REGIONAL BREWER CALIBRATION CENTER-EUROPE
CEOS-ESA CALVAL campaigns instrumental findings

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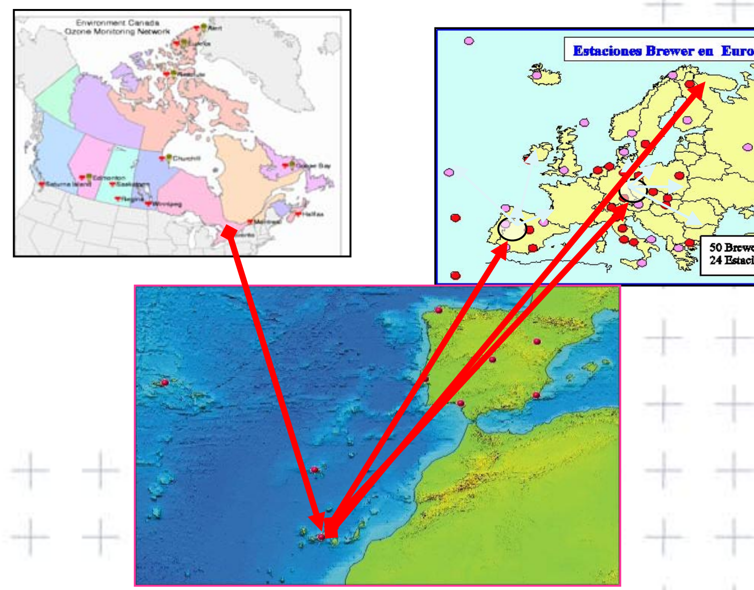
RBCC-E

- In November 2003 the WMO/GAW Regional Brewer Calibration Centre for RA-VI region (RBCC-E) was established at the Observatory Izaña of AEMET, Canary Islands (IZO).

- IZO is located in subtropical region (28ºN) on top of the Izaña Mountain (2370 m.a.s.l.) with clear sky and small ozone variability. This allows routine absolute calibrations of the references similar to the MLO site on Hawaii.

- The IZO Triad is linked to the Environment Canada (EC) Triad by yearly calibrations towards the travelling reference BR 017.



- Recently because of doubts about the support of the world triad by EC , the WMO SAG Ozone authorizes at the meeting of 2011, that the RBCC-E transfers its own calibration based on Langley at Izaña Station. At the recent Arosa 2012 campaign the RBCC-E transfer his own Langley calibration

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CEOS Intercalibration of Ground-based Spectrometers and Lidar, aims to homogenize the European ozone ground network.

Nordic campaigns

Investigate the calibration methodology at two different ozone atmospheric conditions.

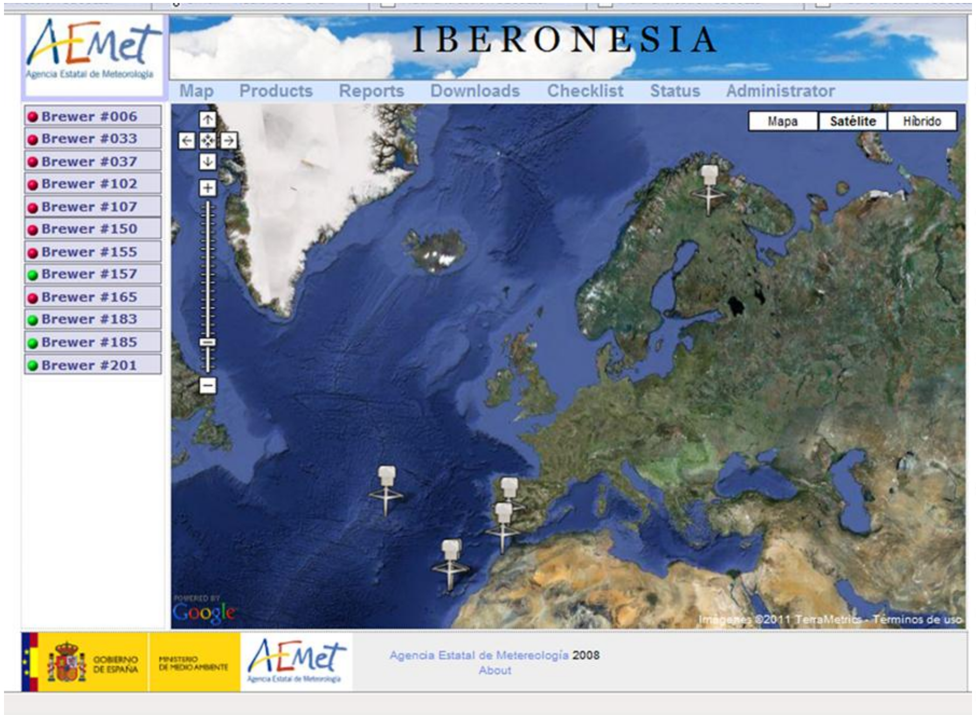
a) Instrumental issues
b) Ozone ETC sensitivity Calibration

RBCC-E campaigns

a) Status of the network (comparison with reference instruments)
b) Brewer – Dobson comparison

