SUbsonic aircraft Contrail & Clouds Effects Special Study (SUCCESS) Langley DAAC Project/Campaign Document

Summary:

SUCCESS is a NASA field program using scientifically instrumented aircraft and ground based measurements to investigate the effects of subsonic aircraft on contrails, cirrus clouds and atmospheric chemistry. The experiment is cosponsored by NASA's Subsonic Assessment Program and the Radiation Sciences Program which are part of the overall Aeronautics and Mission to Planet Earth Programs, respectively. SUCCESS has well over a hundred direct participants from several NASA Centers, other agencies, universities and private research companies.

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1. Project/Campaign Overview:

The SUCCESS project was conducted from the Kansas State University airport facilities in Salina, Kansas from April 8, 1996 until May 10, 1996, with an extension from May 10 until May 15, 1996 at NASA's Ames Research Center in Moffett Field, Ca.

SUCCESS had several objectives:

- to better determine the radiative properties of cirrus clouds and of contrails so that satellite observations can more reliably measure their impact on the Earth's radiation budget.
- to determine how cirrus clouds form, whether the exhaust from subsonic aircraft presently affects the formation of cirrus clouds, and if the exhaust does affect the clouds whether the changes induced are of climatological significance.
- to develop and test several new instruments.
- to better determine the characteristics of gaseous and particulate exhaust products from subsonic aircraft and their evolution in the region near the aircraft.

In order to achieve these experimental objectives the NASA DC-8, and T-39 aircraft were used as *in situ* sampling platforms. The NASA ER-2 aircraft was also employed as a remote sensing platform. The NASA 757 was used as a source aircraft for studies of contrails and exhaust. Table 1 lists the flights that were made by these aircraft.

Table 1: SUMMARY OF SUCCESS FLIGHTS

Date	DC-8	ER-2	T-39	757	CART*	Purpose
4/4		X				Test flight
4/8		X				Ferry flight
4/10	X					Test flight at Ames
4/11			X			Transit flight
4/13	X	X			X	DC-8 transit and contrails, ER-2 Cart site for clear sky Radiation
4/15	X	X	X		X	Coordination practice, near field sampling and clear sky radiation
4/16	X	X	X		X	Near field sampling by T-39 Cirrus profiling by

						DC-8 radiation observations of contrails and cirrus by ER-2
4/18	X		X		Xe	Near field sampling without contrails. DC-8 sampled supercooled water cloud.
4/20	X	X	X		Xe,o	T-39 inst. test flight. ER-2 and DC-8 observed cirrus clouds with multiple vertical profiles.
4/21	X	X			X	Vertical profiling of Cirrus clouds observed from the top. Contrail sampling by DC-8. Studies of convective clouds
4/23		X				ER-2 overflew wave clouds
4/24	X		X		X	T-39 did near field sampling of DC-8 exhaust. DC-8 did vertical profile in cirrus.
4/26		X	X			T-39 followed commercial aircraft, ER-2 did satellite underflight.
4/27	X	X	X		Xe,o	DC-8 sampled contrail of T-39, and profiled cirrus that were observed by the ER-2
4/29	X		X		X	DC-8 profiled stratus clouds at CART site for radar calibration. T-39 sampled DC-8 exhaust.
4/30	X		X	X		DC-8 studied wave cloud and practiced finding 757 exhaust. T-39 sampled 757 exhaust.
5/2	X	X				ER-2 and DC-8 studied wave cloud over Boulder.
5/3	X	X	X	X	Xe	Sampling of 757 contrail by the DC-8 and T-39.
5/4	X	X	X	X	Xe,o	Sampling of the 757

						contrail by the DC-8 and T-39.
5/7	X	X	X	X		Sample persistent contrails over Nebraska
5/8	X	X	X			study convection, T-39 studies DC-8 exhaust.
5/10	X	X	X			transit to Ames or Langley
5/12	X	X				Persistent contrail.
5/15	X	X				Cirrus over water.
Total	19	18	15	4	11	
Flight hours	110	85				

*e=Egret, o=Twin otter

Many of the flights were made over the Department of Energy's Climate and Radiation Testbed (CART) site in Northern Oklahoma, where a suite of ground based remote sensing instruments was located. The DOE also operated an Egret and a Twin Otter aircraft, mostly using remote sensing instruments. The flight dates over the CART site, and those on which the Egret or Otter flew, are also noted in Table 1.

