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

P. Simoneau
R. Berton, K. Caillault, G. Durand, T. Huet,
L. Labarre, C. Malherbe, C. Miesch, A. Roblin, B. Rosier

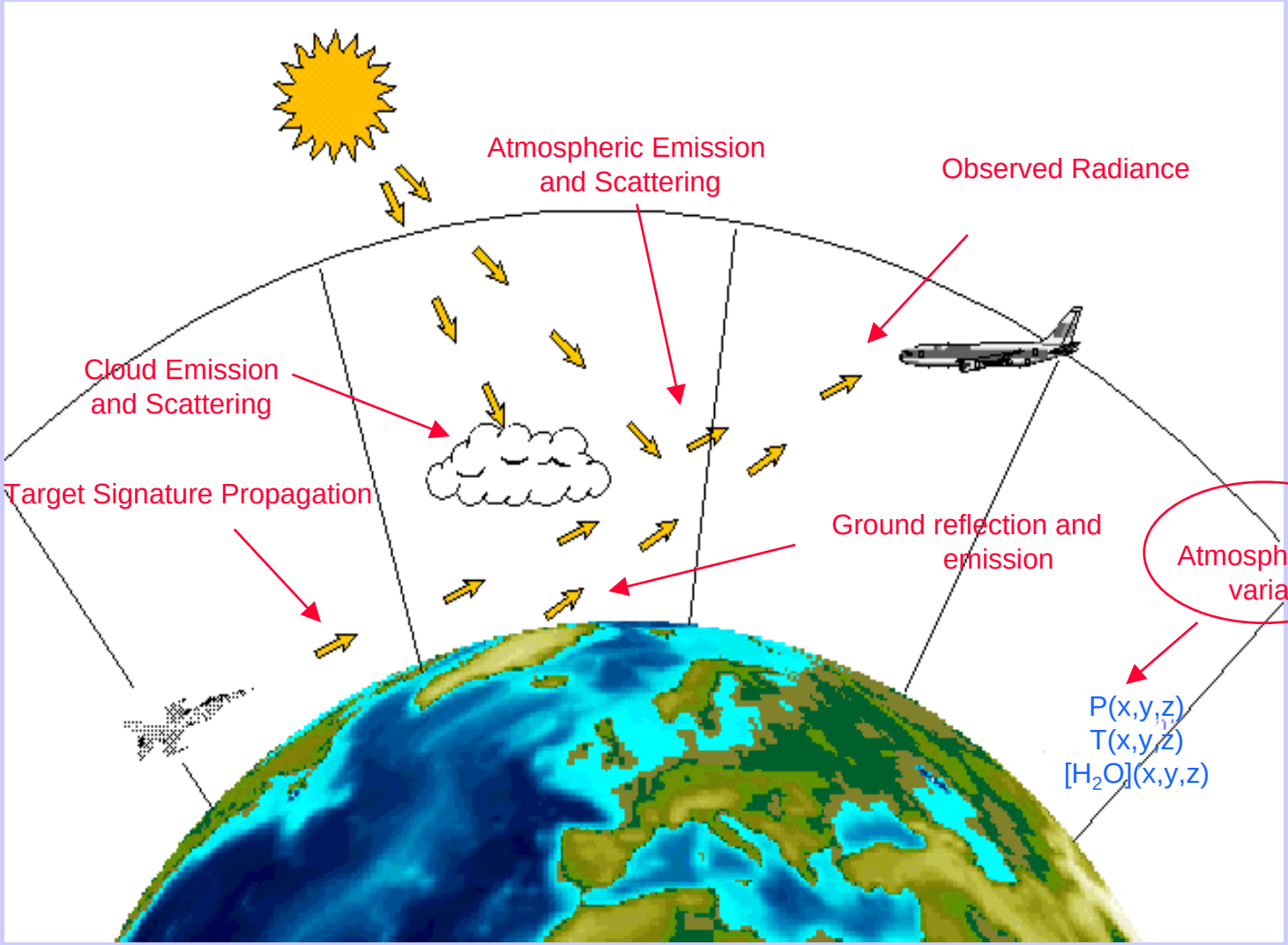
ONERA
Applied and Theoretical Optical Department

ONERA

PRESENTATION OUTLINE

- **Objectives**
- **General code description**
  - initialization module
  - rendering module
  - databases
- **Summary**

