Optical degradation in TROPOMI

E. Loots[1], M. van Hoek[1], J. Leloux[1,2], A. Ludewig[1], E. van der Plas[1], N. Rozemeijer[1,2], S. Spronk[1,2], P. Veefkind[1]

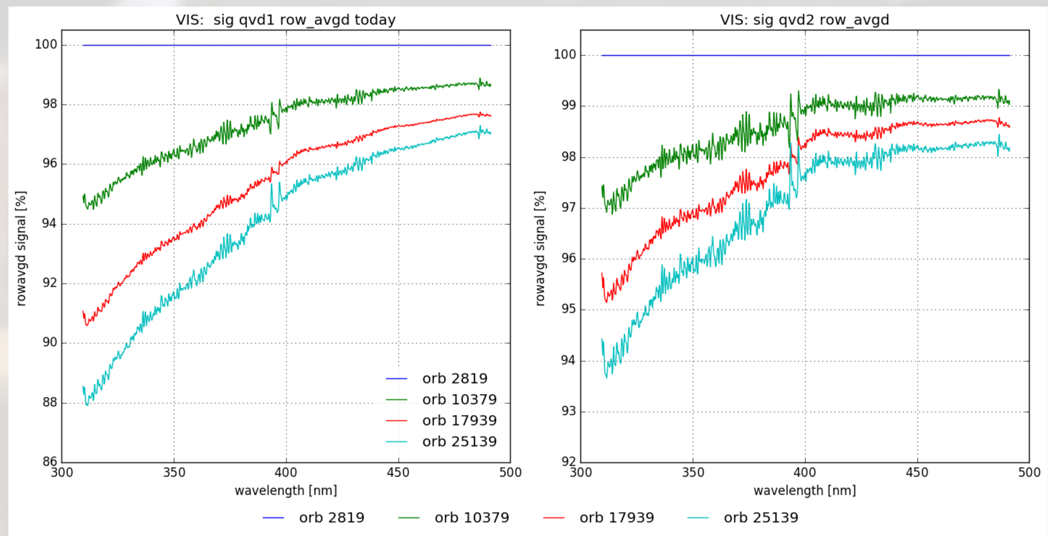
[1]Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands; [2] TriOpSys B.V., Utrecht

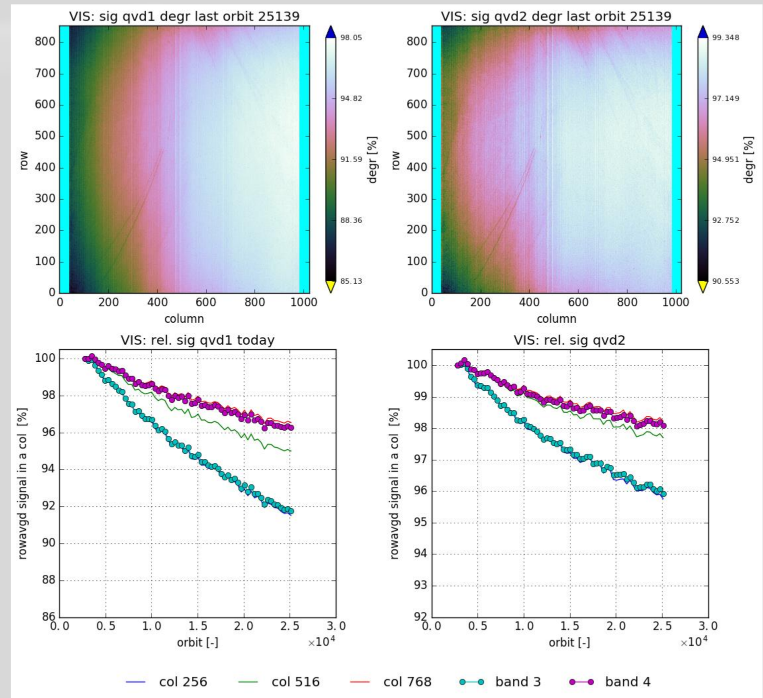
Summary

- Irradiance measurements show that optical degradation occurs in (ir-)radiance spectral paths.
- The degradation is modeled an converted into several degradation component CKDs.
- These temporal CKDs, based on past measurements, are also used by the L01b Processor to correct for degradation in *current* (ir-)radiance measurements.
- Continuous assessment of the quality of the degradation model combined with availability of more recent measurements facilitate timely updates of the CKDs.

