UNIVERSITÄT BERN

OESCHGER CENTRE CLIMATE CHANGE RESEARCH

ICOS INTEGRATED CARBON OBSERVATION SYSTEM

10-years of CO_2, O_2 and APO records at two remote sites of Jungfraujoch, Switzerland and Puy de Dôme, France

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Global Carbon budget overview

33.0±1.8 $GtCO_2$/yr (91%)

3.4±1.8 $GtCO_2$/yr (9%)

44%

26%

30%

Source: Global Carbon Project, 2015

Global Carbon budget overview

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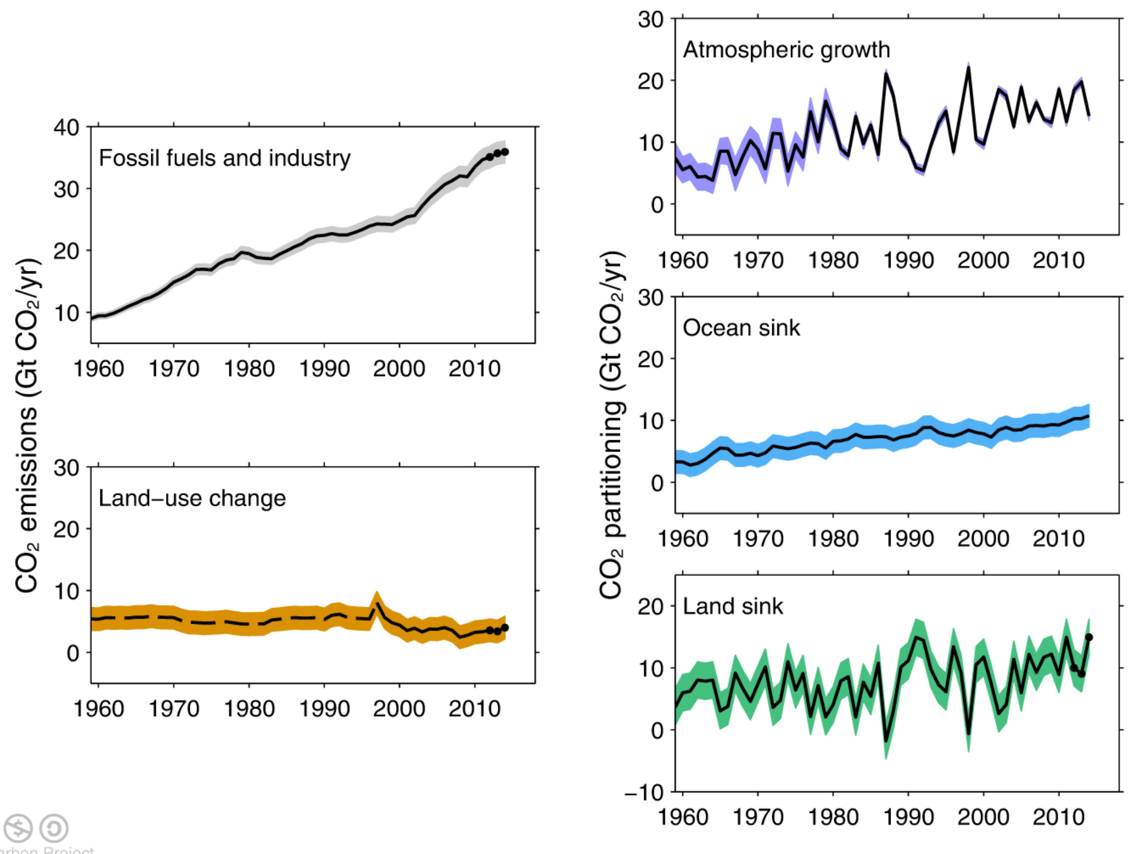