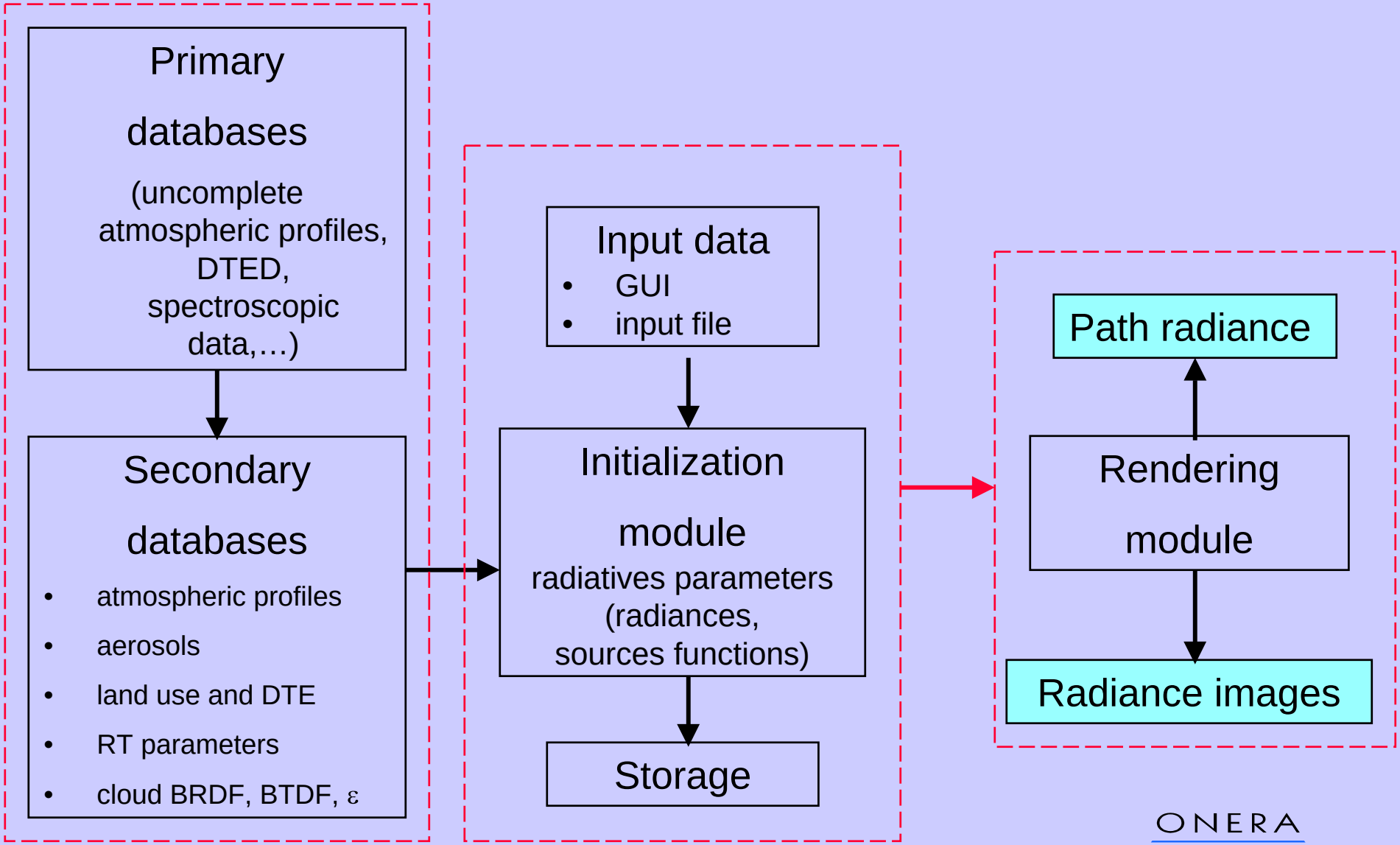
Goal of MATISSE : Radiance images



ONERA

Flow chart

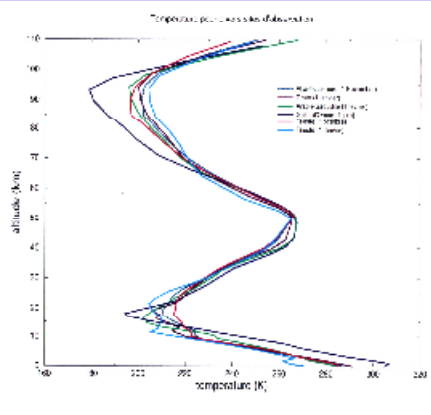
MATISSE : Flow chart



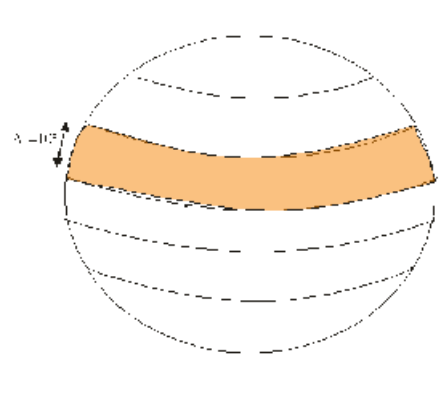
Initialization module

Atmospheric parameters databases

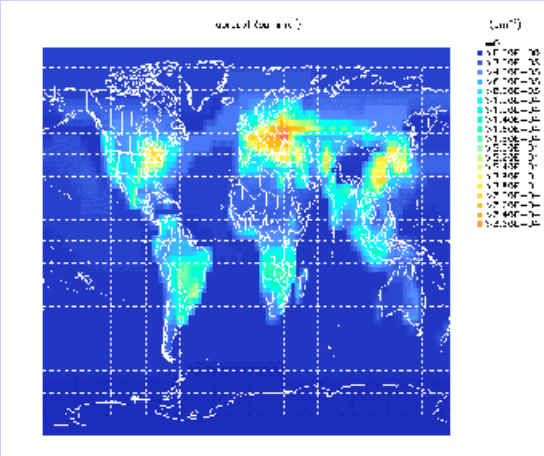
1D database
one profile in the scene



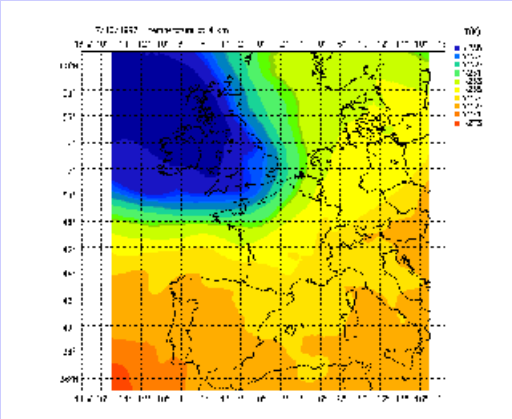
2D database
one profile for each latitude band

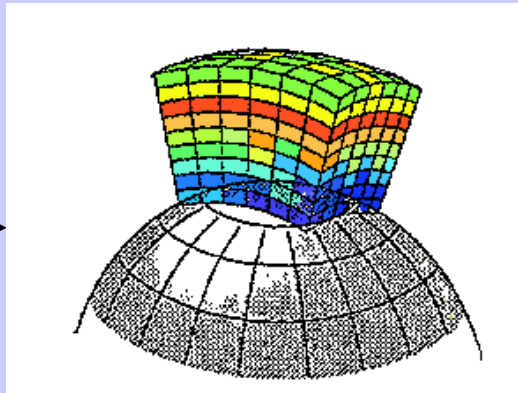


Aerosol database
horizontal spatial resolution :5°x5°



3D database
one profile each 0.25°x0.25°



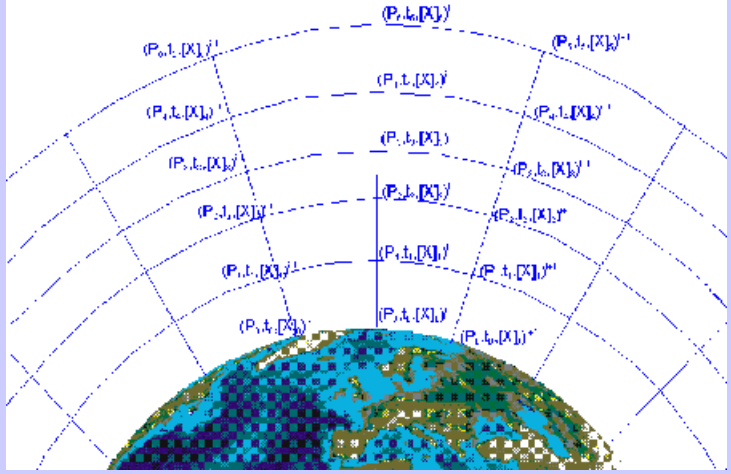


ONERA

Initialization module (3D case)

Atmospheric Source Functions (1/2)

Atmospheric profiles

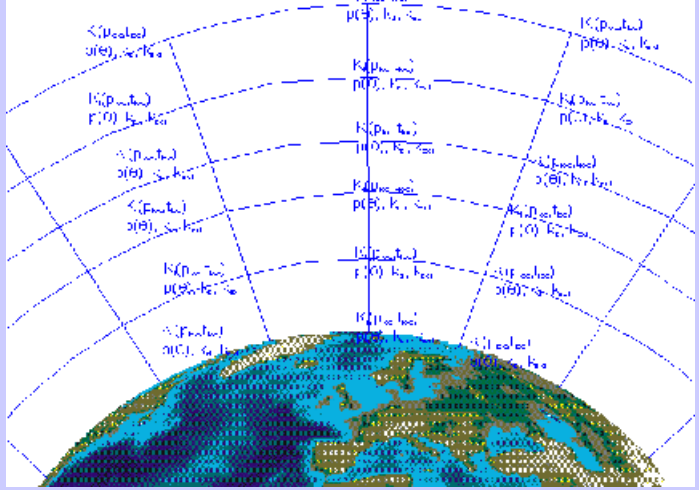


CK profiles database

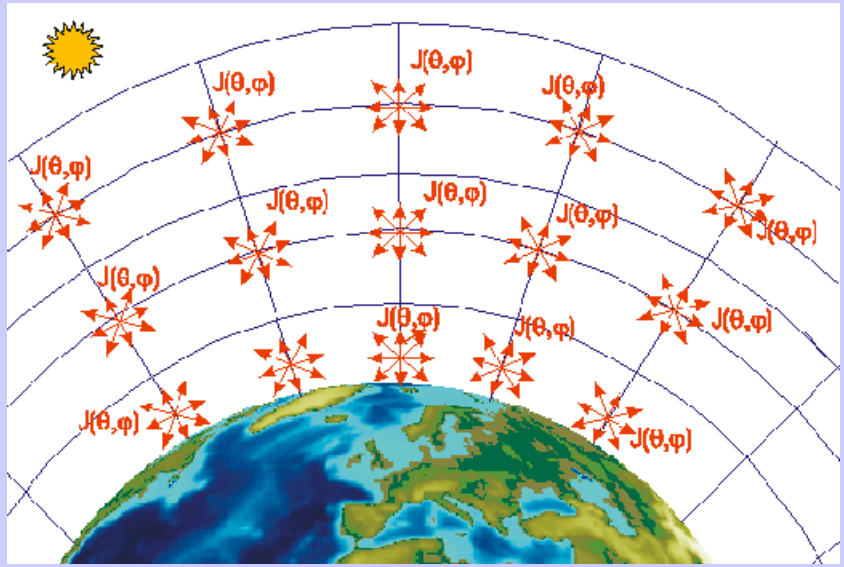
3-13µm

$\delta\sigma/\sigma$ = 5 cm^{-1}

Optical parameters



Total Atmospheric Source Functions



Initialization module (3D case)

