EOS PM-1 Science Data Validation Workshop

Hydrology Products Panel

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The hydrology group identified data products to be produced from EOS-PM sensors of potential use in hydrologic studies. These are: surface (skin) temperature, surface air temperature, precipitation, surface soil wetness, snow water equivalent, and snow areal extent. For each product, a brief summary is given that includes the instrument from which the products will be derived, the anticipated nature of the products, current status of validation plans, opportunities and needs, and potential opportunities for inter-instrument comparisons.

1) Surface (effective skin) temperature (from AIRS)

Surface skin temperature is a variable predicted by coupled land-atmosphere models, and some off-line hydrological models. It is a state variable that is often estimated by an iterative model computation that comes about when the surface energy balance is closed – insofar as the sensible heat, latent heat, and upwelling longwave radiation energy transfers all depend on an effective radiative temperature. For this reason, it is linked, indirectly, to surface resistance to latent and sensible heat transfer, and therefore to soil moisture. There have been some suggestions that skin temperature may have more information content, from the standpoint of the potential for updating (e.g., via assimilation) of land surface models, than does remotely sensed soil moisture. It should be noted, however, that there are complications in interpreting remote sensing estimates of effective skin temperature, particularly in cases of moderate vegetation cover, when the underlying soil temperature can differ substantially from vegetation temperature.

Validation plan: Current validation plans involve using surface (point) measurements (via AERI) of radiative temperature and emissivity, and HIS/MAS airborne measurements (to be flown on the ER-2). Pre-launch field observations at the SGP CART/ARM site are planned for October-November, 1998. Similar post-launch activities are planned.

Opportunities and needs: Greater emphasis needs to be placed on ground-based spatial variability studies – there is some doubt that planned surface and airborne validation data will be sufficient to assess the impact of subgrid variability. Coordination with planned soil moisture validation activities (e.g., SGP follow-on, see below) is apparently absent, notwithstanding that the same or similar sites are planned to be used for both.

Inter-instrument comparison: The possibility of comparisons/evaluations with a MODIS-derived effective temperature should be explored.

2) Precipitation (from AMSR)

Precipitation is perhaps the single most important variable for surface hydrology. However, the need is for temporal resolution of the order of catchment hydrologic response time, which is usually of the order of the time of travel through the channel system from the most remote part of a catchment to its outlet. Except for very large catchments, this is considerably less than one day in most cases. In turn, this is a much shorter time interval than that of the product to be provided by AMSR (currently anticipated to be monthly). Therefore, the AMSR product will be oriented primarily toward climatology. Its usefulness for surface hydrology will most likely be limited to parts of the globe where the current surface network is so sparse that good climatological estimates are lacking, and where catchments are large compared to the AMSR footprint size of about 25 km. Depending on the accuracy of the monthly time series that can be produced, there may be some potential for combining the monthly estimates with statistical disaggregation methods to produce shorter time step products. These products may have some applicability to macroscale hydrological modeling.

Validation plan: The current validation plan is to evaluate the monthly products using gage estimates for those parts of the globe (e.g., North America; Europe) where surface networks are sufficient to produce accurate monthly time series at spatial resolutions substantially finer than the AMSR footprint size. There are also plans to utilize the TRMM validation radars (Darwin, Kwajalein and networks along the Texas Gulf Coast, in southern Florida and near Sao Paulo, Brazil) to evaluate instantaneous precipitation rate estimates at overpass times.

Opportunities: WSR-88D radar products could be effectively utilized for evaluation of the instantaneous precipitation rate estimates, particularly if plans for polarimetric upgrades are implemented (e.g., at NSSL, and/or other radars providing coverage of the SGP area).

Inter-instrument comparisons: If TRMM is still operational at launch time, a potential should exist for comparison of accumulation products.

3) Surface soil wetness (from AMSR)

Soil moisture controls two key hydrological processes: runoff production and evapotranspiration. For this reason, there has long been a hope that hydrologically meaningful soil moisture estimates could be provided via remote sensing. Passive microwave sensors provide one such option, however the signal is rapidly attenuated by soil depths greater than a few cm, and by vegetation at wavelengths much shorter than L-band. Furthermore, there are complications in interpreting soil moisture estimates over large spatial scales, given that there are strong variations related to topography, soil type, and antecedent precipitation at spatial scales as short as meters. For all of these reasons, hydrological interpretation of the AMSR soil moisture product will inevitably be complicated. The most relevant AMSR wavelength (essentially C-band) is too short for effective surface soil moisture estimation where vegetation biomass is greater than about 1.5 kg/m2, which effectively limits its application to grasslands or other sparse vegetation. Nonetheless, significant areas of the interior of North America, Eurasia, and parts of the southern continents have vegetation within this limit.

