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Advanced Solid-state Array Spectroradiometer Data Collection During HAPEX-II Sahel

PROGRESS REPORT

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I. Introduction and Participating Researchers

1. Introduction and Objectives

This document documents data collection using the Advanced Solid-state Array Spectroradiometer (ASAS) during the Hydrologic Atmospheric Pilot Experiment in the Sahel (HAPEX-II Sahel) field campaign in the Republic of Niger, West Central Africa from August 22 to September 19, 1992. Details on the ASAS system such as the hardware, data collection methods, information on system calibration and data processing procedures are included.

The ASAS configuration deployed for HAPEX-II Sahel contains several new components, including a new sensor array and pointing system. Because of this, new calibration procedures are being developed at the same time that the first ASAS images from HAPEX-II Sahel are being processed. These new calibration procedures will be documented in a future publication.

HAPEX-II Sahel Objectives

The objectives of HAPEX-II Sahel are to improve the parameterisation of surface hydrology processes in semi-arid areas within the framework of global climate models and to use the same data in development and application of methods for monitoring the surface hydrology at large scales from remote sensing. Another closely related objective is to retrieve biophysical and geophysical parameters from remote sensing. The experimental strategy consists of observations of climatic characteristics, monitoring of the surface and its variation by means of remote sensing systems, and extended surveys of the vegetation in an area roughly 100 km x 150 km in the Republic of Niger. Three Super Sites within the larger study area, each containing three or more subsites, were chosen for intensive measurements. Observations were carried out at a variety of spatial and temporal scales. The strategy combines limited, long term monitoring of the larger study area and intensive observations at key time periods at selected subsites. The intensive observation period (IOP) or field campaign was timed to follow the dry down of the soil and the associated changes in the climate and the vegetation.

The intermediate objectives of HAPEX-Sahel include:

- Measurement of fluxes of radiation, energy and mass at sites representative of the different surface conditions in the Sahelian zone,

- Relation of these flux measurements to relevant parameters associted with the state of the vegetaiton, the soil conditions and the atmosphere,

- Development of techniques for quantifying the improtant surface states (vegetation conditions, soil moisture, etc.) associated with these fluxes using remote sensing data from aircraft and from satellites,

- Transfer of techniques developed at the local scale to the scales more useful for climatic studies.

ASAS Investigation Objectives

The objectives of the ASAS investigation for HAPEX-II Sahel are:

- Acquire calibrated airborne bidirectional imaging spectrometry data of the subsites,

- Calculate surface hemispherical reflectance using the bidirectional imaging spectrometer data,

- Address the relationship between hemispherical reflectance and surface structure, and

- Develope and demonstrate procedures for calculating APAR using the data, emphasizing the effects of view angle on the estimates.

The specific methods for achieving the data collection and processing portion of the objectives are as follows:

- Collect directional imaging spectrometry data for the individual study sites with one pass/site in the PP and one pass/site in another azimuth.

- Concurrent with the ASAS data, take sun photometer readings and barometric pressure readings. Access Total Ozone Mapping System (TOMS) data during analysis for the time period of the overpass.

- Radiometrically correct the ASAS data using calibration parameters derived from laboratory measurements prior to the field campaign.

- Remove atmospheric effects from the ASAS data sets using inputs from the sun photometer, barometer and TOMS data. Calculate reflectance factors from the ASAS radiance values.

- Using individual pixels or small clusters of pixels, compare the ASAS reflectance estimates with surface measurements. Assess the accuracy and assess the impact of atmospheric effects removal.

It was originally planned to geometrically rectify the nadir and off-nadir ASAS images and tag each pixel with locational coordinates using C-130 navigational data recorded during the overflights. However, research on these procedures has determined that the navigational data is not collected at a rate that is suitable for these procedures.

It is planned to submit radiometrically calibrated ASAS imagery collected during HAPEX-II Sahel to the HAPEX Data Information System.

2. Contacts and Participants

Questions concerning ASAS deployment during HAPEX-Sahel should be directed to:

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Acknowledgements

Deployment of ASAS for HAPEX-Sahel was made possible by the efforts of many talented people. The engineering expertise of Jeff Travis, Peter Shu, Mike Rasten were also welcomed. Dr. Ted Engman, of NASA/Goddard Space Flight Center acted as aircraft coordinator for the experiment and the NASA C-130 crew worked long and hard to assure the success of the HAPEX-Sahel ASAS deployment: Rube Erickson, Warren Hall, Martin Knutson, Mark Koozer, Christine Scofield, Bill Brockett, Phil Henry, Doug McKinnon, Bruce Foutch, Fred Moreno, Bob Billings, John Bush, Rich Rose, Miguel Alvarez, Steve Berge, Bominic Case, Randy Cowart, Eric Gardner, Hughes Guazelli, Kurt Guenther, Glenn Harner, Al Hill, Dan Drasnow, Terry Reiss, Paul Ristrim and Victoria Wood.

