# Alternative Experiment Plan (9/20/00)

# SMEX01 and SMEX02

## Introduction

The purpose of this plan is to describe how the NASA Land Surface Hydrology Program and Aqua AMSR science and validation objectives for soil moisture described in the SGP01+ Experiment Plan (http:/hydrolab.arsusda.gov/sgp01/sgp01.htm) would be accomplished if the launch of the Aqua satellite is delayed until May of 2001. The original plan called for experiments to be conducted in late June through July of 2001 in Iowa, Oklahoma and Georgia. If Aqua is launched on May 15, 2001 (the projected date) it is unlikely that reliable AMSR data would not be available. Also, additional delays are always a possibility. In order to support the satellite validation component of SGP01+ it would be necessary to commit resources that could not be retrieved or carried over in the event of a delay. Therefore, the validation of AMSR soil moisture products should be delayed until the summer of 2002. One benefit of this delay is that both the Aqua and ADEOS-II AMSR instruments should be available at that time.

There were several objectives for the SGP01+ experiment. These included:

1. Development and verification of both AMSR and future mission soil moisture retrieval algorithms for agricultural conditions with high biomass levels for current and future missions
2. Validation of Aqua AMSR soil moisture products for a range of land cover types
3. Land surface hydrology-atmosphere interaction studies using ground and aircraft flux observations
4. Extension of SAR based soil moisture retrieval techniques and integration with passive microwave radiometry
5. Demonstration of new soil moisture retrieval concepts (GPS, 2DSTAR)

Objective 1 is a high priority of the LSHP and is supported primarily by the JPL PALS on the NCAR C-130 aircraft. It involves only the watershed area (5 by 20 km) in Iowa. Funding and aircraft availability considerations support doing this portion of the overall project in the summer of 2001. Ground sampling to support this activity is different than that required for AMSR validation. The same experiment would also support Objective 3. This was planned for only the Iowa watershed.

It would be desirable to broaden the experiment conducted in 2001 to include additional remote sensing techniques that would contribute to AMSR algorithm development and error budgets as well as the exploration of new technologies. Therefore, it is suggested that the ACMR and/or the Step-C should be added to the C-130 in order to support AMSR and that the GPS soil moisture instrument also be included.

Efforts in 2002 would focus on AMSR soil moisture validation using the NASA P-3 with the PSR instrument in Oklahoma. Additional sites could be added based on science priorities, however, we would like to get input from the community on which should be addressed in this experiment. The ESTAR instrument would be on the P-3. It is also possible that a 2D STAR could be available by this time.

A meeting of the NASA LSHP is tentatively scheduled for the Spring of 2001. As part of this meeting, a short workshop will be conducted to refine plans for SMEX02 and updates on SMEX01.

**SMEX01 (Iowa)**

The objective of Soil Moisture Experiment 2001 (SMEX01) is to conduct an experiment that would provide a data set for the development and verification of alternative soil moisture retrieval algorithms under significant biomass levels associated with agricultural crops. It is essential that multi-parameter microwave observations be obtained over a range of soil moisture conditions with moderate to high vegetation biomass conditions.

*Study Site:* A study site called Walnut Creek, IA was selected for investigation. It is a small watershed just south of Ames, IA. Figure 1 shows the general watershed location. It is agricultural with corn and soybeans. Figure 2 is a true color Landsat TM image obtained on July 19, 1999. Nearly all fields rotate between the two each year. Therefore, we expect the land use in 2001 to be quite similar to 1999. Both row and drilled soybeans planting practices are in use. Figure 3 shows row soybean and corn conditions in late June, 2000. Biomass conditions for corn are expected to be in the range of 3 to 4 kg $m^{-2}$ and less than 1 kg $m^{-2}$ for soybeans.

*Schedule:* The schedule will be expanded a bit longer than originally planned for SGP01+. In that plan the P-3 was occupied earlier in June. In order to have an adequate time window for obtaining a range of conditions, we will request that the NCAR C-130 be available for data collection beginning June 20, 2001 through July 3, 2001.

