Emissions of greenhouse gases and transport to the UT/LS region in monsoon Asia

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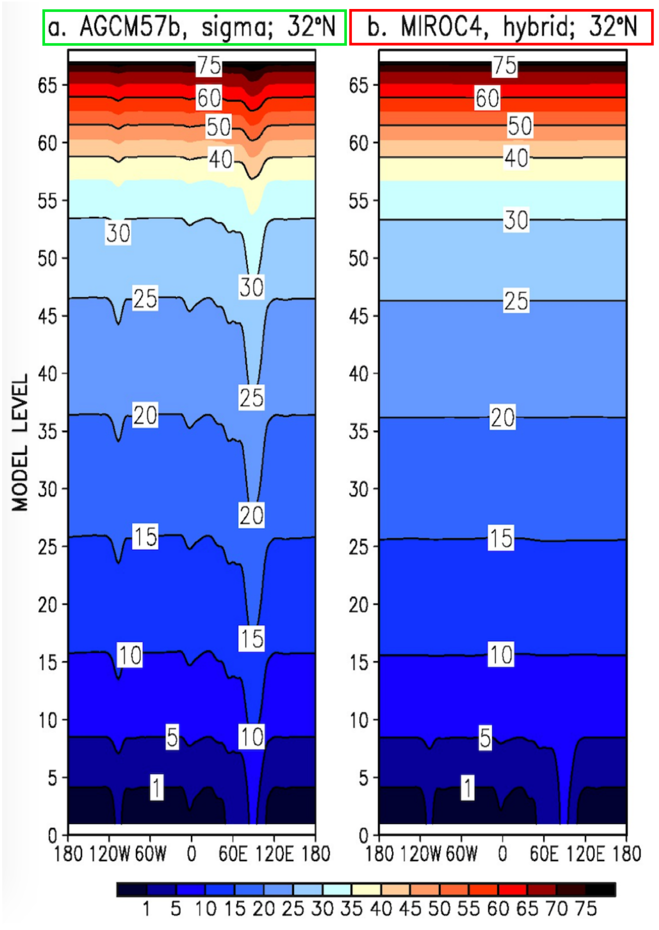
Ministry of Environment, Suishin-hi

Introduction

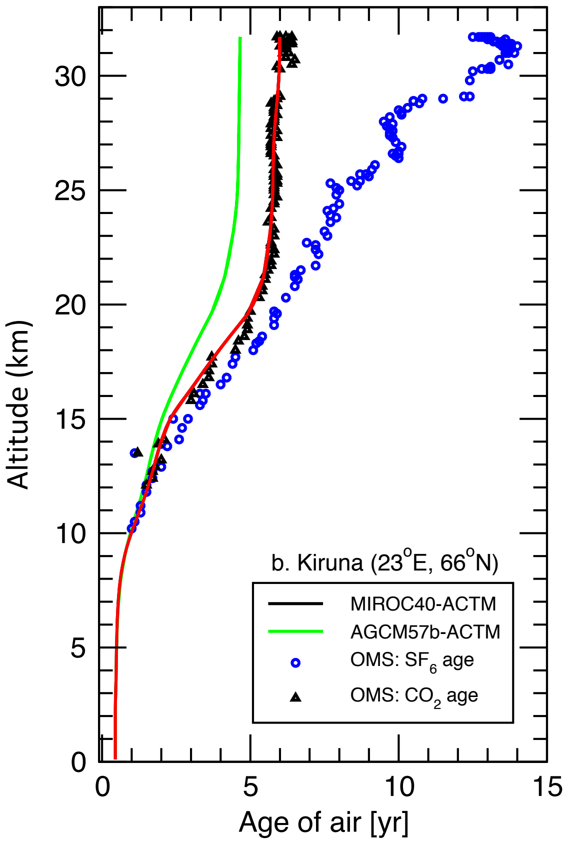
- Greenhouse gases are long-lived and important for global climate change
  - CO_2 being the single largest contributor to the surface air temperature increase since the preindustrial time, circa, 1750
  - CH_4 and N_2O are 2nd and 3rd significant contributors due to human activities
- We develop chemistry-transport models for simulating GHGs concentrations
- We conduct inverse modelling for estimation of their regional emissions
- Because of their longer lifetime, they offer information in atmospheric transport (and chemistry)

Development of MIROC4-ACTM@JAMSTEC for better transport and chemistry



Geopotential height (km)

Age of air **for XCO_2**??
(polar stratosphere)



Ray et al., JGR, 2017
Patra et al., SOLA, 2018

The **AGCM5.7b** atmospheric general circulation model (Numaguti et al., 1997; Patra et al., 2009)

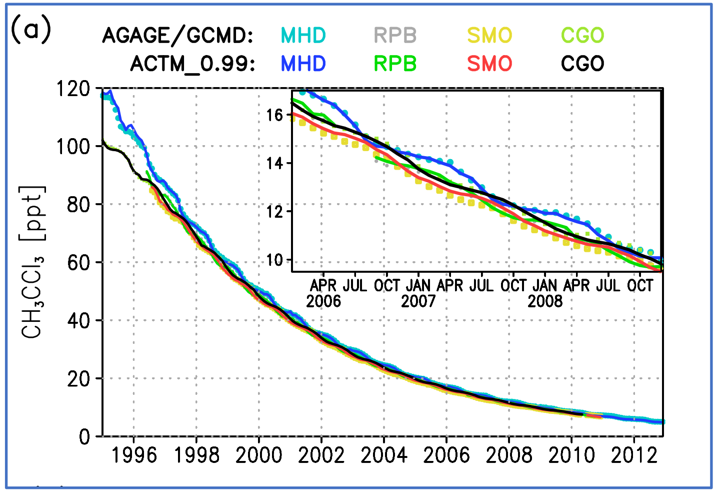
The **MIROC4.0** atmospheric general circulation model (Watanabe et al., 2008; Patra et al., 2018)

Horizontal resolution: T42 (2.8x2.8°) or T106 (1.1x1.1°)

Vertical coordinate : 67 hybrid (p-sigma & pressure)

Meteorology nudged to JMA 55-year Reanalysis (JRA-55; Kobayashi et al., JMSJ, 2015)

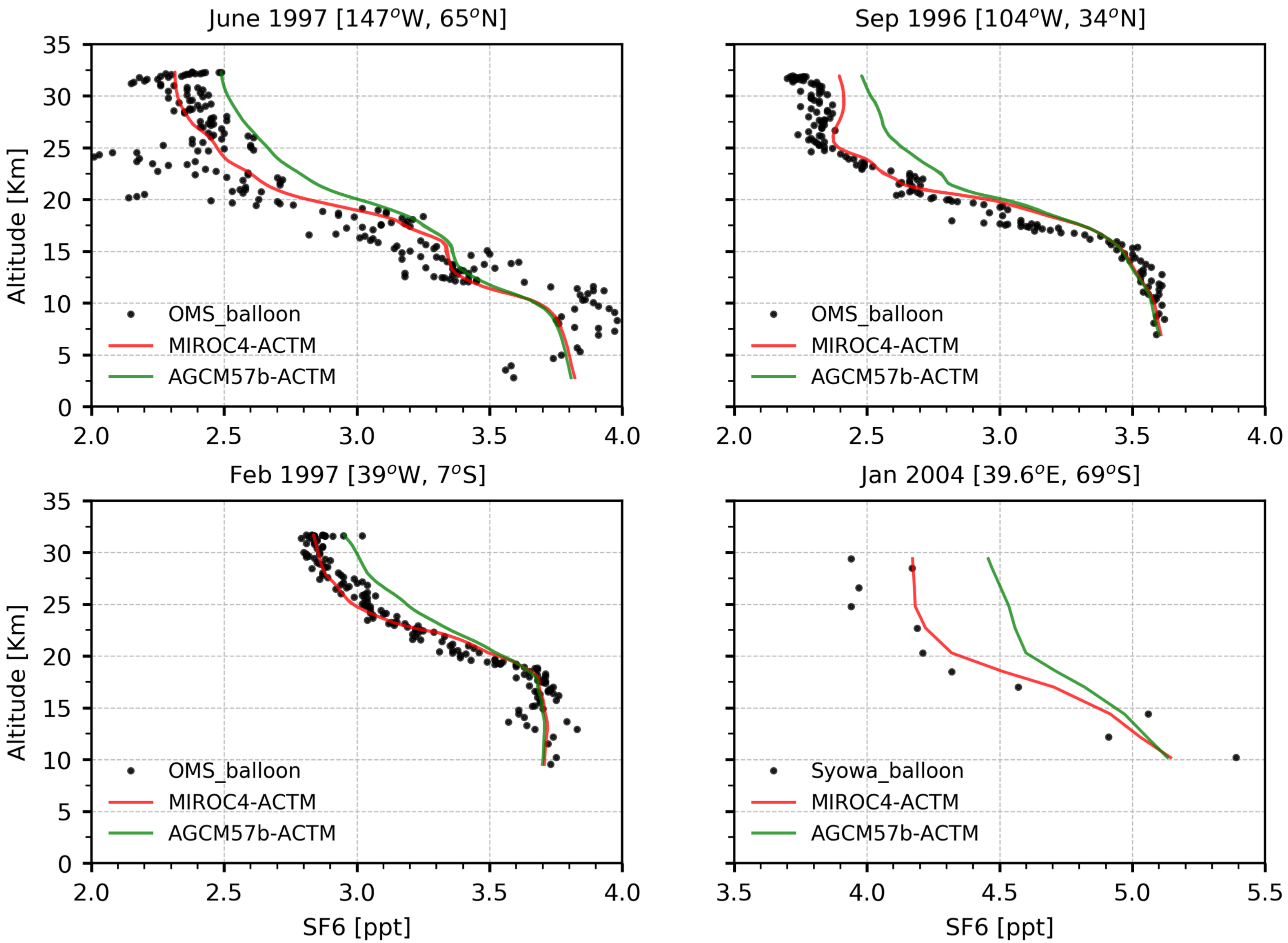
Species simulated: Transport tracers: ^{222}Rn, SF_6
Greenhouse gases: CO_2, CH_4, N_2O
Chemistry (OH) tracer : CH_3CCl_3