Close coordination with other researchers during HAPEX proved valuable. Ron Guzman, operated the C-130-mounted sun tracking photometer and provided useful real-time information on sky conditions during missions which helped tremendously in decision making. Surface-based sun photometer measurements were well coordinated by daily interactions with Rudy Puschel, Bob Wrigley and Didier Tanré.

Special thanks go to the Garrison Aeronautique Nationale (GAN), Niamey, Republic of Niger for their hospitality in hosting the NASA C-130 during HAPEX.

II. ASAS Research Program Description

1. ASAS Instrument Description

Introduction

The Advanced Solid-state Array Spectroradiometer (ASAS) is an airborne imaging sensor employing detector array technology to acquire bidirectional digital image data for 62 spectral channels ranging from the visible (VIS) into the near-infrared (NIR), with a spectral resolution of about 10 nm. A compact optical head and gimballed mounting bracket permit data acquisition at off-nadir view angles up to 70 degrees fore and 55 degrees aft along-track using pushbroom scanning.

A complete bidirectional ASAS data set for a single flight line over a targeted site typically consists of ten separate images of the site taken at 10 different view zenith angles (+70, +60, +45, +30, +15, nadir, -15, -30, -45, -55), however investigators have some flexibility in specification of the number of view angles (and angular increments) to be acquired. These site pass datasets are usually collected at several orientations relative to the solar principal plane: parallel, perpendicular, and less often, oblique.

ASAS is currently the only airborne imaging system with off-nadir pointing capability. The instrument has low noise, variable saturation levels, variable frame rate, and 12-bit dynamic range. Absolute radiometric measurements for all bands are delivered in the standard data product.

Off-nadir pointing imaging devices offer the advantages of multiple direction observations of bidirectional reflectances and the potential for increased temporal coverage. With its bidirectional and spectral characteristics, ASAS is ideally suited to provide data for Earth Observing System (EOS) era research. Pointing capabilities are proposed for the Multiangle Imaging Spectroradiometer (MISR) on EOS.

Instrument Evolution

The first generation ASAS instrument evolved over a number of years. The original optics, built by TRW, were part of the Scanning Imaging Spectroradiometer (SIS) constructed in the early 1970s for NASA's Johnson Space Center (JSC). ASAS1 was created in 1981 when a charge-injection-device (CID) silicon detector array, made by General Electric Company, was incorporated with the optical system (replacing a vidicon) for a joint program involving NASA/JSC and the Naval Ocean Systems Center. The sensor was transferred to NASA Goddard Space Flight Center (GSFC) in 1984, where the aircraft mounting bracket was modified for along-track off-nadir pointing up to 45 degrees fore and aft.

In the fall of 1991, the mounting bracket was modified to extend the off-nadir points up to 70 degrees forward, and to 55 degrees aft. In addition, operator-controlled yaw compensation was implemented. Lastly, in early 1992 the CID array was replaced with a state-of-the-art charge-coupled device (CCD) array, and a new data system was incorporated. This system configuration with the CCD array was first flown for the HAPEX-II Sahel experiment, beginning a new generation of ASAS data products.

Instrument Description

The new ASAS employs a cooled 1024 by 1024 element silicon CCD array located at the focal plane. Using pushbroom scanning mode, the forward motion of the aircraft provides along-track scanning while the array is electronically read across-track. A transmission diffraction grating in the optical path disperses the wavelength spectrum of the radiance onto the spectral rows of the detector array. Only a portion of the array is exposed for imaging, with the remainder of the array masked for frame storage. The real dimensions of the imaging zone are 1024 spatial by 186 spectral elements, however a binning of 2 pixels in the spatial dimension and 3 pixels in the spectral dimension results in an effective area of 512 spatial by 62 spectral pixels.

The spectral channels are spatially registered with respect to each other. Spectral band centers range from 420 nm to 1037 nm. Each channel is 11 nm wide at full-width-half-maximum, and the center wavelengths are spaced at approximately 10-nm intervals. Though data from 62 spectral channels will be provided in the standard ASAS data product, several of the lowest and highest channels are significantly affected by noise. Signal-to-noise ratios for each channel will be provided in ASCII headers for each ASAS image set.

