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Validation of Satellite Retrieved Land Surface Variables

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Abstract – The effective use of satellite observations of the land surface is limited by the lack of high spatial resolution ground data sets for validation of satellite products. Recent large scale field experiments include FIFE, HAPEX-Sahel and BOREAS which provide us with data sets that have large spatial coverage and long time coverage. It is the objective of this paper to characterize the difference between the satellite estimates and the ground observations. This study and others along similar lines will help us in utilization of satellite retrieved data in large scale modeling studies.

BACKGROUND

Large scale studies of hydrology are greatly aided by the use of satellite data. Satellite data have repeat temporal and large scale spatial coverage and can be used in conjunction with station data to infer land surface - atmosphere interactions. However, large spatial and long time scale comparisons of satellite and ground observations have been far and few. Recently, numerous studies have compared the two estimates (Sugita et al. 1993, Jin et al. 1997, Prince et al. 1998, and Goetz et al. 1995). The present study differs from the above mentioned studies as it carries out comparisons over a much longer time period and therefore the difference statistics generated by this study can be used with greater confidence. We use the land surface data of surface skin temperature, surface air temperature and surface specific humidity from the Tiros Operational Vertical Sounder (TOVS) data. TOVS consists of the infrared and microwave sounders HIRS2 and MSU, have flown on the NOAA operational sun synchronous polar orbiting satellites TIROS N, NOAA 6-12 and NOAA 14 from late 1978 to the present day. These satellites view the earth twice daily at roughly 7:30 am/pm local crossing time or 2:30 am/pm local crossing time depending on the satellite. Susskind et. al., (1997) analyzed TOVS data for the period 1985-present to produce the Extended Pathfinder Path A data set which includes surface skin temperature, air temperature, specific humidity and microwave emissivity, atmospheric moisture and temperature profiles. Previous studies on comparison of monthly averages of surface temperature and vapor pressure (Lakshmi et al. 1998) have yielded good results.

DATA AND METHODS

The field observations of the land surface hydrological variables have been collected at the First ISLSCP (International Satellite Land Surface Climatology Project) Field Experiment (FIFE), Hydrologic Atmospheric Pilot Experiment in Sahel (HAPEX-Sahel) and Boreal Ecosystem-Atmosphere Study (BOREAS). The observations in these field experiments were carried out at ten minute to half hour frequency. The surface temperatures were measured by a downward looking InfraRed Thermometer (IRT), the air temperature with a thermometer and the relative humidity with a wet bulb thermometer. The data from the field experiments were compared with the TOVS data for the surface skin temperature (T_s), surface air temperature (T_a), and the surface vapor pressure

(ϵ_a), averaged over the $1^o X 1^o$ grid box including the field site. The field observations at the closest time of the satellite overpass were compared with the satellite data. The various overpass times of the NOAA satellites are listed in Table 1 below. The FIFE experiment area was $15kmX15km$. However, the FIFE area was located in a region where land use is homogeneous and land surface type was mostly tall prairie grass. Therefore, a comparison of the FIFE observations to the satellite data which has a $60km$ X $60km$ footprint was justified. In the case of BOREAS, the field observations were made at 10 flux towers in the study area. The observations from each flux tower was compared with the corresponding $1^o X 1^o$ grid box in which it was located. The flux towers are placed in areas that represent the surrounding location so the measurement is characteristic of a larger region surrounding the tower. The surface vapor pressure was computed from the TOVS data by using the surface specific humidity (which is a standard TOVS data product) and the GEOS-GCM grid point surface pressure. The surface vapor pressure for the field observations at FIFE, HAPEX-Sahel and BOREAS was computed using the observed relative humidity, surface air temperature and/or wet bulb temperatures.

satellite	overpass	period
NOAA 9	230 am/pm	Jan 1985 - Dec 1986
NOAA 10	730 am/pm	Dec 1986 - Jul 1991
NOAA 11	130 am/pm	Nov 1988 - Dec 1994
	730 am/pm	Aug 1997 - present
NOAA 12	730 am/pm	Jul 1991 - Dec 1998
NOAA 14	230 am/pm	Jan 1995 - present
NOAA 15	730 am/pm	Jun 1998 - present

Table 1: List of satellites and nominal overpass times for TOVS

RESULTS AND DISCUSSION

Figure 1 shows the comparisons between the TOVS derived surface air temperatures and the data measured at FIFE (First ISLSCP - International Satellite Land Surface Climatology Project, Field Experiment) corresponding to the NOAA 10 satellite. The NOAA 10 satellite is at 7:30am/pm only for the spots at the nadir. For spots viewed in the off-nadir portions of the scan, the local time can differ from 7:30am/pm by up to two hours. Accounting for this is extremely important when comparing a rapidly varying quantity such as surface skin temperature. In addition, since the HIRS2/MSU spot size is $60kmX60km$, there may be more than one spot in a $1^o X 1^o$ box. In such a case, the average skin temperature at the mean time of the spots is used. The exact local time of satellite measurements in the $1^o X 1^o$ grid box is used in comparing the am and the pm values of the derived surface skin temperature with the closest (with 15 minutes) AMS air temperatures. Results of daily comparisons are shown in Figure 1 separately for the nominal 7:30am and 7:30pm overpass. There has been no tuning or calibration in comparing these two sets of data. Furthermore, these two sets of data are derived from completely different sources with nothing in common. The comparison between the TOVS derived and the FIFE measured surface skin temperatures shows good agreement. This study is similar to the one carried out by Sugita et. al. (1993) except that this result has been carried out over more number of days. The dotted line is for the best fit regression line. More comparisons can be found in Lakshmi et. al. (1999).

