H22I MCC: 3020 Tuesday 1600h

Coordinated Enhanced Observing Period (CEOP) II *(joint with A, OS, GC)*

Presiding: **J O Roads,** Scripps Institution of Oceanography**; R Lawford,** NOAA

H22I-01 1600h

The First Globally Integrated Water Cycle Data Sets by CEOP

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In an effort to achieve more accurate determination of the water cycle and its association with climate variability and change as well as to establish a baseline set of information on the impacts of this variability on water resources, the Coordinated Enhanced Observing Period (CEOP) was launched on July 1, 2001. The preliminary data period, EOP-1, was implemented from July to September in 2001. The first annual enhanced observing period, EOP-3, started on October 1, 2002. CEOP is seeking to achieve a database of common measurements from both in situ and satellite remote sensing, model output, and four-dimensional data analyses (4DDA; including global and regional reanalyses) for a specified period. In this context, a number of carefully selected reference stations are linked closely with the existing network of observing sites involved in the GEWEX Continental Scale Experiments, which are distributed across the world. The initial step of CEOP is to develop a pilot global hydro- climatological dataset with global consistency associated with climate variability that can be used to help validate satellite hydrology products and evaluate, develop and eventually predict water and energy cycle processes in global and regional models. The dataset, will be used to address studies on the inter-comparison and inter-connectivity of the monsoon systems and regional water and energy budgets, and will provide a means for down-scaling from the global climate to local water resources, as a secondary activity.

URL: http://www.ceop.net

H22I-02 1615h

Development of CEOP Reference Site Data Sets

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This presentation will discuss the development of a series of specialized observational data sets for the World Climate Research Programme (WCRP) Coordinated Enhanced Observing Period. CEOP is composed of a number of global WCRP research programmes [i.e. Global Energy and Water Cycle Experiment (GEWEX), Climate Variability and Predictability (CLIVAR), and Climate and Cryosphere (CliC)]. Each one of the GEWEX Continental Scale Experiments selected a number of well instrumented reference sites in various climatic regions of the world (36 in total) to support CEOP research activities. These reference sites provide observations of surface meteorology, radiation, fluxes, soils, and atmospheric profiles in a variety of spatial and temporal resolutions in different formats. The University Corporation for Atmospheric Research/Joint Office for Science Support (UCAR/JOSS) takes these disparate data and conducts a consistent processing and quality assurance methodology leading to the development of a data set in a consistent format and temporal resolution. This presentation will discuss the data processing, quality assurance, and data archival and distribution of the initial CEOP data set (1 July to 30 September 2001) and the current status of (and plans for) the three additional annual cycle data sets that will cover the period from October 2001 to December 2004.

URL: http://www.joss.ucar.edu/ghp/ceopdm/

H22I-03 1630h

CEOP Data Archive Integrated Data Mining System

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The Coordinated Enhanced Observing Period (CEOP) is a coordinated international activity of the World Climate Research Program (WCRP) to archive and distribute in situ data from 36 globally distributed reference sites; satellite data from NASA, NASDA, ESA and Eumetsat; and global Numerical Weather Prediction model output data provided by 10 agencies. The University of Tokyo and the Japanese Space Agency NASDA are working together to create a "data mining" process for the CEOP data archive. This process will have a user interface which will allow users to select the type of data, the location and the time period for the data request. The data mining system will then extract the data from the archive through an integrated process and provide the resulting data to the user. This data mining process will mine disparate data types (i.e. satellite data scenes, in situ data and NWP output data) with widely differing temporal and spatial distributions, in various file formats and data formats in a geospatial manner to provide "integrated" data sets. For example, providing the satellite data pixel values geolocated to be directly over in situ data sites, and in situ data at the same time as the satellite data scene, for algorithm and model output validation. This system is expected to be interoperable with satellite, in situ, climate research and other data archives outside of the CEOP data archive.