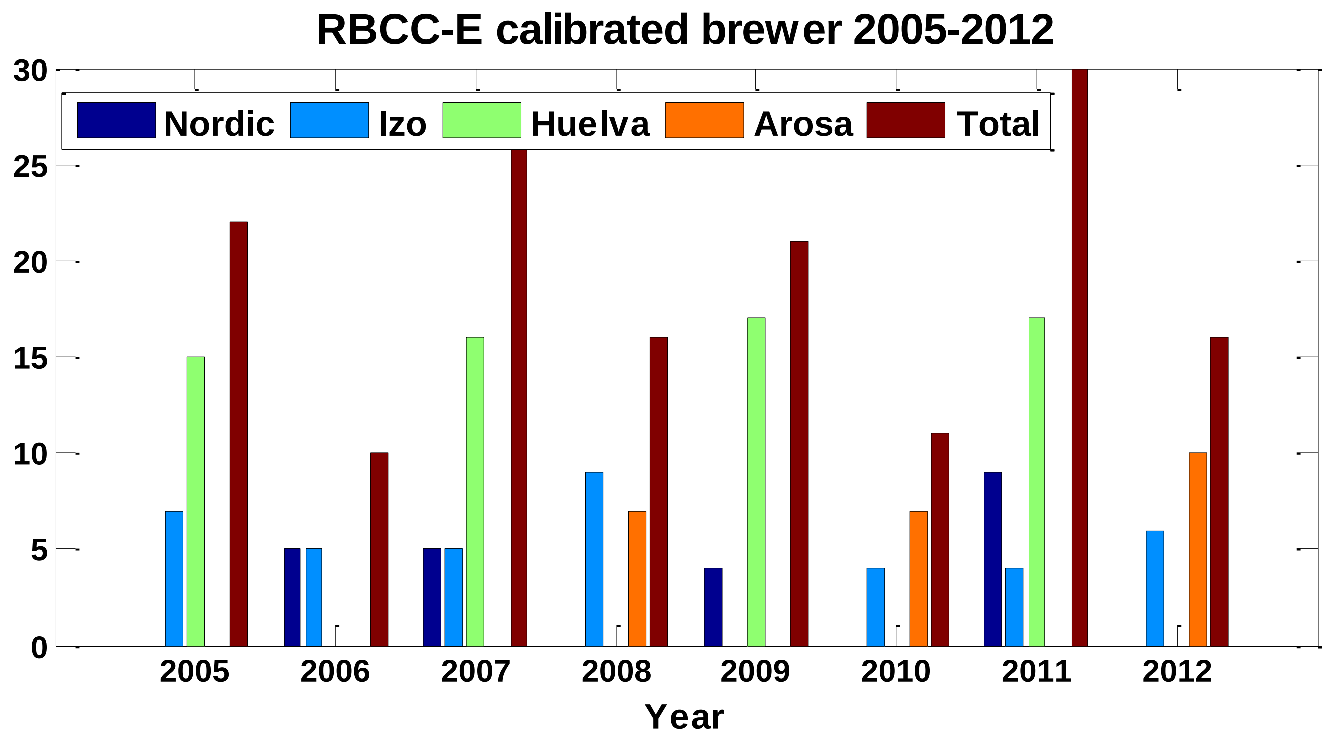
Absolute Calibration(Langley)

a) Reference instruments calibration



http://uv-vis.aeronomie.be/projects/ESA_CEOS/

RBCC-E campaigns



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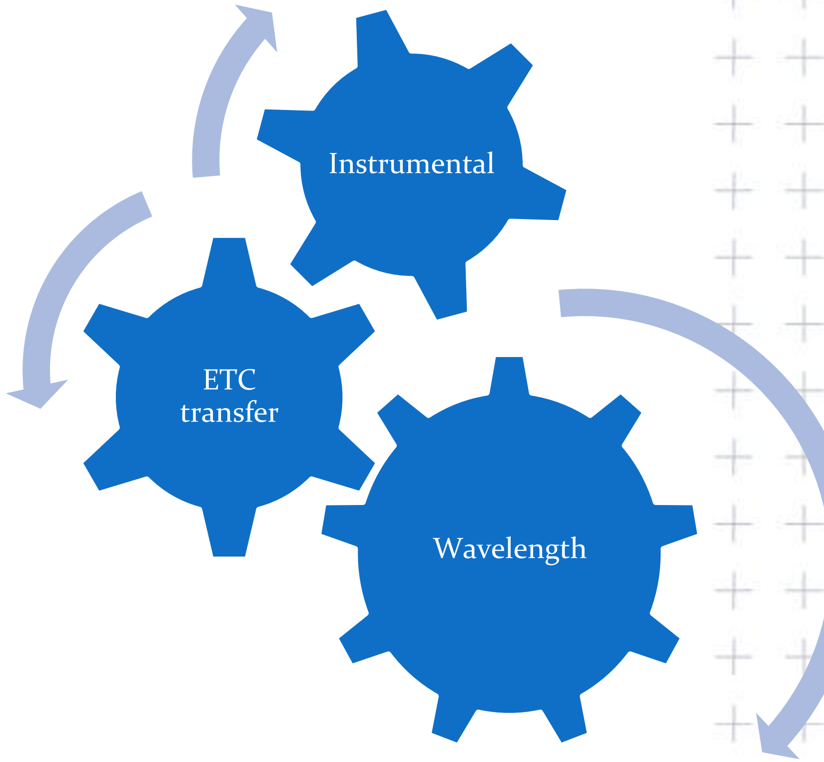
RBCC-E calibration

	IOS/Kipp&Zonen	RBCC-E
	Private	Public/Free
Maintenance/ Repairs	Yes	No
Calibration period	5 days	10 days
Place	On Site	Calibration Campaigns
Transport instrument		Recommended by car
Transport of the reference	Plane/Cargo	Plane (hand luggage) / Boat (car)
Calibration of the reference	Many sites without recalibration or calibration check	Only one campaign
Calibration of the reference	Not provided	Comparison with the permanent reference at Izaña before/after
Instrument type	MKII Single	MK-III Double

Brewer Calibration

$$O_3 = \frac{F - ETC}{\alpha\, m}$$

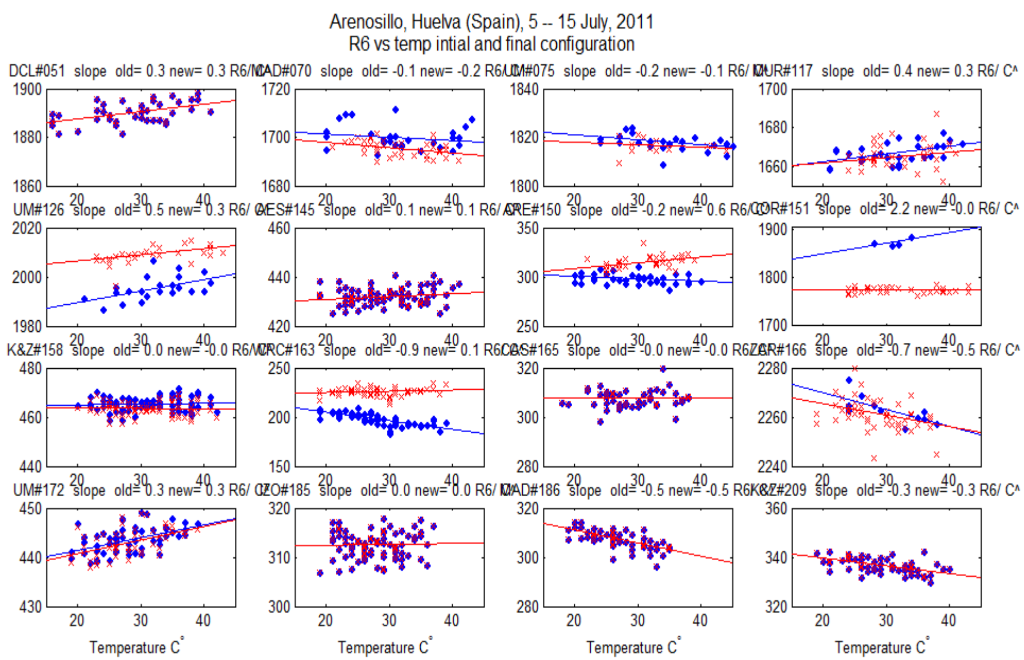
- 1: Instrumental Calibration (F)
- 2: Wavelength Calibration (α)
- 3: ETC transfer.

