DEFENCE R&D DÉFENSE

Standoff Detection and Identification of Nuclear Materials by Passive FTIR Radiometry

Eldon Puckrin, Jean-Marc Thériault, Hugo Lavoie, Tracy Smithson
Optronic Surveillance Section, DRDC Valcartier, Québec, Canada

Q.S. Bob Truong
Canadian Nuclear Safety Commission, Ottawa, Canada

International Safeguards Workshop
Advanced Sensors for Safeguards, 23 - 27 April 2007

Defence Research and Development Canada | Recherche et développement pour la défense Canada

Canada

Outline

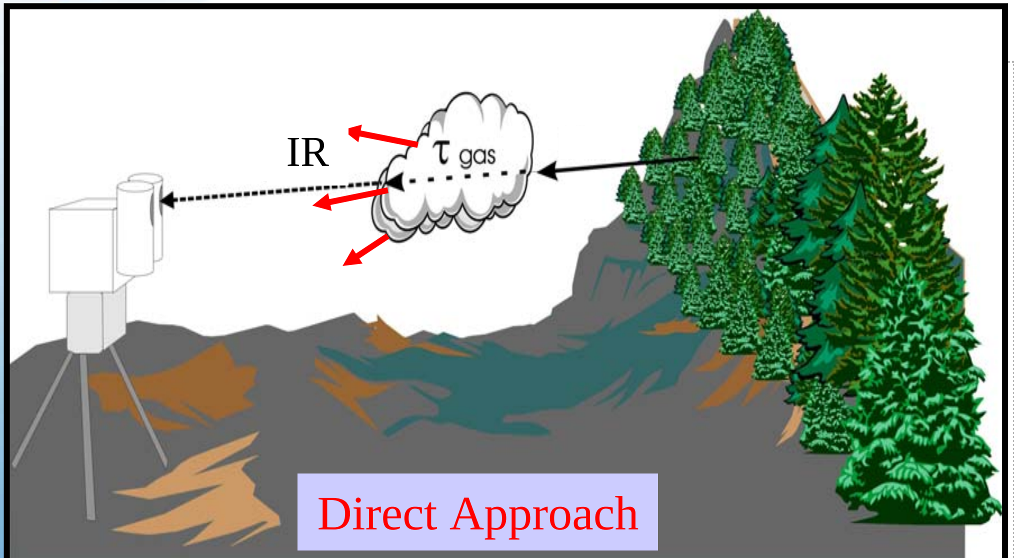
- Passive standoff detection approach for chemical vapour detection
- Signature (fingerprint) measurements of radiological materials
- Simulation of the passive standoff detection of radiological materials
- Standoff detection and identification of radiological materials through passive FTIR radiometry
    - ➢Ground based
    - ➢Airborne
- Future direction

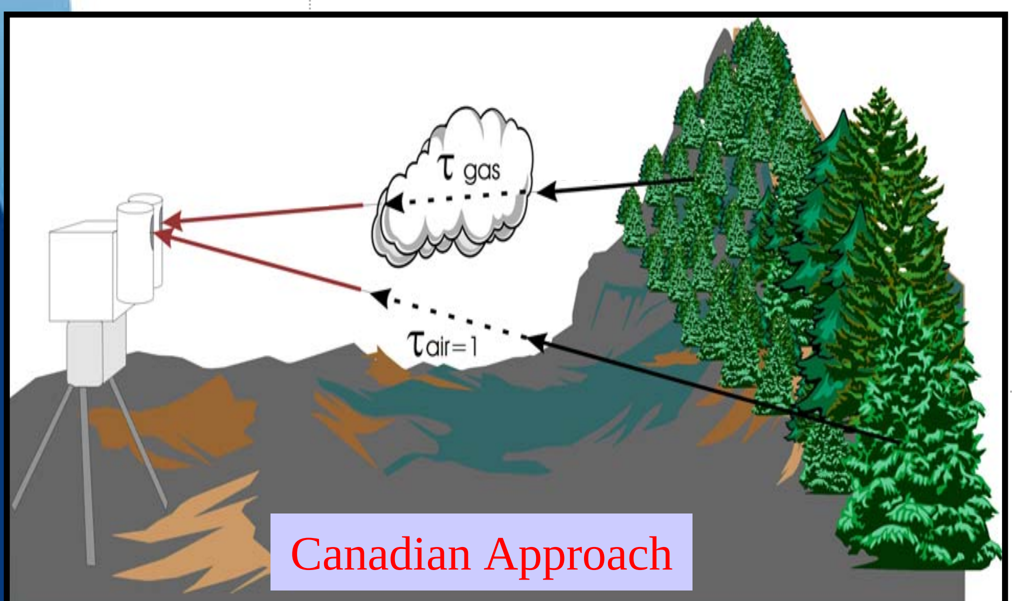
Passive standoff detection approach

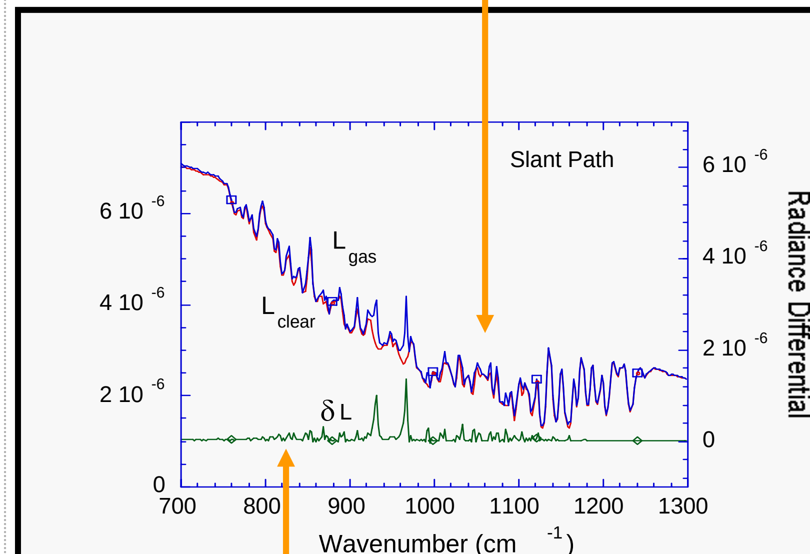
(Chemical Vapours)

Direct vs Differential Detection

Spectroscopy





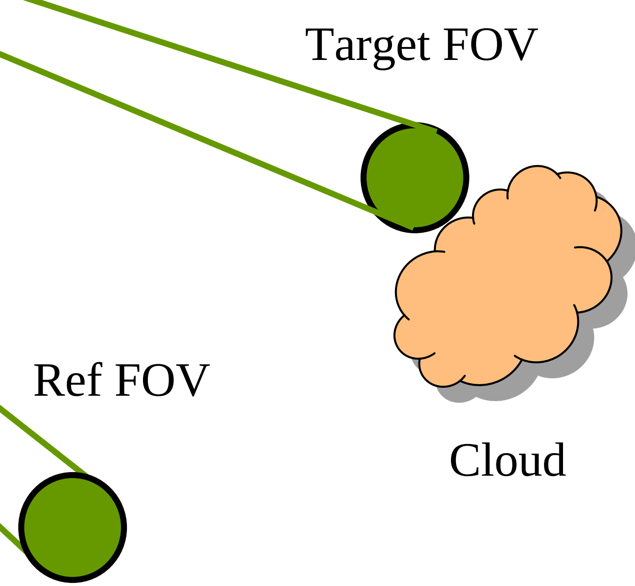


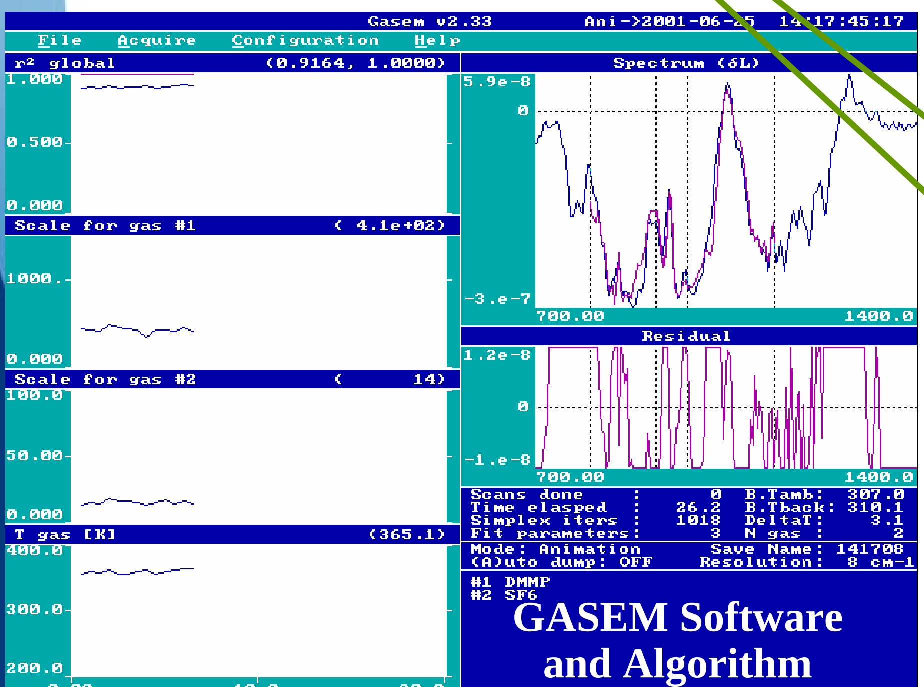
$$L_{gas} - L_{clear} = \left(1-\tau_{gas}\right)\left[B_{air} - L_{clear}\right]$$

