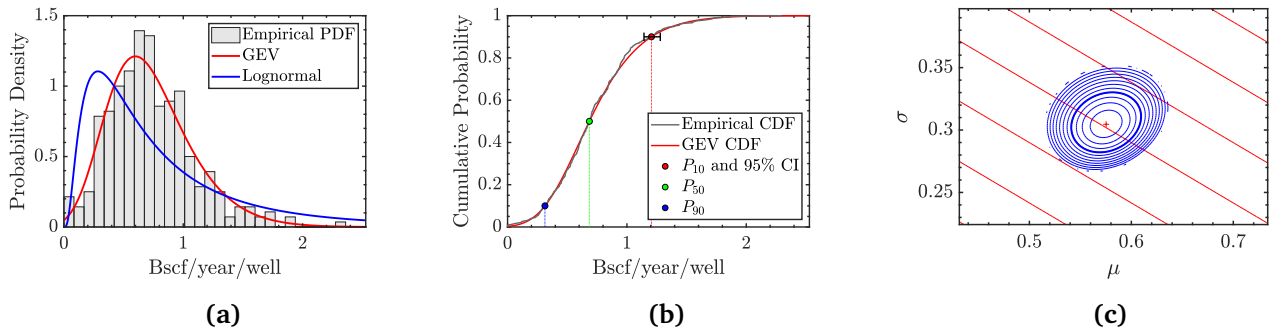


**Figure 63.** Distribution of gas production rates for 332 horizontal wells with one year on production, completed between the year 2013 and 2014 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.08$, $\mu = 0.58$, $\sigma = 0.30$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
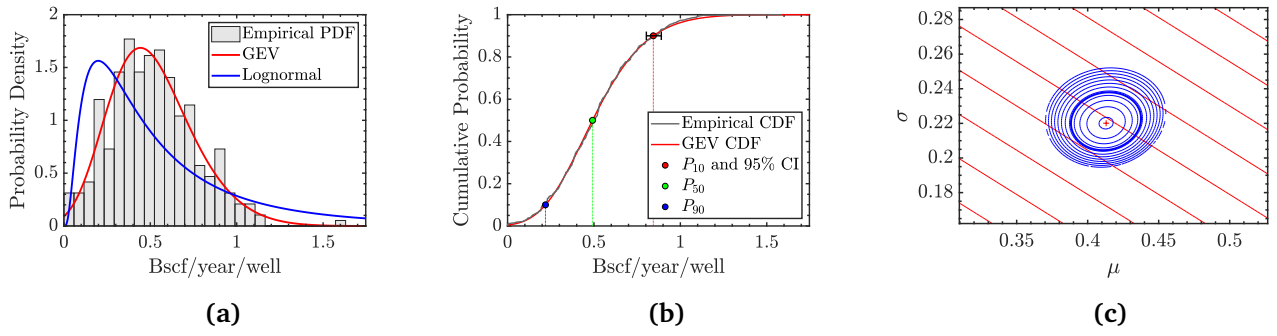
**Figure 64.** Distribution of gas production rates for 330 horizontal wells with two years on production, completed between the year 2013 and 2014 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.13$, $\mu = 0.41$, $\sigma = 0.22$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
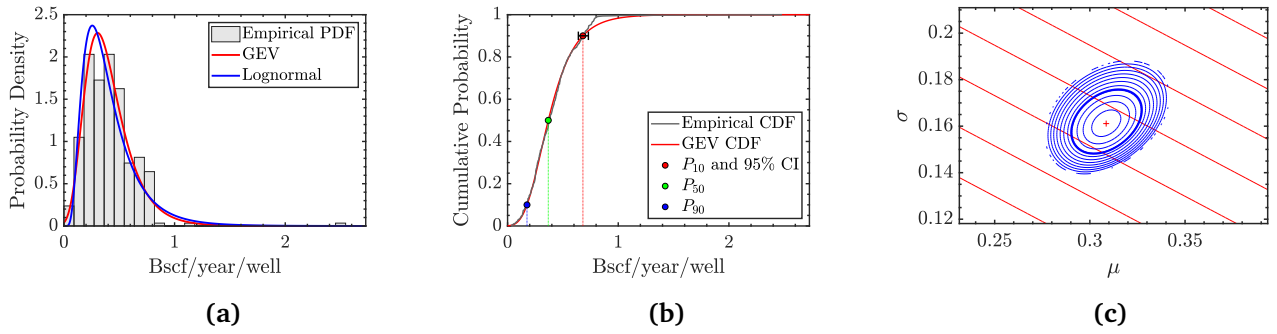


