CO_2 distributions in the upper troposphere observed in the CONTRAIL project, and Recent Activities in the project

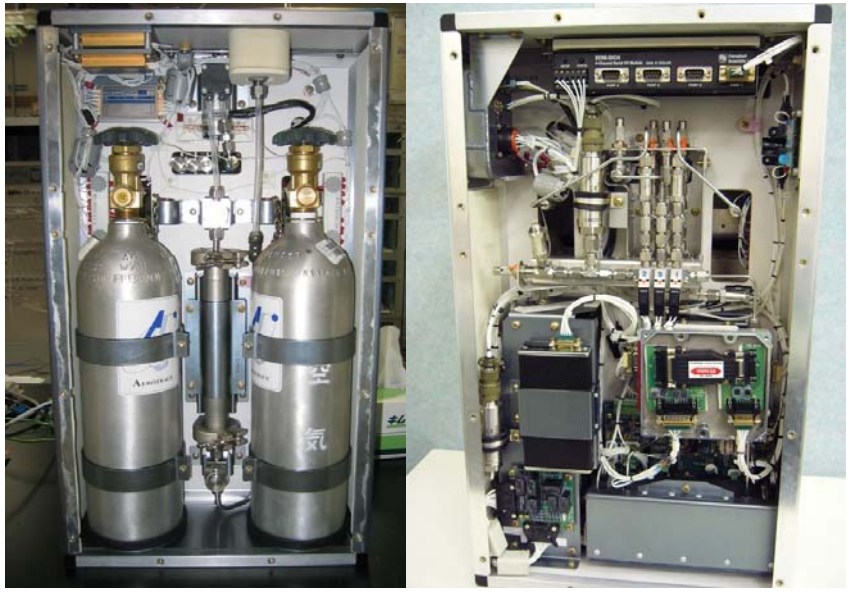
1. **CONTRAIL (Comprehensive Observation Network for Trace gases by AIrLiner) project from 2005**
   Equipment & data set
2. **CO_2 distributions in the upper troposphere**
   - Low CO_2 over the Eurasia in summer
   - Transport of CO_2 to the Southern Hemisphere
3. **Recent activity**
   Publications, research activity, current status & future plan

Annual IAGOS-ERI Meeting 2010
September 29 - October 1, 2010
WMO Headquarters, Geneva, Switzerland

Yousuke Sawa (Meteorological Research Institute)
Toshinobu Machida (National Institute for Environmental Studies)
Hidekazu Matsueda (Meteorological Research Institute)

Continuous CO_2 Measuring Equipment

Continuous CO_2 Measuring Equipment (CME)



H570xW330xD264mm , 25kg

- Ascending/descending: 10 sec average (~80m vertical)
- Cruising altitudes:1 min average (~15 km horizontal)
- Detailed structures

Functions:

- in-situ CO_2 measurement
- 1-2 month continuous observation
- real time control by aviation information (ARINC)
- Onboard calibrations → high accuracy ±0.2 ppm

Machida et al., 2008, JTECH

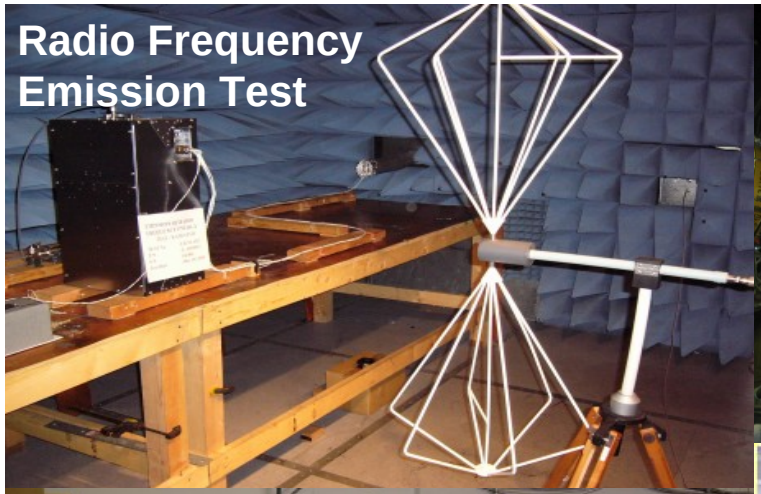
Development(2003-2006)

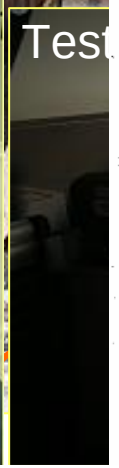
Many tests to get STC…

CME for 747-400 and 777-200

ASE (flask sampling) for 747-400

Environmental test Vibrations, Temperature, Accelerations.





