MATISSE:
MODELISATION AVANCEEE de la TERRE pour l ’IMAGERIE et la SIMULATION des SCENES et de leur ENVIRONNEMENT

« Advanced Earth Modelisation For Imagery and Scene Simulation »

VERSION 1.1

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Goal of MATISSE: Radiance images

- Observed Radiance
- Atmospheric Emission and Scattering
- Ground reflection and emission
- Cloud Scattering
- Target Signature Propagation
- Atmospheric variability

\[ P(x,y,z) \]
\[ T(x,y,z) \]
\[ [H_2O](x,y,z) \]
Why MATISSE?

- Coherent radiance images
  - target detection studies
  - contrast of natural background

- Atmospheric spatial variability computation

- New functionalities

- Insertion of the code in computation chains
Why Matisse?
Atmospheric Spatial variability (prototype results)
Description of the code

• **Core**
  – General method
  – Transmission model
  – Source function computation

• **Natural backgrounds**
  – Ground modelisation
  – Cloud modelisation

• **Target signature transmission**

• **Language and computer**

• **Secondary Data Bases**
General method
Source functions computation

Atmospheric profiles

Optical parameters

Total Source Functions

Atmospheric Transmission Meeting 06/06/2001
General method
Source functions propagation

⇒ all the radiative parameters (sources functions, surfaces, radiances, absorption coefficients, ...) are stored
Application

Visée n°1

Visée n°2
Need to use Beer’s law

→ LBL method

→ K distribution method
Transmission model
CK model (1/3)

• Advantages
  – Beer’s law
  – molecular absorption / aerosols scattering coupling

• Method
  Atmospheric profiles ➔ LBL model
  (Lpma/Snecma/Onera) ➔ CK profiles stored in a Data Base

  Hitran 96 data base

• Characteristics
  – spectral range (MATISSE 1.1) : 3 - 13 µm
  – spectral resolution : 5 cm$^{-1}$
Transmission model
CK model (2/3)

US Standard / 0-15km / ZA = 45°
Transmission model
CK model (3/3)

US Standard / 0-15km / ZA = 45°
Source functions computations (1/2)

\[ J_{\text{tot}}(\theta, \varphi) = J_{\text{ss}}(\theta, \varphi) + J_{\text{th}} + J_{\text{ms}}(\theta, \varphi) \]

Two ‘horizontal’ spatial resolutions

→ High resolution (0.25° x 0.25°)
  – Single scattering: \( J_{\text{ss}}(\theta, \varphi) \)
  – Thermal emission: \( J_{\text{th}} \)

→ Low resolution (5° x 5°)
  – Multiple scattering: \( J_{\text{ms}}(\theta, \varphi) \)
    → RTRN21 (Nakajima): DOM + TMS

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Source functions computations (2/2)
Ground description (1/2)

• **Geometrie**
  – WGS84
  – Digital terrain elevation : USGS-GTOPO30 (30 ”)
  – Shadowing and hidden surfaces : OpenGL routine

• **Ground temperature**
  – thermal model

• **Land-use data base**
  – USGS/GLCC + ASTER
Ground description (2/2):
Land use data base construction

- Global Land Cover Database
- Elementary materials reflectance and emissivity Database
- SST annual Database
- Global Elevation Database

- pixel location/ground cover type association
- ground cover types description
- ground cover types characterization
- seasonal data extraction
- adaptation to MATISSE grid

- World map of ground cover types
- Thermo-optical properties of ground cover types
- Sea surface temperature World Map
- Ground Elevation Map

- MATISSE Database

USGS/GLCC
ASTER
ASST
GTOPO30

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Stratocumulus Clouds

- Thickness and shape: statistical generation
- LWC(z): Feddes method
- Vertically homogeneous
- n(r) = constant

Spatial fluctuations: LWC, Δh
Cloud description (2/2) : Radiation

- Radiative transfer : IPA + BRDF

  → Use of RTRN21 (Nakajima)
  - DOM + TMS
  - Plan parallel

  \[
  \text{BRDF}(\Theta_{\text{sol}}, \Theta, \Delta \phi, \sigma, \omega, \tau) \\
  \text{BTDF}(\Theta_{\text{sol}}, \Theta, \Delta \phi, \sigma, \omega, \tau) \\
  \varepsilon(\Theta, \sigma, \omega, \tau)
  \]

- Shadowing and hidden surfaces : OpenGL routine
Target signature transmission
Method

\[ p(x,y,z)_i \]
\[ t(x,y,z)_i \]
\[ [X](x,y,z)_i \]
\[ \sigma_1, \sigma_2 \]

LBL model

\[ T(\sigma_i) \]

\[ + \]

\[ E_{\Delta\sigma} \]

\[ I(\sigma,\Omega,p) \]
Target signature transmission
Line by Line / FASCOD3 comparisons

- Nadir viewing: 0 → 100 km
- US STANDARD
Language and computer

• **Language**
  - Main programme: C
  - Routines: C, F90
  - GUI: PV-Waves 6.21
  - Quality approach

• **Computer**
  - SUN Ultra 80
  - 2 processors ULTRA SPARC 450MHZ
  - MEMORY: 2 Go
  - Disk storage: 40 Go
Secondaries Data Bases

Atmospheric Profiles 1D,2D (>1800)

Atmospheric profiles 3D 0.25° x 0.25°

Aerosols profiles (GADS) 5° x 5°

MATISSE

- DTED (30'')
- Land-use

Radiative transfer
- CK parameters
- Line by line data
- Solar spectrum

Clouds BRDF, BTDF, ε

Atmospheric Transmission Meeting 06/06/2001
MATISSE 1.1 : Summary (1/2)

- Coherent radiance images
- Atmospheric radiative transfer: CK / 3-13μm / $\frac{\delta \sigma}{\sigma} = 5 \text{ cm}^{-1}$
- Aerosol + molecule scattering: (DOM for MS)
- Atmospheric Spatial Variability for all the LOS
- Clouds Emission and Scattering: Scu / IPA + (BRDF, $\varepsilon$)
- Ground Emission and Reflectance: $T_{\text{ground}} + \text{BRDF} + \varepsilon$
MATISSE 1.1 : Summary (2/2)

- 3D Ground (DTED) + cloud shadowing
- Target signature propagation
- GUI
- High resolution spatial Variability
- Refraction along **only one** line of sight

Release of MATISSE 1.1 : May 2002
Future works

- Sea surface model
- Cirrus clouds
- CK ’s spectral domain and resolution
- Adjacencies effects
- NLTE
- Refraction for all the LOS in the image
- Coupling with high spatial resolution radiative codes
<table>
<thead>
<tr>
<th>Name</th>
<th>Role and Contributions</th>
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<tbody>
<tr>
<td>P. Simoneau</td>
<td>Project manager</td>
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<td>L. Labarre</td>
<td>Development manager, architecture, GUI, OpenGL</td>
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<td>R. Berton</td>
<td>Geometry, cloud generation, high resolution spatial variability, refraction</td>
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<td>K. Caillault</td>
<td>Ground thermal model, high resolution spatial variability</td>
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<td>G. Durand</td>
<td>Atmospheric source function computations</td>
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<td>T. Huet</td>
<td>CK development, target signature transmission</td>
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<td>Cloud radiative transfer</td>
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<td>C. Miesch</td>
<td>Land use data base construction</td>
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Multiple scattering source function computation

- $5^\circ \times 5^\circ$ horizontal resolution
- Only one type of aerosol
Multiple scattering source function computation