**Figure 65.** Distribution of gas production rates for 325 horizontal wells with three years on production, completed between the year 2013 and 2014 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.02$, $\mu = 0.31$, $\sigma = 0.16$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
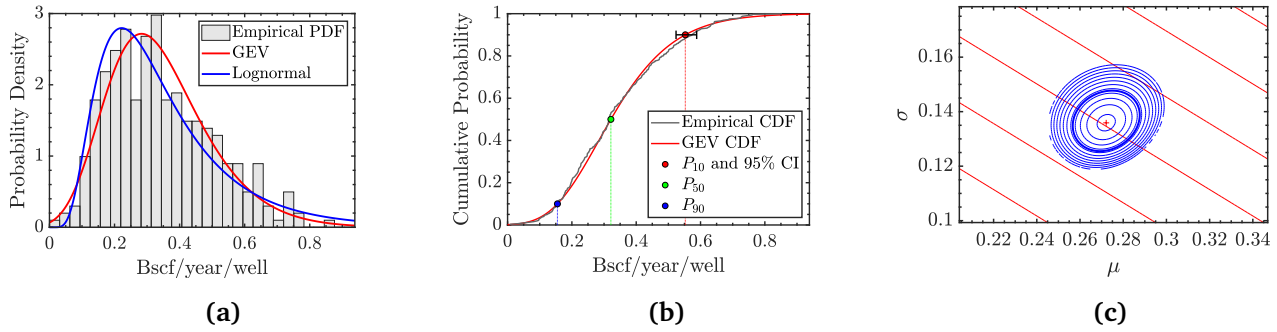


**Figure 66.** Distribution of gas production rates for 322 horizontal wells with four years on production, completed between the year 2013 and 2014 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.08$, $\mu = 0.27$, $\sigma = 0.14$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
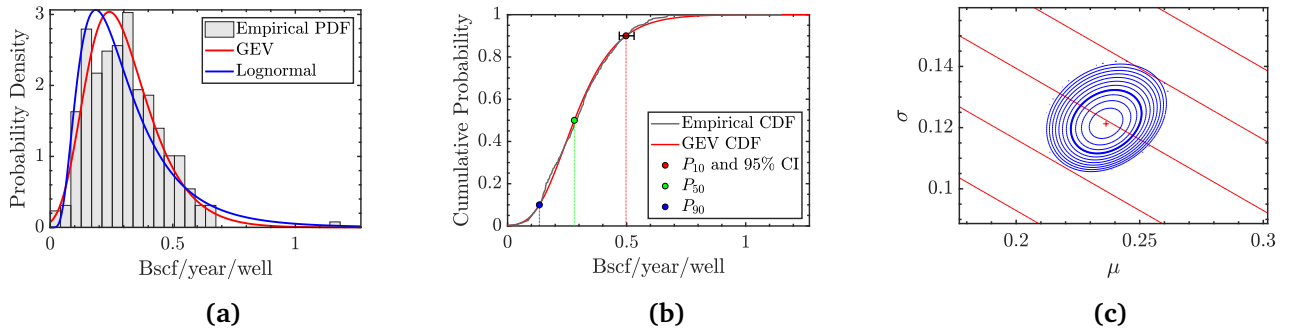
**Figure 67.** Distribution of gas production rates for 305 horizontal wells with five years on production, completed between the year 2013 and 2014 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.04$, $\mu = 0.24$, $\sigma = 0.12$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
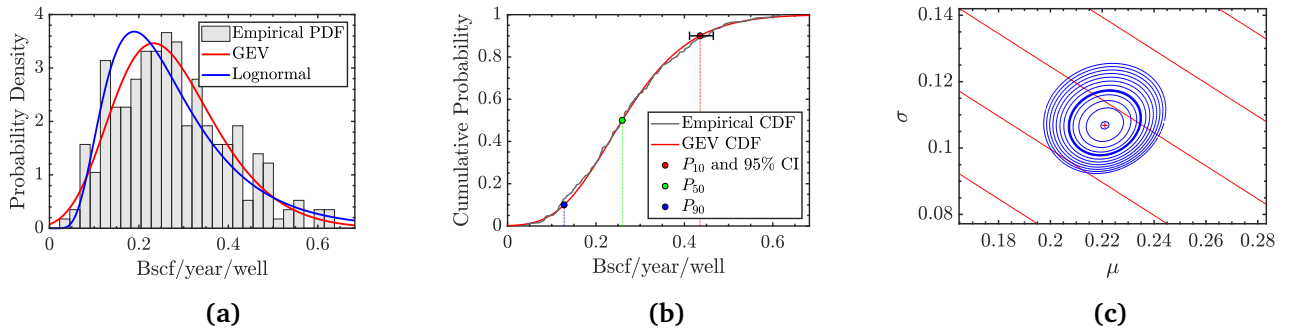