H22I-04 1645h

ECPC Contributions to CEOP

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The Experimental Climate Prediction Center (ECPC) is currently using the NCEP/DOE Reanalysis II (RII) model and the ECPC version of the NCEP seasonal forecast model (SFM) to provide global model output for the Coordinated Enhanced Observing Period (CEOP). The resolutions of these two global models are T62L28 and both global models are initialized from the RII. The output from the RII model and SFM include analysis files (F00), and forecast files every 3hours (F03 and F06) from short-range 6-hour forecasts initialized every 6 hours (00, 06, 12, 18 UTC). Every 24 hours (12 UTC), the 6 hour forecast is extended to 36 hours and again model output is available every 3 hours of the 36 hour forecast. The output from Jul. 1, 2001-Dec. 31, 2004 at several international reference sites as well as in gridded form will be sent to the Max Planck Institute for Meteorology (MPIM), who will soon make it and similar model output from 9 other international centers available to the entire global research community. Preliminary comparisons of ECPC model output to in situ measurements at several tower sites have already shown several potential ECPC model deficiencies including: excessive evaporation and diurnal biases in the precipitation. These comparisons will be described at the meeting.

URL: http://ecpc.ucsd.edu/gcip/

H22I-05 1700h

Using CEOP EOP-1 in situ observations to evaluate land surface processes simulated from the NCEP Global Forecast System coupled with the Noah LSM

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The Coordinated Enhanced Observing Period (CEOP) is a coordinated international activity aimed to establish an integrated global observing system for the water cycle. It contains satellite data, model and assimilation output, and in situ observations, with a focus on hydrometeorological processes in the atmosphere and land surface. In this study, CEOP EOP-1 (covers the time period from 1 July, 2001 to 30 Sept, 2001) in situ observations are used to evaluate land surface processes simulated in the NCEP Global Forecast System (GFS). Two versions of GFS are used in this experiment, one is the operational version and the other is the experimental version coupled with the Noah Land Surface Model (LSM). The development and subsequent evaluation/assessment of the latter version is part of the efforts to unify the Noah LSM in all NCEP regional and global models and their associated data assimilation systems. The fields of interest for this comparison are surface meteorology and fluxes (such as near-surface temperature, humidity, sensible heat flux, latent heat flux) and sub-surface fields (e.g., soil heat flux, soil temperature, and soil moisture). Among 36 in situ reference sites in the CEOP network, only 10 sites contain both surface and sub-surface observations. This study, therefore, will focus on selected sites where multi-layer soil temperature/moisture observations are available.

H22I-06 1715h INVITED

The CEOP Inter-Monsoon Studies (CIMS)

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Prediction of climate relies on models, and better model prediction depends on good model physics. Improving model physics requires the maximal utilization of climate data of the past, present and future. CEOP provides the first example of a comprehensive, integrated global and regional data set, consisting of globally gridded data, reference site in-situ observations, model location time series (MOLTS), and integrated satellite data for a two-year period covering two complete annual cycles of 2003-2004. The monsoon regions are the most important socio-economically in terms of devastation by floods and droughts, and potential impacts from climate change and fluctuations of the hydrologic cycle. Scientifically, it is most challenging, because of complex interactions of atmosphere, land and oceans, local vs. remote forcings in contributing to climate variability and change in the region. Given that many common features, and physical teleconnection exist among different monsoon regions, an international research focus on monsoon must be coordinated and sustained. Current models of the monsoon are grossly inadequate for regional predictions. For improvement, models must be confronted with relevant observations, and model physic developers must be made to be aware of the wealth of information from existing climate data, field measurements, and satellite data that can be used to improve models. Model transferability studies must be conducted. CIMS is a major initiative under CEOP to engage the modeling and the observational communities to join in a coordinated effort to study the monsoons. The objectives of CIMS are (a) To provide a better understanding of fundamental physical processes (diurnal cycle, annual cycle, and intraseasonal oscillations) in monsoon regions around the world and (b) To demonstrate the synergy and utility of CEOP data in providing a pathway for model physics evaluation and improvement. In this talk, I will present the basic concepts of CIMS and the key scientific problems facing monsoon climates and provide examples of common monsoon features, and possible monsoon induced teleconnections linking different parts of the world.

H22I-07 1730h

Asian monsoon system studies in CEOP

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One of the major targets of the CEOP monsoon study is to compare the monsoon systems in various regions on the earth. Although, Asian monsoon is often referred to as typical monsoon system, when viewed the seasonal change processes of convection, the northward and southward seasonal migrations show different character from other continental monsoons. This maybe a result of the land-ocean configuration and topography, but minute dynamics have not been yet realized. Another interesting point is the regional differences of pre-monsoon and monsoon onset processes, for example, between Indian and Indochina monsoon. The heating over the continent in the pre-monsoon season produces low level circulation between the continent and adjacent ocean which furnishes a necessary condition for the sudden monsoon onset both in Australian and Indian monsoon. This process is weak in case of Indochina monsoon onset and suggesting that

