CarbonTracker Statistical Fit with TM5-MP

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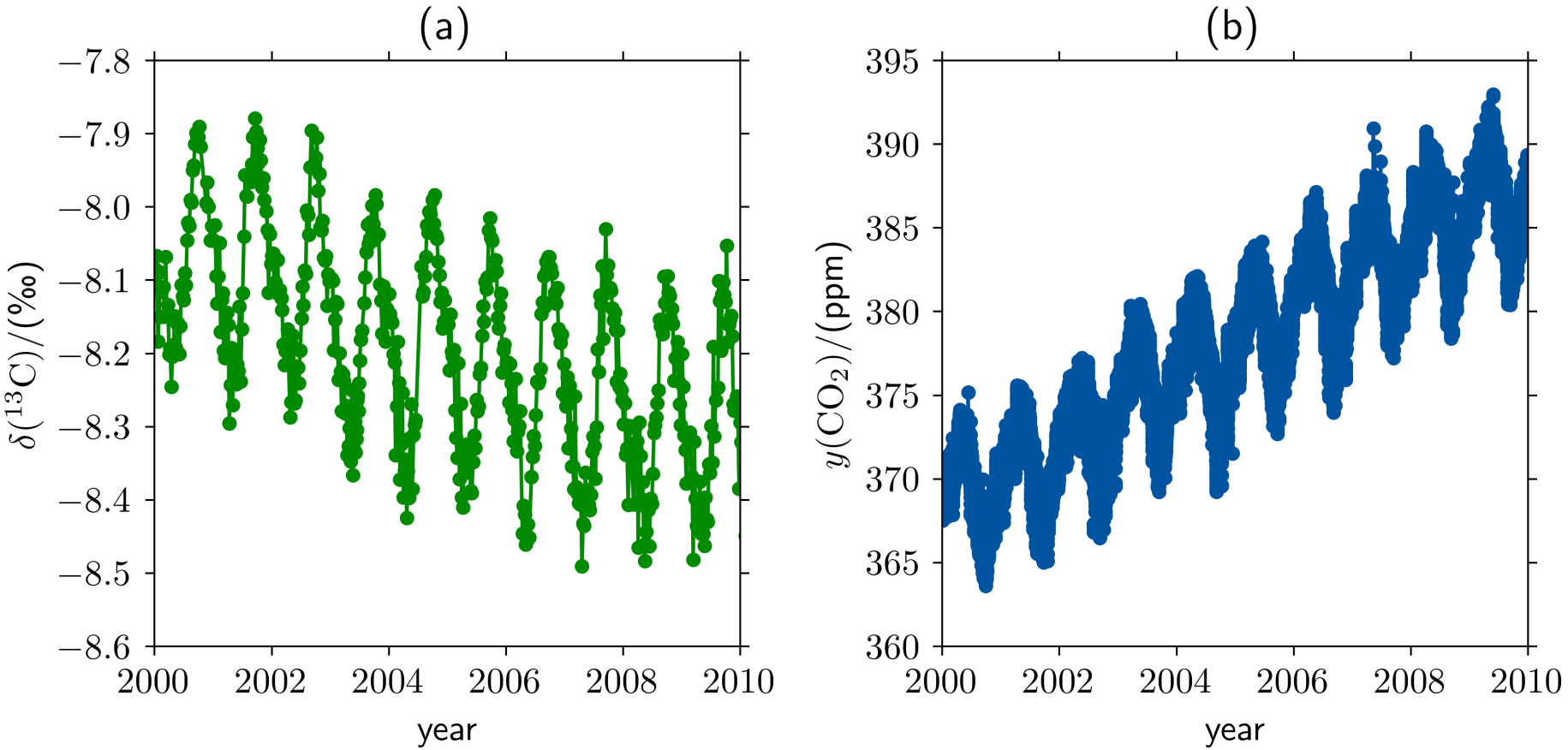
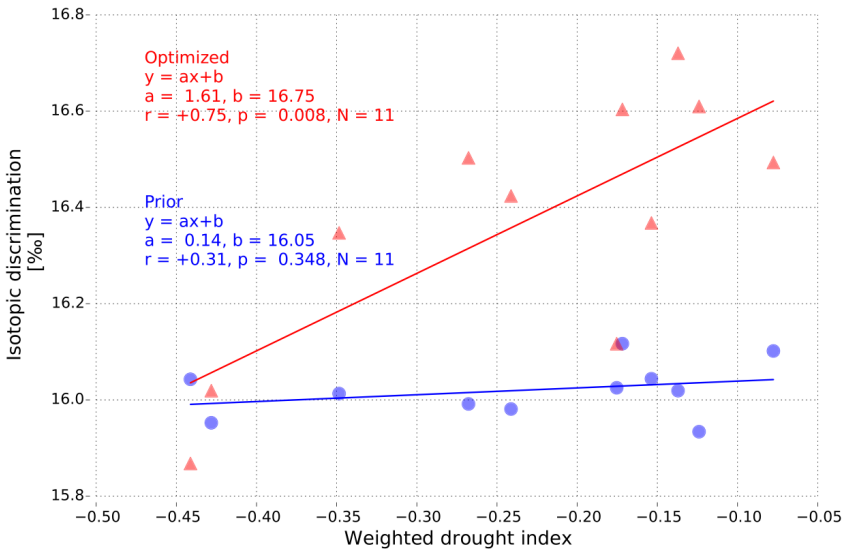
TM5 meeting, 30–31 May 2021