CATSI – Differential Detection

Compact ATmospheric Sounding Interferometer

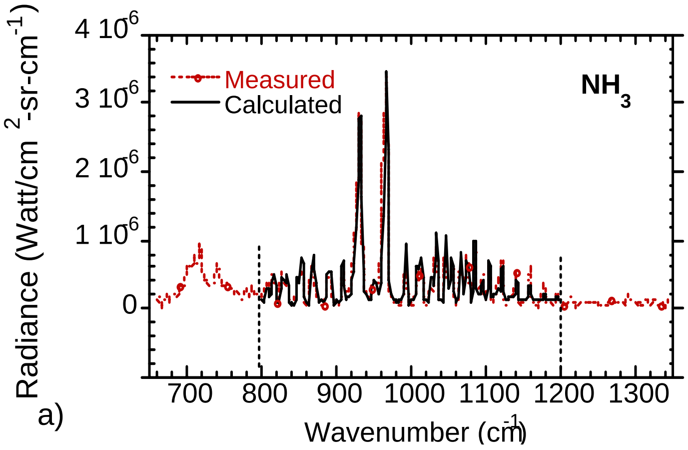
- Double input-beam FTIR
- Spectral Band: 7 - 14 µm
- MCT Detector
- Spectral resol’n: 1 - 64 cm^{-1}
- 4-in telescopes
- FOV (8 mrad)



