

WellDataBaseML example: Predicting Well production within Eagle Ford Play

A problem demonstrating how **Well DataBase ML** can be applied to predict oil/gas production.

The machine-learning problem described here relates to the classical history matching problems.

If **Well DataBase ML** is not installed, first execute `import Pkg;`
`Pkg.add("Well DataBaseML"); Pkg.add("Well DataBase") .`

In [3]: `import Well DataBaseML`

```
[ Info: Precompiling Well DataBaseML [b2fc4b94-a46a-4cf9-bc84-39b1d777371
f]
└ @ Base loading.jl:1278
```

Unable to load WebIO. Please make sure WebIO works for your Jupyter client. For troubleshooting, please see [the WebIO/IJulia documentation](https://juliagizmos.github.io/WebIO.jl/latest/providers/ijulia/) (<https://juliagizmos.github.io/WebIO.jl/latest/providers/ijulia/>).

```
[ Info: Installing pyqt package to avoid buggy tkagg backend.
└ @ PyPlot /Users/vvv/.julia/packages/PyPlot/XHEG0/src/init.jl:118
```

In [6]: `import Well DataBase`

First, the Eagle Ford Play datasets is uploaded:

In [9]: `df, df_header, api, recordlength, dates = Well DataBase.read(["csv-201908102`

...

The loaded data are provided in the following form:

- `df` : data frame containing well production transients
- `df_header` : data frame containing well construction attributes
- `api` : a vector with well API's listed in `df` and `df_header``
- `recordlength` : the maximum record length (in months) for the processed well dataset
- `dates` : range of dates for which production data are available (in months)

Machine learning (ML) analysis can be performed to predict well production based on this dataset.

Under this example, the goal is to use all the data collected up to 2015 for training.

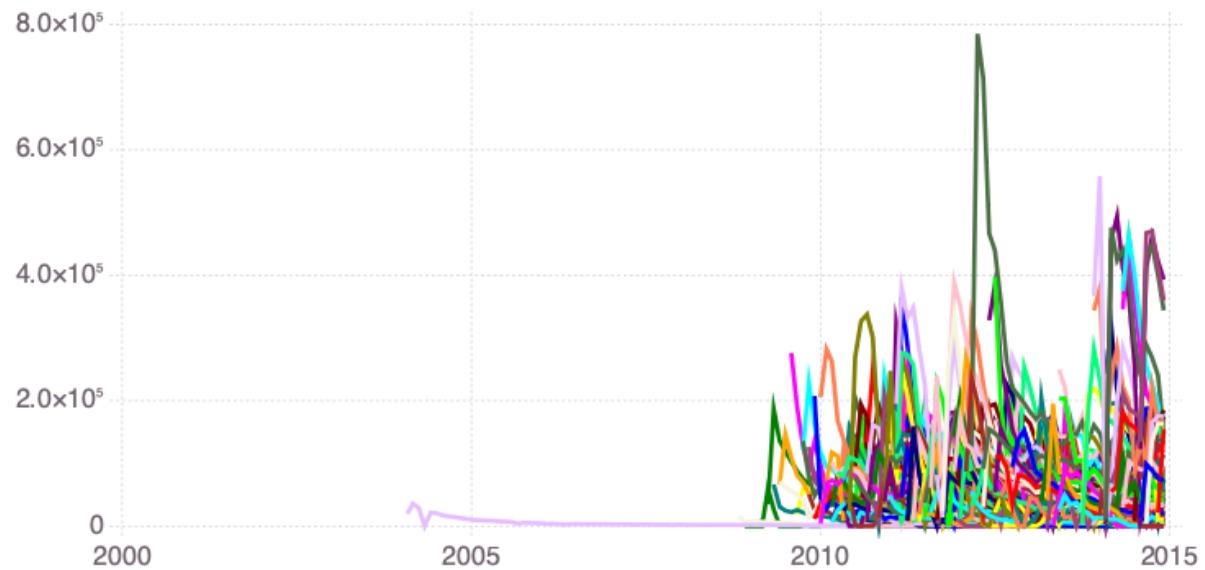
After that, the applied ML methodology performs blind prediction for 1 year ahead (2015-2016).

```
In [22]: syears = [2015]
eyears = syears .+ 1
```

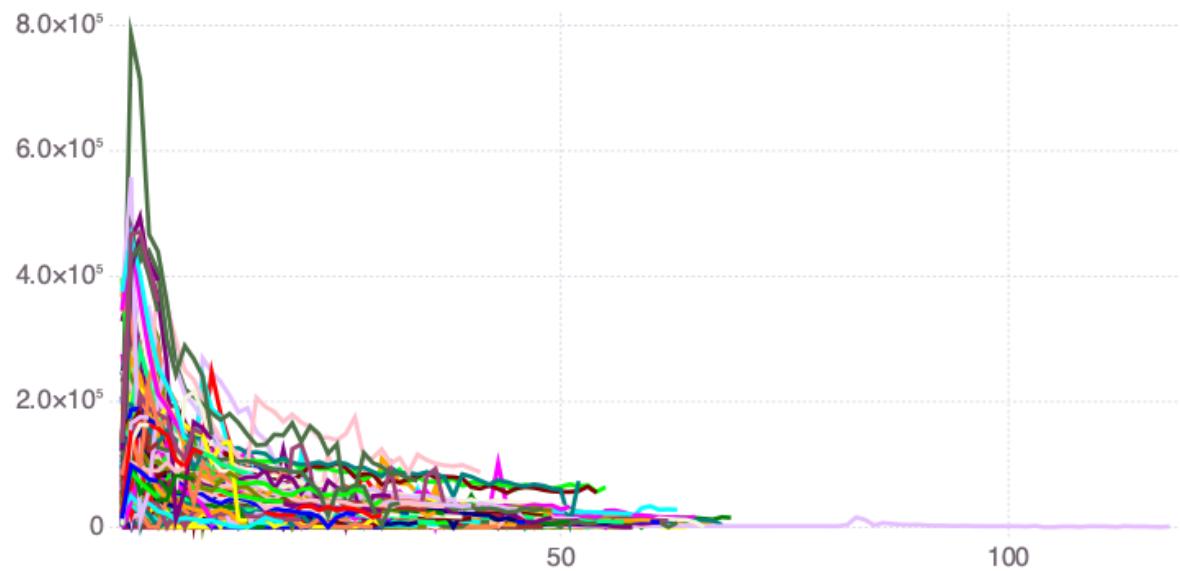
```
Out[22]: 1-element Array{Int64,1}:
 2016
```

ML analyses is excuted as follows:

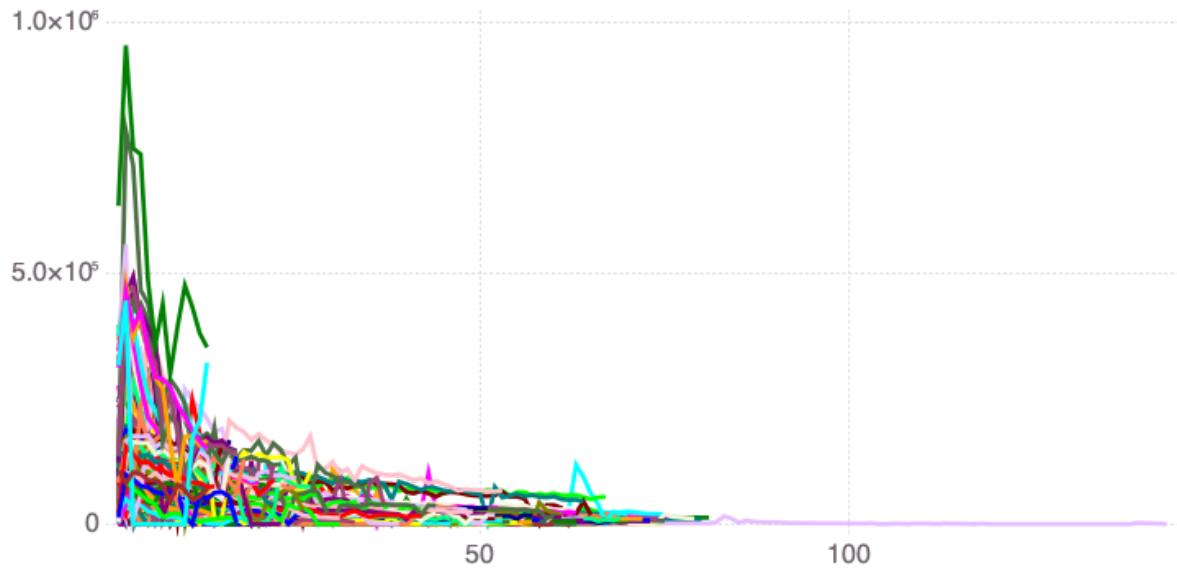
```
In [23]: WellDataBaseML.execute(syears, eyears, df, df_header, api; workdir="/Users/
```



```
[ Info: 2015: Number of wells 322
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:122
[ Info: Training matrix size: (118, 322)
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:137
```



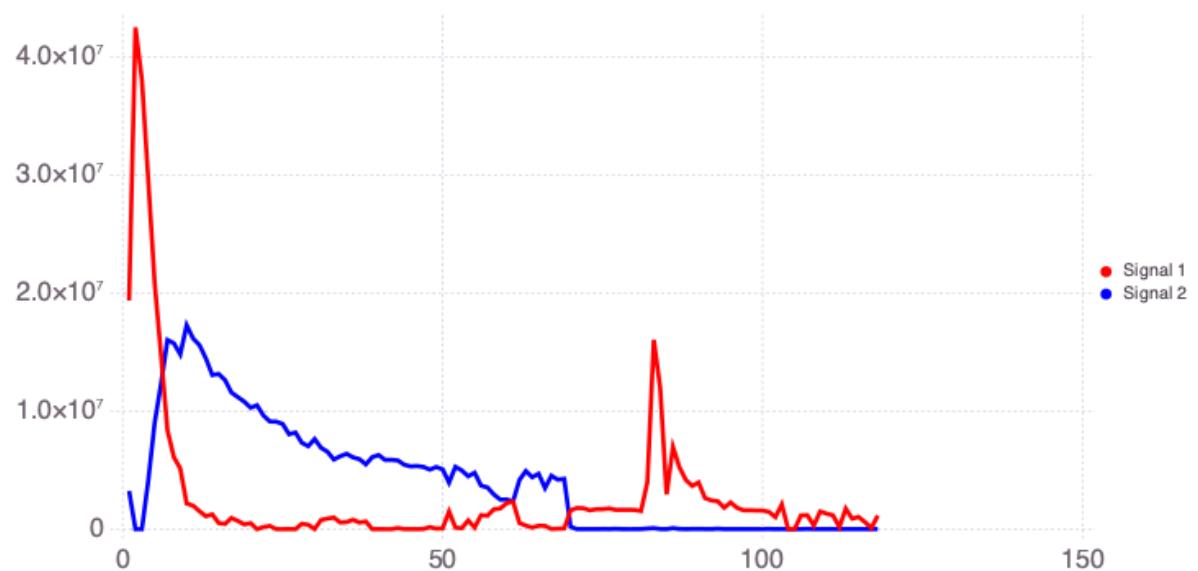
```
[ Info: Training start date: 2004-02-01
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:138
[ Info: Training end date: 2004-02-01
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:139
```



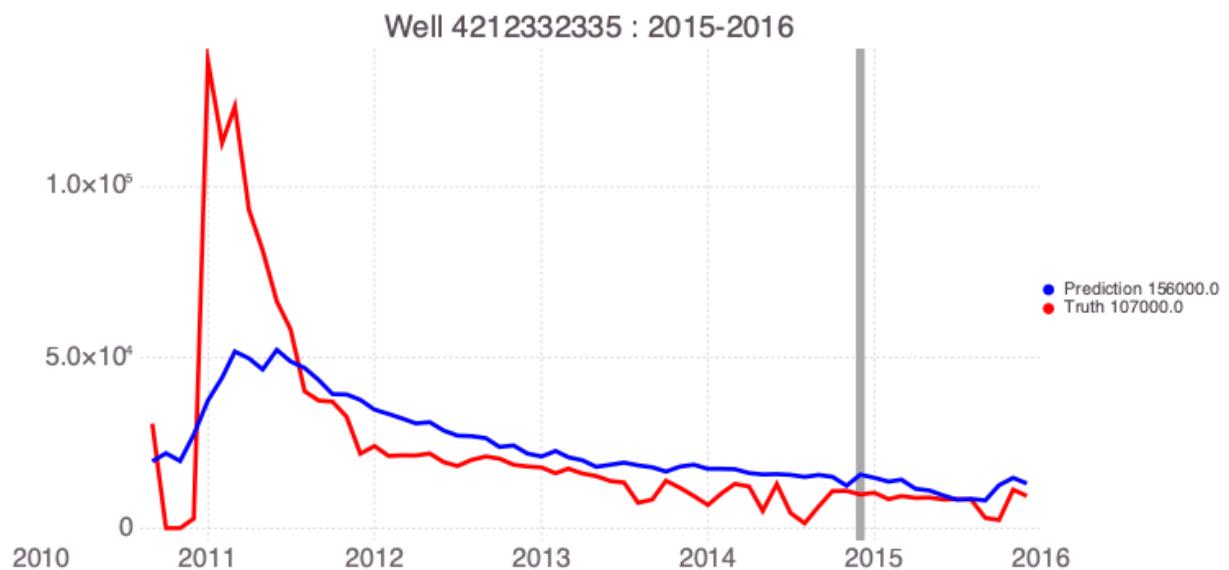
```

[ Info: Prediction matrix size: (143, 322)
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:144
[ Info: Prediction start date: 2004-02-01
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:145
[ Info: Prediction end   date: 2004-02-01
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:146
[ Info: Training window: 118
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:156
[ Info: Prediction window: 25
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:157
Dimension 1: No bad indices!
Dimension 2: No bad indices!
[ Info: Dimension 1 ...
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkChecks.jl:78
[ Info: Dimension 2 ...
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkChecks.jl:78
[ Info: NMFk #1: gas_2015 Window 118
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:65
Signals: 2 Fit: 3.739159e+12 Silhouette: 0.1872708 AIC: 214955.6
Signals: 3 Fit: 2.436588e+12 Silhouette: 0.5115209 AIC: 211191.1
Signals: 4 Fit: 1.811994e+12 Silhouette: 0.1589268 AIC: 208859.1
Signals: 5 Fit: 1.341023e+12 Silhouette: -0.2316457 AIC: 206474.8
Signals: 2 Fit: 3.739159e+12 Silhouette: 0.1872708 AIC: 214955.6
Signals: 3 Fit: 2.436588e+12 Silhouette: 0.5115209 AIC: 211191.1
Signals: 4 Fit: 1.811994e+12 Silhouette: 0.1589268 AIC: 208859.1
Signals: 5 Fit: 1.341023e+12 Silhouette: -0.2316457 AIC: 206474.8
[ Info: Results
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkExecute.jl:15
[ Info: Optimal solution: 3 signals
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkExecute.jl:20
[ Info: Optimal number of signals: [2, 3] Training window sizes: [118, 118]
  @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:163

```



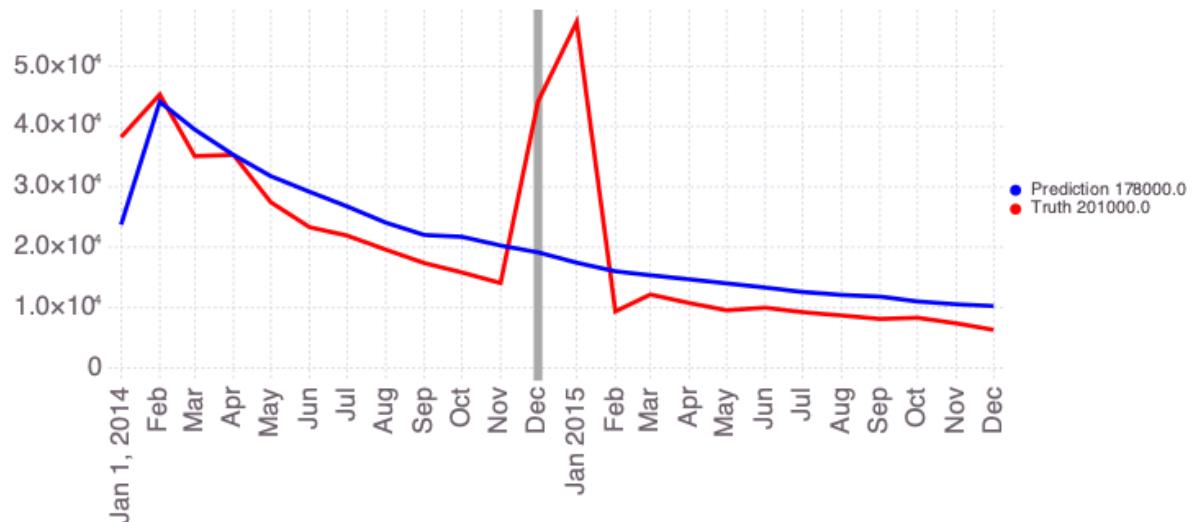
Signals: 2 Fit: 3.739159e+12 Silhouette: 0.1872708 AIC: 214955.6