The spatial footprint of an ASAS pixel is a function of optics, detector dimensions, view angle, and aircraft speed, altitude and attitude. The total field-of-view across-track is 19.3 degrees. At an altitude of 5000 m and a speed of 200 knots, at nadir, the spatial resolution of pixels is approximately 3.3 m across-track and 2.0 m along-track.

Principles of Operation

Radiation incident on the ASAS aperture is focused onto an entrance slit by an f/1.4 objective lens with a 57.2 mm focal length. The lens focuses incoming energy through the entrance slit into a 1:1 relay with an effective focal length of 76.3 mm in each half of the relay, where 90-degree mirror prisms fold the optical path to create a compact optical head. A transmission grating located between the two prisms disperses the radiant energy into its wavelength spectrum, which in turn is directed by the second prism onto the CCD array in the focal plane. Neutral density filters of varying transmission levels can be used in front of the objective lens to accommodate wide ranges in target brightnesses.

As the platform aircraft approaches the site from a distance, the ASAS instrument is pointed forward-looking. A video camera mounted with the ASAS optical head relays a picture to an onboard monitor screen, enabling the operator to identify the site and continue tracking it through a sequence of view angles as the aircraft proceeds on a flight line over the site. When the site comes into view on the forward point, the operator begins data acquisition. The sequence is timed such that the view is at nadir when the aircraft is directly over the site, and aft-looking views are collected after passing the site.

Upon readout, the detector signals are quantized to 12-bit radiometric resolution and recorded in a pulse-code-modulated (PCM) format by an onboard high-bit-rate (HBR) tape recorder. Though data are initially collected with 12-bit radiometric resolution, the least significant bit may be discarded during processing.

Data Calibration and Data Processing

Details concerning the calibration and processing procedures have varied with the evolution of the instrument. This information is included with each data set when it is submitted for archiving and dissemination to the user community.

2. C-130 Aircraft Description

The NASA C-130B Earth Resources Aircraft Program at NASA/Ames Research Center operates a C-130B aircraft as a platform for data collection in support of earth science research. The C-130B is a low and medium altitude, cargo aircraft that has been extensively modified to accomodate a variety of scientific instruments. The aircraft is flown at speeds ranging from roughly 110 to 250 knots calibrated air speed (CAS) up to 25,000 feet above sea level. It carries bays to accomodate the NS001 Thematic Mapper Simulator (TMS), Thermal Infrared Multispectral Scanner (TIMS), PBMR, C-SCAT, NUSCAT, PRT-5, Frost dew point Hygrometer, and Zeiss photographic cameras.

C-130 Aircraft Data Distribution System

The C-130 Aircraft Data Distribution System (CADDS) is used during all NASA C-130 missions. This system provides data to each experimenter station concerning aircraft altitude, position, airspeed, in-situ wind direction and velocity, outside air temperature, surface temperature, dew point, accurate time, and flight line labeling parameters among other parameters. This data is also available to experimenters after the missions via magnetic media.

Automatic Sun Tracking Photometer

The Automatic Sun Tracking Photometer (ASTP) is mounted on the upper part of the C-130 fuselage. The ASTP was deployed for HAPEX-Sahel to support investigations into atmospheric corrections of airborne imagery. The principal investigator for this is Mike Spanner of Ames Research Center.

3. References

Huegel, F.G. 1987. Advanced solid-state array spectroradiometer: sensor calibration and improvements. Proc. of the SPIE, Vol. 834, Imaging Spectroscpy II, 12-15.

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Irons, J.R., P.W. Dabney, J. Paddon, R.R. Irish, and C.A. Russell. 1990. Advanced solid-state array spectroradiometer (ASAS) support of 1989 field experiments. Proced. of SPIE conf. on Imaging Spectroscopy of the Terrestrial Environment. SPIE Vol. 1298.

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Medium Altitude Missions Branch, 1990. NASA C-130 Earth Resources Aircraft. NASA, Ames Research Center, Moffet Field, CA

Stewart, S.E., R.R. Buntzen and J. Carbone. 1985. Advanced CID array multispectral pushbroom scanner. Laser Focus/Electro Optics. p. 88-100.

III. Surface-Based Atmospheric Optical Transmission Measurements Summary

1. Atmospheric Optical Transmission Measurements

Introduction

As part of the ASAS deployment, surface-based atmospheric optical transmission measurements were made. These measurements along with other data sets are to be used for atmospheric correction of the ASAS imagery. Close coordination of these measurements was made with other investigators making similar measurements. These data were collected primarily from the West Central Site.