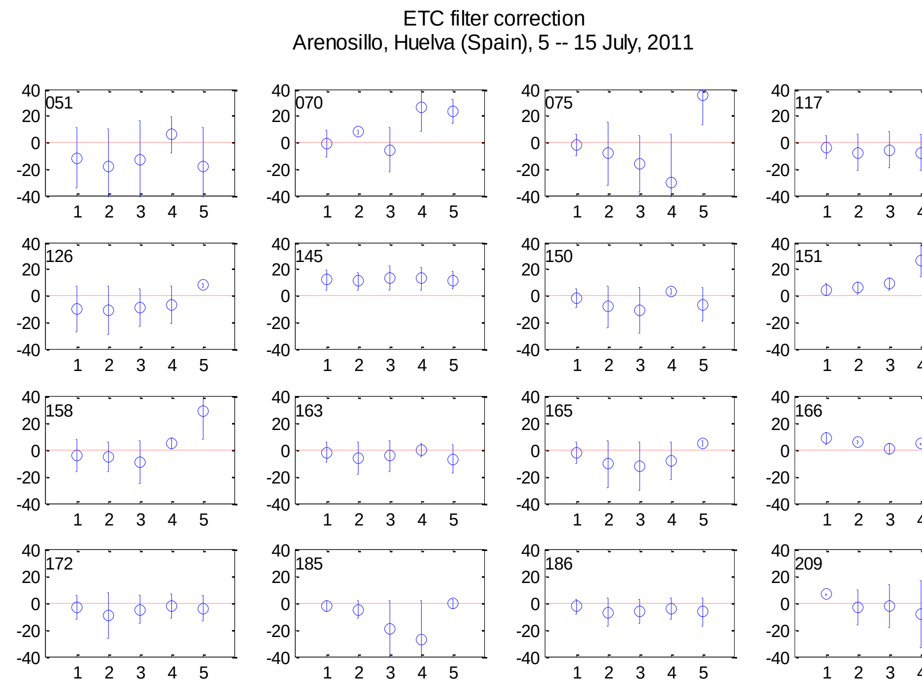


Instrumental calibration

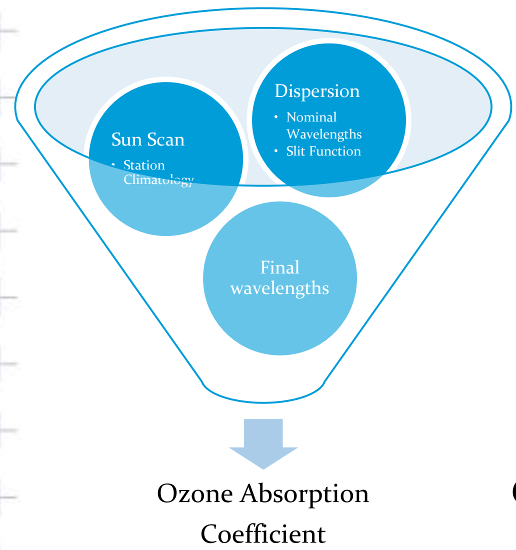
$$F = F(DeadTime, Filter, Temperature)$$

- Characterization test determine /track the changes
- Test are well described on Brewer SOP





Wavelength Calibration



1. Optimized wavelengths
2. Dispersion test, (discharge lamps)
3. Ozone Absorption coefficient (Bass & Paur -45).

$$\alpha(X,\mu) = \sum w_i \frac{\int \alpha(\lambda) * S(\lambda,\lambda') * F(\lambda,\lambda',X,\mu)\,d\lambda'}{\int S(\lambda,\lambda') * F(\lambda,\lambda',X,\mu)\,d\lambda'}$$

$\alpha(\lambda)$ = ozone cross section

Wi= ozone weighting coefficients

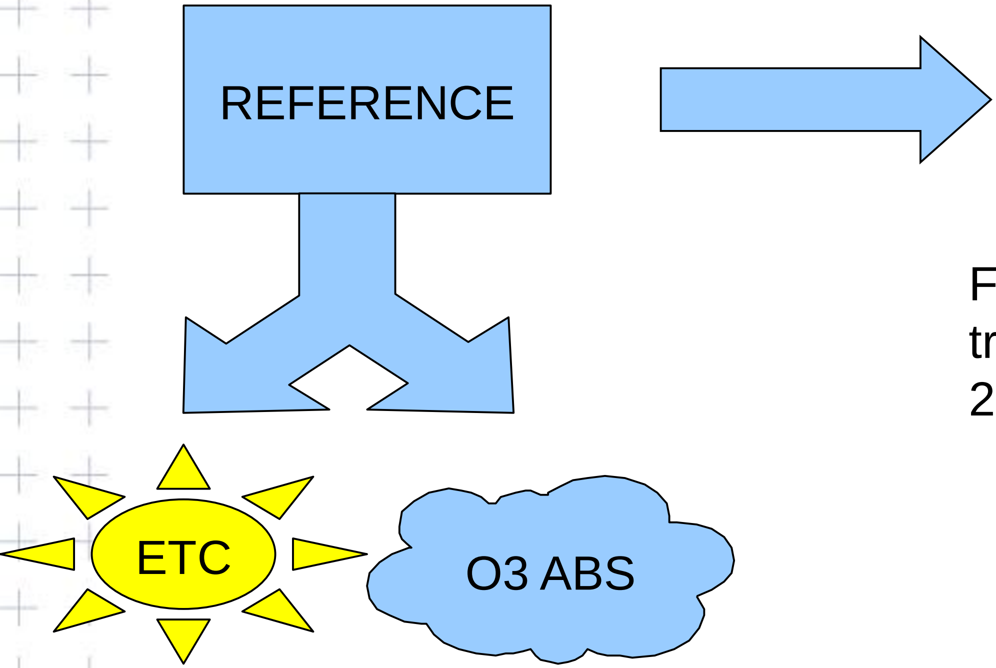
S = Slit Function, (ILS)

