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A New Understanding for the Rain Rate retrieval of Attenuating Radars Measurement

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The retrieval of rain rate from the attenuated radar (e.g. Cloud Profiling Radar on board of CloudSAT in orbit since June 2006) is a challenging problem. L´Ecuyer and Stephens [1] underlined this difficulty (for rain rates larger than 1.5 mm/h) and suggested the need of additional information (like path-integrated attenuations (PIA) derived from surface reference techniques or precipitation water path estimated from co-located passive microwave radiometer) to constrain the retrieval. It is generally discussed based on the optimal estimation theory that there are no solutions without constraining the problem in a case of visible attenuation because there is no enough information content to solve the problem. However, when the problem is constrained by the additional measurement of PIA, there is a reasonable solution. This raises the spontaneous question: Is all information enclosed in this additional measurement? This also contradicts with the information theory because one measurement can introduce only one degree of freedom in the retrieval. Why is one degree of freedom so important in the above problem? This question cannot be explained using the estimation and information theories of OEM.

On the other hand, Koner and Drummond [2] argued that the OEM is basically a regularization method, where a-priori covariance is used as a stabilizer and the regularization strength is determined by the choices of the a-priori and error covariance matrices. The regularization is required for the reduction of the condition number of Jacobian, which drives the noise injection from the measurement and inversion spaces to the state space in an ill-posed inversion. In this work, the above mentioned question will be discussed based on the regularization theory, error mitigation and eigenvalue mathematics.

References

1. L'Ecuyer TS and Stephens G. An estimation based precipitation retrieval algorithm for attenuating radar. J. Appl. Met., 2002, 41, 272-85.
2. Koner PK, Drummond JR. A comparison of regularization techniques for atmospheric trace gases retrievals. JQSRT 2008; 109:514-26.