Progress Report and Plans (August 2000)

NASA Global Aerosol Climatology Project (GACP)

Title: "A Longterm Testbed and Analysis of Radiative Forcing at Two Sites"

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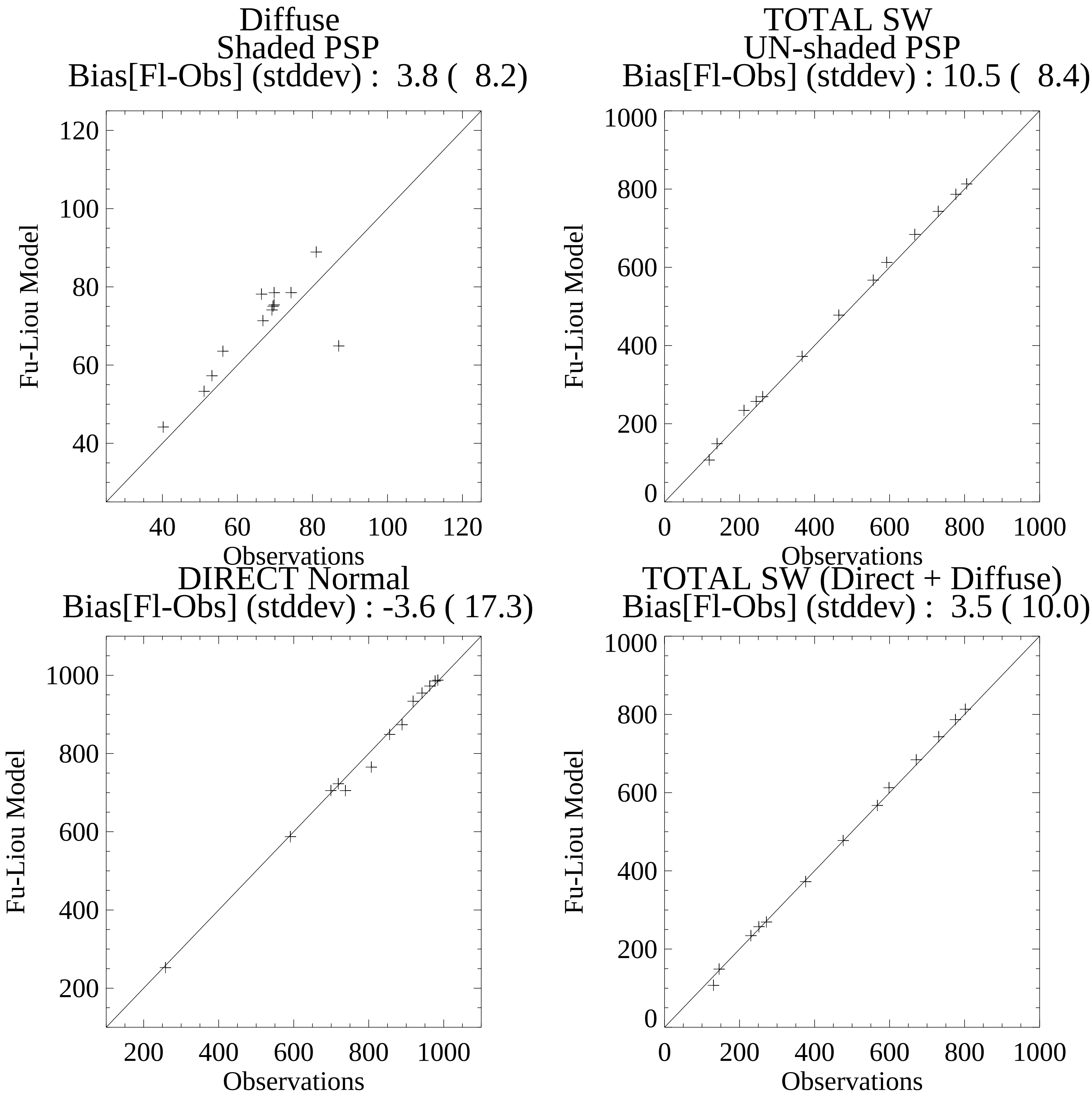
PROGRESS REPORT FOR YEAR 2

