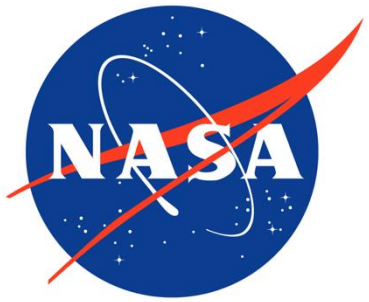


Predicting trend errors in the presence of data gaps

Mark T. Richardson[1], Matthew D. Lebsock[1], R. Chris Wilson[1], Joao Teixeira[1], Maria Z. Hakuba[1]

markr@jpl.nasa.gov

[1]Jet Propulsion Laboratory, California Institute of Technology

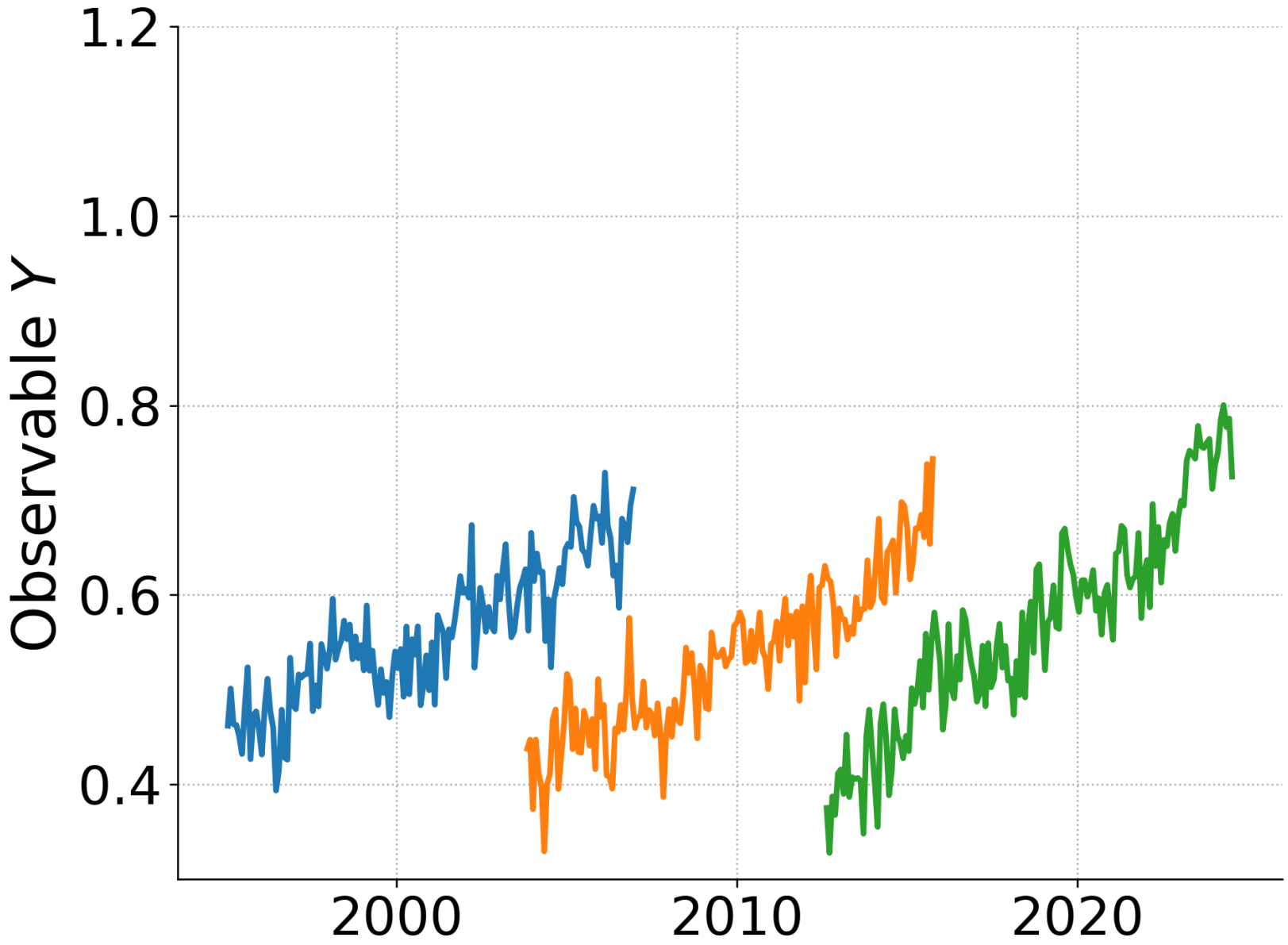
DISCLAIMER: During the preparation of this work the author(s) used Google Gemini in order to generate cartoons. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

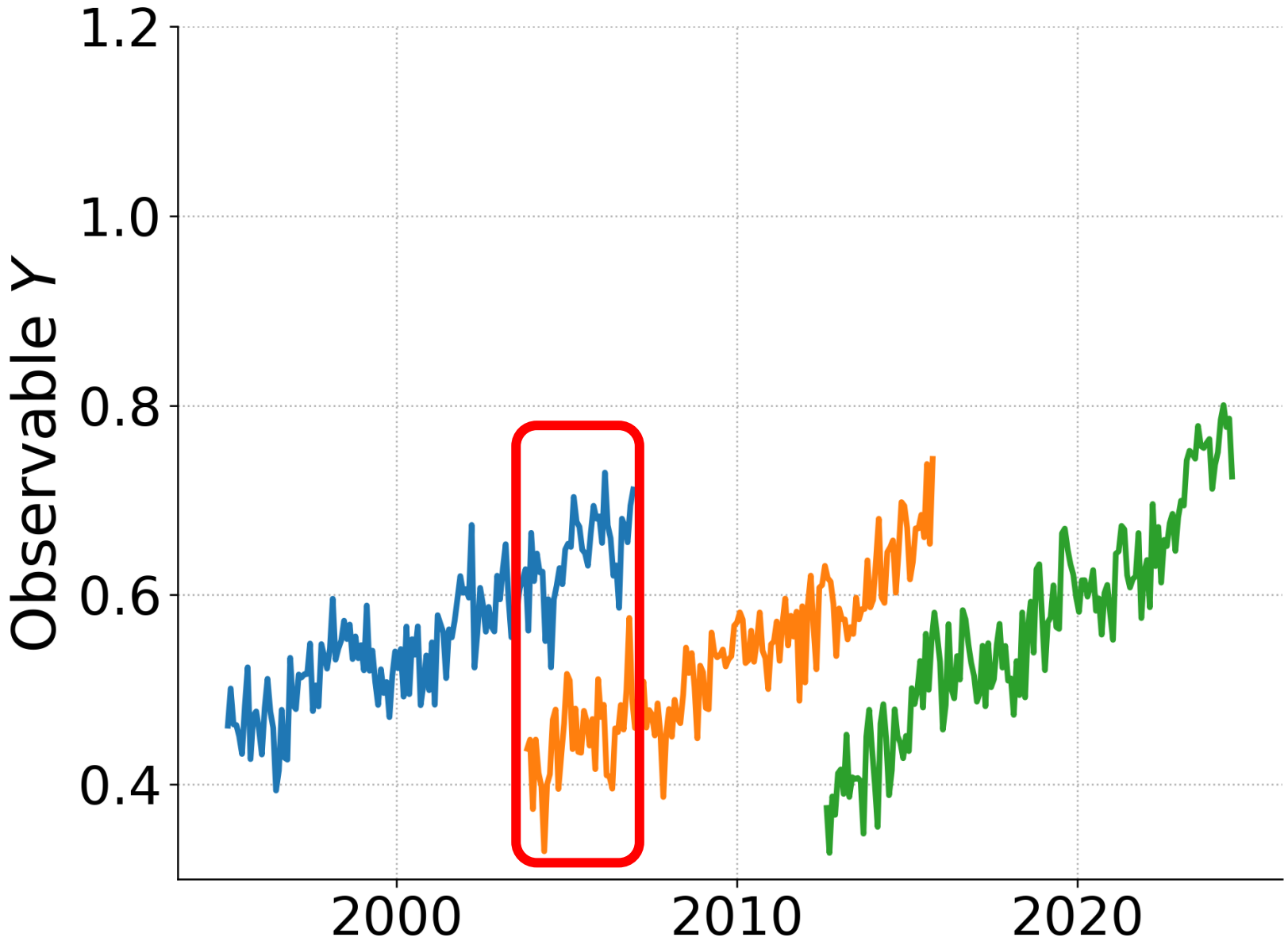
Image source: Google Gemini

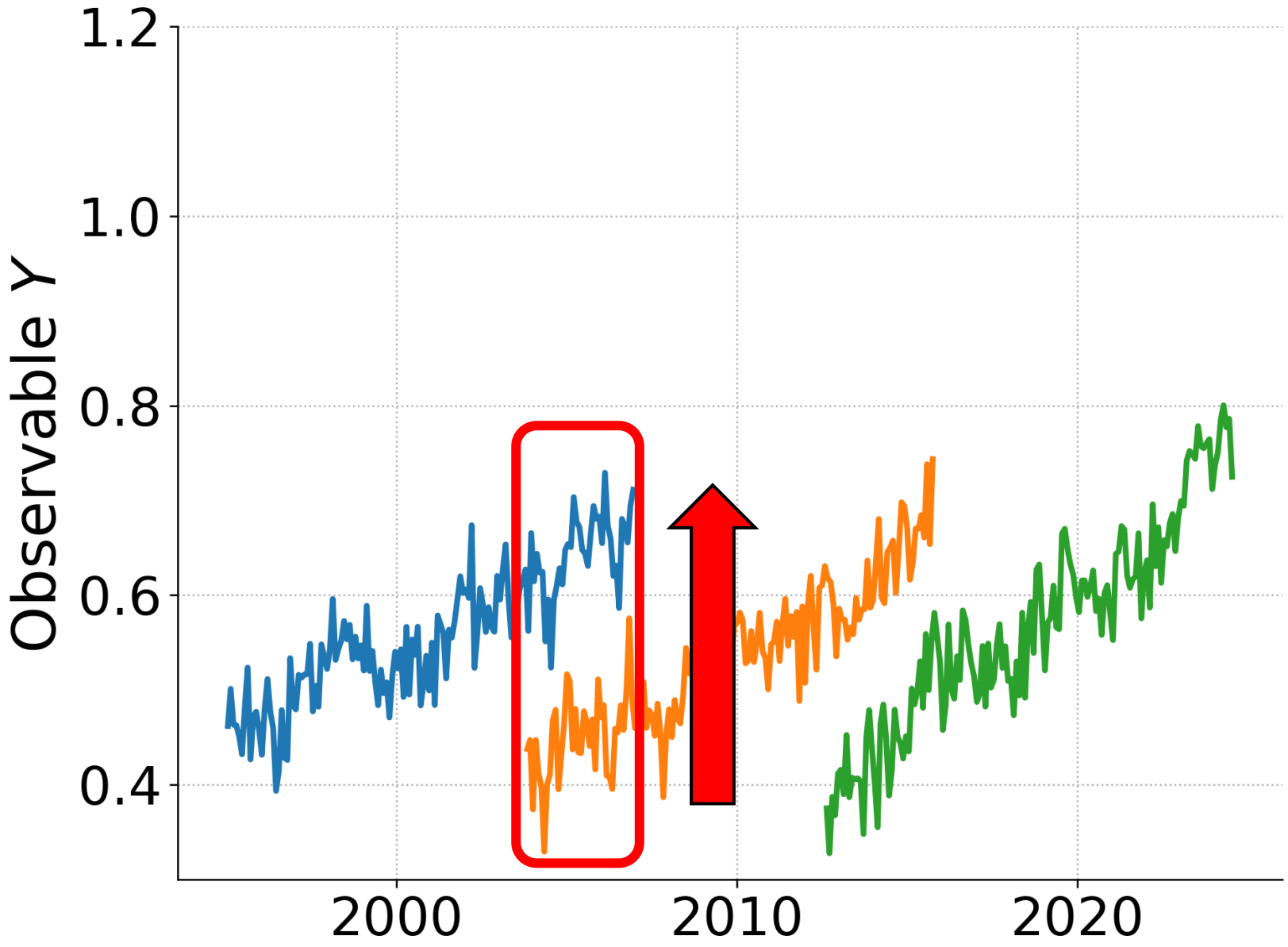
Libera is on its way!