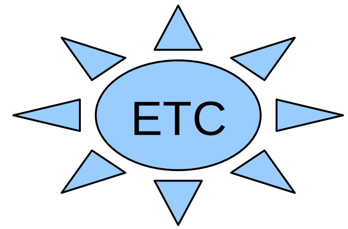
F = Sun Spectra , (X, nu)

Gröbner, J., Wardle, D. I., McElroy, C. T. y Kerr, J. B.: Investigation of the wavelength accuracy of Brewer spectrophotometers, APPLIED OPTICS, 37(36), 1998.

ETC transfer

The reference instruments , the ETC are calibrated by Langley extrapolation
The network instrument the ETC is obtained by comparison with the reference
Before year 2000, ozone absorption cross section and ETC where transferred from the reference





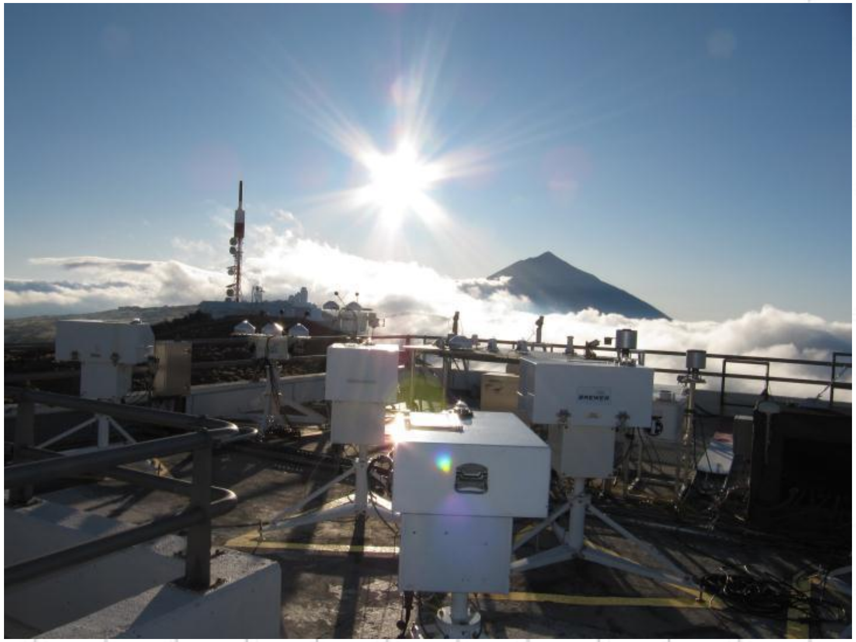
For a one point calibration there is a dependence trough the ozone from a reference (Savastiouk 2009)

$$O'_3 = O_3 * \left[1 - \frac{\overline{O_3 * \mu}}{O_3 * \mu} \left(1 - \frac{\alpha_{ref\,(dm)} / \alpha_{ref\,(bp)}}{\alpha_{inst\,(Dm)} / \alpha_{inst\,(bp)}} \right) \right]$$

There is no effect on ETC transfer with the change of ozone absorption coefficients with a two point calibration.

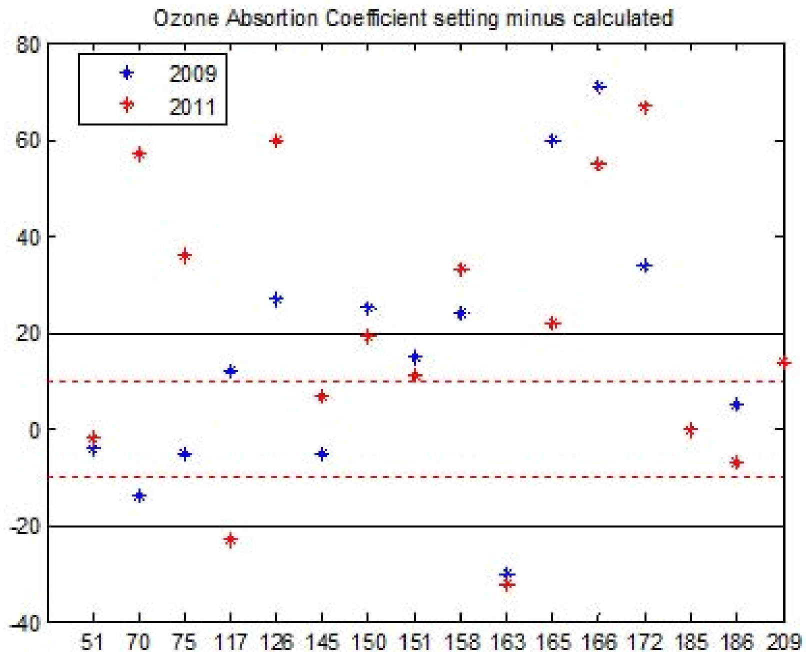
Instrumental issues found at CEOS campaigns