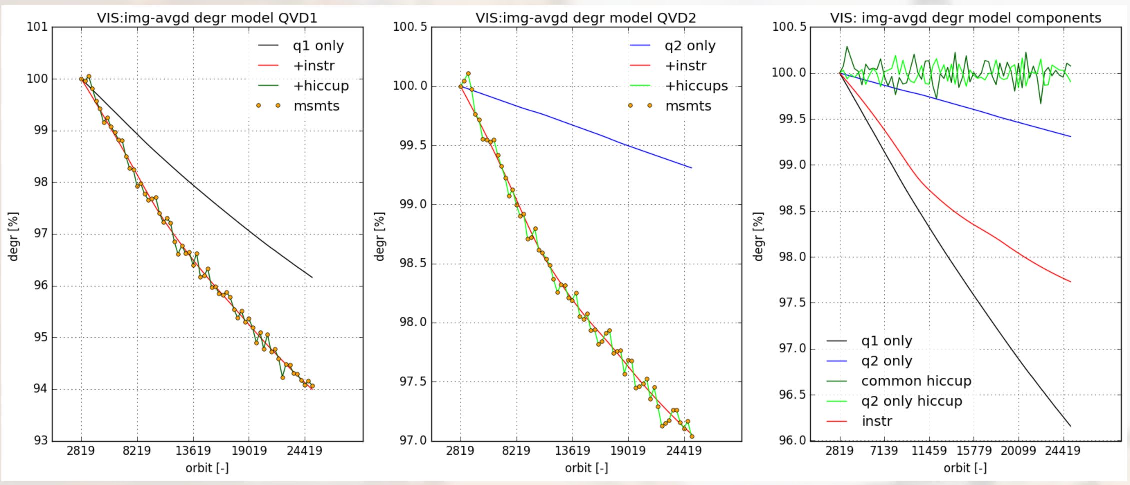
1. Optical degradation from irradiance measurements

Daily (QVD1 diffuser) and weekly (QVD2 diffusers) Sun port measurements show drift w.r.t first E2 orbit.

