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LINKING GCM HYDROLOGIC PARAMETERS TO THE RADIOBRIGHTNESS OF NORTHERN PRAIRIE AND ARCTIC TUNDRA

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England, A.W., J.F. Galantowicz, Y.A. Liou, E.J. Kim, and P.A. Dahl, A model for the radiobrightness of northern prairie, Proc. of ESA/NASA Workshop on Passive Microwave Remote Sensing Research Related to Land-Atmosphere Interactions, Saint-Lary, France, January 11-15, 1993.

England, A.W., and J.F. Galantowicz, The Tower Mounted Radiometer System (TMRS), Proc. of the ISTS Workshop on Ground Based Microwave Radiometry for Snow Cover and Soil Moisture, U. of Toronto Institute for Aerospace Studies, North York, Ontario, June 17, 1993.

Galantowicz, J.F., and A.W. England, Mapping frozen ground from space: Lessons from the first radiobrightness energy balance Experiment, Proc. of Pecora XII, Sioux Falls, S.D., Aug. 24-26, 1993b.

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Galantowicz, J.F., and A.W. England, The first radiobrightness energy balance experiment, Am. Geophysical Union Spring Meeting, Baltimore, May 24-28, 1993a.

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Rojas, T.H. (advised by A.W. England), TDR vs Gravimetric; a comparison of soil moisture determination methods, UM Radiation Laboratory Technical Report 030613-1-T, September, 1993.

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Galantowicz, J.F., and A.W. England, Field data report for the First Radiobrightness Energy Balance Experiment (REBEX-1), October 1992-April 1993, Sioux Falls, South Dakota, UM Radiation Laboratory Technical Report RL-904, December, 1993d.

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II Project objectives

Numerical weather prediction and short-term regional climate studies are based upon mesoscale atmospheric circulation models (e.g., Budyko, 1974; Manabe, 1960; Bhumralkar, 1983; Giorgi and Mearns, 1991; Peixoto and Oort, 1992; and Trenberth, 1992). Boundary forcing estimates of energy and momentum flux at the land interface for the atmospheric models are obtained from biosphere models (e.g., Rind, 1982; Shukla and Mintz, 1982; Dickinson, 1984; Yeh et al, 1984; Sellers et al, 1986; Abramopoulos et al, 1988; Delworth and Manabe, 1988, 1989; Verstraete, 1989; and Avissar and Verstraete, 1990). The Biosphere Atmosphere Transfer Scheme (BATS) (Dickinson et al, 1986) is one of the more popular of these biosphere models. Our goal is to link BATS to satellite radiobrightness for the purposes of better estimating moisture in soil and vegetation, and, eventually, of providing feedback to the biosphere model.

Specific tasks from the original proposal include:

(a) If not completed under NAGW-1983, incorporate soil moisture phase change in the MCRR/Annual model.

(b) Incorporate a more realistic atmospheric model with temporally variable temperature, humidity, cloudiness, and wind speed in the MCRR/Diurnal and MCRR/Annual models.

(c) Select or modify an existing vegetation model for incorporation in the MCRR/Diurnal and MCRR/Annual models. Link soil temperature and moisture to atmospheric temperature, humidity, wind speed, and brightness, i.e., define radiant, latent, sensible, and moisture fluxes through this vegetation model.

(d) Test the resulting MCRR models with SSM/I data, with data from the Konza Prairie experiments (FIFE'87 and FIFE'89), and with data acquired with TMRS in the Matthaei Botanical Garden and the South Dakota field experiments (summer and fall of 1992 under NAGW-1983), in the Alaska experiment (fall of 1993 under the U.S. Geological Survey experiment), and with data from a TBD experiment to be designed under this investigation for the summer of 1995.

(e) Incorporate a canopy scattering model in the MCRR/Diurnal and MCRR/Annual models.

(f) Explore running the MCRR/Annual model interactively with an existing mesoscale climate model.

III Review of progress

By task:

(a) The MCRR/Annual model has been modified to include freezing soil. The work was completed during the fall of 1992 and was reported under this project at the ESA/NASA Workshop on Passive Microwave Remote Sensing Research Related to Land-Atmosphere Interactions, in Saint-Lary, France, January 11-15, 1993 (England et al, 1993).

(b) Development of the atmospheric model is scheduled for next year.

(c) We have obtained a copy of BATS from the National Center for Atmospheric Research (NCAR) and have installed it on our Sun Sparc Station. The predictions of BATS have been compared for a 10 day interval in October, 1992, with the land-atmosphere energy fluxes observed during our First Radiobrightness Energy Balance Experiment (REBEX-1) near Sioux Falls, South Dakota, September 1992 through March 1993. The results will be reported at the 1994 International Geoscience and Remote Sensing Symposium in Pasadena, CA.