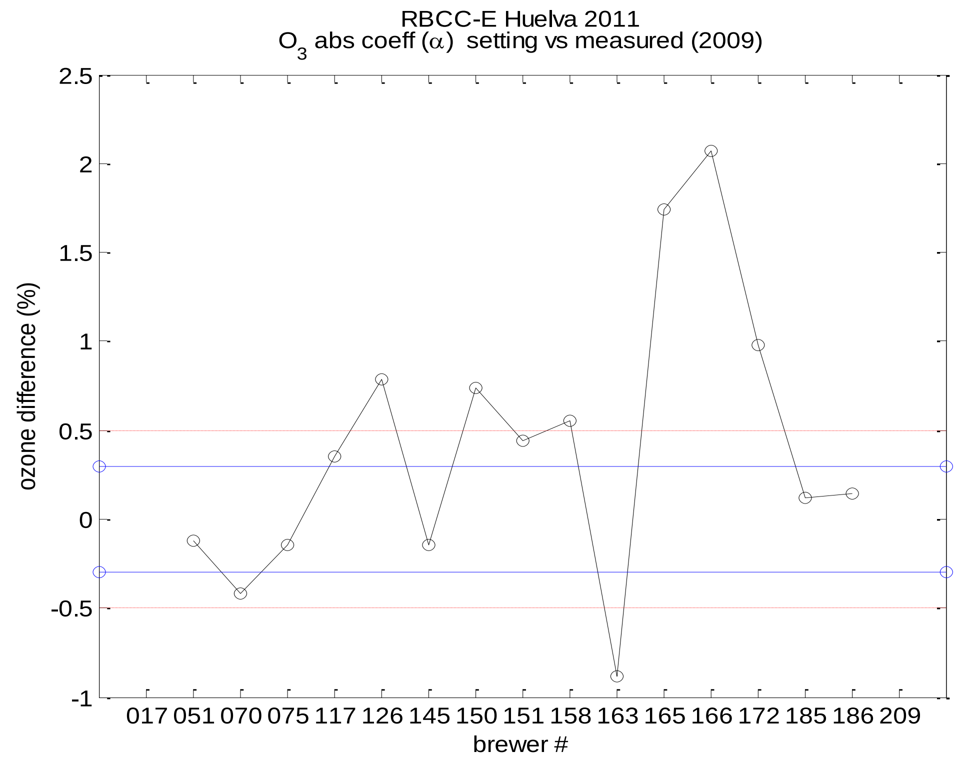
a) Ozone Absorption :Two point vs. one point calibration
b) Stray Light
c) Dead Time
d) Filter Attenuation
e) Stray Light



Ozone Absorption coefficient

About one third of the instruments the ozone absorption calculated are not agree with the calibration setting. They are using two parameters calculation

