Harmonization and assessment of FTIR uncertainty budgets in the EU GAIA-CLIM project

B. Langerock & M. De Mazière

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Project goals

GAIA-CLIM=Gap Analysis for Integrated Atmospheric ECV CLImate Monitoring

Define reference measurement capabilities for TCCON and NDACC

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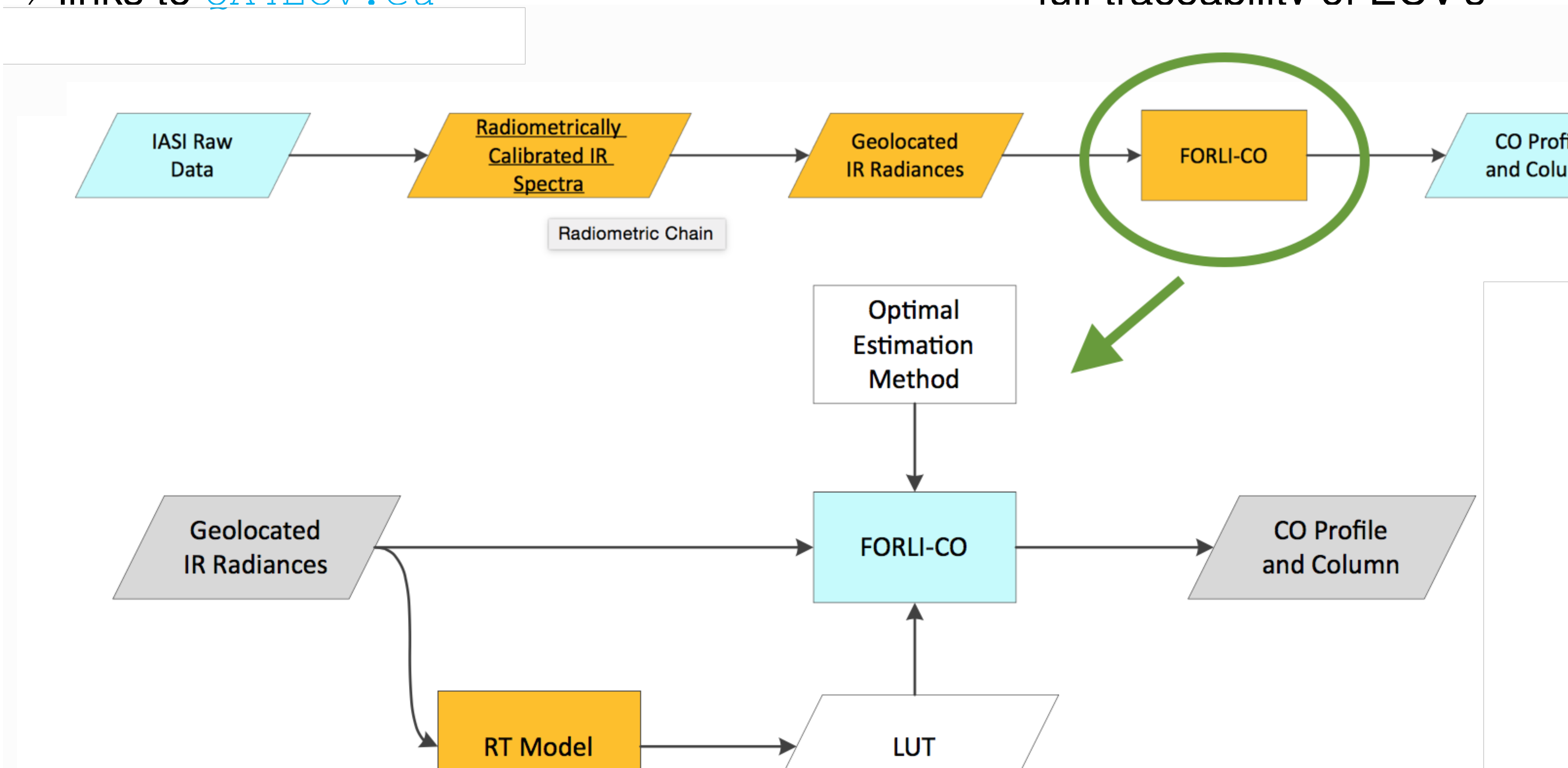
⇒ links to QA4ECV.eu full traceability of ECV's



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In practice

- analyse/harmonize the $\boxed{\text{uncertainties}}$ for NDACC and TCCON, for selected sites for one year
  - temperature, humidity, a priori concentration profiles, spectroscopy
  - TCCON NDACC PROFFIT NDACC SFIT4
- write a paper on retrieval tracebility and uncertainty for O_3, CH_4, H_2O, ...