Table 2 list the targets of the various flights, as planned and as flown. Meteorological opportunities were found for most of the planned missions in the vicinity of Salina, Kansas. However, the cirrus-over-water flight could not be done from Salina, but instead was done over the Pacific Ocean using Ames Research Center as a base of operations. Although a diurnal chemistry flight was attempted, weather conditions prevented it from being done. That was the only objective for which a research flight was not completed. Most of the instruments functioned for the majority of the mission.

Table 2: SUMMARY OF FLIGHT OBJECTIVES DURING SUCCESS

Missions	Flights Proposed	Flights Flown
Contrails	3	6
Cirrus	2	7 (+1 stratus)
Lenticular Clouds	2	2
Cirrus over water	2	2
Near Field	3	3 (757) (parts of 11)

Second Priority Missions:		
Outflow from Convective Clouds	2	2
Diurnal Chemistry in Clear Skies	-	0
Clear sky aerosols	-	many

There were a large number of interesting science results from the SUCCESS project. Although it is too early to determine if every question posed for SUCCESS was answered, it is clear that considerable progress was made.

A great deal was learned about the radiative properties of cirrus clouds and contrails. A number of multiple-aircraft flights were made, with aircraft making radiative as well as *in situ* measurements over the well-instrumented CART site. Several coincident flights with satellite overpasses were made. The most complete set of ice cloud particle size distributions and cloud optical properties to data were obtained, which should help resolve long-standing debates about the role of small particles in ice cloud radiative properties, and the shape of the scattering phase function for ice particles of various shapes. Numerous flights were made in which vertical profiles of cloud properties were obtained, and several flights were performed which helped to calibrate ground-based and aircraft-based remote sensing instruments.

Much data were obtained which should shed light on the formation mechanisms of cirrus clouds and contrails. Supersaturations at which ice nucleation occurs were measured which will aid in the prediction of ice formation, and contrails were observed at temperatures where existing theories did not predict their occurrence so new theories may be needed. The first extensive measurements of ice nuclei (IN), cloud condensation nuclei (CCN), and condensation nuclei (CN) concentrations as well as compositions in the upper troposphere were made. The swelling and pre-activation of aerosols providing insight into the nucleation process were observed, the scavenging of aerosols by ice crystals were observed, and data on the (surprising) composition of the aerosols in the upper troposphere over the US were collected. Much evidence was found for significant mixing between the surface and upper troposphere, and possibly on the alterations of aerosol properties which occur in convective cloud systems. Also observed was a number of interesting dynamical phenomena associated with the tropopause.

One goal was to develop and test a series of new instruments. Each of the new instruments on the DC-8 performed very well. A new suite of instruments for gas phase chemistry, aerosol chemistry and microphysics is now available to the community. In addition, numerous instrument intercomparisons were performed (e.g., 5 independent air temperature measurements, 4 independent water vapor measurements, as well as multiple CN, ice water content, IN and particle size measurements). These intercomparisons indicated not only good agreement in some cases, but revealed problems with some measurements previously thought to be reliable.

The goal of obtaining new Near Field data was clearly met and exceeded. Both gas and particle data were obtained from very close to

the engine (< 50m) to far from the aircraft (>10 km) for a variety of aircraft. Data were obtained in persistent and not- persistent contrails, in exhaust which did not form a contrail, at a variety of altitudes and for fuels with a large range of sulfur contents. Unique data on concentrations of sulfur, nitrogen, and odd- hydrogen species, as well as on particles were obtained. Numerous emission indices were determined for a variety of aircraft and flight conditions.

