Vertical transport in deep convection as inferred from coupling CO2 and other tracers measurements to a back trajectory and a mesoscale models.

presented at the

Salt Lake City, Utah

HARVARD UNIVERSITY : Irï¿½ne Xueref, C. Gerbig, B. Daube, S. Wofsy,
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NASA ARC : Ann Fridlind, A. Ackerman, E. Jensen, J. Lopez, H. Jost & M. Loewenstein
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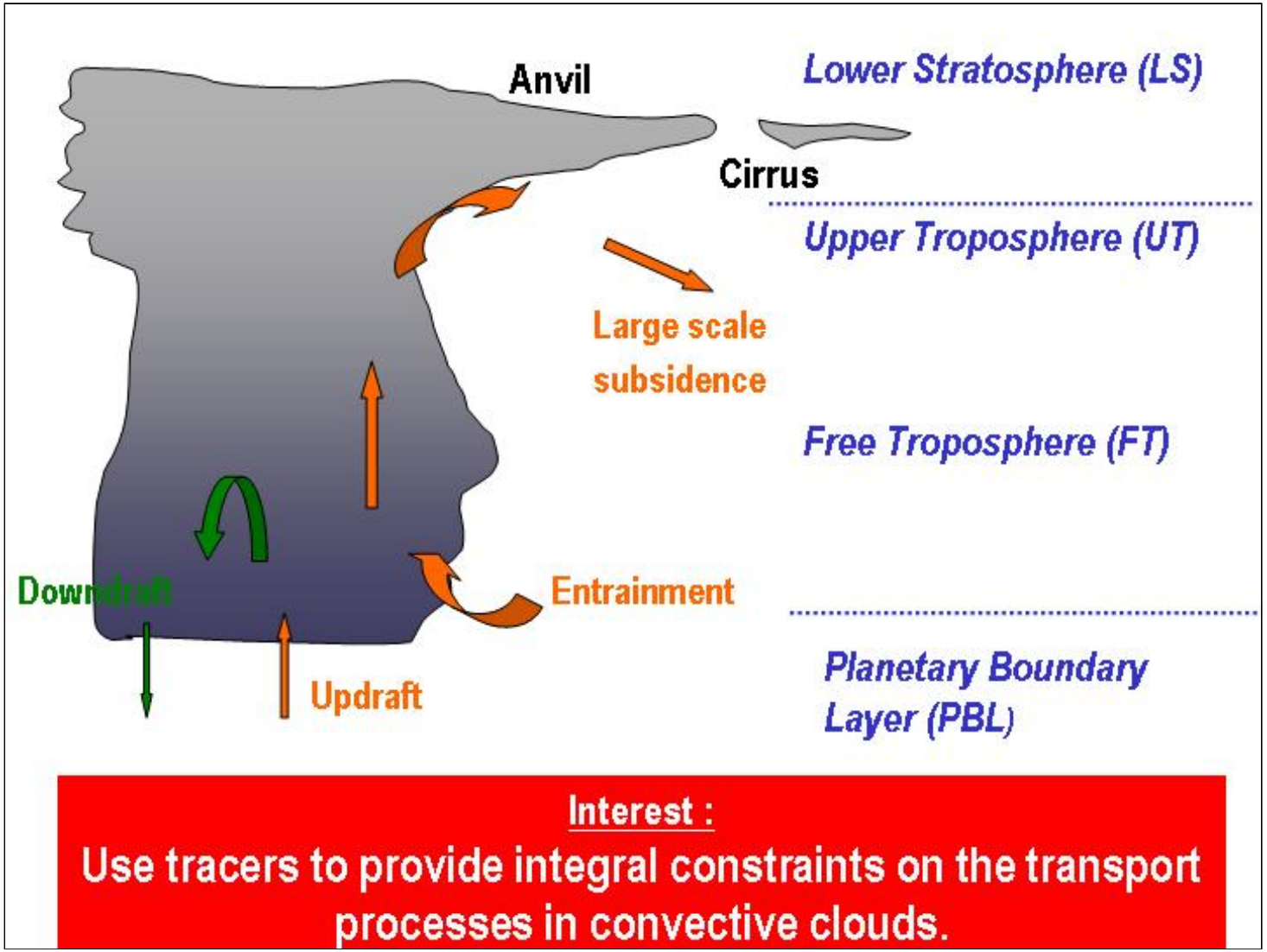


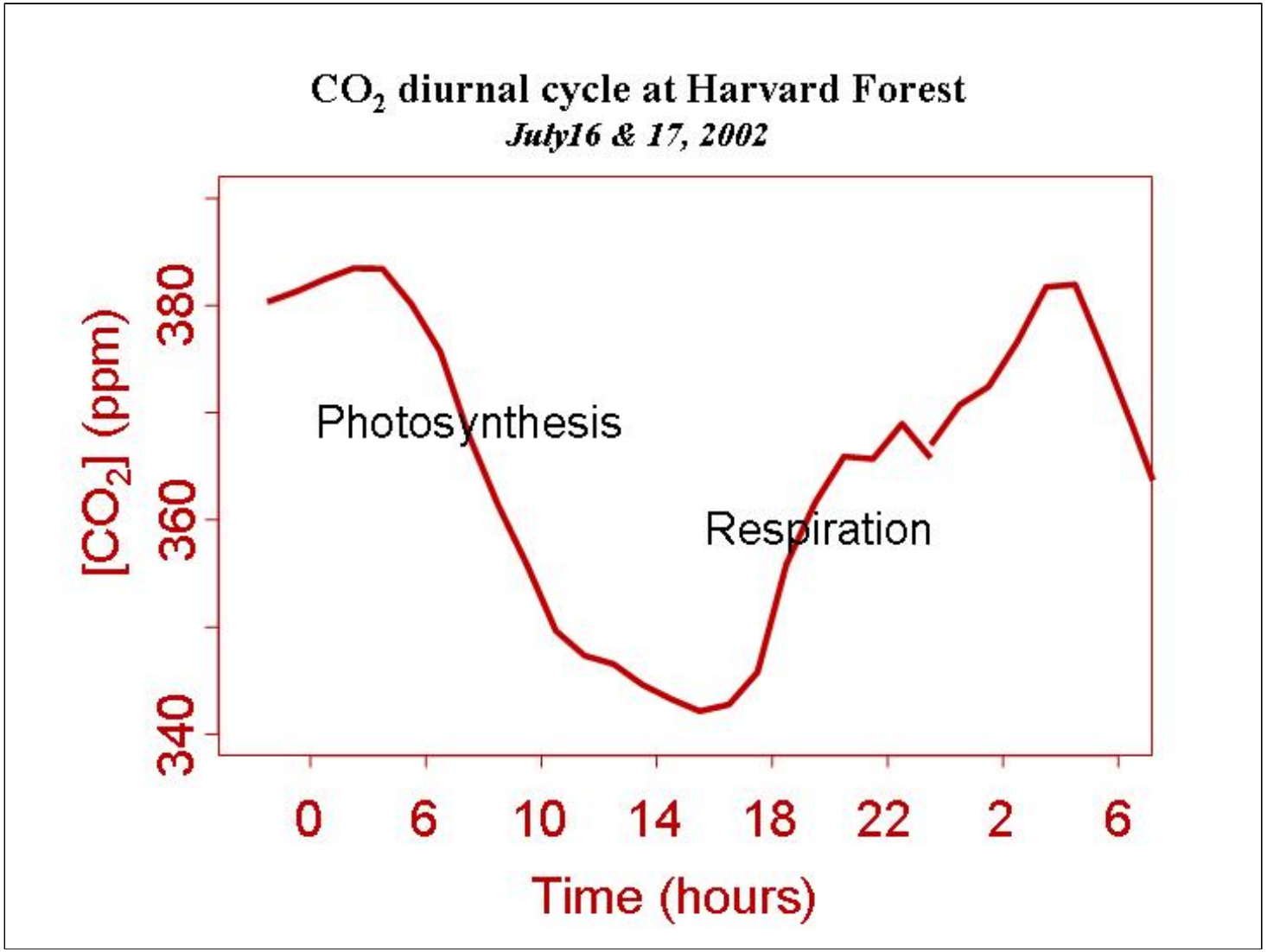
Interest :

