An emergence index

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The US patent data at hand can be best described as "pure trend" data, that is the main source of variation in the data is trend and noise.

We choose to model the data using a Local Linear Model (LLM).

Local linear trend (LLT) state-space model

- A signal plus noise model: Have $y = \{y_i\}_{i=1}^n$ with

$$y_i = \mu_i + \epsilon_i,$$

  where μ_i is a stochastic process (with linear dynamic) and ϵ_i's are iid with mean zero and constant variance.

- Note that y_i can be a vector.
- The stochastic specification of μ_i allows to model y in different ways.

Modeling the signal

- First assume $\mu_i = a + d\,i$, with a and d constant.
- Unsatisfactory for most time series. But, if we assume that $\mu = \{\mu_i\}$ is "smooth", μ could be described LOCALLY by a linear model (Taylor's theorem).
- Let a and d vary with time to allow μ_i to adapt to the evolution of the series.
- If $\mu_i = a + d\,i$ then $\mu_{i+1} = \mu_i + d$.
- To allow for flexibility in the model

$$\begin{aligned} y_i &= \mu_i + \epsilon_i, \\ \mu_{i+1} &= \mu_i + d_i + \nu_i, \\ d_{i+1} &= \delta d_i + \eta_i. \end{aligned}$$

where $\nu = \{\nu_i\}$ and $\eta = \{\eta_i\}$ are independent white noise processes with mean zero and variance σ_ν^2 and σ_η^2 respectively. ϵ is independent of ν and η.

- The LLM is a state-space with a two-dimensional state vector with entries μ_i and d_i.
- μ_i is the signal
- d_i is the rate of change of the signal or "first derivative".
- The signal can be extracted using a combination of Kalman and smoothing filtering.
- My preferred algorithms are the "diffuse" KF and SF.
- The same algorithms allow for (diffuse) prediction.
- For more details on the state-space model and signal-extraction algorithms see

de Jong, P.(1991). The diffuse Kalman filter. *The Annals of Statistics*. Vol 19, No.2, pp 1073 - 1083.

Generalisations

- Model easily generalised to handle unequally spaced data (e.g. missing data)
- Suppose y is observed at times $t_1, \ldots, t_n$ and let $h_i = t_{i+1} - t_i$. Then, if $\mu_i = \mu_{t_i}$

$$\begin{aligned} y_i &= \mu_i + \epsilon_i, \\ \mu_{i+1} &= \mu_i + h_i d_i + \nu_i, \\ d_{i+1} &= \delta d_i + \eta_i. \end{aligned}$$

- Other sources of variation such as seasonal effects, cycles and covariates, can be added to the state vector.

Application to patent data

$y = \{y_i\}_{i=1}^n$ represents one time series of quarterly counts. $\mu = \{\mu_i\}$ represents the signal and σ_ϵ is the noise standard deviation. Also, $d = \{d_i\}_{i=1}^n$ represents the rates of change, or first derivatives, of the signal at each time point.

Positive values of d_i indicate that the signal is increasing, negative values of d_i indicate that the signal is decreasing. If $d_i = 0$ then that indicates a point of maximum, minimum or perhaps an inflexion point.

The index

During a time period, say consecutive times $j_1, \ldots, j_m$, we define

$$E = \sum_{k=1}^{m} d_{j_k}$$

as a measure of emergence. Positive values of E indicate that growth was dominant in the time period. Negative values of E indicate that decline was dominant in the time period. Values of E near zero, positive or negative, could arise in many ways. One way is if, for example, the d_{j_k}'s are mostly very small and so the series ws stationary. Or, it could be that there are approximately an equal number od positive and negative d's, and so there was growth and decline in the same period.

Now, what does "large" value of E mean? The derivative measures the rate of change of a function. Given a function f and two points x and y, the derivative of f at x, the instantaneous rate of change of f at x, is the limit as y tends to x of the ratio of the change of f from $f(y)$ to $f(x)$ divided by $y - x$,

$$f'(x) = \lim_{y \to x} \frac{f(y) - f(x)}{y - x}$$

So, we see that if the total variability of f is large, f' will be larger than the derivative of f if the total variability of f were small.

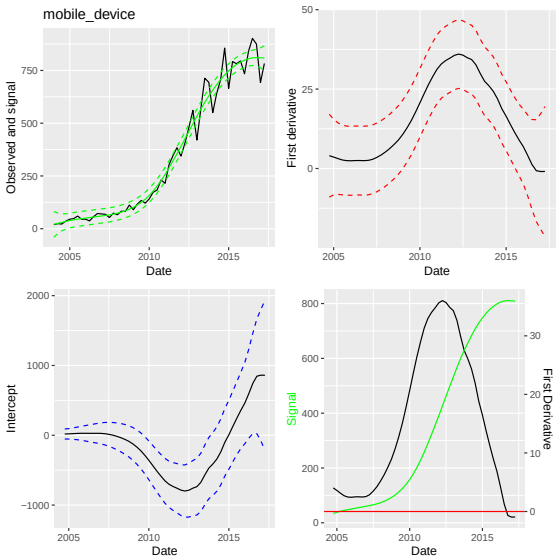
Therefore, we redefine E to be

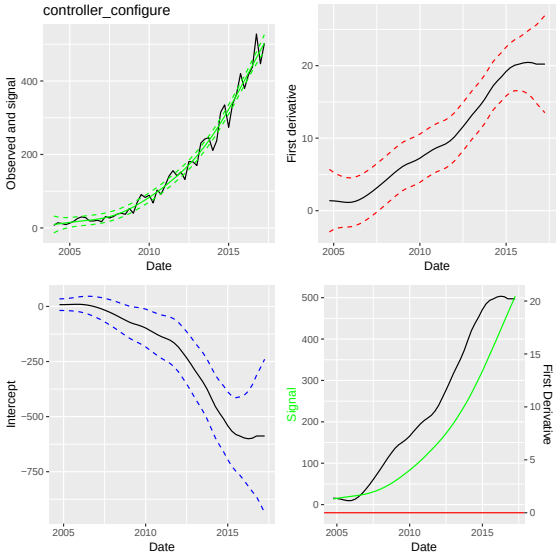
$$E = \frac{\sum_{k=1}^{m} d_{j_k}}{\sigma_\epsilon}.$$

In this way we avoid large values of E, positive or negative, being driven by a large noise variance.

For example, consider the terms "mobile device" and "controller configure". For the time period 1st quarter 2005 - 2nd quarter 2017 we have

Term	σ_ϵ	$\sum d_i$	$\sum d_i/\sigma_\epsilon$
mobile device	48.584	778.173	16.017
controller configure	20.266	511.429	25.235


mobile_device
Observed and signal
First derivative
Intercept
Signal
First Derivative
Date

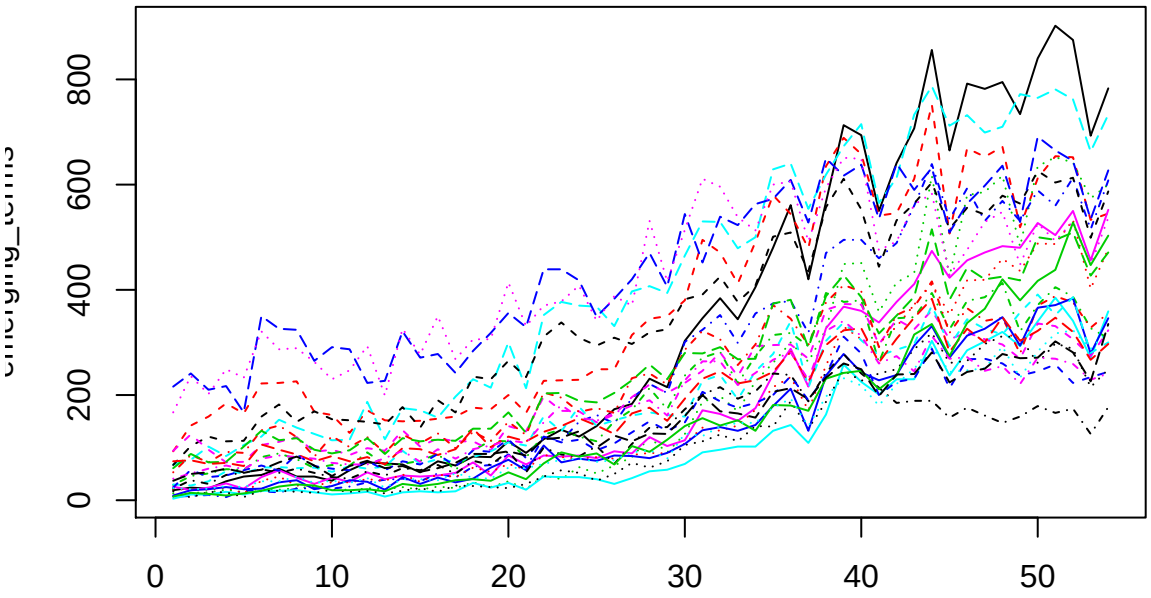

controller_configure
Observed and signal
First derivative
Intercept
Signal
First Derivative
Date

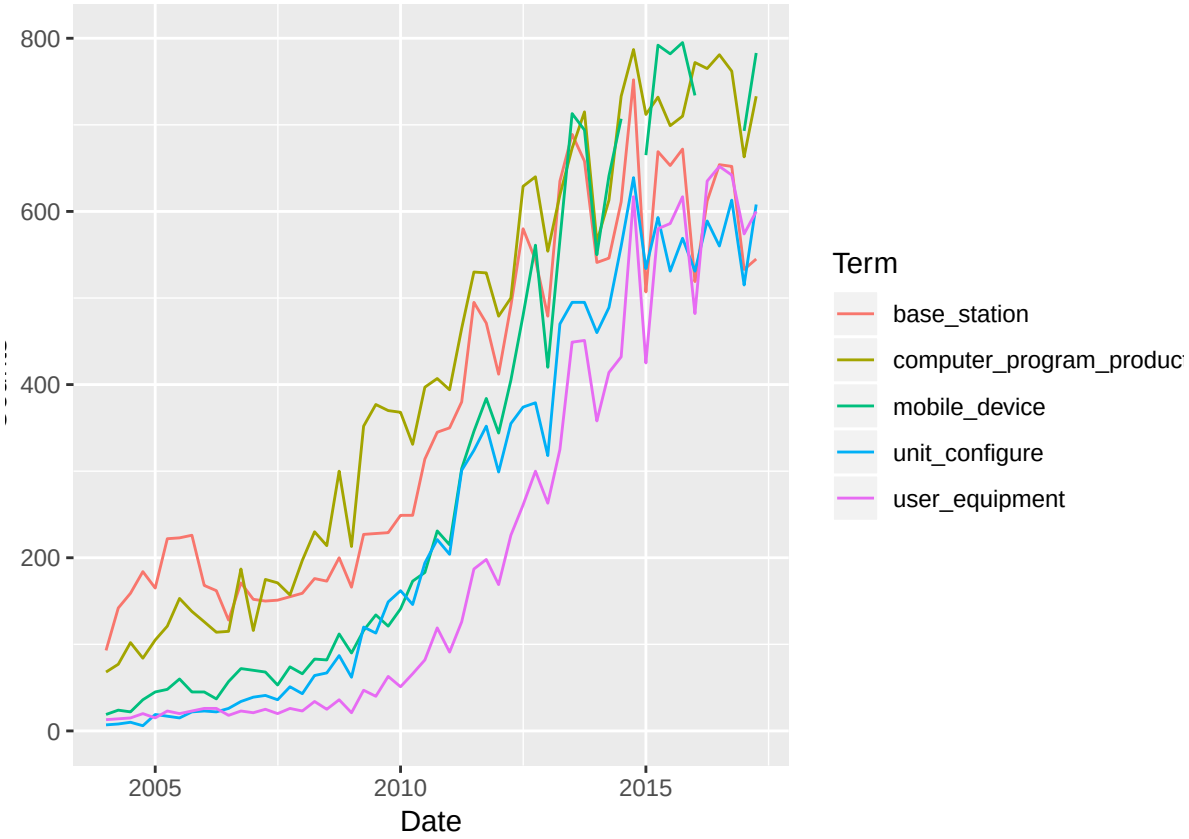
However, if we inspect the plots above, it is clear that although "mobile device" has a larger $\sum d_i$, "controller configure" has a steady grow over the time period, whereas "mobile device" is starting to decline after steady growth.

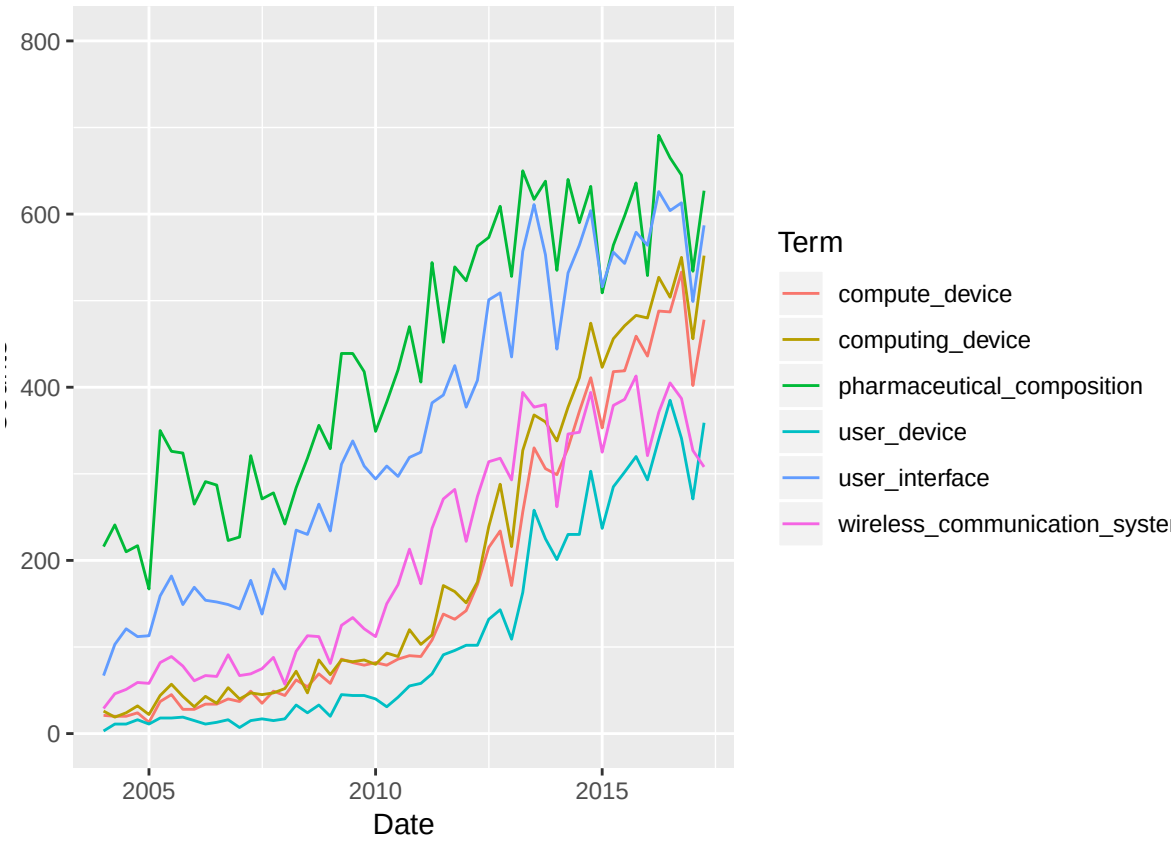
The data I used to test consisted of 74 series (for 74 terms) 25 of which were the top emergent terms, 25 were the top stationary terms and 24 top declining terms.

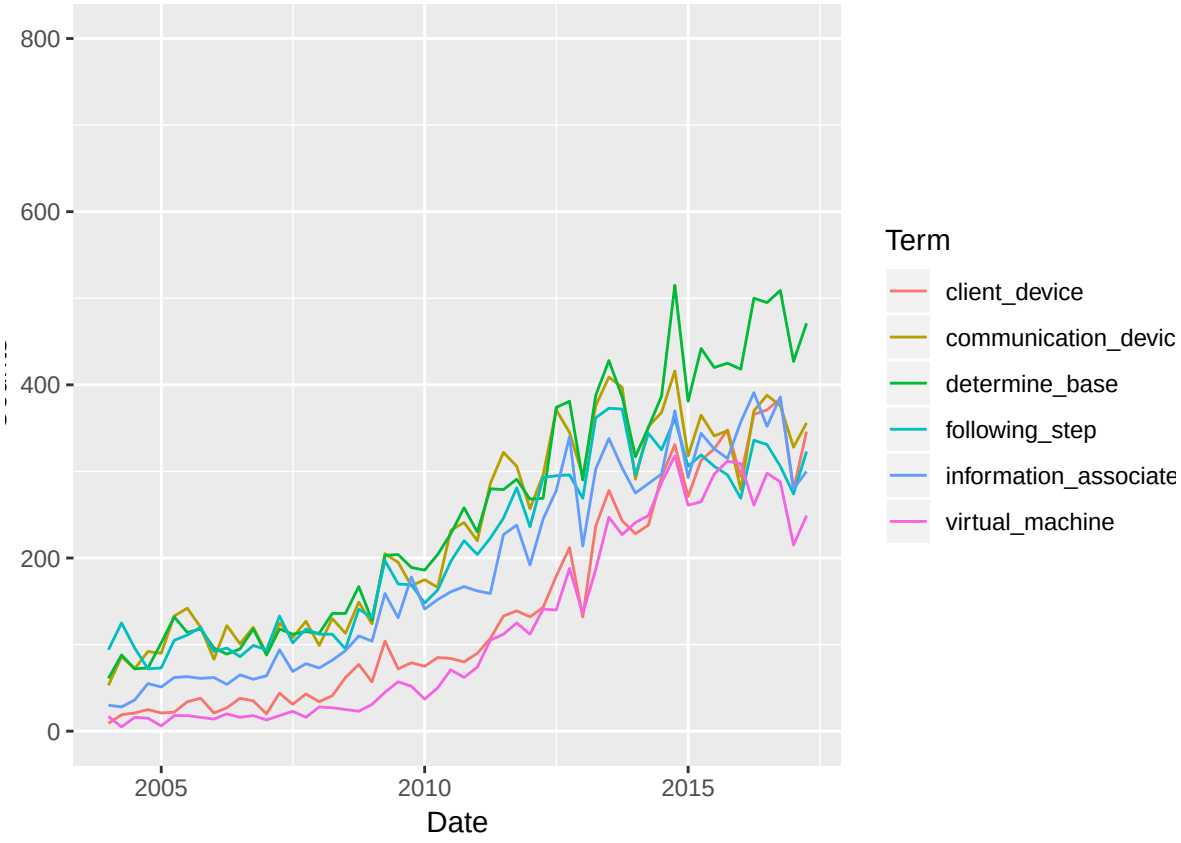
Terms classified as emergent by Porter

The terms are all clearly emergent. I am not sure if Porter's ranking is the same as mine as I don't have Porter's scores.






800
600
400
200
0
2005
2010
2015
Date
Term
compute_device
computing_device
pharmaceutical_composition
user_device
user_interface
wireless_communication_syste


800
600
400
200
0
2005
2010
2015
Date
Term
client_device
communication_devic
determine_base
following_step
information_associate
virtual_machine

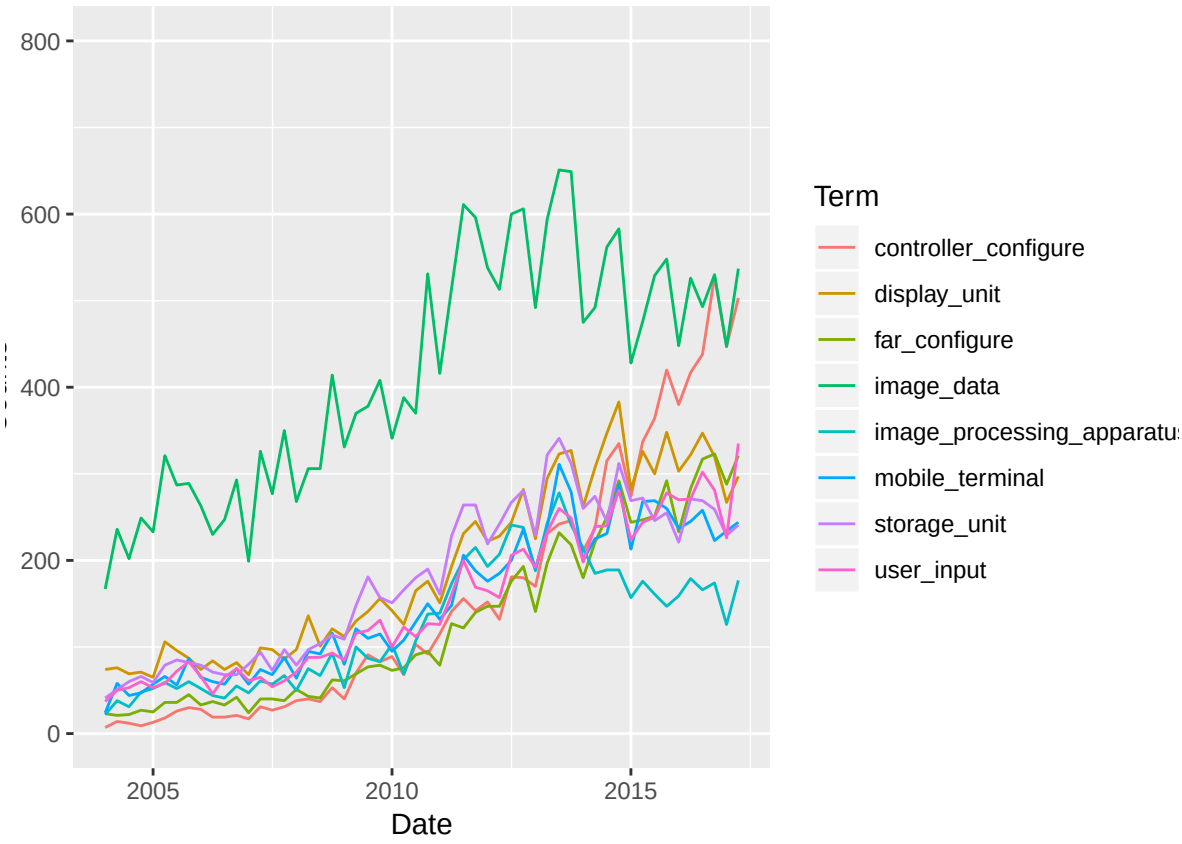

800
600
400
200
0
2005
2010
2015
Date
Term
controller_configure
display_unit
far_configure
image_data
image_processing_apparatu
mobile_terminal
storage_unit
user_input

Table 1: Emerging Terms

Term	σ_ϵ	σ_ν	σ_η	δ	E(sum 1st der)	E(sum 1st der/sd)
controller configure	20.26621	1.4538156	0.0000002	1.0000000	511.4290	25.235554
computing device	22.46527	3.0752379	0.0000095	0.9737273	509.1460	22.663692
compute device	22.77279	2.9092781	0.0000001	0.9706548	464.9410	20.416514
unit configure	30.61585	3.4494549	0.0000044	0.9707211	572.5834	18.702186
far configure	16.86448	0.8969558	0.0000147	1.0000000	300.0263	17.790421
user equipment	38.21802	3.6276779	0.0000034	0.9767679	620.3227	16.231156
mobile device	48.58455	5.1622083	0.0000534	0.9675438	778.1726	16.016875
user device	21.44104	1.8749874	0.0000002	0.9813091	343.3377	16.013114
computer program product	41.39129	2.8362622	0.0000024	0.9798947	658.9539	15.920109
user interface	33.97358	0.0000004	14.7416176	0.9945274	492.6912	14.502186
client device	23.50435	1.8719932	0.0000008	0.9742848	336.8822	14.332760
virtual machine	16.62287	3.1675641	0.0000001	0.9420660	226.5827	13.630783
determine base	32.57034	1.2181121	0.0000011	0.9958347	413.7848	12.704346
user input	19.74913	0.8249383	0.0000002	0.9945268	246.9970	12.506727
information associate	27.75152	1.6463558	0.0000013	0.9706949	297.8188	10.731620
wireless communication system	28.47157	2.9646210	0.0000026	0.9442072	289.4167	10.165115
display unit	22.43741	2.0637547	0.0000496	0.9562891	224.0652	9.986231
communication device	29.40785	0.0000000	13.3705902	0.9903924	287.5876	9.779279
mobile terminal	21.44692	1.7022585	0.0000076	0.9464027	191.8905	8.947228
following step	23.30157	2.7713324	0.0001550	0.9267517	205.9476	8.838356
storage unit	21.48599	2.4570829	0.0000122	0.9290738	181.7098	8.457130
base station	48.62254	6.0875813	0.0000171	0.9170816	410.4200	8.440942
pharmaceutical composition	48.86269	3.0236779	0.0001709	0.9472690	381.2242	7.801949
image processing apparatus	16.46404	4.8710888	0.0000033	0.8095802	121.1640	7.359309
image data	50.01925	5.6798145	0.0000001	0.8585361	274.1318	5.480526

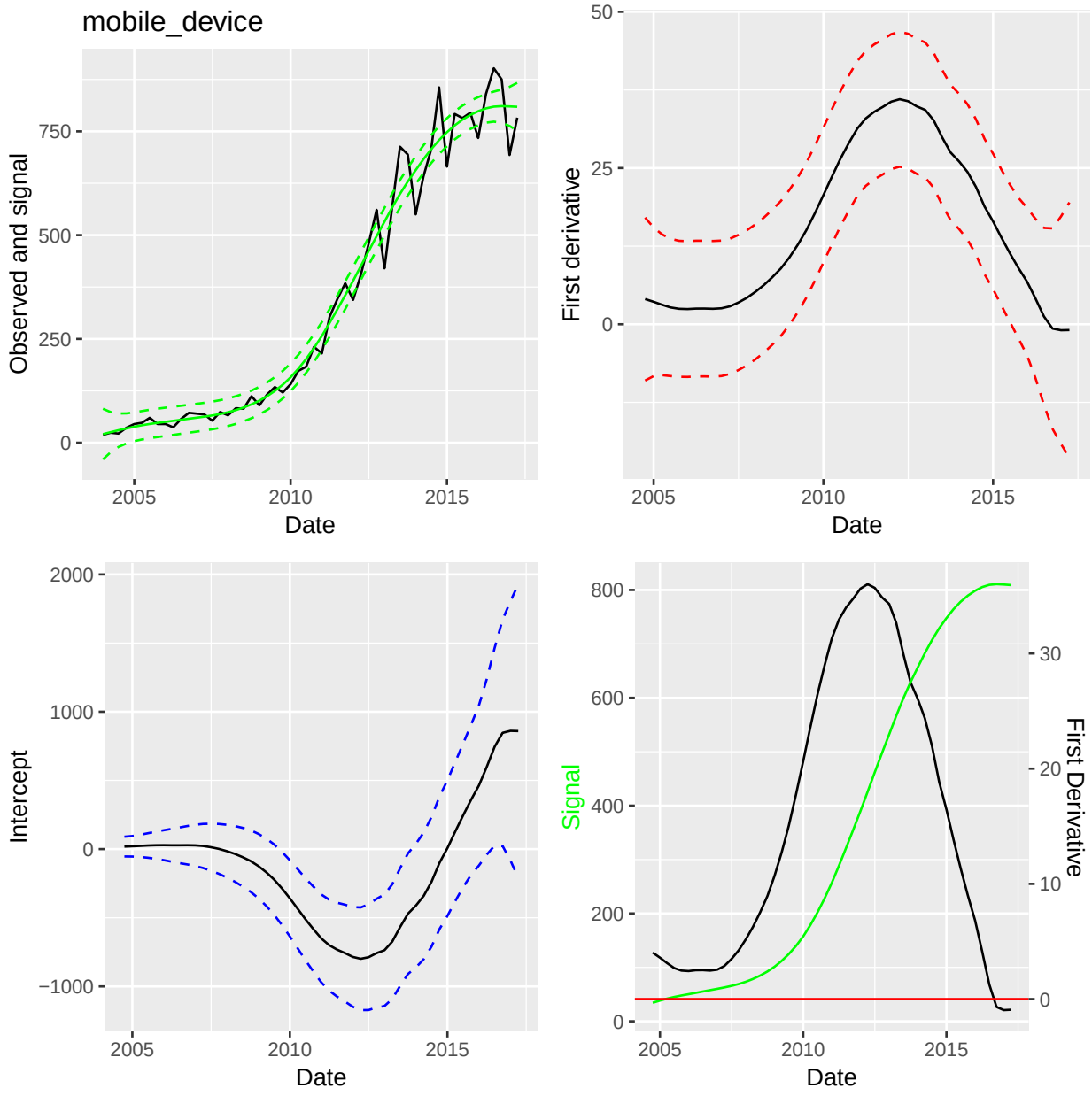

mobile_device
Observed and signal
750
500
250
0
2005
2010
2015
Date
First derivative
50
25
0
2005
2010
2015
Date
Intercept
2000
1000
0
−1000
2005
2010
2015
Date
Signal
800
600
400
200
0
First Derivative
30
20
10
0
2005
2010
2015
Date

Figure 1:

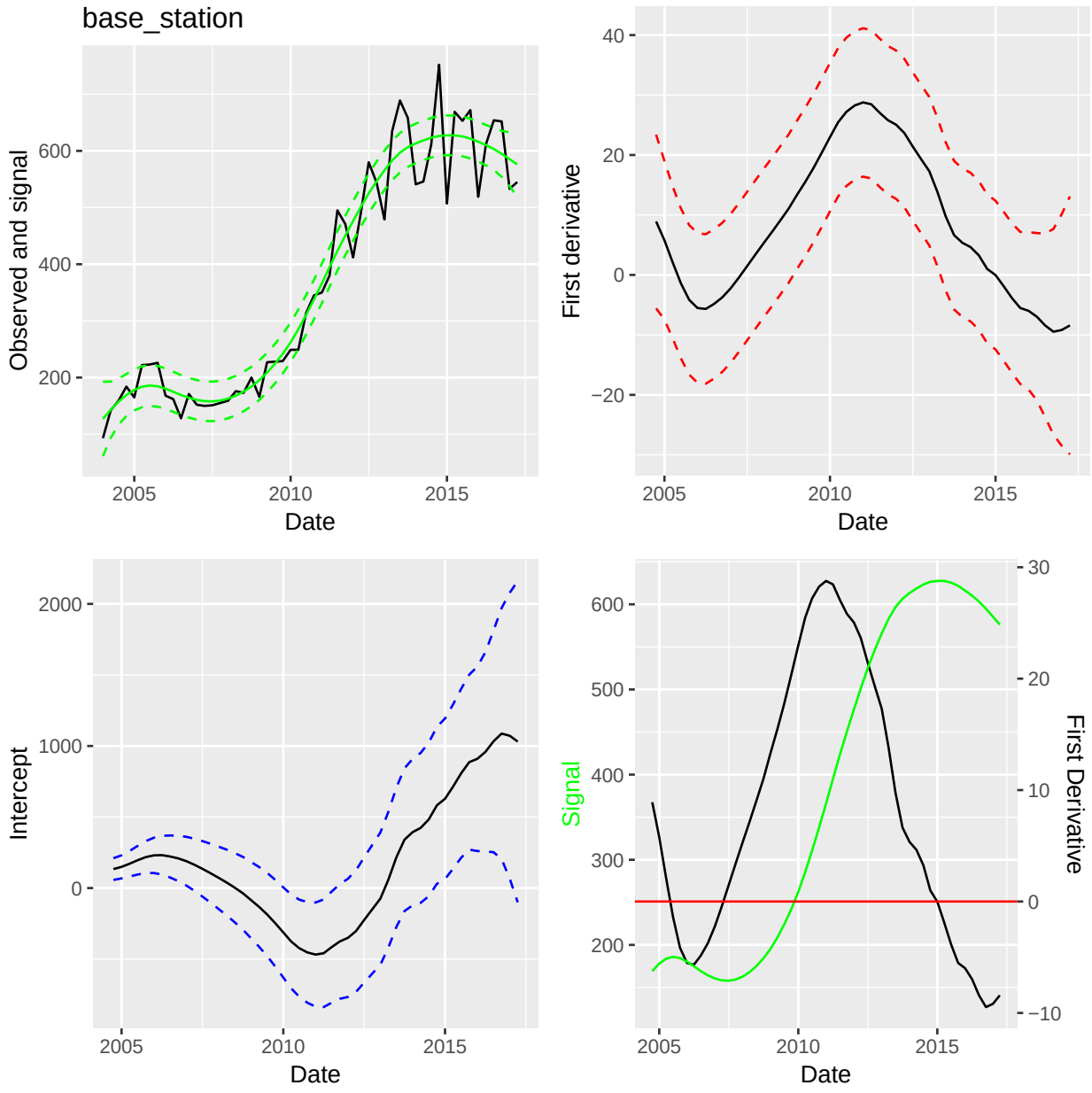

base_station
Observed and signal
600
400
200
2005
2010
2015
Date
First derivative
40
20
0
−20
2005
2010
2015
Date
Intercept
2000
1000
0
2005
2010
2015
Date
Signal
600
500
400
300
200
First Derivative
30
20
10
0
−10
2005
2010
2015
Date

Figure 2:

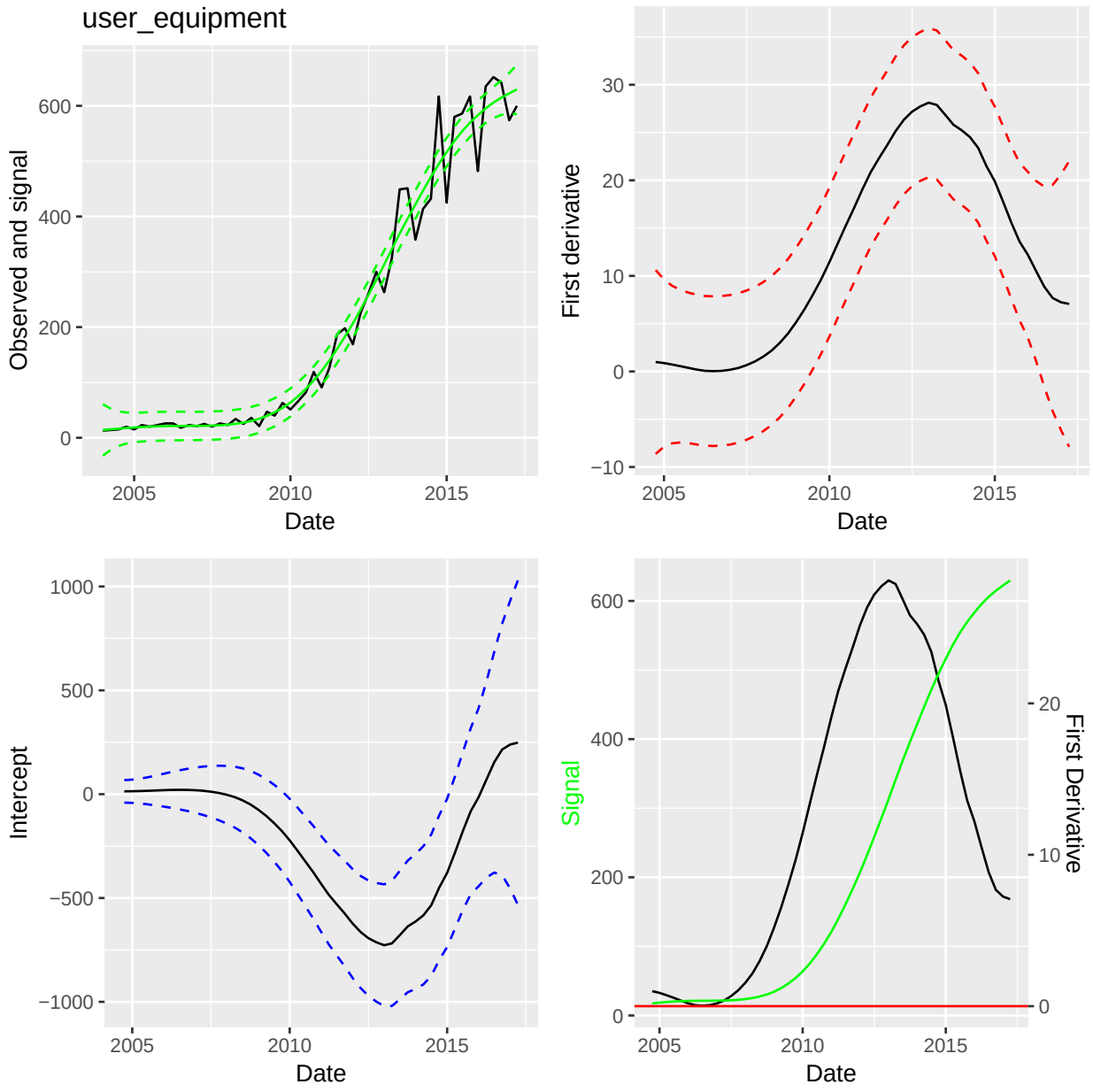

user_equipment
Observed and signal
600
400
200
0
2005
2010
2015
Date
First derivative
30
20
10
0
−10
2005
2010
2015
Date
Intercept
1000
500
0
−500
−1000
2005
2010
2015
Date
Signal
600
400
200
0
2005
2010
2015
Date
First Derivative
20
10
0

Figure 3:

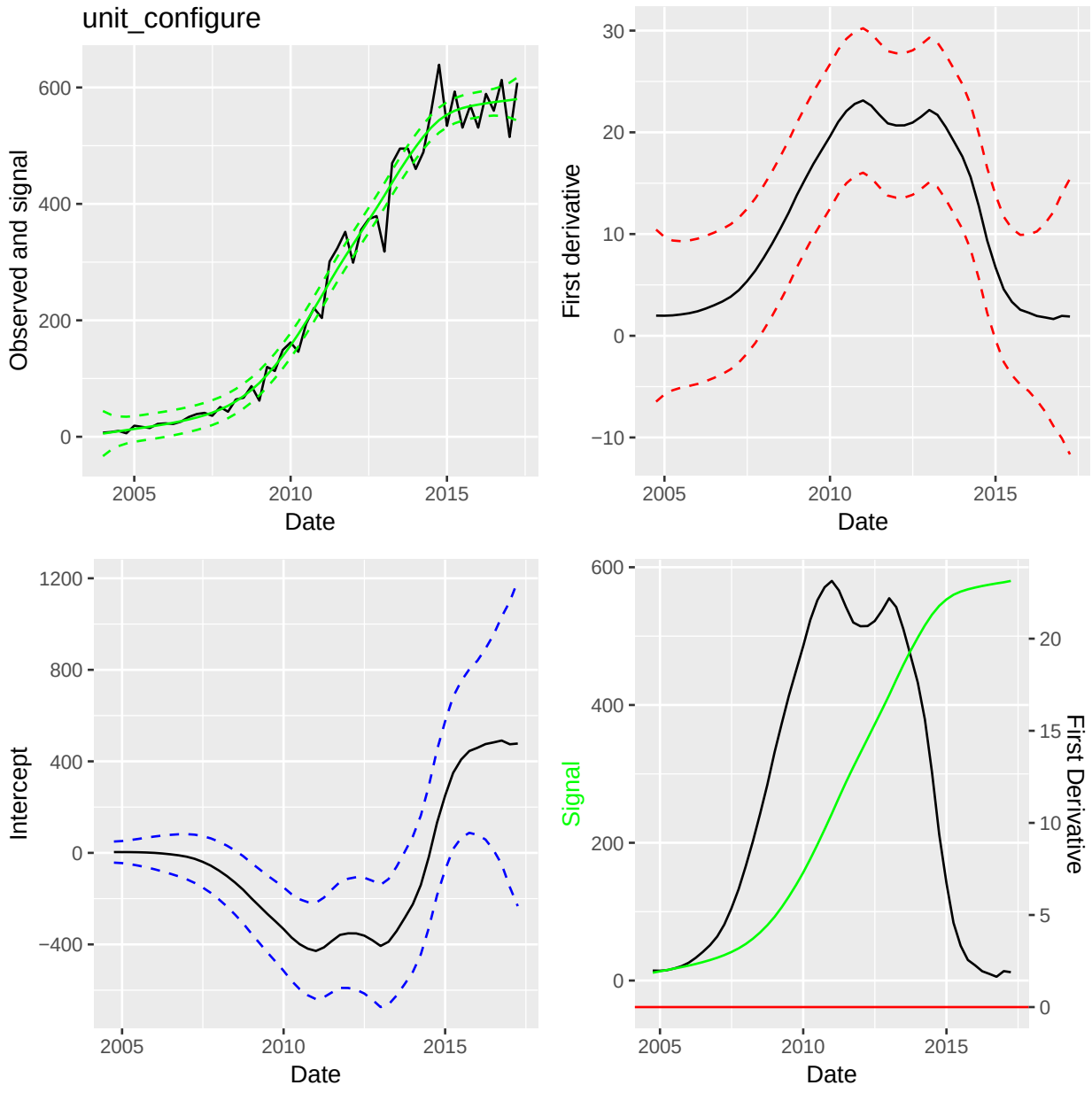

unit_configure
Observed and signal
600
400
200
0
2005
2010
2015
Date
First derivative
30
20
10
0
−10
2005
2010
2015
Date
Intercept
1200
800
400
0
−400
2005
2010
2015
Date
Signal
600
400
200
0
First Derivative
20
15
10
5
0
2005
2010
2015
Date

Figure 4:

