

Potential of high-resolution multispectral optical missions for the monitoring of methane point emissions.

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Landsat 8 (L8) and Sentinel 2 (S2) operational multispectral missions with spatial res. of 20/30 m, 5-16 days revisit time.

WorldView-3 (WV-3) is a commercial mission with 3.7 m spatial res. in the SWIR and pointing capabilities.

WV-3 detection in Turkmenistan with 4 plumes coming out of a pipeline on 29th March 2021

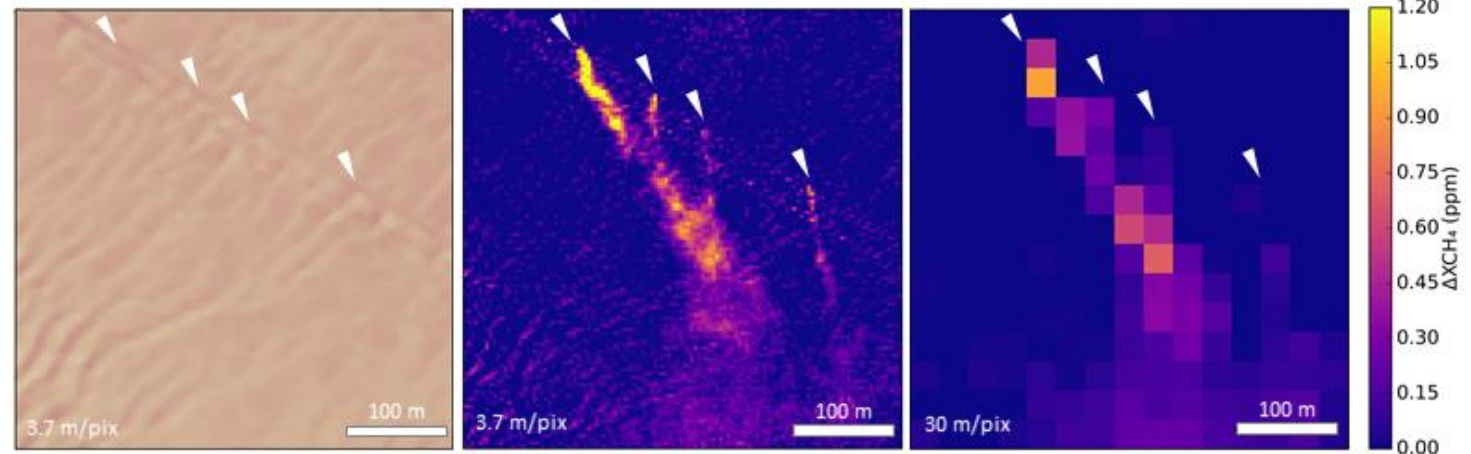


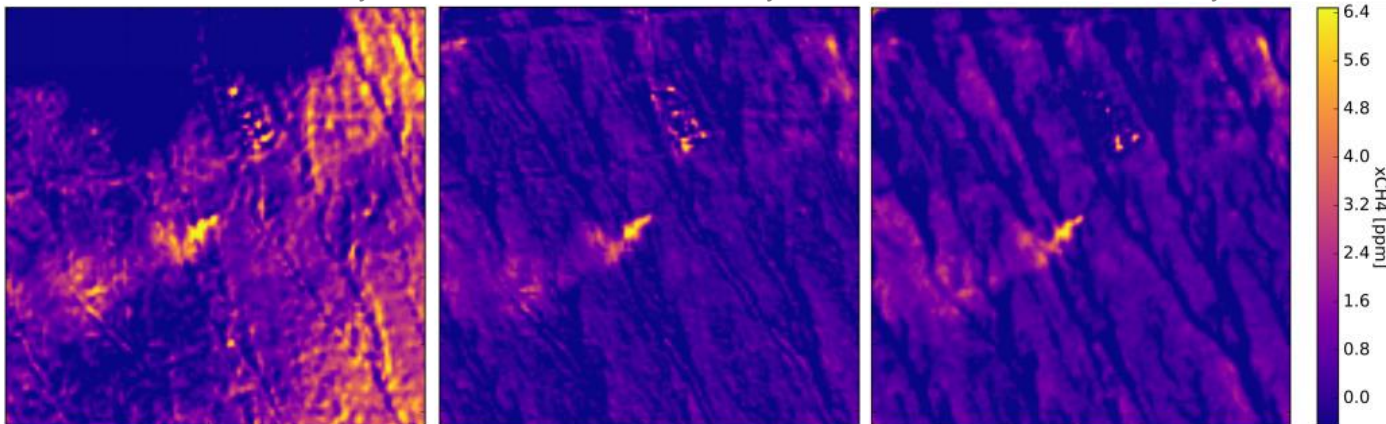
Figure from Sánchez-García *et al.* (in prep.)