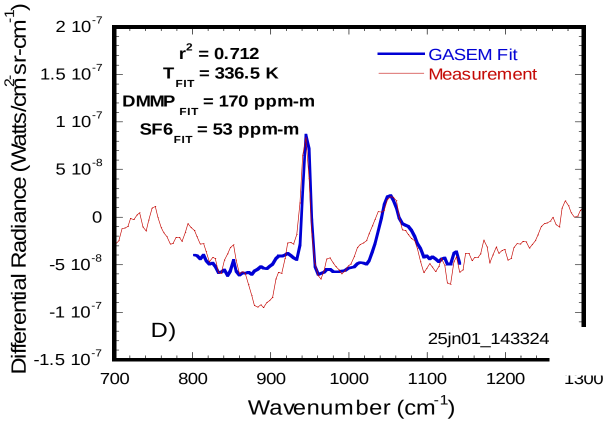


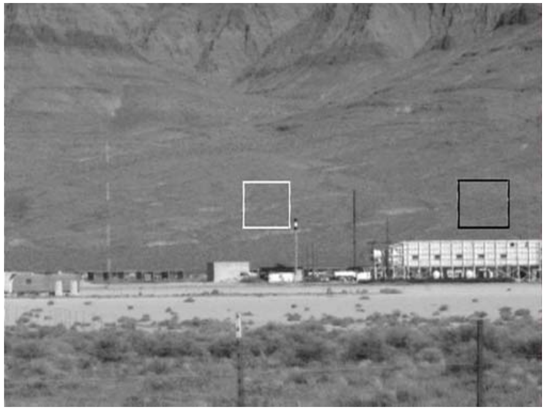
Trials and Milestones

Range = 105 m



Range = 1.5 km





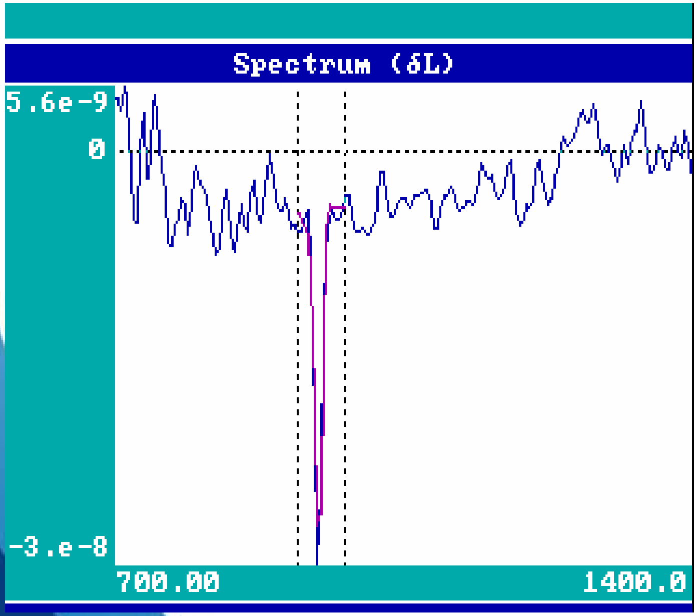
Fort Riley, Kansas, Sept 1998

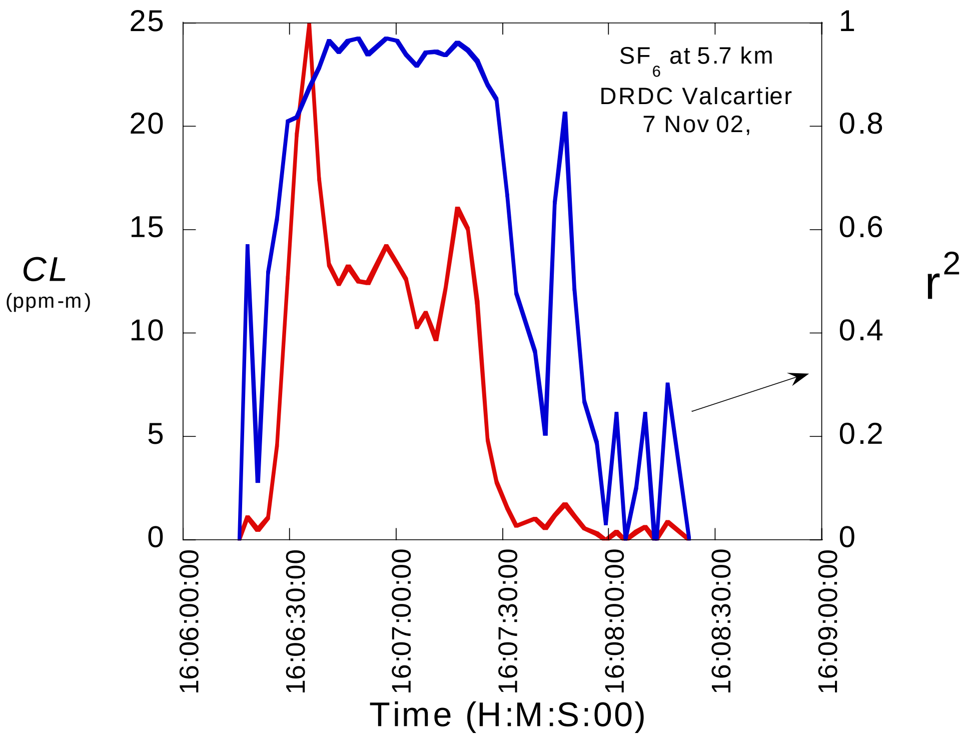
Nevada Test Site, June 2001

Open-Air Range, DRDC Valcartier

SF_6 Detection

Range = 5.7 km



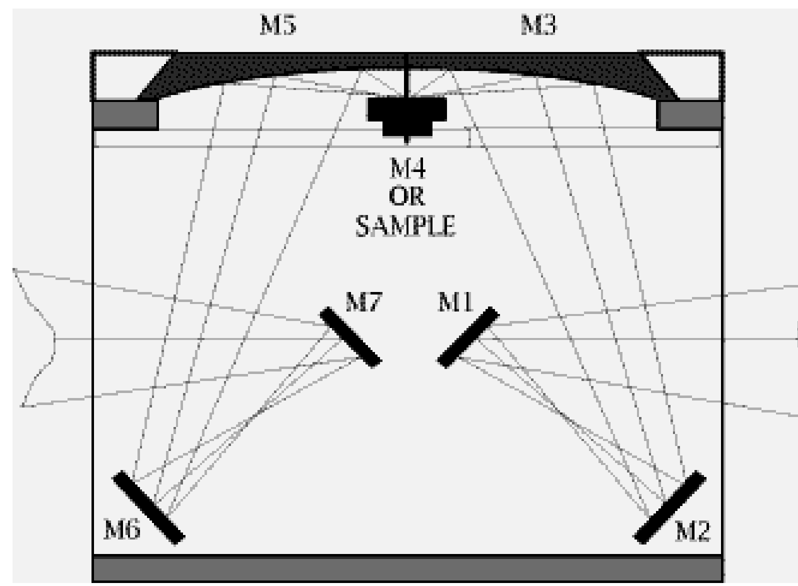


Signature (fingerprint) measurements

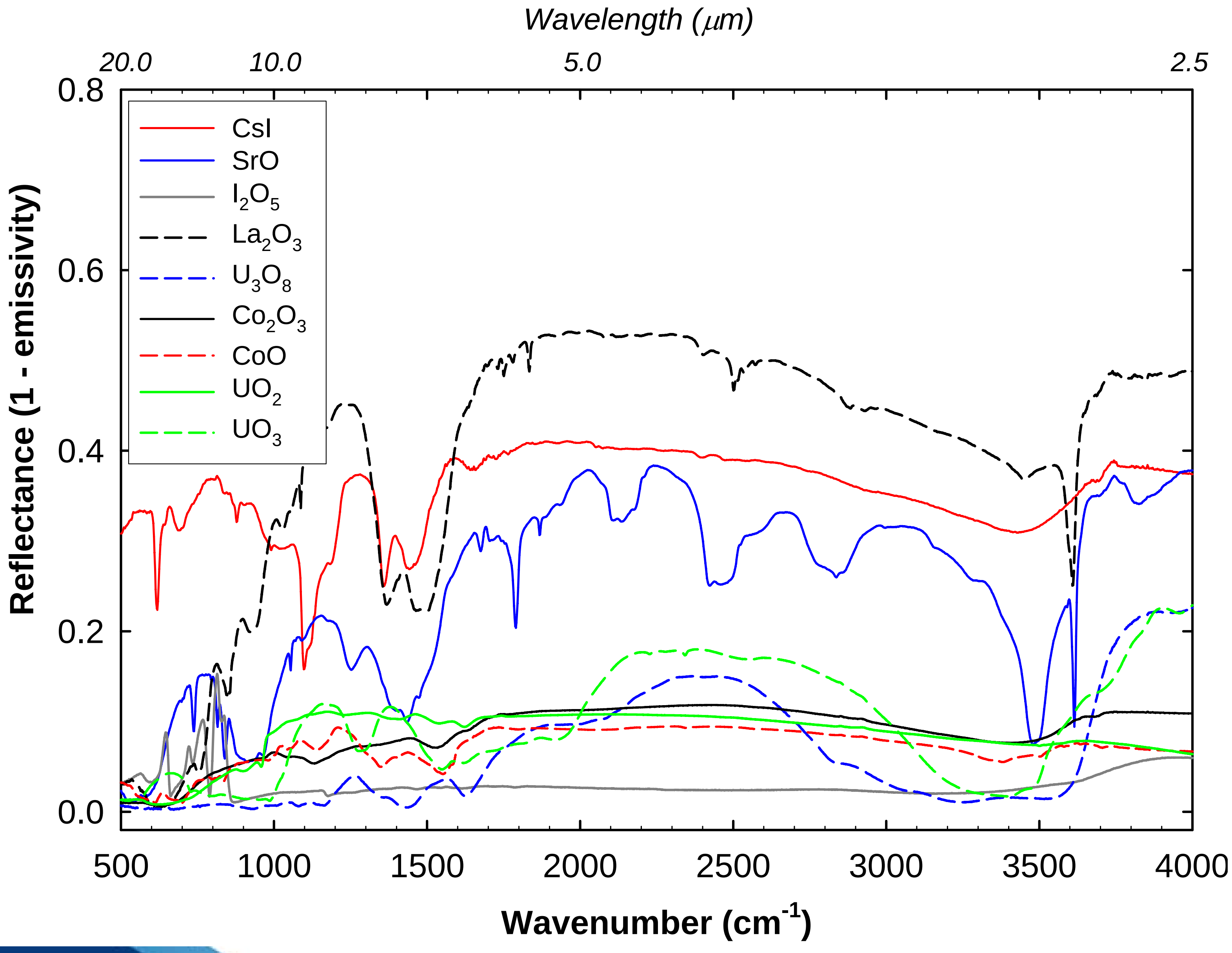
Laboratory Spectral Reflectance Measurements

FTS 3000 (Digi-lab)

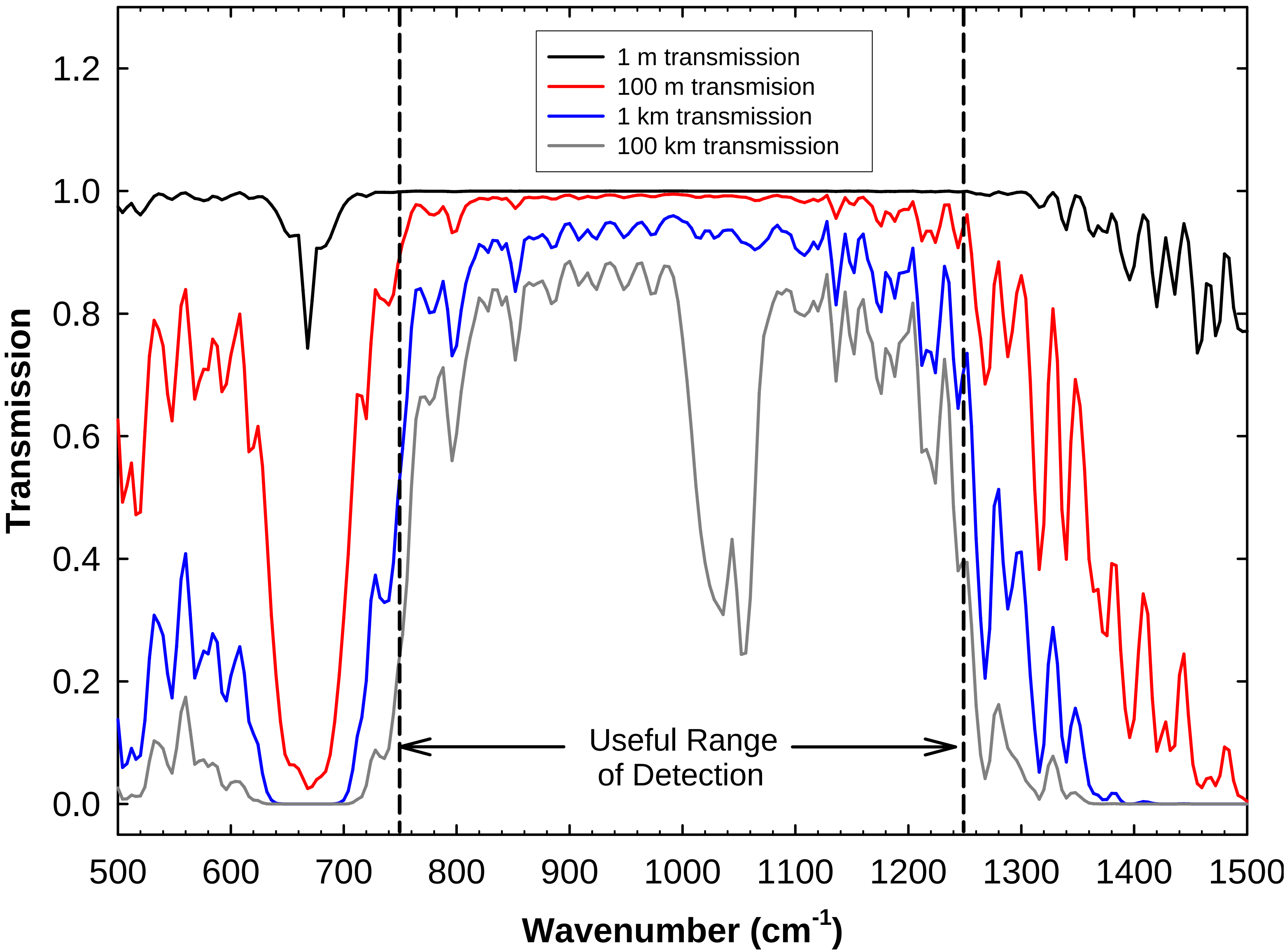
DRIFTS



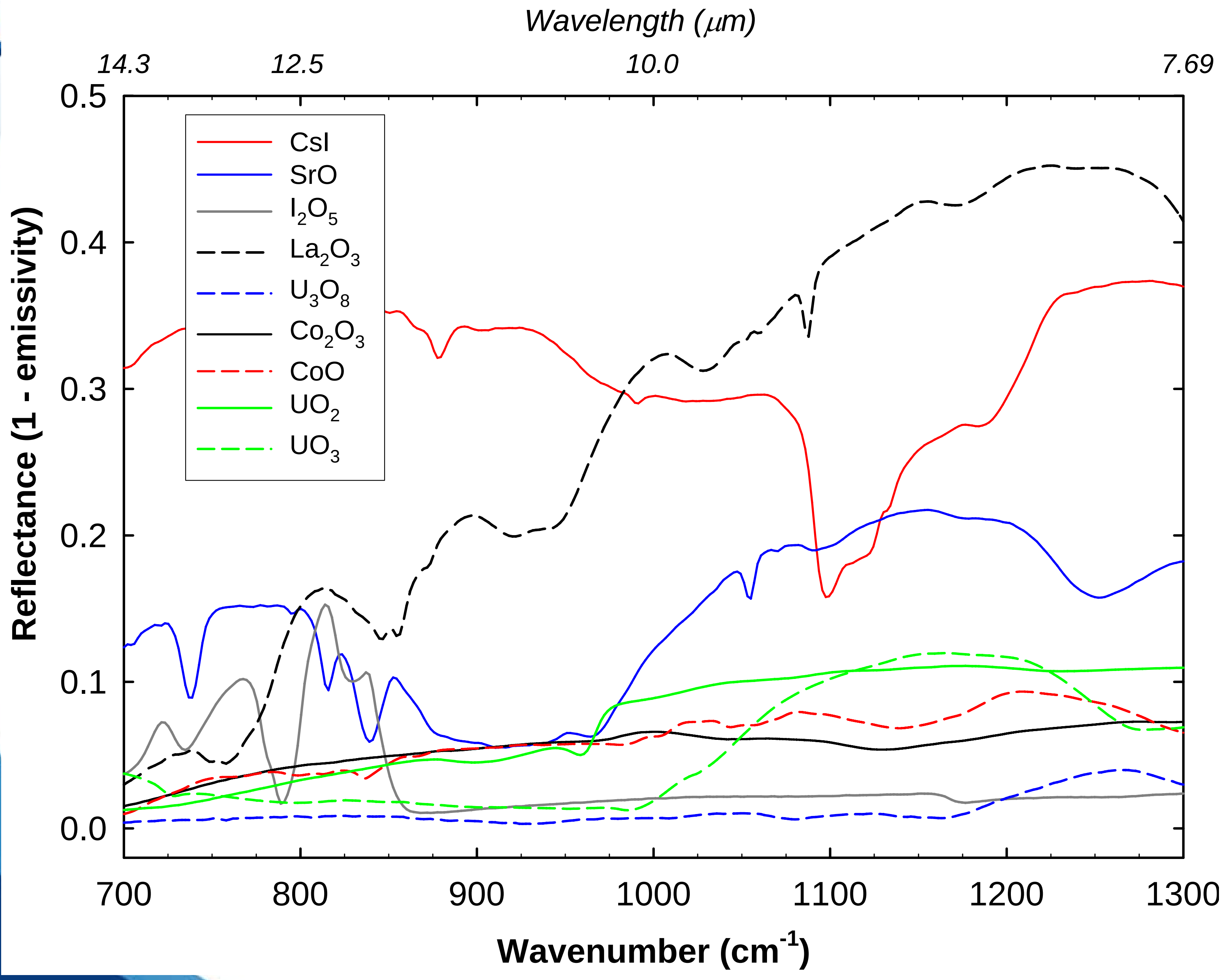
IR Absorption Signatures of Radiological Products



