ATAL aerosol budget from high resolution cloud-chemistry simulations

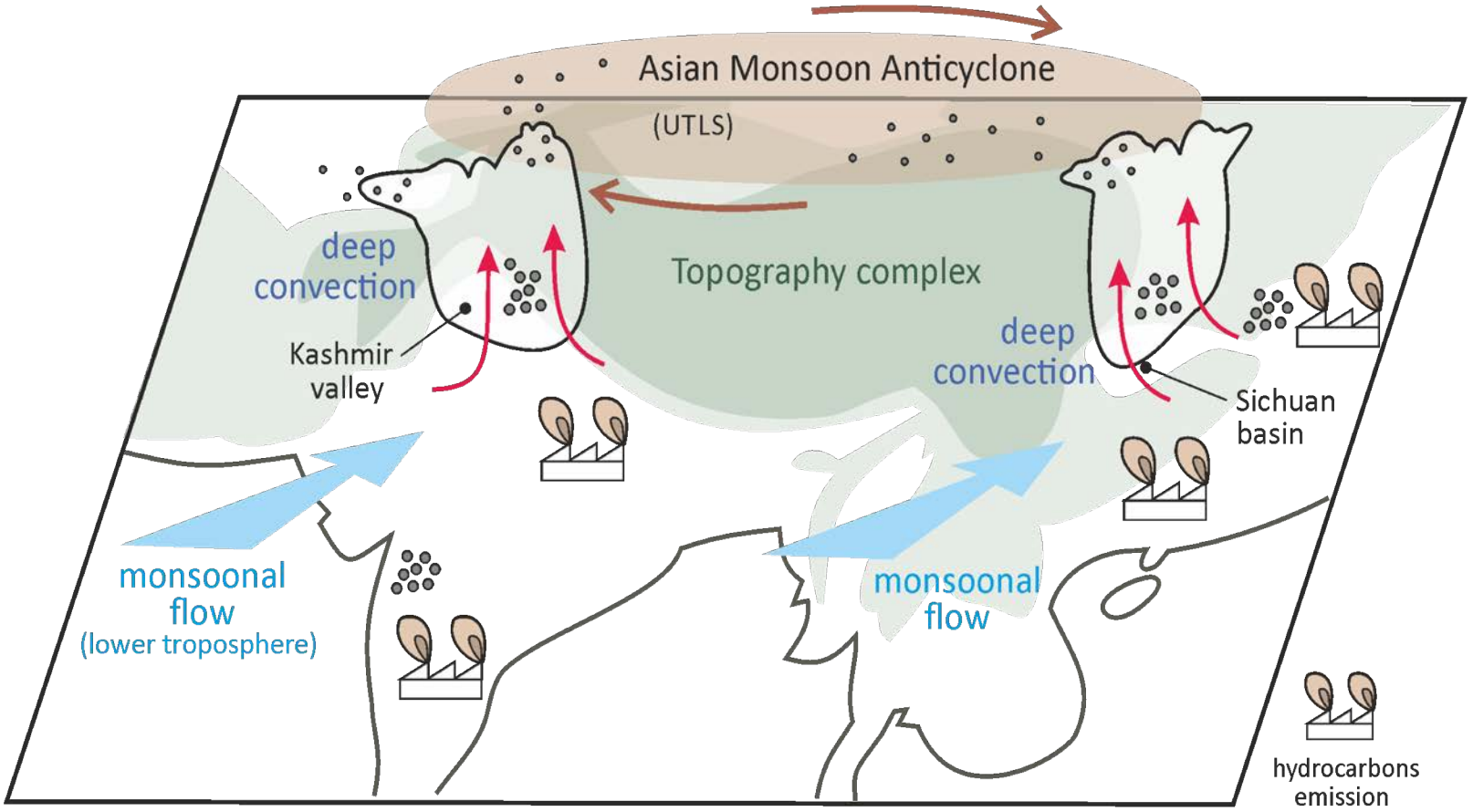
Brice Barret, **Lee KO.**, Eric Le Flochmoën

Laboratoire d'Aérologie, Toulouse, France

and

O. Appel, A. Batenburg, S. Borrmann, A. Dragoneas,
M. Von Hobe, A. Hodzic, A. Hünig, C. Kloss, M. Leriche, S. Molleker,
F. Ravegnani, P. Tulet, A. Ulanovsky

Scientific questions



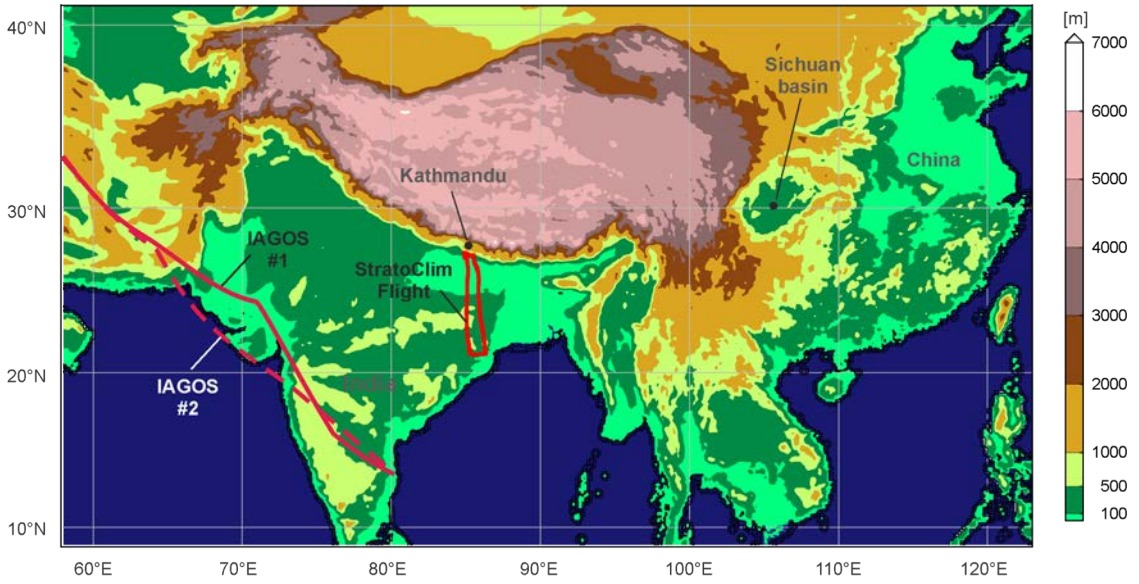
*What are the **transport and formation pathways of the ATAL aerosols** ?*

***What is the impact of the « anomalous » Sichuan deep convection on the AMA composition during StratoClim** ?*

1 Numerical simulation with the Meso-NH cloud-chemistry model

■ Domain

□ Δx=Δy=**15 km**
Δz=100 to 450 m
□ **64 vertical levels**
(ground to 24.5 km)
□ 27 July to 10 Aug 2017