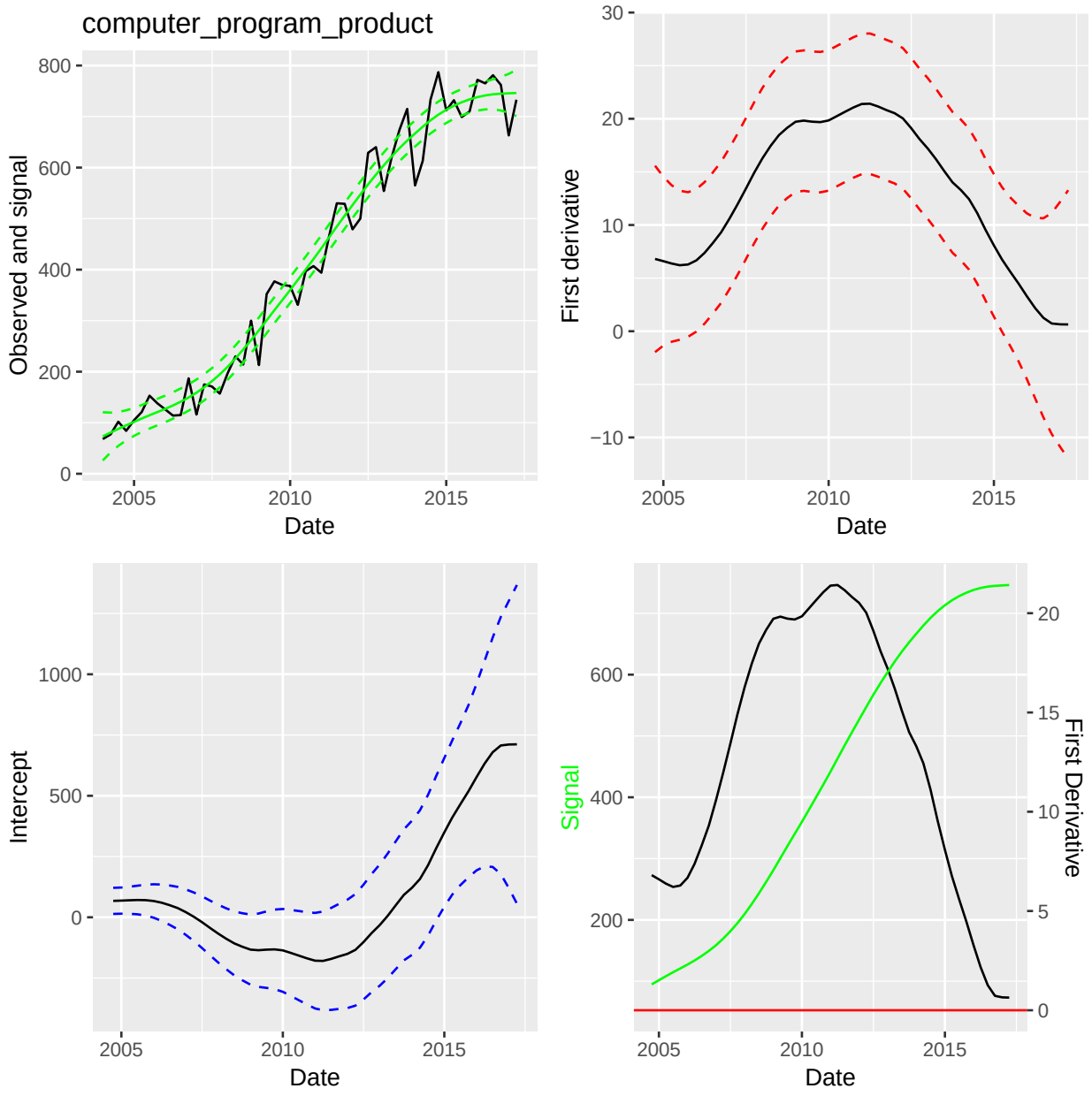
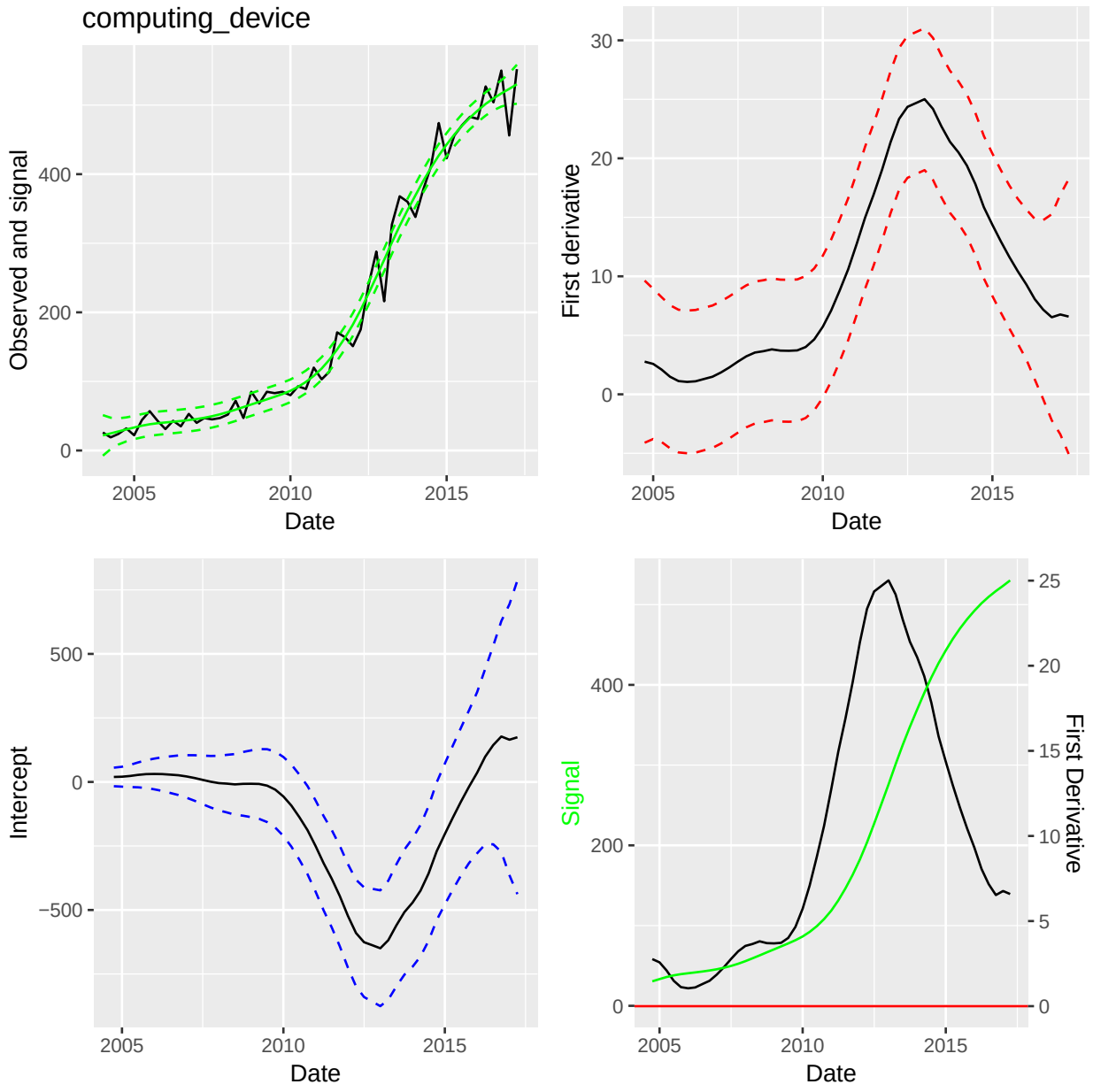

computer_program_product
Observed and signal
800
600
400
200
0
2005
2010
2015
Date
First derivative
30
20
10
0
−10
2005
2010
2015
Date
Intercept
1000
500
0
2005
2010
2015
Date
Signal
600
400
200
First Derivative
20
15
10
5
0
2005
2010
2015
Date

Figure 5:


computing_device
Observed and signal
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200
400
2005
2010
2015
Date
First derivative
0
10
20
30
2005
2010
2015
Date
Intercept
−500
0
500
2005
2010
2015
Date
Signal
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200
400
First Derivative
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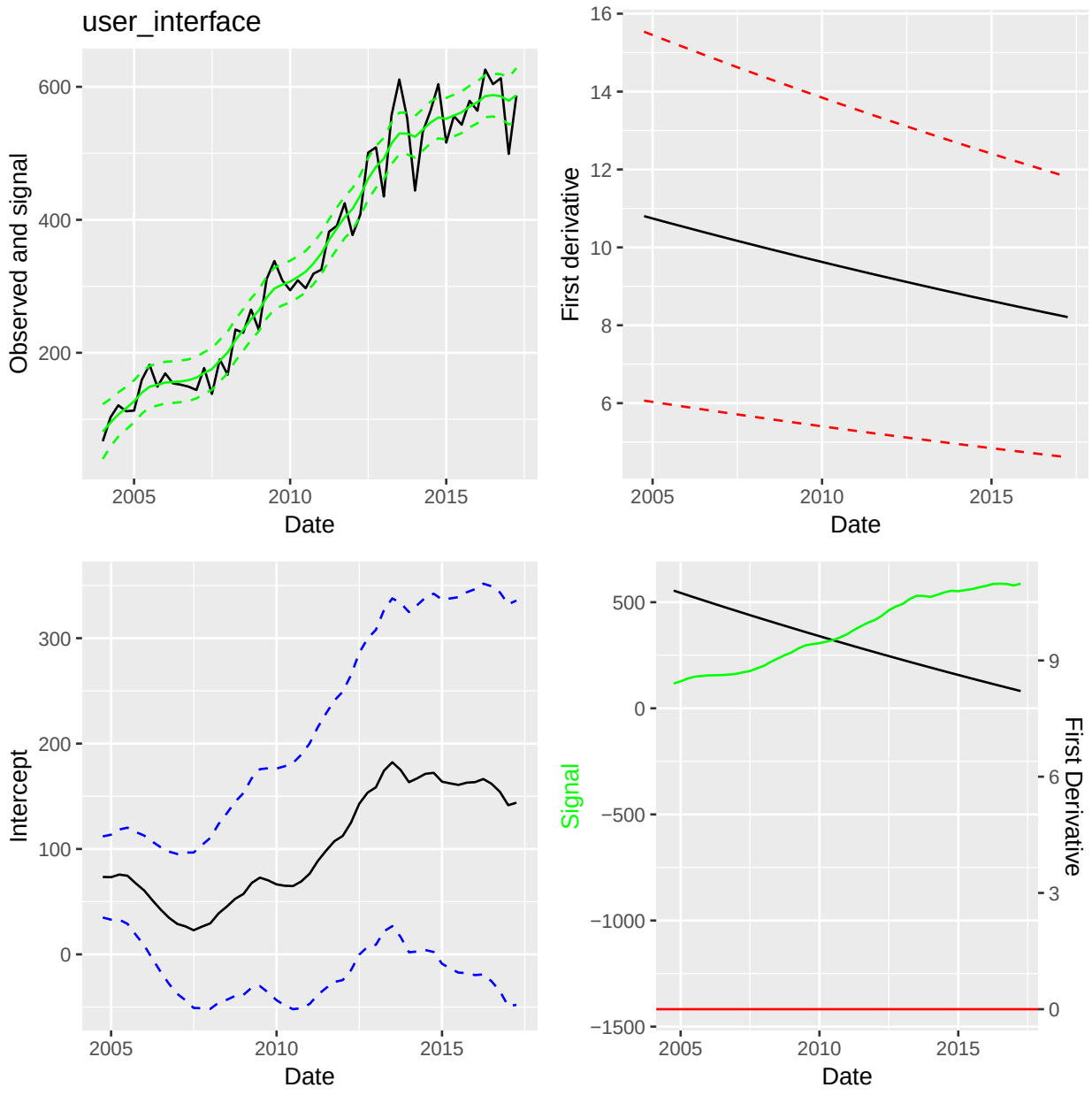
5
10
15
20
25
2005
2010
2015
Date

Figure 6: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Observed and signal
600
400
200
2005
2010
2015
Date
First derivative
16
14
12
10
8
6
2005
2010
2015
Date
Intercept
300
200
100
0
2005
2010
2015
Date
Signal
500
0
−500
−1000
−1500
9
6
3
0
First Derivative
2005
2010
2015
Date

Figure 7:

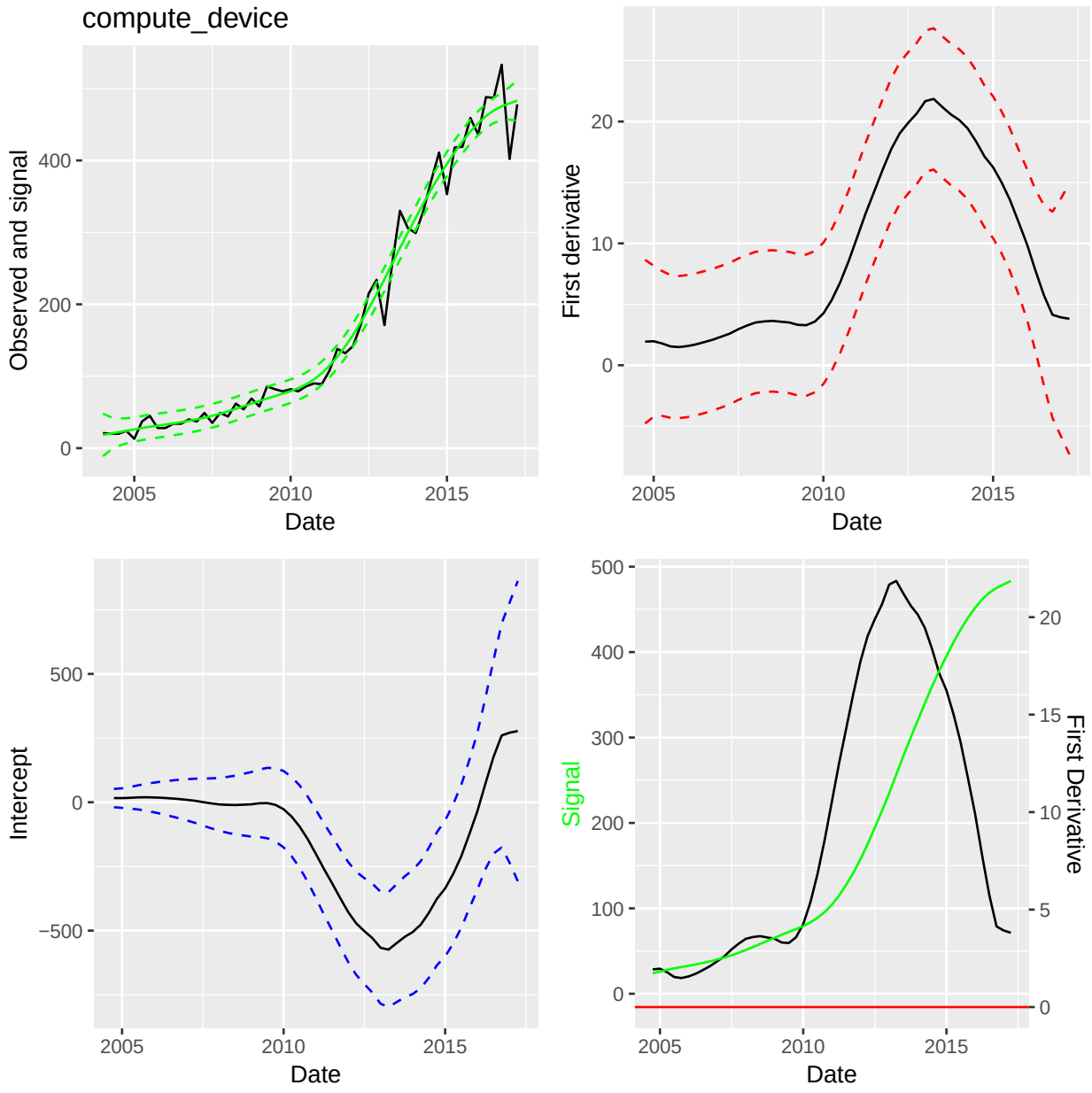

compute_device
Observed and signal
400
200
0
2005
2010
2015
Date
First derivative
20
10
0
2005
2010
2015
Date
Intercept
500
0
−500
2005
2010
2015
Date
Signal
500
400
300
200
100
0
First Derivative
20
15
10
5
0
2005
2010
2015
Date

Figure 8:

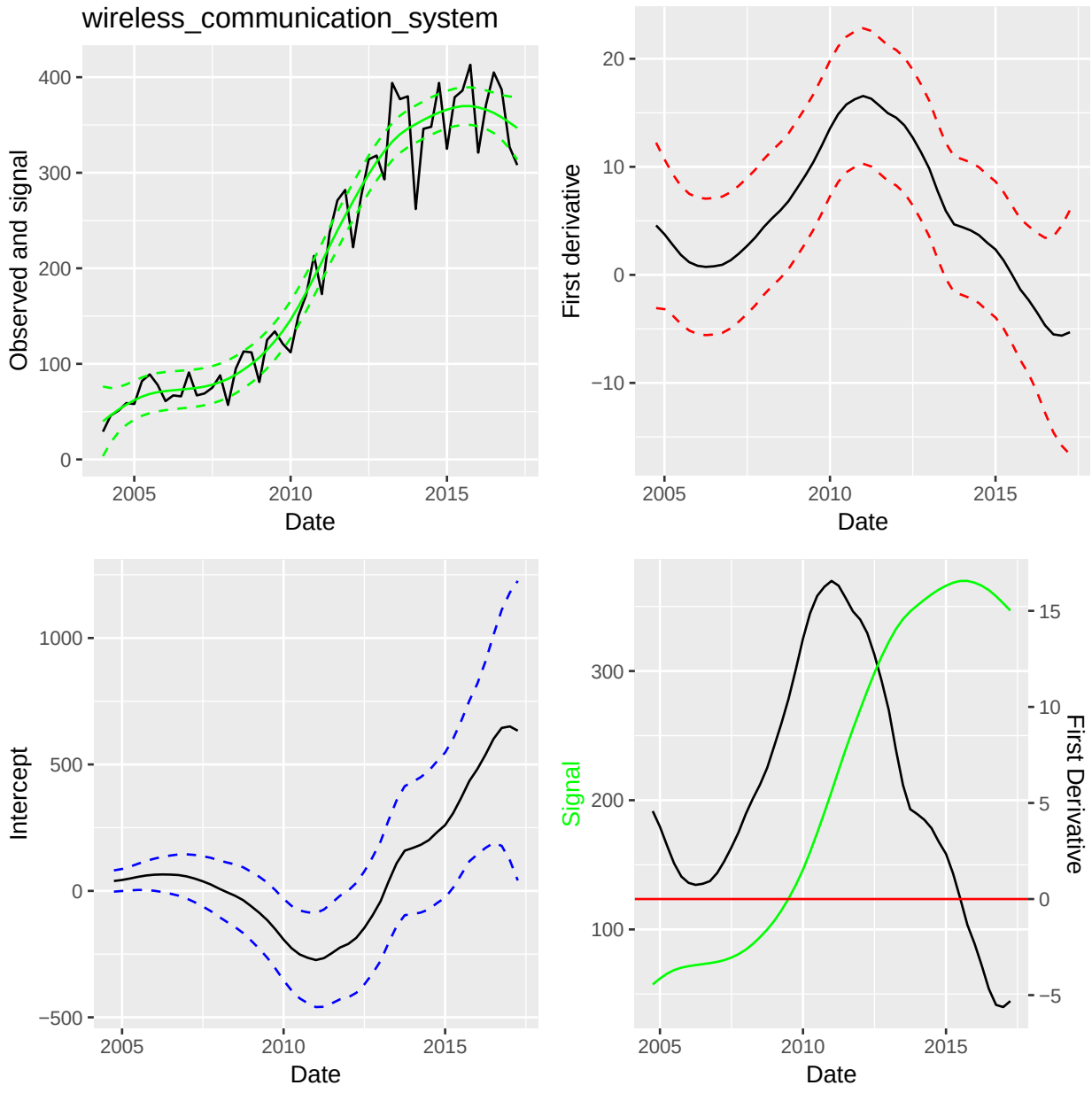

wireless_communication_system
Observed and signal
Date
First derivative
Date
Intercept
Date
Signal
First Derivative
Date

Figure 9:

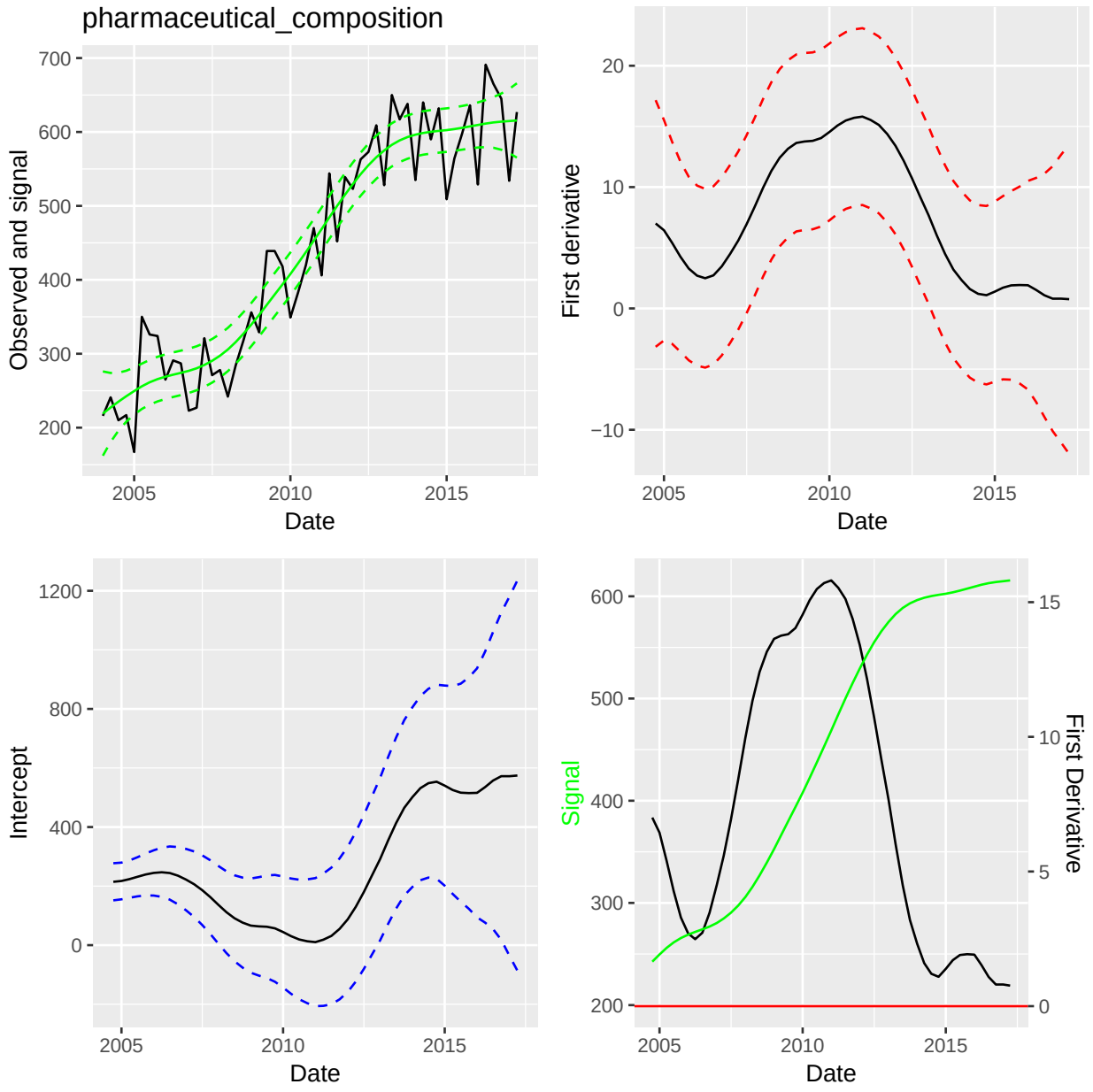

pharmaceutical_composition
Observed and signal
700
600
500
400
300
200
2005
2010
2015
Date
First derivative
20
10
0
−10
2005
2010
2015
Date
Intercept
1200
800
400
0
2005
2010
2015
Date
Signal
600
500
400
300
200
First Derivative
15
10
5
0
2005
2010
2015
Date

Figure 10:

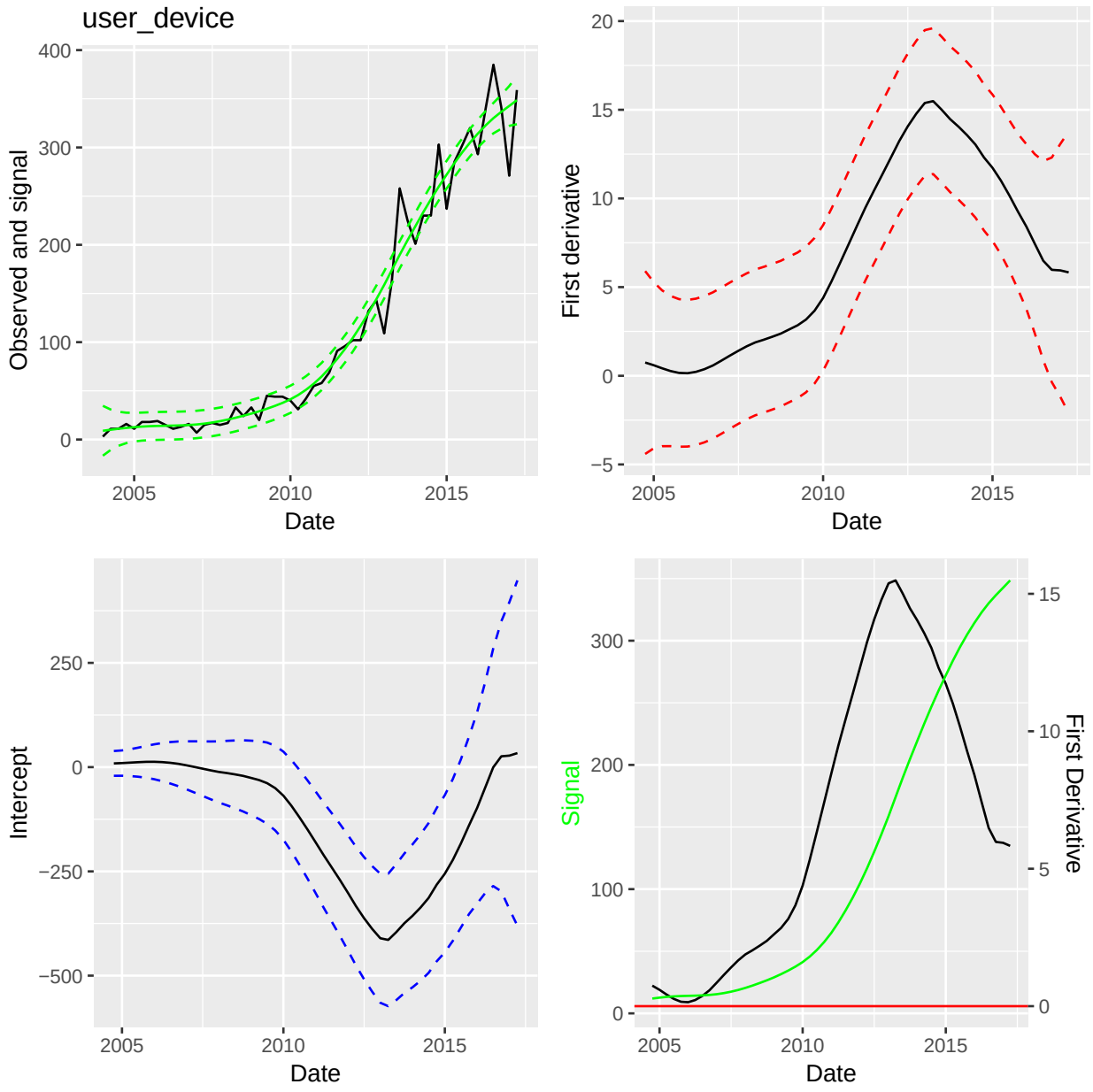

user_device
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 11:

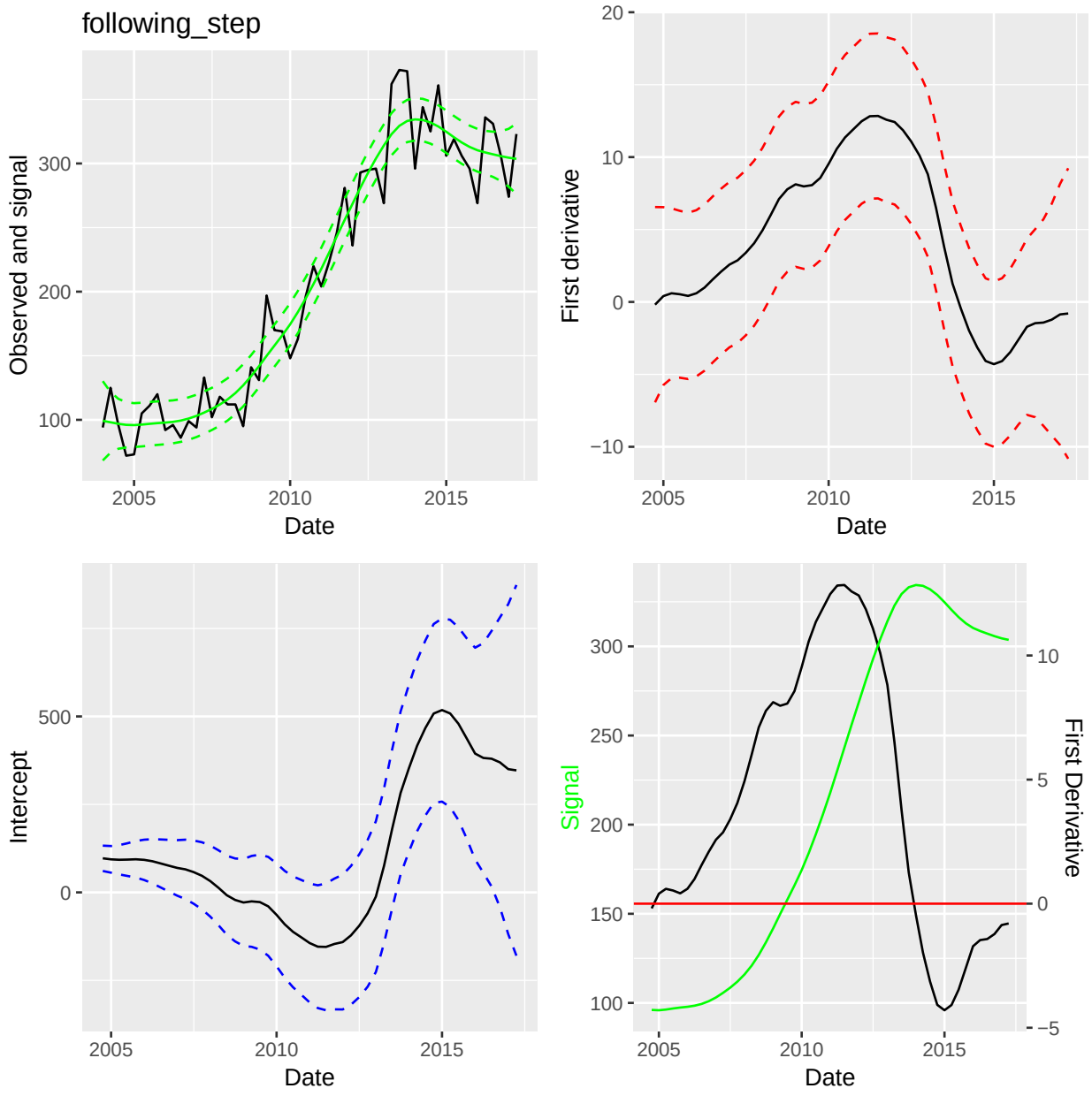
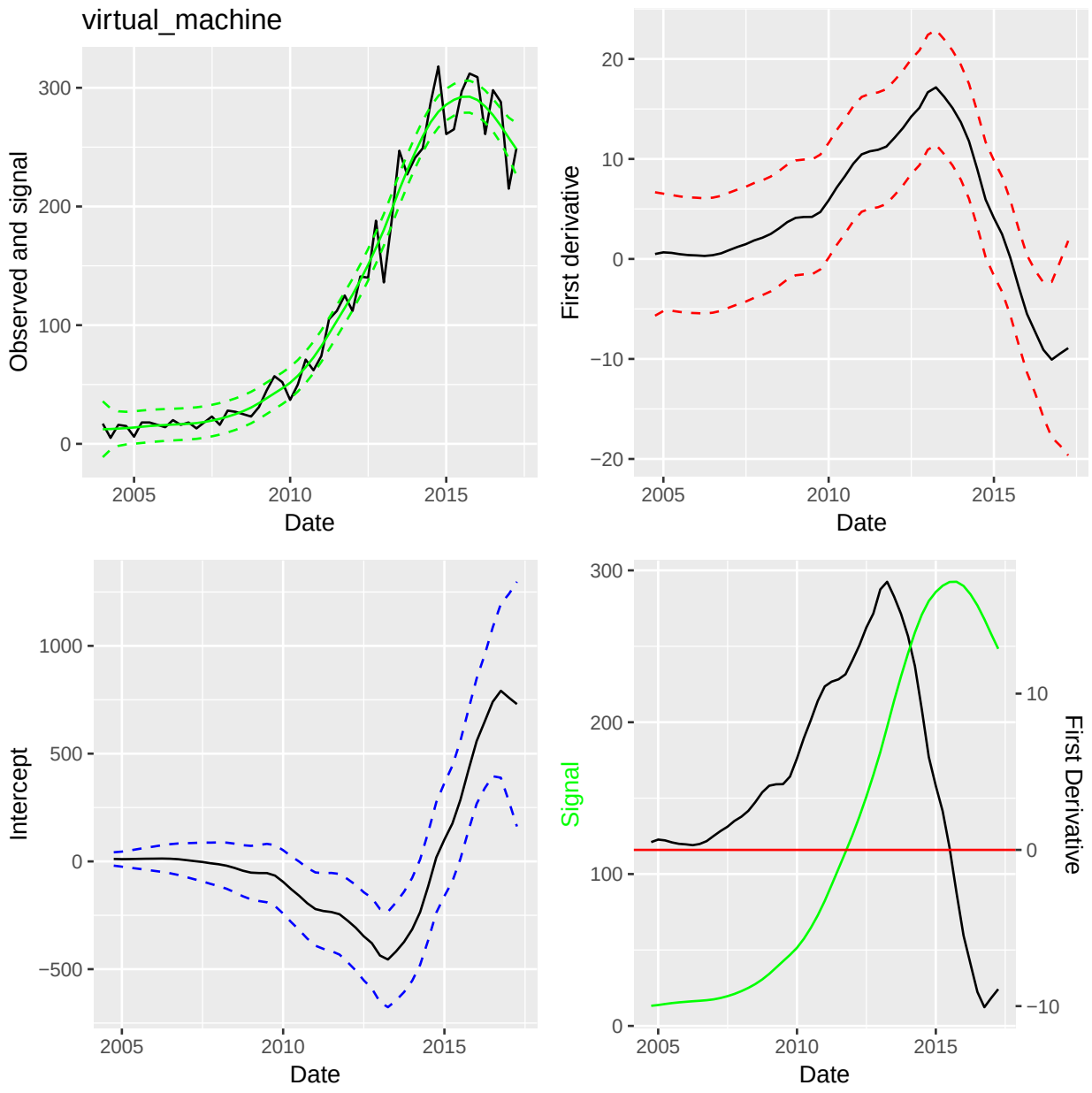

following_step
Observed and signal
300
200
100
2005
2010
2015
Date
First derivative
20
10
0
−10
2005
2010
2015
Date
Intercept
500
0
2005
2010
2015
Date
Signal
300
250
200
150
100
10
5
0
−5
First Derivative
2005
2010
2015
Date

Figure 12:


virtual_machine
Observed and signal
300
200
100
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2005
2010
2015
Date
First derivative
20
10
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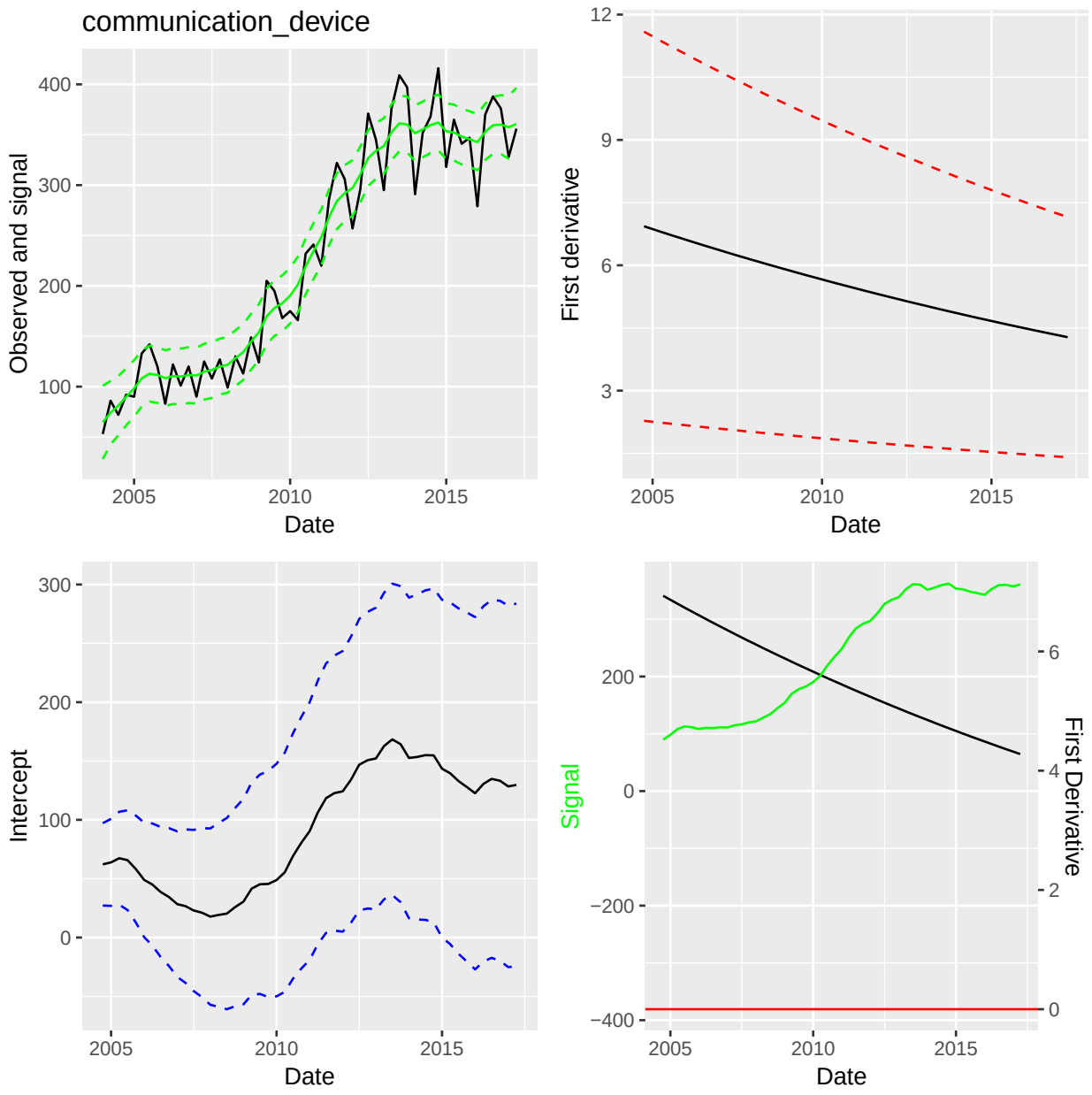
−10
−20
2005
2010
2015
Date
Intercept
1000
500
0
−500
2005
2010
2015
Date
Signal
300
200
100
0
10
0
−10
First Derivative
2005
2010
2015
Date

Figure 13:


communication_device
Observed and signal
400
300
200
100
2005
2010
2015
Date
First derivative
12
9
6
3
2005
2010
2015
Date
Intercept
300
200
100
0
2005
2010
2015
Date
Signal
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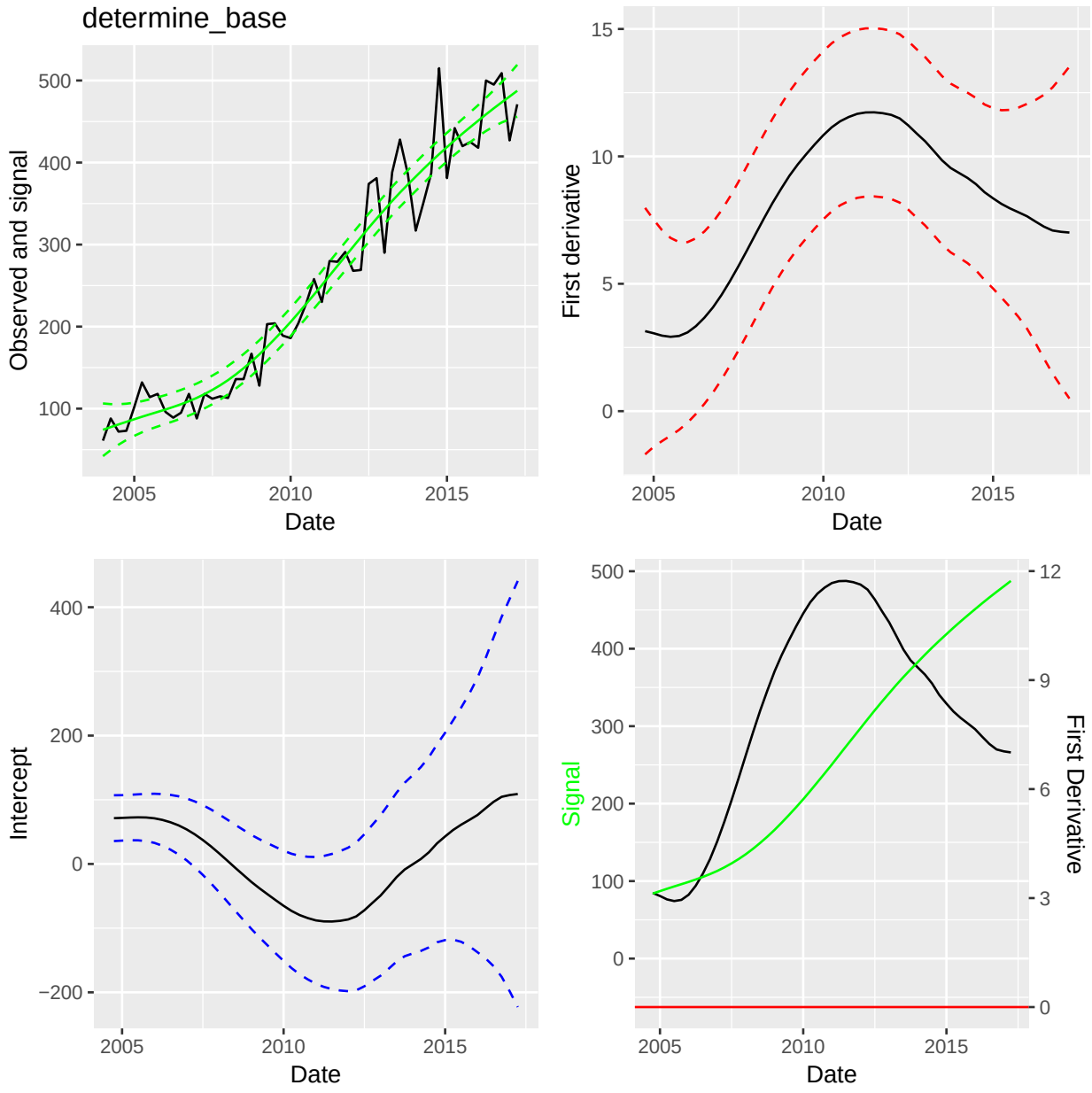
−200
−400
6
4
2
0
First Derivative
2005
2010
2015
Date

Figure 14:


determine_base
Observed and signal
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400
300
200
100
2005
2010
2015
Date
First derivative
15
10
5
0
2005
2010
2015
Date
Intercept
400
200
0
−200
2005
2010
2015
Date
Signal
500
400
300
200
100
0
12
9
6
3
0
First Derivative
2005
2010
2015
Date

Figure 15:

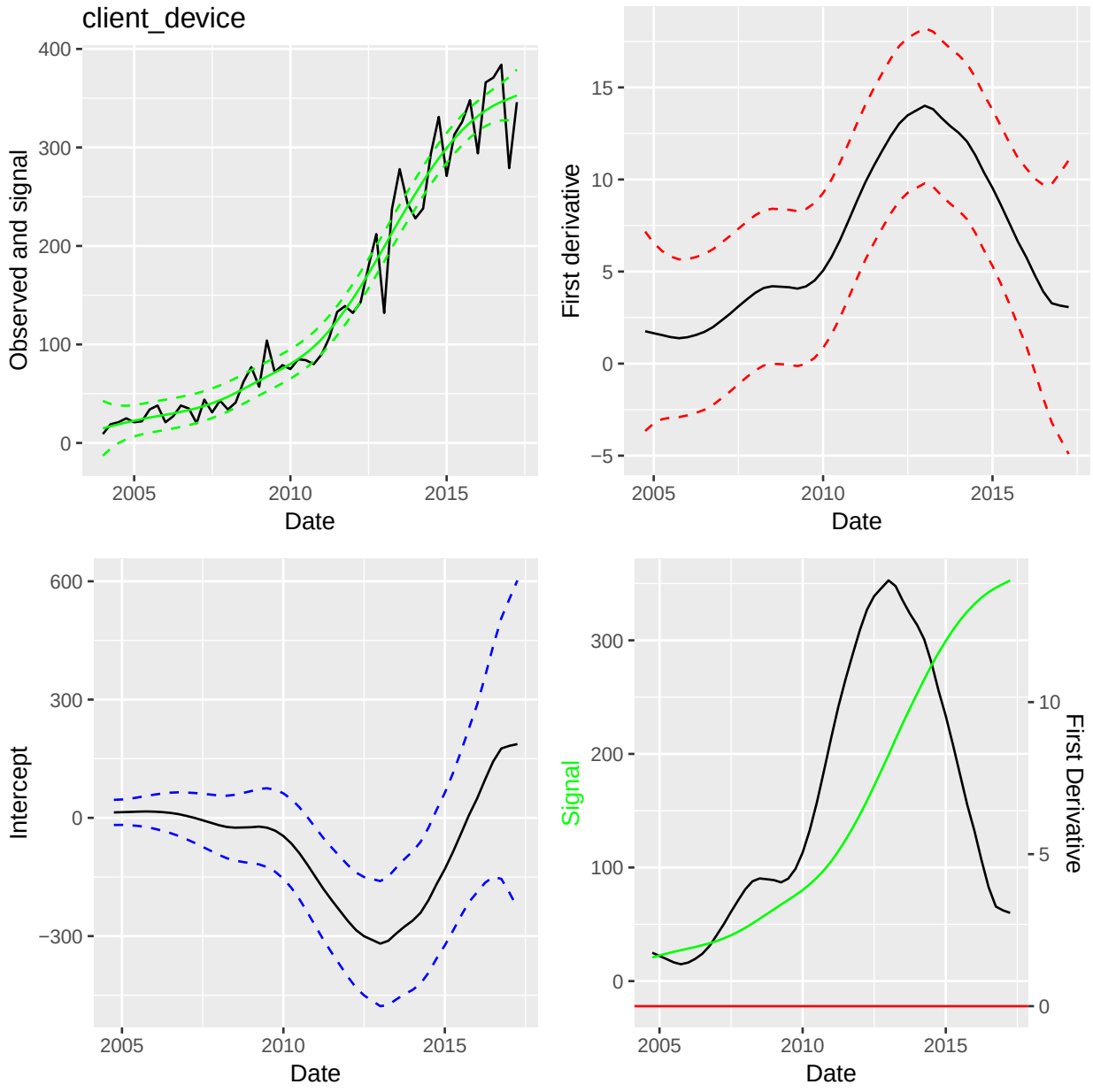

client_device
Observed and signal
400
300
200
100
0
2005
2010
2015
Date
First derivative
15
10
5
0
−5
2005
2010
2015
Date
Intercept
600
300
0
−300
2005
2010
2015
Date
Signal
300
200
100
0
2005
2010
2015
Date
First Derivative
10
5
0

Figure 16:

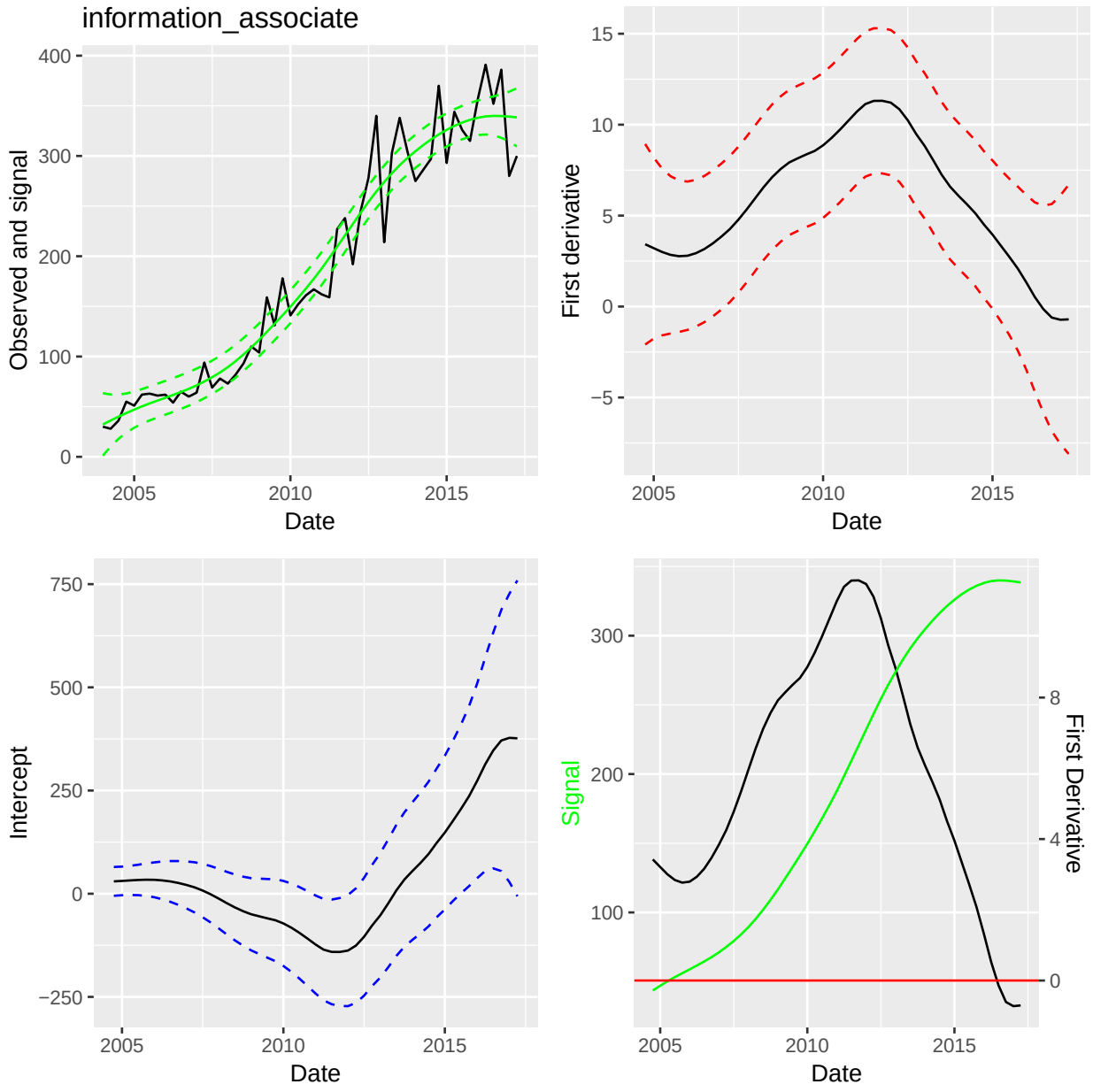

information_associate
Observed and signal
400
300
200
100
0
2005
2010
2015
Date
First derivative
15
10
5
0
−5
2005
2010
2015
Date
Intercept
750
500
250
0
−250
2005
2010
2015
Date
Signal
300
200
100
First Derivative
8
4
0
2005
2010
2015
Date

Figure 17:

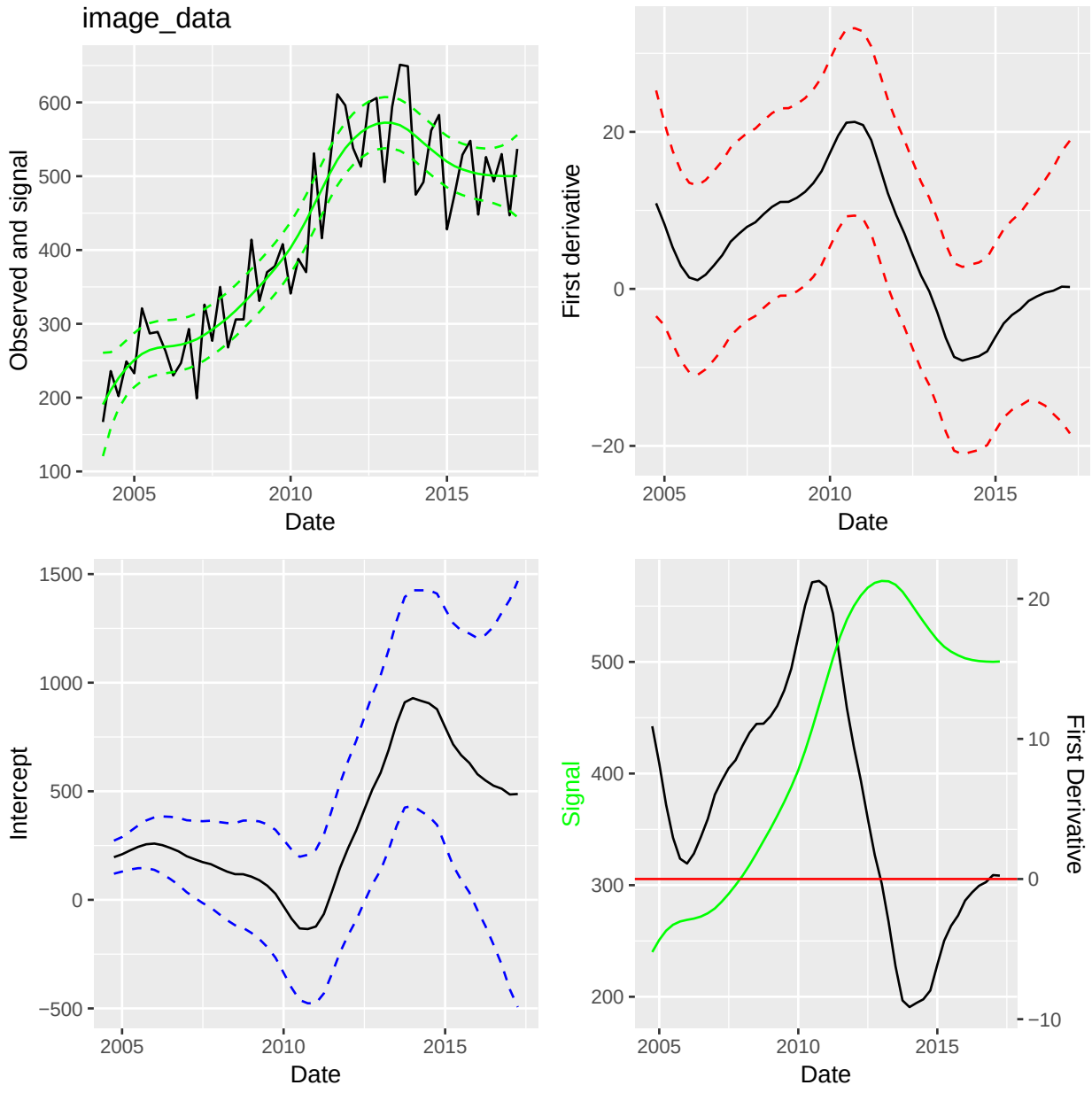

image_data
Observed and signal
600
500
400
300
200
100
2005
2010
2015
Date
First derivative
20
0
−20
2005
2010
2015
Date
Intercept
1500
1000
500
0
−500
2005
2010
2015
Date
Signal
500
400
300
200
20
10
0
−10
First Derivative
2005
2010
2015
Date

Figure 18:

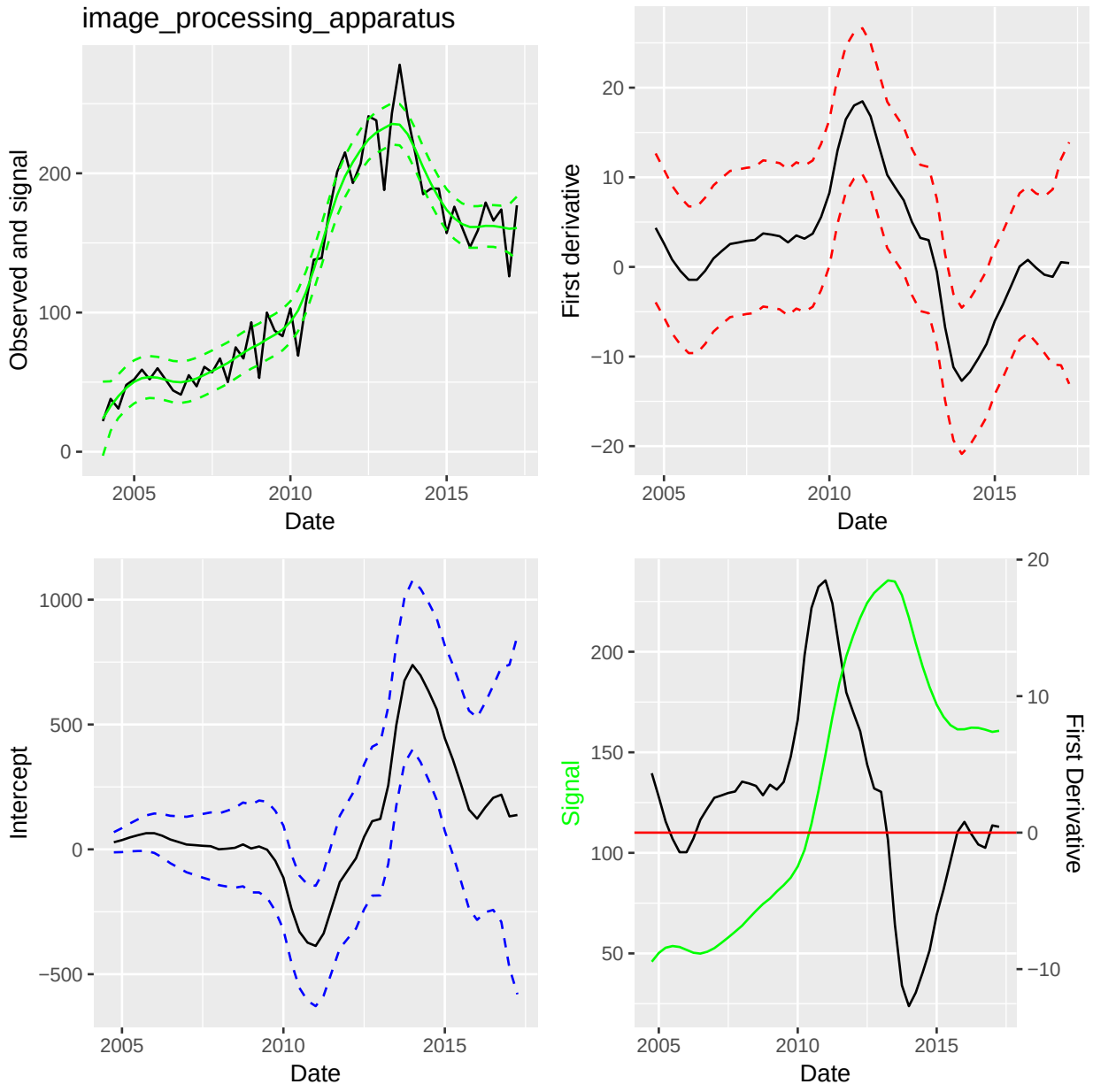

image_processing_apparatus
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 19:

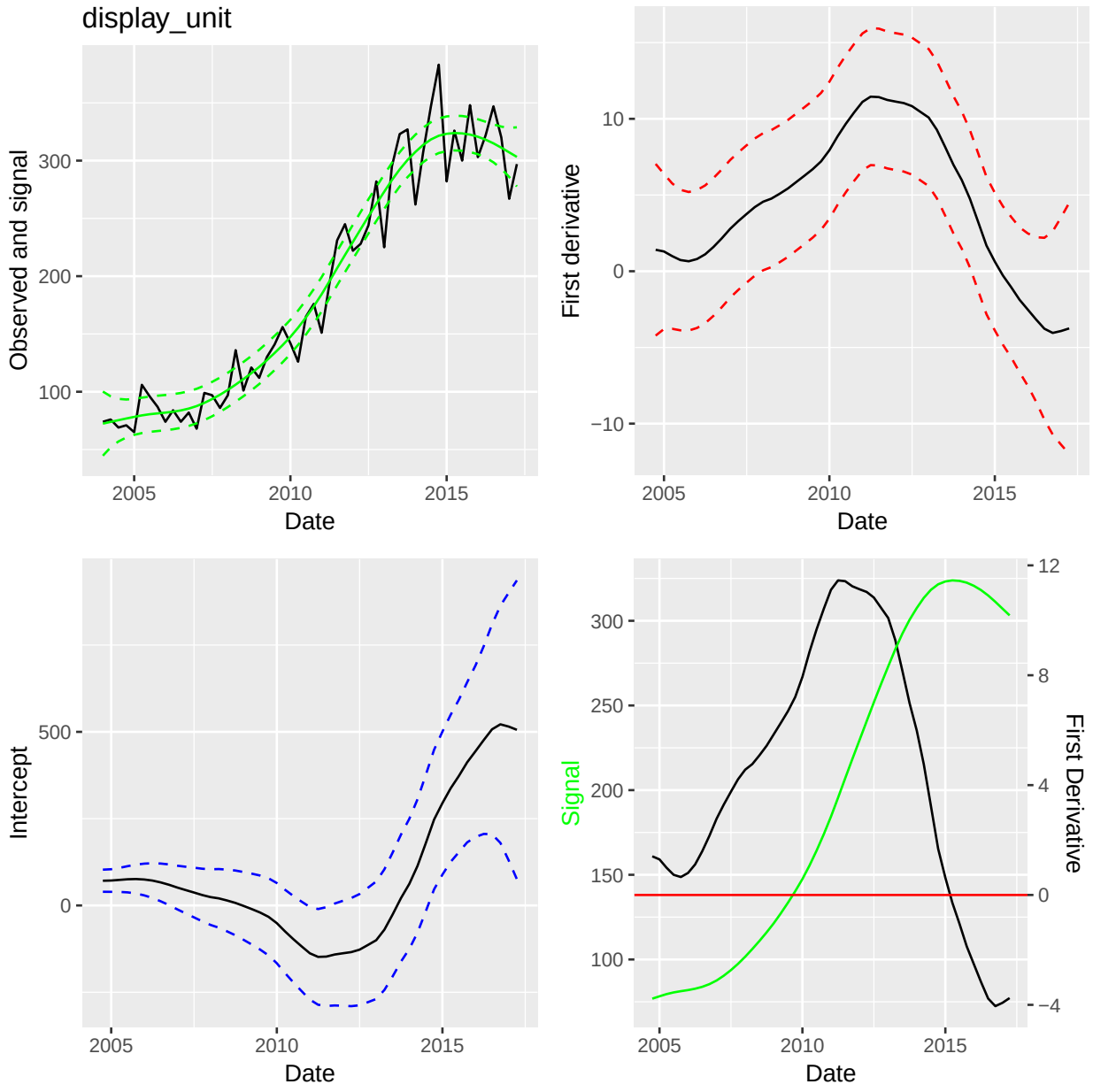

display_unit
Observed and signal
300
200
100
2005
2010
2015
Date
First derivative
10
0
−10
2005
2010
2015
Date
Intercept
500
0
2005
2010
2015
Date
Signal
300
250
200
150
100
12
8
4
0
−4
First Derivative
2005
2010
2015
Date

Figure 20:

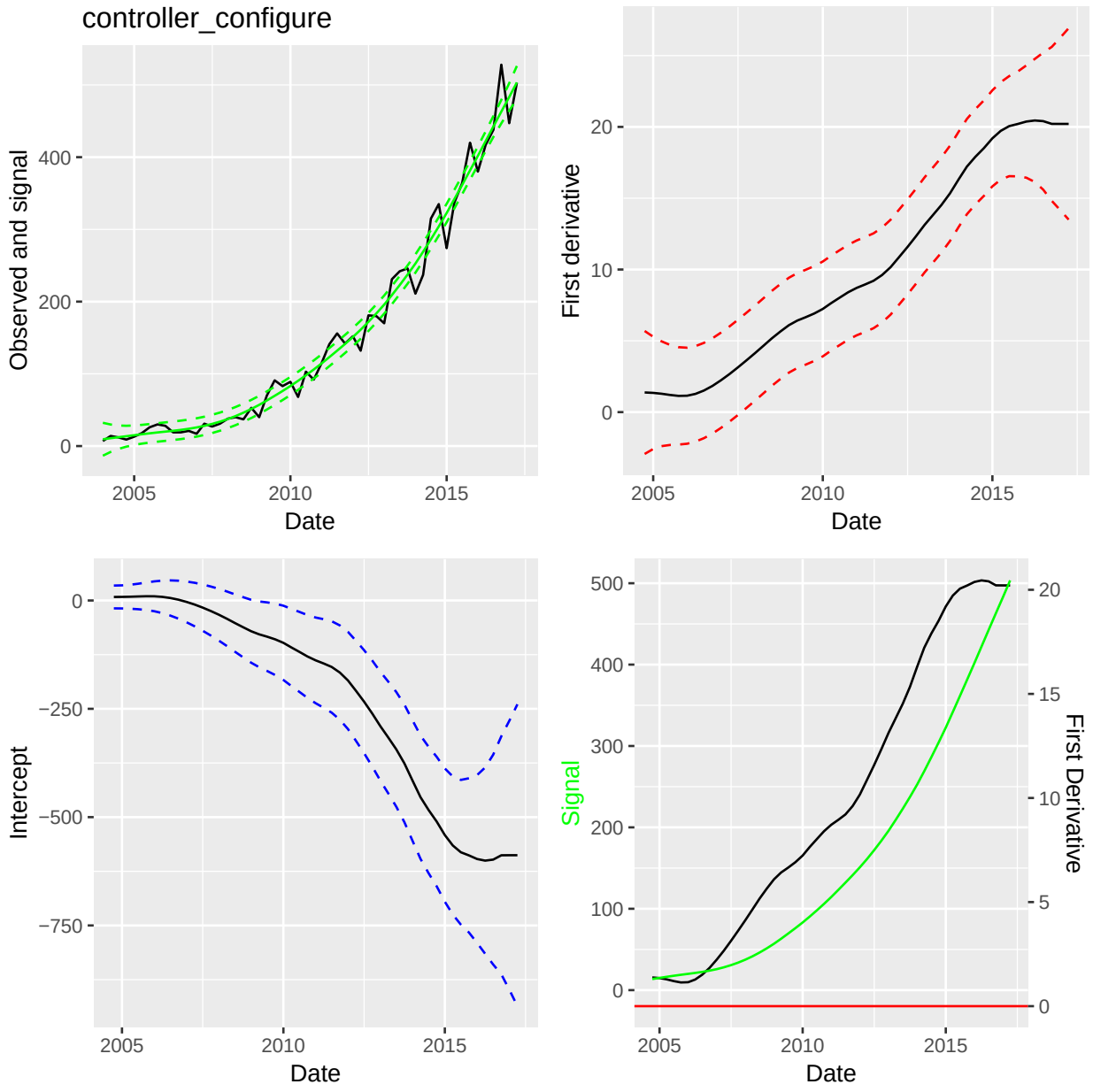

controller_configure
Observed and signal
400
200
0
2005
2010
2015
Date
First derivative
20
10
0
2005
2010
2015
Date
Intercept
0
−250
−500
−750
2005
2010
2015
Date
Signal
500
400
300
200
100
0
First Derivative
20
15
10
5
0
2005
2010
2015
Date

Figure 21:

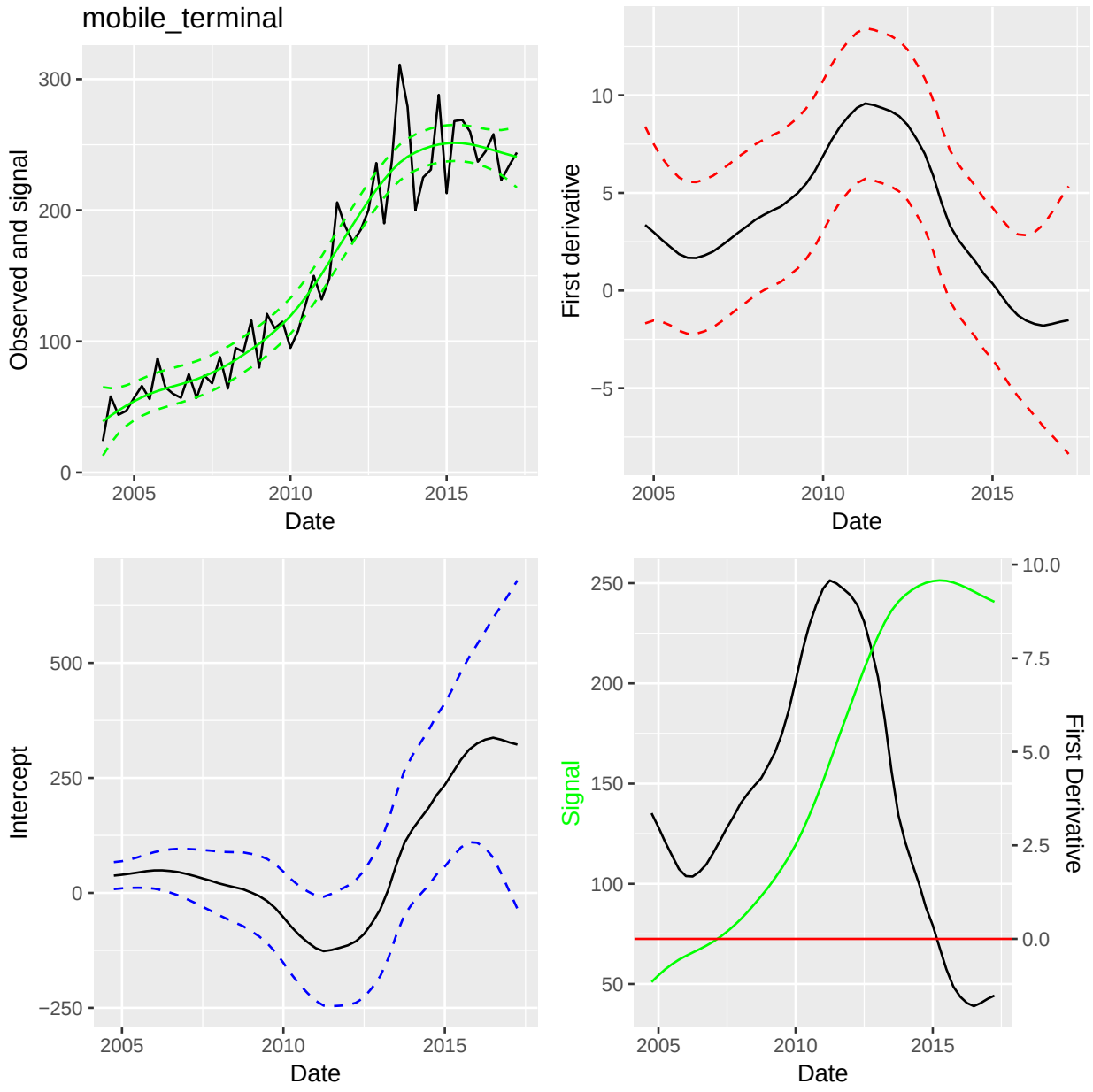

mobile_terminal
Observed and signal
300
200
100
0
2005
2010
2015
Date
First derivative
10
5
0
−5
2005
2010
2015
Date
Intercept
500
250
0
−250
2005
2010
2015
Date
Signal
250
200
150
100
50
10.0
7.5
5.0
2.5
0.0
First Derivative
2005
2010
2015
Date

Figure 22:

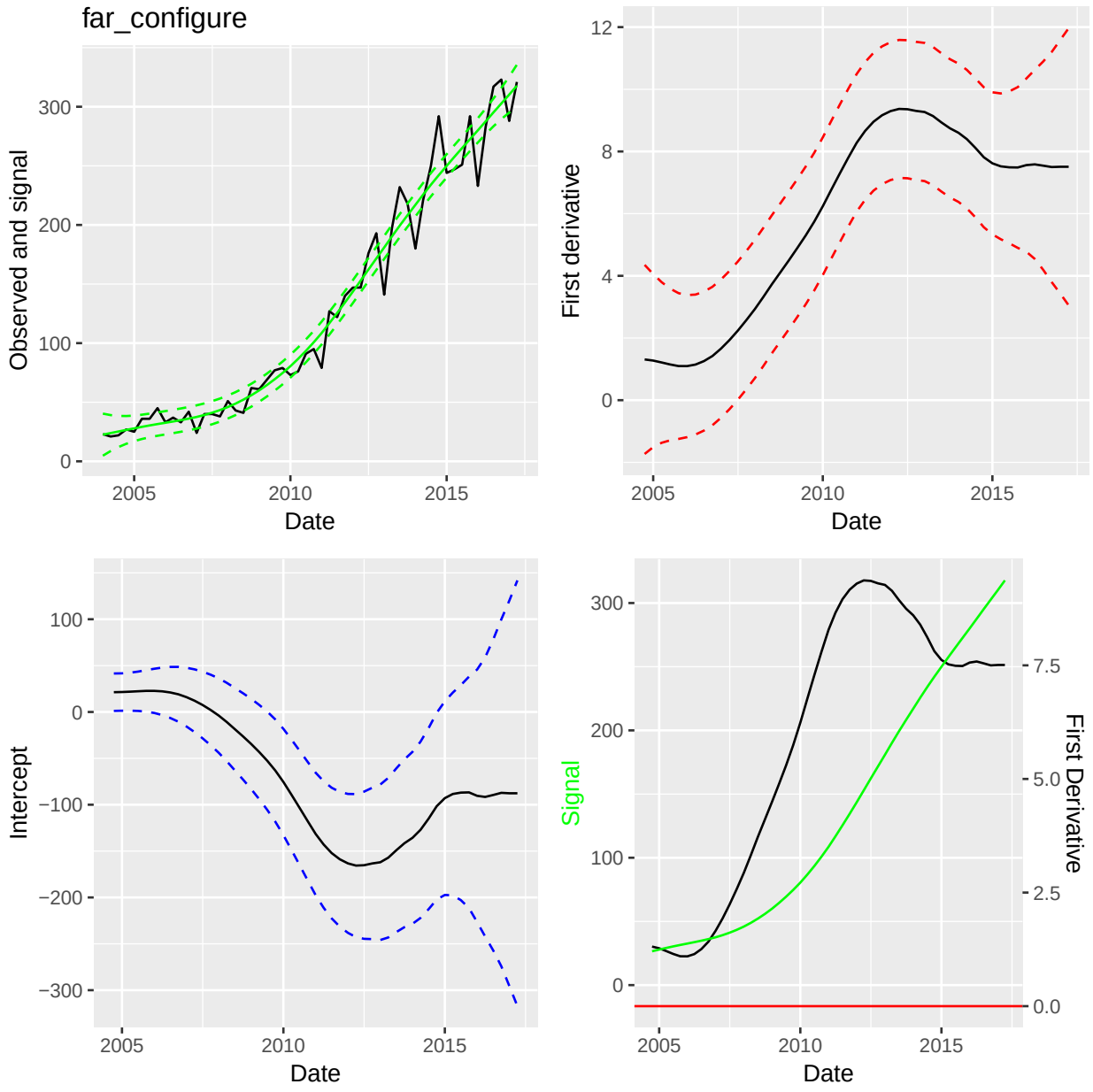

far_configure
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 23:

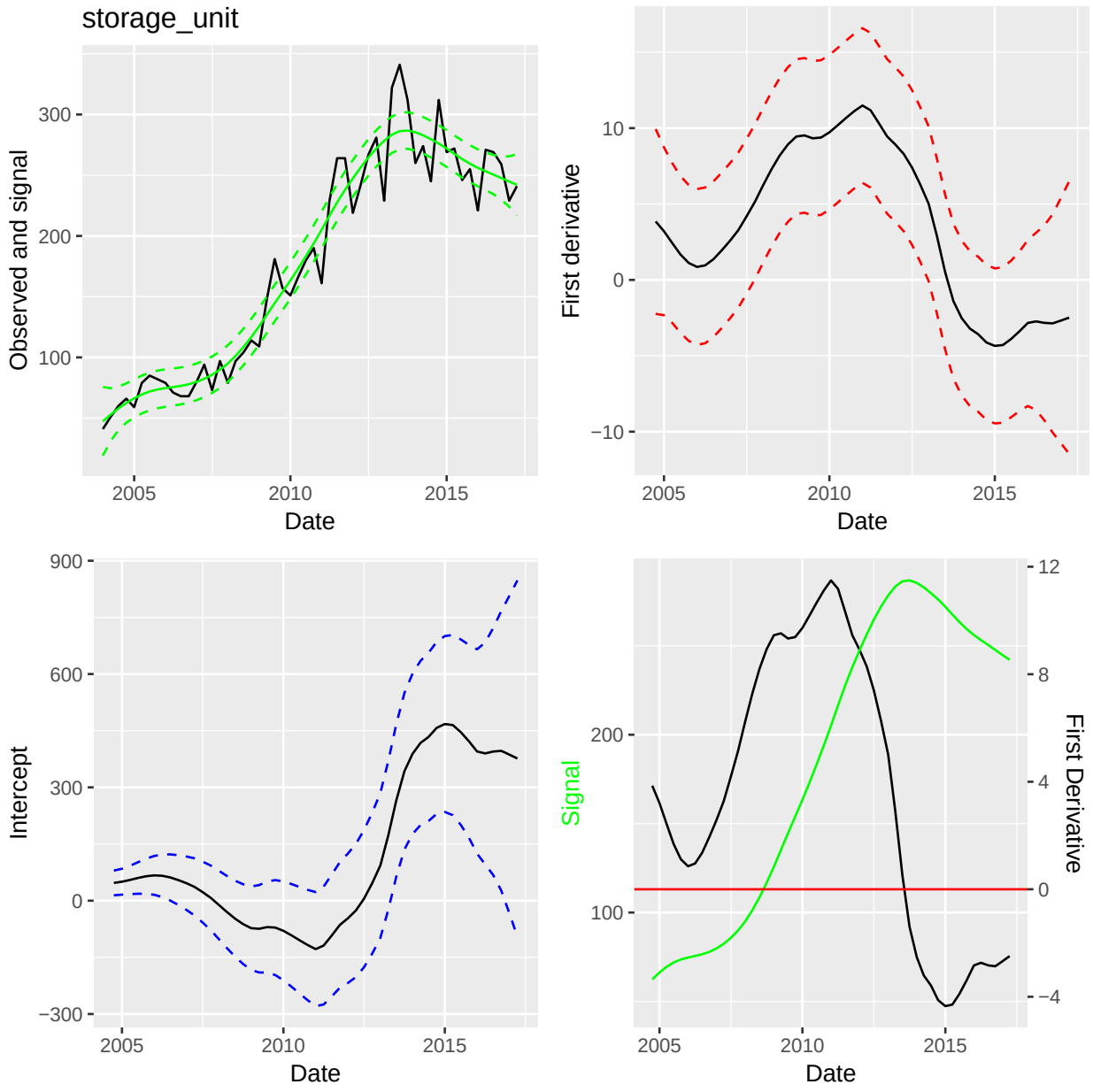

storage_unit
Observed and signal
300
200
100
2005
2010
2015
Date
First derivative
10
0
−10
2005
2010
2015
Date
Intercept
900
600
300
0
−300
2005
2010
2015
Date
Signal
200
100
First Derivative
12
8
4
0
−4
2005
2010
2015
Date

Figure 24:

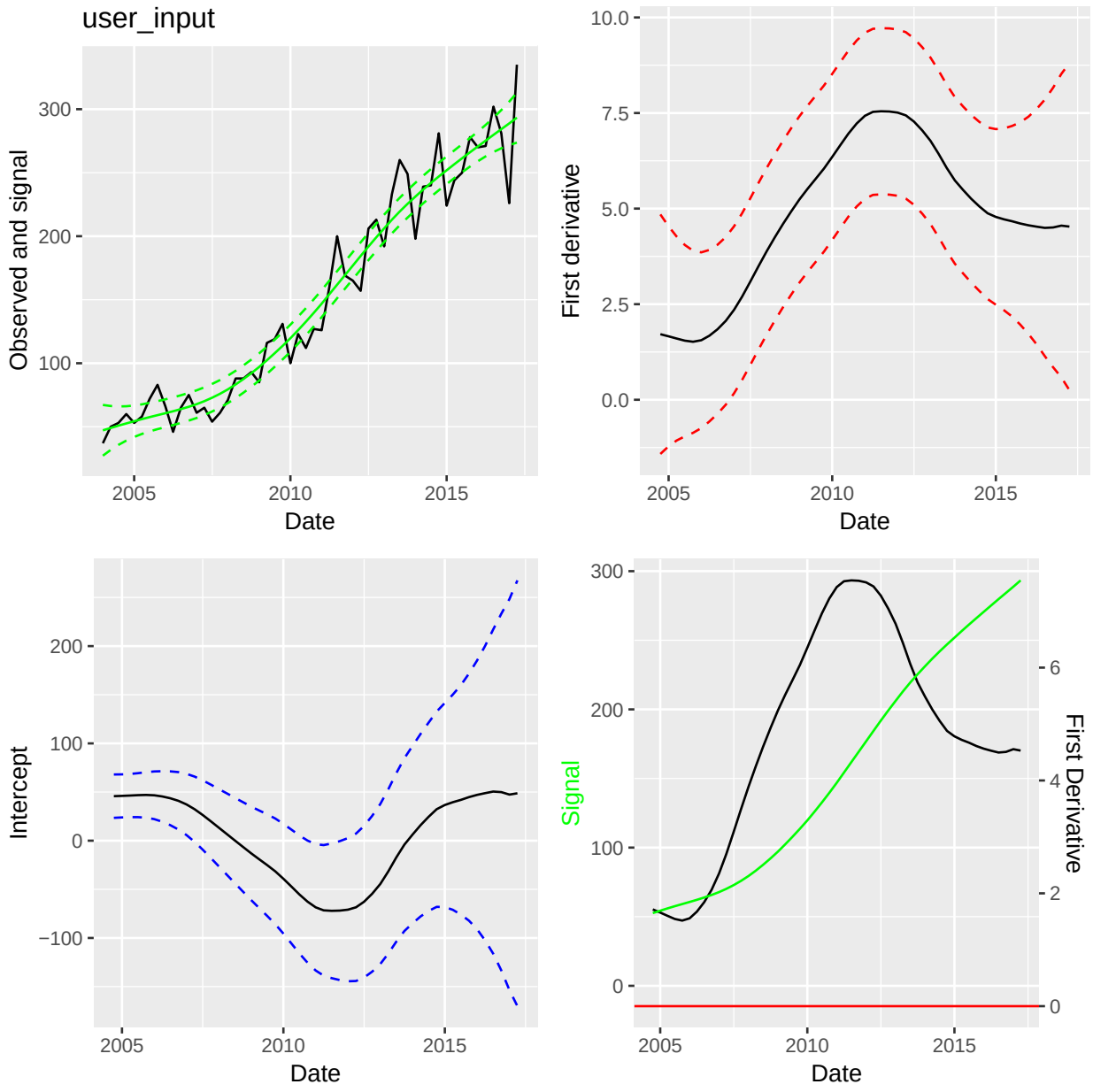

user_input
Observed and signal
300
200
100
2005
2010
2015
Date
First derivative
10.0
7.5
5.0
2.5
0.0
2005
2010
2015
Date
Intercept
200
100
0
−100
2005
2010
2015
Date
Signal
300
200
100
0
6
4
2
0
First Derivative
2005
2010
2015
Date

Figure 25:

Terms classified as stationary by Porter

The trends of some terms in this group are clearly increasing functions.

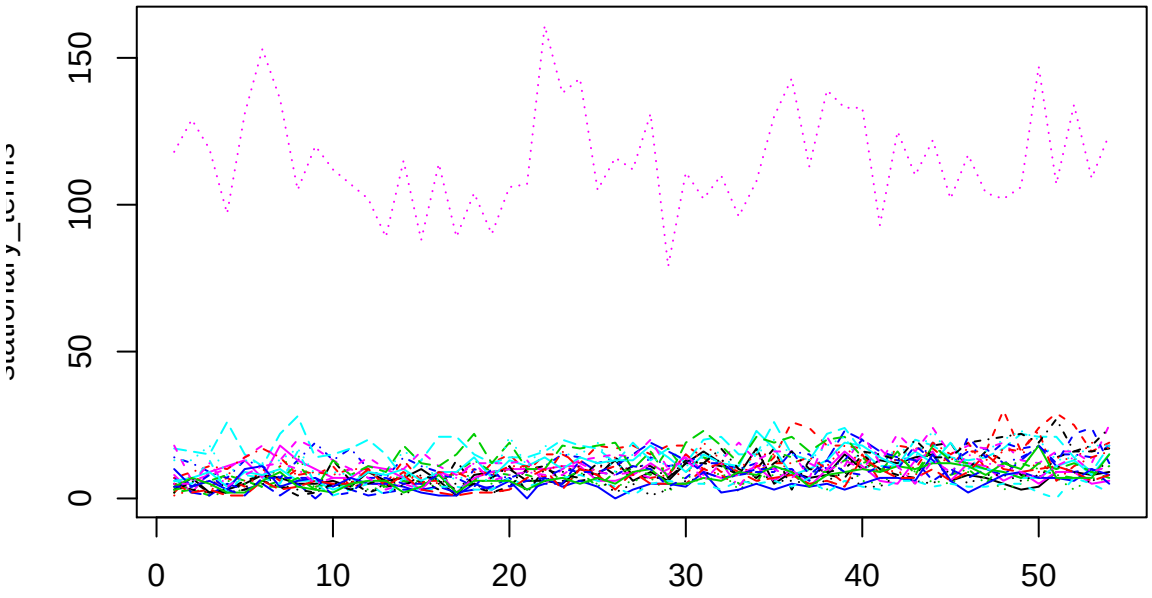
The terms “expression level”, “axially displaceable”, “ovarian cancer”, “wavelength conversion”, “virtual memory”, “cylindrical housing”, “damp element”, “mass flow”, “structure arrange”, “processor module”, “sequentially apply” are clearly emergent terms. The trends are linear with positive slope.

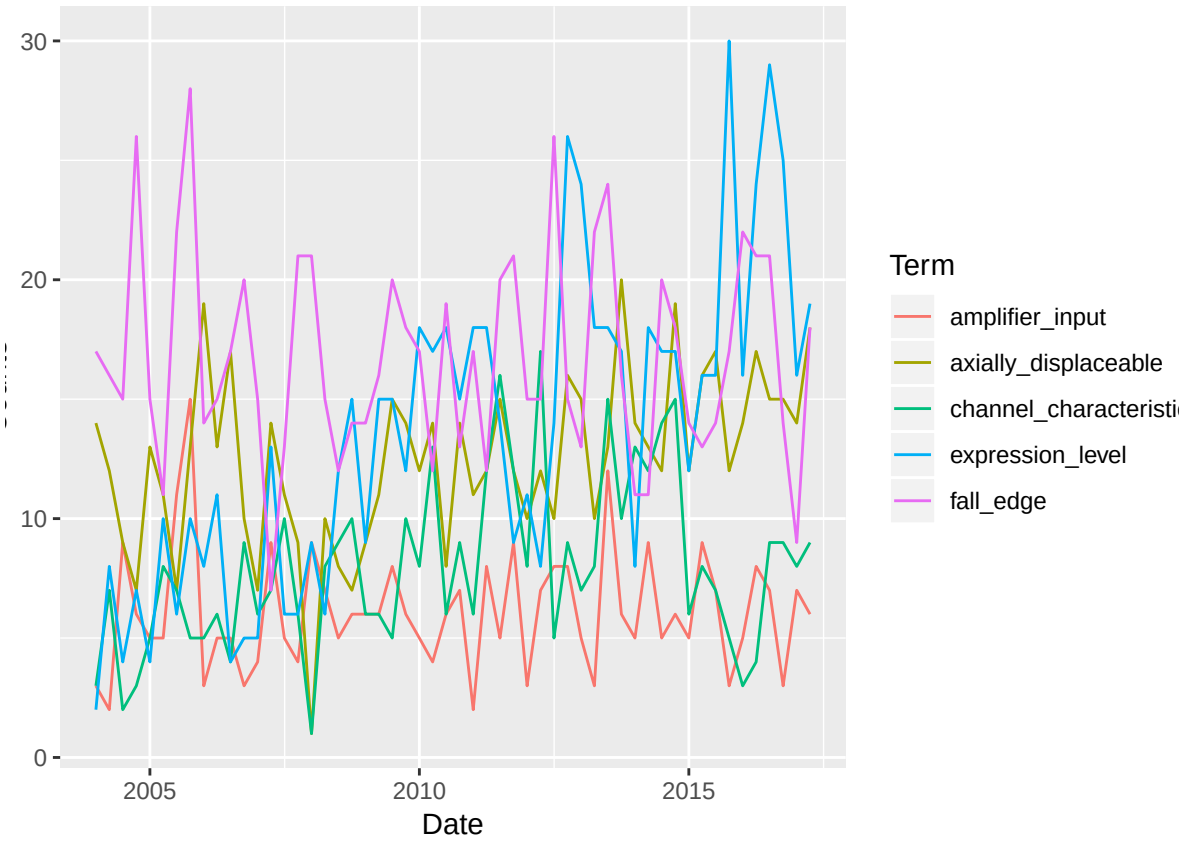
Some terms in this group have a U- or inverted-U-shaped trend. Therefore it’s difficult to classify the term. To avoid this, I suggest that only, say, 5 years are used for the index. In this case we are using 12 years.

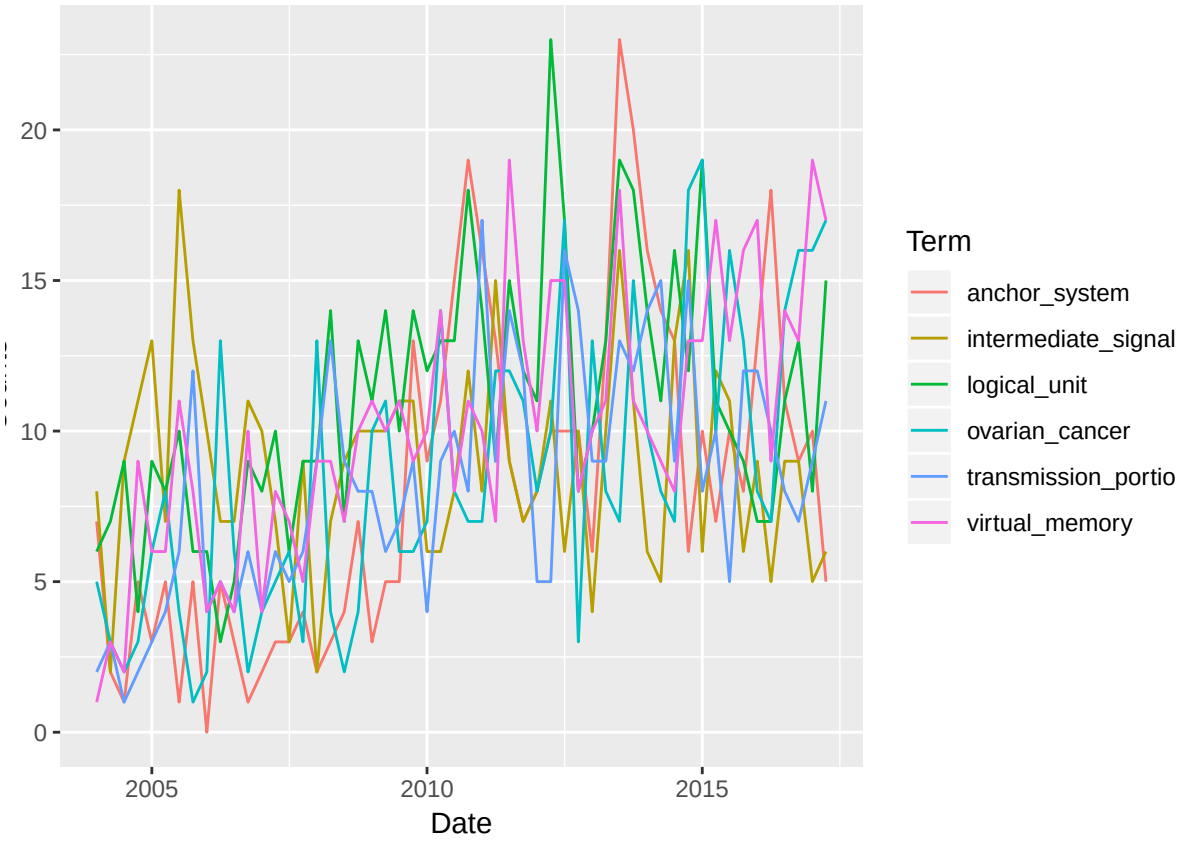
The only terms we can definitely categorise as stationary are “amplifier input”, “fall-edge”, “intermediate signal” and “prior art”.