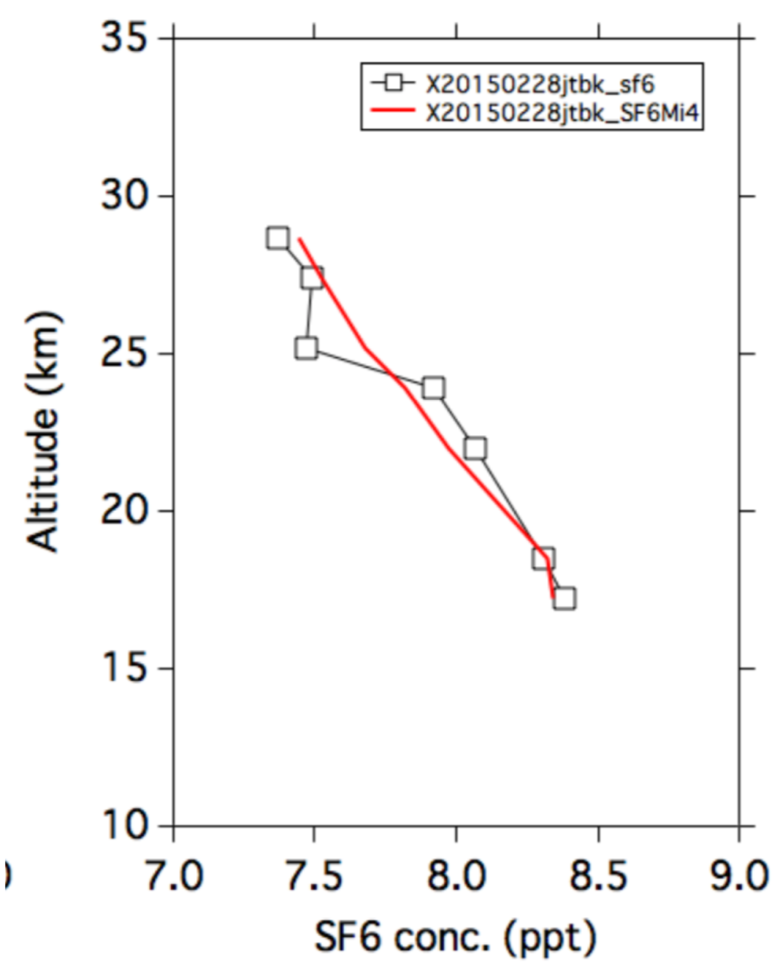
CH_3CCl_3 simulations suggest the validity of global mean OH abundance and NH/SH OH ratio (Patra et al., 2014)
-- for XCH_4

Development of MIROC4-ACTM: Comparison of SF_6 at various locations

Patra et al., 2018

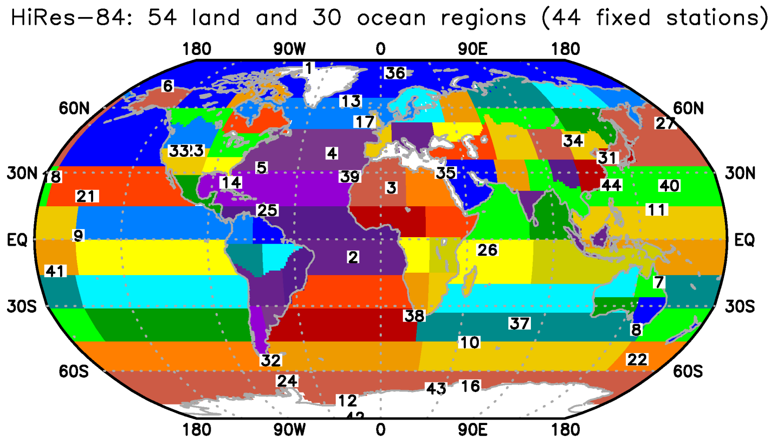


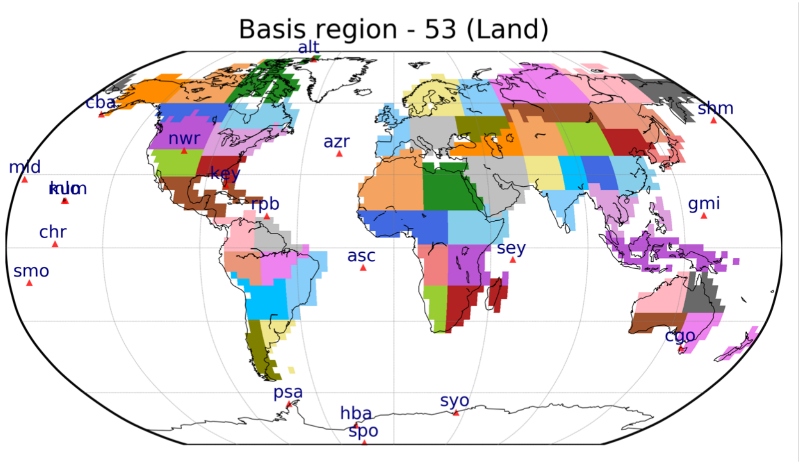
Biak, Indonesia
(**plot from S. Sugawara**)



Inversions using MACTM & data processing

- CO_2 inversions are done for 54 land and 30 ocean regions (top)
  - Non-fossil fluxes are optimized, fossil fuel emissions assumed known!
  - using data from 42 sites (surface only) from NOAA & JMA
- CH_4 inversions are for 53 land regions (bottom)
  - Total CH4 emissions are optimized, sectorial information from a priori
  - Using data from 35 sites (surface only) from NOAA
- N_2O inversions are done for 54 land and 30 ocean regions (top)
  - Non-fossil fluxes are optimized, fossil fuel emissions assumed known!
  - Using data from 39 sites (surface only) from NOAA
- We simulate the "optimised" emissions using the model and compare with GOSAT and aircraft measurements