Atmospheric Source Functions (2/2)

$$J_{tot}(\theta,\varphi) = J_{ds}(\theta,\varphi) + J_{th} + J_{ms}(\theta,\varphi)$$

→ **High spatial resolution**

(3D atmospheric DB : 0.25°x0.25°)

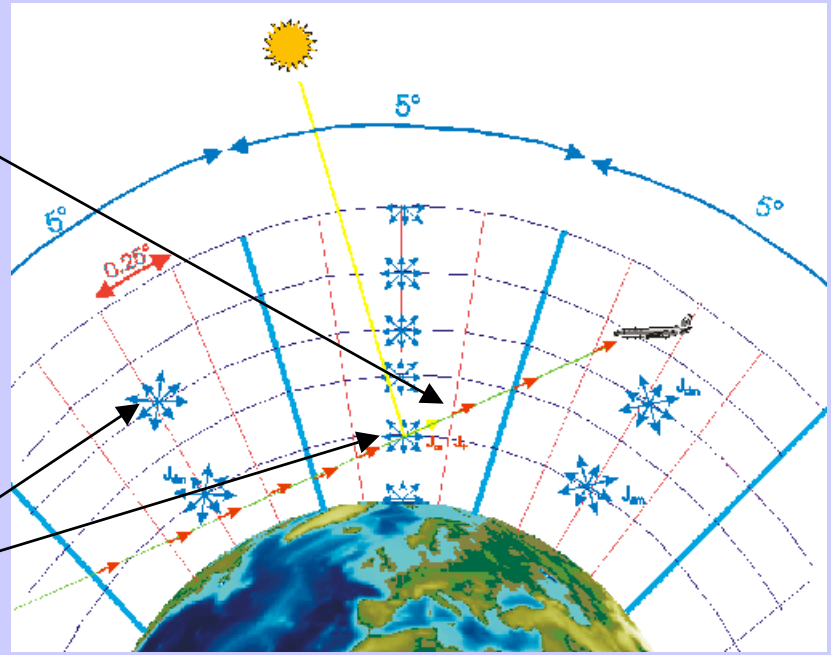
- Direct scattering : $J_{ss}(\theta,\varphi)$
- Thermal emission : J_{th}

→ **Low spatial resolution**

(Aerosol DB : 5°x5°)

- Multiple scattering : $J_{ms}(\theta,\varphi)$

→ RTRN21 (Nakajima) : DOM + TMS



ONERA

Initialization module

Partial or total coverage of stratocumulus clouds

Cloud cover generator

- Shape (inverse Fourier transform)
- Local thickness $\Delta h \Rightarrow (\tau, \omega)$
- Facettisation

Radiative transfer

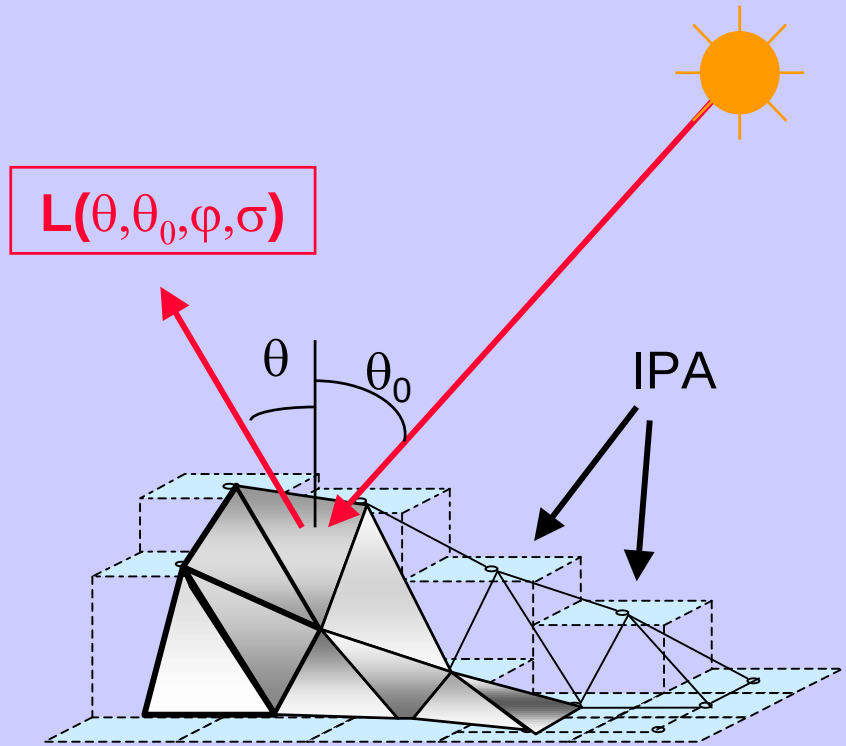
IPA (500m)

+

Database

- **BRDF(Θ_{sol}, Θ, $\Delta\varphi$, σ, ω,τ)**
- **BTDF(Θ_{sol}, Θ, $\Delta\varphi$, σ, ω,τ)**
- $\varepsilon(\Theta, \sigma, \omega,\tau)$