Topography and domain considered in simulation

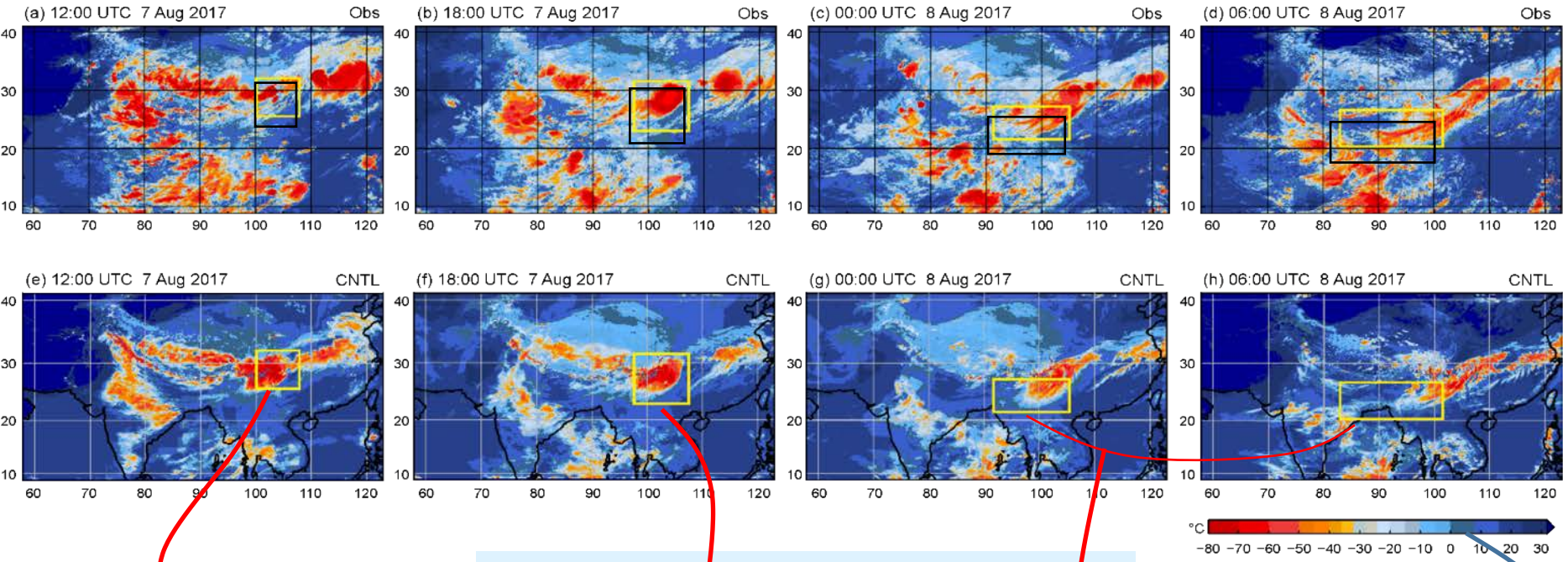
■ Meso-NH V5-3-1

□ Emission: MACCity (Anthro.), MEGAN (Bio), GFEDv3 (BB)
□ Meteo. Boundary: ECMWF
□ Chemical boundary: MOZART-4
□ Chemical scheme: ReLACS-2
□ Microphysical scheme: ICE-3
□ Aerosol Modules: ORILAM and ORILAM-SOA

□ **Gazes and aerosols :** CO-VOCs/NOx/O_3, Nitrates, Sulfates, Ammonium, BC, POA, SOA.

□ **Six water categories** (vapor, cloud water, rain water, pristine ice, snow, graupel)

■ Brightness Temperature (BT) at 10.8 µm



BT at 10.8µm of MSG-HIMAWARI (upper) and CNTL (bottom).

Deep convection develops over the Sichuan basin

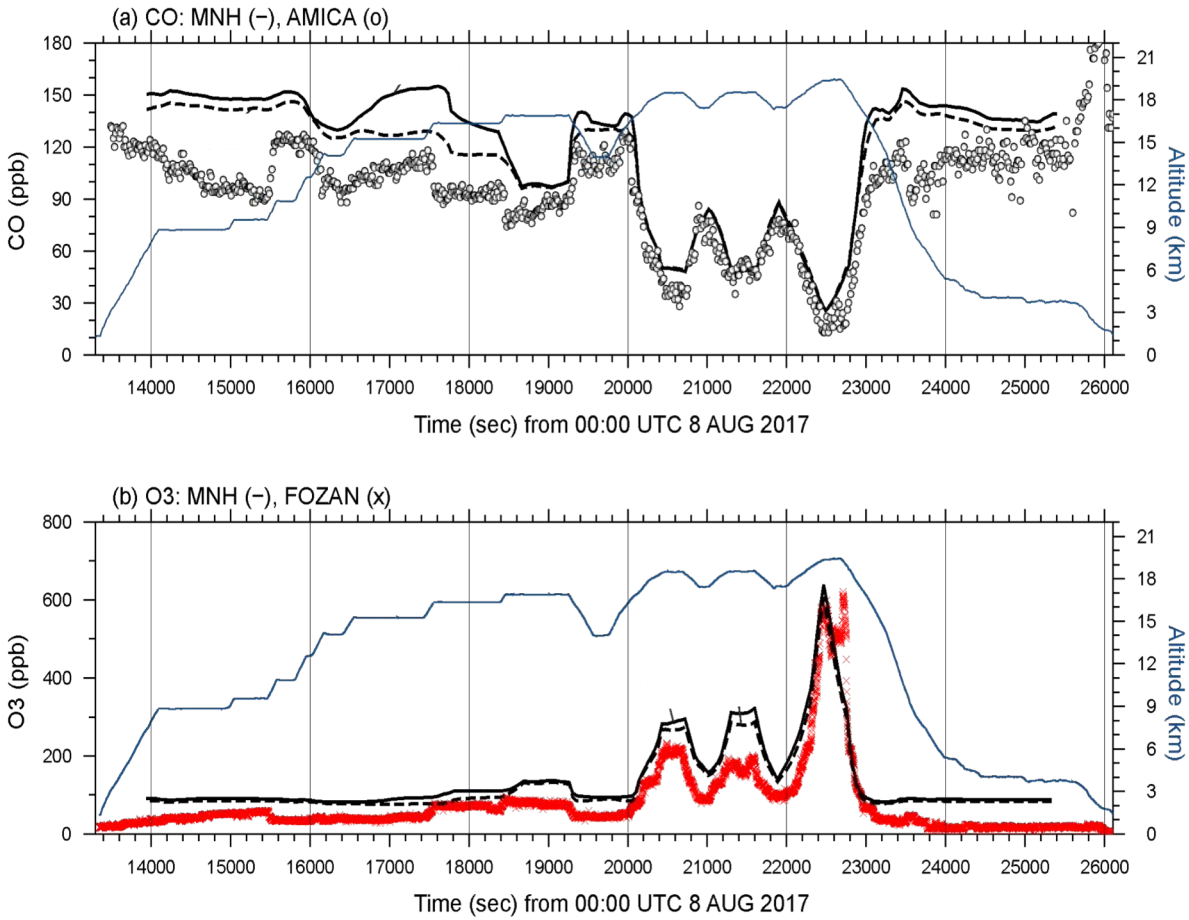
Horizontal and vertical extents of convection reproduced by MNH

Westward propagation of convective clouds

06:00 UTC on 8 Aug
StratoClim Flight #7 south of Kathmandu.