Radiative Transfer – closing the gap between theory and observations

Better observations in ARESE II are reducing the "clear sky insolation discrepancy", wherein computed diffuse insolation was reported to exceed observed values by typically 30 Wm-2. This discrepancy has vexed ground-based studies that have used the recommended summation method (separate instruments for direct and diffuse) and hinted at a possible "anomalous" forcing by aerosols. Preliminary ARESE II results (Figure 1) for clear skies on 8, 9, and 12 March 2000 at SGP show that while the diffuse discrepancy fades to a mean of about 4 Wm-2, such a result is fortuitous; it is partly due to compensating cloud contamination (spurious

Cloud Amount < 0.01
N= 13



point in upper left panel). Discarding the spurious point, the computed diffuse insolation exceeds the observed mean by ~10 Wm-2. This suggests that the aerosol is still absorbing more than supposed in our calculations (10% soot component for an aerosol optical depth observed by Cimel). While a small discrepancy (~10 Wm-2) persists, it is an improvement on the value reported earlier (~30 Wm-2). This was reported by the PI in a invited presentation to the Gordon Conference on Solar Radiation and Climate in June 2000.

The radiative transfer computations, comparison with observations, and diagnoses of aerosol forcing FOR APRIL 1999 AT SGP on http://www-cave.larc.nasa.gov/gacp should be regarded as outdated. Our March 2000, ARESE II results use further modifications to the Fu-Liou code, a newer technology for the measurement of broadband surface insolation, and more thorough cloud screening.

These ARESE II insolation observations included thermistors that were specially mounted to the inner dome of the shaded PSP, so as to account for thermal IR offset to the SW measurement (Haeffelin et al., 2000). While ARM and SURFRAD are moving to correct for thermal IR offset, it is unlikely that all but a handfull of sites will do so successfully within the next few years. Fortunately, the Chesapeake Lighthouse (CERES Ocean Validation Experiment COVE) – at which have developed a joint observing program linking GACP, CERES, AERONET, and BSRN – is one of them.

Just prior to the advance in surface radiometry by Haeffelin et al. (2000), we had considered uncertainty in aerosol optical depth as a possible source for some of the discrepancy between computed and measured surface insolation. Our comparison (Kato et al., 2000) comparison of ground-based (spectral photometers) and aircraft-based (integration of profile data from in situ nephalometers) observations for ARM aerosol Intensive Observing Periods (IOP) suggested inconsistencies in the inferred column optical depth. Without the Haeffelin et al. modifications to the ground radiometers, our prior efforts to achieve consistency of theory and observation for SW clear-sky absorption using CERES at TOA and standard ARM radiometers at the surface were disappointing (Rose and Charlock, 1999 and Charlock et al., 2000).

For radiative transfer calculations, we maintain, advance, and distribute a version of the fast broadband Fu-Liou code as a joint effort of CERES, GACP, and Prof. Qiang Fu (now at the University of Washington). Beyond the code modifications described in the Year 1 report, we have improved the treatment for the overlap of Rayleigh scattering and ozone absorption, using a higher resolution (111 band) version of the code for guidiance. This latest modification produces little change in the broadband horizontal flux at the surface, but it removes a small amount of energy from the direct beam and places it in the diffuse. An on-line verstion of the code with "point and click" radiative transfer calculations and plots for combinations of 18 d'Almeida et al., Tegen and Lacis, and OPAC-GADS aerosols is run by Fred G. Rose on http://srbsun.larc.nasa.gov/fl0300. The aerosol optical properties input from field data are now more spectrally consistent with the model bands (i.e., Schuster et al., 2000). The code is available for download with the concurrence of the PI and Prof. Fu.