with $\omega \in [0,\omega_0]$ et $\tau \in [0, \tau_{max}]$

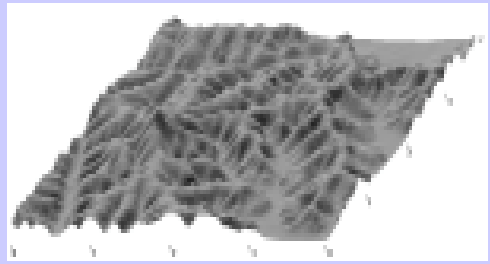


ONERA

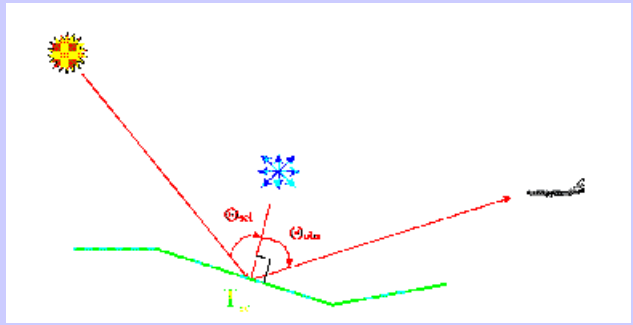
Initialization module

Ground radiation

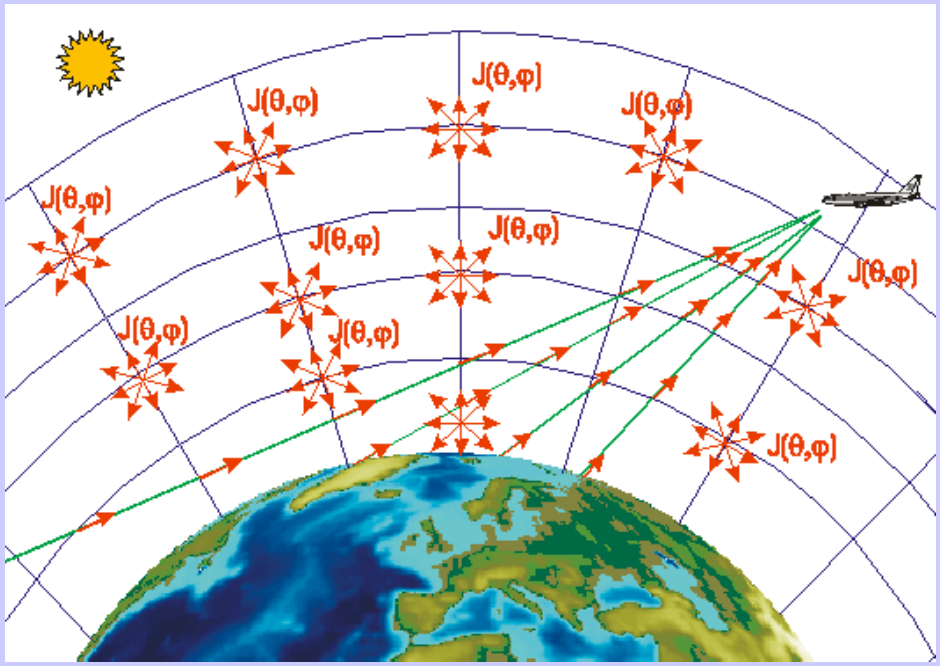
LAND USE / DTED DATA BASE
spatial resolution : 30 ' '

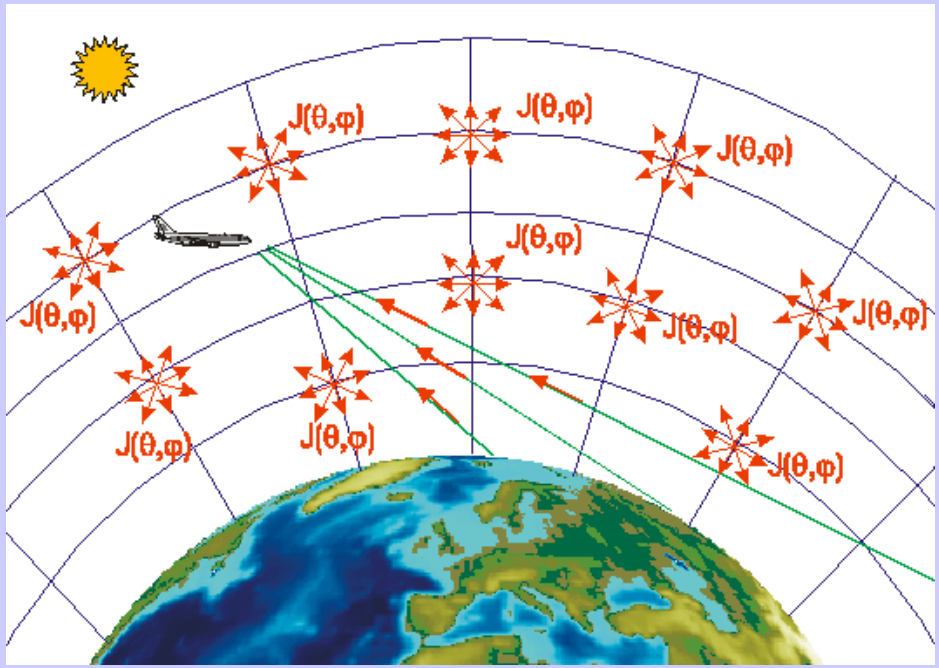


Ground thermal model (Fourier method)