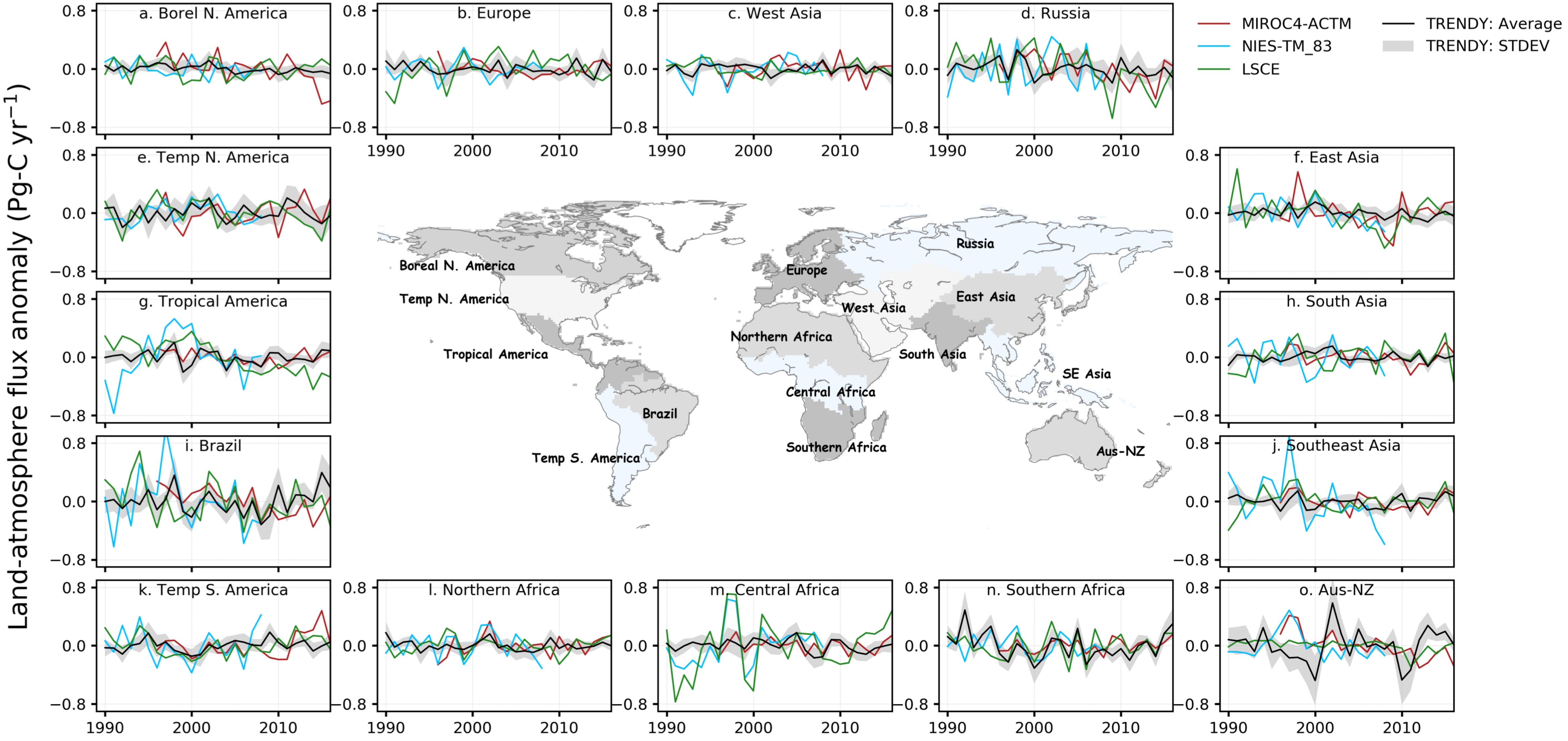




NOAA flask data (Dlugokencky et al.) are mainly used in both the inversions

Natural CO_2 fluxes at subcontinental scale

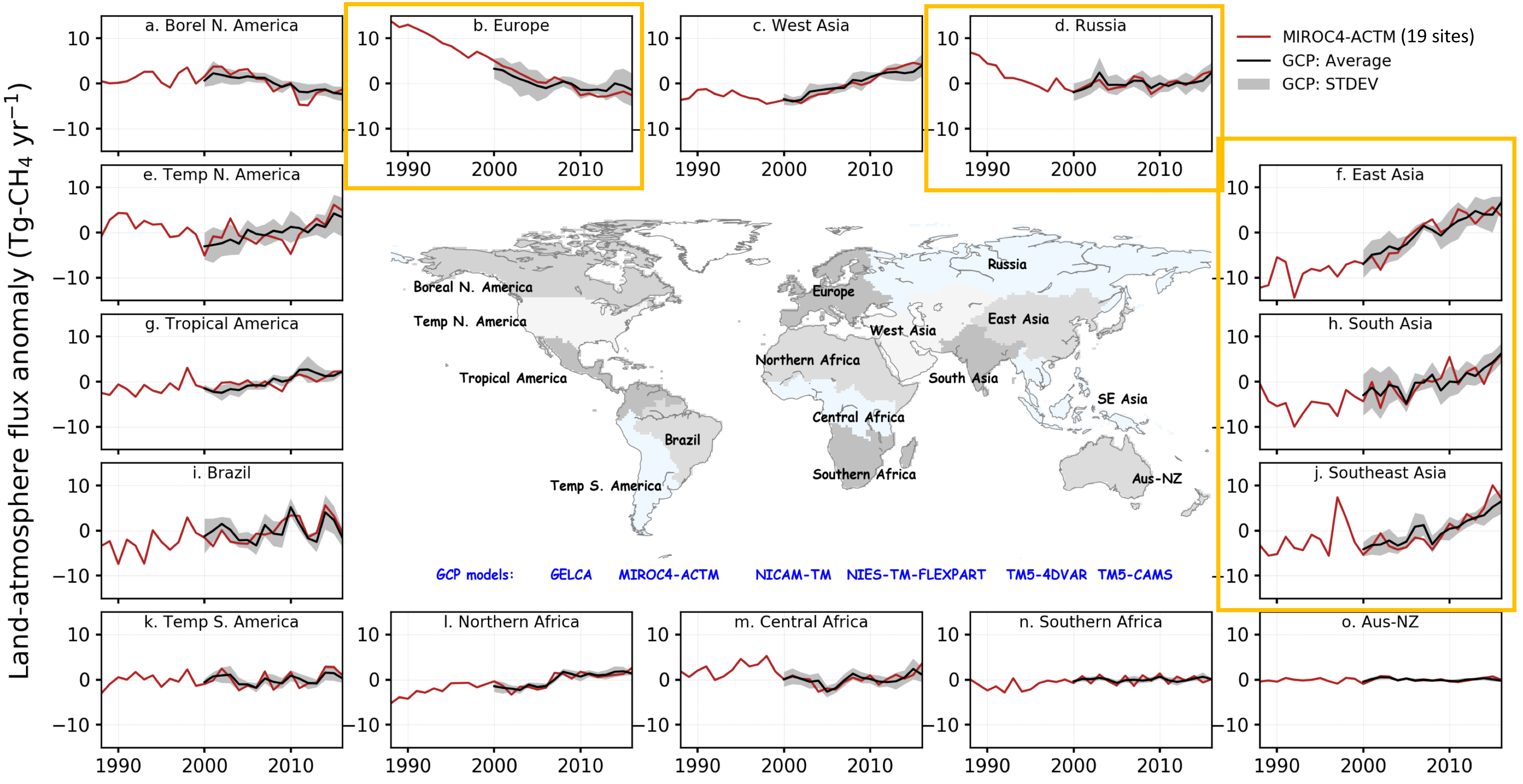
LSCE: Chevallier et al.
TRENDY: Sitch et al.
GCP-CO_2: LeQuere et al.



Analysis in progress (plot courtesy of Naveen Chandra)

Regional CH_4 emissions and trends

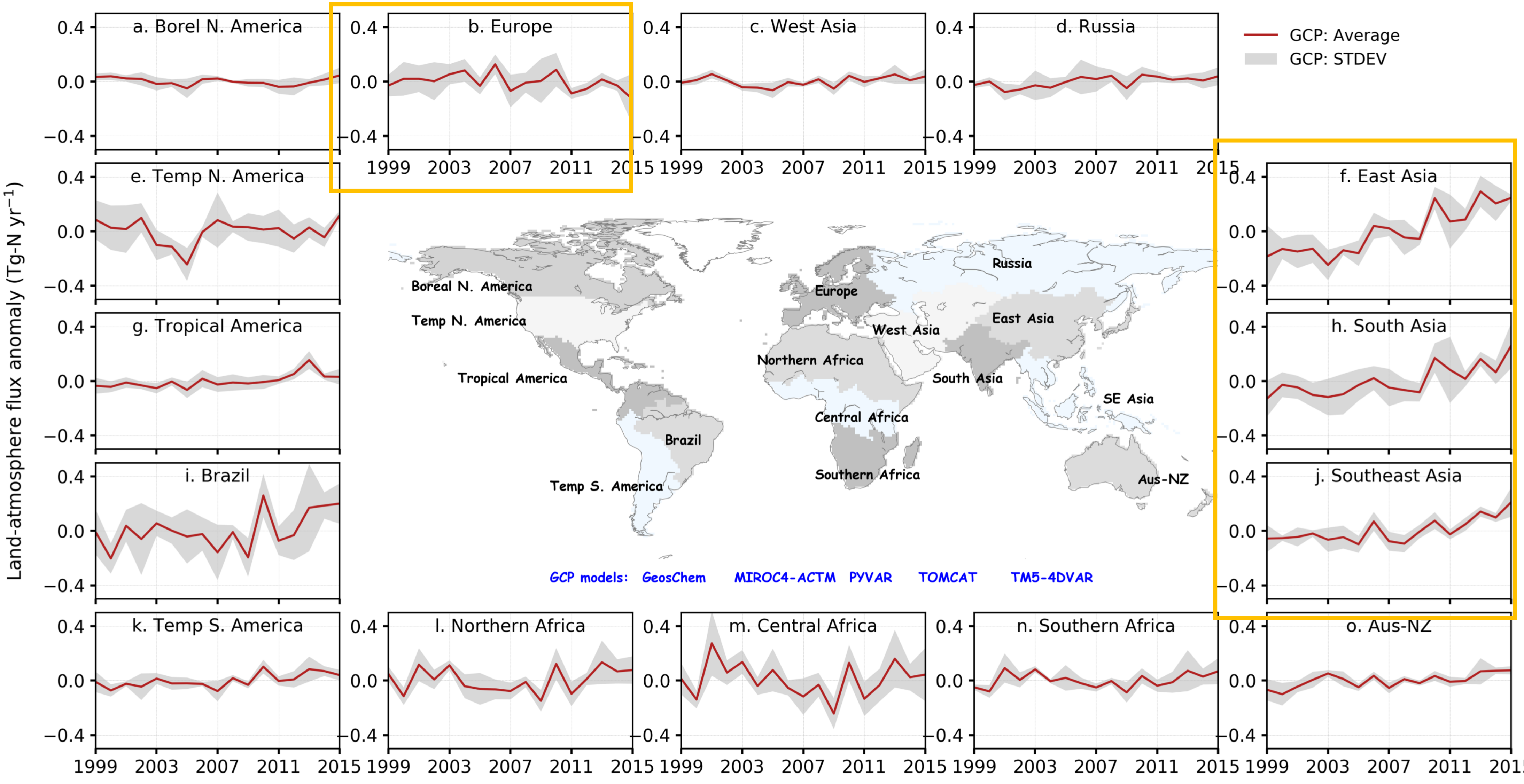
Patra et al., 2016
Chandra et al., in revision
GCP-CH_4: Saunois et al., in prep.



Analysis in progress (plot courtesy of Naveen Chandra)

Regional N_2O emissions and trends

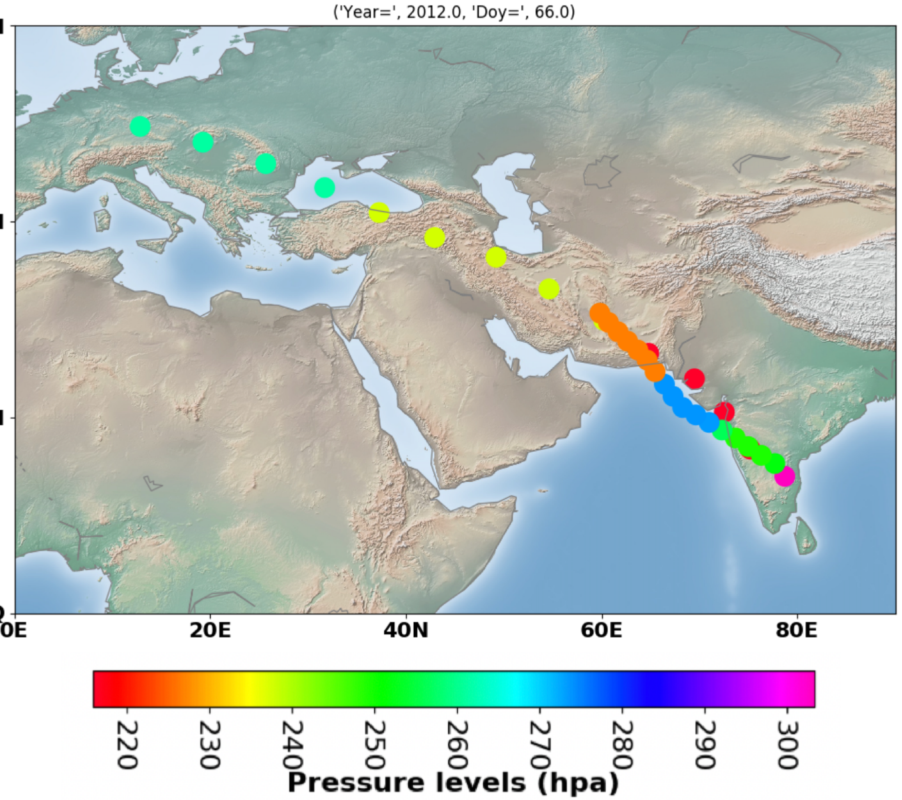
Thompson et al., in revision
GCP-N_2O: Tian et al., in prep.