■ StratoClim Flight #7 vs CNTL

- Overestimation of CO by 20-50 ppbv in tropo. (take-off / landing) and UT
- Excellent agreement in LS
- Overestimation of O3 by 50 (tropo.) to 100 ppbv (strato.)
- Meso-NH captures CO and O_3 UTLS variability :
  - CO decreases whith altitude (trop. tracer)
  - O_3 increases whith altitude (strato. tracer)

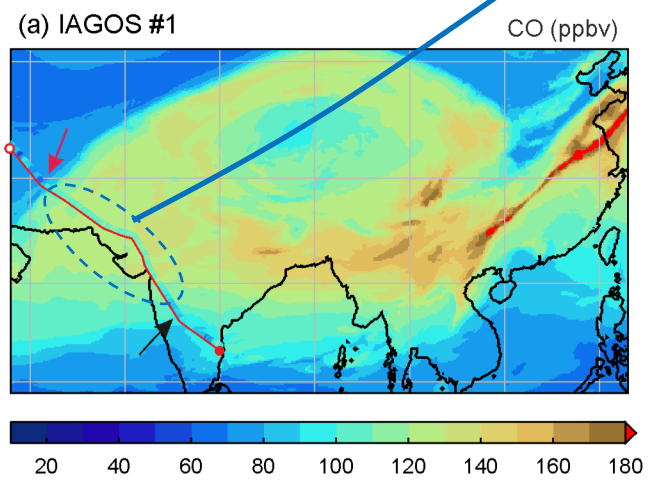


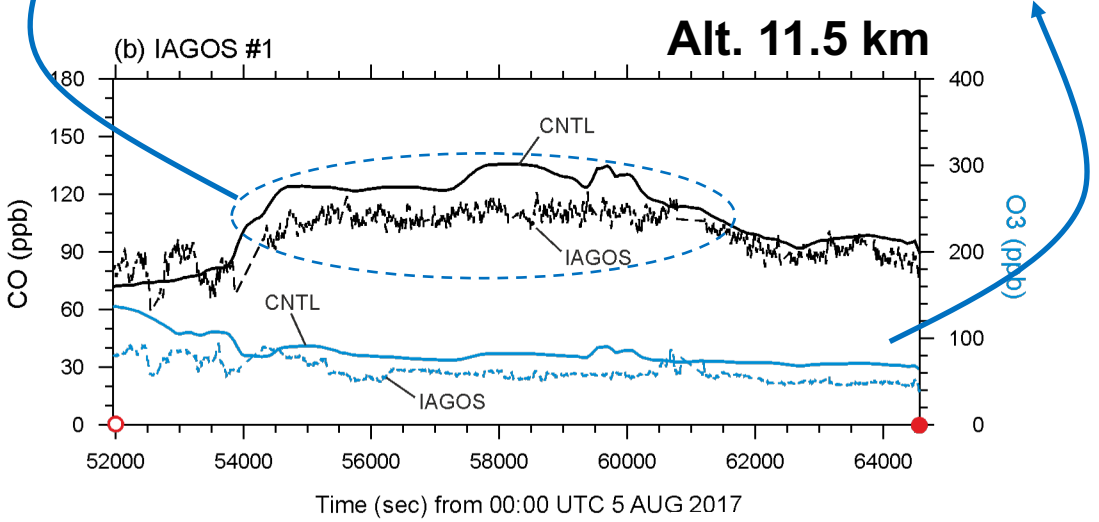
StratoClim F#7 obs. vs. Meso-NH CNTL, (a) **CO** and (b) **O_3**

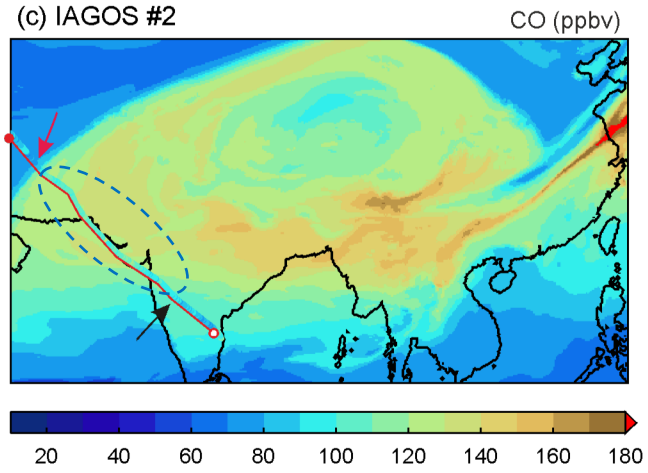
■ IAGOS vs CNTL

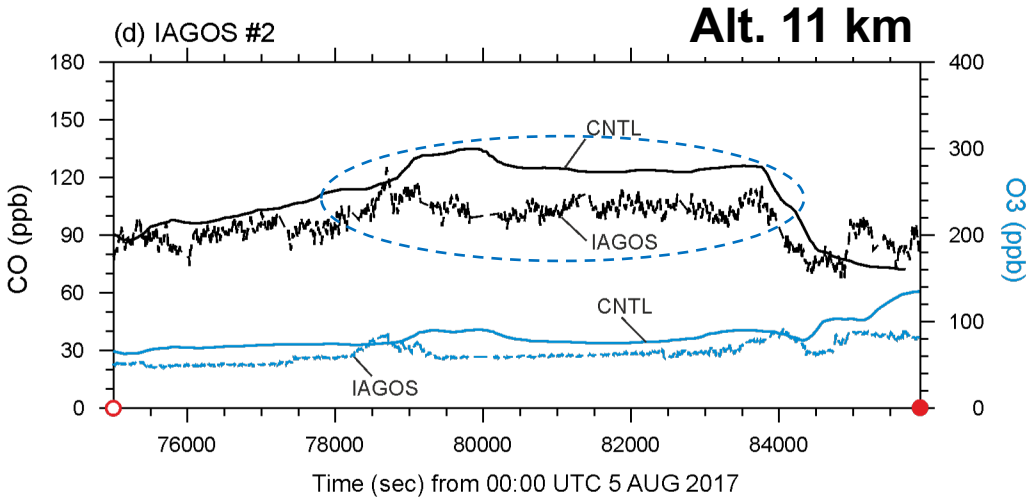
CO increases in AMA

O3 nearly constant





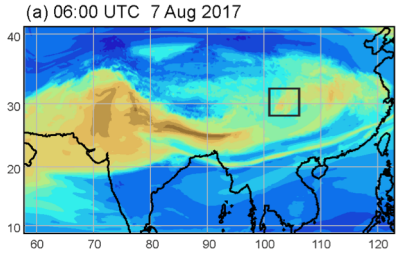




Overestimation of CO in AMA by 10-30 ppbv
and of O3 by 20-50 ppbv

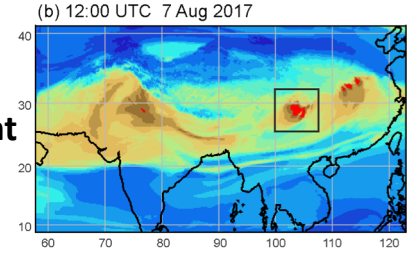
3 Pollution transport from Sichuan basin into UTLS by deep convections: Horizontal distribution

Convection initiation



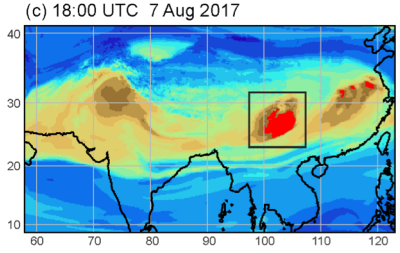
- CO plume initiates

development



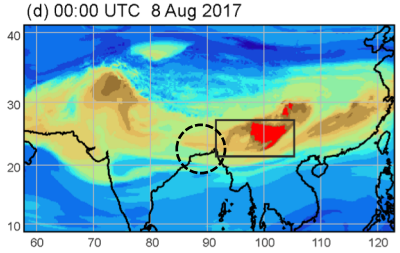
- CO ≥ 180 ppbv

Mature



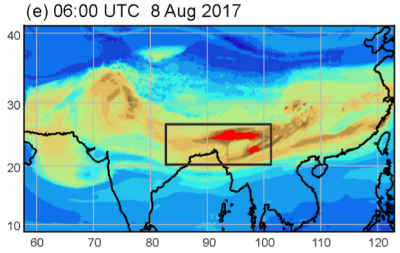
- max. plume size

Decaying



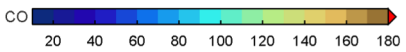
- westward stretch
(CO ≥ 150 ppbv over India ◯)