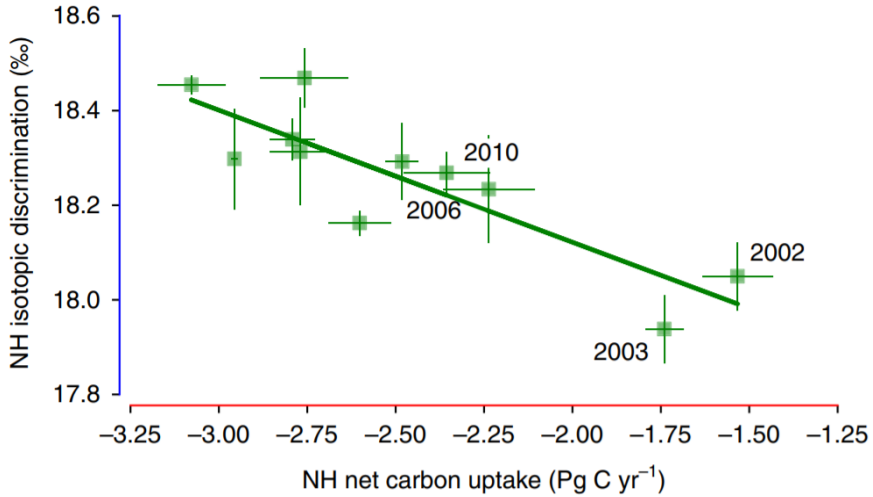
Atmospheric records of CO_2 and $\delta(^{13}C)$ (NOAA Data)



From observable to cause: Inverse modelling

(Velde et al., 2018)





(Peters et al., 2018)

Limitations

1. Limited records of $\delta(^{13}C)$
   1. data gaps
   2. simulations span 2000–2012
2. 5 weeks of lag
3. Inconsistencies in th prior budget of $\delta(^{13}C)$

A new project NOAA–WUR

Aim to understand terrestrial carbon exchange, its variability and relation to drought dynamics using inverse modelling of $\delta(^{13}C)$.

