Responses to Referee #1:

This paper represents an interesting huge work, the main objective of this paper is to detect the possible changes in catchment water storage capacity induced by a prolonged meteorological drought. It will also help improve our ability to simulate the hydrological system. Meanwhile, the structure is clear and analyses and conclusions in this paper are reasonable and logical. Overall, it is a nice paper with proper methodology and complete discussion on the main findings. A minor modification should be considered before publication.

Reply: We are grateful for the reviewer's appreciation of our work and for the professional comments, which are carefully followed in making revision.

General comments:

A1: First, the results indicated that 12 catchments had a significant downward shift in the CWSC. My first principal doubts come from there: are 12 sufficient to be able to analyze regularity about catchments with a significant downward shift.

Reply: Thanks. We will make it clearer in the revised version that to ensure the accuracy of the modeling results, strict criteria were adopted to evaluate the model results and to identify the catchments with a significant change in θ_1 including the minimum NSE requirement, the minimum requirement of significant change, the requirement for maximum performance degradation, and the requirement for the robustness of results (see section 3.2.5). Only these catchments that satisfied all these criteria were identified as catchments undergo significant changes. Actually, only 12 of the 145 catchments, which had experienced a long-term meteorological drought, satisfied all these four criteria and have been identified with a significant downward shift in the CWSC. Thus, the identified 12 catchments that had a significant downward shift should be reasonable results.

We will also clarify that this result depends on the criteria used for evaluation. All catchments from southeastern Australia in the dataset have been tested in this study using the above defined criteria, and we did not find more catchments with a significant downward shift in the CWSC. More explanation will be provided in the revision.

A2: Second: Formulating conclusions is similar to drawing up an abstract. I mean that the emphases of the abstract and conclusions are different.

Reply: Thank you for your comments, following which, the Abstract and conclusion will be rewritten.

The part of Abstract will be modified as follows:

Understanding the propagation of prolonged meteorological droughts helps solve the problem of intensified water scarcity around the world. Most of the existing literature studied the propagation of drought from one type to another (e.g., from meteorological to hydrological drought) with statistical approaches, there remains a difficulty in revealing the causality between the meteorological drought and potential changes in the Catchment Water Storage Capacity (CWSC). This study aims to identify the response of the CWSC to the meteorological drought by examining the changes of hydrological model parameters after the drought events. Firstly, the temporal variation of a model parameter that denotes the CWSC is estimated to reflect the potential changes in real CWSC. Next, the change points of the CWSC parameter were determined based on the Bayesian change point analysis. Finally, the possible association and linkage between the shift in the CWSC and the time-lag of the catchment (i.e., time-lag between the onset of the drought and the change point) with multiple catchment properties and climate characteristics were identified. In total 145 catchments from southeastern Australia were selected as the study areas. Results indicated that (1) significant shifts in the CWSC can be observed in 62.7% of the catchments, which can be divided into two subsets with the opposite response, i.e. 48.2% of catchments had lower runoff generation rates while 14.5% of catchments had higher runoff generation rate; (2) the increase in the CWSC during a chronic drought can be observed in smaller catchments with lower elevation, slope, and forest coverage of Evergreen Broadleaf Forest, while the decrease in the CWSC can be observed in larger catchments with higher elevation and larger coverage of the Evergreen Broadleaf Forest; (3) catchments with a lower proportion of Evergreen Broadleaf Forest usually have longer time-lag and are more resilient. This study improves our understanding of possible changes in the CWSC induced by a prolonged meteorological drought, which will help improve our ability to simulate the hydrological system under climate change.

The Conclusion will be modified as follows:

This study aims to examine the possible changes in the CWSC as well as the time-lag between the onset of the meteorological drought and the change point of the CWSC. A classical hydrological model, GR4J, was used and its parameter θ_1 was selected to denote catchment water storage capacity (CWSC). Thus, the temporal variation in parameter θ_1 was detected to reveal the possible fluctuation in the CWSC, and the causality between the temporal variation in parameter θ_1 and a persistent meteorological drought was examined. One hundred forty-five catchments in southeastern Australia were selected as the study areas. Main conclusions can be drawn as follows:

(1) Significant changes in the CWSC have been identified in 62.7% (52 in 83) of catchments, which can be divided into two subsets with opposite catchment responses: 48.2% (40 in 83) experienced a significant decrease in the CWSC during the drought period and had lower runoff generation rates, while 14.5% (12 in 83) of catchments experienced a significant decrease in the CWSC during the drought period, and had higher runoff generation rate.