Atmospheric Transmission in the LWIR

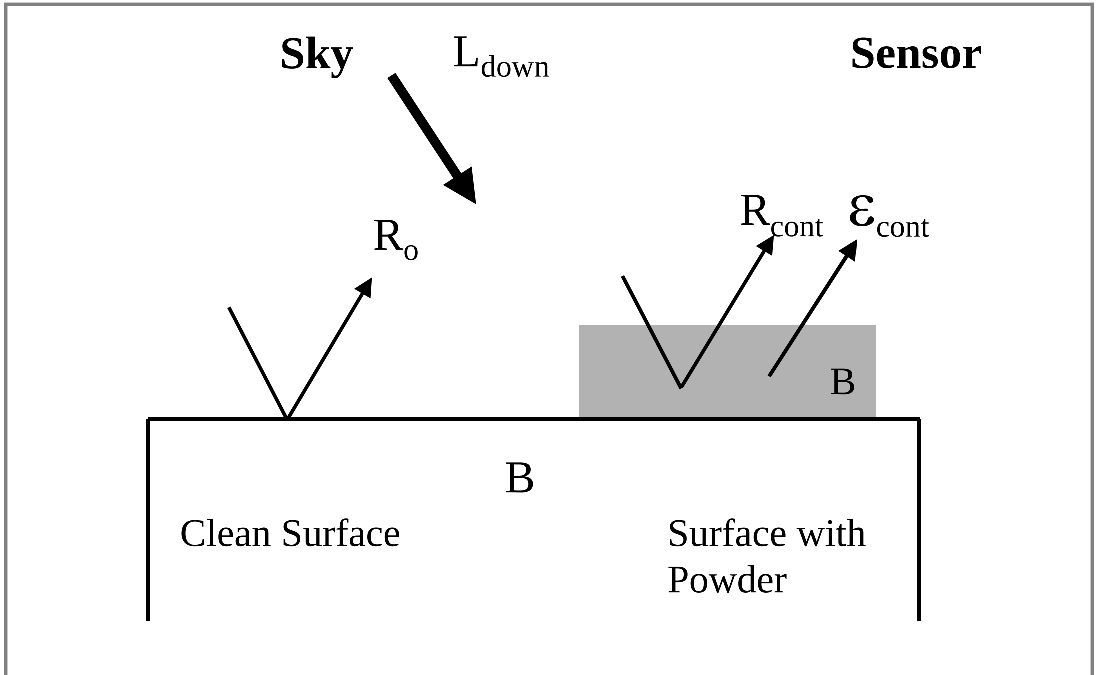


Absorption Signatures in the LWIR



Simulated detection of radiological materials

Differential Detection from Surfaces (Outdoors)



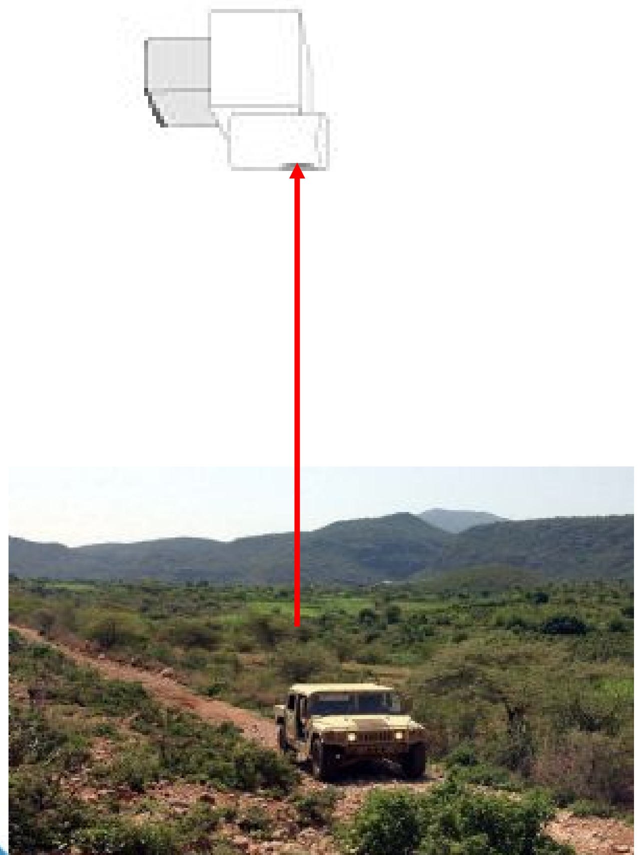
$$L_{clean} = B - R_o\left(B - L_{down}\right)$$

$$L_{cont} = B - R_{cont}\left(B - L_{down}\right)$$

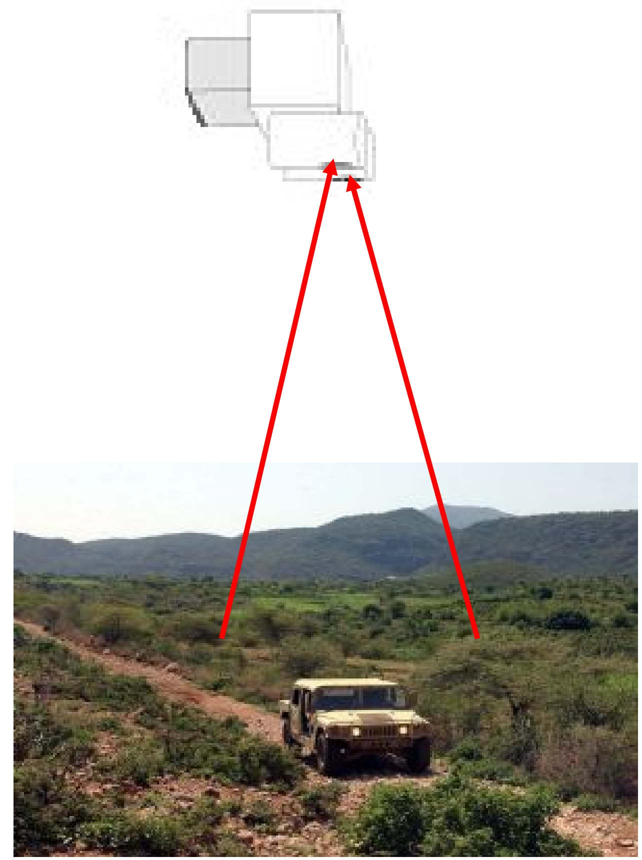
$$L_{cont} - L_{clean} \equiv \Delta L = (R_o - R_{cont})\left(B - L_{down}\right)$$