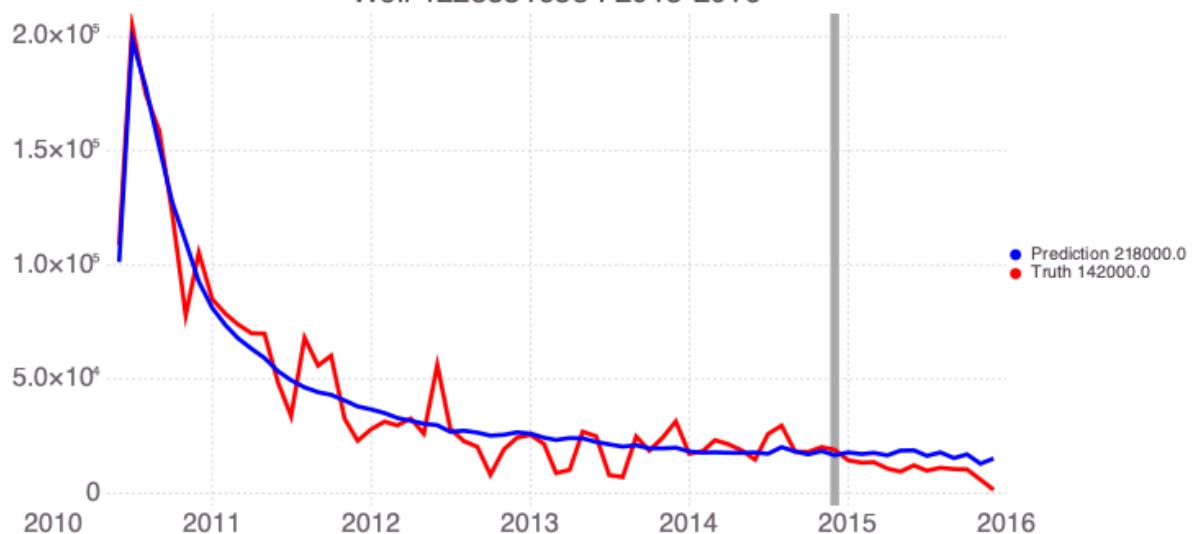
Well 4212332636 : 2015-2016

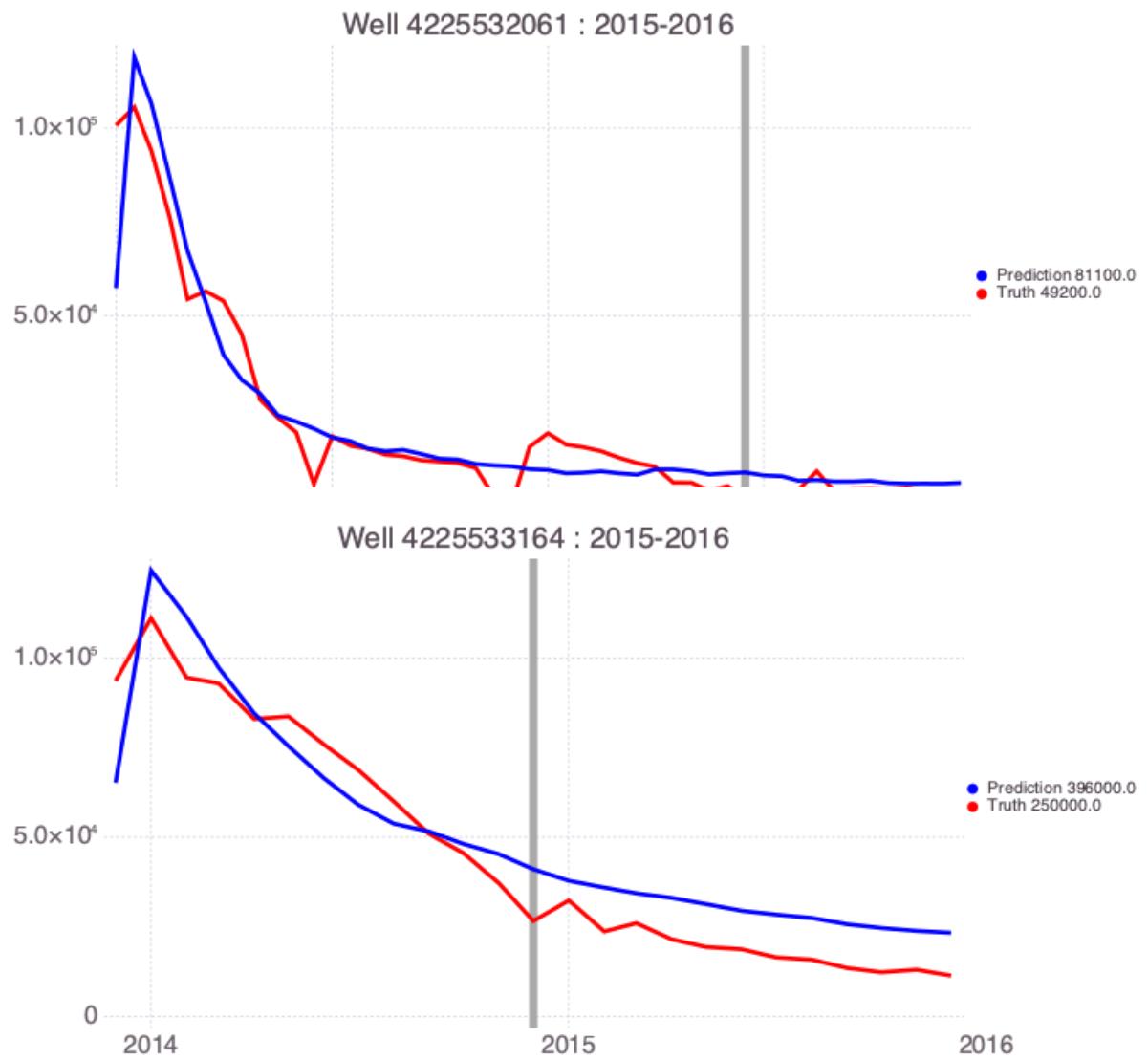


Well 4212333217 : 2015-2016

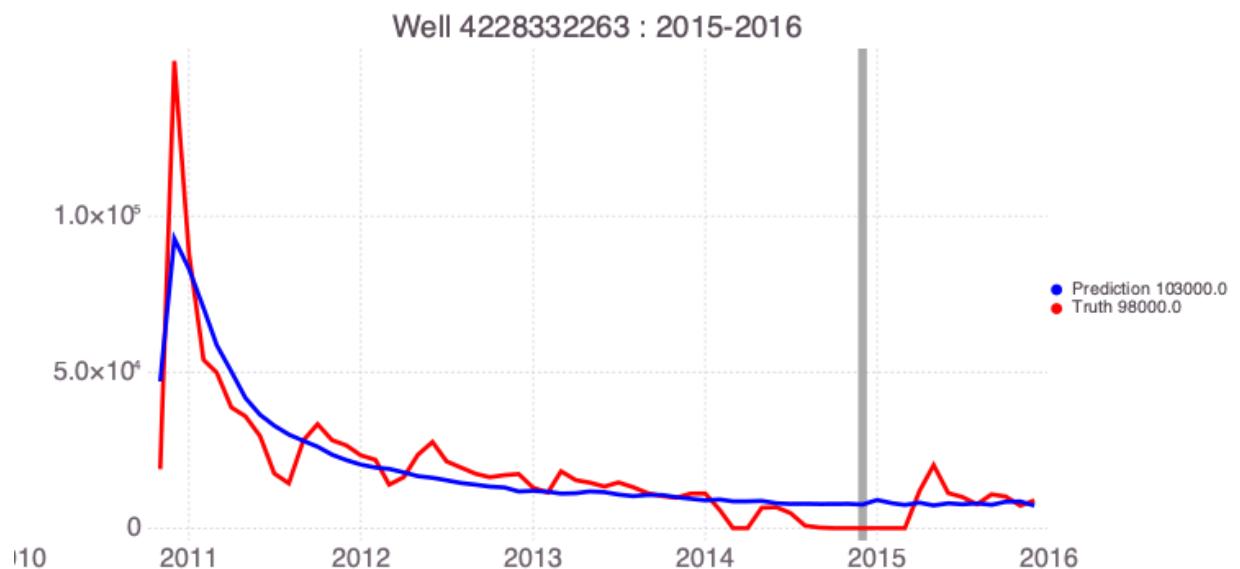


Well 4225531655 : 2015-2016

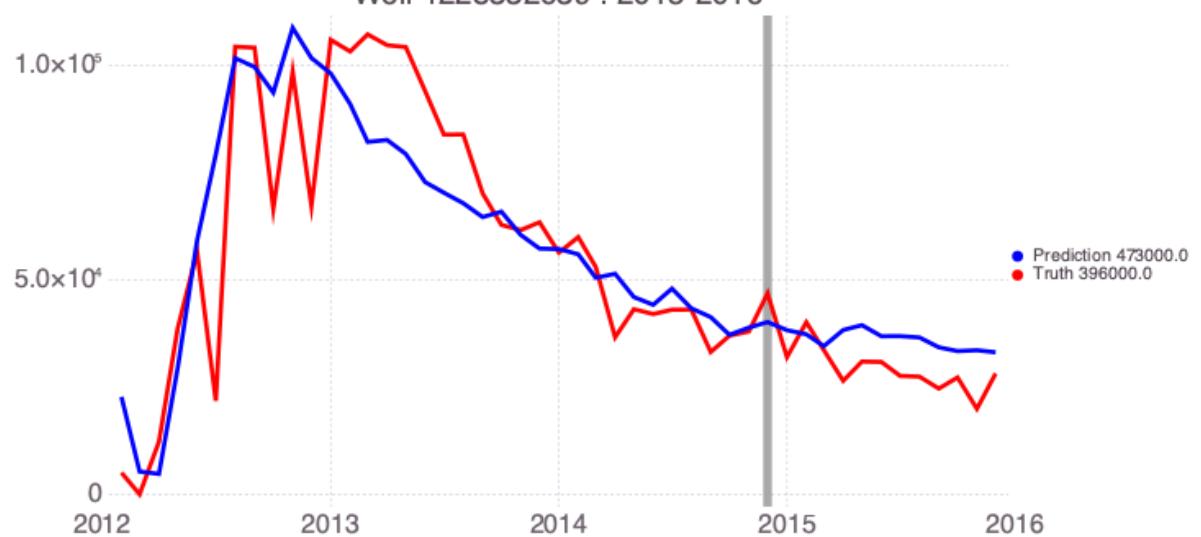




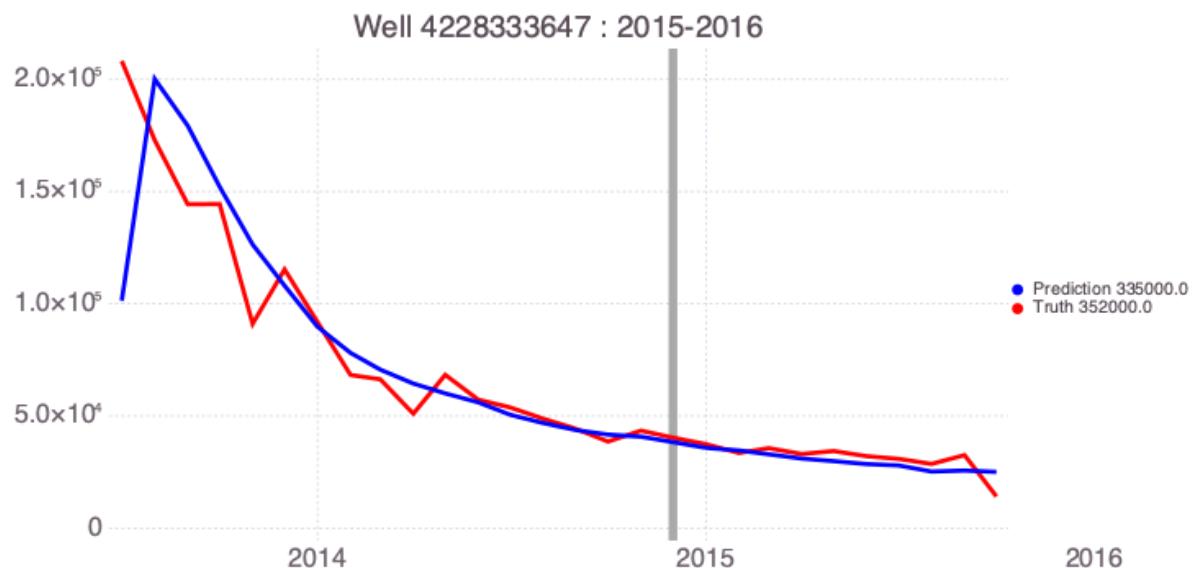
Well 4228332263 · 2015-2016



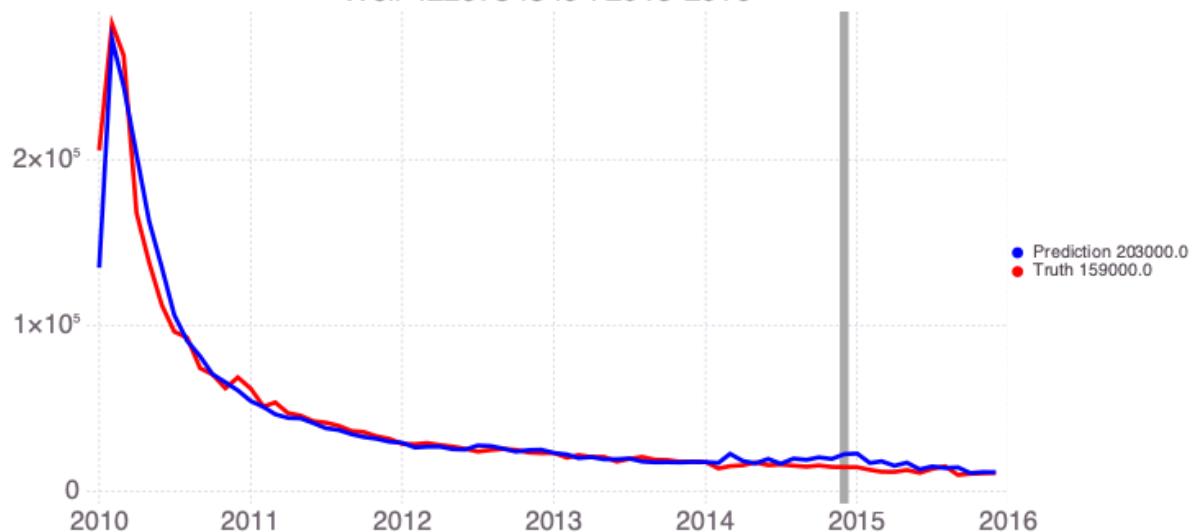
Well 4228332639 : 2015-2016

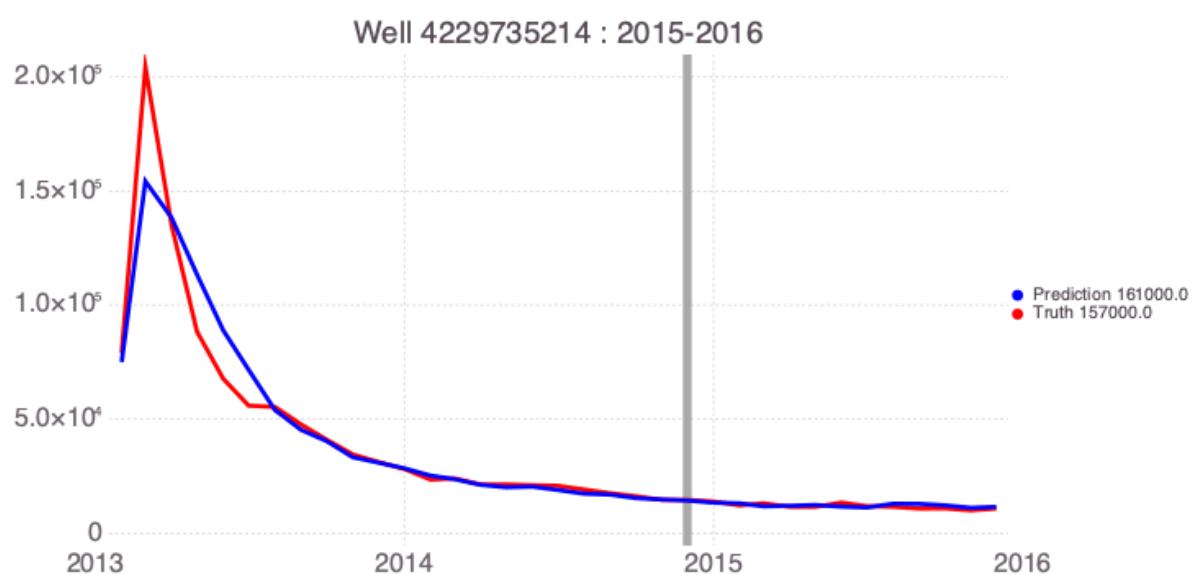
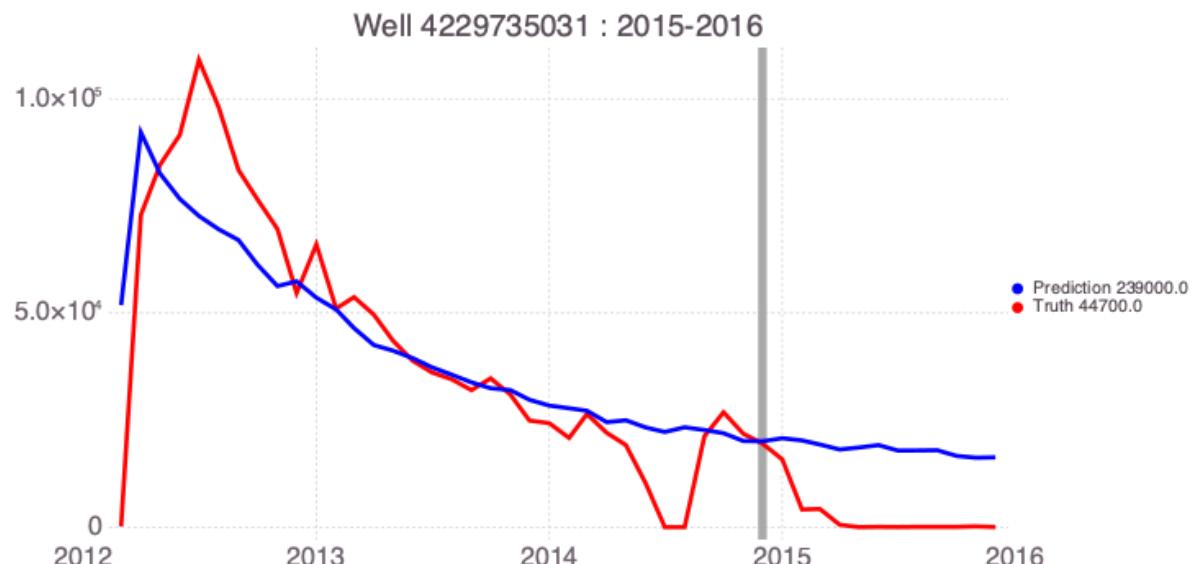


