

Atmospheric inversions using satellite observations (synthesis)

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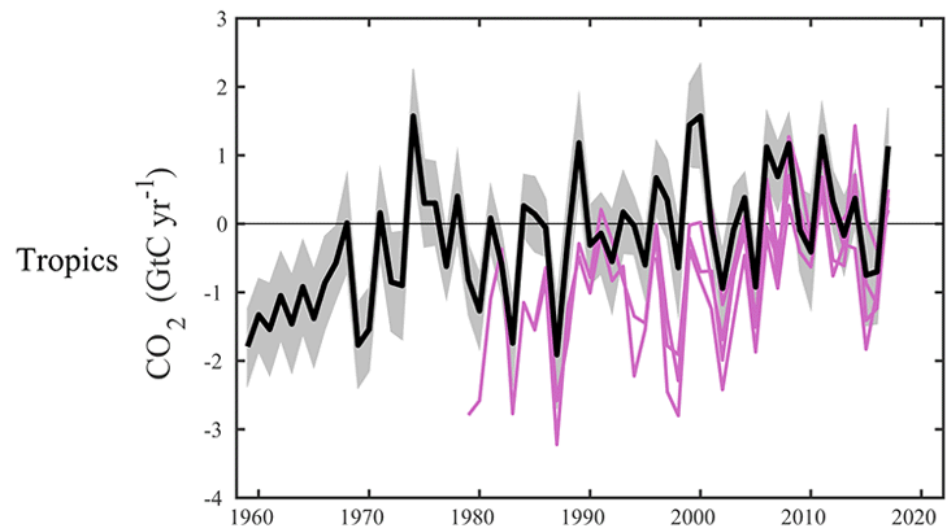
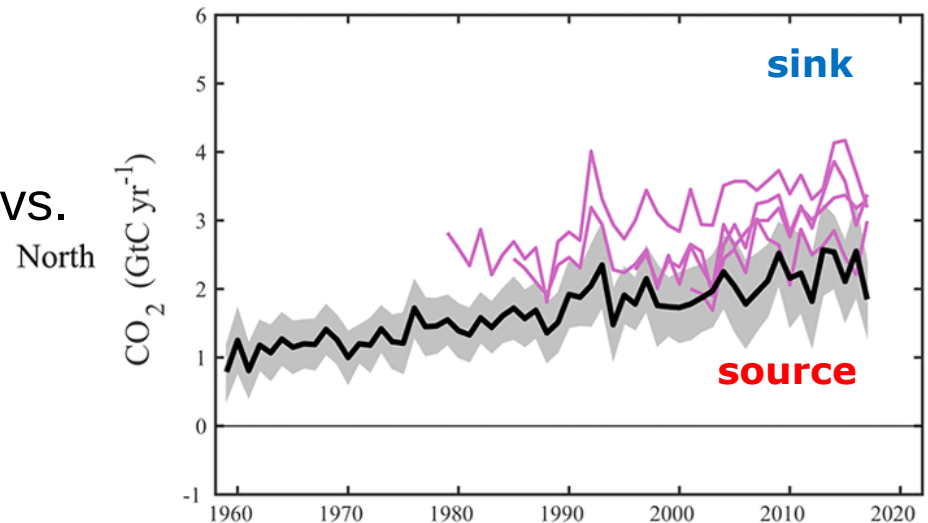
LABORATOIRE DES SCIENCES DU CLIMAT & DE L'ENVIRONNEMENT



Global Carbon Budget 2018

(Le Quéré et al., ESSD, 2018)

- Air-sample measurements only
- 4 global inversion systems
- C natural budget in the Tropics vs. in the NH extra-Tropics
- Use independent aircraft measurements to “rank” the inversions?
 - Stephens et al., 2007
 - Houweling et al., 2015
 - etc.



Ensemble of six CO₂ inversions

- 3 assimilation datasets



- SURF = surface from Obspack, RAMCES, WDCGG, 2000 – 2018
- GOSAT = C3S from Univ of Leicester, April 2009 – Dec 2016
- OCO-2 = NASA v9 over land, Sep 2014 – July 2018