**Figure 68.** Distribution of gas production rates for 252 horizontal wells with six years on production, completed between the year 2013 and 2014 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.10$, $\mu = 0.22$, $\sigma = 0.11$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
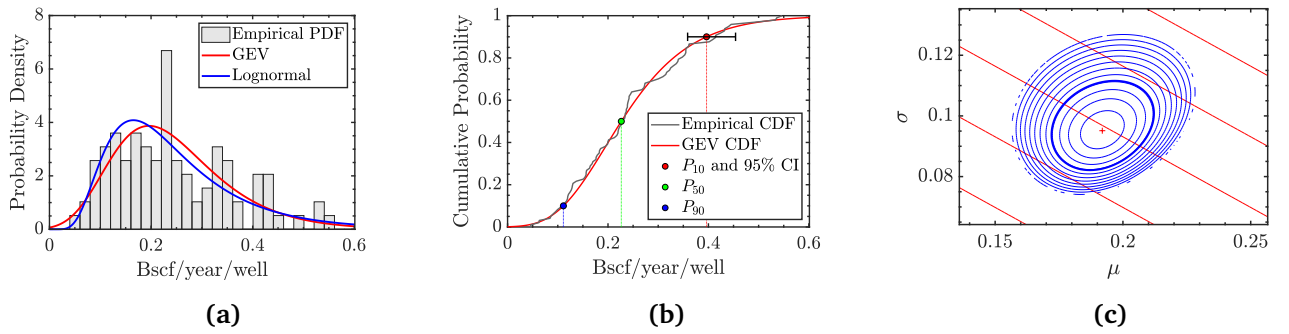


**Figure 69.** Distribution of gas production rates for 97 horizontal wells with seven years on production, completed between the year 2013 and 2014 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.04$, $\mu = 0.19$, $\sigma = 0.10$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
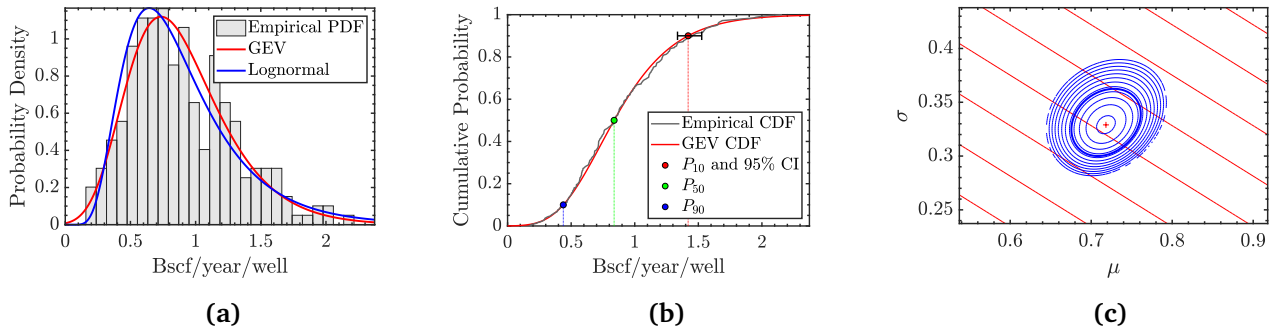
**Figure 70.** Distribution of gas production rates for 250 horizontal wells with one year on production, completed between the year 2015 and 2016 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.05$, $\mu = 0.72$, $\sigma = 0.33$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
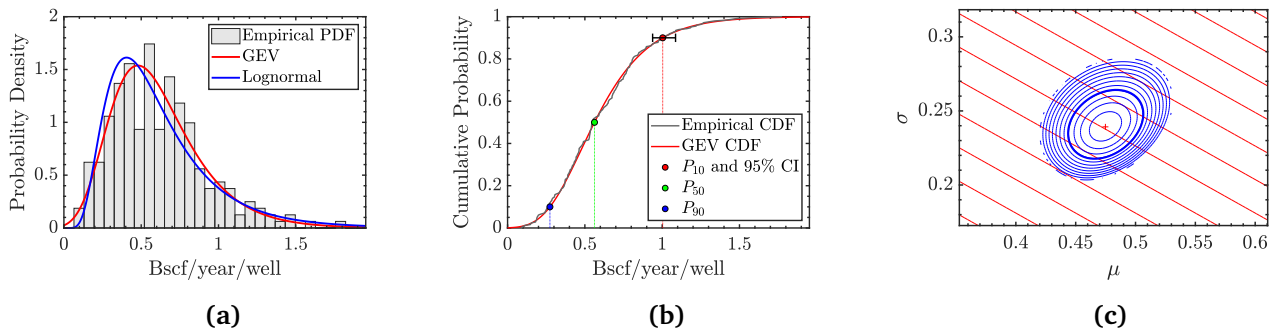