Well 4228332876 : 2015-2016



Well 4229734849 : 2015-2016

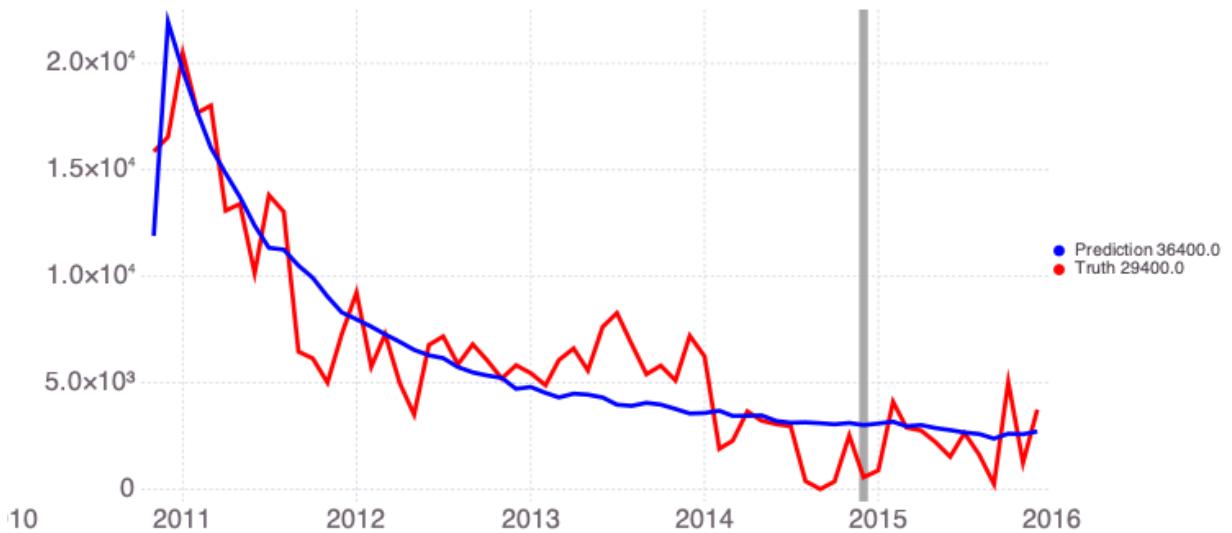




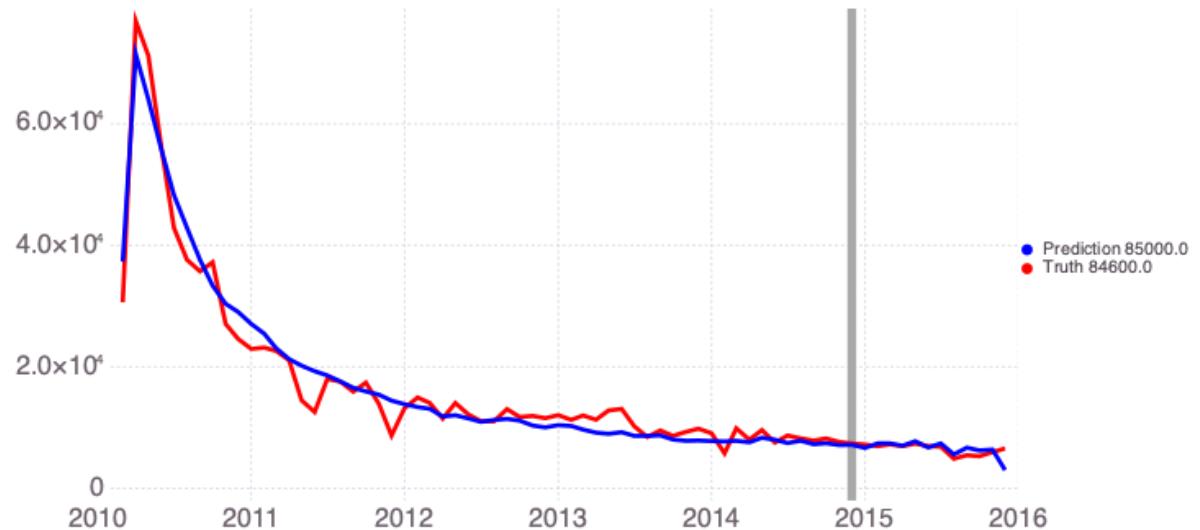
Well 4231134217 : 2015-2016

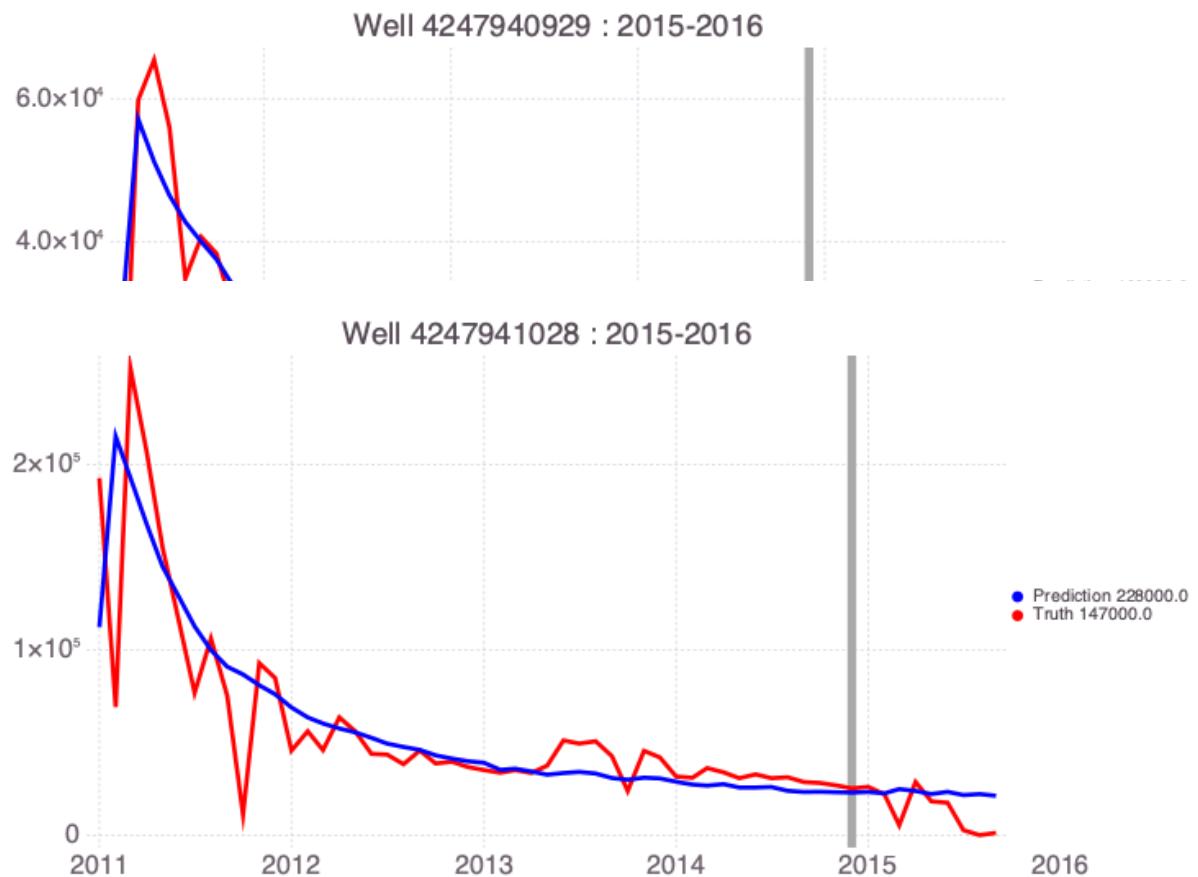


Well 4232333364 : 2015-2016

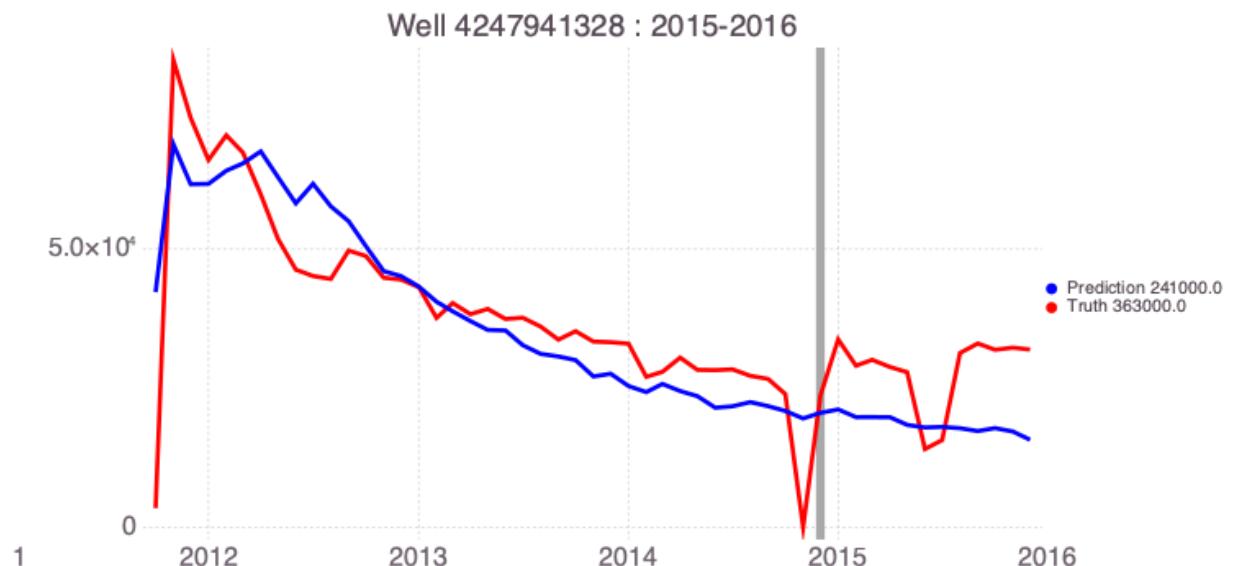


Well 4247940682 : 2015-2016

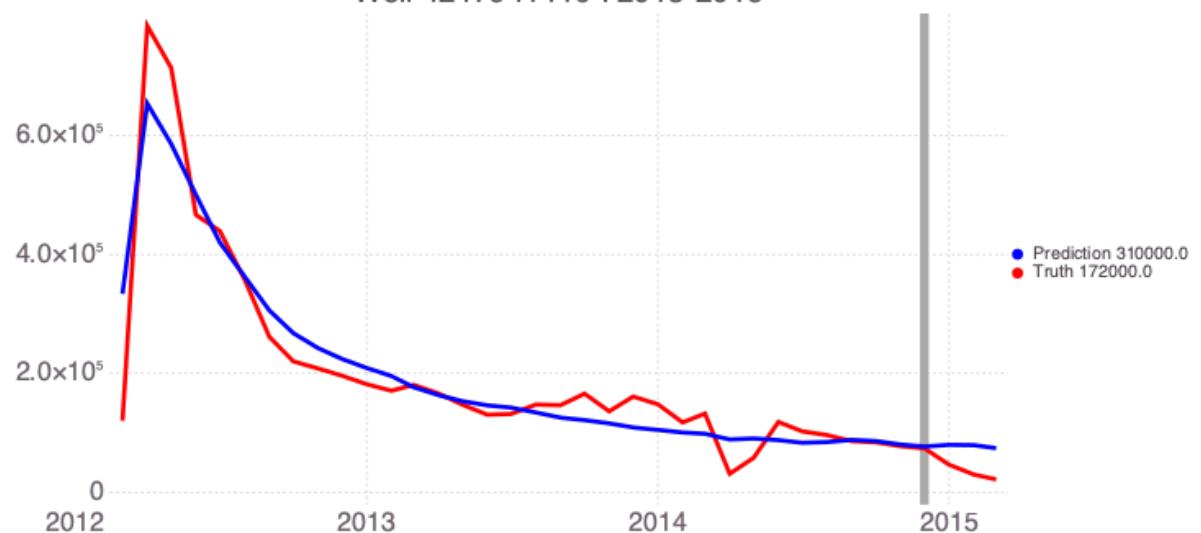




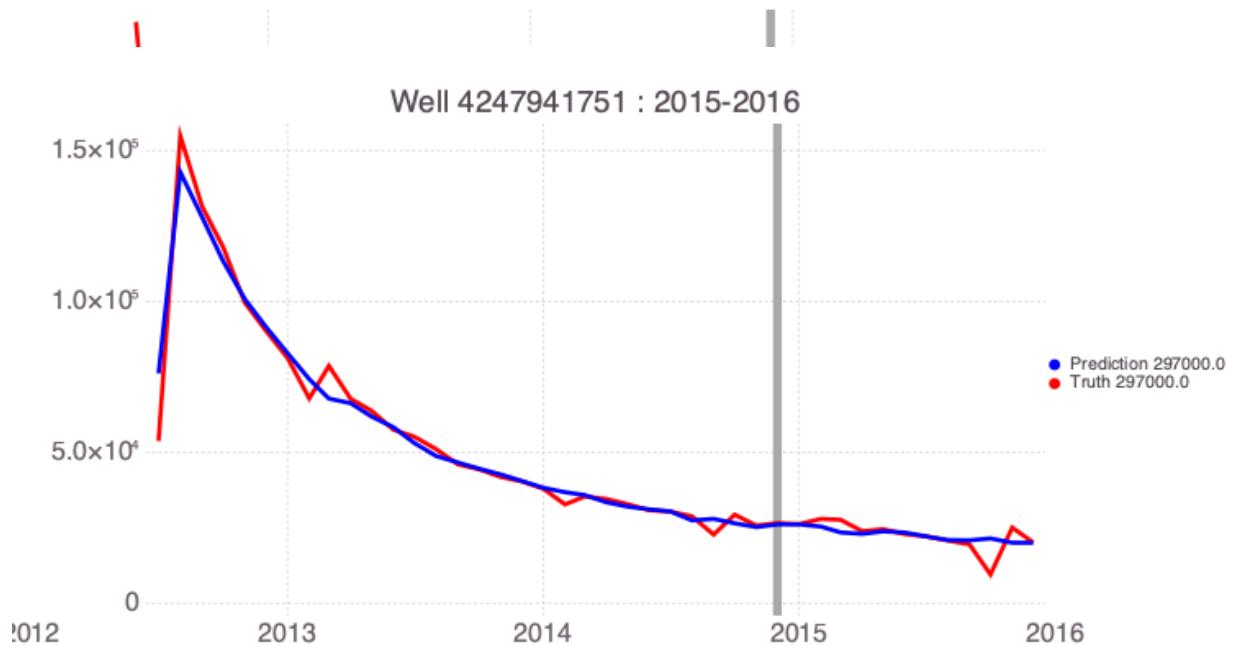
Well 4247941094 · 2015-2016



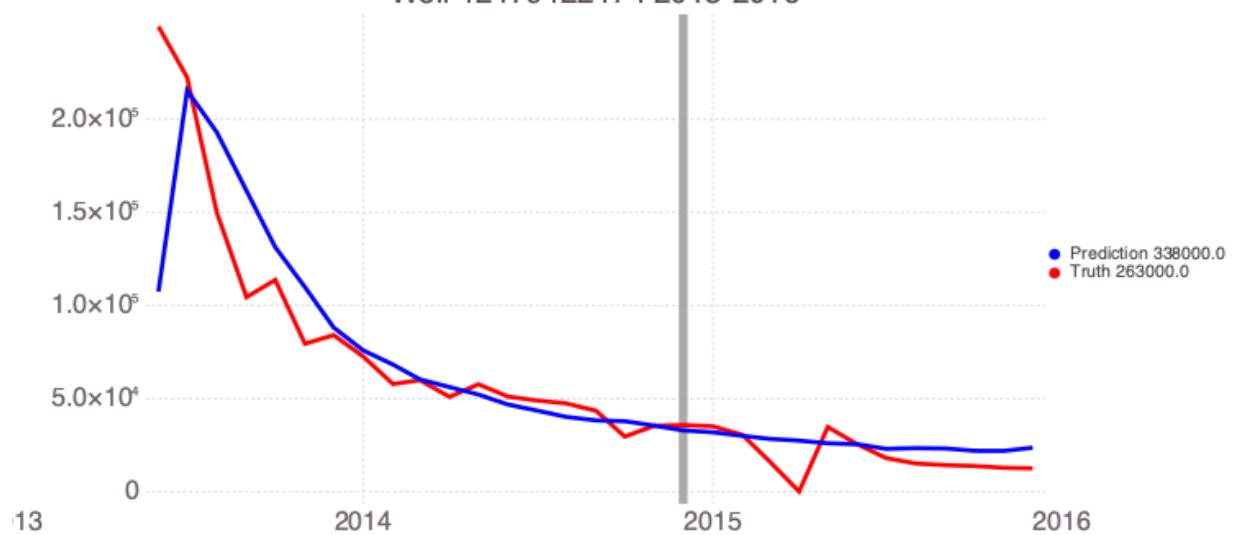
Well 4247941410 : 2015-2016



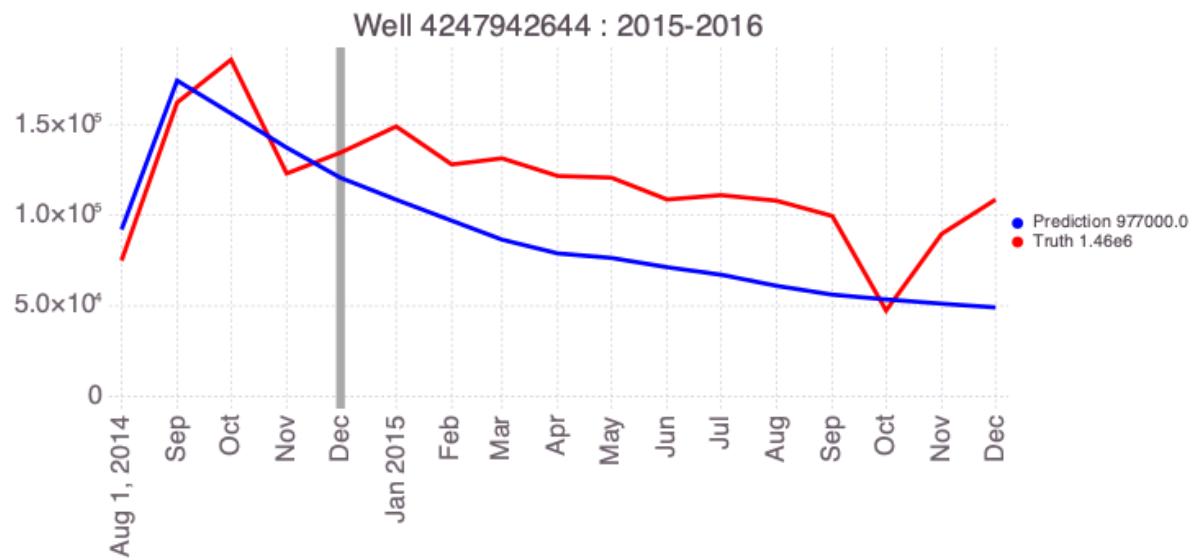
Well 4247941552 : 2015-2016



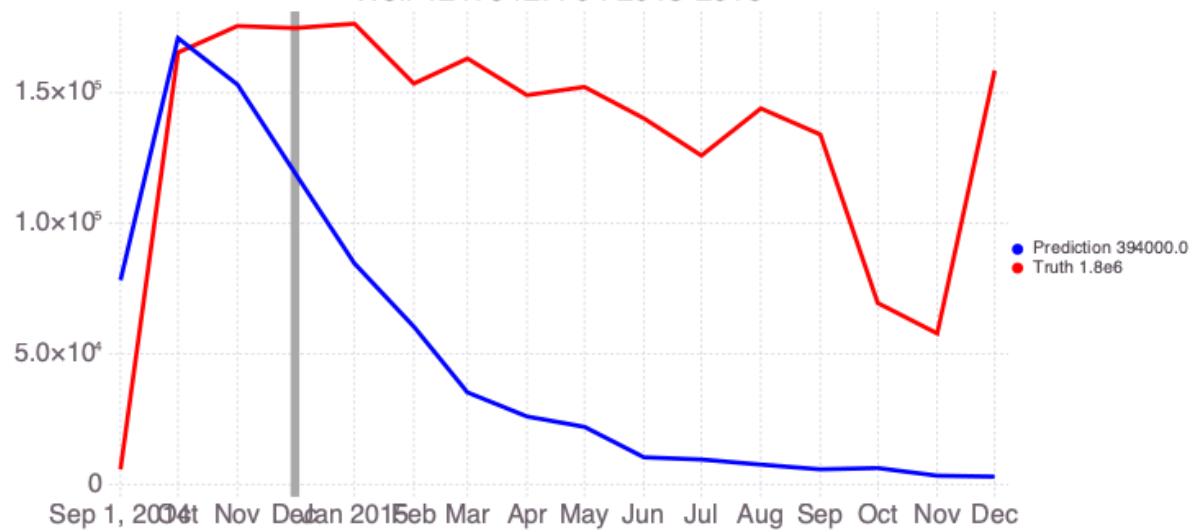
Well 4247942247 : 2015-2016



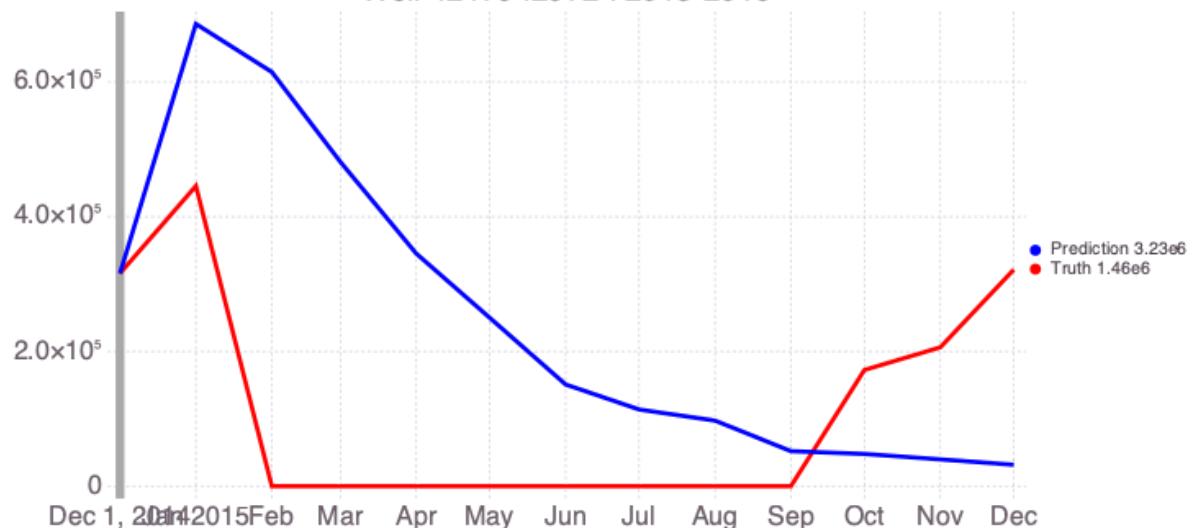
Well 4247942616 : 2015-2016



Well 4247942770 : 2015-2016



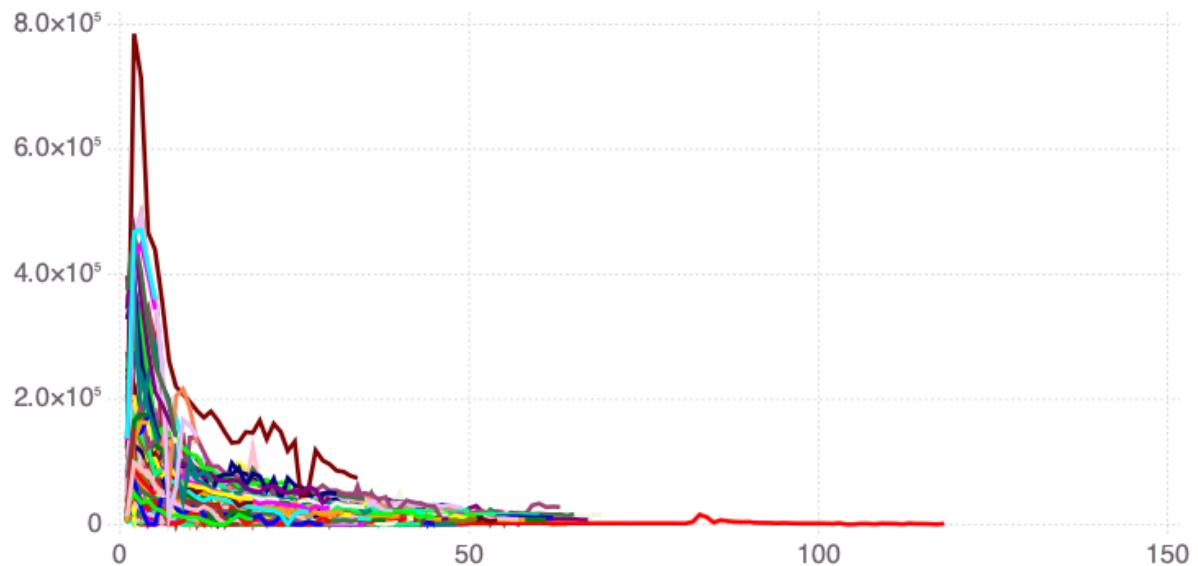
Well 4247942972 : 2015-2016

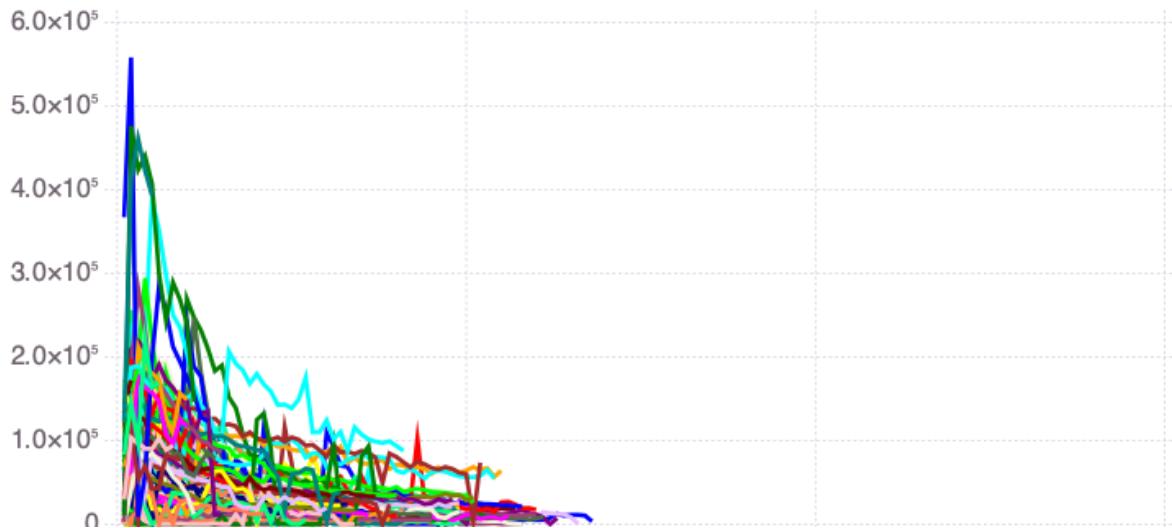


```

r Info: Window 2015: Training size 118 Truth size: 299 Prediction size: 2
99 R2 (pred): 0.6957154770204516 R2 (all) 0.8702610728541793
└ @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFKProgressive.jl:221
[ Info: Type A wells: 202
└ @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFKProgressive.jl:235

```





```
[ Info: Type B wells: 120
@ NMFK /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:235
```

```
1×2 Array{Any,2}:
"EAGLE FORD" 202
```

```
[ Info: Type A wells: 202
@ NMFK /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:241
[ Info: Formation
