SOCRATES - Formally endorsed 09-Feb-2016

Title
Southern Ocean Clouds Radiation Aerosol Transport Experimental Study (SOCRATES)

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Summary
The goal of SOCRATES is to improve our understanding of clouds, aerosols, radiation, precipitation, air-sea exchanges and their interactions over the Southern Ocean (SO) through collection of a set of focused observations over the SO, that will be coordinated with process and large scale modeling spanning a variety of temporal and spatial scales. The observations include both fine-resolution intensive observations from airborne and shipborne platforms and longer timescale observations that capture the seasonal cycle.

Description
SOCRATES is proposed to improve our understanding of clouds, aerosols, precipitation, radiation and air-sea exchanges and their interactions over the Southern Ocean (SO). The remoteness of the SO from anthropogenic and natural continental aerosol sources makes it unique for examining cloud-aerosol interactions for liquid and ice clouds, and the role of primary and secondary marine biogenic aerosols and sea-salt . The strong seasonality in aerosol sources and sinks over the SO are poorly understood. Numerical weather prediction and climate models are challenged by uncertainties and biases in the simulation of SO clouds, aerosols, precipitation and air-sea exchanges which trace to poor physical understanding of these processes, and by cloud feedbacks in response to warming. Models almost universally underestimate sunlight reflected by near surface cloud, and this may be due to difficulties in representing pervasive supercooled and mixed-phase boundary layer (BL) clouds.

To address these challenges, we are proposing the use of the NSF/NCAR G-V aircraft for 1-month in the Austral summer 2018. SOCRATES also includes plans for multi-year cloud and radiation measurements from Macquarie Island under Australian and U.S. DOE funding, for Australian and U.S.-funded cruises, and installation of the DOE Atmospheric Radiation Measurement (ARM) program's Mobile Facility-2 (AMF2) on an Australian icebreaker. SOCRATES will expand upon the sparse observations over the SO by obtaining comprehensive observations of BL structure and vertical distributions of liquid and mixed-phase clouds and aerosols (including cloud condensation nuclei, CCN and ice nucleating particles, INPs), including observations over cold waters poleward of 55oS, where supercooled and mixed-phase boundary-layer clouds are most frequent. SOCRATES thus contributes to YOPP's goal of coordinating a period of intensive observing activities. SOCRATES is closely tied to other projects, including the DOE deployment of the AMF2 during the Western Antarctic Radiation Experiment (AWARE), the planned British Antarctic Survey observations north of the Weddell Sea during the SO Aerosol Clouds and Ice Processes Experiment (SEASCAPE), and measurements from the R/V Tangaro in the sea ice edge region of the Ross Sea from New Zealand.

Specific hypotheses to be tested during SOCRATES will examine variability in SO BL cloud droplet concentration and the occurrence of supercooled liquid clouds with INPs and BL dynamics, as well as relationships between cloud microphysics, BL accumulation-mode

aerosols, wind speeds, precipitation occurrence and overlying free tropospheric aerosols. Parameterization development and testing needs are integrated in SOCRATES' design so that systematic confrontation and improvement of leading climate and numerical weather prediction models with data will be possible so that reasons for the model bias in absorbed shortwave radiation and conditions conducive to extensive supercooled water can be uncovered. These issues impact the SO surface energy balance and winds, and hence the atmospheric and oceanic circulation of the entire Southern Hemisphere and beyond. As such, SOCRATES meets the YOPP goal to "enable a significant improvement in environmental prediction capabilities for the polar region and beyond" and contributes to the sixth YOPP objective of improving the "understanding of linkages between polar regions and lower latitudes and assess[ing] skill of models representing these." SOCRATES data will lead to improved simulation of key climate processes that will impact our ability to estimate cloud feedbacks, carbon uptake and other biogeochemical processes, and Antarctic sea ice and ice shelves. An educational component involves undergraduate and graduate students in research activities and project forecast operations, as well as production of newsletters and blogs for non-specialists as well as a webpage where the public can ask scientists about global change issues. Thus, SOCRATES contributes to the YOPP educational goals.

