A Bayesian approach for an Aquarius soil moisture product

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BRA Methodology

A novel retrieval algorithm (**BRA**, Bayesian Retrieval Algorithm) was developed, which uses Bayesian inference to retrieve soil moisture and optical depth from both H & V channels.

Gaussian PDFs (variance ∝parameter uncertainties)

$$\theta = \begin{bmatrix} h \\ \omega \\ b \\ sand \\ clay \\ Tsoil \\ Tskin \end{bmatrix}$$

Monte Carlo → $\tilde{\theta}_j$

$\begin{bmatrix} s\bar{m}_i \\ \bar{\tau}_i \end{bmatrix}$ sm & τ domain

Forward Model → $Hist_{\tilde{\theta}}(TbH, TbV | s\bar{m}_i, \bar{\tau}_i)$

Measured values $\begin{bmatrix} TbH_m \\ TbV_m \end{bmatrix}$ → Non parametric estimation

BAYES

Likelihood

$$P_L(TbH_m, TbV_m | s\bar{m}, \bar{\tau}, \tilde{\theta})$$

Prior

$$P_P(s\bar{m}, \bar{\tau})$$

Posterior

$$P_Z(s\bar{m}, \bar{\tau} | TbH_m, TbV_m, \tilde{\theta}) = \frac{P_L(TbH_m, TbV_m | s\bar{m}, \bar{\tau}, \tilde{\theta}) P_P(s\bar{m}, \bar{\tau})}{\int\int P_L(TbH_m, TbV_m | s\bar{m}, \bar{\tau}, \tilde{\theta}) P_P(s\bar{m}, \bar{\tau}) ds\, m\, d\tau}$$

MEAN

$$s\hat{m}_{map} = \arg\max_{sm} P_Z(s\bar{m}, \bar{\tau} | TbH_m, TbV_m, \tilde{\theta})$$

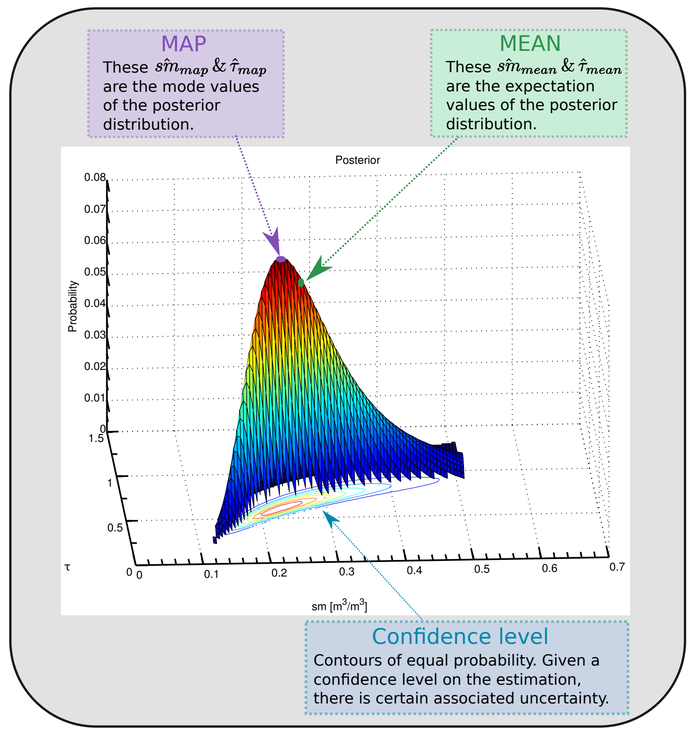
$$\sigma^2_{s\hat{m}_{map}} = \sigma^2_{s\hat{m}_{mean}} + (s\hat{m}_{mean} - s\hat{m}_{map})(s\hat{m}_{mean} - s\hat{m}_{map} - \sigma_{s\hat{m}_{mean}})$$

MAP

$$s\hat{m}_{mean} = \int\int sm P_Z(s\bar{m}, \bar{\tau} | TbH_m, TbV_m, \tilde{\theta}) ds\, m\, d\tau$$

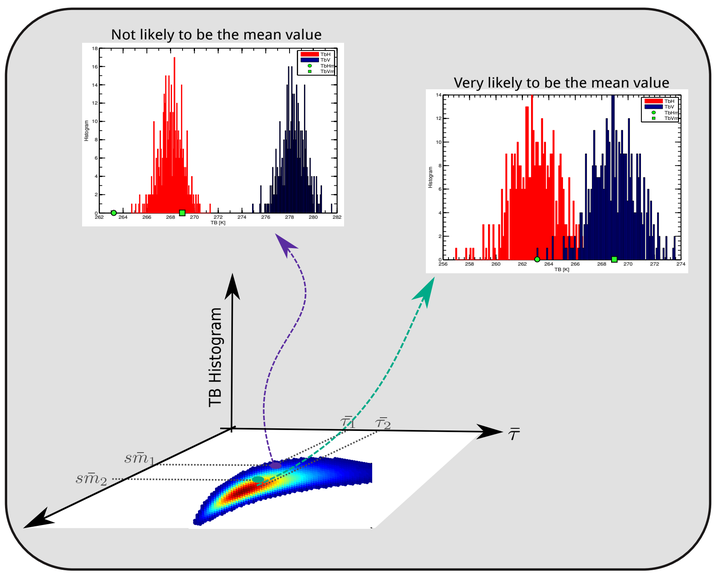
$$\sigma^2_{s\hat{m}_{mean}} = \int\int (sm - s\hat{m}_{mean})^2 P_Z(s\bar{m}, \bar{\tau} | TbH_m, TbV_m, \tilde{\theta}) ds\, m\, d\tau$$

