TIPPING POINTS IN THE EARTH SYSTEM

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Multivariate Estimations of Equilibrium Climate Sensitivity from Short Transient Warming Simulations

Robbin Bastiaansen

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Equilibrium Climate Sensitivity

If CO_2 doubles,

How much warmer will it get eventually?

- Computer models cannot be run for long
- Extrapolation & Estimation methods are needed

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Classic methods do *not* capture all long time scales

Solution:

Incorporate additional observables in new estimation methods

- ☻ Leads to more accurate estimates
- ☻ Leads to multivariate estimates

Robbin Bastiaansen

- Background in (Applied) Mathematics

- 2015-2019:
  PhD @ Leiden University on *desertification*
  (with Arjen Doelman, Martina Chirilus-Bruckner & Max Rietkerk)

- Since JAN 2020:
  PostDoc @ IMAU, Utrecht University on *Climate Sensitivity*
  (with Anna von der Heydt & Henk Dijkstra)

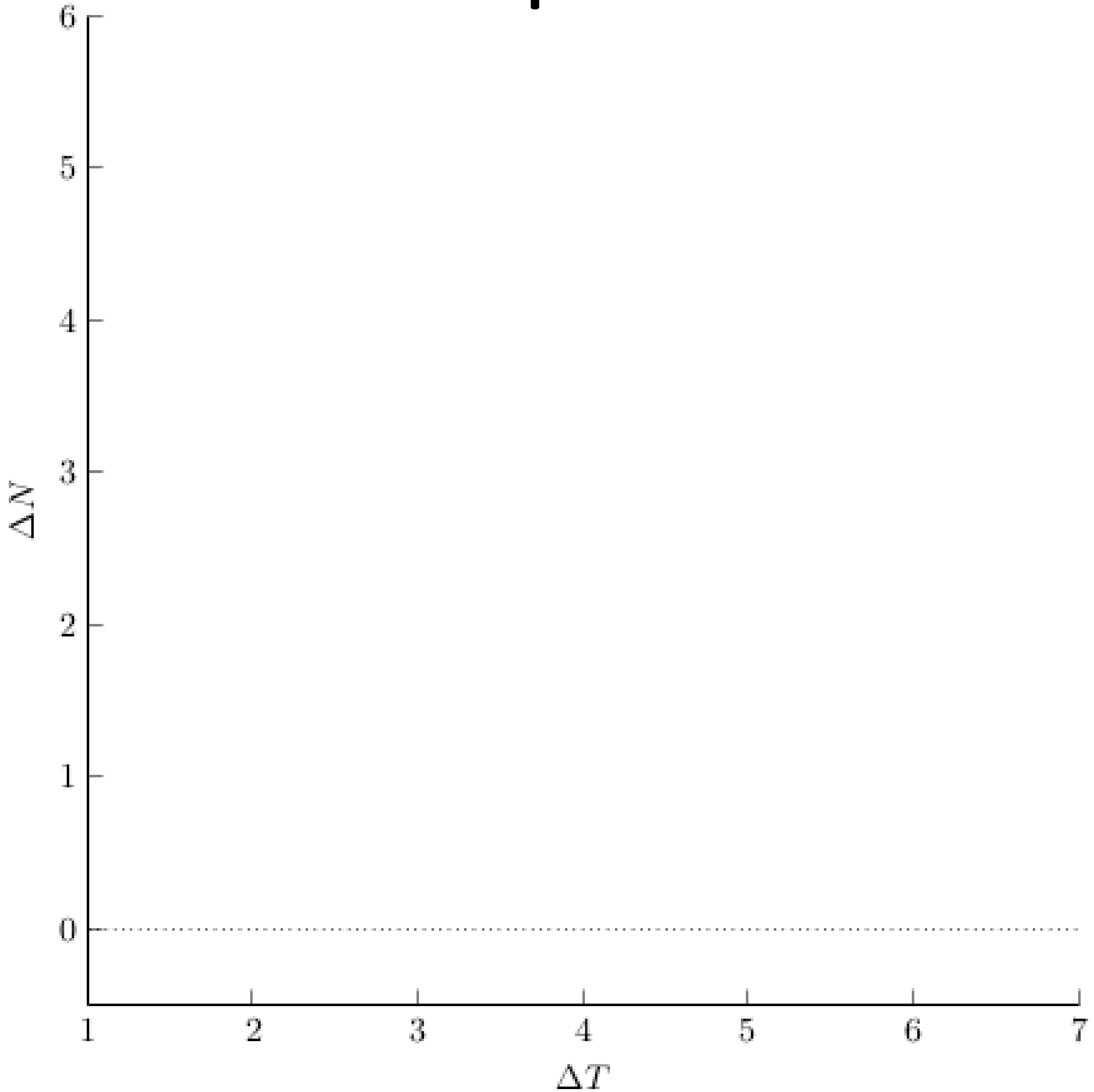
Classic estimation technique

Regress data to

$$\Delta N(t) = \boldsymbol{a}\, \Delta T(t) + \boldsymbol{f}$$

Since $\Delta N_* = 0$ in equilibrium, ECS estimation is

$$\Delta T_*^{est} = -\,\boldsymbol{a}^{-1}\, \boldsymbol{f}$$



[Gregory et al, 2014]

