IMPACT OF A HYDROMETEOR BACKGROUND COVARIANCE MATRIX STRATIFIED BY PRECIPITATION TYPE ON A 1D-VAR PHYSICAL-BASED RETRIEVAL SYSTEM

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1. INTRODUCTION

The physical inversion approach offers the potential of improved performance in retrieving surface and atmospherics parameters, because it can adapt dynamically to particular atmospheric conditions and is more capable of distinguishing the precipitation signal from the water vapor and temperature signals, for example. In this regard, the Microwave Integrated Retrieval System (MIRS) is a physically-based retrieval system based on a one-dimensional variational data assimilation approach (1DVAR) that is capable of optimally retrieving atmospheric and surface state parameters simultaneously in all-weather conditions from spaceborne passive microwave observation [1]. The MIRS system has the ability to provide simultaneously temperature and water-vapor soundings under extreme weather conditions, such as hurricanes, as well as precipitating and non-precipitating cloud parameters in a profile form. In order to do that, the natural correlations between the cloud and hydrometeor parameters are included in the system, through the development of a background covariance matrix that puts constraints on the independence of these parameters, between themselves across the layers as well as between the parameters. In this case, the background covariance matrix is based on an average set of weather conditions (e.g. global climatology). However, the impact of having a more representative covariance matrix for different or particular weather conditions has not been explored yet. This plays a key role in the development of retrieval systems that require adapting dynamically to particular circumstances over a broad set of weather regimes.

2. HYDROMETEOR BACKGROUND COVARIANCE MATRIX STRATIFIED BY PRECIPITATION TYPE

The definition of the covariance matrix plays an important role in the capabilities of the variational algorithms because it defines the error variances and error correlations of the retrieved variables. In the MIRS system, the part of the covariance matrix related to temperature and humidity is based on a set of globally distributed radiosondes. On the other hand, the part related to the cloud parameters is based on the Penn State University and the National Center for Atmospheric Research Mesoscale Model (MM5) simulations, corresponding to hurricane Bonnie (1998). Although the system is able to reach convergence in many conditions that are independent from the set of conditions that were used to generate these covariances, the ability of the covariance matrices to represent the global variability of the retrieved meteorological products on different weather conditions has not fully established and described. Due to the large variability of the hydrometeors under different precipitation conditions, we have placed particular emphasis in this work on the improvement of the hydrometeor background covariance matrix by stratifying it depending on the precipitation type. The suggestion of a hydrometeor background covariance matrix stratified by precipitation type is adequate, because it is intrinsically more representative and contains more information of a particular precipitation event, which in turn helps to better constrain the solution of the retrieval system. In this regard, only a few studies and efforts have been performed on the definition of the error covariances of rain and clouds [2].

This work presents studies oriented to identify the impact of a hydrometeor background covariance matrix stratified by precipitation type, mainly stratiform and convective, on the retrieval of integrated hydrometeors amounts (including cloud and ice water content) using a physical-based retrieval system based on a 1D-VAR approach. In addition, since hydrometeor products derived from the MIRS system are used to retrieve instantaneous surface rain rates using a multi-linear regression approach, the impact of the proposed hydrometeor background covariance matrix is evaluated in terms of its capability to improve the quality of the retrieved surface rain rates. The aforementioned hydrometeor-based multi-linear regression approach has been successfully applied to different satellite platforms, including the NOAA-18, NOAA-19, MetopA and DMSP-SSMIS F16 satellite sensors, to derive operational surface rain rates on a daily basis. On the other hand, this study presents result over both ocean and land surfaces. Moreover, for the definition of the hydrometeor background covariance matrix, mesoscale cloud resolving model simulations carried out under different precipitation regimes over ocean and land are used.

3. ASSESSMENT OF THE HYDROMETEOR BACKGROUND COVARIANCE MATRIX

The assessment of the proposed hydrometeor background covariance matrix is performed by comparing NOAA-18, NOAA-19, MetopA and DMSP-SSMIS F16 surface rain rates retrieved using a hydrometeor-based multi-linear regression approach with respect to state-of-the-art precipitation products derived from rain gauge, radar and satellite-based (CloudSat and Tropical Rainfall Measuring Mission) observations over land and ocean. This comparison includes precipitation map comparisons, histogram comparisons, as well as time series of correlations, false alarm ratio, probability of detection and Heidke Skill Score. In addition, the potential improvement of the cloud liquid water and ice water content retrieved from the MIRS system and radiometric observations from the NOAA-18, NOAA-19, MetopA and DMSP-SSMIS F16 satellite sensors, over ocean and land, is evaluated using hydrometeors retrieved from CloudSat and Tropical Rainfall Measuring Mission (TRMM) Microwave Imager observations.

4. SUMMARY

This work presents a study of the impact of a hydrometeor background covariance matrix stratified by precipitation type on the retrieval of surface rain rate, cloud liquid water, and ice water content using a physical-based retrieval system. For this purpose, a hydrometeor background covariance matrix is defined over different precipitation regimes using mesoscale cloud resolving model simulations. For the assessment of the suggested hydrometeor background covariance matrix, comparisons between hydrometeors retrieved by the MIRS system and well-know and mature hydrometeor references are presented. In addition, the impact of the suggested covariance matrix is evaluated in terms of its capability to improve a rainfall rate algorithm that takes advantage of the intrinsic information contained on integrated hydrometeor amounts to retrieve instantaneous rainfall rate, using a multi-linear regression approach.

5. REFERENCES

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