Ocean Optics – the boundary conditions needed for improved aerosol retrievals with AVHRR

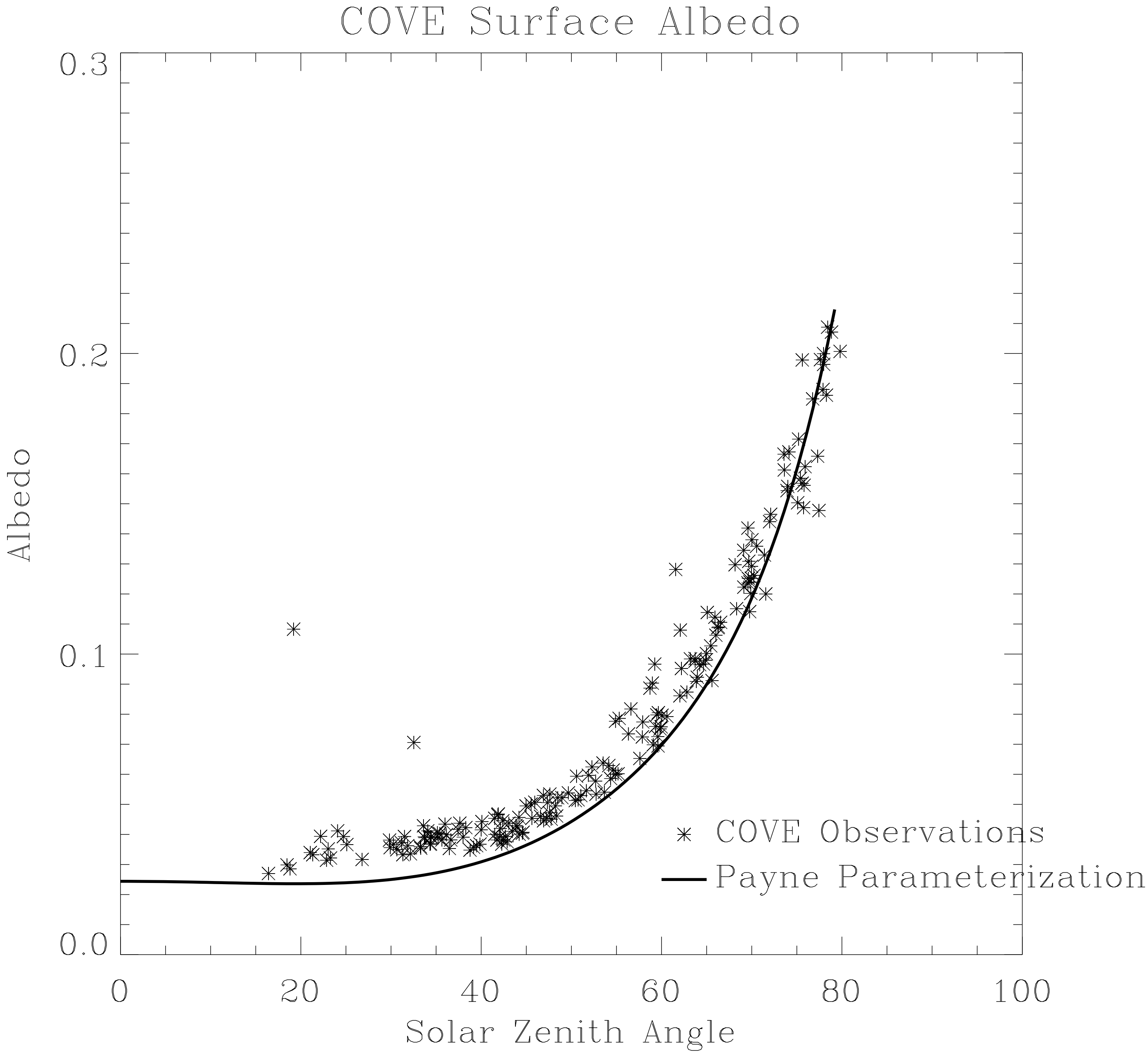
Ken Rutledge has installed the Schulz Spectralphotometer SP1A and sea-worthy tracker (both purchased last year with GACP funds) at the Chesapeake Lighthouse (CERES Ocean Validation Experiment or COVE), from which we continuously scan to observe SW radiances reflected upward from the sea. As noted in the Year 1 Report, our goal is improvement of the spectral BRDF used as a boundary condition in retrievals of aerosol optical depth (AOD) with AVHRR.