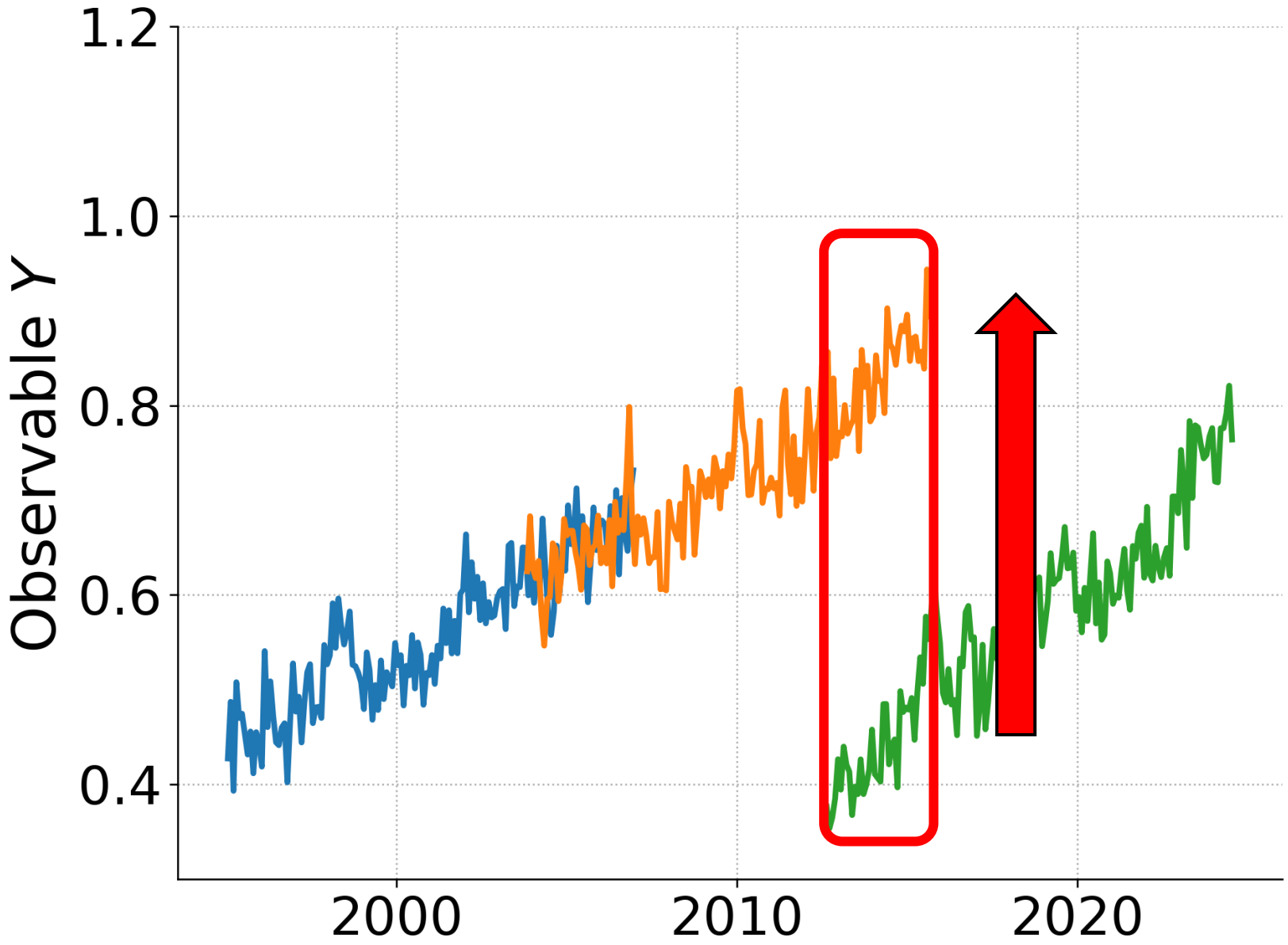
Image source: Google Gemini

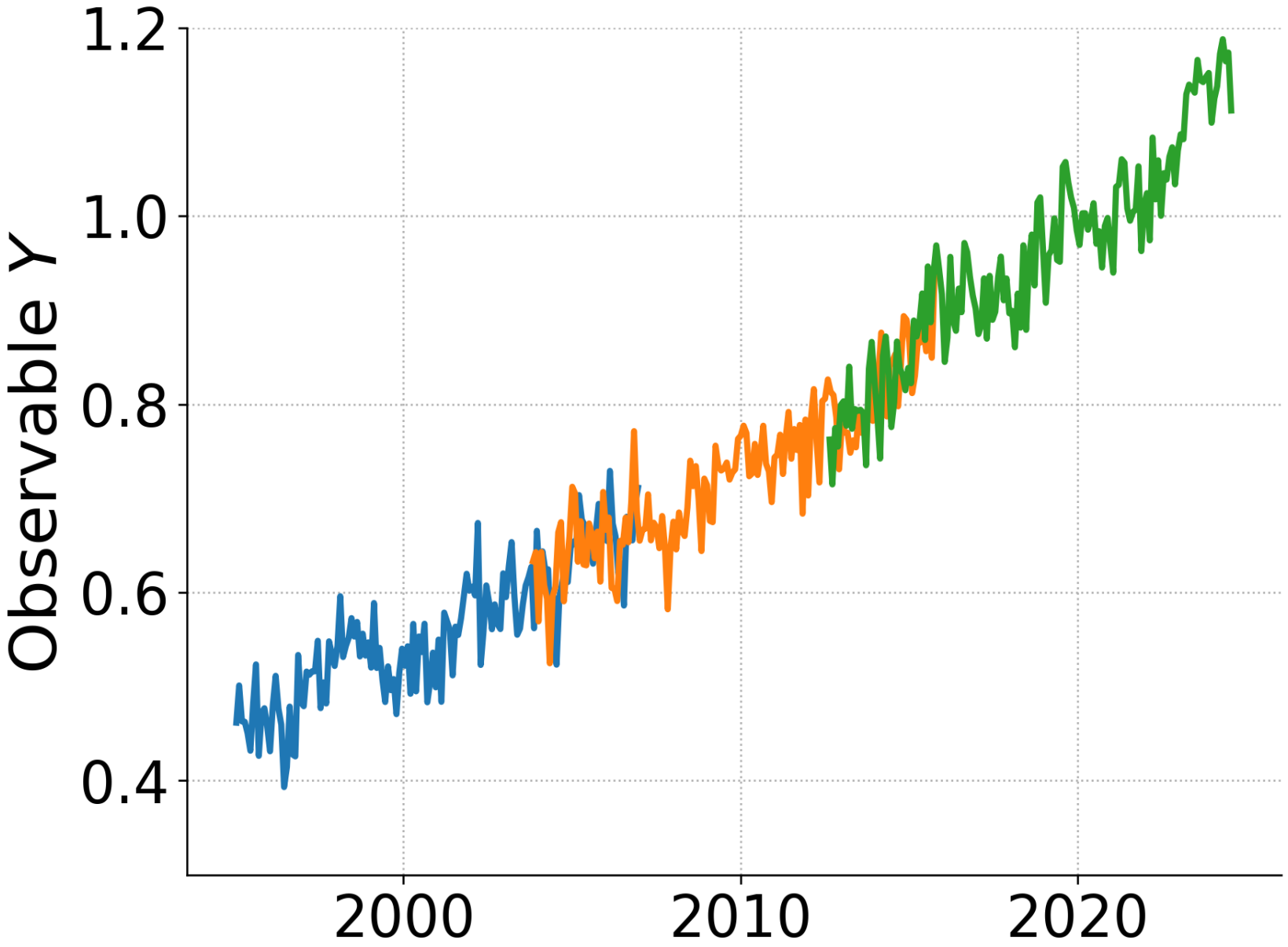
Image source: Google Gemini

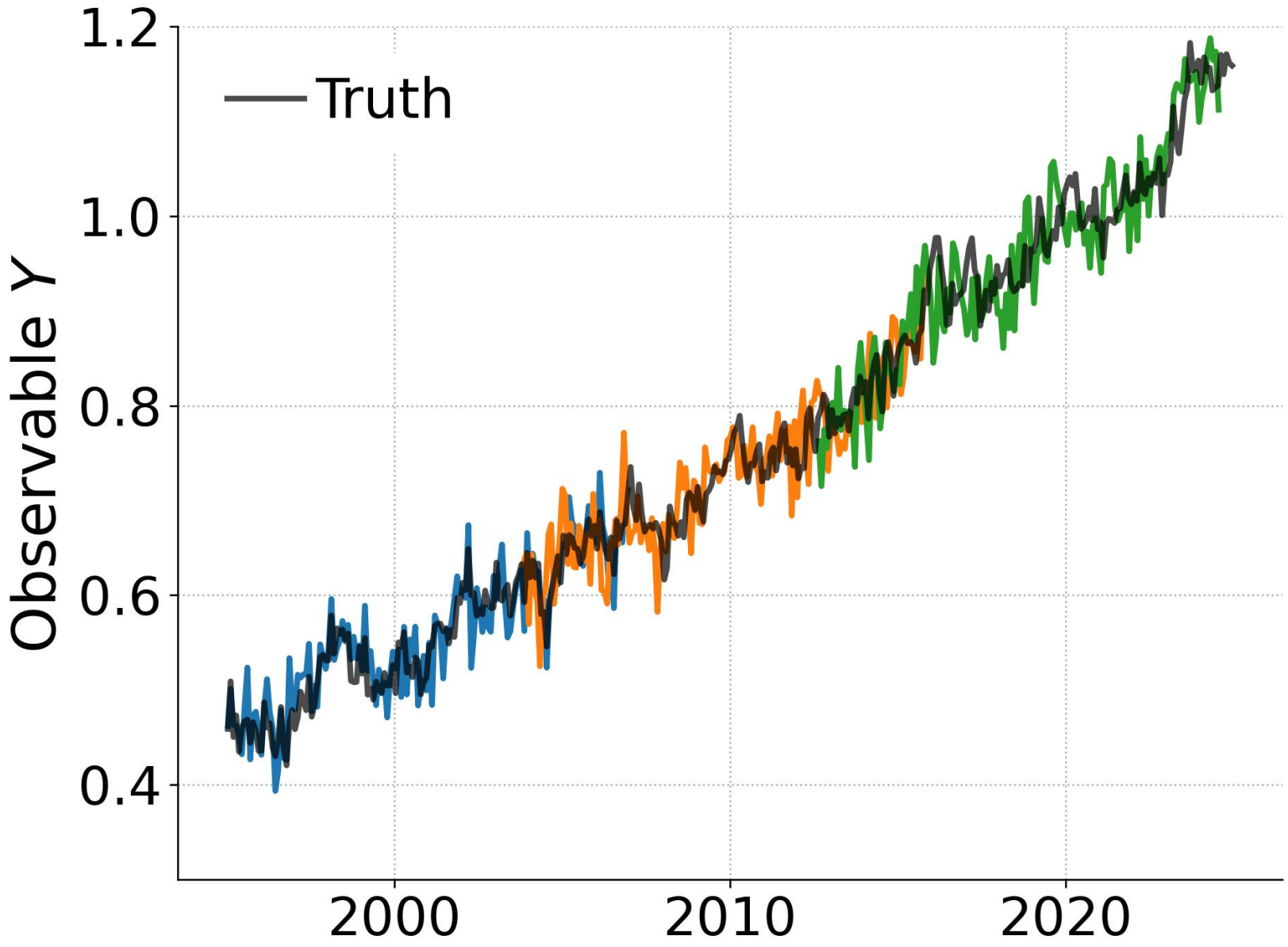

1.2
1.0
0.8
0.6
0.4
Observable Y
2000
2010
2020


1.2
1.0
0.8
0.6
0.4
Observable Y
2000
2010
2020


1.2
1.0
0.8
0.6
0.4
Observable Y
2000
2010
2020

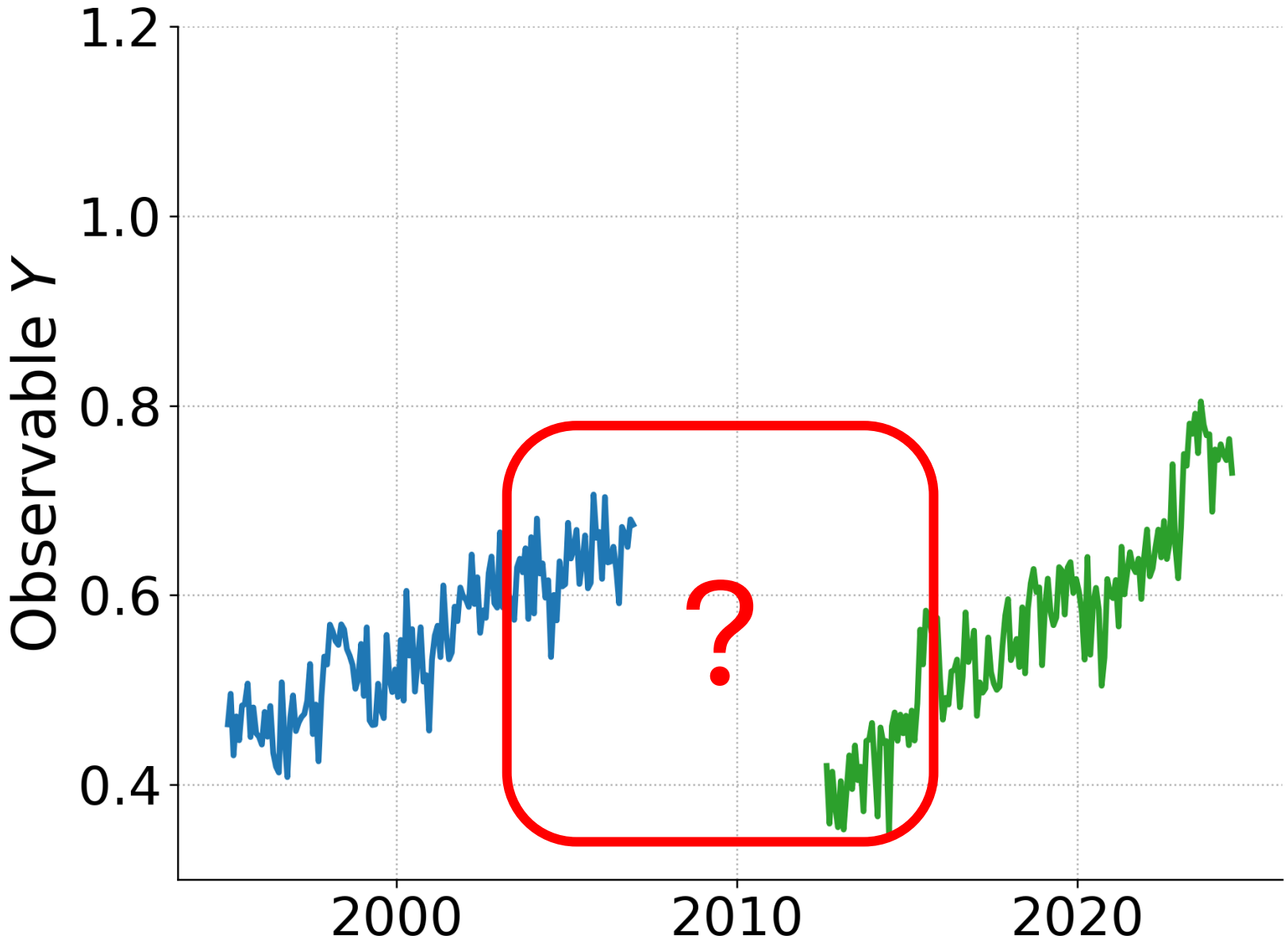

1.2
1.0
0.8
0.6
0.4
Observable Y
2000
2010
2020


Observable Y
1.2
1.0
0.8
0.6
0.4
2000
2010
2020


Truth
Observable Y
1.2
1.0
0.8
0.6
0.4
2000
2010
2020

But what if...