1. Development of a new prior budget (Aleya Kaushik and John Miller)
   1. SiB4 with improved ^{13}C scheme
   2. New ocean $\delta(^{13}C)$ product
2. Extension of the observational record
3. Inverse modelling using CTDAS + TM5 of period 1990–2020

Carbon Tracker Statistical Fit

Parameter optimization inspired by (Rödenbeck et al., 2018)

CTDAS Enkf:

- optimized $= \lambda \times$ prior
- 1 value of λ per week per grid box

CTSF:

- optimized $= \gamma \times$climate anomaly$+$ prior
- γ per month, but the same for each year.

Carbon Tracker Statistical Fit

- optimizations of the coefficients of

$$NEE(x, y, t) = x_0 + x_1 t + x_2 t^2 + \sum_{n=1}^{4} \left[(a_n + b_n t) \cos\left(\frac{2\pi}{T} nt\right) + (c_n + d_n t) \sin\left(\frac{2\pi}{T} nt\right) \right] \quad (1)$$

- To capture long term trend and seasonal cycle. In addition,

$$+\gamma_{\mathrm{m}}(x, y)\Delta P(x, y, t) \quad (2)$$

- to capture spatial and interannual variability

Development of new inversion framework

Combine:

1. TM5-zoom CTDAS-C13 (Velde et al., 2018)
2. TM5-zoom CTE-CTSF (Liesbeth/Gerbrand)
3. TM5-MP-Enkf (test version)

Into a single framework: CarbonTracker Europe Carbon Cycle

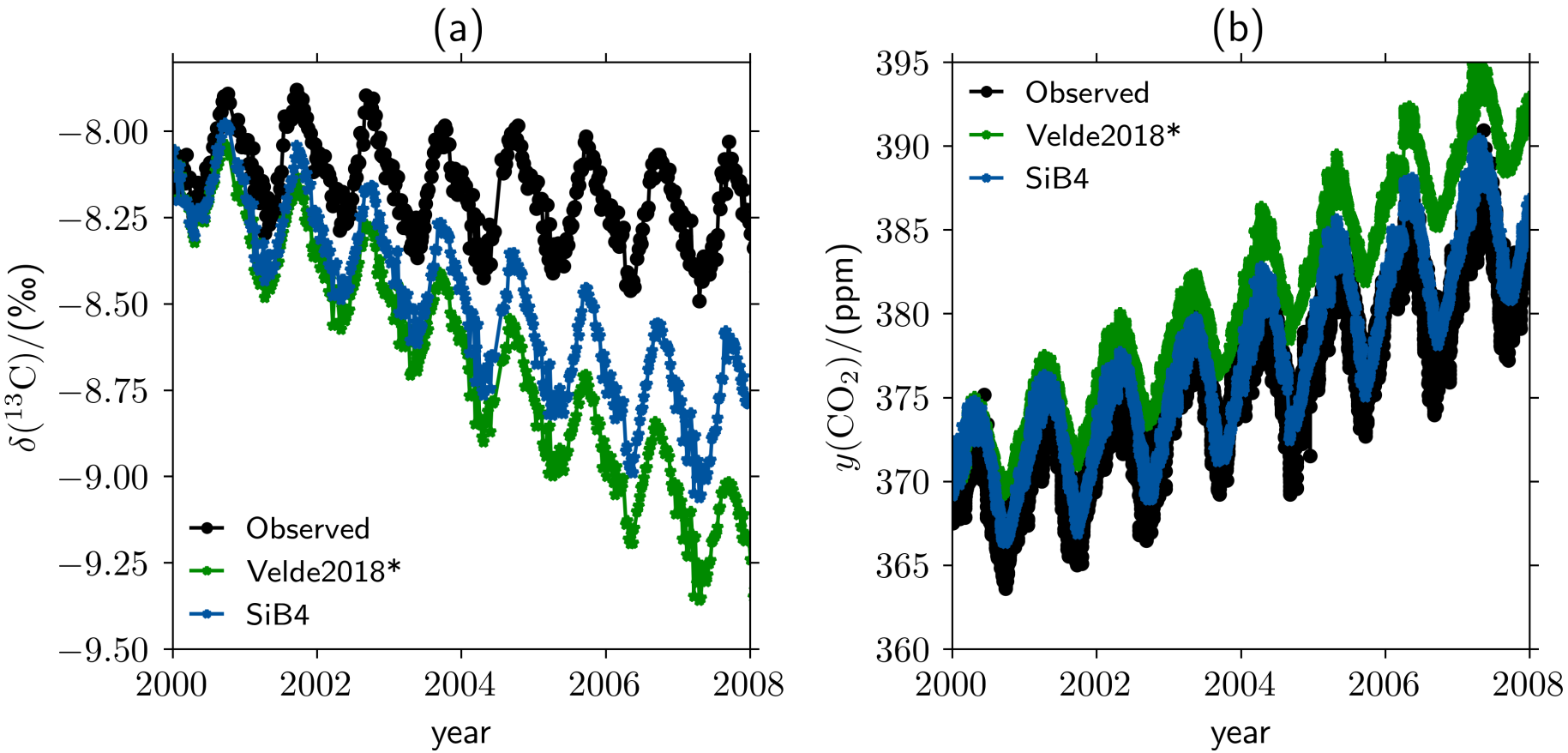
CarbonTracker Europe Carbon Cycle

1. TM5-MP as observation operator

2. Anticipating multi-tracer inversions:
   1. CO_2, $^{13}CO_2$ (JJDH), CO (AWvdB), O_2/N_2 (IL), $^{14}CO_2$ (IL)...
   2. `nspecies`×`nmembers`=`ntracet`
   3. Rc configuration `ct.params.species: co2 co2c13`

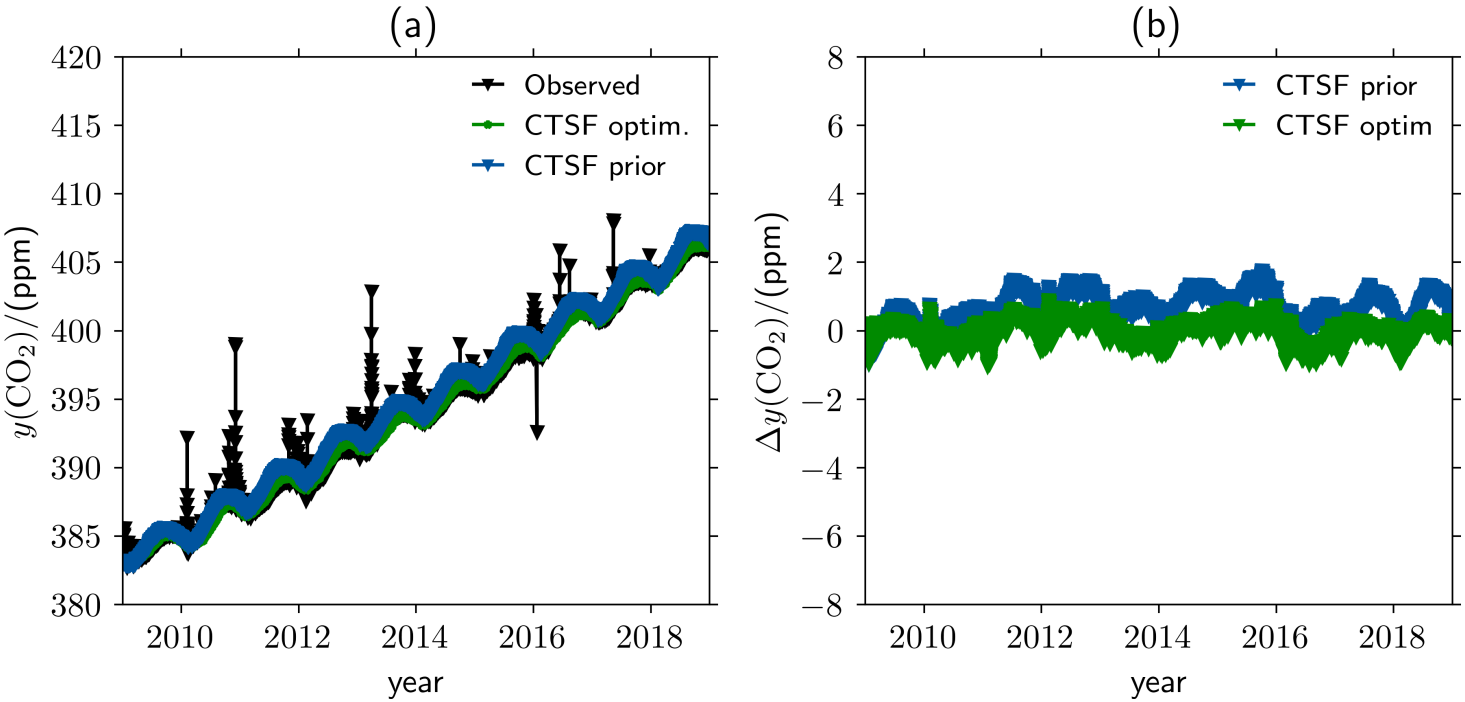
3. Switch optimization method: `<ctsf | classic>`