Initialization module
Method

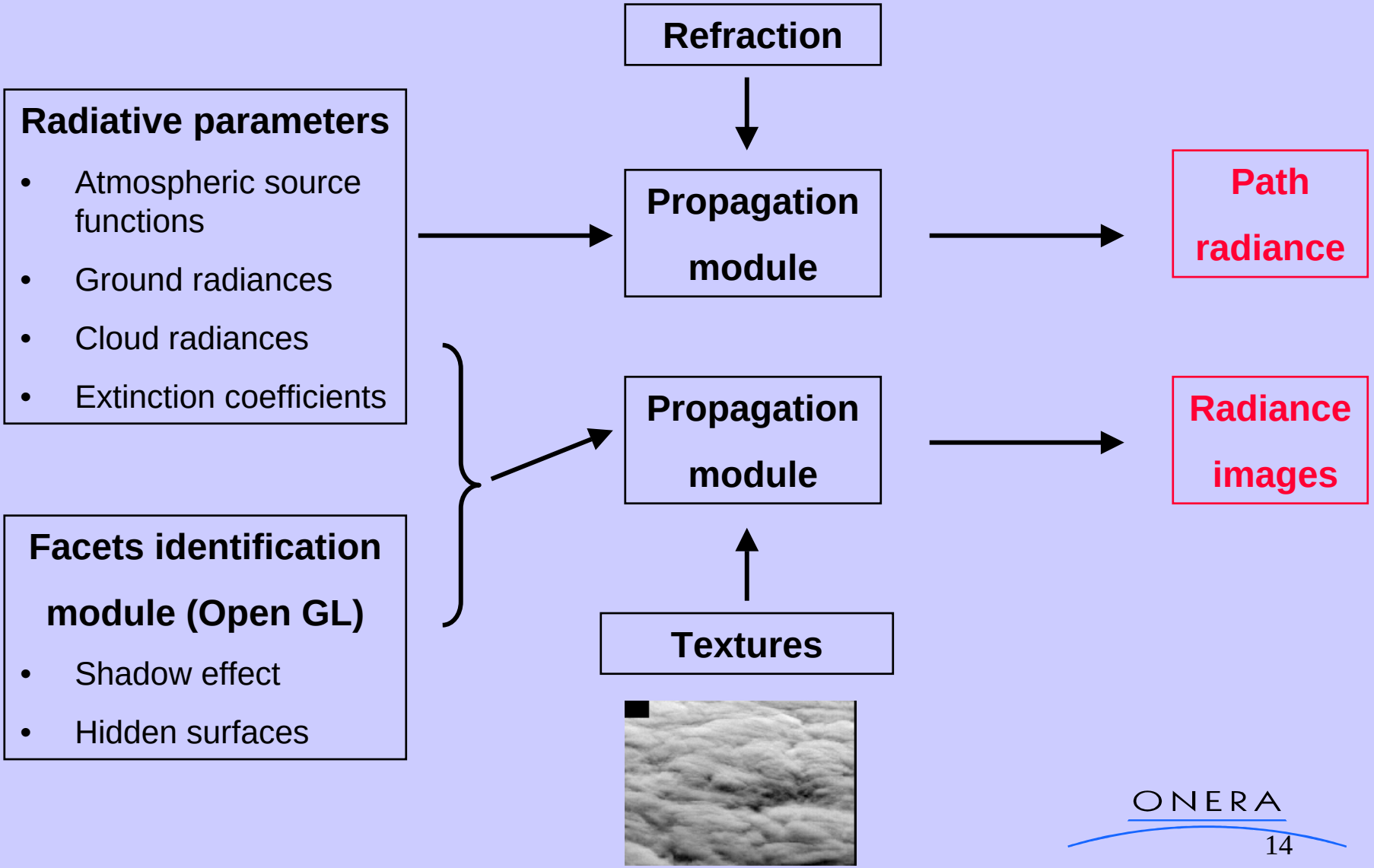




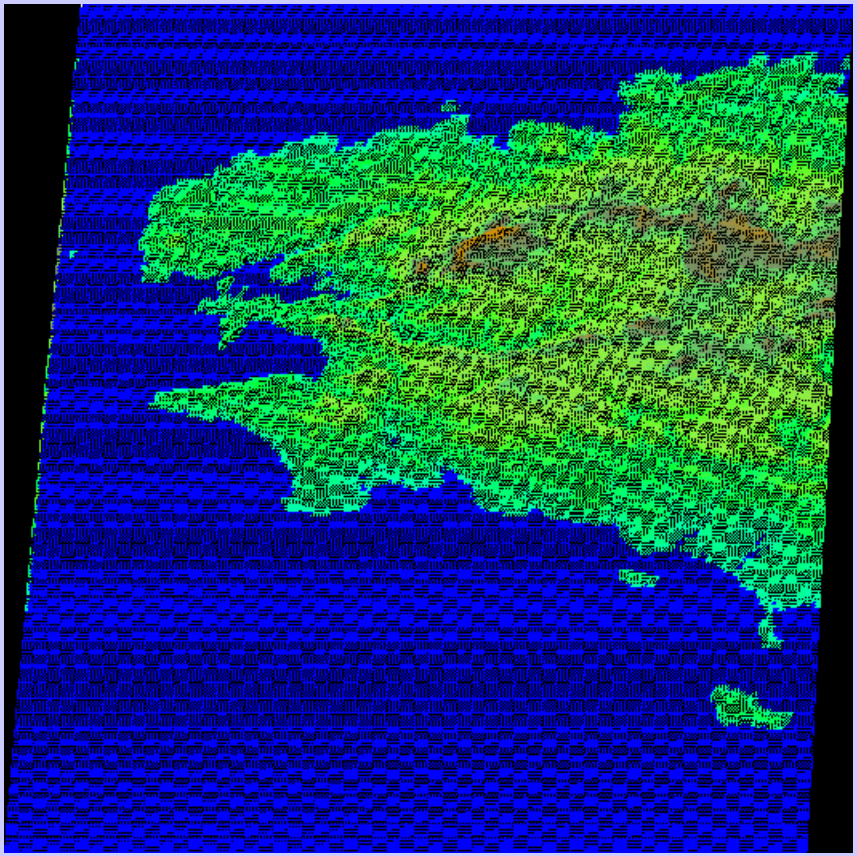
⇒ all the radiatives parameters (atmospheric sources functions, ground and clouds radiances, absorption coefficients, ...) **are stored**