*Flightlines:* Aircraft data will be collected in conjunction with ground observations during the early morning hours. A total of nine flightlines are proposed to cover the watershed area. These are shown in Figure 1 and listed in Table 1.

| Table 1. Iowa Flightlines | | | | | | | |
|---|---|---|---|---|---|---|---|
| Line No. | Altitude (km) | Length (km) | Description | Start Lat. | Start Lon. | Stop Lat. | Stop Lon. |
| 1 | 0.5 | 5 | Water Calibration | TBD | | | |
| 2 | 1 | 20 | C-130 Mapping | 41.933 | -93.75 | 41.933 | -93.50 |
| 3 | 1 | 20 | C-130 Mapping | 41.940 | -93.50 | 41.940 | -93.75 |
| 4 | 1 | 20 | C-130 Mapping | 41.947 | -93.75 | 41.947 | -93.50 |
| 5 | 1 | 20 | C-130 Mapping | 41.955 | -93.50 | 41.955 | -93.75 |
| 6 | 1 | 20 | C-130 Mapping | 41.962 | -93.75 | 41.962 | -93.50 |
| 7 | 1 | 20 | C-130 Mapping | 41.969 | -93.50 | 41.969 | -93.75 |
| 8 | 1 | 20 | C-130 Mapping | 41.976 | -93.75 | 41.976 | -93.50 |
| 9 | 1 | 20 | C-130 Mapping | 41.983 | -93.50 | 41.983 | -93.75 |
| 10 | 1 | 20 | C-130 Mapping | 41.990 | -93.75 | 41.990 | -93.50 |

These flightlines may be modified in altitude to provide a slightly higher resolution footprint. However, watershed coverage will be retained. It may also be necessary to fly in a specific direction if RFI is detected for a particular orientation.

Currently available resources support approximately 26 flight hours. We hope to get 6 days of flights over the area.

*Aircraft Instruments:* The primary mission instrument is PALS which provides dual polarization active and passive S and L band observations. AMSR algorithm and validation would benefit greatly from the addition of at least a dual polarization C band instrument. This would be valuable to extended work on multifrequency retrievals. Therefore, an attempt will be made to install the ACMR or Step-C radiometer on the NCAR C-130. It should be noted that the Step-C flew on this aircraft in 1999. In addition, if it can be accommodated, it is desirable to include the GPS soil moisture instrument on the NCAR aircraft. This should be possible since it requires only a small port. Including this instrument would allow a first look at what this approach can offer for soil moisture estimation.

It is possible that the Canadian aircraft may participate in both the radiometer component and the surface flux component of SMEX01.

*Flux Observations:* A network of tower based surface flux observing stations will be deployed during SMEX01. The purpose is to study the interaction of surface soil moisture and the atmospheric boundary layer. It is possible that the instrumentation and current flightlines of the NCAR C-130 will provide some aircraft flux data. In addition, alternatives for dedicated aircraft flux observations are being pursued.

*Ground Observations*: Soil moisture observations will be made within numerous fields distributed over the watershed. Sampling will be limited to a three hour window centered on the C-130 overflight time. Both gravimetric and TDR sampling will be employed. It is anticipated that a team of two people can sample four fields in this time. We would hope to have at least ten people available.

Therefore, at least 20 fields will be sampled. Data will only be collected on flight days, or if there is a satellite overpass. Vegetation sampling will be conducted on off days and in the afternoons.

*What if Aqua is Available?* If Aqua launches on schedule and it is anticipated that the AMSR instrument will be collecting data, we will conduct some validation studies, if possible. An alternative ground sampling plan will be prepared that includes the spatial domain of an AMSR footprint. On the days of AMSR overpasses (every other day), this sampling will be conducted to coincide with the afternoon pass. There are issues and problems in trying to validate this observation which we will work on in the coming months. All ground sampling would be done using TDR devices. This effort will require additional resources for people, transportation (more cars needed) and TDR instruments. However, we shouldn't miss the opportunity.

**SMEX02 (SGP)**

SMEX02 will focus on AMSR soil moisture validation. The critical element of the experiment is the P-3 mission over the SGP with the PSR instrument. In order to accomplish this the PSR needs an upgrade to include an X band channel. This work must be initiated immediately (40K).

*Study Site:* The primary study site is the SGP region that has been used in previous investigations. Figure 4 shows the general study location. Vegetation in this region in mid summer is very light. Conditions are very compatible with algorithm validation for AMSR. Land cover will be grass, senescent winter wheat and bare soil. Figure 5 is a false color Landsat TM image obtained in July, 1999. Figure 6 shows typical grass and winter heat conditions in the region in mid summer.

In addition, a limited experiment is still planned for Georgia. At least one more site will be added. This will be based on science priorities of both LSHP and AMSR and will depend upon the outcome of SMEX01.