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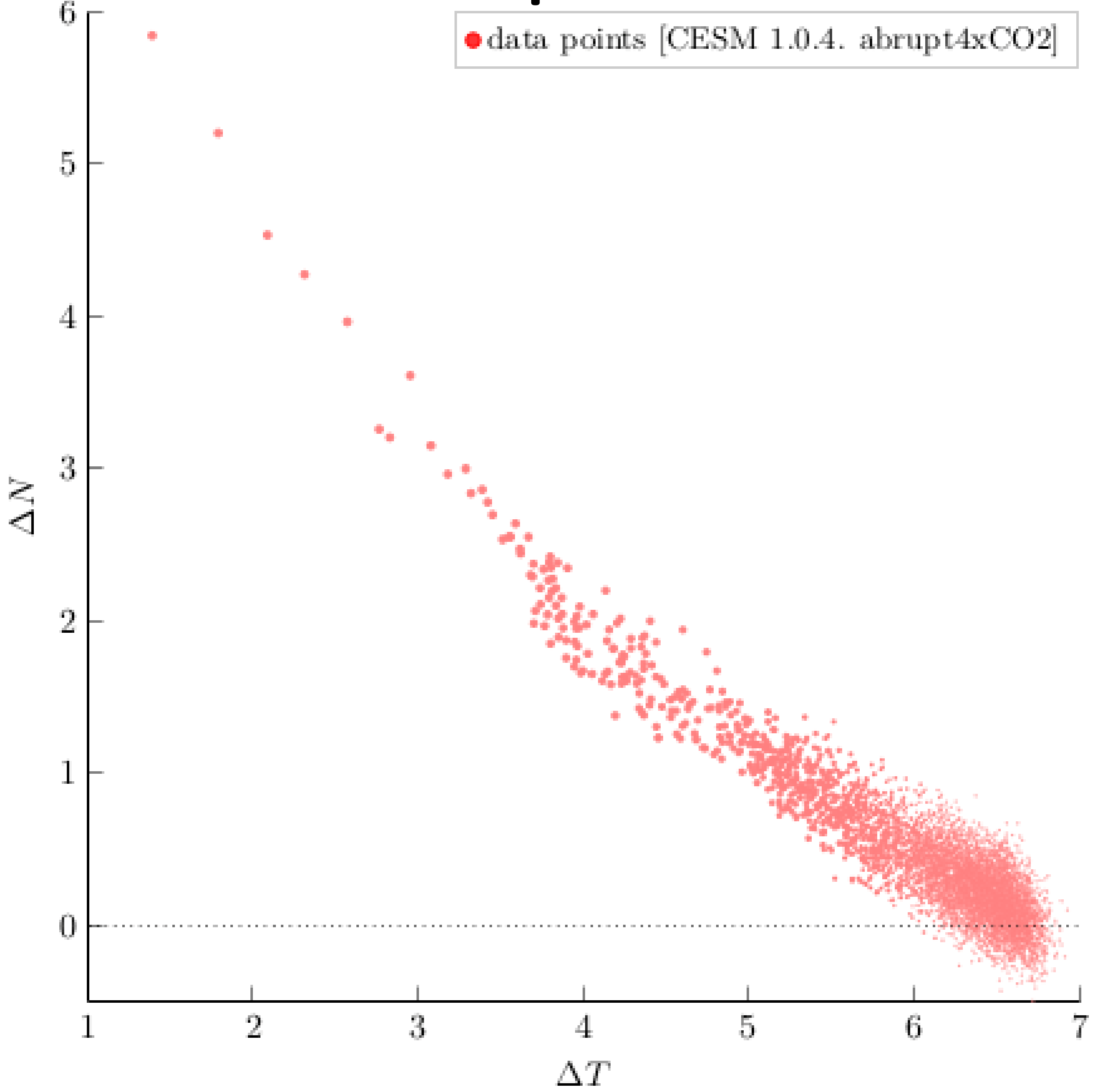

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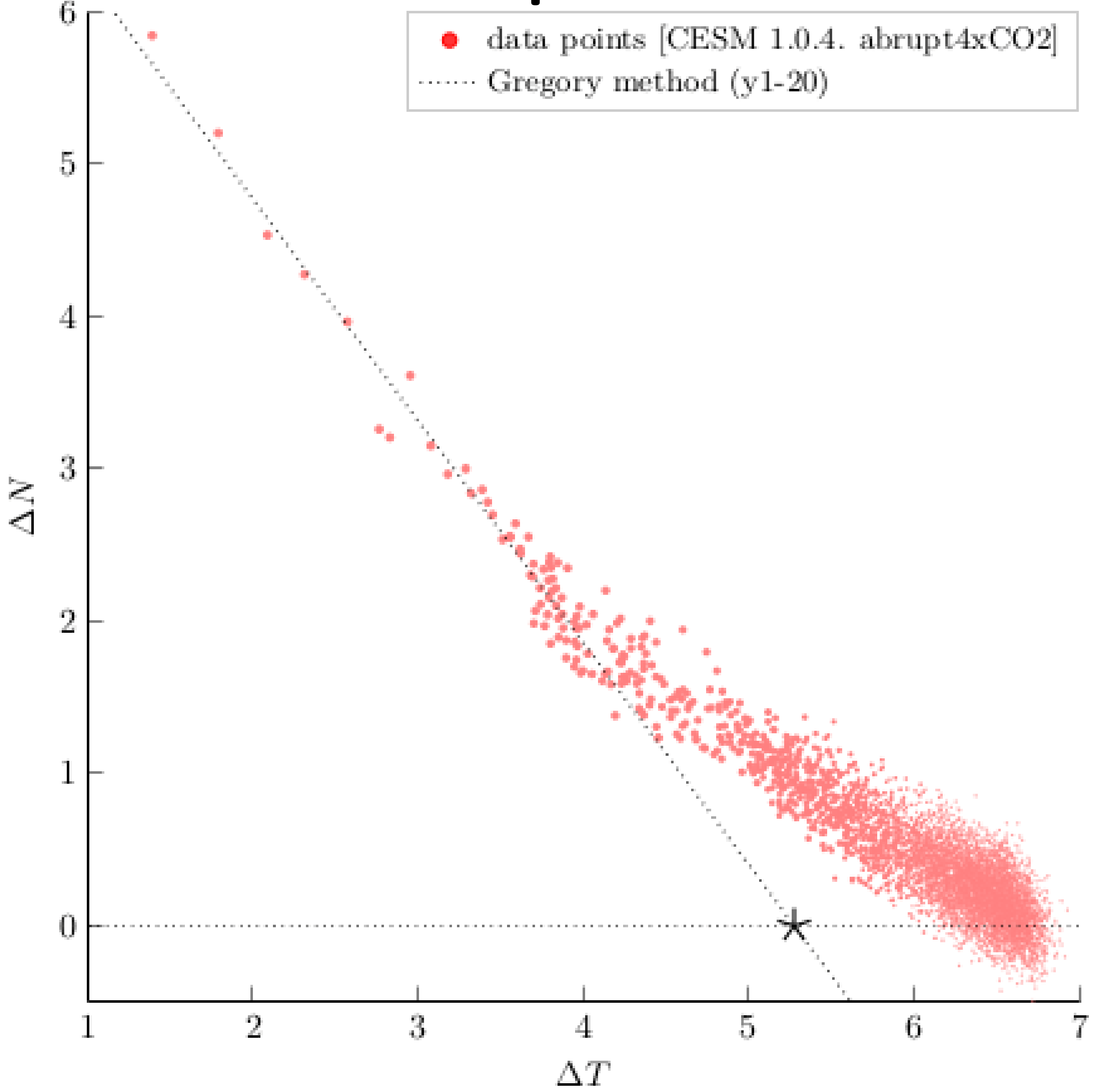