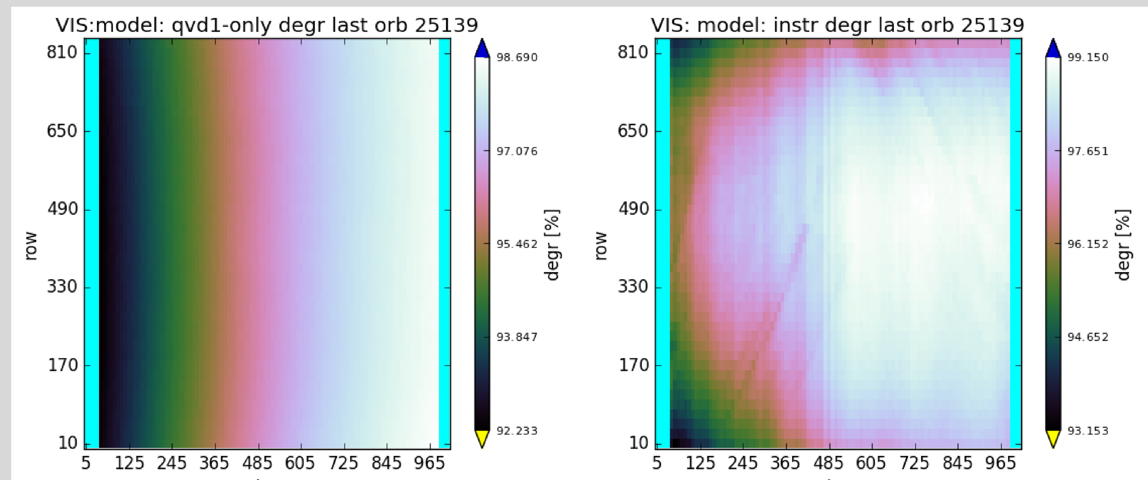




2. Modeling the degradation

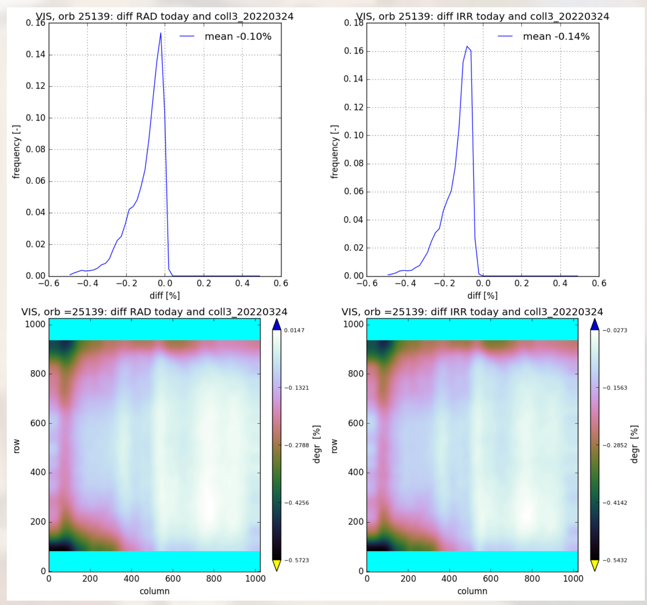


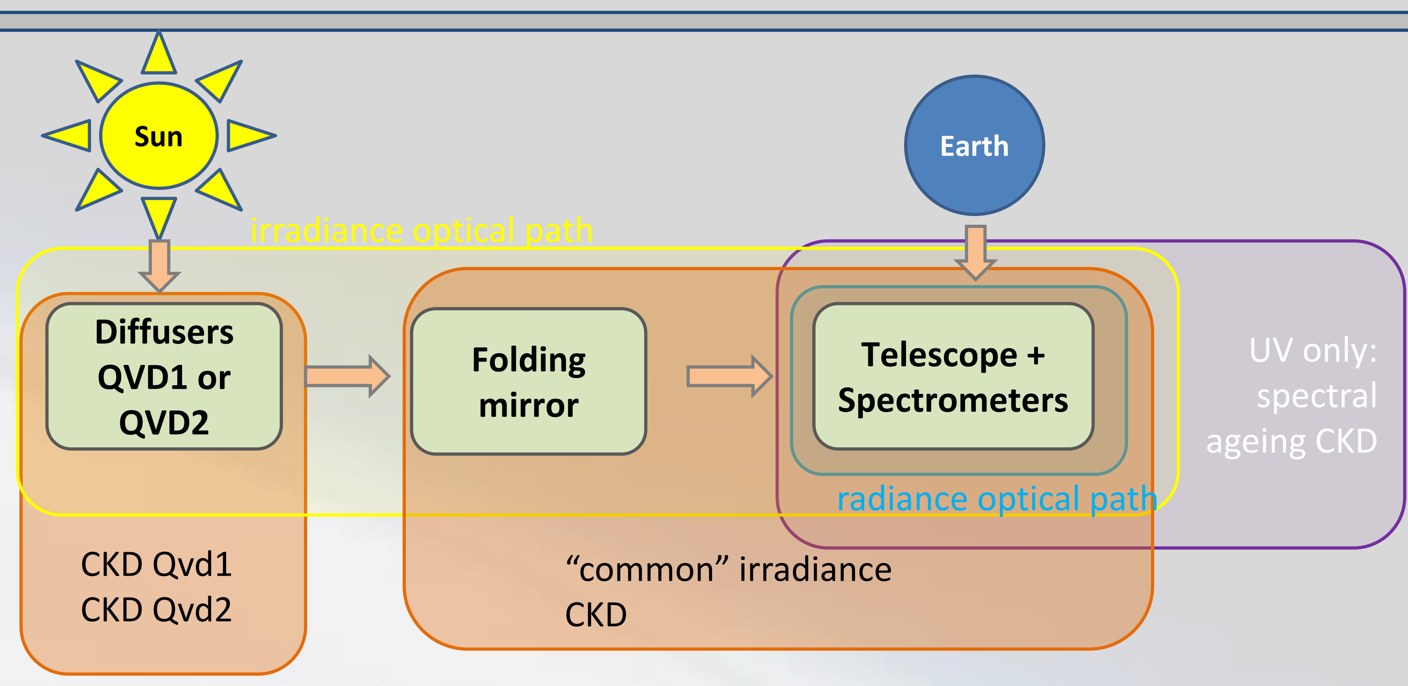
The measured total degradation is the sum of components identified by the optical paths.
Combining QVD1 and QVD2 measurements enables us to separate 'diffuser' part from 'common' part.
Per detector pixel, a simple decay model allows to decompose measurements in three parts: diffuser, common instrument, and temporal residual ('hiccup').
Spatial/spectral smoothness is not prescribed, but is emerging from the data.



