

MATISSE :
MODELISATION AVANCEE de la TERRE pour l'IMAGERIE
et la SIMULATION des SCENES et de leur
ENVIRONNEMENT

**« Advanced Earth Modeling For Imaging and Scene
Simulation »**

Version 1.1 : first results

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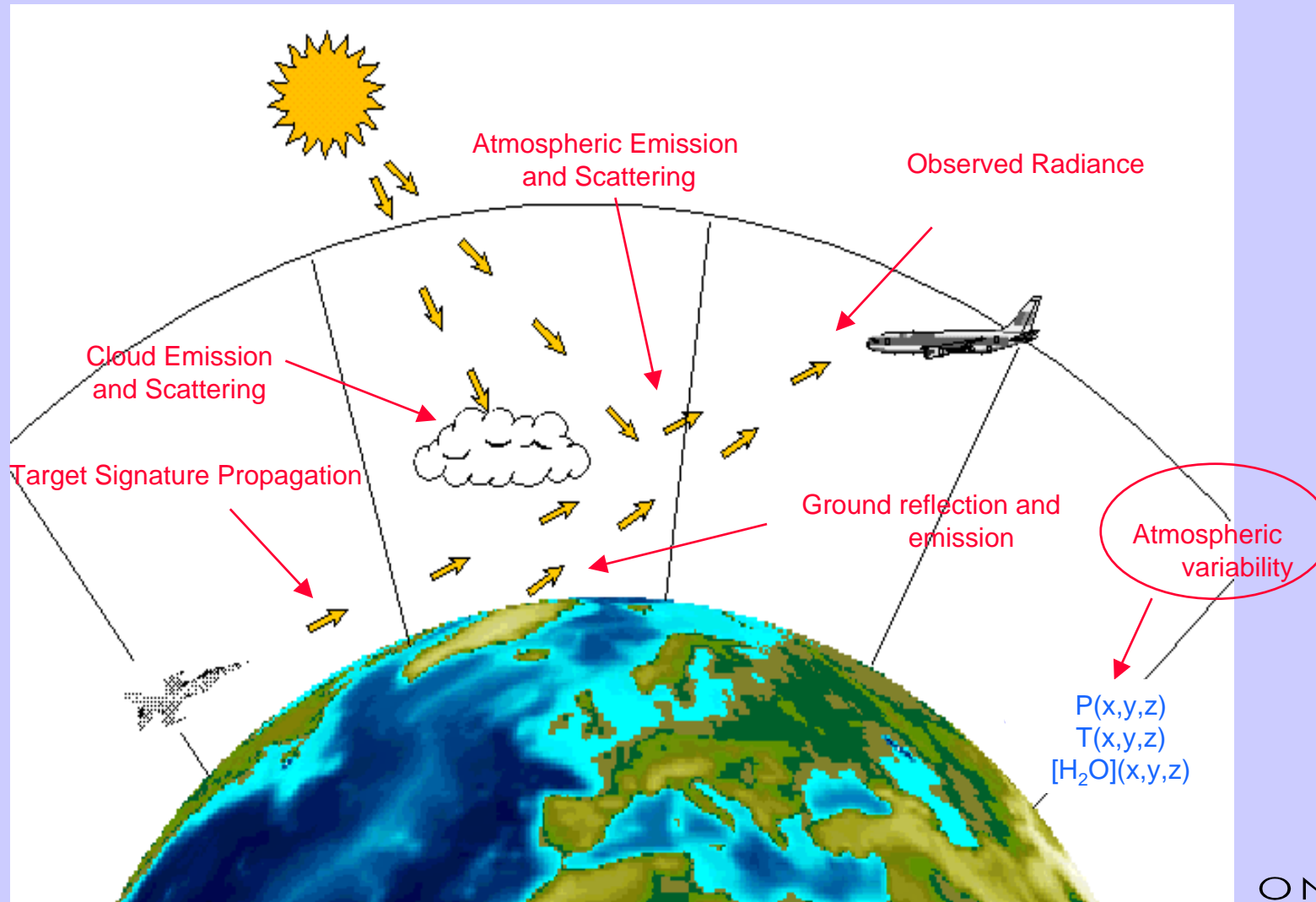
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: Applied and Theoretical Optical Department



PRESENTATION OUTLINE

- **Goal**
- **Main functionalities description**
- **Results**
- **Conclusion and future works**

Goal of MATISSE : Radiance images

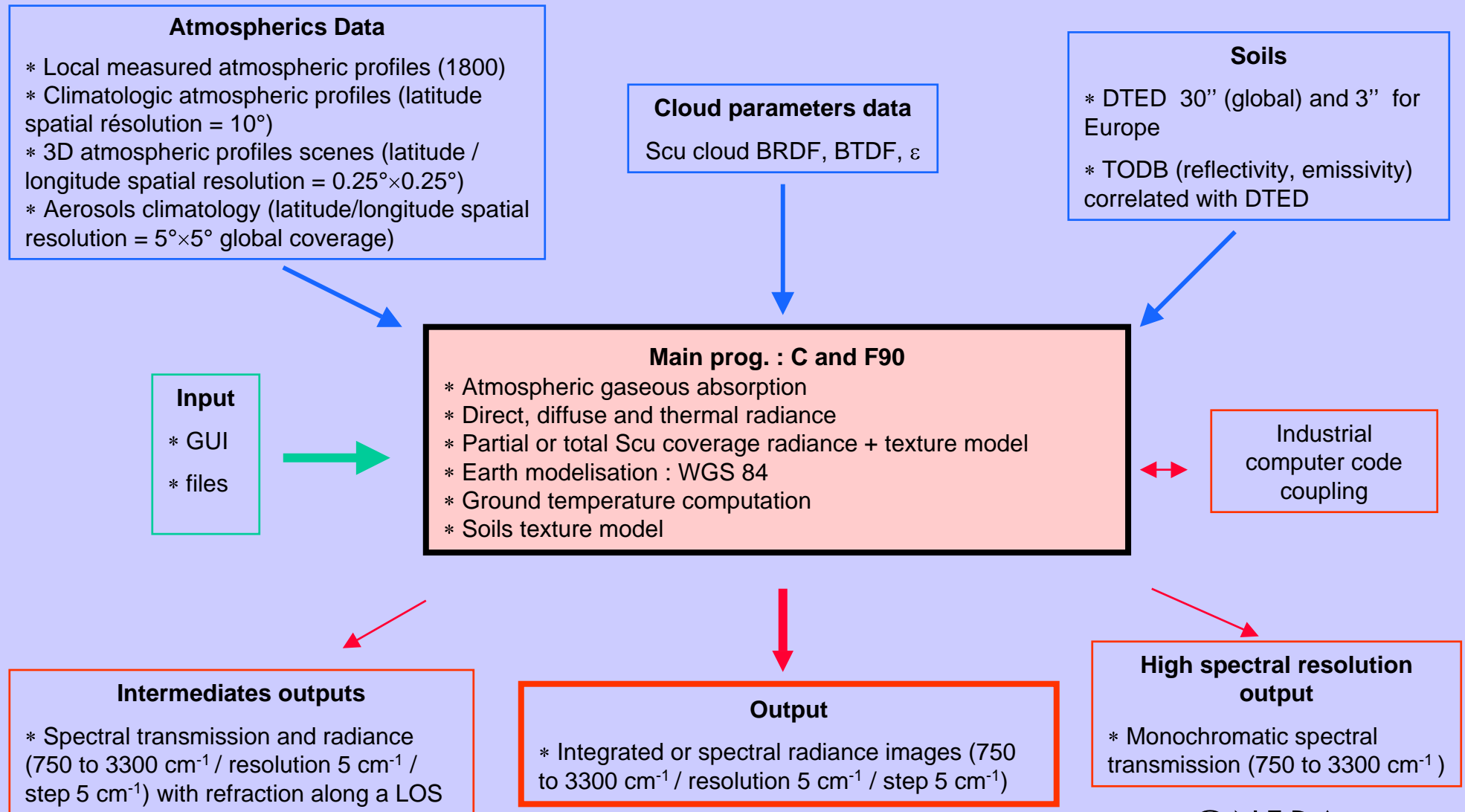


Main functionalities description

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MATISSE 1.1 : main functionalities



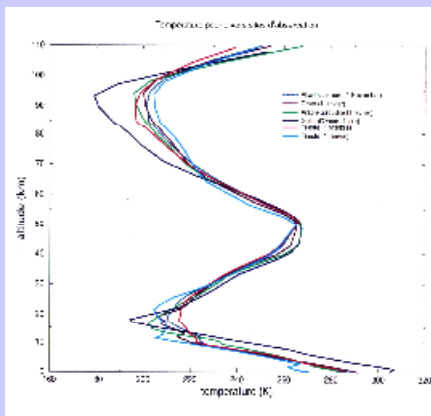
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Main functionalities description :
Atmospheric radiation computation

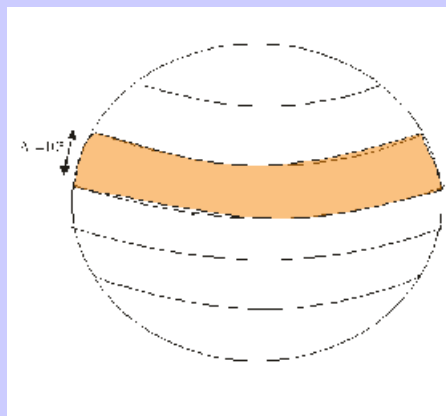
Atmospheric radiation computation :