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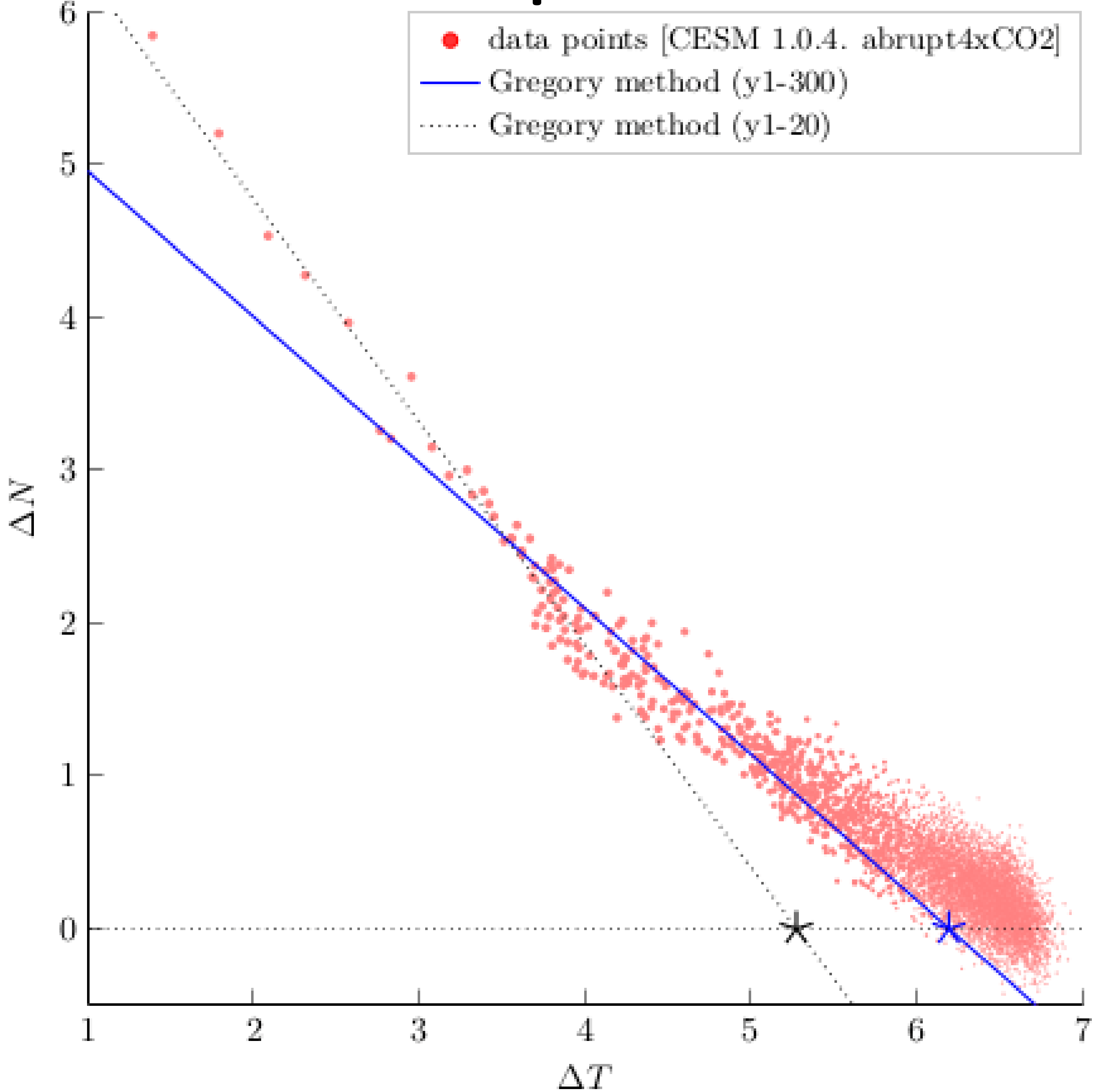

