corresponds to the DF assumptions. Youngs used an integral relation to define a new potential which depends on the free surface height and also on the vertical velocity component, and which for steady flow satisfies a Poisson equation in the horizontal coordinates. We use the assumption of linear variation of vertical velocity to calculate an approximation to the Youngs potential. In some simple flow systems such as the classical dam problem this leads to a simple differential equation for the free surface height, which can be solved numerically. In some cases simple explicit approximations can be found for quantities of interest, such as the maximum free surface height between drainage ditches.

H22G-03 1420h

Approximate Similarity Solutions to the Boussinesq and the Porous Medium Equations.

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The Boussinesq equation models unconfined groundwater flow under the Dupuit assumpion that the equipotential lines are vertical, making the flowlines horizontal. For certain classes of initial and boundary conditions it is possible to reduce problem to a nonlinear ODE and construct approximate analytical solutions. We extend the approach of Lockington, Parlange, Parlange, and Selker (2000) that constructed quadratic approximate similarity solution for the power-law head boundary condition at the inlet. Our new cubic approximation as the original quadratic approximation preserves the scaling properties of the problem, but it produces much better results. Also, we extend this approach to other types of boundary conditions. Discussed method is rather general and we apply it to the porous medium equation that describes the laminar flow of the polytropic gas through porous media.

H22G-04 1435h

Analytical Solutions Of The Degenerate Diffusion Equation

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Certain nonlinear diffusion equations of degenerate parabolic type display a finite speed of propagation of disturbances. This mathematical behavior can be used to describe a wide range of nonlinear phenomena such as the penetration distance of a thermal layer, the boundary of a reaction zone, or a wetting front unsaturated soil moisture flow. However there are two maindifficulties in obtaining solutions to problems of this class. One is that the location of the interface is not known a priori and must be discovered during the analysis. The other is the fact that the differential equation is singular in the neighborhood of the interface. The solution technique developed and presented in this work overcomes these difficulties by extracting a local solution of the differential equation in the neighborhood of the diffusing front. One profound result is the discovery that the velocity of the front is entirely controlled by the first term of the spectral series expansion. Also, by capturing the critical behavior of the solution in the region of the singularity and incorporating the behavior as a dominant factor, the series expansion is provided a means for very rapid convergence. The versatility of the solution technique is demonstrated by solving various boundary value problems covering a broad range of interest and the solutions are tested against previously published results.

H22G-05 1450h

Operator Fractional Motion: Permeability Fields with Anisotropic Long Range Dependence and the Effect on Plume Growth

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Anisotropy in the dependence structure of hydraulic conductivity K is typically handled by a dilation of one or more physical coordinates. However, aquifer K measurements usually have completely different scaling behaviour in the horizontal versus vertical directions. Mandelbrot's original definition of fractional motion is based on fractional-order differentiation or integration of a stable noise, which in a discrete setting can be represented by a field of iid random numbers with any distribution. In one-dimension, fractional integration or differentiation of the noise is handled in Fourier space by division by $p(ik)^{A} + q(-ik)^{A}$, where $A = H + 1/2$ is the scaling exponent (H is the Hurst coefficient) and p and q represent the relative weight on forward versus backward integration. The influence of large values may have directional dependence, i.e., the occurrence of K structures may be causal. A subset of this is isotropic, $p = q = 1/2$, leading to the familiar division by $|k|^{A}$. For multidimensional self-similarity, the exponent A is replaced by a matrix $\mathbf{A}$. Furthermore, the weighting of the directional integrals is described by a random measure (the mixing measure) on the unit sphere. The result is an Operator Fractional Motion (OFM) that has, what is called in hydrologic applications, "Generalized Scale Invariance." The utility of the OFM is that 1) similarity of extreme K values may be restricted to a small set of directions, as one might expect in fractured rock or fluvial depositional environments (such as braided streams), and 2) the scaling matrix A has unique eigenvalues that describe the scaling (e.g., the Hurst coefficients) in any direction. The eigenvectors of A need not be orthogonal. For sedimentary deposits, we might expect that the K field is positively correlated in the horizontal direction, but anticorrelated in the vertical. It has been suggested that a plume's continuously non-Fickian growth rate can be predicted by measuring H (therefore A) in the direction of transport. We generate synthetic K fields with identical statistical properties in the direction of transport, but different values of A in the transverse direction. The growth of plumes in these fields strongly depends on the scaling properties of the K field in the transverse direction. Low values of transverse A lead to plumes that quickly become quite Fickian.