Posterior & Estimators

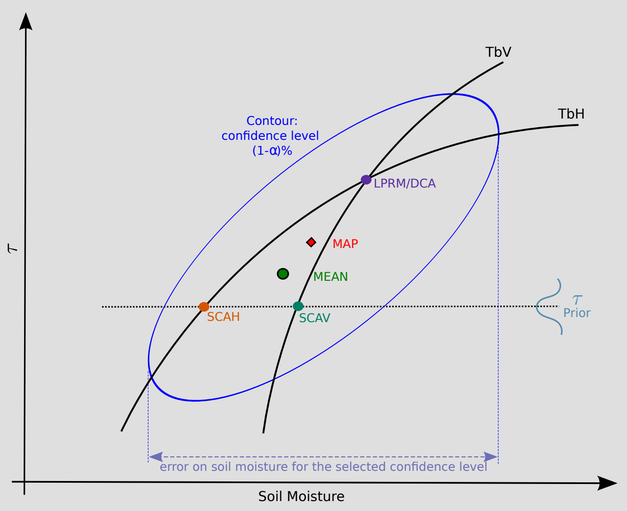


ESTIMATORS

Likelihood

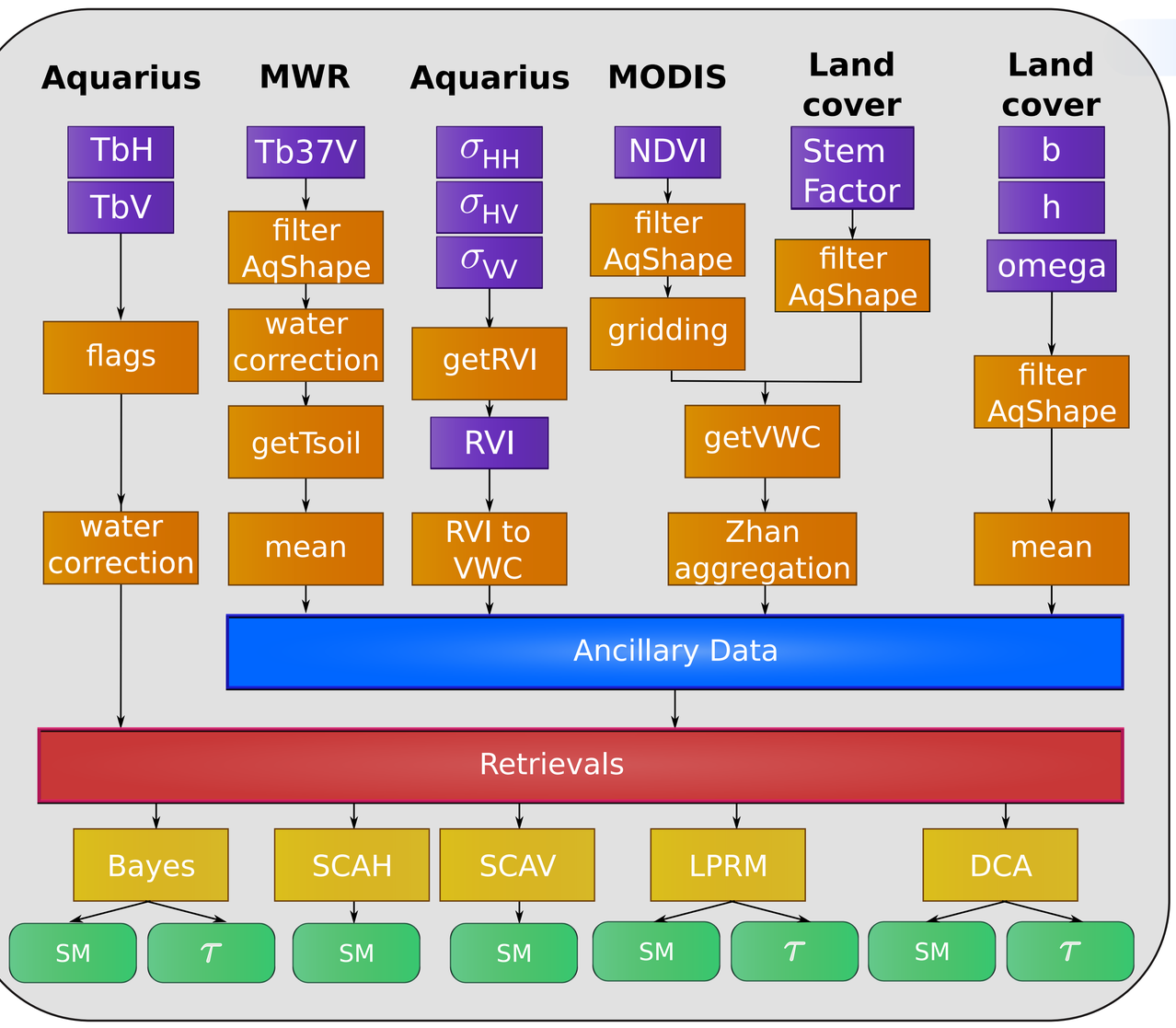


Retrievals comparison



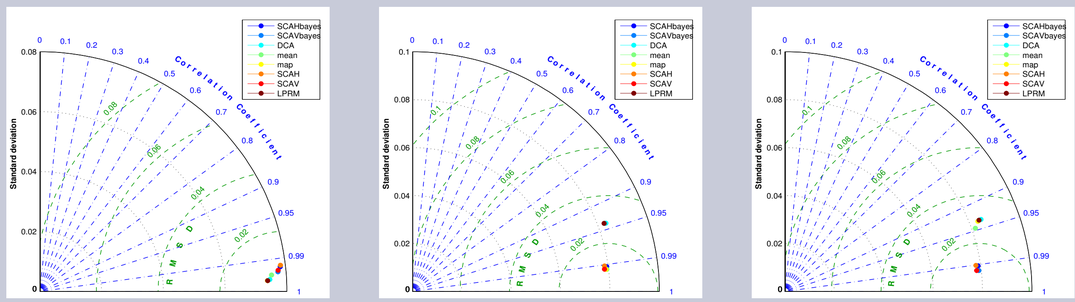
SCA, DCA & LPRM rely on the omega-tao model to link Tb and surface dielectric and geometric properties, and differ among them on the polarization channels they use and the minimization scheme implemented. LPRM and DCA make use of TbH and TbV to retrieve soil moisture and optical depth. One disadvantage of both previous algorithms is their sensitivity to noise in both TbH and TbV. On the other hand, SCAH (SCAV) uses only TbH (TbV) to retrieve soil moisture using optical depth as an auxiliary input to the retrieval algorithm (usually derived from an optical proxy). The main disadvantage of relying on optical depth to retrieve soil moisture is that if optical depth is not well known, SCA will have poor performance.

SM Retrieval Processor



OSSE Results

No parameter uncertainties