Image source: Google Gemini

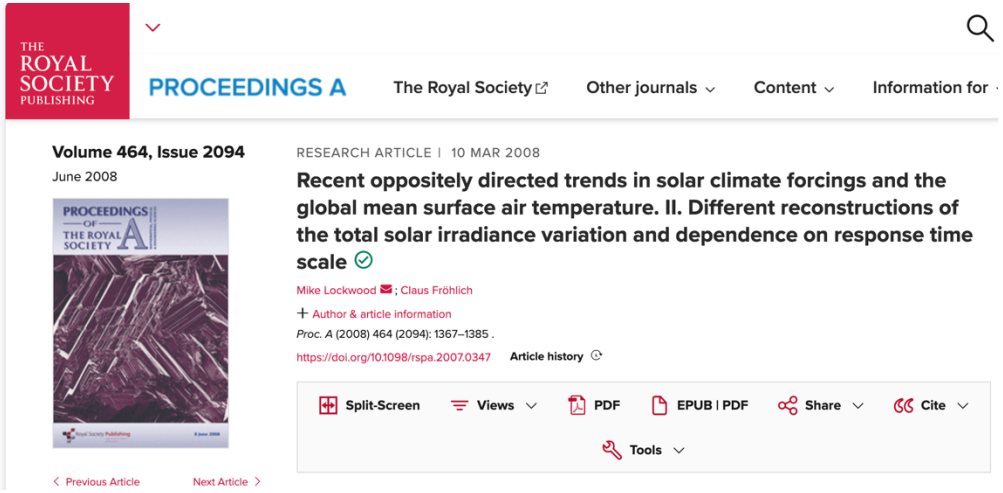

1.2
1.0
0.8
0.6
0.4
Observable Y
?
2000
2010
2020

Examples

ICESat gap:
$15m/year to bridge ICEsat gap
According to MacGregor et al. (2021)*

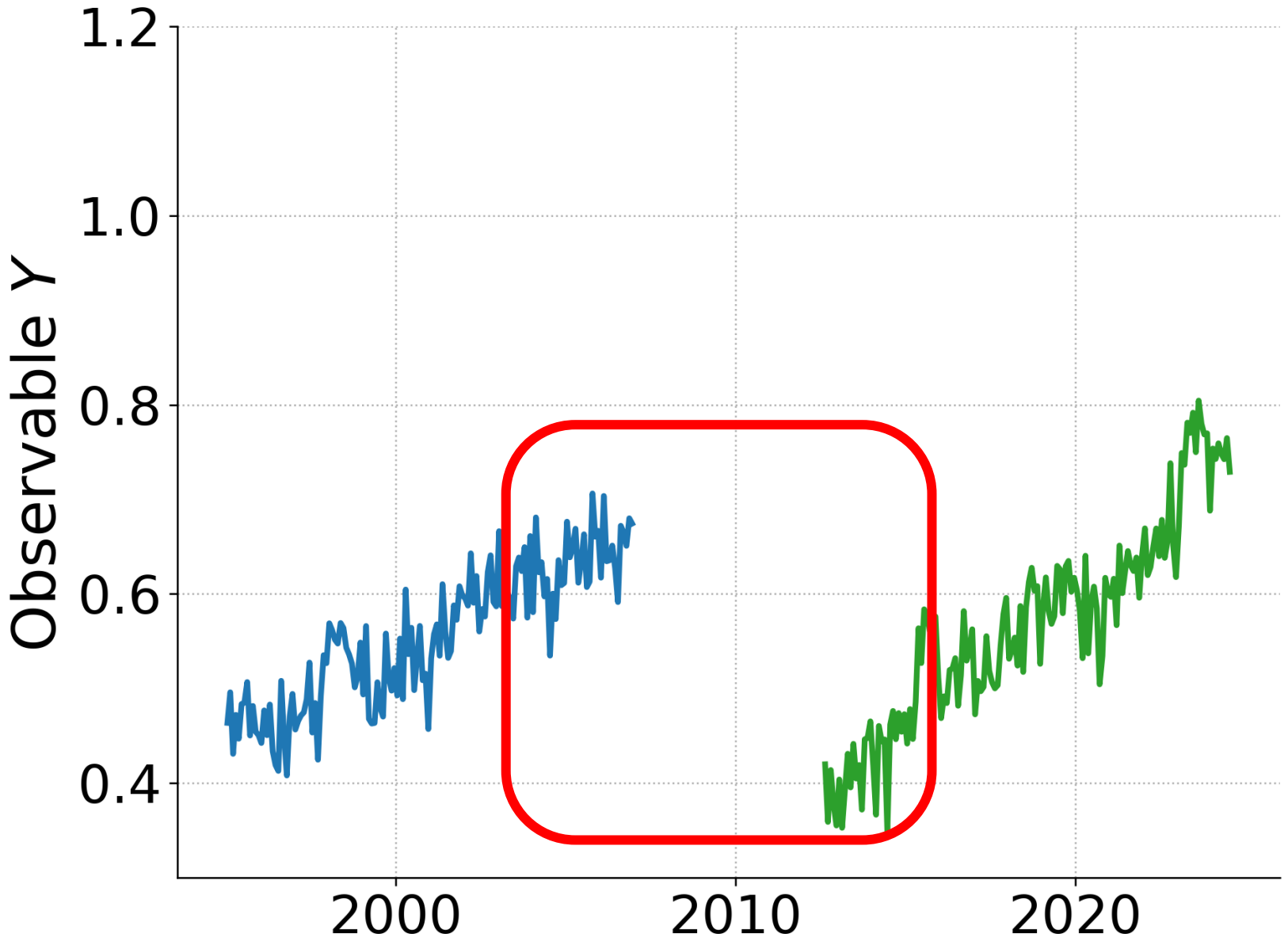
Image source: NASA

ACRIM gap:
20+ years of scientific disagreement

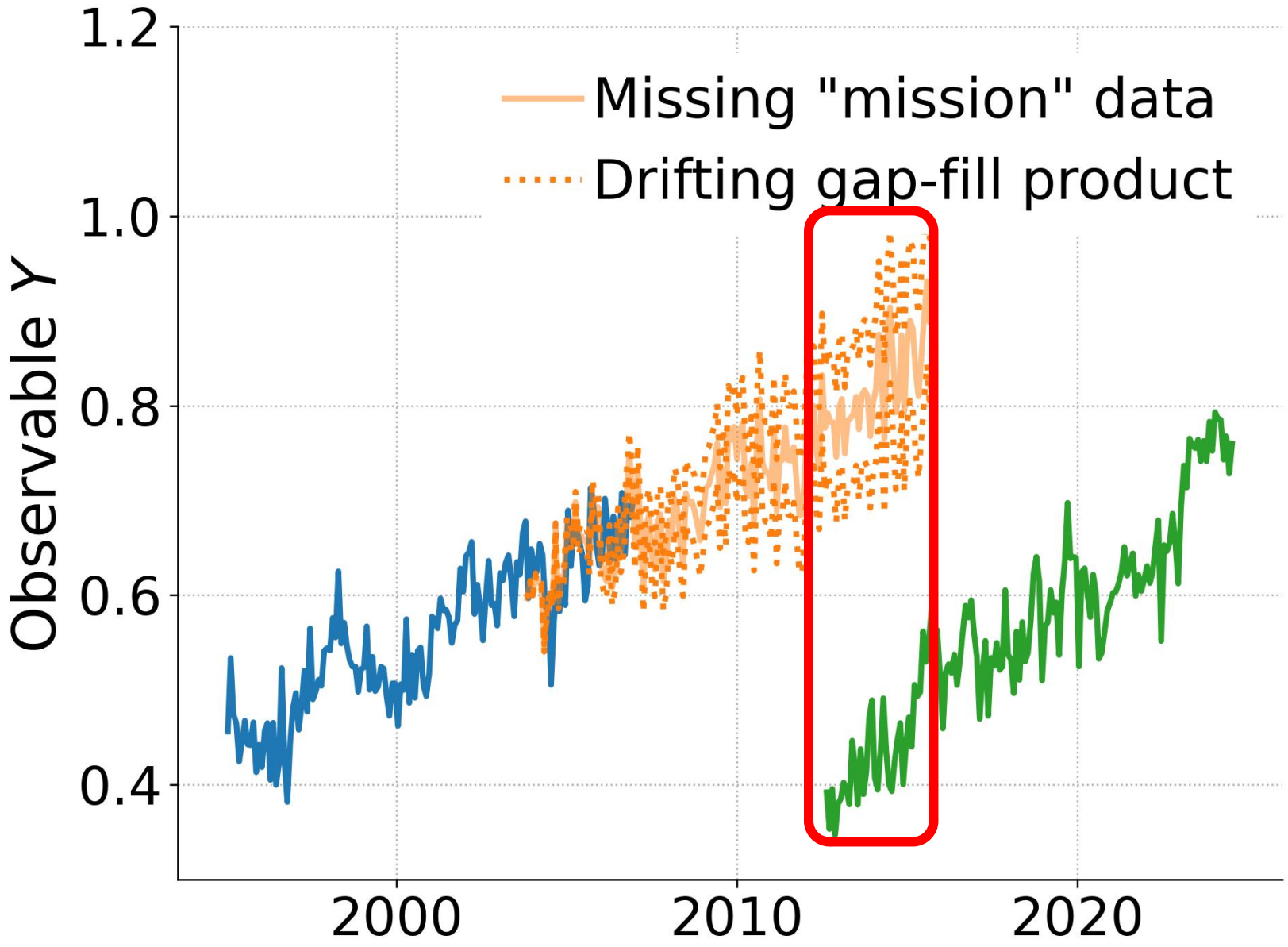


*"part of its budget came from the American Recovery and Reinvestment Act of 2009, which ultimately set OIB [Operation Ice Bridge]'s budget at ~$15M per year." doi: 10.1029/2020RG000712

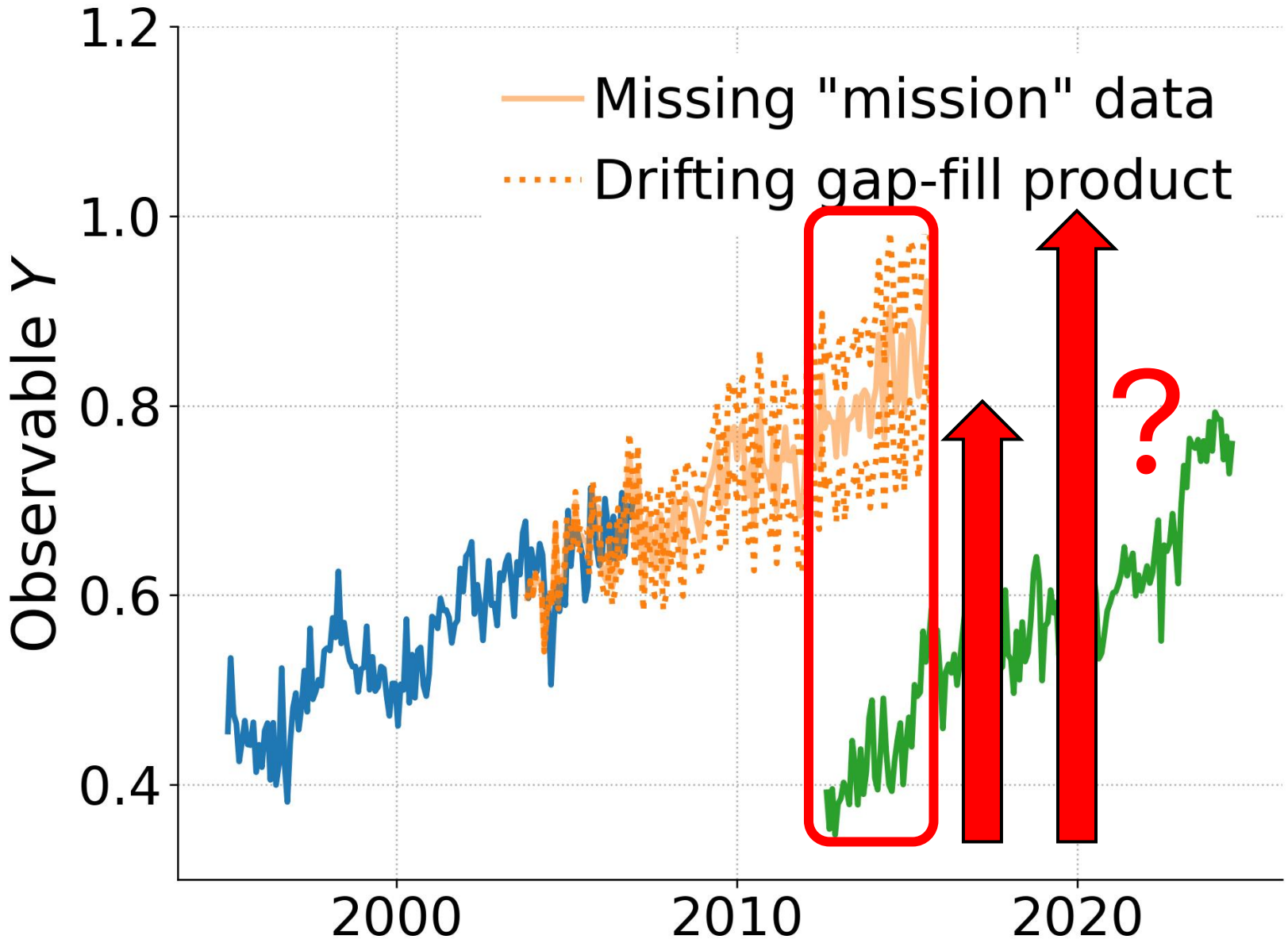