Results: forward simulations of new prior budget



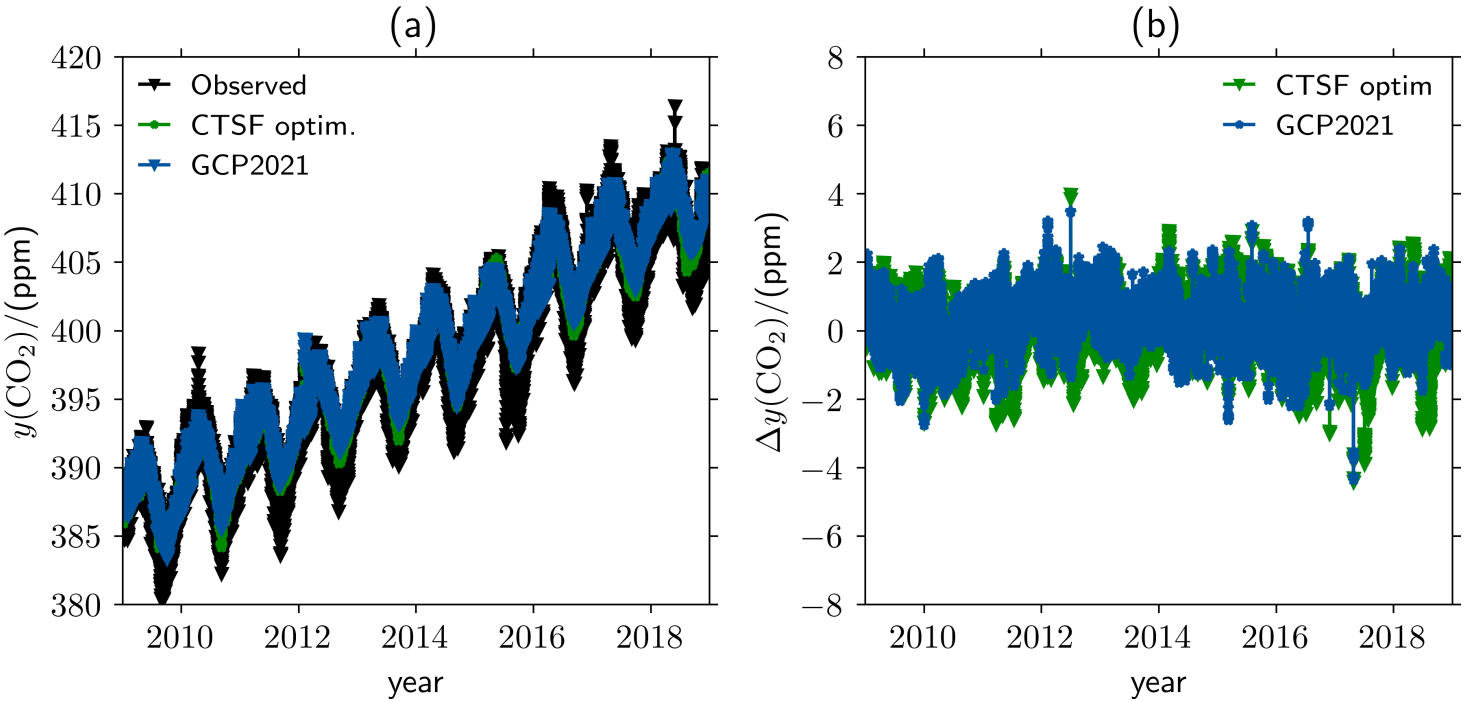
*modified (Velde et al., 2018) budget: CarboScope ocean (Rödenbeck et al., 2013) and climatology for isotopic disequilibrium