Supplemental Type Certificate (FAA)

Department of Transportation Federal Aviation Administration

Supplemental Type Certificate

Number ST01613SE

This certificate, issued to JAMCO America, Inc.
1018 80th Street S.W.
Everett, WA 98203

certifies that the change in the type design for the following product with the limitations and conditions therefore as specified herein meets the airworthiness requirements of Part 25 of the Federal Aviation Regulations.

Original Product—Type Certificate Number: A20WE
Make: Boeing
Model: 747-400 Series

Description of the Type Design Change: Installation of Atmospheric Observation Equipment on Japan Airlines (JAL) B747-400 airplanes in accordance with JAMCO America Master Drawing List (MDL) No. IA-113MDL, Revision A, dated October 16, 2005, or later FAA approved revision.

Limitations and Conditions: Approval of this change in type design applies to the above model aircraft only. This approval should not be extended to other aircraft of this model on which other previously approved modifications are incorporated unless it is determined that the relationship between this change and any of these other previously approved modifications will produce no adverse effect upon the airworthiness of that aircraft. A copy of this Certificate and JAMCO America, Inc. Master Drawing List IA-113MDL must be maintained as part of the permanent records for the modified aircraft.

If the holder agrees to permit another person to use this certificate to alter the product, the holder shall give the other person written evidence of that permission.

This certificate and the supporting data which is the basis for approval shall remain in effect until surrendered, suspended, revoked, or a termination date is otherwise established by the Administrator of the Federal Aviation Administration.

Date of application: August 09, 2004
Date of issuance: October 26, 2005
Date reissued:
Date amended:

By direction of the Administrator
Donald L. Riedel
Acting Manager, Seattle Aircraft Certification Office

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both.
This certificate may be transferred in accordance with FAR 21.47.

(Japan Civil Aviation Bureau)

国土交通省

追加型式設計承認書

第 STC-241-TYO 号

1	航空機の種類	飛行機
2	航空機の型式	ボーイング式747-400型
3	航空機の耐空類別	飛行機　輸送 T
4	追加型式設計の内容	大気観測装置の装備
5	設計者氏名又は名称	JAMCO AMERICA,INC
6	設計者住所	1018 80th Street SW Everett, WA 98203 U.S.A

7 備考
作業区分：「小改造」
耐空性基準：航空法第10条第4項第1号
航空法施行規則付属書第一
Japan Type Certificate Data Sheet No.40
米国STC No. ：ST01613SE(Issued October 26, 2005)

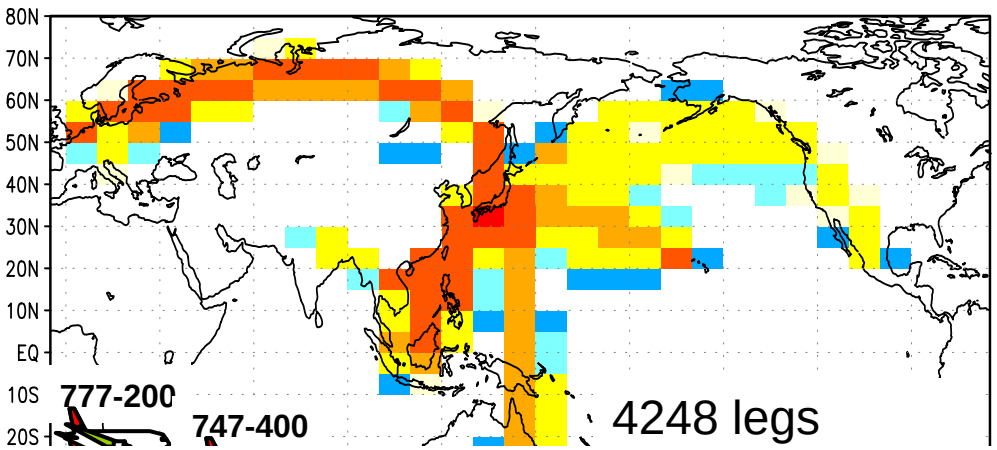
8 上記の追加型式設計は、航空法(昭和27年法律第231号)第10条第4項の基準に適合するものであることを承認する。