S2A detection over Kopeje (Turkmenistan) on the 9th of May 2021

Reference: L8 10th May

Reference: S2B 14th May

Reference: S2A 19th May



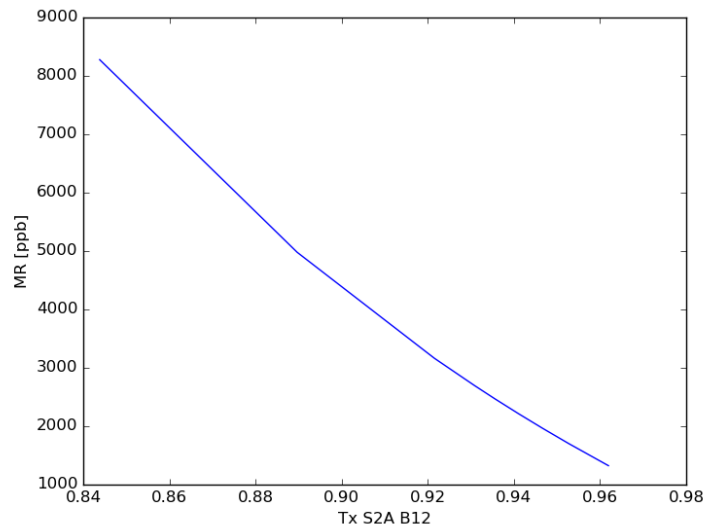
Multispectral missions contain bands in the SWIR methane absorption region that can be used to detect methane point emissions. Combining L8 and S2 provide excellent revisit times (<5 days). WV-3 can detect small methane plumes at request.

Retrieval methodology

Multispectral missions contain methane-sensitive bands in the SWIR (B7/B8 WV-3, B12 S2 and SW2 L8) that can be used to detect and quantify emissions.

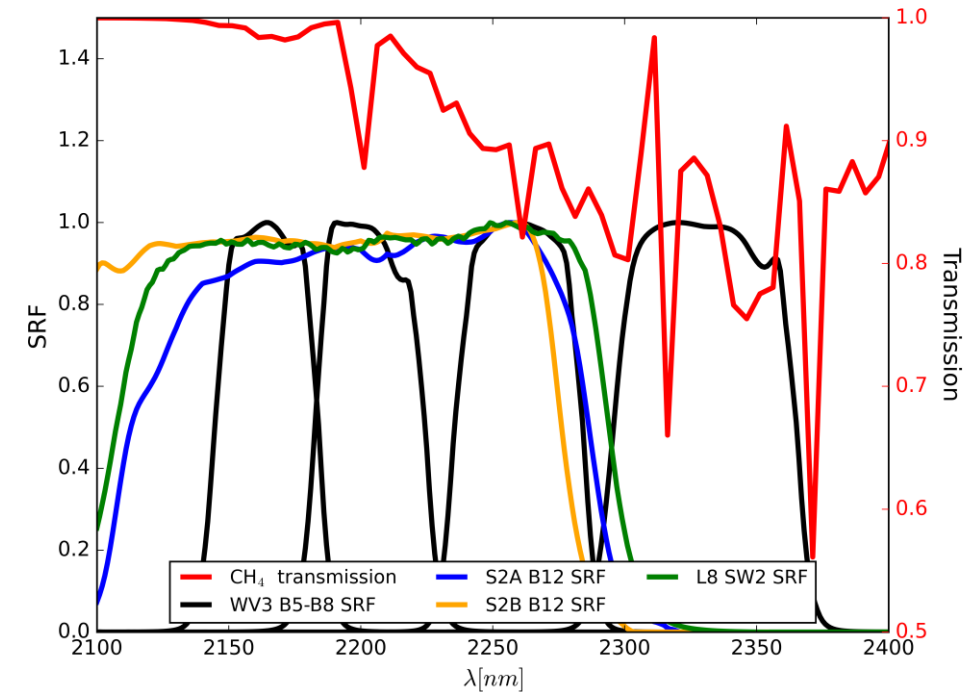
Retrieval obtains a methane enhancement map ΔCH_4 with two methodologies similar to Varon *et al.* 2020:

- Multispectral. A multilinear regression of the bands not affected by methane defines a plume-free band based on sparsity.
- Multitemporal. A methane-sensitive band on a day with no emission is taken as a reference.

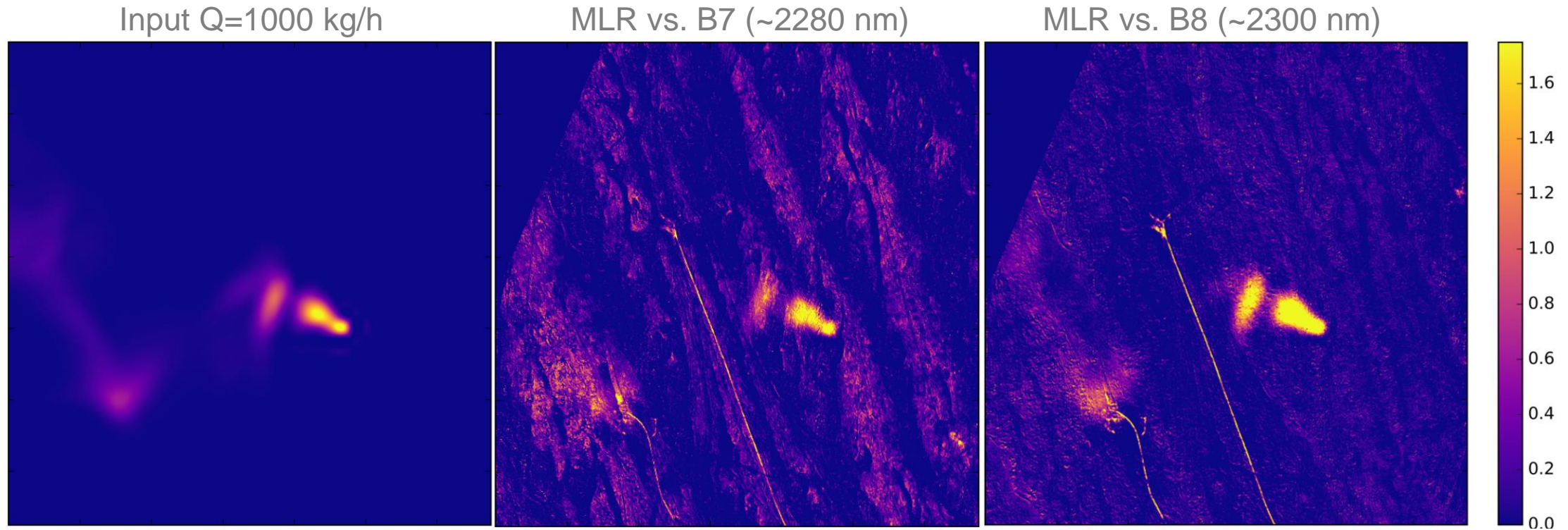


Relates transmission to methane abundance based on Beer law $\log(T)=f(X\text{CH}_4)$.

Methane enhancement map is converted into flux rates Q [kg/h] based on the Integrated Methane Enhancement (IME) method as in Frankenberg *et al.* 2016.



Methane retrieval methods in the spectral dimension



WV-3 detection based on a multiple linear regression (MLR) of B7/B8 against non-methane sensitive bands. B7 is spectrally closer band to the non-methane regions.

Lower sensitivity compensated with Time-Delay Integration (TDI). E.g. WV-3 TDI 16 acquisitions
Narrow bands with narrow spectral distance, optimum band registration and high SNR minimise the heterogeneity impact.