Atmospheric parameters databases

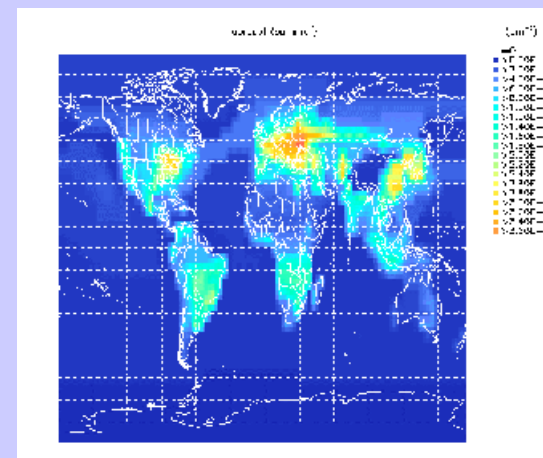
1D database
one profile in the scene



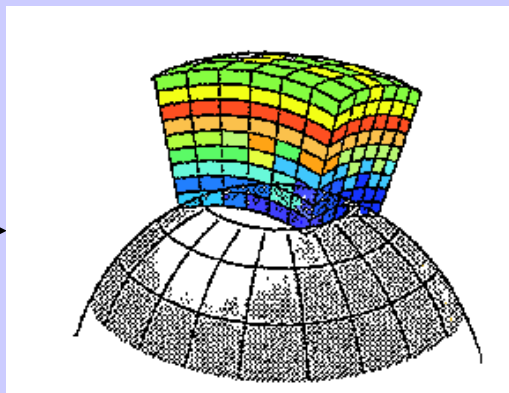
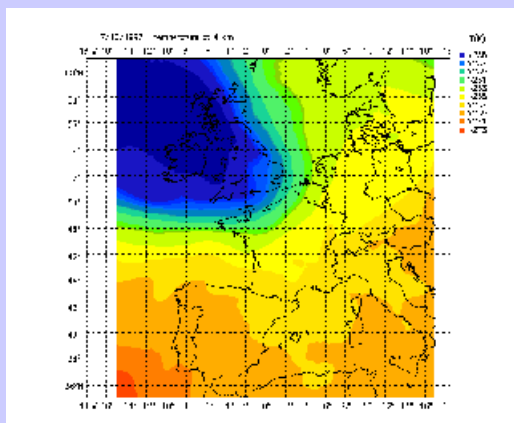
2D database
one profile for each latitude band



Aerosol database
horizontal spatial resolution : $5^\circ \times 5^\circ$

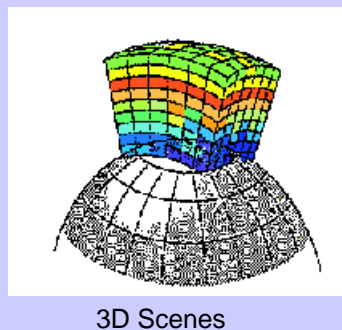
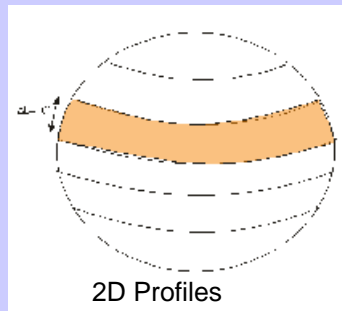
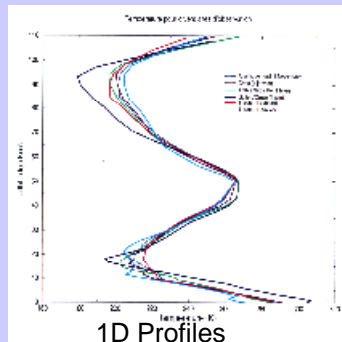


3D database
one profile each $0.25^\circ \times 0.25^\circ$



Atmospheric radiation computation :

Molecular absorption \rightarrow CK profiles database : 3 - 13 μm / $\delta\sigma/\sigma=5\text{cm}^{-1}$

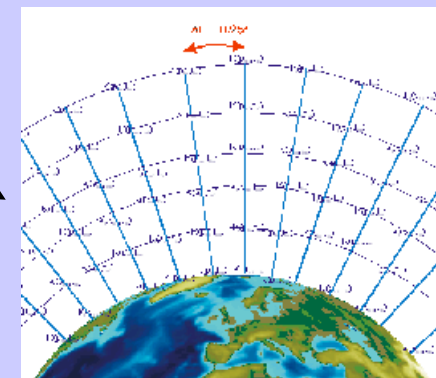
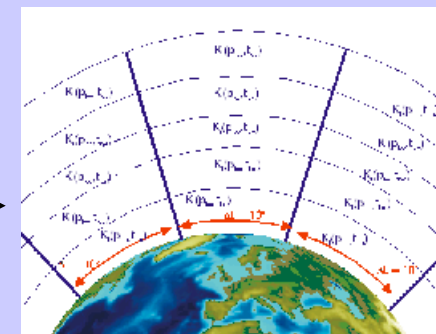
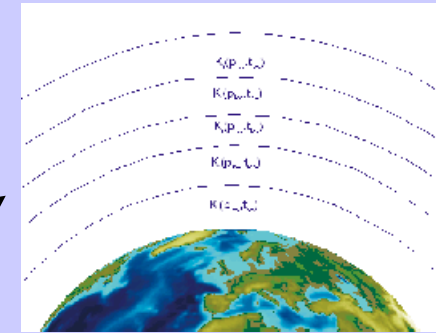


CK profiles generator

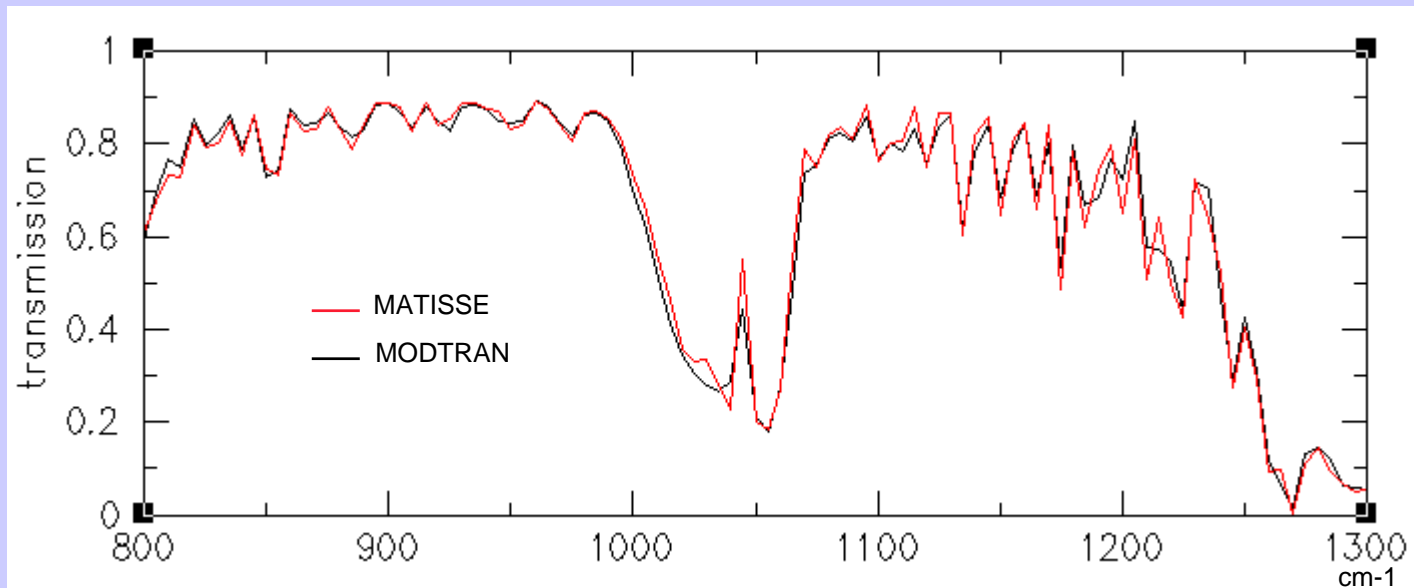
LBL Model
(Lppm/Snecma/Onera)

$K_{\Delta\sigma}(\text{profile}_j(p_i, t_i))$

sorting



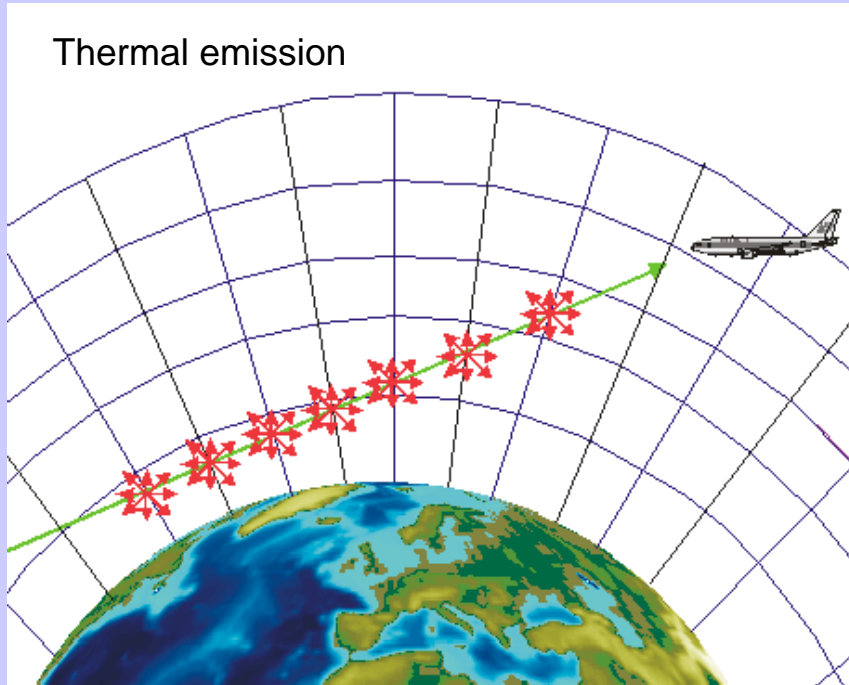
MATISSE / MODTRAN3 Transmission comparisons