*Schedule:* The schedule will included two weeks in Oklahoma and another 10 days to cover additional sites. The mission would begin July 5 and run through July 27, 2002.

*Flightlines:* Aircraft data will be collected in conjunction with ground observations during the early morning hours. Flightlines for the SGP region are shown in Figure 4 and described in Table 2. Flightlines for Georgia are shown in Figure 7 and described in Table 3.

The original plan provided for a total of 70 hours of P–3 flights. This is adequate for the objectives of the revised SMEX02.

Table 2. SGP Flightlines

| Line No. | Altitude (km) | Length (km) | Description | Start Lat. | Start Lon. | Stop Lat. | Stop Lon. |
|---|---|---|---|---|---|---|---|
| 1 | 7.5 | 280 | P3-B Mapping | 37.000 | -97.479 | 34.500 | -97.479 |
| 2 | 7.5 | 280 | P3-B Mapping | 34.500 | -97.671 | 37.000 | -97.671 |
| 3 | 7.5 | 280 | P3-B Mapping | 37.000 | -97.863 | 34.500 | -97.863 |
| 4 | 7.5 | 280 | P3-B Mapping | 34.500 | -98.054 | 37.000 | -98.054 |
| 5 | 7.5 | 280 | P3-B Mapping | 37.000 | -98.246 | 34.500 | -98.246 |
| 6 | 7.5 | 280 | P3-B Mapping | 34.500 | -98.438 | 37.000 | -98.438 |
| 7 | 0.5 | 5 | Water Calibration | 34.783 | -98.353 | 34.856 | -98.359 |

Table 3. Georgia Flightlines

| Line No. | Altitude (km) | Length (km) | Description | Start Lat. | Start Lon. | Stop Lat. | Stop Lon. |
|---|---|---|---|---|---|---|---|
| 8 | 7.5 | 100 | P3-B Georgia | 31.333 | -83.74 | 31.833 | -83.74 |
| 9 | 7.5 | 100 | P3-B Georgia | 31.833 | -83.62 | 31.333 | -83.62 |
| 10 | 7.5 | 100 | P3-B Georgia | 31.333 | -83.50 | 31.833 | -83.50 |

*Aircraft Instruments:* The primary mission instrument is the PSR, which will provide dual polarization C and X band passive observations. In addition, there is another bay on the P-3 that an accommodate either the L band ESTAR or, if it is ready for flight testing, a 2D STAR L band. The GPS instrument could also be included in this mission.

SMEX02 will also coincide with the availability of several new satellite SAR systems, Envisat ASAR and ALOS PALSAR, which will have dual polarization capabilities. It would be desirable to include ground and AIRSAR support for potential soil moisture algorithms utilizing these data and/or combinations of active and passive microwave data.

*Ground Observations*: On the days of AMSR overpasses, this sampling will be conducted in the early morning in an attempt to match the night time overpass. There are issues and problems in trying to validate this observation which we will work on in the coming months. All ground sampling would be done using TDR devices. This effort will require additional resources for people, transportation (more cars needed) and TDR instrument than have been required in previous experiments.