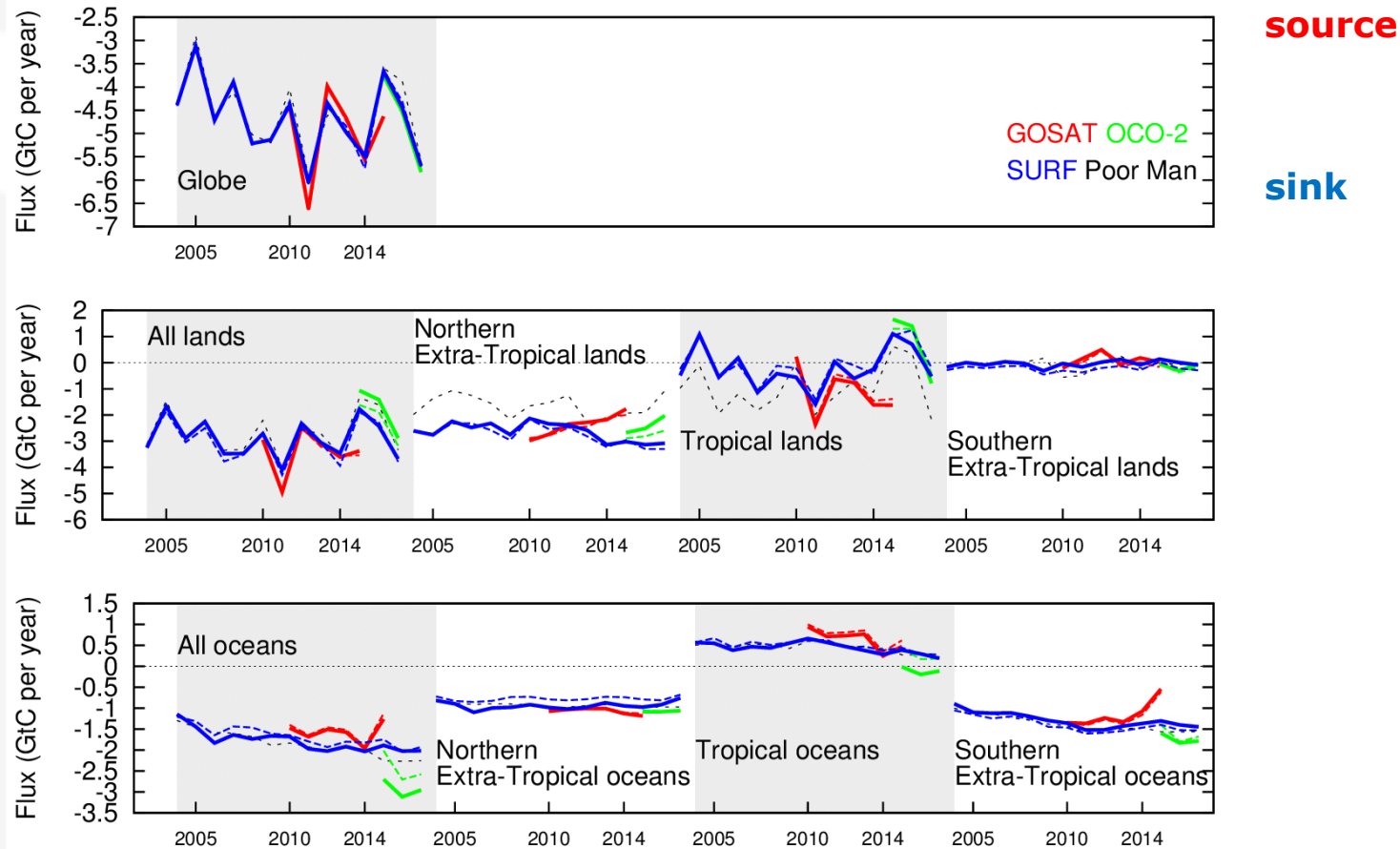
- 2 transport model versions

- LMDZ5A (LMDz code ID 1649, made in 2012) nudged to ERA-Interim
- LMDZ6A (LMDz code ID 3353, made in 2018) nudged to ERA-5

- 4-6 weeks of computation per inversion.

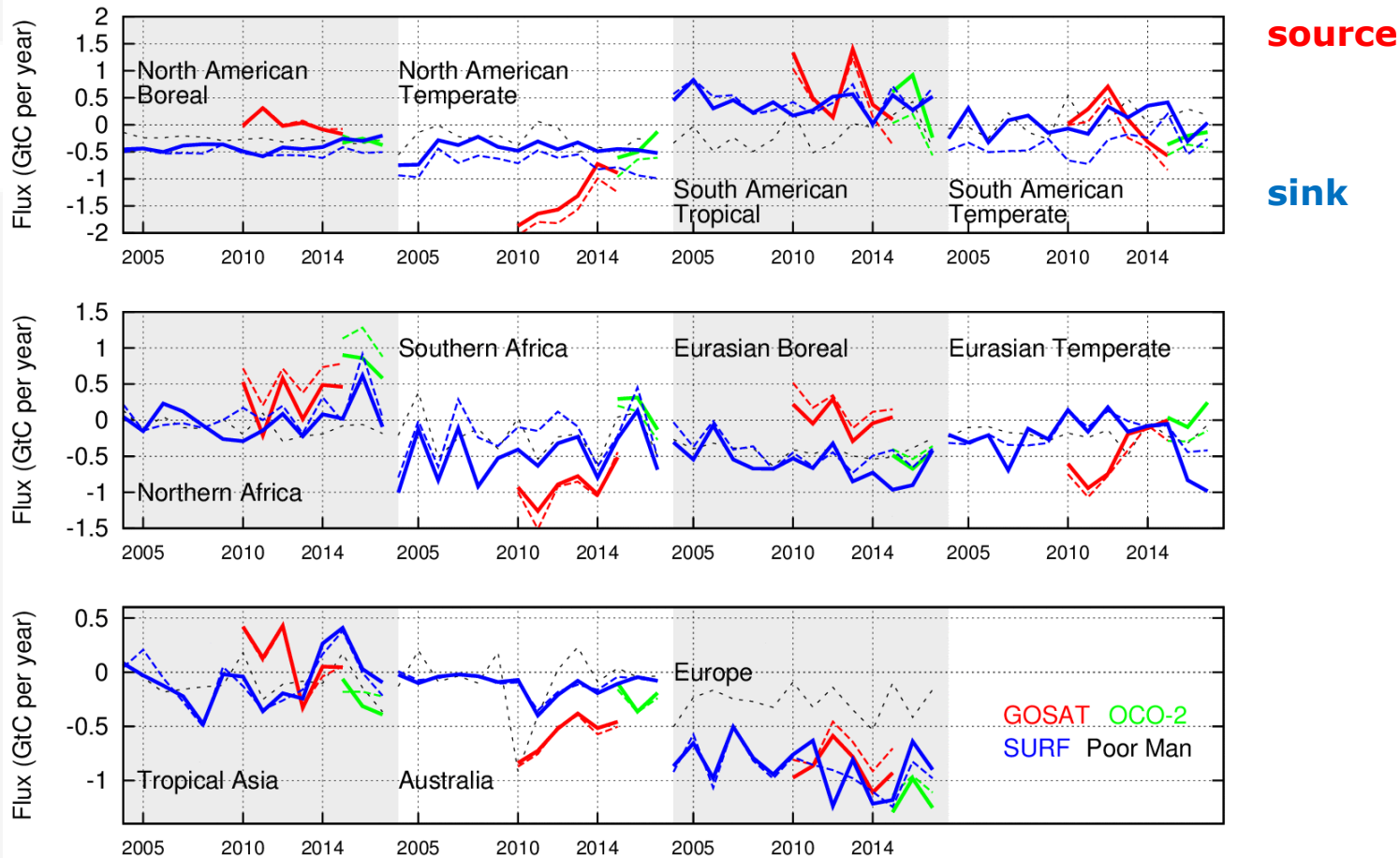
- Extra: Poor man's inversion that corrects a recent bottom-up estimate (ORCHIDEE TrendyS3 + Landschützer et al. + GFED + GCP) with NOAA's growth rate estimate $\times 2.086 \text{ GtC}\cdot\text{ppm}^{-1}$.