- US Std
- Rural 23 km
- LOSZA = 45°
- Obs. altitude = 0 km

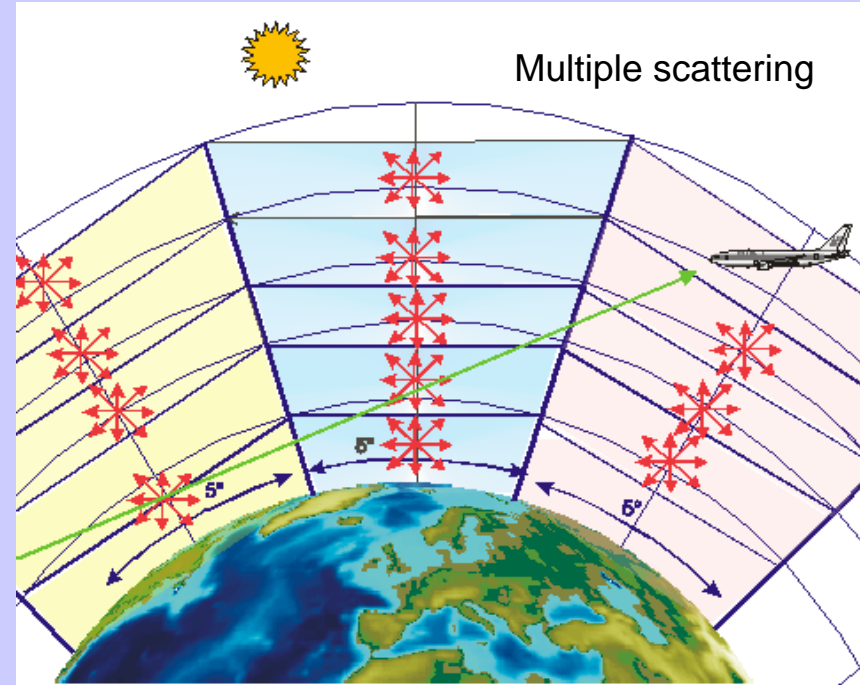
Atmospheric radiation computation : multiple scattering and thermal source functions

Thermal emission



$$J_{th}^i(x, y, z) = [1 - \omega_i(x, y, z)] B_{\Delta\sigma}(T(x, y, z))$$

Multiple scattering



$$J_{dm}^i(\theta, \varphi) = \omega_i \int_{4\pi} R^i(\theta', \varphi') p(\theta, \varphi; \theta', \varphi') \sin\theta' d\theta' d\varphi'$$

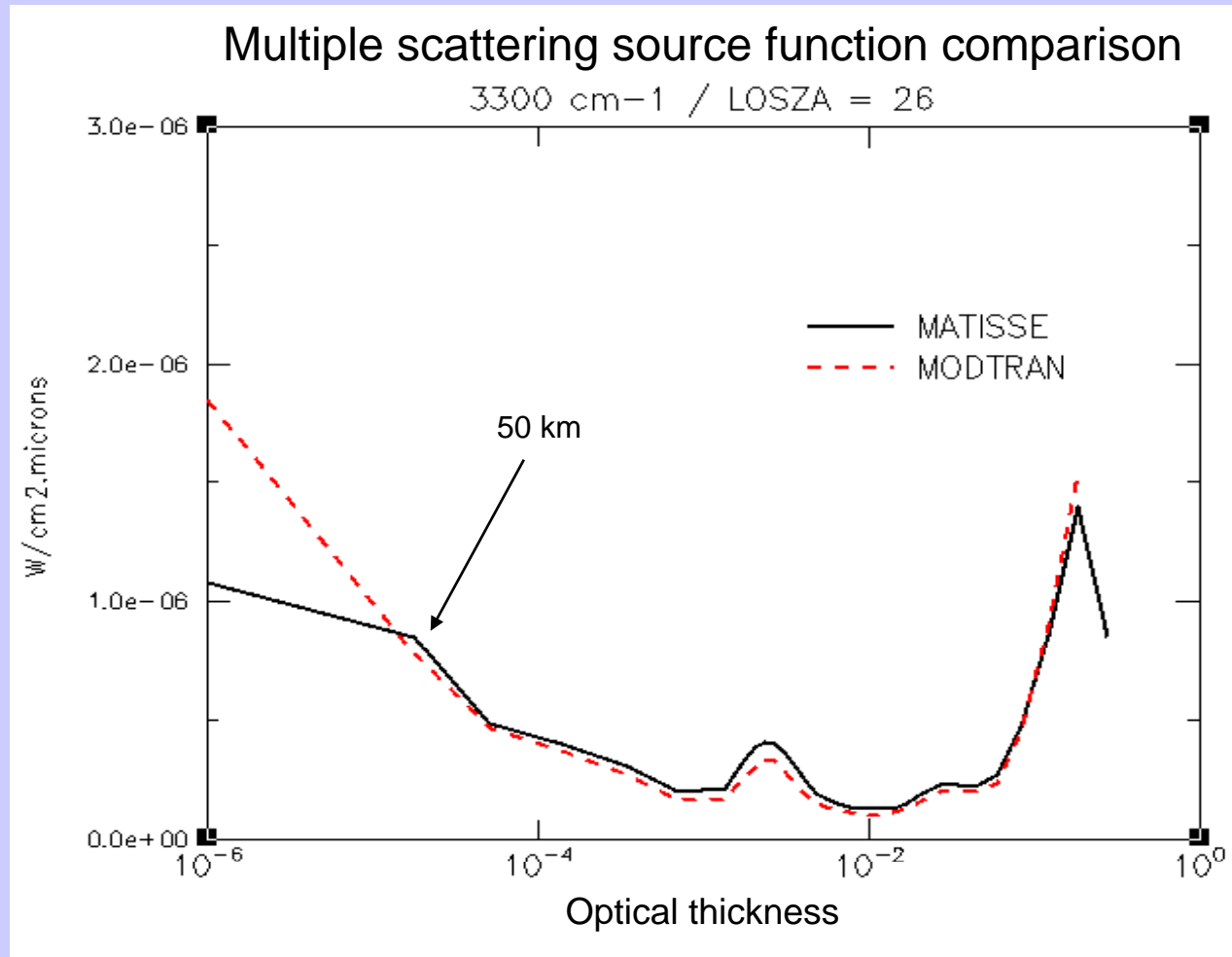
RTRN21 (Nakajima, Tanaka)

- DOM - Plane // - 5°x5° area
- CK coupling
- Atmospheric parameters : central profile

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MODTRAN3 / MATISSE 1.1 multiple scattering source function comparison

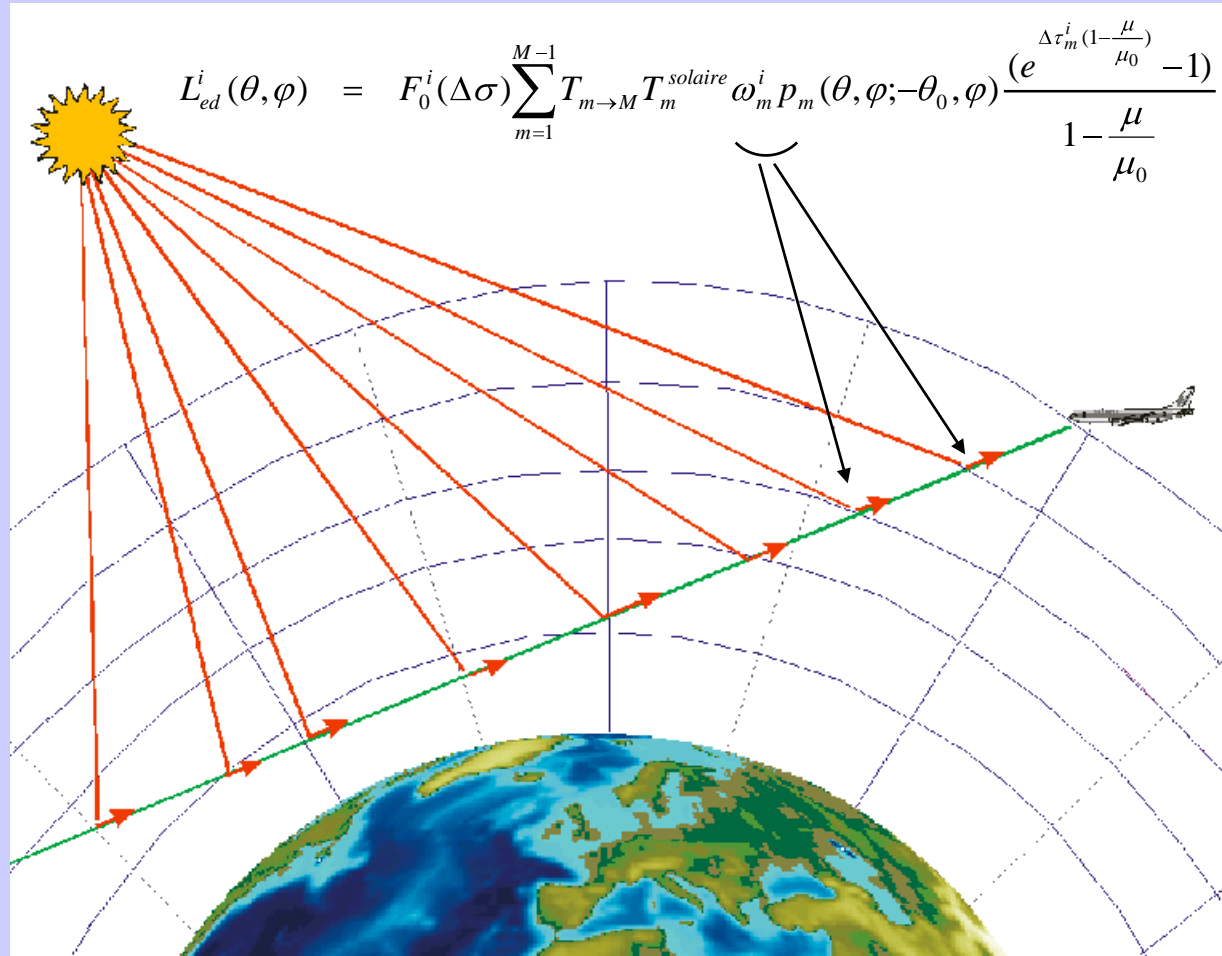


- US Std
- Rural 23 km
- LOSZA = 26°
- SZA = 0°
- 3300 cm⁻¹

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Atmospheric radiation computation : single scattering radiance



Main functionalities description :
Cloud radiation computation

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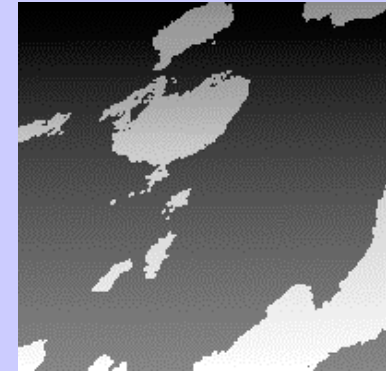
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Cloud radiance computation