3. From model to CKD

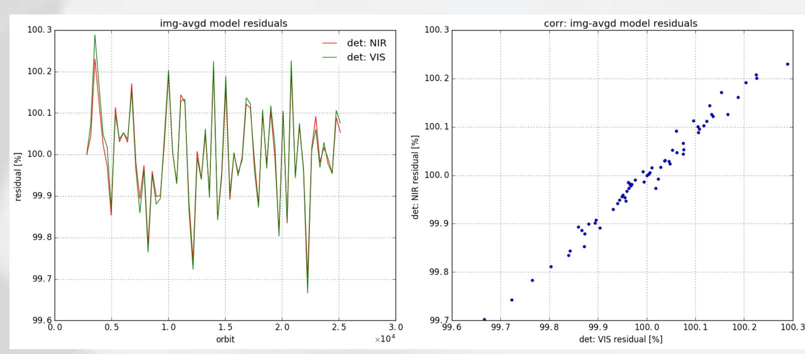
The diffuser and instrument model components can be evaluated for all past orbits and lead directly to temporal CKDs (smoothed image defined along an orbit axis).
The L01b Processor *uses model extrapolation* to estimate degradation for newer orbits. Regular updating of the CKD (i.e. remodeling the degradation using the expanded time series) is necessary.
Shown on the right is a typical off-line comparison between current CKD ('coll3') and update candidate CKD (including all measurements up to today).

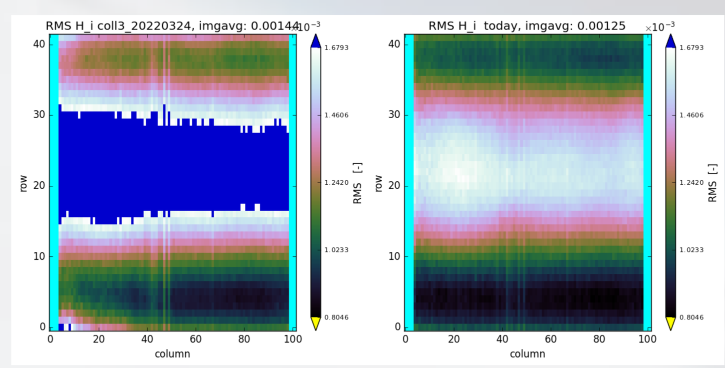




The optical paths and the associated CKDs. Note the 'common' component is shared by the irradiance and radiance paths.