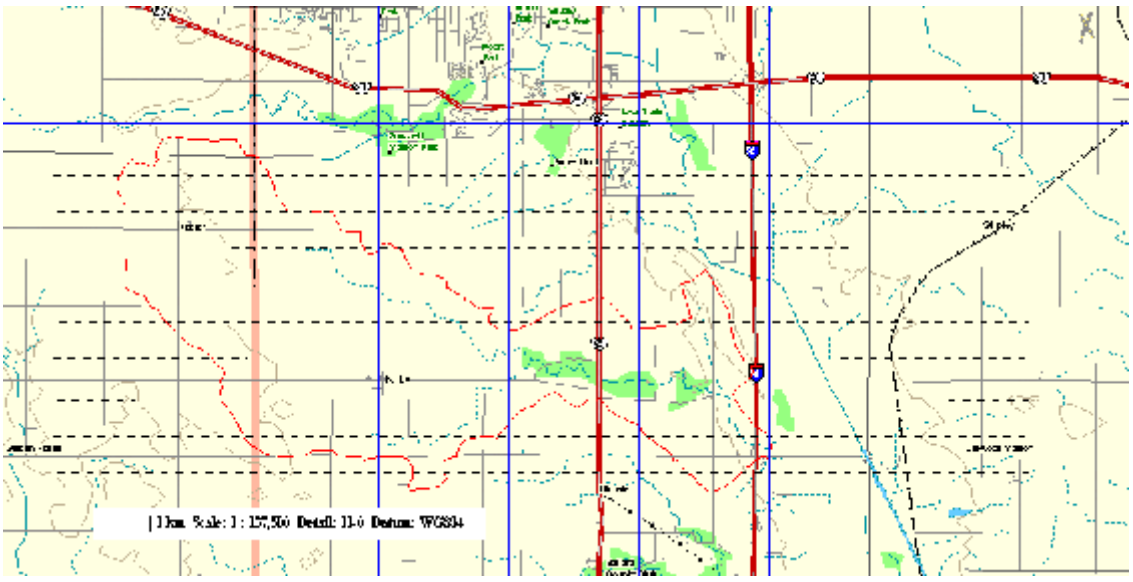

Figure 1. SMEX01 Walnut Creek, Iowa Study Area and Flightlines.

Figure 2. Landsat TM Image of the Walnut Creek, Iowa Study Area obtained in July, 1999.

Figure 3a. Walnut Creek, Iowa Typical Corn Canopy on June 28, 2000.

Figure 3b. Walnut Creek, Iowa Typical Row Soybeans on June 28, 2000.