**Figure 71.** Distribution of gas production rates for 247 horizontal wells with two years on production, completed between the year 2015 and 2016 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.02$, $\mu = 0.47$, $\sigma = 0.24$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
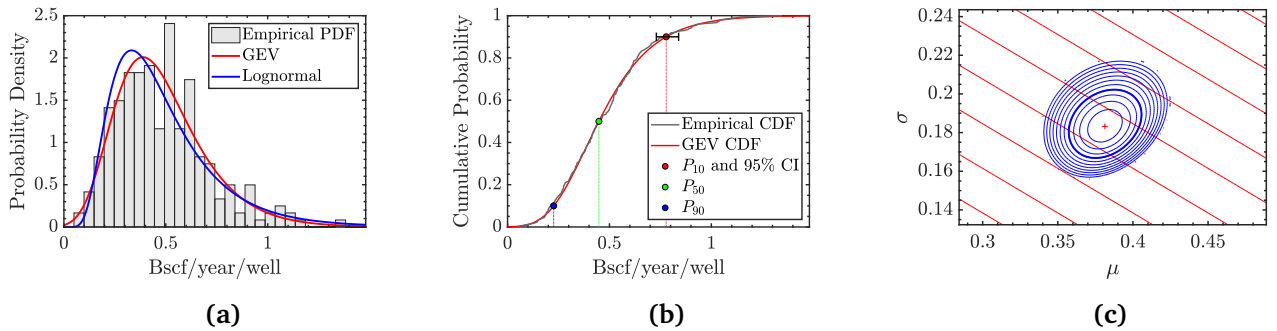


**Figure 72.** Distribution of gas production rates for 244 horizontal wells with three years on production, completed between the year 2015 and 2016 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.03$, $\mu = 0.38$, $\sigma = 0.18$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
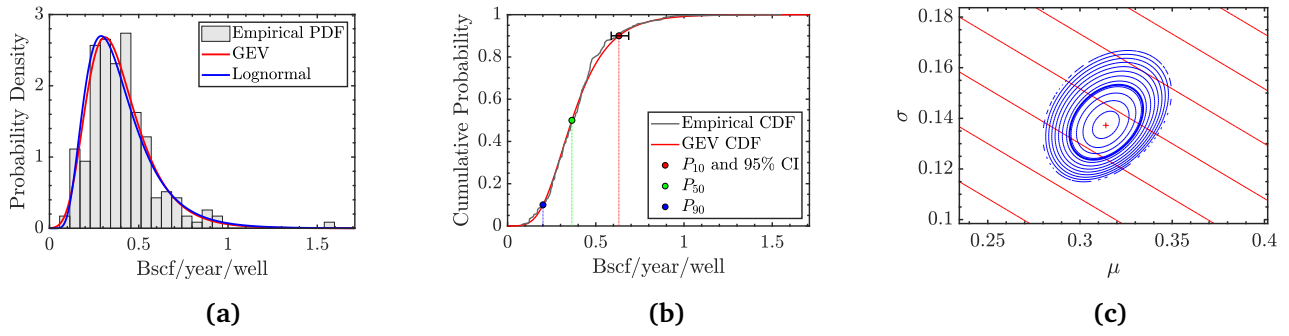
**Figure 73.** Distribution of gas production rates for 205 horizontal wells with four years on production, completed between the year 2015 and 2016 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.02$, $\mu = 0.31$, $\sigma = 0.14$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
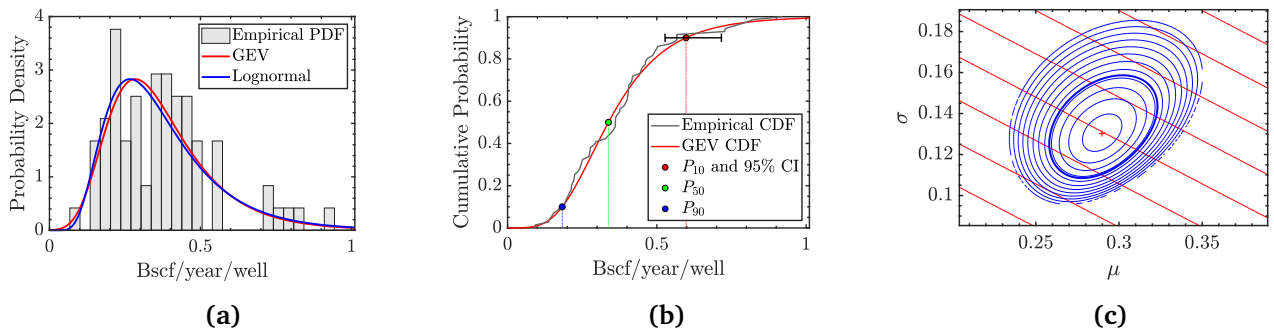