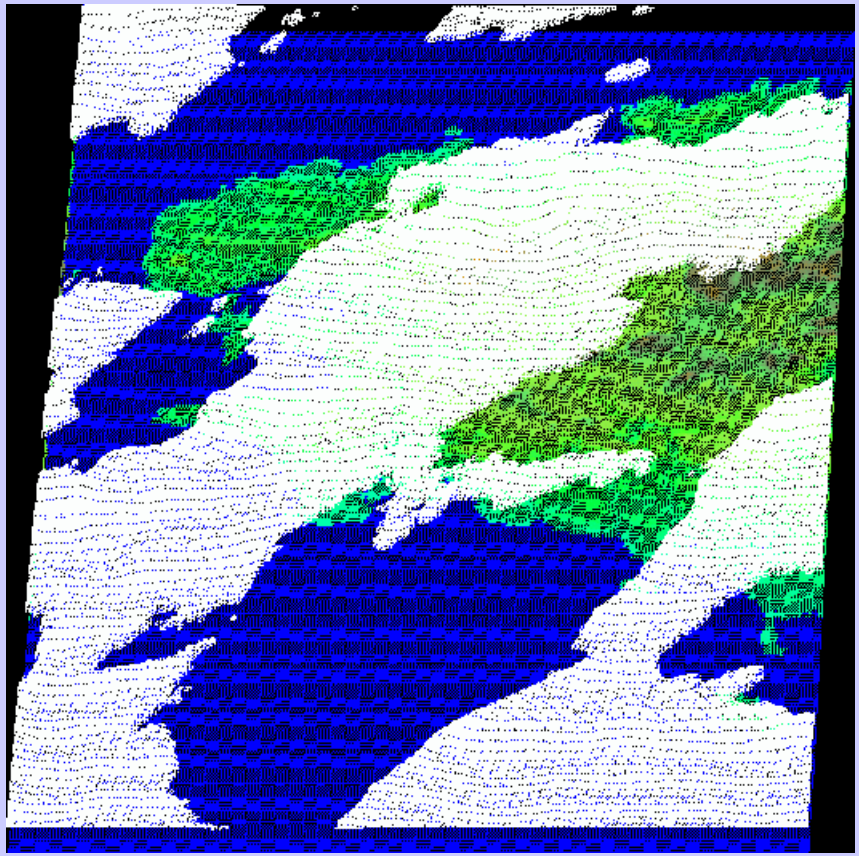
Rendering module

Rendering module : flow chart



Rendering module : visualization



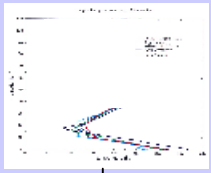


ONERA

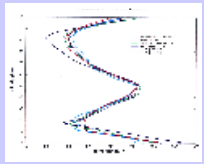
Secondary databases construction

Primary → Secondary databases

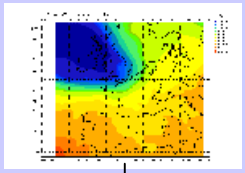
TIGR database



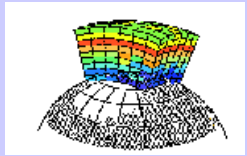
PRFL code



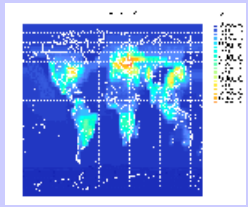
Forecast model outputs



PRFL code

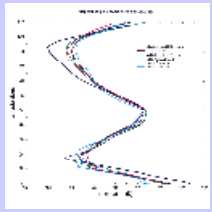


GADS aerosol climatology

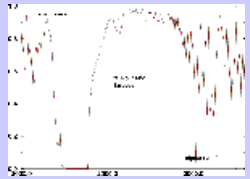


Local water vapour

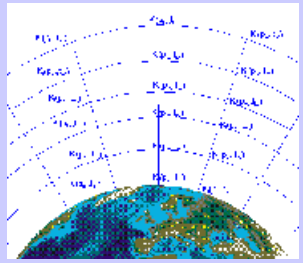
Local aerosols optical parameters



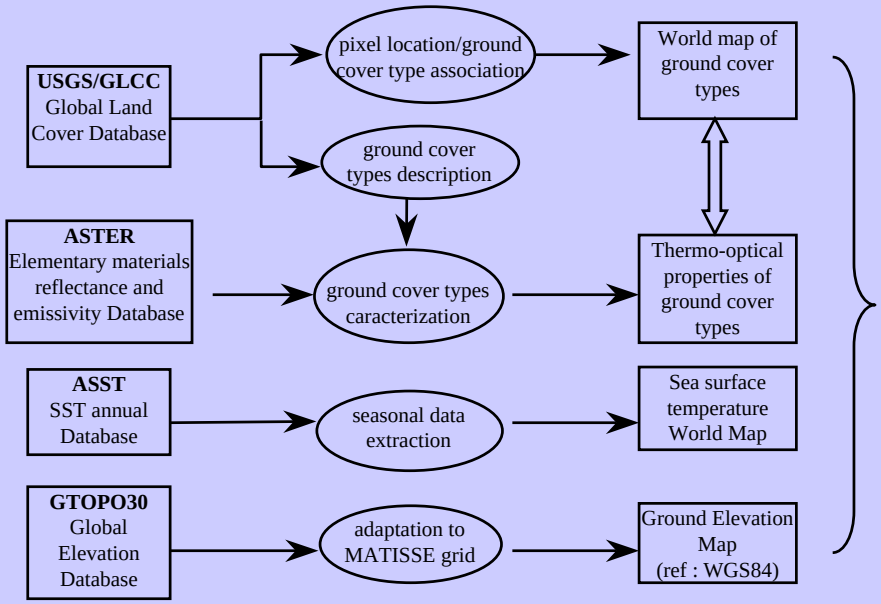
LBL model
(Lppm/Snecma/Onera)



K parameters generator



CK profiles database



Stratocumulus clouds → N_0, LWC_0, ΔZ_0, $p(\Theta)$, k_0^{diff}, k_0^{ext} → $\omega_0 = \frac{k_0^{diff}}{k_0^{ext}}$

molecular absorption → $k^{abs} \in [0, k^{abs}_{max}]$ → $\omega = \frac{k_0^{diff}}{k_0^{ext} + k^{abs}}$

→ **Use of RTRN21 (Nakajima,Tanaka)**

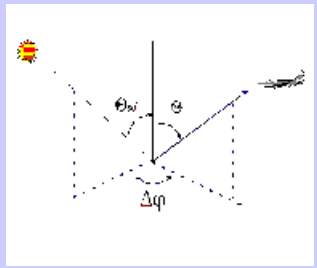
- DOM + TMS
- Plan parallel
- Vertically homogeneous
- n(r) = constant

⇒

Database

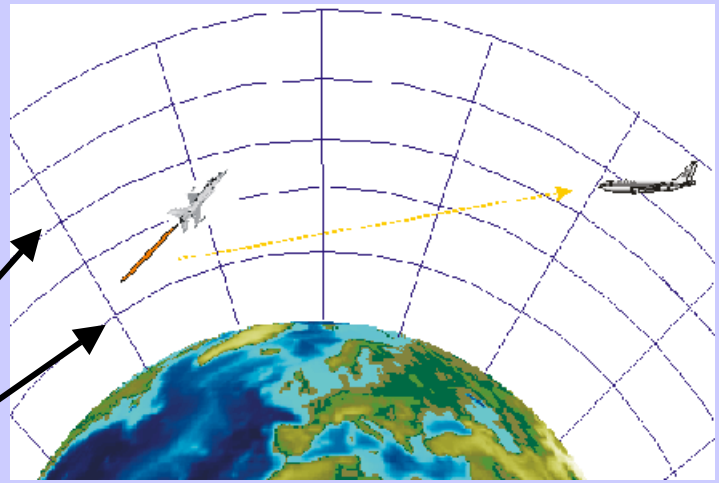
- **BRDF**(Θ_{sol}, Θ, $\Delta\varphi$, σ, ω,τ)
- **BTDF**(Θ_{sol}, Θ, $\Delta\varphi$, σ, ω,τ)
- $\varepsilon(\Theta, \sigma, \omega, \tau)$

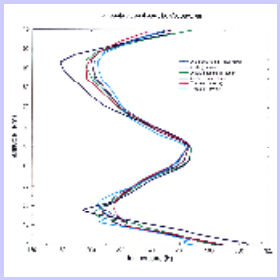
with $\omega \in [0,\omega_0]$ et $\tau \in [0, \tau_{max}]$



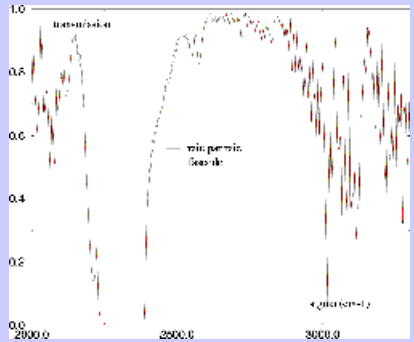
ONERA

Additional functionality : Target signature transmission



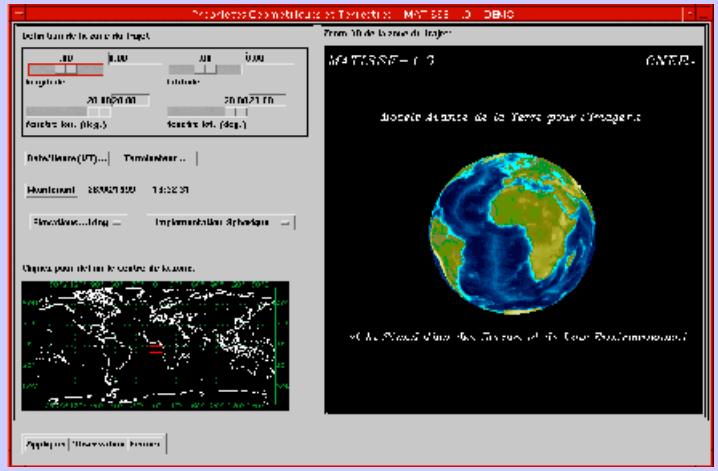


LBL model
(Lppm/Snecma/Onera)



Development

- **Language**
  - C, F90
  - GUI : PV-Waves 7.0



- **Computer**
  - SUN Ultra 80
  - 2 ULTRA SPARC 450MHZ processors
  - MEMORY : 1 Go

- **Quality management**
  - Documentation
  - Programation rules

Release of MATISSE 1.1 : May 2002

ONERA

Summary

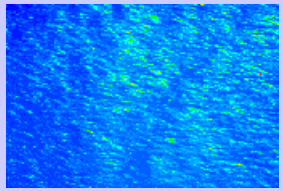
- Computation of radiance images
- Atmospheric radiative transfer : 3-13µm / $\delta\sigma$ /σ = 5 cm^{-1}
- Aerosol + molecular scattering
- Atmospheric Spatial Variability for all the LOS (3D profiles)
- Scu coverage Emission and Scattering (IPA / 500m)
- DTED + Ground Emission and Reflectance (30'')
- Cloud shadowing
- Target signature propagation
- GUI
- High resolution spatial Variability (textures)
- Refraction along only one line of sight

Acknowledgements

Matisse 1.1 is sponsored by the ‘Délégation Générale de l’Armement’