- The model residuals are spectrally and spatially smooth.
- They represent nondeterministic instrument behaviour and are therefore not modeled.
- The residuals of the VIS and NIR detectors are highly correlated. Similarly, UV and SWIR residuals are correlated.
- Features in residuals reveal model lack-of-fit problems, necessitating improvements in the model and, consequently, an update of the CKDs.



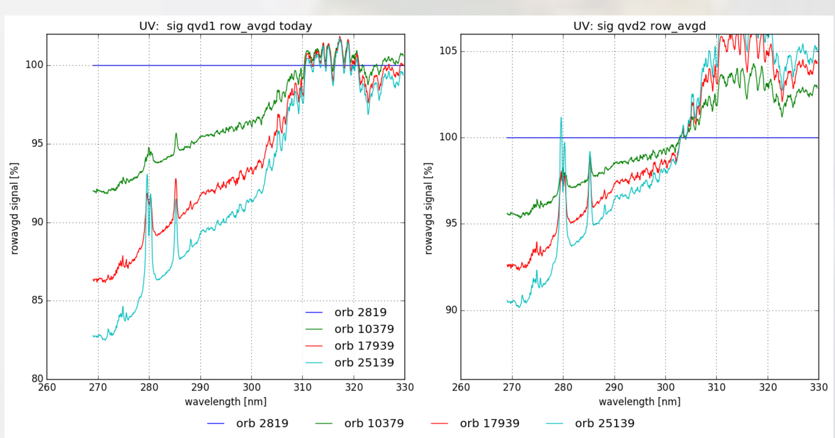


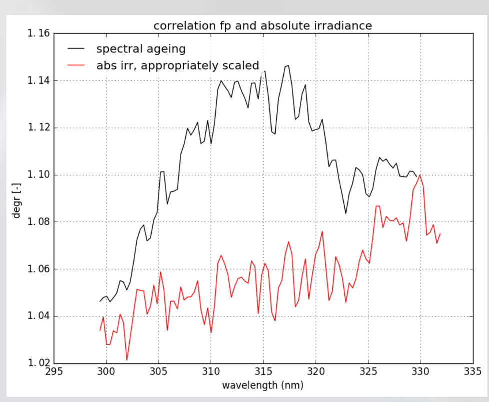
Residuals in time of different detectors are coupled. Spatial/spectral features may question the model.

4. The UV detector special case: spectral ageing

i. measurements

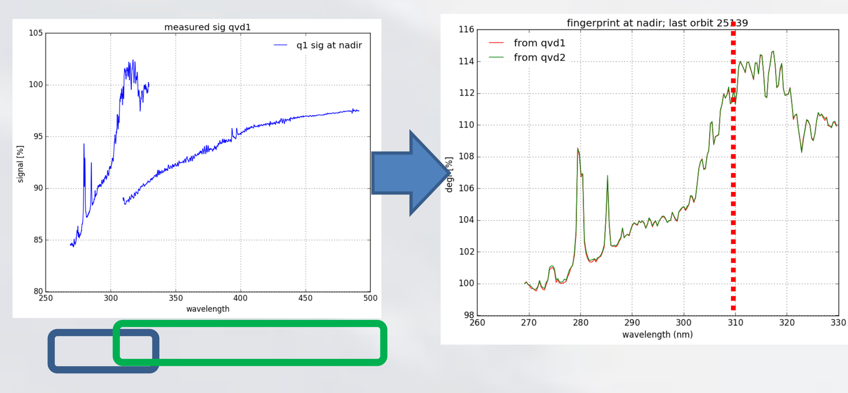
- Measurements show degradation with strong spectral features
- Features correlate with solar spectrum
- "Bleaching" – signal *increases* over time (partly counteracting degradation).
- Coating of detector or lens before detector suspected