Time series of Inferred natural CO₂ annual flux between 2004 and 2017: globe



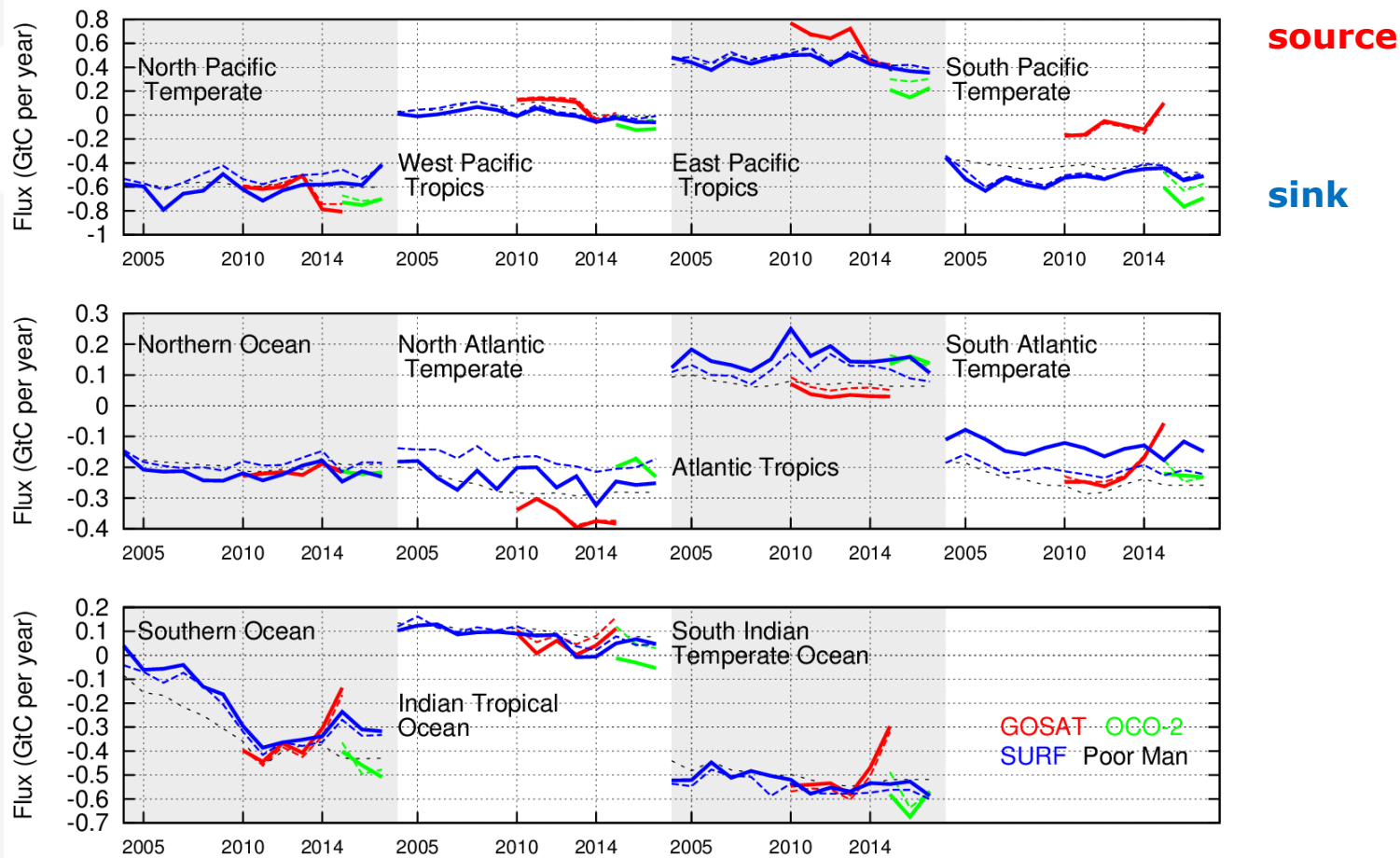
Inversions with LMDz5A (LMDz6A) are shown in continuous (dashed) coloured lines.

Time series of Inferred natural CO₂ annual flux between 2004 and 2017: TransCom land



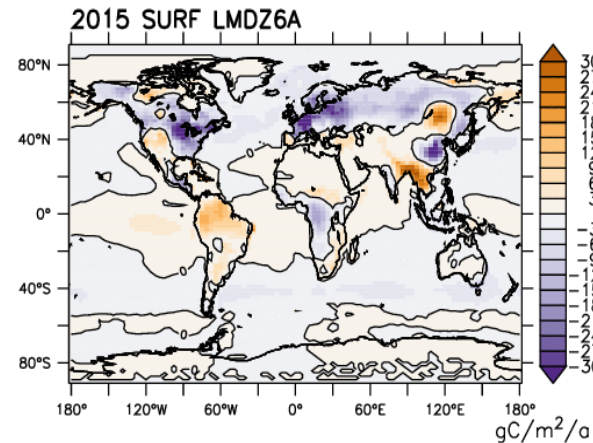
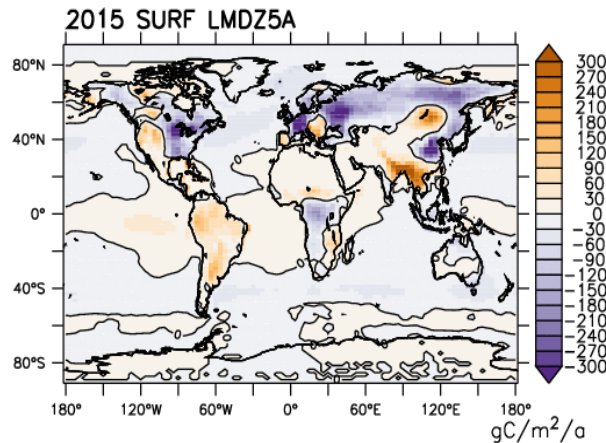
Inversions with LMDz5A (LMDz6A) are shown in continuous (dashed) coloured lines.