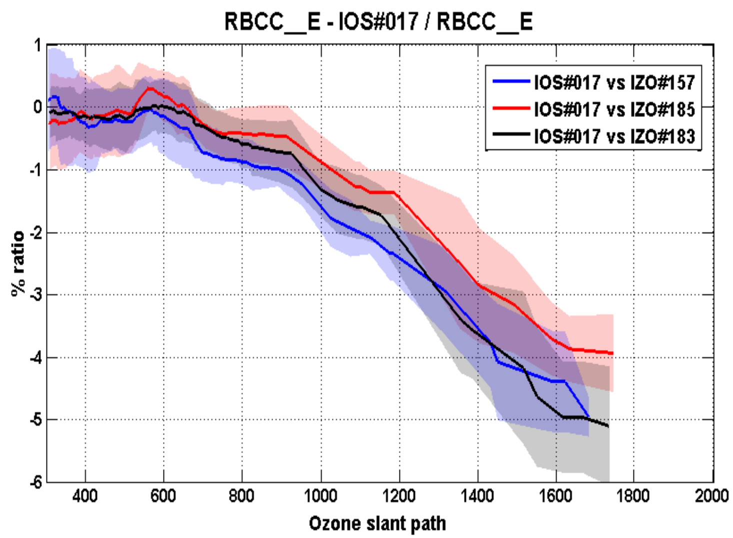


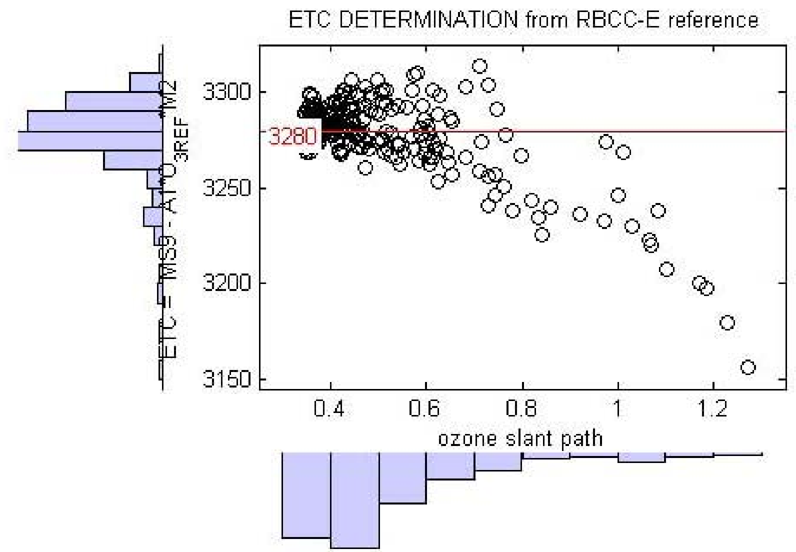


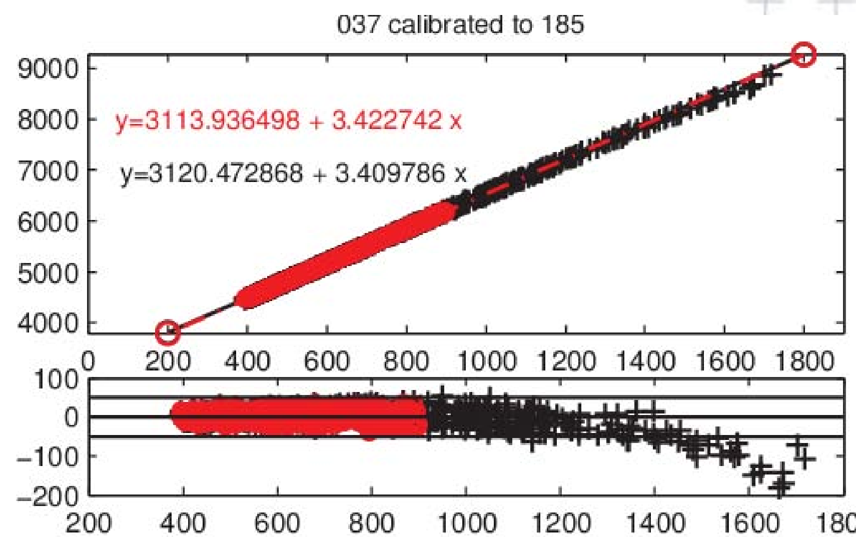
Straylight

Reference instruments are affected by stray light

Limits the useful calibration range



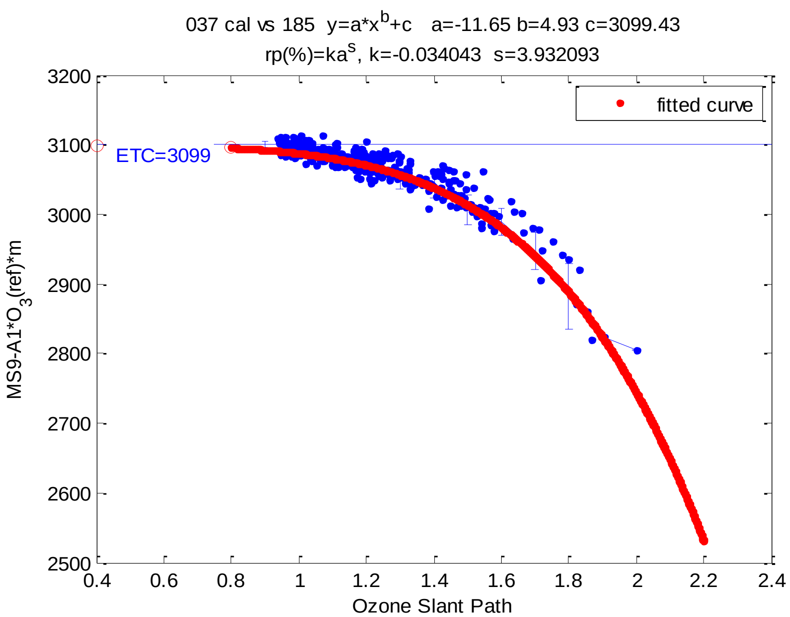




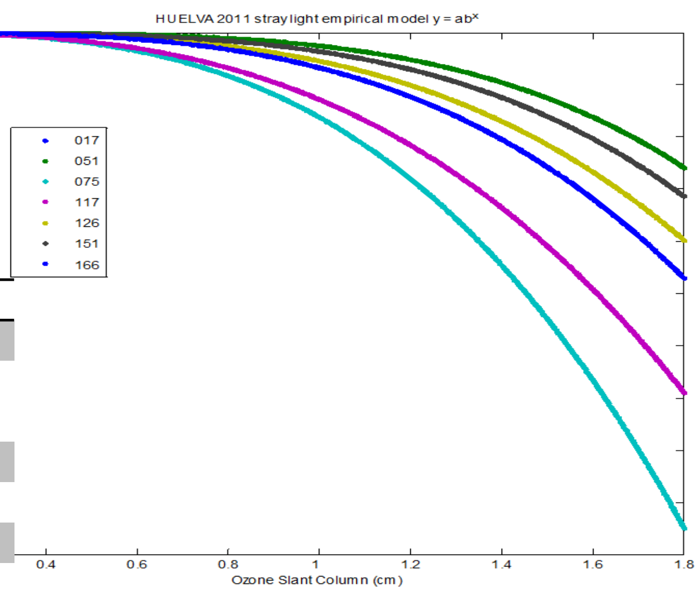
Stray Light

- The empirical relation found at SAUNA with campaigns can be applied to ETC transfer

