Atmospheric Measurement Techniques Discussions

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Reply on RC1

Pierre Dussarrat et al.

Author comment on "Introduction to the ringing effect in satellite hyperspectral atmospheric spectrometry" by Pierre Dussarrat et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-121-AC1, 2021

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1) In view of the referee's comments, we become aware that the subject of our paper is confusingly introduced by frequent use of the generic term "ringing" (in the title, in the abstract, and in certain sub-sections) for the specific ringing phenomenon we are addressing.

Different kinds of ringing effects, related to instrument physics but also to processing artefacts, occurring in FTIR spectra are quoted as such in literature.

The most common "natural" ringing effect is due to the side lobes in the spectral response of weakly self-apodized FTS. This effect is not a measurement error, but constrains the simulation or inversion of the measurement (eg., handling of negative radiance, width of the spectral response to be accounted for). At the expense of spectral resolution loss, numerical apodisation is an efficient and commonly exploited technique in favour of reduced processing burden and of avoiding processing artefacts.

Artificial ringing effects can be caused by any FFT operation within the processing chain of FTIR measurements through improper smoothing of the band edges. Broadly, these artefacts can be assigned to Gibbs effects.

We agree with the referee that the above-mentioned types of "ringing" are well known and do not need to be introduced again as an article in a scientific journal.

Our paper addresses the residual effect of spectrally variable instrument radiometric transmission on the classically calibrated FTIR radiances. In first approximation, the classical linear two-point radiometric calibration (most commonly: deep space view and warm calibration target) removes the impact of instrument radiometric transmission. We intend to demonstrate the theoretical background of this approximation (sections 2.1 – 2.3), which consists in ignoring the irrecoverable mixing of under-resolved features of the source spectrum with local variations of the instrument transmission during the measurement acquisition. We further intend to illustrate semi-quantitatively the residual

radiance errors after calibration for two common sources of instrument transmission variations:

- Low frequency variation (eg. transmission of optical elements), represented by a linear transmission gradient (sections 2.4, 3.1);
- High-frequency variation (eg. etaloning), represented by a modulation (sections 2.5, 3.2).

In practice, both low and high frequency variations will coexist, or dominate over the other in different domains of the spectral band of interest.

In reply to the corresponding reviewer's remark, etaloning is a major source to the specific ringing effect we are addressing in our paper, and we know already about its criticality in the radiometric accuracy budget of future missions.

To clarify the purpose of our paper and to avoid any confusion, we propose to include the discussion of the ringing terminology as provided above in the introduction (section 1), and to clearly identify the effect we are addressing, throughout the entire paper (title, abstract included), with the original term "Calibration Ringing" in replacement of the admittedly misleading and ambiguous term "Ringing".

2)

"Calibration Ringing" is, as mentioned, unavoidably linked to the interferogram acquisition. As such, it is not unknown since long ago, but its effect was generally negligible in past EO missions based on spaceborne IR interferometry.

We see two reasons why this is changing:

- Increasing radiometric requirements (in particular radiometric accuracy) and increasing NRT processing requirements.
- Advent of more and more sophisticated FT spectro-imager concepts, acquiring simultaneously up to thousands of interferograms with considerable spatial coverage.

While "Calibration Ringing" becomes a more and more critical contributor to the radiometric error budget, its handling, if uncorrected, requires the radiometric transmission to be explicitly considered by users of the calibrated L1 radiance product. In practice, this means that each detector of a spectro-imager has to be processed as a self-standing instrument (eg. for fast radiative transfer models), which is considered as unfeasible by the user community, all the more in view of NRT processing (and the potential need to update relevant instrument characteristics in case of temporal instability).

The user requirement to process FTIR measurements independently of any detector dependent instrument characteristics is thus further enhanced for multi-detector FT instrument concepts.

To our knowledge, the effect of "calibration ringing" was not considered in the processing of the (mono-pixel) solar occultation and passive limb sounding interferometer missions mentioned in the reviewer's comment. In the case of IASI (vertical sounding, 2 by 2

detector arrays), “calibration ringing” is considered as irrelevant with respect to radiometric requirements; the instrument radiometric transmission is neither used in the spectral processing, nor it is communicated to the users.

To clarify this point, we propose to introduce a short discussion about the inclusion of SRF distortions in the L2 applications in parts 1 and 2.2.

3)

We intend to introduce a substantial effect that was negligible in past FTIR Earth observation missions.

The present paper is indeed meant to be pedagogical; we try providing a theoretical formulation and illustrating the propagation into the radiometric error budget, illustrated by simple examples (gradient and modulations) without explicit link to any particular FTIR mission.

In this context, we agree with the specific reviewer’s comment about the critical assumption of a wavenumber independent apodisation function. We also agree that this wavenumber dependence is well mastered in current and future operational FTIR processing schemes and therefore felt that a more detailed discussion of this issue would have a distracting effect.

Based on the generic description of the Calibration Ringing effect provided in the present paper, we are preparing a follow-up manuscript addressing the impact of Calibration Ringing, as well as correction schemes.