About Uncertainties and Product Validation

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Sources of errors

All retrieval algorithms of bio-geophysical quantities conceptualise and thus simplify reality.

An inconsistency arises from the fact that reflectance data from actual targets are interpreted as originating from environments that satisfy the algorithms implicit/explicit assumptions.

This leads to two sources of errors:

- quality of the input data together with the retrieval algorithms’ mathematical formulation.
- realism of the assumptions contained within the mathematical formulations of the retrieval algorithm.
FAPAR is the fraction of the incident radiation in the 400-700nm range that is absorbed by vegetation. FAPAR cannot be measured directly.

Satellite retrieval:

\[ \text{FAPAR} \approx A + B \times \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}} \]

In situ retrieval:

\[ \text{FAPAR} \approx 1 - \text{Tran} = 1 - \frac{\text{Fz0}}{\text{Ftbc}} \]
Error propagation methods can be employed to quantify the uncertainty of the algorithms output on the basis of the uncertainty associated with its input.

- classical propagation of errors (combined & expanded uncertainty)
- Monte Carlo based propagation of PDFs (requires knowledge of joint PDFs)
- Optimal control theory (a priori -> a posteriori estimates of uncertainties)
Retrieval of land surface properties

Formulate the inverse problem to optimize all available information and statistically infer the state of the system.

RT model relating observations to process parameters
Prior knowledge on model process parameters as PDF

Inversion package to retrieve model parameters to observations under controlled uncertainty propagations
INPUTS: prior knowledge

- RS Flux products, e.g., Albedo Vis/NIR and/or FAPAR noted $d$
- Updated/benchmarked 2-stream model from Pinty et al. JGR (2006) noted $M(X)$
- A priori knowledge/guess on model parameters noted $X_{prior}$

uncertainty on the RS products is specified in the measurement set covariance matrix $C_d$
uncertainty associated the model parameter is specified via a covariance matrix $C_{X_{prior}}$
prior knowledge on model parameters

\[ \text{LAI}_{\text{prior}} = 1.5 \]

\[ \sigma_{\text{prior}}(\text{LAI}) = 5.0 \]

prior knowledge on model parameters

\[
\text{in case snow occurs}
\]

\[
\text{LAI}_{\text{prior}} = 1.5
\]

\[
\sigma_{\text{prior}} (\text{LAI}) = 5.0
\]

with ‘green’ leaves

in case snow occurs

Optimization of the retrievals

\[
J(X) = \frac{1}{2} \left[ (M(X) - d)^T C_d^{-1} (M(X) - d) + (X - X_{prior})^T C_{X\text{prior}}^{-1} (X - X_{prior}) \right]
\]

- Computer optimized Adjoint and Hessian model of cost function from automatic differentiation technique
- Assume Gaussian theory
- Posterior uncertainties on retrieved parameters are estimated from the curvature of \( J(X) \)

• PDFs of all 2-stream model parameters:

\[ PDF(X) \approx \exp \left( -\frac{1}{2} (X - X_{post})^T C_{X_{post}}^{-1} (X - X_{post}) \right) \]

• Assessment of all fluxes predicted by the 2-stream model and their associated uncertainty:

\[ C_{Flux_{post}} = G C_{X_{post}} G^T \]
Uncertainty in the observation space assuming 5% uncertainty in albedo
JRC-Two-stream Inversion Package: JRC-TIP

- operating on BHRs
- consistent set of products both for NIR & VIS domains
- with posterior uncertainties

**Observations**

**Prior knowledge**

**Posterior uncertainties**
The uncertainty of the satellite retrieval varies within the observation space (VIS/NIR albedo).

The uncertainty of the in situ retrieval varies also with the environment.

Need for a rigorous method to characterise uncertainty of retrieval methods irrespective of where they apply.

Need for method to assess biases wrt truth & compliance with quality requirements.
Scope of the evaluation

• Spectrally invariant canopy interception is a good proxy for canopy absorption. → need for in-situ transmission (pixel-averaged) to evaluate EO absorption products.

• Retrieval algorithms require using spectral variations e.g., to limit the background soil contamination. → need for in-situ transmission and (effective) canopy single scattering albedo in the NIR (pixel-averaged) to evaluate the algorithm.