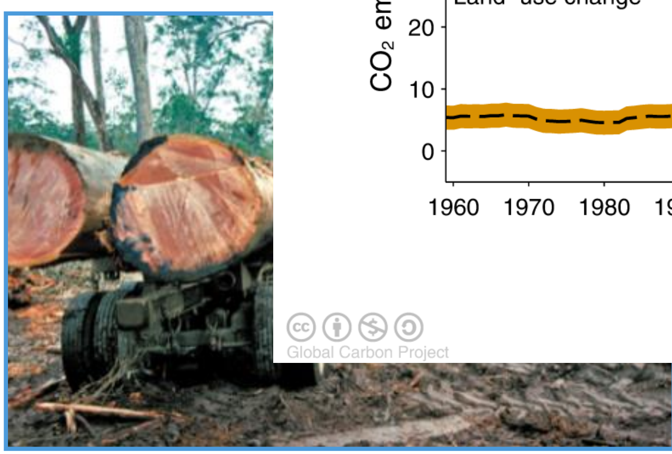

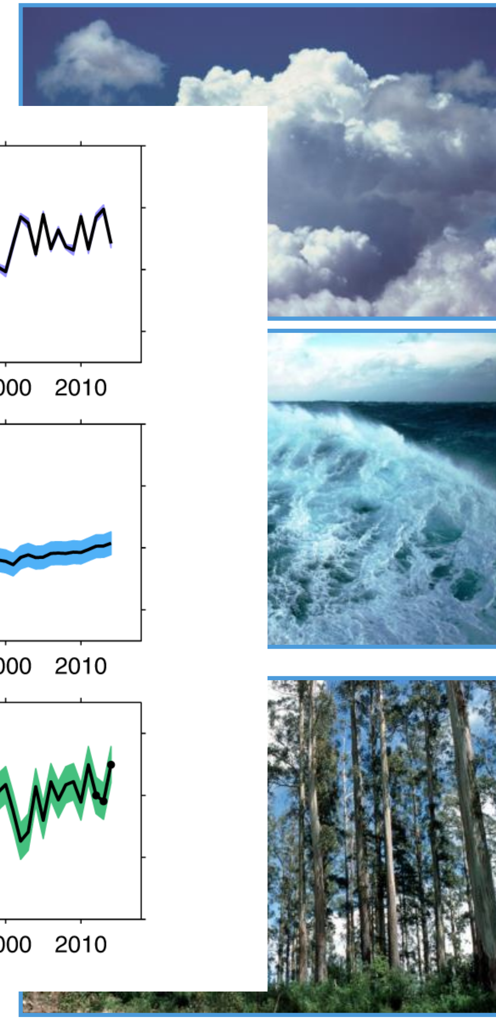

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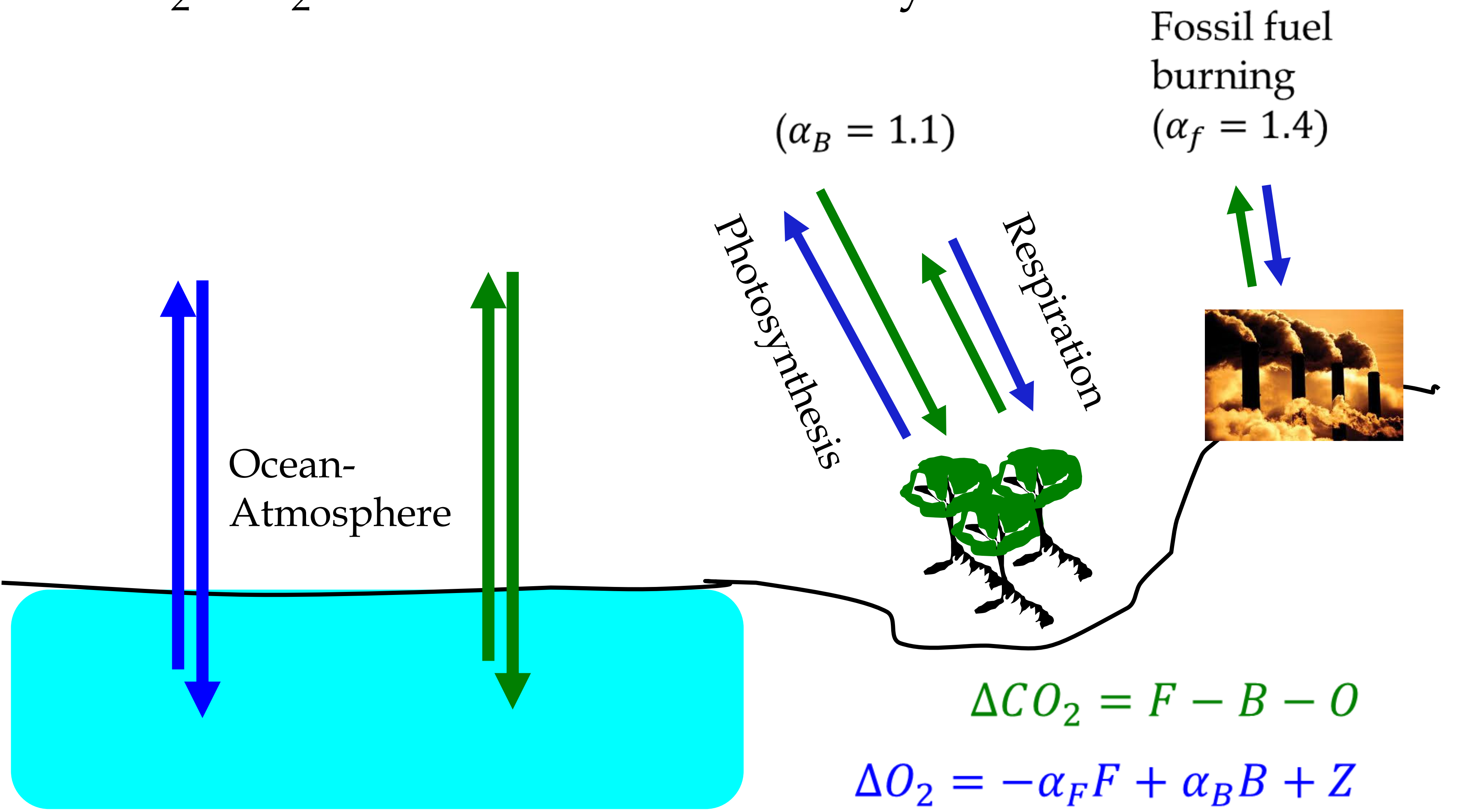
CO_2 – O_2 relation in the carbon cycle



$$\Delta CO_2 = F - B - O$$

$$\Delta O_2 = -\alpha_F F + \alpha_B B + Z$$

Measurement Principles:

- Using Atmospheric Potential Oxygen (APO)

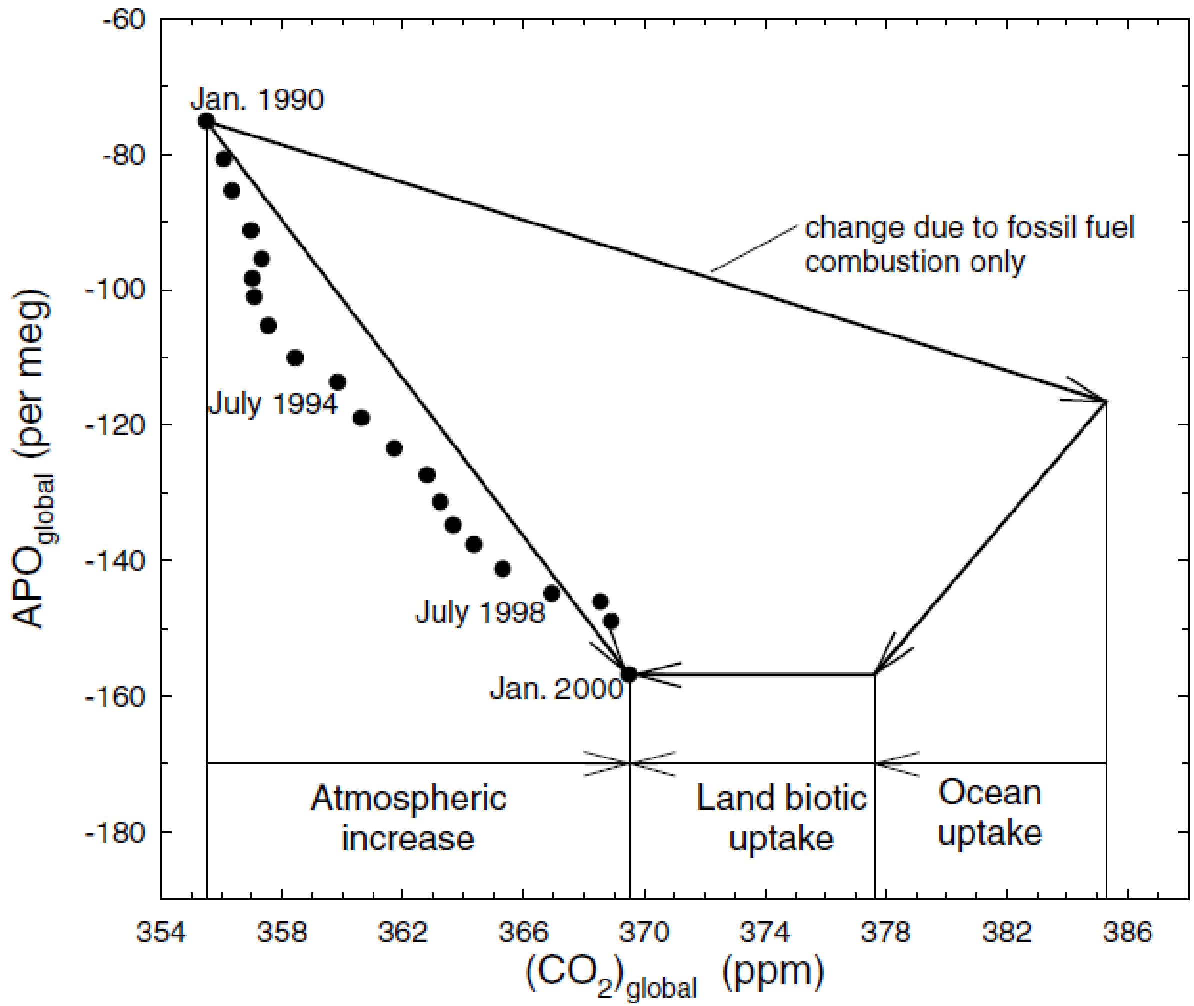
$$APO = (O_2) + \alpha_B(CO_2)$$

$$\Delta APO = F(\alpha_B - \alpha_F) + B(\alpha_B - \alpha_B) - \alpha_B O + Z$$