(2) Different change directions in the CWSC resulted in the opposite impacts on runoff generation, i.e., catchments with increased CWSC would result in lower runoff generation rates for similar amounts of rainfall than before while those catchments with decreased CWSC would have an opposite response (higher runoff generation rate). Generally, the increase in the CWSC during a chronic drought can be observed in smaller catchments with lower elevation, slope, and forest coverage of Evergreen

Broadleaf Forest, while the decrease in the CWSC can be observed in larger catchments with higher elevation and larger coverage of the Evergreen Broadleaf Forest. Among all catchment properties and climate variables considered, our results suggest that two climate variables (i.e., variation in annual rainfall and annual runoff ratio) have the strongest associations with the shift in the CWSC.

(3) The responses of different catchments to persistent meteorological drought were not equally susceptible. Catchments with a lower proportion of Evergreen Broadleaf Forest usually have longer time-lag and are more resilient.

It is noted that although this study resulted in interesting findings that give new insight and have not been fully outlined before, it is based on the lumped GR4J model and the specific case in Australia, which implies that the main findings/conclusions may not directly extendable to other regions. Thus, to examine the generality of the main conclusions, the response of CWSC to the meteorological drought can be analyzed with the other hydrological models in the other regions.

Detailed comments:
A3: Is there a mistake in the inconsistency between the Abstract (L37-L38) and Conclusion (L613-615).
Reply: We are sorry for this error. The sentence in the Abstract and Conclusion will be modified as "…the increase in the CWSC during a chronic drought can be observed in smaller catchments with lower elevation, slope, and forest coverage of Evergreen Broadleaf Forest, while the decrease in the CWSC can be observed in larger catchments with higher elevation and larger coverage of the Evergreen Broadleaf Forest.".

A4: Previous study (Yan et al., 2015) has indicated that the sensitivity of the parameters in the GR4J model has different performance in different parts of the same basin. Therefore, you should cite more citations or do some researches in the study area to support the sentence in the L224-L226.

Reply: Thank you. More citations will be added to the revised manuscript. This sentence will be modified as "Previous studies (Demirel et al., 2013; Pan et al., 2019a; Pan et al., 2019b; Perrin et al., 2003; Westra et al., 2014; Yan et al., 2015) showed that θ_1, which denotes the catchment water storage capacity, is the most sensitive parameter in the structure of the GR4J model.".

Added reference:
1. Yan, X. L., Zhang, J. Y., Wang, G. Q., Bao, Z. X., Liu, C. S., and Xuan, Y. Q.: Application of GR4J Rainfall-runoff Model to Typical Catchments in the Yellow River Basin, Proceedings of the 5th International Yellow River Forum on Ensuring Water Right of the River's Demand and Healthy River Basin Maintenance, Vol V, edited by: Hongqi, S., and Xiangxin, L., Yellow River Conservancy Press, Zhengzhou, 191-198 pp., 2015.
2. Demirel, M. C., Booij, M. J., and Hoekstra, A. Y.: Effect of different uncertainty sources on the skill of 10 day ensemble low flow forecasts for two hydrological

models, Water Resour. Res., 49, 4035-4053, 10.1002/wrcr.20294, 2013.

A5: L503-517: You should cut out much of the repetition with the Section 4.

Reply: Thanks. Changes will be made as suggested. The paragraph in lines 503-517 will be modified as follows:

The results indicate that, under certain circumstances, a long-term meteorological drought would result in a significant change in the CWSC. However, no strong association has been found between the magnitude of the change in the CWSC with any single variable. In addition, the length of dry period was not associated with the shift in the CWSC. Thus, it seems that the catchment response behavior to long-term meteorological drought is controlled by the combination of local catchment properties and climate characteristics rather than a single factor. Thus, further studies are still required to confirm which factors played the most important role in the catchment dynamic.

A6: In the Section 4.4 You had better discuss the factors for the direction first and then the magnitude of shifts in the CWSC.

Reply: Thanks. We will explain better that Section 4.4.1 presents the results that classify the catchments into two groups, one group shows significant shifts in the CWSC, and another does not. While section 4.4.2 continued to discuss the difference between two sub-groups of catchments with significant upward/significant downward shifts in the CWSC. These two sub-groups of catchments were extracted from the group of catchments with significant shifts in the CWSC according to the change direction of the estimated θ_1. Thus, we thought it might be better to discuss the difference between two groups of catchments with/without significant shifts at first, and then illustrate the difference between two subsets of catchments with significant upward/significant downward shifts later.