**Figure 74.** Distribution of gas production rates for 71 horizontal wells with five years on production, completed between the year 2015 and 2016 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.04$, $\mu = 0.29$, $\sigma = 0.13$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
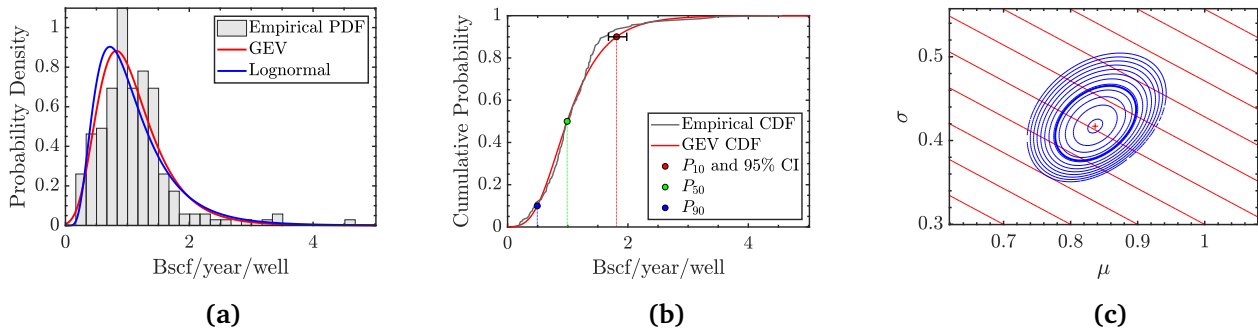


**Figure 75.** Distribution of gas production rates for 207 horizontal wells with one year on production, completed between the year 2017 and 2020 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.03$, $\mu = 0.84$, $\sigma = 0.42$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
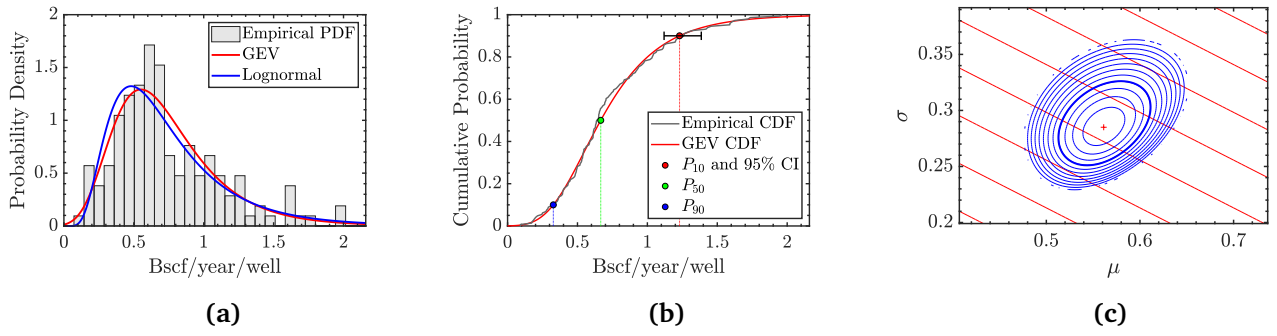
**Figure 76.** Distribution of gas production rates for 146 horizontal wells with two years on production, completed between the year 2017 and 2020 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = 0.04$, $\mu = 0.56$, $\sigma = 0.28$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
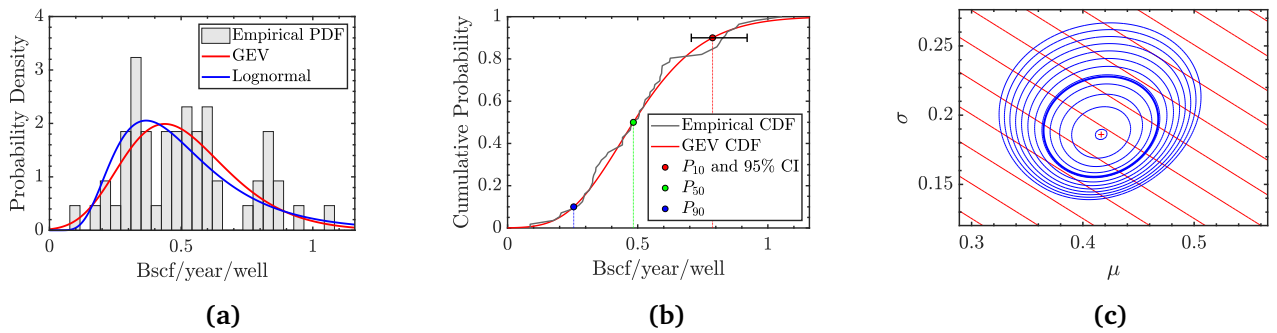