Instrument Descriptions

Two instruments were used to measure aerosol optical thickness and water column abundance from the surface. The first is the SXM-2 auto-sun tracking solar photometer, designed and built at NASA, Goddard Space Flight Center. Seven channels (440, 522, 617, 672, 781, 872 and 1030 nm) are used for aerosol optical thickness measurements. Water column abundance is measured in one channel (940 nm).

The second instrument is the MIAMI-322 solar photometer. This device has four channels. Three are used for aerosol optical thickness (380, 500, 870 nm) and one (940 nm) is used for water column abundance measurement.

Atmospheric pressure was measured using a precision guage and ozone column abundance was inferred from climatology.

Calibration and Data Processing

Calibration measurements were made at Sunspot, New Mexico (elevation 9,200 ft.) where a solar observatory is situated, before and after the HAPEX-II Sahel field deployment. Langley and Modified Langley methods were used for calibration procedures.

2. Measurements Summary

Data collection was made from the West Central Super Site. A summary of measurements is listed in the following table (Table 1). A detailed description of these measurements and the methods can be found in:

Halthore, R. N., 1993. Report on the Atmospheric Transmission Measurements Made During HAPEX'92 Held Near Niamey, Niger Between August 20 and September 20, 1992. Submitted to Code 923, NASA, Goddard Space Flight Center, Greenbelt, MD 20771.

Table 1. Surface-based atmospheric transmission measurements summary.

DATE	TIME	COMMENTS
9/1/92	(08:00 - 10:00)	Clear skies in the morning led to Cu formation by 09:45.
9/3/92	(14:30-17:00)	Cloudy in the morning. Clearing up slowly by 11:30. Considerably clear at 15:00. Wind mild from the South. Pressure = 982.3 mb.
	14:30	Start data.
	15:00	Sun clear. Scattered Cu. Ci to SE.
	15:20	C-130 overhead.
	16:26	Ci in S and E. Cu more numerous now.
	16:34	Ci in WNW.
	17:00	Stop data.
	17:20	Cu near sun.
	17:50	Cu is disappearing but still near sun.
	17:57	Cu near sun.
9/6/92	(12:00-16:00)	At 06:30 clouds covering sun. At 11:00 clearing but some Ci around the sky.
	12:00	Start data.
	12:12	Ci in the sky. Wind <5 mph from S. Pressure= 983.5mb. Ci moving in from E at high speed.
	13:19	Ci seems to disappear near sun. Steady wind from S; SE.
	13:58	Cu,Ci popping up in E. Wind stronger from S.
	14:13	Cu popping up everywhere but not threatening.
	14:39	Cu near sun.
	15:02	Cu covering sun.
	15:06	Sun clear but Cu near sun.
	16:00	Stop data.
9/8/92	(14:30-17:00)	
	14:30	Start data.
	14:39	Cu & Ci everywhere. Path to sun clear.
	16:10	Cu near sun; hazy near sun.
	16:45	C-130 overhead. Pressure=980.7 mb.
	17:16	Stop data.

DATE	TIME	COMMENTS
9/9/92	(14:30-17:00)	Cu covering sun in the morning. Haze layer (desert sand storm) moved in reducing visibility considerably. ASAS flight scheduled for 14:30.
	13:20	Hazy in the boundary layer.
	14:30	Start data.
	14:48	C-130 overhead.
	16:54	Pressure= 979.0 mb.
	17:00	Stop data.
9/10/92	(09:45-11:00)	
	09:00	Ci covering most of the sky. Wind >5 mph gusting to 20 mph.
	09:45	Start data. Pressure= 979.0 mb.
	10:30	Landsat overpass. Ci overhead and everywhere.
	11:00	Data stop. Too many Ci clouds. Data of questionable quality.
9/13/92	(11:30-17:05?)	Cu have popped up and Ci covered the sky partially. Cu formation did not continue in the afternoon with the result that the Ci dominated the sky cover. Later in the evening Ci thinned out thus providing good quality data. Pressure decreased throughout the afternoon and temperature was around 100° F. Winds mild, stationary at high altitude.
	11:30	Start data.
	11:42	Ci to E and N. Pressure=981.4 mb.
	12:17	Ci everywhere. No wind
	14:34	No Cu only Ci.
	14:51	Ci everywhere and non-uniform.
	15:01	Cu formation has been suppressed
	16:02	Sky uniform towards sun.
	16:28	Pressure= 976.9 mb.
	16:39	Ci to N, E at <45° zenith. Wind mild from S,SW.
	17:04	Ci also 20° to N of sun. Otherwise sky is uniform. Pressure= 976.6 mb.
	17:05	Data stop.