(d) Our first prairie experiment, REBEX-1, occurred during the fall and winter of 1992-1993 and yielded an impressive data set -- radiobrightness at 19.35, 37.0 and 85.5 GHz, thermal infrared brightness, solar flux, net flux, local weather, and soil temperature and heat flux every 15 minutes for 7 months (Galantowicz and England, 1993a, 1993b, 1993d). These data have been compared against the predictions of the MCRR/Annual model (Galantowicz and England, 1993c). From the experiment and the comparison, we recognize several weaknesses in both the data and the model.

Our first discovery was that we lacked several critical measurements:

(i) Our Tower Mounted Radiometer System (TMRS) included selectable polarization radiometers at 19.35, 37.0, and 85.5 GHz. We now recognize the need for dual polarized radiometers at the lower frequencies.

(ii) We measured soil moisture on core samples collected several times during the experiment period. We now recognize the need for continuous measurement of soil moisture at several depths. This can be done with time-domain reflectometry.

(iii) We now recognize the need for estimating evapotranspiration rates. This can be done with a Bowen ratio instrument.

(iv) We now recognize the need to measure downwelling, long-wave radiance. This can be done with a pyrgeometer.

TMRS was to have been used in an experiment in wetlands permafrost on the North Slope of Alaska during the fall of 1993. Because of the weaknesses discovered in REBEX-1, we decided to delay the Alaska work for one year and use the first year of this project to improve TMRS. These improvements include the additions of dual polarization at 19.35 and 37.0 GHz, a time-domain soil moisture system, a Bowen ration instrument, and a pyrgeometer. While undergoing these instrument additions, TMRS has been further hardened for field work in Alaska by the addition of a new door with a better seal and heaters to remove ice, by a new door drive, and by relocation of detection, video, and A/D conversion circuits from the trailer to the tower. Enhanced-TMRS should be in the field in January, 1994. Specifications have been documented (Galantowicz et al, 1993) and the new system will be reported at the 1994 International Geoscience and Remote Sensing Symposium in Pasadena.

Our second discovery was that we could no longer ignore latent energy transfer in the MCRR model. We have incorporated a rough estimate of latent energy transfer based upon soil and air temperature, and soil moisture. The predictions of the model appear reasonable. This enhanced MCRR model will be reported at the 1994 International Geoscience and Remote Sensing Symposium in Pasadena, CA.

The basic MCRR model is too primitive to serve our long-range needs. We have acquired a copy of the code for the Biosphere Atmosphere Scheme (BATS) -- a biosphere model that is used to estimate the energy and momentum flux at the land-atmosphere interface. BATS is more complete than the MCRR model in that it includes a much more sophisticated management of biosphere processes like moisture infiltration, runoff, and partitioning between soil and vegetation. We will incorporate the thermal and radiobrightness modules developed for the MCRR model into BATS so that the modified BATS will predict radiobrightness.

As an initial validation of BATS for northern prairie, we have compared the performance of BATS against the data from REBEX-1. This evaluation will be reported at the 1994 International Geoscience and Remote Sensing Symposium in Pasadena, CA.

(e) We have been experimenting with a strong fluctuation model for absorption, emission, and scattering of the radiobrightness by prairie grass. The results of the evaluation will be reported at the 1994 International Geoscience and Remote Sensing Symposium in Pasadena, CA.

(f) We have acquired the code for Mesoscale Model 4 (MM4) from the National Center for Atmospheric Research (NCAR). The model is running on our Sun Sparc Station.

IV Accomplishments this year

Under the essential impetus of this project, we have:

1. Reported an enhanced MCRR model under this project at the ESA/NASA Workshop on Passive Microwave Remote Sensing Research Related to Land-Atmosphere Interactions, in Saint-Lary, France, January 11-15, 1993 (England et al, 1993), and at the Pecora XII Conference in Sioux Falls, South Dakota, Aug 24-26, 1993 (Galantowicz and England, 1993c).

2. Completed the REBEX-1 field experiment and presented various subsets of results at the American Geophysical Union Spring Meeting in Baltimore, May 24-26, 1993 (Galantowicz and England, 1993a), at the Pecora XII Conference in Sioux Falls, South Dakota, Aug 24-26, 1993 (Galantowicz, 1993b), and in a technical report (Galantowicz and England, 1993d).

3. Presented the Tower Mounted Radiometer System (TMRS) at the ISTS Workshop on Ground Based Microwave Radiometry for Snow Cover and Soil Moisture, U. of Toronto Institute for Aerospace Studies, North York, Ontario, June 17, 1993 (England and Galantowicz, 1993).

4. Will have completed the construction, testing, and integration of Enhanced-TMRS radiometers by January 15, 1994 (Galantowicz et al, 1993), and have rebuilt the stand-alone, 37 GHz Dicke test radiometer (Galantowicz and England, 1993e).

5. Constructed, calibrated, and integrated time-domain soil moisture probes for Enhanced-TMRS (Rojas, 1993).

6. Constructed, tested, and integrated a Bowen ratio instrument for Enhanced-TMRS (Galantowicz et al, 1993).

7. Measured and reported the vertical distribution of biomass and moisture in a prairie grass canopy (Dahl et al, 1993).

8. Completed and will report a 10 day comparison between BATS and the REBEX-1 data.

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