Use tracers to provide integral constraints on the transport processes in convective clouds.

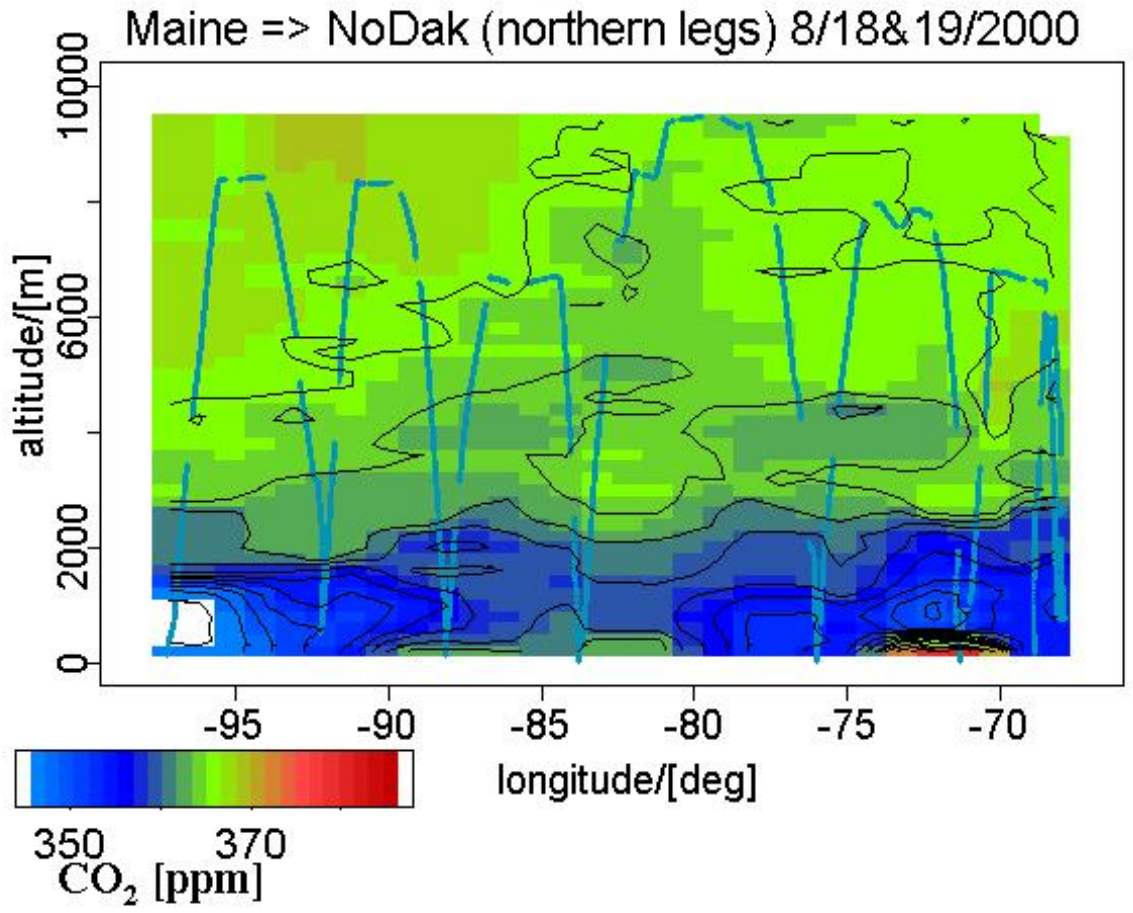
Tracers' **CONCENTRATIONS** and **RATIOS** are function of the air mass **ORIGINS**

CRYSTAL FACE data for CO_2, CO, O_3 and NO_x measured on WB-57F in UT/LS are available.

- **Ocean (clean)**
- **Land:**
  - **Biosphere : CO_2**
  - **Biomass Burning: CO, CO_2**
  - **Fossil Fuel combustion : CO, CO_2**
- **Stratosphere**

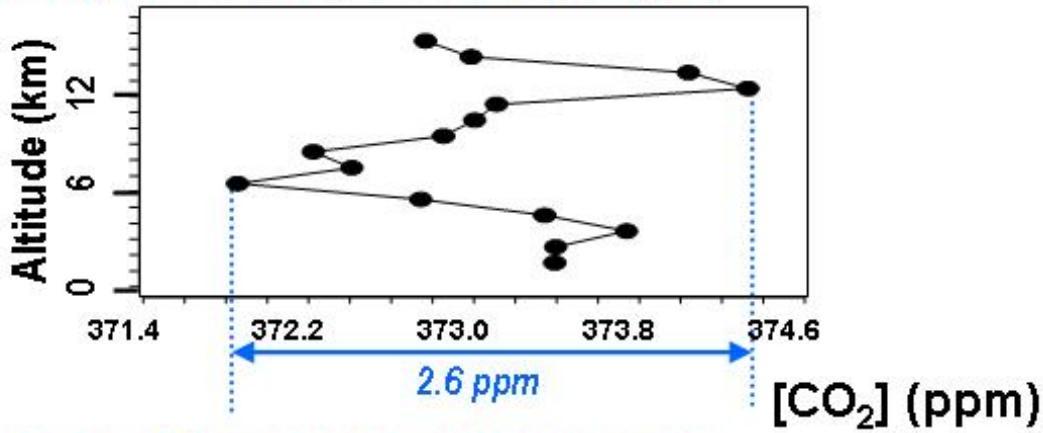

CO_2 diurnal cycle at Harvard Forest
July16 & 17, 2002
[CO_2] (ppm)
340
360
380
Photosynthesis
Respiration
0
6
10
14
18
22
2
6
Time (hours)