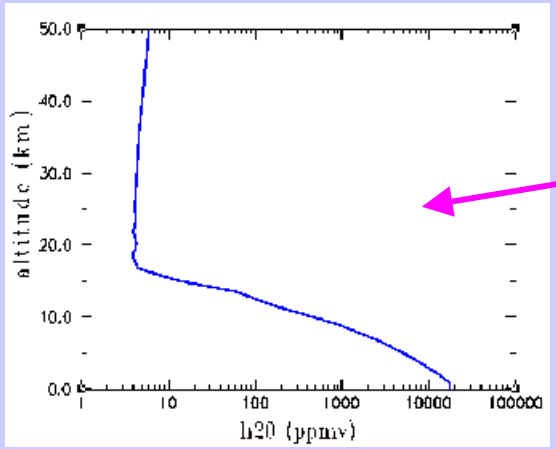
Future works

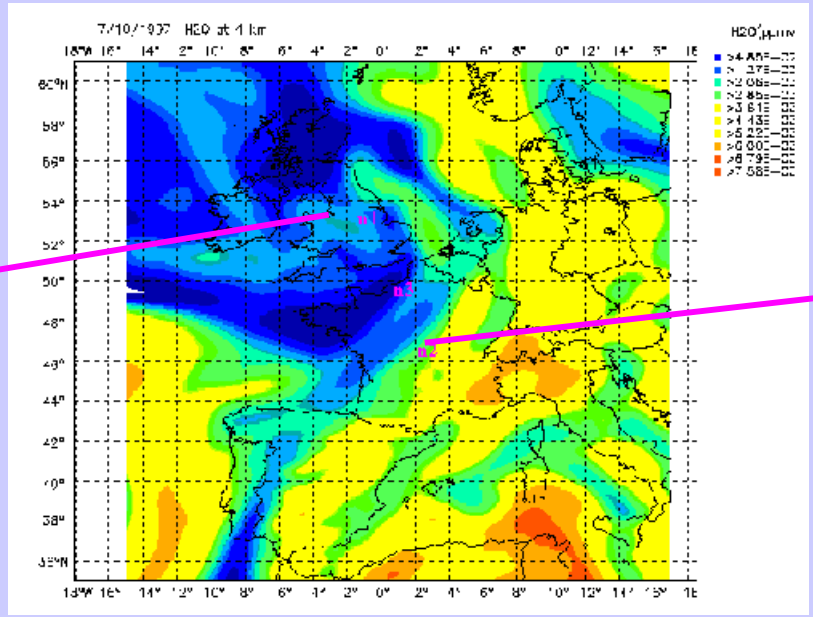
- **Physical representation of the spatial variabilities**
- **Sea surface model**

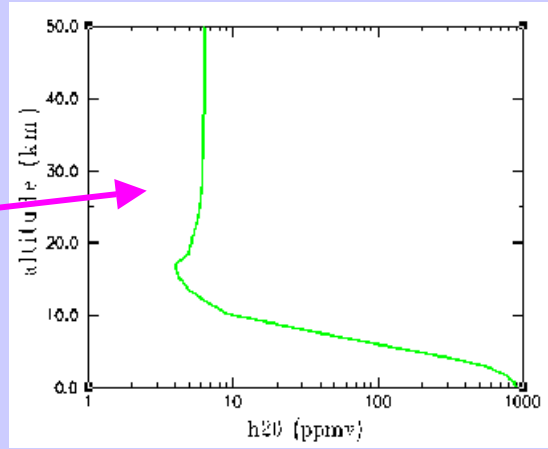


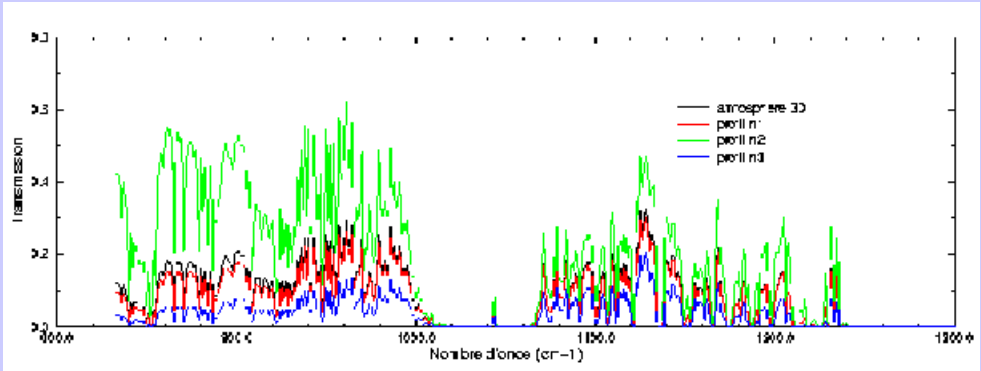
- **Cirrus clouds modelisation**

Why is it important to take into account Atmospheric Spatial Variability ?