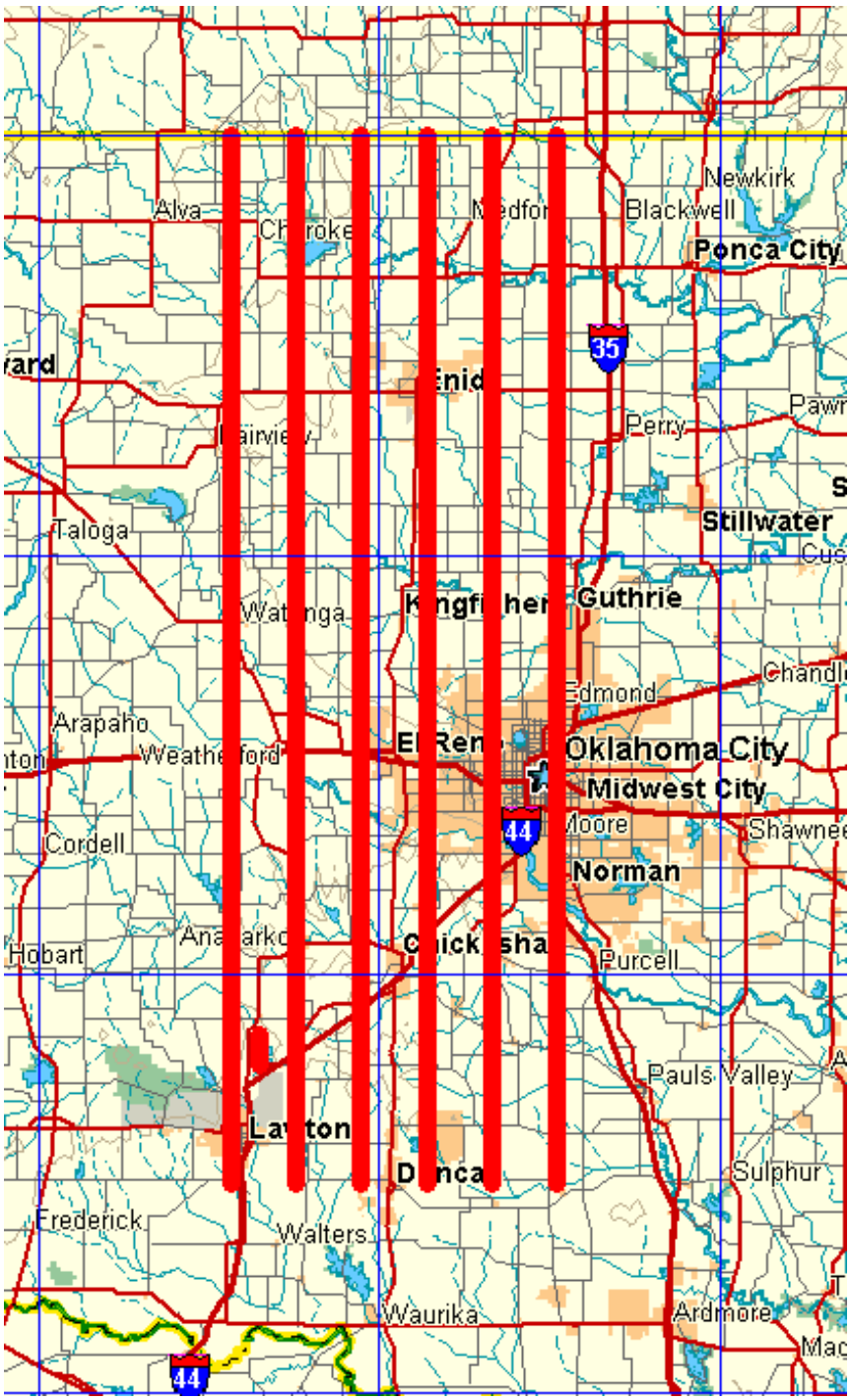


Figure 4. SMEX02 SGP Region, Oklahoma and Flightlines.

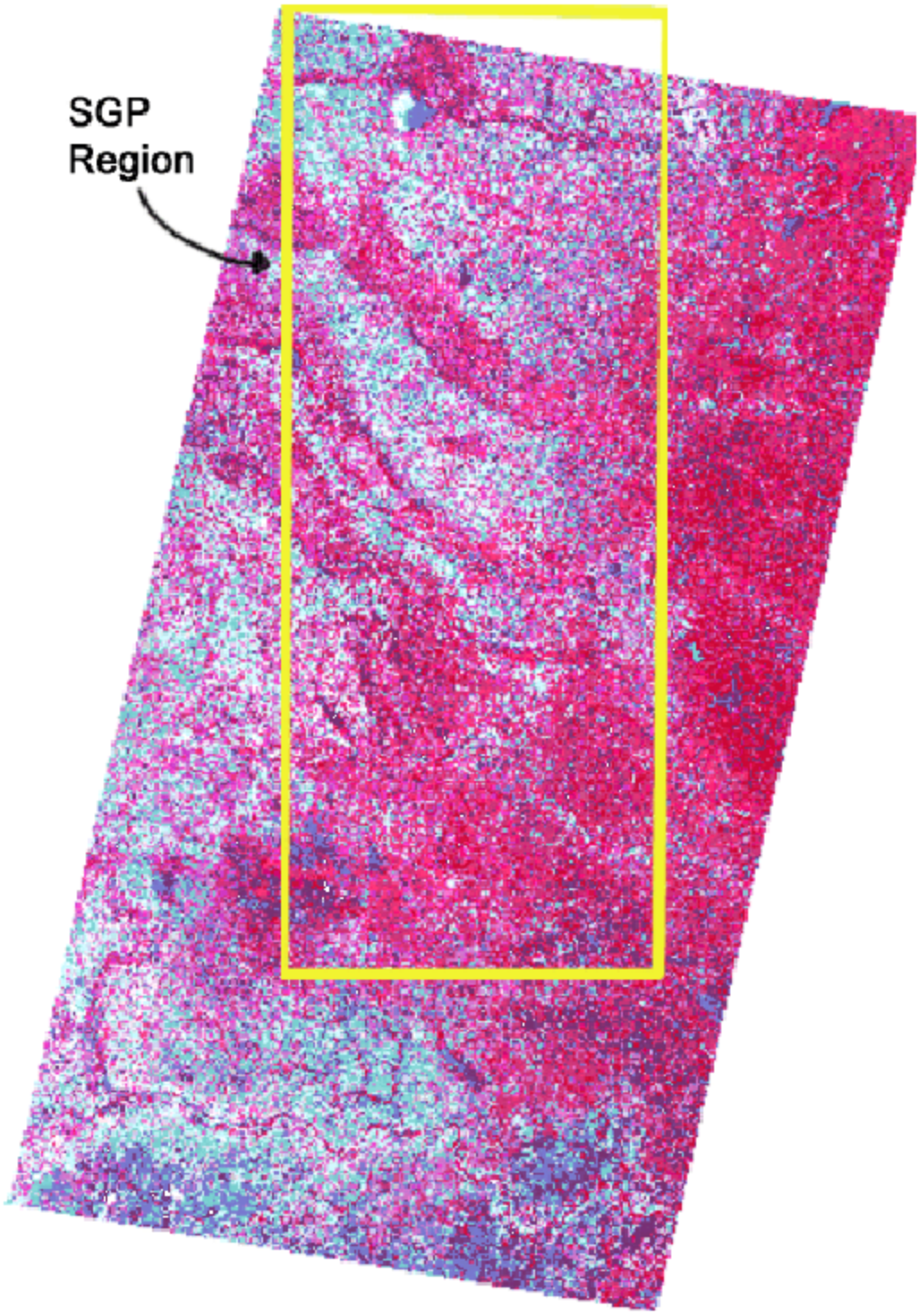


Figure 5. SMEX02 SGP Region Landsat Image

Figure 6a. Typical Rangeland in the SGP Region.