What if we fill the gap with data with more “drift”



What if we fill the gap with data with more “drift”



What if we fill the gap with data with more “drift”



What can we do?

Image source: David C. Bowman NASA, Langley

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What can we do?

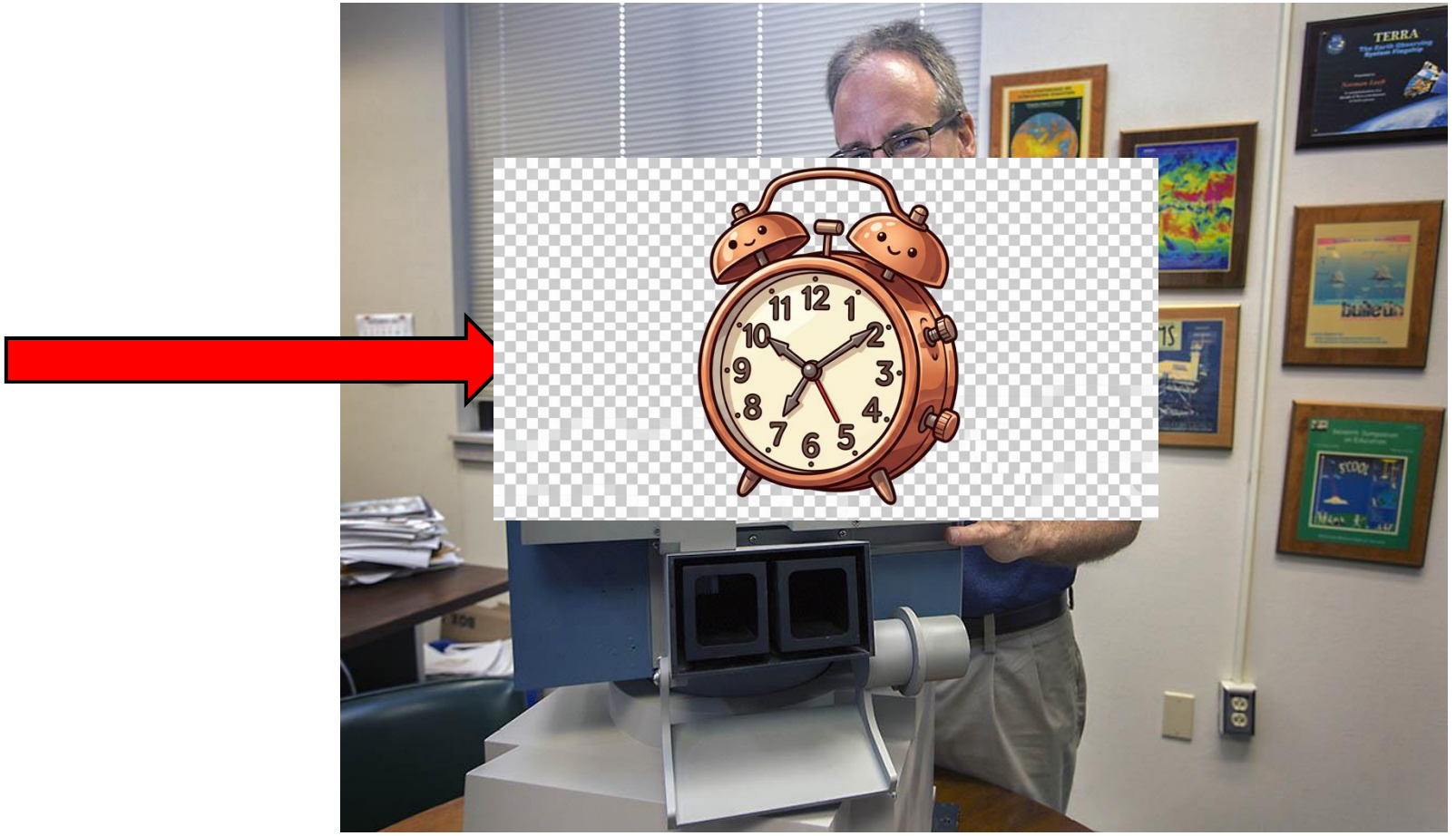


Image source: David C. Bowman NASA, Langley

VOLUME 37 JOURNAL OF CLIMATE 1 DECEMBER 2024

Continuity in Top-of-Atmosphere Earth Radiation Budget Observations

NORMAN G. LOEB,[a] DAVID R. DOELLING,[a] SEIJI KATO,[a] WENYING SU,[a] PAMELA E. MLYNCZAK,[b] AND JOSHUA C. WILKINS[c]