STRONG CO_2 GRADIENTS CASE

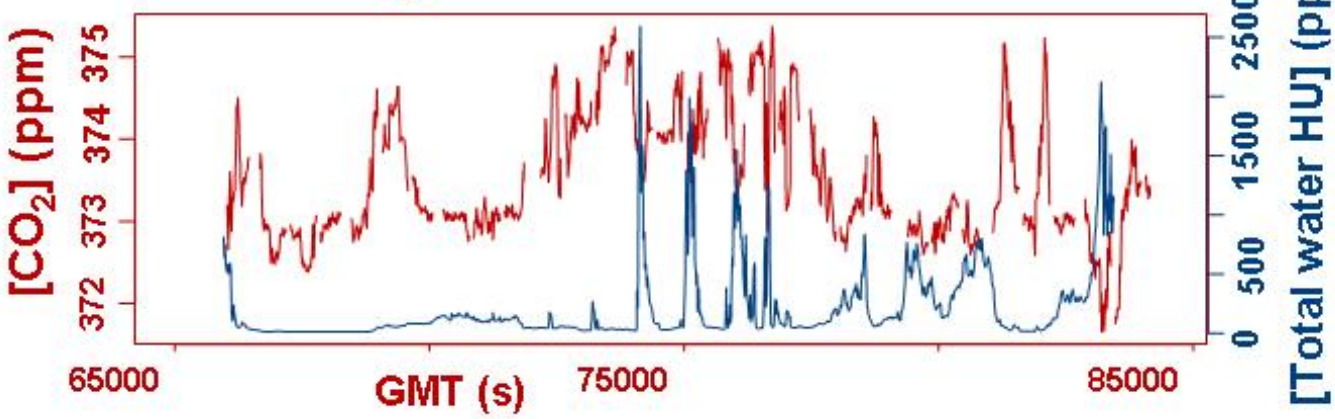


A CASE STUDY : JULY 16, 2002

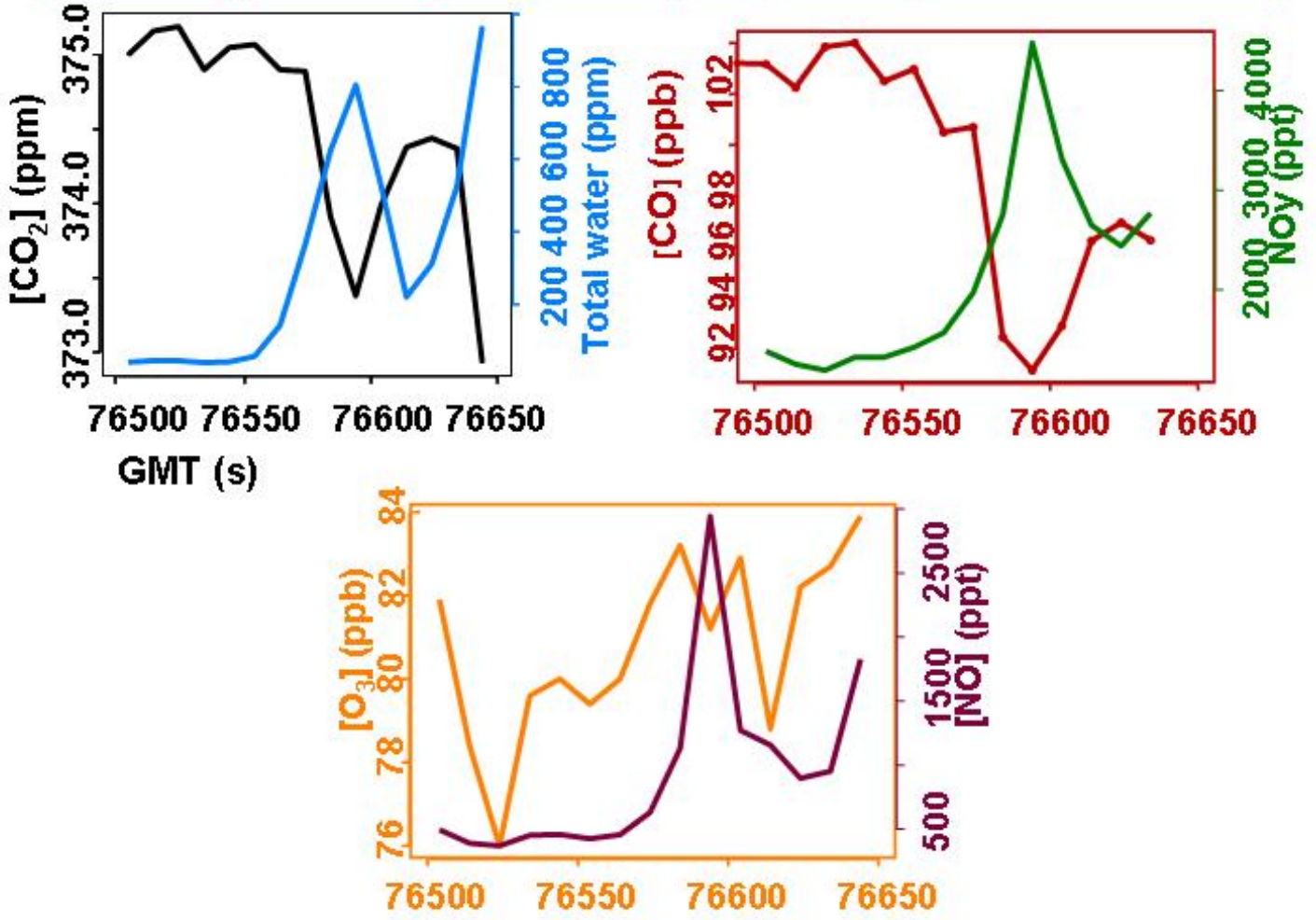
- CO_2 altitude profile averaged for whole flight :



- Time series for CO_2 and total water (Harvard) :

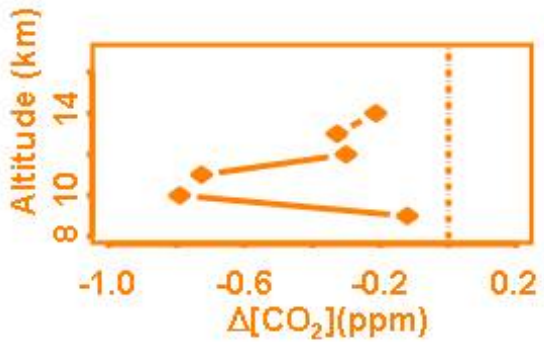


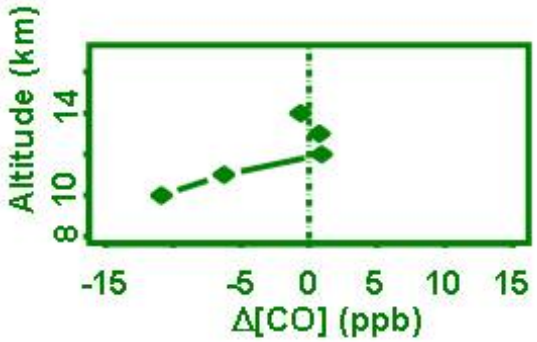
An air layer example for July 16, 2002 (Z=12.4 km to 12.8 km)