Figure 6b. Typical Post Harvest Winter Wheat Field in the SGP Region.

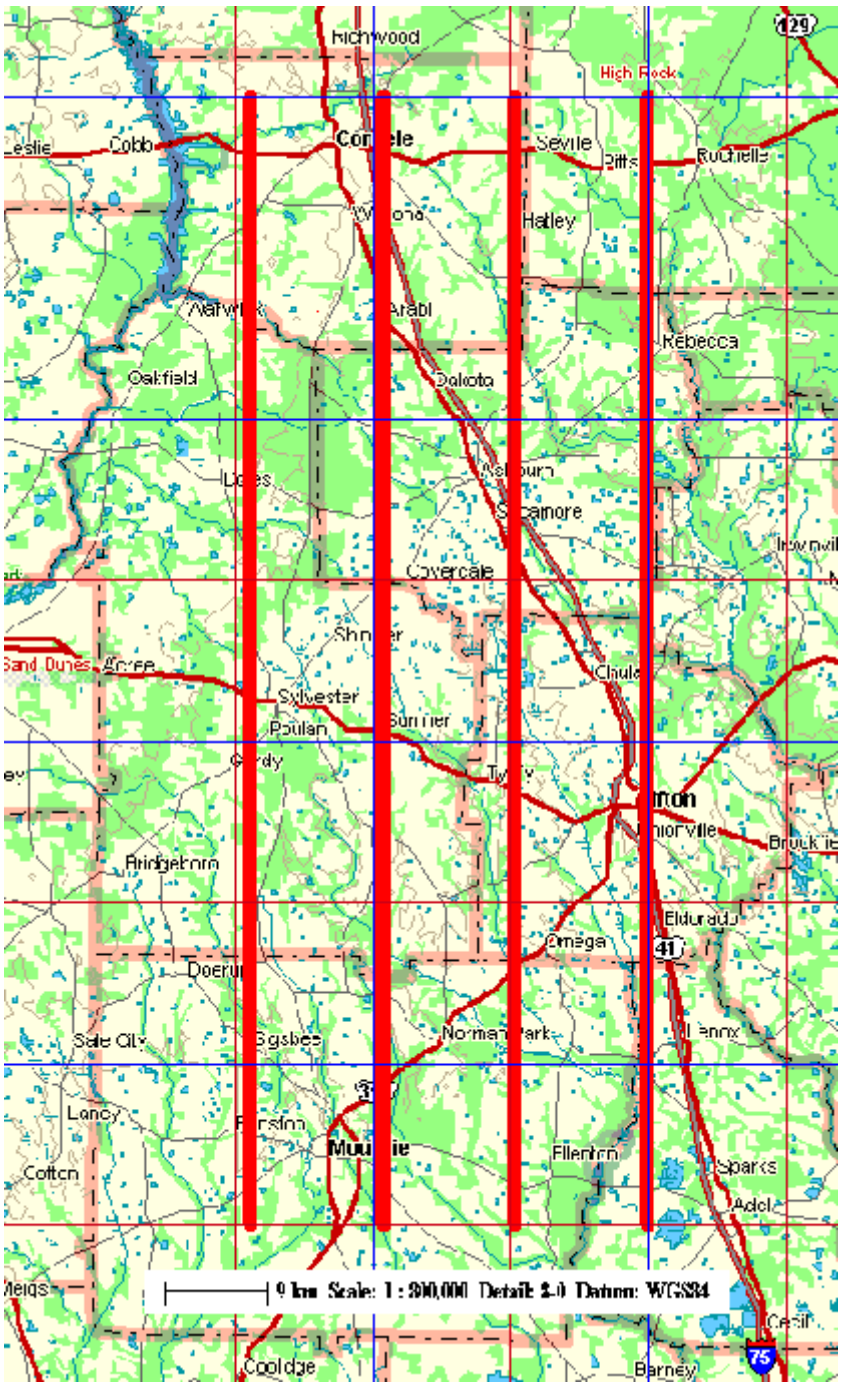


Figure 7. SMEX02 Little River, GA Area and Flightlines.