Methane retrieval methods in the temporal dimension

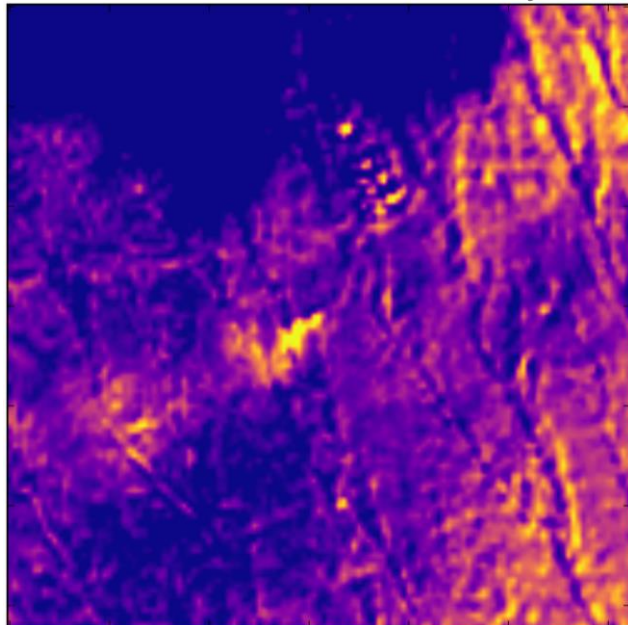
Possibility to combine L8, S2A and S2B for methane detection; <5 days revisit time; $Q > 1500$ kg/h depending on scene & wind conditions.

S2 refined geolocation and L8 collection 2 facilitate the collocation between satellites.

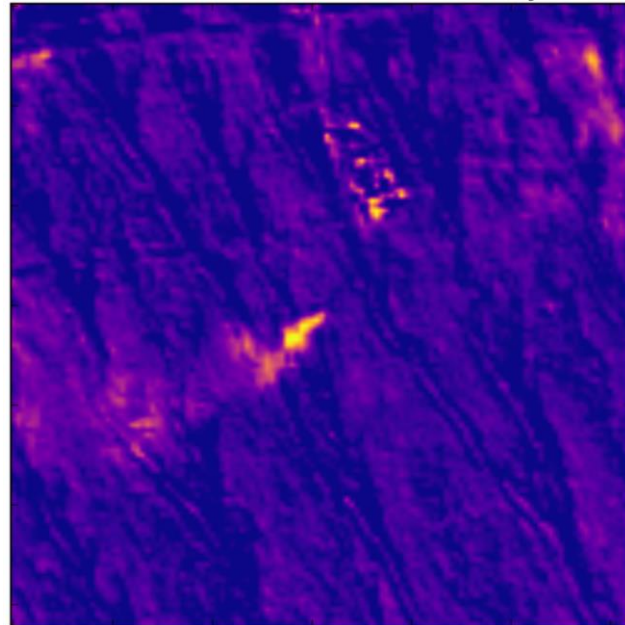
Study on-going to assess spectral, angular and spatial mismatch.

S2A detection over Kopeje (Turkmenistan) on the 9th of May 2021

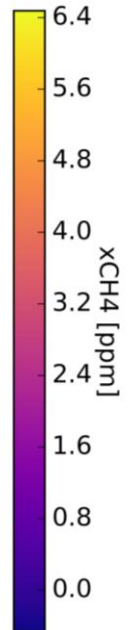
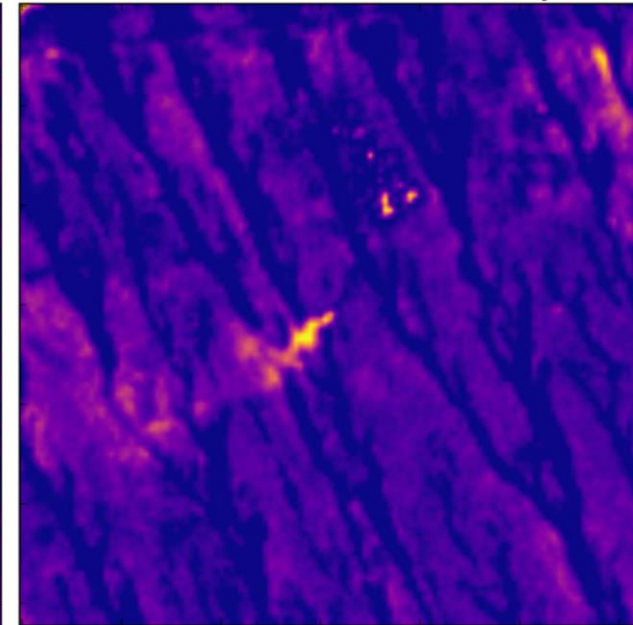
Reference: L8* 10th May



Reference: S2B 14th May



Reference: S2A 19th May



*L8 scene includes cirrus and cirrus shadows.