Passive Standoff Measurement Configuration

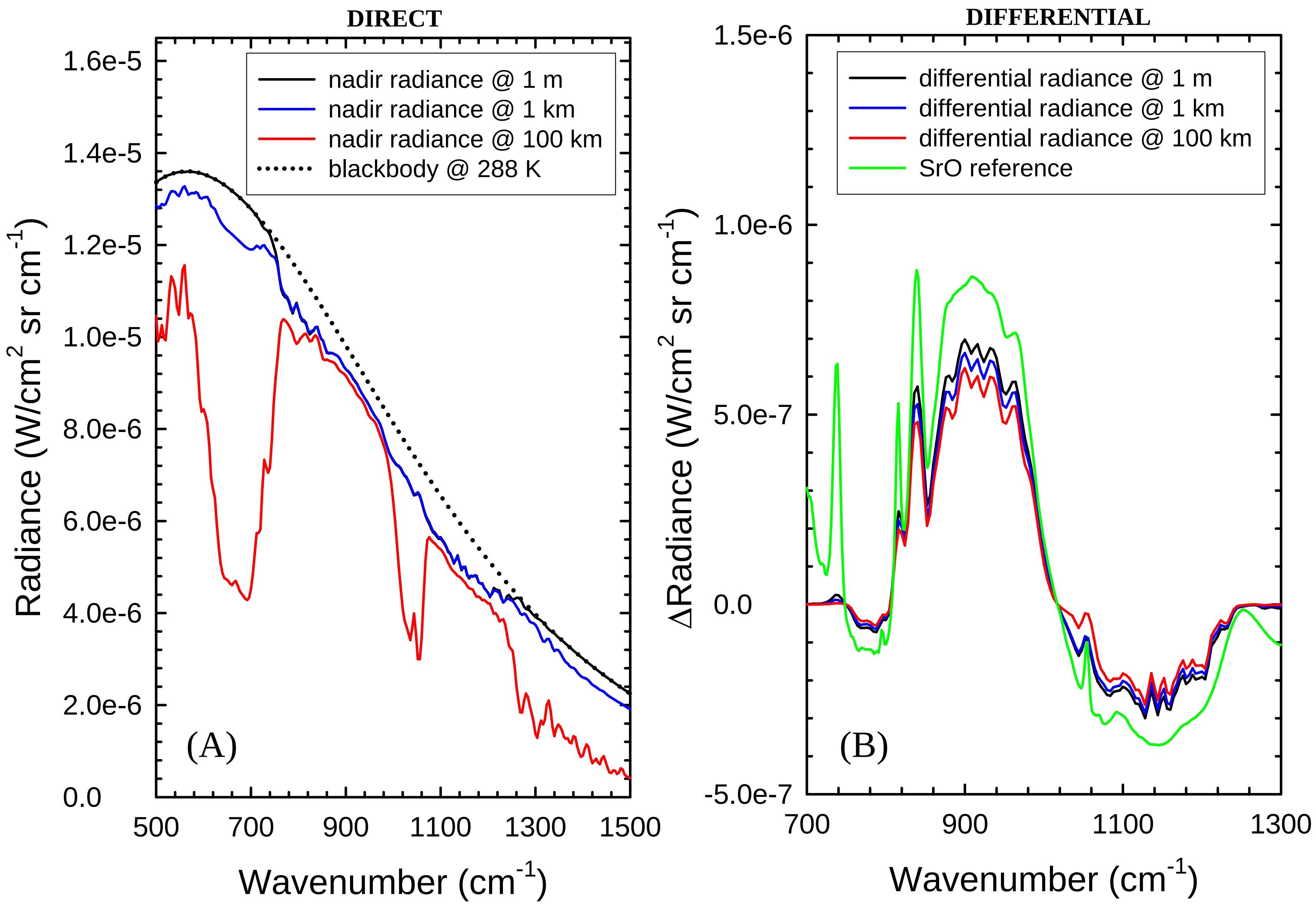
Direct Detection



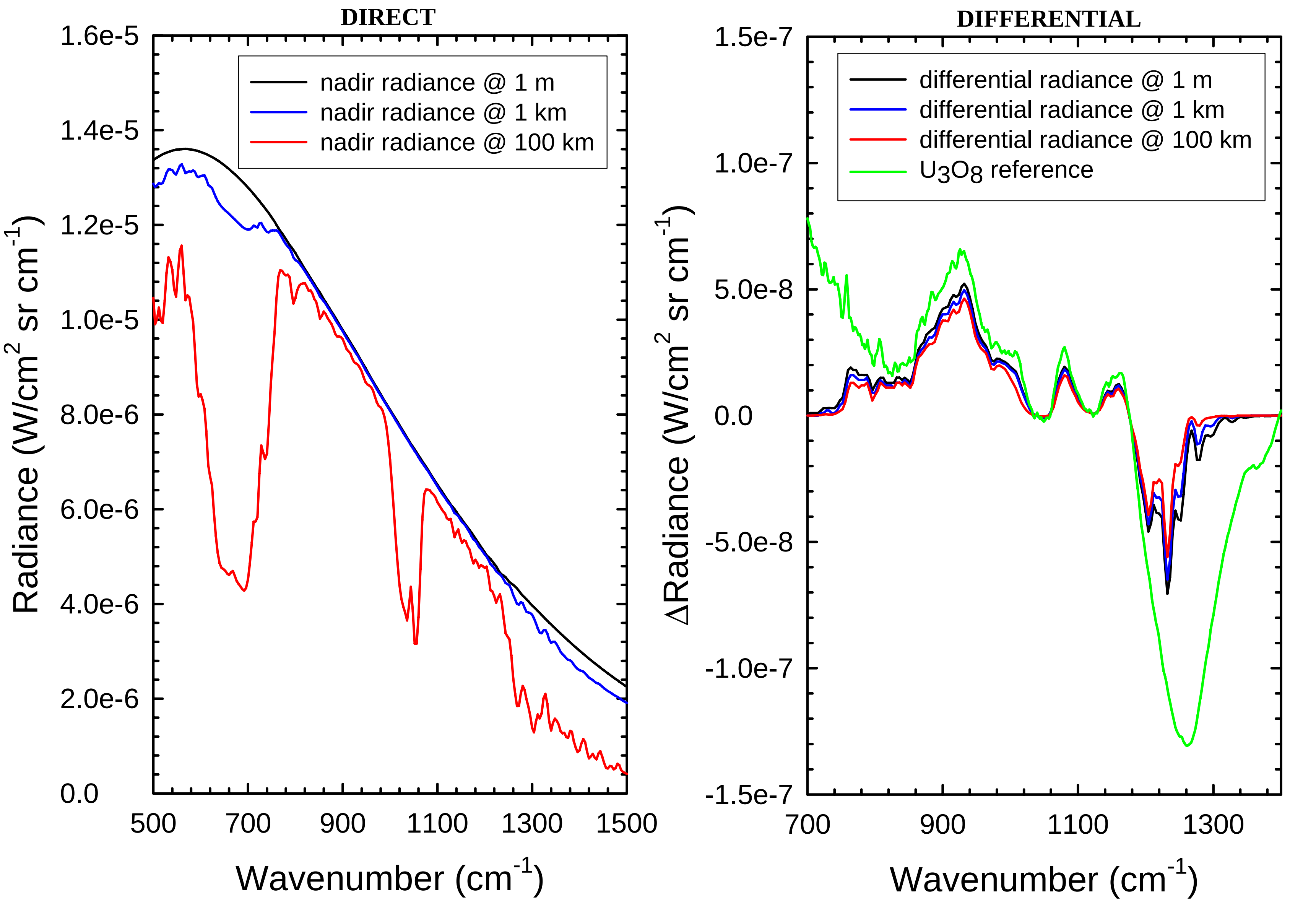
Differential Detection



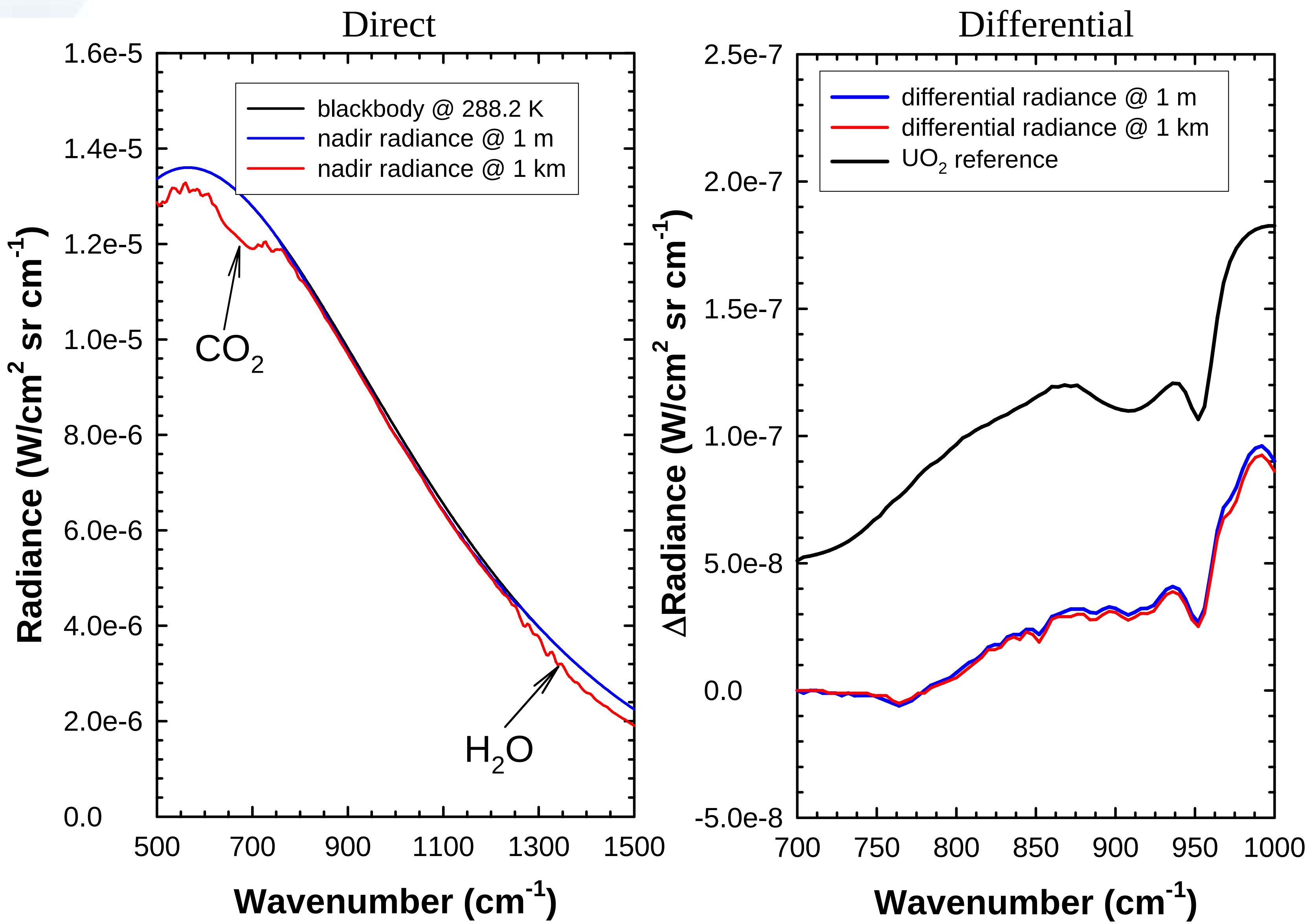
Simulated Detection of SrO for Various Altitudes