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the role of ocean is more important. The warming over the western North Pacific is crucial for the onset of Indochina monsoon, while that over the continent is important for the Indian monsoon onset. Why such difference is generated? The state of pre-monsoon rains over Indochina is also different from that over India. Periodic rains occur in April and early May in the pre-monsoon season over Indochina. These events are influenced by the invasion of mid-latitude disturbances. The major moisture for these rains comes from the Pacific, contrasting with the summer monsoon westerly flows. It is still unclear why Asian summer monsoon starts earliest over Indochina. Apparent regional differences of diurnal variations of tropical rainfall have been revealed in Asian monsoon region using minute rainfall observations, satellite remote sensing, radar observations and non-hydrostatic cloud-resolving numerical models. The diurnal eastward migrating rainfall system during summer monsoon season is investigated in Thailand. However, there are many different characters of diurnal rainfall variability in Asian monsoon region which have not been well understood. The mechanism causing above mentioned problems would be studied under CEOP integrated observational data and CIMS (CEOP Inter-monsoon Model Study).

H22I-08 1745h

Murray Darling Basin Isotope Observations: an Essential Component of the Australian CEOP

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The Murray Darling Basin Coordinated Enhanced Observing Period (CEOP) is the Australian contribution to the international effort by the World Climate Research Program (WCRP) to acquire in situ and satellite hydrometeorological data and to use these data sets to develop improved land surface process understanding in climate models. Within the GEWEX Continental Scale Experiments (CSE) system, the Murray Darling Basin (MDB) isotope collection is also co- coordinated with the International Atomic Energy Agency's Global Network for Isotopes in Rivers (GNIR). The data collection phase extends from 1 July 2002 to 30 June 2005 with a special focus on Darling River in situ reference sites. We are using CEOP data to monitor water and salt processes and to improve their representation in various atmosphere and land surface hydrometeorological models. Specifically, we find that among the 17 AMIP (Atmospheric Model Intercomparison Project) II AGCMs (Atmospheric General Circulation Models) with no reporting errors (Henderson-Sellers *et al.*, 2003) six fail to close the water balance to within ± 0.05 mm d^{-1} in the Murray Darling CSE. Also seven models implausibly simulate 17-year mean evaporation greater than mean precipitation in the MDB due, to some extent, to poor soil water initialisation. Indeed, we find that soil water initialisation is a prevalent problem in all the GEWEX CSE regions. Furthermore, the non-closure of their surface water budget and very different evaporation ratios from observations suggest that reanalyses are not appropriate tools for evaluating the AGCMs' simulated surface water budget components. Due to constrained atmospheric forcing, off-line land-surface schemes, such as VIC, close the surface water balance and simulate evaporation ratios better than any reanalyses but in some regions, such as the MDB, runoff ratios are very different from observations. Here, we report on simulated and observed surface water budget components from models and reanalyses. Finally, we examine isotopes as an alternative tool for the evaluation of AGCMs' hydrometeorology.

H22J MCC: 3022 Tuesday 1600h

Hydrologic Flow Near the Earth's Surface II

Presiding: **D Barry,** University of Edinburgh**; T S Steenhuis,** Cornell University

H22J-01 1600h INVITED

Fingering and Intermittent Flow in Unsaturated Fractured Porous Media

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Because of the dominance of gravitational forces over capillary and viscous forces in relatively large fracture apertures, flow processes in unsaturated fractures are considerably different from flow in rock matrix or in unsaturated soils. Additionally, variations in fracture geometry and properties perturb the delicate balance between gravitational, capillary, and viscous forces, leading to liquid fragmentation, fingering and intermittent flows. We developed a quantitative framework for modeling fluid fragmentation and the subsequent flow behavior of discrete fluid elements (slugs). The transition from a slowly growing but stationary liquid cluster to a finger-forming mobile slug in a non horizontal fracture is estimated from the force balance between retarding capillary forces dominated by contact angle hysteresis, and the weight and shape of the cluster. For a steady flux we developed a model for liquid fragmentation within the fracture plane that gives rise to intermittent discharge, as has been observed experimentally. Intermittency is shown to be a result of interplay between capillary, viscous, and gravitational forces, much like internal dripping. Liquid slug size, detachment interval, and travel velocity are dependent primarily on the local fracture-aperture geometry shaping the seed cluster, rock-surface roughness and wetness, and liquid flux feeding the bridge (either by film flow or from the rock matrix). We show that the presence of even a few irregularities in a vertical fracture surface could affect liquid cluster formation and growth, resulting in complicated flux patterns at the fracture bottom. Such chaotic-like behavior has been observed in previous studies involving gravity-driven unsaturated flow. Inferences based on statistical description of fracture-aperture variations and simplified representation of the fragmentation processes yield insights regarding magnitude and frequency of liquid avalanches. The study illustrates that attempts at describing intermittent and preferential flow behavior by adjustment of macroscopic continuum approaches are destined to failure at most local scales. In accordance with recent observations, flow behavior in partially saturated fractures tends to produce highly localize pathways that focus otherwise diffusive fluxes (film flow or matrix seepage).