Name of Project/Campaign:

SUbsonic aircraft Contrail & Clouds Effects Special Study (SUCCESS)

Project/Campaign Introduction:

See Project/Campaign Overview.

Project/Campaign Mission Objectives:

SUCCESS has several objectives.

- To better determine the radiative properties of cirrus clouds and of contrails so that satellite observations can better determine their impact on Earth's radiation budget.
- To determine how cirrus clouds form, whether the exhaust from subsonic aircraft presently affects the formation of cirrus clouds, and if the exhaust does affect the clouds whether the changes induced are of climatological significance.
- To pave the way for future studies by developing and testing several new instruments.
- To better determine the characteristics of gaseous and particulate exhaust products from subsonic aircraft and their evolution in the region near the aircraft.

Discipline(s):

Cloud Microphysics
Aerosol Properties
Atmospheric Chemistry
Meteorology and Dynamic Radiation
Remoting Sensing

Geographic Region(s):

During the SUCCESS field deployment, all three aircraft were based in Salina, Kansas. A series of flights, averaging one every other day during this period, was made mainly near the Department of Energy's Clouds and Radiation Testbed site (CART)

located in Northern Oklahoma, and Southern Kansas. During this same time period an extensive set of ground based measurements were made by the DOE, which was also operating several aircraft in the area to better understand the radiative properties of the atmosphere. Additional flights were made over the Rocky Mountains, to investigate wave clouds. Flights were also made over the Gulf of Mexico to utilize an oceanic background for remote sensing measurements. See map and a list of aircraft science missions which is on the SUCCESS Homepage

Detailed Project/Campaign Description:

See Project/Campaign Overview.

2. Data Availability:

Two data sets are currently available from the Langley DAAC.

Data Type(s):

- University of Utah PDL in ASCII format with associated images.
- VHS videotapes from forward and aft cameras aboard DC-8 and T-39 aircraft.

Input/Output Media:

Data were transitioned to the Langley DAAC via electronic means. Video data was transferred on VHS videotape. Data are distributed from the Langley DAAC via ftp and 4mm, 8mm and DLT tape. Video data is distributed on VHS video. The remaining data sets are archived at the SUCCESS Archive at Ames Research Center.

Proprietary Status:

There is no proprietary status for the data sets currently on-line at the Langley DAAC.

3. Data Access:

Data Center Location:

Langley DAAC User and Data Services Office
NASA Langley Research Center

Mail Stop 157D
2 South Wright Street
Hampton, Virginia 23681-2199
USA

Telephone: (757) 864-8656
FAX: (757) 864-8807

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Contact Information:

For data sets listed in Section 2:

Langley DAAC User and Data Services Office
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E-mail: larc@eos.nasa.gov

For access to the SUCCESS archive, contact:

Steve Gaines
Ames Research Center
Mail Stop 245-5
Building N245, Room 139
Moffett Field, CA 94035-1000

Telephone: (415) 604-4546
FAX: (415) 604-3625
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Associated Costs:

There is no cost associated with this data.

4. Principal Investigator Information:

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6. References:

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7. Glossary of Terms:

EOSDIS Glossary

8. List of Acronyms:

10baseT
: 10 Mbits/sec Baseband Twisted pair (ethernet)

AEAP
: The NASA Atmospheric Effects of Aviation Project

ARC
: NASA Ames Research Center

ARM
: Atmospheric Radiation Measurement

ARP
: Address Resolution Protocol

ASCII
: American Standard Code for Information Interchange

ATHOS
: Airborne Tropospheric Hydrogen Oxides Sensor

ATC
: Air Traffic Control

AUI
: Attachment Unit Interface [networking]