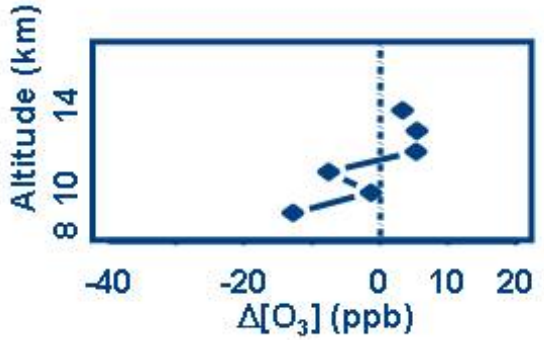


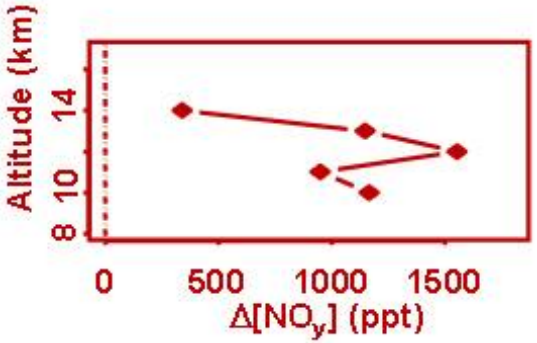
July 16 : In cloud- out of cloud differences (Δ)

TROPOSPHERE ONLY









In cloud, there is a mixture of air from PBL and FT :

[Anvil]=a(z)[PBL]+Σb(z)[FT]. But what are the dilution factors a(z)&b(z)??

We measured [FT] but not [Anvil] precisely (not in the core).
We would need [PBL].
But no tracers data available in PBL!!

⬇

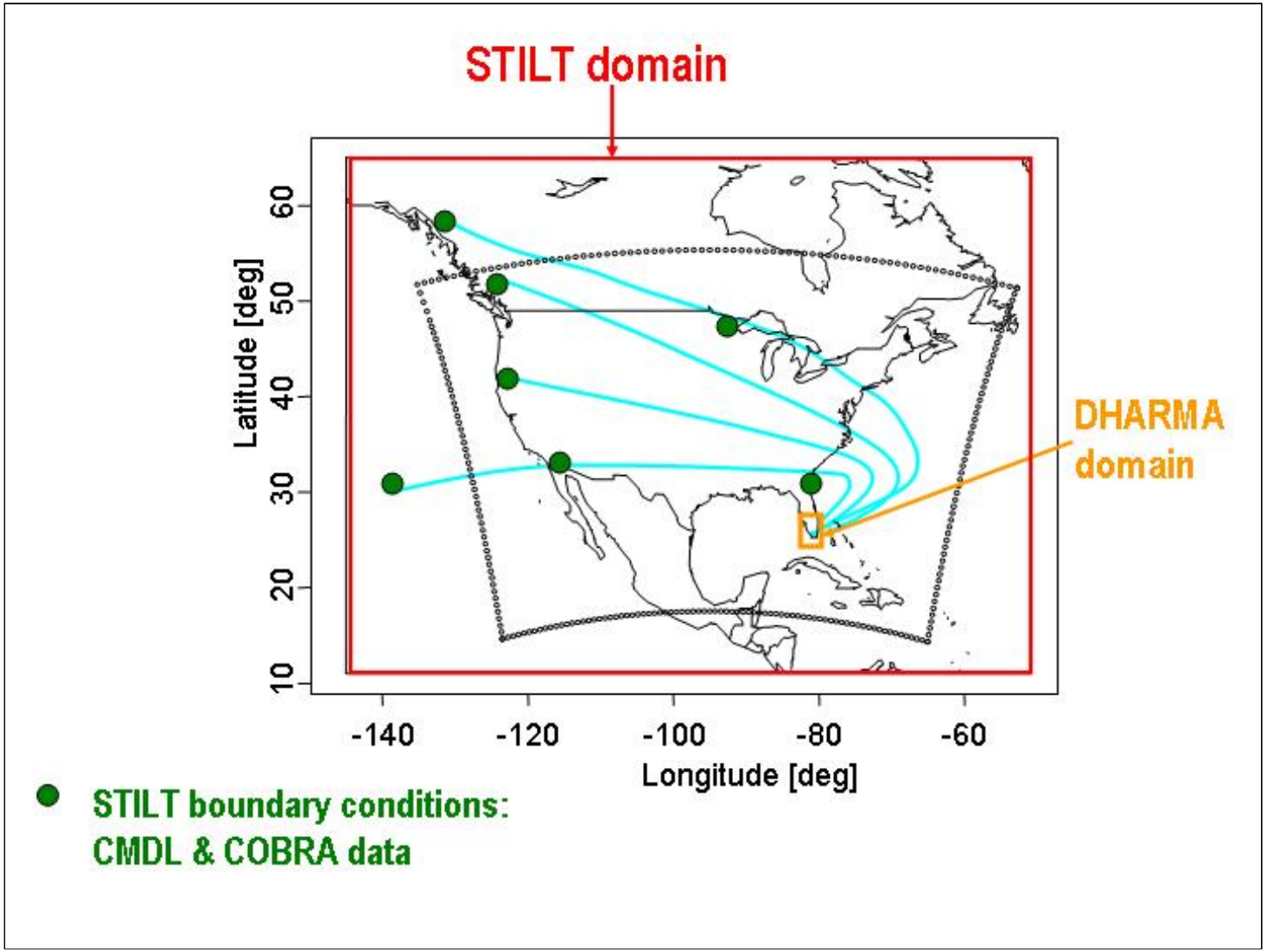
Strategy : STILT-DHARMA coupling

- **STILT Stochastic Time Inverted Lagrangian Transport Model,** *Harvard University* : A Back trajectory model to generate PBL initial conditions

-**DHARMA Distributed Hydrodynamic-Aerosol-Radiation-Microphysics Application,** *NASA Ames* : A Mesoscale model to simulate the transport within the convective system

⇒GOAL : get modeled CO_2 and CO profiles,

Compare to our CF data and determine dilution factors.