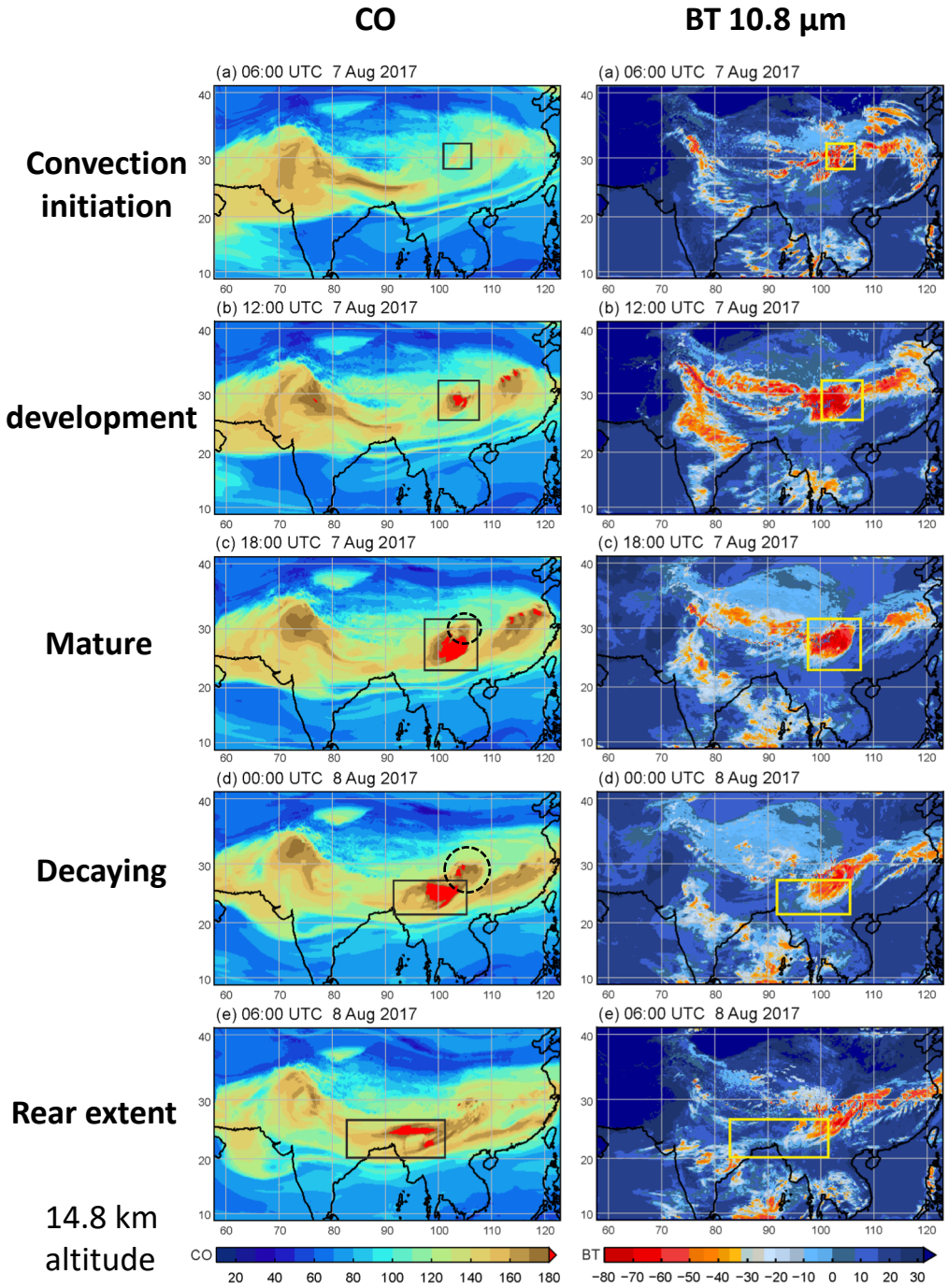
Rear extent



- westward transport
- rear side reaches south Kathmandu

14.8 km altitude

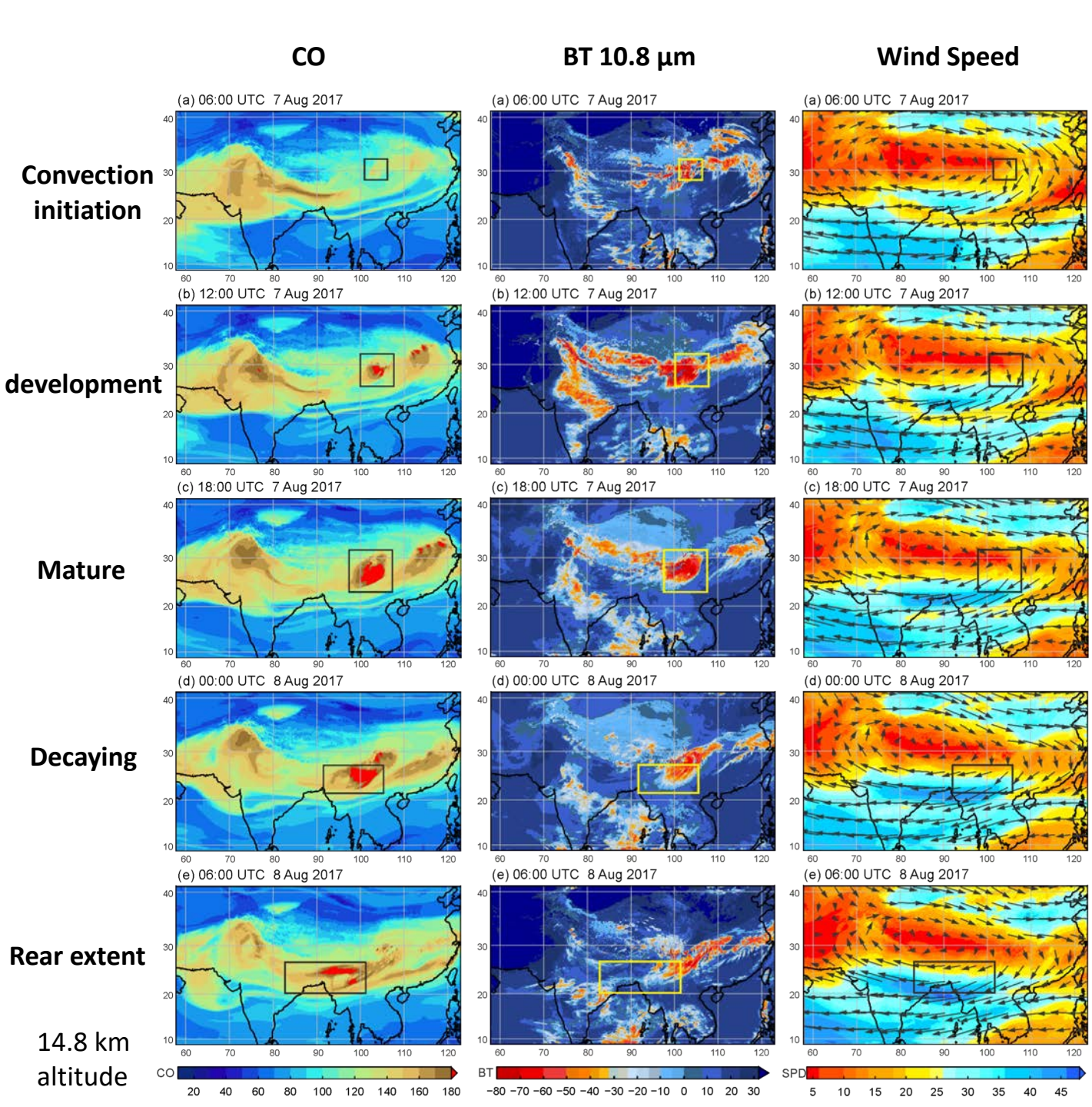


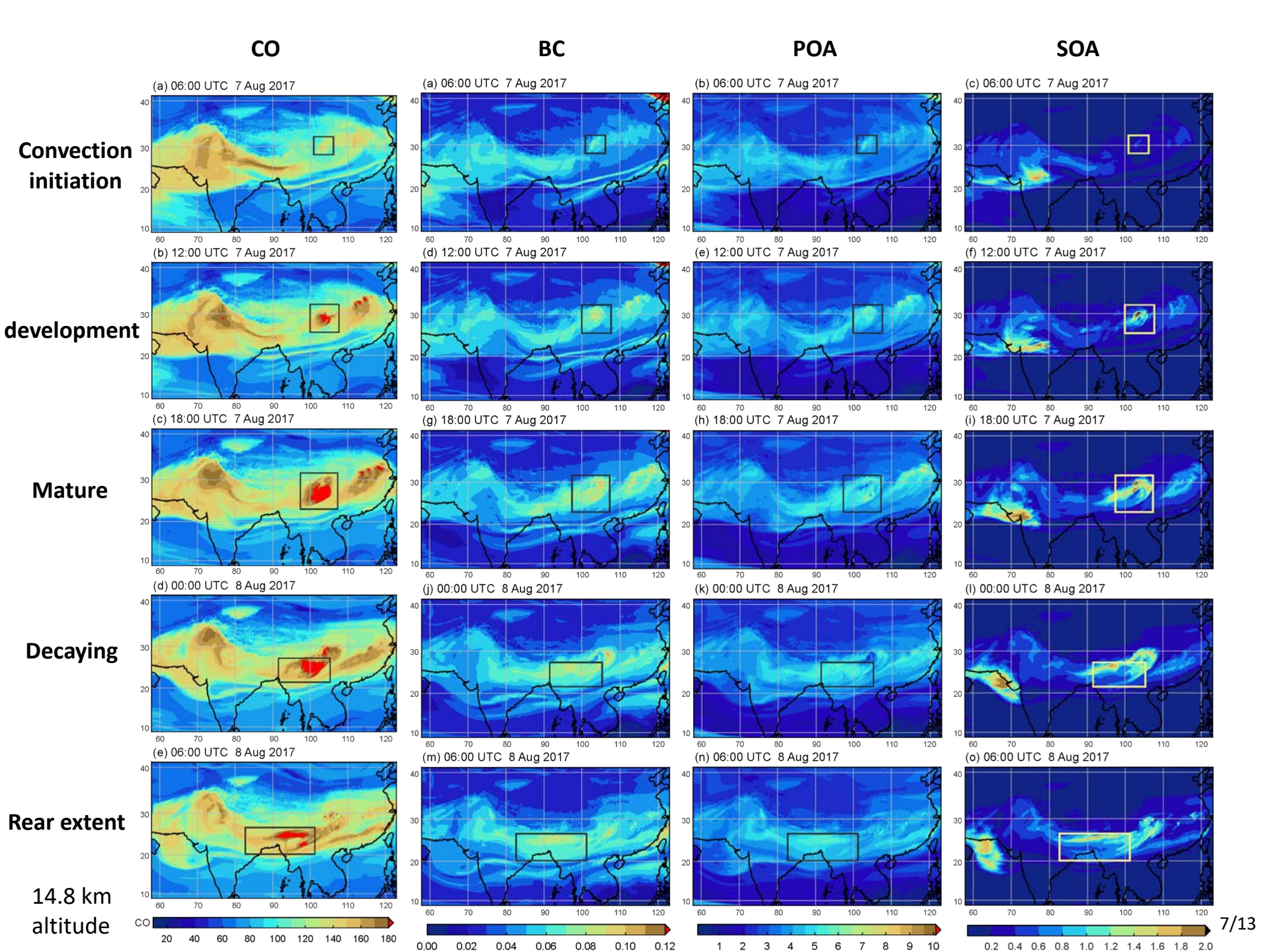


- Low BTs coincident with high CO over Sichuan
- BT ≤ –60°C

◯ : continuous convection initiation in the Sichuan basin

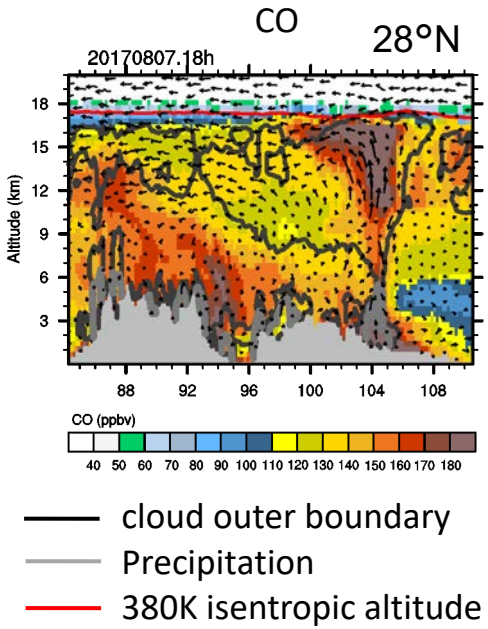
- no deep convection over Nepal and North-Eastern India


CO
BT 10.8 µm
Wind Speed
Convection initiation
development
Mature
Decaying
Rear extent
14.8 km altitude
(a) 06:00 UTC 7 Aug 2017
(b) 12:00 UTC 7 Aug 2017
(c) 18:00 UTC 7 Aug 2017
(d) 00:00 UTC 8 Aug 2017
(e) 06:00 UTC 8 Aug 2017
CO
20 40 60 80 100 120 140 160 180
BT
−80 −70 −60 −50 −40 −30 −20 −10 0 10 20 30