Fossil fuel Land-biosphere Ocean

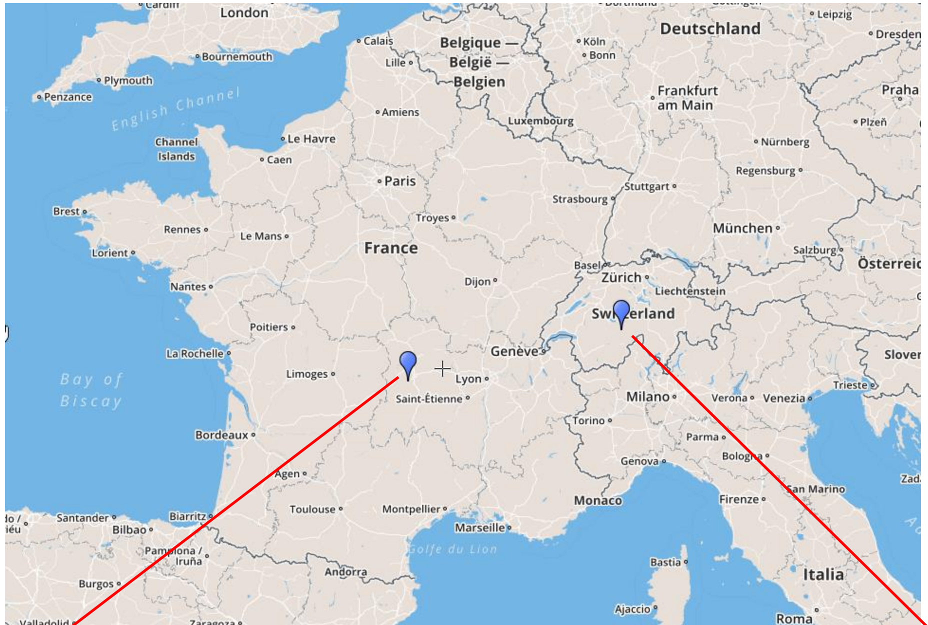
$$\Delta APO^* = \Delta APO - (\alpha_B - \alpha_F)F$$

$$O = \frac{1}{\alpha_B}[(-\Delta(\delta APO) * M_{air} * X_{O_2}) + F(\alpha_B - \alpha_F) + \left(\frac{Z_{eff}}{M_C}\right)]$$



Keeling and Manning 2006

Site description and sampling protocol



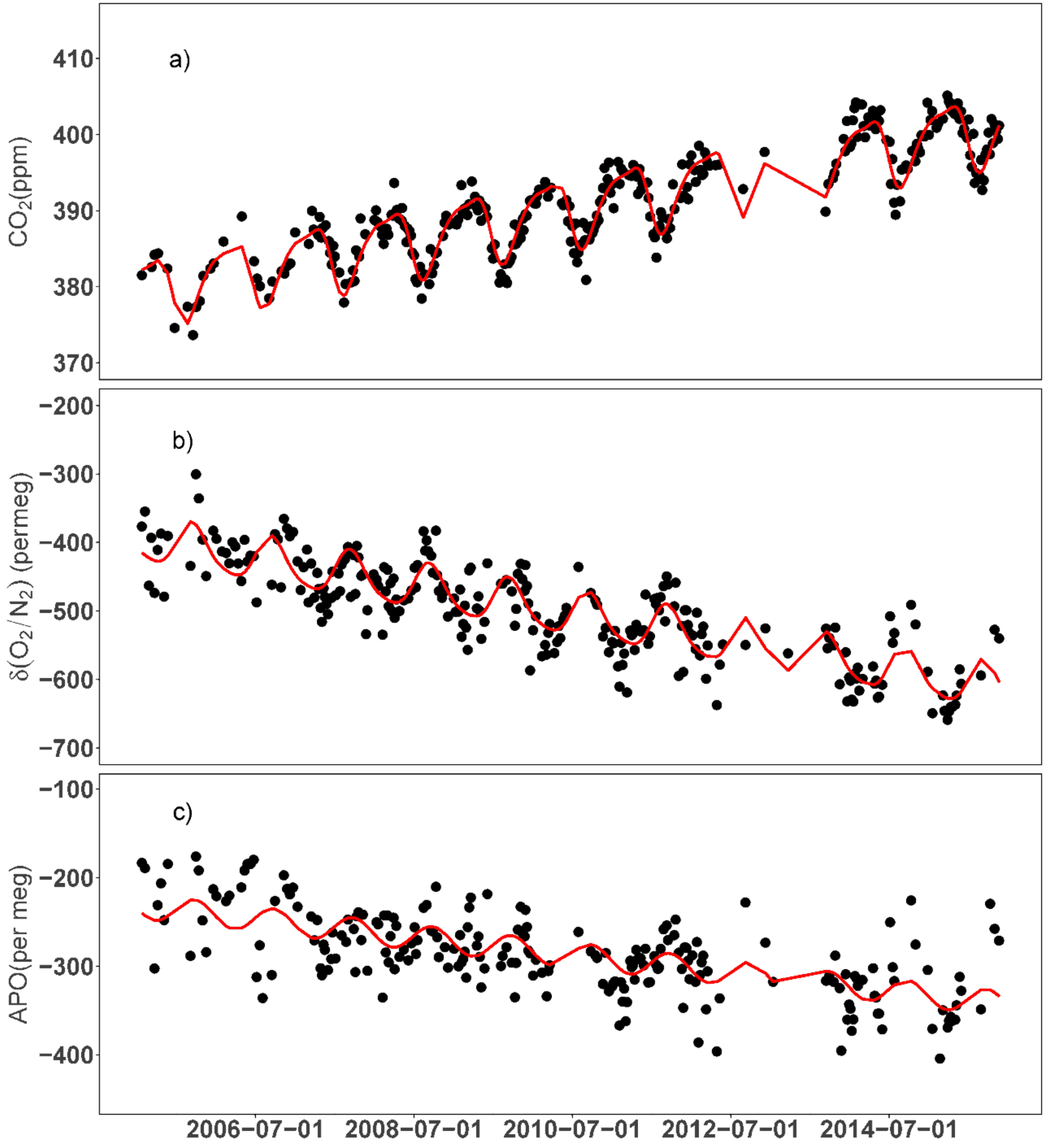
Puy de Dôme

- 1465 m a.s.l
- Westerly air-masses
- One flask/week (time varies mostly 11:00-15:00)