[a] *NASA Langley Research Center, Hampton, Virginia*
[b] *Analytical Mechanics Associates, Hampton, Virginia*
[c] *ADNET Systems, Inc., Hampton, Virginia*

(Manuscript received 3 April 2024, in final form 30 July 2024, accepted 13 August 2024)

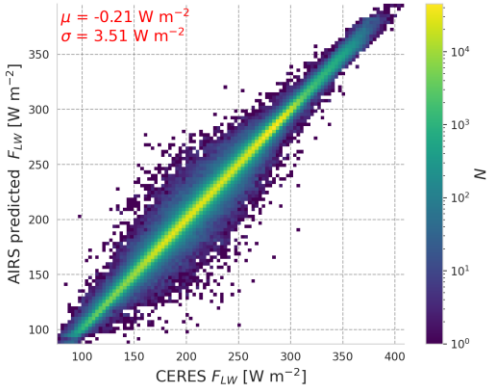
Bridging a data gap using computed TOA fluxes from one satellite product and one atmospheric reanalysis results in errors that are a factor of 4 larger than those obtained when there is overlap between successive missions.

What can we do?

?

JPL

Jet Propulsion Laboratory
California Institute of Technology



Two factors of a gap are:

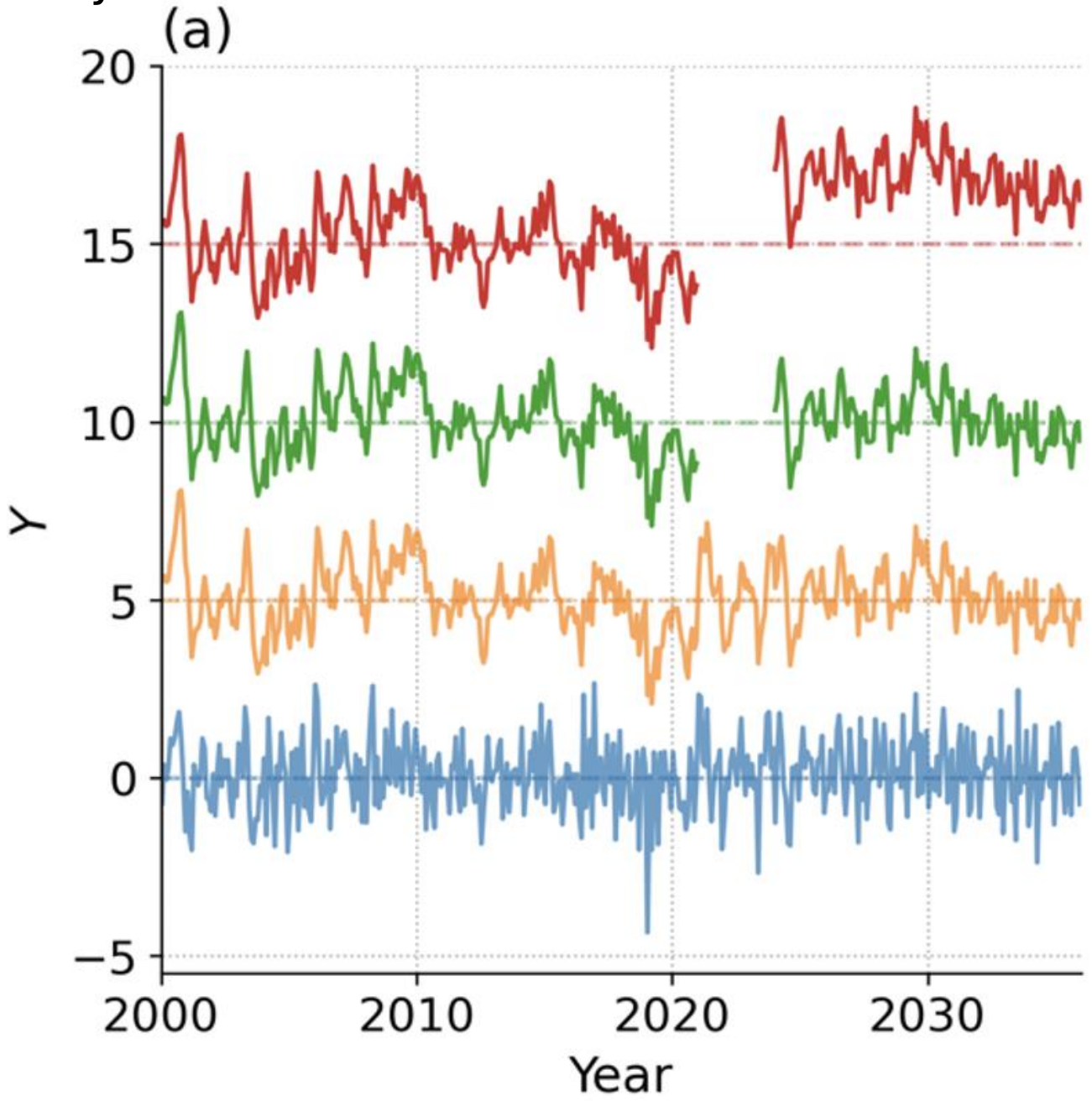
1. How long is the gap? Δt
2. How big is the error? $\sigma_{\Delta Y}$

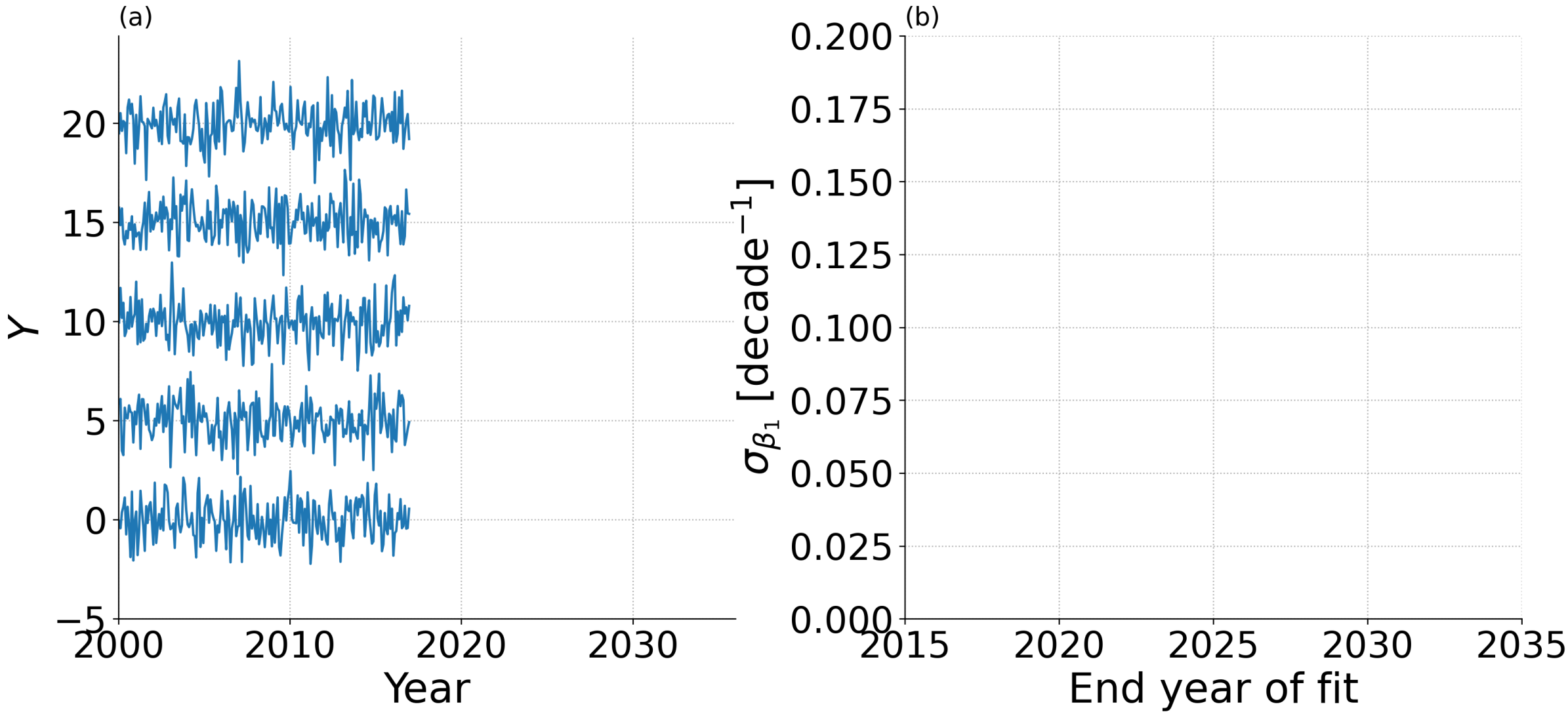
Questions:

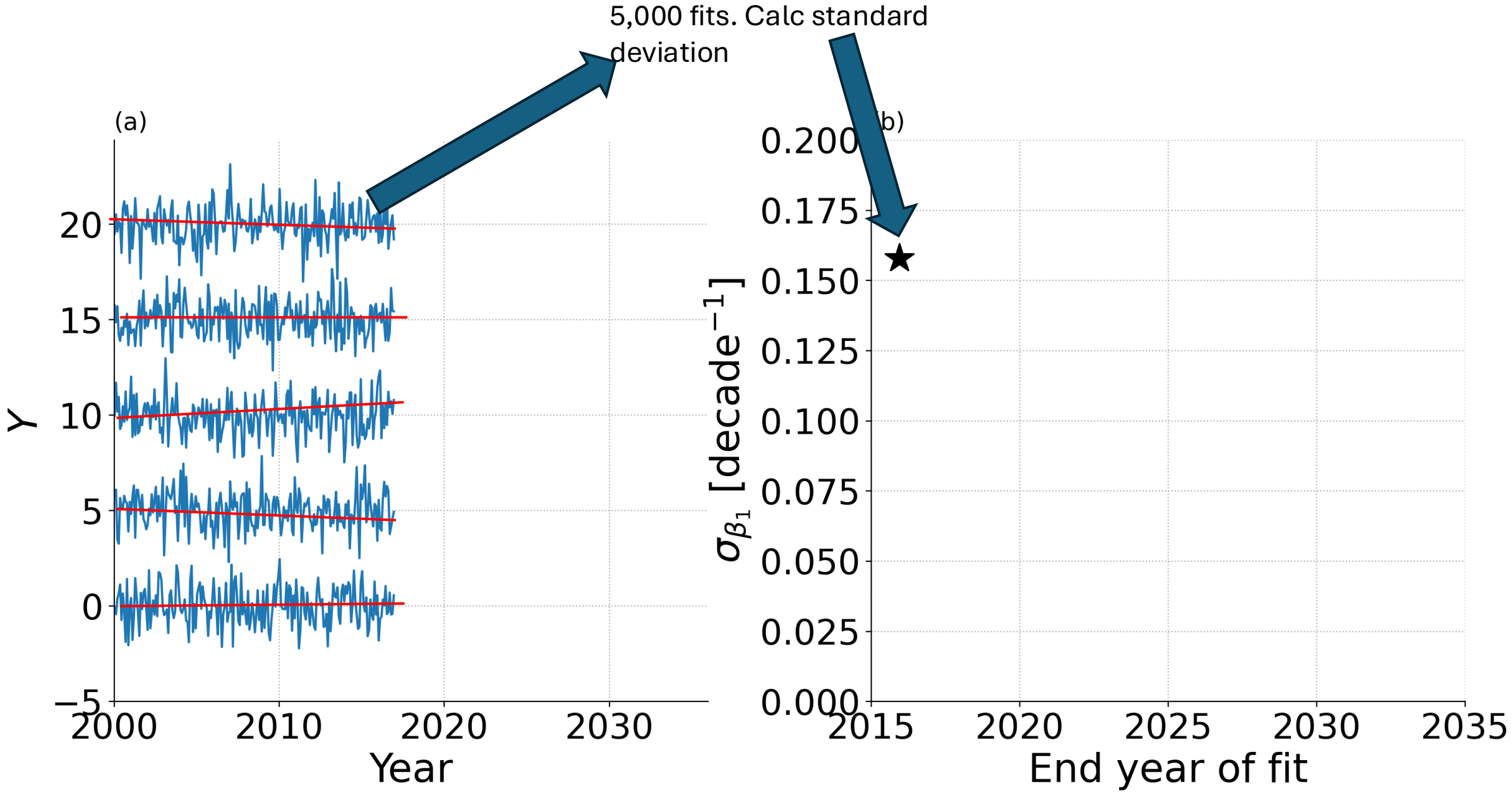
1. How do gap size Δt and error $\sigma_{\Delta Y}$ affect trend uncertainty?

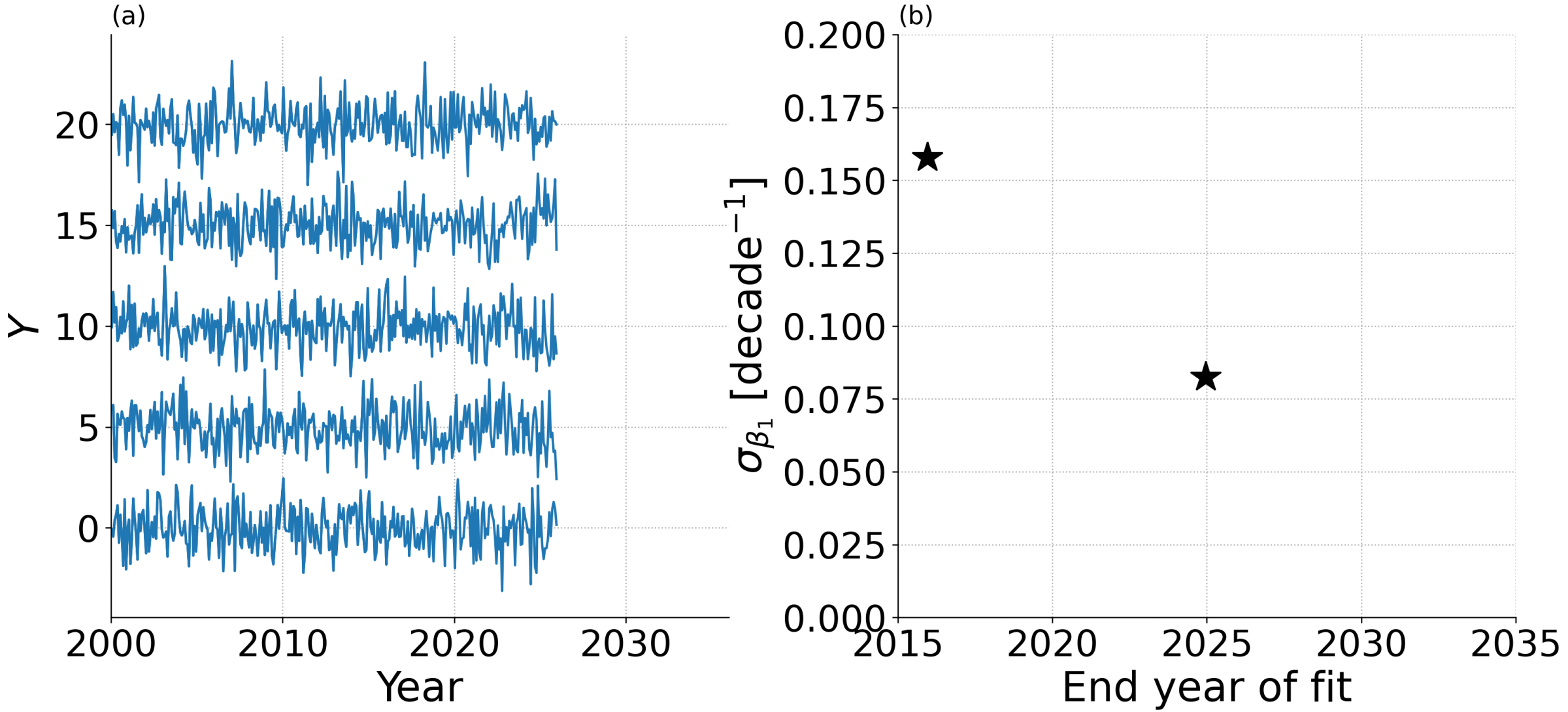
2. Can we predict this ahead of time, and thus estimate scientific value of efforts to change Δt are $\sigma_{\Delta Y}$

We can imagine many scenarios:




(a)
20
15
10
5
0
−5
Y
2000
2010
2020
2030
Year
(b)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
σ_{β_1} [decade^{-1}]
2015
2020
2025
2030
2035
End year of fit


5,000 fits. Calc standard deviation
(a)
(b)
Y
Year
σ_{β_1} [decade^{-1}]
End year of fit
20
15
10
5
0
−5
2000
2010
2020
2030
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
2015
2020
2025
2030
2035