SPD
5 10 15 20 25 30 35 40 45


CO
BC
POA
SOA
Convection initiation
development
Mature
Decaying
Rear extent
14.8 km altitude
(a) 06:00 UTC 7 Aug 2017
(b) 06:00 UTC 7 Aug 2017
(c) 06:00 UTC 7 Aug 2017
(b) 12:00 UTC 7 Aug 2017
(d) 12:00 UTC 7 Aug 2017
(e) 12:00 UTC 7 Aug 2017
(f) 12:00 UTC 7 Aug 2017
(c) 18:00 UTC 7 Aug 2017
(g) 18:00 UTC 7 Aug 2017
(h) 18:00 UTC 7 Aug 2017
(i) 18:00 UTC 7 Aug 2017
(d) 00:00 UTC 8 Aug 2017
(j) 00:00 UTC 8 Aug 2017
(k) 00:00 UTC 8 Aug 2017
(l) 00:00 UTC 8 Aug 2017
(e) 06:00 UTC 8 Aug 2017
(m) 06:00 UTC 8 Aug 2017
(n) 06:00 UTC 8 Aug 2017
(o) 06:00 UTC 8 Aug 2017
CO
20 40 60 80 100 120 140 160 180
0.00 0.02 0.04 0.06 0.08 0.10 0.12
1 2 3 4 5 6 7 8 9 10
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