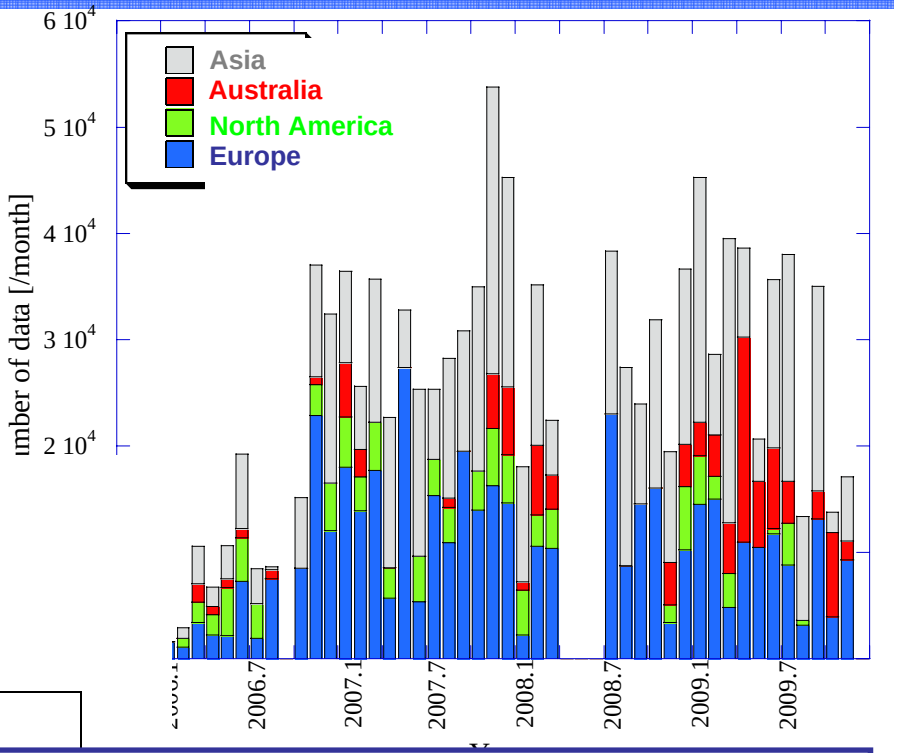
東京航空局長

東京航空局長印

発行年月日　平成17年11月2日

CONTRAIL CO_2 data set (Nov.2005-Dec. 2009)