STILT domain
DHARMA domain
Latitude [deg]
10
20
30
40
50
60
-140
-120
-100
-80
-60
Longitude [deg]
STILT boundary conditions:
CMDL & COBRA data

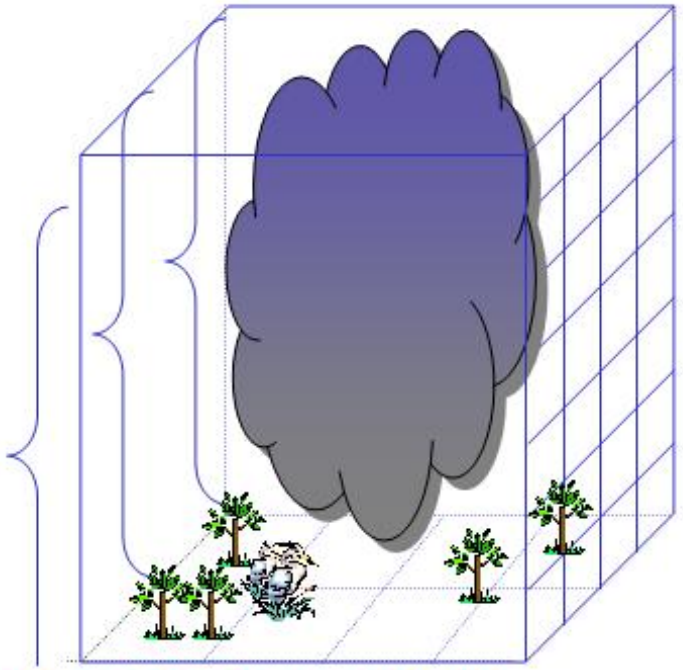
STILT-DHARMA COUPLING :

STILT PARTICLES OVER USA

EDAS/GDAS wind, temperature and radiation assimilated data

Surface-Atmosphere EXCHANGES (COBRA)

DHARMA INITIAL DOMAIN OVER FLORIDA

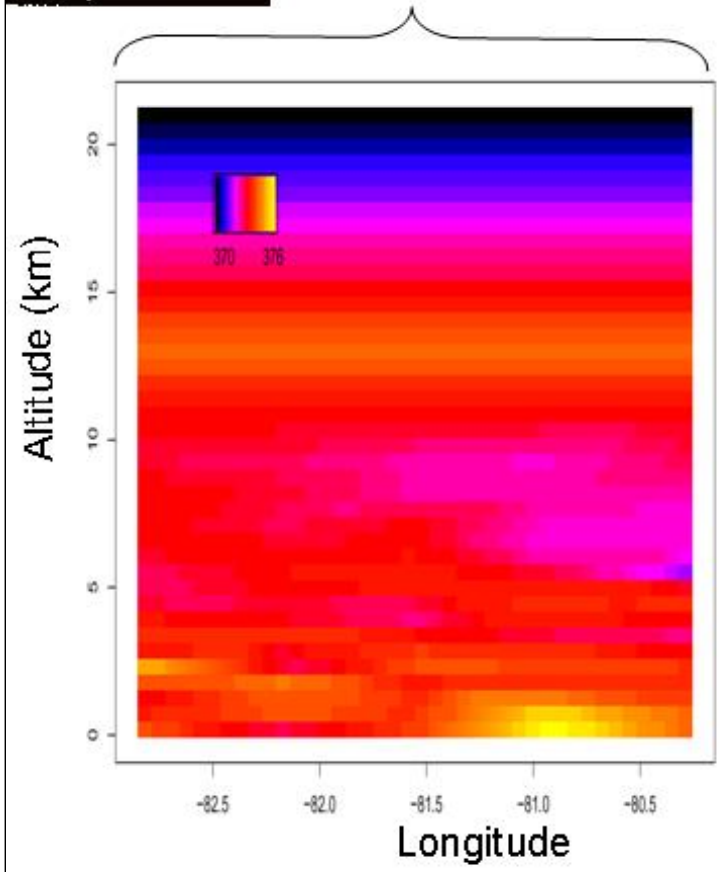


⇒Lateral boundary condition from STILT:

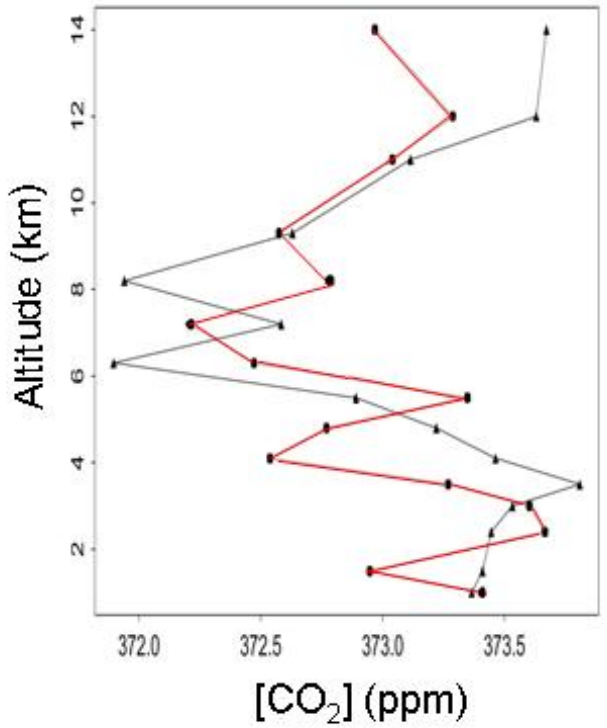
CO_2 and CO concentrations

[CO_2] ALTITUDE PROFILES FROM STILT

Example : Domain mid-cut

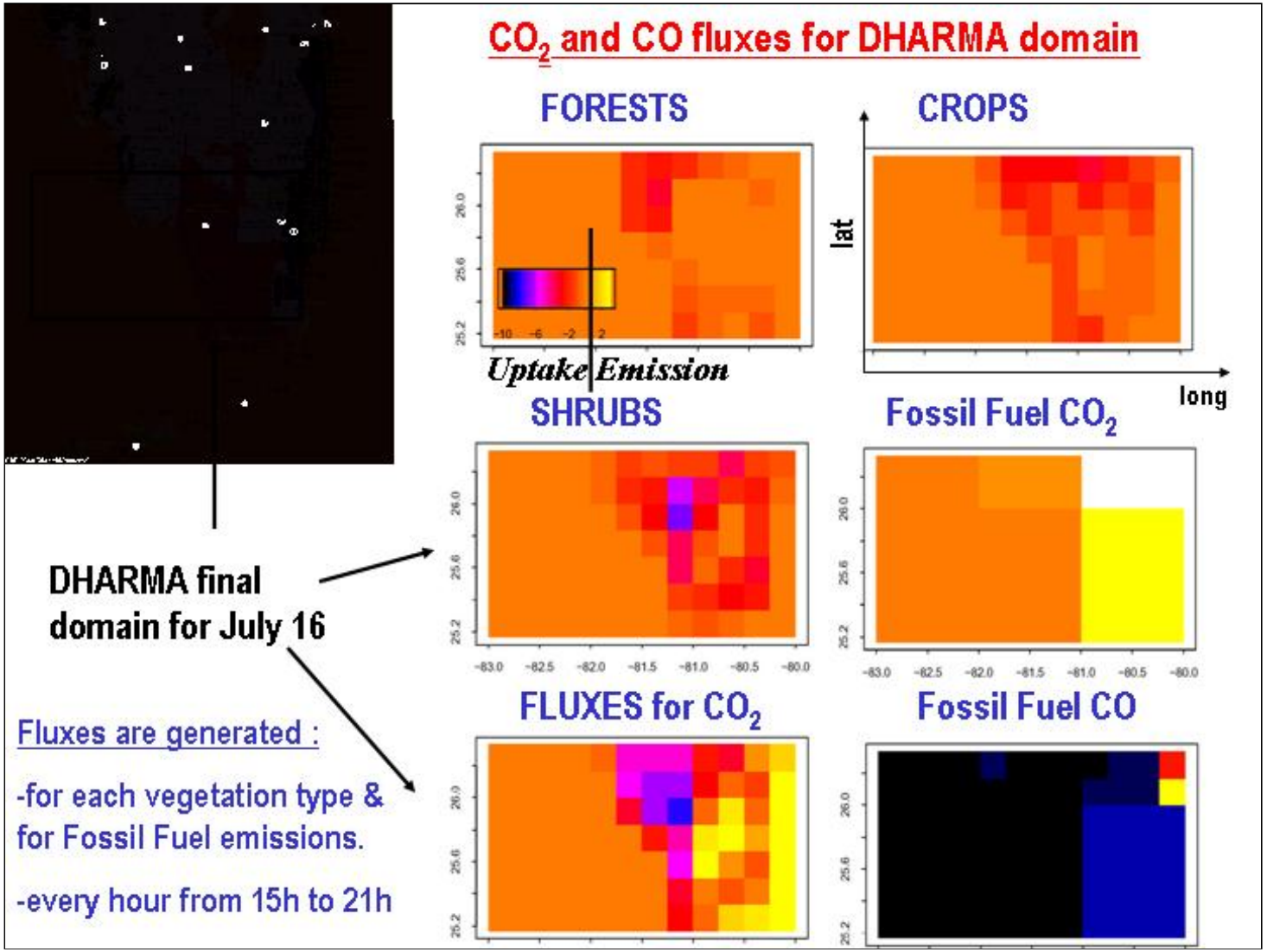


Comparison STILT-CRYSTAL :



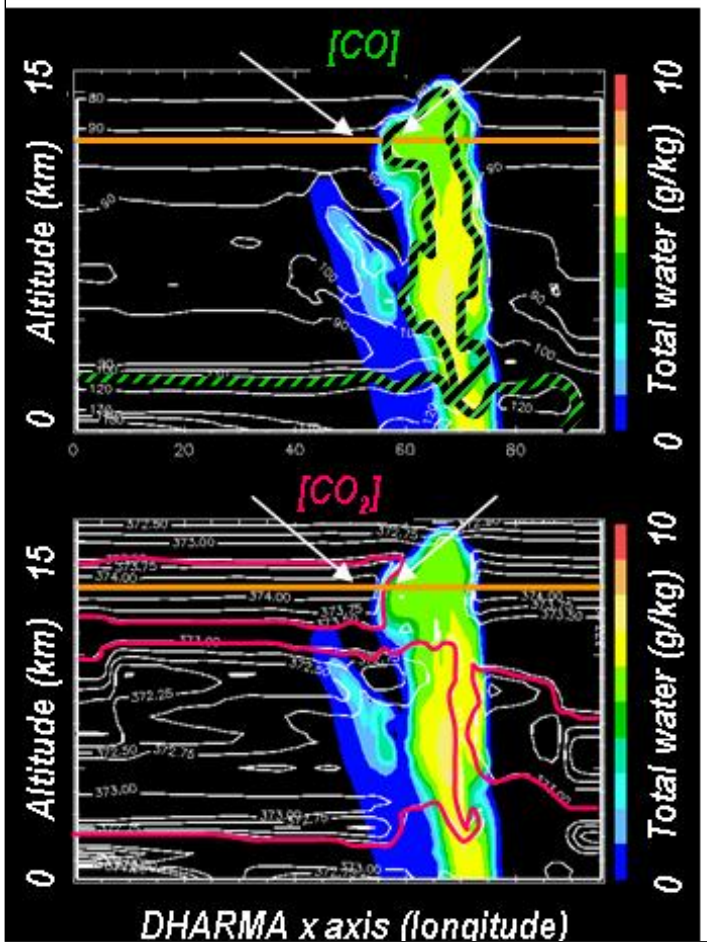
Black : CRYSTAL CO_2 data, out of cloud

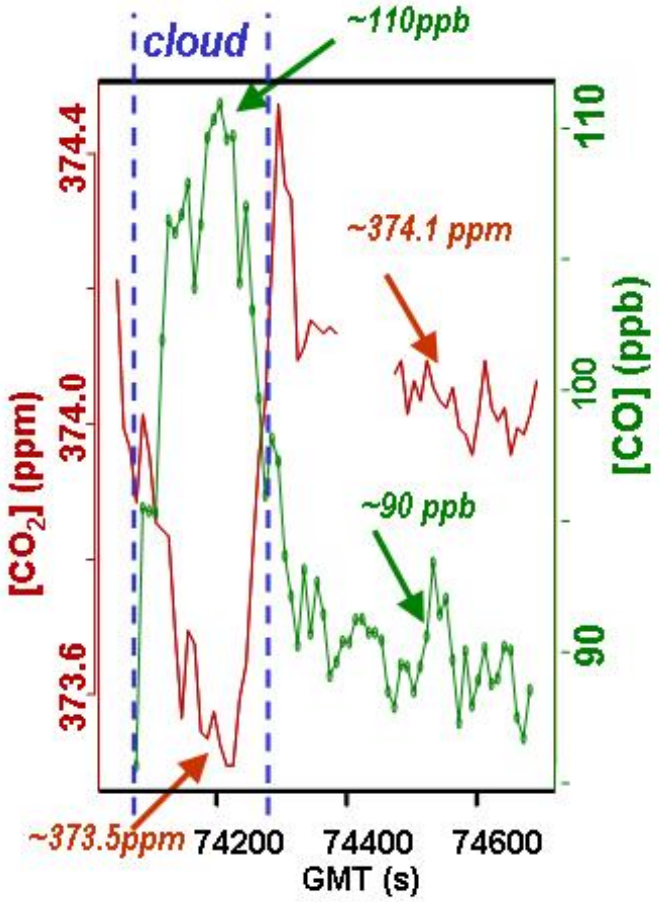
Red : STILT CO_2 output, out of cloud


CO2 and CO fluxes for DHARMA domain
FORESTS
CROPS
lat
long
Uptake Emission
SHRUBS
Fossil Fuel CO2
DHARMA final domain for July 16
FLUXES for CO2
Fossil Fuel CO
Fluxes are generated :
-for each vegetation type & for Fossil Fuel emissions.
-every hour from 15h to 21h