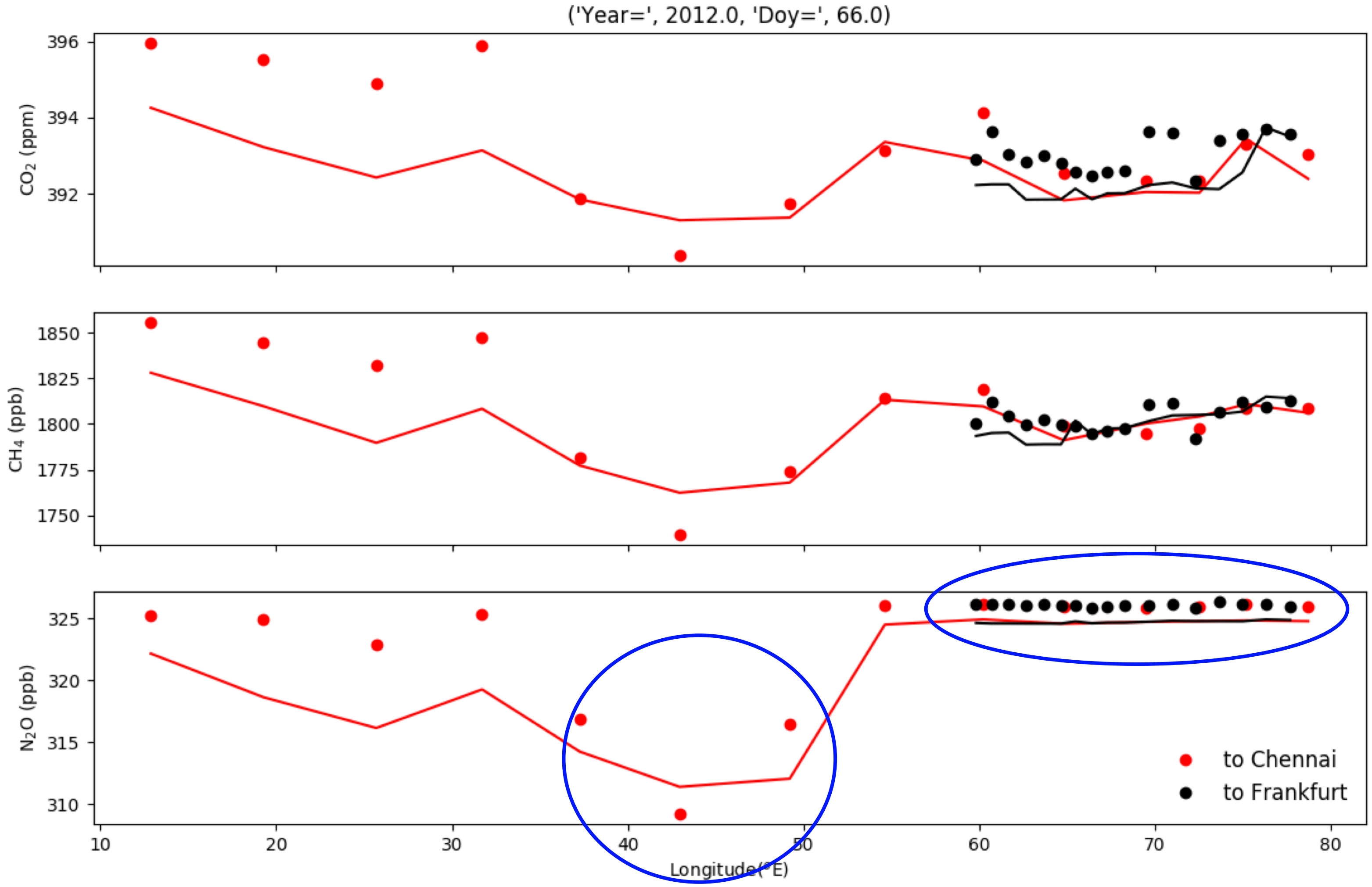


Analysis in progress (plot courtesy of Naveen Chandra)

CO_2, CH_4 and N_2O transport: Frankfurt-Chennai (winter/spring)