H22G-06 1505h INVITED

Land-Atmosphere Exchange Over Complex Terrain

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We study turbulent boundary layer flow over surfaces with varying roughness scales. The goal is to use LES results to formulate effective boundary conditions in terms of an effective roughness height and blending height. The LES are implemented with the dynamic Smagorinsky model based on the Germano identity. To account for geometric complexities associated with surface heterogeneity and its effects on the subgrid scales, the Lagrangian dynamic SGS model is implemented. A systematic array of simulations of flow over patches of differing roughness is performed, covering a range of patch length scales and surface roughness values. The simulated mean velocity profiles are analyzed to identify the height of the blending layer and to measure effective roughness lengths. We propose a simple expression for effective surface roughness and blending height knowing local surface patch roughness values and their lengths. Predictions of the model agree well with the LES results.

H22G-07 1525h

Integrated Modeling of Infiltration, Evapotranspiration, Recharge, Subsurface Flow, Surface Runoff, and River Flow with First Principle, Physics-based Approaches

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Over the past 30 years, progress in the development of physics-based models for individual processes of infiltration, evapotranspiration, recharge, moisture redistribution in vadose zone, groundwater flow, surface runoff, and river flow has been remarkable. However, these individual processes are continuously and dynamically coupled over various spatial and temporal scales. In the past, each individual process was often investigated assuming other coupling and influencing processes were a priori. For example, to model overland flow (surface runoff), it was often implicitly assumed that the infiltration was known and the feedback from groundwater flow and river flow were not explicitly enforced. Integrated approaches to modeling coupled processes have gained momentum recently. Many integrated models have achieved the coupling via external or internal linkage of individual process-level models. As a result, these models often have to introduce undue empiricism. This paper presents the development of an integrated numerical model of the aforementioned processes. A rigorous coupling of these hydrological processes is achieved with the first principle approach by imposing the continuity of volumetric fluxes and state variables. In this integrated model, any process between two media is the natural consequence of interaction and feedback between processes occurring in the media. For example, infiltration and recharge are spatially and temporally varied and are the consequence of interacting flow processes on the land surface (overland) and in the subsurface media and rivers. Numerical implementations of the theoretical coupling are thoroughly discussed. Several example problems will be used to demonstrate theoretical and application aspects of this model. Key Words: Infiltration, Evapotranspiration, Recharge, Surface Runoff, Groundwater Flow, River Flow, Numerical Model

H22H MCC: 3024 Tuesday 1600h

Early Results From NASA's EOS Aqua Spacecraft Mission II *(joint with A, OS)*

Presiding: **S M Graham,** NASA Goddard Space Flight Center**; R Spencer,** University of Alabama in Huntsville

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H22H-01 1600h INVITED

Observation of Sea Surface Temperature by two Microwave Radiometers; AMSR and AMSR-E

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In 2002, two passive microwave radiometers (MR) were launched successfully into the space. One is the Advanced Microwave Scanning Radiometer-E (AMSR-E) aboard AQUA of the National Aeronautics and Space Administration (NASA), and the other is the AMSR aboard the Advanced Earth Observation Satellite-II (ADEOS-II) of the National Space Development Agency of Japan (NASDA). AMSR/AMSR-E have low frequencies, such as 6 and 10 GHz, and one of new parameters derived from those frequencies is the sea surface temperature (SST). MR have a merit to observe geophysical parameters through clouds, and AMSR/AMSR-E also can observe SST through clouds. We can trace continuously the oceanic eddies in the Kuroshio Extension region, from 5 day averaged SST images. On the other hand, MR have a demerit of low spatial resolution. The spatial resolution of instantaneous SST of AMSR or AMSR-E is an order of 50 Km. But, AMSR/AMSR-E take SST samples with 10Km interval. We can see finer structure than 50Km, by composing two sensors data during several days. We will validate composed SST, by using the infrared data of Global Imager (GLI) aboard the ADEOS-II.