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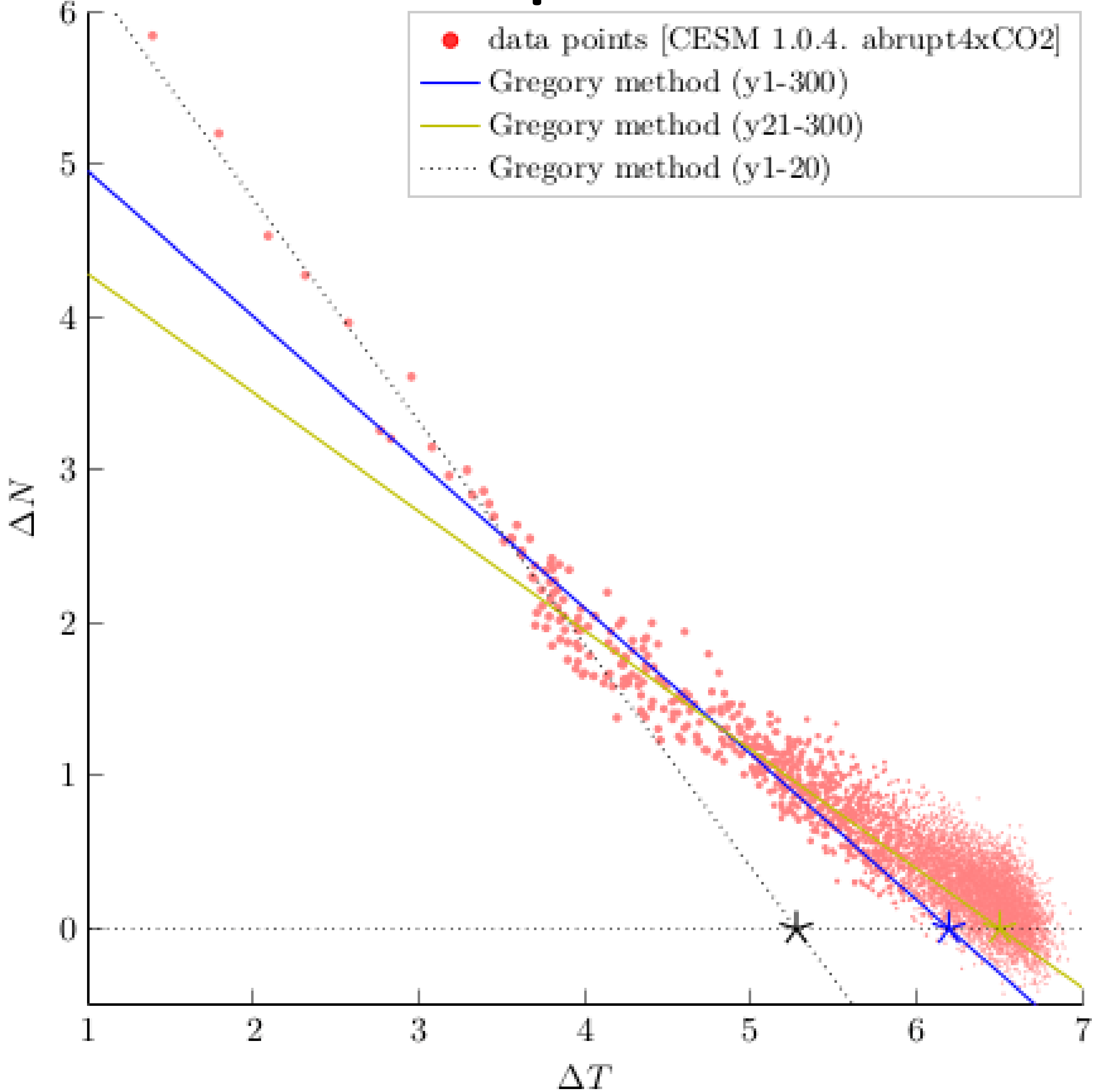

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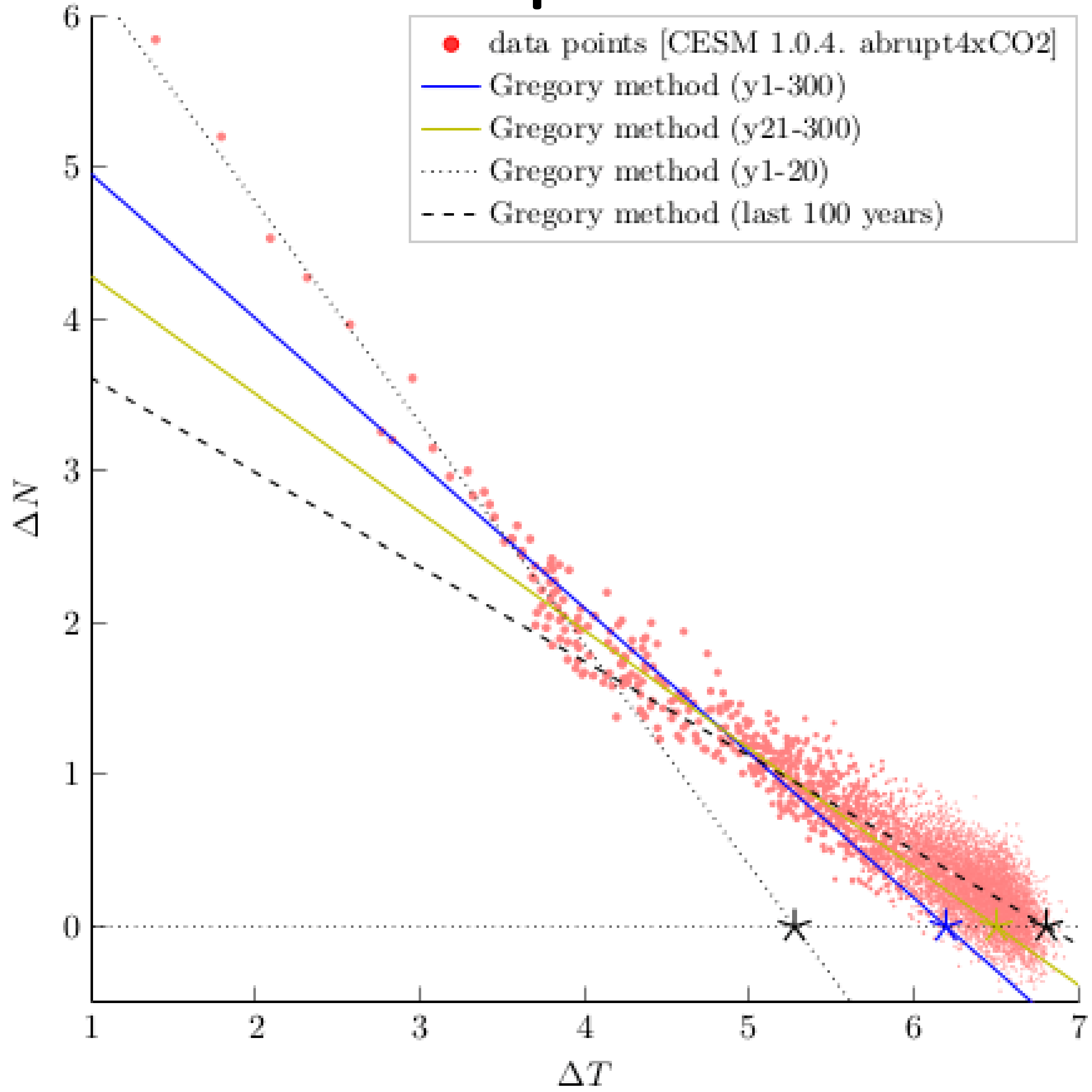