Time series of Inferred natural CO₂ annual flux between 2004 and 2017: TransCom ocean



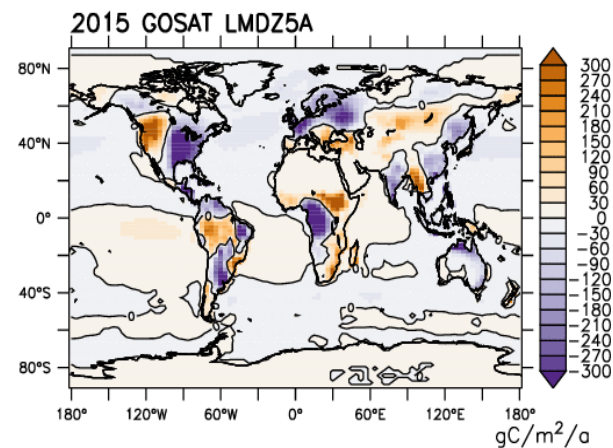
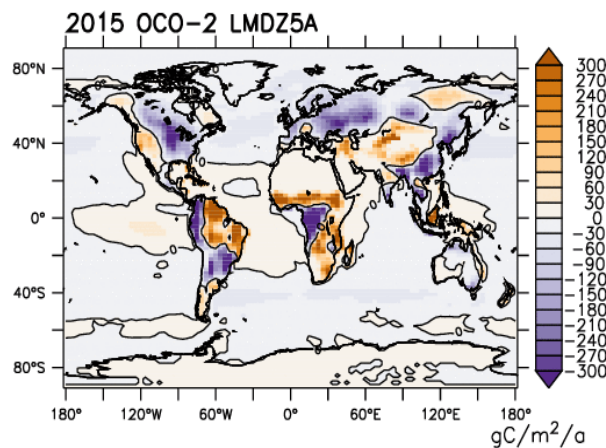
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Grid-point budget of the natural CO₂ fluxes for the year 2015

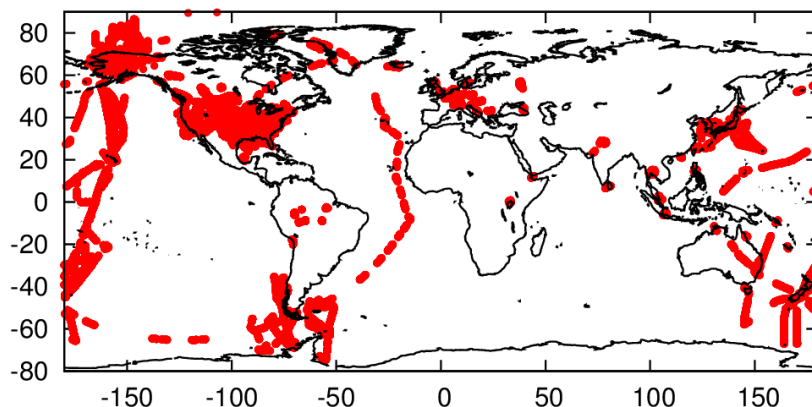


source

sink

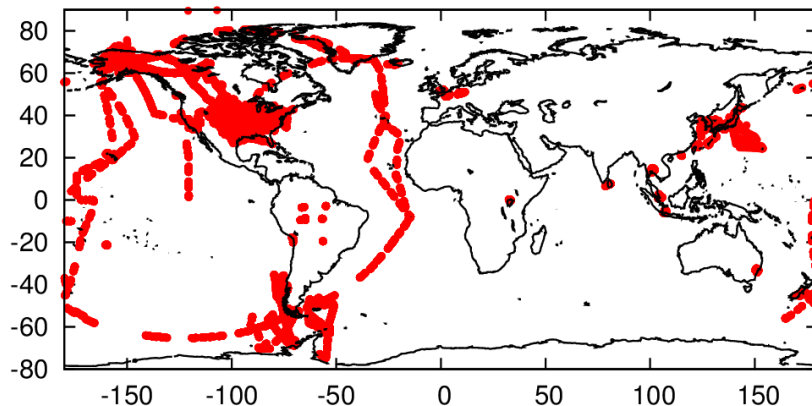


Location of the aircraft measurements in the free troposphere for the two verification periods