@ NMFK /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:242
```

"SILVERBOW RESOURCES OPER, LLC"	27
"LAREDO ENERGY OPERATING, LLC"	21
"PIONEER NATURAL RES. USA, INC."	18
"SM ENERGY COMPANY"	15
"LEWIS PETRO PROPERTIES, INC."	14
"SN OPERATING, LLC"	11
"ROSETTA RESOURCES OPERATING LP"	9
"BHP BILLITON PET(TXLA OP) CO"	8
"BHP BILLITON PETROLEUM"	8
" "	6
"BHP BILLITON PETROLEUM "	6
"BURLINGTON RESOURCES O & G CO LP"	6
"DEVON ENERGY PRODUCTION CO, L.P."	6
"ESCONDIDO RESOURCES OPER CO, LLC"	6
"MARATHON OIL EF LLC"	6
"STATOIL TEXAS ONSHORE PROP LLC"	6
"ENCANA OIL & GAS(USA) INC."	4
"EQUINOR TEXAS ONSHORE PROP LLC"	4
"PROLINE ENERGY RESOURCES INC"	3
"SWIFT ENERGY OPERATING, LLC"	3
"EOG RESOURCES, INC."	2
"PERDIDO ENERGY, LLC"	2
"ZAZA ENERGY, LLC"	2

```
1×2 Array{Any,2}:
"Horizontal" 202
```

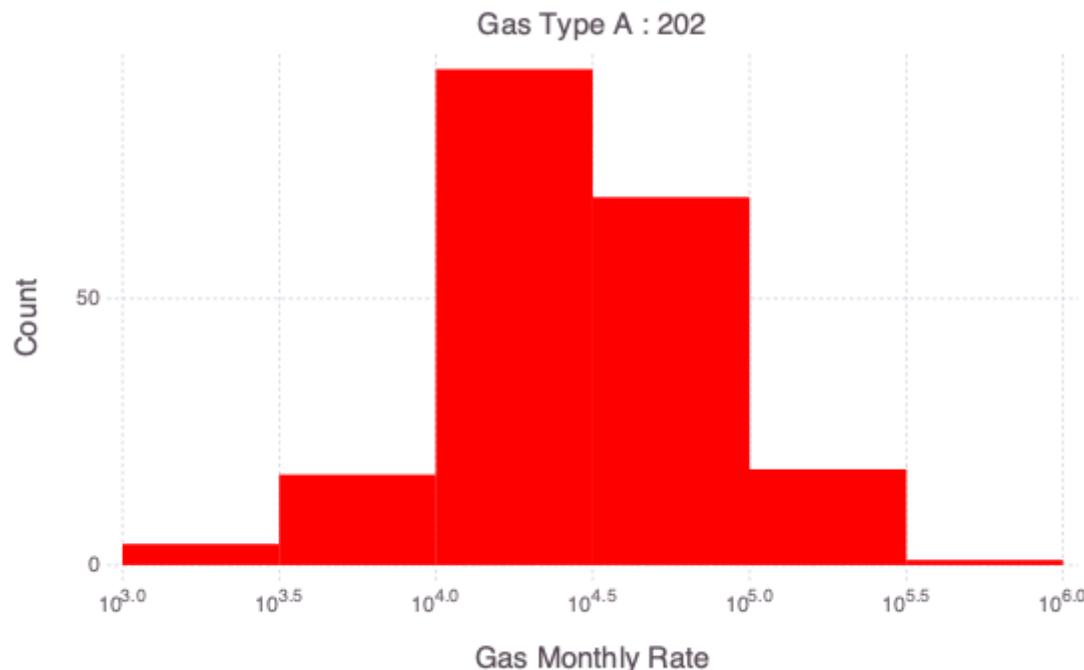
```
1×2 Array{Any,2}:
"EAGLE FORD" 120
```

19×2 Array{Any,2}:

"LEWIS PETRO PROPERTIES, INC."	32
"SM ENERGY COMPANY"	11
"PIONEER NATURAL RES. USA, INC."	10
"BHP BILLITON PET(TXLA OP) CO"	7
"BURLINGTON RESOURCES O & G CO LP"	7
"DEVON ENERGY PRODUCTION CO, L.P."	7
"SILVERBOW RESOURCES OPER, LLC"	7
"MARATHON OIL EF LLC"	4
"SN OPERATING, LLC"	4
"STATOIL TEXAS ONSHORE PROP LLC"	4
"ENDEAVOR NATURAL GAS, LP"	3
"LAREDO ENERGY OPERATING, LLC"	3
"PERDIDO ENERGY, LLC"	3
" "	2
"BHP BILLITON PETROLEUM"	2
"BHP BILLITON PETROLEUM "	2
"ESCONDIDO RESOURCES OPER CO, LLC"	2
"FASKEN OIL AND RANCH, LTD."	2
"ROSETTA RESOURCES OPERATING LP"	2

1×2 Array{Any,2}:

"Horizontal"	120
--------------	-----

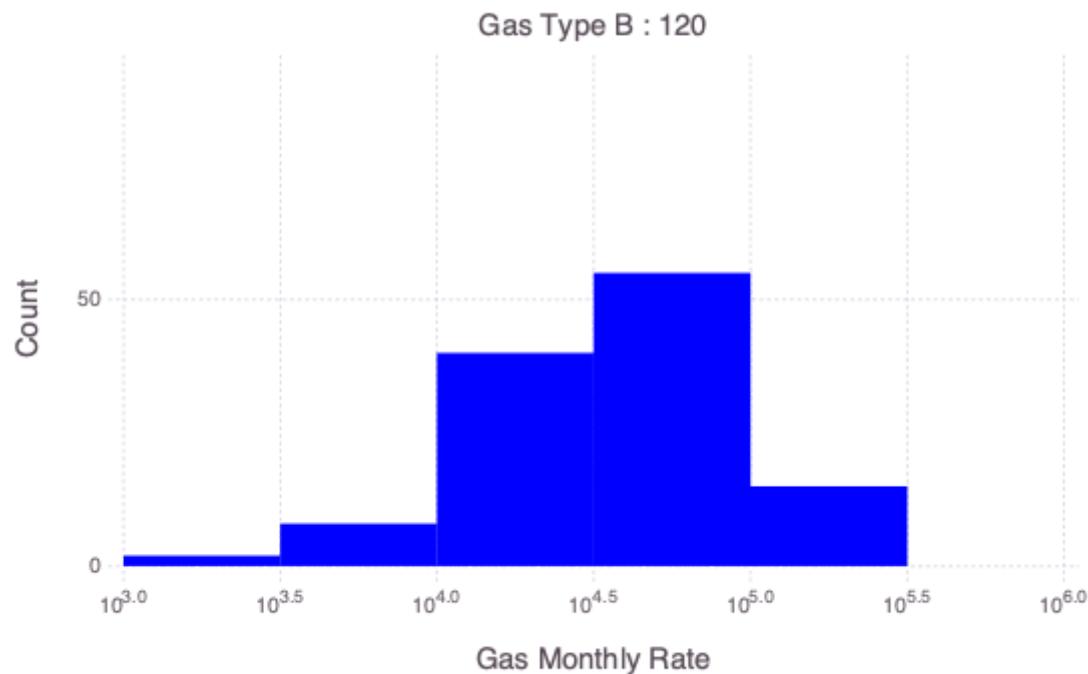


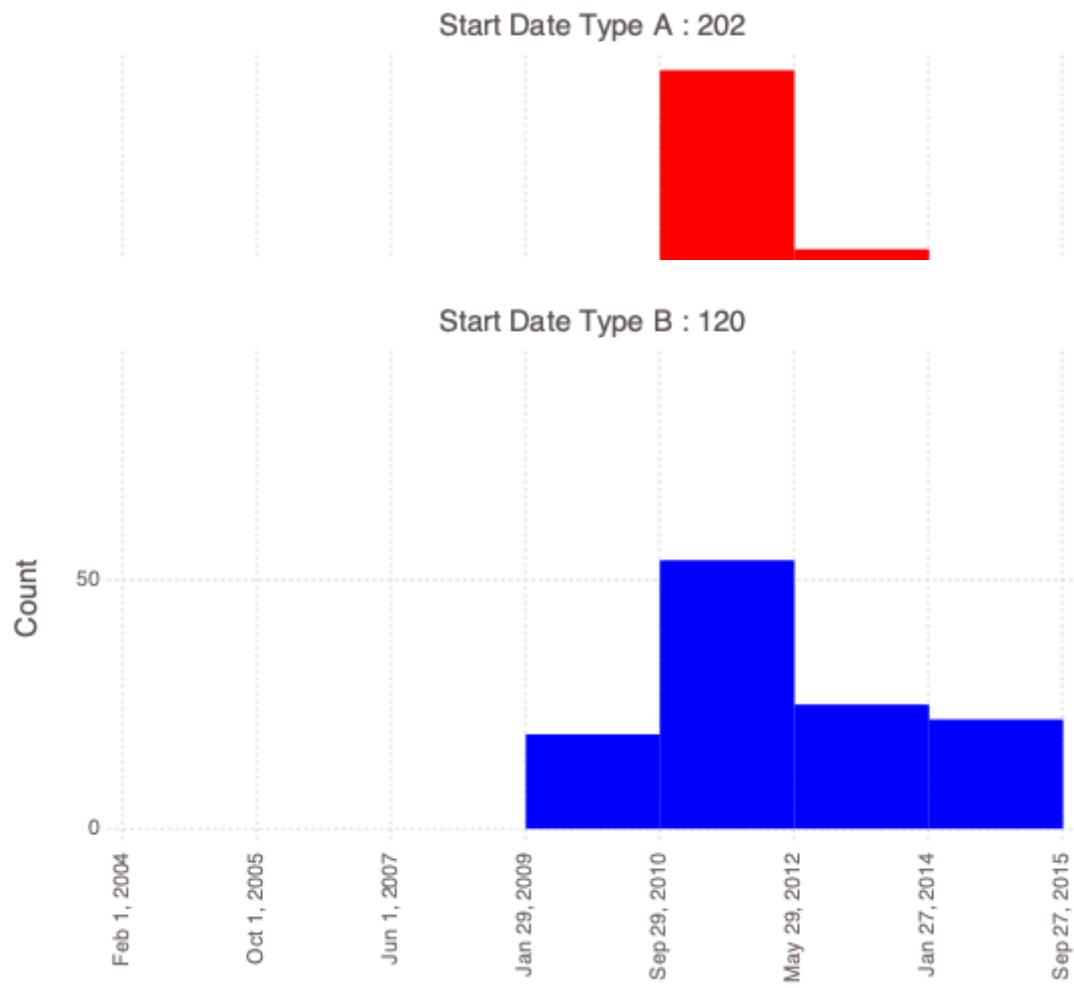
```

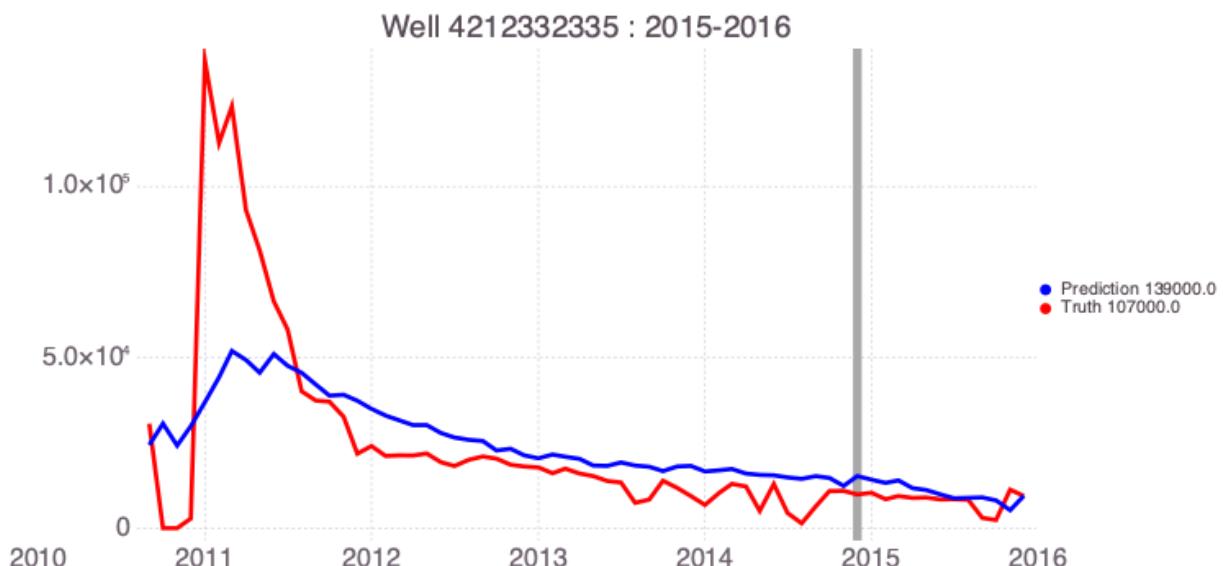
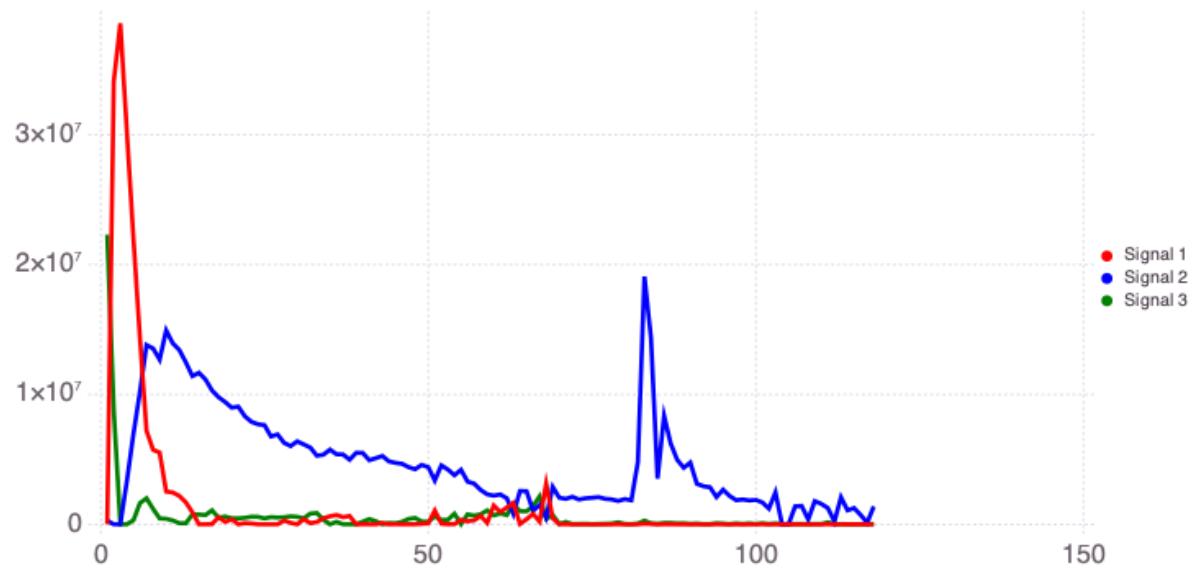
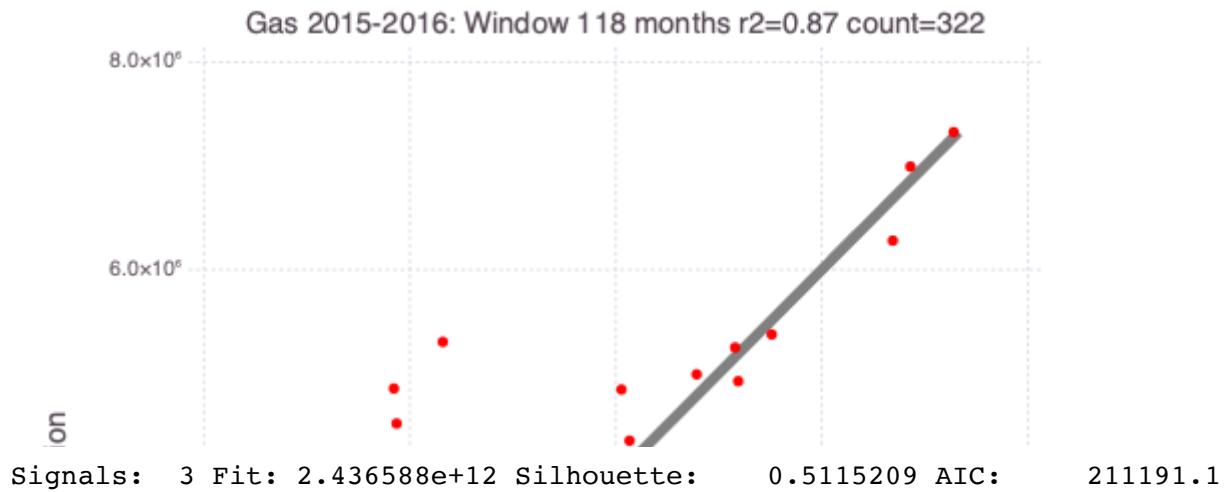
[ Info: Operator
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:244
[ Info: Well type
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:246
[ Info: Type B wells: 120
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:241
[ Info: Formation
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:242
[ Info: Operator
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:244

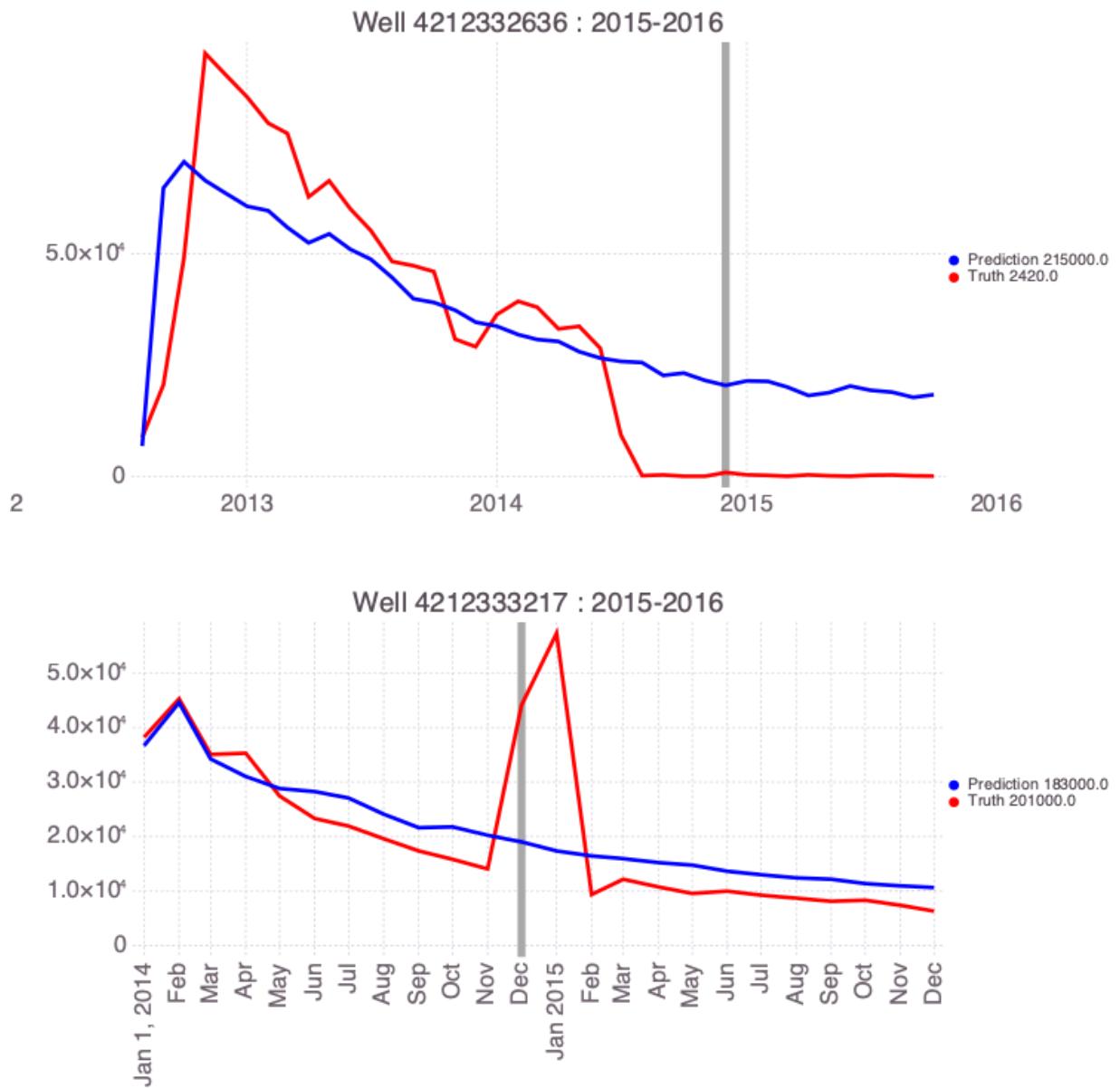
```