**Figure 77.** Distribution of gas production rates for 56 horizontal wells with three years on production, completed between the year 2017 and 2020 in the Marcellus Noncore area. (**a**) GEV PDF: $\xi = -0.11$, $\mu = 0.42$, $\sigma = 0.19$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
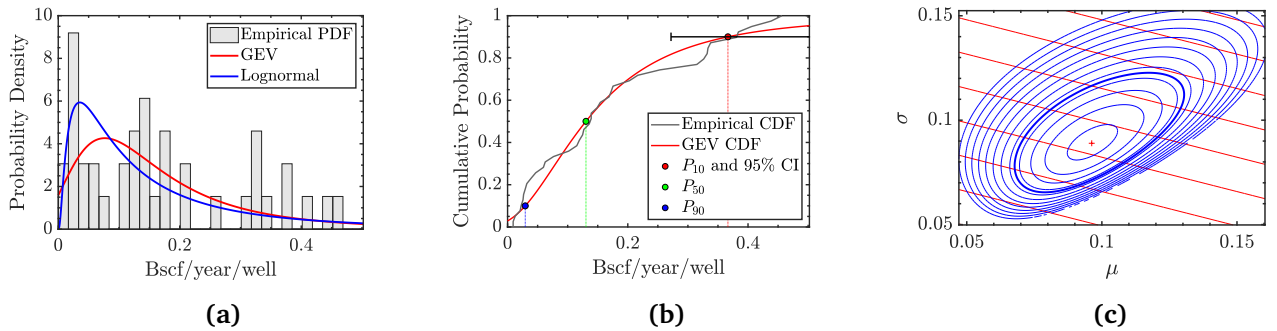


**Figure 78.** Distribution of gas production rates for 39 horizontal wells with one year on production, completed between the year 2009 and 2012 in the Marcellus Outer area. (**a**) GEV PDF: $\xi = 0.25$, $\mu = 0.10$, $\sigma = 0.09$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
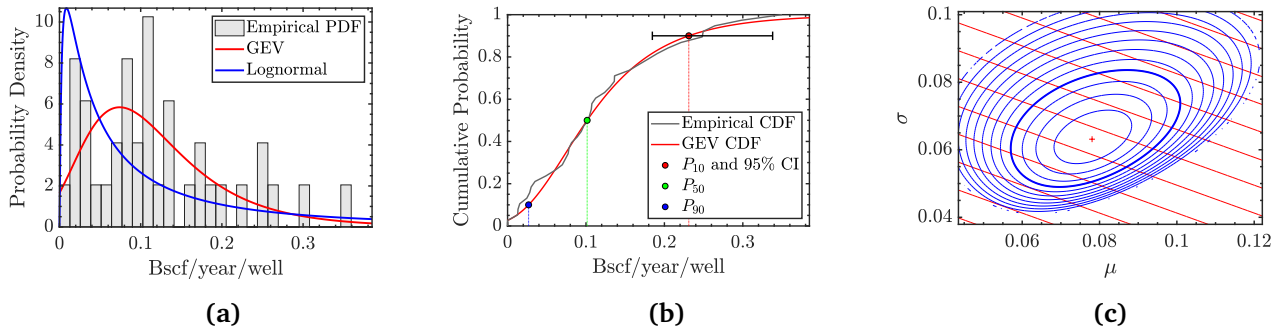
**Figure 79.** Distribution of gas production rates for 38 horizontal wells with two years on production, completed between the year 2009 and 2012 in the Marcellus Outer area. (**a**) GEV PDF: $\xi = 0.07$, $\mu = 0.08$, $\sigma = 0.06$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
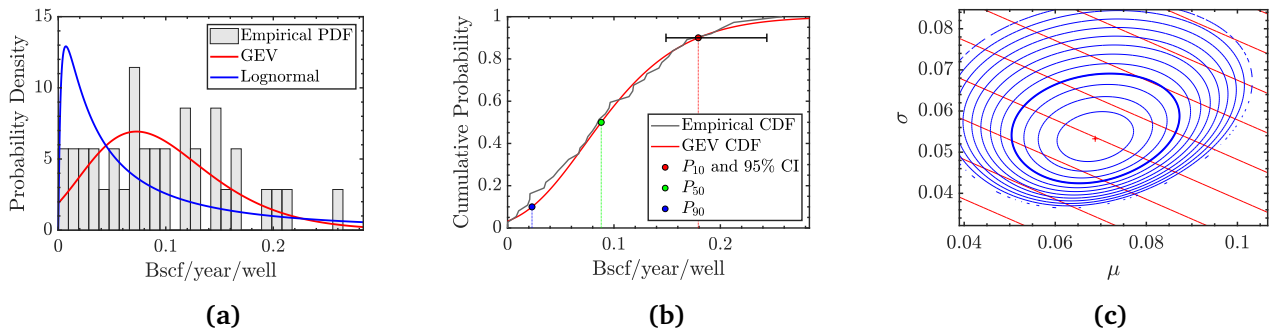