Partial or total coverage of stratocumulus clouds

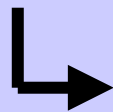
Cloud cover generator

- Inverse Fourier transform \Rightarrow Shape and local thickness $\Delta h(x,y)$
- $T_{\text{local}}(z) + \text{Feddes model} + z_{\text{base}} + \Delta h(x,y) \Rightarrow \text{LWP}(x,y,z)$
- Facetisation

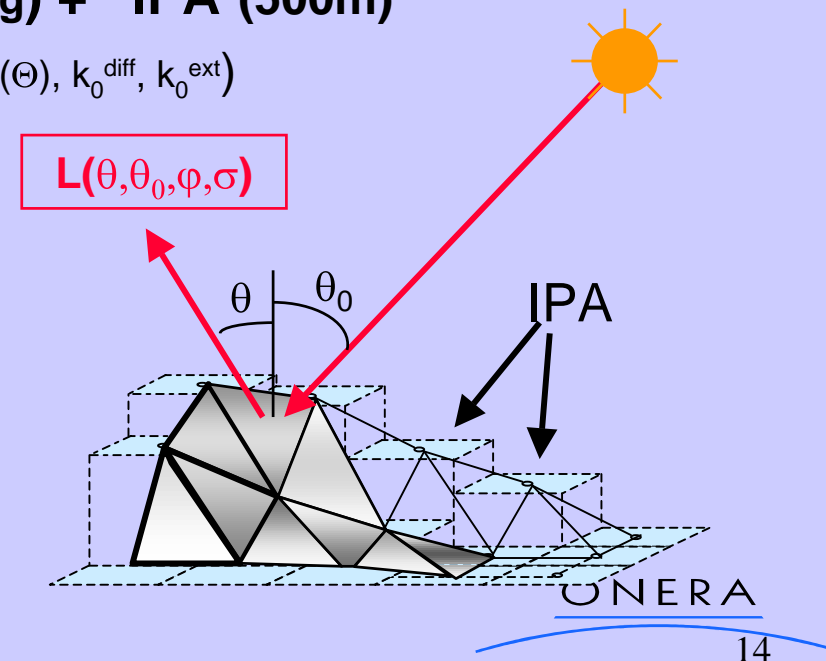


Radiative transfer : BRDF(CK coupling) + IPA (500m)

- Scu standard parameters ($N_0, \text{LWC}_0, \Delta Z_0, \rho(\Theta), k_0^{\text{diff}}, k_0^{\text{ext}}$)
- Use of RTRN21 (Nakajima, Tanaka)
 - DOM / Plane parallel

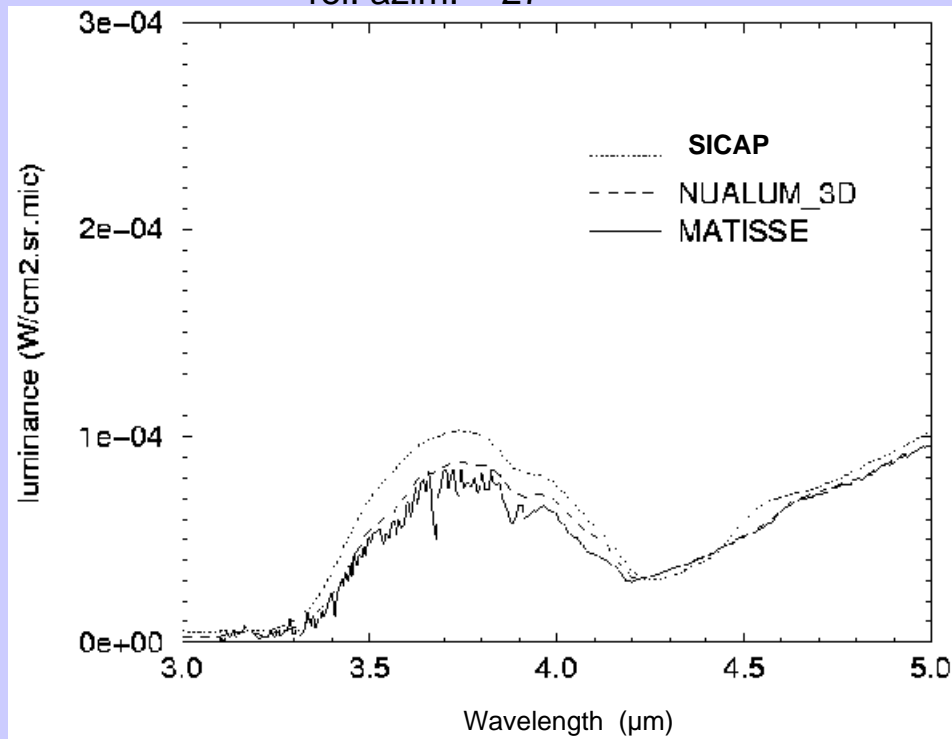


$\text{BRDF}(\Theta_{\text{sol}}, \Theta, \Delta\varphi, \sigma, \omega, \tau)$
 $\text{BTDF}(\Theta_{\text{sol}}, \Theta, \Delta\varphi, \sigma, \omega, \tau)$
 $\varepsilon(\Theta, \sigma, \omega, \tau)$

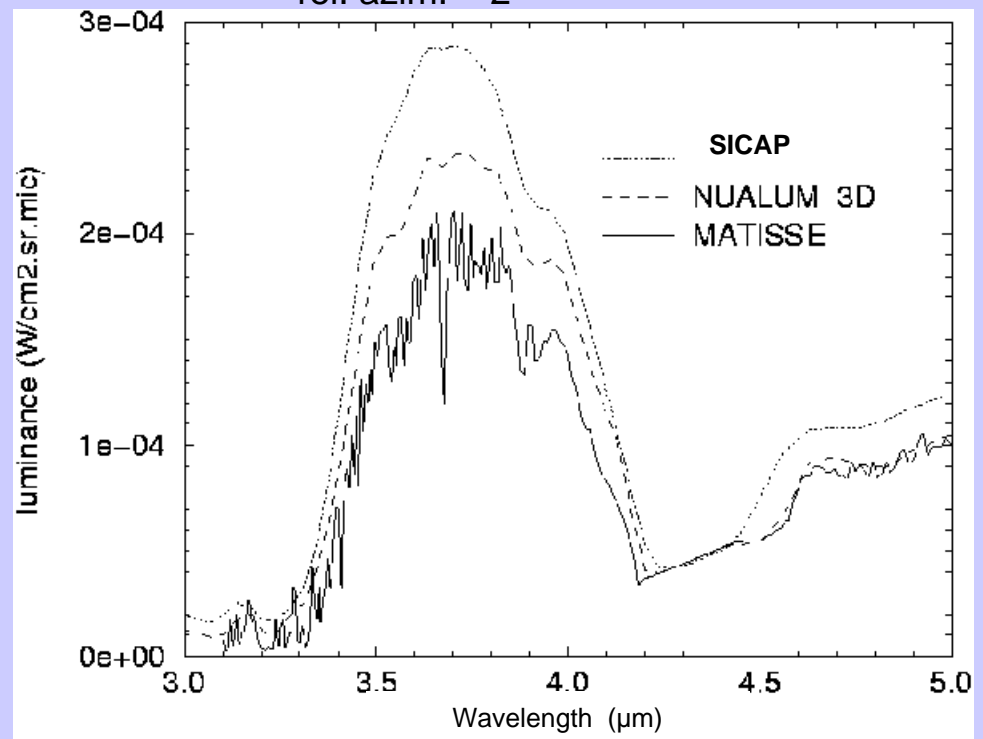


Measurement / NUALUM 3D / MATISSE 1.1 cloud radiance comparison (1 column)

- LOSZA = 120° / SZA = 57°
- rel. azim. = 27°



- LOSZA = 95° / SZA = 57°
- rel. azim. = 2°



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Main functionalities description :
Ground radiation computation

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Ground radiation

Database construction

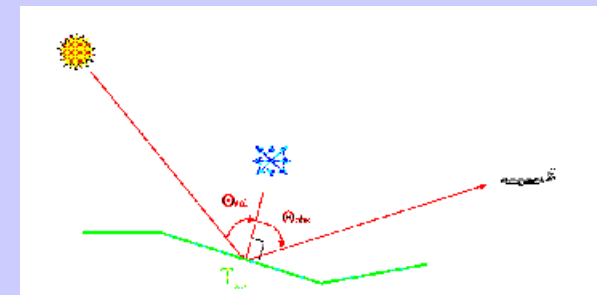
- Global Land Cover Database (GLCC) → World map of ground cover types
- Elementary materials reflectance and emissivity Database (ASTER) → Thermo-optical properties of ground cover types
- Sea Surface Temperature (ASST) → Sea surface temperature World Map
- Global Elevation Database (GTOPO30) → Ground Elevation Map (ref : WGS84)



LAND USE / DTED DATA BASE
spatial resolution : 30 ''