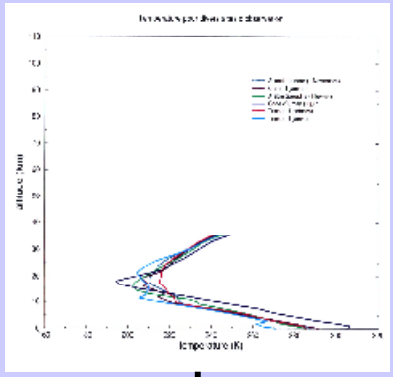




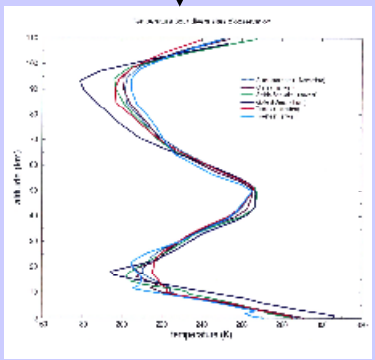
ONERA

Primary → Secondary databases
Atmospheric parameters

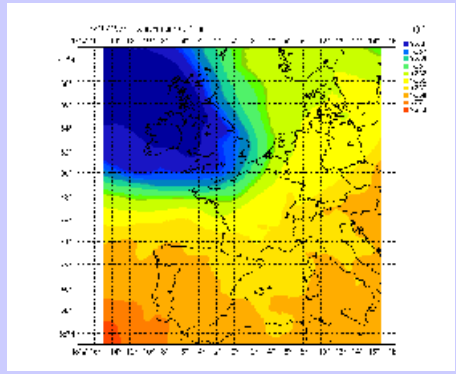
TIGR database



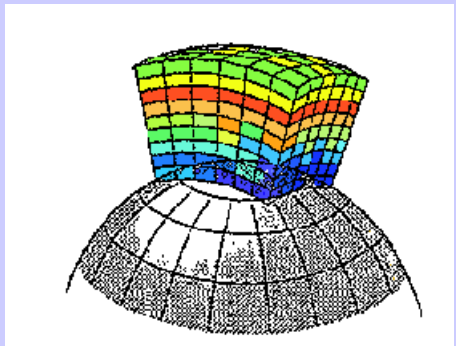
PRFL code



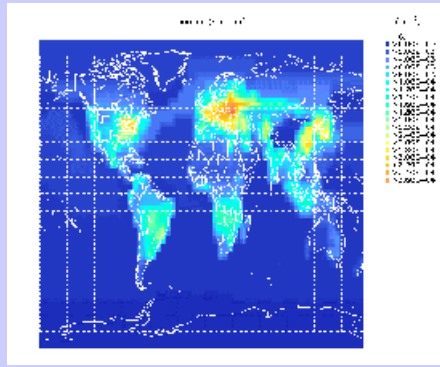
Forecast model outputs : 0.25°x0.25°



PRFL code



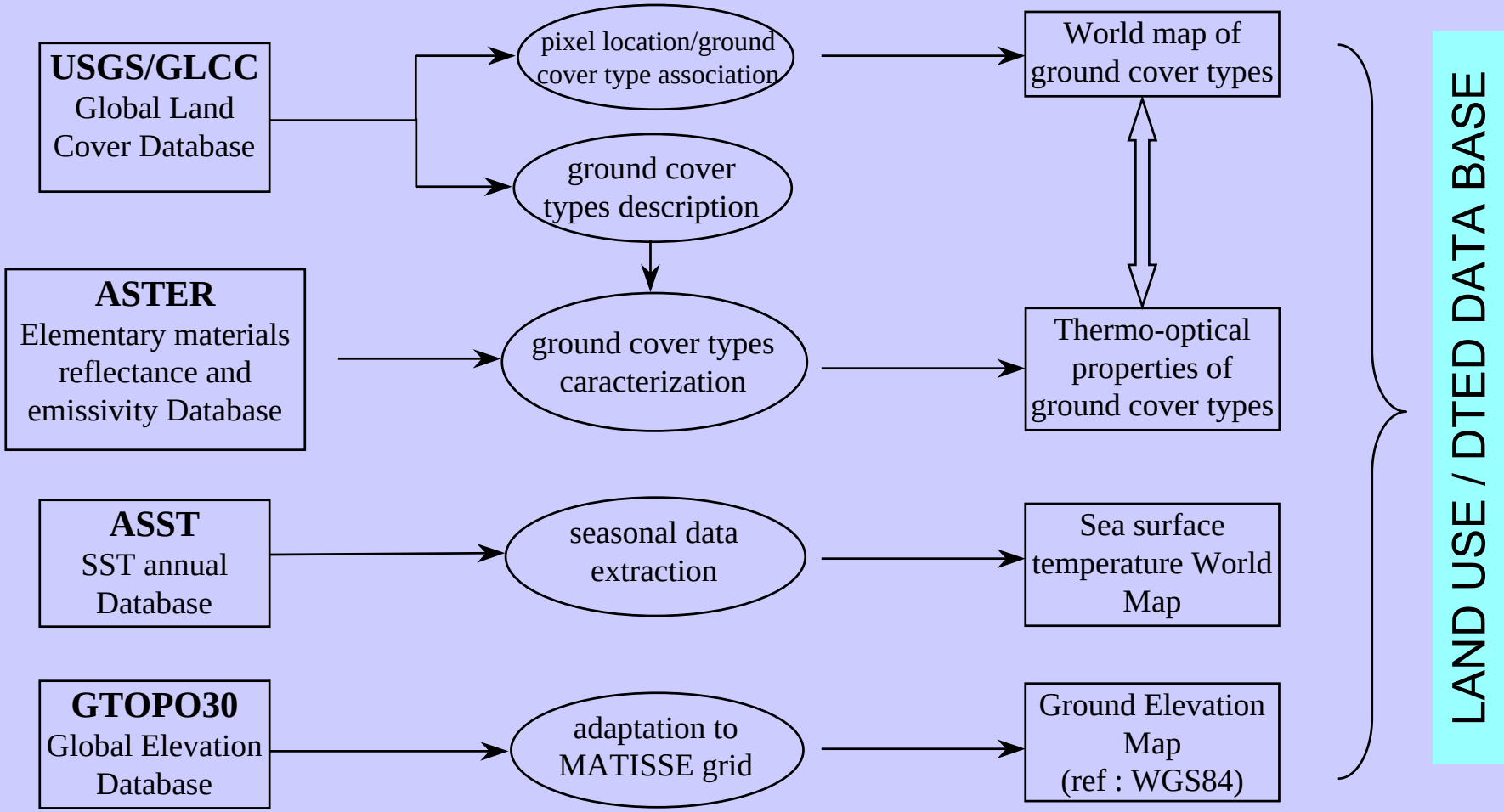
GADS aerosol climatology :5°x5°



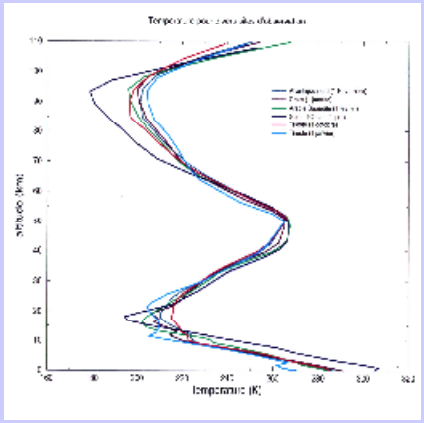
Local water vapour profile

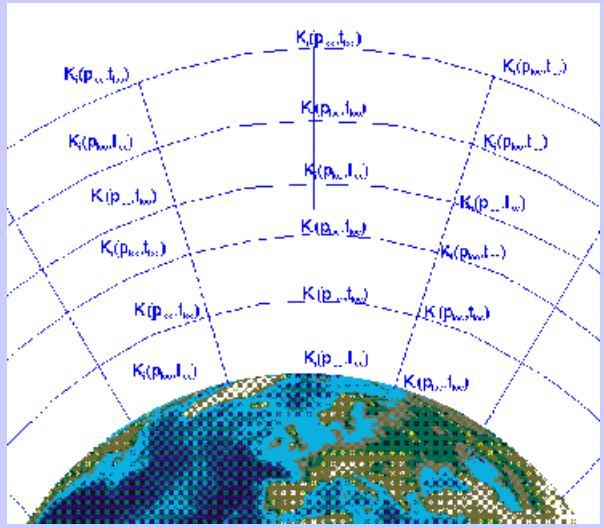
Local aerosols optical parameters

Primary → Secondary databases
DTED and land use : 30”

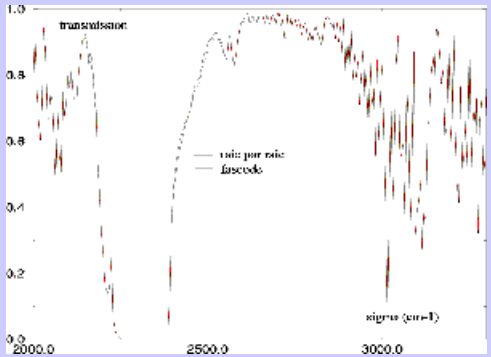


Primary → Secondary databases
CK profile database : 3 - 13 µm / $\delta\sigma/\sigma$=5cm^{-1}





LBL model
(Lppm/Snecma/Onera)



K parameters generator

CK profiles database

Primary → Secondary databases
Cloud BRDF, BTDF, ε

Stratocumulus clouds → N_0, LWC_0, ΔZ_0, $p(\Theta)$, k_0^{diff}, k_0^{ext} ⟶ $\omega_0 = \frac{k_0^{diff}}{k_0^{ext}}$

molecular absorption → $k^{abs} \in [0, k^{abs}_{max}]$ ⟶ $\omega = \frac{k_0^{diff}}{k_0^{ext} + k^{abs}}$

→ **Use of RTRN21 (Nakajima,Tanaka)**

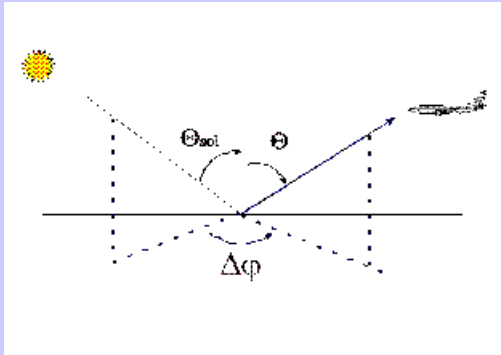
- DOM + TMS
- Plan parallel
- Vertically homogeneous
- n(r) = constant

⇒

Database

- **BRDF(Θ_{sol}, Θ, $\Delta\varphi$, σ, ω,τ)**
- **BTDF(Θ_{sol}, Θ, $\Delta\varphi$, σ, ω,τ)**
- $\varepsilon(\Theta, \sigma, \omega,\tau)$

with $\omega \in [0,\omega_0]$ et $\tau \in [0, \tau_{max}]$



ONERA