Unveiling detailed methane plumes with WV3

WV-3 delivers SWIR bands at 3.7 m spatial resolution.

This incomparable spatial resolution can detect the smallest features; $Q > 500$ kg/h depending on scene & wind conditions.

The WV-3 image shows the detection of 4 independent plumes in an oil pipeline in Turkmenistan.

These plumes are detected as a single one if scaled to L8 30 m spatial resolution.

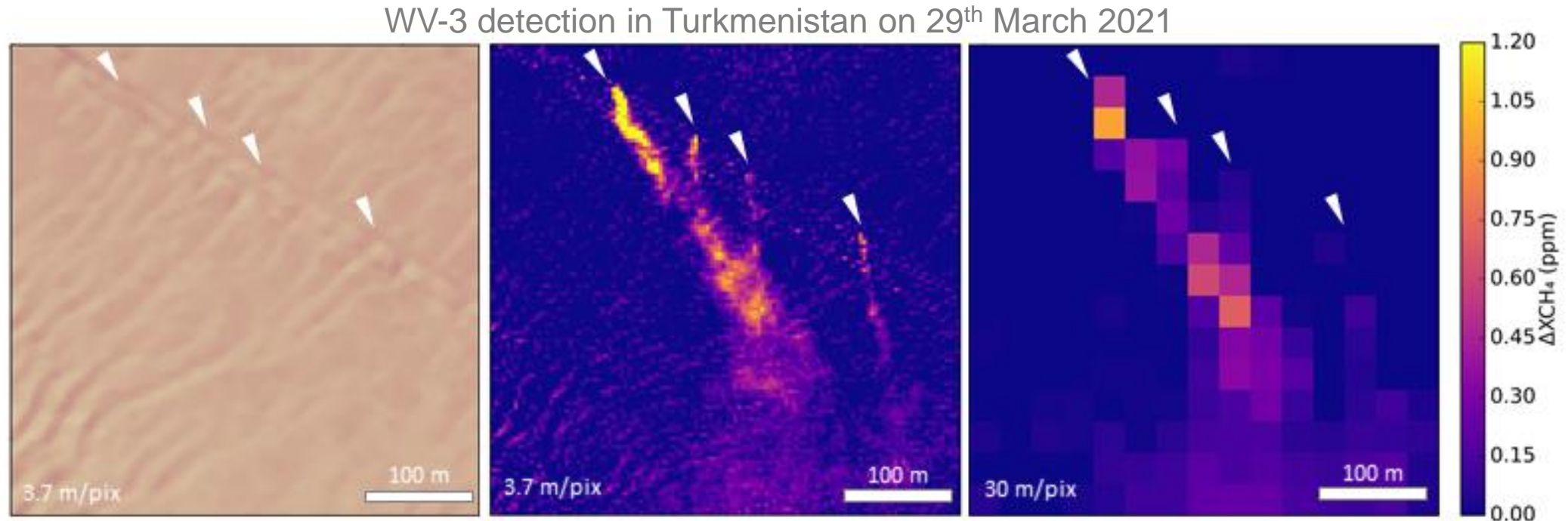


Figure from Sánchez-García *et al.* (in prep.)

Multispectral missions to support the global monitoring of methane point emissions.

- Multispectral missions such as S2, L8 and WV-3 contain methane-sensitive bands in the SWIR region that can be used to detect and quantify emissions.
- They can provide a **high temporal resolution** by combining L8 and S2 missions, **lower spatial resolution** capable of retrieving detailed methane plumes.
- The design of multispectral missions can be optimised for methane detection by introducing TDI stages (**high SNR**) and narrow and spectrally close bands (to maximise **spectral correlation**).