DATE	TIME	COMMENTS
9/17/92	(09:00-16:33)	
	09:00	Start data. Ci to E and S, but path to sun clear.
	09:09	Ci in E,S,N. Heavy in E and S. Light in N.
	09:12	Light wind from W. Pressure= 982.5 mb.
	09:13	Winds from W gusting to 10 mph.
	09:19	Ci moving S.
	09:48	Winds shifting to Southerlies.
	09:58	Ci near sun, but moving SE.
	10:15	Ci covering sun.
	11:02	Wind from SW, gusting.
	12:13	Sun clear. Negligble Cu.
	13:39	Clear. Clouds to E and SE. Pressure=981.7 mb.
	15:16	Winds from N.
	15:32	Winds shifted to easterlies.
	15:51	No wind. Pressure= 980.4 mb.
	16:33	Stop data.

II. HAPEX-II Sahel ASAS Measurements Summary

1. Introduction and Deployment Description

Introduction

This section contains a summary of ASAS data collected during HAPEX-Sahel along with comments recorded during the missions. The comments are taken fromthe ASAS data logs and notes kept by the ASAS operators, and the C-130 data station operator logs. A brief description of the subsites that served as the targets for data collection is also included. Investigators wishing to use the data are urged to consult the full HAPEX-II Sahel Experiment Plan for further details concerning the experiment and the study sites.

Investigators are also urged to access the video tapes taken by the ASAS video camera system during missions. The audio track of these tapes contains conversations among the C-130 crew and the ASAS operators and provide a dynamic record of data collection.

Deployment Description

The modifications of ASAS were completed several weeks prior to the deployment for HAPEX-II Sahel and as a result a full test of the system was not possible before leaving for the misison. The C-130 was based out of the military side of the Niamey, Niger airport at the facilities of the Nigerian Air Force, Garrison Aeronautique Nationale (GAN). GAN made several rooms available to the experiment for storage and office space. Weather data and predicitions were available from the Nigerian Weather Service which was located on the civilian side of the airport. Telephones and radios were used for contact between the airport and the study sites. However, the telephones were often out-of-order following rain events over Niamey. There were no radio contacts between the C-130 and the surface during missions.

Two French aircraft (ARAT and MERLIN) deployed for HAPEX-II Sahel were also based out of GAN, thus allowing easier coordination of data collection. A single-engined Piper Saratoga, fitted with instrumentation for the experiment, was based out of the civilian side of the airport. Most of the planning and coordination of the missions took place at the nightly weather briefings and Experiment coordination meetings where representatives from the various investigators present for the experiment were represented.There were also individual meetings with investigators serving as Super Site- Site Captains to insure that data collection objectives were met.

The sub sites were generally difficult to identify from the air. There were no recent aerial photographs or good maps to work from. A June 8, 1992 SPOT image of the study area was available prior to deployment and was used as an aid in locating sites for measurement. Representatives from each of the Super Sites were consulted for locational information and when possible, flew on missions to assist with site identification. This was not always helpful, however, as the lack of useful aerial photographs and maps along with differing perceptions of where sites were located did little to assist with data collection. The experience of the C-130 navigator, Rich Rose was helpful in locating sites during missions. Global Positioning System (GPS) and Inertial Naviagation System (INS) were helpful on a few occaisions.

Optical missions were given priority during the IOP based on the availability of clear weather. Cirrus clouds were often present and cumulus clouds would begin building on most days at approximately 11:00 AM local time. On several clear days, windborne dust from the Saharan

Desert created poor optical depth situations. During missions on marginal days, close monitoring of the cloud conditions via visual observation (below the aircraft) and conversations with the ASTP operator who had real-time CRT data plots available, assisted greatly in decisions to continue or abort data collection.

It was planned to try and collect data over each Supersite subsite at two different sun angles. Cloud conditions frequently limited this and thus, the available data is somewhat redundant in terms of solar zenith angles.

2. Experiment Site Description

The full HAPEX-II Sahel study area is located in the Republic of Niger, west central Africa. The sub-saharan landscape of the study area is along a north/south vegetation/moisture gradient. The full study area encompasses a 100 km by 150 km area east of Niamey, Niger. Intensive measurements were made at three Super Sites within this area. Each Super Site had three or more subsites representing major types of land cover. Subsites are typcially millet, bushland/fallow and tiger-bush. Millet is agricultural land which is used for growing traditional crops. There is some double cropping present. Fallow represents agricultural land which has not been cropped for a number of years. Tiger-bush is natural open forest which contains large areas of bare soil.The Supersites were named East Central, West Central and South. The East Central and West Central Supersites were located east of Niamey and the Niger River. Supersite South was located south of Niamey close to the ICRISAT center, east of the Niger River. Details on surface activities at the Super Sites are available in the HAPEX-II Sahel Experiment Plan.