H22H-02 1615h

Generation of brightness temperatures using the direct broadcast data from AMSR-E onboard Aqua satellite

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The Advanced Microwave Scanning Radiometer for EOS (AMSR-E) is a six-frequency dual-polarized passive microwave radiometer onboard Aqua satellite and forms an integral part of water cycle monitoring by Aqua. Like other sensors on Aqua, AMSR-E data are direct-broadcasted to local users. In this work we have processed the direct-broadcast data received by the Korea Meteorological Administration (KMA), S. Korea. To our knowledge, this is the first attempt to utilize the AMSR-E direct-broadcast policy. We use the Level 1B data processor developed by Japans NASDA, distributed by U.S. NSIDC. NASDA's processor is configured to handle 50-minute granules. For processing direct broadcast data, which are about 10-minute long, we found that the modification to the NASDA's system is required. The modifications include correction to path/orbit numbers and the land mask selection. Special consideration is necessary during the radiometric calibration because the direct broadcast data appears lacking the cold sky mirror (CSM) count. Pixel-to-pixel comparison with NASDA's product indicates the difference in brightness temperature of about 0.2 K rms and less than 0.05 K mean. These differences are expected to come from the different length of data between NASDA's 50-minute granule and around 10-minute data received by KMA. Some important meta data are incorrect, such as the equatorial crossing time/longitude and slight change in imaging time. However these errors do not affect the geometric and radiometric calibration. Using the Level 1B data, we have retrieved sea surface temperature and soil moisture parameters, to utilize the merit of the AMSR-E's 6.9GHz channel over other sensors in the past. We expect our result would benefit other international users who are interested in AMSR-E direct-broadcast.

URL: http://satrec.kaist.ac.kr

H22H-03 1630h

Sea surface temperature measurements from the MODerate- resolution Imaging Spectroradiometer (MODIS) on AQUA

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Measurements in the infrared atmospheric transmission windows taken on the MODIS instrument on AQUA, along with that on TERRA, provide accurate measurements of the skin surface temperature of the ocean. Details of the instrumental corrections and atmospheric correction algorithms that are applied to derive sea-surface temperature will be given along with results of validation studies that provide estimates of the uncertainties in the derived fields.

H22H-04 1645h

INTRASEASONAL VARIABILITY OF SEA SURFACE TEMPERATURE: A VIEW FROM THE NASA/EOS AQUA SATELLITE

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Based on the AQUA/MODIS sea surface temperature (SST) data, the features of intraseasonal SST perturbation have been investigated. The preliminary results display many interesting phenomena, which haven't been documented in previous SST analyses. The daily MODIS/SST data from April to June 2003 were processed, covering the global domain between 50°S and 50°N. In terms of wavelet transform analysis, the intraseasonal oscillations with 2-week and MJO (30-60 days) have been identified. These two perturbation components shared similar distribution patterns. In the tropical-subtropical zone (i.e., 30°S-30°N), the perturbations were weak (<0.3°C) in large oceanic bodies, but were medium (0.6°) to strong (1°C) in special regions: (1) medium SST perturbations were forward along the coastlines of many continents, namely in the eastern Pacific along the west coast of the Americas, in the western Pacific along the east coast of Asia (but not Australia), and in the western Atlantic along the west coast of Africa; (2) an elongated strong MJO perturbation area was found in the equatorial eastern Pacific; (3) medium perturbations were in the Pacific ITCZ, Atlantic ITCZ, Pacific warm pool, and northern Indian Ocean; and (4) a strong 2-week SST perturbation was shown in eastern Pacific west of Baja California. The two extratropical zones (i.e., 30°N-50°N and 30°S-50°S) each had an extensive 2-week perturbation band with localized strong perturbation areas inside. In the northern band, a large (°) circular MJO SST perturbation area was centered at 170°W and 30°N and a chain of 2-week perturbation areas existed in the northwestern Atlantic. The southern band exhibited a series of 2-week perturbation areas distributed along the Indian, Pacific, and Atlantic Oceans and two MJO SST perturbation areas were southwest of Austria and east of South Africa. The evolution of MJO SST perturbation in the Pacific Ocean showed that the SST perturbations in the area centered at 170°W and 30°N and in the area centered at 140°E and 20°N constitute a pair of inverse variations. However, the 2-week SST perturbations seemed not as coherent and structural as the MJO SST perturbations.