DHARMA :
$\Delta CO_2 \approx 0.5$ ppm $\Delta CO \approx 20$ ppb

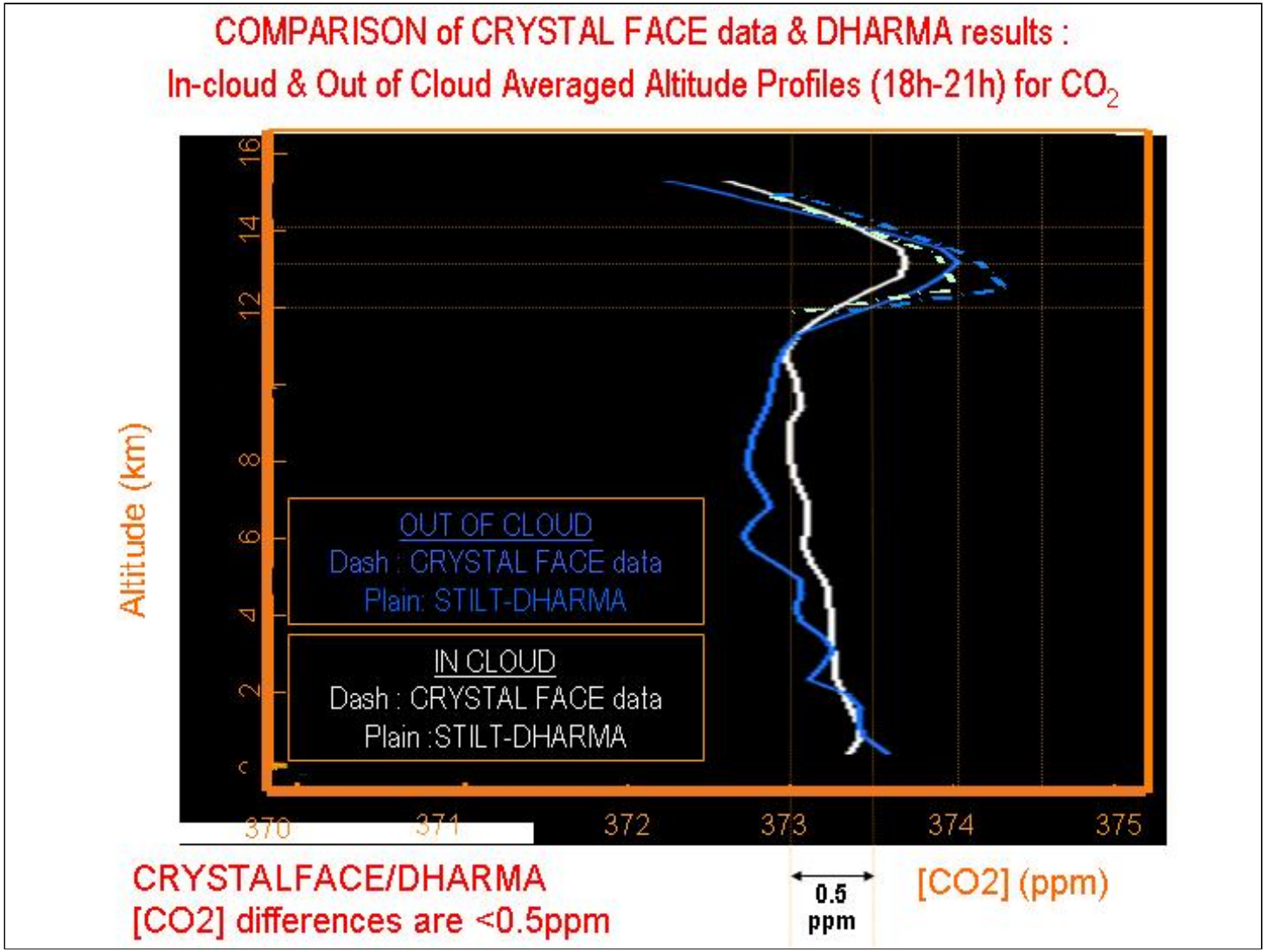
CRYSTAL-FACE :
$\Delta CO_2 \approx 0.6$ ppm $\Delta CO \approx 22$ ppb



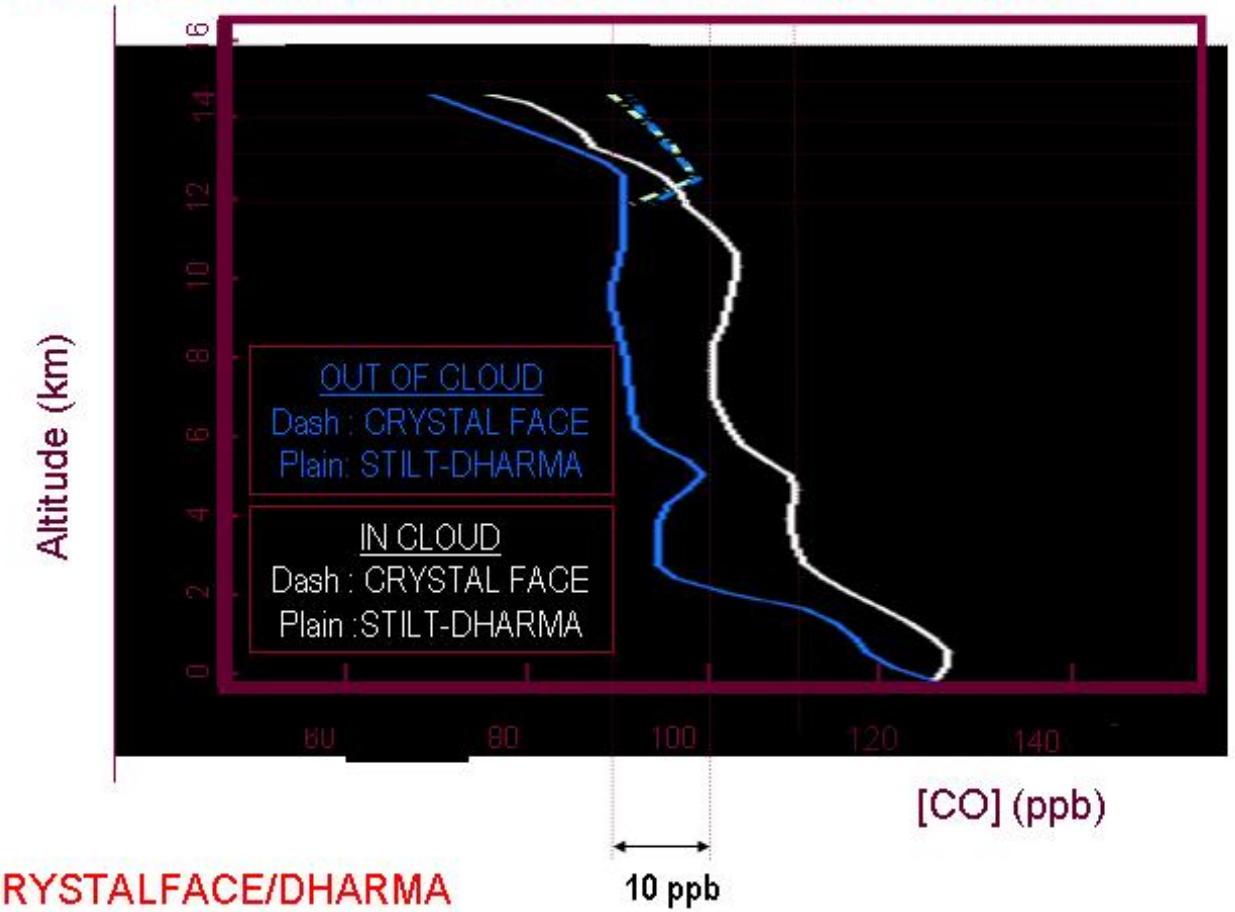


Conclusion & future work

- CO_2 and CO data can well constrain models to study transport processes.
- The coupling of STILT and DHARMA provided promising results to better understand transport processes in convective systems.
- This study supports the fact that data are really needed in the PBL and around the storm (inflow regions) for this kind of analysis.
- Tracers analysis can be very powerful if well planned : measurements should be done in regions where gradients are strong. STILT can be used to predict those and choose proper locations for future campaigns.
- Our next goal is to pursuit work to get dilution factors and understand where the air up drafted and entrained was coming from.