East Central Super Site

The closest village to this site was Banizoumbou. Surface measurements at this site were mostly conducted by French researchers. The East Central Super Site was by far the most difficult to locate from the air. A lack of distinct landscape features and conflicting reports on subsite locations hampered ASAS data collection.

The center point coordinates of the three subsites with brief descriptions follow.

Fallow Bushland: N 13° 33.6′
E 02° 40.7′

Millet: N 13° 32.6′
E 02° 40.5′

Degraded Site: N 13° 32.8′
E 02° 41.7′

This Degraded subsite was considered a low priority site as there were few measurements taken on the surface. The amount of ASAS coverage of this site is sparse.

West Central Super Site

The closest villages to the West Central study sites were Fandou Béri and Kalassi. The West Central Supersite was the primary site of interest for the US teams and the ASAS investigation. This Supersite was actually divided into four subsites, thus requiring an additional set of passes for full data collection.

Center point coordinates of the three subsites with some brief narratives follow.

Millet and Fallow/Bushland: N 13° 32.4′
E 02° 30.8′

This subsite actually consisted of two separate subsites and the above coordinate is for a location in the road between the targets. The millet field was actually south of the road and the bushland along with a cleared bushland area was north of the road.

Degraded Bushland: N 13° 33.2′
E 02° 34.1′

The Degrated Bushland subsite was considered low priority for the experiment by the West Central Supersite Captain. As a result, it was not given as much emphasis during data collection.

Tiger Bush: N 13° 30.1′
E 02° 34.7′

Tiger bush provides a striking contrast in its appearance relative to the rest of the landscape. This along with its position relative to a road and a pond north of the road made identification of the target possible.

In general, the West Central subsites were the easiest to indentify from the air during missions.

Super Site South

Data collection over Super Site South was hampered by frequent cloudy conditions. As a result, ASAS coverage of these subsites is limited or suffers from poor atmospheric optical depth conditions. The proximity of the sites to the ICRISAT experiment station and roads assited greatly in the identification of the subsites from the air during data collection. Surface measurements at this site were largely conducted by researchers from the UK.

Center point coordinates of the three subsites with brief comments follow.

Pearl Millet: N 13° 14.5′
E 02° 17.9′

Fallow: N 13° 14.6′
E 02° 14.7′

The Fallow subsite was considered the lowest priority of the three.

Tiger Bush: N 13° 11.9′
E 02° 14.4′

Transects

ASAS was run in a nadir-looking mode during several missions. This was done to provide high spectral resolution data of portions of the transects. Full transect coverage was not available because of problems with the ASAS tape drive overheating.

3. ASAS Data Logs

The following table is a summary of the data collection for each mission. Most of the mission were flown at 5,000 m AGL. On several days the presence of the French ARAT aircraft necessitated flying at an additional 300 m above this.

Note that not all of these data sets will be processed due to the range of data quality and available resources.

ASAS2 FLIGHT LOG HAPEX/SAHEL NIGER FPS: 38

AFRICA NDF: 17.5

9/1/92

OPERATORS: PD, CW TAPE 1

LINE/RUN	SITE	START (GMT)	STOP (GMT)	HEAD.	ALT AGL (FT)	#LK ANG	GS (KTS)	SZA	COMMENTS
								~	
L101 R1	896 West Cnt Sub 1?	7:54:06	7:59:24	272	16100	9 60-(-55)	218	58	70 Fore-Haze
L102 R1	896 Sub 1?	8:08:00	8:12:25	134	16030	9	221	50	Skip 70 F- Haze No data - can't ID sites
L201 R1	896 Sub 2	8:21:36	8:27:15	319	15960	9	219	48	Skip 70 F- Haze Coverage starts at +45, prob sites a, a'
L201 R2	896 Sub 3	8:34:10	8:38:20	86	16150	9	217		Start w/ +45 problems with site ID
L301 R1	896 Sub 2	8:47:13	8:53:28	278	15900	9	220		Start w/ +45 ID problem
L301 R2	896 Sub 3	9:00:04	9:05:22	87	16200	9	219		Start w/ +60 Missed -45,-55?
L101 R2	897 East Cnt Sub 1	9:14:54	9:19:58	279	16150	9	220	38	
Flight cut	short b/c of	clouds							