1D Ground thermal model

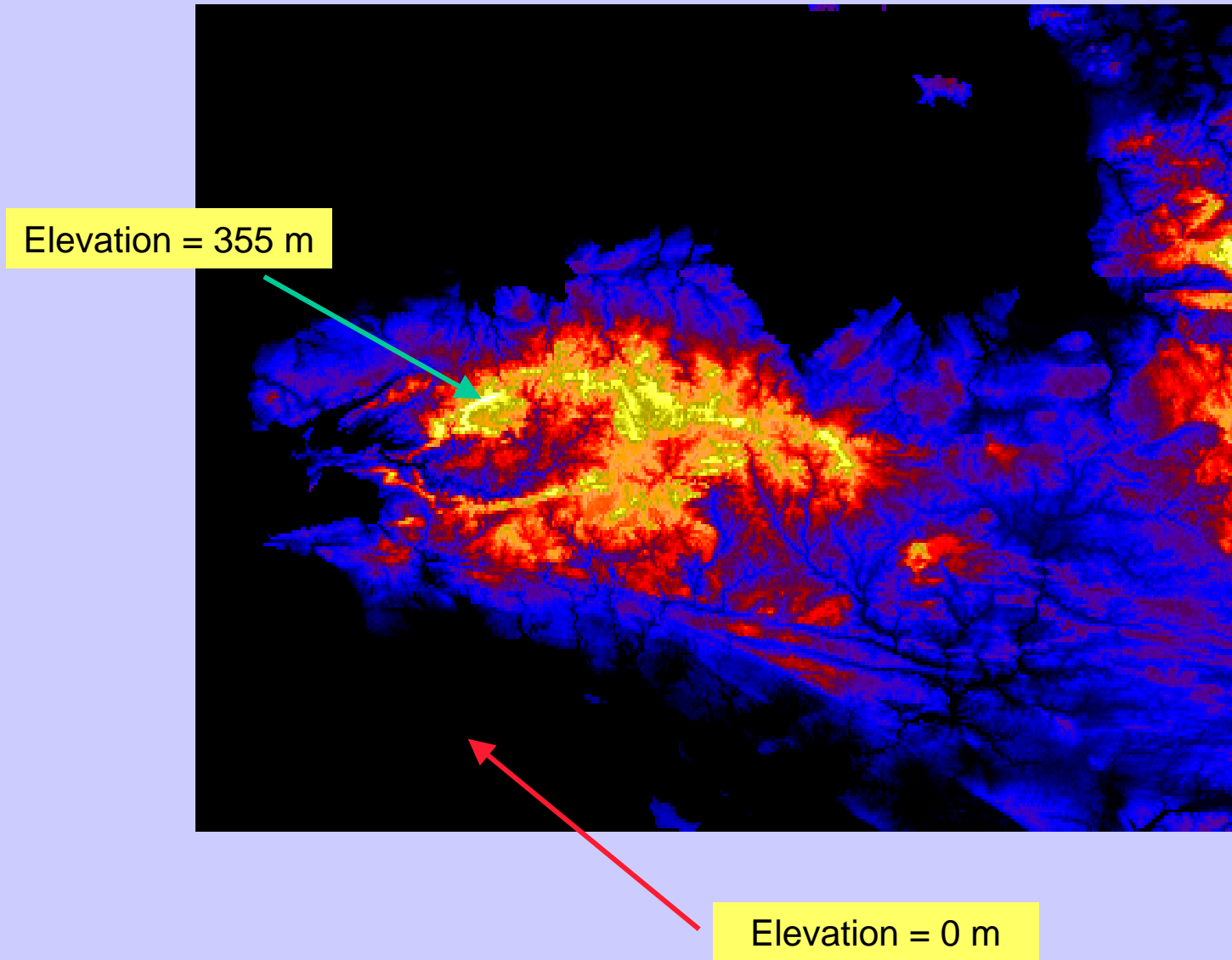
- Homogeneous ground / large horizontal facets
- Periodic energy deposition → **Fourier Method**
- Analytical diffuse energy deposition → $E_{\text{diffus}} = \text{fct}(E_{\text{direct}}, \text{climato}, \text{GADS})$



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DTED validation



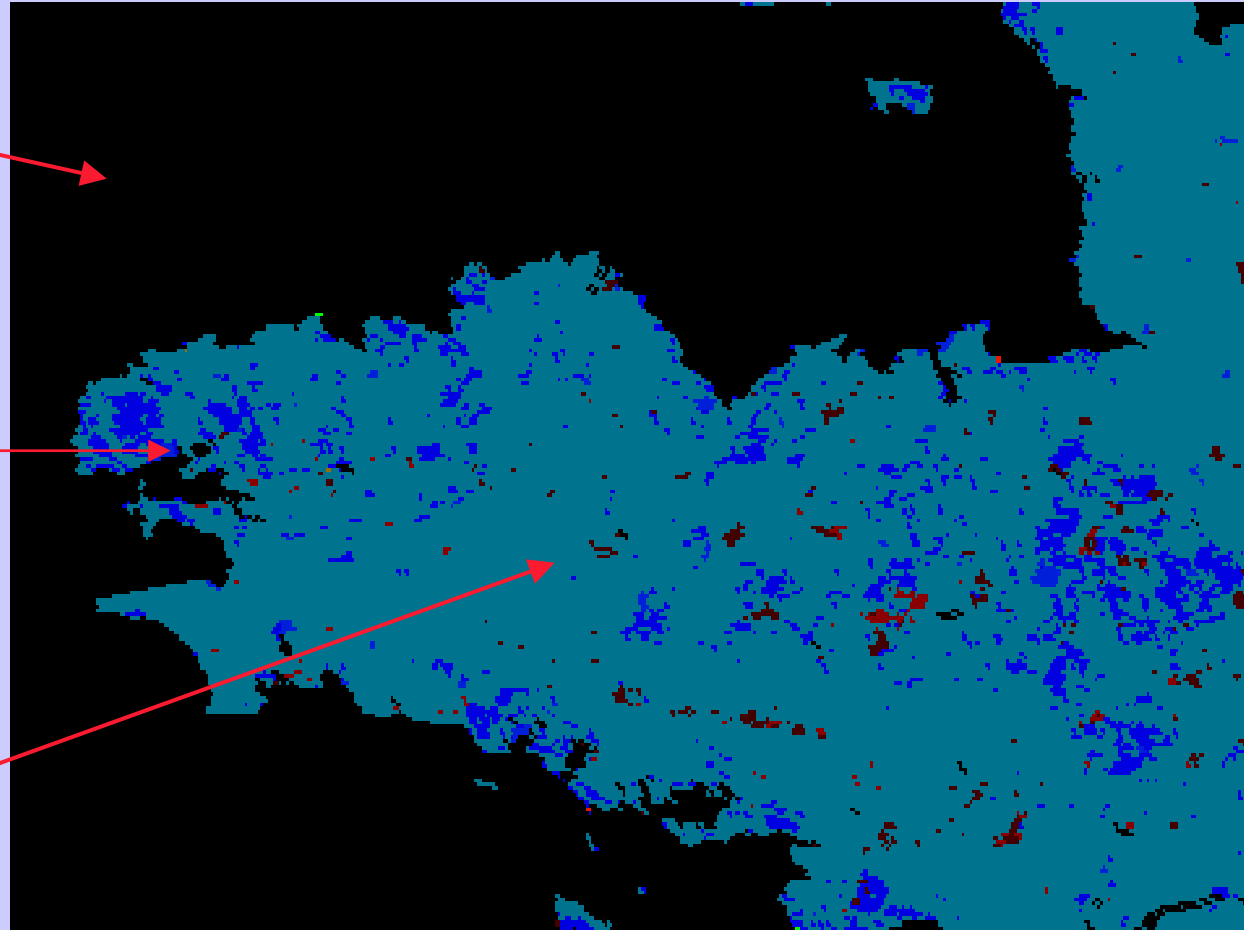
DTED resolution : 30''

Terrain types validation

17 : water

13 : urban

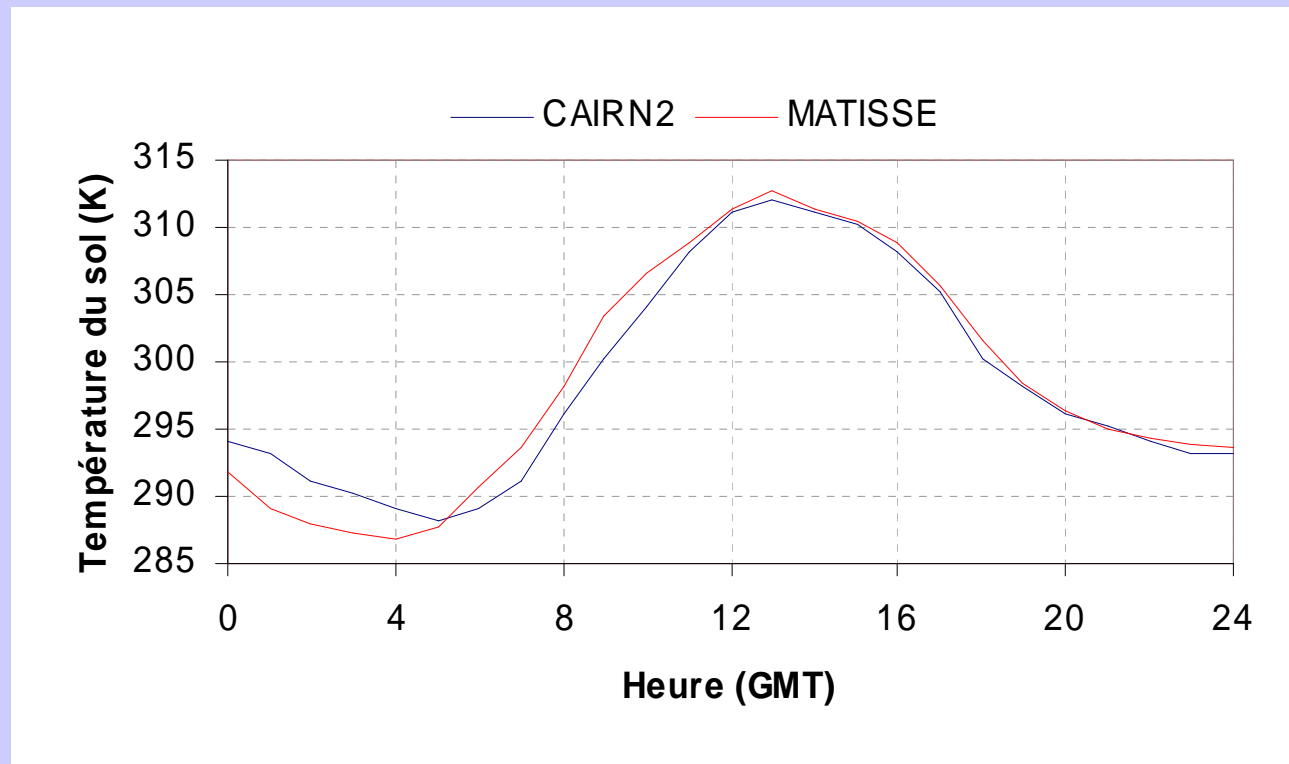
12 : agricultural
area



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Ground thermal model validation



Cairn 2 campaign :

