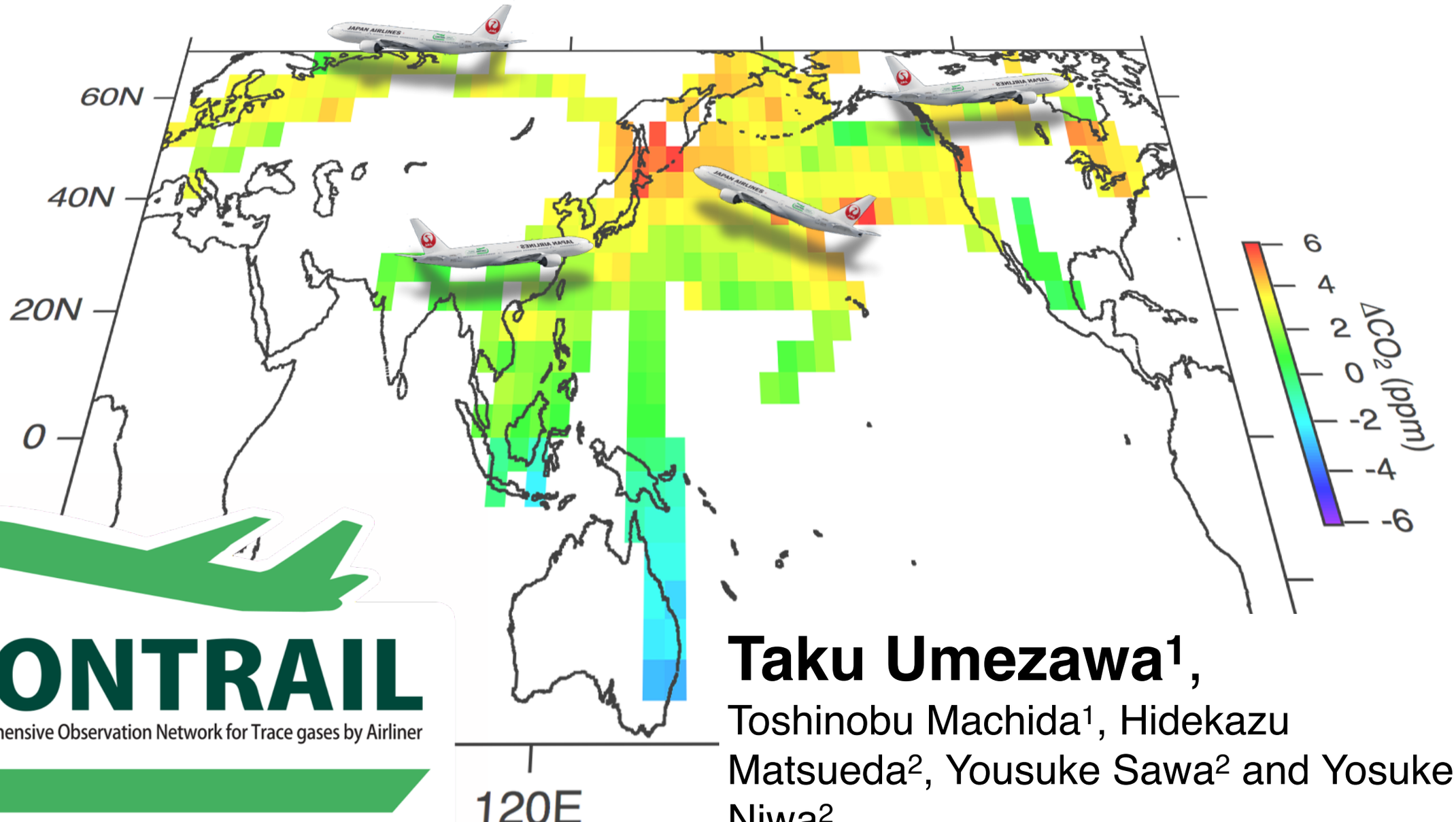
Climatology of tropospheric CO_2 observed by CONTRAIL-CME



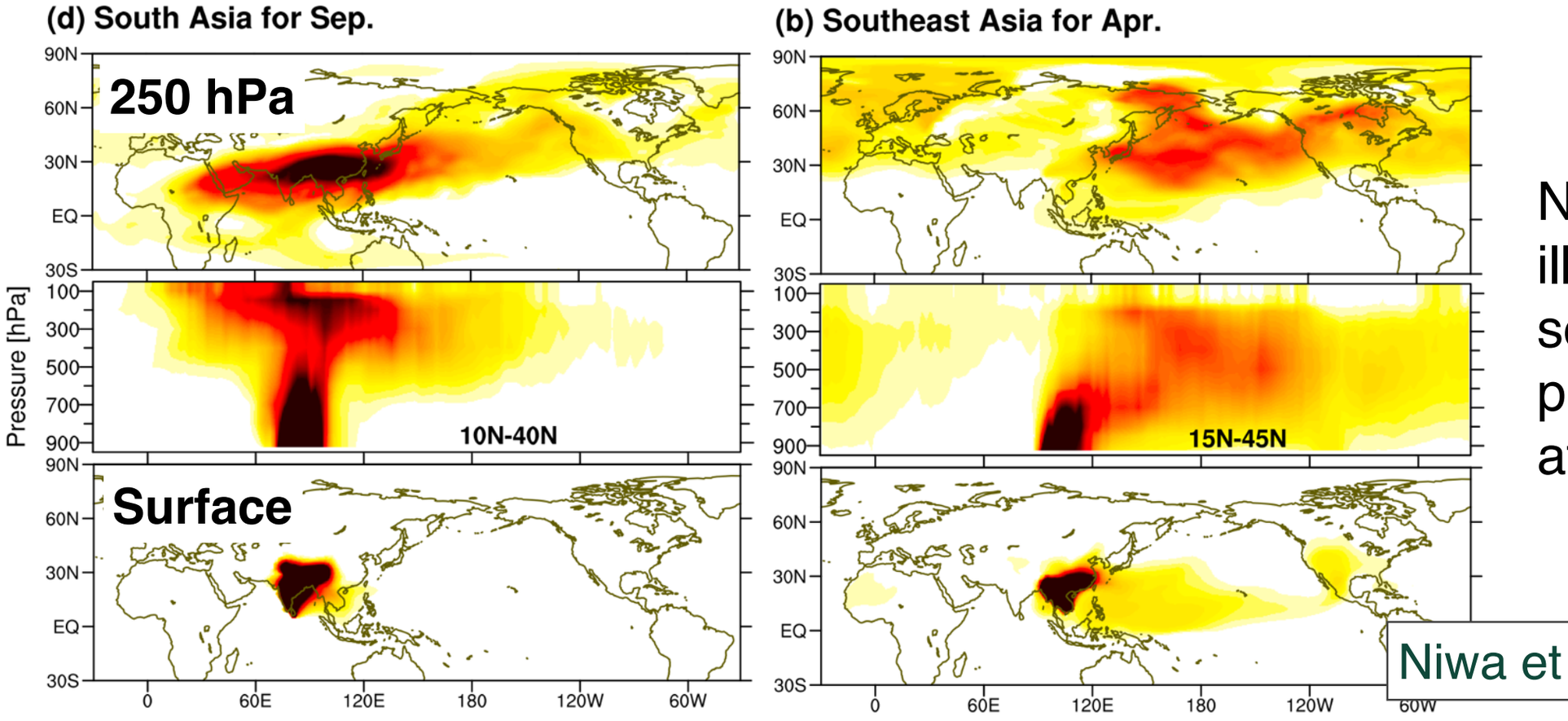
Taku Umezawa[1],
Toshinobu Machida[1], Hidekazu Matsueda[2], Yousuke Sawa[2] and Yosuke Niwa[2]
[1]National Institute for Environmental Studies
[2]Meteorological Research Institute

CONTRAIL
Comprehensive Observation Network for Trace gases by Airliner

JAPAN AIRLINES JAL FOUNDATION Jamco

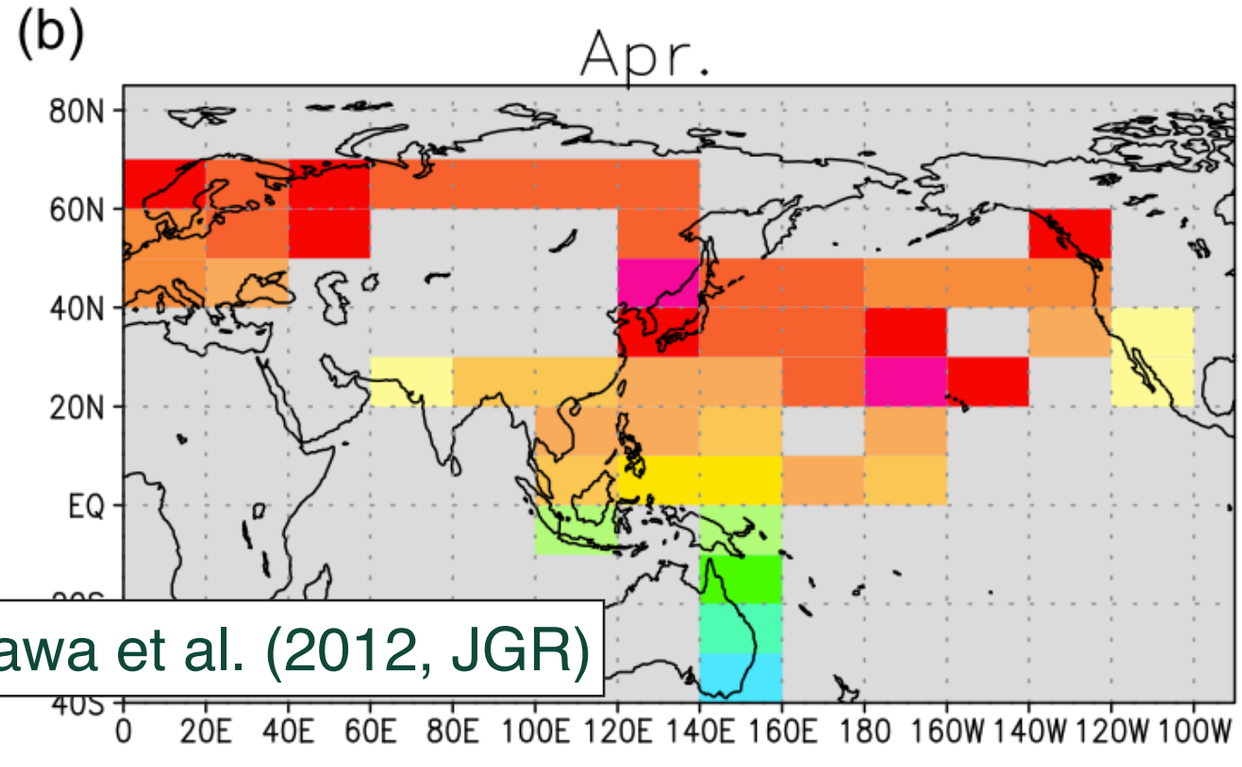
CONTRAIL Sticker Available!

What we see in the free troposphere



Niwa et al. (2012, JGR)

NICAM model illustrates how a source signal propagates in the atmosphere.



Sawa et al. (2012, JGR)

CONTRAIL CME data for 2005–2010:

- Number of flight ~5000
- Number of CME data ~3 millions
- Analysis grid 20° x 10°
- Vertical gradient was not analysed in detail.

Motivation

- **Distribution of CO_2 in the atmosphere is key information** for better understanding of the global carbon cycle.
  - Latitudinal gradient (e.g. Denning et al. 1995)
  - Vertical gradient (e.g. Stephens et al. 2007)

- There are data-scarce regions **where stable station measurements are still almost infeasible**.

- **CONTRAIL** can fill the data gap extensively.

  —and the data have been indeed used to infer surface fluxes (e.g. Niwa et al. 2012; Basu et al. 2014; Zhang et al. 2015).

- Yet complete description of **the CONTRAIL-provided atmospheric CO_2 distribution** (including updates and more of Sawa et al. 2008, 2012) has not be given.
  - In this presentation, we focus on CONTRAIL data in **Asia-Pacific regions**.

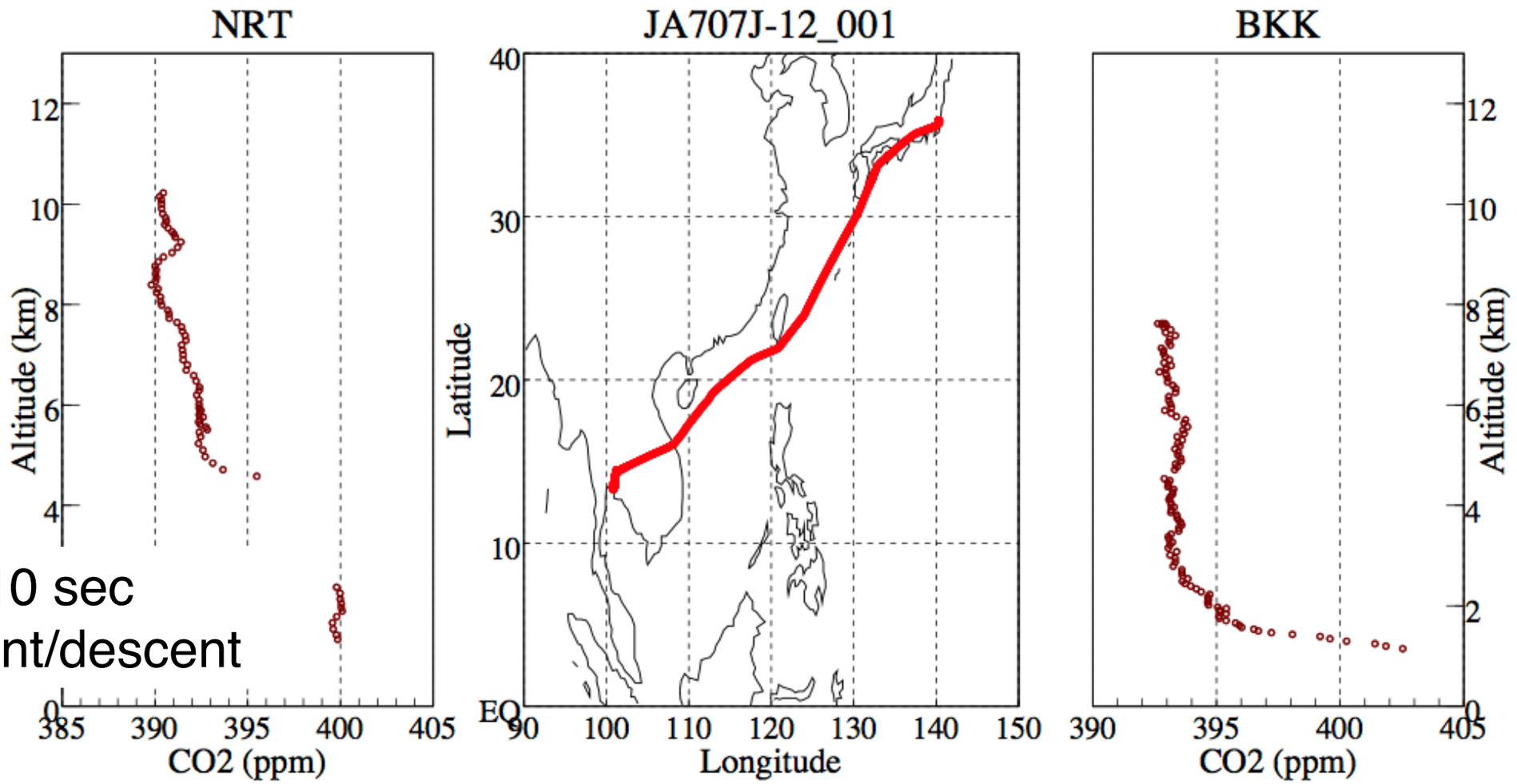
CONTRAIL Project since 2005

Comprehensive Observation Network for Trace gases by Airliner

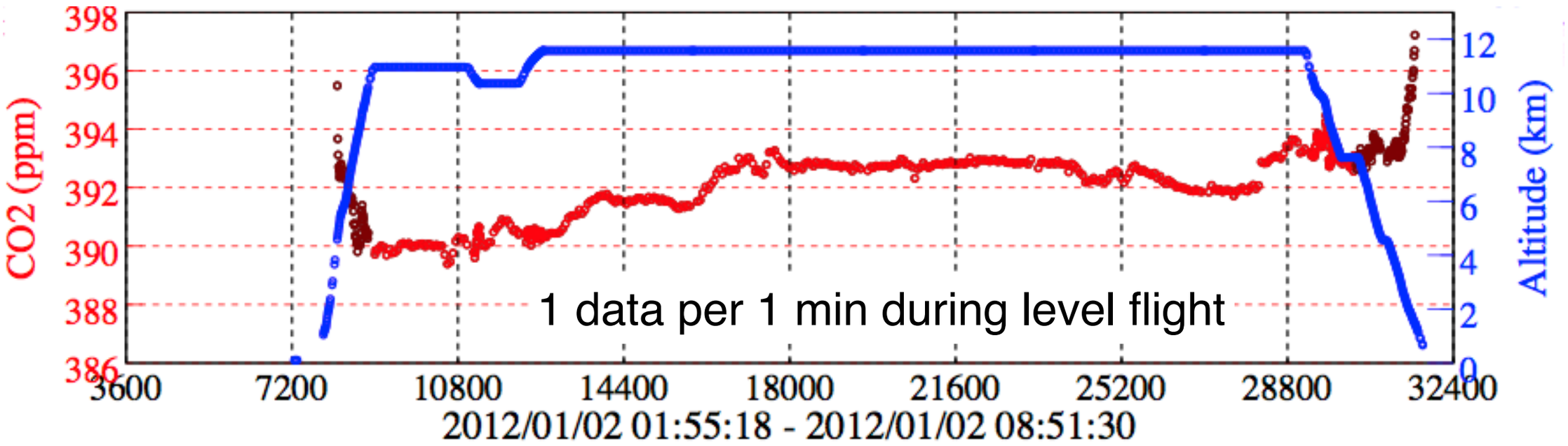
CME:
Continuous CO_2 Measuring Equipment

ASE: Automatic Air Sampling Equipment, for CO_2, CH_4, CO, N_2O, SF_6, H_2, isotopes

An example of CME data

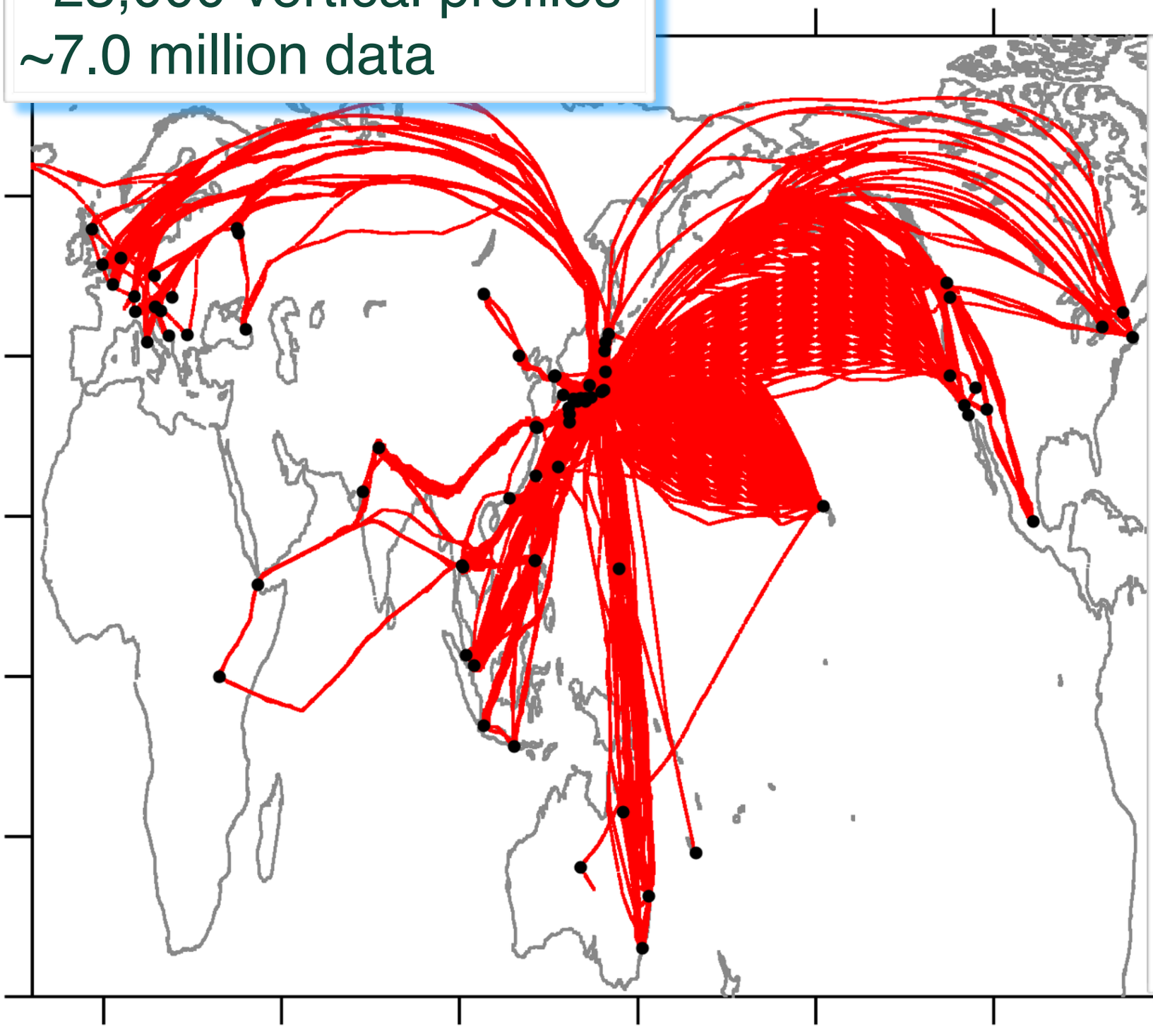


1 data per 10 sec
during ascent/descent



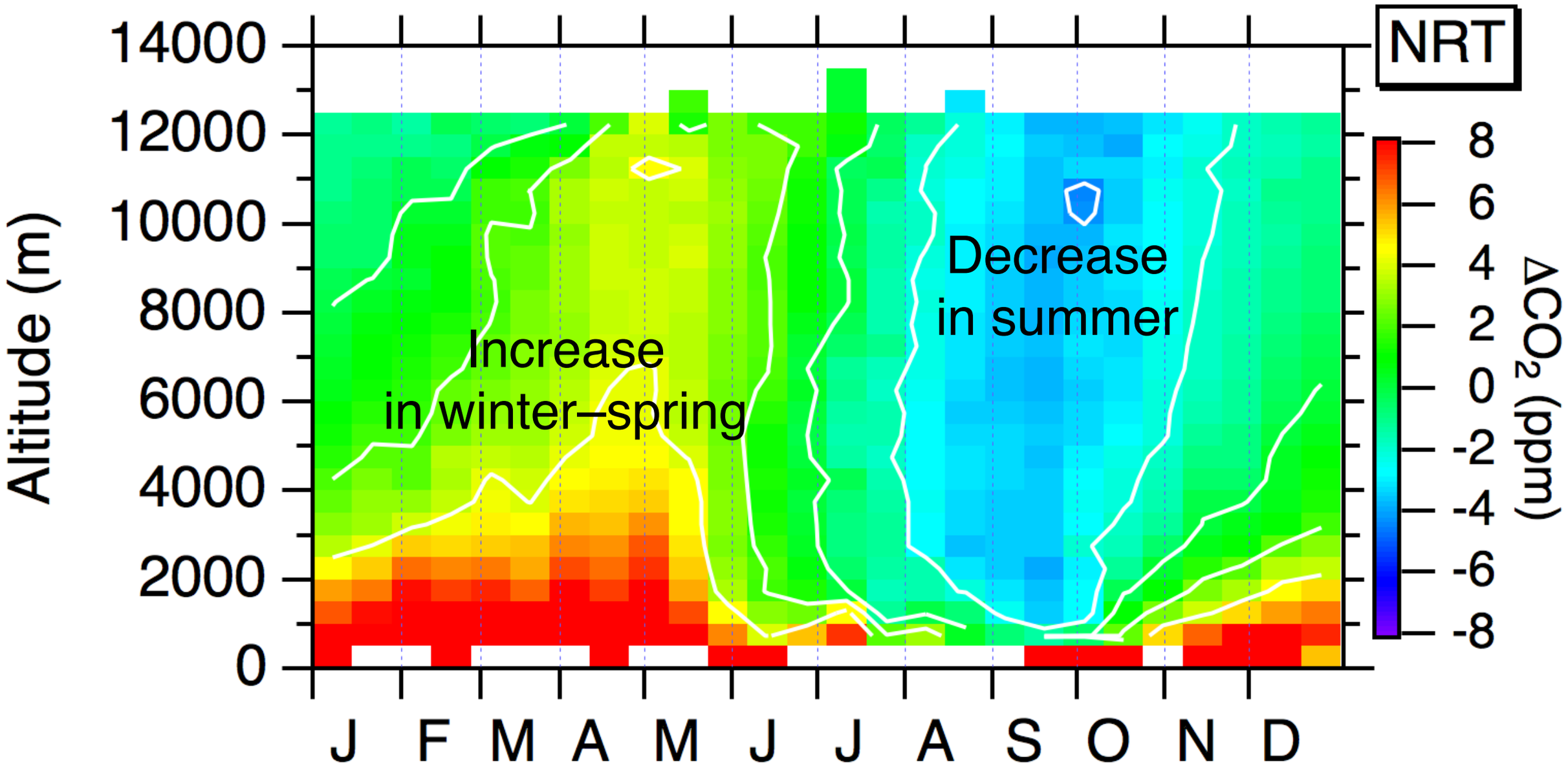
Flight routes with CME (Nov. 2005–Dec. 2014)

~12,000 flights
~23,000 vertical profiles
~7.0 million data



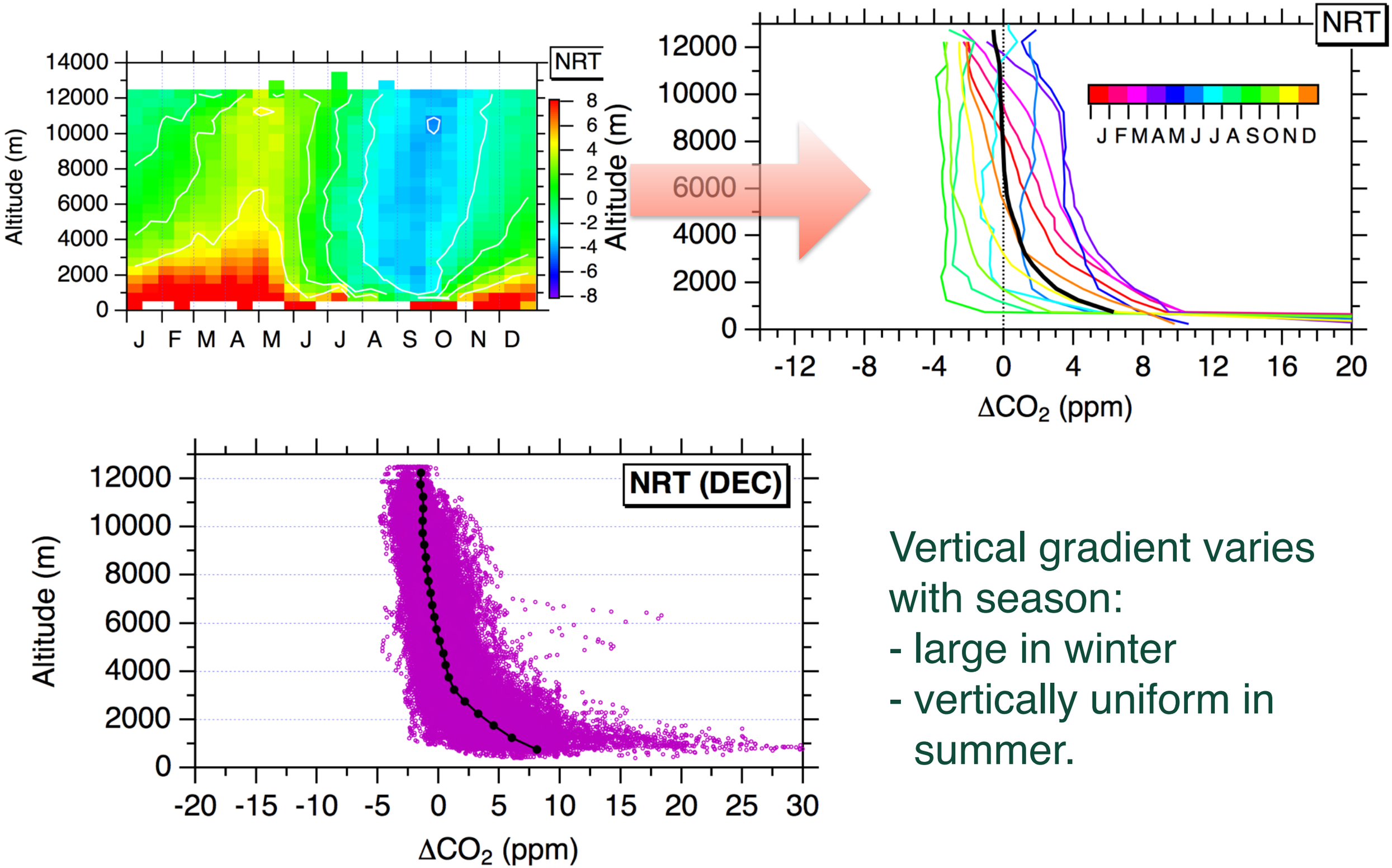
1. ***NRT***, *Japan* 7270
2. ***HND***, *Japan* 2937
3. ***SYD***, *Australia* 1581
4. ***HNL***, *Hawaii* 1455
5. ***BKK***, *Thailand* 1273
6. ***NGO***, *Japan* 855
7. ***DEL***, *India* 787
8. ***SIN***, *Singapore* 686
9. ***CDG***, *France* 683
10. ***KIX***, *Japan* 635
11. ***YVR***, *Canada* 440
12. ***CGK***, *Indonesia* 422
13. ***DME***, *Russia* 409
14. ***SFO***, *California* 366
15. ***AMS***, *the Netherlands* 238
16. ***ICN***, *South Korea* 199
17. ***LHR***, *UK* 196
18. ***FUK***, *Japan* 189

ΔCO_2 = CO_2 (**CONTRAIL NRT**) - CO_2 trend at **MLO**



- Seasonal cycle of CO_2 is not vertically uniform (altitude dependent).
- Vertical gradient of CO_2 varies seasonally.

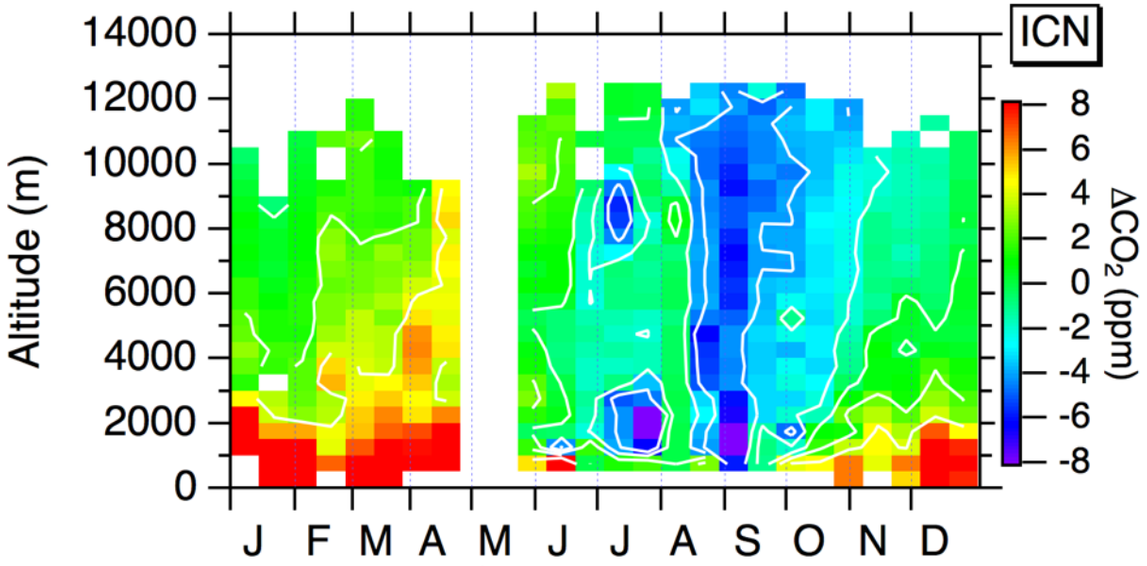
ΔCO_2 composite analysis over Tokyo, Japan

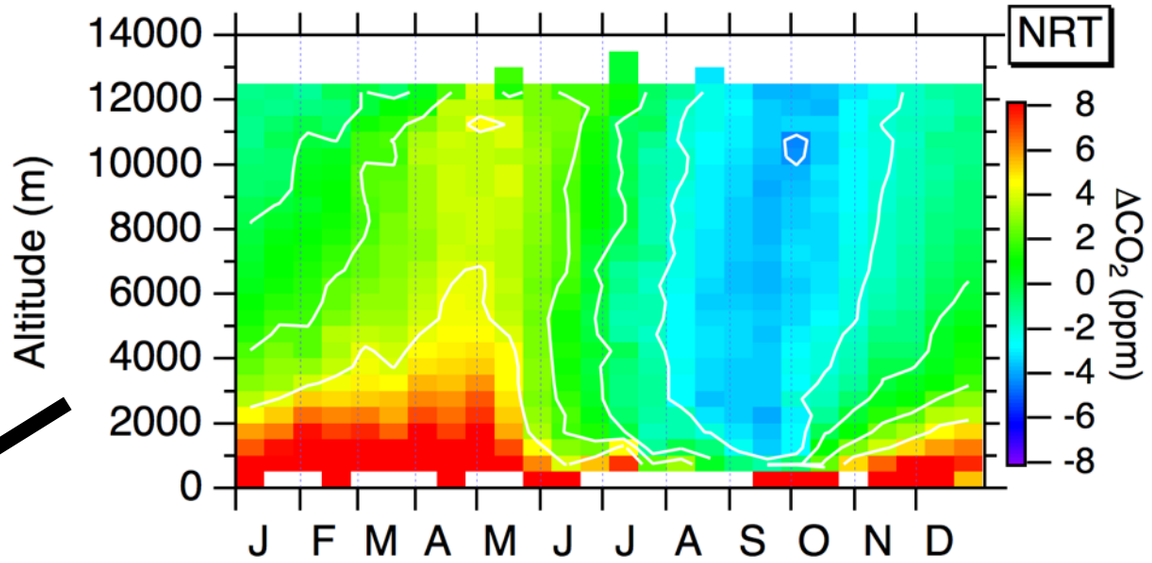


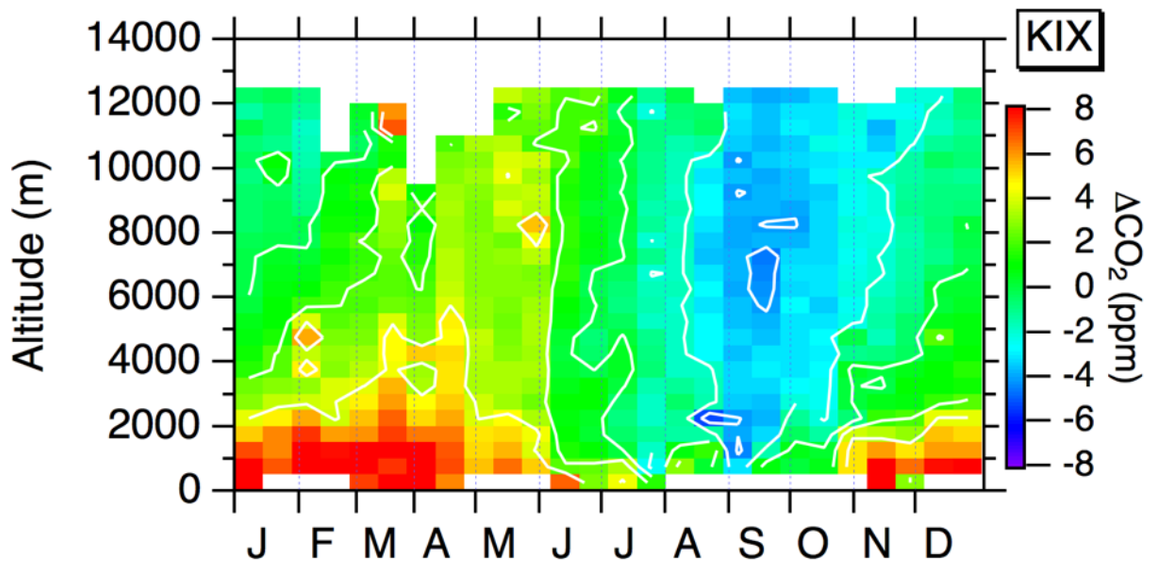
Vertical gradient varies with season:

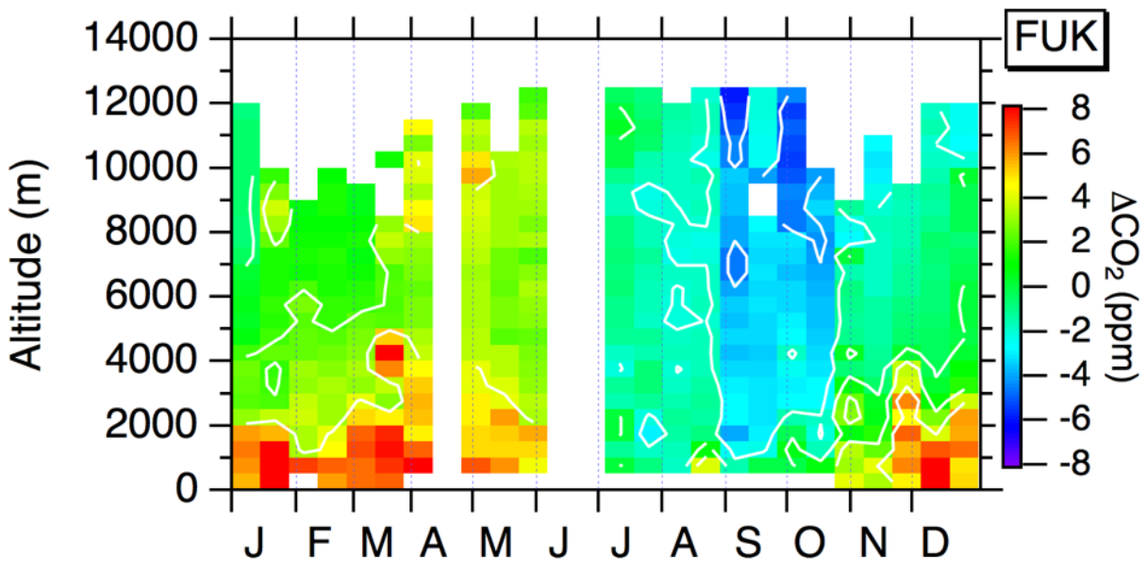
- large in winter
- vertically uniform in summer.

ΔCO_2 over East Asia





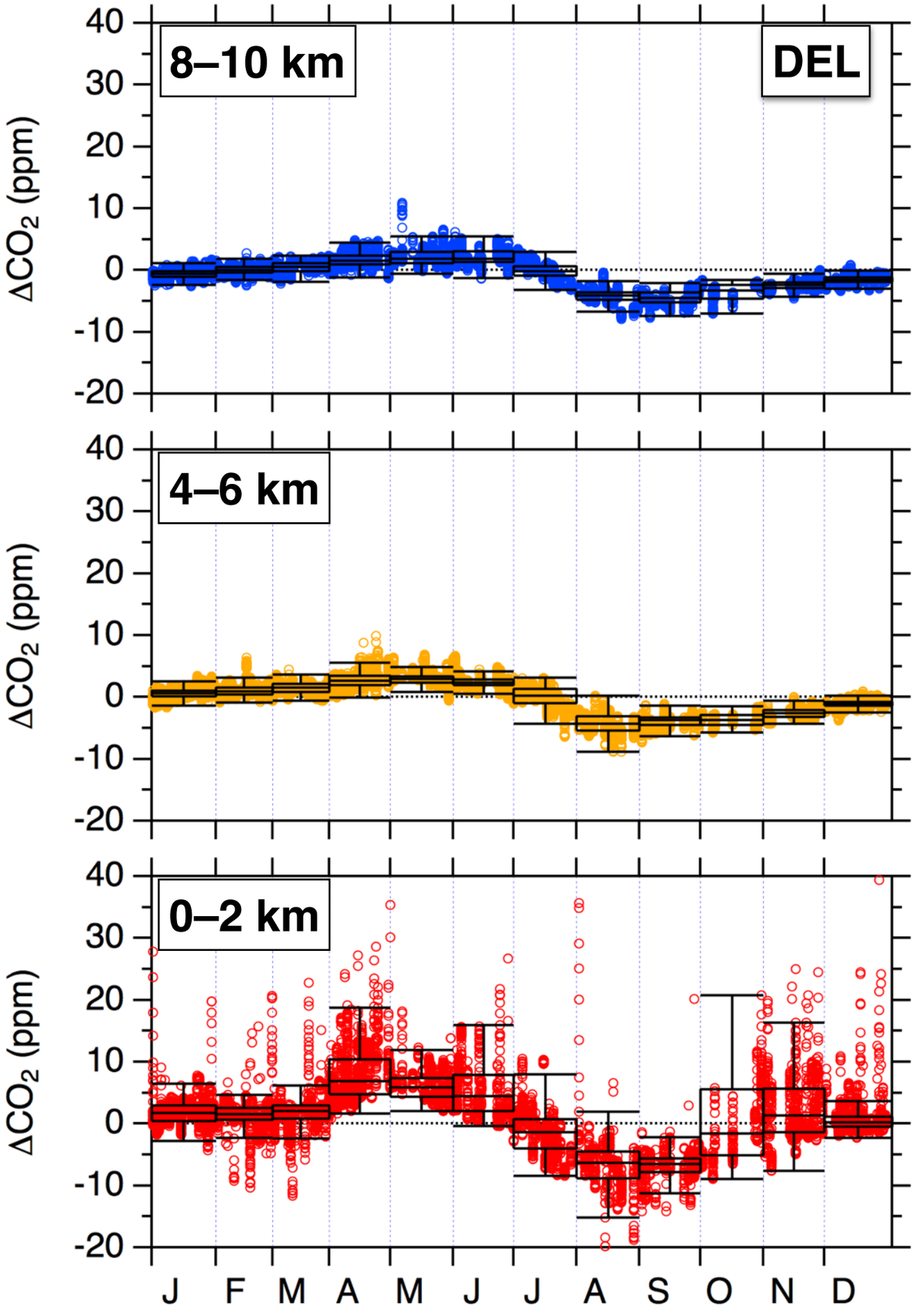


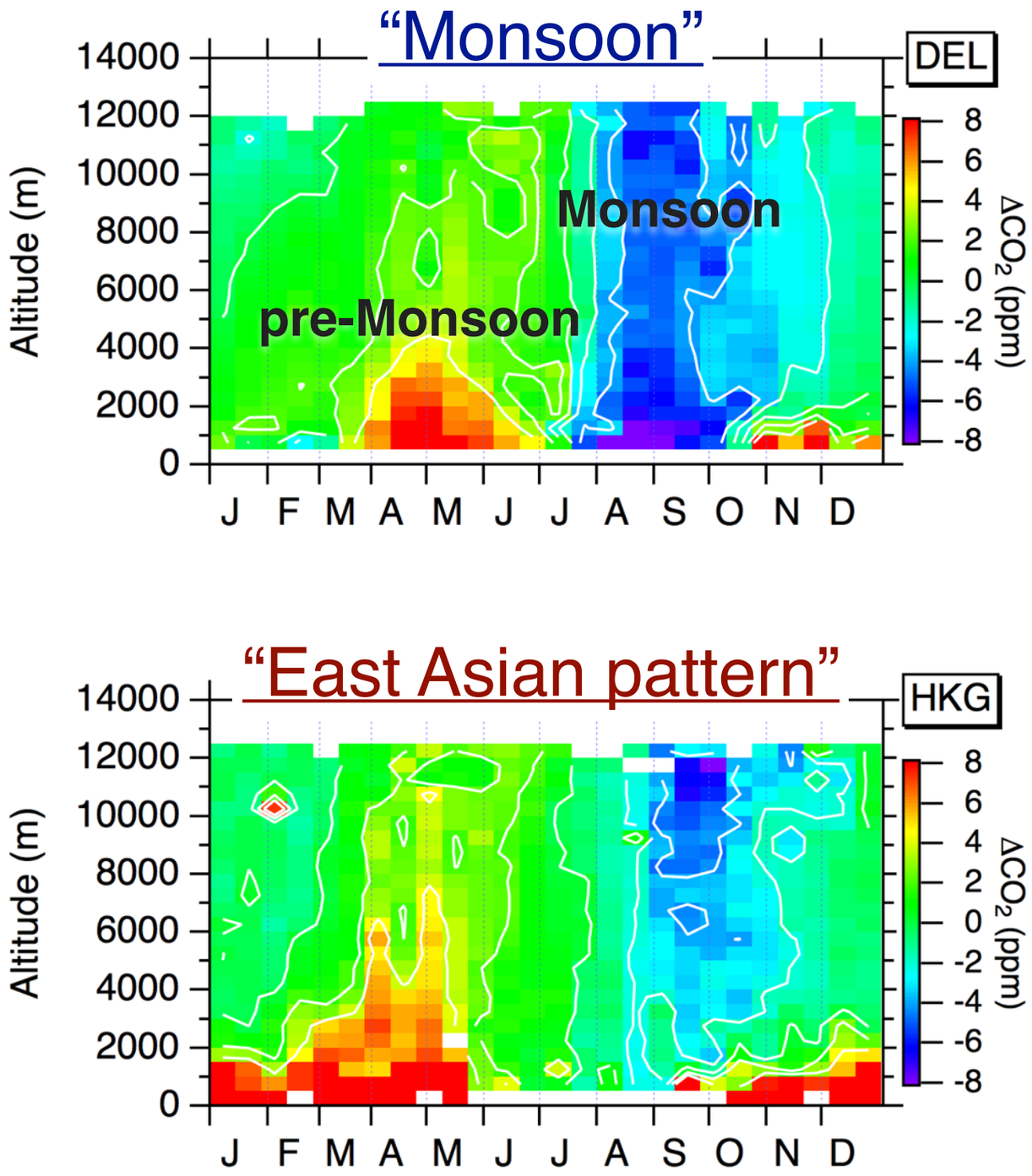


East Asian pattern is characterised by

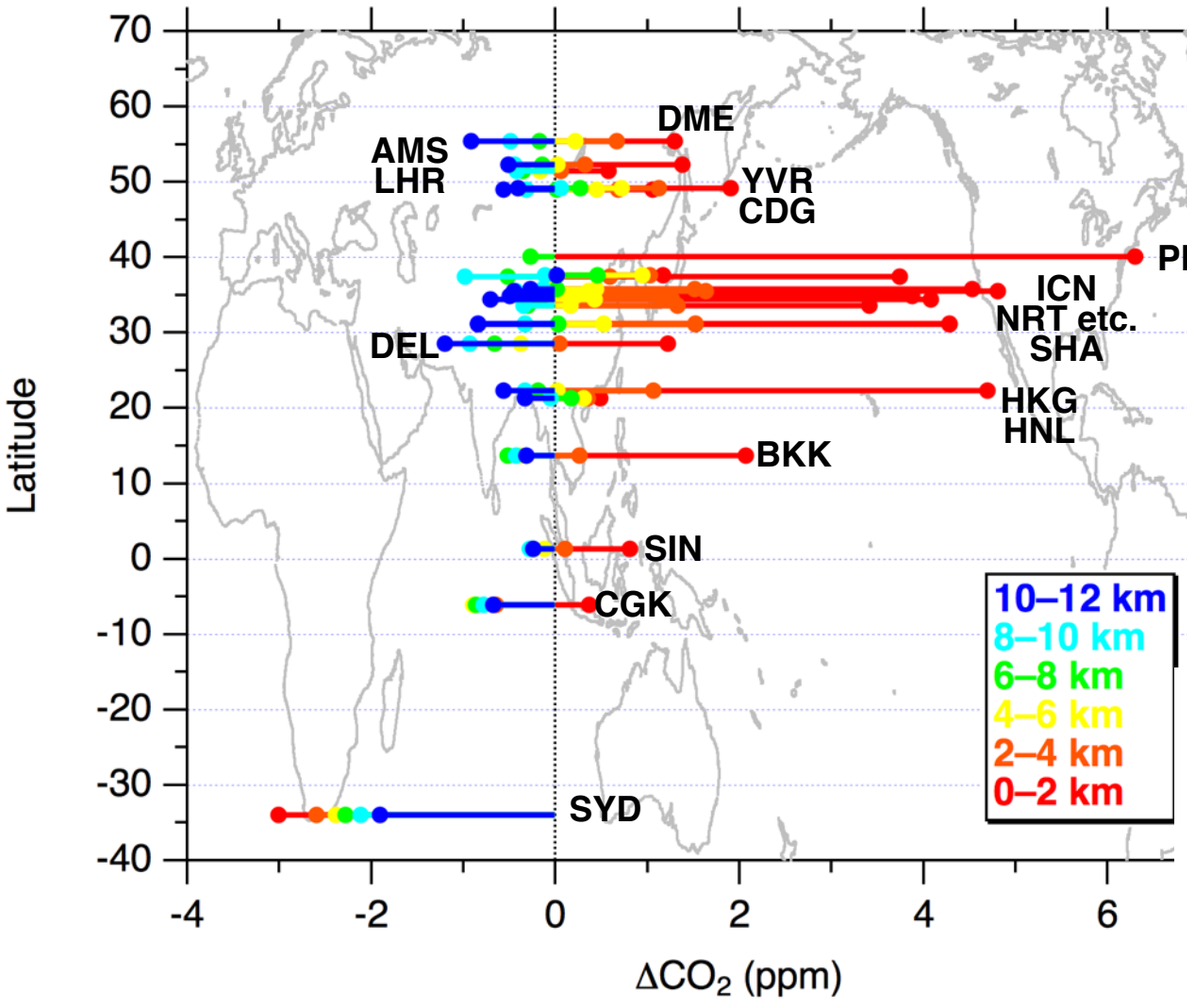
- Increase over winter–spring
- Summer decrease pronounced in the free troposphere

ΔCO_2 over Delhi, India



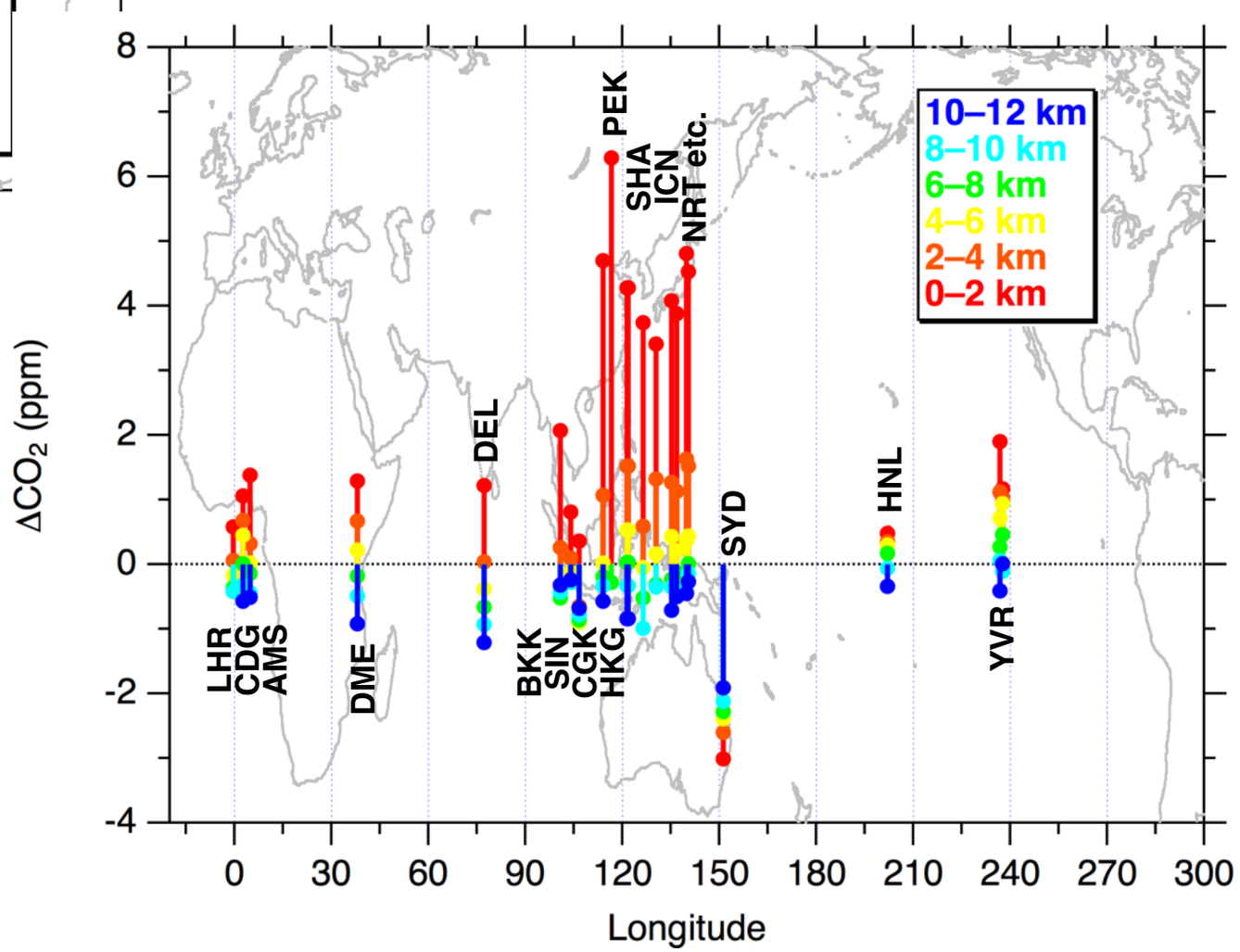


Distribution of annual average ΔCO_2



- ✓ Large latitudinal gradient near the surface
- ✓ Vertical gradient is large at mid latitudes
- ✓ Opposite vertical gradients in the NH and SH

- ✓ Large Longitudinal gradient
- ✓ Vertical gradient is large in East Asia



Summary

- Large number of the **CONTRAIL CME** data enables us to illustrate climatological distributions of tropospheric CO_2, particularly for Asia/Pacific regions.
  - Seasonal cycles/vertical profiles are well characterised.
  - Different patterns are obvious at areas in upstream/ downstream of continental sources/sinks.
- Extensive CO_2 data are available and can push data assimilation powerfully.
- For data use, **see the CONTRAIL website !**

(Visit www.cger.nies.go.jp/contrail/ or google “CONTRAIL NIES”)