↳ Info: Well type

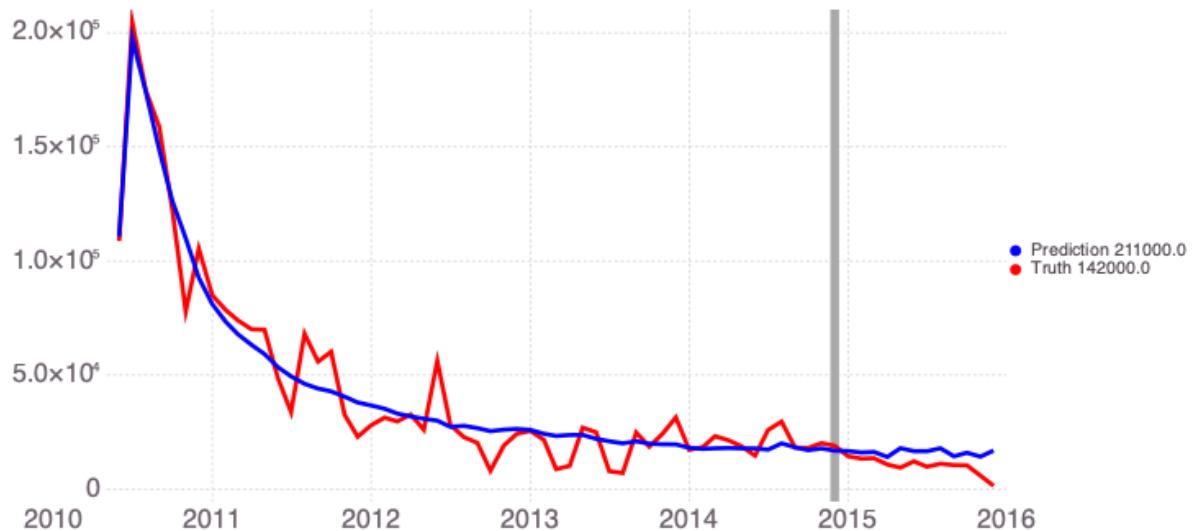




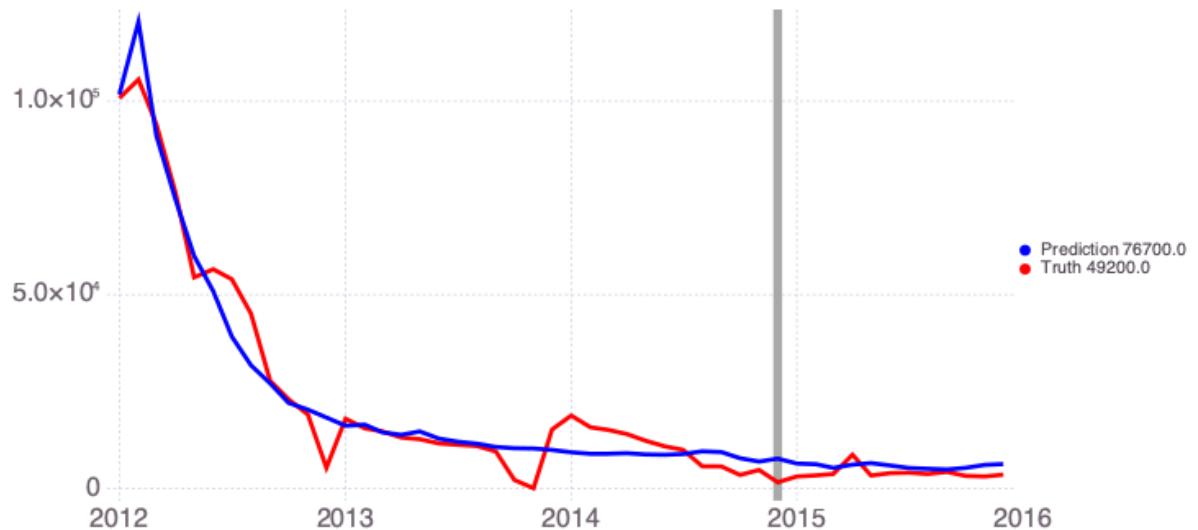




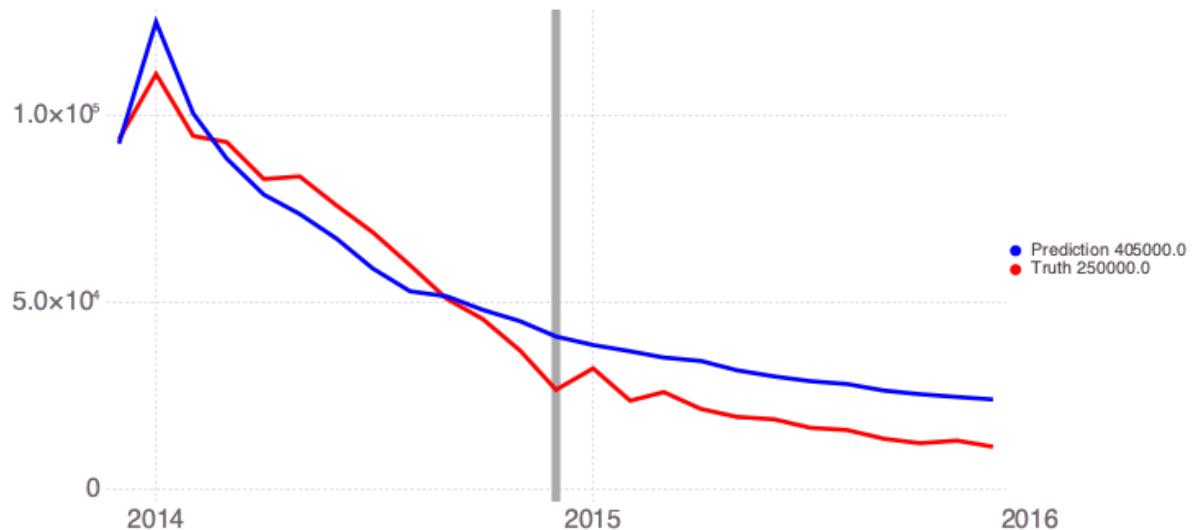
Well 4225531655 : 2015-2016



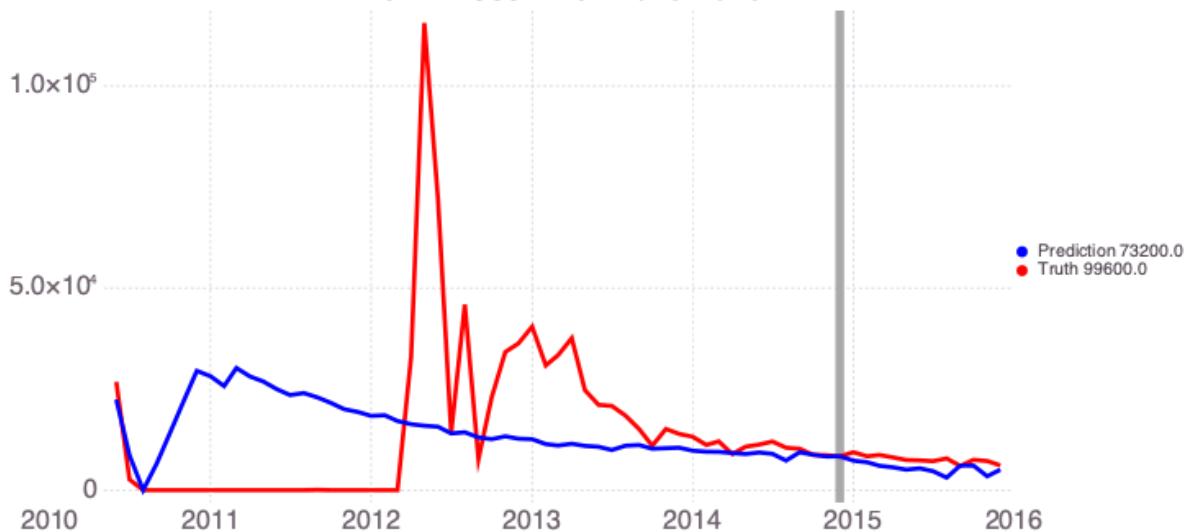
Well 4225532061 : 2015-2016



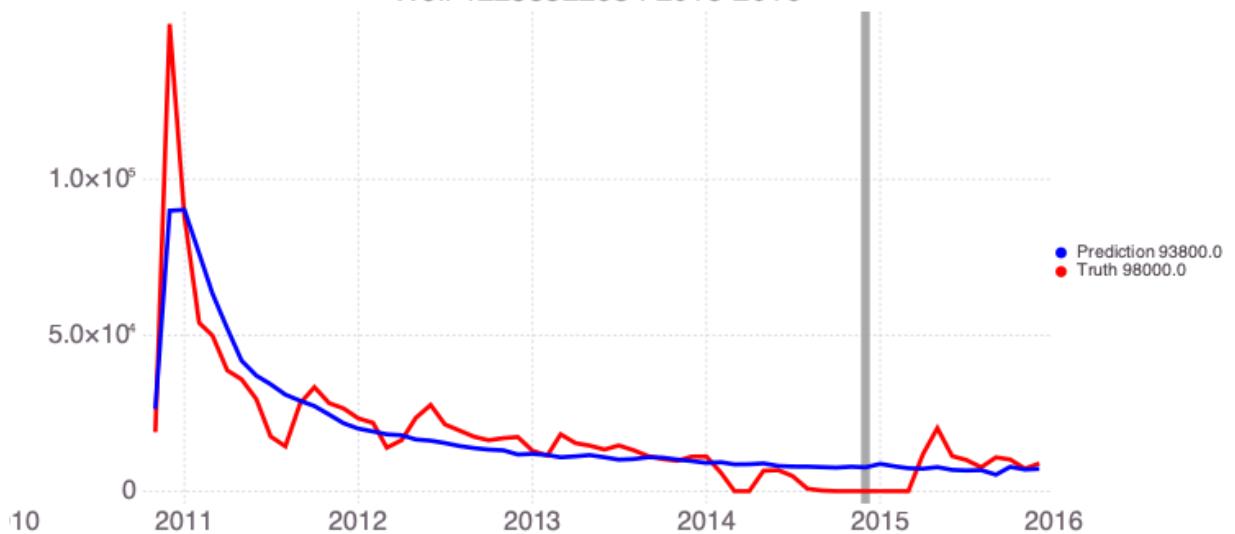
Well 4225533164 : 2015-2016

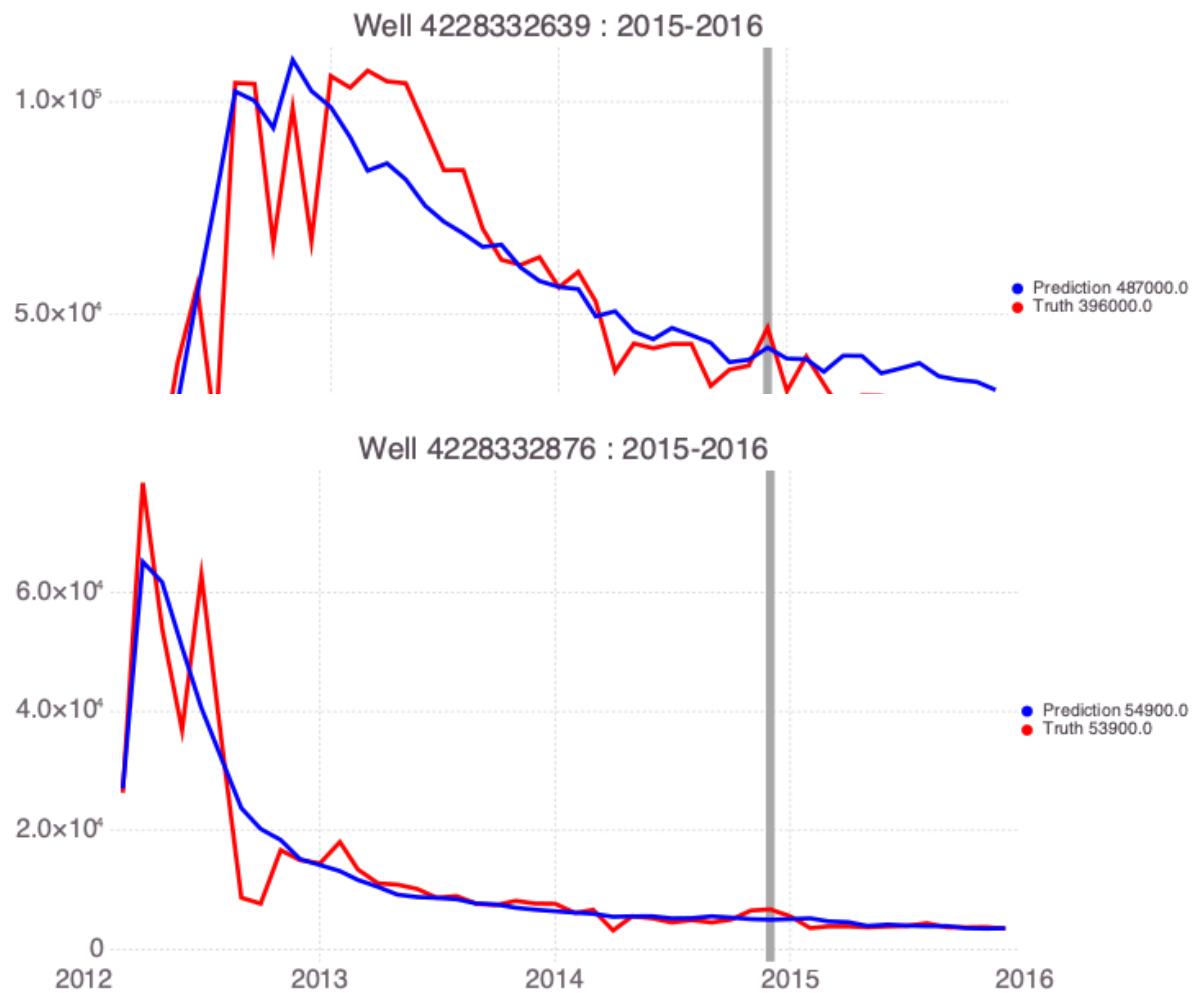


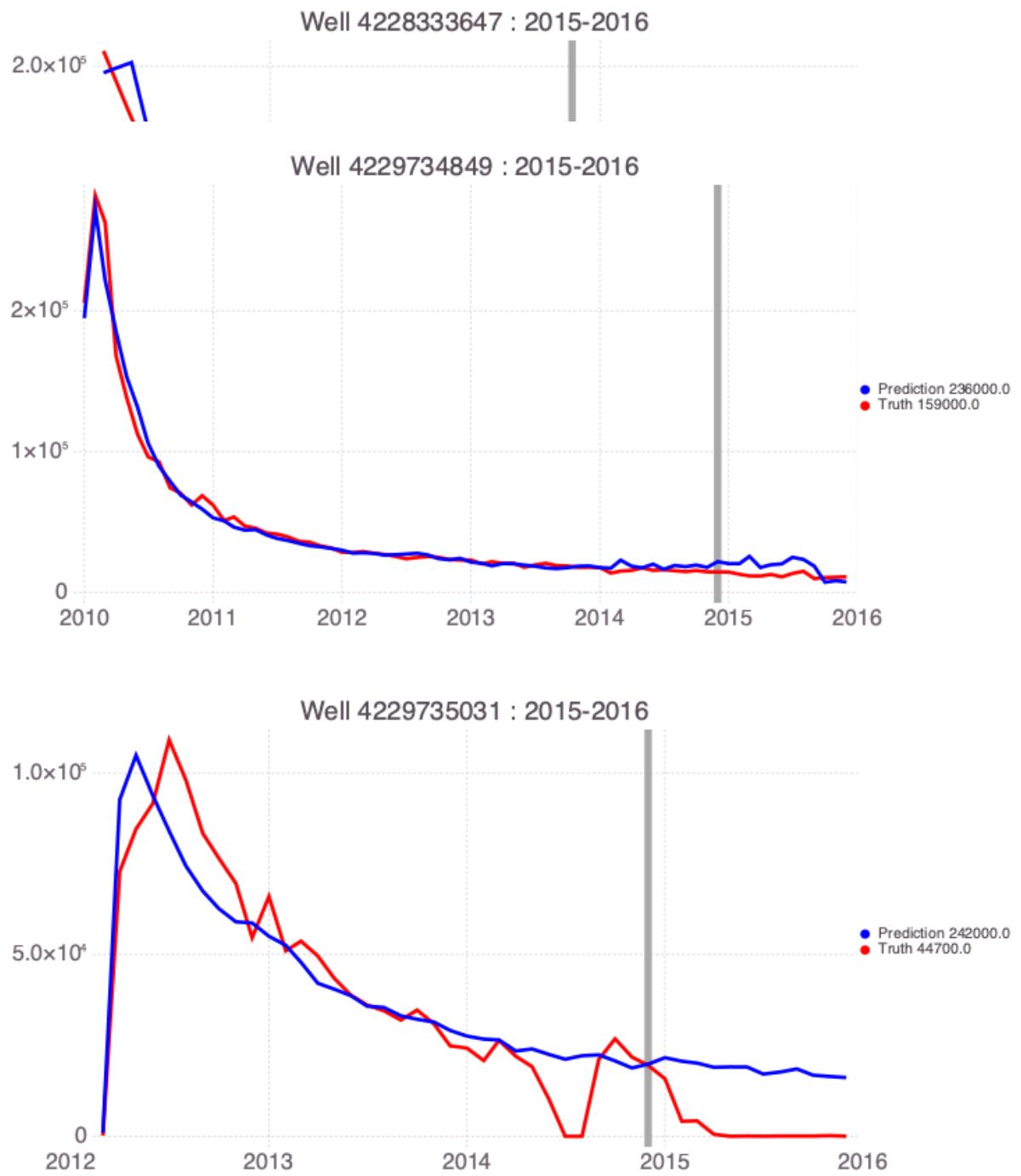
Well 4228332219 : 2015-2016

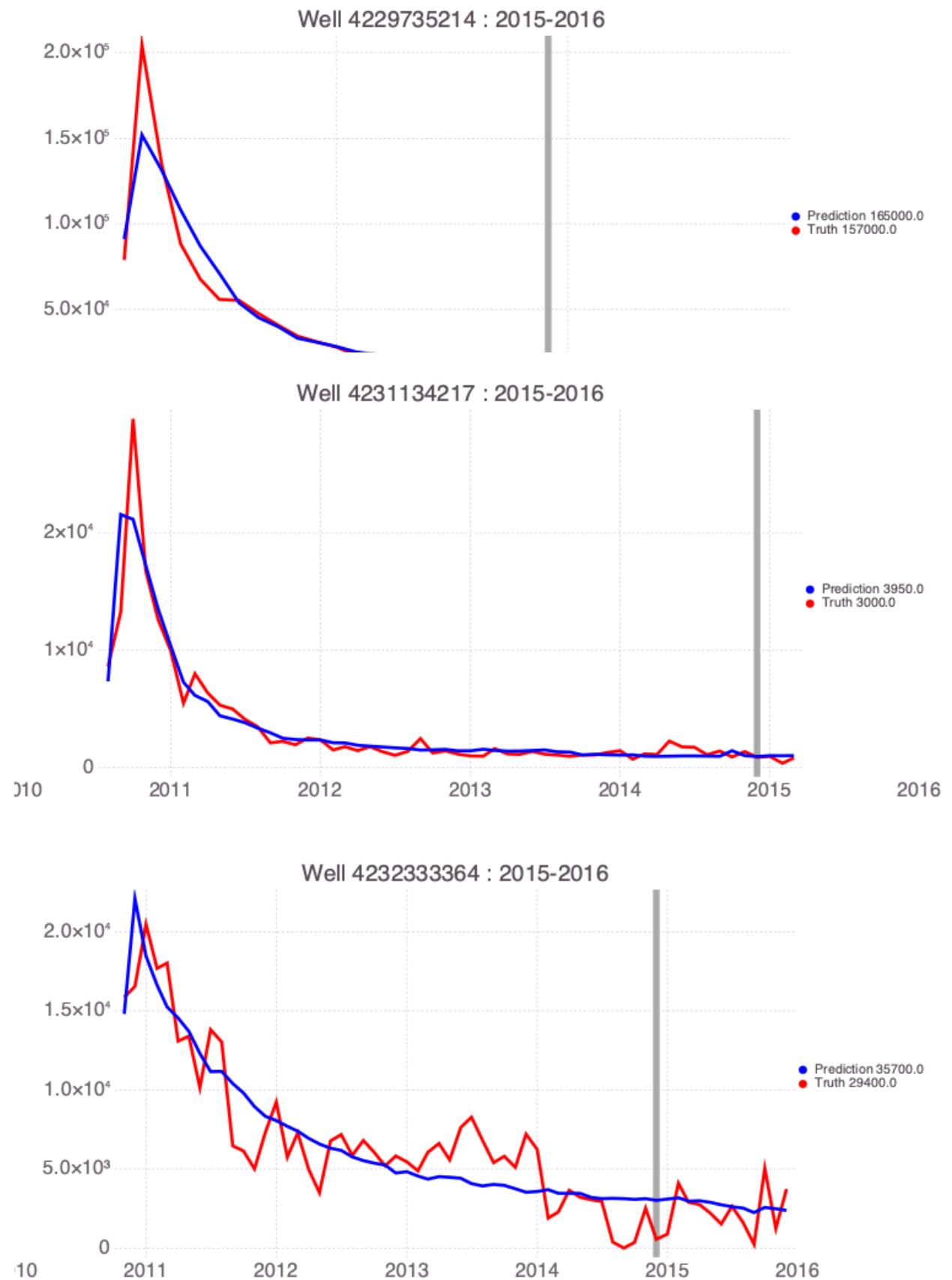


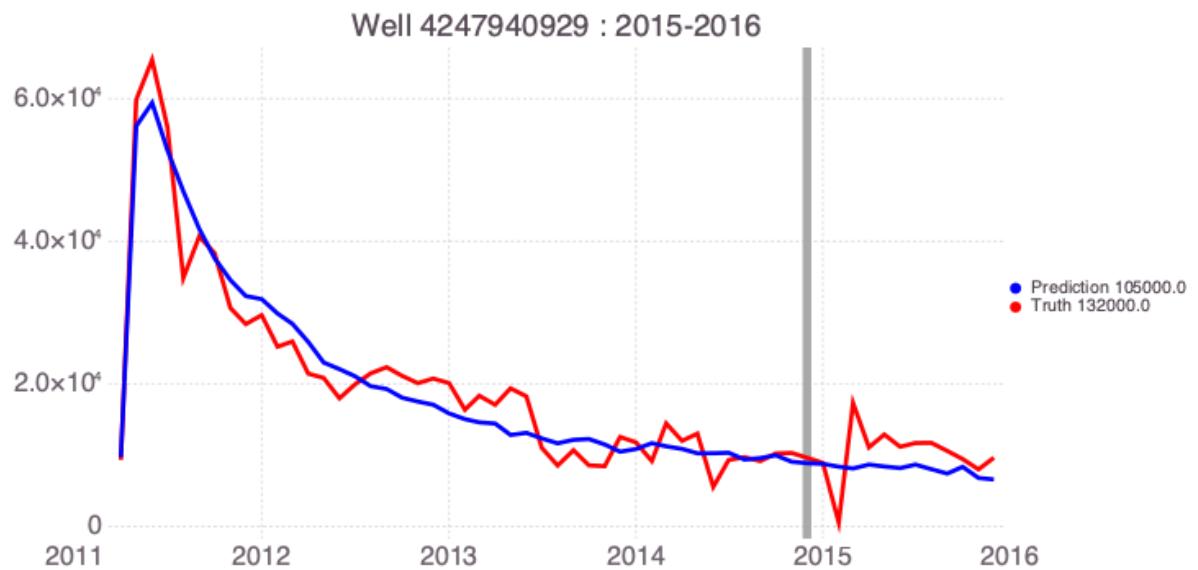
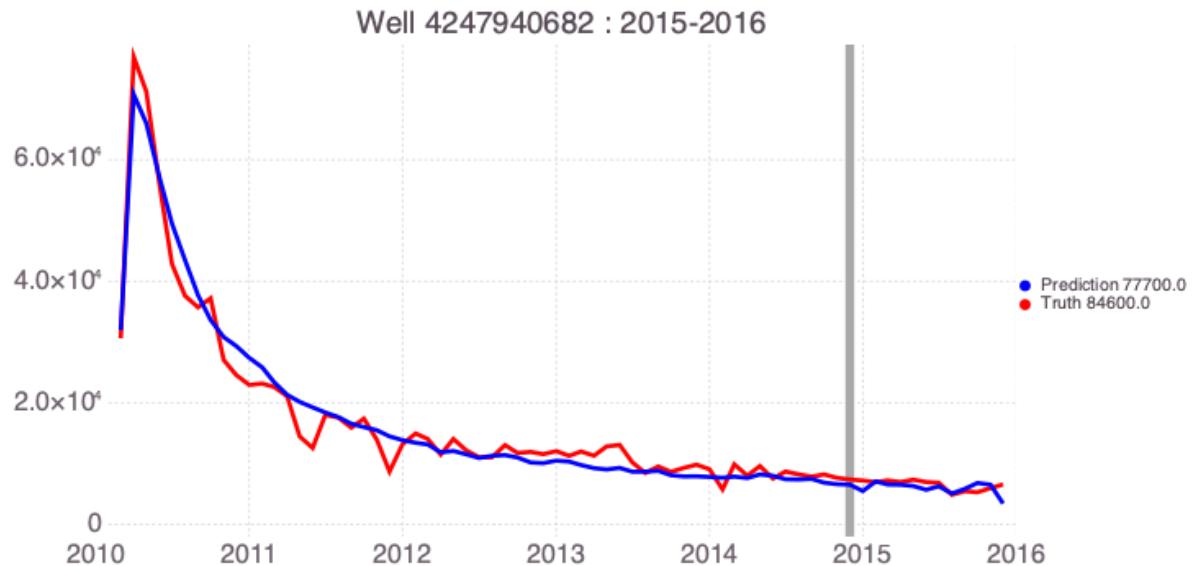
Well 4228332263 : 2015-2016