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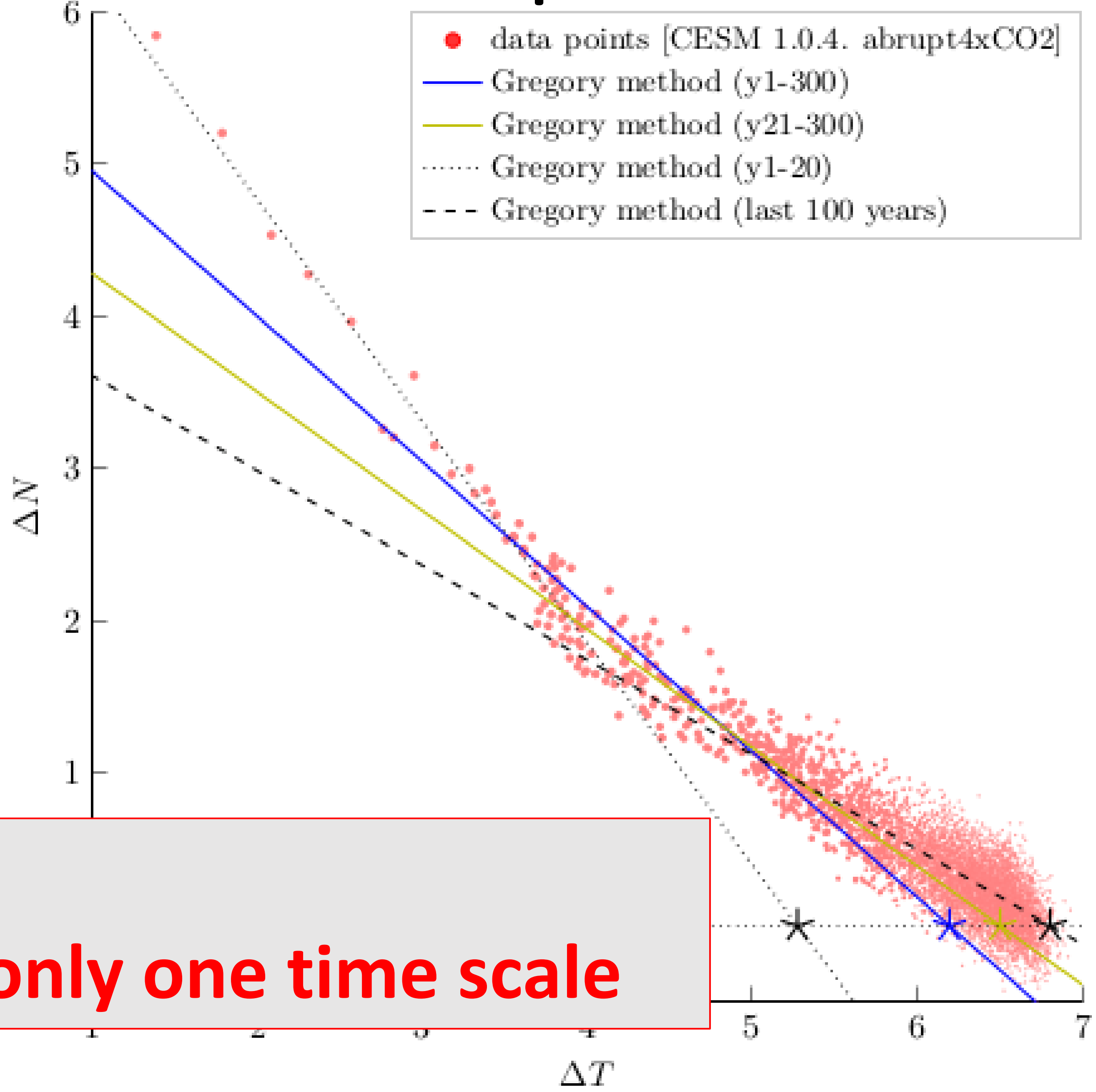


SHORTCOMING:
Linear regression captures only one time scale

New Multicomponent Linear Regression Method

Use additional observables!