H22H-05 1700h

Global optimum interpolated microwave SSTs from Aqua's AMSR-E improve hurricane intensity forecasting

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NASA launched the Earth Observing System (EOS) AQUA spacecraft on May 4, 2002. One of the instruments onboard is NASDA's Advanced Microwave Scanning Radiometer Earth Observing System (AMSR-E), the first polar orbiting microwave radiometer capable of measuring accurate global through-cloud sea surface temperatures (SST). Although microwave SSTs have a lower spatial resolution than the more traditional infrared SSTs, their thru-cloud SST capabilities significantly improve coverage. Retrieval of SST is prevented only in regions affected by sun glitter, rain, or nearby land. As compared to Reynolds OI SSTs, AMSR-E SSTs have a mean bias of 0.001 C and a standard deviation of 0.73 C. The sun glitter and rain-missing data are filled in' using optimum interpolation (OI) to create global, daily, near-realtime SSTs at 25 km resolution. OI SSTs are useful to numerical weather prediction and research activities in which a complete, daily SST map is preferred to one with missing data due to orbital gaps or environmental conditions precluding SST retrieval. The value of these OI SSTs was recently tested in the Statistical Hurricane Intensity Prediction Scheme (SHIPS) model run operationally by the National Hurricane Center. This model is usually run with 100 km weekly SSTs, by substituting the higher temporal and spatial resolution of MW OI SSTs in the model, forecast accuracy was improved up to 1.3% in the North Atlantic and 6.9% in the East Pacific for 2002 storms.

URL: http://www.remss.com

H22H-06 1715h

Uncertainty Estimates for Retrievals of Oceanic Rainfall from AMSR-E

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The paucity of suitable ground truth for oceanic rainfall retrievals forces the use of physically based algorithms. While there are still many advantages to physically based algorithms, we are still left with the problem of validation. Building an error model is the only approach left for meaningful uncertainty estimates for the retrievals. The rainfall retrieval community has considered the primary sources of error and now preliminary estimates are available for the most important ones and many of the less important ones as well. These errors depend on many factors including the rainfall intensity, the freezing level, the frequency, view angle and polarization of the observations, as well as instrument performance and satellite geometry. These dependencies are too complex to permit a simple error estimate. The error model must be integrated with the retrieval algorithm. This has been done for rainfall estimates from AMSR-E. Although there is still a need to refine the individual contributions to the total error, we have adequate understanding to permit a reasonable estimate of the net uncertainty of the rain rate for individual pixels (Level-2) and for 5° x 5° x 1 month boxes (Level-3).

H22H-07 1730h

Coastal Rainfall Estimation using AMSR-E

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The vast majority of microwave rainfall estimation research has been for either ocean-filled or land-filled fields of view, as the physics for both surface types are quite different. However, neither ocean-based nor land-based methods may be used for coastal pixels that contain a mixture of water and land. Current algorithms for coastal regions perform relatively poorly. We have built upon previous coastal rainfall algorithms developed for the Special Sensor Microwave/Imager (SSM/I) and TRMM Microwave Imager (TMI). Using principal component analysis, we found multi-frequency brightness temperature responses to rainfall over coastal regions, enabling us to do a more accurate rain/no-rain classification. The TMI has similar frequencies and resolutions as AMSR-E, so we could use the colocated TMI and Precipitation Radar (PR) data to determine the principal components related to rainfall. These principal components are effective in distinguishing rain from no-rain AMSR-E pixels, as we show with AMSR-E data. We include global results as well as those from the Eureka, CA, coastal radar AMSR-E validation site.

H22H-08 1745h

Flooding Estimates from Aqua Microwave Observations

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A new method to derive estimates of flooding from centimeter-wave satellite based passive microwave observations, with an example from the Aqua Advanced Microwave Sounding Unit (AMSU-A), is described. The observed effect, a deep depression in observed brightness temperatures of flooded land areas compared with dry land, is caused by a very large difference in surface emissivity between the two cases, on the order of 0.5 at wavelengths of a centimeter. Then the surface brightness, i.e. the product of skin temperature and surface emissivity, is much lower for a land surface covered by standing water than for dry land. Two methods for deriving estimates of the areal extent of flooding are discussed. The first is a differential method, which uses repeat overpasses of the same area to determine the apparent cooling, largely due to changes in the emissivity. The second uses the observed brightness temperature and instrument characteristics to estimate the amount of surface covered by water within each field of view. As an example we discuss the flooding caused by Tropical Storm Isidore, which made landfall on the Louisiana coast on September 26, 2002 and proceeded north-northeastward while precipitating heavily and causing extensive flooding in the region. Preliminary AMSU-derived flooding estimates are compared with rainfall totals and flooding estimates derived from Quickscat observations. The method will be extended to other satellite microwave radiometers operating at centimeter wavelengths, such as the Aqua AMSR-E, the DMSP SSM/I, and others.