3 Pollution transport from Sichuan basin into UTLS by deep convections: Vertical distribution

■ Mature stage of deep convection (18:00 UTC 7 Aug 2017)

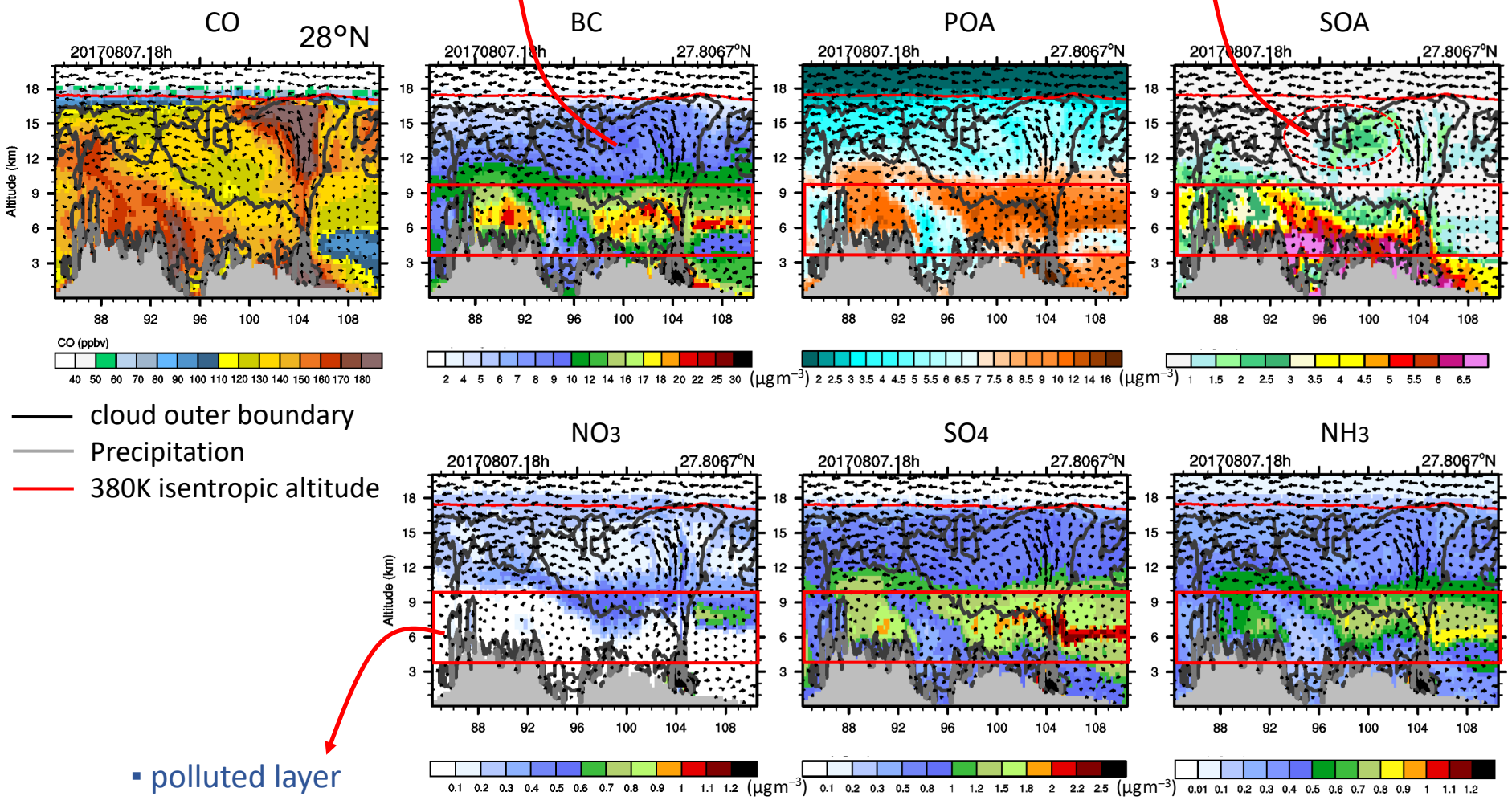


- convection occurs at the Tibetan foothills in the Sichuan basin
- matured convection with top altitude just below 380 K.
- intensive updraughts above 10 km.
- convection detrains large amounts of CO into the UTLS

■ **Mature stage of deep convection** (18:00 UTC 7 Aug 2017)