Easier to model the winter?
N_2O a tracer for STE

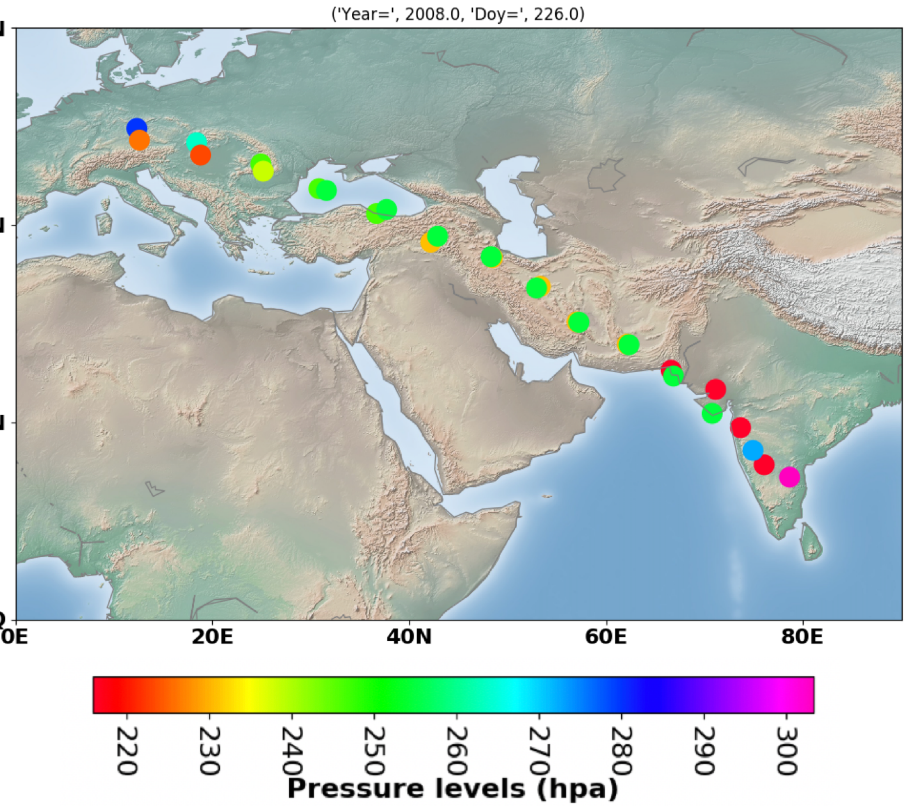


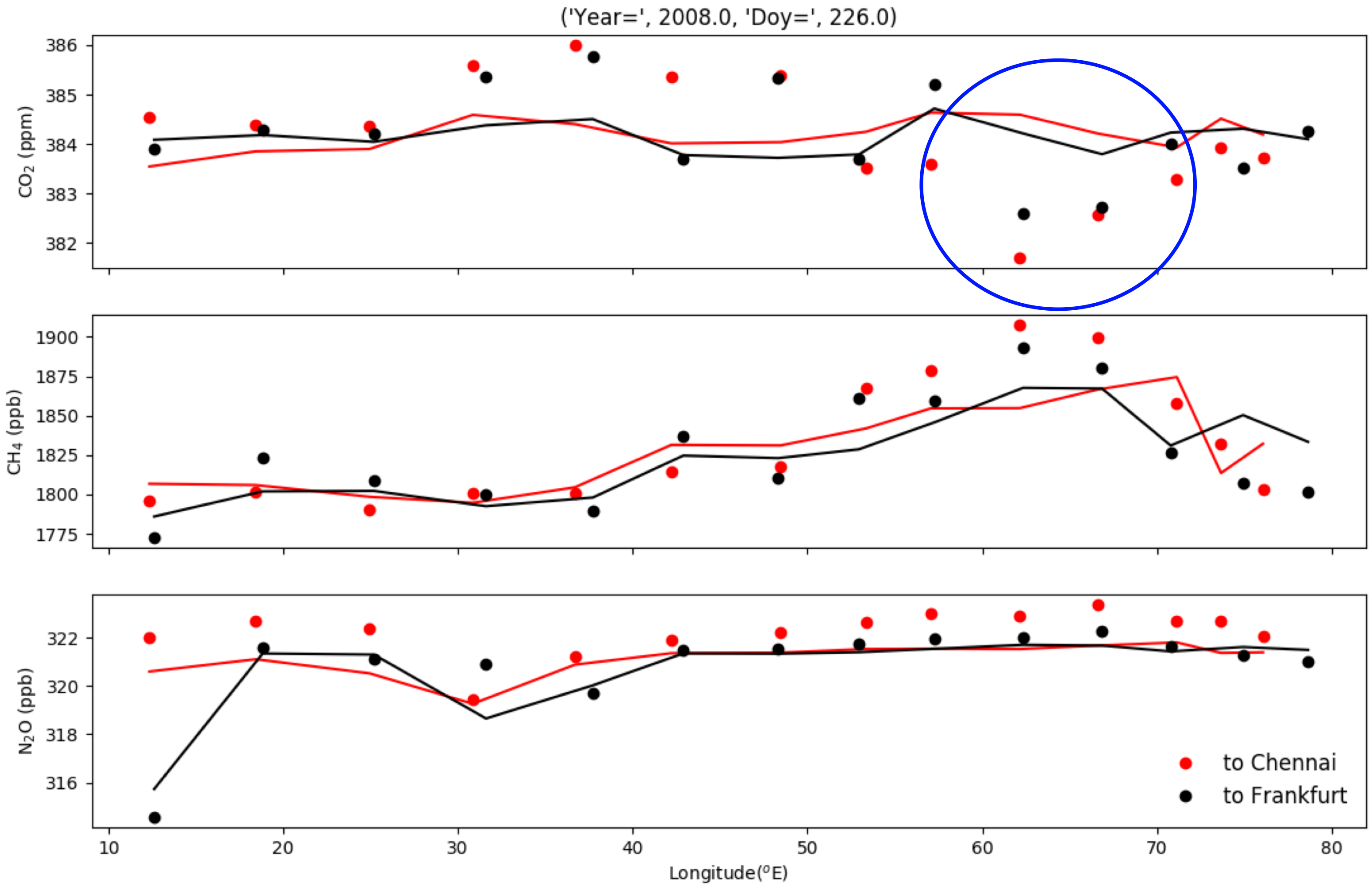


Bisht et al., work in prog.

CO_2, CH_4 and N_2O transport: Frankfurt-Chennai (summer/autumn)

Most difficult is to model summer-time CO_2

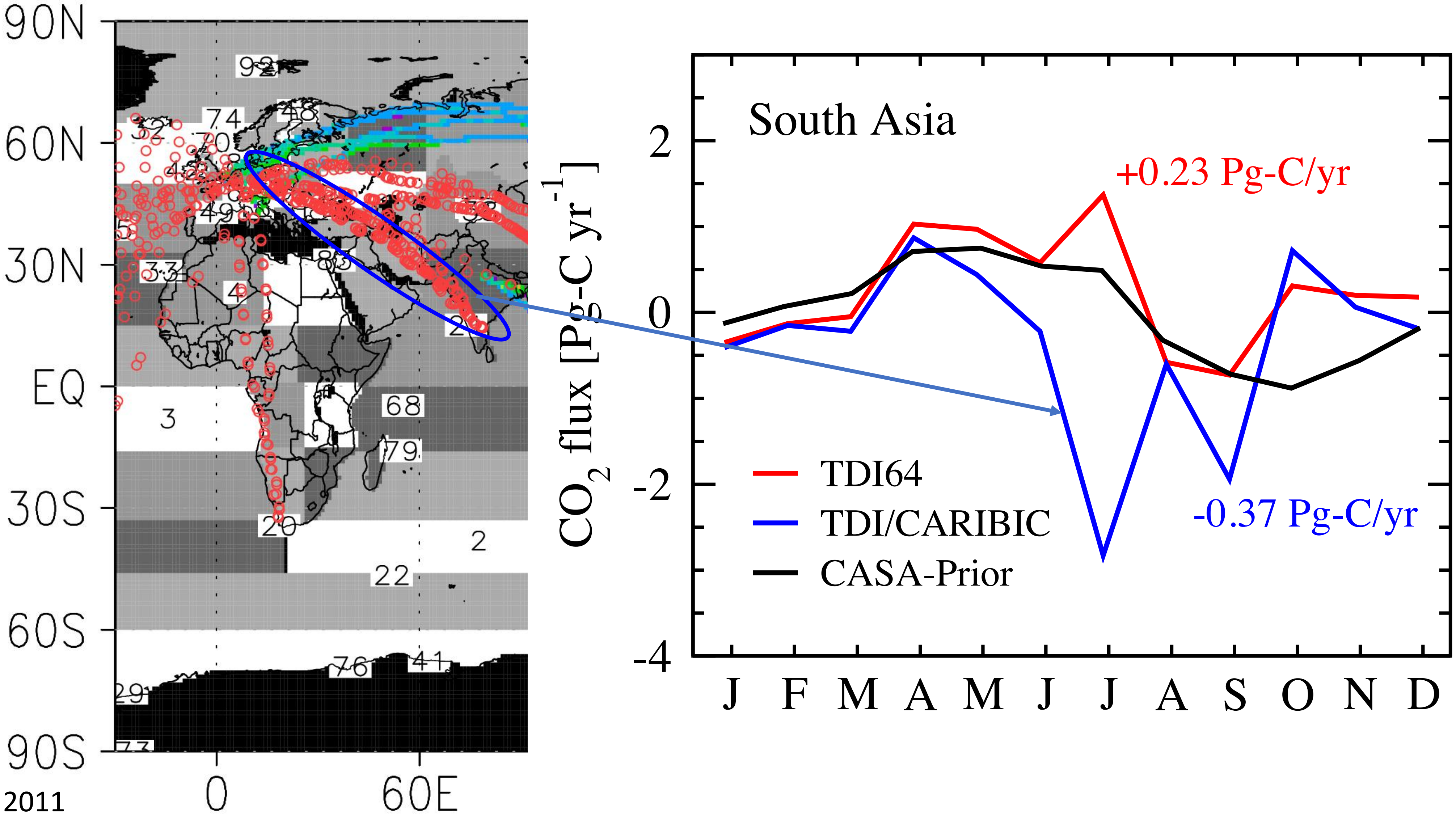




Bisht et al., work in prog.

Inverse modelling using surface + CARIBIC (May-Dec 2008)

