Microwave sensing column oxygen amounts for surface air pressure and greenhouse gas mixing ratio estimates

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For general meteorology and atmospheric sciences, air pressure is a basic required physical variable in calculations of atmospheric dynamics and is also essential for greenhouse gas (GHG) volume mixing ratio (or mole fraction) estimations. Currently, surface air pressure can only be observed by in-situ sensors in limited ground stations over land and very-sparsely over oceans. There are no global or regional observations of surface air pressure fields. This observational gap in surface air pressure generates significant problems in GHG volume mixing ratio measurements. For example, current GOSAT and OCO-2 satellites and the future ASCENDS space mission can measure column CO2 amounts. However, they need modelled (or assimilated) surface air pressure fields to convert the measured column CO2 amounts to column CO2 volume mixing ratio (XCO2). For this conversion, a critical part of surface air pressure is dry air pressure since wet air part can be observed well by current satellite column water vapor measurement capabilities. Because of large sizes of grid boxes of global models and limited constraints in the models over remote land regions and open seas especially the southern ocean, significant errors in surface air pressure fields could be introduced in the areas of satellite column CO2 measurements, which would lead considerable uncertainties in estimated XCO2.

This effort tries to develop a feasible active microwave sensing approach that measures surface air pressure, especially over open seas, from space using a Differential-absorption BArometric Radar (DiBAR) operating at 50-55 GHz O2 absorption band in order to constrain assimilated dynamic fields of numerical weather Prediction (NWP) models to close to actual conditions and to improve the weather forecasts. Analyses show that with the proposed space radar the errors in instantaneous (averaged) pressure estimates can be as low as ~4mb (~1mb) under all weather conditions. With these surface pressure measurements, uncertainties in satellite estimates of GHG mixing ratios, especially those in XCO2 values, will be significantly improved.

NASA Langley research team has made substantial progresses in advancing the column O2 measurement concept since the DiBAR concept developed about a decade ago. The feasibility assessment clearly shows the potential of surface barometry using existing radar technologies. The team has also developed a DiBAR system design, fabricated a Prototype-DiBAR (P-DiBAR) for proof-of-concept, conducted laboratory, ground and airborne P-DiBAR tests. The flight test results are consistent with the instrumentation goals. The precision and accuracy of radar surface pressure measurements are within the range of the theoretical analysis of the DiBAR concept. Observational system simulation experiments for space DiBAR performance based on the existing DiBAR technology and capability show substantial improvements in surface air pressure predictions. DiBAR measurements will provide us an unprecedented level of the prediction and knowledge on global air mass distributions in improving GHG observations.