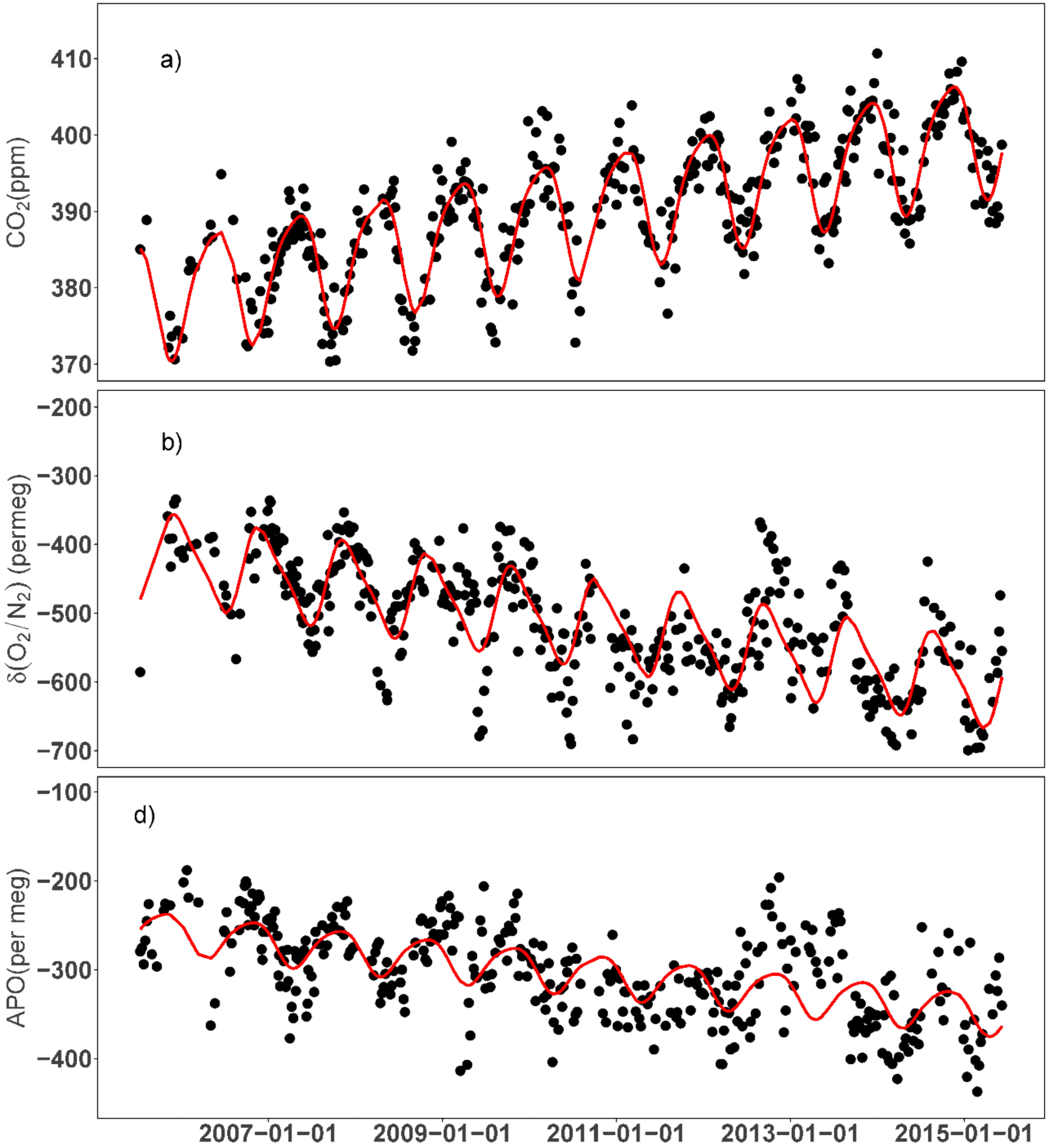
Jungfraujoch

- 3580 m a.s.l
- North-westerly air masses
- Duplicate flasks/ week (06:30-07:30)

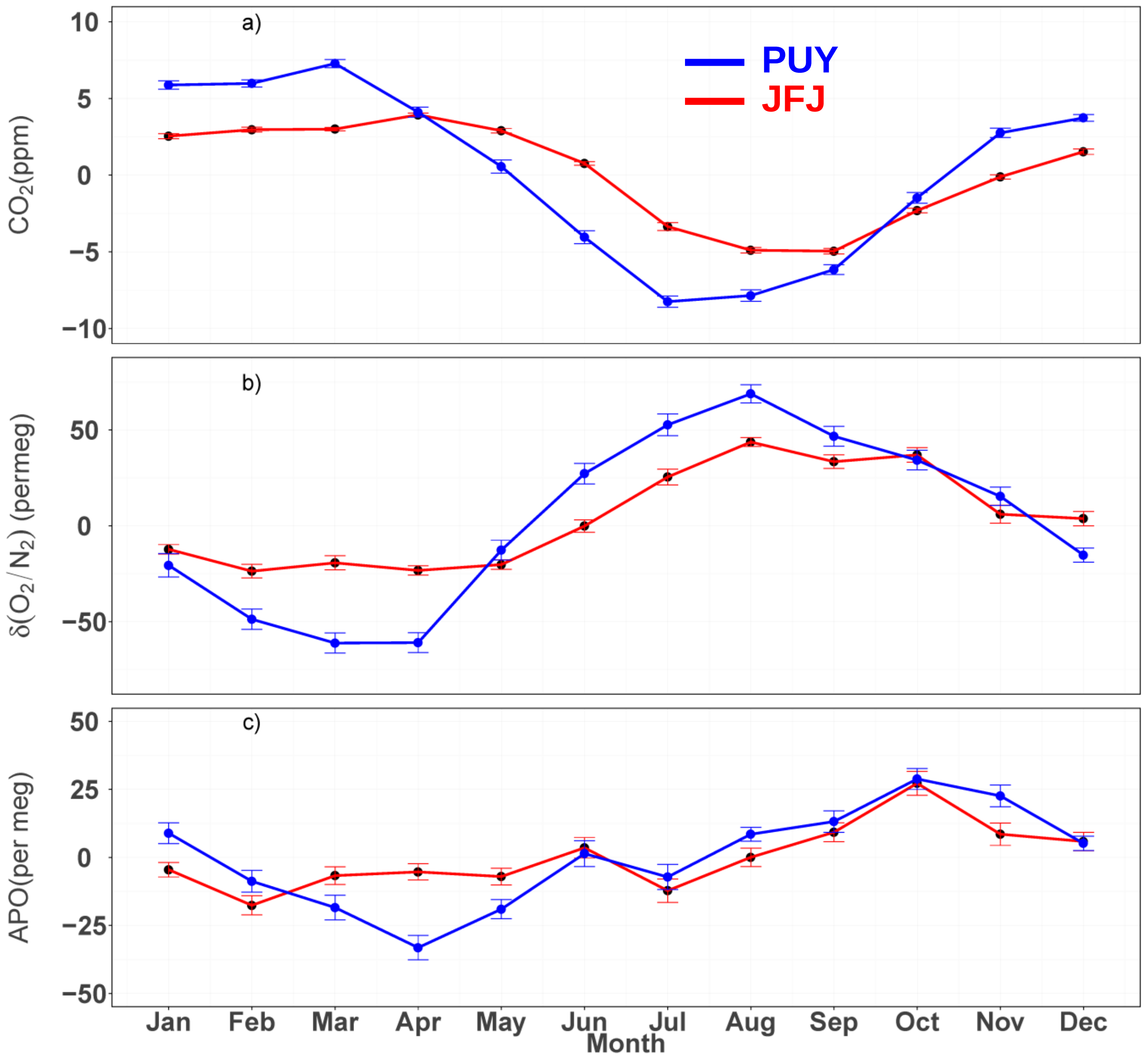
Observed CO_2, $\delta(O_2/N_2)$ and calculated APO after filtering (JFJ)



Observed CO_2, $\delta(O_2/N_2)$ and calculated APO after filtering (PUY)



