Development of a retrieval procedure for inhomogeneous and fractional clouds using neural network techniques.

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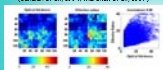
Typical retrieval methods use multispectral information contained in bands that are absorbing and non-absorbing for clouds particles. Solar reflectance measurements in visible and near-infrared atmospheric windows can be used to infer simultaneous cloud optical thickness and effective radius. But, when cloud inhomogeneity or fractional cover becomes too important, these two parameters could be not well defined or wrong. Observational measurements depend also on external parameters of clouds as ground surface and thermal emission at the near-infrared wavelength. These effects can't be neglected and must be corrected before we retrieve cloud parameters.

Neural network can be a way to take into account the complex relations connecting radiance fields and inhomogeneous cloud fields.

1) Building database to train neural network

Optical thickness and effective radius fields computed with bounded cascade model (Cahalan et al., 1994; Marshak et al., 1997)



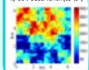
Elementary pixel: 50mx50m

Inhomogeneous clouds parameters on 20x20 pixels (1kmx1km):

- Mean optical thickness: τ
- Mean effective radius: r_{eff}
- Optical thickness inhomogeneity: σ_τ
- Effective radius inhomogeneity: σ_{reff}
- Fractional cloud cover: (1= totally cloudy)

Radiative transfer simulated with SHDOM (Evans, 1997) + atmospheric effects (Nakajima and Nakajima, 1995)

0.544 µm radiances; θ_0=30°; Observation (15°,0°)



Elementary pixel: 50mx50m

Mean of 20x20 pixels ⇒ 1kmx1km pixel

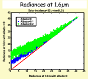
Observation pixel (1kmx1km) at 0.544, 1.6, 2.15, 3.65 and 10.80µm for:
- 10 solar incidence angles (0° to 67.5°)
- 10 view zenithal angles (0° to 67.5°)
- 24 view azimuthal angles (0° to 345°)

Mean of 5x5 pixels ⇒ 250mx250m pixel

Standard deviation at 1kmx1km estimated from 250mx250m pixel at 0.544, 1.6, 2.15µm for same configuration as above

2) Surface albedo effects removed at 0.544, 1.6 and 2.15µm:
- for 1kmx1km radiances
- for standard deviation estimated from 250mx250m

Radiances at 1.6µm



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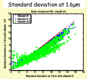
Standard deviation at 1.6µm



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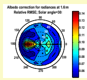
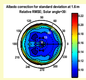
radiances at 0.544µm
standard deviation at 0.544µm
radiances at 2.15µm
standard deviation at 2.15µm
surface albedo at 0.544µm
surface albedo at 1.6µm
surface albedo at 2.15µm
zenithal angular distance
azimuthal angular distance
solar incidence distance

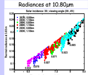
Neural network with two hidden layer (7,5,1)
Training with 10000 random patterns
Training for each viewing directions, each solar incidence and each wavelength
Generalization from unknown data





2') Thermal contribution at near infrared wavelength (3.65µm) removed

Radiances at 10.80µm



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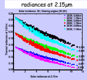
radiances at 2.15µm



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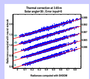
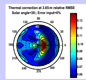
radiances at 0.544µm
surface albedo at 0.544µm
surface albedo at 2.15µm
surface temperature
zenithal angular distance
azimuthal angular distance
solar incidence distance

Neural network with two hidden layers (7,5,1)
Training with 5000 random patterns
Training for each viewing direction and each solar incidence
Generalization from unknown input data



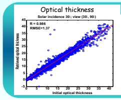


3) Clouds parameters retrieval:

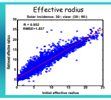
Input vector component: Mean radiances at 0.544, 1.6, and 2.15µm with surface reflexion effects corrected
Radiances standard deviations at 0.544, 1.6, and 2.15µm with surface reflexion effects corrected
Mean radiances at 3.65µm with thermal emission correction
Mean radiances at 10.80µm
Surface temperature

Training with 2000 random patterns for each viewing directions and each solar incidence angle

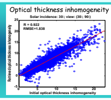
Optical thickness



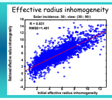
Effective radius



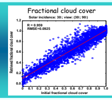
Optical thickness inhomogeneity



Effective radius inhomogeneity



Fractional cloud cover



Current work:

- **Cloud parameters retrieval in case of inhomogeneous and fractional clouds with neural network is possible (retrieval of 5 parameters)**
- **Necessary corrections have to be done:**
  - ✓ **correction of emission at 3.7µm**
  - ✓ **correction of ground albedo effect**
  - ✓ **interpolation to retrieve parameters in all angular configurations (along 3 directions)**

Future work :

- **Validation with real observation measurements (GLI/ADEOS2)**

References:

Evans, K. F., 1998: The spherical harmonics discrete ordinate method for three-dimensional atmospheric radiative transfer, *J. Atmos. Sci.*, **55**, 429-446.

Faure, T., Isaka, H., and Guillemet, B., 2001: Neural network retrieval of cloud parameters of inhomogeneous and fractional clouds: Feasibility study, *Remote Sens. Environ.*, **77**, 123-138.

Marshak, A., Davis, A., Cahalan, R., and Wiscombe, W., 1998: Non local independent pixel approximation: direct and inverse problems, *IEEE Trans. Geo. Remote Sens.* , **36**, 192-205.

Nakajima, T.Y. and Nakajima, T., 1995: Wide-area determination of cloud microphysical properties from NOAA AVHRR measurements for FIRE and ASTEX regions, *J. Atmos. Sci.*, **52**, 4043-4059.

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