Many ocean BRDF models in use are based on the Cox-Munk wind-speed dependence for the statistical distribution of sea slopes, as originally measured in the 1950s. Sea optics is also influenced by large scale sea swell (the effects of distant winds), wave-sun orientation, density fluctuations, foam, bubbles, particles within the sea, and (in coastal areas) bottom reflection. Figure 2 shows how the clear-sky broadband albedo at COVE (first 6 months of 2000) differs from the widely used albedos of Payne (early 1970s). The magnitude of the difference in computed albedo at TOA using the COVE versus the Payne surface albedos is comparable to the estimated globally averaged aerosol radiative forcing.

We presently scan with SP1A channels 6 and 9 with 360 degree sweeps; the first elevation is 3 degrees below the horizon, which is increased in 10 degree steps. Some of the SP1A data is conicident with OV-10 (low level aircraft) observations of upwelling and downwelling fluxes (broadband with Eppleys and spectral with ASD) flights over COVE during March 2000 for CERES and MISR validation.

STATEMENT OF WORK FOR YEAR 3

A welcome addition this year is Dr. Wenying Su, who arrived (August 2, 2000) from NASDA (Tokyo) as a full-time GACP postdoc with Hampton University and NASA Langley. Dr. Su has published on broadband radiative forcing, UV



COVE Surface Albedo
Albedo
Solar Zenith Angle
0.0
0.1
0.2
0.3
0
20
40
60
80
100
COVE Observations
Payne Parameterization

retrievals, and atmospheric correction to satellite sensed ocean optics. She will work on both the radiative tranfer and ocean optics components of the Year 3 tasks.

Radiative Transfer – testbed for comparison with observations

We will develop comprehensive clear-sky testbeds of computed and observed fluxes for one year data bases at both COVE (Chesapeake Lighthouse) and at the ARM SGP Central Facility. As noted in the Year 2 report, we consider that measurements of diffuse insolation with such high quality instrumentation (as Haeffelin et al. using thermistors on the shielding dome) are needed to confidently deduce the direct radiative forcing of aerosol to the surface. The updated and expanded testbed will be placed on-line by David A. Rutan as an extension of current LaRC GACP web page http://www-cave.larc.nasa.gov/gacp/ Radiative transfer computations will use the modified Fu-Liou code.

The TOA observations will be based on the "ERBE-like" fluxes from CERES on Terra. As these are provisional CERES products using ERBE Angular and Directional Models (ADMs), we will not be as confident on the TOA forcing inferred with them. If the CERES team releases its more advanced clear sky TOA fluxes based on ADM models currently under development, we will use those instead. If the GACP AVHRR aerosol retrievals extend partly to cover the CERES TRMM record of January-August 1998, the PI will compare the inferred aerosol forcing with that deduced from the CERES Surface and Atmospheric Radiation Budget (SARB) group, which he leads for CERES. CERES TRMM uses the Stowe algorithm and the VIRS cloud imager for aerosol retrieval. The SARB group is presently experimenting with the Collins-Rasch aerosol assimilation (AVHRR) for processing with CERES TRMM.