Validation Plan: Some pre-launch evaluation is possible via retrospective analysis of SMMR, which had an appropriate spectral band (currently operating SSM/I does not). More effective C-band tests are expected to be possible once a C-band instrument is available for aircraft-based testing (expected within the next year). Completion of the simulator development and conduct of appropriate field observations is a high priority. Post-launch validation is planned via a Southern Great Plains field campaign, perhaps similar to SGP97, tentatively planned for 2001 or 2002. In addition, validation possibilities may exist for the currently planned GEWEX Hydrometeorological Panel transferability studies planned for GAME Tibet, where there are currently plans for flying a Japanese AMSR simulator.

Opportunities/Needs: There is a need to develop a global stratification of areas with vegetation less than the apparent upper limit for C-band surface moisture estimation. Tom Jackson (USDA) has produced a map which could be a starting point for such a classification. Analysis of the vegetation data, along with other relevant factors (i.e., precipitation climatology, topography, and soil characteristics) could form the basis for identification of global "end points" for validation studies.

Inter-instrument comparisons: Comparisons with data from a the similar instrument to be flown on ADEOS-II should be conducted. Opportunities for comparison with other more independent satellite measurements do not presently exist.

4) Snow areal extent (from MODIS and AMSR)

Snow areal extent is a variable predicted by most hydrological models applicable to temperate or high latitudes. Although snow water equivalent (see below) is in fact the state variable of greater interest, snow areal extent is more easily observed, and can be related to snow water equivalent presence/absence. Snow properties are of interest for coupled land-atmosphere modeling (e.g., for weather and climate prediction), primarily because of the considerable contrast in albedo between snow covered and snow-free areas. Snow is also important because of the moisture storage it represents, and is therefore of practical interest for water supply forecasting.

Validation Plan: MODIS will be flown on EOS-AM as well as PM, and validation plans have been developed in connection with EOS-AM. Field campaigns will include intensive observation (primarily using aerial photography) over New England and the Midwestern U.S. Target test sites have been selected to provide contrast in subpixel vegetation characteristics, which are important at the MODIS resolution (approximately 0.5 km for snow products). Current plans for AMSR validation of snow extent products are to use MODIS product intercomparisons.

Opportunities/Needs: There is some question as to whether validation using MODIS products will be sufficient for evaluation of AMSR snow extent, particularly given the differences in footprints. Such a validation approach is subject to any uncertainties associated with the MODIS product. In any event, there is a need for a well thought-out AMSR snow extent validation strategy.

Inter-instrument comparison: As indicated above, there is an opportunity for AMSR-MODIS product intercomparisons. An opportunity also exists for pre-launch comparisons for AVHRR and SSM/I snow extent products.

5) Surface air temperature (from AIRS)

Surface air temperature is used in hydrologic predictions for computation of evapotranspiration and (somewhat less commonly) for estimation of surface sensible heat flux. It is also useful as a surrogate for estimation of downward longwave radiation.

Validation plan: Little information was available to the group about this product. However, there is an extensive global surface air temperature network, which presumably would be used for validation.

Opportunities/needs: Insufficient information was available to address this question.

Inter-instrument comparisons: Comparisons between the AIRS surface air temperature data product and similar products derived from the operational NOAA POES sounders should be done.

6) Snow water equivalent (from AMSR)

Snow water equivalent is an important hydrological state variable. It is predicted by most hydrological models when applied to climates where significant snowfall occurs. It is also important because of the strong contrast in albedo between snow-covered and snow-free areas, which therefore affects the surface energy balance. In some cases, such as the western U.S. and high northern latitudes, winter snow accumulation is the primary contributor to stream flow, and in such cases snow water equivalent at the end of the snow accumulation season is an important predictor of subsequent runoff.

Validation plan: During the pre-launch period, the primary validation sets are snow water equivalent derived from SSM/I, NOAA aircraft transects (primarily Midwestern U.S.) using gamma radiation sensors, and point observations from such sources as the NRCS SNOTEL network (western U.S. only) and Russian observations. In the post-launch period, the main validation data sets are expected to be derived from NOAA gamma flights, and perhaps (as yet unspecified) field campaigns.

Opportunities and Needs: There is a strong need for development of a comprehensive post-launch validation plan. This could be based on global stratification of areas where passive microwave sensing is expected to be most useful (e.g., absence of wet snow). On the ground, it is essential that the relatively large footprint be taken into accounted. This probably means manual transects, e.g., following the lead of the Canadians in collecting data for testing and validation of SSM/I algorithms. Coordination with other ongoing large scale hydrological activities, such as the Coordinated Extended Observing Periods (CEOPs) of the relevant GEWEX continental scale experiments (MAGS, GAME-Siberia, GCIP, BALTEX) should be undertaken.

Inter-instrument comparisons: Comparisons with data from a the similar instrument to be flown on ADEOS-II should be conducted. Opportunities for comparison with other more independent satellite measurements do not presently exist.