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A New Paradigm for Satellite Retrieval of Hydrologic Variables: The CDRD Methodology

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Historically, retrieval of thermodynamically active geophysical variables in the atmosphere (e.g., temperature, moisture, precipitation) involved some time of inversion scheme – embedded within the retrieval algorithm – to transform radiometric observations (a vector) to the desired geophysical parameter(s) (either a scalar or a vector). Inversion is fundamentally a mathematical operation involving some type of integral-differential radiative transfer equation – often resisting a straightforward algebraic solution – in which the integral side of the equation (typically the right-hand side) contains the desired geophysical vector, while the left-hand side contains the radiative measurement vector often free of operators. Inversion was considered more desirable than forward modeling because the forward model solution had to be selected from a generally unmanageable set of parameter-observation relationships. However, in the classical inversion problem for retrieval of temperature using multiple radiative frequencies along the wing of an absorption band (or line) of a well-mixed radiatively active gas, in either the infrared or microwave spectrums, the inversion equation to be solved consists of a Fredholm integral equation of the 2nd kind – a specific type of transform problem in which there are an infinite number of solutions. This meant that special treatment of the transform process was required in order to obtain a single solution.

Inversion had become the method of choice for retrieval in the 1950s because it appealed to the use of mathematical elegance, and because the numerical approaches used to solve the problems (typically some type of relaxation or perturbation scheme) were computationally fast in an age when computers speeds were slow. Like many solution schemes, inversion has lingered on regardless of the fact that computer speeds have increased many orders of magnitude and forward modeling itself has become far more elegant in combination with Bayesian averaging procedures given that the a priori probabilities of occurrence in the true environment of the parameter(s) in question can be approximated (or are actually known).

In this presentation, the theory of the more modern retrieval approach using a combination of cloud, radiation and other specialized forward models in conjunction with Bayesian weighted averaging will be reviewed in light of a brief history of inversion. The application of the theory will be cast in the framework of what we call the Cloud-Dynamics-Radiation-Database (CDRD) methodology – which we now use for the retrieval of precipitation from spaceborne passive microwave radiometers. In a companion presentation, we will specifically describe the CDRD methodology and present results for its application within the Mediterranean basin.