To make it clearer, after considering reviewer's advice and reminder, the headings of sections 4.4.1 and 4.4.2 will be modified as "4.4.1 Factors for the significant/non-significant shifts in the CWSC" and "4.4.2 Factors for the significant upward/downward shifts in the CWSC" in the revised manuscript.

A7: Why not analyze the reasons for conclusion 2 in the Section 5.1? (Catchments with larger elevation and slope, lower forest coverage of Evergreen Broad leaf Forest are more likely to have an increase in the CWSC during a chronic drought while smaller catchments with lower elevation, lower coverage of the Evergreen Broad leaf Forest are more likely to have a decrease in the CWSC.)

Reply: Thanks. We tried but as shown in Figures 7 and 9, no strong PCC association has been found between the magnitude of the change in the CWSC and the single catchment property or climate variable. It seems that the catchment response behavior to long-term meteorological drought is controlled by the combination of local catchment properties and climate characteristics rather than a single factor Thus, we prospected that further studies are still required to confirm which factors played the most important role in the catchment dynamic.

A8: The conclusion should be concise and coherent. It is suggested that only the key and definitive conclusions of this paper should be stated. If you cannot confirm your conclusion, these results may only be used in the Discussion, such as L610-611 and L622-631, etc.

Reply: Thanks. Changes will be made as suggested. The sentences in lines 610-611 will be deleted in the conclusion part of the revised manuscript. In addition, the sentences in lines 622-631 will be modified as follows:

It is noted that although this study resulted in interesting findings that give new insight and have not been fully outlined before, it is based on the lumped GR4J model and the specific case in Australia, which implies that the main findings/conclusions may not directly extendable to other regions. Thus, to examine the generality of the main conclusions, the response of CWSC to the meteorological drought can be analyzed with the other hydrological models in the other regions.

A9: It's better to add latitude and longitude to the location map of the study catchments (Figure 1).

Reply: Thanks. Changes will be made in the revised Figure 1. The modified Figure 1 will be as follows.

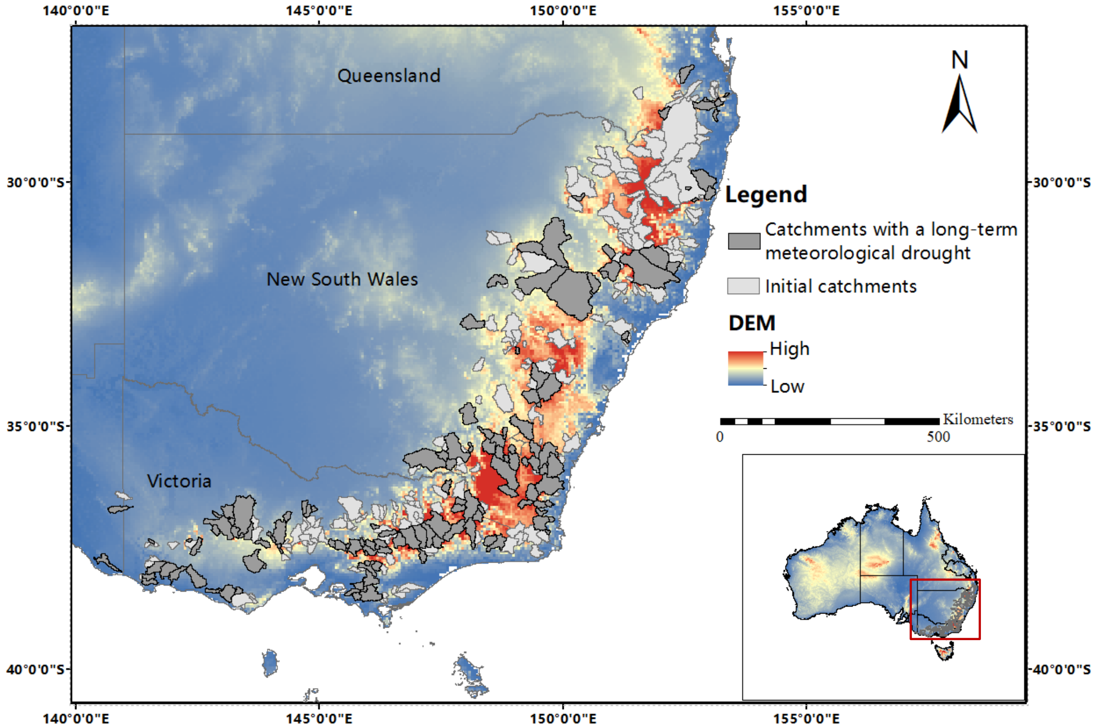

Figure 1. Location map of the study catchments in southeastern Australia. The dark gray color denotes the catchments with a long-term meteorological drought (145 catchments) while the light gray color denotes the catchments without any sustained droughts or has more than one prolonged drought period (253 catchments).