GOSAT period

July 2009 – Sep 2016



OCO-2 period

Dec 2014 – Dec 2017

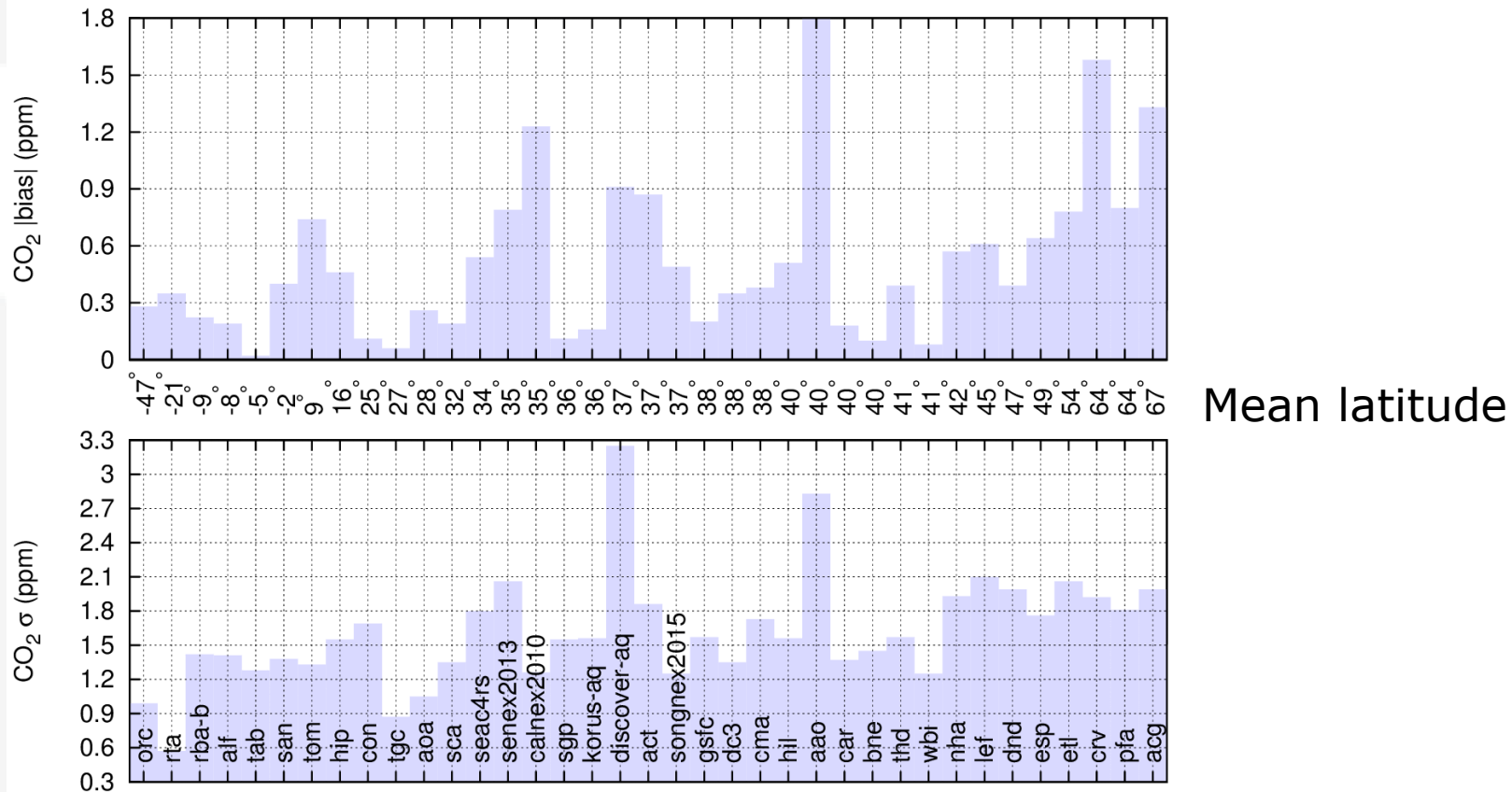
The two periods overlap by 22 months, so that many data appear on both maps.

Free troposphere = 2-7 km asl.

All data from Obspack GV+4.0 and INPE_RESTRICTED_v2.0.



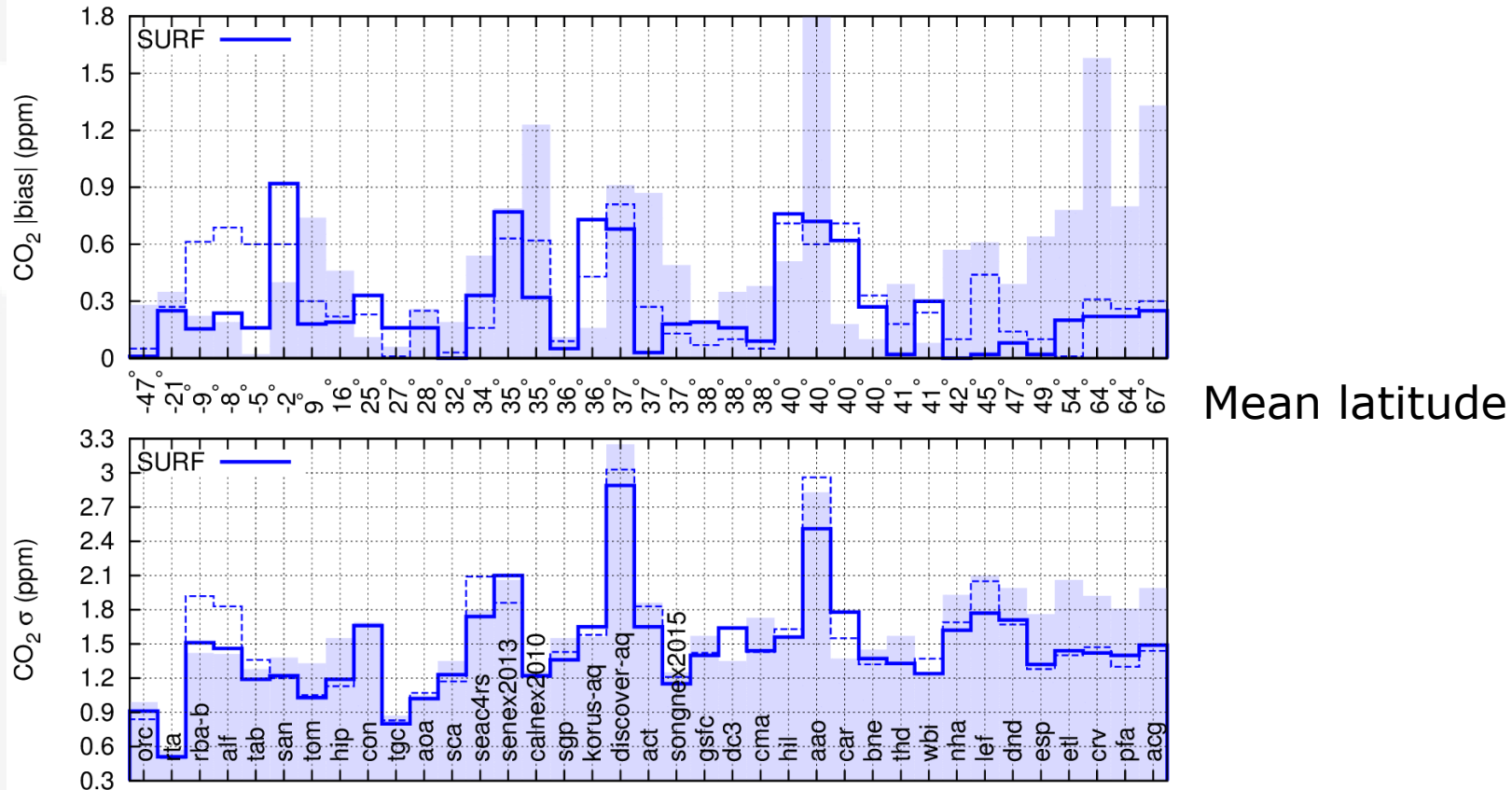
Model-minus-observation $|\delta|$ and σ over the GOSAT period



Poor man's inversion results appear as a shaded area

(ORCHIDEE TrendyS3 + Landschützer et al. + GFED + GCP + NOAA's growth rate estimate).