$$ETC= ETCo + a(osc)^{s}$$

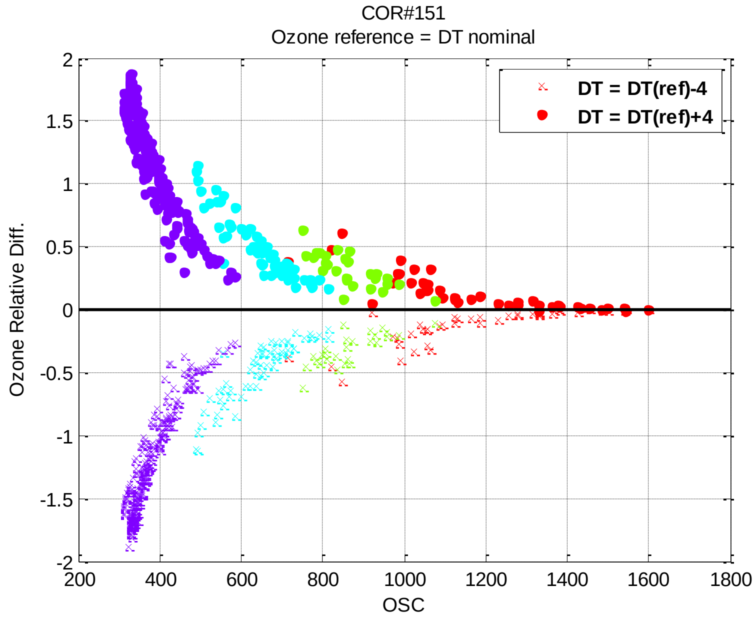


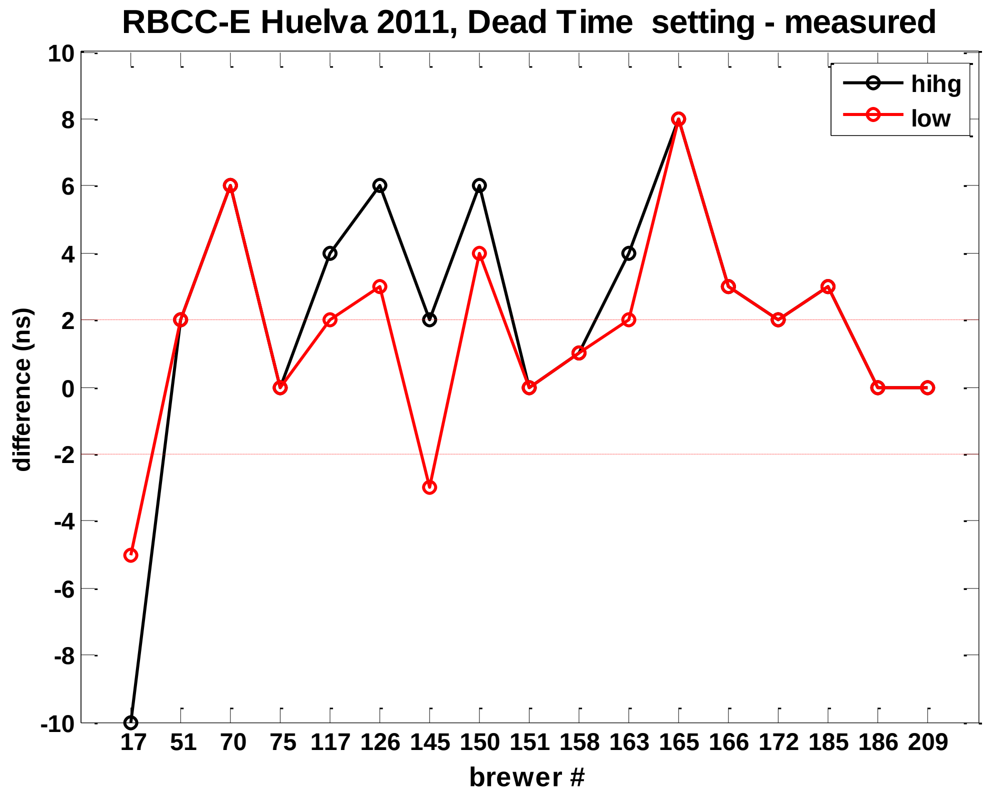
Brewer	a	s
17	-1.09	2.88
51	-0.25	3.97
75	-1.62	3.01
117	-1.28	2.86
126	-0.54	3.39
151	-0.36	3.69
166	-0.67	3.32



Instrumental issues
DT

a) The SOP indicates a tolerance 2 ns.
b) Effect up to 3% in single Brewer
c) The setting on the instrument are not agree with the calculation
d) This also affects to some "reference" instruments like #157 and #017





Filter attenuation:

- Attenuation Filters are “neutral”
- Nominal wavelengths and weights verify

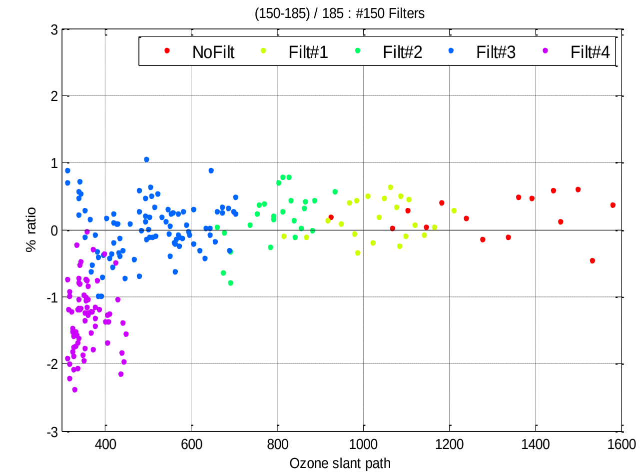
$$\sum_{i=1}^{4} w_i = 0, \qquad \sum_{i=1}^{4} w_i \lambda_i = 0$$

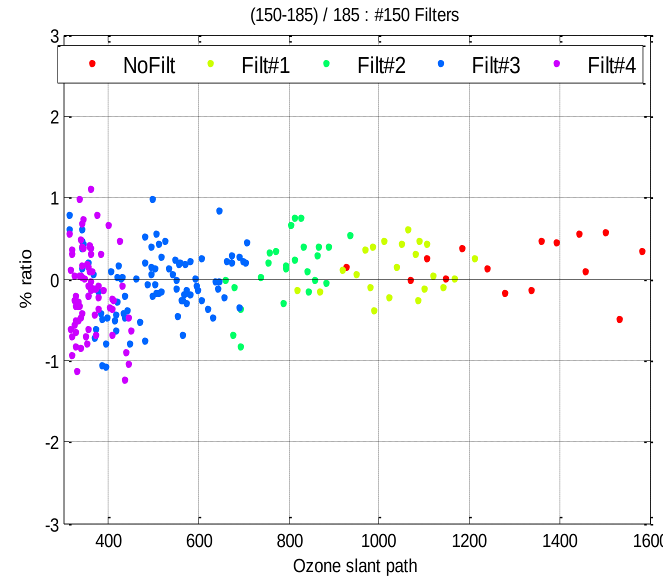
If the attenuation is linear with wavelength, do not affect the ozone calculation.

- The filters can not be neutral and $\sum_{i=1}^{4} w_i \lambda_i \approx 0$

The effect is a correction on ETC for the affected filter (j) , that can be calculated if you know the spectral attenuation AF

$$ETC\_C(j) = \sum_{i=1}^{4} w_i Af(\lambda_i, j)$$





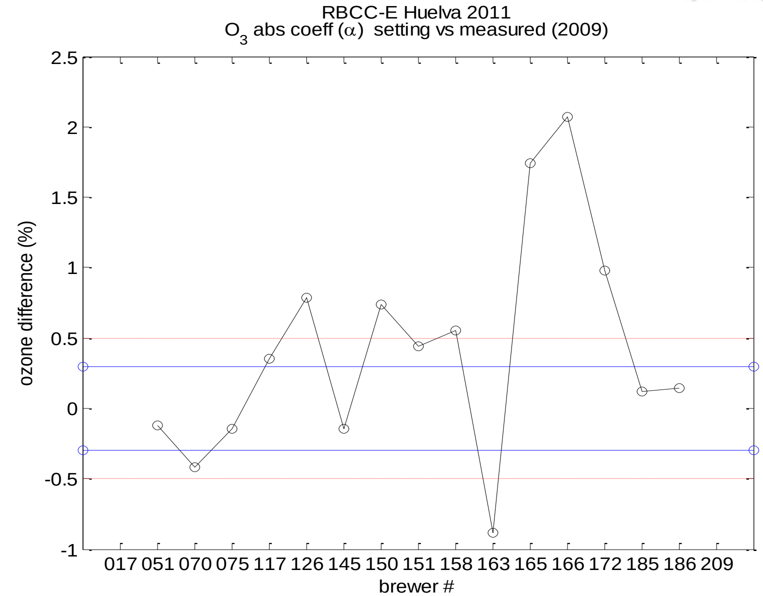
Summary

	17	51	70	75	117	126	145	150	151	158	163	165	166	172	185	186	209	Total
ABS				X		X		X		X		X	X	X				40%
Filter				X		X		X		X		X	X	X	(*)			47%
DT	X		X			X		X			X	X						35%

The instruments calibrated with two point calibration are the same that are affected by filter issues

Coincidence ?