A10: Table 3 should add the results about the fourth criteria.

Reply: Thanks. Changes will be made in the revised Table 3. The modified Table 3 will be as follows.

Table 3. The direction of the shifts in the CWSC due to the long-term meteorological drought for the catchments in southeastern Australia.

Magnitude	Change direction	Percentage (Number of catchments)
Significant change	Downward (Smaller CWSC than the previous estimation suggests)	8.3% (12)
	Upward (Larger CWSC than the previous estimation suggests)	27.6% (40)
Non-significant change	Slight increase	12.4% (18)
	Slight decrease	9.0% (13)
Dissatisfy the criteria of the minimum NSE performance, the maximum performance degradation and the robustness requirement		42.8% (62)
All (catchments with a sustained meteorological drought)		100% (145)

A11: Figure 4 can be improved. The figure should show the change directions and magnitudes of the CWSC at the same time. It is better for readers to understand the shifts of the CWSC in the adjacent catchments.

Reply: Thanks. Changes will be made as suggested. The modified Figure 4 will be as follows:

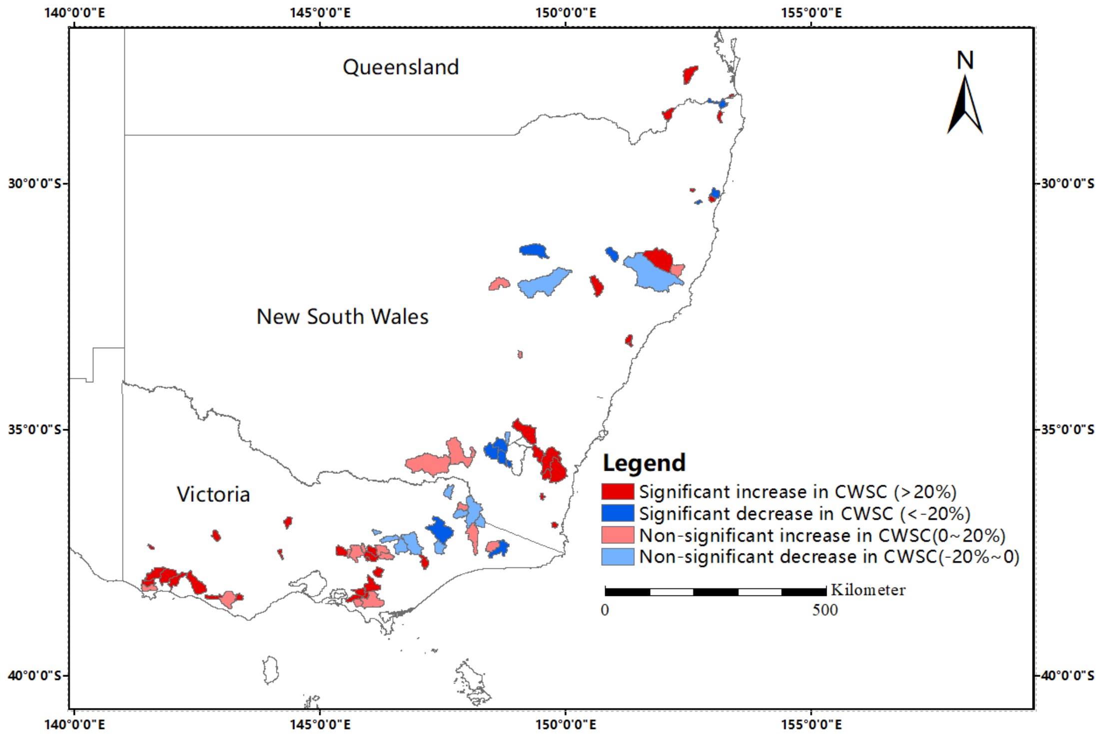

Figure 4. Location map of the catchments with the significant and non-significant shifts in the CWSC. The red (pink) color denotes the catchments that have a significant increase (decrease) in the CWSC after the Change point while the (nattier) blue color

denotes the catchments with a non-significant increase (decrease) in the CWSC.