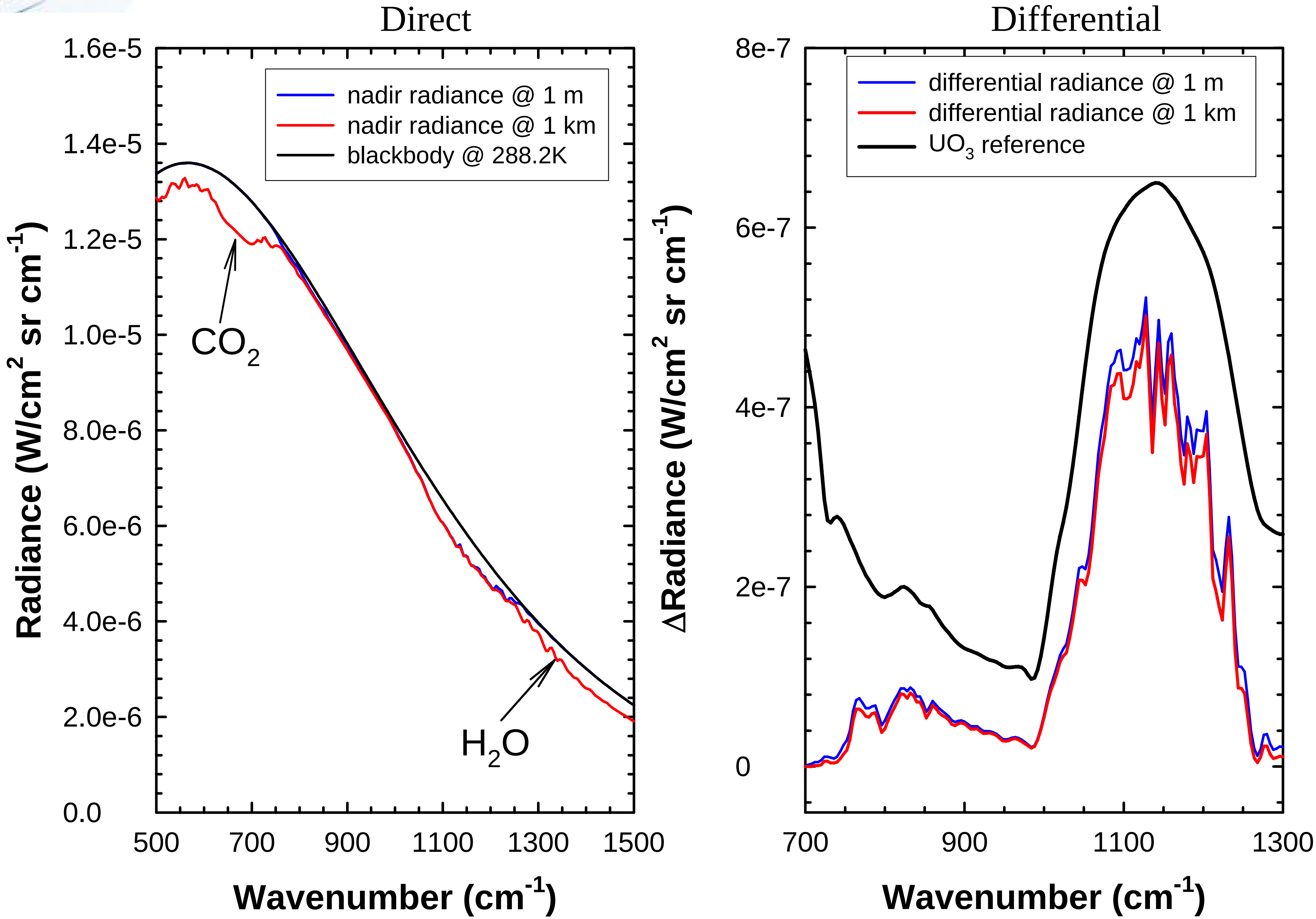
Simulated Detection of U_3O_8 for Various Altitudes



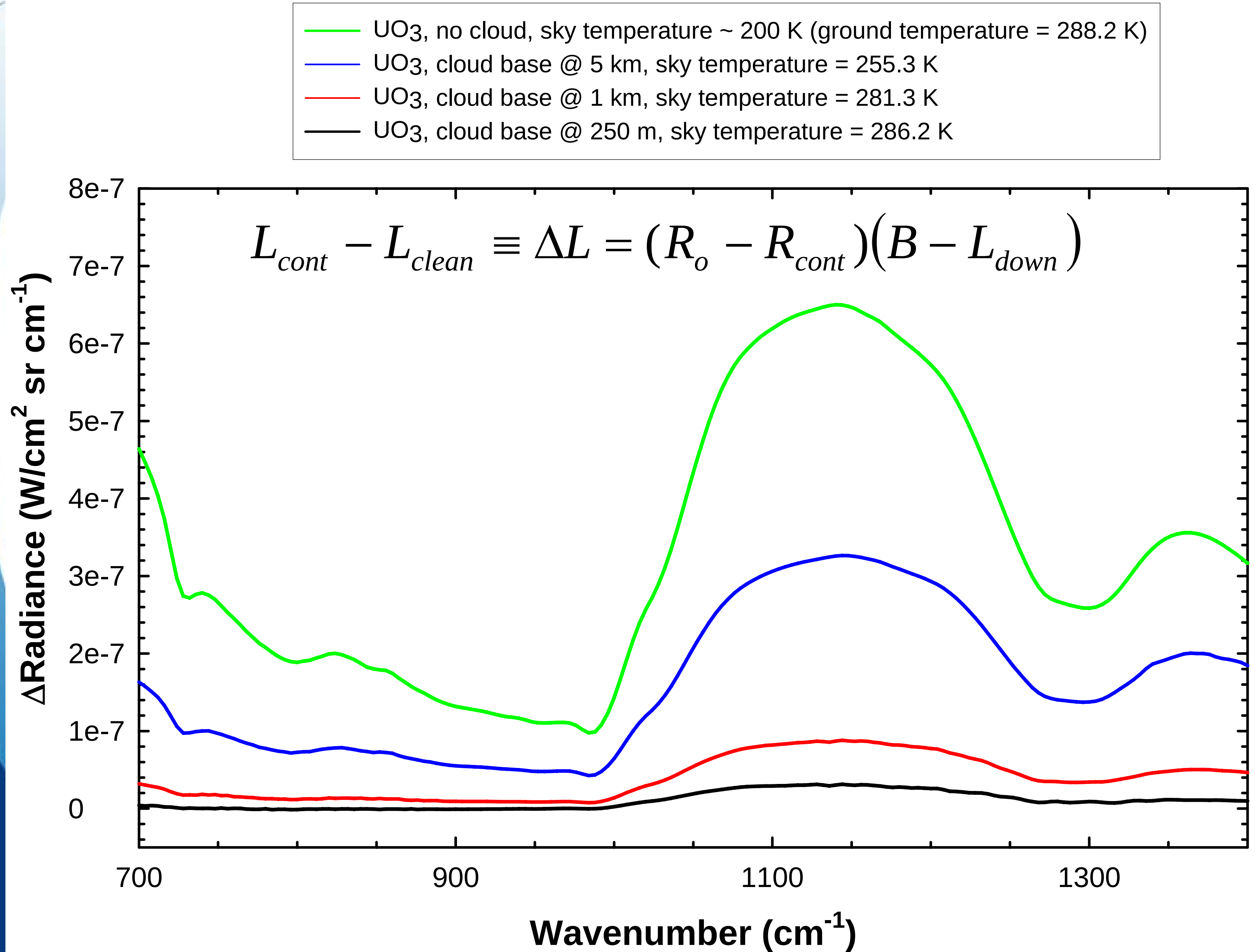
Simulated Detection of UO_2 for Various Altitudes