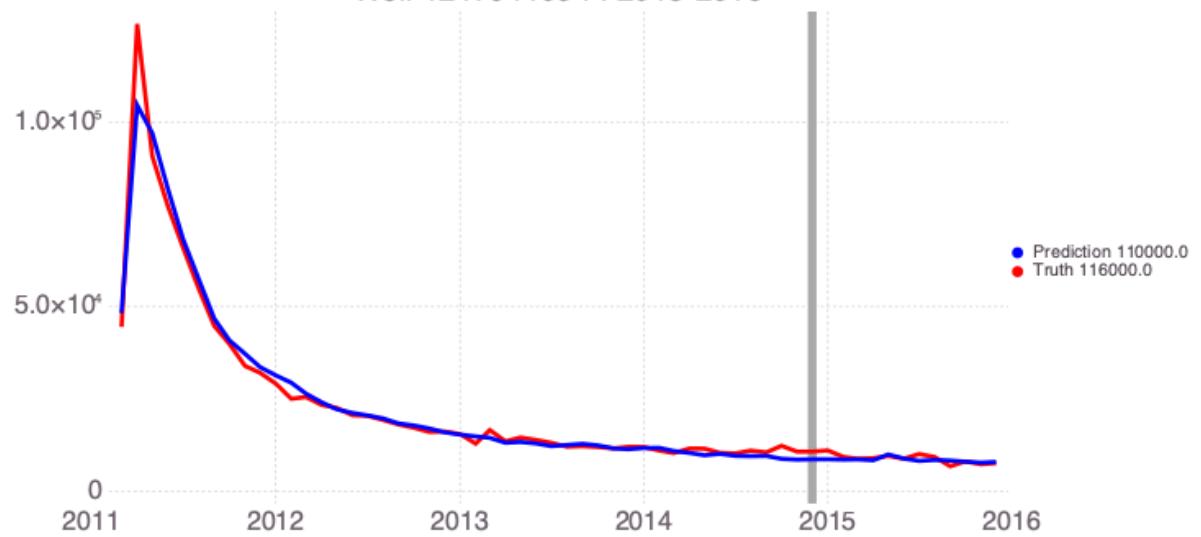




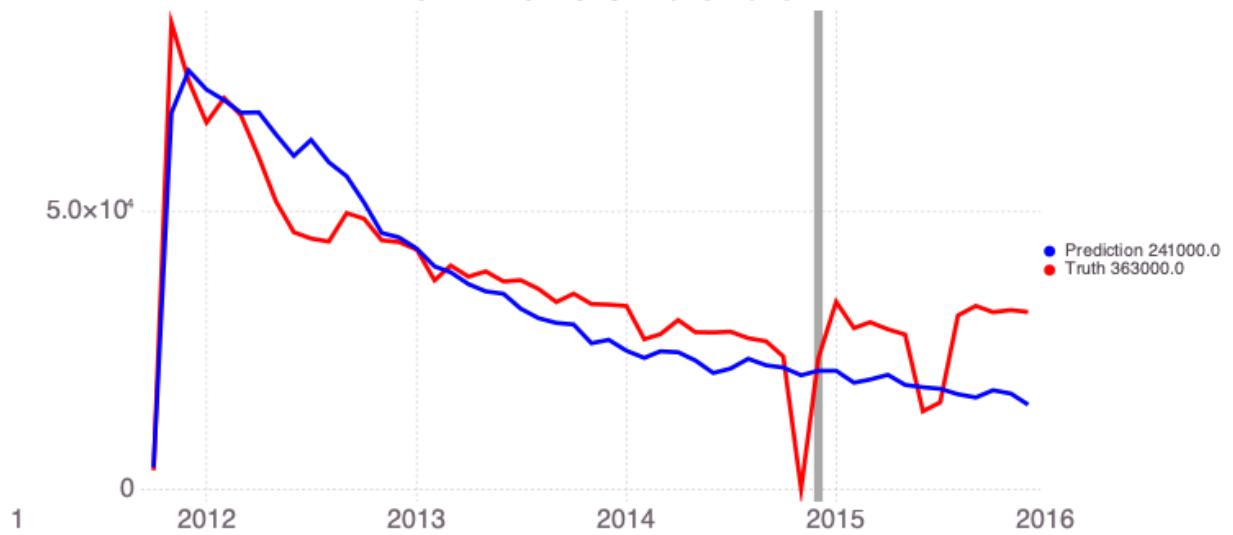
Well 4247941028 : 2015-2016



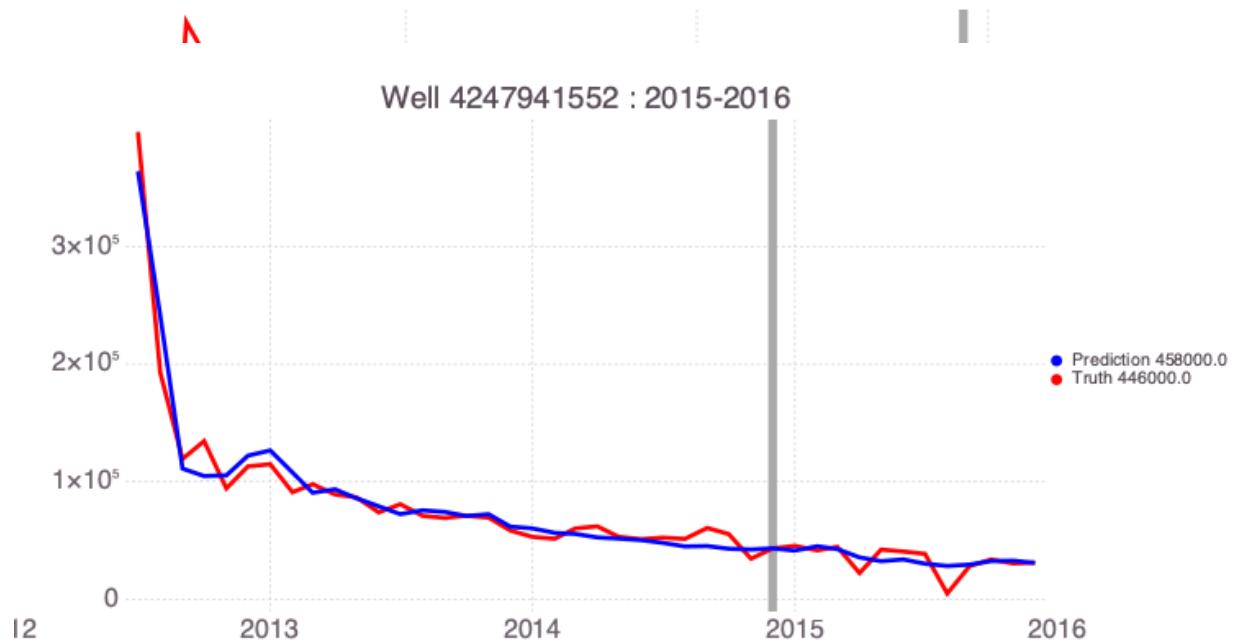
Well 4247941094 : 2015-2016



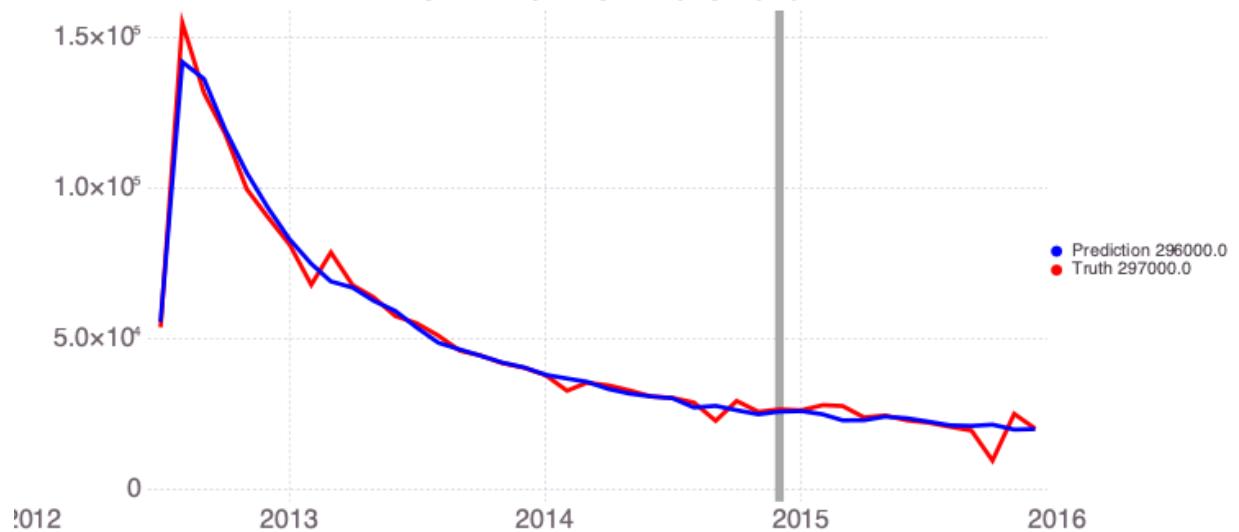
Well 4247941328 : 2015-2016

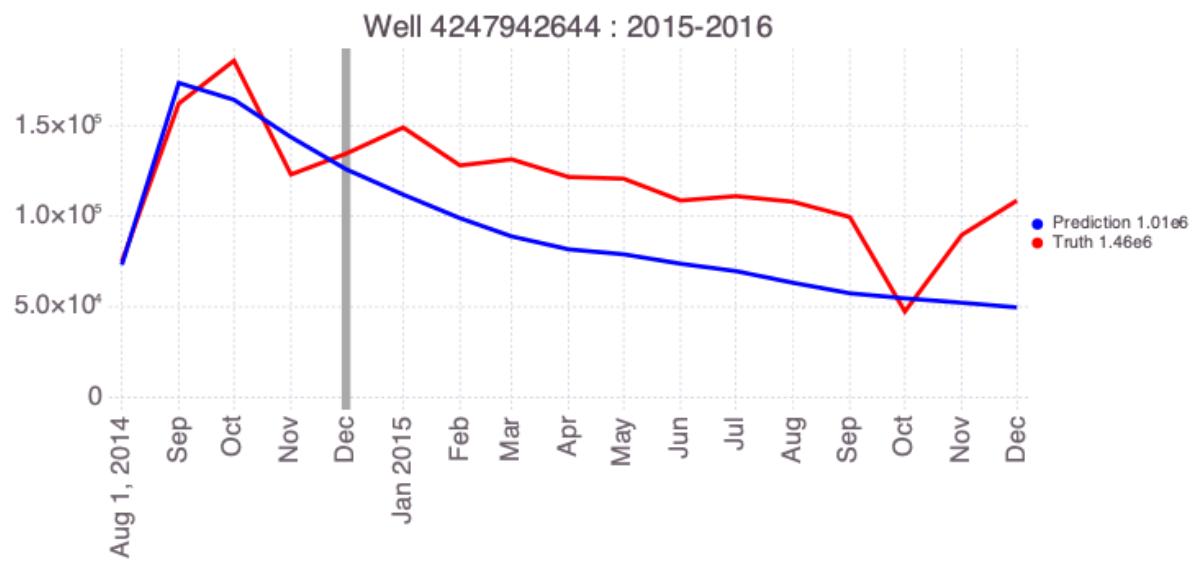
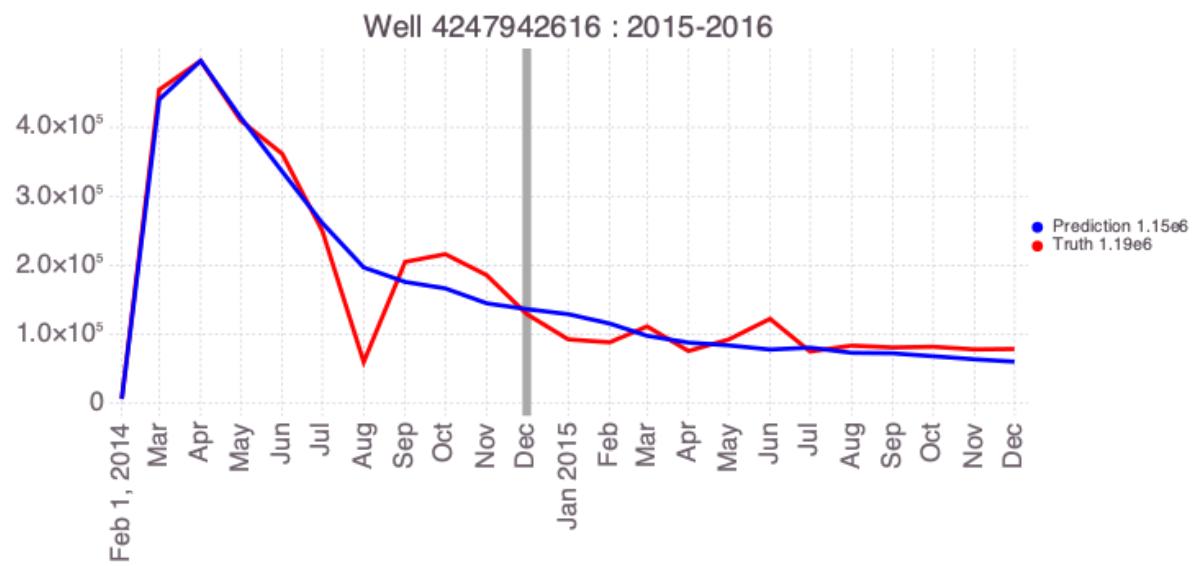
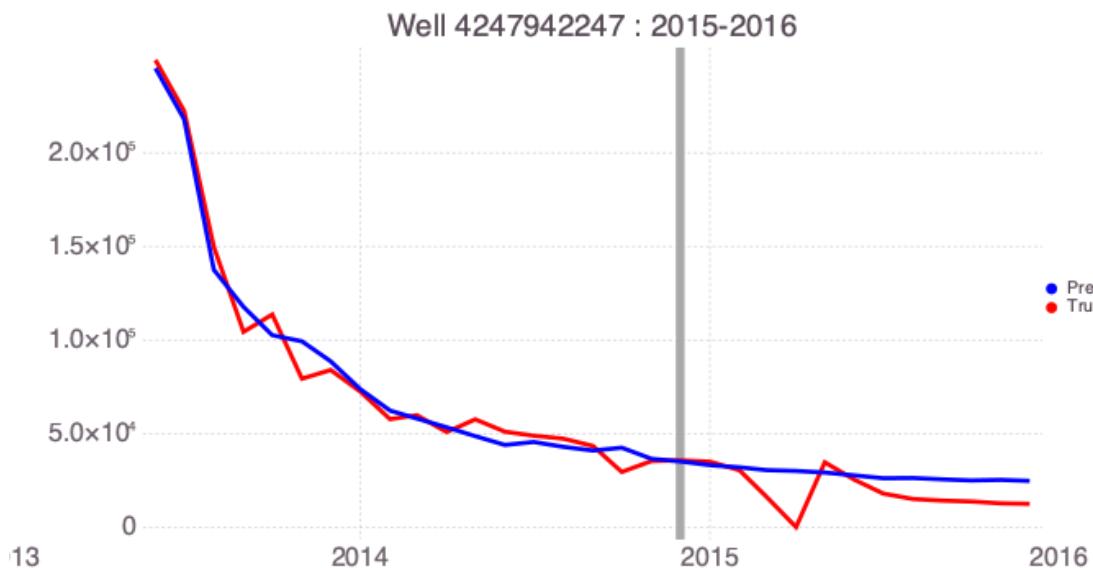