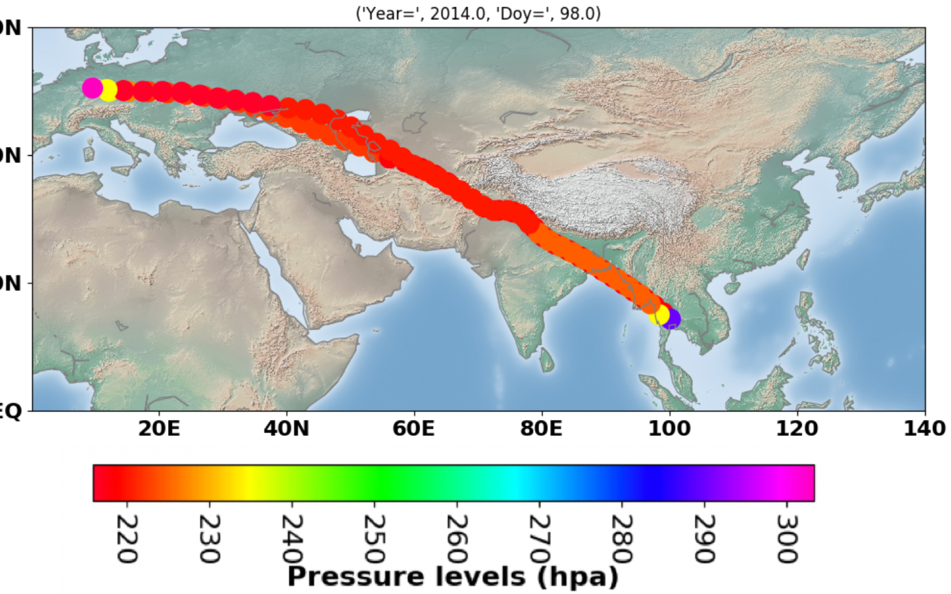
very limited data over India

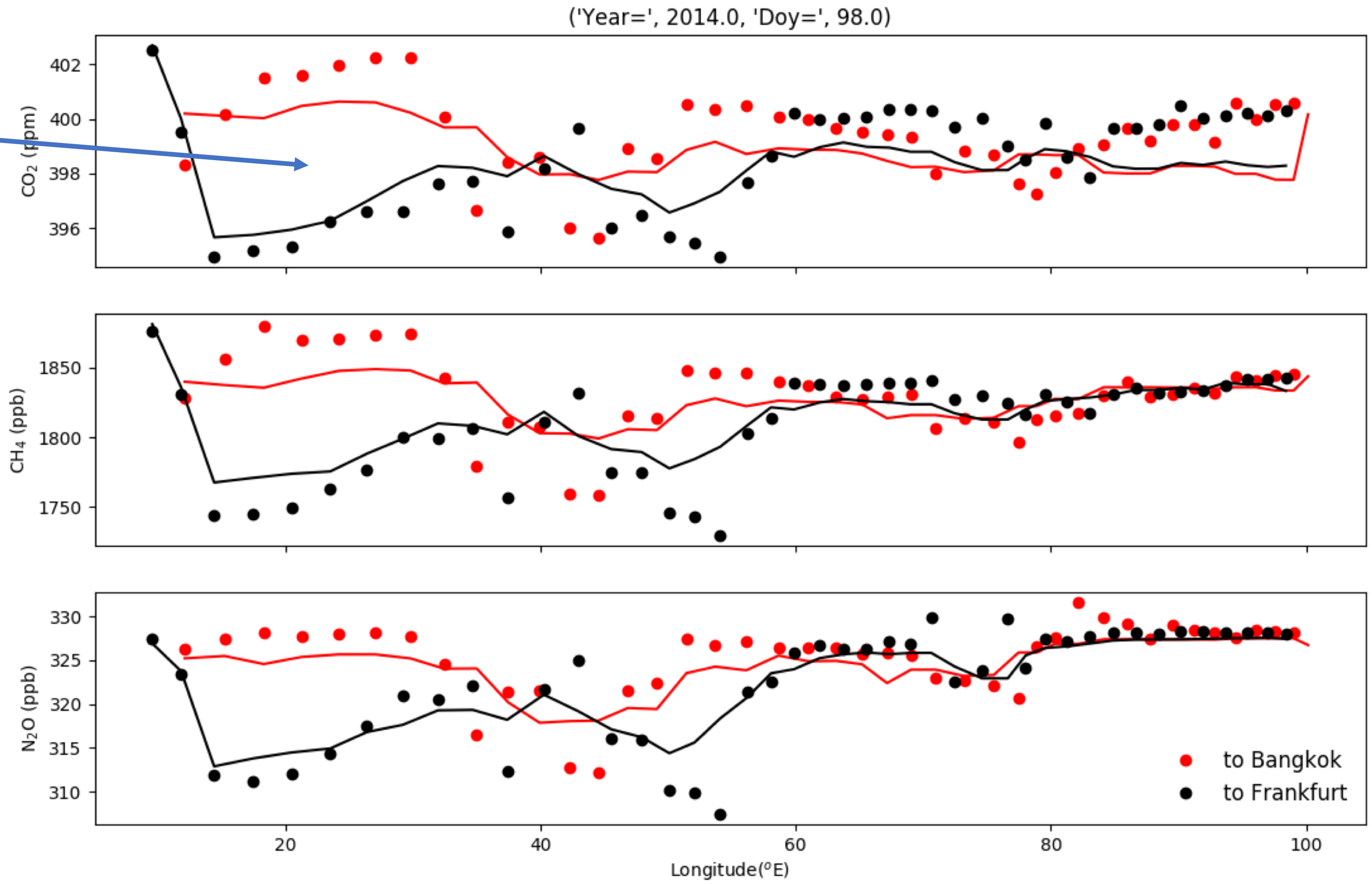


Patra et al., 2011

CO_2, CH_4 and N_2O transport : Frankfurt-Bangkok (winter-spring)

Model simulated the tropospheric (to Bangkok) and stratospheric air (to Frankfurt) well

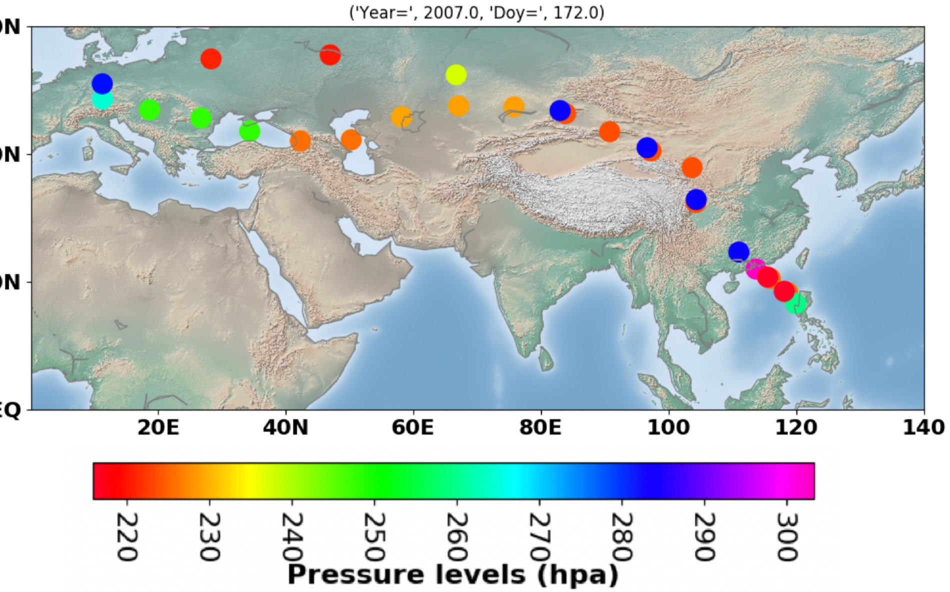


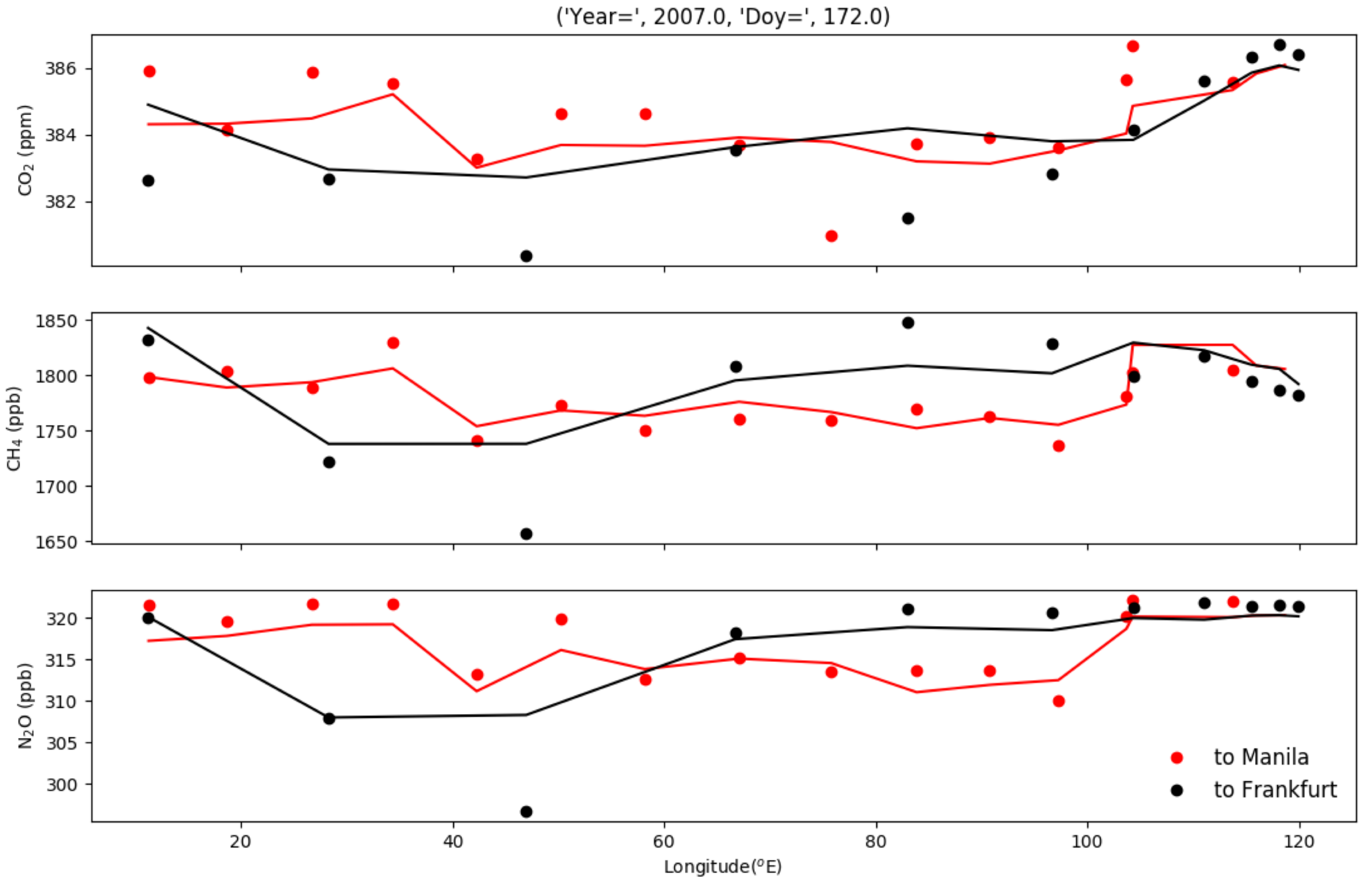


Bisht et al., work in prog.

CO_2, CH_4 and N_2O transport : Frankfurt-Manila (summer)

Model simulated the concentrations well during summer when the flight didn't cross over India