Seasonalities of CO_2, $\delta(O_2/N_2)$ and APO at PUY and JFJ



Calculated Trends and Seasonality at PUY and JFJ

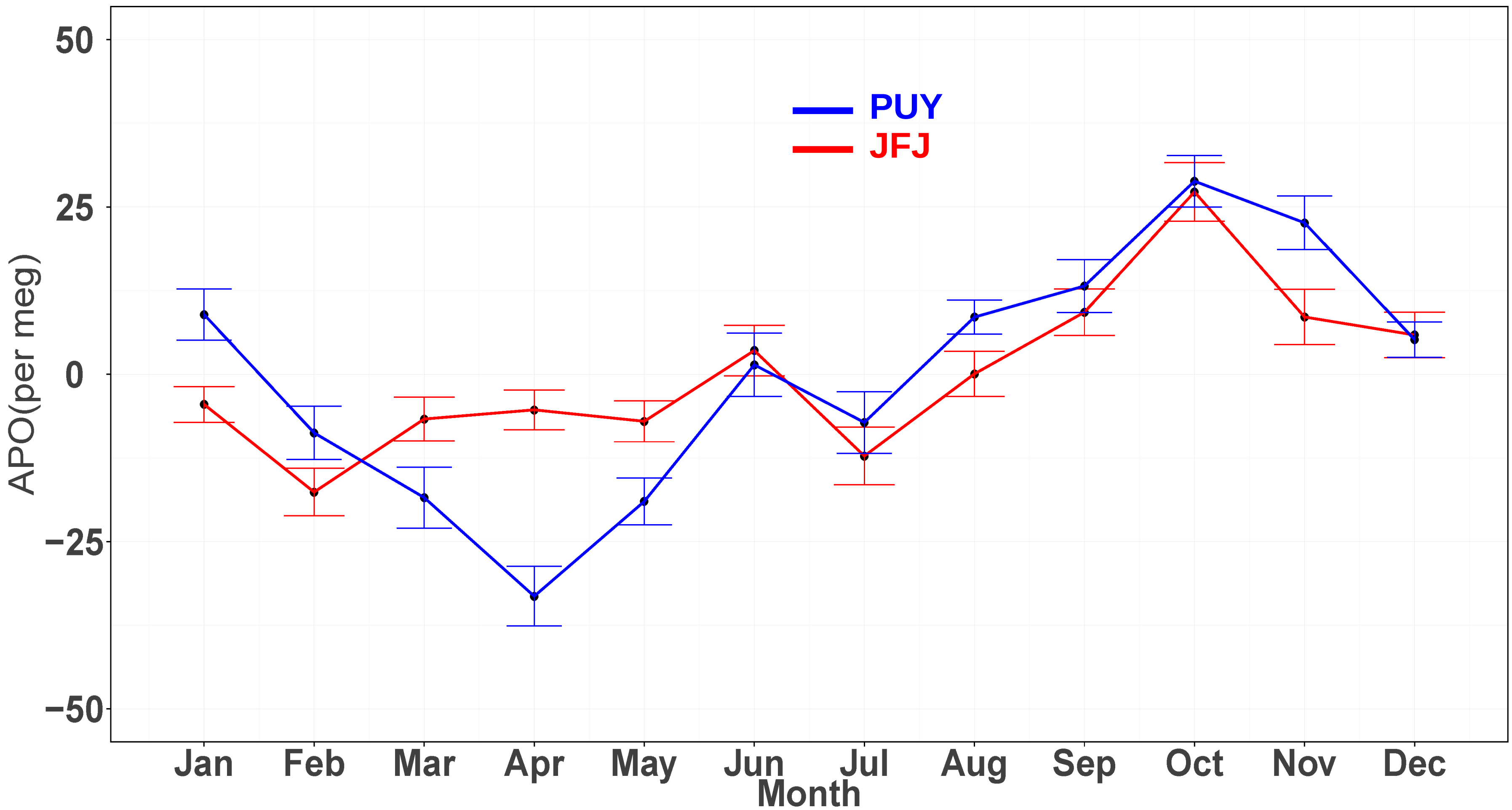
	Trend		Seasonality	
	JFJ	PUY	JFJ	PUY
CO_2	1.99 ± 0.15 (2.07 ± 0.06)*	1.99 ± 0.27	8.88 ± 0.49 (10.68 ± 0.11) *	15.52 ± 0.23
$\delta(O_2/N_2)$	-19.80 ± 1.76 (-23.6 ± 0.6) *	-18.6 ± 2.92	67.37 ± 4.3 (85.2 ± 3.04) *	129.79 ± 7.0
APO	-10.04 ± 0.50 (-9.5 ± 1.7) ¥	-10.20 ± 0.88	44.29 ± 5.44 (44.0 ± 5.0) ¥	61.99 ± 5.81

*Continuous in-situ measurments at JFJ (Schibig, M., PhD thesis, 2015)
¥Mace Head (Sirignano et al., 2010)

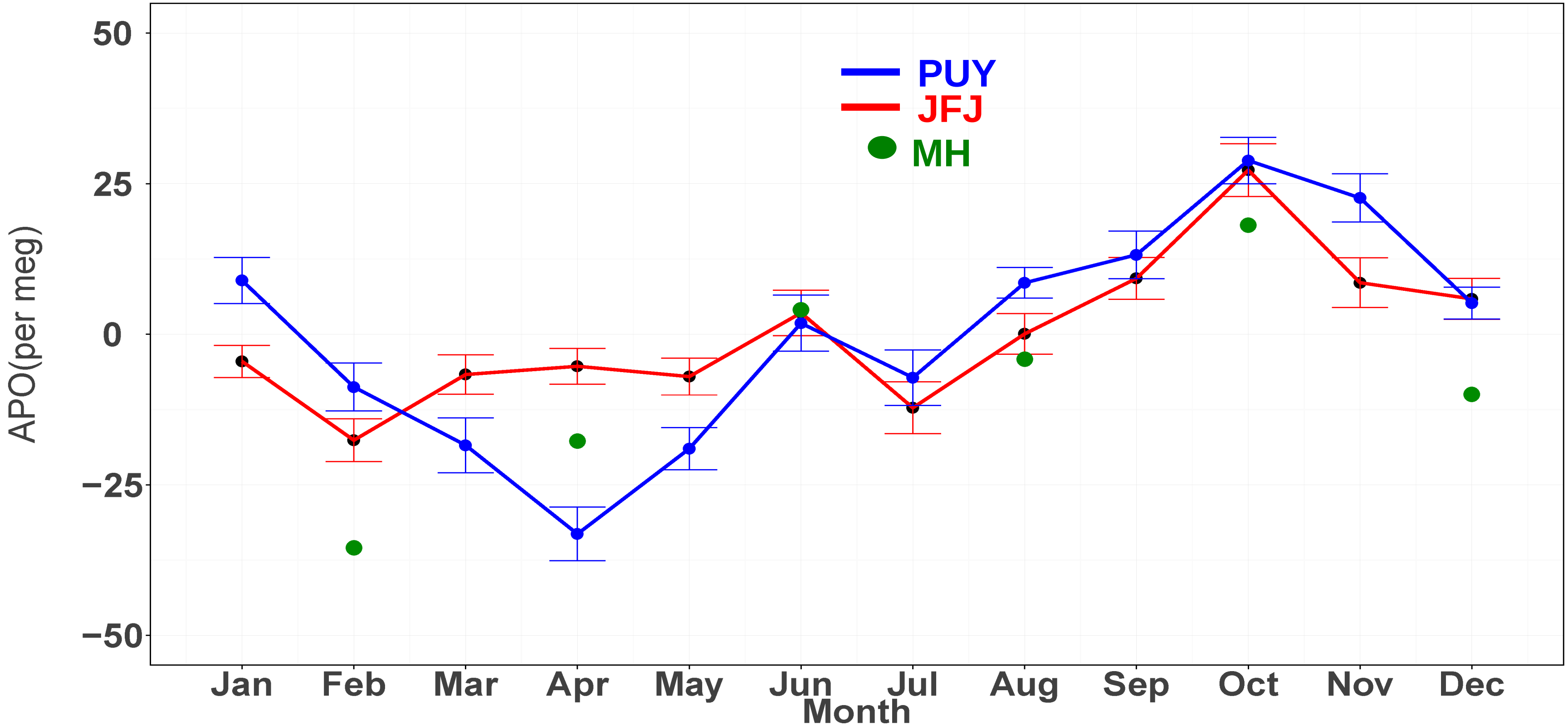
Calculated Trends and Seasonality at PUY and JFJ