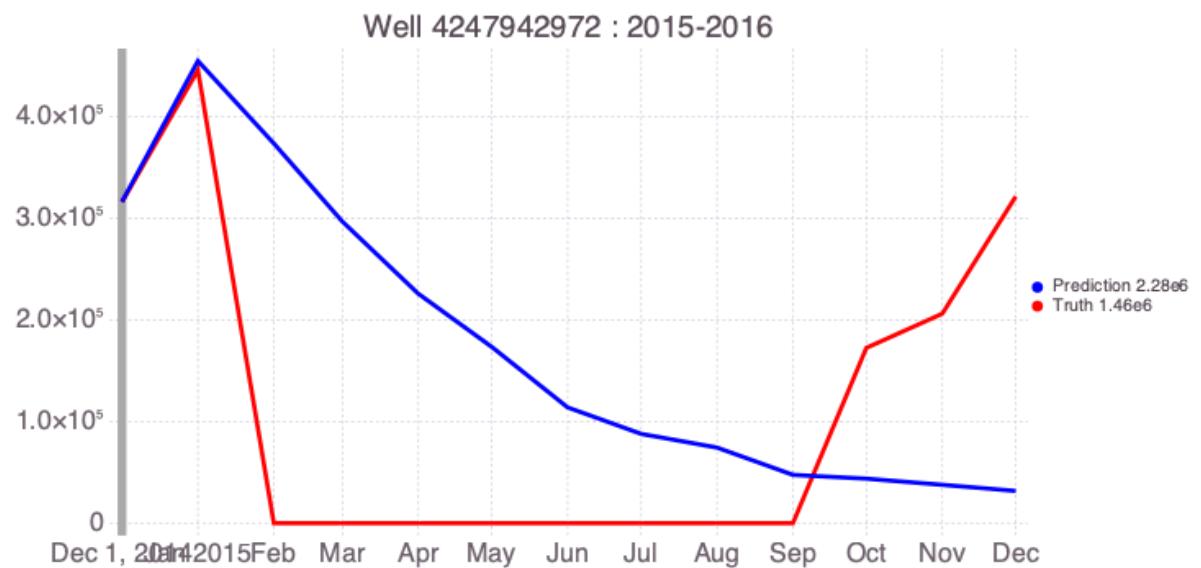
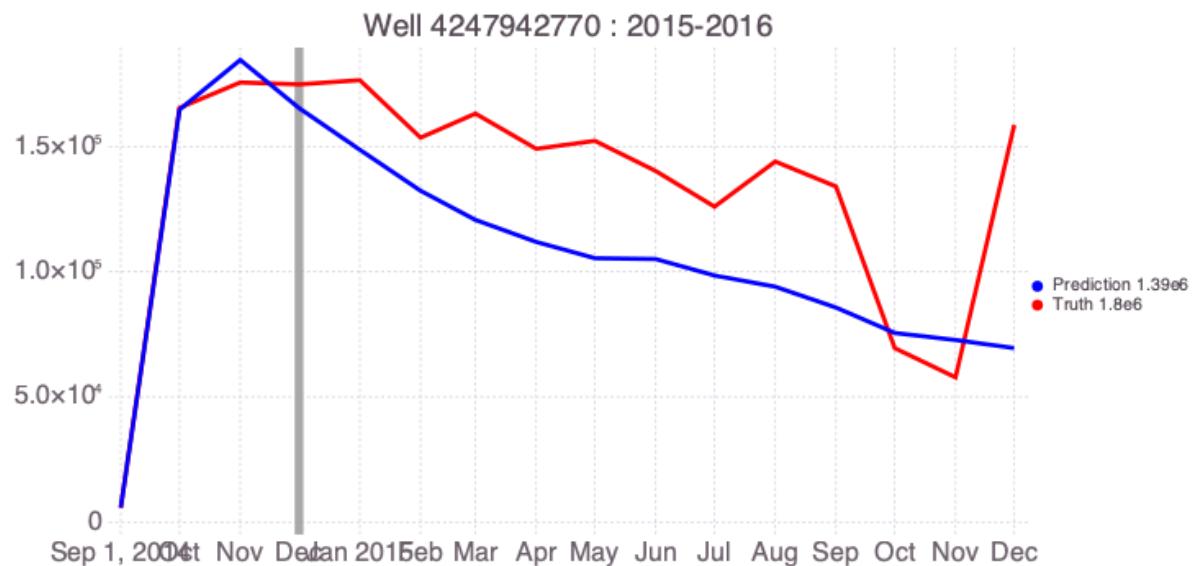
Well 4247941410 : 2015-2016



Well 4247941552 : 2015-2016

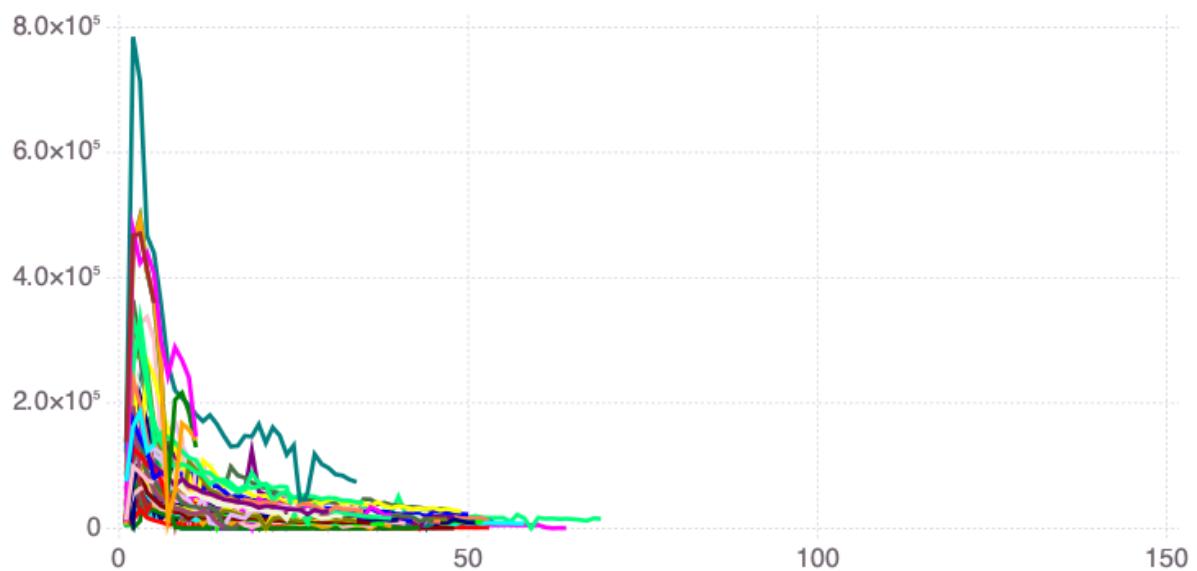








```
Γ Info: Window 2015: Training size 118 Truth size: 299 Prediction size: 2  
99 R2 (pred): 0.8650471996037531 R2 (all) 0.9506983925448549  
└ @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:221  
[ Info: Type A wells: 141  
└ @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:235
```



```
[ Info: Type B wells: 94  
└ @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:235
```



```
[ Info: Type C wells: 87
@ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkProgressive.jl:235
```

```
1×2 Array{Any,2}:
"EAGLE FORD" 141
```

21x2 Array{Any,2}:

"LEWIS PETRO PROPERTIES, INC."	18
"SILVERBOW RESOURCES OPER, LLC"	16
"SM ENERGY COMPANY"	12
"PIONEER NATURAL RES. USA, INC."	11
"LAREDO ENERGY OPERATING, LLC"	9
"SN OPERATING, LLC"	8
"MARATHON OIL EF LLC"	7
"BHP BILLITON PET(TXLA OP) CO"	6
"DEVON ENERGY PRODUCTION CO, L.P."	6
"STATOIL TEXAS ONSHORE PROP LLC"	5
" "	4
"BHP BILLITON PETROLEUM"	4
"BURLINGTON RESOURCES O & G CO LP"	4
"ENDEAVOR NATURAL GAS, LP"	4
"ESCONDIDO RESOURCES OPER CO, LLC"	4
"ROSETTA RESOURCES OPERATING LP"	4
"BHP BILLITON PETROLEUM "	3
"ENCANA OIL & GAS(USA) INC."	2
"EQUINOR TEXAS ONSHORE PROP LLC"	2
"PERDIDO ENERGY, LLC"	2
"PROLINE ENERGY RESOURCES INC"	2

```
1×2 Array{Any,2}:
```

```
1×2 Array{Any,2}:
"EAGLE FORD" 94
```

18×2 Array{Any,2}:

"LAREDO ENERGY OPERATING, LLC"	12
"SILVERBOW RESOURCES OPER, LLC"	12
"PIONEER NATURAL RES. USA, INC."	8
"LEWIS PETRO PROPERTIES, INC."	7
"SM ENERGY COMPANY"	7
"BHP BILLITON PET(TXLA OP) CO"	6
"BHP BILLITON PETROLEUM"	6
"ROSETTA RESOURCES OPERATING LP"	5
"BURLINGTON RESOURCES O & G CO LP"	4
"SN OPERATING, LLC"	4
"BHP BILLITON PETROLEUM "	3
" "	2
"ENCANA OIL & GAS(USA) INC."	2
"EQUINOR TEXAS ONSHORE PROP LLC"	2
"ESCONDIDO RESOURCES OPER CO, LLC"	2
"MARATHON OIL EF LLC"	2

```
"STATOIL TEXAS ONSHORE PROP LLC"      2
```

```
"CLOUD ENERGY OPERATING LLC"          2
```

```
1x2 Array{Any,2}:
```

```
"Horizontal"  94
```

```
1x2 Array{Any,2}:
```

```
"EAGLE FORD"  87
```

```
17x2 Array{Any,2}:
```

```
"LEWIS PETRO PROPERTIES, INC."        21
```

```
"PIONEER NATURAL RES. USA, INC."      9
```

```
"DEVON ENERGY PRODUCTION CO, L.P."    7
```

```
"SM ENERGY COMPANY"                  7
```

```
"SILVERBOW RESOURCES OPER, LLC"       6
```

```
"BURLINGTON RESOURCES O & G CO LP"   5
```

```
"BHP BILLITON PET(TXLA OP) CO"       3
```

```
"LAREDO ENERGY OPERATING, LLC"        3
```

```
"PERDIDO ENERGY, LLC"                3
```

```
"SN OPERATING, LLC"                  3
```

```
"STATOIL TEXAS ONSHORE PROP LLC"      3
```

```
" "                                2
```

```
"BHP BILLITON PETROLEUM "             2
```

```
"EOG RESOURCES, INC."                2
```

```
"ESCONDIDO RESOURCES OPER CO, LLC"    2
```

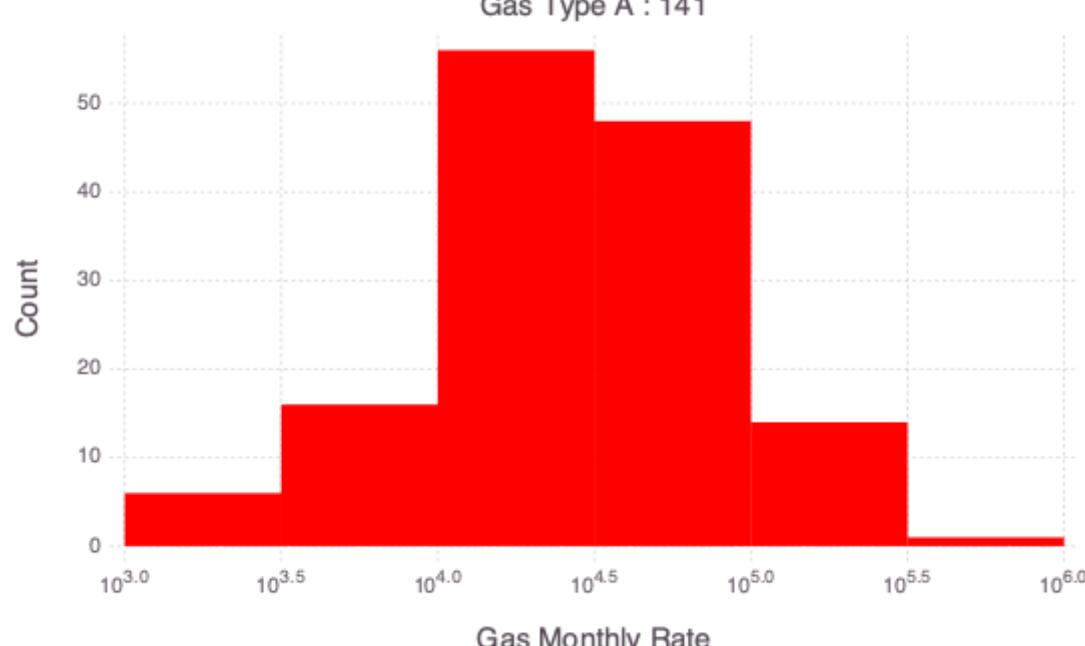
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"FASKEN OIL AND RANCH, LTD."         2
```

```
"ROSETTA RESOURCES OPERATING LP"      2
```

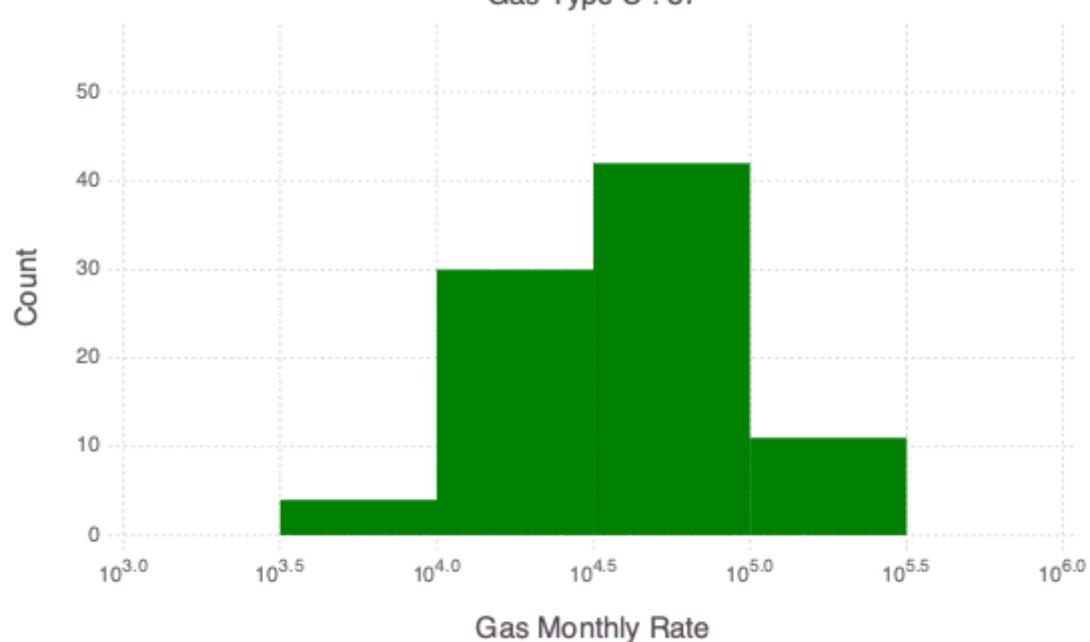
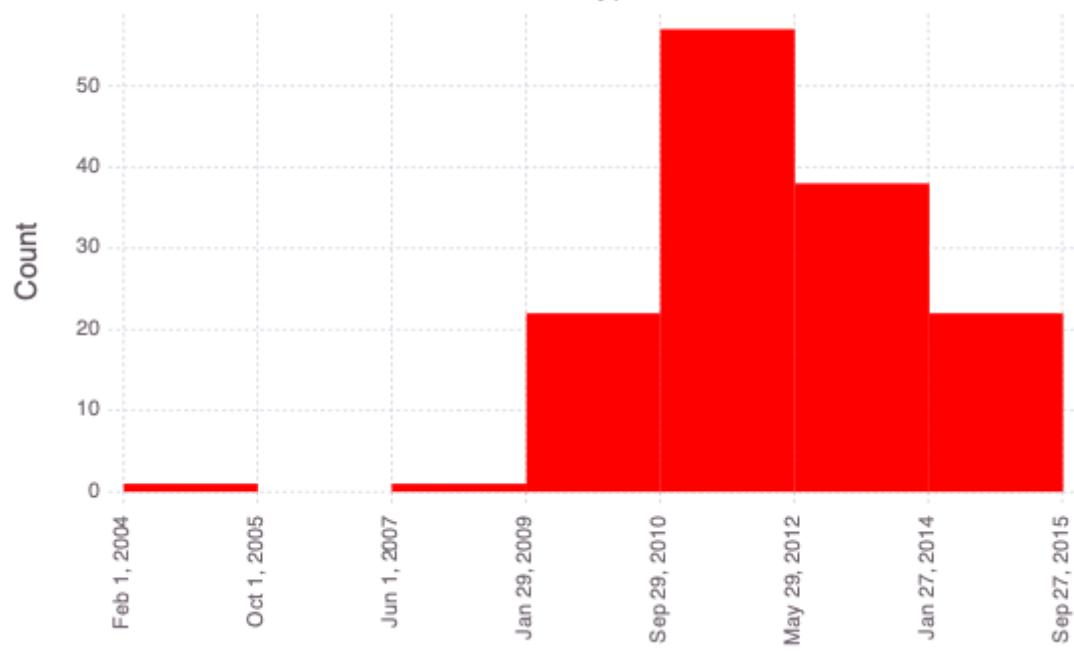
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1x2 Array{Any,2}:
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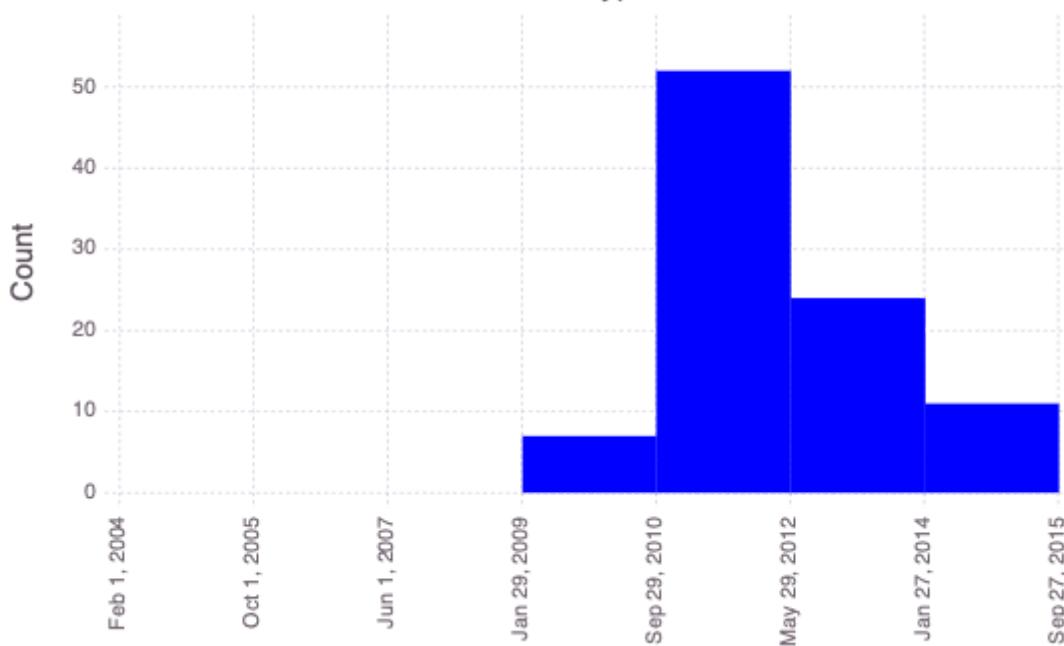
```
"Horizontal"  87
```

Gas Type A : 141



```
[ Info: Type A wells: 141
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:241
[ Info: Formation
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:242
[ Info: Operator
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:244
[ Info: Well type
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:246
[ Info: Type B wells: 94
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:241
[ Info: Formation
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:242
[ Info: Operator
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:244
[ Info: Well type
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:246
[ Info: Type C wells: 87
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:241
[ Info: Formation
  @ NMFK /Users/vvv/.julia/dev/NMFK/src/NMFkProgressive.jl:242
[ Info: Operator
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[ Info: Well type
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Gas Type B : 94**Gas Monthly Rate****Start Date Type A : 141**

Start Date Type B : 94**Start Date Type C : 87**