**Figure 80.** Distribution of gas production rates for 37 horizontal wells with three years on production, completed between the year 2009 and 2012 in the Marcellus Outer area. (**a**) GEV PDF: $\xi = -0.07$, $\mu = 0.07$, $\sigma = 0.05$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
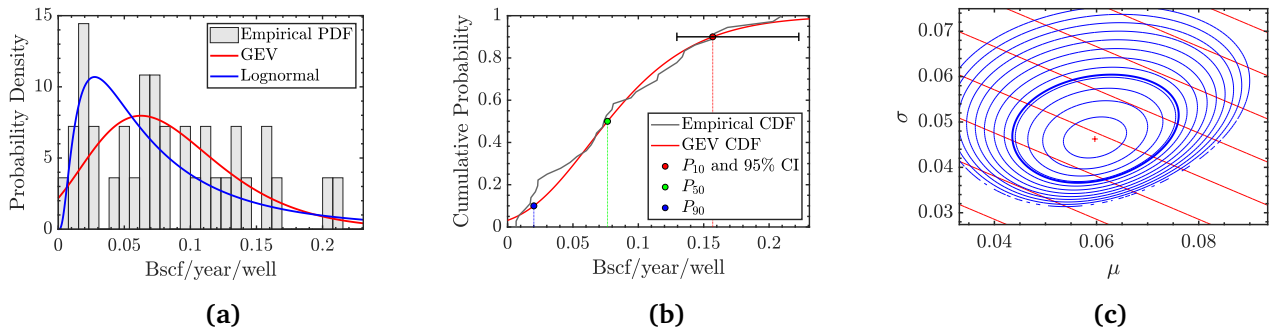


**Figure 81.** Distribution of gas production rates for 36 horizontal wells with four years on production, completed between the year 2009 and 2012 in the Marcellus Outer area. (**a**) GEV PDF: $\xi = -0.06$, $\mu = 0.06$, $\sigma = 0.05$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
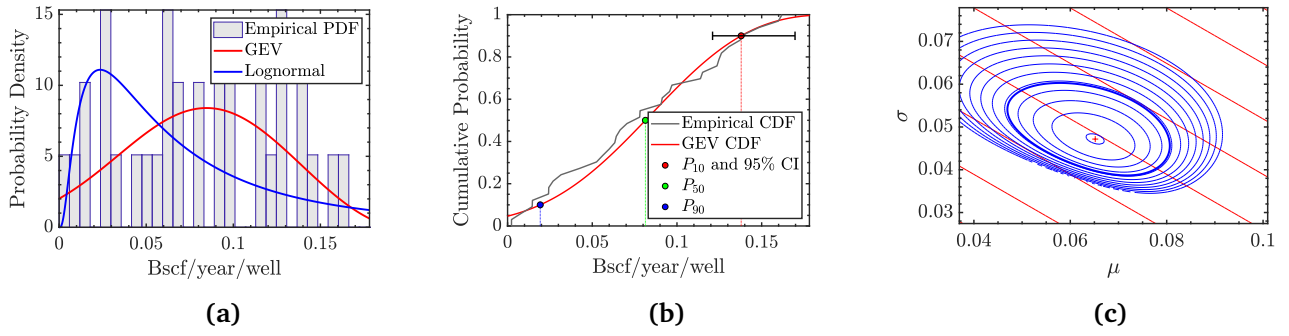
**Figure 82.** Distribution of gas production rates for 33 horizontal wells with five years on production, completed between the year 2009 and 2012 in the Marcellus Outer area. (**a**) GEV PDF: $\xi = -0.36$, $\mu = 0.07$, $\sigma = 0.05$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
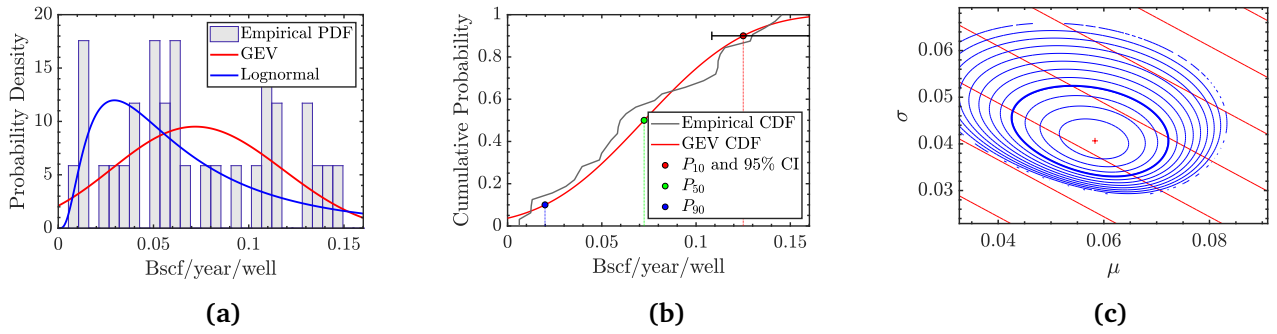