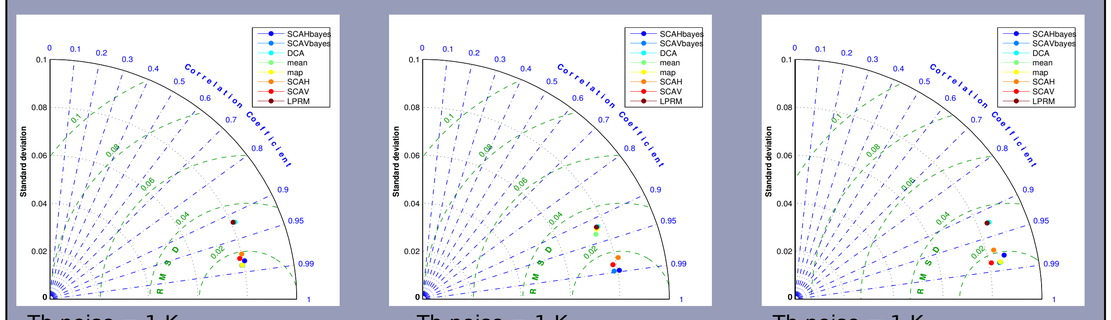


Tb noise = 0 K
Prior = Uniform

Tb noise = 1 K
Prior = Normal 0.01

Tb noise = 1 K
Prior = Uniform

Parameter Uncertainties



Tb noise = 1 K
Prior = Normal 0.01

Tb noise = 1 K
Prior = Uniform

Tb noise = 1 K
Prior = Normal 0.01 & bias 0.03

Conclusions

OSSE results show **BRA** very promising potential for soil moisture & τ retrieval and their associated uncertainty. BRA is currently being implemented on Aquarius data.

The advantages of **BRA** are: i) errors on the retrieved variables can be estimated in an univocal way, ii) it gives the possibility to use prior information about the retrieved variables (provided by other sensors or in situ historical data), iii) it can handle uncertainties on the ancillary parameters.

This work is carried out in the framework of the SAC-D/Aquarius announcement of opportunity (CONAE-NASA-Mincyt), "La Plata Basin floods and droughts: Contribution of microwave remote sensing in monitoring and prediction"