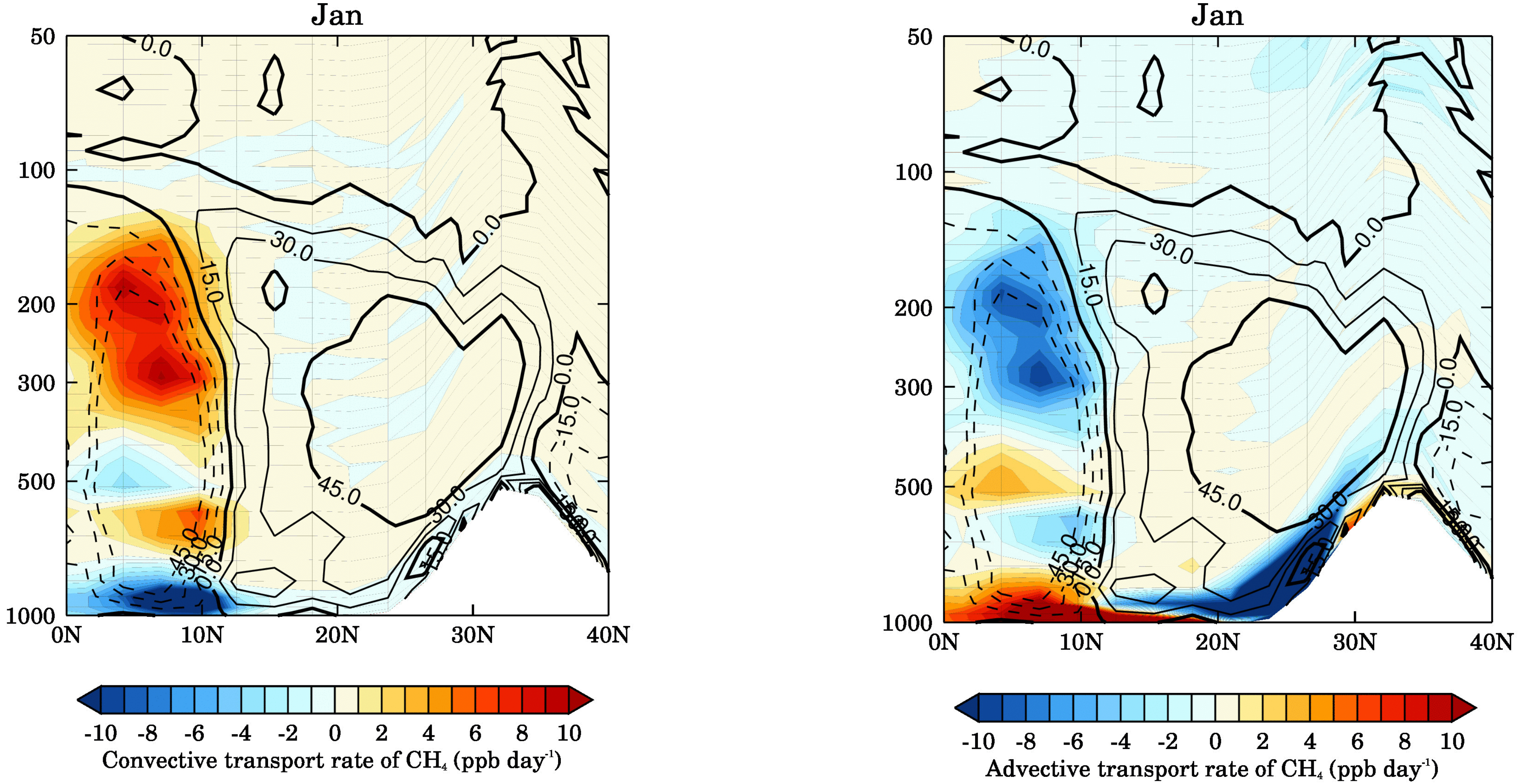




Bisht et al., work in prog.

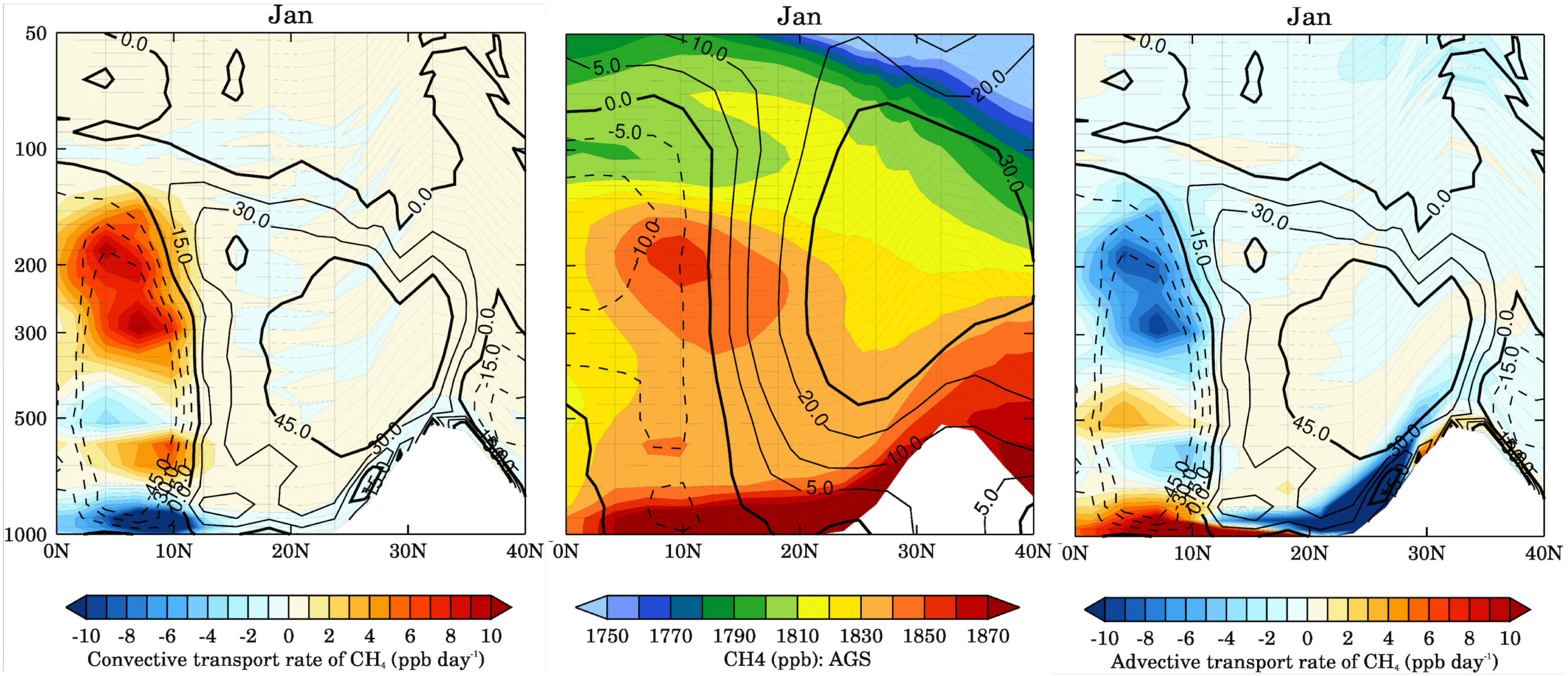
CH_4 transport (convection and advection) over the Indian domain

(mean: 83-93°E)



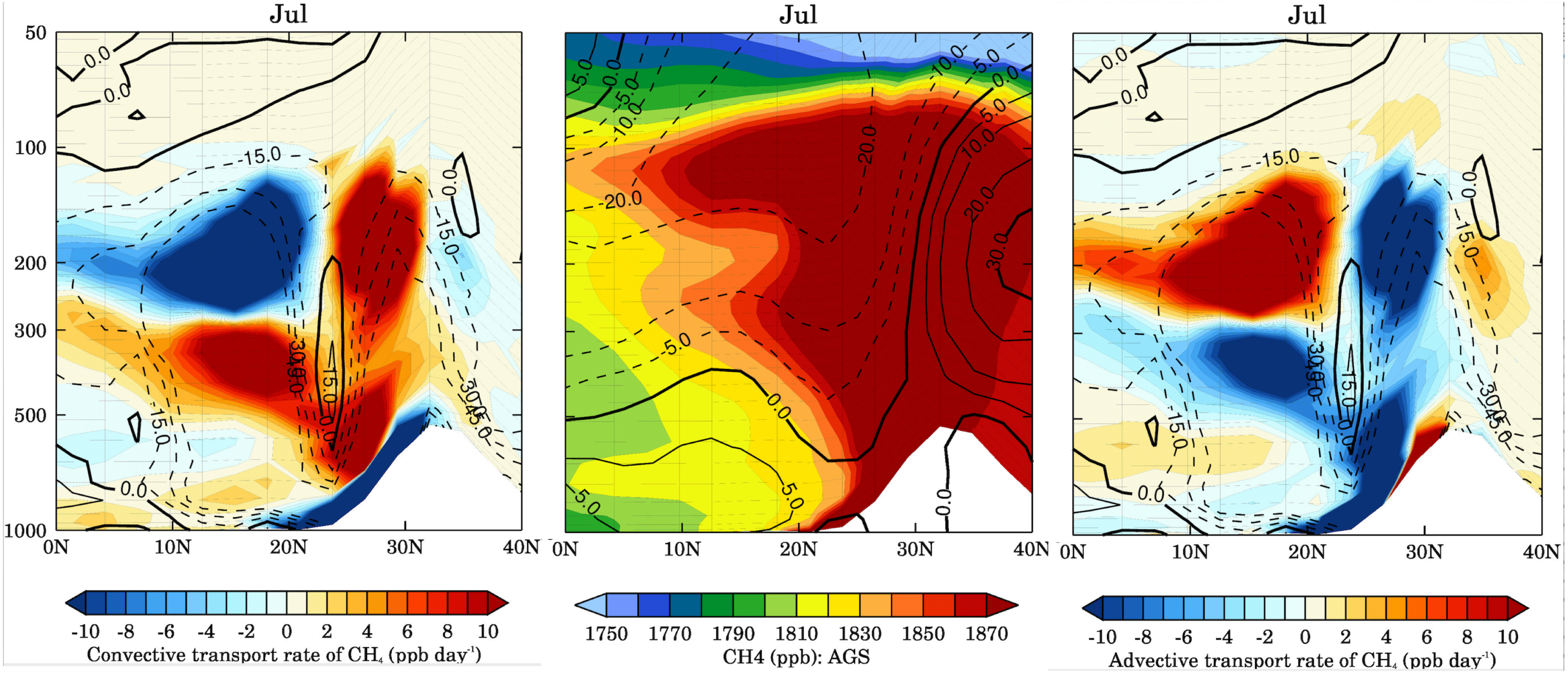
Chandra et al., ACP, 2017

CH_4 transport during the winter monsoon (mean: 83-93°E)