	Trend		**Seasonality**	
	JFJ	PUY	JFJ	PUY
CO_2	1.99 ± 0.15	1.99 ± 0.27	8.88 ± 0.49	15.52 ± 0.23
$\delta(O_2/N_2)$	-19.80 ± 1.76	-18.6 ± 2.92	67.37 ± 4.3	129.79 ± 7.0
APO	-10.04 ± 0.50	-10.20 ± 0.88	44.29 ± 5.44	61.99 ± 5.81

Seasonality in APO at PUY and JFJ



Seasonality in APO at PUY, JFJ and MH

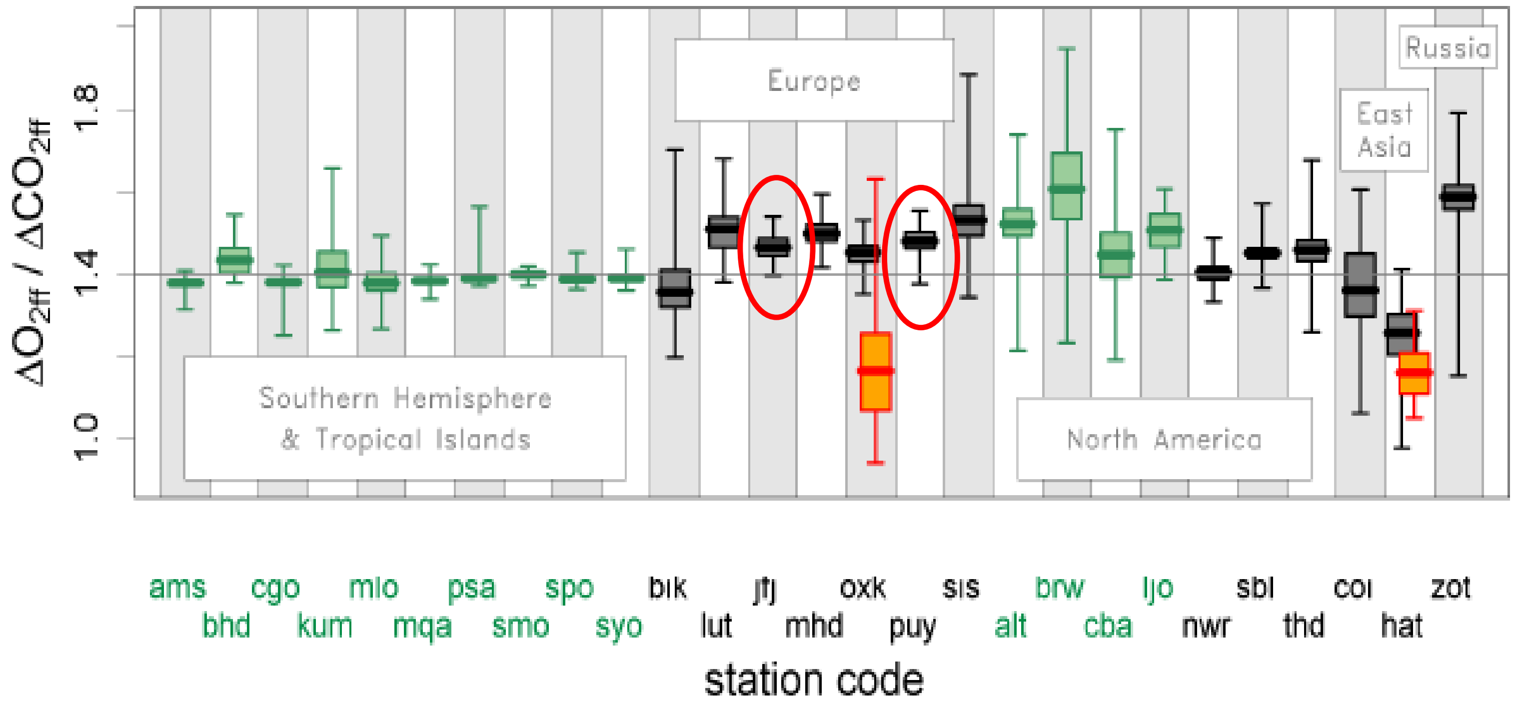


(Sirignano et al., 2010)