Harmonize uncertainty calculations

- Rodgers: $\epsilon_r = \left(\hat{A} - I_n\right)\epsilon_a + \hat{G}\left(\delta + \epsilon + \hat{K}_b\epsilon_b\right)$
  - **smoothing uncertainty**: $\left(\hat{A} - I_n\right)\epsilon_a$
  - **measurement uncertainty**: $\hat{G}\epsilon$
  - **forward model uncertainty**: $\hat{G}\delta$
  - **forward model parameters uncertainties**: $\hat{G}\hat{K}_b\epsilon_b$ for each component in b (temperature, SZA, ILS, ...)

uncertainty propagation well known: S_ϵ = random covariance matrix for noise

$$\hat{G}S_\epsilon\hat{G}^T \qquad \hat{G}\hat{K}_bS_{\epsilon_b}(\hat{G}\hat{K}_b)^T$$

- Leading uncertainty sources are also known: for O_3 M. Schneider (2008 ACP), O. García (2012 AMT), C. Vigouroux (2008, 2015 ACP), ...

Table 1. Assumed uncertainties.

error source		random	systematic
phase error		0.01 rad	–
modulation eff.		1 %	–
intensity offset		0.1 %	+0.1 %
T profile	at surface	1.7 K	−3.5 K
	rest of troposphere	0.7 K	–
	at 30 km	1 K	up to +4 K
	above 50 km	6 K	up to −12 K
solar angle		0.1°	–
line intensity		–	−2 %
pres. broad. coef.		–	−2 %

[α] detailed description see text

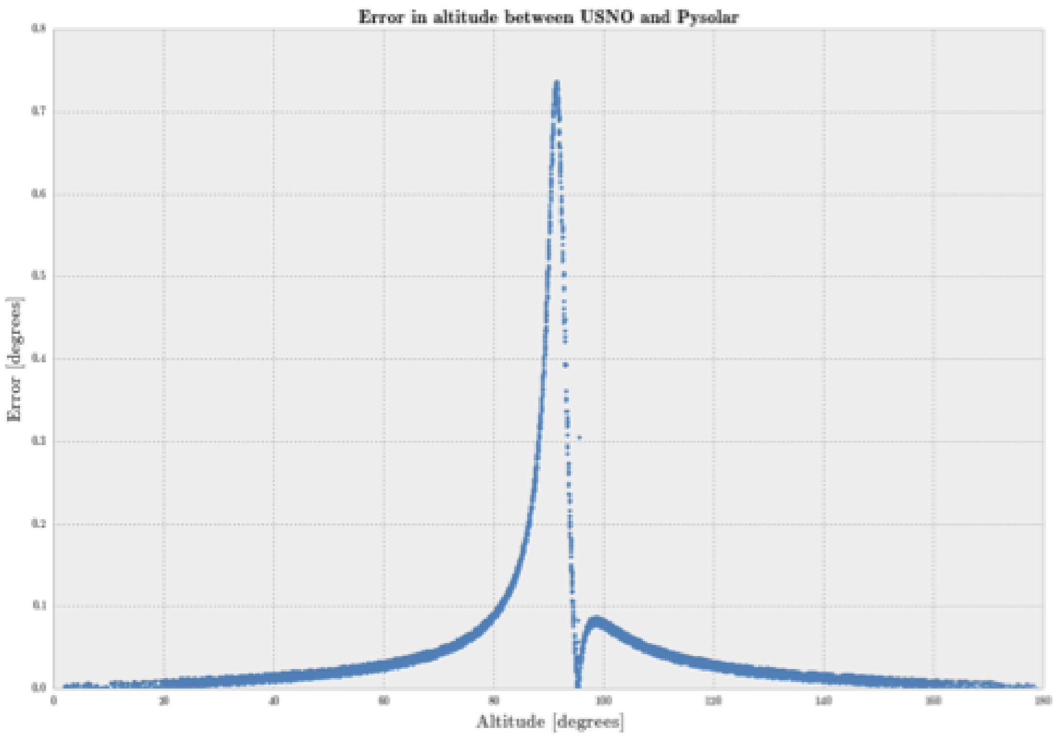
- how are these values determined[α]
- systematic versus random
- how to get covariance matrices for profile parameters