Simulated Detection of UO_3 for Various Altitudes

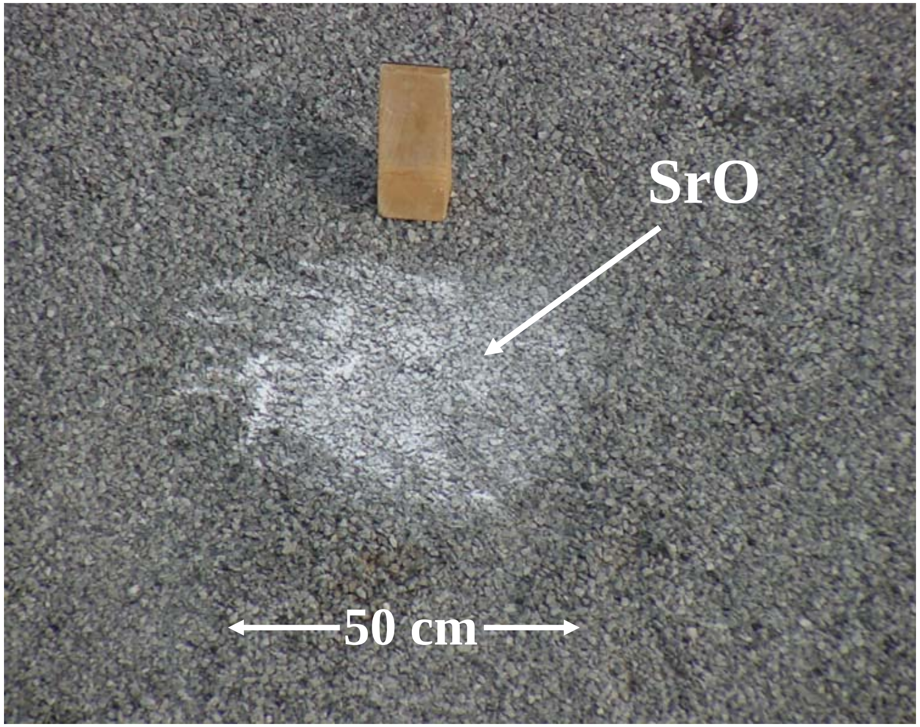


Sky Temperature Effect on the Passive Detection of UO_3

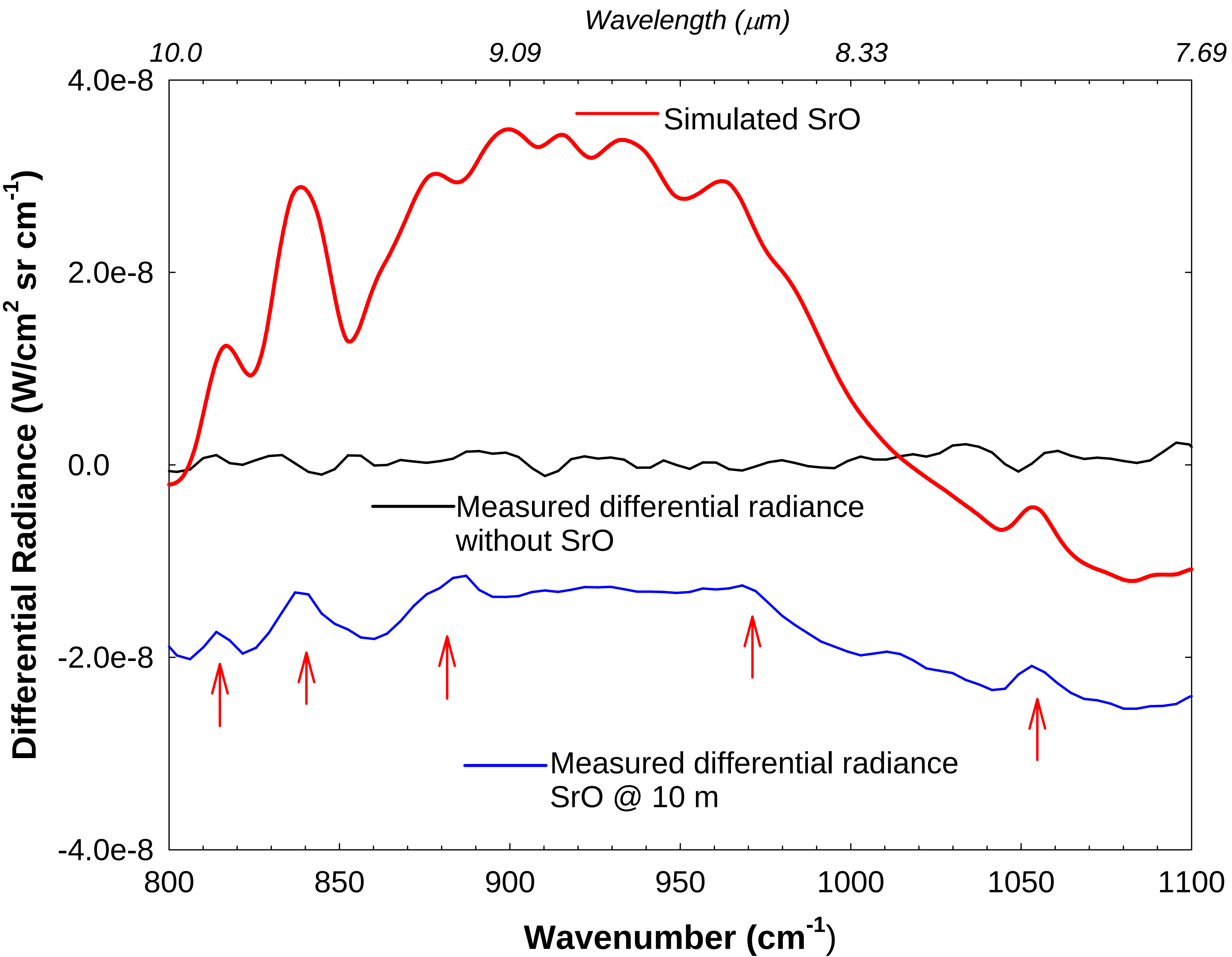


Ground-based and aircraft measurements

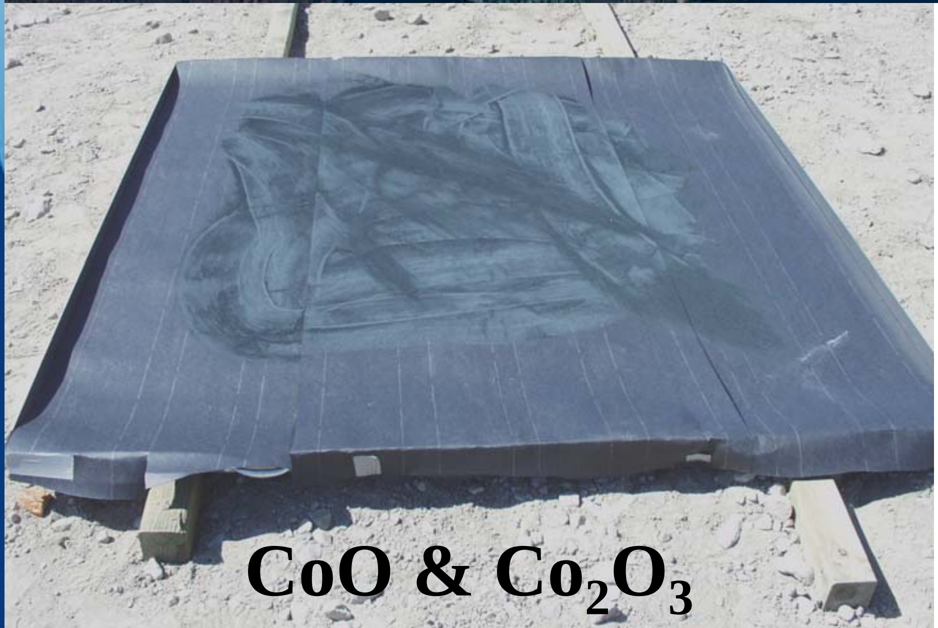
Passive Standoff Detection @ 10m on Roof Top