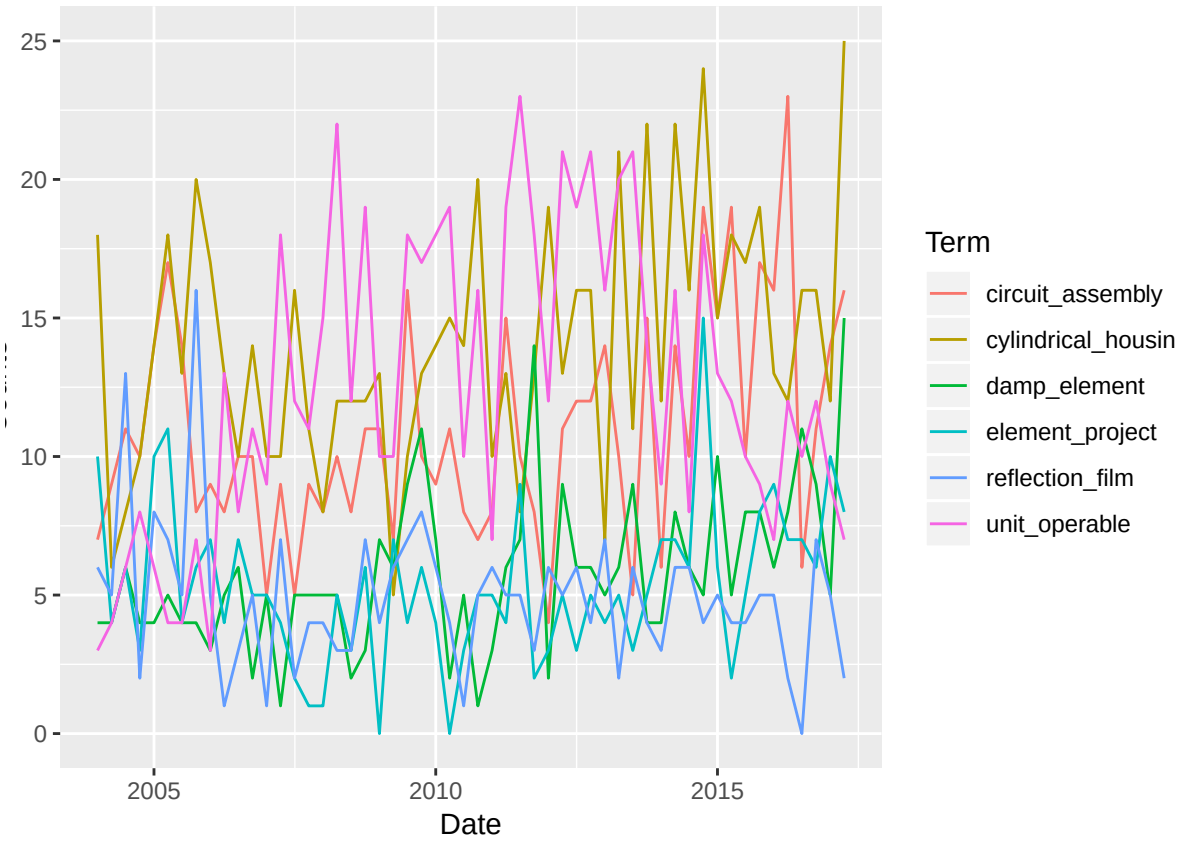
Some terms were tricky to fit (expression level, axially displaceable and anchor system). I still can’t find the optimal parameters of “anchor system”. This is in my TO-DO list.

Generally the issue of fitting the parameters when the counts are low is difficult.




30
20
10
0
2005
2010
2015
Date
Term
amplifier_input
axially_displaceable
channel_characteristi
expression_level
fall_edge


20
15
10
5
0
2005
2010
2015
Date
Term
anchor_system
intermediate_signal
logical_unit
ovarian_cancer
transmission_portio
virtual_memory


25
20
15
10
5
0
2005
2010
2015
Date
Term
circuit_assembly
cylindrical_housin
damp_element
element_project
reflection_film
unit_operable

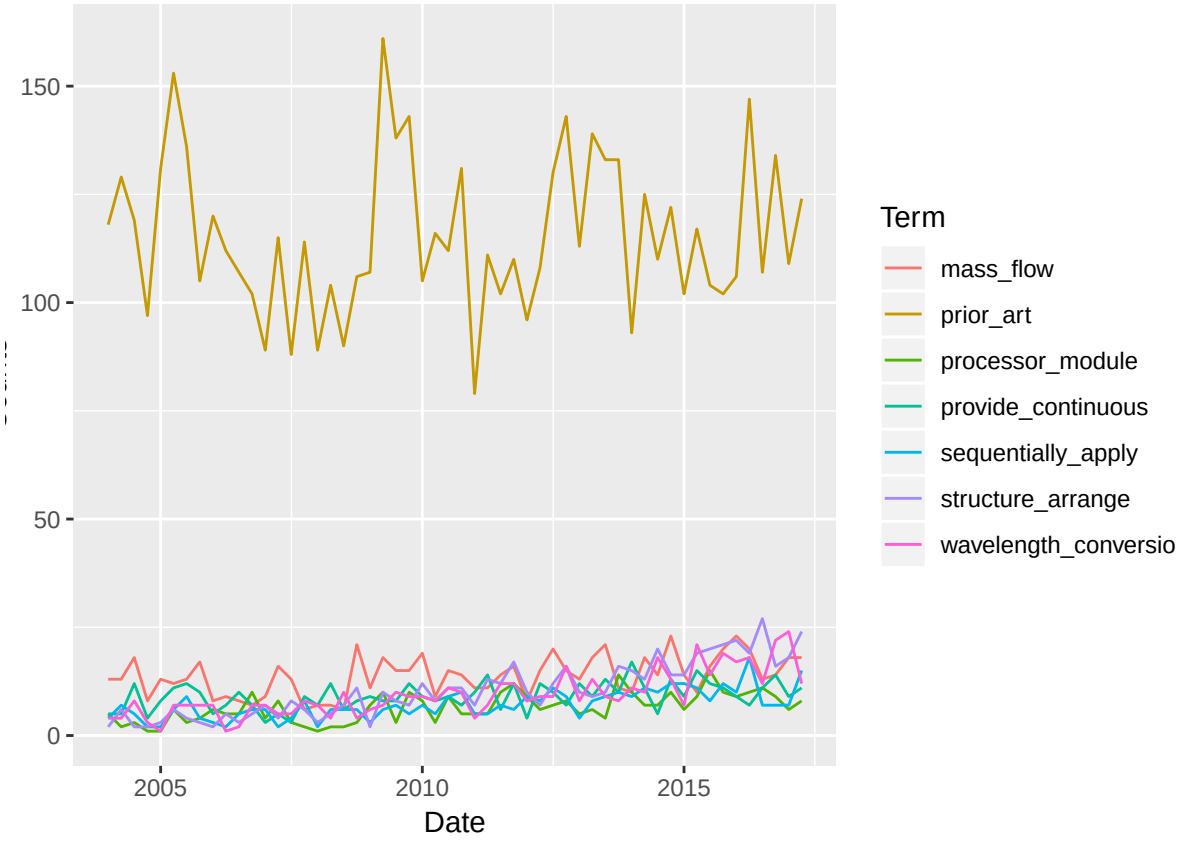

150
100
50
0
2005
2010
2015
Date
Term
mass_flow
prior_art
processor_module
provide_continuous
sequentially_apply
structure_arrange
wavelength_conversio

Table 2: Stationary Terms

Term	σ_ϵ	σ_ν	σ_η	δ	E(1stder)	E(sum1stder/sd)
structure arrange	2.815327	0.0227443	0.0000001	1.0000000	19.2133521	6.8245554
wavelength conversion	3.238696	0.0000000	0.0000001	1.0000000	13.3533067	4.1230506
expression level	4.281186	0.0000000	0.0000000	0.9908559	17.1364327	4.0027297
virtual memory	2.832714	0.0000000	0.0000000	0.9816148	10.3607917	3.6575498
sequentially apply	2.377261	0.0000000	0.0000000	1.0000000	7.7360778	3.2541981
ovarian cancer	3.527516	0.0000000	0.0000000	1.0000000	10.8241662	3.0684951
transmission portion	2.921351	0.0000000	0.0000000	0.9354029	8.2599000	2.8274251
processor module	2.636422	0.0000000	0.0000000	0.9936448	6.7360768	2.5550071
anchor system	1.851920	2.5902237	0.0000000	0.0440073	4.2671578	2.3041809
logical unit	3.155938	0.0000000	0.5510841	0.9499389	6.5023744	2.0603617
damp element	2.523229	0.0000000	0.0000000	1.0000000	4.6678102	1.8499350
channel characteristic	3.150927	0.0000000	0.0000000	0.9253172	5.2756506	1.6743169
axially displaceable	3.193998	0.0000000	0.0000004	1.0000000	5.3454545	1.6735937
mass flow	4.019558	0.0000000	0.0000001	1.0000000	6.6241281	1.6479744
cylindrical housing	4.105870	0.0000000	0.0000000	1.0000000	5.5419097	1.3497527
unit operable	3.754142	0.1217633	0.0000002	0.9440418	4.4542629	1.1864930
provide continuous	2.825754	0.1732193	0.0000001	0.4240296	2.8933171	1.0239099
circuit assembly	3.493271	0.3933979	0.0000001	0.3576427	3.3692957	0.9645103
amplifier input	2.453408	0.0000000	0.0000000	0.3973656	0.5979061	0.2437043
element project	2.483974	0.0535886	0.0000001	0.9128285	0.5532855	0.2227421
intermediate signal	3.340594	0.0000000	0.0000000	0.4867379	0.6964338	0.2084760
fall edge	4.343637	0.0000000	0.0000000	0.8638916	-1.1027240	-0.2538711
prior art	17.489111	0.0000001	0.0000006	0.7796256	-6.0176466	-0.3440796
reflection film	2.547699	0.0000000	0.0000000	0.8827550	-2.4671565	-0.9683861

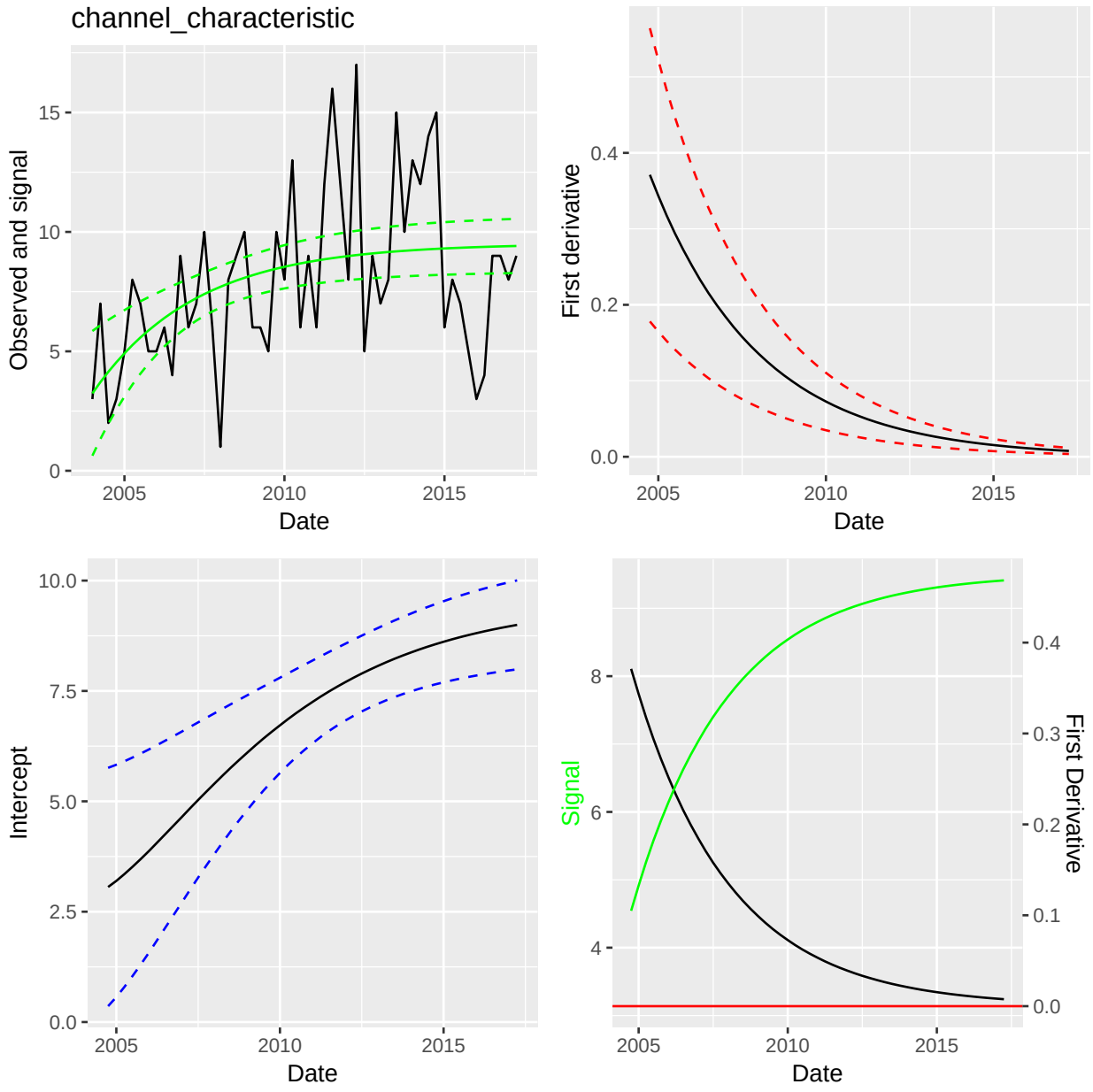

channel_characteristic
Observed and signal
Date
First derivative
Date
Intercept
Date
Signal
First Derivative
Date

Figure 26:

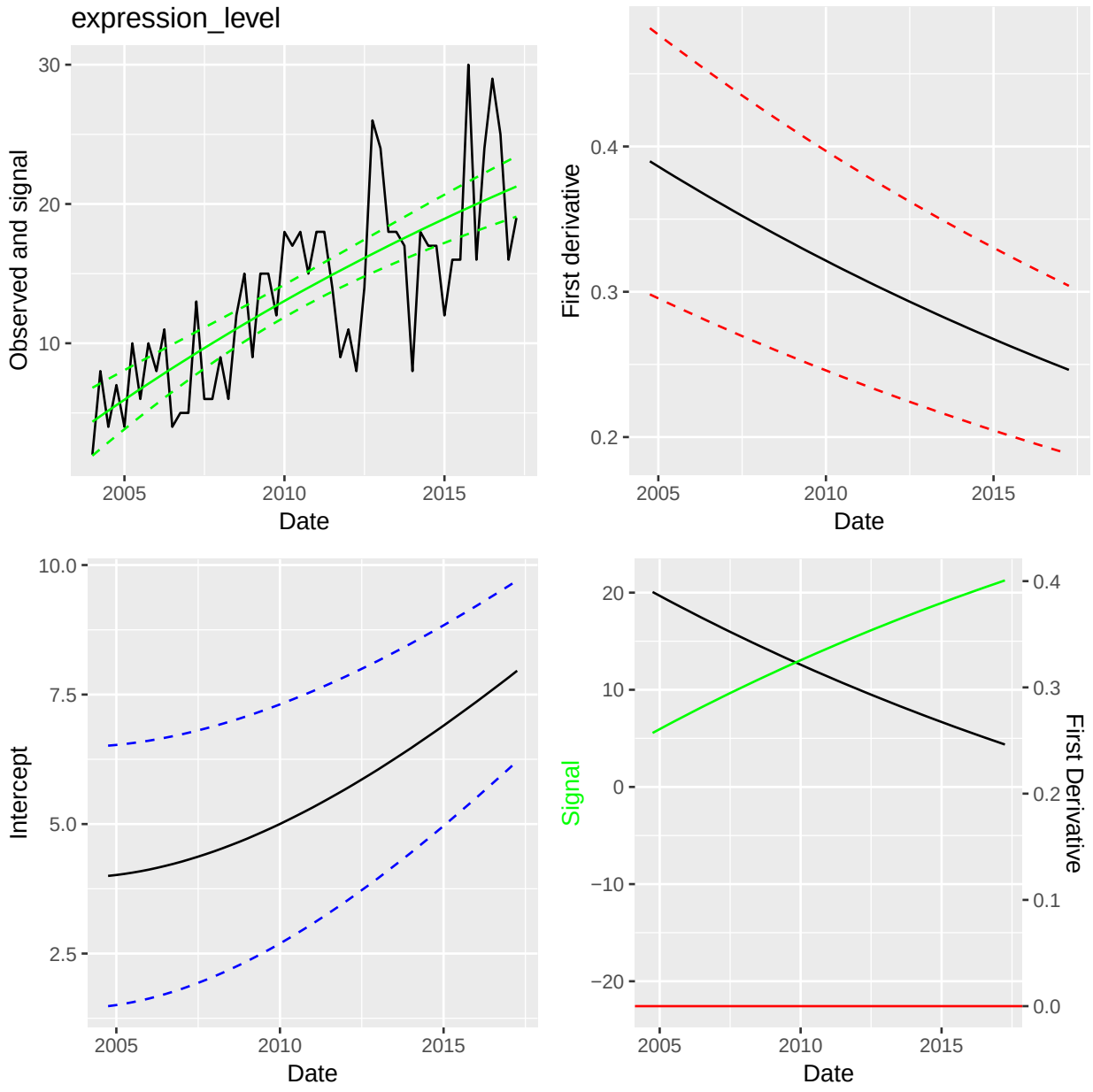

expression_level
Observed and signal
30
20
10
2005
2010
2015
Date
First derivative
0.4
0.3
0.2
2005
2010
2015
Date
Intercept
10.0
7.5
5.0
2.5
2005
2010
2015
Date
Signal
20
10
0
−10
−20
0.4
0.3
0.2
0.1
0.0
First Derivative
2005
2010
2015
Date

Figure 27:

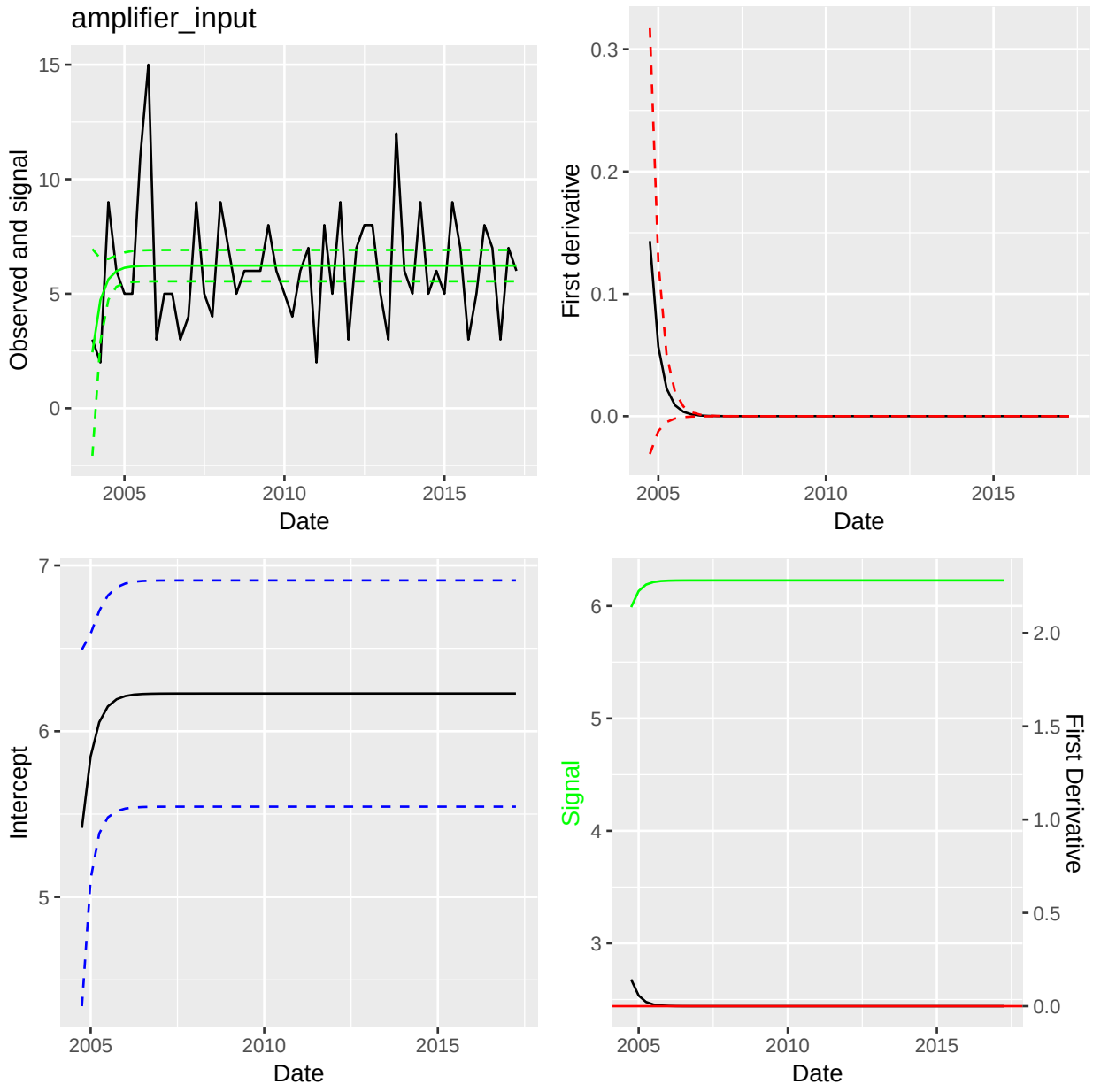

amplifier_input
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 28:

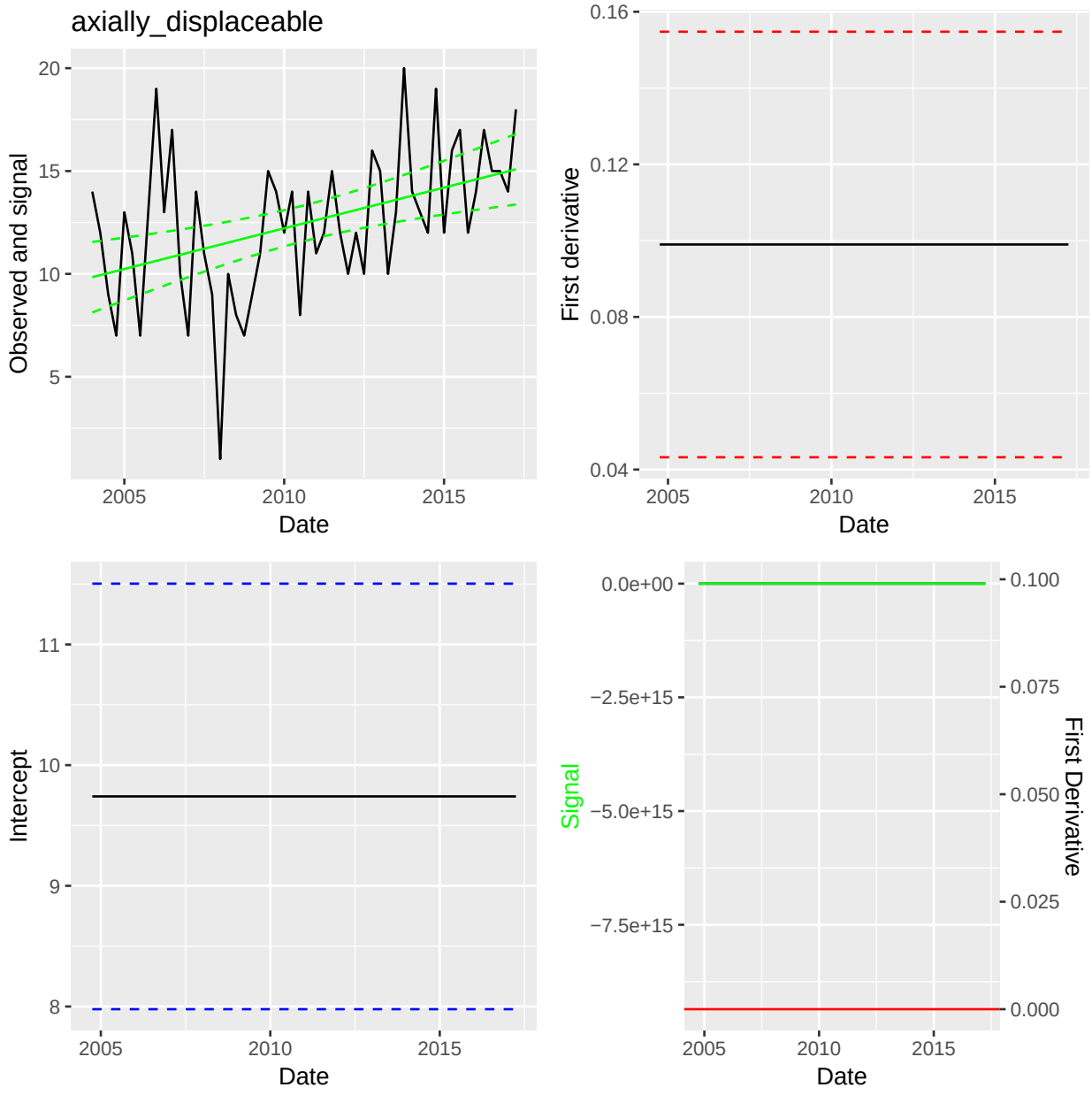

axially_displaceable
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 29:

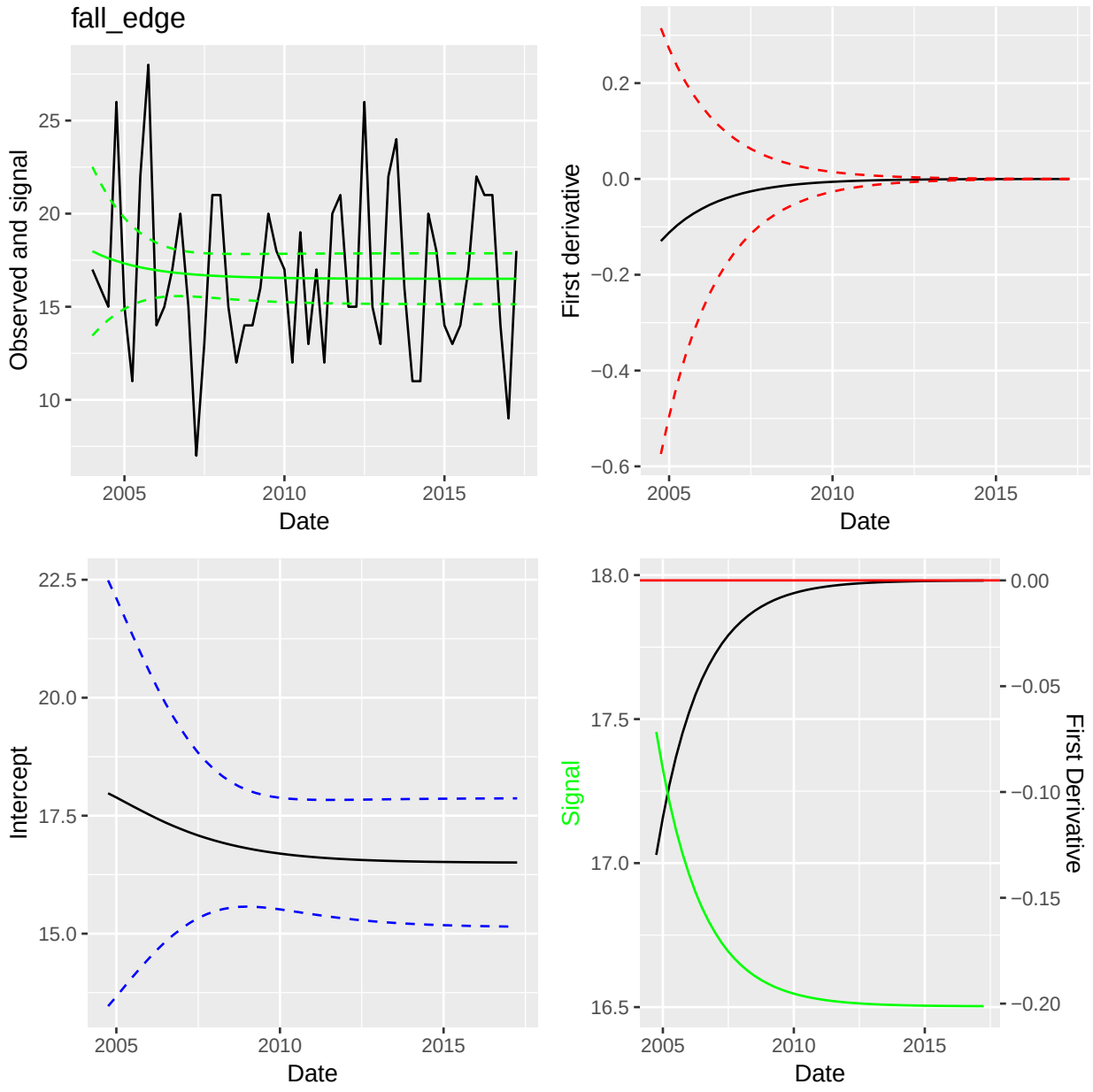

fall_edge
Observed and signal
25
20
15
10
2005
2010
2015
Date
First derivative
0.2
0.0
−0.2
−0.4
−0.6
2005
2010
2015
Date
Intercept
22.5
20.0
17.5
15.0
2005
2010
2015
Date
Signal
18.0
17.5
17.0
16.5
First Derivative
0.00
−0.05
−0.10
−0.15
−0.20
2005
2010
2015
Date

Figure 30:

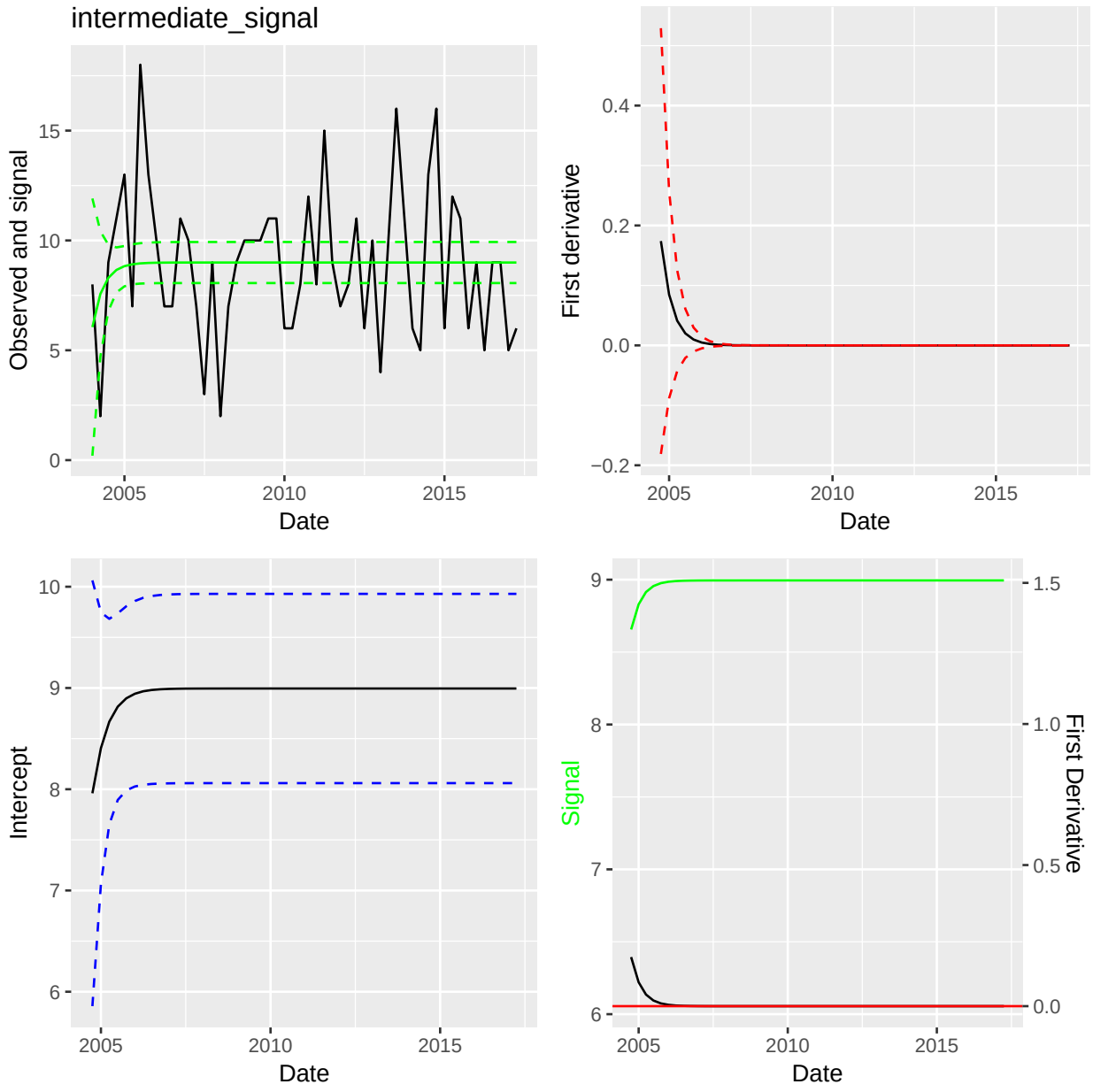

intermediate_signal
Observed and signal
Date
First derivative
Date
Intercept
Date
Signal
First Derivative
Date

Figure 31:

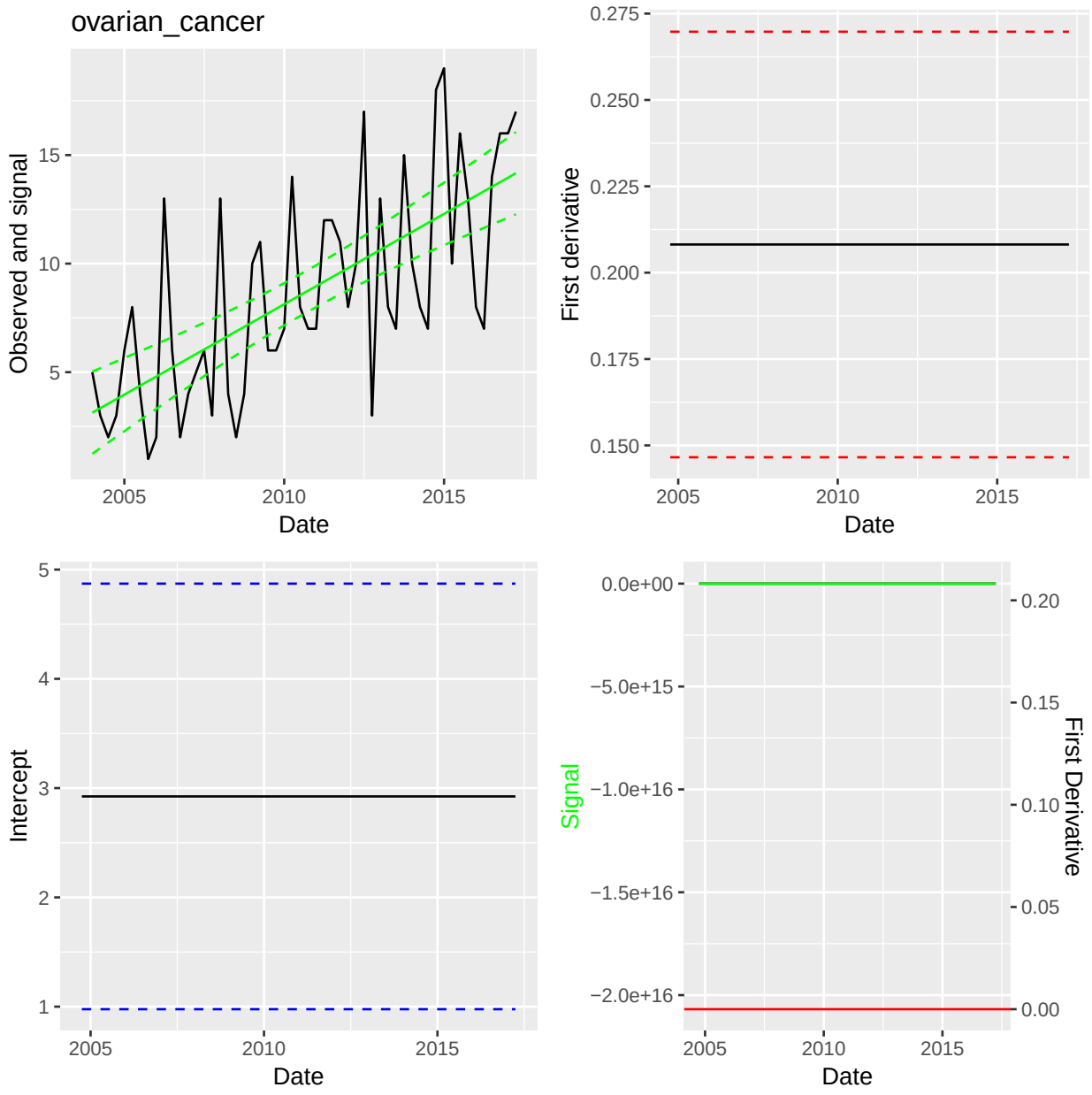

ovarian_cancer
Observed and signal
15
10
5
2005
2010
2015
Date
First derivative
0.275
0.250
0.225
0.200
0.175
0.150
2005
2010
2015
Date
Intercept
5
4
3
2
1
2005
2010
2015
Date
Signal
0.0e+00
−5.0e+15
−1.0e+16
−1.5e+16
−2.0e+16
First Derivative
0.20
0.15
0.10
0.05
0.00
2005
2010
2015
Date

Figure 32:

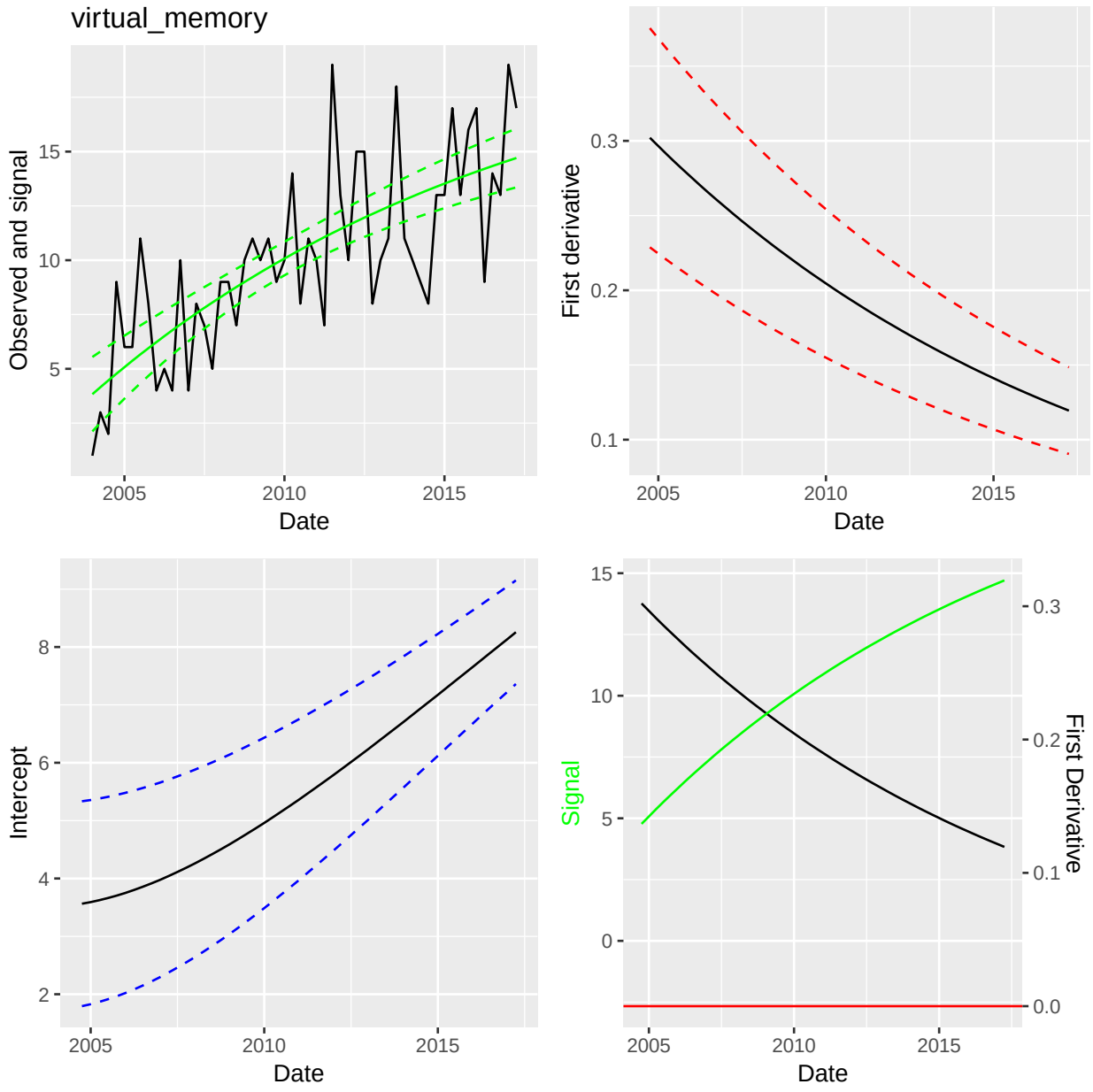

virtual_memory
Observed and signal
15
10
5
2005
2010
2015
Date
First derivative
0.3
0.2
0.1
2005
2010
2015
Date
Intercept
8
6
4
2
2005
2010
2015
Date
Signal
15
10
5
0
First Derivative
0.3
0.2
0.1
0.0
2005
2010
2015
Date

Figure 33:

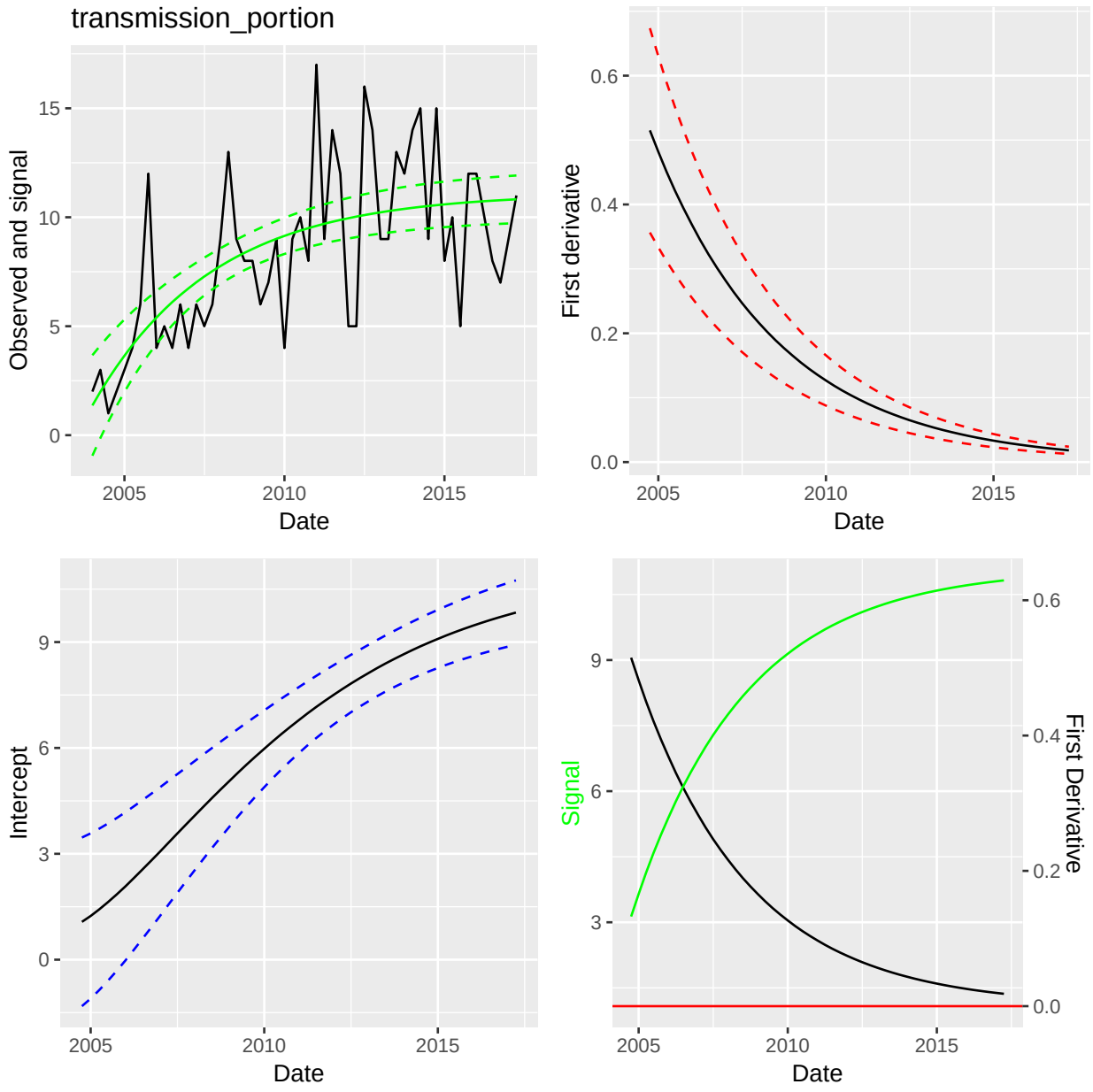

transmission_portion
Observed and signal
Date
First derivative
Date
Intercept
Date
Signal
First Derivative
Date