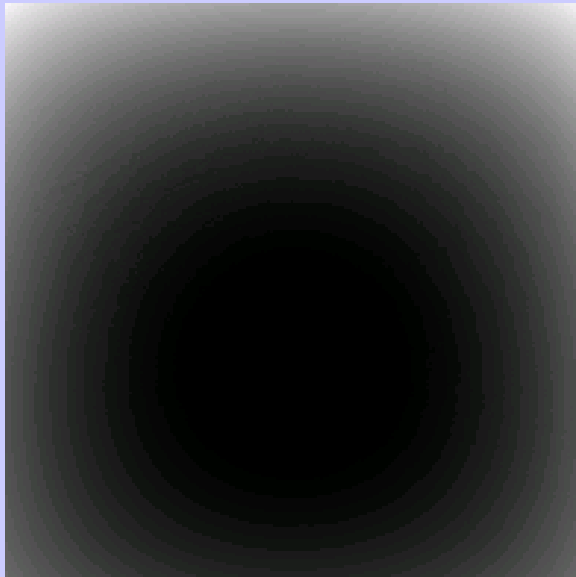
- ground (sand) temperature measurement

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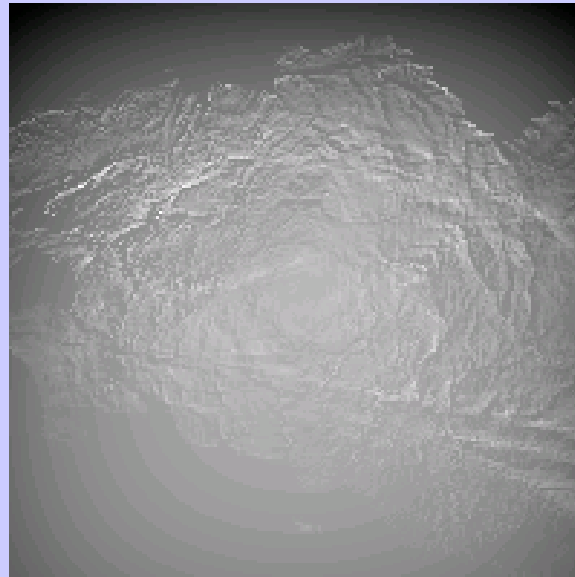
20

Results

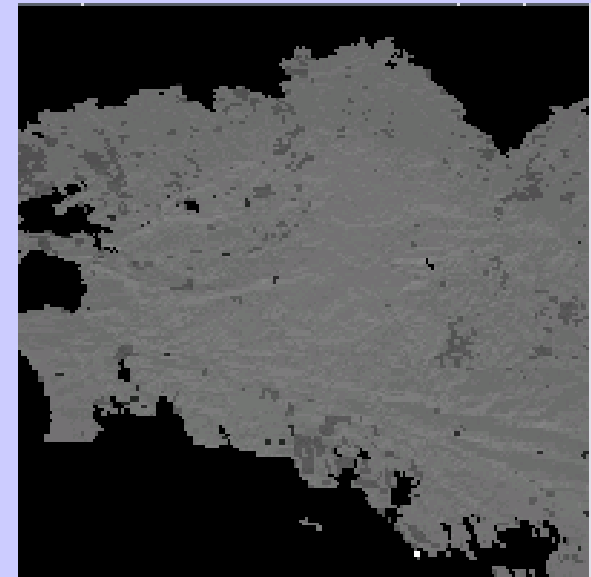
Ground radiance image



Distance image



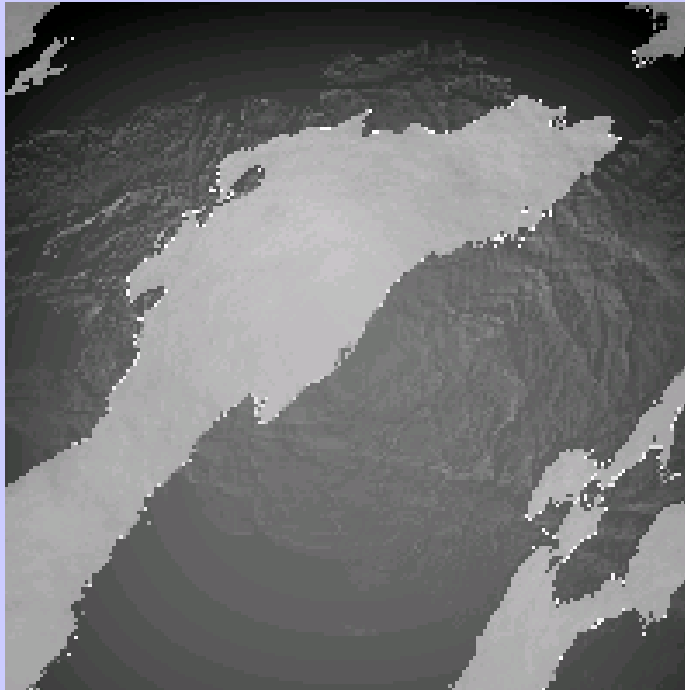
Transmission image



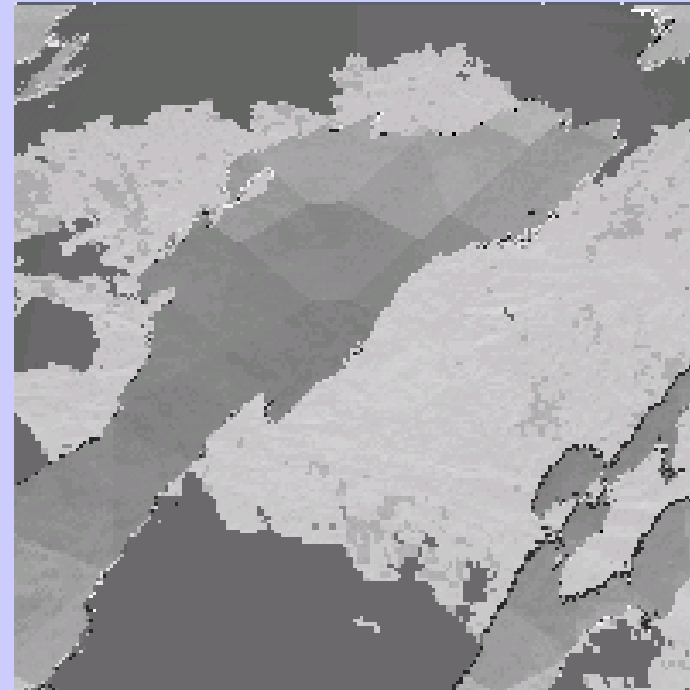
Radiance image

- **Date** : 30/10/02 / 12h TU
- **Obs. alt.** : 90 km / **Obs. Elev.** : -80°
- **FOV** : 80°x80° / **pixel number** : 200x200
- **Wavelength** : 2700 cm⁻¹

Ground + Scu radiance image (2700 cm⁻¹)



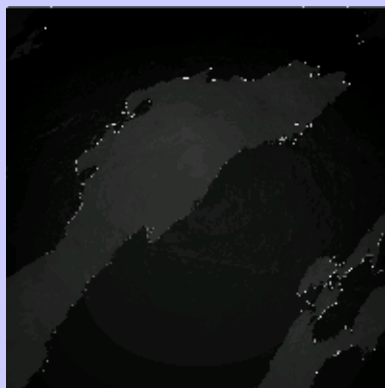
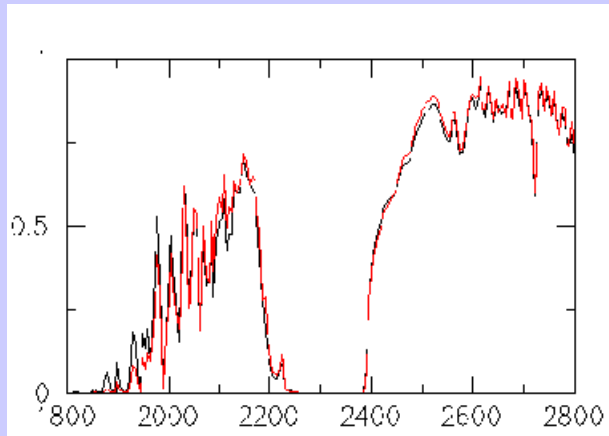
Transmission image (2700 cm⁻¹)



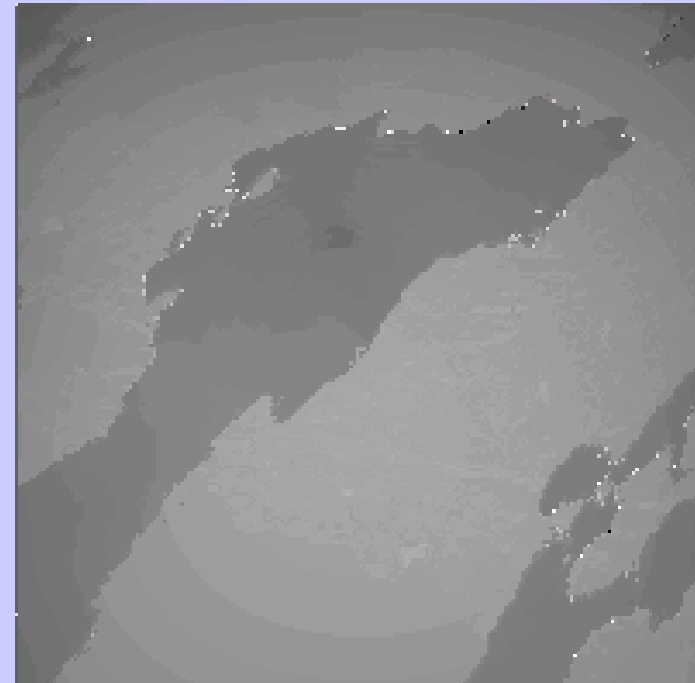
Radiance image (2700 cm⁻¹)

- **Date** : 30/10/02 / 12h TU
- **Obs. alt.** : 90 km / **Obs. Elev.** : -80°
- **FOV** : 80°x80° / **pixel number** : 200x200
- **Wavelength** : 2700 cm⁻¹

Ground + Scu radiance image (2200 cm⁻¹)



Transmission image (2200 cm⁻¹)