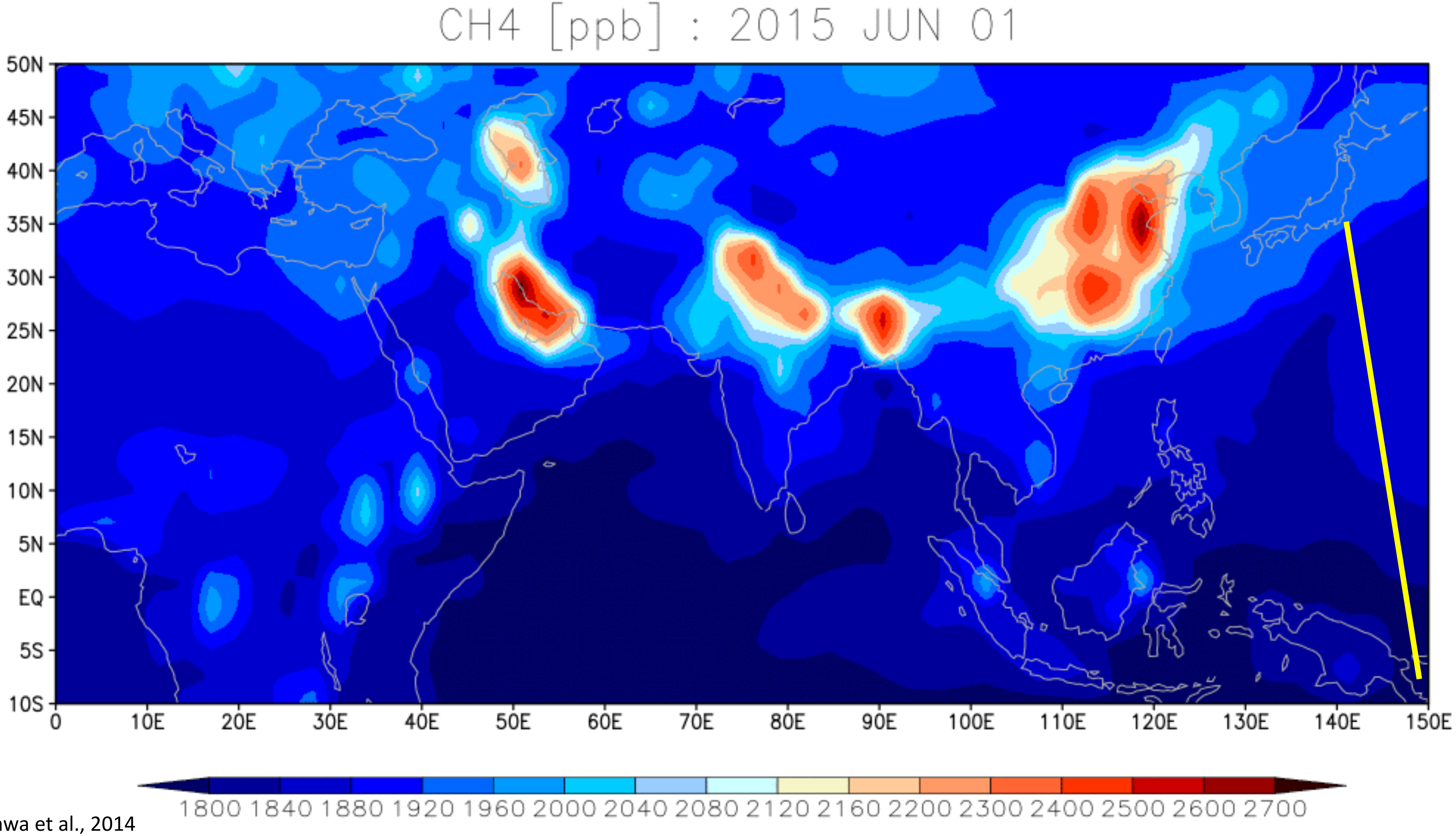
Chandra et al., ACP, 2017

CH_4 transport in the summer monsoon (mean: 83-93°E)



Chandra et al., ACP, 2017

CH_4 at 250 mb as simulated by MIROC4-ACTM



See also: Umezawa et al., 2014

Conclusions

- Asia regions are the emission hotspots for anthropogenically produced greenhouse gases
- We have studied the transport of airmass from troposphere to stratosphere using CO_2 and SF_6
- We can use CH_4 (mainly emissions on surface) for studying surface to upper troposphere transport of constituents
- N_2O is already recognised as one of the nice tracers for stratosphere-troposphere exchange (Ishijima et al., 2010)

Thank you!

All data are available for sharing

Travel funding :
An interdisciplinary study toward clean air, public health and sustainable agriculture:
The case of crop residue burning in North India
Project leader: Sachiko HAYASHIDA

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21.4 Air Quality, Environment and Public Health Impacts in Asia

Convenors: ***Prabir Patra, JAMSTEC and A. P. Dimri, JNU***

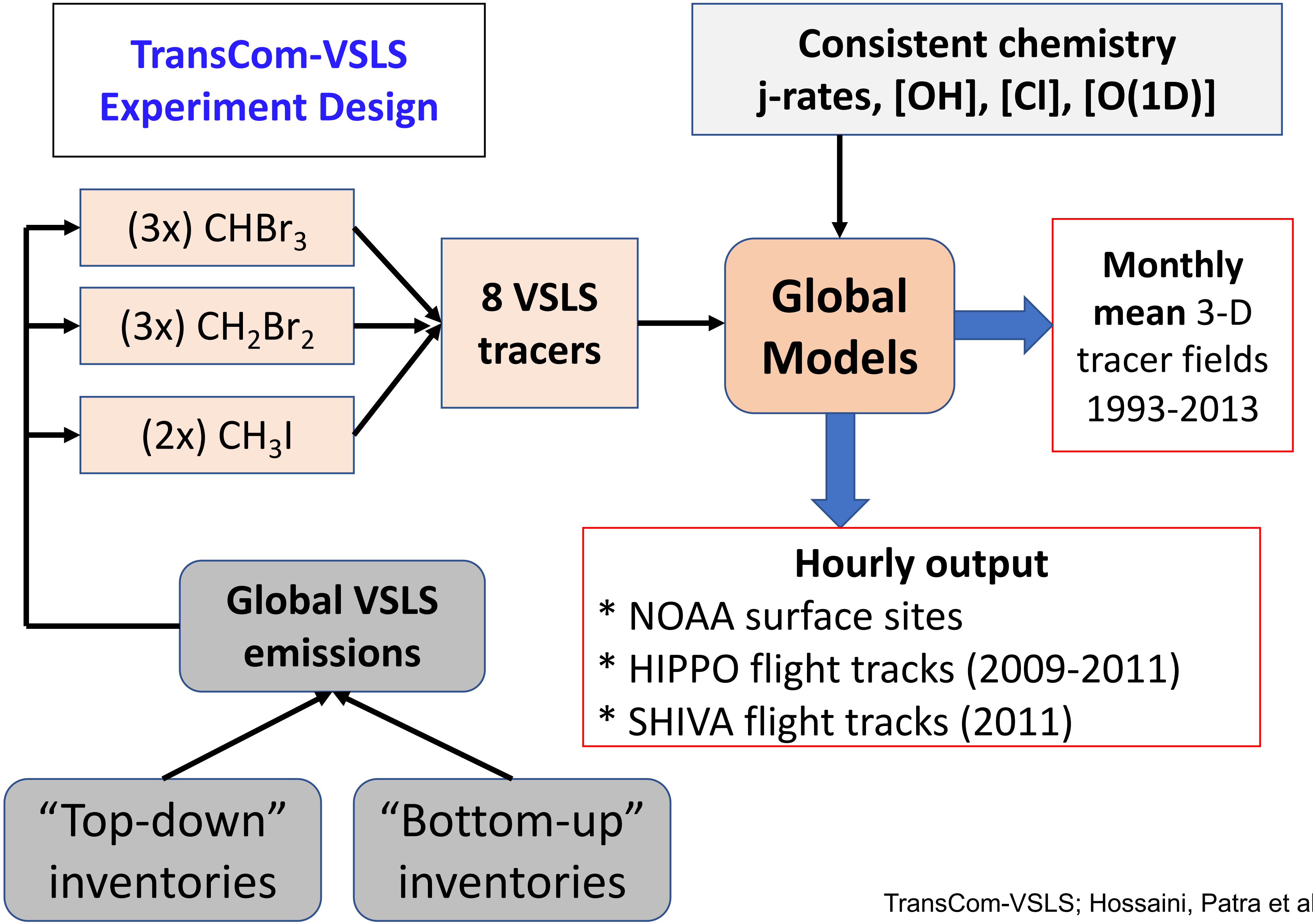
As per the World Health Organisation (WHO), an estimated 4.2 million premature deaths globally are linked to ambient air pollution. Ambient air pollutants for public health concern are particulate matter of less than 2.5 microns in diameter (PM2.5), ozone (O3), nitrogen oxides (NOX) and sulphur oxides (SOX). The air pollutants promote heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, acute respiratory infections in children, and may harm cognitive intelligence.

Studies suggest about two-thirds of all air pollution related deaths occur in Asia, which is home to all of the top 20 World's most polluted cities. Fourteen among 20 of them are located in India (www.bbc.com; 2 May 2018). The sources of air pollution are linked to infrastructure developments, power generation technologies, agricultural waste management and cooking with polluting fuels in the developing countries.

The atmosphere near the Earth's surface plays a major role in processing the gas phase species (NOx, SOx, volatile organic compounds) into the particulate phase (e.g., PM2.5), which affects human health and visibility that bear huge economic implications for both land and air transport sectors. Amount of air pollutants in the cities can be transported hundreds of kilometers to the rural areas and vice versa depending on the winds direction and speed, and stability of the atmosphere (boundary layer meteorology).

The interactions between the sources of air pollutants, air chemistry and atmospheric transport will be addressed in this symposium. Based on the Asia specific deliberations in the presence of international experts, we hope to come up with South Asia-specific solution to mitigate air pollution.

Keywords: *Ozone, PM2.5, NOx, SOx, aerosols*



TransCom-VSLS; Hossaini, Patra et al., ACP, 2016