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I Products this year

Symposia - Proceedings

Liou, Y.A., and A.W. England, Effect of latent heat transfer on diurnal and annual prediction of temperature and radiobrightness of northern prairie, Proc. of IGARSS'94, Pasadena, CA, August 8-12, 1994.

Judge, J., J.F. Galantowicz, and A.W. England, An evaluation of BATS as a basis for a radiobrightness model for northern prairie, Proc. of IGARSS'94, Pasadena, CA, August 8-12, 1994.

Galantowicz, J.F., and A.W. England, Radiobrightness signatures of energy balance processes: Melt/freeze cycles in snow and prairie grass covered ground, Proc. of IGARSS'94, Pasadena, CA, August 8-12, 1994.

England, A.W., and J.F. Galantowicz, A volume emission model for the radiobrightness of prairie grass, Proc. of IGARSS'94, Pasadena, CA, August 8-12, 1994.

Symposia and invited lectures

England, A.W., Use of satellite remote sensing to improve biosphere models, CASE Seminar, University of Michigan, June 13-15, 1994.

England, A.W., Use of satellite remote sensing to improve biosphere models, GEWEX Global Soil Wetness Workshop, Longmont, CO, October 4-6, 1994.

England, A.W., Use of satellite remote sensing to improve land-atmosphere models, Geophysical Institute, Fairbanks, AK, October 12, 1994.

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. BATS was driven during 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. BATS consistently over-estimated daytime vegetation temperature by between 10 and 20%. These discrepancies are far too large for BATS to be the basis of our linked Soil-Vegetation-Atmosphere Transfer (SVAT)–Radiobrightness model. Our results were reported at the 1994 International Geoscience and Remote Sensing Symposium (Judge, Galantowicz, and England, 1994).

(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). As useful as these data are, the comparison between data and model highlighted several weaknesses in both the data and the model.

Our Tower Mounted Radiometer System (TMRS) lacked several critical instruments:

(i) 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. TMRS has been rebuilt to include dual polarization at 19.35 and 37.0 GHz.

(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 (TDR). A TDR system has been added to TMRS. The system measures relative permittivity (interpretable as soil moisture) at several depths in the soil at the TMRS site.

(iii) We recognize the need for estimating evapotranspiration rates. This can be done with a Bowen ratio instrument. Such an instrument has been assembled from components supplied by Campbell Scientific and the system has been integrated into TMRS.

(iv) We need to develop a better snow model. To do so requires temperature and liquid moisture profiles in the snowpack. The TDR system can be used to estimate moisture content, and an array of thermistors have been added to TMRS to measure temperature. An improved snow model that incorporates metamorphism based upon antecedent weather is under development. This new model will be the core of John Galantowicz' Ph.D. thesis.

(v) We now recognize the need to measure downwelling, long-wave radiance. This can be done with a pyrgeometer. For reasons of cost, this instrument has not yet been added to TMRS.

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 time to improve TMRS. These improvements include the additions of dual polarization at 19.35 and 37.0 GHz, the time-domain soil moisture system, and the Bowen ration instrument. 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 is now in the field, 20 miles north of Toolik Lake on the Arctic Slope of Alaska. We control the instrument and receive data dumps through a UHF telephone link. The experiment, REBEX-3 will continue through mid-summer of 1995.

Based upon the results of REBEX-1, we could no longer ignore latent energy transfer in our SVAT 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 model was reported at the 1994 International Geoscience and Remote Sensing Symposium (Liou and England, 1994).

Our improved SVAT model is still too primitive to serve our longer 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. While BATS is more sophisticated than our SVAT model in its management of biosphere processes like moisture infiltration, runoff, and transpiration, we find that

BATS is not adequate for the reasons cited in item c, above, and that it may not contain and adequate model of stomatal resistance. We are building a new SVAT model for prairie that will replace the prairie module within BATS. This new model will be tested during our 4th field experiment (REBEX-4) which is currently scheduled for the Sioux Falls site during 1995-96. This experiment will extend through the 1996 growing season and could support our Priroda experiment as well.

(e) We have been experimenting with various models of emission from prairie grass. We find that a simple refractive emission model performs very well at 19.35 GHz. We drove this model with observed canopy and soil temperatures and moistures during 22 snow-free days of October, 1992, from REBEX-1. The error between observation and model averaged less than -0.1 K for the 1800 measurements and the standard deviation was 1.5 K. These results were reported at the 1994 International Geoscience and Remote Sensing Symposium (England and Galantowicz, 1994). A similar comparison between the 37.0 GHz observations and model shows an average scatter darkening of 4.9 K with a standard deviation of 1.7 K. This darkening is being explained through a strong fluctuation scattering model and will be reported at the Combined Optical-Microwave Earth and Atmosphere Sensing (CO-MEAS) Symposium in Atlanta, April 3-6, 1995.

(f) We want to be able to test our modified BATS against an atmospheric model. Mr. Yuei-an Liou has taken training at the National Center for Atmospheric Research (NCAR) on Mesoscale Model (MM) 5. We plan to run MM5 on the Cray at NCAR, but with the modified BATS that we are developing. The sensitivity tests resulting from these simulations will become the core of Mr. Liou's Ph.D. thesis.

IV Accomplishments this year

Under the essential impetus of this project, we:

1. Rebuilt and greatly enhanced TMRS.
2. Began a new field experiment, REBEX-3, on arctic tundra.
3. Incorporated evapotranspiration in our SVAT–Radiobrightness model (Liou and England, 1994).
4. Completed and a 10 day comparison between BATS and the REBEX-1 data (Judge, Galantowicz, and England, 1994).
5. Analyzed the prairie soil freeze/thaw process and SSM/I radiobrightness signature (Galantowicz and England, 1994).
6. Completed and tested a refractive emission model for 19.35 GHz against REBEX-1 data (England and Galantowicz, 1994).
7. Presented our results through several invited lectures and seminars (see Sec. I).

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