H22J-02 1620h

Dynamic Capillary Pressure Mechanism for Instability in Gravity-Driven Unsaturated Flows

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Several alternative models for describing water flow in unsaturated porous media are presented. These models are each based on an equation for conservation of mass of water, and a generalized linear law for water flux (Darcy's law) containing a term referred to as the dynamic capillary pressure. The distinct form of each alternative model is based on the specific form of expression used to describe the dynamic capillary pressure. The conventional model arises when this pressure is set equal to the equilibrium pressure given by the capillary pressure - saturation function for unsaturated porous media, and this formulation leads to the Richards Equation(RE). Other models are derived by representing the dynamic capillary pressure by a rheological relationship stating that the dynamic capillary pressure is not given directly by the capillary pressure - saturation function. Two forms of rheological relationship are considered in this manuscript, a general non-equilibrium relation, and a more specific relation expressed by a first-order kinetic equation referred to as a relaxation relation. For the general non-equilibrium relation the model equation system is called the general Non-Equilibrium Richards Equation(NERE) model, and for the case of the relaxation relation the model system is called the Relaxation Non-Equilibrium Richards Equation(RNERE) model. Each of the alternative models is analyzed for flow characteristics under gravity-dominant conditions by using a traveling wave transformation of the equations for each model, and more importantly the flow described by each model is analyzed for linear stability. It is shown that when a flow field is perturbed by infinitesimal disturbances, the RE is unconditionally stable, while both the NERE and the RNERE are conditionally stable. Instability of flows for the NERE and the RNERE models are shown to be related to the saturation and pressure profiles being sufficienlty non-monotonic. Through a nonlinear stability analysis it is shown that flows for the RE are unconditionally stable not only to infinitesimal disturbances but to finite disturbances as well for both homogeneous and heterogeneous porous media.

H22J-03 1635h

Experimental Measurements of Saturation Overshoot on Infiltration

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Gravity driven fingers in uniform porous media are known to exhibit saturation overshoot with saturated (or nearly so) tips and much less saturation in the tails. We find that constant flux infiltration into confined (smaller than the finger width) porous media produces saturation overshoot identical to that found in gravity driven fingers. Using light transmission, the saturation profiles were measured as a function of infiltrating flux, porous media grain size, grain sphericity and initial water saturation. Saturation overshoot ceases below a mininum in infiltrating flux which depends greatly on grain sphericity and initial water content and slightly on grain size. We will discuss how the measured 1-D saturation overshoot is inconsistent with continuum models of porous media, but qualitatively matches well predictions using pore filling mechanisms. This suggests that pore-scale physics controls saturation overshoot and in turn gravity driven fingering.

H22J-04 1650h

Visualization and Analysis of Multiple Fluid Phases in Sandstone for Drainage and Imbibition

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In this study, we present results on the measurements of interfacial area per volume (IAV) in a natural three-dimensional porous medium, i.e. sandstone. A set of cored sandstone samples measuring 52 mm in diameter by 100 mm or 25mm in length were used in Wood's metal injection experiments to determine IAV. A wood's metal injection method was used to solidify the non-wetting fluid, which is the metal, and ethylene glycol was used to represent a wetting phase fluid. These samples were injected under different pressures from 0.014 MPa to 0.68MPa. Ethylene glycol flow rates measurements were applied before and after the injections to find the permeability difference of the samples. To visualize different phases and determine the IAV for a sample injected with Wood's metal, images of the Wood's-metal-injected core were taken with a Scanning Electron Microscope (SEM). A custom computer code was used to analyze each SEM image to isolate the rock phase, the wetting phase (EG) and the non-wetting phase, and to calculate the interface between each two phases. Analysis of the images of the metal-injected sample of the imbibitions processes found that average interfacial length per area (ILA) values for a natural