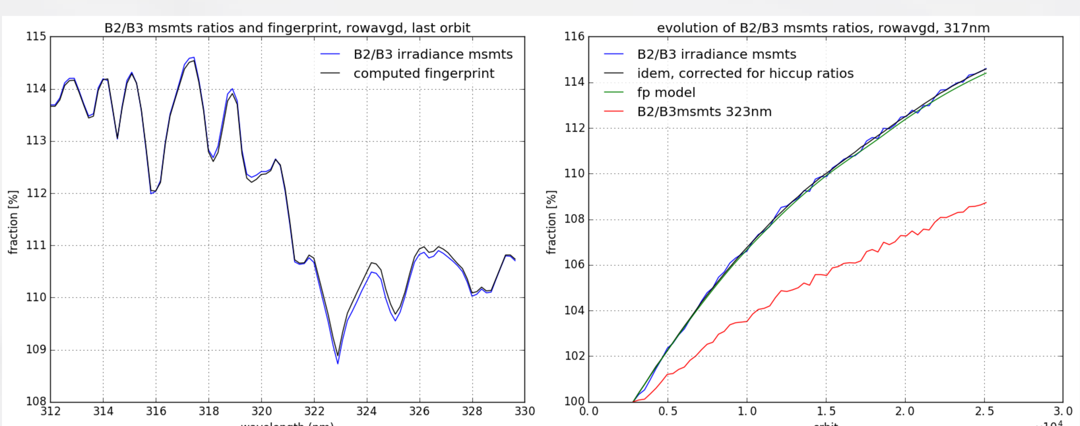


ii. modeling

Strategy: model this additional feature by separating it from the instrument degradation component.
The ageing effect is *measured* in the Band2-Band-3 overlap (312-330nm), and *modeled* for the entire UV detector.

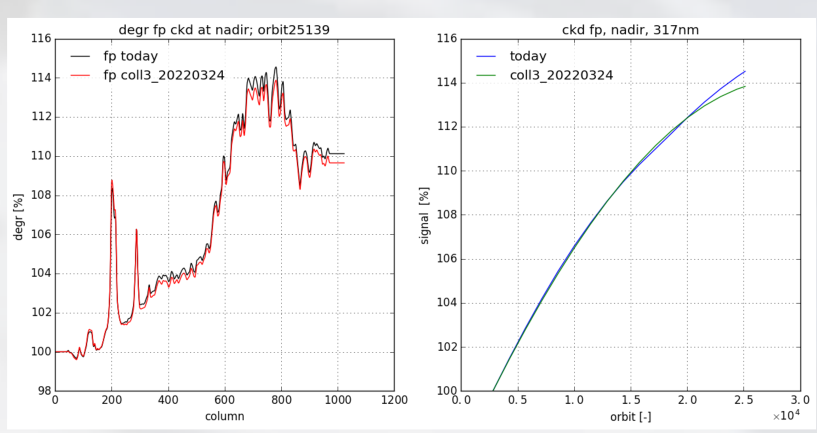


Left: Measurement in UV and VIS; Right: model component in UV detector



iii. evolution

- The spectral ageing model for UV coincides with B2/B3 ratio measurements. Now > 14%.
- Growth of the feature is decreasing, but less fast according to most recent data, again necessitating an update of this CKD component (extrapolated green line ('coll3') vs recent blue line ('today')):



5. Concluding remarks

- Irradiance measurements show that optical degradation occurs in (ir)radiance spectral paths.
- The degradation is modeled and converted into several degradation component CKDs: QVD1, QVD2, common instrument, spectral ageing.
- These temporal CKDs, based on past measurements, are also used by the L01b Processor to correct for degradation in *current* (ir-)radiance measurements.
- Radiance measurements are corrected with common instrument CKD and spectral ageing CKD.
- Daily irradiance measurements are corrected with QVD1 CKD, common instrument CKD and spectral ageing CKD.
- Continuous assessment of the quality of the degradation model combined with availability of more recent measurements facilitate timely updates of the CKDs.

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management

Netherlands Institute for Space Research