**Figure 83.** Distribution of gas production rates for 32 horizontal wells with six years on production, completed between the year 2009 and 2012 in the Marcellus Outer area. (**a**) GEV PDF: $\xi = -0.30$, $\mu = 0.06$, $\sigma = 0.04$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
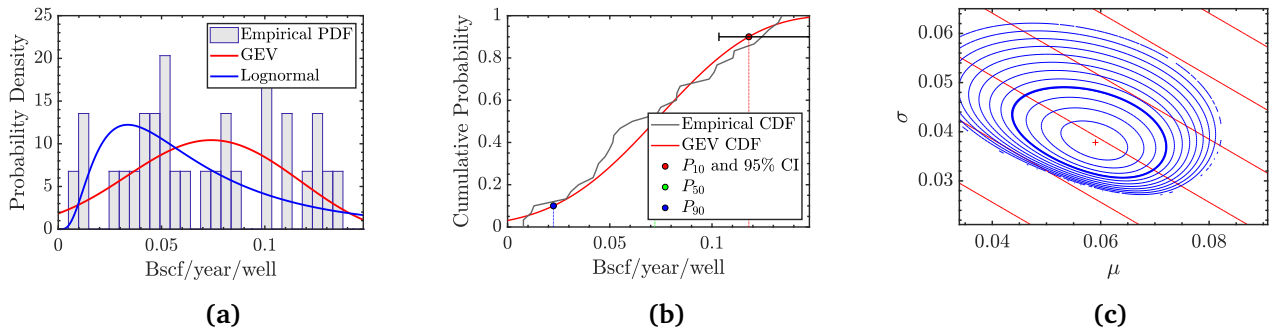


**Figure 84.** Distribution of gas production rates for 30 horizontal wells with seven years on production, completed between the year 2009 and 2012 in the Marcellus Outer area. (**a**) GEV PDF: $\xi = -0.35$, $\mu = 0.06$, $\sigma = 0.04$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.
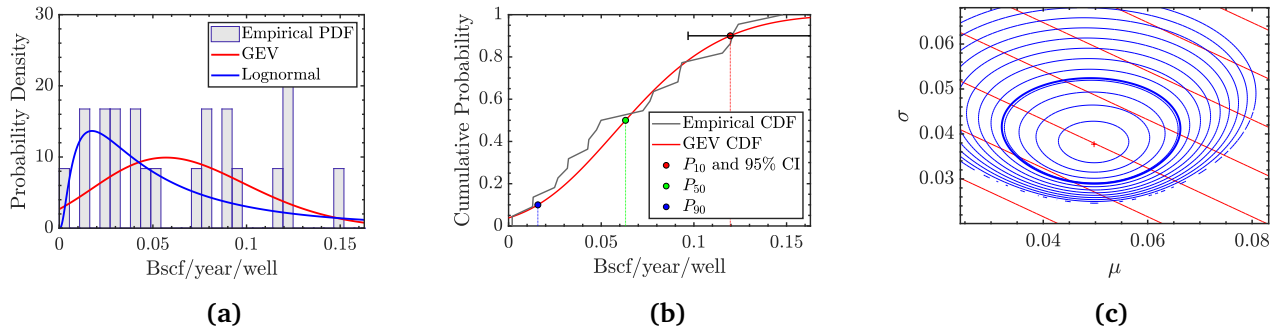
**Figure 85.** Distribution of gas production rates for 22 horizontal wells with eight years on production, completed between the year 2009 and 2012 in the Marcellus Outer area. (**a**) GEV PDF: $\xi = -0.18$, $\mu = 0.05$, $\sigma = 0.04$. (**b**) GEV CDF with the 95% confidence limits (CIs) on the residual for the $P_{10}$ well. (**c**) Maximum Likelihood Estimate, 95% CI for $\mu$ and $\sigma$.