A12: Is the supplementary material missing?

Reply: We are sorry for this mistake. We have uploaded the supplementary material (Table S1) to the system. Please also refer to the material (Table S1) below.

Table S1. Catchments with the long-term meteorological droughts.

FID	Station ID	Drought start	Drought end	drought anomaly	Complete
1	143107	2000	2007	-19.67%	97.03%
2	145010	1993	2009	-10.41%	97.71%
3	146095	1991	1998	-11.24%	96.91%
4	201001	1991	1998	-9.64%	97.44%
5	203005	1991	2007	-11.66%	95.62%
6	203010	1991	2007	-11.84%	96.41%
7	204017	1991	2007	-9.95%	97.77%
8	204025	1991	2007	-12.37%	95.47%
9	204037	1991	2005	-9.15%	97.17%
10	204039	2000	2009	-13.66%	82.96%
11	204041	1991	2006	-12.39%	96.80%
12	204906	1991	2007	-12.71%	97.12%
13	208004	1991	1997	-12.47%	96.94%
14	208005	1991	1998	-10.85%	97.13%
15	208019	1991	1998	-13.11%	80.26%
16	210016	2001	2007	-10.13%	88.07%
17	210031	2001	2007	-9.50%	94.67%
18	210040	2001	2007	-11.87%	96.51%
19	210052	2001	2007	-8.63%	83.18%
20	210093	2001	2007	-12.36%	86.06%
21	211009	1993	2006	-15.08%	96.97%
22	211014	1993	2006	-14.82%	95.30%
23	212040	2000	2009	-12.27%	84.80%
24	215002	2000	2009	-16.58%	89.43%
25	215008	1999	2009	-14.45%	96.36%
26	217002	2000	2009	-19.67%	97.20%
27	218001	2002	2009	-16.00%	98.32%
28	218005	2002	2009	-16.37%	97.73%
29	218007	1996	2009	-11.64%	97.79%
30	218008	2002	2009	-16.56%	93.60%
31	219003	1998	2009	-13.85%	97.36%
32	219006	1998	2009	-15.14%	98.27%
33	219017	2002	2009	-21.36%	97.78%
34	219022	1998	2009	-15.71%	97.35%
35	220003	1998	2009	-12.20%	97.78%
36	220004	1996	2009	-12.28%	97.03%
37	221010	1996	2009	-9.23%	82.23%

FID	Station ID	Drought start	Drought end	drought anomaly	Complete
38	222007	2002	2009	-13.72%	98.28%
39	222016	2002	2009	-12.26%	96.52%
40	222017	1996	2009	-9.98%	89.46%
41	222202	2002	2009	-10.32%	95.67%
42	222206	2002	2009	-10.76%	91.82%
43	222213	2002	2009	-12.23%	91.39%
44	222217	2002	2009	-10.15%	98.81%
45	223202	2002	2009	-13.78%	91.54%
46	224201	2002	2009	-13.64%	98.46%
47	224206	2002	2009	-13.44%	91.88%
48	224213	2002	2009	-15.64%	95.80%
49	224214	2002	2009	-14.36%	99.51%
50	225218	2002	2009	-9.03%	100.00%
51	225219	1997	2009	-11.70%	91.47%
52	226204	1997	2009	-10.91%	96.30%
53	226209	1999	2009	-11.47%	100.00%
54	226220	1997	2009	-10.43%	85.57%
55	226226	1999	2009	-8.73%	99.95%
56	226402	1999	2009	-11.51%	100.00%
57	227202	1997	2009	-9.88%	95.68%
58	227219	1997	2009	-10.50%	92.34%
59	227227	1997	2009	-10.56%	92.09%
60	227231	1997	2009	-10.34%	92.30%
61	227236	1997	2009	-9.31%	83.12%
62	228209	1999	2009	-10.75%	80.24%
63	229661	1997	2009	-11.23%	82.54%
64	231225	1997	2009	-13.26%	100.00%
65	233223	1997	2009	-11.90%	92.68%
66	234200	1997	2009	-10.64%	84.79%
67	234201	1997	2009	-10.33%	94.83%
68	234203	1997	2009	-9.19%	96.24%
69	235203	1997	2009	-6.89%	91.44%
70	236205	1994	2009	-6.52%	92.62%
71	236212	1997	2009	-7.22%	91.93%
72	237202	1993	2009	-6.36%	92.05%
73	237205	1993	2009	-6.20%	92.21%
74	237206	1993	2009	-6.05%	96.41%
75	237207	1993	2009	-6.16%	92.04%
76	238204	1997	2009	-9.65%	89.94%
77	238229	1997	2009	-7.83%	92.24%
78	238231	1997	2009	-9.63%	82.82%
79	238235	1993	2009	-5.95%	92.05%
80	239523	1993	1999	-7.96%	99.72%