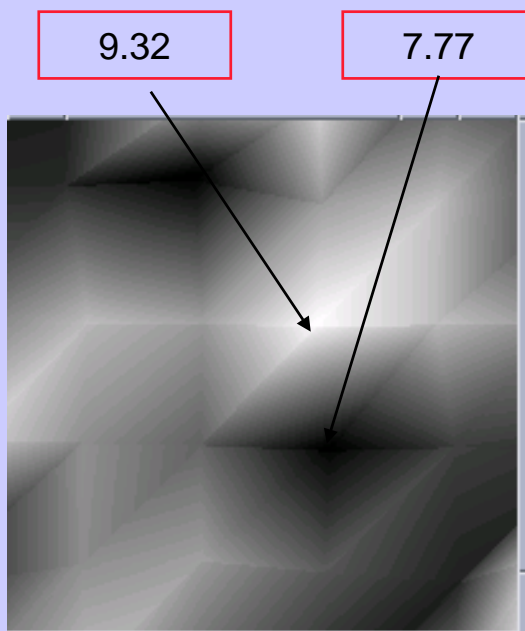
Radiance image (2200 cm⁻¹)

- **Date** : 30/10/02 / 12h TU
- **Obs. alt.** : 90 km / **Obs. Elev.** : -80°
- **FOV** : 80°x80° / **pixel number** : 200x200
- **Wavelength** : 2700 cm⁻¹

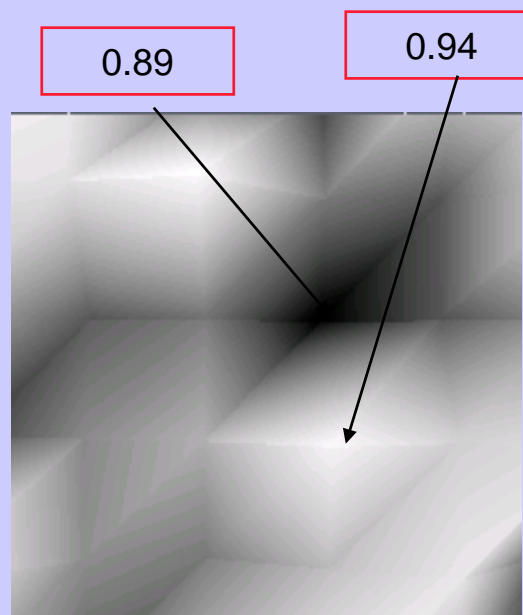
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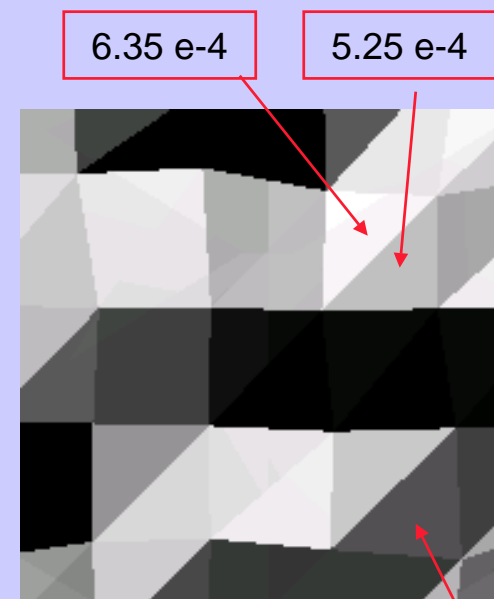
Scu total coverage radiation



Distance image



Transmission image



Radiance image

2.9 e-4

min : 1.19e-4 / max : 6.64e-4 / mean 3.88 e-4
 Modtran (1 pixel) : 3.24 e-4

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- **Date** : 16/10/02 / 13h TU
- **Obs. alt.** : 10 km / **Obs. Elev.** : -90°
- **FOV** : 15°x15° / **pixel number** : 200x200
- **Wavelength** : 2740 cm⁻¹

Conclusion and future works

Conclusion

MATISSE : new Background Scene Generator

- Radiance images 750 to 3300 cm^{-1} / resolution 5 cm^{-1} / step 5 cm^{-1})
- Atmospheric spatial variability
- Partial coverage Scu clouds
- Ground temperature computation
- Texture model
- Refraction (along 1 LOS)
- LBL (along 1 LOS)

Release of MATISSE 1.1 : Today

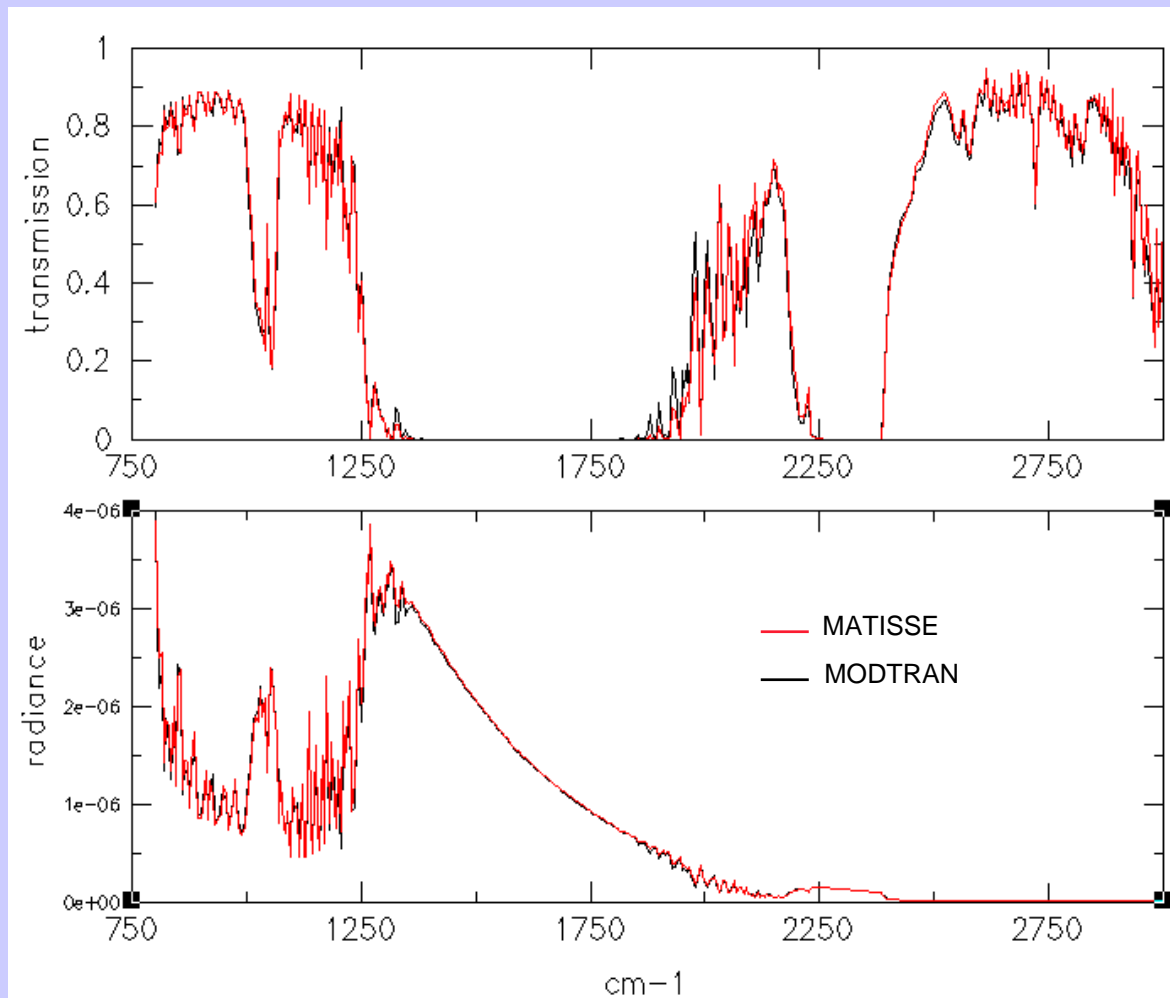
Matisse 1.1 is sponsored by the 'Délégation Générale de l'Armement'



Future works

- **Tests and optimisations**
- **Homogeneous cirrus clouds**
- **Local thermal model**
- **Spectral domain extension and resolution modification**
- **Adjacencies effects**