The acquisition of an intensive set of measurements will be an essential component of the YOPP objective "to gather additional observations through field programs aimed at improving the understanding of key polar processes". In terms of the third YOPP objective, SOCRATES data will allow for development of "improved representation of key polar processes in uncoupled and coupled models used for prediction, including those which are particular hindrances to high-quality prediction for the polar regions" such as "those relating to stable boundary layer representation,... and mixed- phase clouds." SOCRATES educational activities contribute to the ninth YOPP objective of providing "training opportunities to generate a sound knowledge base on polar prediction related issues." Although the proposed SOCRATES observations are earlier than the YOPP Special Observing Period of Austral Spring 2018- Austral Fall 2019, the process-oriented understanding gained from them will still make substantial contributions to YOPP.

Regional emphasis
Southern Hemisphere
Specification:
The base of the project will be Christchurch, New Zealand or Hobart, Tasmania. Either location will provide us the opportunity to fly a North-South curtain between 45° and the Antarctic Circle at a latitude of about 160°E, including observations in the vicinity of Macquarie Island.

Timeline
01/15 2018 for ship/aircraft observations - 02/15/2018 for ship/aircraft observations

Activities
15-Jan-2018 to 15-Feb-2018, Christchurch, NZ
Operational base for NCAR/NSF G-V aircraft. Observations will be made along a N-S curtain at ~ 160E that extends to approximately 65S.

15-Jan-2018 to 15-Feb-2018, Christchurch, NZ
Operational base for NOAA P-3 aircraft. Observations will be made along the same N-S curtain as the G-V, but the P-3 will not penetrate as far south.

15-Jan-2018 to 15-Feb-2018, N-S Curtain at ~ 160°E
Ship borne observations funded by Australian and U.S. sources. Possible inclusion of UAS observations from ship.

March-2016 to March 2018, Macquarie Island
Long-term cloud and radiation measurements at Macquarie Island funded by U.S. DOE and Australian sources. Possible inclusion of UAS observations at time of G-V/P-3 observations.

Key deliverables

- Conduct of approximately 104 research flight hours of the G-V during the SOCRATES deployment, split across 13 flights of approximately 8 hours duration each

- Provision of field-processed quick-look data within 24 hours following completion of each flight

- Release of a processed and quality controlled data set in netCDF format within 6 months after the completion of the campaign, accessible in an open archive maintained by NCAR

- Launch of 120 GPS dropsondes during SOCRATES, which will be made available in real-time through the WMO WIS/GTS system.

- Multi-year cloud and radiation measurements acquired by instruments at Macquarie Island under Australian and DOE funding will be made available through public archives (e.g., http://www.arm.gov for instruments funded by U.S. DOE program)

- If funding received for U.S. cruise (either through NSF UNOLS program or NOAA), all collected data will be made available in public archive within 6 months of the completion of the cruise

- Close collaboration with those running climate models and NWP/seasonal models is expected. Steering committee members A. Protat (Bureau of Meteorology) and S. Siems (Monash University) will closely collaborate with relevant ACCESS (Australian Community Climate and Earth-System Simulator) polar modeling efforts. We will also use a 'nudged meteorology' approach to confront development versions of two flagship US atmospheric general circulation models (AGCMs), the Community Atmosphere Model (CAM6) and the GFDL Atmosphere Model (AM4), with SOCRATES data.

Data management

For the GV data, both the long-term data archiving and field catalog will be provided by NCAR Earth Observing Lab (EOL). Data collected the ground-based U.S. DOE instruments at Macquarie Island will be archived at the DOE Atmospheric Radiation Measurement (ARM) program site. Data collected by the NOAA P-3 will be archived at NOAA. Data collected by ships and ground facilities funded by other U.S. and Australian government agencies will also be archived by their respective funding agency. The NCAR EOL permanent field catalog will provide links to the different locations where all of the data are archived.

Real-time data provision
All collected data will be made available according to requirements of the individual funding agencies. These require that the data be made public after some time period, 6 months for the U.S. funded instruments and up to 18 months depending on the requirements of other agencies. NCAR EOL will implement a real-time internet Field Catalog to assist in the planning and operational phase. The Field Catalog will also include project planning documents, mission reports, facility status updates, field data images, satellite and model products and other information useful for in-field decision making and post-project reference. The catalog will be made available to all participants during the field phase and publicly available approximately 6 months after the project.

Funding
applied at NSF/DOE/NOAA, decision expected in July 2016
(Note that funding for the long-term cloud and radiation surface measurements at Macquarie Island (under the acronyms MICRE/ACRE) has already been obtained.)