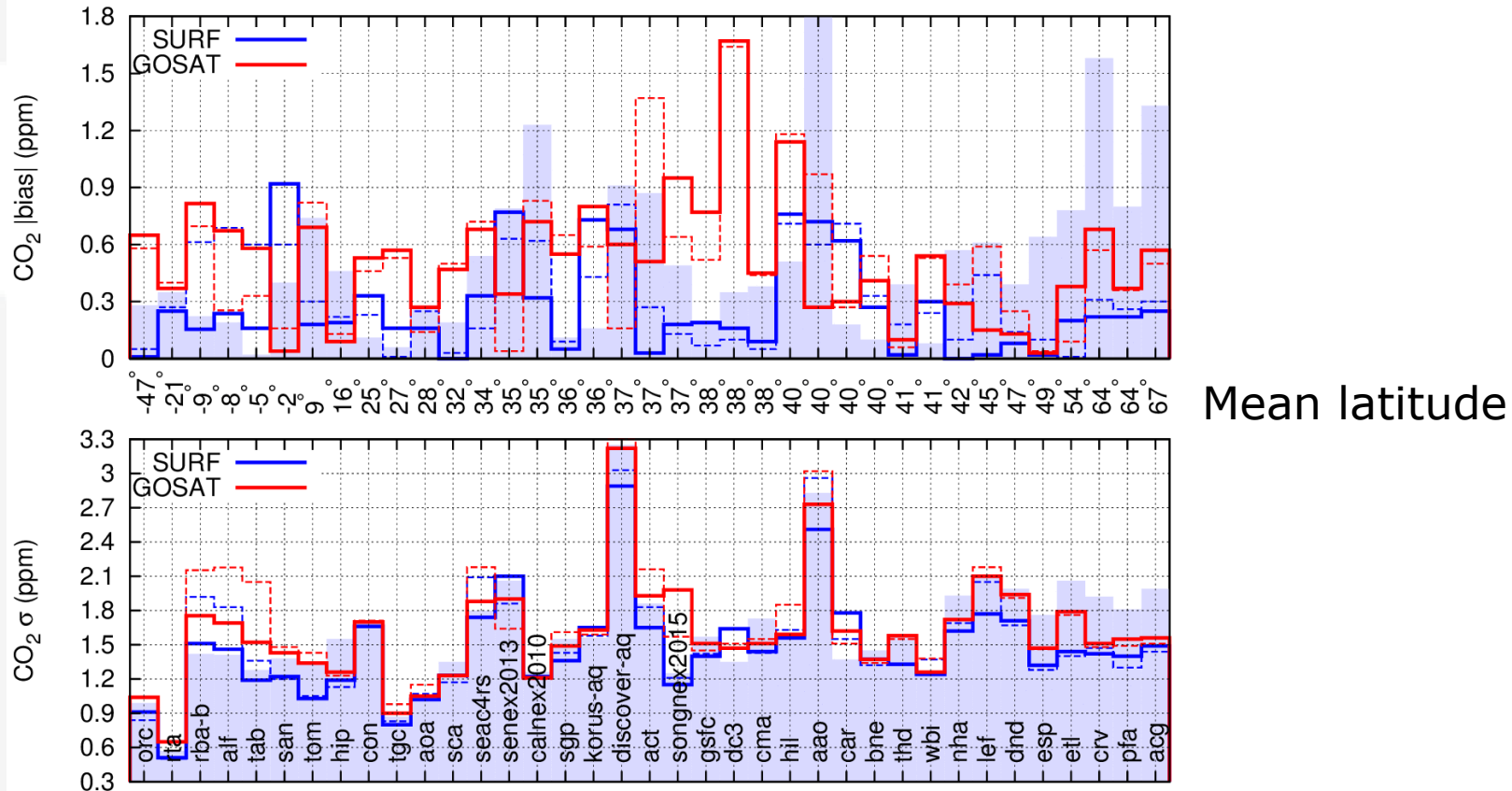
Model-minus-observation $|\delta|$ and σ over the GOSAT period



Poor man's inversion results appear as a shaded area.

Inversions with LMDz5A (LMDz6A) are shown in continuous (dashed) coloured lines. The number of measurement per campaign varies between 113 (BNE) and 901,846 (CON).