MODTRAN3 / MATISSE 1.1 radiance comparison

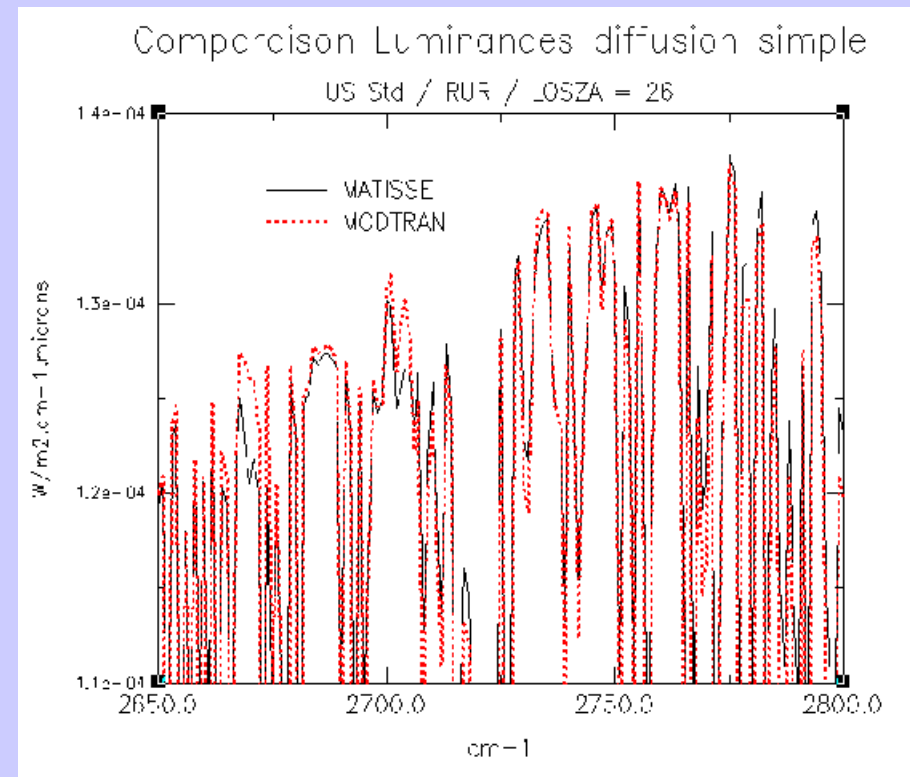
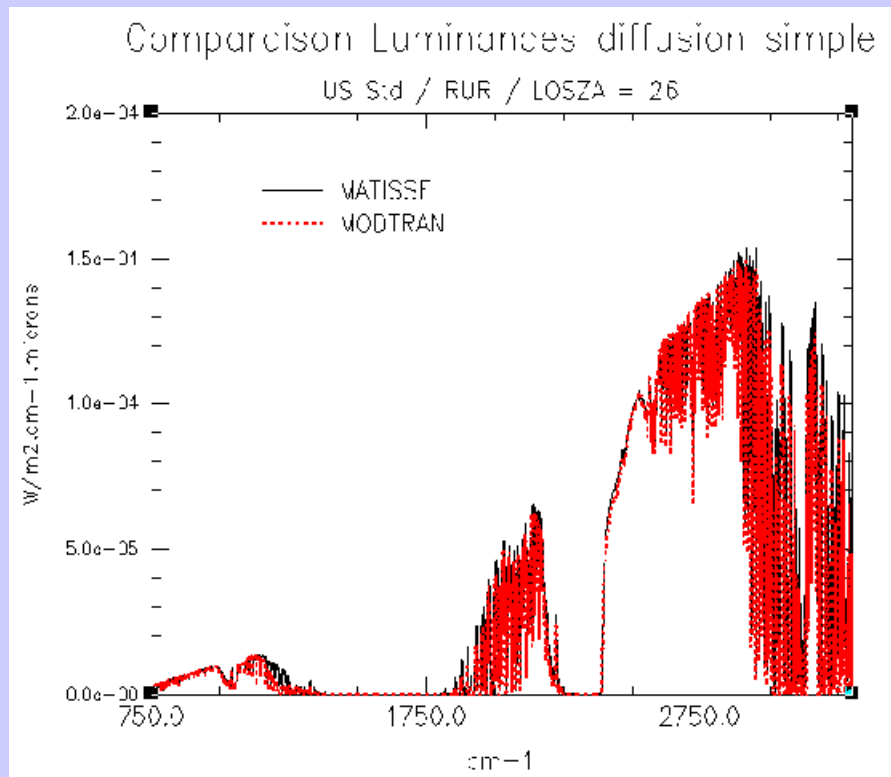


- US Std
- Rural 23 km
- 12 h
- LOSZA = 45°
- Azim = 0°
- Obs. altitude = 0 km

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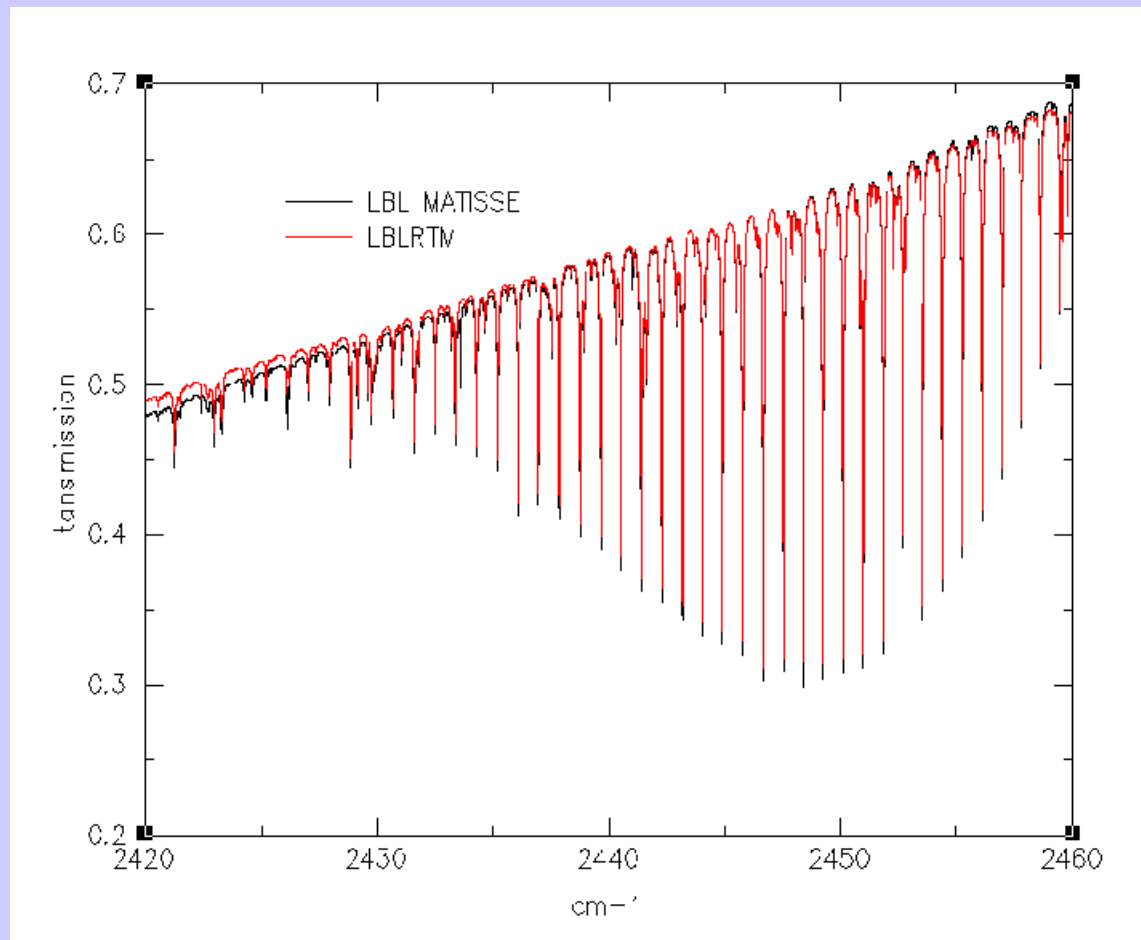
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MODTRAN3 / MATISSE 1.1 single scattering radiance comparison



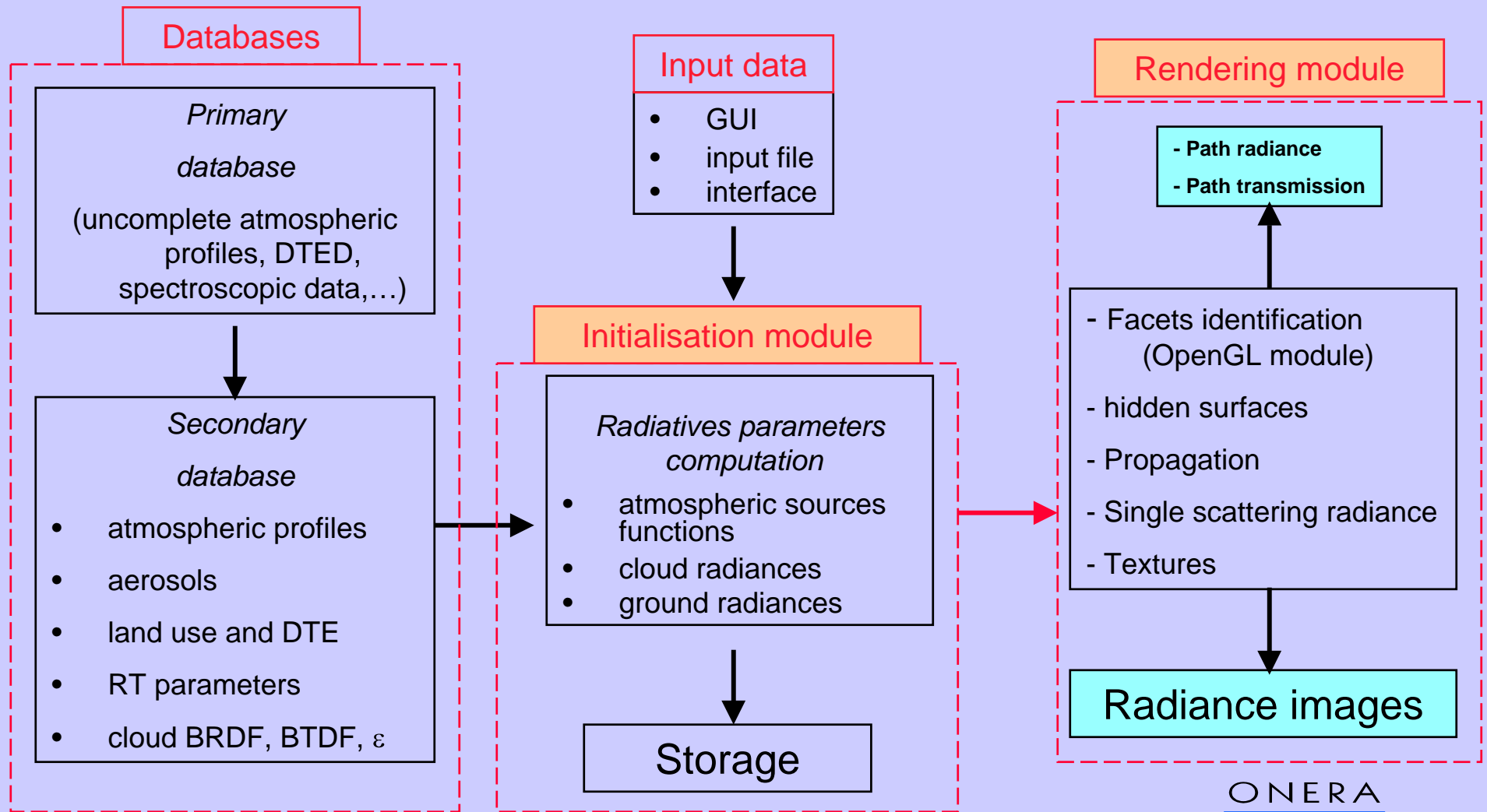
- US Std / Rural 23 km
- Alt. Obs. 0 km
- LOSZA = 26° / SZA = 0°

LBL MATISSE / LBLRTM Transmission comparisons



ARCHITECTURE

MATISSE : Flow chart



MATISSE1.1 architecture : Optimised for multi-imaging