(a)
Y
20
15
10
5
0
2000
2010
2020
2030
Year
(b)
σ_{β_1} [decade^{-1}]
0.200
0.175
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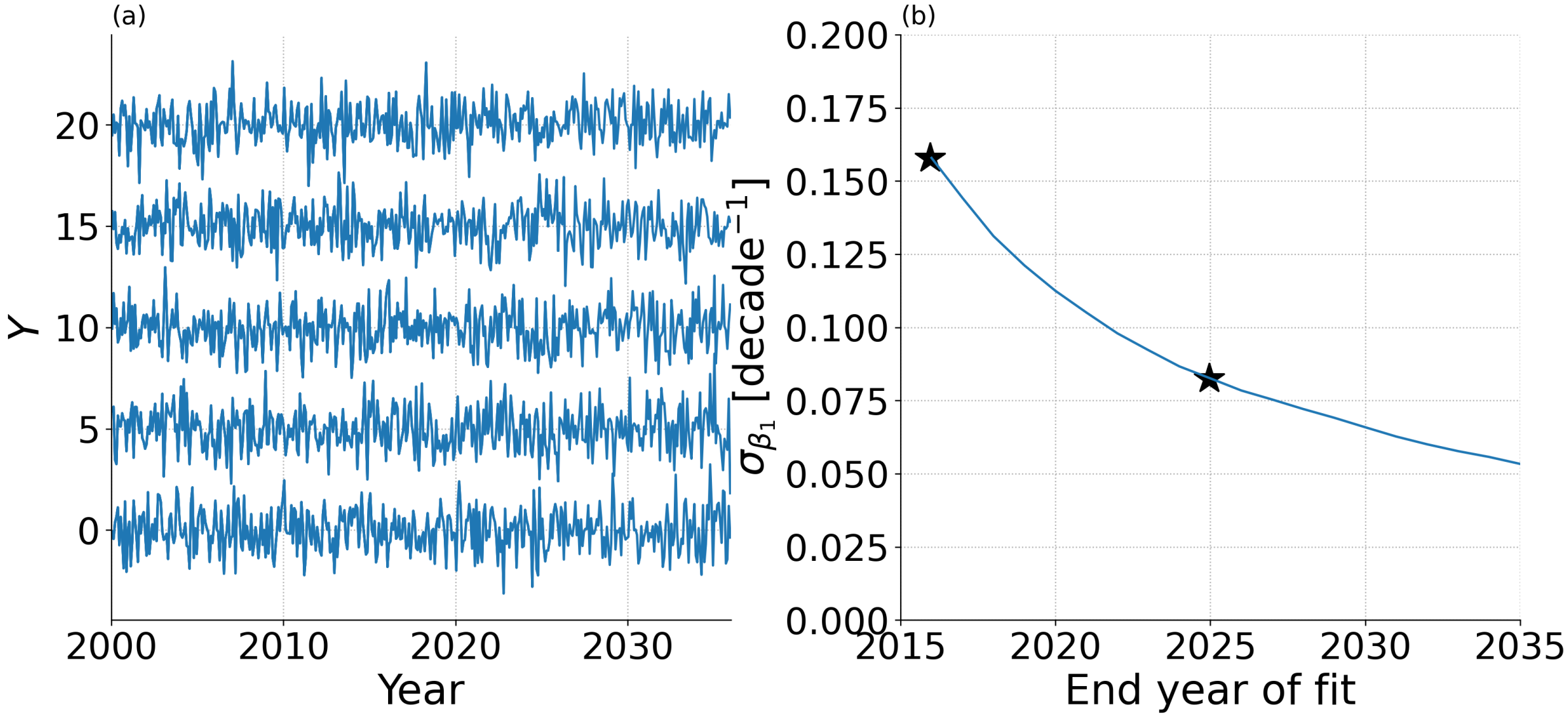
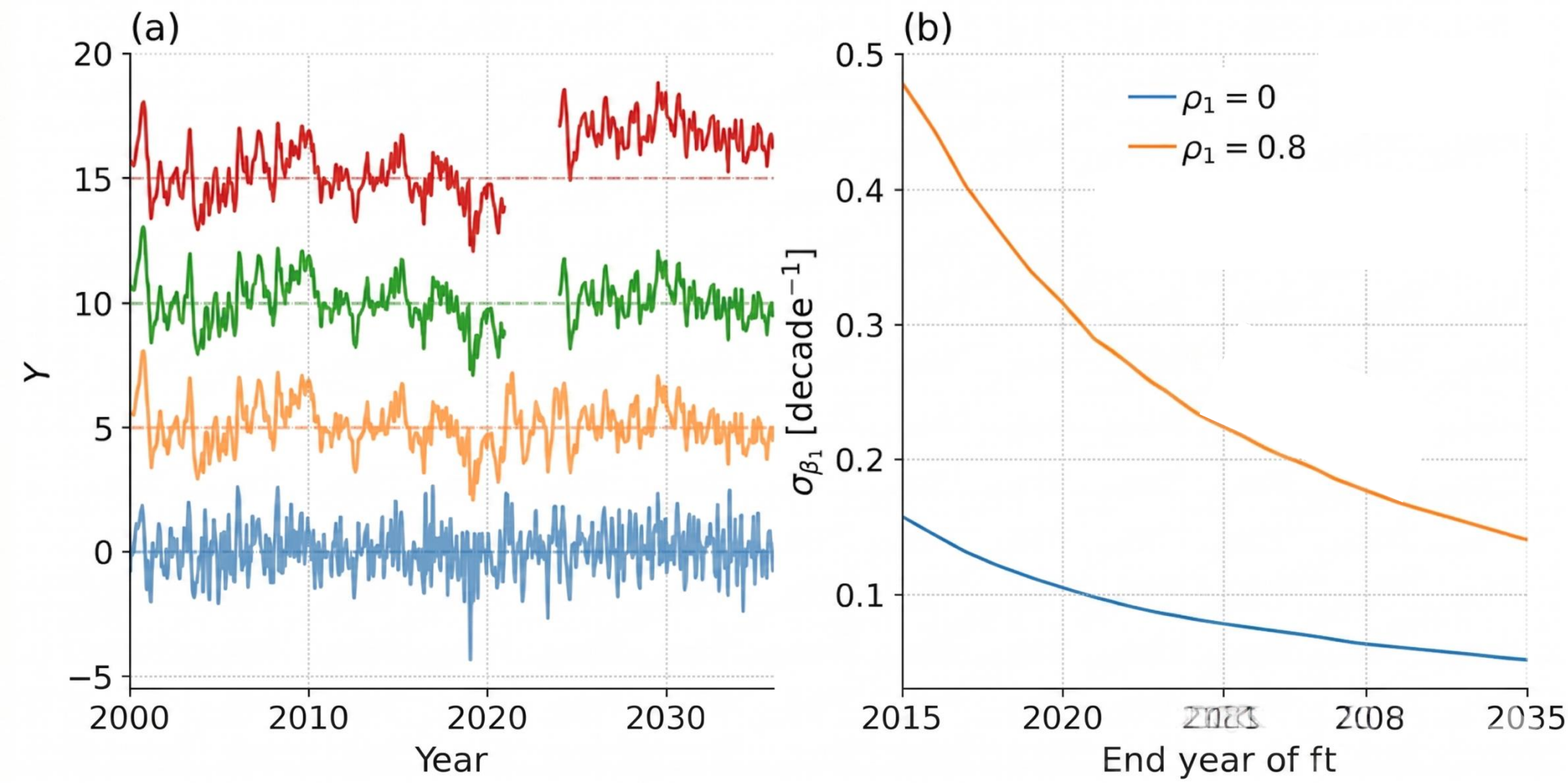
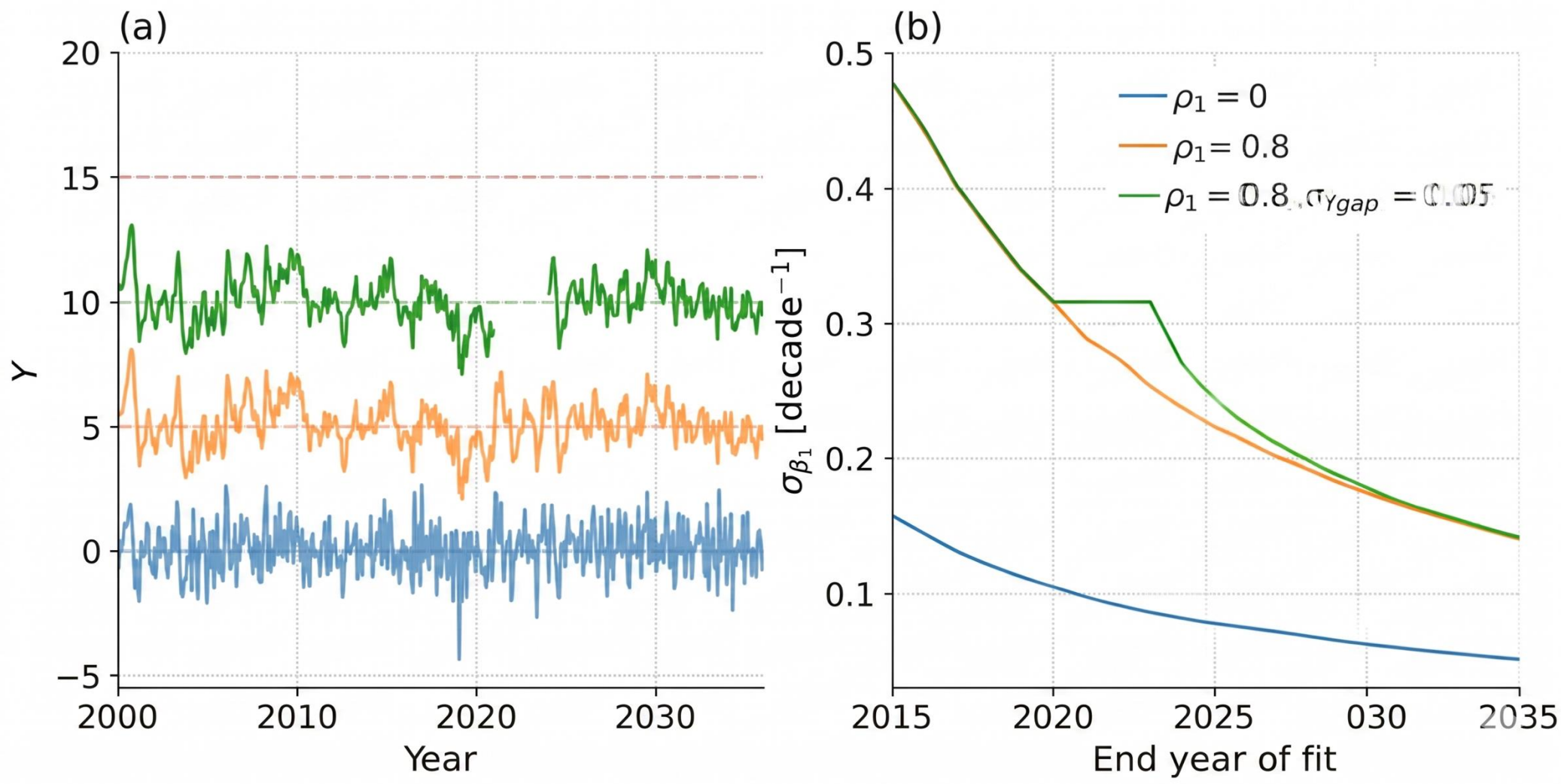
0.125
0.100
0.075
0.050
0.025
0.000
2015
2020
2025
2030
2035
End year of fit


(a)
Y
20
15
10
5
0
2000
2010
2020
2030
Year
(b)
σ_{β_1} [decade^{-1}]
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
2015
2020
2025
2030
2035
End year of fit

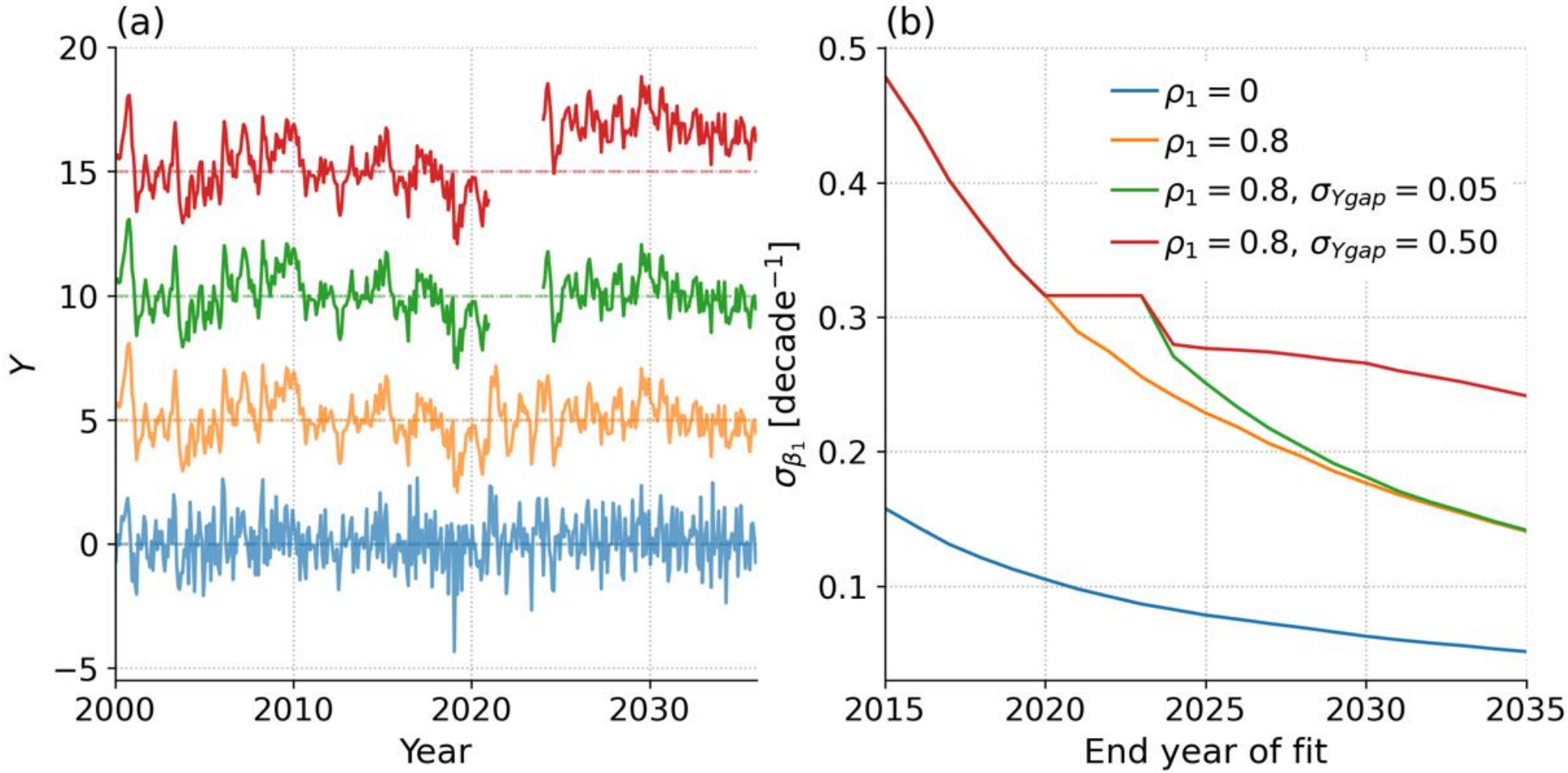
Trends errors (right) usually shrink with time, but not if $\sigma_{\Delta Y}$ is too big



Trends errors (right) usually shrink with time, but not if $\sigma_{\Delta Y}$ is too big



Trends errors (right) usually shrink with time, but not if $\sigma_{\Delta Y}$ is too big