▪ high SOA values (≥ 2 μg m^{-3}) in the stratiform region

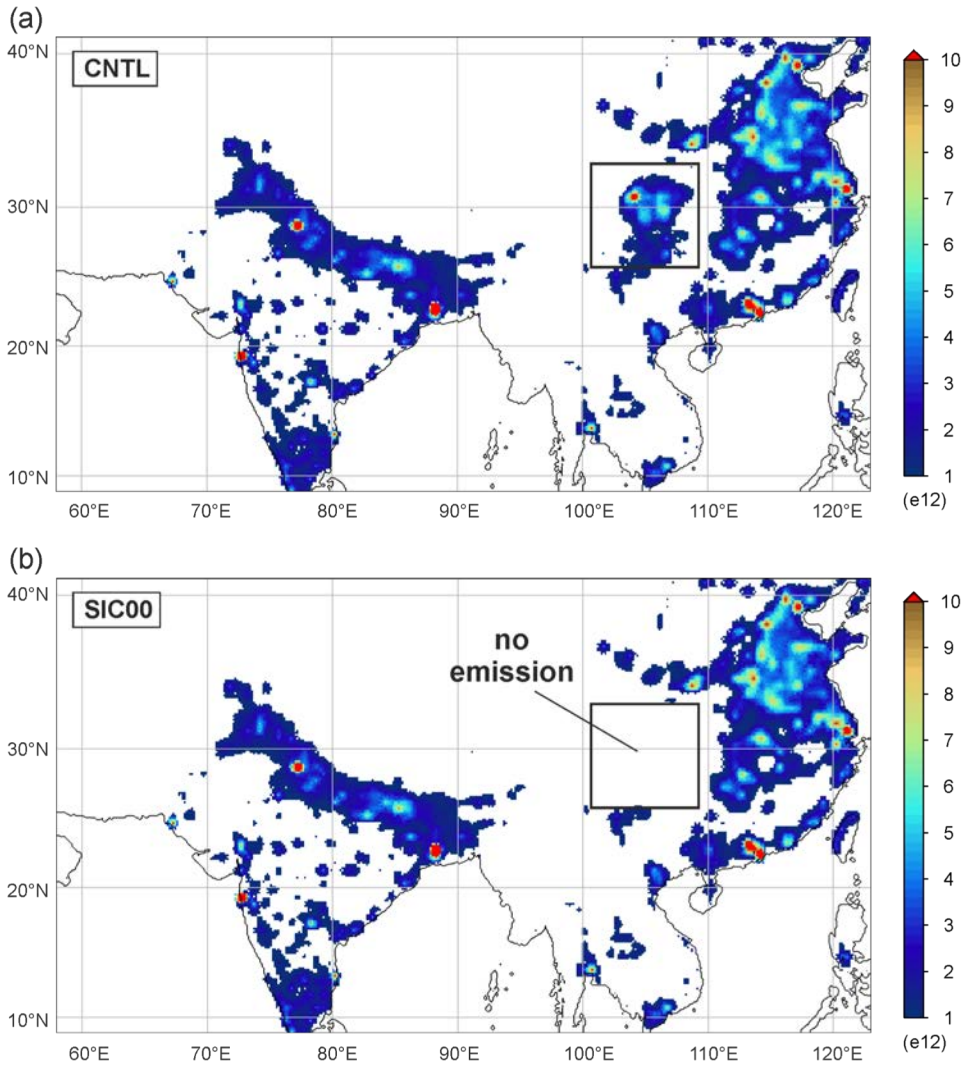
▪ aerosols scavenged by clouds



▪ polluted layer still at 4–10 km

4 Impact of Sichuan pollutant on the UTLS composition

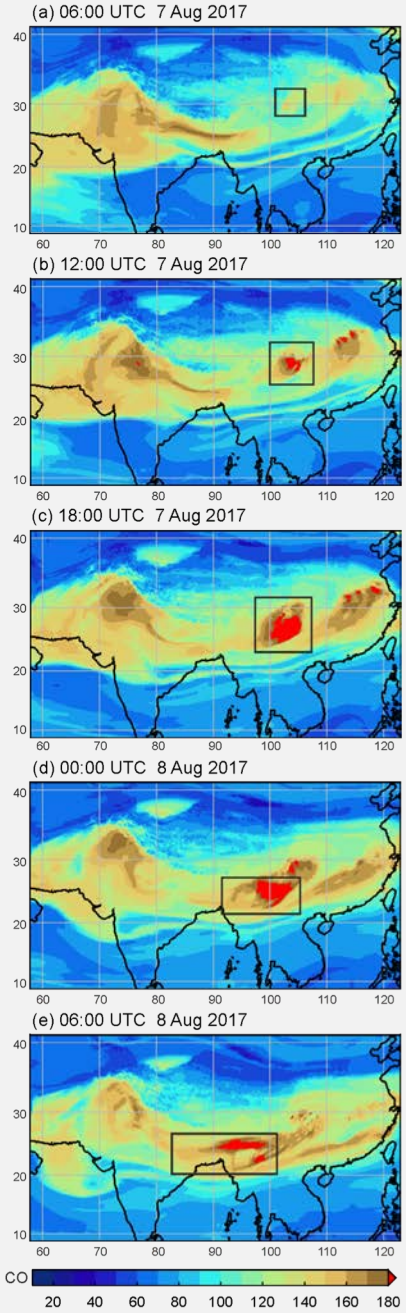
- all emission in the Sichuan basin (box) are set to zero



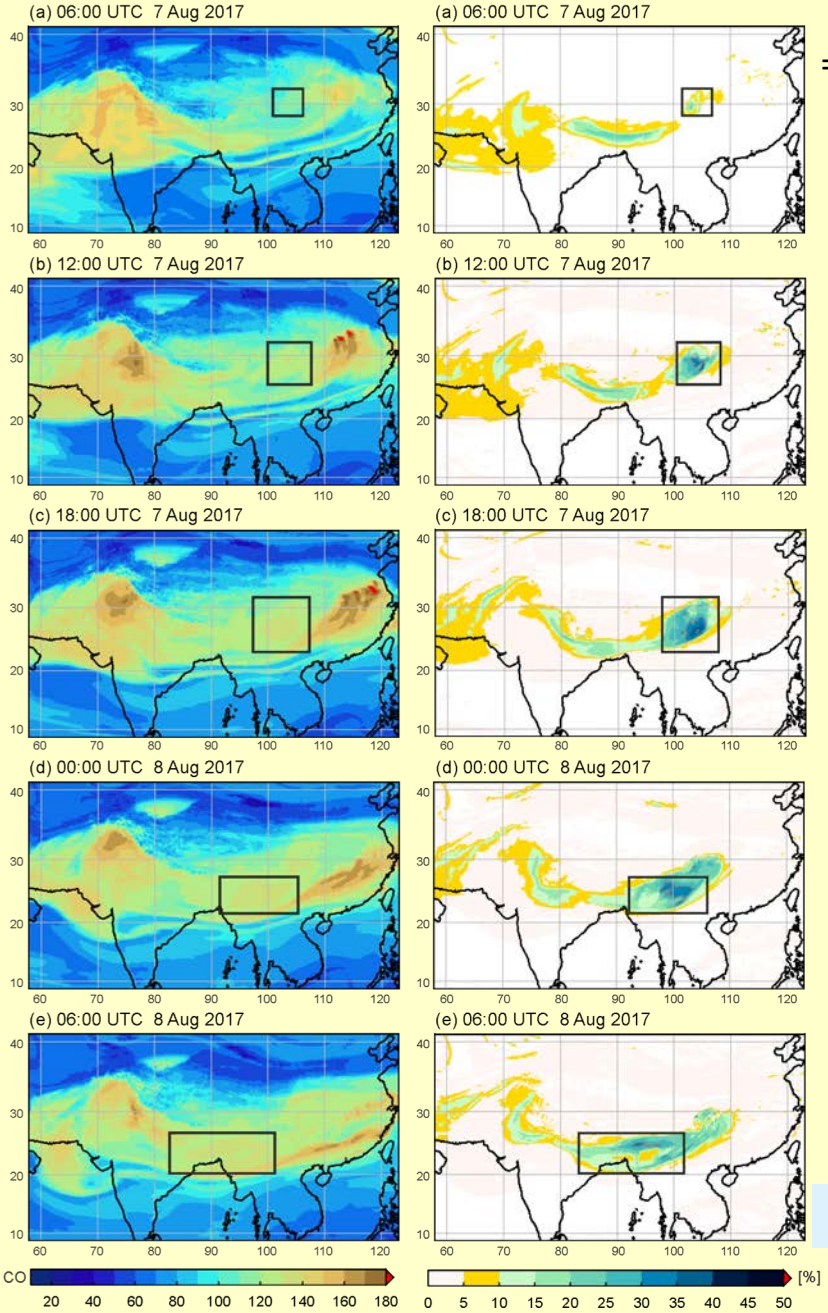
CO initial emission map for (a) CNTL and (b) SIC00 runs.

- **> 35% of CO** in the convective outflow from Sichuan.
- westward transport of Sichuan CO by the AMA circulation