Figure 34:

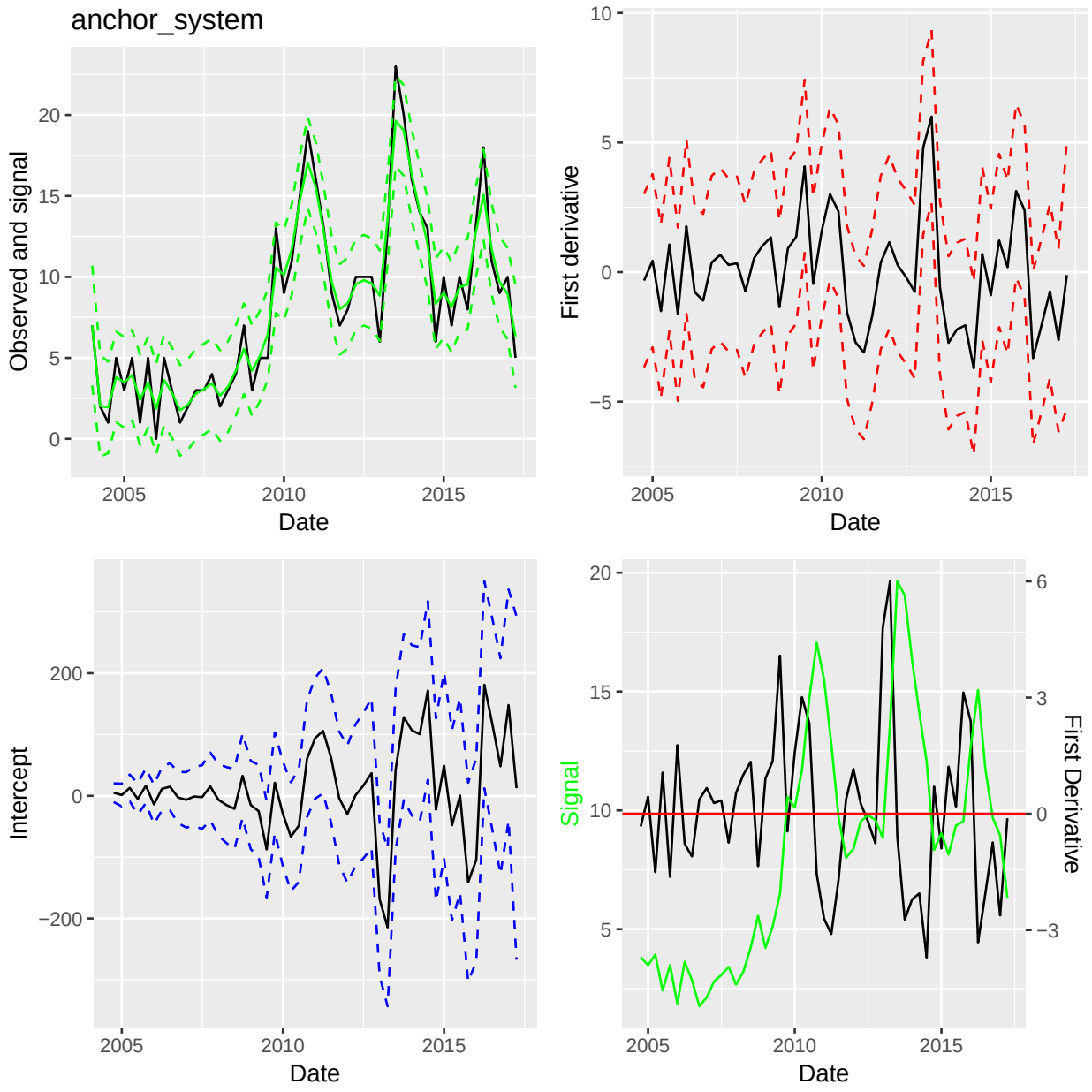

anchor_system
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative
2005
2010
2015

Figure 35:

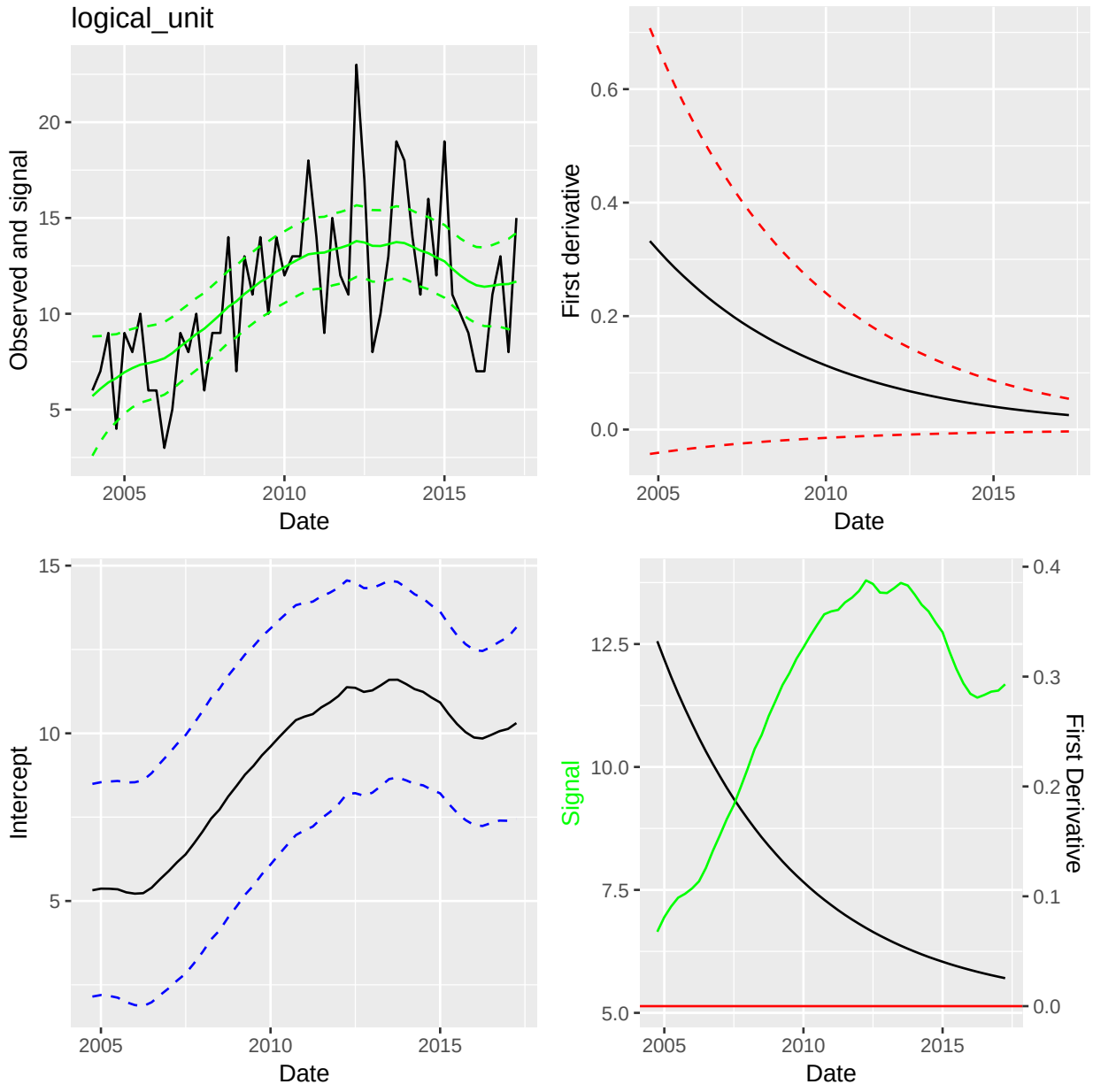

logical_unit
Observed and signal
Date
First derivative
Date
Intercept
Date
Signal
First Derivative
Date

Figure 36:

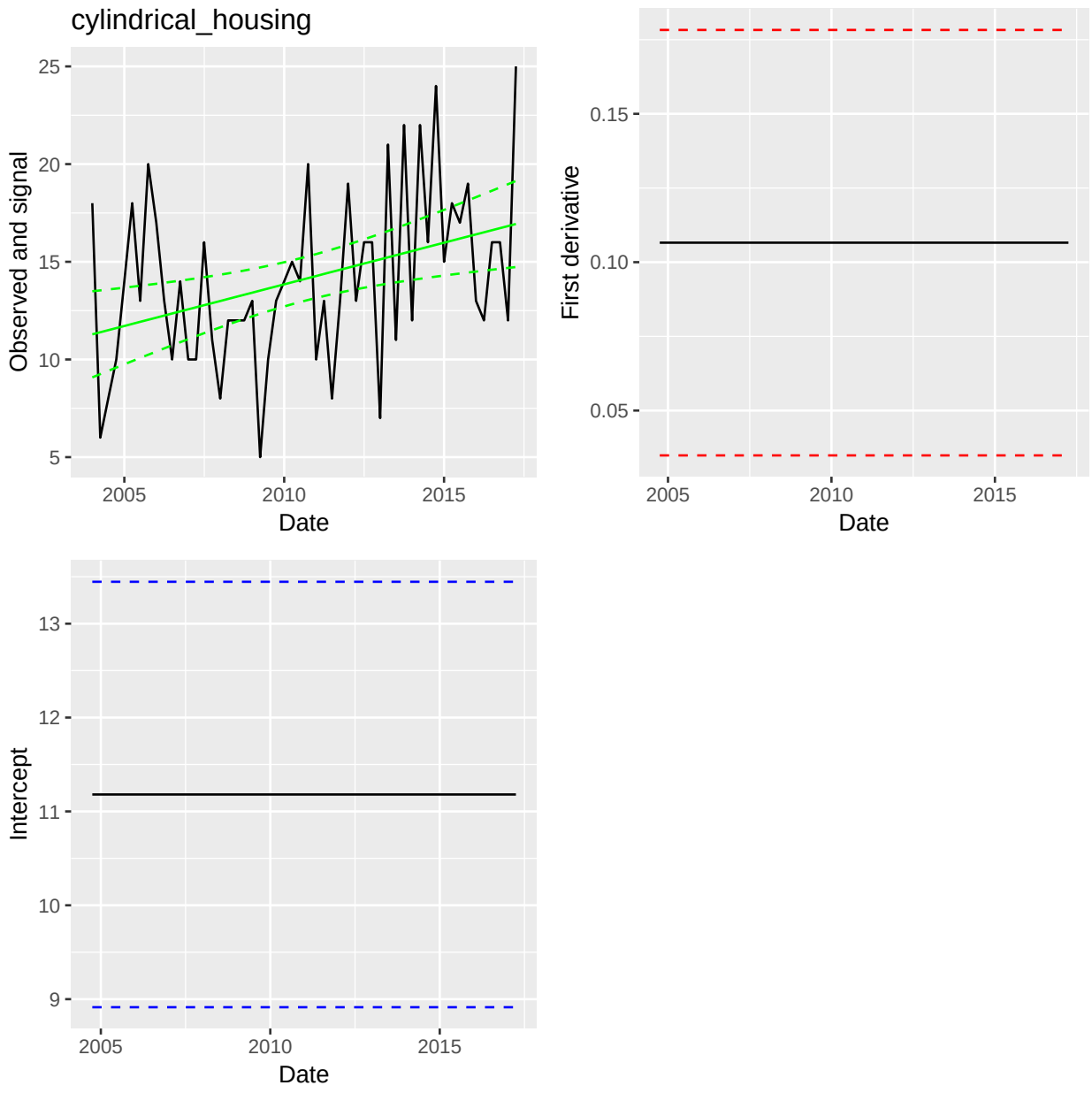

cylindrical_housing
Observed and signal
25
20
15
10
5
2005
2010
2015
Date
First derivative
0.15
0.10
0.05
2005
2010
2015
Date
Intercept
13
12
11
10
9
2005
2010
2015
Date

Figure 37:

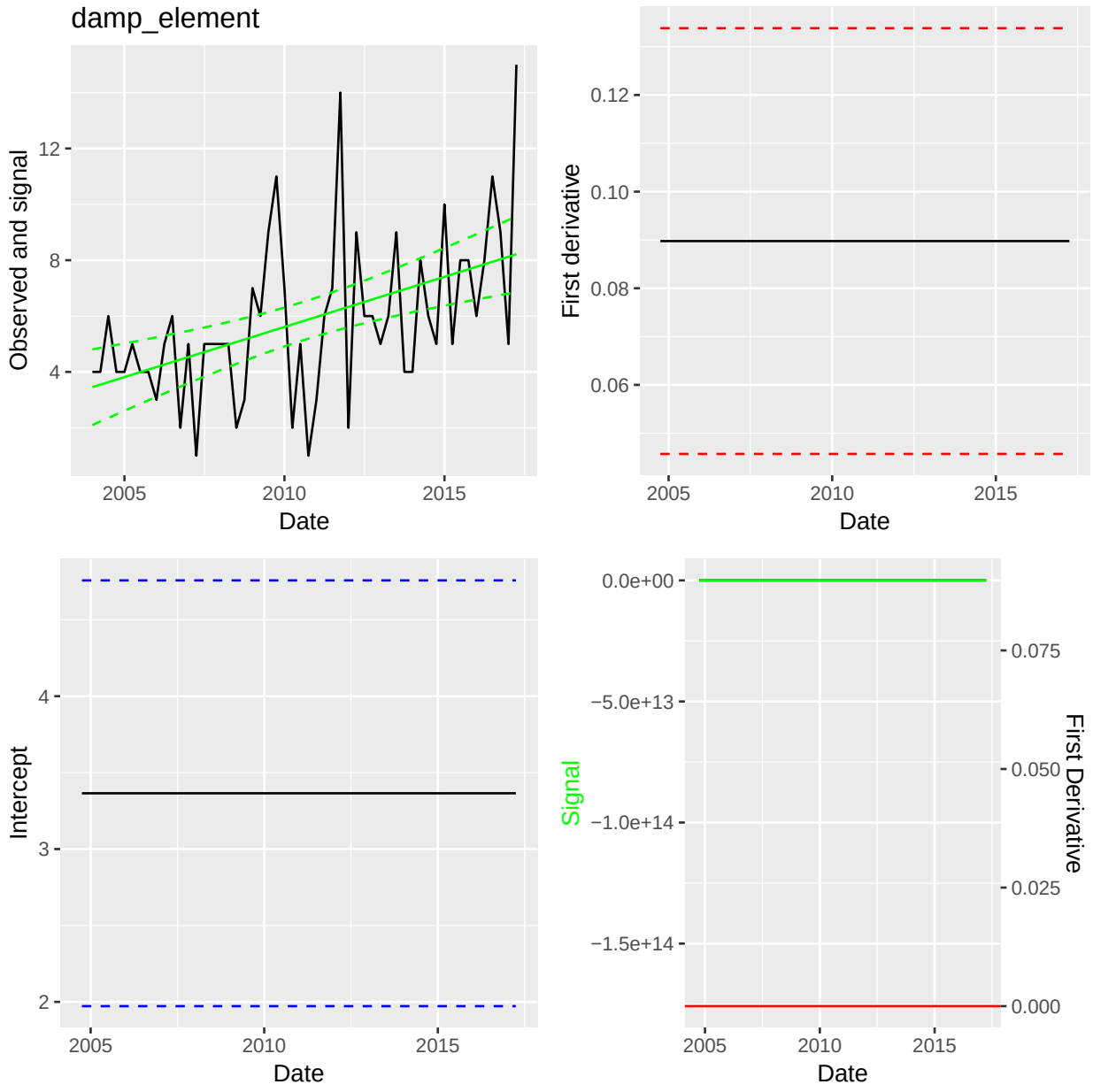

damp_element
Observed and signal
12
8
4
2005
2010
2015
Date
First derivative
0.12
0.10
0.08
0.06
2005
2010
2015
Date
Intercept
4
3
2
2005
2010
2015
Date
Signal
0.0e+00
−5.0e+13
−1.0e+14
−1.5e+14
First Derivative
0.075
0.050
0.025
0.000
2005
2010
2015
Date

Figure 38:

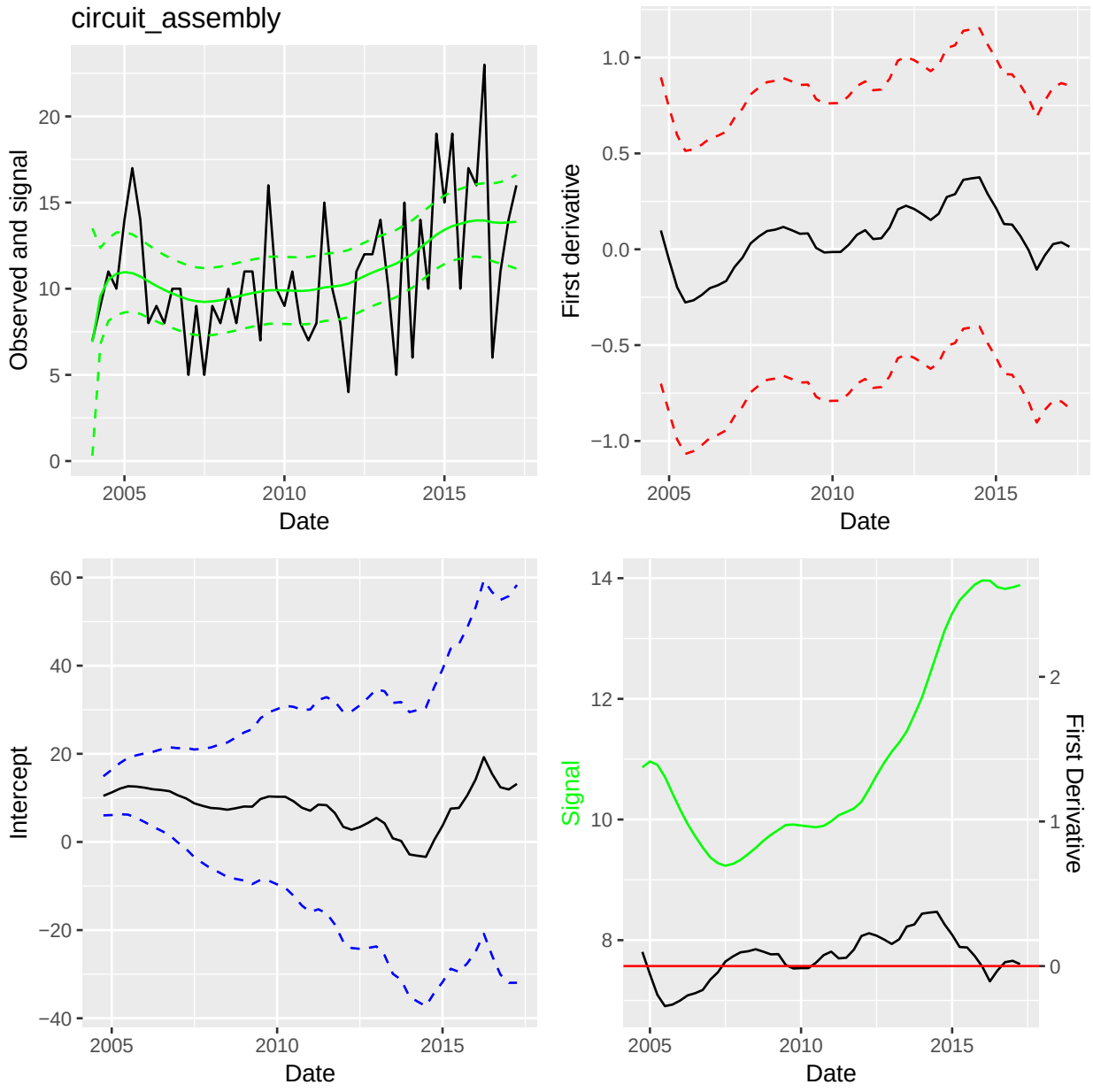

circuit_assembly
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 39:

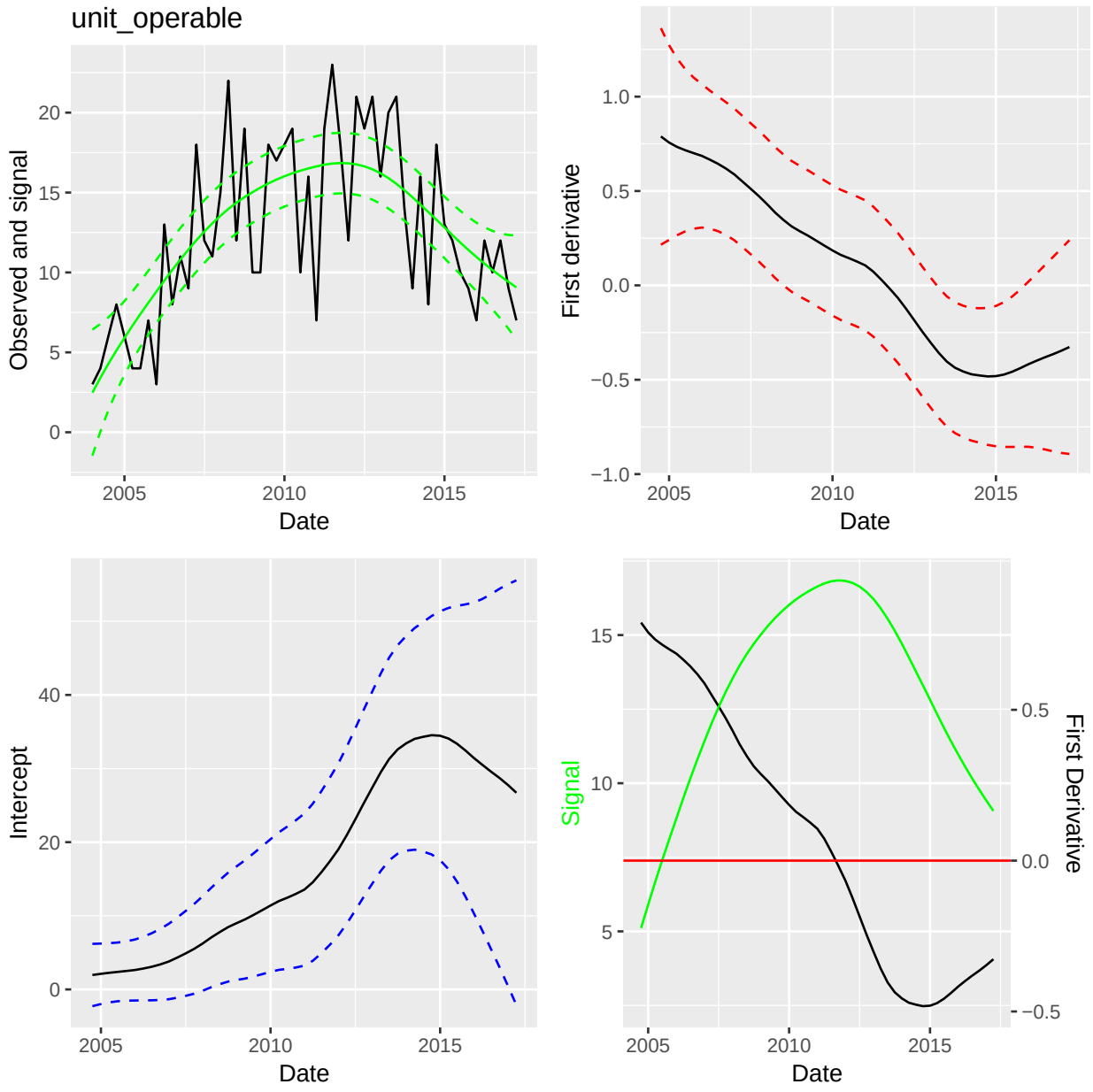

unit_operable
Observed and signal
Date
First derivative
Date
Intercept
Date
Signal
First Derivative
Date

Figure 40:

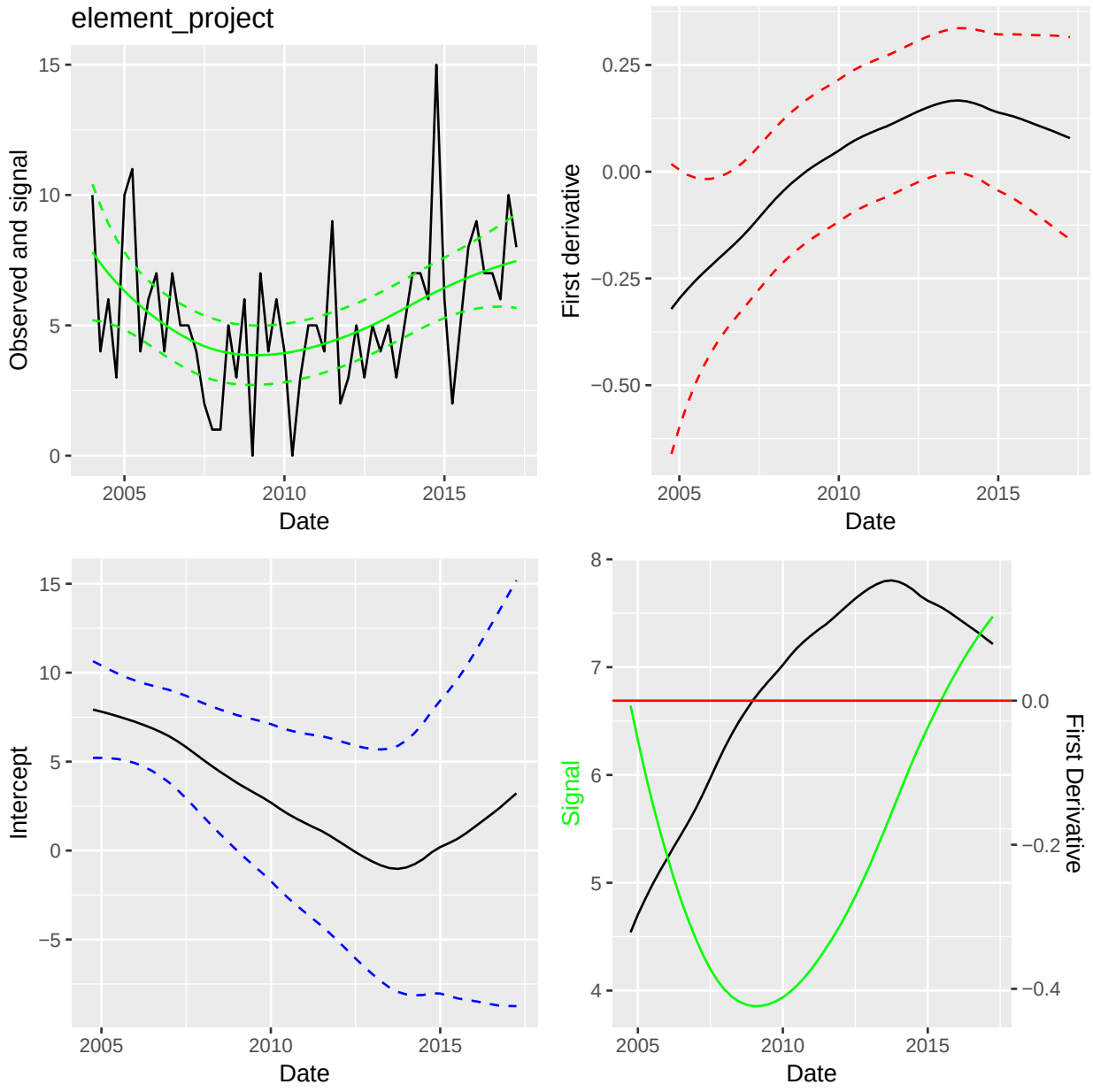

element_project
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative
2005
2010
2015

Figure 41:

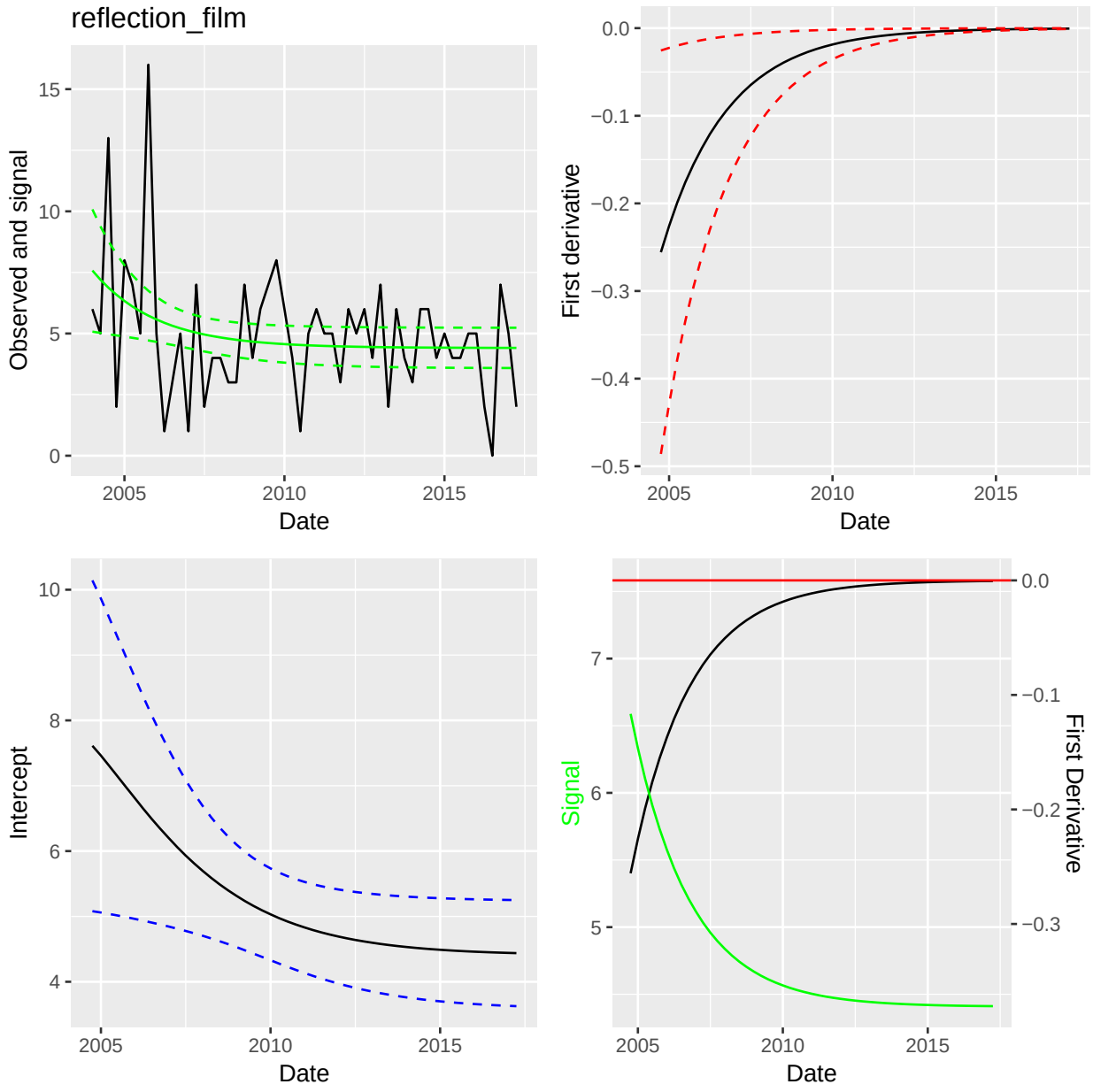

reflection_film
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 42:

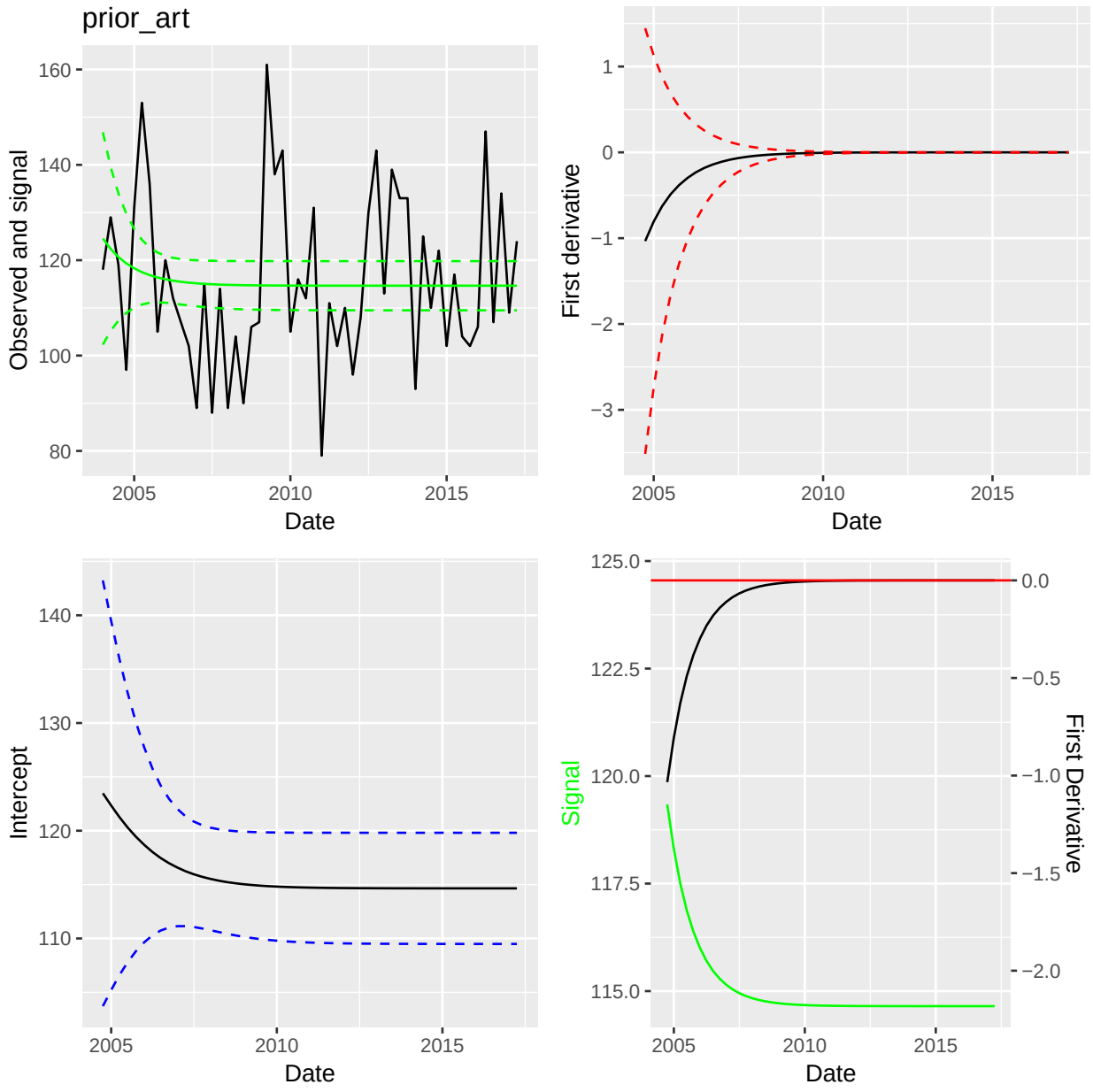

prior_art
Observed and signal
160
140
120
100
80
2005
2010
2015
Date
First derivative
1
0
−1
−2
−3
2005
2010
2015
Date
Intercept
140
130
120
110
2005
2010
2015
Date
Signal
125.0
122.5
120.0
117.5
115.0
0.0
−0.5
−1.0
−1.5
−2.0
First Derivative
2005
2010
2015
Date

Figure 43:

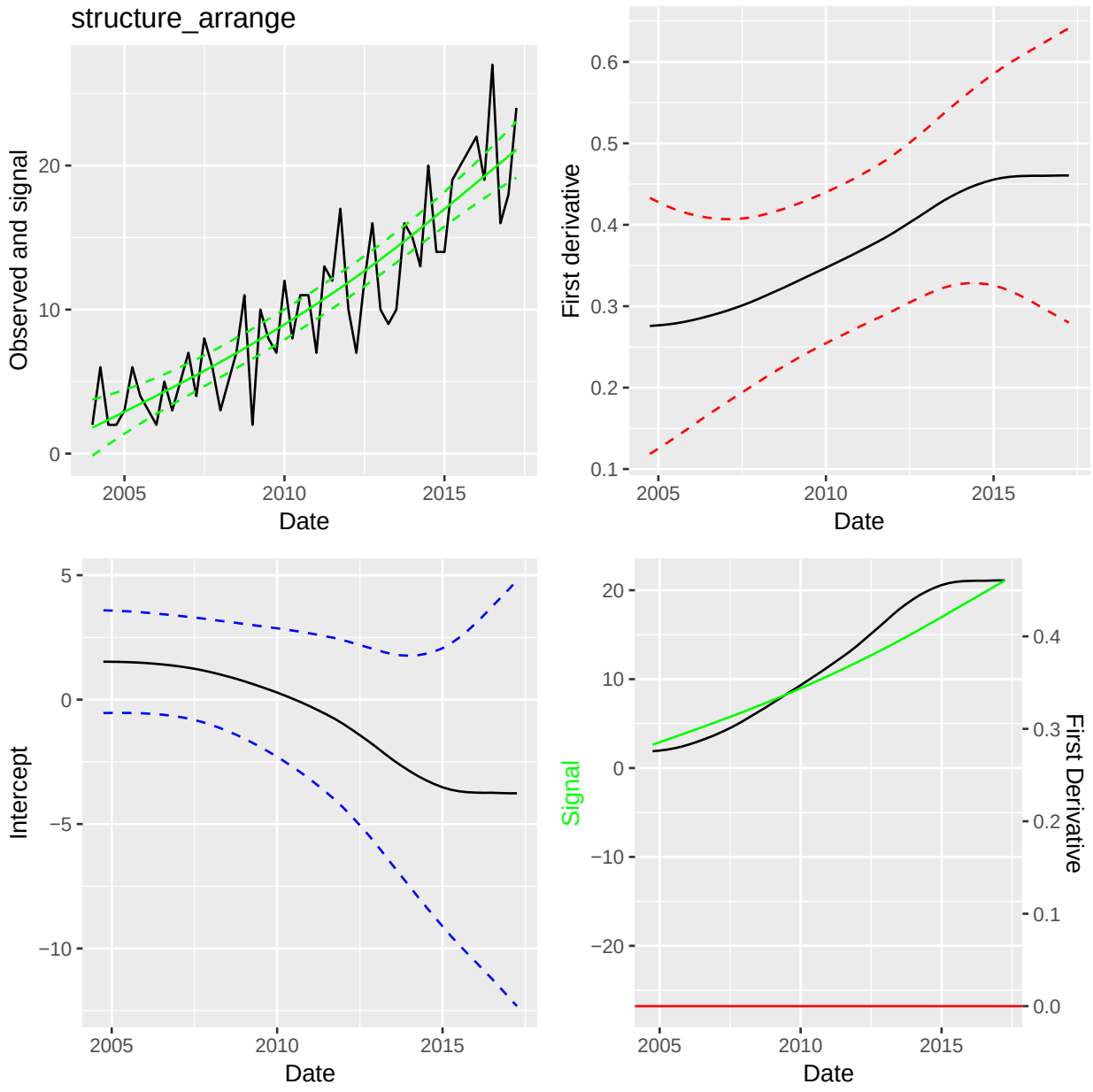

structure_arrange
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative
2005
2010
2015

Figure 44:

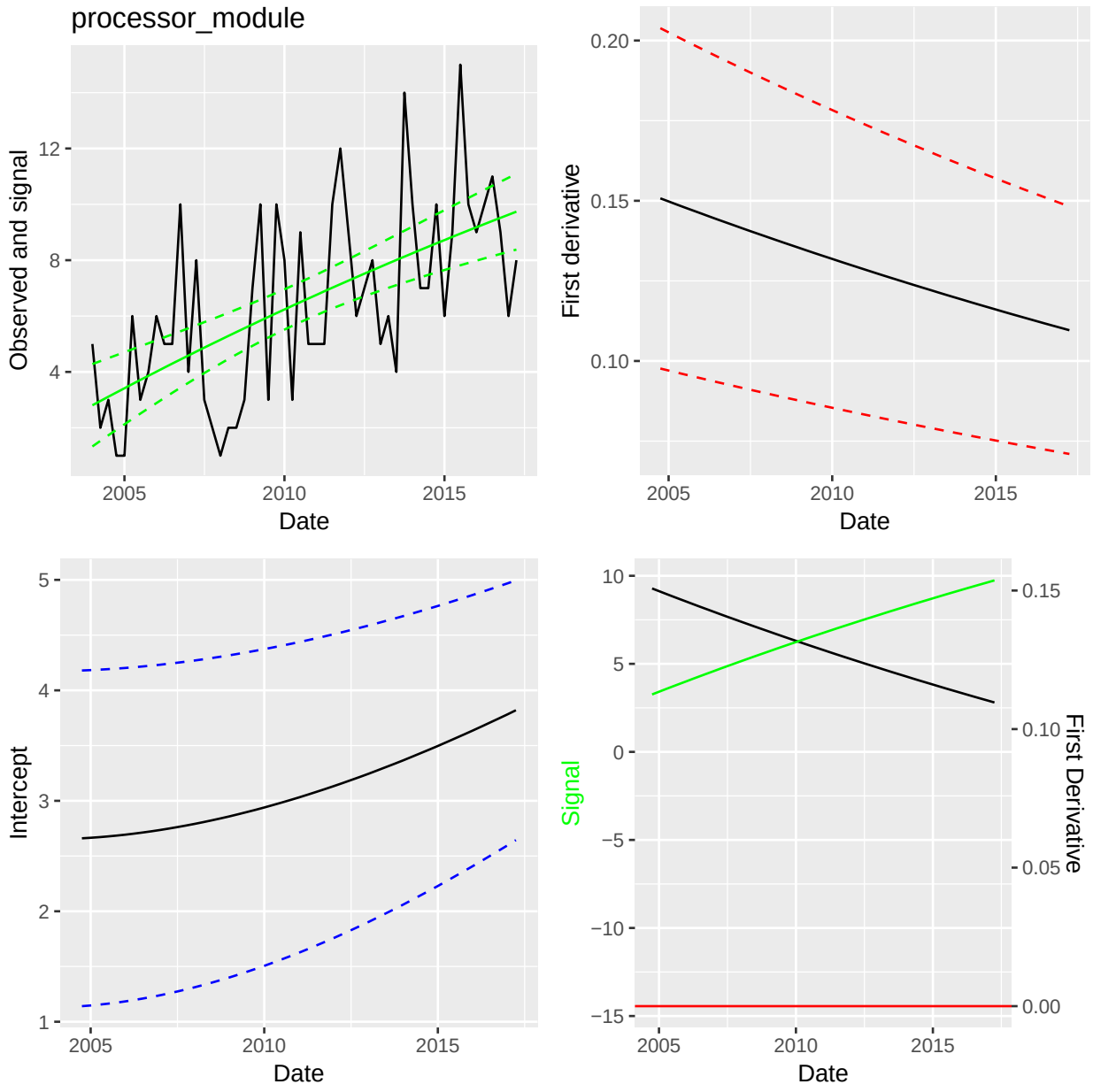

processor_module
Observed and signal
12
8
4
2005
2010
2015
Date
First derivative
0.20
0.15
0.10
2005
2010
2015
Date
Intercept
5
4
3
2
1
2005
2010
2015
Date
Signal
10
5
0
−5
−10
−15
0.15
0.10
0.05
0.00
First Derivative
2005
2010
2015
Date

Figure 45:

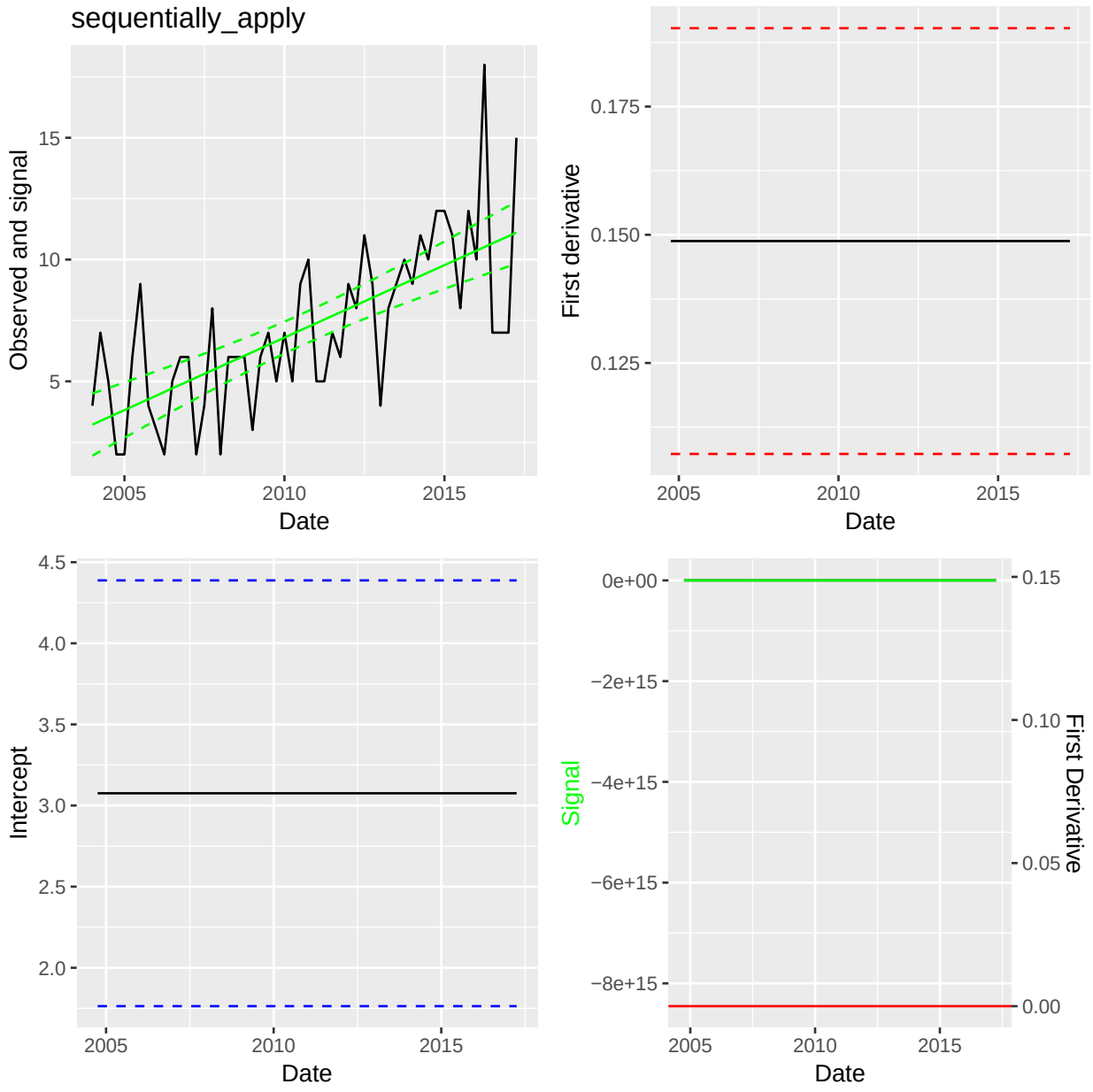

sequentially_apply
Observed and signal
15
10
5
2005
2010
2015
Date
First derivative
0.175
0.150
0.125
2005
2010
2015
Date
Intercept
4.5
4.0
3.5
3.0
2.5
2.0
2005
2010
2015
Date
Signal
0e+00
−2e+15
−4e+15
−6e+15
−8e+15
First Derivative
0.15
0.10
0.05
0.00
2005
2010
2015
Date

Figure 46:

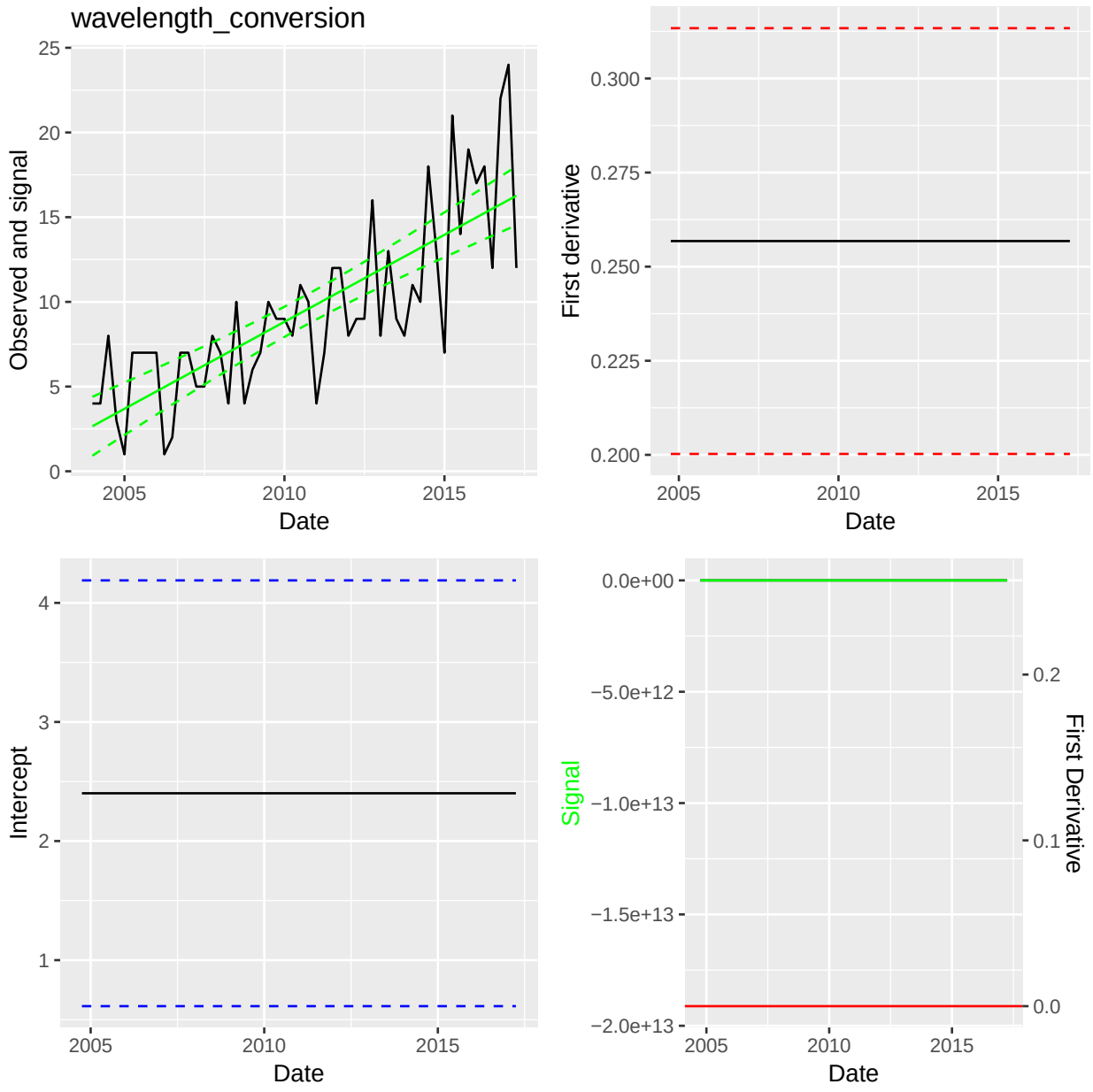

wavelength_conversion
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative
2005
2010
2015

Figure 47:

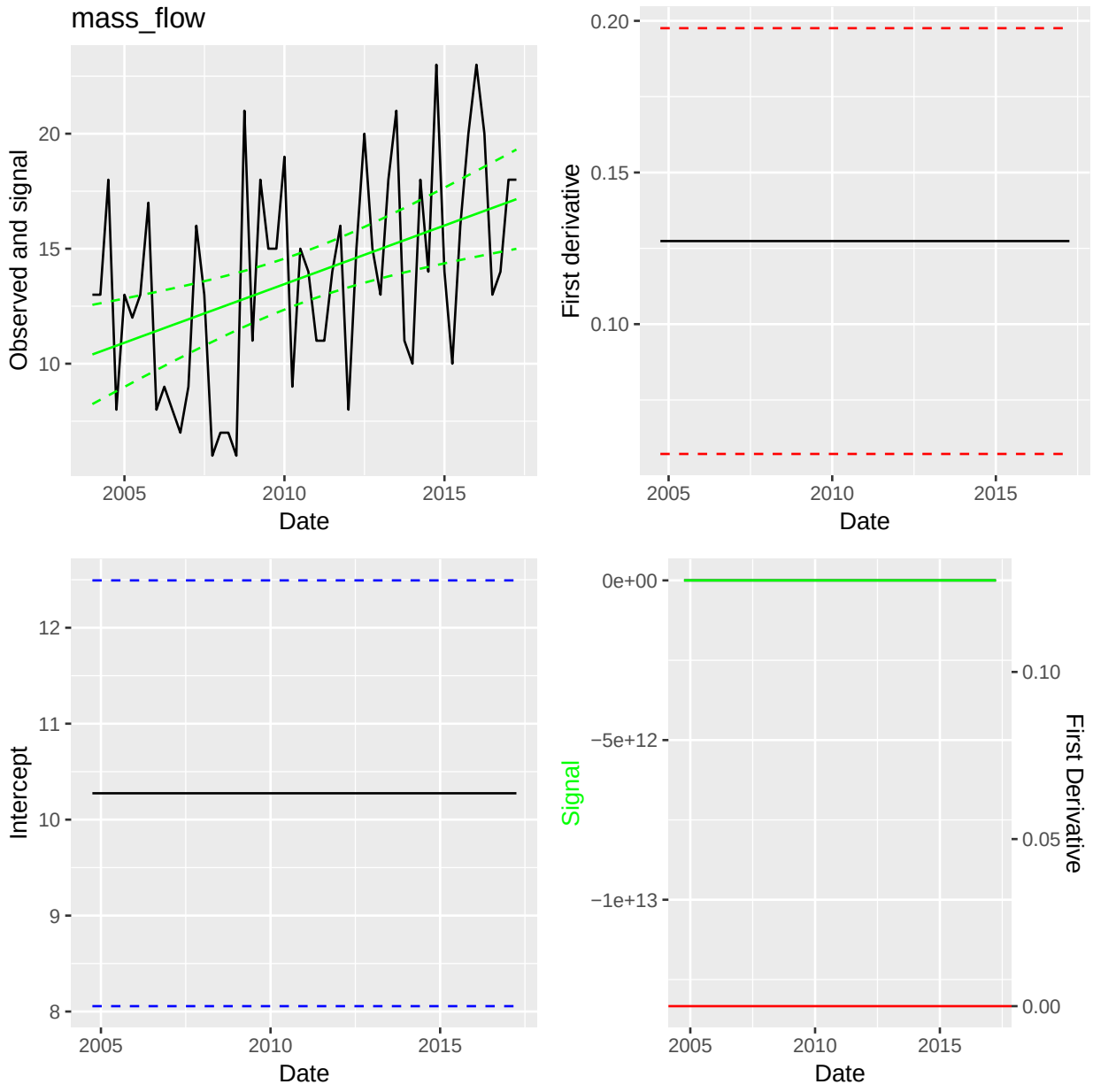

mass_flow
Observed and signal
20
15
10
2005
2010
2015
Date
First derivative
0.20
0.15
0.10
2005
2010
2015
Date
Intercept
12
11
10
9
8
2005
2010
2015
Date
Signal
0e+00
−5e+12
−1e+13
0.10
0.05
0.00
First Derivative
2005
2010
2015
Date

Figure 48:

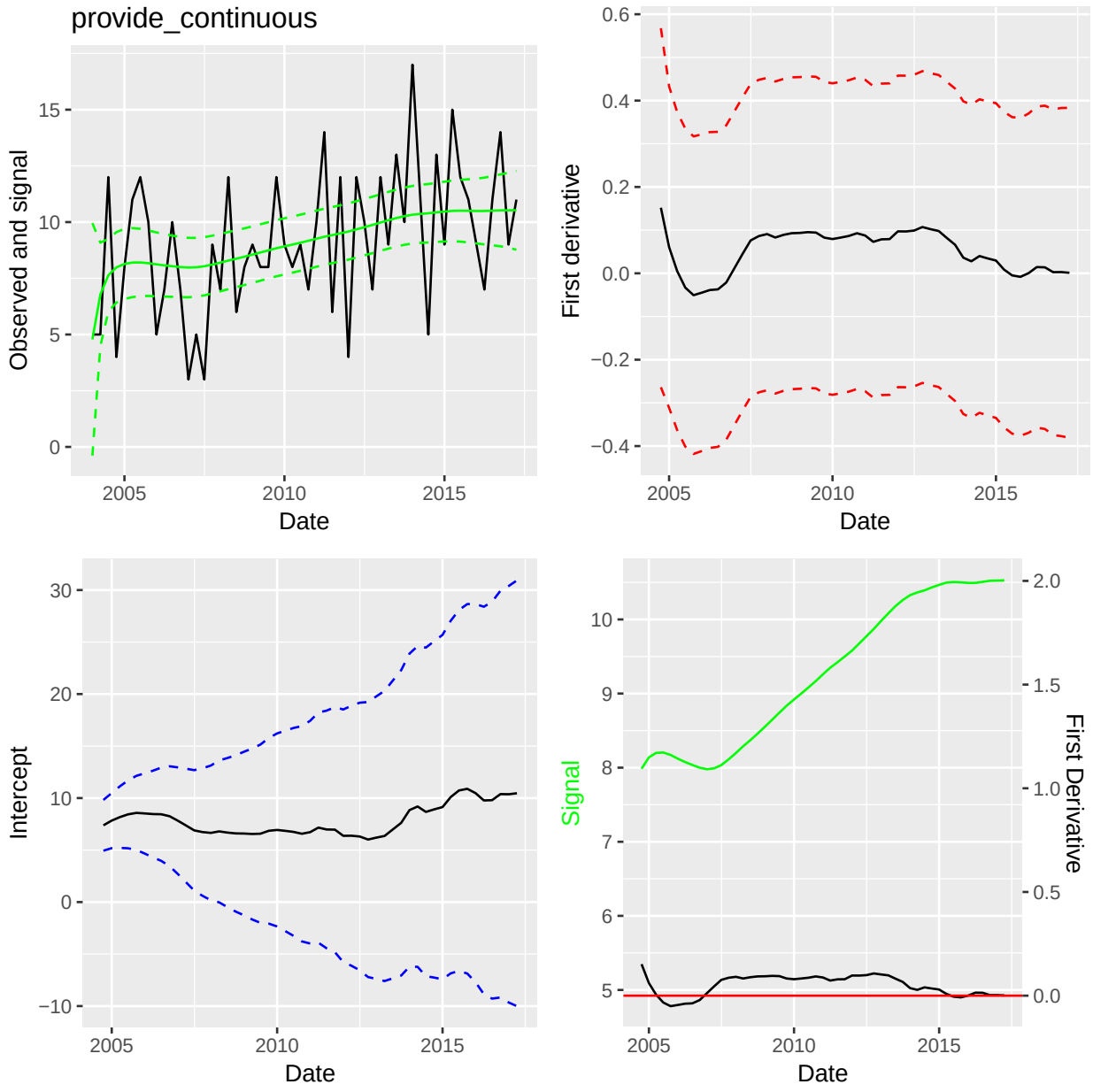
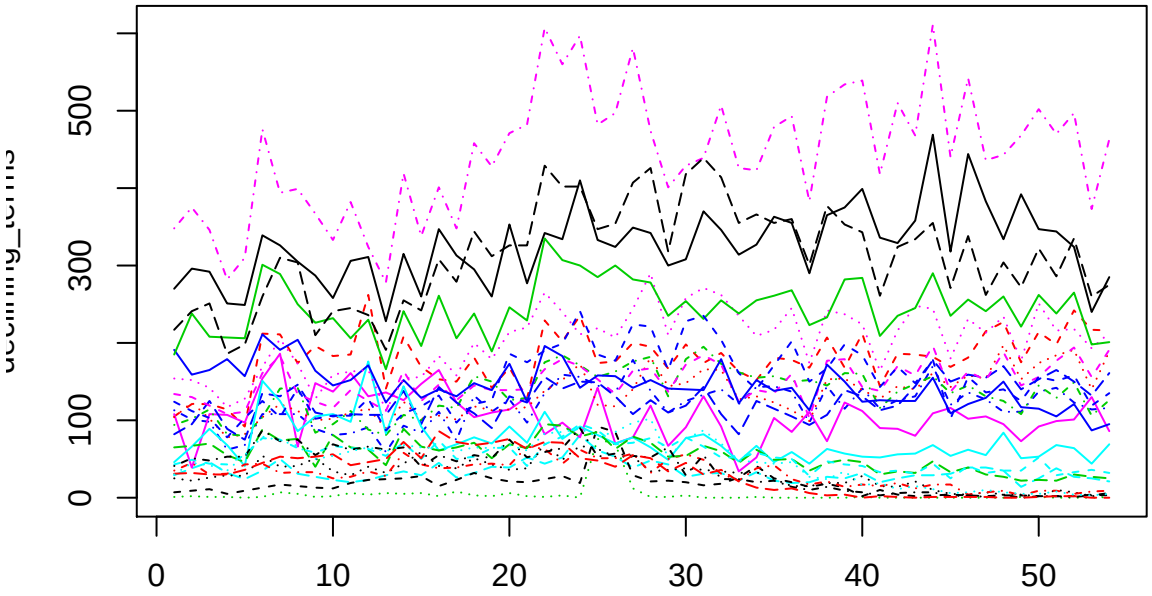
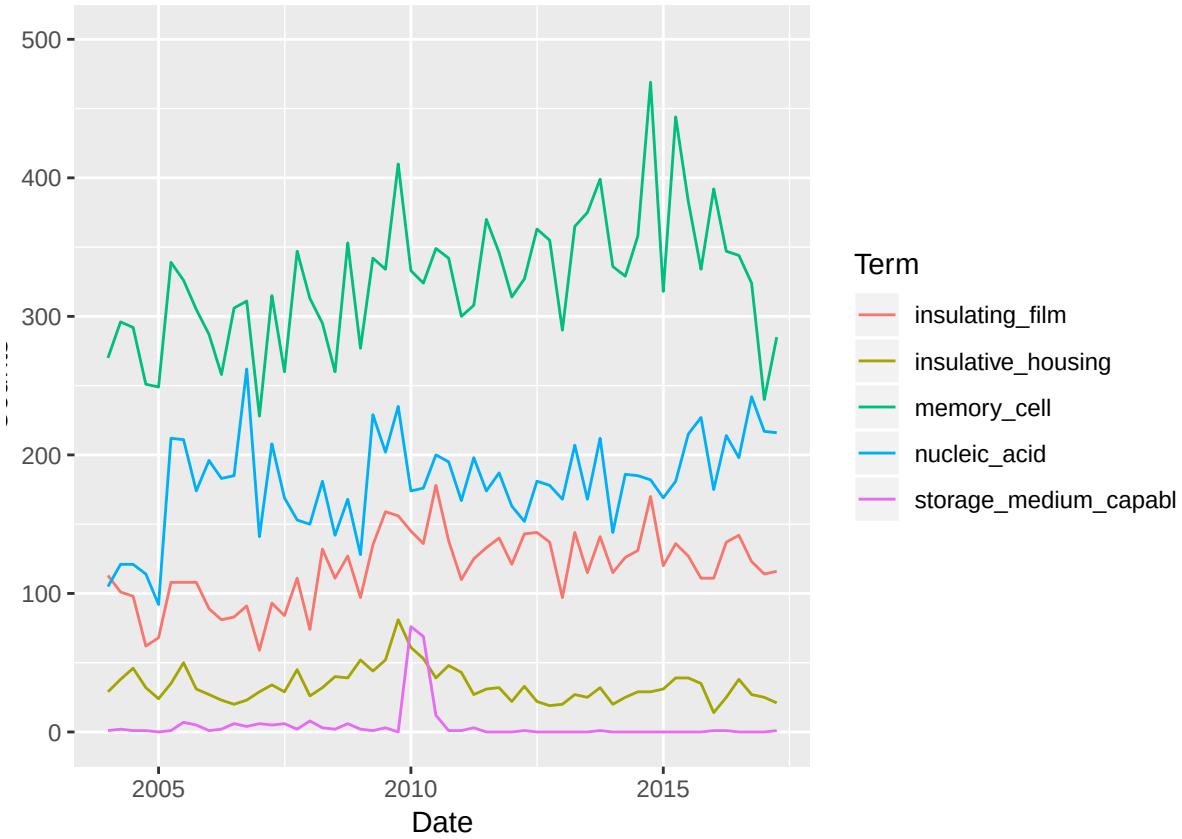

provide_continuous
Observed and signal
Date
First derivative
Date
Intercept
Date
Signal
First Derivative
Date

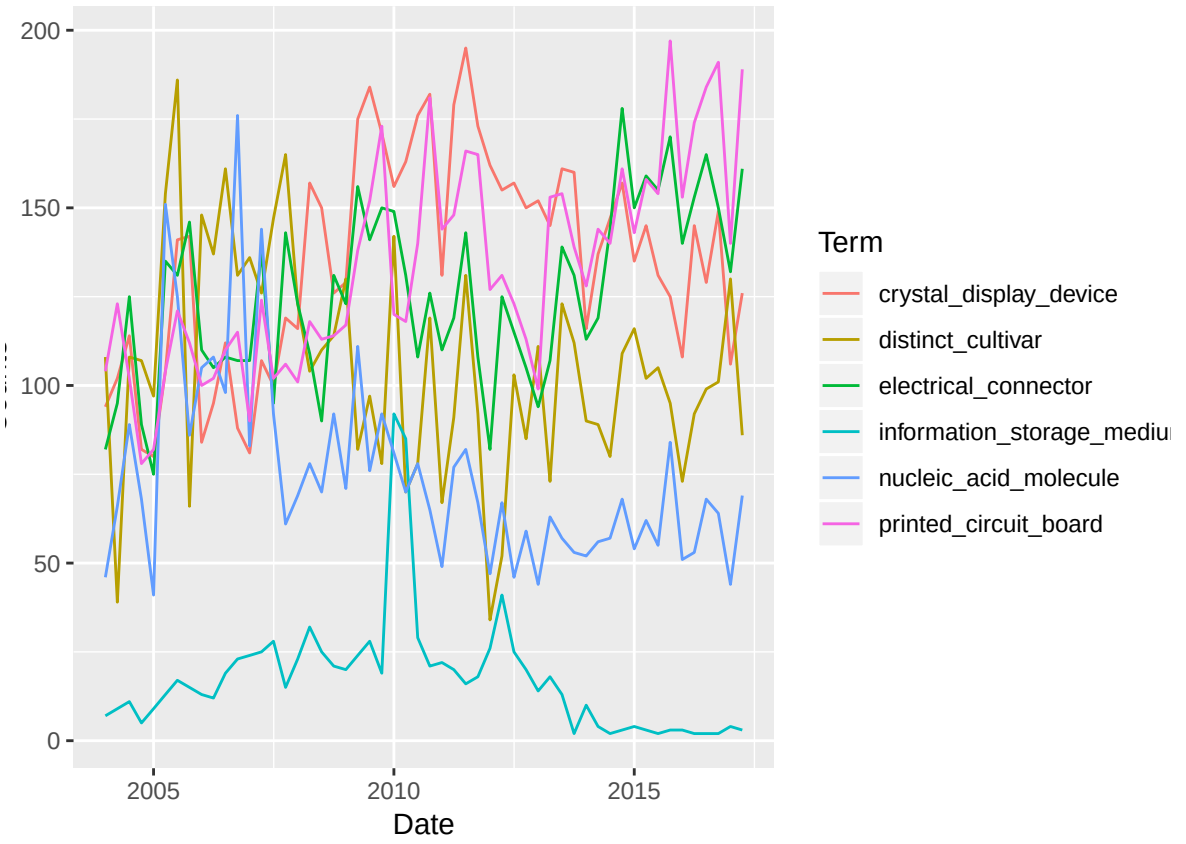
Figure 49:

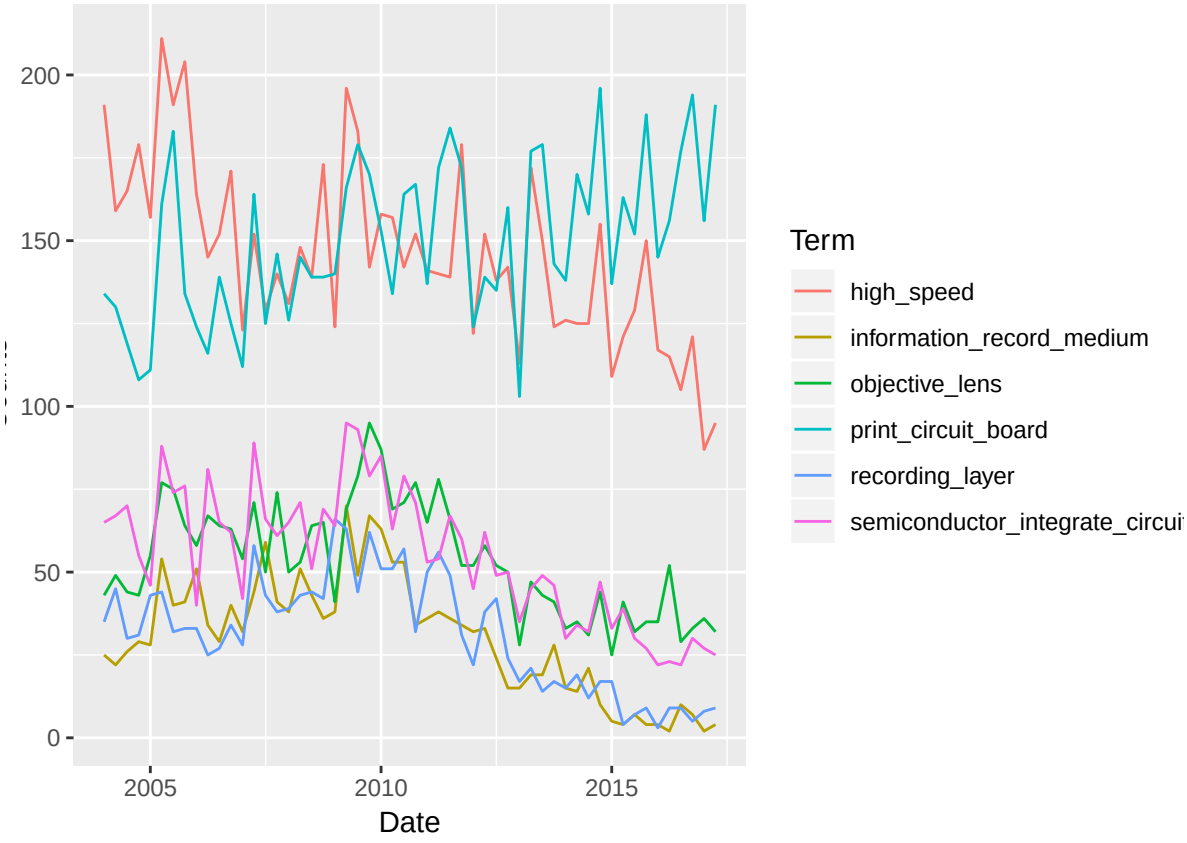
Terms classified as declining by Porter

In this group we also find terms which are emergent (printed circuit board, liquid crystal, electrical connector, semiconductor substrate, print circuit board, memory cell), some terms which are stationary and some which are definitely declining and correspond to negative values of E.






200
150
100
50
0
2005
2010
2015
Date
Term
crystal_display_device
distinct_cultivar
electrical_connector
information_storage_mediu
nucleic_acid_molecule
printed_circuit_board


200
150
100
50
0
2005
2010
2015
Date
Term
high_speed
information_record_medium
objective_lens
print_circuit_board
recording_layer
semiconductor_integrate_circui

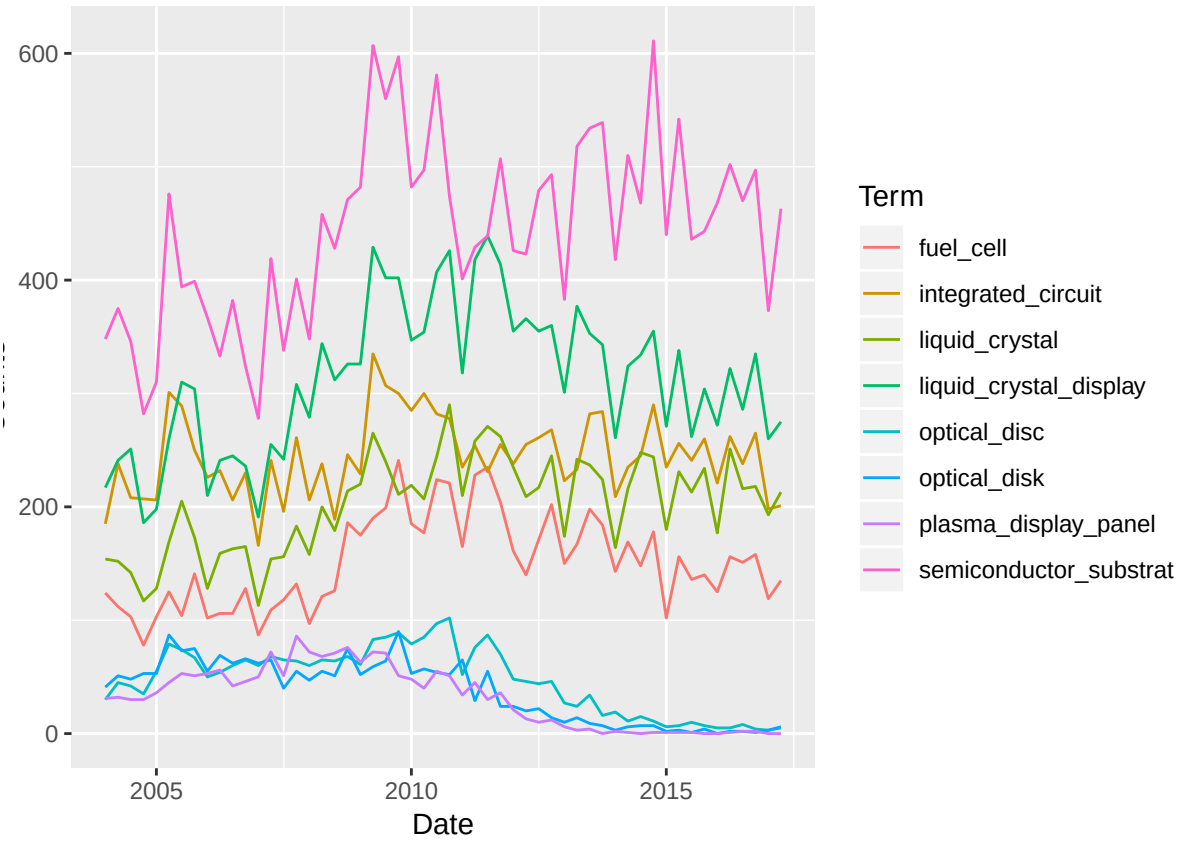

600
400
200
0
2005
2010
2015
Date
Term
fuel_cell
integrated_circuit
liquid_crystal
liquid_crystal_display
optical_disc
optical_disk
plasma_display_panel
semiconductor_substrat

Table 3: Stationary Terms

Term	σ_ϵ	σ_ν	σ_η	δ	E (1st der)	E(sum 1st deriv/sd)
printed circuit board	16.8814054	2.6751424	0.0000027	0.6462724	72.4612968	4.2923735
liquid crystal	25.6584340	0.0000022	7.3869269	0.9559494	80.3576291	3.1318213
electrical connector	17.4718155	2.5759051	0.0000026	0.6144451	48.0061571	2.7476342
semiconductor substrate	52.5273253	0.0000001	19.9688921	0.9544847	128.8800173	2.4535804
print circuit board	20.2674119	0.0000001	0.0000017	0.9935272	41.3127906	2.0383851
memory cell	41.1568180	0.0000000	0.0000000	0.9588138	79.8300160	1.9396547
nucleic acid	29.3694351	0.0000000	0.0000000	0.7605834	55.2646492	1.8817062
insulating film	16.9523824	3.9751699	0.0000000	0.4103918	31.2674991	1.8444310
liquid crystal display	35.8623571	3.7351631	0.0000118	0.8643371	53.1181021	1.4811659
crystal display device	17.3617720	1.7821525	0.0000001	0.8474400	24.8412181	1.4307997
fuel cell	22.1290683	3.8201550	0.0000002	0.7515689	29.1086671	1.3154041
storage medium capable	0.0161356	13.2091776	0.0000000	0.0176129	0.0176097	1.0913582
distinct cultivar	25.6257774	1.4969103	0.0000000	0.7578396	-3.2214607	-0.1257117
integrated circuit	27.0417950	11.1410527	0.0000051	0.0000000	-5.0913343	-0.1882765
information storage medium	7.9695554	8.8728133	0.0000001	0.0186871	-6.3477402	-0.7964987
nucleic acid molecule	20.3585577	1.5392813	0.0000005	0.7107985	-16.9662618	-0.8333725
information record medium	6.8492157	0.6361397	3.4505653	0.8588028	-8.1577469	-1.1910483
objective lens	8.9810872	1.5143200	0.0000694	0.7459124	-17.0764176	-1.9013753
insulative housing	6.4863436	5.1294048	0.0000003	0.0525121	-15.4103872	-2.3758204
high speed	19.7910564	0.0000000	0.0000003	1.0000000	-60.5764818	-3.0608008
semiconductor integrate circuit	10.8518345	0.0000000	3.2936036	1.0000000	-42.1181054	-3.8811968
recording layer	7.5328904	0.8612771	0.0000007	0.8809884	-29.4087321	-3.9040435
optical disc	8.6242686	1.8504228	0.0000008	0.8269351	-41.4522790	-4.8064689
plasma display panel	6.3890714	1.2127295	0.0000001	0.8960973	-32.9283019	-5.1538478
optical disk	8.6028211	1.6913815	0.0000005	0.7846082	-50.1396879	-5.8282844

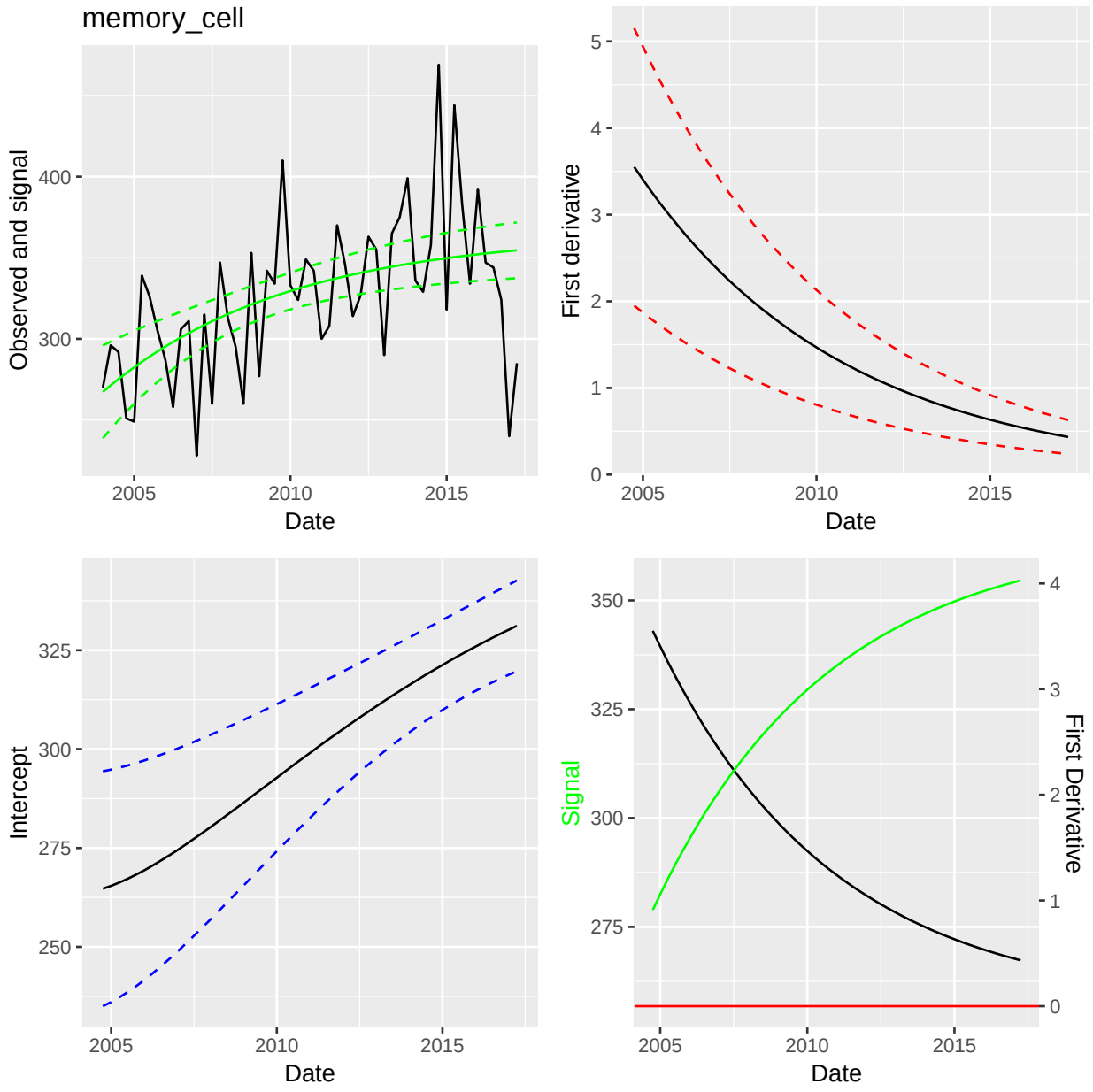

memory_cell
Observed and signal
400
300
2005
2010
2015
Date
First derivative
5
4
3
2
1
0
2005
2010
2015
Date
Intercept
325
300
275
250
2005
2010
2015
Date
Signal
350
325
300
275
4
3
2
1
0
First Derivative
2005
2010
2015
Date

Figure 50:

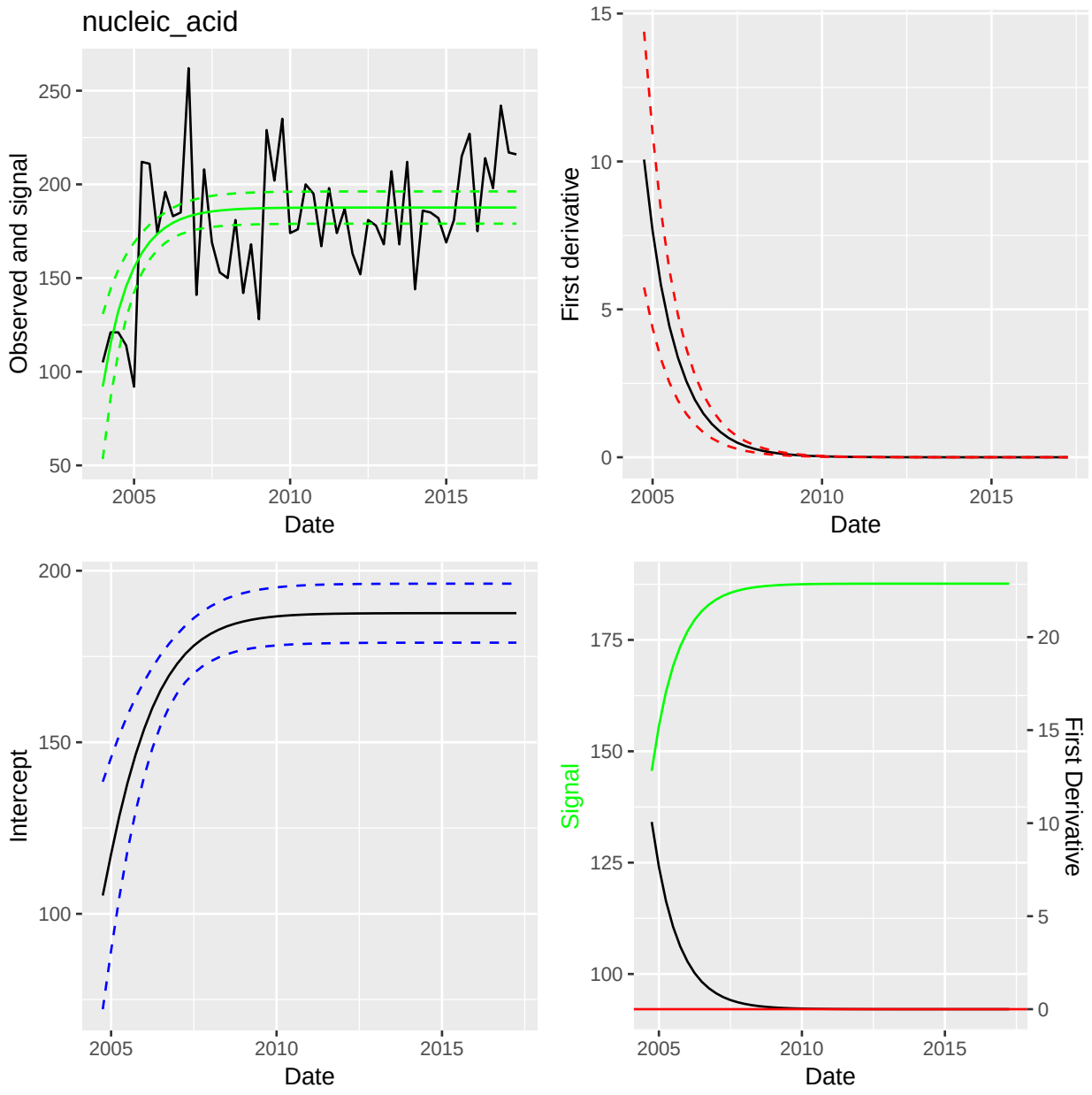

nucleic_acid
Observed and signal
250
200
150
100
50
2005
2010
2015
Date
First derivative
15
10
5
0
2005
2010
2015
Date
Intercept
200
150
100
2005
2010
2015
Date
Signal
175
150
125
100
First Derivative
20
15
10
5
0
2005
2010
2015
Date

Figure 51:

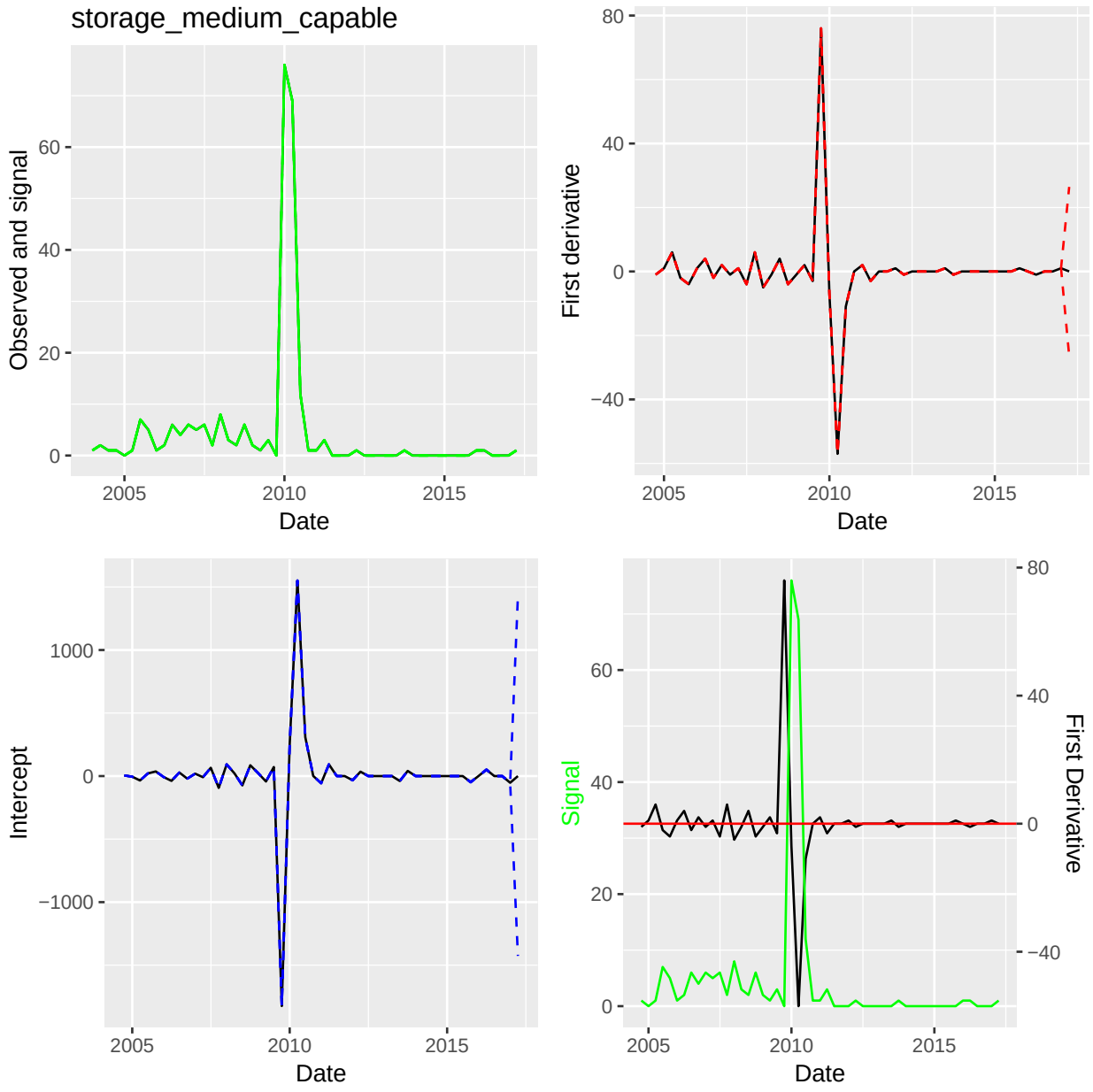

storage_medium_capable
Observed and signal
60
40
20
0
2005
2010
2015
Date
First derivative
80
40
0
−40
2005
2010
2015
Date
Intercept
1000
0
−1000
2005
2010
2015
Date
Signal
60
40
20
0
80
40
0
−40
First Derivative
2005
2010
2015
Date