Predict future errors by combining:

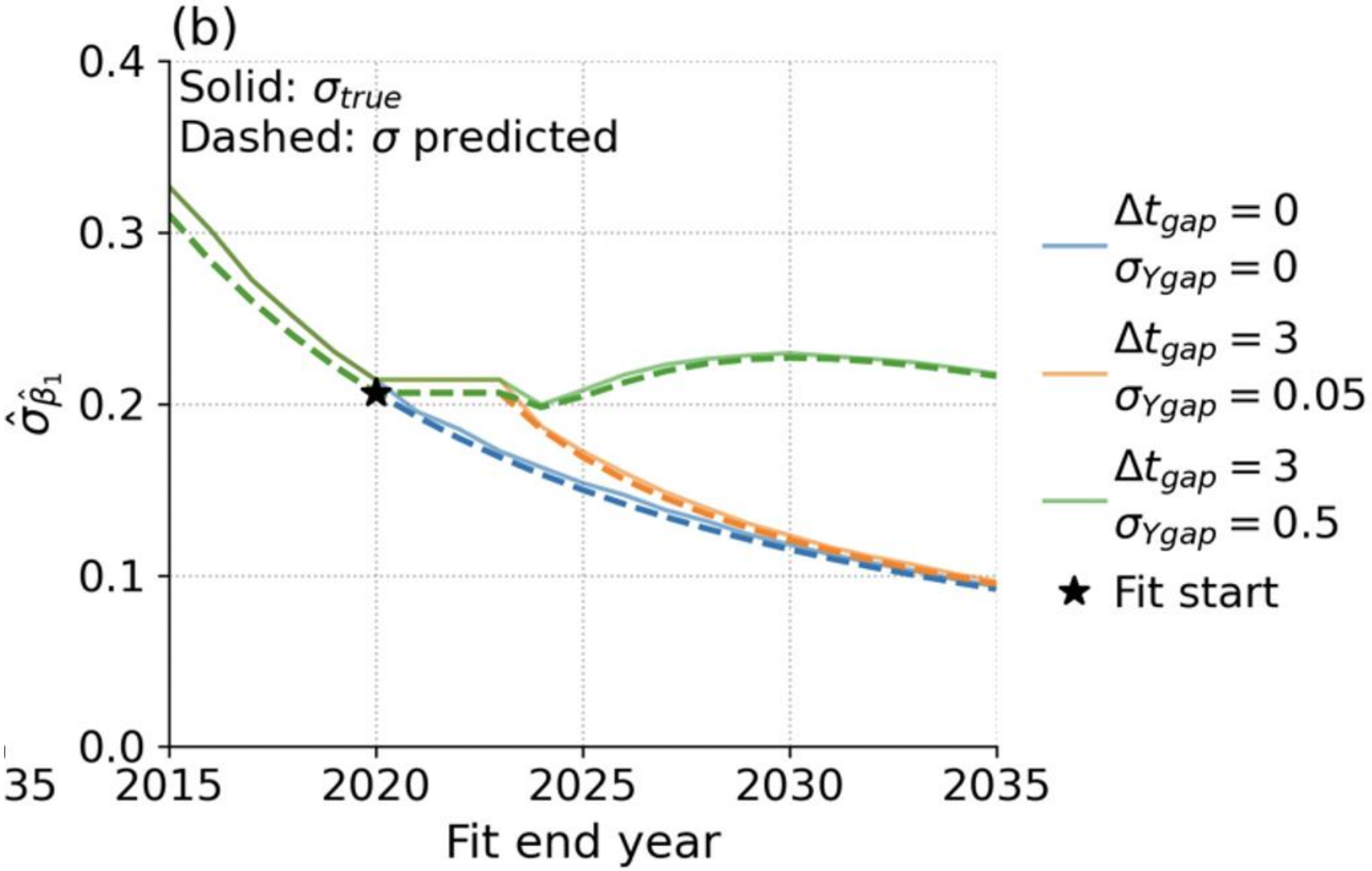
(1) Extending random component of trend today (t1)

$$\hat{\sigma}^2_{\hat{\beta}_1} = \hat{\sigma}^2_{\hat{\beta}_1,t1} \frac{\sum_i^{N_{t1}} \left(t_i - \bar{t}_1\right)^2}{\sum_i^{N} \left(t_i - \bar{t}\right)^2}$$

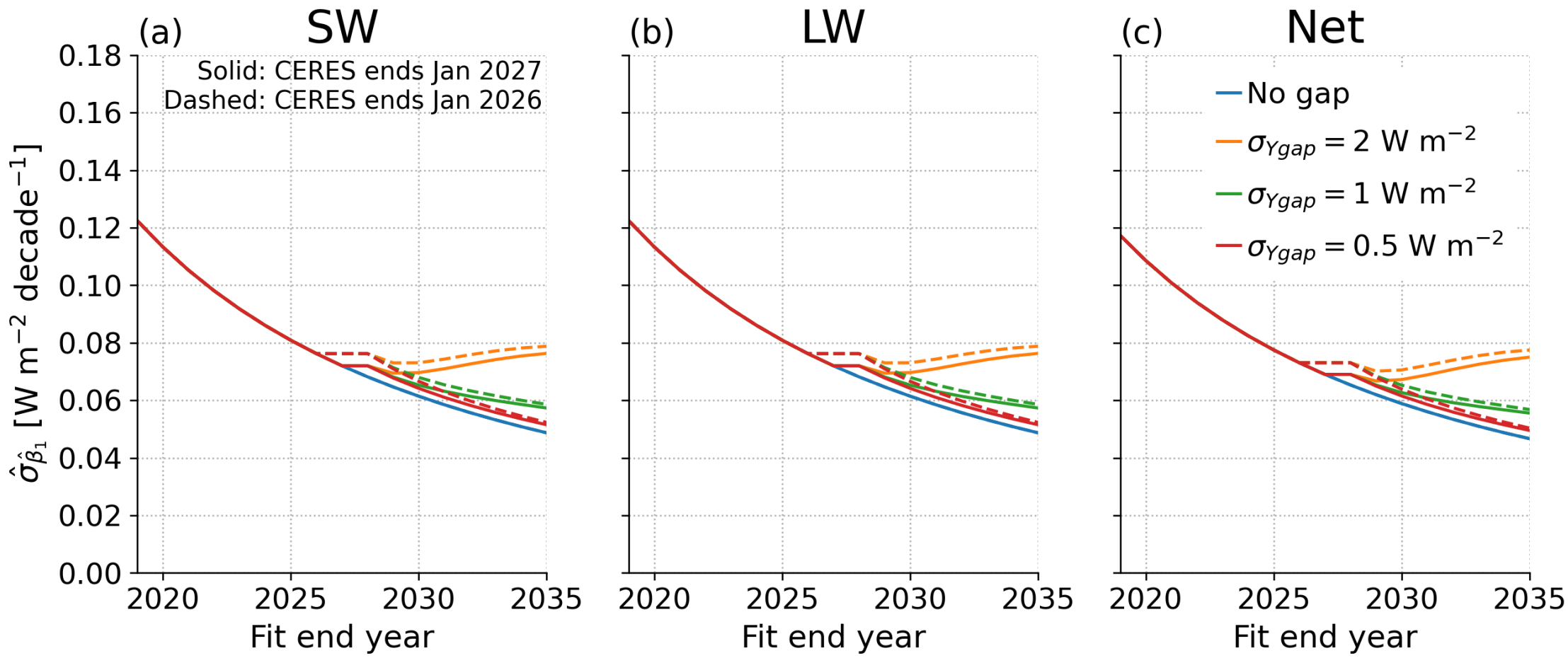
(2) Including $\sigma_{\Delta Y}$ component by fitting a step function

It works!

Predicted errors (dashed) are very close to the true errors (solid).



For CERES global: $\sigma_{\Delta Y} > 1$ W m^{-2} explodes errors

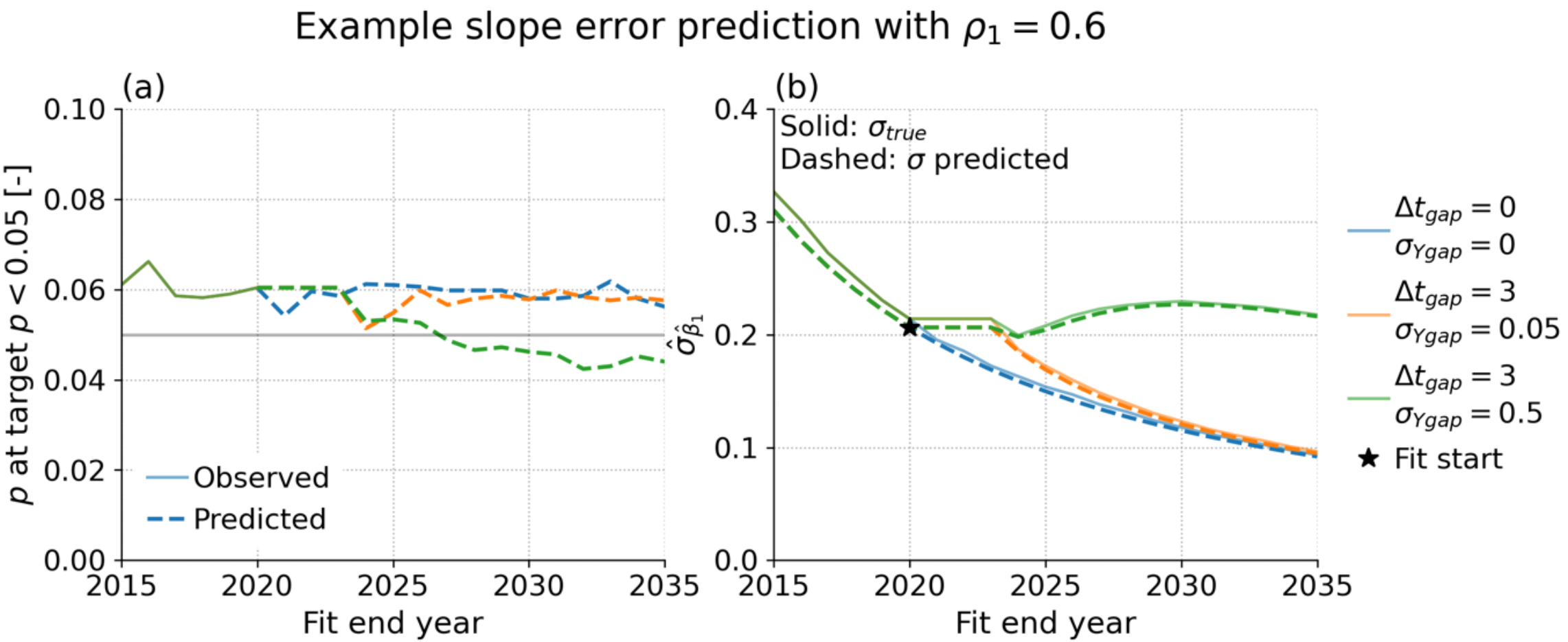


- We *can* predict trends errors for hypothetical data gaps

- The method works for any data series where we can estimate autocorrelation

- Globally? We want $\sigma_{\Delta Y} < 1$ W m^{-2} . Regional answers may differ.

Left is *p* values estimated, very close to goal



If you also fit a “jump” (squares/circles) you remove the dependence on the jump size, but the trend error is way larger – no more information gained by new mission