CART
: Cloud and Radiation Testbed

CCD
: Charged Coupled Device

CCN
: Cloud Condensation Nuclei

CFD
: Continuous Flow Detector

CLS
: Cloud Lidar System [ER-2]

CSU
: Colorado State University

CVI
: Counterflow Virtual Impactor

DACOM
: Differential Absorption, CO Measurement

DASI
: Digital Array Scanned Interferometer

DLH
: Diode Laser Hygrometer

DNS
: Domain Name System/Server

DOE
: Department of Energy

DSU
: Data Service Unit

DRI

	Desert Research Institute
ESE	Earth Science Enterprise (formerly Mission to Planet Earth)
ESPO	ARC Earth Science Project Office
ESSC	Earth System Science Center (Penn State Univ)
ETL	NOAA Environmental Technology Lab
FAA	Federal Aviation Administration
FIRE	First ISSCP Regional Experiment
FSSP	Forward Scattering Spectrometer Probe
FTP	File Transfer Protocol
GIF	Graphics Interchange Format
GSFC	Goddard Space Flight Center
HIS	High Resolution Interferometer Sounder [ER-2]
HTML	Hyper-Text Markup Language

HTTP
: Hyper-Text Transport Protocol

IFO
: Intensive Field Operations

IP
: Internet Protocol

ISCCP
: International Satellite Cloud Climatology Project

JEMS
: Jet Exhaust Mass Spectrometer

JPEG
: Joint Photographic Experts Group

JPL
: Jet Propulsion Lab

KSU
: Kansas State University

LAN
: Local Area Network

LaRC
: NASA Langley Research Center

LIDAR
: LIght raDAR

MAS
: MODIS Airborne Simulator [ER-2]

MASP

Multiangle Aerosol Spectrometer Probe

MASS
Mobile Aerosol Sampling System [DC-8]

MAU
Media Attachment Unit [networking]

MCIDAS
Man Computer Interactive Data Access System

MIR
Microwave Imaging Radiometer [ER-2]

MMS
Meteorological Measurement System

MODIS
Moderate Resolution Imaging Spectroradiometer [ER-2]

MPEG
Moving Pictures Expert Group

MPT
MultiPort Transceiver [networking]

MSFC
NASA Marshall Space Flight Center

MTP
Microwave Temperature Profiler [DC-8]

NASA
National Aeronautics & Space Administration

NCAR
National Center for Atmospheric Research

NCSA
: National Center for Supercomputer Applications

NFS
: Network File System

NIC
: Network Interface Card / Network Information Center

NSI
: NASA Science Internet

NSIPO
: NSI Project Office

NSSDC
: NASA Space Science Data Center

PCMCIA
: Personal Computer Memory Card International Association

PCASP
: Passive Cavity Aerosol Spectrometer

PDL
: Polarization Diversity Lidar

PING
: Packet Internet Groper [networking]

PSCN
: Program Support Communication Network

PSU
: Pennsylvania State University

RAMS

Radiation Measurement System [ER-2]

RPA
Remotely Piloted Aircraft

SASS
Subsonic Assessment

SIO
Scripps Institute of Oceanography

SLN
Salina KS airport

SMTP
Simple Mail Transfer Protocol

SPFR
Spectral Flux Radiometer

SQE
Signal Quality Error

SRB
Surface Radiation Budget

SRI
Stanford Research Institute

SSEC
Space Sciences Engineering Center (Univ of Wisconsin)

SUCCESS
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TRACE
Tropospheric Aerosol Characterization Experiment

TSCC
: Tilt Scan CCD Camera

UARS
: Upper Atmosphere Research Satellite

UAV
: Upper Atmosphere Vehicle / Unmanned Aerial Vechicle

UMR
: University of Missouri at Rolla

UNH
: University of New Hampshire

UTP
: Unshielded Twisted Pair [networking]

USAF
: United States Air Force

VIPS
: Video Ice particle Sampler

WAN
: Wide Area Network

9. Document Information:

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