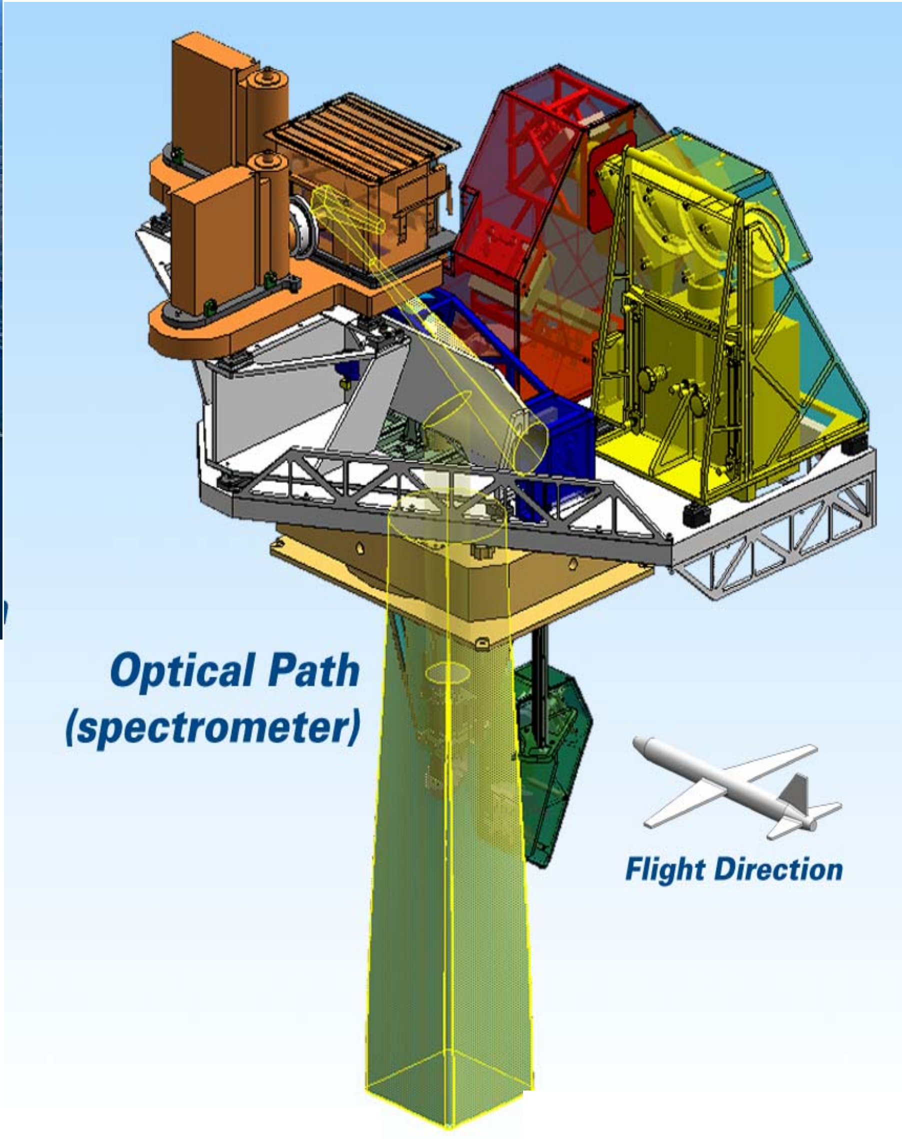
Passive Standoff Detection @ 10m



Airborne Standoff Detection @ 1km

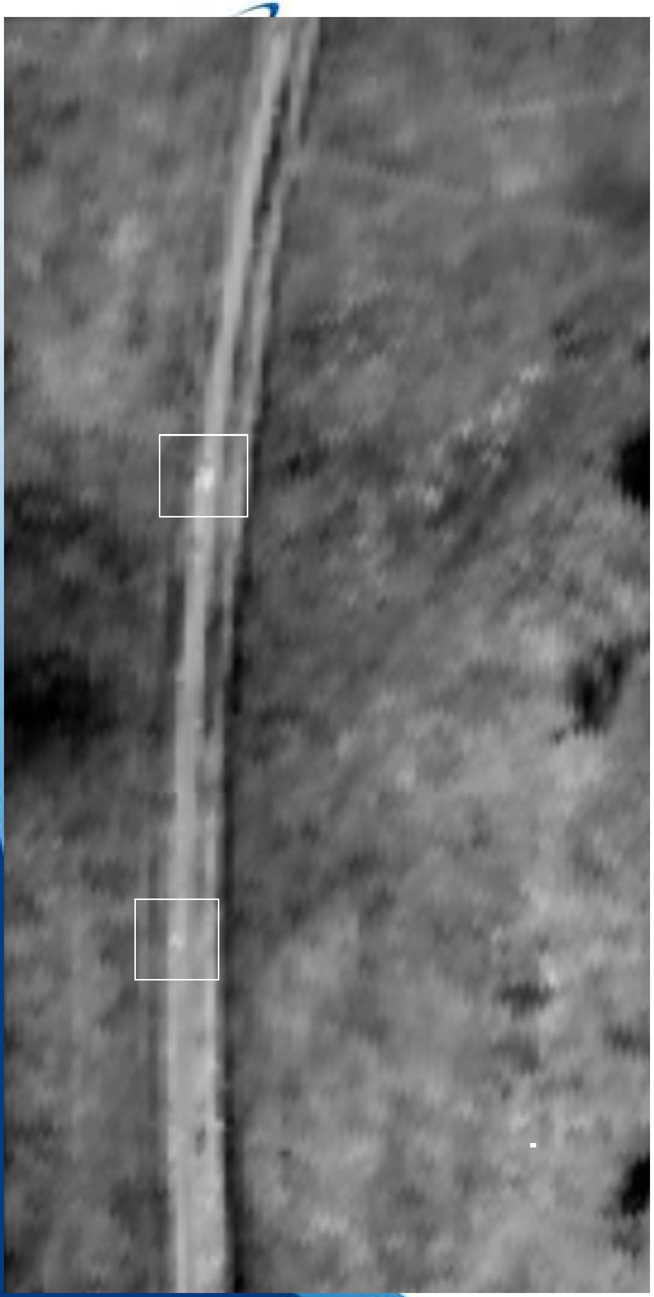


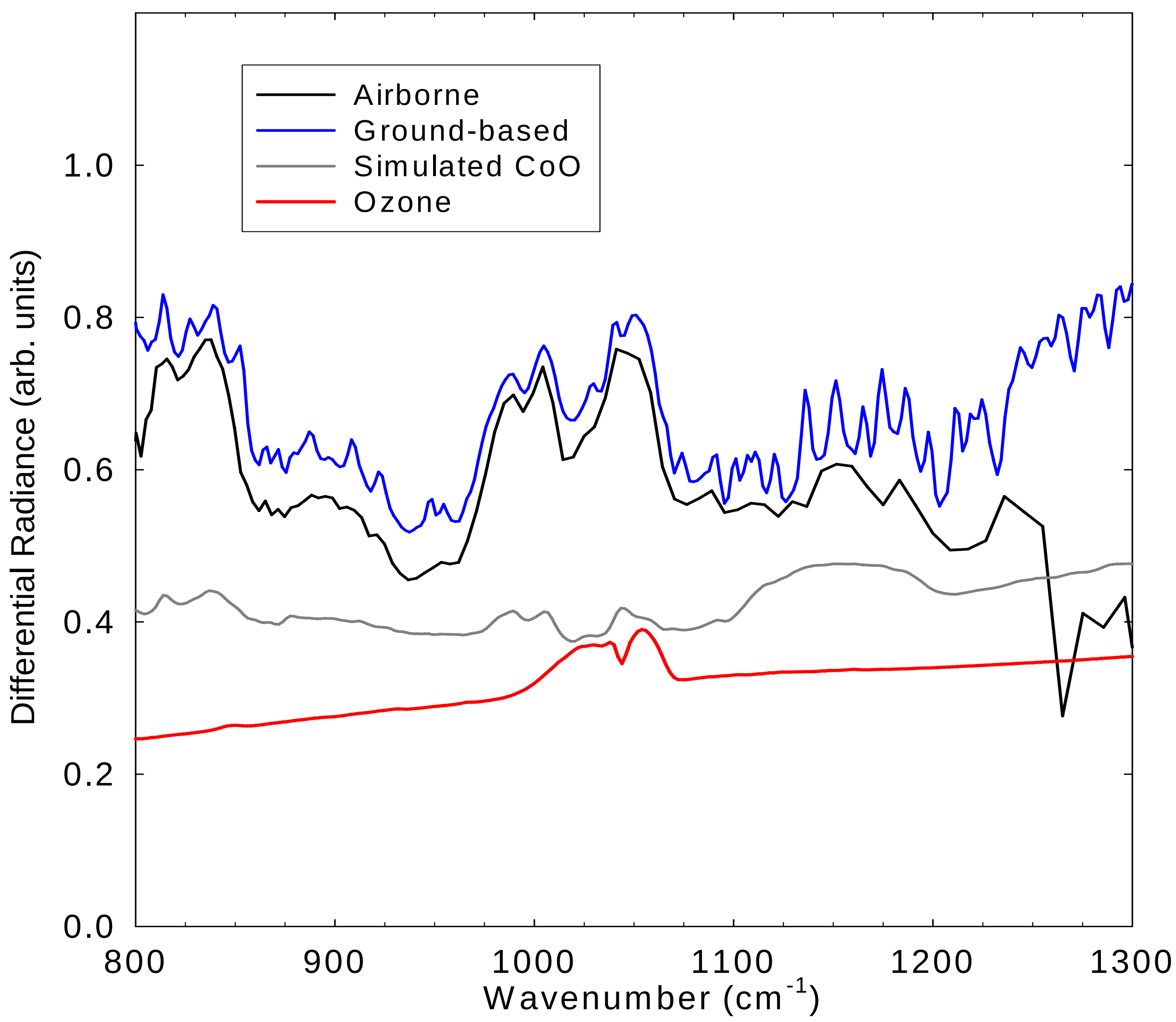
CoO & Co_2O_3



AIRIS (Airborne Imaging IR Spectroscopy)

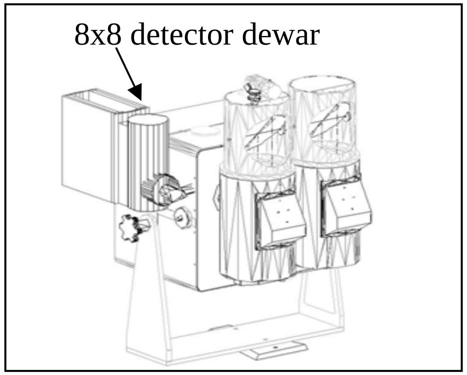
Airborne Detection of Cobalt Oxides @ 1km





Future Activities

- Detection and identification of UF6
- Future field trial with UO_2, UO_3 and U_3O_8
  - ground-based & airborne (AIRIS)
  - full spectrum HSI investigation (VNIR/SWIR, MWIR, LWIR)
  - novel sensors



Imaging CATSI

Lightweight CATSI

Conclusions

- Several radiological materials, including UO_2, UO_3, U_3O_8, CsI, CoO, Co_3O_4, SrO, I_2O_5 and La_2O_3 have detailed infrared signatures in the transparent window region of the thermal infrared spectrum
- Simulations show that these products have a high potential of being detected in nadir spectra from several altitudes above the Earth's surface
- Detection and identification successfully performed at 60m (ground based) and from 1 km airborne platform
- Applications:
  - Detection/mapping of the dispersal of radiological substances from the detonation of an RDD or IND
    - Oxides of Sr, Co, Cs most likely by-product
  - Detection of nuclear bomb making facilities
  - Detection of natural radiological materials in the mining industry
  - Others?