FORUM Sensitivity to water vapour profile and surface reflectivity: contributions from the FIR spectral region

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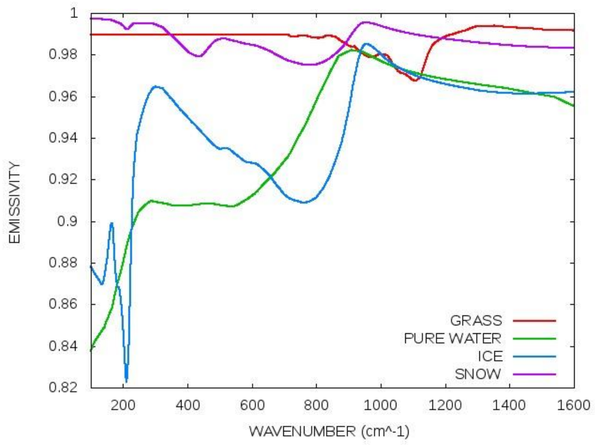
Surface emissivity in the FIR

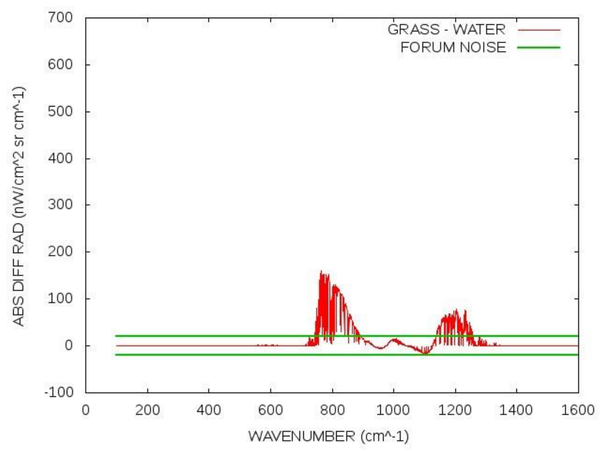
FIR radiation coming from the Earth is generally not detectable from the space because of the strong absorption of atmospheric water vapour. Anyway, preliminary tests performed in the framework of the SCIEF (Sviluppo delle Competenze Italiane per l'Esperimento FORUM) project funded by ASI (Agenzia Spaziale Italiana) shown sensitivity above the instrumental noise in extremely cold and/or dry scenarios. This can lead to possible exploitation of FORUM measurements for ice and snow coverage estimates. We illustrate residuals between convolved spectra at resolution of 0.3 cm^{-1} calculated in the same atmospheric scenario and above surfaces with different emissivity properties, residuals are compared with FORUM noise requirement.

EMISSIVITY

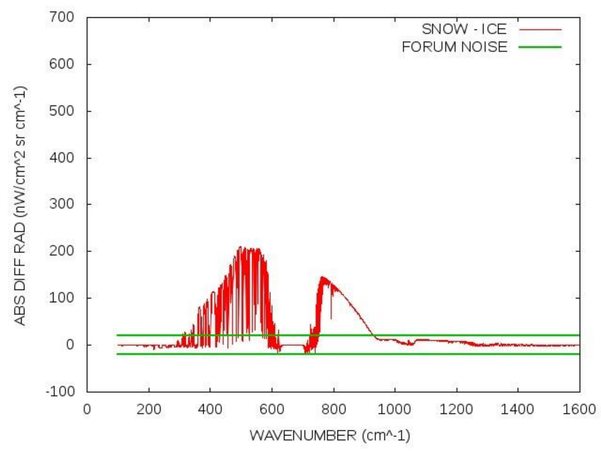
(selected surface types)



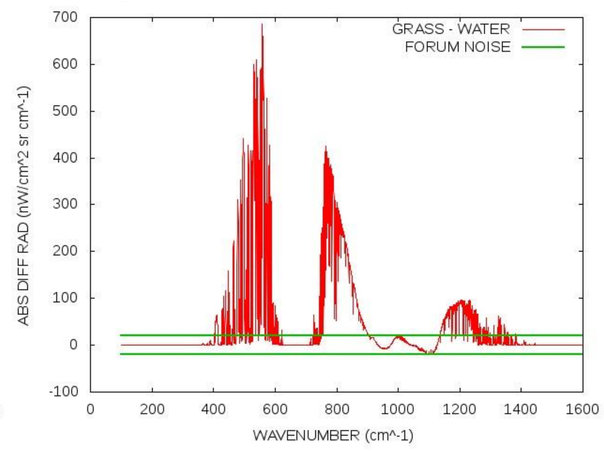
Spectra residual (grass – water) calculated in Mid-latitude standard atmosphere, T_s = 285 K



Spectra residual (snow-ice) calculated in Dome-C scenario at 05/07/2016, T_s = 201.8 K



Spectra residual (grass – water) calculated in Mid-latitude standard atmosphere, T_s = 285 K. H_2O reduced of 90%