- Fossil fuel combustion
- Difference in footprint
- Atmospheric condition

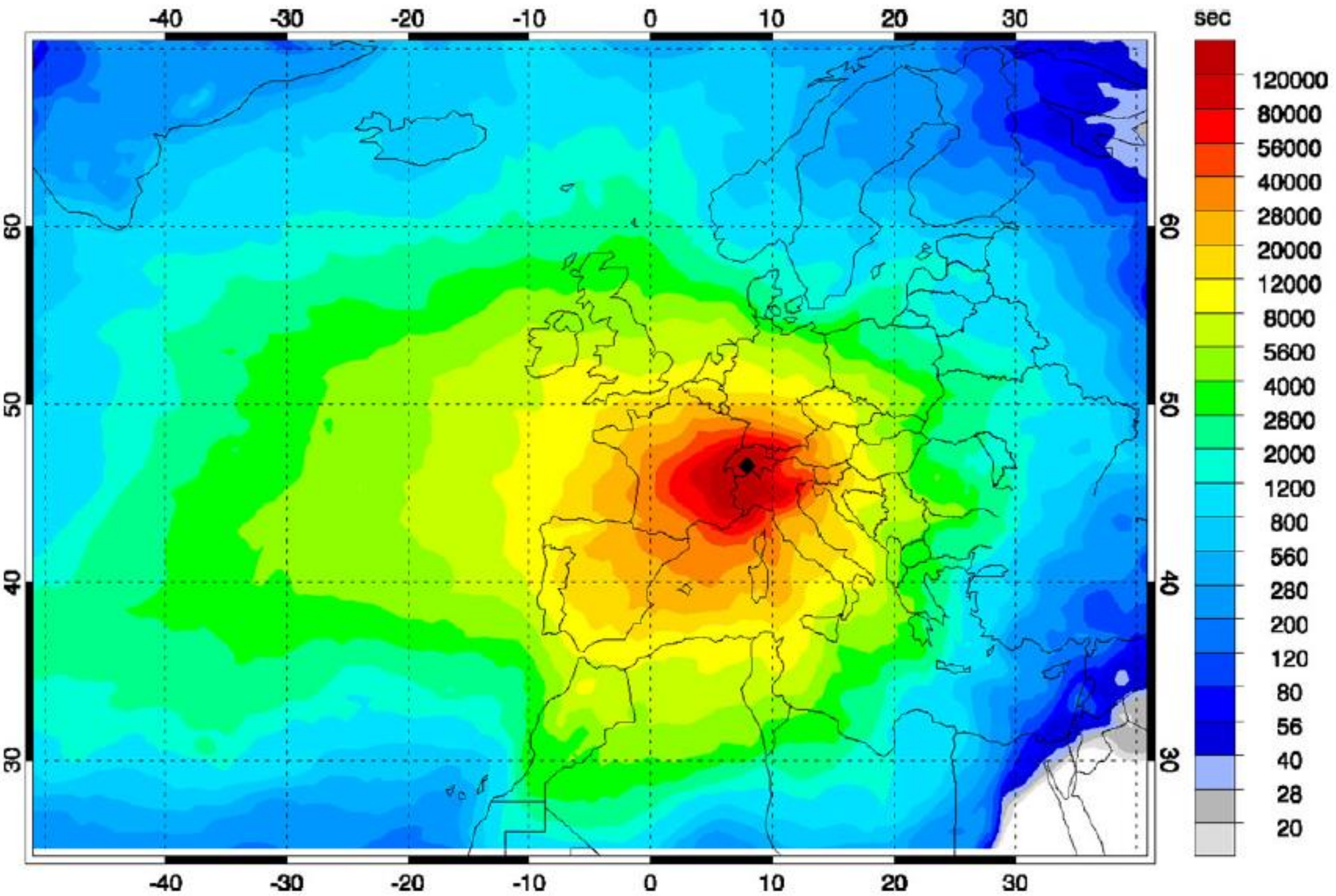
APO and fossil fuel effect

$$\Delta APO^* = \Delta APO - (\alpha_B - \alpha_F)F$$



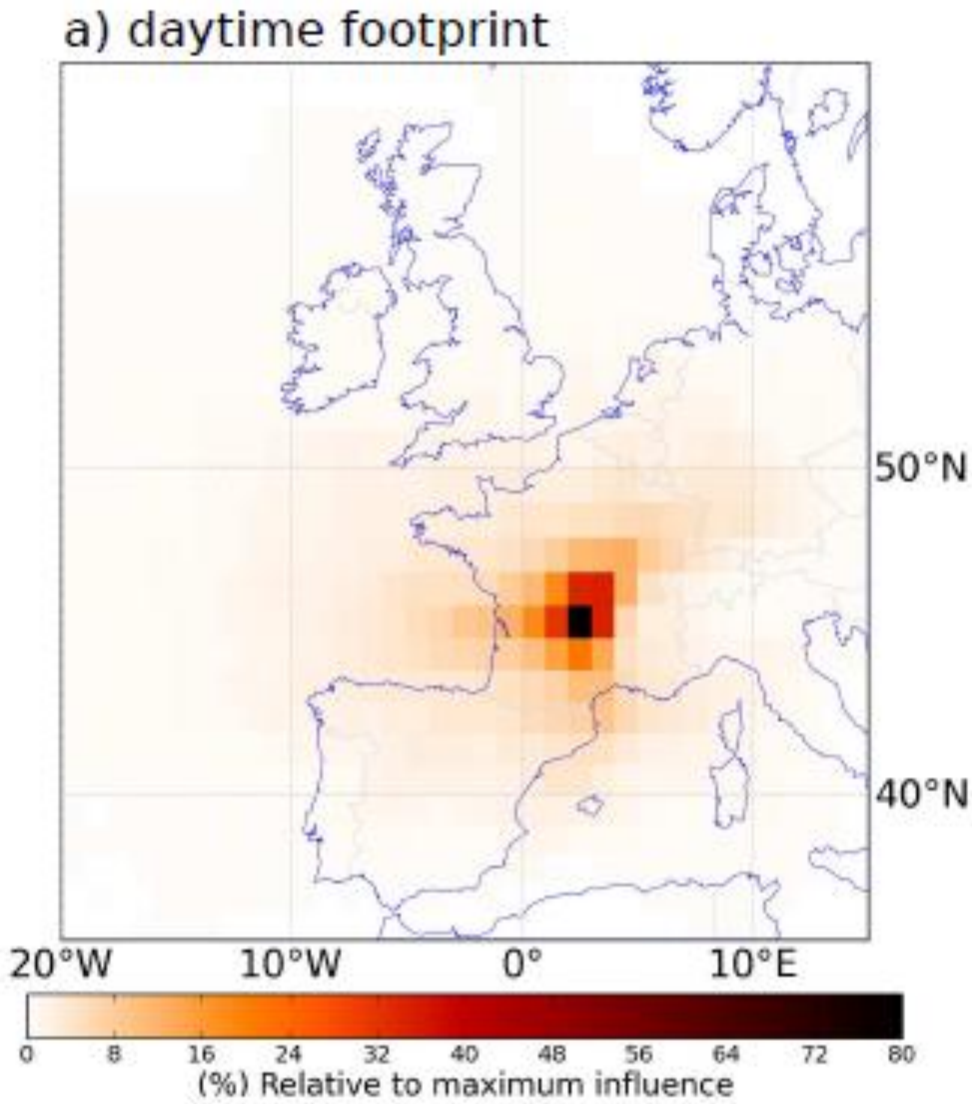
(Steinbach et al., 2011)