390 — CO_2 between Europe and Japan

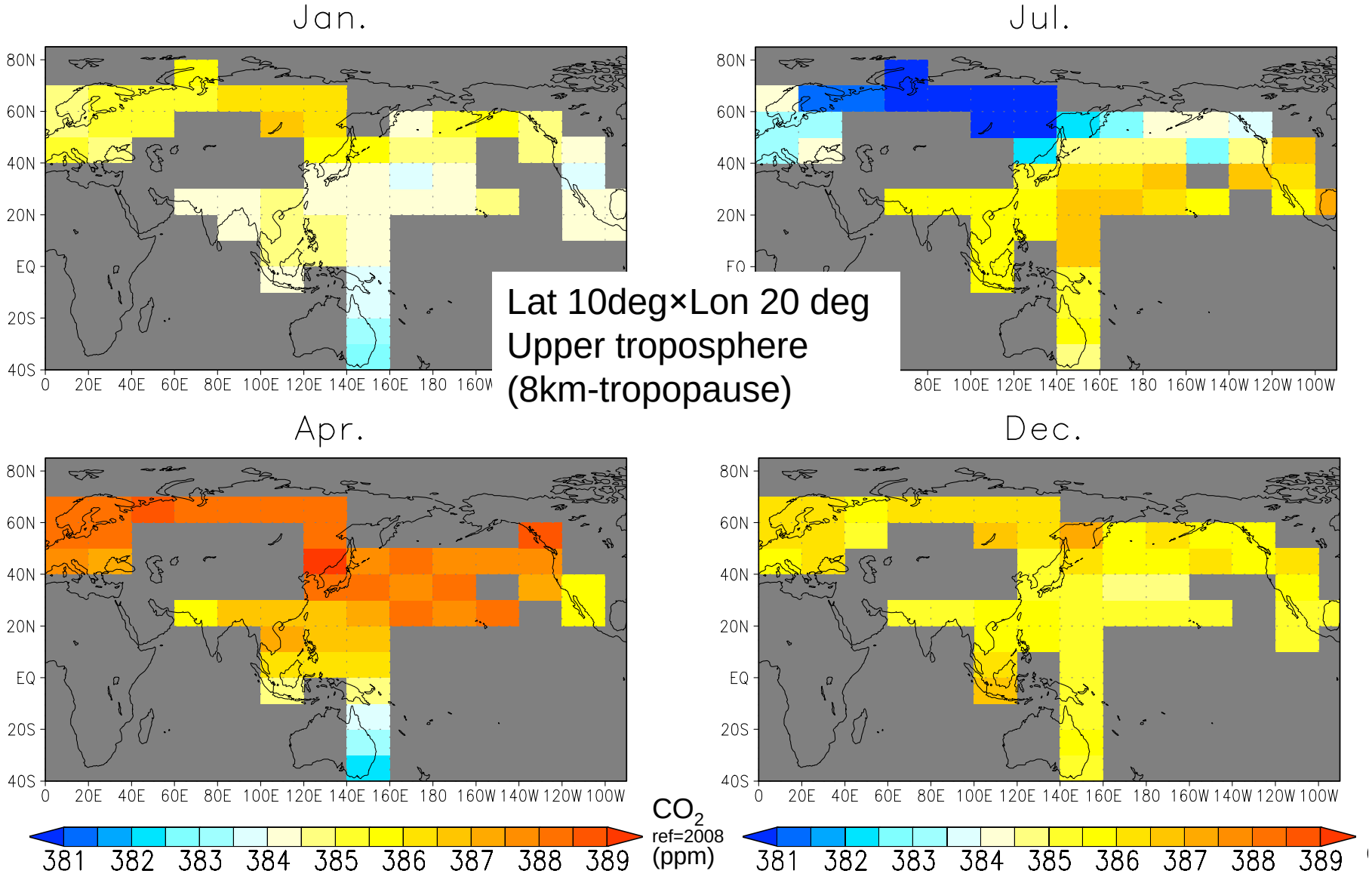
Assume trend 1.9 ppm/year

→CO_2 mixing rations in the reference year=2008

$CO_{2\ ref=2008} = CO_{2\ observed} + Trend \times (2008 - year_{\ observed})$

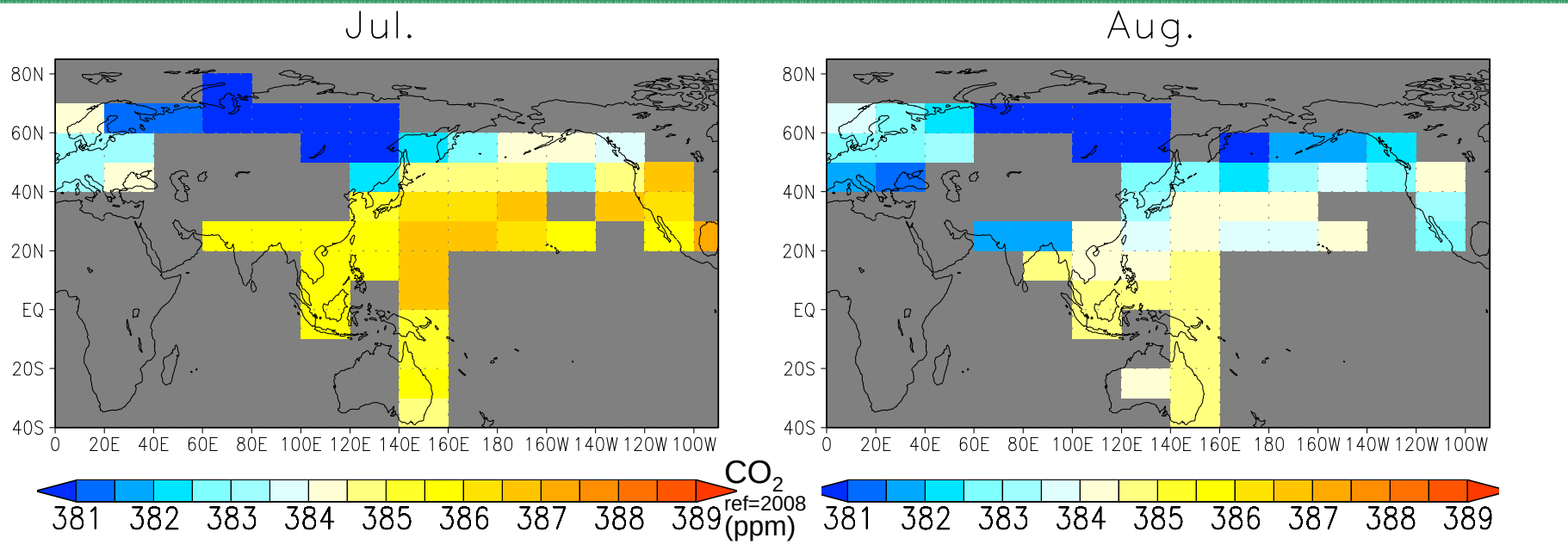
to get climatological distributions and seasonal changes

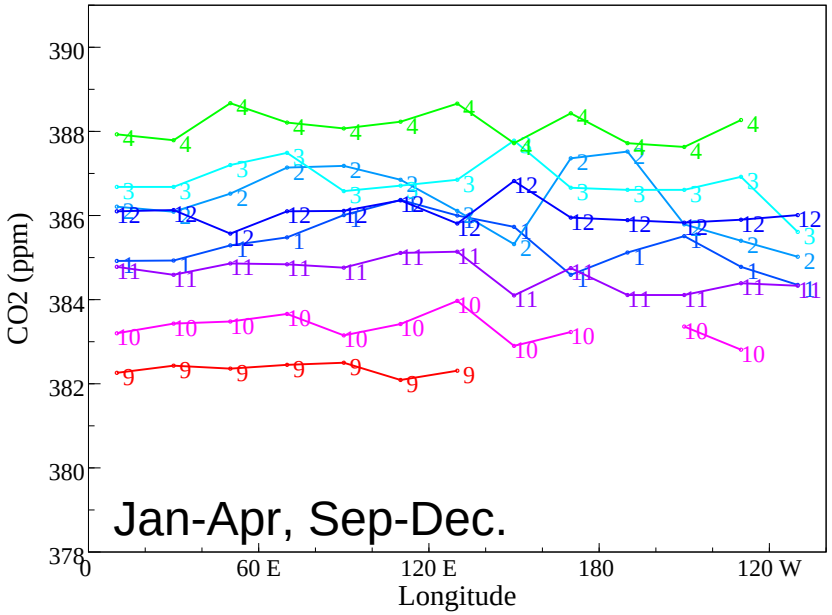
CO_2 distributions in the upper troposphere

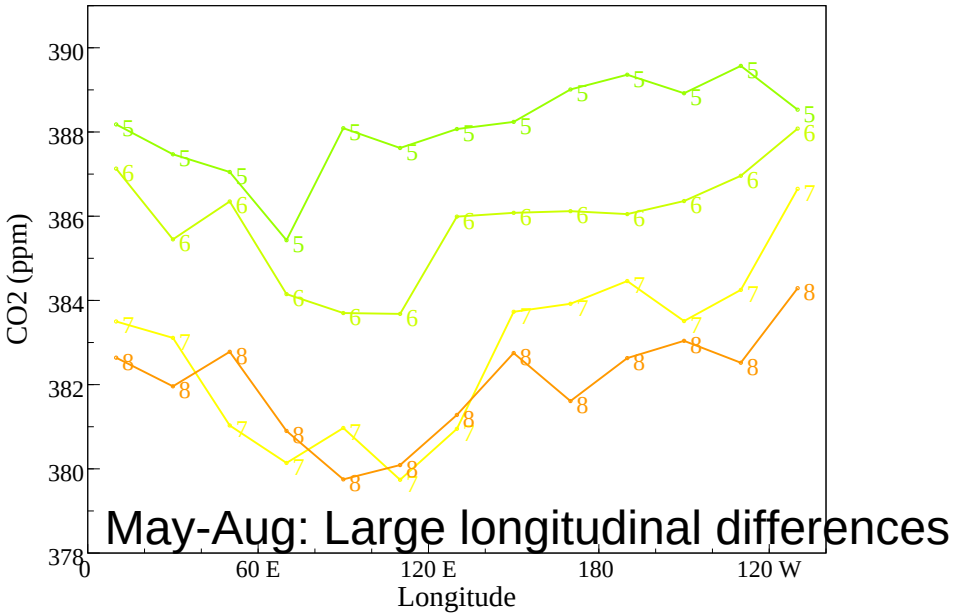


Large seasonal changes in the northern high latitudes : Spring Maximum and Summer Minimum

Low CO_2 mixing ratios over the Eurasia in summer

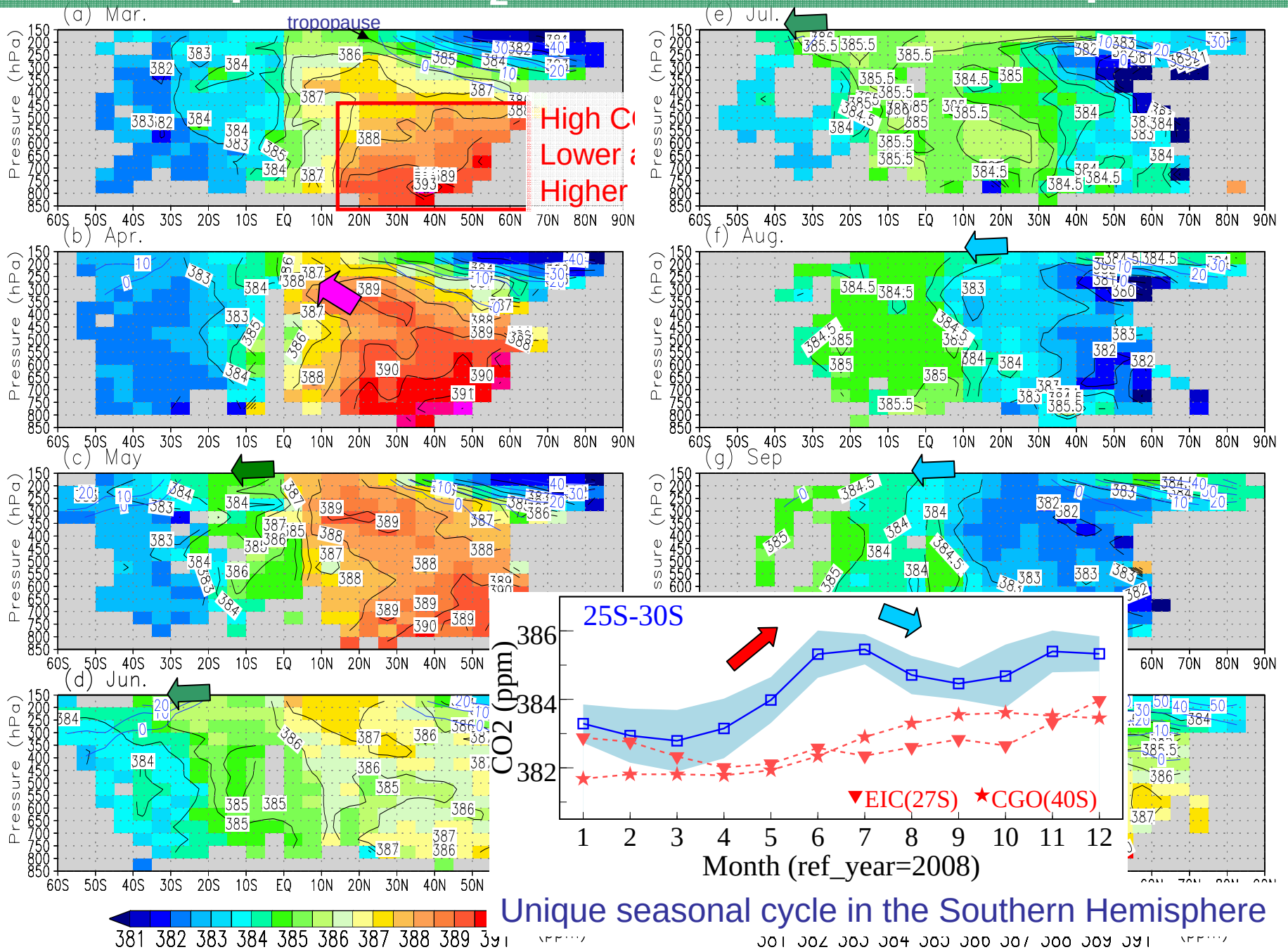






Longitudinal distributions between 40N and 70N

Transport of CO_2 to the Southern Hemisphere



Unique seasonal cycle in the Southern Hemisphere

Seasonal changes in CO_2 in the upper troposphere

- Frequent and wide coverage CO_2 observations were made by using Continuous CO_2 Measuring Equipments. More than two million CO_2 data with 4000 flights.
- Climatological distributions and seasonal changes in CO_2 were derived based on about 4 years observations on the assumption of the increasing trend of 1.9 ppm/year.
- In the upper troposphere
- Longitudinal differences in the northern higher latitudes in summer; Lower mixing ratios over the Eurasian continent, Higher values over the North Pacific region.
- Rapid CO_2 increases were found from April to June in the Southern Hemisphere, suggesting the interhemispheric transport.

Recent activity: publications

- Stratospheric influence on the seasonal cycle of nitrous oxide in the troposphere as deduced from aircraft observations and model simulations,

  Ishijima, K., P. K. Patra, M. Takigawa, T. Machida, H. Matsueda, Y. Sawa, L. P. Steele, P. B. Krummel, R. L. Langenfelds, S. Aoki, and T. Nakazawa

  J. Geophys. Res., doi:10.1029/2009JD013322, in press

- CO_2 surface fluxes at grid point scale estimated from a global 21-year reanalysis of atmospheric measurements,

  Chevallier, F., P. Ciais, T.J. Conway, T. Aalto, B. E. Anderson, P. Bousquet, E. G. Brunke, L. Ciattaglia, Y. Esaki, M. Frohlich, A. Gomez, A.J. Gomez-Palaez, L. Haszpra, P. B. Krummel, R. Langenfelds, M. Leuenberger, T. Machida, F. Maignan, H. Matsueda, J.A. Morgui, H. Mukai, T. Nakazawa, P. Peylin, M. Ramonet, L. Rivier, Y. Sawa, M. Schmidt, P. Steele, S. A. Vay, A. T. Vermeulen, S.C. Wofsy, and D. Worthy,

  J. Geophys. Res., doi:10.1029/2010JD013887, in press

- CO_2 column-averaged volume mixing ratio derived over Tsukuba from measurements by commercial airlines,

  M. Araki, I. Morino, T. Machida, Y. Sawa, H. Matsueda, H. Ohyama, T. Yokota, and O. Uchino

  Atmos. Chem. Phys., 10, 7659-7667, 2010

- Characterization of Tropospheric Emission Spectrometer (TES) CO_2 for carbon cycle science,

  S. S. Kulawik, D. B. A. Jones, R. Nassar, F. W. Irion, J. R. Worden, K. W. Bowman, T. Machida, H. Matsueda, Y. Sawa, S. C. Biraud, M. L. Fischer, and A. R. Jacobson

  Atmos. Chem. Phys., 10, 5601-5623, 2010

- First year of upper tropospheric integrated content of CO_2 from IASI hyperspectral infrared observations,

  C. Crevoisier, A. Chedin, H. Matsueda, T. Machida, R. Armante, and N. A. Scott

  Atmos. Chem. Phys., 9, 4797-4810, 2009

Recent research activity

- Vertical and latitudinal differences of CO_2 seasonal variations at many different airports:
  Machida@NIES et al.
- Long term trend in CO_2 latitudinal gradient:
  Matsueda@MRI et al.
- Short term variations over Narita airport:
  Shirai@NIES et al.
- CONTRAIL transport model intercomparison:
  Niwa@MRI et al.
- Carbon balance of the Indian subcontinent constrained by aircraft CO_2 measurements, using CARIBIC data as well as CONTRAIL data:
  Patra@JAMSTEC et al.
- GOSAT validations/comparisons with FTS:
  Morino@NIES et al.
- Other data users in Australia, France, Germany, Taiwan, US, India, Japan

Current status & Future plan

- Current program (2006-2010) “Research by global environment research coordination system” by Ministry of the Environment
- Proposal for next 5 years adopted by MOE
- Plan for installing Automatic air Sampling Equipment on 777-200

Automatic air Sampling Equipment

Bowing 777-200
In service between Narita and Sydney

References

- Machida et al. (2008): Worldwide measurements of atmospheric CO_2 and other trace gas species using commercial airlines, J. Atmos. Oceanic. Technol. 25(10), 1744-1754, DOI: 10.1175/2008JTECHA1082.1.
- Matsueda et al.(2008): Evaluation of atmospheric CO_2 measurements from new flask air sampling of JAL airliner observation, Pap. Meteorol. Geophys. 59, 1-17.
- Sawa, Y., T. Machida, H. Matsueda (2008): Seasonal variations of CO_2 near the tropopause observed by commercial aircraft, J. Geophys. Res., 113, D23301, doi:10.1029/2008JD010568.

Acknowledgements

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