Global Surface Dry Air Pressure Measurements from Space for Greenhouse Gas Volume Mixing Ratio Observations

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Request for Information

For general meteorology and atmospheric sciences, air pressure is a basic required physical variable in calculations of atmospheric dynamics and also essential for greenhouse gas (GHG) volume mixing ratio (or mole fraction) estimations. Currently, surface air pressure can only be observed by in-situ measurements in limited ground stations over land and very-sparsely over oceans. There are no global and regional observations of surface air pressure fields. This observational gap in surface air pressure generates significant problems in GHG volume mixing ratio measurements [1]. 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 CO2 column amounts to CO2 volume mixing ratio (XCO2) [2][3]. 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. Many active and passive optical remote sensing approaches such as those operating on O2 A-bands for surface dry air pressure have been considered in last three decades or so. None is satisfactory [4]. An example is for the passive O2 A-band measurements from the OCO-2 spacecraft. These measurements are very sensitive to thin clouds and aerosols. Thus, no reliable surface air pressure can be retrieved from passive O2 A-band sensors even in clear conditions. Recent progress in surface dry air barometry using microwave O2-band Differential-absorption BArometric Radar (DiBAR) provides a great potential for surface air pressure remote sensing especially over oceans [4]. The DiBAR system will meet the accuracy and precision requirements of space CO2 missions at suitable small spatial scales [4][5]. The DiBAR technology developed will also enable NASA and the nation to significantly improve severe weather, especially hurricane, forecasts with its remotely sensed sea surface barometric pressure fields [6][7][8]. The development of the DiBAR technology potentially has tremendous impacts on socioeconomics [9].

Because of the changes in GHG and climate, and the extreme importance of tropical storm forecasts for the society, rapid progress in DiBAR technology and preparing surface barometric mission are critical for NASA and the nation. Recently NASA Langley Research Center has formulated a surface barometry concept, developed a DiBAR system design, fabricated a Prototype-DiBAR (P-DiBAR) instrument for proof-of-concept, and conducted lab, ground and low altitude aircraft tests of the P-DiBAR instrument. The flight test results clearly demonstrate the consistency between theoretical analyses of the DiBAR concept and remote sensing measurements of the barometric pressure radar, and show that current DiBAR technology provide a great potential of global precise surface air pressure measurements from space [5][6][9].

Answers to the key questions of RFI:

a. Whether existing and planned U.S. and international programs will provide the capabilities necessary to make substantial progress on the identified challenge and associated questions. If not, what additional investments are needed?

Answer: Existing and planned U.S. and international programs will not provide the capabilities necessary to make substantial progress on the global surface air pressure measurements. The scientific issues related to GHG volume mixing ratio observations could not be solved fundamentally if no space barometry missions are conducted. With current progress in DiBAR technology, additional investments in development of high altitude airborne DiBAR systems for space mission demonstration and validation are needed to improve the technology readiness level (TRL) of the DiBAR concept for space barometry missions.

b. How to link space-based observations with other observations to increase the value of data for addressing key scientific questions and societal needs

Answer: Global surface air pressure measurements from space could be combined with other critical satellite meteorological measurements such as temperature, humidity and wind to increase accuracy of the forecasts of atmospheric basic states and to provide broad applications for carbon, water and energy, and weather sciences.

c. The anticipated scientific and societal benefits

Answer: Space barometry missions using DiBAR technology will improve carbon sink, source and transport estimations, significantly reduce errors in tropical storm and severe weather predictions, shrink uncertainties in predictions of future climate, and increase confidence in climate/carbon related policies.

d. The science communities that would be involved.

Answer: Science communities in weather, climate, water and energy cycle, and carbon cycle will be involved.

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