FORUM NOISE is approximated to 20 $nW/(cm^2\ sr\ cm^{-1})$

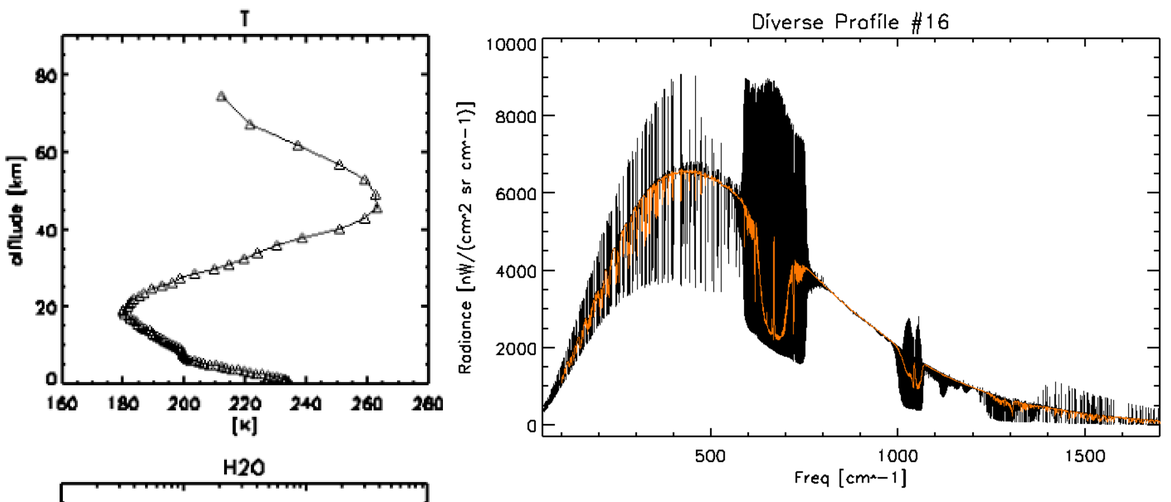
T_s is the surface temperature

FORUM spectra and Jacobians respect to H_2O VMR

We extracted 80 different clear sky reference scenarios from a ECMWF Diverse Profile Database as reference scenes for FORUM simulations. Spectra and Jacobian respect to water vapour Volume Mixing Ratio were calculated with LIDORT Radiative Transfer Model at high spectral resolution of 0.0005 cm^{-1} in the whole spectral range from 100 to 1600 cm^{-1}. Information content on water vapour profile is mostly present in the FIR range and high altitudes (generally from the upper troposphere to the middle stratosphere), therefore in the following analysis we present results for two extreme scenarios. More details on atmospheric scenarios are reported below

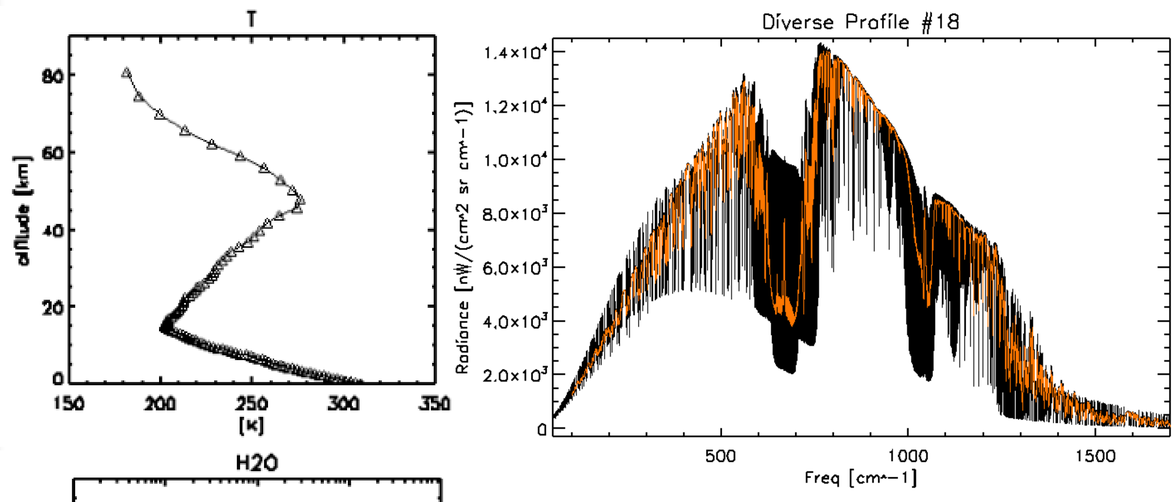
- Spectrum and convolved Jacobian from 100 to 600 cm^{-1} for a polar scenario (Antarctic Plateau) with T_s = 226.14 K
- Spectrum and convolved Jacobian from 100 to 600 cm^{-1} for a desertic scenario (Iran) with T_s = 308.80 K

Antarctic Plateau



Top left: Temperature profile for Antarctic Plateau scenario
Bottom left: H_2O VMR profile for Antarctic Plateau scenario
Top right: High resolution (black) and convolved (orange) spectra
Bottom right: Convolved Jacobian respect to H_2O VMR in the FIR range as a function of wavenumber and altitude

Iran - Desert



Top left: Temperature profile for desertic scenario
Bottom left: H_2O VMR profile for desertic scenario
Top right: High resolution (black) and convolved (orange) spectra
Bottom right: Convolved Jacobian respect to H_2O VMR in the FIR range as a function of wavenumber and altitude

Conclusions

TOA radiance from 400 to 600 cm^{-1} is generally sensitive to change in surface properties in cold and dry scenarios, while it is not affected in moister and warmer scenarios. However, high sensitivity can be found in a typical mid-latitude atmosphere with very low water vapour content. Computed Jacobians show high sensitivity of the UTLS region to changes in water vapour concentration, with a predominance of absorption of the OLR leading to heating. In an optically thick (warm and moist) atmosphere, no information about water vapour concentration is present for altitudes lower than 5 Km and wavenumber lower than 400 cm^{-1}. At the opposite, in a polar scenario the maximum of sensitivity is shifted to lower altitudes and changes in water vapour VMR near the surface can be detected.