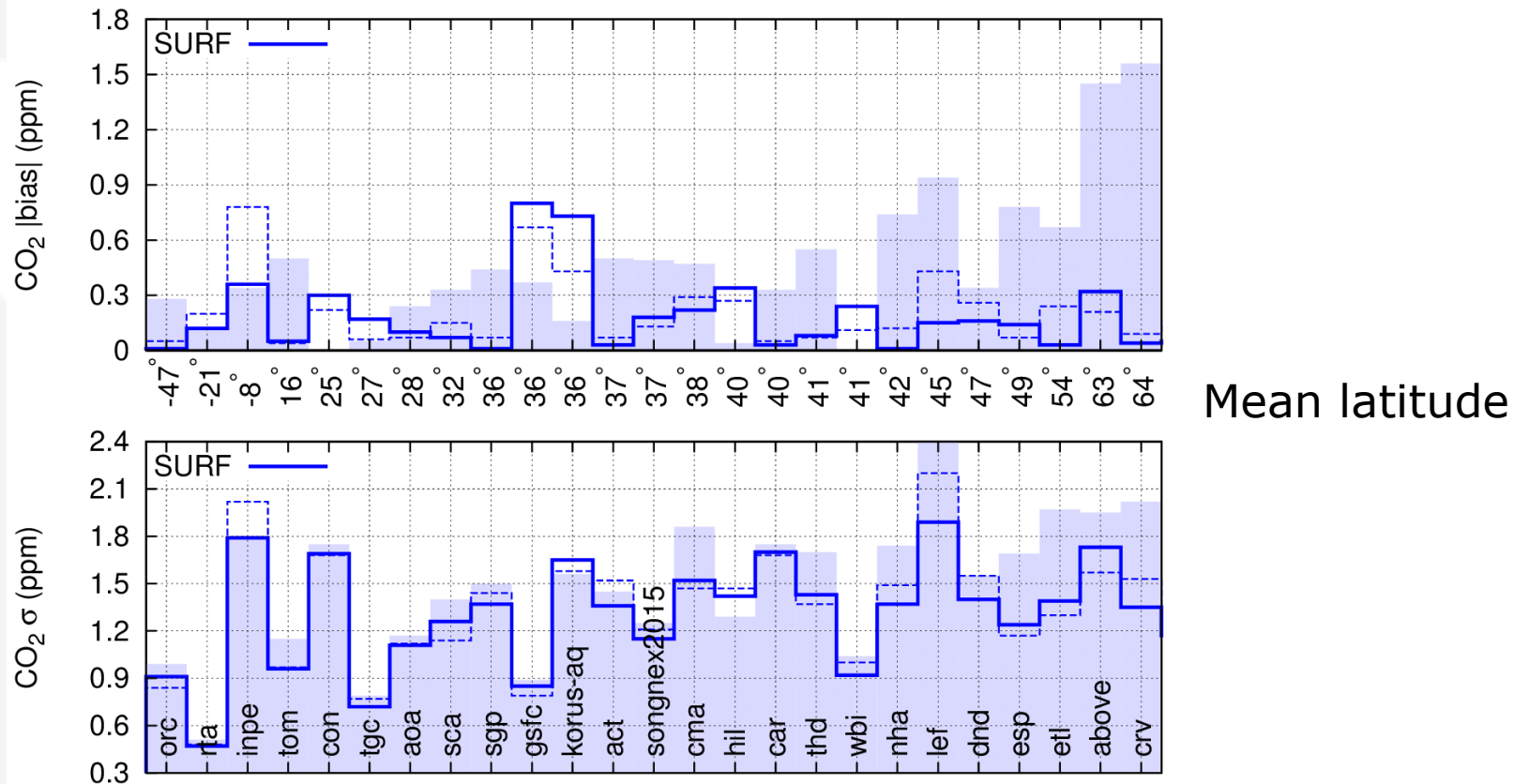
Model-minus-observation $|\delta|$ and σ over the GOSAT period



Poor man's inversion results appear as a shaded area.

Inversions with LMDz5A (LMDz6A) are shown in continuous (dashed) coloured lines. The number of measurement per campaign varies between 113 (BNE) and 901,846 (CON).

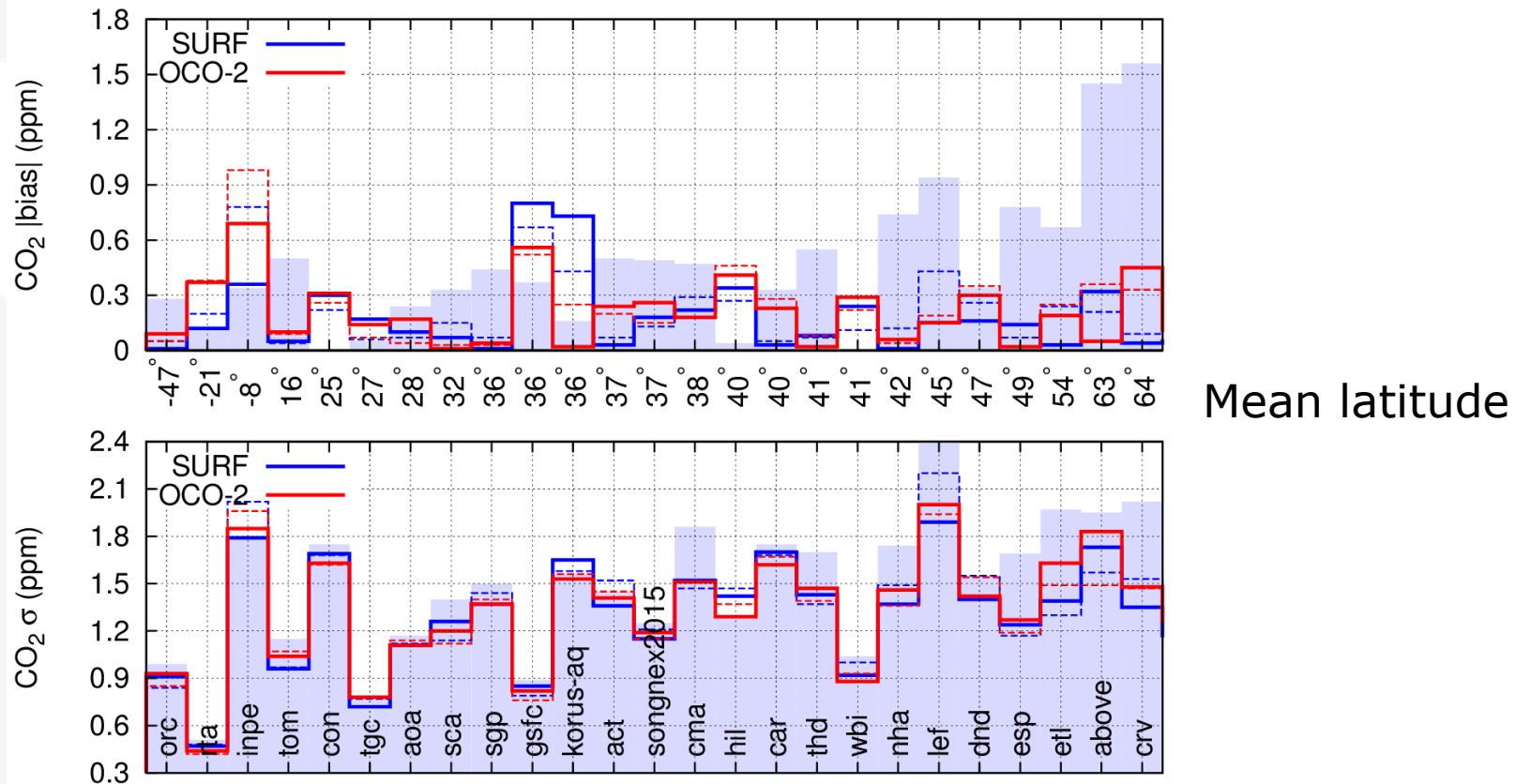
Model-minus-observation $|\delta|$ and σ over the OCO-2 period