CTSF optim vs prior at South Pole Observatory



Mean residual from 0.6 ppm to −0.03 ppm

CTSF vs CTE (GCP2021 biosphere only)



Mean residual

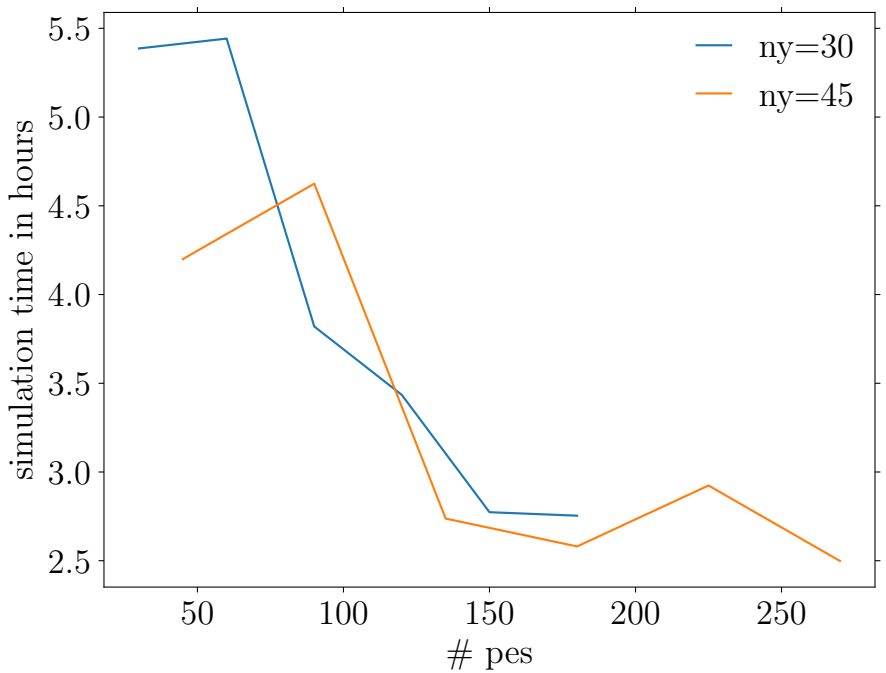
- CTE 0.3 ppm
- CTSF 0.14 ppm

Summary

- Realization of a multi-species inversion framework in TM5-MP
- Updates to $\delta(^{13}C)$ budget
- Continuing development of CarbonTracker Statistical Fit

Benchmarks on Snellius

How well does our application scale?



- glb3x2 coarsened era 5 meteo
- 300 tracers (only transport)
- Results scaled from a simulation of 31 d

Port of Enkf from zoom to TM5-MP

Branches

1. `wur/enkf`
2. `wur/ctsf`
3. `wur/enkf_c13_devel`