FID	Station ID	Drought start	Drought end	drought anomaly	Complete
81	239531	1997	2009	-8.64%	98.30%
82	401012	2002	2009	-14.08%	99.13%
83	401013	2001	2009	-17.54%	98.17%
84	401203	2001	2009	-15.90%	99.86%
85	401208	2001	2009	-17.18%	99.98%
86	401212	2002	2009	-15.96%	99.87%
87	401217	2002	2009	-15.21%	99.87%
88	405205	1997	2009	-13.26%	99.99%
89	405209	1997	2009	-13.07%	99.95%
90	405215	1999	2009	-12.49%	99.84%
91	405217	1997	2009	-13.27%	100.00%
92	405219	1997	2009	-11.16%	99.87%
93	405227	1997	2009	-11.61%	99.86%
94	405229	1997	2009	-14.97%	99.15%
95	405230	1997	2009	-14.79%	100.00%
96	405231	2001	2009	-16.24%	99.87%
97	405241	1997	2009	-13.62%	100.00%
98	405245	1997	2009	-15.99%	99.78%
99	405263	1997	2009	-10.61%	99.87%
100	405264	1997	2009	-11.14%	99.87%
101	406214	1997	2009	-14.23%	99.86%
102	406224	1997	2009	-14.08%	100.00%
103	407214	2001	2009	-16.19%	99.40%
104	407215	2001	2009	-17.73%	99.47%
105	407220	2001	2009	-18.39%	98.77%
106	407230	2001	2009	-17.92%	99.92%
107	408200	2000	2009	-18.03%	99.92%
108	408202	2001	2009	-14.66%	99.54%
109	410024	2001	2009	-19.20%	98.01%
110	410026	2000	2009	-13.19%	97.94%
111	410033	2001	2009	-12.11%	97.38%
112	410038	2001	2009	-20.49%	95.84%
113	410044	2001	2009	-20.21%	94.64%
114	410047	2001	2009	-17.73%	94.48%
115	410057	2001	2009	-19.32%	98.13%
116	410061	2001	2009	-19.12%	97.02%
117	410062	2002	2009	-14.90%	95.29%
118	410088	2001	2009	-17.90%	98.27%
119	410091	2001	2009	-17.43%	82.48%
120	410097	2001	2009	-17.25%	87.34%
121	410107	2001	2009	-19.39%	87.74%
122	410141	2000	2009	-14.70%	80.53%
123	410705	2000	2009	-14.97%	100.00%

FID	Station ID	Drought start	Drought end	drought anomaly	Complete
124	410713	2001	2009	-19.65%	98.40%
125	410730	2000	2009	-15.05%	99.75%
126	410731	2000	2009	-14.82%	97.75%
127	410734	2000	2009	-14.43%	99.43%
128	412028	2001	2009	-16.98%	95.86%
129	412050	2001	2009	-12.92%	88.11%
130	412066	2001	2009	-15.27%	96.69%
131	412080	2001	2009	-14.72%	81.02%
132	415201	2000	2009	-13.22%	99.86%
133	415207	2001	2009	-15.09%	99.54%
134	415220	2000	2009	-18.01%	99.29%
135	415226	2000	2008	-16.44%	99.40%
136	415237	1997	2009	-10.91%	97.17%
137	415238	2000	2009	-17.31%	97.51%
138	418027	2000	2009	-7.76%	95.20%
139	419032	2001	2009	-10.40%	91.78%
140	419035	1991	1997	-8.99%	80.84%
141	420003	2001	2007	-17.20%	95.01%
142	420017	2001	2007	-15.46%	86.20%
143	421042	2001	2007	-12.01%	97.50%
144	421055	2001	2007	-17.33%	80.79%
145	421076	2001	2009	-14.83%	80.21%