Figure 52:

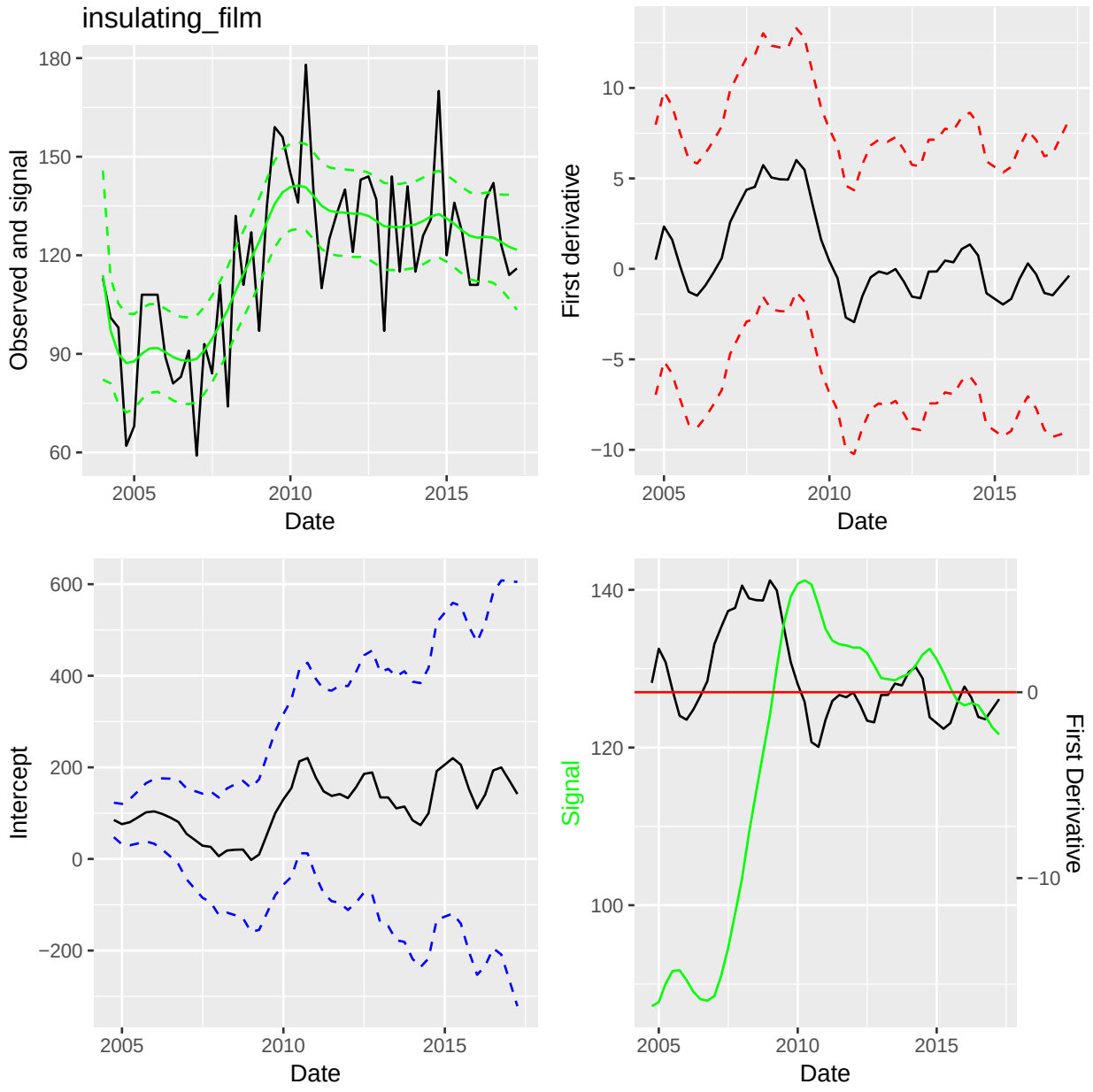

insulating_film
Observed and signal
180
150
120
90
60
2005
2010
2015
Date
First derivative
10
5
0
−5
−10
2005
2010
2015
Date
Intercept
600
400
200
0
−200
2005
2010
2015
Date
Signal
140
120
100
0
−10
First Derivative
2005
2010
2015
Date

Figure 53:

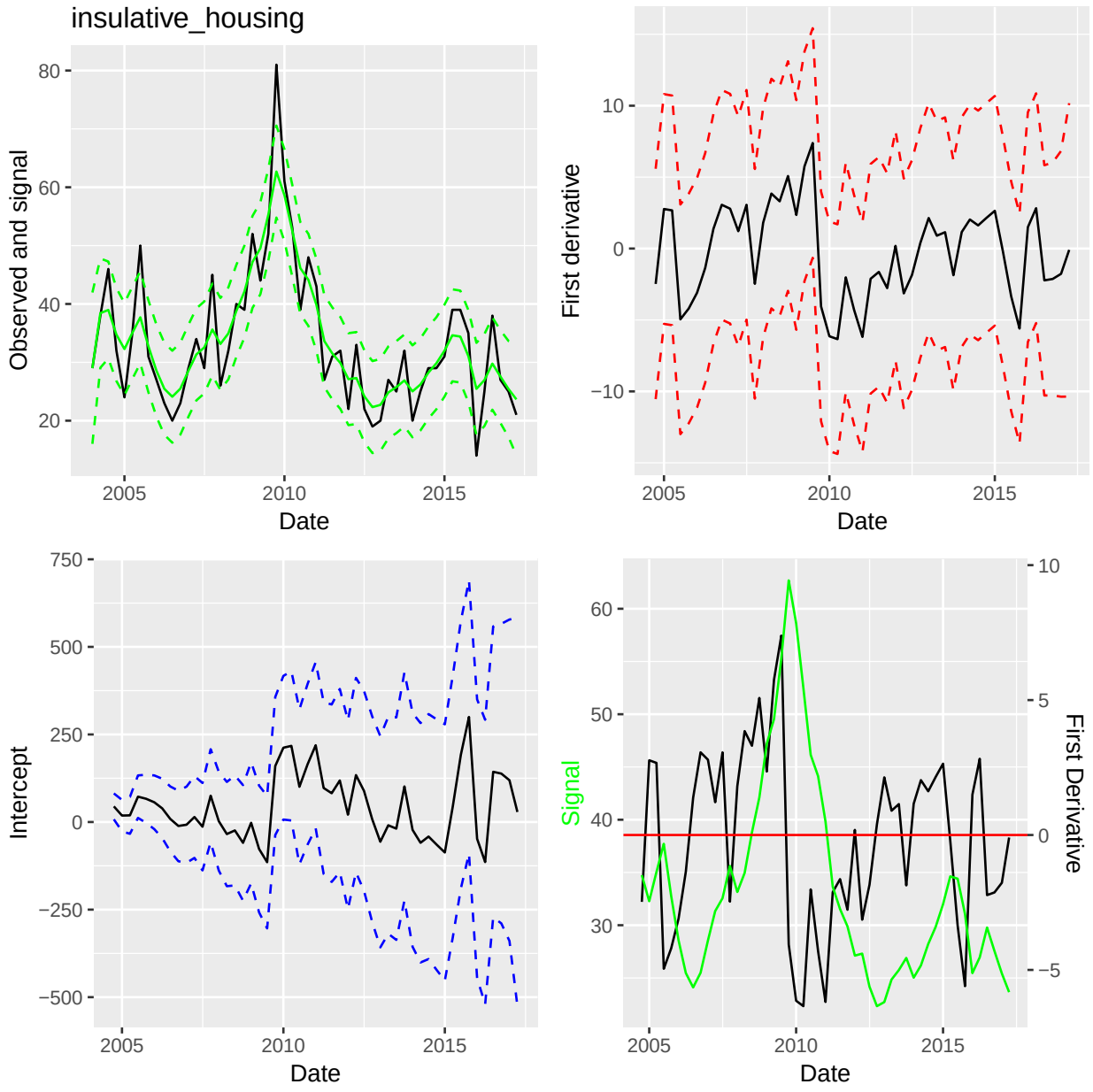

insulative_housing
Observed and signal
80
60
40
20
2005
2010
2015
Date
First derivative
10
0
−10
2005
2010
2015
Date
Intercept
750
500
250
0
−250
−500
2005
2010
2015
Date
Signal
60
50
40
30
10
5
0
−5
First Derivative
2005
2010
2015
Date

Figure 54:

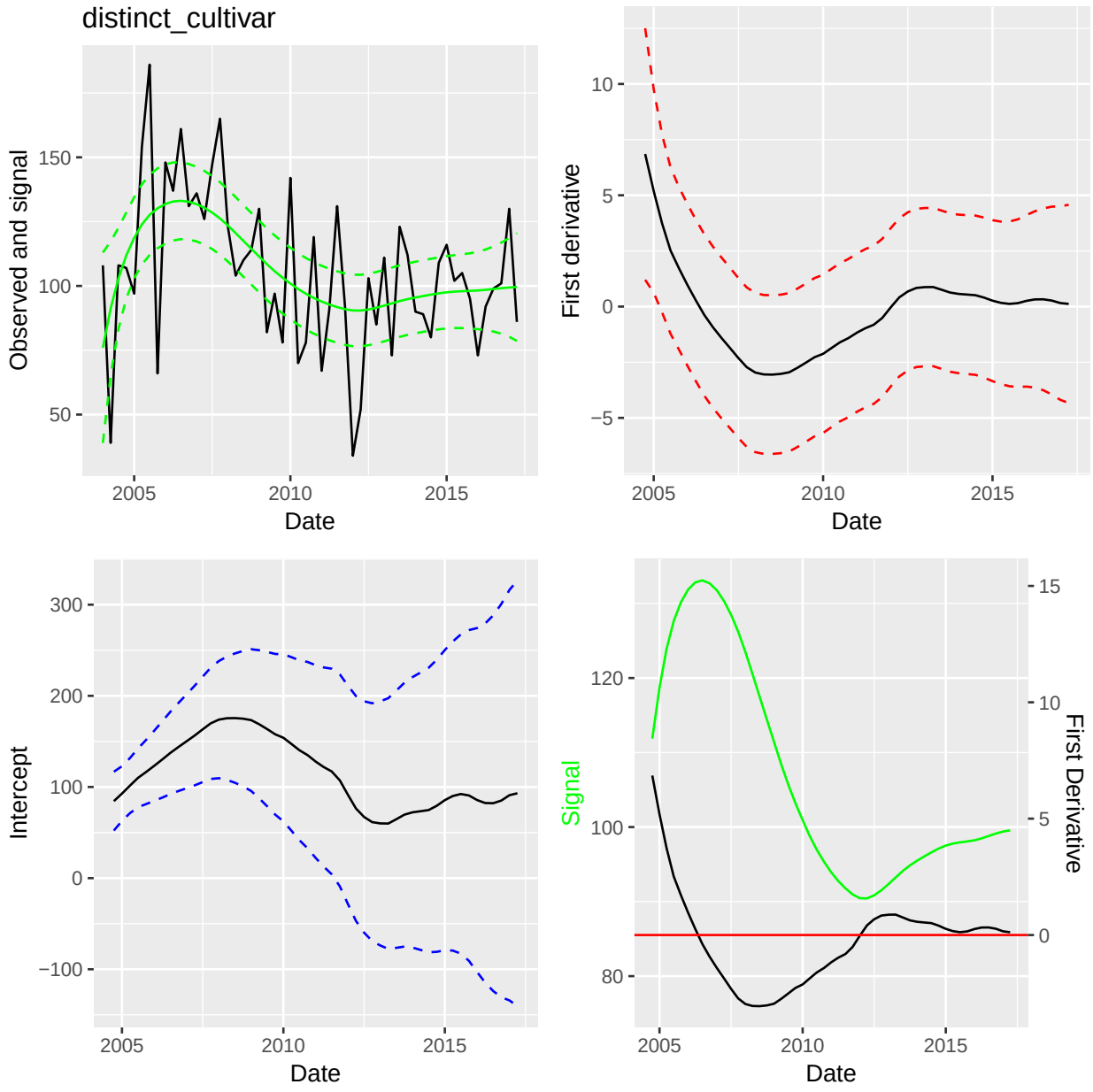

distinct_cultivar
Observed and signal
150
100
50
2005
2010
2015
Date
First derivative
10
5
0
−5
2005
2010
2015
Date
Intercept
300
200
100
0
−100
2005
2010
2015
Date
Signal
120
100
80
First Derivative
15
10
5
0
2005
2010
2015
Date

Figure 55:

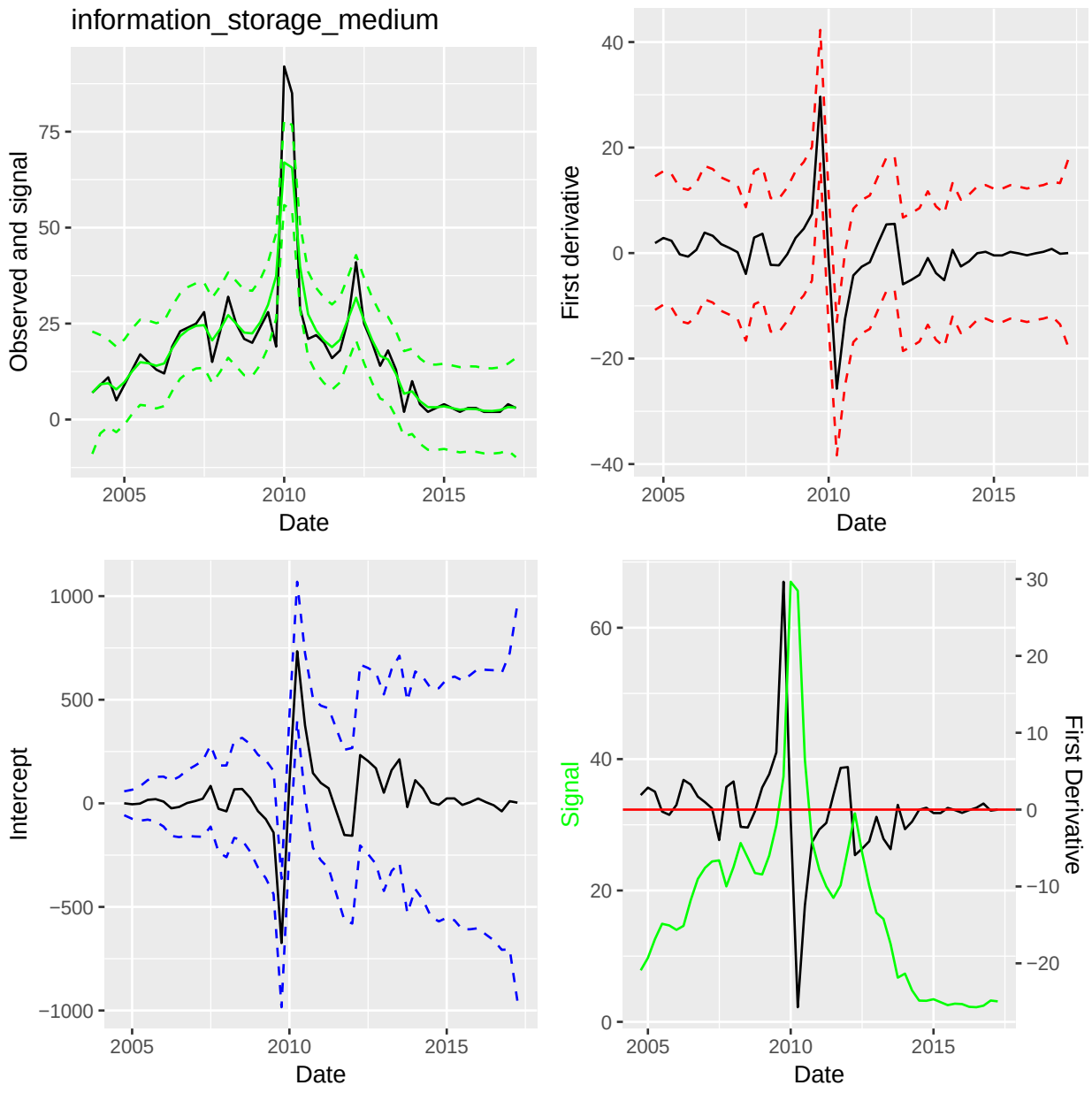

information_storage_medium
Observed and signal
75
50
25
0
2005
2010
2015
Date
First derivative
40
20
0
−20
−40
2005
2010
2015
Date
Intercept
1000
500
0
−500
−1000
2005
2010
2015
Date
Signal
60
40
20
0
2005
2010
2015
Date
First Derivative
30
20
10
0
−10
−20

Figure 56:

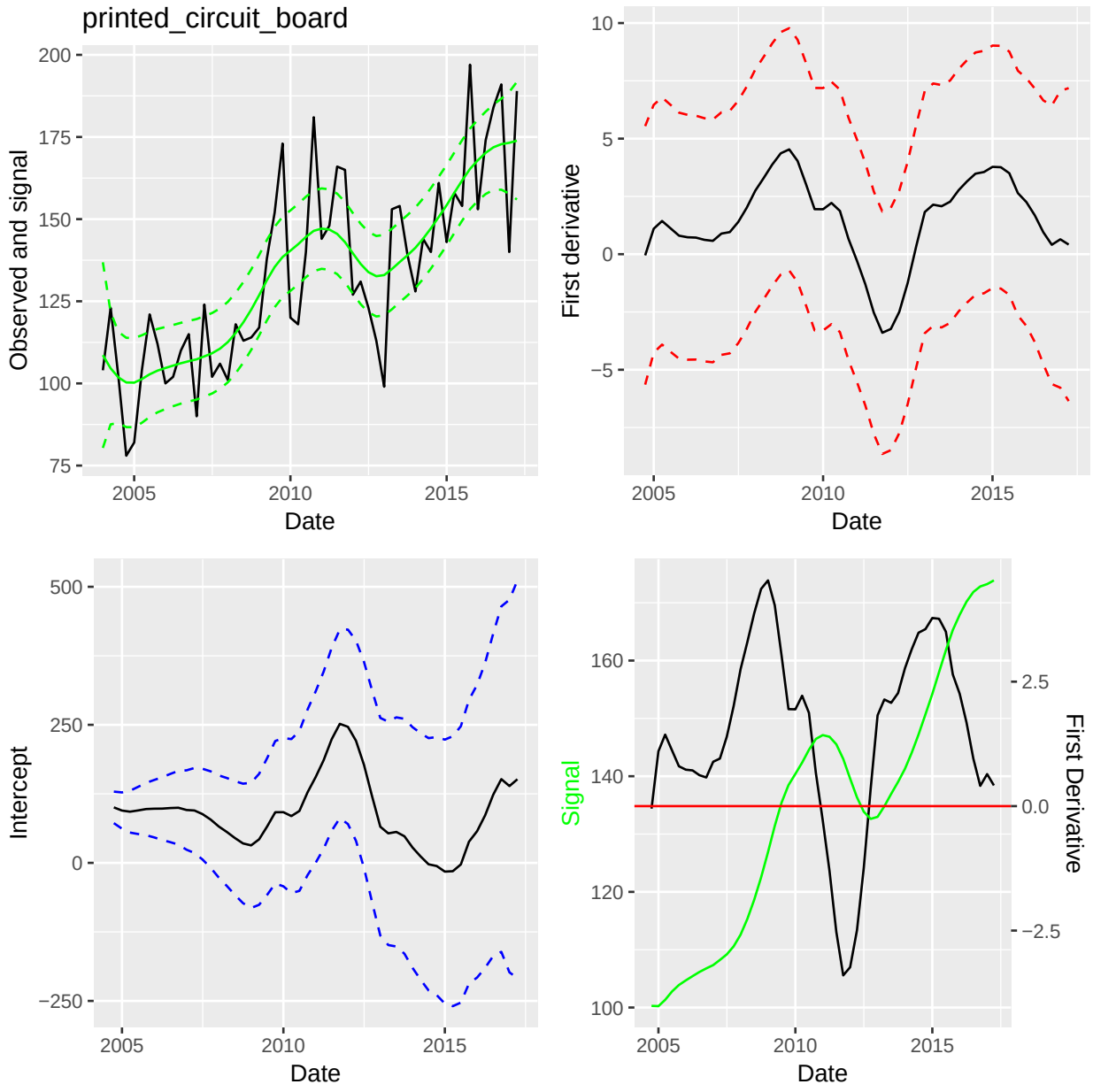

printed_circuit_board
Observed and signal
200
175
150
125
100
75
2005
2010
2015
Date
First derivative
10
5
0
−5
2005
2010
2015
Date
Intercept
500
250
0
−250
2005
2010
2015
Date
Signal
160
140
120
100
2.5
0.0
−2.5
First Derivative
2005
2010
2015
Date

Figure 57:

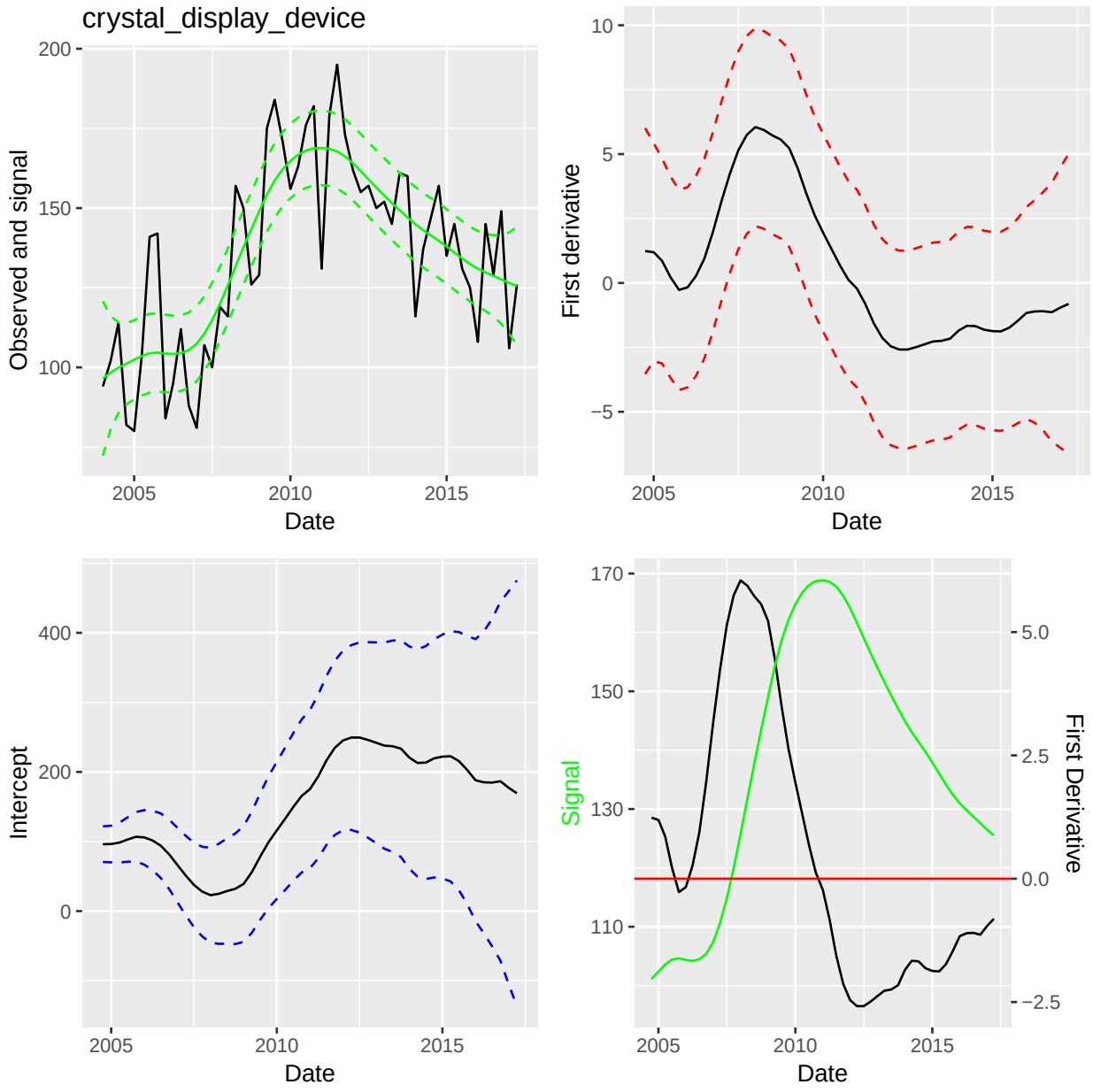

crystal_display_device
Observed and signal
200
150
100
2005
2010
2015
Date
First derivative
10
5
0
−5
2005
2010
2015
Date
Intercept
400
200
0
2005
2010
2015
Date
Signal
170
150
130
110
5.0
2.5
0.0
−2.5
First Derivative
2005
2010
2015
Date

Figure 58:

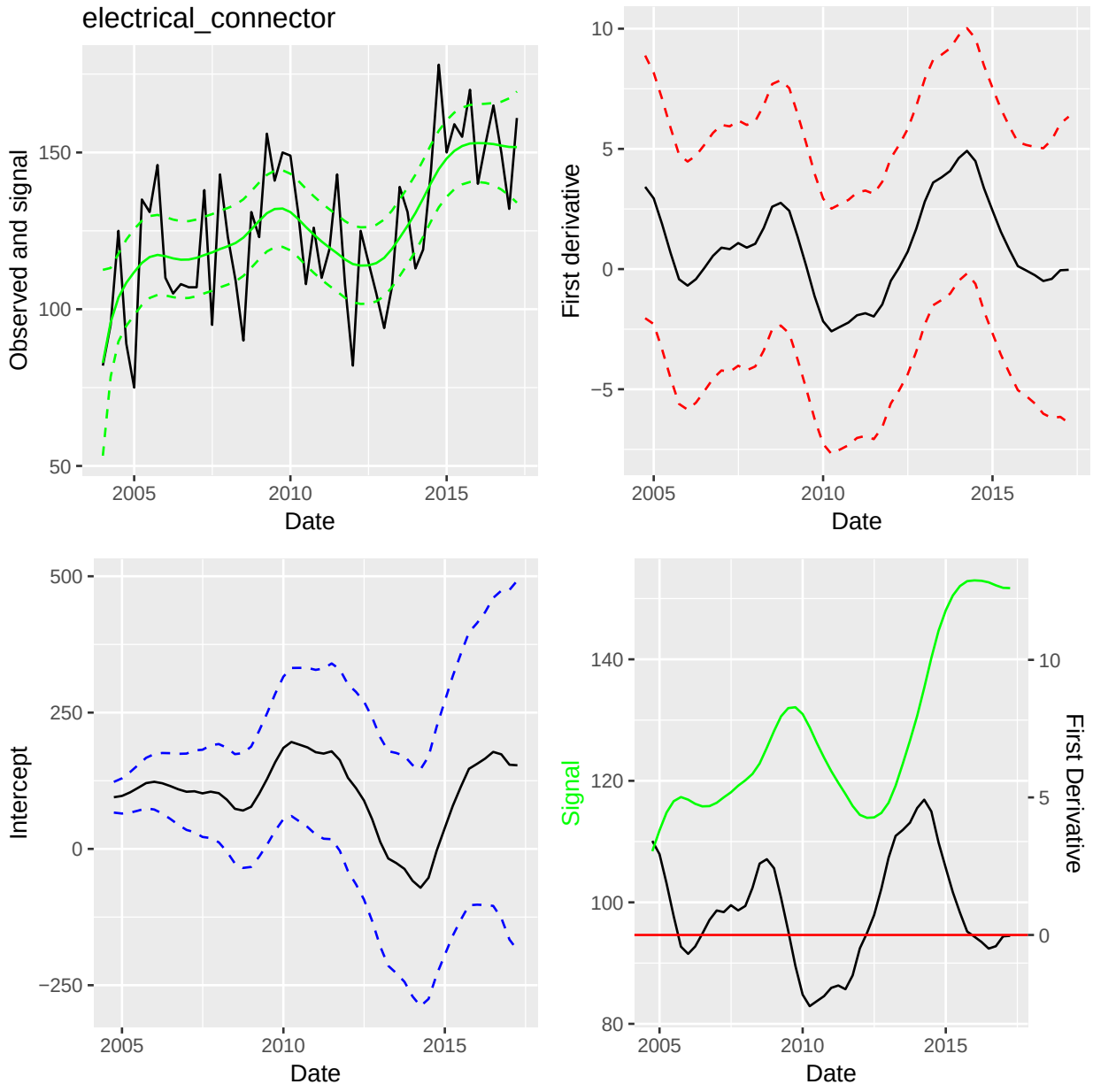

electrical_connector
Observed and signal
150
100
50
2005
2010
2015
Date
First derivative
10
5
0
−5
2005
2010
2015
Date
Intercept
500
250
0
−250
2005
2010
2015
Date
Signal
140
120
100
80
10
5
0
First Derivative
2005
2010
2015
Date

Figure 59:

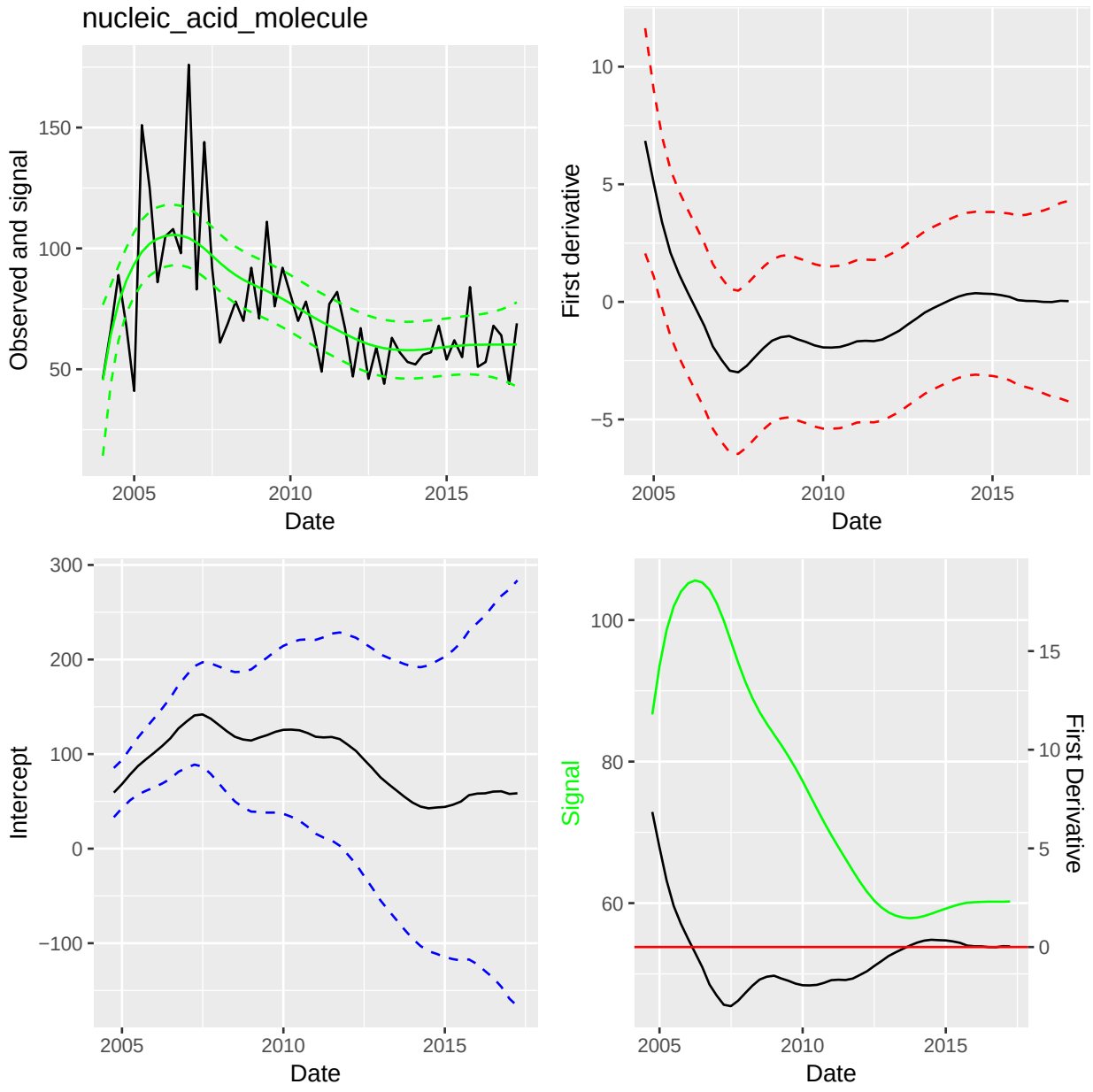

nucleic_acid_molecule
Observed and signal
150
100
50
2005
2010
2015
Date
First derivative
10
5
0
−5
2005
2010
2015
Date
Intercept
300
200
100
0
−100
2005
2010
2015
Date
Signal
100
80
60
First Derivative
15
10
5
0
2005
2010
2015
Date

Figure 60:

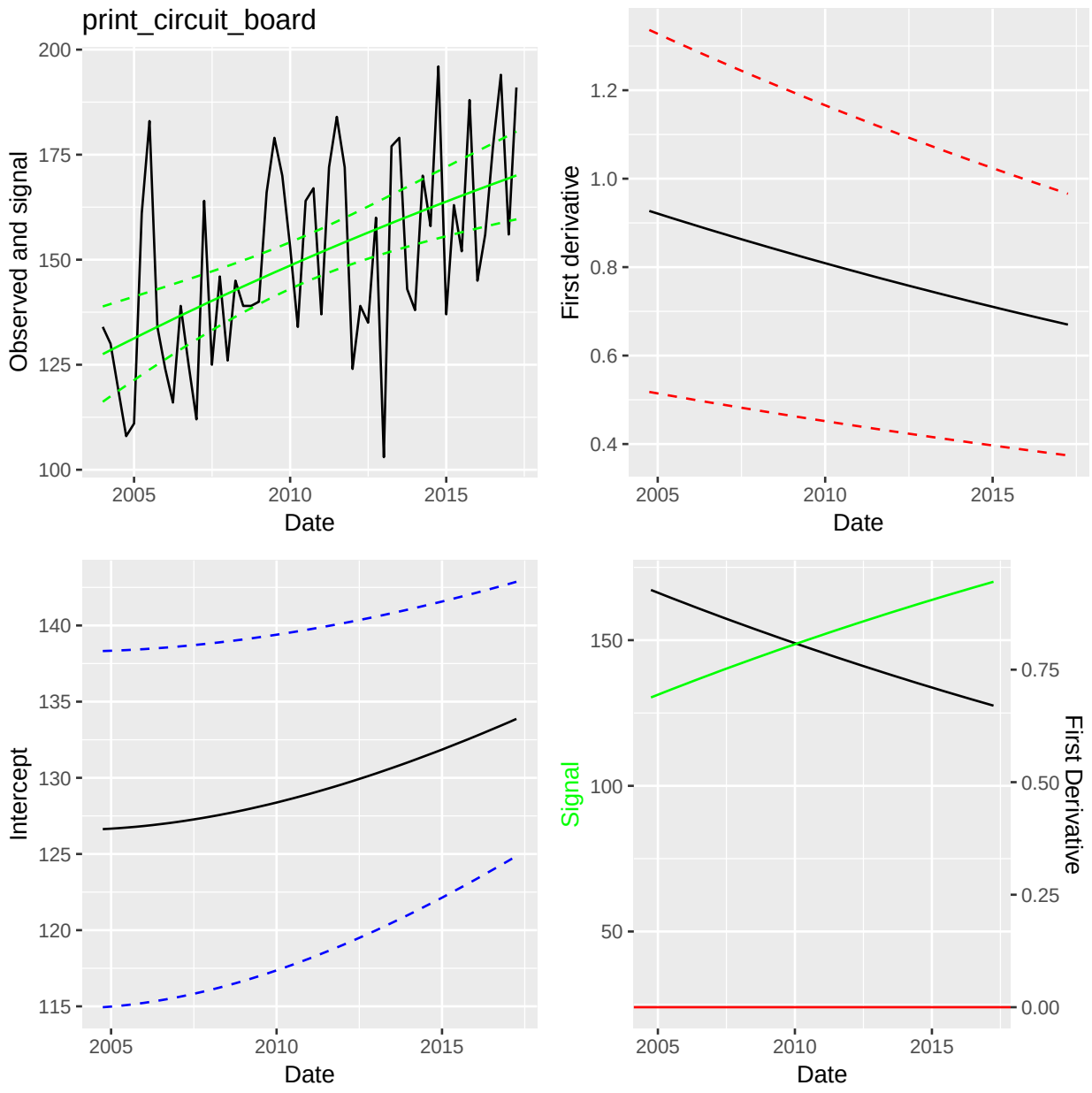

print_circuit_board
Observed and signal
Date
First derivative
Date
Intercept
Date
Signal
First Derivative
Date

Figure 61:

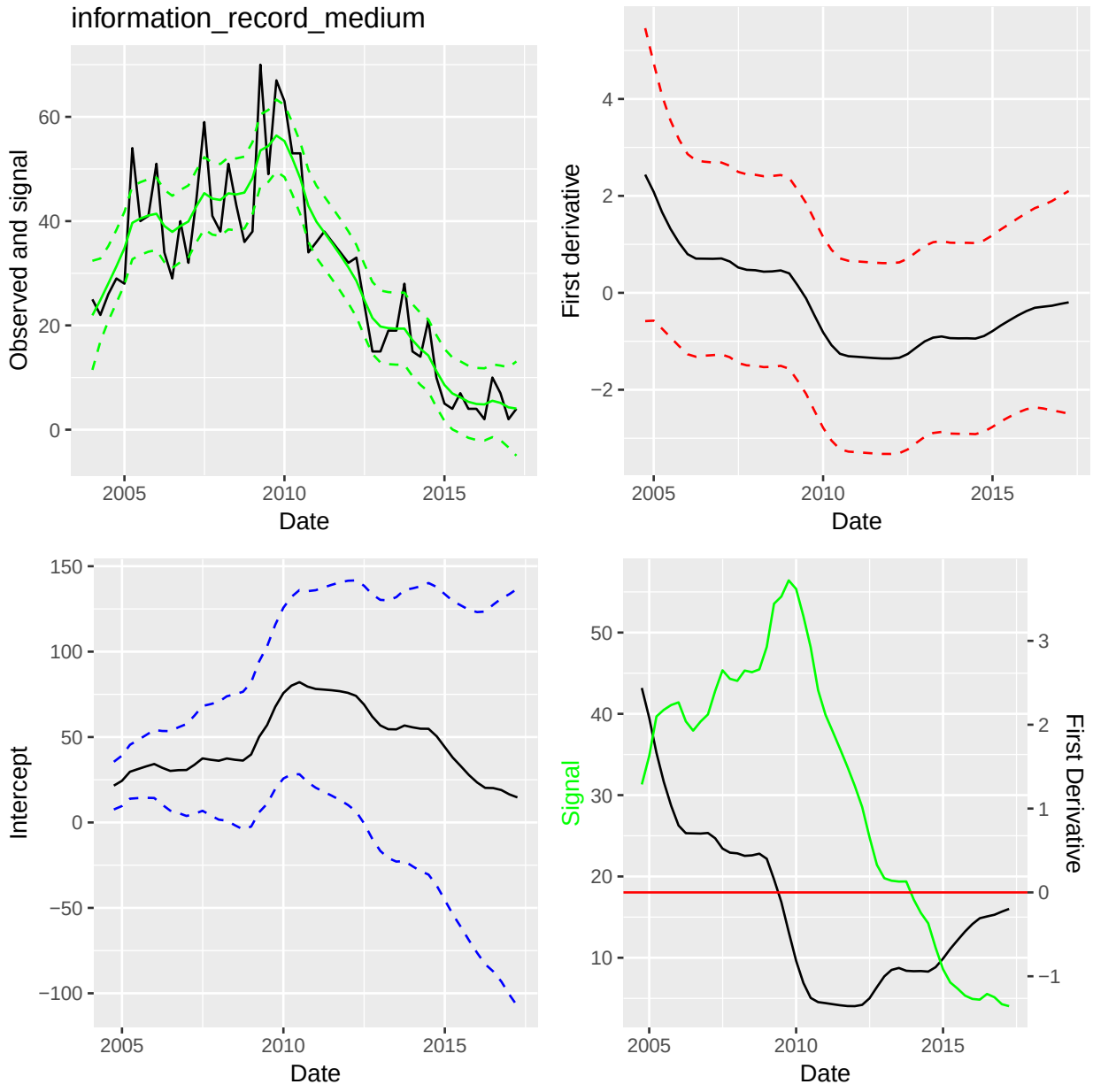

information_record_medium
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 62:

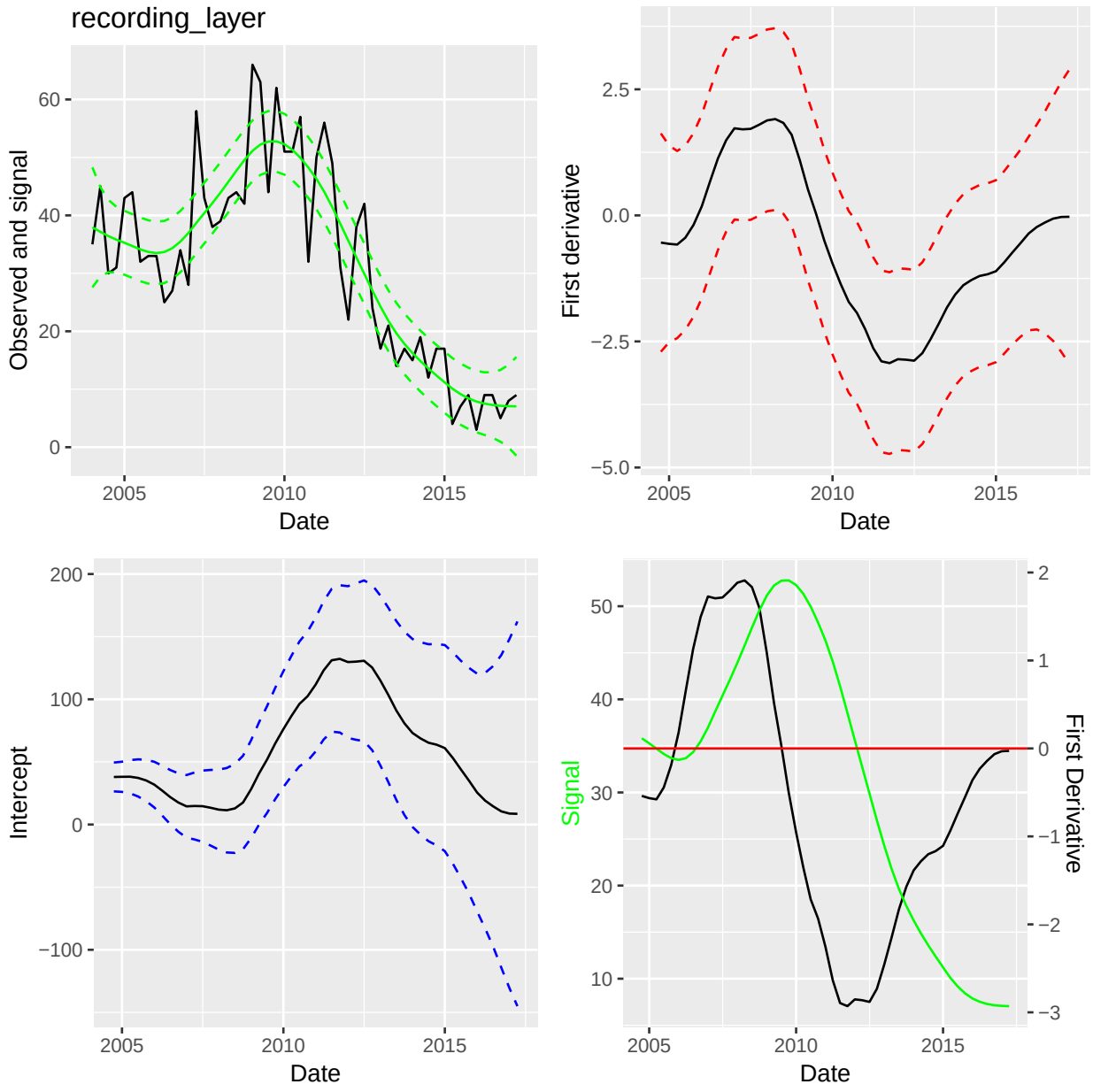

recording_layer
Observed and signal
Date
First derivative
Intercept
Signal
First Derivative

Figure 63:

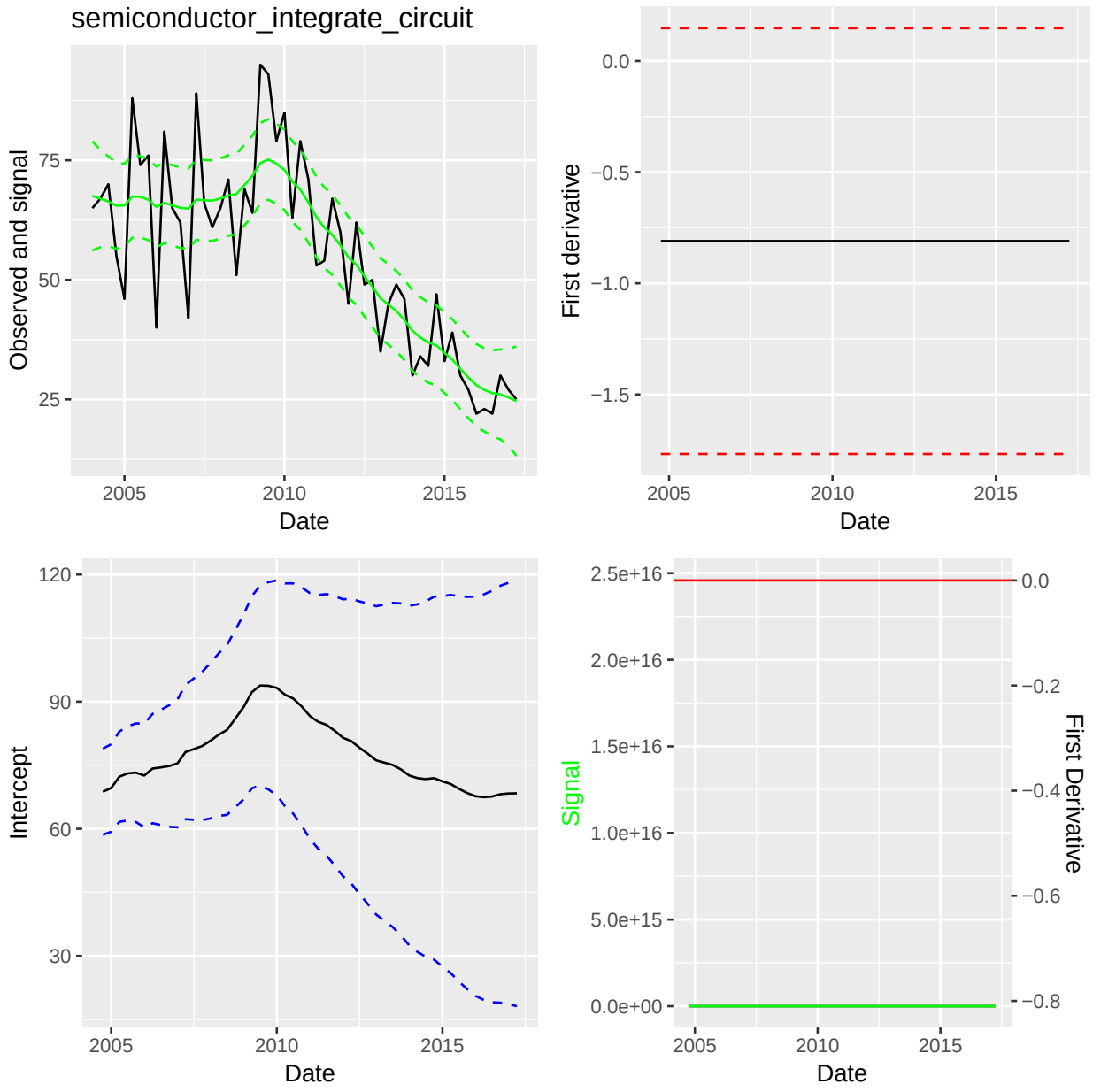

semiconductor_integrate_circuit
Observed and signal
75
50
25
2005
2010
2015
Date
First derivative
0.0
−0.5
−1.0
−1.5
2005
2010
2015
Date
Intercept
120
90
60
30
2005
2010
2015
Date
Signal
2.5e+16
2.0e+16
1.5e+16
1.0e+16
5.0e+15
0.0e+00
First Derivative
0.0
−0.2
−0.4
−0.6
−0.8
2005
2010
2015
Date

Figure 64:

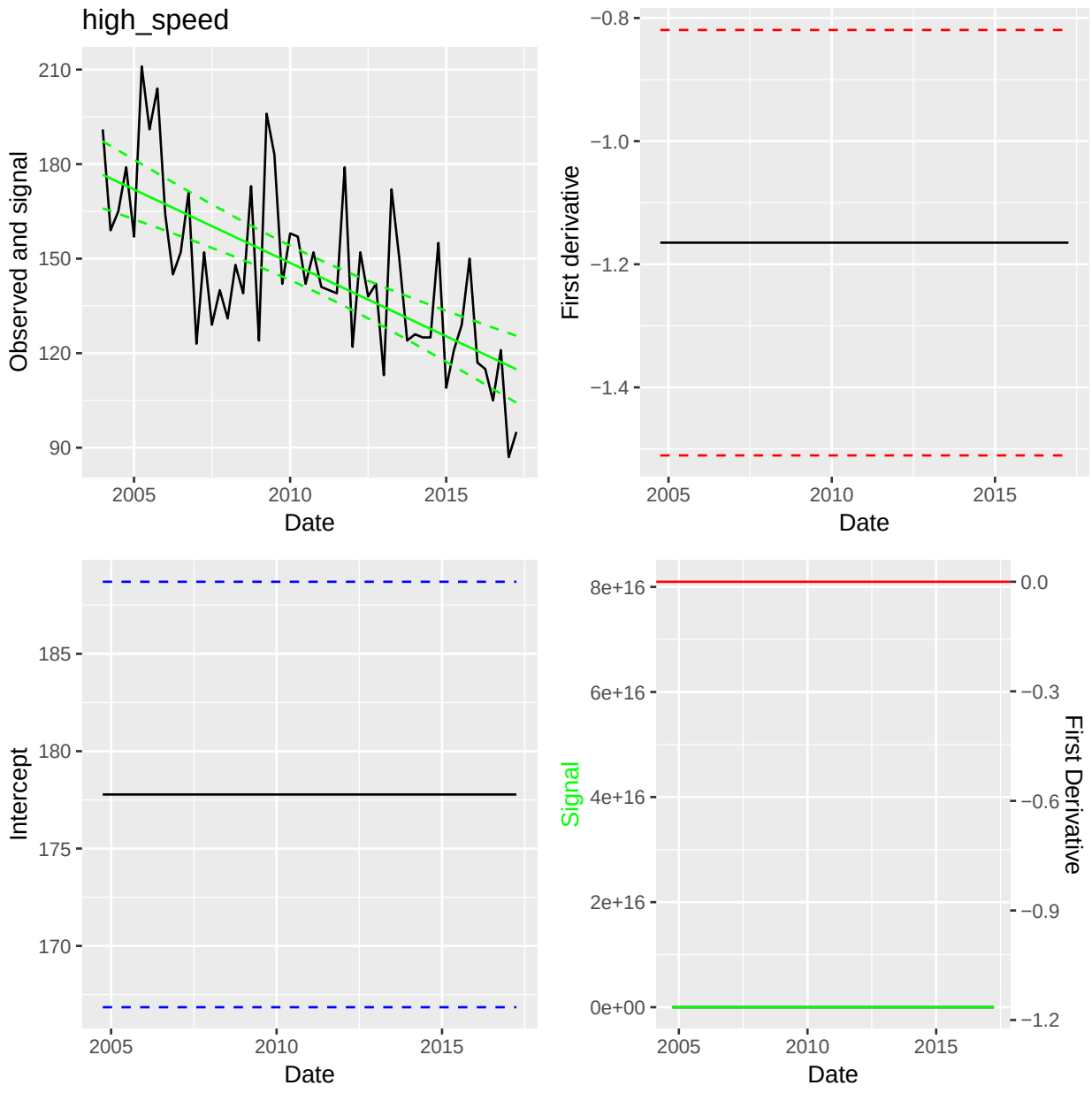

high_speed
Observed and signal
210
180
150
120
90
2005
2010
2015
Date
First derivative
−0.8
−1.0
−1.2
−1.4
Intercept
185
180
175
170
Signal
8e+16
6e+16
4e+16
2e+16
0e+00
First Derivative
0.0
−0.3
−0.6
−0.9
−1.2

Figure 65:

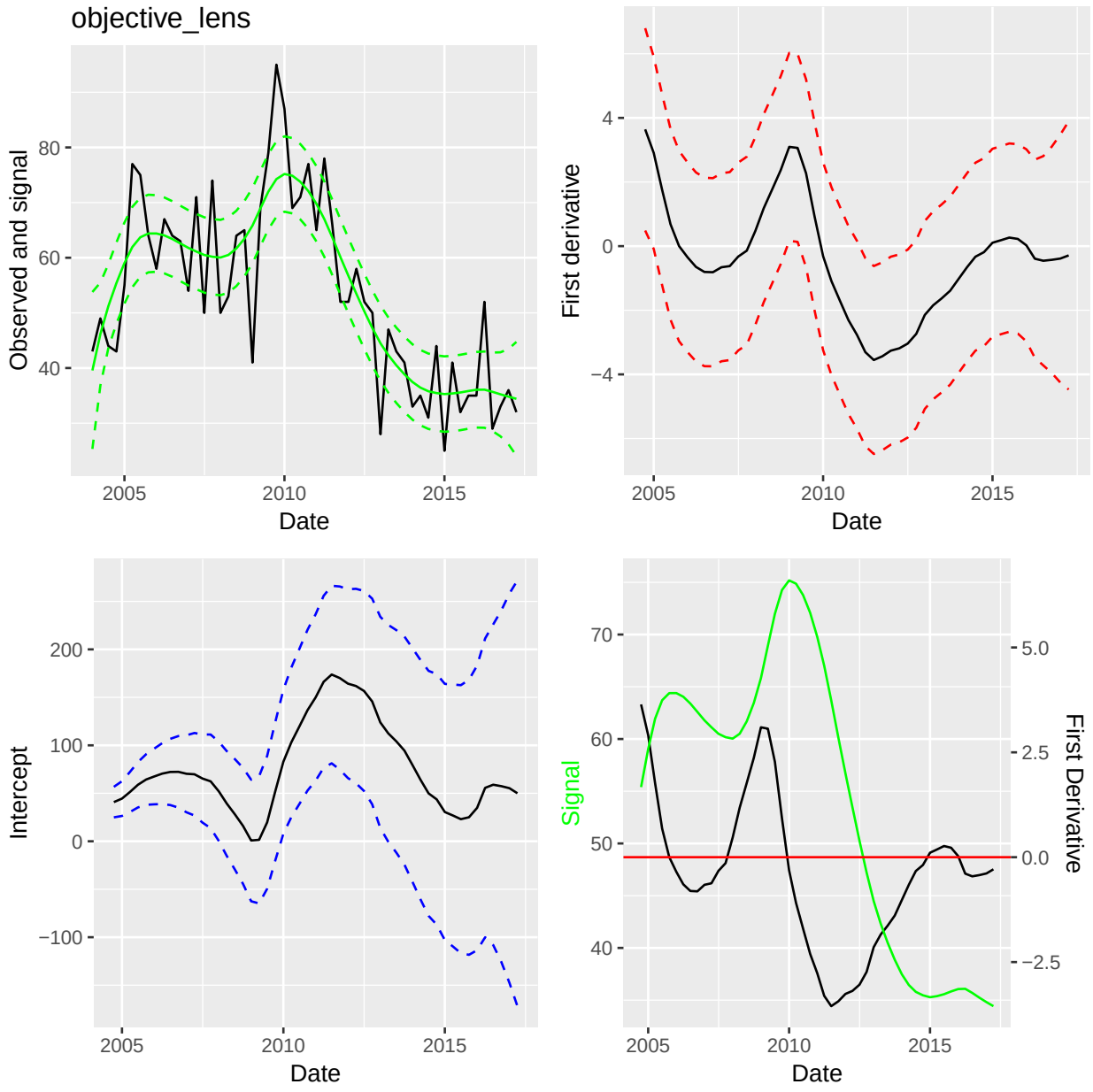

objective_lens
Observed and signal
80
60
40
2005
2010
2015
Date
First derivative
4
0
−4
2005
2010
2015
Date
Intercept
200
100
0
−100
2005
2010
2015
Date
Signal
70
60
50
40
5.0
2.5
0.0
−2.5
First Derivative
2005
2010
2015
Date

Figure 66:

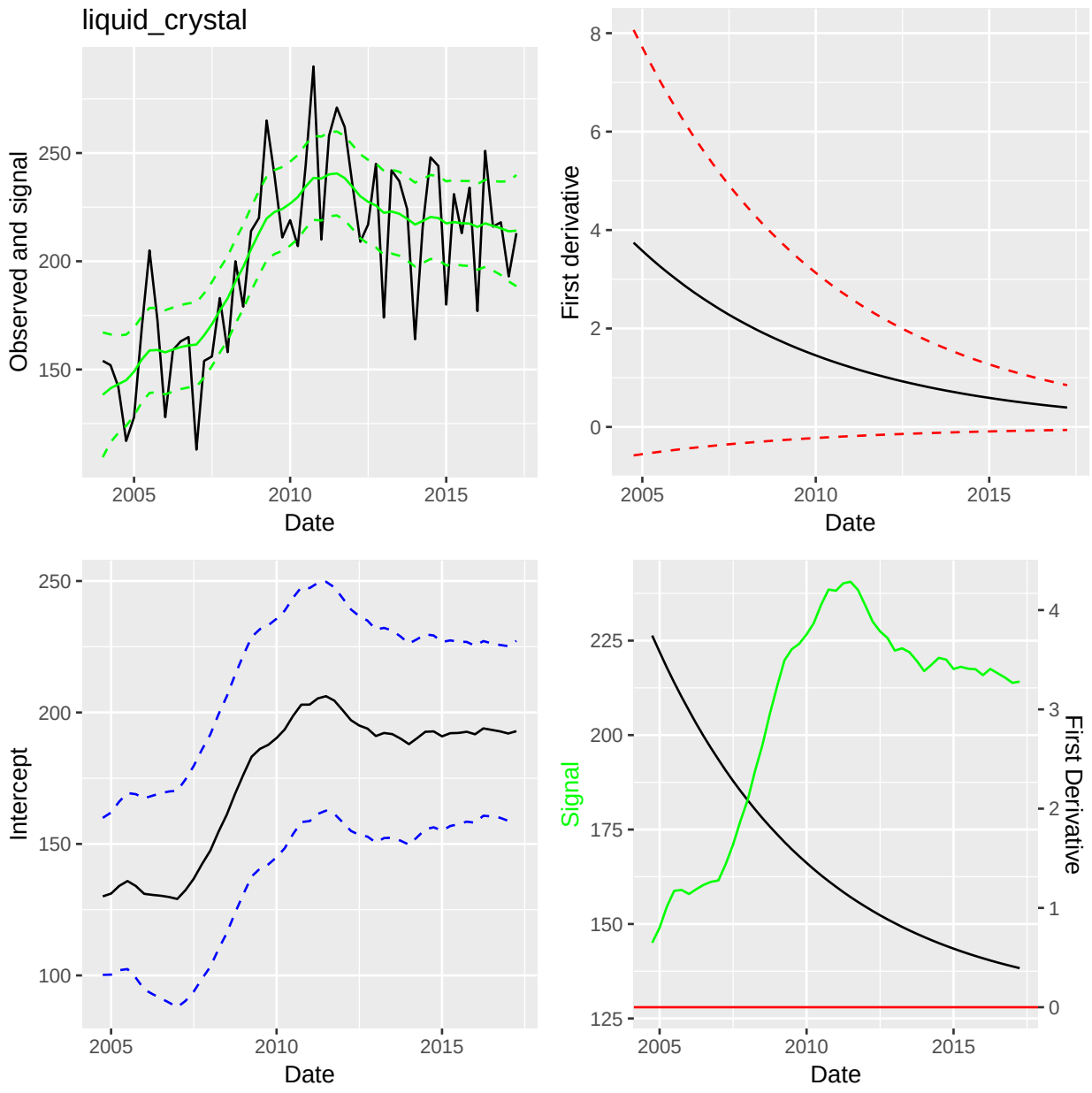

liquid_crystal
Observed and signal
250
200
150
2005
2010
2015
Date
First derivative
8
6
4
2
0
2005
2010
2015
Date
Intercept
250
200
150
100
2005
2010
2015
Date
Signal
First Derivative
225
200
175
150
125
4
3
2
1
0
2005
2010
2015
Date

Figure 67:

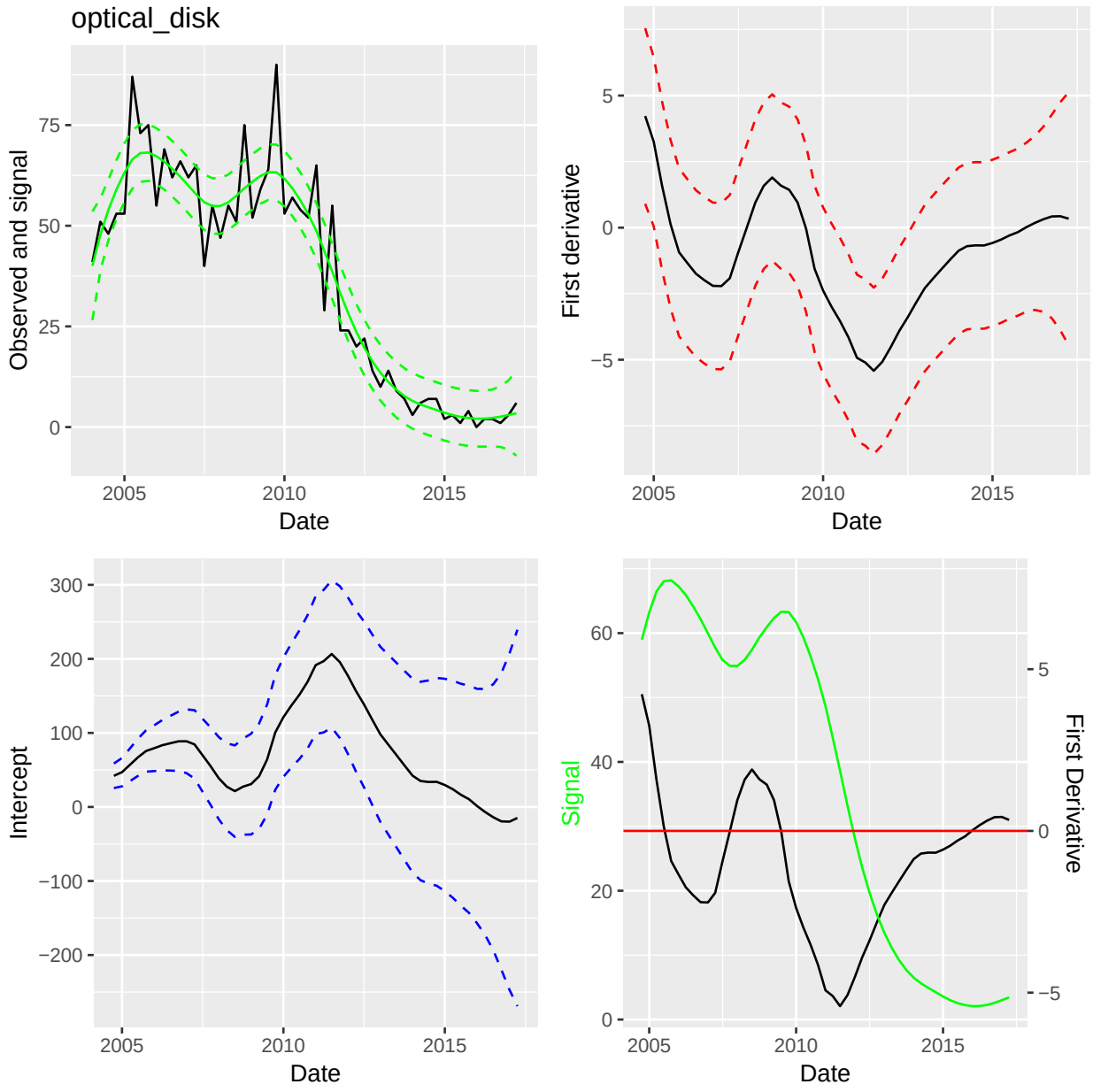

optical_disk
Observed and signal
75
50
25
0
2005
2010
2015
Date
First derivative
5
0
−5
2005
2010
2015
Date
Intercept
300
200
100
0
−100
−200
2005
2010
2015
Date
Signal
60
40
20
0
5
0
−5
First Derivative
2005
2010
2015
Date

Figure 68:

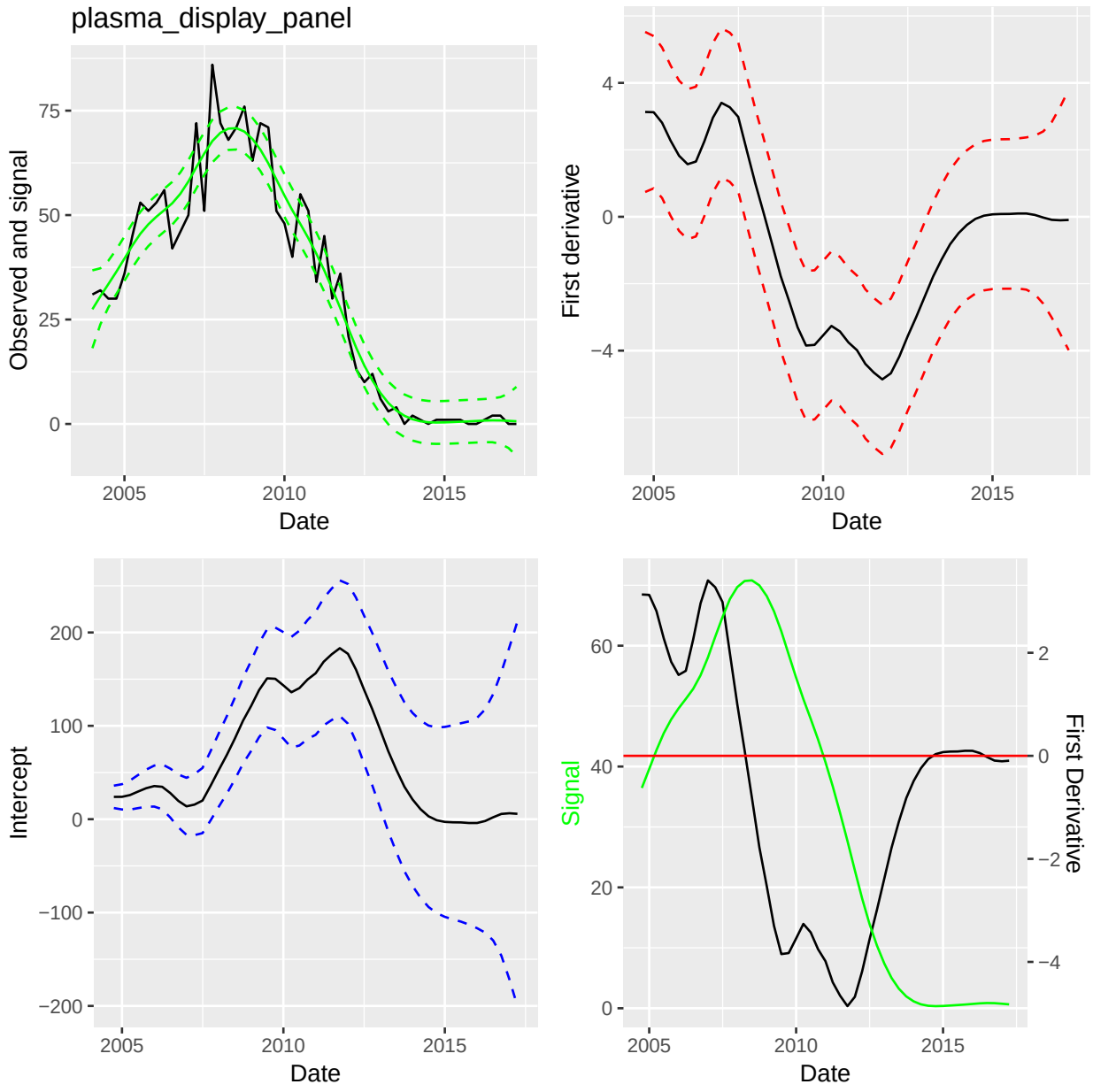

plasma_display_panel
Observed and signal
75
50
25
0
2005
2010
2015
Date
First derivative
4
0
−4
2005
2010
2015
Date
Intercept
200
100
0
−100
−200
2005
2010
2015
Date
Signal
60
40
20
0
2
0
−2
−4
First Derivative
2005
2010
2015
Date

Figure 69:

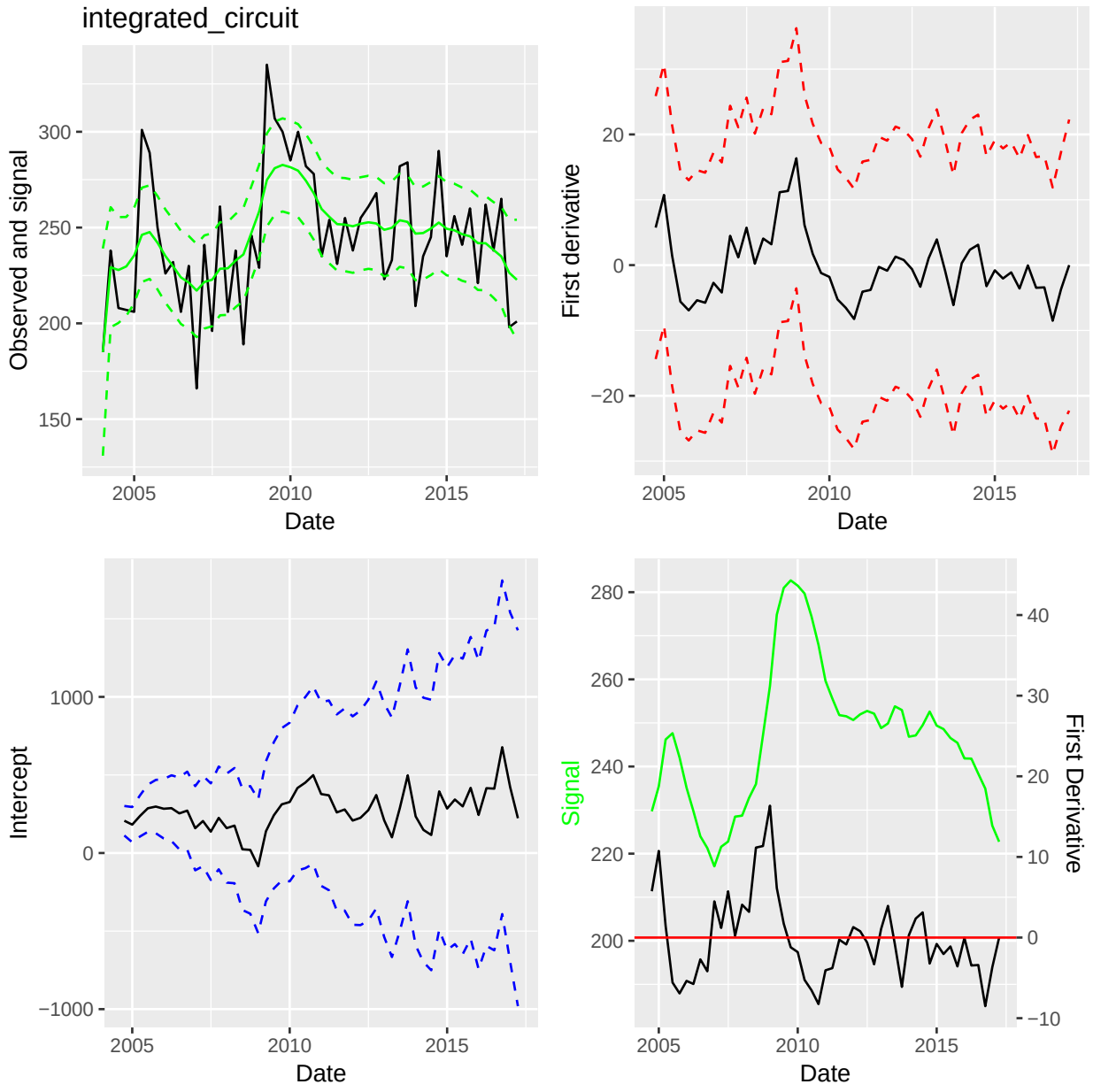

integrated_circuit
Observed and signal
300
250
200
150
2005
2010
2015
Date
First derivative
20
0
−20
2005
2010
2015
Date
Intercept
1000
0
−1000
2005
2010
2015
Date
Signal
280
260
240
220
200
2005
2010
2015
Date
First Derivative
40
30
20
10
0
−10

Figure 70:

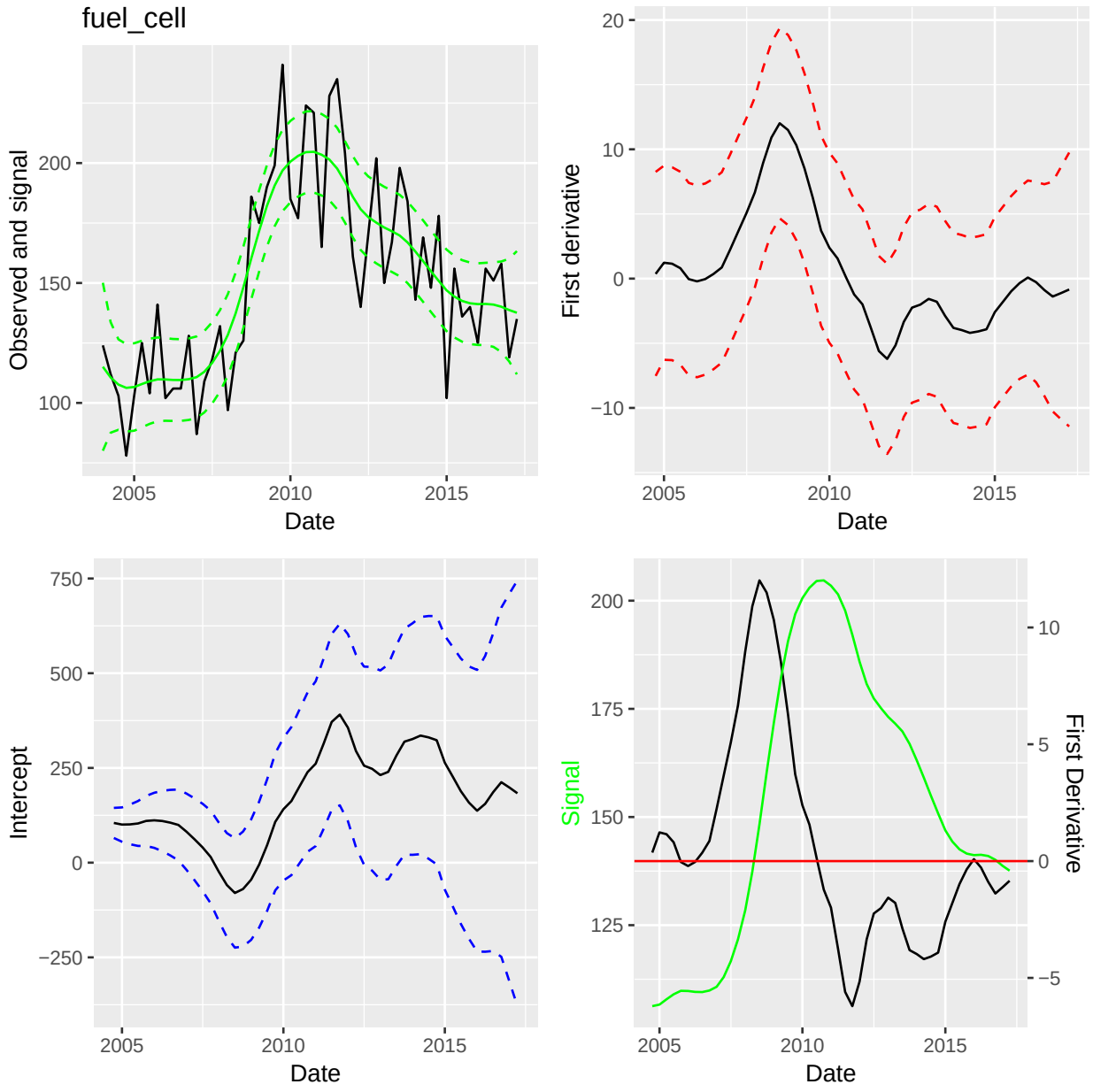

fuel_cell
Observed and signal
200
150
100
2005
2010
2015
Date
First derivative
20
10
0
−10
2005
2010
2015
Date
Intercept
750
500
250
0
−250
2005
2010
2015
Date
Signal
200
175
150
125
10
5
0
−5
First Derivative
2005
2010
2015
Date

Figure 71:

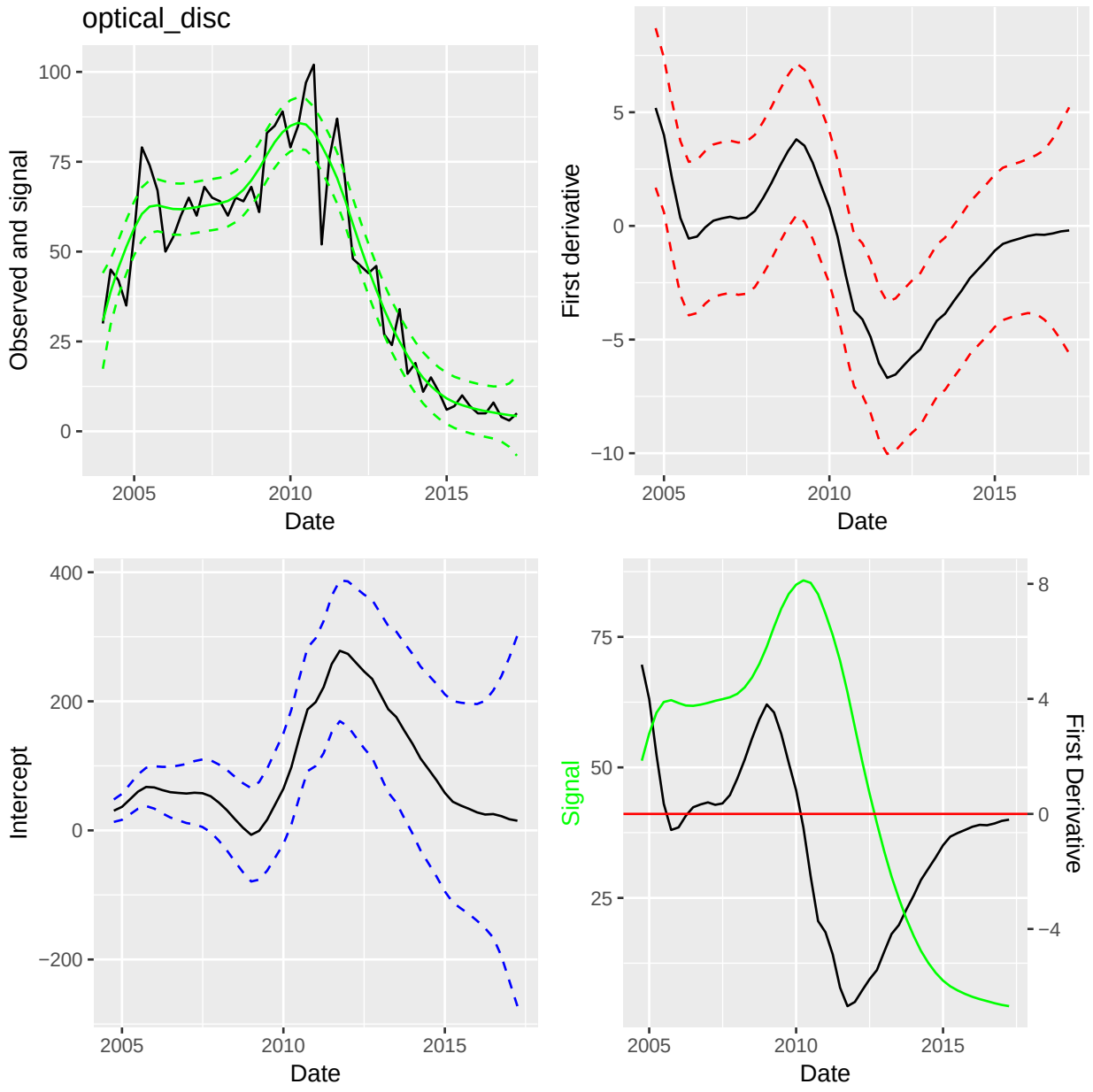

optical_disc
Observed and signal
100
75
50
25
0
2005
2010
2015
Date
First derivative
5
0
−5
−10
2005
2010
2015
Date
Intercept
400
200
0
−200
2005
2010
2015
Date
Signal
75
50
25
8
4
0
−4
First Derivative
2005
2010
2015
Date

Figure 72:

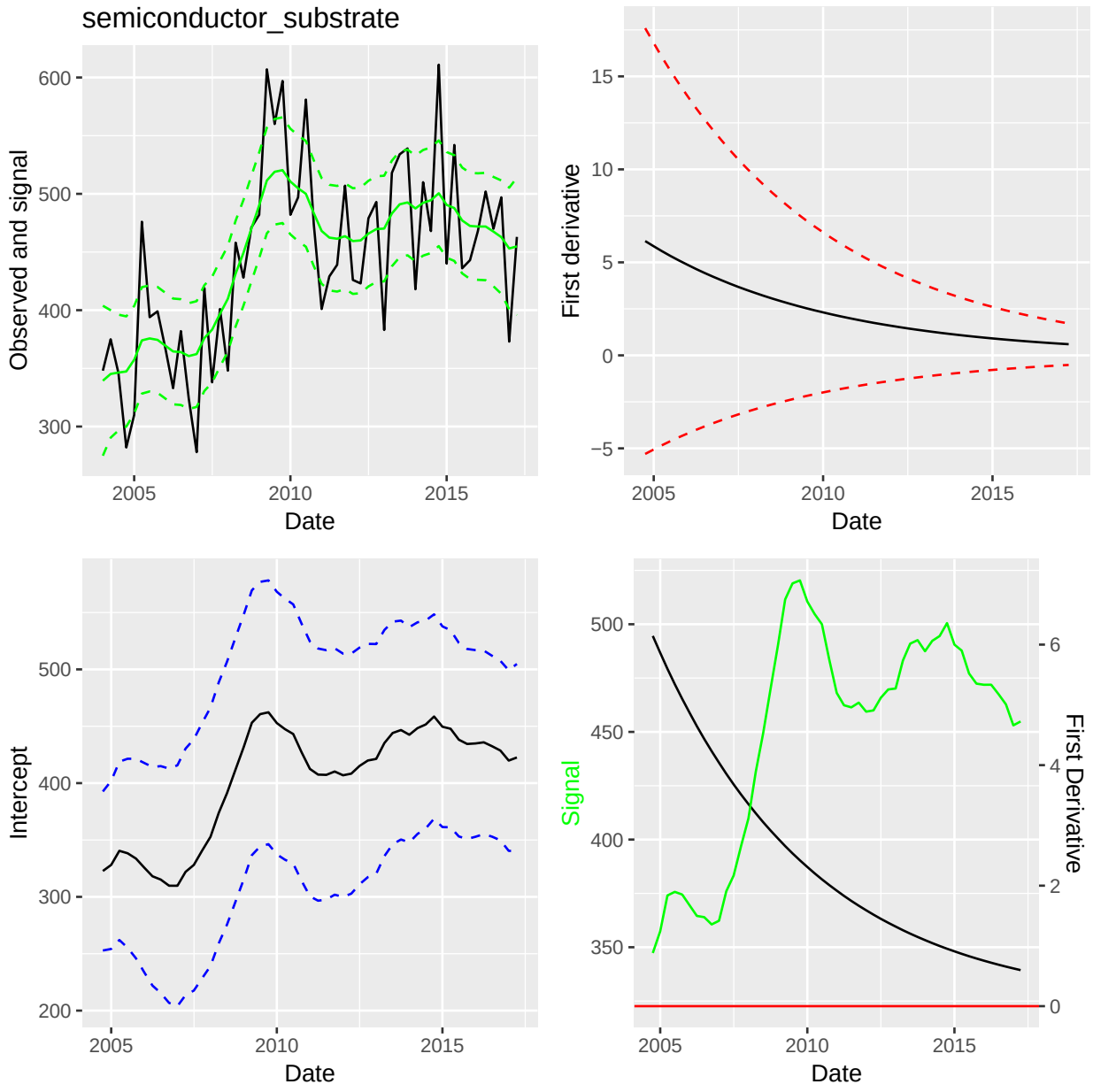

semiconductor_substrate
Observed and signal
600
500
400
300
2005
2010
2015
Date
First derivative
15
10
5
0
−5
2005
2010
2015
Date
Intercept
500
400
300
200
2005
2010
2015
Date
Signal
500
450
400
350
First Derivative
6
4
2
0
2005
2010
2015
Date

Figure 73:

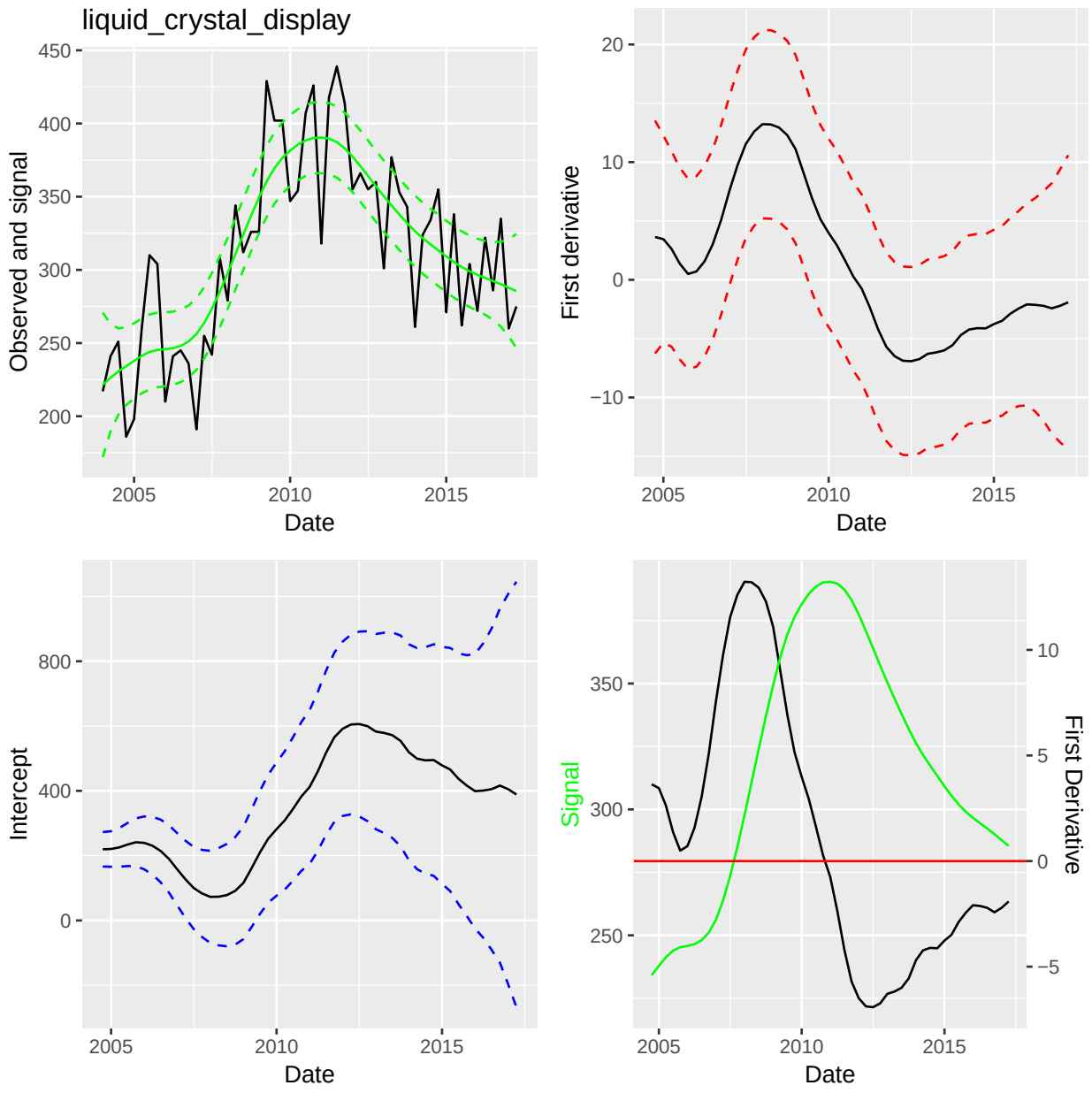

liquid_crystal_display
Observed and signal
450
400
350
300
250
200
2005
2010
2015
Date
First derivative
20
10
0
−10
2005
2010
2015
Date
Intercept
800
400
0
2005
2010
2015
Date
Signal
350
300
250
First Derivative
10
5
0
−5
2005
2010
2015
Date

Figure 74: