Carbon balance of South Asia constrained by passenger aircraft CO_2 measurements

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Patra et al. ACPD 2010

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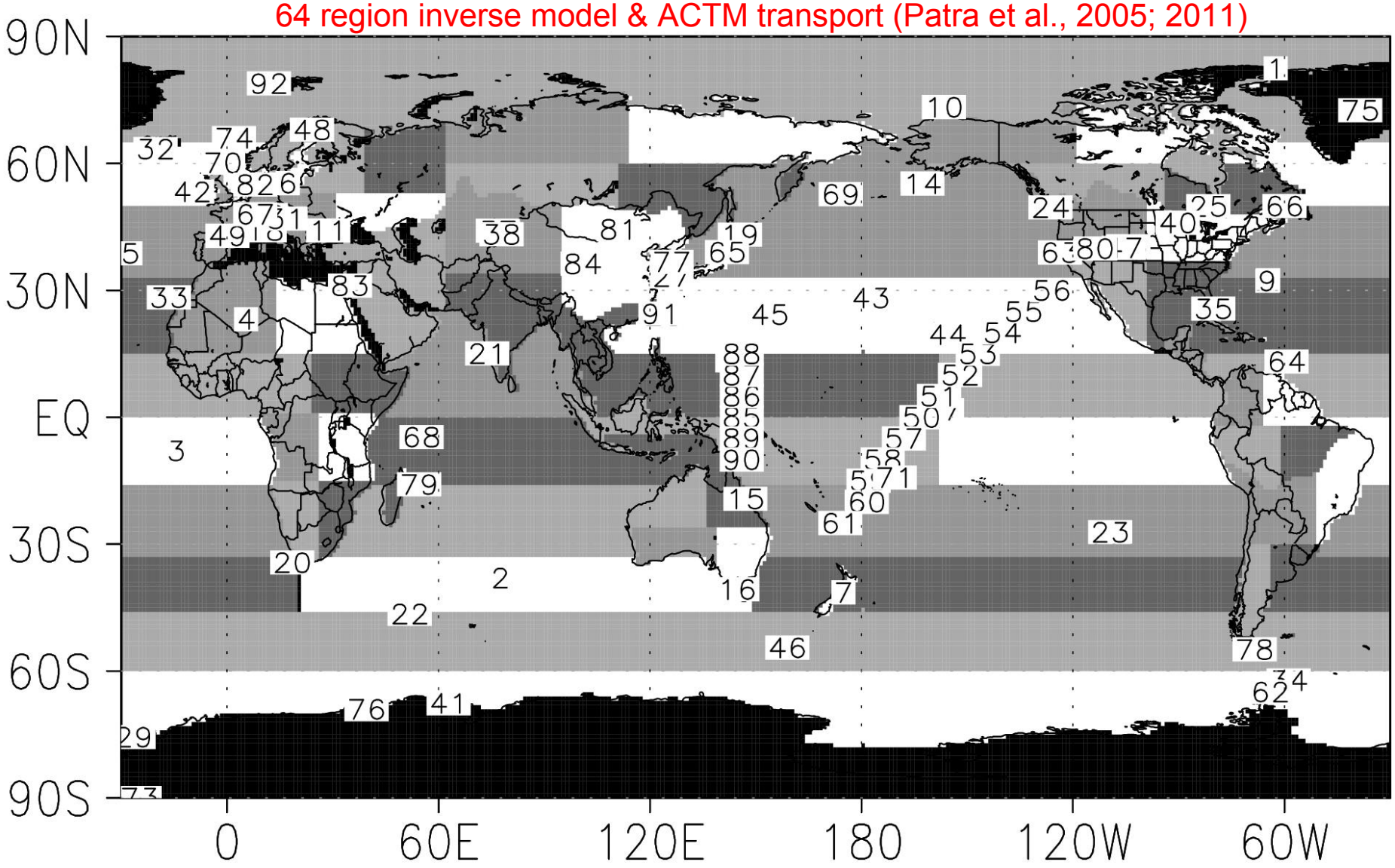
Introduction

- Carbon cycle of Asian regions is poorly studied compared to North America or Europe

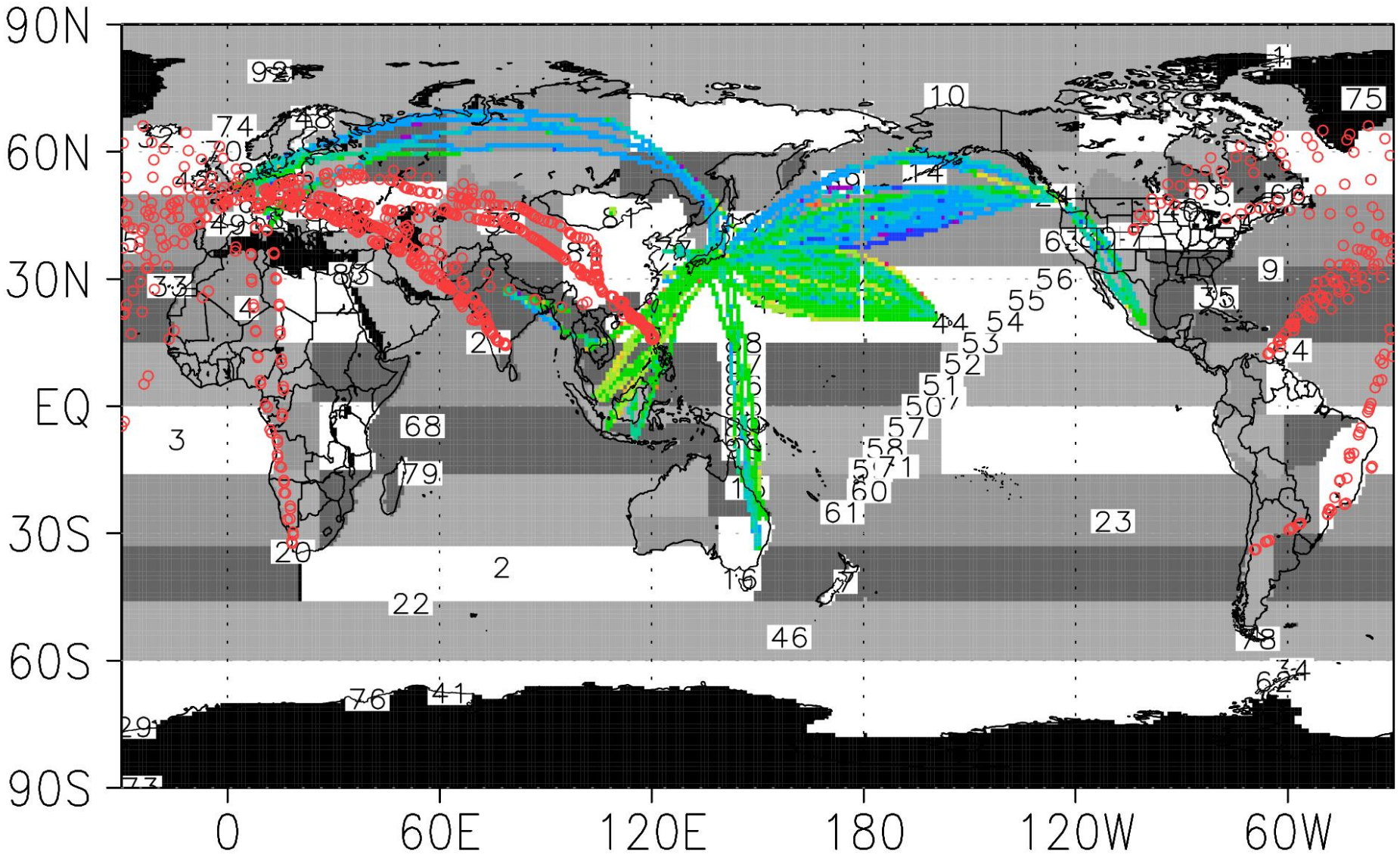
- The CARIBIC and CONTRAIL aircraft projects offer a new view of the South Asian air (shown by transport model intercomparison)

- Here we attempt to conduct inversion using these new CO_2 observations in the upper troposphere

Inverse modelling and data coverage (surface mainly)



Inverse modelling and data coverage (surface + CONTRAIL + CARIBIC)



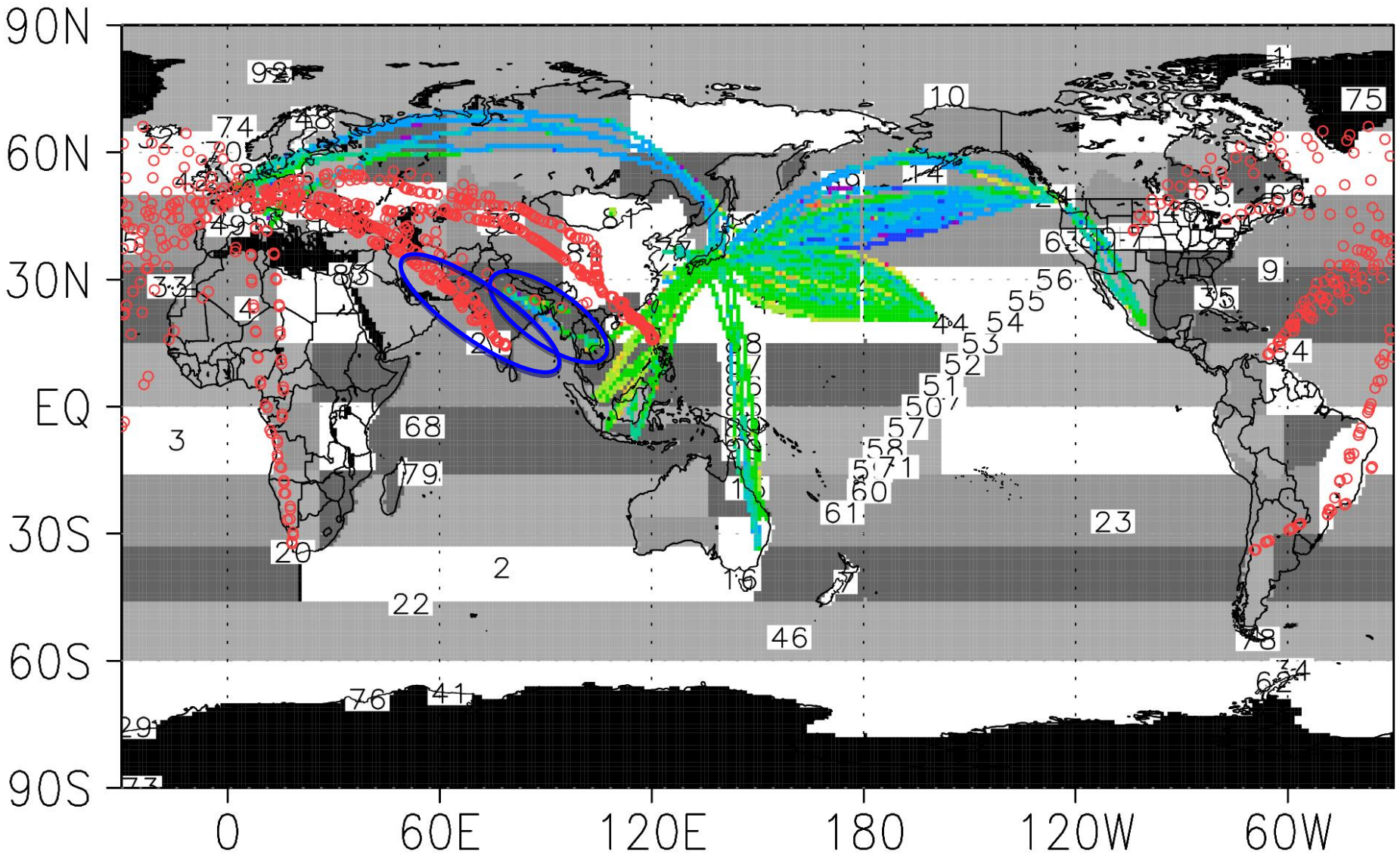
Can we use these aircraft data to constrain surface fluxes in an inversion approach ?

- Yes — if there is strong convection providing a pathway for rapid vertical transport from the PBL into the free troposphere such as during the South Asian summer monsoon

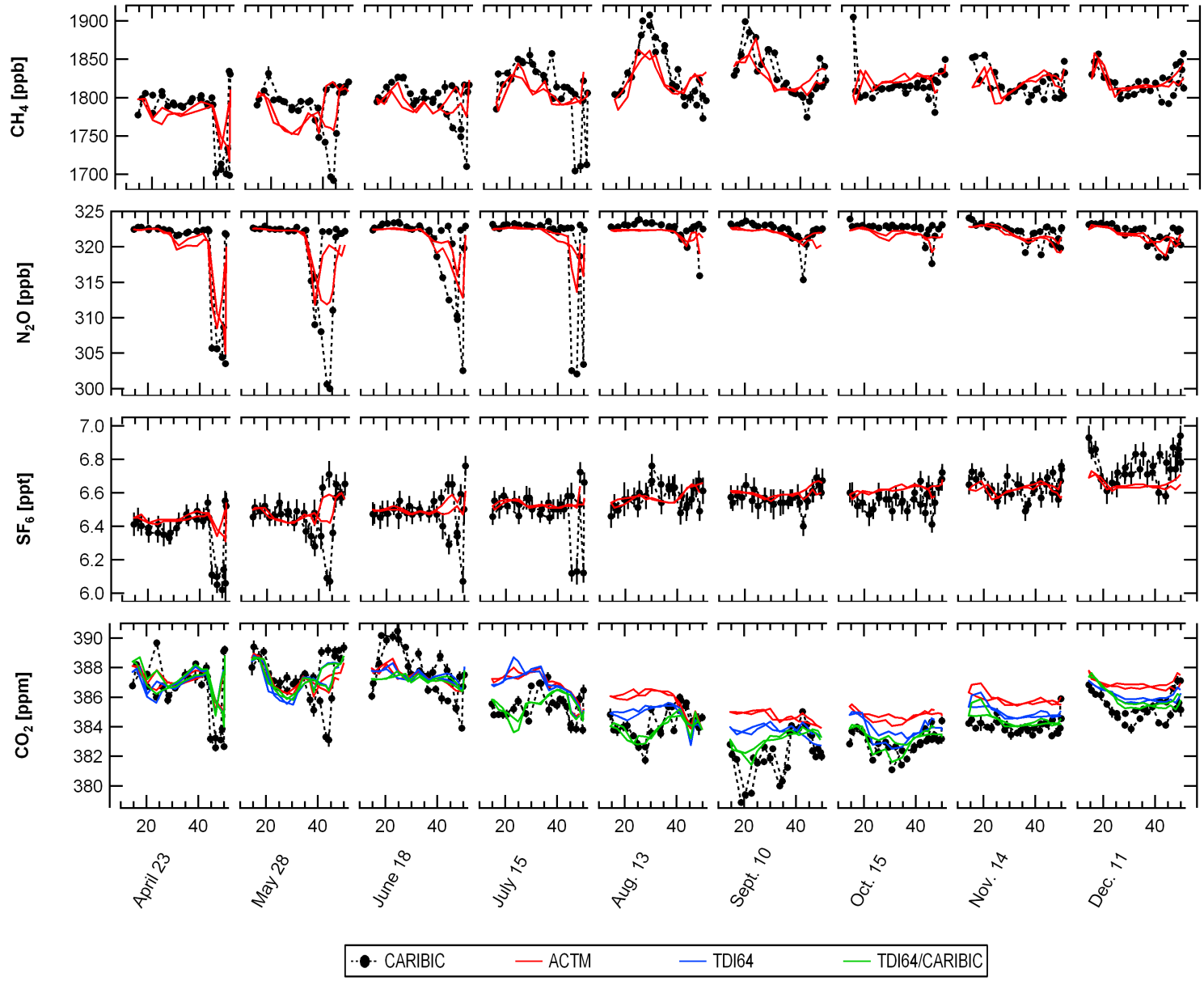
- Use one dataset (CARIBIC) for constraining the inversion

- Use the second, independent dataset (CONTRAIL) for validation

Inverse modelling and lack data "usage"
(surface + CONTRAIL + CARIBIC)



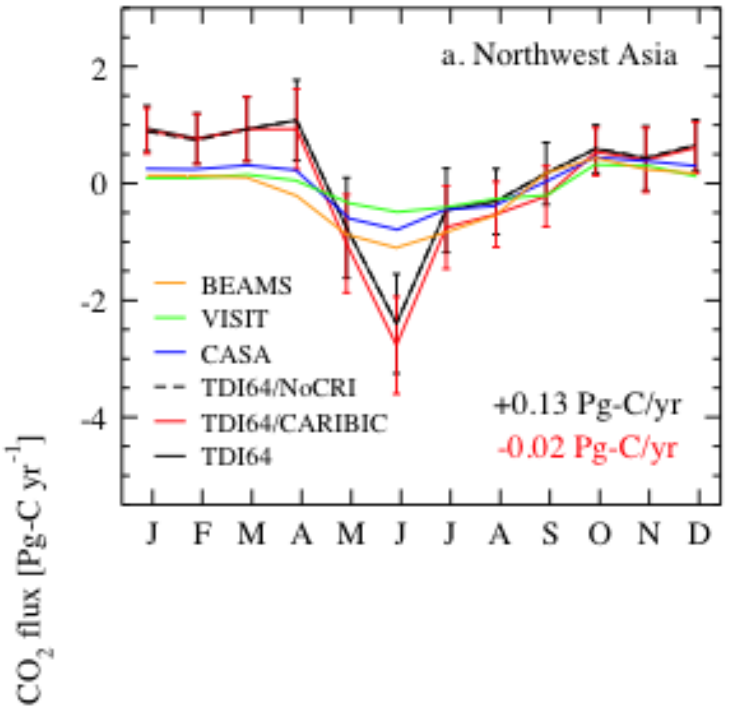
CARIBIC measurements and ACTM (T42L32) simulations between Frankfurt and Chennai



model validation:
Patra et al. 2009
Ishijima et al. 2010

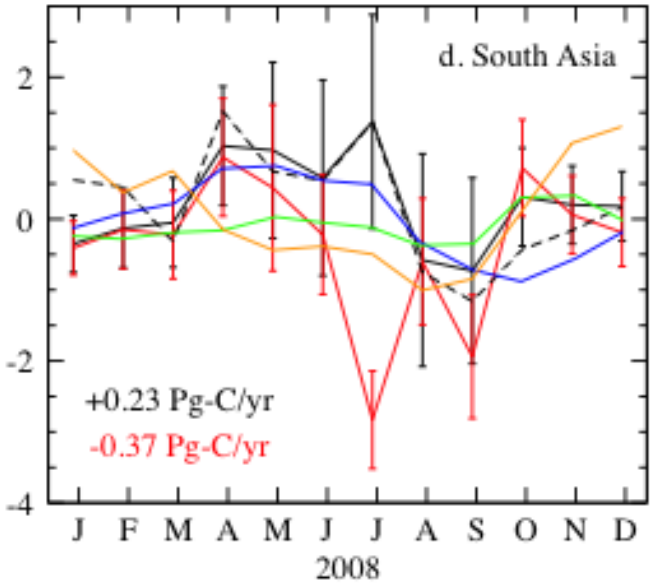
CARIBIC observations:
Schuck et al. ACP 2010
Baker et al. ACP 2011

TDI64 flux seasonal cycles for 2 Asia regions



using CARIBIC data to constrain the model results in **large changes** for the **South Asian region**, especially in July but does not change the results for other parts of Asia

South Asia was a net sink of CO_2 during 2008 (and 2007) at the rate of 0.37 Pg-C/yr



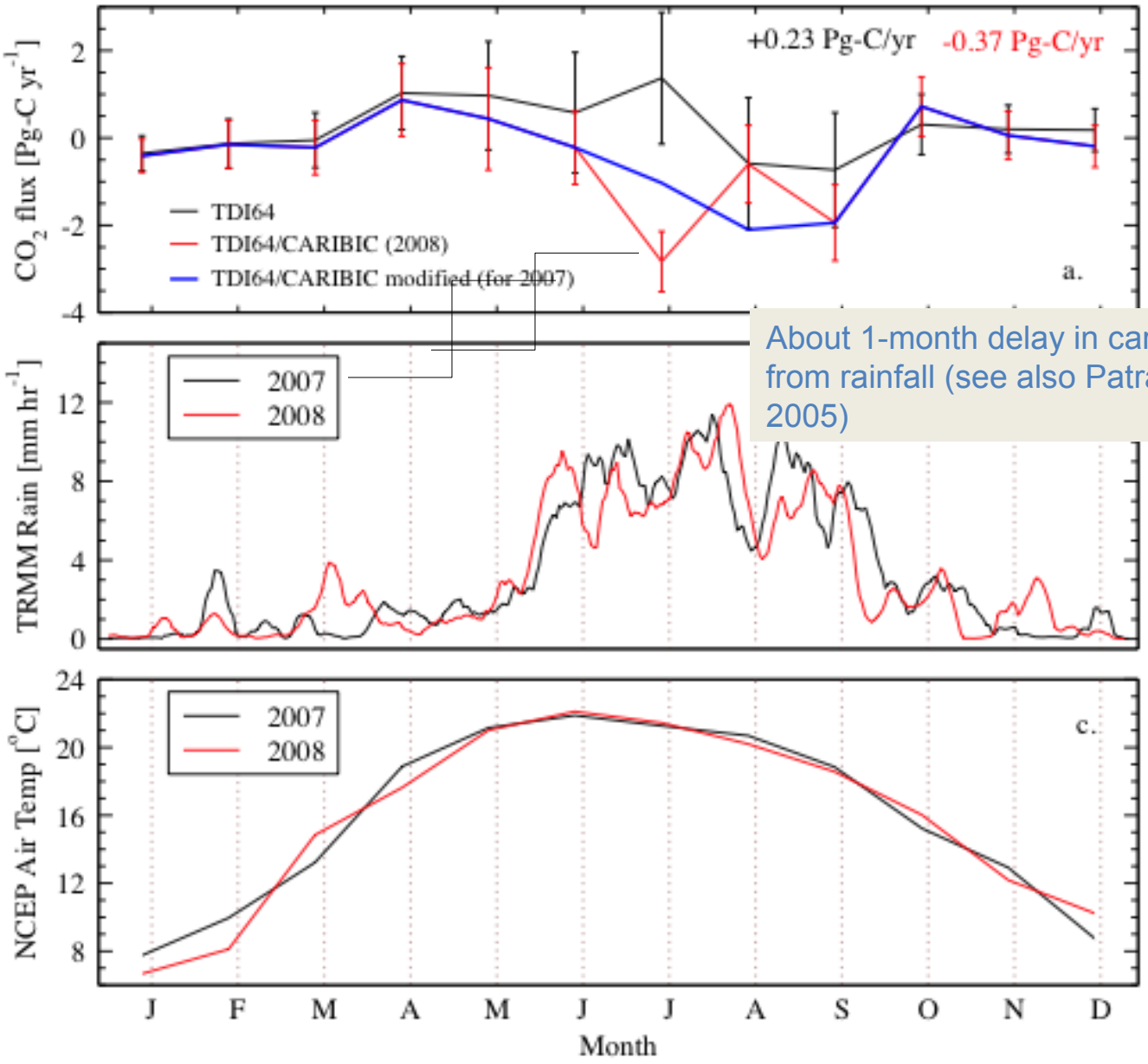
High Interannual Variability of the South Asian Summer Monsoon

- CARIBIC currently provides data for 2008

- CONTRAIL data (profiles over Delhi) available for 2007

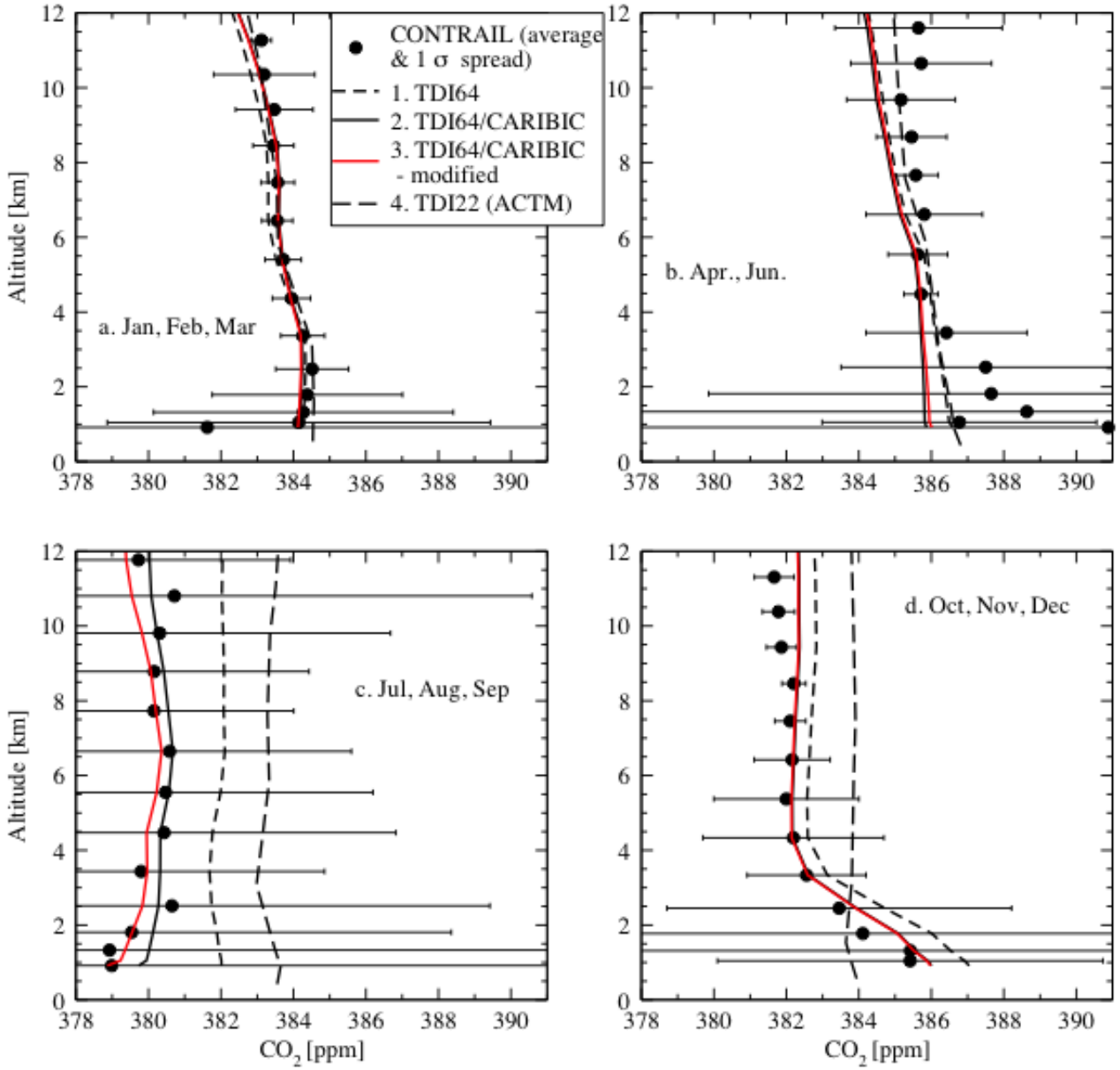
$\rightarrow$ Can we compare these two datasets ?

Climate control of South Asian flux seasonality



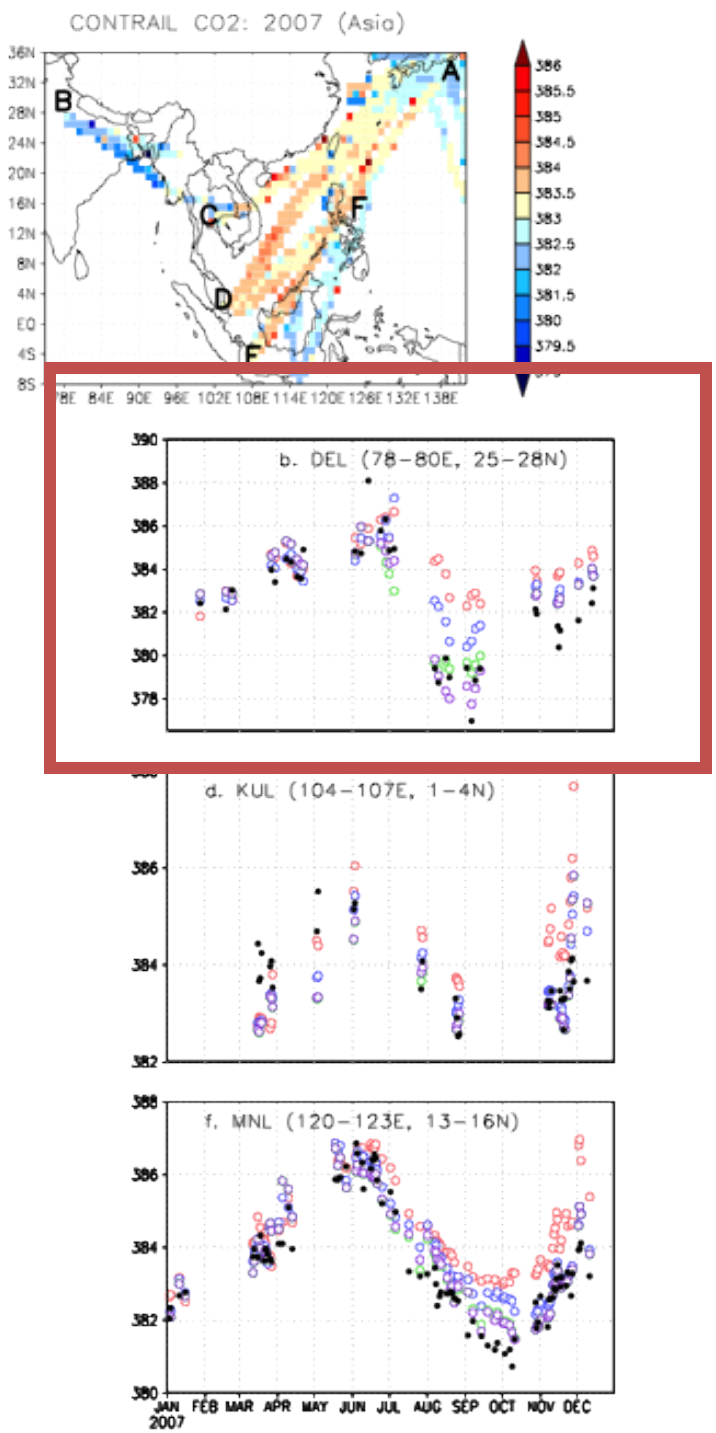
About 1-month delay in carbon uptake from rainfall (see also Patra et al., 2005)

CONTRAIL CO_2: Role of fluxes on vertical profile simulation



Observed
TDI22 (or ACTM)
TDI64
TDI64/CARIBIC
TDI64/CARIBIC modified

SEASONALITY



Conclusions

- JAL/CONTRAIL and Lufthansa/CARIBIC project provide a large amount of data
  - Upper tropospheric data of CO_2 and other species contains surface flux signal of tropical regions, particularly during deep cumulus convection
  - Forward and inverse modelling is conducted with a focus on South Asia region
  - We found South Asia acted as a net sink of CO_2 during 2007 and 2008 at the rate of 0.37 Pg-C/yr

- Future work:
  - Continue regular measurements of greenhouse gase in the UT
  - Include CARIBIC data for 1999 - 2001

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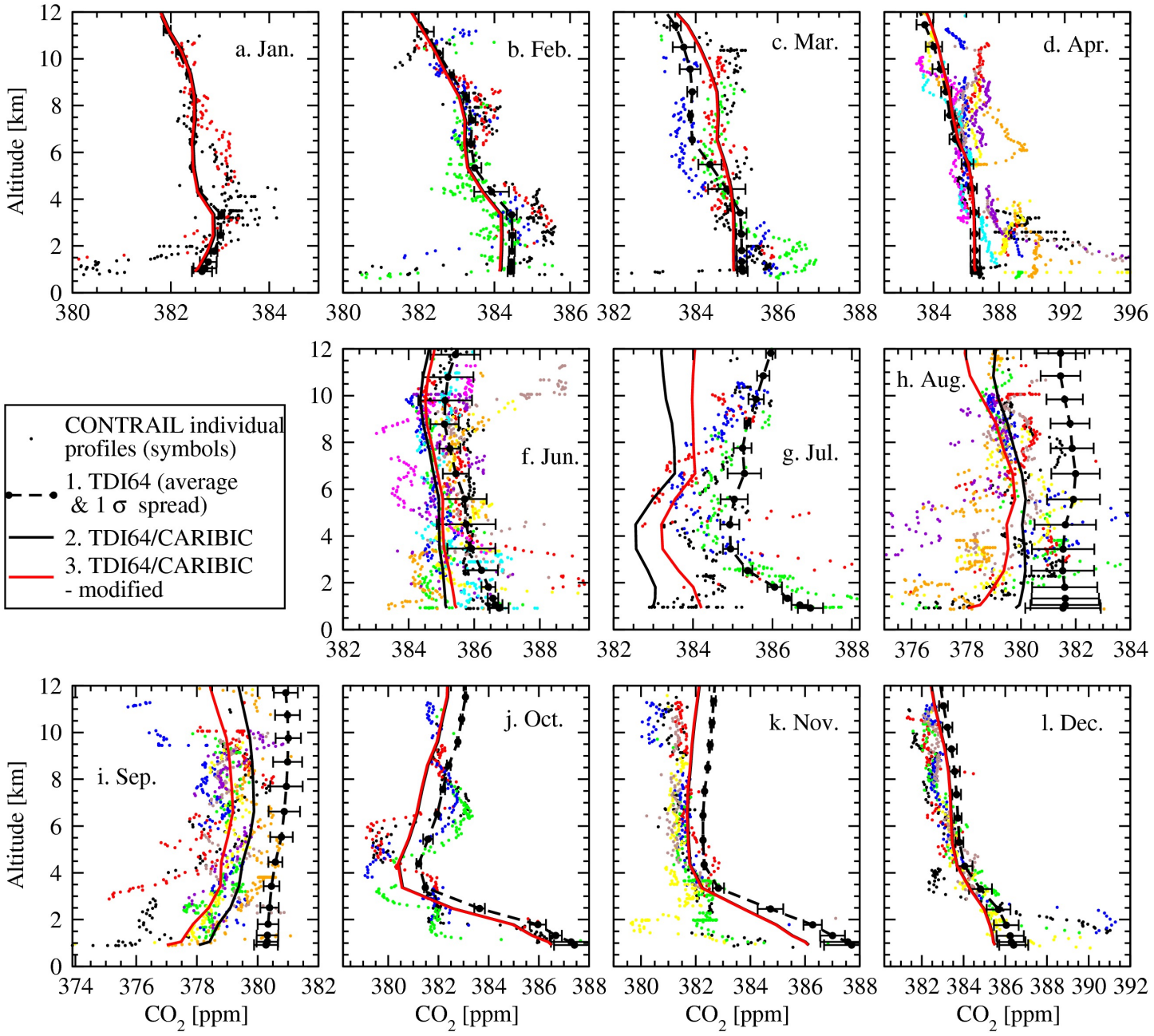
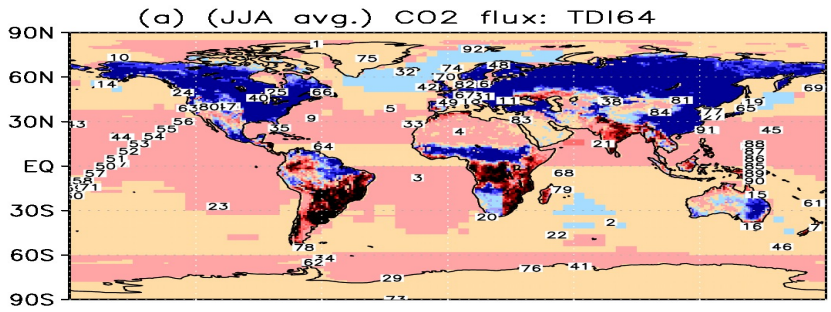
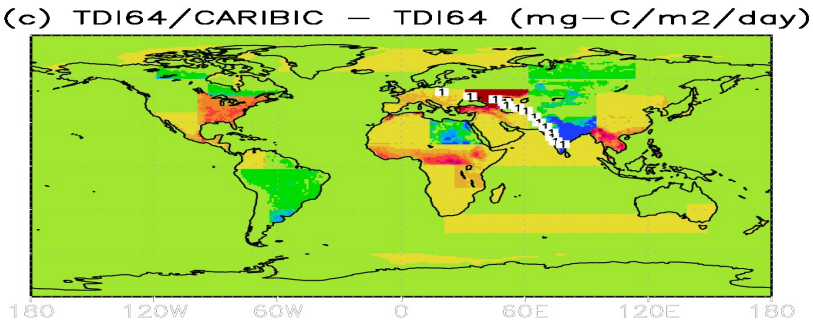
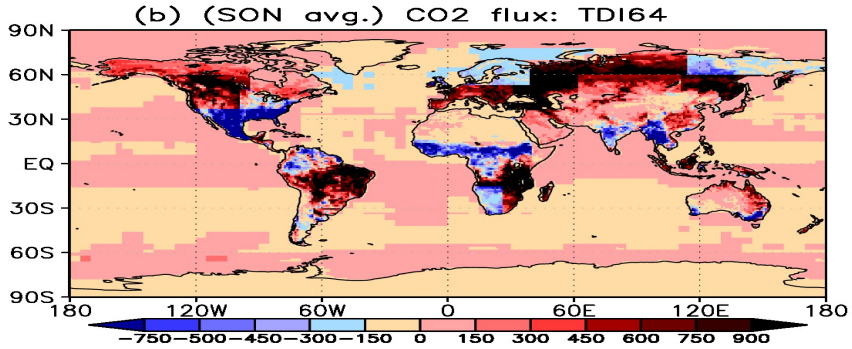
Validation of South Asian flux using CONTRAIL data over Delhi

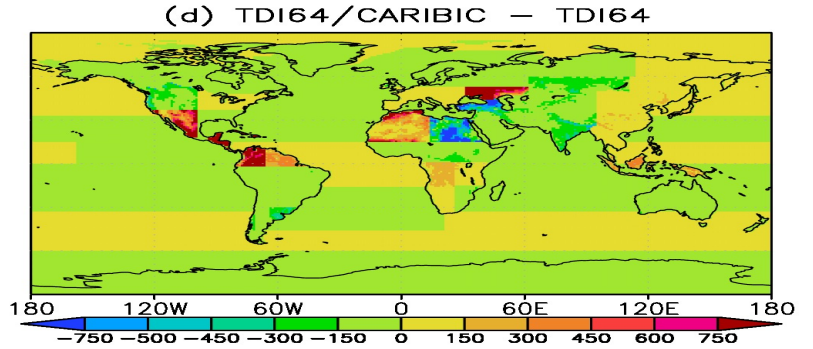


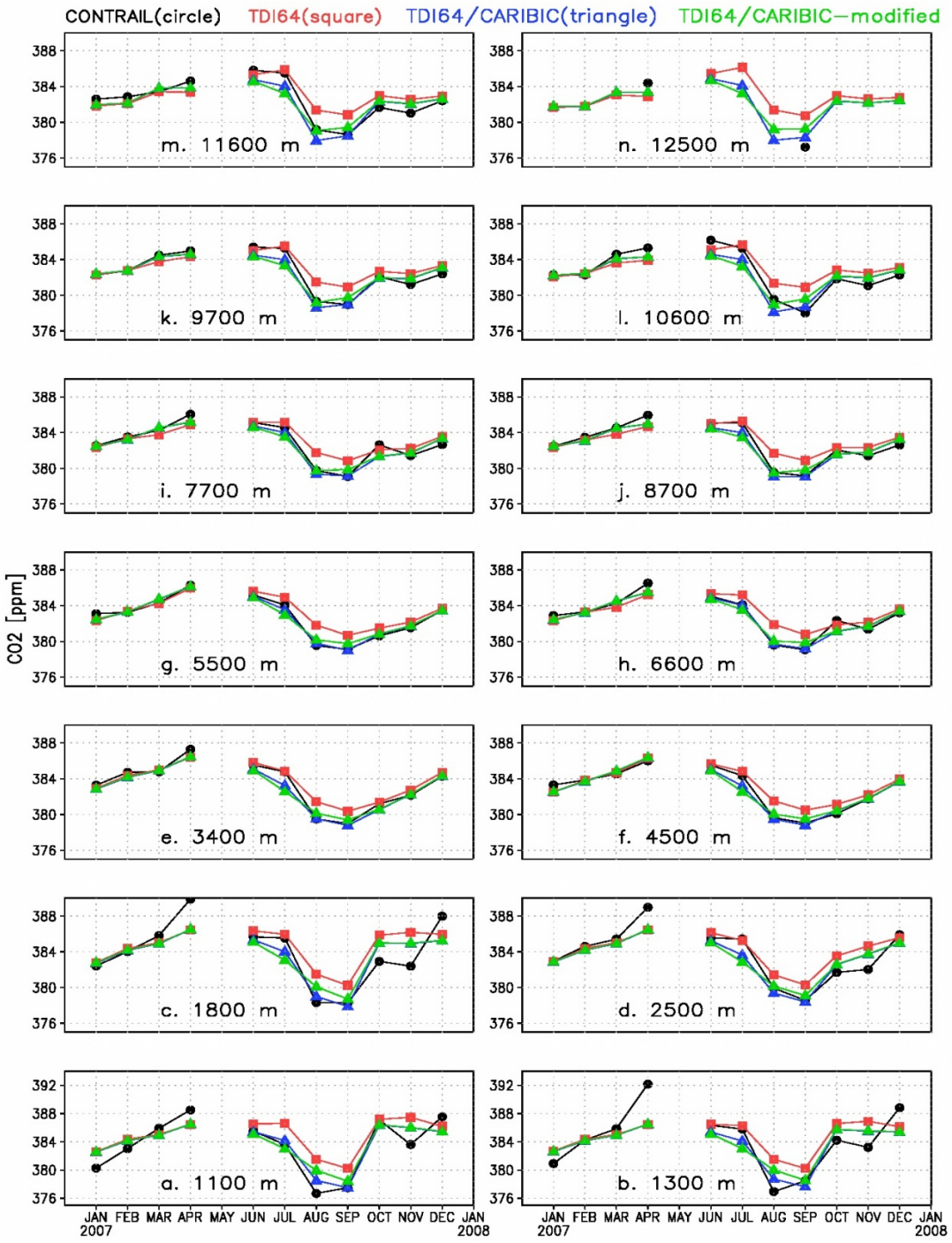
TDI64 results using (surface + CARIBIC) data



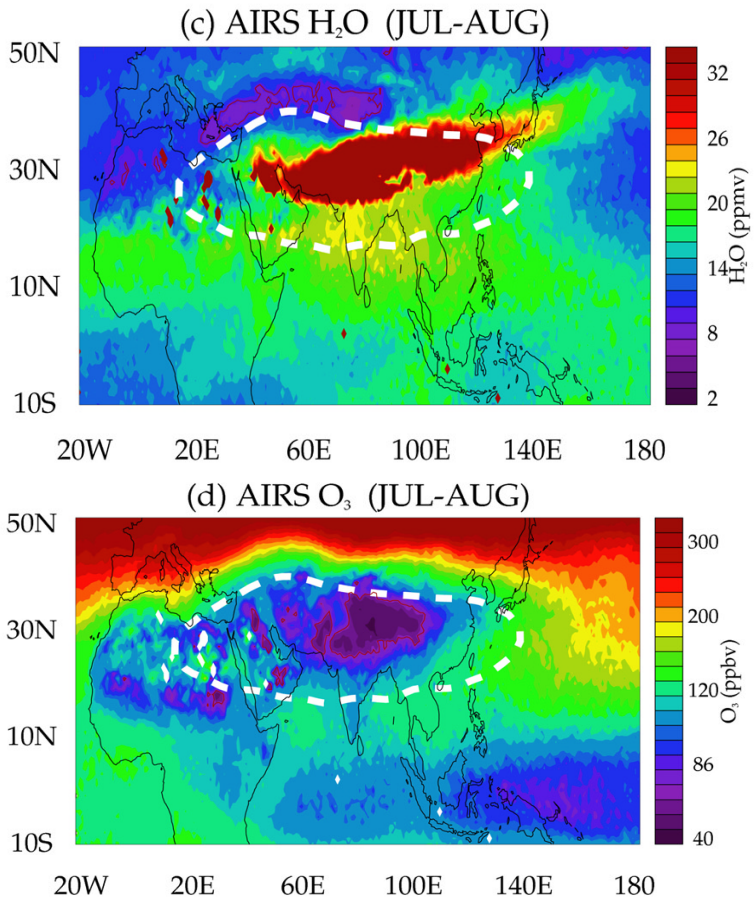







CONTRAIL(circle)
TDI64(square)
TDI64/CARIBIC(triangle)
TDI64/CARIBIC—modified
CO2 [ppm]
m. 11600 m
n. 12500 m
k. 9700 m
l. 10600 m
i. 7700 m
j. 8700 m
g. 5500 m
h. 6600 m
e. 3400 m
f. 4500 m
c. 1800 m
d. 2500 m
a. 1100 m
b. 1300 m
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN
2007
2008

Satellite Observations



*Randel and Park, JGR **111**, 2006*

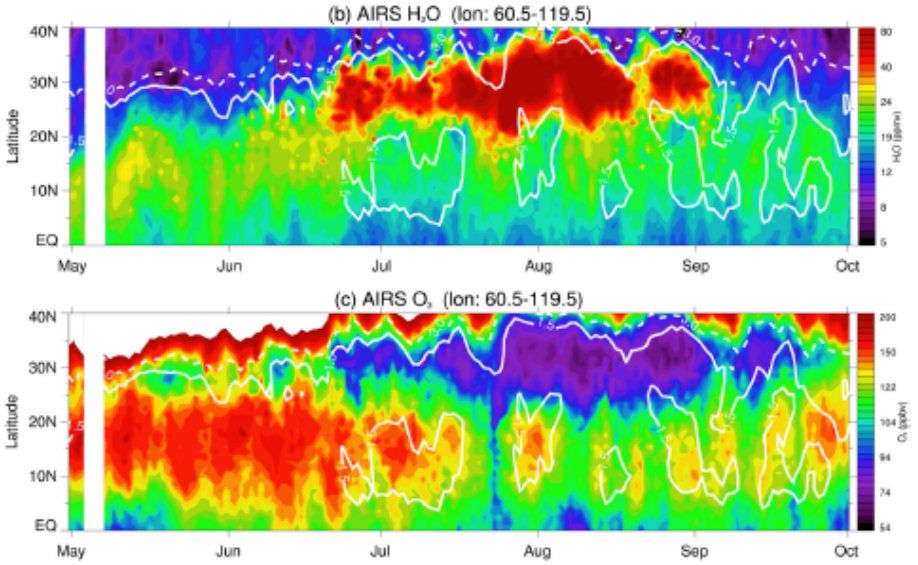


Figure 7. Time and latitude sections of (a) MPV (PVU), (b) AIRS water vapor (ppmv), and (c) ozone (ppbv) averaged over 60°–120°E on the 360 K isentrope (May to September 2003). The white solid contours overlaid on the AIRS data show MPV contours of 1.5 (solid) and 3.0 (dashed) PVU.

Randel and Park (2006), JGR, 111, D12314, doi:10.1029/2005JD006490

elevated H_2O mixing ratios and O_3 depletion during the South Asian summer monsoon due to convective transport