Foot print of air masses at JFJ during 2005-2009



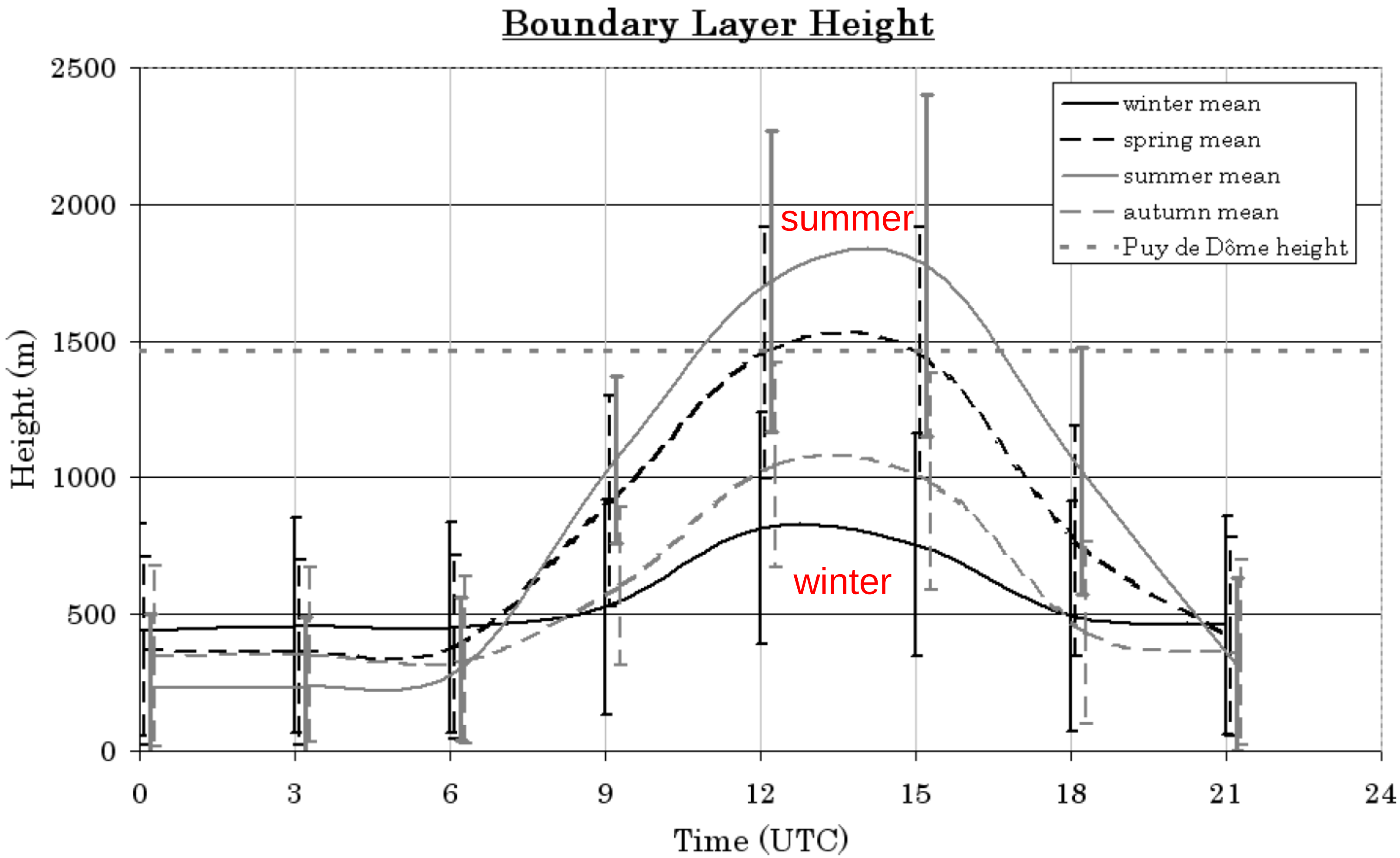
(Uglietti et al., 2011)

Foot print of air masses at PUY during 2010-2012



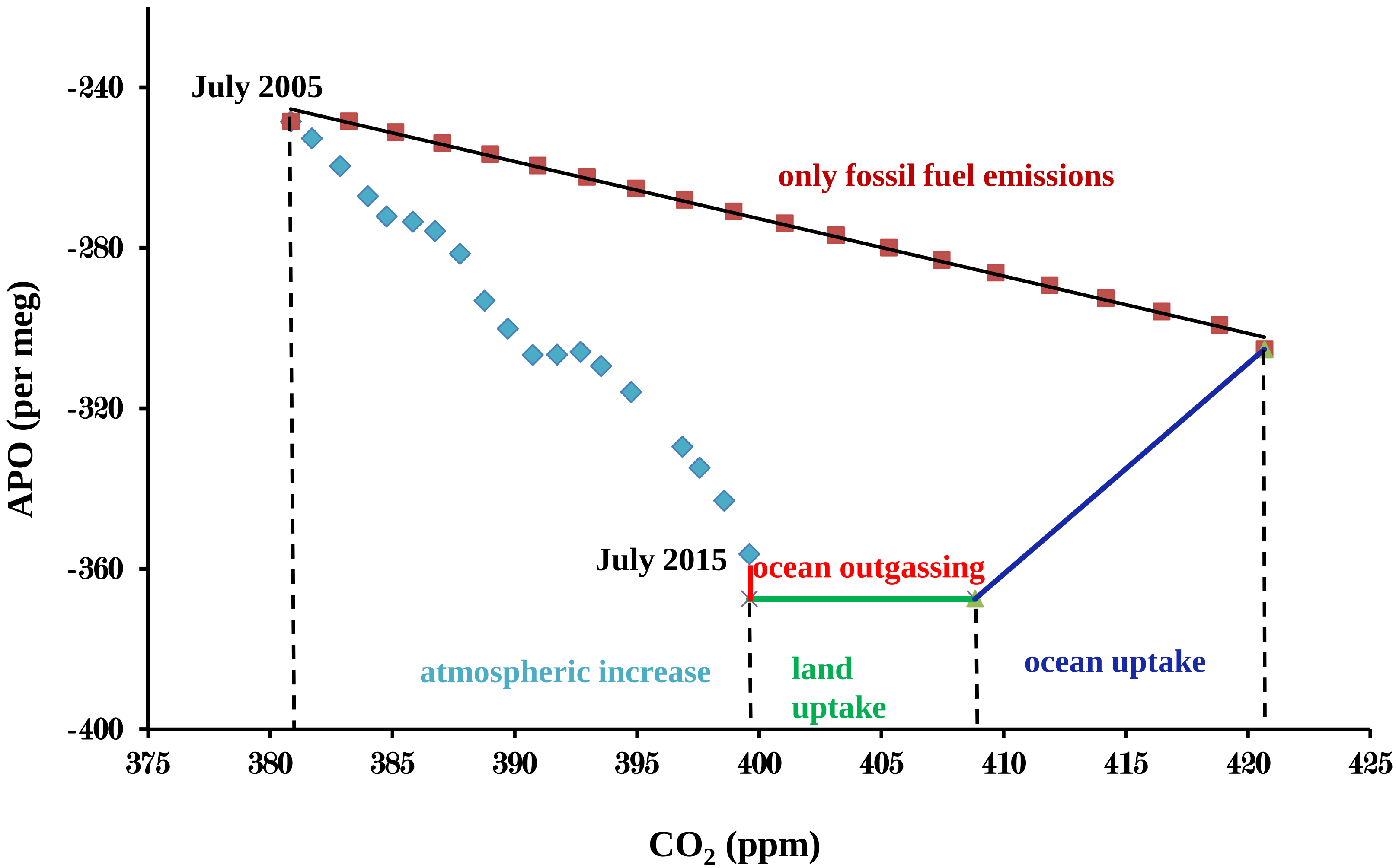
(Lopez et al., 2015)

Seasonal dependent diurnal variation in PBL at PUY



(Venzac et al., 2009)

Partitioning of atmospheric CO_2 based on APO data at JFJ



Calculated CO_2 partitioning using APO at PUY and JFJ

Site	Atmosphere (%)	Ocean (%)	Land-biosphere (%)
JFJ	47.1	29.7	23.2
PUY	48.2	17.9	33.9
Global*	44.4	26.2	30.4
JFJ¥	50.4	28.9	20.7

*Global atmospheric CO_2 partitioning calculated for 2005 – 2014 (Le Quéré et al., 2015)
¥Values derived from continuous in-situ measurements at JFJ (Schibig, M. Phd Thesis 2015).

Summary

- Observed significant differences in APO seasonalities between the two sites are associated with fossil fuel influence and differences in air-masses at each site.
- Better comparison can be obtained between the two sites if samplings at PUY can be made only during hours of the day when the site is clearly above the PBL (before 09:00 UTC).
- CO_2 partitioning among resrviors using APO should consider possible anthropogenic influences .

THANK YOU