COMPARISON of CRYSTAL FACE data & DHARMA results :
In-cloud & Out of Cloud Averaged Altitude Profiles (18h-21h) for CO_2
Altitude (km)
16
14
12
8
6
4
2
OUT OF CLOUD
Dash : CRYSTAL FACE data
Plain: STILT-DHARMA
IN CLOUD
Dash : CRYSTAL FACE data
Plain :STILT-DHARMA
370
371
372
373
374
375
CRYSTALFACE/DHARMA
[CO2] differences are <0.5ppm
0.5
ppm
[CO2] (ppm)

COMPARISON of CRYSTAL FACE data & DHARMA results :
In-cloud & Out of Cloud Averaged Altitude Profiles (15h-21h) for CO



CRYSTALFACE/DHARMA
[CO] differences are <8 ppb

Tracers' **CONCENTRATIONS** and **RATIOS** are function of the air mass **ORIGINS** :

- **Clean oceanic air : background**

[CO]=74ppb * [CH_4]=1756ppm * [NO_x]= 400ppt * [O_3]=20ppb * [CO_2]~ 373ppm

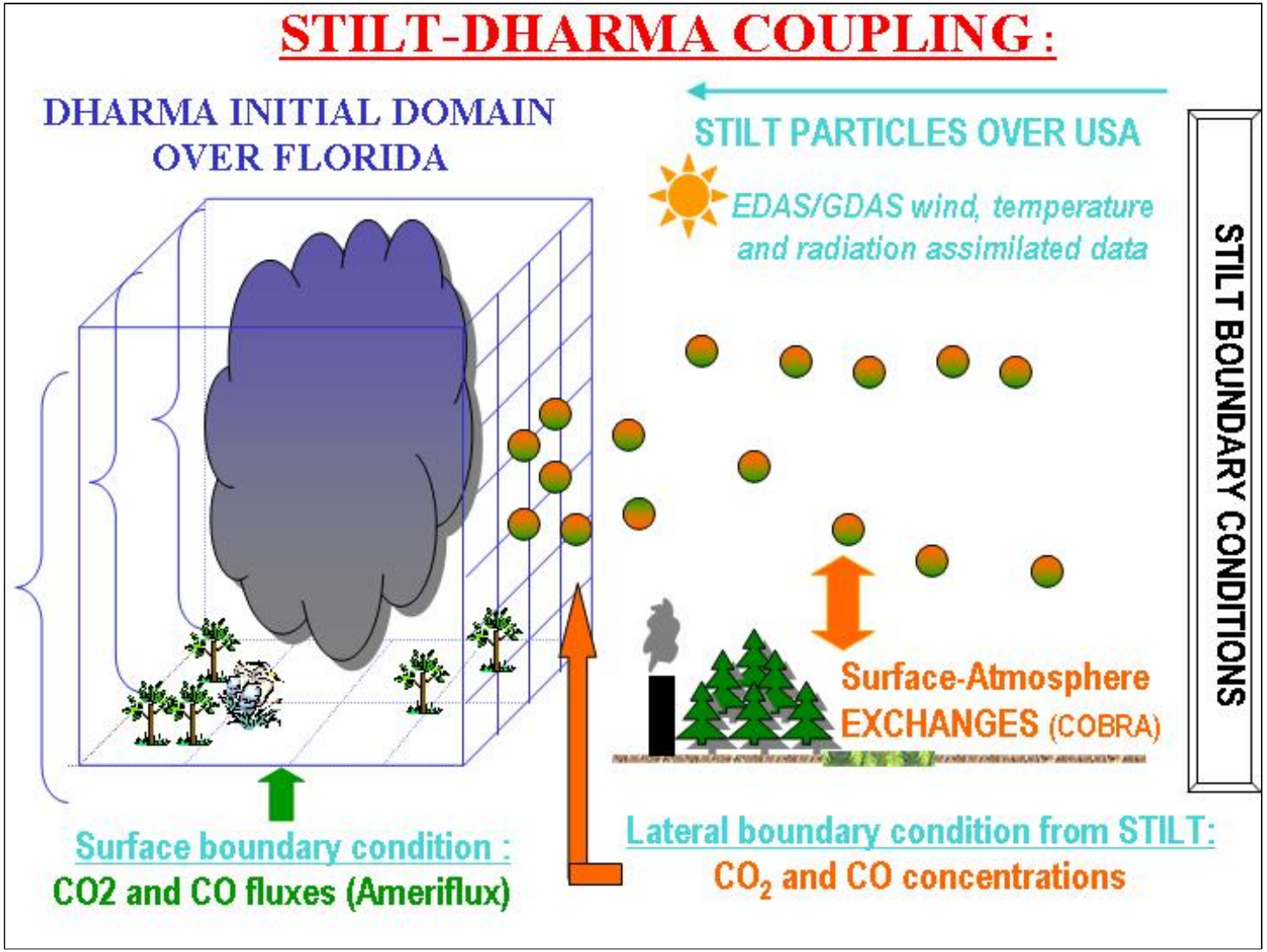
- **Biosphere : CO_2** Ex. CO_2 diurnal cycle at Harvard Forest

- **Biomass Burning : $\Delta CO/CO2$** (+7) **$\Delta CH_4/CO$** (+0.27)

- **Fossil Fuel combustion : $\Delta CO/NO_y$** (+12.5) **$\Delta CO_2/CO$** (+0.03ppm/ppb) **$\Delta CH_4/CO$**(+2.54)

- **Stratosphere : O_3**>200 ppb **H_2O**<20ppm

CRYSTAL FACE data for CO_2, CO, O_3 and NO_y measured on WB-57F in UT/LS are available.


STILT-DHARMA COUPLING :
DHARMA INITIAL DOMAIN
OVER FLORIDA
STILT PARTICLES OVER USA
EDAS/GDAS wind, temperature
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STILT BOUNDARY CONDITIONS
Surface-Atmosphere
EXCHANGES (COBRA)
Surface boundary condition :
CO2 and CO fluxes (Ameriflux)
Lateral boundary condition from STILT:
CO_2 and CO concentrations

July 16, 20:39z layer