CNTL



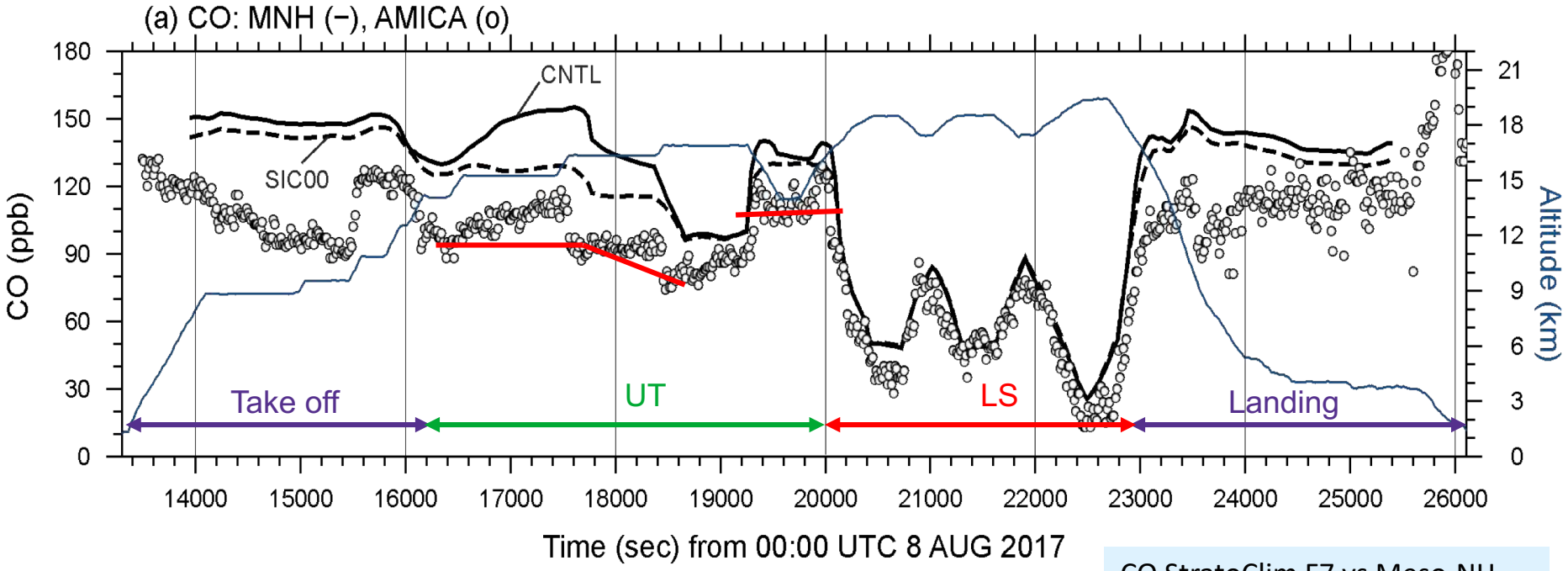
SIC00



=(CNTL–SIC00)/CNTL ×100

14.8 km altitude

■ Meso-NH CNTL and SIC00 vs. StratoClim



CO StratoClim F7 vs Meso-NH

- Meso-NH +AMICA CO => Sichuan impact along F#7:
  - from 14.5 up to 17 km
  - 10 to 30 ppbv CO along track
- Meso-NH => Sichuan impact within whole AMA (15-20 km):
  - max 8-10 August
  - 3 %CO – 1.5% POA – 1% BC

5 Conclusions and Perspectives

- High resolution cloud-chemistry simulations with Meso-NH => ATAL aerosol budget

- MSG-Himawari BT (10.8mum) => Meso-NH captures deep convective clouds / over Sichuan
- StratoClim/IAGOS => Meso-NH reproduces UTLS CO and O_3 variations

- Deep convection over Sichuan 7-8 August:
  - reaches the 380 K tropopause
  - [CO] > 180 ppbv

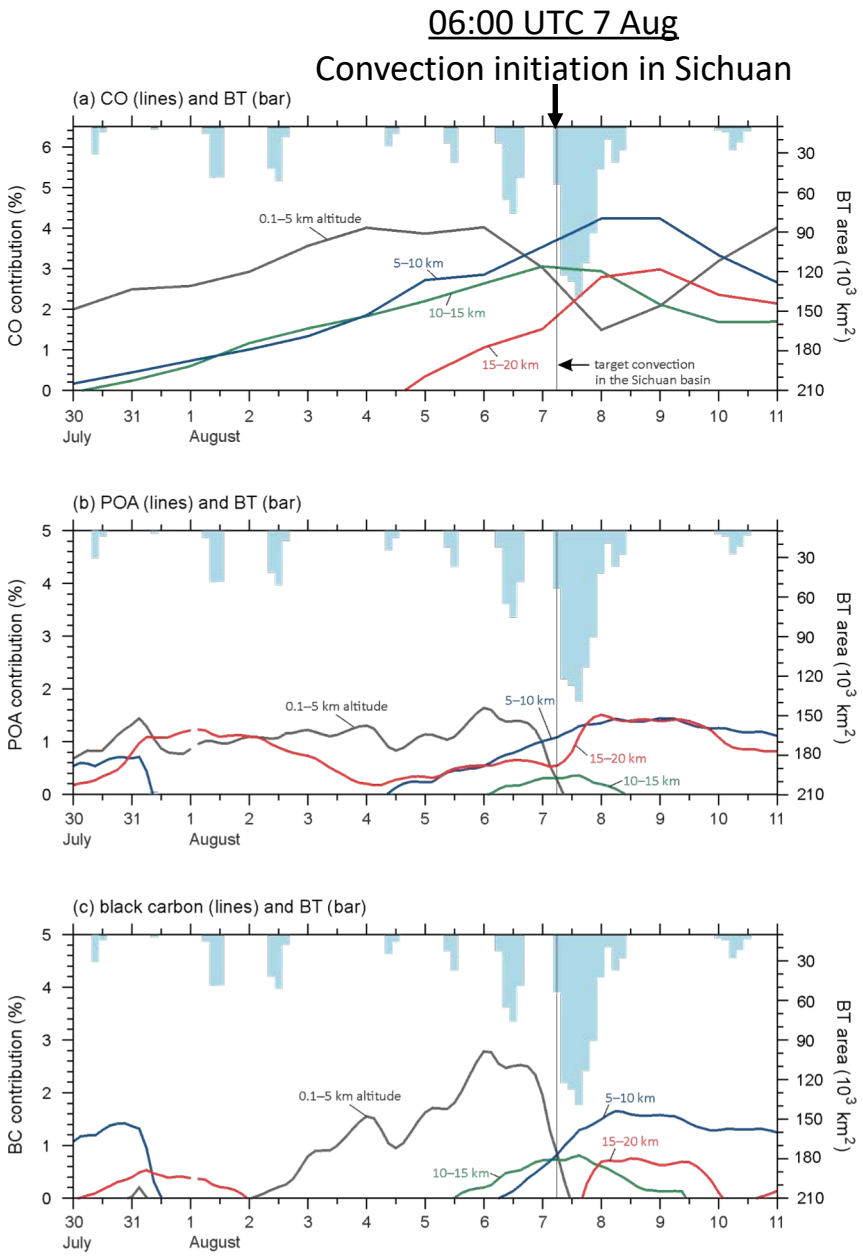
- Aerosol species (BC, POA, SOA, nitrates, sulfates, ammonium) scavenged within the cloud => enhanced within the AMA

- Strong easterly winds (≥ 40 m s^{-1}) south of AMA => westward transport of Sichuan pollution (CO, particles) towards Nepal

- Sichuan uplifted emissions are responsible for :
  - 10-30 ppbv CO from 14.5 to 17 km along StratoClim F#7
  - 3% CO, 1.5 % POA and 1 % BC within AMA

- Perspectives:
  - validation of Meso-NH with other StratoClim flights
  - validation of aerosol composition (Sulfates / Nitrates / Organics with ERICA, particles with UHSAS OPC)
  - ATAL aerosol budget (POA vs SOA, OA vs Sulfates…)

■ Contribution of Sichuan emissions to AMA composition



- Sichuan CO emissions impact the entire AMA region starting in the low. Mid. and upper tropo.

- Deep convection on 6 and 7 August
- ➔ Decrease of CO drop BC/POA in low. tropo.
- ➔ Increase in UTLS

- Max. impact over the entire AMA (15-20 km)
- ➔ 8-10 August
- ➔ 3 % CO / 1.5 % POA / 1 % BC

Evolution of the contribution of Sichuan emissions to the entire AMA region.
Blue bars: area with BT values ≤ –60°C.