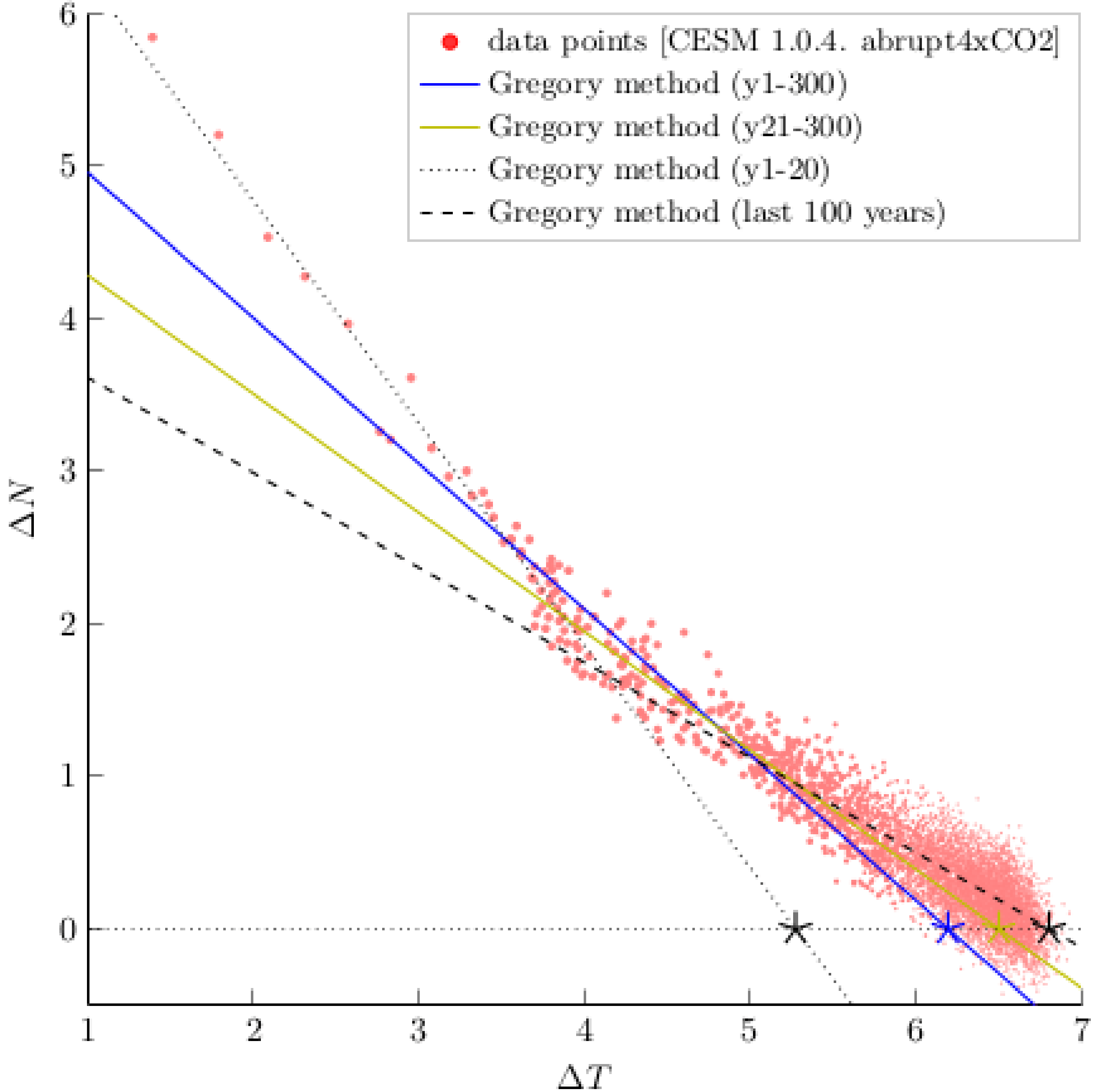
Regress to:

$$\begin{bmatrix} \Delta N(t) \\ \vdots \\ \vdots \end{bmatrix} = \boldsymbol{A} \begin{bmatrix} \Delta T(t) \\ \vdots \\ \vdots \end{bmatrix} + \vec{\boldsymbol{F}}$$

Examples of potential observables:

- Albedo
- Emissivity
- Ocean Heat Content
- …

[Bastiaansen et al, 2021]



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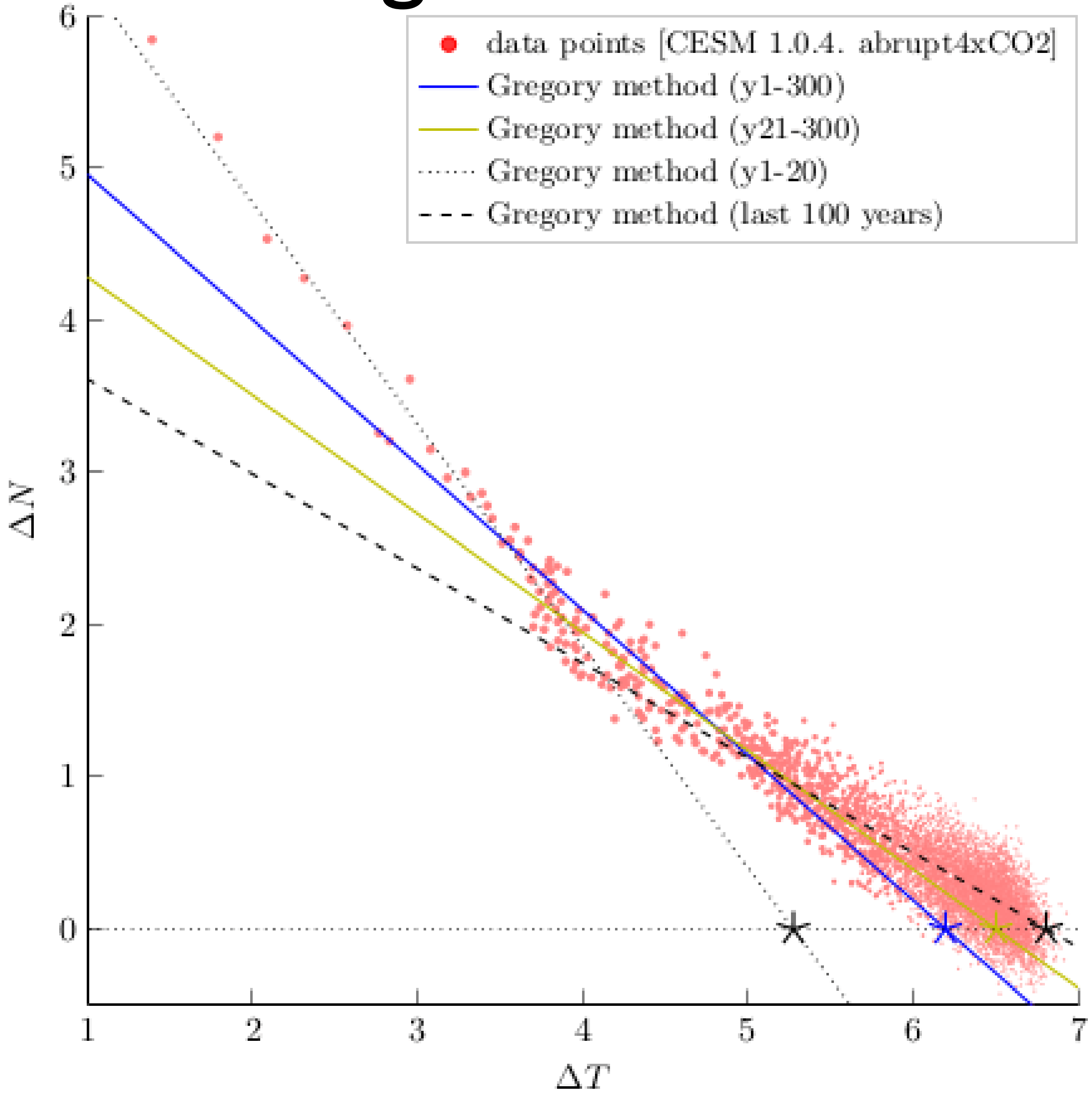