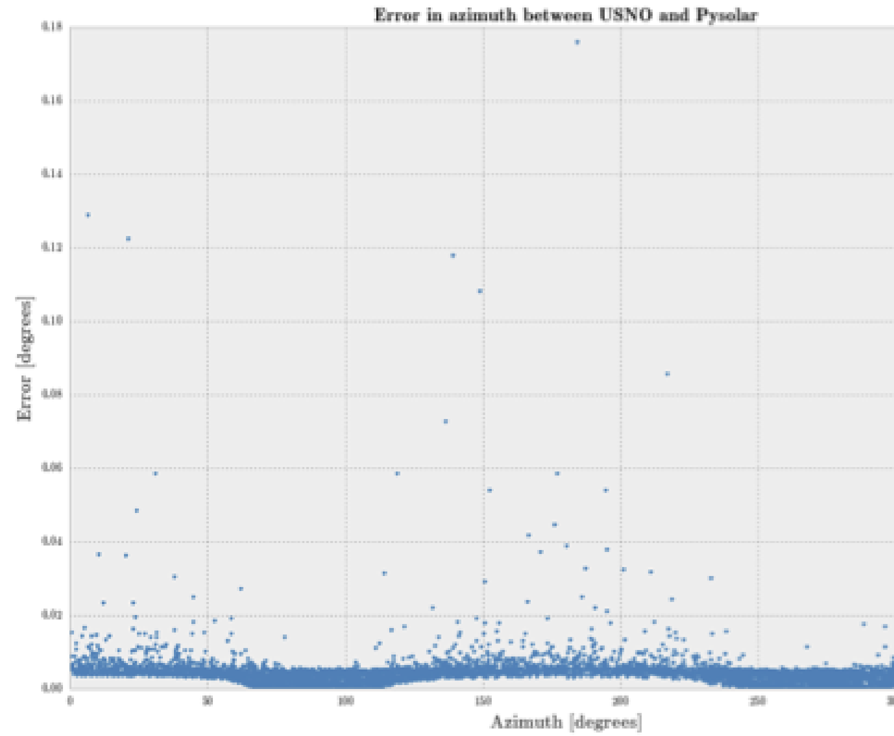
Example SZA calculation

How to estimate the uncertainty for your SZA calculation formula?

general idea: get an ensemble of differences

Example: there is a python module pysolar to calculate solar position.
Compare against US Naval Observatory datapoints...
http://aa.usno.navy.mil/data/docs/topocentric.php#notes





SZA error?

- ▷ Mean error: 0.0736 degrees
- ▷ Standard deviation of error: 0.124 degrees

error ϵ in a parameter is a stochastic variable with a PDF GUM08

Systematic uncertainty = $\boxed{\text{mean of } \epsilon = \mu_\epsilon}$ (no sign!, relates to bias)

Random uncertainty = $\boxed{\text{standard deviation of } \epsilon = \sigma_\epsilon}$

- ▷ Get estimates for μ_ϵ and σ_ϵ using an ensemble of differences
- ▷ Each error contribution has a random and systematic part
- ▷ Random uncertainties decrease $1/\sqrt{n}$ when averaging on n measurements

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Systematic (covariance) uncertainty = μ_ϵ^2

Random covariance uncertainty = σ_ϵ^2

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- ▷ Agrees with the definitions in T. von Clarmann (2014) for smoothing systematic uncertainty

SFIT4 vs PROFFITT

PROFFIT:

- ▷ the input files accepts patterns for the definition of a covariance matrix
- ▷ the resulting matrix is a sum of matrices with a systematic nature (i.e. each pattern determines a fully correlated matrix)...
- ▷ allows systematic matrices as a single pattern input, random matrices can be approximated with (many) different patterns

SFIT4:

- ▷ the uncertainty computation module should be adapted to allow fully correlated matrix ... some work required

TCCON: ?

The next steps

1. process one years data: retrieval strategy?
   - ▷ C. Vigouroux wants to investigate some retrieval settings for O_3
   - ▷ for CH_4 we would like to work with new spectroscopy Darko Dubravica
   - ▷ CO, H_2O ?
2. we would like to invite
   - ▷ Ny Alesund, Bremen, Izana, Reunion, Lauder or/and Wollongong, Thule
   - ▷ others?
3. Write a paper on the retrieval strategy, the uncertainty budgets so that it can be refererred to as the 'reference for the FTIR measurement capability' NDACC and TCCON.