No linearity of the filters are not take in to account on the current analysis software, the “synthetic” absorption coefficient can compensate this.



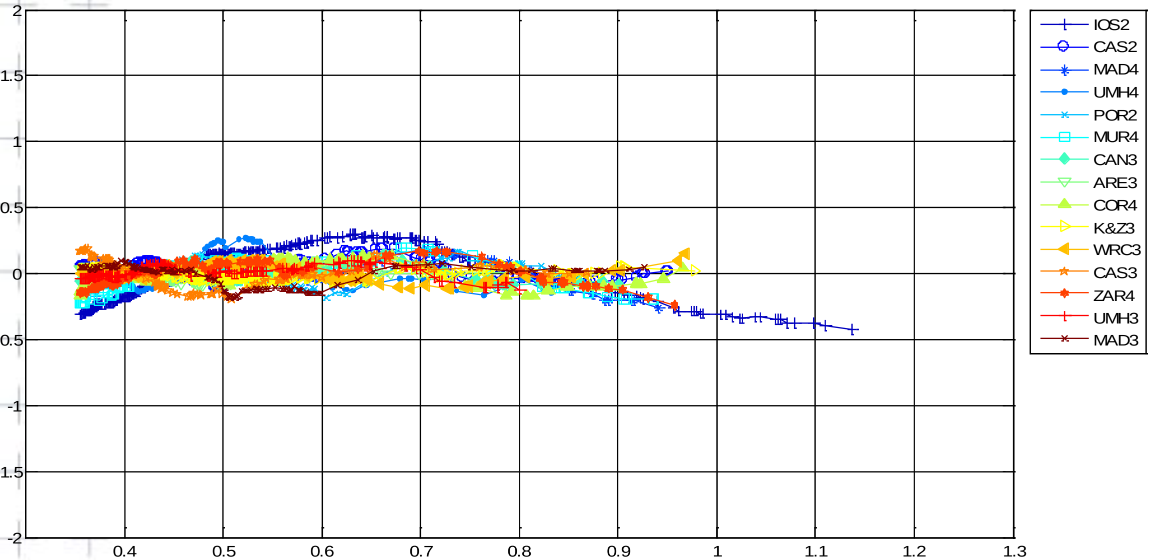
Summary / Conclusions

- A significant number of brewers use two parameters calibration to compensate no linearity's.
- If a proper calibration is use both calibrations are agree, and this agreement can be use as indication of the quality of the instrument.
  - Class I: ETC (+/- 5 units .4% , $o_3$abs +/- 1 step 0.3%)
  - Class II : ETC (+/- 10 units .8%, $o_3$abs +/- 2 step .6%)

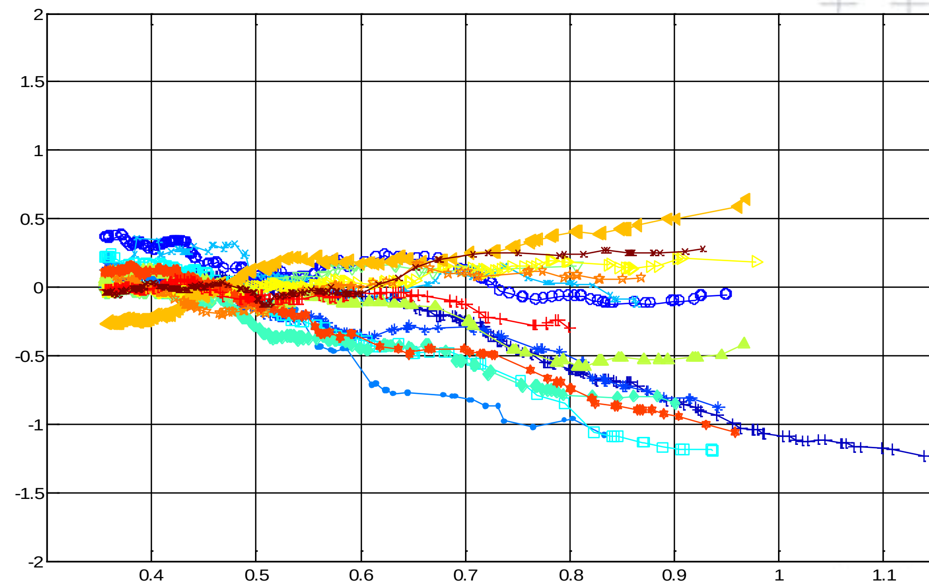
- About 2/3 of the instruments shows an agreement of +/-0.5% after two year calibration.

THANKS !!

II RBCC-E Campaing September 2007
FINAL DAYS 2p Reference Brw#185



II RBCC-E Campaing September 2007
FINAL DAYS 1p reference RBCC-E Brw#185



$$O_3 = \frac{\sum_{i=1}^{4} w_i \cdot \left[Log(F_i) - Log(Fo_i) - AMF_{SCA} \cdot \frac{p}{p_0} \cdot \tau_{SCAi} \right]}{AMF_{O3} \cdot \sum_{i=1}^{4} w_i \cdot \tau_{O3i}}$$

weights w_i	: −1, +0.5, +2.2, and −1.7
Wavelengths	: 310, 313, 317, and 320nm .
Fo	: extraterrestrial count rates.
F	: measured count rates
P_o ,p	: standard surface air pressure /average station air pressure
τ_{SCAi}	: molecular scattering optical depths for each wavelength I at po.
τ_{O3i}	: ozone absorption optical depths for each wavelength i.
AMF_{SCA}	: direct sun air mass factors for molecular scattering
AMF_{O_3}	: direct sun air mass factors for ozone absorption respectively.

$$AMF_x = \sec\left\{ \arcsin\left[\frac{R}{R+h_{EFFx}} \cdot \sin(SZA) \right] \right\}$$

R is the Earth's radius (6370km)
h_{EFFx} is the effective layer height. (It is set to h_{EFFSCA}=5km and h_{EFFO_3}=22km.