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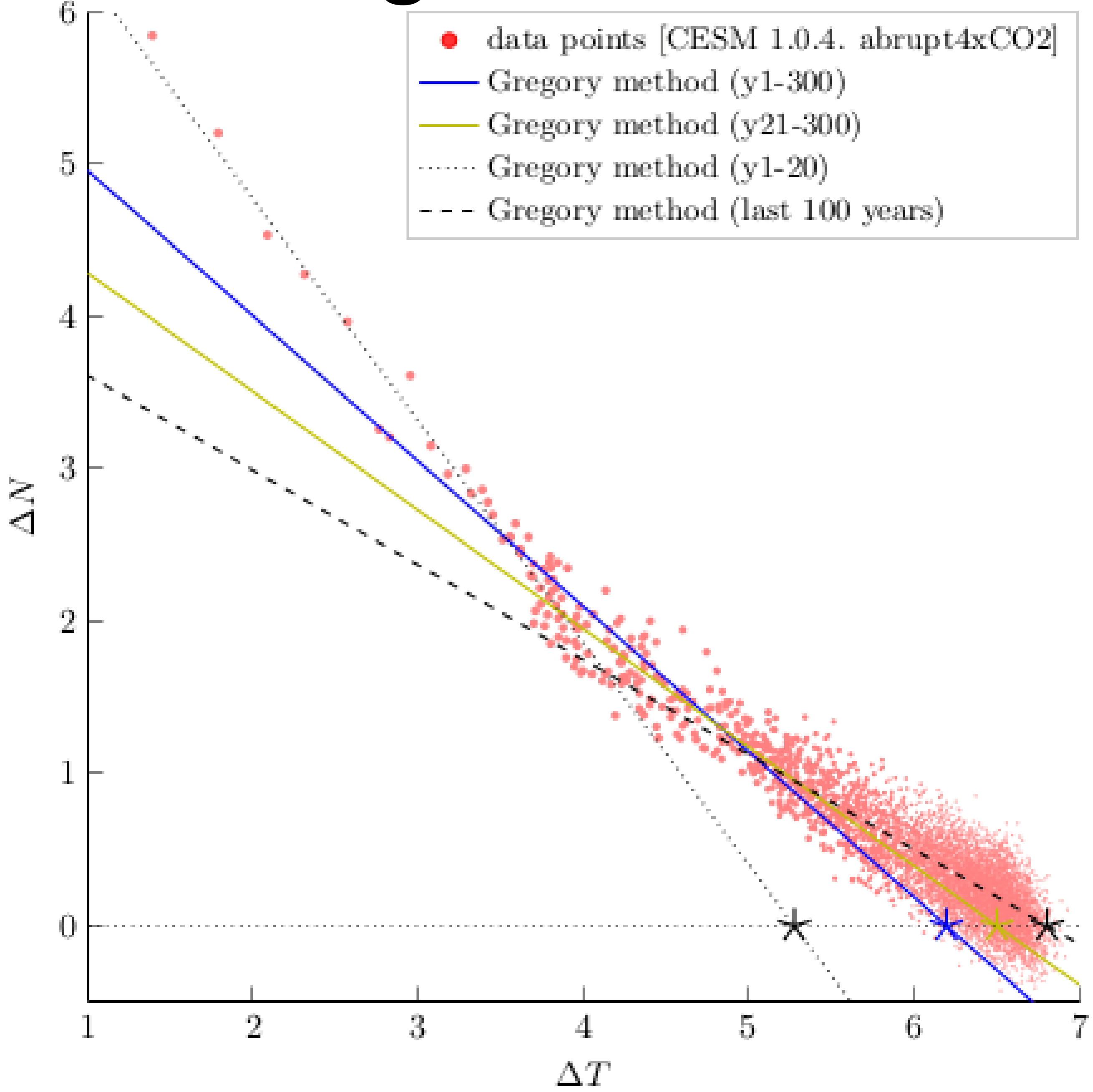

