Radiative Transfer Modeling for Observing Urban Areas with TRISHNA

- Doctorat, 36 mois, temps plein
- Maitrise, IEP, IUP, Bac+4
- Continental biosphere

https://recrutement.cnes.fr/fr/annonce/3515297-25-132-radiative-transfer-modeling-for-observing-urban-areas-with-trishna-59655-villeneuve-dascq

Mission

More than two-thirds (68%) of the global population will live in urban areas by the middle of the 21st century, compared to 55% in 2018. This significant increase in urban population accentuates the necessity to understand microclimates in urban environments and to anticipate their potential changes. Remote sensing, especially in the thermal infrared (e.g., TRISHNA, SBG and LSTM), is one of the most efficient and economical techniques to monitor urban environments (e.g., air quality, heat waves) at various space and time scales. However, an accurate interpretation of remote sensing observations, as surface parameters for instance, is still challenging because of the complex 3D architecture of land surfaces, and of the various radiative interactions in the atmosphere (gaseous absorption and emission, scattering by clouds, etc).

Radiative transfer models (RTM) simulate radiation propagation in the land surface and in the atmosphere. RTM are at the present time compulsory to understand and interpret remote sensing observations. During the last four decades, two distinct types of RTMs have been developed by two communities: atmospheric RTMs on one side and land surface RTMs on the other side.

Atmospheric RTMs aim at simulating accurately radiative mechanisms (e.g., absorption, scattering, transmission and emission) and properties (e.g., molecule/particle concentration and cross section, pressure, temperature) in the atmosphere with, most of the time, a simplified modelling of the geometry and of the radiative mechanisms of land surfaces. For example, the 3DMCPOL model, developed at LOA since 2010, represents landscapes as an essentially flat, horizontally homogeneous surface, without accounting for the bidirectional nature of surface reflectance, except for the specular reflection of the ocean.
Land surface RTMs aim at simulating accurately radiative mechanisms in land surfaces but use, most of the time, simplified models for the radiative mechanisms in the atmosphere. For example, the DART model, developed at CESBIO since 1992, simulates the remote sensing images of urban and natural surfaces acquired by spectrometers from the visible to the thermal infrared spectral domain. However, it treats atmospheric interactions with a constant absorption coefficient over each spectral band (grey model), whereas real atmospheric absorption spectra consist of narrow absorption lines of molecular species that vary significantly even in relatively narrow spectral bands (width on the order of 1 cm^-1).
As emphasized in https://gcos.wmo.int/index.php/en/essential-climate-variables, the thematic

applications of remote sensing for land surfaces require an accuracy higher than 1 K for land surface temperatures (LST) and better than 3% for albedo. Either the simplification of the atmosphere or of the land surface components reduces the precision of the modelling and hence its capacity to provide accurate estimates of these quantities. A collaboration between the atmospheric and land surface communities has the potential to relax the simplifications used at the present time in the DART and 3DMCPOL codes and to increase the complete end-to-end (source to sensor) radiative transfer models' accuracies up to the levels required for operational applications.

The objective of the PhD thesis is to build a bridge between the atmosphere and land surface communities. Accordingly, the work will be supervised by scientists from LOA who develop 3DMCPOL and CESBIO who develop DART in the context of urban studies using TRISHNA. After, learning the physics of radiative transfer modeling in the land surfaces and the atmosphere, the PhD student will take 3DMCPOL and DART in hand and will master their physical bases, before carrying out his own developments inside these numerical models. The preliminary analysis of the strengths and potential areas for improvement of both codes has led to the following sharing of elements: (1) From 3DMCPOL to DART: integration into DART of the model used in 3DMCPOL for handling the absorption by atmospheric gases, (2) From DART to 3DMCPOL: generation of datasets and modelling of directional reflectance / thermal emission to improve land surface modelling in 3DMCPOL. The PhD student will participate to the development and validation of these components in 3DMCPOL and DART. The improved models will then be applied to simulate top of atmosphere observations of TRISHNA for simplified and realistic urban environments. CESBIO has already adapted several urban geometric models to DART (e.g., Bruxelles, Toulouse). The possibility and relevance of a stronger coupling of the two models will be studied and analyzed, following the conclusions and results of the PhD work.

This work will allow the two models, DART and 3DMCPOL, to share information. It will benefit to Cal/Val activities of next satellite missions such as CNES-ISRO TRISHINA and ESA LSTM missions and for deriving land surface parameters from space.

=================

For more Information about the topics and the co-financial partner (found by the lab !); **contact Directeur de thèse - frederic.andre@univ-lille.fr**

Then, prepare a resume, a recent transcript and a reference letter from your M2 supervisor/ engineering school director and you will be ready to apply online before March 14th, 2025 Midnight Paris time !

Profil

The candidate must hold a master's degree or an equivalent degree. He or she is expected to have good knowledge in remote sensing, physics, and mathematics. He or she must have a solid background in scientific programming (e.g., C, C++, Python, Fortran). Also, the ability to pursue independent research and good writing and fluency in English is appreciated.