ASAS2 FLIGHT LOG HAPEX/SAHEL NIGER AFRICA FPS: 38 NDF: 17.5

9/3/92

OPERATORS: PD, CW TAPE 1 ,2 & 3

LINE/RUN	SITE	START (GMT)	STOP (GMT)	HEAD.	ALT AGL (FT)	#LK ANG	GS (KTS)	SZA	COMMENTS
								~	
L0 R1	DARK CURRENT	13:16:15	13:16:30			1			
L101 R1	895 southern millet 1	13:21:19	13:26:45	81	15500	10? 70-(-55)	220	22	Plus 60 ? Otherwise good
L201 R1	895 bush/fal 2	13:32:18	13:36:16	258	15400	10	225	26	OK, but maybe site ID off
L201 R2	895 bush/fal 2	13:43:53	13:47:36	82	15400	10	219	29	Cloud shadows at nadir to -45
L301 R1	895 Tigerbush 3	13:56:05	13:57:10	263	15575	?	220		Abort - Clouds
L101 R2	896 WestCnt millet 1	14:11:57	14:15:09	86	15610	10	220	35	Most angles OK Got site SW of road
L101 R3	896 bushland 1	14:19:52	14:23:12	265	15500	10	225	37	Good - got site NE of road Pitch problem?
L201 R3	896 degradbush2	14:31:20	14:34:26	84	15600	10	219	40	Good
L301 R2	896 WestCnt tigerbush 3	14:41:00	14:43:10	260	15500	10	223	42	OK, some drift aft angles
L101 R4	897 EastCnt 1	14:57:21	15:00:46	85	15500	?	218		Couldn't locate sites
L301 R3	897 3	15:07:43	15:10:04	263	15470	?	238	49	OK, some pitch
L301 R4	897 Degraded 3	15:28:05	15:32:10	265	15400	10	222	54	Start w/ +15 OK
L104 R1	896 WestCnt millet ?	15:50:59	15:52:46	134	15470	< 10	219	60	Oblique Start w/ +45 Haze, shadows?
L103 R1	896 millet 1	16:00:18	16:02:37	270	15570	< 10	220	62	OK - shadows? Start w/ +45
L203 R1	896 millet 1	16:21:54	16:25:09	269	15425	< 10	223	67	OK, missed +60 Start w/ +45

ASAS2 **9/3/92 cont.**

LINE/RUN	SITE	START (GMT)	STOP (GMT)	HEAD.	ALT AGL (FT)	#LK ANG	GS (KTS)	SZA	COMMENTS
L0 R2	DARK	16:28:30	16:29:00			1			Bay doors open No good
L0 R3	DARK	16:30:15	16:30:45			1			doors closed

ASAS2 FLIGHT LOG HAPEX/SAHEL NIGER AFRICA FPS: 38 NDF: 17.5

9/8/92

OPERATORS: PD, CW TAPE 3 & 4

LINE/RUN	SITE	START (GMT)	STOP (GMT)	HEAD.	ALT AGL (FT)	#LK ANG	GS (KTS)	SZA	COMMENTS
								~	
L101 R1	897 EastCnt 1	13:53:27	13:59:04	264	17200	9	240	33	OK - Haze, +15 cloud Start w/ +60
L201 R1	897 2	14:06:56	14:12:51	79	17125		209	36	Can't ID sites
L102 R1	897 1	14:22:10	14:26:08	311	17209	9	238	39	Oblique Good Start w/ +60
L202 R1	897 2	14:32:58	14:37:00	124	17150	9	236	42	Oblique OK Start w/ +60 Coverage?
L103 R1	897 1	14:44:55	14:47:40	266	17180	8	235	43	Missed +60
L101 R2	896 WestCnt 1	15:04:15	15:09:00	81	17190	?	234	49	Problems w/ clouds, review video
L201 R2	896 2	15:16:02	15:20:07	270	17226	8	239	52	OK, start w/ +45 Some drift
L202 R2	896 2	15:27:29	15:31:36	139	17130	9	235	55	Oblique Good Start w/ +60
L104 R1	896 millet 1	15:43:45	15:48:04	310	17100	9	241	59	Oblique Start +60
L103 R2	896 millet 1	15:54:59	15:58:58	88	17115	9	237	62	Good Start +60
L103 R3	896 fallow 1	16:05:52	16:09:49	280	17160	9	241	64	Good Start +60 got millet also
L0 R1	DARK	16:11:45	16:12:00						Bay open for cold exposure