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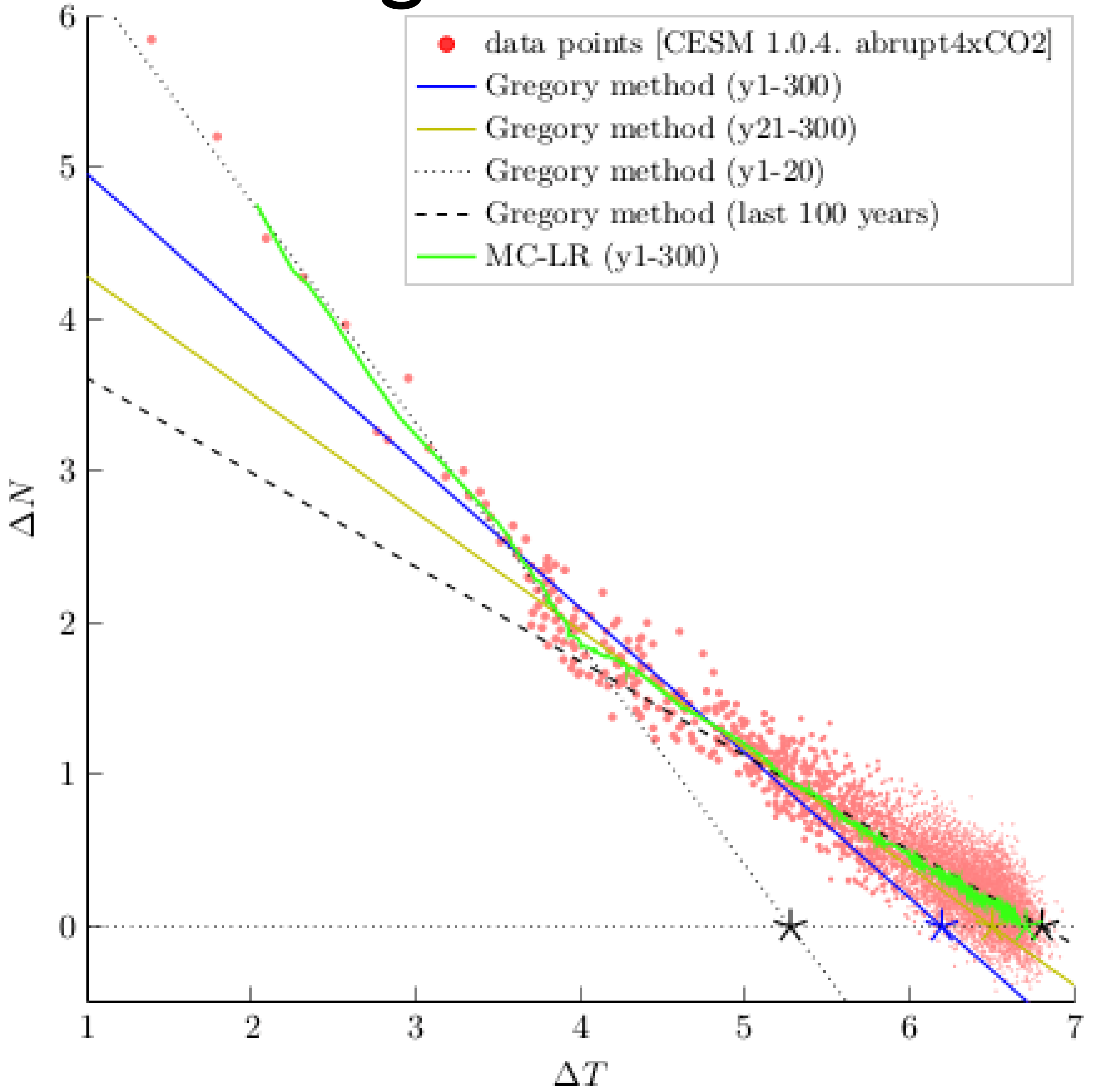
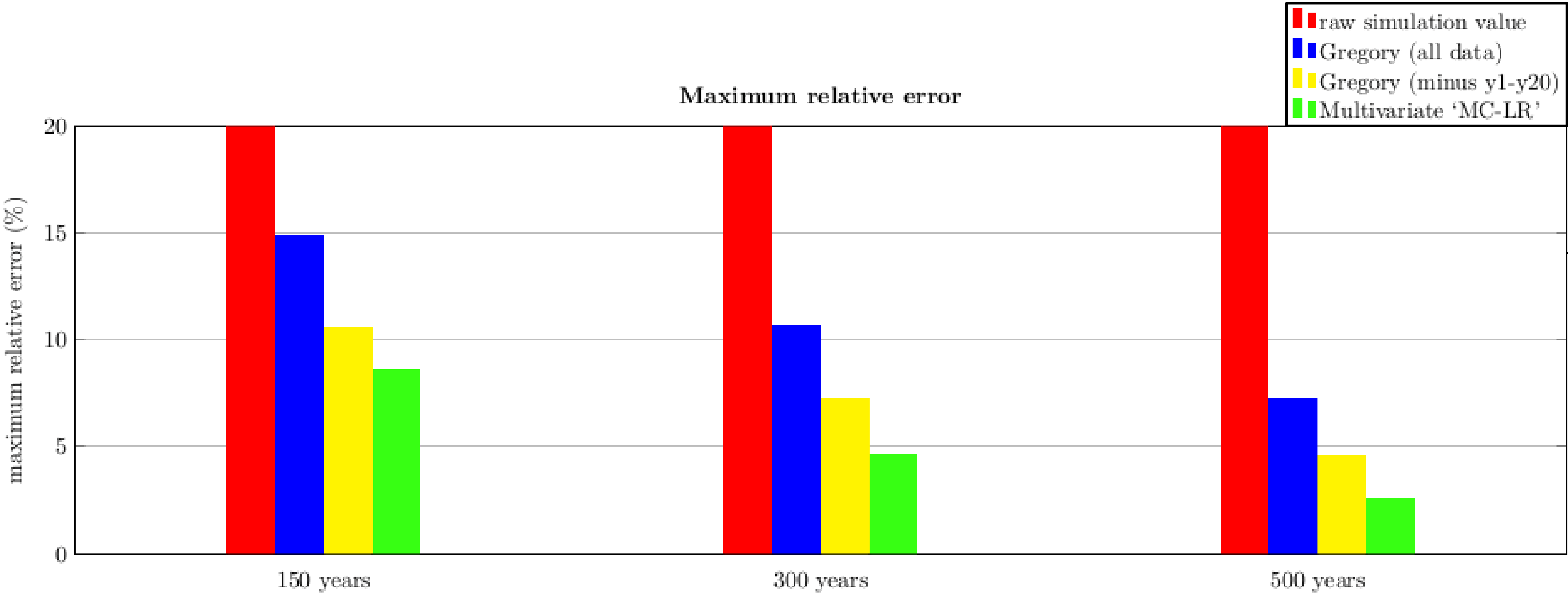


[Bastiaansen et al, 2021]

Other Global Climate Models



Computed as average of 11 millenia-long runs from LongRunMIP [Rugenstein et al, 2019]

[Bastiaansen et al, 2021]

Discussion

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OUTLOOK:

- ✪ Method can help in design of model experiments
- ✪ Multivariate estimate also provides insight in *how* climate changes