We will examine our first order corrections to thermal offset in the ARM SGP shaded PSP record. David Rutan maintains an on-line record of first order corrections (not using the dome thermistors) at the CERES ARM Validation Experiment (CAVE) URL. If comparison with the rigorous Haeffelin et al. technique is favorable, we will be able to extend the testbed to periods before Spring 2000 (when the new measurement technique was first implemented continuously at the Chesapeake Lighthouse).

Ocean Optics – routine observations and an EOS-GACP summer 2001 campaign at COVE

Ken Rutledge will install a remote-command scanning capability for the SP1A Spectralphotometer during September-

October 2000. The present scan pattern for ocean BRDF is continuous and can only be changed during visits to the Chesapeake Lighthouse (typically every 10 days by helicopter). Remote command scanning will enable us to select the pattern at a desktop on NASA Langley. This will be explained at the GACP Science Team Meeting. The scan patterns requested by individual Science Team members will be considered for appropriate time periods.

Several months of data will be required to build the empirical ocean BRDF. Our theortetical BRDF, which uses sea slope as a function of wind, was developed by Yongxiang Hu and is similar to Mishchenko's GACP BRDF. By late spring 2001, we will have sufficient data to describe more accurately the PERTURBATIONS to BRDF by local surface wind waves and sea swell, both as functions of sky condition and aerosol optical depth. Note that (a) wind and (b) sea state are routinely observed at COVE by NOAA, as is (c) cloud screening (by processing of the Long-Ackerman algorithm with BSRN data as in Figure 2) and (d) aerosol optical depth (AERONET Cimel). Variables a, b, c, and d are available for global processing by GACP; i.e., (a) wind from NWP Reanalyses; (b) sea state from reanalysis by the NOAA Ocean Modeling Branch; (c) cloud screening and (d) aerosols from AVHRR itself. The new BRDF product will enable GACP to retrieve aerosols with higher accuracy by better accounting for the effects of sea swell and foam.

Summer 2001 CLAMS (Chesapeake Lighthouse and Aircraft Measurements for Satellite)

The above strategy stresses perturbations to BRDF by wind waves and swell. The absolute value of sea BRDF also varies with particles in the sea and bottom reflection. We will test our absolute value of BRDF by participating in a major clear sky field and aircraft experiment at the Chesapeake Lighthouse (COVE) during the summer of 2001; a joint venture of EOS and GACP. CERES will deliver the OV-10 aircraft, which will be configured to measure upwelling (sea-reflected) SW radiances or broadband and spectral fluxes, depending upon the individual mission. Roughly 10 OV-10 flights are expected with the CERES Fixed-wing Airborne Radiometer (C-FAR). Having an OV-10 C-FAR capability to scan directionally for SW spectral radiances by summer 2001 is likely but not 100% assured; the current OV-10 C-FAR spectrometer measures only flux. The MISR team will deliver 1-2 hours of ER-2 flight time with the AirMISR. Discussions are underway with the MODIS-Atmospheres group, which plans to request placement of the MODIS Airborne Simulator (MAS) and Spinhirne's Cloud Lidar on the ER-2. MODIS-Atmospheres is also considering the Russell airborne spectral photometer. MODIS-Ocean has been invited.

The low level OV-10 will (1) test the spatial representativeness of the sea optics at the Chesapeake Lighthouse (i.e., nearby areas with different depth to bottom and particle loading), (2) validate our empirical model of spectral BRDF for a limited sample of sun angles and sea states, and (3) observe broadband and spectral SW fluxes (upwelling and downwelling) to infer aerosol radiative forcing. (1), (2), and (3) would be greatly enhanced with ER-2 measurements with AirMISR, MAS, and CL. The Terra teams will validate retreivals by CERES, MISR, and MODIS.

The PI will handle the GACP and CERES liaison for the summer 2001 CLAMS. Ken Rutledge is the site scientist for COVE. Bill Smith, Jr., will direct the OV-10 C-FAR. Ralph Kahn is the liaison to both MISR and GACP. Jose Vanderlei Martins is the MODIS-Atmospheres contact.

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