We have comparisons between all the three variables, viz. - surface skin temperature, surface air temperature and surface specific humidity versus the corresponding observations at (1) FIFE, (2) HAPEX-Sahel and (3) BOREAS. We present in Table 2 below the statistics of the comparisons for surface skin temperature at the above-mentioned field experiments. Please note that overpass includes the NOAA satellite number, i.e. 11/130 am means NOAA 11, 130am overpass. The number of colocated observations and retrievals have been noted as n. It can be seen that there are about 10,000 comparisons. The statistics of these comparisons show that all the three variable are relatively unbiased (bias = 0.0) and their standard deviation are 4 ^oC, 3.5 ^oC and $3.5mb$ for surface skin temperature, surface air temperature and surface

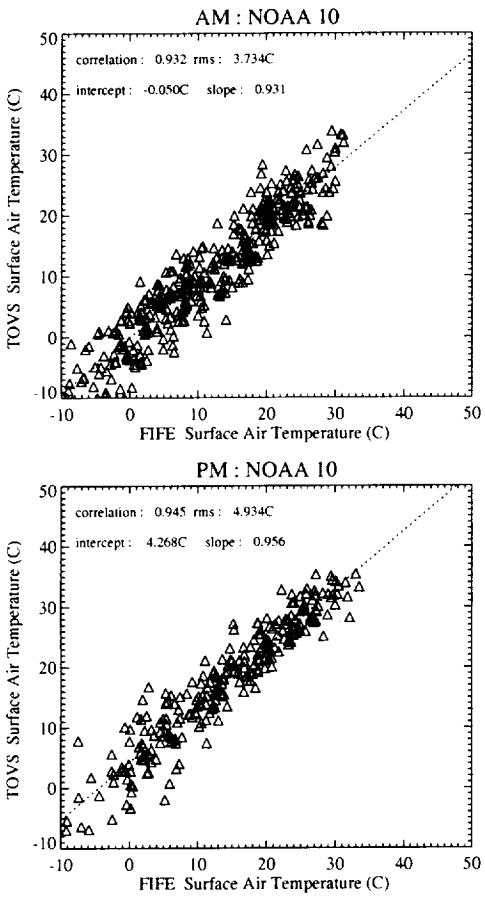

Figure 1: Surface air temperature measured in FIFE versus derived from NOAA 10

vapor pressure respectively. This is based on all three experiments. In conclusion, the results show good agreements between the TOVS retrieved and the ground data from field experiments. This will be great use in large scale hydrological modeling.

	overpass	n	std	corr	slope	bias
1	11/130 am	200	3.3^oC	0.93	1.02	0.68^oC
	11/130 pm	180	7.7^oC	0.85	1.04	-0.48
	10/730 am	552	4.9^oC	0.91	0.99	-0.06^oC
	10/730 pm	533	5.2^oC	0.89	0.99	-2.00^oC
2	11/130 am	18	2.8^oC	0.25	0.57	1.6^oC
	11/130 pm	21	4.1^oC	0.62	0.71	0.6^oC
	12/730 am	14	3.0^oC	0.63	1.0	3.2^oC
	12/730 pm	27	1.7^oC	0.81	1.09	0.5^oC
3	11/14/230 am	5640	5.8^oC	0.93	0.95	1.5^oC
	11/14/230 pm	5555	5.2^oC	0.94	0.95	0.6^oC
	12/730 am	5423	6.2^oC	0.93	0.96	0.6^oC
	12/730 pm	5605	5.2^oC	0.94	0.92	0.9^oC

Table 2: Daily comparisons in surface fields for surface skin temperature

REFERENCES

[1] Goetz, S. J., R. Halthore, F. G. Hall and B. L. Markham, Surface Temperature Retrieval in a Temperate Grassland with Multi-Resolution Sensors, *Journal of Geophysical Research*, 100, 25397-25410, 1995

[2] Jin, M., R. E. Dickinson and A. M. Vogelmann, A Comparison of CCM2-BATS Skin Temperature and Surface-Air Temperature with Satellite and Surface Observations, *Journal of Climate*, 10, pp1505-1524, 1997

[3] Lakshmi, V. and J. Susskind, Determination of Land Surface Skin Temperatures and Surface Air Temperature and Humidity from TOVS HIRS2/MSU Data, *Advances in Space Research*, Vol. 22, No. 5, pp629-636, 1998

[4] Lakshmi, V. and J. Susskind, Validation of TOVS Land Surface Variables using Ground Observations, Under review, *Journal of Geophysical Research*, 1999

[5] Prince, S. D., S. J. Goetz, R. O. Dubayah, K. P. Czajkowski, M. Thawley, Inference of surface and air temperature, atmospheric precipitable water and vapor pressure deficit using AVHRR satellite observations: validation of algorithms, *Journal of Hydrology*,212-213, pp230-250, 1998

[6] Sugita, M. and W. Brutsaert, Comparison of Land Surface Temperatures Derived from Satellite Observations with Ground Truth During FIFE, *International Journal of Remote Sensing*, 14, pp1659-1676, 1993 [7] Susskind, J., P.Piraino, L.Rokke, L.Iredell and A.Mehta, Characteristics of the TOVS Pathfinder Path A Data Set, *Bulletin of the American Meteorological Society*, Vol. 78, No. 7, 1449-1472, 1997