Poor man's inversion results appear as a shaded area.

Inversions with LMDz5A (LMDz6A) are shown in continuous (dashed) coloured lines. The number of measurement per campaign varies between 133 (CRV) and 211,358 (CON).

Model-minus-observation $|\delta|$ and σ over the OCO-2 period

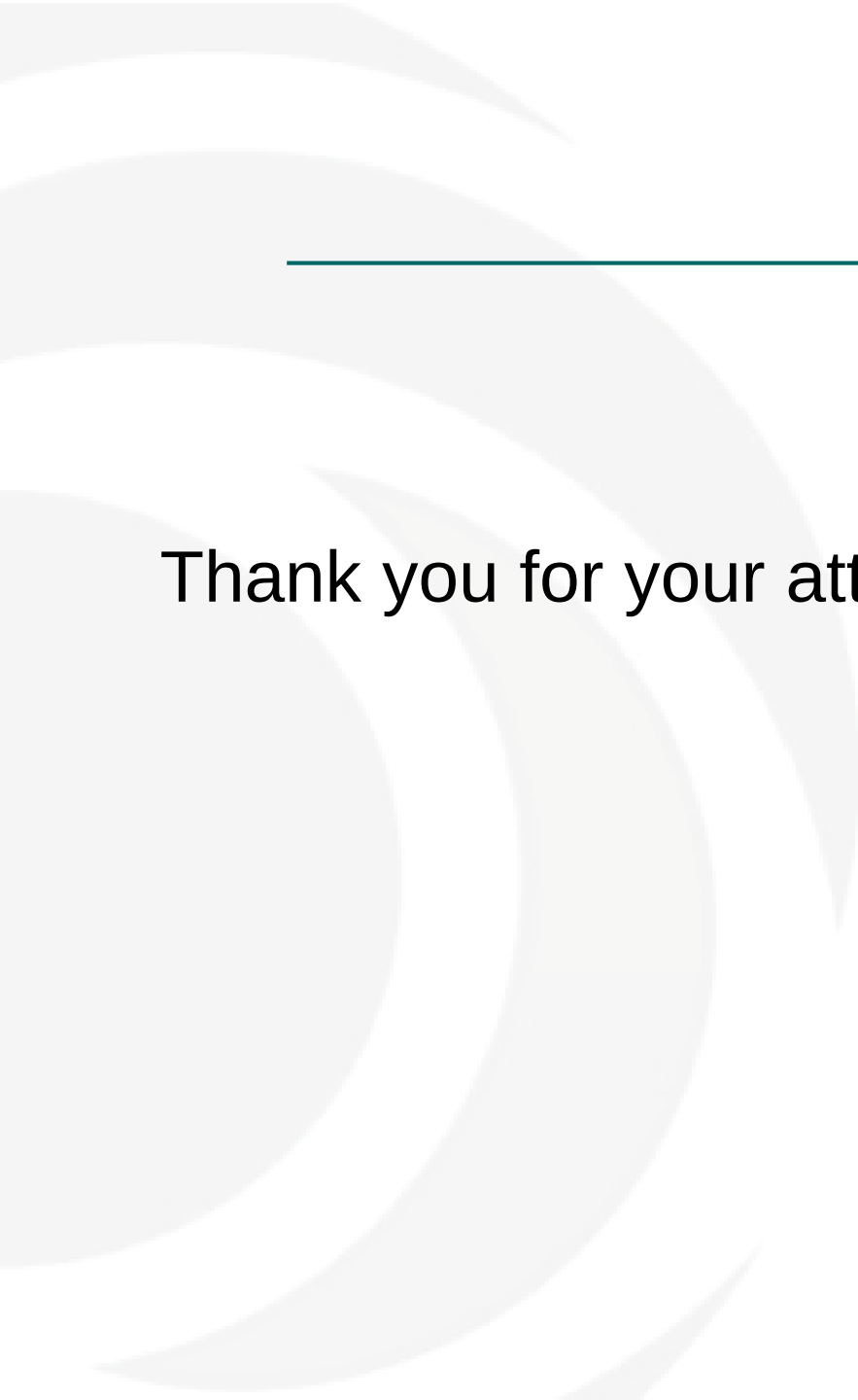


Poor man's inversion results appear as a shaded area.

Inversions with LMDz5A (LMDz6A) are shown in continuous (dashed) coloured lines. The number of measurement per campaign varies between 133 (CRV) and 211,358 (CON).

Conclusions

- SURF and OCO-2 inferred fluxes are close to each other. GOSAT fluxes (and Poor man's) are quite different.
- SURF and OCO-2 perform similarly wrt aircraft. GOSAT (and Poor man's) perform less well.
- Ranking/selection approach is desirable and may be possible now based on aircraft data, at least for long inversions.
 - May help decision-making, even for a given inversion system.
- No improvement brought by the more complex and more recent transport model version.
- Uncertainty in the inferred natural fluxes remain large.
- Both OCO-2 and SURF locate the recent terrestrial sink in the NH extratropics.
 - There are regional differences though, mostly in the Tropics.



Thank you for your attention