ASAS2 FLIGHT LOG HAPEX/SAHEL NIGER AFRICA FPS: 38 NDF: 17.5

9/9/92

OPERATORS: PD, CW TAPE 5 & 6

LINE/RUN	SITE	START (GMT)	STOP (GMT)	HEAD.	ALT AGL (FT)	#LK ANG	GS (KTS)	SZA	COMMENTS
								~	
L101 R1	895 South 1	14:00:09	14:04:19	78	15600	9	211	34	Dust at sfc, clear above plane
L301 R1	895 3	14:17:21	14:20:25			9		38	Aircraft vibrations, pitch at start Array temp too cold?
L102 R1	895 1	14:30:05	14:32:46			9		41	Oblique, many corrections during run, array temp adjusted
L302 R1	895 3	14:39:24	14:42:12			9		43	Oblique nadir & -15 ?
L103 R1	895 1	14:50:32	14:53:30			9		46	Good
L301 R2	896 WestCnt 3	15:04:18	15:07:37			9		49	Good
L302 R2	896 3	15:16:53	15:19:45			9		52	Oblique Aft 15,30 ?
L105 R1	895 1	15:32:39	15:35:22					56	Good
L303 R1	895 3	15:42:31	15:45:28			9		58	Good
L104 R1	895 1	15:52:42	15:54:49			8		60	Oblique Missed +60 Array temp too cold?
L304 R1	895 3	16:00:27	16:03:36			9		62	Oblique, good Aft 15 - roll
L0 R1	DARK	16:06:46	16:07:03			1			Bay open shutter closed

ASAS2 FLIGHT LOG HAPEX/SAHEL NIGER AFRICA FPS: 38 NDF: 17.5

9/13/92

OPERATORS: PD, CW TAPE 7

Sun photo reported good sky

LINE/RUN	SITE	START (GMT)	STOP (GMT)	HEAD.	ALT AGL (FT)	#LK ANG	GS (KTS)	SZA	COMMENTS
								~	
L101 R1	896 WestCnt fallow 1	14:26:36	14:32:06	76	15600	9	223	41	Good, millet in some angs
L101 R2	896 millet 1	14:41:20	14:43:58	260	15500	9	215	44	Good, but some corrections aft
L102 R1	896 mil&fal 1	14:49:26	14:53:20	122	15700	9	217	46	Oblique Good
L302 R1	896 tigerbush 3	14:59:10	15:02:40	308	15700	9	230	48	Oblique Missed -15
L301 R1	896 t.b. 3	15:08:17	15:12:11	81	15670	9	224	51	Good Array temp good
L201 R1	897 East Cnt 2	15:21:18	15:23:57	84	15700	9	221	53	Good Missed +30 ?
L101 R3	897 1	15:29:06	15:32:44	267	15700	9	225	56	Good
L202 R1	897 2	15:37:18	15:40:53	120	15700	9	225	58	Oblique Good
L102 R2	897 1	15:45:51	15:50:03	314	15700	9	222	60	Oblique Good
L103 R1	896 West Cnt fallow 1	15:57:42	16:00:08	272	15760	9	220	62	Good Some angs have millet also
L104 R1	896 fallow 1	16:05:57	16:09:36	128	15600	10	218	65	Oblique Start +70 Missed -30,-55

ASAS2 FLIGHT LOG HAPEX/SAHEL NIGER AFRICA FPS: 38 NDF: 17.5

9/17/92

OPERATORS: PD, CW TAPE 8

LINE/RUN	SITE	START (GMT)	STOP (GMT)	HEAD.	ALT AGL (FT)	#LK ANG	GS (KTS)	SZA	COMMENTS
								~	
L0 R1	DARK	8:42:00	8:42:20						Without TEC warming and bay doors closed
L301 R1	895 South Tigerbush 3	8:50:22	8:54:01	285	15760	10	220	43	Good sun photo OK
L302 R1	895 3	9:00:50	9:04:07	141	15870	10	218	41	Oblique Good Sun photo good
L301 R2	896 West Cnt	9:22:56	9:26:49	286	15700	10	221	36	Good sun photo OK
L201 R1	897 East Cnt 2	9:32:11	9:34:30	110	15900		218		Abort - cant find site
L201 R2	897 2	9:44:58	9:47:48	286	15644	10	216	31	
L302 R2	896 3	9:55:14	9:59:13	149	15735	10	220	28	Oblique Good sun photo good
L202 R1	897 2	10:05:05	10:08:41	335	15800	10	220	27	Oblique Good
L303 R1	896 3	10:17:49	10:21:34	113	15800	10	214	23	Good sun photo good
L0 R2	DARK	10:22:51	10:23:23			1			doors open